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Late Pliocene hominid knapping skills: The case of Lokalalei 2C, West Turkana, Kenya

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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 than 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 *d ebitage* 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.

R esum e

Les activit es de taille des hominid es plioc enes sont   ce jour repr esent ees par un nombre restreint d'ensembles lithiques et ceux-ci n'ont quasiment pas  t   tudi es en termes d'habilit es et d'acquis techniques. Dans ce registre du d veloppement technologique des premiers hominid es, le site de Lokalalei 2C (Kenya), estim    2.34 Ma, fournit un ensemble de donn ees qui remet en question tout autant l'id e d'une  volution lin airement continue que celle qui privil gie au contraire l'immobilisme des productions humaines anciennes. L' tude de cet ensemble lithique r v le un

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

41 Introduction

42 Although Late Pliocene hominids (genera
43 *Australopithecus* and *Homo*, between 2.6 and
44 2.0 Myr) form a numerically important and widely
45 discussed group of fossil taxa, their stone tools are
46 still poorly documented. For several decades, the
47 main focus of research has been the discovery of
48 new fossil hominids, while the archaeology itself
49 received only cursory attention. As a result, we
50 know more about the hominids of these periods
51 than about their technical achievements. More-
52 over, the association of the former with the latter
53 remains problematic. The context is so far fully
54 reliable for under a dozen sites (Hadar and Gona :
55 Corvinus and Roche, 1976; Roche and Tiercelin,
56 1980; Harris 1983; Kimbel et al., 1996; Semaw
57 et al., 1997; Semaw, 2000; Omo : Chavaillon 1976;
58 Merrick and Merrick, 1976; West Turkana :
59 Kibunjia et al., 1992; Kibunjia, 1994; Roche
60 et al., 1999; Kanjera : Plummer et al., 1999), and
61 only one of these (Hadar AL 666, Kimbel et al.,
62 1996) has yielded hominid fossil remains asso-
63 ciated with stone artefacts. In addition, the scanty
64 data available to date are not exploited in terms of
65 knapping skills and technological evolution. Yet
66 the very earliest hominid stone tools known
67 provide unmistakable evidence for **intentional**
68 flaking, implying an empirical understanding of
69 the mechanics of fracture of hard rocks, geared
70 towards obtaining a substantial number of sharp-
71 edged implements. This understanding demands
72 that the basic technical constraints peculiar to
73 stone knapping be mastered. The major raw
74 material constraints are homogeneity and shape,

the ideal shape showing intersecting striking 75
surfaces and regular convex or flat flaking 76
surfaces, with edge angles below 90°. Knapping 77
constraints dictate requiring accurately aimed 78
blows, which must not fall too far or too close to 79
the edges, and blows delivered with a strength 80
matched to the resistance of the materials. It is 81
evident that the Plio-Pleistocene hominids respon- 82
sible for making these earliest stone assemblages 83
have moved far beyond the stage of an un- 84
intentional production of debris such as that 85
resulting from the accidental breakage of hammer- 86
stones at the nut-cracking loci of chimpanzees 87
(Mercader et al., 2002), which should not be 88
mistaken for intentional flaking. Late Pliocene 89
stone-working is not technology in its infancy. No 90
discovery has so far documented such a primary 91
stage, and it is likely that the corresponding 92
remains would be very difficult to identify, 93
although it may be assumed that modified stones 94
were used prior to the oldest clearly intentionally 95
flaked artefacts dated between 2.6 and 2.5 Ma 96
(Semaw et al., 1997; Panger et al., 2002). Does this 97
necessarily mean that similar competence ap- 98
peared everywhere according to a synchronic and 99
uniform pattern, or is there evidence for a stag- 100
gered development of knapping skills during 101
almost a million years? This is precisely what the 102
study of the Lokalalei 2C material, estimated at 103
2.34 Myr, strongly suggests. The Lokalalei knap- 104
pers appear to have reached a more advanced state 105
of technological development than most of their 106
East-African counterparts. This is shown by their 107
planning capabilities, their manual dexterity, the 108
consistency of their flaking processes and resulting 109

110 productivity. Clearly, a technological reassessment
 111 of Plio-Pleistocene assemblages is required to
 112 allow meaningful comparisons and to position
 113 Lokalalei 2C within the context of Plio-Pleistocene
 114 technological development. The question remains
 115 as to which hominid species the Lokalalei 2C
 116 knappers belonged. Since the first Lokalalei results
 117 were published (Kibunjia, 1994; Roche et al.,
 118 1999), a first lower molar germ attributed to *Early*
 119 *Homo* was found at Lokalalei 1 α , in close
 120 proximity to the Lokalalei 1 archaeological site
 121 and within the same lithostratigraphic unit (Prat
 122 et al., submitted for publication). *Early Homo* thus
 123 becomes a possible candidate for making the lithic
 124 assemblages of Lokalalei 1 and Lokalalei 2C,
 125 although the robust australopithecine (KNM-WT
 126 17000 : Walker et al., 1986, attributed by most
 127 researchers to *Australopithecus aethiopicus* was
 128 also present at 2.5 Myr in West Turkana.

129 General context (Fig. 1)

130 The site of Lokalalei 2C was excavated as part
 131 of the West Turkana Archaeological Project
 132 (WTAP) (1), a multidisciplinary project of

133 archaeological survey and exploration of the
 134 Nachukui Formation. This formation spans the
 135 Late Miocene to Middle Pleistocene. It lies in the
 136 Lake Turkana basin, which also encompasses the
 137 Shungura Formation to the north and the Koobi
 138 Fora Formation to the east. The major objective
 139 of the project is to document the diversity of Late
 140 Pliocene and Early Pleistocene hominid behavior-
 141 al adaptations, within a topographically circum-
 142 scribed study area where chronology and
 143 paleoenvironments are well understood (Kibunjia
 144 et al., 1992; Roche and Kibunjia, 1994; Roche
 145 et al., 1999; Roche et al., 2003; Brugal et al., 2003;
 146 Prat et al., 2003).

147 The Nachukui Formation spans the period
 148 4.35–0.7 Myr. Its archaeological importance is
 149 due to the succession of multiple hominid occu-
 150 pations in the time interval between 2.34 Myr and
 151 0.7 Myr. Of the thirty or so sites, grouped into five
 152 site complexes, recorded to date, twenty have been
 153 tested or partly excavated, and seven intensively
 154 excavated. The latter include the two Pliocene sites
 155 of Lokalalei 1 (GaJh 5), excavated in 1991
 156 (Kibunjia, 1994; Kibunjia, 1998), and Lokalalei 2C
 157 (GaJh 6C), excavated in 1997 (Roche et al., 1999).

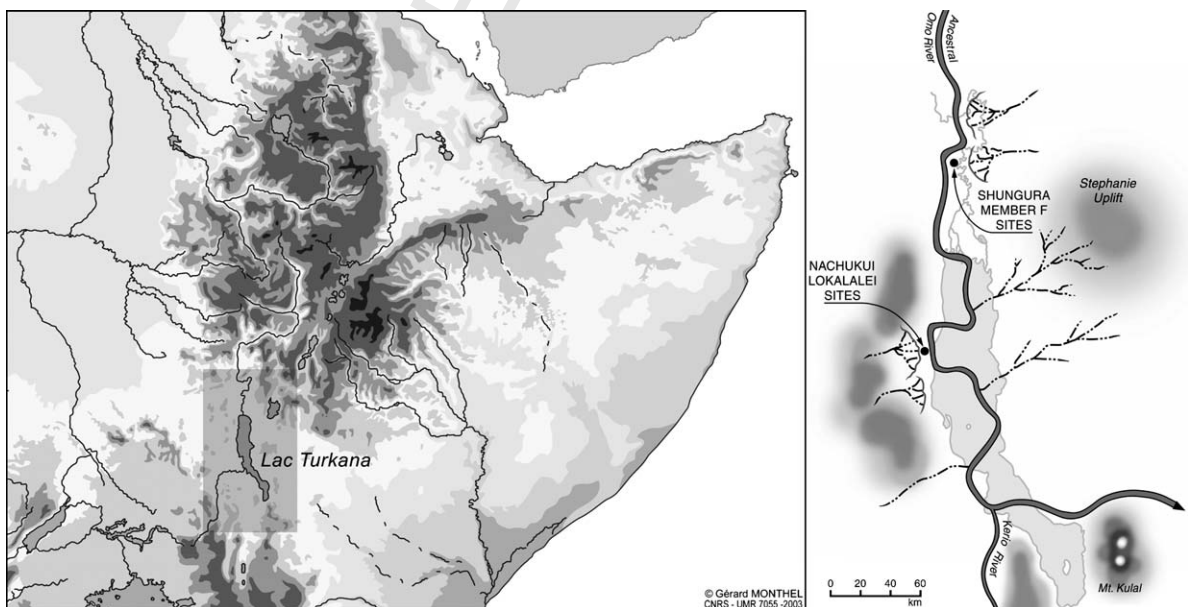


Fig. 1. Localization of Lokalalei 2C in East Africa context and Turkana Basin.

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

161 *Geological and chronological context*

162 The regional paleogeography and paleoenviron-
163 ments are described in a series of publications (e.g.
164 Harris et al., 1988; Brown and Feibel, 1988, 1991;
165 Feibel et al., 1989; Feibel et al., 1991), so that only
166 the main features need be recalled here. The
167 Nachukui Formation (cumulative thickness
168 730 m) appears in the form of a long thin band
169 of sediments exposed between the shore of present-
170 day Lake Turkana to the east and the Labur and
171 Murua Rith ranges to the west by which this part
172 of the basin is bounded. It has been divided into
173 eight members each characterized by major
174 tephtras. These differ from one another in their
175 geochemical composition and can be correlated
176 with the tephtras punctuating the Shungura and
177 Koobi Fora Formations.

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

188 Locally, Lokalalei 1 and Lokalalei 2C are
189 correlated by a mollusc-packed sandstone, which
190 underlies both sites. This marker was used by
191 Brown (in Harris et al., 1988) as the local
192 boundary between the Lokalalei and Kalochoro
193 Members (2.35 Myr). The Kokiselei and Ekalalei
194 Tuffs lying below the Lokalalei 1 and Lokalalei 2C
195 sites are correlated with Tuffs E and F-1 re-
196 spectively of the Shungura Formation. The Koki-
197 selei Tuff (= Tuff E) has an estimated age of
198 2.40 ± 0.05 Myr, while the Ekalalei Tuff (= F1)
199 is slightly younger than 2.34 ± 0.04 Myr (Harris
200 et al., 1988; Feibel et al., 1989). An age of $2.34 \pm$
201 0.05 Myr is thus estimated for the Lokalalei
202 archaeological sites (Roche et al., 1999). The
203 stratigraphic position of Lokalalei 2C, slightly

higher in the section than Lokalalei 1, is compat- 204
205-206-207-208-209-210-211-212-213-214-215-216-217-218-219-220-221-222-223-224-225-226
ible 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 demon-
strated. 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 “approx-
imately 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 ± 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 is discussed later.

Archaeological context

228 The site of Lokalalei 2 spans a series of small
229 hills, and scattered archaeological remains (faunal
230 and lithic) appeared on the surface of nearly all the
231 slopes. Only two concentrations were found at the
232 localities of Lokalalei 2C and Lokalalei 2A (80 m
233 south of Lokalalei 2C at the same elevation). At
234 Lokalalei 2A, two test excavations were carried
235 out in 1994 and 1997. Lokalalei 2C was exhaus-
236 tively excavated in 1996 and 1997 (Fig. 2). A total
237 of 17 m² was excavated. All *in situ* deposits of this
238 spatially restricted site were removed. All the
239 surface materials located on the southern slope
240 were plotted over 3 m², while those lying around
241 the site were collected and recorded over 104 m².

242 The archaeological horizon of Lokalalei 2C lies
243 within a vertisol developed on clays interstratified
244 with sands. At the base of the section (Fig. 3),
245 there is a very dense dark brown silty clay with
246 a prismatic structure, cut into by coarse grained
247 sands in which the artefacts are distributed.
248 Laminations of finer grained sands can be seen.
249 An erosional contact separates the sands from an



Fig. 2. Lokalalei 2C during excavation.

250 overlying clayey deposit. This sedimentary succes- 273
251 sion and the asymmetrical profile of the sand 274
252 deposit strongly suggest the peripheral zone of 275
253 a periodic stream. 276

254 The archaeological deposit forms a dense ob- 277
255 long patch, extending laterally roughly north- 278
256 south over an area of 10 m² (Fig. 4). Its vertical 279
257 distribution, over 50 cm, is consistent with the 280
258 profile of the sand deposit. Such a dispersion is 281
259 compatible with a vertisol context. 282

260 The homogeneity of the assemblage is demon- 283
261 strated by the spatial distribution of the refitted 284
262 elements (Fig. 5). Artefacts belonging to a single 285
263 refitting group can be found scattered, horizon- 286
264 tally and vertically throughout the entire sand 287
265 deposit in which the remains occur. Moreover, the 288
266 refitting groups include both *in situ* pieces and 289
267 pieces from surface context. The distribution of 290
268 the cores included in refitting groups does not 291
269 show any obvious spatial patterning and nor are 292
270 artefacts belonging to the same technological 293
271 category (unmodified cobbles, partly flaked cob- 294
272 bles, percussion implements, cores, flakes) grouped 295

273 together. This does not argue for the preservation 274
275 of spatially identifiable knapping areas, owing to 276
277 a degree of vertical and horizontal displacement. 278
279 As a result, issues regarding the spatial distribu- 280
281 tion of on-site activities cannot be addressed. 282

283 The archaeological deposit is truncated by 284
285 erosion on its western and eastern edges, and 286
287 elements were scattered on the southern erosional 288
289 slope. However, the preserved part of the site, 290
291 which was exhaustively excavated, shows clear evi- 292
293 dence of good preservation. This is suggested by 294
295 the high ratio (28%) of very small elements (< 1cm) as

287 Lithic remains (n = 2614) outnumber faunal 288
289 specimens (n = 390) (Roche et al., 1999; Brugal 290
291 et al., 2003). The faunal remains, poorly preserved, 292
293 include twelve mammals species (bovids, suids, 294
295 equids and an hypsodont rhinocerotid) repre- 296
297 sented mainly by teeth, as well as reptile bones 298
299 (Crocodylidae), shell fragments of a large tortoise 300
301 and fragments of ostrich egg shell. Except one cut- 302
303 mark on a mammal bone fragment (gazelle size) 304
305

