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Journal of Human Evolution 48 (2005) 435–472
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Late Pliocene hominid knapping skills: The case of Lokalalei 2C, West Turkana, Kenya

Anne Delagnes[a,*], Hélène Roche[b]

[a] *PACEA-UMR 9155 du CNRS, Bât. Géologie, Avenue des Facultés, 33405 Talence, France*
[b] *UMR 7055 du CNRS, Maison de l'Archéologie et de l'Ethnologie, 21, allée de l'Université, 92023 Nanterre, France*

Received 12 January 2004; accepted 22 December 2004

Abstract

Relatively few remains of Late Pliocene hominids' knapping activities have been recovered to date, and these have seldom been studied in terms of manual dexterity and technical achievements. With regard to early hominid technological development, the evidence provided by the data from 2.34 Myr site of Lokalalei 2C (Kenya) questions both the prior assumption of a continuous and linear evolutionary trend in lithic production and the idea that it long remained static. The level of elaboration evinced by the lithic assemblage is quite unexpected in view of its age, and seemingly more advanced that what can be surmised for other Late Pliocene East-African sites, including the nearby site of Lokalalei 1. Analysis relies mainly on the dynamic reconstruction of entire cobble reduction sequences from particularly informative refitting groups. The Lokalalei 2C knappers had already internalised the notion of planning and foresight in raw material procurement and management. Beyond simple mastery of the basic technical constraints peculiar to stone knapping, they conducted a highly controlled *débitage* of flakes following constant technical rules and resulting in high productivity. The data suggest that early hominids displayed distinct technical competencies and techno-economic patterns of behavior, thus pointing to an intrasite complexity and intersite diversity which are not accounted for by the existing chrono-cultural classifications.

Résumé

Les activités de taille des hominidés pliocènes sont à ce jour représentées par un nombre restreint d'ensembles lithiques et ceux-ci n'ont quasiment pas été étudiés en termes d'habiletés et d'acquis techniques. Dans ce registre du développement technologique des premiers hominidés, le site de Lokalalei 2C (Kenya), estimé à 2.34 Ma, fournit un ensemble de données qui remet en question tout autant l'idée d'une évolution linéairement continue que celle qui privilégie au contraire l'immobilisme des productions humaines anciennes. L'étude de cet ensemble lithique révèle un

* Corresponding author. Tel.: +33 5 40 00 84 52; fax: +33 5 40 00 84 51.
E-mail address: a.delagnes@ipgq.u-bordeaux1.fr (A. Delagnes).

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doi:10.1016/j.jhevol.2004.12.005

niveau d'élaboration inattendu compte tenu de son ancienneté, et semble-t-il plus élevé que celui pressenti dans les sites est africains sub-contemporains, y compris dans le site voisin de Lokalalei 1. L'analyse s'appuie sur une lecture directe des séquences de réduction des blocs à partir d'ensembles remontés particulièrement informatifs. Les tailleurs de Lokalalei 2C avaient déjà acquis la notion d'anticipation dans l'acquisition et l'exploitation de la matière première. Bien au-delà de l'élémentaire maîtrise des contraintes liées à la taille des roches dures, ils pratiquaient un débitage d'éclats selon des principes techniques constants, conduisant à une forte productivité, au moyen de gestes de percussion parfaitement maîtrisés. Ces données suggèrent une complexité intra-site et une diversité inter-site des comportements techniques des plus anciens hominidés dont les classifications chrono-culturelles existantes sont loin de rendre compte.
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Keywords: East Africa; West Turkana; Kenya; Early Hominids; Pliocene Archaeology; Technical Skills; Lithic Technology; Refittings

Introduction

Although Late Pliocene hominids (genera *Australopithecus* and *Homo*, between 2.6 and 2.0 Myr) form a numerically important and widely discussed group of fossil taxa, their stone tools are still poorly documented. For several decades, the main focus of research has been the discovery of new fossil hominids, while the archaeology itself received only cursory attention. As a result, we know more about the hominids of these periods than about their technical achievements. Moreover, the association of the former with the latter remains problematic. The context is so far fully reliable for under a dozen sites (Hadar and Gona : Corvinus and Roche, 1980; Roche and Tiercelin, 1980; Harris 1983; Kimbel et al., 1996; Semaw et al., 1997; Semaw, 2000; Omo : Chavaillon 1976; Merrick and Merrick, 1976; West Turkana : Kibunjia et al., 1992; Kibunjia, 1994; Roche et al., 1999; Kanjera : Plummer et al., 1999), and only one of these (Hadar AL 666, Kimbel et al., 1996) has yielded hominid fossil remains associated with stone artefacts. In addition, the scanty data available to date are not exploited in terms of knapping skills and technological evolution. Yet the very earliest hominid stone tools known provide unmistakable evidence for **intentional** flaking, implying an empirical understanding of the mechanics of fracture of hard rocks, geared towards obtaining a substantial number of sharp-edged implements. This understanding demands that the basic technical constraints peculiar to stone knapping be mastered. The major raw material constraints are homogeneity and shape, the ideal shape showing intersecting striking surfaces and regular convex or flat flaking surfaces, with edge angles below 90°. Knapping constraints dictate requiring accurately aimed blows, which must not fall too far or too close to the edges, and blows delivered with a strength matched to the resistance of the materials. It is evident that the Plio-Pleistocene hominids responsible for making these earliest stone assemblages have moved far beyond the stage of an unintentional production of debris such as that resulting from the accidental breakage of hammerstones at the nut-cracking loci of chimpanzees (Mercader et al., 2002), which should not be mistaken for intentional flaking. Late Pliocene stone-working is not technology in its infancy. No discovery has so far documented such a primary stage, and it is likely that the corresponding remains would be very difficult to identify, although it may be assumed that modified stones were used prior to the oldest clearly intentionally flaked artefacts dated between 2.6 and 2.5 Ma (Semaw et al., 1997; Panger et al., 2002). Does this necessarily mean that similar competence appeared everywhere according to a synchronic and uniform pattern, or is there evidence for a staggered development of knapping skills during almost a million years? This is precisely what the study of the Lokalalei 2C material, estimated at 2.34 Myr, strongly suggests. The Lokalalei knappers appear to have reached a more advanced state of technological development than most of their East-African counterparts. This is shown by their planning capabilities, their manual dexterity, the consistency of their flaking processes and resulting productivity. Clearly, a technological reassessment of Plio-Pleistocene assemblages is required to allow meaningful comparisons and to position Lokalalei 2C within the context of Plio-Pleistocene technological development. The question remains as to which hominid species the Lokalalei 2C knappers belonged. Since the first Lokalalei results were published (Kibunjia, 1994; Roche et al., 1999), a first lower molar germ attributed to early *Homo* was found at Lokalalei 1α, in close proximity to the Lokalalei 1 archaeological site and within the same lithostratigraphic unit (Prat et al., submitted for publication). *Early Homo* thus becomes a possible candidate for making the lithic assemblages of Lokalalei 1 and Lokalalei 2C, although the robust australopithecine (KNM-WT 17000 : Walker et al., 1986, attributed by most researchers to *Australopithecus aethiopicus*) was also present at 2.5 Myr in West Turkana.

General context (Fig. 1)

The site of Lokalalei 2C was excavated as part of the West Turkana Archaeological Project (WTAP) (1), a multidisciplinary project of archaeological survey and exploration of the Nachukui Formation. This formation spans the Late Miocene to Middle Pleistocene. It lies in the Lake Turkana basin, which also encompasses the Shungura Formation to the north and the Koobi Fora Formation to the east. The major objective of the project is to document the diversity of Late Pliocene and Early Pleistocene hominid behavioral adaptations, within a topographically circumscribed study area where chronology and paleoenvironments are well understood (Kibunjia et al., 1992; Roche and Kibunjia, 1994; Roche and Kibunjia, 1996; Roche et al., 1999; Roche et al., 2003; Brugal et al., 2003; Prat et al., 2003).

The Nachukui Formation spans the period 4.35–0.7 Myr. Its archaeological importance is due to the succession of multiple hominid occupations in the time interval between 2.34 Myr and 0.7 Myr. Of the thirty or so sites, grouped into five site complexes, recorded to date, twenty have been tested or partly excavated, and seven intensively excavated. The latter include the two Pliocene sites of Lokalalei 1 (GaJh 5), excavated in 1991 (Kibunjia, 1994; Kibunjia, 1998), and Lokalalei 2C (GaJh 6C), excavated in 1997 (Roche et al., 1999).

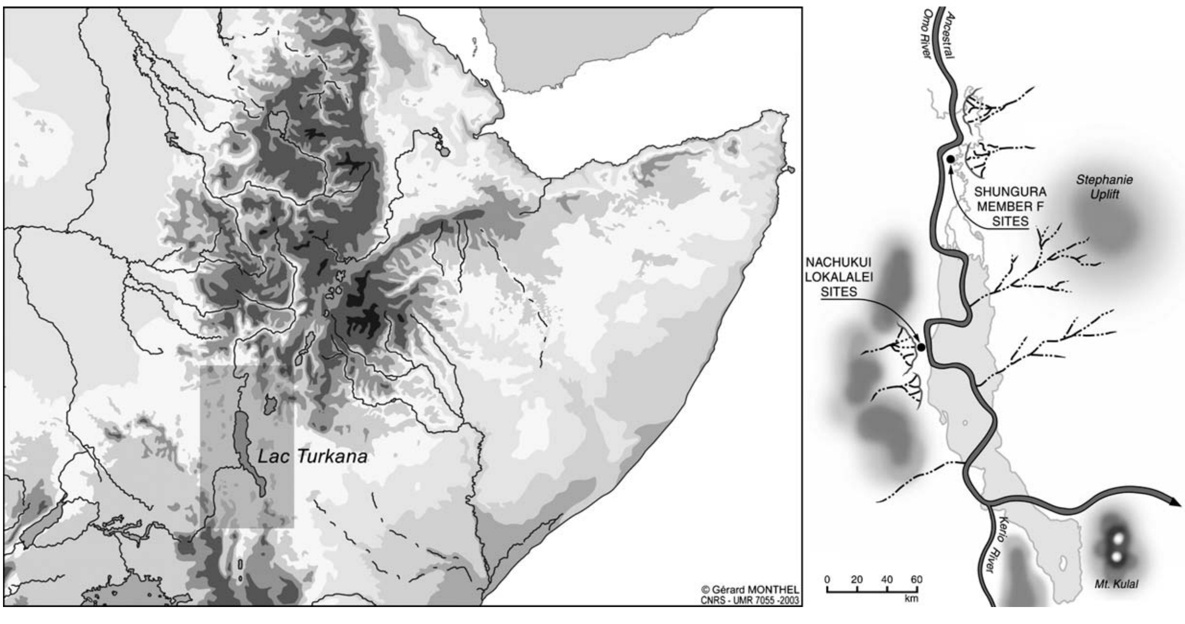


Fig. 1. Localization of Lokalalei 2C in East Africa context and Turkana Basin.

Fig. 2. Lokalalei 2C during excavation.

Both sites are located in exposures along the Lokalalei drainage, Lokalalei 2C being just 1 km south of Lokalalei 1.

Geological and chronological context

The regional paleogeography and paleoenvironments are described in a series of publications (e.g. Harris et al., 1988; Brown and Feibel, 1988, 1991; Feibel et al., 1989; Feibel et al., 1991), so that only the main features need be recalled here. The Nachukui Formation (cumulative thickness 730 m) appears in the form of a long thin band of sediments exposed between the shore of present-day Lake Turkana to the east and the Labur and Murua Rith ranges to the west by which this part of the basin is bounded. It has been divided into eight members each characterized by major tephras. These differ from one another in their geochemical composition and can be correlated with the tephras punctuating the Shungura and Koobi Fora Formations.

Lying in the southern area of exposure, the Lokalalei sites are enclosed within paleosols that formed in the alluvial plain of a fluviatile system (Paleo-Omo), within the Kalochoro Member. Sandstones associated with these paleosols suggest that the sites are located in the proximal part of the alluvial plain where small and probably short-lived east-flowing streams joined the main axial river system, which flows north to south (Roche et al., 1999).

Locally, Lokalalei 1 and Lokalalei 2C are correlated by a mollusc-packed sandstone, which underlies both sites. This marker was used by Brown (in Harris et al., 1988) as the local boundary between the Lokalalei and Kalochoro Members (2.35 Myr). The Kokiselei and Ekalalei Tuffs lying below the Lokalalei 1 and Lokalalei 2C sites are correlated with Tuffs E and F-1 respectively of the Shungura Formation. The Kokiselei Tuff (= Tuff E) has an estimated age of 2.40 +/−0.05 Myr, while the Ekalalei Tuff (= F1) is slightly younger than 2.34 +/−0.04 Myr (Harris et al., 1988; Feibel et al., 1989). An age of 2.34 +/−0.05 Myr is thus estimated for the Lokalalei archaeological sites (Roche et al., 1999). The

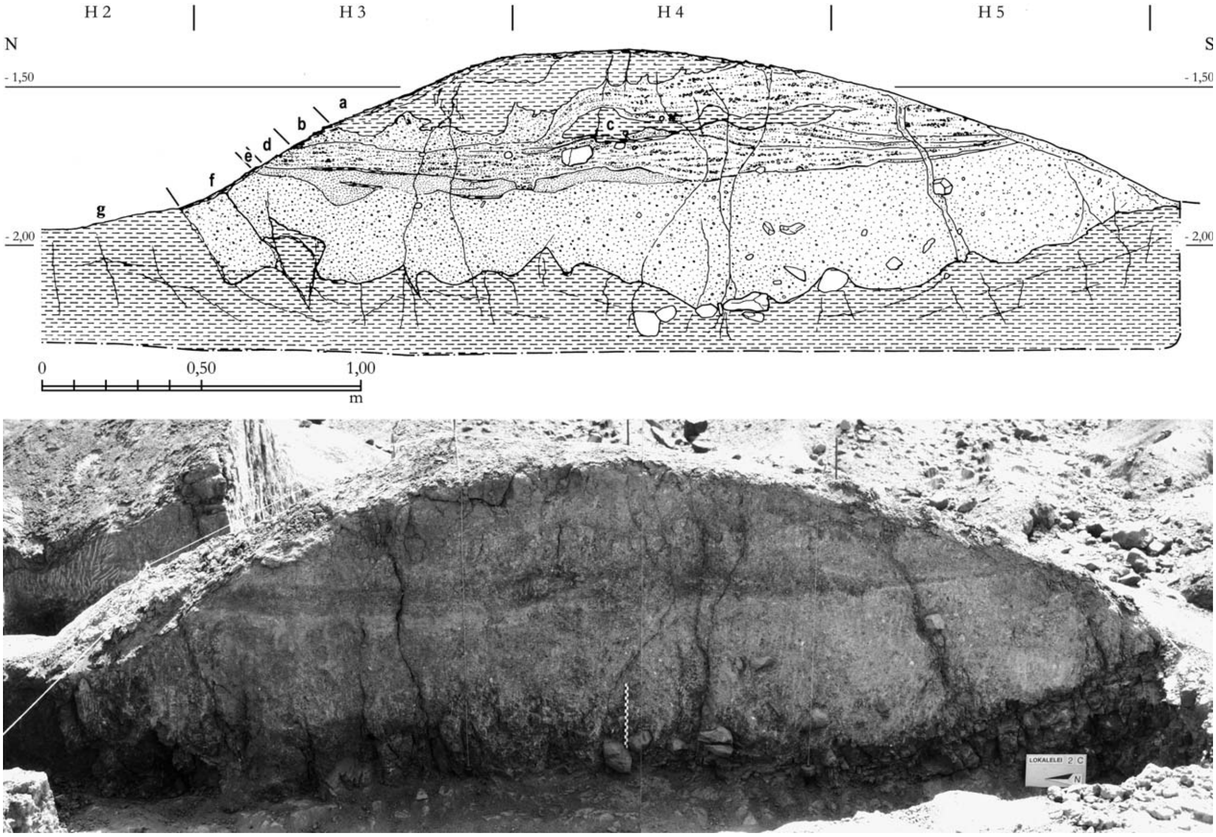


Fig. 3. Detailed stratigraphic section.

stratigraphic position of Lokalalei 2C, slightly higher in the section than Lokalalei 1, is compatible with a chronological attribution inside the same time interval. This point has been recently discussed by Brown and Gathogo (2002) who have proposed a revision of the local lithostratigraphy and of the stratigraphic correlation between the two sites. They suggest that Lokalalei 2C should be placed higher in the section than previously assumed; this is possible though not yet demonstrated. What is questionable is the temporal implications. Depending on the comparative data used to estimate the rate of sediment accumulation between the two sites, Lokalalei 2C could be "only marginally younger than Lokalalei 1" or "approximatively 100 000 years younger than Lokalalei 1" (Brown and Gathogo, 2002). For no explicit reason, Brown and Gathogo clearly favor the second possibility. Whatever the option, an age of 2.34 Myr with a standard error of $\pm$ 0.1 Myr for Lokalalei 2C is still consistent with the available data. Lokalalei 1 is slightly older. The implications of the technological differences between the two sites are discussed later.

