ex oriente e.V.

JORDAN الأردن
جامعة اليرموك
YARMOUK UNIVERSITY

bibliotheca neolithica Asiae meridionalis et occidentalis

Editors-in-Chief:

Hans Georg K. Gebel
Gary O. Rollefson

Basta Final Publication, Editors

Hans J. Nissen
Mujahed Muheisen (deceased)
Hans Georg K. Gebel

Managing Editor of this Volume:

Hans Georg K. Gebel

Cooperating Institutions for Publishing this Volume:

Faculty of Archaeology and Anthropology, Yarmouk University, Irbid
Institut für Vorderasiatische Altertumskunde, Freie Universität Berlin
Deutsche Forschungsgemeinschaft, Bonn

Financial Support for Printing this Volume:

Deutsche Forschungsgemeinschaft, Bonn
ex oriente e.V., Berlin

Hans Jörg Nissen, Mujahed Muheisen (deceased),
and Hans Georg K. Gebel (eds.)

BASTA I

THE HUMAN ECOLOGY

with contributions by

Maria Thaís Crepaldi Affonso, Cornelia Becker, Hans Georg K. Gebel,
Andreas Hauptmann, Bo Dahl Hermansen, Ulrich Kamp, Mujahed Muheisen,
Reinder Neef, Hans J. Nissen, Ernst Pernicka, and Nabil Qadi

bibliotheca neolithica Asiae meridionalis et occidentalis
&
Yarmouk University,
Monograph of the Faculty of Archaeology and Anthropology,
Volume 4

ex oriente, Berlin (2004)

address of the bibliotheca neolithica Asiae meridionalis et occidentalis:

ex oriente e.V, c/o Institut für Vorderasiatische Altertumskunde,
Freie Universität Berlin, Hüttenweg 7, 14195 Berlin, Germany

Printed in Germany by dbusiness GmbH, Berlin

ISSN 1616-9360 (bibliotheca neolithica Asiae meridionalis et occidentalis)
ISBN 3-9807578-0-3

Cover Photo by Yusuf Zu'bi, Yarmouk University.

BASTA JOINT ARCHAEOLOGICAL PROJECT

Joint Enterprise of

the Department of Antiquities
of the Hashemite Kingdom of Jordan,

the Institute of Archaeology and Anthropology
at Yarmouk University at Irbid,

and the Institute für Vorderasiatische Altertumskunde
at Berlin Free University,

supported by

the Deutsche Forschungsgemeinschaft, Bonn
the Yarmouk University, Irbid
and the Department of Antiquities, Amman

Table of Contents

List of Figures

Editors' Introduction

Present-day Site Setting and Physiographic Units, by Hans Georg K. Gebel

Geomorphological Site Setting and Geochemical Results, by Ulrich Kamp

"Greenstones" from Basta. Their Mineralogical Composition and Possible Provenance, by Andreas Hauptmann

Vegetation and Plant Husbandry, by Reinder Neef

On the Identification of Sheep and Goats: the Evidence from Basta, by Cornelia Becker

List of Tables, Diagrams, and Appendices

Raw Materials of the Flint and Ground Stone Industries, by Mujahed Muheisen, Nabil Qadi, and Hans Georg K. Gebel

"Greenstones" from Basta. Their Mineralogical Composition and Possible Provenance, by Andreas Hauptmann

Towards a Framework for Studying the Basta Industries, by Bo Dahl Hermansen and Hans Georg K. Gebel

Vegetation and Plant Husbandry, by Reinder Neef

On the Identification of Sheep and Goats: the Evidence from Basta, by Cornelia Becker

List of Plates

Editors' Preface and Acknowledgements

Present-day Site Setting and Physiographic Units, by Hans Georg K. Gebel

Site Preservation and Site Formation Processes, by Hans Georg K. Gebel

Raw Materials of the Flint and Ground Stone Industries,
by Mujahed Muheisen, Nabil Qadi, and Hans Georg K. Gebel

Mineralogical Analysis of Late PPNB Rings,
by Maria Thaís Crepaldi Affonso and Ernst Pernicka

Vegetation and Plant Husbandry, by Reinder Neef

On the Identification of Sheep and Goats: the Evidence from Basta, by Cornelia Becker

Editors' Preface and Acknowledgements

The preface to the first volume of the final publication of the excavations at Neolithic Basta offers the possibility for a brief retrospective view at the successful joint operation between the Institute of Archaeology and Anthropology of Yarmouk University (Jordan) and the Institute of Near Eastern Archaeology of the Free University of Berlin (Germany) on the one side, and to thank all those who on various occasions before, during, and after the excavation seasons set the stage for writing this successful story.

But before going into details, it is both our sad duty and our deep-felt sense of remembering and mourning to mention our long-time partner and friend, Dr. Mujahed Muheisen, who as the co-director of the Basta excavations made an invaluable contribution to the achievements of the joint project. His untimely death - though foreshadowed - shocked us all. Mujahed's sound scientific judgment, his openness in discussions, and his pleasant sense of humor not only helped to shape the objectives and the course of our work, but they were also essential in both avoiding and solving those controversies which unavoidably turn up during any joint venture. In particular, it should be mentioned that the field of specialization of both co-directors previously had lain outside of the area of Neolithic studies: Muheisen's in the Palaeolithic and Nissen's in later periods. The differing challenges offered by the particular requirements of a Neolithic excavation compelled all involved to adjust their attitudes, and this was instrumental in creating an atmosphere of deep mutual understanding. It is with profound sadness that we have to acknowledge the fact that we cannot fall back on the participation of Dr. Muheisen in the publication process. We miss him.

The list of acknowledgements is long. However, one person deserves to be mentioned in particular. As will be outlined later in greater detail, from the beginning former Crown-Prince Hassan bin Talal took an active interest in the Basta project, not only suggesting that a Jordanian and a German university should join forces, but also that the Jordanian Department of Antiquities should accept an active part in that joint project. We also gratefully acknowledge his loan of a helicopter for close-up aerial photography during the later days of the excavation.

As might be expected from the lists of participants, except for the pilot season of 1986, the size of the crew was rather large, and thus there was great need for financial support. This came from both universities involved, from the Department of Antiquities of the Hashemite Kingdom of Jordan, and in particular, from the German Research Association ("Deutsche Forschungsgemeinschaft"). We are greatly indebted to their authorities and pertinent committees for their generous support. Special thanks go to the Institute of Archaeology and

Anthropology (IAA) for providing the entire range of equipment for the living and working quarters by supplying everything from cutlery and bedding to tables and chairs to refrigerators and stoves.

In drafting and finalizing the agreement for the joint operation, it was a joy to have as partners Dr. Adnan Hadidi, then Director of the Department of Antiquities, and Prof. Dr. Moawwiyah Ibrahim, then Director of the IAA: it was a trusting cooperation that resulted in an agreement that proved to provide the foundation for fruitful cooperation. We also happily acknowledge the splendid support from the successors and their representatives both in the Department and the IAA, Drs. Safwan Tell, Fawzi Zeyadine, and Ghazi Bisheh, and Zeidan Kafafi, Fawwas al-Kreisheh, and Dr. Ziad al-Sa'ad, as well as the good services of the German ambassador to Jordan, Dr. Herwig Bartels.

As in any enterprise like ours, nothing could be achieved without those institutions and individuals mentioned above who provided the financial and material frame; yet, the outcome depended directly on the members of the excavation teams. We were lucky in being able to find a number of excellent people both on the Jordanian and foreign sides who formed a kind of core, either participating several seasons or joining us for almost the entire length. In particular, we wish to single out Nabil Qadi and Wajeeh Karasneh on the Jordanian side, and Bo Dahl Hermansen on the side of the foreign mission; the quiet, unfailing and enthusiastic involvement of all three constituted a pillar of consistency. In addition, we were able to recruit a varying number of participants, sometimes augmented by collaborating guests. There were times when the normal capacity of our main dining area of 24 seats was overstretched; but even that contributed to the joyful atmosphere.

The excavation would not have reached its success and extent without our excellent workmen from Basta, Ail, Bir Abu Dhanna, Fardah, and other villages around. We warmly thank all of them. Splendid cooks (1986-88: Adnan Farahad; 1989: Abu Muhammad; 1992: Ahmad Rashid Otallah Eshbul) cared about our health and well-being; Nabil Qadi was a most efficient camp manager in all the seasons. Abu Ibrahim (the mayor of Basta), Auda (the owner of Area B), and many other members of the Basta community accompanied our work over the years with their friendship.

The following is a listing of all team members of the various seasons; we gratefully acknowledge their work:

1986

Dr. Muheisen was supported by Nabil Qadi, Wajeeh Karasneh and Ibrahim Zu'bi, while the German side consisted of Hans J. Nissen, Hans Georg Gebel (deputy director), Gunnar Lehmann, Roland Lamprichs, and Gerald Sperling (photographer); in addition the crew was joined for two weeks by surveyor Thomas Rüth, in charge of drawing a master plan of the modern village of Basta and surroundings. The Department of Antiquities was represented by Suleiman Farajat, who also worked as a square supervisor.

1987

Again work was co-directed by Mujahed Muheisen and Hans J. Nissen, supported by their deputies Nabil Qadi and Hans Georg Gebel. The other members of the team were on the Jordanian side: Wajeeh Karasneh, Abdel Salam and Hisaiko Wada (site supervisors), Zaydoun Za'id (architect); on the German side: Bo Dahl Hermansen, Lykke Leonardsen and

Arno Kose (site supervisors), Gerald Sperling (photographer), Nikolaus Schlüter (excavation technician), and Irmgard Raidt (draftswoman). For shorter periods help came from Abdelrahim Hazim, Deifallah Obeidat and Katherine I. Wright (site supervisors), Michael Schultz and Tyede Helene Schmidt (physical anthropologists), Cornelia Becker (archaeozoologist), Reinder Neef (palaeoethnobotanist), and Hans Joachim Pachur and Michael Goschin (geomorphologists) and Margret Nissen (small find assistant). For a shorter period the excavation received help from Josef Raidt and the architect Ali Omari. The Department of Antiquities was represented by Suleiman Farajat, who also worked as a square supervisor.

1988

Co-directors were again Mujahed Muheisen and Hans J. Nissen, supported by their deputies Nabil Qadi and Hans Georg Gebel. On the Jordanian side the team consisted of Wajeeh Karasneh, Hisahiko Wada and Medi Becher (site supervisors), Zaydoun Za'id (architect); on the German side of: Bo Dahl Hermansen, Sevil Gülcur, Henning Hassmann (site supervisors), Gerald Sperling and Margret Nissen (photographers), Nikolaus Schlüter (excavation technician), Michaela Ruth Peter (draftswoman), Elisabeth Stephan (sieve supervisor), Christina Wittsack (small find assistant). For shorter periods we had the assistance of: Ulrike Ebeling, Martin Engeldinger, Andreas Mäckler (site supervisors), Ali Omari, Berta Nissen and Kay Prill (architects), Andreas Scherer, Abdullah and Petra Nabulsi (physical anthropologists), Cornelia Becker (archaeozoologist), Ulrich Kamp and Markus M. Nüsser (geomorphologists). The Department of Antiquities was represented by Sami Rabadi, who also worked as a square supervisor.

1989

Co-directors were again Mujahed Muheisen and Hans J. Nissen, supported by their deputies Nabil Qadi and Hans Georg Gebel. The Jordanian team consisted of Wajeeh Karasneh, Hisahiko Wada, Ibrahim Abdallah Hassan (site supervisors); Zaydoun Za'id (architect); Mohammed Khalid M. Rashid (social anthropologist). On the foreign side members were: Bo Dahl Hermansen, Sevil Gülcur, Henning Hassmann (site supervisors), Gerald Sperling and Margret Nissen (photographers), Nikolaus Schlüter (excavation technician); Wolfgang Reinhard Teitge (draftsman); Charlott Hoffmann Petersen, Jan von Richthofen, Beate Anne Schröder, Barbara Lydia Feller (flint and small find assistants); Cornelia Becker (archaeozoologist); Rainer Pasternak (palaeoethnobotanist); Hans Joachim Pachur, Ulrich Kamp, Michael Goschin (geomorphologists). For shorter periods we enjoyed the help of Matthias Starck, Sabine Karg, Deifallah Obeidat, Sally Randall, and Ibrahim Zu'bi. The Department of Antiquities was represented by Wajeeh Karasneh.

1992

Since both official co-directors were unavailable, work in the field was supervised by Nabil Qadi and Hans Georg Gebel. The crew consisted of Wajeeh Karasneh, Ibrahim Abdallah Hassan, Mohammed Jeredat, Mohammed Nasar (site supervisors), Zaydoun Za'id and Ali Omari (architects, parts of the season); Bo Dahl Hermansen, Frank Hahme (site supervisors); supported for shorter periods by Thomas Becker and Stephanie Brandl (students); Ute Schmidt (draftswoman); Rula Shafiq (student of physical anthropology); Friedrich and Mrs. Zink (restorers); Yusuf Zu'bi (photographer); and Ibrahim Zu'bi (site supervisor). Hans J. Nissen joined the team for the final week. The Department of Antiquities was represented by Wajeeh Karasneh.

This first volume of the Basta final publication is devoted to the ecology of human life at the Late Pre-Pottery Neolithic B village of Basta. It presents the palaeophysiography of an extraordinary Early Neolithic site in southern Jordan, with information on its abiotic and biotic resources as analyzed up to now. The contributions introduce to the major ecological foundations of the material culture and subsistence of this mega-site. Neolithic life in Basta was conditioned by the physical and social environments that interacted and competed on various levels with other neighboring, complex reciprocal systems of micro- and macroeconomies. Our data were approached by the human ecology- perspective, understood "as part of a human ecosystem within which [the Basta community] once interacted spatially, economically, and socially with the environmental matrix into which they were adaptively networked" (K.W. Butzer, *Archaeology as Human Ecology*, 1982: 211).

The other planned volumes will present in detail the material culture and its technologies as well as the physical anthropology (Stratigraphy and Architecture; The Burials and Human Remains; Small Finds and the Ornament Industries; The Mouldable Materials Industries; The Ground Stone and Bone Industries; The Chipped Stone Industries). A summarizing volume (The Neolithic Village of Basta), which includes also the remaining analysis of the subsistence data, is planned to come out from a concluding symposium completing our efforts to present the final publication of Basta. The focus of the final publication of Basta has to be data presentation with an emphasis on basic evaluation, much influenced by the possibilities of our post-dig resources.

Gary Rollefson supported this publication by editorial help. We warmly thank him.

Plate 1. Dr. Mujahed Muheisen, Basta 1987 (photo by M. Nissen).

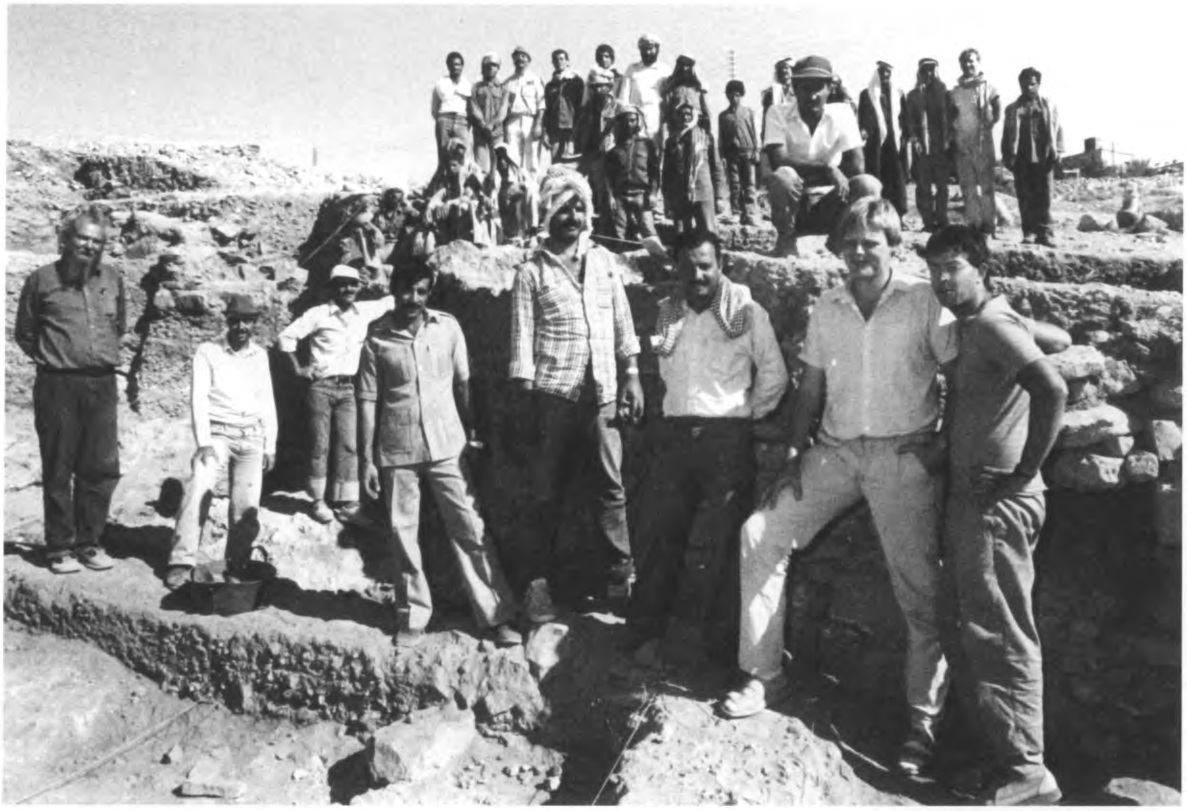


Plate 2.A. The 1986 crew.

Plate 2.B. The 1987 crew.

Plate 3.A. The 1988 crew.

Plate 3.B. The 1989 crew.

Editors' Introduction

Part I: The Course of Work

The Prelude

During his regional project *Palaeoenvironmental Investigations in the Greater Petra-Area - Holocene Research,* carried out for the Tübingen Atlas of the Near East (Gebel 1986, 1988), Hans Georg Gebel was alerted to Neolithic Basta in 1984 by Suleiman Farajat, head of the Petra Section of the Department of Antiquities of the Hashemite Kingdom of Jordan on the basis of a report on a survey carried out by the Department in 1972. Basta had been mentioned as Nabatean and Chalcolithic by Nelson Glueck (1934-35), who obviously passed Basta along the Southern flank of Wadi Basta, missing the Neolithic occupation on its Northern slope. The site was visited again by Diana Kirkbride during her work at Beidha between 1956 and 1982, attributing Basta to the Chalcolithic on account of a few scattered pottery sherds (Kirkbride 1959). It was only Ghazi Bisheh during the survey mentioned above who classified the site as "Pre-Pottery Neolithic" (Bisheh 1972). In 1973 Manfred Lindner passed Basta, also mentioning it as a Neolithic site (Lindner 1973).

After Gebel's brief sounding in 1984, the latter date could be confirmed and more closely identified as the latest phase of the Pre-Pottery Neolithic, the PPN B. Being largely covered by the modern village of Basta, the Neolithic site had undergone continuous destruction due to building activities of the villagers. Gebel's sounding in one of the building plots (Bakhit's house in 1985 = Cut 13; see below, Fig. 4) provided the entire range of what later became recognized as Basta's material culture. This included a diversified kit of flint implements, a large variety of ornaments, well-preserved walls and organic matter, and a young man's skull that testified to an intra-mural burial ground of Neolithic Basta (Röhrer-Ertl 1988). However, this visit was too short to realize both the size and significance of Basta.

On being notified of the problem of ongoing destruction Fawzi Zayadine of the Department of Antiquities revisited the site in late 1984, and recognizing the importance he invited H.G. Gebel to excavate Basta. However, since neither he nor the Tübingen Atlas project were able to come up with the necessary funds, Gebel approached both HRH Crown-Prince Hassan bin Talal for help as well as Hans J. Nissen, the director of the Institute of Near Eastern Archaeology at the Free University of Berlin. Both eventually became instrumental in the implementation of the Basta Joint Archaeological Project.

At this point Basta appeared to be simply another Early Neolithic site in the Petra area whose potential was suggested by the 1984 finding, the nearby settlements of Beidha and

Ba'ja, and the recently exposed and extraordinarily rich results from 'Ain Ghazal. The date of the 1984 finding furthermore indicated that in all probability excavations in Basta could be expected to yield information on the practically unknown LPPNB of Southern Jordan.

Nevertheless, though all reports on the site had been positive, there was no information on the actual feasibility of fieldwork within the village of Basta since work would have to be done between the modern houses. While work in Basta clearly had the character of a rescue operation, both Nissen and the prospective funding agency in Germany (the German Research Association) would insist that full involvement would be necessary if apart from doing rescue work enough undisturbed areas had survived to enable regular excavations. If during a pilot operation no such area could be found, this would have been the end of Basta excavations.

In spite of this uncertainty, it was decided to go ahead with the preparations for an archaeological investigation. Crown-Prince Hassan suggested the formation of a joint project between Jordanian and German partner universities in which the Department of Antiquities should take part, including funding. On the German side, Nissen saw the possibility of enlarging the field activities of his institute; not the least attraction was the prospect to enter a joint cooperation with the Jordanian colleagues. On the Jordanian side, the Institute of Archaeology and Anthropology at Yarmouk University, Irbid, under the directorship of Moawiyah Ibrahim, presented itself as a potent partner for a joint expedition. As part of the Institute's policy to advance joint operations, and based on an earlier successful cooperation between Mujahed Muheisen of the IAA and Hans Georg Gebel (co-directors of the 'Ain Rahub excavations in 1985), Mujahed Muheisen was proposed as prospective co-director of the planned Basta Project.

The parties met for the first time during the 3rd International Conference on the History and Archaeology of Jordan, held at Tübingen University in the spring of 1986. The meeting was attended by Dr. Adnan Hadidi on behalf of the Department of Antiquities, Dr. Moawiyah Ibrahim (Institute of Archaeology and Anthropology, Yarmouk University), and Hans J. Nissen and Hans Georg Gebel (both Free University of Berlin). Being aware of the impending danger for the site, a positive decision was reached within minutes that led to a draft of a contract on the actual procedures. When accepted it provided for an equal share cooperation between the two universities while the Department of Antiquities would contribute on housing and labor costs. The "Basta Joint Archaeological Project" would be co-directed by Dr. Mujahed Muheisen of the IAA of Yarmouk University, and Prof. Dr. Hans J. Nissen, Institut für Vorderasiatische Altertumskunde of the Free University of Berlin. It was decided to start as early as possible with a pilot operation in summer of 1986.

The 1986 Season

The pilot operation lasted from August 20 to September 20, 1986.

The aims were to

- establish a site plan;
- survey the area in order to delineate the approximate limits of the Neolithic settlement;
- sound as many different parts of the site as possible, taking advantage of exposed cuts and sections along streets, building excavations *etc.*, and if necessary
- carry out minor clearances on construction sites; and most importantly,
- look for a potential area for regular excavation; a positive result would lead to drawing up an operation plan for future work.

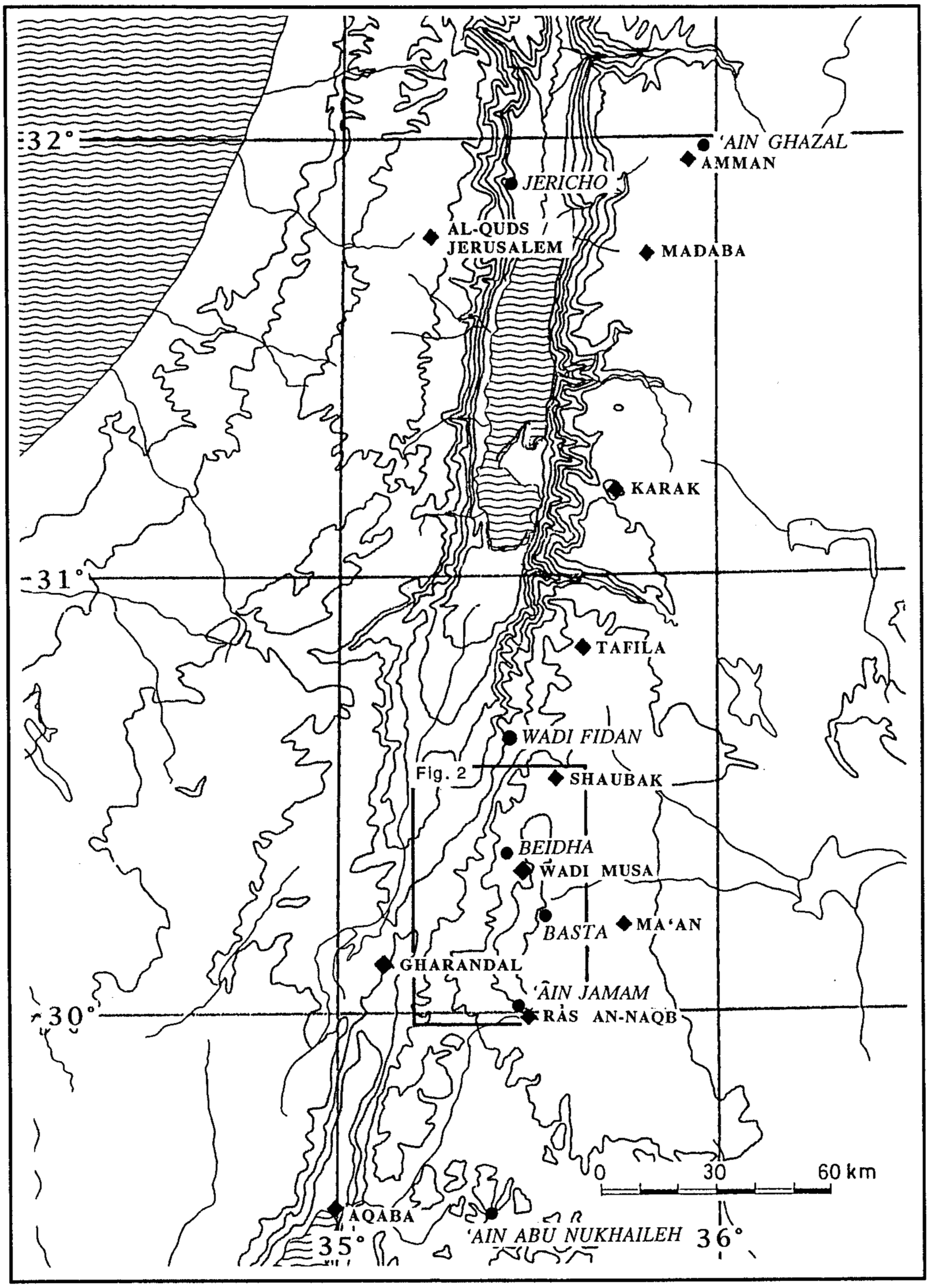


Fig. 1. Location of Basta in southern Jordan.

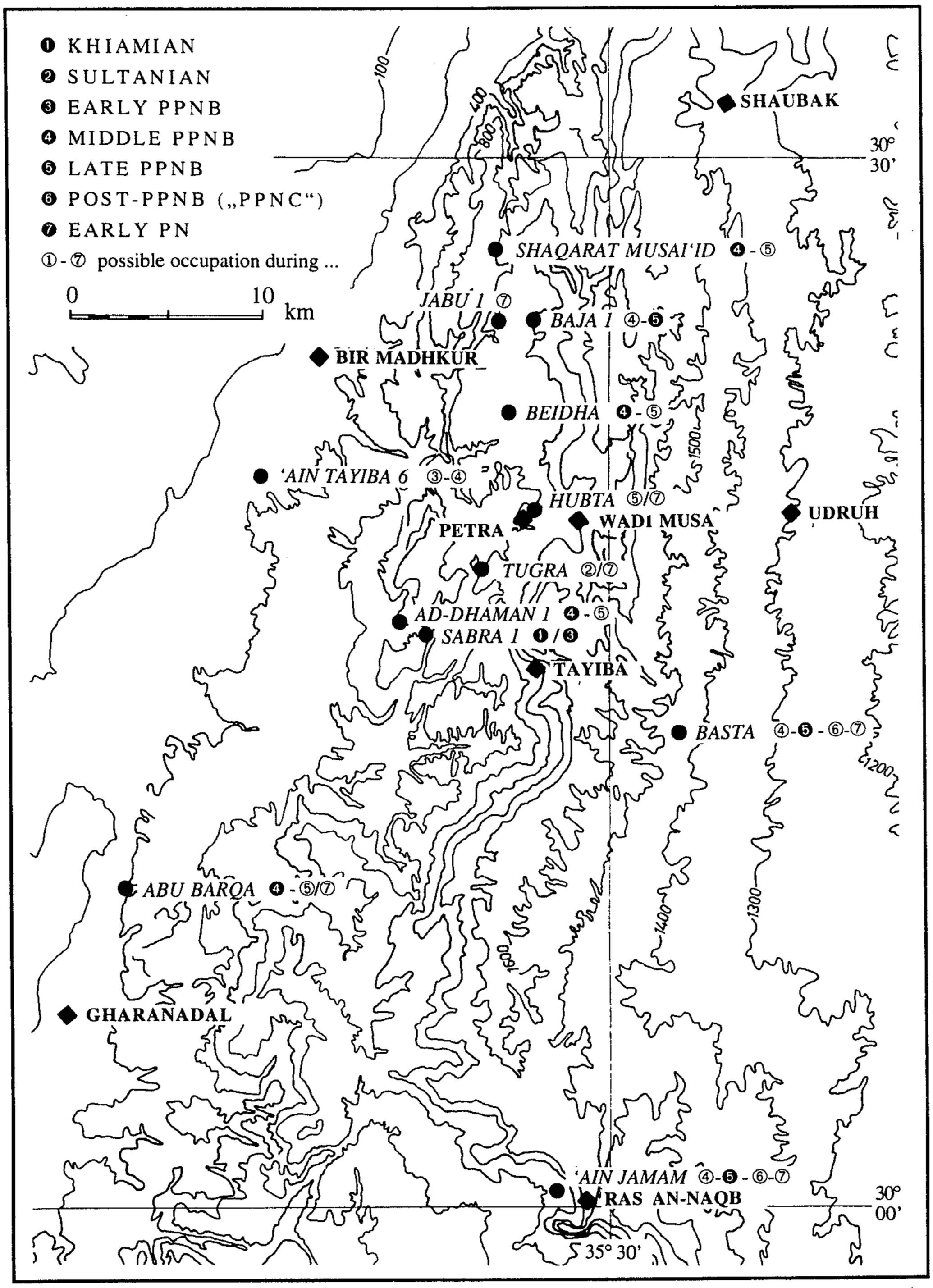


Fig. 2. Basta and other Neolithic sites in the Greater Petra Area.

While all aims of this pilot season were eventually met, the actual course of work was thoroughly altered from the original plans, for it was found that shortly before arrival at the site a building lot of *c.* 400 sq.m. had been cut into the slope using bulldozers. Remains of Neolithic walls were visible both on the ground and in the sections where they could be followed to a height of 2 m in some places.

Thus, instead of starting with the archaeological survey and spending some time on small soundings, we were forced to jump full force into the bulldozer cut to rescue as much information as possible. As a matter of course, the owner resisted our action, but the archaeological site protection law was on our side. Attempts to interfere with our work (including worker's strikes) were thwarted with the help of the governor of the provincial capital of Ma'an, and by the authority of Dr. Muheisen, who was a member of a renowned sheikh's family of Tafilah.

Since we could not be sure that this building lot - which subsequently became our Area A - would be left open for further investigation in a following season, we had to make an effort to clear this excavation site as thoroughly as possible. This forced us to concentrate on this task at the expense of the other objectives. Since these tasks were considered equally important for the project, working hours were stretched to the utmost limits, without days off or excursions. Readiness to work and enthusiasm of all members of the team were admirable.

The Surveyor's Report (Thomas Lüth)

The aim was to produce a 1:1000 site and contour plan of the modern village of Basta (for the topography of the site and the areas of investigations please consult Fig. 1 of the contribution by U. Kamp, this volume). Since no connection could be established to a regional grid, we created a grid of our own, taking 6 power poles forming a straight line along one of the main streets of the village as the base line (Sketch I). A datum was established by a cross marked on the rock with the coordinates y = 2697.6; x = 1165.00. From the y-axis of our grid, North could easily be easily established through the ratio of 21.83:14.60, or 1:0.6088. The fixed point for the archaeological grid at 500 N; 700 E was defined within the x/y grid (Sketch II). Four more points (P1-P4) connected to the archaeological grid were laid out from existing fixed points within the village (Sketch III); although outside of the present areas of archaeological concern, they may prove helpful for future excavation. The elevation was taken from a regional map and transferred to the cross mentioned above, establishing for this datum an elevation of 1430.00 m above sea-level.

Table 1. List of squares excavated in Areas A, B, and C (1986-92), with reference to their N/E designations (according to their Northwestern corners).

Area A	Area B		Area C
A1 (505N/685E)	B22 (415N/585E)	B70 (400N/610E)	C208 (545N/540E.C+D)
A2 (505N/690E)	B23 (415N/590E)	B83 (395N/585E)	C217 (550N/585E.A+D)
A3 (505N/695E.A+D)	B34 (410N/585E)	B84 (395N/590E)	
A5 (500N/685E)	B35 (410N/590E)	B85 (395N/595E)	
A6 (500N/690E)	B36 (410N/595E)	B86 (395N/600E)	
A7 (500N/695E.A+D)	B48 (405N/585E)	B87 (395N/605E)	
A8 (495N/680E.B+C)	B49 (405N/590E)	B102 (390N/590E)	
A9 (495N/685E)	B50 (405N/595E)	B103 (390N/595E)	
A10 (495N/690E)	B51 (405N/600E)	B104 (390N/600E)	
A11 (495N/695E)	B52 (405N/605E)	B105 (390N/605E)	
A12 (490N/680E)	B53 (405N/610E)		
A13 (490N/685E)	B65 (400N/585E)		
A14 (490N/690E)	B66 (400N/590E)		
A17 (485N/680E)	B67 (400N/595E)		
A18 (485N/685E)	B68 (400N/600E)		
A22 (480N/680E)	B69 (400N/605E)		

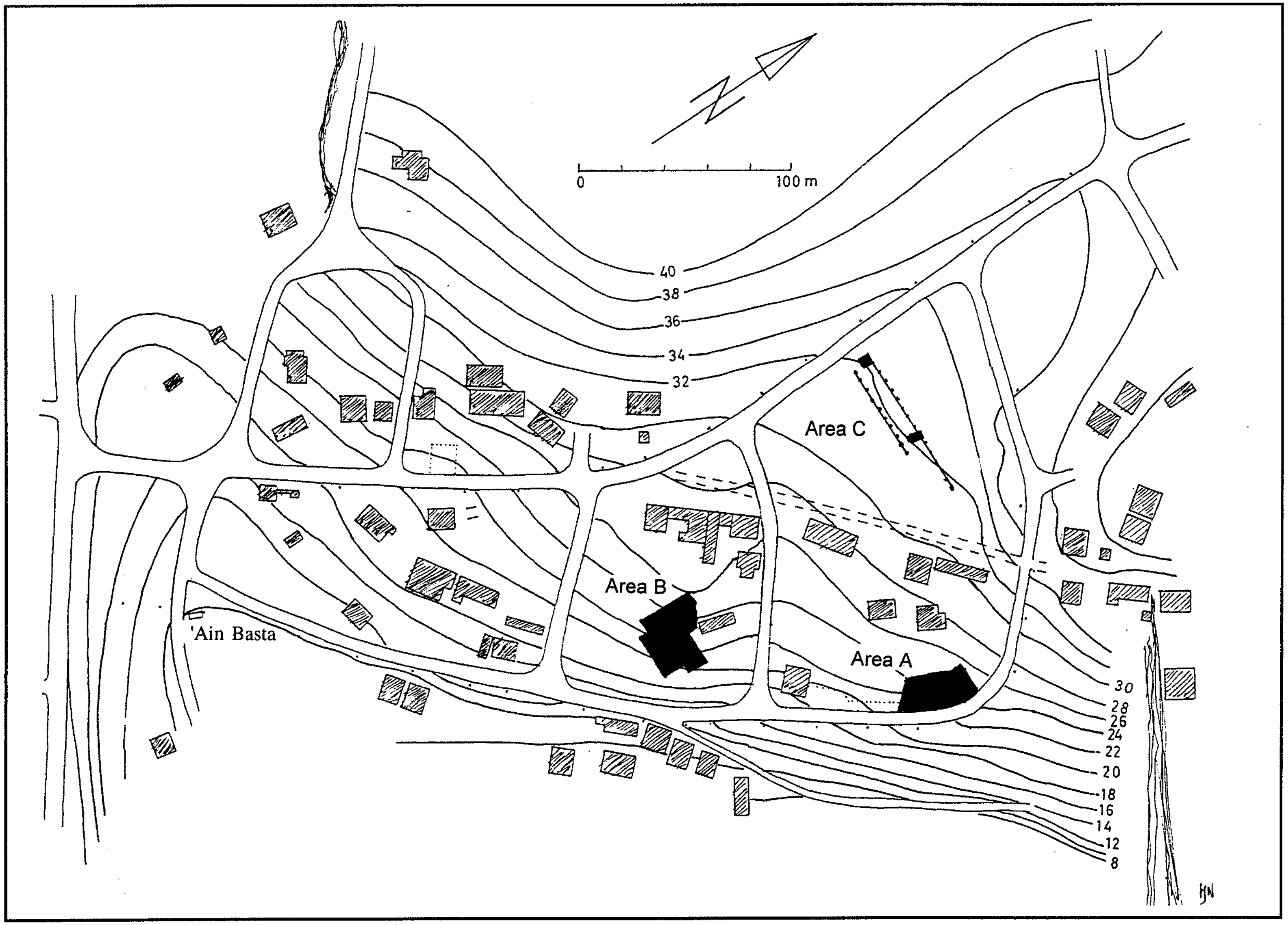


Fig. 3. Plan of Basta showing the modern houses in 1986 and the areas of later investigations.

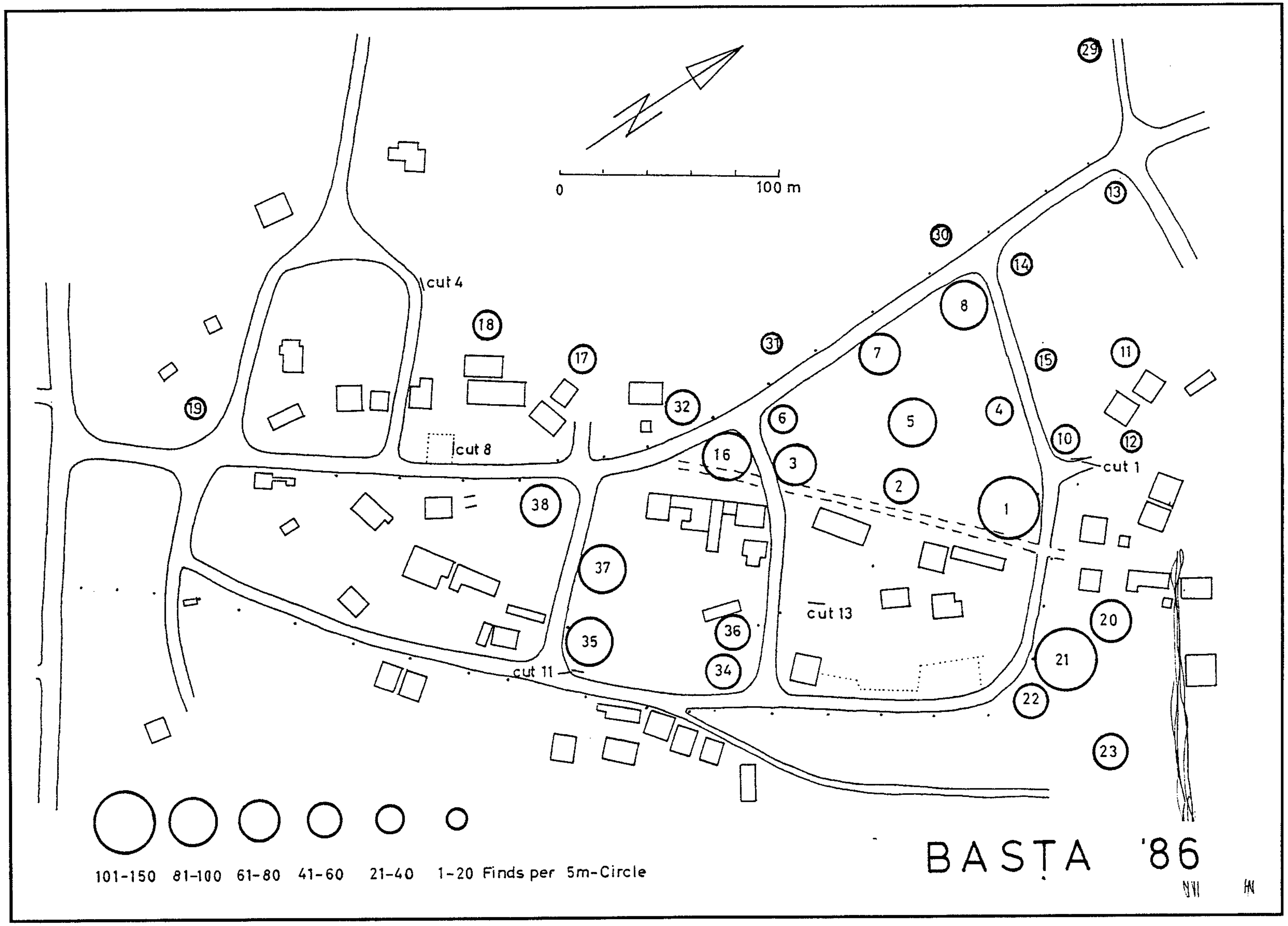


Fig. 4. Location of the surface collections and cuts.

Surface Collection #	1	2	3	4	5	6	7	8	10	11	12	13	14	15	16	17	18	19	20	21	22	23	26	30	31	32	34	35	36	37	38
Irregular Flake Cores		2	1	3	6	1	2	8		1			1		3		1		2	5	1	9	2	2	1	1	4	1	4	2	1
Single Platform Blade Cores			1		1	2		1								1			1		1							2		2	
Bipolar Blade Cores		1	1			1									2				2	1		1						1	1	1	
Bifacial Blade Cores			1				1																			1				2	
Levallois Cores						2																									
Discs						1																									
Ret. Core Fragments	3	1		2	3	1	4	3		2			1		1	3				2	2				1						6
Retouched Debris	20	11	24	8	10	1	18	17	2	4	5	2	1	3	21	8	7		10	31	5	4	7	4	3	7	7	21	10	15	11
Core Tablets										1					1											1					
Crest Blades	1		1		3		1	1	3							1				1	1	3									
Unretouched Flakes	12	15	23	3	14	4	10	17	2	5	1	2	2	3	11	5	7	2	12	35	13	11	1	1	1	16	17	28	13	18	16
Unretouched Blades/ Blade Fragm.	15	10	3	2	12	2	9	6	4		7		4		8	1	3	3	28	12	12	6	2	1		6	4	3	11	11	11
Unretouched Blades and Fragm. LD	7			1	6	5	4	1	5	2	1				1	1											2	1	2	4	
Éclat de taille																				6											
Retouched Flakes	10	7	1	1	3	1	1	3		1			2	1	17	1	1	1	3	24	2	3	1		1	4	5	5	2	12	4
Retouched Blades / Blade Fragm.	4	1	3		1		1	3		2	1		1		4		1		6	12	6	6				4	4	2	2	6	
Retouched Blades and Fragm. LD	13	2	1	1	4	3	4	5	5	4		1	3		8	3			1	10	5	3		2		13	2	1	3	3	1
Knifes									1													1					1				
Endret. Blades	1	1																													
Denticulated Blades and Flakes	2		3		1	2	1		2						1			1	1	2											1
Truncated Pieces	3	1	2		2		1	3	1		1				1			1		3		1					1	4	2	3	3
Backed Pieces					1										2								1						1		
Semi-abrupt Pieces	2				3			3		2					4																
Notched Blades		1		1	8		1			1	2		1		3					1	4	1	1			2	3	2	2	1	1
Piercing Tools	2				2						1				1		1														1
Notched Flakes	2	1			7	1		2							2	1	1	1	1	1	2	3						2	2	1	2
Burins	1	1		1	3					1							1		1							1	1		1		
Scrapers	1	1	4		4	4	1	9	1	3				1	2		1			4	1	1	1		1		2	5	2	1	3
Arrowheads	1																														
Double Tools					2												1														1
Axes	1		1		2								1								1										
Picks			1				3	1						1						1	1							2			
Spherical Hammerstones			1				1														1							1	1		1
Grinders (Sandstone)			1			1																				1					
Other / Unidentified		3	4																	3	1					1					
Total	12	61	77	23	98	32	63	83	26	29	19	5	17	9	93	25	25	9	68	154	59	53	16	10	8	58	53	81	59	82	63

Table 2. Chipped stone artefacts recorded from the site's surface collections 1 - 38 (after the field notes of 1986 by M. Muheisen).

The Grid System

While the x/y grid of Basta allows addressing the location of any point in the larger sites' area, it appeared practical for the excavation to operate with additional square designations. This lead to the existence and use of two square designations at Basta, for which Table 1 provides a reference list. The N/E designation of a square derives from the coordinates of its Northwestern corner; the A or B or C designation of a square comes from a serial addressing of squares within the area of investigation. *E.g.* Square B 22 refers to a square in Area B, which is also named after its Northwestern corner: 415N/585E. Table 1 lists all the squares excavated from 1986 - 1992.

Report on the Archaeological Surface Survey and Soundings

As a matter of course, no system could be followed for defining the points for surface collections, since only stretches between houses and cultivated gardens were available. In addition, even if unused for the time being, the surface of most empty parts of the town nevertheless proved to be disturbed at least to some degree. Even so, since we did not find anything but remains of the PPNB phase, there was no danger of contamination. Furthermore, although the density of surface finds depended highly on the degree of disturbance, we nevertheless found a pattern in surface collections, being denser in a central area and becoming more diffuse towards the margins.

Wherever the situation allowed we fixed a point as the center of a 5 m diameter circle where everything showing traces of human activities would be collected. These points were located according to existing features (houses, light or power poles, *etc.*) and eventually entered into the plan prepared by our surveyor. Of 38 collections, seven (No. 9, 24-25, 27-29, and 33) turned out to yield no information.

In addition, 14 cuts and sections were noted throughout the village; however, only four of them presented more than a couple of the usual ashlar stones that probably once belonged to the walls of a Neolithic house.

Surface Collections

Altogether 1560 items were recorded in 31 collections; their classification and distribution is illustrated in Table 2. The classification was done by Mujahed Muheisen. In terms of the periods present, the surface looked very homogeneous, at least as far as chronologically diagnostic features would tell us: they all fit into a normal PPNB assemblage.

As can be seen, the quantity of artifacts differs widely from one collection to the other: from fewer than 10 to more than 150 over the area of a circle of 5 m in diameter. In spite of the precautions mentioned above, we feel entitled to draw conclusions from this diversity. In particular, the collections with a high density of finds clustered in one area, probably marking the center of the old habitation area, while areas with lower densities might indicate the margins of the old settlement.

There is one exception, however, since we obviously were totally misled in what we came to call the "Triangular Field", or Area C. As the Table 2 shows Collections 1 through 8 present a particularly high density. This slightly depressed area to the North of the village had not yet been incorporated into the modern built-up area, and the surface looked fairly untouched. Both pieces of information would have qualified this area as a spot for regular excavation. However, the absence of any features and the consistency of the soil caused us to shy away from this choice, sensing that we might be dealing with a filled-in depression. In fact, this was corroborated by a series of corings and by a trial trench we decided to sink during the 1989 season. While the cores produced nothing but 3-4 m of layers of heavy silting, the trench presented us with a flintknapping locus on a working floor at 3.4 m below the surface, without any traces of architecture. Despite the rich surface collections this area obviously was already beyond the limits of the built up area, although it still belonged to the activity area of the settlement. This would reduce the estimated size of the closely built-up area to around 8-10 ha as opposed to 10-12 ha we first suggested.

The Cuts

As mentioned, most cuts or sections exposed by recent building activity turned out to be of no archaeological value.

Cut 1 North of the "Triangular Field" and beyond the area of the depression is interesting because in an exposed section 80 cm below the surface there were no traces of architecture or any habitation features. A little admixture of chipped stone pieces in the lower 40 cm parallels the low density of surface collections taken nearby. Cut 1 probably is already outside the settlement limits proper.

Cut 8 (*cf.* Gebel, Site Preservation ..., this volume: App. 2) produced valuable information because of its location in what is presently a densely built-up area where no surface collections could be taken. This cut was left by work that widened the main road from Basta to Bir Abu Danna. At a depth of 60 cm below the surface a horizontal line proved to be part of a plastered floor. On closer examination this line turned out to consist of two thin layers of plaster on top of each other, almost fused together. The lower one could be exposed just enough to see that it was stained red. On enlarging the cut the floor could be followed until it merged into a perpendicular line of plaster. Since no traces of a wall were found, there is a possibility that this feature is part of a plaster lined sub-floor pit like one we found in Area A. In all probability this feature indicated that in this part of the modern village we were still within the limits of the old settlement.

Cut 11 is at the Southern tip of what became our main excavation area (Area B). This pit gave us welcome information because it turned out that deep (old) destruction pits from heavy stone robbing had interrupted all connections between the excavated structures and the adjacent areas. The neatly dressed stones stacked outside this cut to be taken away resembled the stonework of Neolithic buildings, and they proved conclusively the continuation of Neolithic architecture beyond the destructive pits. Again, being close to a heavily built up area where no surface collection was possible, this pit proved that we are still within the old settlement's boundaries.

Cut 13 is the site of the original trial cut of Gebel in 1984 that initiated the project (Gebel 1986, 1988).

Cut 14 is the exposure that initially aroused great hopes because it seemed to provide information on an otherwise inaccessible part of the site. The Eastern main street parallel to the wadi bottom for some time had been the dividing line between the moderately sloping area occupied by the core of the modern village and the steeper slope bordering the wadi. In fact, during earlier building activities the material from both street and house construction had been tipped down the slope, hopelessly concealing the original surface. Thus, there was no way of getting any information on the extension of the old settlement into the wadi. In more recent time, however, people had begun to build houses on the lower slope. This required a new road that cut into the slope, and this activity left a section. Unfortunately, a line of stones that prompted us to cut back the section by 40 cm turned out to be the remains of a former (but still modern) irrigation canal buried by the construction refuse mentioned before.

The Excavation in Area A

As mentioned above, a few days prior to our arrival a large rectangular excavation had been cut into the slope creating an exposed level area of *c.* 400 sq.m. ending in a section of 2 -3 m in height. Wall lines could be traced on the ground. While trying to match these various pieces of walls we had a first impression of what later became an established fact: the old occupation sat on a slope with the houses built on terraces of different heights; unfortunately, however, nearly all connections were lost because of the bulldozer activities.

In spite of the disturbances created by the bulldozer and the limited time set aside for this pilot operation, two important observations were made. On the hand we encountered a superb building technique using stones neatly dressed to ashlar blocks set in mud-mortar with small wedge stones driven into the joints to reinforce the stability of the walls. This technique turned out to be used throughout the old settlement.

The second observation started as a puzzle. While cleaning the floor of an oblong room partly hidden below the section, we encountered parallel rows of large flat stones alternating with smaller ones. Sand disappeared between some of the flat stones, and this indicated hollow spaces below the stones. After removal of the stones a grid became visible, consisting of several parallel channels about 50 cm deep with a width of 20 cm, all connected to a central spine. They were partly filled with fine earth that over the millennia had seeped through the holes between the stones. No other finds were encountered.

The initial proposal of this grid of channels as drainage facilities had to be abandoned because where accessible they ran onto the walls of the room, and thus they were closed at the ends. This was the first encounter with a feature that later turned out to be the standard construction beneath the floors of the houses.

Besides the architecture, nothing was found what could be attributed to the original inventory of the houses. The deep layers of unarticulated rubble that had been visible in the high section of the bulldozer cut proved to reach all the way down into the lower levels beneath the floor of the cut. Apart from gravel and pieces that looked like scattered remains of wall plaster, the rubble contained thousands of flints and animal bones. On brief inspection the flint items looked very homogenous and matched those known from Beidha. Although the architecture was not familiar for this period, the flint industry provided a sound dating to the period of PPNB.

Conclusions from the Survey

During the survey of the site we had noticed a large empty space in the center of the modern village that was used occasionally as a sheep pen. The surface density of artifacts was considerably high, and in addition a small stone robber's hole at a corner of this area (reported above as Cut 11), where people had already pulled out some of the typical Neolithic ashlars, convinced us that if there was future excavation work in Basta, this was the ideal spot for regular, unrestricted excavations.

Impact of the season

Both the survey and the operation in Area A not only showed the potential of the site and the feasibility of doing both rescue work and archaeological investigation on undisturbed ground, but they also sharply refined our research goals. In addition, the superb architecture and what we had seen of the small finds and their contexts led us to believe that a host of approaches could be pursued to answer specific questions in the fields of technology, economy and social structure.

Nevertheless, it was obvious that the limited information of this pilot season did not allow the formulation of a firm set of goals beyond these general ideas. Instead, both questions and goals developed gradually from one year to the next. To give just one example: one aim in later years was to locate any significant open areas between the houses in order to gain information about communication paths to and between houses. We first recognized this as a problem after we could not find any such traces. But with these general ideas in mind, the decision was reached without hesitation that preparations should start immediately to begin a regular excavation at Basta.

The 1987 Season

After the approval of the three funding institutions (the Department of Antiquities of Jordan, Yarmouk University and the German Research Association), work in Basta started on August 17, 1987, and ended on October 7. Suleiman Farajat represented the Department of Antiquities.

At our request, the Department had reached an agreement with the local authorities to reserve the area within the village that we had chosen before for archaeological studies. Accordingly, work was divided between Area A of the previous year and the new Area B.

In Area A the excavation was enlarged to cover the entire base of the bulldozer cut. But even with this extension the damage turned out to prevent the reconstruction of a meaningful context. A better understanding of the walls suggested a strict contemporaneity because of their bonding. Only in two spots were stones visible that probably belonged to a lower level of houses following a different layout. Since no intact walls were supposed to be removed, the problem of stratigraphy could not be pursued.

Particularly in the southern part of Area A, better evidence was gained for the houses having been built on different levels following the slope: a deep wall could be classified as a retaining wall between two terraces, the height being surmounted by a staircase.

In the previous year several human burials were found, but they were in unclear relationships to the architecture, which prevented a relative dating. In 1987 more several burials and a deposit of skulls were found. While the latter were found lying on the floor in the corner of a room, the burials, including a child with numerous beads made of bone and other ornaments, clearly did not belong to our main level of architecture. They were either interred after the abandonment of the houses or belonged to an upper level of structures of which nothing remained.

Work in Area B started slowly because contrary to our expectations, nourished by the evidence of several cuts, walls did not show up close to the surface. Instead, we initially found ourselves trapped in meters of rubble of the same kind encountered in Area A. Our perseverance was rewarded, however, for subsequently this very spot proved to be the center of a large building whose walls still stood up to 2 m in places. Around a central space, rows of small rooms bordered all four sides, leaving an opening close to the SW corner. Of particular interest was the connection between the central space and the small rooms, reflected by window-like openings with a threshold 60 to 70 cm above the floor. One long stone formed the lintel.

Small finds matched those found in 1986, and once again all were found in the rubble layers that filled the spaces between the walls. Of exceptional importance was the find of a stationary vessel of a local natural mixture as an installation in the central space of the house around the corner and separated from an open fireplace that rested on shoulder blades of 3 large mammals. (Becker, in press)

Planning the next seasons was greatly enhanced by geomorphological investigation. Coring in both Areas A and B revealed that we had to cope with at least 3 m of occupational debris below the floors we had reached. An idea of a possible deep sounding had to be abandoned quickly, however, because of the principle that no architecture was to be dismantled.

While these cores thus had no direct effect on our work, the coring in what we had come to call Area C changed our view considerably. As mentioned above, during the surface survey an area to the NW of the modern village presented an exceptionally dense artifact distribution. On the one hand, this area commended itself for further investigation, but its outer appearance indicated that it might have been nothing but a filled-in depression. Two cores reached 4.10 and 7.30 m respectively, and they revealed no occupational traces at all, so we abandoned our plans to make Area C a main focus for the 1988 season.

The 1988 Season

Work started on August 2, 1988, and lasted until September 18. Contrary to our expectations, <u>Area A</u> was still open for investigation. This changed our plans to some extent because we had intended to put all our efforts into enlarging the exposure in Area B. Later in the season, we decided to open a trench in Area C despite the previous year's negative experience. This enabled us to get some stratigraphic control for the results of the coring operation conducted there by the geomorphologists. Only part of Area A was selected for further investigation, in particular the southeastern squares. There we found the floors to consist of that particular mud/gravel mixture that we had recognized earlier overlying the capstones that covered channel systems. Consequently we removed part of the mud floor duly coming upon rows of large stones covering a channel system.

There were differences, however, from what we had seen before. The walls creating the "channels" were built of huge undressed boulders with spaces 35-40 cm wide, while the height decreased from 1.20 m close to the down-slope retaining wall to 20 cm at the up-slope end. Obviously parallel walls of increasing height were erected on a slope that created supports for rows of capstones at the same level. The base of these channels was formed by the same yellowish material we now recognized as decayed material of the limestone bedrock. Thus, it became clear that the walls of that lower network of "channels" represented the first building activity in this area, resting on virgin soil.

Again in this case, the channels ran up to the walls eliminating an interpretation as either for drainage or ventilation. Our idea that these channels represented air chambers was corroborated by another observation. While the walls of the houses above the terraces used mortar, there were no traces of mortar in the supporting walls of the terrace. This is explained by the fact that capillary action would have transported moisture through the mortar up to the terrace. Avoiding the use of mortar in the sub-floor constructions is taken as another effort to keep the floors dry.

Still, the channels had another surprise in store for us. Already confronted with the relative space of the channels, we had joked about the possibility of people moving around in these sub-floor systems. It became serious when we found a fully articulated burial in one of the slots of that system, and behind it skulls and long bones were neatly stacked, evidently the remains of earlier burials. Since capstones and mud floor were totally intact above these burials the only solution was that there was an entrance into the system somewhere else.

In Area B (Fig. 7), progress consisted mainly of enlarging the area. With nine new squares opened, the area currently exposed in Area B added up to 350 sq.m. Apart from simply adding to our evidence, the excavations here produced two points worth mentioning.

Completing the excavation of the Western part of last year's main building led to an unexpected discovery. This wing consisted of a double row of rooms larger than any uncovered earlier. Wider openings offered an easy access from the central space, and for the first time we came across *in situ* finds in the form of grinding implements on the floor. As a consequence there was a chance to find out about internal functional differences within the building.

Enlarging the exposure into the area beyond the limits of Building I, remains of more houses were found, partly on higher or lower terraces. Although none equaled the main building in size and number of rooms, a common principle was discernible as in all cases a central space is bordered at least on one side by a row of small rooms. In all cases the walls of the central space show an attached pillar, probably part of a roofing construction, and again a fire place was found in all central spaces.

Finally, there were other common features that connected the houses of Area B to those of Area A: the use of dressed stones set in mortar with wedge stones driven into the joints, and the sub-floor channel systems.

Trial Trench and Coring in Area C

It was felt that more information was needed about the potentials of Area C. To this end a more systematic coring program was set up. In particular, it was hoped to get cores that were better than before. But again there was no final answer to the question of whether there were any traces of occupational debris at all, and if so, at what depth.

Despite this negative result, we decided to use the conventional way of opening a 2 x 4 m trench sunk to 3.40 m. below surface. We found neither architectural remains nor stone settings. However, below the surface soil and adjacent sandy layers we encountered a long series of different surfaces and lenses of slightly different colors, sometimes only 10 cm thick, with very few traces of carbonized material. At times the surfaces consisted of a mortar-like substance also used for plaster floors. There were ashy layers interlaced within the sequence in a few cases. The total absence of the thick layer of rubble stones that overlay the architectural remains in both Areas A and B is one of the most conspicuous aspects of the stratigraphy. On one of these surfaces a large number of flint pieces were found that represented the debitage from a bipolar core, and parts of the original block of flint could be restored from them. In two other cases, unretouched waste was found together with numerous unfinished broken borers, burins, and other implements. In all probability these finds represent a flint knapping site outside the settlement proper.

The finds in the selection of raw materials, knapping techniques, and arrowhead types from the trench in Area C correlate with those of the lower building phase in Area A; and, they are clearly different from those of Area B.

The 1989 Season

Excavation work started on August 8 and closed on September 19, 1989. The season was preceded by an archaeological survey of the wider surroundings of Basta, led by Hans Georg Gebel with some members of the excavation team. Apart from this survey, the objectives of this season were primarily to enlarge the operation in Area B, and to take another look into the potential of Area C.

Together with areas visited previously, a total area of 11.5 square kilometers around Basta has been investigated; 76 sites dating to various periods were located. Each one of the major post-Palaeolithic periods is represented at least once; most numerous are Iron- and post-Iron Age sites. Palaeolithic traces were found in 18 cases, while four small sites are contemporary with Basta.

Though work in Area B basically augmented the information gathered during the previous seasons, new features became visible. On the one hand, pieces of wall plaster found in the fill of the rooms had already suggested that originally the walls had been plastered. This was corroborated by two cases where painted plaster was found still attached to walls. In one case the piece of plaster was only stained red, but another very fragmented one presented the remains of a larger decoration where red paint was applied to a white background in such a way as to leave blank white geometric forms. Larger pieces found in the fill showed several superimposed layers painted white or red. Some may have carried vegetal designs in black on white plaster. In each case they were too small to reconstruct a larger context.

The other new feature was revealed by expanding the Northwestern part of Area B. In contrast to the rectangular rooms and straight walls using fairly large ashlars, we came across traces of curvilinear walls of a totally different character as they used small unworked stones. Unfortunately, one of the ubiquitous ancient pits had disturbed the stratigraphic connection between these walls and our regular structures, but odds are very high that these curving walls represent a successive building phase. This finds some support in differences in the flint material, though none of that could securely tied to a floor.

In spite of last year's negative results from the investigation in Area C, a new attempt was launched to reach a decision on the question of the presence or absence of architecture in that area. In addition to new coring activities, another 2 x 4 m trench was sunk down to virgin soil 3.20 m below surface. Again no traces of architecture or walls were found, offering the final proof that what we call Area C was outside of village area proper of Neolithic Basta.

The 1992 Season

Work in the field started on August 14 and ended October 8, 1992. As mentioned before, since both co-directors were unavailable for full participation, Hans Georg Gebel and Nabil Qadi supervised fieldwork. In contrast to previous years, the crew was reduced because apart from continuing work in Area B, the only main objective for this final season was to conduct a stratigraphic sounding on limited scale starting from the floor reached in Area B. A number of unfortunate circumstances prevented us from reaching this goal. On the other hand, enlarging the excavation in the Southwestern part of Area B added a new dimension, for contrary to our findings in previous seasons, the pattern of similarly spaced houses attached to each other was disturbed by the discovery of part of a building, still attached to the other houses, consisting of two elongated rooms. Though interesting in itself, there was neither time to confirm their stratigraphic relation to the previously excavated structures nor was it any help on clearing up the stratigraphic situation in general.

Another point that had become visible before was verified. Enlarging the excavated area in Area B in all directions from the initial sounding, we were confronted everywhere with deep pits reaching to 3 m below surface filled with the usual rubble mixed with occupational debris. Everywhere they had destroyed the architecture, leaving no chance of finding the connections between the structures of Area B and any structures that would supposedly turn up if adjacent areas would be opened. Although in accordance with the original plans, the 1992 season would have been the last one anyway - unless there was an urgent need to continue, - this observation added the final argument for closing Basta operations. There would have been an argument for continuation if there was a chance to find any traces of communication ways to and between the houses, but it became clear that unless a totally new and larger area could be opened, there would be no answer. And such an undertaking certainly would have been beyond all means and plans. Still, Basta has shown its potential, and one day some future archaeologist may decide to take a new attempt.

Part II: Basta 2002

When first investigated, Basta appeared to be unique in Southern Jordan, for it was an exceptionally large site: 10-12 ha suggested by the surface coverage of Neolithic artefacts. However, soon new findings proved that Basta was but one of a number of such settlements which were established and vanished within a rather short period during the second half of the 8th millennium BC along the mountainous ranges to the East of the Jordan Rift Valley. Today, we tend to see this "hypertrophic" development (Nissen, in press) of "mega-sites" (Rollefson 1989, 1992) as an ultimately "socially unsuccessful step towards social stratification" (Gebel 2002b, in press).[1]

Over the past several years, they mega-site phenomenon has become a heavily debated issue along with the recently discovered PPNA Göbekli symbolic and cultural interaction sphere (Schmidt 2002) and the Early PPN "colonization" of Cyprus (McCartney and Peltenburg 2000, Peltenburg n.d.). However, because we continue thinking in old concepts (unidirectionalism or monocausalities in explanation), we keep underestimating Early Neolithic complexity. It is in this context that being excavated on a larger scale than other sites, Basta has the potential for being a regional key for the understanding of the mega-site phenomenon and what hitherto was called "hiatus palestinienne".

The study of the Basta material culture offers the opportunity for understanding Neolithization as a process in which temporally and spatially shifting interaction spheres and barriers controlled the dispersal and transformation of steadily mixing Neolithic ingredients in their evolving physical and social environments (polycentrism approach, *cf.* Gebel 2002a). On the other hand, both for its own sake and in order to avoid a premature and over-simplistic

---

[1] Here, we use the more neutral term "mega-site"; in our understanding, we deal with "mega-villages".

generalization of regional phenomena for the Near Eastern Neolithization, we have to understand Basta in its local and regional peculiarities in the first place.

The Role of Basta in Recent Neolithic Discourse

Reconstructing a size of possibly 15 ha for LPPNB 'Ain Ghazal, Gary Rollefson propagated the term "mega-site" as early as in 1989 (Rollefson 1989). It was only after the discovery of equally large sites, however, that along with other colleagues we started to see Basta as part of this phenomenon and as a link in a North-South chain of mega-sites. The mega-sites excavated South of 'Ain Ghazal in the 90ties include: 'Ain Jammam near Ras an-Naqb (Gebel 1992a, Bisheh *et al.* 1993, Waheeb 1996, Waheeb and Fino 1997); es-Sifiya in Wadi Mujib (Mahasneh 1997, 2001, in press; Bienert and Mahasneh 1998; Mahasneh and Gebel 1999); Khirbet al-Hammam (Peterson 2000) and al-Hammeh (Rollefson 1999) in Wadi al-Hasa; and al-Baseet ('Amr, in press) in Wadi Musa. Still belonging to the mega-site phenomenon, but not mega-sites by size, are Ghwair 1 in Wadi Feinan (Simmons and Najjar 1999, 2000) and Ba'ja, North of Petra (Gebel and Bienert *et al.* 1997; Gebel and Hermansen 1999, 2000, 2001; Gebel 2001). The new evidence contributed to reopening the long-left discussion of the second half of the 1950s of the PPN Jericho findings ("Jericho, the Oldest Urban "Settlement"; Kenyon 1953, 1956; Braidwood 1957) that soon was extended to include a Temple/ Town-Debate initiated by Gary O. Rollefson (*e.g.* Rollefson 2001). In addition, a chrono-stratigraphical reconsideration of the architectural sequence of Beidha appeared necessary, new questions arose from the unique setting of Ba'ja, and the increase of vessels made from mouldable materials in LPPNB context received increasing attention. However, it was not until the provocative statements of Gary Rollefson on temples, shrines, and towns in Neolithic context that a symposium was convened (1997 in Petra), which aimed to discuss both the actual findings and the phenomena mentioned above. While the concept of mega-sites was generally accepted, Rollefson's and Bienert's equally provocative usage of the term "Proto-Urbanism" was rejected to be left for periods that could be defined as direct predecessors of accepted urban phases (Bienert, Gebel, and Neef 2004).

The Emergence of Neolithic Basta

Basta may have been part of an expansion of settlers around 7600 / 7500 BC that started in Northern and central Jordan and expanded towards South. This wave would have occupied semi-arid territories next to rich springs at the border or at corridors to the Eastern (Arabian Plateau) or Western (Wadi Araba) steppic environments with their vast grazing grounds and migration routes of ungulates. Only in rare cases did the new settlements make use of older MPPNB localities; instead, they seem to have been attracted by varying combinations of the aforementioned environmental conditions. Sites offering these new conditions including vast herding and hunting grounds led to the founding of new sites such as Basta, 'Ain Jammam, es-Sifiya, Wadi al-Hammeh, Ghwair I, and al-Baseet. While populations from MPPNB sites that didn't provide these conditions may have been absorbed by nearby newly founded settlements (*e.g.* Beidha by Ba'ja), MPPNB sites conforming to these conditions were transformed into mega-sites (*e.g.* MPPNB 'Ain Ghazal and Wadi Shu'eib, which continued into the LPPNB) (Gebel 2002a, in press).

For the time being, it is not more than pure speculation to see the source for the mega-site stimulus in the Mediterranean core areas of Palestine. There, favorable conditions had created positive population dynamics in the PPNA. New social paradigms had to be developed in order to cope, at least for a while, with the environmental restrictions and impacts that the growing population faced in the Southern Levant. However, although the social management of growth may have been successful for the PPNA and earlier parts of the

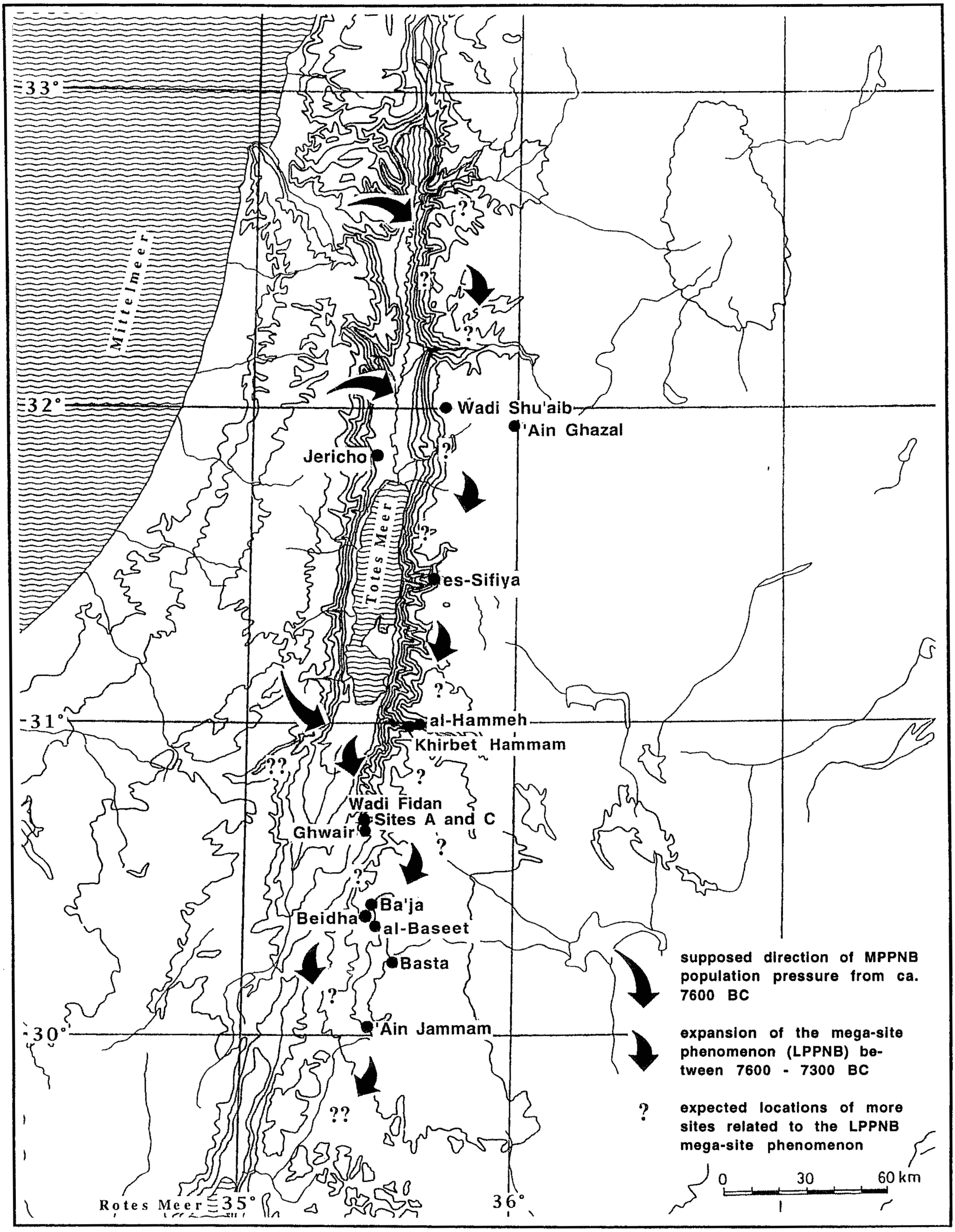


Fig. 5. Distribution of sites of the LPPNB Mega-Site Phenomenon (from: Gebel, in press).

PPNB, pressure must have mounted during MPPNB, eventually forcing parts of this population to cross the Jordan River eastwards. PPNA Jericho may represent an even earlier example of the same process of expanding from a core area to a more semi-arid setting with vast grazing and hunting grounds.

Sites like Jericho thus may not only serve as model for the export of the new social and economic structures (corporate patterns), including new group sizes (assumed 3+ ha for PPNA Jericho), but Jericho may actually have functioned as a bridgehead for their movement to the East. Such settlers could have arrived first in sites like Wadi Shu'eib and 'Ain Ghazal, were the MPPNB complexity provided the ground for the accelerated development of LBBNB social, and economic structures. Eventually, they would become part of the LPPNB cultural unit encompassing the entire Levantine area. The mega-site stimulus perhaps is a twofold affair: it could have been initially just what we propose to call the Jericho Stimulus, but it could have been enhanced once established in areas of literally unlimited grazing and hunting grounds, as at 'Ain Ghazal. The rich animal protein resources presented the base for an ongoing, unrestricted consolidation of the new corporate structures.

A successful corporate societal organization must have arrived in the Greater Petra Area (Basta, Ba'ja, al-Baseet, 'Ain Jammam) fairly quickly as a result from its expansion from Northern and central Jordan. Around 7500 BC, the small MPPNB settlements (up to two ha) in the South, such as adh-Dhaman, Shaqarat Mazyad, and Beidha, were deserted, and their core-family structures dissolved. Instead, and replacing them, the new mega-sites (> 10 ha) emerged close by. There is no evidence that this change was a violent one. It could have been a rapid but calm infiltration in the course of which the inadequate catchment areas of MPPNB sites were either abandoned or included into of the local catchment area of a mega-site. The MPPNB catchments in the sandstone areas of Southern Jordan could serve as examples since their rugged hinterland certainly was not suited for the more space-consuming new organization of mega-sites.

Basta lies on a North-South line of favorable spots because of abundant springs along the contact zone of the Jordanian mountains and the adjacent Eastern semi-arid steppe. Farther to the South villages like 'Ain Jammam show that the Mediterranean vegetational zone in the Early Holocene extended eastward at least into the Ras an-Naqb area, and it would be no surprise to find mega-sites even between Ras an-Naqb and Wadi Rum in similar environments. When the mega-sites arrived, the natural habitats certainly were still preserved as in MPPNB times. It means that the soil cover was still intact, and that therefore the hydrological situation of the habitats was much richer and more secure than today, even if we assume a rainfall was not higher and better distributed than at present.

The collapse of the mega-sites remains an enigma in spite of a number of proposals as to its answer. One is that it may have started in the environmentally sensitive fringes in the Southernmost expansion area of the mega-sites. Another one sees it having been caused by environmentally sensitive links within this chain of settlements, which directly reacted to an assumed unfavorable climatic fluctuation ("hiatus palestinienne"- approach of explanation) around 6900 BC. Still another attempt sees local man-made environmental disasters responsible (wood harvesting, monocultures, overgrazing, *etc.*). While each of these factors may have contributed, none should be considered as singly decisive, since Basta did not provide any argument for an environmental or subsistence disaster or a technological decline, not even as some kind of foreshadowed event (Nissen, in press) To the contrary: we have good evidence for a flourishing community up to its end and for its role as a hub in regional trade of flint blanks. Although according to the physical anthropologists we recognize a rising rate of skull traumata, they may indicate a higher level of conflict in LPPNB societies than in

Late Epipaleolithic/ Early Neolithic ones (Gebel), being a symptom of a collapse of the social structure.

Nevertheless, a society rapidly developing from a flat-topped (Gebel 2002b) to a conical chiefdom inevitably would have created social interference that may have influenced emerging hierarchical settlement patterns and long-distance networks of basically reciprocal exchange more strongly than local environmental reasons. What if these potential causes acted in a much larger framework that was determined by its hybrid socioeconomic factors? What if this sudden collapse was a social collapse starting from the major mega-sites and caused by their rapid growth that could not find the social answers expeditiously enough to secure the dynamics and consequences of growth?

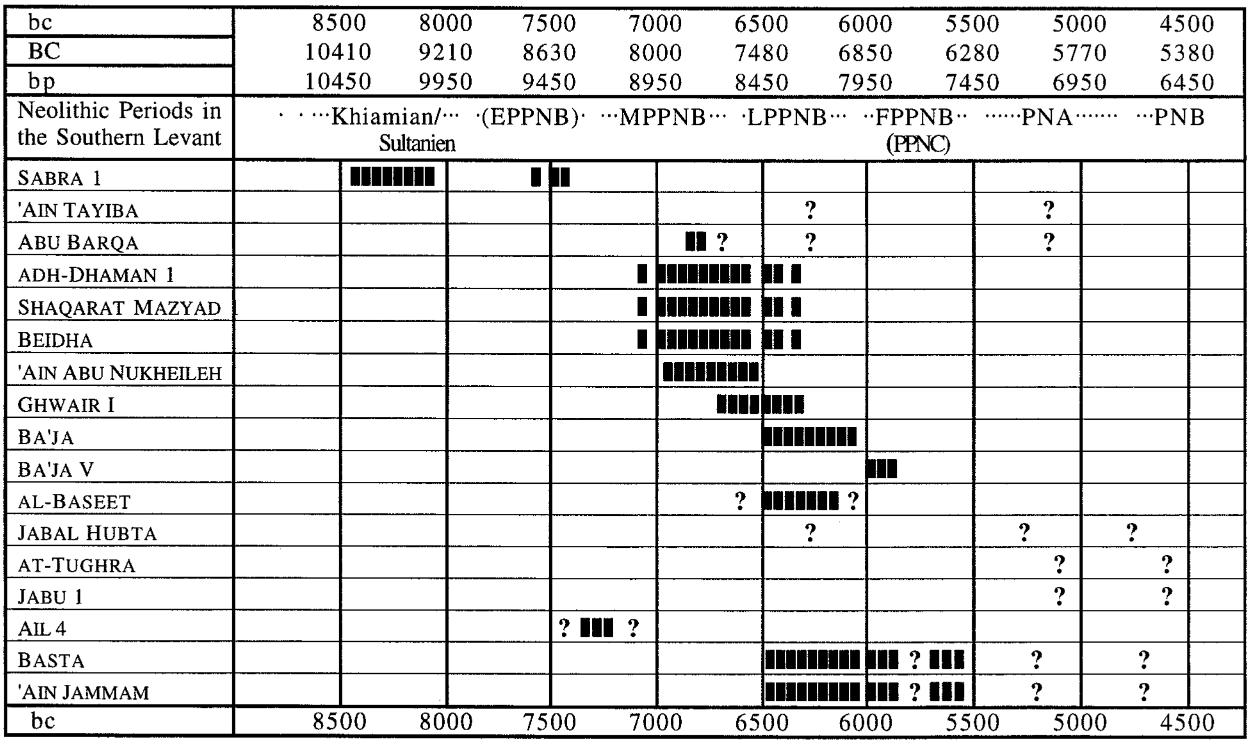


Fig. 6. Relative chronology of the Neolithic sites in the Greater Petra Area.
(abbreviations: E/M/LPPNB: Early/ Middle/Late Pre-Pottery Neolithic B; PPNC: Pre-Pottery Neolithic C; FPPNB: Post- or Final Pre-Pottery Neolithic B; PNA/B: Pottery Neolithic A/B)

Each one of the arguments presented above sounds plausible, but none can provide the full answer by itself. Whatever the trigger was for the sudden end of Basta, Ba'ja, 'Ain Jammam, and possibly al-Baseet in the Greater Petra area, it should be clear from the host of reasonable explanations that we have to follow a multi-factorial approach in analyzing this development. The evidence seems clear: LPPNB cultural identity and socioeconomic structures disappeared and gave way to final PPNB (or PPNC-related) societies, often witnessed by squatter-like evidence in the previously flourishing sites (*e.g.* Basta, Ba'ja, 'Ain Ghazal). As suggested by the discussion of the corridor buildings in Beidha dating to final PPNB, Beidha may have been reoccupied by people coming from deserted Ba'ja. This Final LPPNB is still badly understood, basically because of the lack of archaeological evidence. It seems to be a transitional period during which an adaptation towards pastoral economies took place in southern Jordan. Its end is marked by the rise of the Pottery Neolithic, parts of which remained materially aceramic in southern Jordan. Of this PN only a few settlements existed in topographically and environmentally favored settings (*e.g.* Wadi Feinan, 'Ain Jammam), apparently representing a locally confined feature.

On Basta's Architecture

Without any doubt, the most striking result of the Basta project is its LPPNB architecture with its multi-roomed domestic units built on terraces, which instead of being dug into the slope were laid out on grill-like walls of dry stone masonry extending from the slope. Although other sites appeared after 1986/87 with similar substructures (es-Sifiya, 'Ain Ghazal, Ghwair I, Khirbet Hammam, al-Hammeh, al-Baseet, and 'Ain Jammam, but not Ba'ja) and with groundplans more or less close to the ideal Basta-type, none of these sites allowed such a clear identification of a house unit as Basta Area B. The Basta evidence helps us to understand the type of master plan in the mind of the LPPNB architects elsewhere, where different topographical conditions required local adaptations. However, the "Basta House", as we came to call it, is not the only form, as is shown by our Area A units; obviously, we are confronted with a more complex architecture at Basta, yet imperfectly understood because of the still limited evidence. To be sure, there is no correlation possible between areas A and B in Basta, neither by means of stratigraphy or other features. But if our assumption of the main levels in A and B being contemporary is correct, this may indicate that in Basta different social structures and economic activities materialized with a diversified architecture. Moreover, we should expect communal spaces apart from house roofs, "monumental" facades like in Ba'ja, or house shrines as in es-Sifiya. It is striking to see that each site added new elements to LPPNB architecture, all of which points towards a more complex architectural expression of human life than merely reflecting local traditions.

Basta was the first site to show the extraordinary preservation of walls using a building previously unknown technique. The fascination was furthered by the almost regular faces of the walls using dressed ashlars laid out in neat courses with small wedge stones driven into the joints. It takes a while to realize, however, that this excitement was solely ours, since walls were covered by thick layers of plaster as shown in some cases. Instead of Basta providing the explanation of the LPPNB site preservation, help comes from Ba'ja, where several interacting factors and processes provide evidence that influence this specific kind of LPPNB site preservation. The first reason is the higher amount of stone materials present in this small-roomed architecture. Secondly, these rooms tend either to be filled up more rapidly when becoming a ruin, or they were intentionally filled in LPPNB in order to create a new storey using old walls. Thirdly, and this may occasionally be the case in Basta too, (parts of) upper storeys may eventually have been transformed into basements, serving as the substructure of an upper floor (*cf.* also Kinzel 2003). In this way high walls emerged, the lower parts of which where protected by the Actions 1 and 2 mentioned before. A fourth reason, finally, is the sealing of the surface by fluvial and deflation processes, causing a compacted layer covering the walls. Other reasons influencing the preservation may consist of long use and constant maintenance of the structures, as well as of possible ritual or magic behavior that prevented the re-use of building material from demolished walls. (*cf.* also Gebel, Site Preservation ..., this volume)

On Basta's Subsistence Economy

Much evidence is available both in print and on an advanced general stage of analysis of the Basta faunal remains (Becker 1987, 1991, 1998, 1999, 2000, 2002, n.d.). On the palaeobotanical side, unfortunately, the yield was rather low.

Fig. 7. Groundplans as exposed in Basta Area B by 1992.

LPPNB Basta was located on the fringes of a sandstone region in which earlier, smaller permanent settlements had existed for about half a millennium using more compact and more varied catchment areas. Both the permanent and strong spring and the "new" setting of Basta with its immense steppe environments and rich ungulate wildlife provided a much greater potential for growth. While other areas with a longer settlement history, like in the Palestinian, Lebanese or Upper Mesopotamian heartlands, show an increasing drop of hunting activities, the Greater Petra Area around 7500 BC still enabled a subsistence economy relying on a high percentage of hunted animals at the onset of settled life: 45 % of the animal bones in Basta belong to wild species (Becker 1999, 2000). Domestic species introduced to the area coexisted for a while with local wild forms. Apparently, this can vary within short distances: in Ba'ja, at the same time of the main level in Basta, hunted animals had already been replaced by their domestic counterparts.

Back to the problem of the "hiatus palestinienne" and possible reasons for the abandonment of Basta, it is important to note that Becker (1999, 2000) could not find any faunal evidence for environmental stress that could be taken as a premonition of an imminent collapse. Granted, less than 1 % of the site was excavated, but it is very unlikely that the rich sample including the contents of the so-called rubble layers between and above the preserved LPPNB wall tops should have excluded entire sectors of the evidence that were once present.

On the floral side, Basta has provided the ordinary selection of carbonized field and garden fruits (Neef 1997: Tab.1), but it does not allow for many ethnobotanical conclusions on the cultivated-natural environment. The presence of open juniper forests, supposed to have crossed the Western escarpment and penetrated into the Irano-Turanian Basta surrounding in the 8th millennium BC, especially awaits an explanation. Yet, the reconstruction of the mid-8th millennium BC environment (Gebel, this volume) is based on this biotic scenario.

On Basta's Labor Organization

It is an ongoing debate whether or not the LPPNB *chaînes opératoires* reflect labor division to an extent that we can speak of a possible onset of social hierarchy through labor. Furthermore, there is the possibility that this approach appropriate for later periods may not be appropriate for the LPNB at all.

As shown by material from Basta, Ba'ja, and contemporary sites, we are dealing with work processes split into various technological stages of production that require different skills. This was suggested for the flint industry of Basta (Gebel 1996), which in addition has an *ad hoc* sector on the household level, and to some extent probably applies to the ornament industries. A similar pattern of a split work process (*chaînes opératoires* or Event-Tree Processes) is mirrored in the labor organization of the stone ring production at Ba'ja. "Initial Craft Specialization" (Quintero and Wilke 1995) definitely characterizes the Basta flint production, shown by the presence of most features of the procurement, primary production (blank manufacture), and secondary production (tool making). In Basta, specialized workshops deposited tons of naviform waste outside the living areas. It remains open whether specialized households operated the workshops, or a workshop was a cross-household corporation. The huge amounts of production waste found in Basta may reflect a surplus production beyond the needs of the own community. Benefiting from the nearby sources of good quality flint, Basta may have been a production site for the export of bidirectional blade blanks.

Comparing Basta's tool kit with those from the Pottery Neolithic is another source for answers on craft specialization. For instance, the diversified but standardized ornament industries of the LPNNB are obviously a result of leisure time and the demand for manifestations of social difference in its widest sense. This necessarily affected the diversification and standardization of Basta's tool kit. Both the decline of the ornament industry and the bidirectional core technologies resulted in the less specialized "poorer" tool-kit of the lower rubble-layers above LPPNB Basta. It is the material reflection of the mobile life of the FPPNB Bastians.

On Basta's Social Organization

Though the question of the social organization discussions for the LPPNB still remains a matter of controversial discussion, the evidence of Basta and related sites invites some comments. Prior to Basta and the mega-sites in the region, we see a regional shift from a longer period of territorially-tied bands (Late Natufian to the Proto-Neolithic Khiamian, 12000-8800 BC) to an E-MPPNB core family-dominated society (8800-7600 BC). However, it remains open as to what prompted this change in the Greater Petra Area during a time in which we already had flourishing permanent settlements in the Mediterranean zones. At least, there is no evidence for a local emergence of the new social structure, and instead all evidence points towards a hitherto ill-understood ousting of the late foragers' economy in the area by permanent settlers during the early 9th millennium BC.

The architecture of Basta, the evidence from its initial craft specialization, the assumed social differentiation by a hitherto unknown wealth of luxury goods, *etc.*, suggest the presence of yet another social structure, possibly consisting of larger social units beyond the LPPNB core family level (kin groups or lineage families). This means, however, that again we have to explain a change of social structure. Although the change may have been brought in from North, as indicated above, this cannot be the full answer. In our view, the MPPNB sites were on the brink of adapting to the arriving corporate structures. Corporate exploitation and consumption with its more successful social management for deficit regions under population pressure may already have been recognized as an attractive answer. At first they may not have been viewed as competition for the newly established mega-sites in the region but instead helped to stabilize the situation. But the older structures must have given way at the moment when it became evident that the new structures were not supported by the limited-range catchment areas of the mountainous zones.

But there is another argument for the new structures. Presumably the limited-range habitats of the sandstone environment in southern Jordan had caused territorial stress before the end of the MPPNB. With the arrival of mega-sites, problems increased because of the scalar stress originating from intra-mural problems (Schultz, Berner and Schultz, in press; Berner and Schultz, in press; Gebel 2002b) in fast-growing villages like Basta (and certainly Ba'ja). This was even intensified since the use of the vertical space contributed to increasing the population density. All LPPNB settlements excavated since Basta have recorded second storeys, and for Ba'ja we do not rule out roof terraces enclosed by walls that were used as a kind of third storey. The new corporate large family structures reduced competition and thus conflict levels.

It must be expected that Basta society consisted of equally large but internally differentiated families or kin groups that balanced their interests by mutual understanding aided by a chief (flat-topped chiefdom). This chief may not have relied on social force, but may have ruled only by helping shifting alliances within the community. In Basta we seem to have developments towards social differentiation within group structures, which, however, for unknown reasons did not have the time to develop into a viable structure, but which may have contributed (or even been the main factor) for the disappearance of the mega-site phenomenon.

Bibliography

Note: This bibliography serves also the purpose to present all publications on Basta through 2002; not all of the following entries are referred to in the text.

'Amr K.

in press A note on the discoveries at al-Basît during the implementation of the Wadi Musa Water Supply and Waste Water Project. In: H.D. Bienert, H.G.K. Gebel, and R. Neef (eds.), *Central Settlements in Neolithic Jordan.* Studies in Early Near Eastern Production, Subsistence, and Environment 5. Berlin, ex oriente.

Berner M. and Schultz M.

in press Demographic and taphonomic aspects of the skeletons from the Late Pre-Pottery Neolithic B population of Basta (Jordan). In: H.D. Bienert, H.G.K. Gebel, and R. Neef (eds.), *Central Settlements in Neolithic Jordan.* Studies in Early Near Eastern Production, Subsistence, and Environment 5. Berlin, ex oriente.

Becker C.

1987 Faunal remains. In: H.J. Nissen *et al.* 1987.

1991 The analysis of mammalian bones from Basta, a Pre-Pottery Neolithic Site in Jordan: problems and potential. *Paléorient* 17.1: 59-75.

1998 The role of hunting in Pre-Pottery Neolithic pastoralism and its ecological implications: the Basta example (Jordan). *Anthropozoologica* 27: 67-78.

1999 Early domestication in the southern Levant as viewed from Late PPNB Basta. In: L.K. Horwitz, E. Tchernov, P. Ducos, C. Becker, A. von den Driesch, I. Marzin, and A.N. Garrard, Animal domestication in the southern Levant. *Paléorient* 25.2: 70-72.

2000 Bone and species distribution in Late PPNB Basta (Jordan) - rethinking the anthropogenic factor. In: M. Mashkour, A. Choyke, H. Buitenhuis, and F. Poplin (eds.), *Archaeozoology of the Near East IV/A.* Proceedings of the 4th International Symposium on the Archaeozoology of Southwestern Asia and Adjacent Areas, Paris: 196-207.

2002 Nothing to do with indigenous domestication? Cattle from Late PPNB Basta. In: H. Buitenhuis, A.M. Choyke, M. Mashkour, and A.H. al-Shiyab (eds.), *Archaeozoology of the Near East V.* Proceedings of the 5th Intern. Symposium on the Archaeozoology of Southwestern Asia and Adjacent Areas, Groningen 8: 112-137.

in press Fire-damaged bone artefacts and a vessel: a remarkable marriage. In: J. Schibler (ed.), *Bone Antler and Teeth. Raw Materials for Tools from Archaeological Contexts.* Proceedings of the 3rd Meeting of the ICAZ Worked Bone Research Group, Basel 2001.

Bienert H.D. and H.G.K. Gebel

1998 Archaeological excavations at Late PPNB Ba'ja. Preliminary report on the 1997 season. *Annual of the Department of Antiquities* 42: 75-90.

Bienert H.D. and H.M. Mahasneh

1998 Es-Sifiya, eine Siedlung des frühen Neolithikums in Südjordanien. In: H. Hübner and A. Knauf (eds.), *Nach Petra und ins Königreich der Nabatäer.* Bonner Biblische Beiträge 118: 9-21 (Festschrift Manfred Lindner). Bodenheim, Philo.

Bienert H.D., H.G.K. Gebel, and R. Neef (eds.)

in press *Central Settlements in Neolithic Jordan.* Studies in Early Near Eastern Production, Subsistence, and Environment 5. Berlin, ex oriente.

Bisheh G.

1972 Report About a Survey in the Ma'an District (Petra-Area, Wadi Rum, Shobak, Aqaba), 25th September - 8th October 1972. Amman, Department of Antiquities: Open File Report.

Bisheh G. *et al.*

1993 The Cultural Resources Management Project in Jordan: archaeological rescue survey of the Ras an-Naqab-Aqaba Highway Alignment 1992. *Annual of the Department of Antiquities of Jordan* 37: 119-134.

Braidwood R.J.

1957 Jericho and its setting in Near Eastern history. *Antiquity* 31:73-80.

Gebel H.G.

1984 *Das Akeramische Neolithikum Vorderasiens. Subsistenzformen und Siedlungsweisen. Tabellarische Material- und Befundpräsentation zu Fundorten des Protoneolithikums und des Akeramischen Neolithikums.* Beihefte des Tübinger Atlas des Vorderen Orients B 52. Wiesbaden, Ludwig Reichert.

1986 Die Jungsteinzeit im Petra-Gebiet. In: M. Lindner (ed.), *Petra. Neue Ausgrabungen und Entdeckungen*: 273-308. München, Delp.
1988 Late Epipalaeolithic-Aceramic Neolithic sites in the Petra-Area. In: A.N. Garrard and H.G. Gebel (eds.), *The Prehistory of Jordan. The State of Research in 1986*. British Archaeological Reports- Intern. Series 396.1: 67-100. Oxford, B.A.R.
1990 *Vorderer Orient. Neolithikum. Beispiele zur Fundortökologie. Petra- Region.* Middle East. Neolithic. Examples of the Ecological Setting of Sites. Petra Region. Tübinger Atlas des Vorderen Orients B I 15.1. Wiesbaden, Ludwig Reichert.
1992a Neolithic 'Ain Jammam Near Ras an-Naqab: Observations on the Site Preservation Since 1986 and the Field Operation in September 1992. Unpublished report submitted to the Department of Antiquities of Jordan, Amman.
1992b Territories and palaeoenvironment: locational analysis of Neolithic site setting in the Greater Petra area, southern Jordan. In: S. Kerner (ed.), *The Near East in Antiquity. German Contributions to the Archaeology of Jordan, Syria, Lebanon and Egypt* 3: 85-96. Amman, al- Khubta Publishers.
1996 Chipped lithics in the Basta Craft System. In: S.K. Kozlowski and H.G.K. Gebel (eds.), *Neolithic Chipped Stone Industries in the Fertile Crescent, and Their Contemporaries in Adjacent Areas.* Studies in Early Near Eastern Subsistence, Production, and Environment 3: 261-270. Berlin, ex oriente.
1998 Die Petra-Region im 7. Jt. vor Chr. Betrachtungen zu Ausbildung und Auflösung einer frühneolithischen Siedlungskammer. In: H. Hübner and A. Knauf (eds.), *Nach Petra und ins Königreich der Nabatäer.* Bonner Biblische Beiträge 118 (Festschrift Manfred Lindner): 1-8. Bodenheim, Philo.
2001 Frühseßhafte verborgen in Felsen. Ba'ja in Süd-Jordanien stellt der Jungsteinzeitforschung neuartige Fragen. *Antike Welt* 32/3: 275-283.
2002a The Neolithic of the Near East. An essay on a polycentric process and other research problems. In: A. Hausleiter, S. Kerner, and B. Müller-Neuhof (eds.), *Material Culture and Mental Spheres. Internationales Symposium für Hans J. Nissen.* Alter Orient und Altes Testament 293: 313-324. Münster, Ugarit-Verlag.
2002b *Subsistenzformen, Siedlungsweisen und Prozesse des sozialen Wandels vom akeramischen bis zum keramischen Neolithikum,* II: *Grundzüge sozialen Wandels im Neolithikum der südlichen Levante.* http://www.freidok.uni-freiburg.de/volltexte/466. Freiburg, Universiätsbibliothek.
in press Central to what? Remarks on the settlement patterns of the LPPNB mega-sites in Jordan. In: H.D. Bienert, H.G.K. Gebel, and R. Neef (eds.), *Central Settlements in Neolithic Jordan.* Studies in Early Near Eastern Production, Subsistence and Environment 5. Berlin, ex oriente.

Gebel H.G. and J.M. Starck.
1985 Investigations into the stone age of the Petra area (Early Holocene research). A preliminary report on the 1984 campaigns. *Annual of the Department of Antiquities of Jordan* 29: 89-114.

Gebel H.G., M. Muheisen, and H. J. Nissen, with contributions by N. Qadi and J.M. Starck.
1988 Preliminary report on the first season of excavations at the Late Aceramic Neolithic site of Basta. In: A.N. Garrard and H.G. Gebel (eds.), *The Prehistory of Jordan. The State of Research in 1986.* British Archaeological Reports - Intern. Series 396.1: 101-134.Oxford, B.A.R.

Gebel H.G., F.Hahme, B. Dahl Hermansen, and N. Qadi.
1994 Brotbacken in Basta. *Das Altertum* 39: 301-316.

Gebel H.G.K. and H.D. Bienert, with contributions by T. Krämer, R. Neef, B. Müller-Neuhof, J. Timm and K. I. Wright.
1997 Ba'ja hidden in the Petra Mountains. Preliminary results of the 1997 investigations. In: H.G.K. Gebel, Z. Kafafi and G.O. Rollefson (eds.), *The Prehistory of Jordan,* II. *Perspectives from 1997.* Studies in Early Near Eastern Production, Subsistence, and Environment 4: 221-262. Berlin, ex oriente.

Gebel H.G.K. and B. Dahl Hermansen
1999a A third little head from LPPNB Basta, southern Jordan. *Neo-Lithics* 2/99: 11-12. Berlin, ex oriente.
1999b The Ba'ja Neolithic Project 1999: short report on architectural findings. *Neo-Lithics* 3/99: 18-21. Berlin, ex oriente.
2000 The 2000 Season at Late PPN Ba'ja. *Neo-Lithics* 2-3/00: 22-24. Berlin, ex oriente.
2001 LPPNB Ba'ja 2001. A Short Note. *Neo-Lithics* 2/01:15-20. Berlin, ex oriente.

Gebel H.G., Z. Kafafi, and G.O. Rollefson (eds.),
1997 *The Prehistory of Jordan,* II. *Perspectives from 1997.* Studies in Early Near Eastern Production, Subsistence, and Environment 4. Berlin, ex oriente.

Gebel H.G. and M. Muheisen.
1997 "Basta". In: E.M. Meyers, *The Encyclopedia of Near Eastern Archaeology* 1: 279-80. New York, Oxford University Press.

Glueck N.
1934-35 Explorations in Eastern Palestine, II. *Annual of the American School of Oriental Research* 15.

Hermansen B. Dahl
1997 Art and ritual behavior in Neolithic Basta. In: H.G.K. Gebel, Z. Kafafi and G.O. Rollefson (eds.), *The Prehistory of Jordan,* II. *Perspectives from 1997.* Studies in Early Near Eastern Production, Subsistence, and Environment 4: 333-343. Berlin, ex oriente.

Johnson G.A.
1982 Organizational structure and scalar stress. In: C. Renfrew (ed.), *Theory and Explanation in Archaeology: 389-421.* New York.

Karasneh W.
1989 *Bone Artifacts from Basta.* Irbid, Yarmouk University: unpub.M.A. thesis. (in Arabic)

Kenyon K.M.
1953 Mankind's earliest walled town. *Illustrated London News* 17.10.1953: 603-604.
1956 Jericho and its setting in Near Eastern history. *Antiquity* 30: 184-196.

Kinzel M.
2003 *Basta, Südjordanien. Überlegungen zur Rekonstruktion von Area B (7000 BC)nach bauarchäologischen Befunden.* Berlin, Technische Universität: unpub. Abschlußarbeit Aufbaustudium Denkmalpflege.

Kirkbride D.
1959 Short note on some hitherto unrecorded prehistortic sites in Transjordan. *Palestine Exploration Quarterly* 98: 8-72.

Kuijt I.
2000 People and space in early agricultural villages: exploring daily lives, community size, and architecture in the Late Pre-Pottery Neolithic. *Journal of Anthropological Archaeology* 19: 75-102.

Lindner M.
1973 Eine archäologische Expedition nach Jordanien (1973). *Jahresmitteilungen der Naturhistorischen Gesellschaft Nürnberg* 1973: 20-42.

Mahasneh H.M.
1997 A Pre-Pottery Neolithic B site in the Wadi el-Mujib. In H.G.K. Gebel, Z. Kafafi, and G.O. Rollefson (eds.), *The Prehistory of Jordan,* II. *Perspectives from 1997.* Studies in Early Near Eastern Production, Subsistence, and Environment 4: 203-214. Berlin, ex oriente.
2001 The Neolithic burial practices in Wadi al-Mujib during the seventh millennium B.C. In: G. Bisheh (ed.), *Studies in the History and Archaeology of Jordan* 7: 121-141. Amman, Department of Antiquities of Jordan.
in press Spatial and functional features of Area B in the Neolithic es-Sifiya, Jordan. In: H.D. Bienert, H.G.K. Gebel, and R. Neef (eds.), *Central Settlements in Neolithic Jordan.* Studies in Early Near Eastern Production, Subsistence and Environment 5. Berlin, ex oriente.

Mahasneh H.M. and H.G.K. Gebel
1999 Geometric objects from LPPNB es-Sifiya, Wadi Mujib, Jordan. *Paléorient* 24.2: 105-110.

McCartney C. and E. Peltenburg
2000 The colonization of Cyprus: questions of origins and isolation. *Neo-Lithics* 1/00: 8-11. Berlin, ex oriente.

Neef R.
1997 Status and perspectives of archeobotanical research in Jordan. In: H.G.K. Gebel, Z. Kafafi, and G.O. Rollefson (eds.), *The Prehistory of Jordan,* II. *Perspectives from 1997.* Studies in Early Near Eastern Production, Subsistence, and Environment 4: 601-609. Berlin, ex oriente.

Neuberger J.
1999 *Plastisch formbare Materialien und frühe Gefäßtechnologie in der südlichen Levante.* Berlin, Freie Universität: unpub. M.A.- Thesis. To appear as: J. Neuberger, Technology of Containers. In: Basta VI.2. Mouldable Materials.

Nissen H.J.
1993 The PPNC, the Sheep, and the "hiatus palestinienne". *Paléorient* 19.1: 177-183.
in press Proto-Urbanism: an early Neolithic feature?- in lieu of an introductory remark. In H.D. Bienert, H.G.K. Gebel, and R. Neef (eds.), *Central Settlements in Neolithic Jordan.* Studies in Early Near Eastern Production, Subsistence, and Environment 5. Berlin, ex oriente.

Nissen H.J., M. Muheisen, H.G. Gebel with contributions by C. Becker, R. Neef, H.J. Pachur, N. Qadi, and M. Schultz
1987 Report on the first two seasons of excavations at Basta. *Annual of the Department of Antiquities of Jordan* 31: 79-120.

Nissen H.J., M. Muheisen, H. G. Gebel with contributions by C. Becker, B. Dahl Hermansen, W. Karasneh, N. Qadi, M. Schultz, and A. Scherer
1991 Report on the excavations at Basta 1988. *Annual of the Department of Antiquities of Jordan* 35:13-40.

Peltenburg E.
n.d. Social space in early sedentary communities of Southwest Asia and Cyprus. In: E. Peltenburg and A. Wasse (eds.), *Neolithic Revolution. New Perspectives on Southwest Asia in the Light of Recent Discoveries on Cyprus.* Levant Supplementary Series 1. Oxford, Oxbow Books.

Peterson J.
2000 Test excavations at PPNB/PPNC Khirbet Hammam, Wadi el-Hasa, Jordan. *Neo-Lithics* 1/00: 2-4.

Roehrer-Ertl O., K.W. Frey, and H. Newesely
1988 Preliminary note on the early Neolithic human remains from Basta and Sabra1. In: A.N. Garrard and H.G. Gebel (eds.), *The Prehistory of Jordan. The State of Research in 1986.* British Archaeological Reports - Intern. Series 396: 135-136. Oxford, B.A.R.

Rollefson G.O.
1989 The Aceramic Neolithic of the Southern Levant: the view from 'Ain Ghazal. *Paléorient* 15.1: 135-140.
1992 Neolithic Settlement patterns in Northern Jordan and Palestine. In: S. Tell (ed.), *Studies in the History and Archaeology of Jordan* 4: 123-127. Amman, Department of Antiquities.
1999 El-Hammeh: a Late PPNB-PPNC village in the Wadi el-Hasa, Southern Jordan. *Neo-Lithics* 2/99: 6-8. Berlin, ex oriente.
2001 Jordan in the seventh and sixth millennia BC. *Studies in the History and Archaeology of Jordan* 7: 95-100. Amman.

Schmidt K.
2002 Göbekli Tepe -Southeastern Turkey. The seventh campaign 2001. *Neo-Lithics* 1/02: 23-25. Berlin, ex oriente.

Schultz M., M. Berner, and T.H. Schmidt-Schultz
in press Preliminary results on morbidity and mortality in the Late PPNB population of Basta (Jordan). In: H.D. Bienert, H.G.K. Gebel, and R. Neef (eds.), *Central Settlements in Neolithic Jordan.* Studies in Early Near Eastern Production, Subsistence, and Environment 5. Berlin, ex oriente.

Simmons A.H. and M. Najjar
1999 Preliminary field report of the 1998-1999 excavations at Ghwair 1, a Pre-Pottery Neolithic B community in Wadi Feinan Region of southern Jordan. *Neo-Lithics* 1/99: 4-6. Berlin, ex oriente.
2000 Preliminary report of the1999-2000 excavation season at the Pre-Pottery Neolithic settlement of Ghwair 1, southern Jordan. *Neo-Lithics* 1/00: 6-8. Berlin, ex oriente.

Waheeb M.
1996 Archaeological excavations at Ras an-Naqab-Aqaba road alignment: preliminary report (1995). *Annual of the Department of Antiquities of Jordan* 40: 339-348.

Waheeb M. and N. Fino
1997 'Ain Jammam: a Neolithic site near Ras an-Naqab, southern Jordan. *Studies in Early Near Eastern Production, Subsistence, and Environment* 4: 215-219. Berlin, ex oriente.

Present-day Site Setting and Physiographic Units

Hans Georg K. Gebel

The thorough analysis of the present-days' physiographic setting of an Early Neolithic site guides to the understanding and reconstruction of its palaeophysiography[1] and thus is essential to the interpretation of its human ecology. This chapter presents a short overview and summary of the present-day physiography of Basta, and otherwise refers to the data and discussions presented by Gebel, Site Preservation ...; Muheisen, Qadi and, Gebel; Neef; and Becker, this volume.

Physiographic Setting

Geographical and Climatic Setting

Modern Basta is located some 14 km SSE of Wadi Musa, and some 20 km WNW of Ma'an in Southern Jordan (Fig. 1). The upper part of Wadi Basta passes through the modern and old village, roughly from W to E (Plate 1.C). The strong spring of 'Ain Basta today is located immediately S of the Early Neolithic village. Its deposits rest under the NW parts of the modern village, situated at 30° 13' 47" N / 35° 32' 06" E between 1460 - 1420 m a.s.l. They occupy here the NW slope stratigraphy of Wadi Basta (Plate 1.A-C). The panoramic views of Plates 2-4 explain the present-day local landscapes by panoramic views (for the locations of the panoramic Views A-D, *cf.* Plate 1.C).

Basta rests in the lowermost Eastern foothills of the escarpment that separates the sandstone area of Petra in the West and the vast plains of the Arabian Plateau in the East (Fig. 4). The topography here changes from steeper and dissected in the West to flat and shallow in the East.

---

1 The reconstruction of the Early Neolithic catchments and their potentials is an interdisciplinary task of the Basta final publication team. Since not all palaeobiological analysis could be completed for *Basta* I. *The Human Ecology* due to restricted resources, the joint reconstruction of the palaeohabitats has become the task of the last volume of the final publication, aimed to summarize the excavation results on "cross-subject" and "cross-discipline" levels.

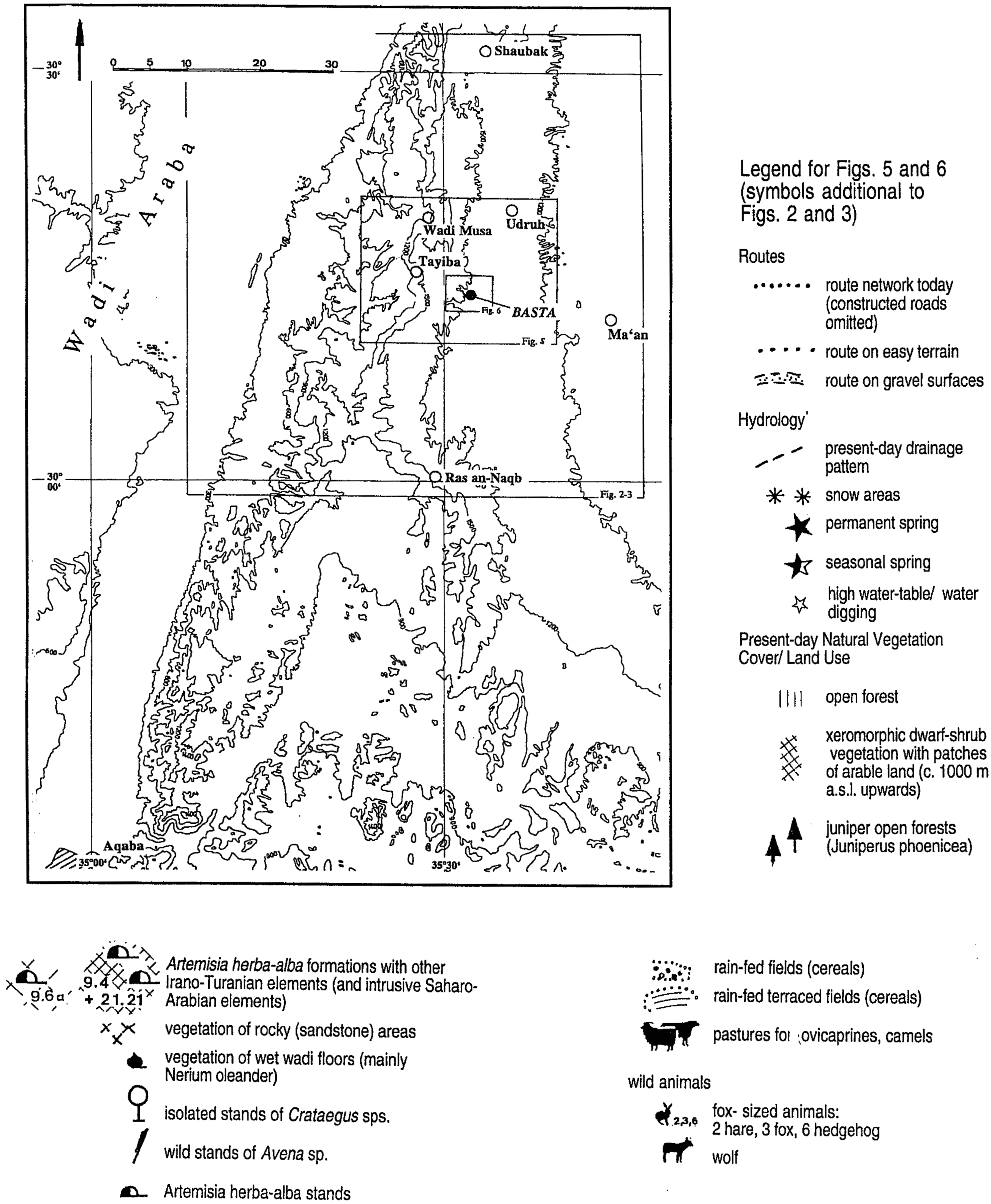


Fig. 1. Location of Basta in Southern Jordan, index map and legend for Figs. 5-6.

The area presently lies in the semi-arid cold region of Southern Jordan (Emberger classification, NAJ I) and receives 150/ 200 mm mean annual rainfall (dry/ wet years), which mostly falls in winter and early spring (Fig. 2, 4). However, precipitation may vary from 200-300mm in wet years to as little as 50-100 mm in dry years. This annual rain fluctuation makes the area agriculturally marginal. The Shobak "safe" dry farming region begins some 25 km N of Basta (Fig. 2: V-VI). The steep slopes (*cf.* below: Units I and II in Fig. 4) bordering the sandstone region in the West receive the highest precipitation in the area, and are therefore potentially more fertile. But for topographic reasons agriculture is limited: the erosive energy is too high to preserve extensive arable land. The vast agricultural areas on the eastern slopes of the escarpment (Unit III, Fig. 2) suffer towards East more and more from reduced rainfall and overgrazing. For a further discussion of the dry farming question and crop husbandry at Basta *cf.* Neef, this volume, and the data provided in the NAJ II (1986); Neef sees Basta today at the extreme eastern border of rain-fed agriculture.

Phytogeographical Setting

After Kürschner 1986, Basta today lies in a 15-30 km wide N-S strip of the Irano-Turanian Region (Fig. 2), which also contains N-S oriented "islands" of the Mediterranean phytogeographical region. Such a zone is to be found just W of Basta, between the villages of Tayiba and Rajif. Further to the East of Basta (10 km), an almost 10 km wide strip of a mixed Saharo-Arabian/ Irano-Turanian Region can be recorded, before the Saharo-Arabian Region starts to dominate the Arabian Plateau E of Ma'an. Looking at the present-day phytogeographical setting of Basta (Fig. 2), it is obvious that the site is in the reach of 7 phytogeographical regions, or their penetration zones respectively, along a 50 km W-E axis. This present-day phytogeographical variability of the Greater Petra Area not only reflects the rich variety of (partly very restricted) habitats to be expected for the Early Holocene within a limited area, it also explains the many socioeconomic possibilities Neolithic adaptation had in the Greater Petra Area (Gebel 1992, 1998). LPPNB Basta, however, seems to have developed only by the exploitation of its steppe environments.

Vegetational Setting, Land Use

For the present-day vegetation around Basta see Figs. 3-5 and Neef, this volume: Fig. 2.A. The transect in Gebel, Muheisen, and Nissen 1988 (Fig. 2) and Figs. 4-6 provide also information on the present-day land use in the greater Basta area. Plate 5 illustrates views of the present-day and subrecent agriculture in the region. A thorough study of the present-day vegetation in Southwestern Jordan was presented by H.U. Baierle (1993); prehistoric and historic degradation is discussed in Baierle, Frey, Jagiella, and Kürschner 1989.

Hydrological Setting

The escarpment to the West dominates the hydrological situation of Basta and its vicinities. This ridge (reaching heights of more than 1600 m a.s.l.) separates the Petra sandstone area and the Arabian Plateau, and acts as a watershed for the region. Many springs are located in the wadis of its Eastern foothills, and 'Ain Basta is a typical location for such a spring. But due to today's degraded soil cover of the area, many springs are seasonal, dried out, or fossil ones.

Bir Basta and 'Ain Basta are situated some 700 m after the confluent of Wadi Dinareh and Wadi Muheidirat (NW of Basta), locally named Wadi Muheidirat by reaching the modern

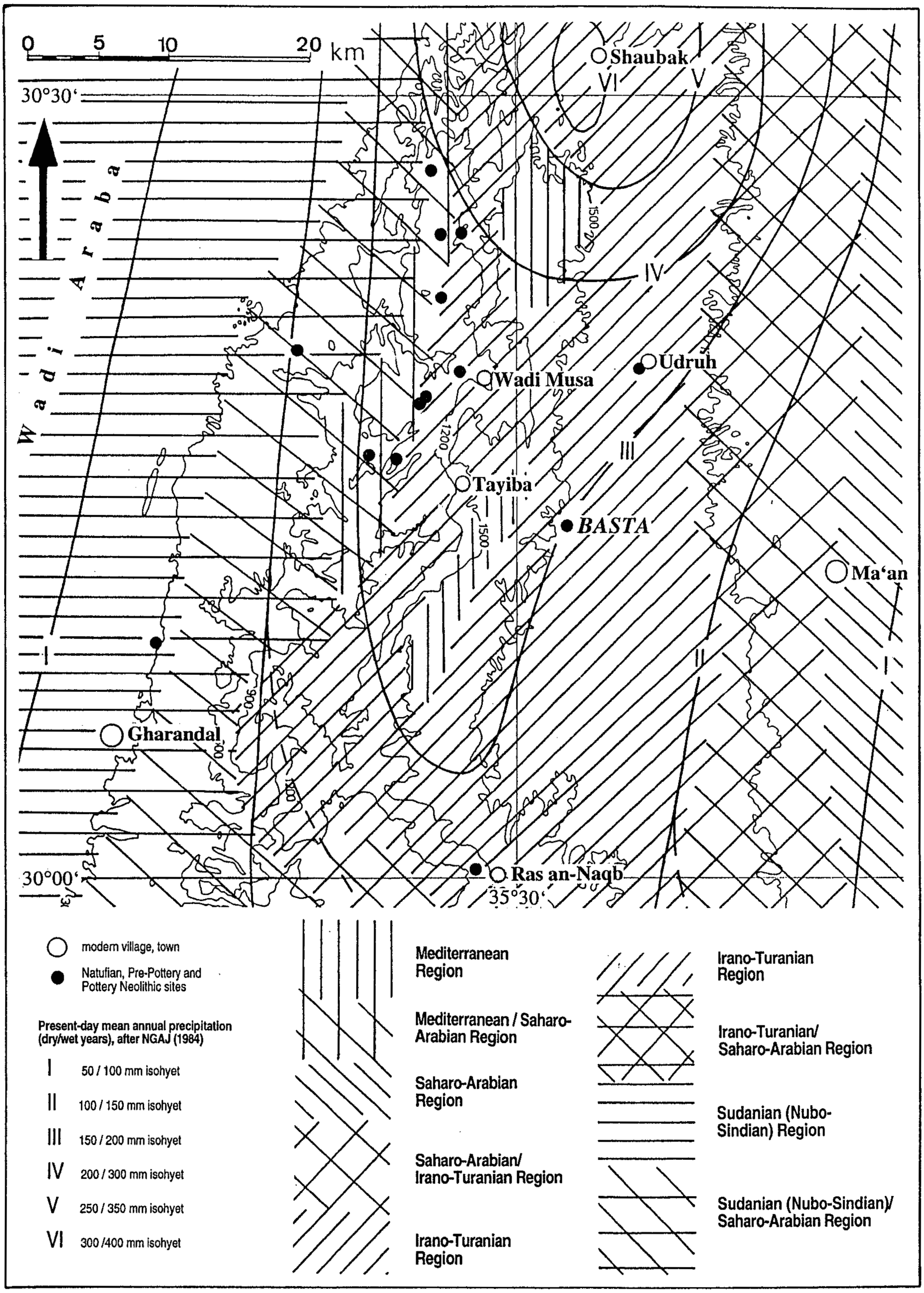


Fig. 2. Present-day phytogeographical regions of the Greater Petra Area with their transitional zones (after Kürschner 1986) and the isohyets of the mean annual precipitation (dry/wet years; after NAJ 1984).

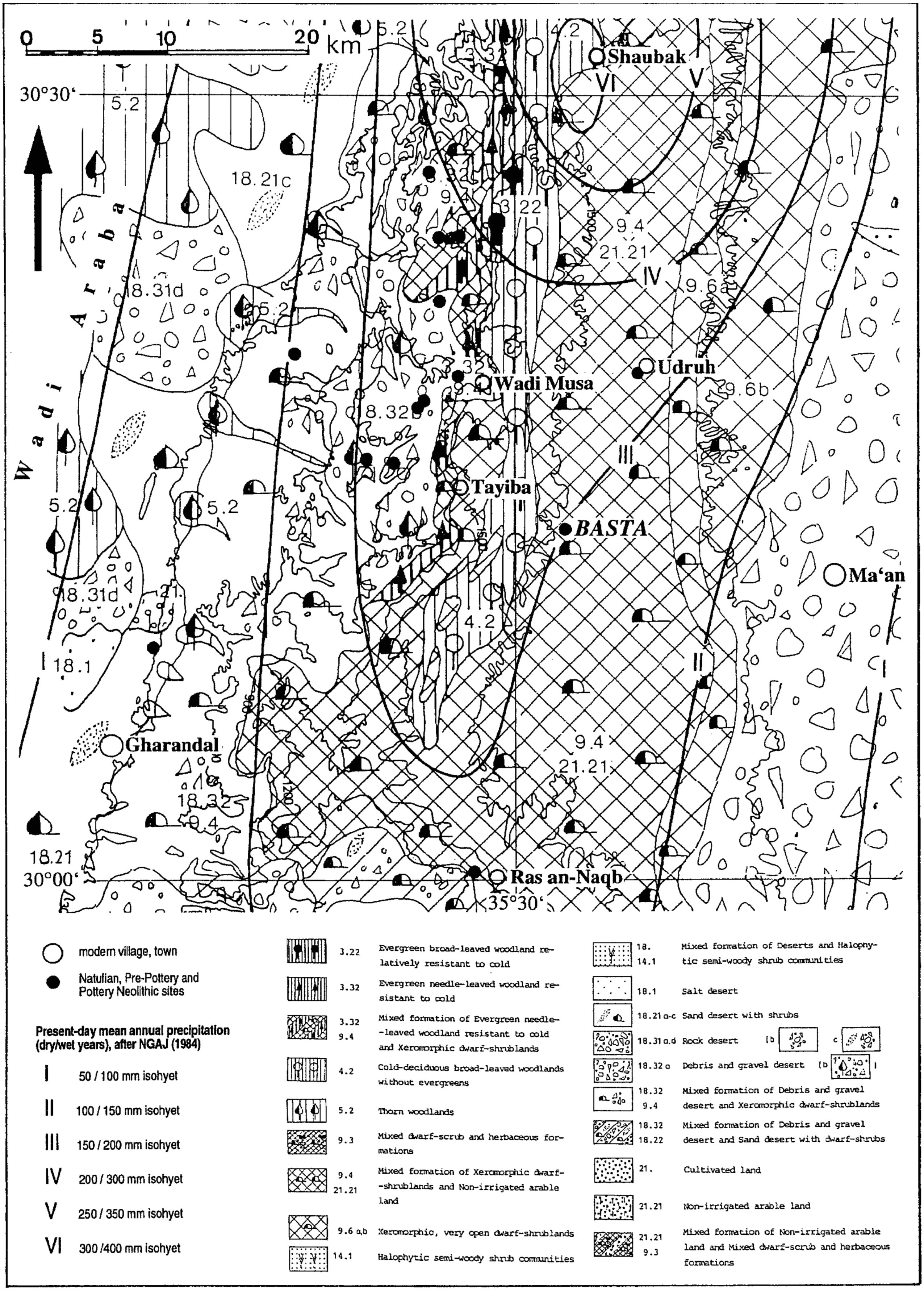


Fig. 3. Present-day vegetation units of the Greater Petra Area (after Kürschner1986) with the isohyets of the mean annual precipitation (dry/wet years; after NAJ 1984).

Plate 1.A. View of the excavations` setting in Area A, from SE <*photo by H.G. Gebel in 1988*>.

Plate 1.B. View of the excavations` setting in Area B and C from SSW <*photo by H.G. Gebel in 1988*>.

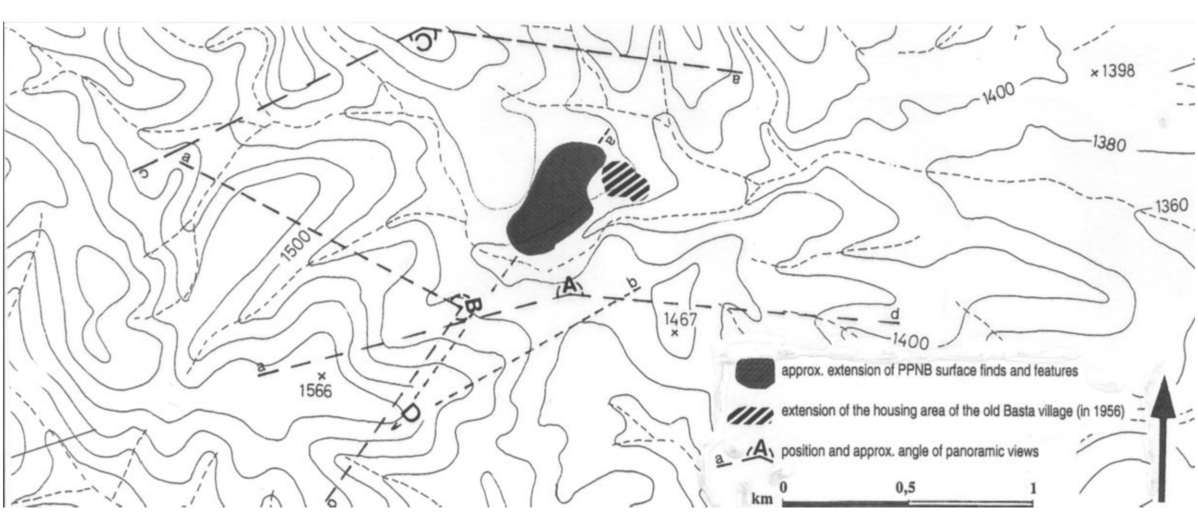


Plate 1.C. Locations of panoramic views A-D (*cf. Plates 2-4*).