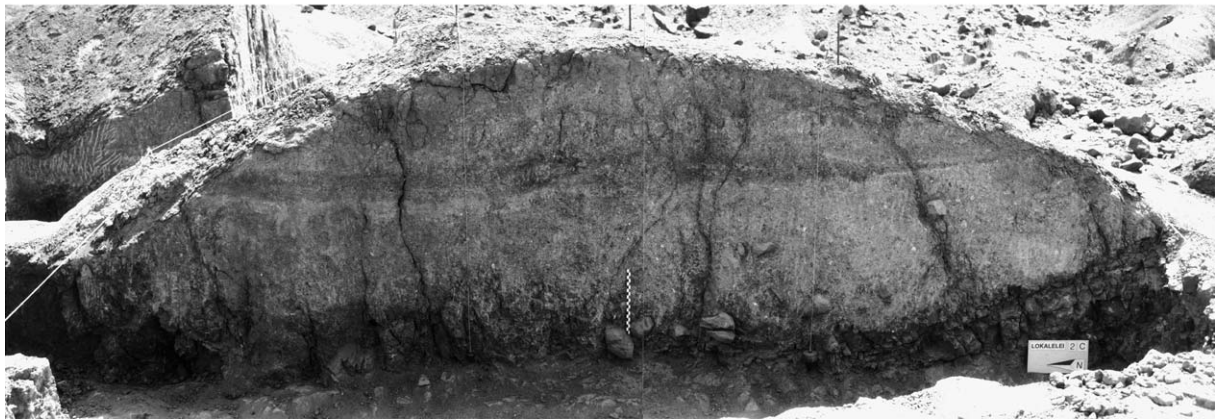
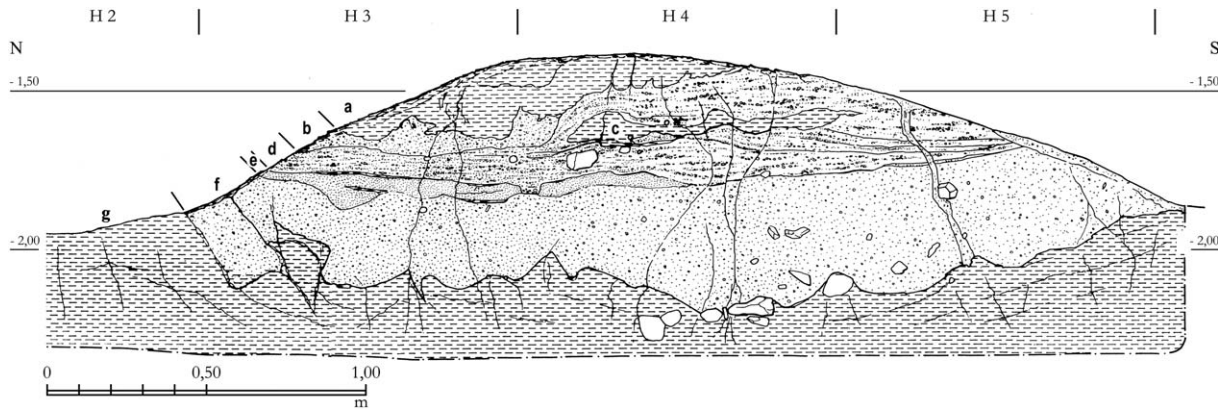


Fig. 3. Detailed stratigraphic section.

296 from surface context, no other evidence of
 297 hominid action on bones has been recognized
 298 (Brugal, pers. com.).

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

309 The relative proportions of the different cate-
 310 gories of artefact suggest that Lokalalei 2C was
 311 a knapping spot. Between 185 and 195 cobbles or
 312 fragments of cobbles were transported to the site,
 313 90 to 95 of which were flaked on the spot,
 314 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 20 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 subsis-
 tence-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”. It is

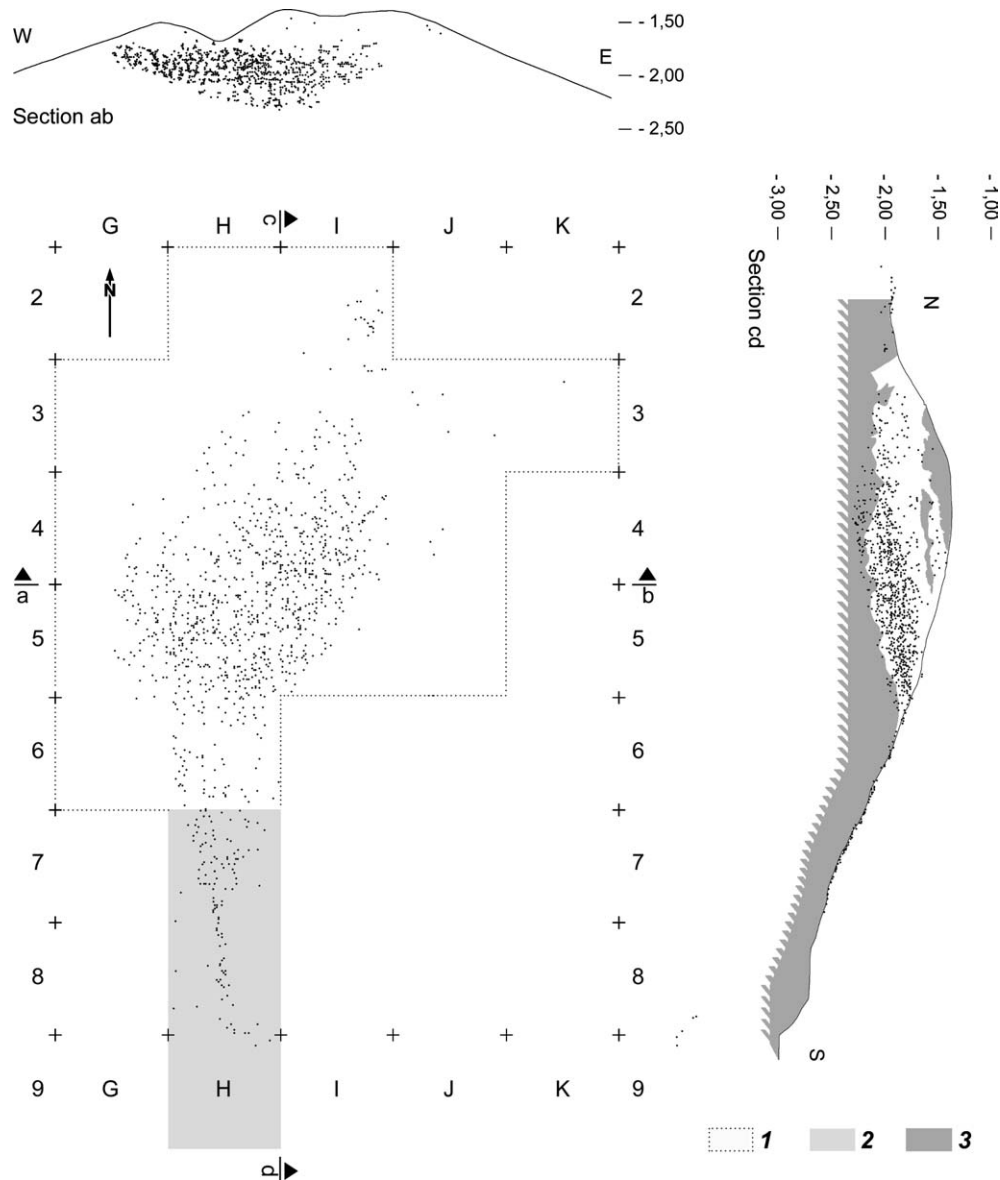


Fig. 4. Map of the excavated area and vertical projection of all the remains following the NS and WE axes. (1) *in situ* plotted material, (2) surface plotted material, (3) clay embedding the archaeological horizon.

331 opposed to *shaping*, which refers to a “knapping
 332 operation carried out for the purpose of
 333 manufacturing a single artefact by sculpting the
 334 raw material in accordance with the desired form”
 335 (Inizan et al., 2000, p.138 and 155). The first set,
 336 characterized by a small number of cores and
 337 flakes, corresponds to a type of *débitage* that we

338 describe as simple. Included within this set are 338
 339 pieces displaying few flake scars, as well as split
 340 and unmodified cobbles. The second set, which is
 341 the more significant, hinges upon a principle of
 342 *débitage* that we identify as organized. The
 343 characteristics of this technological set are docu-
 344 mented by our study of the refitting groups and of

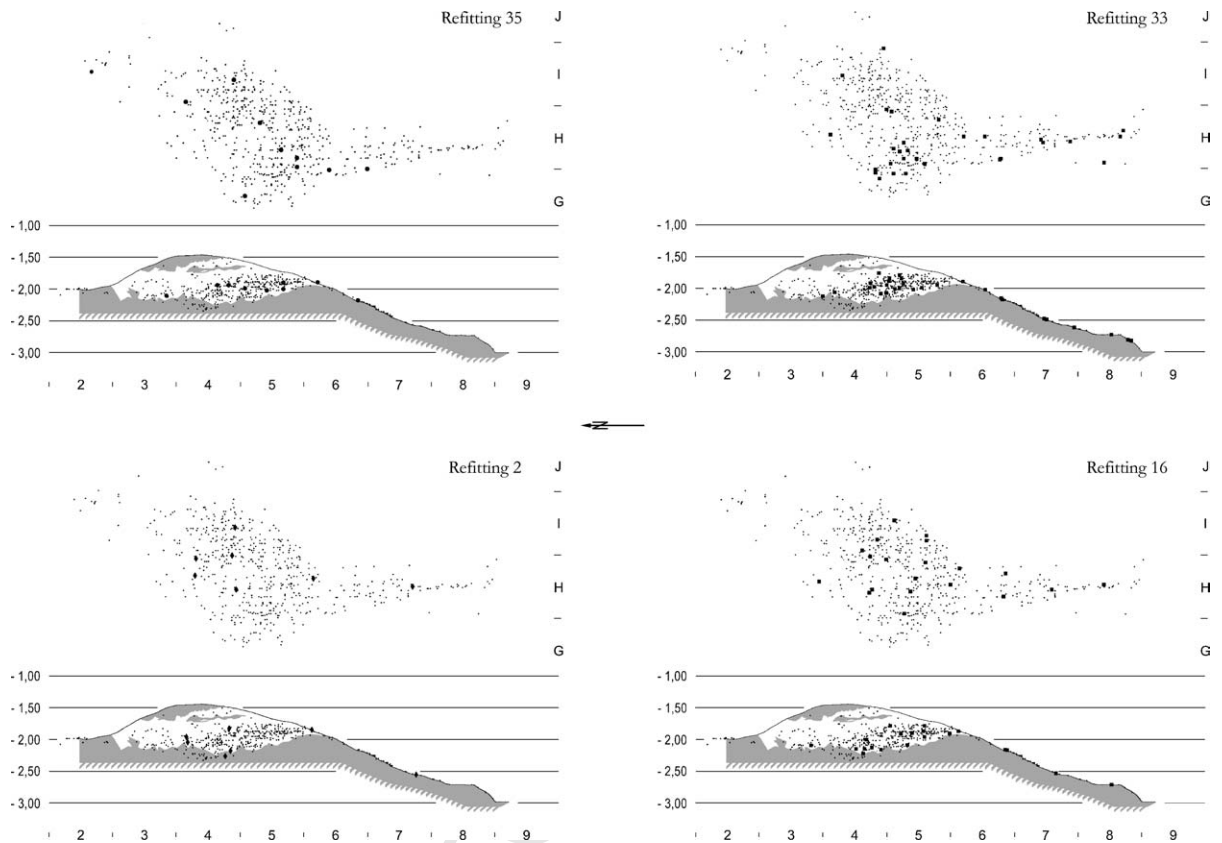


Fig. 5. Vertical and horizontal distribution of the products for four refitting groups.

345 the set's core component. The two sets are made of
 346 petrographically distinct lava cobbles, whose
 347 physical and mechanical properties and overall
 348 shape are quite different. All those lavas (phono-
 349 lite, trachyte, basalt and rhyolite) were available in
 350 a channel at a maximum distance of 50 m from the
 351 site (Harmand, in prep).

352 *Unmodified material and simple débitage*

353 The whole or split unmodified cobbles and
 354 those with rare flake scars are medium-sized
 355 specimens (mean 7.6 cm x 5.4 cm x 4.2 cm, and see
 356 Table 2), with maximum dimensions not exceeding
 357 a dozen centimetres for the biggest pieces. They
 358 possess shorter lengths and narrower widths than
 359 the flaked cobbles resulting from the organized
 360 *débitage*, but similar thicknesses. Original mean

361 dimensions of the flaked cobbles (12 cm x
 362 6.7 cm x 4.2 cm) are inferred from the refitting
 363 groups.

364 The majority of the 54 unmodified pieces are
 365 rounded cobbles, with only seven angular speci-
 366 mens. They are mostly trachyte and basalt, unlike
 367 the flaked component, mostly phonolite.

368 The very slightly modified cobbles (20) gener-
 369 ally display a single flake scar, occasionally two or
 370 three, as if the pieces had been discarded after
 371 having been tested. It should be noted that most of
 372 these cobbles are angular specimens, their shape
 373 being quite similar to that of the cores on which an
 374 organized *débitage* was carried out. On the other
 375 hand, most of them are medium grained trachyte,
 376 a less homogeneous raw material than the
 377 phonolite that represents the dominant raw
 378 materials used at Lokalalei 2C (Harmand, in

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

379 prep.). The reason for the premature abandon- 396
 380 ment of these specimens very likely lies in the poor 397
 381 flaking quality of the raw material. 398

382 A small number of cores present a moderately 399
 383 high count of removal scars (up to a dozen), with 400
 384 seemingly random distribution, either on two 401
 385 distinct faces of the core or on all the faces. These 402
 386 removals are often hinged. The cores were worked 403
 387 from thick cobbles with a generally quadrangular 404
 388 cross-section and made of medium-grained pho- 405
 389 nolite. Differences in shape set them apart from all 406
 390 the other cores, and this probably accounts for 407
 391 their heterogeneous character and their expediently 408
 392 knapped condition. 409

393 *The organized débitage*

394 The study of the organized *débitage* relies 410
 395 mainly on the data provided by the refitting 411

412 groups. The number and quality of these refittings 396
 413 (Table 3) have allowed a precise reconstruction of 397
 414 the flaking sequences. The proportion of the 398
 415 refitted elements reaches 10.9% of the total 399
 416 assemblage and 16.1% of the *débitage* component 400
 417 (excluding the very small elements < 1cm). The 401
 418 refitting groups contain valuable information that 402
 419 would have been impossible to access by any other 403
 420 means. In particular they reveal information on 404
 421 productivity (number of flakes produced per core), 405
 422 on the stages of introduction of materials at the 406
 423 site, and on the knappers' technological flexibility 407
 424 in coping with unexpected flaking incidents. The 408
 425 analysis entails scrutinizing each of the pieces in 409
 426 the refitting groups, following the chronology of 410
 427 the reduction process from the first flake produced 411
 428 to the final discard of the core. The order and 412
 429 direction of detachment of the flakes, as well as the 413
 430 technical consequences of each removal for the 414

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

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)

415 continuation of *débitage* are thus recorded in
416 detail, a method that has already proved successful
417 in other contexts (Delagnes, 1996a, 1996b).

418 The refitting groups range from very incomplete
419 (a few conjoining flakes) to nearly complete. The
420 latter include six particularly important sets
421 comprising most of the flakes from the same
422 cobble, as well as the residual cores, that allows the
423 reconstruction of almost the entire reduction
424 sequence. (Figs 6–13).

