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NUMBER 3
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THE CUTTING EDGE:

New Approaches to the Archaeology of Human Origins

Editors

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COVER CAPTIONS AND CREDITS

Top: Homo habilis Utilizing Stone Tools. Painting by artist-naturalist Jay H. Matternes. Copyright 1995, Jay H. Matternes. Inspired by a prehistoric scenario by K. Schick and N. Toth in Making Silent Stones Speak: Human Origins and the Dawn of Technology (1993), Simon and Schuster, New York. Pp.147-149.

Lower right: Whole flake of trachyte lava from the 2.6 million-year-old site of Gona EG-10, Ethiopia. Reported by S. Semaw (2006), "The Oldest Stone Artifacts from Gona (2.6-2.5 Ma), Afar, Ethiopia: Implications for Understanding the Earliest Stages of Knapping" in The Oldowan: Case Studies into the Earliest Stone Age, eds. N. Toth and K. Schick. Stone Age Institute Press, Gosport, Indiana. Pp. 43-75. Photo courtesy of Tim White.

Lower left: Prehistoric cut-marks from a stone tool on Sterkfontein hominin partial cranium StW 53. Reported by T. Pickering, T. White, and N. Toth (2000) in "Cutmarks on a Plio-Pleistocene hominid from Sterkfontein, South Africa". American Journal of Physical Anthropology 111, 579-584. Scanning electron micrograph by N. Toth.

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CHAPTER 8

THE OLDOWAN INDUSTRY FROM STERKFONTEIN CAVES, SOUTH AFRICA

K. KUMAN AND A.S. FIELD

INTRODUCTION

The earliest archaeological deposits in southern Africa have thus far been found in South Africa, within the dolomitic limestone cave infills of Gauteng Province (Figure 1). Absolute dating techniques are still poorly developed for most of these underground cave breccias, and currently Oldowan period artifacts have only been identified by the age of associated fauna. Of the 14 sites in this geological setting, six or possibly seven preserve Plio-Pleistocene artifacts from *ca* 2 to 1.0 My in age; and of these, only two or possibly three sites have deposits of Oldowan age: Kromdraai B has only two certain artifacts and is *ca* 1.9 My by palaeomagnetic dating; Sterkfontein has 3,500 artifacts that are of similar age; and the Lower Bank of Member 1 at Swartkrans is believed to date to *ca* 1.7 or 1.8 Ma (see Kuman 2007 for references and details). The purpose of this paper is to describe the Oldowan industry from Sterkfontein and its implications for hominid behaviour. Fortunately, the Sterkfontein Oldowan is the best preserved of all the Plio-Pleistocene assemblages from the Gauteng sites, and despite its cave infill context, it is informative because of its largely intact nature and large sample size. The assemblage was excavated in the early 1990s by R.J. Clarke from Member 5 East of the Sterkfontein Formation (Partridge 1978; Partridge and Watt 1991).

The Sterkfontein Formation refers to six massive and complex infills or members, with Members 1 to 3 contained in an underground system of caverns (Clarke 2006), and Members 4 to 6 exposed at the surface through erosion of the cave roof. Since this terminology for the cave infills was developed by Partridge (1978), deposits in the Jacovec Cavern (the lowest situated cavern in the system) have also been identified as one of the earliest infills (Partridge et al. 2003). Along with Members 2 and 4, it has yielded *Australopithecus* fossils. Member 5 is younger but of Plio-Pleistocene age and contains Oldowan and early Acheulean artifacts in a complex stratigraphic relationship (see Kuman and Clarke 2000). Member 6 overlies Member 5 West and is of mid-Pleistocene age but lacks artifacts. The Post-Member 6 Infill and the Lincoln Cave deposits are of late to mid-Pleistocene age and contain Middle Stone Age artifacts, along with some older material re-worked from Member 5. There are additional caverns with infills in the underground system that have not yet been excavated, but one exception is the Name Chamber. It directly underlies the Oldowan Infill in Member 5 East and contains artifacts that eroded from this deposit and filtered down into this underlying chamber (see later discussion).

The subject of this paper is the archaeology of the Oldowan Infill in Member 5 East, which is the second of at least four sequential infills contained in the Member 5 breccias (Clarke 1994; Kuman 1994a; Kuman and Clarke 2000). Initially published as dating about 1.7 to 2.0 Ma on fauna, the age of this infill has been confirmed at the older end of this range, with an absolute date of *ca* 2 Ma now achieved on a manuport (Granger *et al.*, in preparation). This paper presents the details of the complete assemblage, as defined stratigraphically in Kuman and Clarke (2000), and it provides an updated and revised analysis of the sample initially presented in Field (1999).

The reason for the rarity of Oldowan archaeology in southern Africa is the restricted geological circumstances under which such early sites are preserved. These are all underground 'keyhole' sites, capturing ma-

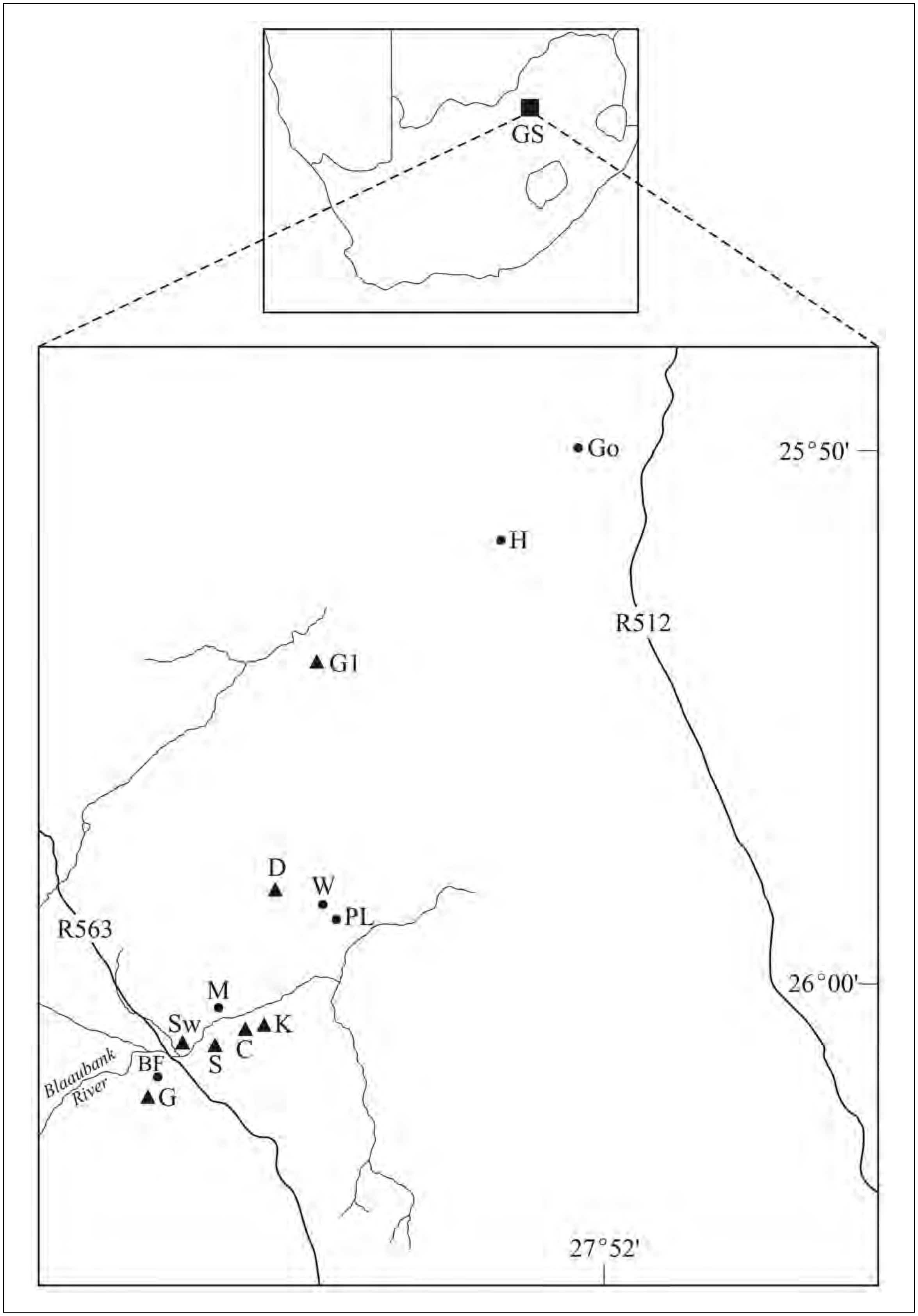

Figure 1. The suite of early sites in Gauteng Province (GS), designated as a UNESCO Cradle of Humankind World Heritage Site in South Africa, is located about 50 km northwest of Johannesburg. Sites indicated with a triangle contain artifacts of Plio-Pleistocene age: G (Goldsmith's), Sw (Swartkrans), S (Sterkfontein), C (Coopers), K (Kromdraai), D (Drimolen), and Gl (Gladysvale). PL (Plover's Lake) contains Middle Stone Age artifacts. BF (Bolt's Farm), M (Minaar's), W (Wonder Cave), H (Haasgat), and Go (Gondolin) have thus far not produced artifacts, nor has Motsetse, which is not shown.

terial from surface occupations around cave entrances that led to talus slope deposits through steep shafts, up to 15-20m deep. The Sterkfontein Oldowan Infill is no exception, having entered the system through a narrow opening immediately west of the australopithecine breccias of Member 4 (Kuman 1994a). Taphonomic analysis by Pickering (1999) indicates the associated fauna accumulated largely as a death-trap assemblage, with only some minor contribution from slope wash processes.

