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Oldowan: Rather more than smashing stones

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THE ARCHAEOLOGY OF THE PENINJ "ST COMPLEX" (LAKE NATRON, TANZANIA)

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Introduction

Presently, research at Peninj (West of Lake Natron, Tanzania) is being carried out in three geographical areas: North Escarpment (NE), South Escarpment (SE) and Type Section (Figure 1). The first two areas are more distant to the former paleo-lake than the latter. In those two areas, sites devoid of fauna and containing Acheulian stone tools have been discovered. Type Section is, conversely, situated in a deltaic paleoenvironment close to the former lake shoreline. Sites in Type Section preserve dense concentrations of bones and lithic tools adscribed to the Oldowan industry.

Previous publications (Isaac 1965, 1967; Dominguez-Rodrigo et al. 2001a) have paid special attention to the Acheulian sites discovered in the region, and recently to the lithics (de la Torre et al. 2003) and zooarchaeological and taphonomic characteristics (Domínguez-Rodrigo et al. 2002) from the ST Site Complex at Maritanane (Type Section). This paper is presented as a synthesis of the works at the ST Site Complex, that is composed of a pene-contemporary cluster of 11 archaeological sites, which share the following properties: similar stratigraphic position on the same paleosol, similar taphonomic conditions and topographic proximity, since all these sites appear in a reduced area.

Radiometric dating (Manega 1993; Isaac & Curtis 1974), paleomagnetic dating (Thouveny & Taieb 1986, 1987), and bio-stratigraphic correlations (Geraads 1987; Denys 1987) place these archaeological sites in the 1.6-1.4 Ma interval (Dominguez-Rodrigo et al. 2001a, 2001b, 2002).

Geology of the ST Site Complex

Introduction: Regional geology

The Peninj Group is a Plio-Pleistocene sedimentary unit exposed on the south-western section of the Magadi-Natron basin in the south of Kenya and in the north of Tanzania. The exposures appear on the Tanzanian sector of the basin in the form of extensive areas of outcrops on the Sambu and Sanjan tectonic escarpments in the current semi-graben to the west of lake Natron (Figure 1). During the formation of these sedimentary exposures between 2.0 and 1.0 Ma, the lake basin showed a substantially different aspect, since the 400-meter-high western tectonic escarpment of the Rift Valley (Nguruman Escarpment) did not exist.

The relief was formed by volcanic cones and the distant precambric highlands of Oldoinyo Ogol. The basin is situated to the north of the point where the Gregory rift system is divided into three branches: Eyasi, Manyara and Kilimanjaro. It is also in a region of high volcanic activity known as the northern volcanic province of Tanzania (Dawson & Powell, 1969). The current configuration of the Rift in this area ocurred at about 1.0 Ma.

The Plio-Pleistocene deposits of Peninj were initially described by Isaac (1965, 1967). Isaac made a stratigraphic synthesis of these sediments due to their importance in the study of the archaeological sites discovered in 1963. The deposits are 80 m. thick. They are composed of lacustrine and alluvial sediments with interbedded volcanic tuffs.

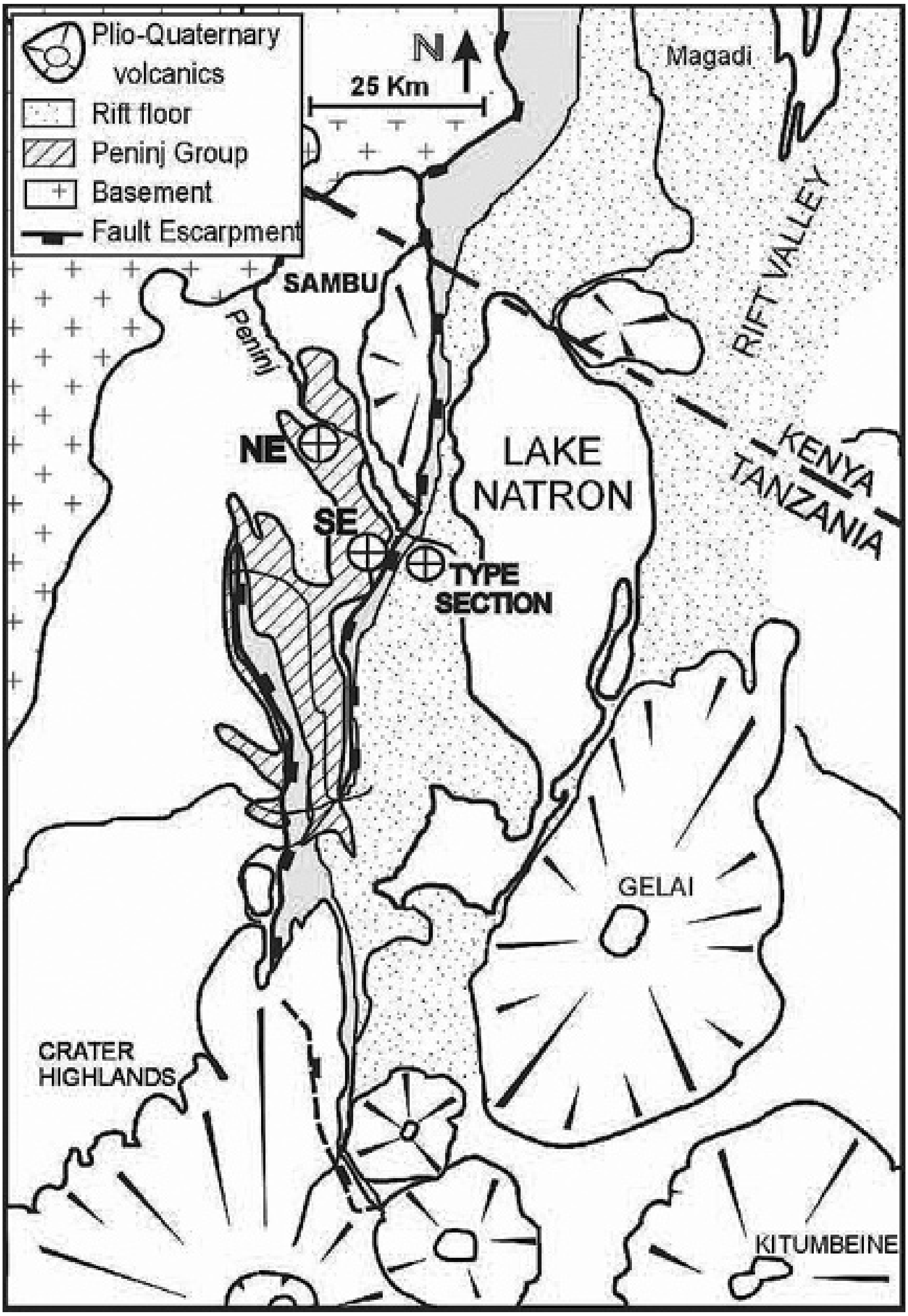

Fig. 1. Location of the Plio-Pleistocene deposits of the Humbu Formation in the Peninj area. Key: NE(North Escarpment); SE (South Escarpment), and Type Section. The ST site complex is located in Type Section (Maritanane).

The Peninj Group was formed on a 400 m. thick lava basement (the Sambu lavas) dated to 2.0 Ma, 1.9-1.77 Ma. and 3.5 Ma (Isaac 1967; Isaac & Curtis 1974). This basalt deposit together with the nephelinite and phonolite Pliocene deposits overlay a precambric quartzite stratum belonging to the Mozambique Belt (Lubala & Rafoni 1987). Both in the middle and at the top of the Sambu lavas, sediments similar to those of the Peninj Group appear. They have been called Naikuruku and Hajaro beds respectively (Isaac, 1965).

The Hajaro beds are overlaid by a 10 m. thick basaltic flow showing reverse paleomagnetic polarity and a radiometric date (K/Ar) of 2.0 Ma (Thouveny & Taieb 1987). These beds are the base of the Peninj Group (Isaac 1967). Isaac (1965, 1967) divided the Peninj Group into two units (Figure 2): the Humbu Formation (approximately, 40 m. thick and mostly alluvial) and the Moinik Formation (between 30 and 40 m. thick and basically of lacustrine facies).

Fossils have appeared so far mainly in the alluvial facies of the Humbu Formation. This formation was also divided into three members.

The first of them is the basal sands with clays (BSC), which constitute the initial detritic infill of the basin. They show mid-fan facies and proximal alluvial fan facies which fill the tectonic basin which was limited by the proto-escarpment of Sambu (approximately 20 m. high). The second member is the Main Tuff (MT), constituted by basaltic tuffs originated in a small volcanic cone situated to the south of the modern Peninj river delta. The third member is the Upper Sandy Clays (USC), deposited in a flat landscape with hardly any noticeable relief. They show distal and intermediate alluvial facies to the north and lacustrine facies to the south. They contain most of the fossils and stone tools discovered thus far.