Archaeological context

The site of Lokalalei 2 spans a series of small hills, and scattered archaeological remains (faunal and lithic) appeared on the surface of nearly all the slopes. Only two concentrations were found at the localities of Lokalalei 2C and Lokalalei 2A (80 m south of Lokalalei 2C at the same elevation). At Lokalalei 2A, two test excavations were carried out in 1994 and 1997. Lokalalei 2C was exhaustively excavated in 1996 and 1997 (Fig. 2). A total of 17 m^2 was excavated. All *in situ* deposits of this spatially restricted site were

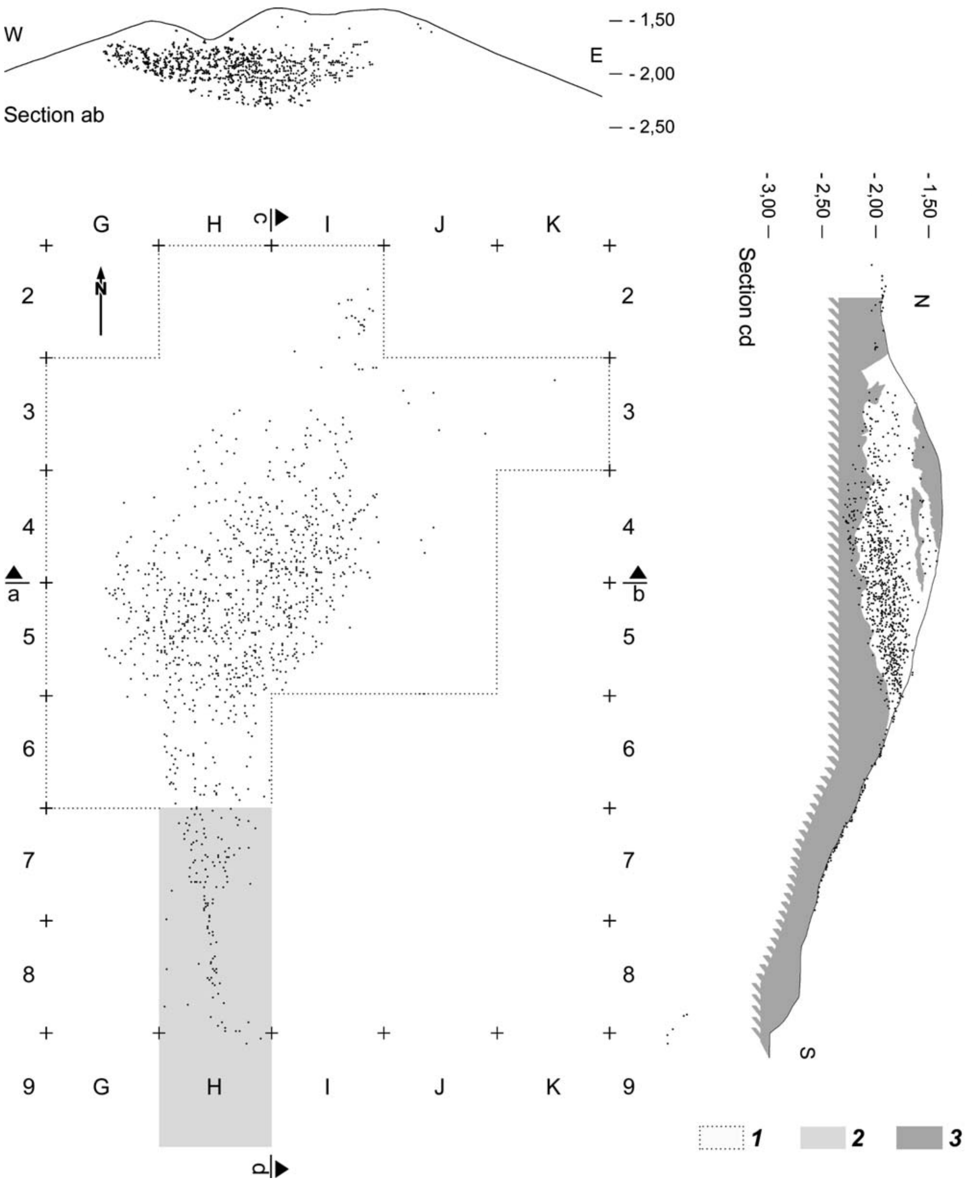


Fig. 4. Map of the excavated area and vertical projection of all the remains following the NS and WE axes. (1) *in situ* plotted material, (2) surface plotted material, (3) clay embedding the archaeological horizon.

removed. All the surface materials located on the southern slope were plotted over 3 m^2, while those lying around the site were collected and recorded over 104 m^2.

The archaeological horizon of Lokalalei 2C lies within a vertisol developed on clays interstratified with sands. At the base of the section (Fig. 3), there is a very dense dark brown silty clay with a prismatic structure, cut into by coarse grained sands in which the artefacts are distributed. Laminations of finer grained sands can be seen. An erosional contact separates the sands from an overlying clayey deposit. This sedimentary succession and the asymmetrical profile of the sand deposit strongly suggest the peripheral zone of a periodic stream.

The archaeological deposit forms a dense oblong patch, extending laterally roughly north-south over an area of 10 m^2 (Fig. 4). Its vertical distribution, over 50 cm, is consistent with the profile of the sand deposit. Such a dispersion is compatible with a vertisol context.

The homogeneity of the assemblage is demonstrated by the spatial distribution of the refitted elements (Fig. 5). Artefacts belonging to a single refitting group can be found scattered, horizontally and vertically throughout the entire sand deposit in which the remains occur. Moreover, the refitting groups include both *in situ* pieces and pieces from surface context. The distribution of the cores included in refitting groups does not show any obvious spatial patterning and nor are artefacts belonging to the same technological category (unmodified cobbles, partly flaked cobbles, percussion implements, cores, flakes) grouped together. This does not argue for the preservation of spatially identifiable knapping areas, owing to a degree of vertical and horizontal displacement. As a result, issues regarding the spatial distribution of on-site activities cannot be addressed.

The archaeological deposit is truncated by erosion on its western and eastern edges, and elements were scattered on the southern erosional slope. However, the preserved part of the site, which was exhaustively excavated, shows clear evidence of good preservation. This is suggested by the high ratio (28%) of very small elements (< 1cm) as well as by the fact that, on the whole, the stone artefacts appear remarkably fresh.

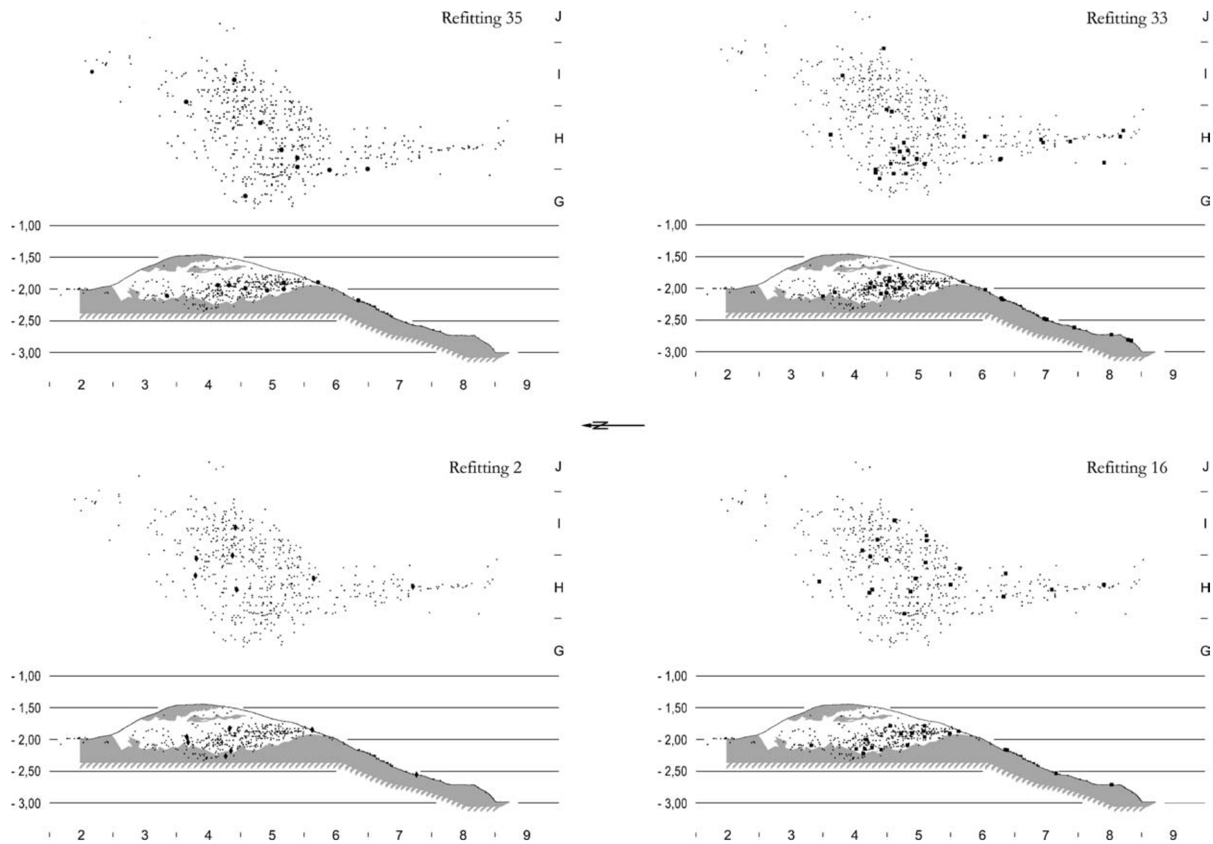


Fig. 5. Vertical and horizontal distribution of the products for four refitting groups.

Lithic remains (n = 2614) outnumber faunal specimens (n = 390) (Roche et al., 1999; Brugal et al., 2003). The faunal remains, poorly preserved, include twelve mammals species (bovids, suids, equids and an hypsodont rhinocerotid) represented mainly by teeth, as well as reptile bones (Crocodylidae), shell fragments of a large tortoise and fragments of ostrich egg shell. Except one cut-mark on a mammal bone fragment (gazelle size) from surface context, no other evidence of hominid action on bones has been recognized (Brugal, pers. com.).

The *in situ* and surface plotted lithic material (Table 1) falls into two main categories. The knapped component comprises cores, whole or broken flakes and retouched pieces, some cobbles displaying a few flake scars and hammerstones. The remainder consists of a small number of unmodified split cobbles. Judging from the grain size of the enclosing sediments, these appear to have been intentionally brought in to the site as "manuports".

The relative proportions of the different categories of artefact suggest that Lokalalei 2C was a knapping spot. Between 185 and 195 cobbles or fragments of cobbles were transported to the site, 90 to 95 of which were flaked on the spot, following an organized knapping sequence for 55 of these. Preliminary microwear studies of a sample of 12 flakes have so far yielded no positive indications. Nevertheless, some 22 pieces bearing evidence of retouch demonstrate that hominids at the Lokalalei 2C site used at least some of the artefacts produced for on-site probably subsistence-related activities.

The lithic assemblage of Lokalalei 2C

The lithic material of Lokalalei 2C can be divided into two technologically significant sets, both related to a *débitage* system. The word *débitage* is used here in its original meaning, which is an "intentional flaking of blocks of raw material, in order to obtain products that will either be subsequently shaped or retouched, or directly used without further modification" (Inizan et al., 1999, p.155). It is opposed to *shaping*, which refers to a "knapping operation carried out for the purpose of manufacturing a single arterfact by sculpting the raw material in accordance with the desired form" (Inizan et al., 1999, p.138). The first set, characterized by a small number of cores and flakes, corresponds to a type of *débitage* that we describe as simple. Included within this set are pieces displaying few

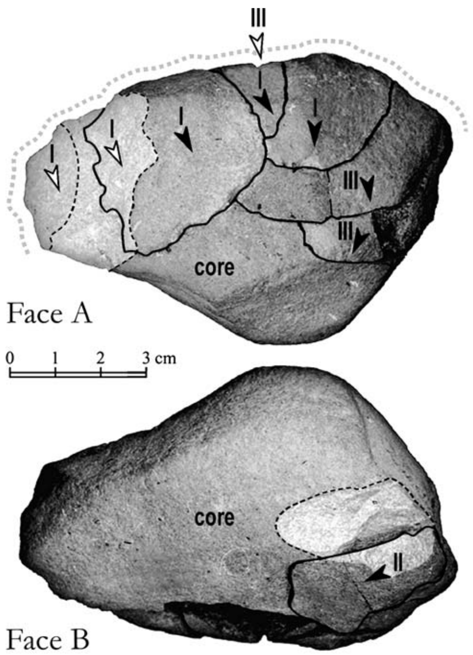
Table 1
Lokalalei 2C lithic assemblage components (the final figures in this table differ slightly from those published in the preliminary study by Roche et al., 1999)

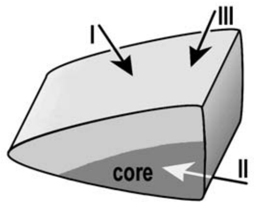
Category	Excavation	Surface	Total	% of assemblage	Refitted	% of category
Whole flakes	366	134	500	*19.1*	98	*19.6*
Broken flakes	517	242	759	*29.0*	123	*16.2*
Small flakes (< 1 cm)	692	30	722	*27.6*	0	*0*
Fragment indet.	329	51	380	*14.5*	19	*5.0*
Retouched pieces	13	8	21	*0.8*	6	*28.6*
Whole cores	52	18	70	*2.7*	27	*38.6*
Broken cores	12	3	15	*0.6*	8	*53.3*
Hammerstones	18	0	18	*0.7*	0	*0*
Worked cobbles	20	1	21	*0.8*	1	*4.8*
Broken cobbles	49	5	54	*2.1*	3	*5.6*
Unmodified cobbles	54	0	54	*2.1*	0	*0*
Total	2122	492	2614	*100.0*	285	*10.9*

flake scars, as well as split and unmodified cobbles. The second set, which is the more significant, hinges upon a principle of *débitage* that we identify as organized. The characteristics of this technological set are documented by our study of the refitting groups and of the set's core component. The two sets are made of petrographically distinct lava cobbles, whose physical and mechanical properties and overall shape are quite different. All those lavas (phonolite, trachyte, basalt and rhyolite) were available in a channel at a maximum distance of 50 m from the site (Harmand, in prep.).

Unmodified material and simple débitage

The whole or split unmodified cobbles and those with rare flake scars are medium-sized

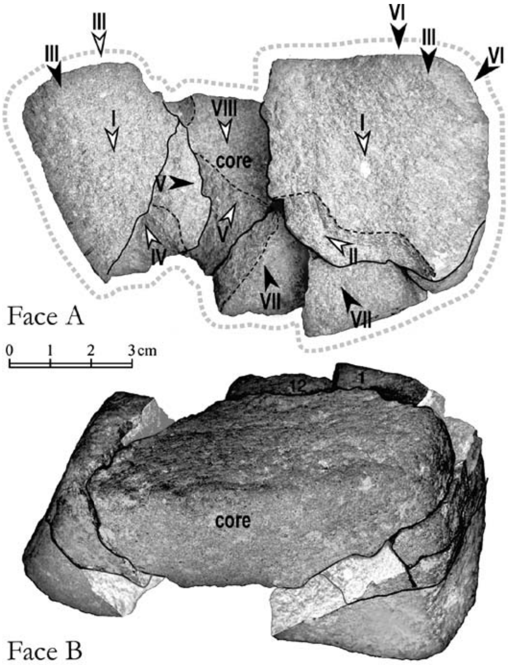


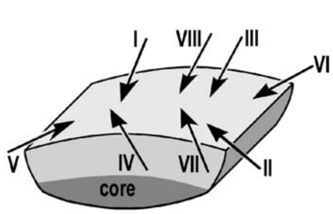


Series	Refitted pieces *(fragments)*	Missing pieces	Total of refitted and missing pieces
I	3 *(3)*	2	5
II	1 *(1)*	0	1
III	2 *(3)*	1	3
core	1 *(1)*	0	1
TOTAL	**7** *(8)*	**3**	**10**

direction of refitted flakes
direction of missing flakes
direction of successive series of removals
I, II, III .. successive series of removals
extension of suitable natural striking platforms

Fig. 6. Refitting group 2 (8 items). This group comprises the majority of the products detached from a small elongated ovoid medium-grained phonolite cobble (L = 9.4 cm, B = 6.3 cm, Th = 4.1 cm), with a large flat face opposed to a markedly convex and irregular one. *Débitage* was carried out on the flat face. Flakes were removed from a single edge, the longest one, which is also the only edge showing slightly acute angles that are serviceable as striking platforms. A large portion of this edge was exploited to produce a first series (I) of short to invasive flakes. The term "series" refers to a set of parallel or sub-parallel removals struck from the same edge; the passage from one series to another implies a change of flaking direction. The knapper then proceeded to rectify the striking platform, which presented along its yet unexploited edge a small step liable to impede further progress. The block was therefore inverted and the irregularity suppressed by a single removal (II) parallel to the edge of the striking platform. This is a flake broken into three fragments, one of which is missing. A final series of flakes (III), at a slight angle to the first, was then struck from the platform thus regularized. The last flake of the series is deeply hinged, after which the core was abandoned (Fig. 14, n°2). One of the flakes of this refitting group shows continuous retouch along one edge (Fig. 18, n°2).Refitting group 2 presents an example of a technical deadlock. The possibilities the knapper was presented with were undeniably restricted by the lack of extensive edges with appropriate striking angles. Since flakes could only be struck from one edge, the flaking surface was rapidly disfigured, and this inevitably resulted in a knapping accident. Moreover, as it was impossible to produce further flakes perpendicular or opposed to the hinged flake, the knapper was unable to restore the core and this caused its discard. The knapper proved capable of overcoming the difficulty presented during *débitage* by the irregularity of the striking platform, by means of a single shrewdly placed blow, which removed the impeding projection.