425 *Cores*

426 The analysis of the 70 whole cores included here
427 within the organized *débitage* category provides
428 additional information on the variants within this
429 approach to *débitage*. Almost 40% of the cores
430 belong to refitting groups. The blanks used for
431 these cores include whole cobbles, broken up
432 fragments, and flakes. In the latter case, it is the
433 ventral face of the blank, usually opposed to
434 a convex and cortical dorsal face, that is nearly
435 always selected as a flaking surface, most likely
436 because it is naturally flat.

437 *The dimensions of the cores and the whole flakes*

438 Considerable reduction in size of the cores at
439 discard has already been demonstrated by the
440 refitting groups. The differences in measurements
441 between the cores (Table 4) and the cobbles prior
442 to *débitage* emphasize this point, especially as

regards core and cobble lengths (mean length for 443
cores is 6.6 cm against 11.6 cm for cobbles). 444
Distinctions could be drawn between five major 445
types of cores. 446

Cores with a single flaked surface (n = 22). This 447
category accounts for a majority of the cores. The 448
flaked surface is opposed to an unflaked cortical 449
face, which is markedly convex although its cross- 450
section may vary in shape. At discard, the flaked 451
surfaces may still possess an exploitation potential, 452
with no significant knapping accident accounting 453
for the abandonment of the core (Fig. 14, n°1, 4, 454
5), or they may display hinged flake scars (Fig. 16, 455
n°5), which caused *débitage* to be discontinued. 456
There are often several such hinged removal scars, 457
suggesting that the knapper relentlessly attempted 458
to continue exploiting the core. The flaking 459
surfaces of cores with a single flaked surface also 460
quite frequently possess a distinctly convex profile 461
when they are finally discarded (Fig. 16, n°2, 6). 462
This is a sign that the knappers did not always 463
succeed in producing flakes sufficiently invasive to 464
ensure that the flaked surface remained flat and 465
well balanced as the cores were being reduced in 466
size. Such examples are very informative about the 467
technical difficulties most frequently met with by 468
the knappers during the final stages of core 469
reduction. 470

*Cores with a single flaked surface and evidence of 471
platform rectification (n = 8).* A small number of 472
cores with a single flaked surface can be set apart 473
from the others. They display one or more 474
removals that occur on a natural striking platform 475
prior to the detachment of flakes from the flaking 476
surface. Their location does not seem casual and 477
they very likely were intended to rectify the 478
striking platform by removing an impeding 479
irregularity (e.g. refitting group 2, Fig. 14, n°2, 480
and refitting group 16, Fig. 15, n°2). This is not 481
a common practise and usually consists of a few 482
removals (Fig. 16, n°4). Occasionally it involves 483
a large number of removals, which range around 484
the entire perimeter of the core (Fig. 16, n°7). All 485
recorded examples testify to the care with which 486
the knappers controlled the detachment of flakes. 487
However, the angle of the initial striking platform 488

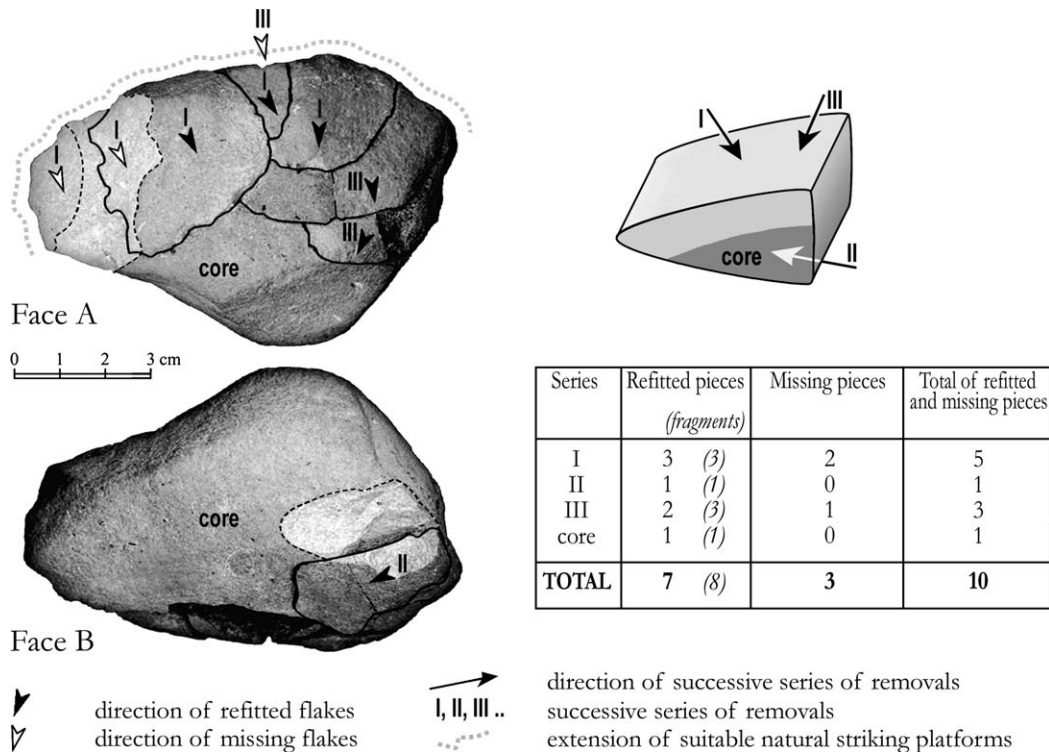


Fig. 6. Refitting group 2 (8 items). This group comprises the majority of the products detached from a small elongated ovoid medium-grained phonolite cobble (L = 9.4 cm, B = 6.3 cm, Th = 4.1 cm), with a large flat face opposed to a markedly convex and irregular one. *Débitage* was carried out on the 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.

489 is not modified. And it should be noted that the
 490 knappers never achieved genuine preparation of
 491 the striking platform that entailed either the
 492 creation of a protruding percussion zone or
 493 a significant modification of one edge of the core
 494 in order to obtain a suitable striking angle.

495 *Cores with a single major flaked surface and final*
 496 *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

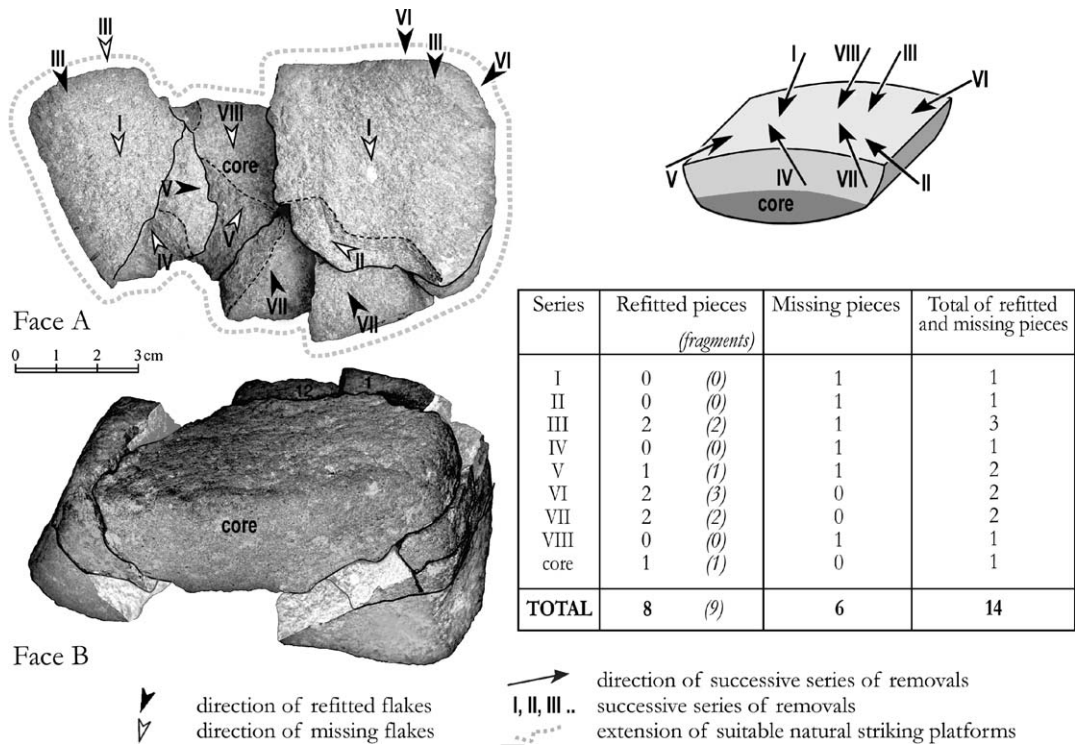


Fig. 7. Refitting group 3 (9 items). Refitting group 3 is characteristic of the technological principles that guided the production of flakes at Lokalalei 2C. Substantially less complete than the refitting group 2, this group includes some of the products struck from a medium-sized fragment of a medium-grained 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. Together with a few other pieces, 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. These could be signs of use damage (Fig. 14, n°1).

506 a final core reduction phase whose purpose was the
507 production of a few additional flakes at a stage
508 when the flaking surface was no longer serviceable,
509 or to a curtailed attempt at *débitage* after switch-
510 ing faces.

511 *Cores with at least two flaked surfaces*
512 ($n = 15$). Switching faces can actually be identi-
513 fied on a substantial number of cores. The two
514 surfaces were successively used as flaking surfaces
515 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 in-
cludes cores that cannot be included within

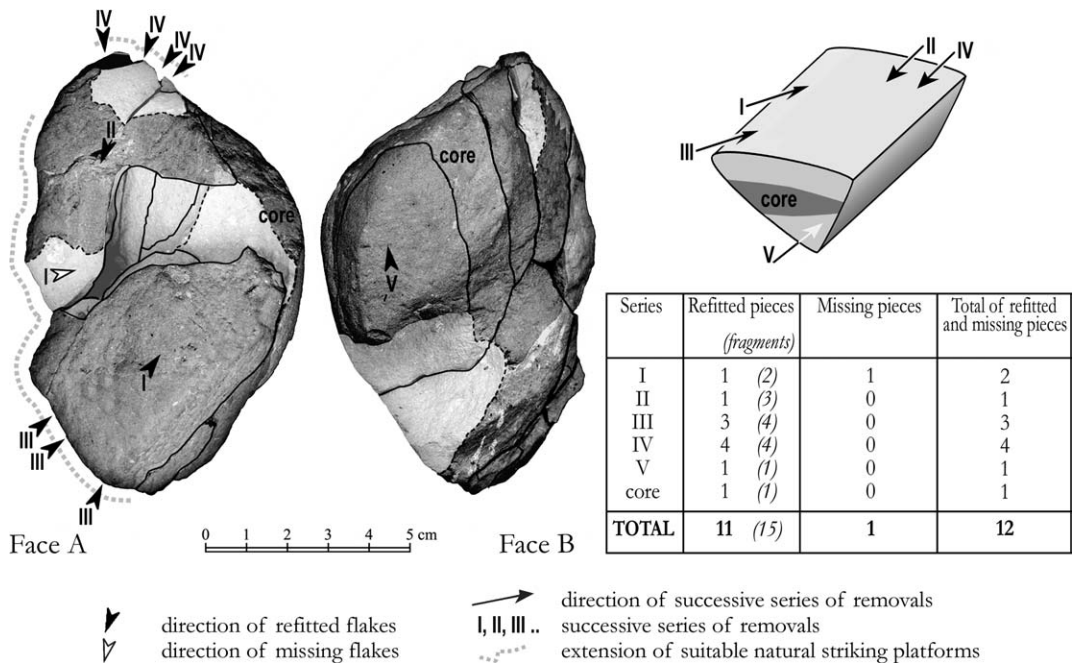


Fig. 8. Refitting group 9 (15 items). This refitting group reveals the almost complete reconstruction of an elongated ovate fine-grained porphyritic phonolite cobble (L = 11.3 cm, B = 6.4 cm, Th = 4.4 cm). It has a large and relatively flat natural face opposed to a highly convex one, resulting in a 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.

526 the simple *débitage* category either because of the
 527 nature of the blank (a flake), or because of the
 528 relatively high number of flakes produced. A
 529 substantial proportion (n = 9) of these cores lack
 530 natural striking angles suitable for the removal of
 531 flakes. As a result, the cores are globular and
 532 display significant knapping accidents. This cate-
 533 gory also includes a few cores worked from flakes,
 534 which only show a very small number of removals
 535 on their ventral faces (Fig. 16, n°8).

536 Flakes

537 Flakes are small to medium-sized and relatively
 538 thin (Table 4). Elements < 2 cm represent 77% of
 539 the whole flakes. Dimensions fall within a unim-
 540 odal distribution (Fig. 17) for whole flakes

> 2 cm. Their shape is generally quadrangular 541
 and barely elongated (Fig. 18). They frequently 542
 possess cortical butts (46%) adjacent to cortex 543
 back on one of their lateral edges. Noncortical 544
 butts are mostly plain. Long portions of the lateral 545
 and distal edges are sharp and quite obviously 546
 suited to cutting. These characteristics are shared 547
 by all of the flakes, owing to the same technical 548
 approach to production. A majority of the flakes 549
 are cortical (74%) and bear cortex either on their 550
 dorsal faces (38.7% of all cortical flakes), on both 551
 their butts and dorsal faces (36.1%), or exclusively 552
 on their butts (25.5%). Cortical flakes with cortex 553
 covering < 25% of the dorsal face are the best 554
 represented (Table 5), and this is in keeping with 555
 the heavily reduced cores deduced from the 556
 analysis of the refitting groups. 557

