ACHEULIAN BASALT TOOLS OF GESHER BENOT YA'AQOV:

EXPERIMENTAL AND TECHNOLOGICAL STUDY

Hebrew University - MA Thesis

This work was written under the supervision of

Prof. Na'ama Goren Inbar and Dr. Bo Madsen

Gonen Sharon

Jerusalem

August 2000

TABLE OF CONTENTS

List of Tables

List of Figures

List of Graphs

List of Maps

INTRODUCTION

The unique assemblages of basalt bifaces from the Acheulian site Gesher Benot Ya'aqov have been, from the very beginning of research at the site, the most notable and described aspect of human presence and activity. Gesher Benot Ya'aqov (henceforth GBY), dated to 780,000 B.P., is unique among the Lower Paleolithic sites of Israel and the world in the variety of information that it has yielded. The excellent preservation of organic material, including bones, will help to shed light on many environmental and biological aspects of the Lower Paleolithic hominid ways of life. Nevertheless, for the archaeologist, the lithic assemblage is still the most visible and measurable aspect of hominid behavior available.

The GBY lithic assemblage is characterized by its unique basalt tools of which the most remarkable are the handaxes and cleavers. Thousands of these tools have been found along the banks of the Jordan River since the discovery of the site in the early 1930's. They were found both during systematic excavation and in surface collections. The great majority of these tools were made from large flakes (Gilead 1970b; Goren-Inbar and Saragusti 1996; Goren-Inbar et al. 1991; Stekelis 1960). No parallels are known to the GBY Acheulian basalt assemblage in the Levantin Acheulian (Bar-Yosef 1994).

Clark (1975) made reference to other sites with lithic assemblages somewhat similar to the GBY assemblage. The only site outside of Africa noted by Clark is the Narmada Basin in Upper India with quartzite bifaces made from large flakes (Lumley 1985). Large non-flint cutting tools made on flakes were reported from the Iberian Peninsula (Moloney et al. 1996; Santonja and Villa 1990) and large cutting tools have recently been reported from South China (Yamei et al. 2000). However, no full technological report has been published for any of these sites.

Stekelis (1960) and Gilead (1968), the pioneer researchers of the site, noticed the close resemblance between Gesher Benot Ya'aqov's (henceforth GBY) handaxes and cleavers and similar basalt tools from many African sites. GBY and the much earlier site of 'Ubeidiya are the only known Acheulian sites in the Levant where basalt was the primary raw material used for biface manufacturing.

Indeed, Africa is the place where we should look for parallels to the GBY basalt assemblage. Sites with assemblages that resemble the basalt tools of GBY are reported from the eastern desert of Egypt (Haynes et al. 1997), the South African sites of Vaal River Younger and Gravels II (Clark 1966; 1975), and from North Africa (Biberson 1961). In east Africa, the sites of Olorgesailie (Isaac 1977) and Isenya (Roche et al. 1988) are the most similar to GBY (and see {Goren-Inbar et al. 2000} for further information). The Acheulian assemblages from Olduvai Gorge are significant as they are the subject of important lithic technological studies about basalt tools (Callow 1994; Jones 1979; 1981; 1994).

The rich lithic assemblage of GBY excavated using modern techniques, provides an opportunity to learn about the cognitive and technical abilities of the site's inhabitants and perhaps even of their connection (cultural? technical? traditional?) with their home continent of Africa. One of the ways to establish the technological and cultural nature of the assemblage is to reconstruct the reduction sequence (*chaîne opératoire*) used by the prehistoric knappers to produce their tools.

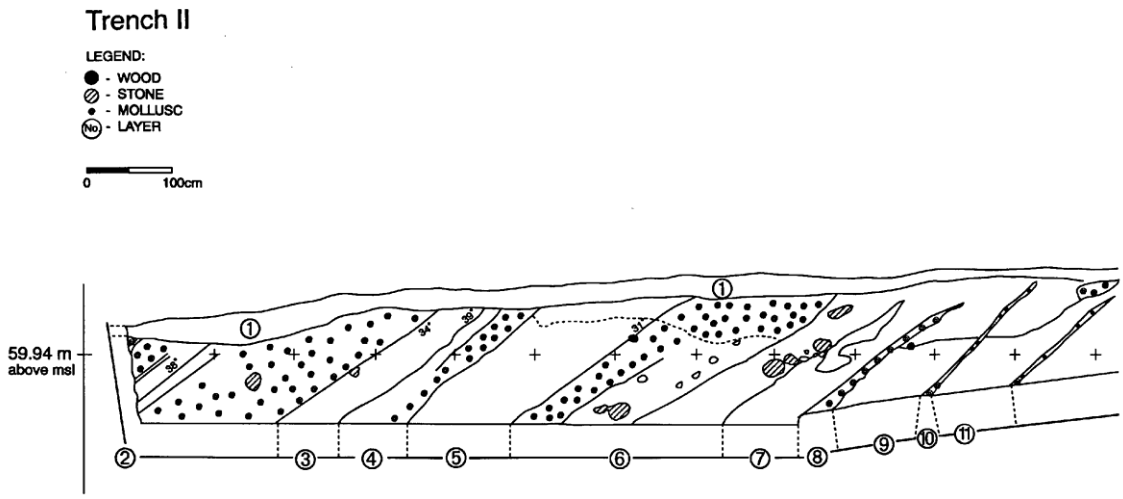
This work will focus on the basalt "reduction sequence" of GBY in an effort to gain such insight by study of the technological aspects of production of basalt tools uncovered in Level 1 of Layer II-6 of area B (Map 1; henceforth II-6/L1) of the recent excavation project directed by Prof. N. Goren-Inbar.

In order to study these aspects, experimental work was conducted together with Dr. B. Madsen, who attempted to replicate the different stages of the basalt reduction sequence of the GBY assemblage. These experimental assemblages will be used for comparative study of the artifacts of II-6/L1 and as a reference for modeling the reduction sequence of basalt tools in GBY.

Layer II-6 Level 1 at GBY

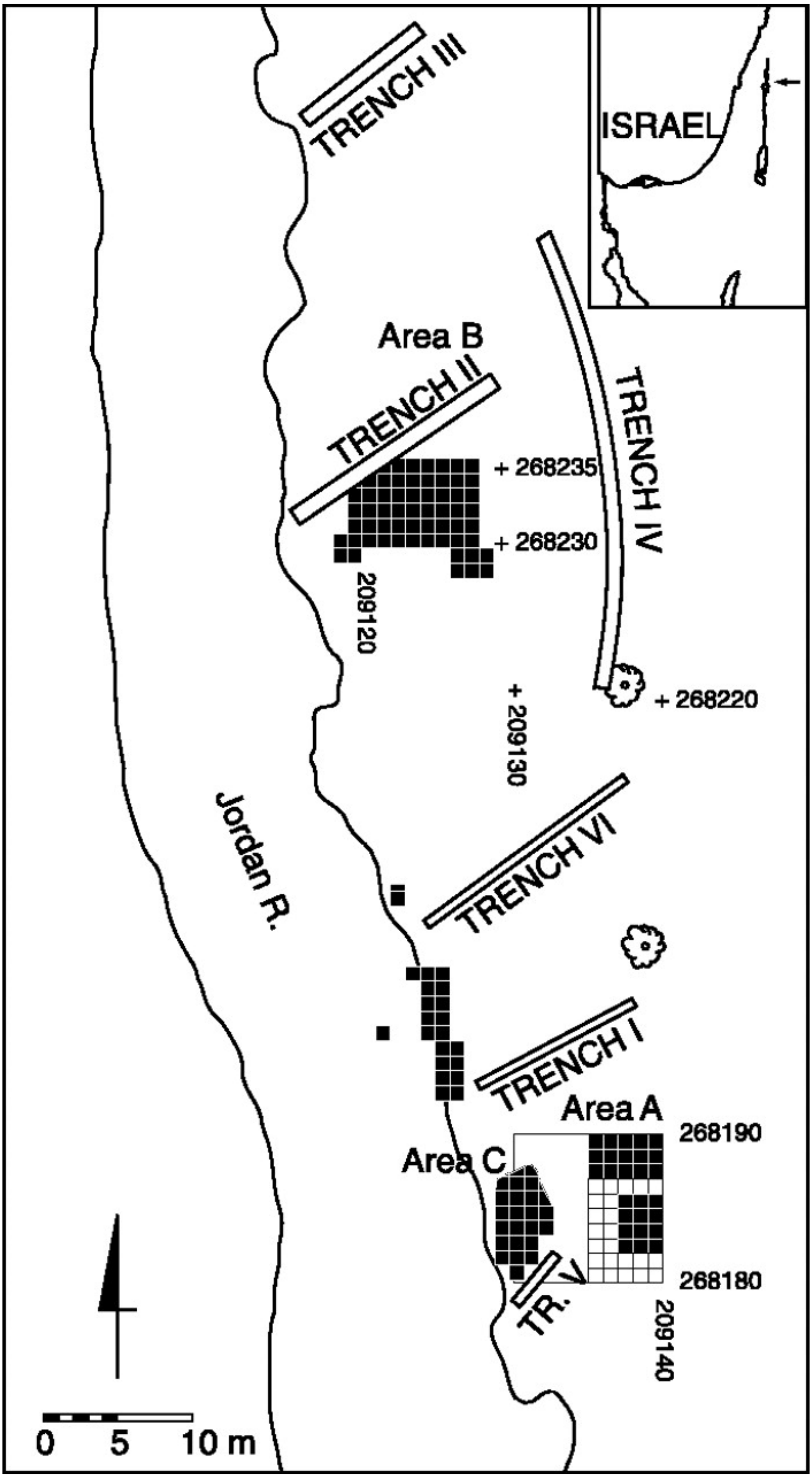
The recent excavation at GBY was conducted over seven seasons from 1989 to 1997. It included three areas of excavation (A, B and C) and an additional smaller area on the bank of the Jordan River (Map 1). The primary excavated area was area B of which Level II-6/L1 is a part. It is the uppermost level out of 8, forming layer 6 of trench II. Layer II-6 is about 1.5 meters thick and dips 40-45º to the wsw. The majority of Level II-6/L1 was excavated during the 1989–91 seasons with a smaller area added during the 1995 season. The total size of the excavated area is 17.4 sq. m. It consists of sediments of fluvial-limnic origin (Goren-Inbar et al. 1992; Goren-Inbar and Saragusti 1996; Feibel et al. 1998). The stratigraphic sequence of Trench II is shown in Figure 1.

Figure 1: Trench II of Area B at GBY (After Goren-Inbar and Saragusti 1996)



Level II-6/L1 is rich in organic material including a large variety of wood, bark and seeds. It was excavated along the dip and strike of the tectonically slanting layers of the Benot Ya'akov formation. In the season of 1989, a butchered elephant (*Palaeoloxodon antiquus*) skull was excavated in this level (Goren-Inbar et al. 1994). The heavily damaged skull was found turned upside-down by humans in an attempt to obtain the brain tissue. The skull was located in close proximity to a large wooden log and lithic artifacts including basalt bifaces and large cores. The finds have been interpreted as indicating a hunting and butchering scene. Humans used the basalt tools found in the vicinity of the skull to butcher the elephant, crush the skull bones and even turn the skull upside-down to reach the brain. However, at the present stage of research these are suggestions only.

Map 1 – GBY Study Area



Basalt Tools in Prehistory

Studies on the use of basalt in the production of stone tools are rare. Flint is the focus of most lithic studies due to the fact that it was the raw material most commonly used by prehistoric knappers in Europe and tools made from it are easy to recognize and describe. Obsidian has also been the subject of many studies, however, its knapping qualities are in many ways very close to those of high quality flint. Among other raw materials used by prehistoric humans, most attention has been dedicated to quartzite and quartz, which are in many cases the substitute for flint in areas where the latter is hard to find (Moloney et al. 1996).

The geological definition of basalt is dark, fine-grained lava made primarily of pyroxene and plagioclase, rich in iron and low in silica content. This definition encompasses many kinds of possible mineralogical compositions and crystal sizes. To the archaeological eye, they result in different features of hardness, breakage and other qualities that affect the nature of knapping in ways that are very hard to define. Thus, while the type of basalt found in North American sites can be used for the manufacturing of arrowheads by pressure flaking (Crabtree 1967); the basalt found near GBY is much harder and probably cannot be used for producing such tools. The olivine basalt from east Africa such as the ones used by P. Jones in the experimental knapping of bifaces (see below) may also be of significantly different quality from the GBY material due to its fine grained nature.

Other raw materials such as flint and even obsidian have shown different breakage qualities when coming from different sources. In the case of basalt, a hard material to work with in the first place, the problem seems to be critical. Even within the same lava flow, different areas can yield different qualities of raw material. The amount of vesicles, the pace of cooling and size of crystals resulting from it, as well as other attributes, will result in different quality raw material from chemically identical basalt.

Technological studies of basalt tools are reported from the Lower Paleolithic of Africa (see below) and from North America where it was used by the Paleo-Indians (Bucy 1974; Richards 1988; Wallace 1962; to mention just few). Another area of the world where basalt tools were studied is Hawaii (Deunert 1995 and references therein). In continental America as well as in Hawaii, basalt was used for the production of late prehistoric period tools, such as arrowheads and axes. The experimental and technological studies of basalt in these areas naturally focused on the production of these tool types. The chronological and typological gap significantly limits the relevancy of these assemblages and researches to this study.

Some aspects of basalt tools have been the subject of some studies, in particular, the question of use wear patterns (Deunert 1995; Price-Beggerly 1976; Richards 1988). Magne and Pokotylo (1981) performed an experimental study of basalt bifacial reduction sequences and were able to use their debitage classification quite efficiently in blind test classification of material from Paleo-Indian sites in Canada. However, the high quality basalt used by Magne and Pokotylo and the size scale and typology of the Indian bifaces, limits the contribution of their work to the technological study of Lower Paleolithic basalt tools.

The primary experimental and technological work dealing with Lower Paleolithic tools was carried out by P. Jones at Olduvai Gorge (Jones 1979; 1981; 1980; 1994). He worked with a variety of raw materials and used by the hominids of Olduvai for the manufacturing of tools and used the tools to perform butchering and woodworking in order to study their efficiency and qualities. His work was found very useful as a source of ideas and reference for this work.

Although basalt was one of the most frequently used raw materials in Olduvai Gorge, no special preference in raw material is observed in its biface assemblages. Callow's (1994) attempts to distinguish between the Acheulian and the Developed Oldowan based upon the raw material used did not meet the expected results. Jones noted that:

> "The Olduvai bifaces, both Acheulian and Developed Oldovan, are made from a variety of raw materials which vary in their proportions from site to site. Within all the assemblages one finds bifaces occurring in several different materials: sometimes the biface assemblage will be dominated by one material and sometimes it will split between two or even three. This is in marked contrast to some of the other artifact categories where a definite preference material can be seen." (1994: 262)

In the Levant, the lithic assemblage of 'Ubeidiya dated to 1.4 million years B.P. contains a major component of basalt tools (Bar-Yosef and Goren-Inbar 1993). In particular, basalt was the dominant raw material for the manufacturing of bifaces and other artifacts in 'Ubeidiya. It is interesting to note that basalt flakes are underrepresented in the 'Ubeidiya assemblages given the number of bifaces. This finding led the researchers to suggest that not all manufacturing stages of the bifaces took place on site. It was noted that most of the bifaces and other basalt tools in 'Ubeidiya were made from stream pebbles and cobbles that were available in the site area. The reason for the predominant use of pebbles and cobbles over large flakes for the manufacturing of bifaces in 'Ubeidiya may have been technological or stylistic. It may be that the use of large flakes as blanks for bifaces was unknown to the 'Ubeidiya knappers. On the other hand, it should be noted that large basalt flakes are present in the 'Ubeidiya assemblage and only future research can provide definitive answers.

The Mousterian site of Quneitra in the Golan Heights yielded a basalt tool assemblage that comprises circa 9% of the total assemblage (Goren-Inbar 1990). The knappers of Quneitra chose basalt for specific reduction sequence, different from the sequences evidenced in their flint artifacts. Large scrapers, hammerstones, manuports and anvils were made of basalt. Basalt was available in the immediate area of the site while flint was brought to the site from a source 10-km away (Hovers 1990). The technological nature of the basalt tools of Quneitra is different from that of GBY, but there are some similarities, as in the case of the large basalt scrapers found in these two assemblages.

Basalt bifaces are reported in very small numbers from the Berekhat Ram Acheulian site but these assemblages are the exception that teach about the rule: Basalt is absent from lithic assemblages of the Levant until its reappearance as raw material for grinding stones in the Epi-Paleolithic.

Basalt as Raw Material in GBY – General Introduction

The basalt of GBY is, as all other basalt in Israel, Alkali Olivine Basalt (Heimann 1990; Mor 1986). Basalt is magnetic rock, low in silicates (SiO_2) with a high presence of iron, giving it its dark color. Alkali Olivine Basalt is typical continental basalt. As the exact stratigraphical position of the site in the geological sequence of the region has not yet been determined, it is impossible at this point to identify the sources of basalt used by the GBY hominids for their tools. The GBY occupation time is well within the massive volcanic activity of the Golan Heights, near the end of the activity phase that formed the Ortal Formation (Mor 1986). The basalt flows found on the slopes of the Golan Heights are of an average age of 1 to 1.2 my (Heimann 1990). Therefore, basalt undoubtedly was available in the immediate vicinity of the site in the form of outcrops, where streams cut through flows, and as eroded boulders and cobbles.

The breakage qualities of the different basalt sources in the area were probably known to the prehistoric knappers. Did they have a preferred outcrop for quarrying? Did they search for a specific kind of basalt for their tools? These questions will not be answered here although, judging from some of the tools found in GBY, I would argue yes. The cleavers from the Jordan River Bank near Area C (Map 1), where some 30 bifaces were found in less than 2 square meters, look like they were all made from the same high quality basalt. A study of the basalt tools origin from a geological point of view (Light et al. 1999) will hopefully help shed light on this matter.

<u>Basalt Tools of Gesher Benot Ya'aqov – History of Research</u>

Stekelis (1960) was the first to publish a surface collection from the Jordan River bed and its banks as well as the material coming from his various excavations in different parts of the site. The basalt artifacts were described in detail and the following technological observations were noted:

> "*The artifact of lava*: Artifacts were represented by bifaces (hand axes), cleavers and rough flakes. They were obtained either from pebbles or from lumps of lava, by "block on block" technique.
>
> *Hand-axes*: the entire surface of the hand axes made on pebbles was trimmed on both faces and care was taken to produce a cutting edge along both sides and a rough tip. On some of the specimens the base retained the natural face of the pebble, on others extended around it; in their section they are biconvex and the edges have a S-line twist. Hand-axes on flakes were made of lumps of lava. One face was flat, the other trimmed all over by large flaking. Sometimes the flaking extends around the base or on the edges of the flat surface. The sections were planoconvex; the striking platforms thick and broad were thinned by chipping. The edges were straight and sharp. The following shapes were among the hand-axes: almond, pointed almond, piriform, limande, various.
>
> *Cleavers*: The cleavers were made of flakes from lumps of lava by "block on block" technique. The striking platforms were broad and thick, and percussion was used for the thinning or removals of it. The cutting edge which is never trimmed is, however, sharp and straight, convex or oblique. Some of the cleavers are markedly U-shaped in form, others are rectangular. Their sections are rectangular planoconvex or parallelograms. The predominating side-struck cleavers are the most characteristic type.
>
> *Flakes*: Twenty flakes of lava from 114 to 157 mm in length mostly with markedly obtuse angles of the striking platform were recorded. No special comments." (1960: 70).

Gilead (1970a) surveyed the site in 1967-8 and carried out a limited sounding. In his doctoral dissertation, he published conclusions based on his observations of four assemblages: a) the Rockefeller Museum small collection; b) the Hebrew University collection most likely coming from Stekelis' excavations and surveys; c) the Department of Antiquity collection; and d) his own collection from 1967-8. The exact stratigraphic provenance of the three first collections is uncertain. Following Stekelis (1960) and despite his own doubts, Gilead divided the lithic industries according to the raw material, placing the flint implements as coming from beds II-IV while the basalt industry was considered as derived from bed V.

The basalt assemblage studied by Gilead holds more then 300 implements, among them 144 handaxes and 135 cleavers. His discussion deals only with these typical Acheulian tool types. He noted that the "use of large flakes in the manufacturing of handaxes (and cleavers) is very characteristic." (Gilead 1970a: 79) When referring to cleavers he noted that:

> "Of these 40% are made in side-struck flakes, c. 10% on end-struck flakes, 8% are on oblique-struck flakes. The rest are on flakes that can not be classified with certainty though many may be side-struck as well. Hence, it may be assumed that the characteristic cleaver made on side-struck flake accounts for about two-thirds of these implements. The flakes have a wide, plain striking platform; the flaking angle is 110° - 125° " (*ibid*: 80)

Other observations made by Gilead are discussed in the relevant parts of this work.

Goren-Inbar and others (1991) described technological aspects of the basalt cleavers collected by D. Ben-Ami on the banks of the Jordan River after the drainage work of the late 1960's. The basalt artifacts from the new excavations were preliminary described in a series of recent publications (Goren-Inbar et al. 1992; 1994; Goren-Inbar and Saragusti 1996). The technological data in these publications will be discussed below in the relevant context.

<u>Natural Basalt Flakes and Differentiating Artifacts from Natural Flakes</u>

The question of naturally formed pseudo-tools has been the subject of a long and continuous debate among archaeologists since the very beginning of stone tool research. Recently, this issue has become relevant to the earliest occupation of East Asia and Western Europe debate (Roebroeks and Kolfschoten 1995 and references therein). Because of the flaking qualities of basalt and the poor preservation of the GBY assemblage, in many cases it is difficult to distinguish natural basalt pieces from man-made flakes. The following natural processes have been pointed out as resulting in naturally flaked artifacts and they are examined below in regard to the GBY environment.

High-energy environments

Rivers, streams or canyons will sometimes produce "pebble tools" and flakes. Clark (1958) studied such an assemblage of naturally fractured cobbles from Batoka Gorge in Northern Rhodesia (now Zimbabwe). His study was aimed at the debate over the Kafuan lithic industries of Africa. The collected fractured basalt cobbles and flakes enabled him to establish a typological list of naturally flaked implements and to describe their characteristic morphology. The assemblage of 24 flakes is described as follows:

> "The commonest form is ellipsoidal, whether struck from the side or from the end. The Main features – absence of platform and bulb, acute angle with pebble surface and shatter lines…" (Clark 1958: 69).

Large blocks of stone falling from the high cliffs were the agent causing basalt fractures at the Batoka Gorge. Clark noted from his experience with African sites and his experimental work with underwater knapping, that it is unlikely that water energy of a river can result in a "real" and homogenous assemblage such as the one from Batoka Gorge. He also pointed out other natural agencies capable of removing flakes of the kind struck from the Batoka specimens: violent wave action or violent torrent action, the fracturing properties of ice and frost and thermal fracture (*ibid*: 72). The Batoka assemblage include some flakes that: "… if found on a factory site, would without any doubt have been accepted as a product of human agency" (*ibid*: 70). Observation at streambeds of the Golan Heights during experimental work has shown that natural flakes do occur in this high-energy environment (Figure 2).

Figure 2: Natural Flake at Nahal Hamdal.

We cannot rule out the possibility that some of the basalt flakes in GBY are the result of these natural forces. On the other hand, geological and sedimentological observations show that the deposition of the archaeological layers of GBY accumulated place in a relatively low-energy environment such as lake shore or a shallow swamp (Feibel et al. 1998). It is unlikely therefore, that high-energy water is responsible to creation of non-human "artifacts" at GBY.