Series	Refitted pieces *(fragments)*		Missing pieces	Total of refitted and missing pieces
I	0	*(0)*	1	1
II	0	*(0)*	1	1
III	2	*(2)*	1	3
IV	0	*(0)*	1	1
V	1	*(1)*	1	2
VI	2	*(3)*	0	2
VII	2	*(2)*	0	2
VIII	0	*(0)*	1	1
core	1	*(1)*	0	1
TOTAL	**8**	*(9)*	**6**	**14**

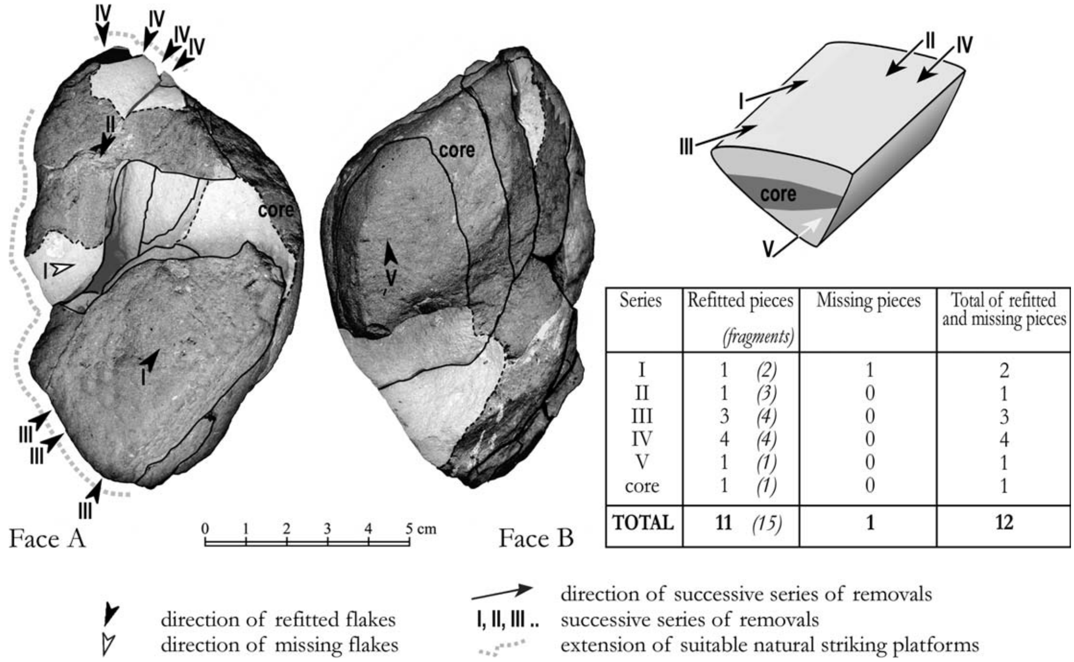
direction of refitted flakes
direction of missing flakes
direction of successive series of removals
I, II, III .. successive series of removals
extension of suitable natural striking platforms

Fig. 7. Refitting group 3 (9 items). Refitting group 3 is characteristic of the technological principles that guided the production of flakes at Lokalalei 2C. Substantially less complete than the refitting group 2, this group includes some of the products struck from a medium-sized fragment of a medium-grained phonolite cobble (L = 10.1 cm, B = 6.8 cm, Th = 4 cm). First, the cobble was split lengthwise, reducing its thickness by half. One of the two fragments thus obtained could not be refitted and seems to be missing altogether from the assemblage. This item raises the question of an initial phase of fragmentation of the blocks taking place off-site, perhaps where the raw material was collected. Flaking of the remaining fragment was carried out on the large plane created by the initial break surface. The dihedron formed by this surface and the opposite convex face shows an edge angle below 90° around almost the entire perimeter. The knapper turned to use all of these natural striking platforms. The two longest available edges are the most intensively flaked, and *débitage* therefore runs mainly across the breadth of the core. The eight series of removals (I to VIII) do not comprise more than three successively struck flakes and are sometimes restricted to a single flake. The numerous changes of flaking direction ensured that the surface remained reasonably flat and regular. The flakes produced have cortical butts and thick cortical backs that severely reduced the thickness of the core. Probably because it was no longer thick enough for further flaking, the core was then abandoned. It shows small and sometimes hinged final flake scars (< 1 cm) on parts of the two longest edges (Fig. 14, n°1). These could be signs of use damage.

specimens (mean 7.6 cm x 5.4 cm x 4.2 cm, and see Table 2), with maximum dimensions not exceeding a dozen centimetres for the biggest pieces. They possess shorter lengths and narrower widths than the flaked cobbles resulting from the organized *débitage*, but similar thicknesses. Original mean dimensions of the flaked cobbles (12 cm x 6.7 cm x 4.2 cm) are inferred from the refitting groups.

The majority of the 54 unmodified pieces are rounded cobbles, with only seven angular specimens. They are mostly trachyte and basalt, unlike the flaked component, mostly phonolite.

The very slightly modified cobbles (20) generally display a single flake scar, occasionally two or three, as if the pieces had been discarded after having been tested. It should be noted that most of these cobbles are angular specimens, their shape being quite similar to that of the cores on which an organized *débitage* was carried out. On the other hand, most of them are medium grained trachyte, a less homogeneous raw material than the



Series	Refitted pieces (*fragments*)	Missing pieces	Total of refitted and missing pieces
I	1 (*2*)	1	2
II	1 (*3*)	0	1
III	3 (*4*)	0	3
IV	4 (*4*)	0	4
V	1 (*1*)	0	1
core	1 (*1*)	0	1
TOTAL	**11** (*15*)	**1**	**12**

Fig. 8. Refitting group 9 (15 items). This refitting group reveals the almost complete reconstruction of an elongated ovate fine-grained porphyritic phonolite cobble (L = 11.3 cm, B = 6.4 cm, Th = 4.4 cm). It has a large and relatively flat natural face opposed to a highly convex one, resulting in a sub-triangular cross-section. Flaking was carried out on this large plane from the longest available edge and a shorter adjacent edge, which are the only portions of the perimeter of the core with suitable natural striking angles. The series of flakes were alternately struck from these two edges. Their flaking directions are opposed or markedly oblique. The invasive removals of the first two series (I and II) were followed by shorter ones, several of which are very thick and severely reduced the thickness of the core (series III and IV). This applies particularly to the final flake (V), detached from the face opposed to the initial surface. As suggested for refitting group 3, the insufficient thickness of the core at this late stage (Fig. 14, n°6) led to its abandonment. Refitting group 9 illustrates the technological principles of the organized *débitage* at Lokalalei 2C, with some variation during the final phase in the flaking of the opposite face.

phonolite that represents the dominant raw materials used at Lokalalei 2C (Harmand, in prep.). The reason for the premature abandonment of these specimens very likely lies in the poor flaking quality of the raw material.

A small number of cores present a moderately high count of removal scars (up to a dozen), with seemingly random distribution, either on two distinct faces of the core or on all the faces. These removals are often hinged. The cores were worked from thick cobbles with a generally quadrangular cross-section and made of medium-grained phonolite. Differences in shape set them apart from all the other cores, and this probably accounts for their heterogeneous character and their expediently knapped condition.

Table 2
Comparison between the dimensions and weight of hammerstones and those of unmodified cobbles ("manuports")

	Length (cm)		Width (cm)		Thickness (cm)		Weight (gr.)	
	Manup.	Hamm.	Manup.	Hamm.	Manup.	Hamm.	Manup.	Hamm.
Mean	7.6	9.5	5.4	7.0	4.2	5.8	266	486
Max.	12.3	11.7	10.2	9.3	7.5	8.2	925	850
Min.	3.4	6.9	2.2	4.7	1.4	4.1	18	211
S.D.	24.28	14.24	18.52	14.21	14.53	13.02	225.36	211

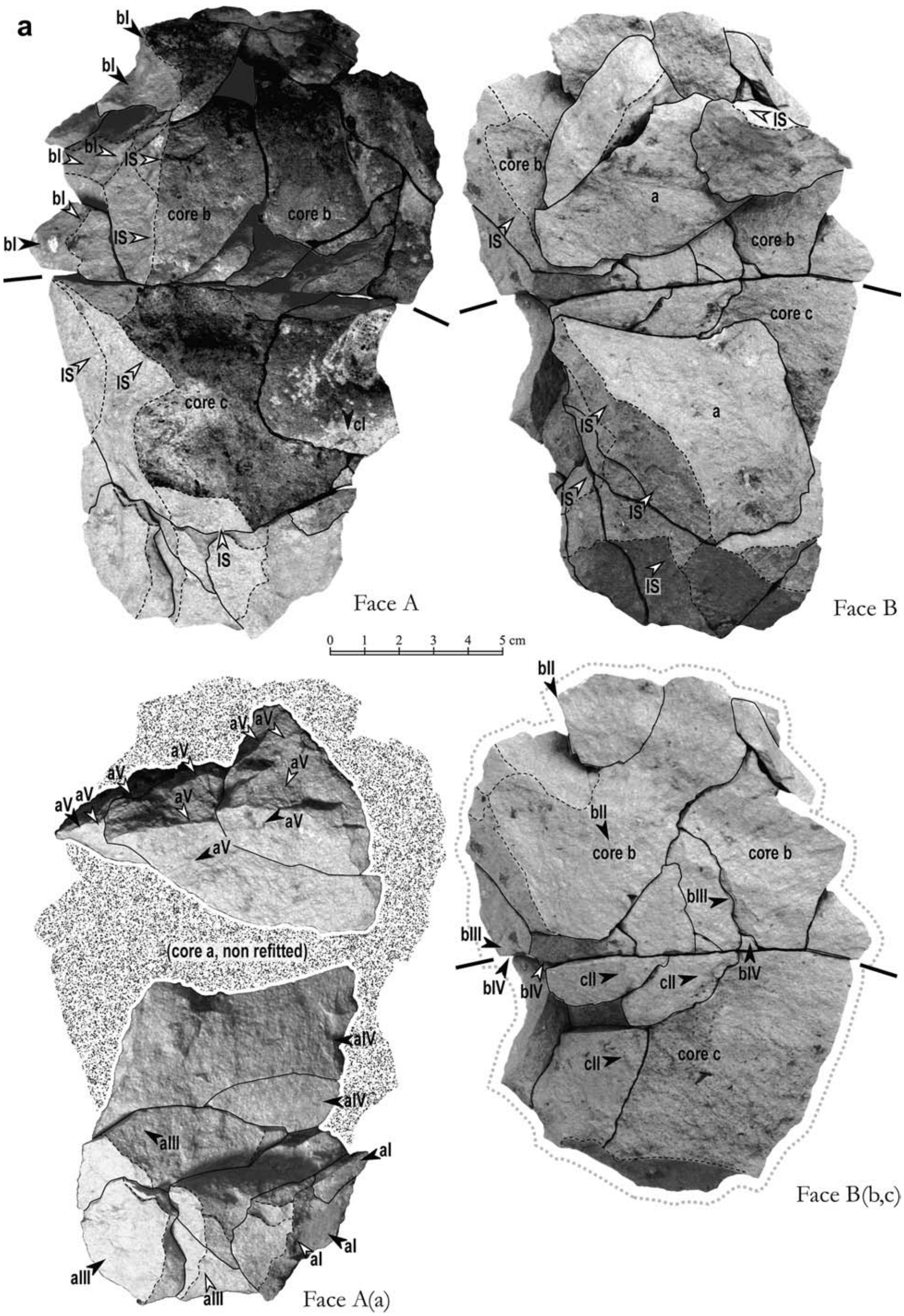
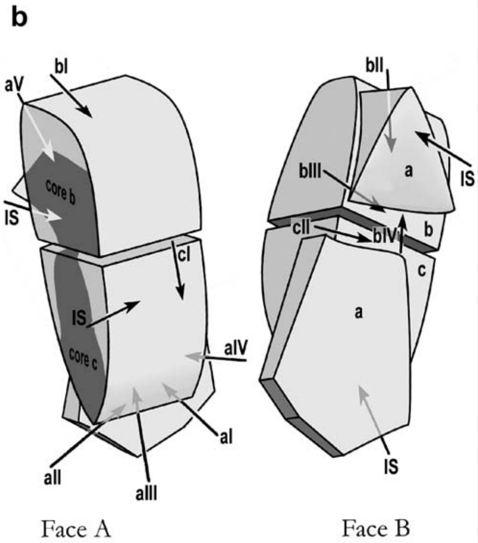


Fig. 9. Refitting group 16 (34 items). Although incomplete, refitting group 16 was shown to be made up of three distinct sub-groups (a, b, c), each of which includes a core and its related flakes. All were originally part of a large cobble (L > 20 cm) of distinctive porphyritic fine grained phonolite. There are some gaps, primarily associated with the initial phase of flaking (initial series: IS > 15 missing products) and with the final phase (sub-group a: > 16 missing products). Except for core of sub-group a and a few tiny elements, all of the products from this block could be refitted. And this is the only block of this locally available phonolite in the assemblage. Clearly, the missing elements of the initial phase, and those of the final phase (sub-group a), were either flaked off-site or removed from the site after having been produced there. The initial series (IS) are composed of a large number of relatively thin and not very invasive removals. The flakes were struck from

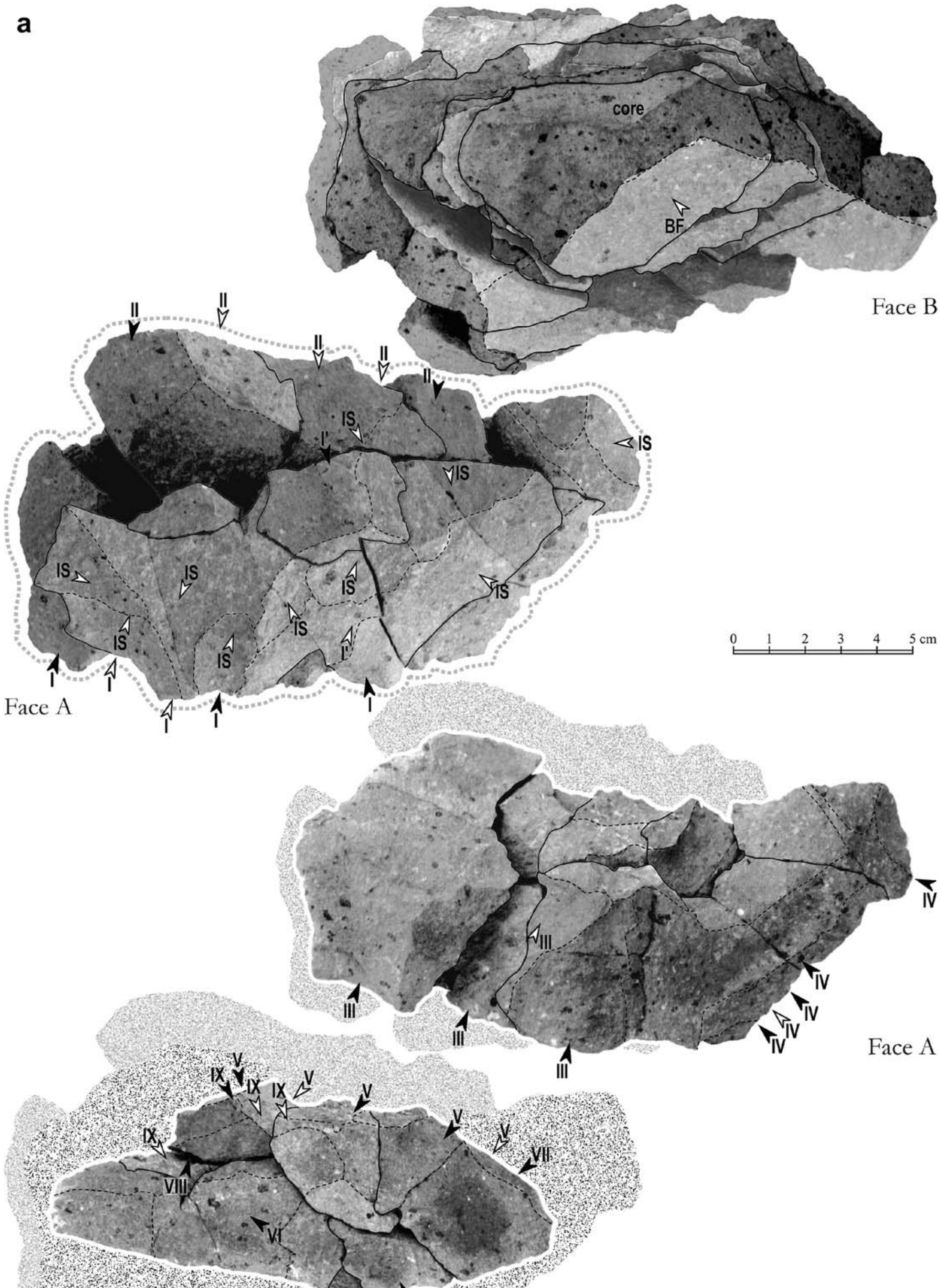


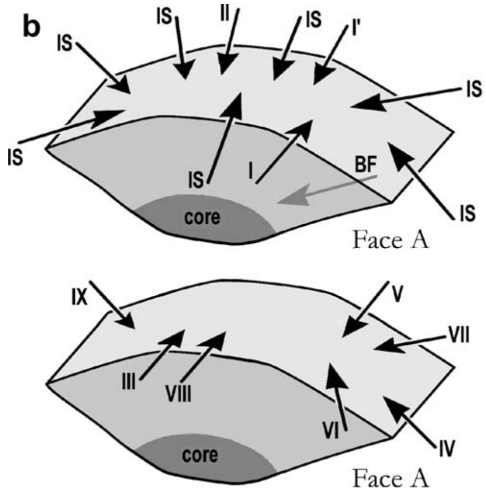
Series	Refitted pieces *(fragments)*	Missing pieces	Total of refitted and missing pieces
Initial Series	**0** *(0)*	**≥15**	**≥15**
aI	3 *(3)*	1	4
aII	1 *(1)*	0	1
aIII	1 *(1)*	1	2
aIV	5 *(5)*	0	5
aV	3 *(3)*	>5	>8
aVI	0 *(0)*	>16	>16
core	0 *(0)*	1	1
Total a	**13** *(13)*	**>24**	**>37**
bI	3 *(3)*	3	6
bII	2 *(3)*	0	2
bIII	2 *(5)*	0	2
bIV	3 *(3)*	≥2	≥5
core	1 *(2)*	0	1
Total b	**11** *(16)*	**≥5**	**≥16**
cI	1 *(1)*	0	1
cII	2 *(3)*	1	3
core	1 *(1)*	0	1
Total c	**4** *(5)*	**1**	**5**
TOTAL	**28** *(34)*	**>45**	**>73**

direction of refitted flakes
direction of missing flakes
direction of successive series of removals
I, II, III .. successive series of removals
extension of suitable natural striking platforms
IS initial series