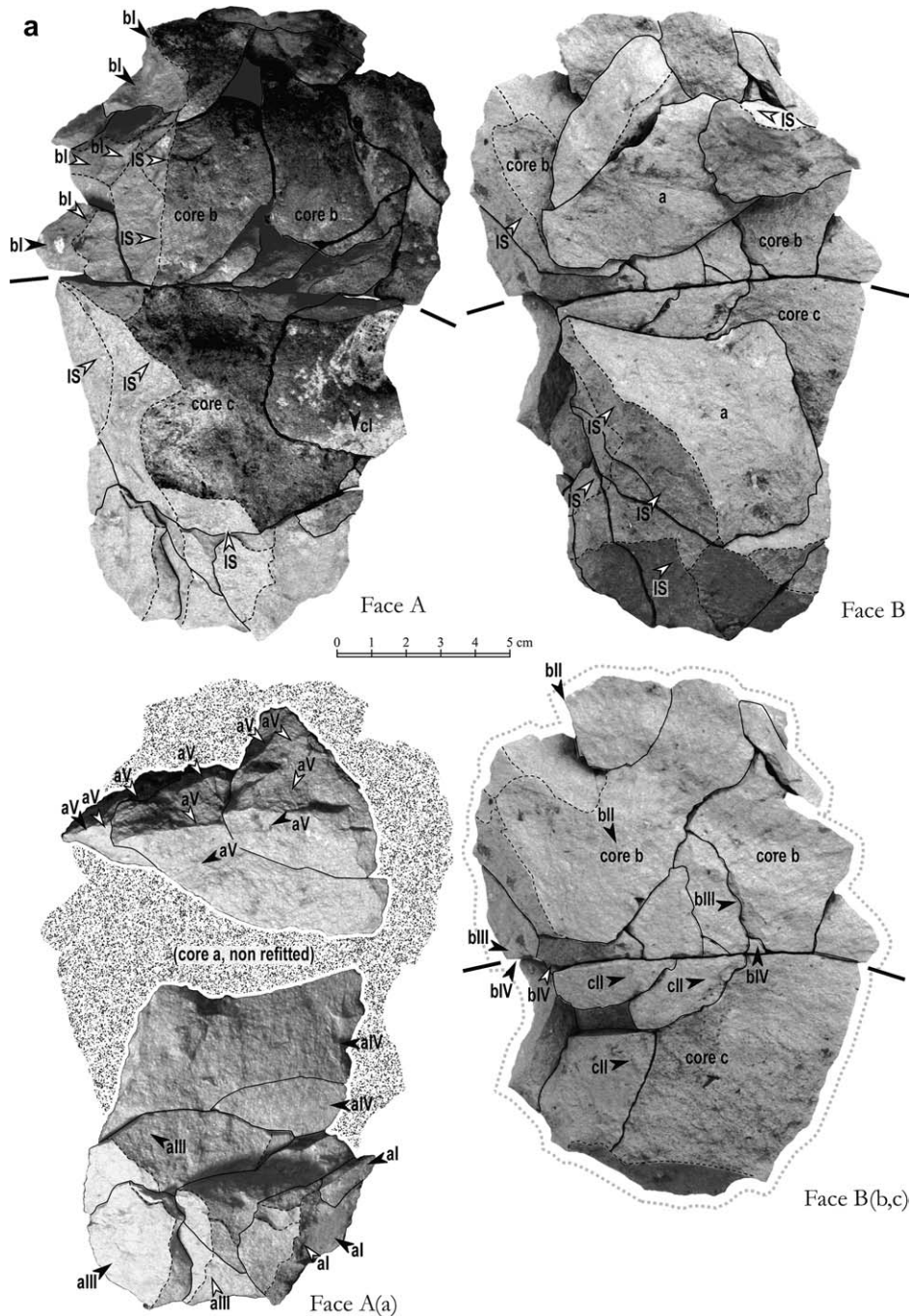


Fig. 9a and 9b. Refitting group 16 (34 items). Although incomplete, refitting group 16 was shown to be made up of three distinct sub-groups (a, b, c), each of which includes a core and its related flakes. All were originally part of a large cobble ($L > 20$ cm) of distinctive porphyritic fine grained 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

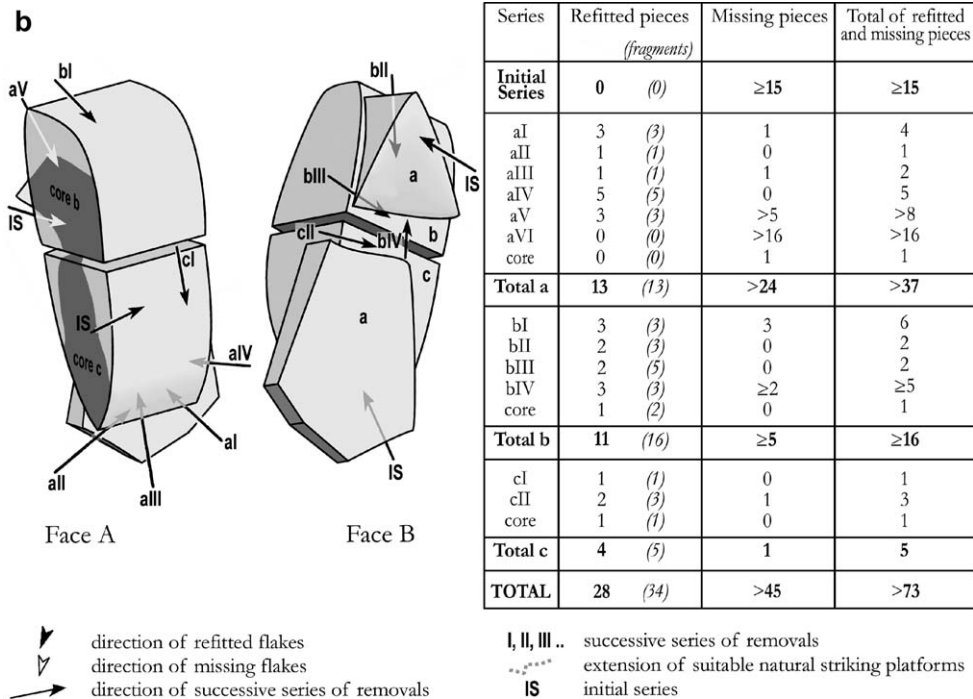


Fig. 9 (continued).

flakes were struck from 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.

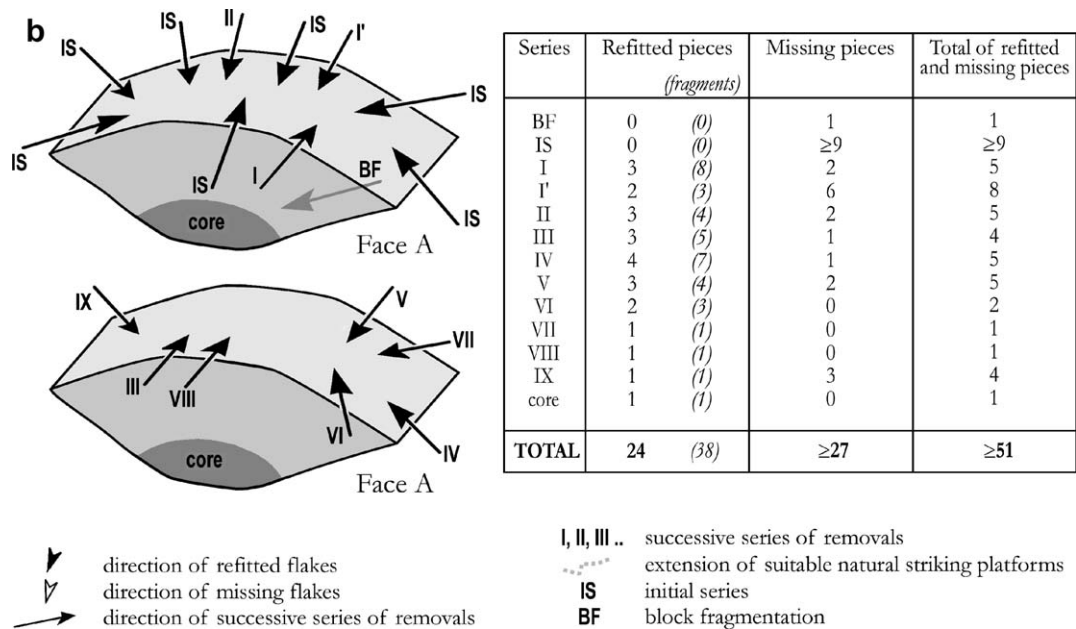


Fig. 10 (continued).

558 Broken flakes (60% of the flake component
 559 > 2 cm) outnumber whole flakes (see Table 1).
 560 The proportion of *Siret*-type fragments (16% of
 561 the broken flakes), corresponding to lateral frag-
 562 ments initiated at the percussion point, indicates

frequent breakage during *débitage*. Ongoing rep- 563
 licative experimentation is aimed at testing the 564
 connection between breakage and the flaking 565
 quality of Lokalalei 2C raw materials (Harmand, 566
 in prep.). 567

Fig. 10a and 10b. 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.

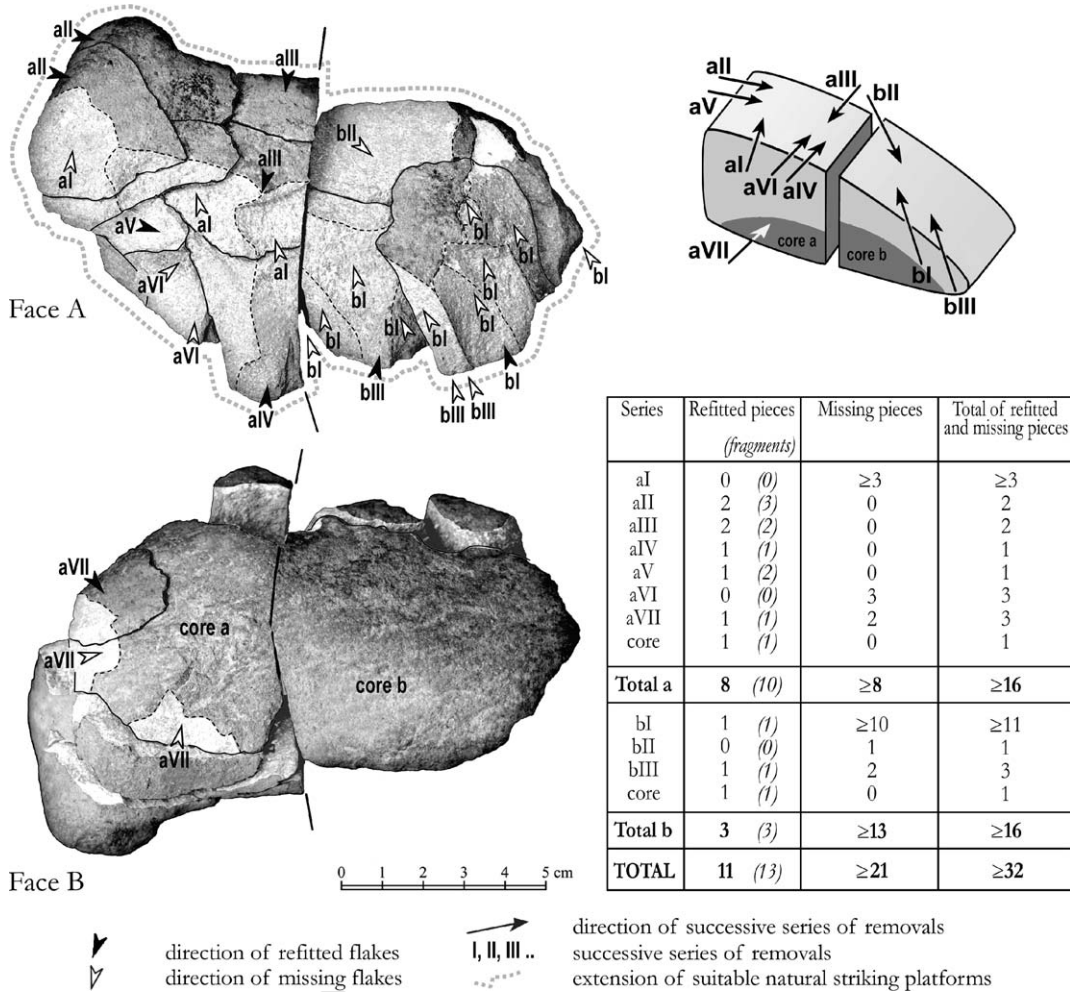
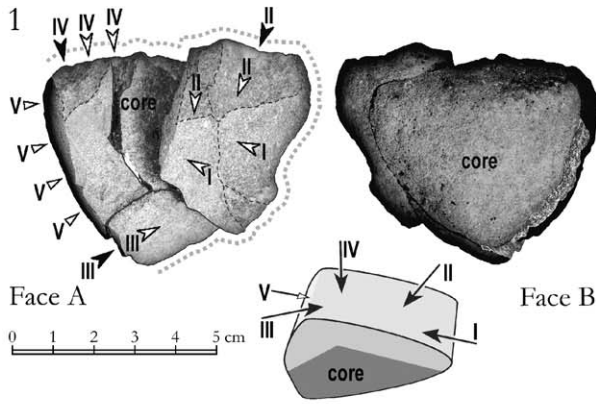
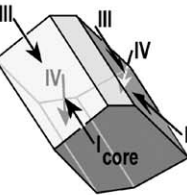
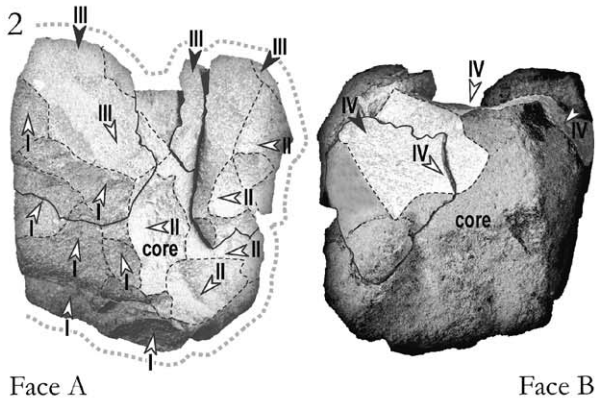


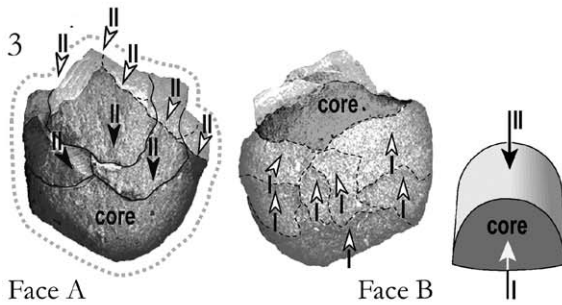
Fig. 11. Refitting group 35 (13 items). This refitting group illustrates the reconstruction of a medium-sized (L = 13.1 cm, B = 8 cm, Th = 3.7 cm) elongated roughly rectangular medium-grained phonolite cobble. In section, it is characterized by a large slightly convex cortical face opposed to a markedly 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.