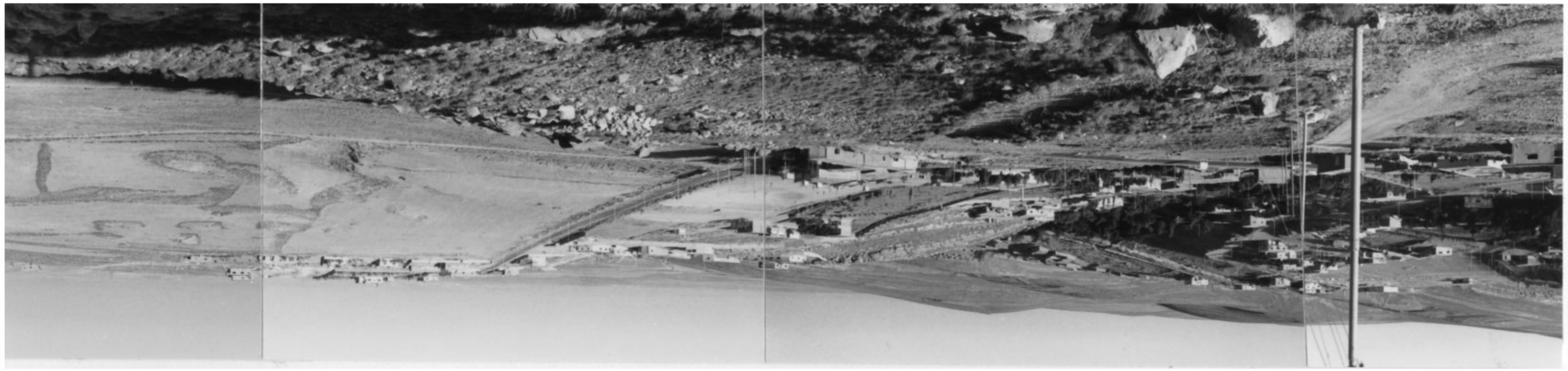
a b

b c

c d

Plate 2. Panoramic view A. Village area of Basta with left bank of Wadi Basta from S at an angle of c. 200° (a: WSW - b: E) <*photos by H.G. Gebel in 1988*>.

a  b

b  c

c  d

Plate 3. Panoramic view B. Village area of Basta and ist immediate surrounding from WSW at an angle of c. 280° (a: WSW - b: E) <*photos by H.G. Gebel in 1988*>.

a

b

Plate 4.A. Panoramic view C. Village area of Basta from NNW at an angle of c. 145°
(a: E -c: SW) <photos by H.G. Gebel 1988>

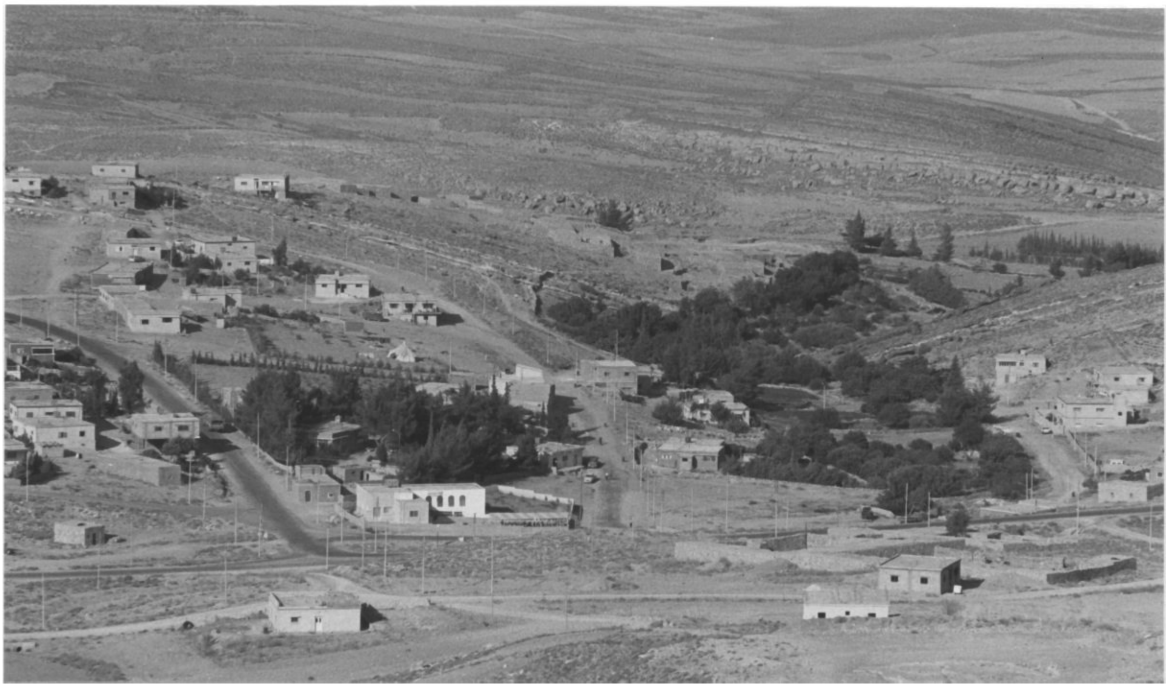


Plate 4.B. Panoramic view D. Village area of Basta from SW at an angle of c. 24°
(a: NNE -b: ENE) <photos by H.G. Gebel 1988>

Plate 5.A. Present-day agriculture in the Basta area: the example of terraced fields near Tayiba on the western slopes of the escarpment <photos by H.G. Gebel 1988>

Plate 5.B. Present-day agriculture in the Basta area: the example Fardah near Ail. <photos by H.G. Gebel 1988>

Plate 5.C. Subrecent agriculture in the Basta area, field clearing piles: the example South of Ail, an area in which dry farming was given up. <photos by H.G. Gebel 1988>

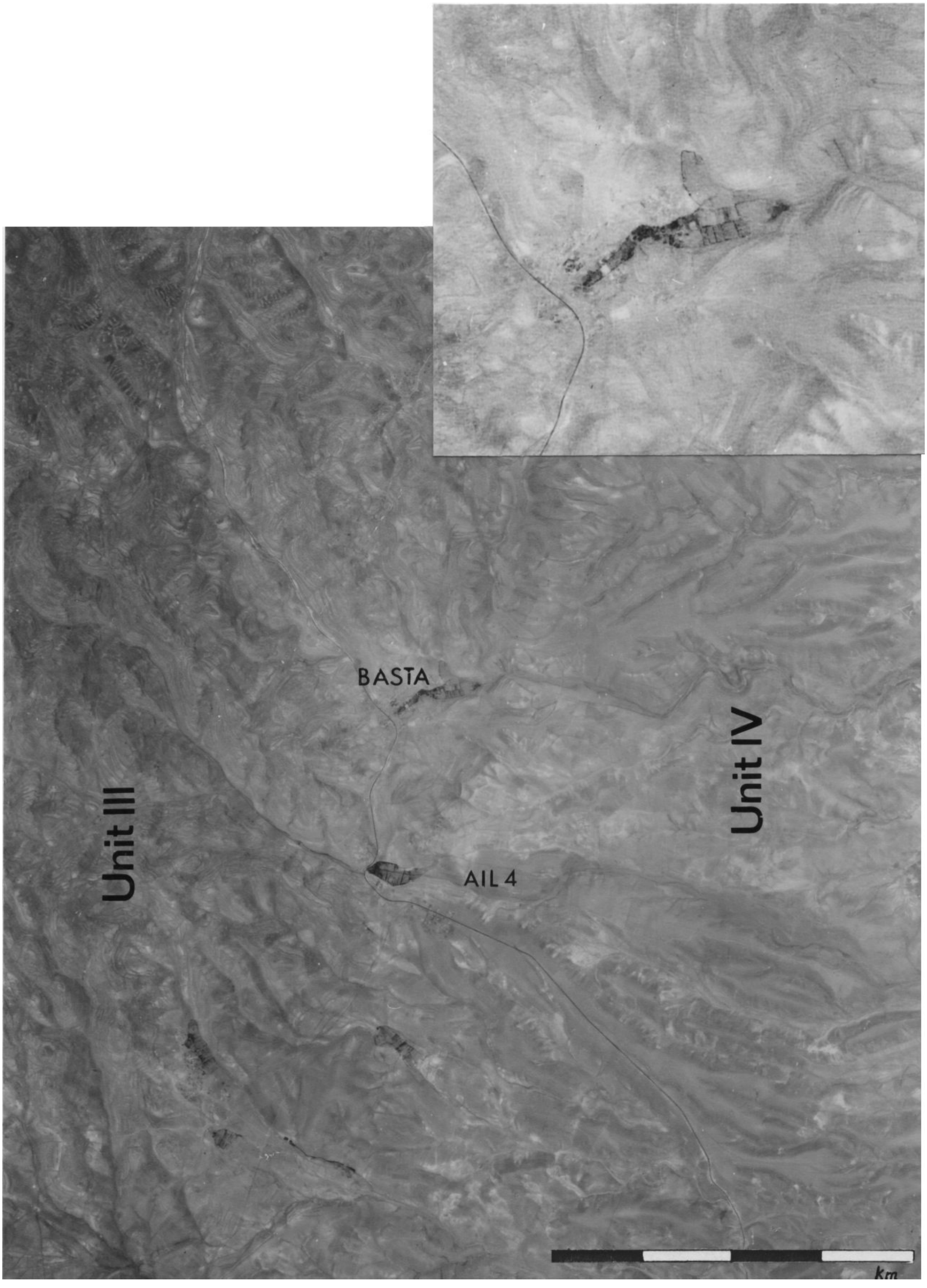


Plate 6. Air photograph (IGN 45/ 600/ shot 499, 1981?) Of the Basta region
(1- 1,5 walking dinstances), with the location of the early Neolithic sites of Basta and Ail 4.

village of Basta. Hereafter the wadi is named Wadi or Seyl Basta. The well Bir Basta is located next to the wadi bottom in 100 m distance from the rich of spring 'Ain Basta (*cf.* Fig. 3 in the Editors' Introduction), which is located further down the wadi. Water here can be obtained from a concrete recevoir. Three more springs belong to the present-day Basta catchment:

- 'Ain Aqil(eh): some 200 m N of the old village of Basta in Wadi 'Ain Aqil(eh), which is named Wadi Zhara in its upper parts; dry since *c.* 20 years, that time destroying apple / apricot plantages and vegetable gardens (gardens of Sheikh Sanad ibn-Saba'a of Abu Danna). Today the gardens are fed from 'Ain Basta by channels, bearing corn and olive trees as well as pines along the channels.
- 'Ain Zhara: situated some 100 m W of the wadi bottom of Wadi Zhara (Northern confluent of Wadi Basta) between Basta and Abu Danna.
- 'Ain Muheidirat: *c.* 1200 m NW of Bir Basta in upper Wadi Muheidirat.

Other springs and wells of various intensity in the greater Basta area (including the western slopes of the escarpment) are: Bir Abu Dhanna, 'Ain Abu Dhanna, Bir Qa', 'Ain al-Hatteh, Bir al-Bitar, 'Ain al-Numaileh, 'Ain al-Ma'in, 'Ain Quseib, 'Ain Ail, 'Ain Sheikh, 'Ain Abu al-Idham, 'Ain Fardah, 'Ain Aneiq, 'Ain Dirbasi, 'Ain Ammoun, 'Ain Braq, 'Ain M'allaqa, 'Ain Bde'u, 'Ain Tayiba, 'Ain Dilbe, 'Ain Ganam, 'Ain Saman, 'Ain Rajif, and others.

Geological Setting

Geologically, Basta is situated on the border between the limestone /marl / dolomite - formations of the West and the chalky marls / bituminous limestone / marls of the East (Bender (1968: Sheet Aqaba - Ma'an). In this area there is also the most Westerly appearance of the fluviatile gravels and mantle rocks, which are characteristic of the areas around Ma'an. For more detailed information about the geological setting and the abiotic resources used in the flint and ground stone industries *cf.* Muheisen, Qadi, and Gebel, this volume.

The Area's Physiographic Units

Fig. 4 illustrates the present-day physiographic units along a W-E- transect at Basta[1]. Fig. 2 of Neef, this volume, presents his reconstruction of LPPNB vegetational zones along the same transect. The comparison of both charts explains the shift of the vegetational zones and the degree of degradation in the region.

In the following the present-day physiographic units W and E of Basta are described:

Unit I) 1000-1400/1450 m: Lower parts of the Western slopes of the escarpment separating the sandstone area in the West and the Arabian Plateau in the East. *Artemisia herba-alba* (Irano-Turanian element) penetrates from the Eastern plateau/ escarpment into the Xero-Mediterranean savanna-type forests of *Juniperus phoenicea.* (pistachio has not survived in this area of the transect). Wild species of barley occur, as does hawthorn, but these are often overgrazed. Drainage systems are oriented E-W and the network of routes used runs N-S.

---

[1] The western continuation of the transect (Wadi Araba – escarpment) is published with Gebel 1990 and in Gebel 1992.

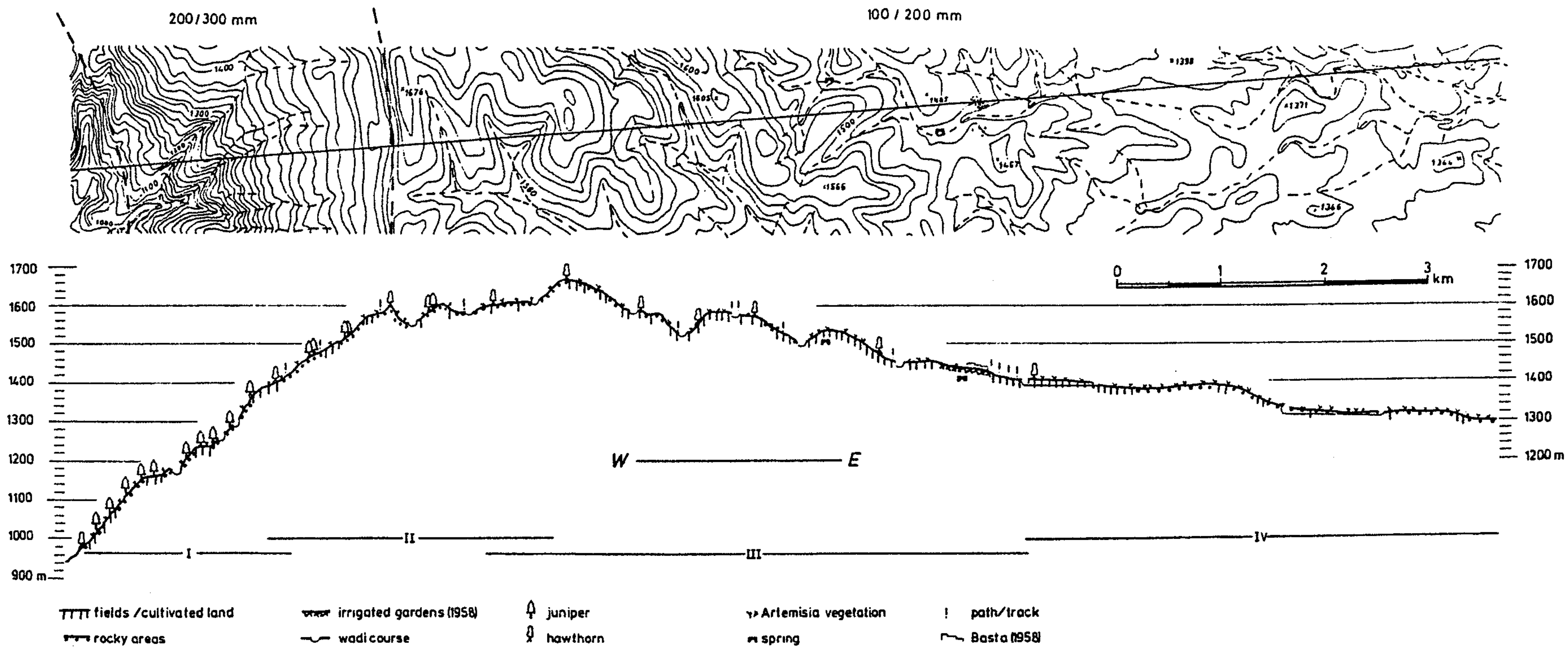


Fig. 4. W-E- transect with present-day physiographic units (from: Gebel, Muheisen, Nissen 1988).

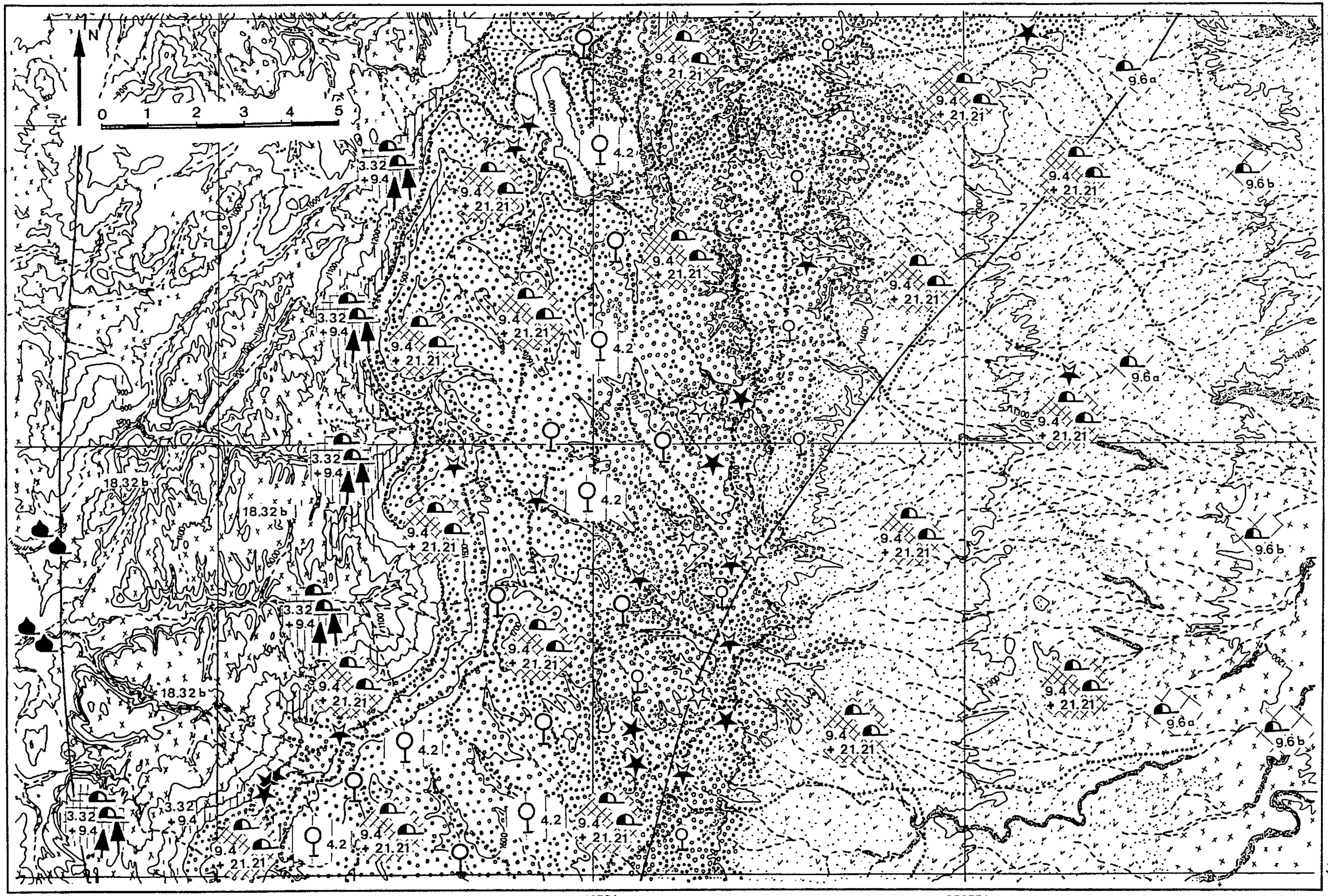


Fig. 5. Present-day natural vegetation, habitats and land use, hydrology, abiotic resources, and routes (2h walking distances). *<for legend cf. Figs. 1 and 3>*

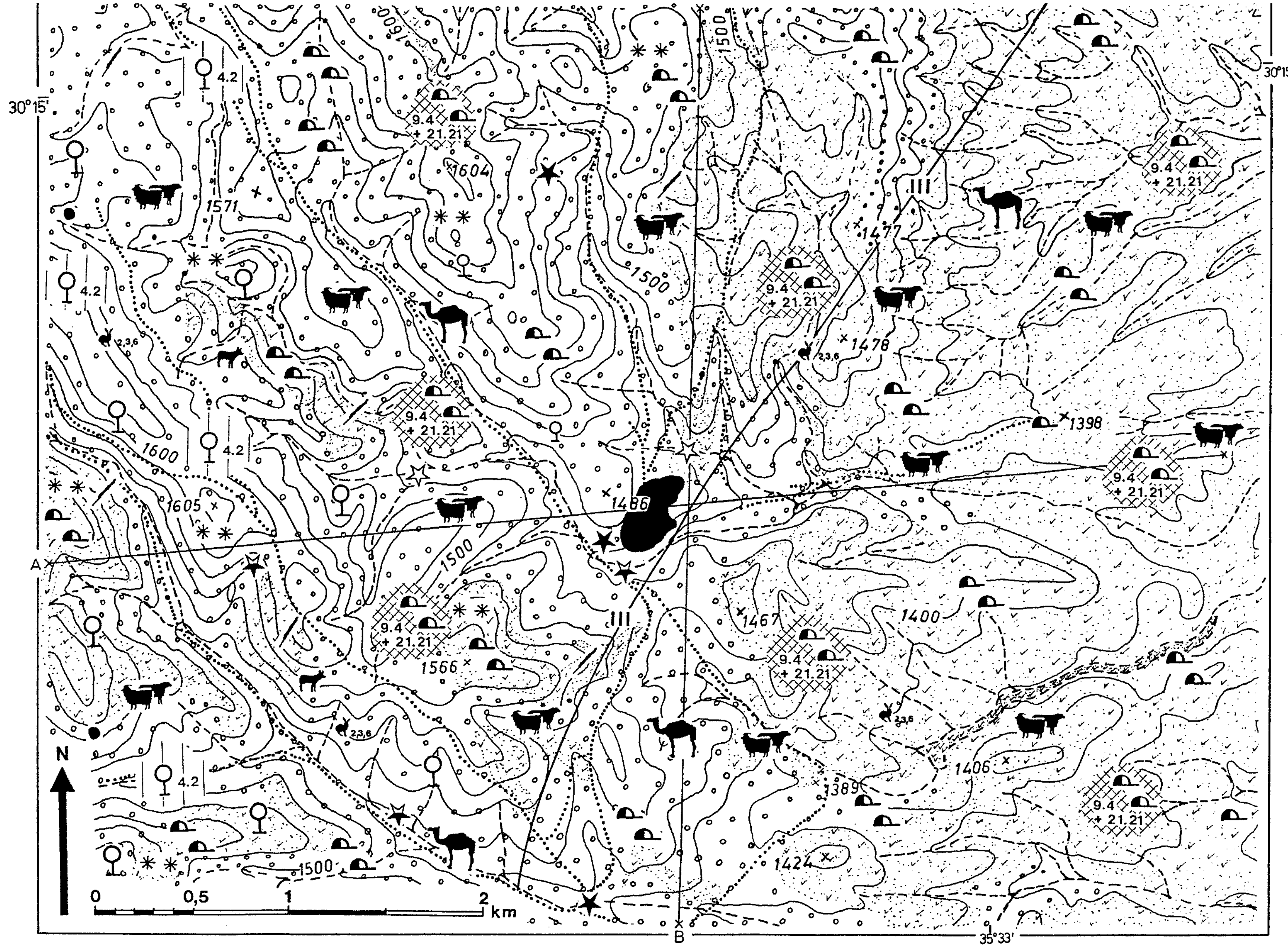


Fig. 6. Present-day physiographical setting and route network (immediate vicinity). <*for legend cf. Figs. 1 and 3*>

Relief is steep with spots of exposed bedrock (in the lower parts: contact zone limestone/sandstone). Area of high erosive energy. Unit I is the lower part of Zone V in R. Neef's (this volume: Fig. 2) palaeovegetational reconstruction of the Basta environment.

Unit II) 1400/1450 - 1600-1700 m: Upper parts of the Western slopes of the escarpment. Vegetation cover (dwarf-shrub vegetation with *Artemisia* - dominated associations: 30-35 %) same as Unit I, but the occurrence of juniper is restricted to linear, steep-sided rock formations where water accumulates in cracks and clefts, and which are less accessible to ovicaprines. In the North of the transect area small periodical and perennial springs around 1400-1500 m allow for limited gardens. Relief is very steep with high proportions of exposed bedrock. Area of high erosive energy. Unit II is the upper part of Zone V in R. Neef's (this volume: Fig. 2) palaeovegetational reconstruction of the Basta environment.

Unit III) 1600-1400 m: Eastern slopes of the escarpment, dissected by many wadis. *Artemisia* vegetation (30-35 %) with increasing intensity towards E and occasional hawthorn (*Crataegus azarolus* and *Crataegus* cf. *monogyna*), stands of wild barley and oats in areas protected from animals. Fields with maccaroni wheat (*Triticum durum*), barley (*Hordeum distichum*), chickpea (*Cicer aviatinum*), and lentils (*Lens culinaris*) seem to concentrate at higher altitudes. Non-irrigated gardens with cypresses, olive trees, and sometimes grapes are on the slopes around 1500 m, but often suffer badly from a lack of water. Spring-fed gardens (Basta, 'Ail) support figs, apricots, plums, apples, grapes, corn, cucumber, tomato and other vegetables. The lower parts/ foothills of the Eastern escarpment's slopes have many perennial, seasonal, and dry/ fossil springs. Unit III is roughly Zone IV in R. Neef's (this volume: Fig. 2) palaeovegetational reconstruction of the Basta environment. For an aerial view of Unit III *cf.* Plate 6.[1]

Unit IV) 1400-1300 m: Flat arid landscape with shallow wadis draining to the E. Treeless dwarf shrub vegetation with increasing *Artemisia* proportions. Unit IV is roughly Zone II in R. Neef's (this volume: Fig. 2) palaeovegetational reconstruction of the Basta environment. For an aerial view of Unit IV *cf.* Plate 6.

Hans Georg K. Gebel
Freie Universität Berlin
Institut für Vorderasiatische Altertumskunde
Hüttenweg 7
Germany - 14195 Berlin

References

Baierle H.U., Frey W., Jagiella C., and Kürschner H.
1989 Die Brennstoffressourcen im Raum Fenan (Wadi Araba, Jordanien) und die bei der Kupfererzverhüttung verwendeten Brennstoffe. In: A. Hauptmann, E. Pernicka, and G.A. Wagner (eds.), *Old World Archaeometallurgy. Proceedings of the International Symposium "Old World Metallurgy"*. Der Anschnitt Beiheft 7: 213-222. Bochum, Deutsches Bergbau-Museum.

---

[1] Plate 6 informs about the location of an interesting PPNB site, which is the closest yet found in the immediate neighborhood of Basta: Ail 4 (owner of the field: Sari Esa, Ail). The site was identified in 1988 by the present author. The find distribution (ploughing zone) extends over at least 200 x 100 m. In its center one major and one smaller hillock are preserved, containing rectangular architecture with double-faced walls in its upper stratigraphy. The chipped lithic industries show a bidirectional blade element and naviform cores. Although the Jiththa sources (*cf.* Muheisen, Qadi and Gebel, this volume) are closer to Ail 4 than Basta, its lithic surface inventory does not indicate workshop activities like in Basta. Also a clear orthoquartzite element is attested with the surface finds. The site should be multi-period: an EPPNB cannot be excluded, deep Beidha-type mortars suggest a MPPNB; a substantial part of the chipped lithics is identical with LPPNB Basta; and the sherds possibly attest a Pottery Neolithic. Ail 4 provides the most promising approach for an investigation of Basta's settlement system. Settlement system questions are still a rather neglected topic for the mega-sites ...

Bender F.
1968 Geological map of Jordan, Sheet Aqaba-Ma'an. 1:250,000. Berlin, Borntraeger

Baierle H.U.
1993 Vegetation und Flora im südwestlichen Jordanien. In: *Dissertationes Botanicae* 200. Berlin, Stuttgart, J. Cramer.

Gebel H.G.
1990 *Vorderer Orient. Neolithikum. Beispiele zur Fundortökologie. Petra- Region.* Middle East. Neolithic. Examples of the Ecological Setting of Sites. Petra Region. Tübinger Atlas des Vorderen Orients B I 15.1 <incl. Appendix Sheet>. Wiesbaden, Ludwig Reichert.
1992 Territories and palaeoenvironment: locational analysis of Neolithic site setting in the Greater Petra area, southern Jordan. In: S. Kerner (ed.), *The Near East in Antiquity. German Contributions to the Archaeology of Jordan, Syria, Lebanon and Egypt* 3: 85-96. Amman, al- Khubta Publishers.
1998 Die Petra-Region im 7. Jt. vor Chr. Betrachtungen zu Ausbildung und Auflösung einer frühneolithischen Siedlungskammer. In: H. Hübner and A. Knauf (eds.), *Nach Petra und ins Königreich der Nabatäer.* Bonner Biblische Beiträge 118 (Festschrift Manfred Lindner): 1-8. Bodenheim, Philo.

Gebel H.G., M. Muheisen, and H. J. Nissen, with contributions by N. Qadi and J.M. Starck.
1988 Preliminary report on the first season of excavations at the Late Aceramic Neolithic site of Basta. In: A.N. Garrard and H.G. Gebel (eds.), *The Prehistory of Jordan. The State of Research in 1986.* British Archaeological Reports - Intern. Series 396.1: 101-134.Oxford, B.A.R.

Kürschner H.
1986 A physiognomical-ecological classification of the vegetation of Southern Jordan. In: H. Kürschner (ed.), *Contributions to the Vegetation of Southwest Asia.* Beihefte des Tübinger Atlas des Vorderen Orients, Reihe A, 20: 45-79. Wiesbaden, Ludwig Reichert.

NAJ I
1990 *National Atlas of Jordan* I. *Climate and Agroclimatology.* Amman, Jordan National Geographic Center.

NAJ II
1991 *National Atlas of Jordan* II. *Hydrology and Agrohydrology.* Amman, Royal Jordanian Geographic.

Geomorphological Site Setting and Geochemical Results

Ulrich Kamp

Introduction[1]

The aim of the geomorphological part of the project is the integration of prehistoric cultural strata of the 9th millennium bp into the geomorphological evolution of the area surrounding the excavations. The aspects of sedimentational setting described below thus contribute to the reconstruction of the palaeohabitats.

In order to achieve an interdisciplinary understanding of geomorphological methods and their application to the archaeological project, the methods of examination and their possible interpretations will be explained briefly in the following sections. A detailed description can be found in Kamp 1992.

The burial of the settlement beneath later deposits leads to the question of the local sedimentation process. Grain size analysis, gravel morphometry, chemical-analytical and X-ray diffraction methods are able to give promising indications. Looking to the predominant weathering processes and their resulting material masses, the potential transportation agents are suggested. Concerning denudation, the relief plays a major role since it is oriented according to the given geomorphology. The results of these kinds of material transportation are alluvial and colluvial deposits. In Area C drillings were made in order to describe the palaeorelief and the stratigraphy of the accumulated colluvial deposits.

Using phosphate analysis, cultural strata can be clearly determined. Area C is presumed to be the Northern boundary of the Early Neolithic settlement. This leads to the question of the spatial limits of human activities beyond Areas A and B, which requires first of all that the depositional sequences in Areas A and B are described.

---

[1] For the geoarchaeological descriptions of some of the sections discussed in this contribution *cf.* Gebel, Site Preservation ..., this volume (Area A, NE- Section) and Gebel, forthcoming (Area A, NW- Section, B103, Test Units C 208 and 217).

Analytical Methods

The survey of the localities was conducted using a WILD T1 theodolite, an infrared tachymeter and a simple reflector target. The results were then linked onto the Basta topographical map 1:1000, prepared by Thomas Rüth in 1986.

The method of drilling used is suitable for the mapping of loose clastic sediments, since their thickness and abundance can vary even in a relatively confined area.

Gravel morphometry is the method of quantitative examination of pebbles and stones. It indicates either the direction of motion of the known sedimentation agent, or the method of transportation if its direction is known.

Granulometry is a basic method to examine the substratum. Using this method, the composition of the sediment in terms of different grain sizes can be determined. The soil probes were first treated in an ultrasonic disintegrator, followed by wet sieving with an electromechanical screen, and finally an elutriation analysis was undertaken in a sedimentation cylinder using a pipette titration device.

Applying X-ray diffraction techniques, the composition of the minerals in rocks and sediments can be determined. The examinations were done with a Philips Müller-Mikro 1011 powder diffractometer using the method of Debye-Scherrer (after Hartge 1978). Initially, test measurements were taken from the powdered preparations of the soil samples. Structure preparations were made for the examination of the clay minerals. Subsequent examination entailed ethylene glycol treatment at 600° C and again at 550° C. This method permits the identification of smectites and vermiculites, since smectites embed two layers of glycerin while vermiculites embed only one layer. Smectites and vermiculites expand in this process; in contrast, illites and chlorites show no expansion. The final identification of minerals followed Tröger (1971) and the international mineralogical ASTM table of the Joint Committee On Powder Diffraction Standards (1974).

For the measurement of salt content in a soil horizon, one can measure the conductivity of a moist soil extract. The (evaporitic) salt content itself can give indications about syn- or post-sedimentary groundwater influences. Even a repeated surface saturation by (slightly) saline run-off water can lift the salinity in the sediment. Perhaps the respective duration of subaerial exposure of each stratum is reflected in the conductivity. The measurements using the Schott CG 868 conductometer showed that there is little difference between the 10-min. and the 60-min. readings. This led to the conclusion that there was just a small proportion of poorly soluble salts (sulfates) (Kröpelin 1989). Consequently, anaylisis relied primarily on the 10-min. results. A classification of salinity was conducted by S. Salinity Laboratories For Water (1954), and later modified by Thorne and Peterson (1954) in Yaron *et al.* (1973: 75).

Agricultural land use drains the soil mostly of salts from weak acids, resulting in a rise in acidity (Rottländer 1983). If the pH-values of a horizon are significantly lower than the "blind value", indications about former human use can be derived, but the tendency for natural acidification must be kept in mind (Scheffer and Schachtschabel 1984). The measurements were executed with a Schott pH-meter. A gradation of the soil into pH-values was made according to Scheffer and Schachtschabel (1984: 107)

The carbon analysis (total and inorganic) was accomplished using a Ströhlein C-mat 500 device. The organic content is derived from the difference of "total content" minus "inorganic content", leaving the "organic C content". From the organic C content two

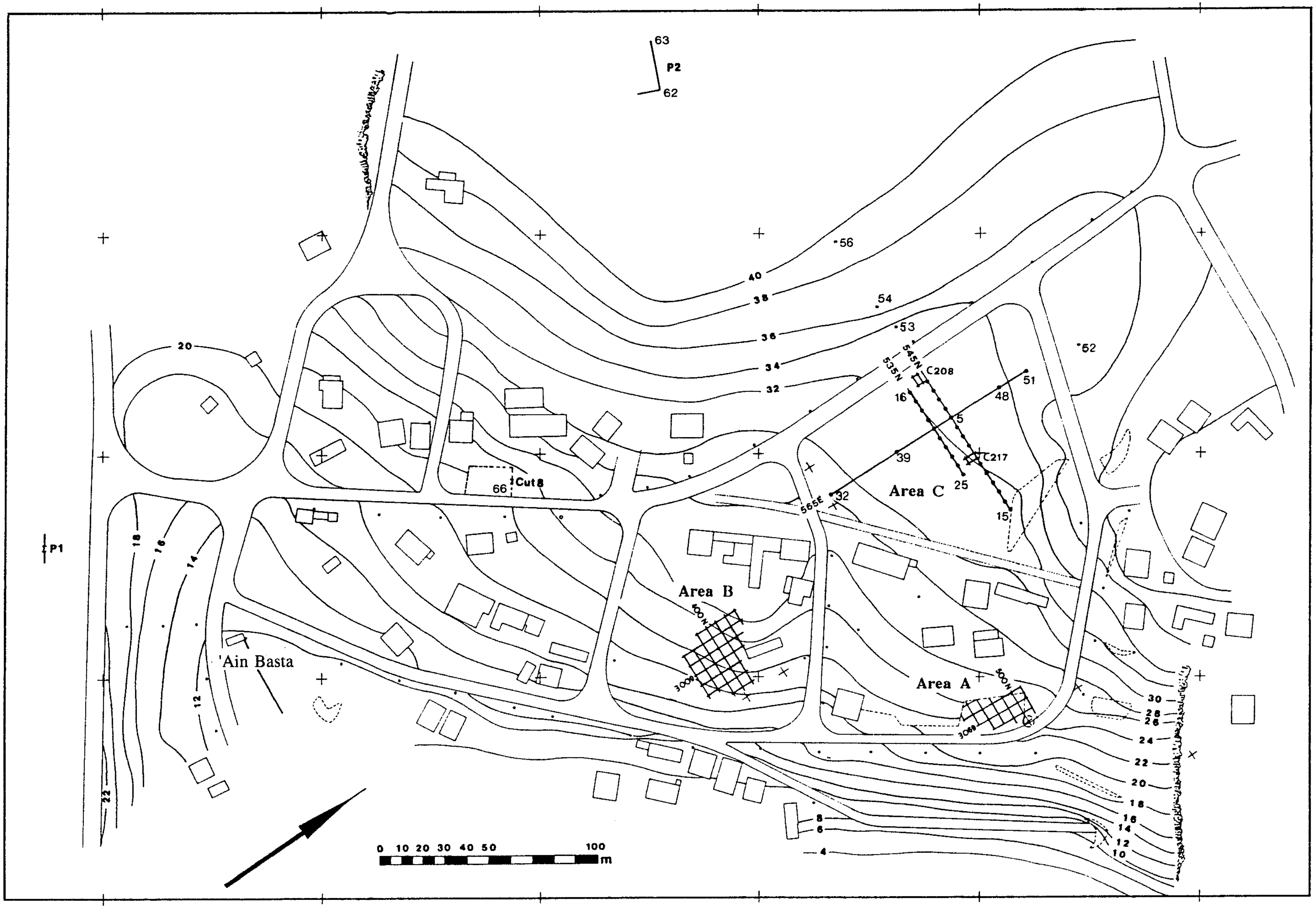


Fig. 1. Areas of investigation.

important values can be deduced mathematically: the carbonate content (factor 4.996, Pachur and Röper 1987) and the organic substance level (factor 1.724, Scheffer and Schachtschabel 1984). A significant level of organic substances makes it possible to classify a horizon as a palaeosol (*cf.* Albritton and Bryan 1939, Bryan 1941, Butzer 1974, Clayton *et al.* 1976, Davidson 1978, Ferring 1986, Ferring and Peter 1987, Henry *et al.* 1983, Holliday 1989, Jorstad *et al.* 1986, Macphail 1986, Pope *et al.* 1984). A humus content of above 2 % (= 1.16 % org. C) was taken as a first indication for possible soil development. Any content of over 2.5 % was regarded as clear proof for a palaeosol.

Phosphate enrichment of palaeosols caused by man can be determined, and former areas of settlement can be reconstructed using phosphate analysis (*cf.* Arrhenius 1929, 1931; Bleck 1976; Hassan 1981; Kiefmann 1975; Kiefmann and Schlede 1972; Proudfoot 1976; Rottländer 1983; Sjöberg 1976; Voigt 1956; Zölitz 1980). The advantage of this method lies in the appearance of increased phosphate concentrations in the settlement area, whereas bones, artefacts, charcoal *etc.* can be dislocated and so may not give clear evidence for a former horizon of human occupation. The method of analysis used was the one proposed by Goschin (1983, 1984). The phosphate concentration of a certain horizon must be viewed in relationship to the range of phosphate values of adjacent horizons; in a profile of the individual strata, the one with the highest phosphate concentration could be interpreted as a settlement horizon. In the research area the layers, which were clearly determined to be colluvials, show values up to 1.4 mg/g PO_4^{3-}. The averages and standard deviations show that for phosphate concentrations of up to 1.6 mg/g PO_4^{3-} one can speak of natural contamination. Any layer with higher concentrations can be addressed as a cultural horizon.

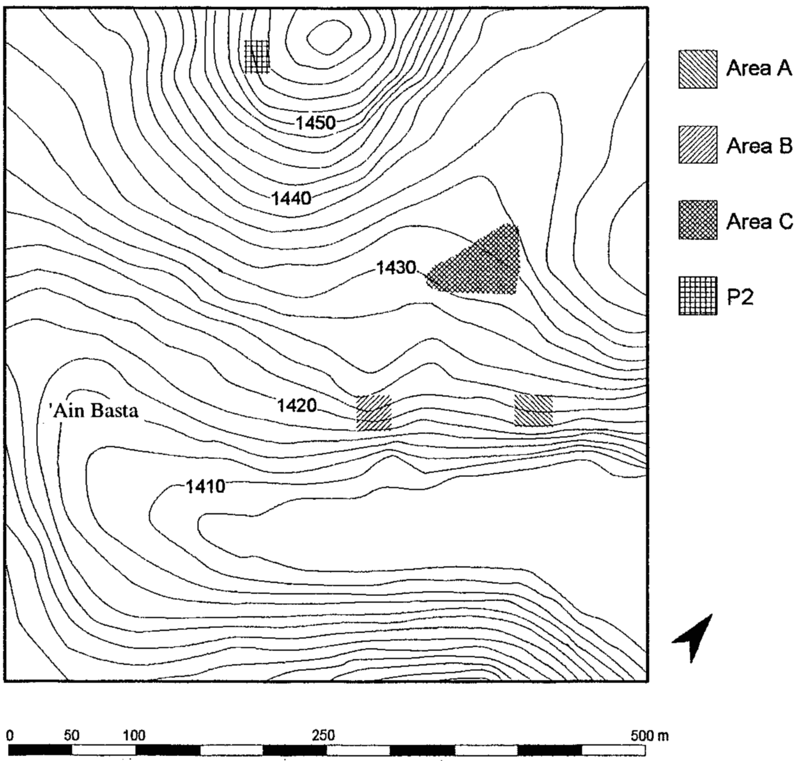


Fig. 2. Topography of the modern village area with areas of investigations.

Location of Investigated Areas

The landscape of the research area is characterized by a number of dry tributary valleys draining into the larger wadi systems. In the region of Basta the Wadi Muhaidarat descending from NW joins the Wadi Basta, which runs from W to E. The Neolithic settlement of Basta is located on the North flank of this intersection.

The areas of investigation are presented in Fig. 1: Area A, Area B, Area C with Test Units C208 and C217 as well as the drillings, P1 (App. 1), P2 (App. 2), VP56 ("Garden"). The location "Field" is not within the territory covered by the map, but is situated about 5 km North of Basta near the road to Wadi Musa.

The original 1:1000 topographical map of Basta (prepared by Rüth in 1986) was compared to the survey data and altered if necessary. Since it did not cover some important localities - for example the Southeastern slope of Wadi Basta, which is vital for a composite view of the main wadi - the map was expanded (Fig. 2). Fig. 3 shows three-dimensional models of the Basta terrain seen from different perspectives.

Climatic Development of the Region since the Late Pleistocene[1]

The Pleistocene is characterized by a number of alternating cold and warm intervals. In the Late Pleistocene the alluvial sedimentation changed to a more colluvial one; cementation and crust formation slowly ceased (Besançon *et al.* 1984). In the Levant from 21.000 to 12.000 bp the climate was moister than today, but there were drier phases (*e.g.*, *c.* 15.000 to 13.500 bp), in which aeolian sedimentation gained importance and even dunes developed (Garrard *et al.* 1987). These climatic conditions allowed soil development under steppe vegetation and the existence of immense lakes (Lake Azraq, Lake el-Haza, Lake Lisan) (Garrard *et al.* 1987, Macumber 1984, Schuldenrein 1987). Near the end of the Pleistocene lakes either completely dried out or were preserved until today in form of playas. The regression of the lakes correlates with a phase of stronger erosion in the Late Pleistocene (Besançon *et al.* 1984, Macumber 1984, Schuldenrein and Goldberg 1981), which is reflected by the hypsometric position of Epipaleolithic sites: Early Natufian campsites lie above those of the Late Natufian (Macumber 1984).

The change from Pleistocene to Holocene is determined by a distinct switch to a more arid climate (Besançon and Hours 1985, Macumber 1984), although until 9.000 bp the climate was more humid than it is today. In the Early and Middle PPNB the annual rainfall is estimated to have been 50/100 mm (dry/humid years) higher. From this time on the climate changed to todays aridity (Garrard *et al.* 1987, Gebel 1986).

Between 8.800 and 8.500 bp aeolian activity increased and dunes were formed. Garrard *et al.* (1987) attributes this development to agricultural practices. Permanent settlements were ultimately abandoned by 8.000 bp caused by the human impact of overexploitation from the increasing number of Late PPNB settlements (*c.* 8.500-8.000 bp), supported by a possible minor deterioration of climate. Some areas had enjoyed local advantages like rich springs and were used as refuges not only until the very end of the Late PPNB, but were inhablitated in the 8th millennium bp, too. In these areas the ongoing intensive agriculture and other human environmental stress caused the later adaptation to desertification, the mobile herding economies of the earliest pastoralism (Gebel 1986, 1992). In recent discussions, Gebel

---

[1] Dates referred to in this contribution are uncalibrated radiocarbon dates bp.

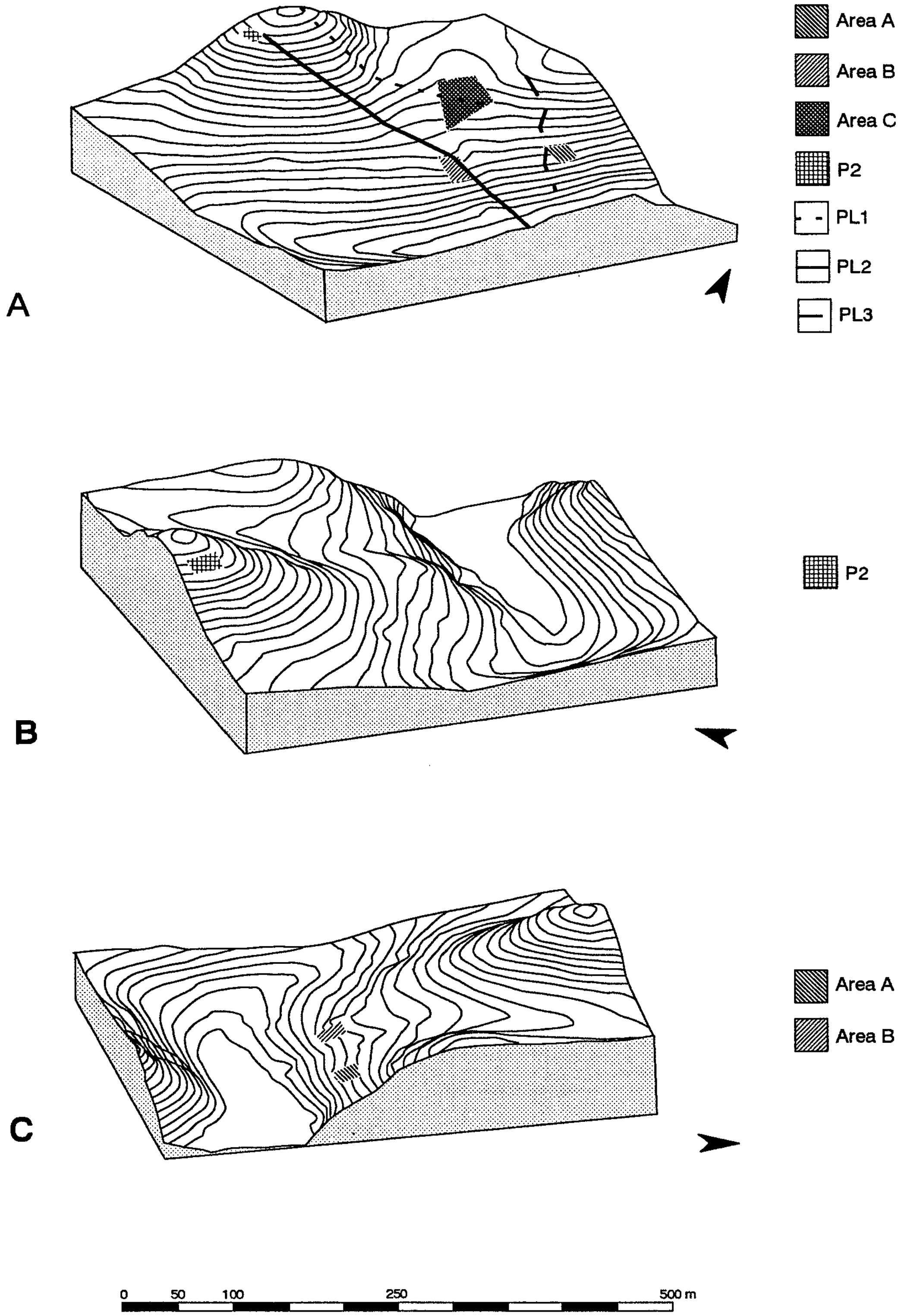


Fig. 3. Relief of the Basta area (A: view from S; B: view from W; C: view from E).

introduced an additional argument for the collapse of the Late PPNB, that of a social depression as a result of the hypertrophic population and socioeconomic development in the Southern Levantine LPPNB (*cf.* the Editors' Introduction, this volume).

Weathering Processes

In the Basta research area most of the bedrock is composed of dolomite and rarer feldspars and quartzite (Table 1: ZA.1-5, ZAb.1-2). The carbonate contents lie around 60 % (Table 2). The solution residues are small (< 12 %) and almost exclusive clayey and silty. Other stones like marls, which show higher solution residues and produce fine sand mainly composed of quartz grains during weathering, are relatively rare (ZA.4, ZAb.4). Therefore, in the research area chemical weathering produces little material mass.

Physical weathering produces rock detritus that can result in meter-sized blocks down to fine sand. The detritus is angular; during transport a polishing takes place and important masses of fine material are produced, which are angular, too (Wagner 1984). This is the most important process of fragmentation in the Basta research area.

Since local salinity is low, salt wedging is not important. Frost wedging of rocks with high feldspar and quartz content result in fragmentation. With regard to rock fragmentation, thermal effects have a great importance; in sediments it reaches down to a depth of 50 cm (Scheffer and Schachtschabel 1984).

Erosion and Mass Movement

Ridges and Gully Clints

In the research area the solid geological beds of lower Cretaceous and Santon-Turon-Cenoman are tipped, so today variably resistant bedrock types appear in the form of plates or small ridges. The softer calcarenites (ZA.1-3, 5) were eroded; the sandy limestones, dolomites and sandstones (f.e. ZAb.3, 29011) withstood erosion better (Table 1). Neolithic humans were aware of erosional variability, soils and bedrock composition: the Early settlements were built on the (exposed) ridges, whereas the softer beds with their deeper soils were used for agriculture.

"Inactive karstification" (Leser and Panzer 1981) of the limestones and dolomites formed gully clints, a type of drainage, down which the weathering material and the sedimentation masses from higher places accumulated and were transported downslope. This process of erosion especially affected the uppermost sediment layer and objects lying at the surface, such as artefacts, bones and charcoal.

Above Area C one erosion gully was exposed in a modern digging cutting into the bedrock (Locality P2, App. 2) (Fig. 1). The Northern section is built up by solid bedded dolomites (ZA.1-3, 5) and thin layers of clay and marl (ZA.4) (Table 1). It strikes N 100°, and the beds dip to NE. The Eastern profile is filled with detritus (Fig. 4). The digging extends to a depth of 3.50 m, with its base formed by dolomites, too. A shaft of 10 m depth and 1-1.5 m diameter shows the continuing sequence of bedded calcarenites and layers of clay and marl.

The matrix of the sediments is a sandy silt, which is hard and porous. Imbedded into this matrix are mainly limestones and dolomites, as well as detritus, which do not outcrop in the immediate area. An imbrication of psephites could not be detected.

Table 1. Minerals and soluble residues of stones and sediments <*soluble residue in percent of weight*>.

Sample	Haema-tite	Quarzite	Calcite	Dolomite	Biotite	Chlorite	Feldspar	Kaoli-nite	Montmor-ollonite	Musco-vite	Vermicu-lite	Others	Soluble Residue (%*)
ZA.1		+++		+++++			+						5.47
ZA.2		+		+++++			+					Siderite(+)	3.26
ZA.3		++		+++++			+		(+)			Siderite(+)	
ZA.4		+++		+++		+	+		++			Magnesite +	75.62
ZA.5	(+)	(+)		+++++			+	(+)					
ZP.1		+++	++	+++++	+		+						
ZP.2		+++	+++	++++	+							Magnesite +	
ZP.3		++++	+++	++++	+		+						
ZP.4		+++	+++	++++	+	+	+						
ZP.5		+++	+++	+++++	+		+						
ZP.6		+++	+++	++++	+		+						
ZAb.1		++	+	+++++	+		+						11.89
ZAb.2	(+)	++		+++++	+		+						
ZAb.3		+++++	+++	+	++		+						89.78
ZAb.4	+	+++++	+	+	++		+		+	++	+		53.30
ZAb.5		+++++	++++	+	+	+	+			+			
29006	+	++++	+	++++	+					+			
29011		++++	+++++	(+)	+						+	Apatite +	
29017		+++++	+	++++	++		+			++			
VP5.1		++++	++++	+++	+		++		+				
VP5.6		++++	++++	++	+		+	+	+		+		
VP5.10		++++	+++	++	++		+	+	+				
VP5.14		++++	++++	+++	+		++	+				Magnesite +	

Impulses/sec.:

<50	(+)	"signs"
50-200	+	"little"
200-500	++	"some"
500-1000	+++	"clear"
1000-2500	++++	"much"
>2500	+++++	"very much"

Table 2. Geochemistry of stones and sediments <*: *in percent of weight; **: (+) few, + clear, ++ much*>.

Sample	Location	Inorg. C (%)*	Carbonate (%)*	Org. C (%)*	Organic Substance (%)*	Phosphate (mg/g)	pH	Conductivity (uS/cm)	Content of Charcoal**
29006	Stone survey 6	9.88	49.4						
29011	Stone survey 11	7.95	39.8						
29017	Stone survey 17	4.47	22.4						
ZA.1	P2 bedrock 1	11.60	58.0						
ZA.2	P2 bedrock 2	11.80	59.0						
ZA.3	P2 bedrock 3	12.00	60.0						
ZA.4	P2 bedrock 4	2.30	11.5						
ZA.5	P2 bedrock 5	12.70	63.5						
ZAb.1	P2 clast 1	11.20	56.0						
ZAb.2	P2 clast 2	12.00	60.0						
ZAb.3	P2 clast 3	3.31	16.6						
ZAb.4	P2 clast 4	0.70	3.5						
ZAb.5	P2 clast 5	5.79	29.0						
ZP.1	P2.(layer)1	7.40	37.0	0.81	1.40		8.7	284	
ZP.2	P2.2	6.51	32.6	+/-0	+/-0		8.5	158	(+)
ZP.3	P2.3	6.67	33.4	0.87	1.50		8.4	164	(+)
ZP.4	P2.4	7.16	35.8	0.53	<1.00		8.7	290	
ZP.5	P2.5	8.17	40.9	1.05	1.81		8.7	430	
ZP.6	P2.6	5.78	28.9	1.22	2.10		9.0	475	(+)
VP66.1	Cut 8.(layer)1	4.85	24.3	2.48	4.28	1.1	8.8	144	
VP66.2	Cut 8.2	10.00	50.0	<0.50	<1.00		9.1	130	
VP66.3	Cut 8.3	3.93	19.6	1.77	3.05		8.6	148	
VP66.4	Cut 8.4	8.56	42.8	1.43	2.47	1.1	8.7	940	
29022.1	P1.(layer)1	5.43	27.2	<0.50	<1.00		8.6	220	
29022.2	P1.2	2.88	14.4	<0.50	<1.00		8.9	180	
29022.3	P1.3	5.93	29.7	<0.50	<1.00		8.8	200	
29022.4	P1.4	1.36	6.8	<0.50	<1.00		8.9	127	
29022.5	P1.5	1.85	9.3	<0.50	<1.00		9.0	155	
29022.6	P1.6	1.78	8.9	0.71	1.22		8.8	250	
29022.7	P1.7	2.00	10.0	0.51	<1.00		8.9	253	
29022.8	P1.8	3.92	19.6	<0.50	<1.00		9.1	275	
29022.9	P1.9	1.85	9.3	<0.50	<1.00		8.9	275	
29022.10	P1.10	2.02	10.1	<0.50	<1.00		8.9	190	
29022.11	P1.11	1.59	8.0	<0.50	<1.00		8.7	250	
29022.12	P1.12	2.24	11.2	<0.50	<1.00		8.6	310	
29022.13	P1.13	5.27	26.4	0.51	<1.00		8.9	275	
29022.14	P1.14	2.42	12.1	<0.50	<1.00		8.8	280	
29022.15	P1.15	1.57	7.9	<0.50	<1.00		8.7	220	
29022.16	P1.16	2.55	12.8	<0.50	<1.00		8.8	216	
29022.17	P1.17	6.55	32.8	<0.50	<1.00		9.0	830	
29022.18	P1.18	2.24	11.2	<0.50	<1.00		9.0	300	(+)

Table 2 cont. Geochemistry of stones and sediments <*: *in percent of weight; **: (+) few, + clear, ++ much*>.

Sample	Location	Inorg. C (%)*	Carbonate (%)*	Org. C (%)*	Organic Substance (%)*	Phosphate (mg/g)	pH	Conductivity (uS/cm)	Content of Charcoal**
1053	A/NW.(layer)38	4.98	24.9	1.15	1.98	1.4			+
1054	A/NW.45	4.55	22.8	1.40	2.41	1.2			
1055	A/NW.21	5.31	26.6	<0.50	<1.00	1.1			+
1056	A/NW.23	5.40	27.0	1.36	2.35	1.3			+
1057	A/NW.43a	5.64	28.2	2.46	4.24	1.2			++
1058	A/NW.2	5.70	28.5	<0.50	<1.00	1.3			++
1059	A/NW.15	4.75	23.8	1.62	2.79	1.3			+
1060	A/NW.13	4.83	24.2	0.95	1.64	1.3			+
1062	A/NW.60	4.67	23.4	1.38	2.38	1.3			++
1063	A/NW.50	4.21	21.1	1.77	3.05	1.1			
1065	A/NW.18	5.03	25.2	1.08	1.86	1.3			+
A.HB	A/NW.61g	5.13	25.7	1.09	1.88	1.3			
B.RL	B103-N.(layer)2	5.11	25.6	0.68	1.17	0.8	8.3	91	
VP54.1	Drilling Garden.(layer)1	5.62	28.1	0.76	1.31	0.4	8.6	71	
VP54.2	Drilling Garden.2	5.82	29.1	<0.50	<1.00	0.5	8.6	75	
VP54.3	Drilling Garden.3	5.38	26.9	0.81	1.70	1.0	8.6	82	
VP54.4	Drilling Garden.4	5.94	29.7	<0.50	<1.00	0.4	8.5	88	
VP54.5	Drilling Garden.5	5.89	29.4	<0.50	<1.00	0.4	8.5	92	
VP54.6	Drilling Garden.6	6.49	32.5	<0.50	<1.00	0.6	9.3	137	
VP54.7	Drilling Garden.7	10.30	51.3	+/-0	+/-0	0.3	9.3	110	
27740	C208-W.(layer)1	4.99	25.0	1.05	1.81	0.7	8.4	125	
27742	C208-W.2	5.86	29.3	1.22	2.10	1.2	8.6	152	
27743	C208-W.3	5.80	29.0	1.15	1.98	1.6	8.7	156	+
27749.2	C208-W.7s	4.95	24.7	0.92	1.59	1.6	8.7	190	+
27749.3	C208-W.5ob	5.33	26.7	1.18	2.03	1.8	8.9	160	+
27749.4	C208-W.4	5.37	26.9	0.79	1.36	1.4	8.6	179	+
27749.5	C208-W.5ut	4.71	23.5	1.54	2.65	0.9	8.6	158	++
27749.6	C208-W.6	5.42	27.1	0.64	1.10	1.4	8.6	179	+
27749.7	C208-W.7n	4.77	23.9	2.28	3.93	1.4	8.9	202	+
27749.8	C208-W.8	5.24	26.2	1.65	2.84	1.3	9.0	250	++
27749.9	C208-W.9	4.74	23.7	3.12	5.38	1.4	8.9	240	++
27749.10	C208-W.11a	4.09	20.4	<0.50	<1.00	0.6	8.7	230	
27749.12	C208-W.12	5.30	26.5	1.46	2.52	1.9	9.1	255	++
27749.13	C208-W.13a	5.56	27.8	0.78	1.34	1.3	8.9	213	+
27749.14	C208.W.13b	5.45	27.3	2.73	4.71	1.6	8.9	270	++
27749.16	C208-W.14	5.70	28.5	0.73	1.26	1.7	9.0	370	+
27749.17	C208-W.15	5.05	25.3	2.84	4.90	1.7	8.9	420	+
27749.20	C208-W.17	4.93	24.7	0.81	1.40	1.4	9.1	330	+
27749.22	C208-W.19	1.53	7.7	+/-0	+/-0		9.1	190	+
27749.23	C208-W.20a	5.21	26.0	3.56	6.14	1.8	9.3	375	++
27749.26	C208-W.22a	3.17	15.9	2.79	4.81	1.2	9.1	393	++
27749.27	C208-W.23	4.92	24.6	0.90	1.55	1.3	8.8	197	
27749.28	C208-W.24	4.26	21.3	0.91	1.57	1.2	9.3	330	+

Table 2 cont. Geochemistry of stones and sediments <*: *in percent of weight; **: (+) few, + clear, ++ much*>.

Sample	Location	Inorg. C (%)*	Carbonate (%)*	Org. C (%)*	Organic Substance (%)*	Phosphate (mg/g)	pH	Conductivity (uS/cm)	Content of Charcoal**
27749.31	C208-W.9a	4.79	23.9	0.94	1.62	0.8	9.0	237	
VP5.1	C Drilling 5.(layer)1	5.04	25.2	0.80	1.38	1.1	8.5	192	
VP5.2	C Drilling 5.2	6.21	31.1	<0.50	<1.00	1.2	8.5	180	
VP5.3	C Drilling 5.3	5.18	25.9	2.03	3.50	1.2	8.8	205	+
VP5.4	C Drilling 5.4	4.58	22.9	1.72	2.97	1.1	8.6	133	
VP5.5	C Drilling 5.5	4.92	24.6	2.32	4.00	1.2	8.6	403	+
VP5.6	C Drilling 5.6	5.82	29.1	1.41	2.43	1.2	8.6	630	+
VP5.7	C Drilling 5.7	6.07	30.4	<0.50	<1.00	1.0	8.6	304	+
VP5.8	C Drilling 5.8	5.61	28.1	1.17	2.02	1.2	9.0	830	++
VP5.9	C Drilling 5.9	6.03	30.2	0.87	1.50	1.1	9.0	860	++
VP5.10	C Drilling 5.10	4.10	20.5	3.33	5.74	1.5	9.2	1020	++
VP5.11	C Drilling 5.11	5.17	25.9	1.08	1.86	1.4	8.7	480	
VP5.12	C Drilling 5.12	6.05	30.3	2.01	3.47	1.1	9.3	800	
VP5.13	C Drilling 5.13	4.76	23.8	3.33	5.74	1.3	9.2	930	++
VP5.14	C Drilling 5.14	4.60	23.0	1.89	3.26	1.2	8.9	238	
37701.1	C217-N.(layer)1	5.01	25.0	0.70	1.21	0.7	8.3	95	
37701.2a	C217-N.2ob	4.98	24.9	<0.50	<1.00		8.2	84	
37701.2b	C217-N.2ut	4.78	23.9	<0.50	<1.00	0.8	8.4	92	
37701.3a	C217-N.3ob	4.69	23.4	<0.50	<1.00		8.5	99	
37701.3b	C217-N.3ut	4.36	21.8	0.64	1.10	1.1	8.4	80	
37701.4	C217-N.4	5.09	25.5	0.87	1.50	1.1	8.5	105	
37701.5a	C217-N.5ob	5.05	25.3	0.98	1.69	1.4	8.7	105	
37701.5b	C217-N.5ut	5.39	27.0	1.24	2.14	1.4	8.7	89	
37701.6	C217-E.6	5.17	25.8	1.07	1.84	1.4	8.6	124	(+)
37701.7	C217-N.7	5.11	25.5	0.69	1.19	1.8	8.7	136	
37701.8	C217-N.8	5.04	25.2	3.66	6.31	1.6	8.4	140	
37701.9	C217-N.9	5.39	27.0	<0.50	<1.00	2.1	8.9	153	
37701.10a	C217-E.10s	6.10	30.5	0.43	<1.00	1.1	8.8	200	
37701.10b	C217-E.10n	5.70	28.5	0.36	<1.00		9.0	198	
37701.12	C217-N.12	5.50	27.5	0.50	<1.00	1.3	8.9	210	
37701.13	C217-N.13	5.27	26.4	0.50	<1.00	1.2	8.9	189	+
VP19.1	C Drilling 19.(layer)4					1.1			
VP21.1	C Drilling 21.(layer)4					0.9			
VP21.2	C Drilling 21.7					2.9			
VP22.1	C Drilling 22.(layer)2					1.4			
VP22.2	C Drilling 22.4					1.6			
VP22.3	C Drilling 22.5					2.4			
VP23.1	C Drilling 23.(layer)2					1.3			
VP23.2	C Drilling 23.3					2.4			
VP23.3	C Drilling 23.4					1.4			

Table 3. Averages and standard deviations of chemical results <* *in percent of weight*>.

Location	Inorganic C (%)*	Carbonate (%)*	Organic C (%)*	Organic Substance (%)*	Phosphate (mg/g)	Conductivity (uS/cm)
Garden	5.90/----	29.30/----	0.54/----	0.98/----	0.50/0.24	94/---
P1	3.00/1.64	15.00/8.20	0.50/1.00			267/---
P2	6.95/0.68	34.80/3.40	0.75/0.28	1.30/0.50		300/---
Area A	4.90/0.50	24.50/2.50	1.42/0.60	2.45/1.03	1.25/0.20	235/---
C208	5.00/1.20	25.00/6.00	1.40/0.90	2.42/1.55	1.30/0.30	245/---
VP5	5.30/0.70	26.50/3.50	1.64/0.90	2.83/1.55	1.20/0.12	515/---
C217	5.20/0.40	26.00/2.00	0.80/0.80	1.36/1.36	1.30/0.30	131/---

Table 4. Granulometry of sediments.

Fraction (mm)	Field	Garden	Area B	Area C
> 5.0	27.10	65.70	69.50	53.40
5.0 - 2.0	8.58	12.77	5.78	6.88
2.0 - 1.0	1.61	0.66	0.97	1.28
1.0 - 0.63	1.18	0.47	0.64	0.98
0.63 - 0.315	1.78	1.27	1.07	2.32
0.315 - 0.2	1.18	1.41	0.97	2.57
0.2 - 0.125	1.41	1.72	1.51	3.69
0.125 - 0.063	2.98	3.00	2.81	5.82
0.063 - 0.02	20.89	7.51	9.17	14.70
0.02 - 0.0063	14.56	2.92	3.50	4.62
0.0063 - 0.002	9.39	1.56	1.99	2.40
< 0.002	9.34	0.98	1.79	1.30
Stones + Gravels	35.68	78.47	75.28	60.28
Sand	10.15	8.53	8.30	16.66
Silt	44.84	11.99	14.66	21.72
Clay	9.34	0.98	1.79	1.30
Porosity (%)	55.50	23.00	42.30	49.80
Void ratio	1.22	0.30	0.73	1.00
Compactness (g/cm^3)	1.18	2.04	1.54	1.33

Table 5. Situmetric results of clast-rich sediments.

Layer	I	II	III
A/NW-61g	49	27	24
B84-W	56	17	27
B84-S	18	24	53
B104-W	53	25	22
B104-S	14	41	45

Table 6. Minerals of clay fraction.

Sample	Quarzite	Calcite	Chlorite	Feldspar	Smectite	Illite
Field	++	+	++	+	+++	+
Garden	+	+	+	+	++	+
Area B	+	+	+	+	(+)	+
Area C	+	+	+	+	(+)	+

Impulses/sec.:

< 50	(+)	"signs"
50-200	+	"little"
200-500	++	"some"
500-1000	+++	"clear"
1000-2500	++++	"much"
> 2500	+++++	"very much"

In comparison to other layers in the research area, here the carbonate levels are higher, averaging 34.8 % and ranging between 28.9 % (ZA.6) and 40.9 % (ZP.5) (Tables 2-3). This and the mineral composition of the sediments (ZP.1-6) (Table 1) indicates a process in which the weathered material of the surrounding bedrock is involved, especially proportions of the dolomites. In contrast, the increased proportions of quartz and calcite were produced by stones that were transported to the area from higher places. Especially in terms of the quartz proportion, an aeolian accumulation seems to be important.

In Layer 5, which is only 10 cm thick, the carbonate content and the colour change point to calcification; the higher proportion of gravel suggests more intensive physical weathering and transport. Several authors interpret these characteristics as indicators for a more arid environment (Bryan 1941, Butzer 1974, Clayton *et al.* 1976, Henry *et al.* 1983, Jorstad *et al.* 1986). For Layer 3 a stronger aeolian sedimentation can be accepted due a conspicuously low proportion of psephites and an increased proportion of quartz. Again, more arid conditions are signaled. A charcoal date yielded an age of 6055 +/- 255 bp (HV 17192, uncalibrated).

Aquatic Slope Erosion

Alluvial processes are reflected in the detritus accumulation. An increase of grain size points to higher flow energy and hence to an increasing intensity of denudation and weathering processes. According to Hjulström (1935, in: Louis 1968: 90), material up to 100 mm in grain size is deposited at rapidity of flow of 200 cm/s, material up to 1 mm in grain size at 8 cm/s. During the formation of the coarse material layers the development of vegetation and soil cover in the valleys and on the slopes was hindered. The gravels show low values of roundness, which signify a short path of transport or a first-time participation in the fluvial/aquatic process of redeposition. Accordingly these sediments have their origin in the nearer vicinity of the wadis.

In Basta the matrix of sediments is mainly silty and fine-sandy (Fig. 5, Table 4). Silty sediments possess a poorer structural stability than clayey sediments and a higher flexibility than sandy sediments. Their moisture-holding capacity is very high up to a fixed saturation value, where they suddenly reach a point of high erodibility (Gehrenkemper 1981), and these sediments are characterized by an enhanced erosion susceptibility.

A high proportion of soil skeleton (stones and gravels, psephites) increases the capacity of infiltration, resulting in decreased surface run-off and erosional action. A concentration of psephites on the surface in form of a boulder pavement protects the underlying sediment. These characteristics can be found in the "Garden" (78.5 %) and Area C (60.3 %) (Fig. 5, Table 4). In contrast, the absence of a boulder pavement and the low proportion of soil skeleton (35.7 %) in the "Field", a recent agricultural land, are criteria for higher danger to erosion. And this was the situation in the Neolithic period: during field preparation for agriculture the boulder pavements were taken away by man. The stones were carried together to the "field clearance piles".

The carbonate-rich sediments are characterized by secondary cementation, which is a result of leaching and new separation of carbonate in the capillaries. It means a loss of porosity and permeability. Chamayon and Ruhard (1977) give permeability values of 1.5 x 10-2 m/s for wadi alluvials. This means worse water conductivity and thus more surface run-off, which can lead to greater erosion.

The research area often experiences heavy rainfall. The splash obstructs and silts up the coarse pores, so the moisture-holding capacity will be reduced or worn out. Moreover, a

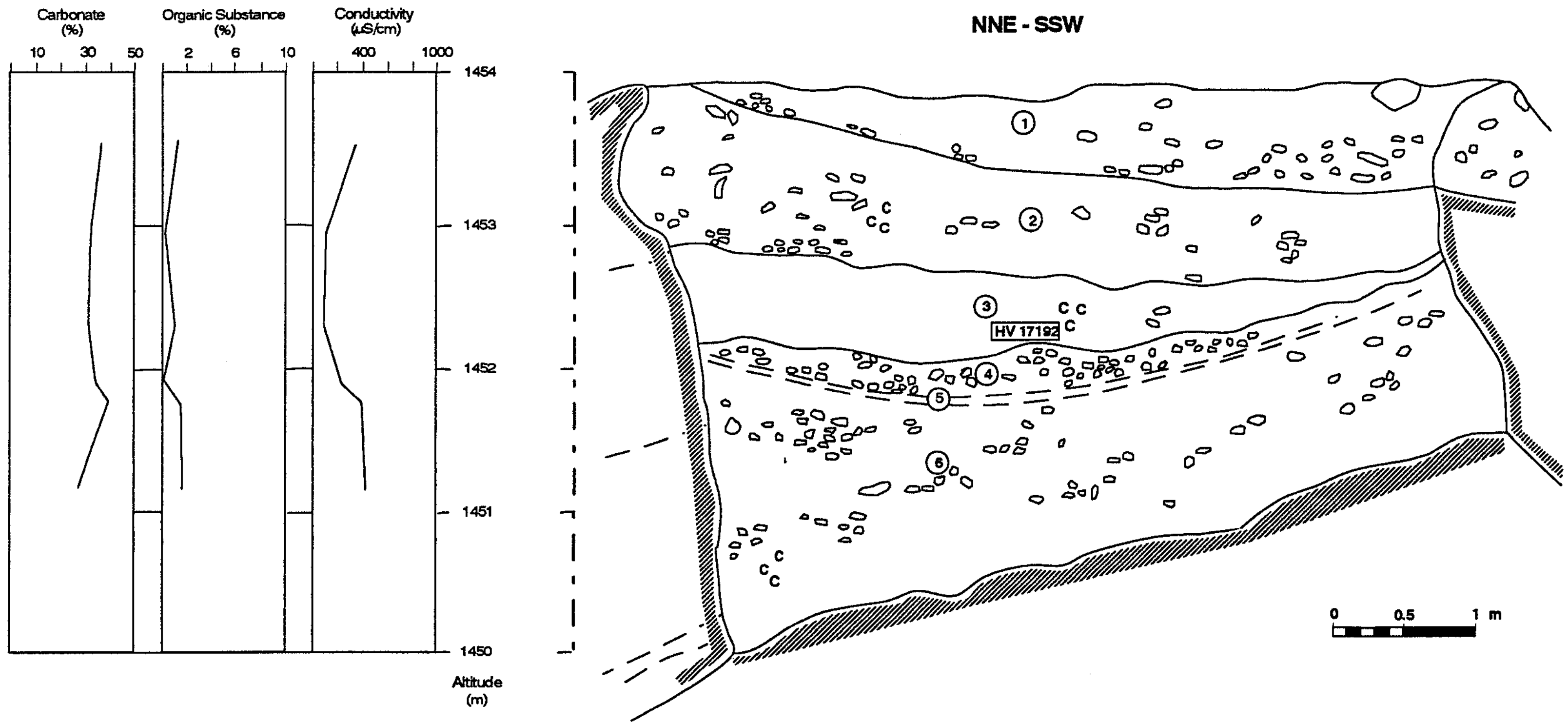


Fig. 4. Profile and geochemistry of P2 <*Carbonate and organic substance in percent of weight; section description see App. 2*>.

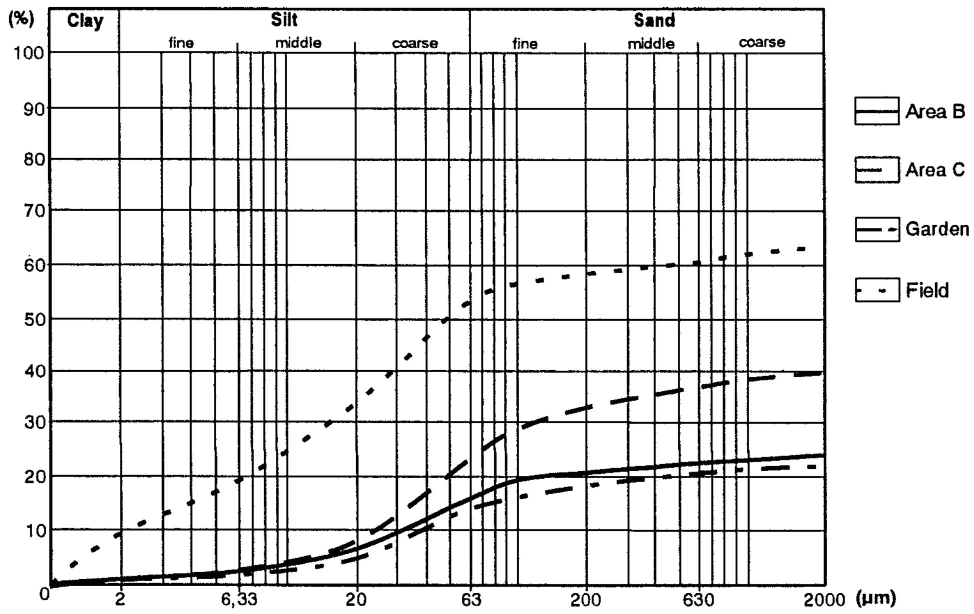


Fig. 5. Granulometry of sediments.

direct displacement of the different fractions occurs. The finer grains are displaced by the splash only over a short distance, but coarser grains are transported downslope with a mechanical impulse (Gehrenkemper 1981). Consequently, the rainfall can barely penetrate into the soil; instead, they gather and flow downslope like a mud- or debris flow (Füchtbauer and Müller 1988, Press and Siever 1986). The water is only minimally slowed by the rare vegetation, and the slope wash picks up loose rock debris and quickly becomes overloaded with sediment. The higher the proportion of clasts, and the larger and more angular they are, the more energy is necessary for their transport. Horizontally aligned clasts are an indication of a low energy flow.

The flattest slopes on which denudation by direct mass movements can be noticed have a natural fall of *c.* 2-3 %. With angles of incline >20 % the soil erosion increases enormously. In the immediate area of Basta this critical value of 20 % can be encountered. When lower slope angles are reached, erosion suddenly gives way to accumulation (Richter 1965), and hence colluvials are produced.

The results of gravel morphometry (Table 5) indicate solifluction and mudflow sediments produced when debris moved viscously downslope after probably high soaking events (Pachur 1970). The high proportions of fine material of the sediments in Areas A and B (Fig. 5, Table 4) are typical for displacement by solifluction.

Aeolian Erosion

In the Basta research area aeolian erosion is an important process of mass movement. Dust storms are frequent. Especially material smaller than the coarse sand fraction is involved into this process, while bigger grains move more ponderously because of their weight (Richter 1965). Silt and clay can be transported in aerial suspension over vast distances (Wagner 1984). Clay can only be lifted by winds in the form of aggregates (Hartge 1978).

The proportions of aeolian material vary between 17.7 % in the "Garden", 20.8 % in Area B and 32.5 % in Area C (Fig. 5, Table 4). In Area C aeolian sedimentation was more intensive.

The erosion of the pelites result in a concentration of psephites on the surface. Such boulder pavements protect against further aeolian erosion. In the lee of the psephites, in fact, aeolian material can be deposited. Furthermore cementation produces a better resistance against deflation.

Anthropogenic Influences

Anthropogenic activities have an influence on erosional resistance. A change or removal of the natural vegetation cover or the collection of psephites from the fields reduce the protection of the surrounding soil from erosion. Intensive agriculture can destroy the cementation zone, and because the soil is periodically aerated, farming reduces organic accumulation levels, which lowers the aggregate stability. During the Neolithic period sedentarism increased and agricultural practices intensified, which resulted in an acceleration of soil degradation.

Tectonic Influences

According to Bender (1968) the Basta research area is part of the mountain region in the Eastern edge of the Wadi Araba-Jordan Valley Trench and therefore a zone of tectonic activity. At the present time the spread-rate of the Red Sea runs up to *c.* 5 cm/year. The Petra area Northwest of Basta is a seismic zone with 2-8 earthquakes/ 9000 km^2/ year and magnitudes from 4.5 to 5.5 (Gebel 1992).

Earthquakes are potential inductors of mass movements, mostly as high energetic events; great masses and very coarse material (blocks) will be transported. Cultural deposits and constructions will be influenced: walls can be destroyed directly by the erosive sediments or by field clearance piles, which slide down. An identification of seismic disturbance situations is difficult, as can be noticed with the evidence of displaced and cracked walls in the main occupation of Area B.

Sediments

Soil Sediments

According to Moormann (1959) the research area is located within a transitional region of Mediterranean yellow-soils to yellow steppe-soils. They are mostly virgin soils on wadi gravels and on bedrock. The Mediterranean yellow-soil includes a yellowish-brown to brown A-horizon of crumbly to cloddy structure and a finely grained B-horizon of crumbly structure. The yellow steppe-soil has a weakly developed yellowish-brown A- or (A)-horizon, which, due to little soaking, lacks a B-horizon, evolving into the barely distinguishable C-horizon. The crumbly to cloddy soil aggregates are easier to pulverize than those of the Mediterranean yellow-soil (Bender 1968). In general, both soils consist of a skeleton-rich texture and an ill-defined structure.

A reddish colouring of the soils is not necessarily related to recent soil formation processes but instead to the reddish or yellowish colour of the parent material, which experienced a laterization or rubification in semi-moister or moister phases. The limestone and dolomite of the research area occasionally show such colours. Recent soils, which did not evolve from such preweathered material but directly from unchanged parent material, appear light grey to light brown in general (Ganssen 1968).

Climatic aridity, little plant cover, mostly physical weathering and little transition in the soil inhibit the formation of soils *sensu stricto* according to Ganssen (1968). The alluvials and colluvials on the valley slopes and wadis make up a soil-equivalent substrate that cannot be differentiated in soil profiles.

In Basta, rendzinae, xero-rendzinae and terrae fuscae lie on top of the bedrock, partly of colluvial character. The xero-rendzina, a humus carbonate soil, includes a soil skeleton-rich, crumbly and humic A-horizon over carbonate rock (Xero means that the soil is dry and the content of humus is lower than in normal rendzinae.). Often the uppermost rock horizon is divided and enriched with secundary lime. The terrae fuscae, a type of braunerde, develops from rendzinae. The B-horizon is bright yellowish- or reddish-brown and results from oxidation of iron. The profile walls of these two soils often have a high solidity and therefore indicate at coherent structure in which the primary particles are kept together by cohesive attraction and form an undissected mass. This is especially the case for the lower horizons, since the upper strata dry out more thoroughly allowing aggregates to form. Within horizons where carbonate concentrations occur, the primary particles are cemented at their points of suction by, for example iron oxide or calcium carbonate, and an envelope structure develops. If aggregates of clay and silt are stabilized by calcium carbonate or iron oxide, then one is dealing with a coagulate structure. Aggregates have a positive effect on the erosional resistance (Scheffer and Schachtschabel 1984).

On inclined slope sections that have not been under recent human influence, lithosols with colluvial character can be found, as in the "Garden" (VP56) on the hill above Area C (Fig. 1).

All sediments show pH-values between 8.2 and 9.3 (Table 2). At pH-values >7 the formation of mycorrhiza is restricted, the absorption of nutritive substances by plants is more difficult and therefore the development of chlorophyll is reduced. The amount of fulvo acids in the organic matter rises in comparison to the proportion of humic acids, wherby a fertilisation of the soil can be less successful, since fulvo acids are more slowly exposed to oxidation (Ganssen 1968).

The very low precipitation considerably limits clay mineral development as well as the mobilisation of clay minerals. The smectites of the clay fraction of the sandy silt partly originate directly from bedrock (Table 6; compare montmorillonite content ZA.4, ZA.3 and ZAb.4 in Table 1). Furthermore, they can be seen as chemical weathering products of biotites and muscovites that evolved out of the bedrock. Due to the alkaline milieu the chlorites are present in primary form, which shows a low intensity of chemical weathering. The low clay proportion of only 1 % supports this interpretation. A chloritization of smectites and vermiculites to secondary chlorites seems possible in regard to dolomitic bedrock as the donor of magnesium and in view of the low level of organic matter. Calcium ions are products of chemical weathering of biotites and destruction of organic matter. They will be exchanged by vermiculites, whereby the expansion of clay minerals will be cancelled and illites come into existence. Physical weathering is indicated by the presence of illites, which are produced through the transformation of biotites and muscovites (Table 6).

In dry areas with distinct rainy and dry periods, redeposited carbonates disperse throughout the total matrix. In Basta the sediments contain carbonate particles up to 5 mm in size. Periodic rainfall is sufficient for carbonates to wash out into deeper sediment layers.

Caused by a higher evaporational activity in the dry months, the soil solution rises through capillaries and evaporates, precipitating the dissolved carbonates. Crystalline precipitates initially loosen the soil structure, but later the process can result in soil compaction though either diagenesis or intensified crystallisation. This accumulation of carbonates in the subsoil from washing out or capillary action leads to the formation of hardened carbonate strata, isolated tufaceous limestone and calcerous concretions, or caliches (Scheffer and Schachtschabel 1984). These indicators of intensive drying and soaking periods can be found for example in the wadi alluvials (*cf.* following paragraph) or in the colluvials in Areas A and B.

Wadi Alluvials

Today the wadis follow erosive channels, which according to Glennie (1970) were created during the pluvial periods. Slowly they were filled with their own sediments and/or with aeolian sands. Glennie (1970:29) describes such a wadi accumulation as follows: "... the wadi may be filled with a flowing slurry of sand or mud, which can support boulders of considerable size, which are then deposited as an unsorted muddy gravel - the mudflow conglomerates of Blachwelder (1928) and Bluck (1965, 1967)". Bender (1968) regards the wadi sediments as clayey, silty, fine-sandy substrata, which were moved together with unsorted rock detritus during heavy winter rains and were redeposited after a short transport.

As a result of road construction work, a 15 year-old profile P1 exists at the road from Ma'an to Wadi Musa (Fig. 1). It shows a wadi accumulation of 5.20 m in depth with layers of different thicknesses formed of silts, sands, pebbles and/or stones with interbedded blocks (Fig. 6).

Clayey or silty grains are rare, and the matrix consists mostly of pebbles and sands. Kröpelin (1989) contends that this is characteristic for fluvial accumulations. The inclusions are oriented mostly horizontal, which also indicates a fluvial transport. The dominant distribution of only edge-rounded or angular pebbles argues for a short distance of transport or transport in a kind of mudflow (Glennie 1970). With regard to this mudflow, water erodes the colluvials of the slopes, so this erosive material accumulates as the wadi sediment. Kröpelin (1989) claims low values of roundness and sorting - which can be found in nearly all layers - as characteristic of a typical wadi accretion.

In some layers some evidence of carbonate formation can be found, which in these cases are products of scouring processes after soaking. Layers 4, 5 and 6 show very low carbonate values. The boundary between Layer 6 to Layer 7 at a depth of 2.30 m is composed of caliche. In some parts these layers were delimed due scouring. The carbonate mainly accumulates on top of Layer 7, which contains lime concretions up to 3 cm in size. Porous lime aggregates up to 5 cm in size are found in Layer 13; here is a lime tufa. The matrix of the layer is a sandy silt, so a capillary ascent and an enrichment caused by an increased evaporation is to be expected.

Area C Palaeorelief and Colluvials

Western Lower Slopes

In the area of the Western lower slopes erosion changed to an accumulation, resulting in a buildup of colluvium. Drilling VP54 (App. 5) was placed 35 m below the "Garden" (Fig. 1, Fig. 7). The weathering horizon of the bedrock was reached at 2 m depth. The colluvium looks homogeneous vertically, and no cultural horizons were found. The carbonate values are

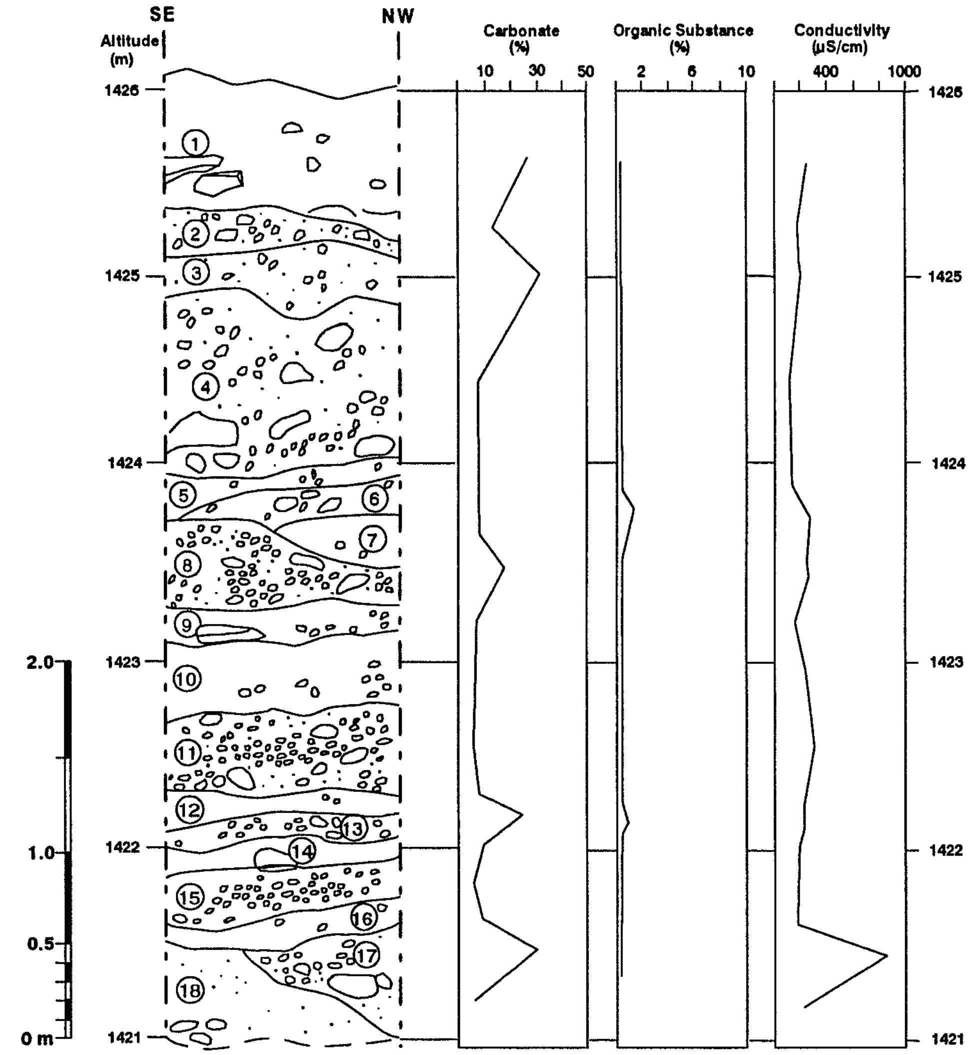


Fig. 6. Profile and geochemistry of P1 <*Carbonate and organic substance in percent of weight; legend see Fig. 17, section description see App. 1*>.

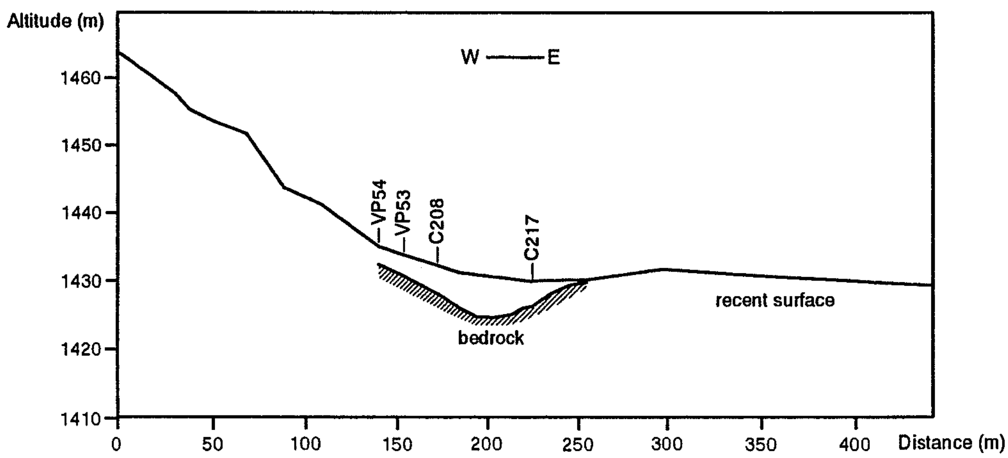


Fig. 7. Profile PL1: Slope in Area C (see Fig. 3:A).

slightly higher than average, which means a stronger influence of bedrock. There are no signs for any soil development; the contents of organic matter were less than 2 % (Table 2).

Drilling VP53 (App. 4) was done 15 m further downslope (Fig. 1). At a depth of 2.90 m the weathering horizon was reached. There are some indications of initial soil development, and human influence is demonstrated by dark brown and dark grey colours and some charcoal presence.

Valley

Area C lies 60 m Northwest (uphill) of Area A in a field with the form of an equilateral triangle with sides about 100 m long (Fig. 1). In contrast to Areas A and B, which are localities of higher relief energy, Area C rises only from 1428 to 1436 m above sea level over a distance of 100 m.

In the upper part of Area C the surface is slightly convex, but in the lower part it is slightly concave and dips towards Area B. Before reaching Area B a shallow depression bends to the SE. The overlying area, which stretches from W to NE, constitutes the catchment area of the sediments with the hill in the West as the main source (Fig. 2, Fig. 3).

All of the drillings, which were done along the three gridlines 535N, 545N and 565E, reached bedrock, so a reconstruction of the fossil relief can be made. The profiles (Fig. 7, Fig. 8) show a fossil wadi with steeper slopes in some parts. The deepest point of the channel lies 5.90 m under the modern surface (VP5, 545N/565E), although 50 m East the sediment reaches a thickness of only 0.2 m (VP15, 545N/615E). The fossil surface is very wavy. Over time, sediments from the slopes filled the fossil wadi, so that the modern surface does not reflect the earlier depression. The main part of the sediments is erosion debris from the Western slope; the Eastern slope played an unimportant role as a catchment area.

Western Sector (C208)

Test unit C208 lies in the Western sector of Area C (Fig. 1). The catchment area for the sediments is the Western hill. Excavations reached a depth of 3.10 m without reaching bedrock. The sediments look much more complex than in C217. During fieldwork at least 37 horizons could be identified, which reflects an uncommon variety in the research area. The layer thicknesses vary between 2 and 45 cm; 24 layers are only 10 cm or less thick, and some are only sediment lenses (Fig. 9).

The first 0.5 m sediment resembles the comparable one in the Eastern area (C217). The colluvial material has a silty-sandy matrix of yellow-brown colour and contains stones up to 10 cm in size that show no imbrication. This material contains Middle Palaeolithic artefacts which also are found on the surface of the slopes to the West of C208. Below 0.5 m the colour changes to greyish tints, with only rare yellow and pale-brown nuances. The matrix of these sediments is silty-sandy, too. The presence of ash deludes finer grain sizes in some layers. Beyond this, ash and charcoal may be responsible for colour variations.

In nearly all layers the levels of organic carbon are influenced by the presence of charcoal (Fig. 10, Table 2), and the high proportions in some layers prevent an identification of palaeosols. The layers without charcoal are at most low humic, including colluvial Layers 1, 2, 11a and 23, which appeared yellowish (-brownish) or whitish. The conductivities point to

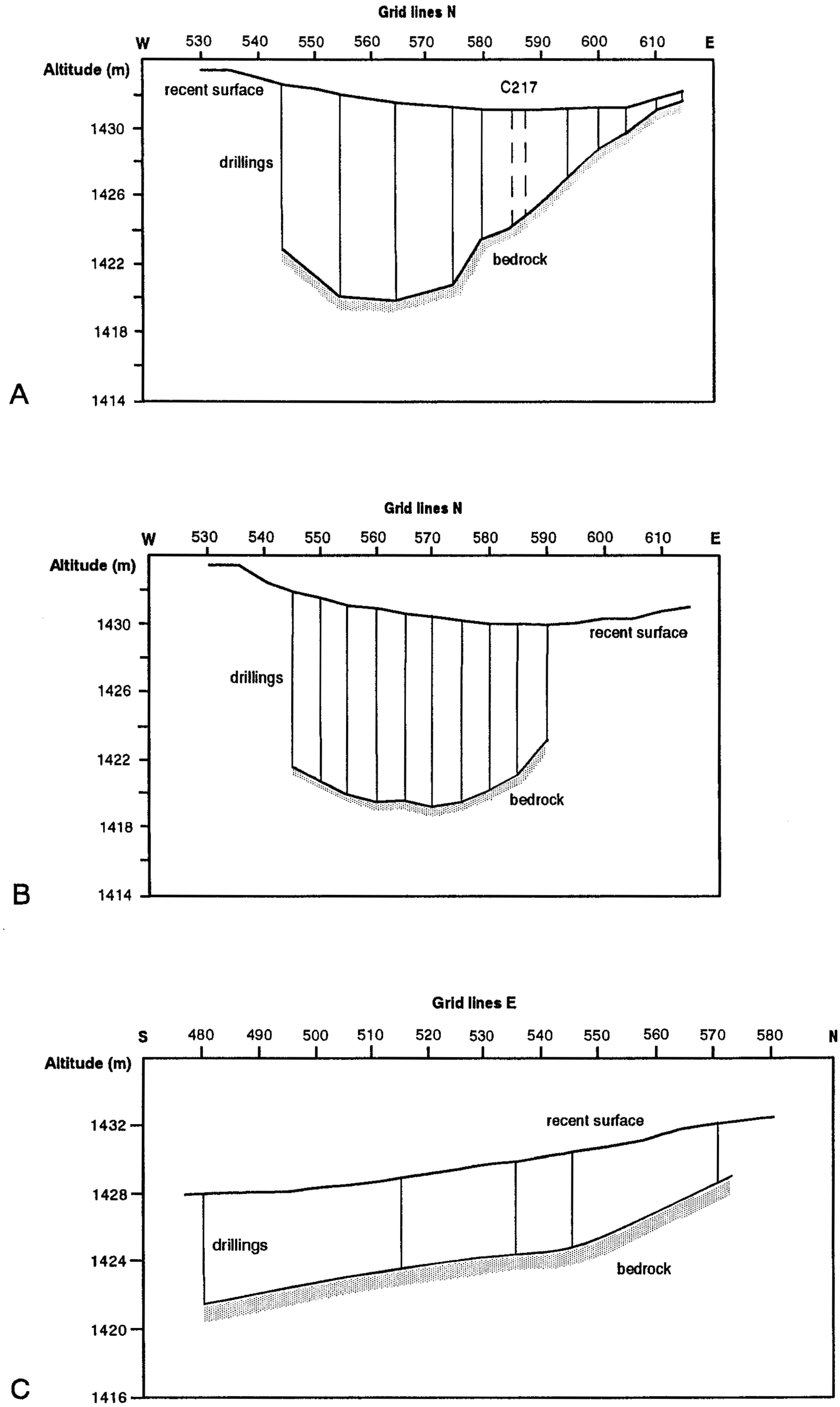


Fig. 8. Profiles Area C (A: gridline 545N; B: gridline 535N; gridline 565E) *<distance between two gridlines 10 m>*.

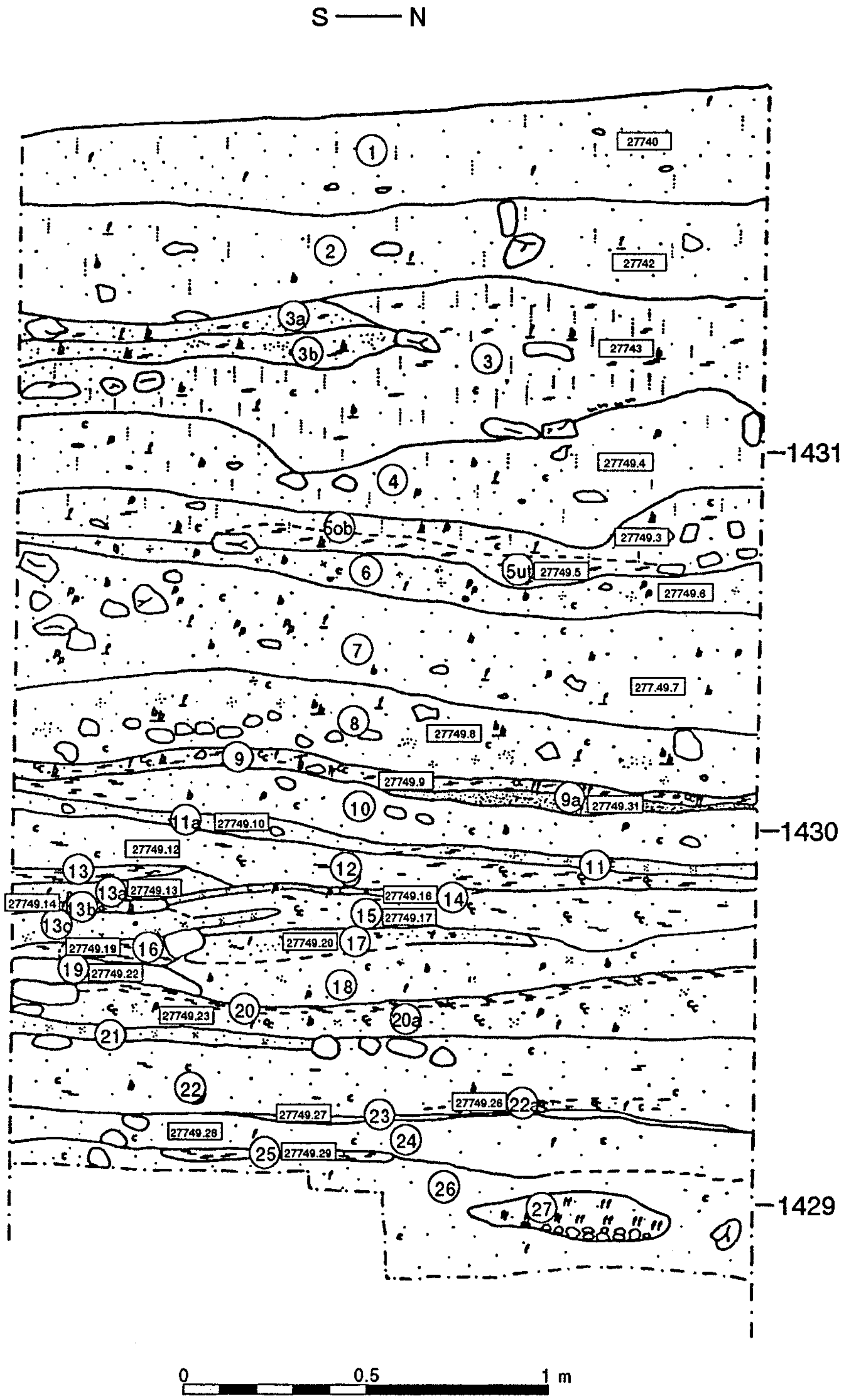


Fig. 9. W-Profile C208 <*legend see Fig. 17; section description see Gebel, forthcoming*>.

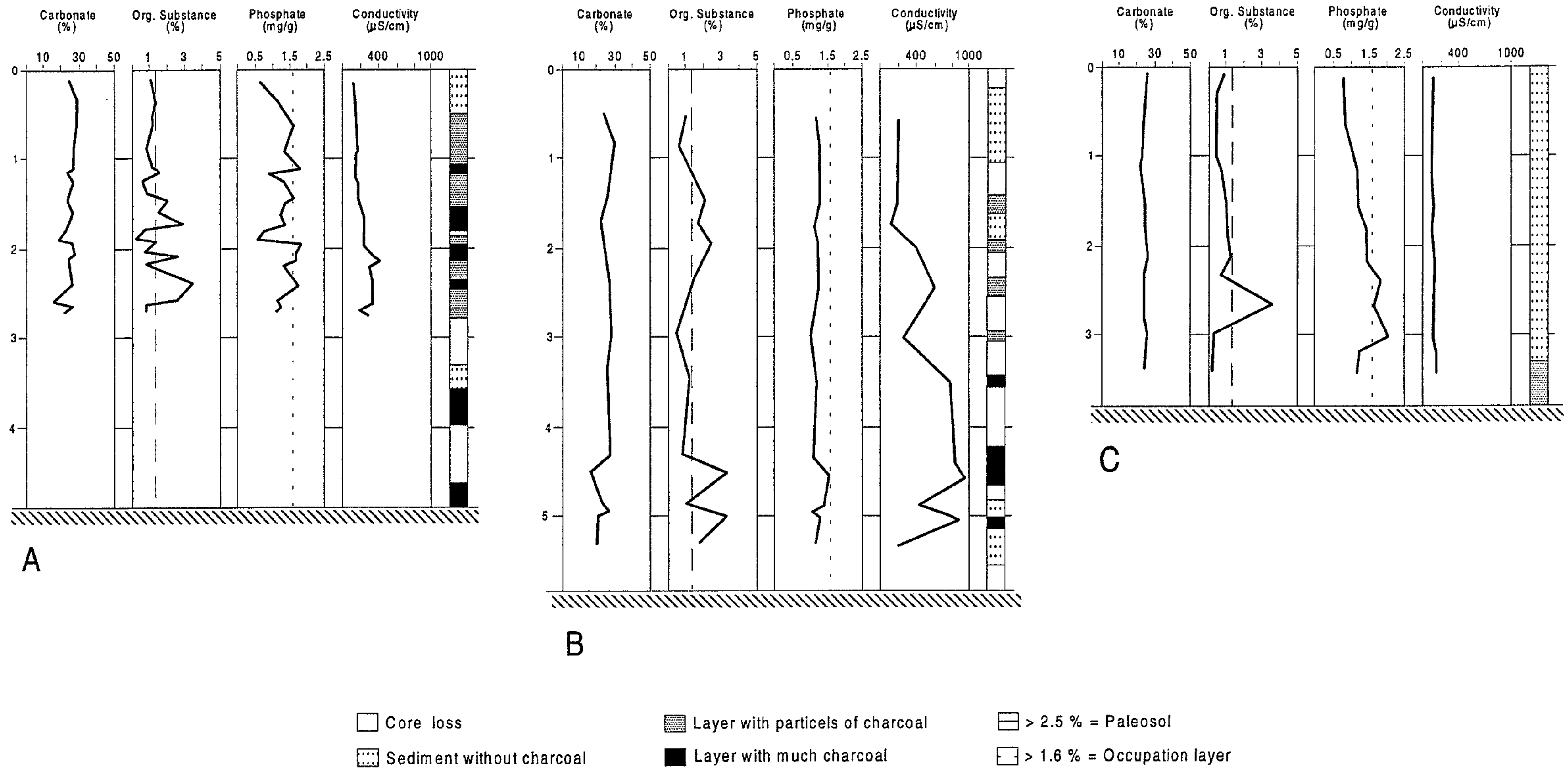


Fig. 10. Geochemistry and charcoal finds in Area C (A: C208; B: Drilling VP5; C: C217) *<section descriptions see Gebel, forthcoming>.*

moderate salinities, although some layers (9, 12, 20a, 21) are moist and are therefore influenced by ground water. Hydromorphic characteristics such as reductions were not found.

Drilling VP1 in the NE corner of Square C208 reveals the rest of sediments down to the dolomitic bedrock at a depth of 4.85 m. From 3.35 to 3.53 m depth there is a pale-brown, silty-sandy colluvium, followed by (dark-)grayish and brownish silty-sandy sediments down to a depth of 3.97 m that contain charcoal and occasional bones. A human tubular bone was found in a depth of 3.74 m (Becker, pers. comm.). Down to 4.64 m no core material was found. The last 20 cm above the weathering layer of bedrock matches the last named sediments.

In summary, in the Western part of Area C there are (dark) grayish and brownish coloured sediments containing bones and sometimes a lot of charcoal stretching down to the slope of the fossil wadi.

Central Part (Drilling VP5) (App. 3)

The sediments in the central part of Area C (Fig. 1) match the structure seen in squares C208 and C217, with occasional bones and sometimes abundant charcoal. The colours vary among yellowish, brownish and grayish tones.

The results of X-ray diffraction techiques show that the sediments contain abundant quartz and calcite and some dolomite (Table 1). Thus these colluvials are different from those of the filled channel of P2 (Fig. 4, App. 2). In Area C a more balanced fragmentation of carbonatic bedrock as well as transported sandy carbonate rocks and sandstones is reflected. More intensive aeolian sedimentation is documented by a high quartz content. The smectites and vermiculites are products of biotite and muscovite weathering.

Table 7 presents the phases of sedimentation and soil development. The presence of occasional high charcoal concentrations elsewhere makes additional determinations of palaeo-sol horizons impossible.

Eastern Sector (C217)

Square C217 lies in the Eastern sector of Area C above the steep Eastern slope of the fossil channel (Fig. 1, Fig. 7). Initially, accumulation of material transported from the East was more important; during the leveling of the fossil wadi sedimentation from the West increased until eventually it dominated.

The excavation reached dolomitic bedrock at a depth of 3.00-3.70 m (Fig. 11). Twelve horizons could be identified, although in structure and texture they appear homogeneous. The layer thicknesses vary from 15 to 65 cm with an average of 36 cm. The matrix is a sandy silt to silty sand, mostly porous and lightly aggregated. The density of stones is low in general; for most of the layers stones are either totally absent or present in low proportions. Reasons for these characteristics include the greater distance to the catchment area of the sediments and their fragmentation during transport. The upper, stony parts of Layers 3 and 5 point to more vigorous processes of downwash and physical weathering.

The stone concentration in Layer 10 should be regarded as a special situation. The sedimentation originated from directly above the bedrock on the Eastern slope and settled in a small hollow. This debris accumulation was not caused by a natural barrier; instead, it must

Table 7. Colluvials and palaeosols in Area C, central part (Drilling VP5).

Depth (cm)	Layer	Characteristics	Interpretation	Events
000-150	1,2,3	chlorites, few smectites	lower intensive weathering	colluvials
150-184	4	high content of organic substance		paleosol
184-200	5	very high content of organic substance, charcoal		(paleosol)
230-250	6	kaolinites, charcoal	intensive weathering after groundwater influence	colluvials
290-440	7,8,9	much charcoal		colluvials
440-460	10	kaolinites, very high content of organic substance and charcoal	intensive weathering after groundwater influence	(paleosol)
480-491	11			colluvial
491-494	12	high content of organic substance		paleósol
494-510	13	very high content of organic substance and charcoal		(paleosol)
510-550	14	kaolinites	intensive weathering	paleosol
580	---	---	---	bedrock

Table 8. Deposits in C208/ Drilling VP1.

Depth (cm)	Layer	Characteristics	Events
000-105	1, 2, 3, 3a, 3b, 4		colluvials
105-183	5ob, 5ut, 6, 7, 8, 9a, 9	high density of artefacts (5ut, 7, 8, 9), building debris (6)(?), in situ floor (9a), high phosphate value (5ob)	cultural horizons
180-196	10, 11, 11a		colluvials
196-216	12, 13, 13a, 13b, 14, 15	high density of artefacts (13b), ash lens (13), buliding debris (14), high phosphate value (12, 14, 15)	cultural horizons
216-230	17, 18, 19, (16)	embedded ash lense (16)	colluvials
235-245	20, 20a	ash layer (20), high phosphate value (20a)	cultural horizons
245-310	21, 22, 23, 24, 26, (22a), (25), (27)	embedded ash lenses (22a, 25), flint chipping floor (27)	colluvials
353-397	VP1	much charcoal, artefacts	cultural horizons
464-485	VP1	much charcoal, artefacts	cultural horizons
485	---	---	bedrock

have been a cultural obstruction, perhaps resulting from a field-clearance stone pile that was eroded and transported over a short distance.

The carbonate levels of the sediments vary between 22 and 31 % (Fig. 1, Table 2). The sediments show low salinities and are poorly humic except for Layer 8, at a depth of 2.45-2.90 m (N-profile), which is strongly humic (6.3 % organic matter) and therefore can be interpreted as a palaeosol (Fig. 10).

Discussion

The analytical results described above can provide a reconstruction of the sedimentary history of the fossil wadi across the entire area. The former relief energy was greater than it is today with the Eastern slope of the fossil wadi steeper than the Western one (Fig. 7, Fig. 8). At the beginning of sedimentation both slopes belonged to the catchment area, but finally the Western hill dominated. Thus the accumulation of talus deposits increased with material from the West; from the East the material became more fragmented, so that finer fractions were deposited. In the cross section of the valley different intensities of fluvial or aeolian erosion are presumed to have operated locally across the area, so local truncations of layers are probable.

In the Eastern part of Area C (C217) only 12 layers of relatively great thickness and homogeneous structure and texture could be identified. In the Western part (C208) 37 horizons are found. This variation from East to West underscores the process of sedimentation described above.

The carbonate levels vary between 19 and 31 % with the greatest variations in the Western part. The conductivities are very low in general (µS-range). In C208 values reach 420 µS/cm and in C217 only 220 µS/cm. In the middle part of the wadi values increased up to 1020 µS/cm, but the topographic position points to a potential influence by groundwater (Fig. 10, Table 2).

Paleosols lie at a depth of 2.45-2.90 m in the Eastern part and at depths of 1.50-1.84 m, 4.91-4.94 m and 5.10-5.50 m in the central part. Soil horizons that extend across the whole cross section of the wadi can not clearly be identified. However, in some layers (C208-W.15, 20a; VP5.10, 13, *cf.* App. 3) the densities of organic substance are so high that palaeosols, which stretch across the entire wadi, can be assumed (Fig. 12).

Slope Sediments near Basta

Area C is an arable field. To understand the influence of agriculture on erosion and deposition, the sediments of a field outside Basta were examined.

The psephite proportion is only half of that in Area C (Fig. 5, Table 4), which can be explained to some degree in terms of agricultural technology: the preparation of the field for easier tillage includes the collection of stones and pebbles, which are then concentrated in field clearance piles. The matrix of the sediments is medium clayey to loamy silt and the soil skeleton is medium stony/ pebbly. A protective pavement against deflation doesn't exist, so the sand proportion is strongly reduced and consists of medium and fine sand. The coarse sand proportion is nearly the same as in Area C since aeolian erosion of this material is hindered by grain weight. An intensive chemical weathering is suggested by high clay proportion (9 %) and the highest level of smectites (Table 6). The weathering of ferruginous

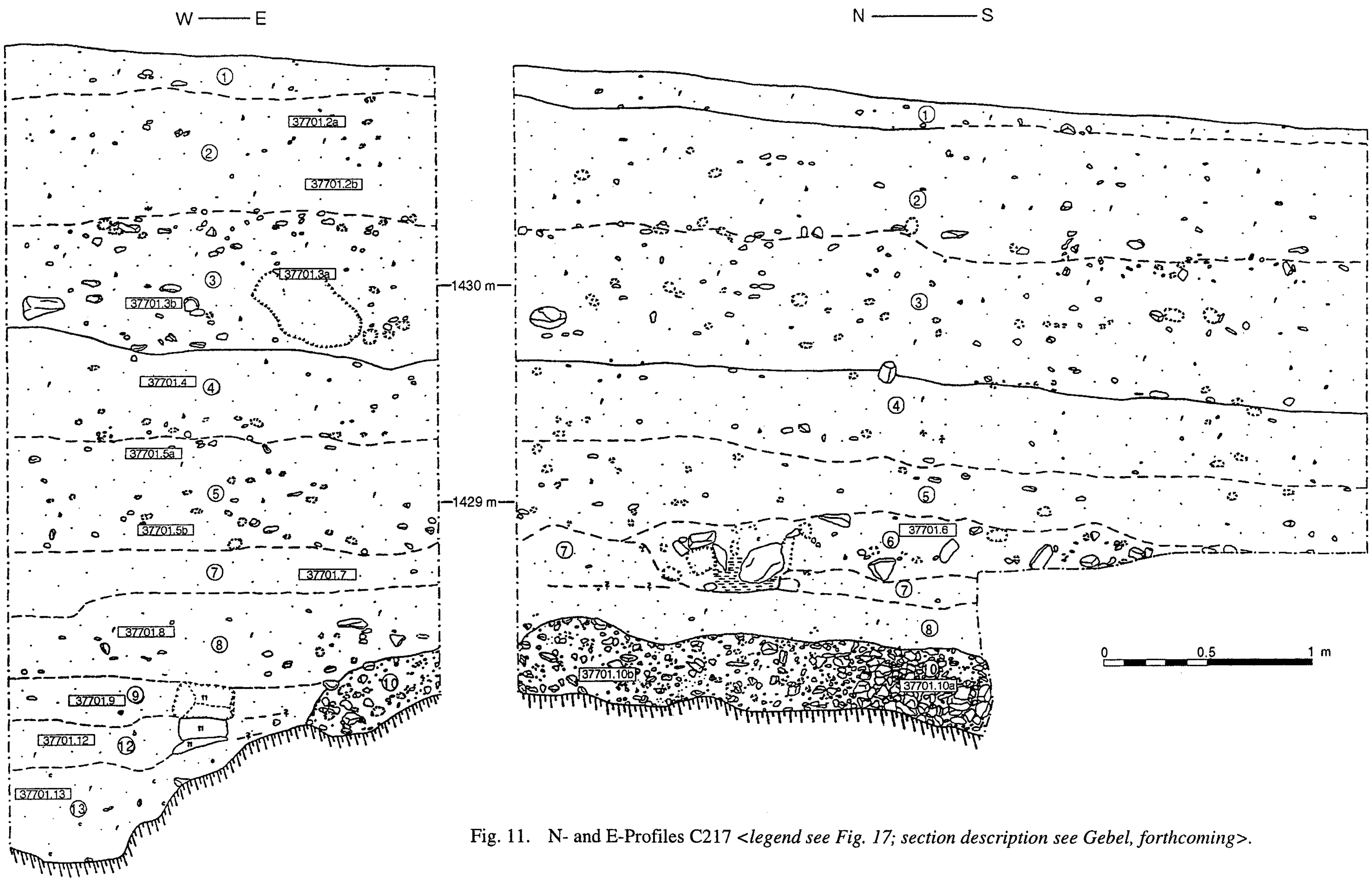


Fig. 11. N- and E-Profiles C217 <*legend see Fig. 17; section description see Gebel, forthcoming*>.

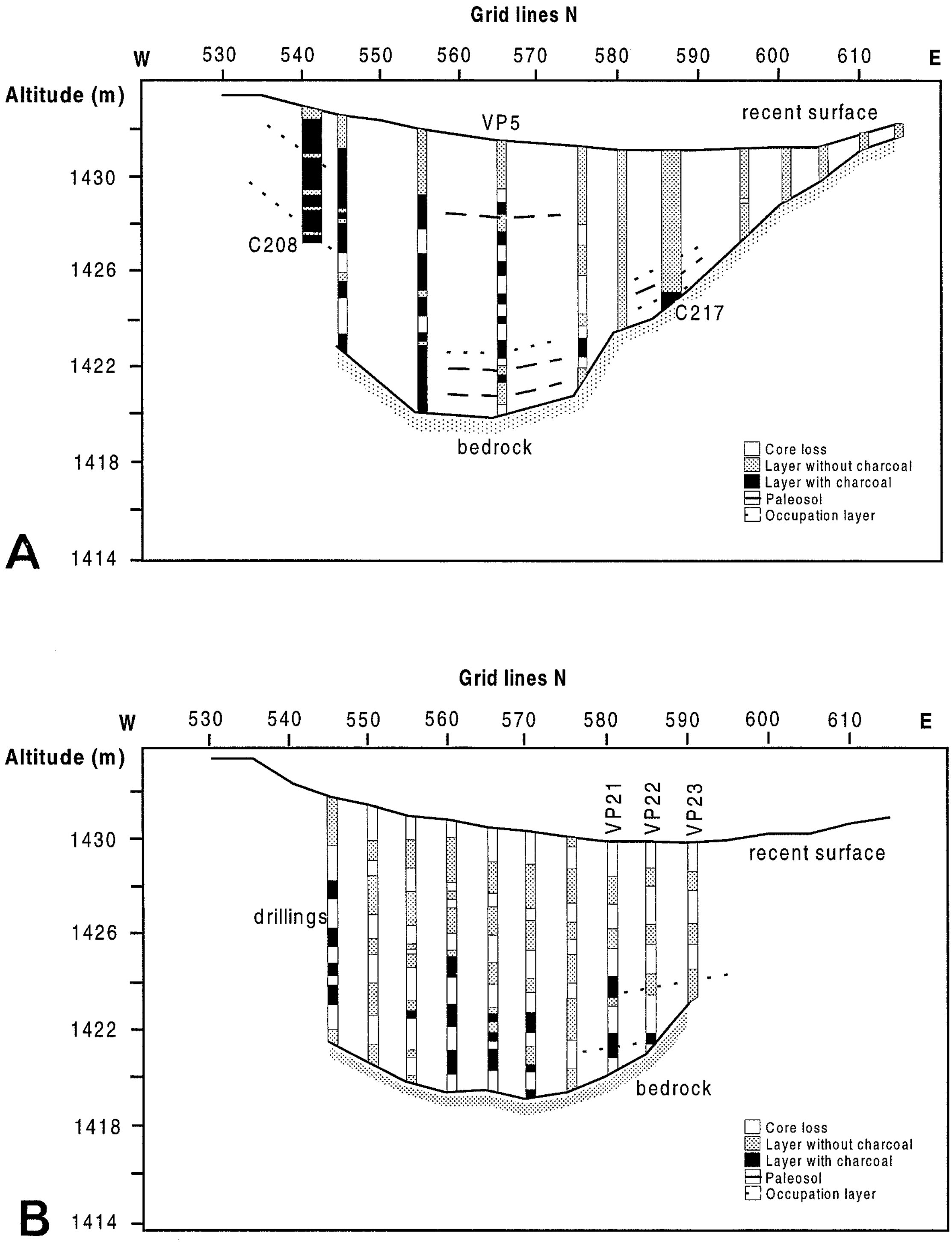


Fig. 12. Palaeosols, charcoal finds and occupation layers in Area C (A: gridline 545E; B: gridline 535E).

minerals such as biotites, which are found in most of the sediments and rocks, produces iron oxides such as goethites and haematites that in turn lead to a reddish colour. At the same time loam development is connected with a scouring of some of the weathering products as the soil degrades. Some drillings reached the weathering horizon of bedrock at depths of only 0.75-1.00 m. Such shallowness leads to intensive erosion and rare accumulation.

With regard to these modern circumstances, the palaeohorizons should also be characterized by low proportions of pesphites and - as a result of deflation - fine and medium sand.

In the research area with its semiarid climate, the landscape must be seen as a labile geosystem that reacted and reacts sensitively to human impacts. An intensive or overutilization is followed by soil degradation.

Deposits in Areas A, B, and C

Area A

Area A is located on the Northern bank of Wadi Basta *c.* 20-24 m above its bed (Figs. 1-3, 13). This topographic situation excludes fluvial accumulations. The catchment area of sediments comprises a small hill rising towards North, which today is covered by shallow sediments.

To the NW of Area A are exposures of calcearous bedrock with quartzite veins. The relief is undulating and slopes to the S/SE. The relief energy of the fossil slope was much higher than of the modern slope. The fossil surface dips 75° from the Northern corner of Area A towards a point only 7 m to SE. The surface of the limestone shows small depressions formed by natural solution weathering and human activities. It is probable that Neolithic inhabitants took building material from here, later using the holes for rubbish and rubble dumps. Moreover, burials, which in cases reach down to bedrock, show that this part of the area was a kind of cemetery before the first stone buildings were constructed, as *in situ* graves and scattered bones demonstrate (Gebel *et al.* 1988).

While the earliest structures in the Northern corner of Area A are founded on shallow cultural debris layers, which in turn rest on and follow the slope inclination, the structures to the South are founded on terraces with a stratigraphy of a thickness of 2.10 (Drilling 1) to 2.40 m (Drilling 2), according to drilling operations of H.J. Pachur and M. Goschin in 1987. Colluvials and cultural layers lie on top of a 0.45 m thick yellowish-brownish weathering horizon of calcearous bedrock (Pachur in Nissen *et al.* 1987). A radiocarbon date on pistachio charcoal found in the cultural horizon lying directly on top of the bedrock in A5 (500N/685E) produced an age of 8380 +/- 100 bp (GrN-14537, uncalibrated) (Gebel *et al.* 1988).

On top of the walls redeposited cultural layers and colluvials were found (*cf.* Gebel, Site Preservation ..., this volume; Gebel, forthcoming). With regard to gravel morphometry results (Table 5) the colluvials were deposited by mud flows and debris flows from the N/NW direction. The Northern corner of the area is oriented towards the catchment area of slope debris material, so destruction of walls by erosive material started in this part of the area. Local disturbances - such as an accumulation in front of or a transport around a wall - created sediments that vary considerably, reaching up to the top of walls.