Fig. 9 (*continued*).

the two longest opposing edges of the original cobble, and removed on one face from one edge and on the other face from the opposite edge. Being not very invasive and because their fracture planes intersect the flaking surfaces at a steep angle, these removals appear quite different from those observed on the other cores. They could belong to a phase of core preparation. This suggestion is particularly attractive since they occur immediately before the detachment of a very large flake (L = 15.2 cm, B = 10.5 cm, Th = 4.3 cm) that greatly exceeds the dimensions of other flakes. This flake broke lengthways into two during *débitage*, an incident known as a *Siret* accidental break (i.e. initiated at the impact point and splitting the flake into two equal parts). At this point, flaking was subsequently conducted on three distinct elements, sub-group a, corresponding to the original cobble on which *débitage* was pursued after the large flake was detached and sub-groups b and c, corresponding to the two pieces of the large flake recycled as flake-cores. Very incomplete sub-group a is made up of two independent sets of flakes, which could however each be refitted on the previously detached large flake. The refitting products consist of five successive series of removals (aI to aV), struck primarily from one of the two long edges of the core and secondarily from the two short adjacent edges. The flakes are moderately invasive and most of them have thick wide butts. One or possibly several subsequent series are lacking and add up to a substantial number of flakes (> 16). On the other hand, the final core, although not refitted, is present in the assemblage. The core was flaked on both its faces and apparently around its entire perimeter. At this final stage, the two faces are relatively convex and disfigured by short, deeply hinged flake scars. How does one account for the missing specimens that fit in between the final core and the refitting series? Could they have been removed wholesale and discarded elsewhere after having been flaked on the spot? Or were they produced off-site? Whatever the answer, these gaps nonetheless certainly ensue from a spatial and temporal break in the lithic production. The *débitage* of sub-group b (the left-hand side fragment of the large flake) begins on the dorsal face of the blank, which has a high proportion of cortical covering. The removals of this first series (bI) are small (between 1 and 3 cm), the curvature of the flaked face precluding the detachment of invasive flakes. Subsequently, *débitage* was continued on the ventral face of the blank, consisting of a large plane. Three series (bII to bIV) were produced, struck from adjacent edges exploited one after the other as flaking progressed around the flake-core. The last series (bIV) intersects the original accidental break of the large flake. These tiny hinged final removals caused the flake-core to break into two fragments (Fig. 15, n°1). It was then discarded. Do these removals show that the knapper stubbornly strove to strike flakes from an unsuitable edge, with slightly too high an angle? Since no similar behavior can be observed on any of the other cores, it seems more likely that the core was recycled for use as a pounding implement producing unintentional small flakes. Sub-group c, the right-hand side fragment of the flake recycled as a flake-core, was flaked from one of its edges only. *Débitage* starts off on the dorsal face of the blank, with a flake (cI) struck from the initially broken edge removing a markedly concave cortical zone. As in group 2, the knapper rectified the striking platform, from which no *débitage* could be immediately conducted owing to its concave profile. The plane thus created was used as a platform to detach a series of flakes (cII) from the opposite face. The flake-core (Fig. 15, n°2) was abandoned at a stage of reduction when there was still a volume of exploitable material and even though no knapping accident had occurred.


a
core
BF
Face B
Face A
Face A
Face A
IS
I'
II
I
III
IV
V
VI
VII
VIII
IX
0 1 2 3 4 5 cm



Series	Refitted pieces	(fragments)	Missing pieces	Total of refitted and missing pieces
BF	0	(0)	1	1
IS	0	(0)	≥9	≥9
I	3	(8)	2	5
I'	2	(3)	6	8
II	3	(4)	2	5
III	3	(5)	1	4
IV	4	(7)	1	5
V	3	(4)	2	5
VI	2	(3)	0	2
VII	1	(1)	0	1
VIII	1	(1)	0	1
IX	1	(1)	3	4
core	1	(1)	0	1
TOTAL	**24**	(38)	**≥27**	**≥51**

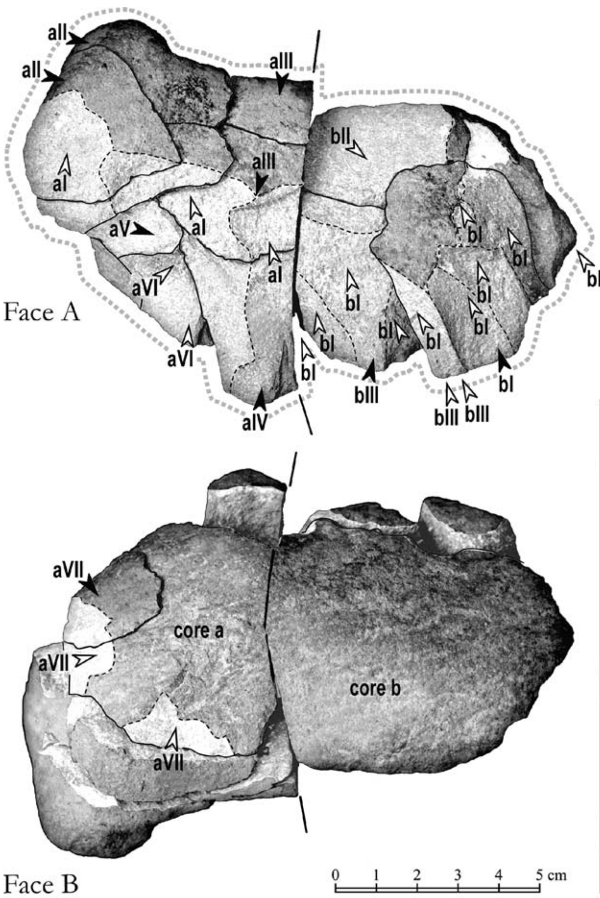
direction of refitted flakes
direction of missing flakes
direction of successive series of removals
I, II, III .. successive series of removals
extension of suitable natural striking platforms
IS initial series
BF block fragmentation

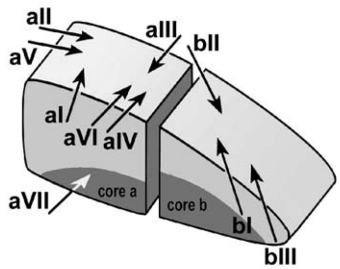
Fig. 10 (*continued*).

Organized débitage

The study of the organized *débitage* relies mainly on the data provided by the refitting groups (Figs. 6–13). The number and quality of these refittings (Table 3) have allowed a precise reconstruction of the flaking sequences. The proportion of the refitted elements reaches 10.9% of the total assemblage and 16.1% of the *débitage* component (excluding the very small elements < 1cm). The

Fig. 10. Refitting group 33 (38 items). This is a large refitting group (L = 15.7 cm, B = 7.4 cm, Th = 5.6 cm) which includes a substantial number of the products detached from a fragment of a porphyritic and fine grained basalt cobble. Only 10 small flakes (< 2 cm) or flake fragments removed from this cobble of distinctive and easily recognizable raw material are not refitted. The cobble was first broken up, as shown by the large fracture plane (BF) on one of the faces of the flaked fragment. The fracture plane forms with the adjoining cortical zone a markedly convex face, thus giving the fragment a trapezoidal shape with a large flat face on which the flaking was carried out. The other fragment of the cobble is missing from the assemblage. The initial phase is made up of several series of multidirectional flake removals struck from all around the core. These flakes (n ≥ 9) are entirely missing. They clearly do not belong to a phase of core preparation. The size of the removal scars, their invasiveness, their organization on the flaked surface, are in every respect similar to those of the following series of flakes. The absence of the flakes corresponding to the initial series suggests, as for refitting group 16, that this initial phase of *débitage* was conducted off-site after the cobble was fractured. An alternative possibility would be that all of the products of these series were carried away after having been flaked on-site. The first refitted series (I) starts off with a large flake that intersects all previous removals. This flake was then modified by removals struck from the two long proximal and distal edges, from both its faces (I'). The purpose of this operation is not readily understood. The deliberate production of these flakes seems unlikely considering their diminutive size. Rather they seem to result from the use of the flake as a tool, in which case the scars would correspond either to intentional retouch or to signs of damage from use. At eight, the number of successively flaked series (I to IX) is particularly high for this core, struck mainly from the two long opposing edges. Each series is characterized by removals from a direction either opposed or at an angle to that of the removals of the previous series. The number of flakes within a single series is also high, at least for the first series. There is a trend towards fewer flakes for the final series (VI, VII and VIII), a result of the diminishing core dimensions. No significant knapping accidents occurred, and *débitage* comes to an end when the core (Fig. 14, n°5) has been considerably reduced. The final phase (IX) consists of a series of very small removals (< 1 cm), resulting in contiguous retouch scars along a limited portion of a long edge. Again, it is difficult to say whether this is intentional retouch or use damage.



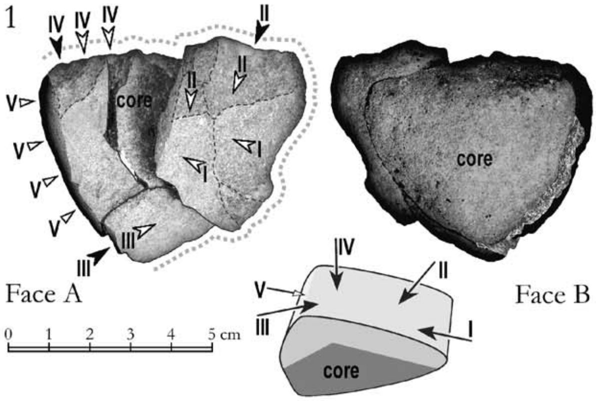


Series	Refitted pieces *(fragments)*		Missing pieces	Total of refitted and missing pieces
aI	0	*(0)*	≥3	≥3
aII	2	*(3)*	0	2
aIII	2	*(2)*	0	2
aIV	1	*(1)*	0	1
aV	1	*(2)*	0	1
aVI	0	*(0)*	3	3
aVII	1	*(1)*	2	3
core	1	*(1)*	0	1
Total a	**8**	*(10)*	**≥8**	**≥16**
bI	1	*(1)*	≥10	≥11
bII	0	*(0)*	1	1
bIII	1	*(1)*	2	3
core	1	*(1)*	0	1
Total b	**3**	*(3)*	**≥13**	**≥16**
TOTAL	**11**	*(13)*	**≥21**	**≥32**

direction of refitted flakes
direction of missing flakes
direction of successive series of removals
I, II, III .. successive series of removals
extension of suitable natural striking platforms

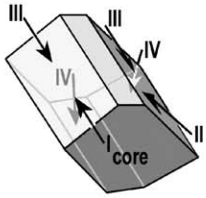
Fig. 11. Refitting group 35 (13 items). This refitting group illustrates the reconstruction of a medium-sized (L = 13.1 cm, B = 8 cm, Th = 3.7 cm) elongated roughly rectangular medium-grained phonolite cobble. In section, it is characterized by a large slightly convex cortical face opposed to a markedly convex one. The cobble was fractured widthwise into two broadly identical fragments. This occurred at an early stage of its exploitation, either at the very beginning, or just after the removal of one of the first flakes (not refitted). It is difficult to determine whether the breakage is accidental or intentional. Flaking was then conducted for each of the two fragments (a and b) on the flattest face of the original cobble. All of the flakes corresponding to the first series are missing for both fragment a (aI) and fragment b (bI and bII), with the exception of the last element from fragment b. Does this imply once again that the initial phase of *débitage* did not take place on-site? There is no firm evidence for this, because the number of missing flakes is quite high in the subsequent series, and because owing to the abundance of this type of raw material in the assemblage it has proved impossible to match all flakes with their corresponding cobble. The flaking of fragment a was carried out from three of its edges, and the series produced (aI to aVI) are broadly perpendicular to one another. No flakes could be struck from the fourth edge formed by the break surface of the block due to its obtuse angle. In the final phase of core reduction, a few small removals were taken from the previously unflaked opposite cortical face (VII). At this point, the flaked face was distinctly more convex than in the early stages of production, and this is probably why it was abandoned (Fig. 14, n°3). Fragment b was also flaked around a major part of its perimeter. However, one of the edges was preferentially used for *débitage*. The two unidirectional series (bI and bIII) are struck from this edge, opposed to the single removal (bII) which fits in between the series and restores the balance of the flaked surface. *Débitage* was discontinued despite the large residual size of the core (Fig. 14, n°4), and despite the fact that no significant knapping accident has occurred.

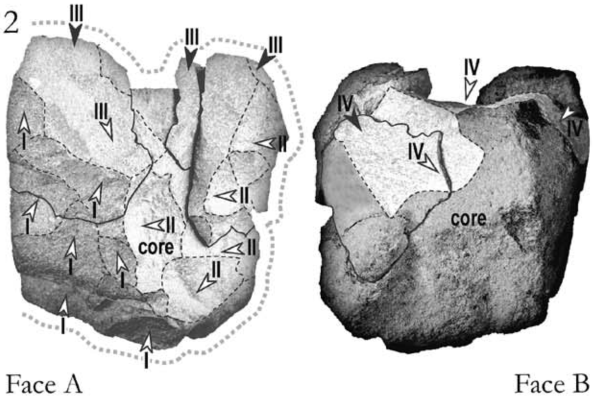
1



Series	Refitted pieces	*(fragments)*	Missing pieces	Total of refitted and missing pieces
I	0	*(0)*	2	2
II	1	*(1)*	2	3
III	1	*(1)*	1	2
IV	1	*(1)*	2	3
V	0	*(0)*	4	4
core	1	*(1)*	0	1
TOTAL	**4**	*(4)*	**11**	**15**

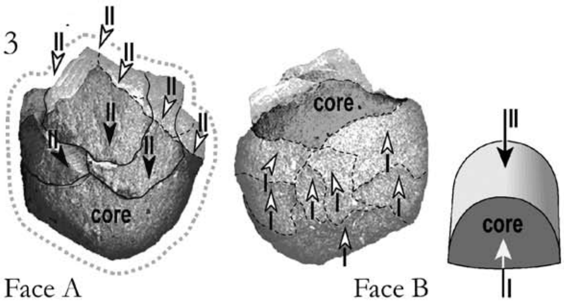
2





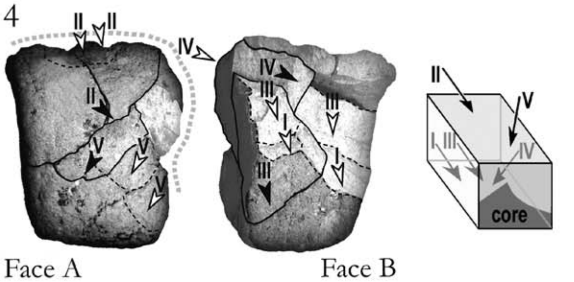
Series	Refitted pieces	*(fragments)*	Missing pieces	Total of refitted and missing pieces
I	0	*(0)*	≥7	≥7
II	0	*(0)*	≥4	≥4
III	3	*(3)*	1	4
IV	1	*(1)*	3	4
core	1	*(1)*	0	1
TOTAL	**5**	*(5)*	**≥15**	**≥20**

3



Series	Refitted pieces	*(fragments)*	Missing pieces	Total of refitted and missing pieces
I	0	*(0)*	7	7
II	3	*(3)*	5	8
core	1	*(1)*	0	1
TOTAL	**4**	*(4)*	**12**	**16**

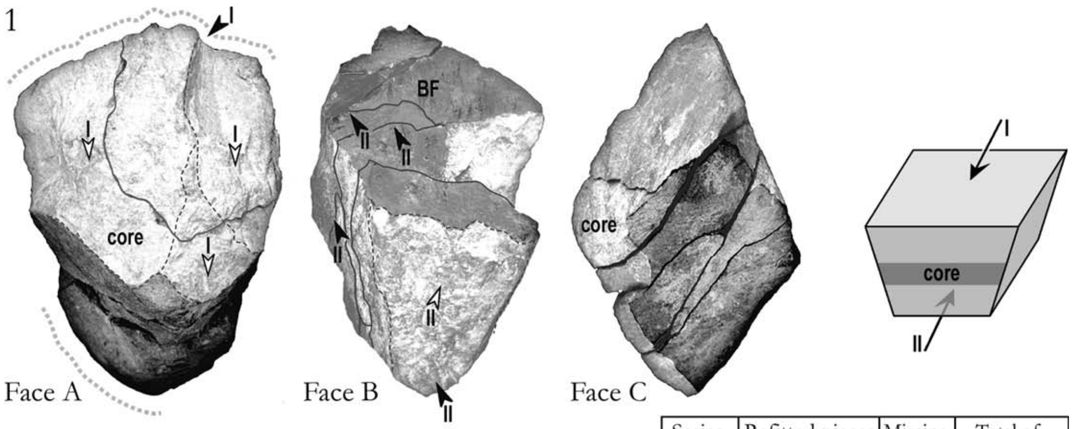
4



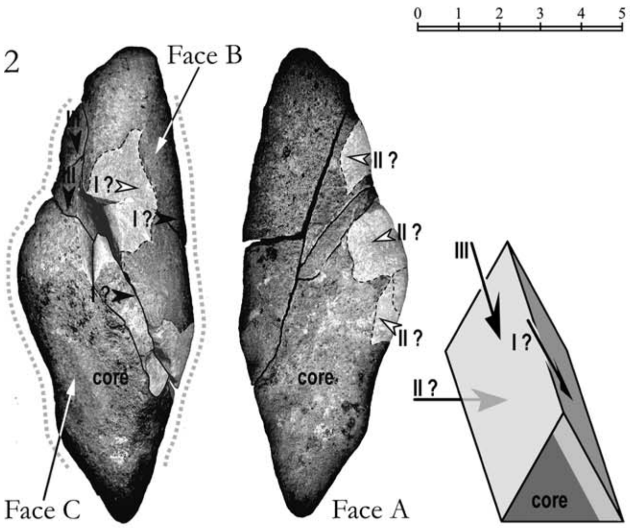
Series	Refitted pieces	*(fragments)*	Missing pieces	Total of refitted and missing pieces
I	0	*(0)*	2	2
II	1	*(2)*	2	3
III	1	*(1)*	2	3
IV	1	*(1)*	1	2
V	1	*(1)*	3	4
core	1	*(1)*	0	1
TOTAL	**5**	*(6)*	**10**	**15**

direction of refitted flakes — direction of successive series of removals
direction of missing flakes — I, II, III .. successive series of removals
direction of retouch — extension of suitable natural striking platforms

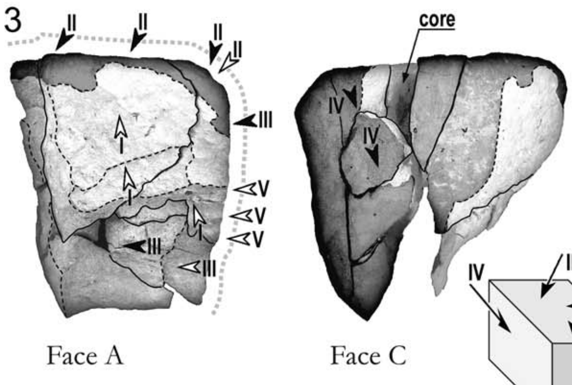
Fig. 12.