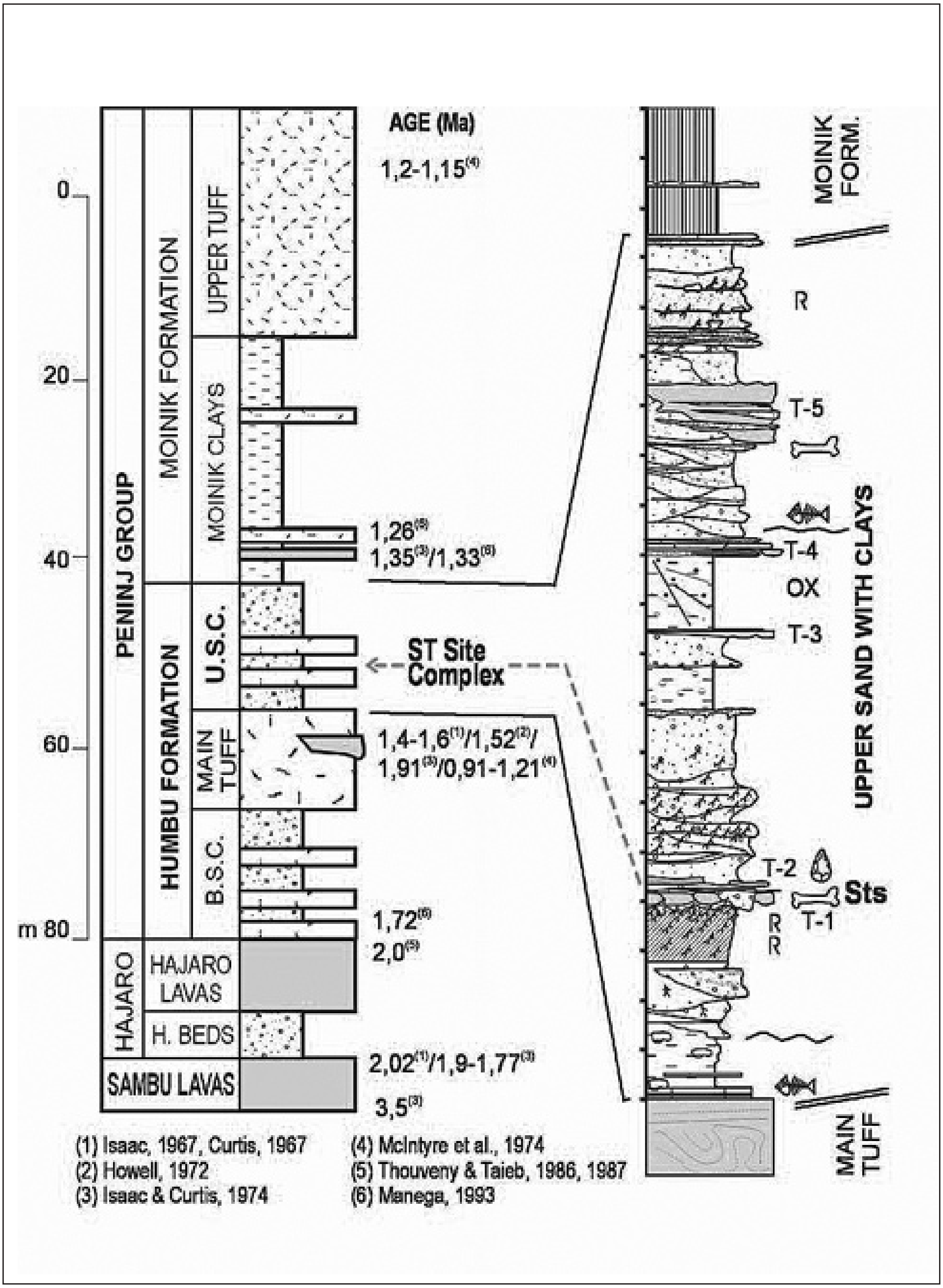

Fig. 2. Stratigraphic sequence of the Peninj Group with the current dates available.

The age of these deposits is controversial, although they have been dated by K/Ar and Ar/Ar as well as by paleomagnetism. The reason for controversy is that the tuffs appear altered by diagenetic zeolitization of volcanic crystals.

The base of the Peninj Goup would be younger than the Hajaro lavas (dated at 2.0 Ma) (Isaac 1965, Isaac & Curtis 1974). A basaltic tuff interbedded into the Main Tuff (Wa Mbugu basalt) shows normal polarity and has been dated to 1.4-1.6 and 1-9 Ma (Isaac & Curtis 1974; Howell 1972; McIntyre et al. 1974). It is temporarily assumed to represent the Olduvai subchron in the Matuyama phase (Thouveny & Taieb 1987) dated between 1.9 and 1.78 Ma (Walter et al. 1991; McDougall et al. 1992; Valet & Meylander 1992).

A basaltic tuff situated at the base of the Moinik Formation has been dated to 1.33-1.4 Ma (Isaac & Curtis 1974; Manega 1993). This tuff corresponds to the end of the USC sedimentation process. Also at the base of the Moinik Formation and overlying the previous tuff, Manega (1993) has dated another tuff to 1.26 Ma, which reinforces the validity of the date of the underlying tuff (Intra-Moinik tuff). After the Moinik Formation, the Peninj Group sedimentation ends at about 1.2-1.15 Ma (McIntyre et al. 1974).

The most complete outcrop series of the Peninj Group is found in what Isaac (1965) called Type Section. It is an area situated at the foot of the modern escarpment by the current delta of the Peninj river. This area has been strongly modified by tectonics and erosion has created a complex of gullies exposing fossiliferous sediments.

The abundance of archaeological sites in Type Section has made us define the ST site complex. The Type section embodies Kamare, Maritanane and Kipalagu. Most of the outcrops are contained in the Maritanane area and so is the ST site complex.

The Upper Sands with Clays (USC)

The USC member is widely distributed along most of the exposures of the Peninj Group. It overlays the Sambu Escarpment (North and South) and is also found along all the Type Section outcrops (Figure 3).

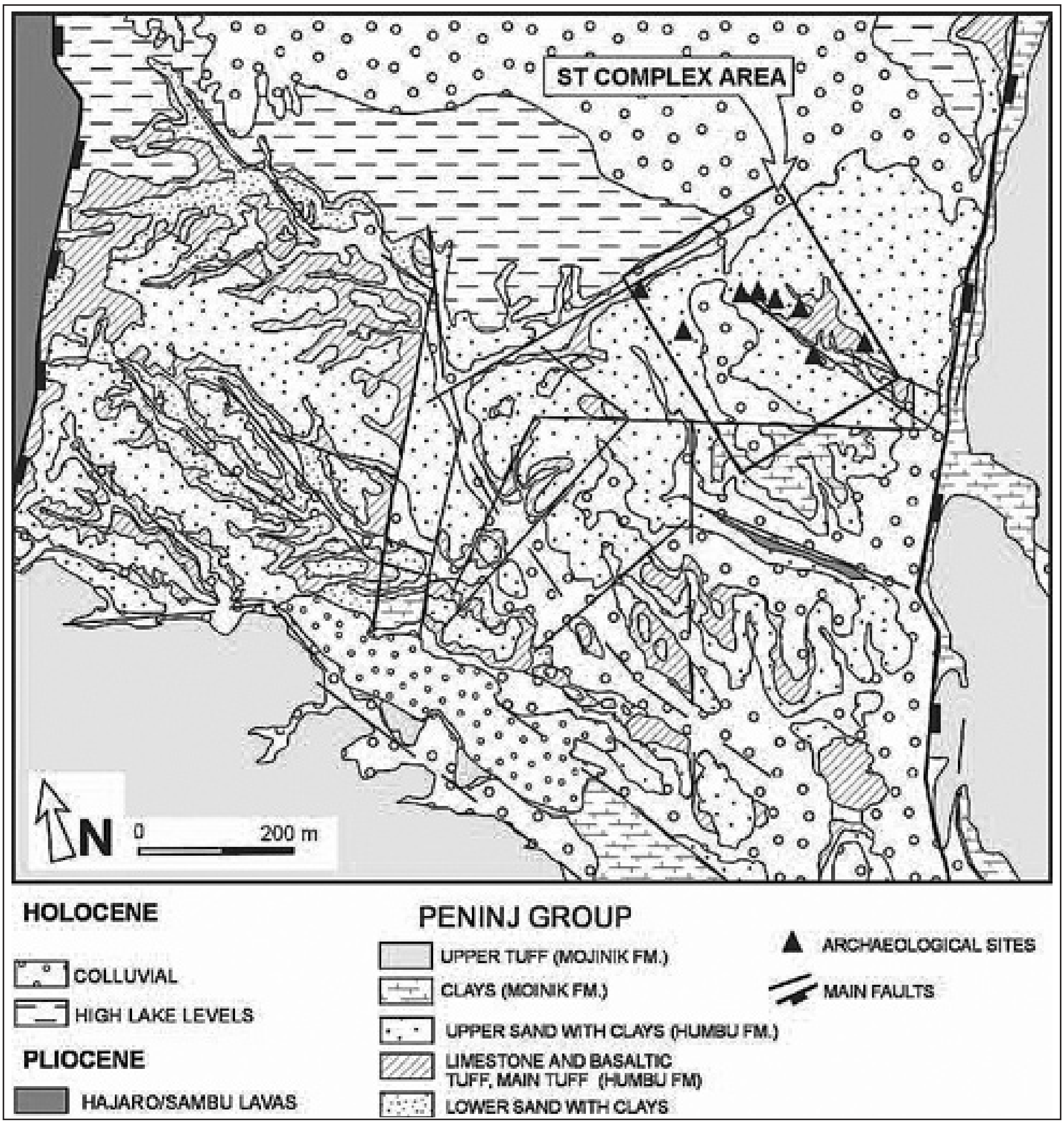

Fig. 3. Geomorphological map of the Peninj Group in Maritanane, Type Section, and location of the ST site complex.

The thickness of the USC varies between 4 m. to 20 m. In Type Section, the USC represents a proximal alluvial facies towards the west and a distal alluvial facies towards the east and the south. The materials that constitute the USC in this area are lacustrine-swampy dolomitic carbonates, clays and silts, sands ranging from fine grained to coarse grained and interbedded volcanic tuffs. The sedimentary structures observed show the intervention of geological processes of different origin, such as the variation of the lake shoreline, the volcanic activity and tectonic movements which produced periods of erosion, sedimentation and edaphic processes.

The paleoenvironmental evolution of the USC at the ST site complex level can be documented in the modification of the alluvial facies. Around the ST site complex, the evolution of the landscape can be summed up in the following description. Lacustrine carbonates were deposited on the surface of the basaltic tuff of the Main Tuff. These carbonates contain abundant bioturbation due to the activity of boring organisms. On the lacustrine facies, mudflat lacustrine facies appear interbedded with marshy carbonated sediments containing carbonate nodules. This indicates variation in the base level as a result of fluctuations in the lake shoreline. Gradually, these sediments incorporated fine grained sands with root casts and oxidation processes in a paleoecological setting of a distal alluvial fan.

Then, the first phase of channel formation occurred due to a decrease in the water level of the lake and a progradation of the most proximal deltaic facies. This change might have been tectonically induced. The channels show their greatest development to the north of the ST site complex area, but are visible along most of the outcrops, eroding the fine grained underlying sediments. The channel infill is constituted by coarse grained sands showing a horizontal and crossed lamination. After this filling phase, fine grained sands and sandy clays containing isolated root casts are deposited again.