A notable fact is that all but a few artifacts at the Gauteng sites are found in close proximity to the Blauubank River gravels (see Figure 1). Only four artifacts have been found at sites distant from these gravels (3 at Drimolen and 1 at Gladysvale), and given their early age, this pattern is not unexpected (Kuman 2003). The three richest sites (Sterkfontein, Swartkrans and Kromdraai) all lie within 300m of the closest Blauubank gravels and within 500m of the modern-day river. With the largest early Pleistocene artifact assemblages, Sterkfontein must have provided the most comfortable occupation site in the valley, attracting repeated visits that resulted in large accumulations during both the Oldowan and early Acheulean periods (Kuman 1994a,b, 1998). Details of the stratigraphy and associated hominid fossils for Sterkfontein are provided in Kuman and Clarke (2000), and the Member 5 faunal assemblages are presented in Pickering (1999).

Assemblage Characteristics and Site Formation

The Sterkfontein Oldowan (Table 1) has been classified using the typology of Leakey (1971), with modifications as published by Kuman (1996, 1998) and Field (1999). *Small Flaking Debris* is defined as all material less than 20 mm in maximum length. It is not discussed further in this paper, but Field (1999) provides more detail on the traits of the Oldowan debitage. With the exception of one retouched flake that is 18 mm long, all other material that is 20 mm or more in maximum length has been categorized as follows:

Terminology

Complete flakes are whole enough to provide all technological information. Some occasional pieces may present minor modern or ancient damage, but this does not interfere with the measurements or technological attributes. *Incomplete flakes* include all flakes that lack a platform or are not complete enough to provide accurate measurements. Where platform information was available, however, this information was recorded in Field (1999). The incomplete flake category includes flake fragments, a category that is often used by other researchers for flakes or flake portions which lack platforms. *Core trimming flakes* are complete flakes with angular cross-sections, suggestive of some form of platform correction to assist with continued flaking of the core. There is only one example, and it is included in the complete flakes. *Core rejuvenation flakes*, with clear evidence of actual platform removal, are not present in this assemblage. *Chunks* are angular, blocky-shaped fragments. They are often produced through the fragmentation or shatter of thick flakes, but they are distinguished from flake fragments by their blocky volumes. *Retouched pieces* are flakes, chunks or flake fragments with clear evidence of secondary trimming on one or more edges. *Core tools*, as a category, include core forms that appear to be intentionally shaped for some use, or alternatively, a core that shows evidence of utilization on one or more edges. In this assemblage, there is only one core tool, a protobiface that could also be termed a pointed chopper. *Cores* are cobbles or other forms with clear evidence of removals, with either freehand or bipolar (hammer and anvil) technique. *Core fragments* are broken cores, lacking enough surface to be classified into any of the core types. *Manuports* are cobbles (or pebbles) that do not generally occur naturally on the landscape near the site. They are transported from the river gravels within 300-500 m of the site and lack any signs of use, including battering. While they are common in the early Acheulean breccias at Sterkfontein, there are only 10 specimens in the Oldowan, and three possible manuports.

For the core types, the following definitions apply:

Bipolar cores show clear evidence of being flaked with a hammer and anvil technique. Such cores do not show any negatives for a bulb of percussion on dorsal scars, and they typically have planed or slightly convex fracture surfaces, often with evidence of crushing at the point/s of impact. Flakes and fragments removed with this technique, which is most common in quartz materials, may show a variety of attributes: crushing at the point/s of impact, shattered platforms or very thin platforms, and more occasionally, spalled flakes and segment-shaped core fragments (*i.e.*, shaped like the segments of an orange). We have defined these attributes for the bipolar technique through extensive experiments in flaking of the local vein quartz.

Casual Cores possess only one or two removals and may represent testing of raw materials or just minimal flaking, for whatever reason. The scars on such cores should have a negative bulb of percussion to indicate freehand flaking. Cobbles possessing unintentional removals—*e.g.*, spalls removed when a cobble is used as a hammerstone—do not usually show a clear negative of bulb of percussion in these raw materials. *Chopper-Cores* are cores flaked (unifacially or bifacially) along an edge, an end, or a combination of the two, and although they may suggest an attempt at radial flaking, the removals do not continue along enough of the circumference to be classified as radial or discoidal flaking. *Discoidal Cores* are both radially and bifacially flaked around most of the circumference, and there is only one such example (in quartz) in this assemblage. *Polyhedral Cores* are extensively flaked from three or more platforms in differing directions, while *Irregular Polyhedral Cores* are defined in the same way but are less extensively flaked, which results in a less spherical and more irregular form.

Assemblage Characteristics

Table 1 shows that the assemblage is dominated by vein quartz (90.5% of all material), but it also includes some chert (6.7%) and quartzite (2.8%).

If all material <20mm and the unworked cobbles are excluded from the count, quartz still dominates at 79.7%, with chert at 5.7% and quartzite at 14.6%. And if only the 24 cores are considered (Table 2), quartz contributes 71%.

The size profile of the assemblage is dominated by small flaking debris, defined as all artifacts <20 mm in size, and comprising 82% of all measurable material (Table 3 and Figure 2). This compares well with experimental replications in the local raw materials (Table 4). In exhaustive flaking experiments of cores in quartz and quartzite directed by J. McNabb (see Kuman et al. 2005; also Field 1999 for a similar study), the proportion of small flaking debris under 20 mm maximum size was 85%; the local chert (which forms in association with the dolomite) flakes in a similar manner to quartz, but we did not include it in the experiments because chert does not figure prominently at Sterkfontein until the Middle Stone Age (Kuman 1994a). The vein quartz is brittle and shatters easily, producing a higher proportion of small flaking debris than quartzite (87% v. 79% respectively). In experiments replicating East African assemblages in lava at Koobi Fora, Kenya, Schick (1987) recorded means of 60 to 75% for material <20 mm in size. These figures are somewhat lower than ours for three reasons. First is the difference in raw materials. Secondly, the Koobi Fora experiments were intended to reproduce specific core types rather than to exhaust a core's potential. Thirdly, Schick quantified material beginning at 5 mm size, while we included material from 4 mm. In sum, Schick's and our own experiments demonstrate that a well-preserved assemblage produced by tool manufacturing should be characterised by 60% to 87% of flaking debris <20mm in size.

Details of the <20 mm size category, however, vary. While our overall experiments produced 65% and 20% respectively in the <10 and <20 mm size intervals, Schick records 28% and 41% for these categories, which is a reversal in dominance of the 10 to <20mm size interval to our own figures. This discrepancy may be due to the more exhaustive flaking of our cores, as well as to raw material differences or other unknown factors. Regardless of the reasons though, the 10 to <20mm size interval in the Sterkfontein Oldowan appears to be over-represented. It is unlikely to be due just to the export of some of the larger flakes from the site. The Sterkfontein material is a long-term accumulation that is in a re-deposited context, and it was undoubtedly somewhat altered by those natural processes that swept material into the cave shaft. Although it does not represent a pristine manufacturing assemblage, it does nonetheless indicate that knapping took place near the opening to the cave.

Table 4 also shows that the smallest component (<10 mm size) is under-represented, and as 2mm sieve mesh was used for the excavation, this under-representation is not a recovery problem. Work by D. Stratford (2008) has now accounted for the paucity of this smallest component of the Oldowan assemblage. At some point in the history of the Oldowan Infill assemblage, breccia was decalcified, and re-working of the deposit resulted in the loss of a portion of the artifacts down an underlying shaft into a lower chamber. This is the Name Chamber, which directly underlies the Oldowan breccia, connecting with it via a 12m-long shaft (Clarke 1994). Today the Old-

Table 1. Artifact types and raw materials for the complete Oldowan assemblage, including manuports. Apart from the small flaking debris, all material in the other categories is ≥20mm in maximum length, with the exception of one retouched flake which is 18mm.

	quartzite	chert	quartz	Total	%
Small flaking debris <20mm	9	204	2744	**2957**	**84.17%**
Complete flakes	20	7	57	**84**	**2.39%**
Incomplete flakes	38	22	231	**291**	**8.28%**
Chunks	11	0	120	**131**	**3.73%**
Retouched pieces	1	1	5	**7**	**0.20%**
Core tools	1	0	0	**1**	**0.03%**
Cores	7	0	17	**24**	**0.68%**
Core fragments	1	1	3	**5**	**0.14%**
Manuports	7	1	2	**10**	**0.28%**
Manuports?	2	0	1	**3**	**0.09%**
TOTAL	97	236	3180	3513	100.00%
%	2.76%	6.72%	90.52%	100.00%	

Table 2. Core types and their raw materials from the Sterkfontein Oldowan assemblage. There are no cores in chert.

	Raw Material Types			
Core Types	Quartzite	Quartz	Total	%
Bipolar Core	0	3	**3**	**13%**
Casual Core	0	2	**2**	**8%**
Chopper Core	3	1	**4**	**17%**
Discoidal Core	0	1	**1**	**4%**
Polyhedral Core	0	6	**6**	**25%**
Irregular Polyhedral Core	3	3	**6**	**25%**
Single Platform Core	1	1	**2**	**8%**
Total	7	17	24	100%
%	29%	71%	100%	

Table 3. Size profile of the Oldowan assemblage by raw material, with size intervals in mm. N=3492, which excludes damaged artifacts that could not be measured. Q is quartz, Ch is chert, and Qz is quartzite.