With regard to sedimentation processes, the walls were effective barriers. Layer 52 of the NW- Section (Gebel, forthcoming), which lies between two walls, was examined. The proportion of matrix is very low and clasts propped up each other, which can be explained as a

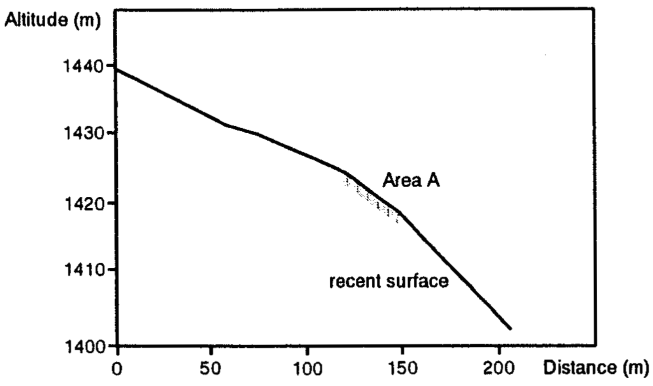


Fig. 13. Profile PL3: Slope in Area A (see Fig. 3.A).

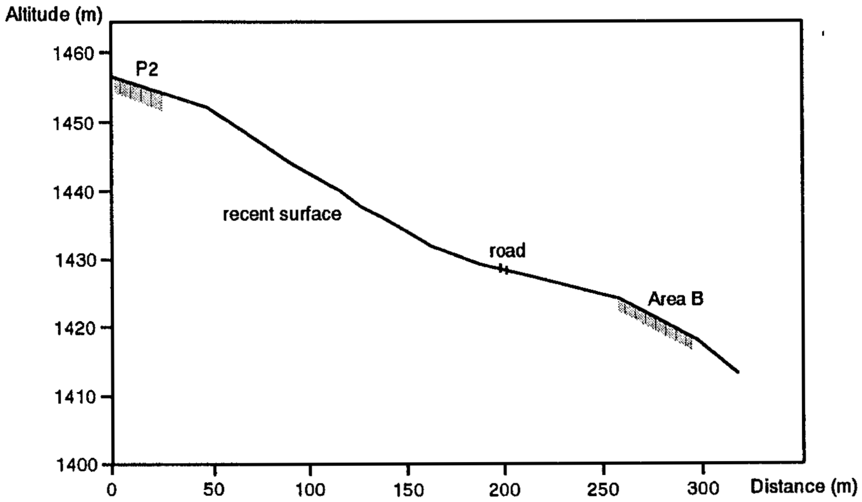


Fig. 14. Profile PL2: Slope in Area B (see Fig. 3.A).

consequence of a scouring of finer fractions after sedimentation of debris. Also rich in clasts are Layers 32a, 33a, and 49 of the NW- , as well as 8 and 29 of the NE- Section (Gebel, Site Preservation ..., this volume: App. 1). The latter was not affected by walls during sedimentation, and it points to more intensive erosion activities. The energy of this run-off event induced a cut of Layers 25-27 of the NE- Section.

In the NE- Section human activity can be noted in some of the layers: 11 and 13 are chipping deposits; 9, 15, and 31 are ash lenses/ layers; 17 is a burial dug directly into a debris layer. The concentrations of artefacts, bones and charcoal are higher than in overlying layers. A leveling of the sediments by the human use of the area is probable; it would explain the more or less horizontal bedding. This non-homogeneous sediment unit was partly cut by the colluvial Layers 35 and 40 of the NW- Section, as well as Layers 7 and 10 of the NE- Section, which are not bedded horizontally but roughly parallel to modern slope. These sediments reflect different erosional activities (*e.g.*, Layer 61a-g of the NW- Section).

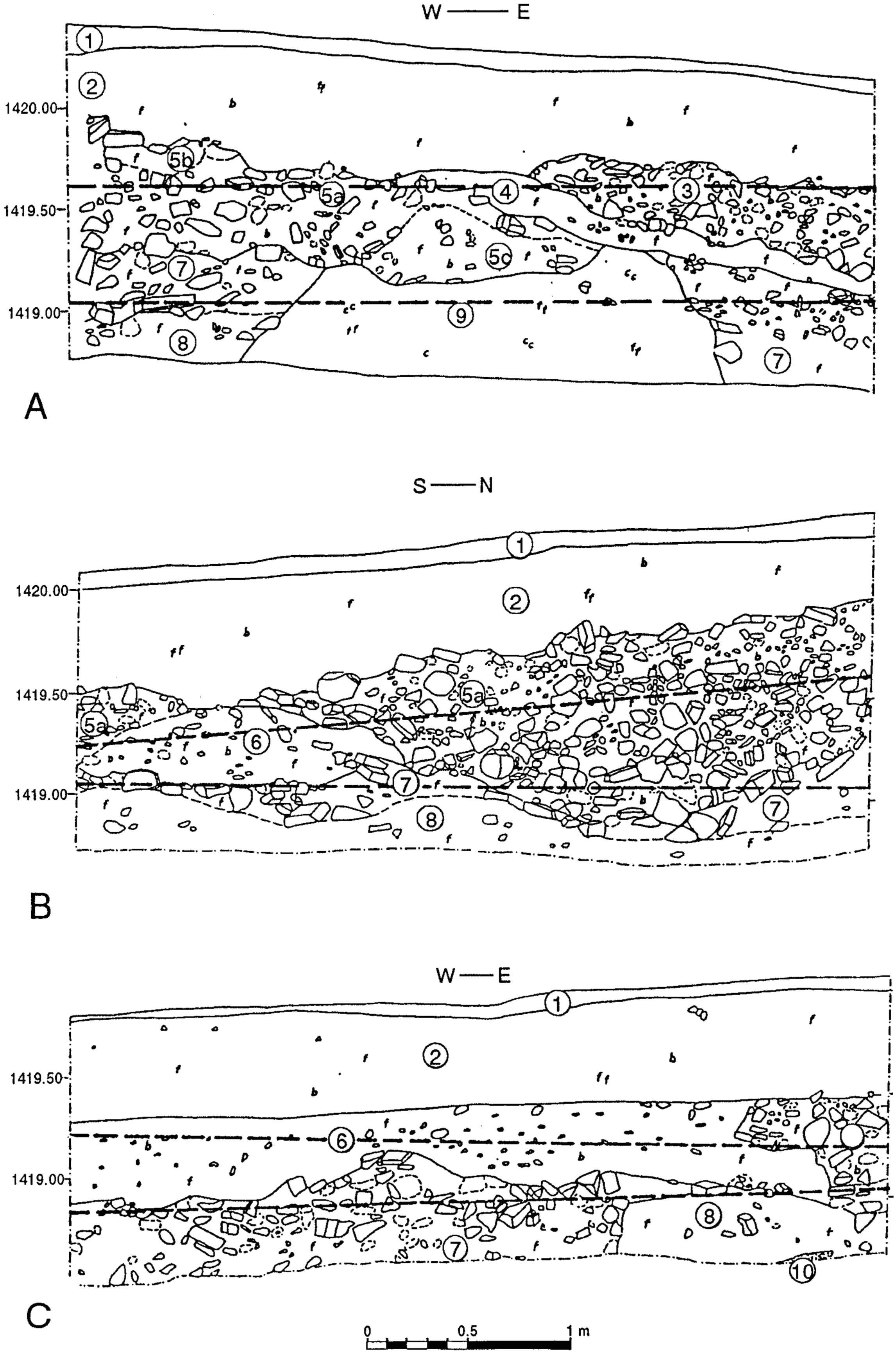


Fig. 15. Profiles B103 (A: Northern profile; B: Western profile; C: Southern profile) <*legend see Fig. 17; section description see Gebel, forthcoming*>.

Area B

Area B lies 100 m Southwest of Area A on the North bank of Wadi Basta 17-24 m above the wadi bed (Fig. 1-3, Fig. 14). Here fluvial accumulations are prevented, too. The catchment area is the terrain rising to Northwest.

The fossil wadi in Area C curves to the SE either at Area B or somewhere farther to the North before reaching it (Fig.1). In the first case, Area B would have occupied the outer bank of the fossil wadi, and during high-energy events such as mud and debris flows erosion and accumulation could have possibly affected Area B. In the second case the settlement had the function of a barrier. But in either case, the outer zone of Area B was more susceptible to erosion than Area A.

In contrast to the situation in Area A, here no walls were built up directly on top of bedrock. Drillings by Pachur and Goschin did not reach bedrock or the weathering horizon after 3 m (Drillings 6, 6a). The settlement horizon lies atop more than 3 m of colluvials and cultural horizons.

In Square B103 (390N/395E) layers are relatively homogeneous in texture and structure; only proportions of psephites and calcearous particles vary (Fig. 15). The gravel morphometric results identify the sandy-silty layers with higher proportions of psephites (3, 5a, 5c, 7) as mud flow sediments, which were transported from the N/NW (Table 5). During this sedimentation process walls were destroyed. Stones showing marks of flaking were redeposited (Layers 3, 5, 7), giving an exaggeratedly high proportion for psephites. Moreover, the terrain above the area was agricultural land, so possible field clearance piles must be considered as sources of some of the psephites.

Layer 11 (not to be seen in Fig. 15) is very compact and contains many concentrations of ash and charcoal. The archaeologists interpret this horizon as a cultural one. Directly on top of it occur Layers 7, 8 and 9. Layer 9 partly covers a destroyed wall. It is characterized by a low density of clasts, which perhaps were picked out by people. In contrast to other layers, here artefacts and charcoal are regulary dispersed. A utilisation of settlement during sedimentation seems possible. Later on parts of the layer were cut.

Layer 8 contains even lower densities of clasts of great size. From here a rhythmic sedimentation of clasts can be detected up to Layer 3. Clast-rich (7, 5, 3) and clast-poor (9, 8, 6, 4) layers alternate, reflecting varying intensities of physical weathering and erosion. Layer 7 represents a more intensive sedimentation event during which walls were destroyed, as is attested by presence of dressed stones. Layer 6 was a sedimentation event characterized by decreased grain size or a lower erosion activity. Layer 5 is again rich in psephites, and the density of 10-25 cm clasts is variable. After this high energy phase of sedimentation layers in the Northeastern part of the square were cut. Layers 5, 7 and 9 form a foundation dipping to the East for Layer 4. The matrix is fine to medium-fine, very compact, porous and contains many calcareous particles and gravels; the erosive activity was not intensive. Clast-rich Layer 3 was later deposited, but it can only be found in the Eastern part of the square. The proportion of psephites 5-15 cm in size is very high (75.3 %, Table 4), which reflects a special situation: walls damned up coarser fractions, whereby finer ones were transported downslope, particularly the sand fraction. With diminishing grain size cohesion of the particles hindered erosion. Layers 2 and 1 are covering layers over this sequence. In square B103 they have the same thickness, although Layer 2 thins out upslope.

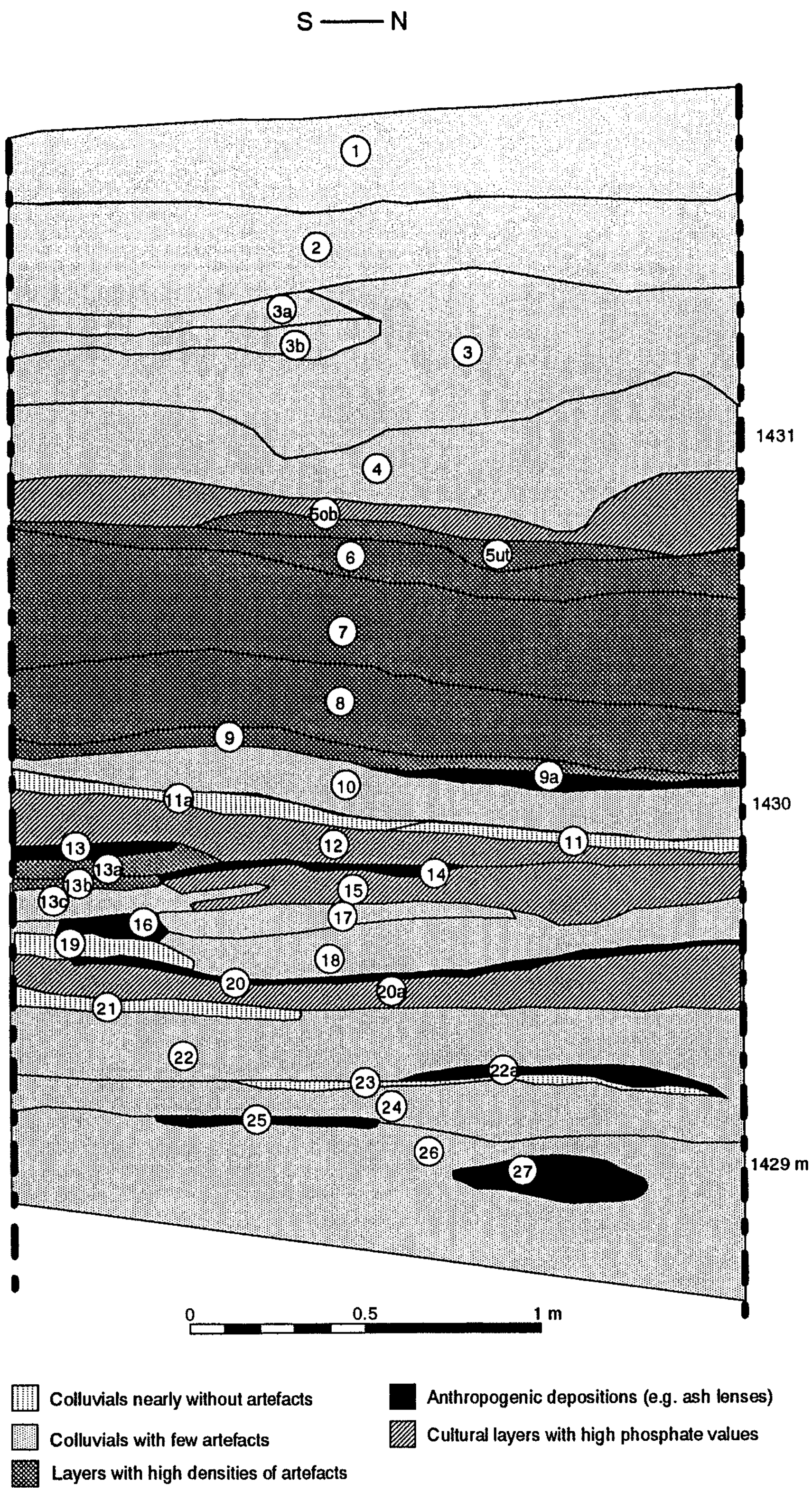


Fig. 16. Geoarchaeological interpretation of layers in C208
<section description see Gebel, forthcoming>.

The depositional sequence in Area B resulted from different sedimentation and erosion processes. Not all of them cover the whole area: some are only local events, others were cut. Walls of the settlement were barriers: erosive material was deposited in front of them, flowed round or over them and destroyed them. Field clearance stone piles were sources for clast-rich sediments.

Area C

C208 and Drilling VP1

Table 8 and Fig. 16 describe the Western slope of the fossil wadi as an area of intensive human activities. Since C208 didn't reach bedrock, Drilling VP1 was done in a corner of the square. The profile descriptions and phosphate analysis show an alternation of phases of human use and natural sedimentation.

C217 and Drillings VP21-23

In C217 (Fig. 11) Layers 7, 8 and 9 can be characterized as cultural horizons because of high phosphate concentrations (Table 2). These horizons, which together are 0.85 m thick, lie above a burial (Layer 11) and an eroded field clearance pile (Layer 10). The upper stratigraphy of C217 lacks phosphates and *in situ* archaeological evidence, although there are transported, secondarily deposited PPN materials.

Drillings VP21-23 were located 10 m downslope from C217 (Fig. 1). Three samples show high phosphate levels (Table 2): Drilling VP21/Layer 1 (3.83-4.34 m), Drilling VP22/ Layer 3 (2.77-3.00 m) and Drilling VP23/Layer 2 (2.48-3.00 m) (Fig. 12). In accordance with stratigraphy in C217, the sequences in VP21-23 demonstrate human occupation for the lower, near-bedrock sections (Fig. 12.B).

The Eastern slope of the fossil wadi was not as intensively occupied as the Western slope, and it was used over a shorter period of time.

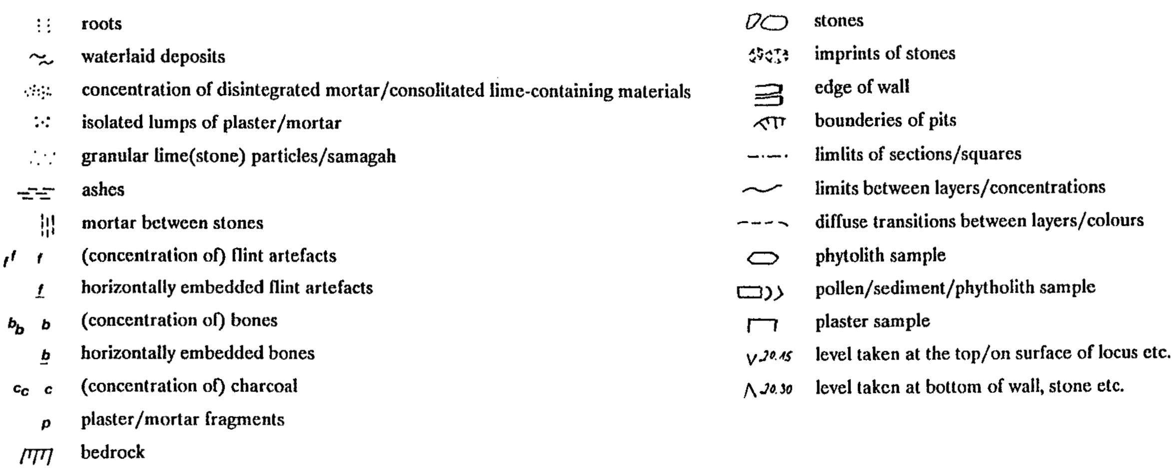


Fig. 17. Legend for section drawings in Figs. 6, 9, 11, 15, and Fig. 2 in Gebel, Site Preservation ..., this volume.

Discussion

In Area C concentrations of cultural deposits, artefacts and charcoal decrease from the Western to the Eastern parts of the wadi. Whether they are of autochthonous or allochthonous origin can not be identified for all layers of intensive cultural influence. The existence of floors and flint chipping areas in addition to large chunks of charcoal indicates that the evidence here is *in situ*, and that the Western slope near C208 was an area of intensive human activity.

Indisputable indications for cultural horizons are provided by phosphate analysis. In the Western sector occupation layers occur at depths of 1.05-1.15 m, 1.96-2.16 m and 2.37-2.45 m; in the Eastern sector at depths of 2.25-3.10 m and 3.83-4.34 m. But occupation layers stretching across the entire wadi cannot be unequivocally identified. In view of the phosphate value of Layer 10 in Drilling 5 (1.15 mg/g PO_4^{3-}) such an occupation layer could be possible (Fig. 12). The two slopes of the depression were localities of human activities; the Western slope was occupied over a longer period of time.

Temporal Relations in Site Use

At the beginning of human use of Areas A and B, the fossil wadi in Area C was almost free from erosional sediments; erosion dominates over sedimentation.[1] During this earlier occupation the filling of the central part of this wadi was a balanced process of deposition and erosion of materials which originate from the Western slope and from aeolian sedimentation. It is expected that this material transported downslope already created an instability for the dwellings on the lower flanks of the wadi (Area B). In slope situations like Area A, such a process must have resulted in a downslope "pressure" of colluvials (mixed with cultural debris) against the standing walls of the village. Already by this time people possibly were forced to rebuild structures on higher levels or to protect existing foundation levels or terraces.

From the beginning of the 8th millennium bp, sedimentation became dominant and by 8.000-7.500 bp the wadi was filled up with sediments. Precipitation and slope runoff were insufficient to empty the wadi. Less material was transported and deposited in form of mud and debris flows by periodic and episodic rainfalls; coarse psephites point to high energy erosive activity. Parallel to this a stronger aeolian accumulation is evidenced by high amounts of fine material, particularly in the central parts of Area C. Vegetation cover became less dense, probably this is rather more linked with human activity (field clearing, monoagriculture, overgrazing) than to climatic change. For people life became harder because of the repeated destruction of the settlement habitats.

A simultaneous occupation of Areas A/B and Area C before the onset of more arid conditions around 8.000 bp cannot be determined because of missing data from Area C. All archaeological evidence from both test units (C208 and C 217) indicate that this area represents the margins of the PPNB settlement, with activities such as the deposition of leftovers, ashes, and unused building material and building debris, *ad hoc* chipping floors, cadavre burials, possibly garden areas, *etc.* When the main occupation in Areas A and B had been abandoned, Area C still seems to have been used, especially its Western slope, despite the fact that sedimentation was taking place. Possibly these people were pastoral groups.

---

[1] In C208 the cultural horizon lying directly on bedrock dates 6780 +/- 205 bp (HV 17193, uncal.). This soil sample originated from the western slope and not from the central part of the wadi.

Summary

In the research area the bedrock is composed of dolomites, limestones, clay and marl layers and sandstones, which are tipped. Different resistivity to erosion produced ridges; gully clints (a type of drainage) are results of karstification of the carbonate rocks. In these depressions debris was transported downslope. Psephites, bones, artefacts *etc.* lying on the surface were included in the process of redeposition.

Different erosion activities produce sediments in which proportions of stones and blocks vary. With greater distance from its area of origin the substrate becomes finer. Periodic to episodic rainfall can result in high energy force sufficient to erode psephites of decimeter size. The sediments in Basta showed relatively light resistence to aquatic slope erosion and their surfaces were cemented, which led to mud and debris flows. The debris accumulated as colluvials or alluvials at the base of slopes and in depressions. In Area C a fossil wadi cut into the undulating bedrock and later was filled with silty sediments of nearly 6 m thickness. Aeolian erosion was effective in places where a protective pavement was absent, *e.g.* fields, which were cleared of stones. Aeolian sedimentation is signalled by high proportions of fractions smaller than coarse sand, as it is in Area C.

Physical weathering was much more important than chemical alteration, verified by the presence of angular fine material and low levels of clay and clay minerals, which are indicators of slight chemical weathering. The solution residues of rocks are relatively low. Finer grain fractions are mostly products of fragmentation processes during transport.

The matrix of sediments show carbonate contents of 20-30 % in general, which is traceable in part to local bedrock (primarily limestone) and partly to carbonate accumulation (secondary lime) owing to processes of scouring in moister months and evaporation in drier months. Lime particles often can be found in the whole matrix, as well as caliches, concretions and tufaceous limestone. The sediments are characterized by low salinity; higher values are presumed to reflect the influence of groundwater in (former) depressions. Humus levels are around 2 %. Sparse vegetation cover as a product of human activity leads to small biomass; intensive erosion activity is principally responsible for preventing its accumulation. Nevertheless, soil development was possible at some locations. In Area C some palaeosols could be identified, even though generally the soils were degraded. The recent soils of the area are rendzinae, xero-rendzinae and terrae fuscae, which show coherent and coagulate fabrics. Partly they are of colluvial character. The sediments overlying bedrock often contain many artefacts, which are either of autochthonous or allochthonous origin. The research area is old agricultural land.

In Area A some burials were dug into the weathering horizon of bedrock by Neolithic inhabitants. The first cultural debris horizon on top of this weathering layer is 8.380 years old (bp). The former slopes were steeper than they are today, so planation of terraces was part of ground preparation. If it was not possible to build directly on the bedrock or the ridges, people began to construct permanent houses on the colluvials and older cultural layers, which are 2.10-2.40 m thick. But the constructed walls hindered transport of erosive material. At first sediments accumulated in the Northern corner of Area A. The planation of material and high concentrations of archaeological finds indicate a utilization during phases of sedimentation. The non-homogeneous sediment unit reaches up to the tops of walls, covered by later colluvials and subsequently partially cut.

The main (last) occupation in Area B was constructed on colluvials and cultural layers of at least 3 m thickness. This locality was not as propitious as Area A with regard to the

greater catchment area of sediments and the fossil wadi in Area C. The long slope situated above contributed to higher erosion activities of negative impacts, as the rhythmic sedimentation of psephites indicates. If field clearance piles of stones existed upslope, they could have been a source for coarse grained material. In Area B a longer utilization was prevented by intensive accumulation events. The sedimentation of layers rich in psephites directly upon cultural layers and the absence of autochthonous finds such as house floors, flint chipping areas, or ash lenses above this psephite level, lead to the conclusion that this part of the settlement was abandoned and not reoccupied, as is postulated for Area A.

In Area C cultural layers can be found directly on the bedrock across the entire fossil wadi. In C208 the subsequent cultural layers are not associated with the settlement layers in Areas A and B. The PPNB artefacts in Area C must have been redeposited from elsewhere upslope, for *in situ* deposits are not of Neolithic age. Farther to the West the cultural horizons lie at lower depths. Near C208, situated on the Western slope, they lie only 1 m under the modern surface. The formation of the relatively non-homogeneous sediment unit of colluvials and cultural layers was heavily influenced by human activity, as is manifested by many archaeological finds. Near C217 on the Eastern slope, the youngest cultural horizons lie at a depth of 2 m beneath the surface. Human utilization is evidenced by an eroded field clearance pile lying directly upon bedrock and a burial 0.15 m above bedrock. High phosphate values of the overlying 0.85 m sediments point to human use of the slope for a considerable time.

Acknowledgements: I kindly thank all friends and colleagues, who helped me during my field work in 1988 and 1989 and in the work carried out in the laboratories and at home. Prof. Dr. Hans J. Nissen (Seminar für Vorderasiatische Altertumskunde, Free University of Berlin) and Dr. Mujahed Muheisen (Institute of Archaeology and Anthropology, Yarmouk University) kindly invited me to study the sedimentary environment of Basta. Hans J. Nissen particularly promoted my field research by consistent discussion. Prof. Dr. Hans Joachim Pachur (Geomorphologisches Laboratorium, Free University of Berlin) offered me the geomorphological research in this interdisciplinary project. We had many discussions about the work, especially during his visit in Basta in 1989. Hans Georg K. Gebel (Institut für Vorderasiatische Altertumskunde, Free University of Berlin) was a continuous companion of my work, as well in the field as during the later evaluations. Many discussions introduced me into the archaeological view of the geomorphological problems. Dr. Michael Goschin (Geomorphologisches Laboratorium, Free University of Berlin) introduced me into the chemical and physical methods. He also helped me during his visit in Basta in 1989. Dipl.-Geogr. Marcus Nüsser (Zentrum für Entwicklungsländerforschung, Free University of Berlin) accompanied and helped me in 1988. The survey of the localities was done with the help of Zaidoun Za'id (Yarmouk University, Free University of Berlin). This contribution was carefully reviewed by Dr. Joseph Schuldenrein (Geoarchaeology Research Associates Inc., New York), and I owe him thanks for many helpful suggestions. Prof. Dr. Christian Hannß (Geographisches Institut, University of Tübingen) made further useful suggestions. Prof. Dr. Gary Rollefson ('Ain Ghazal Research Institute, Wembach) kindly edited the English, including a number of most useful comments.

Ulrich Kamp
DePaul University,
AAG Mountain Geography Specialty Group
Department of Geography & Environmental Science Program
U.S.A. - 990 W Fullerton Parkway, Chicago, IL 60614

References

Albritton C.C. Jr. and K. Bryan
1939 Quaternary stratigraphy in the Davis Mountains, Trans-Pecos, Texas. *Geological Society of America Bulletin* 50: 1423-1474.

Arrhenius O.
1929 Die Phosphatmethode. *Zeitschrift für Pflanzenernährung, Düngung und Bodenkunde* 14: 121-140, 185-194.

Arrhenius O.
1931 Die Bodenanalyse im Dienst der Archäologie. *Zeitschrift für Pflanzenernährung, Düngung und Bodenkunde* 10: 427-439.

Bender F.
1968 *Geologie von Jordanien.* Berlin/Stuttgart, Bornträger.

Besançon J., L. Copeland, F. Hours, J.J. Macaire, and P. Sanlaville
1984 The lower and Middle Palaeolithic of the upper Zarqa and Khirbet Samra area of Northern Jordan, 1982-1983 survey results. *Annual of the Department of Antiquities of Jordan* 28: 91-141.

Besançon J. and F. Hours
1985 Prehistory and geomorphology in Northern Jordan. In: A. Hadidi. (ed.), *Studies in the History and Archaeology of Jordan* 2: 59-66.

Bleck R.D.
1976 Anwendungsmöglichkeiten phosphatanalytischer Untersuchungen im Bereich der Ur- und Frühgeschichte. *Ausgrabungen und Funde* 21.6: 259-268.

Bryan K.
1941 Correlation of the deposits of Sandia Cave, New Mexico, with the glacial chronology (appendix). In: F.C. Hibben (ed.), *Evidences of Early Occupation in Sandia Cave, New Mexico, and other Sites in the Sandia-Manzano Region.* Smithsonian Miscellaneous Collections 99: 45-64.

Butzer K.W.
1974 Geo-archaeological interpretation of Acheulian calcpan sites at Doornlaagte and Rooidam (Kimberley, South Africa). *Journal of Archaeological Science* 1: 1-25.

Chamayou J. and J.P. Ruhard
1977 *Sillon préafricain à l'est du Siroua: Les bassins de Quarzazate et de Errachidia (Ksar-Es-Souk)-Boudenib.* Notes Mém. Serv. Géologie 231. Rabat.

Clayton L., S.R. Moran, and W.B. Bickley Jr.
1976 *Stratigraphy, origin and climatic implications of Late Quaternary upland silt in North Dakota.* North Dakota Geological Survey Miscellaneous Series 54.

Davidson D.A.
1978 Soils on Santorini at 1500 BC. *Nature* 272: 130-137.

Ferring C.R.
1986 Rate of fluvial sedimentation: implications for archaeological variability. *Geoarchaeology* 1: 259-274.

Ferring C.R. and D.E. Peter
1987 Geoarchaeology of the Dyer site, a prehistoric occupation in the Western Ouachitas, Oklahoma. *Plains Anthropologist* 32: 351-366.

Füchtbauer H. and G. Müller
1988 *Sedimente und Sedimentgesteine.* Stuttgart, Schweizerbart.

Ganssen R.
1968 *Trockengebiete. Böden, Bodennutzung, Bodenkultvierung, Bodengefährdung.* Mannheim/ Zürich, Bibliographisches Institut.

Garrard A.N., A. Betts, B. Byrd, and C. Hunt
1987 Prehistoric environment and settlement in the Azraq Basin. An interim report on the 1985 excavation season. *Levant* 19: 5-25.

Gebel H.G.
1986 Die Jungsteinzeit im Petra-Gebiet. In: M. Lindner (ed.), *Petra. Neue Ausgrabungen und Entdeckungen:* 273-308. München/ Bad Windsheim, Delp.
1992 Territories and palaeoenvironment: locational analysis of Neolithic site settings in the Greater Petra Area, southern Jordan. In: S. Kerner (ed.), *The Near East in Antiquity* 3: 85-96. Amman, al Kutba.
forthcmg. The stratigraphies and locus data. In: H.J. Nissen, M. Muheisen, and H.G.K. Gebel (eds.), *Basta* II. *The Architecture and Stratigraphy.* Berlin, ex oriente.

Gebel H.G., M. Muheisen, and H.J. Nissen
1988 Preliminary report on the first season of excavation at Basta. In: A.N. Garrard and H.G. Gebel (eds.), *The Prehistory of Jordan. The State of Research in 1986. British Archaeological Reports* - Intern. Series 396.1: 101-134.

Gehrenkemper K.
1981 *Rezenter Hangabtrag und geoökologische Faktoren in den Montes de Toledo, Zentralspanien.* Berliner Geographische Abhandlungen 34.

Glennie K.W.
1970 *Desert Sedimentary Environments.* Developments in Sedimentology 14.

Goschin M.
1983 *Methode und Grenze der Phosphatanalyse in der Archäometrie am Beispiel von Siedelplätzen in der Sahara.* Berlin, Free University: unpub. Staatsexamensarbeit.
1984 Phosphate analysis of Neolithic sites in the Sahara. *Berliner Geowissenschaftliche Abhandlungen* (A) 50: 285-291.

Hartge K.H.
1978 *Einführung in die Bodenphysik.* Stuttgart, Enke.

Hassan F.
1981 Rapid quantitative determination of phosphate in archaeological sediments. *Journal of Field Archaeology* 8: 384-387.

Henry D.O., F.A. Hassan, K.C. Henry, and M. Jones
1983 An investigation of the prehistory of southern Jordan. *Palestine Exploration Quarterly* 115: 1-24.

Holliday V.T.
1989 Paleopedology in archaeology. *Catena Supplement* 16: 187-206.

Jorstad T., T. East, J.M. Adovasio, J. Donahue, and R. Stuckenrath
1986 Paleosols and prehistoric populations in the High Plains. *Geoarchaeology* 2: 163-181.

Kamp U.
1992 *Geomorphologische und geochemische Untersuchungen im Rahmen des Basta Joint Archaeological Projet in Südjordanien.* Berlin, Free University: unpub. diploma thesis.

Kiefmann H.M.
1975 Die Phosphatmethode: neue Erkenntnisse über eine Prospektionsmethode der Siedlungs- und Kulturlandschaftsforschung. *Informationsblätter zu Nachbarwissenschaften der Ur- und Frühgeschichte* 6: Chemie 4.1-4.16.

Kiefmann H.M. and J. Schlede
1972 Phosphatkartierung. *Offa Ergänzungsreihe* 29: 149-155.

Kröpelin S.
1989 Untersuchungen zum Sedimentationsmilieu von Playas im Gilf Kebir (Südwest-Ägypten). In: R. Kuper (ed.), *Forschungen zur Umweltgeschichte der Ostsahara. Africa Praehistorica* 2: 183-306. Köln.

Leser H.
1977 *Feld- und Labormethoden der Geomorphologie.* Berlin/ New York, de Gruyter.

Leser H. and W. Panzer
1980 *Geomorphologie.* Braunschweig, Westermann.

Louis H.
1979 *Allgemeine Geomorphologie.* Berlin/New York, de Gruyter.

Macphail R.J.
1986 Paleosols in archaeology: their role in understanding Flandrian pedogenesis. In: V.P. Wright (ed.), *Paleosols: Their Recognition and Interpretation:* 263-290. Princeton, Princeton University Press.

Macumber P.G.
1984 Geology and geomorphology of the lower Wadi Hammeh sites. In: A. McNicoll *et al.*, Preliminary report on the University of Sydney's fifth season of excavation at Pella in Jordan. *Annual of the Department of Antiquities of Jordan* 28: 55-86.

Molle H.G.
1979 *Gliederung und Aufbau fluviatiler Terrassenakkumulationen im Gebiet des Enneri Zoumri, Tibesti-Gebirge.* Berliner Geographische Abhandlungen 13.

Moormann F.
1959 Report on the soils of East Jordan. *FAO-Report No. 1132 for the Government of Jordan.* Rom.

Nissen H.J., M. Muheisen, and H.G. Gebel *et al.*
1987 Report on the first two seasons of excavations at Basta (1986-1987). *Annual of the Department of Antiquities of Jordan* 31: 79-119.

Pachur H.J.
1970 Zur Hangformung im Tibesti-Gebirge. *Die Erde* 101: 41-54.

Pachur H.J. and H.P. Röper
1987 *Zur Paläolimnologie Berliner Seen.* Berliner Geographische Abhandlungen 44.

Pope K.O., C.N. Runnels, and T.L. Ku
1984 Dating Middle Paleolithic red beds in Southern Greece. *Nature* 312: 264-266.

Press F. and R. Siever
1986 *Earth.* New York, Freemann.

Proudfoot B.
1976 The analysis and interpretation of soil phosphorus in archaeological contexts. *Geoarchaeology* 85: 93-113.

Richter G.
1965 *Bodenerosion: Schäden und gefährdete Gebiete in der Bundesrepublik Deutschland. Forschungen zur Deutschen Landeskunde* 152.

Rottländer R. (ed.)
1983 *Einführung in die naturwissenschaftlichen Methoden in der Archäologie.* Tübingen, Archaeologica Venatoria.

Scheffer F. and P. Schachtschabel
1984 *Lehrbuch der Bodenkunde.* Stuttgart, Enke.

Schuldenrein J.
1987 Geographical observations. In: G.A. Clark *et al.*, Palaeolithic Archaeology in the southern Levant. A preliminary report of excavations at Middle, Upper and Epi-Palaeolithic sites in Wadi el-Hasa, West-Central Jordan. *Annual of the Department of Antiquities of Jordan* 31: 67-70.

Schuldenrein J. and P. Goldberg
1981 Late quaternary palaeoenvironments and prehistoric site distributions in the lower Jordan Valley: a preliminary report. *Paléorient* 7: 57-71.

Sjöberg A.
1976 Phosphate analysis of anthropic soils. *Journal of Field Archaeology* 3: 447-454.

Tröger W.E.
1971 *Optische Bestimmung der gesteinsbildenden Minerale,* 1. *Bestimmungstabellen.* Stuttgart, Schweizerbart.

Voigt T.
1956 Neue Erkenntnismöglichkeiten bei modernen Ausgrabungen. Die Phosphatmethode I - II. *Vorgeschichtliche Museumsarbeit und Bodendenkmalpflege* 2, 1951-1954: 9-13; 1956: 21-23.

Wagner P.
1984 *Rezente Abtragung und geomorphologische Bedingungen im Becken von Quarzate, Süd-Marokko.* Berliner Geographische Abhandlungen 38.

Yaron B., E. Danfors, and Y. Vaadia (eds.)
1973 *Arid Zone Irrigation.* Berlin/ Heidelberg/ New York, Springer.

Zölitz R.
1980 *Bodenphosphate als Siedlungsindikator.* Offa Ergänzungsreihe 5.

Appendix 1. Geoarchaeological layer description of P1 (wadi section/ road cut SE of the site).

Layer (Locus) No.	Depth Below Surface (cm) Sample No. (Depth of Sample in cm)	Matrix (Witrh Ash/Charcoal Components) and Munsell Colour Notation	Mineral Inclusions and Cultural Deposits (Without Artefacts)/ Orientation / Characterization of Layer / Notes	Interpretation of Layer
1	000-066 29022.1 (040)	sandy silt; 10 YR 6/1 "grey"	various diameters, including larger than 10cm; including flint artefacts, pottery and worked tabular stones / silty-sandy layer	eroded cultural (Chalcolithic) deposits, topsoil
2	066-086 29022.2 (075)	sandy silt with high proportion of fine gravel; lime particles; very compact; 7.5 YR 6/8 "reddish-yellow"	edged flints of different size, limestones 7-10cm, mostly platy; horizontal orientation/ gravelly-stony layer	alluvium
3	086-126 29022.3 (100)	sandy silt; many lime particles; 10 YR 7/4 "very pale brown" to 10 YR 8/6 "yellow"	many lime gravels < 1cm, some < 5cm; chalky white lime / homogeneous / silty-sandy layer	alluvium with with chalky deposit
4	126-206 29022.4 (160)	fine sand with high proportion of fine gravel; very compact; lime particles; 7.5 YR 6/8 "reddish-yellow"	blocks < 30cm; limestones and -gravels often platy; sandstones; angular or edge-rounded flints < 3cm / horizontal orientation/ gravelly-stony layer with blocks	alluvium
5	206-214 29022.5 (210)	silty fine sand with high proportion of fine gravel; 5 YR 7/6 "reddish-brown"	flints; limestones and -gravels, partly sandy; sandstones < 3cm; hard aggregates of fine sand, 10 YR 8/8 "yellow" / horizontal orientation/ gravelly layer	alluvium
6	214-230 29022.6 (225)	silty fine sand with low proportion of fine gravel; 10 YR 6/8 "brownish-yellow"	hard aggregates of silt, 10 YR 8/8 "yellow"; limestones and flints < 2cm; some sandstones < 10cm; sharp edged flints up tp 15cm / chalky band at base / stony layer	alluvium with caliche at base
7	230-245 29022.7 (240)	silty fine sand with high proportion of fine gravel; 10 YR 7/6 "yellow"	edge-rounded, rounded and angular flints, limestones and -gravels; chalky lime gravels < 3cm / horizontal orientation / gravelly layer with carbonate nodules	alluvium with loess dolls (?)
8	254-276 29022.8 (260)	silty fine sand with low proportion of fine gravel; 10 YR 7/6 "yellow"	5-10cm, some < 15cm; flint nodules < 5cm; many angular or edge-rounded gravels < 2cm / horizontal orientation / stony layer	alluvium
9	276-290 29022.9 (285)	silty fine sand with medium proportion of fine gravel; 7.5 YR 6/6 "reddish-yellow"	edge-rounded lime gravels and flints < 2cm, some < 4cm; block of 25cm / strong horizontal orientation / gravelly layer	alluvium
10	290-332 29022.10 (310)	few fine sand, mostly fine gravel; 7.5 YR 7/8 "reddish-yellow"	edge-rounded flints < 5cm; rounded lime gravels < 6cm / horizontal orientation / lamination: two black and one reddish-brown bands / gravelly layer	alluvium with ash band and band of rubification (?)
11	332-376 29022.11 (350)	silty fine sand; lime particles; 7.5 YR 6/8 "reddish-yellow"	flint particles of 3-5mm; some laminated, sandstones < 10cm free from lime; edge-rounded flints and flint nodules < 12cm; edge-rounded lime gravels < 6cm / black band / stony layer	alluvium with ash band, here fossile bones were found in 1986
12	376-384 29022.12 (380)	silty fine sand with high proportion of fine gravel; compact; 10 YR 6/6 "brownish-yellow"	edge-rounded flint particles < 3mm; rounded lime gravels < 1cm; greater edge-rounded flints / gravelly layer	alluvium
13	384-398 29022.13 (390)	sandy silt; 10 YR 6/4 "yellowish-brown"	porous aggregates of chalky lime < 5cm; rounded limestones of 6-10cm; some edge-rounded flints of mostly 3-6cm / horizontal orientation / gravelley-stony layer	alluvium with concretions of lime tufa
14	398-414 29022.14 (405)	silty fine sand with high proportion of fine gravel; 7.5 YR 6/8 "reddish-yellow"	mostly medium gravel; stones of 15cm / horizontal orientation / gravelly layer	alluvium
15	414-436 29022.15 (425)	silty fine sand with medium proportion of fine gravel; 7.5 YR 6/6 "reddish-yellow"	high proportion of (edge-rounded) gravels < 3cm and stones < 10cm / horizontal orientation / gravelly-stony layer	alluvium
16	436-458 29022.16 (445)	few silty fine sand with high proportion of fine gravel; 10 YR 7/6 "yellow"	rounded, edge-rounded and angular flints / partly black colour (ash?) / very fine lamination / coarser inclusions with horizontal orientation / gravelly layer	alluvium with lamination and ash
17	458-472 29022.17 (465)	sandy silt with medium proportion of fine gravel; in contact zone with Layer 16 harder and more porous; lime particles finer than in Layer 18	rounded and angular limestones; limy sandstones; flint nodules around 10cm, some < 30cm; in contact zone with Layer 16 coarser limestones / stony layer with blocks	alluvium
18	472-504 29022.18 (490)	sandy silt in form of hard, compact aggregates < 7cm; lime particles; 5 YR 5/8 "yellowish-red"	mostly sharp edged, sometimes rounded flints; fine-sandy, lime free aggregates ofmm seize, 10 YR 8/8 "yellow"; charcoal / perhaps root channels / silty-sandy layer	alluvium

Appendix 2. Geoarchaeological layer description of P2.

Layer (Locus) No.	Depth Below Surface (cm) Sample No. (Depth of Sample in cm)	Matrix (With Ash/Charcoal Components) and Munsell Colour Notation of Matrix	Mineral Inclusions and Cultural Deposits (Without Artefacts)/ Orientation / Characterization of Layer / Notes	Interpretation of Layer
1	000-060 ZP.1 (030)	sandy silt; some aggregates; lime-rich; 10 YR 6/6 "brownish-yellow"	limestones, some < 20cm	dump
2	060-135 ZP.2 (090)	sandy silt; porous aggregates < 1cm; lime-rich; 10 YR 6/4 "light yellowish-brown"	few limestones and -gravels; charcoal (HK1: 090cm)	colluvium
3	135-185 ZP.3 (160)	sandy silt; many aggregates of gravel fraction, some < 4cm; lime-rich; 10 YR 6/6 "brownish-yellow"	few limestones and -gravels; charcoal (HK1: 170cm)	colluvium
4	185-210 ZP.4 (200)	sandy silt, partly in porous aggregates < 2cm; lime-rich; 10 YR 6/6 "brownish-yellow"	less gravel than in Layer 5; many angular and edge-rounded limestones around 5cm	colluvium
5	210-220 ZP.5 (215)	sandy silt; lime-rich; 10 YR 8/4 "very pale brown"	high proportion of gravel; angular and edge-rounded limestones < 3cm	calcified colluvium , indicator for a more arid environment
6	220-330 ZP.6 (275)	sandy silt, partly in porous aggregates < 1cm; lime-rich; 10 YR 6/6 "brownish-yellow"	fless gravel than Layer 5; angular and edge-rounded limestones < 10cm, some < 20cm; charcoal (HK3: 340cm)	colluvium

Appendix 3. Geoarchaeological layer description of VP5.

Layer (Locus) No.	Depth (cm) Sample no.(cm)	Matrix (With Ash/Charcoal Components) and Munsell Colour Notation of Matrix	Mineral Inclusions and Cultural Deposits/ Characterization of Layer/ Notes	Associated Artefacts	Interpretation of Layer
1	017-073 VP5.1 (050)	sandy silt/ 10 YR 6/3 "pale brown"	stones < 2,5cm; chaff		Colluvium
2	073-100 VP5.2 (085)	sandy silt/ 10 YR 5/4 "yellowish-brown" with inclusions of 10YR 8/4 "very pale brown"	angular stones < 2,5cm	bones	Colluvium
3	136-150 VP5.3 (145)	sandy silt/ 10 YR 4/3"brown to dark brown" with inclusions of 110YR 8/4 "slightly yellowish brown" and particles of 2.5 YR 4/6 "red"	angular stones < 2cm	bones; some charcoal	Colluvium; palaeosol
4	150-184 VP5.4 (170)	sandy silt/ 10 YR 6/4 "slightly yellowish brown"	large number of angular stones < 3cm	bone splinters	Colluvium; palaeosol
5	184-200 VP5.5 (195)	cf. no. 3	cf. no. 3	cf. Layer 3	Colluvium; palaeosol
6	230-250 VP5.6 (240)	sandy silt/ 10 YR 4/2 "dark greyish brown"	angular stones	charcoal	Colluvium; palaeosol
7	290-300 VP5.7 (295)	sandy silt/ 10 YR 5/4 "yellowish brown"		charcoal; bone splinters	Colluvium
8	340-350 VP5.8 (345)	sandy silt/ cf. above	stones 2,5cm	high charcoal density	Colluvium
9	420-440 VP5.9. (430)	sandy silt/ 10 YR 4/2 "dark greyish brown" mottled with 10 YR 5/4 "yellowish brown", 10 YR 8/2 "white", and 2.55 YR 6/8 "slightly red"	angular stones < 3cm		Colluvium
10	440-460 VP5.10 (450)	sandy silt/ 10 YR 4/2 "dark greyish brown" mottled with 10YR 5/4 "yellowish brown", 110 YR 8/2 "white", and 2.5 YR 6/8 "slightly red"	angular stones < 3cm	high charcoal density	Colluvium; palaeosol
11	480-491 VP5.11 (485)	sandy silt/ 10 YR 10 YR 4/3 "brown to dark brown"	stones, to a large extent distinctly smaller than 1cm		Colluvium
12	491-494	sandy silt/ 5 YR 7/1 "slightly grey"	none		Colluvium; palaeosol
13	494-510VP5.12 (492) VP5.13 (500)	sandy silt/ 10 YR 4/3 "brown to dark brown" with inclusions of 10 YR 5/8 "yellowish brown" and 10 YR 8/3 "very pale brown"	none	flint fragments; high charcoal density	Colluvium; palaeosol
14	510-550 VP5.14 (530)	sandy silt/ 10 YR 4/3 "brown to dark brown" with inclusions of 10 YR 8/3 "very pale brown"	fractured flint and dolomite < 2cm		Colluvium; palaeosol
15	580-590				weathered surface

Appendix 4. Geoarchaeological layer description of VP53.

Layer (Locus) No.	Depth (cm) Sample no.(cm)	Matrix (With Ash/Charcoal Components) and Munsell Colour Notation of Matrix	Mineral Inclusions and Cultural Deposits/ Characterization of Layer/ Notes	Associated Artefacts/ Archaeological Finds	Interpretation of Layer
1	020-070 VP53.1 (050)	sandy silt/ 10 YR 6/4 "light yellowish brown"	very few stones; chaff		tillage soil
2	070-080 VP53.2 (075)	sandy silt/ 10 YR 5/4 "yellowish brown"	few stones		colluvium
3	080-120 VP53.3 (100)	sandy silt/ 10 YR 4/3 "brown to dark brown"	many stones < 2cm; limestone particles	charcoal particles	colluvium, palaeosol
4,5	150-180 VP53.4 (160); VP53.5 (175)	cf. no. 3	cf. no.3		colluvium, palaeosol
6,7	180-220 VP53.6 (190); VP53.7 (210)	sandy silt/ 10 YR 4/3 "brown to dark brown" mottled with 10 YR 6/8 "brownish yellow"	many stones < 2cm		colluvium, palaeosol
8	220-230 VP53.8 (225)	sandy silt/ 10 YR 4/2 "dark greyish"	many stones < 2cm	bone splinters; high charcoal density	colluvium, palaeosol
9	230-260	sandy silt/ 10 YR 5/4 "yellowish brown", some 10 YR 7/8 "yellow"	many limestone particles		colluvium
10	290-300 VP53.9 (295)				weathered soil

Appendix 5. Geoarchaeological layer description of VP54.

Layer (Locus) No.	Depth (cm) Sample No. (cm)	Matrix (With Ash/Charcoal Components) and Munsell Colour Notation of Matrix	Mineral Inclusions and Cultural Deposits/ Characterization of Layer/ Notes	Associated Artefacts/ Archaeological Finds	Interpretation of Layer
1,2	000-085 VP54.1 (040); VP54.2 (075)	sandy silt/ 10 YR 6/4 "light yellowish brown"	many stones		colluvium
3	085-120 VP54.3 (100)	sandy silt/ 10 YR 5/4 "yellowish brown"	many stones < 3cm		colluvium
4,5	120-160 VP54.4 (130); VP54.5 (150)	sandy silt/ 10 YR 6/4 "light yellowish brown"			colluvium
6,7	160-240 VP54.6 (180); VP54.7 (220)	sandy silt/ 10 YR 7/6 "yellow" with an increasing amount of 10 YR 8/2 "white" after 180	limestones		weathered surface

Site Preservation and Site Formation Processes

Hans Georg K. Gebel

Introduction[1]

The Basta site formation and preservation took place in the framework of an Early Holocene sedimentary environment. It controlled the conditions of the formation processes by providing their material conditions and resources, and they were subjects of human impact and reaction to their changes during the habitation period. The post-occupational preservation and processes were ruled by the changing conditions of the sedimentary environments. Thus, we see the Basta site formation and preservation in a sequence of specific local processes, which had influential human episodes in the Late Pre-Pottery Neolithic B (LPPNB), the Final Pre-Pottery Neolithic B (FPPNB), and the Pottery Neolithic A (PNA). These occupations were events that modified the local natural sedimentary and erosional events, as well as the habitats of plants and animals in the area. This makes it sometimes impossible to clearly separate archaeological and natural causes for the formation and preservation of a Neolithic deposit. Such evidence always advised us to use a geoarchaeological approach in explanation. Contemporary sites, *e.g.* 'Ain Jammam, al-Baseet, Wadi Fidan, Ba'ja, es-Sifiya, and others, may show similar patterns in their formation and preservation, but it not necessarily means that they had the same conditions.

Basta, like the aforementioned Early Neolithic sites (see the Editors' Introduction, this volume: Fig. 5), provides the advantage of studying a site not much affected by later occupations. Disturbances from the modern village occupation easily can be identified, and thus are not much a source of misleading interpretation. Several major questions related to the striking features of Basta's formation and preservation (*e.g.* the tall-standing walls, gullies of the palaeorelief, the huge Post-PPNB accumulations of both cultural and natural

[1] This contribution benefited much from the work of Ulrich Kamp (*cf.* this volume). The geoarchaeological information used here was compiled jointly by U. Kamp and H.G.K. Gebel. It is presented in Kamp, this volume (*cf.* App. 1-5 for P1, P2, VP5, VP53, and VP54), and in *The Stratigraphy and Locus Data* by H.G.K. Gebel, forthcoming in *Basta* II. *The Architecture and Stratigraphy* (for Area A, NW- Section; Test Units C208 and C217; B103). The description of the NE- Section of Area A and Cut 8 is to be found in this contribution (App. 1-2).
All dates used in this contribution are dates BC (calibrated radiocarbon dates before Christ).

debris) can only be approached by the sedimentary environment perspective. These questions are to be discussed in this chapter, and approaches are made to answer them:

1) How the palaeorelief influenced the geoarchaeological stratigraphy?

2) How we can reconstruct the settlement, its intra-site pattern and marginal areas on the slopes?

3) What is the explanation for the huge deposits of either settlement debris or natural layers above the ruined wall tops in Area A? (Plates 1.A, 6A, App. 1; Gebel 1996: Plate 1.A)

4) Which conditions caused the well-preserved village architecture, with walls still standing at heights of up to 3.80 m? (Plates 1.C, 3.B)

5) What is the explanation for the huge mud and debris flows through and over the LPPNB ruin in Area B, of our so-called rubble layers? (Plates 1.B, 2.B-C, 3.A)

6) How the huge silt accumulations of Area C can be explained?

The discussion of the geomorphological site setting and its geochemistry is subject of the U. Kamp's contribution in this volume. In the following we interpret these and others results from the geoarchaeological perspective of Basta's site preservation and formation.

Localities and Topography of the LPPNB Occupation

There are limited chances to observe the present-day topographical units within the modern settlement of Basta. Thus our area designations in Basta were just "operational" designations for the zones of excavation activities. The topographical units of the Northwestern slopes of the Wadi Basta, in which the Early Neolithic deposits rest, are covered by modern houses, compound walls and garden vegetation. To some extend, the units can be identified from the site's topographical map (Kamp, this volume: Fig. 1):

1) Area A: a slope between a small gully (a present-day village street) in the SW and the outcrops/ banks of quartzite veins in the NE: length *c.* 150 m. The lower parts of the slope are very steep and border Wadi Basta. The upper parts of Area A are rather flat and pass at the 30 m contour line into the flat topography of the former fields in Area C. (Fig. 1, Plate 1.A)

2) Area B: a steeper and spur-like part of the wadi's Northwestern slopes between the small gully (a present-day village street) in the NE and the flat slope areas in W and SW: length *c.* 100 m. In the SE it is bordered by steeper parts touching the floor of Wadi Basta. In the NW it meets a flat area (Auda's property) which topographically belongs to Area C. The spur-like topography of Area B seems to be the result of two Early Holocene drainages into Wadi Basta from the NW. (Fig. 1, Plate 1.B)

3) unnamed area: flat slopes above the present-day spring, located WNW – NNE of 'Ain Basta: length *c.* 180 – 200 m. Most probably its flat topography was formed by the Wadi Basta drainage which (here named Wadi Muheidirat) shifts its direction near 'Ain Basta from roughly West – East to the East (*cf.* also Kamp, this volume: Figs. 2 and 3.C). In this part of modern Basta, the first houses were built after the old village (NE of Area A; Plate 5) started to be deserted in the 60ties of the last century. Villagers recorded that they found deep archaeological deposits with strong walls characteristic for our LPPNB walls NNW of 'Ain Basta (*e.g.* the building of a well by Abu Ibrahim met such still at a depth of *c.* 5 m). (Fig. 1)

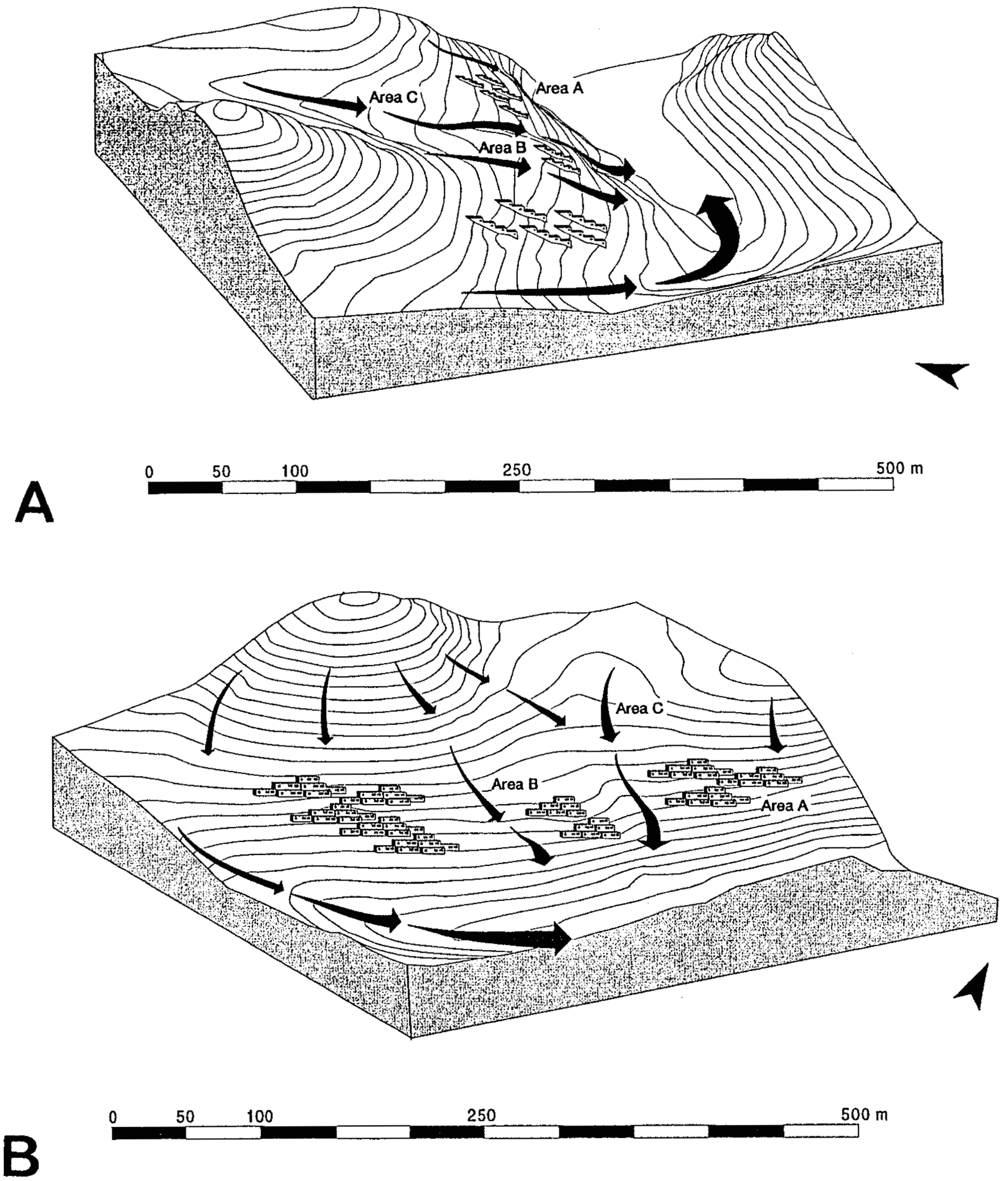


Fig. 1. Supposed drainage pattern in LPPNB Basta.
A: view from WSW, B: view from SSE (graphs by U. Kamp).

4) Area C: flat terrace-like triangle with its sides measuring approx. 100 m, extending to the North between the higher summit NW of modern Basta and a lower elevation NNE of modern Basta. (Fig. 1)

Compared with the situation in 1986-1988 (Kamp, this volume: Fig. 1; Gebel, Present-Day Site Setting ..., this volume: Plates 1.A-B, 2-4), modern Basta in 2003 was occupied by almost a doubled number of compounds/ houses. The disturbances of Neolithic layers continued in Basta after the end of the excavations in 1992, but worst damages were and are prevented by the Department of Antiquities.

The other topographical units in the modern village of Basta provided very few traces of the Neolithic. The slopes bordering the street SW of P1 contained Chalcolithic remains, and on the hill's surfaces NNE of P2 scatters of a Pottery Neolithic were found. The upper slopes and summits opposite the old village of Basta, the Southeastern slopes of Wadi Basta, bear the remains of large Nabatean buildings.

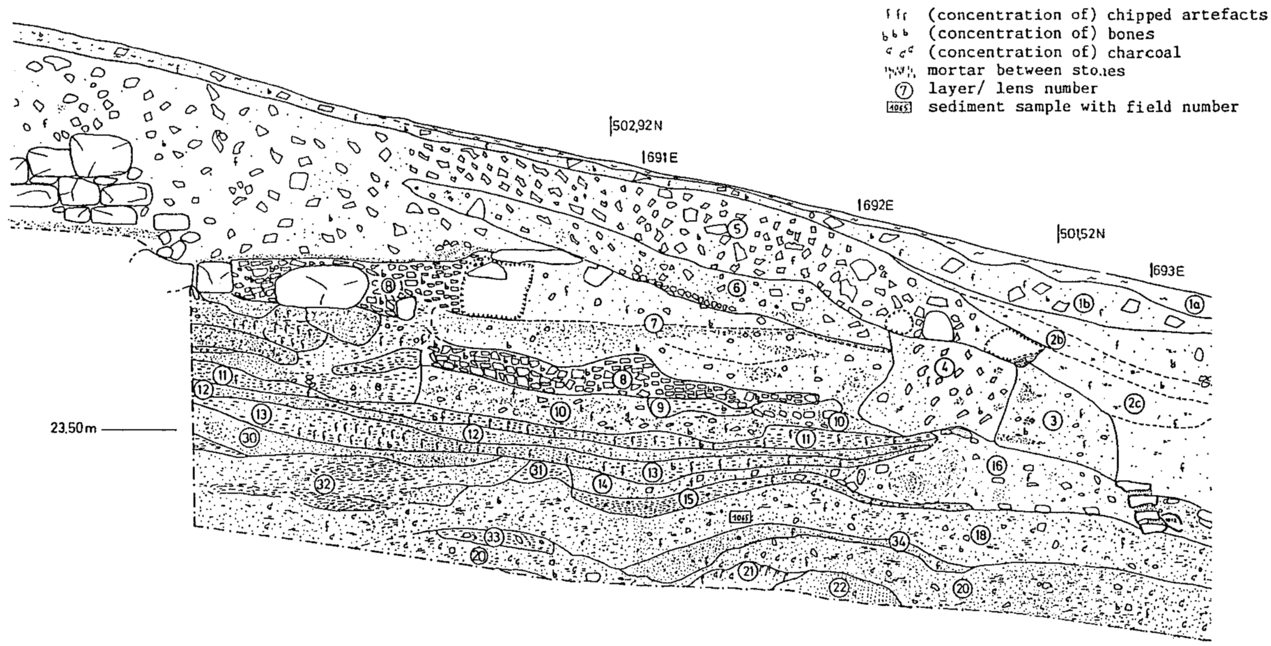


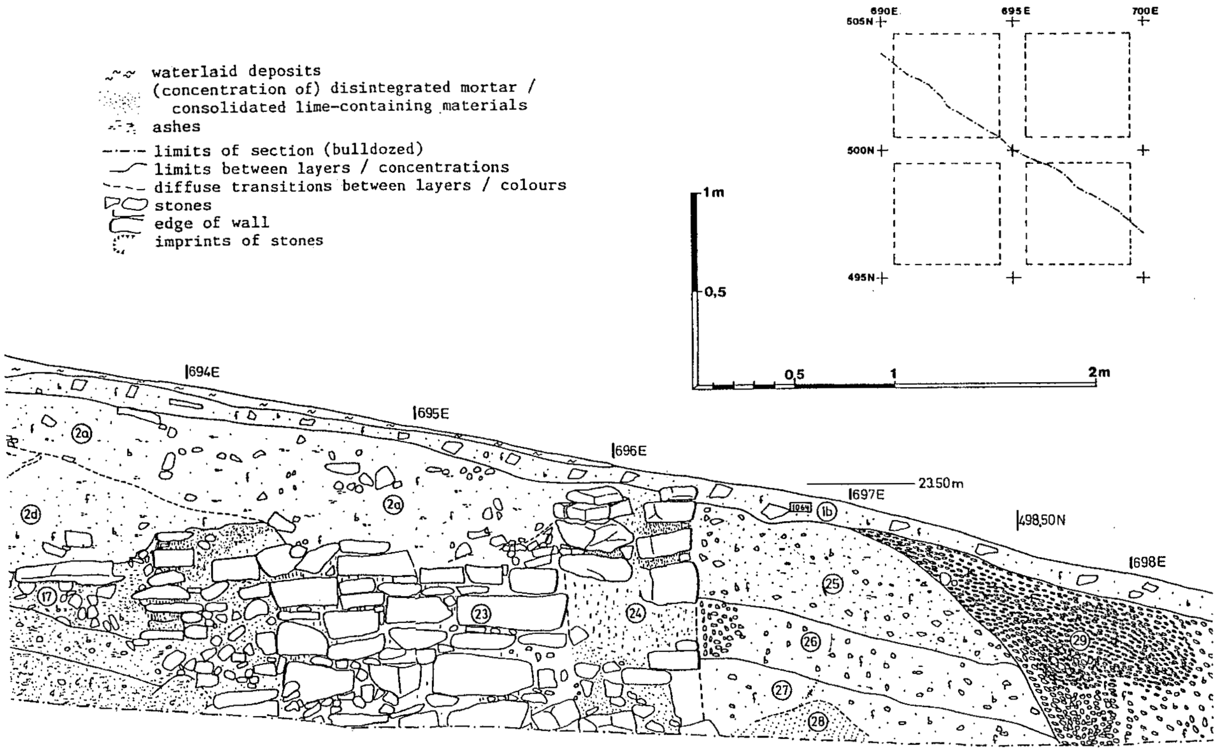
Fig. 2. NE- Section of Area A (see. App. 1)

The LPPNB inhabitants of Basta were topographically not hindered to expand their village onto surrounding territories. Site surveys revealed that at least the architectural LPPNB occupation was restricted to the NW wadi slopes, and outliers were not found. However, an architectural occupation stretching underneath the old village of Basta cannot be excluded.[1] Spatial constraints and pressure may thus not have existed for topographical reasons, but they of course can develop in an Early Neolithic community for social reasons (population dynamics, property management, arable land degradation, *etc.*). (Gebel 2002)

Functional units so far identified at the site are domestic areas on artificial terraces, built into the NW slopes of Wadi Basta in Areas A, B, and the unnamed area (*cf.* above). Between the housing areas, which may not have been occupied at the same time, dump areas of different character seem to have existed. House ruins or even deserted living quarters may also have served as dump areas and burial grounds. E.g. the "channel" burials or the "collective burial" in a room of Area A (Schultz, In: Nissen, Muheisen, and Gebel 1987) must not be related to the inhabitants of a "living" house, but could be burials using the protection of a ruin. Dumps not only developed between these living quarters. They also appear to be re-deposited and further used when they moved downslope onto decaying settlement parts (Fig. 2, App. 1; Gebel 1996: Plate 1.A). The site's fringes, touched only by the soundings and drillings in Area C, were used for all sorts of open-air activity, among which are flaking ateliers and garden work. The more passive use witnesses all sorts of disposal: carcass and garbage disposal, leftovers from building (materials), burials (Gebel, forthcoming).

---

1 Quite a proportion of the wall stones in the old village is of LPPNB origin, but they also could have been collected from the eroded and deflated slopes containing the major part of the LPPNB settlement.



Natural Processes and the Palaeorelief

As stated above, anthropogenic deposits, or archaeological layers respectively, cannot be understood isolated from the natural sedimentary framework they took place in. Here, we separate the natural and anthropogenic processes for the sake of clearness, although we are aware that most of the depositional processes during an occupation are the result of related natural and human activities. For the formation of such a palaeohabitat the major natural influences have to be known. In the case of Basta this means the evaluation of weathering processes, their products or material masses, and the agents of transportation. Another very important aspect for the interpretation of the site formation and preservation is the understanding its palaeoterrain. For Basta, only limited information is available on the palaeorelief (*cf.* Kamp, this volume). However, for the immediate questions related to the palaeotopography and architectural preservation in Area B -and thus to domestic security in terms of water flushes attacking the LPPNB buildings on the terraces- casual and systematic drilling was applied. Especially the drilling cores from Area C helped much to understand its palaeorelief, showing how much a present-day surface in Basta can mislead interpretation of potential intra-site drainage impacts.

To which extend the LPPNB climate could have affected the sedimentary framework of LPPNB Basta? The information on the climatic development in the Southern Levant between 7600 and 6900 BC (LPPNB) remains unreliable. The general understanding is that after a humid period a gradual desiccation took place from 8000 BC. Questioning the local relevance of the Southern Levantine macroclimatic situation and lacking solid evidence, the Basta research has followed the working premise that the climate wasn't much different from today. Instead, the preserved moisture storage capacity of a still intact soil cover in the Basta catchments provided the ground for extensive open forests and arable land "worth" a mean annual precipitation of 50-100 mm higher than today. Under such conditions, erosional impacts on the LPPNB cultural sedimentary environments must have been less severe than in post-occupational periods, if we disregard the possibility that an ongoing local overexploitation of the Basta soil resources already during occupation resulted in soil degradation, and created localities endangering the built terraces.

Physical weathering products (angular rock detritus from block size to sand/ silt) played the major role among the material masses developing in the site's catchments (*cf.* Kamp, this volume); thermal (frost, heat) fragmentation is the most common type of physical weathering. Chemical weathering is of insignificant importance for the amount of depositional material originating on-site. Aquatic slope erosion is another and most important type of natural influence on Basta's formation and preservation processes. It permanently contributed to denudation, accumulations, and weathering during and after the occupations. Due to the expected better moisture storage capacity in the area during the LPPNB occupation, aquatic slope erosion may not have affected the settlement and its suspected garden area (Wadi Basta) to the same extend as today. However, torrential rainfall is common in the area, and it may have resulted in episodic accumulations of coarse-grained detritus. These were most likely removed seasonally by the inhabitants, especially where such deposits conflicted with domestic and horticultural aims. Part of the annual rainfall falls as snow and melts over a longer period, and is thus not causing larger accumulations.

Aquatic slope erosion must have been also responsible for the considerable early - mid 7th millennium BC sedimentation, when tremendous amounts of detritus and mud flows passed through and above the LPPNB ruins near the drainages (*cf.* below), depositing and re-depositing our so-called rubble layers (Fig. 1; Plates 2.B-C, 3.A).

Aeolian deposition also played an important role in the formation of the site's sedimentary environments (*cf.* Kamp, this volume), both during occupation and in the post-occupational deposits. The stratigraphy of Area C witnesses a high proportion of aeolian silts (> 30 %; *cf.* Kamp, this volume), accumulated here by meters; this phenomenon is not sufficiently explained. Dust storms are a common element of weather in the area, and they contributed considerably to the fine-grained components of Basta's stratigraphies. It has to be expected that the aeolian material reached the settlement's area from far, and not originates from the site's "substance". In some cases, the sections even contained such aeolian events preserved *in situ*. But the dust storms are also responsible for the aeolian erosion so well attested for Basta's site formation and preservation processes. But it seems to be difficult to calculate the relation of the aeolian "in- and output" at Basta.

The palaeorelief of Basta is rather unknown. Bedrock was touched only in the NW corner of Area A and along the gridlines 535N, 545N, and 565E (*cf.* Kamp, this volume: Figs. 1, 7-8). The bedrock of Basta is composed of dolomite, limestone, weathered dolomite and limestone, sometimes of feldspars and quartzite; at some spots in the side valleys marl deposits may outcrop. Weathered bedrock was reached after 2.1 and 2.5 m by the drillings carried out by H.J. Pachur and M. Goschin in Area A (from the level reach by excavation, *cf.* Pachur 1987). Drillings in Area B did not touch bedrock after getting halted by structures 3 m below the excavated levels.

For the sedimentary history at Basta, the information from Area C appears most interesting. It shows that a quite pronounced valley can have completely disappeared in the Basta area since the Early Holocene. It is buried under this mysterious accumulation of fine-grained material with high proportions of aeolian silt, reaching a height of 5.90 m in the valley's center. The lower parts of the stratigraphy (Kamp, this volume: Fig. 7-12, *cf.* also Gebel, forthcoming) in Area C contain archaeological *in situ* layers, probably all representing

Plate 1.A. Basta Area A in 1988, from SE.<*photo: M. Nissen*>

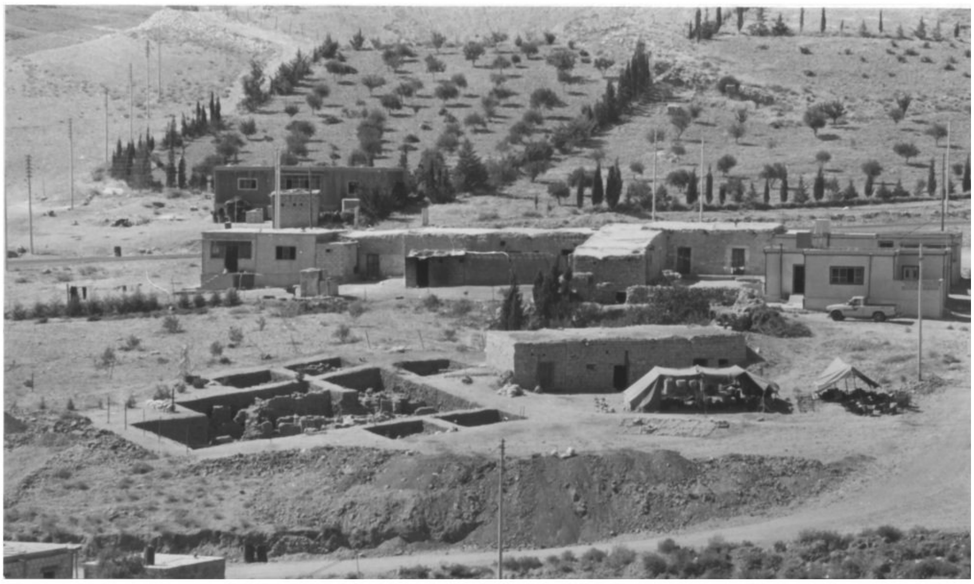


Plate 1.B. Basta Area B in 1988, from SE.<*photo: M. Nissen*>

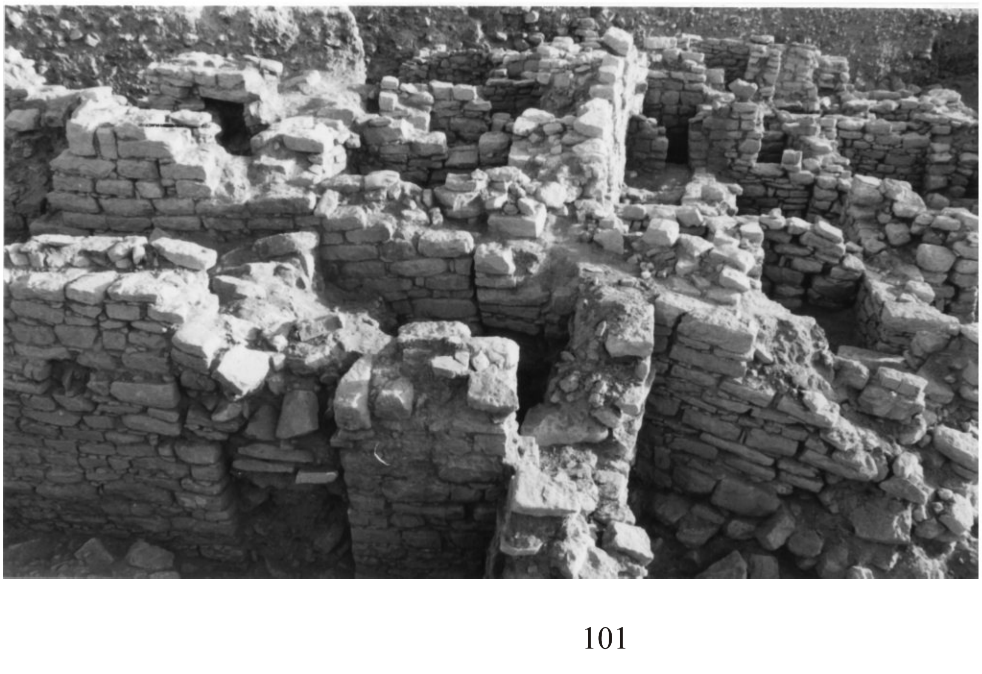
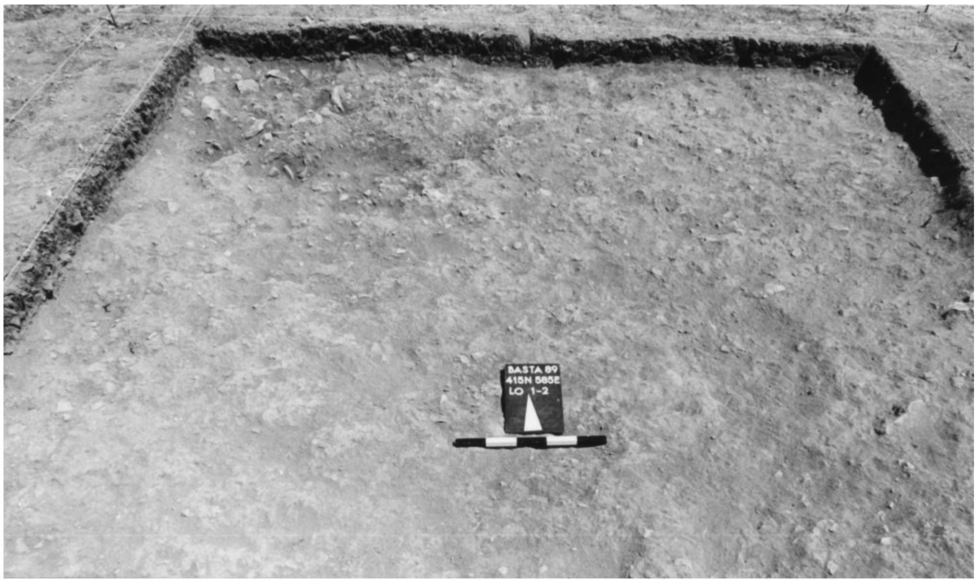


Plate 1.C. Basta Area B: density of walls. <*photo: G. Sperling*>

Plate 2.A. Basta Area B: characteristic fine grained topsoil/ colluvium in the squares. <*Photo: G. Sperling*>



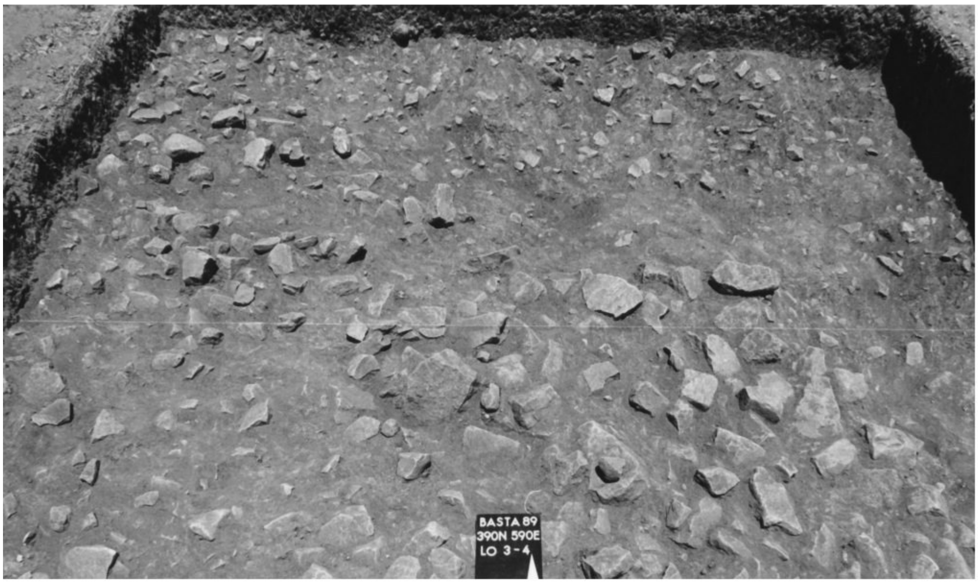


Plate 2.B. Basta Area B: top of the characteristic “rubble layer” in the squares.<*photo: G. Sperling*>

Plate 2.C. Basta Area B: Example of preserved LPPNB wall tops in relation to the “rubble layer” (2) and topsoil (1)., <*photo: G. Sperling*>

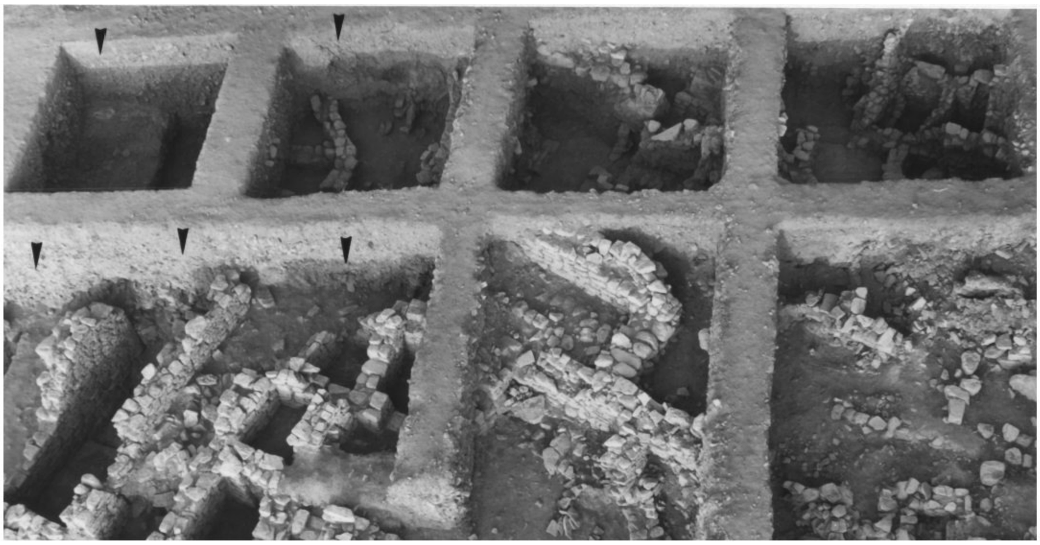


Plate 3.A. Basta Area B: Northwestern parts of excavation showing the "rubble layers" (arrows) and the different preservation heights of walls. <*photo: Y. Zu´bi*>

Plate 3.B. Basta Area B: preservation of a larger room with *in situ* evidence of an upper floor (arrows mark the supports for the ceiling`s beams) and ist entrance to the sub-floor "channels" (cf. 1). <*photo: Y. Zu´bi*>

settlement fringe activities (human and animal carcass burial, flaking ateliers, garden areas, fire places, ash/ charcoal/ kitchen dumps).[1]

Until the start of the LPPNB occupation, the palaeorelief of Basta was mainly formed by gully clints which transported weathered materials down into Wadi Basta (*cf.* Kamp, this volume). Mainly aquatic slope erosion shaped the palaeorelief by accumulations of colluvials and alluvials in depressions and on the wadi banks and floors. From the time of occupation, we have to assume that the inhabitants reacted to such natural drainage processes by building protective (terrace) walls, barriers, and ditches. At least two major drainages (Fig. 1) must have affected the settlement area of Basta: one must have started in Area C and passed the domestic area approximately where the present-day street between Areas A and B runs downslope (*c.* 30 m NE of Area B; *cf.* Kamp, this volume: Fig. 1). The other drainage or wadi must have arrived from the slope depression of the hill some 120-160 m NW of Area B, and then passed through the NW side of Area B (*cf.* Kamp, this volume: Fig. 1; Fig. 1 of this contribution). Here it could have influenced the preservation of the terraces and their architecture, or building planning respectively, during the LPPNB. After the LPPNB occupation, in the early to the middle 7th millennium BC, a considerable mass transportation went through this drainage and eroded the ruins of the LPPNB architecture bordering this gully (*cf.* the Editors' Introduction, Fig. 7; Plate 1.B: squares to the left in the excavation area).

These mud and debris flows are a common feature for the preservation of LPPNB sites in Southern and Central Jordan[2]. Very often it remains unclear, from where all their material originated. Most of the catchments appear to restricted for the amount of the transported masses, and sometimes the present-day topography does not allow imagining how these accumulations arrived at the spot of their deposition. Seen from Basta, these are several strong sedimentation events, possibly taking place within a rather restricted period. The Basta evidence suggests that they must have started shortly after the abandonment of the settlement, since the walls of the ruin were still standing tall. An additional argument for a date between 6900 and 6500 BC is the finds in the flow deposits, culturally belonging to the FPPNB. In the upper parts, however, already pottery occurs which could be of PNA origin (M. Muheisen, N. Qadi, pers. comm.). To which extend these flows relate to the recently discussed so-called 8.2 ka aridity event (B. Weninger and G. Rollefson, pers. comm.) must be subject of further discussion. However, the accumulations attest more a slow and "porridge"-like transport, indicating that the amount of rain/ slope runoff was just sufficient for a constant sedimentation. Thus, the flows of Basta may represent a period of progressing aridity. U. Kamp (this volume) has observed "parallel to this a stronger aeolian accumulation of fine material", an observation which also could refer to drier conditions. The recent suggestion by H.J. Pachur (Free University of Berlin), and independently by C. Hannß (University of Tübingen), to see in these huge mud and debris flows even the reason for the termination of the PPNB dwellings, deserves also further discussion.

Anthropogenic Processes

The semi-arid setting of Basta represents an environment sensitive to human impacts. This not only concerns the Early Neolithic land-use in the site's vicinity, it also has direct conse-

---

[1] In the western part of Area C, Middle Palaeolithic artefacts were deposited from the slopes to the W, resting here above the Early Neolithic layers.

[2] It has to be emphasized that these mud and debris flows certainly contributed to the excellent preservation of LPPNB ruins, since they rapidly buried what had survived after abandonment. However, this is not the only reason for the excellent preservation of most LPPNB structures. Among many other reasons, the long use of the major walls "growing" vertically during the occupation and the intentional filling of rooms during the "rejuvenation" of groundplans (Gebel and Hermansen 2001) are the major reasons responsible for the good preservation.

quences on the type and chances sedentary life would have at the locality. In the nineties of the last century, much explanation of the so-called *hiatus palestinienne* focussed on environmental explanations for the collapse of many L-FPPNB settlements around 6900 BC. But was the human impact on the environment of the hypertrophically growing settlements really so severe that larger regions in Southern Jordan shifted from sedentary to mobile life? C. Becker, at least, did not find faunal evidence for this notion (Becker 1999, 2000). Although we do not exclude degradation processes in the site's immediate neighbourhoods due to overexploitation (monocultures, deforestation, soil erosion), they may not have been a sufficient cause for the abandonment of the site at the end of the LPPNB[1]. The adaptations into mobile life modes (herders) by the end of the LPPNB in the Basta area could have been more a social adaptation than an environmentally caused change. The large population may not have found the social answers quick enough for the fast growing community and its developing internal conflict levels and complex socio-economic and ecological rivalry with neighboring settlements (Gebel 2002). The *hiatus palestinienne* may turn out to be primarily a "social implosion" of the LPPNB, starting in sensitive semi-arid environments like Basta. The background of the LPPNB abandonment of Basta, however, may only be of limited help to understand the features of the site's early preservation.

The most influential anthropogenic impacts on Basta's natural site conditions are the topographic modifications of the palaeorelief by terracing the Northwestern slopes of Wadi Basta. These terraces created the building grounds for the houses.

It is quite clear that the inclination of the bedrock under the domestic Areas A and B was much steeper than the inclination suggested by the LPPNB house terraces and the present-day surfaces. This certainly is a major parameter of the LPPNB site formation, and a fine example how anthropogenic processes change a site's topography. The preservation of the LPPNB inclination until recent times also has anthropogenic causes. The Early Neolithic population brought to the settlement much solid material, *e.g.* wall stones, beds of flint debris, which later helped to form a dense pavement on and near the surface, hindering deflation. Plate 6.C illustrates such an example of a rather undisturbed stone pavement in Basta; Plate 6.A-B shows how building plots created prior to 1986 destroyed such a protected surface.

The excavation Areas A and B of Basta are situated in slope settings some 17-24 m above the bottom of Wadi Basta; both areas do not have larger catchments which produce much weathered material or bring fluvial accumulations. Pronounced accumulations (*e.g.* the so-called rubble layers, containing also eroded wall stones of the LPPNB architecture) occur above the ruined top of the LPPNB walls where drainages had formed in post-occupational times. It seems that the earliest structures in Area A were founded either on the dolomite bedrock, or its weathered surfaces, or on a layer of settlement debris resting on these. The preserved height of the architectural remains in Area A seems to reach some 2.5 m. Apart from the main domestic occupation of Area A more architectural remains existed in the upper stratigraphy of Squares 505N/ 690-695E (Fig. 2: Locus 24; Gebel, Muheisen, and Nissen 1988: Fig. 6). Their stratigraphical link to the main occupation and to the wall remains Locus 23 in the NE Section (Fig. 2, App. 1) isn't clear, and the masonry differs from that of the typical LPPNB walls (many cobbles instead of the tabular/ dressed wall stones were used). It could be that we deal here with very latest phase of the PPNB occupations at the site (Gebel, forthcoming). However, it is very clear from the NE- and NW-Sections (*cf.* Fig. 2,

---

[1] Basta Area B was occupied in the FPPNB, represented by flimsy walls below and in the "rubble layer" and *in situ* horizons (like *e.g.* animal bone middens, fireplaces) in the rubble layer. The arrowhead inventory clearly differs from the LPPNB layers, and stands for an intermediate phase between the Yarmoukian and LPPNB. Isolated pottery sherds, presumably from the PNA, could be intrusive. A similar site was found by D. Vieweger close to the entrance of Siq al-Ba'ja (Bienert, Lamprichs, and Vieweger 2002); it is probably the location of those groups who were using the area after LPPNB Ba'ja was deserted.

Plate 4.A. Modern Ácoma pueblo, New Mexico. (from: Muench, Pike, and Waters 1986)

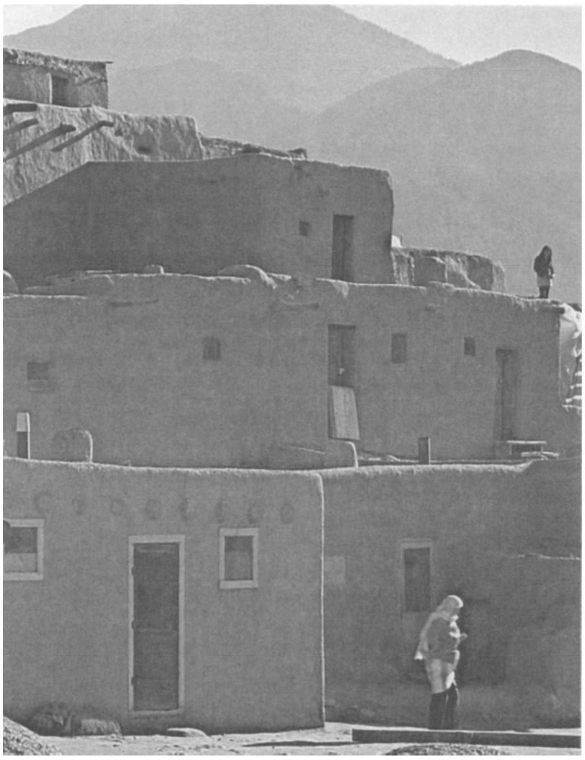


Plate 4.B. Modern Taos pueblo, New Mexico. (from: Muench, Pike, and Waters 1986)

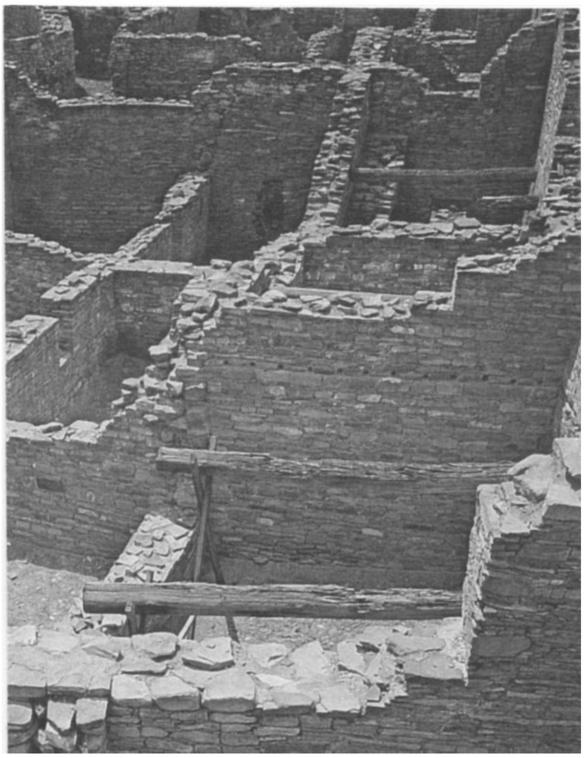


Plate 4.C. Ruin of Chettro Kettle pueblo, New Mexico. (from: Muench, Pike, and Waters 1986). *<Note the raised window-like wall openings between the rooms; buildings have two or three floors.>*

Plate 5.A. Basta: old village with the gardens of Wadi Basta in 1988 (foreground), from SE. *<photo: M. Nissen>*

Plate 5.B. Basta, old village: aerial view in 1988. *<photo: M. Nissen>*

Plate 5.C. Basta, old village: view of a house in 1988. *<photo: M. Nissen>*

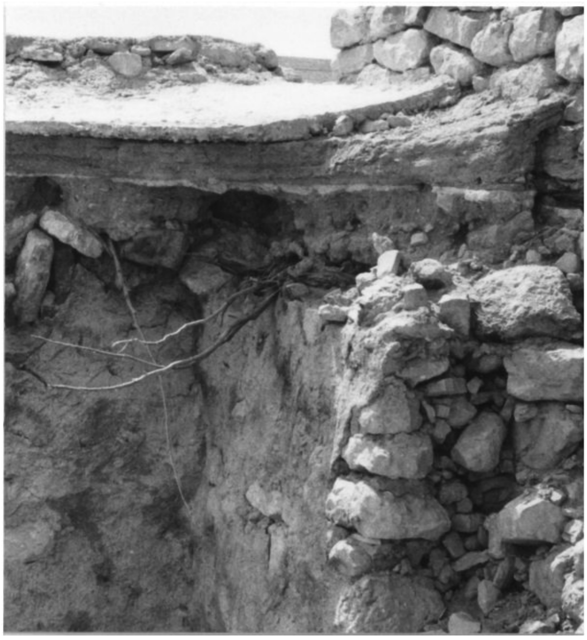


Plate 5.D. Basta, old village: example of decaying roof and wall in 1988. *<photo: M. Nissen>*

Plate 6.A. Basta: the building plot which was choosen in 1986 as Area A for excavation. <*photo: G. Sperling*>

Plate 6.B. Basta: spot of H.G.K. Gebel´s initial section trimming in 1984, using a villagers´ cut into the layers of the LPPNB village (*cf.* Cut 13 in Fig. 4, Editors´ Introduction). <*photo: M. Lindner*>

Plate 6.C. Basta: character of "undisturbed" site surface between the houses in 1986. <*photo: M. Lindner*>

App. 1, Plate 6.A; Gebel 1996: Plate 1.A; Gebel, forthcoming), as well as from the excavated squares in the Northern corner of Area A that these spots on the slope were garbage/ dump zones of nearby domestic quarters; colluvials got mixed into the deposits, too. The dump also was used as a burial ground, a pattern, which not seems to be rare in Basta (*e.g.* the evidence from Cut 13 (App. 2; Gebel 1986; Röhrer-Ertl, Frey, and Newesely 1988; or the evidence from basal C217). The Northern corner of Area could be a testimony that Basta expanded by its architecture "migrating" into marginal dump areas of the site.

The buildings on the slopes of Basta acted as barriers for the mixture of cultural debris and natural sediments that permanently moved downslope towards the Wadi Basta. Although we have to expect that the inhabitants cleared areas by re-dumping and levelling (*cf. e.g.* the horizontal Deposits 8-13 in Fig. 2), part of the settlement garbage and non-recycled building material remained in the domestic parts and accumulated here. This contributed to the rise of intra-mural floors and the surfaces of open spaces. In general, we expect a rather long use of the domestic units in Basta. If this assumption is correct, we possibly deal with a considerable cleaning activity in the used architecture; not much evidence shows the raising of floors during occupation. What we have are room fills build up by the typical settlement debris, separated by deposits from fallen wall parts and ceilings of these rooms (Table 1). This indicates that the inhabitants used the ruins to fill them with settlement debris including leftovers from nearby building activity; it also suggests that ruins existed in the settlement while other parts of the settlement were inhabited.

The general sequence of the events involved in the formation of the occupational stratigraphy at Basta is presented in Table 1[1]. It shows an ideal sequence, which explains more the relation of involved natural and anthropogenic sedimentary events. An actual sequence is more complex, and sometimes impossible to reconstruct completely since not all events may have left traces, or evidence left the archaeological record again. However, it is astonishing to see how stable groundplans in Basta were. Other LPPNB sites, especially those with steeper slopes, witnessed a lot of alterations of the original groundplans through added walls and reinforcements, blockages and insertions of wall openings and staircases, floor raising, the establishment of a split house level or a second storey, *etc.* These many expressions of a "living" architecture appear less pronounced in the excavated areas of Basta. Of course, alterations of groundplans relate to structural instability, but they also could be an expression of the rate of social adaptations reflected in groundplan modifications.

Other important aspects of anthropogenic site formation are the specific LPPNB building techniques; structural innovation seems to play a minor role in Basta. The characteristics of foundation and wall construction (see below) could cause structural instability which influenced the lifetime of buildings, and subsequently the mass of intra-site accumulations of (non-recycled) building materials. Contrary the notion of U. Kamp (this volume) that

> "Neolithic humans were aware of erosional variability, soils and bedrock composition: the early settlements were built on the (exposed) ridges, whereas softer beds with their deeper soils were used for agriculture."

our recent picture from the LPPNB sites in Jordan including Basta is much different. Except[2] for the moisture regulating function of the terrace substructures made of dry stone masonry

---

[1] The designations of the event classes (1a-6) refer, for the sake of comparability, to those already published for Ba'ja (*cf.* Gebel and Bienert *et al.* 1997: Table 2); the events, however, could be of a different nature at both sites. How this generalized stratigraphy appears modified in specific contexts in Basta is shown by examples in Gebel, forthcoming.

[2] Here it has to be mentioned that bedrock foundations of walls/ buildings were hardly observed in LPPNB sites, due to the fact that excavations mostly did not reach these depths. However, in Ba'ja bedrock foundation is attested,

(the so-called sub-floor "channels" of Basta, 'Ain Jammam, es-Sifiya, al-Baseet) not much "foundation care" can be observed for the LPPNB buildings in Jordan. Substantial walls appear set without proper foundations into loose sediments (*e.g.* Ba'ja) or debris layers (all sites), and buildings started to lean downslope during their lifetime due to the weight of their mass and the inclination of the slopes. Although considerable efforts in structural mending and supports (buttresses) are observed for LPPNB wall maintenance, not only on extreme slopes like in 'Ain Jammam and Ba'ja, quite a degree of ignorance for statics needs is attested in all LPPNB sites: We may speak of a restricted statics competence in LPPNB planning, building and maintenance. However, we have to consider that architectural experience goes back in the area for only *c.* half of a millennium, and that the LPPNB structures are the first highly complex architecture in existence – a complexity not reached again in the following millennium. Even the construction of the typical LPPNB double-faced walls by only runners, and walls joints without bonding, shows that structural instability characterises the architecture. A hitherto neglected argument for the LPPNB architectural instability is "weight": The small room groundplans, wall thicknesses of up to 90 cm (in Basta!), massive buttresses, split floor levels/ second storeys, *etc.*, created masses and weights on the terraces difficult to survive for longer. Another major reason for the instability of the substantial and repair-intensive architecture seems to be the combination of socially rooted space constraints in the settlement and the subsequent need to expand on insecure strata or to add floors. This increases the horizontal and vertical architectural density (*e.g.* Plate 1.C), adding more to the high stone concentration per cubic metre in such settlements. Depending on the maintenance behaviour and other social aspects of house use and stone recycling, this stone mass is of major importance for the growth of cultural sediments in an LPPNB settlement.

The "sliding value" of LPPNB architectural preservation (*cf. e.g.* Gebel and Bienert *et al.* 1997: 232-233), which is most important for a settlement's security and preservation, appears to be a comparatively less important factor for Basta. However, Basta is situated in a zone of seismic activity (2-8 earthquakes/ 9000 sq. km/ year with magnitudes from 4.5 – 5.5; Gebel 1992), resulting from tectonic movements along the Rift Valley. Although seismic activity is more a natural impact on a site's preservation and thus formation (adaptive planning in building, renovation, re-building), the human fear of such potential catastrophes must have found expression in relevant measures influencing anthropogenic site processes. In Area B we may have evidence of damage by an earthquake (wall clefts, a buttress build in support of the wall). But all such evidence, also from other LPPNB sites, could also result from the aforementioned slope pressure and sliding slope strata. Of course, such existing instabilities easily would get enlarged through even minor seismic influence, which normally wouldn't have caused damages. Thus, we consider the potential seismic impact on the use cycles of LPPNB houses at Basta as an important parameter of archaeological deposit formation and preservation.

Other influences on site preservation, not discussed in detail here, include: field clearance activities by prehistoric and historic farming (through which stone piles accumulate and erode; evidence of such in Basta's rubble layers), agricultural terracing, destroyed stone pavements, and topographical impacts these activities had on erosional energy. A local example of subrecent field clearance is seen in Gebel, Present-Day Site Setting ..., this volume: Plate 5.C.

---

and appears to have much to do with intra-site space constraints (houses established on exposed bedrock overlooking deep gorges).

Table 1. Generalized stratigraphy as attested in the LPPNB housing areas of Basta (Note: Not all deposits/ events need to be represented in one location.).

	Deposit	Event Class	Position
1a	surface pavement: dense and unstable pavement of LPPNB wall rubble and artefacts on the slopes; pavement protects layers underneath; rarely higher preserved LPPNB wall tops are part of the pavement (*e.g.* in upper parts of NE Area A)	deflation and downslope aquatic erosion; destroyed in spots by recent construction/ building activity (This remark concerns all the event classes.)	surface above topsoil; higher concentrations of pavement elements at the slopes' bottoms
1b	topsoil: 15-50 cm thick, fine grained material with finds	very limited soil formation	topsoil/ colluvium, covering most of the site
2	sequence of mud and debris flows ("rubble layers"): may reach thicknesses of 200 cm (considerable variation in thicknesses), carries stone rubble and finds of all sizes (but fist- to head-sized stones dominate); contains or is related to FPPNB and PNA artefacts, wall constructions and fireplaces, remains of field clearing piles ("Lesesteinhaufen"); higher preserved LPPNB walls could reach into the rubble layers	predominantly aquatic downslope erosion of building and settlement debris/ ruins from the upper housing terraces or (re-) deposited cultural sediments; anthropogenic impacts (fields, field clearing piles, stone "quarrying" by squatters for LPPNB wall stones)	over the ruined wall tops of the LPPNB architecture or filling depressions inside the LPPNB ocupation
3a	uppermost room fills: material of latest collapses and decay of walls / ceilings/ roofs mixed with colluvial material/ the material of the mud and debris flows of 2 arriving from further upslope	collapse and decay of last exposed walls/ ceilings/ roofs inside and outside rooms, in spots with earliest share of redeposited (cultural) debris and mud arriving from further upslope (events shortly after the end of the LPPNB occupation)	depending on the topographical position of the room: central to upper room stratigraphy (intramural or laid against preserved walls)
3b	central parts of room fills: composed of material from tumbling walls, decaying wall plaster, and upper floor/ ceiling/ roofs with their inventory; may contain deposits influenced or created by ruin squatters	rapid filling of the room interior by the structure's own debris; lower fill may contain temporary floors, fireplaces or other evidence of LPPNB ruin squatters, *e.g.* wall stone extractions (immediately after the end of the LPPNB occupation)	major (central) part of room stratigraphy
4	lowermost room fills: shallow layers with temporary floors and high density of cultural debris and artefacts/ animal bones/ other organic matter, representing last permanent occupation and/ or ruin use (mostly food processing and preparation, burials)	earliest products of collapse and decay overlie/ mixed with the evidence of the last permanent room occupations and/or the remains of LPPNB squatters; secondary use of houses (*e.g.* as burial ground?)	lowermost room stratigraphy above earliest floors
5	*in situ* deposits related to the original room functions: food processing and preparation, burials, storage, *etc.* (disturbed by events in 4)	related to room function in the LPPNB community	near-floor room stratigraphy
6	building of houses and altering/ maintenance of structures during use (insertions of walls, buttresses, stairs, window-like wall openings; blockage of passages and windows; plastering/ re-plastering; raise of floor levels by intentional fills; establishing split house levels/ second storeys?; *etc.*); accumulation of immense quantities of stone materials on the artificial terraces	LPPNB planning, building, re-building/ renovation(maintenance; Events 5 and 6 in cases difficult to distinguish	rooms of the last main building phase in Basta
7	substructures ("channels") of artificial terraces; could rest on earlier architectural phases/ deposits	last LPPNB terracing of the slopes by building substructures of dry stone masonry which carry the even floors of the superimposed rooms	substructures of last main building phase in Basta, founded above earlier architectural phases and deposits

Comparative Aspects of the LPPNB Architecture[1]

Among the many comparative aspects for the LPPNB architecture to be found in the semi-arid regions around the globe (*cf.* Kinzel 2003), two major sources of comparison are to be mentioned: the *pueblo* architecture of the American Southwest (Plate 4) and the traditional architecture of Southern Jordan (Plate 5, Gebel and Bienert *et al.* 1997: Plate 6.B-C). Some of the *pueblo* architecture shows strong similarities with the LPPNB architecture: in wall construction (even in the aesthetics of wall faces, *cf.* Plate 4.C), with internal space organization (*e.g.* rooms connected by window-like wall openings, Plate 4.C; the settlements communication

[1] This topic will be thoroughly treated in *Basta* II. *The Stratigraphy and Architecture*, forthcoming.

network (roofs as open spaces, Plate 4.A-B), terraced housing with a tendency for missing lanes and open spaces, *etc.* The traditional village architecture of Southern Jordan provides many comparative ethnoarchaeological features. In sites like Basta (Plate 5.A-B), Ail, Tayiba, Rajif, Dana, and many others, sedimentary environments, structural and functional elements can be studied resembling much the LPPNB findings: houses are build on terraced terrains; supports for endangered walls; double-faced walls are constructed the same way (with somewhat larger tabular stones, Plate 5.C); causes for intra-site accumulations of building debris; the development of stone and dump deposits (Plate 5.C); the rise of intra-mural and open space levels; split levels inside one building (*e.g.* Rajif); decay studies for walls and roofs (sedimentary developments in a ruin, *e.g.* Plate 5.D), *etc.*

The present author introduced the term "*pueblo*-like" for the LPPNB architecture, for the sake of a quick understanding or imagination. However, it has to be stressed that the unique LPPNB architecture needs an understanding of its own. We are well aware of the danger to what extend comparative studies are tempting and offer misleading interpretations. However, these studies also offer extraordinary insights into the possibility of independent cultural and socioeconomic developments taking place anywhere and any time if similar conditions start to exist. This dimension of the Basta/ Ba'ja studies is at its beginning, and already offered helpful support for the interpretation of the architectural findings.

Summary

In the previous sections, basic information on the genesis of sedimentary environments at Basta was discussed, as well as the relations of site formation processes and cultural stratigraphy, the post-occupational processes, and the conditions of site preservation. This summary refers to the major and unique characteristics of a LPPNB site formation and preservation, as attested with Basta.

A site's formation is to be seen as the interrelation of developing socioeconomic conditions and needs, locally available resources and environmental conditions, and the technological momentum and innovative frameworks by which these could establish a settlement. The formation of the LPPNB site of Basta underlies the specific and progressive regime of growth characteristic for the socioeconomic developments in the LPPNB. The local environmental conditions and resources supported this trajectory. The "non-material" framework of Basta's formation was:

- a progressive population development in Southern Jordan
- vast steppe hinterlands covering an almost unlimited production of animal protein
- social adaptation to/ using corporate family and community structures
- surplus production of blade blanks and establishment of markets and exchange networks
- developments of crafts, labour division, and products of prestige
- complex communal organisation and architectural pre-planning
- potentially: domestic use of the vertical space

The material framework for Basta's formation was:

- artificial slope terraces allowed the agglomerations and agglutination of buildings
- type of groundplans and building technologies formed considerable material body (of deposits) on the slopes
- long duration and high variability and intensity of activities formed considerable non-architectural deposits on the slopes

- expansion of the architectural agglomerations may have reduced the rate of intra-mural alterations (compared with other LPPNB sites) at Basta, causing the site's extension

For the preservation of Basta, the following major reasons are responsible:

- large intra-site masses of building material and small room groundplans are responsible for a rapid filling of the rooms (both during the occupation as well as during their decay), and thus causing high wall preservation
- re-use and maintenance of major walls and terrace walls helped their continual use and thus height of preservation
- stone extraction during and after the LPPNB occupation is responsible for bad preservation at certain spots (e.g. in 390N/ 595E)
- extensive layers on the slopes of LPPNB flint waste from the workshops protected archaeological deposits
- gully erosion destroyed architectural and other depositional remains adjacent to drainages during the LPPNB occupation
- aquatic slope erosion, the mud and debris flows of the 1st half of the 7th millennium BC, and other combined colluvial, aeolian, erosive and anthropogenic processes (e.g. surfaces created by deflation *etc.* at the "equilibrium" level of filled depressions and eroded LPPNB wall tops) covered rapidly the site's LPPNB architecture and preserved much of its substance
- huge accumulations of weathering products and high aeolian silt proportions developed rapidly during the LPPNB and especially in the two millennia after (e.g. Area C), and embedded in addition the Neolithic deposits
- partial preservation of *in situ* remains of LPPNB squatters and of a flimsy FBBNB occupation in sediment traps during the mud and debris flows ("rubble layers") of the 1st half of the 7th millennium
- surface protection of the site in later prehistoric and historic periods by the deflated accumulations of its natural and archaeological material
- disturbance and destruction of Neolithic layers by recent building and road construction activities in the modern village; occasional reuse of LPPNB wall stones

Acknowledgements: I thank Ulrich Kamp, Hans-Joachim Pachur, Hans J. Nissen, and Christian Hannß for their valuable information and discussion of the geomorphology at Basta. Much of this early understanding developed further over the years, and was influenced by new insights into the specific LPPNB architectural site formation and its geomorphological consequences. Today, the interrelations between the various natural processes, the unique principles of terraced LPPNB architectural planning and re-planning, and the human behavior in the built environment appears more complex and difficult to explain than before; thus, this contribution is not the end of the discussion. I thank warmly the many colleagues and specialists, with whom I revisited and revisited Basta, Ba'ja, al-Baseet, es-Sifiya, Ghwair I, and 'Ain Jammam since 1992, and who helped me to reach the insights presented here.

Hans Georg K. Gebel
Freie Universität Berlin
Institut für Vorderasiatische Altertumskunde
Hüttenweg 7
Germany - 14195 Berlin

References

Becker C.

1999 Early domestication in the southern Levant as viewed from Late PPNB Basta. In: L.K. Horwitz, E. Tchernov, P. Ducos, C. Becker, A. von den Driesch, I. Marzin, and A.N. Garrard, Animal domestication in the southern Levant. *Paléorient* 25.2: 70-72.

2000 Bone and species distribution in Late PPNB Basta (Jordan) - rethinking the anthropogenic factor. In: M. Mashkour, A. Choyke, H. Buitenhuis, and F. Poplin (eds.), *Archaeozoology of the Near East IV/A.* Proceedings of the 4th International Symposium on the Archaeozoology of Southwestern Asia and Adjacent Areas, Paris: 196-207.

Bienert, H.D., R. Lamprichs, and D. Vieweger

2002 Ba'ja. Archäologie einer Landschaft. Bericht über archäologische Feldforschungen. In: R. Eichmann (ed.), *Ausgrabungen und Surveys im Vorderen Orient,* I. Orient-Archäologie 5: 159-214. Rahden/ Westf., Marie Leidorf.

Gebel H.G.

1986 Die Jungsteinzeit im Petra-Gebiet. In: M. Lindner (ed.) Petra. Neue Ausgrabungen und Entdeckungen: 273-308. München, Delp.

1996 Chipped lithics in the Basta Craft System. In: S. Kozlowski and H.G.K. Gebel (eds.), *Neolithic Chipped Stone industries of the Fertile Crescent, and Their Contemporaries in Adjacent Regions.* Studies in Early Near Eastern Production, Subsistence, and Environment 3: 261-270. Berlin, ex oriente.

2002b *Subsistenzformen, Siedlungsweisen und Prozesse des sozialen Wandels vom akeramischen bis zum keramischen Neolithikum,* II: *Grundzüge sozialen Wandels im Neolithikum der südlichen Levante.* http://www.freidok.uni-freiburg.de/volltexte/466. Freiburg, Universiätsbibliothek.

forthcmg. The stratigraphies and locus data. In: H.J. Nissen, M. Muheisen, and H.G.K. Gebel (eds.), *Basta* II. *The Architecture and Stratigraphy.* Berlin, ex oriente.

Gebel H.G.K. and H.D. Bienert, with contributions by T. Krämer, R. Neef, B. Müller-Neuhof, J. Timm ,and K. I. Wright

1997 Ba'ja hidden in the Petra Mountains. Preliminary results of the 1997 investigations. In: H.G.K. Gebel, Z. Kafafi and G.O. Rollefson (eds.), *The Prehistory of Jordan,* II. *Perspectives from 1997.* Studies in Early Near Eastern Production, Subsistence, and Environment 4: 221-262. Berlin, ex oriente.

Gebel H.G.K. and B. Dahl Hermansen

2001 LPPNB Ba'ja 2001. A Short Note. *Neo-Lithics* 2/01:15-20. Berlin, ex oriente.

Kinzel M.

2003 *Basta, Südjordanien. Überlegungen zur Rekonstruktion von Areal B (7000 BC) nach bauarchäologischen Befunden.* Berlin, Technische Universität: unpub. Abschlußarbeit Aufbaustudium Denkmalpflege.

Pachur H. J.

1987 Aspects of physical and geomorphological setting. In: H.J. Nissen, M. Muheisen, and H.G. Gebel *et al.*, Report on the first two seasons of excavations at Basta (1986-1987). *Annual of the Department of Antiquities of Jordan* 31: 82-95.

Pike G. and A.C. Vroman

1974 *Anasazi. Ancient People of the Rock. The Monumental Remains of the Legendary American Indian Civilization.* New York, American West Publishing Company.

Röhrer-Ertl O., K.W. Frey, and H. Newesely

1988 Preliminary note on the Early Neolithic remains from Basta and Sabra I. In: A.N. Garrard and H.G. Gebel (eds.), *The Prehistory of Jordan. The State of Research in 1986.* British Archaeological Reports – Intern. Series 396.1: 135-136. Oxford, B.A.R.

Schultz M.

1987 Human remains. In: H.J.,M. Muheisen,H.G. Gebel with contributions by C. Becker, R. Neef, H.J. Pachur, N. Qadi, and M. Schultz, Report on the first two seasons of excavations at Basta. *Annual of the Department of Antiquities of Jordan* 31: 79-120.

Appendix 1. Geoarchaeological layer description of the NE Section of Area A.

Layer (Locus) No.	Matrix (with ash/charcoal components) and Munsell Color Notation of Matrix <Field No. of Sample>:	Cultural Deposits and Larger Mineral Inclusions (Without Artefacts)/ Orientation/ Characterization of Layer	Associated Artefacts	Interpretation of Layer
1a	water-laid; fine grained; loose consistency; 10 YR 8-7/1 "light grey/white"			colluvium , topsoil
1b	fine grained; lime particles < 10mm; rather hard consistency, possibly resulting from disintegrated plaster/mortar; 10 YR 8/2-3 "white/very pale brown"	stones preponderant sharp-edged limestones (5-10cm); plaster/mortar; bones	flint artefacts; ornaments	colluvium , topsoil
2 a-d	fine grained; 2c more densely accumulated with higher content of lime particles (2-4mm); 2a: 7.5 YR 7-6/0-4 "grey - light brown", rippling after touching; 2b: cf. 2a, but 7.5 YR 4-5/0 "grey - dark grey"; 2c: cf. 2a, but 10 YR 6/3-4 "very pale brown"	disintegrated plaster/mortar fragments; building debris; bones; bones and artefacts oriented downslope; stones < 8cm	flint artefacts	colluvium
3	fine grained; 10 YR 5/0 "grey"	high content of disintegrated plaster/mortar; patches of ashes; stones < 2cm; bones	flint artefacts	layer of higher influence by man
4	fine to coarse grained; fine porous; crumbly; rather hard; 10 YR 4-6/1 "dark grey - grey"	sharp-edged stones 2-6cm, irregulary embedded; plaster/mortar particles and concentrations	flint artefacts	layer of higher influence by man
5	coarse grained; 10 YR 5-6/1 "grey"	many sharp-edged stones 6-10cm; rare plaster/mortar particles; occasional bones	flint artefacts	colluvium
6	fine grained; rather porous; 10 YR 6-5/1 "grey"	high content of disintegrated plaster/mortar particles/ sharp-edged, irregularly distributed stones 7-9cm		layer of higher influence by man
7	fine grained; rather porous; 10 YR 6-7/1 "grey - light grey"	like Layer 6, but I fewer tones and horizontal concentrations of plaster/mortar particles < 4cm; bones of random distribution	flint artefacts	layer of higher influence by man
8	10 YR 5/1 "grey"	dense layer of sharp-edged stones, oriented horizontally downslope; many bones		colluvium
9	10 YR "dark grey"	ash; bone splinters		powdery, ashy lens
10	10 YR 7-8/2 "light grey - white"	disintegrated plaster/mortar (fragments, densely packed concentrations); sharp-edged stones 4-5cm; horizontally embedded stones; smaller ashy lenses; bits of charcoal	flint artefacts	layer of higher influence by man
11	very loose, powdery; occasional lime particles; 10 YR 3/1 "very dark grey"	evenly distributed plaster/mortar particles; bones irregularly embedded	flint artefacts, horizontally embedded	ash lens
12	10 YR 7/2 "light grey"	plaster/mortar concentration, partly mixed with higher content of ashes, therefore different consistencies	at border to Layer 13 horizontally embedded chipped flint artefacts (mostly blades)	layer of higher influence by man
13	cf. Layer 11	cf. Layer 11, but Ifewer bones		ash lens
14	non-consolidated material: 10 YR 8/4 "very pale brown"; consolidated plaster/mortar: 10 YR 7/2 "light grey"	layer of disintegrated, crumbly plaster/mortar concentrations, not consolitdated; small stones c. 5mm concentrated in the non-consolidated plaster/mortar concentrations		layer of higher influence by man
15	powdery; 10 YR 3/1 "very dark grey"	ash; plaster/mortar particles; small stones 5mm; occasional larger stones 3cm		ash layer
16	main sediment: 10 YR 4/1 "dark grey"; large plaster concentrations: 10 YR 7/2-8/4 "light grey - very pale brown", 5 YR 8/4 "pink"	ash; plaster/mortar particles in different concentrations; consistency ranges from rather consolidated to loose interbedded; highly plaster/mortar concentrations of different dimensions; bones and charcoal rare; limestones of different sizes		material of large plaster concentration possibly exposed to open fire; layer of higher influence by man
17	powdery; 10 YR 4/1 "dark grey"	ash; some concentrations of plaster/mortar particles, which consolidate parts of the layer; bones; human skull; stones of different sizes; large flat limestone with attached mortar partly covers the layer		ashy layer; burial
18	10 YR 7/1-8/2 "light grey - white" <1065>	rather consolidated layer of disintegrated plaster/mortar with densely distributed charcoal; occasional bones and stones 0.5-5cm	flint artefacts	layer of higher influence by man
19	powdery; 10 YR 4/1 "dark grey"	ash; plaster/mortar particles; stones 0.5-5cm; rare bones	rare flint artefacts	ash layer
20	cf. 18, but higher content of sand	cf. Layer 18	cf. Layer 18	layer of higher influence by man
21	10 YR 8/1 "white"	dense and consolidated plaster/mortar layer; charcoal particles		layer of higher influence by man
22	sandy; crumbly; porous; 10 YR 7/6 "yellow"	plaster-like material; charcoal		layer of higher influence by man
23		parts of face stones fallen off, exposing the mortar - mixed with smaller stones - of interior wall parts; face stones flaked into rectangular shapes		limestone wall
24				limestone wall
25	fine grained; highly consolidated; porous from roots; 10 YR 7/1 "light grey"	sharp-edged, irregularly distributed stones 2-7cm; bones; plaster/mortar particles	flint artefacts	colluvium
26	cf. Layer 25, but not consolidated and rather powdery; 10 YR 4/1 "dark grey"		flint artefacts	colluvium
27	cf. Layer 25; 10 YR 6/1 "grey"	cf. Layer 25, but Ifewer and smaller stones 0.5-4cm	flint artefacts	colluvium

28	cf. Layer 21 and Layer 22 (?)	cf. Layer 21 and Layer 22 (?)		layer of higher influence by man
29	crumbly consistency; 10 YR 5/2 "greyish brown"	densely packed concentration of sharp-edged and rolled stones 0.5-4cm, oriented downslope; bones; plaster/mortar particles 10mm; below 22.50 m fewer stones	flint artefacts	colluvium
30	lime particles	medium compact disintegrated plaster/mortar		layer of higher influence by man
31				ash lens
32	cf. Layer 30	cf. Layer 30, but with large ashy lenses; no clear bounderies between lenses and disintegrated plaster/mortar and lime particles		layer of higher influence by man
33		ash; small stones	flint artefacts	ash lens
34		compact layer of disintegrated plaster/mortar	flint artefacts	layer of higher influence by man

Appendix 2. Geoarchaeological layer description of Cut 8.

Layer (Locus) No.	Depth Below Surface (cm) Sample No. (Depth of Sample in cm)	Matrix (With Ash/Charcoal Components) and Munsell Colour Notation of Matrix	Mineral Inclusions and Cultural Deposits (Without Artefacts)/ Orientation / Characterization of Layer / Notes	Associated Artefacts	Interpretation of Layer
1	000-025 VP66.1 (010)	silty sand; aggregates; roots, root channels and animal burrows; 10 YR 5/2 "greenish-brown" to 10 YR 4/2 "dark greyish brown"	edged and edge-rounded lime gravels, flints and dolomites < 5cm	flint artefacts, anthropogenic deposits	colluvium
2	025-035 VP66.2 (030)	finely pulverized, weathered dolomite (silty sand); very compact; 10 YR 7/6 "yellow"	edged fine gravel; some dolomites < 5cm		*in situ* weathering, local sedimentation event or anthropogenic deposit
3	035-115 VP66.3 (060)	silty sand; aggregates; roots, root channels and animal burrows; 10 YR 5/2 "greenish-brown" to 10 YR 4/2 "dark greyish brown"	edged, limy, red sandstones < 6cm; edged, limy and bituminous, grey-black gravels < 4cm; rounded dolomites < 2cm; platy dolomites < 3cm	flint artefacts; pottery; in eastern direction reddish floor fragments were found at the same depth	colluvium with anthropogenic deposits
4	115-... VP66.4 (125)				weathering horizon of limy bedrock

Raw Materials of the Small Finds Industries

Bo Dahl Hermansen

Introductory Remarks, Approaches

The intention of this contribution is to present data on the use of raw materials in Basta, as attested with the "small finds" industries. For this qualitative evaluation, a sample of 159 of the small finds manufactured from rocks and minerals from Basta Area A was considered (1986-88 seasons, *cf.* Appendix A). Raw materials not attested in Area A are mentioned in Appendix B.

When the raw materials used in a prehistoric industry have been identified, the source areas from which they were extracted may, under ideal conditions, be identified with reasonable precision, thus providing useful information for the definition of sources and sinks in prehistoric distribution networks. In order to determine Basta's situation, a collaborating group of specialists was established. Majdi O. Barjous, Tim Charlesley and Khalil M. Ibrahim, all from the National Resources Authority in Amman, Jordan, provided mineralogical identifications and important sourcing information. Their identifications were obtained by observing the objects under 10x magnification and subjecting them to a hydrochloric acid test. Their expertise with regards to Jordan's general resource situation and geological contexts enabled them in additon to suggest probable raw material sources for the analysed objects.

Additionally, polished thin sections of three objects of a soft, bituminous chalky marl, used for production of rings, or "bracelets", were investigated by Maria Thaís Crepaldi Affonso and Ernst Pernicka (*cf.* this volume). They used a Leitz-Orthoplan petrographic microscope and a JEOL JSM-6400 scanning electron microscope equipped with an energy dispersive X-ray analyser (EDXA) at the Institut für Archäometallurgie of the Deutsche Bergbau-Museum in Bochum, Germany. Their identifications, together with those published by J.M. Starck (1988a), provided the basis for identifying the raw materials used for rings of the "bracelet" category.