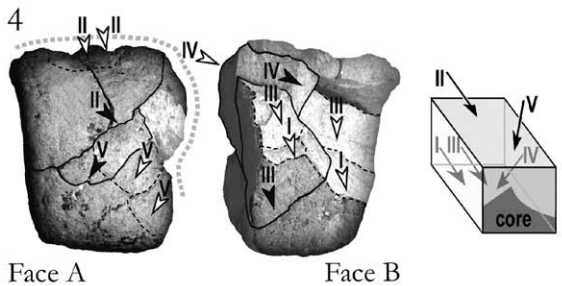
Series	Refitted pieces (fragments)	Missing pieces	Total of refitted and missing pieces
I	0 (0)	2	2
II	1 (1)	2	3
III	1 (1)	1	2
IV	1 (1)	2	3
V	0 (0)	4	4
core	1 (1)	0	1
TOTAL	4 (4)	11	15



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



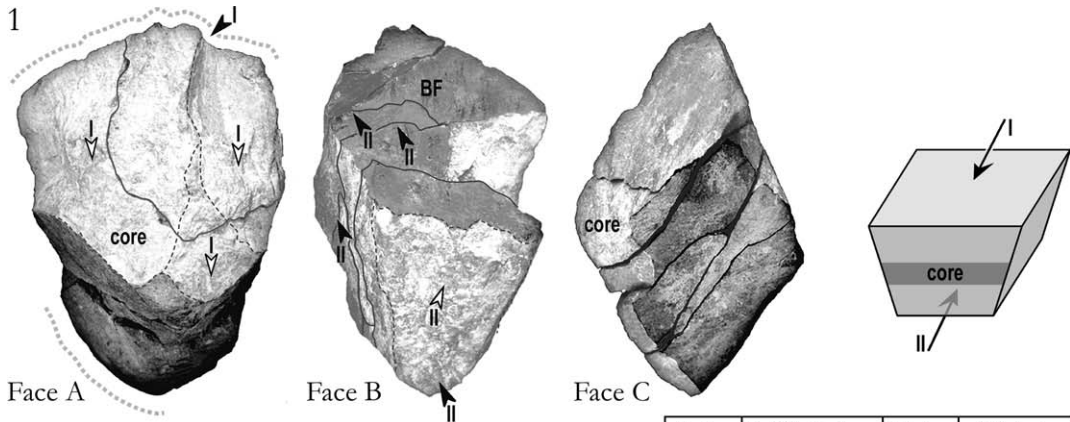
Series	Refitted pieces (fragments)	Missing pieces	Total of refitted and missing pieces
I	0 (0)	7	7
II	3 (3)	5	8
core	1 (1)	0	1
TOTAL	4 (4)	12	16



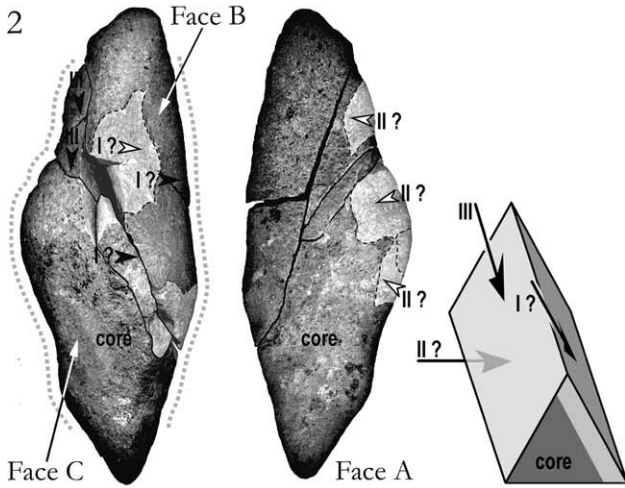
Series	Refitted pieces (fragments)	Missing pieces	Total of refitted and missing pieces
I	0 (0)	2	2
II	1 (2)	2	3
III	1 (1)	2	3
IV	1 (1)	1	2
V	1 (1)	3	4
core	1 (1)	0	1
TOTAL	5 (6)	10	15

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

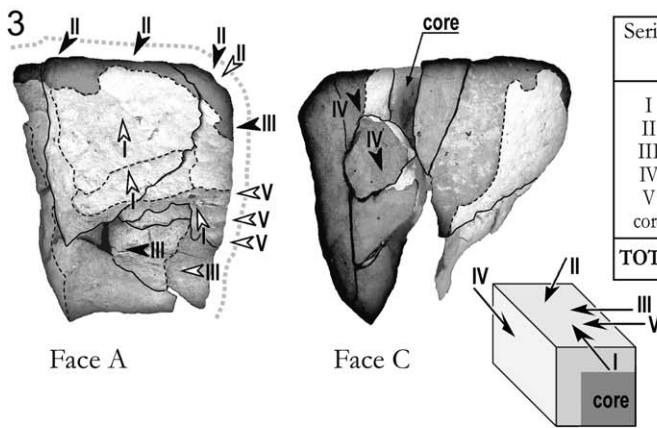
Fig. 12.



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

Fig. 13.

568 *Retouched pieces*

569 Few artefacts ($n = 22$) bear evidence of re-
570 touch. While most of the retouched pieces are
571 flakes ($n = 16$), some are cores ($n = 6$) recycled for
572 use as tools after *débitage* was completed (Fig. 18,
573 $n^{\circ}7$, Fig. 19).

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

580 Retouch on flake tools is sometimes opposed to
581 a cortical back (Fig. 18, $n^{\circ}4$, 5). It can be either
582 direct or inverse, and is predominantly located on
583 the lateral edge. In few cases, it extends along both
584 lateral edges (Fig. 18, $n^{\circ}1$) or adjacent edges
585 (Fig. 18, $n^{\circ}6$). Retouched pieces are fairly big,
586 ranging between 4 and 7 cm in maximum dimen-
587 sion, which is more than the mean length
588 recorded for unretouched flakes (see above).

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

Retouch on cores (Fig. 18, $n^{\circ}7$) 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, $n^{\circ}1$ and of refitting
group 16, Fig. 15, $n^{\circ}1$), retouch occurs on
edges with a very high angle, close to 90° , and
could ensue from a repeated and very localized

Figs 12 and 13. 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). 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, $n^{\circ}1$), 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, $n^{\circ}1$) or on a preferentially flaked surface (refitting group 48, Fig. 12, $n^{\circ}2$), 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, $n^{\circ}6$), 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, $n^{\circ}2$). The five other refitting groups display some variants in relation to the Lokalelei "classical" pattern described above. *Débitage* was successively conducted on two either opposing (refitting group 4, Fig. 12, $n^{\circ}4$; refitting group 12, Fig. 13, $n^{\circ}1$; refitting group 37, Fig. 12, $n^{\circ}3$) or adjacent faces of the blocks (refitting group 25, Fig. 13, $n^{\circ}3$; refitting group 54, Fig. 13, $n^{\circ}2$). 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, $n^{\circ}4$; refitting group 25, Fig. 13, $n^{\circ}3$) or a triangular cross-section (refitting group 54, Fig. 13, $n^{\circ}2$). 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, $n^{\circ}4$), which are the only ones with natural serviceable striking angles, or from two opposing edges (refitting group 12, Fig. 13, $n^{\circ}1$; refitting group 37, Fig. 12, $n^{\circ}3$), or, finally, from two adjacent edges (refitting group 25, Fig. 13, $n^{\circ}3$; refitting group 54, Fig. 13, $n^{\circ}2$). 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, $n^{\circ}3$; refitting group 37, Fig. 12, $n^{\circ}3$). 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, $n^{\circ}3$; refitting group 25, Fig. 13, $n^{\circ}3$; refitting group 37, Fig. 12, $n^{\circ}3$).

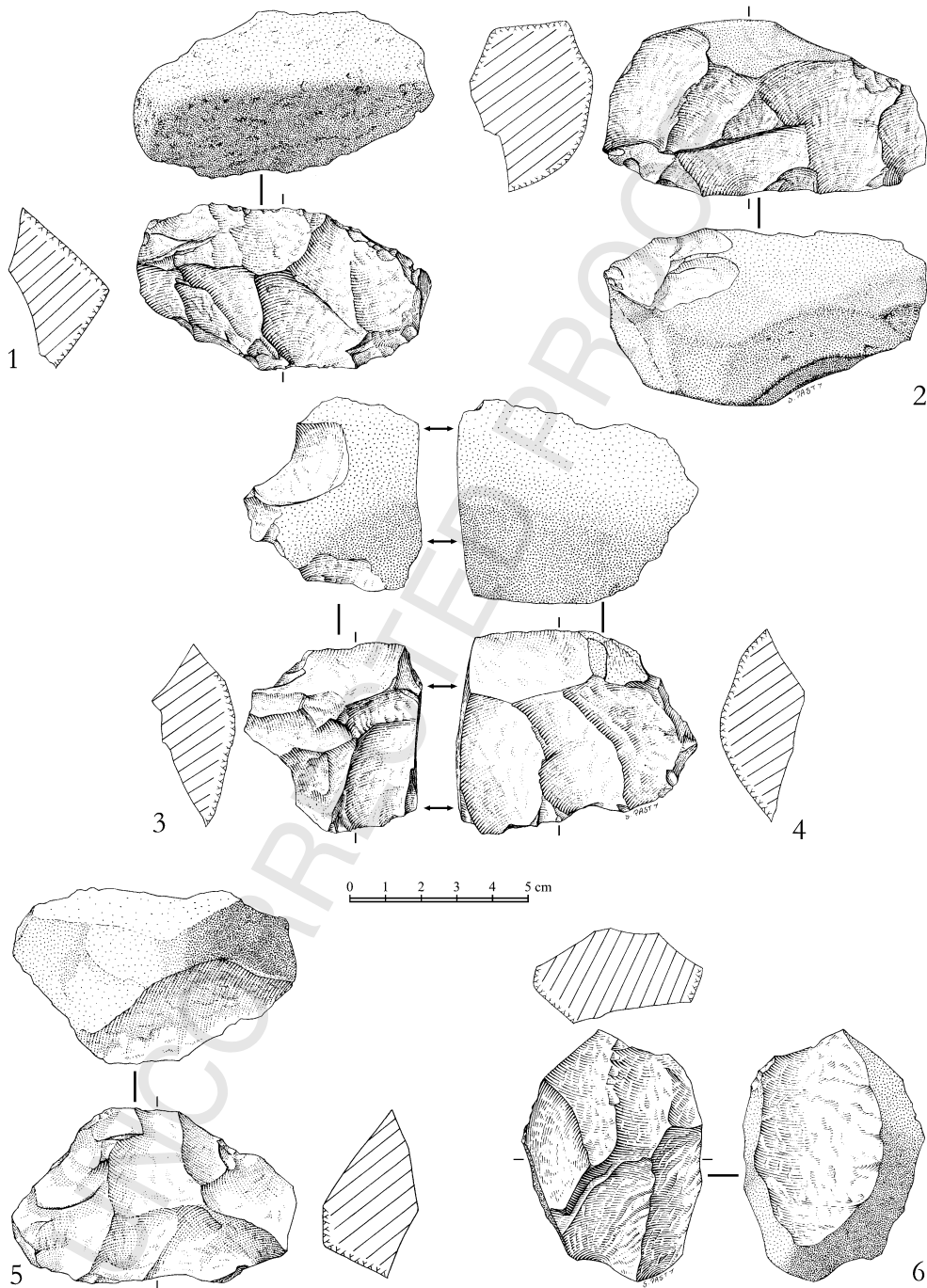


Fig. 14. Cores with a single flaked surface, (1) from refitting group 3, (4) from refitting group 35, (5) from refitting group 33. Cores with a single flaked surface and evidence of platform rectification, (2) from refitting group 2. Cores with a single flaked surface and final removals on the other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

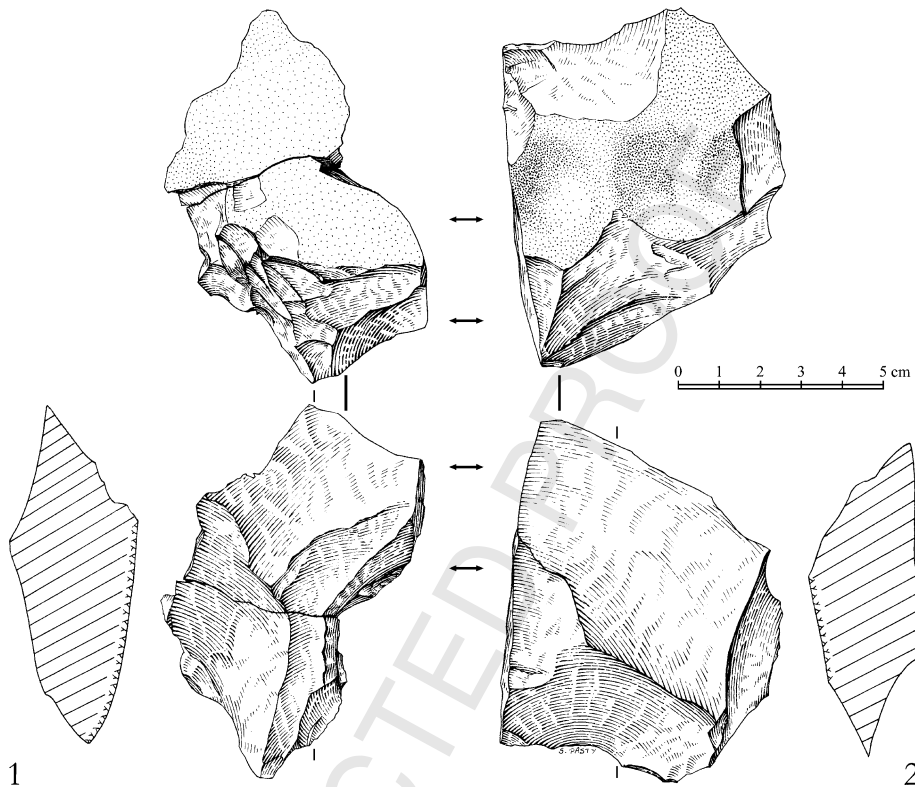


Fig. 15. Cores belonging to refitting group 16, (1) with a single flaked surface, (2) with a single flaked surface and evidence of platform rectification.

600 percussion motion. On these pieces, rather than
 601 creating a potentially functional active edge,
 602 retouch completely crushes the involved edge,
 603 and can very likely be attributed to use damage. Such
 604 a possibility might also be considered for the entire
 605 set of retouched pieces. However, barring the few
 606 above mentioned specimens, the edges of the
 607 retouched pieces (on flakes and on cores) are still
 608 definitely suitable for such actions as scraping or
 609 slicing after having been modified by retouch.

610 *Hammerstones (Fig. 20)*

611 A total of 18 artefacts bear clear evidence of
 612 percussion. Twelve of the specimens display
 613 numerous battering marks concentrated on one
 614 or two protruding zones, and their density is such
 615 that the natural surface of the block has become
 616 pitted. Six others bear more minor signs of impact
 617 damage (in terms of size of the patches and/or in

618 terms of density of the battering marks). This hints
 619 at less intensive or shorter-lived use as hammers.