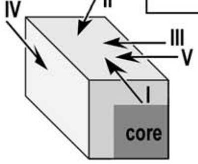
Series	Refitted pieces *(fragments)*		Missing pieces	Total of refitted and missing pieces
BF	0	*(0)*	1	1
I	1	*(1)*	3	4
II	4	*(4)*	1	5
core	1	*(1)*	-	1
TOTAL	**6**	*(6)*	**5**	**11**



Series	Refitted pieces *(fragments)*		Missing pieces	Total of refitted and missing pieces
I ?	2	*(4)*	1	3
II ?	0	*(0)*	3	3
III	2	*(2)*	0	2
core	1	*(1)*	0	1
TOTAL	**5**	*(7)*	**4**	**9**



Series	Refitted pieces *(fragments)*		Missing pieces	Total of refitted and missing pieces
I	0	*(0)*	≥3	≥3
II	3	*(3)*	1	4
III	2	*(2)*	1	3
IV	2	*(5)*	0	2
V	0	*(0)*	3	3
core	1	*(1)*	0	1
TOTAL	**8**	*(11)*	**≥8**	**≥16**



direction of refitted flakes
direction of missing flakes
direction of successive series of removals
I, II, III .. successive series of removals
extension of suitable natural striking platforms
BF block fragmentation

Fig. 13.

refitting groups contain valuable information that would have been impossible to access by any other means. In particular they reveal information on productivity (number of flakes produced per core), on the stages of introduction of materials at the site, and on the knappers' technological flexibility in coping with unexpected flaking incidents. The analysis entails scrutinizing each of the pieces in the refitting groups, following the chronology of the reduction process from the first flake produced to the final discard of the core. The order and direction of detachment of the flakes, as well as the technical consequences of each removal for the continuation of *débitage* are thus recorded in detail, a method that has already proved successful in other contexts (Delagnes, 1996a, 1996b).

The refitting groups range from very incomplete (a few conjoining flakes) to nearly complete. The latter include six particularly important sets (Figs. 6–11) comprising most of the flakes from the same cobble, as well as the residual cores, that allows the reconstruction of almost the entire reduction sequence. Additional informations are given by seven less complete refitting groups (Figs. 12, 13).

Table 3
Overall count of refitting groups

Nb of pieces per refitting	Nb of refittings	TOTAL (Nb of cores)
2	**29**	**58** (8)
3	**8**	**24** (3)
4	**7**	**28** (5)
5	**3**	**15** (5)
6	**3**	**18** (3)
7	**2**	**14** (1)
8	**1**	**8** (1)
9	**1**	**9** (2)
11	**1**	11 (1)
13	**1**	**13** (2)
15	**1**	**15** (1)
31	**1**	**31** (3)
39	**1**	**39** (1)

Cores

The analysis of the 70 whole cores included here within the organized *débitage* category provides additional information on the variants within this approach to *débitage*. Almost 40% of the cores belong to refitting groups. The blanks used for

Fig. 12. refitting group 65 (1), refitting group 48 (2), refitting group 37 (3), refitting group 4 (4). Fig. 13: refitting group 12 (1), refitting group 54 (2), refitting group 25 (3). Figs 12 and 13. The analysis of seven other slightly less complete sets complements the observations made on the six main refitting groups. These originated as smaller pieces of raw material (range in maximum dimension 5-12 cm), most brought to the site as cobbles rather than as broken fragments. One exception is refitting group 12 (Fig. 13, n°1), a cobble of basalt with a trapezoidal cross-section, three sides of which correspond to break surfaces. The very distinctive raw material has allowed all the extant components to be refitted, and it could therefore be ascertained that what was introduced was indeed a fragment of a larger cobble. The first series of flakes are missing in all these incomplete refitting groups. Two of the refitting groups are in keeping with the technological principles highlighted by the six major sets previously described. *Débitage* was carried out on a single surface (refitting group 65, Fig. 12, n°1) or on a preferentially flaked surface (refitting group 48, Fig. 12, n°2), which is the largest plane available on the block and is opposed to a markedly convex face. All the edges showing suitable angles are successively or alternately used to produce series of flakes. The final core reduction phase consisted, for refitting group 65, in a series of continuous retouch along one edge (Fig. 18, n°6), while for refitting group 48 the last phase corresponds to the production of several short to invasive removals on the face opposed to the surface previously flaked (Fig. 12, n°2). The five other refitting groups display some variants in relation to the Lokalalei "classical" pattern described above. *Débitage* was successively conducted on two either opposing (refitting group 4, Fig. 12, n°4; refitting group 12, Fig. 13, n°1; refitting group 37, Fig. 12, n°3) or adjacent faces of the blocks (refitting group 25, Fig. 13, n°3; refitting group 54, Fig. 13, n°2). No surface stands out as having been preferentially used. This probably results from the original shape of these blocks. Some of them have either a square cross-section (refitting group 4, Fig. 12, n°4; refitting group 25, Fig. 13, n°3) or a triangular cross-section (refitting group 54, Fig. 13, n°2). Unlike the other knapped blocks, they do not possess a large flat or convex face, which could be selected as a flaking surface. The two surfaces were flaked either from two edges of the same striking platform (refitting group 4, Fig. 12, n°4), which are the only ones with natural serviceable striking angles, or from two opposing edges (refitting group 12, Fig. 13, n°1; refitting group 37, Fig. 12, n°3), or, finally, from two adjacent edges (refitting group 25, Fig. 13, n°3; refitting group 54, Fig. 13, n°2). Nevertheless, all five refitting groups abide by the previously observed principle of a maximum exploitation of all appropriate edges. Consistent with the principle of several successive series of flakes on the same surface, the faces were flaked one after the other rather than alternately. When removals occurring on the same face have been struck from a single edge, they are very moderately invasive (refitting group 4, Fig. 12, n°3; refitting group 37, Fig. 12, n°3). Such technical variants possibly derive from the knappers' finding it difficult to exploit nodules of unfamiliar sizes and shapes (particularly refitting group 4, Fig. 12, n°3; refitting group 25, Fig. 13, n°3; refitting group 37, Fig. 12, n°3).

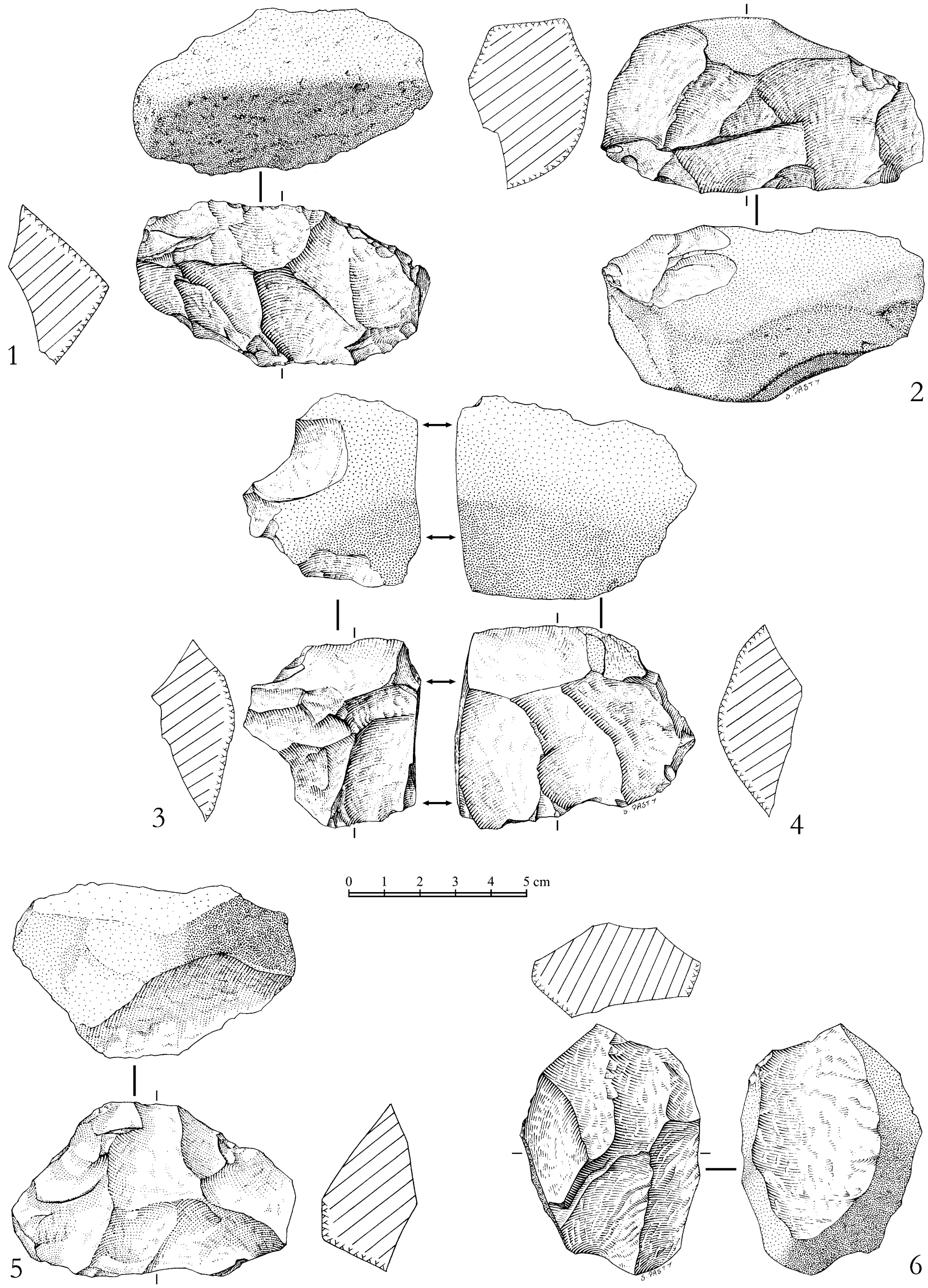


Fig. 14. Cores with a single flaked surface: from refitting group 3(1), from refitting group 35(4), from refitting group 33(5), cores with a single flaked surface and evidence of platform rectification: from refitting group 2(2), cores with a single flaked surface and final removals on the other face: from refitting group 35(3), from refitting group 9(6).

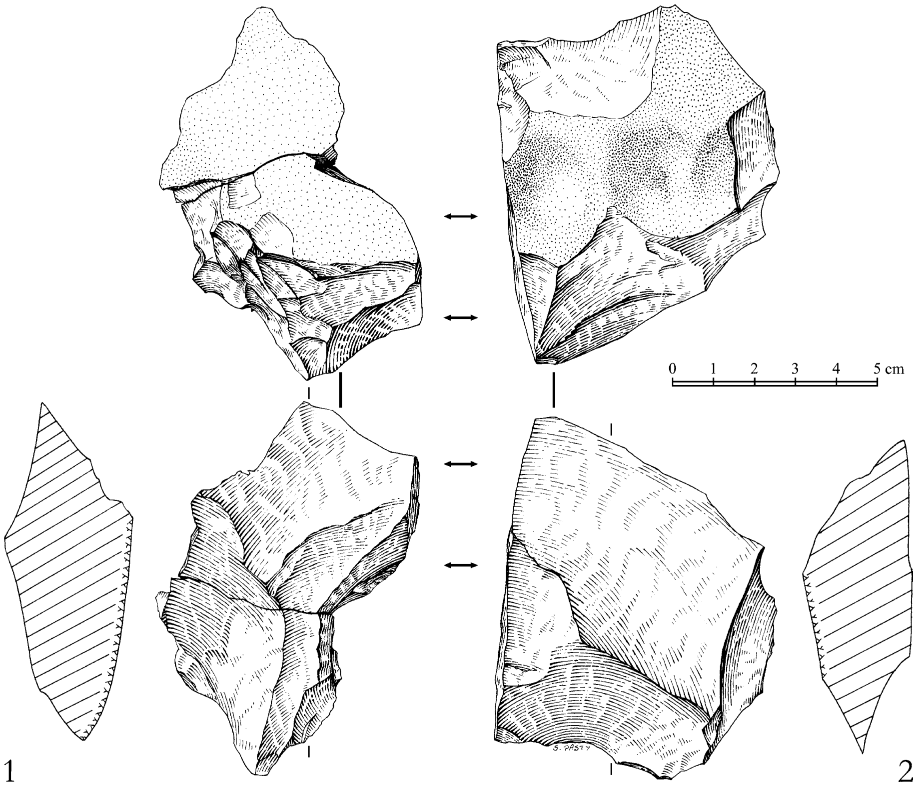


Fig. 15. Cores belonging to refitting group 16: with a single flaked surface (1), with a single flaked surface and evidence of platform rectification (2).

these cores include whole cobbles, broken up fragments, and flakes. In the latter case, it is the ventral face of the blank, usually opposed to a convex and cortical dorsal face, that is nearly always selected as a flaking surface, most likely because it is naturally flat.

Considerable reduction in size of the cores at discard has already been demonstrated by the refitting groups. The differences in measurements between the cores and the cobbles prior to *débitage* emphasize this point, especially as regards core and cobble lengths (mean length for cores is 6.6 cm against 11.6 cm for cobbles). Distinctions could be drawn between five major types of cores.