Tephrofacts

Non-flint "geofacts" or natural pseudo-artifacts produced by volcanoes of the Massif Central in France were discussed by Raynal and others who noted that:

> "Among these are a number of flakes and some objects with multiple flake scars with very regular pattern: none of them would be discarded out of hand if they

> occurred in solid archaeological context. *However, they are undoubtedly tephrofacts which have resulted from several mechanical and thermal actions during various different eruptive stages of volcanic events*" (1995: 130. emphasis in the original)

According to my knowledge, tephrofacts were never reported from the volcanic areas of Israel.

Tectonic fractures

One potentially relevant agency in the case of the GBY basalt assemblage is flaking caused by the tectonic movements such as those pushing the Benot Ya'akov Geological Formation in its present tilted position. There is no evidence yet, however, for this type of natural fracture in the excavated area or its vicinity.

Historical and modern flakes

A further problem to consider is the creation of artificial flakes by the heavy machinery employed in recent years in drainage projects to deepen the Jordan River. Quarry-like work done by tractors results, in many cases, in the production of numerous large flakes. In addition, a basalt quarry dated to historical times was found on the western slopes of the present Jordan River ca. 1km northwest of the excavated site (Map 3). Since the discovery of the site during construction of the Benot Ya'aqov Bridge in 1933 (Stekelis 1960), piles of dumped material have always been a problem for the definition of an *in-situ* origin of surface lithic collections from GBY (Gilead 1970a).

All of the above is of little relevance to the lithic assemblage from the recently excavated study area of GBY. The tools were uncovered as part of an i*n-situ* assemblage and many of them are highly sophisticated tools such as bifaces that cannot, under any circumstances, result from natural fracture.

A more likely agent causing natural flake-like basalt items is the typical "onion peel" weathering of basalt known as exfoliation. After weathering from the basalt source these "onion peels" can break into a variety of sizes of flat basalt slabs. Take an exfoliated piece and place it among human made basalt flakes, let it accumulate for 780,000 years in a waterlogged environment, and you will have difficulty distinguishing it from the other. This is true for large flakes and even more so for the small fracture component of the assemblage. It should be noted, however, that during a reexamination of the flake assemblage of II-6/L1, with the exfoliation factor in mind, only one flake was recognized as possibly originating from exfoliation of basalt rather than from intentional knapping.

In many cases, the basalt artifacts of GBY are extremely weathered, to a stage when unquestioned observation is not possible. The weathering of the basalt artifacts of GBY may result from two main factors:

1. The rolling of the artifacts in streams as can be seen occasionally in the assemblages coming from the conglomerates in the GBY sequence.
2. The heavy abrasion of some of the basalt as a result of a long period deposition in a waterlogged environment. For chemical reasons yet unclear, *some* of the basalt pieces become extremely fragile and, if dried, they disintegrate. Sedimentological observations show that in many cases basalt artifacts are weathering *in situ* to clay. In other cases, the weathering may have an effect similar to that of river rolling while in others the basalt remains relatively fresh. One of two basalt flakes excavated at 1 cm apart might disintegrate in no time when exposed (if not treated by a conservationist) while the other will remain fresh. As a result, in many of the cases technological observations are nearly impossible and researchers must rely on their experience only.

What, then, can be done to distinguish natural flakes from human-made artifacts within the basalt flake assemblage of level II-6/L1 in GBY?

First, flat natural basalt slabs that result from basalt weathering will not show evidence of blows or the impact of mechanical force. In the case of basalt, this type of evidence is different than that characteristic of other, more fine-grained materials. One of the goals of this work is to describe these characteristic features of basalt in a more detailed way than described to date in the literature (Clark 1958).

Second, weathered artifacts are, in many cases, excluded from the quantitative analysis of the technological attributes of the II-6/L1 assemblage. The state of preservation of the basalt artifact assemblage of II-6/L1 is shown in Table 1:

Table 1: Preservation State of II-6/L1 Basalt Artifacts

	Flake and Flake Tools		**Cores and Core Tools**		**Handaxes**		**Cleavers**	
Preservation State	N	%	N	%	N	%	N	%
Fresh	183	21.7	1	0.8	-	-	1	11.1
Slightly Abraded	331	39.3	47	36.2	10	28.6	2	22.2
Abraded	300	35.6	74	56.9	14	40.0	6	66.7
Rolled	28	3.3	7	5.4	8	22.9	-	-
Exfoliation	1	0.1	1	0.8	3	8.6	-	-
Total	843	100	130	100	35	100	9	100

As can be seen from the table, most of the basalt artifacts from II-6/L1 are not in fresh condition. This picture is emphasized in the case of the core tools (63.1% abraded or rolled) and even more so for the handaxes (71.5% abraded or rolled). However, 61% of the flakes from this layer are fresh or only slightly abraded. In addition, small artifacts are under represented in the assemblage as they suffering from a high degree of weathering and eroding into clay. Sedimentological research will hopefully help in answering these problems in the future.

The statistical data for the different attributes of the GBY assemblage will be presented in this work for the entire assemblage as well as separately for the group of fresh and slightly abraded flakes. In most cases, the difference between these two groups is insignificant. This supports the assumption that all of the flakes of the II-6/L1 assemblage result from intentional knapping and not from natural processes.

This suggestion also finds support in the geomorphological data. If future research confirms that the accumulation of the II-6/L1 occurred in a low energy environment, then it will be safe to argue that most of the GBY stones today suspicious as flakes are truly knapped flakes.

Questions of Research

In addition to the description of the II-6/L1 archaeological assemblage, I will attempt to answer the following questions regarding the basalt assemblage of GBY:

1. What was the reduction sequence (*chaîne opératoire*) employed for the production of the basalt tools of GBY? Was there only one reduction sequence for the manufacturing of all tool types? Were all tools of one type manufactured by a single reduction sequence? Which aspects of the reduction sequence are represented in this particular assemblage?
2. What kinds of blanks were used for the bifaces in GBY and from what kind of cores were they flaked? Can we recognize a systematic reduction of these cores?
3. Do the attributes used by us to describe and analyze basalt tools really suffice? As most stone tools found in archaeological sites are made of flint, the research methodology, particularly that used in attribute analysis, is heavily biased in favor of the “flint point of view”. Are all the attributes employed by us to describe basalt

tools relevant? What other attributes should we employ in order to achieve a better description and understanding of basalt tools?

4. Why, as will be shown in this work, did the toolmakers at GBY use basalt as the primary raw material for their tools? Was it due to functional qualities of the basalt? Was it primarily due to the availability of basalt around GBY? Or was it only due to the shortage of other raw materials in the area? Or perhaps other reasons such as cultural preference and tradition such as African affinity (as was suggested in the past {Goren-Inbar and Saragusti 1996; Stekelis 1960}) should be considered?

5. Why did Lower Paleolithic toolmakers stop using basalt after GBY? There is almost no evidence of use of basalt in later archaeological sites until the Epi-Paleolithic period (with the exception of Quneitra – see Goren-Inbar 1990) though basalt flows and boulders were definitely available in large areas of the Levant. Are we looking at a research-biased picture or at a real shift in raw material use between the Middle and the Lower Acheulian?

METHODOLOGY

Terminology

The terminology used in this work is compiled from different sources. The main typological terminology is the one used by Goren-Inbar in the description of the GBY assemblages. It is based on F. Bordes typology for the Lower and Middle Paleolithic (Bordes 1961) grouped with some African terminology of M. D. Leakey (Leakey 1971) for the description of aspects not represented by European terminology. Many of these terms are normally used to describe flint artifacts and, as such, do not always serve to describe the detailed features of the basalt artifacts. As for technological terms, those used for the attribute analysis are given in Appendix I and are defined in the relevant sections of this work. As the study of the lithic assemblage of GBY is an ever-learning process, new attributes were introduced during analysis when they were considered essential for better description and understanding of the assemblage. The experimental work done by Dr. Madsen, for example, has lead to the definition of new features and terms for use in lithic analysis. Undoubtedly, the terminology will be refined further as result of future study of the assemblage.

The biface waste typology is that defined by Newcomer (1971) and was found useful in describing many of these flake characteristics. Geological terms are defined in accordance with the Glossary of Geological Terms (Jackson 1997).

In cases where no terms were available or where the existing terms were not appropriate to describe technological features and shapes of the GBY basalt, we were forced to suggest our own terms. The aim of these suggested terms is not to increase the ever-growing lithic terminology but to define technological features absent from the standard lexicon of attribute nicknames. I hope that the description of these typical basalt features is sufficiently clear and can be used for future studies.

II-6/L1 Lithic Assemblage

Level II-6/L1 yielded an assemblage of almost 9000 lithic pieces with at least one dimension larger then two centimeters and tens of thousands of smaller pieces. They were divided, typologically, into the following categories:

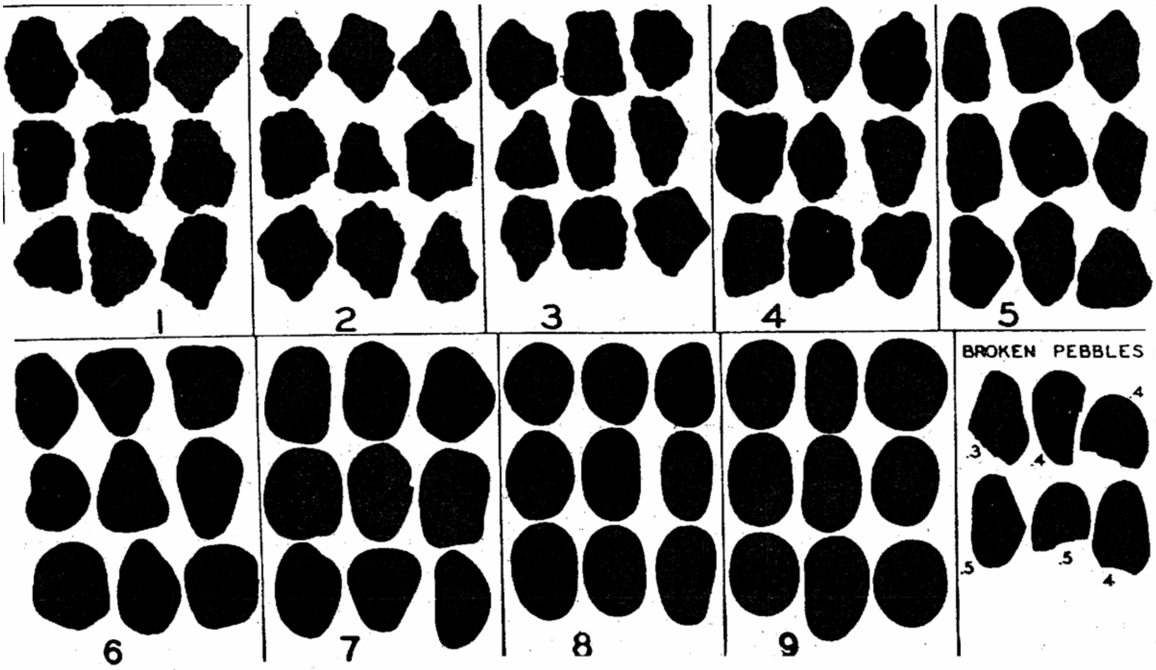
- **Natural Pieces** (n=6422) – all lithic pieces larger than 2 cm that bear no signs of human modification or utilization.
- **Chips –** all lithic material smaller than 2 cm in diameter.
- **Flakes and flake tools** (n=1593).
- **Cores and core tools** (n=820).
- **Bifaces** (handaxes n=39 and cleavers n=9) **–** large cutting tools bifacely flaked.

All of the lithic pieces underwent a detailed attribute analysis using the same method for all GBY lithic assemblages. A different attribute analysis has been employed for each of the lithic categories.

The attributes recorded for the natural pieces are granulometric and include measurements of maximum sizes (length, width and thickness) and the raw material and the “roundness” of the piece (according to the scheme presented in Figure 3). In later stages of the study, weight was added as well, but this attribute is unavailable for most of the natural pieces of II-6/L1.

The attributes recorded for the flakes and flake tools as well as for the cores and core tools is a combination of metric measurements with technological non-metric attributes. The flakes and flake tool attributes included length; width; and thickness; raw

Figure 3: Roundness Scale for GBY Natural Pieces:



material; preservation state; patina; breakage state; cortex cover on dorsal face; direction of blow; nature of striking platform; pattern of scars of dorsal face; technological observations such as lipped striking platform; presence of cone and others.

The attributes recorded for the cores and core tools of the II-6/L1 assemblage include raw material; preservation state; patina; breakage state; cortex cover; type of retouch; pattern and number of scars; shape of section; number and form of the working edges and the number of striking platforms. As with the flakes and flake tools, size observations have been recorded. The specific measurements for cores were the length of working edge, the circumference and the length and width of the last scar removed. As this work focuses on technology many typological observations will not be discussed.

The attributes recorded for the bifaces (handaxes and cleavers) are described in Goren-Inbar and Saragusti (1996).

The Experimental Study

To further study the technology used in the manufacturing of the basalt assemblage of GBY, experimental work was carried out together with Dr. Bo Madsen. On three different occasions (May and November 1998 and April 2000) we went to the vicinity of Gesher Benot Ya'aqov in an attempt to replicate all stages of basalt tool manufacturing at GBY. This work will deal mainly with the data obtained in the first two excursions. The data from the third field tour is currently under study.

The experimental work was carried out in three different stages:

The **first stage** involved the selection of the hammerstones. We followed the recommendation of D. Ben-Ami and collected basalt cobbles to be used as hammerstones at an area northeast of the Kinneret Lake. Nahal Meshushim (nahal is Hebrew for stream) that flows into the Kinneret Lake from the northeast, was found to be a good source for well rounded basalt cobbles and boulders (Map 2). A survey of Nahal Hamdal canyon on the western slopes of the Golan Heights north of GBY (Map 2) revealed that the Hamdal does not run for a long enough distance to produce sufficiently rounded cobbles to be used as hammerstones. The longer Meshushim stream has a variety of well-rounded basalt pieces of all sizes that are excellent in terms of shape, size and density for many tasks of stone knapping.

The selection of the hammerstones was based on the long knapping experience of Dr. Madsen. The desired hammers were selected according to the stage of reduction for which they were to be used. Some boulder-sized hammers, cf. 30-kg in weight, were selected as throwing hammers for the flaking of the giant cores. Smaller hammers for later stages of the knapping were selected for their well rounded and easy to hold size. The area contact with the flaked material should be wide and smooth enough in order to achieve an accurate and hard strike. The basalt cobbles chosen for these hammerstones should be dense and heavy as they are used for the manufacturing of the first stage large flakes and blanks.

The **second stage** included surveying the area around GBY in an attempt to find a source of basalt to be used as raw material for knapping. Some present day outcrops were examined (Map 3) as well as the availability of cobbles available in the present day Jordan River bed. An outcrop of basalt created by construction of a lake as part of an electricity project by Kibbutz Kfar Hana'asi (Map 2) was chosen as a good place for quarrying basalt slabs. Those were then knapped on location to produce large preforms for the manufacturing of the experimental bifaces as described in Table 2. A more detailed study of these stages of the basalt tools manufacturing is underway and will be discussed in future works.

In the **third stage**, the preforms selected in the field as suitable to be knapped were taken to the Institute of Archaeology at the Hebrew University in Jerusalem where they were shaped into bifaces by B. Madsen. The implements that were part of the manufacturing process in the first two experimental field excursions were recorded under the following categories:

- **Group A** - naturally occurring basalt shapes suitable for utilization.
- **Group B** - primary flakes and blanks – " preform" flakes.
- **Group C** - biface reduction flakes.
- **Group D** - implements with special attributes – flakes with special technological features, hammerstones etc…

Map 2 – The Southern Golan Heights

Map 3 - Jordan River at GBY

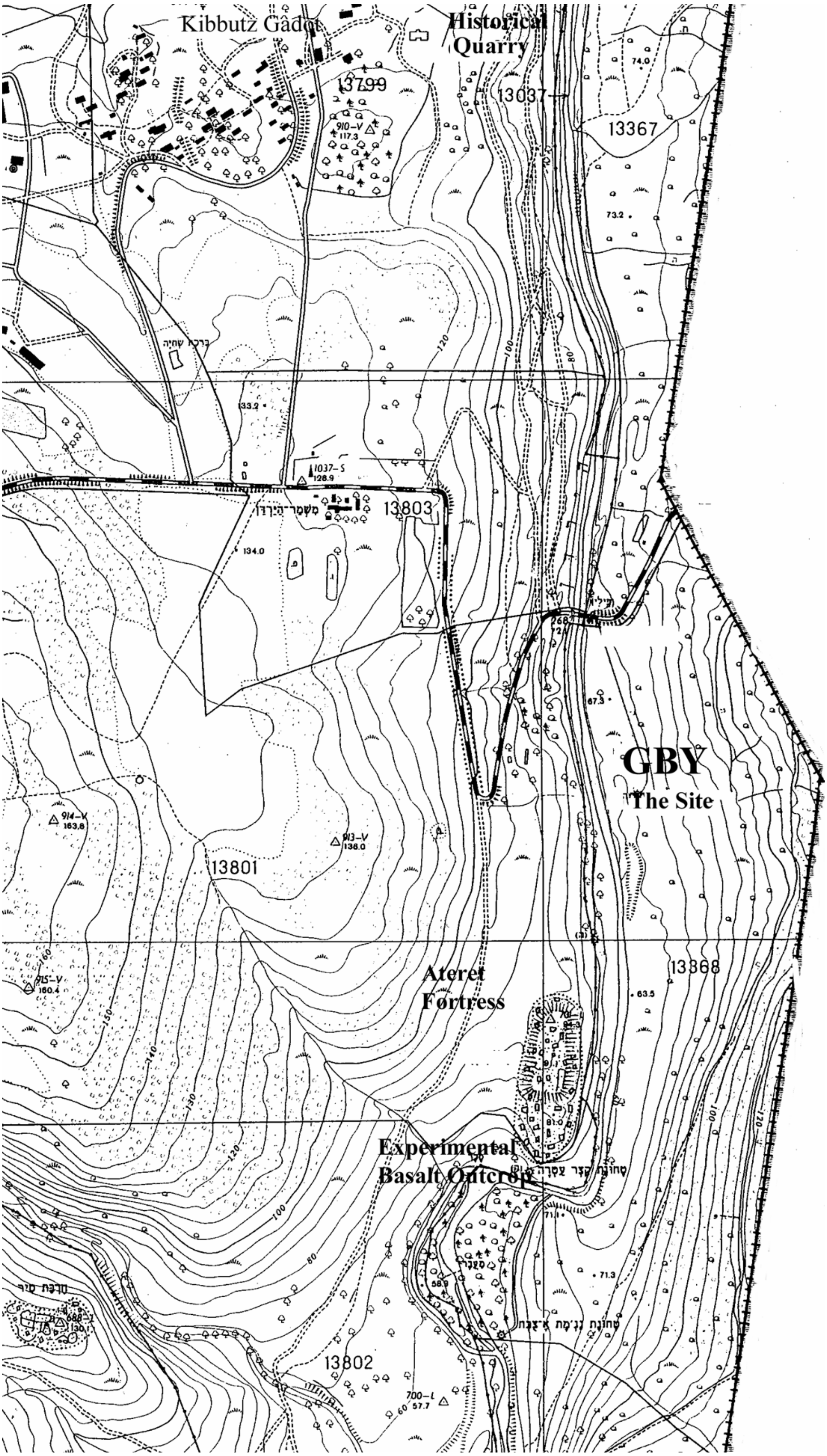


Table 2 shows the details of experimental "Group C" tool. Two antler billets were used as hammers, a heavy wapiti billet weighing 789 grams and a medium size Dama billet weighing 289 grams. Time was measured for the duration of work from the preform stage to the finished biface.

Table 2: Group C – Experimental Biface Flakes Data

Exp. No.	**Weight of Preform (grams)**	**Hammer**	**Notes and Observations**
C1			Experimental exercise. Not all flakes kept
C-2	4637	Wapiti billet	4 minutes of knapping work. A typical pre-form for hand-axe
C3	1950	Wapiti billet	9 minutes of knapping work
C4	624	Dama billet	6 minutes of knapping work
C5	1412	Wapiti billet	6 minutes of knapping work
C-6	1456	Wapiti billet	7 minutes of knapping work
C7	706	Dama billet	
C8	677	Limestone hammerstone	hammerstone breaks in the process
C9	574	Dama billet	
C10	972	Limestone	
C-11	1705	Wapiti billet	
C12	870	Dama billet	
C13		Wapiti billet	

Out of these experimental assemblages, two bifaces (handaxe C-6 –Figure 4; cleaver C-11- Figure 5) and one preform (C-2) were chosen to be analyzed in detail as they appear to most closely resemble the archaeological bifaces from GBY. These tools were made with the same Wapiti heavy billet. A large and heavy soft hammer was found to be the most efficient tool in knapping the basalt flakes and preforms. The use of such hammer prevented the typical breaking of the basalt resulting from the use of a hard hammer on this difficult to control material. A more detailed study of the effects of different hammers on basalt flaking will hopefully take place in the future.

All of the *debitage* flakes were collected and underwent an attribute analysis similar in all relevant attributes to the one applied to the archaeological GBY flakes. The attributes measured for the experimental flakes are given in Appendix 1. All flakes with at least one dimension larger than 2 cm were analyzed and all of the smaller ones (chips) were collected and weighed.