	0-9	**10-19**	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	**70-79**	**80-89**	**90-99**	**100+**	**N**
Ch	24	175	16	5	6	4	1	1	0	0	0	232
	10.3%	75.4%	6.9%	2.2%	2.6%	1.7%	0.4%	0.4%	0.0%	0.0%	0.0%	100.0%
Qz	0	9	15	24	12	12	5	1	4	5	2	89
	0.0%	10.1%	16.9%	27.0%	13.5%	13.5%	5.6%	1.1%	4.5%	5.6%	2.2%	100.0%
Q	321	2343	374	82	26	8	10	1	3	0	3	3171
	10.1%	73.9%	11.8%	2.6%	0.8%	0.3%	0.3%	0.0%	0.1%	0.0%	0.1%	100.0%

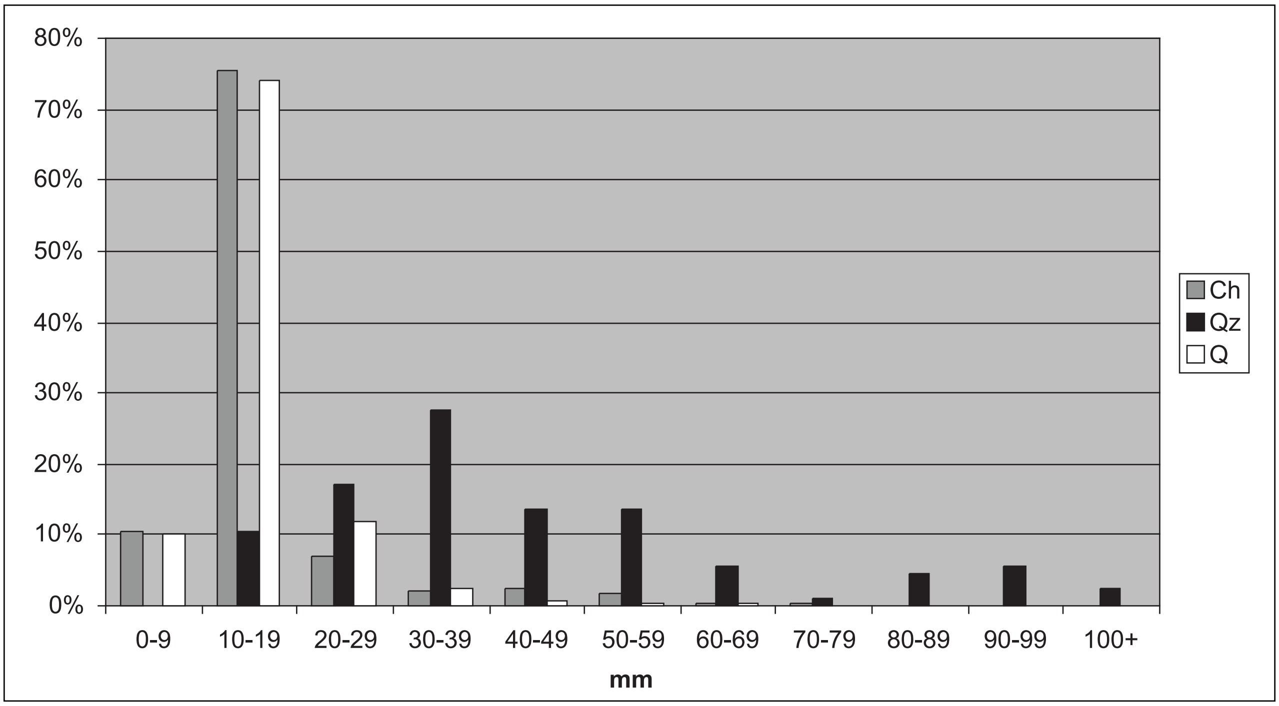

Figure 2. Size profile of the Oldowan assemblage by raw material type. Some material that could not be measured accurately is excluded.

Table 4. All measurable Oldowan artifacts, excluding manuports, compared with data from the experimental flaking of quartz and quartzite (Kuman et al. 2005).

Experiments	**Quartz**		**Quartzite**				**Combined**	
Size categories	N	%	N	%			N	%
4-9 mm	10295	**69%**	4631	**57.6%**			14926	**65%**
10-19 mm	2749	**18%**	1745	**21.7%**			4494	**20%**
20 and above	1933	**13%**	1670	**20.8%**			3603	**16%**
Total	14977	**100%**	8046	**100.0%**			23023	**100%**
Oldowan	**Quartz**		**Quartzite**		**Chert**			
Size categories	N	**%**	N	**%**	N	**%**	N	%
4-9 mm	321	**10.1%**	0	**0.0%**	24	**10.3%**	345	**9.9%**
10-19 mm	2343	**73.9%**	9	**10.1%**	175	**75.4%**	2527	**72.4%**
20 and above	507	**16.0%**	80	**89.9%**	33	**14.3%**	620	**17.8%**
Total	3171	**100.0%**	89	**100.0%**	232	**100.0%**	3492	**100.0%**

owan Infill is exposed at the surface through erosion of the dolomite cave roof, but it was once an upper chamber that overlay the lower chamber (or Name Chamber), in the modern underground cave system.

Stratford's analysis of artifacts excavated from a portion of the Name Chamber talus confirms that this latter assemblage is dominated by smaller artefacts. As material eroded out of the Oldowan breccia, it filtered down the shaft leading to the Name Chamber talus below, but it was mainly the smaller component that was able to pass through the restrictions created by rubble blocking the specific feeding shaft (Stratford 2008). This analysis has been confirmed by the stratigraphic and sedimentological details of the Name Chamber talus slope (*ibid.*). Our conclusion is that the Oldowan assemblage was once a largely complete occupation assemblage, with some portion of it re-worked and eroded into the underlying shaft.

Future analysis of the abraded component of the Oldowan assemblage is expected to demonstrate areas of re-worked breccia within the infill, which may show bias in certain size categories. The great majority of the assemblage, however, is in fresh condition. Artifacts derive from the area around the cave entrance, which correlates with the fact that there would have been relatively little higher ground from which weathered and abraded artifacts could have entered the site's catchment. Quartz, the dominant material, is resistant to weathering and it generally needs abrasion to obtain a weathered appearance. Thus the quartz component that is not fresh (and particularly the abraded component) suggests that the assemblage underwent some mechanical abrasion, either on the immediate landscape or in the process of re-working within the cave infill.

We conclude that most of the assemblage must have accumulated within a limited catchment area around the cave entrance, with hominid activities presumably taking place under shade trees. This is a logical conclusion because the surface fissures associated with cave shafts normally are marked by denser vegetation and trees due to greater moisture (Kuman 1994b). The assemblage composition points to a relatively stable land surface minimally affected by erosion. Sedimentological analysis by Partridge (1993) shows a higher clay and silt content for this breccia than for any other infill in Members 4 and 5, which include breccias that are both older and younger than the Oldowan Infill. If this phenomenon is not purely attributable to internal cave processes, it could indicate locally moist conditions that reflect more advanced pedogenesis of sediments entering the cave at this time (*ibid.*). Supporting evidence for this possibility may come from a study of carbon isotopes analysed from faunal teeth by Luyt and Lee-Thorp (2003), who conclude that a moderately wooded environment was present during the Oldowan accumulation. The combination of this environmental data and the good assemblage preservation thus suggests that catchment of artifacts around the cave entrance was aided by a stable, fairly well-vegetated land surface. It is not surprising then that Pickering's (1999) taphonomic study of the fauna indicates that a death-trap-like opening existed at this time. Local vegetation could have obscured a cave shaft, which was also relatively narrow because it formed early in the history of the Member 5 cave openings.

Raw Material Properties and Hominid Selection

Only 152 pieces in the assemblage have cortex that directly indicates the source of raw materials (Table 5). Of this informative portion, however, 72% have river gravel cortex, indicating a significant degree of manuport and artifact transport into the site from the nearby gravels. Of the cores, core fragments and one core tool, at least a quarter have cortex which indicates they were made on material sourced from the gravels. In addition, virtually all the quartzite artifacts without cortex can be added to the total of gravel-sourced pieces. Quartzite is not found around the caves today (Kuman 1996), and there is little evidence that there are remnant deposits from earlier times. In contrast with quartzite, chert in the Sterkfontein valley occurs as thin layers interbedded within the dolomite, and it can be found both at the caves and in the gravels. Quartz formed as veins within the dolomite and other local rocks, and hence it is also found both at the caves and within the gravels. As both chert and quartz are resistant rocks, they often litter the landscape in areas where the dolomite has decayed through weathering and dissolution.

Although shapes for chert are more rounded in the gravels than on the landscape, the quality of the chert is generally comparable between the two sources, but chert was a minor raw material in the Sterkfontein Oldowan. For quartz, however, it is much more difficult to find sizeable, good quality pieces on the landscape than in the gravels, where there is a variety of available sizes, from pebble to cobble grade. Vein quartz may have been preferred for some activities because it produces very sharp flakes with a clean cutting edge. Our flaking experiments show that it is brittle and fractures easily, regardless of shape. It is not so common in the gravels

Table 5. Raw material sources determined by cortex type for the entire Oldowan assemblage.