Oxidation processes intervene afterwards, as shown by the presence of reddened sediments. After this period, proximal alluvial fan facies erode the anterior substrate.

These deposits are constituted of coarse grained sands with abundant clayish and zeolitic matrix, showing important bioturbation by the presence of a compact web of root casts. This facies is very cemented. After this sediments were deposited, a volcanic eruption was responsible for the deposition of a tuff (T1), which is 20 cm thick on average. In some areas it becomes 40 cm. thick. After the eruption, the area appears sealed by the tuff. Then, a new fluvial incision phase erodes the tuff, which in some spots shows signs of important subaerial weathering (cracking of the surface, formation of split blocks). In some parts, the faulting created by posterior tectonic dynamics can be observed. This sin-sedimentary tectonic activity can be documented by the presence of material sismically slumped which formns part of the Main Tuff.

This process ended when there was a new rising of the base level with the creation of crusting in the channels because of carbonate precipitated by algae. Later, the channels were filled with coarsed grained sands and the surface ressembled the previous one deposited prior to the formation of T1. During this period, most of the ST archaeological sites were formed both on the edges of channels which excavated and eroded the tuff (T1) as well as on the well-cemented tuff surface including a sandy and clayish matrix.

Not long afterwards, a new tuff was deposited (T2). This tuff is laminated and is adapted to the landscape relief. It is also affected by tectonic processes and eroded as a result of the continuation of the formation of channels. The alluvial sedimentation was discontinuous, with the incision of channels and the sedimentation of river deposits with coarse grained sands and clays in sheetflow and channel fill deposits. During this time, there was a very widespread and intense drainage system. After this phase, a new lacustrine transgression took place, depositing a dolomitic limestone layer overlaid by fine grained sands and clays. Then the delta expanded again. At the base of the Moinik Formation, the lake covered most of the area because of either a climatic change or a tectonic tilting of the lake basin towards the west.

The ST site complex

Maritanane (formely called Type Section by Isaac, 1967) comprises about 1 km2 of Plio-Pleistocene sedimentary exposures. The northeastern section of Maritanane is occupied by two gullies, which contain the greatest density of fossil bones and artefacts retrieved so far from the whole area. Within these gullies, archaeological remains are distributed more or less regularly (Figure 4), with higher density spots which were formally called sites (ST2A, ST2C, ST2D, ST2E, ST2G, ST3, ST4, ST6, ST15, ST30, ST31 & ST 32). The sediments exposed in between these sites are also littered with archaeological remains, though in smaller amounts, which makes artifact and archaeofauna distribution a continuum in this reduced area.

The archaeological ocurrences are situated in the Upper Sands with Clays (USC) of the Humbu Formation, directly overlying a volcanic tuff and covered with carbonated sands. The tuff is widely exposed in most of the outcrops, over an area comprising almost 75% of Maritanane. The archaeological materials appear on a paleosol right on the surface of the tuff in most of the area, except when the tuff is eroded or cut through by river channels. Many materials appear exposed but encrusted to the tuff by the effects of carbonate.

ST2. This big site, divided by small modern gullies (ST2A, ST2C, etc) is found at the top of a small slope in the northeast of the ST complex in a fine and coarse grained sandy matrix right above the tuff (T1).

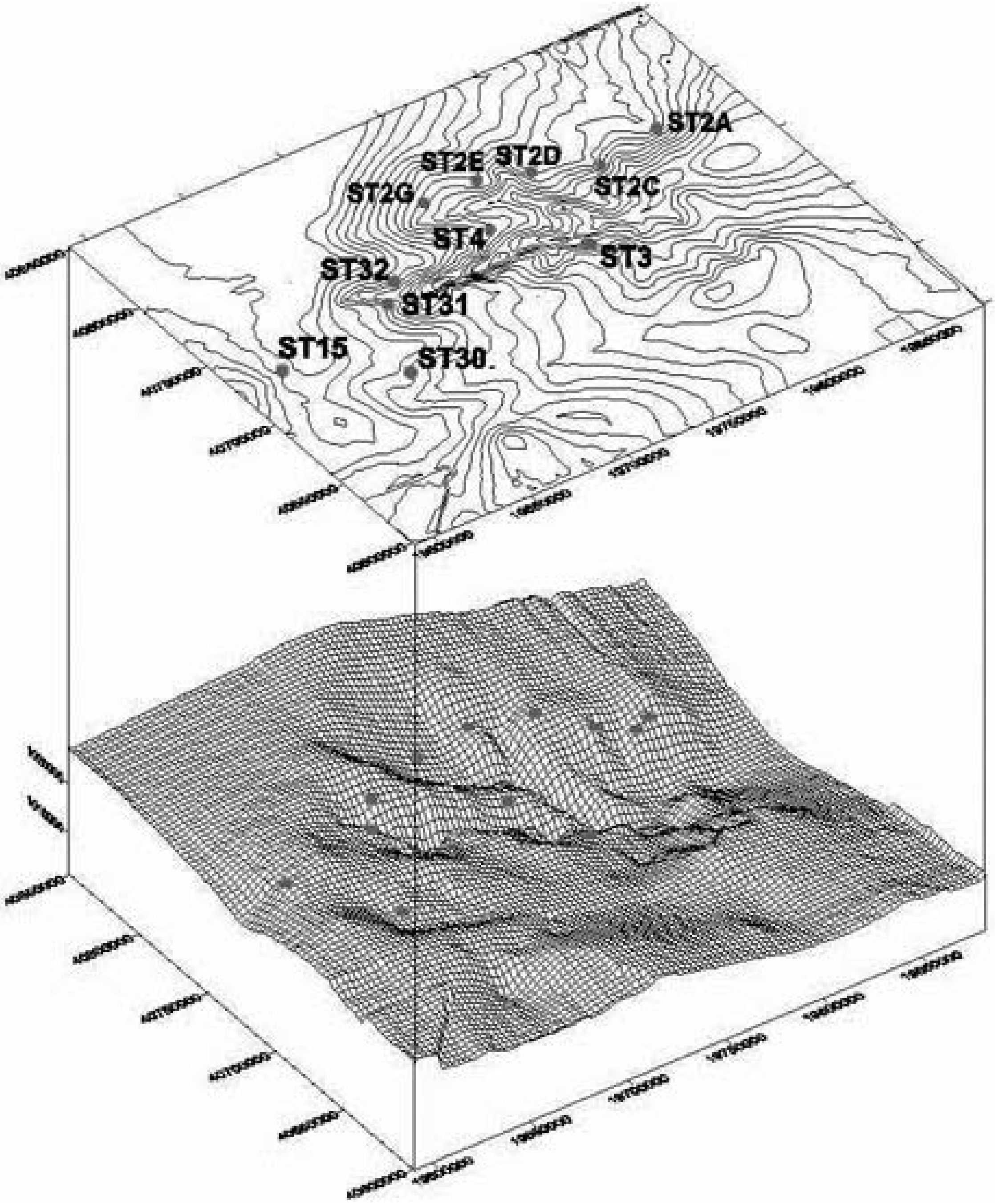

Fig. 4. 3D reconstruction of the modern topography of the St site complex showing the sites distributed around the main gully.

The sandy sediments covering the fossiliferous deposit are 10 cm thick. The archaeological remains appear on the top of the tuff surface, covered by greenish sands and clays and a reduced sand infill in a channel structure overlying clayish lacustrine and distal alluvial sediments. The site is situated about 2.8 m above the Main Tuff. In a part of the exposed outcrop, the tuff (T1) appears eroded because of the presence of a small channel. The erosion is very straight and could be conditioned by a fault which follows a 105º-107º E direction.

ST3. This site is situated in the Eastern margin of the ST site complex. Archaeological remains are mainly found at the base of the sand deposit of a river channel. The base of the channel presents a bio-precipitated laminated carbonate, where some faunal specimens and stone tools are found. Other archaeological remains appear on the non-cemented sides of this carbonate and even underneath.

The channel described follows a west-east direction and was formed on brown sands with root casts. Under these sands, coarse grained sands containing basaltic blocks from the tuff are found. The site is about 1.5 m above the Main Tuff.

ST4. This site is located in the intermediate zone of the ST site complex, on top of a slope which follows a west-east direction. It is constituted by coarse grained sands in a channel fill formed in a clay matrix which might have followed a northwest-southeast direction. The channel includes blocks from the tuff and presents a carbonate layer on the basal erosive surface. On the base, volcanic blocks have been retrieved which have a diameter of approximately 0.5 m and which are covered by algae-deposited carbonate. The base of the channel is situated only 0.4 m. from the top of the Main Tuff. The proximity of the channel to the Main Tuff could confuse the actual stratigraphic location of the channel by placing it in the channel deposits found at the bottom of the USC.

However, the existence of the carbonate level at the bottom of the channel, the upper contact with the greenish sands and the existence of basaltic blocks from T1 prove that the formation of the channel took place after the deposition of T1 which the channel itself eroded. This site was strongly altered by tectonic movements, showing some variation in the disposition of the archaeological materials, ranging from 0.2m. to 0.4 m. due to faulting.

ST6. This site is found on the same slope as ST4 about 20 m. to the west. Archaeological remains are found on the tuff surface (T1) in the cemented greenish sands. A few meters away T2 can be observed, a little displaced by tectonic dynamics, but stratigraphically above the archaeological deposit. In this zone, T1 is 0.4 m thick. It is not easy to determine the situation of the site with respect to the Main Tuff, because it was highly modified by tectonic faulting but it ranges between 2.5 m and 3.5 m.

ST15. This site is the westernmost locality of the ST site complex. It is situated on a slope about 1.8 m. above the Main Tuff. The archaeological level is situated in strongly cemented sandy sediments and right on the surface of T1 which appears highly altered. At the same point, an erosional front can also be observed. It cuts the tuff at the level of formation of a small stream channel with coarse grained sands. The channel infill appears laminated and its base is close to the top of the Main Tuff. A few meters south of the site the tuff is observed continuously with 1.2 m of underlying sand sediments and 0.4 of clays with carbonate nodules above the Main tuff.