Figure 4: Handaxe C-6

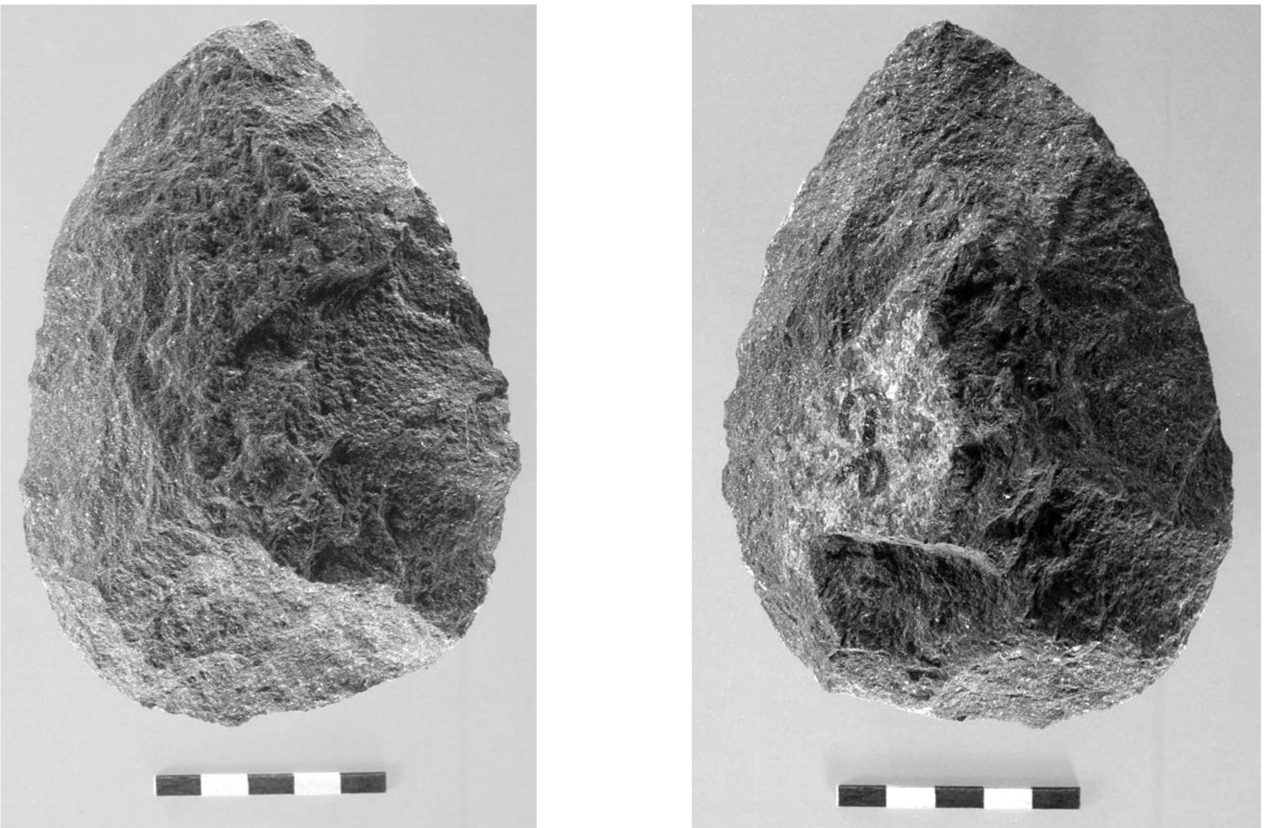
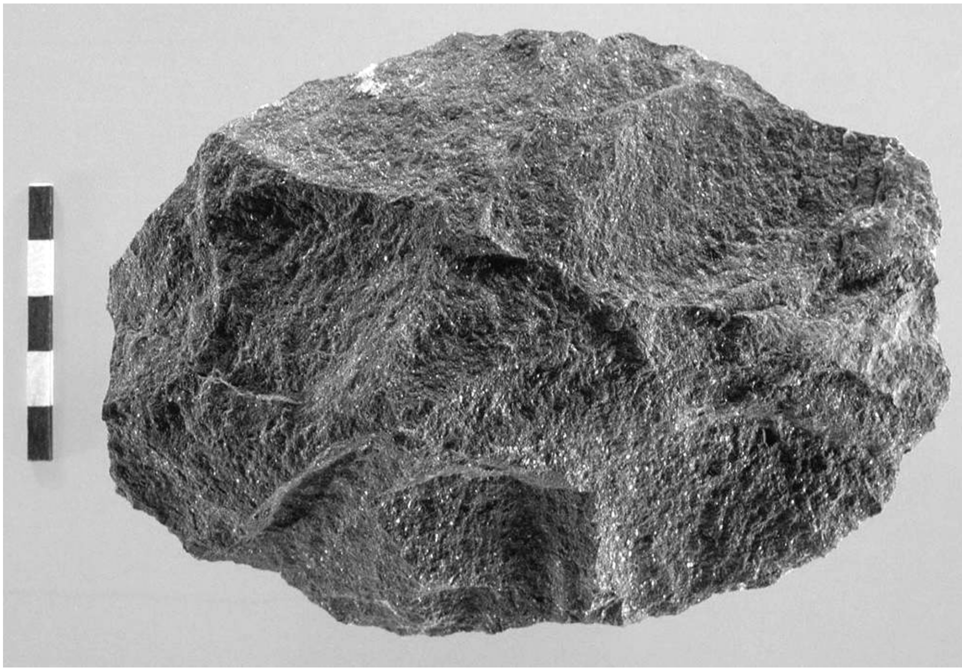


Figure 5: Cleaver C-11



RESULTS

II-6/L1 Lithic Assemblage

Raw Material Distribution

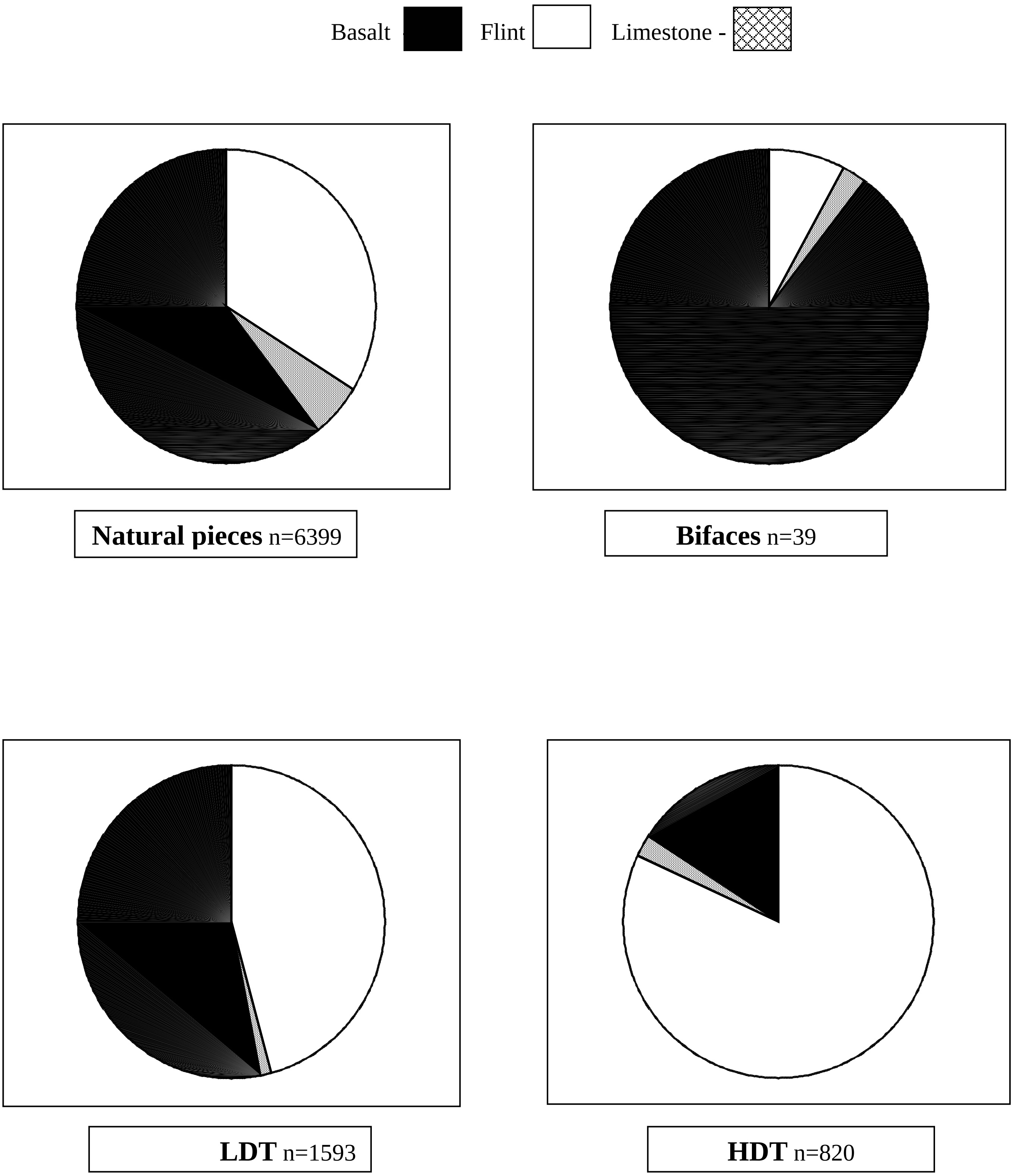
The raw material distribution of the II-6/L1 lithic assemblage (chips not included) is shown in Table 3 and in Graph 1.

Table 3: Raw Material Distribution of II-6/L1 Lithic Assemblage

II-6/L1	**Flint**		**Limestone**		**Basalt**		**Total N**
	N	**%**	**N**	**%**	**N**	**%**	
All Lithic Pieces	3567	40.3	402	4.5	4891	55.2	8860
Natural Pieces	2164	33.8	362	5.6	3873	60.3	6399
Flake and Flake Tools	729	45.8	20	1.2	844	53.0	1593
Cores and Core Tools	671	81.8	19	2.3	130	15.9	820
Handaxes	3	7.7	1	2.6	35	89.7	39
Cleavers	-	-	-	-	9	100	9

As can be seen from Table 3, the distribution of the raw material among the natural pieces is quite similar to the distribution of the entire assemblage from II-6/L1. This fact is not surprising considering the relative weight of the natural pieces (72.2%) in the assemblage. Table 3 and Graph 1 show that the raw material distribution for flakes and natural pieces is similar. A reasonable conclusion might be that lithic material was used for knapping in similar proportion to its natural availability in the vicinity of the site. On the other hand, sedimentological research has shown that artifacts and fossils are generally found on surfaces above or below beach deposits that lack the energy needed for natural accumulation of medium to large size lithic material (Feibel et al. 1998).

Graph 1 - GBY II-6/L1 Raw Materials Distribution



It seems safe to argue that human agency is responsible for the introduction of most medium to large size lithic pieces in the II-6/L1 assemblage.

Some points should be noted. The cores and core tools shows a clear dominance of flint. If we assume that all of the flakes in the II-6/L1 assemblage originated from these cores, it would be reasonable to expect a similar dominance of flint among the flake assemblage. However, this is not the case; 53% of the flakes are basalt. It seems that there are not enough basalt cores to account for the number of basalt flakes. An alternative source for the basalt flakes of II-6/L1 is the waste flakes resulting from bifaces reduction process. This issue will be discussed in detail in the discussion section of this work.

The raw material distribution for large cutting tools is very clear. Ninety percent of the bifaces and all of the cleavers of II-6/L1 were made from basalt. This distribution is similar to the one from II-6/L4 (Goren-Inbar and Saragusti 1996) and is consistent with most other assemblages from GBY. It should be noted that when flint and limestone have been used for the manufacturing of bifaces, the blank selected is almost always a cobble.

Most of the GBY basalt bifaces were produced from large flakes (see discussion below). While basalt is available in almost any size in the vicinity of GBY, it seems that flint was available only in the form of small to medium pebbles and for this reason large flint flakes were rarely made or used. As larger flint raw material is available in the Upper Galilee and the Golan Heights, it can be suggested that the knappers of GBY used only the raw material available in the vicinity of the site. They did not travel over a distance of more than a few kilometers in their search for flint.

Can we argue the same for the collection strategy of basalt? As was mentioned above, the sources of basalt for the GBY tools are yet unknown. On the other hand, it seems that in many cases good quality basalt was selected for the production of large flakes. Was there a nearby source of basalt or did the GBY knappers travel some distance in their search for it? The answer is probably somewhere in the middle, meaning that some of the flakes were obtained from a good quality source outside of the site and brought to it, while some Lower quality basalt was collected from the immediate vicinity of the site as needed.

It is interesting to note that no large flint flakes were found at the new excavations of GBY. In a recent surveying, Some medium to large size flakes were collected from the surface some 500 meters north of the Benot Ya'aqov Bridge. Only one of these flakes is comparable in size to the large basalt flakes used by the GBY knappers as blanks for biface production. The technology used in knapping this large flint flake into a finished biface resembles the technique used by the GBY knappers for the shaping of basalt bifaces on large flakes (namely, trimming of the bulb area with minimum investment of energy - Goren-Inbar and Saragusti 1996).

Typology of Basalt Tools

As the focus of this work is the technology used in the production of basalt tools at GBY, this section will not bring a full description of the typology of the assemblage. Typology is presented here to the extent it aids in understanding technological factors involved in creating the assemblage. Raw materials other than flint will not be discussed nor will the aspects of typology such as cultural meaning and so on.

Cores and Core Tools Typology

Table 4 shows the typological frequencies of the cores and core tools of this assemblage. Some of the terms used in the table are defined below:

- **Angular fragment** – a fragment of artifact that cannot be defined, but that bears signs, mainly flake scars, of intentional modification.
- ***Varia*** **–** an artifact of indeterminate shape that is not an angular fragment.

- **Modified** – M. D. Leakey defined modified battered nodules and blocks as "…various fragments of no particular form but generally angular, which bear a minimum of flaking and some evidence of utilization." (Leakey 1971: 6). Flakes removed from a modified artifact are primary with no preparation of a striking platform, making them opportunistic in nature.

Table 4: II-6/L1 Basalt Cores and Core Tools Typology

Typology		**n**	**%**	**Mean Number of Scars**
Cores	Levallois	2	1.5	12
	Divers	5	3.8	5
	Inform	2	1.5	4
	Core on Flake	2	1.5	5
	Modified	40	30.8	4
Waste	Angular Fragment	63	48.5	6
	Varia	4	3.1	4
	Core Waste	1	0.8	3
	Hammers	8	6.2	3
Tools	Atypical Burin	1	0.8	3
	Denticulate	1	0.8	3
	Chopping tool	1	0.8	3
Total		130	100	5

It seems that we can argue that cores were not a major aspect of basalt tool production in GBY. Only 11 cores are present in the assemblage of which only two resulted from a systematic reduction sequence – the Levallois. We can once again argue here that the basalt knapper of GBY had the knowledge to perform a sophisticated knapping sequence on basalt cores. They chose not to do so. When basalt flakes were needed, they were taken from the waste products of the bifaces or were flaked out of whatever was on hand, i. e. the modified pieces. Of the cores in GBY 30.8 percent are these *ad hoc* cores with a minimum number of removals. As can be seen from Table 4, there are almost no basalt core tools in II-6/L1. The three tools (atypical burin, denticulate and chopping tool) are too small of a sample from which to draw any kind of conclusions.

Flakes - Tools and Waste Typology

The typological frequencies of the II-6/L1 flakes and flake tools assemblage are given in Table 5:

Table 5- II-6/L1 Basalt Flake and Flake Tools Typology

Typology		N	%
Tools	Single straight side scraper	1	0.1
	Single convex side scraper	3	0.4
	Single concave side scraper	1	0.1
	Double convex side scraper	1	0.1
	Straight transverse scraper	1	0.1
	Convex transverse scraper	1	0.1
	Side scraper on ventral face	1	0.1
	Side-scraper with thinned back	2	0.2
	Atypical end scraper	2	0.2
	Atypical borer	1	0.1
	Notch	7	0.8
	Denticulate	8	0.9
	Retouch on ventral face	1	0.1
	Denticulate point	1	0.1
	End-notch piece	3	0.4
	Retouch flake	11	1.3
	Heavy Duty scraper on flake	8	0.9
Composite Tools	Abrupt retouched scraper & end notch	1	0.1
	Recloir a dos aminci & divers	1	0.1
	Notch on bifacial finishing flake	1	0.1
	Notch on retouched flake	1	0.1
	Denticulate on retouch flake	1	0.1
	Notch on modified flake	1	0.1
Waste	Atypical Levallois flake	3	0.4
	Pseudo-Levallois point	1	0.1
	Angular fragment	2	0.2
	Core waste	2	0.2
	Flake	730	86.5
	Bifacial finishing flake	4	0.5
	Kombewa flake	32	3.8
	Core on flake	1	0.1
	Varia	1	0.1
	Modified	9	1.1
Total		844	100

Tools make up 6.6% of this assemblage. While this is quite high, the percentage of tools among the flint flakes is much higher as can be seen from Table 6.

Table 6: Frequency of Tools vs. Waste in II-6/L1 Flint and Basalt Flakes

	Tools		**Waste**	
	N	%	N	%
All Raw Material	228	14.3	1366	85.7
Basalt	59	6.6	785	93.4
Flint	172	23.6	557	76.4
Limestone	3	15.0	17	85.0

The high percentage of tools of the II-6/L1 assemblage may suggest that some of the tools were brought to the site in their finished form. Again, it is too early to jump to conclusions before other assemblages of GBY are studied.

Scrapers are the most dominant tool in the assemblage – 2.3% (1.2% scrapers, 0.2% end-scrapers and 0.9 heavy-duty scrapers). Table 7 shows the descriptive statistics for the metric measurements of the II-6/L1 scrapers:

Table 7: Descriptive Statistics of II-6/L1 Scrapers (n=15) and Other Tools (n=36)

	Mean (S. D.)		**Range**	
	Scrapers	Other Tools	Scrapers	Other Tools
Length	66.74 (18.09)	69.42 (31.97)	37 - 98	21 - 170
Width	72.65 (19.37)	62.28 (26.79)	34 - 105	20 – 140
Thickness	27.35 (8.88)	25.19 (13.34)	10 – 45	7 - 68
Max Length	83.07 (18.92)	76.53 (33.47)	37 - 108	11 - 170

The II-6/L1 basalt scrapers are made, in most cases, on relatively large and wide flakes that stand as a distinguished size group among all other flakes. This size preference is further demonstrated in Graph 2. It seems that basalt flakes in the size range of 50 to 100 mm were selected for the modification of tools and that these flakes tend to be wide and thick in comparison with other flakes of the II-6/L1 assemblage. When the scrapers are isolated (Graph 3) from other tools, this size difference is even more emphasized. On the other hand, the small sample size prevents us from drawing any further conclusions.

Size of Basalt Flakes

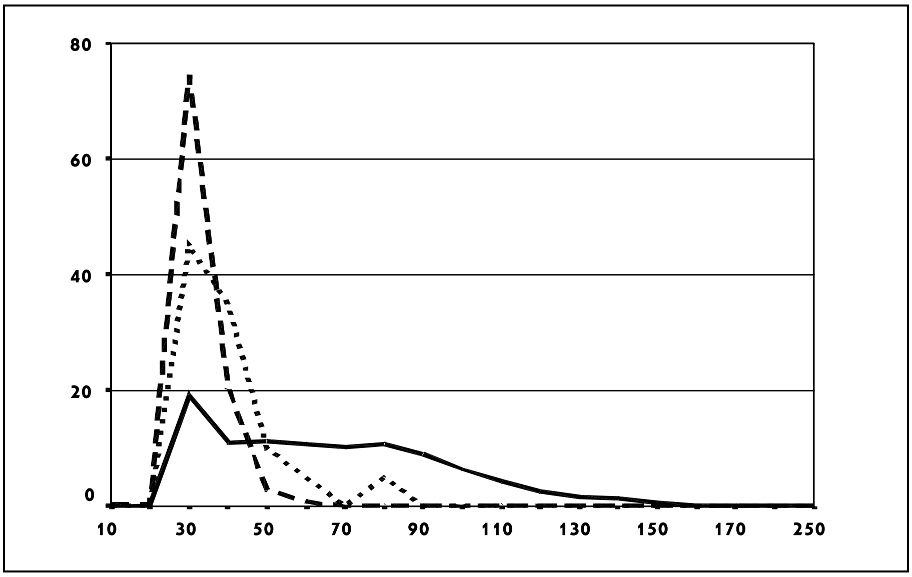
The different metric measurements for the basalt flakes of II-6/L1 (and the experimental bifaces flakes) are shown in Graph 4 and in Table 8.

Table 8: Size of Flakes. All Basalt Flakes Included

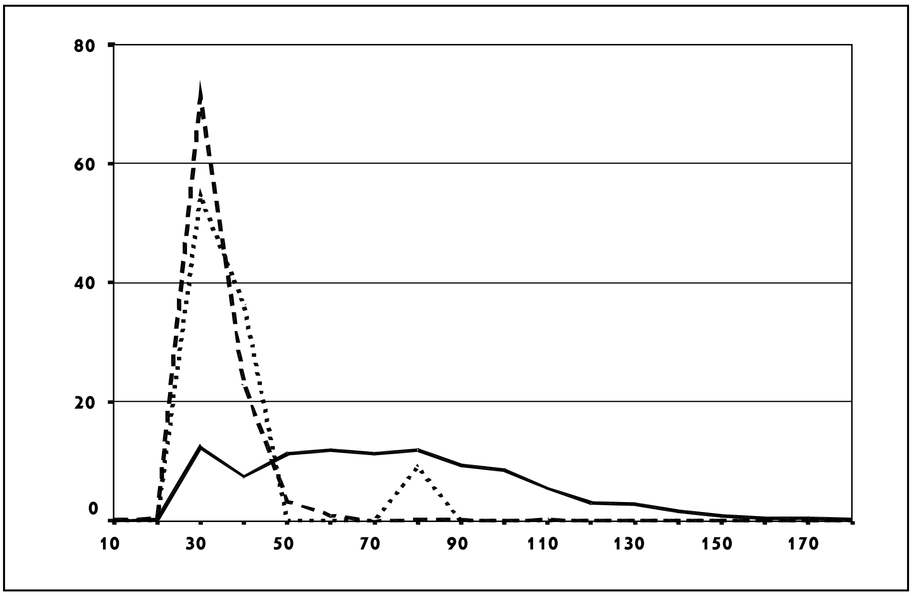
Assemblage	N	Mean (S. D.)	Size Range min - max
Maximum Length			
C-2	47	59.60 (34.78)	22-165
C-6	113	34.03 (13.57)	11-98
C-11	94	36.38 (16.81)	17-122
GBY II-6/L1	847	61.96 (30.98)	11-242
Length (along the flaking axis)			
C-2	47	46.40 (30.16)	9-162
C-6	113	26.93 (12.55)	6-69
C-11	94	25.83 (12.00)	8-66
GBY II-6/L1	827	55.76 (29.63)	13-219
Maximum Width (perpendicular to flaking axis)			
C-2	47	49.17 (29.07)	9-118
C-6	113	28.30 (12.04)	3-82
C-11	94	32.57 (17.30)	10-122
GBY II-6/L1	829	50.83 (25.88)	4-177
Maximum Thickness			
C-2	47	13.00 (7.97)	2-31
C-6	113	6.94 (4.27)	2-25
C-11	94	7.62 (5.13)	2-30
GBY II-6/L1	849	23.09 (12.55)	5-80

It was found that the attribute of maximum length of the artifact best demonstrates the size of the flakes. Furthermore, the other attributes measured for the experimental as well as for the archaeological flakes yielded similar data distribution curves. Of these graphs, the following points should be noted:

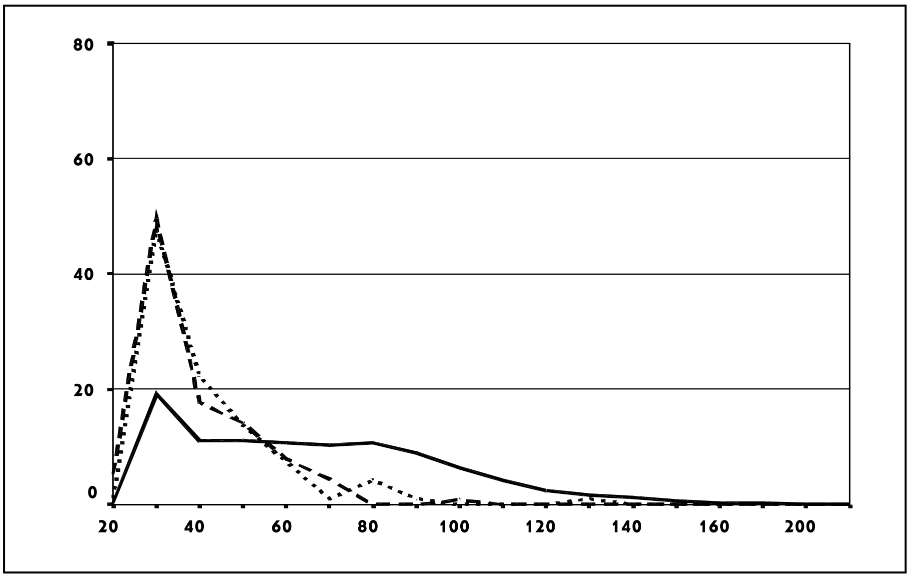
Graph 2: GBY – II-6/L1 Basalt
Size of flakes in maximum diameter
(Y - frequency in %; X - size in mm)