	Gravel cortex	Hillslope cortex	Indeterminate	N
Raw Material				
Chert	2 (0.8%)	4 (1.7%)	230 (97.5%)	236
Quartzite	55 (56.7%)	n/a	42 (43.3%)	97
Quartz	52 (1.6%)	39 (1.2%)	3089 (97.1%)	3180
Total	109	43	3361	3513

as quartzite, and hence it may have been selected for its ease of fracture, or alternatively for tasks that required a razor-sharp cutting edge. The chert also flakes easily, but this particular type of chert, formed interbedded with dolomite, produces flake edges with a somewhat rougher texture than that of vein quartz. This could explain its limited use at Sterkfontein, but it is more prominent at nearby Swartkrans (Field 1999), where chert and silica-enriched dolomite are more common on the immediate landscape around the cave. Hence the use of quartz and chert at Sterkfontein may be reflecting some combination of factors relating to the task at hand and raw material availability.

As both quartz and chert were flaked on site, they appear to represent an expedient use of these stones, probably for some activity that required sharp rather than robust edges. Our student butchery experiments over the years have shown that quartz makes very efficient cutting tools, even if a number of flakes has to be used because of their generally smaller size and brittle edges. The Oldowan quartzite, on the other hand, shows a size profile that does not indicate flaking on site (Figure 2, Table 3). There is a lack of small flaking debris in quartzite, with most quartzite pieces occurring in the 20 to 59 mm size intervals, and there is a wider range of artifact sizes present in quartzite than in quartz and chert. This suggests transport of this material, rather than differential capture for this sub-assemblage, particularly because all three materials are likely to have been subjected to the same depositional conditions. Transport may also have been desirable because it is easier to produce whole flakes from quartzite than from quartz. Field's (1999) experiments resulted in 40% of removals as whole flakes from quartzite cores versus 5% for quartz.

Where flaking method is evident, it is dominated by the freehand technique, but there is some evidence for the bipolar (hammer and anvil) method. However, vein quartz can be particularly difficult to assess quantitatively, as its high degree of shatter deletes most diagnostic bipolar traits. Freehand flaking probably dominates because cobbles are more common than pebbles in the gravels (pebbles are <64mm in size).

Cobble shapes for all raw materials are rarely spheroidal but occur in a range of other forms, which can be described as: blocky angular, blocky rounded, rounded polyhedral, wedge, disc, and tabular-disc (Kuman 1996; Field 1999). The lack of well rounded cobbles reflects the short transport distance these gravels have undergone, with the source of the Blaaubank River only about 24 km distant (Kuman 1996).

To summarize, all three raw materials are readily available in the area, and the situation is unlikely to have differed during the Oldowan occupation of the valley. Although quartz and chert may vary in their relative abundance around individual sites, they are both ubiquitous on the landscape and in the gravels. As some raw materials were clearly sourced from the gravels, we also know that these terrace deposits were accessible during the Oldowan. Therefore, environmentally influenced shifts in access to the three rock types are not a factor for the archaeology, and curated *v.* opportunistic use of raw materials can be interpreted with some confidence. There is good indication that hominids were not merely using the raw materials immediately available at the site but were transporting many rocks, as well as some pre-flaked quartzite, into the site. Quartz was often selected from the gravels, where it is not the most common material, probably for its ease of fracture and sharp flake edges. The lack of cores in chert and its availability on the landscape suggest that this material was most often accessed near to the site. These patterns thus indicate that the Sterkfontein hominids practiced both an expedient and a curated (*i.e.*, transported) use of stone at the site.

Typological Classification and the Influence of Raw Materials

The typological classification of the assemblage (Table 2, and see Figures 3 to 9 for representative types) shows that retouched pieces are only 0.2% (N=7), which means that an expedient strategy dominates. Manuports are also poorly represented at 0.3%, which is typical for most Oldowan period sites. A variety of core types is present, but polyhedral cores dominate (50% of 24 cores). This is due to two factors—the dominance of a non-organised flaking strategy that exploits any available surface on cobbles with varying platform opportunities; and the prominence of vein quartz, which in these gravels is found in a variety of shapes and which, during flaking, can shatter into exploitable portions or chunks. Some of quartz cores have been made on chunks. As a result of this tendency for quartz to shatter, extremes occur in quartz core sizes, which range from 30 to 120 mm (Table 6).

The only discoidal core is one in quartz. Our experiments showed that discoids are fairly easy to make on these cobble shapes, but continued flaking can transform them into polyhedrons (Kuman *et al.* 2005). Of the four chopper-cores (Fig. 3), only one quartzite example (No. 1) approaches the classic type of Oldowan chopper flaked on the edge of a cobble (as per Leakey 1971); the two other quartzite chopper-cores (Nos. 2-3) resemble radially flaked cores on split or fractured blanks; the blank for the quartz example (No. 4) cannot be determined. The few chopper-cores therefore highlight the limitations of the classic Leakey typology and the value of a *chaine opératoire* approach, which pays more attention to the raw material shapes, blank forms, and flaking process (*e.g.*, Toth 1985). Of the 24 cores, several also have irregular fracture surfaces that suggest pieces may have been thrown or split prior to flaking. This feature fits with the opportunistic technology, but it could also be due to flaws within the quartzite.

There is no edge damage or macroscopic wear that suggests any of the cores was used as a core tool. How-

*Table 6. Details of the 24 cores in the assemblage, with measurements in mm. Length, Width and Thickness have been provided so that core volumes could be analysed (Field 1999). In one case (No. 2502), the Maximum Length differed with the orientation of the core used for volumetric measurements.'Irreg. Fracs.' refers to the number of irregularly fractured surfaces. 'Reduction' is the degree of core reduction for freehand cores (1, minimally reduced with more than 2 platforms remaining; 2, partially reduced with 1-2 platforms remaining; 3, fully reduced with no remaining platforms). Cortex is estimated as 0 (none), 1 (up to 25%), 2 (up to 50%), 3 (up to 75%) and 4 (more than 75%). *3303 is a rolled complete polyhedron that appears to have been imported to the site as a manuport. **44 lacks details because it could not be located.*

Catalogue No.	Type	Max Length	Length	Width	Thick-ness	Scar No.	Longest scar	Irreg. Fracs.	Reduc-tion	Cortex
Quartzite										
4920	chopper	85	85	79	40	12	49	2	2	1
2502	chopper	94	89	64	51	3	56	1	2	4
2932	chopper	94	94	86	55	15	63	1	1	1
8854	polyhedron	69	69	45	35	10	32	0	3	1
8841	polyhedron	89	89	59	35	3	61	0	3	1
3019	polyhedron	91	91	81	57	4	49	1	3	2
2789	single platform	55	55	41	25	5	25	0	1	2
Quartz										
6212	bipolar	103	103	63	53	n/a	n/a	.	.	3
3708	bipolar	58	58	46	44	n/a	n/a	.	.	0
2771	bipolar	30	30	26	22	n/a	n/a	.	.	1
2693	casual core	34	34	25	19	1	23	0	2	0
8911	casual core	68	68	60	42	1	51	0	2	0
3977	chopper	66	66	47	39	8	49	0	3	0
3065	discoid	63	63	50	40	15	43	0	3	0
3705	polyhedron	105	105	91	57	4	50	0	1	4
4965	polyhedron	120	120	99	70	25	84	0	3	0
2487	polyhedron	36	36	31	29	3	30	0	3	1
2457	polyhedron	42	42	40	34	10	29	0	3	1
2772	polyhedron	42	42	33	22	8	28	0	3	0
2629	polyhedron	45	45	42	27	8	34	0	3	0
7334	polyhedron	62	62	46	38	8	47	0	3	0
2903	polyhedron	75	75	62	50	6	61	0	2	2
3303*	polyhedron	84	84	74	66	.	.	.	.	.
44**	single platform	44	.	.	.	.	.	.	.	1

ever, the one protobiface (Fig. 4, No. 5) has been classed as a core-tool because the removals concentrated at one end of the piece give it a pointed 'functional' end. Although the artifact can clearly be called a protobiface because these removals appear to be shaping the tip, it is also possible that this shape is the fortuitous result of flaking the more acutely angled end of the cobble.

Finally for the typological analysis, we re-iterate that vein quartz tends to produce a high proportion of incomplete flakes, due to its tendency to shatter. Although the archaeological sample sizes for chert and quartzite are small, there is a clear pattern that shows a much greater dominance of incomplete flakes for quartz for material ≥20mm:

	Quartzite	*%*	*Chert*	*%*	*Quartz*	*%*
Complete flakes	20	34%	7	24%	57	20%
Incomplete flakes	38	66%	22	76%	231	80%
Total	58	100%	29	100%	288	100%

This is corroborated by the experimental data, and although we have not included chert in the quantified experiments, our flaking experience suggests a generally similar pattern to quartz, as the chert is friable and tends to shatter. The data on quartzite, however, is not representative of a full knapping sequence and thus is not so useful.