Cores with a single flaked surface (n = 22). This category accounts for a majority of the cores. The flaked surface is opposed to an unflaked cortical face, which is markedly convex although its cross-section may vary in shape. At discard, the flaked surfaces may still possess an exploitation potential, with no significant knapping accident accounting for the abandonment of the core (Fig. 14, n°1, 4, 5), or they may display hinged flake scars (Fig. 16, n°5), which caused *débitage* to be discontinued. There are often several such hinged removal scars, suggesting that the knapper relentlessly attempted to continue exploiting the core. The flaking surfaces of cores with a single flaked surface also quite frequently possess a distinctly convex profile when they are finally discarded (Fig. 16, n°2, 6). This is a sign that the knappers did not always succeed in producing flakes sufficiently invasive to ensure that the flaked surface remained flat and well balanced as the cores were being reduced in size. Such examples are very informative about the technical difficulties most frequently met with by the

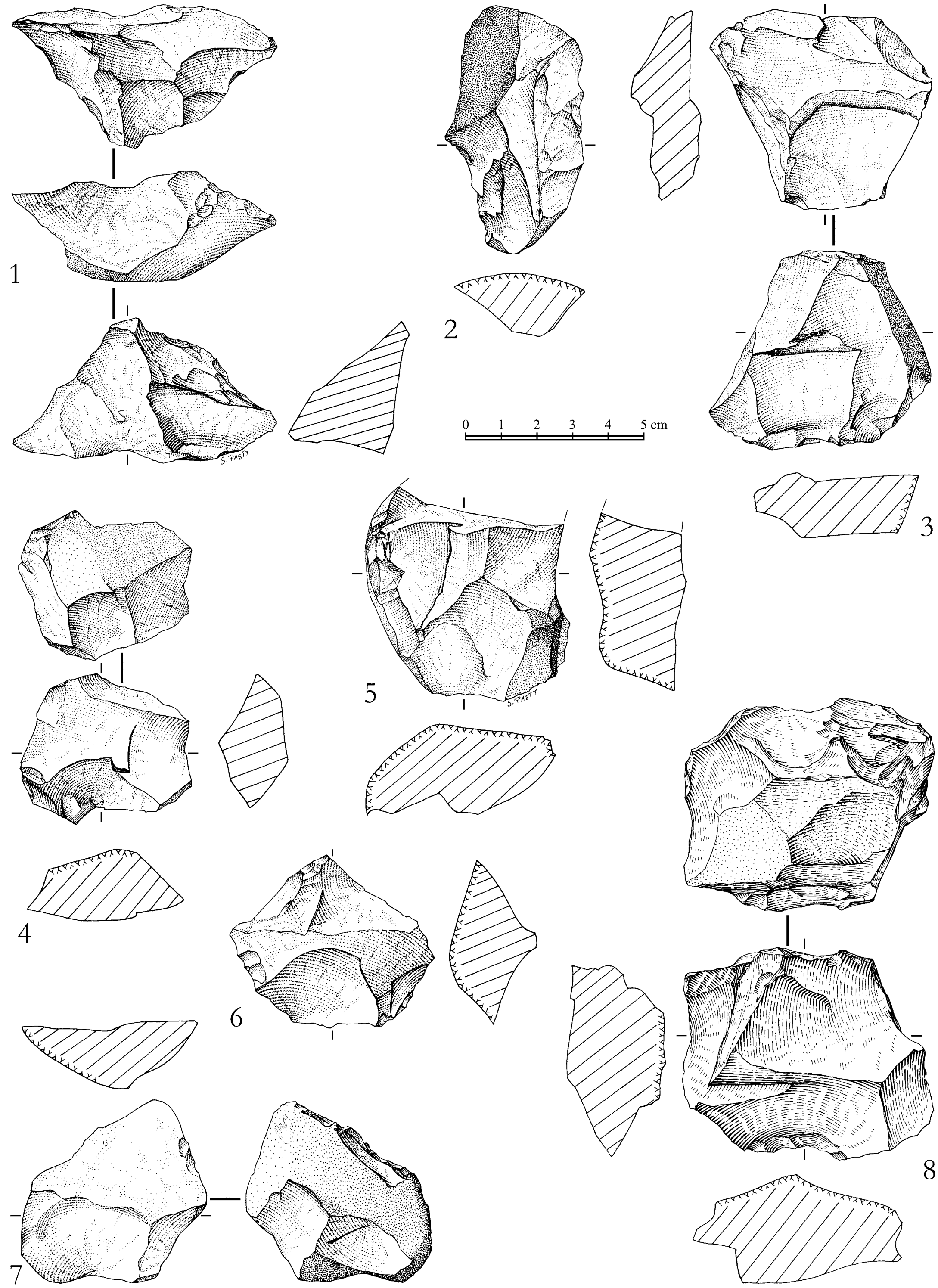


Fig. 16. Cores with a single flaked surface (2, 5, 6), cores with a single flaked surface and evidence of platform rectification (4, 7), cores with at least two flaked surfaces (1, 3), miscellaneous core (8).

knappers during the final stages of core reduction.

Cores with a single flaked surface and evidence of platform rectification (n = 8). A small number of cores with a single flaked surface can be set apart from the others. They display one or more removals that occur on a natural striking platform prior to the detachment of flakes from the flaking surface. Their location does not seem casual and they very likely were intended to rectify the striking platform by removing an impeding irregularity (e.g. refitting group 2, Fig. 14, n°2, and refitting group 16, Fig. 15, n°2). This is not a common practise and usually consists of a few removals (Fig. 16, n°4). Occasionally it involves a large number of removals, which range around the entire perimeter of the core (Fig. 16, n°7). All recorded examples testify to the care with which the knappers controlled the detachment of flakes. However, the angle of the initial striking platform is not modified. And it should be noted that the knappers never achieved genuine preparation of the striking platform that entailed either the creation of a protruding percussion zone or a significant modification of one edge of the core in order to obtain a suitable striking angle.

Cores with a single major flaked surface and final removals on another face (n = 10). This category differs from the previous one in that the removals occurring on the face initially used as a striking platform are detached during the final core reduction phase and are not directly related to the flakes detached from the main flaking surface. While they may be either short or invasive, they never involve more than a limited portion of the face from which they are removed (Fig. 14, n°3, 6). Such removals probably correspond either to a final core reduction phase whose purpose was the production of a few additional flakes at a stage when the flaking surface was no longer serviceable, or to a curtailed attempt at *débitage* after switching faces.

Cores with at least two flaked surfaces (n = 15). Switching faces can actually be identified on a substantial number of cores. The two surfaces were successively used as flaking surfaces and as striking platforms to produce several series of flakes (Fig. 16, n°3). This category of cores can be considered as a variant within the organized *débitage* pattern. Cores with three flaked surfaces are very poorly represented. The shape of such cores is unlike other Lokalalei 2C cores. They have a triangular cross-section and possess three large planes (Fig. 16, n°1) that could be exploited for flake production.

Miscellaneous cores (n = 15). This category includes cores that cannot be included within the simple *débitage* category either because of the nature of the blank (a flake), or because of the relatively high number of flakes produced. A substantial proportion (n = 9) of these cores lack

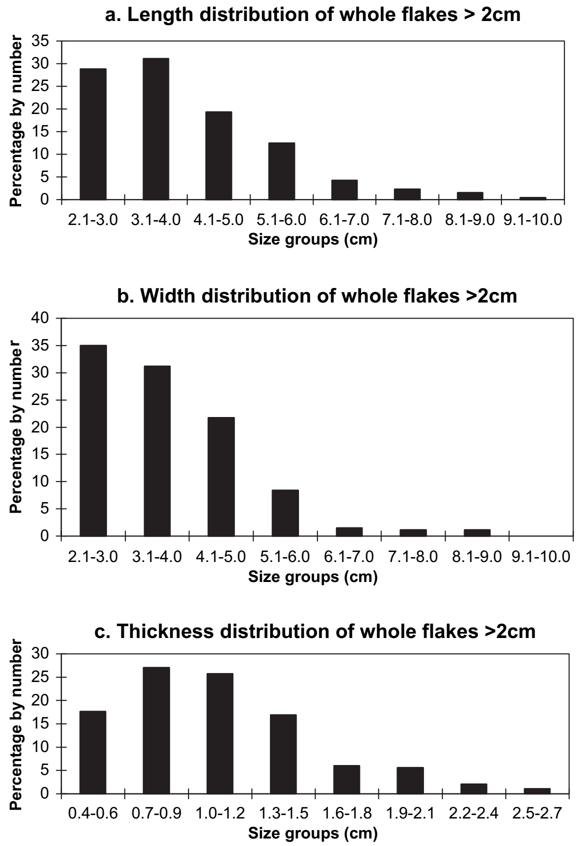


Fig. 17. Distribution of length (a), width (b) and thickness (c) of the whole flakes whose maximum dimension is higher than 2 cm.

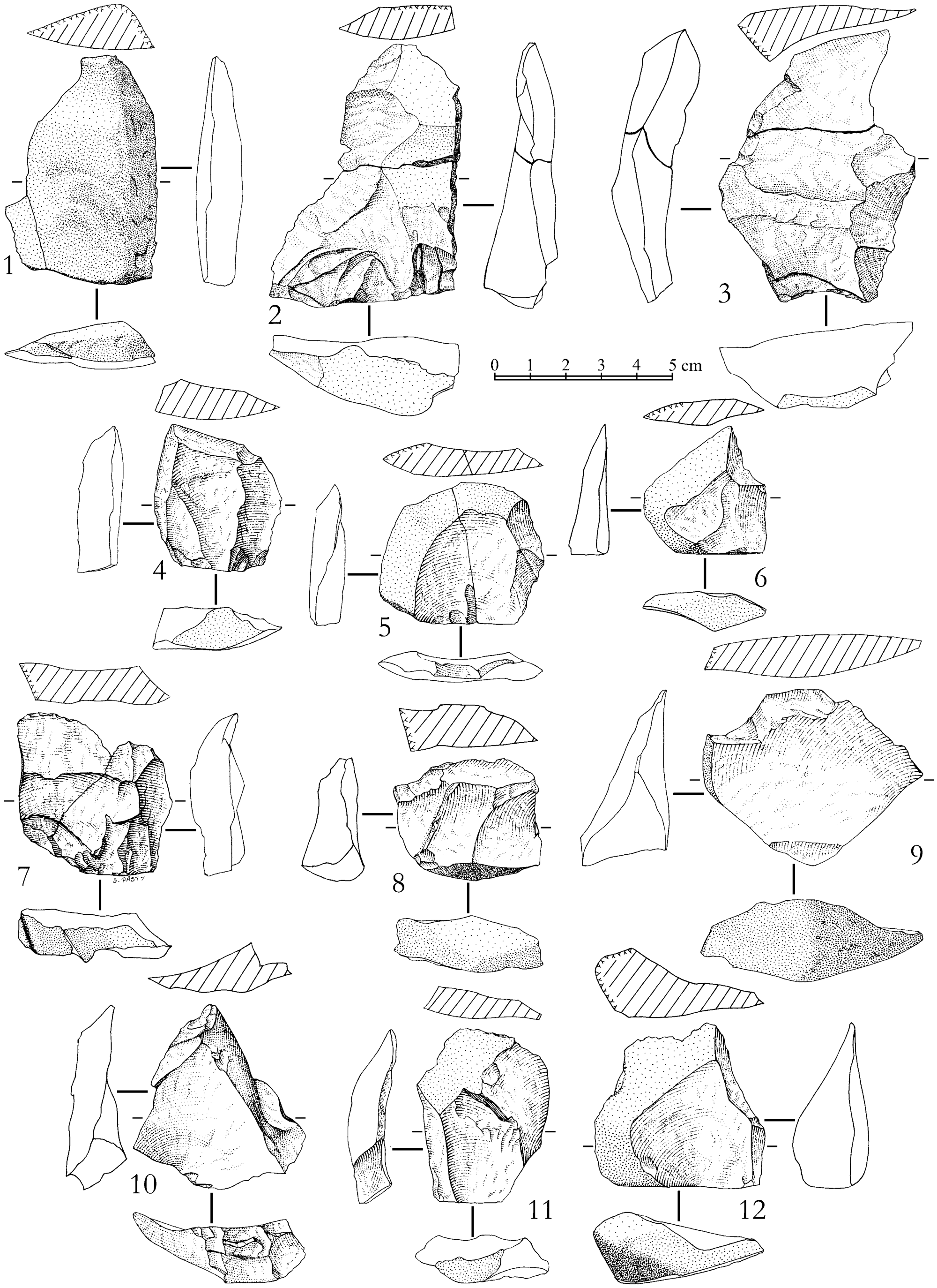


Fig. 18. Flakes wholly cortical (1), flakes with a partly cortical dorsal face (5), flakes with cortical butt and partly cortical dorsal face (2, 6, 11), flakes with cortical butt (4), flakes with cortical butt and cortical back (3, 7, 8, 9, 12), flake with no cortex (10).

Table 4
Comparison between the dimensions of the cores and the whole flakes

	Length (cm)		Width (cm)		Thickness (cm)	
	Cores	Whole flakes	Cores	Whole flakes	Cores	Whole flakes
Mean	6.6	3.8	5.2	3.5	3.2	1.1
Max.	12.3	9.6	9.5	12.8	7.8	2.8
Min.	3.9	1.2	3.2	0.7	1.2	0.3
S.D.	1.8	1.5	1.4	1.4	1.2	0.5

natural striking angles suitable for the removal of flakes. As a result, the cores are globular and display significant knapping accidents. This category also includes a few cores worked from flakes, which only show a very small number of removals on their ventral faces (Fig. 16, n°8).

Flakes

Flakes are small to medium-sized and relatively thin (Table 4). Elements < 2 cm represent 77% of the whole flakes. Dimensions fall within a unimodal distribution (Fig. 17) for whole flakes > 2 cm. Their shape is generally quadrangular and barely elongated (Fig. 18). They frequently possess cortical butts (46%) adjacent to cortex back on one of their lateral edges. Noncortical butts are mostly plain. Long portions of the lateral and distal edges are sharp and quite obviously suited to cutting. These characteristics are shared by all of the flakes, owing to the same technical patterns of production. A majority of the flakes are cortical (74%) and bear cortex either on their dorsal faces (38.7% of all cortical flakes), on both their butts and dorsal faces (36.1%), or exclusively on their butts (25.5%). Cortical flakes with cortex covering < 25% of the dorsal face are the best represented (Table 5), and this is in keeping with the heavily reduced cores deduced from the analysis of the refitting groups.

Table 5
Proportion of cortex on the dorsal face of the whole flakes

% cortex	0	<25	25-50	50-75	>75	100	Total
N	83	128	46	26	24	11	318
%	*26*	*40.5*	*14.5*	*8*	*7.5*	*3.5*	*100*

Broken flakes (60% of the flake component > 2 cm) outnumber whole flakes (see Table 1). The proportion of *Siret*-type fragments (16% of the broken flakes), corresponding to lateral fragments initiated at the percussion point, indicates frequent breakage during *débitage*. Ongoing replicative experimentation is aimed at testing the connection between breakage and the flaking quality of Lokalalei 2C raw materials (Harmand, in prep.).

Retouched pieces

Few artefacts (n = 22) bear evidence of retouch. While most of the retouched pieces are flakes (n = 16) (Fig. 19, n°1–6), some are cores (n = 6) recycled for use as tools after *débitage* was completed (Fig. 19, n°7).

Retouch generally occurs only along one of the edges and consists of a single row, or at the very most two rows, of continuous retouch scars. These are quite deep, slightly invasive and not very regular, resulting in a cutting edge with a sinuous and often denticulated shape.

Retouch on flakes is sometimes opposed to a cortical back (Fig. 18, n°4, 5). It can be either direct or inverse, and is predominantly located on the lateral edge. In few cases, it extends along both lateral edges (Fig. 18, n°1) or adjacent edges (Fig. 18, n°6). Retouched pieces are fairly big, ranging between 4 and 7 cm in maximum dimension, which is more than the mean length recorded for unretouched flakes.

Retouch on cores (Fig. 18, n° 7) always corresponds to the very last phase of exploitation, and the related scars are entirely different from the previous removal scars connected with the *débitage* process. Besides being much shorter, they are numerous and continuously distributed along one edge or portion of an edge. In some cases (cores of refitting group 3, Fig. 14, n°1 and of refitting group 16, Fig. 15, n°1), retouch occurs on edges with a very high angle, close to 90°, and could ensue from a repeated and very localized percussion motion. On these pieces, rather than creating a potentially functional active edge, retouch completely crushes the involved edge and can very likely be attributed to use damage. Such

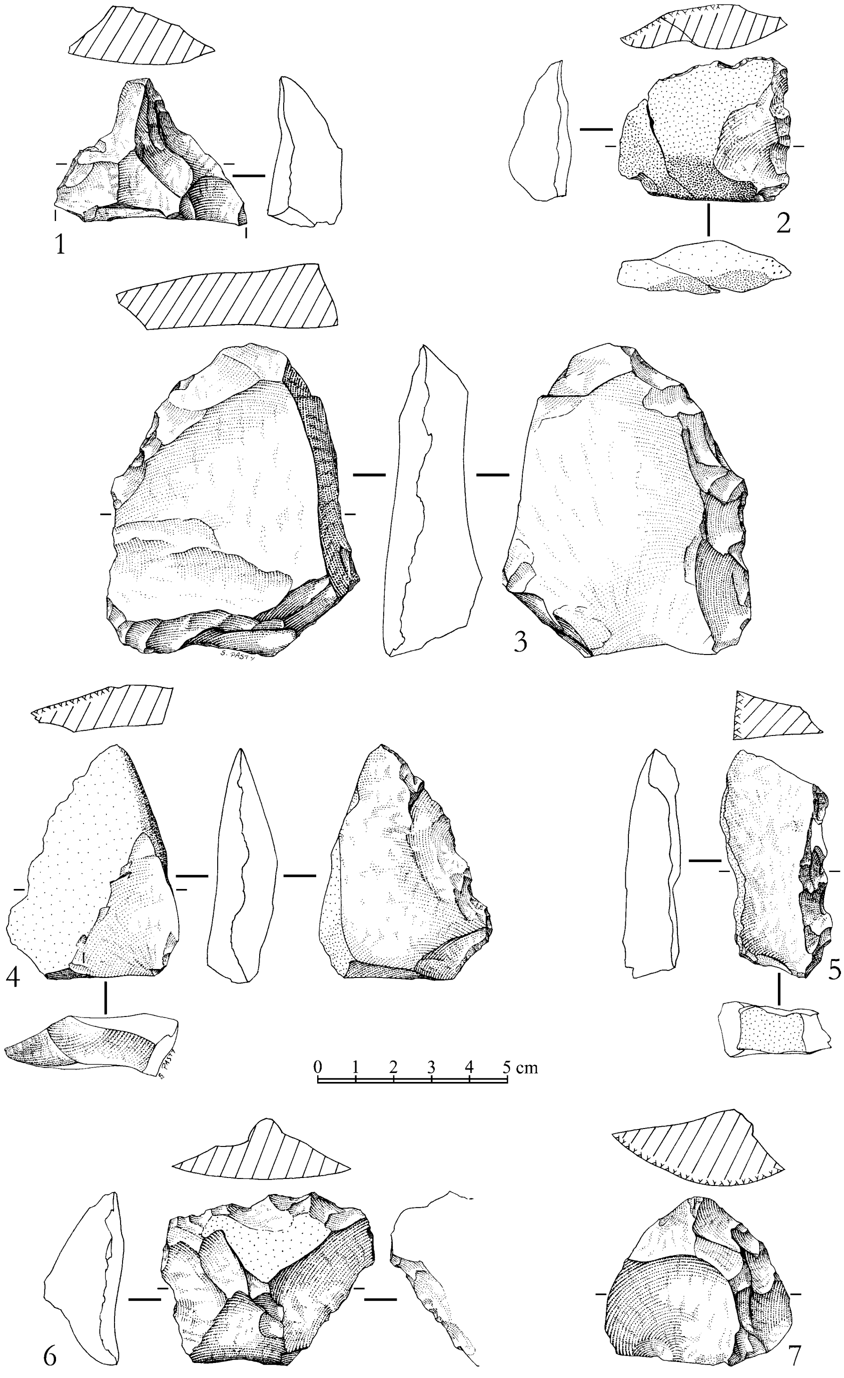


Fig. 19. Retouched pieces on flakes (1 to 6), on core (7).

a possibility might also be considered for the entire set of retouched pieces. However, barring the few above mentioned specimens, the edges of the retouched pieces (on flakes and on cores) are still definitely suitable for such actions as scraping or slicing after having been modified by retouch.