A. All II-6/L1 flakes
By raw material
Basalt (n=844)
Flint (n=729)
Limestone (n= 20)



B. II-6/L1 complete flakes
By raw material
Basalt (n=362)
Flint (n=421)
Limestone (n= 11)

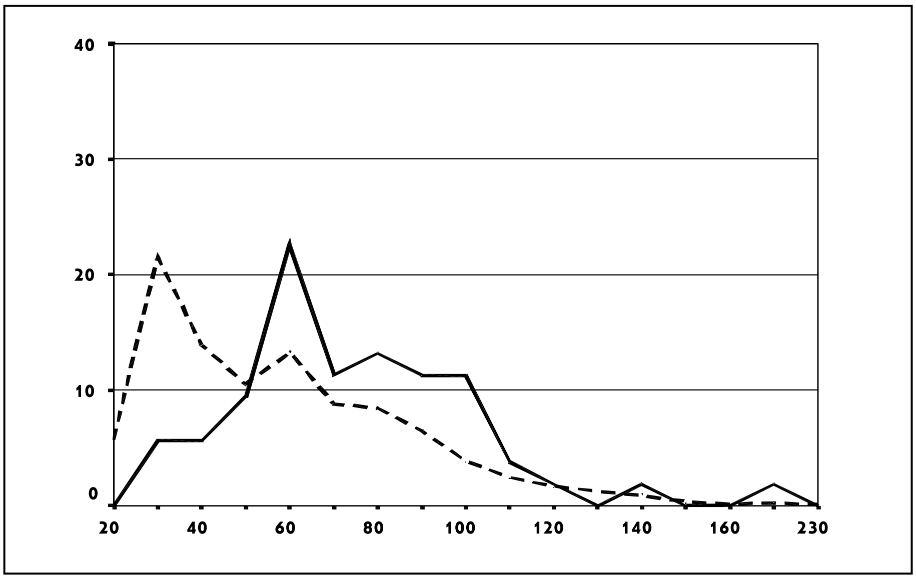


C. II-6/L1 vs. C6 & C11
Size of flakes
II-6/L1 (n=844)
Biface C-6 (n=113)
Biface C-11(n= 94)

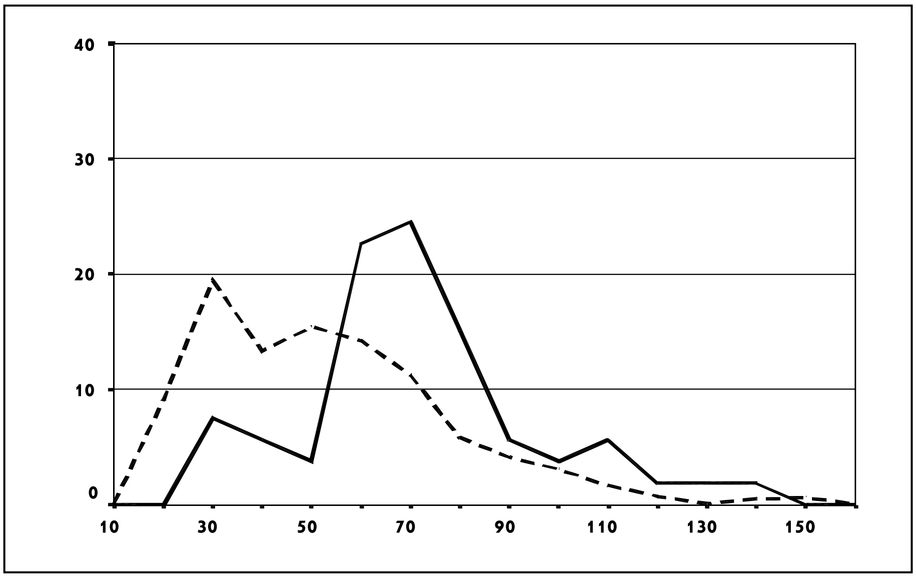
Graph 3: GBY – II-6/L1 Basalt

Size of waste flakes vs. flake tools
(Y - frequency in %; X - size in mm)

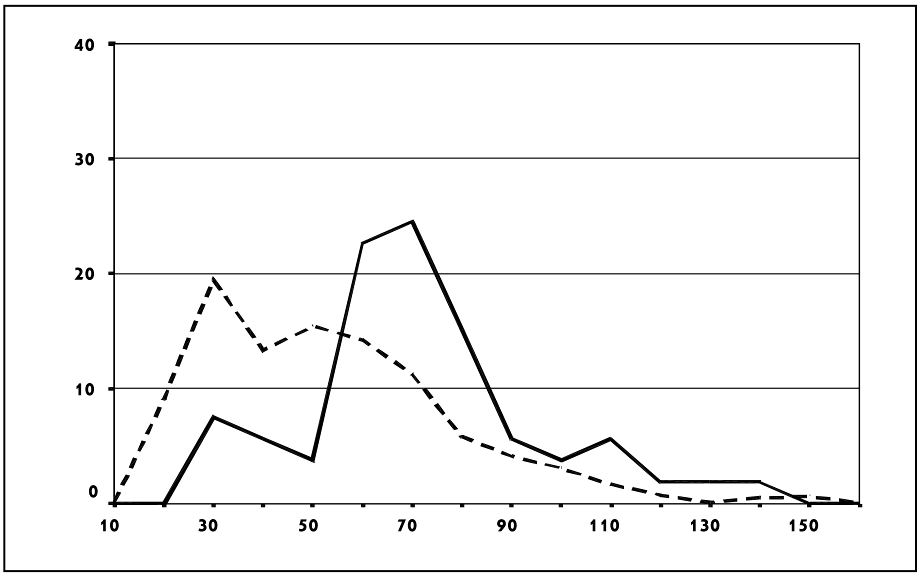
Waste (n = 791)
———
All Tools (n = 53)
– – –



A. Length



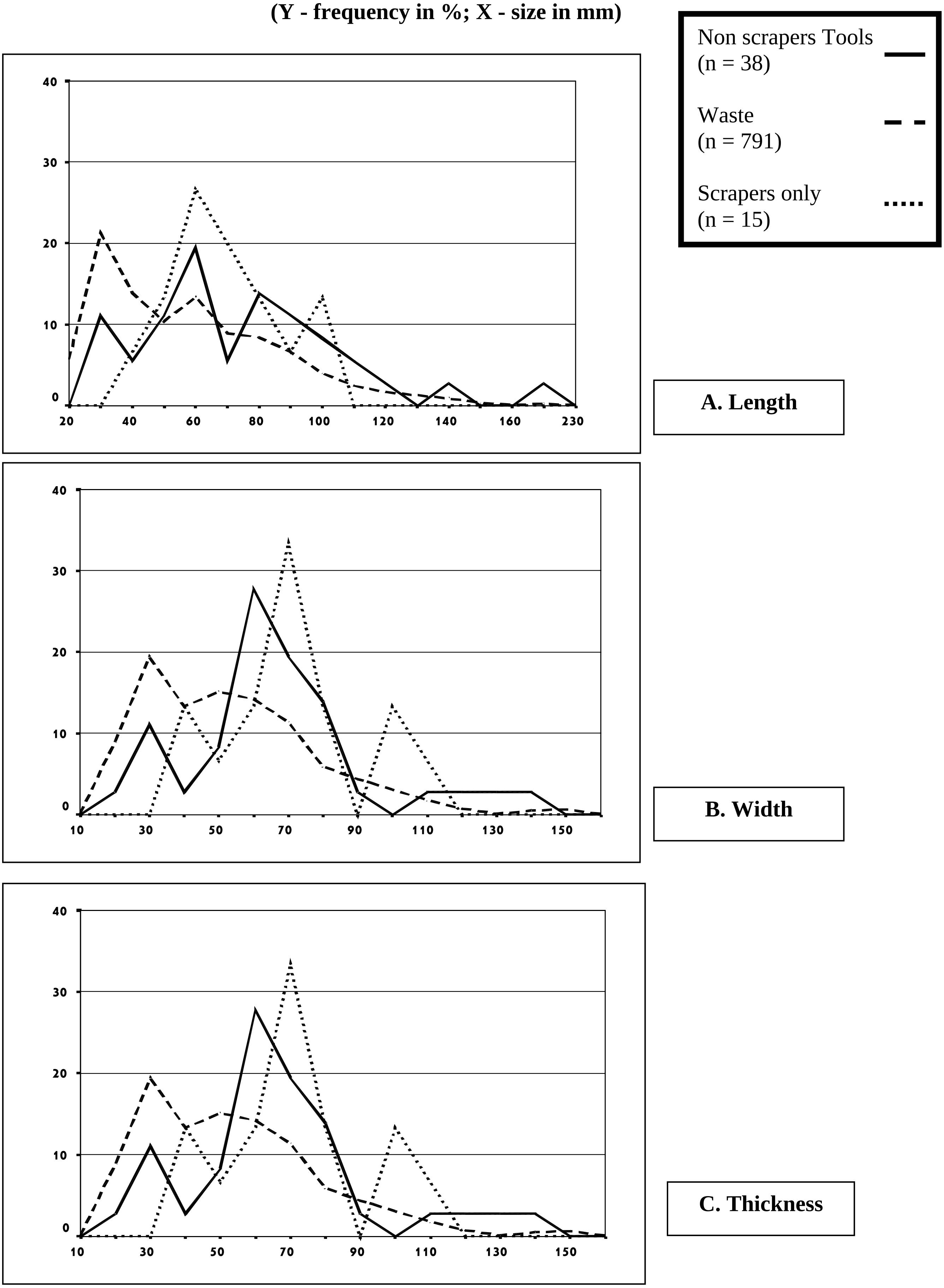
B. Width



C. Thickness

Size of waste flakes vs. flake tools vs. flake scrapers

(Y - frequency in %; X - size in mm)



The size distribution of basalt flakes is different from that of other raw materials (Graph 4 – A & B). A majority of the flint and limestone waste flakes are small in size. In contrast, the distribution pattern for basalt shows a wide variety of sizes and only a slight numerical superiority of small size flakes. The following reasons may explain this difference in size distribution:

First, the size distribution of basalt flake might reflect different reduction sequences than that of flint and limestone.

Second, the variation may result from other human behavior such as importing of different flake sizes into the site.

Third, some post-depositional processes may effect different raw materials in different ways. Based on observation during excavation, the small basalt pieces are extremely fragile and vulnerable to waterlogged environment.

The true explanation is probably a combination of all of the above. While the low number of small basalt flakes is partly a result of the post-depositional processes and the "disappearing" of the basalt flakes, the primary reason for this particular size distribution is human behavior. While flint and limestone probably represent a "normal" knapping site distribution, the basalt distribution pattern results from another scenario.

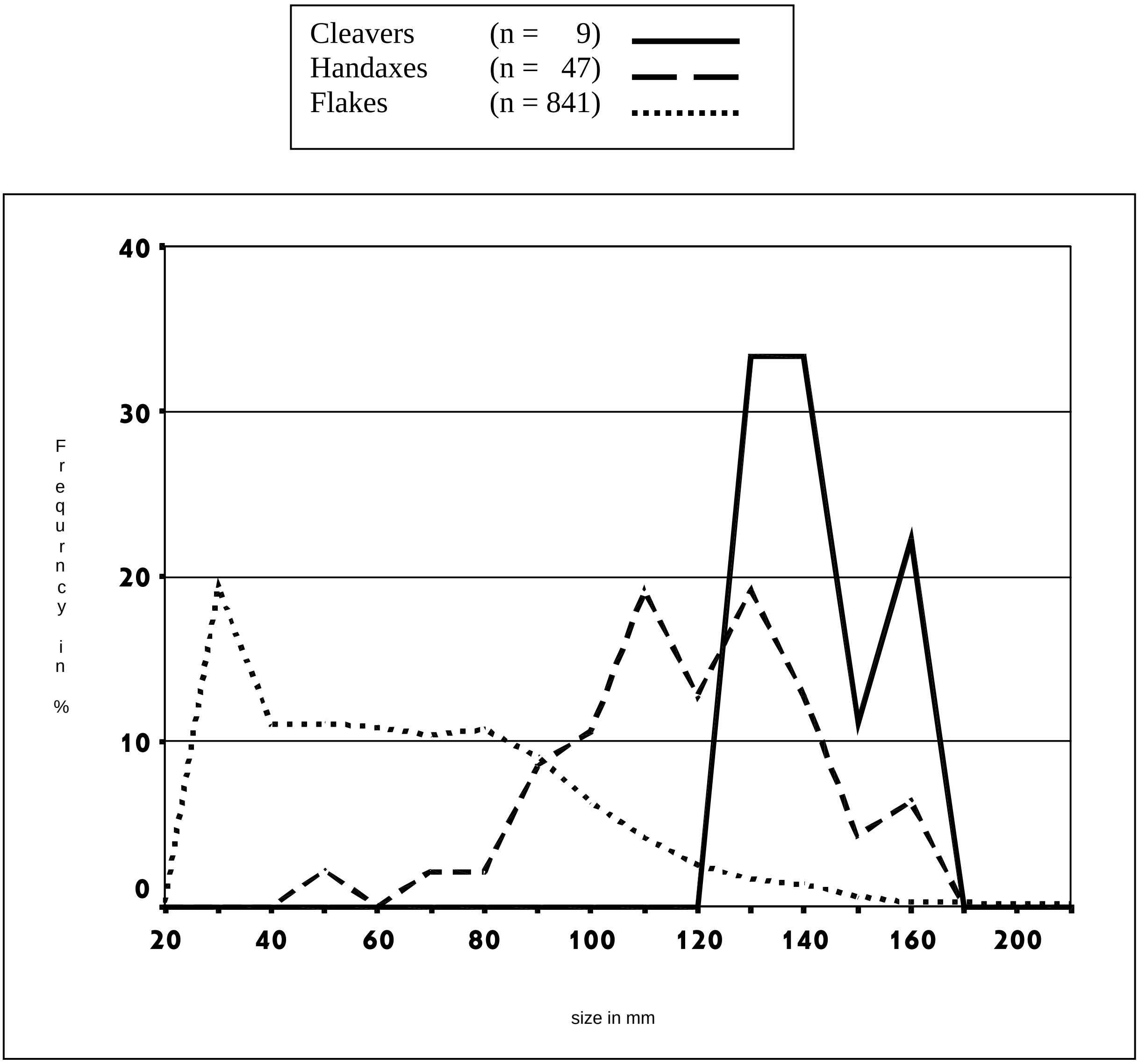
Graph 4-C shows the size distribution of the II-6/L1 flakes in comparison with that of the two experimental bifaces C-6 and C-11. Taking into consideration all differences between the assemblages, such as sample size and different methods of knapping, it is still a good illustration of the difference between the archaeological assemblage and the "ideal" experimental biface flaking assemblage. The difference is even more striking when the similarity between the experimental flakes size distribution and that of the flint and limestone flakes (Graph 4) is noted.

The size distribution of II-6/L1 cleavers and bifaces versus that of the basalt flakes is shown in Graph 5. Table 8 and Graph 5 clearly show that flakes big enough for the production of large cutting tools are nearly absent. It seems that the flakes brought to the site as preforms or blanks were all used as blanks for bifaces and were rarely abandoned untouched.

Another alternative is that few, if any large flakes were produced at the site. The two giant cores and the few large flakes found at II-6/L1 suggest that some large flake production was done on site. However, the numbers are negligible. The data from the size distribution of the basalt suggests that the majority of the bifaces were introduced to the site as finished tools or as preforms. From the preliminary data of the experiment, we can roughly estimate the number of flakes resulting from the shaping of a big flake into a biface as 100. Thus, the 48 bifaces found in II-6/L1 should have produced 4800 flakes. Even if we cut the number of flakes in half, we get three times more flakes than the 820 flakes in this layer. Furthermore, we have not taken into account that some of the 820 flakes may have resulted from other processes such as giant core reduction.

Graph 5 - GBY – II-6/L1 Basalt

Maximum length of bifaces and flakes



Morphology and Technology: II-6/L1 Flakes and the Experimental Flakes

The results of the attribute analysis of the II-6/L1 flakes will be presented here with reference to the flake assemblages of the experimental preform (C-2) and bifaces (C-6 and C-11). The correlation between the archaeological and the experimental assemblage is problematic for the following reasons:

First, to a certain extent, all stages of basalt knapping, beginning with the trimming of a giant core and ending with the finest retouch of the smallest tools, are represented in the archaeological assemblage of II-6/L1. However, only the "blank to biface" stage is represented in the experimental assemblage.

Second, the technology used in manufacturing the experimental bifaces cannot be, of course, an exact replication of the GBY technology. A great number of flakes were removed to produce the experimental ones in comparison to the minimum energy investment in making the archaeological bifaces,. Antler hammers were used for all stages of the experimental biface manufacturing, however, we cannot conclude with certainty that they were used to produce the GBY bifaces as well.

Correlation is even more problematic for the C-2 preform, which yielded an assemblage of only 47 flakes. The small sample size and the absence of final stages of biface trimming limits the relevance for some of the attributes measured.

These problems limit the significance of the experimental assemblage for comparison with the archaeological one primarily to size and frequency of flake forms. It does, nevertheless, give us some direction of thought on issues such as technological features appearance and the frequencies of technological phenomena typical for basalt. The fresh and slightly abraded basalt flakes of II-6/L1 are presented as a distinct group in some of the cases to illustrate certain points. The difference in sample size results from the fact that different attributes are not always available for all of the artifacts.

The Shatter Rate of the Flakes

Table 9 shows the location of breaks and the frequency of their occurrence during the process of knapping for the experimental and the II-6/L1 basalt flakes:

Table 9: Location of Breaks

Location of Break (%)	**C-2**	**C-6**	**C-11**	**II-6/L1 Flakes**	**II-6/L1 Flakes Fresh & Slightly Abraded**
N	47	113	94	840	514
Complete	44.7	26.5	41.5	43.1	40.9
Distal	23.4	39.8	33.0	14.0	16.7
Lateral	14.9	7.1	6.4	11.1	10.1
Proximal	2.1	10.6	4.3	10.4	11.1
Lateral & Distal	6.4	3.5	3.2	2.9	3.9
Proximal & Distal	-	7.1	3.2	1.9	2.5
Fragment	2.1	4.4	2.1	12.1	10.5
Proximal & Lateral	-	-	5.3	2.2	2.7
Indeterminate	6.4	0.9	1.1	2.3	1.6

Only a small percentage of the experimental flakes are broken. One possible explanation lies in the absence of post-depositional processes impacting on the experimental flakes. All breaks in the experimental assemblages are a direct result of the knapping procedure only. Thus, it is interesting to note that the rate of whole flakes is very similar between the experimental and archaeological assemblages. We can suggest that the basalt flakes of II-6/L1 underwent only low energy taphonomic processes that had minor impact on the large flake component of the assemblage. Another interesting observation is that there is a great degree of similarity between the whole assemblage and the fresh flakes when taken as distinct group. A notable difference between the two assemblages is the percentage of fragments. The high percentage of distally broken flakes among the experimental flakes should be noted. The tools and technology of knapping can perhaps explain this unexpected observation. Nevertheless, this point should be further examined when a larger sample is available.

As can be seen from Table 9, the most frequently broken area is the distal end of the flake, as can be expected, for it is the thinnest part of the flake. Next in frequency are the other simple breaks (lateral and proximal) and all of the more complex breaks are fairly evenly distributed among the other areas of the flakes. This is true for the experimental as well as for the archaeological flakes. The reasons for the high percentage of distally broken flakes of the C- 6 biface are unclear. The breaks may be the result of poor quality raw material or from the technique of knapping.

Amount of Cortex Cover on the Dorsal Face of the Flakes

The amount of cortex cover for the different study assemblages is shown in Table 10:

Table 10: Amount of Cortex Cover

Cortex Cover (frequency in %)	C-2	C-6	C-11	II-6/L1 Flakes	II-6/L1 Flakes Fresh & Slightly Abraded
N	47	113	94	715	473
No Cortex	70.2	69	70.2	76.4	78.0
0- 25	12.8	8.8	11.7	4.6	4.9
25-50	12.8	8.0	5.3	2.4	3.0
50-75	-	5.3	3.2	2.4	2.3
75-100	2.1	8.8	6.9	11.6	9.9
Indeterminate	2.1	-	-	2.7	1.9

As can be seen from the table, some 70% of the flakes, experimental and archaeological alike show a high tendency to have no cortex on their dorsal face. Again, the similarity between the assemblages is clear. It should be noted here that basalt does not have a real cortex, as does flint. The term cortex is used here to describe the natural face of the raw material used. These natural faces of basalt cobbles and giant cores are sometimes distinguishable from surfaces resulting from human knapping but in many cases, it is impossible to differentiate between them. This is particularly true for the heavily weathered basalt from GBY. This fact led to the definition of the attribute "indeterminate" for the nature of cortex cover on the basalt artifacts. The irregular nature of the ventral faces of basalt flakes (see discussion on special waste types) on the one hand, and the smooth faces of many natural faces on the other, makes defining this attribute impossible for many of the GBY basalt artifacts. Under these circumstances, this attribute cannot be regarded as very meaningful for the analysis of the GBY assemblages.

Direction of Blow

The distribution of the direction of blow for the basalt flakes is shown in Table 11.

Table 11: Direction of Blow

Direction of Blow (frequency in %)	**C-2**	**C-6**	**C-11**	**II-6/L1 Flakes**	**II-6/L1 Flakes Fresh & Slightly Abraded**
N	46	111	94	777	499
Longitudinal	23.9	20.7	6.4	44.1	41.9
Latitudinal	13.0	16.2	21.3	21.5	22.2
Side Strike	34.8	9.9	24.5	4.4	5.4
Indeterminate	28.3	53.2	47.9	30.0	30.5

Unlike other attributes, the distribution of the direction of blow shows marked difference between the experimental and archaeological assemblages as well as within each assemblage. We should, perhaps, look for more significant results by analyzing only the completed flakes or by distinguishing between large flakes of the archaeological assemblage and the small flakes of the experimental biface manufacturing. Table 11 does not contain data for the large flakes used experimentally for the production of bifaces. The comparison of the direction of blow for the large flakes experimentally removed from giant cores recorded for the archaeological bifaces made on flakes will hopefully be the focus of future studies.

The close similarity between the whole II-6/L1 assemblage and the II-6/L1 fresh only assemblage should be noted. It seems that the direction of blow is a technological attribute usable for basalt artifacts in any weathering stage.

Pattern of Scars on the Dorsal Face

The scar patterns on the dorsal face of the flakes and their frequencies are shown in Table 12. The high percentage of the indeterminate group, for which it was impossible to identify this pattern, is notable. The direction from which the flakes were removed is very hard to read from the scars on the dorsal face of the basalt flakes. Cortical flakes appear more or less in the same frequency as in the “cortex cover” attribute (but see also discussion of the cortex above). The relatively high percentage of radial dorsal faces in the experimental flakes is probably due to their origin from biface manufacturing, which involves multi-directional blows. The relatively low number of most other patterns should be noted. Higher frequencies of complex scar pattern for flakes resulting from knapping of bifaces could have been expected.

Plain dorsal faces can result, as in the case of the experimental flakes, from the use of large flakes as blanks for the reduction of the biface (Dag and Goren-Inbar in prep.). This may also account for the high number of the plain dorsal faces among the archaeological flakes.

The high percentage of indeterminate flakes in the archaeological sample and the low number of flakes with sophisticated scar patterns, cast doubt on the contribution of this attribute for the understanding of the GBY basalt technology.

Table 12: Pattern of Scars on the Dorsal Face

Nature of Dorsal Face (frequency in %)	**C-2**	**C-6**	**C-11**	**II-6/L1 Flakes**	**II-6/L1 Flakes Fresh & Slightly Abraded**
N	47	112	94	765	496
Indeterminate	36.2	40.2	39.4	48.5	40.9
Cortical	2.1	17.0	13.8	10.7	9.9
Plain	25.5	21.4	14.9	10.5	10.9
Simple	12.8	10.7	12.8	12.8	16.1
Parallel	-	-	-	0.1	0.2
Convergent	-	-	-	0.1	-
Opposed	-	-	-	1.0	1.0
Radial	10.6	7.1	12.8	3.8	5.6
Ridge	-	-	1.1	0.4	0.4
Side	-	-	-	5.4	0.6.5
Simple & Side	6.4	1.8	4.3	3.3	4.0
Simple & Opposed	2.1	1.8	-	2.7	3.4
Side & Opposed	4.3	-	-	0.4	0.6
Simple & Radial	-	-	1.1	0.3	0.4

Type of Striking Platform

The distribution of shapes of striking platforms for the different study assemblages is shown in Table 13. The difference in the frequency of indeterminate striking platforms between all flakes (23.1%) and the fresh flakes (17.2%) should be noted. On the other hand, there is very little difference between these two groups for most of the other types of striking platforms. It can be suggested, therefore, that the heavily abraded flakes significantly raise the number of indeterminate flakes in the II-6/L1 assemblage. Large differences occur between the different experimental assemblages. The high percentage of cortical striking platforms for the C-11 flakes might result from the visible nature of the cortical layer in the preform.