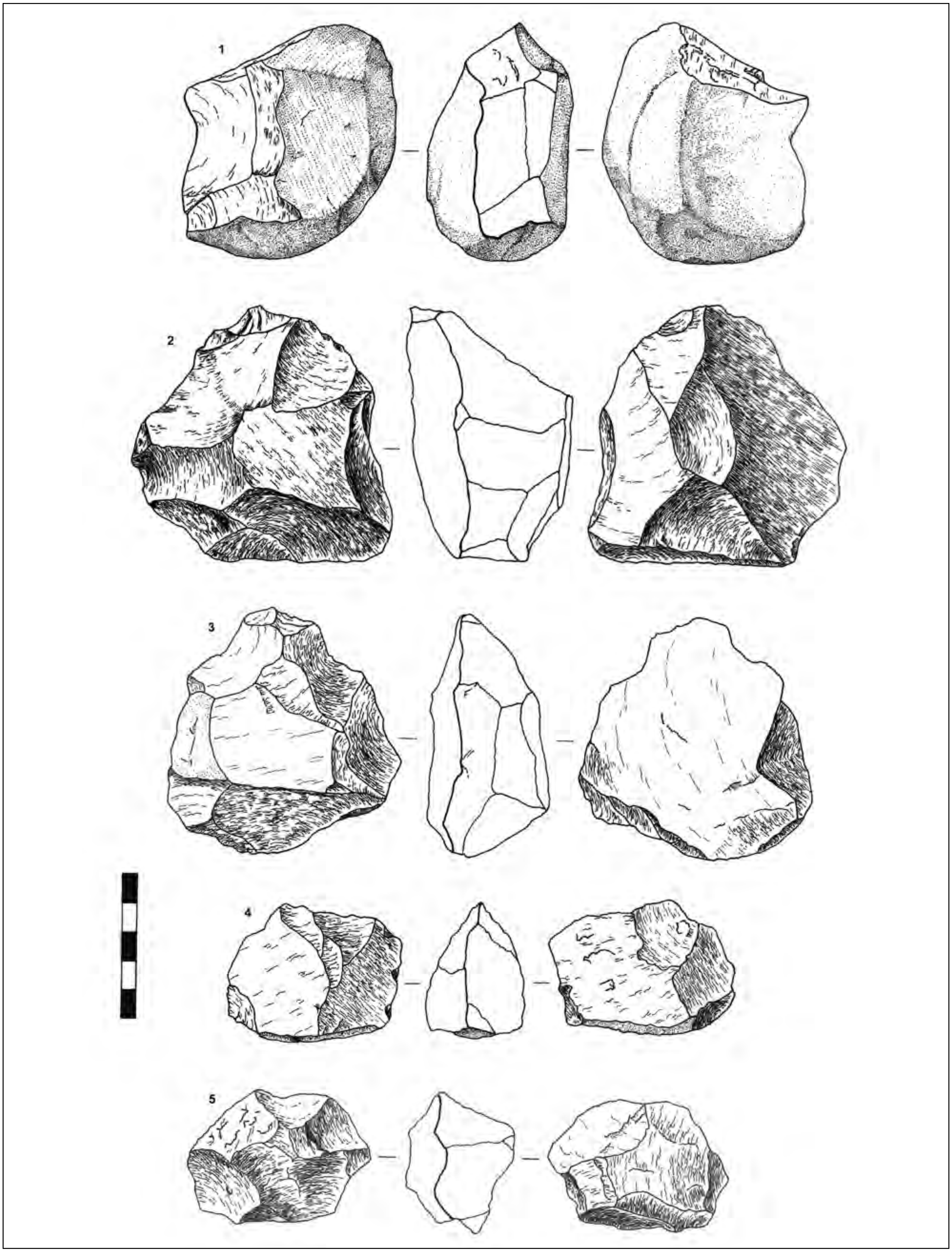

Figure 3. Chopper-cores and discoid: No. 1, a unifacial chopper-core in quartzite (#2502), made on a cobble with an irregular fracture at top; No. 2, a partly bifacial chopper-core in quartzite (#2932), with a radial flaking pattern and an irregular fracture formed by a planed surface that probably followed a natural flaw in the rock; No. 3, a unifacial chopper-core in quartzite (#4920), with a radial flaking pattern and made on a large flake or cobble fragment, with two irregular fracture surfaces; No. 4, a bifacial chopper-core in quartz (#3977); No. 5, a bifacial discoidal core in quartz (#3065).

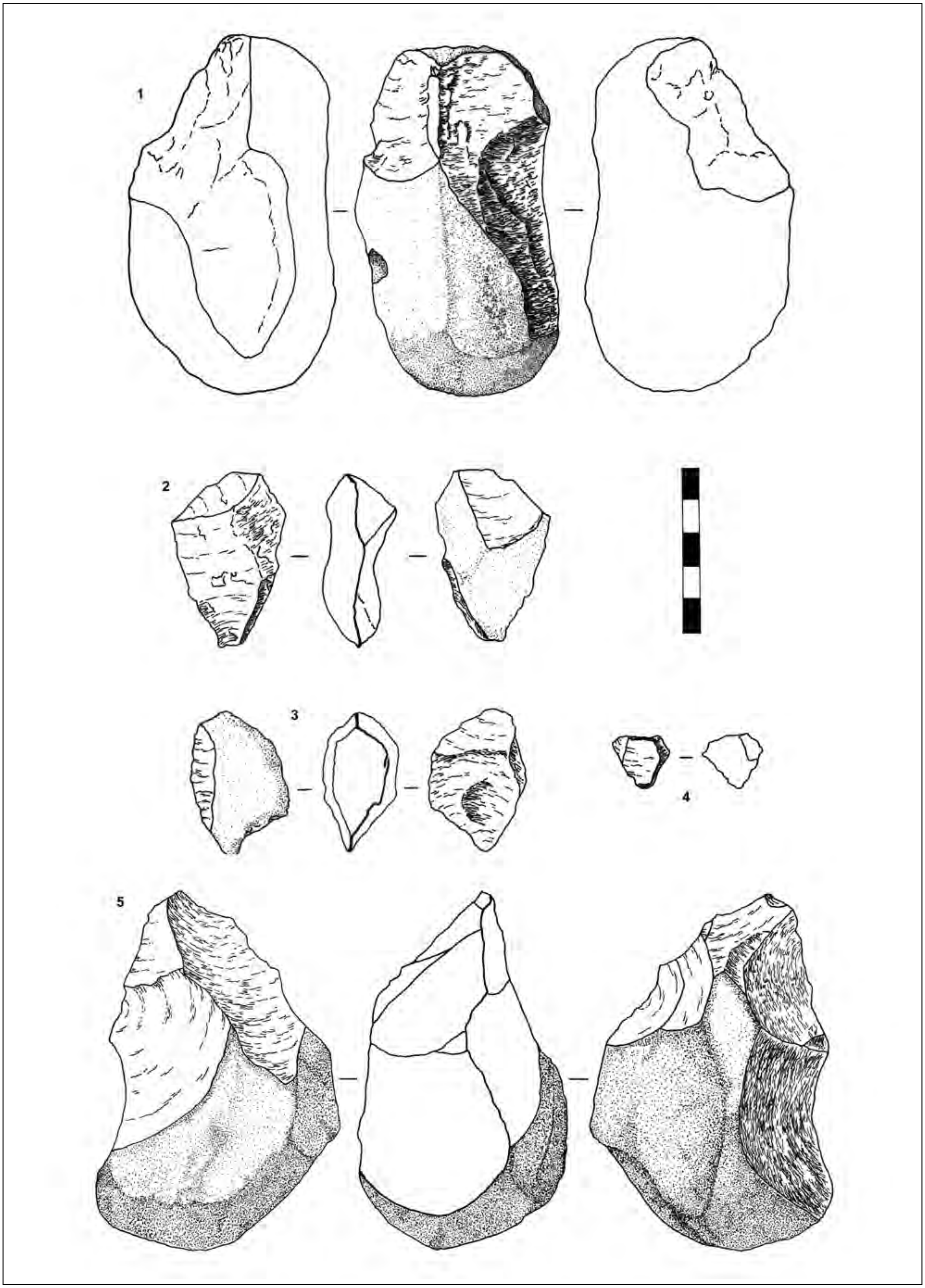

Figure 4. Bipolar pieces and protobiface: No. 1, a bipolar core on a quartz cobble (#6212), with fractured surfaces probably produced by a single blow; Nos. 2-4, quartz bipolar core remains or fragments; No. 5, a protobiface in quartzite (#2371).