620 A majority of the hammerstones are medium-
 621 sized rounded cobbles, but five of them are more
 622 angular and geometric cobbles. In most cases the
 623 percussion zone is situated at one or both ends of
 624 the cobble's long axis. However, in three cases the
 625 impact scars have a more central location. The
 626 cross-sections of these hammerstones are either
 627 plano-convex or in the shape of a truncated
 628 pyramid (Fig. 20 n°1), thus affording a somewhat
 629 stable "base" opposite which the percussion zone
 630 lies. In view of this configuration, the possibility of
 631 their having served as anvils cannot be ruled out.
 632 This suggestion mainly concerns one relatively
 633 bulky specimen (9.8 cm x 8.7 cm x 8.2 cm). It ap-
 634 pears less relevant for the two others whose
 635 dimensions (9.1 cm x 17.3 cm x 4.7 cm, and
 636 8.4 cm x 7.1 cm x 5.3 cm, Fig. 20, n°1), and shapes
 637 make them perfectly suitable for a knapper to

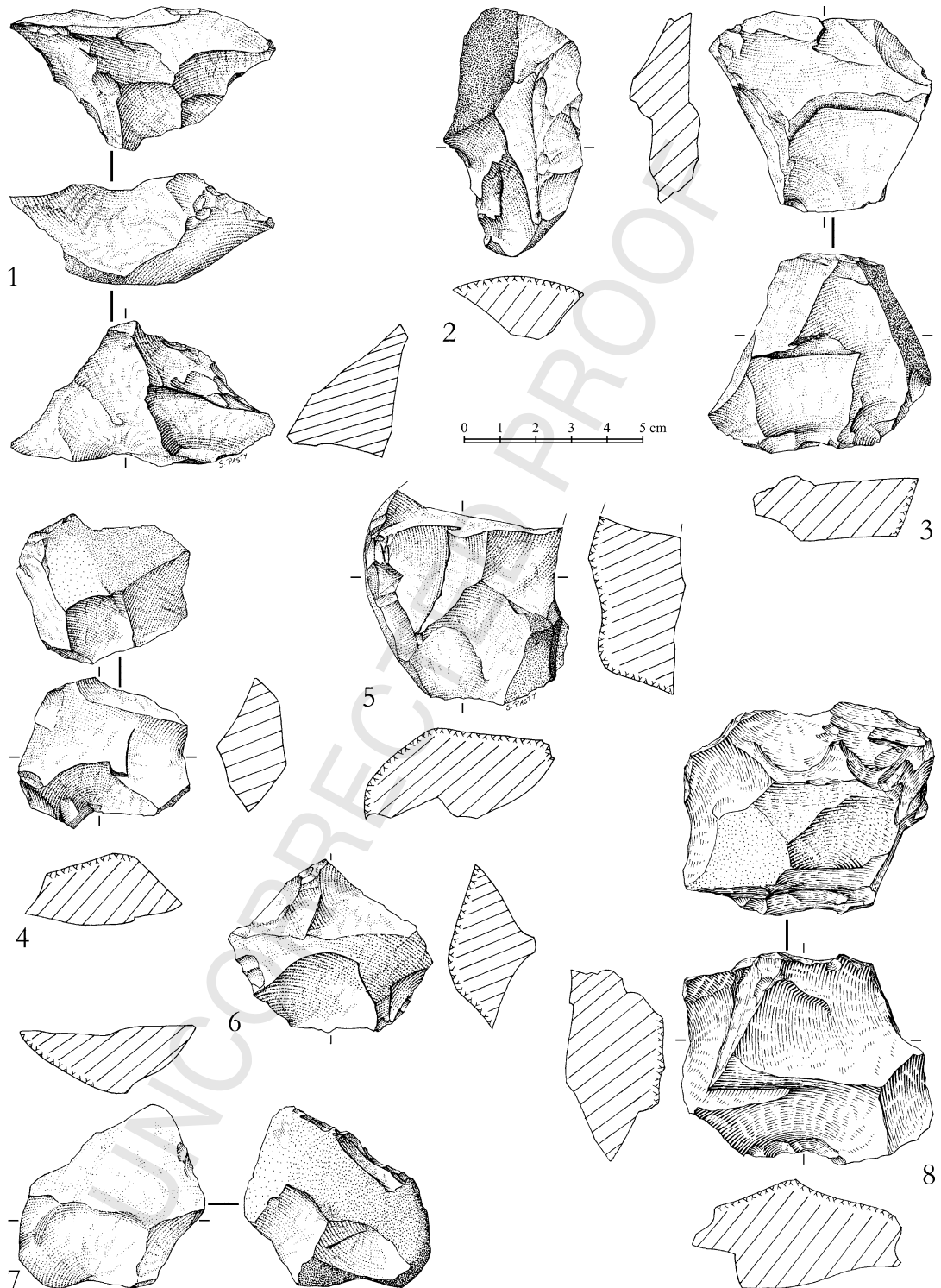


Fig. 16. Cores with a single flaked surface (2, 5, 6). Cores with a single flaked surface (4, 7). With at least two flaked surfaces (1, 3). Miscellaneous core (8).

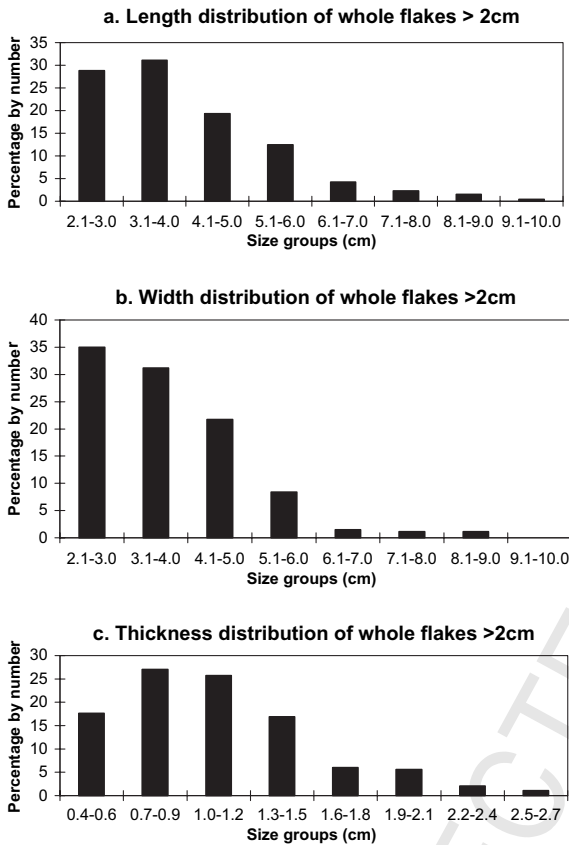


Fig. 17. Distribution of length (a), width (b) and thickness (c) of the whole flakes whose maximum dimension is higher than 2 cm.

638 wield, and a hand-held use is therefore equally
 639 plausible. Moreover, two of these hammerstones
 640 have been knapped. On the first, a large flake scar
 641 intersects the percussion zone, and two other
 642 flakes, struck from the same edge, were sub-
 643 sequently removed on the opposite face. The three
 644 removals occurred after the cobble was used for
 645 percussion. Had the second one not borne signs of
 646 impact damage, it would have been classified as
 647 a core with a single flaked surface. The flat face
 648 opposed to the convex one bearing the percussion
 649 zone displays the scars of a series of four
 650 identically oriented removals, which were struck
 651 from a natural platform. Since the negative traces
 652 of these two technical actions do not overlap, it is
 653 impossible to tell which one took place first. The
 654 same holds for two other hammerstones showing
 655 one and two flake scars.

656 One of the most remarkable features of this
 657 collection of hammerstones is the highly circum-
 658 scribed character of the impact zones. This
 659 suggests that each specimen was repeatedly used
 660 according to stable motor habits. This observation
 661 supports the conclusions from the refitting groups
 662 and the cores, concerning the precision of the
 663 blows struck to detach flakes.

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

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

685 Patterns of hominid techno-economic behavior

686 The detailed technological analysis carried out
 687 on the Lokalalei 2C assemblage allows fundamen-
 688 tal behavioral issues to be addressed. These include
 689 the degree of hominid planning and foresight in
 690 raw material management, and the assessment of
 691 their technological capabilities and manual dex-
 692 terity.

693 Raw material procurement: small whole 694 cobbles vs. large split cobbles

695 Although the lavas exploited at Lokalalei 2C
 696 were all available close to the site, the analysis
 697 points to different behavioral patterns, related to

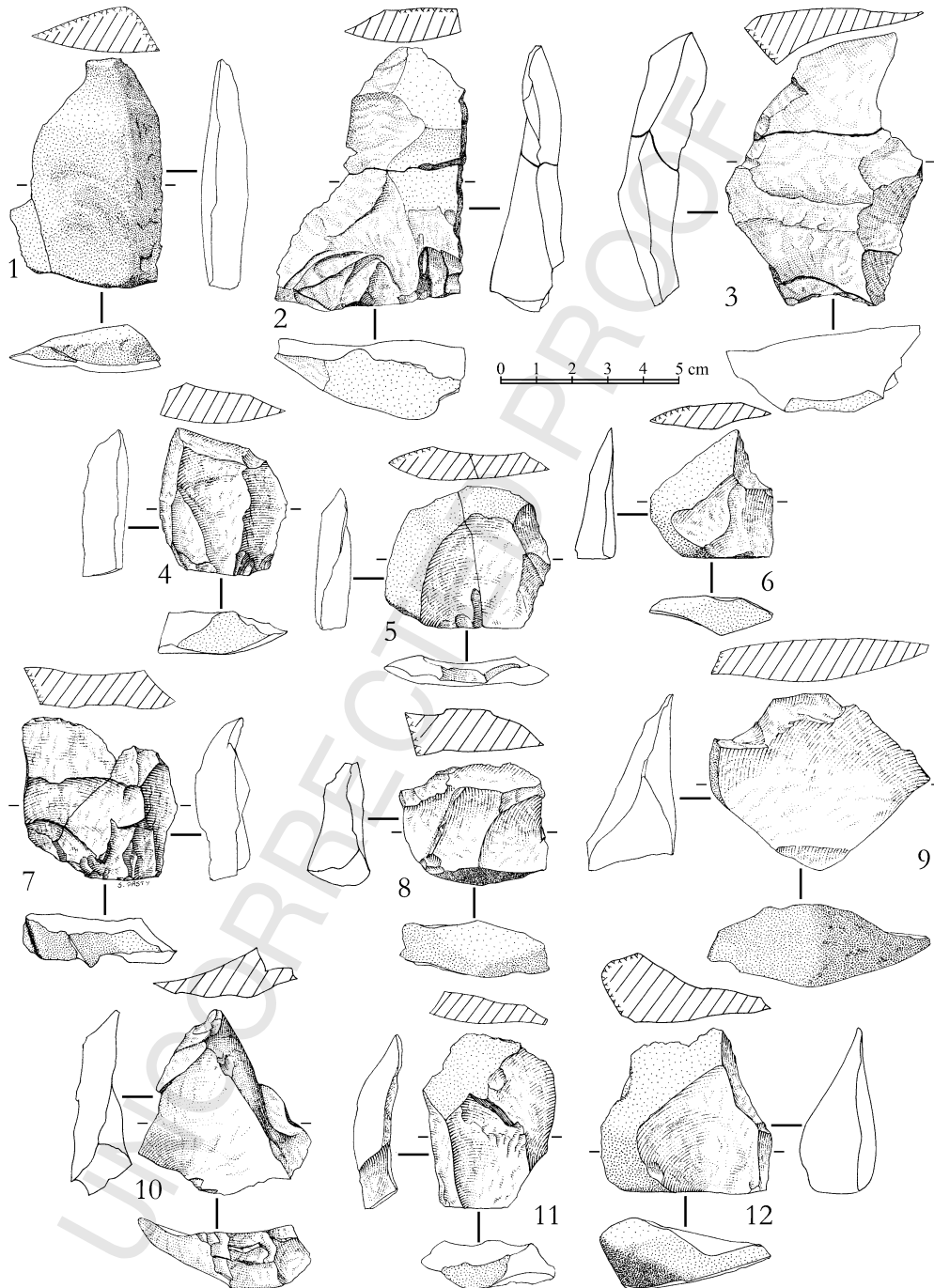


Fig. 18. Flakes wholly cortical (1), flakes with a partly cortical dorsal face (5), flakes with cortical butt and partly cortical dorsal face (2, 6, 11), flakes with cortical butt (4), flakes with cortical butt and cortical back (3, 7, 8, 9, 12), flake with no cortex (10).

Table 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

698 the quality and shape of the raw material. The
699 shape of cobbles and fragments of cobbles brought
700 to the site is such that the pieces can be knapped
701 without any preparation; *débitage* therefore begins
702 immediately. When a preliminary phase is present,
703 it generally consists of deliberate breakage of the
704 cobbles into several large chunks Fig. 21. This
705 phase possibly took place off-site, since in most
706 cases it seems that for each cobble only one of the
707 pieces thus obtained was brought to the site.
708 Intentional breakage concerns primarily the larger
709 cobbles (> 15 cm maximum dimension), but also
710 some medium-sized ones (range in maximum
711 dimension between 8 and 15 cm). It is not
712 documented for any of the smaller pebbles
713 (< 8 cm maximum dimension). Clearly, the orig-
714 inal size of the cobbles had a bearing on the
715 condition in which they were introduced.

716 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.

726 The strong relationship between intentional
727 breakage and the size of clasts provides indisput-
728 able evidence for planning and foresight in raw
729 material procurement and management. It seems
730 that anticipation can also be detected in the
731 preparation of the core. In some cases, this
732 involves much more than merely splitting the
733 cobbles. This is borne out by the fact that the two
734 most substantial refitting groups (16 and 33) testify
735 to a phase of *débitage* clearly conducted off-site.
736 This phase consists in detaching a large number of

multidirectional flakes from either one or two faces 737
of the core. Whereas the majority of the flakes 738
from the following series are refitted, all the 739
products corresponding to this initial phase are 740
missing in the assemblage, which is unlikely to be 741
the result of erosion. For refitting group 33, such 742
removals are already consistent with a phase of 743
flake production, and this therefore indicates 744
a spatial and temporal break during *débitage*. On 745
the other hand, for refitting group 16, the removals 746
belong to a phase of core preparation that 747
precedes the detachment of the large flake which 748
was then split into two fragments exploited as 749
cores. In these two cases, the knappers probably 750
opted for this practise because of the large size of 751
the cores. Transporting of partially flaked cores to 752
the site seems to be a common feature, as shown 753
by the smaller proportions of refitted products for 754
the first series in comparison with intermediate and 755
final series (Fig. 22). Like the breaking up of 756
cobbles prior to transport, this practice reveals 757
spatial and temporal breaks in the reduction 758
sequence, which can therefore be assumed to be 759
relatively complex. 760

*A reduction sequence involving constant 761
technical rules 762*

In contrast to simple *débitage*, which does not 763
involve any repetitive technological principle at 764
Lokalalei 2C, the organized *débitage* is character- 765
ized by strong technical rules. As shown by the 766
refitting groups, from the outset of reduction, 767
flaking is carried out on the largest available 768
surface (see refitting groups 2, 3 and 9). It is 769
sustained throughout reduction as a single or 770
preferential flaking surface. Flakes from other 771
faces are always produced during a second and/or 772
final core reduction phase. *Débitage* then consists 773
of a few removals only, which are usually 774
moderately invasive, or of a new production 775
sequence based on successive series of removals. 776

Flakes are struck from platforms that are most 777
often natural (i.e. cortical). The extension of the 778
striking platforms around the perimeter of the core 779
varies according to the angles formed by the 780
intersection of flaked and adjacent surfaces. 781
Angles smaller than 90° are suitable for the 782