Table 13: Type of Striking Platform

Type of Striking Platform (%)	C-2	C-6	C-11	II-6/L1 Flakes	II-6/L1 Flakes Fresh & Slightly Abraded
N	44	110	93	844	500
Cortical	13.6	12.7	48.4	1.7	2.0
Punctiform	-	8.2	1.1	0.4	0.6
Plain	45.5	18.2	10.8	41.0	44
Dihedral	4.5	0.9	-	1.3	1.6
Faceted	18.2	20.9	16.1	3.6	4.4
Removed	-	-	-	2.5	3.6
Missing	4.5	2.0	10.8	26.4	26.6
Crushed	11.4	15.5	9.7	-	-
Indeterminate	2.3	3.6	3.2	23.1	17.2

The high percentage of plain striking platforms for the C-2 flakes should be noted. The knapping of the C-2 preform was stopped in the roughout stage and it lacks the thinning and shaping stages. These stages involve a higher degree of platform preparation by the knapper than does the roughout stage. The similarity between the percentage of plain striking platforms in the archaeological assemblage and the C-2 preform flakes should be noted as well. It may be suggested that the last stage of the biface manufacturing is underrepresented in the archaeological assemblage. Another possibility is that the experimental manufacturing of the bifaces involves a higher degree of platform preparation than the archaeological one.

The experimental flakes show a high percentage of crushed striking platforms. This attribute was introduced into the GBY lithic analysis only recently as a result of the study of the effects of soft hammer use on flint flakes (Sharon and Goren-Inbar 1999). For this reason the data for the II-6/L1 is not available. As was mentioned above, all experimental bifaces were made using a soft hammer. It seems that the crushed striking platforms should be attributed to the application of soft hammer to basalt as well as to flint.

The high resolution of the experimental flakes enables us to see many details unobservable in the archaeological ones. For example, the experimental flakes show much higher frequencies of facetted striking platforms than the archaeological flakes. One possible explanation for this higher frequency is the poor preservation state of the archaeological assemblage. On the other hand, I found it hard to define or even recognize the striking platform in some of the new and fresh flakes. Even in a small sample of large flakes experimentally produced from giant cores, defining the striking platform was difficult. The lack of bulbs of percussion (see below), the spontaneous shatter of the striking platform, (which in some cases resemble facetted striking platforms) and the absence of visible cortex, all make the definition of this attribute for some of the flakes almost impossible.

Lipped Striking Platform

The lip between the striking platform and the ventral face was attributed to the use of soft hammers in flint biface reduction (Sharon and Goren-Inbar 1999 and references therein). Table 14 shows the frequencies of lipped striking platforms in the different assemblages:

Table 14: Lipped Striking Platform

Lipped Striking Platform (%)	**C-2**	**C-6**	**C-11**	**II-6/L1 Flakes**
N	39	78	73	844
Lipped	61.5	59.0	57.5	5.8
Unlipped	23.1	29.5	21.9	93.7
Indeterminate	15.4	11.5	20.5	0.5

The frequency of lipped striking platforms in the experimental assemblages is clearly higher than that of the archaeological material. Nevertheless, when considering the fact that lip fractures are in many cases vulnerable to weathering, the percentage of lipped flakes in the II-6/L1 assemblage is relatively high. It reaches 7.5% when only complete flakes are counted. At this point, we do not know the significance of the lip for basalt fracture mechanics. Does it result from the use of a soft hammer or is it the characteristic nature of the basalt? The answer probably lies in a combination of these possibilities and future experimental work will focus on this issue.

Bulb of Percussion Magnitude

Table 15 shows the frequencies of the different magnitudes of the bulb of percussion for the experimental flakes. There is no available data for the archaeological flakes. However, general observation suggests that the data will be quite similar to that of the experimental flakes. This attribute is very hard to quantify and should, at this point, be regarded as suggestive rather than conclusive.

Table 15: Bulb of Percussion

Bulb of Percussion Magnitude (%)	**C-2**	**C-6**	**C-11**
Emphasized	7.1	7.3	16.0
Normal	52.4	43.9	53.3
Diffused	40.5	48.8	30.7

As can be clearly seen from Table 15, the experimental flakes rarely show emphasized bulbs of percussion. The results for the C-11 biface differ significantly. The reason for this difference is unclear. The variability within the experimental assemblages is notable here as with many other attributes studied in this work. Furthermore, none of the larger experimental flakes show emphasized bulbs or even normal or easy to observe ones. This observation is valid for the large flakes that were knapped from giant cores using a huge throwing hammerstone as well as for the smaller, secondary flakes that were knapped with a medium sized hand hammerstone.

Experimental flakes from all stages of biface manufacturing have diffused or small bulbs and very low frequencies of emphasized ones. The distinct nature of basalt is demonstrated even more by the fact that no clear connection is seen between the size of the hammer and the magnitude of the bulb, a relationship observed in flint assemblages (Sharon & Goring-Morris in prep).

The probable explanation for this phenomenon is that the basalt used by the GBY knappers had the tendency to break without resulting in a bulb of percussion. Another possible explanation can lie in the knapping method used to detach these flakes. Considering other works (Clark 1958), it appears that the first explanation is more probable. On the other hand, it should be noted that some of the bifaces made from large flakes show a bulb of percussion that gives the tool a convex morphology. This morphology was used by the toolmakers to achieve the desired convex shape. Basalt bulbs of percussion are present in many of the basalt bifaces of GBY, however, their morphology is different than that of other raw materials. In many of the large archaeological basalt flakes, for example, the bulb occupies most of the ventral face. More quantitative data about the magnitude of the bulb of percussion will be available for the large experimental flakes in the future.

Hammerstones

Geological observations suggest that at the time of occupation, many suitably sized and shaped basalt cobbles for use as hammerstones were available from the nearby conglomerates. Another source of hammerstones was probably the limestone cobbles that could be collected from the riverbed flowing from the Upper Galilee high mountains to the west such as the paleo Rosh Pina Wadi (Map 2). Such pebbles and cobbles were collected by us from the present day Rosh Pina Wadi and are found also in the GBY assemblages (see below). As for basalt hammers, some well-rounded cobbles of excellent size for hammers were recently collected from the banks of the Jordan River north of the Benot Ya'aqov Bridge during a survey conducted after the damage caused to the site by the Kinneret Drainage Authority in December 1999. The cobbles come from the same area where the late Prof. Stekelis excavated in the 1930's and 40's. It should be noted that the stratigraphic correlation between this area and the new excavation area is as of yet far from being clear.

Thirteen hammerstones were excavated from II-6/L1 (Table 4). Of those, 8 (61%) are made of basalt and 5 (39%) are of limestone. The metric data for these hammerstones is given in Table 16:

Table 16: II-6/L1Hammerstone Size (in mm)

	Mean (s. d.)	**Range (min–max)**
Maximum Length	99.7 (15)	74
Width	75.15 (11)	98
Thickness	48.6 (12)	34

All of these hammers are rounded cobbles and pebbles that show traces of battering. In many cases, the intensive battering results in the formation of a flat ridge bordering the hammer margins. In other cases, the side of the hammer used as a hammering surface is battered and flat. This morphology was recognized in the experimental hammers as well as in the archaeological ones.

The pebble assemblage of II-6/L1 was examined to determine the approximate number of suitably sized and shape cobbles for potential use as hammerstones. Two criteria were chosen as representing this potential: maximum length of the stone larger than 65 mm and the rate of roundness defined according to the scale given in Figure 3. 115 cobbles were found to have at least one dimension larger than 65mm. The raw material frequencies for these cobbles are given in Table 17:

Table 17: Raw Material of II-6/L1 Natural Cobbles

Raw Material	**N**	**%**
Flint	44	38.3
Limestone	5	4.3
Basalt	66	57.4

A roundness value of 7-9 (Figure 3) was assigned arbitrarily as signifying sufficient roundness for hammer use. Of the 115 suitably sized cobbles mentioned above, 42 also fall into these categories of roundness (7=17; 8=17; 9=8). Out of these, only three are flint cobbles and the absolute majority is of basalt. It is interesting to note the low number of limestone cobbles (two only) particularly when compared to their relatively high presence among the hammerstones of II-6/L1. A possible explanation for the low number is that the limestone hammers are easily recognizable in the archaeological assemblage and hence are not considered as natural pieces when analyzed. It should be noted that limestone cobbles are, in many cases, not strong enough for use in giant core knapping. A limestone cobble was broken to pieces when experimentally used for biface manufacturing. Future experiments will attempt to use local limestone for basalt knapping.

One way or the other, the limestone component among the naturally fractured cobbles of II-6/L1 is very small. Furthermore, sedimentological research suggests that the environment in which the lithic assemblage of II-6/L1 was accumulated lacked the energy for deposition of large to medium size lithics (Feibel et al. 1998). We can argue that most of the II-6/L1 limestone cobbles were brought by humans to be used for different tasks. In his discussion of hammerstones from Olduvai, P. Jones notes that:

> "The archaeological sample only rarely shows all-around intensive battering of a stone; most stones show only one or two small areas of damage which, if caused by use for tool manufacture, would be the result of only five to fifteen minutes of flaking" (1994: 281).

In the experimental work done at GBY, extensive use of basalt hammers in the large scale flaking caused massive damage to the stone in one or two areas of its margins. On the other hand, the marginal ridge observed in some of the GBY hammerstones is a feature that might result from a different knapping technique or from use for tasks such as secondary small scale flaking or retouch. We should always bear in mind the possibility that the artifacts identified as hammerstones in the GBY II-6/L1 assemblage were not used for flaking stones but for other purposes.

Experimental knapping of GBY basalt suggests that soft hammers, probably of antler, were used for the secondary knapping of the GBY basalt bifaces (B. Madsen, personal communication). The hardness of the basalt forces the knapper to apply a lot of force to the strike in order to detach large roughout or shaping flakes. Considering the very brittle nature of the basalt, only the softness of the antler can prevent the blank from completely breaking. Other soft material such as bone or wood is hardly strong enough for use on the basalt. Cervid antlers were found in GBY fauna assemblages but only further research can yield more direct evidence for the use of antlers as hammers in GBY sites such as that found in Boxgrove, England (Pitts and Roberts 1997).

DISCUSSION

In the introduction to this work the following questions were placed as directing the study:

1. Can we describe the reduction sequence of basalt tool making at GBY? What stages of the sequence are represented in the archaeological assemblage?
2. What kinds of blanks were used for the biface manufacturing at GBY and from what kind of cores were they flaked?
3. Is the method of study that has been employed here for the lithic assemblage of GBY suitable, as a whole, for the study of basalt tools?
4. Considering the problematic nature of basalt as raw material for tool production, why did the toolmakers at GBY use basalt as the primary raw material for their tools?
5. Why did people stop using basalt after GBY?

I will try to offer some answers to these questions below based on the data described in this work. The model for the reduction sequence to be described here is, in many ways, preliminary and of hypothetical nature. The following observations and assumptions should be considered:

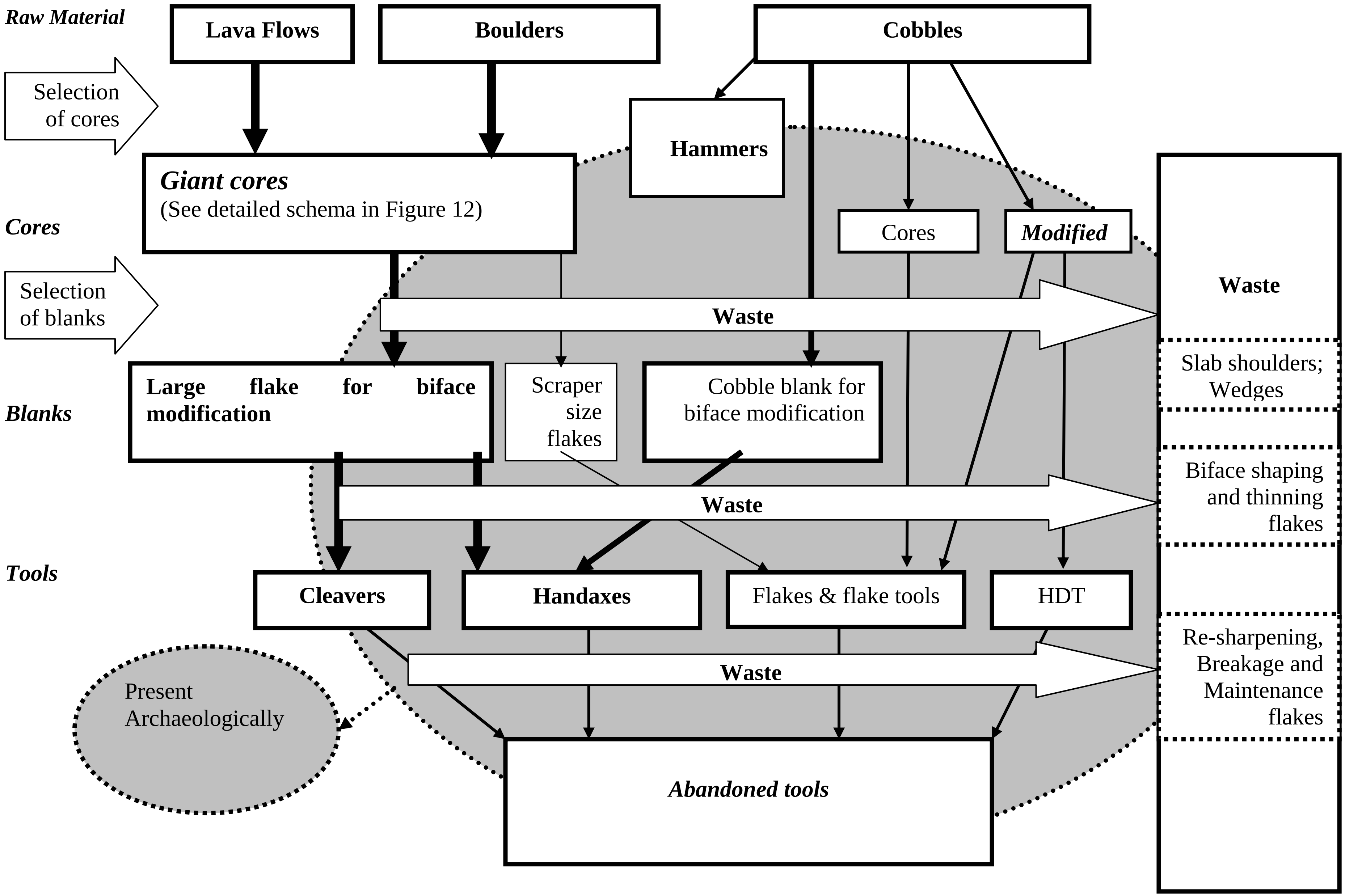
1. The technological study of the basalt assemblage of Gesher Benot Ya'aqov is ongoing. The II-6/L1 assemblage is only a small part of the Area B assemblage that, itself, offers only a glimpse into the basalt stone tool technology of GBY. Many aspects of the reduction sequence such as the giant cores and flake tools may be under represented in the II-6/L1 assemblage. In the future, when the technological schema suggested here for the basalt tool making in GBY will be studied with respect to all the artifacts retrieved from GBY, final conclusions regarding the reduction sequence may be altered.

2. This is only a preliminary study of the forms of raw material in which basalt is available in the vicinity of the site at present. The geological setting of the site is highly complex and we have no way of knowing what kinds of basalt outcrops and sources were available to its inhabitants. The data presented here is based upon observations made at present day streams and outcrops of the Golan Heights, but the exact source and type of basalt used by the GBY inhabitants is unknown.
3. The experimental work done as an effort to replicate the basalt assemblage of GBY is in its early stages. The work raises some assumptions and hypotheses that are presented here but that will need to be examined in the future.
4. Some of the terminology used here was defined by Clark (1980). Terms such as form, availability, texture and so on are defined in his general discussion about raw material and African lithic technology.

The Reduction Sequence of Basalt Artifacts at Gesher Benot Ya'aqov

The primary model for the reduction sequences of basalt artifacts production at GBY is illustrated in Figure 6. The main assumption behind this model is that the aim of the basalt toolmakers of GBY was the production of large cutting tools, bifaces and cleavers. Almost all other basalt artifacts result from this main reduction sequence as waste, including the medium-size flakes probably selected for the manufacturing of scrapers. The large flakes produced from the giant cores were used in some cases as blanks for flake tools and, in other rare cases, as the blank for opportunistic cores. At will, the basalt knappers of GBY could have produced a core from a stream cobble and obtained a flake tool out of it, but they preferred to use other raw material, mainly flint, for this purpose. In any case, the use of basalt as small cores for flakes was rare and opportunistic. The main sequence, as suggested here, of the production of large cutting

Figure 6: GBY II-6/L1 Reduction Sequence of Basalt Artifacts



tools from large flakes removed from giant cores is emphasized in the flow chart (Figure 6) by thick arrows.

The reduction sequence is comprised of planning and implementation stages. These stages required a certain degree of mental acuity and physical dexterity. The implementation stages are those involving knapping of the cores and blanks into their desired shape. The cognitive selection involves the identification and choosing of the raw material and the selection of the flakes according to their suitability as blanks for various desired tools. These stages of essential cognitive selection of raw material and blanks in the reduction sequence are emphasized in the flow chart by arrows.

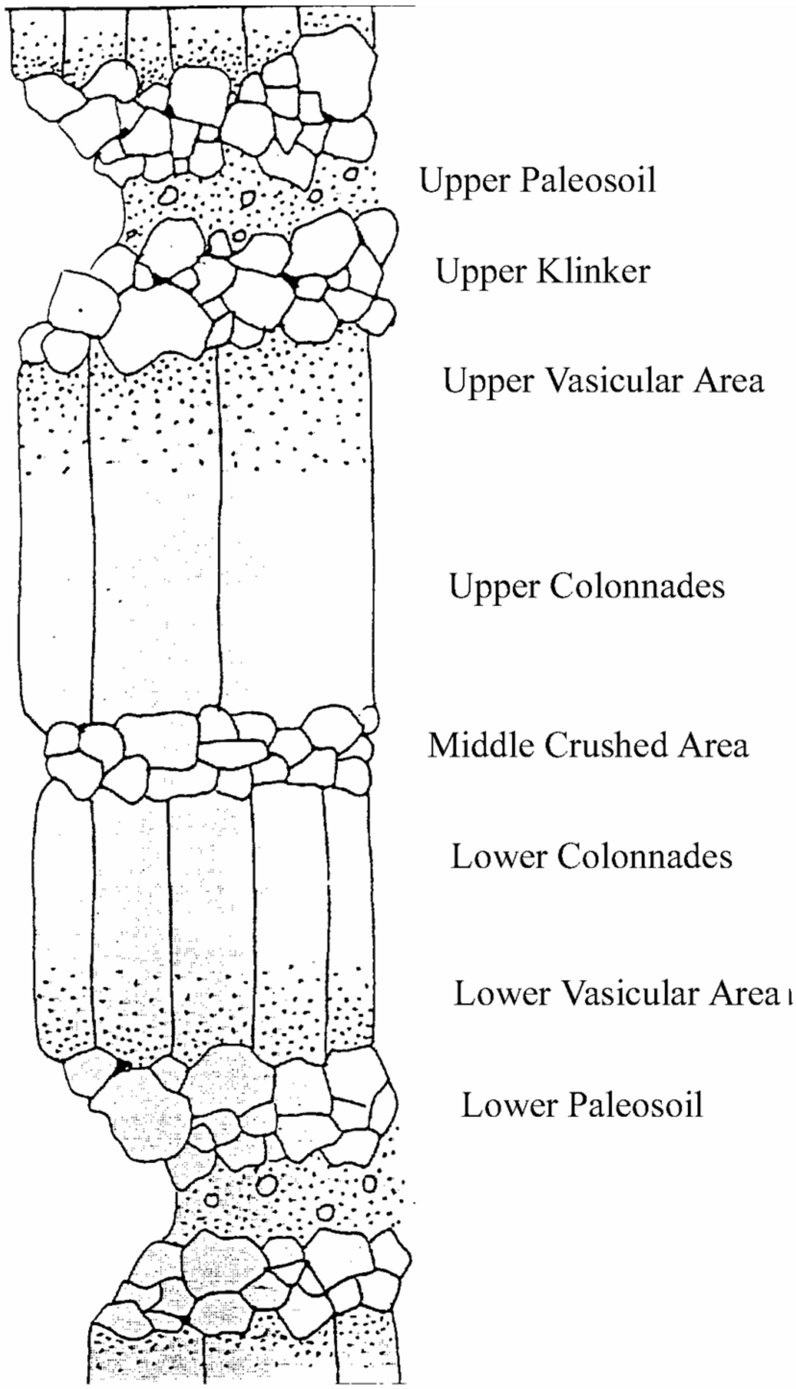
The reduction sequence as presented in Figure 6 is divided into four stages. Each has many aspects and is subdivided further to make the description of the sequence clearer. These stages are a) selection of the raw material; b) production of flakes from cores; c) selection of blanks and shaping of them into tools; and d) the end products and waste types typical for basalt use in GBY.

Stage 1 – Raw Material Selection, Form and Availability

Basalt was, and still is, available in the vicinity of the site in the following forms:

Lava flows where, for example, a stream cuts a gorge and creates exploitable outcrops available as a source for raw material. The ideal section of a lava flow in the Golan Heights was described by Mor (1986: 121-123) and is shown in Figure 7. Slabs suitable to be used as huge cores can be obtained from the upper and lower colonnades as well as from the middle section of the flow. As the cooling of the lower colonnade is slower and less disturbed, the lower polygons are denser and have fewer vesicles than those of the upper section of the flow (apart than in the lowermost section of the flow where gas emitted from the surface creates the lower vasiculated area).

Figure 7: Section of Ideal Golan Heights Lava Flow (After Mor 1986)



This description, however, is of an ideal section, which is almost never found in an outcrop. Only thick *aa* flows result in this kind of section and the cooling of the basalt is highly influenced by the heterogeneous composition of the basalt, the rate of movement, and many other factors.

Natural basalt structures appearing in some of the Golan Heights lava flows, namely the flat slab, are ideal raw material for use as huge cores. The experimental work has shown that quarrying these slabs directly from the outcrop or collecting the polygons weathered into boulders from riverbeds (Figure 8) is easily done.

Figure 8: Weathered Basalt Polygons at Nahal Hamdal

It should also be noted that a natural angle of basalt chunk raising out from a lava flow section could be used by humans as a striking platform for the production of one flake or more, given the opportunity.

Boulders (worn rocks with a diameter exceeding 256 mm {Jackson 1997}) are found in all conglomerates visible in the GBY geological sequence. There is no doubt that at the time of occupation, there were enough high-energy streams that could bring giant basalt boulders to the vicinity of the site. As can be seen today at many places in the Golan Heights, basalt flows have eroded into boulders and hominids could have used them after the boulders were transported down stream.