Finally, the greenstone objects from Basta were studied by Andreas Hauptmann. Several of these were subjected to X-ray diffraction and/or SEM/EDX analysis by him in the Deutsche Bergbau- Museum in Bochum, Germany. Unfortunately Hauptmann's results could not be integrated in this contribution, but see his article in this volume.

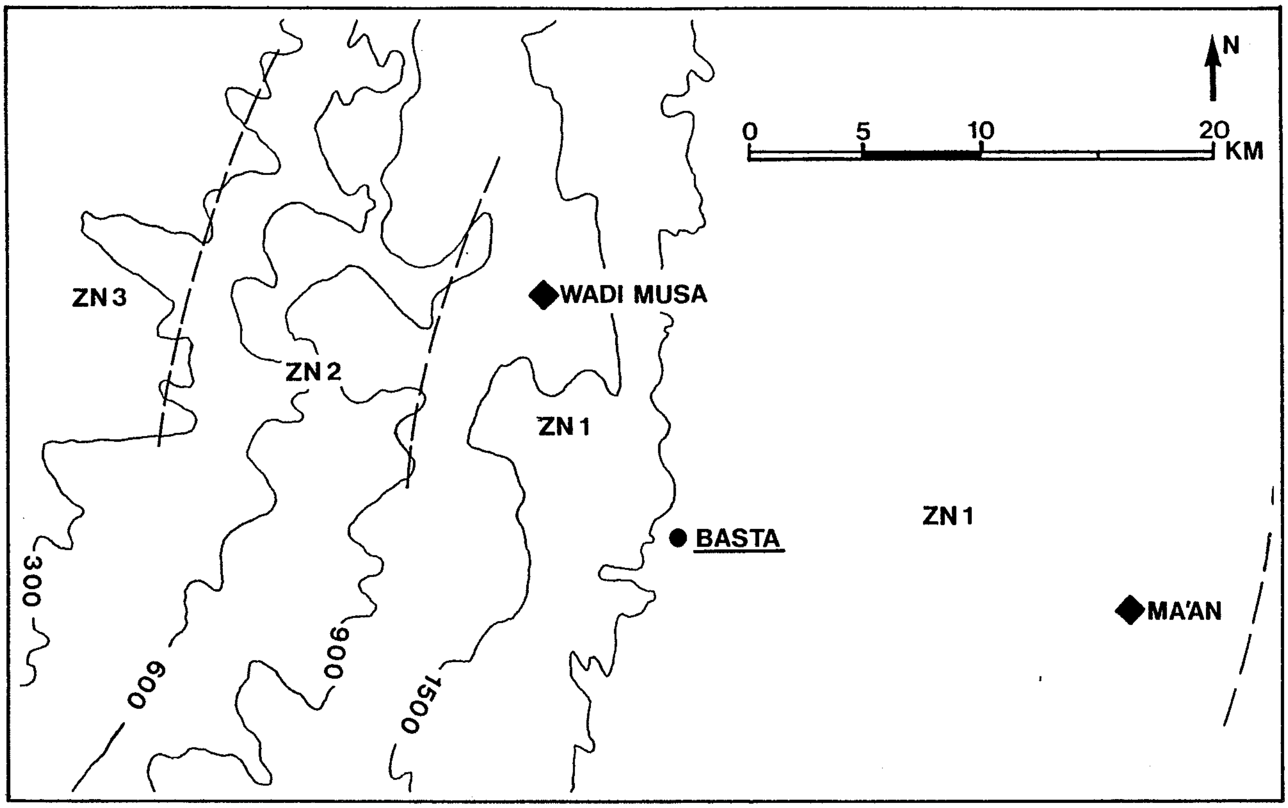


Fig. 1. Basta region: borders of Zones 1, 2, and 3 <*raw materials available in these zones are listed in Table 1*>.

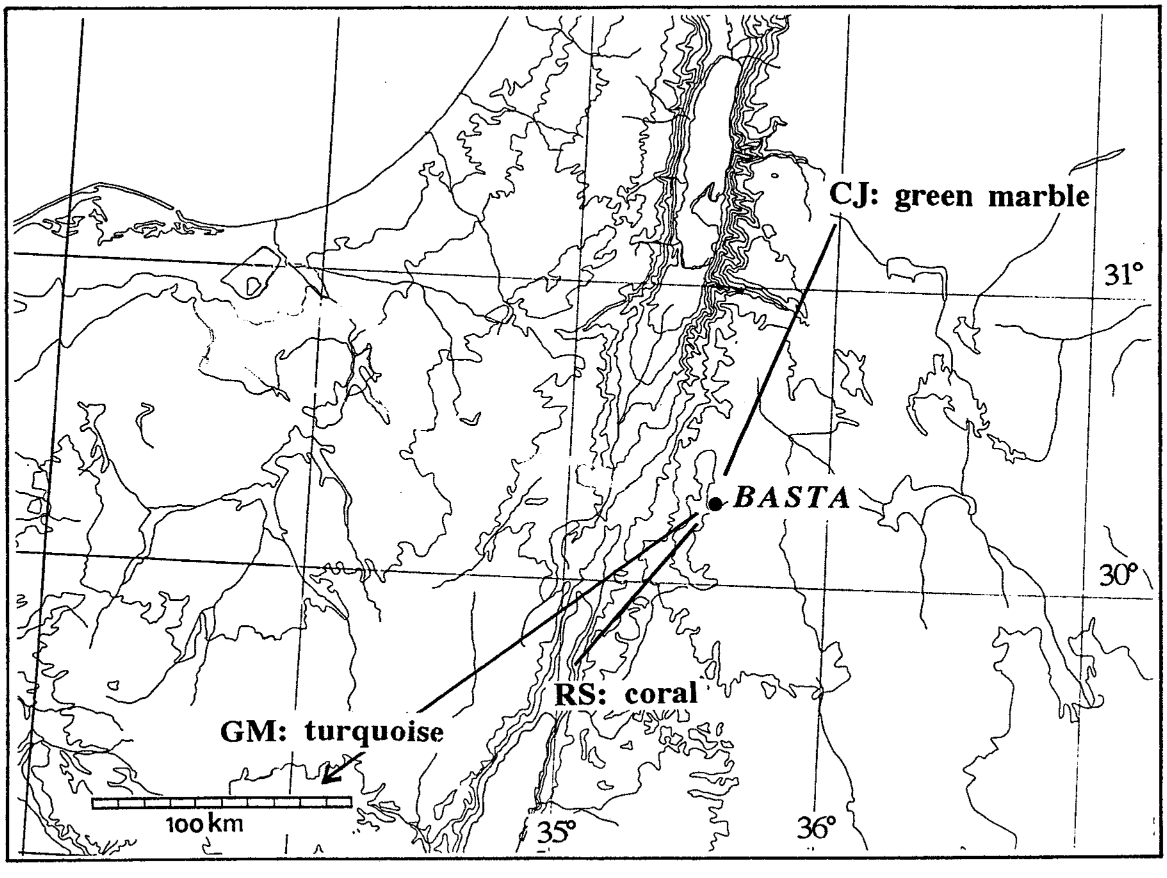


Fig 2. Location of sources of coral, green marble, and turquoise <*for the turquoise evidenc cf. A. Hauptmann, this volume; cf. also Affonso et al., this volume*>.

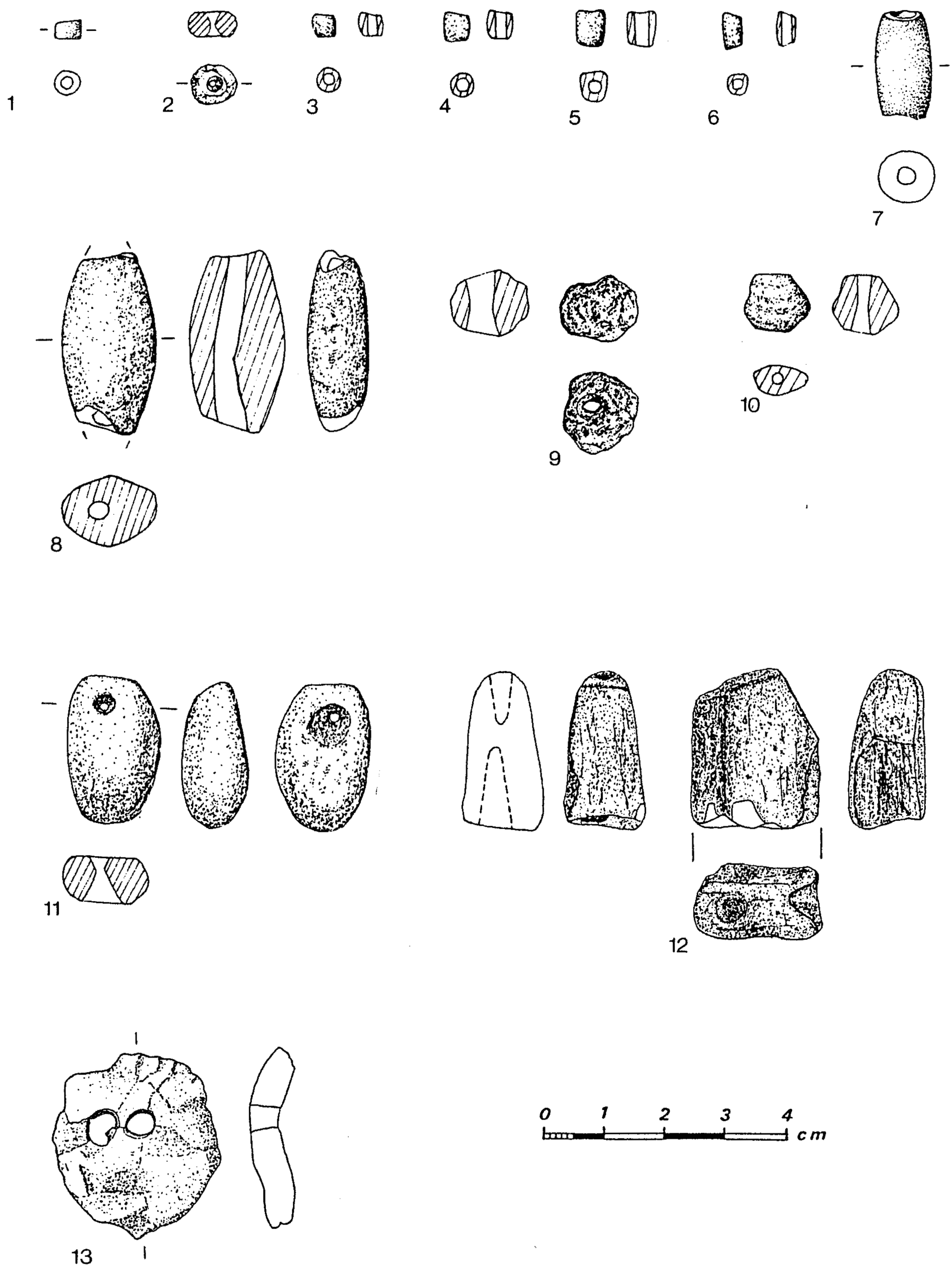


Fig. 3. Raw materials represented by artefact classes: 1, 3-6 coral beads; 2, 9 haematite beads; 7, 10 limestone beads; 8 calcite bead; 11 marl pendant; 12 unfinished bead of chalky marl; 13 paillette, apparently of silty sandstone.

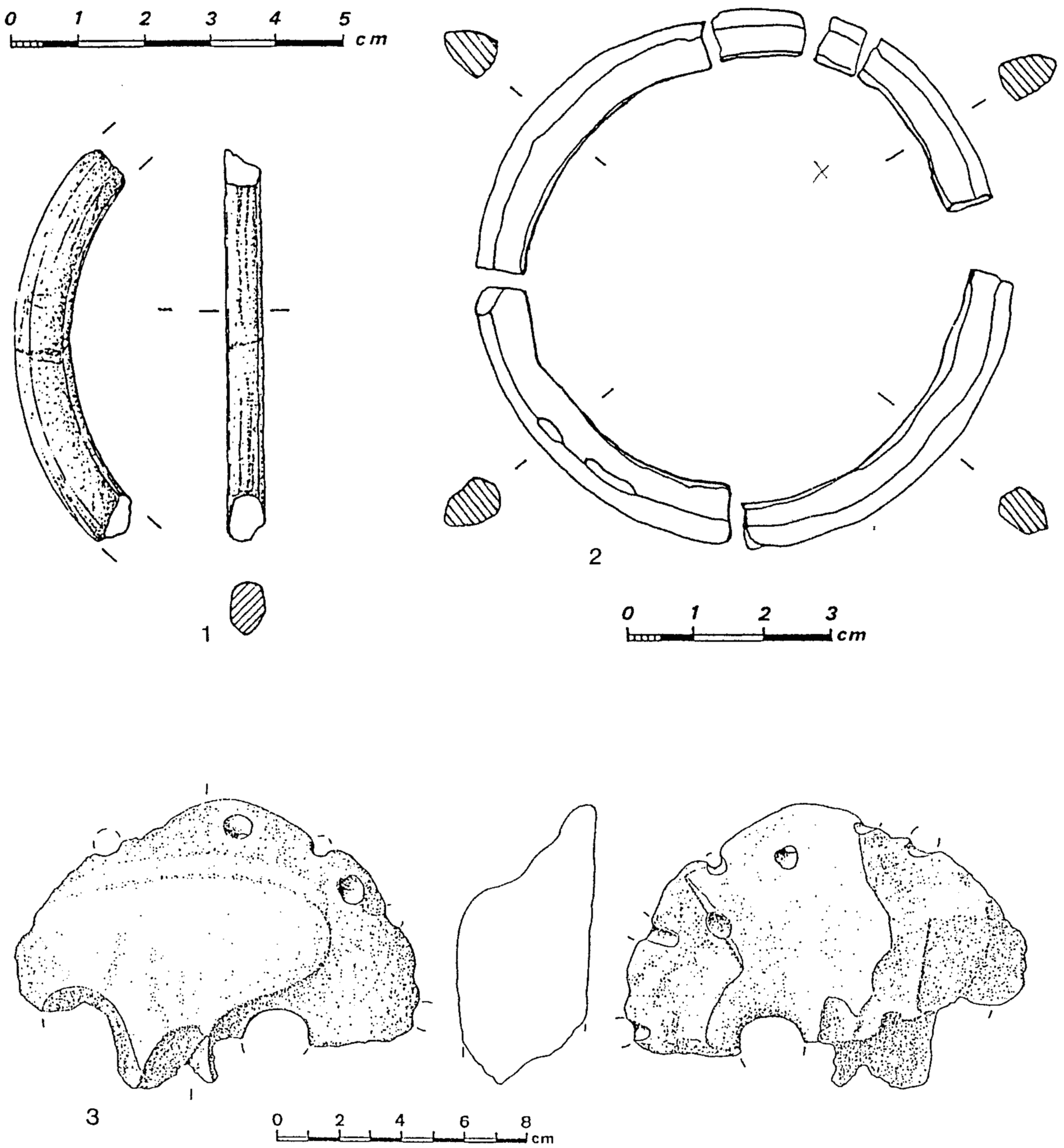


Fig. 4. Raw materials represented by artefact classes: 1 ring fragment of limestone; 2 ring of bituminous chalky marl; 3 fragment of a limestone mask.

With the resulting material and source identifications at hand, it will be attempted here to draw connecting lines between Basta and various probable source areas, identified by the appropriate specialists. It will be attempted to synthesize and interpret the data in terms of the adaptive behaviour of the Neolithic inhabitants of Basta.

This approach is supplemented with a contextual analysis aimed, in the context of the present work, at specifying the premises and consequently determining the reliability of the results of any statistical analysis based on the finds in this collection (Tables 1-3).

Ecological Setting

For the description of the ecological setting of Basta we refer to Gebel, Present-day Site Setting ..., this volume; Neef, this volume; and Becker, this volume. However, a few remarks on the local resource setting would be appropriate here in order to assess the raw material situation.

Basta is located on a limestone plateau of cretacious origin which extends from West the of the sandstone formations of the Greater Petra Area at an altitude of *c.* 1420-1460 m towards the East into the Arabian Desert at an altitude of *c.* 1300 m. In terms of the local resource setting, the area to the West of the site is characterized by formations of limestone, dolomite, and marl. And to the East of the site we find bituminous limestone and marl, chalky marl, and bituminous chalky marl, the latter situated as far away as the Ma'an area some 30 or 40 km to the East (*cf.* Affonso and Pernicka, Fig. 6., this volume). As we shall see, objects made of some of these materials are prominent among the Basta small finds. It would also have been possible to collect chert along the wadis in the local setting (Muheisen, Qadi, and Gebel, this volume) and minerals like calcite and quartz would also have been readily available within close range of the site (Gebel 1996). Such materials have been recovered at Basta in small quantities.

About 12 km West and North-West of Basta (*c.* 20 km in walking distance), the landscape changes. Here it is dominated by the palaeozoic sandstone formations of the Petra area which most probably provided the raw materials for the frequently recorded sandstone objects. Due to the high content of iron within the sandstone formations, it was also possible to collect ferruginous sandstone and haematite in this area. Both materials occur in small quantities in the Basta A collection.

These formations are followed, to the West, by the basement rocks along the Eastern flank of the Wadi Araba and finally by the Wadi Araba itself. Within this area it was possible to collect the phyllite and the green feldspar used for two objects in the collection.

Analysis and Discussion

For the purposes mentioned in the introduction, the data have been compiled into three tables.

Table 1 reflects data on the raw materials used in the industry (Raw Material), on the general location of the closest known natural occurrence of each material (Source), on the quantity (n), and on the relative frequency (%) of each kind of rock and mineral in the collection.

With reference to the raw material situation outlined in the previous section, the designation ZN 1 (Zone 1) signifies the limestone plateau on which Basta is situated (Fig. 1); ZN 2 refers to the palaeozoic sandstone formations, at some 20 km walking distance to the West of Basta (Fig. 1); and ZN 3 represents the basement rocks along the Eastern flank of the Wadi Araba (Fig. 1). RS indicates the Red Sea area (Fig. 2), and CJ signifies Daba, a source area of 10 x 15 km in Central Jordan, some 50 km south of Amman near the Desert Highway (Fig. 2).

Table. 1. Raw materials of small finds from Basta Area A.

Raw Material	*Source*	*n*	*%*
bituminous chalky marl	ZN1	40	25.16
chalky marl	ZN1	1	0.63
marl	ZN1	2	1.26
marly limestone	ZN1	1	0.63
limestone	ZN1	15	9.43
calcite	ZN1	4	2.52
dolomite	ZN1	1	0.63
chert	ZN1	1	0.63
quartz	ZN1	1	0.63
sandstone	ZN2	56	35.22
ferruginous sandstone	ZN2	7	4.40
haematite	ZN2	3	1.89
green feldspar	ZN3	1	0.63
phyllite	ZN3	1	0.63
coral	RS	23	14.47
green marble	CJ	1	0.63
unidentified	?	1	0.63
Total		***159***	***100.01***

It must be emphasized that the source identifications refer to the location of the closest known sources of the materials in question. There is no definite proof that these were the real sources; and no *a priori* reason to believe that all objects in locally available materials were in fact locally produced. Many of these materials have a quite wide distribution, and in the absense of specific source identifications it is possible that some of the objects manufactured from these could have been imported rather than locally produced. This problem will be further explored in Basta Vol. IV.1, which will be specifically devoted to the publication of the Basta small finds.

Considering that other LPPNB sites, like Ba'ja and al-Baseet, are located within, or near the border, to the sandstone area of the Petra region (ZN2), it is likely that the Neolithic inhabitants of Basta only had direct access to local and regional limestone formations (ZN1). Resources from the sandstone massif (ZN2), as well as from the basement rocks on the Eastern flank of Wadi Araba (ZN3), would probably have to be acquired to a large extent through exchange with contemporary communities. Of course the same is the case with materials deriving from more remote sources. As seen from Table 2, this means that only 41.51 % of the 159 specimens included in the analysis are manufactured from materials that could have been collected in the local and regional environment. One object was manufactured in an unspecified material for which, as a consequence, the source is unknown. The rest would have been imported, either as raw materials or as finished products. To these should be added the occurence of turquoise from Wadi Maghara reported by Andreas Hauptmann (this volume). Unfortunately that material could not be included in the present analysis but the approximate location of the source is indicated on Fig. 2 by the designation GM (Gebel el-Maghara in SW Sinai).

Table 2. Geographical distribution of raw materials.

	ZN1	*ZN2*	*ZN3*	*RS*	*CJ*	*Unid.*	*Total*
n	66	66	2	23	1	1	159
%	41.51	41.51	1.26	14.47	0.63	0.63	100.01

Among the raw materials listed in Table 1, limestone was used for a mask recovered at Basta A (Fig. 4:3), but otherwise mainly for beads and rings (Fig. 3:7,10; Fig. 4:1). The bituminous chalky marl was apparently used solely to produce rings (Fig. 4:2) of the type earlier designated "bracelets" (*e.g.* Starck 1988a). Marl and chalky marl were used for pendants and beads (Fig 3. 11-12) and calcite for beads (Fig. 3:8). Ferruginous sandstone sandstone, and bituminous chalky marl, were mainly used for rings of the "bracelet" type, but a paillette was made from what appears to be white silty sandstone (Fig 3:13). Haematite (Fig. 3:2,9), green feldspar, green marble, and coral (Fig. 3:1,3-6) were used for beads. Additionally, manufacturing waste of dolomite, haematite, and phyllite has been identified, and ferruginous sandstone with extremely high contents of iron was brought to the site as manuports. A systematic and comparative study of the material will be included in the Basta final publication. Here the illustrations should suffice to indicate some of the range of objects that have been recovered at Basta. (for additional information *cf.* Starck 1988a, 1988b; Hermansen 1991).

Table 3. Raw materials in primary context.

	n	%
BURIALS		
sandstone	1	0.63
bituminous chalky marl	1	0.63
coral	22	13.84
limestone	2	1.26
calcite	1	0.63
haematite	1	0.63
	28	17.61%
SURFACES		
sandstone	5	3.14
bituminous chalky marl	3	1.89
coral	1	0.63
	9	5.66%
PITS/DUMPS		
sandstone	1	0.63
bituminous chalky marl	1	0.63
limestone	1	0.63
	3	1.89%
Total	*40*	*25.16%*

It remains to consider the overall reliability of the statistical effort offered above. In this regard the following considerations are relevant. First, it must be stated that the statistics account only for the material that has been investigated by the present author. A complete analysis will have to integrate these data with those of David Reese (marine molluscs) and Andreas Hauptmann (this volume; *cf.* also Affonso and Pernicka this volume; Muheisen, Qadi and Gebel, this volume; data will be available with the final publication of the Basta small finds in this series. The consequence of this is of minor importance. Finally, a considerable proportion of the objects of sandstone and all those of bituminous chalky marl are ring ("bracelet") fragments. In cases where it has been possible to identify joints with certainty, the relevant pieces have been catalogued under a single entry (Appendix A). However, pieces which could not be joined with certainty were registered separately. Thus, both these materials may well be over-represented in Table 1.

Table 3 presents the results of a contextual analysis. It shows that of the objects included in this contribution, only a minor proportion (40 objects or 25.16 %) were found in primary and secondary contexts. By far the larger proportion of the investigated objects were recovered from so-called fill layers or other kinds of mixed contexts, such as "top soil", "baulk removal", "bulldozed layers of S. Rashid's building plot", "surface", *etc.*

Thus, the stratigraphic situation does not allow us to certify that the picture outlined above is representative for any given point in time during the occupation of Basta. Rather, with all its weaknesses, it should be understood as a generalized picture.

Concluding Remarks

In summary, through the collaboration of a number of specialists, the raw materials of some 159 objects have been identified. Sourcing data concerning these materials resulted in the recognition that most materials were apparently extracted from sources beyond the direct reach of the Basta population.

Finally, a contextual analysis reveals that only 40 out of the 159 objects in the collection (25.16 %) were found in primary contexts; most were found in secondary, tertiary or ambigous contexts. This, together with certain biases due to the nature of the material, forces us to accept that the statements made above should be understood as indicators of general trends; and not as representative for any given moment in time during the existence of the Basta community.

Thus, the small collection of finds, investigated in this contribution, would seem to have a limited impact on our understanding of the human ecology of LPPNB Basta and its neighhourhood.

Acknowledgements: I am indebted to Majdi O. Barjous, Tim Charlesley and Khalil M. Ibhrahim (all from the National Resources Authority of Jordan) for their considerable help. Without the raw material and source identifications so kindly provided by them this study would not have been possible. Maria Thaís Crepaldi Affonso and Ernst Pernicka identified the bituminous chalky marl, erroneously termed "plaster-like material" in our preliminary report. Finally, I should like to thank the editors, Hans J. Nissen, Mujahed S. Muheisen and Hans Georg K. Gebel, for allowing me to study this material and contribute to the present publication on the human ecology of Basta. I am especially grateful to Hans Georg K. Gebel for reading several preliminary draughts of the manuscript and to Paul Larsen for correcting my English.

Bo Dahl Hermansen
The Carsten Niebuhr Institute
University of Copenhagen
Snorresgade 17-19
Denmark - 2300 Copenhagen S

References

Garrard A.N. and H.G. Gebel (eds.)

1988 *The Prehistory of Jordan. The State of Research in 1986.* British Archeological Reports - Intern. Series 396.1-2. Oxford, B.A.R.

Gebel H.G.

1992 Territories and palaeoenvironment: locational analysis of Neolithic site setting in the Greater Petra area, southern Jordan. In S. Kerner (ed.), *The Near East in Antiquity. German Contributions to the Archaeology of Jordan, Syria, Lebanon and Egypt* 3: 85-96. Amman, al-Khubta.

1996 Chipped lithics in the Basta Craft System. In: S.K. Kozlowski and H.G.K. Gebel (eds.), *Neolithic Chipped Stone Industries in the Fertile Crescent, and Their Contemporanities in Adjacent Areas.* Studies in Early Near Eastern Subsistence, Production, and Environment 3: 261-270. Berlin, ex oriente.

Gebel H.G., M. Muheisen, and H.J. Nissen

1988 Preliminary report on the first seasons of excavations at the Late Aceramic Neolithic site of Basta. In: A.N. Garrard and H.G. Gebel (eds.), *The Prehistory of Jordan.* British Archeological Reports - Intern. Series 396.1: 101-134. Oxford, B.A.R.

Hermansen B.D.

1991 Small finds. In: H.J. Nissen *et al.*, Report on the excavations at Basta 1988. *Annual of the Department of Antiquites of Jordan* 35: 26-29.

Nissen H.J., M. Muheisen, and H.G. Gebel

1991 Report on the excavations at Basta 1988. *Annual of the Department of Antiquites of Jordan* 35: 13-40.

Nissen H.J., M. Muheisen, and H.G. Gebel

1987 Report on the first two seasons of excavation at Basta (1986-1987). *Annual of the Department of Antiquites of Jordan* 31: 79-119.

Starck J.M.

1988a Comparative analysis of stone-ring artefacts from Baga and Basta. In: A.N. Garrard and H.G. Gebel (eds.) *The Prehistory of Jordan.* British Archeological Reports - Intern. Series 396.1: 137-174. Oxford, B.A.R.

1988b Small finds. In: H.G. Gebel, M. Muheisen, and H.J. Nissen, Preliminary report on the first seasons of excavations at the Late Aceramic Neolithic site of Basta. In: A.N. Garrard and H.G. Gebel (eds.), *The Prehistory of Jordan.* British Archeological Reports - Intern. Series 396.1: 126-130. Oxford, B.A.R.

Appendix A. Catalogue of investigated Objects from Area A.

Field No.	Square	Locus	Raw Material	Source-Area	Object-Class
0003	A12 (490N/680E)	surface	dolomite	ZN 1	waste
0004	A12 (490N/680E)	1	yellow to whitish sandstone	ZN 2	ring fragm.
0011.1	A12 (490N/680E)	1	grey sandstone	ZN 2	ring fragm.
0011.2	A12 (490N/680E)	1	red sandstone	ZN 2	ring fragm.
0019	A18 (485N/685E)	5	reddish sandstone	ZN 2	ring fragm.
0025.1a	A12 (490N/680E)	1	whitish sandstone	ZN 2	ring fragm.
0025.1b	A12 (490N/680E)	1	red sandstone	ZN 2	ring fragm.
0025.2	A12 (490N/680E)	1	red sandstone	ZN 2	ring fragm.
0025.3	A12 (490N/680E)	1	red sandstone	ZN 2	ring fragm.
0047	<no records>	<no records>	carbonate-encrusted limestone	ZN 1	ring fragm.
1003.1	A17 (485N/680E)	6	limestone	ZN 1	ring fragm.
1011.2a	A8 (495N/680E)	section trimming	red soft sandstone	ZN 2	ring fragm.
1011.2b	A8 (495N/680E)	section trimming	ferruginous sandstone	ZN 2	ring fragm.
1011.3	A4-8 (495-500N/680E)	section trimming	red sandstone	ZN 2	ring fragm.
1011.4	A4-8 (495-500N/680E)	section trimming	haematite	ZN 2	waste
1052	A3 (505N/695E)	4	red sandst. with a yellow vein	ZN 2	ring fragm.
1144	<no records>	<no records>	brown sandstone	ZN 2	ring fragm.
3030.1	A3 (505N/695E)	4	grey sandstone	ZN 2	ring fragm.
3030.2	A3 (505N/695E)	4	whitish sandstone	ZN 2	ring fragm.
3034	A1 (505N/685E)	4	red sandstone	ZN 2	ring fragm.
3075	A3 (505N/695E)	4	white schistic sandstone	ZN 2	ring fragm.
3076	A5 (500N/685E A-D)	3	limestone	ZN 1	bead
3901	A11 (495N/695E)	1	ferruginous sandstone	ZN 2	manuport
4008.1	bulldozed layers	-	red sandstone	ZN 2	ring fragm.
4008.2	bulldozed layers	-	red sandstone	ZN 2	ring fragm.
4009.2a	bulldozed layers	-	bituminous chalky marl	ZN 1	ring fragm.
4009.2b	bulldozed layers	-	very soft sandstone	ZN 2	ring fragm.
4009.3	bulldozed layers	-	grey stone	not ident.	ring fragm.
4019	A8 (495N/680E) B	1	limestone	ZN 1	ring fragm.
4068	A8 (495N/680E)	18	reddish sandstone	ZN 2	ring fragm.
4071	A8 (495N/680E)	8	grey sandstone	ZN 2	ring fragm.
4072	A8 (495N/680E)	5	whitish sandstone	ZN 2	ring fragm.
4079	A9 (495N/685E)	6	sandstone	ZN 2	ring fragm.
4085	A9 (495N/685E)	2	red sandstone	ZN 2	ring fragm.
4117.1	A8 (495N/680E)	Locus17, Layer 1	red sandstone	ZN 2	ring fragm.
4117.2	A8 (495N/680E)	Locus17, Layer 1	sandstone	ZN 2	ring fragm.
5006	A1 (505N/685E)	2	black haematite	ZN 2	bead
5020	A1 (505N/685E)	2	red ferruginous sandstone	ZN 2	ring fragm.
7046	A17 (485N/680E)	10	pink sandstone	ZN 2	ring fragm.
7046.2	A17 (485N/680E)	10	red sandstone	ZN 2	ring fragm.
7066	A17 (485N/680E)	16	red sandstone	ZN 2	ring fragm.
7075.1	A17 (485N/680E)	20	bituminous chalky marl	ZN 1	ring fragm.
7075.2	A17 (485N/680E)	20	bituminous chalky marl	ZN 1	ring fragm.
7075.3	A17 (485N/680E)	20	hard reddish sandstone	ZN 2	ring fragm.
7075.1-2	A17 (485N/680E)	20	bituminous chalky marl	ZN 1	ring fragm.
7076.1	A17 (485N/680E)	20	brown sandstone	ZN 2	ring fragm.
7091	A18 (485N/685E)	5	hard blackish sandstone	ZN 2	ring fragm.
8007.1	A2 (505N/690E)	top soil	ferruginous sandstone	ZN 2	ring fragm.
8007.2	A2 (505N/690E)	top soil	sandstone	ZN 2	ring fragm.
8007.3	A2 (505N/690E)	top soil	ferruginous sandstone	ZN 2	ring fragm.
8007.4	A2 (505N/690E)	top soil	red sandstone	ZN 2	ring fragm.
8007.5	A2 (505N/690E)	top soil	reddish sandstone	ZN 2	ring fragm.
8013	A2 (505N/690E)	1	rose red sandstone	ZN 2	ring fragm.
8019.1	A2 (505N/690E)	3	white sandstone	ZN 2	ring fragm.
8019.2	A2 (505N/690E)	3	carbonate-encrusted limestone	ZN 1	ring fragm.
8019.3	A2 (505N/690E)	3	carbonate-encrusted limestone	ZN 1	ring fragm.
8023	A2 (505N/690E)	4	limestone	ZN 1	ring fragm.
8035	A2 (505N/690E)	10A	limestone	ZN 1	ring fragm.
10804.3	A5 (500N/685E)	3	marl	ZN 1	pendant
10820	A3 (505N/695E)	2	limestone	ZN 1	bead
10820.2	A3 (505N/695E)	2	calcite	ZN 1	bead unf.
10820.4	A3 (505N/695E)	2	limestone	ZN 1	bead
10826	A3 (505N/695E)	1	calcite	ZN 1	bead
10844	A18 (485N/685E)	31	chert	ZN 1	manuport
10846.3	A22 (480N/680E)	8	quartz	ZN 1	bead
10851.6	A14 (490N/690E)	3	red coral	RS	bead
10851.9	A14 (490N/690E)	3	rosy coral	RS	bead
10858.3	A5 (500N/685E)	17	green feldspar	ZN 3	bead
11202.12+15-18	A18 (485N/685E)	9/10	bituminous chalky marl	ZN 1	ring fragm.
11202.3-5	A18 (485N/685E)	9/10	bituminous chalky marl	ZN 1	ring fragm.
11202.8	A18 (485N/685E)	9/10	bituminous chalky marl	ZN 1	ring fragm.
11202.10+12	A18 (485N/685E)	9/10	bituminous chalky marl	ZN 1	ring fragm.
11202.11+13	A18 (485N/685E)	9/10	bituminous chalky marl	ZN 1	ring fragm.
11205.1	A9 (495N/685E)	5	soft red sandstone	ZN 2	ring fragm.
11205.2	A9 (495N/685E)	5	bituminous chalky marl	ZN 1	ring fragm.
11206.5	A18 (485N/685E)	19	bituminous chalky marl	ZN 1	ring fragm.
11206.7	A18 (485N/685E)	19	bituminous chalky marl	ZN 1	ring fragm.
11206.8-9+11-12	A18 (485N/685E)	19	bituminous chalky marl	ZN 1	ring fragm.

Appendix A cont. Catalogue of investigated Objects from Area A.

11206.10	A18 (485N/685E)	19	bituminous chalky marl	ZN 1	ring fragm.
11208.2	A18 (485N/685E)	19	bituminous chalky marl	ZN 1	ring fragm.
11208.3	A18 (485N/685E)	19	bituminous chalky marl	ZN 1	ring fragm.
11208.6a	A18 (485N/685E)	19	bituminous chalky marl	ZN 1	ring fragm.
11208.6b	A18 (485N/685E)	19	bituminous chalky marl	ZN 1	ring fragm.
11208.10	A18 (485N/685E)	19	bituminous chalky marl	ZN 1	ring fragm.
11208.4+7+11+12	A18 (485N/685E)	19	bituminous chalky marl	ZN 1	ring fragm.
11209.1	A18 (485N/685E)	23	bituminous chalky marl	ZN 1	ring fragm.
11209.2	A18 (485N/685E)	23	bituminous chalky marl	ZN 1	ring fragm.
11209.4	A18 (485N/685E)	23	bituminous chalky marl	ZN 1	ring fragm.
11209.5+7	A18 (485N/685E)	23	bituminous chalky marl	ZN 1	ring fragm.
11209.8	A18 (485N/685E)	23	bituminous chalky marl	ZN 1	ring fragm.
11211.1+2	A18 (485N/685E)	23	bituminous chalky marl	ZN 1	ring fragm.
11211.3	A18 (485N/685E)	23	bituminous chalky marl	ZN 1	ring fragm.
11211.4	A18 (485N/685E)	23	bituminous chalky marl	ZN 1	ring fragm.
11211.5+7	A18 (485N/685E)	23	bituminous chalky marl	ZN 1	ring fragm.
11211.6	A18 (485N/685E)	23	bituminous chalky marl	ZN 1	ring fragm.
11215.3-6	A18 (485N/685E)	23	bituminous chalky marl	ZN 1	ring fragm.
11216	A18 (485N/685E)	14	soft mauve sandstone	ZN 2	ring fragm.
11217.1+3	A3 (505N/695E)	4	bituminous chalky marl	ZN 1	ring fragm.
11217.2	A3 (505N/695E)	4	bituminous chalky marl	ZN 1	ring fragm.
11220	A18 (485N/685E)	26	bituminous chalky marl	ZN 1	ring fragm.
11221	A18 (485N/685E)	30	bituminous chalky marl	ZN 1	ring fragm.
11222	A22 (480N/680E)	5	grey to mauve sandstone	ZN 2	ring fragm.
11226.1	A22 (480N/680E)	8	red sandstone	ZN 2	ring fragm.
11232.1	A22 (480N/680E)	8	grey sandstone	ZN 2	ring fragm.
11232.2	A22 (480N/680E)	8	grey sandstone	ZN 2	ring fragm.
11232.4	A22 (480N/680E)	8	grey sandstone	ZN 2	ring fragm.
11233	A22 (480N/680E)	11	brown sandstone	ZN 2	ring fragm.
11242.1	A 8-9 (495N/680-85E)	3	soft yellowish to grey sandstone	ZN 2	ring fragm.
11255	A22 (480N/680E)	12	limestone	ZN 1	ring fragm.
11258	A22 (480N/680E)	15	red sandstone	ZN 2	ring fragm.
11259	A22 (480N/680E)	17	red sandstone	ZN 2	ring fragm.
11260	A22 (480N/680E)	34	mauve/grey-blue sandstone	ZN 2	ring fragm.
11265	A14 (490N/690E)	4	bituminous chalky marl	ZN 1	ring fragm.
11269	A22 (480N/680E)	41	red sandstone	ZN 2	ring fragm.
11277	A22 (480N/680E)	37	bituminous chalky marl	ZN 1	ring fragm.
11280	A22 (480N/680E)	18	red soft sandstone with dark spots	ZN 2	ring fragm.
11298.5	<no records>	<no records>	hard red sandstone	ZN 2	ring fragm.
11801	A5 (500N/685E)	4	sandstone	ZN 2	tab. obj.
11813.2	A5 (500N/685E)	11	calcite	ZN 1	waste
11815.1	A22 (480N/680E)	11	ferruginous sandstone	ZN 2	manuport
11815.3	A22 (480N/680E)	11	phyllite	ZN 3	waste
11816.1	A22 (480N/680E)	8	marly limestone	ZN 1	paillette
11816.2	A22 (480N/680E)	8	white silty sandstone?	ZN 2	paillette
11826	A14 (490N/690E)	5	limestone	ZN 1	mask
11889.3	<no records>	<no records>	green marble	CJ	bead
20829	A13 (490N/685E)	Room 18/ Locus 20	red coral	RS	bead
20903	A18 (485N/685E)	57	marl	ZN 1	pendant
20916.2	A17 (485N/680E)	Room 28/ Locus 23	rosy coral	RS	bead
20916.3	A17 (485N/680E)	Room 28/ Locus 23	rosy coral	RS	bead
20916.4	A17 (485N/680E)	Room 28/ Locus 23	rosy coral	RS	bead
20916.5	A17 (485N/680E)	Room 28/ Locus 23	rosy coral	RS	bead
20916.6	A17 (485N/680E)	Room 28/ Locus 23	rosy coral	RS	bead
20916.7	A17 (485N/680E)	Room 28/ Locus 23	limestone	ZN 1	bead
20916.8	A17 (485N/680E)	Room 28/ Locus 23	red coral	RS	bead
20916.9	A17 (485N/680E)	Room 28/ Locus 23	red coral	RS	bead
20916.10	A17 (485N/680E)	Room 28/ Locus 23	rosy coral	RS	bead
20916.11	A17 (485N/680E)	Room 28/ Locus 23	rosy coral	RS	bead
20918.1	A18 (485N/685E)	63	ferruginous sandstone	ZN 2	manuport
20918.2	A18 (485N/685E)	63	limestone	ZN 1	bead
20927.1	A14 (490N/690E)	18	limestone	ZN 1	bead
20936.1	A17 (485N/680E)	Room 28/ Locus 23	rosy coral	RS	bead
20936.2	A17 (485N/680E)	Room 28/ Locus 23	rosy coral	RS	bead
20936.3	A17 (485N/680E)	Room 28/ Locus 23	rosy coral	RS	bead
20936.4	A17 (485N/680E)	Room 28/ Locus 23	rosy coral	RS	bead
20936.5	A17 (485N/680E)	Room 28/ Locus 23	red coral	RS	bead
20936.6	A17 (485N/680E)	Room 28/ Locus 23	pinkish brown coral	RS	bead
20936.7	A17 (485N/680E)	Room 28/ Locus 23	red coral	RS	bead
20936.8	A17 (485N/680E)	Room 28/ Locus 23	rosy coral	RS	bead
20936.9	A17 (485N/680E)	Room 28/ Locus 23	calcite	ZN 1	bead
20936.10	A17 (485N/680E)	Room 28/ Locus 23	rosy coral	RS	bead
20936.11	A17 (485N/680E)	Room 28/ Locus 23	haematite	ZN 2	bead
20936.12	A17 (485N/680E)	Room 28/ Locus 23	red coral	RS	bead
20936.13	A17 (485N/680E)	Room 28/ Locus 23	rosy/red coral	RS	bead
21202	A18 (485N/685E)	46	bituminous chalky marl	ZN 1	ring fragm.
21207	A18 (485N/685E)	46	red sandstone	ZN 2	ring fragm.
21209	A18 (485N/685E)	46	bituminous chalky marl	ZN 1	ring fragm.
21211	A18 (485N/685E)	45	bituminous chalky marl	ZN 1	ring fragm.
21222	A14 (490N/690E)	Room 21/ Locus 11	hard red/grey mottled sandstone	ZN 2	ring fragm.
21804	A18 (485N/685E)	54	chalky marl	ZN 1	bead unf.

Appendix B. Remark on additional raw materials from Areas B and C.

Since the investigation of objects from Areas B and C has not been completed yet, they were not included in the analysis presented above. However, some additional and important raw materials have been identified among the objects from those areas :

amber

anhydrite (?)

chalk

mudstone

green quartz, siltstone (?)

calcareous sandstone

dolomitic

crystalline limestone

Except for amber, for which the source is unknown, the team from The National Resources Authority have suggested that all these materials could have been extracted from areas within Zones 1 and 2. This further strengthens the impression that locally and regionally available resources were used extensively. However, as mentioned in the main text of this contribution, this does not necessarily mean that objects in some of these materials could not have been imported. Again, the stratigraphic situation does not allow us to certify "that the picture ... is representative for any given point in time during the occupation of Basta." (above, p. 124).

Raw Materials of the Flint and Ground Stone Industries

Mujahed Muheisen, Nabil Qadi, and Hans Georg K. Gebel[1]

Introduction

Rock industries are those industries of the PPNB village life which most extensively reflect mans' daily interaction with nature on all levels of acquisition, production, and consumption. Sedentism brought substantial changes for the conditions of lithic behavior and the management of abiotic resources. Surplus factors (such as "more time" and "abundant labour force" in sedentary communities with progressive population dynamics), a fixed territoriality (with an intensifying concentration on specific mineral resources), and long distance exchange helped to create new products and markets both within and outside a region. "Lithic identities" began to characterize resource areas and production sites, and the mineral-rich geology of an area could promote the material culture and the importance of an area with all its social, economic and cognitive consequences (Gebel 2004). It was the permanent village life of the later PPNB that had reached the advanced technological needs and skills, as well as demands for goods which promoted the so far most developed specialization and diversified tool kits (Gebel 1994b, 1996). Neither the Epipalaeolithic sites (Muheisen 1983), nor the 9th – early 8th millennium or the 7th millennium BC Neolithic villages in the Southern Levant show this degree of innovation in their rock industries. Studying the ground and flint tool and vessel types, and being fortunate enough to deal with extreme large lithic samples at Basta, it soon becomes obvious that there is a close relation between the special quality of a raw material and blank character with the needs of the intended tool or vessel to be produced. *E.g.* the borers with tips between 1.5-2.5 mm in diameter only were made out of the central ridges of blades between 3 and 6 cm of the Flint Raw Material Group (FRMG) 2, while the borers with the tips around 5 mm mostly were made on the more tough FRMGs 1 or 3. Similar preferences in raw material selection within the major types' spectra can be traced in any LPPNB sample large enough to analyze its raw materials statistically. For Basta, it illustrates that we deal with a rather low rate of *ad hoc* tool production and use, at least in the LPPNB layers. Very specific raw material qualities were linked with specific, mostly one-task functions. Non-

---

[1] The raw material analysis of the flint artefacts was completed by Katsunori Iketani under the supervision of late Mujahed Muheisen. Mr. Iketani prepared Fig. 2 and Tables 3-5.

formal, multi-task tools do exist but seem to be linked with houshold and *ad hoc* levels of use. On the other hand, several examples show that destroyed or worn-out items were recycled in other functions, representing the *ad hoc* element in the often complex life of a tool: Such an example we do have *e.g.* with the flake cores from the Post- PPNB levels, recycled from typical Late PPNB hammerstones, which once were LPPNB naviform cores (Gebel 1996).

Resource Identification and Raw Material Grouping

We emphasize that the survey activity[1] connected with the Basta Joint Archaeological Project was too limited for the systematic location of the local and regional mineral raw materials. Only some of the raw materials used in the flint and ground stone industries could be survey-mapped for their location and geological context. However, the knowledge of the local geology gained over the years, and the assistance of the Natural Resources Authority, Amman, and of Hakam Mustafa, Yarmouk University, allowed us to identify the locations of the major mineral sources by their geological contexts on the geological maps, and later visits to the area verified most of them. The results are shown in Fig. 1. It is quite clear that we are dealing with source areas rather than specific spots, thus the designations of geological contexts in Fig. 1 (for explanation *cf.* Table 1) are marking roughly the provenance areas. The three major flint raw material groups were located by their outcrops (FRMGs 1-3, *cf.* Fig. 1). The potential and contribution of local and regional secondary sources (*e.g.* wadi fills, alluvial fans, *etc.*) is difficult to estimate[2]. In this work, we exclusively refer (Table 1) to the geological contexts identified for Southern Jordan by F. Bender and his collaborators (Bender 1968a-b, 1974a-b).

The large amount of chipped and "ground" rock artefacts to record made it necessary to identify raw material groups (*cf.* below, and the tables in this contribution). Their data are an element of all primary classifications of the rock artefacts at Basta. The grouping of FRMG 4-9 appears reliable, but it cannot be excluded that parameters of the more ill-attested raw material groups appear "overlapping" with one artefact or the other. It needs to be emphasized that the grouping of our flint raw material groups is dominated by technological aspects (*e.g.* flaking ability and nodular/ tabular sizes, *cf.* Table 2) rather than mineralogical parameters. This approach meets the needs of quick processing of large material quantities, and avoids sophisticated mineralogical distinctions which can be expected beyond the concerns of the Neolithic knapper. It also allows a more clear understanding of raw material preferences. Sometimes classes (sub-groups) were identified for the raw material groups (recorded with the statistical and metrical data), since they represent technologically different qualities of one source. They have been ignored in this presentation, since they are of limited relevance for the questions related source locations.

Geological Contexts of Used Lithic Sources

For the Basta sources of flint raw materials we observe primary, secondary and tertiary sources. The majority of the LPPNB material comes from primary sources, meaning that it was extracted from outcrops. Considerably less represented are secondary sources (eroded material from outcrops, transported in colluvials, alluvials, gravels, *etc.*); they characterize the

[1] Except for the systematic survey conducted in 1988 by H.G.K. Gebel with 6 persons for 7 working days, only occasional survey days and excursions in the Basta surroundings contributed to the knowledge of locally and regionally available mineral sources. 11.5 sq. km were systematically surveyed, concentrating in the vicinities of hydrologically favourable locations. For the raw materials used in the Pre-Pottery Neolithic sites in the sandstone area of Petra, intensive surveys were made by H.G.K. Gebel from 1981-85 (Gebel 1988). Insights from these were considered in this present study.

[2] In its strict sense, the lime-marl deposits of *e.g.* FRMG 2 at Jiththa (Plate 1.A-B) are a secondary source, since they are re-deposited and contain Levallois flakes.

Plate 1.A. Jiththa PPNB flint testing site (between the arrows) and present-day outcrops of FRMG 3 (1: greyish nodular flint) and FRMG 2 (2: tabular chocoloate flint), from N.
<photo: H.G.K. Gebel>

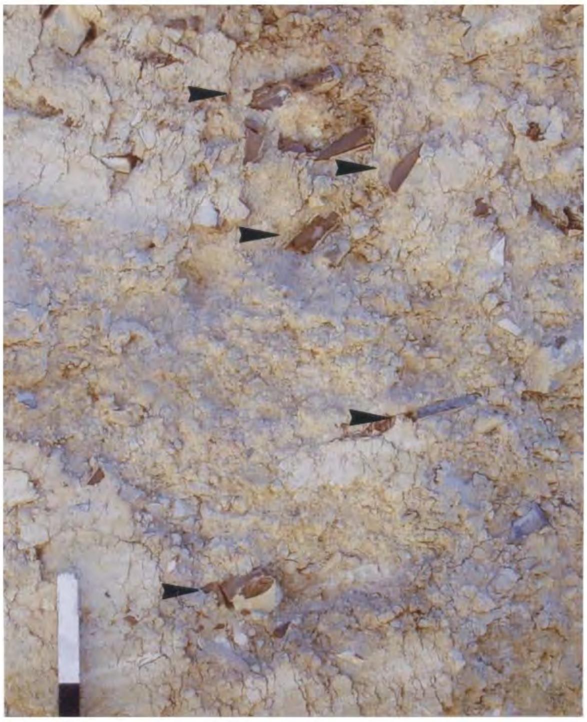


Plate 1.B. Jiththa: section of a FRMG 2 Outcrop. Note the fractured redeposited tabular chunks (arrows) in the lime-marl matrix.
<photo: H.G.K. Gebel>

Plate 1.C. Jiththa: layers with FRMG 3 nodules (arrows) in the upper stratigraphy of Jabal Jiththa..
<photo: H.G.K. Gebel>

Plate 1.D. Jiththa: a LPPNB grinding slab found in vicinity of the LPPNB flint testing site by Khairieh `Amr..
<photo: Khairieh `Amr>

material in the "rubble layers" (*cf.* Gebel, Site Preservation ..., this volume). Evidence of tertiary sources (re-used lithic artefacts) is rare and appears to be a feature of the "rubble layers" (FPPNB-PN).

The question if non-local sources of raw material (importing procurement) are attested in the acquisition framework of Basta LPPNB cannot be answered yet. We so far identified the sources of the major FRMGs, but not yet those of FRMG 4-9 (12 %). But they most likely are local (or regional), too. If non-local sources were used in LPPNB Basta, they did not have a significant proportion in the chipped lithic production (1 % for exotic flint, *cf.* Fig. 2). Prior to a final analysis we may assume that this picture is different for the "rubble layers", when higher proportions of non-local and wadi-battered raw materials arrived at the site, and the raw material records diversify.

The problem of identifying actually used sources is difficult for an area where flint is deposited almost everywhere in secondary sources, and where suitable qualities can be expected in contexts which not necessarily are mapped in the generalized geological maps. The major problem is that we have to expect small c5 and tt1 occurrences preserved on the c2-4 formations around Basta (Fig. 1).[1]

The rock sequence in the greater Basta area is as follows: c3-4 are underlying the c5 formation; on top of the latter the tt1 formations rest. c5 and tt1 covered once all the area before c3-4 were exposed. At locations where this sequence is preserved we can expect the major FRMGs 1-3 used by the Bastans. Eroded raw materials of the tt1 and c5 provenances can be found in all the wadis of the q2 areas, too (*cf.* Fig. 1)

Quartzite is attested in the c3-4 limestones around Basta, where it has a very coarse quality. The fine-grained orthoquartzite is attested here at several restricted spots, too. Silicified flakeable limestone also stems from these (c4).

Chipped Stone Raw Materials[2] (H.G.K.G., M.M.)

The majority of the chipped lithic artefacts in LPPNB Basta is represented by the Flint Raw Material Groups 1-3 (FRMG 1-3 of the Upper Cretaceous). They are predominantly the waste of bidirectional naviform production. FRMG 1 is used for a large blade production, somewhat unusual for the LPPNB industries. The existence of specialized workshops, of course, has to be considered when we discuss the statistical significance of a raw material use and bidirectional waste (Nissen, Muheisen, and Gebel 1989).

Chipped Stone Sources (Table 1, Fig. 1)

Basta is situated in a flint-rich environment. All raw material groups seem to have been collected within a maximum of 2-3 hours walking distances. The major sources , however, are just some one hours away from the site: thus flint procurement must have been a work easy to carry out from the village as a base. Intact LPPNB workshop dumps show that we deal with discriminating and specializing procurement. Although we should expect that dumping areas in the site were used by several workshops, the bulk of a dump mostly represents a certain raw material or a relatively fixed proportion of two raw material groups.

1 Hakam Mustafa did not find chert in the nodular limestone member (c2).

2 We would like to emphasize that the use of the term flint here is in its general archaeological meaning; by means of geology and petrography, the term "chert" is more correct. Whenever we use the term "lime inclusions", it refers to inclusions not analyzed yet. It well might be that these are phosphate inclusions, too (H. Mustafa, pers. comm.).

Table 1. Geologic contexts of used lithic sources in Basta (according to rock sequence, from Bender 1974; *cf.* Fig. 1).

q5: Fluviatile deposits, eolian sands, loess-like sediments, mantle rocks; Holocene

***q2*:** Fluviatile conglomerate, gravel, sand of elev. terraces and "old" mantle rock, up to 50 m thickness exposed

tt1: Chert-limestone member; conformably overlies the chalk-marl member, nummulitic limestone (up to 20 m thick) is developed in the uppermost part of this rock unit which varies in thickness between 60 m and 90 m. It is of marine origin except one intercalation (5 m) in its uppermost part which contains exclusively non-marine fossils; the marine fossils indicate Paleocene, and Early, Middle and Late (?) Eocene ages

tt+c5-2: Upper Cretaceous and Lower Tertiary sedimentary rocks, undifferentiated

c5-2: Upper Cretaceous sedimentary rocks, unidifferentiated

c5: Chalk-marl member; rests conformably on phosphorite member; varies in thickness between 50 m and 180 m, may increase to about 350 m with bituminous intercalations in sedimentary basins East of the area; was deposited during synsedimentary structural movements; marine fossils indicate Late Maestrichtian, Danian and Early Paleocene ages. Chalk-marl-facies deposition may have extended into Late Paleocen and Early Eocene in areas of continued subsidence

c4: Silicified limestone member; follows conformably above echinoid and sandy limestone members; it is approx. 100 m thick in the North and decreases Southward to about 50 m; contains Campanian marine fossils and is followed by the phosphorite member which consists of alternating limestone, some chert and impure phosphorite, decreases in thickness from 80 m (North) to 30 m (South), and contains marine fossils of Capanian to Maestrichtian age

c3: Echinoid limestone member; rests conformably on nodular limestone member, decreases in thickness from 210 m (East of Jordan River) in the North to about 80 m in the South; its upper portion grades Southwards laterally into the sandy limestonte member (80 m -110 m); Cenomanian, Turonian and Santonian marine fossils

c2: Nodular limestone member; overlies conformably the varicoloured sandstone, is marine, decreases in thickness from 120 m (North) to 80 m (South); bears abundant fossils of Early Cenomanian age

c1: Varicoloured sandstone, up to 150 m thick, non-marine with Early Cretaceous plant fossils; some shaly and marly intercalations in its uppermost portion yield fossils indicating a shallow marine depositional environment of Early Cenomanian age, grades downwards into massive white sandstone; overlies with a regional, slightly angular and strongly erosional unconformity either Cambrian or remnants of Lower Ordovician sandstone; non-marine, up to 180 m thick with Early Cretaceous plant fossils

o1: Massive, whitish weathered sandstone; overlies with transitional contact the massive, brownish weathered sandstone; up to 250 m thick within area shown on the Aqaba and Gharandal sheets; depositied in an alternating non-marine and deltaic-marine environment; yields well-preserved Early Ordovician Arenigian (?) trace fossils East of the Aqaba sheet

cb: Massive brownish weathered sandstone; overlies conformably the bedded arkose sandstone in the Southern section of the rift valley's East side; interfingers with the white fine sandstone in the area of Gharandal and also overlies conformably the white fine sandstone and, further to the North, the dolomite-limestone-shale formation; it is up to 350 m thick, non-marine and according to stratigraphic position of Cambrian age

P: Quartz porphyry, porphyrite, ignimbrite; pieces of clastic rocks, schist, gneiss and dike quartz in a volcanic (quartz porphyric) matrix, large masses, irregularly shaped stocks, sills and dikes of quartz porphyry occur either within or above the Proterozoic plutonites, or within the Late Upper Proterozoic sediments, or locally, within the Lower Cambrian clastic sediments; 18 physical age determinations of quartz porphyry give ages between 574 (+/- 8) and 510 (+/- 6) million years. Ignimbrite and pieces of different rocks in a quartz porphyric matrix resemble vent breccia; local occurrences of 4 m to 20 m thick, irregular beds. Physical age determinations: 510 (+/- 6), 471 (+/- 7) million years

Ga: Biotite and biotite-muscovite aplitic granite; most common plutonic rock exposed at East side of rift valley; rose-coloured and uniformly textured, or whitish-grey and porphyritic, or light red and pegmatitic. Physical age determinations: 590 (+/- 20), 592 (+/- 8) millions years

We do not have secure evidence for importing as a procurement method. Rare and exotic raw materials (13 %) did not play a significant economic role in the Basta flint economies. The large-scale exploitation of local high-quality raw materials and the qualitative and quantitative character of the dumps clearly indicate chipped lithic surplus production at LPPNB Basta. The manufacture of bidirectional blades flourished at the site beyond the needs of the inhabitants. We expect that Basta was an industrial center for the production of blades, and supplied the region with these tool blanks, and possibly also tools.

It has to be noted that the tt1 formations/ source areas survived quite restricted in the Basta catchments. The nearest tt1 sources of the FRMG 1 ('Ain Abu al-Idham, Fig. 1) are some 5-7 km to the South of Basta, and the tt1 Jiththa[1] sources providing the FRMG 3 are located some 6-7 km ESE of Basta. FRMG 2 was found in the c5 chalky marls/ marls underneath tt1 at Jiththa. The large tt1 remnant South of Jiththa is some 9-10 km away, and probably contains only FRMG 3. Major sources of the FRMG 3 are to be found South and North of Ma'an, at distance of more than 15 km from Basta. All the tt1 formations seem to provide either the FRMG 1 or 3, and are more easy to locate since they form the upper part of the geological stratigraphy (limestones with cherts of the Eocene - Paleocene) in the region. They rest on top the c5 chalky marls/ marls of the Late Maestrichtian – Danian – Late Paleocene , which developed between the Mesozoic and the Cenozoic (Bender 1968a-b). However, it seems that Levallois material erodes from these c5 chalky marls/ marls, at least at the section investigated West of Jiththa (Pl. 1.A-B).

The 'Ain Abu al-Idham sources appear as nodules in the present-day fields, and at some spots bedrock is exposed, showing the nodules in its layers. A lot of flaking activity is attested, among which is a proportion of a bidirectional large-blade production, most likely representing this element known from the workshops of LPPNB Basta.

Immediately at the NE foot of Jabal Jiththa, on a flat surface bordered by smaller wadis, a deflated area (*c.* 3000 sq.m.) with LPPNB flaking grounds was preserved between heavily bulldozed surfaces (Plate 1.A). It is characterized by a lot of tested material. The artefacts indicate that irregularities were removed from the raw material chunks of the nearby exploited tabular chocolate flint (FRGM 2; *cf.* below). They tried to set up cores with one or two parallel ridges, in order to see if it is useful to transport the chunk/ pre-core to the workshop. No such pre-cores were found on the surface. Initial steps of blade production are attested, too, including platform preparation.

These flaking grounds exclusively show the extraction of FRMG 2, and lie E of the present-day wadi which exposes a FRMG 2- outcrop (Plate 1.A: "2"). The tabular chunks of FRMG 2 appear as redeposited fragments (Plate 1.B) within the c5 chalk-marl layers, mixed with Levallois flakes. The FRMG 3 was found exposed by bulldozers in the upper stratigraphy of Jabal Jiththa (Plate 1.C). Nodules of up to one meter (!) are common in the flint bands. Due to the heavy bulldozing for lime quarrying in the area, no Neolithic procurement areas were encountered yet for the FRMG 3 during the three first visits.

The locations of FRMG 2 ("chocolate" varieties of tabular flint not requiring cresting for blade production) are difficult to map. They can occur everywhere in the c5 chalky marls/

---

[1] We would like to acknowledge that Khairieh 'Amr has drawn our attention to Jabal Jiththa, who first reported about a Neolithic site near Jiththa ('Amr 2001; *cf.* Pl. 1.D in this contribution). The site was subsequently researched by one of the present authors (H.G.K.G.) with members of the Ba'ja team in September 2003, and found to be an extensive flint source area in the Basta catchments. It was revisited again with Leslie Quintero and Mark Hintzmann in May 2004, who added further insights on the nature of the sources and testing ground. Due to the heavy bulldozing in the area, it is not clear if we could relocate the spots described earlier by K. 'Amr. We also thank Leslie Quintero and Mark Hintzmann for the on-site discussion of the evidences.

Table 2. Questionnaire and descriptive standards of the flint raw material list for the Greater Petra Area (after Gebel 1994).

A) Characteristics of pebble/ nodular and tabular bodies

1. dimensions *(pebble/ nodule dimensions, range of thicknesses of tabular raw material)*
2. shapes of pebble/ nodule/ tabular flint shapes *(e.g. with tabular flint: parallel-sided slabs, lenticular/ spherical bodies with hollows)*
3. marginal (= near cortex) areas *(e.g. coral-like parts)*

B) Natural surfaces

1. cortical and cleft surfaces of bedrock material *(e.g. formed in geologic source: chemical weathered cortex formed in bedrock/ bedrock-fresh cortex, partly silicified/ silicified cortex, hard/ scratchable/ easily worn cortex etc.)*
2. eroded chalky cortex *(thin (below 1 mm) / medium thick (2-4 mm) / thick larger (4 mm) / irregular thick cortex)*
3. rolled (transport) surfaces *(e.g. cobble cortex from abrasive wadi processes, smoothed chalky cortex, only silicified cortex parts left by abrasion, transport batterings and chippings, removals in flake sizes, etc.)*
4. characteristic patination of raw material *etc.(heavy/ light patination, patination colour(s), evidence of in- soil/ surface patination types, desert varnish, etc.)*
5. character of contact area between cortex and silicified core *(e.g. clear separation, gradual transition, indistinct contact area, etc.)*

C) Matrix/ texture and homogeneity (characterized by chipped surfaces)

1) matrix/ texture *(very fine grained, fine grained, slightly fine grained, sligthly coarse grained, coarse grained, very coarse grained)*

2. homogeneity *(non-homogeneous, homogeneous, indeterminate)*

D) Inclusions, clefts/ pores, flaking ability

1. macroscopically recognizable inclusions and fossils *(e.g. lime inclusions)*
2. clefts/ hollows *etc. (e.g. "breccious" material, quartz veins, very small hollows (below 0.2 mm)*
3. status of silification of inclusions *(not silicified, partly silicified, mostly silicified, completely silicified)*
4. distribution of inclusions *(e.g. irregular, discontinous, parallel condensed with cortex, regular (density), etc.)*
5. flaking ability *(problematic/ parameters to be discussed: barely manageable, manageable, very manageable (e.g. parallel-sided blade manufacture)*

E) Translucency (characterized at edges of blade-flakes)

completely opaque, opaque with slight translucency at very thin edges, slightly translucent, milky translucent, vitreous/ highly translucent

F) Colour variation of main matrix (without coloured patterns; Munsell Soil Colour Chart notation(s)

1. notation
2. variation *(e.g. considerable, little variation, not considerable)*

G) Coloured patterns (Munsell Soil Colour Chart notations)

1. character of pattern *(e.g. without evidence/ homogeneous, fine dotted, fine speckled, coarse speckled, cloudy, "marble veins", streaky, laminated, etc.)*
2. distribution of pattern *(e.g. irregular, discontinous, concentric, isolated, etc.)*

H) Lustre (characterized on fresh chipped surfaces, but sickle/ tempering sheen not considered)

highly lustrous, silky/ slightly high lustre, faintly lustrous, without lustre or dull

I) Geological context/ Allocated source (areas)

J) Other characteristics, comments

marls localities Northeast and Southeast of Basta (Fig. 1), and have been located *e.g.* below Jabal Jiththa. This raw material appears sharp-edged and fractured in this geological environment, where it is embedded without any recognizable orientation (Pl. 1.B).

Both the LPPNB workshop dumps as well as the evidence from Jiththa show discriminating and specializing procurement. The 'Ain Abu al-Idham and Jiththa lithic procurement sites or complexes (Fig. 1) most likely were the major source areas for the LPPNB Bastans.

Chipped Stone Raw Material Groups (FRMGs)[1]

In the following, we describe the raw materials attested with the chipped stone industries from unmixed LPPNB layers at Basta. In our so-called "rubble layers", the layers above the preserved LPPNB wall tops, a different choice, more and other raw materials can be observed, often in poor qualities. We interpret this as the result of the presence of Late Neolithic mobile groups temporarily visiting/ using the ruins, while mud and debris flows were covering the site.

The description of raw material groups follows the order presented in Table 2. For the sake of terminological uniformity and standards of definition, potential parameters are presented in this table. The description of the FRMGs was done macroscopically, if necessary with the help of magnification. Raw material classes (FRMC) were introduced to distinguish sub-qualities within a group, referring to differences in matrix/ texture/ homogeneity and flaking ability. However, too much differentiation in this respect has to be questioned, since we recognized with known sources quite a variation of quality in one context, layer, or even a nodule.

It is the opinion expressed here that chances do exist to evaluate raw material groups and classes, even on the level of in-field recording, if a standard checklist of parameters is followed (Table 2). Experience has shown that a parameters' list provokes a fine subdivision of visually and physically different raw materials by the non-mineralogist, although the degree of "fine divisions" could be the result of an analytical insecurity. Of course, it cannot be expected to reflect any understandings of raw material made by the Neolithic craftsmen. In our pragmatic approach, rare raw materials receive attention as separate groups (important for trade questions) which can result in quite elaborated lists (*e.g.* originally 19 groups for LPPNB Basta, without the obsidian, limestone, quartzite, quartz *etc.* groups and classes). Subjective use of the parameters is to be expected, but it remains independently testable on a rather high level, especially when regrouping is following new source information. This regrouping should be subject to mineralogical consultation, must regard the results of a site-oriented flint source survey as well as the geological setting of the site. These groups then should reflect the source situation of the site as well as the quality and other selection aspects to be reconstructed for the Neolithic knapper's preferences. The regrouping also

[1] The list of the flint raw materials available in the Greater Petra Area was continuously developed since 1983 (by the projects: Prehistoric Investigations in the Greater Petra Area (PIGPA) – Early Holocene Research, the Basta Joint Archaeological Project, and the Ba'ja Neolithic Project). The description of the raw materials follows a questionnaire (*cf.* Table 2). The list allows additions, also for occurring new qualities within existing groups; the various qualities of one flint raw material group (FRGM) or source would be described by FRGCs (Flint Raw Material Classes). On the other hand, the system allows groups and classes to be regrouped whenever a more detailed knowledge of a poorly understood raw material group demands it. The aim of our FRMG– collection is to allow comparability of raw material choices at the various Neolithic sites in the Greater Petra Area.
Note: Since the sources of FRMGs 1-3 are now precisely located (*cf.* Fig. 1), Table 2 in Gebel 1996 can be supplied accordingly.

brings together materials which technologically served similar purposes. However, the improvisation aspect remains an imponderable argument for any production at a non-industrial level.

Raw material recording belongs to the primary classification level of flint analysis on which core, core trimming, debitage, and tool classes are listed by count and weight for each raw material group/ class. To reduce raw material recording and to consider *e.g.* only cores for reasons of analysis economy, might appear legitimate - but it introduces other limits for interpretations.

As mentioned above, regrouping of the flint classes and groups requires mineralogical assistance. Flaking ability and other flint knapping aspects (*e.g.* the dimension range of a tabular flint) are not mineralogical categories, and mineralogical categories of course ignore the technological meanings of flint knapping. Relevant problems of mineralogical character *versus* technological qualities can only be resolved through the discussion between the prehistorian and the mineralogist in order to achieve useful raw material regroupings. We found no problems in the Basta analysis to regroup the detailed statistics of our original raw material classes. In some cases, a misunderstood and ill-attested class could be assigned to one or two raw material groups.

Flint Raw Material Group 1

A) *Characteristics of Pebble / Nodular or Tabular Bodies:* parallel-sided and roughly parallel-sided tabular bodies with thicknesses ranging between 3-8 cm, occasionally beds of 12 cm
B) *Natural Surfaces:* cortex preserved from geologic source (bedrock-fresh cortex), easily scratchable; thin to thick cortex thickness (1 - >4 mm); no evidence of rolled material (not collected from wadis); no patination, including in-soil patination, no desert varnish *etc.* observed with used material; patination of exposed surfaces at the source have reddish brown colours; in most cases clear separation between cortex and flint body, however, sometimes grayish-cloudy streaks appear between (<2 mm)
C) *Matrix / Texture and Homogeneity (Chipped Surfaces):* slightly fine-grained to slightly coarse-grained, sometimes rather fine grained; inclusions influence homogeneity
D) *Inclusions, Clefts / Pores, Flaking Ability:* irregular distributed clearly isolated lime inclusions (c. 0,5 mm max.), not silicified; inclusions often are condensed in regular bands, also along cortex; no cflefts or hollows, body of flint is homogeneous despite the lime inclusions; flaking ability: grim-dogged / tough material, which is very good for a controlled large-blade detachments, because it not allows an uncontrolled spread of the energy
E) *Translucency (at Edges of Blades / Flakes):* completely opaque, some varieties with with slight translucency at very thin edges
F) *Colour Variation of Main Matrix (Munsell Notations without Coloured Patterns):* 10YR 2/2-7/2 "light gray - lightbrwonish gray - grayish brown - dark grayish brown - very dark grayish brown - very dark brown", considerable colour variation
G) *Coloured Patterns (Munsell Notations):* very rare and irregularily distributed coloured clouds within the flint bodies
H) *Lustre of Raw Material (Freshly Chipped Surfaces):* no lustre / dull
I) *Geological Context / Allocated Source (Areas*): in the tt1 chert/ limestone "islands"above the c5 formations; as eroded material in the q2 fluviatile conglomerate/ gravels/ sand sand and Holocene wadi deposits
J) *Other Characteristics / Comments:* materials were directly exploited from the sources (discriminating and specializing procurement): nearest sources are known from South of Ail ('Ain Abu al-Idham vicinity); material was selected especially for the bidirectional

(large) blade production, since the *c.* 3-4 cm thicknesses of the tabular bodies allow blade production without cresting

Flint Raw Material Group 2

A) *Characteristics of Pebble / Nodular or Tabular Bodies:* parallel-sided tabular bodies with thicknesses of 1-5 cm; characteristic thicknesses are 1.5-2 cm
B) *Natural Surfaces:* cortex preserved from geologic source / chemically weathered cortex formed in bedrock (bedrock-fresh cortex): easily scratchable; cortex thicknesses 0,5-7 mm; no evidence rolled, patinated, or material bearing desert varnish attested with used material; clear separation between cortex and flint body
C) *Matrix / Texture and Homogeneity (Chipped Surfaces):* fine-grained, homogeneous matrix
D) *Inclusions, Clefts / Pores, Flaking Ability:* no inclusions or fossils, clefts, or hollows, very homogenious material; flaking ability: very good, especially because the parallel-sided tabular bodies allow for naviform cores without much core preparation
E) *Translucency (at Edges of Blades / Flakes):* opaque with slight translucency at thin edges
F) *Colour Variation of Main Matrix (Munsell Notations without Coloured Patterns):* 10YR 4-6/3-6 "pale brown - light yellowish brown - brownish yellow - brown - yellowish brown - dark brown - dark yellowish brown"; considerable variation of matrix colour
G) *Coloured Patterns (Munsell Notations):* irregularily distributed whitish to light coloured clouds or bands (near-cortex bands are run parallel with the cortex)
H) *Lustre of Raw Material (Freshly Chipped Surfaces):* faintly lustrous
I) *Geological Context / Allocated Source (Areas):* c5 chalky marls/ marl, *e.g.* the Jiththa sources; as eroded material in the q2 fluviatile conglomerate/ gravels/ sand sand and Holocene wadi deposits
J) *Other Characteristics / Comments:* materials were directly exploited from the sources (discriminating and specializing procurement): nearest sources are known from South of Ail (Jabal Jiththa); material was selected especially for the bidirectional blade production; possibly closely related to FRMG 4; most workshop refuse contains this raw material

Flint Raw Material Group 3

A) *Characteristics of Pebble / Nodular or Tabular Bodies:* nodular bodies of minimum sizes of 20-30 cm, sizes may range up to 100 x 50 30 cm; nodular, lenticular, and/or semi-tabular shapes
B) *Natural Surfaces:* mostly abraded/ weathered cortex surfaces: cortex preservation ranges from completely abraded (chalky) cortex to scratchable multi-layered chalky cortex with uneven surface; mostly "cloudy" but distinct transition into lower silicified cortex layer; in some cases sharp separation of the lowermost silicified cortex layer from the flint body: when preserved, thin flint layers (below 0.5 mm) are interbedded into the cortex layers (status of silification reduces towards outer parts); patination of natural fractures in light colours
C) *Matrix / Texture and Homogeneity (Chipped Surfaces):* fine grained to slightly fine grained; homogeneous matrix
D) *Inclusions, Clefts / Pores, Flaking Ability:* no inclusions, quartz hollows possible, occasionally non-silicified clefts; flaking ability: tendency for a grim / dogged or tough material respectively: resistant against uncontrolled spread of removal energy (good flaking quality); tendency for scaly fractures and negatives
E) *Translucency (at Edges of Blades / Flakes):* opaque with milky transluscence at thin edges; translucent parts: 5YR 7/2-4, 8/2-4 "pinkish gray - pinkish white - pink"

F) *Colour Variation of Main Matrix (Munsell Notations without Coloured Patterns):* 7.5 YR 5/0, 6/0-2, 7/0-2, 8/0-2 "gray - pinkish gray - light gray - white- pinkish white" and 10YR 5-8/1-4 "white - very pale brown - light gray, gray, light brownish gray - pale brown - light yellowish brown"; colour variation concerns also the concentric coloured patterns characteristic for this raw material; considerable variation

G) *Coloured Patterns (Munsell Notations):* irregularly distributed whitish "clouds", occasionally roughly parallel or concentric whitish bands with cortex deliniation; colours see also F)

H) *Lustre of Raw Material (Freshly Chipped Surfaces):* slightly high lustre - faintly lustrous

I) *Geological Context / Allocated Source (Areas):* in the tt1 chert/ limestone "islands"above the c5 formations; as eroded material in the q2 fluviatile conglomerate/ gravels/ sand and Holocene wadi deposits

J) *Other Characteristics / Comments:* materials were directly exploited from the sources (discriminating and specializing procurement): nearest sources are known from South of Ail (Jabal Jiththa); material was selected especially for the bidirectional blade production

Flint Raw Material Group 4

A) *Characteristics of Pebble / Nodular or Tabular Bodies:* predominantly parallel-sided tabular bodies, mostly (selected?) between 1-4 cm thick

B) *Natural Surfaces:* cortex preserved from geologic source, sometimes chemically weathered (bedrock-fresh cortex); easily scratchable; thicknesses of cortex 0.5-7 mm; no rolled surfaces, patinations, or desert varnish attested with used materials; sharp separation between cortex and flint bodies

C) *Matrix / Texture and Homogeneity (Chipped Surfaces):* fine-grained - slightly fine-grained; homogeneous matrix

D) *Inclusions, Clefts / Pores, Flaking Ability:* rare and very fine lime inclusions (not silicified), stratified in streaks or in clusters; no clefts or hollows; flaking ability: very good, especially suitable for naviform large blade production

E) *Translucency (at Edges of Blades / Flakes):* opaque - opaque with slight translucency at thin edges

F) *Colour Variation of Main Matrix (Munsell Notations without Coloured Patterns):* 5YR 3/2-3, 2.5/2 "dark reddish brown"

G) *Coloured Patterns (Munsell Notations):* do not occur with this raw material

H) *Lustre of Raw Material (Freshly Chipped Surfaces):* faintly lustrous - without lustre/ dull

I) *Geological Context / Allocated Source (Areas):* c5 chalky marls/ marl, *e.g.* in *samagah* outcrops near Basta; as eroded material in the q2 fluviatile conglomerate/ gravels/ sand and Holocene wadi deposits

J) *Other Characteristics / Comments:* possibly closely related to FRMG 2; this raw material might either be rarely collected because it seems mostly to exist as smaller nodules

Flint Raw Material Group 5

A) *Characteristics of Pebble / Nodular or Tabular Bodies:* nodular bodies of unknown dimensions (Blade III- class is attested with this raw material!)

B) *Natural Surfaces:* cortex preserved from geologic source: chemically weathered cortex (bedrock- fresh); scratchable - semihard cortex with thicknesses of 1-3 mm; no rolled, patinated cortex or desert varnish *etc.* appears with used raw material; sharp separation between cortex and flint body

C) *Matrix / Texture and Homogeneity (Chipped Surfaces):* slightly fine-grained; homogeneous matrix

D) *Inclusions, Clefts / Pores, Flaking Ability:* irregular distributed lime inclusion (not silicified) in varying intensity; flaking ability: very good
E) *Translucency (at Edges of Blades / Flakes):* completely opaque - occasionally with slight translucency at very thin edges
F) *Colour Variation of Main Matrix (Munsell Notations without Coloured Patterns):* 7.5YR 2/0 and 10YR 3/1 "black - very dark grey"
G) *Coloured Patterns (Munsell Notations):* without evidence, homogeneous
H) *Lustre of Raw Material (Freshly Chipped Surfaces):* without lustre / dull, occasionally faintly lustrous
I) *Geological Context / Allocated Source (Areas):* c5 chalky marls/ marl, *e.g.* in *samagah* outcrops near Basta; as eroded material in the q2 fluviatile conglomerate/ gravels/ sand and Holocene wadi deposits
J) *Other Characteristics / Comments:* this raw material might either be rare or rarely collected because it seems mostly to exist as smaller nodules

Flint Raw Material Group 6

A) *Characteristics of Pebble / Nodular or Tabular Bodies:* nodular bodies of unknown dimensions
B) *Natural Surfaces:* completely abraded / weathered cortex (<1 mm) from in situ exposure (eroded cortex); patination of natural fractures in light colours; sharp separation between cortex and flint body
C) *Matrix / Texture and Homogeneity (Chipped Surfaces):* very fine-grained - fine-grained; homogeneous matrix
D) *Inclusions, Clefts / Pores, Flaking Ability:* no inclusions, clefts or hollows; flaking ability: very good
E) *Translucency (at Edges of Blades / Flakes):* milky translucent at thin edges
F) *Colour Variation of Main Matrix (Munsell Notations without Coloured Patterns):* 10YR 5-8/1-4 "white - very pale brown - light gray, gray, light brownish gray - pale brown - light yellowish brown"; colour variation concerns also the concentric coloured patterns characteristic for this raw material
G) *Coloured Patterns (Munsell Notations):* cloudy concentric patterns, colours see F)
H) *Lustre of Raw Material (Freshly Chipped Surfaces):* slightly high lustre - faintly lustrous
I) *Geological Context / Allocated Source (Areas):* c5 chalky marls/ marls; as eroded material in the q2 fluviatile conglomerate/ gravels/ sand and Holocene wadi deposits
J) Other Characteristics / Comments: -

Flint Raw Material Group 7

A) *Characteristics of Pebble / Nodular or Tabular Bodies:* nodular bodies of unknown dimension, most likely only smaller dimensions; tabular variant exists?
B) *Natural Surfaces:* cortex most probably preserved from the source (raw material was extracted from the source); irregular cortex thicknesses of 1-10 mm; no patinations or desert varnish found with this raw material; clear separation between cortex and flint body
C) *Matrix / Texture and Homogeneity (Chipped Surfaces):* very fine-grained -fine grained; homogeneous matrix
D) *Inclusions, Clefts / Pores, Flaking Ability:* no inclusions, clefts, *etc.*; flaking ability: very good, but not suitable for large blades (nodule dimensions)
E) *Translucency (at Edges of Blades / Flakes):* milky translucent at thin edges
F) *Colour Variation of Main Matrix (Munsell Notations without Coloured Patterns):* 5YR 3/3 "dark reddish brown" to 10YR 6/4 "light yellowish brown"

G) *Coloured Patterns (Munsell Notations):* occasionally concentric streaky patterns of lighter colours
H) *Lustre of Raw Material (Freshly Chipped Surfaces):* slightly high lustre - faintly lustrous
I) *Geological Context / Allocated Source (Areas):* c5 chalky marls/ marls, *e.g.* in *samagah* outcrops near Basta, q2?
J) Other Characteristics / Comments: -

Flint Raw Material Group 8

A) *Characteristics of Pebble / Nodular or Tabular Bodies:* probably nodular flint bodies
B) *Natural Surfaces:* rolled surfaces / natural transport batterings with whitish patination
C) *Matrix / Texture and Homogeneity (Chipped Surfaces):* coarse-grained; non-homogeneous matrix
D) *Inclusions, Clefts / Pores, Flaking Ability:* many irregular clefts and quartz veins, resulting in a "conglomeratic" character; flaking ability: barely good, not suitable for blade production (spread of energy hard to control)
E) *Translucency (at Edges of Blades / Flakes):* completely opaque
F) *Colour Variation of Main Matrix (Munsell Notations without Coloured Patterns):* 10YR 8/2-3 and 2.5Y 8/2 "white - very pale brown" and "white"
G) *Coloured Patterns (Munsell Notations):* streaks of 10YR 6/3 "pale brown"
H) *Lustre of Raw Material (Freshly Chipped Surfaces):* without lustre, dull
I) *Geological Context / Allocated Source (Areas):* not located, found in surrounding wadis terrace and gravels
J) Other Characteristics / Comments: -

Flint Raw Material Group 9

A) *Characteristics of Pebble / Nodular or Tabular Bodies:* tabular (occasionally lenticular) bodies of unknown dimensions
B) *Natural Surfaces:* cortex character?
C) *Matrix / Texture and Homogeneity (Chipped Surfaces):* matrix highly interspersed with lime inclusions; homogeneous matrix
D) *Inclusions, Clefts / Pores, Flaking Ability:* high proportion of tiny lime inclusions; no clefts or hollows, pores; inclusions not silicified; inclusions equally distributed or parallely condensed in streaks; flaking ability: grim or dogged / tough material; very good for controlled detachments (resistant against uncontrolled spread of removal energy)
E) *Translucency (at Edges of Blades / Flakes):* completely opaque
F) *Colour Variation of Main Matrix (Munsell Notations without Coloured Patterns):* problematic to determine because of high concentration of inclusions: approx. 10YR 7/2 "light gray"
G) *Coloured Patterns (Munsell Notations):* concentric (or parallel to clefts), sometimes almost invisible streaks in the matrix of colours varying between 10YR 5/6-8 "yellowish brown"
H) *Lustre of Raw Material (Freshly Chipped Surfaces):* without lustre
I) *Geological Context / Allocated Source (Areas):* not located
J) Other Characteristics / Comments: -

Other Chipped Stone Raw Material Groups

Among the chipped raw materials, the use of flint/ chert dominates over flaked quartzite, silicified limestone and other limestone varieties; obsidian is attested by a few pieces only[1] What is named "exotic" in our tables is exotic in terms of unusual and infrequent, and not necessarily means "imported". The only and surely imported chipped raw material at Basta is obsidian.

Raw Material Selection in the Chipped Stone Industries (Fig. 2)

At Basta, information on raw material selection is attested in two contexts: we do have "ordinary" distributions in the mixed chipped lithic evidence from the squares, and we have the statistically – concerning raw material preferences – less reliable workshop dumps with high concentrations/ certain proportions of specific raw materials (FRMGs 1-3). Established workshops producing on an industrial scale in permanent Early Neolithic villages like Basta provide a basic source for the understanding of specialized raw material and tool blank selection in primary and secondary production.

Based on the evidence from primary and secondary production, the Flint Raw Material Groups 1-3 outnumber all other occurrences in the samples from Squares A3, 5, 9-10, 13-14, 18, and 22 (Fig. 2.a-b, Table 3). 85 % of the raw material comes from these groups (by weight: 84%). FRGMs 4-9 are infrequently attested (by pieces: 1-6 %, exotic: 1 %). Quartzite arte-facts are attested by 2% (by weight: 5 %). Fig. 2.c illustrates that Groups 1 and 3 in general have a higher representation in "ordinary" squares, whereas the FRMG 2 is most frequent (almost 60 %) in squares (here *e.g.* A5) with flint workshop dumps. If we consider the raw material distribution in secondary production (tool class arrowheads, borers, and heavy duty tools; Fig. 2.d-f), we notice considerable differences. While almost equal preferences exist for FRMGs 1-3 and quartzite arrowheads (between 15 and 25 %), it is clear that for borers the Bastans preferred Group 2 (52 %), followed by Group 3 (24 %). Borers with tips <3 mm were made of FRMG 2, borers with tips >4 mm use FRMG 3. The high preference of FRMG 3 for heavy duty tools could be related to the fact that the dimensions of the tabular FRMGs 1 and 2 might have been less suitable for large tools.

It is difficult to judge about the importance or role of the individual FRMG 1, 2, or 3. in Basta. The percentages of available raw material records (Tables 3-5) from the squares differ, and it could be the wrong question to ask. The preferences in raw material selection were controlled by the planned tool functions and needs. Thus we expect that questions of raw material selection are answered by the evaluation of the secondary production rather than by waste counting (especially if the latter are statistically insignificant due to the existence of dumps).

We cannot give information here on the operation of flint quarries[2] (which could not have been the same for all three groups, however), and some of the statements are based on secondary evidence from the "Archaeological Level" (*cf.* Gebel 1996). Questions about the most profitable sources (which were not necessarily the largest or nearest), engineering designs of quarrying, source-different knapping capabilities for the same raw material, *etc.*, must remain mute.

---

[1] No analysis for the sources of this raw material was carried out yet.
[2] For LPPNB flint mining evidence see Taute 1994 and Quintero 1996.

All this evidence shows that about 85 % of the chipped lithic raw materials processed in LPPNB Basta came from primary sources (exploited at flint mines). This changed after the end of the LPPNB occupation, since we found in the "rubble layers" and in strata related to the decay of the LPPNB houses higher concentrations of raw materials from secondary sources (mainly of FRMG 3). These are battered chunks from wadi or surface transport, sometimes heavily patinated, and obviously eroded from outcrops. This material, associated with a FPPNB (we might hesitatingly say PPNC) and PN flake industry, unifacially pressure-flaked small arrowheads already resembling Yarmoukian shapes, and relicts of flimsy structures and ephemeral fire places, comes from the surrounding heights and was gathered in the wadis around Basta. Thus, for the FPPNB-PN use of the area, supposedly by mobile herders using the ruins near the spring as shelters, we must conclude a non-discriminating procurement for flint raw materials for them. This even includes evidence for "tertiary sources," such as the transformation of naviform cores, re-used as LPPNB hammerstones, into flake cores. The collection and use of LPPNB flint artefacts by post-PPNB visitors to Basta are not rare cases.

Table 4. Raw materials of chipped lithic artefacts (based on the assemblages from selected loci of Squares A3, A9, and A18).

Raw Material	Square A5: Loc.2,11,13				Square A9: Loc.4,5,6,9,12,26				Square A18: Loc.4,10,24,26,28,36			
	Count		Weight		Count		Weight		Count		Weight	
	n	%	g	%	n	%	g	%	n	%	g	%
Flint Group 1	397	12.65	2941.0	14.88	244	16.21	1056.9	16.17	116	14.81	491	8.95
Flint Group 2	157	5.00	8141.5	41.20	554	36.81	1579.5	24.17	113	14.43	395.2	7.20
Flint Group 3	822	26.20	6510.5	32.94	458	30.43	2563.0	39.22	450	57.47	3851.5	70.20
Flint Group 4	118	3.76	619.5	3.13	73	4.85	201.5	3.08	34	4.34	95.5	1.74
Flint Group 5	35	1.12	101.0	0.51	11	0.73	21.5	0.33	5	0.64	10.5	0.19
Flint Group 7	33	1.05	113.2	0.57	11	0.73	18.5	0.28	16	2.04	56.2	1.02
Flint Group 8	2	0.06	21.5	0.11	4	0.27	260.5	3.99	0	0.00	0	0.00
Flint Group 9	79	2.52	636.0	3.22	45	2.99	161.0	2.46	10	1.28	93	1.70
Exotic Groups	16	0.51	161.0	0.81	13	0.86	73.2	1.12	10	1.28	60	1.09
Quartzite	65	2.07	517.2	2.62	90	5.98	590.5	9.04	29	3.70	433.5	7.90
Limestone	0	0.00	0.0	0.00	2	0.13	9.5	0.15	0	0.00	0	0.00
Total	3138	100.00	19762.4	100.00	1505	100.00	6535.6	100.00	783	100.00	5486.4	100.00

Table 5. Raw materials of chipped lithic artefacts (added up results from Squares A3, A9, and A18, *cf.* Table 3).

Raw Material	Count		Weight	
	n	%	g	%
Flint Group 1	757	13.95	4488.9	14.12
Flint Group 2	2238	41.25	10116.2	31.83
Flint Group 3	1730	31.88	12925.0	40.66
Flint Group 4	225	4.15	916.5	2.88
Flint Group 5	51	0.94	133.0	0.42
Flint Group 7	60	1.11	187.9	0.59
Flint Group 8	6	0.11	282.0	0.89
Flint Group 9	134	2.47	890.0	2.80
Exotic Groups	39	0.72	294.2	0.93
Quartzite	184	3.39	1541.2	4.85
Limestone	2	0.04	9.5	0.03
Total	5426	100.00	31784.4	100.00

Ground Stone Raw Materials (N.Q.)

The assemblage of ground stone tools and stone vessels from Basta is characteristic for the LPPNB of Jordan. However, the abundance of grinders in Basta (60-75 % of the 1986-88 finds) is striking and demands for an explanation. It also requires a detailed contextual research for Basta and a comparison with the grinding tools' distribution and quantities in other LPPNB sites of similar ecological settings. These studies need to focus on four major subjects (Qadi, forthcoming): manufacturing techniques, raw material preferences, functional aspects/ traces of wear, relation of artefacts with information on plant subsistence/ ecological setting. This report presents a preliminary classification of the ground stone tool and stone vessel types and their raw materials, based on the 1988 sample.[1]

The abundance of grinding tools (handstones, "rubbing stones", grinding slabs, and querns) seems to emphasize an importance of plant processing at Basta. 1200 grinding tools (complete and fragmentary) can be reported from just the 1988 season, constituting 75 % of the ground stone items. But it appears doubtful that this large number of grinders all represents the food processing sector. Either they were used in other functions, too, and/or Basta was a production center for grinding tools. The latter is suggested by the many items not showing traces of wear. Similar arguments appear to be justified for the pounding tools, represented by the pestles, mortars, cupmark, and hammerstones.

The raw materials exploited for the manufacture of ground stone tools and stone vessels seem to be all available in the Basta geological catchments, or from the sandstone area in the West. Limestone in various qualities, carbonate rocks, quartzitic sandstone are known from the Basta vicinity; sandstone, granite, conglomerate rocks, igneous rocks, and silicate stones stem from the sandstone area. Basalt can have arrived from both the limestone as well as from the sandstone area (*e.g.* basalt is frequent on surfaces near Jabal Jiththa).

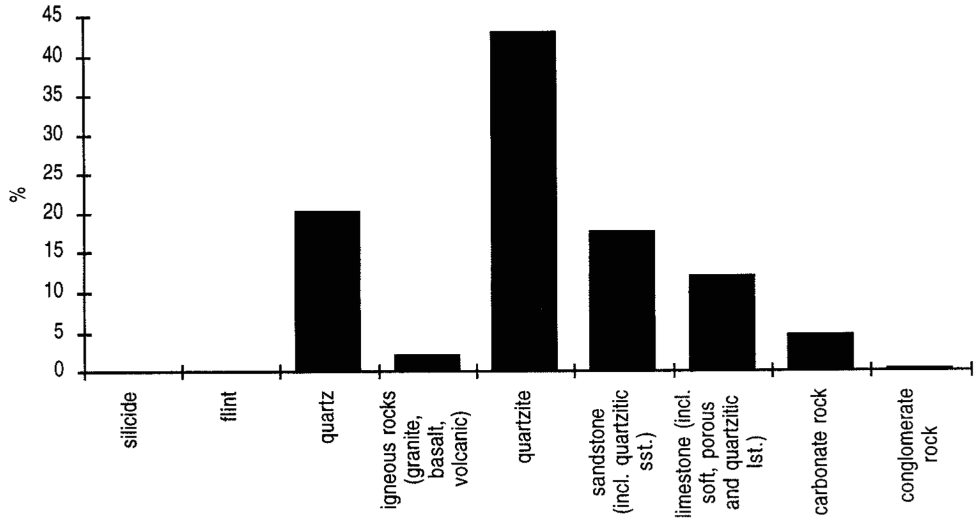


Fig. 3. Raw material use in the ground stone industries (based on the 1988 sample of finds).

---

[1] Areas A, B and C were not separated for this presentation. The meaning of "ground stone" implies both: that the tool or item was produced by flaking/ chipping and hereafter by a grinding, or that the shape results from a use process of grinding after it was roughly shaped by flaking/ chipping. In addition to the raw materials to be mentioned here is soap stone, attested from other seasons of the excavation.

Table 6. Quantitative representation of raw materials in the ground stone and stone vessel industries. *<percentages of the 1988 finds based on piece numbers, both complete and fragmentary tools and vessels>*

Raw Materials	**%**
silitite	0,06
flint	0,18
quartz	20,10
Igneous Rocks	
granite	0,12
volcanic rock	0,92
basalt	1,05
Sedimentary Rocks	
quartzite	42,90
sandstone	17,50
limestone	12,10
carbonate rock	4,57
conglomerate rock	0,30

Table 7. Raw materials of the ground stone and stone vessel artefacts (for the raw material percentages *cf.* Table 8).

Grinding slabs (querns, metates) - 5,94 %	quartzite, quartzitic sandstone, sandstone, limestone, carbonate, basalt (rare), conglomerate rock (rare)
Grinding slabs - 4,85 %	quartzite, quartzitic sandstone, sandstone
Handstones (manos) of various transverse sections - 64,32 %	quartzite, quartzitic sandstone, sandstone, limestone (rare), carbonate rock (rare), basalt (rare), volcanic rock (rare), conglomerate rock (rare)
Pestles -1,54 %	quartzite, sandstone, carbonate stone (occasionally), limestone (occasionally), basalt (rare)
Spherical hammerstones (of various diameters) - 2,59 %	limestone, quartzite, flint, carbonate rock (rare), sandstone (rare), volcanic rock (rare)
Disks - 1,66 %	limestone, sandstone, quartzite, carbonate rock (rare), quartz (rare), conglomerate rock (rare)
Perforated stones - 0,92 %	limestone, sandstone, carbonate rock (rare), quartz (rare), quartzite (rare)
Weight stones - 6,05 %	porous limestone, soft limestone (rare), quartzitic sandstone (rare), sandstone (rare), basalt (rare), volcanic rock (rare)
Grooved stones - 2,01 %	sandstones, limestone (rare), quartzitic sandstone (rare), granite (rare), basalt (rare), silitites (rare)
Stone vessels - 4,25 %	carbonate limestone, soft limestone (rare), quartizitic limestone (rare), basalt (rare)
Egg-shaped stones - 2,84 %	soft limestone, quartzitic sandstone
Celts - 0,06 %	limestone

Chisels, "stoppers", and polishers were not considered here.

Table 8. Raw material origins as represented in the flint and ground stone/ stone vessel industries. *<percentages of the ground stone and stone vessel industries based on the 1988 find; both complete and fragmentary tools and vessels; from Late PPNB layers in Areas A, B, and C>*

Raw Material	%	***Attested with the Artefact Groups...***	***Provenance/ Geological Context***												
Geological Formation			***tali, wadis***	***q5***	***q2***	***tt1***	***c5***	***c4***	***c3***	***c2***	***c1***	***o1***	***cb***	***P***	***Ga***
Flint/ Quartzite Industry															
FRMG 1	19,00	flint industry, raw material prefered by workshops	◆			◆									
FRMG 2	38,00	flint industry, raw material prefered by workshops	◆				◆								
FRMG 3	28,00	flint industry, raw material from the wadi floors	◆			◆									
FRMG 4-9	12,00	flint industry	?			?									
(ortho-)/ quartzites	2,00	chipped quartzite industry	?					◆	◆						
Ground Stone Industry															
silitite	0,06	grooved stones*													
quartz	20,10	polishers ("Handschmeichler")									?	?	◆		
granite	0,12	grooved stones*												◆	?
volcanic rock	0,92	weight stones*, spherical hammerstones (of various diameters)*, handstones (manos) of various transverse sections*												◆	◆
basalt	1,05	stone vessels*, grooved stones*, weight stones*, pestles*, handstones (manos) of various transverse sections*, grinding slabs (querns, metates)*						◆	◆					◆	
quartzite	42,90	spherical hammerstones (of various diameters), pestles, handstones (manos) of various transverse sections, grinding slabs, grinding slabs (querns, metates)						◆	◆						
sandstone	17,50	grooved stones, weight stones*, spherical hammerstones (of various diameters)*, pestles, handstones (manos) of various transverse sections, grinding slabs, grinding slabs (querns, metates)									◆	◆	◆		
quartzitic sandstone		egg-shaped stones, grooved stones*, handstones (manos) of various transverse sections, grinding slabs, grinding slabs (querns, metates)									◆	◆	◆		
limestone	12,10	celts, grooved stones*, spherical hammerstones (of various diameters), pestles**, handstones (manos) of various transverse sections*, grinding slabs (querns, metates)						◆	◆	?					
quartzitic limestone		stone vessels*, weight stones*						◆	◆	?					
porous limestone		weight stones						◆	◆	?					
soft limestone		egg-shaped stones, stone vessels*, weight stones*						◆	◆	?					
carbonate rock	4,57	stone vessels, spherical hammerstones (of various diameters)*, pestles**, handstones (manos) of various transverse sections*, grinding slabs (querns, metates)						◆	◆	?					
conglomerate rock	0,30	handstones (manos) of various transverse sections*, grinding slabs (querns, metates)*						?	?	?				◆	

* rare with this raw material **occasionally with this raw material

Raw Material Selection in the Ground Stone Industry

The raw material selection for the various tasks of ground stone tools and vessels is much related to the process and function a ground stone item is planned to be used for. Different from flint/ chert, the variety and variability of the heavy-duty tasks of ground stone tools caused a more differentiated procurement. In addition, non-technological influence on the raw material choice seems to be present, like *e.g.* aesthetic/ style necessities or needs to adapt to local qualities rather than transporting heavy raw material. The transport aspect of the ground stone raw materials always makes these artefacts a matter of local exploitation.

The location of Basta in the c3-4 formations, and within the neighbourhood to the sandstone area (from E to W: c1-, o1-, and cb- sandstone formations; *cf.* Fig. 1, Table 1), helped access to a considerable choice of raw material qualities. It appears not astonishing that an excellent raw material situation is reflected by large amounts of ground stone items in the layers of the permanent LPPNB occupation at Basta. Like with the flint raw material situation, we may assume for the ground stone industries that their good and versatile raw material situation caused a surplus production at Basta. We have to stress that we did not found chipping/ flaking floors, or their dumps, related to ground stone tool production at Basta[1]. We expect such workshops near the sources in the vicinity of Basta, or in stations maintained by Basta- related groups in the sandstone region. While Basta also was the base for flint processing workshops, it only must have been a market place for the distribution of the ground stone artefacts.

To what extend we deal in Basta with a specializing and discriminating ground stone procurement remains an open question. We imagine an economic control of the distribution of ground stone artefacts, but not do not see a direct technological involvement of workshops in the site. The contact to the individuals or groups producing the artefacts appears to be socially related to LPPNB Basta. We most likely have to expect a pattern of "outsourced" activities organized from Basta. The scale of the production, however, did not play a role similar to the flint primary production. Without a proper functional (and contextual) analysis it is difficult to decide about the degree of a discriminating source management. For the stone vessels we cannot exclude different patterns in production and distribution; they may have been also subject of import.

Table 8 gives an insight into raw material preferences among the various ground stone tool types. It shows that *e.g.* grinding slabs not necessarily were made of quartzite. Conglomerate rock, carbonate rock, limestone, quartzitic sandstone, sandstone, and basalt occur also with grinding slabs. This could indicate that different activities were executed with morphologically similar tools. The same is true for the handstones.

Quartzite is the dominant ground stone raw material (42.9 %). It is used in almost all the ground stone tool classes, even stone bowls were made from quartzite. Most handstones, grindings slabs, querns, and pestles were made of quartzite. Quartzite is to be found everywhere in the vicinity of Basta, and is characteristic for the silicified (c4, *cf.* Fig. 1)) and echinoid (c3) limestone member. These formations are also the source for the many kinds of limestone (12.1 %) used in Basta, among which quartzitic, porous and soft qualities were exploited. Sandstone (17,5 %) is commonly used for most of the grinding tools, and was exploited in many different qualities, too. So far we could only identify some qualities exploited in the vast sandstone formations of Petra (cb, o1, c1). In the c3 areas closer to

[1] The same has to be reported for the flakes of the LPPNB wall stone dressing. We located the sources of the banked limestone/ sandy limestone used in the Basta architecture in lower Wadi Muheidirat W and NW of the site. Here we expect the chipping floors of the LPPNB stonemasons.

Basta, a sandy limestone is available, which easily can be mixed up -if not tested- with sandstone. However, the cb- sandstone sources would have meant a considerable transportation effort for the Basta consumers and distributors (minimum 4-5 hours walking distance, crossing elevations of 700- 800 m). The origins of the various igneous rocks used in Basta are quite unknown, while basalt in all qualities is common on the Eastern side of the escarpment. Here it can be collected from the surfaces and wadi gravels. Granite and other volcanic rock are to be found far from Basta, in the West of the Petra-Tayiba sandstone area (Fig. 1), close to the fringes of Wadi Araba (*e.g.* the P and Ga - formations). Their percentages indicate more casual contacts than a direct exploitation.

Summary on Resources of the Stone Raw Materials

Specializing and discriminating procurement in raw material management is part of the craft specialization observed in Basta's abiotic resource management. For the first time it found its social and economic basis in the densely populated and expanding sedentary agglomerates of the later PPNB. The chipped and ground stone industries developed by the abundance of Basta's local sources, certainly promoting also technological innovation related to the peculiarities of the raw materials. The economic growth of LPPNB Basta must have relied considerably on its lithic economies, and it must have been a market center for traded chipped and ground stone artefacts. Whenever the socioeconomic surplus conditions for the production of goods beyond the immediate subsistence needs (and a demographically powerful demand for them) were no longer profitable, the social and economic basis for this craft specialization and thus markets collapsed. This event is sharply recognizable in the archaeological record, and is co-responsible for the decline of permanent village life at Basta and in the region (after 6900 BC). Basta is a fine example for a framework of "initial craft specialization" (Quintero and Wilke 1995: 125).

The sources of the three major flint raw material groups (FRMGs 1-3) used in LPPNB Basta were identified in the local tt1 and c5 contexts (Fig. 1, Table 1). These sources could be reached within a one-hour walking distance. Other minor sources closer to the site are not excluded. Local (ortho-) quartzite played a minor role in chipped lithic production, and might be related to aesthetic demands. The economic role of the other FRMGs 4-9 remains not clear. Specializing and discriminating procurement is attested with the archaeological evidence from Basta; socially, economically, and environmentally invasive procurement and production patterns may have characterized the chipped lithic industries. All primary production took place in the workshops of LPPNB Basta, where huge waste dumps accumulated (of course, primary production at the household and *ad hoc* levels is also attested, *cf.* Gebel 1996). The extraction of the raw material at the sources was accompanied by discriminating efforts (testing of chunks, removal of irregularities, occasional set-up of pre-cores), before chunks were brought to Basta. A LPPNB competition between the sources (especially for the FRMG 3- quality) and their socioeconomic backgrounds in the region East and West of the escarpment cannot be excluded. Basta was a major distribution center for its chipped lithic blanks in the region.

The local (c3-4) and regional (c1, cb, P, Ga;) source areas for most of the ground stone raw materials were roughly identified (Fig. 1 and Tables 1, 8). Specific locations or procurement sites were not encountered yet. The procurement patterns seem to reflect "outsourced" activities of the LPPNB, settlement, linked socially and economically to the site. A surplus production and trade of grinding tools is most likely for the LPPNB occupation in Basta.

Acknowledgements: We are indebted to the National Resources Authority of Jordan, Amman for basic information on the raw materials of the Basta ground stone industries. Especially we would like to thank Drs. Majdi O. Barjous, Tim Charlesley, and Khalil M. Ibhrahim for sharing their impressive knowledge on the sources of Southern Jordan. In addition, we received advice on these raw materials from Prof. Hans Joachim Pachur, Geomorphologisches Laboratorium, Free University of Berlin. For the flint sources, we were helped by late Friedrich Helmdach, Amman/ Berlin, and especially Hakam Mustafa, Geology Department, Yarmouk University.

Nabil Qadi
Faculty of Archaeology and Anthropology
Yarmouk University
Jordan - Irbid

Hans Georg K. Gebel
Freie Universität Berlin
Institut für Vorderasiatische Altertumskunde
Hüttenweg 7
Germany - 14195 Berlin

References

'Amr K. and A. Momani
2001 Preliminary report on the archaeological component of the Wadi Musa Water Supply and Wastewater Project (1998-2000). *Annual of the Department of Antiquities of Jordan* 45: 253-285.

Bender F.
1968a Geologie von Jordanien. Berlin, Borntraeger.
1968b Geological map of Jordan, Sheet Aqaba-Ma`an. 1:250.000. Berlin, Borntraeger.
1974a Geology of Jordan. Berlin, Borntraeger. <Translation of Bender F. 1968a)>
1974b Geological Map of Jordan, Sheet Gharandal. 1:100.000. Hannover, Bundesanstalt für Bodenforschung.

Gebel H.G.
1994a Proposal on minimum standards of raw material description *Neo-Lithics. A Newsletter on Southwest Asian Lithics Research* 2/94: 4-5. Berlin, ex oriente.
1994b Neolithic primary production in the southern and central Levant. (Theses to approach a synthesis). In: H.G. Gebel and S.K. Kozlowski (eds.), *Neolithic Chipped Stone Industries of the Fertile Crescent.* Studies in Early Near Eastern Production, Subsistence, and Environment 1: 393-394. Berlin, ex oriente.
1996 Chipped lithics in the Basta Craft System. In: S.K. Kozlowski and H.G.K. Gebel (eds.), *Neolithic Chipped Stone Industries of the Fertile Crescent, and Their Contemporaries in Adjacent Regions.* Studies in Early Near Eastern Production, Subsistence and Environment 3: 261-270. Berlin, ex oriente.
2004 Lithic economic systems and early sedentism. In: K. von Folsach, H. Thrane, and Ingolf Thuesen (eds.), *From Handaxe to Khan. Essays Presented to Peder Mortensen on the Occasion of his 70th Birthday:* 55-66. Aarhus, Aarhus University Press.

Muheisen M.
1983 La préhistoire en Jordanie. Recherches sur l'épipaléolithique. L'example du gisement de Kharaneh IV. Bordeaux, Université de Bordeaux I: unpublished doctorate thesis.

Nissen H.J., M. Muheisen, H. G. Gebel with contributions by C. Becker, B. Dahl Hermansen, W. Karasneh, N. Qadi, M. Schultz, and A. Scherer
1991 Report on the excavations at Basta 1988. *Annual of the Department of Antiquities of Jordan* 35: 13-40.

Qadi N.
1989 Basta 1988. Ground stones and stone vessels. Unpubl. Manuscript.
forthcmg. The ground stone and stone vessel industries. In: H.J. Nissen, M. Muheisen, and H.G.K. Gebel (eds.), *Basta* IV.3. *The Ground Stone and Bone Industries.* Berlin,. ex oriente.

Quintero L.A.
1996 Flint mining in the Pre-Pottery Neolithic: preliminary report on the exploitation of flint at Neolithic 'Ain Ghazal in Highland Jordan. In: S.K. Kozlowski and H.G.K. Gebel (eds.), *Neolithic Chipped Stone Industries of the Fertile Crescent, and Their Contemporaries in Adjacent Regions.* Studies in Early Near Eastern Production, Subsistence and Environment 3: 233-242. Berlin, ex oriente.

Quintero L.A. and P.J. Wilke
1995 Evolution and economic significance of naviform core-and-blade- technology in the southern Levant. *Paléorient* 21.1: 17-34.

Taute W.
1994 Pre-Pottery flint mining and flint workshop activities Southwest of the Dead Sea, Israel (Ramat Tamar and Mesad Mazal). In: H.G. Gebel and S. Kozlowski (eds.), *Neolithic Chipped Stone Industries of the Fertile Crescent.* Studies in Early Near Eastern Production, Subsistence and Environment 1: 495-510. Berlin, ex oriente.

Mineralogical Analysis of Late PPNB Rings

Maria Thaís Crepaldi Affonso
and Ernst Pernicka

Introduction

Three ring fragments from the Early Neolithic settlement of Basta, some 200 km south of Amman in Jordan, have been investigated in order to clarify if they consisted of natural materials or if they were fabricated artificially by man. Such rings, that were presumably used as adornments, begin to appear in the Pre-Pottery-Neolithic of the Near East and have apparently been produced from different materials. A compilation of finds (Starck 1988) has shown that the shapes of the rings vary only within narrow limits even in different regions. As raw materials sandstone, limestone (less frequent) and sporadically "plaster" were macroscopically identified, although their description remained somewhat superficial from the petrographic point of view. Especially the exact identity of the "plaster" is uncertain, because it has been described as "raw material comparable to white ware" (Starck 1988). However, the so called white ware in the Near East is a general term used for artefacts that are made of a white and relativ dense material, of limestone or marl (natural products) as well as of artificial materials. Since the latter possibly represent the earliest evidence for early pyrotechnology in the Near East, a clear differentiaton of these terms and an unequivocal identification of the nature of the raw materials is very important.

For this purpose three ring fragments from Basta that were classified as "plaster-like material" and dated to the Late Pre-Pottery Neolithic (LPPNB, about the 7th millenium b.c. according to uncalibrated 14C dates) were investigated. The production of such fragile objects as flat rings from plaster in this early period seems to indicate a very developed handicraft technique that would be surprising or at least noteworthy.

Polished thin-sections were prepared and examined using a Leitz-Orthoplan petrographic microscop and in a JEOL JSM-6400 scanning electron microscope equipped with an energy dispersive X-ray analyser (EDXA) at the Institut für Archäometallurgie of the German Mining Museum in Bochum, Germany.

Macroscopic Description

The three analysed fragments represent about 1/4 to 1/6 of the respective original rings (Plate 1.a). The pieces have different cross-sections and different internal diameters and, therefore, cannot derive from a single ring (Fig. 1). Their cross-sections are approximately pentagonal with a width of 4-5 mm and a thickness of 8-9 mm (Fig. 2). The internal rim is more irregular than the external one in all three cases and shows oblique scratches. This observation can be explained by the manufacturing technique. It is probably easier to drill a circular hole than to cut a circular plate, but it is also easier to polish an external rim than an internal one. The rings are bluish-white on the surface and blackish-brown in the interior. Small dark dots that are visible within the matrix turned out to consist of foraminifers filled with bitumen (see below). According to the secant's formula ($r = s^2/8h + h^2/2.$; Bartsch 1991, Starck 1988) the internal diameters of the rings can be calculated as follows:

Sample	11202.11	11221	11208.1
internal diameter [mm]	68	75	58
thickness [mm]	40	45	40

These data are compatible with the published dimensions of the Basta rings (Starck 1988) where the internal diameters ranged from 40 to 90 mm and the thickness from 1.5 to 12.5 mm.

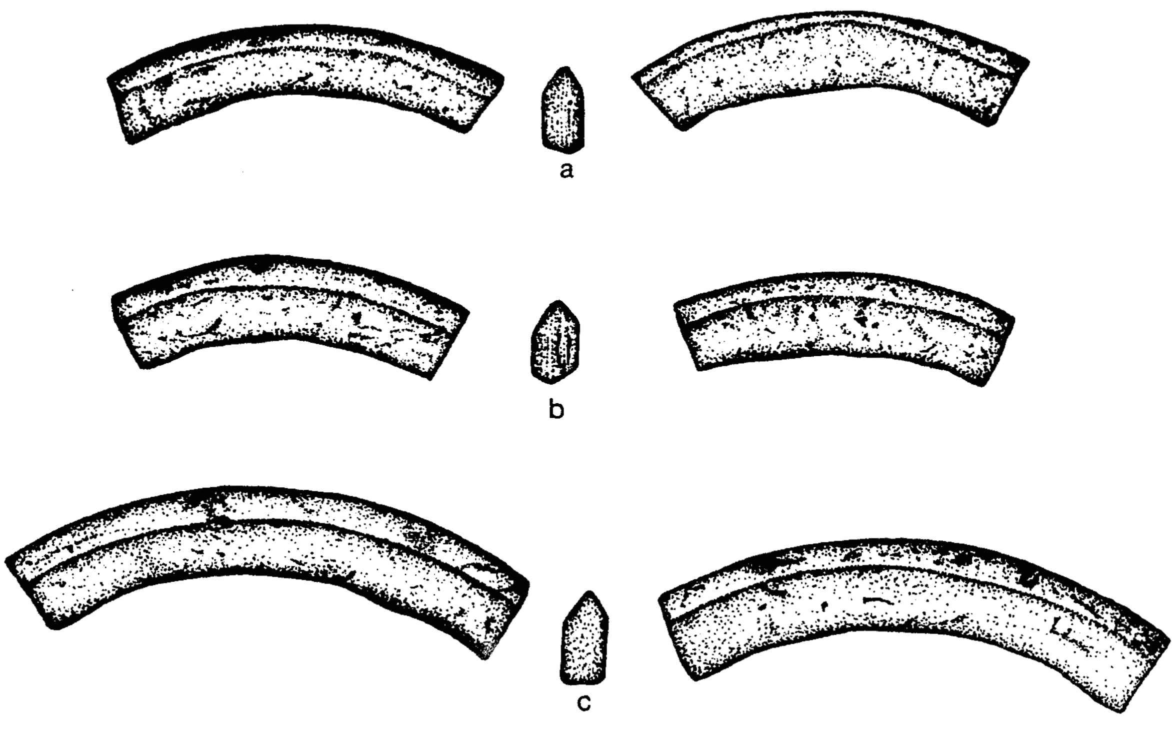


Fig. 1. Drawings of the analysed samples with cross-sections (a 11208.1; b 11221; c 11202.11) *<scale =1:1.41>*.

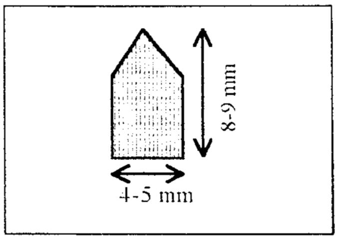


Fig. 2. Typical cross-section of the stone rings from Basta.

Microstructure

All three investigated fragments consist of a highly fossiliferous marly sediment. This is a material that occurs abundantly in nature and should thus not be termed "plaster" or "plaster-like". The rings were obviously produced without burning or modelling, but by drilling and shaping of the natural rock. The rock splits easily and it is likely that the thickness of the rings is governed by this property that should also have simplified their production. It contains mainly planctonic foraminifers (Globigerinae) and minor fish debris (Plate 1.b). Geologically it can be described as a sediment from the Late Tertiary or Early Cretaceous.'

In the Samples 11221 and 11208.1 practically all the foraminifers are filled with a red material (Plate 1.c) that is not resistant to high temperatures and that chemically consists mainly of Ca and minor S according to the EDX-analysis (Plate 2.a and Fig. 3; it was not possible to measure light elements like H, N, O and C with the employed equipment).

The shells of the foraminifers consist practically only of Ca; Mg was not detected (Fig. 4), while the material of the filling probably consists of hardened bitumen (mineral wurtzelite, Hufnagel 1984).

The microstructures of the Fragments 11221 and 11208.1 are very similar and are characterized as follows:

- Matrix clayish-lime, finely crystallized, reddish-brown
- Fossil content about 20-30 % by volume
- Fossil types:
  1) Foraminifers (mainly planctonic) with a size range of about 35-500 µm, mostly filled with red material.
  2) Fish debris, size range mainly 35-40 µm, occasionally up to 400 µm.
- Mineral particles:
  1) Quartz with a size range of about 35-40 µm; content less than 1 % by volume.
  2) Fe-hydroxide minerals are dispersed in the matrix or form part of the filling of the microfossils.
  3) Opaque minerals in the size range of 10-20 µm, content 5 % by volume or less.
- Structure:
  1) Both fragments show layers which extend parallel to the longest dimension of the cross-section (Plate 2.b).
  2) Many of the observed fissures have a thickness between 15 and 50 µm, parallel to the layers of the rock and subsequently to two of the external rims. The fissures observed in Sample 11221 are on average thicker than the ones of Sample 11208.1 (Plate 2.c).

Sample 11202.11 exhibits a finer stratification and is clearly more homogeneous than the other two samples. Its microstructure is characterized as follows:
- Matrix clayish-lime, finely crystallized, reddish-brown

- Fossil content about 30 % by volume

- Fossil types:
  1) Foraminifers (mainly planctonic) with a size range of about 50-300 µm, mostly filled with red material or empty (Plate 3.a), occasionally filled with carbonatic material (probably calcite) and/or Fe-hydroxide-minerals.
  2) Fish debris.

- Mineral particles:
  1) Quartz with a size range of about 35-40 µm; content less than 1 % by volume.
  2) Fe-hydroxide minerals are dispersed in the matrix or form part of the filling of the microfossils.
  3) Opaques minerals with a size range of about 10-20 µm; content about 5 % by volume or less.
  - Structure:
  1) Layers are slightly inclined towards the two longest rims of the cross-section (Plate 3.b).
  2) Pores and fissures are practically absent; the matrix is very homogenous and finely grained.

According to the EDX-analysis the matrix consists of Si, Ca, Al, P, K, Fe, S and Mg, listed in order of decreasing concentrations (Plate 4.a and Fig. 5).

The observed chlorine derives from the resin that was used to prepare the thin section and is thus not characteristic of the sample. The contents of P and S are due to the phosphate inclusions and fish debris (*e.g.* teeth and scales) that have been observed in the microscope. The elements Si, Ca, Al, K, Fe ans Mg are typical constituents of clay minerals. The high content of Ca is explained by the fine carbonatic cement as well as by the foraminifer shells.

All three samples can be classified texturally as biomocrite (Flügel 1982) and petrographically as bitumen-rich, highly fossiliferous marly-limestone. The matrix consists of a fine-grained mass of clay minerals and carbonatic cement. The material of the Ring 11202.11 probably derives from a different part of the sediment formation than the other two samples. The petrographic examination confirms the previous observation that the three fragments do not belong to one single ring.

Provenance of the Raw Materials

Several occurrences of this rock in Jordan have been reported by Hufnagel (1984). He described them petrographically as a bitumen-rich carbonatic marl and called it oil-schist (Ölschiefer). The oil-schists belong geologically to Late Tertiary and Early Cretacious formations that are rather common in Jordan. The deposits occur mainly along the Desert Highway (Amman-Aqaba) along a North-South line East of the Jordan Valley, exposed to the surface or underground (Fig. 6). For our considerations the deposits that are exposed to the surface are of prime interest although also deeper lying strata may be exposed along steep cliffs. Three such exposures are situated about 50 km from Basta (East Ma'an, Wadi Arja, Shobak). The deposits in the region of Yamourk have long been known and were used as a source of fuel during World War I.

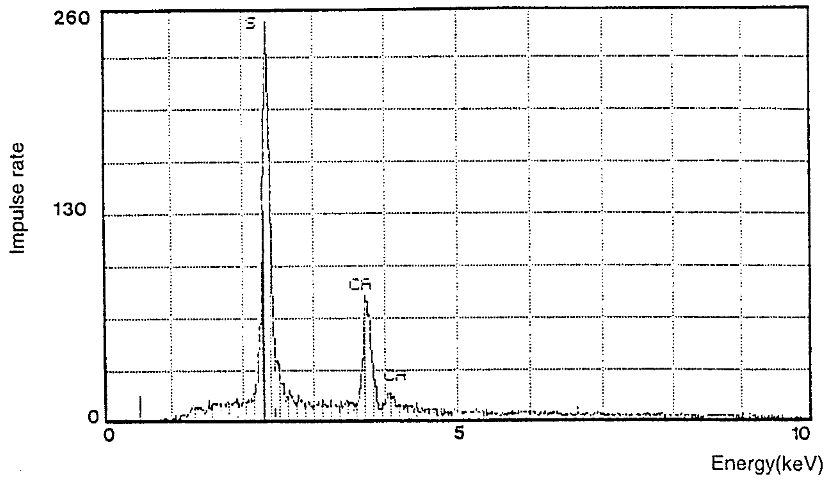


Fig. 3. EDX-analysis of the bituminous filling material of a foraminifer at point A (see Fig. 6). In the spectrum (diagram of energy versus intensity) the chemical elements can be identified by the position of the signal (= energy) and its concentration by the area or by the height of the relevant peak.

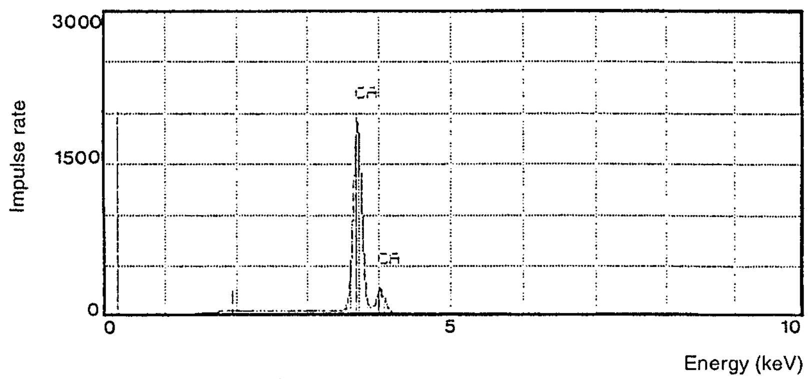


Fig. 4. EDX-analysis of the same foraminifer at point B (see Plate 2.a).

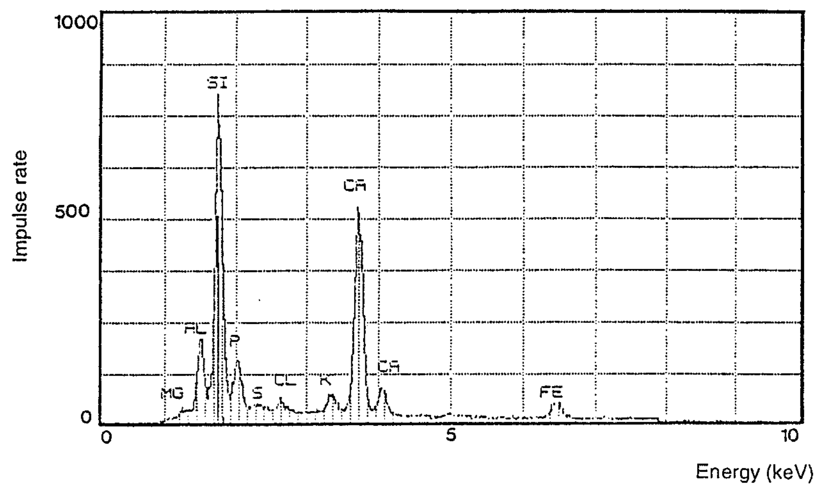


Fig. 5. EDX-analysis of the matrix. Measured point A, see Plate 4.a. Elements identified are indicated in the spectrum.