ST30. This site is situated on a small platform formed in between two small gullies. It is the southernmost site in the ST site complex. Its surface is practically horizontal. Laterally, T1 can be observed to the south. It is highly weathered on surface. To the north, the greenish sands with root casts are found. The facies where archaeological materials appear is composed of cemented sands.

The archaeological level corresponds to the level of the paleosol where the other sites are located. From the southern outcrop of the locality it can be deduced that the site is situated 5 m. above the Main Tuff.

ST31. This site is located at the beginning of the gully that separates ST4 and ST3. The archaeological horizon is located on the surface of T1 in a sandy matrix and under the fill deposit of a shallow paleochannel (0.3 m. thick). T2 overlays this channel. The base of the sequence is covered with sediments. Thus, the distance between ST 31 and the Main Tuff is uncertain. Under T1, there are a few cms of greenish sands.

ST32. This site is similar to ST31 and both sites are separated by an erosional gully. It is directly on the tuff surface. However, there is more than 1 m of sedimentary sequence between T1 and T2, which could indicate that there was a posterior subsidence movement or that T2 was deposited on an elevated paleorelief. The site is 3.5 m above the Main Tuff.

Geological Interpretation of the ST Site Complex

The redundant stratigraphic situation of all the archaeological sites of the ST complex on the surface of a tuff (T1), suggests that all the sites were deposited on the same paleosol. The eruption of a volcanic cone to the south of the lake created the deposition of T1 on an alluvial fan environment. Sedimentation stopped at a certain time. Then erosion proceeded to weather, crack and shatter the tuff. Then, the lake briefly covered the area forming a laminar carbonate layer in the lowest areas because of the action of algae and stromatolites. Afterwards, sedimentation by a deltaic system followed the regression of the lake and sands and clays were deposited on the carbonate and tuff surface. In the initial phase of this deltaic process with the combination of large and several small and shallower channels, early hominids occupied the area and created the ST site complex.

The paleorelief of the area (Figure 5) has been obtained by measuring the distances of sites to the Main Tuff (after considering recent tectonic changes but not those that ocurred after the deposition of the Main Tuff and before the formation of T1). The data were obtained along an extended area where the outcrops have allowed us observe the thickness among different stratigraphic units (Figure 6). The most elevated zone is situated to the south and west. A channel, which originated in the northwest, goes across ST4 and by ST3. Other smaller streams joined this main channel. The direction of relief is north-south, similar to those currently observable, which indicates the reactivation of the faulting.

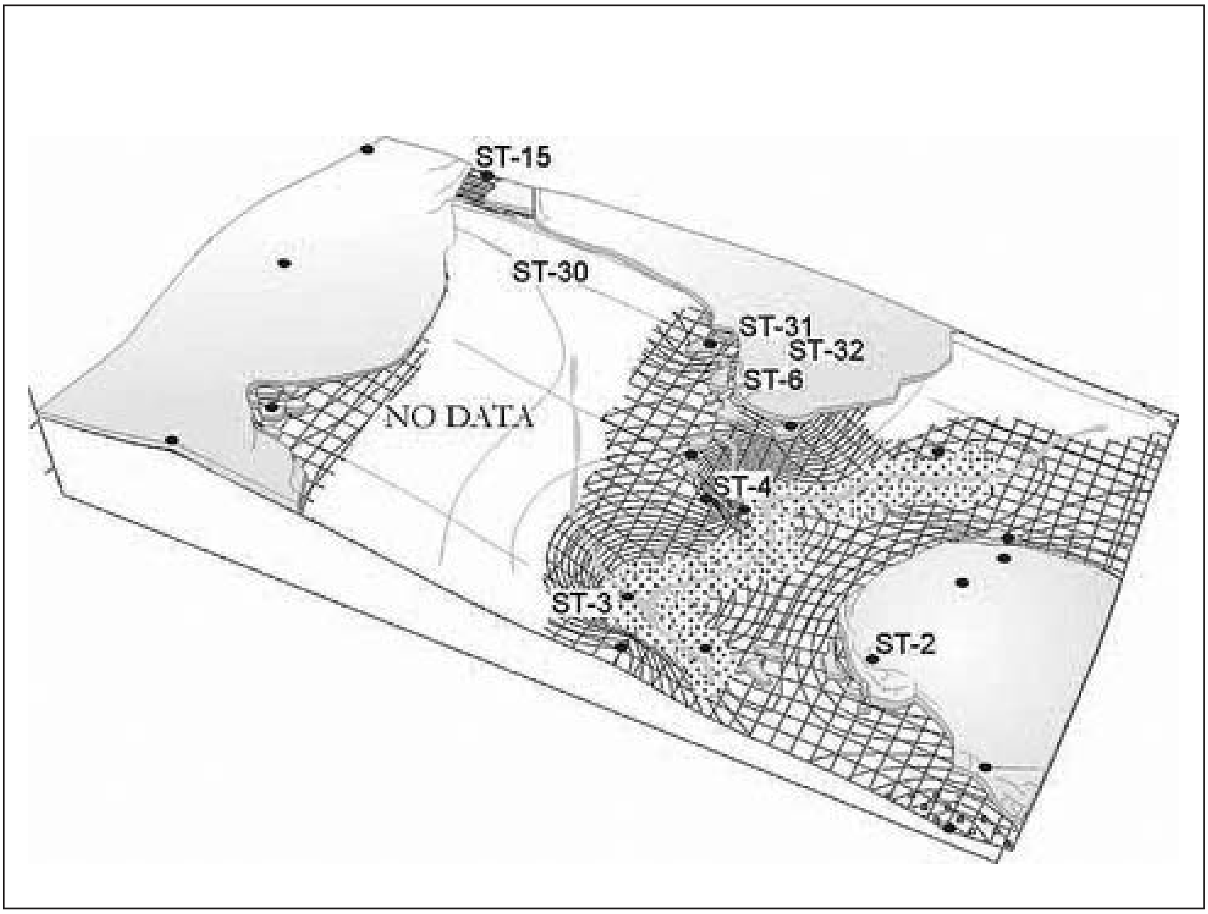

Fig. 5. Location of the archaeological sites in the ST site complex on the paleotopography of the area and showing the paleoecological landmarks.The shaded area shows the zones where T1 has been preserved. White areas show the erosive processes created by channel fills.

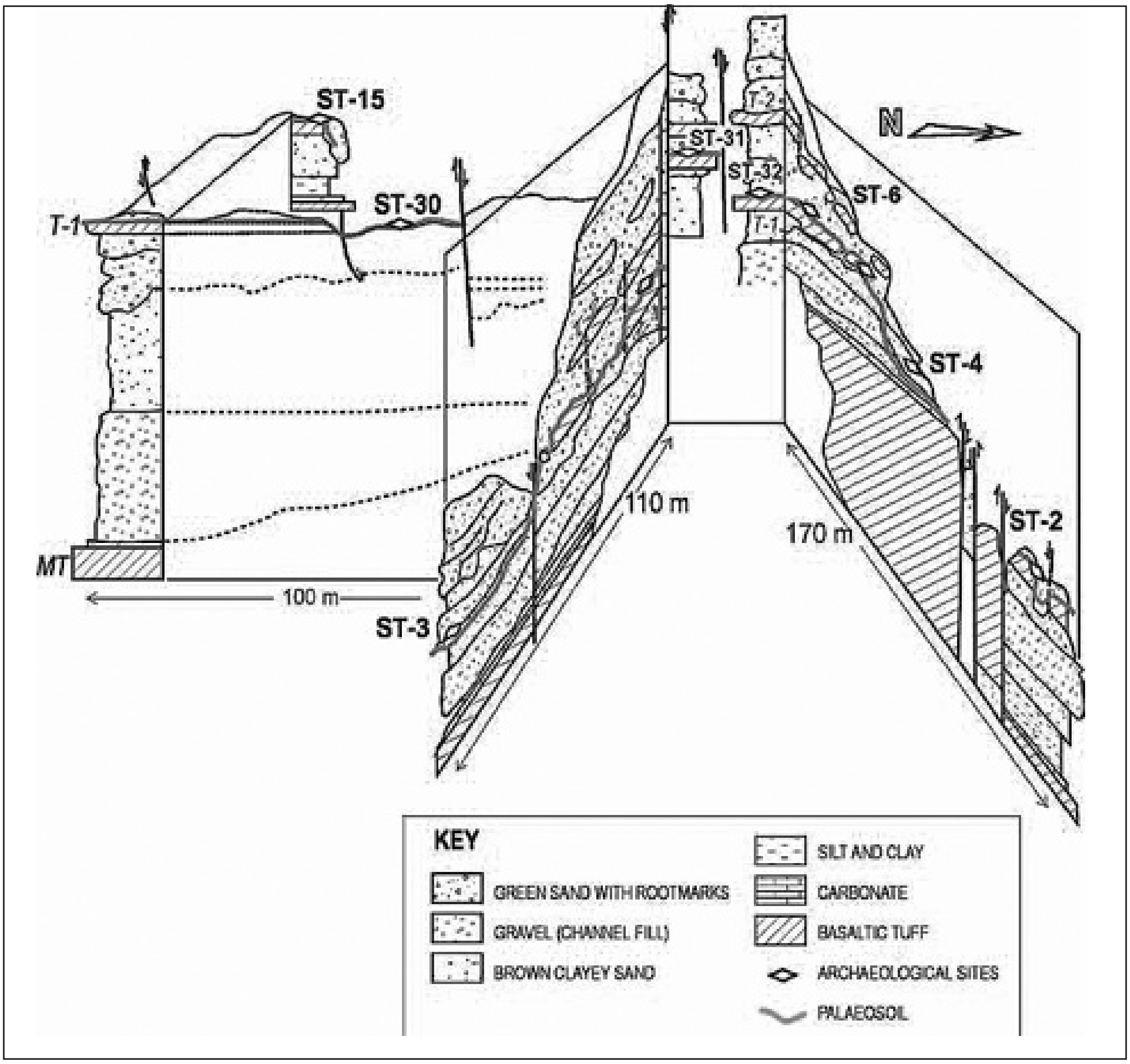

Fig. 6. Isometric stratigraphic reconstruction of the St site complex with the main lithological features shown.