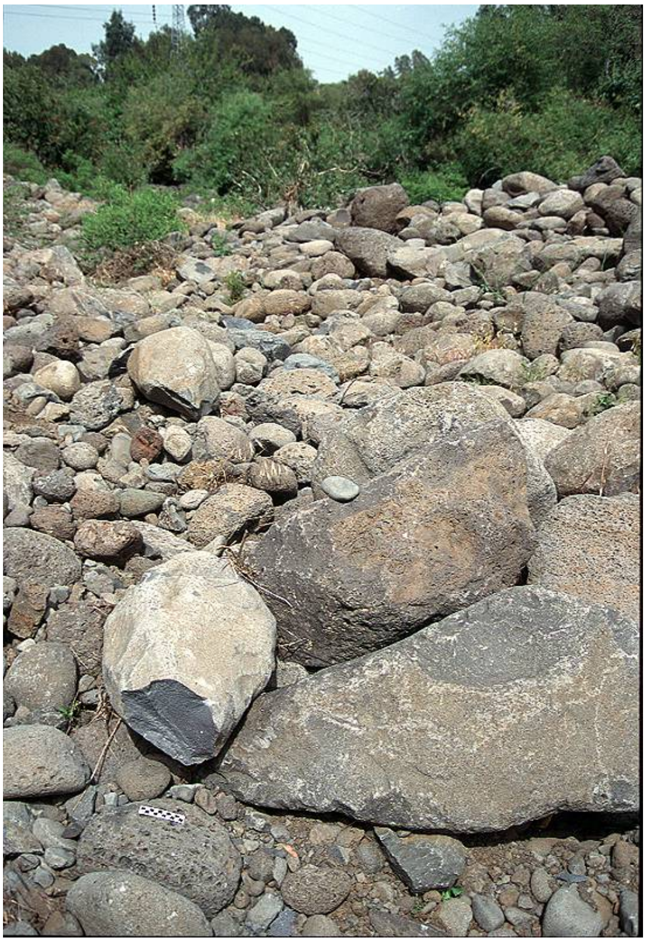
Cobbles (rock fragments having a diameter in the range of 64-256 mm {Jackson 1997}) are also present in all conglomerates and streams. Cobbles that were suitable in shape and size were shaped into bifaces in a technique markedly different from the technique used to modify large flakes (see below).

It can be suggested that the environment in which the hominids of GBY searched for raw material for their tools is somewhat similar to that of the streams flowing in the Golan Heights today. At some of the longer streams, one can find a variety of quality, shapes and sizes of basalt. In Lower Nahal Meshushim (Map 2), for example, the basalt was available in the following forms: 1) well-rounded small to medium size cobbles perfect for hammerstones (Figure 9); 2) flat slabs in sizes suitable to be used as blanks for bifaces (Figure 10); and 3) boulders of all sizes and shapes that could be used as fully worked cores or struck once or twice for opportunistic flakes on the spot when the suitable striking angle was found (Figure 11).

Figure 9: Hammerstone Sized Cobbles at Nahal Meshushim

Figure 10: Flat Cobbles at Nahal Meshushim

Figure 11: Giant Core Sized Boulders at Nahal Meshushim.



Many different qualities of basalt are present in the riverbed of Nahal Meshushim. The various qualities may be the result of stream erosion acting on different lava flows or erosion acting on different parts of the same flow.

Nahal Hamdal, in the western slopes of the Golan Heights north of GBY (Map 2) has a shorter stream course and, therefore, its basalt cobbles and boulders are less rounded than those of Nahal Meshushim. Hence, well-rounded cobbles usable as hammerstones are rare. However, one can find perfectly shaped hexagonal and flat slabs and it seems that the basalt is of good quality.

The selection of appropriate raw material for knapping is primarily a cognitive process. Time must be invested in selecting the high quality pieces from the variety found in nature. Both time and knowledge required to select the right size and shape raw material should be accounted for in the manufacturing process of the final tools. Experimental work with various qualities of basalt and the high quality of the tools in the archaeological assemblage, suggest that the hominids of GBY identified and used a source of high quality basalt for their large cutting tools. Our experiments as well as other studies (Jones 1994) show that one can learn to recognize the quality of basalt in its raw state.

In some cases, however, a dexterous knapper using a naturally suitably shaped piece can compensate for poor quality raw material. In these situations, the knapper may prefer to use basalt available nearby rather than travel greater distance in search of higher quality material. It should be noted that not even one tool made on vasicular basalt was ever found in GBY. The GBY knappers were willing to compromise only to a limited extent the quality of raw material they selected for their tools.

Stage 2 – the Cores

The basalt cores found at GBY can be divided into two groups. The first and dominant group contains the giant cores made from different types of boulders. The other, and smaller group is that of the small-scale basalt cores used for the production of flakes. The model suggested for the understanding of the type of giant cores produced at GBY is shown in Figure 7.

Cobbles used for the production of bifaces were found in surface collections from GBY. Therefore, they should be considered a branch of the sites biface reduction sequence. However, the main trunk is the production of large flakes from giant cores. It should be noted that giant cores are rarely found in Lower Paleolithic sites and very few of them are described in the literature as found *in situ* in archaeological layers anywhere (Isaac 1977). At GBY, however, giant cores are found in almost all levels of the II-6 layer but only two were assigned to level II-6/L1, the subject of this work. I will discuss the giant cores here as part of a possible model to test against archaeological data in future studies.

Cores for large flakes for biface blanks are, in most cases, giant when compared to later period cores. It is not possible to define the term giant as an exact size at the present stage of research. Any core bigger than 300 mm is a potential member of this group. Boulders have, in past studies, been pointed to as the source for large flakes (Goren-Inbar and Saragusti 1996; Isaac 1977; Jones 1994). The cores found at GBY, as well as the experimental work performed, enable us to define sub-groups within the boulder group based on the original shape of the natural piece and on the nature of flakes knapped from it. Whatever the nature of the original chunk used as giant cores, the technological and volumetric approaches are very sophisticated and show great variability. This stage of the reduction sequence demands from the knapper technical knowledge of the flaking qualities of the basalt and a great deal of dexterity and experience. Even modern day knappers with vast experience in flint have a long learning curve before they can systematically produce large flakes (B. Madsen and D. Ben Ami personal communication; Jones 1994).

As can be seen in Figure 12, giant cores can be produced from boulders described as belonging to the following sub-groups:

- **Slabs** - flat pieces, rectangular or trapezoid in section resulting from the cooling fractures of the basalt flows. These boulders have plain faces, which provide a usable angle for systematic removals of large flakes from this natural striking platform. Examples of slab giant cores were found in the archaeological assemblage of GBY (Figures 13- 15).

Figure 12: GBY Giant Slab Core (# 5447).

Figure 13: Model of Giant Cores Reduction at GBY

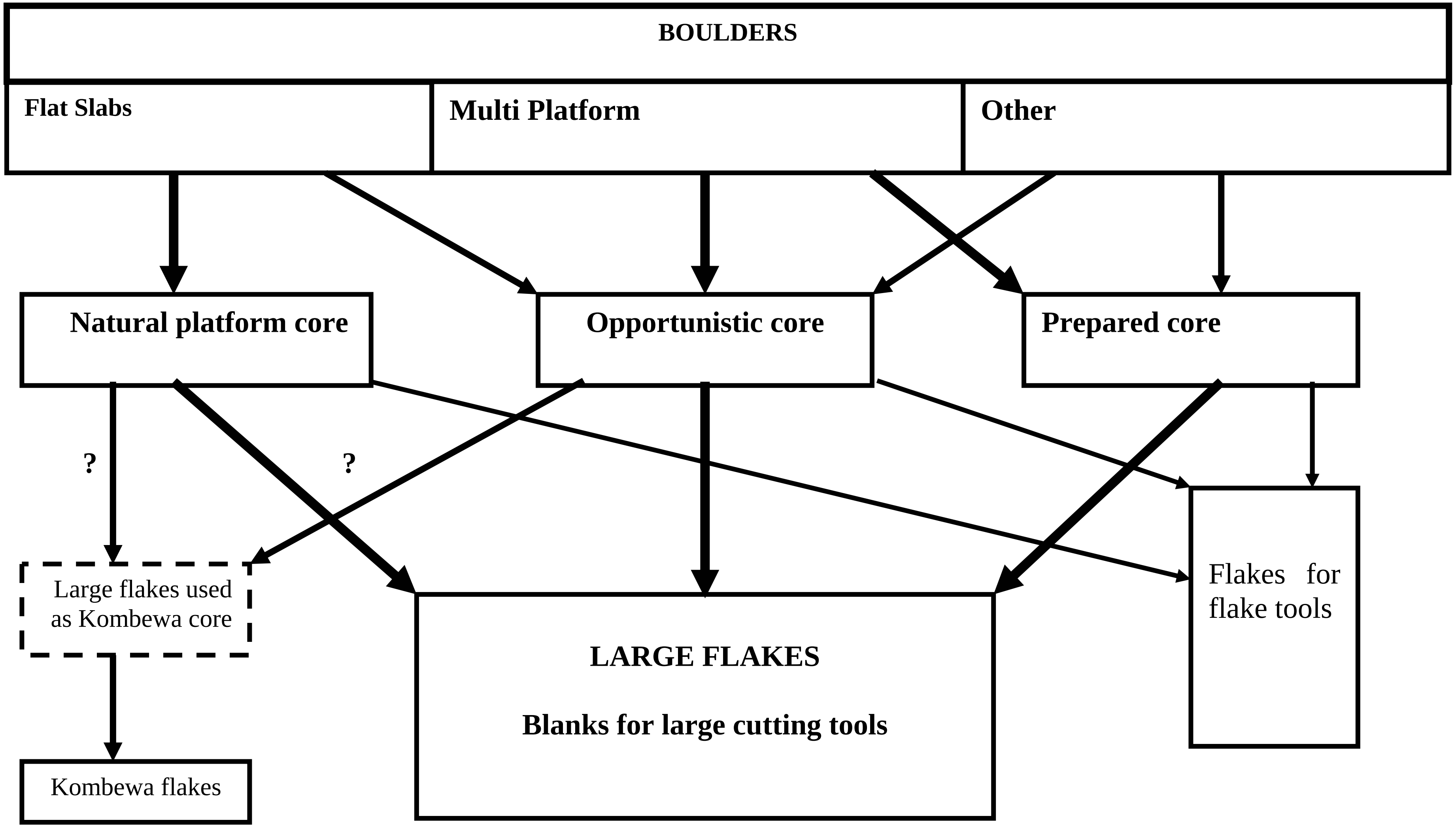


Figure 14: GBY Giant Slab Core (# 5446)

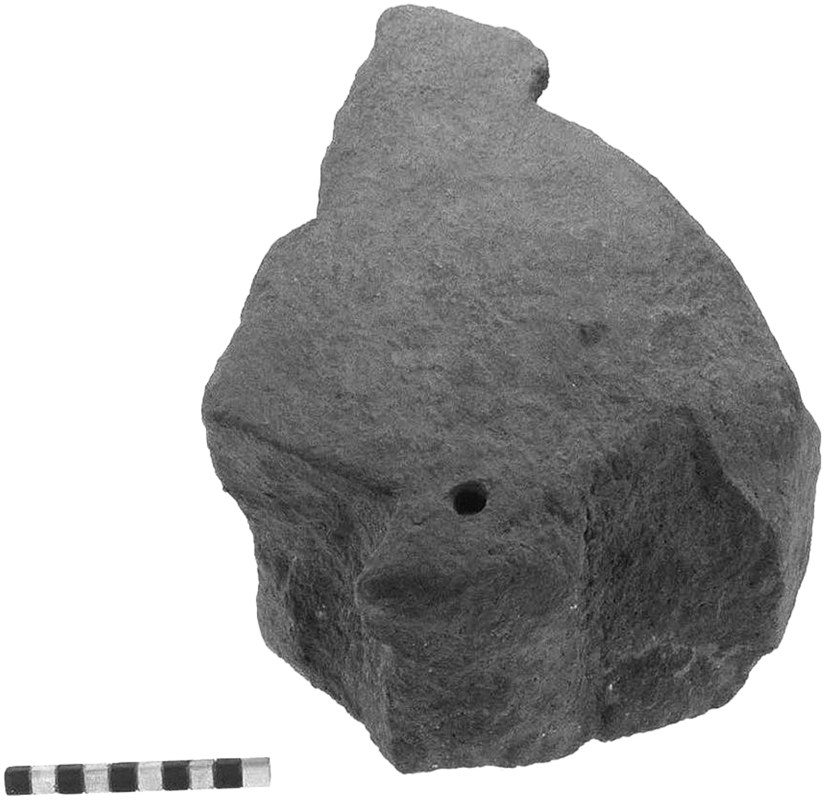


Figure 15: GBY Slab Giant Core (# 10476).

- **Multi-facetted boulders** - boulders having many flat surfaces that usually enable the knapper to find a good angle to attack and "open" the core (Figure16).

Figure 16: GBY Multi-Facetted Giant Core (# 7696).

- **Other** shapes of boulders are present in very small numbers in the archaeological assemblage but could not, to date, be grouped by distinguishable character traits. Some are giant boulders that cannot be moved but have a suitable platform and angle for flaking. Other boulder shapes were probably used by the hominids but cannot be reconstructed from the cores abandoned at the site.

In many cases, the original shape of the boulder selected dictates the technique employed by the knapper for the production of large flakes. The following types of giant cores can be defined:

Opportunistic Giant Core – the term opportunistic is used here to express the "taking advantage of an opportunity" nature of these cores. When a boulder is found with a natural striking platform and striking angle, flakes can be removed with minimum investment of energy. The riverbeds of the Golan Heights that were inspected during the experimental work are very rich in potential opportunistic cores. Some of them are simply too big to be removed but are of high quality basalt. Others are not suitable for systematic knapping as the quality of the basalt is insufficient, among other reasons. It should be noted that high-energy environments such as those of the Golan streams could naturally produce flakes out of boulders that can be mistaken for opportunistic giant cores (Figure 2).

Natural Platform Giant Cores – created when the shape of a selected core determines the knapping process because of the use of its natural face as a striking platform. In contrast to the opportunistic cores, the knapping of the natural platform cores is systematic and can yield many large flakes. A typical example is the flat slab giant core (Figure 13; 14 and 15). Slabs are one of the most common features to result from the weathering of the Golan Heights basalt flows. These slabs are, in many cases, usable for the production of large flakes as their natural shape enables the knapper to "slice" them using the natural faces of the slab as striking platforms. The term "ramp shape" core was suggested by B. Madsen to describe this special kind of core, as the knapper uses the natural ramp shape of the slab as a striking platform. These cores are found within the GBY archaeological assemblages more often than other giant core types.

Prepared Platform Giant Cores – pieces of basalt chosen for their desirable shape and systematically knapped to produce large flakes. The main characteristic of these cores is that their shape and platforms are created by the knapper as the work progresses. Two types of these cores may be described at the present state of research:

(Proto?) Levallois Giant Cores – Goren-Inbar and Saragusti noted that techniques that "…involve predetermination of flake characteristics" (1996: 16) can be identified among the GBY giant cores. This technological approach results in a giant core similar to a centripetal Levallois core. Not all aspects of the Levallois technique are present and there are doubts about the justification for using the term Levallois to describe these giant cores. On the other hand, smaller flint and basalt Levallois cores are found in the GBY Acheulian assemblage.

The term proto-Levallois technique as defined by Clark (1980) has been used to described the manufacturing of large flakes from giant cores at many Acheulian African sites. Clark noted that:

> "…the high frequency of cleavers in assemblages where the raw material occurs in the form of large blocks or boulders, is closely related to the use of the proto-Levallois method. The occurrence of this technique at sites in north, east and South Africa is an indication that the prehistoric population there made a deliberated choice of this method, rather than another of the basic technique used at this time, for producing the large primary flake forms required. It seems unlikely that the deciding factor was the texture of the raw material rather then its form since, had it been the texture, it might be expected that there would be a higher correlation between the use of the proto-Levallois technique and certain materials such as quartzites and lavas. This is, however, not the case…" (*ibid*: 48)

We can therefore argue that the availability of basalt in the form of large blocks and boulders in the vicinity of GBY enabled the use of this proto-Levallois technique by the knappers. However, the availability of other forms of basalt as raw material indicates that the proto-Levallois method is only one among a wide variety of large flake knapping methods.

Kombewa Cores – The presence of Kombewa technique in the GBY reduction sequence was suggested due to the high percentage of Kombewa flakes used as blanks for bifaces manufacture (Goren-Inbar and Saragusti 1996). No Kombewa giant cores have yet been found in GBY and the biface assemblage from II-6/L1 yielded only one cleaver shaped on a Kombewa flake. In addition, the final shaping of the tools by secondary flaking and the poor state of preservation of many of the bifaces excavated from the site create difficulties in identifying a ventral face from a natural surface. The experimental work has demonstrated that natural surfaces are, in many cases, smooth and convex and it takes a great deal of experience to distinguish them from ventral faces of large flakes (see below for discussion of the nature of basalt flake ventral faces). Hence, the conclusion that the dominant presence of Kombewa flakes presumes that they were the primary source for blanks for the bifaces at GBY should be reconsidered. As a technique, the Kombewa defined by Owen (1938) and Newcomer and Hivernel-Guerre (1974) is of a prodigal nature because only one large flake can be produced out of a Kombewa flake-core. In many cases, the GBY knappers employed much more efficient and sophisticated techniques than that demanded of the Kombewa technique.

An alternative explanation for the presence of Kombewa flakes in the GBY assemblage can be suggested. When a large flake knapped from a giant core is bifacially knapped, the flakes obtained sometimes have two "ventral" faces, or Kombewa. These flakes can be considerably large.

Small Basalt Cores (Figure 6 above) **–** In addition to the above primary sequence of large basalt flake reduction, the lithic assemblage of II-6/L1 contains a minor basalt reduction sequence involving the production of flake tools (and flakes utilized as cutting tools) made from small cores. In the case of small basalt tools, the problematic nature of the GBY assemblage due to its state of preservation is critical. I argue here that this particular reduction sequence is indeed minor. Sophisticated core types such as Levallois cores are present in very small numbers in the II-6/L1 small basalt core assemblage. The knappers of GBY could, at will, shape almost any kind of core from basalt. In most cases, they chose not to invest in complicated cores for small flake production. Large cutting tools are very efficient for butchering large animals (Jones 1980; 1994) but smaller flakes could be used as well and probably were; however, the poor preservation of most basalt flakes prevents us from observing any marks of utilization.

The following types of cores are most characteristic of those found in the small artifact section of the basalt reduction sequence at GBY:

Modified cores (see terminology section of material of study for definition**)** - the equivalent of the opportunistic giant cores, perhaps representing an *ad-hoc* use of a chunk as a core for flakes. When in need of a flake, the knapper simply chose an available piece of basalt, using one face of it as a striking platform to produce a flake. Modified cores represent over 30% of the small cores at GBY **(**Table 4) and are an important section of the small-scale flake production at the site.

Small Flake Cores – eleven small cores were excavated from II-6/L1 (Table 4). Two Levallois cores for flakes and two cores on a flake clearly indicate that these techniques were within the repertoire of the basalt knappers of GBY. The small number of basalt cores in this level supports the suggestion that small-scale basalt knapping at GBY occupied a minor role in the production of basalt tools at the site.

Stage 3 – The Blanks

The production of blanks is the primary aim of the main reduction sequence of basalt tools at GBY. It was noted at the very beginning of research at GBY as the predominant characteristic of its lithic industry. This characteristic technological feature has been pointed out as an indication for African affinities (Bar-Yosef 1994; Gilead 1970a; Goren-Inbar and Saragusti 1996; Stekelis 1960).

Two primary blank types are represented in the GBY assemblage – large flakes and stream cobbles. Attention should be given to the technological difference between flakes and cobbles. The shaping of a cobble into a biface involves higher investment of work and energy than for that of a large flake. The advantages of flake blanks over slab (cobble) blanks for bifacial modification of the Olduvai non-basalt assemblage were discussed in detail by Jones (1994: 267). In his discussion of the use of basalt and trachyandesite as raw materials he noted that:

> "Since these materials occur in the form of water-rounded cobbles and boulders there are only two approaches available for tool manufacture. Small cobbles of stone can be selected from which a small core tool can be made; or the large boulders can be flaked in an organized way to produce suitable pieces for subsequent tool manufacture. The first approach restricts the toolmaker greatly in the type of tools that can be made and their morphology. This is due to the general difficulty of carrying out extensive, controlled secondary flaking from rounded cobble surfaces, and the fact that cobbles are generally thick in relation to their length and breadth. Thus, unless a great deal of time and effort is spent shaping and retouching a large cobble one is restricted to flaking an edge around the perimeter of a small cobble.
>
> The second approach, that of breaking into the large boulders to produce angular pieces from which to make tools, is evident at most of the Acheulian sites at Olduvai where bifaces are generally made on large flakes. This method vastly increases the gross amount of raw material available to tool makers and there is considerably more control of the tool blank size and shape and final tool morphology. Without this technique of extracting large flakes from boulders, it would be hard to produce consistently large sharp-edged tools in these materials." (*ibid*.: 262)

The advantages detailed by Jones of large flakes over cobbles as blanks for bifaces can be summarized in the following points: a) the overall time of production is shorter for flakes; b) the quality of the tool edges is better; and c) the ratio "weight of tool to edge length" is higher for flakes. Table 18 shows the rate of flake versus non-flake blanks used for the modification of bifaces in different GBY assemblages.

As can be seen from the table, there is a clear preference for the use of flakes as blanks for biface manufacturing at GBY. In the case of cleavers, the blanks are almost exclusively flakes. As for handaxes, cobbles were used in some cases. Handaxes are, in many cases, much more heavily worked than cleavers and the original blank is impossible to recognize. We should also keep in mind the typological definition and terminological differences between different archaeological approaches.

Table 18: Blank Types used for Biface Manufacturing

Assemblage	Flake				Non-Flake				Indet
	Handaxe		Cleavers		Handaxe		Cleaver		
	N	%	N	%	N	%	N	%	N
Stekelis* 12 handaxes & 11 Cleavers	4	28.5	10	71.5	8	88.8	1	11.2	-
Gilead** 144 handaxes & 135 cleavers		~50		~90		~50		~10	-
II-6/L4*** 105 handaxes & 41 cleavers	95	90.4	40	97.6	1	1.0	1	2.4	9
Ben Ami Collection **** 98 cleavers	-	-	89	90.8	-	-	-	-	9
II-6/L1 35 handaxes and 9 cleavers	24	68.5	7	77.8	_	_	1	11.1	12

Notes: * (Stekelis 1960); ** (Gilead 1970a); ***(Goren-Inbar and Saragusti 1996); **** (Goren-Inbar et al. 1991).

We can expect that cobbles used as blanks will be selected for their flat morphology; such flat cobbles are present on the Jordan River banks today. They were also observed in Nahal Meshushim where the riverbed has a surprisingly high number of large, flat cobbles that can be used as blanks for bifaces (Figure 10).

The selection of flakes suitable for the production of bifaces and cleavers is the second primary cognitive selection stage in the basalt reduction sequence (Figure 6). The experimental work has shown that a single giant basalt core in the order of 45 kg (Figure 17) can provide up to 6 flakes suitable for cleavers, 12 flakes for bifaces and at least 12 smaller flakes suitable for medium size scrapers (Figure 18).

Figure 17: Experimental Giant Core Knapping.

Figure 18: Experimental Giant Core Products.

The knapper most probably used his experience and technological knowledge to classify the flakes into blank groups by their shape and size. This classification determined the nature of work to be invested in each of the tools produced. The selection of the right shape flake to become a cleaver can save a great deal of work in the next stage of the reduction sequence.

Stage 4 –Tools and Waste

Bifaces, the main tool of the GBY assemblage, were discussed in detail by Goren-Inbar and Saragusti (1996) referring in particular to the technological attributes of the II-6/L4 biface assemblage. I will focus here on other aspects of the lithic assemblages, primarily from a technological point of view.

Non-bifacial tools comprise 1.6% of the cores and core tools and 7.1% of the flake and flake tools of the GBY II-6/L1 assemblage (Table 4 and 5). The primary technological question to ask is, if the main reduction sequence at GBY is that of large flakes production from giant cores, can we assume that most of the tools were made on waste resulting from this reduction sequence? Or, in other words, does the presence of the tools indicate of a reduction sequence different from that used to produce the large flakes and large cutting tools?