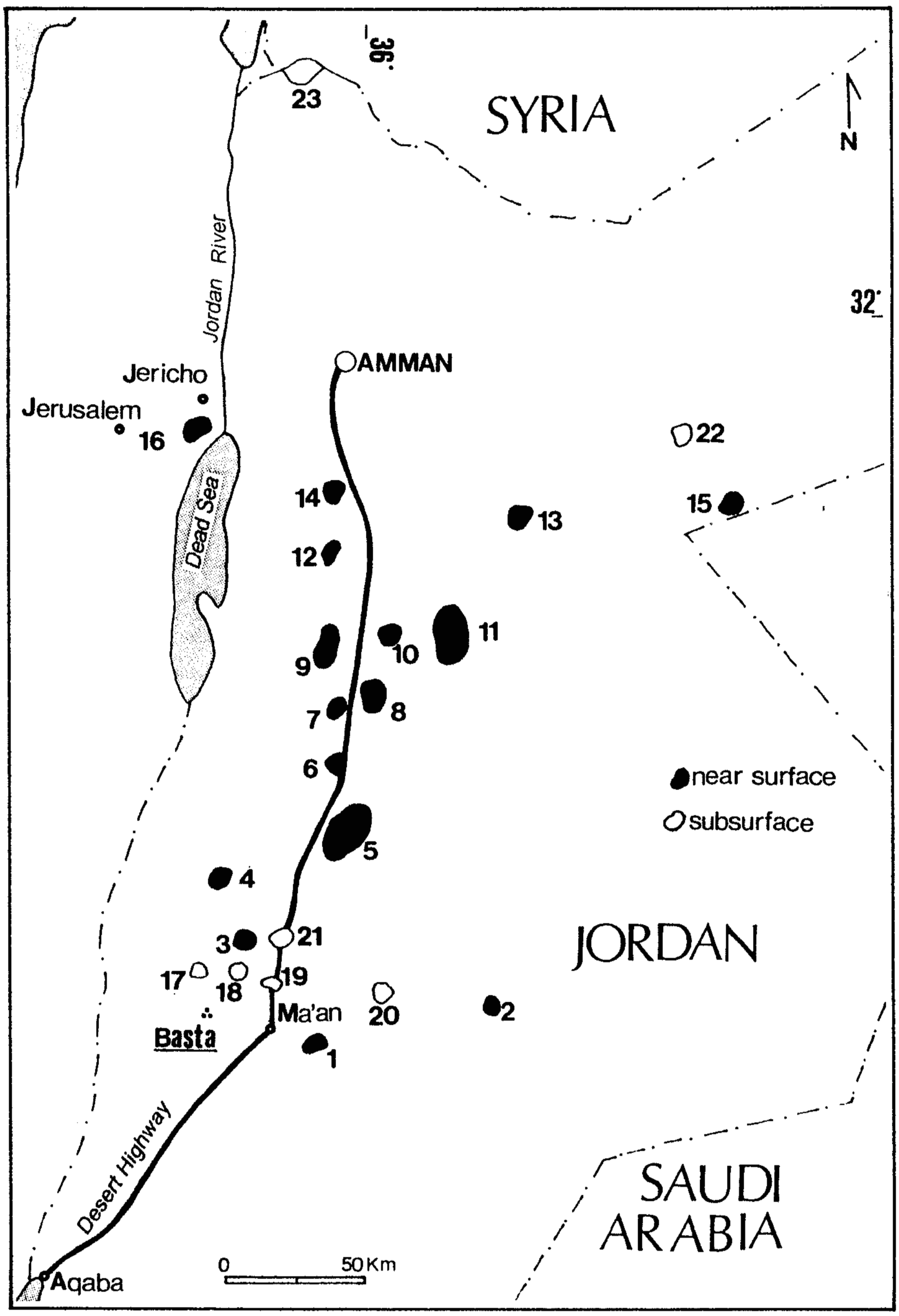
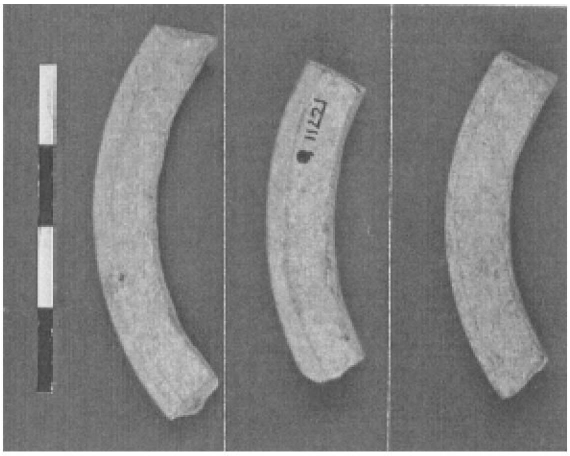
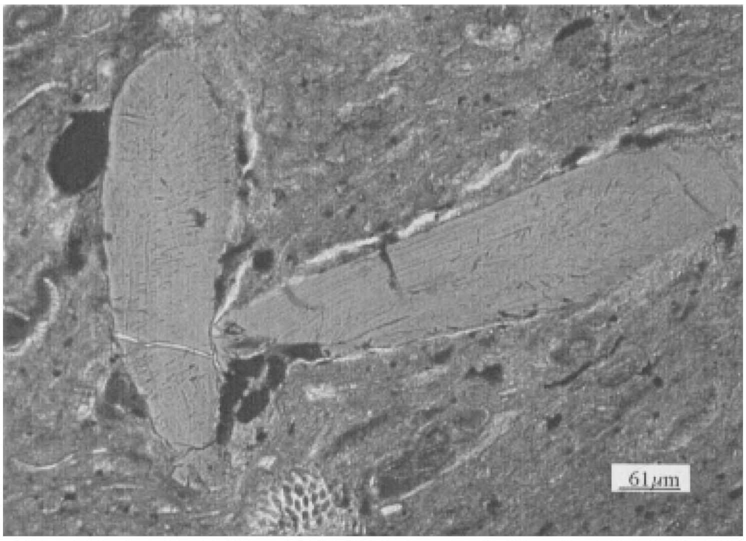


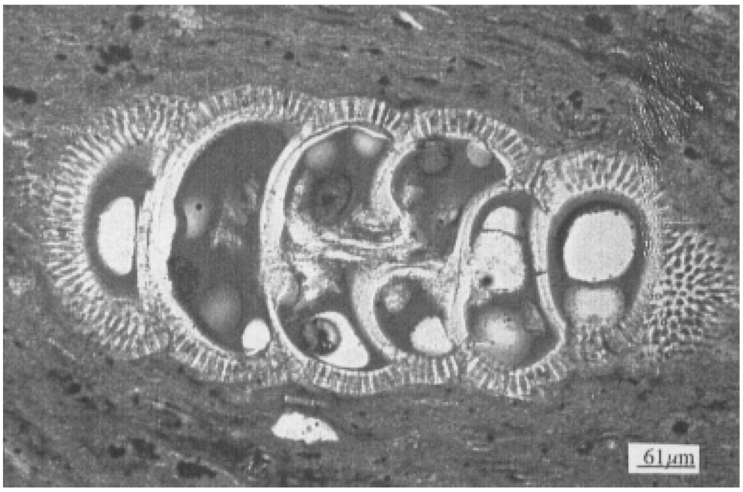
Fig. 6. Oil-schist occurrences in Jordan (after Abu-Ajamieh *et al.*, 1988 - simplified).
Near the surface: 1 East Ma'an; 2 El Jafr-East; 3 Wadi Arja; 4 Shobak; 5 Jurf Ed Darawish; 6 El Hasa; 7 Wadi Geith; 8 Sultani; 9 El Lajjun; 10 Qatrana (Siwaqa); 11 Attarat Um Ghudran.
Underground: 12 Wadi Sudeida; 13 Wadi Ash Shawmari (Khan Ez Zabib); 14 Wadi Eth Thanat; 15 Faydat Ad Dahikitya; 16 Nabi Musa; 17 Udruh; 18 Wadi Ueina; 19 Wadi Jhurdan; 20 El Jafr-West; 21 Ishush; 22 Azraq-Southeast; 23 Yarmouk.



a



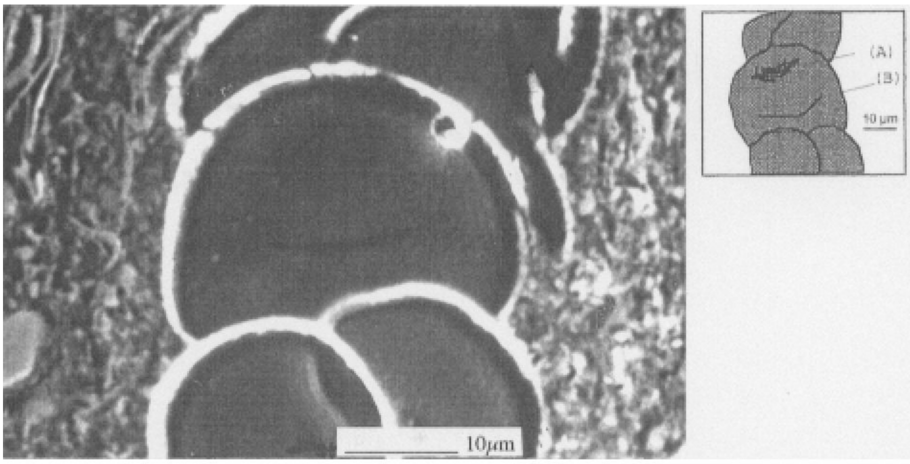
b



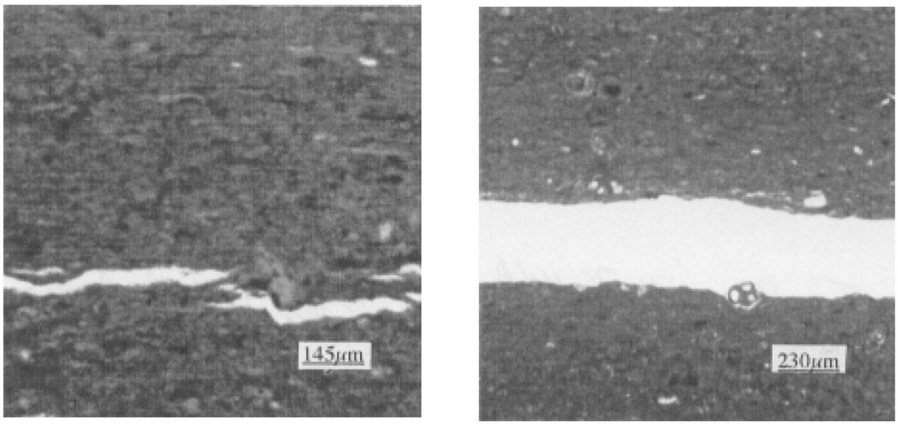
c

Plate 1.
a Photographs of analysed samples.
b Thin section of Sample 11208.1 in transmitted light, plane polarized, at a magnification of 145 X. Fish debris in matrix, probably scale.
c Thin section of Sample 11221 in transmitted light, plane polarized, at a magnification of 145 X. Foraminifer (Globigerina) filled with hard bituminous material.

a



b



c

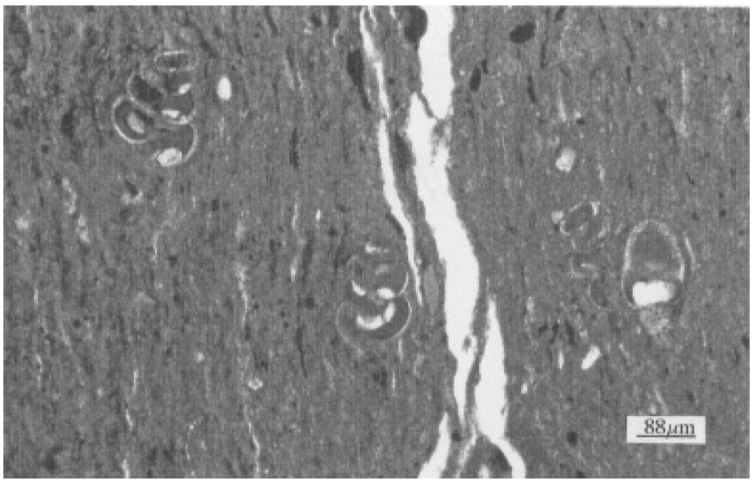
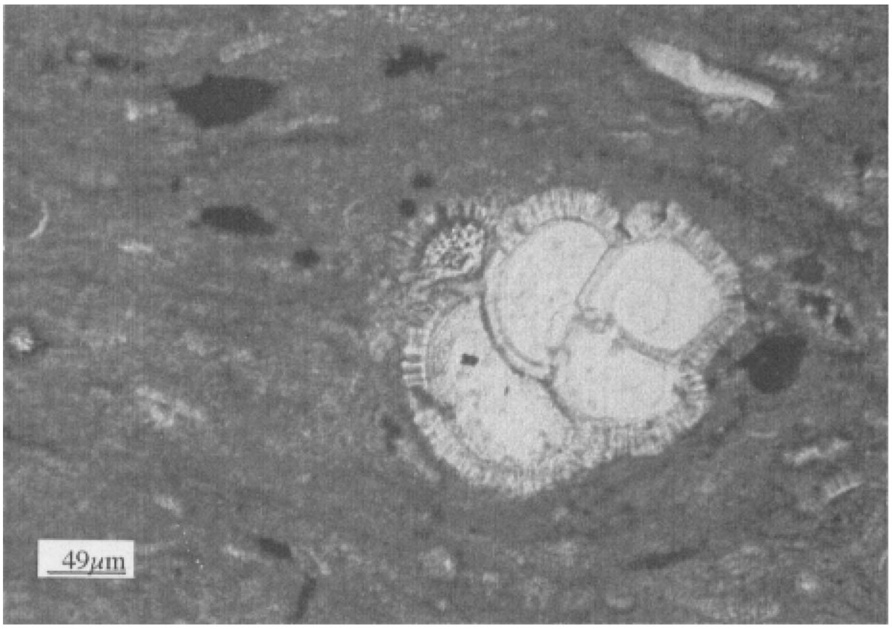


Plate 2.
a Scanning electron image with adetail of a filled foraminifer. Magnification 1500 X. Measurement points A und B (see Figs. 3 and 4) are indicated on the drawing.
b (left) Thin section of Sample 11221 in transmitted light, plane polarized, at a magnification of 63 X. Sediment layers are parallel to a crack which is also parallel to the rim.
b (right) Same as above with Sample 11208.1 at a magnification of 40 X. The sample has been cut twice and the two parts are visible at the top and the bottom. Both rims are exposed in the middle.
c Thin section of Sample 11201 in transmitted light, plane polarized, at a magnification of 100 X. Cracks extend parallel the layering of the rock.

a



b

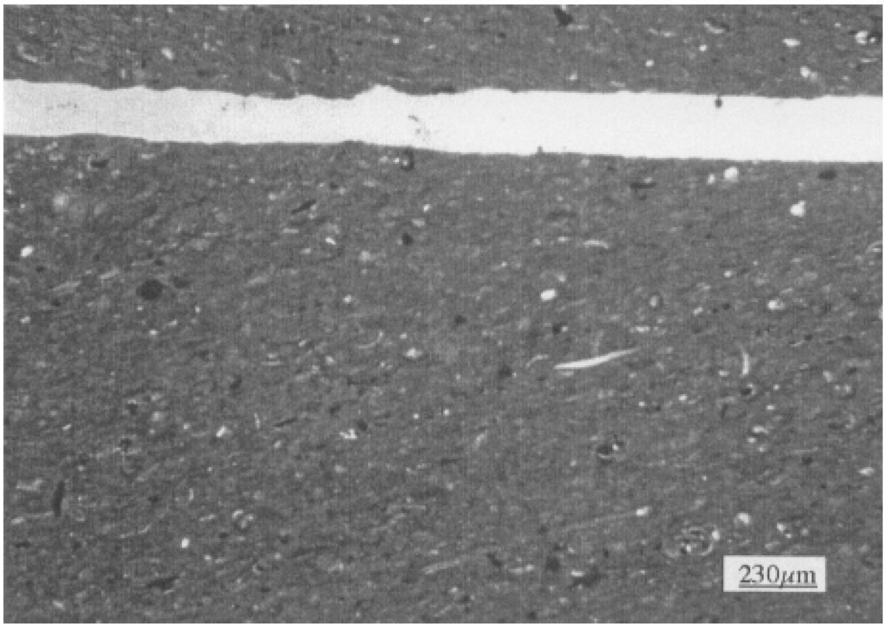
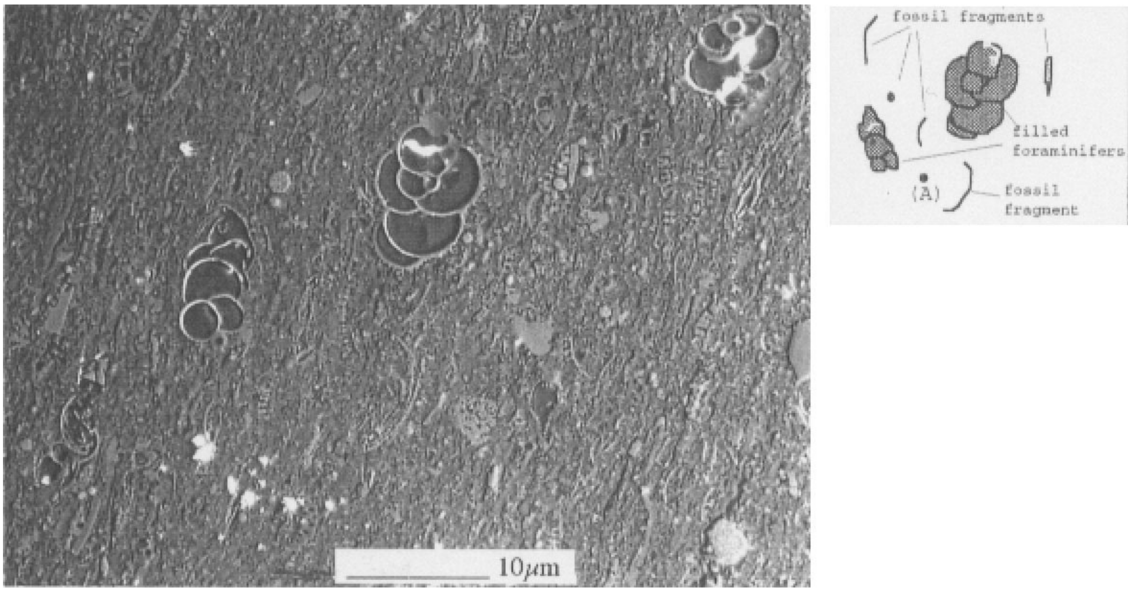


Plate 3.
a Thin section of an empty foraminifer (Globigerina) in Sample 11202.22 in tranmitted light, plane polarized, at a magnification of 160 X.
b Thin section of Sample 11202.11 in transmitted light, plane polarized, at a magnification of 40 X. Note that the layers are somewhat inclined towards the rim, which is the white strip in the upper third of the figure. On the top there is a second thin section (with rim) of the same sample.

a


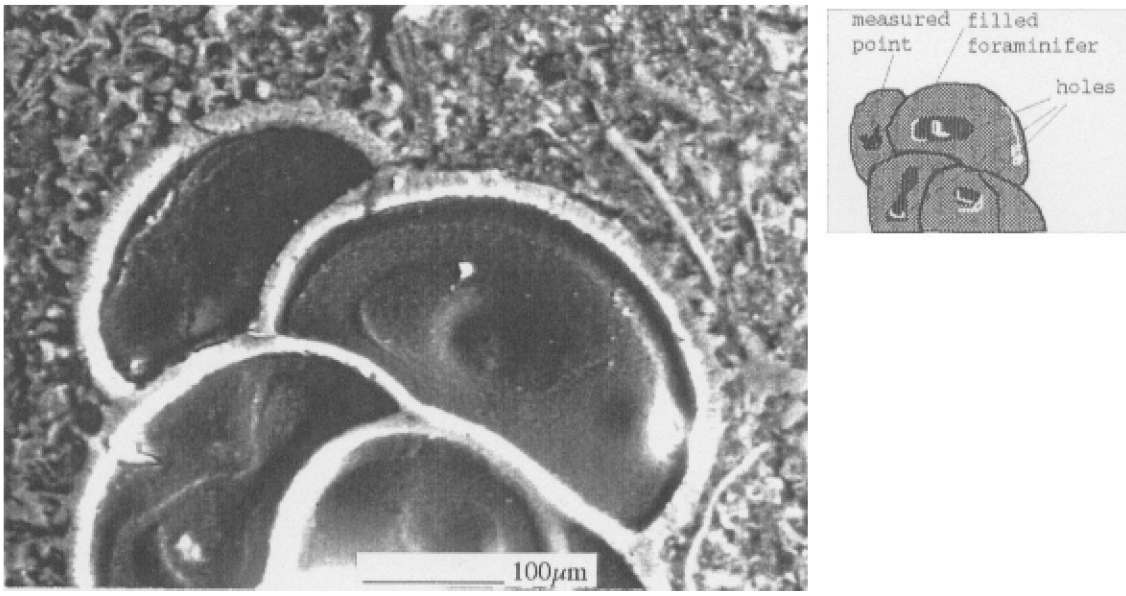
b


Plate 4.
a Scanning electron image at amagnification of 190 X. General view of the matrix;
point A is indicated on the drawing.
b Scanning electron image at a magnification of 1200 X of a foraminifer filled with red bituminous material. The depression at the measured point is due to the heating by the electron beam.

Typical for the Jordanian oil-schists are phosphate inclusions and foraminifers filled with hard bitumen (wurtzelite, Hufnagel 1984) instead with calcite. This reddish, light brown hard bitumen is a relatively strong fluorescent material and was formed from so-called pre-bitumen that has existed around the foraminifers and entered the shells through their pores (Jacob 1983). Also typical is the bluish alteration colour at the surface of the rock that is brown on fresh fractures. This carbonatic marl called oil-schist is a soft rock and it is very easy to work. Sachsee (1897) mentioned that the bitumen-rich limestones from Nebi Musa were used at his time for Bethlehem's adornment manufactures.

Manufacturing Techniques[1]

For the reconstruction of the manufacturing technique (Fig. 7) we propose the following steps: a) The raw material was extracted from the source in tabular form. b) A wooden or a stone drill was used to perforate the plate. It was rotated either by hand or by use of a bow string. The shape of the drill was probably conical, which resulted in a convex cross-section of the perforation, if the plate was drilled from both sides. In order to facilitate the drilling process, an abrasive was probably used, *e.g.* quartz sand. c) The next step was to chip the outer edge until the plate had acquired an approximately circular shape. d) The outer edge was further ground into shape with a grooved stone of harder material, *e.g.* sandstone, and smoothed. Such a grroved stone has actually been found in the excavation at Basta (Gebel and Starck 1985: Fig. 11-10). e) Finally, the surface of the ring was finished with a polishing device, possibly made of leather with the use of a fine-grained abrasive and water. In some cases, stages b) and c) may have been performed in reverse order.

Conclusions

All three ring fragments consist of a natural sediment that was formed only by drilling and polishing; the material consists neither of a modelled and dried mass of clay nor of a plaster-like material and it was not burnt. Burning rims or burning zones could not be identified.
The natural character of the material can be demonstrated by three observed features:

1) The material does not show any variation in colour or in mineral composition and/or mineral orientation between the rim and the core of the fragments that might be expected if they were modelled. The fine layering of fossils and minerals could only result, if
a) a turning wheel was used, which is out of consideration at such an early period as the PPNB or
b) a paste of fine powdered sediment and water was prepared and dried inside a shaping vessel.

In the second case one would expect some grain size gradation that can not be observed in the microscope.

2) The layers of Sample 11202.11 are inclined to the rim. This is impossible to obtain by modelling but is easily explained by polishing.

[1] The reconstruction of the manufacturing techniques of the stone rings from Basta is studied in detail by Bo Dahl Hermansen, Carsten Niebuhr- Institute of Copenhagen University, and will be presented in the final publications of Basta.

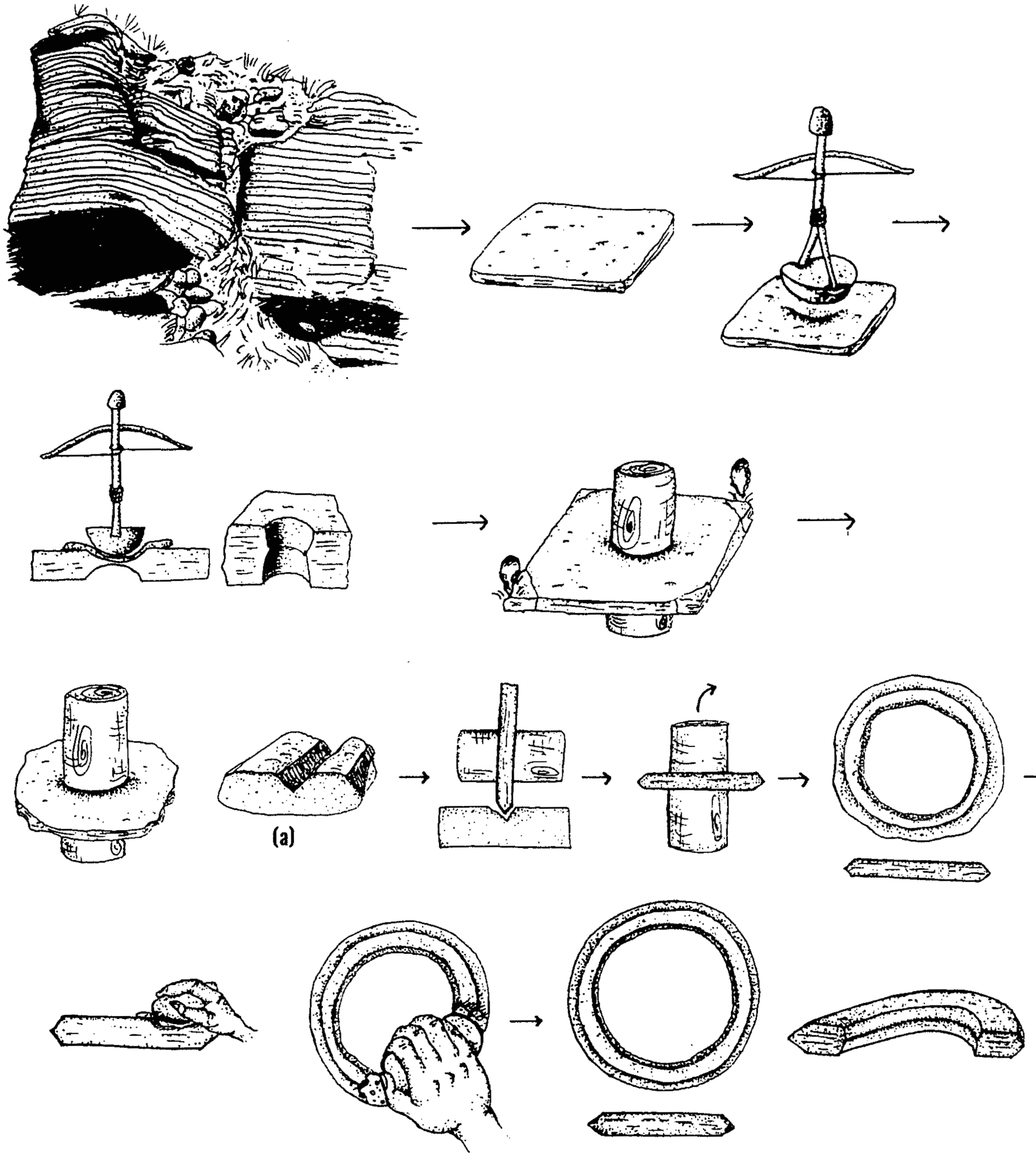


Fig. 7. Sketch drawing of the proposed production technique of the analysed stone rings <(a) "fragment of a grooved stone", cf. Gebel and Starck 1985: Figs. 11-10>.

3) During the investigations with the scanning electron microscope it has been observed that the red bituminous filling material of the fossils does not resist high temperatures (Plate 4.b). If the rings had been hardened by burning then this material could not have survived.

The rock is petrographically a bitumen-rich, highly fossiliferous chalky-marl that is called oil schist in the literature (Hufnagel 1984, Wiesemannn 1969). The exact location where it derives can at present not be identified but there are several occurrences of a similar material in the vicinity of Basta, the nearest being the deposit of Wadi Arja, at a distance of about 30 km from Basta. It is possible but not certain that further investigations including trace element studies *e.g.* by neutron activation would allow a more detailed location of the source material.

Acknowledgements: We are grateful to Dr. Knabe, Dr. Gramman and Prof. Dr. Wiesemann, Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover, Germany, for helpful discussions on the possible fabrication techniques of the rings and on the classification and identification of the natural resources.

Maria Thaís Crepaldi Affonso and Ernst Pernicka
Technische Universität Bergakademie Freiberg
Gustav-Zeuner-Straße 5
Germany - 09599 Freiberg

References

Abu-Ajamieh M.M., F.K. Bender, and R.N. Eicher
1988 *Natural Resources in Jordan.* Amman, Natural Resources Authority.

Bartsch H.J.
1991 *Mathematische Formeln.* Leipzig.

Flügel E.
1982 *Microfacies Analysis of Limestones.* New York.

Gebel H.G. and J.M. Starck
1985 Investigations in the stone age of the Petra Area (Early Holocene Research) - a preliminary report on the 1984 campaigns. *Annual of the Department of Antiquities of Jordan 29*: 89-114.

Hufnagel H.
1984 Die Ölschiefer Jordaniens. *Geologisches Jahrbuch A* 75: 295-311. Hannover.

Jacob H.
1983 Mikroskopische Analyse fester bis halbfester Erdölbitumina. *Microsc. Acta* 87.3: 277-291.

Sachsee R
1897 Beiträge zur chemischen Kenntnis der Mineralien, Gesteine und Gewächse Palästinas. *Zeitschrift des Deutschen Palaestina-Vereins 20:* 1-33. Leipzig.

Starck J.M.
1988 Stone rings from Baga and Basta - geographical and chronological implications. In: A.N. Garrard and H.G. Gebel (eds.) *The Prehistory of Jordan.* British Archeological Reports - Intern. Series 396.1: 137-174. Oxford, B.A.R.

Wiesemann G.
1969 Zur Tektonik des Gebietes östlich des Grabenabschnittes Totes Meer - Jordantal. *Beihefte Geologisches Jahrbuch* 81: 215-247. Hannover.

"Greenstones" from Basta. Their Mineralogical Composition and Possible Provenance

Andreas Hauptmann

Introduction

In the history of colours, hematite, red ochre, and similar red materials from the decomposition of iron ores were probably the first materials that were utilized by man for religious and cosmetic purposes (Weisgerber and Pernicka 1995). Red was the prevailing colour during the Palaeolithic period. The change to green is a hallmark of the Pre-Pottery Neolithic period in the Near and Middle East. The finds of "greenstones" at Basta, therefore, are typical for a period when green beads and green powder became popular all over Transjordan and Palestine (Garfinkel 1987), but they were utilized in Anatolia and in the Balkan peninsula as well (Glumac 1985).

Sources of "greenstones" are usually not that widespread in the environment. An inventory of such "exotica" seems promising, and the study of their provenance, like obsidian or lapis-lazuli, may provide useful information to reconstruct trade connections. In turn, the identification of sources of "greenstone" from Neolithic sites may also contribute to the question of when its exploitation started. Usually, it is almost impossible to find the earliest traces at the source itself.

In many cases, the finds of "greenstones" have not been specified for their materials composition, and the collective name has been used in archaeology for a variety of green minerals such as malachite, chrysocolla, dioptase, turquoise, emerald, amazonite, serpentinite and others, and even rocks were labelled with this term. The name "greenstones", however, does not exist in geoscience. We emphasize especially that a large variety of secondary copper minerals is among these "greenstones," and this may have had a key role for the earliest stages of metallurgy.

As to the provenance of the "greenstones" from Basta, there are several ore deposits and mineral occurrences in the region from which they could have been transported to the site. They are in distances between 30 to 250 km. We considered these as preferential localities since they are the nearest possible sources, although we are fully aware that a complex long-

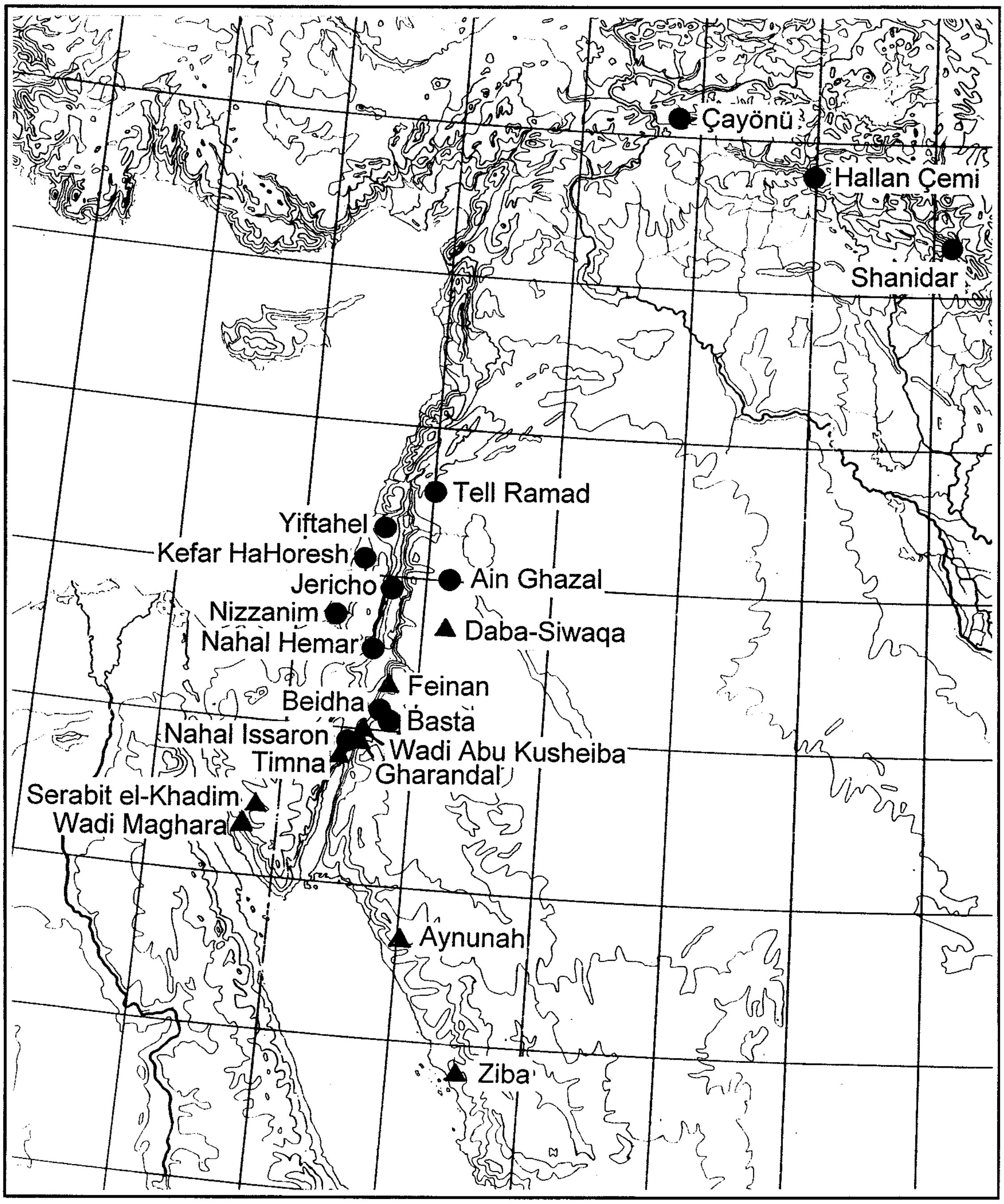


Fig. 1. Map of the Near East showing sites with Neolithic "greenstones" evidence (full dots) and sources mentioned in the text (triangles).

distance trade existed even in the Neolithic period (Schoop1995), and therefore, even more removed sources can not be excluded with certainty.

"Greenstones" in the Near East

Objects of malachite have been found sporadically as early as Epipaleolithic/ Protoneolithic contexts, *e.g.*, a pendant from the cave of Shanidar in Northern Iraq (Solecki 1969). At Hallan Çemi Tepesi, in the Taurus Mountain range, some pieces of green secondary copper ores have been retrieved from the floors of some houses (Rosenberg 1994). They date back as far as the 10th millennium. But the first widespread use of "greenstones" is in the Pre-Pottery Neolithic B period. Generally, these materials were utilized for making beads, but a green powder was also used for cosmetic purposes, attached most probably by organic solutions on the surface of masks or figurines (Bar-Yosef and Alon 1988, Tubb 1985).

A concentration of PPN "greenstones" exists in the Southern Levant. Nearly a hundred beads and pendants made of malachite and other "greenstones" were found at Jericho, mostly in PPNA-levels (Wheeler 1983, Talbot 1983). Similar material is also known from 'Ain Ghazal (Rollefson and Simmons 1986), Beidha (Kirkbride 1966), Tell Ramad (France-Lanord and de Contenson 1973), Nahal Hemar (Bar-Yosef and Alon 1988), Nahal Issaron North of Timna (Goring-Morris and Gopher 1983), Yiftahel (Garfinkel 1987), Kefar HaHoresh (Goring –Morris *et al.* 1995) and from many other sites in the region. Several Neolithic sites are known in the Southern Sinai where malachite and turquoise were found (Rothenberg 1972), but turquoise was also found in PPN levels at Jericho and at a PPN site near Nizzanim (deVaux 1966, Yeivin and Olami 1979).

Of special interest are sources of "greenstones" in Anatolia. Copper ores are abundant in this region, and are, in contrast to the Levant, in many deposits associated with native copper. Hence, it is not surprising that the hundreds of green beads that were found at the PPN settlements of Çayönü Tepesi (Özdoğan and Özdoğan 1999) consisted exclusively of secondary copper ores, mostly malachite, and were associated with the earliest known finds of metal objects made of native copper (Maddin *et al.* 1991). The basis for this impact on the beginnings of metallurgy is in the nature of the sources and is specific for Anatolia.

"Greenstones" from Basta

Measurement and Materials Identification of the Samples

The Basta samples revealed that they consist of only a limited variety of different materials. Hence, it was relatively easy to divide them into a few groups and to select a representative number of samples from these groups for more detailed investigations. These were mainly done using X-Ray diffraction (Siemens D 500). In order to avoid the destruction of the samples – in geoscience, X-Ray analysis is usually performed with pulverized samples – a special sample-holder was constructed, and the complete specimens were X-rayed. Additionally, a selected number of samples was chosen for microanalysis. This was carried out using an energy-dispersive spectrometer (TRACOR/NORAN) attached to a JEOL 6400 scanning electron microscope. Finally, all the samples were compared mineralogically and petrographically with a reference collection of copper ores from the Wadi Arabah and from Sinai in the Deutsches Bergbau-Museum. The results and a short description of the samples are compiled in Table 1. The localities and sites mentioned in the text are shown in a map (Fig. 1).

Table 1. Raw materials and provencances of "greenstones" from Basta. For turquoise, sources located at Wadi Maghara and Serabit el-Khadim seem possible. Hence, only "Sinai" is indicated.

Inv.Nr.:	Locality	Description	Material	Provenance
1011.1	xxx	pendant; emerald-green	amazonite	South Jordan
3031	xxx	bead; green, fine grained	hydroxyl-apatite	Daba / Jordan
10860	B68, Loc. 30	bead; whitish-green with brown spots	turquoise	Sinai
10871	B68, Loc. 38	bead; whitish-green	turquoise	Sinai
11210	B86, ('rubble layer')	fragment of a ring; green	turquoise	Sinai
17826	A14, Loc. 4	unworked piece; blueish-green with white spots	amazonite	South Jordan
20406.1	B67, Loc. 8	double perforated disc; whitish-green with brown spots	turquoise	Sinai
20849	B52, Loc.4	bead; whitish-green with fine network of brown veins	turquoise	Sinai
20894.1	B61, Loc. 49	bead; whitish-green	marine mollusc	Red Sea
20894.2	B61, Loc. 49	bead; whitish-green with brown spots	turquoise	Sinai
20894.3	B61, Loc. 49	bead; whitish-green with brown spots	turquoise	Sinai
20926	B85, Loc. 14	bead; whitish-green brown spots	turquoise	Sinai
27887	B86/87, Loc. 5	unworked piece of green and brown sandstone minerals	malachite, limonite	Timna
30836	xxx	bead; whitish-green with network of brown veins	turquoise	Sinai
30850	B22, Loc. 5	broken bead; dense, green with blue spots	chrysocolla, plancheite	Feinan
30873.a	B22, Loc. 4	bead; whitish-green with fine network of brown veins	turquoise	Sinai
30894	B23, Loc. 13	bead; whitish-green with fine network of brown veins	turquoise	Sinai
30896	B22, Loc. 11	bead; green with white inclusions, fine grained	hydroxyl-apatite	Daba / Jordan
30914	B22, Loc.23	bead; whitish-green with fine network of brown veins	turquoise	Sinai
30954	B48, Loc. 9	bead; dark blue with green spots	plancheite, chrysocolla	Feinan
30959	B48, Loc. 18	bead; whitish-green with brown spots	turquoise	Sinai
30977.a	B50, Loc.34	bead; whitish-green, tiny brown spots	turquoise	Sinai
30977.b	B50, Loc. 34	bead; whitish-green, tiny brown spots	turquoise	Sinai
30977.c	B50, Loc. 34	bead; whitish-green, tiny brown spots	turquoise	Sinai
30977.d	B50, Loc. 34	bead; whitish-green with network of brown veins	turquoise	Sinai
30977.e	B50, Loc. 34	bead; whitish-green	turquoise	Sinai
30977.f	B50, Loc. 34	bead; bluish green with network of brown veins	turquoise	Sinai
30977.g	B50, Loc. 34	fragment of perforated bead emerald-green	amazonite	South Jordan
30984.a	B50, Loc.34	bead; whitish-green with brown spots	turquoise	Sinai
31005	B34, Loc.5	bead; whitish-green with fine network of brown veins	turquoise	Sinai
31841	B22, Loc.31	broken tabular fragment; pale turquoise-green	chrysocolla	Feinan (Timna?)
31846	B48, Loc.17	semi-finished pendant; emerald-green, fibrous	atacamite, malachite	Feinan
37813	B43, Loc.17	unworked piece with dark crust, inside emerald-green, friable	atacamite in sandstone	Timna or Feinan
37830	B23, Loc.4	3 unworked pieces, 2 irregularly formed, 1 prill	malachite with sand-stone	Timna or Feinan
37938	B84/85, Loc. 16	unworked bluish-green mineral with striking cleavages		Feinan
37945	B84b,85a, Loc.16	unworked piece of green mineral	malachite with sand-stone	Timna
40802	xxx	bead; whitish-green	turquoise	Sinai
40806	xxx	double perforated, flat bead; green with brown spots	turquoise	Sinai
40810	xxx	fragment of flat bead; whitish-green	turquoise	Sinai
40816.1	xxx	bead; whitish-green	turquoise	Sinai
40829	xxx	2 beads; whitish-green with brown spots	turquoise	Sinai
41637	xxx	truncated cone; pale turquoise-green	chrysocolla	Feinan (Timna?)

The Composition of the "Greenstones" from Basta and Their Possible Levantine Sources

The most abundant material among the "greenstones" utilized for making beads is turquoise. Of 42 analyzed samples, 26 consist of this mineral. Ten samples are comprised of secondary copper ores such as malachite, chrysocolla, plancheite or (par-)atacamite. From these, only five (semi-) finished and partly broken beads were counted; the others are unworked fragments. Three specimens of amazonite have been identified, and two of hydroxyl-apatite.

Turquoise

Turquoise is a copper phosphate with the chemical formula $CuAl_6[(OH)_2PO_4].4H_2O$; sometimes it contains minor amounts of iron and zinc. The turquoise owes its greenish colour to the presence of copper. One characteristic is a network of fine brown veins or spots as was often observed among the finds from Basta.

There are only a few source regions for turquoise in the entire Near and Middle East. Occurrences are known from Nishapur (Iran), East of the Caspian Sea, from the Province of Khorassan and near Yazd. It is found in the Ferghana-Basin (Ritter 1837), near Bokhara, and in Afghanistan near Firukush and Badakhshan at the Northwest decline of the Hindu-Kush, which is known for its ruby mines and lapis-lazuli deposits (see overview at Pogue 1915). Three small occurrences of turquoise are reported to occur East of the Red Sea (Bauer 1932) in ancient Midian at Ziba (Burton 1879), Aynuneh, and Gebel Shekayk (Streeter 1898).

Obviously the most important source for turquoise in the Near East with extensive evidence of prehistoric mining activities is located in the Southwestern part of the Sinai (Petrie 1906). It is this region, at a distance of 250 km, that most probably supplied Basta with turquoise. Most of the mines are located in the Wadi Magarah, other mines at nearby Gebel Adeida and Serabit el-Khadim (Beit-Arieh 1980, 1985). Numerous inscriptions and reliefs prove the exploitation of the turquoise by Egyptian expeditions since the Early Bronze Age. Turquoise was the prevalent stone among the jewelry in ancient Egypt through the ages. Hence, the mining activities observed at Serabit el-Khadim and Wadi Maghara are mostly traced back to the Egyptians (Beit-Arieh 1980).

Turquoise from these sources occurs in veins, crusts and concretions that partly fill cavities, and grains and nodules are disseminated in the Cambrian sandstone. A typical feature that proves the turquoise from Sinai to be of inferior quality compared to other sources is the fading to an unsightly grayish colour soon after it is mined. This was also observed at the beads from Basta. Beads made of turquoise have been identified too at the nearby Beidha (Bochum, unpublished results).

Other Secondary Copper Ores

The identified copper ores are malachite ($Cu_2[(OH)_2/CO_3]$), (par-)atacamite ($Cu_2(OH)_3Cl$), chrysocolla ($CuSiO_3$ + aq.), and the blue clinopyroxene plancheite ($Cu_8[(OH)_2/Si_4O_{11}]_2$.

They all occur abundantly in the copper and mineral deposits along the Eastern and Western margins of the Wadi Arabah, with the main ore deposits at Feinan, Timna, and Wadi Abu Kusheibah the nearest ones to Basta. Due to their individual geological settings, each of these deposits has specific mineral contents and ore petrography that is described in more detail by Hauptmann (2000) and Segev *et al.* (1992). It is, however, not always possible to pinpoint a sample securely to a source.

Sample 27887 shows an indistinguishable texture of cuprified remains of plants with some limonite. This texture occurs exclusively at Timna (Bartura *et al.* 1980), and it was not observed in any other copper mineralization in the Wadi Arabah.

Copper silicates such as chrysocolla and plancheite (Samples 30850, 30954, 31841, 41637) are more typical for the Feinan area, where they are found in the Dolomite-Limestone-Shale Unit (Hauptmann 2000). (This formation occurs also at Timna but, except for one small outcrop, is buried under a sequence of Cambrian sandstone). The large crystals of malachite in # 37938 and the fibrous variety of this mineral are also typical for Feinan.

Amazonite

Amazonite is an emerald- to bluish-green feldspar of the microcline type ($K[AlSi_3O_8]$). The colour is caused bytraces of copper. A very finely dispersed network of whitish lamellae is typical.

Amazonite occurs in pegmatitic rocks of the Precambrian basement at the East side of the Wadi Arabah. Even if primary sources are not reported yet from this area, amazonite was collected from wadi gravel in the Wadi Barqanear Gharandal (pers. comm. Dr. I. Khalil, Natural Resources Authority, Amman). Another possible source are several outcrops of pegmatites with K-feldspar that are known in the region Southeast of Basta in a distance of *c.* 30-40 km (Bender 1968, Abu-Ajamieh *et al.* 1988). We suppose that this is where the amazonite found at the Neolithic site of Jebel Rabigh comes from (Borzatti von Löwenstern 1984, Sozzi *et al.* 1991). Amazonite was frequently used at 'Ain Ghazal, a Neolithic settlement located in the modern city of Amman, some 150 km to the North (Bochum, unpublished data).

Simply for geographic reasons it seems unlikely that the amazonite found at Basta comes from Egypt. Even if amazonite is a well known semiprecious stone in the prehistory of Egypt (Lucas 1962), it is subordinate in comparison to the widespread use of emerald (Schneider and Azruni 1892) that occurs in the Eastern desert of Egypt and inthe region of Kush in the upper Nile.

Apatite

Another source of green minerals is reported from the vari-coloured Daba-Siwaqa Marble which occurs some 50 km South of Amman (Khoury and Nassir1982). Here (silicified) limestone, phosphorite, chalk, marl, and travertine of Upper Cretaceous-Lower Neogene age were affected by contact-metamorphosis caused by combustion of organic matter and sulfides in the originally bituminous rocks. The Daba-Siwaqa marble is correlated to the "Mottled Zone" of Palestine (Bender 1968). Nassir and Khoury (1982) described 48 metamorphic minerals. The most common greenish mineral is fluorapatite ($Ca_5F(PO_4)_3$) which is the major cause of coloration in the Daba-Siwaqa rocks. If fluorine is replaced by OH^-, the structure changes to hydroxyl-apatite. Its dark green colour is attributed to a chromium content. Fluorapatite is associated with other green minerals such as calcite ($CaCO_3$), spurrite ($Ca_5CO_3(SiO_4)_2$), and smectite, a clay mineral. From this variety of minerals, only fluorapatite has been identified at Basta.

The Daba-Siwaqa Marble seems to be a unique source for PPN "greenstones" in the Levant; at least the minerals have not been identified before. So far, fluorapatite and green calcite have been identified among the beads from 'Ain Ghazal (Bochum, unpublished data).

Acknowledgements: The author gratefully acknowledges the support of Dipl.-Min. Dirk Kirchner (Bochum), who carried out the X-Raydiffraction analyses. I am very thankful to Prof. Dr. G.O. Rollefson for critical reading the text and improving the English language.

Andreas Hauptmann
Deutsches Bergbau-Museum
Forschungsstelle Archäologie und Materialwissenschaften
FB Archäometallurgie
Germany - 44797 Bochum

References

Abu-Ajamieh M.M., Bender F., and Eicher R.N.
1988 *Natural Resources in Jordan.* Amman, National Resources Authority.

Bar-Yosef O. and D. Alon
1988 The excavations. In: O. Bar-Yosef and Alon D. (eds.), Nahal Hemar Cave. *Atiqot* 18: 1-31.

Bartura Y., A. Hauptmann, and G. Schöne-Warnefeld
1980 Zur Mineralogie und Geologie der antik genutzten Kupferlagerstätte im Timna-Tal. In: H.G. Conrad and B. Rothenberg (eds.), *Antikes Kupfer im Timna-Tal.* Der Anschnitt, Beiheft 1: 41-56

Bauer M.
1932 *Edelsteinkunde.* Leipzig

Beit-Arieh I.
1980 A Chalcolithic site near Serabit el-Khadim. *Tel Aviv* 7: 45-67.
1985 Serabit el-Khadim: new metallurgical and chronological aspects. *Levant* 17: 89-116.

Bender F.
1968 *Geologie von Jordanien.* Beiträge zur Regionalen Geologie der Erde 7. Berlin/ Stuttgart, Borntraeger.

Borzatti von Löwenstern E.
1984 Pitture schematiche in ripari sotto roccia nel deserto della Giordana. *Studi per L'Ecologia del Quaternario* 6: 71-79.

Burton R.F.
1879 *The Land of Midian.* London

France-Lanord A. and de Contenson H.
1969 Une pendeloque en cuivre natif de Ramad. *Paleorient* 1: 107-115.

Garfinkel Y.
1987 Bead manufacture on the Pre-Pottery Neolithic B Site of Yiftahel. *Journal of the Israel Prehistoric Society* 20: 79-90.
Glumac P. D.
1985 Earliest known copper ornaments from prehistoric Europe. *Ornament* 8,3: 15-17.

Goring-Morris A. N. and Gopher A.
1983 Nahal Issaron: a Neolithic settlement in the southern Negev. *Israel Exploration Journal* 33: 149-162.

Goring –Morris A.N., Y. Goren, L.K. Horwitz, D. Bar-Yosef, and I. Hershkovitz
1995 Investigations at an early Neolithic settlement in Lower Galilee: results of the 1991 season at Kefar HaHoresh. *'Atiqot* 27: 37-62.

Hauptmann A.
2000 *Zur frühen Metallurgie des Kupfers in Fenan, Jordanien.* Der Anschnitt, Beiheft 11.

Kirkbride D.
1966 Five seasons at the Pre-Pottery Neolithic village of Beidha, Jordan. *Palestine Exploration Quarterly* 98: 8-72.

Khoury H.N. S.G. and Nassir
1982 A discussion on the origin of Daba-Siwaqa marble. *Dirasat* 9: 55-66.

Lucas A.
1962[4] *Egyptian Materials and Industries.* London.

Nassir S.G. and H.N. Khoury
1982 Geology, mineralogy and petrology of Daba Marble, Jordan. *Dirasat* 9: 107-130.

Özdoğan M. and A. Özdoğan
1999 Archaeological evidence on the early metallurgy at Çayönü Tepesi. In: A. Hauptmann, E. Pernicka, Th. Rehren, and Ü. Yalcin (eds.), *The Beginnings of Metallurgy.* Der Anschnitt, Beiheft 9: 13-22.

Pogue J.E.
1915 The Turquoise. A Study of its History, Mineralogy, Geology, Ethnology, Archaeology, Mythology, Folklore, and Technology. *Natural Academy of Science – Memoires* 12.

Ritter C.
1837 *Die Erdkunde* VII. Berlin.

Rollefson G. and A. Simmons
1986 The Neolithic village of 'Ain Ghazal, Jordan: preliminary report on the 1984 Season. *Bulleten of the American School of Oriental Research* Supplement 24: 145-164.

Rosenberg M.
1994 Hallan Çemi Tepesi: some further observations concerning stratigraphy and material culture. *Anatolica* 20: 121-140.

Rothenberg B.
1972 Sinai explorations 1967-1972. *Museum Haaretz*: 31-45.

Schneider O. and A. Azruni
1892 Der Ägyptische Smaragd nebst einer vergleichenden mineralogischen Untersuchung der Smaragde von Alexandrien, vom Gebel Sabara und vom Ural. *Zeitschrift für Ethnologie* 24: 41-100.

Schoop U.D.
1995 *Die Geburt des Hephaistos. Technologie und Kulturgeschichte neolithischer Metallverwendung im Vorderen Orient.* Internationale Archäologie 24. Espelkamp, Marie Leidorf.

Segev A., M. Beyth M., and M. Bar-Matthews
1992 The geology of the Timna Valley with emphasis on copper and manganese mineralization updating and correlation with the Eastern margins of the Dead Sea Rift. *Geol. Survey Israel*, Rep. No. GSI 14: 1-31.

Solecki R.S.
1969 A copper mineral pendant from Northern Iraq. *Antiquity* 43: 311-314.

Sozzi M., S. Vannucci, O. Vaselli, and F. Vianello
1991 Indagini sulle amazzoniti provenienti dai siti neolitici della Giordania Meridionale. *Studi per l'Ecologia del Quaternario* 13: 35-42

Streeter E.W.
1898 *Precious Stones and Gems*. London.

Talbot G.
1983 Beads and pendants from the tells and tombs. In: K.M. Kenyon and T.A. Holland (eds.), *Excavations at Jericho* V: 788-801. London, The British Academy.

Tubb K.W.
1985 Preliminary report on the 'Ain Ghazal statues. *Mitteilungen der DeutschenOrientgesellschaft* 117: 117-134.

deVaux, R.
1966 *Palestine during the Neolithic and Chalcolithic Periods*. The Cambridge Ancient History (rev. ed.). Cambridge.

Weisgerber G. and E. Pernicka
1995 Ore mining in prehistoric Europe. In: G. Morteani and J.P.Northover (eds.), *Prehistoric Gold in Europe:* 159-182. Dordrecht/Boston/London, Kluwer.

Wheeler M.
1983 Greenstone amulets. In: K.M. Kenyon and T.A. Holland (eds.), *Excavations at Jericho* V: 781-788. London, The British Academy.

Yeivin E. and J. Olami
1979 Nizzanim. A Neolithic site in Nahal Evtah, Israel. Excavations of 1968-1970. *Tel Aviv* 6: 99-135.

Towards a Framework for Studying the Basta Industries

Bo Dahl Hermansen and Hans Georg K. Gebel

Introduction

This contribution is a preliminary attempt to organize our present insights into the Basta material within a general framework. It is our hope that it will eventually serve as a practical guide enabling us to summarize our interpretations of the Basta industries. In order to meet this demand the framework must be sufficiently flexible to be able to integrate the individual insights of all members of the Basta research team with their many different backgrounds. Hence, what is presented below is by no means an adequate description of prehistoric Basta, but, as stated above, a framework for summarizing our interpretations.

Diagram 1 is a graphic depiction of the flow of raw materials through a system of hypothesized activities at Pre-Pottery Neolithic B Basta. Each of the "boxes" in the diagram represents a class of activities which is described in catchwords; and the "arrows" that connect them represent the flow of raw materials through chains of activities. The boxes are grouped into vertical columns which represent stages in these activity chains progressing from left to right as follows:

Stage A) procurement
Stage B) production
Stage C) use
Stage D) deposition/export

After deposition most objects recovered at Basta were further subjected to

E) post-depositional modification

which, among other factors, include reclaiming behaviour on part of the contemporary and later prehistoric populations of Basta and redeposition of material into stratigraphically later contexts through various agents.

The progressing flow of materials from Stage A to Stage E is represented by unbroken lines with arrows whereas stippled lines symbolize recirculation. The boxes in the diagram are designated "1-22" and the vertical columns "Stage A-E" in order to fascilitate cross reference between text and diagram.

It will be noticed that the written contents of the boxes in the diagram only refer to classes of activities in general terms. It neither elucidates where specific activities took place nor what symbolic meaning materials or objects might have had to the inhabitants of Basta in various contexts. This means that propositions about the spatial and symbolic dimensions will have to be summarized differently.

The sequence of five stages suggested here is of course not a new revelation. On the contrary, it resembles both the concept of archaeological site formation theory developed by the socalled "behavioral" archaeologists (Schiffer 1976, 1987, Sullivan 1978) and the scheme outlined by Hodder from an entirely different perspective (Hodder 1978). However, as Hodder would agree (ibid.), there is more to the study of the archaeological record than site formation theory, or as Binford formulated it in a polemic publication from yet a third viewpoint: "If Schiffer recognized 'formation processes' as relevant considerations, good for Schiffer. It simply represented a contribution to the very goals of the new archaeology to reduce our 'methodological naivete'. I should point out, however, that I know of no archaeologists operating in the 1960s and worth their salt who did not know that the archaeological record as observed by the archaeologist was apt to have been modified by 'time's arrow'" (Binford 1989: 77). Thus, in the present contribution, we aim at identifying not formation processes but dynamics in the PPNB Basta system. These would not only have included finds recovered from the site itself, by implication the main object of research in site formation studies, but certainly also the influx and outlet of material through exchange with other human groups as suggested in the Boxes 3, 7, and 21.

Finally, it should be made clear that the framework is basically abducted from patterns observed in the field and the lab. Consequently, the activity sets contained in the boxes may seem somewhat selective since we have only included activities that may reasonably be inferred from our material. We can only hope that analytical work, presently under preparation, may result in a more complete picture.

Table 1 presents more detailed information about the system of activities represented by the boxes in the diagram. Hypothesized activities are specified here and it is mentioned which raw materials were subjected to each kind of activity. This table is far from complete and it will necessarily be considerably modified during the progress of research. Nevertheless, in order to illustrate the concept we have in mind it is presented here. In the presentation of the framework, below, references to boxes in the diagram are followed immediately by a reference to the relevant entries in Table 1.

The Framework

Ad Stage A: Local and regional resources were either mined (1) (Table 1: A.1.1-1.2) or collected (2) (A.2.1-2.6). These expressions cover what must have been a complex set of strategies and techniques which cannot be pinned out in details at this early stage of research on the Basta material. Indeed, the complex behaviour behind these terms will itself be subject to investigation in future volumes of the Basta publication.

Some raw materials identified among the Basta material were only obtainable at long distances from the Basta region (*cf.* Affonso and Pernicka, this volume; Hauptman, this volume). Ultimately such raw materials must have been imported (3) (A.3.1-3.3). Neither can we completely exclude the possibility that some locally available materials were imported as raw materials as well.

Table 1. Expected activities and the raw materials used in the PPNB industries at Basta.
<Explanation of codes (*e.g.* C.8.1): C refers to Stage C in Diagram 1, 8 refers to Box 8 in Diagram 1, and 1 is a serial number for the indiviual activity. Notice that the raw materials under each entry are listed alphabetically in order to facilitate search for specific materials. Biotic resources known by species are printed in italics. All other raw materials are printed in bold. Artifact classes are mentioned in brackets after each material. Note: Information in the table is based on a still incomplete list of raw materials. Some materials mentioned in the entries under the Stages B, C, D, and E are not mentioned among the entries of Stage A. Additional information may consequently be obtained by consulting the table in Affonso and Pernicka, this volume.>.

STAGE A: **procurement**	**STAGE B:** **production**	**STAGE C:** **use**	**STAGE D:** **deposition/ export**	**STAGE E:** **post-depositional disturbances**
A.1.1: mining local minerals and rocks: **calcite** **clay** **flint/chert** **lime** **limestone** **quartzite** **quartzitic limestone** ***samagah*** **sandy limestone** **soil** **A.1.2: mining regional minerals and rocks:** **bituminous chalky marl** **calcite** **calcareous sandstone** **clay** **flint/chert** **lime** **limestone** **quartzite** **quartzitic sandstone** ***samagah*?** **sandstone** **sandy limestone** **silicides** **A.2.1: collecting nodules and pebbles of local minerals and rocks:** **calcite** **chalk** **chalky marl** **crystalline limestone** **dolomite** **dolomitic limestone** **flint/chert** **limestone** **marl** **marly limestone** **quartz** **quartzite?** **A.2.2: collecting nodules and pebbles of regional minerals and rocks:** **amazonite** **calcite** **calcareous sandst.** **chalk** **chalky marl** **crystalline limestone** **dolomitic limestone** **ferruginous sandst.** **flint/chert** **green feldspar** **green quartz** **haematite** **limestone** **marl** **marly limestone** **mudstone** **phyllite** **quartzite?** **sandstone** **siltstone**	**B.4.1: stone cutting for architecture and permanent installations:** **limestone** **sandy limestone** **B.4.2: recirculation of ground stone objects through secondary use as building material:** **basalt** **carbonate stone** **conglomerate rock** **flint/chert** **granite** **limestone** **quartzite** **quartzitic sandstone** **sandstone** **silicides** **volcanic rock** **B.4.3: preparing clay for stationary installations** **clay** **vegetable temper** **B.4.4: burning lime** **lime** **fuel** **B.4.5: mixing mortar, and plaster for beddings, coats, wash, and pigments for decoration:** **lime** **soil** **vegetal temper** **B.4.6: building stationary installations:** **clay** **lime** (plaster, mortar) **limestone** (masonry) ***samagah*** **sandy limestone** **soil** **timber** **B4.7: building houses, and terraces:** **lime** (plaster, mortar) **limestone** (masonry) **sandy limestone** (masonry) **soil** (plaster, mortar) **timber** **B.5.1: chipped stone industry: core preparation from chuncks of tabular flint in workshops (primary production):** **flint/chert**	**C.8.1: use of house roofs as space of transport and communication:** **lime** (mortar, plaster) **limestone** (masonry) **sandy limestone** (masonry) **soil** (mortar, plaster) **timber** **vegetable temper** **C.8.2: use of downslope foundation walls as terrace walls supporting settlement upslope:** **lime** (mortar, plaster) **limestone** (masonry) **sandy limestone** (masonry) **soil** (mortar, plaster) **timber** **vegetable temper** **C.9.1: use of houses as spatial organization of domestic life:** **lime** (mortar, plaster) **limestone** (masonry) **sandy limestone** (masonry) **soil** (mortar, plaster) **timber** **vegetable temper** **C.9.2: use of stationary installations for domestic purposes:** **clay** (bins, ovens) **lime** (plaster, mortar) **limestone** (masonry) ***samagah*** (bins, ovens) **sandy limestone** (masonry) **soil** (plaster, mortar) **timber** **vegetable temper** **C.10.1: use of houses and furnishings as status symbols** **clay** (bins, ovens) **lime** (plaster, mortar) **limestone** (masonry) **pigments** (wall and floor decoration) ***samagah*** (bins, ovens) **sandy limestone** (masonry) **soil** (plaster, mortar) **timber** **vegetable temper** **C.11.1: display of ornaments and symbolic objects in public and private contexts:** **amazonite** (objects) **amber** (beads) *Ancilla* (beads) *Arcularia* (beads) **bituminous chalky marl** (rings)	**D.17.1: abandoning architecture:** **clay** (bins, ovens) **lime** (mortar, plaster) **limestone** (masonry) **pigments** (wall and floor decoration) ***samagah*** (bins, ovens) **sandy limestone** (masonry) **soil** (mortar, plaster) **timber** **vegetable temper** **D.18.1: burying the dead:** **bituminous chalky marl** (rings) **calcite** (beads), **coral** (beads), *Conus* (beads) *Cypraea* (beads/paillettes) **haematite** (beads) **limestone** (beads) *Nerita* (beads) *Pinctada* (mother-of-pearl paillettes), **sandstone** (rings) **D.19.1: sacrifice of zoomorphic and anthropomorphic figurines and pendants:** **clay** (bucranium) **green marble** (anthropomorphic pendant) **limestone** (zoomorphic figurines and pendants) **D.20.1: discard and loss:** **amazonite** (objects) **amber** (beads) *Ancilla* (beads) *Arcularia* (beads) **basalt** (querns, metates, manos, pestles, weight stones, grooved stones, stone vessels) **bituminous chalky marl** (rings) **bone** (awls, spatulae) **calcite** (beads) **carbonate limestone** (vessels) **carbonate rock** (querns, metates, manos, pestles, hammerstones) **chalky marl** (beads) **chalk** (objects) **clay** (geometrics, art works, vessels) *Columbella* (beads) **conglomerate rock** (querns, metates, manos) *Conus* (beads, rings) **coral** (beads) **crystalline limestone** (objects) *Cypraea* (beads/paillettes) *Dentalium* (beads) **dolomitic limestone** (objects) *Engina mandicaria* (beads) **ferruginous sandstone** (rings, manuports) **flint/chert** (chipped stone tools, hammerstones)	**E.22.1: human digging, erosional activities, and other factors resulting in destruction of walls and redeposition of masonry and other architectural elements:** **clay** (bins, ovens) **lime** (mortar, plaster) **limestone** (masonry) **pigments** (wall and floor decoration) ***samagah*** (bins, ovens) **sandy limestone** (masonry) **soil** (mortar, plaster) **timber** **vegetable temper** **E.22.2: human digging, erosional activities, pedoturbation *etc.* resulting in redeposition of artifacts from houses, workshops, burials, cachettes, pits and dumps:** **amazonite** (objects) **amber** (beads) *Ancilla* (beads) *Arcularia* (beads) **basalt** (querns, metates, manos, pestles, weight stones, grooved stones, stone vessels) **bituminous chalky marl** (rings) **bone** (awls, spatulae) **calcite** (beads) **carbonate limestone** (vessels) **carbonate rock** (querns, metates, manos, pestles, hammerstones) **chalky marl** (beads) **chalk** (objects) **clay** (geometrics, art works, vessels) *Columbella* (beads) **conglomerate rock** (querns, metates, manos) *Conus* (beads, rings) **coral** (beads) **crystalline limestone** (objects) *Cypraea* (beads/paillettes) *Dentalium* (beads) **dolomitic limestone** (objects) *Engina mandicaria* (beads) **ferruginous sandstone** (rings, manuports) **flint/chert** (chipped stone tools, hammerstones) **granite** (grooved stones) **green feldspar** (beads) **green marble** (beads, rings) **green quartz** (beads) **haematite** (beads) **limestone** (beads, rings, mask?, geometrics, querns, metates, manos, pestles, hammerstones, grooved stones, vessels, celts, discs) **marl** (pendants) **mudstone** (objects) *Natica* (beads) *Nerita* (beads) **oistrich shell** (containers?) **other volcanic rocks** (manos, hammerstones, weight stones)

STAGE A:

A2.3: collecting local vegetable and arboreal resources:

plant fiber
fuel
timber

A2.4: collecting regional vegetable and arboreal resources:

plant fiber
fuel
timber

A.2.5: extracting raw materials from domestic and local wild fauna:

bones

A.2.6: extracting/collecting animal resources on regional basis:

bone
oistrich shell

A.3.1: importing rocks and minerals as rawmaterials and semifinished goods:

obsidian
subfossil *Tridacna*
turquoise

A.3.2: importing wild animal resources:

oistrich shell?

A3.3: importing shell raw materials:

Conus
Cypraea
Nerita
Pinctada
Strombus

A.7.1: importing finished goods:

amazonite (objects)
amber (beads)
Ancilla (bead)
Arcularia (beads)
bituminous chalky marl (rings)?
Columbella (beads)
coral (beads)
Conus (beads)
Cypraea (beads/paillettes)
Dentalium (beads)
Engina mandicaria (beads)
subfossil *Tridacna* (beads)
ferruginous sandstone (rings)
green marble (pendant, bead)
Natica (beads)
Nerita (beads)
Pinctada (beads, rings, paillettes)
sandstone (rings, beads, polishers?)
Strombus (beads, rings)
Terebra (bead)
Theodoxus/Smargidia (beads)
Turquoise (beads, rings)

STAGE B:

B5.2: tool fabrication from blanks produced in workshops of the settlement (secondary production):

flint/chert

B.5.3: ground stone industry: pre-shaping of ground stone products:

basalt
carbonate limestone
carbonate rock
conglomerate rock
flint
granite
limestone
quartz
quartzite
quartizitic limestone
quartzitic sandstone
sandtsone
silicides
soft limestone
volcanic rock

B.5.4: manufacture of ornaments from shells in workshops:

Conus
Cypraea
Nerita
Pinctada
Strombus

B.5.5: manufacture of ornaments amd symbolic objects from minerals and rocks in workshops:

amazonite
calcite
clay objects
haematite
green marble
green quartz
limestone
phyllite
quartz
turquoise

B.6.1: small scale/*ad hoc* fabrication of chipped artifacts (core prep., debitage, and tools):

flint/chert
quartzite

B6.2: small scale/*ad hoc* fabrication of other artifacts (tools and ornamentsments):

bone
calcite
chalk
clay
crystalline limestone
dolomitic limestone
limestone
mudstone
siltstone
sandstone

B.6.3: manufacturing matts and textiles:

plant fibre

B6.4: recirculation of artifacts in shell, minerals/rocks, bone. and textiles:

in principle all materials and goods in these industries may have been recirculated, specific cases have not yet been identified yet.

STAGE C:

calcite (beads)
chalk (objects)
chalky marl (beads)
clay (geometrics, art works)
Columbella (beads)
Conus (beads, rings)
coral (beads)
crystalline limestone (objects)
Cypraea (beads/paillettes)
dolomitic limestone (objects)
Dentalium (beads)
Engina mandicaria (beads)
ferruginous sandstone (rings, manuports)
green feldspar (beads)
green marble (beads, rings, pendant)
green quartz (beads)
haematite (beads)
limestone (beads, rings, mask?)
marl (pendants)
mudstone (objects)
Natica (beads)
Nerita (beads)
oistrich shell (containers?)
Pinctada (mother-of-pearl beads, rings, paillettes)
quartz (beads)
sandstone (beads, rings)
siltstone (objects)
Strombus (beads, rings)
subfossil *Tridacna* (beads)
Terebra (beads)
Theodoxus/Smargidia (beads)
turquoise (beads, rings)

C.12.1: tool kits used for processing in the industries and crafts:

bone (awls, spatulae)
flint/chert (chipped stone tools)
quartz (polishers)
sandstone (polishers)

C.13.1: food processing: grinding and pounding:

basalt (querns, metates, manos, pestles, weight stones, grooved stones stone vessels)
carbonate limestone (vessels)
carbonate rock (querns, metates, manos, pestles, hammerstones)
conglomerate rock (querns, metates, manos)
flint (hammerstones)
granite (grooved stones)
limestone (querns, metates, manos, pestles, hammerstones, grooved stones, celts discs)
other volcanic rock (manos, hammerstones, weight stones)
quartz (polishers)
quartzite (querns, metates,manos, pestles, hammerstones)
quartizitic limestone (vessels)
quartzitic sandstone (querns, metates, manos, weight stones, grooved stones, egg-shaped st.)
sandstone (querns, metates, manos, pestles, hammerstones, weight stones, grooved stones, polishers)
silicides (grooved stones)
soft limestone (weight stones, egg-shaped stones)

C.14.1: mobile storage technology

carbonate limestone (vessels)
clay (vessels)
limestone (vessels)
quartzitic limestone (vessels)
soft limestone (vessels)
samagah (vessels)

C.15.1: clothing, covering and roofing(?):

plant fiber (textiles, mats, covers)

C.16.1: counting, play(?):

clay (geometrics)
limestone (geometrics)

STAGE D:

granite (grooved stones)
green feldspar (beads)
green marble (beads, rings)
green quartz (beads)
haematite (beads)
limestone (beads, rings, mask?, geometrics, querns, metates, manos, pestles, hammerstones, grooved stones, vessels, celts, discs)
marl (pendants)
mudstone (objects)
Natica (beads)
Nerita (beads)
oistrich shell (containers?)
other volcanic rocks (manos, hammerstones, weight stones)
Pinctada (mother-of-pearl beads, rings, paillettes)
plant fiber (textiles, mats, covers, temper)**quartz** (beads, polishers)
quartzite (querns, metates, manos, pestles, hammerstones)
quartzitic limestone (vessels)
quartzitic sandstone (querns, metates, manos, weight stones, grooved stones, egg-shaped stones)
samagah (vessels)
sandstone (rings, polishers, querns, metates, manos, pestles, hammerstones, weight stones, grooved stones)
silicides (grooved stones)
siltstone (objects)
soft limestone (weight stones, egg-shaped stones, vessels)
Strombus (beads, rings)
subfossil *Tridacna* (beads)
Terebra (beads)
Theodoxus/Smargidia (beads)
turquoise (beads, rings)

D.21.1: exporting raw materials, semi-finished goods, and finished goods.

in principle all materials and goods may have been exported in exchange operations.

STAGE E:

Pinctada (mother-of-pearl beads, rings, paillettes)
plant fiber (textiles, mats, covers, temper)
quartz (beads, polishers)
quartzite (querns, metates, manos, pestles, hammerstones)
quartzitic limestone (vessels)
quartzitic sandstone (querns, metates, manos, weight stones, grooved stones, egg-shaped stones)
samagah (vessels)
sandstone (rings, polishers, querns, metates, manos, pestles, hammerstones, weight stones, grooved stones)
silicides (grooved stones)
siltstone (objects)
soft limestone (weight stones, egg-shaped stones, vessels)
Strombus (beads, rings)
subfossil *Tridacna* (beads)
Terebra (beads)
Theodoxus/Smargidia (beads)
turquoise (beads, rings)

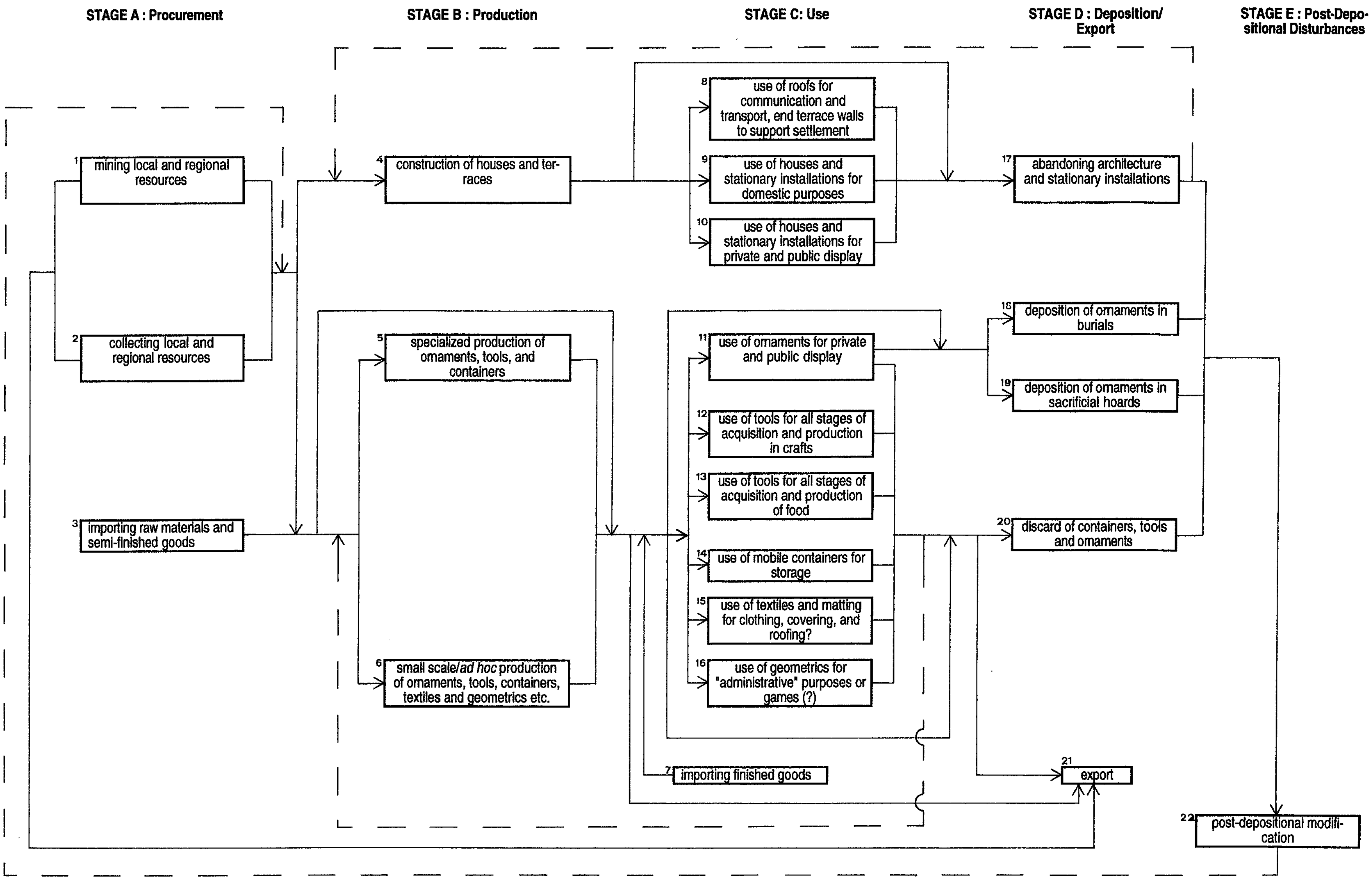


Diagram 1. Flow of raw materials through the Basta system.

Whether mined (1), collected (2), or imported (3), the raw materials would have reached producers and been subjected to artificial modification by them. *I.e.*, in the diagram they would pass from Stage A to Stage B. Alternately, in some cases raw materials may have been exported directly from Stage A in exchange for goods or raw materials (21) (D.21.1). In some cases pieces of raw material found their way to Stage C without passing through the production stage.

Not only raw materials were imported from external sources but also semi-finished goods (3) (A.3.1-3.3) and finished goods (7) (A.7.1). The former usually, but not always, entered Stage B and the latter Stage C.

There is no certainty that all objects manufactured in local or regional materials were produced locally, and it may well be that some local sources were not known by the prehistoric inhabitants or were left untouched for other reasons. Likewise some materials may have been both mined and collected on different occasions and for different or identical purposes. Consequently it must be emphasized that the procurement stage, as expressed in the diagram is a highly simplified version of what actually happened. Thus, a hole complex of interesting research questions are implicitly built into the diagram's Stage A. The present volume is specifically addressing questions about the raw material situation.

Ad Stage B: Via Stage A, raw materials and semi-finished goods flow into the production stage. This process may have involved transport and storage. In Stage B we have defined three classes of activities: construction of architectural structures, including stationary installations (4) (B.4.1-4.7), specialized production of goods (5) (B.5.1-5.5), and small scale/ *ad hoc* production of goods (6) (B.6.1-6.6).

Notice the stippled lines which indicate that some materials or objects which enter stage B in the diagram are recirculated from the later Stages C, D and E.

Objects which had been manufactured in the production stage would mostly have been transmitted to Stage C, the context of use, perhaps, in individual cases, with some delay due to temporary storage and/or transport. Alternately, some objects would have left the Basta system as export items (21) (D.21.1) instead of being transmitted to Stage C, or simply deposited (18, 19) (D18.1, D.19.1) or discarded as production waste (20) (D.20.1).

Ad Stage C: Those finished goods which had been manufactured at Basta, and not exported or transfered directly to stage D by whatever means, were used within the Basta system itself.

Boxes 8-10 represent the use of architectural structures and stationary installations (C.8.1-8.2, C.9.1-9.2, C.10.1) wheras Boxes 11-16 represent the use of goods manufactured through specialized production or small scale/*ad hoc* production, respectively (C.11.1,. C.12.1, C.13.1, C.14.1, C.15,.1, C.16.1).

When used, objects are subjected to various agents of modification, wear, and, sooner or later, destruction. Objects made useless in this way might be repaired or modified for other uses. A stippled line in the diagram symbolizes the recirculation loop which is thus established. Of course, from Stage C, like Stage A and Stage B, objects would have been exported in exchange of other materials or goods (21) (D.21.1). Objects or materials in this stage of their "life histories" would often have been exchanged between members of the Basta community and sometimes put to secondary use when they were worn out rather then recirculated to Stage B. However, sooner or later they were incorporated in activities that led them to the "sinks", or exit contexts, where some of them were recovered during the archaeological excavations at Basta. These terminal activities comprise Stage D in the diagram. Again the objects may have been temporarily stored before they were transfered to Stage D.

Ad Stage D: This stage comprises the complex of activities through which objects left the living system. We have evidence of at least four kinds of actions apart from export of objects (21) (D.21.1). These are abandonment of architecture (17) (D.17.1), deposition of objects as burial equipment (18) (D.18.1) or as sacrifices (19) (D.19.1), as well as discard and involuntary loss of objects (20) (D.20.1). These activities resulted in the exit from the living system of the objects in question. *I.e.* they were transfered to archaeological context.

In some cases the objects were recovered from those contexts where they originally left the living system, but most were redeposited to tertiary contexts and otherwise modified by post-depositional processes as shown in Box 22 (E.22.2).

From stage D, too, a loop of recirculation is connected to stage B. This is represented by the stippled line in the upper part of the diagram which indicates that architectural units were recirculated in the sense that they were rebuilt and reused through long periods of occupation.

Ad Stage E: Stage E in the diagram represents the postdepositional factors that modified the archaeological record of prehistoric Basta (22) (E.22.1-22.2). This is another subject of the present volume of the Basta publication. These include disturbances due to reoccupation of ruined architecture by groups who occupied the land after the Pre-Pottery Neolithic B settlement had been abandoned and various natural agents. Also, and more interesting in the present context, dealing as we are with the PPNB occupation, the reuse of abandoned architecture for burial purposes would have been a disturbing factor; and "scavenging" activities by the PPNB villagers themselves would have lead to recirculation of masonry from abandoned architectural units which had fallen into disuse. The latter is indicated in the lower part of the diagram by the recirculation loop symbolized by the stippled line that leads back to Stage B.

An Hypothetic Example

In order to demonstrate the use of the framework proposed here we have selected the example of sandstone. This material was used *e.g.* for rings of a "bracelet" type and for "polishers". The easiest way for the Basta inhabitants to acquire this material would have been to collect (2) (Table 1: A.2.2) tabular chunks of it in the Petra region. On a larger scale mining (1) (A.1.2) of this material would have been easy as well because of the abundant availability of easily accessible sandstone types in the Petra region. Unfortunately, due to the high erosional activity in that region, we have not found preserved evidence of the techniques involved in such mining operations. In all probability, though, by far the larger proportion proportion of sandstone objects were imported to Basta as finished products (7) (A.7.1). At least the evidence of local production of sandstone objects at Basta is quite limited in quantity. Meanwhile it turned out that the site of Ba'ja (*cf.* Fig. 1 in the Editors' Introduction, this volume) was a major production center for the sandstone rings; almost each household (Gebel, Bienert, *et al.* 1997; Gebel 2001) maintained a workshop for their production, and dumps of the rings' production waste were found in the site's fringes.

No raw material for sandstone objects has been identified among the objects recovered at Basta. However, a small proportion of waste from the production of sandstone rings of the "bracelet" type has been found as well as fragments of unfinished rings. Consequently it appears that in a few cases blanks were imported to the settlement where secondary production and refinement was completed. However, this probably happened on a small scale only

(6) (B.6.2). At the present stage of research it seems that only a quite small proportion of sandstone rings passed through the production stage at Basta itself which does not account for the large quantity of rings that have actually been found on the site. We therefore propose that most sandstone rings were imported as finished products (7) (A.7.1). A suggestion for the actual manufacturing processes behind similar rings of bituminous chalky marl is offered by Affonso and Pernicka, this volume; and a more detailed study of ring production in general will be presented in Volume IV of the Basta final publication by Hermansen (*cf.* also Starck 1987; Gebel, Bienert *et al.* 1997: 252-257, Figs. 13-14, Plate 7, Table 4).

Few rings were recovered from primary contexts and we cannot certify whether all finished rings entered the use stage in our diagram. Indeed, it is possible that many rings were exported (21) (D.21.1) directly without ever having been put to use in Basta itself. At any rate, the use of such rings is enigmatic. Starck (1987) suggests that they were used as clasps or pendants rather than bracelets or bangles. But this interpretation is based entirely on a metric analysis. So far no rings have been recovered in contexts that allowed clarification of the specific use or uses of this class of objects. Thus, in the absence of a clear understanding of their use, we suggest that those rings that did flow through the use stage were either used as pendants or paillettes (11) (C.11.1) or served the more functional use as clasps in textiles for clothing (15) (C.15.1). By far the majority of ring fragments from Basta are without perforations. In statistic terms (Starck: 1987) this would seem to indicate that the finished product was supposed to be unperforated. Thus, the few perforated fragments which have been recovered may have been secondarily perforated, perhaps to serve a different purpose, or perhaps in order to mend broken specimens. This allows us to follow the recirculation of rings from Stage C back to Stage B in the loop of recirculation indicated in the diagram by the stippled arrows in the lower part of the diagram.

However, there are limits to recirculation. And sooner or later the sandstone rings were transfered to stage D. Some were demonstrably deposited as burial equipment (18) (D.18.1). Some would have been discarded or lost by their owners (20) (D.20.1). Others, not recovered on the site, might have been exported before or after having passed through Stage C (21) (D.21.1). Most rings, however, were found in contexts which indicate that they had been redeposited and fragmented, sometimes through a sequence of post-depositional events. Thus, in some cases it can be demonstrated that sandstone rings were originally deposited in graves. These were first disturbed by digging activities and later the redeposited burial fill was subjected to erosional redeposition (22) (E.22.1-22.2). Of course other post-depositional factors also worked on the archaeological record (*cf.* Schiffer 1989) but, as stated above, formation theory *per se* is not the topic of this contribution and consequently these are not considered here.

As stated above sandstone was also used for another kind of artifacts, *i.e.* as polishers. The raw material for these objects could have been mined (2) (Table 1: A.1.2) or collected (1) (A.2.2) during the seasonal movements of the Basta population. But most of it would have reached the site together with the rings of the same material, discussed above, through the exchange networks in which the Bastans participated (7) (A7.1). Thus, sandstone polishers may also have been exported together with rings (21) (D.21.1). There are no positive indicators that any significant manufacturing processes were involved and it may be that suitable sandstone pieces would have entered the Basta system directly in stage C without prior modification save that which might have been applied in the procurement stage and thus achieved their function as polishers by simply using them in this capacity (12) (C.12.1). We are not aware that any such objects have been recovered from other contexts than discard (20) (D.20.1) and redeposited contexts (22) (E.22.1-22.2).

From these examples it should be clear that it is possible to trace the hypothetic flow of any raw material used in the PPNB Basta inventory through the system of activities indicated in Diagram 1.

Concluding Remarks

As stated in the introduction this contribution is a preliminary attempt to organize our present insights into the Basta material within a general framework. It is our hope that the framework will turn out to be useful in future research as a general framework for summarizing our interpretations of the PPNB Basta assemblage. In addition to this purpose, stated in the introduction as our main aim, we have seen that the framework may help us to organize the study of separate raw material groups. In consequence of this additional property it is intended to test the framework further in vol. V which will be devoted to the study of the socalled "small finds" from Basta. With some luck, this should result in an elaborated version which may serve as a working base for tracing the flow of each individual raw material documented at Basta in a synthesis to be published in the final volume of the Basta publication.

Bo Dahl Hermansen
The Carsten Niebuhr Institute
University of Copenhagen
Snorresgade 17-19
Denmark - 2300 Copenhagen S

Hans Georg K. Gebel
Institut für Vorderasiatische Altertumskunde
Free University of Berlin
Hüttenweg 7
Germany - 14195 Berlin

References

Binford L.R.
1989 *Debating Archaeology.* Studies in Archaeology. San Diego, Academic Press.

Garrard A.N. and H.G. Gebel (eds.)
1988 *The Prehistory of Jordan. The State of Research in 1986.* British Archaeological Reports - Intern. Series 396.1: 137-174. Oxford, BAR.

Gebel H.G.
1992 Territories and palaeoenvironment: locational analysis of Neolithic site setting in the Greater Petra area, southern Jordan. In: S. Kerner (ed.), *The Near East in Antiquity. German contributions to the archaeology of Jordan, Syria, Lebanon, and Egypt* 3: 85-96. Amman, al-Khubta.
2001 Frühseßhafte verborgen in Felsen. Ba'ja in Süd-Jordanien stellt der Jungsteinzeitforschung neuartige Fragen. *Antike Welt* 32/3: 275-283.

Gebel H.G.K. and Bienert H.D., with contributions of T. Krämer, R. Neef, B. Müller-Neuhof, J. Timm and K.I. Wright
1997 Ba'ja hidden in the Petra Mountains. Preliminary results of the 1997 investigations. In: H.G.K. Gebel, Z. Kafafi, and G.O. Rollefson (eds.), *The Prehistory of Jordan,* II. *Perspectives from 1997.* Studies in Early Near Eastern Production, Subsistence, and Environment 4: 221-262. Berlin, ex oriente.

Hodder I.
1978 Towards a mature archaeology. In: I. Hodder and N. Hammond (eds.), *Pattern of the Past.*

Hodder I. and N. Hammond
1978 *Pattern of the Past.*

Schiffer M.B.
1976 *Behavioral Archeology.* Studies in Archeology. New York, Academic Press.

1987 *Formation Processes of the Archaeological Record.* Albuquerque, University of New Mexico Press.

Starck J.M
1988 Comparative study of stone-ring artefacts from Baga and Basta. In: A.N. Garrard and H.G. Gebel (eds.), *The Prehistory of Jordan. The State of Research in 1986.* British Archaeological Reports - Intern. Series 396.1: 137-174. Oxford, BAR.

Sullivan A.P.
1978 Inference and evidence in archaeology: a discussion of the conceptual Problems. In: M.B. Schiffer (ed.), *Advances in Archaeological Method and Theory* 1: 183-222. New York, Academic Press.

Vegetation and Plant Husbandry[1]

Reinder Neef

Introduction

The Neolithic site of Basta (30°13'47" N / 35°32'06" E) is located in the lower foothills East of the southern highlands mountain ridge (Fig. 1). Along with 'Ain Ghazal, Basta is one of the largest PPNB settlements in Jordan. The extensive settlement layers cover an area of at least 10 ha to probably 14 ha. They lie on a slope bordering the Wadi Basta at an altitude of 1420-1460 m. Most of the site is unfortunately built over by present-day Basta.

After an initial sounding in 1984 (Gebel and Starck 1985), five excavations were subsequently carried out between 1986 and 1992. The excavations took place in two main areas, A and B. They revealed very well preserved architecture. The building technique was nearly identical in both areas of excavation. Excellently preserved walls remain which in parts still reach a height of 1.9 m above floor level. They are built of dressed local limestone, formed into rectangular

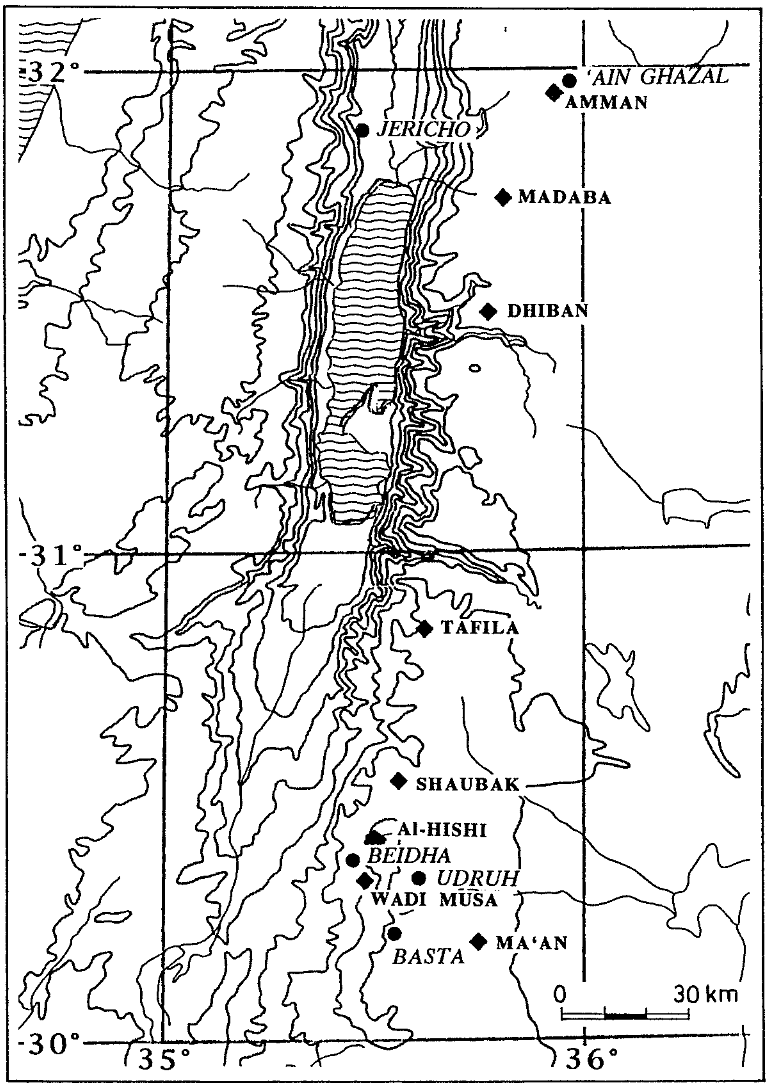


Fig. 1. Location of sites mentioned in the text.

[1] The editors received this contribution in Sept. 1995.

blocks. The stones are bedded mainly in mud-mixtured mortar. The rectangular rooms had plastered floors, some of which were painted red.

Although the architecture in areas A and B differ quite markedly from each other, they belong to the same period. In Area A, rectangular rooms varying in size were found. Under the floor of the main room a so-called "channel system" (floor substructures) was found. However these "channels"clearly differ from those found at Çayönü, Munhatta or Nevalı Çori. In Area B a large room of 6 x 3.5 m is surrounded on three sides by rows of small rooms. They are connected by low, narrow passages (Gebel *et al.* 1988, Nissen *et al.* 1987).

The main occupation phase of the site is dated Late PPNB. The site appears to have been settled for about 500 years (Gebel 1988). Two charcoal samples of the pistachio tree (*Pistacia atlantica*) were dated at the Centre for Isotope Research, University of Groningen. Both samples were taken from Area A, and according to the preliminary phase designations belong to Phase 4, the main Late PPNB occupation (Gebel, pers. comm.). The samples are from Square A5, from the cultural debris in a profile (23.46-23.33): 8380 ± 100 bp (GrN-14537, calibrated 7550-7050 BC), and from Square A6, Locus 7, an ash lens: 8155 ± 50 bp (calibrated 7290-7032 BC)[1].

In this study the analysis of the botanical remains, including the numerous charcoal fragments retrieved from the excavations at Basta, is presented. A crucial question addressed is the kind of subsistence upon which such large settlements could develop. Furthermore, could subsistence provide clues as to why these large settlements were almost completely abandoned in the Late PPNB in Jordan, after which very few settlements of any size were to be found?

The present environment around Basta seems uninviting to large scale settlement. Basta is located in an agriculturally marginal and ecologically degraded area. It lies in the semi-arid Irano-Turanian steppe region at the outer margins of rain-fed agriculture. This region borders the highlands to the West, with their more humid and cold climatic conditions, and the arid desert region to the East. However, the results of the study of plant remains from the PPNB at Basta, presented in this paper, contrast with the present situation. They hardly reflect the present environment of an almost treeless area around Basta. Therefore a general discussion on climate and the recent vegetation in a wide area around Basta is made, to consider whether these differences could all be man-induced and/or whether or not the recent climate differs substantially from that of the PPNB in this region.

Present-Day Climate, Crop Husbandry and Vegetation

The archaeobotanical data presented here is elucidated initially by a general synopsis covering the climate and its agricultural implications, plant cultivation and the remains of natural vegetation around Basta.

Climate

Basta lies in a zone with a Mediterranean climate; the rainfall is concentrated in winter and early spring. Mean annual precipitation in Basta is about 160 mm PA. Mean daily temperature during the coldest month (January) is 6° C and during the hottest month (July) 18° C.

[1] Calibration with a 95,4 % confidence level. C.I.O. Groningen Radiocarbon Calibration Program (van der Plicht 1993).

During winter and early spring night frosts occur. Snow is not infrequent in the highlands. The Emberger classification of bioclimatic regions places Basta in the semi-arid cold region (Alex 1985, NAJ 1 1984, Long 1957).

The climatic conditions in the region around Basta are barely adequate to sustain stable dry-farming. For lowland Iraq, Thalen (1979) calculated an absolute minimum requirement of 250 mm precipitation p.a. for stable rain-fed agriculture, a requirement which should not be taken too literally; local factors such as the capacity of the soil to retain water, and dew which can affect the microclimate, can also be contributory factors. Another aspect which can have an impact is the distribution of rainfall throughout the year. For Syria, Wirth (1971) mentions that on a well developed soil with a favourable distribution of precipitation during the winter months, barley still grows well in 200 mm precipitation and wheat in 250 mm. Heavy showers on the other hand can release more than 50 mm of rainfall within an hour, whereby much of the water is just runoff, sometimes causing severe soil erosion on the slopes.

In the fringe areas of dry-farming, annual rain fluctuation is decisive to the success of the harvest. Compared to the average amount of rainfall this can be considerable; as an example, the standard deviation of rainfall measured over 25 years at the 200 mm isohyet in Jordan is between 50 and 75 mm (NAJ 1 1984). During rainy years this enables an expansion of rain-fed agricultural areas, explaining why many ploughed fields, as far East of Basta as the 140 mm isohyet, can be seen. The water retention capability of soil is positively influenced in the short-term by tilling; however, in the long run the effect of tilling is negative because of the resultant soil erosion. Despite these factors, one should keep in mind that the land suitable for rain-fed agriculture in this part of southern Jordan, *i.e.* with an annual precipitation higher than 200 mm, measures no more than 3-4 kms East-West, as the crow flies. Wirth (1971) calculated that only in areas with precipitation higher than 400 mm could the risks to dry-farming crops be considered as small. This implies that farming in the Basta region can never be reliably based on rain-fed crops alone.

Crop Husbandry

At Basta the lower part of the wadi is terraced. The parcels on the terraces are divided by stone walls with cypresses (*Cupressus sempervirens*) planted along them. On a small scale, irrigation based horticulture is practised on the terraces. The most commonly cultivated fruit-trees are fig (*Ficus carica*) and olive (*Olea europea*), besides some pomegranates (*Punica granatum*), plums (*Prunus domestica*) and apricots (*Armeniaca vulgaris*). According to some old villagers, the massive apricot trees were imported from the West Bank about 100 years ago. Vines (*Vitis vinifera*) are grown under these trees and along the stone partition-walls. In the small vegetable gardens on the lower terraces the main crops are maize (*Zea mays*), a small cucumber variety (*Cucumis sativus*) and squash (*Cucurbita* sp.). The domestic animals, most notably sheep, goats and donkeys, are watered at the wadi's perennial well. Over the last ten years the well barely provided enough water to irrigate the fields on the wadi terraces. On the most Easterly fields, fruit trees and planted Aleppo pines (*Pinus halapensis*) were seen dying of drought. This is not entirely due to some extremely dry years during the eighties, although this did aggravate the problem. The main cause is the overexploitation of the vegetation by man through herding and wood collection.

The main dry-farming zone is West of the village of Basta. Where no soil erosion has taken place there are well developed red and yellow Mediterranean soils, which are excellent for dry-farming. The cereals grown are winter sown macaroni wheat (*Triticum durum*) and two-row hulled barley (*Hordeum distichum*). In years with little winter rainfall, two-row hulled barley is also sown as a summer crop (Pasternak 1991). On a very limited scale pulses, mainly lentils (*Lens culinaris*) and chickpeas (*Cicer arietinum*), are grown. Those areas that are not in use as fields are mostly too rocky and/or too steep. East of Basta farmers tend to keep large areas ploughed, which are only sown in wet years.

Vegetation

It is hard to imagine what kind of vegetation would grow in the area of Basta without the influence of man. In semi-arid and arid zone vegetation, balances are easily upset. Under the pressure of civilisation, ecological degradation caused by herding, ploughing and wood cutting has been in progress for thousands of years. As a result of this process the natural vegetation has been greatly reduced or even destroyed. Around Basta this has led to uniform vegetation dominated by the economically least viable steppic elements of this vegetation.

In Fig. 2.A the present-day vegetation is presented in a transect ranging from the fringes of the Southern highlands over the highlands and into the steppic region East of Basta. Plant species principally taken into consideration are the structural elements of contemporary vegetation. Special attention is paid to those species which are found in the study's botanical samples as charcoal (representing remains of timber or firewood), seeds and fruits of collected or browsed plants, *etc.*

Basta lies in the Irano-Turanian steppe zone. The characteristic vegetation of this region is typically steppic, the climax vegetation being dominated by grasses and dwarfshrubs (Plate 3.A). Most of the species in the steppe are summer annuals and biennials. The plants die after their fruits have ripened in May or June. This group of plants includes the best fodder/grazing plants of the steppes. Most of the wild grasses such as *Bromus danthoniae*, *Taeniatherum crinitum*, *Avena* spp. (wild oat species), *Hordeum bulbosum* (bulbous barley) and *Hordeum spontaneum* (the ancestral wild form of cultivated barley) can be found. There are several other species of good fodder plants from the leguminous family, especially from the genera *Medicago* (medick) and *Trifolium* (clover). When palatable, the dwarfshrubs provide fodder for the whole year. The dwarfshrub vegetation is dominated by *Artemisia herba-alba*, especially on deeper, more developed soils. It is locally dominated by the dwarfshrubs *Ononis natrix*, *Noaea mucronata* and *Varthemia iphinoides*. Higher arboreal elements occur very sporadically East of Basta. In favourable locations such as rock crevices, isolated patches of hawthorn (*Crataegus aronia* and *C. cf. azarolus*) or fig (*Ficus pseudosycomorus*) can be found. Of the former riverine vegetation along the Wadi Basta almost nothing remains. Only one bushy willow (*Salix cf. pseudo-safsaf*) could be found.

About 4 km East of Basta where the annual precipitation is approximately 140 mm, the dwarfshrub vegetation of the *Artemisia* steppe becomes dominated by the drought resistant dwarfshrubs *Anabasis articulata* and, locally, *Salsola vermiculata*. Here the last of the ploughed fields, and consequently the definitive limits to rain-fed agriculture, can be found. Ploughing is especially destructive to dwarfshrub vegetation, leaving no protection against soil erosion in late summer or autumn, when other plants are dead or in a dormancy state.

The *Artemisia* steppe stretches further to the West of Basta over the Southern highlands. This is the main area of cereal cultivation with average precipitation between 170-220 mm. The only taller element is presented by hawthorne (*Crataegus aronia*), of which some rare individuals can be found in the areas North and West of Basta (Plate 3.B). Conspicuous examples, browsed back to a dwarfshrub appearance, are not uncommon. Overgrazing in the whole area has generally led to the disappearance of the arboreal elements. It has also led to an invasion and/or increasing dominance of less palatable species, with concurrent reduction in the formerly dominating grazed species. These are plants with etheric oils and sticky or

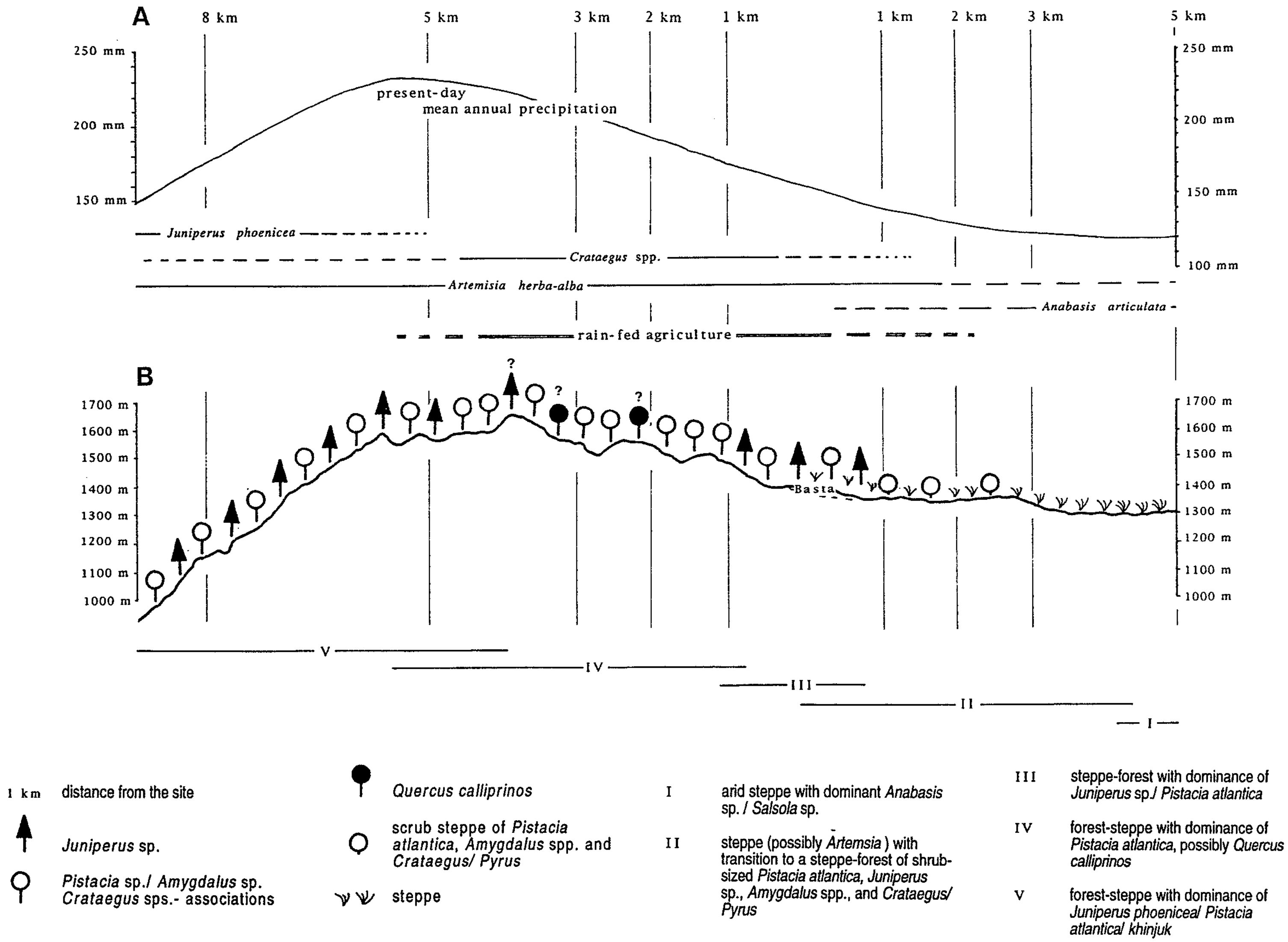


Fig. 2. E-W- transect of the present-day (A) and supposed late 8th millennium BC (B) vegetation in the Basta area.

prickly species, such as the sticky dwarfshrub *Ononis natrix,* growing in moister locations and, East of Basta, the thorny dwarfshrub *Noaea mucronata.*

On the steep Western slopes of the highlands, remnants of phoenician juniper (*Juniperus phoenicea)* forest can be found. This juniper owes its existence to the steep slopes which make agriculture virtually impossible, whilst sheep and goats rarely browse on this tree. The undergrowth is dominated by the widespread *Artemisia herba-alba.* In general, deforestation allows steppic species to either invade or expand. At an altitude of about 1100 m on the West slope, as a result of increasing temperatures, more thermophilous species appear, like *Raetama raetam* and the unpalatable *Urginea maritima.* Baierle (1993) provides a more detailed study of the recent vegetation in the Southwest of Jordan.

Samples

During the excavations carried out between 1986 and 1992, botanical samples were obtained at Basta. They can be distinguished in so-called hand-picked samples, which in this case all consist of charcoal, and flotation samples.

The total numbers of seeds, fruits and other plant remains, and the amount of charcoal (in ml) from the flotation samples taken in areas A and B are presented in Tables 1 and 2. In Table 3 the results of the hand-picked charcoal (in ml) are listed separately. The charcoal from the flotation samples of 1989 was not available for identification. In the tables a character is given representing the feature from where the sample was taken: M stands for samples which cannot directly be related to a spatial or *in situ* context. The samples from the profiles also belong to this category. Those samples which can be related to a spatial context are characterized by R (room) and W (wall). Most of this material represents erosion debris which cannot directly be related to an *in situ* context. Most of the botanical samples taken belong to this category. Samples from *in situ* contexts are rare. They are marked: B (sample from human burial), C (from the channel-like substructures), F (floor), I (fireplace), P (pit), R (room), T ("tabun"), and RS (room storage).

The phase designations given in the tables are preliminary designations pertaining to the present stage of stratigraphical evaluation. Four phases have been distinguished (Gebel, pers. comm.):

Phase 1: Remains of the Pottery Neolithic occupation, with similarities to the Yarmukian (PNA).

Phase 2: Remains of a Final PPNB in the so-called rubble layers.

Phase 3: Remains of a (later ?) architectural (sub-?) phase related to the last main Late PPNB occupation.

Phase 4: Main Late-PPNB occupation.

In both the tables and discussion, Phases 1 and 2 and Phases 3 and 4 have been grouped together because they could not be effectively separated until recently.

The number of seeds and fruits of collected and cultivated plants and their sample frequencies from areas A and B are given in Table 4. The same has been done with the charcoal. For the flotation samples, the total amount of charcoal and the sample frequencies of the different wood types are given in Table 5. The hand-picked charcoal is treated accordingly in Table 6.

Table 1. Basta, Area A. Total number of seeds, fruits and other plant remains from the flotation samples <* = *estimated number of complete seeds and fruitstones from small fragments, n = presence in number of samples*>.

N	505	502	502	502	502	502	502	502	502	502	500	500	500	500	500	500	500	500	500	500	500	500	500	500	485/500	500	500
E	690	687	687	687	687	687	687	687	687	687	680	685	685	685	685	685	685	685	685	685	685	685	685	685/90	685	690	690
Square	A2	A5	A5	A5	A5	A5	A5	A5	A5	A5	A4	A5	A5	A5	A5	A5	A5	A5	A5	A5	A5	A5	A5	A5-6	A5-9	A6	A6
Locus	1	23.56-51	23.51-46	23.50-40	23.46-33	23.40-30	23.40-20	23.33-13	23.12-22.92	23.08-22.90	1	1	4	6	7	7	8	10	14	15	15	20	23	8	26	7	9
Field No.	17702	.	.	.	.	.	.	.	.	.	1008	.	.	17605	17714	17606	17716	17742	17726	17720	17772	17735	17750	17745	17759	.	.
Year of excavation	1987	1986	1986	1986	1986	1986	1986	1986	1986	1986	1986	1986	1986	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987	1986	1986
Phase	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Feature	B	NE-sec.	NE-sec.	NE-sec.	NE-sec.	NE-sec.	NE-sec.	NE-sec.	NE-sec.	NE-sec.	M	M	B	M	M	M	R	W	M	M	M	M	?	W	W	A	M
Cerealia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	.	3	.	.	.	.	.
Triticum sp.	½	1	.	.	1	.	.	3*	3*	½	1	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	.	.
Triticum monococcum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Triticum dicoccum	.	.	.	.	.	.	2	½	4	.	.	.	.	.	.	.	.	3	2	2	7	.	.	.	.	.	.
Triticum dicoccum (spik. forks)	.	2	1	.	2	.	.	.	1	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.
Triticum mono-/dicoccum (gl. bases)	.	1	1	.	3	.	.	.	2	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Triticum aestivum/durum (rachis intern.)	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hordeum sp.	.	.	.	.	1	.	.	.	½	½	.	.	.	.	.	.	.	2	.	3	.	1	.	.	1	.	.
Hordeum distichum	.	2	1½	.	.	.	.	.	.	.	.	.	15*	.	.	.	.	1	.	.	.	.	.	.	.	.	.
Hordeum sp. (intern.)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pisum sativum	.	.	¼	.	½	.	1	.	2	.	.	.	.	.	.	.	.	.	2	1	1*	.	.	.	.	.	.
Lens culinaris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Vicia ervilia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ficus	.	.	.	.	.	.	.	.	1	.	.	1	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
Amygdalus	.	.	.	.	¼	.	.	½*	1*	1*	¼	.	.	+	.	.	.	½*	+	1*	1½*	¼	.	.	.	.	.
Pistacia atlantica/khinjuk	+	2*	2*	1*	5*	1*	.	4*	5*	1*	½*	2*	4	4*	1½*	½*	.	3½*	5*	5*	5*	3½*	+	.	1½*	.	.
Alkanna orientalis	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Arnebia linearifolia	.	.	.	.	.	.	.	.	.	.	.	.	6	.	.	.	.	.	1	.	.	.	.	.	.	.	.
Lithospermum tenuiflorum	1	.	.	.	.	.	.	.	.	.	.	.	42	.	.	1	.	.	3	1	2	1	.	.	.	.	.
Silene	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
Salsola	.	.	.	.	.	.	.	.	.	.	.	.	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Helianthemum	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gramineae	.	3	.	1	4	.	.	½	2	.	.	.	1½	.	.	.	.	1	.	1½	.	.	.	.	.	.	.
Gramineae (rachis internodes)	.	.	2	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Avena	.	.	.	.	.	.	.	½	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Avena (awn fragments)	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
Eremopyrum bonaepartis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
Malva	.	.	1	.	.	.	.	.	.	.	.	.	2	.	.	.	.	1	.	.	.	.	.	.	.	.	.
Papilionaceae	.	.	2	.	15	.	2	4	12	2	1	.	3	.	.	.	.	1	.	.	.	.	.	.	.	.	.
Astragalus B	2	1	.	1	3	.	1	2	11	1	.	.	.	.	.	.	.	.	3	2	10	1	.	.	.	.	.
cf. *Ononis*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Trifolium/Melilotus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.
Trigonella	.	.	.	.	.	.	.	.	2½	.	.	.	½	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Galium	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ammi majus	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Indet.	2	.	.	.	.	.	.	1	.	.	.	.	22	3	.	.	.	4	11	.	14	1	.	.	1	.	.
Claviceps	.	.	.	1	2	.	.	.	.	.	.	.	11	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Wood (ml)																											
Pistacia atlantica/khinjuk	.	8	.	140	40	25	38	155	165	35	0,5	60	65	.	.	.	2	110	260	4	250	5	2	.	.	110	40
Juniperus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	20	75	210	2	.
Quercus calliprinos -type	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Fraxinus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.
Amygdalus	.	.	.	.	.	.	.	.	.	.	0,2	.	.	.	.	.	.	.	.	2	.	.	2	.	.	.	.
Populus/Salix	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tamarix	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
Not identified	6	.	.	.	.	.	.	.	.	.	11	.	.	110	60	9	1	.	.	135	.	205	190	.	7	.	.
Liter	3	10	10	22	38	12	12	50	50	10	13	14	28	9	6	3	3	12	40	11	30	15	30	10	12	2½	3

Table 1 cont. Basta, Area A. Total number of seeds, fruits and other plant remains from the flotation samples <* = *estimated number of complete seeds and fruitstones from small fragments, n = presence in number of samples*>.

N	500	495	495	495	495	495	490	490	485	485	485	485	485	485	485	485	480	480	480	480			505	505
E	690	680	680	680	680/5	685	680	680/5	680	680	680	680	680	680/5	685	685	680	680	680	680			693	693
Square	A6	A8	A8	A8	A8-9	A9	A12	A12/13	A17	A17	A17	A17	A17	A17/18	A18	A18	A22	A22	A22	A22			A3	A3
Locus	22	1	6	9	3	12	3	9	-	I	5	6	9	-	30	39	12	30	33	-			2	2
Field No.	.	4021	4029	.	17746	17712	8005	17769	.	.	7023	7033	.	17706	17717	17610	17748	17756	17757	17758			17011	17603
Year of excavation	1986	1986	1986	1986	1987	1987	1986	1987	1987	1986	1986	1986	1986	1987	1987	1987	1987	1987	1987	1987			1987	1987
Phase	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4			2	2
Feature	F	W	W	?	?	?	W	C	F	R	W	W	W	?	RS?	W	W	W	W	?	Total	n (47)	M	M
Cerealia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8	2	.	.
Triticum sp.	.	.	.	.	½	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	12½*	10	.	.
Triticum monococcum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Triticum dicoccum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	20½	7	.	.
Triticum dicoccum (spik. forks)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	9	7	.	.
Triticum mono-/dicoccum (gl. bases)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8	5	.	.
Triticum aestivum/durum (rachis intern.)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	.
Hordeum sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	9	7	.	.
Hordeum distichum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	19½*	4	.	.
Hordeum sp. (intern.)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pisum sativum	.	.	.	.	.	.	.	.	½	.	.	.	.	.	1	.	.	.	.	.	9¼	9	.	.
Lens culinaris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Vicia ervilia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1½	2	.	.
Ficus	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	4	.	.
Amygdalus	.	.	.	.	1*	.	.	.	.	.	.	.	.	¼	.	+	.	.	.	.	8*	14	.	.
Pistacia atlantica/khinjuk	+	.	.	¼*	3*	.	½*	½*	1	½*	.	1	¼	¼*	¼*	2*	.	1*	.	+	68*	38	1*	1*
Alkanna orientalis	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	2	2	.	.
Arnebia linearifolia	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8	3	.	.
Lithospermum tenuiflorum	.	2	1	.	1	.	1	.	.	.	.	.	.	2	2	3	.	.	.	.	63	14	1	.
Silene	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	3	3	.	.
Salsola	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	1	.	.
Helianthemum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.
Gramineae	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	14½	8	.	.
Gramineae (rachis internodes)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	2	.	.
Avena	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	½	1	.	.
Avena (awn fragments)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	.	.
Eremopyrum bonaepartis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.
Malva	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	3	.	.
Papilionaceae	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	44	10	.	.
Astragalus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	39	13	.	1
cf. *Ononis*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1½	2	.	.
Trifolium/Melilotus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	.
Trigonella	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	2	.	.
Galium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.
Ammi majus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.
Indet.	.	.	.	.	1	.	.	1	.	.	.	.	1	.	.	1	.	.	.	½	.	.	.	.
Claviceps	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	14	3	.	.
Wood (ml)																								
Pistacia atlantica/khinjuk	.	.	.	.	3	.	.	5	.	.	0,6	11	.	5	1	.	1	2	2	.	1545	29	.	.
Juniperus	.	.	.	.	.	3	.	.	.	.	0,2	.	.	.	.	.	3	2	15	7	337	10	.	.
Quercus calliprinos- type	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Fraxinus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	1	.	.
Amygdalus	.	.	.	.	.	.	.	.	.	.	0,2	.	.	.	.	0,1	.	.	.	.	4,5	5	.	.
Populus/Salix	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0,5	.	.	.	0,5	1	.	.
Tamarix	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.
Not identified	.	.	.	.	65	8	.	.	75	.	0,5	.	.	.	21	45	15	19	40	18	1066	.	15	8
Liter	10	4	2	9	15	3	10	4	10	10	1½	1	3	5	8	6	5	3½	3	4	577		5	5

Table 2. Basta, Area B. Total number of seeds, fruits and other plant remains from the flotation samples <* = *estimated number of complete seeds and fruitstones from small fragments, n = presence in number of samples*>.

N	415	415	415	415	415	415	415	415	415	415	415	415	415	415	410	405	405	405	405	405	405	405	405	405	405	400	400	400	400	400	400	400	400	400	400	400	400	400	400
E	585	585	585	585	585	585	585	585	585	585	585	585	590	590	590	595	595	595	595	600	605	605	605	605	605	595	595	595	595	595	595	600	600	600	600	600	600	600	600
Square	B22	B22	B22	B22	B22	B22	B22	B22	B22	B22	B22	B22	B23	B23	B35	B50	B50	B50	B50	B51	B52	B52	B52	B52	B52	B67	B67	B67	B67	B67	B67	B68	B68	B68	B68	B68	B68	B68	B68
Locus	5	5	8	9	13	13	20	20	20/28	28	29	32	40	50	26	8	8	35	35	31	6	6	30	43	48	39 upp	39 low	46	47	49	56	20	24	28	29	30	32	33	35
Field No.	37428	37418	37442	37419	37454	37425	37450	37430	37437	37440	37446	37447	37449	37451	37432	37404	37404	37455	37457	27412	27402	27406	47423	47422	47409	27409	27410	27420	27414	27416	27421	.	17729	17732	17718	17736	17738	17736	17751
Year of excavation	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989	1988	1988	1988	1992	1992	1992	1992	1992	1992	1992	1992	1992	1987	1987	1987	1987	1987	1987	1987	1987
Phase	3	3	3	3	3	3	3	3	3	3	3	3	3(-2?)	3(-2?)	3	3	3	3	3	3-4	4	4	4	4	4	4	4	4	4	4	4	4?	4?	4?	4?	4?	4	4	4
Feature	M	M	M	B	MBI?	MBI?	W	?	W	W	WF?	W	F	I?	M	WS	W	M	?	R	I?	?	R	R	R	M	M	M	M	M	M	M	W	W	W	W	W	IF38	IF38
Cerealia	.	.	.	2*	1*	.	.	1*	4*	.	.	1*	1*	.	.	.	2*	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
Triticum sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tritcum monococcum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Triticum dicoccum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Triticum dicoccum (spik. forks)	.	.	.	.	.	.	.	1	.	.	1	1	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Triticum mono-/dicoccum (gl. bases)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	18	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Triticum durum/aestivum (rachis intern.)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hordeum sp.	.	.	.	1*	1	.	.	.	.	.	.	.	.	1	.	1*	1*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hordeum distichum	.	.	.	.	.	.	.	.	.	.	.	.	.	..	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hordeum sp. (rachis intern.)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	33	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pisum sativum	.	.	.	2	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lens culinaris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	1	.	.	.	.	1	.	.	.
Vicia ervilia	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ficus	.	.	.	.	1	.	2	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Amygdalus	.	¼*	¼*	½*	1*	½*	.	¼*	¼*	¼*	.	½*	.	.	.	.	.	¼*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	¼	.	.	.	.
Pistacia atlantica/khinjuk	¼*	1*	1*	8*	9*	½*	4*	5*	5*	2*	3*	7*	½*	1*	½*	.	.	1*	4*	.	.	½*	1	.	1	2*	1½*	.	½*	2*	2*	¼*	1*	1	+	.	½*	.	.
Alkanna orientalis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Arnebia linearifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lithospermum tenuiflorum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Silene	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Salsola	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Helianthemum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gramineae	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gramineae (rachis internodes)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Avena	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Avena (awn fragments)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eremopyrum bonaepartis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Malva	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Papilionaceae	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1*	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Astragalus B	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
cf. *Ononis*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Trifolium/Melilotus	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Trigonella	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Galium	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Indet.	.	2	.	.	.	.	.	.	.	1	.	2	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	1	.	.	.	.	.	.	.	.
Claviceps	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Wood (ml)																																							
Pistacia atlantica/khinjuk																				0,3	.	.	- 0,4	0,8	5	.	.	22	0,2	0,5	5	.	.	.	.	23	2	.	.
Juniperus																				0,2	24	59	.	1	.	.	.	.	0,1	0,1	.	0,3	.	0,5	.	.	0,5	350	600
Quercus calliprinos-type																				.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Fraxinus																				.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Amygdalus																				.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Populus/Salix																				.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tamarix																				.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Not identified																				3	.	.	1	5	4	15	6	.	2	2	.	11	24	11	10	12	15	.	.
Liter	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	4	10	6	6	6	5	5	6

Table 2 cont. Basta, Area B. Total number of seeds, fruits and other plant remains from the flotation samples <* = *estimated number of complete seeds and fruitstones from small fragments, n = presence in number of samples*>.