According to these data, the most depressed parts of the ST site area correspond to the zones where T1 has been eroded and channel deposits are well represented. This could indicate that T1 was eroded and even the older deposits were also eroded to incorporate the channels. The most elevated areas are situated on well preserved tuff (T1). The disposition of the deposits supports the paleotopographic reconstruction, with a minor relief exposed showing a 4 m difference between the lowest and the highest point.

The larger channel would flow southeast or south by the zones where ST4 and ST3 are located. Smaller shallow channels appear nearby also eroding T1. The overall impression is that hydraulic energy did not play a major role in the final configuration of archaeological sites.

The side channels are too small and the situation of ST4 and ST3 on the edge of the channel supports the contentions that most of the materials were not transported by water. Judging by the size, if seasonality was as marked as it is today in modern savannas, most of these streams in the areas where archaeological materials were deposited might have been dry or the water level might have been low at the time hominids were foraging in the area.

Data Collecting Method

Most sites in the ST complex are located on individual slopes, except ST2 (comprising five slopes: A,B,C,D,E, G, most of them with archaeological materials). T1 is exposed along the whole area connecting all the slopes that constitute the main gully. Most sites contain sediments overlying the archaeological horizon, varying from thick strata (ST3) and moderately thick strata (ST4 & ST30) to thin deposits (ST2A, ST15 & ST32), and lack of overlying sediments (ST31 & ST2B,C,D,E).

Test excavations have yielded the same kind of carbonated materials adhered to the tuff surface. In all these sites, archaeological materials also appeared on the surface of the slopes due to erosion. These surface materials were also documented as belonging to these sites because of the following reasons:

In Maritanane, clusters of surface archaeological materials are spatially restricted to the localities where sites have been documented to exist *in situ* through excavations.

Therefore, there seems to be a lack of significant transportation due to erosive processes. The densities of the material observed on the surface are similar to those documented through excavation in the same localities.

In the whole area of Maritanane, no archaeological materials have been retrieved above the horizon documented on T1 in the USC. There is no difference whatsoever in raw material types, technology and morphology of the artifacts collected on the surface from those unearthed through excavation. Most of the materials (both faunal and lithic) appear fresh, without any traces of erosion from exposure.

Despite these observations, to further ensure that the archaeological remains on the surface belonged to the same archaeological horizon identified on T1, only those remains observed on the upper parts of the slopes, right under T1 were included in this study. The ST6 site was not included in the present analysis, because even if faunal remains and stone tools have been documented in it, none of it has been collected so far.

Archaeological materials included in this study, thus, come from three sources: surface, *in situ* on the tuff paleosol exposed and *in situ* through excavation. Test excavations were carried out at all sites (except ST6, ST31 and ST32) to establish relationships between materials unearthed and those adhered to the paleosol surface exposed. These relationships were expressed in terms of density, taphonomy (preservation stages of fauna, types and sizes of bones represented, orientation, abrasion, polishing, taxonomy), technology and raw material types used in the elaboration of the artifacts discovered. The sedimentological and taphonomical analyses of the carbonate surfaces of the tuff exposed proved that the archaeological materials were adhered to the tuff in the past and not as a result of recent re-elaboration and carbonating of sediments.

In some cases, anatomical parts of the same animal were found both in the horizon covered by sediments and the horizon exposed on the paleosol surface exposed. The carbonate sediment on top of the tuff was indistinguishable from that documented under the sedimentary deposits. The same density of materials and the same taphonomic results were obtained in both buried and exposed archaeological contexts, further supporting their common provenience.

Bone preservation in the ST complex is not very good. A significant amount of the bone sample contains specimens with cortical surfaces damaged by carbonate crusts, water etching and weathering. A smaller amount of specimens show better preservation, especially around ST4. Only the bones with intact or well preserved cortical surfaces were used for the analysis of bone surface modifications.

The distributions of artifacts and faunal remains was plotted by using a laser theodolite. A careful topographic map of the main gully and the surrounding area embodying the ST site complex was made to plot archaeological materials more accurately. All the main geological features, especially the web of faults of the gully were also recorded. This allowed a 3D reconstruction of the paleotopography of the area, featuring the main characteristics of the paleolandscape and site distribution therein (Figure 5).

The Oldowan Industry

Raw materials

The difraction X-ray analyses and the mineralogical analyses have resulted in the identification of several types of basalt (basanites, aphiric basalts, hawaian basalts and aphitic basaltic tuffs), as well as piroxenic nephelinites and quartz.

Nevertheless, only three types of raw materials are clearly differentiated de viso: basalt, quartz and nephelinite. Quartz is the most difficult raw material, of those represented, to be transformed through an organized knapping process.

A large variability in the properties of the basalts that hominids used in Type Section has been documented. Some artefacts were elaborated from very fine-grained basalts, which are very apt for flaking. Other basalts are very porous, thick-grained and with internal irregularities. Conchoidal fractures would have been very hard to obtain from this type of basalts. Nephelinite must have been highly appreciated by hominids, since it is fine-grained and produces very sharp-edged tools without internal vesicular irregularities. Thus, nephelinites and some basalts were the most adequate raw materials for tool elaboration.

Raw material sources have not yet been precisely identified. As pointed out previously, Type Section is composed of deltaic sediments. Depositional energy is, thus, very low and the sedimentary matrix is fairly fine-grained, missing conglomerate deposits. So far, no gravel or conglomerate level exposed during the formation of the Humbu Formation has been discovered.

Basalt is the predominant raw material type in the ST Site Complex industry, comprising 74.3% of the total number of stone artefacts. Nephelinite is represented by 16.9% of all the lithic tools. The presence of quartz is smaller (8.6%), although in some sites, such as ST2E or ST3, it is more abundant than nephelinite (Table 1). With respect to the representation of raw materials according to artefact type, quartz seems to have been used mostly for hammerstones.

The remaining tool types are evenly made in basalt and nephelinite. Detached pieces (flakes, debris and flake fragments) are mostly made of basalt (75.4%), nephelinite (18.4%) and quartz (5.3%).

%	NEPHELINITE	BASALT	QUARTZ
ST30	14,5	75,8	9,7
ST15	16,7	83,3	-
ST31	17,1	82,9	-
ST32	43,8	56,3	-
ST3	15,6	62,5	18,8
ST4	16,3	67,3	16,3
ST2A	-	100	-
ST2C	18,3	80,5	-
ST2D	66,7	33,3	-
ST2E	11,5	73,1	15,4
ST2G	-	80	20
TOTAL N	60	263	29
TOTAL %	16,9	74,3	8,2

Table 1: Percentages of the representation of the diverse raw material types in the St Site Complex.

Table 2. Percentages of artefact types in the ST Site Complex.

%	Unmodif pieces	Hammer-stones	Cores	Retouched Flakes	Flakes	Flakes Frags	Chunks	Chips	Total
ST30	11,3	4,8	8	4,8	14,5	32,3	19,4	4,8	17,5
ST15	-	-	16,7	16,7	16,7	33,3	16,7	-	1,7
ST31	4,9	4,9	17*	-	14,6	43,9	12,2	4,9	11,6
ST32	-	6,3	18,8*	6,3	25	31,3	12,5	6,3	4,5
ST3	-	6,3	9,4	15,6	25	25	9,4	9,4	9
ST4	6,1	2	12,2	6,1	24,5	26,5	10,2	12,2	13,8
ST2A	-	-	-	16,7	-	50	33,3	-	1,7
ST2C	-	-	2,4	9,8	24,4	30,5	30,5	2,4	23,2
ST2D	-	-	-	33,3	-	33,3	33,3	-	0,8
ST2E	-	-	5,8	7,7	26,9	23,1	25	11,5	14,7
ST2G	-	-	-	20	40	20	20	-	1,4
TOTAL N	**12**	**9**	**29**	**28**	**76**	**108**	**70**	**23**	**354**
TOTAL %	**3,4**	**2,6**	**8,2**	**7,9**	**21,5**	**30,5**	**19,8**	**6,5**	**100**

Light-duty tools are also distributed, according to raw material type, in similar percentages: basalt (77.8%), nephelinite (18.5%) and quartz (3.7%). Cores are made in basalt (72.4%), nephelinite (24.1%) and quartz (3.4%). Therefore, raw material use in the ST Site Complex is similar to its distribution in the landscape. Basalt is the most abundant rock type. Nephelinite and quartz are more geographically located and limited in distribution. Their exploitation by hominids, thus, was more ocassional.

Tool types

Detached pieces are the most abundant tool type (Table 2) in all the lithic assemblages from the ST Site Complex. They make up 66.4% of the total number of artefacts. Flake fragments are predominant (30.5%), followed by complete flakes (21.5%). Debris (6.5%) is scarcer, supporting a slight taphonomic bias in the preservation of lithic component of the assemblages in the ST Site Complex. Cores are represented by 8.2% of all the artefacts retrieved, and retouched flakes constitute 7.9%. Approximately 22% of these retouched pieces were made from complete flakes. The remaining retouched artefacts were made on flake fragments. The size of these retouched tools is similar to the average size of regular flakes (**Table 3**). Light-duty scrapers (*sensu* Leakey, 1971) are the most abundant retouched elements (71.4%), followed by notches (17.8%) and endscrapers (7.1%) (Figure 7).

Flakes are 40 mm long on average (Table 3). Their quadrangular shape is even in all the assemblages from the ST Site Complex. This is indicative of both similar flaking processes and homogeneous core volumes in all these sites. Pieces showing cortical surfaces are rare. Only 20.6% of flakes and flake fragments show some cortical areas and none of them belong to the initial flaking stage. Knapping and tool making is supported by the presence of cores, hammerstones and rejuvenation flakes.