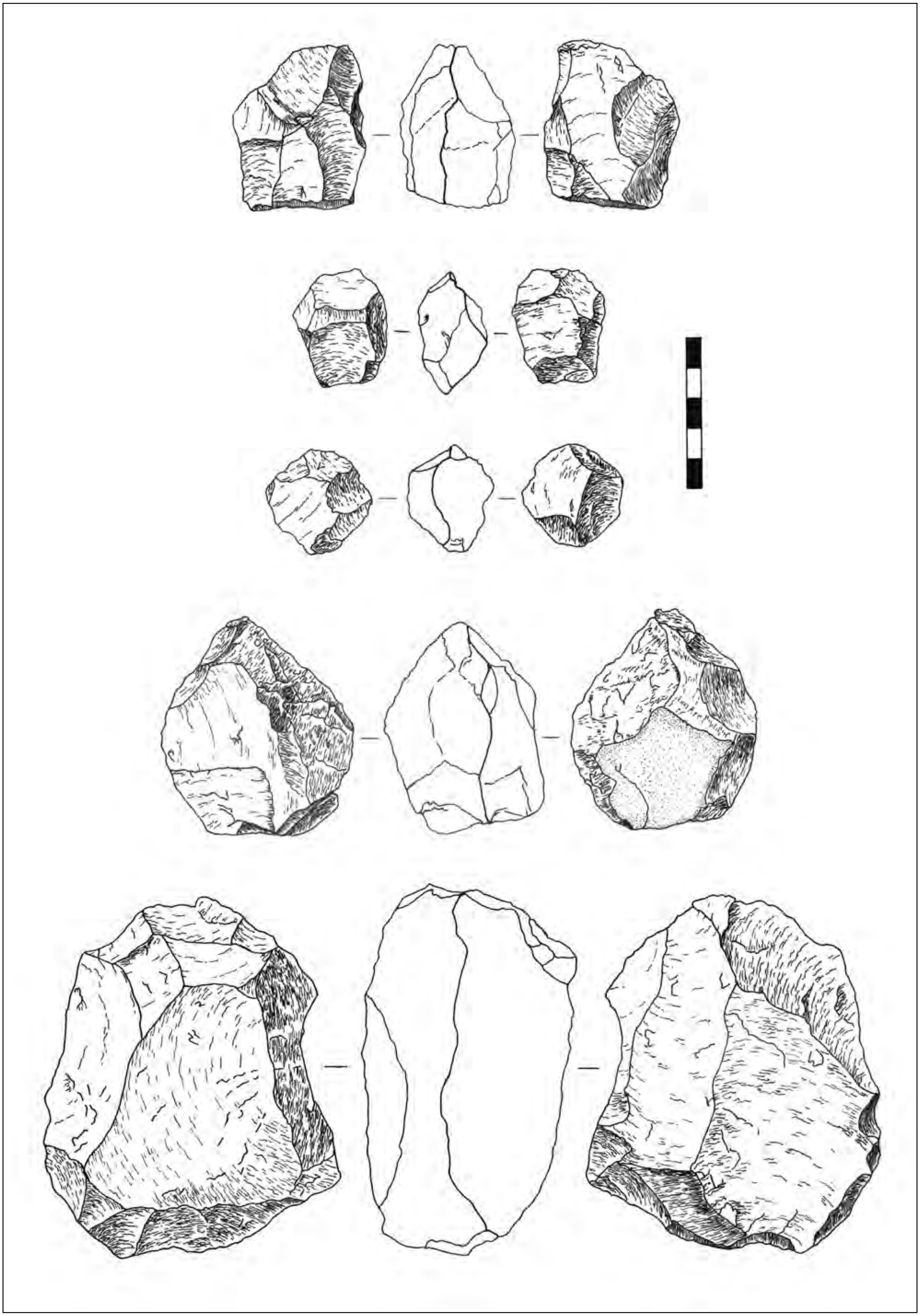

Figure 5. Polyhedral cores in quartz (in sequence from top: #'s 7334, 2772, 2487, 2903, 4965).

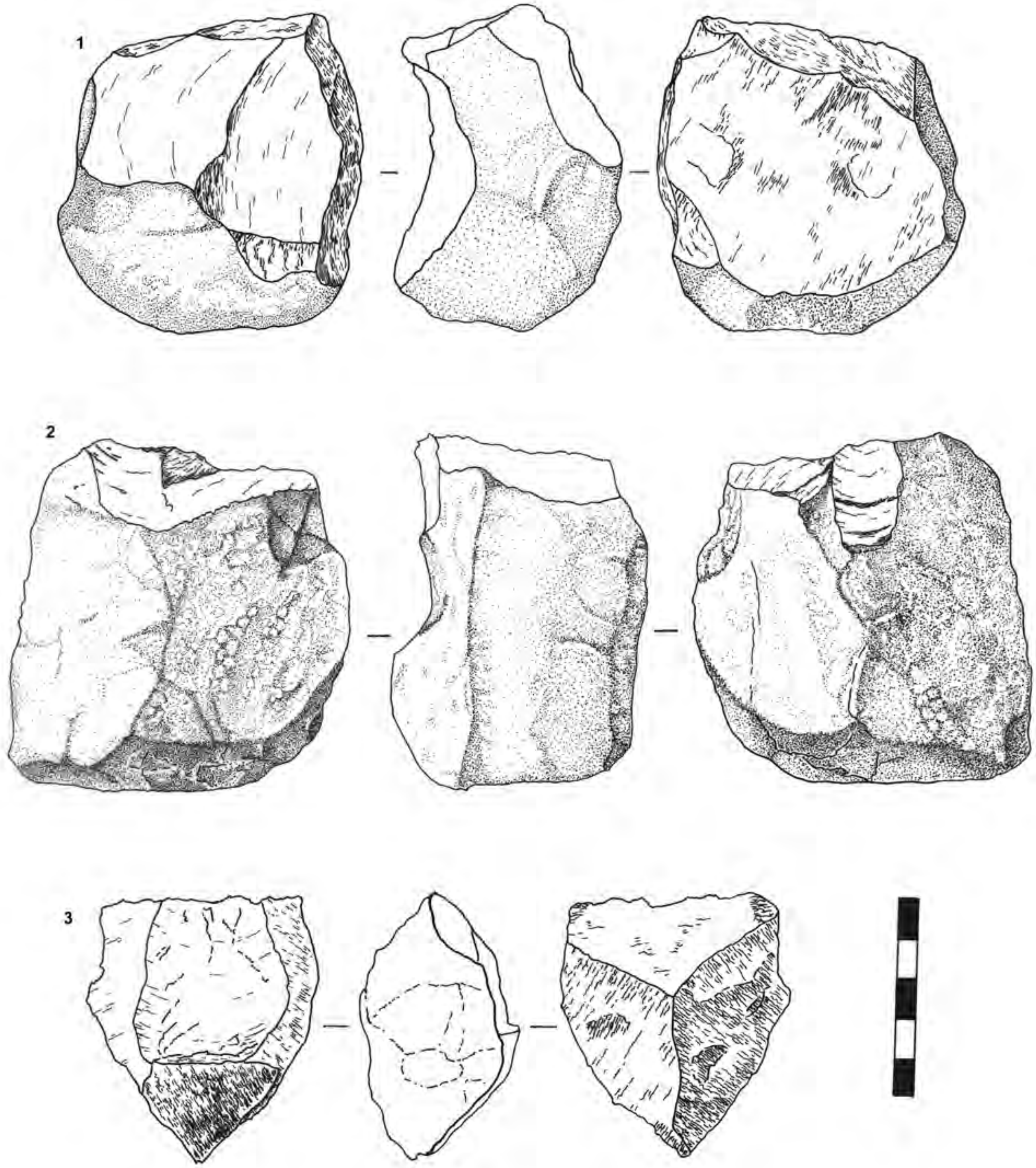

Figure 6. Polyhedral and casual cores: No. 1, polyhedral core in quartzite (#3019), with an irregular fracture visible in profile and 3rd views; No. 2, polyhedral core in quartz (#3705), with removals concentrated at top end; No. 3, casual core in quartz (#8911), made on a chunk.

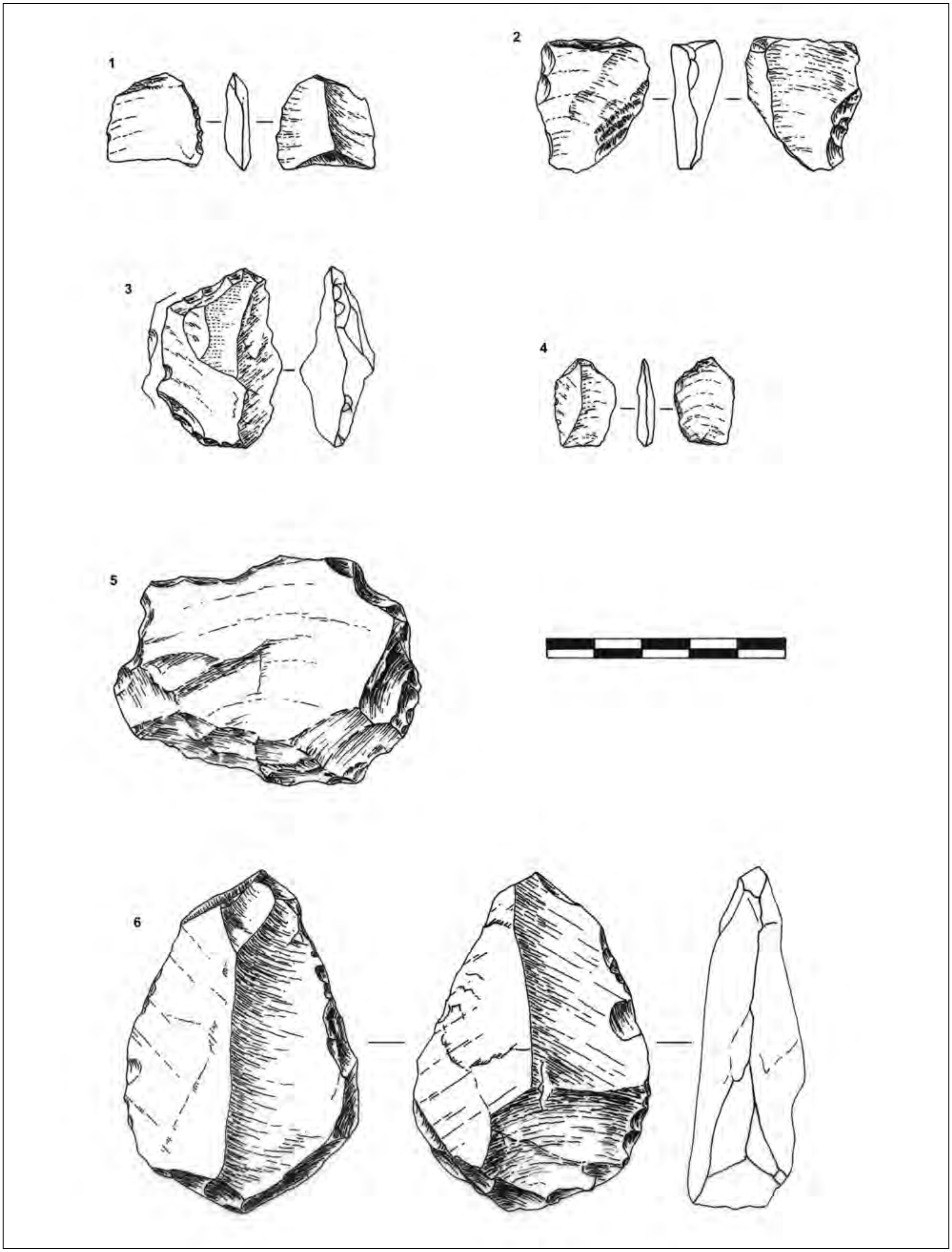

Figure 7. Retouched pieces. No. 1, distal portion of an incomplete flake with marginal retouch (#2647, quartzite); No. 2, proximal portion of an incomplete flake with inverse-obverse retouch on one edge (#3206, quartz); No. 3, an incomplete flake with denticulated retouch along most of the unbroken perimeter (#6121, quartz); No. 4, a complete flake with fine marginal retouch (or utilization?) on the ventral face (#7430, quartz); No. 5, a flake with abrupt edges showing ventral retouch (at right) (#7229, poor quality quartz); No. 6, a flake with sporadic retouch (#3228, chert, ventral face is the middle view).