N	400	400	400	400	395/400	400	400	400	400	400	400	400	400	400	395	395	395	395	395	395	395	395	395	390			400	400	400	390	390	390
E	600	600	600	600	600/605	605	605	605	605	605	605	605	605	610	590	595	600	600	600	600	600	600	605	600			585	600	600	595/600	595/600	595/600
Square	B68	B68	B68	B68	B68/9,86/7	B69	B69	B69	B69	B69	B69	B69	B69	B70	B84	B85	B86	B86	B86	B86	B86	B86	B87	B104			B65	B68	B68	B102/3	B102/3	B102/3
Locus	37	37	37	40	23	18	21	21	23	26	28	29	30	11	28	15	4	4	6	7	9	11	11	9			15	14	14	48	53	57
Field No.	17744	17743	17752	17754	27403	17763	17772	17773	17775	17776	17780	17781	17783	37402	47404	27424	17749	17785	17739	17737	.	17793	17784	17727			47421	.	17719	47420	47418	47419
Year of excavation	1987	1987	1987	1987	1992	1987	1987	1987	1987	1987	1987	1987	1987	1989	1992	1992	1987	1987	1987	1987	1987	1987	1987	1987			1992	1987	1987	1992	1992	1992
Phase	4	4	4	4	?	4	4	4	4	4	4	4	4	4?	4?	4?	4?	4?	4?	4?	4?	4?	4?	4?			2	1-2?	1-2?	1-2	1	1-2?
Feature	I	?	?	IF38	M	IR	F	F	W	M	F	F	M	R	FT/P?	T?	M	M	M	M	W	M	M	M	Total	n (63)	M	I	MI?	M	MW	MW
Cerealia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	14*	9	.	.	1	.	.	.
Triticum sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1	.	.	3	3	.	.	.	.	.	.
Tritcum monococcum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.
Triticum dicoccum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Triticum dicoccum (spik. forks)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	4	.	.	.	.	.	.
Triticum mono-/dicoccum (gl. bases)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	19	2	.	.	.	.	.	.
Triticum durum/aestivum (rachis intern.)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11	1	.	.	.	.	.	.
Hordeum sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5*	5	.	.	.	.	.	.
Hordeum distichum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hordeum sp. (rachis intern.)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	33	1	.	.	.	.	.	.
Pisum sativum	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	3	.	.	.	.	.	.
Lens culinaris	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1*	.	.	.	.	.	.	.	.	.	7	5	.	.	.	.	.	.
Vicia ervilia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	.	.	.	.	.	.
Ficus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	6	.	.	1	.	.	.
Amygdalus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4¼*	11	.	.	.	.	.	.
Pistacia atlantica/khinjuk	.	.	.	¼*	.	+	1*	2*	3*	½*	1*	+	+	½*	3	.	½*	2*	.	¼	.	1*	.	.	80*	45	.	1*	1½*	.	.	.
Alkanna orientalis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Arnebia linearifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	1	.	.	.	.	.	.
Lithospermum tenuiflorum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	3	1	.	.	2	.	.	.
Silene	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Salsola	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Helianthemum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gramineae	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gramineae (rachis internodes)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Avena	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Avena (awn fragments)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eremopyrum bonaepartis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Malva	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.
Papilionaceae	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	3	.	.	.	.	.	.
Astragalus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.
cf. *Ononis*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Trifolium/Melilotus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	2	2	.	.	.	.	.	.
Trigonella	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.
Galium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.
Indet.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Claviceps	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Wood (ml)																																
Pistacia atlantica/khinjuk	.	.	280	.	.	.	3	.	2	.	.	.	.	.	0,1	.	.	.	.	.	.	.	.	.	344		4	36	0,1	.	0,2	.
Juniperus	280	160	.	125	75	.	.	9	.	11	8	2	.	.	0,1	3	.	2	26	10	0,5	.	2	.	1751		5	4	2	0,6	0,1	4
Quercus calliprinos-type	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	3		.	.	.	.	.	.
Fraxinus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		.	.	.	.	.	.
Amygdalus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0,2	.	.	.	.	.	.	.	.	.	0,2		.	.	.	.	.	.
Populus/Salix	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1		.	.	.	.	.	.
Tamarix	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		.	.	0,1	.	.	.
Not identified	.	.	.	.	.	1	.	.	.	.	.	.	0,5	.	0,8		5	.	29	2	4	25	.	.	188		17	.	20	1	0,2	8
Liter	7	4	5	5	?	5	6	8	5	5	8	5	7	?	?	?	6	5	5	5	5	8	5	1			?	11	7	?	?	?

Table 3. Basta, Areas A and B. Handpicked charcoal <*in ml, x = baulk*>.

N	415	415	415	415	415	410	410	405	405	405	405	405	405	405	405	405	405	405	400
E	585	590	590	590	590	595	595	585	595	600	605	605	605	605	605	605	605	605	585
Square	B22	B23	B23	B23	B23	B36	B36	B48	B50	B51	B52	B52	B52	B52	B52	B52	B52	B52	B65
Locus	24	8	9	27	30	36	36	53	29	28	32	34	36	41	44	45	47	48	15
Field No.	37212	37209	37218	37211	37213	37203	37201	47245	37206	27208	47205	47200	47203	47209	47210	47202	47204	47228	47201
Year of excavation	1989	1989	1989	1989	1989	1989	1989	1992	1989	1988	1992	1992	1992	1992	1992	1992	1992	1992	1992
Phase	3	3(-2?)	3(-2?)	3(-2?)	3(-2?)	3-4	3-4	4	3	3-4	4	4	4	4	4	4	4	4	4
Context	?	W	F	FW	F?	W	W	M	S	F	?	R	R	R	R	R	R	R	M
Pistacia atlantica	6		2,5	.	.	3,5	.	.	0,5	.	0,2	8	3	1	2	2	0,2	3,5	3
Juniperus	.	1		0,1	1,5		0,5	4		13	0,5	.	.	.	.	.	.	.	.
Quercus calliprinos -type	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Fraxinus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Amygdalus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Populus/Salix	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tamarix	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pyrus/Crataegus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Not identified	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

N	400	400	400	395	395	395	395	395	395	395	395	390	390	390	390	390	390	390	390
E	595	595	600	590	590	590	590	590	590	590	605	595/600	595/600	595/600	595/600	595/600	595/600	595/600	595/600
Square	B67	B67	B68	B84	B84	B84	B84	B84	B84	B84	B87	B102/3	B102/3	B102/3	B102/3	B102/3	B102/3	B102/3	B102/3
Locus	25	51	30	25	25	26	26	26	27	28	11	30	34	35	39	40	65	73	82
Field No.	27207	27209	17741	47222	47224	47231	47235	47230	47237	47243	17727	47219	47214	47216	47225	47221	47239	47241	47246
Year of excavation	1987	1987	1987	1992	1992	1992	1992	1992	1992	1992	1987	1992	1992	1992	1992	1992	1992	1992	1992
Phase	3-4?	4	4?	4	4	4	4	4	4	4	4?	4?	4?	4?	4	4	4	4	4
Context	M	F?	W	W	W	W	W	W	P?	FT/P?	?	R2	R1	R1	R1	M	W	R4	R4
Pistacia atlantica	.	.	.	21	0,5	3	.	2	.	.	.	.	0,1	.	.	0,2	!	.	2
Juniperus	2	2	x		70	13	155	1	140	42	x	3	.	2	0,2		0,7	0,8	.
Quercus calliprinos -type	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Fraxinus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Amygdalus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Populus/Salix	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tamarix	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pyrus/Crataegus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0,1	.	.
Not identified	.	.	.	.	.	110	.	11	.	.	.	.	.	.	.	.	.	.	.

N	405	400	400	400	400	395	395	395	395	395	395	390	390	390	390	390	390	390	390	390	390
E	605	585	585	585	600	585	585	585	585	585	585	595/600	595/600	595/600	595/600	595/600	595/600	595/600	595/600	595/600	595/600
Square	B52	B65	B65	B65	B68	B83	B83	B83	B83	B83	B83	B102/3	B102/3	B102/3	B102/3	B102/3	B102/3	B102/3	B102/3	B102/3	B102/3
Locus	6	26	26	26	14	7	7	8	8	14	15	27	29	42	49	49	55	57	58	69	79
Field No.	27205	47212	47218	47220	17223	47232	47242	47233	47244	47251	47250	47207	47208	47223	47230	47226	47234	47238	47236	47240	47249
Year of excavation	1988	1992	1992	1992	1987	1992	1992	1992	1992	1992	1992	1992	1992	1992	1992	1992	1992	1992	1992	1992	1992
Phase	1-2	2	2	2	1-2?	1-2	1-2	1-2	1-2	1-2	1-2	1-2	2?	1-2	1-2?	1-2?	1-2	1-2?	1-2?	1-2	1-2?
Context	F	?	S	S	I	W	W	M	M	M	M	W	R2	W	M	M	M	W	W	W	M
Pistacia atlantica	.	.	2	1,5	2	.	.	0,2	4	4	.	.	.	.	2	.	4	.	3	.	2,5
Juniperus	5	1	.	.	18	3	9	0,4	0,3		4	0,5	0,1	0,5	1	1	.	4	.	32	.
Quercus calliprinos -type	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Fraxinus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Amygdalus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Populus/Salix	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tamarix	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pyrus/Crataegus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Not identified	.	.	.	.	.	.	.	1,5	17	.	.	.	.	.	9	.	.	.	.	.	.

N	500	500	500	500	500	500	500	500	500	495	495	495	495	495	495	495	495	490	490	485	485	480-85	480-85	480
E	685	685	685	685	685	685	685	685	685	685	685	685	685	685	685	685	690	685	690	685	685	680	680	680
Square	A5	A5	A5	A5	A5	A5	A5	A5	A5	A9	A9	A9	A9	A9	A9	A9	A10	A13	A14	A18	A18	A22/17	A22/17	A22
Locus	3	4	4	5	5	6	7	7	7	4	5	6	9	12	12	13	2	8	9	4	56	35	38	33
Field No.	17202	17207	17203	17211	17213	17219	17222	17221	.	17216	17210	17208	17212	17214	17217	17215	.	17210	17225	17206	27206	.	17228	17229
Year of excavation	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987
Phase	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Context	PB	PB	PB	P?	P?	M	M	M	M	M	M	M	M	F?	?	M	F	M	M	F14	C	M	M	W
Pistacia atlantica/khinjuk	18	3	6	25	4	7	.	.	x	.	.	.	.	.	.	.	14	.		.	32	x	.	3
Juniperus	.	.	.	.	.	.	7	.	.	13	20	45	4	1,5	8	14	8	.	29	3	.	.	x	
Quercus calliprinos -type	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.	.	.	.
Fraxinus	.	.	.	.	.	.	.	.	.	5	.	.	.	.	.	.	.	3	.	.	.	.	.	.
Amygdalus	.	.	.	.	4	.	.	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Populus/Salix	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0,5	.	.	.	.	.	.	.
Tamarix	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Not identified	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	.	.	.	.	.	.	.

Table 4. Basta, Areas A and B. Subtotals and the total number of macroremains of cultivated and collected plants and their sample frequencies expressed as a percentage <*n %*>.

Area	A		B		A+B		A+B	
Phase	3-4		3-4		3-4		1-2	
No. of samples	47		63		110		8	
	Total	n (%)	Total	n (%)	Total	n (%)	Total	n
Cerealia	8	4,3	14*	14,3	22*	10,0	1	1
Triticum sp.	12½*	21,3	3	4,8	15½*	11,8	.	.
Tritcum monococcum	.	.	1	1,6	1	0,9	.	.
Triticum dicoccum	20½	14,9	.	.	20½	6,4	.	.
Triticum dicoccum (spik. forks)	9	14,9	5	6,3	14	10,0	.	.
Triticum mono-/dicoccum (gl. bases)	8	10,6	19	3,2	27	6,4	.	.
Triticum durum/aestivum (rachis intern.)	2	2,1	11	1,6	13	1,8	.	.
Hordeum sp.	9	14,9	5*	7,9	14*	10,9	.	.
Hordeum distichum	19½*	8,5	.	.	19½*	3,6	.	.
Hordeum sp. (rachis intern.)	.	.	33	1,6	33	0,9	.	.
Pisum sativum	9¼	19,1	4	4,8	13¼	10,9	.	.
Lens culinaris	.	.	7	7,9	7	4,5	.	.
Vicia ervilia	1½	4,3	2	3,2	3½	3,6	.	.
Ficus	4	7,7	10	9,5	14	7,8	1	1
Amygdalus	8*	29,8	4¼*	17,5	12¼*	22,7	.	.
Pistacia atlantica/khinjuk	68*	80,9	80*	71,4	148*	75,5	4½*	4

Table 5. Basta, Areas A and B. Subtotals and the total amount of charcoal from the flotation samples <*in ml and as a percentage ml %, n = number of samples*> and the sample frequencies expressed as a percentage <*n %*>.

Area	A			B			A+B			B	
Phase	3-4			3-4			3-4			1-2	
No. of samples	47			44			91			6	
Flotation/Handpicked	F			F			F			F	
Total	ml	ml (%)	n (%)	ml	ml (%)	n (%)	ml	ml (%)	n (%)	ml	ml (%)
Pistacia atlantica/khinjuk	1545	81,7	61,7	344	16,4	31,8	1889	47,6	47,3	41,3	72,3
Juniperus	337	17,8	21.3	1751	83,4	59,1	2088	52,3	39,6	15,7	27,5
Amygdalus	4,5	0,5	10,6	0,2	+	2,3	4,7	0,1	6,6	.	.
Pyrus/Crataegus	.	.	.	.	.	.	.	.	.	.	.
Quercus calliprinos-type	.	.	.	3	0,1	4.5	3	0,1	2,2	.	.
Fraxinus	3	0,2	2,1	.	.	.	3	0,1	1,1	.	.
Populus/Salix	0,5	+	2,1	1	+	2,3	1,5	+	1,1	.	.
Tamarix	1	0,1	2,1	.	.	.	1	+	1,1	0,1	0,2
Total (ml)	1891		(n = 47)	2099		(n = 44)	3990		(n = 91)	57,1	

Table 6. Basta, Areas A and B. Subtotals and the total amount of charcoal from the handpicked samples <*in ml, x = balk, n = number of samples*> and the sample frequencies expressed as a percentage <*n %*>.

Area	A		B		A+B		B	
Phase	3-4		3-4		3-4		1-2	
No. of samples	24		36		60		21	
Flotation/Handpicked	H		H		H		H	
	ml	n (%)	ml	n (%)	ml	n (%)	ml	n (%)
Pistacia atlantica/khinjuk	112+x	45,8	62,2	52,6	174,2	50,0	25,2	47,6
Juniperus	152,5+x	50,0	451,5+x	57,9	604	54,8	79,8	71,4
Amygdalus	11	8,3	.	.	11	3,2	.	.
Pyrus/Crataegus	.	.	0,1	2,6	0,1	1,6	.	.
Quercus calliprinos-type	4	4,2	.	.	4	1,6	.	.
Fraxinus	8	8,3	.	.	8	3,2	.	.
Populus/Salix	0,5	4,2	.	.	0,5	1,6	.	.
Tamarix	.	.	.	.	.	.	.	.
Total (ml)	288+x	(n = 24)	513,8+x	(n = 38)	801,8	(n = 62)	105	(n = 21)

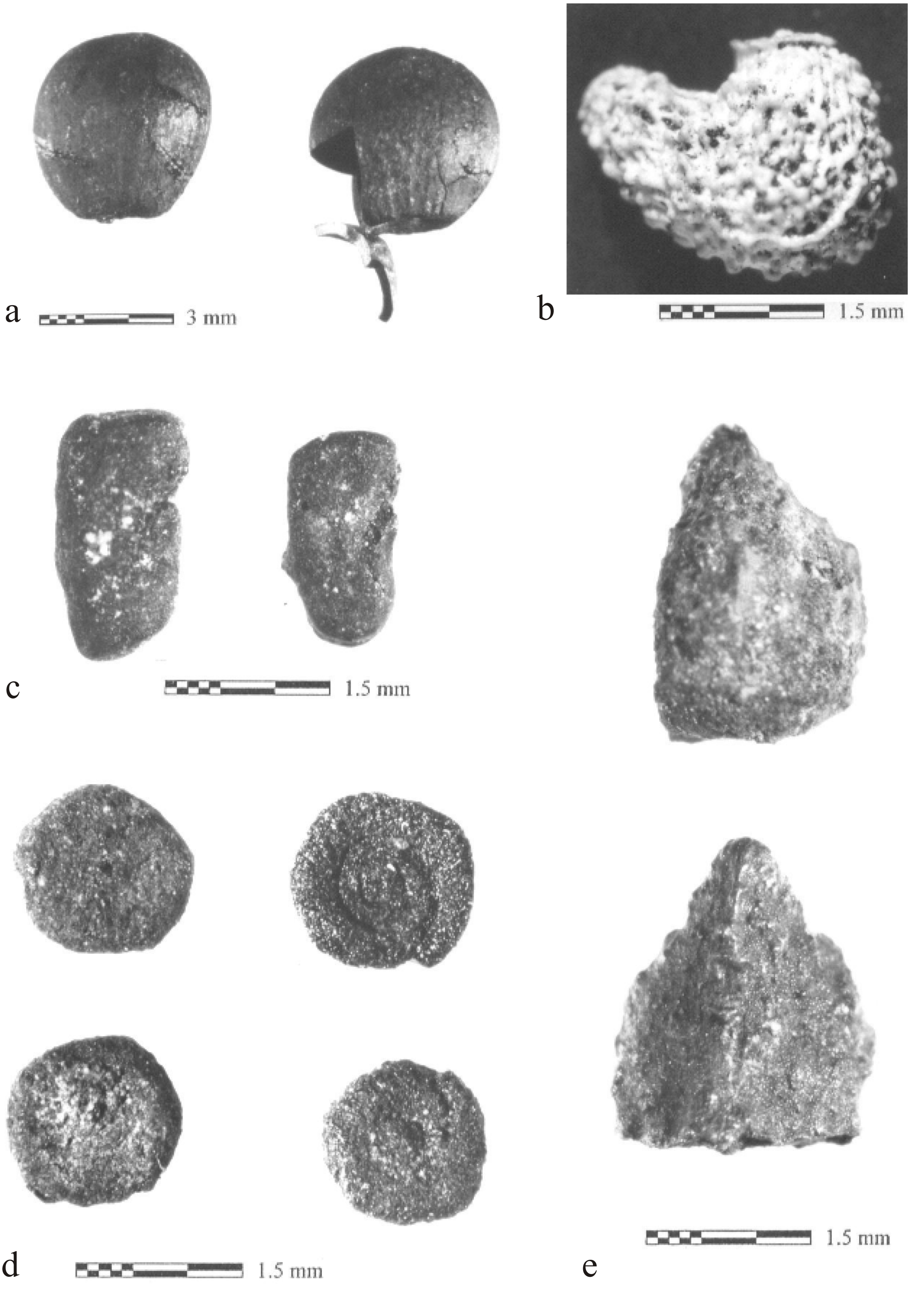


Plate 1. Botanical macroremains from Basta: nuts of *Pistacia atlantica* (a), nutlet of *Alkanna orientalis* (b), seed of *Trigonella* sp. (c), fruit of *Salsola* sp. (d), and nutlet of *Arnebia linearifolia* (e)

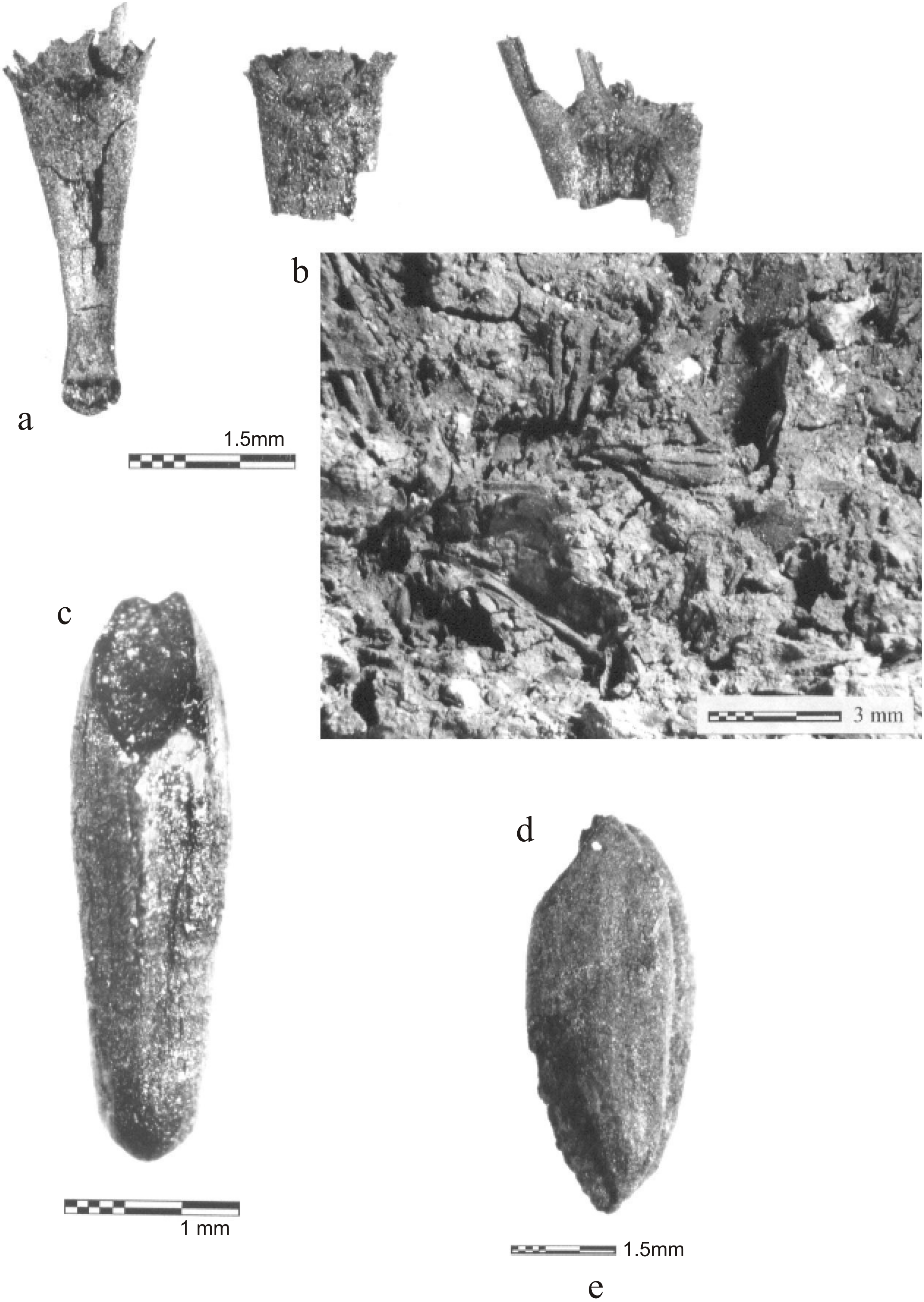


Plate 2. Botanical macroremains from Basta: rachis and rachis fragments of *Hordeum* cf. *spontaneum* (a), rhachis and rhasis fragments of *Hordeum* cf. *Spontaneum* found in “tabun” sherds (B50, Locus 8) (b), grain of *Eremopyrum bonaepartis* (c), and a grain of *Triticum monoccum* (d)

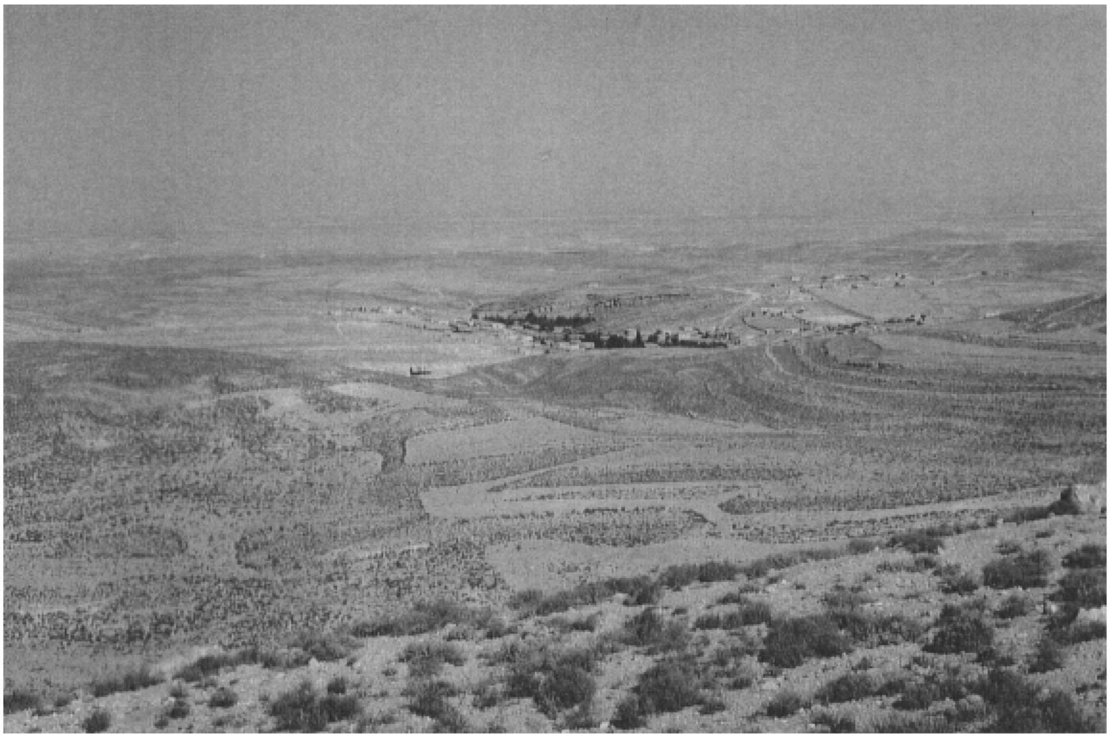


Plate 3.A. View on Basta from NW (summer aspect). In the foreground wormwood, *Artemisia herba-alba*, <photo H.G.K. Gebel 1989>

Plate 3.B. Some of the rare shrubs/ trees in the vicinity of Basta: hawthrone (*Crataegus aronia*), c. 3km W of Basta <photo by R. Neef 1986>

Descriptions

A brief morphological description will be given of most of the different seed/fruit types, wood and other botanical remains. The nomenclature accords generally to the Flora Palaestina (Zohary 1966-1985). The identification of wood types was accomplished using the atlases on wood anatomy of Fahn *et al.* (1986) and Schweingruber (1990).

Anacardiaceae

Pistacia atlantica Desf. (Plate 1.a). In most of the samples from Basta numerous tiny fragments of pistachio nutshells were found. In Table 1 and 2 an estimate of the total amount of complete seeds is marked with an asterisk. The shape of the relatively rare whole pistachio nuts is ovoid to ovoid-globular, somewhat laterally compressed. As for the shape and size of the stone fruit, no satisfactory separation between the species which appear relevant, viz. *P. atlantica, P. khinjuk* and *P. palaestina*, could be made. Particularly with regard to their general form, according to the material in our reference collection, the nuts of these pistachio species were very heterogeneous. Kislev (1988) used the hilum as an analytical characteristic in the identification of pistachio nuts. In *P. palaestina* the hilum is very shallow, flat to slightly convex, whereas in *P. khinjuk* and more notably in *P. atlantica* the hilum is a more or less deep crater. In *P. khinjuk* the smooth face of the crater is disturbed by a more or less conspicuous radial ridge. It stretches from the proximity of the hole through which the vascular bundles enter the endocarp, almost to the hilum rim, and is an extension of the keel encircling the nut. Almost all of the pistachio nuts found at Basta have a more or less crater-like hilum and do not show a radial ridge. Morphologically, the pistachio nuts from Basta appear to be *P. atlantica*.

Table 7. Dimensions (in mm) of pistachio nuts.

Square	Locus	Year	Phase	L	B	T
A5	NE- Section	1986	4	4.7	4.25	3.25
	23.12-22.92			3.9	4.0	3.25
				3.5	3.6	3.1
A5	14	1987	4	4.8	3.75	3.2
A5	10	1987	4	4.75	4.3	3.1
A17	-	1987	4	4.1	4.1	3.0
B68	28	1987	4?	3.7	3.5	2.9
B22	29	1989	3	3.8	3.7	2.8
				4.4	4.6	3.5
B22	9	1989	3	4.0	4.0	3.0
				4.7	3.8	3.1
B22	20	1989	3	4.7	4.0	3.2
B52	48	1992	4	4.0	4.0	3.1
B52	30	1992	4	4.5	4.0	3.1
B84	28	1992	4?	4.7	4.0	2.9
				5.0	4.8	3.5

Pistacia wood is ring- to semi-ring-porous with distinct growth rings. The vessels of the earlywood generally form only one row. In these vessels tyloses are very frequent. Vessels in the latewood are mainly in radial multiples or clusters, sometimes arranged in a dendritic pattern. The perforations are simple. Except for the large vessels in the earlywood all vessels have distinct spiral thickenings. The criteria used to differentiate the wood-types of the varying pistachio species are the full range ray width and the predominant ray width. The heterocellular rays are 1 to 6 seriate. Amongst those pieces of charcoal which were not too small to reliably count the number of rays for their raywidth, 4 seriate rays predominate. Multiseriate rays are up to 30 cells high. Some of the multiseriate rays have resin ducts. These characters tend to *P. atlantica*, for which wood Fahn *et al.* (1986) give a full range ray width of 1-5(6) cells and a predominant width of 4-5 cells. The wood of *P. palaestina* and *P. khinjuk* have a full range ray width of 1 to 4 cells with a predominant width of 3 cells. Because many of the identified charcoals were very small, the possible existence of other pistachio species cannot be excluded, principally *P. khinjuk*.

Boraginaceae

Nutlets of the boraginous species are usually not found in a charred state, but rather preserved in a whitish-grey color. Helbaek (1970) has already noted that when the nutlets are burnt, they turn whitish-grey, rather than black, because of their high mineral content. This applies to most of the fruits of the boraginous species with a strong silica skeleton. In only a few cases did seeds with a slightly blackish surface appear. Particularly in dry regions this silica skeleton enables boraginous nutlets to be well preserved without carbonization. The problem is deciding whether or not we are dealing with recent material, particularly since most of the boraginous nutlets are dispersed by ants. They collect the nutlets for the oil-body (elaiosome) which forms part of the receptacle which stays attached to the nutlet (Ridley 1930). In many cases the ants take the seeds right into their nests, which can very well be located in archaeological features. By crushing the nutlets after identification it is at least possible to remove the most recent ones.

Alkanna orientalis (L.) Boiss. (Plate 1.b). The nutlet is more or less ovate with a strongly curved beak. It has a round somewhat protruding hilum. The surface of the nutlet is strongly wrinkled. Dimensions of 2 nutlets: 2.9 x 2.0 x 2.1 (A5, profile 23.50-40) and 2.9 x 2.1 x 2.2 mm (A17, Locus 9). The plant is a perennial herb which grows in rocky dry places, in southern Jordan, where it is part of the *Artemisia herba-alba* steppe vegetation.

Arnebia linearifolia D.C. (Plate 1.e). Broad nutlets, almost trigonal in outline, with two flat sides and one domed side, two rounded edges and one sharp edge. About 2/3 up from the broad base the fruit is rather abruptly beaked. The surface is unequally verrucose. Measurements of 5 nutlets: 3.0 (2.8-3.2) x 2.0 (2.0-2.1) x 1.9 (1.8-2.2) mm (A5, Locus 4). *A. linearifolia* is a small annual, common in desert areas in the lower Jordan Valley, Moav and Edom.

Buglossoides tenuiflora (L. fil.) I.M. Johnston (syn. *Lithospermum tenuiflorum* L. fil.). Eggshaped nutlets strongly gibbous at the sides with a long pointed beak. The surface is densely and unequally verrucose. Dimensions of five nutlets (A5, Locus 4): 2.6-2.7(2.6) x 1.8-2.0(1.8) mm; the base diameter varies from 0.8-1.0 mm. This annual is very common mainly in batha and on fallow fields.

Caryophyllaceae

Silene L. Kidney-shaped seeds with concentric rows of radially elongated and flat verrucae. The verrucae on the dorsal side are more pronounced than those at the lateral sides. Unfortunately the preservation is not optimal. The seeds were so swollen by carbonisation that no distinction between flat, rounded or arched dorsal sides could be made. Dimensions of two seeds: 1.2 x 1.1 (A5, Locus 20) and 1.0 x 0.8 mm (A 18, Locus 39). In Jordan more than 30 catchfly species are reported. Their habitats vary.

Chenopodiaceae

Salsola L. (Plate 1.d). The fruit is circular in shape with the two sides being almost flattened. In all of the material the characteristic spirally coiled embryo is visible. Dimensions of four fruits (A5, Locus 4): 1.5-1.7(1.6)mm. Herbaceous or shrubby plants especially found in steppes and deserts, sometimes under saline conditions.

Cistaceae

Helianthemum Mill. Seed ovoid, pointed at the apex with a smooth surface, swollen by carbonization. Only one found, dimensions (A5, Locus 4): 1.0 x 0.8 mm. Several habitats.

Cupressaceae

Juniperus L. Coniferous wood with distinct growth rings and no resin canals. There is a continuous transition from early- to latewood. The mostly uniseriate, sporadically biseriate rays are 1-10 cells high, which almost excludes the cypress (*Cupressus sempervirens* L.). The cypress has a wood anatomy similar to juniper, but with a ray height of up to 20 cells. No satisfactory differentiation can be made between the wood of the different juniper species. The only juniper species existing in Southern Jordan at present is *J. phoenicea* L.

Gramineae

Avena L. Only one grain and two lower twisted parts of the awns of wild oats were found. The grain is oblong in shape, almost cylindrical, with a grooved ventral side. The scutellum on the dorsal side has a characteristic triangular shape. Dimensions (Profile 545N/685E, 23.33-13): 4.3 x 1.1 x 1.0 mm. Wild oat species are found in batha, steppes and fields.

Eremopyrum bonaepartis (Spreng.) Nevski (Plate 2.c). Almost oblong grain, slightly broader in the lower half. On the ventral side a deep groove; the linear hilum almost as long as the grain. On the dorsal side the grain is longitudinally keeled. Dimensions (A5, Locus 15): 3.0 x 0.9 x 0.8 mm. Annual grass of the dry-steppe zone occasionally found in fields.

Hordeum distichum L./*spontaneum* C. Koch. All of the barley grains are of the slender symmetrical type. The clearly outlined rims indicate hulled barley. Because most of the barley grains were broken, only two grains could be measured: 5.2 x 3.3 x 2.7 (A5, Locus 10) and 5.7 x 2.5 x 2.6 (A5, Section 23.56-51). All of the rachis internodes of barley (Plate 2.a) came from sample Square B50, Locus 8. They were originally used to temper a "tabun". (Plate 2.b). Some internodes still show the remains of the stalk of the sterile lateral florets, indicative of a two-rowed barley. The rachis internodes are all of the brittle-rachis type, showing an intact articulation scar. This points to wild barley. However the thickness of the well preserved grains and grain fragments are indicative of domesticated, two-rowed barley. The thickness of 10 partly broken grains ranges between 2.5 and 2.8 mm, much larger than the material from Mureybit, which varied from 1.0 to 1.9 (van Zeist and Caspari 1968) and larger than other modern reference material of *H. spontaneum* from Syria, varying from 1.2-1.8 mm, (n= 10, van Zeist and Caspari 1968) and Jordan 1.2-1.7 (n= 10). Because of the proportionally very well preserved barley grains, it is not likely that this difference would be the result of deformations by carbonisation. According to Helbaek (1966) all the rachis imprints found at neighbouring Beidha belonged to the brittle-rachis type, whereas the size of the grains point to domesticated barley. Helbaek described these remains as from a "transitional crop" between the wild and the domesticated form. For Basta this seems unlikely, since the botanical remains from Basta are at least 500 years younger than those found at Beidha. It is more likely that the rachis internodes from the "tabun" represent the cleanings from a cereal crop infected by the noxious field weed *H. spontaneum*. The wild barley *H. spontaneum* is still present in the steppe and field weed vegetation around Basta. But of the sparse material from Basta it is difficult to say whether we are dealing with *H. distichum* or its wild progenitor *H. spontaneum*, or both.[1]

Triticum aestivum L./*durum* Desf. No grains of a free-threshing wheat have been recovered. Only five complete rachis internodes and some rachis fragments were found. The length and breadth of five internodes: 1.4-1.5(1.4) x 1.0-1.6(1.2) mm (B50, Locus8).

Triticum dicoccum Schübl. Only a low number of remains of emmer wheat have been found, but there can be little doubt that they are domestic forms. Wild emmer-type grains are markedly slender, which finds its expression in the L/B index values. For the grains of wild emmer (*T. dicoccoides* (Koern. ex Aschers. et Graebn.) Aaronsohn) Bor (1968) gives the following dimensions: 9-11 (L) x 1.7-2.5 mm (B), which brings a L/B index value of *c.* 480. Van Zeist and de Roller (1994) calculated L/B index values of 246 to 400 (mean 295) for wild emmer-type grains obtained from the aceramic levels at Çayönü. Emmer wheat from Basta has an L/B index value of 200 to 267 (mean 233, Table 8).

Table 8. Dimensions (in mm) and index values of emmer grains.

Square	Locus	Year	Phase	L	B	T	100 L/B	100 T/B
A5	NE- Section 23.12-22.92	1986	4	6.3	2.5	1.9	250	76
A5	NE- Section 23.12-22.92	1986	4	5.4	2.3	1.9	235	83
A5	NE- Section 23.40-23.20	1986	4	5.6	2.4	2.3	233	96
A5	NE- Section 23.40-23.20	1986	4	5.6	2.1	2.2	267	105
A5	15	1987	4	6.0	2.9	2.5	207	86
A5	14	1987	4	6.0	3.0	2.75	200	92
A5	10	1987	4	6.25	2.6	2.1	240	81

Triticum monococcum L. (Plate 2.d). Only one grain of the one seeded type of einkorn was found. The grain had a rather plump appearance, the breadth being much larger than that of wild einkorn. Dimensions of one grain: 6.0 x 2.5 x 1.8 mm (B 50, Locus 8).

Malvaceae

Malva L. Mallow has reniform, wedge-shaped seeds with flattened sides. No remains of the fruit wall were preserved which makes species identification rather impossible. Dimensions of two seeds (A5, Locus 4): 1.4 x 1.2, 1.5 x 1.2 mm. Mallow species grow mainly in gardens, fields and on waste ground.

[1] For a discussion on the problem of rachis remains from wild and domesticated cereals see Hillman and Davies (1992).

Moraceae

Ficus L. Small, somewhat laterally compressed nutlets, ovate to circular in outline, with a small round to elliptic hilum just below the pointed apex. Unfortunately it is not possible to distinguish between pips from wild and cultivated figs. Dimensions of two nutlets: 1.2 x 1.0 (Profile A5, 23.12-22.92) and 1.1 x 1.0 mm (A8-9, Locus 3).

Papilionaceae

Astragalus L. The seeds are irregularly quadrangular, slightly laterally compressed, with a rough surface. They have a characteristic indentation with the hilum on the ventral side. Dimensions of five seeds (Profile A5, 23.12-22.92): 1.4 (1.3 - 1.6) x 1.2 (1.1 - 1.3) x 0.7 (0.5 - 0.8)mm. The genus Astragalus comprises many species in the Near East, representing shrubs and perennial and annual herbs, which flourish in several habitats.

Lens culinaris Medik. Dimensions of three seeds: 3.3 x 3.1 x 2.3 mm (B 69, Locus 21), 3.2 x 3.2 x 1.9 mm (B 68, Locus 30) and 3.1 x 3.1 x 1.9 (B67, Locus 39). These dimensions are larger than its most likely progenitor *L. orientalis* (Boiss.) Schmalh., having seeds of up to approximately 3 mm. The dimensions of the seeds from Basta fall within the largest size class of the carbonized, most probably cultivated, lentils from a large hoard at PPNB Yiftah'el near Nazareth (n=100): 2.0-3.2 (2.53) x 1.3-1.9 (1.52) mm (Garfinkel *et al.* 1988). But owing to the low number of lentils measured, one cannot fully exclude the wild lentil. This wild lentil is also sporadically found in Edom.

Melilotus Mill./*Trifolium* L. Seeds ovate in outline, laterally slightly flattened, with a weak incurvation. Radicula length extends around 3/4 of the length of the cotyledons. The seeds of large-seeded clover species are difficult to separate from those of small-seeded melilot species, in particular without a preserved seed coat as in Basta.

Cf. *Ononis*. Subglobular seeds, with a smooth seed wall and small round hilum. Dimensions of one seed (A5, Locus 4): 1.5 x 1.3 mm.

Pisum sativum L. None of the seed coats had been preserved. This makes the distinction between wild peas, with a rough or granular seed coat, and the cultivated pea with a smooth seed coat difficult. The more so because of their coinciding dimensions. The dimensions of five measurable peas are given in Table 9.

Table 9. Dimensions (in mm) of peas.

Square	Locus	Year	Phase	L	B	T
A5	14	1987	4	3.65	3.0	-
A5	15	1987	4	4.7	4.2	-
				3.75	3.3	2.7
A17	-	1987	4	4.3	3.8	-
A18	30	1987	4	4.25	3.7	3.7
B22	13	1989	3	4.0	3.7	-
B69	18	1987	4	3.8	3.7	3.4

Trigonella L. (Plate 1.c). In general, seeds of fenugreek have a clearly marked off radicle. The seeds found at Basta are oblong in outline, truncated, with flattened lateral sides. The radicle extends to 70 % of the seed length. The seed surface is minutely punctated. Dimensions of two seeds (Profile A5, 23.12-22.92): 1.9 x 1.0 and 2.2 x 1.1 mm. No positive species identification could be made.

Vicia ervilia (L.) Willd.. Dimensions of one seed: 2.6 x 2.4 x 2.3 mm (B22, Locus 28). The wild ancestor of *V. ervilia* is distributed in a limited area, which reaches as far South as Mount Hermon nowadays. But on account of the size alone, it is impossible to be certain that we are dealing with cultivated bitter vetch (*cf.* Zohary and Hopf 1993).

Rosaceae

Amygdalus L. Only small fragments of almond fruit-stones were found. The fragments have a pitted and grooved surface, with a thickness of around 1.5 mm. The wood of almond is ring-porous with distinct growth rings. The perforations are simple. All vessels have fine spiral thickenings. The slightly heterocellular rays are uni- and multiseriate (3-8). Most vessels are solitary and densely spaced in the latewood, which tends to *A. korschinskii* (Hand.-Mazzetti) Bornm. But other almond species cannot be excluded. *A. korschinskii* is a deciduous tree or shrub from maquis and steppe forest.

Rubiaceae

Galium L. The fruit of bedstraw separates into 2 mericarps. The mericarps found at Basta are almost globose with a round concavity on the somewhat flattened side, where the hilum was. The carbonised mericarps have a smooth surface. Dimensions of 2 mericarps: 2.2 x 2.2 x 1.7 (Profile A5, 23.08-22.90) and 2.1 x 2.0 x 1.7 mm (B22, Locus 8). From the reference collection *G. tricornutum* Dandy, *G. pisiferum* Boiss. and *G. samuelssonii* Ehrendf. appear to match. In particular, the outer fruit wall of *G. tricornutum* is densely tuberculate, but after carbonisation this outer fruit wall has mostly disappeared, leaving a smooth inner fruit wall. *G. tricornutum* is a common weed in cultivated fields.

Results

Preservation and Distribution

The results of the flotation samples from Areas A and B are given in the Tables 1 and 2. The samples are arranged according to excavation coordinates, not to the preliminary classification of samples to features (*cf.* "Samples"). In addition to the total of 118 flotation samples with botanical remains (49 from Area A and 69 from Area B), there were 42 other samples with no identifiable botanical material not listed in the tables. Only 8 samples belong to the more recent Phases 1 and 2, making a direct comparison with the samples of the older Phases 3 and 4 unreliable. All of the following data concerning the botanical remains from Basta refer to the older phases unless otherwise specified. No comparison is made generally between areas A and B. This would be an artificial comparison since most of the samples do not originate *in situ* (*cf.* "Samples").

All the flotation samples show great uniformity which, at least in the case of the lower excavation levels, is not the result of selection due to bad preservation. The flotation samples from the lower levels were partly well preserved in contrast with the samples from the upper settlement layers. Intensive plant rooting and direct exposure to temperature and humidity changes in the upper settlement layers will have caused the destruction of their carbonized plant materials.

Almost all of the listed samples are rich in charcoal remains and tiny fragments of the nut scales of a wild pistachio tree, most likely *Pistacia atlantica* (*cf.* "Descriptions"), and fruit stone fragments of a wild almond (*Amygdalus* sp.). But the samples yield relatively little in terms of other fruit and seed remains from wild as well as cultivated plants. This applies not only to numbers but also types, particularly for Area B.

There are only two samples which differ from the other samples. In a burial (A5, Locus 4), almost half the number of different types of plant remains found in all other samples at Basta were observed. Included were broken grains of cultivated barley, a proportionally high number of seeds of the boraginous species *Lithospermum tenuiflorum* and *Arnebia linearifolia*, and small fruit bodies of an ergot (*Claviceps* sp.). Judging by size, this ergot probably infected a wild grass. It seems most likely that the location of this obviously unsorted and carbonized plant material was the result of closing the burial with surface material containing these plant remains, rather than as burial gifts of grain and flowers; most of the boraginous species carry both flowers and ripe seeds at the same time.

The other deviation comes from Square B50, Locus 8. It held some small sherds, probably from a "tabun". These sherds were tempered with numerous remains of crop processing (*cf.* "Results: Plant Husbandry and Plant Collecting").

The samples from the channel-like substructures below the floor of Room 10 in Area A failed to shed light on the channels' possible function. The samples were either comparable with the bulk of the other samples or contained no plant remains at all.

Charcoal Analysis

A total of *c.* 1450 wood identifications were made for the oldest phases and 85 for the younger Phases 1 and 2. By far most of the charcoal from the flotation and hand-picked samples from Basta belonged to pistachio (most probable species *Pistacia atlantica*, *cf.* "Descriptions") and juniper trees (*Juniperus* sp., *cf.* "Descriptions"). For the flotation samples from Areas A and B (Phases 3 and 4) they represent 99.7 % of the total amount of wood identified, for the hand-picked samples 97 % (ml expressed as percentage). For interpreting results this is not always the best criterion (*cf.* Willcox 1974). Burnt timber, for instance, is not always recognizable as belonging to a single beam. Large amounts of splintered charcoal from one beam in one sample can heavily influence the picture if the amounts (ml) or number of identifications are the criteria being used. A better means is to ascertain the number of samples in which the wood type is present. The sample frequency, expressed as a percentage, is 47.3 % for pistachio and 39.6 % for juniper, for all the flotation samples in Areas A and B (Fig. 3). If only samples with identified charcoal are considered, the results are 72.7 % and 65.5 % respectively. This clearly shows the dominance of these xerophilous trees and shrubs (Table 5). The same is true for the sample frequency of the hand-picked samples: 50.0 % and 54.8 % respectively (Table 6). Charcoal of the xerophilous almond (*Amygdalus* sp.) is present in 10.9 % of the flotation samples, but only 0.1 % of the total amount of charcoal (ml expressed as a percentage) found, belongs to this wood-type.

Charred wood other than that of the xerophilous trees and shrubs characteristic of steppe-forest and forest-steppe environments were sporadically found in the samples. Only approx. 0.2 % of the wood in the flotation samples and 1.1 % of the hand-picked samples (ml expressed as a percentage) belong to hydrophilous trees and shrubs of riverine vegetation (*Tamarix* sp., *Fraxinus* sp. and *Populus*/*Salix*).

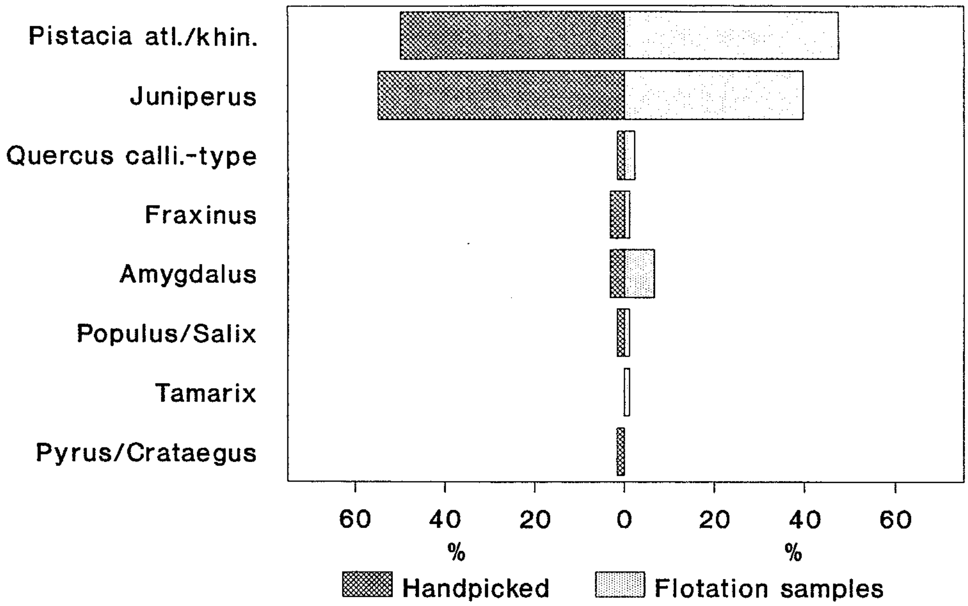


Fig. 3. Basta, Areas A and B (Phase 3-4). The sample frequency expressed as a percentage of the charcoal remains from the handpicked and the flotation samples.

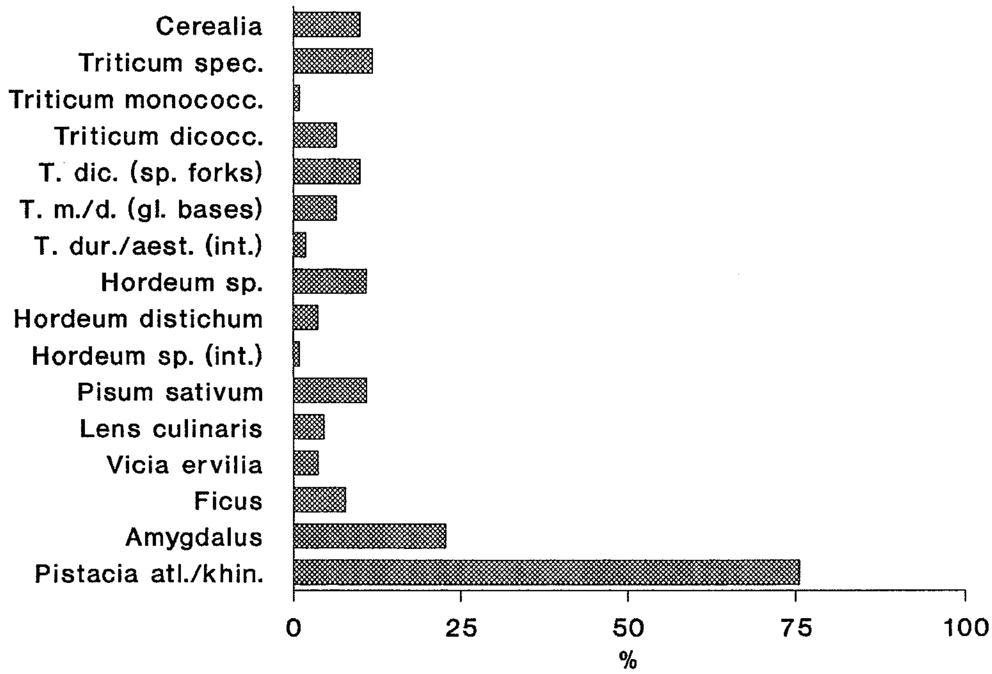


Fig. 4. Basta, Areas A and B (Phase 3-4). The sample frequency expressed as a percentage of the macroremains of cultivated and collected plants.

For a reconstruction of the local environmental conditions on the basis of the charcoal found at a site, it must be understood that the wood in the settlement was chosen selectively. Certain trees can be preferred because they supply good timber, other trees can be spared because of their economic importance, bad utilisation of the wood, traditions, *etc.* Guest (1966: 107) gives examples of deforested areas in Iraq where only pistachio trees are spared because of their economic importance (seeds, gum). In Basta nutshells, fruit stones and wood from the pistachio and almond trees were found, suggesting that these trees grew abundantly in the vicinity.

The utilisation of wood could be ascertained with certainty in only a few of the Basta samples. A differentiation can be made between use for timber and tools as opposed to heating and cooking. Wood used for timber and tools is only found left as charcoal when (part of) a building had burnt down or when used wood utilized as raw material is fired for heating or cooking. Five large carbonised beams were found for instance, which are specimens of the pistachio tree used for construction timber (A5, Loci 14 and 15, B68, Locus 37 and the loci marked with X in Table 3 of the hand-picked samples). Six further beams came from the juniper tree (B68, Loci 33, 35 and 40 and the loci marked with X in Table 3).

A piece of charcoal from an evergreen oak species was found with a small hole drilled in it, suggesting that it had been part of a construction or a tool (B 87, Locus 11). Such special implements may very well have been imported from another region.

In one, possibly two fireplace(s) (B68, Loci 37 and B52, Locus 6) burnt juniper wood was found. In one fireplace from the younger phases there was both juniper and pistachio wood (B68, Locus 14). Usually the local vegetation is used as a source for fire wood. There are no indications of dung being used as fuel in Basta. This practice, from arid regions with little or no arboreal vegetation, is an important source of botanical remains in the Near East (Miller and Smart 1984).

On the basis of the botanical remains, we postulate that juniper and pistachio were the main arboreal elements in the vegetation in the immediate vicinity of PPNB Basta. However the results of the plant analysis of PPNB Basta do not reflect the present environment around the site, where forest or even steppe-forest is totally absent nowadays (*cf.* "Present-Day Climate, Crop Husbandry and Vegetation: Vegetation"). There are not even any so-called "standing witnesses" of juniper and pistachio to be found. "Standing witnesses" are old, solitary trees in the landscape, which have not been felled for any number of reasons. They are often indicative of the former vegetation. Besides this, the present average annual rainfall of between 130 and 200 mm within a 2 km radius around Basta does not seem to allow for more than a scrub steppe. Transportation of *J. phoenicea* to Basta from its present habitat on the Western slopes of the highlands (*cf.* "Present-Day Cimate, Crop Husbandry and Vegetation: Vegetation") seems very unlikely in view of the large quantities found during charcoal analysis. *J. phoenicea* grows at a distance of at least 6 km from Basta as the crow flies, which would have made transportation over the highland mountains unavoidable.

The apparent difference between contemporary vegetation in the Basta area and that indicated by the analysis of botanical remains, especially the charcoal analysis, poses an interesting question. Is the difference explainable by human influence, or did the climate of PPNB Basta differ from that of today? Was a combination of both these factors responsible? The results of the botanical macroremains from Basta are all the more exciting because there is no other reliable data on the vegetation history, based on pollen analysis, for Southern Jordan during the Neolithic.

Vegetation and Climate of the Period of Occupation

When reconstructing a picture of the past vegetation around Basta in the light of the extant data, it is interesting to look at the ecology and present distribution of the most likely pistachio (on the base of charcoal and whole nuts *Pistacia atlantica*, *cf.* "Descriptions"), juniper (only species in Jordan *Juniperus phoenicea*, but other species cannot be excluded, *cf.* "Descriptions") and other species present in the charcoal samples, on the assumption that their ecology did not change since the Neolithic.

J. phoenicea is a thermophilous maquis tree, or shrub, found throughout the Mediterranean (Zohary 1973). In Jordan, quite large stands of *J. phoenicea* exist in the highlands of Edom; they have survived in less accessible places, such as steep escarpments unsuitable for agriculture. To the North of Wadi Musa *J. phoenicea* forms a steppe-forest with *Pistacia atlantica* on siliceous sandstone. Rainfall varies between 200-380 mm annually. To the South, with an increasingly arid climate, *J. phoenicea* becomes the only arboreal element on the steep slopes of the Southern highlands due to its high drought tolerance (*cf.* "Present-Day Climate, Crop Husbandry and Vegetation: Vegetation"). In this area, where rainfall varies between 50-200 mm annually, *J. phoenicea* forms an open steppe-forest to shrub-steppe, at altitudes ranging up to 1600 m (Long 1957). To suggest limestone-derived soils East of the Southern highlands as a potential habitat for *J. phoenicea* during the Neolithic does not run counter to its present distribution. That the species is not restricted to sandstone areas, which is apparent for its dispersal in Jordan, is clear from its presence on limestone in the Northern Sinai (Danin 1983). But its temperature requirements seem too high for an occurrence East of the Southern highlands, where a more continental climate prevails (Baierle 1993). The assumption that the juniper charcoal found at Basta belongs to *J. phoenicea* would than imply a different climatic regime for the PPNB. It is therefore possible that most of the juniper charcoal belongs to a drought as well as cold resistant juniper species, which is extinct in Jordan today. The most likely candidate is *Juniperus excelsa* s.l., which extends as far South as the Lebanese mountains, where it can form stately trees. But it also appears as a dwarf-shrub, bordering the timberless steppes of Central Anatolia. This juniper has a wide ecological range of climatic and soil conditions and is competitive against other arboreal species (Zohary 1973).[1] However these are also arguments against a former distribution in Southern Jordan. It is hard to explain why we still find forest remnants of *J. phoenicea*, and also of the evergreen oak *Q. calliprinos*, but not of *J. excelsa*. So the possibility should be considered that *J. phoenicea* was capable of growth East of the highlands.

Pistacia atlantica is dominant in steppe-forests or forest-steppes. In the North of Jordan the tree is mainly found in the transition zone between the deciduous Tabor oak forests and the steppe. Under increasingly arid conditions the xerophilous *P. atlantica* forms steppe forests either exclusively or in association with other xerophilous species such as almond (*Amygdalus korschinskii*) and hawthorn (*Crataegus azarolus* and *C. aronia*). Remnants of Tabor oak forests are predominantly found on the Eastern slopes of the Northern highlands. The most Southerly distribution of the Tabor oak (*Quercus ithaburensis* s.l.), the only deciduous oak species in Jordan, nowadays extends as far as Dhiban on the plateau of Madaba (Long 1957). The absence of deciduous oak wood in the samples from Basta is rather interesting. Charcoal analysis from the oldest PPNB layers at 'Ain Ghazal showed that more than 90 % of the charcoal recovered belonged to a deciduous oak species (Neef, in prep.). So it can be argued that its absence in PPNB Basta is due to climatic reasons. The rather thermophilous tree in question requires a minimum amount of about 350 mm annual precipitation (Long 1957).

In the regions of Wadi Musa, Shaubak and Tafila, *P. atlantica* is associated with the evergreen oak, *Quercus calliprinos*, at altitudes of over 1400 m. The annual average rainfall there varies from 200-380 mm. The distribution of *Q. calliprinos* depends largely on a minimum precipitation level, so that the tree can only flourish at higher altitudes in the South of Jordan. Nowadays its most Southern distribution lies at Al Hishi (Baierle 1993). In PPNB layers at Basta only a small amount of charcoal from this oak was found, which supplies excellent timber and can be used for the manufacture of all kinds of tools. A much higher percentage would

[1] Remnants of comparable steppe-forests with a dominance of *Pistacia atlantica*, *Juniperus polycarpos* (systematically close to *J. excelsa*), and *Amygdalus* spp. are only found in Iran today. This kind of vegetation always characterizes in its ecology marginal conditions for tree- and shrubgrowth (Zohary 1973).

have been found in the samples if this oak had been indigenous to the highlands directly West of Basta. This suggests that its distribution must have been relatively far to the West of Basta in the highlands, or further North, in highlands proximate to its present most Southerly location, where precipitation levels were sufficient.

Most tree species found in the Basta charcoal samples are tolerant of relatively marginal conditions; they mainly comprise drought-resistant vegetation such as forest-steppe and steppe-forest. Coincident with the absence of the deciduous oak *Quercus ithaburensis* s.l. and the sparse presence of the evergreen oak *Quercus calliprinos*, this gives rise to the assumption that the climatic conditions in PPNB Basta did not differ substantially from those of today. Only a slightly higher annual precipitation, no more than approximately 50 mm, and maybe slightly higher minimum temperatures during the winter months, can be considered. Van Zeist and Bottema (1988 and 1991) compiled the data available on Southern Jordanian climate from several disciplines (archaeology, archaeozoology, geomorphology, pollen analysis based on site sediments, *etc.*). Most of these data point to somewhat moister conditions for the PPNB than today. But it should be considered that initial settlement at Basta during the PPNB took place in an intact environment, *i.e.*, with intact vegetation that prevented soil erosion. The consequently well developed soil profile, with a high water retention capacity, would have enabled a corresponding improvement in plant growth potential, despite arid climatic conditions.

Undoubtedly, an intact environment has a positive, stabilising influence on the climate. The effect of vegetation on the microclimate and, in the long run probably on the climate as a whole, is illustrated by an example from the border of Northern Sinai in Egypt and the Western Negev in Israel. On both sides of the border the same type of *Artemisia* steppe thrives, enjoying an annual precipitation of 100-150 mm. On the Egyptian side the density of the vegetation was drastically reduced by shrub collection for fuel and intensive grazing. On the Israeli side of the border these activities took place on a much smaller scale. A substantial plant cover developed here with even an accumulation of organic matter. The effect was that owing to the resultantly darker soil colour on the Israeli side, the temperature was 4-5° C higher there. Higher temperatures lead to extra convection which would positively affect rainfall. An opposite, negative effect could be caused by overexploitation of the vegetation by man. The hypothesis is that large scale overexploitation could trigger a chain of events which eventually leads to changes in the climate, inducing the development of new types of vegetation (Waisel 1986). This is especially true in sensitive ecosystems where conditions for tree growth are marginal. Therefore it should be considered that the climate at PPNB Basta did not differ substantially from todays climate, which has been negatively influenced by a degraded environment.

Basta was abandoned at the same time as most other contemporary settlements, particularly those in Southern Jordan, resulting in the so-called "hiatus palestinienne". The impact of a large permanent settlement, as Basta, on its environment must have been large. But botanical remains from Basta provide no indication that human activity during the PPNB induced a degradation of the environment, such as that apparent at 'Ain Ghazal (Köhler-Rollefson and Rollefson 1990), that led to the abandonment of the settlement. The samples from the younger Phases 1 and 2 lie in numbers/amount of plant remains within the range from those of the older Phases 3 and 4. But the low number of samples from the younger phases does not allow reliable comments on the chronological distribution of the plant remains.

However it should be appreciated that even with an almost intact vegetation, as reconstructed for PPNB Basta on the basis of botanical remains (see below), the area for zonal treegrowth from East to West is very narrow. Many plant species, especially arboreal ones, grow close to the margins of their range in terms of cold or aridity in this area. This makes the complete ecosystem extremely susceptible to human interference. Under such conditions human impact, combined with slight climatic fluctuations such as a series of extremely dry years, could have easily upset the ecological balance.

Reconstruction of the Local Environment

In Fig. 2.B an attempt is made to reconstruct the past environment of PPNB Basta utilising the results on the botanical remains from the site. Five zones of vegetation are proposed. Under the prevailing conditions most of the vegetation types would have been transitional, and the zones are best defined using the predominance of selected species. These for a substantial part do not represent vegetation types known in this specific form. Nonetheless, taking into account all factors which could have been an influence, the results of charcoal analysis are clear (*cf.* also Discussion in "Results: Vegetation and Climate in the Habitation Period").

In the Basta area rainfall and temperature vary quite noticeably within a relatively short distance; the same applies to the vegetation ranging over the ecotones of (open) forest, steppe-forest and steppe. These different habitats led to a rich plant and animal life with a great diversity of species within a small region, making it very attractive in terms of herding, foraging and hunting. This offered the inhabitants of PPNB Basta much better conditions than the present degraded environment.

Zone I Arid steppe zone with drought tolerant dwarf shrubs such as *Salsola* sp. This was the transition zone to the semi-arid steppe Zone II. Game such as goitred gazelle (*Gazella subgutturosa*) and onager (*Equus hemionus*) also point to open steppe-like habitats (Becker, this volume).

Zone II Semi-arid dwarfshrub steppe-zone with possible *Artemisia* dominance, although it is difficult to determine whether or not wormwood (*Artemisia herba-alba*), at present the dominant dwarfshrub around Basta, was already an important constituent of the vegetation in the Neolithic. Archaeobotanical remains of this plant, with its tiny fragile seeds, have never been found. Being less palatable, its present dominance is certainly in part culturally induced. Most of the identified weedy plants from the plant record originate in steppic habitats (*cf.* "Descriptions"), typical of this zone and Zone III. To the West, with increasing precipitation, there was a transition to an open, bushy, vegetation with pistachio (*Pistacia atlantica*) and juniper (*Juniperus* sp., *cf.* "Discussion: Vegetation and Climate of the Habitation Period"). Associated arboreal elements are hawthorn/pear (*Crataegus aronia/azarolus* and/or *Pyrus* sp.) and almond (probably *Amygdalus korschinskii*).

Zone III Steppe-forest with juniper (*Juniperus* sp.) and pistachio (*Pistacia atlantica*) dominating. Minor arboreal elements of vegetation are hawthorn/pear and almond species and shrubs such as *Astragalus* spp. It may have been savanna-like: the open spaces between individual trees covered with a grass floor, offering good opportunities not only for herding and the harvesting of wild cereals, but also for laying out fields. Many Neolithic settlements were founded in steppe-forest areas, which at that time seem to have been more widely distributed than today (*cf.* Willcox 1991). This typical juniper/pistachio steppe-forest on the Eastern foothills of the southern highlands had disappeared by the Iron Age at the latest. Wood analysis from an Iron Age site near Udruh (some 12 km NNE of Basta) revealed predominantly wood of pistachio and scarcely any of juniper (Neef 1987). Nowadays juniper forests, where *J. phoenicea* is associated with *P. atlantica*, are only found on the Western slopes of the southern highlands between Tafila and Wadi Musa (*cf.* "Results: Vegetation and Climate of the Habitation Period").

The scarcity of water during the long hot summers makes permanent settlement only possible in the vicinity of perennial wells. Along the wadi near Basta the hydrophilous trees and shrubs tamarisk (*Tamarix* sp.), willow (*Salix* sp. but poplar, *Populus euphratica*, cannot be excluded) and ash (most likely the Syrian ash, *Fraxinus syriaca*) grew. The presence of ash points to a well developed riverine vegetation along a perennial stream, indicated by its relatively high moisture requirements. In present-day Jordan, *F. syriaca* is found no further South than Gilead.

Zone IV Forest-steppe to relatively dense forests, dominated by pistachio (*Pistacia atlantica*) associated with almond, hawthorn and possibly the evergreen oak (*Quercus calliprinos*). This zone reflects the highest annual precipitation levels and the loWest temperatures.

V Forest-steppe/steppe-forest with juniper (*Juniperus phoenicea*) and pistachio (*Pistacia atlantica*). Pistachio dominated in the transition area to Zone IV, while to the West (with increasing temperatures and decreasing annual precipitation) juniper was the dominant species. Minor elements were hawthorn and almond. Besides these, the thermophilous pistachio *P. khinjuk* may have been found at lower altitudes.

Foraging and Plant Husbandry

The collecting of wild fruits, especially pistachio (*Pistacia atlantica*), must have been a common practice at PPNB Basta. The calculated number of 148 complete pistachio nuts for Area A and B may not seem high, but this sum is made up of 25 complete nuts and about 2100 small nutshell fragments. More than 75 % of the flotation samples (Table 4, Fig. 4) held fragments of pistachio nut shells and more than 22 % held fragments of almond nuts. Both almond (*Amygdalus* sp.) and pistachio nuts are rich in fat and may have been an important source for vegetable oil. The pistachio tree can also be used for its resin as well as providing tree fodder. Another wild fruit, fig (*Ficus* sp.), was probably also collected.

Cereals definitively cultivated at Basta are emmer (*Triticum dicoccum*), einkorn wheat (*Triticum monococcum*) and a free-threshing wheat (*Triticum aestivum/durum*). For barley, only the brittle-rachis type of internodes was found, which points more to wild barley (*Hordeum spontaneum*). However, the grains suggest cultivated barley (*Hordeum distichum*, *cf.* "Descriptions").

There were also only a small number of pulse seeds found. The sizes of the pulse seeds point more towards cultivated pea (*Pisum sativum*), lentil (*Lens culinaris*) and bitter vetch (*Vicia ervilia*) than to their wild ancestors (*cf.* "Descriptions"). But based on such a low number of seeds, size is not a reliable criterion. There is merely circumstantial evidence suggesting the cultivation of bitter vetch, insofar as its wild ancestor is only distributed in a limited area that does not reach as far South as Jordan (Zohary and Hopf 1993).

The amount of plant impressions left in plaster was low. Only three imprints of barley grains (*Hordeum* sp.) were found in some pieces of plaster from Area A.

The only rich carbonized plant material came from a few small "tabun" sherds from Area B (50, Locus 8). These sherds were tempered with a large amount of cereal-crop processing remains (Fig. 2.b, Table 2), proportionally higher than that found in all the flotation material from the site. They included spikelet forks of emmer wheat, brittle-rachis type internodes of barley and rachis internodes of a free-threshing wheat.

Observing the sum of the remains of cultivated plants and their sample frequencies in Table 4 and Fig. 4, it is tempting to argue that plant cultivation in PPNB Basta played only a minor role. This impression could be the result of bad preservation of botanical remains, especially in the upper settlement layers (*cf.* "Results: Preservation and Distribution"), and/or could be caused by the fact that the excavated area (c. 860 m^2) is small in comparison with the size of the site (10-14 ha). The threshing, further processing and storage of cereals, pulses, *etc.* may not have taken place inside the excavated area of Basta. On the other hand, activities practiced for several hundred years should be reflected in most of the settlement layers. Perhaps this would not be directly observable in the *in situ* layers, but there should at least be evidence in layers with erosional settlement debris, layers which are very common in Basta. But most of these samples contained none or hardly any of the by-products of crop processing, such as spikelet forks or rachis internodes, which are normally abundant where cereal cultivation took place on a large scale.

That the exploitation of wild and cultivated cereals was only practiced on a small scale could also be indicated by the low number of flint tools with "sickle sheen" in Basta (Gebel, pers. comm.). The high number of groundstone tools found at the site is no proof for the importance of plant cultivation. Mortars, grinding stones, *etc.* can also be used for the processing of collected wild plants.

A more plausible reason of why subsistence at LPPNB Basta seems to have been based on crop cultivation to only a limited degree could lie in the fact that Basta lay and still lies in a climatic region which is marginal for rain-fed agriculture. Subsistence mainly based on crop cultivation, even under intact environmental conditions, would not have been reliable in such unpredictable circumstances (*cf.* "Results: Vegetation and Climate of the Period of Occupation").

Many other PPNB sites are located in a marginal zone for rain-fed agriculture, but they have abundant remains of cultivated plants. In the settlement layers from the large PPNB sites at Jericho (Hopf 1983) and 'Ain Ghazal (Rollefson and Simmons 1985) in Palestine and Central-Jordan, there are various cultivated plant remains found in large amounts. But both sites enjoy different ecological conditions compared to Basta. Jericho has a hot and arid climate. It may be assumed that even then, water from the spring in the oasis was already being diverted to the fields for crop cultivation (Hopf 1983). However, large scale irrigation, or a crop cultivation on the lower periodically flooded river terraces, or growing with the use of high ground-water, seem unlikely under the given hydrological conditions at Basta. 'Ain Ghazal lay and lies in an ecologically more favourable area for crop cultivation than Basta according to the results on the charcoal remains (Neef unpubl.).

A successful exploitation of the environmental resources will highly depend on the abilities of the community and the opportunities offered by the environment. Apparently inhabitants of large settlements such as Basta developed (were forced to develop) different subsistence strategies to maximize the exploitation possibilities of their environmental resources. Summarizing the results on the five excavation campaigns, subsistence at Basta seems to be have been mainly based on goat and sheep herding, hunting (Becker this volume) and foraging, and only to a limited degree on plant husbandry. In addition to the theme explored here, further research could be rewarding, for example, regarding the way of subsistence of small contemporary settlements near Basta and the overall human impact exerted on sensitive ecosystems, such as the area East of the southern highlands.

Acknowledgements: This study was made possible by a grant from the *Netherlands Organization for the Advancement of Pure Research* (N.W.O.) and by the cooperation with Prof. Dr. Willem van Zeist, State University of Groningen. Also I am obliged to the excavators Prof. Dr. Hans Nissen, Freie Universität Berlin, Dr. Mujahed Muheisen, Yarmouk University Irbid and Mr. Hans Georg Gebel, Freie Universität Berlin. This study profited by the stimulating discussions with Mr. Hans Georg Gebel. I thank Mr. Rainer Pasternak, University of Kiel for botanical sampling during the 1989 season and Mrs. Evi Werner, Freie Universität Berlin for processing the photographs. The English text was improved by Prof. Dr. Gary O. Rollefson, A.G.R.I. Ober-Ramstadt and Mr. Brian Willcock, Berlin.

Reinder Neef
Deutsches Archäologisches Institut
Eurasien-Abteilung
Im Dol 2-6
Germany - 14195 Berlin

References

Alex M.
1985 *Klimadaten ausgewählter Stationen des Vorderen Orients.* Beihefte zum Tübinger Atlas des Vorderen Orients, *Reihe A.*14. Wiesbaden, Ludwig Reichert.

Baierle H.U.
1993 *Vegetation und Flora im südwestlichen Jordanien.* Dissertationes Botanicae 200. Berlin/ Stuttgart, J. Cramer.

Bor N.L.
1968 *Gramineae.* In: C.C. Townsend, E. Guest and A. al-Rawi (eds.), Flora of Iraq 9. Glasgow/ Baghdad.

Danin A.
1983 *Desert Vegetation of Israel and Sinai.* Jerusalem, Cana.

Fahn A., E. Werker, and P. Baas
1986 *Wood Anatomy andIdentification of Trees and Shrubs from Israel and Ajacent Regions.* Jerusalem, The Israel Academy of Sciences and Humanities.

Garfinkel Y., M.E. Kislev and D. Zohary
1988 Lentil in the Pre-Pottery Neolithic B Yiftah'el: additional evidence of its early domestication. *Israel Journal of Botany* 37: 49-51.

Gebel H.G. and J.M. Starck
1985 Investigations into the stone age of the Petra area (Early Holocene research). A. Preliminary report on the 1984 campaigns. *Annual of the department of Antiquities of Jordan* 29: 89-114.

Gebel H.G.
1988 Late Epipalaeolithic - Aceramic Neolithic sites in the Petra area. In: A.N. Garrard and H.G. Gebel (eds.), *The Prehistory of Jordan.* British Archaeological Reports- Intern. Series 396.1: 67-100.

Gebel H.G, M.S. Muheisen, H.J. Nissen, N. Qadi, and J.M. Starck
1988 Preliminary report of the first season of excavations at Basta. In: A.N. Garrard and H.G. Gebel (eds.), *The Prehistory of Jordan. The State of Research in 1986.* British Archaeological Reports - Intern. Series 396.1: 101-136.

Guest E. (ed.)
1966 *Flora of Iraq* I. *Introduction to the Flora.* Glasgow/Baghdad, Ministry of Agriculture, Republic of Iraq.

Helbaek H.
1966 Pre-pottery Neolithic farming at Beidha. *Palestine Exploration Quarterly* 98: 58-64.
1970 The plant husbandry of Hacilar. In: J. Mellaart (ed.), *Excavations at Hacilar* 1: 189-244.

Hillman G.C. and M.S. Davies
1992 Domestication rate in wild wheats and barley under primitive cultivation: preliminary results and archaeological implications of field measurements of selection coefficient. In: P.C. Anderson (ed.), *Préhistoire de l'agriculture.* Monographie du CRA 6. Paris, CNRS.

Hopf M.
1983 Jericho plant remains. In: K.M. Kenyon and T.A. Holland (eds.), *Excavations at Jericho* 5: 576-621. London, British School of Archaeology in Jerusalem.

Kislev M.E.
1988 Desiccated plant remains: an interim report. In: O. Bar-Yosef and D. Alon (eds.), *Nahal Hemar Cave.* Atiqot English Series 18: 76-81.

Köhler-Rollefson I. and G.O. Rollefson
1990 The impact of Neolithic subsistence strategies on the environment: the case of 'Ain Ghazal, Jordan. In: S. Bottema, G. Entjes-Nieborg, and W. van Zeist (eds.), *Man's Role in the Shaping of the Eastern Mediterranean Landscape*: 3-14. Rotterdam, Brookfield

Long G.A.
1957 The bioclimatology and vegetation of Eastern Jordan. *FAO Working Paper 57/2/1109.* Rome.

Miller N.F. and T.L. Smart
1984 Intentional burning of dung as fuel: a mechanism for the incorporation of charred seeds into the archaeological record. *Journal of Ethnobiology* 4: 15-28.

NAJ
1984 *National Atlas of Jordan* I. *Climate and Agroclimatology.* Amman, Jordan National Geographic Centre.

Neef R.
1987 Botanical remains. In: A. Killick (ed.), *Udruh - Caravan City and Desert Oasis. A Guide to Udruh and its Surroundings.* Romsey.

Nissen H.J., M. Muheisen, and H.G. Gebel
1987 Report on the first two seasons of excavations at Basta (1986-1987). *Annual of the Department of Antiquities in Jordan* 31: 79-119.

Pasternak R.
1991 Getreide: Lebensmittel, Abfall oder Futtermittel? Analysen von heutigem Dreschgut aus Jordanien als Interpretationshilfen zur Bewertung archäologischer Getreide-Funde. *Archäologisches Korrespondenzblatt* 21: 151-158.

Plicht J. van der
1993 The Groningen Radiocarbon Calibration Program. *Radiocarbon* 35.1: 231-237.

Ridley H.N.
1930 *The Dispersal of Plants Throughout the World.* Reprint 1990. Koenigstein, Koeltz.

Rollefson G.O. and A.H. Simmons
1988 The Neolithic settlement of 'Ain Ghazal. In: A.N. Garrard and H.G. Gebel (eds.), *The Prehistory of Jordan. The State of Research in 1986.* British Archaeological Reports - Intern. Series 396.2: 393-421.

Schweingruber F.H.
1990 *Anatomie europäischer Hölzer- Anatomy of European woods.* Bern/Stuttgart, Haupt.

Thalen D.C.P.
1979 *Ecology and Utilization of Desert Shrub Rangelands in Iraq.* The Hague.

Waisel Y.
1986 Interactions among plants, man and climate: historical evidence from Israel. *Proceedings of the Royal Society of Edinburgh* 89: 255-264.

Willcox G.
1974 A history of deforestation as indicated by charcoal analysis of four sites in Eastern Anatolia. *Anatolian Studies* 24: 117-133.
1991 Exploitation des espèces ligneuses au Proche-Orient: données anthracologiques. *Paléorient* 17.2: 117-126.

Wirth E.
1971 *Syrien. Eine geographische Landeskunde.* Darmstadt, Wissenschaftliche Buchgesellschaft.

Zeist W. van and S. Bottema
1988 Late Quaternary vegetational and climatic history of Southwest *Asia. Proc. Indian natn. Sci. Acad.* 54 A3: 461-480.
1991 *Late Quaternary Vegetation of the Near East.* Beihefte zum Tübinger Atlas des Vorderen Orients A18. Wiesbaden, Reichert.

Zeist W. van and W.A. Casparie
1968 Wild einkorn wheat and barley from Tell Mureybit in Northern Syria. *Acta Botanica Neerlandica* 17.1: 44-53.

Zeist W. van and G.J. de Roller
1994 The plant husbandry of Aceramic Cayönü, S.E. Turkey. *Palaeohistoria* 33-34: 65-96.

Zohary M.
1973 *The Geobotanical Foundations of the Middle East* 1-2. Geobotanica selecta 3. Stuttgart, Fischer.
1966-1985 *Flora Palaestina* 1-4. Jerusalem, The Israel Academy of Sciences and Humanities.

Zohary D. and Hopf M.
1993 *Domestication of Plants in the Old World. The Origin and Spread of Cultivated Plants in West Asia, Europe, and the Nile Valley.* Oxford, Clarendon.

On the Identification of Sheep and Goats: the Evidence from Basta[1]

Cornelia Becker

Introduction

The settlement layers of Neolithic Basta are hidden below the modern name-giving village. Basta is approximately 12 km to the South-East of Wadi Musa, a small centre not far from the famous Nabatean site of Petra (Southern Levant, Jordan; Fig. 1). The site is located on a slope at an altitude ranging between 1420 and 1460 m above sea-level amidst a rocky limestone area along the Easterly perimeters of the mountains flanking the Jordan Rift Valley. The landscape around Basta is relatively diverse and is distinguished by its highly structured relief (for further details *cf.* Gebel, in this volume). The flora of the region is to a large extent composed of elements from the Irano-Turanian steppe. In the immediate neighbourhood of the village the landscape is practically bare of trees. Some natural plant cover is found where moisture accumulates as in the wadi but also within the confines of the irrigated zone of the nearby gardens (Neef, in this volume). A perennial spring inside the village supplies a constant flow of water, plenty enough for human and animal consumption throughout the year. Judging by today's fauna and flora, the climate of the region is assumed not to have changed significantly since the Neolithic age. As drawn from the archaeobotanical evidence from the site, past vegetation must have been quite diverse. While fringe forests bordered the wadis, the hills were covered with juniper, pistachio and other trees as well as bushes. In the semi-desert to the East, typical steppe vegetation predominated (Neef 1987: 115). Both biospheres were inhabited by a great variety of wild animals, of which a number have been identified using the extracted bone refuse from the site.

Five excavation campaigns took place during the summers of 1986, 1987, 1988, 1989, and 1992 under the co-directorship of Hans J. Nissen (Freie Universität Berlin) and Mujahed Muheisen (Yarmouk University, Irbid; Nissen, Muheisen and Gebel 1987).

---

[1] The manuscript was completed in 1993. It is presented here unchanged, without any additions. For recent results and updates on references please consult Becker 1999 and C. Becker, Bone and species distribution in Late PPNB Basta (Jordan): rethinking the anthropogenic factor. In: M. Mashkour *et al.*, *Archaeozoology of the Near East IVA. Proceedings of the 4th International Symposium on the Archaeozoology of Southwestern Asia and Adjacent Areas.* ARC-Publicaties 32 (2000): 196-207. Groningen.

In conjunction with other archaeological findings as mainly drawn from the flint evidence, the entire cultural debris of the ancient site has been tagged to the Late "Pre-Pottery Neolithic B" period ("PPNB") which roughly refers to the second half of the 7th millennium B.C. Two radiocarbon dates from pistachio samples are available to date (8380 $\pm$ 100 and 8155 $\pm$ 50 B.P. respectively). The assumed duration of occupation lasted for about 400 years, at most probably 500 years. The dating of the bone material is in general based on its location in relation to the unearthed architecture which in some cases is additionally supported by even closer associations with specific types of lithic artefacts.

There can be no doubt that the site was permanently inhabited. The settled area probably covered a surface larger than 10 ha. Hence Basta must be included in the short list of large Late PPNB sites known in the Levant to date. As such, its size is comparable to that of Abu Hureira, 'Ain Ghazal and Beisamoun (Bar-Yosef and Belfer-Cohen 1989: 61). Because some of the walls are preserved to a height of more than 2 m, the excavated area conveys a rather vivid impression of the original appearance of this 8000 year-old settlement. Anyhow, that visual aspect should not delude us as to the true function of the constructions, not to mention the former organisation of the site. The fill of the units in question are only to a lesser extent thought to have been connected with either living, storage or some other fields of activity. Although the variety and number of finds is great, not much can be said about the original furnishing of the "rooms". Stone vessels, grinding stones, bracelets and beads, a great number of lithic artefacts and bone refuse were found, to name but some types (*cf.* the chapters about abiotic and biotic resources, in this volume). Area A represents the location where archaeological investigation first began at Basta. It is situated on the south-Western slope of Wadi Basta. The architecture found in Area A (Plate 1.a-b) fits in with the general description given above and was concealed by a thick layer of coarse-grained, colluvial deposits (Pachur 1987: 85). These so called surface deposits contained a considerable amount of animal bones (Plate 1.c) as well as flint artefacts quite similar to those found in the room fills located immediately above the Neolithic floors.

Field work proceeded by excavating arbitrary layers about 10 cm thick. Approximately 60 % of the bone deposits were dry-screened through 2 and 5 mm meshes. The remaining samples were sorted by hand. Animal bones were cleaned with brushes (dry and wet with water and/or dilute acetic acid). The material was frequently covered by a thin skin of concretion. Some bones were quite brittle, suggesting that part of the collagen had gone lost. Other specimens were of harder texture. Unfortunately the different states of preservation led to divergencies in the fragmentation patterns of the bones, which as a rule occurred from inadequate handling during excavation.

Most of the general archaeozoological analyses were carried out on visits lasting between three or four weeks during the 1987, 1988 and 1989 campaigns[1]. The work included registration of basic archaeozoological and archaeological data such as number and weight of all finds per excavated unit, classification of specimens to genera and species, skeletal elements and age of death, documentation of recent and/or prehistoric fragmentation patterns *etc.* During the time at my disposal I was able to treat about 60 % of the entire bone material unearthed during those three campaigns. The samples requiring further examination[2] were taken to Berlin (Seminar für Ur- und Frühgeschichte der Freien Universität Berlin) where they are still being stored. All specimens were registered in a catalogue. All the remaining bones both, examined and not, are at the Institute of Archaeology (Irbid/ Jordan). No material was discarded.

---

[1] and partly in the British Institute for Archaeology, Amman.

[2] That includes in some cases species identification, measuring, drawing, photographing *etc.*

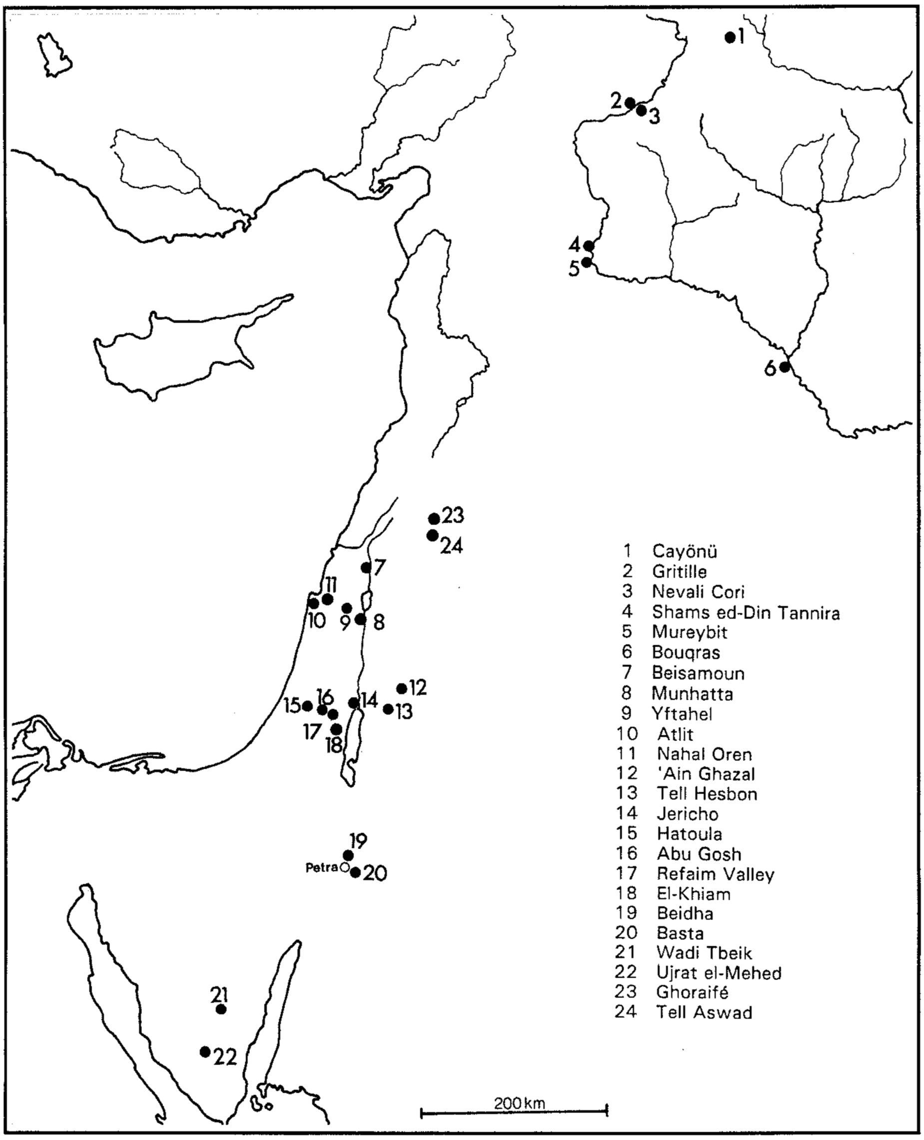


Fig. 1. Distribution of important Near Eastern sites mentioned in the text.

Preliminary archaeozoological results were already presented in some shorter reports (Becker 1987, 1991a and b). This paper constitutes the final publication of all data connected with the caprine remains from Area A[1]. For the bone material deriving from other species like equids and gazelles the same concept will be used.

The Faunal Remains

The complete sample unearthed in Area A comprises about 50 000 specimens. Research was restricted to the bones I analysed on location (n= 38 433) 54.2 % of which were identified (Table 1). This corresponds with 80.7 % of the total weight. The average weight of an identified bone or bone fragment was 4.8 g, an unidentified bone weighed only 1.4 g. That last figure illustrates well the great degree of fragmentation and the poor state of preservation of the material, especially if one considers that the majority of these bones stem from skeletal ele-

[1] The manuscript was completed in December 1993.

ments of middle-sized and large animals. The unidentified bones in terms of genus are grouped into three size categories (n= 17 604; Table 2). The largest group is represented by bone splinters being less than 1 g in weight and smaller than 1 cm (n= 16 266). I assume that most of them derive from goats and sheep. The same applies for the second category which consists of slightly larger and heavier (1.4 g) units. Category 3 includes bone fragments which most probably once belonged to large animals such as deer and onager. Those fragments average around a weight of 7.2 g. The ratio between small and middle sized mammals on the one hand and the large ones on the other as reflected by this unidentified material corresponds with the overall results obtained from the identified bones as shown in Table 3.

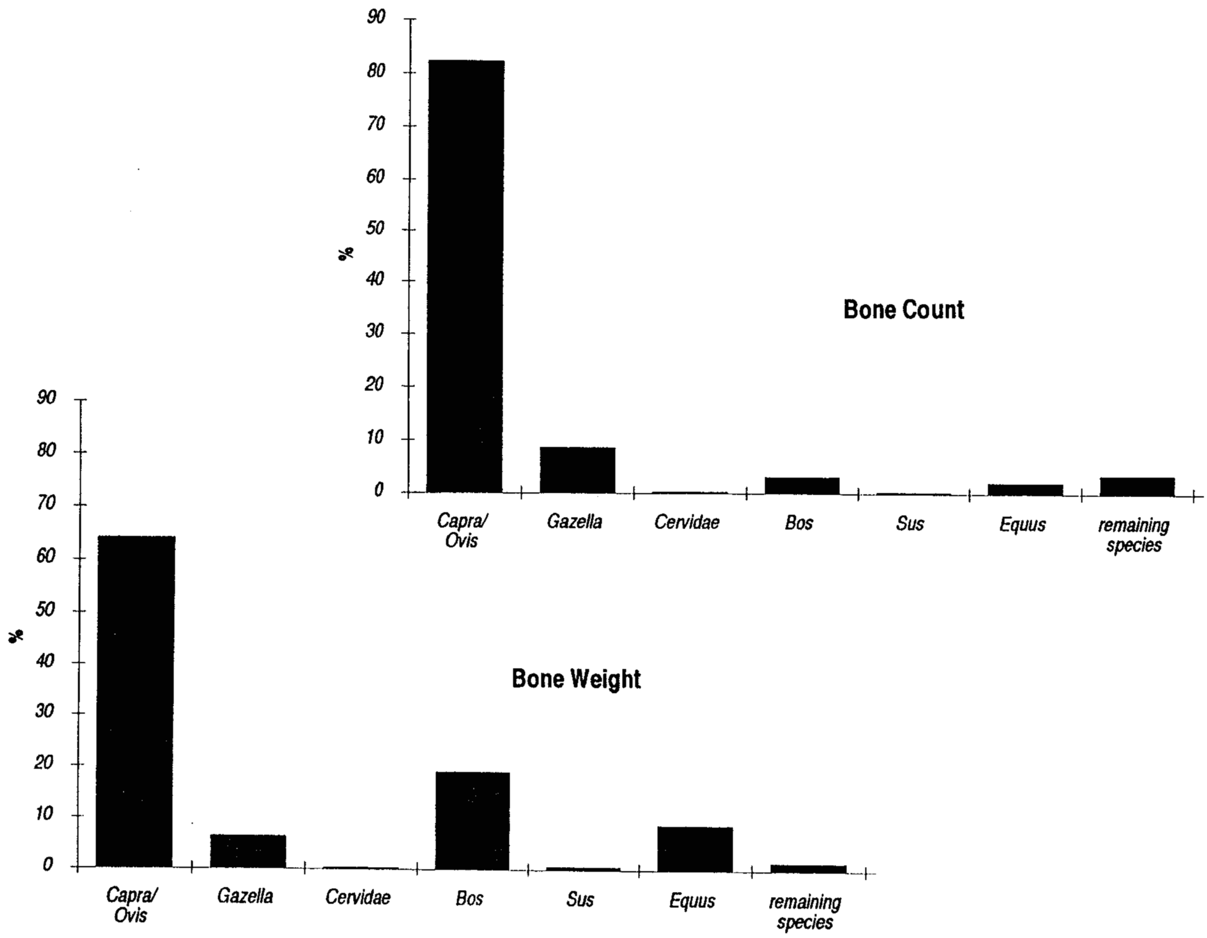


Fig. 2. Basta, Area A. Recovery rates of different taxa <*cf. Table 3*>.

Table 3 and Fig. 2 give the frequencies of genera and classes per bone count and weight[1]. On the basis of the total number of identified bones, *Capra* and *Ovis* form more than 80 % of the material. The second best represented genus is *Gazella* (8.5 %), whereas genera like *Bos* (3.1 %), *Sus* (0.2 %), *Cervus* (< 0.1 %), *Dama* (< 0.1 %), *Equus* (2.1 %) or classes such as carnivores and lagomorphs occur in far lower frequencies. From the perspective of weight, *Bos* (19.1 %) and *Equus* (8.7 %) exhibit comparatively large figures permitting rough estimations as to their relative importance in the meat diet of the Neolithic settlers. But as already reflected by the data obtained from the bone count, the majority of the meat was

[1] The MNI (minimum number of individuals) was not established because a detailed stratigraphical evaluation and identification to species level for gazelle and equid bones were not available as yet.

supplied by caprines as their bones add up to 64 % of the total weight of the sample. The figures in Table 3 nevertheless cannot be taken literally - they only reflect a trend.

Apart from some general comments on subsistence strategies and ecology this paper only treats one single data category: the caprine sample. One purpose of this report is to present a largest possible amount of data connected with the caprine remains in order to stimulate comparisons with available data from other sites and to contribute to the discussion on early domestication and trends within animal husbandry in this part of the Levant and adjacent regions.

Ecological Setting

The study on the fauna started out from the hypothesis that the evidence of animal remains is not only diagnostic of subsistence strategies, but in fact upholds considerable importance for zoogeographical and ecological interpretations as well. Due to the large quantity of discarded and preserved animal bones it becomes worthwhile to look upon them as among the prime evidence for the management of environmental resources. Other data can be obtained from botany, the flint artefacts, as well as agricultural and hunting implements. The bulk of the faunal sample may well be viewed as kitchen refuse as supported by the heavy fragmentation and carcassing patterns.

Although the Late PPNB evidence from Basta attests to goat and sheep husbandry as a major activity of the subsistence of the settlement (*cf.* next chapter but one) hunting remained a determining factor in everyday life. According to number and types of identified wild species, ungulates represent the most hunted animals. The variety of ungulates includes the goitred gazelle and the mountain gazelle, wild sheep, wild goat, onager, African wild ass, Persian fallow deer, red deer, roe deer, aurochs and wild boar (Table 4). Among these species two are typical elements of a steppe habitat: the goitred gazelle *Gazella subgutturosa* and the onager *Equus hemionus*. Unfortunately, neither for *G. subgutturosa* nor for *E. hemionus* the exact amount of bones can be given as long as their bones can not completely be distinguished from elements deriving from the closely related species *G. gazella* and *E. africanus* respectively. As we know from previous analyses (Becker 1991a), all four species do occur in the Basta bone assemblage. The former distribution of Levantine gazelle species in general is still under discussion (*i.e.* Tchernov *et al.* 1986/87). The occurrence of a considerable number of horn cores attributed to *Gazella subgutturosa* (and presumably at least the same amount of post cranial elements) found in Late PPNB levels of Basta might seem surprising on account that the main distribution area of the goitred gazelle is thought to have stretched much further to the North and North-East of the "Fertile Crescent" (Uerpmann 1987: 103). Basta would be at the southern boundary of the former spreading of *G. subgutturosa*. Next to Basta, only 'Ain Ghazal has produced some *subgutturosa*-bones (Köhler-Rollefson *et al.* 1988: 425). Gazelles are among the most regularly encountered animals in all twelve PPNB settlements listed in Table 4. By comparison only wild boar and aurochsen are encountered on a similar scale although a lot less often.

Like the goitred gazelle, onagers typically frequent semi-desert plains and steppes. Both species prefer a large variety of different food plants and are able to profit by meagre halophytic vegetation (Heptner *et al.* 1966). To a certain degree the hare has to be added to this category of steppe animals, although hares can also be met in hilly regions covered with trees and bushes. Even wild sheep as they are good runners and thrive well on many types of shrub vegetation in semi-arid and arid steppes, could have been hunted in these flat plains. Hunting fast ungulates in this open landscape favours the use of bow and arrow. This is supported by the presence of a number of silices, labelled as "arrow heads" as well as other implements which could have been used as hunting projectiles.

The former inhabitants of Basta also hunted those animals that preferred hilly areas with open woods or fringe forests near the wadi borders. The "forest" element is mainly represented by wild boar, cervids and to some extent by wild cattle, too. Fallow deer, red deer and roe deer are generally said to inhabit similar habitats. They require reasonably large areas of high and dense vegetation to find cover and adequate food plants. A broad biological adaptability supports their wide distribution. They differ slightly to another by their specific methods of adapting to rapidly changing environments and partly as well by distinct biological requirements[1]. It is surprising to note that these cervids are missing in the slaughter and consumption residue of Beidha and 'Ain Ghazal (Table 4). Both sites have produced a great amount of bone material which seems to indicate that there is more to this phenomenon. In this respect a possibility of preferential hunting patterns can not be excluded which in this instance would form a "cultural filter" leaving out particular animals from the dietary plan. In PPNB layers of Yiftahel (Lower Galilee) fallow as well as roe deer have been identified. Due to climatic factors a North-South cline in cervid abundance occurs. In the dry and fairly hot environment of the Southern Sinai (Wadi Tbeik, Ujrat el-Mehed) the absence of deer was to be expected. The same applies to the boar remains (*Sus scrofa*) which are only absent in the two most Southernly located sites listed in Table 4. Although adaptable to many different biotopes, wild pigs are quite heat sensitive and require a steady water supply. Their occurrence in the Basta sample marks the Southern boundary of their distribution in the Levant (Uerpmann 1987: 45). On the other hand, the recovery of bones of *Bos primigenius* in settlements located in Southern Sinai is striking as these large ruminants highly depend on the availability of fresh drinking water at least every second day. Their demand for food plants, on the other hand, seemed to have been relatively unspecified. It is generally accepted that *Bos primigenius* tolerated a wide spectrum of vegetation[2]. The occurrence of aurochsen in Wadi Tbeik and Ujrat el-Mehed might either suggest a greater tolerance toward high temperatures and water deficiency or in fact a more humid and slightly cooler climate in the Southern Sinai during the 7th to 6th millennium B.C.

Another species represented by a considerable portion of the Basta bone sample is the African wild ass. Its presence at Basta was to be expected as it had already been identified at other Near Eastern sites, for example Mureybit (Ducos 1970, 1986), Shams ed-Din (Uerpmann 1982, 1986) and Ras al-Hamra (Uerpmann 1991). During the Early Holocene, wild asses were widely spread over parts of the Arabian Peninsula (Uerpmann 1987: Fig. 9). The ancestors of domestic donkeys are now confined to remote, arid parts of Africa, where they feed on almost any vegetation. It can be assumed that wild asses avoided sand deserts, but inhabited most probably grass covered plains, hills and rocky landscapes. These animals are said to be good climbers which move well in difficult terrain (Dorst and Dandelot 1970: 117). Consequently these animals would have found adequate habitats in the hilly and mountainous environs surrounding ancient Basta. In the bone refuse of nearby Beidha only bones of onagers occur, although the landscape there seems even more suitable for wild asses than near Basta[3]. The complete lack of equids in PPNB levels of 'Ain Ghazal is striking

---

1 Among the cervids, the Persian or Mesopotamian fallow deer tolerates for example the highest temperatures. Dense growth of tamarisks, willows and poplars characterise its habitat (Chapman and Chapman 1975: 215 ff.). The red deer can primarily be characterised as a species preferring temperate woodland.

2 The aurochs was a non-obligatory grazer, but presumably did not survive exclusively on grass and herbs but also leaves. It is generally excepted that the Mediterranean woodland where wild cattle would have found adequate food was more widespread in prehistoric times than recorded today.

3 The Beidha material will be re-analysed by S. Bökönyi and he told me that some equid bones most probably can be assigned to *E. africanus* in contrast to former judgements (Bökönyi, oral comm. 1992).

(Table 4). Another mountain- or hillside- ungulate has to be mentioned: *Gazella gazella*. The exact amount of bones of this species has not been established as yet, but its occurrence within the Basta assemblage has been confirmed (Becker 1991a: 68). As observed by Mendelssohn (1974: 729) mountain gazelles may even rush down steep ravines at full speed without effort when fleeing. Otherwise they prefer open country with some trees and bushes which they use for shade. They generally feed in a goat-like manner. *G. gazella* grazes and browses a large variety of plants, even succulents. The mountainous areas with gorges and steep slopes were also inhabited by wild goats who are typical steep-rock dwellers. They were hunted regularly by the inhabitants of Basta and many other sites in the region. Wild goats are superb and fast climbers. Because of their agility they are able to reach herbs and leaves of shrubs in even extremely difficult terrain. They have a relatively short flight distance, barely feeling safe in this highly structured and remote ground. They are very hard to follow. This terrain favours hunting by ambushing from distances which are easily overcome by hand flung weapons or arrows catapulted by a bow. In the light of the evidence from nearby Beidha, even ibex could be expected in the Basta bone collection, as these animals are said to live in a similar macro-habitat like *Capra aegagrus*. Furthermore, Basta is located close to the presumed zone of contact between *C. aegagrus* and *C. ibex* (Uerpmann 1987: 134). Hence, neither horn cores nor any post cranial elements of ibex could be recovered in the Basta material, as far as my present research is concerned.

Unlike the ungulates species foxes, cats and other carnivores were only very rarely hunted. Only hares occur in relatively high numbers (n= 274 = 1.3 %; Table 3). It has to be checked whether the small numbers of identified reptiles and rodents should be added to the consumption residue or whether they belong to the natural thanatocoenosis. Bones of birds were scarcely found. Like the other, as yet unidentified taxa they will be published in detail elsewhere (Becker, in prep.).

To sum up, the Basta bone sample provides data which reflect the intensive exploitation of a diverse area topography. It yields considerable contribution to our knowledge about the occurrence and range of wild ungulates in the Southern Levant during the 7th millennium B.C. The striking co-occurrence of closely related species whose bones have accumulated within 400 or 500 years of cultural activities at Basta, is to date not totally understood and needs further study. Taking for example into account some hypotheses regarding the ancient distribution of onagers and wild asses (Uerpmann 1991: 30) it does in fact no longer seem appropriate to deny that *E. hemionus* and *E. africanus* inhabited the same macro-habitat (in different altitudes) and that the same applies for other ungulate species such as *Gazella gazella* and *G. subgutturosa*, too. Furthermore, it becomes evident that the PPNB period in this area was characterised by a broad-spectrum economy. A corresponding result has been achieved from archaeozoological analysis of the PPNB material of 'Ain Ghazal where more than 50 different species have been identified (Köhler-Rollefson 1989a, b).

Stratigraphical Analysis

Particular emphasis will be accorded to the distribution of species in the southern part of Area A. The faunal samples are grouped into three categories concerning their stratigraphical provenience: 1. bones from the surface deposits, 2. bones from room fills and 3. bones from substructures. Substructures and room fills can be characterised as belonging to the same cultural level. As already mentioned, the length of cultural activities represented in the accumulations of room fills, is estimated to have spanned 400 to 500 years. As for the surface deposits time evaluation seems impossible. Thus, the following hypothesis can be advanced: archaeologists on the one hand imagine that rooms suited for dwelling were cleaned from any refuse during usage and that on the other hand storage facilities were emptied when given up.

Accordingly debris from elsewhere only got there after they had lost their original function. As the site is in fact located on a steep slope, slope erosion has had a significant effect on the archaeological setting. Hence, a certain part of the archaeological deposits including the animal bones, may actually originate from cultural levels from another site located further up the slope[1]. Qualitative differences between the contents of room fills/ substructures and the surface deposits are to be expected on account of differencies in subsistence strategies being practised in the assumed two settlements. To a certain extent the findings do in fact differ one from each other (Table 5): in the substructures and the room fills, the amount of gazelle bones is twice the size (11.1 % - 11.5 %) of that from surface deposits (5.5 %). The occurrence of aurochsen[2] doubles from 2.5 %/ 3.0 % in the lower levels to 5.8 % in the surface deposits. Pigs even only occur in the surface deposits in low numbers (0.1 %). It is obvious that the small ruminants dominate the faunal assemblage in the room fills as well as in the surface material. As will be seen below, no drastic changes in the percentages of wild versus domestic goats and sheep can be detected. Despite some differences mentioned above, the overall impression dictated by the caprine remains is one of a relatively coincident composition of faunal material in both stratigraphical compounds, whatever their initial provenience.

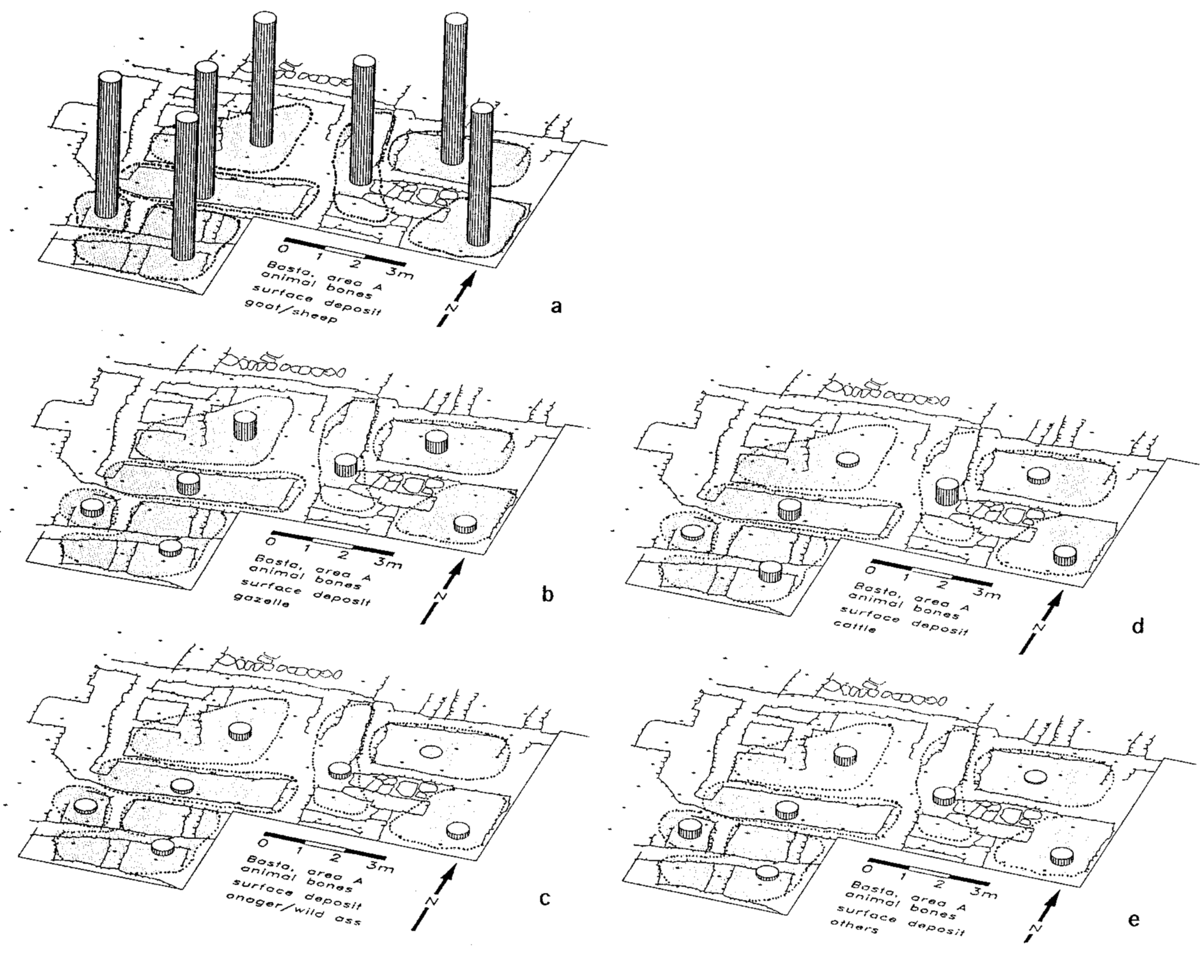


Fig. 3. Basta, Area A. Relative distribution of genera in the room fills *[basis: bone count).*

---

1 Nevertheless, the total filling of these units from floor to bottom can be dated by the occurrence of thousands of flint artefacts to the period of the Late Pre-Pottery Neolithic, although the lithic repertoire slightly differs in the upper and lowermost sequence of accumulations (Gebel, oral comm. 1992).

2 which presumably are even located at the very beginning of a domestication process (*cf.* Becker 1991a: 66f.).

Turning now to the horizontal distribution (Plate 1.c), it can be affirmed that within the surface deposits animal bones were irregularly distributed with a slight concentration in the Western part of the area. Discrepancies occur in the amount of material per unit. Some units were filled with a dense package of animal bones (Unit 32, 29), others were almost empty (39, 34). The highest concentration can be detected in the Eastern and Northern part of the area. Sometimes, the accumulation of finds varies a lot within the same area, *i.e.* the surface deposit above unit 28 was relatively rich in bones (n= 1657) whereas the room fill located directly beneath contained only 106 specimens. Other examples exhibit contrasting findings, *e.g.* in unit 32 not only the room fill (n= 1750) and the substructures (n= 446) but also the surface deposits (n= 784) yielded a large amount of material. Each room fill is dominated by a high amount of caprine bones (Fig. 3, first line). These remains will be dealt with in detail in one of the following chapters. The horizontal distribution of gazelle, equid and cattle bones is demonstrated in Fig. 3, Lines 2 and 3. These species seem to have had an overall similar history of accumulation. Differences in the patterning of gazella and onager bones might be explained through the context with other archaeological remains, a future task.

Capra and Ovis: Species Identification

Bones of sheep and goats make up the bulk of this collection. The total amounts to more than 17 000 units. The fragmented condition of the bone assemblage has often made it difficult to distinguish between goat and sheep. In the charts therefore both species are often treated as one group and referred to as "caprines" in the text. The method of species identification was largely based on the generally accepted and often cited criteria, worked out by Boessneck *et al.* (1964), Boessneck (1969), Payne (1969), Clutton-Brock *et al.* (1990), Clutton-Brock and Uerpmann (1974), Noddle (1978), Geddes (1985), Davis *et al.* (1982) and many other archaeozoologists. One of the oldest studies which also gave me some precious hints was written in 1926 by Wetzel. There is a large body of basic research which can be applied to questions of goat-sheep differentiation. For this reason, a comprehensive list of references to particular criteria will not be given in this paper. All such can be found within already existing summaries named above. My aim was to identify and catalogue as close as possible every typical caprine bone found in this very assemblage, and evaluate the reliability of distinctive characters detectable from internal evidence. As Clutton-Brock and Uerpmann (1974: 262) have pointed out "the range in variation of the characters often differs from one archaeological site to another".

In this chapter not only the identification of species but also the metrical diversity of the caprine remains will be discussed touching another main problem concerning the caprine bones: the recognition of their wild and/or domesticated nature. It is generally accepted that the domestication of many species is next to other criteria outlined by a diminishing process (*i.e.* Horwitz 1989: 160, Herre and Röhrs 1990: 222ff.). This diminution is expected to be reflected in the size and dimension of every skeletal element of a domesticated animal. In such cases where size variability of the wild ancestors is known, measuring length, width and diametre of a questionable bone provides us with data which would characterise the provenience of a particular element. Unfortunately such a necessary amount of comparative data does not exist neither for *Ovis* nor for *Capra* populations having once roamed about the Levant. The range of variation in both metrical and morphological features of wild caprines is not fully understood to date. Data from recent animals lose their value for any prehistoric comparison considering that they are remarkably smaller than those that lived in the same region some thousand years ago. This fact increases substantially the problem of evaluating prehistoric samples of questionable domesticates. For *Capra*, Uerpmann (1979: 110) puts it: "Ein Vergleich der Variationsbreiten zeigt, daß Tiere von der Größe der beiden rezenten Individuen im bronzezeitlichen Haustiermaterial nicht aufgefallen wären. Dies wiederum ist ein Beleg dafür, daß durch Größenvergleiche zwischen rezenten Wildziegen und prähistorischen Ziegenfunden der Eintritt der Domestikation nicht hätte festgestellt werden können". The comparison of measurements from the Basta bone sample with data from caprine populations having existed in adjacent regions or lived during other cultural periods might be helpful but at the same time poses other problems. It is nearly impossible to estimate in how far differences in climate, vegetation, nutrition, herding practise, to name but a few, might influence body growth of a domestic stock and entails differences in size and proportion of individuals respectively.

For the following description I would like to focus mainly on those skeletal elements which are well preserved, occur in considerable numbers and in such state of preservation to allow measuring. Small numbered or/and poorly preserved, unmeasurable fragments are disregarded which applies for numerous cranium fragments, upper and lower jaws, most of the horncores, vertebrae, pelves and femora. Carpalia, tarsalia, patellae, the second and third phalanges as well as other small elements were also obliterated in the descriptive part of the manuscript[1], although I tried to analyse them as closely as possible. As an example two horn cores from this category are presented in Plate 2[2]. I first made a sorting of "at first glance" goat and sheep bones with only better preserved elements deriving from adults and after that, turned over to less completely preserved pieces and bones from non-adults. Only those elements were measured which could be identified as to *species* level. Measurements were taken according to the publication of von den Driesch (1976). If additional measurements were necessary, these are named and outlined at the end of Table 21. The measured bones are not assigned to their special location within the stratigraphical context because the sequence of debris accumulation and the differentiation of layers are not fully worked out yet in detail for the entire Area A.

Scapula: In the sample of caprine scapulae found in Basta Area A, unquestionable morphological differences can not be seen in the form and shape of the glenoid cavity, in the appearance of the fossa synovialis or in the occurrence of the so-called pecten on the posterior border of the neck (these are said to be present mainly in sheep scapulae). Most of the shoulder blades reveal an intermediate, somewhat ambivalent character. Three other criteria were more useful for a distinction between these two species: a. The processus coronoides often was angularly shaped in goat scapulae whereas in those of sheep it mostly had a rounded profil; b. the heigth of the neck was considerably shorter in sheep than in goat scapulae (*cf.* Plate 2.c, d); *c.* the angle of spina and blade in their position to each other differed considerably. In sheep the spina juts out over the anterior margin (in the neck region) while in goat scapulae, the spina rises vertically, immediately above the blade in an upright manner. In addition to this, the shape of the scapula's neck differs a lot in both species: in goat, the anterior and posterior margin run over a long distance more or less parallel to each other, forming a rather straight collum. On the other hand sheep scapulae have a more curved, waisted collum. Only the first mentioned character (heigth of neck) produces any useful results on a metrical basis. Differences between Capra and Ovis are evident (Fig. 4.a, Table 21). The larger dimensioned shoulderblades most probably come from from wild species. Taking all aspects into consideration, which are known for the characterization of caprine scapulae, I find the results less than satisfactoryly, because a relatively large amount of scapulae from Basta remain unspecified.

---

[1] because the time at my disposal for analysing the Basta material was limited.

[2] In total, 21 horn cores of domestic goats (Plate 1.a), one of a domestic sheep (Plate 2.b) and six horncores of wild goats were discovered in the material from Area A. Unfortunately the latter were that badly preserved that measuring had become impossible.

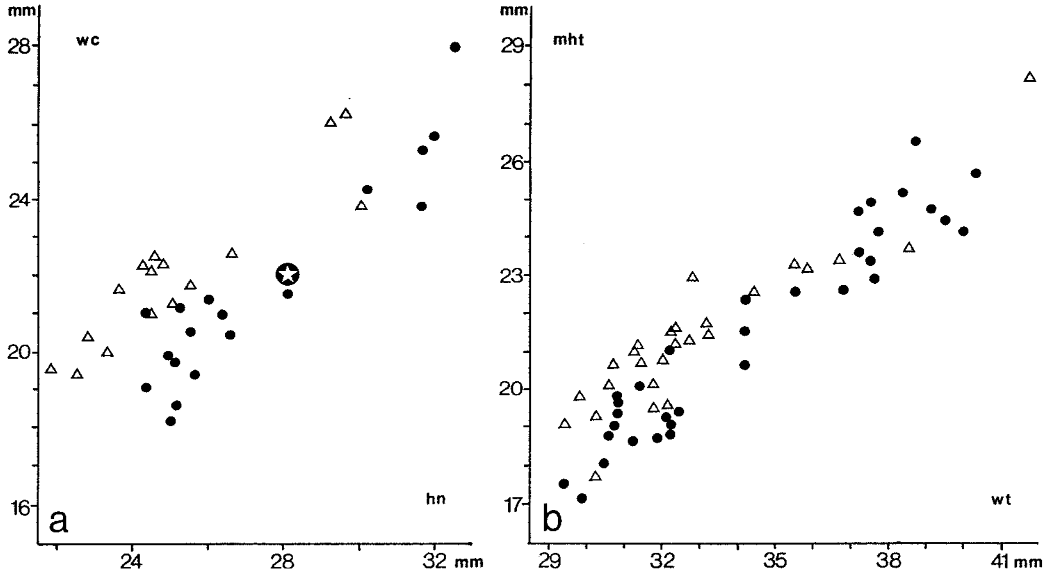
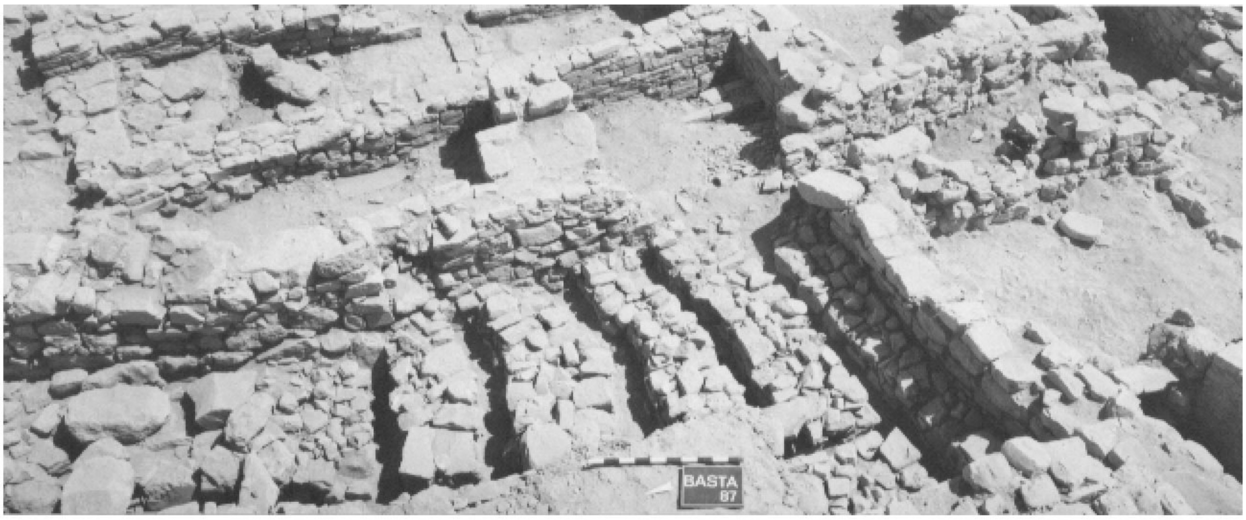


Fig. 4. Basta, Area A. Caprines: divariate plotting of measurements
[Capra (circle), Ovis (triangle); Ovis Jericho (star). a Scapula (hn height neck, wc width collum), b humerus (wt width trochlea, mht medial height trochlea].

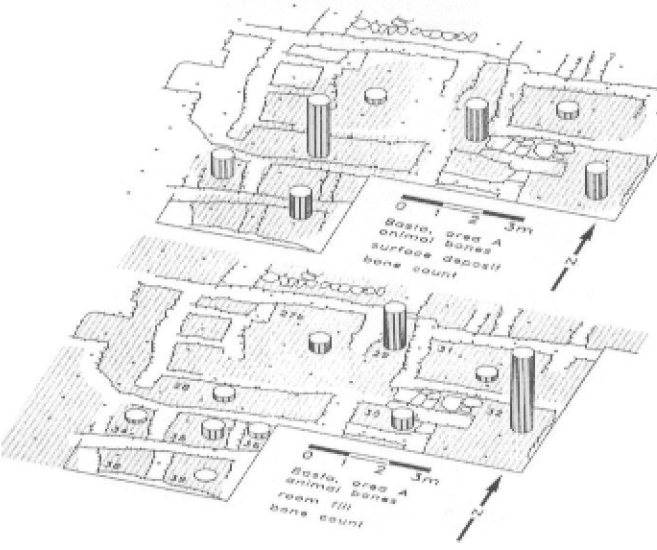
Humerus: Within this caprine material, no proximal ends of humeri with fused epiphyses were preserved which would allow species identification. The distal parts of humeri from adult (and subadult, *cf.* Plate 3.a, c) caprines can be identified quite easily. 1. The medial epipcondylus of sheep humeri has a rounded shape and is formed in a rather right- or an obtuse angle (Plate 3.c) whereas in goat this edge looks as though it has been cut off obliquely (Plate 3.f). 2. The trochlea humeri varies a lot in both species with regard to proportion and shape. In goat the lateral and the medial heights differ only to a relatively small extent. The overall impression is one of an elongated, slender trochlea (Plate 3.a, d). In contrast to this, the trochlea of sheep humeri is relatively high on the medial and conspicuously low on the lateral side. The projectible angle is considerably wider than in goat humeri (Plate 3.b, e). 3. The crista sagittalis is more sharply developed in goat than in sheep humeri. 4. The position of the crista sagittalis and the ratio of the pars medialis versus the pars lateralis differs clearly in both species. I tried to grasp these criteria metrically, but it did not produce very satisfying results. It might be worth noticing that one of the measurable sheep humeri stands out by its enormous size (Fig. 4.b).

Radius and Ulna: The most distinctive features of those radii preserved in their proximal parts are 1. the prominently developed lateral edge in sheep and 2. the fusion area between radius and ulna. This area is relatively small, less sharply limited in sheep radii (Plate 4.c) and more elongated, furrowed and standing out considerably from the shaft in goat radii (Plate 4.a, b). In the ulna this part of the bone is formed correspondingly to the criteria mentioned for the radius (Plate 4.d, e); other characteristic features could not be observed because of the bad preservation of this skeletal element. In the distal joint of goat radii, the facet for the articulation with the os carpi radiale is clearly dented in, while in sheep radii this facet is flat (Plate 4.i, j). Measurable and unmeasurable radii show a broad variation in size, indicating the heterogeneous character of this material (Table 21, *cf.* Plate 4.a, b and f, h). Even some unfused distal epiphyses of radii are outstanding for their large size (Plate 4.g).



a

b



c

Plate 1. Basta, Area A. Distribution of animal bones in the southern part of excavation.
a view of the southern part of the excavation (from W, status of excavation in 1987),
b view of the southernmost part of the excavation (from NW, status of excavation in 1987),
c scetch map with the relative amount of animal bones distributed in surface deposits (n_T= 5307) and in the room fills (n_T= 3738).

Plate 2. Basta, Area A. Caprines: horn cores and scapulae: *Capra hircus* (a female, c), *Ovis aries* (b male/ female, d) (Scale 1:1).