As can be seen from the typological frequencies (Table 4) there are only 11 cores in the II-6/L1 assemblage. To these we can add 40 modified pieces and one chopping tool as the potential sources for flakes. These are definitely not enough to produce all the basalt flakes excavated from this level.

Scrapers are the most frequent tool type and it seems that they stand apart as a group distinguished by their size and shape (Graph 4). The sample from II-6/L1 consists of only 15 scrapers, a number too small from which to draw any conclusion. The experimental work has shown that in the production of large flakes from a giant core, more than 15 flakes suitable in size for the production of flake tools, scrapers in particular, become available (Figure 18). These flakes were probably selected and brought to the site for use as flake tools. No evidence of a different reduction sequence producing medium size flakes from flake cores can be detected from the II-6/L1 assemblage. Judging from the experimental work, there was no need for a different sequence as the GBY toolmakers and users could find all their tool blanks among the products of the giant cores.

Typical Waste Types of the Basalt Reduction Sequence

Typical waste types originating from the different stages of the reduction sequence can be separated into the following main groups:

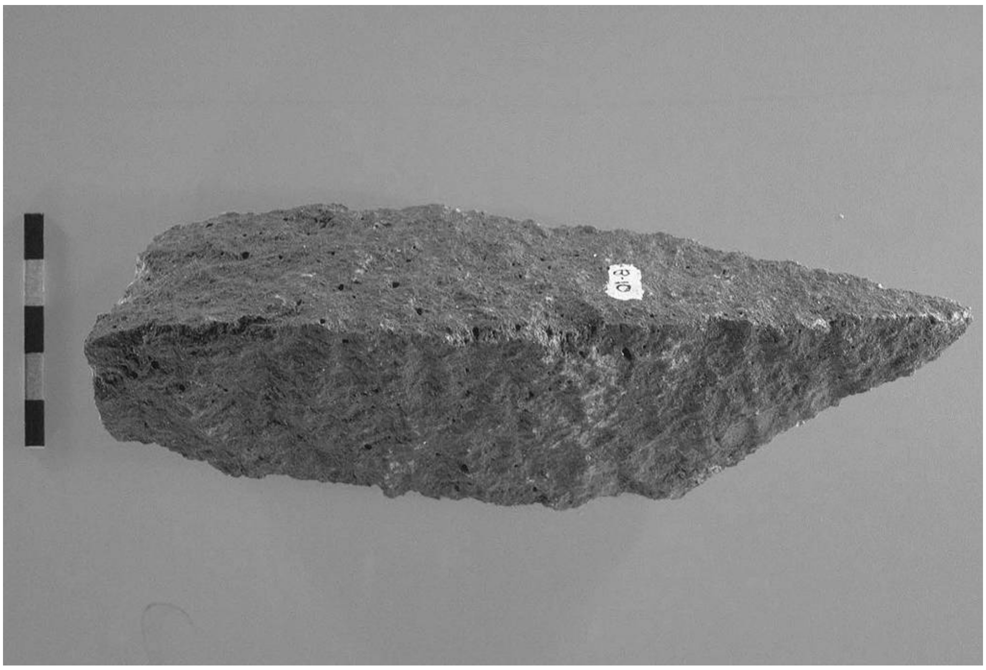
Giant Core Waste

Giant cores of rounded boulder or slab shape have a typical flat surface that, in some cases, can be observed also on their products. These surfaces, that are the equivalent of cortex in other raw material, are in some cases visible even on the end product, the bifaces. This observation is, in many cases, a highly suggestive one due to the weathering stage of the basalt. The waste types described here were observed during the experimental work on the giant cores, and their presence in the archaeological material was examined later.

Shoulder flake is the proposed name for a flake that results from a breakage of a slab or boulder corner and that shows special morphology on its dorsal face**.** Some roundness and the typical surface of weathered basalt can sometimes be identified on these flakes. Of the II-6/L1 assemblage, 7 flakes were identified as belonging to this group and additional 7 flakes are suspected as resulting from this stage of the giant core flaking. Together they form 1.6% of the basalt flakes of this layer.

Wedge flake is the suggested term for a flake resulting from "slicing" a slab giant core when a flake is removed in order to repair the core. The experimental assemblage yielded some of these easily identifiable flakes (Figure 19) and an examination of the archaeological assemblage enables us to recognize 4 flakes (0.3% of the basalt flakes) that can be attributed to this technological group. 15 additional flakes (0.9% of the basalt flakes) were recognized as belonging to this group with a Lower degree of certainty. Technologically, these flakes are similar to flakes obtained from blade cores where the elongated proportions are determined by the scars left by the final stage of flaking. The difference between the two is that in the case of the blade cores, the blades are the aim of the knapping process. However, the basalt wedges of the giant slab cores are knapped in order to repair the core and to create a new platform and guiding scars for the next stage of large flake production. The examination of the archaeological flake assemblage from II-6/L1 has suggested that these flakes should be separated into two sub-groups.

Figure 19: Experimental Wedge Flake.



The first sub-group results from the early stages of the giant slab core reduction. These are long flakes (sometimes up to blade proportions) with a “cortical” dorsal face. They can be similar in shape to the slab shoulder flakes but they are the result of a different stage of reduction. The second is comprised of wedge flakes that come from a more advanced stage of the slab knapping. The final stage scars determine this sub-group dorsal face as well as its shape. These are the “true” wedge flakes.

Waste Typical of Biface Manufacturing

Newcomer (1971) established the terminology used here based upon his experimental work in manufacturing flint bifaces. I will use his terminology although the knapping of basalt bifaces and cleavers at GBY is different in many aspects from the technology employed by Newcomer. This is particularly true in the case of large flakes, which have a unique reduction sequence (Goren-Inbar and Saragusti 1996). Nevertheless, Newcomer’s terms were found helpful in describing the type of flakes in terms of both morphology and the stage of knapping.

Rough-Out Bifacial Flakes – this term refers here only to those flakes obtained from the blank stage onwards and not to the giant core flaking. However, experimental work has shown that flakes similar to the rough-out flakes defined by Newcomer can result from the knapping of a giant core. One of the main characteristics of many of these flakes is their cortical dorsal face. The problem of distinguishing between cortex and flaking scars on basalt is mentioned more than once in this work. No quantitative data is available for this group of flakes. If most bifaces were brought to the site as finished tools, then we should expect no such flakes in the assemblage. On the other hand, if some were brought as blanks and performs, then we should expect the presence of rough-out flakes (see discussion below).

Shaping, Thinning and Finishing Flakes – The process of shaping large flakes into bifaces, particularly in the case of cleavers, was planned with a minimum investment of energy as described in detail by Goren-Inbar and Saragusti (1996). It is fundamentally different from the knapping method used by Newcomer in terms of number of flake removals needed to shape the biface, the spacing of the blows (the number of blows along the cutting edge that determinate the size and number of flakes removed), their size and morphology and other aspects as well.

These small-scale flakes resulting from the final stages of bifacial knapping are fragile and exposed to post-depositional processes. Nevertheless, in some cases, flakes are recognized as resulting from these stages of biface manufacturing. Fifteen flakes (0.9% of the basalt flakes) were recognized in the II-6/L1 assemblage as belonging to the final stage of biface manufacturing (finishing flakes). Their presence in the assemblage is probably higher than expressed by this value. The experimental flakes discussed in this work all come from the different post-blank stages of biface manufacturing and are discussed above.

Plain Dorsal Face Flakes (PDF) **–** Dag and Goren-Inbar (in prep) suggested this term in their effort to describe groups of flakes resulting from different stages of biface knapping which all share a plain dorsal face. Most of the plain dorsal face flakes result from the removing of flakes from the ventral face of a large flake used as a blank. Topologically, 32 (3.8%) of the II-6/L1 basalt flakes were associated with this group, in other publications referred to as Kombewa flakes. As Dag and Goren-Inbar demonstrated, the picture is complicated and the whole subject should be further investigated.

Basalt Flakes: Breakage Features and Morphology

The analysis of the experimental flakes revealed typical features that can be used to characterize basalt flakes. These features rarely appear in other, more homogenous raw materials. Many of the features described as typical for flint fracture mechanics such as cone and point of percussion, bulb of percussion and conchoidal waves are rarely present in basalt flakes or are hard to recognize. On the other hand, other features such as striations raising out from the point of percussion on the flake's ventral face can now be described and even quantified for the II-6/L1 basalt assemblage.

Clark (1958) describing the naturally broken assemblage from the Batoka Gorge noted that:

> "…Only in one case is there any vestige of a bulb or semi-cone of percussion but this is presumably due to the nature of the rock, *i. e*., basalt, which usually shatters and crumbles at the point of impact rather than forming a bulb. Shatter lines radiating from the point where the pebble was struck are clearly seen, however, on most specimens, whether 'core' or flakes. Had the pebbles been in chalcedony or some other homogeneous siliceous rock one might expect that bulbs and semicones of percussion would be present."(*ibid*: 67)

The main technological and morphological features observed on the experimental items as well as on the artifacts from II-6/L1 are described below. These will hopefully help in identifying and analyzing other basalt assemblages. But first, it is interesting to note which of the features associated with other raw materials should not be expected in basalt:

Points of percussion are very hard to recognize in basalt flakes, archaeological and experimental alike. In the experimental work, it was noted that a white crushed area is sometime visible at the point of percussion resulting from the dusty nature of the crystals crushed by the hammer. This phenomenon cannot be seen on the weathered archaeological material with the naked eye but perhaps microscope observation can trace this characteristic feature in the future to help in recognizing points of impact on basalt flakes.

Cones are very rare in basalt. Only one cone was observed in the II-6/L1 flake assemblage.

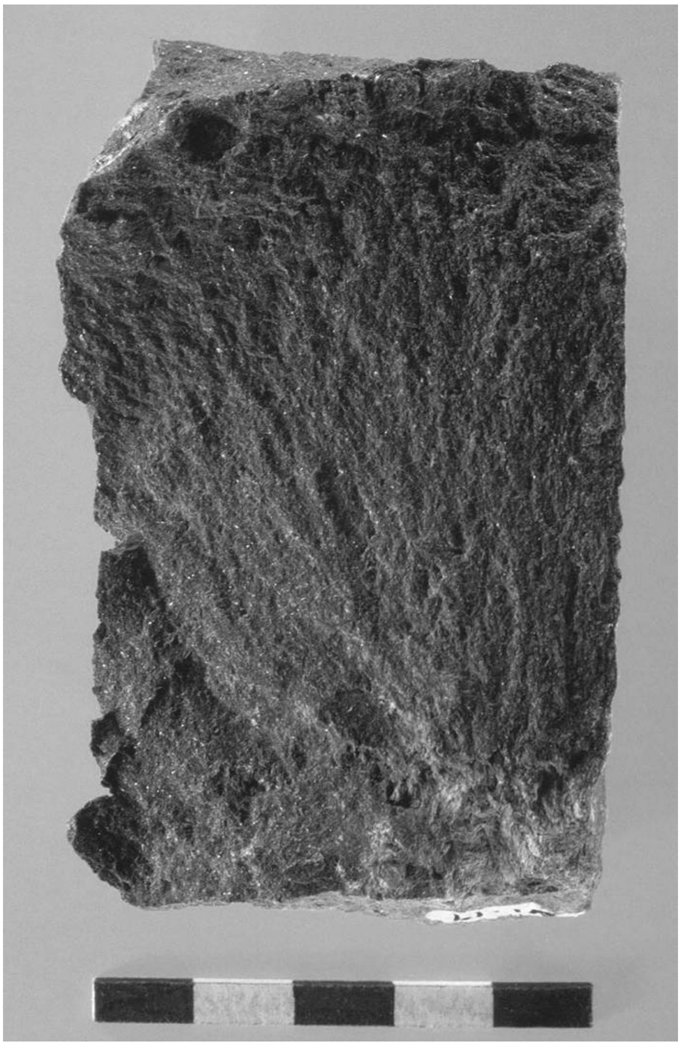
Conchoidal waves rarely occur in the archaeological or in the experimental assemblages from GBY. However, Jones noted that “Some of the finer olivine basalt flakes extremely well while other cobbles will hardly show any conchoidal features at all when a flake is removed” (1994: 258), meaning that some basalts will show Conchoidal features. This was confirmed also for the highest quality basalt used for experimental work in GBY.

Hinge fractures are scarce in the experimental as well as in the archaeological assemblages. They form only 0.4% of the II-6/L1 assemblage and are present in only one flake (C-2 biface) of the entire experimental assemblage. It seems that although Hinge fractures can occur, they should not be considered as characteristic of basalt flaking. The experimental work with the giant cores resulted in somewhat more hinges than in the smaller size flakes but quantifiable data is still unavailable.

The following features were recognized as typical for the experimental and archaeological basalt assemblages from GBY:

Striations on ventral face (“mustache**” -** Figures 20) - start in many cases from the point of impact and spread half way around the ventral face in an acute angle to the axis of the flake. We were able to observe this phenomenon on 17 flakes (2%) of the II-6/L1 basalt assemblage. It is an infrequent feature, but, taking into consideration the problematic nature of the basalt ventral face (see below) and the weathering nature of the assemblage, it is well represented among the II-6/L1 flakes.

Figure 20: Striations on Ventral Face of Experimental Flake.



Irregular surface of ventral face – a term suggested for a group of features that are observed on ventral faces of different flakes that have no consistent form. It can appear in the shape of "steps" along the axis of the blow (Figure 21), in the shape of waves or just as a mess of different protruding features on the ventral face (Figure 22). Irregularity of ventral face was observed on 24 (2.8%) of the II-6/L1 basalt flakes. In many cases, it is very hard to tell a ventral face from a natural face of the cobble or the giant core because the more "rough" face of the flake is the real ventral face while the smooth surface is the dorsal one.

Figure 21: Steps on Ventral Face of Experimental Flake

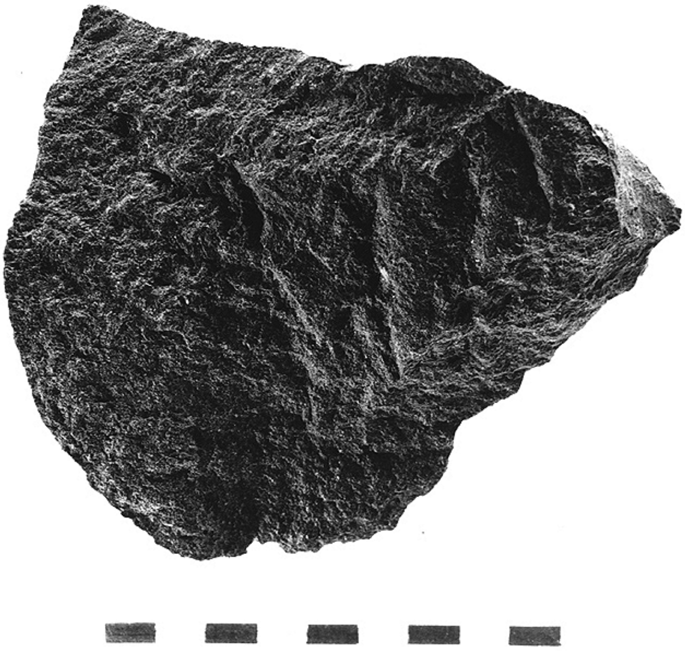
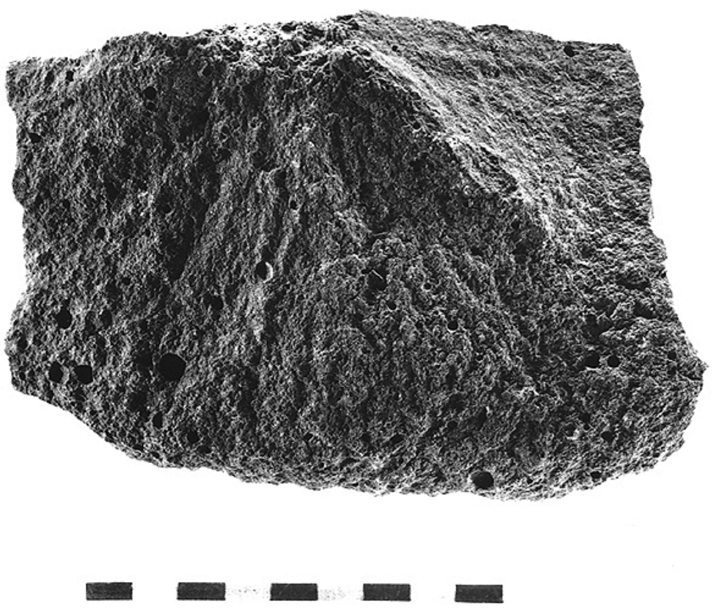


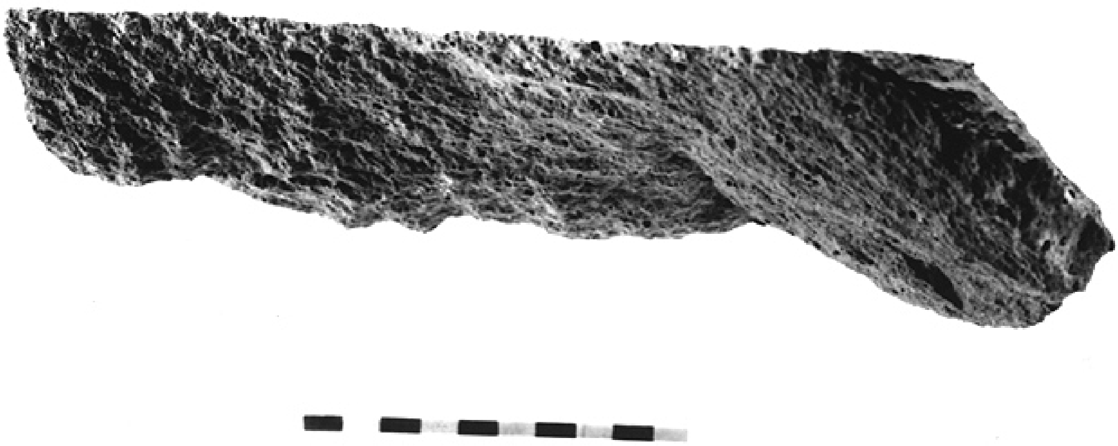
Figure 22: Irregular Surface of Experimental Flake Ventral Face.



It should be noted, on the other hand that in the same assemblage, some of the flakes have a very easy to recognize ventral face. Some of the better quality basalt experimental cores exhibited a low tendency for an irregular surfaced ventral face. This observation is strengthened by the fact that most of the finest bifaces, especially the cleavers, have very smooth faces. Future studies will hopefully enable us to correlate the quality of basalt with the nature of the ventral faces of the basalt flakes.

Angular profile of ventral face is caused in some cases, when the energy of the blow running through the basalt will change its direction creating an obtuse angle to occur, visible in the profile of the ventral face (Figure 23). This phenomenon was first observed on the larger experimental flakes and later on 25 (1.6%) of all sizes of II-6/L1 basalt flakes. This is one of the most characteristic and easy to recognize technological features of basalt.

Figure 23: Angular Profiled Ventral Face of Experimental Flake.



Éclat Siret is an accidental breakage of a flake from the point of percussion to the distal end resulting in two flakes that are half the size of the original one (Figure 23). This is a well-known result of hard rock knapping or from knapping that involves an investment of a lot of force. This phenomenon was observed in experimental flakes (Figure 24) as well as in II-6/L1 flakes.

Figure 24*: Experimental Éclat Siret*

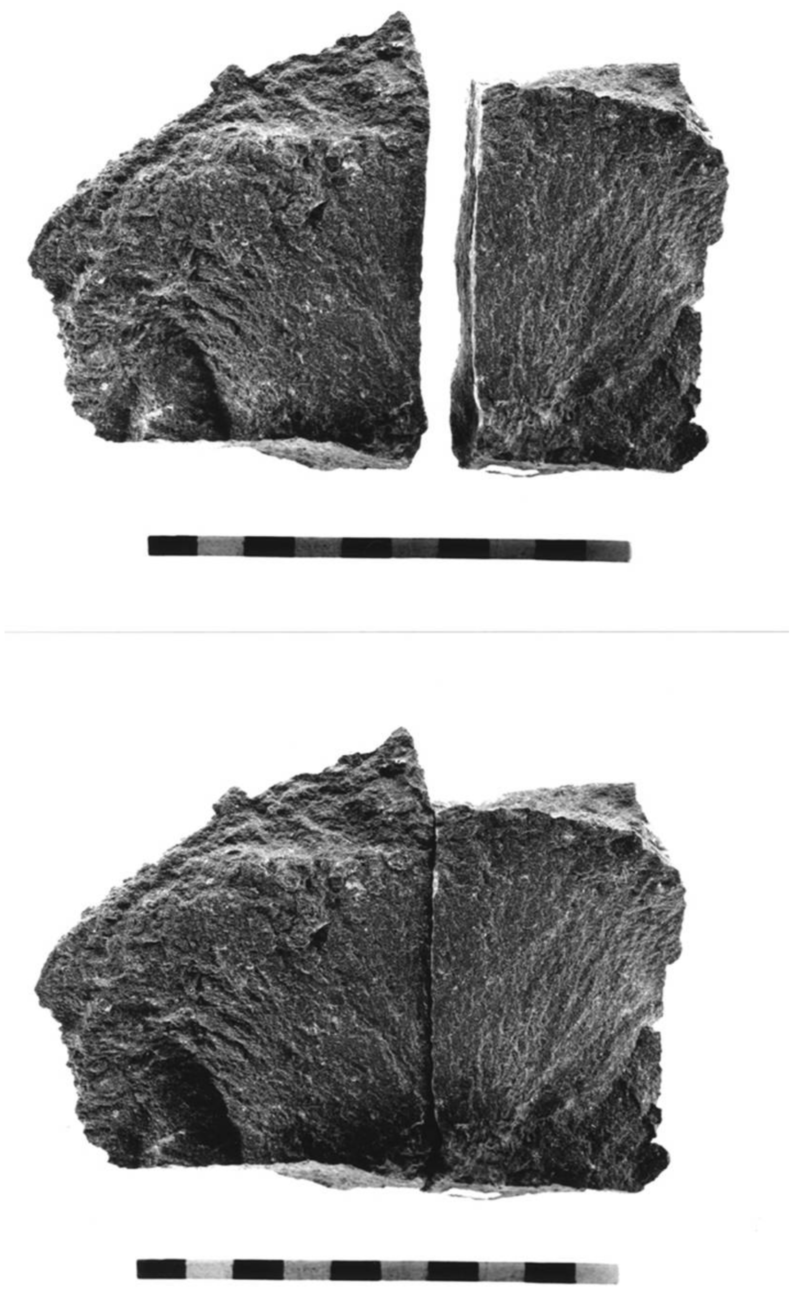


Table 20 shows the frequencies of *Éclat Siret* in the different assemblages analyzed in this work.

Table 19: *Éclat Siret* I

C-2		**C-6**		**C-11**		**II-6/L1**		**II-6/L1 Fresh & Slightly Abraded**	
N	%	N	%	N	%	N	%	N	%
10	21.3	10	8.8	7	7.4	5	0.6	3	0.6

A revision of the first classification of the II-6/L1 assemblage yielded the following results (Table 20):

Table 20: *Éclat Siret* II

	II-6/L1		**II-6/L1 Fresh & Slightly Abraded**	
	N	%	N	%
Siret	22	2.6	10	2.3
***Siret*?**	44	5.2	19	4.4
Total	66	7.8	29	6.7

It seems reasonable to state that we should expect about 5% of the flakes in a basalt assemblage to resemble *Siret* flakes. P. Jones noted that:

"When starting with a new raw material, or when learning to flake for the first time, a knapper will tend to use much larger amounts of force then is strictly necessary to achieve a particular goal. As an interesting example, I found that while experimenting with quartzite, each blow, which removed a flake, would also often split it longitudinally from the point of impact down its length and sometimes the core split as well. Each resulting piece had triangular shape accordingly, which in fact compares well with much of the debitage from BK and Upper Bed II. In due course I learned to flake the quartzite without these side effects." (1994: 260)

The basalt knappers of GBY were certainly not beginners with this raw material, however, we do see many *Siret* accidents in the II-6/L1 assemblage and this is probably due to the nature of this raw material. It would be interesting to try and quantify the occurrences of *Éclat Siret* in different raw material but this is beyond the scope of the present work. *Éclat Siret* in GBY sometimes resulted in a flake with two ventral faces, the “true” one and the broken lateral face. At times, when the original flake was of narrow proportions, these ventral faces are equal in size. When we examine these quite typically shaped flakes, we should remember to consider the option that they resulted from *Siret* accidents.