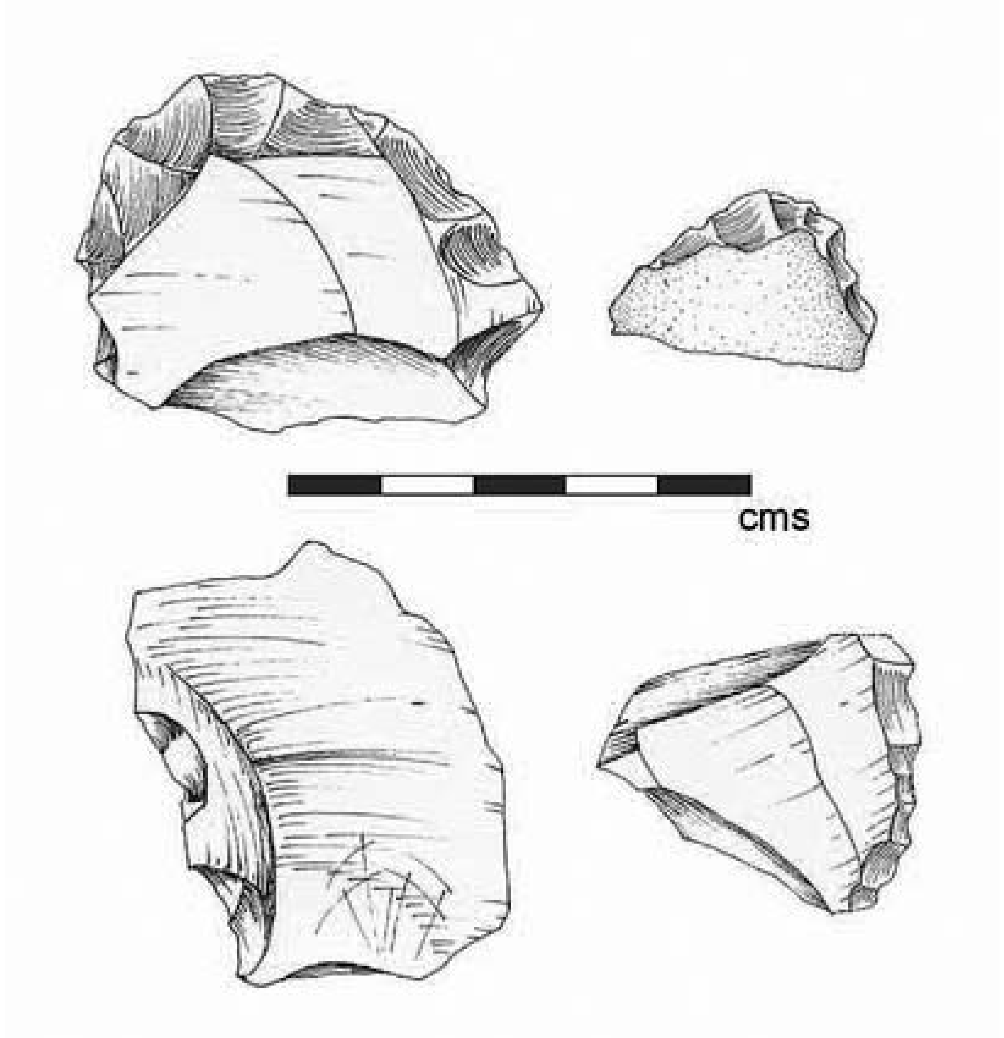

Fig. 7. Some light duty scrapers of the ST site complex (Drawn by Noemi Morán).

	Length (mm)	Width (mm)	Thickness (mm)	Weight (gr)
Unmodified pieces	82,42	70,42	61,92	529,83
Hammerstones	67,29	58,29	53,71	435,22
Cores	59,43	70,20	61,80	423,00
Retouched Flakes	42,54	37,36	15,50	33,89
Flakes	40,49	36,63	12,30	24,93
Flake Frags.	35,60	32,36	12,53	20,06
Chunks	31,46	21,57	11,06	15,76
Chips	16,83	13,91	4,87	1,52

Table 3. Mean sizes of the artefacts from the St Site Complex.

However, the paucity of cortical elements indicates that the initial flaking of cores took place somewhere else outside.The technological attributes of flakes also supports this. Approximately, 90.9% of the striking platform of flakes show no cortex at all. This indicates that either the striking platform was prepared before flaking or that previous flakes had been obtained in the same direction. Striking platforms are mostly uni-facial (79%), although bifacial (8.4%) and multi-facial (3.5%) striking platforms are also documented, suggesting that there was a redundant care in the extraction of flakes with determined characteristics. The analysis of the dorsal surfaces of flakes is also relevant to reconstruct the technological strategies used by hominids.

More than 70% of the flakes analysed show 3 or more negative scars from previous flaking. The presence of these previous flaking does not show *per se* the complexity of the knapping process. However, the high percentage of flakes this type indicates that hominids were repeatedly exploiting the same flaking surfaces.

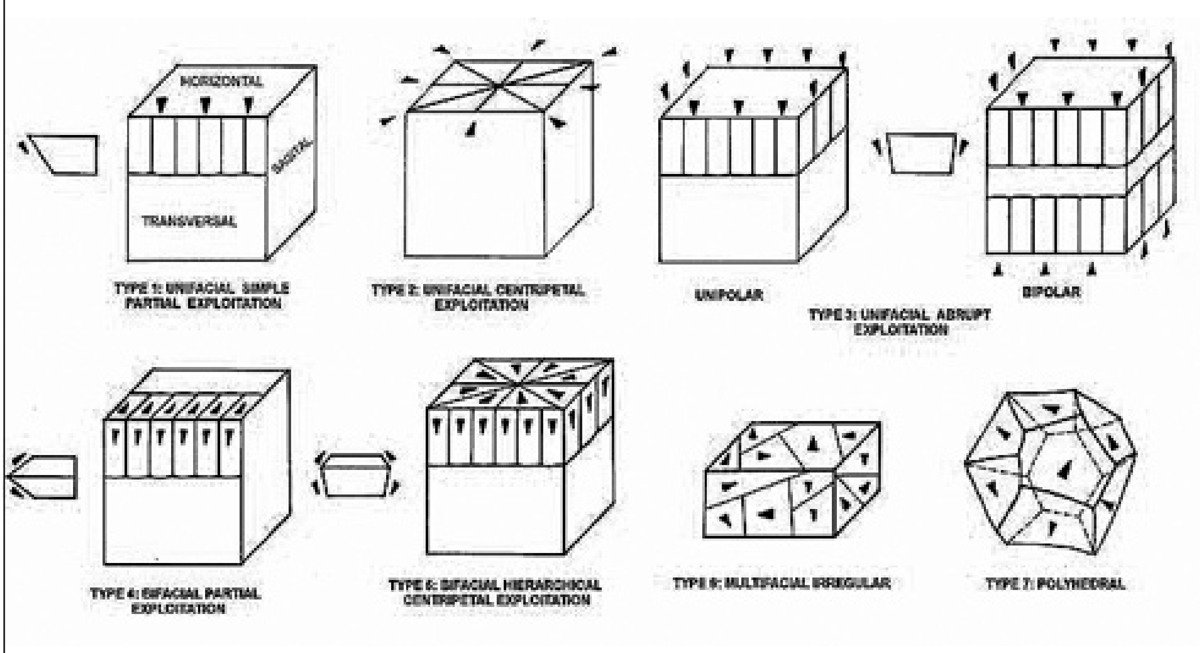

Fig. 8. Ideal schemes of the exploitation methods documented in the ST site complex.

Core types

Our core classification (de la Torre et al. 2003) is based on the consideration of cores as geometric volumes in which, at least, six schematic surfaces have been differentiated.

Flaking on these surfaces and the resulting interaction among them result in unifacial, bifacial, trifacial and multifacial systems. The directionality of flaking allows the distinction of unipolar, bipolar and centripetal strategies. The angle formed by the intersection of the different exploited surfaces can be described as simple or as abrupt.

Considering all these attributes together, the exploitation strategies followed by hominids and documented in the ST site lithic assemblage are (Figure 8):

<u>Type 1</u>. Unifacial simple partial exploitation. It is represented by choppers. Flaking takes place on a surface generated by the natural or cortical plane. The striking platform and the flaking surface adopt an acute angle; that is, the edge appears only on part of the perimeter of the core.

<u>Type 2</u>. Unifacial centripetal exploitation. It consists of the exploitation of the horizontal plane from both the sagittal and transversal planes. Flaking is carried out from unprepared striking surfaces. It is differentiated from Type 1 in the development of the edge, which now occupies all the perimeter of the core. In addition, the only exploitation (flaking) surface is generated through radial flaking.

<u>Type 3</u>. Unifacial abrupt exploitation. It can also be defined as the exploitation of the transversal and/or sagittal plane from one or two of the horizontal planes. Thus, from natural or prepared striking platforms, parallel and longitudinal flakes are obtained. The flaking surface forms a straight percussion angle with respect to the striking platform.

Type 4. Bifacial partial exploitation. It is the strategy documented for chopping tools or bifacial choppers. The negative scars of flaking on one plane are used as the striking surface to flake the adjacent plane. A configuration edge is obtained this way with a simple angle. The edge occupies only a determined area of the piece and not all its perimeter.

Type 5. Bifacial hierarchical centripetal exploitation. The geometric volume of these cores is divided into two asymmetrical convex surfaces which share an intersection plane. The surfaces are hierarchical; the subordinate surface acts as a preparation plane to obtain the radial flakes that characterize the main surface. Besides, the striking surface is oriented with respect to the flaking surface in a way in which the edge created by the intersection of both surfaces is perpendicular to the knapping axis of the centripetal flaking.

Type 6. Multi-facial irregular exploitation. This group is constituted by the cores that present several exploitation surfaces without a clear organization in the reduction process. In the ST Site Complex, cores of this category are always small-sized and with hardly any cortex. This suggests that they may be overexploited cores which could have been more systematically flaked in a previous stage of the reduction sequence.

Type 7. Polyhedral exploitation. It is similar to type 6. It consists of cores exploited from several planes or striking surfaces. However, in this case, it is supposed that the striking surfaces are intentionally chosen to shape the artefact or, at least, there is a tendency for cores to become spherical.

Even if the hierarchical centripetal exploitation is the most common strategy used by the Peninj hominids (30%), type 3 (unifacial abrupt) is also frequently represented (20%), as well as type 6 (multi-facial irregular) (20%) and type 2 (unifacial centripetal) (16.7%). Unifacial choppers (type 1), bifacial choppers (type 4) and polyhedrons (type 7) are poorly represented (3.3%, 6.7%,and 3.3%, respectively).