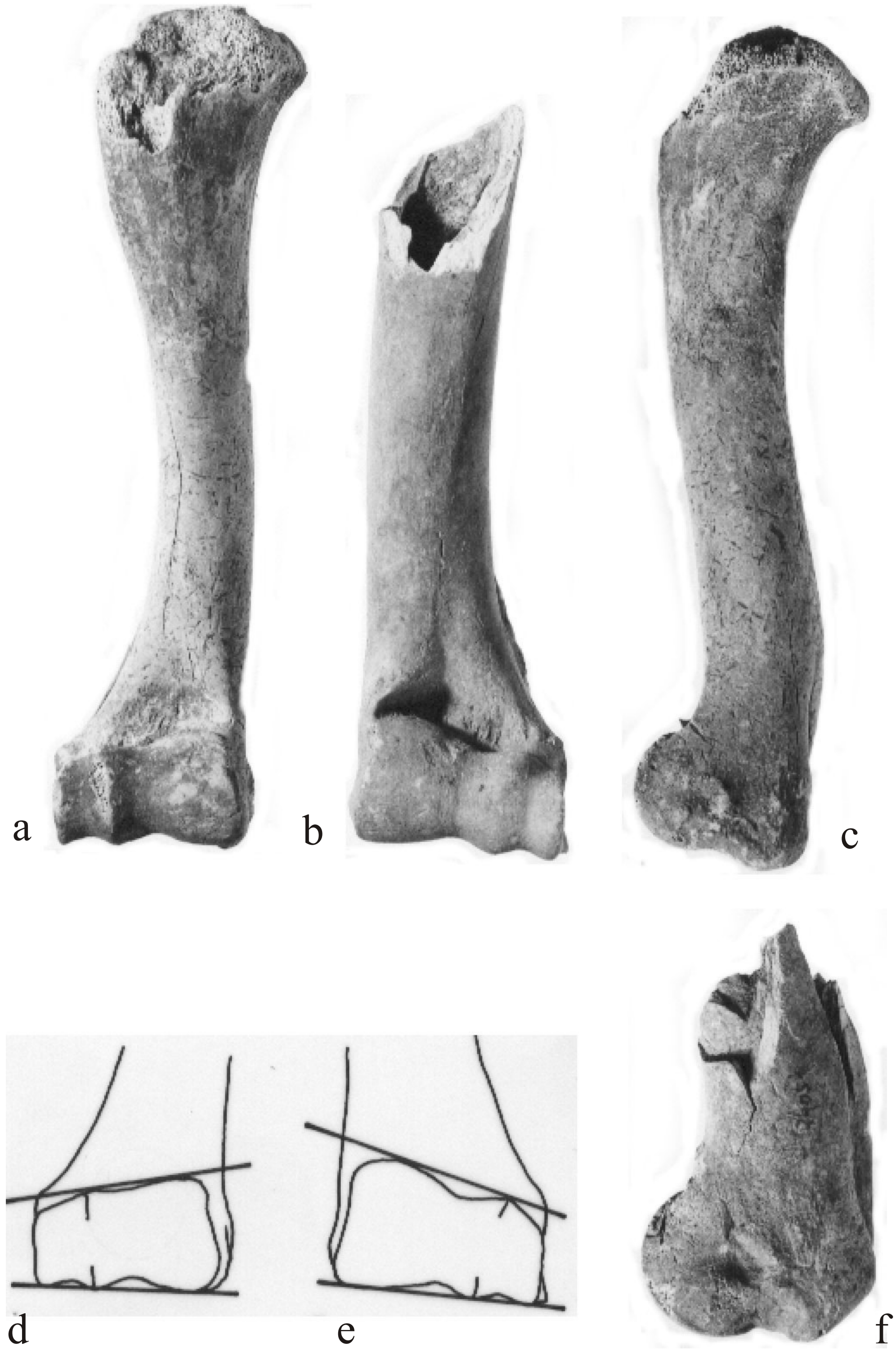


Plate 3. Basta, Area A. Caprines: humeri "prototypes".
Capra hircus (a,d,f), *Ovis aries* (b, c, e)) (Scale 1:1).

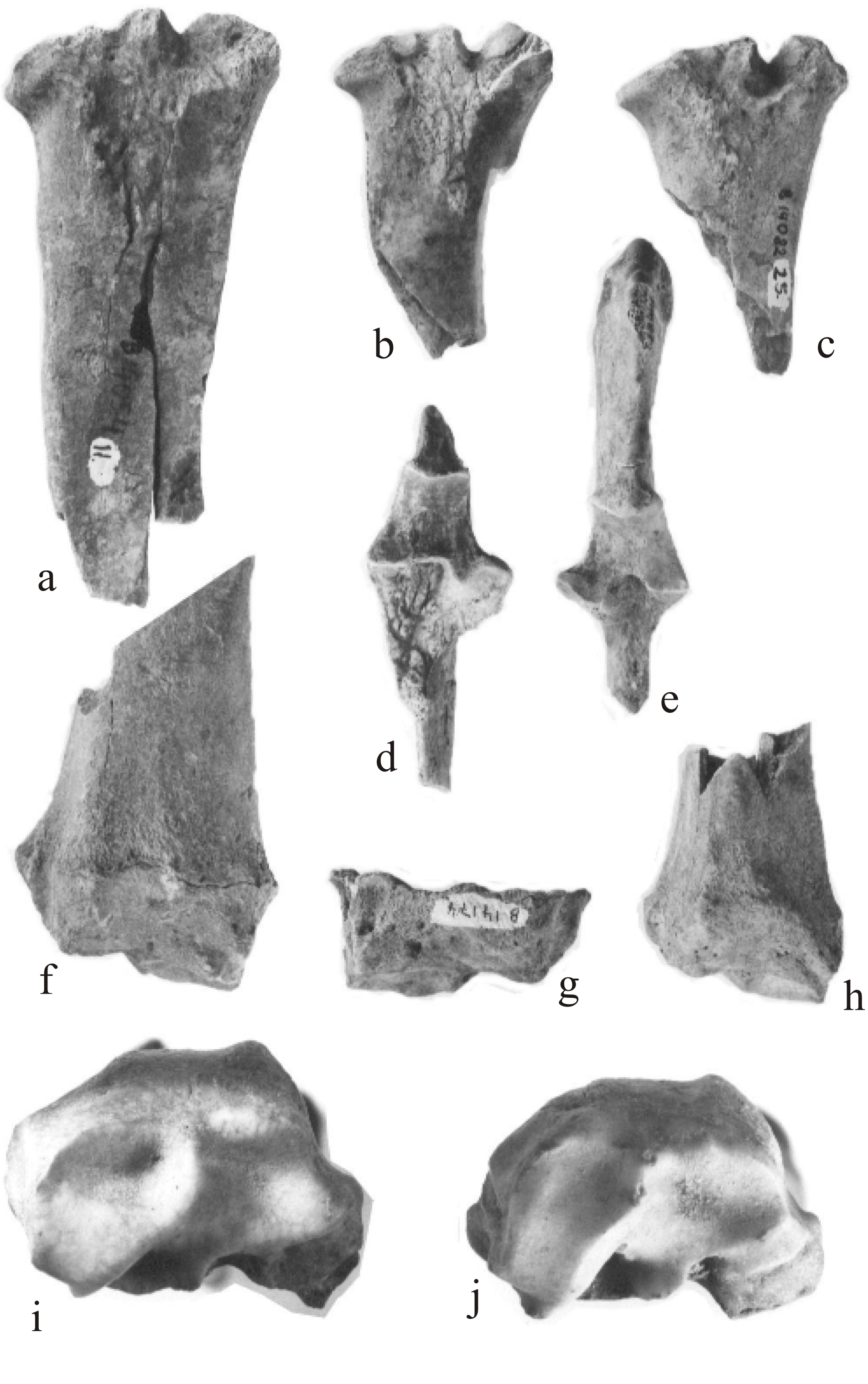


Plate 4. Basta, Area A. Caprines: radii and ulnae "prototypes". *Capra aegagrus* (a,f,g?), *C. Hircus* (b, d, h, i), *Ovis aries* (c, e, j)) (Scales a-h 1:1; j 2:1).

Plate 5. Basta, Area A. Caprines: metacarpi "prototypes". *Capra aegagrus* (h), *C. Hircus* (a, c, d, i), *Ovis orientalis* (f- from Area B!), *Ovis aries* (b, e, g)) (Scales a, b 2:1; c- i 1:1).

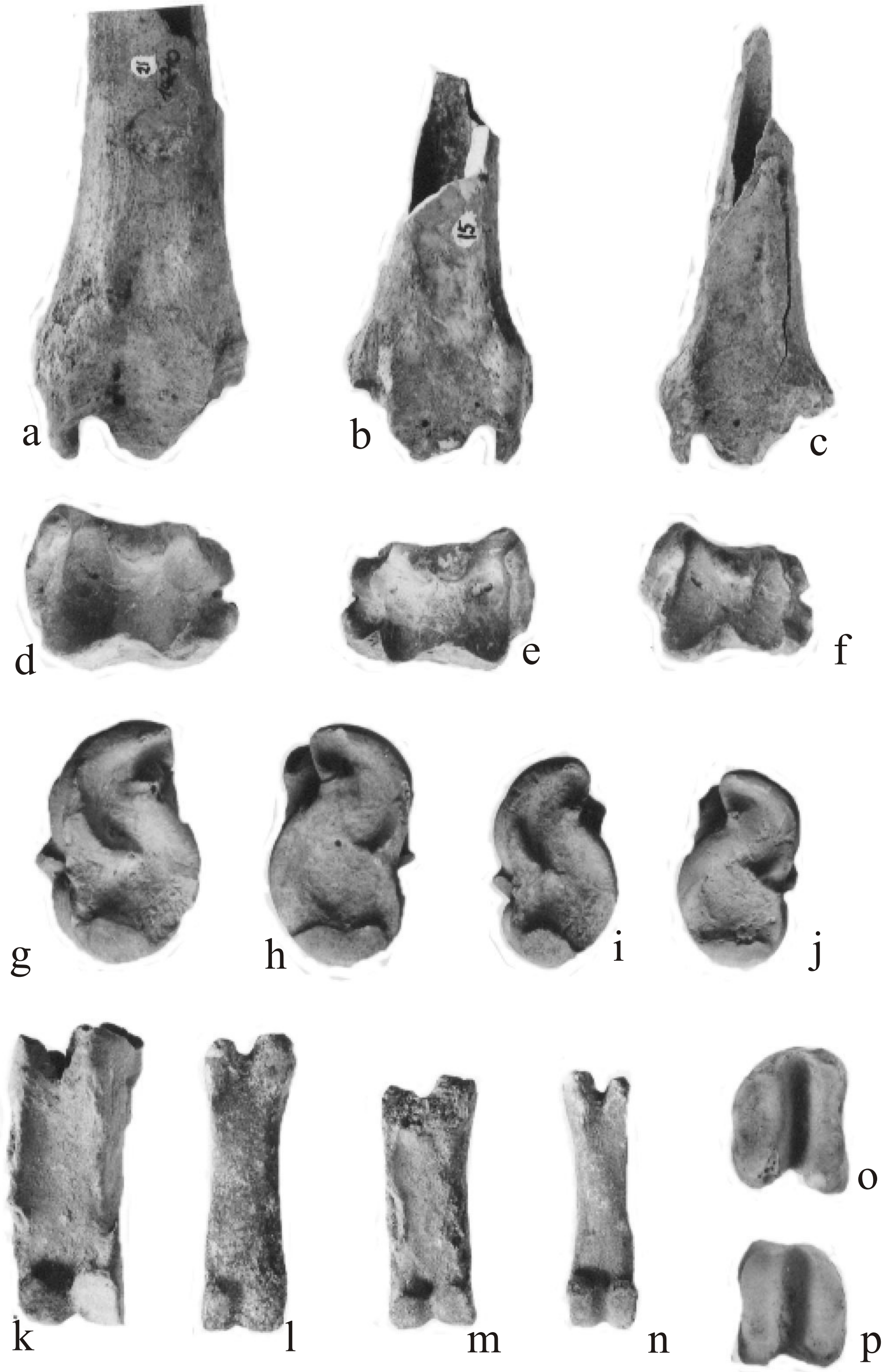


Plate 6. Basta, Area A. Caprines: tibiae, tali and first phalanges "prototypes". *Capra aegagrus* (a, d, g, k), *C. Hircus* (b, e, i, m, o), *Ovis orientalis* (h, l?), *Ovis aries* (c, f, j, n, p) (Scales a-n 1:1; o, p 1,7:1).

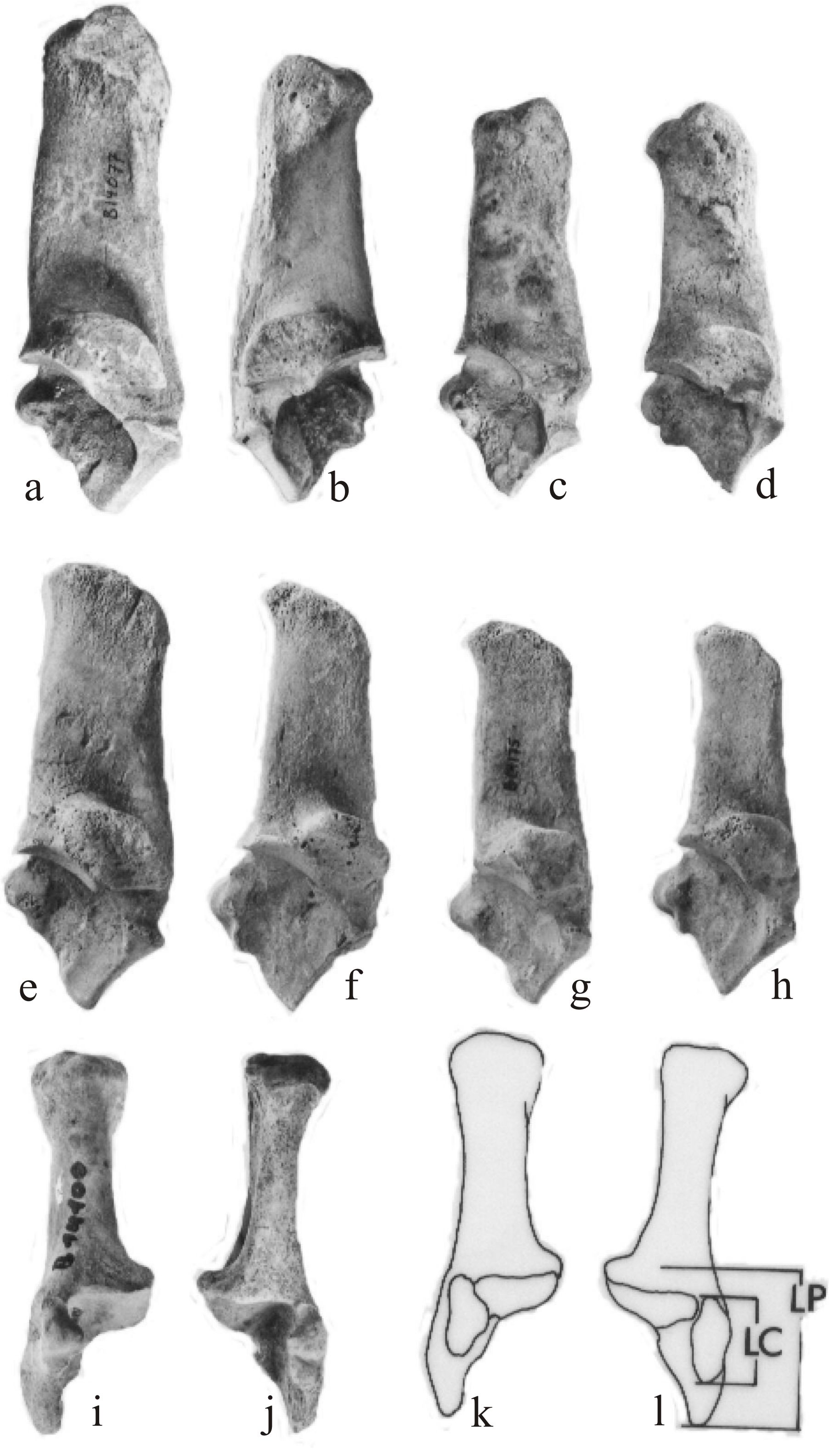


Plate 7. Basta, Area A. Caprines: calcanei "prototypes". *Capra aegagrus* (a, e juvenile), *C. Hircus* (c, g juvenile, i, k), *Ovis orientalis* (b, f juvenile), *Ovis aries* (d, h juvenile, j, 1) (Scale1:1).

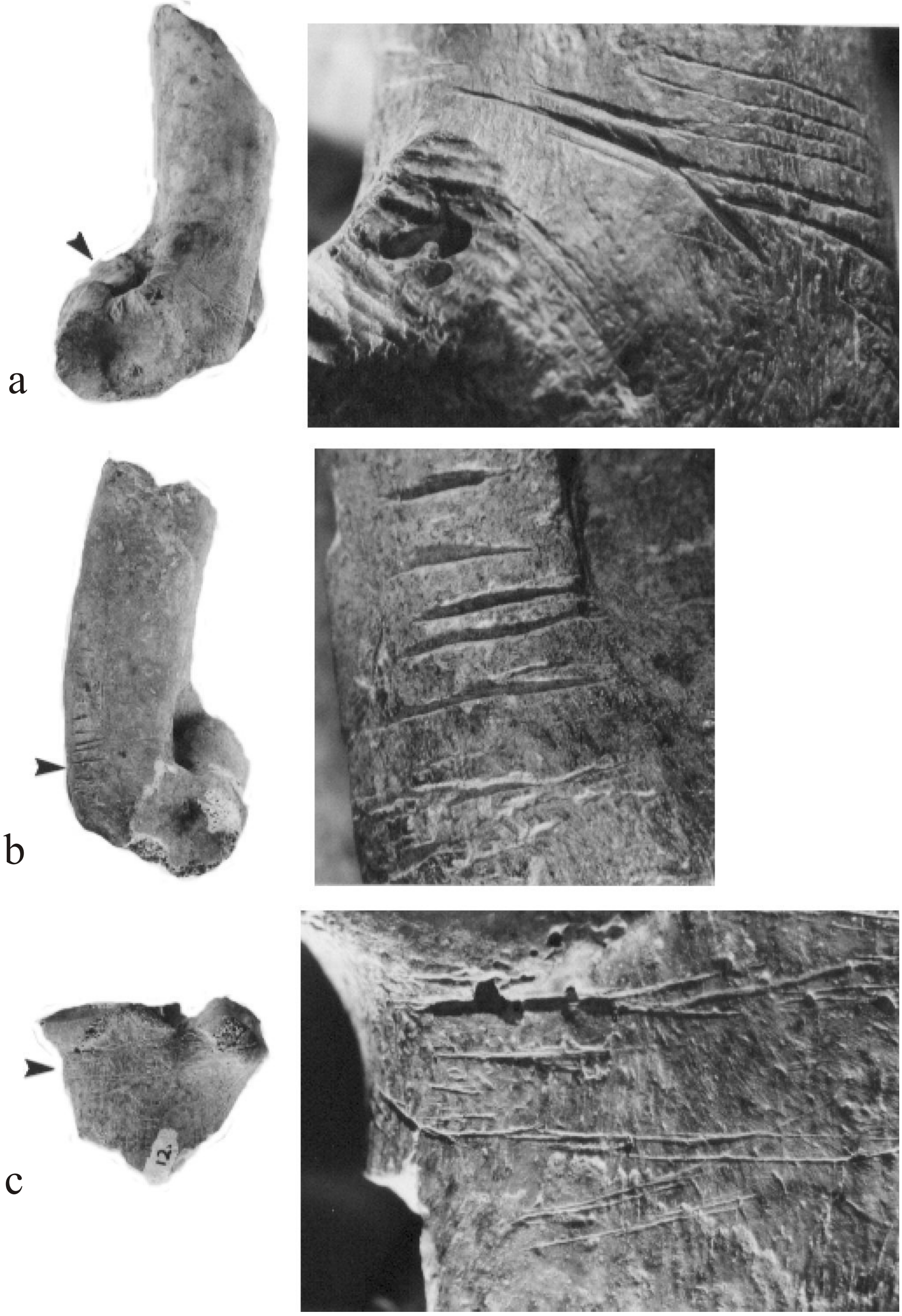


Plate 8. Basta, Area A. Caprines: location, size and appearence of cut marks on humeri (a, b) and radii (c) (Scale1:1, details (right) magnified 5.5 times).

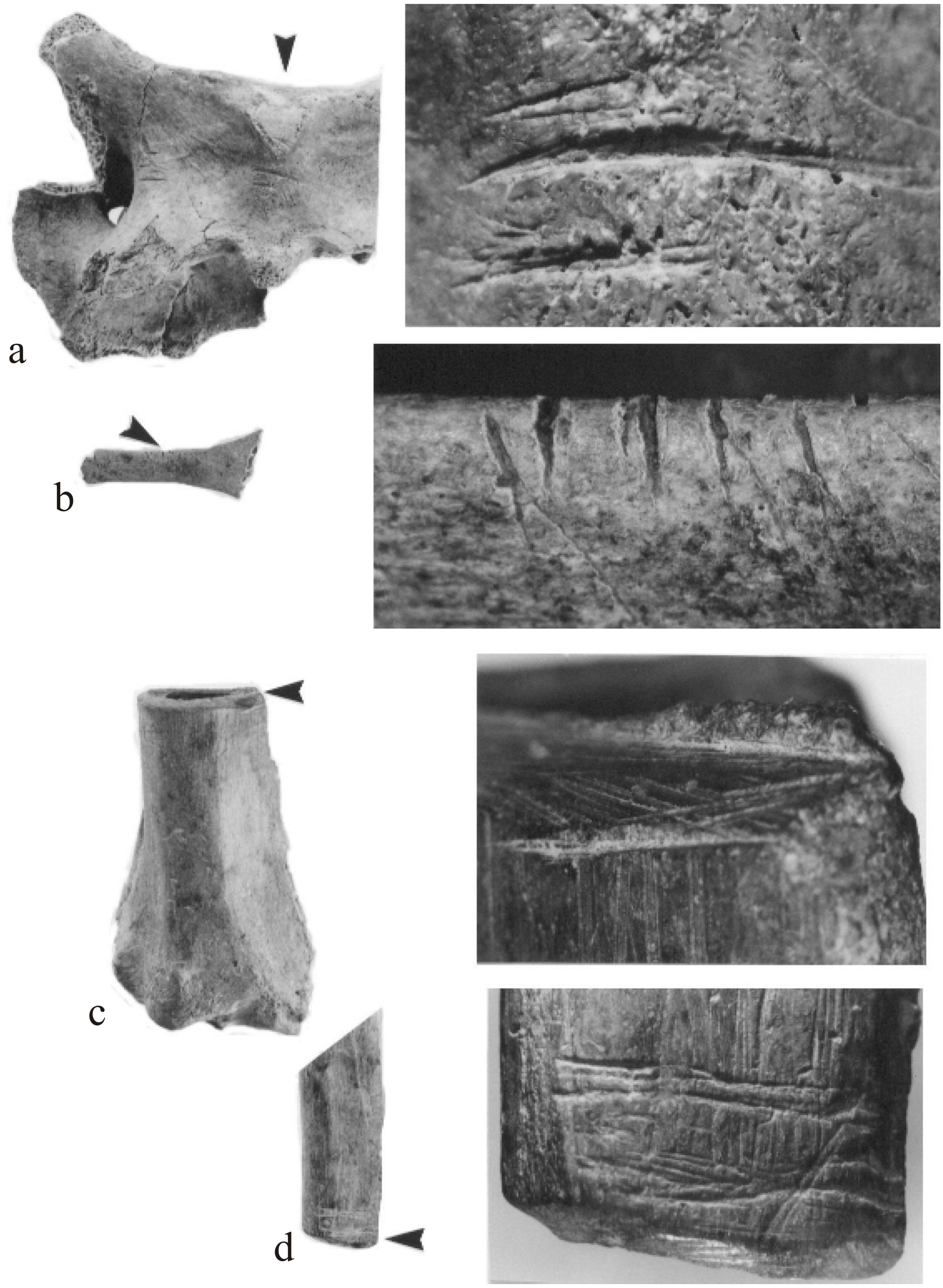


Plate 9. Basta, Area A. Caprines: location, size and appearence of cut marks (a, b) and saw marks (c, d) on atlas, os hyoideum and radii (Scale1:1, details (right) magnified 8 times).

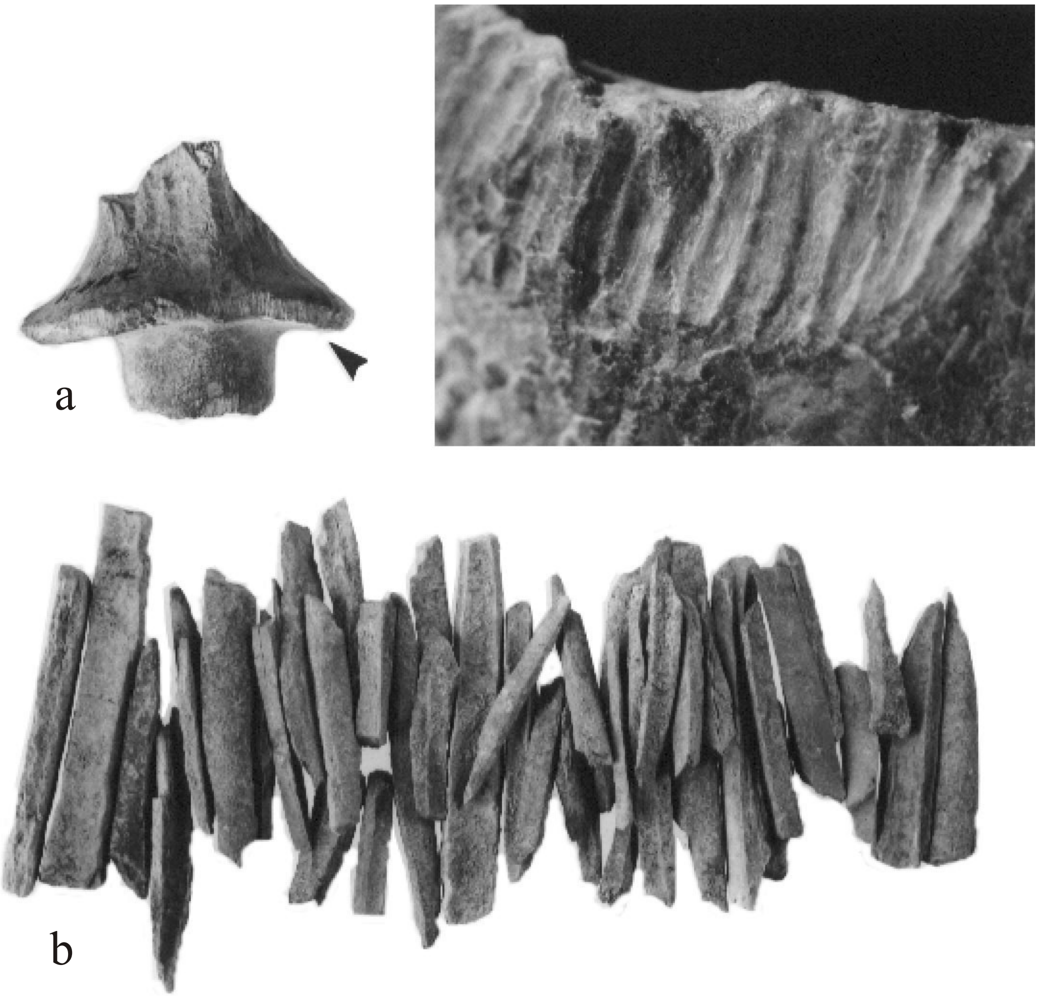


Plate 10. Basta, Area A. Caprines: lepistropheus with gnaw marks (a) and some examples of typically splintered metapodial shaft fragments (b) (Scale1:1, details (right) magnified 8 times).

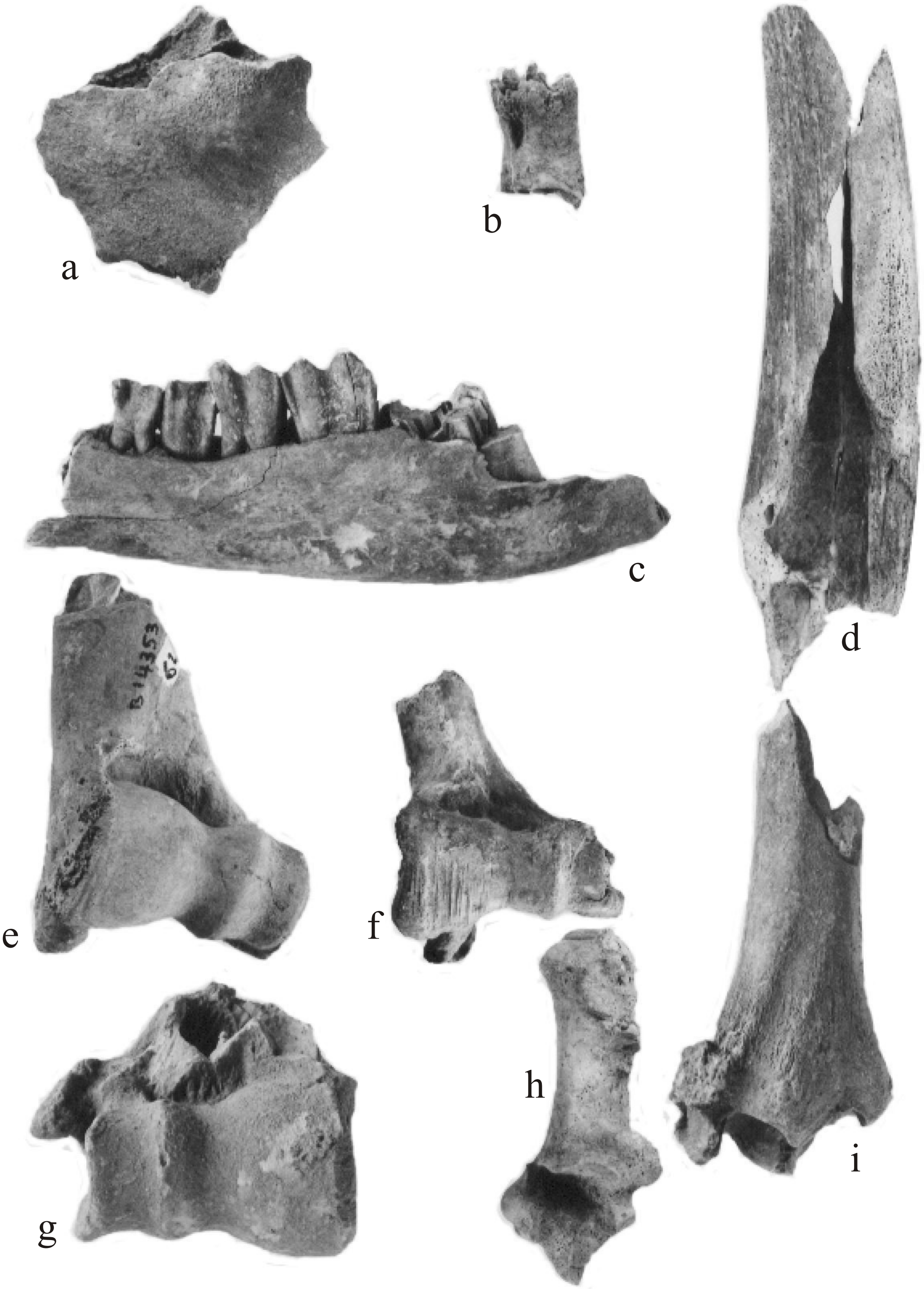


Plate 11. Basta, Area A. Caprines: abnormalities, pathologies. *Capra hircus*: hornless cranium (a), *Ovis/ Capra*: dens superior (b), *Capra hircus*?: mandibula (c), *C. hircus*: horn core (d), *C. aegagrus*: humerus (e), C. Hircus: humerus (f), *O. orientalis*: humerus (g), *O. aries*: calcaneus (h), *Capra*: tibia (i) (Scale 1:1).

Metacarpus and Metatarsus: The morphological and metrical distinguishing features in goat and sheep metapodials have already been discussed at length (Payne 1969, Schibler 1980, 11). In the Basta caprine sample excavated in Area A, these generally accepted characteristics can be recognized as well (Becker 1991: 65f.). In addition, it can be stated that discrimination between goat and sheep metapodials was more successful in the distal than in the proximal articular part of these skeletal elements. Furthermore, these differences occurred more clearly in metacarpi (Plate 5.f-i) than in metatarsi. For a categorization of proximal metacarpus joints, I used the proportion and shape of the facies articularis. In goat the facies looks like a regularly porportioned half-circle (Plate 5.a); in sheep the dominance of the pars medialis is striking (Plate 5.b), producing the typical, asymmetrical appearance of the surface. Determination was even practised on fragmented bones, if at least a part of one articular end plus the diaphysis was preserved, *i.e.* if the shaft allows consideration of its particular proportion. In case of the metapodials, even elements from young and very young caprines could be specified, because they have a characteristic shape almost from birth (Plate 5.c-e): more elongated and slender in sheep and shorter and more robust looking in goat. The metrical differentiation of domesticated and wild specimens was rather successful in goat metacarpals and evidently disputable in sheep (*cf.* Becker 1991: Fig. 3a, b and Fig. 4).

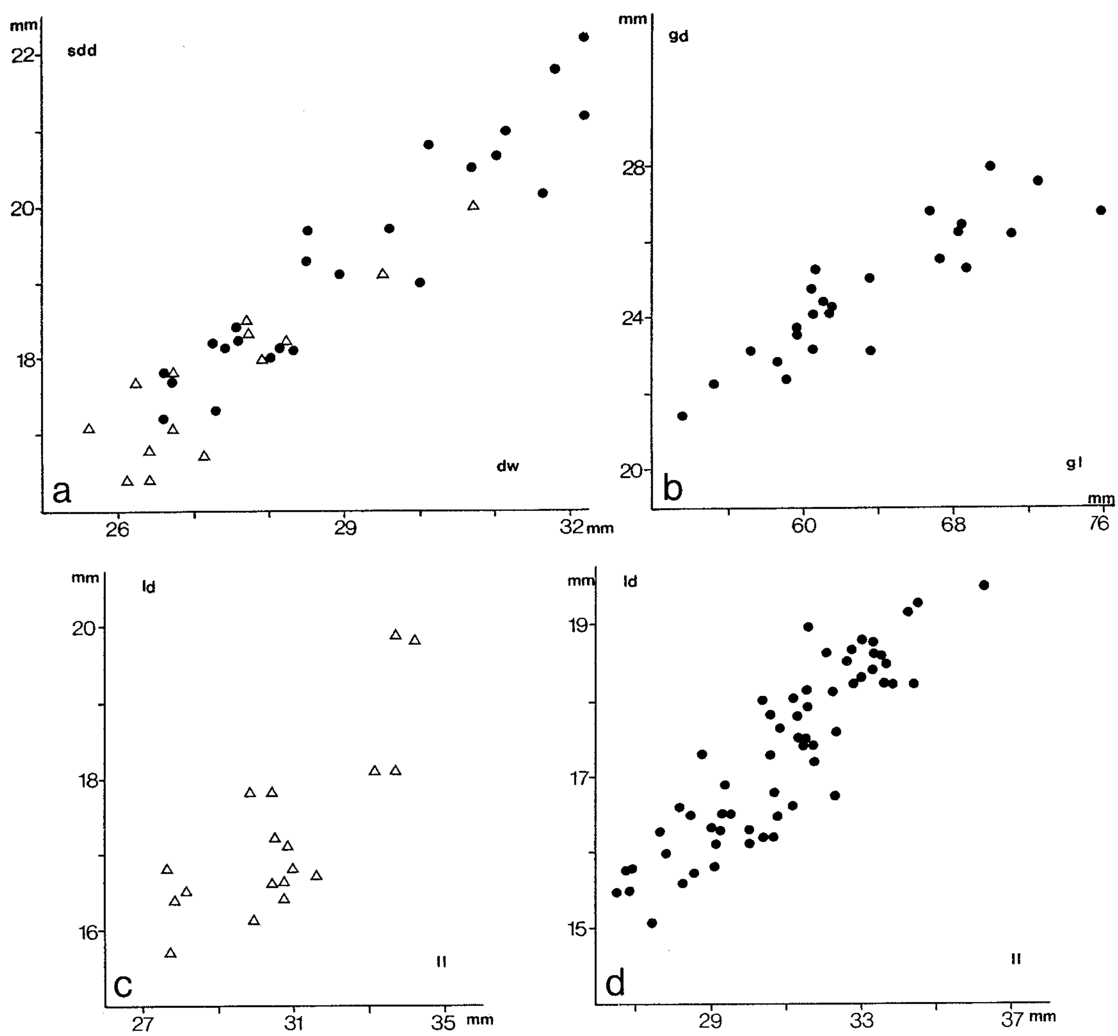


Fig. 5. Basta, Area A. Caprines: divariate plotting of measurements *[Capra (circle), Ovis (triangle). a. tibia (dw distal width, sdd smallest distal diametre), b. calcaneus (gl greatest length, gd greatest diametre), c. - d. talus (ll lateral length, ld lateral diametre)].*

Tibia: Only distal ends with fused epiphyses are preserved in satisfying numbers to allow a classification according to visual and metrical characteristics (*cf.* Plate 6.a-c; also Kratochvil 1969). The most useful feature for distinguishing was the shape of the distal articular end, looked at from the ventral side. In goat this articular surface has an almost rectangular shape (Plate 6.d, e) whereas in sheep it turns out to be formed like a trapezium (Plate 6.f). Furthermore, the ratio of the pars medialis versus the pars lateralis is about 50:50 in goat and about 70:30 in sheep. I expected these differences to be reflected in the measurements of all distal tibiae, but no clear metrical differences could be recognized. The assumption of Uerpmann (1971, 44) that the correlation of the distal width and the distal diameter in caprine tibiae would lead to a discrimination of goat and sheep elements, as indicated by the results from the Talayot-settlement of S'Illot, could not be verified (Fig. 5.a). Anyhow, this analysis gives the opportunity to focus one more time on a major problem, concerning goat bones: three groups of differently dimensioned elements do occur (*cf.* also Plate 6.a, b). In sheep only two tibiae have a reasonable size which clearly contrasts with the remaining sample (Fig. 5.a).

Calcaneus: For the distinction of caprine calcanei, a combination of various criteria was used. 1. In goat calcanei the proximal part of the bone is shaped almost straight or slightly convex on its anterior border (Plate 7.a, c, e, g). In sheep it is formed rather like a triangle with one concave side, ending in a little "nose" on the tuber calcanei (Plate 7.b, d, f, h). 2. The length of the condylus versus the length of the lateral processus (LC:LP, Plate 7.k, l) differs. This criterion could not be established metrically, because I found it difficult to fix an unambiguous point for measuring the true length of the processus. In goat the condylus is relatively short and slightly thicker in its middle part (Plate 7.i, k), whereas in sheep it seems to be more elongated and rectangular (Plate 7.j, l). The following criterion which is often cited, was not very useful for identifying the Basta caprine calcanei: the occurrence or non-occurrence of a bony bridge between the articular facets. The facets are said to be separated in sheep and linked (by this bridge) in goat. Some of the Basta sheep and goat calcanei display this bridge and others do not, independently from the very species affiliation. According to bone dimensions, two size classes can be outlined for goat calcanei (Fig. 5.b). Probably due to their small number, measurements of elements from sheep did not reveal any clear discriminative results.

Talus: The identification of goat and sheep tali/astragali followed generally accepted and often cited criteria (*cf.* Davis *et al.* 1982, 88f.). I would like to focus on two easily recognizable aspects, typical for the Basta material. The first one concerns the development of the medial articular ridge which is always weakly developed in sheep (*cf.* Jericho: Clutton-Brock and Uerpmann 1974, Fig. 7) while in goat this ridge is prominent, standing out from the corpus in a noticeable way (*cf.* Abu Gosh: Ducos 1978, Plate 22). Correspondingly, its position is hardly recognizable in sheep. It tends to stand almost horizontally, in contrast to the mostly downwards oriented ridge in goat astragali. It has to be stressed that in the Basta material, the orientation of the ridge by itself does not allow a species differentiation. The other criterion concerns the shape of the small facies articularis on the lateral side of the caput (Plate 6.g-j). In goat this facet is rounded and slightly extended towards the dorsal region, whereas in sheep this facet looks more flattened. It stretches over the whole length of the distal arch. These features are significant for domesticated specimens as well as for wild ones. A metrical differentiation between tali of Capra and Ovis did not turn out to be successful, although the tali jugded by appearance, seem to be differently proportioned. Clustering all measurements, only in the sheep a certain "grouping" of data can be recognized (*cf.* Fig. 5.d and c).

Phalanges: In the Basta caprine material, first phalanges with a flat or slightly convex surface of the palmar sides and those with a concave surface do occur. These features are said to be typical for sheep and goat phalanges (*cf.* Clutton-Brock *et al.* 1990, 36). In addition, sheep phalanges generally display poorly marked muscle scars (Plate 6.k-n). Another widely accepted criterion for identification can be seen from the angle, recognizable at the palmar side of the distal condylus. It is said to be wide in sheep and narrow, acute-angled in goat phalanges.

This accounts for 66 % of all posterior and anterior goat elements from Basta, but only 16 % of the sheep phalanges followed this rule; the remaining 84 % of the phalanges displayed in this respect an intermediate and even goat-like character. Furthermore the ratio of the pars lateralis versus the pars medialis of the proximal articular end seems to vary. In goat the pars medialis is noticeably slender in comparison to the lateral one (Plate 6.o), whereas in sheep both parts seem to be equally proportioned (Plate 6.p). Moreover, the sulcus proximalis is incised more deeply in goat than in sheep phalanges. These features differ only gradually and therefore can not easily be presented in a photograph. Anyhow, I would like to illustrate it (Plate 6.o, p).

While focusing on the distinguishing criteria between goat and sheep elements found in Late PPNB levels of Basta, Area A, the large metrical variability of this material has been touched. The general clustering of *Capra* measurements indicates a remarkable heterogeneity of the material. It falls into two, sometimes three groups of different dimensioned elements: one of small bones, the other of extremely large ones and finally a third group of medium-sized elements. Some skeletal elements are more affected than others. In contrast to these results, the study indicates a more homogeneous character of the *Ovis* material. Measurements mostly vary to a limited degree, the clustering is not that widespread and only some specimens from their massiveness reveal an outstanding character. It will be discussed in the next section whether this can be interpreted as exclusively sex-related differences or whether the possibility has to be taken into consideration that the caprine material is composed of domestic and wild individuals. The view adopted here is that it will be informative to examine these data not only from the angle already pointed out, but in two other ways, using a size index calculation and the principal component analysis.

Size Index Calculation

A series of some 287 *Capra* bones and 157 *Ovis* bones are available for a size index calculation (method after Uerpmann 1979: Appendix 2). It has to be stressed that this method may not generally be used for identifying every particular bone regarding its association to a domestic or wild animal but to reveal an overall size trend for the whole sample. The basic assumption is that domestication can be detected via size differences, to be more precise, in a substantial decrease of bone dimensions in domestic goats and sheep as compared to generally large sized skeletal elements of the wild ancestors *Capra aegagrus* and *Ovis orientalis*. For the Fertile Crescent and adjacent regions these developments have been analysed and illustrated in detail by Uerpmann (1979). In adding the size indices calculated from the Basta sample, the following results can be obtained[1]:

Goats: Even populations of wild goats yield great size variability which is caused by a highly marked sexual dimorphism. Size differences between populations of wild goats from Palaeolithic and Protoneolithic sites do occur as seen in lines 1 to 4 in Fig. 6. They are also influenced by ecological factors such as vegetation cover and precipitation[2]. The decrease of the mean value indicates a decisive change between Line 4 and 5. This development is presumably caused by human manipulation on these very populations, being finally denoted as domestication. With a more sophisticated husbandry in Post-PPNB phases the decrease in body size becomes extremely evident (Line 7 and 8). The Basta bone material is now integrated into this picture from its dating in relation to Jericho and Cayönü (line 6). The analysis of 287 *Capra* bones reveals a great variability of size indices. Their clustering ranges from large to fairly small data, spanning from obviously domestic values to very large ones

---

1 The 50-index-line represents the dimensions of selected bones of a wild standard individual (*cf.* Uerpmann 1979: App. 2).

2 For further details see Uerpmann (1979: 106ff.).

which cannot be characterised other but wild. The mean-value nearly coincidences with the mid-index of 50. The histogram almost shows a slightly bimodal distribution. It is noteworthy that a high accumulation can be seen left of the mean value, clearly indicating a relatively large percentage of small sized (= domestic) bones. Furthermore, the Basta sample seems to exhibit a comparably high percentage of large (= wild?) goats compared to other PPNB sites like Cayönü. The difference between the data from Late PPNB-Basta and samples from the Pottery Neolithic turns out to be more dramatic. As visible in the next line, the amount of indices above 50 has decreased to a minimum. Between 80 % and 90 % of all measured bones from Pottery Neolithic levels can be affiliated with domesticates.

The dilemma as to the interpretation of the results presented in Fig. 6 affects the chronological location of Neolithic Basta as well as certain incalculabilities regarding comparative data. Firstly, many archaeozoologists who have carried out detailed analyses on caprine material from Levantine PPNB sites, have come to the conclusion that the process of domesticating goats was not all that well advanced during this period. They mostly characterise this period as a phase of semi-domestication or proto-élevage (further details are given on the following pages) and as a result of this characterisation all bone measurements available from these sites are not clearly allocated. Secondly, it has to be stressed that in areas with low precipitation like the one around Basta wild goats are assumed to reach a medium sized body only (Uerpmann 1979: 196f.). This leads to the predicament that differences between any given average sized wild goat and a strongly built domesticated specimen can barely be made on a metric scale. Furthermore, goats in general have pronounced sexual dimorphisms. Especially the size of male goats can vary considerably among both, wild as well as to a certain extent domesticated individuals (Kersten 1987: 126). In addition, a certain change in population structures are to be expected as a result from husbandry. The first goat herders may predominately have bred female specimens while male goats were slaughtered at a young age, thus not reaching full body height and consequently being underrepresented in the group of the adults. The question must therefore be asked as to how far clustering phenomena of measurements being taken from bones of adult animals only, is reflected by the occurrence of female in relation to male individuals.

Keeping these debatable points in mind, my judgement regarding the Basta material was based on the following arguments:

1. Basta dates to the final stages of the PPNB period, when goat herding may already look back on some hundred years of experience as established on the basis of the evidence from other, slightly earlier PPNB sites. Indicated by a large amount of remarkably small sized bones (*cf.* Fig. 6), the animals carcassed and consumed at Basta seem in fact to have belonged to a population which had been bred selectively for some time and hence had entered an advanced stage of domestication. I suspect the period of semi-domestication or proto-élevage to have taken place some time earlier, maybe during the middle or beginning phase of the PPNB period. Furthermore I expected that this process was to a great extent more problematic to detect revealing in the end a much more incoherent picture than the one presented here.

2. Even in a phase of semi-domestication juvenile wild goats for example, could still be captured, reared and kept for interbreeding with a (half-) domestic stock. Toward the end of their productive phase those originally wild animals, finally tamed, could just as well have been carcassed and consumed, leaving behind their bones in the slaughter refuse. In other words, the statement that a semi-domesticated stock is represented in a sample does not free the osteologist from the need to try to distinguish and isolate bones from semi-domestic individuals on the one hand and those from wild ones on the other.

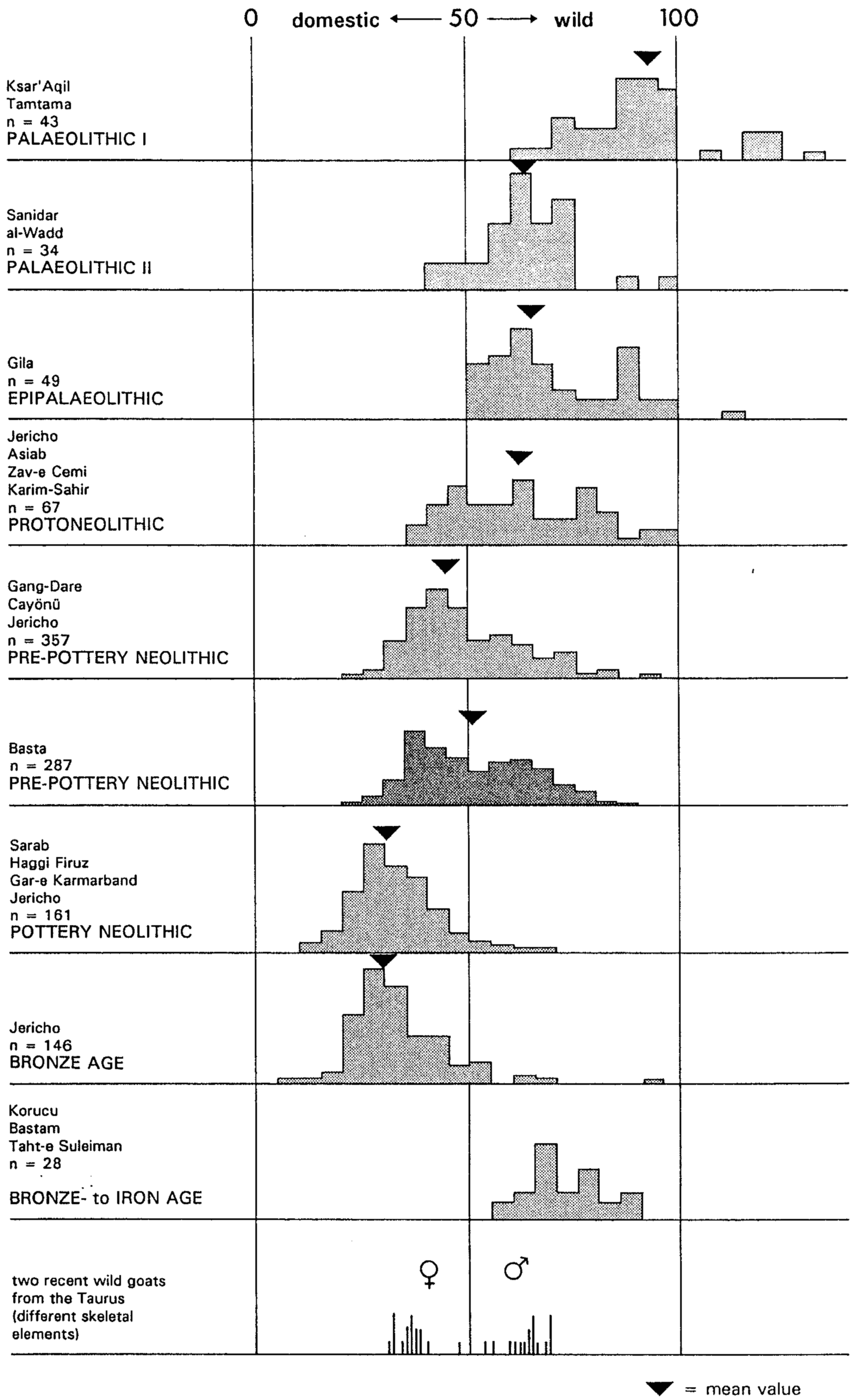


Fig. 6. Comparison of size index variation in *Capra aegagrus/ Capra hircus* from Basta and other Near Eastern sites <*illustration from Uerpmann 1979: 104 and Appendix 2*>.

3. The ancient settlers at Basta practised unspecialised hunting in that they exploited all habitats in the close and far neighbourhoods of the site. Wild goats occurred in this region in considerable numbers as we know from recoveries of particular bones found at Beidha, 'Ain Ghazal and other sites. Why then should the Basta hunters neglect this abundant source of meat?

Taking all the imponderabilities into consideration explained above, I came to the conclusion that the Basta goat material does not stand for a homogeneous group of animals, being either semi-wild or half-domesticated, but rather a mixture of fully domesticated goats as well as hunted wild ones. As to the results on the kill-off patterns (*cf.* Tables. 12-14) the Basta inhabitants seem to have practised goat husbandry in its literal sense, keeping herds of mainly adult female sex plus their kids. In my view, these animals are represented by indices left of the mid-index 50 (Fig. 6). In addition, also some larger built male domestic animals are represented, although in considerably smaller numbers. At the same time, wild goats were hunted and consumed. These animals are outlined by the largest indices in the upper third of the cluster. Near the mean-value large dimensioned (male) domestics and small dimensioned (female) wild animals are most probably mixed. A distinguishing line between both groups consequently can not be drawn. This basic assumption also served as a model for the final identification of particular bones. It should be noted that the discovery rate differs from element to element. This becomes apparent if one takes a closer look at, for instance, the long bones as well the small elements of the autopodium.

Sheep: A corresponding analysis was made with regard to *Ovis* (Fig. 7). Again, the size differences between bones of sites older than the Pottery Neolithic versus those from Pottery Neolithic or younger periods is striking. The most evident change occurs from Line 3 to 4. It is evident that mean size as well as variation shifts to the left, towards the smaller values. Uerpmann (1979: 101) proclaims that most of the Cayönü findings (line 4) can be applied to domestic animals and that in the upper range of the distribution, indices from wild sheep are represented. The clustering of the Basta data (n= 157; Line 5) is unimodal with a tendency of accumulating towards the "wild" side of the measurements. Anyhow, it shows striking similarities to the Cayönü curve, if one compares Line 4 and 5 in Fig. 7, although the Basta mean value is posed right of the 50-index line. In the light of this comparison I can only propose the same answer as H.-P- Uerpmann gave for the Cayönü sheep assemblage. The majority of the *Ovis* bones excavated at Late PPNB Basta can be characterised as domestic whereas some few, obviously large dimensioned specimens at the right-hand end of the cluster are supposed to belong to wild animals. Furthermore, the domestic nature of most of the *Ovis* remains found at Basta becomes more probable through zoogeographical considerations cited in the last chapter.

Principal Component Analysis

The principal component analysis (PCA) draws together a large amount of information to a manageable form and proves extremely useful for the perception of patterns in multivariate data. The method has been employed in archaeozoology at different instances, *e.g.* by Prummel (1983), Dive and Eisenmann (1991) for equids and by Armitage and Clutton-Brock (1976) for cattle. I carried out the same analysis to test the reproducibility of the results described above, *i.e.* to establish that the allocation to wild and domestic specimens was based on objective measurements rather than on subjective impressions alone. Measurements from selected elements (humeri, metapodia, tibiae, calcanei and tali) formed the basis for the statistical tests. The PCA adds and independently weighs these data or "variables" and diminishes them to a few number of factors. Factor 1 explains the largest part of the total variability, factor 2 a smaller part of it and so on. Rotation according to the varimax criterion method produces a particular loading of the factors, explaining the binding to

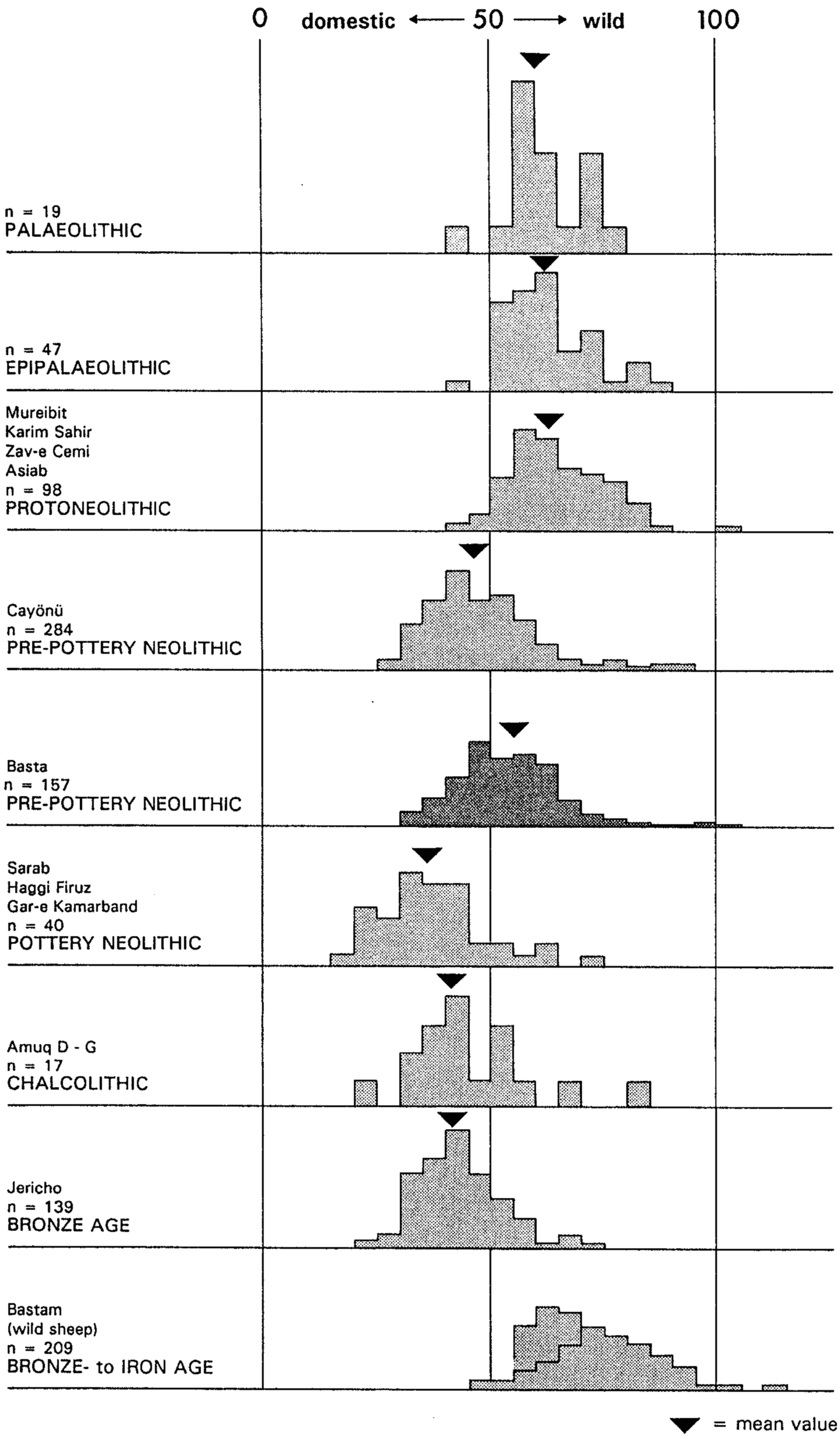


Fig. 7. Comparison of size index variation in *Ovis orientalis/ Ovis aries* from Basta and other Near Eastern sites <*illustration from Uerpmann 1979: 98 and Appendix 2*>.

particular variables. The research on *Capra* humeri might serve as an example (Table 22, Fig. 8). For 38 humeri with only few missing data on the chosen five measurements factor scores were calculated. Factor 1 explains 91.5 %, the second factor 4.8 % and the third 2.1 % of the variation. Factor 1 in our example was heavily loaded with the width measurements (width of the trochlea as well as the total distal width). The smallest height of the trochlea gave a high loading on factor 2 and the lateral height of the trochea the highest loading on factor 3. The two-dimensional plotting of factor 2 against factor 1 permits a subdivision of the *Capra* humeri into two groups (Fig. 8, first line). Eight bones with a factor loading higher than 0.7 are grouped together, all being previously characterised from the size index calculation and the divariate analysis as *Capra aegagrus* (*cf.* Table 21). The remaining humeri have a smaller or even negative factor loading and most probably belong to domesticated animals. It can also be seen that the questionable humeri are placed on the border line between the two groups. A similar procedure was carried out for metacarpi, metatarsi, tibiae, calcanei and tali. The results are on display in Fig. 8. Not in every case, the outcome was as clear as for the humeri, but at least all exhibit similar patterns. I would like to emphasise that particular measurements independently account for the highest amount of variance, *i.e.* in metacarpi the diametre of the distal condylus, in metatarsi the width of the distal condylus, or in tali the distal width (Table 22, values printed in bold). The distribution of factor 1 in a histogram provides a curve which only in the right part differs from the normal Gauß-frequency, indicating the existence of a certain number of large specimens (the F1 histogram for *Capra* tali is presented in Fig. 8 base line). Unfortunately the number of measurable sheep bones was considerably lower and consequently the results of the principal component analysis did not turn out to be that convincingly (Fig. 9). From sheep humeri, 26 specimens with three measurements were selected and analysed. The leading factor 1 accounts for 94.8 % of the variation and its loading is dominated by the measurement "smallest height of the trochlea". Only factor 2 shows the expected high loading on the measurement "width trochlea". The plotting of the factor-scores leads to the identification of specimens of large size, in particular through a combined evaluation of the loading of factor 1 and 2. A very clear grouping was achieved on *Ovis* tibiae, gained through a combination of factor 1 (dominated by the measurement "smallest distal diametre") and factor 2 (dominated by the measurement "greatest distal diametre"). To sum up, the outcome of the PCA was useful for the definition of specimen groups which could underscore the previously suggested affiliation of particular bones to either domestic or wild animals.

All methods used led to similar results with a relatively high degree of reliance. There is wide agreement between the results of the statistical analysis and the original identification based upon visual classification. In the end, the classification of specimens into meaningful categories and the allocation of a substantial number of measured bones, listed in Table 21, became possible. I would like to emphasise once again that this allocation to *Capra aegagrus/Ovis orientalis* or *Capra hircus/Ovis aries* can not be final. It only portrays a proposition gained from this very material. Particularly those bones labelled with a question mark are debatable in their wild and/or domestic nature.

To corroborate these results a final research was done, examining the stratigraphical location of skeletal elements, finally established as "domesticated" or "wild". To narrow down the first occurrence of domestic traits, the caprine samples from the very deepest layers are examined (Fig. 10). Wild goat, wild sheep and also domesticated goat were represented in the substructures whereas only domesticated sheep is missing. But *Ovis aries* does occur in the room fills which are from archaeological results said to have the same dating as the substructures. This means that even from the oldest excavated cultural layers, the occurrence of a domesticated stock of caprines plus their wild ancestors can be verified.

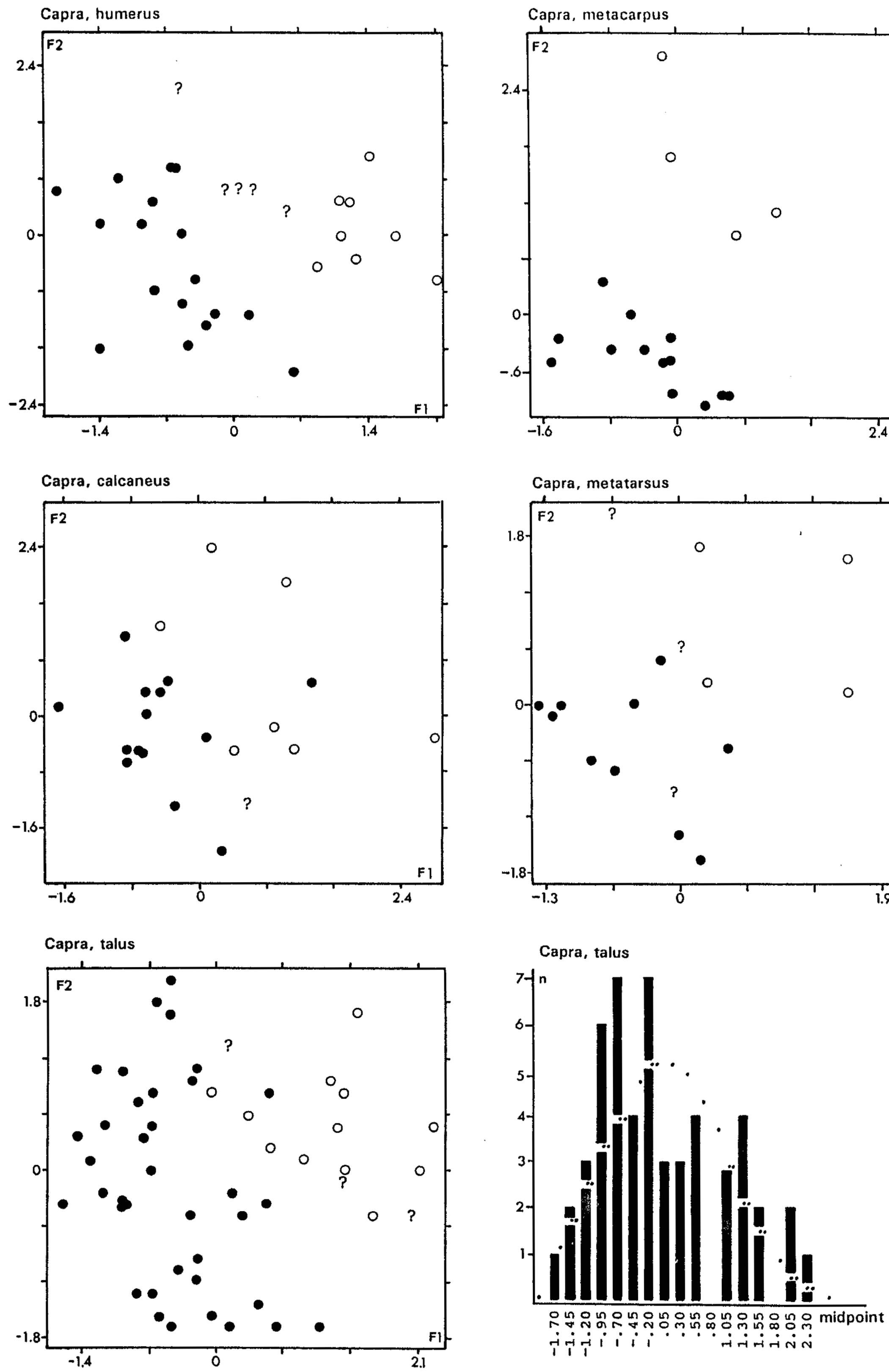


Fig. 8. Basta, Area A. *Capra*, principal component analysis: plot of factor-scores on Factor 2 against Factor 1 <*Capra aegagrus (circles), Capra hircus (dots), C. aegagrus? (question marks) and histogram of Factor 1 frequency (cf. Tables 21-22)*>.

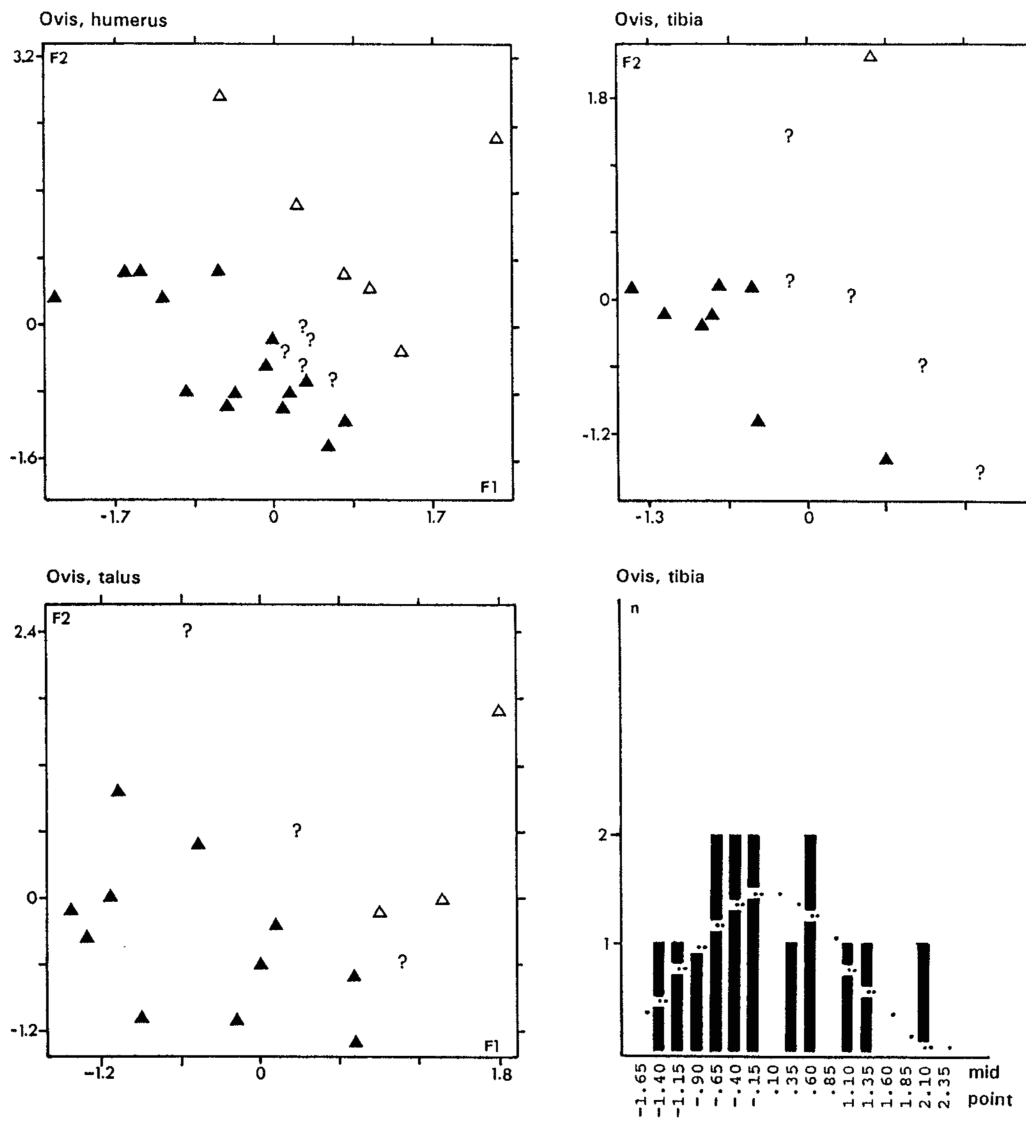


Fig. 9. Basta, Area A. *Ovis*: plot of factor-scores on Factor 2 against Factor 1 *[(Ovis orientalis unfilled triangles, O. aries filled triangles, O. orientalis? question marks) and histogram of factor 1 frequency (cf. Tab. 21 and 22)].*

As demonstrated by analyses of caprine remains from other Levantine PPNB-sites (Abu Gosh, Beisamoun, Beidha, 'Ain Ghazal), no keeping of domesticated goats in a strict sense has been postulated, but only controlled herding of wild or semi-wild goats. Although such allegations have remained unrefutet as yet, recent research deepens the impression that "true" goat husbandry becomes more important during the Late PPNB (Horwitz 1993). In my opinion the Basta material illustrates well this process. I believe that the point of controversy rather lies in the interpretation of the osteological evidence but also in conflicting definitions of the term "domestication" than in a lack of available data (more detailed Horwitz 1989).

The data from slaughtering ages and the large amount of pathologically altered bones supports conjectures made regarding a special relationship between humans and goats at PPNB 'Ain Ghazal. However, all of the preserved horn core fragments, which after all forward the most conclusive evidence as to stages of domestication, derived from wild animals (Köhler-Rollefson 1987). An investigation on size developments has disclosed a distinct decrease in body size from the PPNB to the PPNC/ Yarmoukian phases at 'Ain Ghazal as observed on a shift in culling patterns (Köhler-Rollefson 1989). The authors' judgement concerning the nature of these goats is as follows: "The goats from PPNB 'Ain Ghazal, comprising a 2:1 majority of females to males, by this standard can be said to be well on their way to domestication. By the Late Neolithic period (PPNC/Yarmoukian) practically all goats exploited at 'Ain Ghazal were domestic" (Köhler-Rollefson 1989b: 145). The comparison

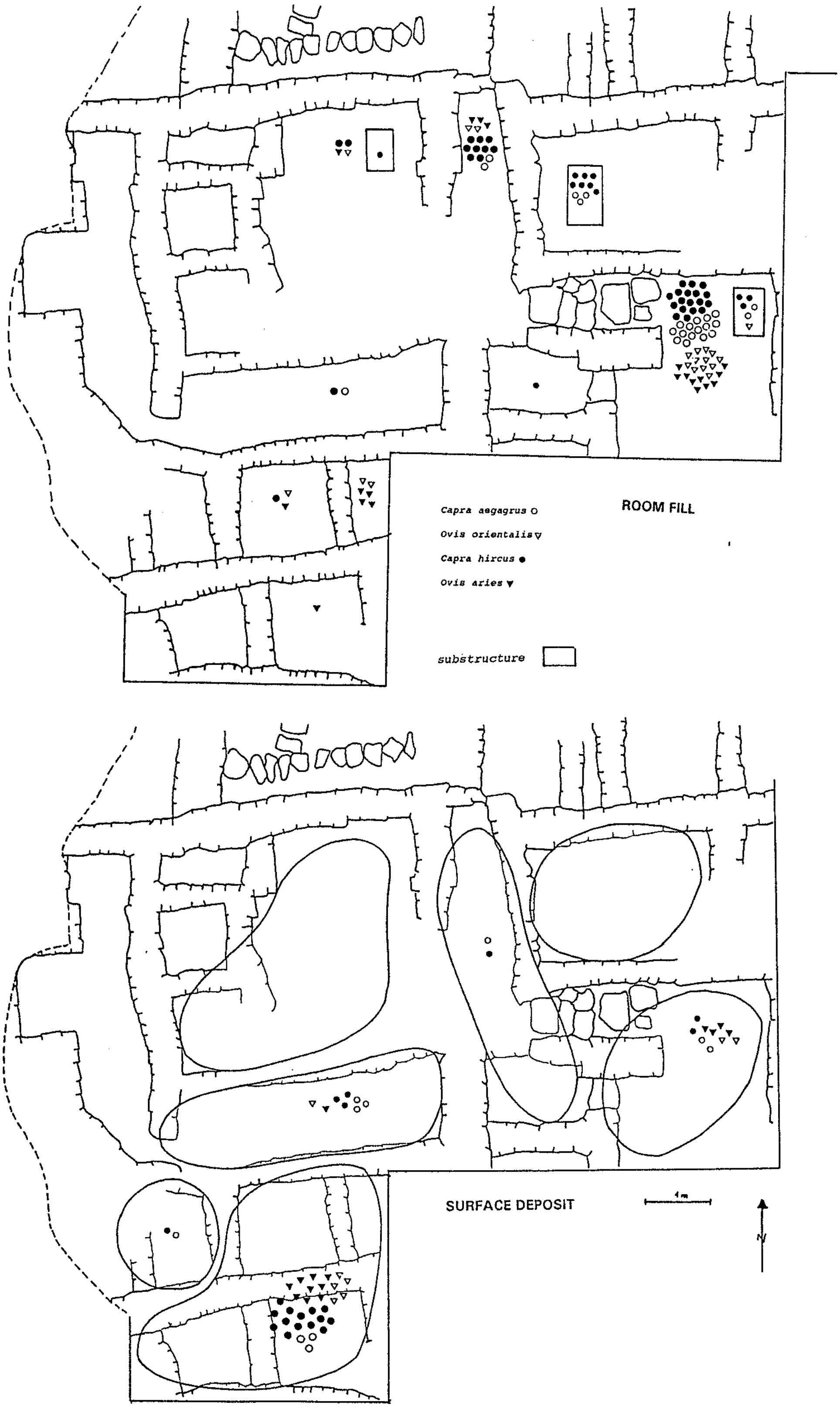


Fig. 10. Basta, Area A. Caprines: frequency and distribution of reliably determined specimens in the excavated units.

of the 'Ain Ghazal data from PPNB levels with the Basta measurements comprises a more or less corresponding variability in tali and an overall higher amount of large specimens in humeri and tibiae in the Basta material (Fig. 11)[1]. All in all certain similarities between the measurements of goats from 'Ain Ghazal and Basta can not be denied. I suppose that at least the small and middle sized bones from the 'Ain Ghazal sample derive from a truly domestic stock.

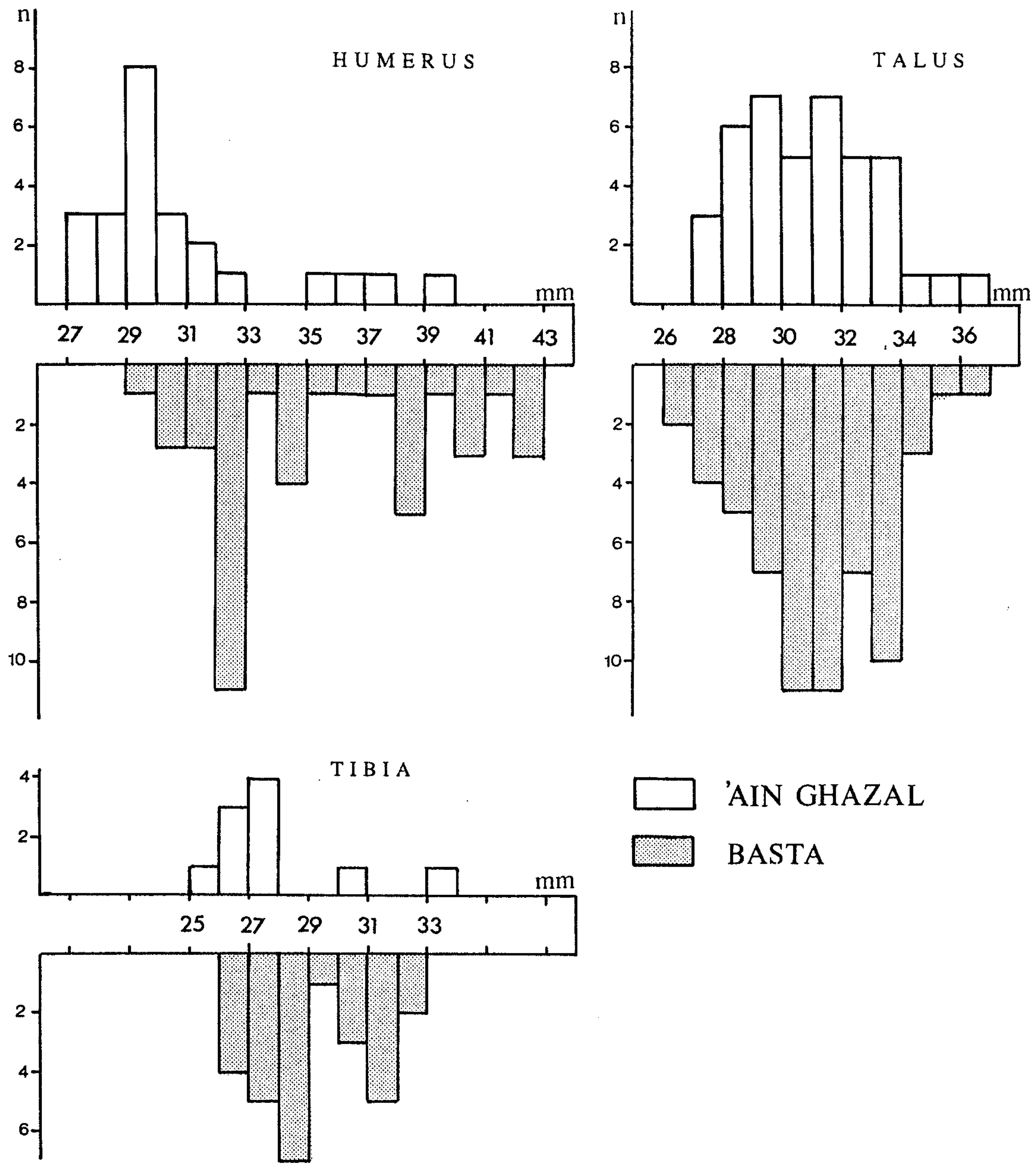


Fig. 11. 'Ain Ghazal and Basta. *Capra:* comparison of size distribution of selected elements from PPNB layers: humerus (distal width), talus (lateral length), tibia (distal width) <*illustration from Köhler-Rollefson 1989: 143*>.

[1] A more precise comparison with Köhler-Rollefson's data is not possible, since she does not provide the original measurements on which her figures are based.

"Cultural control" on goats is assumed to have been practised at Beidha, too (Hecker 1982). L. Horwitz recently repeated the generally accepted opinion that "at Beidha, the caprine remains have been identified as wild" (Horwitz 1993: 29). H.-P. Uerpmann while examining the Beidha measurements, came to a contrasting result[1]. He applies on measurements which clearly demonstrate by their large variability a heterogeneous character, *i.e.* the distal width of 290 measured humeri varies between 25.5-45.0 mm with a mean value of 33.1 mm. This value is quite similar to the one, encountered for the Basta domesticates (x = 32.2 mm) and the variability even reaches below the smallest Basta data (minimal distal width: 29.8 mm). If we now take into account that proved from the existence of typically shaped horn cores, not only small built, most probably domesticated or half-domesticated goats but also wild goats are represented in the Beidha sample, the existence of a mixed compound of animals gains probability, closely resembling the Basta material.

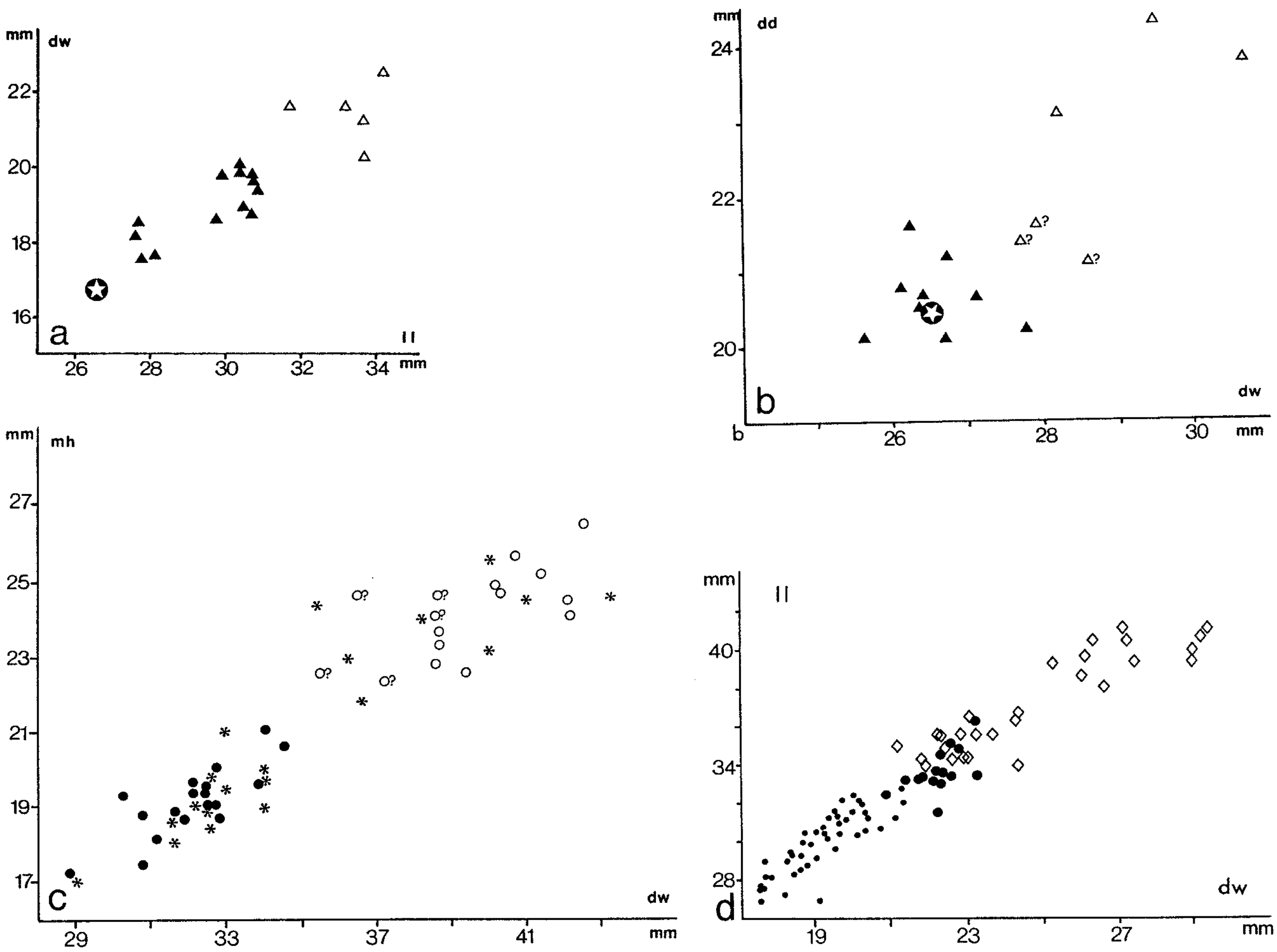


Fig. 12. *Capra* and *Ovis:* divariate plotting of measurements. Comparison between Basta *[Capra (dot), Ovis triangle), Abu Gosh (asterisk), Jericho (star) and Ksar 'Akil (rhombus)].* a *Ovis* talus (ll lateral length, dw distal width), b *Ovis* tibia (dw distal width, dd greatest distal diametre), c *Capra* humerus (dw distal width, mh medial height trochlea), d *Capra* talus (ll lateral length, dw distal width); *(filled/small symbols = domestic, unfilled symbols = wild specimens).*

A similar conclusion presents itself in comparing the data from Basta with that of Abu Gosh, another PPNB site to the West of the Dead Sea. On the basis of several measure-

[1] "So läßt sich an Hand der Maßangaben von Hecker für die distale Humerusbreite der Ziegen von Beidha erschließen, daß auch in diesem Fundkomplex überwiegend Hausziegenreste enthalten sind" (Uerpmann 1979: 110-111).

have been among the few known PPNB sites in the Southern Levant where herding of domesticated sheep was practised on a large scale. Recently a similar conjecture has been revoked regarding the Neolithic site at Jericho. The few sheep remains that were discovered in PPNA and PPPNB levels at that site[1] were originally viewed upon as "unique" (Clutton-Brock and Uerpmann 1974), but later on, their number was considered too small to be indicative of a sheep husbandry practice in this region[2]. Compared with the Basta sheep remains, all Jericho sheep bones are significantly smaller and partly fall even below the cluster of the smallest bones from Basta (Fig. 12.a, b). Even the only measurable sheep scapula (Fig. 4.a) from Jericho is hardly perceptible for its size. On the whole the comparison confirmes the first appreciation that domestic sheep were in fact kept at Jericho, though to what extent remains debatable.

There is unequivocal morphological evidence as to the appearance of *Ovis* in the Late PPNB levels of Basta and it can not be neglected that sheep bones occur in substantial numbers. Following the well advocated opinion that wild sheep formerly did not range into this area[3] the Basta bones are even regardless of their metrical values effortlessly interpreted as bearing domestic features. On the other hand, one cannot turn a blind eye to the metrical variability of the Basta sheep material (*cf.* Fig. 7), which includes some very large bones, clearly contrasting from the rest of the sample. These bones are suspected to belong to wild sheep. In comparison to the amount of wild goats, they do not occur very often. This seems to confirm the possibility that *Ovis orientalis,* though in small numbers, might have constituted a part of the natural fauna in this part of the Levant already many thousand years ago.

In the analysis, a total number of 1022 bones were definitely identified to the respective species level. The list in Table 8 includes not only measurable specimens, but also those which only on the basis of their large dimensions and morphological features (like horn cores) had accountable credentials. A total number of 211 bones were identified as *Capra aegagrus* and 93 bones as *Ovis orientalis*. Whereas 497 bones could be allocated to domesticated goats, only 221 certainly belonged to domesticated sheep. The domesticated animals greatly outnumber the hunted ones, displaying a ratio of 7:3. The comparatively large number of wild goats might suggest a higher density of *Capra aegagrus* than *Ovis orientalis* in the local fauna and subsequently a higher probability of them being caught. Keeping the number of all goat/sheep remains in mind, it seems questionable as to what extent the established ratio of 7:3 for domestic versus wild animals, drawn from only 6 % of the complete caprine sample, may be regarded as representative. Judging from my familiarity with the entire bone sample, I would estimate the percentage of domestic animals to be even higher, maybe around 85 %, although this is only a guess which would require an enormous effort if it were to be checked on an objective level.

Body Part Representation

All statements on excavated slaughter and consumption residues become biased by several agents such as method of excavation, preservation, selective transport, slaughtering methods, *etc.* Diagenetic features may affect the preservation of different body parts. Stable

---

[1] Two sheep bones were found in PPNA levels, twelve in PPNB levels.

[2] Uerpmann (1979: 101): "Die Seltenheit von Schafresten im Tahunien von Jericho läßt jedoch Zweifel daran aufkommen, ob das Schaf tatsächlich ein Haustier der präkeramisch-neolithischen Bewohner von Jericho war."; and J. Clutton-Brock qualifies that "there is no osteological evidence for this supposition" (Clutton-Brock 1979: 152).

[3] "In spite of the isolated find by Davis *et al.* (1982) of wild sheep in the Negev of Israel, no other firm evidence for the occurrence of wild sheep in this region is known (but see Uerpmann 1987, 1989)" quotes Tchernov (1993: 16).

elements such as teeth and small sized compact bones are more resistant to destruction than hollow limb bones with empty marrow cavities, or flat and thin elements like scapulae or crania. The same applies for bones of juvenile or infantile animals. Their bones are as a rule considerably more brittle than the ones from adults. This results to differentiated patterns of preservation, being particular to certain parts of the skeleton, age classes and body part distribution. Next to other taphonomic agents, such phenomena may also obstruct understanding of redistribution patterns of carcasses. Hence, interpretations of differential disposal patterns should be approached with some caution. The body parts of caprines from Basta are more or less evenly distributed which seems to suggest that slaughtering and carcassing happened on the site or in close proximity and that most of the edible parts were consumed there (Table 8, 9). The moderate size of the wild caprines would have permitted the hunters to return with the entire booty. It is likely that these animals too were carved up near the place of consumption. In consequence remains of all body parts are expected to be abundant as well as in wild and domesticated individuals. Trash deposits would then contain skeletal elements representing both bones with flesh and those without. The high frequency of richer meat-bearing limb (35.9 %) and trunk bones (40.9 %) in comparison to the low frequency of foot bones (7.5 %) does suggest some selection (Table 9): a certain removal of pure slaughtering carcass seems to be indicated. The relative deficiency of phalanges might be placed in context with skinning practices and the production of hides[1]. A similar trend can be detected in the body part distribution at the PPNB site of Atlit (Horwitz 1987) and from Early Bronze Age sites in the Refaim Valley (Horwitz 1990). The Middle Bronze Age sites from the same region exibit a quite different image as indicated by an increase of cranial elements and a decrease of forelimb, hind limb and trunk elements (Table 9). This finding is explained with the habit of consuming crania on site as well as removing meat-bearing parts of the body (Horwitz 1990: 52).

The recognition of different distribution patterns of faunal remains within a settlement is of major archaeological interest. Through mapping down the bones different activity areas may emerge where people dumped their waste, stored, prepared or consumed meat, produced artefacts, slaughtered or even sacrified animals. The caprine bones found in various units were examined as to their qualitative composition concerning particular "meat values"[2]. The distribution patterns of these categories vary within the units examined (Fig. 13, Table 10, 11). Category A is usually best represented with percentages exceding 30 %; in units 28, 30 and 35 it is even higher than 40 %. Chop bones are best represented in units 34, 35, 27b and 30, whereas parts of skulls and pure waste accumulated to a highest degree in units 28, 36, 27b, 29, 30 and 32. Interpretation efforts of this distribution are hampered by the circumstance that none of the units contained one particular category exclusively. This means that the limited use of those units for storing smoked, dried or any other form of processed meat as indicated by special carcassing or over-representation of particular parts of the body is just as little discernible as the exclusive function of other units as waste compartments. Anyhow, a certain over-representation of meat-bearing bones in units 34, 35 and 36 can be noticed. In those cases the possibility that they might in fact were used as storage facilities is somewhat higher. Derelict houses on the other hand most probably functioned as waste dumps. Evidence for tool manufacturing in any of the examined units was not discovered. Such activities seemed to have taken place outside those units.

---

[1] From ethnological research it is well known that hides were used as bags with the foot bones still being attached to the skin.

[2] These meat values are classified into four categories: Bones with a lot of meat of very high quality like femora and humeri (Category A), bones with another meat quality and quantity like ribs and vertebrae (Category B), parts of skulls bearing a little meat and a certain amount of tasty brainmass (Category C) and finally the so-called refuse - bones without any meat attached like phalanges (Category D).

ments, combined with the total amount of *Capra* in that faunal sample[1] as well as slaughtering age[2] and sex ratio[3], Ducos (1978: 118) describes the assumed subsistence strategy as "pas une véritable chasse ...pas non plus une véritable domestication. ... Une telle situation a été définie par Leroi-Gourhan... comme une situation de proto-élevage". Considering the variability of measurements at Abu Gosh, *i.e.* on distal humeri, a remarkable similarity with the Basta material has to be stressed (Fig. 12.c). Ducos (1978) evaluates this diversification of sizes in the Abu Gosh sample exclusively as sex related differences whereas I would not hesitate to postulate an intermingling with some wild specimens.

Over and above that, Ducos believes that the caprine material excavated in PPNB levels at El-Khiam contains skeletal elements of "nearly domesticated goats"[4]. This assessment grounds on the high percentage of *Capra* remains in the bone assemblage (85,3 %) as well as on his hypothesis that had they all been wild, hunting would consequently have played an important role in the overall subsistence strategy. That would however, have stood in overt conflict with the occurrence that gazelles - under normal conditions the main source of hunted meat in the region - were totally obliterated by the settlers at El-Khiam. Ducos' goes on to argue that there was an apparent large percentage of young goats (20.8 %) in this material. The interpretation seems to be quite logical, although the conclusiveness is diminished by the small amount of material (29 caprine remains in total).

To sum up, goat husbandry might in fact have been an important and widely practised activity in the subsistence strategy during Late PPNB of the Southern Levant. The comparison of measurements, although riddled with gaps, displays close similarities between most of the PPNB sites. Needs to be added that, from the Jericho material, reliable morphometrical evidence for the appearance of domestic goats in the Pre-Pottery Neolithic B levels has been presented (Clutton-Brock and Uerpmann 1984: 273)[5]. There is however one exception: *Capra* remains from PPNB levels at Munhatta (Ducos 1968) seem exclusively to belong to wild animals. The Munhatta measurements roughly cover the upper third of the Basta data (Table 7). From a perspective of size they are indicative of a wild or at least semi-wild status of the goats. Finally, I would like to focus on a comparison between some data from Basta and that from wild goats, excavated in a Lebanese Palaeolithic rock shelter of Ksar 'Akil (Kersten 1987). The comparison is based on 28 tali from *Capra aegagrus* of Ksar 'Akil and 60 tali from domestic and wild goats from Basta. The scatter diagrams display a clear distinction of a large group of small specimens from Basta, namely domesticated animals and a cluster of larger measurements, that partly match with the lower third of the measurements from the Epipalaeolithic wild goats (Fig. 12.d). With this result I would like to end the debate on the evidence which proves the existence of both, domestic stock as well hunted goats within the dietary plan of the Basta inhabitants.

Evidence as to the earlier phases of sheep holding is more scanty (Davis 1982: 14). P. Ducos (1993) has recently published new results from Tel Aswad and Ghoraifé, two PPNB sites in the Damascus basin. In Ghoraifé the numerous appearance of *Ovis* is interpreted as suggestive for sheep husbandry and "the sequence Tel Aswad - Ghoraifé gives an important chronological reference for the appearance of domestic sheep in the Southern Levant, namely around 6600 B.C." (Ducos 1993: 40). Beside these two settlements Basta seems in fact to

---

1 "...le rôle central de la Chèvre à partir du Néolithique PPNB est confirmé à Abou Gosh" (Ducos 1978: 117).

2 "80 % des individues consommés appartiennent aux jeunes adultes" (Ducos 1978: 117).

3 " 36 % des individues consommés paraissent êtremales contre 64 % de femelles" (Ducos 1978: 117).

4 Ducos 1968: 78: "...aucune pièce n'a pu être attribuée de façon décisive à *Ovis orientalis* ou à *Capra hircus aegagrus*; - aucune ossement n'a pu être attribué de façon certaine à *Ovis aries*; - certains ossements peuvent etre attribués sans aucune doute à un animal très proche de *Capra hircus prisca.*"

5 Unfortunately, original data from precisely identified specimens have not published in detail to date.

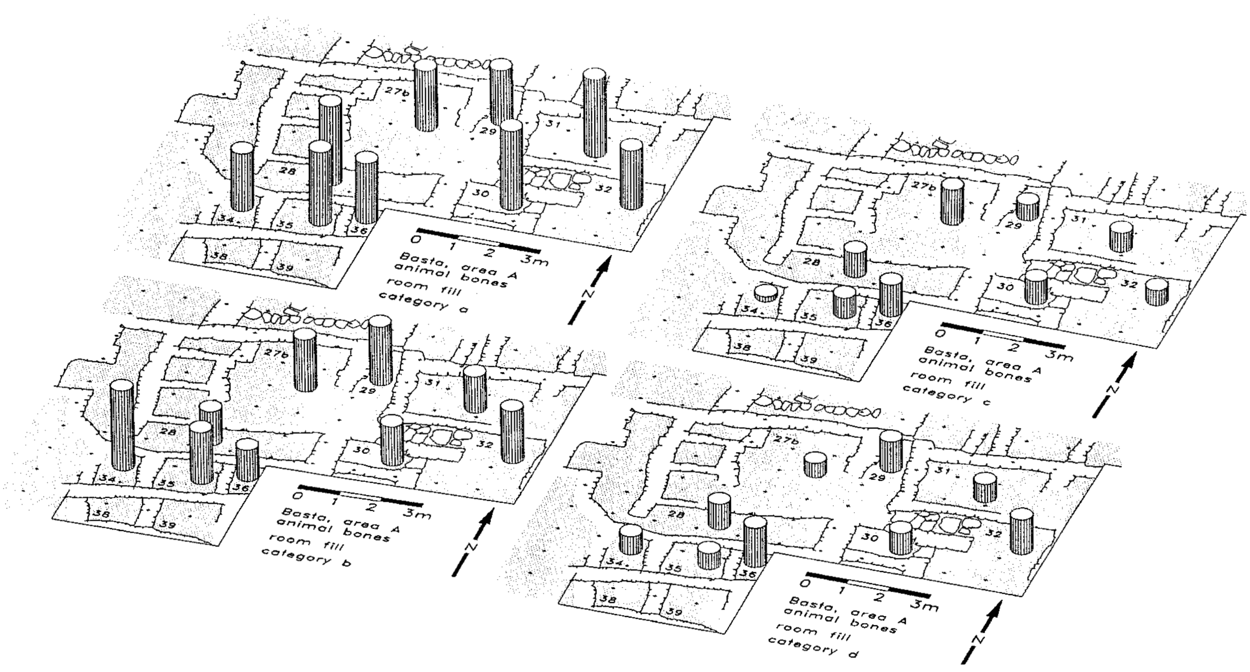


Fig. 13. Basta, Area A. Caprines: relative distribution of meat categories in the room fills.

Slaughtering Age and Sex Composition

In addition to size analysis, age of death provides another criterion for determining the degree of animal manipulation. The dominance of young caprines in a faunal sample is generally interpreted as reflecting domestication (*i.e.* Hesse 1982, Ducos 1968). Objections against the validity of this argument have often been advanced, as for example by Meadow (1984), Grigson (1989) and Ducos (1993). Analysis of slaughtering age in a large animal bone sample is ideally combined with information on sex ratios, in order to identify caprine herding strategies and characteristic culling patterns. We know that herders would cull female and male goats or sheep at different ages, depending on the desired economic goals. Efforts might have been made to maximise meat return for forage and labour investment. It makes sense in a meat-producing economy to slaughter at a stage toward the end of the animals immaturity, being around its second year (Redding 1981) with a preferent choice of male individuals. Only few of them are needed for breeding purposes in order to maintain the perpetuation of the herd. Information on sex ratios can mainly be drawn from horn cores and pelves. Unfortunately, only very few of these elements were adequately preserved as to be associated with male or female individuals (Table 12). Thus, only tendencies on this matter are available. Fifteen horn cores of domesticated goats and sheep can be identified as male or female. Among goats the largest number was established for adult females. A more satisfactory result was obtained by the analysis of the pelvic bones. Female adult goats outnumber males by far (32: 4). In sheep this ratio amounts to 8:4. Among the young individuals, only male specimens were detected. The ratio of female and male specimens in goat and sheep samples can also be estimated by plotting measurements of particular bones in scatter diagrams. On the Basta material, this apparently uncomplicated method was unsuccessful on account that the frequent lack of criteria for a clear-cut distinction between small wild animals and large domestic ones does as well as the relatively small number of remaining elements being exactly determined not permit a breakdown into sexes. But in looking at the pooled data in Figs 4.b, 5.a,b and 12.c, it seems that measurements (from female domestic goats) occur more frequently and that they these do cluster around an imaginary centre in contrast to a smaller number of larger measurements, probably representing some domestic males (and of course some female wild animals).

The number of caprine mandibles found in Area A of Basta amounts to n= 345. All in all 87 % of all mandibulae were preserved to a quarter of a complete jaw or less. Most of the loosely found teeth were crushed. The very poor preservation of these elements encumbered a *species* related classification of goat and sheep mandibulae and teeth. Consequently all sheep and goat mandibles and teeth needed to be treated together in the case of age estimation. No mandibles of wild caprines could be identified with great reliability. Only 67 specimens (19 % of the jaw material) plus 63 isolated teeth were suitable for the estimation of age structure. According to the method of Payne (1973) nine phases were noted in the eruption of teeth and their specific wear stages (Table 13). In the left column of Table 13 an attempt is shown to relate this sequence to ages in months and years. The age estimation on the basis of the mandibles provides another result as if calculating the age classes through mandibles *and* loose teeth. In the first case, age estimation reveals maxima in stages C and D (19.4 % and 17.4 %). Over half of the mandibles (69 %) belonged to animals killed before the completion of tooth eruption (< 3 years), whereas in the summarising graph, this amount is equal to only 53 %. In this case, we find an over-proportionally high rate of single M3 and M2 from stage G (*cf.* Fig. 14, base line). For further interpretations I will rely on the results mentioned first (Fig. 14, top line) because it is impossible to detect which of the teeth belonged to which mandible. Counting all may bias the result towards stage G. Although the Basta sample is small, the clustering of mandibles between stages B to E is of considerable interest. These stages are equivalent to the first to third year of life and amount to 64 % of the sample. In a hunting system, an explicit selection of the stages under four years seems unlikely[1] whereas in herding and husbandry strategies these kill-off data make sense[2]. At an age of 2 - 3 years or slightly earlier, animals show the greatest return of fodder and meat. A preference of these animals in slaughtering indicates animal domestication primarily for meat production. The other part of the animals have probably been used for their milk, fibre production and breeding purposes. Referring to the Basta sample, we have no direct evidence for dairy and wool production as a principal goal of herding. This becomes evident if one converts the data listed in Table 13 into a survivorship curve (Fig. 15). This curve expresses the percentage of animals killed each year (method from Stein 1987), beginning with a 100 % survival rate at birth through zero percent survival by the age of ten years. The Basta material is then directly compared with three different production strategies[3]. A herding strategy aimed at *dairy production* would exhibit a herd reduction of almost 50 % before the end of the first year, followed by a secondary smaller peak in culling at 6-7 years[4]. With *wool production* over half of the animals would survive their first three years, the main culling peak would take place at 6-7 years. *Meat production* in a self-sufficient community would represent practically all age classes and display a culling peak in the 1-3 years intervall, being the prime ages for the production of meat (mainly from male individuals). A second peak would occur between 6 and 7 years when infertility begins to increase among females. The Basta data conform neither with the dairy curve nor with the textile curve. It rather matches in well with the meat oriented patterns (Fig. 15; compare also results from sex ratio in Table 12). The overall result however, does not seem to suggest specialisation on a large scale but rather a generalised level of primary subsistence based on herding for local consumption of meat and to some extent milk and other secondary products. Any clue for exchangable surplus production were not detectable. This less specialised strategy bears the advantage of a certain flexi-

---

1 A rather vivid example is given by Kersten (1987: 125 f.): hunters from Ksar 'Akil mainly killed mature individuals (73 %) whereas young adults or infants were scarcely caught.

2 Among the wild animals, the mortality rate is high in the first year, low for the following years and increases only toward the end of the animals life-span (Geist 1971).

3 although only a part of all the caprines kept, slaughtered and consumed in the settlement is represented here. any activity from outside the excavations areas is not witnessed. Comparative data were taken from Stein 1989.

4 Present-day sheep and goat continue to provide substantial quantities of milk until 4-7 years old (Davis 1984: 274).

bility and independence. Anyhow, these findings should be treated with caution as it is impossible to decide whether this evidence applies to both sheep and goats or wether one has to expect some species-related differences.

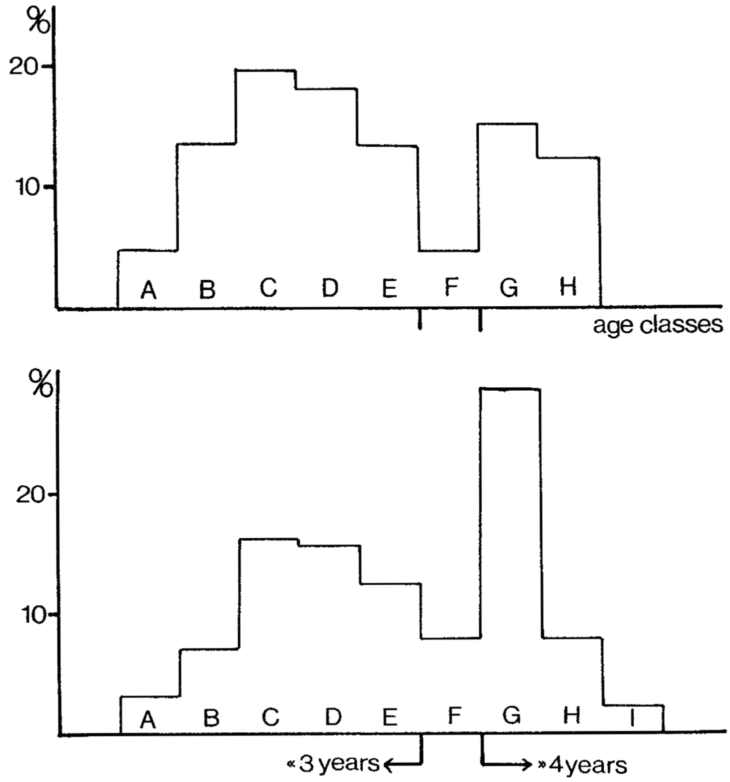


Fig. 14. Basta, Area A. Caprines: histogram of age classes on the basis of mandibulae (above) and mandibulae plus loose teeth (below).

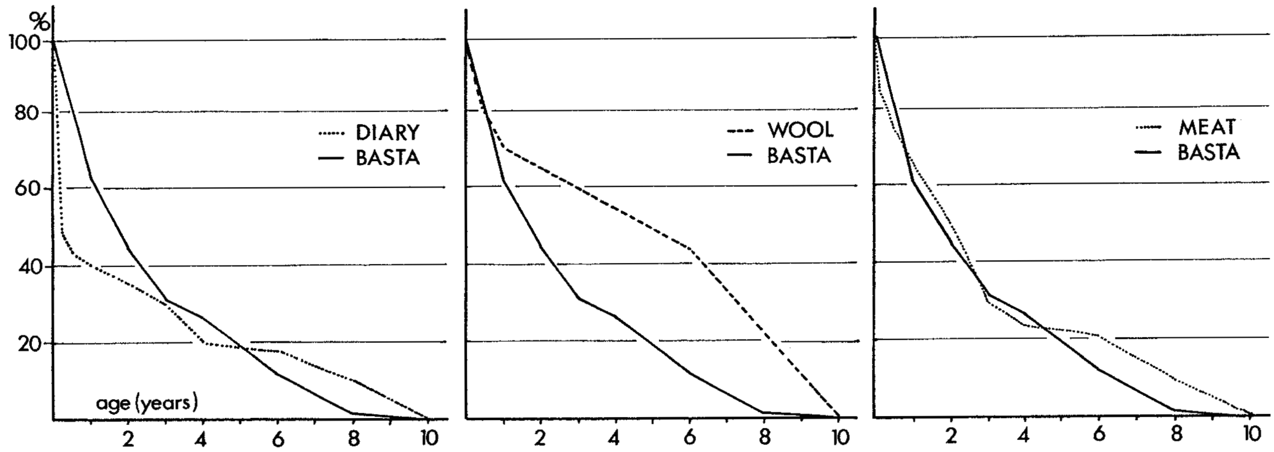


Fig. 15. Basta, Area A. Caprines: comparison of survivorship curves <*data from Stein 1987*>.

Species-related age estimation, however, can be drawn up by fusion data (Table 14). In my view this is best done by aid of reliably identified long bones. According to the calculation listed (Table 15), no wild sheep were consumed as young individuals. Three calcanei with unfused epiphyses which are not included in this figure indicate that a small number of younger animals have in fact been consumed. 35 % of all wild goats, carcassed at the site were younger than 24 to 48 months (after Noddle 1974: 198f.). That pattern would be atypical for hunted animals. It might suggest that controlled herding of wild goats was practised, maybe for the improvement of the domestic stock. These bone might have belonged to goats that formed a particular group of (half-tamed) animals. Starting out on the other hand from those bones which definitely belong to the domestic category, the number of non-adults (represented in Group 3) amounts to 24 % in goats and 11 % in sheep. These figures are very low compared with the tooth-wear data which state that an amount of more than 55 % of the animals were killed as juveniles. The results for the domesticated caprines suffer from the lack of information provided by those long bones, which remained unspecified and were grouped as "*Capra/Ovis* total" (Table 14). If one separates from the latter the finally determined wild specimen and all "probable" age classes, the data base for domesticates increases by a factor of six. The following result makes more sense as 56 % of the domesticates were slaughtered before they reached their third year of life (base line in Table 15). Comparisons between tooth eruption and epiphyseal fusion data are burdened with problems. The influence of differential preservation on the sample bias and the difficulties of absolute ageing are well known[1]. In the Basta material, at any rate, the findings on the tooth eruption and epiphyseal fusion coincide quite well. Finally, the main purpose behind herding in this PPNB site was meat production. The data currently available on the PPNB caprine material from Basta yield economic codes which also are found at other PPNB sites, as for example Gritille (Stein 1987).

Fragmentation Patterns

From ethnographic documents we know that although the rules of butchery are not universal, they exhibit considerable cross-cultural regularities. In general butchery technique is dictated by the size of the animals culled, their anatomy and slaughtering age, the type of butchering tools available and the experience of the person carcassing the animal. It is still a matter of contention as to what extent regularities or differences in butchery techniques are reflected in the archaeological record[2]. Concerning the Basta material the first step of analysis was to recognise and exclude recently inflicted fractures from old ones, as indicated by varying shades of the breakages. In average 10 % of the material was freshly broken. The technique of documenting fragmentation patterns is borrowed from an earlier report (Becker 1986: 331) using an easily applicable method which is not very time-consuming. Differentiation between bones of different species or domesticated and wild animals was not made, because most of the material lacks exact determination[3]. Six main strategies theoretically guide bone fragmentation processes: 1. skinning, 2. dismemberment of the carcass, 3. reduction of meat sections for cooking, 4. defleshing, 5. breakage of bone for marrow extraction, 6. bone tool manufacturing. Although the body of data from Basta seems to provide a broad basis for recognition and interpreting of past behaviour, the difficulty lies in the nature of these data. They have been produced by a variety of processes and agents. The reflection of each factor in the fragmentation pattern cannot be separately recognized. Furthermore, bone accumulations from different localities within the excavated area may have had different taphonomic histories. Therefore I intend to differentiate only between the intensity or degree of fragmentation (indicated by the completeness/ incompleteness of bones and the *size* of fragments) and the patterns of disarticulation and fragmentation (indicated by the *shape* of fragments and the occurrence of cut marks).

---

[1] Maltby (1982: 85) made an attempt to combine these two types of data.

[2] Lyman (1987) gives an overview on the growing amount of literature published on this topic in the last decade. He also summarizes nearly all aspects of carcass modifications.

[3] Only some detailed information can be drawn from Table 16, counting proximal and distal joints, determined as to species.

Intact skeletal joints or more or less complete fore- and hind limbs or vertebral columns have not been found in Area A. All joints were disarticulated and most of the bones were intensively fragmented. The ratio of completely preserved elements and those preserved to two thirds (Categories 1/1 and 2/3) versus incomplete bones (Categories 1/2, 1/3 and <1/3) amounts to 1:9 (Table 16, 17). If we now look at particular parts of the carcasses the following results can be achieved:

- Skulls and horn cores are badly crushed. More than 90 % of the identified skull and horn core fragments derive from category <1/3,

- The vertebral column in general is not that intensively fragmented (category < 1/3 = 40,5 %). The atlas is broken much worse than the epistropheus, indicating the dismemberment of head and trunk by chopping with an adz within the region of the first vertebra.

- Most of the ribs had been cut into three or four pieces.

- In limb bones the degree of fragmentation decreases from the scapula/pelvis over humerus/ femur down to the metapodials and phalanges (Table 16-17, Fig. 16). Elements from the hind limb are in general more intensively fractured than those from the forelimb. Meat-bearing and non meat-bearing bones display different results: femora and tibiae are the most intensively fragmented elements. Metapodials, calcanei, tali and phalanges are broken in less occurrence. Among the long bones, metacarpus and metatarsus are the best preserved elements and provide coincident results in their degree of fragmentation.

The patterning of breakage locations highlights structural differences between body parts and skeletal elements. A gauge of these patterns is the representation of proximal and distal articular ends versus diaphysis fragments (Fig. 17). Femora and tibiae provide an over-abundance of shaft fragments. Parts around the knee-joints have almost completely vanished. The same is relevant for the shoulder-joints: the proximal humerus is represented by only very few pieces (< 5 %). In contrast to femur and tibia, the most encountered part of the humeri are distal articular ends (< 40 %). There is a drop from the late fusing (proximal) epiphysis to the early fusing (distal) one. Presumably not only the associated meat dictates the economic utility of certain bones, but also their quantity and quality of bone marrow. Different skeletal elements require different amounts of marrow, based on the marrow cavity volume and the percentage of the total fatty acids (Jones and Metcalfe 1988, 419). Elements with a high cavity volume such as femora and humeri seem to have been favoured for marrow processing. This is also attested by the location and orientation of breakage pattern (Fig. 18). They often show a similar location and orientation. The diaphysis of marrow bearing elements are splintered in a spiral manner, often U-shaped in cross section, testifying to a dull rather than a sharp friction. The diaphyses are more often cut diagonally and horizontally than longitudinally. In contrast to this, shafts of metapodials were often fragmented longitudinally. The different shaft splinter technique provides us with some evidence suggesting that certain elements such as metapodials were selected for different purposes, *i.e.* tool processing. This is illustrated also by particular fragmentation patterns of the metapodials which often had been sliced into longitudinal sections (Fig. 18, Plate 10.b).

Despite the generally high fragmentation rate, a certain number of complete or well preserved (two thirds) bones do occur (Table 18). Among them a small number derive from adult individuals. The bulk is represented by elements from non-adult specimens. This giving leads to an important interpretative point: the relation between fragmentation pattern and slaughtering age. Commonly, carcasses of younger animals do not necessarily need such an intensive dismemberment as the larger carcasses of older animals. Even a rough dislocation of smaller carcasses produces manageable meat-cuts. In addition, there might have existed

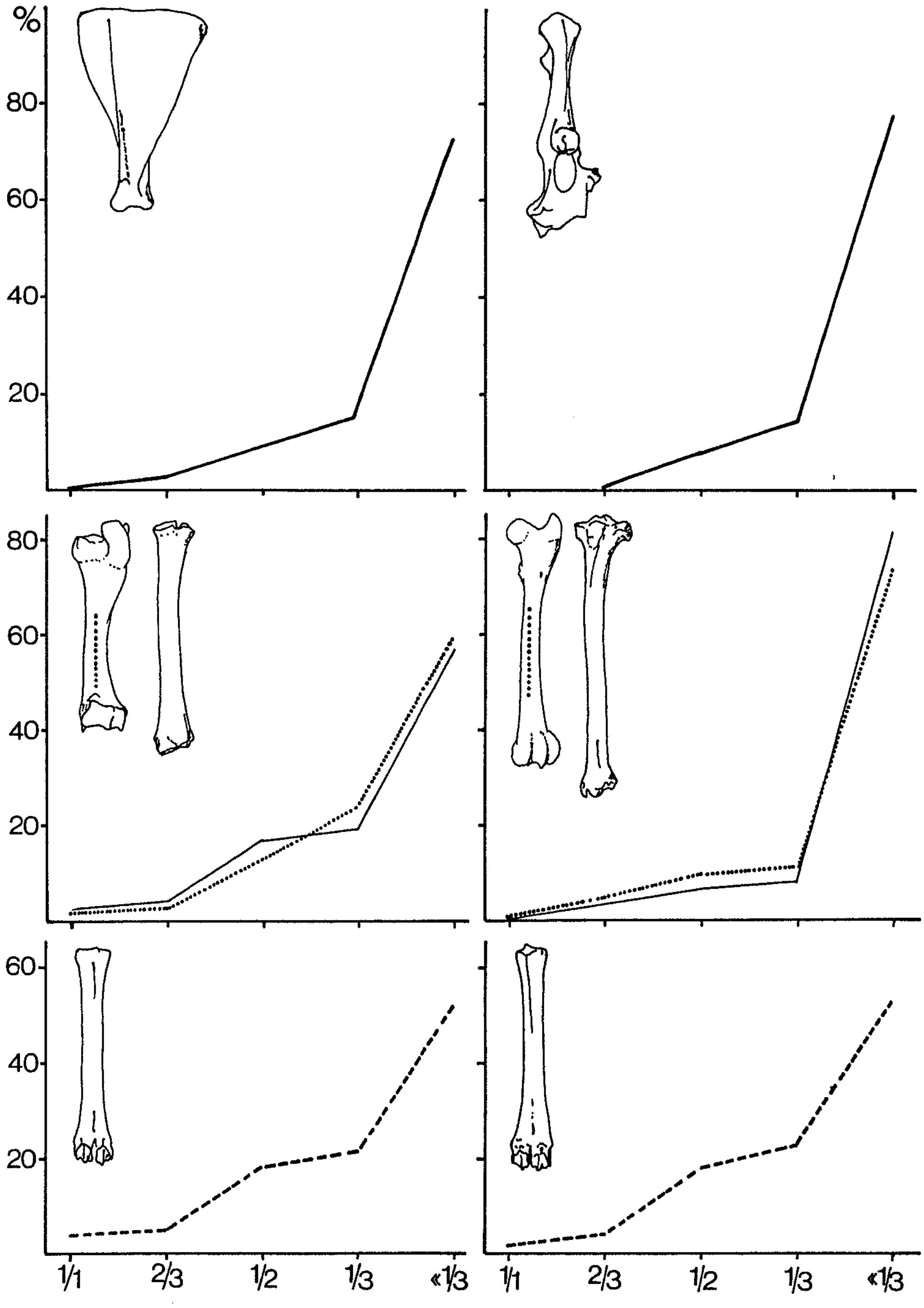


Fig. 16. Basta, Area A. Caprines: relative frequencies of fragmentation categories in scapulae, pelves, humeri, radii, femora, tibiae and metapodia.

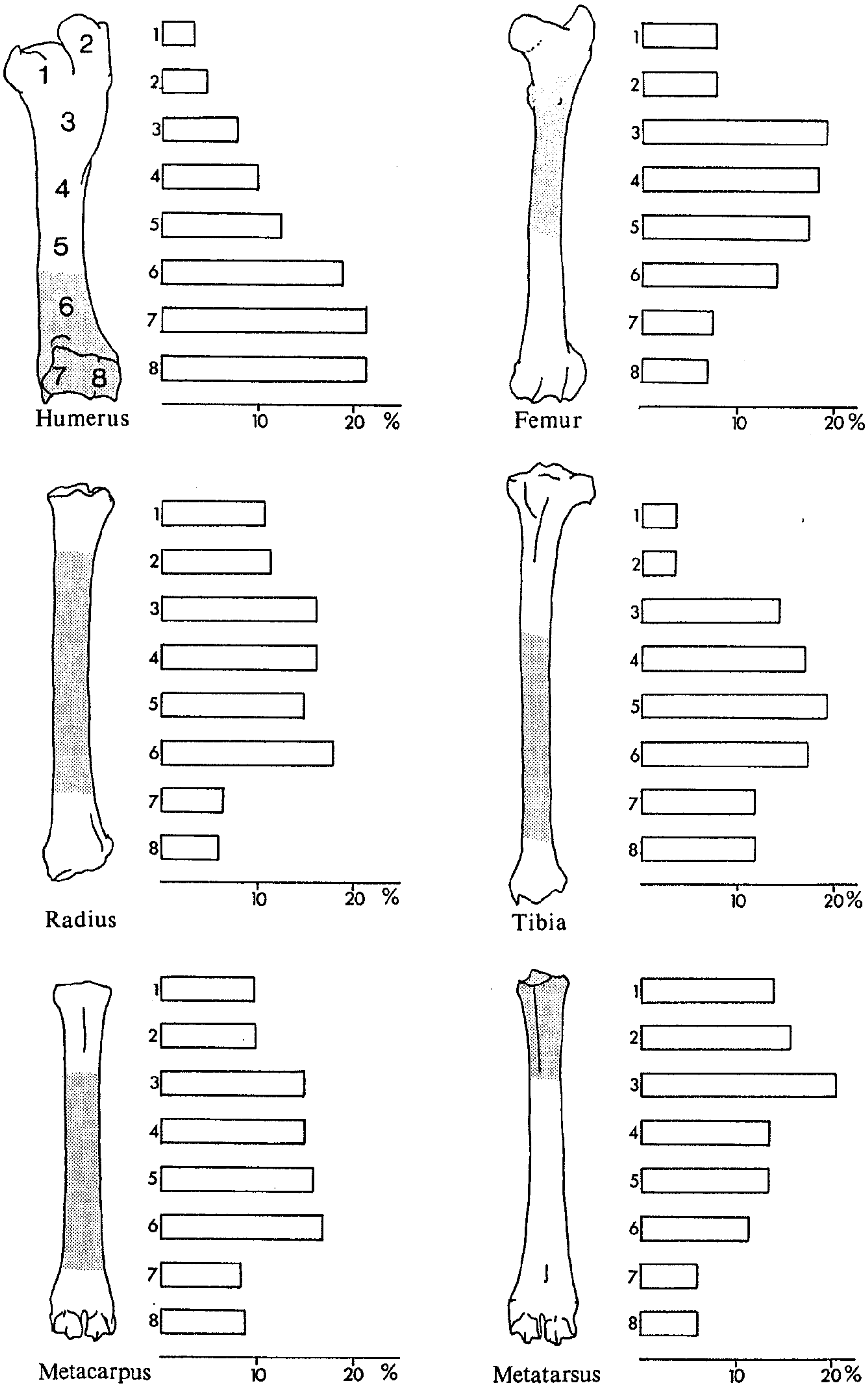


Fig. 17. Basta, Area A. Caprines: relative representation of particular parts in long bones.

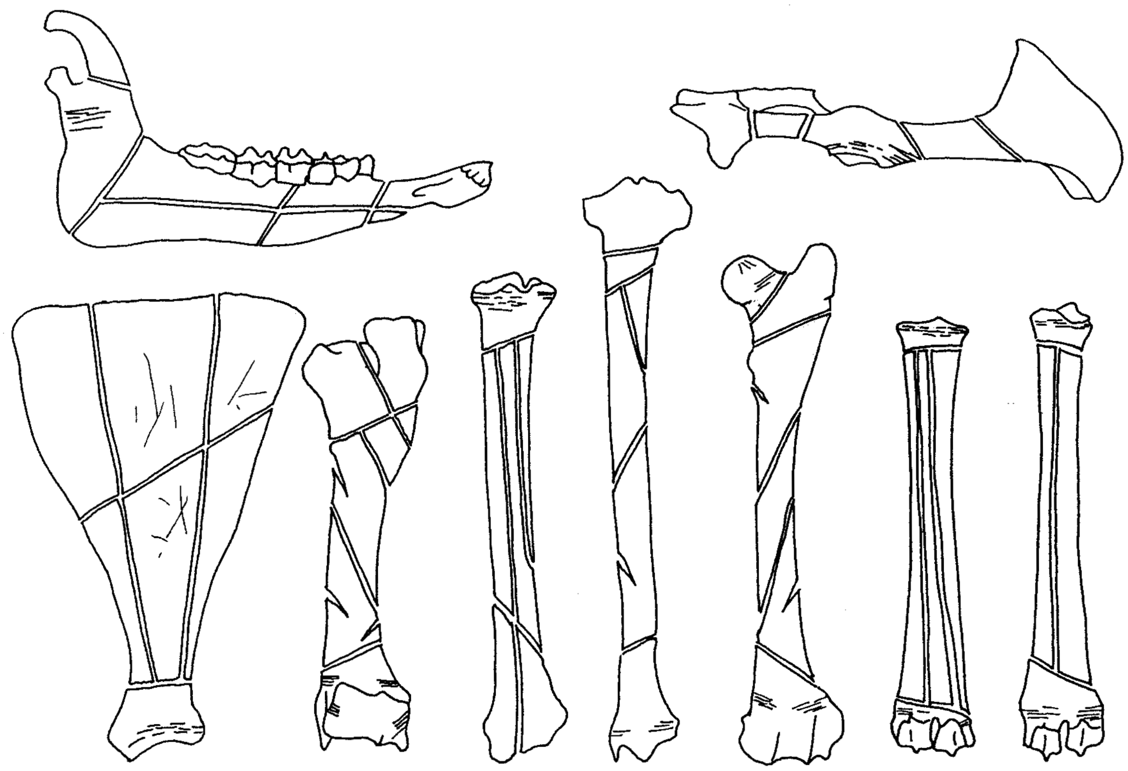


Fig. 18. Basta, Area A. Caprines: patterns of fragmentation, location of marks produced through cutting and defleshing.

another butchering technique which was related with diverging use of the dead animal. Young animals as a rule have less meat of a different quality than that of adults. The tenderness of their bones render them unsuitable for bone tool manufacture. The amount of fat and marrow is lower and finally the quality of the sinews might not be as satisfactory as those of adult animals. Otherwise, the durability of bones in the process of growth is generally reduced. Agents such as post-depositional fracturing through building activities, secondary stacking of refuse or damage through trampling (Olsen and Shipman 1988) would lead to an earlier breakage than on bones from adults.