The above features are typical of the GBY basalt flakes and can probably be expected in any basalt flake assemblage to be found in the Levant. There is no way yet of knowing to what degree these characteristics can be helpful in describing assemblages from other parts of the world where basalt might have different flaking qualities. Nevertheless, it can be expected that at least some of these features will be shared by other hard rock assemblages.

The Benefits of Basalt Tool Use

Why did the prehistoric toolmakers of GBY choose basalt as their primary raw material for the modification of bifaces? Due to the lack of experiments in the use of basalt tools and the preliminary stage of experiments in making basalt bifaces presented here, the discussion below will be a hypothetical one.

As noted, basalt was rarely used as raw material for stone tools in the Paleolithic of the Levant. ‘Ubeidiya and GBY are the only sites in the region where this raw material forms a major part of the assemblage. In other Lower Paleolithic assemblages, flint was used almost exclusively in stone tools making. This is true with only few exceptions in later Paleolithic periods. One of the first and most clear observations resulting from the GBY basalt experiments can be phrased as follows: basalt is very hard to knap! While large flint flakes can be removed from a large core relatively easily, basalt demands a long learning curve for the same task (Jones 1994). The shaping of large flakes into bifaces, and actually any kind of knapping, is a very difficult task because of the great difficulty in controlling this raw material. So, after admiring the basalt knappers of GBY for their very hard to replicate dexterity in knapping basalt, we should ask why did they use this kind of raw material in the first place?

The first and probably best answer lies in the availability of the raw material. Basalt is available everywhere in the vicinity of GBY, in forms suitable for the production of giant cores (slabs and boulders) or to be used as blanks for bifaces (flat cobbles). As was mentioned above, flint was probably available to the inhabitants of GBY only in the form of medium to small pebbles and cobbles. The only raw material available in suitable form for the production of large flakes to be used as biface blanks in the vicinity of GBY is basalt. The benefits of flakes over other blank forms for the production of bifaces are, in short, the ability to get maximum cutting edge with minimum investment of energy (Goren-Inbar and Saragusti 1996; Jones 1994). Large flake blanks have the benefit of being very close to the desired shape and having high quality "ready to use" cutting edges. The very experienced and skilled knappers of GBY could probably produce a biface out of a large flake with minimum investment of time and energy. Jones (1994) measured an average time of 1.5 minutes for the production of a single biface in his experiments. He also noted that after he gained experience, he was able to recognize the higher quality boulders of basalt from among the variety of available boulders. I have no doubt that so could the GBY toolmakers.

Is the availability of basalt as raw material the only reason for its massive use? Does basalt possess other qualities making it preferable to flint? First it should be pointed out that the tool users of GBY were probably familiar with the various practical qualities of different raw materials. This is evident from the selection of different raw materials for specific tool types, similar to that observed in the ‘Ubeidiya assemblage (Bar-Yosef and Goren-Inbar 1993). We may not know what these tools were used for, but it is clear that their makers knew what kind of raw material was suitable for the tasks they had to fulfill. As to recognizing such qualities in large cutting tools made of basalt we should, again, consult P. Jones. In his experiments using different tools for different tasks (1980; 1994), Jones pointed out some factors for which basalt might have an advantage over other raw materials:

- **Edge quality –** basalt was found to be suitable for most of the tasks concerning elephant butchery such as meat cutting, skin removing and so on. Basalt edges are sharp, straight and do not blunt quickly .
- **The weight of tool –** for many tasks, the relatively heavy weight of basalt tools was found to be useful. This is true for large animal butchering as well as for woodworking.

In sum, basalt was readily available in the immediate vicinity of the site, in a variety of forms easily shaped into very efficient tools with a minimum investment of energy. This may be one of the reasons why there are so many basalt bifacial tools in the GBY archaeological horizons.

If basalt is such a practical and effective raw material why is there a large gap in use of basalt in the prehistory of the Levant? Basalt use is very rare after GBY until its reappearance as grindstone tools in the Epi-Paleolithic. Why do Acheulian sites such as Ma’ayan Baruch in the Upper Hula Valley (Stekelis and Gilead 1966) and Berekhat Ram (Goren-Inbar 1985) located in the middle of the massive basalt plains of the Golan heights lack a dominant basalt component in their assemblages? Why is it that bifaces are made almost exclusively of flint in all later Acheulian sites with no relation to the availability of basalt? Some preliminary directions of thought are proposed below:

- Other sites where basalt was extensively used probably exist and are still unknown. The sites of ‘Ubeidiya and GBY are located in the Rift Valley and are exposed today only due to the extensive tectonic movements that pushed them up above the kilometers of sediments covering other sites of this region. It is very unlikely that a site such as GBY would be the only one of its unique culture in all of the Levant.
- Basalt is hard to knap. It is not that the late Acheulian flint knappers somehow lost the dexterity needed for basalt knapping as time went on. They might have preferred to search for flint in more remote sources than to invest this energy in making tools of basalt.
- Despite of the qualities of basalt discussed above, flint might be a better raw material for whatever purposes they were used.
- There might be other reasons such as a higher availability of flint in later periods or even the fact that flint, we have to admit, can be modified into more aesthetic tools.

Applying Flint Attributes to Basalt Lithic Analysis

Traditionally, flint and its characteristics form the basis for all lithic study. In most lithic technology studies, a “flint point of view” governs the methodological approach used in lithic analysis. I do not think that one should start again and invent new terminology, criteria and attributes for basalt analysis. However, some special characteristics of the basalt debitage deserve more attention and some of the attributes employed for basalt study were found to be only somewhat useful or even meaningless.

Some of the points in the following discussion are relevant primarily to the basalt assemblage of GBY while others may be helpful in analyzing other archaeological basalt assemblages.

One of the attributes found irrelevant for basalt is the amount of cortex on the dorsal face of the flake. Basalt does not have a true cortex and in many cases it is impossible to tell a natural surface from a large flake scar.

Another attribute found to be problematic when applied to basalt is the pattern of scars. In the absence of conchoidal waves to help define the direction of scars and considering the poor state of preservation of the flakes, the information that can be gleaned from this attribute is very limited. Nevertheless, most other technological attributes discussed in this work can be applied to basalt as well as to flint.

SUMMARY AND CONCLUSIONS

The reduction sequence suggested here for basalt tool production in GBY is based on experimental work and on study of the basalt assemblage of II-6/L1. The main argument suggested here is that the primary basalt reduction sequence is aimed at the production of large flakes for use as bifacial blanks. Most other basalt tools and waste are marginal to this sequence or the result of opportunistic use of its waste. The one exception to this finding is the use of cobbles for the production of bifaces. The weight of this alternative line cannot be determined at the present stage of research.

The reason for the difference between the excavated L1 and L4 assemblages (Goren-Inbar and Saragusti 1996) and surface collections from the site cannot yet be determined. In these two assemblages of layer II-6, the flake blanks are extremely dominant in comparison to other surface assemblages from GBY (Table 18), where only 50% of the handaxes are made on cobbles or chunks. It remains to be seen whether the difference is a result of terminology or size and origin of samples (surface collections compared to excavated assemblage) or whether are we facing a true archaeological difference.

Referring to all other lines of the reduction sequence as marginal does not imply that the basalt knappers of GBY did not have the technological “know-how” to perform different reduction sequences in basalt. They simply preferred the sequences presented above for the production of large flakes. This fact is evident from the different reduction sequences employed for other raw materials. And, furthermore, although medium to small size basalt flakes were definitely used by the GBY inhabitants (especially as scrapers – Table 7) almost all stages of tool manufacturing, from core to flake, can be linked to the use of waste from giant core knapping. In other words, no distinctive reduction sequence for the production of tools other than bifaces can be recognized from the archaeological material of the II-6/L1 assemblage. Most of the other flakes and tools result from opportunistic use of cobbles as modified cores for the production of *ad hoc* flakes.

The Basalt Reduction Sequence and the GBY Archaeological Assemblage

In Figure 6 the part of the reduction sequence represented by the archaeological assemblage is highlighted in gray. The data from GBY can be summarized by the following:

- All stages of the reduction sequence discussed above are present in the GBY assemblage, from the giant cores to large flakes and biface knapping flakes to the smallest fraction of chips.
- The number of flakes and cores however, is relatively small. No quantitative data is yet available for the experimental reduction of giant cores, but observations clearly show that if all stages of production process of the II-6/L1 bifaces would have taken place on site, the number of flakes in the excavated assemblage would have been significantly higher.
- Moreover, large flakes are almost entirely absent from the archaeological assemblage and so are giant cores. The knapping of large flakes from a giant core will also naturally result in the production of some large flakes that are not suitable for use as blanks. These are not represented in the archaeological assemblage.
- The size distribution of the II-6/L1 basalt flakes is different from the typical distribution of experimental biface manufacturing flakes. It is also different from the flint and limestone distributions.
- The percentage of tools among the basalt flakes from II-6/L1 is high.

Although it is too early to draw conclusions at the present stage of research, the following interpretation can be suggested:

- All stages of reduction sequence are represented at the site but in minimal numbers.
- Most of the bifaces and tools in the GBY excavated area were introduced to the site as finished tools or perhaps in some cases as blanks and preforms.
- Most of the II-6/L1 tools were brought in their finished form to be used at the site for unknown tasks (butchering of an elephant in II-6/L1?).
- As the excavated area of II-6/L1 is small, the interpretation presented here for the II-6/L1 assemblage does not necessarily reflect the state of things as left behind by the inhabitants of the site.

The basalt tools from II-6/L1 at Gesher Benot Ya'aqov are highly sophisticated and indicate a great degree of cognitive ability on the part of their producers. The hominids that performed the reduction sequence described above used preplanning and imagination. They were dexterous in stone work in a way that only few people can replicate today. Anyone who attempts to make tools out of GBY basalt will gain respect for the prehistoric craftsmen. When considering the fact that these people lived on the banks of the paleo Hula Lake 780,000 years ago, the respect for their abilities grows even greater.

The Gesher Benot Ya'aqov basalt assemblage was mentioned as stemming from African lithic tradition (Goren-Inbar 1992; Goren-Inbar and Saragusti 1996). Technologically, it stands alone with no known parallel assemblages in the Levant or anywhere outside of Africa. The basalt industry of GBY was probably shaped by knowledge and cultural tradition at least as much as it was shaped by availability of raw material or functional qualities of basalt. The study of new sites and re-examination of excavated lithic assemblages will hopefully help to close some gaps in our knowledge and enable us to gain better understanding of these cultural as well as functional aspects of human behavior.

Acknowledgements:

To Eyal, Hagar, Idit, Irena, Ofer and the many other people who shared the difficulties of the II-6/L1 basalt analyzes and made it possible to draw general observations from unreadable stones. Gaby Laron photographed the experimental material and the giant cores. Prof. Anna Belfer-Cohen corrected many faults in a previous draft of this work and did not miss even one of my bibliographic mistakes (all the mistakes yet to be found are mine alone). Amy Klein who battled through my spelling and grammar mistakes and now knows more about basalt than any other Rabbi in the world. Dr. Bo Madsen not only spilled the sweat in knapping all of the experimental material discussed here but also gave me guidance and shared his knapping experience with me. Many of the ideas and observations in this work are his. And to Prof. Naama Goren-Inbar who did all of the above and most of the rest.

Appendix I

Gesher Benot Ya'aqov Lithic Experiments – Flake Attribute Analysis

	List of Attributes
Complete/Broken	**Presence of cortex cover on dorsal face**
1. Complete	1. No Cortex
2. Distal breakage	2. 0%- 25%
3. Lateral	3. 25%-50%
4. Proximal	4. 50%-75%
5. Lateral & Distal	5. 75%-100%
6. Proximal & Distal	6. Indeterminate
7. Fragment	
8. Proximal & Lateral	
9. Indeterminate	**Direction of blow**
	1. Indeterminate
	2. Longitudinal
Shape of striking platform	3. Latitudinal
1. Indeterminate	4. side strike
2. Cortical	
3. Punctiform	**Nature of dorsal face**
4. Plain	1. Indeterminate
5. Dihedral	2. Cortical
6. Faceted	3. Plain
7. (Removed)	4. Simple
8. Missing	5. Parallel
9. Crushed	6.
	7. Opposed
	8. Radial
Convexity	9. Ridge
1. Convex	10. Side
2. Straight	11. Simple & Side
3. Indeterminate	12. Simple & Opposed
	13. Side & Opposed
	14. Simple & Radial
Technological observations	
1. (*Outrpasse*)	**General observations**
2. Hinge	1. (Removals on ventral face)
3. (*Debordant*)	2. Double cone
4. Kombewa	3. Big cone
5. Kombewa?	4. (Reducing the bulb thickness)
7. (Steps)	5. Scar on bulb of percussion
8. Éclat Siret	
	Bulb of percussion magnitude
	1. Emphasized

	2. Normal
Lipped striking platform	3. Diffused
1. Lipped	
2. Unlipped	
3. Indeterminate	**Other metric measurements**
	Length
	Width
	Thickness
	Maximum length
	Maximum length of striking platform
	Maximum thickness of striking platform
	Number of scars

Attributes inside ( ) – not relevant to the experimental analysis

References

Bar-Yosef O. 1994. The Lower Paleolithic of the Near East. *Journal of World Prehistory* 8: 211-265.

Bar-Yosef O. and Goren-Inbar N. 1993. *The Lithic Assemblages of 'Ubeidiya*. Qedem 34 Jerusalem: Hebrew University.

Biberson P. 1961. *Le Paleolithique Inferieur du Maroc Atlantique* Vol. 17. Rabat: Publications du service des antiquites du Maroc.

Bordes F. 1961. *Typologie du Paleoolithique Ancien et Moyen.* Presses du CNRS.

Bucy D.R. 1974. A Technological Analysis of a Basalt Quarry in Western Idaho. *Tebiwa* 16: 1-45.

Callow P. 1994. The Olduvai Bifaces: Technology and Raw Materials. In Leaky M.D. and Roe D.A. (eds.), *Olduvai Gorge* 5: 235-253. Cambridge: Cambridge University Press.

Clark J.D. 1958. The Natural Fracture of Pebbles from the Batoka Gorge, Northern Rodesia and its Bearing on the Kafuan Industries of Africa. *Proceeding of the Prehistoric Society* 24: 64-77.

Clark J.D. 1966. Acheulian Occupation Sites in the Middle East and Africa: A Study in Cultural Variability. *American Anthropologist* 68: 202-237.

Clark J.D. 1975. Comparison of the Late Acheulian Industries of Africa and the Middle East. In Butzer K.W. and Isaac G.L. (eds.), *After the Australpithecines: Stratigraphy, Ecology and Culture Change in the Middle Pleistocene,* pp. 605-659. The Hague: Mouton.

Clark. J. D. 1980. Raw Material and African Lithic Technology. *Man and Environment* 4: 44-55.

Crabtree D.E. 1967. Notes on experiments in flintknapping: 3 the flintknapper raw materials. *Tebiwa* 10: 8-25.

Dag D. and Goren-Inbar N., N. D. An Actual Study of Dorsal Plain Flakes - A Technological Note.

Deunert B. 1995. *A fundamental basalt flake analysis: based on experimentally-produced and used flakes as well as the prehistoric Waikalua material*. BAR International Series 614. Oxford.

Feibel C.S., Goren-Inbar N., Verosub K.L. and Saragusti I. 1998. Gesher Benot Ya'aqov, Israel: New Evidence for its Stratigraphic and Sedimentologic Context. *Journal of Human Evolution* 34: A7.

Gilead D. 1968. Gesher Benot Ya'aqov. *Hadashot Archeologiot* 27: 34-35.

Gilead D. 1970a. *Early Palaeolithic Cultures in Israel and the Near East*. Ph. D Thesis. Hebrew University, Jerusalem.

Gilead D. 1970b. Handaxe Industries in Israel and the Near East. *World Archaeology* 2: 1-11.

Goren-Inbar N. 1985. The Lithic Assemblage of the Berekhat Ram Acheulian Site, Golan Heights. *Paléorient* 11: 7-28.

Goren-Inbar N. 1990. *Quneitra: A Mousterian Site on the Golan Heights*. Qedem 31. Jerusalem: The Hebrew University.

Goren-Inbar N. 1992. The Acheulian site of Gesher Benot Ya'aqov - an Asian or an African Entity? In Akazawa T., Aoki K. and Kimura T. (eds.), *The Evolution and Dispersal of Modern Humans in Asia*, pp. 67-82. Tokyo: Hokusen-sha.

Goren-Inbar N., Belitzky S., Goren Y., Rabinovitch R. and Saragusti I. 1992. Gesher Benot Ya'aqov - the "Bar": an Acheulian Assemblage. *Geoarchaeology* 7: 27-40.

Goren-Inbar N., Feibel C.S., Verosub K.L., Melamed Y., Kislev M.E., Tchernov E. and Saragusti I. 2000. Pleistocene Milestones on the Out-of-Africa Corridor at Gesher Benot Ya'aqov, Israel. *Science* 289: 944-947.

Goren-Inbar N., Lister A., Werker E. and Chech M. 1994. A Butchered Elephant Skull and Associated Artifacts from the Acheulian Site of Gesher Benot Ya'aqov, Israel. *Paléorient* 20: 99-112.

Goren-Inbar N. and Saragusti I. 1996. An Acheulian Biface Assemblage from the Site of Gesher Benot Ya'aqov, Israel: Indications of African Affinities. *Journal of Field Archaeology* 23: 15-30.

Goren-Inbar N., Zohar I. and Ben-Ami D. 1991. A New Look at Old Cleavers - Gesher Benot Ya'aqov. *Mitekufat Haeven - Journal of the Israeli Prehistoric Society* 24: 7-33.

Haynes C.V., Maxwell T.A., Hawary A.E., Nicoll K.A. and Stokes S. 1997. An Acheulian Site Near Bir Kisebia in the Darb el Arabi'an Desert, Egypt. *Geoarchaeology* 12: 819-832.

Heimann A. 1990. *The Development of the Dead Sea Rift and its Margins in Northern Israel During the Pliocene and the Pleistocene*. Unpublished Ph.D. Thesis. Hebrew University, Jerusalem.

Hovers E. 1990. The Exploitation of Raw Material at the Mousterian Site of Quneitra. In Goren-Inbar N. (ed), *Quneitra: A Mousterian Site on the Golan Heights*. Qedem 31: 150-167. Jerusalem: The Hebrew University.

Isaac G.L. 1977. *Olorgesailie*. Chicago: The University of Chicago Press.

Jackson J.A. (ed), 1997. *Glossary of Geological Terms*. Alexandria, Virginia: American Geological Institute.

Jones P. R. 1981. Experimental Implement Manufacture and Use: A Case Study from Olduvai Gorge, Tanzania. In Young J.Z., Jope E.M. and Oakley K.P. (eds.), *The Emergence of Man*, Vol. 292 No. 1057, pp. 189-195. London: Philosophical Transactions of the Royal Society of London.

Jones P.R. 1979. Effects of Raw Material on Biface Manufacture. *Science* 204: 835-836.

Jones P.R. 1980. Experimental Butchery with Modern Stone Tools and its Relevance for Archaeology. *World Archaeology* 12: 153-165.

Jones P.R. 1994. Results of Experimental Work in Relation to the Stone Industries of Olduvai Gorge. In Leaky M.D. and Roe D.A. (eds.), *Olduvai Gorge 5*: 254-298. Cambridge: Cambridge University Press.

Leakey M.D. 1971. *Introduction to Olduvai Gorge 3*: 1-8. Cambridge: Cambridge University Press.

Light J.P., Verosub K.L. and Goren-Inbar N. (1999) Sourcing of Basaltic Artifacts from the Gesher Benot Ya'aqov Archaeological Site, Israel: Raw Material Selection and Hominid Behavior. In: *Proceedings of INQUA XV*.

Lumley H.de. and Sonakia A. 1985. Contexte Stratigraphique et Archeologique de L'Homme de la Narmada, Hatnora, Madhya Pradesh, Inde. *L'Anthropologie* 89: 3-12.

Magne M. and Pokotylo D. 1981. A Pilot Study in Bifacial Lithic Reduction Sequences. *Lithic Technology* 10: 34-47.

Moloney N., Raposo L. and Santonja M. (eds.), 1996. *Non-Flint Stone Tools and the Palaeolithic Occupation of the Iberian Peninsula*.B.A.R. International Series Vol. s649. Oxford.

Mor D. 1986. *The Volcanism of the Golan Heights* Vol. GSI/5/86. Jerusalem: Geological Survey of Israel.

Newcomer M.H. 1971. Some Quantitative Experiments in Handaxe Manufacture. *World Archaeology* 3: 85-94.

Newcomer M.H. and Hivernel-Guerre F. 1974. Nucleus sur eclat: technologie et utilisation par differentes cultures prehistoriques. *Bulletin de la Societe Prehistorique Française* 71: 119-127.

Owen W.E. 1938. The Kombewa Culture, Kenya Colony. *Man* : 203-205.

Price-Beggerly P. 1976. Edge Damage on Experimentally Used Scrapers of Hawaiian Basalt. *Newsletter of Lithic Technology* 5: 22-24.

Pitts M. and Roberts M. 1997. *Fairweather Eden: Life in Britain Half a Million Years Ago as Revealed by the Excavation at Boxgrove*. London: Century.

Raynal J.-P., Magoga L. and Bindon P. 1995. Tephrofacts and the First Human Occupation of the French Massif Central. In Roebroeks W. and Kolfschoten T.V. (eds.), *The Earliest Occupation of Europe*, pp. 129-146. Leiden: University of Leiden.

Richards T.H. 1988. *Microwear Patterns on Experimental Basalt Tools*. B.A.R. International Series Vol. 460. Oxford.

Roche H., Brugal J.-P., Lefevre D., Ploux S. and Texier P.-J. 1988. Isenya: état des recherches sur un nouveau site Acheuléen d'Afrique. *The African Archaeological Review* 6: 27-55.

Roebroeks W. and Kolfschoten T.V. (eds.), 1995. *The Earliest Occupation of Europe*. Leiden: University of Leiden.

Santonja M. and Villa P. 1990. The Lower Paleolithic of Spain and Portugal. *Journal of World Archaeology* 4: 45-94.

Sharon G. and Goren-Inbar N. 1999. Soft Percussor Use at the Gesher Benot Ya'aqov Acheulian Site? *Mitekufat Haeven - Journal of the Israel Prehistoric Society* 28: 55-79.

Sharon G. and Goring-Morris N. In Prep. The Knives of Har Qeren XIV - Technological Aspects. *Lithic Technology*.

Stekelis M. 1960. The Paleolithic Deposits of Jisr Banat Yaqub. *Bulletin of the Research Council of Israel* G9: 61-87.

Stekelis M. and Gilead D. 1966. Ma'ayan Barukh, a Lower Paleolithic site in the Upper Galilee. *Mitekufat Haeven - Journal of the Israel Prehistoric Society* 8.

Wallace W.J. 1962. Two Basalt Quarries in Death Valley. *Archaeology* 15: 46-49.

Yamei H., Potts R., Baoyin Y., Zhengtang G., Deino A., Wei W., Clark J., Guangmao X. and Weiwen H. 2000. Mid-Pleistocene Acheulean-like Stone Technology of the Bose Basin, South China. *Science* 287: 1622-1626.