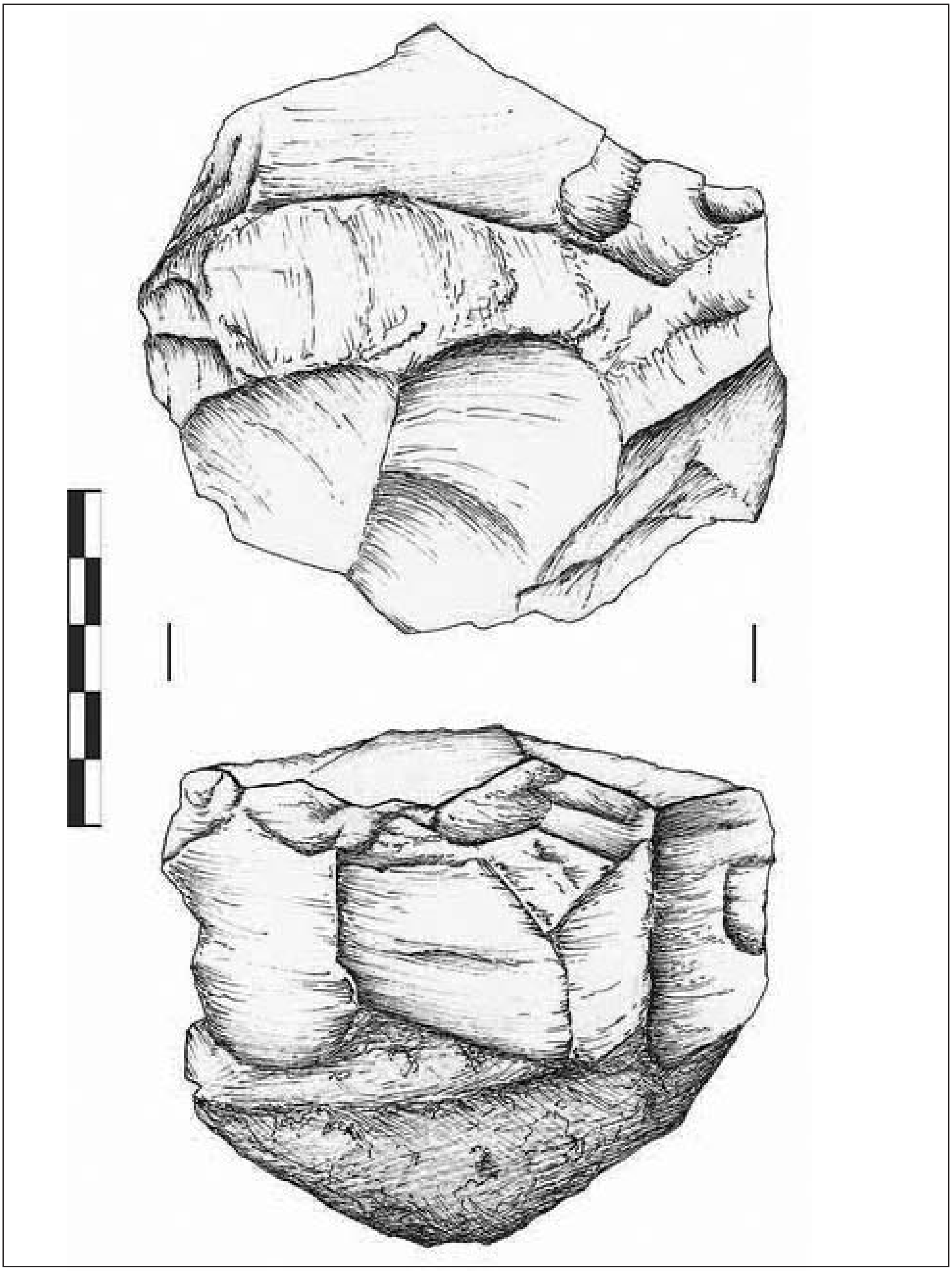

Fig. 9: Hierarchical bifacial centripetal core from the ST site complex in a initial reduction stage (Drawn by Noemi Morán).

Basalt has been more extensively used in all the exploitation strategies. The only exception in which nephelinite becomes more abundant than basalt is in the representation of the multi-facial irregular cores, with 50% and 33.3% respectively of the cores of this category.

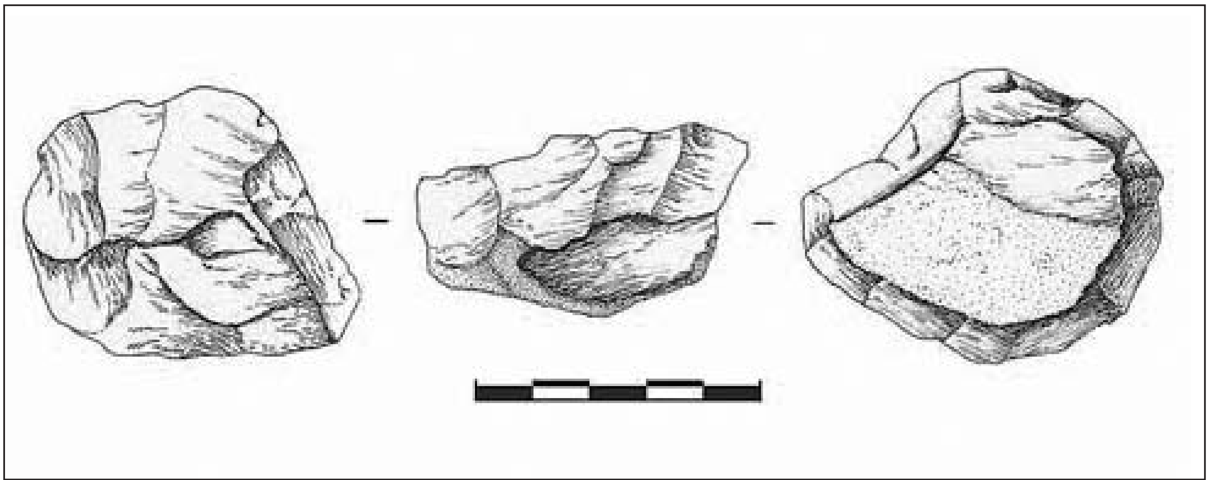

Fig. 10. Exhausted hierarchical bifacial centripetal core from the ST site complex in a final reduction stage.

Table 4: Total number of faunal specimens recovered in the ST site complex.

	ST30/31/32	ST15	ST3	ST4	ST2
Macromammals					
Identifiable	55	58	39	296	129
Skull	6	8	9	54	15
Axial	5	17	8	53	26
Appendicular	44	33	22	189	88
Non-identifiable					
Axial	26	18	22	118	167
Appendicular	22	54	48	71	43
Total macromammals	103	130	109	485	339
Chelonia	4	19	36	43	51
Reptilia	3	0	2	13	7
Aves	1	0	0	0	0
Pisces	212	0	0	0	0
Crustacea	0	0	0	6	6
TOTAL	323	149	147	547	547

The bifacial hierarchical centripetal strategy of core exploitation (type 5, our classification) is fairly complex, since a bifacial flaking process is obtained through the creation of an artificial edge of configuration, keeping this structure throughout all the flaking process (Figure 9). This bifacial structure is not maintained by simply alternating the impacts on both sides (discoid method), but through the configuration of one of the surfaces as a subordinate plane used to exploit the principal surface.

The maintenance of the adequate convexities of such a surface is a key part of the process. This explains the redundancy in creating rejuvenation flakes used to recreate the necessary angles and to continue reducing the core until its exploitation is not feasible anymore (Figure 10). This process is documented by several examples from the ST Site Complex and reveals that Peninj hominids had the capabilities to undertake complex reduction processes from a bifacial edge and to keep them through the whole flaking sequence.

Faunal Analysis

The total number of faunal specimens recovered from the ST site complex is summarized in Table 4. The specimens are distributed in the area exposed. The higher number of specimens documented in ST4 is due to a more prolonged and extensive excavation that has taken place at the site.

Because of this reason, the information provided by the analysis of the faunal remains from this site is presented separately from the remainder of sites, where only test trenches have been carried out.

The taxa identified so far in the ST site complex archaeofauna are: *Ceratotherium simum, Hipparion* cf. *cornelianum, Equus* sp., *Sivatherium maurisium, Giraffa* cf. *pygmaea, Synceros* sp., Tragelaphus *strepsiceros, Megalotragus kattwinkeli, Connochaetes taurinus, Damaliscus niro, Hippotragus* sp., *Aepyceros melampus, Sylvicapra* sp., *Antidorcas* cf. *recki, Gazella* sp, *Kolpochoerus* sp., *Metridichoerus compactus* and *Theropithecus* sp. (Geraads 1987; our fieldwork).

A taphonomic study of the fauna based on specimen size distribution, skeletal part representation and bone abrasion and polishing was conducted to evaluate the influence of water in the bone accumulation at all these sites. Most specimens do not show the abraded and polished surfaces and edges typical of water transport. More than 95% of the specimens do not seem to have undergone any significant transport beyond local rearrangement.

The only exception seems to be the bone assemblage recovered from ST3. There, as many as 19% of the specimens show polishing on some of the edges and moderate abrasion on the surfaces typical of water modified assemblages. In this case, either hydraulic transport or local water erosion seem to have been operating in the site. Some of these specimens are located in a coarse-grained sand deposit in a river channel indicating a high energy context.The distribution of specimen sizes also indicates lack of transport. Most ST archaeological sites show a percentage of specimen sizes similar to experimental assemblages that have not undergone any water transport and also similar to some archaeological sites in low-energy depositional environments for which non-significant hydraulic transport is inferred.

The high percentage of small-sized specimens (between 20 and 50 mm.) indicates that most of the faunal assemblage was deposited by non-hydraulic agents in the same are from which it was recovered. Further support for this statement comes from the types of elements represented. Axial, cranial and appendicular elements appear associated in the same sites, despite the differences in density factors.