Cutting

The interpretation of cut marks make sense when they occur in above certain frequencies on specific skeletal elements and when their position on the element is compatible with some human activities. As noted in the preceding section, the creation of butchery marks depends a lot on processes connected with the disarticulation of the carcass. Four main human activities can be derived from cut marks on the bones: a. skinning, b. dismemberment, c. meat removal, and d. tool manufacture. Even after an intensive inspection of every piece excavated, cut marks are scarcely found. They can be discovered from only 0.4 % (n= 73) of the caprine material (Table 19, 20). This low abundance leads to questions whether the observed frequencies allow for general conclusions on human activities in the Late PPNB site of Basta or whether it only sheds light on occasional events. At present I have no idea why cut marks are so seldomly found. From the repeated use of very sharp edged silex tools for carcassing one is inclined to expect a higher frequency of their marks. These fine multiple incisions, originating from flint tools, do not vary considerably in their appearance. The majority clusters in the vicinity of joints, as typically observed on distal humeri (Plate 8.a, b). They are generally located on the major joint capsules and permit the correlation with specific dismemberment procedures, for example the severing of tendons and ligaments on the elbow joint (Plate 8.c). As demonstrated by cut marks on 9.1 % of all ossa hyoidea (Table 20, Plate 9.b) the removal of the tongue seemed to have been practised, too. Single striations are deeply incised and of narrow diameter, suggesting the use of flaked, slender and sharp edged silex knives used with some strength. Cut marks on vertebrae mostly are fixed around the body of the bone, implying a round-cut on the neck (Plate 9.a). Several phalanges with lots of incisions (Phalanges 1-3: 6,3 %) witness skinning. Especially goat skin is even today widely used for water transport and milk processing (production of *laban* and butter; Korsching 1980, 51). Such activities however are not that frequently recognised from the archaeological record. Meat removal was also testified by the presence of scraping marks on the flat parts of some ribs and shoulder blades (Fig. 18). The fourth activity, tool manufacturing, is linked with another type of flint artefact: the saw. The tooth-like cutting edge of the silex saw produces a particular type of incisions (Plate 9.c, d). Unfortunately I could analyse only very few of such saw marks on bone fragments, which occasionally occurred on the slaughter refuse from different locations[1]. Karasneh points out (1989: 39ff.) that a greater part of the artefacts illustrates that the routine of sawing was not unusual in the PPNB to produce a special type of raw pieces. In his classification of the bone artefacts from Basta, implements associated with skin working, sewing and weaving are the most common (awls make 48 % of all implements). Needles, cutting edge tools, hafts, a spoon and some ornamental specimens round out the inventory. Most of the worked bone artefacts are rather of utilitarian purpose than ornamental.

Burning

The frequency of burned bones in the Basta caprine collection is very low (0.8 %, Table 20). The affected bones did not concentrate in special areas of the settlement. It seems evident that the detritus from hearths was mixed with other debris from slaughtering and consumption of cooked meals. Burning patterns can be recognised on bones from both domesticated and wild goats and sheep and all age classes. In nearly every anatomical category, some ele-ments with burning marks are detectable. Their exact location on the bone as well as the degree of heat they reflect may vary a lot. In some occasions only a part of a bone was burnt, in others the entire bone had gone black or even greyish-white after being exposed to very high temperatures. Otherwise they were coloured brownish, indicative of a more superficial or less intense heat. All in all, no meaningful traits were observed, except for possibly one feature: the affected parts concentrate in the peripheral parts of the hind legs, giving evidence that particular cuts of meat were roasted.

Gnawing

In most of the bone materials from pre- and protohistoric times, carnivores usually have left characteristic chewing marks on parts of the skeletal elements. Dogs are known to consume a certain part of the slaughter refuse, preferring spongy areas. They often select elements from young animals (Becker 1981: 32f.). In the Basta material there was no sign of carnivore gnawing, which does not surprise considering that *Canis familiaris* is very scarce in this collection (n= 4) and that wild predators like the jackal or the fox, probably had no access to the refuse on account of the compact and solid arrangement of the room-like facilities it was extracted from. According to an examination under the microscope 0.15 % (n= 26) of the caprine material bear chewing marks from small rodents (Table 19). Animals like mice, when

---

[1] All bone and antler artefacts were analyzed by W. Karasneh (The Bone Artifacts from Basta. Yarmouk University, Institute of Archaeology and Anthropology: unpub. M.A.- thesis, 1989). He did not have opportunity for using of a microscope while examining the specimen. Unfortunately this thesis summarizes only a certain part of all bone artefacts excavated - many half-completed and raw-cut pieces still wait for detailed studies.

nibbling on the bones closely parched, leave parallel grooves perpendicular to the bones' edges (Plate 10.a) and on the opposite side very tiny, point-like engravings[1]. The distinction of rodent gnawing marks from cut marks presents no problems, as illustrated on a goat humerus bearing both (Plate 8.a). It cannot be ascertained whether these rodent marks are of subrecent or even recent provenience. Small mouse-like rodents from PPNB layers are reprsented in small numbers.

Abnormalities, Pathologies and Traumata

The frequency of ill-developed bones in the caprine material of Basta is quite low (n= 15 = 0.09 %; Table 19). The involved species, skeletal elements, the precise location and surface texture are given in the following list, as well as some proposals for the aetiology[2]:

Ovis/ Capra, domesticated: fragment of a cranium, hornless (Plate 11.a).

Capra, domesticated: horn core with a localised, porous coating of 3 cm length on the lateral side of the bone. The pitted surface implies an inflammational condition, probably caused by a lesion (Plate 11.d).

Ovis/Capra, domesticated: five cases of disease in molars of the upper jaw, affecting the roots. The roots exhibit a "feathery" quality (Plate 11.b); the affected tooth also has irregular wear patterns at the occlusional sides. All these teeth derive from old-adult individuals. The same can be recognized at one heavily worn M2 of the lower jaw. This disease may be linked with a chronic infection (Baker and Brothwell 1980: 150) caused by injuries or impaction of foreign bodies like straw, wood or other material packed between the teeth which initially produces infection of soft tissue, later involving the hard tissue. The same goes for the periontal disease, mentioned in the next line.

Capra ?, domesticated: lower jaw with an alveolar recession at P3 to M1 (Plate 11.c), presumably a periostitis. This periodontal disease may be caused by an absess formation. In the living animals, this disease can cause severe pain and affect mastication; weight loss can also occur.

Capra, domesticated: one distal humerus shows arthritic modifications (osteoarthritis). The evidence of disease is provided by the presence of several grooves, polishing of the joints' surface and marginal exostoses (Plate 11.f).

Capra, wild: distal humerus with lateral exostoses (Plate 11.e), caused by arthritic processes[3].

Ovis, wild: distal humerus with laterally protruding exostoses (Plate 11.g).

---

1 "Das Nagen geschieht hauptsächlich mit den Zähnen des Unterkiefers, während die des Oberkiefers den Gegenstand beim Nagen festhalten." (Mourier and Winding 1979: 84). Another typical example is given by Brothwell and Sandison (1967: 11) who discuss these gnawing marks in a chapter entitled "pseudopathologies"; very detailed analyses of rodent-created marks, verified by scanning electronic microscope inspections, are given by Shipman and Rose (1983: 81ff.).

2 A refined microscopical analysis will be carried out by M. Schultz in his Laboratory for Human Palaeopathology in Göttingen, Germany.

3 "In sheep, exostoses around the elbow joint which severely reduce the mobility of the joint are common. They appear to star on the lateral aspect of the joint..." (Baker and Brothwell 1980: 127).

Capra, domesticated: proximal femur with many exostoses; the changes occur mostly on the neck of the femur with only slight involvement of the articular surface. It may be an initial stage of coxarthrosis or a probable suppurative arthritis of the hip joint in a mature goat.

Capra, domesticated ?: distal tibia with lateral exostoses (Plate 11.i).

Capra and Ovis, domesticated: two calcanei from adult individuals with exostoses and porous areas on the tuber (one is shown in Plate 11.h), probably caused by traumatic lesions.

Bone pathology is a problematic subject, because pathological patterns are extremely difficult to link positively with specific diseases. Many diseases have no impact on the skeletal system, others affect it too late to leave clear evidence because the animal might be killed or slaughtered in advance. If one considers the enormous amount of archaeozoological material from pre- and protohistoric sites analysed to date, the number of pathological or abnormally developed bones is minute. The same regards our knowledge of animal disease in prehistory, although the kinds and frequencies of abnormalities can shed light on cultural behaviour and the standard and knowledge of former husbandry. The degree of involved species in the domestic livestock of this ancient site is relatively low (> 0,1 %). At first place, the instances described above reflect individual destinies, not common tendencies of malnutrition, bad treatment or improper breeding practises. If animals of prey like wild goat or sheep are affected, they could have been hunted and killed by predators much more easily as they were handicapped by their ailment.

Conclusions

According to the archaeological and osteological material unearthed in Area A, Late PPNB Basta provides a large amount of data. Any attempt at reconstructing economy and environment requires the interplay of many different categories of evidences such as the potential natural resources (plant cover, fauna and water regime), the carrying capacity of an area, population size, territorial extent of a community and finally its social structure. It is assumed that communities in the PPNB were self-sufficient in procuring the largest subsistence requirement: food. Ancient populations react to local abundance, diversity and predictability of resources. Although the record of bone samples is fragmentary and biased, it can be used to formulate a model of Neolithic subsistence. The large sample of data now available enables us to evaluate independently a regional development. The faunal remains brought to light at Late PPNB Basta represent a direct reflection of a man-animal or man-nature relationship in this particular region. Therefore, my first aim was to throw some light on the nature and scale of the exploitation of faunal resources in the environment of ancient Basta. Consequently that provides a frame into which the diverse sources of archaeological information are integrated. The inhabitants of this settlement exploited a diversity of ecosystems and took advantage of whatever stock was locally available: the steppe in the East (goitred gazelle and onager, but also to some extent wild sheep and hare), the nearby hilly regions and the fringe forest (aurochsen, wild boar, cervids) and even mountainous regions (wild goat, African wild ass and mountain gazelle, both of which are also found in lower, less mountainous areas). Ungulates constituted the main proportion of the prey. A specialisation with respect to a specific type of prey however, cannot be determined. The subsistence strategy reconstructed from the bone refuse excavated in Basta, reveals substantial dietary diversity. Domesticated caprines appear as dominant components.

In the first detailed analysis of the bone material from Basta *Capra* and *Ovis* formed the core of this presentation. Bone assemblages from the same stratigraphical level produced specimens from animals of the same genera but were very different in size. The variability evident in many bone measurements turned out to be much too large as to be induced by sexual dimorphism of a wild or domestic population alone. Therefore, it is suggested that the Basta material in fact contains a large number of domesticated goats and sheep of both sexes as well as a certain number of wild living individuals. Thus, the distinction of both categories - wild and domestic - often turned out to be difficult, sometimes even impossible. That was reflected by the outcome of the metrical analyses furnishing the existence of a broad intermediate zone with a more or less dense clustering of data. This zone exhibits only vaguely defined limits and is characterised by measurements either obtained from wild female specimens or large domesticated males. In my opinion the decision where to draw the border between clusters of domestic and wild specimens, often rests upon tentative judgements of the archaeozoologists themselves although they take a lot of care in accounting for a largest possible number of criteria as well as their individual familiarity with the examined bone sample. Nevertheless, while analysing the faunal material of Basta I was repeatedly given the impression that an intra-site decision is to a great degree more adequate than any comparison to recent faunal material or caprine samples excavated at sites located in different environments and produced under different conditions. I wish to emphasise the point that my conclusions presented here consequently should not be judged as being in any way definite but merely as a preliminary proposition. Size differences in bones, though not sufficient on their own, are compelling as regards for the demonstration of the former presence of domestic stocks and strongly support the possibility of a well advanced stage in the overall process of domestication. That supposition is firmly backed by the established age profiles as well as the distribution of sexes. Here, specialised culling of young animals (mainly males) for meat production was practised while female animals were predominatly slaughtered as old-adults. According to stratigraphical findings, a considerable stock of domesticates even in the earliest phases of occupation was identified while at the same time, wild goat and to a lesser extent wild sheep were hunted.

From the simultaneous occurrence of domestic animals and the existence of their specific forebears in the same macro-habitat several questions ensue which to my opinion have not been answered in a satisfactory manner. Was the process of domestication initiated by the people living in this part of the Levant, or did they get this idea from someone else, possibly even by way of a stock of already domesticated animals? If so, where from? Did they start with a flock of sheep or a herd of goats or were these animals imported together? Should we even go as far as to assume that both species underwent isolated domestication processes? I do not intend to expand on this topic. This has already been done (for example by Meadow 1989 and Bökönyi 1993; Horwitz 1989, 1993; Uerpmann 1987). But I would like to give some thought on this matter based on the impressions I received from the Basta bone material.

As deduced from the regular and numerous representation in many bone samples of several Levantine sites, wild goats have been present in large numbers as indigenous populations in many parts of the Fertile Crescent. Their ancient range to the Southwest has most probably reached as far as into the Basta region and even beyond (Uerpmann 1987: Fig. 52). From the archaeozoological record, one tends to notice a certain expertise on the part of the ancient hunters with the biology of the wild goats. From this "familiarity" the first efforts in domestication could have found its origins, because this process is supposed to have originated in those regions where domesticable species like *Capra aegagrus* occurred in seizable numbers and where a link between man and animal was most likely to happen. And if osteologists, after having analysed caprine material from PPNB sites, come to the conclusion that semi-domestication was practised during this period in parts of the Southern Levant, why then should the origin of goat domestication be sought in distant regions? The PPNB in the Levant spans some 1500 years, a period long enough to set into action a sequence of ideas of capture, taming and subsequently breeding goats. I do not dare to presume that this might, among all other regions of the Fertile Crescent, have also happened in the Southern

Levant. The archaeozoological evidences from 'Ain Ghazal, Beidha, Jericho and Basta tend to confirm that suggestion.

This model can not be applied to sheep domestication, because the limits of the former distribution of *Ovis orientalis* are even less known than for *Capra aegagrus*. Some scattered data from the Negev (Davis *et al.* 1982), the lowlands of Northern Mesopotamia and Southern Jordan (Uerpmann 1987: 126ff.) suggest that in prehistoric times wild sheep were widely spread. The data gained from Basta back up the impression that these animals may in fact have occurred in the periphery of the Jordan Rift Valley, maybe in fragmented and isolated flocks. The scarcity of wild sheep compared to the number of wild goats in the Basta sample adds weight to the idea that a local process of sheep domestication would be less likely than a self-initiated domestication of wild goats.

It remains questionable where sheep domestication originated. Evidence for the occurrence of domesticated caprines appeared on the Anatolian plateau several hundred years earlier than in the Southern Levant. In PPNB sites such as Cayönü, sheep came under human control first[1]. Lawrence (1982: 190) states, that "domestication seems to have appeared relatively suddenly ... and goats, the most commonly used of the two caprines in the wild fauna, declined in importance with the appearance of domestic sheep." The dominance of sheep continues, as drawn from results on a large faunal assemblage excavated at PPNB Gritille. Domesticated caprines form 76 % of the identified fragments, sheep and goats occur in a percentage of 2,89 : 1 (Stein 1989: 89). At Suberde and Aşikli, sheep domestication early in the 7th millennium is indicated (Uerpmann 1987: 140). The foothills of the Zagros mountains is a region where domestication is also assumed to have found its roots (Uerpmann 1979, Davis 1987, Bar-Yosef and Belfer-Cohen 1989). Furthermore, in the Indo-Iranian borderlands the very early domestication of caprines has been proven. The carefully documented Mehrgarh assemblage has turned out to be one of the most important sources for identifying local domestication of sheep (and cattle) whereas the existence of domesticated goats was detected even from the very earliest, aceramic levels of occupation at this site. Meadow (1984) consequently suspects the latter to have been introduced from other regions. To sum up, it seems generally agreed that the process of sheep domestication did not take place in the Mediterranean Levant but in the flanks of the Taurus-Zagros ranges. One can assume that either a diffusion of the concept or a transport of domesticated animals prepared the ground for a new subsistence strategy in the Southern Levant. The "seed" could have sprung up in every region along the "Levantine Corridor", especially where wild goat and wild sheep occurred in their natural habitats and where people, through continuous hunting gradually acquired an increasing knowledge of the animals' specific biology. Against the background of the results gained from the Basta caprine material, I can even imagine a mixed process to have taken place, probably in a chronological sequence: Goats were tamed and domesticated from a wild local stock, sheep were introduced as domesticates. In order to obtain a substantial flock of animals, the Basta people could have tried to interbreed these imported animals with wild ones living in the vicinity of the settlement. During the PPNB period, neither goat nor sheep domestication seemed to have reached regions further South, *i.e.* the Sinai. Reasonable hints of domestication or even attempts at domesticating any of the species represented have not been found in the abundant faunal sample from Ujrat el-Mehed; only a selected hunting of ibex may have been practised there (Dayan *et al.* 1986). The same applies for the assemblage of PPNB Wadi Tbeik (Tchernov and Bar-Yosef 1982). It seems as if this economic innovation moved at relatively slow speed into Southern regions.

[1] As Lawrence (1982: 175) points out, it was found that in the earliest PPNB levels of Çayönü *Ovis* surely and *Capra* possibly were domestic.

The remaining question is that why Basta of all other known Southern Levantine places represents the site where domesticated goat *and* sheep turned up so clearly and unquestionably. For reasons of topography and vegetation Basta's environ gained quite favourable conditions for (transhumant ?) exploitation via goat and sheep herding. But then again, other PPNB sites were set in similar ecological surroundings. The particularity about PPNB Basta is probably best explained by aid of its economic setting. The estimated size of the settlement which covers about 10 ha, is indicative for a relatively large population or at least an increasing number of people living in the vicinity of the site. The population level may have passed a certain critical threshold and alternative or diversified sources of meat would have had to be sought. Continuing demographic pressure might in fact have forced the inhabitants to adopt new subsistence strategies. The most likely ones to be introduced were those that were already practised with success elsewhere, - in this case the herding and breeding of domesticated caprines[1]. The increase and improvement of the domestic livestock through interbreeding with locally captured wild caprines seemed to have been carried out by the inhabitants of ancient Basta. They probably might have experienced very soon that a mixed economy, consisting of husbandry and hunting, minimised the risk of failure. And despite specific problems set by domestication, husbandry turned out to become increasingly effective. An intensive and well-structured exploitation of secondary products (milk, wool and hair) of domestic herd animals which would refer to specialised types of pastoralism could not be diagnosed on a significant scale from the caprine sample, although milk processing and wool production may have taken place to a limited extent. However, the analyses of fragmentation patterns and cut marks have pointed out that dismemberment was intentionally practised. This was mainly done for purposes removing meat and sinews, extracting marrow, as well as skinning and tool processing. The inhabitants of ancient Basta may finally have attached additional importance on their flocks, because a herd of goat can serve as symbol of wealth and prestige.

But herding can not be understood as an isolated activity within the Basta economy - the Basta inhabitants practised four subsistence strategies: herding, farming, gathering and hunting. The seasonality and scheduling of each sector imposes constraints on the choice and organisation of the other. I suggest that the Basta settlers supplemented lower levels of meat consumption of domestic caprines either regularly or only in seasons of nutritional shortages by hunting parties, which concentrated on the local game which was available in the imme-diate neighbourhood all year round (*i.e.* boar, cervids). The other adopted effective strategy was probably to trap herds whose known migration routes passed throught the vicinity of the Neolithic settlement. It is in fact no coincidence that considerations referring to animal behaviour, group sizes or seasonal changes are laden with many quandaries. Our knowledge about the natural life in the Levant today is very restrained. The evidence of the faunal assemblage from Basta illustrates well the situation. It includes animals which today are either under world-wide threat of extinction, as for example the Persian fallow deer and the African wild ass, or else have already died out as the aurochs and the Syrian onager. Other species like the red deer and hartebeest[2] are known to have disappeared during the Early Holocene and later periods. However, it remains safe to argue that in the Basta environment certain months must have been more favourable for hunting than others. Another possible explanation for this hunting large varieties of species may even be sought in tradition.

---

[1] Similar hypothesis have been discussed by Davis (1989: 43ff.) concerning man-animal relationships in PPNA Hatoula. Another example for a rapid economic adaptation comes from Nahal Oren (Noy *et al.* 1973: 90f.).

[2] identified from the Jericho bone sample (Tab. 4) and from the Bronze Age site of Tel Gat (Ducos 1968: 49). Its range is now restricted to Africa south of the Sahara (Clutton- Brock 1978: 34). Among others, elephant, beaver and lion have to be added (Garrard 1984).

On a longer term, overhunting, land clearance for purposes of plant cultivation, fuel supply, building material and even plaster manufacture[1] would finally have led to serious shortages in the availability of natural resources. Shrinkage of undisturbed habitats was the consequence, which received extra generation by the new and growing sector of herding. The number of hunted animals gradually decreased from the catchment area of the site. An already perceptible impoverishment of resources might hence help to explain why the hunters of Basta roamed so many different natural habitats within a relatively broad radius, sometimes covering large distances in order to kill particularly choiced prey. The lack of permanent settlements in the greater Petra area, dating to post-PPNB times (Gebel 1985: 112) may in fact partly have been engendered by a devastation of the environment, a direct consequence of over-exploitation of biotic resources.

With this increased amount of data on natural resources and subsistence strategies, distinct regional variants are emerging which do not challenge previous interpretations of Neolithic economy and organisation in the Southern Levant, but diversifies and enlarges our knowledge considerably.

Acknowledgements: I would like to thank Prof. Nissen for letting me analyse the faunal material from Basta and Prof. Hänsel for releasing me from my duties at the institute to participate at the excavations in Jordan. My special thanks go to H.-P. Uerpmann (Tübingen) for his invaluable help on the identification of goat and sheep bones and the opportunity to use his reference collection of Near Eastern ungulates. Computer assistance was provided by T. Urban who translated the stratigraphical data into distribution patterns (basis: open access III) and by J. Müller and N. Benecke who both shared their experiences with the SSPS/PC program for the principal component analysis. D. Wolf kindly took the photographs except those on Plate 1. My thanks also go to U. Münch for translating the Arabic text of the thesis from W. Karasneh. I finally owe my warmest thanks to A. Garrard, A. McQuitty and K. Rielly for their generous hospitality during my repeated stays at the British Institute of Archaeology in Amman. I also express my thanks to P. Larsen for correcting the English. Final responsibility for contents and drawings rest with the author.

Dr. Cornelia Becker
Institut für Prähistorische Archäologie
Freie Universität Berlin
Altensteinstr. 15
Germany - 14195 Berlin

References

Armitage P.L. and J. Clutton-Brock
1976 A system for classification and description of the horn cores of cattle from archaeological sites. *Journal of Archaeological Science* 3: 329-348.

Baker J. and D. Brothwell
1980 *Animal Diseases in Archaeology.* London, Academic Press.

Bar-Yosef O and A. Belfer-Cohen
1989 The Levantine "PPNB" interaction sphere. In: I. Hershkovitz (ed.), *People and Culture in Change. Proceedings of the Second Symposium on Upper Palaeolithic, Mesolithic and Neolithic Populations of Europe and the Mediterranean Basin. British Archaeological Reports* - Intern. Series 508.1-2: 59-72.

Becker C.
1981 Bißpuren. In: C. Becker and F. Johansson, *Die neolithischen Ufersiedlungen von Twann*11. *Tierknochenfunde, Zweiter Bericht*: 32-33, Bern, Haupt.
1986 *Kastanas. Ausgrabungen in einem Siedlungshügel der Bronze- und Eisenzeit Makedoniens (1975-1979). Die Tierknochenfunde.* Prähistorische Archäologie Südosteuropas 5.

[1] Rollefson *et al.* (1989: 79) calculated that by about 6250 B.C. more than 30 000 trees had been used for this purpose in the vicinity of 'Ain Ghazal and that a land strip of more than 2000 ha, representing a radius of 2.6 km around the settlement, has been deforestated.

1987 Faunal remains. In: H.J. Nissen, M. Muheisen, and H.G. Gebel *et al.*, Report on the first two seasons of excavations at Basta (1986 - 1987). *Annual of the Department of Antiquities of Jordan* 31: 115-117.

1991a The analysis of mammalian bones from Basta, a Pre-Pottery Neolithic site in Jordan: problems and potential. *Paléorient* 17.1: 59-75.

1991b Faunal remains. In: H.J. Nissen, M. Muheisen, and H.G. Gebel *et al.*, Report on the third season of excavation at Basta 1988. *Annual of the Department of Antiquities of Jordan* 35: 29-32, Plate 6.

1998 The role of hunting in Pre-Pottery Neolithic pastoralism and its ecological implications: the Basta example. *Anthropozoologica* 27: 67-78.

1999 Early domestication in the Southern Levant as viewed from Late PPNB Basta. In: L.K. Horwitz, E. Tchernov, P. Ducos, C. Becker, A. von den Driesch, I. Marzin, and A. Garrard, Animal Domestication in the Southern Levant. *Paléorient* 25.2: 70-72.

2000 Bone and species distribution in Late PPNB Basta (Jordan): rethinking the anthropogenic factor. In: M. Mashkour *et al.*, *Archaeozoology of the Near East IVA. Proceedings of the 4th International Symposium on the Archaeozoology of Southwestern Asia and Adjacent Areas.* ARC-Publicaties 32: 196-207. Groningen.

2002 Nothing to do with indigenous domestication? Cattle from Late PPNB Basta. In: H. Buitenhuis, A. Choyke, M. Mashkour (eds.), *Archaeozoology of the Near East V. Proceedings of the 5th International Symposium on the archaeozoology of the Near East and adjacent areas.* ARC Publicaties 62: 112-137. Groningen.

in press Fire-damaged bone artefacts and a vessel: a remarkable marriage. In: J. Schibler (ed.), Bone, Antler and Teeth. Raw materials for tools from archaeological contexts. Knochen, Geweih und Zähne. Rohstoff für Werkzeuge aus archäologischem Zusammenhang. In: *Proceedings of the 3rd Meeting of the ICAZ Worked Bone Research Group, Basel/Augst, 4th - 8th Sept. 2001 (Basel 2002).* Rahden/Westf., Marie Leidorf.

in prep. Faunal remains from the Pre-Pottery Neolithic B site of Basta, Area B.

Bökönyi S.

1993 Domestication models: the Anatolian-Mesopotamian and the others in southwest Asia. In: H. Buitenhuis and A.T. Clason (eds.), *Archaeozoology of the Near East. Proceedings of the First International Symposium on the Archaeozoology of Southwestern Asia and Adjacent Regions*: 4-9. Leiden, Universal Book Services.

Boessneck J.

1969 Osteological differences between sheep (*Ovis aries* Linné) and goat (*Capra hircus* Linné). In: D. Brothwell and E. Higgs (eds.), *Science in Archaeology:* 331-358.

Boessneck J., H.H. Müller, and M. Teichert

1964 Osteologische Unterscheidungsmerkmale zwischen Schaf (*Ovis aries* L.) und Ziege (*Capra hircus* L.). *Kühn-Archiv* 78: 1-129.

Brosius G.

1989 *SPSS/PC + Advanced Statistics and Tables.* Hamburg/New York, McGrawhill.

Buitenhuis H. and A.T. Clason (eds.)

1993 *Archaeozoology of the Near East. Proceedings of the First International Symposium on the Archaeozoology of Southwestern Asia and Adjacent Regions.* Leiden, Universal Book Services.

Chapman D. and N. Chapman

1975 *Fallow Deer. Their History, Distribution and Biology.* Lavenham, Suffolk, Terence Dalton.

Clutton-Brock J.

1978 Early domestication and the ungulate fauna of the Levant during the Pre-Pottery Neolithic period. In: W.C. Brice (ed.), *The Environmental History of the Near and Middle East Since the Last Ice Age:* 29-40. London, Academic Press.

1979 The mammalian remains from the Jericho Tell. *Proceedings of the Prehistoric Society* 45: 135-157.

Clutton- Brock C., K. Dennis-Bryan, P.L. Armitage, and P.A. Jewell

1990 Osteology of the Soay sheep. *Bulletin British Museum Natural History (Zoology)* 56.1: 1-56.

Clutton- Brock J. and H.P. Uerpmann

1974 The sheep of early Jericho. *Journal of Archaeological Science* 1: 261-274.

Davis S.

1978 Étude de la faune. In: M. Lechevallier (ed.), *Abou Gosh et Beisamoun.* Mémoires et Travaux du Centre d' Archéologie Préhistoire Français de Jerusalem 2: 195-197.

1982 Climatic change and the advent of domestication: the succession of ruminant artiodactyls in the Late Pleistocene - Holocene in the Israel region. *Paléorient* 8.2: 5-15.

1984 The advent of milk and wool production in Western Iran: some speculations. In: J. Clutton-Brock and C. Grigson (eds.), *Animals in Archaeology* 3. *Early Herders and their Flocks.* British Archaeological Reports - Intern. Reports 202: 265-278.

1987 *The Archaeology of Animals*. London, Batsford.
1989 Why did prehistoric people domesticate food animals? In: O. Bar-Yosef and B. Vandermeersch (eds.), *Préhistoire du Sud-Levant. Investigations in South Levantine Prehistory*. British Archaeological Reports - Intern. Series 497: 43-59.

Davis S., N. Goring-Morris, and A. Gopher
1982 Sheep bones from the Negev Epipalaeolithic. *Paléorient* 8.1: 87-93.

Dayan T., E. Tchernov, O. Bar-Yosef, and Y. Yom-Tov
1986 Animal exploitation in Ujrat el-Mehed, a Neolithic site in southern Sinai. *Paléorient* 12.2: 105-116.

Dive J. and V. Eisenmann
1991 Identification and discrimination of first phalanges from Pleistocene and modern Equus, wild and domestic. In: R. Meadow and H.P. Uerpmann (eds.), *Equids in the Ancient World* II. Beihefte zum Tübinger Atlas des Vorderen Orients (Beihefte TAVO) A 19.2: 278-333. Wiesbaden, Reichert.

Dorst J. and P. Dandelot
1970 *Säugetiere Afrikas*. Hamburg/Berlin, Parey.

Driesch von den A.
1972 *Osteoarchäologische Untersuchungen auf der Iberischen Halbinsel. Studien über frühe Tierknochenfunde von der Iberischen Halbinsel 3*. München, UNI-Druck.
1976 *Das Vermessen von Tierknochen aus vor- und frühgeschichtlichen Siedlungen*. München, UNI-Druck.

Ducos P.
1968 L'Origine des Animaux Domestiques en Palestine. *Publications de l'Institut de Préhistoire de l'Université de Bordeaux* 6.
1975 A new find of an equid metatarsal bone from Tell Mureibit in Syria and its relevance to the identification of equids from the Early Holocene of the Levant. *Journal of Archaeological Science* 2: 71-73.
1978 La faune d'Abou Gosh. Proto-élevage de la chèvre en Palestine au Néolithique Pré-céramique. In: M. Lechevallier (ed.), *Abou Gosh et Beisamoun*. Mémoires et Travaux du Centre de Archéologie Préhistoire Français de Jérusalem 2: 107-120.
1986 The equids of Tell Mureibit, Syria. In: R. Meadow and H.P. Uerpmann (eds.), *Equids in the Ancient World* I. Beihefte zum Tübinger Atlas des Vorderen Orients (Beihefte TAVO) A 19.1: 237-245 Wiesbaden, Reichert.
1993 Some remarks about Ovis, Capra and Gazella remains from two PPNB sites from Damascene, Syria, Tell Aswad and Ghoraifé. In: H. Buitenhuis and A.T. Clason (eds.), *Archaeozoology of the Near East. Proceedings of the First International Symposium on the Archaeozoology of Southwestern Asia and Adjacent Regions*: 37-45. Leiden, Universal Book Services.

Evins M.A.
1982 The fauna from the Shanidar Cave: Mousterian wild goat exploitation in Northeast Iraq. *Paléorient* 8.1: 37-58.

Ewbank J.M., D.W. Phillipson, R.D. Whitehouse, and E.S. Higgs
1964 Sheep in the Iron Age: a method of study. *Papers of the Prehistoric Society* 30: 423-426.

Garrard A.N.
1984 Community ecology and Pleistocene extinctions in the Levant. In: R. Foley (ed.), *Hominid Evolution and Community Ecology. Prehistoric Human Adaptation in Biological Perspective*: 261-277.

Garrard A.N. and H.G. Gebel (eds.)
1988 *The Prehistory of Jordan. The State of Research in 1986. British Archaeological Reports* - Intern. Series 396.1-2.

Gebel H.G.
1988 Late Epipalaeolithic - Aceramic Neolithic sites in the Petra area. In: A.N. Garrard and H.G. Gebel (eds.), *The Prehistory of Jordan. The State of Research in 1986*. British Archaeological Reports - Intern. Series 396.1: 67-100.

Gebel H.G. and J.M. Starck
1985 Investigations into the stone age of the Petra area (Early Holocene Research). A preliminary report on the 1984 campaign. *Annual of the Department of Antiquities of Jordan* 29: 89-114.

Geddes D.S.
1985 Mesolithic domestic sheep in West Mediterranean Europa. *Journal of Archaeological Science* 12: 25-48.

Geist V.
1971 *Mountain Sheep. A study in behaviour and evolution*. Chicago, University Press.

Grigson C.
1989 Size and sex: evidence for the domestication of cattle in the Near East. In: A. Milles, D. Williams, and N. Gardner (eds.), *The Beginnings of Agriculture.* British Archaeological Reports - Intern. Series 496: 77-109.

Hecker H.
1975 *The Faunal Analysis of the Primary Food Animals from Pre-Pottery Neolithic Beidha (Jordan).* Columbia University: unpub. PhD dissertation.
1982 Domestication revisited. Implications for faunal analysis. *Journal of Field Archaeology* 9: 217-236.

Heptner V.G., A.A. Nasimov, and A.G. Bannikov
1966 *Die Säugetiere der Sowjetunion* 1. *Paarhufer und Unpaarhufer.* Jena, Fischer.

Hershkovitz I. (ed.)
1989 *People and Culture in Change. Proceedings of the Second Symposium on Upper Palaeolithic, Mesolithic and Neolithic Populations of Europe and the Mediterranean Basin.* British Archaeological Reports - Intern. Series 508.1-2.

Herre W. and W. Röhrs
1990 *Haustiere - zoologisch gesehen.* Stuttgart/ New York, Fischer.

Hesse B.
1982 Slaughter patterns and domestication: the beginning of pastoralism in Western Iran. *Man (N.S.)* 17: 402-417.

Horwitz L.K.
1987 The fauna of the PPNB site of Yiftahel: new perspectives on domestication (abstract of a lecture delivered at the annual meeting of the Israel Prehistoric Society, Tel Aviv University, Nov. 1986). *Mitekufat Haeven. Journal of Israel Prehistoric Society* 20: 181-182.
1989 A reassessment of caprovine husbandry in the Levantine Neolithic: old questions, new answers. In: I. Hershkovitz (ed.), *People and Culture in Change. Proceedings of the Second Symposium on Upper Palaeolithic, Mesolithic and Neolithic Populations of Europe and the Mediterranean Basin.* British Archaeological Reports - Intern. Series 508.1-2: 153-181.
1990 Diachronic changes in rural husbandry practices in Bronze Age settlements from the Refaim Valley, Israel. *Palestine Exploration Quaterly:* 44-54.
1993 The development of ovicaprine domestication during the PPNB of the southern Levant. In: H. Buitenhuis and A.T. Clason (eds.), *Archaeozoology of the Near East. Proceedings of the First International Symposium on the Archaeozoology of Southwestern Asia and Adjacent Regions:* 27-42. Leiden, Universal Book Services.

Horwitz L. and P. Smith
1991 A study of diachronic change in bone mass of sheep and goats in Jericho (Tel-Es Sultan). *Archaeozoologia* 4.1: 29-38.

Horwitz L.K. and E. Tchernov
1987 Faunal remains from the PPNB submerged site of Atlit. *Mitekufat Haeven. Journal of the Israel Prehistoric Society* 20: 72-78.

Jones K.T. and D. Metcalfe
1988 Bare bones archaeology: bone marrow indices and efficiency. *Journal of Archaeological Science* 15: 415-423.

Karasneh W.
1989 *Bone Artifacts from Basta.* Irbid, Yarmouk University: unpub.M.A. thesis. (in Arabic)

Kersten A.M.P.
1987 Age and sex of epipalaeolithic fallow deer and wild goat from Ksar 'Akil. *Palaeohistoria* 29: 119-131.

Köhler-Rollefson I.
1987 Goat husbandry in Jordan from a diachronic perspective. Unpublished manuscript.
1989a Resolving the revolution: Late Neolithic refinements of economic strategies in the Eastern Levant. *Archaeozoologia* III.1,2: 201-208.
1989b Changes in goat exploitation at 'Ain Ghazal between the early and the Late Neolithic: a metrical analysis. *Paléorient* 15.1: 141-146.

Köhler-Rollefson I., W. Gillespie, and M.Metzger
1988 The fauna from Neolithic 'Ain Ghazal. In: A.N. Garrard and H.G. Gebel (eds.), *The Prehistory of Jordan. The State of Research in 1986. British Archaeological Reports* - Intern. Series 396.1: 423-430.

Korsching F.
1980 *Beduinen im Negev. Eine Ausstellung der Sammlung Sonia Gidal.* Mainz, von Zabern.

Kratochvil Z.
1969 Species criteria on the distal section of the tibia in *Ovis ammon* f. aries L. and *Capra aegagrus* f. hircus L. *Acta Veterinaria* 38: 483-490.

Lawrence B.
1980 Evidence of animal domestication at Cayönü. In: H. Çambel and R.J. Braidwood (eds.), *The Joint Istanbul-Chicago Universities Prehistoric Research in Southeast Anatolia* 1*:* 285-308. Istanbul, Edebiyat Fakültesi Basimevi.
1982 Principal food animals at Çayönü. In: L.S. Braidwood and R.J. Braidwood (eds.), *Prehistoric Village Archaeology in South-*East *Turkey (The eigth Millennium B. C. Site at Cayönü: Its Chipped and Ground Stone Industries and Faunal Remains)* . British Archaeological Reports - Intern. Series 138: 175-199.

Lyman R.L.
1987 Archaeofaunas and butchery studies: a taphonomic perspective. In: M.B. Schiffer (ed.), *Advances in Archaeological Method and Theory* 10: 249-337.

Maltby J.M.
1982 The variability of faunal samples and their effects upon ageing data. In: B. Wilson, C. Grigson, and S. Payne (eds.), *Ageing and Sexing Animal Bones from Archaeological Sites.* British Archaeological Reports - Intern. Series 109: 81-90.

Meadow R.
1984 Animal domestication in the Middle East: a view from the Eastern margin. In: J. Clutton-Brock and C. Grigson C. (eds.), *Animals and Archaeology* 3. *Early Herders and their Flocks.* British Archaeological Reports - Intern. Series 202: 309-337.
1989 Prehistoric wild sheep and sheep domestication on the Eastern margin of the Middle East. In: P.J. Crabtree, D. Campana, and K. Ryan (eds.), *Early Animal Domestication and its Cultural Context. MASCA Research Papers* 6: 24-36.

Meadow R. and H.P. Uerpmann
1986 *Equids in the Ancient World* I. Beihefte zum Tübinger Atlas des Vorderen Orients (Beihefte TAVO) A 19.1. Wiesbaden, Reichert.
1991 *Equids in the Ancient World* II. Beihefte zum Tübinger Atlas des Vorderen Orients (Beihefte TAVO) A 19.2. Wiesbaden, Reichert.

Mendelssohn H.
1974 The development of the populations of gazelles in Israel and their behavioural adaptations. *International Union for Conservation of Nature and Natural Resources Publication* 24/40: 722-744.

Mourier H. and Winding O.
1979 *Tierische Schädlinge und andere ungebetene Tiere in Haus und Lager.* München, BLV.

Neef R.
1987 Palaeoethnobotany. In: H.J. Nissen, M. Muheisen, and H.G. Gebel *et al.,* Report on the first two seasons of excavations at Basta (1986-1987). *Annual of the Department of Antiquities of Jordan* 31: 115.

Nissen H.J., M. Muheisen, and H.G. Gebel *et al.*
1987 Report on the first two seasons of excavations at Basta (1986-1987). *Annual of the Department of Antiquities of Jordan* 31: 79-119.

Noddle B.
1974 Ages of epiphyseal closure in feral and domestic goats and ages of dental eruption. *Journal of Archaeological Science* 1: 195-204.
1978 Some minor skeletal differences in sheep. In: R. Brothwell, K.D. Thomas, and J. Clutton-Brock (eds.), *Research Problems in Zooarchaeology.* Institute of Archaeology Occasional Publications 3: 133-141, London.

Noy T, A.J. Legge, and E.S. Higgs
1973 Recent excavation at Nahal Oren, Israel. *Proceedings of the Prehistoric Society* 39: 75-99.

Olsen S. L. and P. Shipman
1988 Surface modification on bone: trampling versus butchery. *Journal of Archaeological Science* 15: 535-553.

Pachur H. J.
1987 Aspects of physical and geomorphological setting. In: H.J. Nissen, M. Muheisen, and H.G. Gebel *et al.*, Report on the first two seasons of excavations at Basta (1986-1987). *Annual of the Department of Antiquities of Jordan* 31: 82-95.

Payne S.
1969 A metrical distinction between sheep and goat metacarpals. In: P. Ucko and G. Dimbleby (eds.), *The Domestication and Exploitation of Plants and Animals:* 295-305, London, Duckworth.
1973 Kill-off patterns in sheep and goats: the mandibles from Aşvan Kale. *Anatolian Studies* 23: 281-303.
1985 Animal bones from Aşıklı Hüyük. *Anatolian Studies* 35: 109-122.
1988 Animal bones from Tell Rubeidheh. In: R.G. Killick (ed.), *Tell Rubeidheh. An Uruk Village in the Jebel Hamrin.* Iraq Archaeological Reports 2 (Hamrin Salvage Project Report 7): 98-145, Plate 8-10.

Prummel W.
1983 Medieval horses from Utrecht (Jan Meijenstraat). *Palaeohistoria* 25: 195-210.

Redding R.W.
1981 *Decision Making in Subsistence Herding of Sheep and Goats in the Middle East.* Ann Arbor, University of Michigan: unpub. PhD dissertation.

Rollefson G.O. and I. Köhler-Rollefson
1989 The collapse of early Neolithic settlements in the Southern Levant. In: I. Hershkovitz (ed.), *People and Culture in Change. Proceedings of the Second Symposium on Upper Palaeolithic, Mesolithic and Neolithic Populations of Europe and the Mediterranean Basin.* British Archaeological Reports - Intern. Series 508.1-2: 73-89.

Schibler J.
1980 *Osteologische Untersuchungen der cortaillodzeitlichen Knochenartefakte. Die neolithischen Ufersiedlungen von Twann* 8. Bern, Haupt.

Schultz M.
1987 Human Skeletal Remains. In: H.J. Nissen., M. Muheisen, and H.G. Gebel *et al.*, Report on the first two seasons of excavations at Basta (1986-1987). *Annual of the Department of Antiquities of Jordan* 31: 96-97.

Shipman P.
1983 Early hominid lifestyle: hunting and gathering or foraging and scavenging? In: J. Clutton-Brock and C. Grigson (eds.), *Animals and Archaeology* 1. *Hunters and their prey.* British Archaeological Reports - Intern. Series 163: 31-49.

Shipman P. and J. Rose
1983 Early hominid hunting, butchering and carcass-processing behaviours: approaches to the fossil record. *Journal of Anthropological Archaeology* 2: 55-98.

Stein G.J.
1987 Regional economic integration in early state societies: third millennium B.C. pastoral production at Gritille, southeast Turkey. *Paléorient* 13.2: 101-111.

Stein G.
1989 Strategies of risk reduction in herding and hunting systems of Neolithic southeast Anatolia. In: P. Crabtree, D. Campana, and K. Ryan (eds.), *Early Animal Domestication and Its Cultural Context. MASCA Research Papers in Science and Archaeology:* 87-97.

Tchernov E.
1984 Faunal turnover and extinction in the Levant. In: P.S. Martin and R.G. Klein (eds.), *Quaternary Extinctions:* 528-552. Tuscon, University of Arizona Press.
1993 The impact of sedentism on animal exploitation in the Southern Levant. In: H. Buitenhuis and A.T. Clason (eds.), *Archaeozoology of the Near East. Proceedings of the First International Symposium on the Archaeozoology of Southwestern Asia and Adjacent Regions*: 10-26. Leiden, Universal Book Services.

Tchernov E. and O. Bar-Yosef
1982 Animal exploitation in the Pre-Pottery Neolithic period at Wadi Tbeik, southern Sinai. *Paléorient* 8.2: 17-37.

Tchernov E., T. Dayan, and Y. Yom-Tov
1986/87 The palaeogeography of *Gazella gazella* and *Gazella dorcas* during the Holocene of the southern Levant. *Israel Journal of Zoology* 34: 51-59.

Uerpmann H.P.
1971 *Die Tierknochenfunde aus der Talayot-Siedlung von S'Illot (San Lorenzo/ Mallorca). Studien über frühe Tierknochenfunde von der Iberischen Halbinsel* 2. München, UNI-Druck.
1979 *Probleme der Neolithisierung des Mittelmeerraums.* Beihefte zum Tübinger Atlas des Vorderen Orients (Beihefte TAVO) B 28. Wiesbaden, Reichert.
1982 Faunal remains of Shams ed-Din Tannira, a Halafian site in Syria. *Berytus* 30: 3-52.

1986 Halafian Equid Remains from Shams ed-Din Tannira in Northern Syria. In: R. Meadow and H.P. Uerpmann (eds.), *Equids in the Ancient World* I. Beihefte zum Tübinger Atlas des Vorderen Orients (Beihefte TAVO) A 19.1: 246-265. Wiesbaden, Reichert.

1987 *The Ancient Distribution of Ungulate Mammals in the Middle East.* Beihefte zum Tübinger Atlas des Vorderen Orients (Beihefte TAVO) A 27. Wiesbaden, Reichert.

1991 *Equus africanus* in Arabia. In: R. Meadow and H.P. Uerpmann (eds.), *Equids in the Ancient World* II. Beihefte zum Tübinger Atlas des Vorderen Orients (Beihefte TAVO) A 19.2: 12-33.

Wetzel A.

1926 Studien zur vergleichenden Osteologie von *Capreolus vulgaris, Ovis aries* und *Capra hircus* für die Fleischbeschau und forensische Praxis. *Münchner Tierärztliche Wochenschrift* 77.28.

Appendix: Tables 1-22
Pages 278-310

Table 1. Basta, Area A. Faunal remains, rate of identification.

category	*count*	*%*	*weight*	*%*
identified	20.829	54.2	99.675	80.7
not identified	17.604	45.8	23.776	19.3
total	*38.433*	*100.0*	*123.451*	*100.0*

Table 2. Basta, Area A. Grouping of unidentified remains to size classes: 1 splinters *(max. length: 1 cm, max. weight: 1 gram)*, 2 bone fragments of middle sized animals *(such as ovicaprines or gazelles)*, 3 bone fragments of large sized animals *(such as cattle, onager or deer)*.

group	*count*	*weight*	*average weight per fragment*
1	16.266	16.117	1.0
2	345	497	1.4
3	993	7.162	7.2
total	*17.604*	*23.776*	*1.4*

Table 3. Basta, Area A. Frequency of genera and classes.

genera/classes	*count*	*%*	*weight*	*%*
Capra/ Ovis	17.141	82.3	63.821	64.0
Gazella	1.769	8.5	6.246	6.3
Dama	6	<0.1	102	0.1
Cervus	5	<0.1	94	0.1
Capreolus	2	<0.1	20	<0.1
Bos	649	3.1	19.028	19.1
Sus	40	0.2	562	0.6
Equus	431	2.1	8.682	8.7
Canis	7	<0.1	32	<0.1
Vulpes	9	<0.1	24	<0.1
Felis	10	<0.1	26	<0.1
Lepus	274	1.3	393	0.4
Erinaceus	1	<0.1	5	<0.1
Carnivora (indet.)	37	0.2	104	0.1
Rodentia/small mammalia (indet.)	391	1.9	497	0.5
Aves (indet.)	43	0.2	64	<0.1
Reptilia (indet.)	14	<0.1	15	<0.1
total	*20.829*	*100.0*	*99.675*	*100.0*

Table 4. List of ungulates from Levantine sites and adjacent regions with PPNB occupation layers: 1 Yiftahel (Horwitz 1987), 2 Munhatta (Ducos 1968), 3 Jericho (Clutton-Brock 1979), 4 'Ain Ghazal (Köhler-Rollefson 1988), 5 Abu Gosh (Ducos 1978), 6 Beisamoun (Davis 1978), 7 Beidha (Hecker 1982), 8 Basta, 9 Wadi Tbeik (Tchernov and Bar-Yosef 1982), 10 Ujrat el-Mehed (Dayan *et al.* 1986); 11 Nahal Oren (Noy et al 1973); 12 El-Khiam (Ducos 1968); for location of sites see Fig. 1.

taxa	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
Capra aegagrus	+	+	+	+	+	+	+	+			?	
Capra ibex							+		+	+		
Ovis orientalis		+	?			?		+				
Capra hircus			+	?	?	?	?	+			+	+
Ovis aries			+					+				
Bos primigenius	+	+	+	+	+	+	+	+	+	+	+	+
Gazella sp.*	+		+	+		+	+	+	+	+	+	+
Alcelaphus busel.			+									
Cervus elaphus			?					+				
Dama mesopotamica	+		+			+		+			+	
Capreolus capr.	+	+	+					+			+	
Equus hemionus							?	+	?			
Equus africanus								+				
Equus sp.			+			+				+		+
Sus scrofa	+	+	+	+	+	+	+	+			+	+

* The gazelles are not listed with their species affiliation, because in most cases their identification is still controversial.

Table 5. Basta, Area A. Analysis of bones in the architectural context: relative distribution of genera and classes *(basis: bone count).*

genera/classes	*surface deposit*	*room fill*	*sub-structure*
Capra and Ovis	84.3	81.9	80.9
Gazella	5.5	11.1	11.5
Dama	0.1	<0.1	-
Cervus	0.1	<0.1	-
Bos	5.8	2.5	3.0
Sus	0.1	-	-
Equus	2.4	2.5	0.9
Canis	0.1	-	-
Vulpes	-	<0.1	0.5
Felis	0.1	<0.1	0.5
Lepus	1.3	1.0	0.9
Carnivora	0.1	<0.1	0.9
Aves	0.1	0.6	0.9
total	*100.0*	*100.0*	*100.0*
n	*5307*	*3738*	*777*

Table 6. Basta, Area A. Capra and Ovis.

skeletal element	*bone count*
Os cornu	292
Cranium/Maxilla	660
Dentes superiores	373
Mandibula	345
Dentes inferiores	457
Os hyoideum	11
Atlas	71
Epistropheus	59
Vertebrae cervicales 3 - 7	608
Vertebrae thoracicae	983
Vertebrae lumbales	520
Vertebrae caudales	110
Vertebrae indet.	750
Os sacrum	25
Costae	2.452
Sternum	18
Scapula	497
Humerus	557
Radius	533
Ulna	189
Carpalia	93
Metacarpus	338
Pelvis	531
Femur	629
Patella	64
Tibia	678
Talus	147
Calcaneus	214
Tarsalia	84
Metatarsus	339
Metapodium	444
Phalanx 1	565
Phalanx 2	236
Phalanx 3	222
Os sesamoideum	28
hollow bone	3.019
total	*17.141*

Table 7. Basta, Area A and Munhatta (Ducos 1968). Capra: comparison of measurements.

element/ measurement	*Munhatta*			*Basta*		
	n	*x*	*min.-max*	*n*	*x*	*min. - max.*
Humerus, dist. width	1	41.7		21 13	32.2 40.2	29.8-34.4 (d) 38.6-42.5 (w)
Tibia, dist. width	5	34.3	31.8-36.2	15 12	27.6 30.9	26.6-28.7 (d) 28.9-32.2 (w)
Talus, lat. length	10	35.4	34.2-36.4	56 7	30.9 34.1	26.8-34.3 (d) 32.2-36.3 (w)

Table 8. Basta, Area A. Capra and Ovis: results of final identification as to species and their attribution to wild and domesticated status *(bone count)*.

skeletal element	*CAPRA*			*OVIS*		
	dom.	*wild*	*total*	*dom.*	*wild*	*total*
Os cornu	21	6	27	1	-	1
Cranium	2	1	3	3	-	3
Atlas	1	5	6	1	-	1
Epistropheus	9	2	11	7	1	8
Scapula	23	10	33	10	14	24
Humerus	42	19	61	27	19	46
Radius	39	27	66	10	2	12
Ulna	10	5	15	6	2	8
Metacarpus	69	18	87	35	6	41
Pelvis	49	2	51	14	9	23
Femur	9	16	25	6	2	8
Tibia	39	18	57	11	8	19
Talus	57	14	71	22	5	27
Calcaneus	38	16	54	18	10	28
Metatarsus	45	25	70	27	5	32
Phalanx 1	44	27	71	23	10	33
total	*497*	*211*	*708*	*221*	*93*	*314*

Table 9. Comparison of relative bodypart distributions* in several sites of the Levant: 1 Basta PPNB, 2 Atlit PPNB (Horwitz 1987), 3 Refaim Valley sites/ Early Bronze Age (Horwitz 1990), 4 Refaim Valley sites/ Middle Bronze Age (Horwitz 1990).

Bodypart	*1*	*2*	*3*	*4*
Cranium	15.6	29.0	12.4	54.7
Forelimb	16.2	11.0	20.2	11.8
Hindlimb	19.7	18.0	17.9	13.0
Trunk	40.9	38.0	36.7	11.2
Feet	7.5	4.0	12.8	9.3
total	100.0	100.0	100.0	100.0
n	*13621*	*55*	*228*	*166*

* This calculation is based on particular elements, see Horwitz 1987: 74.

Table 10. Basta, Area A. Capra and Ovis: distribution of body parts in the fill of the rooms 27b and 28 - 36.

skeletal element	*27b*	*28*	*29*	*30*	*31*	*32*	*34*	*35*	*36*
Cranium	12	7	33	8	2	82	1	15	13
Vertebrae	9	5	69	4	4	152	11	17	3
Costae	8	5	49	10	-	139	8	23	11
Sternum	-	-	1	-	-	1	-	-	-
Os sacrum	-	-	-	-	-	9	-	-	-
Scapula	6	1	9	-	-	67	1	4	8
Humerus	1	-	14	2	-	40	2	5	1
Radius	-	5	6	-	2	24	-	3	-
Ulna	3	-	3	-	-	16	-	4	-
Carpalia	-	-	8	-	-	2	-	-	-
Metacarpus	-	1	6	1	-	24	-	1	4
Pelvis	-	5	8	-	-	30	2	7	4
Femur	2	1	11	3	-	31	-	3	1
Patella	-	-	2	1	-	3	-	-	1
Tibia	3	3	12	2	4	41	-	5	3
Talus	-	-	2	-	-	6	1	1	1
Calcaneus	-	-	4	-	-	10	-	-	3
Tarsalia	-	-	1	-	-	6	-	1	1
Metatarsus	1	1	5	2	-	15	-	1	6
Phalanges	4	5	32	3	2	106	1	7	1
Metapodium	-	-	9	1	1	21	2	1	1
hollow bone	5	7	45	19	2	76	8	23	8
total	*54*	*46*	*329*	*56*	*17*	*901*	*37*	*121*	*70*

Table 11. Basta, Area A. Capra and Ovis: relative distribution of meat bones (A), ribs and vertebra (B), cranium (C) and refuse (D) in the fill of the rooms.

cate-gory	*27b*	*28*	*29*	*30*	*31*	*32*	*34*	*35*	*36*
A	37.1	47.8	33.5	48.1	47.1	36.3	35.1	44.6	37.1
B	31.5	21.0	36.2	25.o	23.5	33.4	51.3	33.0	20.0
C	22.2	15.2	10.0	14.3	11.8	9.1	2.7	12.4	18.6
D	9.2	16.0	20.3	12.6	17.6	21.2	10.9	10.0	24.3
total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*

Table 12. Basta, Area A. Caprines: sex ratio in horncores and pelves *(bone count)*.

	Capra hircus	*Ovis aries*	*Capra aegagr.*	*Ovis orient.*
horncores (plus crania)				
male, juvenile	2	-	-	-
female, juvenile	1	-	-	-
male, adult	2	3	-	-
female, adult	9	-	1	-
pelves				
male, juvenile	3	2	-	-
female, juvenile	-	-	-	-
male, adult	4	4	2	2
female, adult	32	8	-	7

Table 13. Basta, Area A. Capra and Ovis: mandibles and single teeth. Analysis of slaughtering age (after Payne 1973).

class		*age*		*mandibles*			*single teeth*		
				M3	*M2*	*M1*	*P4 Pd4*		
		n	*%*	*n*	*n*	*n*	*n*	n_T	*%*
A	0- 2 months	3	4.5	-	-	-	1	4	3.1
B	2- 6 months	9	13.4	-	-	-	-	9	6.9
C	6-12 months	13	19.4	-	-	8	-	21	16.1
D	1- 2 years	12	17.9	-	2	3	3	20	15.4
E	2- 3 years	9	13.4	6	-	-	1	16	12.3
F	3- 4 years	3	4.5	-	3	4	-	10	7.7
G	4- 6 years	10	14.9	10	10	2	5	37	28.5
H	6- 8 years	8	11.9	-	2	-	-	10	7.7
I	8-10 years	-	-	3	-	-	-	3	2.3
total		*67*	*100*	*19*	*17*	*17*	*10*	*130*	*100*

Table 14. Basta, Area A. Capra and Ovis: extremity bones, analysis of epiphysal closure *(bones characterised as "Capra aegagrus?" or "Ovis orientalis?" are subsumed to column "total").*

+	completely fused
(+)	compl. fused, but fusion line still visible
-	unfused
p-d-	unfused shaft
p?d?	proximal and distal state not visible
l.d.e.	unfused (loose) distal epiphyses
l.p.e.	unfused (loose) proximal epiphyses
pr.	probably

skeletal element	*age/ epip.clos.*	*total*	*Capra dom.*	*Capra wild*	*Ovis dom.*	*Ovis wild*
SCAPULA	foetal	6				
	neonat	21				
	infantil	22				
	juvenil	72				
	ad tuber +	90	15	10	10	14
	pr. adult	23	8	-	-	-
	total	*234*	*23*	*10*	*10*	*14*
HUMERUS	p+d?	30				
	p(+)d?	1				
	p?d+	182	26	16	18	19
	p?d(+)	15	1	-	3	-
	p-/d+	3	1	-	2	-
	p-d?	35	-	1	-	-
	p?d-	20				
	l.p.e.	15				
	l.d.e.	14				
	pr. neonat	14				
	pr. inf.	15				
	pr. juv.	7				
	pr. adult	24	14	2	4	-
	total	*375*	*42*	*19*	*27*	*19*
RADIUS	p+d?	120	8	13	6	1
	p(+)d?	17	2	-	-	-
	p?d+	51	14	3	1	1
	p?d(+)	10	-	1	-	-
	p-d-	1				
	p-d?	4				
	p?d-	55	-	1	-	-
	l.p.e.	6				
	l.d.e.	49	8	6	1	-
	pr. foetal	5				
	pr. neon.	14				
	pr. inf.	17				
	pr. juv.	16				
	pr. adult	41	7	3	2	-
	total	*406*	*39*	*27*	*10*	*2*

Table 14. cont.

skeletal element	*age/ epip.clos.*	*total*	*Capra dom.*	*Capra wild*	*Ovis dom.*	*Ovis wild*
ULNA	p+	26	2	3	1	2
	p(+)	7	–	–	1	–
	p-	12	3	2	2	–
	pr.juv.	10	1	–	1	–
	pr. adult	31	4	–	1	–
	total	*86*	*10*	*5*	*6*	*2*
METACARPUS	p+d+	2	–	–	1	–
	p+d?	103	16	4	9	1
	p?d+	72	24	7	14	5
	p?d(+)	13	2	–	–	–
	p+d-	9	4	–	–	–
	p?d-	47	6	3	3	–
	l.d.e.	14	2	–	–	–
	pr. foetal	1				
	pr. neonat	2				
	pr. inf.	8				
	pr. juv.	9	–	1	–	–
	pr. adult	34	15	3	8	–
	total	*314*	*69*	*18*	*35*	*6*
			m/w	m/w	m/w	m/w
PELVIS	foetal	5				
	neonat	9				
	infantil	30				
	juvenil	74	3/-	-/-	2/-	-/-
	adult		4/32	2/-	4/8	2/7
	adult,sex?	132	10	–	–	–
	total	*250*	*49*	*2*	*14*	*9*
FEMUR	p+d?	81	4	5	4	2
	p(+)d?	5	–	4	–	–
	p?d+	35	3	–	1	–
	p?d(+)	4	2	–	1	–
	p-d?	60	–	1	–	–
	p?d-	38				
	p-d-	2				
	l.p.e.	60				
	l.d.e.	60	–	1	–	–
	pr. foetal	5				
	pr. neonat	6				
	pr. inf.	24				
	pr. juv.	9				
	pr. adult	21	–	5	–	–
	total	*410*	*9*	*16*	*6*	*2*

Table 14. cont.

skeletal element	*age/ epip.clos.*	*total*	*Capra dom.*	*Capra wild*	*Ovis dom.*	*Ovis wild*
TIBIA	p+d?	47	6	–	1	1
	p?d+	85	23	13	8	7
	p?d(+)	21				
	p-d+	7				
	p-d?	74	–	2	–	–
	p?d-	35	–	1	–	–
	l.p.e.	31	–	1	–	–
	l.d.e.	29	4	–	–	–
	pr. foet.	1				
	pr. neonat	8				
	pr. inf.	20				
	pr. juv.	8				
	pr. adult	19	6	1	2	–
	total	*385*	*39*	*18*	*11*	*8*
METATARSUS	p+d+	2	–	–	2	–
	p+d?	161	9	11	4	1
	p?d+	47	18	8	14	4
	p?d(+)	2	–	–	1	–
	p+d-	3				
	p?d-	8	6	–	2	–
	p-d-	1				
	l.d.e.	8	–	4	–	–
	pr. foetal	2				
	pr. neonat	1				
	pr. inf.	6				
	pr. juv.	9	–	1	–	–
	pr. adult	38	12	1	4	–
	total	*288*	*45*	*25*	*27*	*5*
TALUS	neonat	1				
	infantil	3				
	juvenil	11				
	adult	104	57	14	22	5
	total	*119*	*57*	*14*	*22*	*5*
CALCANEUS	p- (neon.)	1				
	p- (inf.)	11				
	p- (juv.)	69	15	5	8	3
	p+	60	18	9	6	6
	pr. adult	14	5	2	4	1
	l.e.	4				
	total	*159*	*38*	*16*	*18*	*10*
PHALANX 1	p- (inf.)	22				
	p- (juv.)	91				
	p+	226	44	27	23	10
	l.e.	16				
	total	*355*	*44*	*27*	*23*	*10*

Table 15. Basta, Area A. Capra and Ovis: combined data on epiphyseal fusion *(after Payne 1988, 107: group 1 epiphyses: tuber scapulae, distal humerus, proximal radius, group 2 epiphyses: distal tibia, distal metapodia, group 3 epiphyses: proximal humerus, distal radius, proximal and distal femur, proximal tibia; data base see Table 14)*

Species	*g.*	*unfused shafts*	*unfused epi- physes*	*fused + fusing articul.*	*% killed before fusion**
Capra aegagrus					
	1	-	-	33	0%
	2	4	4	28	13%
	3	5	7	13	35%
O. orientalis					
	1	-	-	34	0%
	2	-	-	10	0%
	3	-	-	4	0%
Capra hircus					
	1	-	-	52	0%
	2	16	6	67	19%
	3	1	8	26	24%
Ovis aries					
	1	-	-	39	0%
	2	-	5	40	11%
	3	1	1	8	11%
*Capra hircus + Ovis aries***					
	1	146	20	354	29%
	2	103	43	200	34%
	3	313	164	247	56%

* percentages are calculated using the largest count for unfused shafts and unfused epiphyses

** data calculated from the column "total" minus *Capra*/ wild, *Ovis*/ wild and minus all probable age classes, cf. Table 14

Table 16. Basta, Area A. Capra and Ovis: degree of fragmentation.

skeletal element	*total*	*1/1*	*2/3*	*1/2*	*1/3*	*<1/3*
Os cornu	292	-	-	10	17	265
Cranium	614	-	-	-	10	604
Maxilla	46	-	6	27	13	-
Dentes superiores*	373	126	-	247	-	-
Mandibula	345	-	12	33	131	169
Dentes inferiores*	457	139	-	318	-	-
Os hyoideum	11	-	3	8	-	-
Atlas	71	-	9	21	30	11
Epistropheus	59	-	21	19	12	7
Vertebrae cerv. 3.-7.	608	-	59	190	212	147
Vertebrae thoracicae	983	-	96	321	346	220
Vertebrae lumbales	520	-	49	172	179	120
Vertebrae caudales	110	-	72	38	-	-
Vertebrae indet.	750	-	-	-	-	750
Os sacrum	25	-	-	7	14	4
Costae	2452	-	-	260	962	1230
Sternum	18	-	-	-	10	8
Scapula	497	-	12	48	76	361
Humerus	557	8	15	71	133	330
Radius	533	16	21	91	104	301
Ulna	189	-	10	17	21	141
Carpalia	93	80	13	-	-	-
Metacarpus	338	20	28	104	116	70
Pelvis	531	-	-	43	73	415
Femur	629	7	30	59	68	465
Patella	64	41	10	13	-	-
Tibia	678	-	23	47	56	552
Talus	147	86	29	21	11	-
Calcaneus	214	36	42	50	46	40
Os centrotarsale	47	40	7	-	-	-
Tarsalia	37	37	-	-	-	-
Metatarsus	339	10	25	101	129	74
Metapodium	444	-	-	-	-	444
Phalanx 1	565	209	69	72	111	104
Phalanx 2	236	112	61	42	11	10
Phalanx 3	222	65	79	30	18	30
Os sesamoideum	28	28	-	-	-	-
hollow bone, indet.	3019	-	-	-	-	3019
total	*17141*	*1060*	*801*	*2480*	*2909*	*9891*

* for teeth I used two categories only: completely preserved = 1/1
and not completely preserved = 1/2

Table 17. Basta, Area A. Capra and Ovis: relative distribution of fragmentation patterns *(metacarpus and metatarsus are calculated plus the "metapodia" with n= 222 pieces each in column <1/3, see Table 16).*

region	*skeletal element*	*1/1*	*2/3*	*1/2*	*1/3*	*<1/3*	n_T
SKULL	Os cornu	-	-	3.4	5.8	90.8	100
	Cranium	-	-	-	1.6	98.4	100
	Maxilla	-	13.0	58.7	28.3	-	100
	Mandibula	-	3.5	9.6	38.0	49.0	100
	Os hyoideum	-	27.3	72.7	-	-	100
VERTEBRAE	Atlas	-	12.7	29,5	42.3	15.5	100
	Epistropheus	-	35.6	32.2	20.3	11.9	100
	V. cerv. 3-7	-	9.7	31.3	34.8	24.2	100
	V. thorac.	-	9.7	32.7	35.2	22.4	100
	V. lumb.	-	9.4	33.1	34.4	23.1	100
	V. caud.	-	65.5	34.5	-	-	100
	V. indet.	-	-	-	-	100.0	100
	V. total	-	*9.9*	*24.5*	*25.1*	*40.5*	100
RIBS	Costae	-	-	10.6	39.2	50.2	100
EXTREMITY BONES	Scapula	-	2.4	9.7	15.3	72.6	100
	Humerus	1.4	2.7	12.7	23.9	59.3	100
	Radius	3.0	3.9	17.1	19.5	56.5	100
	Metacarpus	3.6	5.0	18.6	20.7	52.1	100
	Pelvis	-	-	8.1	13.7	78.2	100
	Femur	1.1	4.8	9.4	10.8	73.9	100
	Tibia	-	3.4	6.9	8.3	81.4	100
	Metatarsus	1.7	4.5	18.0	23.0	52.8	100
	Talus	58.5	19.7	14.3	7.5	-	100
	Calcaneus	16.8	19.6	23.4	21.4	18.7	100
FOOT BONES	Phalanx 1	37.0	12.2	12.7	19.6	18.4	100
	Phalanx 2	47.5	25.8	17.8	4.7	4.2	100
	Phalanx 3	29.3	35.6	13.5	8.1	13.5	100

Table 18. Basta, Area A. Capra and Ovis: distribution of completely preserved (1/1) and almost completely preserved extremity bones (2/3) to age classes *(basis: bone count)*.

skeletal	*p+d+*	*p+d-/ p-d+*	*(p-)d- juv.*	*inf.*	*neon.*	*foetal*	n_T
1/1							
Humerus	-	3	-	2	3	-	8
Radius	-	-	1	7	3	5	16
Metacarpus	2	1	9	5	2	1	20
Femur	-	-	2	3	1	1	7
Metatarsus	2	1	2	3	1	1	10
2/3		*p?d+*					
Scapula	-	-	-	7	3	2	12
Humerus	-	-	5	6	4	2	15
Radius	-	-	7	10	4	-	21
Metacarpus	-	8	17	3	-	-	28
Femur	-	-	7	18	4	1	30
Tibia	-	7	5	6	4	1	23
Metatarsus	-	12	9	3	-	1	25

Table 19. Basta, Area A. Capra and Ovis: number of burning, cut and gnaw marks as well as pathologies.

skeletal element	*burning*	*cutting*	*gnawing*	*pathology*
Os cornu	6	-	-	1
Cranium/Maxillare	4	-	-	-
Dentes sup.	-	-	-	5
Mandibula	1	1	2	1
Dentes inferiores	1	-	-	1
Os hyoideum	-	1	-	-
Atlas	-	2	-	-
Epistropheus	2	1	1	-
Vertebrae cerv. 3.-7.	1	1	-	-
Vert. thoracicae	6	1	-	-
Vertebrae lumbales	-	1	-	-
Vertebrae caudales	-	-	-	-
Os sacrum	-	2	-	-
Costae	1	8	1	-
Sternum	-	-	-	-
Scapula	9	6	-	-
Humerus	9	14	-	3
Radius	10	7	3	-
Ulna	2	4	1	-
Carpalia	2	-	-	-
Metacarpus	4	4	1	-
Pelvis	10	5	1	-
Femur	8	9	2	1
Patella	2	-	1	-
Tibia	12	1	2	1
Talus	4	2	1	-
Calcaneus	3	-	-	2
Os centrotarsale	4	-	-	-
Tarsalia	-	-	-	-
Metatarsus	5	-	3	-
Metapodium	5	-	1	-
Phalanx 1	9	-	2	-
Phalanx 2	9	-	4	-
Phalanx 3	2	-	-	-
Os sesamoideum	-	-	-	-
hollow bone, indet.	3	3	-	-
total	*134*	*73*	*26*	*15*

Table 20. Basta, Area A. Capra and Ovis: relative frequency of burning and cut marks per skeletal element (= 100%).

skeletal element	*burning*	*cutting*
Os cornu	2.1	-
Cranium/Maxillare	0.6	-
Mandibula	0.3	0.3
Dentes inferiores	0.2	-
Os hyoideum	-	9.1
Atlas	-	2.8
Epistropheus	3.4	1.7
Vertebrae cerv. 3.-7.	1.2	0.2
Vertebrae thoracicae	0.6	0.1
Vertebrae lumbales	-	0.2
Os sacrum	-	8.0
Costae	0.1	0.3
Scapula	1.8	1.2
Humerus	1.6	2.5
Radius	1.9	1.3
Ulna	1.1	2.1
Carpalia	2.2	-
Metacarpus	1.2	1.2
Pelvis	1.9	0.9
Femur	1.3	1.4
Patella	3.1	-
Tibia	1.8	1.5
Talus	2.7	1.4
Calcaneus	1.4	-
Os centrotarsale	8.5	-
Metatarsus	1.5	-
Metapodium	1.1	-
Phalanx 1	1.6	-
Phalanx 2	3.8	-
Phalanx 3	0.9	-
hollow bone, indet.	0.1	-
average, total	*0.8*	*0.4*

Table 21. Basta, Area A. Capra and Ovis: measurements. (*Measurements were taken following the definitions given by von den Driesch (1976). Any deviation from this is described at the end of Table 21. Measurements in brackets characterise slightly damaged bones. All measurements are given in millimetres. Factor loading from the principal component analysis (listed as factor 1, 2; statistics see Table 22)).*

H o r n c o r e s

1. greatest basal diametre, 2. smallest basal diametre

	1.	2.
Capra hircus, female	.	23.1
Capra hircus, female	.	21.7
Ovis aries, female/male	45.1	28.1

S c a p u l a

1. greatest length of processus articularis, 2. greatest length of glenoid cavity, 3. greatest width of glenoid cavity, 4. smallest width of collum, 5. greatest height of neck.

	1.	*2.*	*3.*	*4.*	*5.*
Capra hircus	(29.2)	(22.9)	(18.4)	18.6	25.1
	(30.6)	(25.0)	(22.4)	19.1	.
	31.5	24.8	23.4	21.0	24.4
	(31.3)	26.2	(21.7)	21.0	26.3
	32.4	25.5	21.4	21.5	28.1
	(32.3)	(26.6)	(21.3)	19.4	25.6
	32.5	27.4	22.6	20.5	25.5
	33.1	26.1	(20.0)	19.0	24.4
	.	26.5	21.3	18.2	25.0
	34.6	27.9	22.2	19.8	25.1
	34.1	26.3	(22.5)	19.9	25.0
	34.0	25.7	21.8	21.1	25.2
	35.9	27.7	23.3	21.3	26.0
	35.1	26.6	22.1	20.1	.
	(38.3)	30.2	25.1	20.5	26.6
	.	.	.	26.6	.
	.	.	.	26.7	.
Capra aegagrus	37.2	32.1	28.6	25.3	31.6
	37.8	31.0	27.3	28.0	32.5
	38.8	31.3	25.6	.	.
	39.2	32.5	25.9	23.8	31.6
	.	.	(28.5)	.	29.5
	38.6	31.5	24.5	22.2	.
	39.1	.	(26.7)	24.2	30.2
	41.1	32.2	27.8	25.7	32.0
Ovis aries	32.7	25.3	(19.0)	.	20.4
	31.7	25.1	(20.7)	19.5	21.8
	32.7	26.6	.	19.4	22.5
	.	.	22.8	21.2	25.1
	.	.	.	22.3	23.8
	33.3	25.6	22.3	20.0	23.3
	33.1	27.5	21.8	22.2	24.3
	33.8	26.3	(21.7)	22.1	24.5
	35.6	28.6	21.8	21.6	23.6
	35.6	27.5	(22.8)	20.4	21.8
	35.4	27.2	23.2	21.7	25.5
	36.7	28.5	22.8	21.0	(24.5)
	36.4	27.7	22.6	22.5	26.6

Table 21. cont.

	1.	2.	3.	4.	5.
Ovis orientalis?	38.4	31.2	24.3	22.5	24.6
Ovis orientalis	38.5	30.4	.	23.8	30.0
	39.7	(31,0)	26.7	26.0	(29.2)
	40.8	33.0	.	25.1	.
	41.1	22.3	.	26.3	29.6

H u m e r u s

1. greatest distal width, 2. greatest width trochlea, 3. greatest medial height trochlea, 4. smallest height trochlea, 5. greatest lateral height trochlea, 6. smallest width shaft.

	1.	2.	3.	4.	5.	6.	factor 1
Capra hircus	30.8	30.2	18.8	13.5	12.8	.	-.17613
	30.8	(29.4)	17.5	13.8	.	.	
	30.3	32.1	19.3	14.2	13.3	18.5	-.38731
	29.8	29.9	17.2	13.8	12.7	.	-.85348
	32.5	30.8	19.6	15.5	15.2	.	-1.84529
	32.8	31.9	18.7	13.3	13.1	.	.65109
	32.1	30.8	19.7	13.7	13.9	18.8	-.28309
	32.1	32.1	19.7	14.5	.	.	
	31.2	(30.5)	18.1	13.7	.	.	
	32.4	31.4	.	14.4	13.9	.	
	31.9	31.2	18.7	13.6	14.1	.	-.45994
	32.7	32.2	19.1	14.3	14.6	.	-.58762
	32.2	30.6	.	13.5	12.9	.	
	32.4	32.3	19.4	15.3	14.2	.	-.86782
	32.2	(30.8)	19.4	14.7	13.5	.	-.58710
	32.7	31.4	20.1	15.1	14.5	.	-.96897
	31.6	30.6	18.8	13.8	15.2	.	-1.38779
	32.5	30.7	19.0	15.1	14.6	.	-1.42665
	33.9	32.2	19.6	14.1	14.1	.	
	.	30.8	.	14.1	.	.	
	34.1	(32.2)	21.1	15.8	(14.5)	.	
	34.4	32.2	.	15.1	14.7	.	
	34.1	(32.2)	21.1	15.8	(14.5)	.	
	34.5	34.2	20.7	16.2	16.1	.	
	.	(34.1)	21.5	15.7	15.1	.	
Capra aegagrus ?	35.5	35.5	22.6	16.1	(15.7)	.	-.04465
	.	(36.8)	.	.	16.1	.	
	36.5	37.2	24.7	16.5	16.7	.	.19611
	(37.2)	34.2	22.4	17.2	15.8	.	-.58977
	38.7	37.2	23.7	16.7	17.4	.	.07953
	38.7	37.5	23.4	16.4	16.8	.	.59495
Capra aegagrus	38.6	37.7	24.1	16.3	.	.	
	38.6	37.6	22.9	15.8	16.7	.	.87305
	38.7	.	24.7	17.5	16.8	22.4	
	39.4	36.8	22.6	15.8	15.2	.	1.67240
	40.7	40.3	25.7	16.8	18.3	.	1.10333
	40.3	(39.1)	24.7	16.2	17.6	.	1.24503
	40.2	(37.5)	24.9	16.5	16.8	.	1.15992
	41.4	38.4	25.2	16.8	17.6	.	1.12292
	42.2	40.0	24.1	16.1	17.2	.	2.11410
	(42.5)	(38.7)	26.5	18.3	.	.	
	42.1	39.5	24.4	17.4	17.1	.	1.41461

Table 21. cont.

	1.	2.	3.	4.	5.	6.	factor 1
Ovis aries	29.5	30.2	17.7	13.2	13.2	.	-2.44093
	30.8	29.8	19.8	14.2	(15.1)	.	-1.29176
	31.7	29.4	19.1	13.8	14.9	.	-.56645
	32.1	31.4	20.7	15.1	13.8	.	-.15894
	32.7	31.3	21.1	15.8	15.4	16.7	
	32.7	32.1	19.6	14.5	15.0	17.7	
	32.3	31.7	20.1	14.3	13.3	.	
	33.1	30.2	19.3	14.6	13.9	.	-.63726
	33.6	30.6	20.1	15.6	16.2	.	
	33.8	32.0	20.8	15.8	14.9	.	.23710
	33.3	30.7	20.7	14.9	14.2	.	
	33.6	31.8	19.5	14.2	.	.	
	33.1	32.2	21.5	15.3	17.2	16.7	
	33.3	31.2	21.0	15.2	15.3	.	
	33.7	(33.2)	21.5	15.2	16.3	.	-.62449
Ovis orientalis ?	.	32.3	21.2	15.8	14.7	18.7	.30455
	34.8	(32.2)	21.6	15.5.	16.2	.	.20321
	34.3	32.7	21.3	16.4	17.0	.	.71892
	34.5	33.1	21.7	16.2	16.3	18.0	.46305
	35,4	.	21.5	15.3	.	.	
	36.1	32.8	22.9	15.5	16.7	.	.35263
Ovis orientalis	(34.5)	34.4.	22.5	17.5	16.2	.	1.34542
	36.8	36.6	23.3	17.2	.	.	.22679
	37.1	35.5	23.2	17.2	18.8	.	.74500
	36.8	35.8	23.1	17.7	17.7	20.4	1.04346
	37.9	.	.	18.7	.	.	
	.	34.8	.	17.2	15.9	19.9	
	.	38.5	23.7	17.2	15.1	.	-.58946
	.	41.8	28.2	20.4	21.7	.	2.41025

R a d i u s

1. greatest proximal width, 2. greatest width facies proximalis, 3. greatest diametre facies proximalis.

	1.	2.	3.
Capra hircus	31.8	30.1	15.4
	32.7	30.1	15.9
	32.9	31.1	15.8
	32.7	31.0	16.1
	33.2	31.1	15.6
Capra aegagrus	39.0	35.5	17.8
	(40.8)	38.4	.
	40.6	36.4	.
	40.8	37.4	19.6
	(42.6)	40.2	19.4
	40.8	(38.6)	(19.8)
	40.5	38.1	19.9
	.	.	20.3

Table 21. cont.

4. greatest distal width, 5. greatest width facies distalis, 6. smallest width shaft.

	4.	5.	6.	
Capra hircus	29.8	25.1	.	
	29.4	24.6	.	
	30.0	26.0	.	
	33.7	(29.0)	.	
	30.3	25.1	.	
	31.7	26.1	.	
	30.1	24.6	.	
	31.2	26.5	.	
	33.2	26.9	.	
	32.5	26.7	20.6	
	32.3	27.9	20.7	
	30.8	27.9	.	
	32.3	28.1	.	
	33.0	29.4	21.6	
Capra aegagrus	41,7	33,4	.	
	41.2	31.6	.	distal (+)

	1.	2.	3.
Ovis aries	31.5	29.7	15.1
	32.3	30.2	16.3
	32.8	29.8	16.7
	32.4	29.0	17.0
	33.9	32.0	16.3
	33.4	31.8	17.0
Ovis orientalis	35.0	32.2	17.0

	4.	5.	6.
Ovis aries	31.8	26.3	.
Ovis orientalis ?	34.2	27.7	.

U l n a

1. greatest length olecranon, 2. smallest depth olecranon, 3. depth at processus articularis, 4. width proximal articular surface.

	1.	2.	3.	4.
Capra hircus	50.6	22.8	28.8	.
	42.9	23.1	25.4	21.0
Capra aegagrus	59.2	29.8	34.1	22.4
Ovis aries	43.8	23.6	.	.
Ovis orientalis	47.6	24.6	29.8	.
	46.5	26.1	29.3	20.4

Table 21. cont.

M e t a c a r p u s

1. greatest length, 2. greatest proximal width, 3. greatest proximal diametre, 4. smallest width shaft, 5. greatest distal width, 6. greatest width condylus 7. greatest diametre condylus, 8. lateral diametre condylus.

	2.	*3.*	*4.*	*5.*	*6.*	*7.*	*8.*
Capra hircus	24,7	18.1	.				
	25.0	(15.9)	.				
	26.6	.	.				
	24.5	17.7	16.7				
	25.1	18.1	.				
	.	18.5	.				
	.	16.7	.				
	25.5	16.8	.				
	.	17.6	.				
	.	16.6	.				
	(27.5)	17.6	.				
	.	18.0	.				
	23.8	17.1	.				
	23.1	17.1	.				
	26.7	17.8	.				
	26.2	18.1	.				
Capra aegagrus	29.4	21.3	.				
	30.6	20.5	.				
	28.1	19.6	.				

	5.	*6.*	*7.*	*8.*	*factor 1*	*factor 2*
Capra hircus	28.0	12.8	17.5	11.1	.29335	-.98414
	28.6	13.2	(17.5)	10.5	-.37123	-.33522
	29.1	13.0	17.9	11.3	.52045	-.86126
	26.8	12.5	16.1	9.7	-1.45839	-.26098
	29.4	13.4	17.7	10.3	-.53999	-.02963
	28.7	13.3	17.8	10.7	-.06496	-.46170
	27.9	12.8	17.2	9.8	-.82990	-.35427
	28.1	13.3	17.7	10.6	-.14392	-.51188
	29.6	13.5	(17.5)	11.3	-.05149	-.21748
	29.0	13.4	18.5	11.1	.65503	-.80732
	27.7	12.8	17.1	10.9	-.10954	-.78767
	26.1	12.0	15.7	9.6	-1.52492	-.53958
	29.3	13.9	17.5	10.3	-.89944	.38533
	.	13.0	16.8	10.4		
		12.6	16.8	10.7		
	.	13.1	(18.4)	10.7		
Capra aegagrus	36.5	15.7	20.1	12.8	1.19109	1.06641
	33.3	15.3	20.7	13.7	2.79048	-.56886
	33.1	15.1	.	12.1		
	33.3	15.7	(19.7)	12.1	.75130	.80273
	34.4	16.1	(19.0)	12.1	-.06230	1.65273
	37.4	.	.	.		
	(36.7)	17.8	(19.3)	13.1	-.14562	2.81280

Table 21. cont.

Ovis aries

1.	2.	3.	4.	5.	6.	7.	8.
111,1	25.2	18.1	15.1	26.0	12.0	16.7	11.6
.	.	.	.	.	12.1	17.9	13.1
.	.	.	.	.	12.5	17.6	12.8
.	.	.	.	.	12.4	16.8	11.5
.	.	.	.	.	12.2	15.5	11.9
.	.	.	.	26.4	12.2	16.3	11.7
.	.	.	.	25.5	11.6	16.8	12.1
.	.	.	.	24.9	11.8	(17.2)	11,8
.	.	.	.	24.7	11.5	16.2	11.4
.	.	.	14.5	24.4	11.3	16.0	11.1
.	.	.	.	25.7	11.2	17.2	12.5
.	.	.	.	24.3	11.3	(16.2)	10.3
.	.	.	.	25.3	11.4	.	.
.	23.1	16.8	.	.	.	.	.
.	22.4	16.3	.	.	.	.	.
.	24.1	18.2	.	.	.	.	.
.	23.1	16.4	.	.	.	.	.
.	23.9	17.4	.	.	.	.	.
.	24.9	18.7	.	.	.	.	.
.	24.0	18.1	.	.	.	.	.
.	24.8	18.1	.	.	.	.	.
.	26.1	18.1	.	.	.	.	.

Ovis orientalis ?

1.	2.	3.	4.	5.	6.	7.	8.
.	.	.	.	27.6	12.5	18.9	13.1
.	.	.	.	27.6	13.1	17.0	13.1
.	.	.	.	27.3	12.4	18.6	13.0
.	.	.	.	29.0	12.6	(17.0)	12.5
.	.	.	.	.	12.6	(18,5)	(13.1)
.	.	.	.	29.6	13.1	.	13.1

(*Ovis orientalis*, area B)

1.	2.	3.	4.	5.	6.	7.	8.
.	.	.	.	30.7	15.0	20.4	14.4

M e t a t a r s u s

1. - 8. see metacarpus

	2.	3.	4.
Capra hircus	22.6	22.4	.
	21.0	20.7	.
	22.0	21.6	.
	19.8	19.0	.
	22.7	22.3	.
	21.0	19.6	.
	20.8	19.4	.
	21.6	.	.
	21.1	21.0	.
Capra aegagrus ?	23.8	23.6	16.3
	23.6	22.3	.
	23.3	23.5	.
	24.5	23.3	.
	24.2	22.5	.
	24.3	24.6	16.0
	25.4	23.4	
	(25.8)	24.4	

Table 21. cont.

	2.	3.	4.
Ovis aries	21.6	21.7	.
	19.6	19.2	12.7
	23.2	23.4	.
	20.0	19.0	.

	5.	6.	7.	8.	factor 1	factor 2
Capra hircus	25.8	11.5	17.2	10.7	-1.15166	-.03109
	26.7	11.8	16.0	10.3	.45848	-.51098
	26.4	11.5	17.3	10.4	-.82723	-.64449
	25.4	11.3	16.6	10.2	-.63362	-.68109
	(24.2)	10.2	15.9	10.3	-1.33983	.00870
	26.4	11.9	16.8	10.1	.01638	-1.10940
	24.4	10.8	(16.3)	10.4	-1.21480	-.06197
	25.6	11.4	(15.7)	10.7	-.22566	.45583
	25.6	11.7	16.4	10.6	-.43869	.00712
	24.1	11.2	15.6	9.4	.17685	-1.70289
	.	12.0	16.3	8.7		
	.	11.8	16.2	9.7		
	.	11.4	.	10.3		
	.	11.2	16.7	10.6		
Capra aegagrus?	28.7	13.8	18.2	11.6	-.01939	.63187
	29.9	14.0	19.6	11.0	-.07626	-.99575
	30.3	13.6	(18.7)	12.5	-.66692	2.02001
Capra aegagrus	31.1	14.4	18.7	12.4	.20250	1.62843
	34.6	16.1	(19.5)	12.8	1.59538	1.52405
	31.6	15.0	18.3	11.6	1.62167	.15958
	31.5	13.6	18.8	11.6	.26574	.28412
	33.7	15.3	19.0	11.2	2.25703	-.98205
Ovis aries	(24.5)	(10.4)	(17.0)	(12.2)		
	24.6	11.2	15.2	10.1	distal (+)	
	24.3	11.0	15.7	11.4		
	23.6	10.0	16.3	10.6		
	25.5	11.5	(17.0)	12.0		
	25.2	10.7	16.6	11.4		
	.	11.7	17.5	11.6		
	26.1	12.2	17.0	12.6		
	26.1	11.2	17.2	11.0		
	26.3	12.2	16.7	11.4		
	27.0	11.4	18.4	12.4		
Ovis orientalis ?	26.6	12.6	18.1	12.6		
Ovis orientalis	28.5	13.0	.	11.4		
	28.0	12.7	18.1	12.2		
	28.2	13.1	19.7	13.1		

	1.	2.	3.	4.	5.	6.	7.	8.
Ovis aries	166,6	23.7	22.2	15.8	26.7	11.8	16.7	11.2
	158.4	21.4	22.3	15.5	26.0	12.2	17.5	11.7

Table 21. cont.

P e l v i s

1. greatest width acetabulum, 2. smallest height os ilium, 3. smallest width os ilium.

	1.	2.	3.
Capra hircus	27.5	.	.
	28.3	.	.
	32.6	.	.
	.	16.7	10.4
	.	16.4	12.0
Ovis aries	28.6	.	.

F e m u r

1. greatest proximal width. 2. greatest width caput, 3. greatest diametre caput, 4. greatest distal width, 5. greatest distal diametre.

	1.	2.	3.	
Capra hircus	43.3	23.5	21.7	
	(45.0)	.	22.0	
	.	23.6	20.6	
	.	24.4	20.8	
Capra aegagrus	.	29.4	27.1	
	54.0	30.4	27.4	
	50.8	28.2	24.5	
	49.8	27.6	24.2	proximal (+)
	56.3	31.2	26.8	proximal (+)
	.	28.5	25.5	
	.	29.2	(24.8)	proximal (+)
	.	29.0	25.0	
	.	32.6	27.5	proximal (+)
Ovis aries	47.3	26.7	21.7	
	.	26.3	20.8	
Ovis orientalis	.	28.0	22.6	
	51.0	28.6	22.7	

	4.	5.	
Capra hircus	40.3	(42.9)	
	(40.8)	43.4	
	36.7	41.9	distal (+)
	.	46.4	
Ovis aries	(37.0)	40.3	

Table 21. cont.

T i b i a

1. greatest distal width, 2. greatest distal diametre, 3. smallest distal diametre, 4. smallest width shaft 5. greatest proximal width.

	1.	*2.*	*3.*	*4.*	*factor 1*
Capra hircus	28.5	22.3	19.3	17.4	-.21289
	27.2	21.0	18.2	15.5	-.94778
	26.6	21.5	17.8	.	-1.05301
	28.0	21.3	18.0	.	-.79350
	28.1	21.0	18.1	.	-.80943
	26.8	21.0	17.7	.	-1.13528
	27.6	21.2	18.2	.	-.83800
	28.5	22.1	19.7	.	-.15833
	27.4	21.5	18.1	18.4	-.84002
	27.6	21.6	18.4	17.5	-.71570
	28.3	21.6	18.1	.	-.65952
	26.6	20.7	17.2	.	-1.34389
	28.7	.	.	17.0	
	26.7	.	17.7	.	
	28.9	22.7	19.1	17.7	-.11139
	27.3	20.2	17.3	.	-1.29015
Capra aegagrus?	29.6	23.8	19.7	21.5	.36211
	30.0	23.1	19.0	19.4	.13887
Capra aegagrus	30.7	22.4	20.5	20.2	.47860
	30.1	24.9	20.8	20.5	.91544
	31.0	24.5	20.7	.	.97779
	31.6	24.7	20.2	19.7	1.00775
	32.2	26.3	22.4	22.3	1.02861
	31.1	25.8	21.0	20.5	1.31220
	31.6	24.7	20.2	19.7	1.00775
	31.8	24.7	21.8	.	1.41392
	.	25.1	.	.	
	32.2	24.8	21.2	21.3	1.36585
Ovis aries	25.6	20.1	17.1	.	-.41190
	26.7	21.2	17.1	.	-.71984
	26.2	21.6	17.7	.	-.42411
	26.7	20.1	17.8	.	.65996
	26.1	20.8	16.4	.	-1.43015
	27.1	20.7	16.7	15.4	-.76849
	26.4	20.7	16.8	15.2	-.85305
	26.4	20.5	16.4	.	-1.43015
Ovis orientalis ?	27.9	21.6	18.0	15.6	.37594
	27.7	21.4	18.5	.	.97966
	28.2	23.1	(18.2)	.	-.15765
	27.7	20.2	18.3	.	1.42927
	28.6	21.1	17.1	15.7	-.13725
Ovis orientalis	29.5	24.3	19.1	.	.52006
	30.7	23.8	20.0	.	2.11736

	5.
Capra hircus	42.0
Capra aegagrus	51.8
Ovis aries	43.7
Ovis orientalis	51.1

Table 21. cont.

C a l c a n e u s

1. greatest length, 2. greatest diametre, 3. greatest width, 4. greatest length processus coracoideus, 5. greatest width processus coracoideus, 6. smallest diametre tuber.

	1.	*2.*	*3.*	*4.*	*5.*	*6.*	*factor 1*	*factor 2*
Capra	53.5	21.4	19.8	11.3	6.3	13.5	-1.71663	.21617
hircus	55.4	22.3	(19.7)	10.1	6.8	13.8	-.84989	-.52674
	57.7	.	19.8	.	.	14.4		
	57.4	23.1	19.1	11.0	6.7	14.1	-.31623	-1.20613
	58.7	22.8	19.6	13.1	6.5	14.4	-.74183	-.52847
	59.1	22.4	20.3	10.1	5.5	15.7	1.32438	.40180
	59.6	23.6	21.5	10.8	7.2	15.0	-.50208	.38189
	59.5	23.7	20.4	11.6	7.0	14.1	-.74672	-.55497
	60.4	23.2	21.1	11.5	7.3	14.5	-.62249	-.04870
	60.6	25.3	21.7	11.2	6.6	15.1	-.41416	.42906
	60.6	24.1	21.1	12.9	6.7	15.3	-.60266	.33655
	(60.3)	24.8	20.6	12.2	7.5	14.8	-.84021	-.65729
	61.0	24.5	20.7	11.5	7.0	15.3	.06132	-.38669
	61.2	24.1	22.4	12.2	7.3	15.5	-.86672	1.06066
	61.3	24.2	18.6	13.3	6.6	14.7	.24806	-1.87306
Capra	63.7	23.1	.	12.8	(6.0)	14.0		
aeg.?	63.1	25.0	20.2	11.7	7.3	15.3	.58711	-1.24495
Capra	66.7	26.8	23.1	.	.	17.3		
aeg.	67.3	25.5	22.1	12.8	9.0	16.7	.43420	-.53685
	68.5	26.4	24.2	14.6	9.3	18.0	-.44962	1.25155
	68.4	26.3	22.7	12.2	8.3	16.7	.87178	-.11323
	68.7	25.4	21.3	14.8	7.2	16.8	1.13664	-.40491
	70.0	28.0	25.1	12.6	8.4	19.1	1.03670	1.89329
	71.1	26.2	26.0	12.8	8.7	17.5	.18020	2.36277
	72.4	27.7	25.3	12.7	.	17.5		
	76.1	26.8	23.6	12.7	8.7	18.0	2.78885	-.25176
Ovis	57.6	22.2	19.1	13.2	6.6	14.3		
aries	64.6	24.5	22.8	13.0	7.1	15.3		
	60.2	.	20.1	.	.	13.9		
	64.8	26.4	22.5	13.4	7.5	14.5		
Ovis	65.7	.	21.3	.	.	16.0		
or.?	(65.6)	(24.5)	22.0	13.2	(6.8)	15.7		
Ovis	67.3	25.4	(22.0)	14.4	7.2	15.8		
orien.	66.7	22.9	23.1	12.8	6.4	14.9		
	68.1	26.8	22.2	14.3	7.4	15.5		
	67.7	26.1	23.0	15.9	7.3	15.5		

Table 21. cont.

T a l u s

1. greatest lateral length, 2. greatest medial length, 3. distal width, 4. lateral diametre, 5. medial diametre (factors for *C. hircus* are partly listed only)

	1.	*2.*	*3.*	*4.*	*5*	*factor 1*	*factor 2*
Capra	26.9	25.7	17.5	15.8	.		
hircus	26.8	25.8	19.1	15.5	.		
	(27.6)	25.8	17.5	16.3	(14.2)	-1.32533	.06130
	27.8	25.7	17.5	16.0	14.5		
	27.4	26.3	(18.2)	(15.1)	15.0	.12895	-1.72718
	27.8	25.7	17.5	16.0	14.5	-.94666	-.32659
	28.2	26.0	17.8	15.6	14.9	-.40307	-1.06915
	28.4	27.4	18.3	16.5	14.8		
	28.6	27.1	18.6	15.7	14.6		
	28.8	28.4	18.8	17.3	(16.2)	-.96051	1.03626
	28.2	26.9	17.7	16.6	(14.9)		
	29.1	26.5	19.6	16.1	14.8	.41264	-1.41334
	29.3	(27.1)	18.3	16.5	.		
	29.2	26.7	19.0	16.3	16.2		
	29.4	28.5	18.6	16.9	16.6		
	29.5	27.6	18.3	16.5	15.4	-.98529	-.38228
	29.1	28.0	17.6	16.3	(15.3)		
	29.1	26.4	18.2	15.8	15.2		
	30.0	27.7	18.8	16.3	14.8	-.86548	-1.27985
	30.7	27.5	19.2	16.8	15.7	-.27063	-.53457
	30.7	29.1	20.3	-	17.0		
	30.0	27.7	18.6	16.1	16.1		
	30.8	28.7	20.7	16.5	15.9	.64125	-1.70590
	30.4	27.7	19.3	16.2	15.4		
	30.4	(29.2)	19.6	18.0	(16.0)		
	30.8	28.7	19.2	17.6	16.7		
	30.6	28.7	19.0	17.3	.		
	30.6	28.8	18.7	16.2	16.1		
	30.6	29.2	20.1	17.8	.		
	(31.5)	29.0	19.5	17.4	16.3		
	31.2	29.3	21.1	16.6	16.7	1.06238	-1.62823
	31.4	29.2	19.3	17.5	16.8		
	(31.7)	(29.0)	(20.3)	(17.2)	16.8		
	31.2	30.4	19.6	18.0	.		
	31.6	(30.3)	(21.0)	19.0	17.4		
	31.5	29.5	20.3	18.1	17.3		
	31.7	29.6	20.4	17.4	17.1	.14053	-.20931
	31.3	29.8	19.6	17.8	(17.0)		
	31.6	30.1	19.8	17.9	16.4		
	32.1	30.7	20.2	18.6	18.1		
	32.3	29.7	19.7	16.7	16.1	-.60256	-1.58255
	32.6	30.2	20.0	18.5	18.2		
	32.3	29.3	21.3	17.6	18.0		
	32.8	28.9	20.2	18.2	.		
	32.8	30.4	21.3	18.7	17.1	-.28086	.92572
Capra	31.5	28.8	22.2	17.5	17.4	1.99762	-.44954
aeg.?	32.2	29.7	20.9	18.1	18.0	1.34055	-.06092
	33.1	31.2	21.4	18.8	18.5	.15153	1.34710

Table 21. cont.

	1.	2.	3.	4.	5	factor 1	factor 2
Capra aegag.	33.0	(31.4)	22.3	18.3	(18.3)	.93869	.17282
	33.3	30.5	21.8	18.4	19.1	1.32737	.86072
	33.3	30.4	22.4	18.8	18.3	1.16561	.94579
	33.4	30.8	22.6	18.6	18.3	1.25717	.47328
	33.5	30.8	23.3	18.6	(19.1)	2.23763	.47428
	33.6	31.7	22.2	18.5	18.2	.54945	.23503
	33.8	30.8	22.2	18.2	18.6	1.33649	.00854
	33.7	31.3	22.9	18.2	19.4	2.09922	-.00317
	34.3	30.7	22.4	19.2	(19.6)	1.50304	1.67144
	34.4	31.4	22.8	18.2	18.8	1.63659	-.43295
	34.5	32.6	22.5	19.3	18.2	-.08985	.89620
	36.3	33.9	23.2	19.5	19.3	.34015	.56277
Ovis aries	27.8	26.7	17.5	16.4	15.3	-1.46320	-.08222
	27.7	26.8	18.5	15.7	15.0	-.16409	-1.09501
	27.6	26.2	18.2	16.8	14.6	-.45718	.50521
	29.8	28.5	18.6	17.8	(16.5)	-1.10273	.94598
	28.1	26.7	17.8	16.5	15.3	-1.11929	-.02428
	29.9	28.2	19.8	16.1	15.6	.74514	-1.32162
	30.7	28.7	18.7	16.4	15.7	-.87841	-1.04739
	30.9	28.5	19.4	16.8	15.9	-.00491	-.58214
	30.5	30.2	18.9	17.2	.	-1.34184	-.33302
	30.7	28.0	19.8	16.6	16.1	.72247	-.74233
	30.8	28.7	19.6	17.1	15.6	.11984	-.24323
	31.6	29.2	.	(16.7)	.		
Ovis or.?	33.7	30.9	20.2	19.9	.	-.53453	2.43289
	30.4	28.9	19.9	17.8	16.8	.31740	.64602
	30.4	27.7	20.0	16.6	15.2	1.09765	-.65383
Ovis orient.	34.2	(32.2)	22.5	19.8	.	1.77667	1.72113
	33.2	31.1	21.6	18.1	18.4	1.39595	-.00970
	33.7	31.4	21.3	18.1	16.2	.89107	-.11646

P h a l a n x 1

1. greatest lateral length, 2. greatest medial length, 3. greatest proximal width, 4. smallest width shaft, 5. greatest distal width.

		1.	2.	3.	4.	5.
Capra hircus	anterior	39.5	30.0	13.5	11.0	14.0
		37.5	35.4	12.7	10.4	11.9
		39.8	38.9	13.6	12.0	13.8
		37.5	37.2	13.2	10.3	11.7
		39.3	38.1	13.1	12.5	13.8
		37.0	37.3	12.8	10.6	11.4
		38.6	38.8	14.1	12.1	13.1
		36.0	36.3	14.0	11.6	13.6
		36.7	36.2	13.2	11.6	12.1
		37.4	36.1	13.3	10.7	12.7
		37.5	37.2	13.3	11.5	12.6
		39.3	38.5	13.1	10.8	12.8
		38.8	37.5	13.7	11.3	14.5
		40.4	39.8	15.2	13.6	15.6
		40.2	40.3	14.1	11.3	13.6
		40.2	40.3	14.5	11.6	14.6
		40.5	41.8	16.5	13.8	15.7

Table 21. cont.

		1.	2.	3.	4.	5.
	posterior	39.2	38.6	11.7	10.1	10.9
		35.7	35.2	12.0	9.5	11.5
		36.2	35.9	11.2	9.4	11.7
		36.8	37.1	12.1	9.8	11.4
		40.9	40.6	12.5	10.3	11.8
		39.1	39.6	12.3	10.4	12.0
		38.9	39.2	13.0	9.8	12.1
		37.0	36.6	12.4	9.0	10.8
		36.8	36.5	12.2	9.4	11.5
		39.8	39.6	11.1	9.3	11.0
		37.2	37.6	11.2	8.9	10.9
		(36.8)	(36.2)	11.8	9.0	10.9
		38.0	37.6	12.4	9.7	11.7
		39.8	39.2	13.5	10.4	12.1
		41.3	40.6	12.6	10.3	12.1
		41.1	41.4	11.6	9.5	11.8
		40.1	39.5	12.3	9.6	11.4
Capra aegagrus	anterior	42.8	42.5	15.7	15.1	16.1
		42.9	41.7	13.8	11.4	12.6
		42.6	41.5	16.1	13.8	(15.9)
		43.8	43.3	14.1	12.2	14.1
		44.5	42.5	16.8	15.1	16.0
		44.8	(42.8)	15.6	13.0	15.1
		45.5	45.1	17.0	14.5	17.1
		45.1	44.3	14.3	12.2	14.5
		44.4	43.0	15.4	12.7	14.4
		46.3	46.0	15.0	12.2	15.2
		46.4	44.2	16.7	16.1	16.4
		44.8	.	.	14.4	15.1
		45.1	45.2	16.3	14.0	16.3
		44.9	44.2	16.3	14.9	17.5
	posterior	44.4	42.7	14.6	11.5	14.5
		43.2	43.5	13.6	10.5	13.2
		45.9	45.2	14.5	10.9	14.2
		45.3	45.3	13.3	11.0	12.9
		46.6	47.1	15.3	11.9	14.9
		46.3	46.5	14.9	12.2	15.1
		43.9	43.0	13.8	11.0	12.3
		(43.7)	45.7	14.6	10.8	14.1
		42.9	42.8	13.3	11.0	12.4
		46.0	45.0	15.2	12.5	(13.7)
		45.1	45.6	15.5	11.6	15.0
		44.4	43.6	14.3	12.1	13.9
		47.3	45.3	16.1	13.6	15.7
Ovis aries	anterior	40.7	41.3	12.6	10.7	12.6
		38.6	38.2	14.1	12.0	14.2
		38.3	38.9	14.5	12.3	14.2
		39.9	40.1	13.8	13.3	14.3
		38.4	39.2	14.1	12.7	14.5
		40.5	40.0	12.7	10.6	12.2
		37.7	38.7	13.7	11.6	14.1
		35.5	35.1	13.5	11.4	12.9
		38.6	39.1	14.1	13.1	14.2
		40.7	40.2	14.9	12.2	14.1
		42.4	42.3	13.2	11.0	13.4

Table 21. cont.

		1.	2.	3.	4.	5.
	posterior	37.7	37.2	11.6	10.0	11.8
		37.1	38.1	11.8	10.0	12.0
		39.1	39.1	13.2	10.3	11.7
		37.8	38.0	11.8	9.8	11.9
		37.6	37.1	10.6	8.8	10.4
		36.3	36.0	11.4	9.3	11.0
		36.9	37.2	11.1	8.7	10.8
		36.0	35.6	11.1	8.5	10.2
		36.0	37.3	12.2	10.2	12.1
		40.4	39.7	12.2	9.1	11.6
Ovis orientalis	anterior	(46.8)	(44.1)	(16.8)	(14.9)	(16.2)
		(46.1)	.	18.2	.	18.1
		42.6	42.4	15.6	14.1	16.1
Ovis orientalis ?	posterior	40.9	40.9	13.8	11.1	13.3
		41.3	41.9	14.3	11.1	13.7
		41.4	41.1	12.5	10.6	13.0
		41.8	41.8	12.7	10.2	11.5
		40.9	40.6	13.0	10.5	12.3
		41.4	41.1	12.1	10.1	12.1
Ovis orientalis	posterior	43.4	42.9	12.3	10.3	12.5
		43.2	43.5	13.6	10.5	13.2

Table 21. cont.

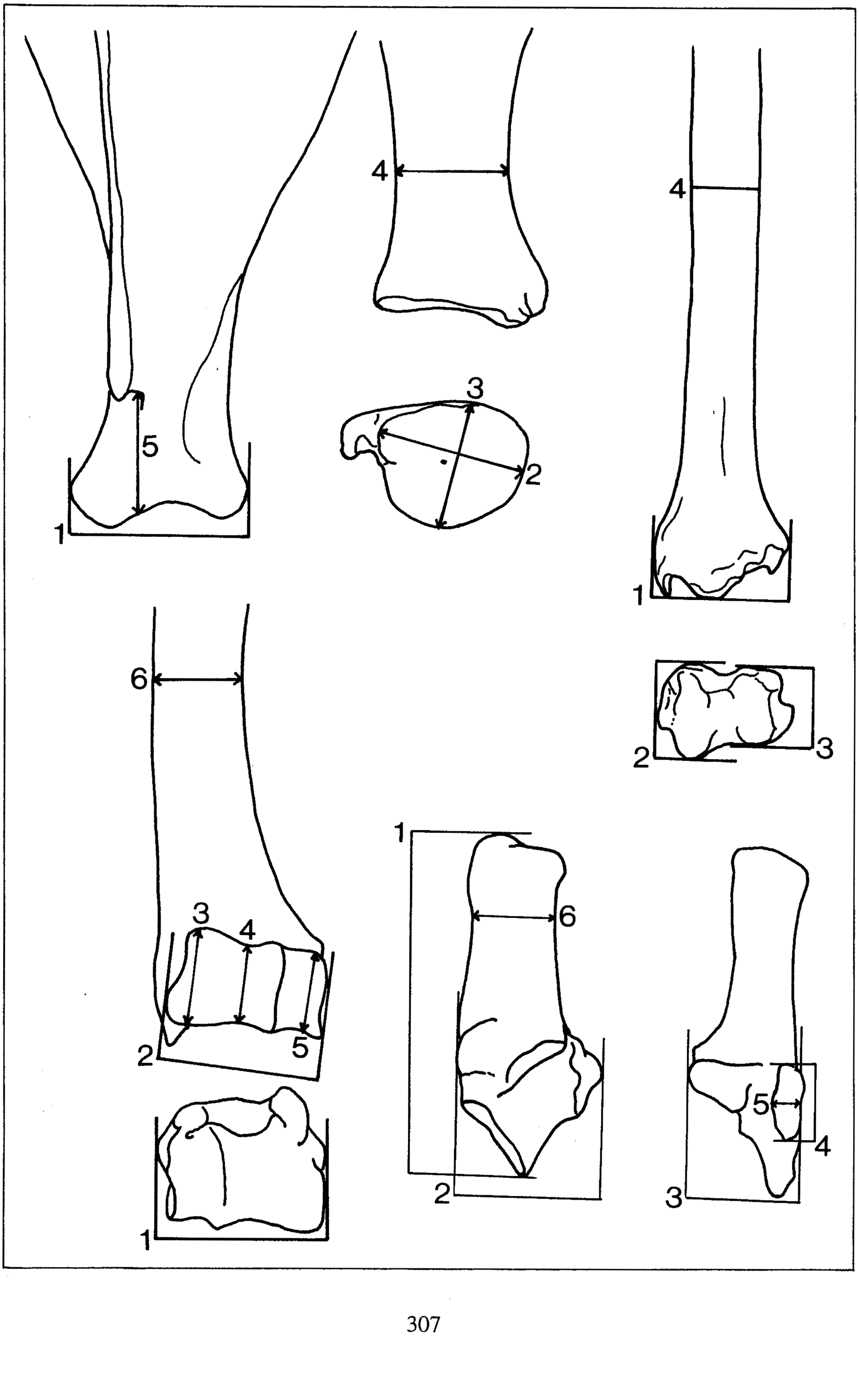


Table 22. Results of the principal component analysis.

C A P R A, H U M E R U S

final statistics:	*factor*	*eigenvalue*	*percentage of variation*
	1	**4.57266**	**91.5**
	2	.23803	4.8
	3	.10533	2.1

rotated factor matrix:	*factor 1*	*factor 2*	*factor 3*
distal width	**.82113**	.42648	.34206
width trochlea	**.82204**	.39267	.38783
medial height trochlea	.72881	.53134	.38937
smallest height troch.	.42042	**.85007**	.31424
lateral height troch.	.56731	.46119	**.68173**

C A P R A, M E T A C A R P U S

final statistics:	*factor*	*eigenvalue*	*percentage of variation*
	1	**3.65716**	**91.4**
	2	.23882	6.0

rotated factor matrix:	*factor 1*	*factor 2*
distal width	.56361	**.81531**
width condylus	.46678	**.87811**
diametre condylus	**.85925**	.47750
lateral diametre con.	**.83174**	.51625

C A P R A, M E T A T A R S U S

final statistics:	*factor*	*eigenvalue*	*percentage of variation*
	1	**3.62357**	**90.6**
	2	.22984	5.7
		.12148	3.0

rotated factor matrix:	*factor 1*	*factor 2*	*factor 3*
distal width	.77511	.44225	.43575
width condylus	**.80128**	.41668	.41597
diametre condylus	.51481	.40944	**.75319**
lateral diametre con.	.40390	**.85100**	.33559

C A P R A, T I B I A

final statistics:	*factor*	*eigenvalue*	*percentage of variation*
	1	**2.85724**	**95.2**

Table 22. cont.

C A P R A, C A L C A N E U S

final statistics:	*factor*	*eigenvalue*	*percentage of variation*
	1	**4.70969**	**78.5**
	2	.67311	11.2
	3	.26918	4.5
	4	.19415	3.2
	5	.10059	1.7

rotated factor matrix:	factor 1	factor 2	factor 3
length	**.76063**	.36117	.32976
diametre	.59708	.38214	.28077
width	.37083	**.82777**	.12151
length processus	.22598	.12363	**.94457**
width processus	.34148	.38769	.26326

C A P R A, T A L U S

final statistics:	*factor*	*eigenvalue*	*percentage of variation*
	1	**4.58898**	**91.8**
	2	.19182	3.8
	3	.10784	2.2

rotated factor matrix:	factor 1	factor 2	factor 3
lateral length	.62053	.45256	.62366
medial lenth	.47628	.54192	**.68272**
distal width	**.81422**	.37113	.41666
lateral diametre	.41199	**.80589**	.41013
medial diametre	.70156	.58699	.35322

O V I S, H U M E R U S

final statistics:	*factor*	*eigenvalue*	*percentage of variation*
	1	**2.84357**	**94.8**
	2	.10063	3.4

rotated factor matrix:	*factor 1*	*factor 2*
width trochlea	.54650	**.83597**
medial height trochlea	.77059	.60971
smallest height troch.	**.84291**	.52024

O V I S, M E T A C A R P U S

final statistics:	*factor*	*eigenvalue*	*percentage of variation*
	1	**3.53432**	**88.4**
	2	.26845	6.7
	3	.13423	3.4

Table 22. cont.

rotated factor matrix:	*factor 1*	*factor 2*	*factor 3*
distal width	.75077	.33103	.54557
width condylus	**.84656**	.43073	.28774
diametre condylus	.44768	**.84204**	.34768
lateral diametre con.	.44768	.54204	**.70138**

O V I S, M E T A T A R S U S

final statistics:	factor	eigenvalue	percentage of variation
	1	**3.18428**	**79.6**
	2	.47599	11.9
	3	.27141	6.8

rotated factor matrix:	factor 1	factor 2	factor 3
distal width	.76180	.58993	.19825
width condylus	**.89990**	.23561	.34367
diametre condylus	.34769	**.81366**	.45004
lateral diametre con.	.29620	.31893	**.89758**

O V I S, T I B I A

final statistics:	*factor*	*eigenvalue*	*percentage of variation*
	1	**2.56760**	**85.6**
	2	.26335	8.8

rotated factor matrix:	factor 1	factor 2
distal width	.72283	.60688
greatest dist. diametre	.40795	**.90262**
smallest dist. diametre	**.90325**	.37837

O V I S, T A L U S

final statistics:	*factor*	*eigenvalue*	*percentage of variation*
	1	**3.50593**	**87.6**
	2	.32750	8.2
	3	.12434	3.1

rotated factor matrix:	*factor 1*	*factor 2*	*factor 3*
lateral length	.59275	.44558	.65108
medial length	.47557	.46675	**.73616**
distal width	**.86696**	.31572	.38304
lateral diametre	.31191	**.88380**	.34872

Invitation to join
the new series devoted to final publications
of Neolithic Excavations in Southwest Asia

bibliotheca neolithica Asiae meridionalis et occidentalis

In the continuing efforts of *ex oriente* e.V. to promote Neolithic research in the Near and Middle East, we have founded a new series exclusively devoted to final publications of Neolithic sites in Southwest Asia. The *bibliotheca neolithica Asiae meridionalis et occidentalis* (Library of Neolithic Excavations in Southwest Asia) offers a venue for publication of all Neolithic excavations. All teams from all nations contributing to Neolithic research in Southwest Asia are invited to place their final publication on this shelf. The structure of the *bibliotheca* is aimed to enable rapid, high quality publication by accepting "modules" of excavation series (*cf.* below) representing the individual excavation project.

Structure

Each field project has its independently structured excavation series in the *bibliotheca* and decides about formats and style (from the design and colour of the cover to the formal styles of text, etc.). This ensures an individual identity for a publication project. Only the hardcover and paper quality and the page formats are fixed by *bibliotheca* standards. There will be also no serial numbers within the *bibliotheca* series, although we expect that excavation reports would appear in a series format, as in the following example (The following list of volumes and titles/contents is offered as an example only, and does not represent a fixed *bibliotheca* format for a final publication.).

Site Name Vol. I Human Ecology
Site Name Vol. II Stratigraphy and Architecture
Site Name Vol. II.1 The Stratigraphy and Architecture of Area X
Site Name Vol. II.2 The Stratigraphy and Architecture of Area Y
Site Name Vol. III The Burials and Human Remains
Site Name Vol. IV The Industries
Site Name Vol. IV.1 Chipped Industries
Site Name Vol. IV.2 Ground Stone Industries
Site Name Vol. IV.3 Vessel Industries
Site Name Vol. IV.4 Plaster and other Moldable Material Industries
Site Name Vol. IV.5 Ornament Industries
Site Name Vol. V The Subsistence Economy
Site Name Vol. VI Miscellaneous and Special Studies
Site Name Vol. VII The Neolithic Village of Site Name. Conclusions

Quick Publication

The structure of the *bibliotheca* publications specifically considers the difficulties many projects have with publishing planned comprehensive monographs. Usually such publications are delayed, even by decades, because some of the contributors do not while the others who comply with scheduled deadlines face the risk that their work will be out-dated when it is eventually published (or that they will have to rework their material years later). In order to foster communication of Neolithic knowledge, the *bibliotheca* provides the opportunity to publish in "modules" (which should have at least 150 printed pages). For example, if the responsible editor(s) realize that a large monograph on, say, "The Finds" cannot be produced as scheduled, but that part of the chipped lithics are ready for publication, they can release this section for print as *e.g. Vol. IV.1.1: The Chipped Lithic Industries. The Primary Production*, as a module of *Vol. IV: The Industries*. If next the architecture and stratigraphy of Area Y is ready, it may appear -according the excavation series plan- as *Vol. II.2: The Stratigraphy and Architecture of Area Y*, representing a part of *Vol. II: The Stratigraphy and Architecture*. However, the plan of the excavation series should consider a final or interim volume that summarizes excavation results, perhaps as the proceedings of a symposium held for that purpose.

Editors and Responsibilities

Editing responsibilities remain completely with the individual excavation project. Editors of the volumes of an excavation series are solely responsible for the excavation's publication. They provide the pdf version of the publication to the editors of the *bibliotheca* (Hans Georg K. Gebel and Gary O. Rollefson). No extra work -either technical or editorial- will be accepted by the *bibliotheca* editors for the publication of volumes. However, we might be of assistance in some cases to overcome specific difficulties.

It is obligatory that each volume or module that is delivered for print is accompanied by three peer reviews by distinguished colleagues not involved in the publication project. Neither the general editors nor *ex oriente* can arrange for a peer review process. The editors of the *bibliotheca* have the right to demand further independent reviews and even to reject individual parts of an excavation series in the worst case, if improvement demands are not followed. Natural sciences contributions need to be reviewed by specialists from the appropriate fields.

In order to protect the reputation of the *bibliotheca*, prior to agreeing to publish an excavation series, a publication program must be presented by the site report editor(s) that shows that agreements with contributors have been arranged. However, we are well aware that in one case or another such a program might not develop as originally planned, or even that a volume (or a part of one) might never appear. We will also consider the possibility of producing single-volume site monographs in the *bibliotheca*.

Publishing House

The publisher is *ex oriente*, Berlin. Copyrights become the property of *ex oriente* e.V. if no other arrangements are made. *ex oriente* accepts to publish joint volumes with other series if the style and format of the *bibliotheca* is respected.

Publishing Quality / Costs

We publish A4 hardbound on 115 gr. paper. The quality of books is standard throughout the *bibliotheca* series. Colour photos, folding plans, etc. represent additional costs and are possible if these costs will be covered by the editors of the excavation series.

If a (ready layouted) pdf file of the book is provided for printing, the *biblioteca* may not ask for a contribution to the printing costs from the publication project. Any work necessary by the *biblioteca* to produce a layouted version for printing will be billed to the site report editors by *ex oriente*. If a publication in the *bibliotheca* is done without a financial contribution from the book editors, no free copies will be given to the editors and authors. In this case, a limited number of copies can be obtained with a discount of 40% off the selling price. If a publication in the *bibliotheca* is supported financially, free copies are available according to the financial support. Contracts will be made to clarify conditions for both sides in advance.

ex oriente advertises and distributes the books, organizes book reviews, etc.

Hans Georg K. Gebel and Gary O. Rollefson

ex oriente e.V.
Early Near Eastern Production, Subsistence, and Environment

Studies in Early Near Eastern Production, Subsistence, and Environment

Editors-in-Chief: Hans Georg K. Gebel and Reinder Neef

Vol. 1 (1994) ***Neolithic Chipped Stone Industries of the Fertile Crescent*, edited by Hans Georg Gebel and Stefan K. Kozlowski** (44 contributions, IV + 601 pages, 270 figures, 16 plates, 89 tables, paperback - 45 Euro) [ISBN 3-9804241-0-3]

Vol. 2 (1995) ***Die neolithische Keramik aus Abu Thawwab, Jordanien (with English Summary)*, by Daif'allah Obeidat** (XIII + 186 pages, 62 figs., 9 tables, paperback - 28 Euro) [ISBN 3-9804241-1-1]

Vol. 3 (1996) ***Neolithic Chipped Stone Industries of the Fertile Crescent, and Their Contemporaries in Adjacent Regions*, edited by Stefan K. Kozlowski and Hans Georg K. Gebel** (39 contrib., IV + 460 pages, 214 figs., 21 plates, 52 tables, paperback - 60 Euro) [ISBN 3-9804241-2-X]

Vol. 4 (1997) ***The Prehistory of Jordan, II: Perspectives from 1997*, edited by Hans Georg K. Gebel, Zeidan Kafafi, and Gary O. Rollefson** (49 contributions, III + 662 pages, 207 figures, 46 plates, 153 tables, paperback - 80 Euro) [ISBN 3-9804241-3-8]

Vol. 5 1998 (2004) ***Central Settlements in Neolithic Jordan. Proceedings of the Symposium Held in Petra, July 1997*, edited by Hans-Dieter Bienert, Hans Georg K. Gebel, and Reinder Neef** (21 contributions, XIV + 300 pages, 82 figures/ diagrams, 12 tables, 36 plates incl. 2 color plates, paperback, 48 Euro) [ISBN 3-9804241-4-6]

Vol. 6 1999 (2002) ***The Dawn of Farming in the Near East*, edited by René T.J. Cappers and Sytze Bottema** (16 contributions, I + 189 pages, 52 figures, 11 tables, paperback - 38 Euro) [ISBN 3-9804241-5-4]
with contributions by: R.T.J. Cappers & S. Bottema *(Editors' Foreword)*, R.T.J. Cappers & S. Bottema & H. Woldring & H. van der Pflicht & H.J. Streurman, D.O. Henry, S. Bottema, H. Woldring, L. Grosman & A. Belfer-Cohen, O. Bar-Yosef & A. Belfer-Cohen, D.R. Harris, N.F. Miller, M.A. Blumler, M. Nesbitt, G. Willcox, S. Colledge, M. Özdogan, J. McCorriston, I. Köhler-Rollefson & G.O. Rollefson, H. Buitenhuis

Vol. 7 (2000) ***Die Neolithisierung im Vorderen Orient. Theorien, archäologische Daten und ein ethnologisches Modell*, by Marion Benz** (V + 260 pages, 59 + 2 figures, 7 tables, 3 appendices, 6 transparencies, paperback - 70 Euro) [ISBN 3-9804241-6-2]

Vol. 8 (2002) ***Magic Practices and Ritual in the Near Eastern Neolithic*, edited by Hans Georg K. Gebel, Bo Dahl Hermansen, and Charlott Hoffmann Jensen** (12 contributions, III + 173 pages, 62 figures incl. plates, one clour plate, 8 tables, paperback - 35 Euro) [ISBN 3-9804241-9-7]

Vol. 9 (2001) ***Beyond Tools. Redefining the PPN Lithic Assemblages of the Levant. Proceedings of the Third Workshop on PPN Chipped Lithic Industries (Ca' Foscari University of Venice, Nov. 1998)*, edited by Isabella Caneva, Cristina Lemorini, Daniela Zampetti, and Paolo Biagi** (33 contributions, IV + 455 pages, 206 figures incl. plates, 63 tables, paperback - 72 Euro) [ISBN 3-9804241-8-9]

Vol. 10 (2004) ***Vorratshaltung. Die spätepipaläolithische und frühneolithische Entwicklung im westlichen Vorderasien. Voraussetzungen, typologische Varianz und sozio-ökonomische Implikationen im Zeitraum zwischen 12,000 und 7,600 BP*, by Karin Bartl** (I-XXX + 841 pages; 222 plates with more than 600 illustrations, incl. 4 colour figures; more than 367 tables, paperback - 120 Euro) [ISBN 3-9807578-1-1]

Vol. 11 *(2005)* ***Flint and Stone Axes as Cultural Markers. Socio-Economic Changes as Reflected in Holocene Flint Tool Industries of the Southern Levant*, by Ran Barkai** (I-XIV + 410 pages, 126 figs., 26 tables, paperback - 68 Euro) [ISBN 3-9807578-2-X]

Vol. 12 (2006) ***Domesticating Space: Construction, Community, and Cosmology in the Late Prehistoric Near East*, edited by E.B. Banning and Michael Chazan** (11 contributions, 112 pages, 52 figs., 7 tables, paperback - 25 Euro) [ISBN 3-9807578-3-8]
with contributions by: E.B. Banning & M. Chazan, T. Watkins, D. Nadel, N. Samuelian & H. Khalaily & F.R. Valla, S.K. Kozlowski, S. Kadowaki, H.G.K. Gebel, M. Verhoeven, Z.A. Kafafi, M. Cutting, Y. Garfinkel