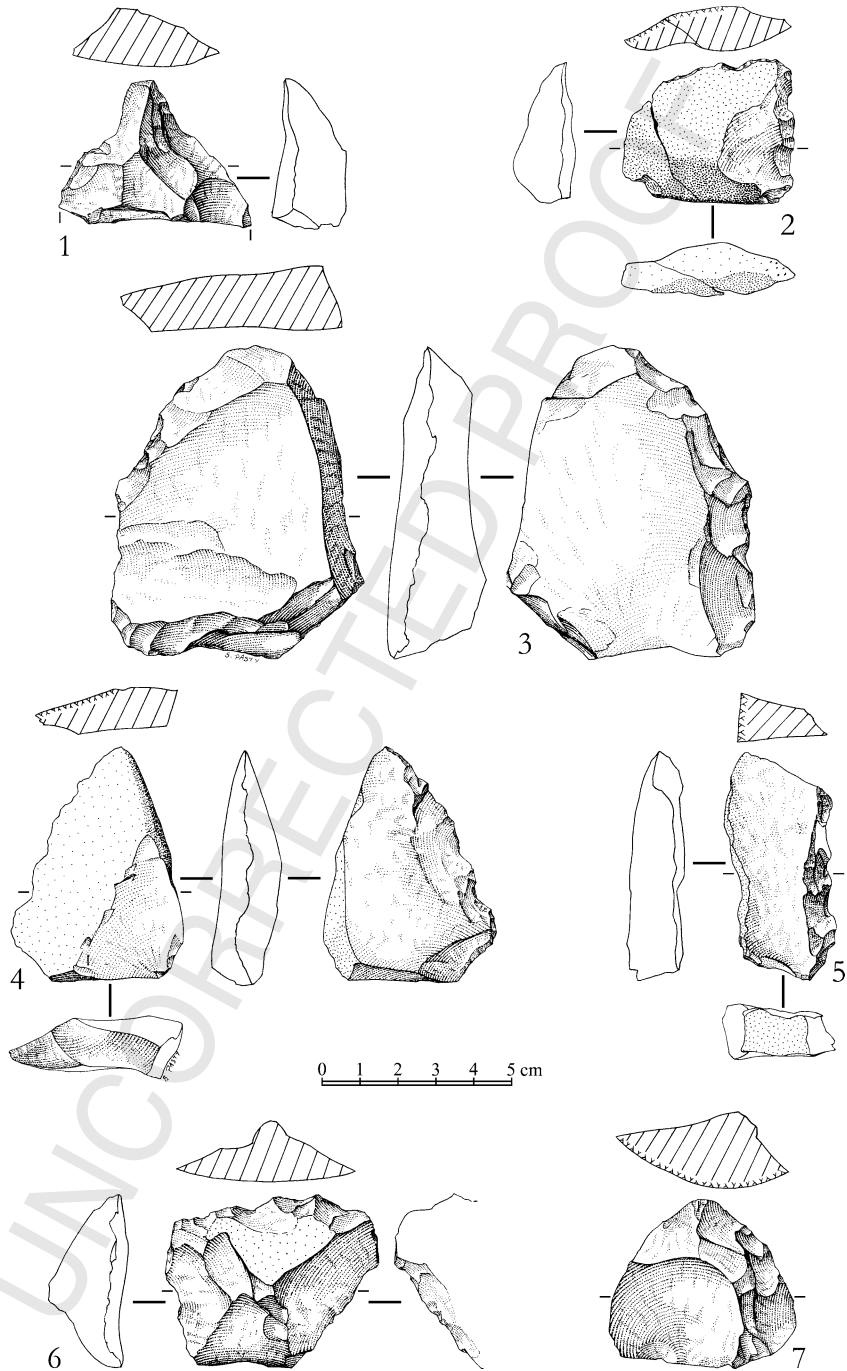


Fig. 19. Retouched pieces on flakes (1 to 6), on core (7).

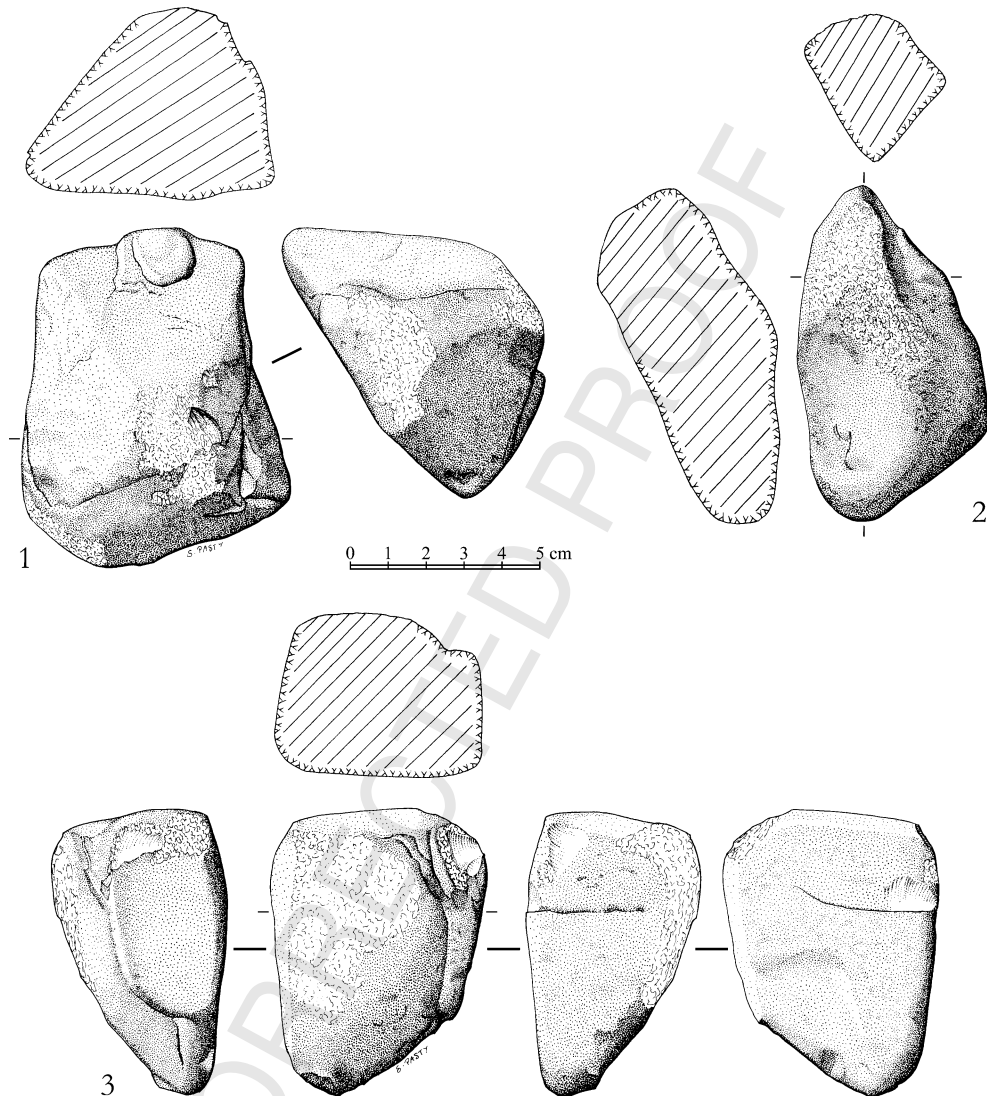


Fig. 20. Hammerstones.

783 removal of flakes. This technical constraint, which
 784 is peculiar to the knapping of hard rocks, plays
 785 a determining part here. What knappers did was to
 786 maximize the exploitation of naturally existing
 787 platforms, without ever reducing, or attempting to
 788 reduce, edges with angles greater than 90° .
 789 Removals therefore range around the entire
 790 perimeter of the flaked surfaces whenever this
 791 perimeter shows serviceable edge angles (see
 792 refitting groups 3, 16, 33 and 35). They are

793 otherwise restricted to the more or less extensive
 794 portion of the perimeter which can be directly used
 795 as a striking platform (see refitting groups 2 and
 796 9). The flakes are mostly struck from the longest
 797 available edges, and their *débitage* axis is usually
 798 perpendicular to the morphological axis of the
 799 cores, which are more often than not broadly
 800 ovate or quadrangular in shape.

801 As the flakes produced are proportionately
 802 long, and each one usually travels across at least

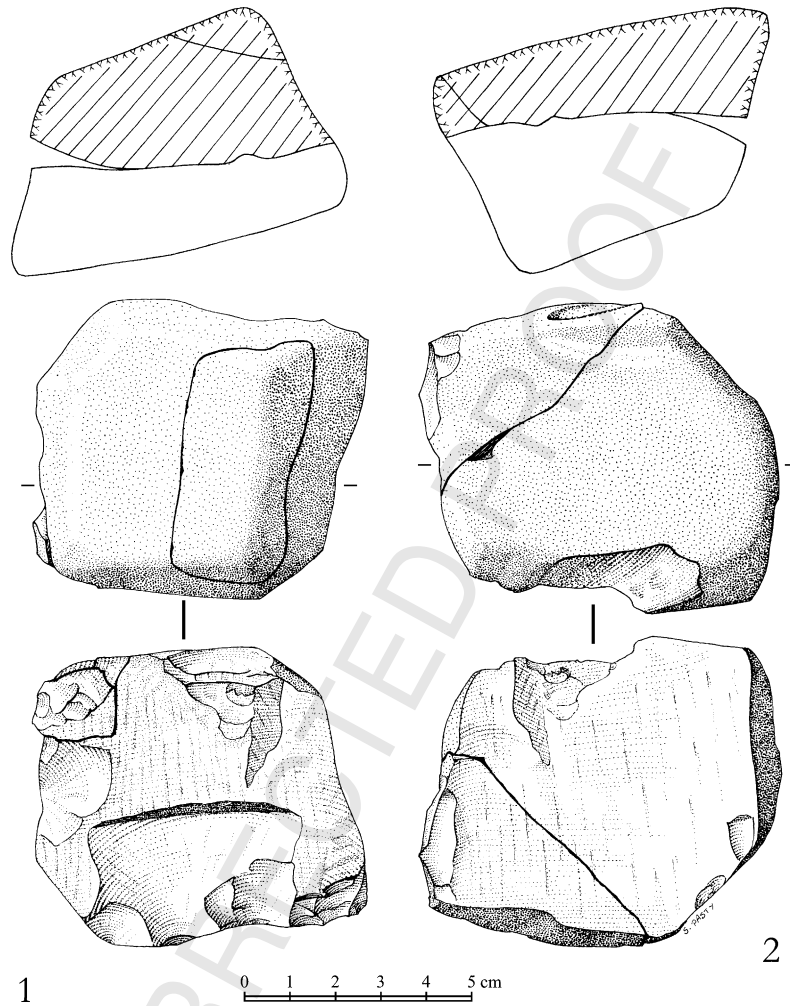
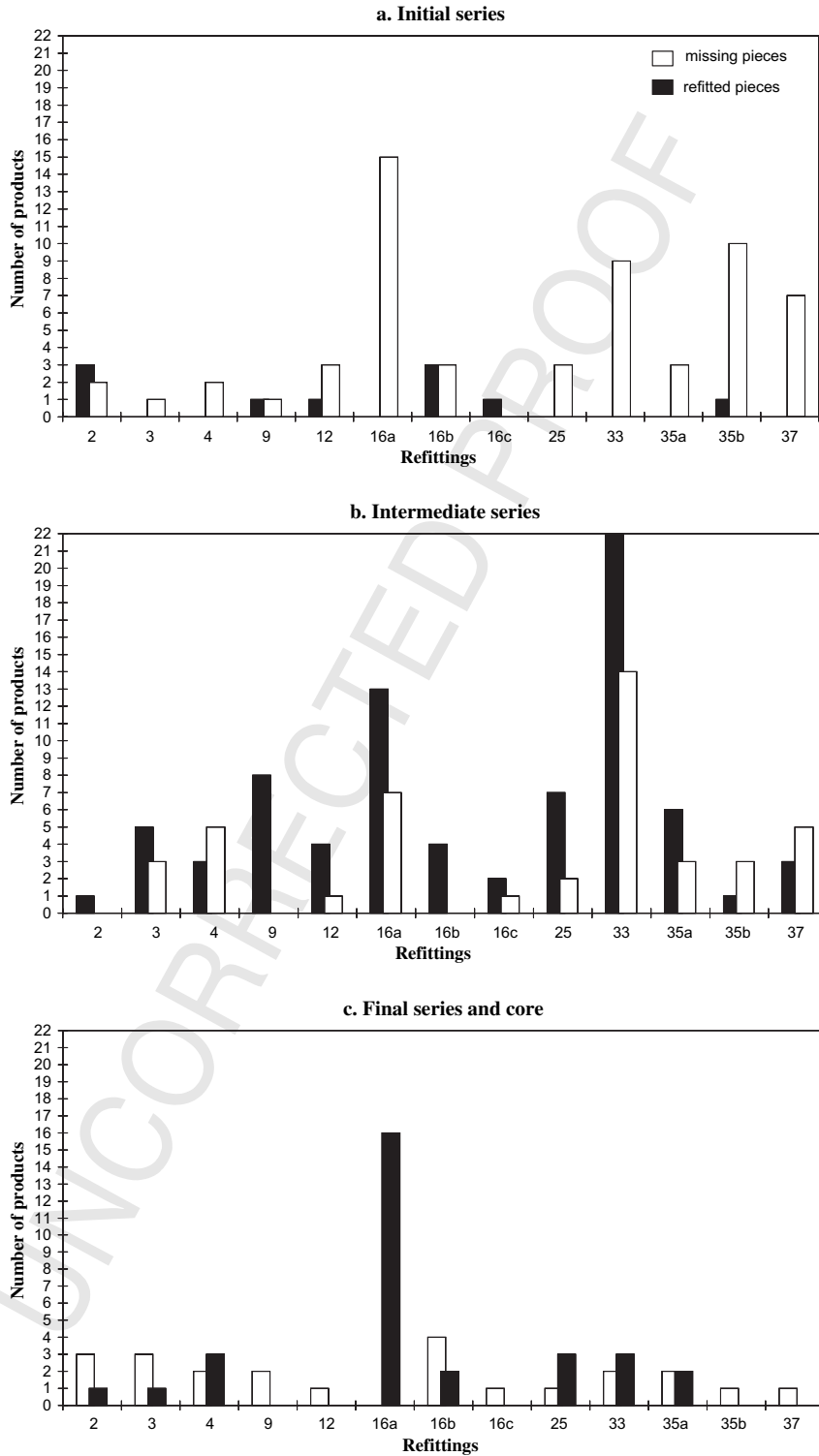


Fig. 21. Refitting group 14 (cobble split into two fragments exploited as cores).

803 half the flaked surface, they rapidly cover this
 804 entire surface. They are organized into successive
 805 series. Within a single series the removals are
 806 parallel or sub-parallel, and they are struck from
 807 the same portion of the edge of the core. Each new
 808 series of flakes can be oblique, perpendicular or
 809 opposed to the previous one. In most cases, the
 810 number of flakes per series ranges between two
 811 and five (two or three flakes for 48% of the series,
 812 four or five flakes for 27% of the series). Occasion-
 813 ally, there may be as many as 11. The main
 814 refitting groups are made up of two to nine
 815 successive series of flakes. Most of them consist
 816 of three to five series.