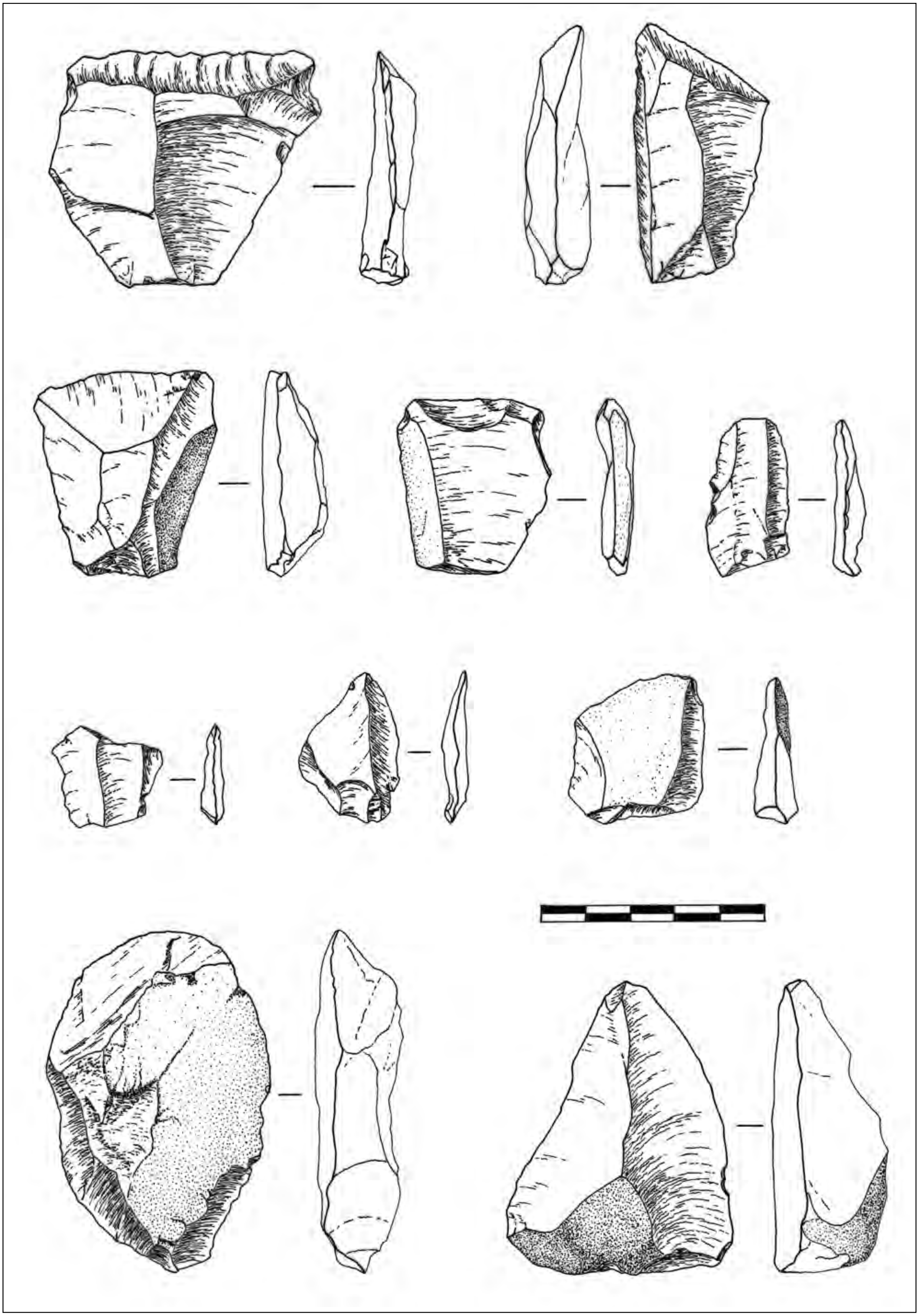

Figure 8. Complete flakes in quartzite.

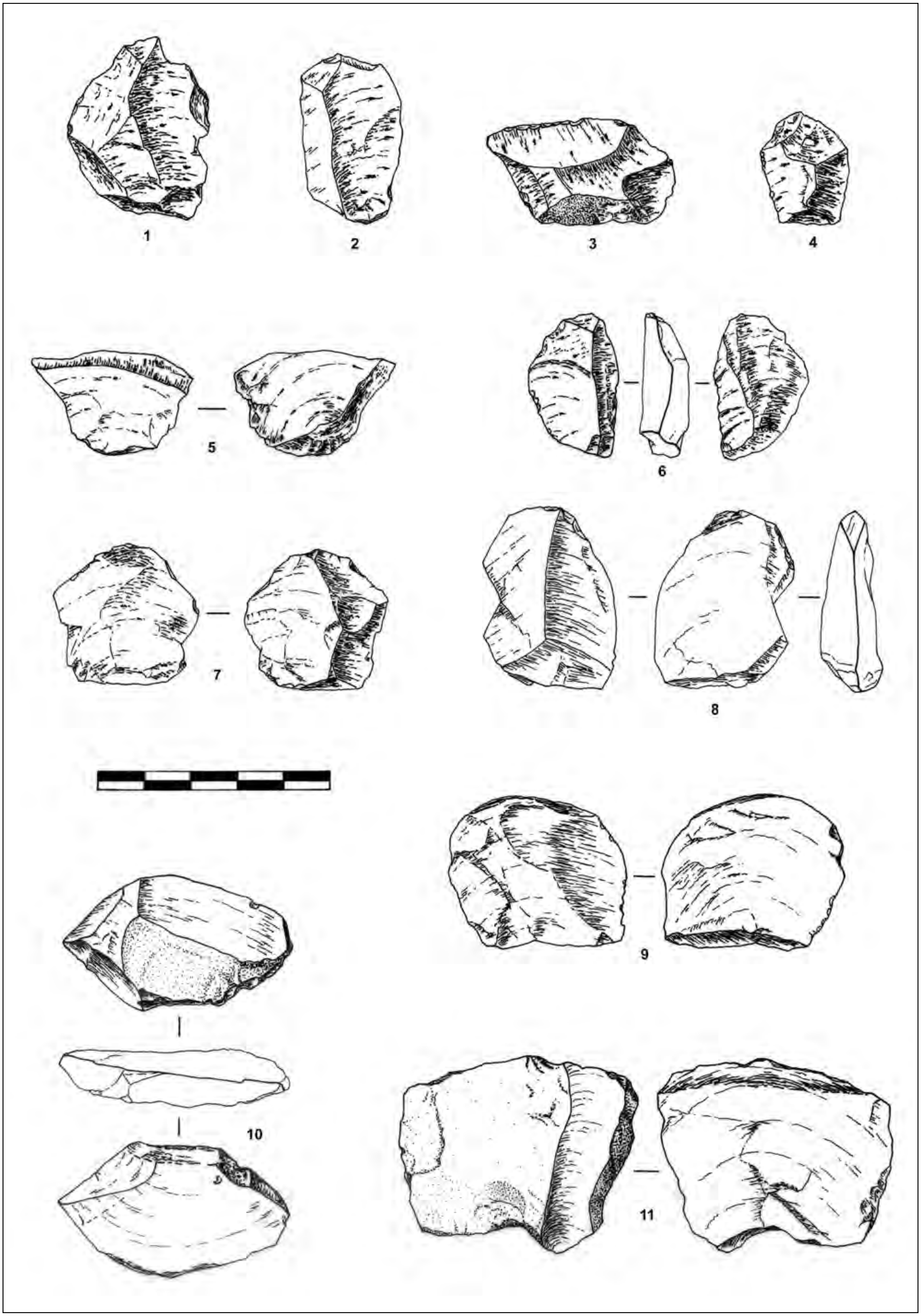

Figure 9. Complete flakes in quartz and chert. Nos. 1-7 in quartz, Nos. 8-11 in chert.

Examples of complete flakes in the three raw materials are provided in Figs. 8 and 9. Fig. 7 illustrates six of the retouched pieces. Retouch varies from sporadic removals to more consistent but marginal or nibbling edge working, and none is invasive, highlighting the casual nature of the assemblage.

Technological Analysis

A variety of technological attributes was analyzed for the sample used by Field (1999) to gain insight into the industry. Our results on this slightly smaller sample are summarized below, and Field (1999) may be consulted for further details:

Flake shapes

Flake shapes were recorded for 84 pieces, with the striking platform at base, as:

	convergent	*divergent*	*irregular*	*parallel*	*Total*
Quartz	40	9	6	7	62
Quartzite	5	5	3	4	17
Chert	4	1	0	0	5
Total	49	15	9	11	84
	58%	18%	11%	13%	100%

The majority of shapes is convergent (58%), but the chert and quartzite samples are too small to compare raw material trends. For the more reliable quartz sample, 65% are convergent. This attribute probably only reflects the manner in which quartz tends to detach with the simple flaking patterns evident in this assemblage.