Hammerstones (Fig. 20)

A total of 18 artefacts bear clear evidence of percussion. Twelve of the specimens display numerous battering marks concentrated on one or two protruding zones, and their density is such that the natural surface of the block has become pitted. Six others bear more minor signs of impact damage (in terms of size of the patches and/or in terms of density of the battering marks). This hints at less intensive or shorter-lived use as hammers.

A majority of the hammerstones are medium-sized rounded cobbles, but five of them are more angular and geometric cobbles. In most cases the percussion zone is situated at one or both ends of

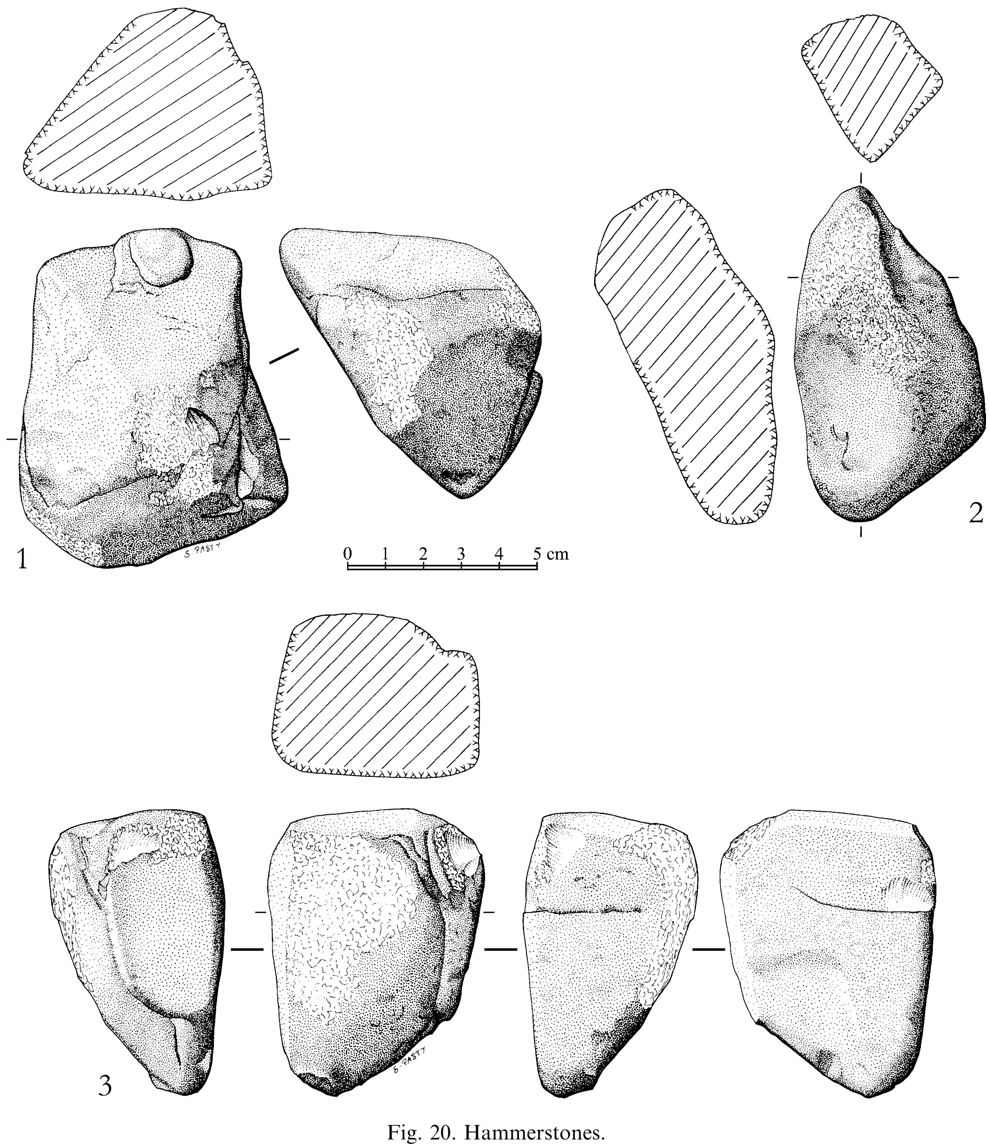


Fig. 20. Hammerstones.

the cobble's long axis. However, in three cases the impact scars have a more central location. The cross-sections of these hammerstones are either plano-convex or in the shape of a truncated pyramid (Fig. 20 n°1), thus affording a somewhat stable "base" opposite which the percussion zone lies. In view of this configuration, the possibility of their having served as anvils cannot be ruled out. This suggestion mainly concerns one relatively bulky specimen (9.8 cm x 8.7 cm x 8.2 cm). It appears less relevant for the two others whose dimensions (9.1 cm x 17.3 cm x 4.7 cm, and 8.4 cm x 7.1 cm x 5.3 cm, Fig. 20, n°1), and shapes make them perfectly suitable for a knapper to wield, and a hand-held use is therefore equally plausible. Moreover, two of these hammerstones have been knapped. On the first, a large flake scar intersects the percussion zone, and two other flakes, struck from the same edge, were subsequently removed on the opposite face. The three removals occurred after the cobble was used for percussion. Had the second one not borne signs of impact damage, it would have been classified as a core with a single flaked surface. The flat face opposed to the convex one bearing the percussion zone displays the scars of a series of four identically oriented removals, which were struck from a natural platform. Since the negative traces of these two technical actions do not overlap, it is impossible to tell which one took place first. The same holds for two other hammerstones showing one and two flake scars.

One of the most remarkable features of this collection of hammerstones is the highly circumscribed character of the impact zones. This suggests that each specimen was repeatedly used according to stable motor habits. This observation supports the conclusions from the refitting groups and the cores, concerning the precision of the blows struck to detach flakes.

Another interesting feature appears when the size, weight, and type of raw material of hammerstones and unmodified or slightly modified cobbles are compared (see Table 2 above). The hammerstones are larger than the unworked cobbles (*manuports*) and sizes are less variable. Most importantly, the discrepancy between the mean weights for the two categories clearly shows that the hammerstones are heavier, which cannot be explained by differences in raw materials because medium-grained trachyte is the dominant raw material for both hammerstones and unworked cobbles.

It is therefore likely that within the supply of cobbles and blocks transported to the site, the knappers selected specimens better suited for percussion. Considering the number of hammerstones, there is good reason to believe that they were used for knapping most, if not all of the cores flaked at the site (18 hammerstones for 85 cores or so).

Patterns of hominid techno-economic behavior

The detailed technological analysis carried out on the Lokalalei 2C assemblage allows behavioral issues to be addressed. These include the degree of hominid planning and foresight in raw material management, and the assessment of their technological capabilities and manual dexterity.

Raw material procurement: small whole cobbles vs. large split cobbles

Although the lavas exploited at Lokalalei 2C were all available close to the site, the analysis points to different behavioral patterns, related to the quality and shape of the raw material. The shape of cobbles and fragments of cobbles brought to the site is such that the pieces can be knapped without any preparation; *débitage* therefore begins immediately. When a preliminary phase is present, it generally consists of deliberate breakage of the cobbles into several large chunks. This phase possibly took place off-site, since in most cases it seems that for each cobble only one of the pieces thus obtained was brought to the site. Intentional breakage concerns primarily the larger cobbles (> 15 cm maximum dimension), but also some medium-sized ones (range in maximum dimension between 8 and 15 cm, Fig. 21). It is not documented for any of the smaller pebbles (< 8 cm maximum dimension). Clearly, the original size of the cobbles had a bearing on the condition in which they were introduced.

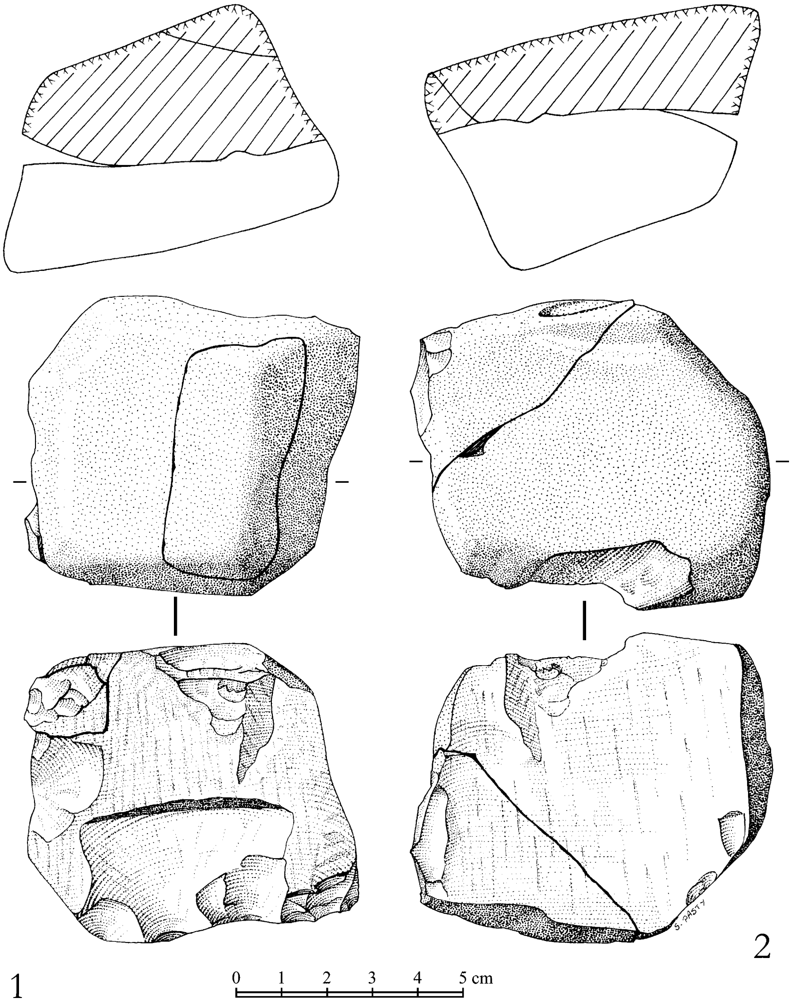


Fig. 21. Refitting group 14 (cobble split into two fragments exploited as cores).

Breakage has two consequences :

- from a technical point of view, it means obtaining blanks with sharp edges directly serviceable as striking platforms. The large plane opened up by the fracture is more often than not used as a flaking surface;
- from an economic point of view, it entails obtaining several suitable blanks for flaking from the same cobble, which increases the number of flakes produced per cobble.

The strong relationship between intentional breakage and the size of clasts provides indisputable evidence for planning and foresight in raw material procurement and management. It seems that anticipation can also be detected in the preparation of the core. In some cases, this involves much more than merely splitting the cobbles. This is borne out by the fact that the two most substantial refitting groups (16 and 33) testify to a phase of *débitage* clearly conducted off-site. This phase consists in detaching a large number of multidirectional flakes from either one or two faces of the core. Whereas the majority of the flakes from the following series are refitted, all the products corresponding to this initial phase are missing in the assemblage, which is unlikely to be the result of

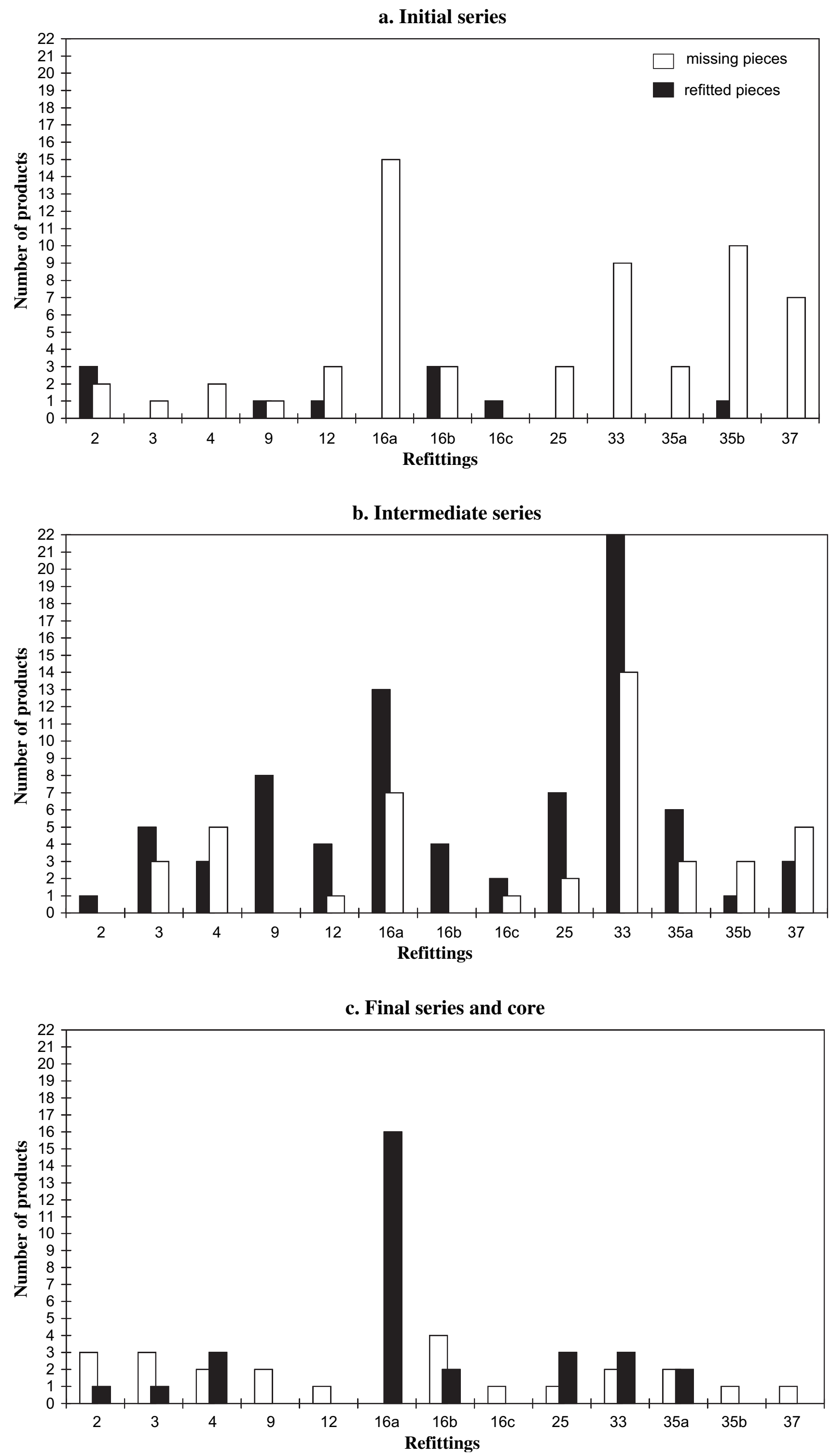


Fig. 22. Number of refitted and missing pieces *per* phase of *débitage*, for each of the main refitting groups (a : first series are the earliest in the knapping sequence, whether they correspond to a phase of core preparation or cobble fragmentation prior to flake production, or to immediate flaking without preparation; c : final series and cores, include the flakes from the very last series and the core; b: intermediate series comprise all the series produced between the first and final series).

erosion. For refitting group 33, such removals are already consistent with a phase of flake production, and this therefore indicates a spatial and temporal break during *débitage*. On the other hand, for refitting group 16, the removals belong to a phase of core preparation that preceeds the detachment of the large flake which was then split into two fragments exploited as cores. In these two cases, the knappers probably opted for this practise because of the large size of the cores. Transporting of partially flaked cores to the site seems to be a common feature, as shown by the smaller proportions of refitted products for the first series in comparison with intermediate and final series (Fig. 22). Like the breaking up of cobbles prior to transport, this practice reveals spatial and temporal breaks in the reduction sequence, which can therefore be assumed to be relatively complex.

A reduction sequence involving constant technical rules

In contrast to simple *débitage*, which does not involve any repetitive technological principle, the organized *débitage* is characterized by strong technical rules. As shown by the refitting groups, from the outset of reduction, flaking is carried out on the largest available surface (see refitting groups 2, 3 and 9). It is sustained throughout reduction as a single or preferential flaking surface. Flakes from other faces are always produced during a second and/or final core reduction phase. D*ébitage* then consists of a few removals only, which are usually moderately invasive, or of a new production sequence based on successive series of removals.

Flakes are struck from platforms that are most often natural (i.e. cortical). The extension of the striking platforms around the perimeter of the core varies according to the angles formed by the intersection of flaked and adjacent surfaces. Angles smaller than 90° are suitable for the removal of flakes. This technical constraint, which is peculiar to the knapping of hard rocks, plays a determining part here. What knappers did was to maximize the exploitation of naturally existing platforms, without ever reducing, or attempting to reduce, edges with angles greater than 90°. Removals therefore range around the entire perimeter of the flaked surfaces whenever this perimeter shows serviceable edge angles (see refitting groups 3, 16, 33 and 35). They are otherwise restricted to the more or less extensive portion of the perimeter which can be directly used as a striking platform (see refitting groups 2 and 9). The flakes are mostly struck from the longest available edges, and their *débitage* axis is usually perpendicular to the morphological axis of the cores, which are more often than not broadly ovate or quadrangular in shape.