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



831 In order to ensure the removal of more than
832 a few relatively invasive flakes from an initially flat
833 or slightly convex surface, this surface must be
834 kept flat by the *débitage* process itself. By striking
835 flakes from several adjacent or opposing edges, the
836 knappers can work across the entire flaking
837 surface and thus lower it through successive stages
838 of flaking. The flaked surface therefore remains
839 flat until the core is abandoned. As shown by Figs
840 6 to 13, this process results in cores whose final
841 shape is similar to that of the original block, while
842 being of course much smaller.

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

865 Technologically speaking, the system is un-
866 arguably geared towards the production of flakes.
867 These are particularly suitable for cutting and were
868 probably intentionally produced for such a pur-
869 pose. Cores clearly fall into the category of waste.
870 They can be abandoned following a knapping
871 accident (hinged flake or fracture of the core), or at
872 a stage when they have been considerably reduced

in size, but there is also often no obvious technical
reason for their discard.

873
874
875 The overall technical rules seen in this assem-
876 blage strongly suggest a measure of forethought.
877 The flaking process is anything but rigid, as
878 demonstrated by the knappers' flexible response
879 to the accidents inherent in stone-knapping. In
880 several instances, this technological flexibility
881 enabled them to repair the consequences of minor
882 knapping accidents. For example, they managed
883 to eliminate the traces of hinged removals disfig-
884 uring the flaked surface by means of a blow
885 shrewdly struck from an opposing or adjacent
886 edge. In other cases, they took advantage of major
887 knapping accidents, such as the fracturing of a big
888 core (e.g. refitting group 35) or that of a large flake
889 during *débitage* (e.g. refitting group 16), by
890 recycling the fragments as cores. On the other
891 hand, a drastic transformation of the shape of the
892 core, such as to make serviceable a striking
893 platform with too high an angle, was quite beyond
894 the scope of the Lokalalei 2C knappers' techno-
895 logical capabilities.

896 *Manual dexterity*

897 An insight into the Lokalalei 2C knappers'
898 manual dexterity can be gained by examination of
899 the precision of the blows struck on the cores. The
900 latter do not show any impact damage from failed
901 percussions, such as might be caused by faulty
902 estimation of the force required, or by erratically
903 aimed blows, falling for instance too far away
904 from the edge. Precision of arm and hand move-
905 ments is particularly evident where flaked edges
906 adjoin edges unsuitable for flaking: the blows are
907 always strictly restricted to the portion showing
908 serviceable edge angles, and never extend beyond
909 it. Additional evidence of precision is provided by
910 the knappers' ability to strike several (generally 2
911 to 9) series of flakes producing as many as 15
912 removals from small pebbles: four of the refitting

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).

913 groups and several unfitted cores represent
 914 blocks originally no more than 5 or 6 cm long
 915 and about 3 cm thick. In such cases, precision
 916 implies not only a highly controlled movement,
 917 but also a firm and constant grasp while handling
 918 both core and hammerstone. Capable of flaking
 919 small nodules, the Lokalalei 2C knappers felt
 920 equally at ease when tackling far bigger ones. They
 921 had thoroughly mastered the process of obtaining
 922 large fragments from sizeable blocks. Precision is
 923 also borne out by the observations made on the
 924 hammerstones they left behind. The patches of
 925 battering marks are highly circumscribed, imply-
 926 ing precise and recurrent percussion motions.

927 Discussion

928 Stone working at Lokalalei 2C is represented by
 929 a system of *débitage sensu stricto* and not by
 930 a compound system, combining *débitage* and
 931 shaping. The flakes are the intended end products
 932 and the cores clearly fall into the category of
 933 technological waste, even though some bear signs
 934 of retouch suggesting a secondary use as tools. The
 935 detailed study of this *débitage* system shows that
 936 the makers of the Lokalalei 2C artefacts were not
 937 casual, opportunistic or clumsy knappers. Indeed,
 938 they appear to have already achieved a mastered,
 939 structured and even planned technical production.
 940 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 ($<90^\circ$);
 - 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 984 the intrinsic qualities of rocks and their flaking 985 properties is suggested by the differential use they 986 made of the raw materials available. Simple 987 *débitage* was performed on poor quality types of 988 raw material while more elaborated *débitage* was 989 pursued on good quality types. 990

However, this does not imply that the hominids 991 at Lokalalei 2C had already fully mastered all the 992 technical parameters of stone knapping. They were 993 clearly somewhat constrained by the raw material, 994 and this hampered their exploitation of some of 995 the cobbles, in particular the rounded cobbles used 996 for simple *débitage*. Simple *débitage* seems to be 997 a response to the difficulty experienced by the 998 knappers in exploiting such cobbles, owing to their 999 inappropriate shapes rather than their poor 1000 quality in terms of grain and homogeneity. In 1001 the organized *débitage* the knappers were con- 1002 strained by the original shape of the cobbles, to 1003

1004 such an extent that at discard the volume is
 1005 reduced while the shape remains constant. This is
 1006 because in the absence of naturally occurring
 1007 striking angles, the knappers did not strive to
 1008 create any such angles. In such cases their progress
 1009 was impeded, resulting in knapping accidents and
 1010 the occasional switching of flaking surfaces on the
 1011 same core. It is therefore suggested that the
 1012 hominids at Lokalalei 2C had already assimilated
 1013 the advantages of angular shapes. They had the
 1014 cognitive abilities to exploit angles when encoun-
 1015 tered but not to create new ones.

1016 *Comparisons with Lokalalei 1*

1017 How do the Lokalalei 1 knappers compare with
 1018 those of Lokalalei 2C? There are fewer artefacts at
 1019 Lokalalei 1 and they do not offer the same refitting
 1020 possibilities. Analysis was based mainly on the
 1021 cores (n = 27), which divide into three groups. A
 1022 first group comprises cores worked from relatively
 1023 large squarish cobbles (mean length of cores
 1024 = 12.5 cm, mean width = 9.9 cm, mean thick-
 1025 ness = 7.6 cm, mean weight = 1060 g) displaying
 1026 at least one flat face. They were flaked according
 1027 to principles different from the ones prevailing at
 1028 Lokalalei 2C. The flat face is used as a striking
 1029 platform instead of as a flaking surface (see Fig. 3
 1030 in Kibunjia, 1994). A second group includes cores
 1031 also worked from relatively large cobbles (mean
 1032 length of cores = 9.5 cm, mean width = 8.0 cm,
 1033 mean thickness = 5.8 cm, mean weight = 885 g),
 1034 but with more globular shapes. They were flaked
 1035 on two or three faces by means of multidirectional
 1036 removals. A third group is made up of small cores
 1037 (mean length = 8.1 cm, mean width = 6.5 cm,
 1038 mean thickness = 3.8 cm, mean weight = 250 g)
 1039 with a single preferentially flaked surface, or with
 1040 two opposing flaked surfaces, roughly similar to
 1041 those which characterize the organized *débitage* at
 1042 Lokalalei 2C. This last group does not however
 1043 provide the same impression of morpho-technical
 1044 homogeneity as the corresponding Lokalalei 2C
 1045 material. The blanks display different shapes that
 1046 are not suitable for carrying out *débitage* on
 1047 a preferential surface. The cobbles are round and
 1048 lack flat surfaces or suitable natural striking
 1049 platforms. The resulting knapping sequences are

1050 opportunistic and there are few successful at-
 1051 tempts at removing whole serviceable flakes. The
 1052 cores also bear evidence of frequent knapping
 1053 accidents (see Fig. 3 in Kibunjia, 1994) and
 1054 repeated impact damage from failed percussions.

1055 Generally speaking, stone working at Lokalalei
 1056 1 is heterogeneous. This can be seen in the shape
 1057 and sizes of the original cobbles as well as in the
 1058 unpatterned *débitage*. This type of *débitage* cannot
 1059 be termed organized because opportunism prevails
 1060 over the implementation of constant technical
 1061 rules. Nor do the Lokalalei 1 cores bear witness
 1062 to the advanced manual dexterity on the knappers'
 1063 part seen in the cores from Lokalalei 2C.

1064 The ancient hominid groups responsible for
 1065 manufacturing and utilizing flaked stones *c.*
 1066 2.3 Myr in West Turkana display distinct levels
 1067 of technological skills. Because Lokalalei 1 is older
 1068 than Lokalalei 2C, Brown and Gathogo (2002)
 1069 have suggested that the differences between the
 1070 two assemblages are related to evolutionary pro-
 1071 cesses. This is plausible insofar as *Early Homo* is
 1072 a possible candidate for making both industries,
 1073 but other factors, environmental or task related,
 1074 cannot be ruled out. Variations in available
 1075 resources or in the way resources are processed
 1076 can result in different patterns of site occupation,
 1077 and this would explain the more expedient
 1078 character of the Lokalalei 1 assemblage.

1079 *Conclusion : Lokalalei 2C in the context of* 1080 *the East African Late Pliocene (2.6-2.0 Myr)*

1081 At Lokalalei 2C production of flakes is the
 1082 desired end of knapping. Knapping does not
 1083 appear so clearly geared towards such a "mono-
 1084 specific" end at the other Late Pliocene and Early
 1085 Pleistocene East African sites, such as the Omo
 1086 sites within the Shungura Formation (Chavaillon,
 1087 1976; Merrick et al., 1976; Howell et al., 1987 ;
 1088 A.L. 666 site within the Hadar Formation, Kimbel
 1089 et al., 1996), the Kada Gona and East and West
 1090 Gona sites within the Hadar Formation (Corvinus,
 1091 1975; Corvinus and Roche, 1976; Roche and
 1092 Tiercelin, 1977, 1980; Semaw et al., 1997, 2003;
 1093 Semaw, 2000), or the Kanjera South sites within
 1094 the Kanjera Formation (Plummer et al., 1999).
 1095 While flake production dominates the Omo

1096 assemblages, in other assemblages there is some
 1097 evidence of shaping, represented by polyhedral
 1098 forms. Choppers, endowed with the ambiguous
 1099 status of “core-tools”, could be the by-product of
 1100 the production of flakes, or be the result of
 1101 deliberate cobble modification in order to obtain
 1102 a sturdy cutting edge. Comparing these assemb-
 1103 lages is difficult because often only preliminary
 1104 descriptions have been made, or because descrip-
 1105 tions are not backed by detailed technological
 1106 analysis such as that which has guided the study
 1107 of Lokalalei 2C. At this stage of research,
 1108 evolutionary trends cannot be substantiated. Such
 1109 are however the only terms of comparison by
 1110 which evolutionary trends in the technological
 1111 behavior of Pliocene hominids can be successfully
 1112 brought to light. In this respect, the contribution
 1113 of Lokalalei 1 and Lokalalei 2C to our un-
 1114 derstanding of the Pliocene is significant.

1115 Prior to the discovery of Lokalalei 2C (Roche
 1116 et al., 1999), one of us assumed a “lack of
 1117 technological elaboration” (Roche, 1989, followed
 1118 by Kibunjia, 1994, 1998) for the Pliocene sites
 1119 known at the time (Omo, Kada Gona, and
 1120 subsequently Lokalalei 1). Roche (1989) also
 1121 argued for a temporal break *c.* 2 Myr between
 1122 a pre-Oldowan phase and an Oldowan phase, on
 1123 the grounds that “a more elaborate work and
 1124 a better understanding of stone flaking properties”
 1125 emerged with the development of the Oldowan
 1126 (*sensu* Leakey, 1971). Continuous technological
 1127 improvements seemed evident, but the material
 1128 from Lokalalei 2C falsifies this view. However,
 1129 while this site provides evidence for the existence
 1130 before 2 Myr of an organized and highly pro-
 1131 ductive type of *débitage*, it has not been yet
 1132 demonstrated that a similar level of elaboration
 1133 exists elsewhere. It now seems fairly certain that
 1134 the Pliocene is more complex technologically, or at
 1135 least more diverse than has previously been
 1136 assumed, and that this assumption should be
 1137 extended to the beginning of the Pleistocene
 1138 (Roche, 2000; Roche et al., 2003; Martínez-
 1139 Moreno et al., 2003; de la Torre et al., 2003).

1140 This contention is at variance with the currently
 1141 prevailing view that all the African Plio-Pleistocene
 1142 stone assemblages dated between 2.6 and 1.6 Myr
 1143 group into one techno-cultural Oldowan complex.

1144 It is debatable whether this grouping of industries
 1145 is heuristically valuable. It is an understandable
 1146 temptation to classify each new discovery accord-
 1147 ing to existing nomenclature. Nevertheless, com-
 1148 bining under the same heading (Oldowan or Mode
 1149 1 : Clark, 1977) industries spanning such a wide
 1150 spatio-temporal range presents the hazard of
 1151 erasing all inter-site differences. Our aim is to
 1152 better define these differences so as to better assess
 1153 their implications in terms of evolving skills and
 1154 technical practices. Were it at all relevant to
 1155 maintain a single term – Oldowan – this could
 1156 only be to designate a chronological period.

1157 Grouping these industries into the same com-
 1158 plex leads to the impression of a long period of
 1159 technological stasis (Semaw et al., 1997; Semaw,
 1160 2000). One of the contributions of the Lokalalei
 1161 data is to provide insight into variability that does
 1162 not tally with the notions of stasis. In the East
 1163 African Pliocene sites, at least four species grouped
 1164 into two or three genera (*Paranthropus*, *Australo-*
 1165 *opithecus*, and *Homo*) are represented, some of
 1166 which lived contemporaneously while others ap-
 1167 peared successively : *A. aethiopicus* in the Omo
 1168 Valley and West Turkana, *A. boisei* in the Omo
 1169 Valley and Lake Turkana basin, *A. garhi* (known
 1170 in the Middle Awash but not in the Gona and at
 1171 Hadar), *Early Homo* in West Turkana, Lake
 1172 Baringo Basin, Hadar and Omo (*H. aff. Habilis*).
 1173 This suggests that the Pliocene knappers could
 1174 have belonged to different hominid taxa. Neither
 1175 the notion of linear technological evolution even
 1176 with a Pre-Oldowan and an Oldowan phases, nor
 1177 a long lasting static Oldowan makes sense
 1178 considering this paleoanthropological diversity
 1179 and the assumed technological diversity. These
 1180 two notions were implicitly based on the paradigm
 1181 of a unique techno-cultural entity implying only
 1182 one species capable of tool-making. This paradigm
 1183 is not supported by the current data and it seems
 1184 most unlikely that the hominids groups inhabiting
 1185 the East African Rift Valley for over one million
 1186 years (between 2.6 and 1.6 Myr) could have shared
 1187 the same techno-cultural traditions, nor that inter-
 1188 group transmission of technical knowledge was yet
 1189 an established practice.

1190 Lastly, it should not be forgotten that while there
 1191 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 H el ene Roche and Mzalendo Kibunjia (National Museums of Kenya). It is a joint research program between the National Museums of Kenya (NMK) and the *Mission Pr ehistorique au Kenya* (MPK), directed by H el ene Roche.

Uncited references

Brown et al., 2001; Roche and Kibunjia, 1996

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