Flake dorsal scars

The mean number of dorsal scars on complete flakes (≥20mm, with obvious bipolar flakes excluded) is slightly higher for quartzite than for quartz or chert:

	Mean	*Range*	*N*
Chert	2.5	1 to 5	6
Quartzite	3.4	2 to 6	16
Quartz	2.3	1 to 7	54

Although the sample size for quartzite is small, this difference could reflect the greater degree of flaking of quartzite off-site. The low mean numbers of dorsal scars in general correlates with the simple flaking patterns that dominate this assemblage. Dorsal Scar Patterns on whole flakes were also recorded for 86 pieces lacking cortex as: Unidirectional from the Platform, Opposed to the Platform, Transverse to the Platform, Unidirectional and Transverse to the Platform, Irregular, Radial or Converging. The patterns are overwhelmingly simple, reflecting the kind of flake types that would result from the dominance of polyhedrons and chopper-cores:

	Uni-directional	*Opposed*	*Transverse*	*Uni-Trans-verse*	*Irreg*	*Radial*	*Con-verg*	*Total*
Quartz	40	2	5	6	6	0	5	64
Quartzite	6	1	2	5	2	0	0	16
Chert	4	0	1	0	0	1	0	6
Total	50	3	8	11	8	1	5	86
	58%	3%	9%	13%	9%	1%	6%	100%

Flake terminations

Of 90 whole flakes for which flake terminations could be recorded, only seven had hinge terminations, with the remainder showing feathered terminations. This pattern is due to the dominance of quartz, which produces many incomplete flakes. If flakes terminate in a step in this material, they appear to be incomplete flakes and are classed as such, resulting in an elevated ratio of incomplete flakes. For every quartz complete flake, there are 4.56 incomplete flakes.

Cortex

The amount and position of cortex on whole flakes is used as an indication of degree of reduction (Villa 1983; Toth 1985). Flakes have been classed according to the six types described by Toth (1985) as successive stages of core reduction:

Cortex Location	*1: full/ platform and dorsal*	*2: platform and part dorsal*	*3: platform and no dorsal*	*4: dorsal and no platform*	*5: part dorsal and no platform*	*6: none*	*N*
Chert	0	0	1	0	2	3	6
Quartzite	2	0	1	0	6	9	18
Quartz	1	4	4	0	10	47	66
Total							90

The six chert flakes are too few to provide meaningful information. However, 83% of the 18 quartzite flakes fall into Types 5-6, consistent with the expectation that quartzite was largely flaked off-site. On the other hand, 86% of the 66 quartz flakes also fall into Types 5-6, even though quartz was clearly flaked on-site. This must be due to the brittle nature of vein quartz, which provided non-cortical fragments and chunks that would have been used as cores for on-site flaking, reducing the number of cobbles needing to be imported. 74% of all cores have less than 25% cortical surface remaining. However, the proportions of cortex on cores is not particularly informative of reduction in this assemblage, as quartz can be flaked as chunks, and there are few quartzite cores and none in chert. The amount of remaining cortex would also be influenced by cobble shape as much as by degree of reduction.

Core reduction

Scar counts on freehand cores range between 1 and 25 removals at time of core abandonment. There are only two casual cores (defined as a minimally flaked core with only 1-2 removals), which are both made on quartz. Chopper-core scars range from 3 to 15, and the only discoid in the assemblage is in quartz, with 15 removals. For the polyhedral cores, the most completely worked examples are all in quartz, with up to 25 scars. Overall and regardless of type for freehand cores, the quartzite cores average 7.8 scars, while the quartz cores average 8.7 scars. In our experiments, we also achieved up to 25 scars by core abandonment, but the mean was 10.5 scars. The experimental cores were, however, fully reduced, which is not always the case with the archaeological specimens. A more accurate measure of core reduction for the Oldowan cores is the number of remaining 'flakeable' platforms. We recorded this attribute based on our subjective but mutual decision that a platform could continue to be used. The result was that the majority of the Oldowan cores has no potential for further flaking, showing a relatively extensive use of materials, particularly for quartz.

Striking platform facets

Striking platforms of flakes are predominantly simple, with 1.2 being the mean number of facets for quartz flakes (N=43), 1.4 the mean for quartzite flakes (N=14), and 1.5 the mean for chert flakes (N=5). Although sample sizes are small, this pattern is not unexpected for the types of cores dominating the assemblage.

Flake platform angles

For non-cortical flakes, the mean angle formed between the striking platform and the ventral surface is greatest in quartz at almost 97°, but sample sizes for chert and quartzite are very small:

Material	*Mean*	*N*
Quartz	96.7°	45
Chert	92.4°	5
Quartzite	95.5°	13
Total		63

The range of values is also great—from 48° to 136°. Such a wide range could relate to the casual nature of the industry, or even to the ease with which quartz flakes, thus creating more variability.

Conclusions

Although we currently have only one certain site (dominated by quartz artefacts) to provide insight into Oldowan hominid behaviour in southernmost Africa, some interesting conclusions are evident in the Sterkfontein assemblage. Where it is possible to distinguish the source of raw materials from the cortex remaining on artifacts, the majority was brought into the site from the nearby gravels. Better quartz could be obtained from the gravels than from the landscape, and this shows a degree of selectivity, despite the expedient use of quartz at the site. Although chert was only occasionally used, both quartz and chert show near-complete size profiles, indicating they were flaked on-site. This fact and the paucity of retouched tools support an interpretation of the assemblage as generally expedient. Quartz may have been favoured because it was easy to flake and produced very sharp (if brittle) edges. The chert sample is small, but this rock is easily obtained on the landscape near the site and similarly appears to represent an expedient use of stone which was flaked on-site. Quartzite, on the other hand, creates more robust flake edges than these more brittle rock types. It was less commonly flaked on site and was largely transported, perhaps for use in certain tasks or even as an individual preference. Therefore the dominance of quartz at Sterkfontein should be viewed as a site-specific pattern that could be activity-related, random, or idiosyncratic to the site or the individuals involved. In addition to the selection of quartz from the gravels, there is evidence for transport of quartzite into the site as this material is not found on the hillslopes today, and it is unlikely that it was present in any significant amounts in the past. Transport for some pre-flaked quartzite tools is also a pattern, as there is a preference for medium-size quartzite flakes.

This overall pattern of selection, transport and curation at Sterkfontein shows forethought and appreciation of raw material properties, which mirrors Oldowan behavioural patterns in a variety of East African sites (*e.g.*, Stout et al. 2005). Many Oldowan sites show transport of raw materials over some distance, pre-flaking of cores, transport of flakes, or selection for specific raw material quality or flaking properties (see Plummer 2005 and Schick and Toth 2006 for syntheses). At least one early Oldowan site also shows a degree of selectivity for manageable rock shapes and maintenance of shape through the flaking process (Delagnes and Roche 2005). After 1.5 Ma, there is indication of some organised flaking strategy (De La Torre *et al.* 2003), which is a logical development following on the cognitive sophistication seen in earlier assemblages (e.g., De La Torre 2003; Delagnes and Roche 2005; Semaw 2006). While simple flaking patterns dominate at Sterkfontein and organized flaking patterns are not particularly evident in the small number of cores, much of this 'simplicity' can be explained by raw material shapes and flaking properties. There is also ample evidence for well-controlled flaking of the better raw materials in the assemblage, as well as a tendency for radial and alternate flaking of even the simplest type, *i.e*., chopper-cores. More sites will be needed to provide a fuller picture of the range of early hominid behaviour in southern Africa, but the Sterkfontein industry does show a strong consistency in cognitive abilities with the Oldowan in other parts of Africa.

Although the majority of Oldowan cores appears to be relatively intensively worked, this attribute bears a significant relationship with raw material. As with core and dorsal scar counts, such traits should be assessed for each material. Experiments with flaking the local rocks have been invaluable for assessing raw material properties and shapes. Because the brittle vein quartz is easy to flake, it was easier to reduce cobbles and cores more fully than to transport new material to the site.

It is possible to produce all of the basic Oldowan core types on the local cobbles, which tend to have facetted or polyhedral and blocky shapes, but polyhedral cores dominate. This is also true for the Sterkfontein early Acheulean assemblage, in which quartzite was used for the majority of cores. With our less extensive experience of knapping than the Oldowan hominids would have possessed, we found the discoid the easiest core type to reduce fully because, when the two platforms are established, they can more easily be maintained. However, many of the Oldowan polyhedral cores are well reduced (as well as those in the Acheulean). This may be correlated not only with raw material, but also with skills in core reduction that come with greater practice and dependence on stone tool technology. While there are smaller numbers of complete flakes in quartz than in quartzite, quartz shows higher average scar counts on cores. These observations correlate with the tendency of quartz to shatter more readily than quartzite, and once again this highlights the importance of raw material comparisons for understanding technological attributes. The assemblage is characterized by relatively small average flake sizes.

The Sterkfontein Oldowan is only one assemblage, with characteristics that may be activity-related or due to individual biases, and it is clear that much more data is needed for a fuller picture. However, the assemblage is informative enough to allow us to conclude that the southernmost expression of this industry shows traits comparable with the East African pattern. We hope that renewed excavations in Member 1 at Swartkrans, which began in 2006 with a team led by T.R. Pickering, may help to round out this picture a little more.

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