From the 1544 identifiable mammal bone specimens, a total Minimum Number of Elements (MNE) of 306, belonging to different anatomical parts, has been documented. MNE identification for long limb bones was made within each animal group by examining bone specimens individually and using the following criteria: animal size, cortical thickness according to bone section, overlap of homologous parts, differences in size and morphology.

There is a small number of limb bone epiphyses, so most of the diagnostic criteria were applied in identifying the abundant shaft fragments. Specimens were compared against one another to make sure they belonged to different elements before using them as valid MNE indicators. These estimates very likely underestimate the total number of bones originally present in the bone accumulation at the ST sites.

By transforming the MNE obtained in the different ST sites into Minimum Animal Units (MAU), an overall underrepresentation of animal units according to the MNI (Minimum Number of Individuals) can be observed in the bone assemblage.

When the percentage of these animal units (% MAU) is calculated, the axial parts of the skeleton (vertebrae and ribs) and the small compact limb bones (carpals, tarsals and phalanges) appear underrepresented.

This situation is documented in all the sites irrespective of animal size. Pelves and scapulae are also moderately represented. Long limb bones are dominant, when skull remains are ignored. Upper limb bones (ULB) (humeri and femora) and intermediate limb bones (ILB) (radio-ulnae and tibiae) are represented by similar number of elements, although ULB seem to be more abundant in most animal size categories.

Metapodials are, comparatively, underrepresented. Curiously, forelimbs seem to be more abundant than hindlimbs. This situation was documented in all the ST sites.

	Smaller mammals		Larger mammals		TOTAL	
Tooth marks	N	%	N	%	N	%
Upper limb bones	2/46	4.3	1/12	8.3	3/58	5.1
Intermediate limb bones	1/51	1.9	1/11	9.0	2/62	3.2
Lower limb bones	2/28	7.1	0/4	0	2/32	6.2
Total	5/125	4.0	2/27	7.4	7/152	4.6
Percussion marks	N	%	N	%	N	%
Upper limb bones	12/46	26.0	3/12	25.0	15/58	25.6
Intermediate limb bones	11/51	21.5	3/11	27.2	14/62	22.5
Lower limb bones	1/28	3.5	0/4	0	1/32	3.1
Total	24/125	19.2	6/27	22.2	30/152	19.7

Table 5: Total numbers and percentages of tooth and percusión marks (shaft specimens).

The low representation of ribs, vertebrae, compact limb bones, the low epiphisis:shaft ratio and the significant tooth marking of epiphyseal fragments support the hypothesis of significant carnivore involvement in the formation of the faunal assemblages at the ST site complex.

Bone weathering

Given the structural difference of axial, cranial and appendicular bones, long limb bone weathering analyses in the ST site complex were focused on shaft fragments from long limb bones alone.

From the sample of bones that had not been affected by diagenesis, specimens from the ST4 showed the largest amount of best preserved surfaces with stages 0 and 1 being predominant. ST2 showed a wider variety of weathering stages, being stage 1 predominant and with some specimens showing stages 2 and 3. ST3 is similar to ST2. ST15 showed mostly fresh bone surfaces with only 25% of the specimens showing weathering stage 2 features.The ST30, ST31 & ST32 complex showed a curious distribution. Most of the bones analyzed for weathering purposes from these sites came from ST30.

Bone specimens range between fresh O stage (43%) and weathering stage 3 (57%). In this case, it can be clearly observed that the fresh bones belong to small fauna and the more weathered specimens are from larger fauna, especially the postcrania of a Bovini.

This would rule out differential preservation in bones of the same carcass and would support an interpretation of weathering in this site as an indicator of the time of the total bone accumulation.

Most of the bone assemblage from ST4 and ST15 would have been accumulated in relatively little time, whereas ST2, ST30, ST31 and ST32 seem to have spanned a longer period, probably involving several occupational episodes.

An alternative explanation would be that the bones representing weathering stages 2 and 3 are a small part of the sample, which could result as a background scatter from previously to the hominid intervention in the area. Future research will grant further support to either interpretation.

Bone surface modifications

Results from the analysis of bone surface modifications and their anatomical distributions are presented in table 5. Tooth marks have been observed in almost one out of two epiphyses from limb bones and one out of three rib fragments. Tooth marks occur in a fairly low percentage (4.6%) on limb shaft fragments, with a moderately higher percentage in large-sized carcasses (Table 5). Metapodials appear tooth marked at a higher rate than meat-bearing bones.

Percussion marks occur in all limb bone types. The contrast of their occurrence in meat-bearing bones compared to metapodials is fairly marked. Percussion mark rates are broadly similar in both carcass size categories.

Both percussion marks and tooth marks at the ST site complex support the hypothesis that hominids had primary access to carcass resources, both meat (low tooth mark percentages) and marrow (percussion mark percentages).

Tooth mark occurrence on shaft fragments appears in the lower range of variation of the Hominid-Carnivore dual-patterned experimental model (Blumenschine, 1988, 1995: Capaldo, 1995, 1998).

Cut mark patterns also support this behavioral inference: From the 154 bone fragments showing weathering stage O, several were smaller than 50-40 mm and hard to identify to element type (i.e., humerus or femur), even when limb section (i.e., upper limb bones) could be ascertained in several cases.

Overall cortical thickness and a reduced section of the shaft rendered the differentiation between intermediate and lower limb bones difficult to identify in several specimens smaller than 5 cms. A total of 90 shaft bone fragments showing weathering stage 0 were classified to element type. The resulting cut mark pattern shows a high proportion of cut marked upper limb bone shaft specimens, followed by intermediate and lower limb bone fragments.

Both in smaller mammals and larger mammals, the cut mark patterns are broadly similar. Furthermore, mid-shaft specimens are cut marked in a much higher percentage than limb bone ends. Only two epiphyses (two proximal radii from size 3 carcasses) bear cut marks on the near-epiphyseal section. The remainder of the cut marks have been documented on mid-shaft sections.

Further, a large portion (>75%) of meat-bearing mid-shaft specimens are cut marked in both carcass sizes. This is indicative of intensive defleshing (Dominguez-Rodrigo 1999). If taken together, the bone surface modification evidence reflects primary hominid access to fleshed carcasses as modeled in Hominid-Carnivore experimental scenarios (Dominguez-Rodrigo 1997, 1999).

The main difference observed between these experiments and the ST archaeofauna -which for the analysis of cut marks comes mostly from the well-preserved bone assemblage excavated at ST4- is the scarcity of cut marked limb ends. Therefore, the only carcass processing activity that can be reconstructed with the current information available is carcass defleshing, but not disarticulation. This could be a reflection of hominid behavior or sampling bias. Cut marks have been observed in all the ST assemblages (except ST3), although in smaller amounts than in ST4.

Conclusions

The paleosol exposed horizontally at Maritanane, spanning an area close to 1 km2, offers a unique opportunity to assess hominid behavior across a paleolandscape. Although small scatters of archaeological remains have been discovered in some spots of this paleolandscape, most archaeological materials are concentrated in the ST site complex area.

The detailed geological analysis of the area shows that the ST sites were situated in an alluvial setting in a deltaic environment at the intersection of several river channels. Although isotopic analyses should confirm it, the abundance of fossil root casts from plants bigger than grasses suggests some degree of closed vegetation.The widespread nature of all the archaeological materials at the ST sites contrasts with the discrete densities documented at Koobi Fora (Kenya) and Olduvai Gorge (Tanzania).

The existence of spatially differentiated bone concentrations, the different degrees of weathering on limb bone shafts and the overall low densities of materials (both of stones and bones) supports the interpretation that the ST site complex represents an overlaping set of loci in the alluvial landscape of Maritanane that hominids created by repeatedly visiting the area.

Carcasses may have been obtained in or near that alluvial setting. Remains bearing cut marks and belonging to large-sized animals such as rhinoceros and *Sivatherium* suggest that hominids obtained carcasses in the same area. The *Sivatherium* remains at ST4 indicate that they belonged to the same individual, which was complete when processed by hominids.

If the alluvial area was not very open, the abundance of antilopini and alcelaphini would be indicative of their transport by hominids from the nearby more open areas. Regardless, most game could have been obtained very close to the ST sites given the overall open nature of the landscape (Dominguez-Rodrigo et al. 2001a).

Most likely, carcasses were fully fleshed when transported to sites, as indicated by the percentages and distribution of cut marked and tooth marked bone specimens. Based on a landscape taphonomy study in the area, there was a high degree of carnivore competition in Maritanane during the formation of the paleosol.

This contradicts the widely accepted scavenging scenarios proposed to account for early hominid behavior. In fact, the ST site complex at Peninj suggests that hominids were obtaining and transporting fleshed carcasses to certain areas and then, leaving these places after processing the carcasses. The behavior reconstructed implies a substantial degree of complexity, planning and dynamic interaction with the environment to obtain carcasses, in which predatory strategies on small and middle-sized animals should seriously be considered.

The analysis presented in this work also suggests that the industry from the ST Site Complex of Peninj corresponds mostly to flaking activities carried out at sites. This is inferred by the predominance of flakes and cores.

The initial stages of the operational chain (raw material obtainment, initial core flaking) are absent. These unrepresented phases were probably carried out outside the ST Site Complex area. This process must have included not only the initial debitage of cores, but also posterior flaking stages, since the percentage of flakes showing some cortex is always low. However, flaking activities *in situ* are clearly documented as suggested by the presence of split fractures, the abundance of flakes and cores and the presence of hammerstones.

These flaking activities were very likely related to carcass processing behaviors, as indicated by the close spatial association of bones and stone tools and the presence of cut-marked bone specimens.Indeed, the technology displayed by the Peninj hominids is fairly complex; the aim of this technical process is the preparation of the extractions on the main flaking surface of the cores, in order to obtain predetermined flakes.

This predetermination is similar to the Levallois method, which modifies raw materials from a volumetric conception of cores. The cognitive processes, the technical knowledge and the manual dexterity behind both strategies are very similar.

Assuming the complexity of the Levallois method and its similarities with the strategies observed in Peninj, it seem necessary to revise the technology of traditional Oldowan industries and the cognitive and behavioural inferences for Plio-Pleistocene hominids drawn thereof.

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