As the flakes produced are proportionately long, and each one usually travels across at least half the flaked surface, they rapidly cover this entire surface. They are organized into successive series. Within a single series the removals are parallel or sub-parallel, and they are struck from the same portion of the edge of the core. Each new series of flakes can be oblique, perpendicular or opposed to the previous one. In most cases, the number of flakes per series ranges between two and five (two or three flakes for 48% of the series, four or five flakes for 27% of the series). Ocasionally, there may be as many as 11. The main refitting groups are made up of two to nine successive series of flakes. Most of them consist of three to five series.

These series constitute technical breaks in the progress of the production sequences and compelled the knapper to rotate the core. The repetitive nature of these actions, and their technological consequences, show that such changes of course were intentional. Neither are they the result of knapping accidents or of flaws in the raw material, which would have prompted the knapper to switch platforms to circumvent the difficulty. In fact, among the refitting groups, a new series never starts off following a knapping accident. The *débitage* of successive series clearly hinges upon conscious planning, rather than being driven by technical difficulties.

In order to ensure the removal of more than a few relatively invasive flakes from an initially flat or slightly convex surface, this surface must be kept flat by the *débitage* process itself. By striking flakes from several adjacent or opposing edges, the knappers can work across the entire flaking surface and thus lower it through successive stages of flaking. The flaked surface therefore remains flat until the core is abandoned. As shown by Figs 6 to 13, this process results in cores whose final shape is similar to that of the original block, while being of course much smaller.

The intensity of core reduction resulted in the production of a large number of flakes. This is borne out by the counts obtained from the more exhaustive refitting groups, where in addition to the refitting products the number of missing elements can be assessed. The 13 more exhaustive refitting groups, for which an estimate of the overall number of products was possible, show an average of 18 flakes per core, with a minimum of nine flakes. One of the cores (refitting group 33) produced at least 51 flakes (this is a minimum number based on the sum of refitted and missing flakes). In some cases, productivity was increased by the recycling as cores of large accidentally produced flake fragments or chunks. This applies to refitting group 16 (>73 flakes from three independently exploited cores originating from the same cobble), and quite likely also to refitting group 35 (two cores from the same cobble). While such a practice suggests that high productivity was the aim of knapping, how does this condition the technological principles at work at Lokalalei 2C?

Technologically speaking, the system is unarguably geared towards the production of flakes. These are particularly suitable for cutting and were probably intentionaly produced for such a purpose. Cores clearly fall into the category of waste. They can be abandoned following a knapping accident (hinged flake or fracture of the core), or at a stage when they have been considerably reduced in size, but there is also often no obvious technical reason for their discard.

The overall technical rules seen in this assemblage strongly suggest a measure of forethought. The flaking process is anything but rigid, as demonstrated by the knappers' flexible response to the accidents inherent in stone-knapping. In several instances, this technological flexibility enabled them to repair the consequences of minor knapping accidents. For example, they managed to eliminate the traces of hinged removals disfiguring the flaked surface by means of a blow shrewdly struck from an opposing or adjacent edge. In other cases, they took advantage of major knapping accidents, such as the fracturing of a big core (e.g. refitting group 35) or that of a large flake during *débitage* (e.g. refitting group 16), by recycling the fragments as cores. On the other hand, a drastic transformation of the shape of the core, such as to make serviceable a striking platform with too high an angle, was quite beyond the scope of the Lokalalei 2C knappers' technological capabilities.

Manual dexterity

An insight into the Lokalalei 2C knappers' manual dexterity can be gained by examination of the precision of the blows struck on the cores. The latter do not show any impact damage from failed percussions, such as might be caused by faulty estimation of the force required, or by erratically aimed blows, falling for instance too far away from the edge. Precision of arm and hand movements is particularly evident where flaked edges adjoin edges unsuitable for flaking: the blows are always strictly restricted to the portion showing serviceable edge angles, and never extend beyond it. Additional evidence of precision is provided by the knappers' ability to strike several (generally 2 to 9) series of flakes producing as many as 15 removals from small pebbles: four of the refitting groups and several unrefitted cores represent blocks originally no more than 5 or 6 cm long and about 3 cm thick. In such cases, precision implies not only a highly controlled movement, but also a firm and constant grasp while handling both core and hammerstone. Capable of flaking small nodules, the Lokalalei 2C knappers felt equally at ease when tackling far bigger ones. They had thoroughly mastered the process of obtaining large fragments from sizeable blocks. Precision is also borne out by the observations made on the hammerstones they left behind. The patches of battering marks are highly circumscribed, implying precise and recurrent percussion motions.

Discussion

Stone working at Lokalalei 2C is represented by a system of *débitage sensu stricto* and not by a compound system, combining *débitage* and shaping. The flakes are the intended end products and the cores clearly fall into the category of technological waste, even though some bear signs of retouch suggesting a secondary use as tools. The detailed study of this *débitage* system shows that the makers of the Lokalalei 2C artefacts were not casual, opportunistic or clumsy knappers. Indeed, they appear to have already achieved a mastered, structured and even planned technical production. This claim is supported by four main points.

1. A flaking process structured by technical rules. These are:
   - the selection of angular cobbles, cobbles fragments and flakes with serviceable striking angles ($<90°$);
   - the exploitation of a large flat face as a flaking surface rather than the opposed convex and irregular one;
   - successive and multidirectional series of invasive and subparallel flakes, a practice that maintains a flat flaking surface.
2. A high flake to core ratio demonstrated by an average production of 18 flakes per core, with a minimum of 9 flakes for the 13 most important refitting groups. In one instance at least 51 flakes were knapped from the same core (refitting group 33). In some cases, several cores (2 or 3) all originally part of the same cobble were exploited. As a result, a single cobble (refitting group 16), broken into several large fragments, yielded $>$ 73 flakes.
3. Highly controlled percussion motions. Evidence for this is provided by both the hammerstones and the cores. The hammerstones display circumscribed impact zones and a high density of impact scars, testifying to their repeated use according to stable motor habits. The cores have no impact damage from failed percussions, such as might imply clumsiness or hesitation. The fact that flaking was restricted to edges with suitable striking angles also points to an understanding of knapping constraints.
4. The planning and foresight detected in the management of raw material. Whereas the small cobbles were brought to the site in one piece, the larger cobbles were broken up, possibly where the raw material was collected, prior to being flaked. Because the raw material was available close to the site ($<$ 50 m), the large blocks were likely broken in order to obtain a flat flaking surface and perhaps several suitable blanks from the same cobble, rather than to reduce the cost of raw material transport.

That the Lokalalei knappers had internalized the intrinsic qualities of rocks and their flaking properties is suggested by the differential use they made of the raw materials available. Simple *débitage* was performed on poor quality types of raw material while more elaborated *débitage* was pursued on good quality types.

However, this does not imply that the hominids at Lokalalei 2C had already fully mastered all the technical parameters of stone knapping. They were clearly somewhat constrained by the raw material, and this hampered their exploitation of some of the cobbles, in particular the rounded cobbles used for simple *débitage*. Simple *débitage* seems to be a response to the difficulty experienced by the knappers in exploiting such cobbles, owing to their inappropriate shapes rather than their poor quality in terms of grain and homogeneity. In the organized *débitage* the knappers were constrained by the original shape of the cobbles, to such an extent that at discard the volume is reduced while the shape remains constant. This is because in the absence of naturally occurring striking angles, the knappers did not strive to create any such angles. In such cases their progress was impeded, resulting in knapping accidents and the occasional switching of flaking surfaces on the same core. It is therefore suggested that the hominids at Lokalalei 2C had already assimilated the advantages of angular shapes. They had the cognitive abilities to exploit angles when encountered but not to create new ones.

Comparisons with Lokalalei 1

How do the Lokalalei 1 knappers compare with those of Lokalalei 2C? There are fewer artefacts at Lokalalei 1 and they do not offer the same refitting possibilities. Analysis was based mainly on the cores (n = 27), which divide into three groups. A first group comprises cores worked from relatively large squarish cobbles (mean length of cores = 12.5 cm, mean width = 9.9 cm, mean thickness = 7.6 cm, mean weight = 1060 g) displaying at least one flat face. They were flaked according to principles different from the ones prevailing at Lokalalei 2C. The flat face is used as a striking platform instead of as a flaking surface (see Fig. 3 *in* Kibunjia, 1994). A second group includes cores also worked from relatively large cobbles (mean length of cores = 9.5 cm, mean width = 8.0 cm, mean thickness = 5.8 cm, mean weight = 885 g), but with more globular shapes. They were flaked on two or three faces by means of multidirectional removals. A third group is made up of small cores (mean length = 8.1 cm, mean width = 6.5 cm, mean thickness = 3.8 cm, mean weight = 250 g) with a single preferentially flaked surface, or with two opposing flaked surfaces, roughly similar to those which characterize the organized *débitage* at Lokalalei 2C. This last group does not however provide the same impression of morpho-technical homogeneity as the corresponding Lokalalei 2C material. The blanks display different shapes that are not suitable for carrying out *débitage* on a preferential surface. The cobbles are round and lack flat surfaces or suitable natural striking platforms. The resulting knapping sequences are opportunistic and there are few successful attempts at removing whole serviceable flakes. The cores also bear evidence of frequent knapping accidents (see Fig. 3 *in* Kibunjia, 1994) and repeated impact damage from failed percussions.

Generally speaking, stone working at Lokalalei 1 is heterogeneous. This can be seen in the shape and sizes of the original cobbles as well as in the unpatterned *débitage*. This type of *débitage* cannot be termed organized because opportunism prevails over the implementation of constant technical rules. Nor do the Lokalalei 1 cores bear witness to the advanced manual dexterity on the knappers' part seen in the cores from Lokalalei 2C.

The ancient hominid groups responsible for manufacturing and utilizing flaked stones *c.* 2.3 Myr in West Turkana display distinct levels of technological skills. Because Lokalalei 1 is older than Lokalalei 2C, Brown and Gathogo (2002) have suggested that the differences between the two assemblages are related to evolutionary processes. This is plausible insofar as E*arly Homo* is a possible candidate for making both industries, but other factors, environmental or task related, cannot be ruled out. Variations in available ressources or in the way ressources are processed can result in different patterns of site occupation, and this would explain the more expedient character of the Lokalalei 1 assemblage.

Conclusion : Lokalalei 2C in the context of the East African Late Pliocene (2.6-2.0 Myr)

At Lokalalei 2C production of flakes is the desired end of knapping. Knapping does not appear so clearly geared towards such a "mono-specific" end at the other Late Pliocene and Early Pleistocene East African sites, such as the Omo sites within the Shungura Formation (Chavaillon, 1976; Merrick and Merrick, 1976; Howell et al., 1987; A.L. 666 site within the Hadar Formation, Kimbel et al., 1996), the Kada Gona and East and West Gona sites within the Hadar Formation (Corvinus, 1975; Corvinus and Roche, 1976; Roche and Tiercelin, 1977, 1980; Semaw et al., 1997, 2003; Semaw, 2000), or the Kanjera South sites within the Kanjera Formation (Plummer et al., 1999). While flake production dominates the Omo assemblages, in other assemblages there is some evidence of shaping, represented by polyhedral forms. Choppers, endowed with the ambiguous status of "core-tools", could be the by-product of the production of flakes, or be the result of deliberate cobble modification in order to obtain a sturdy cutting edge. Comparing these assemblages is difficult because often only preliminary descriptions have been made, or because descriptions are not backed by detailed technological analysis such as that which has guided the study of Lokalalei 2C. At this stage of research, evolutionary trends cannot be substantiated. Such are however the only terms of comparison by which evolutionary trends in the technological behavior of Pliocene hominids can be successfully brought to light. In this respect, the contribution of Lokalalei 1 and Lokalalei 2C to our understanding of the Pliocene is significant.

Prior to the discovery of Lokalalei 2C (Roche et al., 1999), one of us assumed a "lack of technological elaboration" (Roche, 1989, followed by Kibunjia, 1994, 1998) for the Pliocene sites known at the time (Omo, Kada Gona, and subsequently Lokalalei 1). Roche (1989) also argued for a temporal break *c.* 2 Myr between a pre-Oldowan phase and an Oldowan phase, on the grounds that "a more elaborate work and a better understanding of stone flaking properties" emerged with the development of the Oldowan (*sensu* Leakey, 1971). Continuous technological improvements seemed evident, but the material from Lokalalei 2C falsifies this view. However, while this site provides evidence for the existence before 2 Myr of an organized and highly productive type of *débitage*, it has not been yet demonstrated that a similar level of elaboration exists elsewhere. It now seems fairly certain that the Pliocene is more complex technologically, or at least more diverse than has previously been assumed, and that this assumption should be extended to the beginning of the Pleistocene (Roche, 2000; Roche et al., 2003; Martínez-Moreno et al., 2003; de la Torre et al., 2003).

This contention is at variance with the currently prevailing view that all the African Plio-Pleistocene stone assemblages dated between 2.6 and 1.6 Myr group into one techno-cultural Oldowan complex. It is debatable whether this grouping of industries is heuristically valuable. It is an understandable temptation to classify each new discovery according to existing nomenclature. Nevertheless, combining under the same heading (Oldowan or Mode 1 : Clark, 1977) industries spanning such a wide spatio-temporal range presents the hazard of erasing all inter-site differences. Our aim is to better define these differences so as to better assess their implications in terms of evolving skills and technical practices. Were it at all relevant to maintain a single term – Oldowan – this could only be to designate a chronological period.

Grouping these industries into the same complex leads to the impression of a long period of technological stasis (Semaw et al., 1997; Semaw, 2000). One of the contributions of the Lokalalei data is to provide insight into variability that does not tally with the notions of stasis. In the East African Pliocene sites, at least four species grouped into two or three genera (*Paranthropus*, *Australopithecus*, and *Homo*) are represented, some of which lived contemporaneously while others appeared successively : *A. aethiopicus* (or *P. aethiopicus*) in the Omo Valley and West Turkana, *A. boisei* (or *P. boisei*) in the Omo Valley and Lake Turkana basin, *A. garhi* (known in the Middle Awash but not at Gona and Hadar), early *Homo* in West Turkana, Lake Baringo Basin, Hadar and Omo (*H. aff. Habilis*). This suggests that the Pliocene knappers could have belonged to different hominid taxa. Neither the notion of linear technological evolution even with a Pre-Oldowan and an Oldowan phases, nor a long lasting static Oldowan makes sense considering this paleoanthropological diversity and the assumed technological diversity. These two notions were implicitly based on the paradigm of a unique techno-cultural entity implying only one species capable of toolmaking. This paradigm is not supported by the current data and it seems most unlikely that the hominids groups inhabiting the East African Rift Valley for over one million years (between 2.6 and 1.6 Myr) could have shared the same techno-cultural traditions, nor that inter-group transmission of technical knowledge was yet an established practice.

Lastly, it should not be forgotten that while there is but one elementary knapping motion, there are multiple ways of combining sequences of such elementary actions in order to flake, shape or retouch stone. These combinations translate into different knapping sequences and therefore particularize the skills of a group or individual's performance. These skills can be identified in every site and compared on a site-by-site basis in terms of anticipation, elaboration, manual dexterity, productivity, and raw material management, etc. Lithic technology is a powerful device for bridging the huge temporal and anthropological gap between ourselves and the earliest tool-makers. Refitting, a remarkably effective analytical tool, makes it possible for a very high level of precision to be attained, which provides information on the way hominids proved capable of adjusting themselves to the qualities of the raw materials, how they managed or failed to overcome technical difficulties, and how they circumvented them by thinking ahead. Succumbing to the temptation to categorize assemblages should be postponed until warranted by a significant increase in the number of detailed analysis of Pliocene archaeological sites. Meanwhile, technological analysis is the only approach liable to shed light on the all-important question of early hominid techno-economic behavior.

Notes

(1) The West Turkana Archaeological Project is co-directed by Hélène Roche and Mzalendo Kibunjia (National Museums of Kenya). It is a joint research program between the National Museums of Kenya (NMK) and the *Mission Préhistorique au Kenya* (MPK), directed by Hélène Roche.

Acknowledgments

We thank the Office of the President of the Goverment of Kenya and the Board of Governors of the National Museum of Kenya for permission to work in West Turkana; Dr. George Abungu, and Dr. Karega Muñene, respectively Director of the National Museums of Kenya and Head of the Department of Archaeology when we excavated and undertook the study of Lokalalei 2C; the members of the West Turkana Archaeological Project, who participated in the field work, and particularly Craig Feibel, Jean-Philippe Brugal, Vincent Mourre, Pierre-Jean Texier, James Ekwiyeni, Boniface K. Kimeu, Bernard Kimolo, Rafael M. Kioko, Benson Kyongo, Ethekon L.Lokokodi, Samuel Mekwea, Victor Mugao, Kimolo S.Mulwa, Ali Mutisya, Samuel Mutuku, Akwam A. Nares, Longelei K. Ngolokerem, Thomas Nume, Mustapha Taha; Mzalendo Kibunjia for allowing us to look at the Lokalalei 1 lithic material, Craig Feibel for useful comments, Sonia Harmand for information about the raw materials, and Sandrine Prat for her review of the paleoanthropological data. We are indebted to Jehanne Feblot-Augustins for the translation of this paper and for meaningful comments during the preparation of the manuscript; to Sylvain Pasty for artefacts drawings, to François Lacrampe-Lacuyaubère for spatial distribution diagrams and to Gérard Monthel for all other figures included in this paper. The constructive comments provided by Fred Spoor, Joint Editor, Sally McBrearty and two other anonymous reviewers greatly improved the content and style of this paper.

This research was funded by the Minister of Foreign Affairs (*Sous-direction de la recherche*) and by the *Centre National de la Recherche Scientifique* (program *Paléoenvironnement et Evolution des Hominidés*).

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