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Insights into early lithic technologies from ethnography

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Oldowan lithic assemblages are often portrayed as a product of the need to obtain sharp flakes for cutting into animal carcases. However, ethnographic and experimental research indicates that the optimal way to produce flakes for such butchering purposes is via bipolar reduction of small cryptocrystalline pebbles rather than from larger crystalline cores resembling choppers. Ethnographic observations of stone tool-using hunter-gatherers in environments comparable with early hominins indicate that most stone tools (particularly chopper forms and flake tools) were used for making simple shaft tools including spears, digging sticks and throwing sticks. These tools bear strong resemblances to Oldowan stone tools. Bipolar reduction for butchering probably preceded chopper-like core reduction and provides a key link between primate nut-cracking technologies and the emergence of more sophisticated lithic technologies leading to the Oldowan.

1. Introduction

Because of the great time and biological differences that separate hominin tool use in the Lower Palaeolithic from the tool use of contemporary hunter-gatherers, it may be wondered if anything useful can be inferred about early tool use from observations of contemporary hunter-gatherers. There are several reasons why I believe that, despite the differences, such a comparison can yield critical insights into early tool use and behaviour. First, the best information for stone tool use among ethnographic hunter-gatherers comes from semi-arid environments such as the Australian Central Desert and Namibia. These environments are similar to those in South and East Africa where early stone tool use has been documented. Second, the basic subsistence was probably similar for early and contemporary groups, essentially being composed of hunting, scavenging and gathering plant foods. Third, in both instances, mobility was undoubtedly high and imposed major constraints on the amount of material, including tools or raw material, that could be transported. Fourth, probably because of these conditions, there appears to have been no food storage beyond a few days and no midden accumulations at sites. Fifth, in neither case was there any production of surpluses or their use in feasting or to produce prestige items related to any socio-economic inequalities. Sixth, as a consequence of the above factors, in both situations, the stone and wood technology was very simple and basic. It is worth emphasizing the extremely basic nature of the tools involved. In the cases of Tasmanian and Ova Tjimba hunter-gatherers, hafting was not even used. In sum, I would contend that, at least in terms of the examples to be examined, both early hominins and contemporary hunter-gatherers faced similar basic problems, similar constraints and a similar narrow range of acceptable solutions. I doubt that any cognitive differences would have made significant differences at this basic behavioural level, although smaller stature of early hominins may have affected some aspects of tool size, grip and use. Thus, heuristically, let us see what kinds of insights such comparisons might yield. I suggest that these can be addressed in terms of: use of stone tools, tool morphologies, reduction strategies and differing abilities.

2. Stone tool use

On the basis of my own ethnoarchaeological work in the Australia Central Desert [1–3], I would emphasize that by far the vast majority of ethnographic

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stone tool use in this type of environment is related to making wooden technological items such as spears, digging sticks, throwing sticks, shields, and bowls or troughs. Before dealing with specific examples, it is worth making a few important preliminary observations. First, in the Australian case, if rocks with naturally sharp fractures, especially with right-angled edges or acute-angled edges, were available, they were often used for woodworking instead of stones that had to be procured or carried about and then broken to create sharp edges. This is a technological aspect that was similarly recorded by Mountford [4] for the Pitjandjara. Even in butchering kangaroos, heavy stones, especially with good angular edges, were often used to snap off the ribs from the vertebral column once the ventral cavity had been opened [2, pp. 41–49]. Whether the cut marks reported by McPherron *et al.* [5] on bones dating to 3.39 Ma could have been made by using naturally fractured stones is an open question. While the existence of 'manuports' at a number of Oldowan sites is a somewhat contentious issue [6], the ethnographically documented practice of using naturally fractured stones for either butchering or woodworking [2,4] has not thus far been taken into consideration in the contending interpretations of archaeological manuports, and thus this aspect may add a new dimension to the investigation.

A second preliminary point to be made is that unretouched primary flakes were generally used for most activities including scraping wood, creating sharp points and butchering, and these were replaced when dull by other primary flakes (usually after less than 15 min use). Occasionally, these flakes were resharpened when dull. However, stone material was abundant in the experimental situations that I recorded in the Australian Western Desert [2], whereas if good stone was in short supply under traditional conditions, resharpening by retouching may have been much more frequent. One specific flake type that was commonly used but rarely resharpened or retouched was right angle breaks. These were extremely effective for working shaft tools such as spears but have almost never been recorded or analysed by archaeologists. With these preliminary observations in mind, let us examine the recorded tasks involving stone tools.

(a) Spears

There is now considerable support for the view that hominins from the Oldowan on were effectively and regularly hunting at least small- and medium-sized animals ([7–10, pp. 659, 682]; [11, p. 146]; [12]). Hominins lacked sharp teeth and fast locomotion so that it is questionable whether they could have gotten near enough to ungulates in order to dispatch them with clubs or other unmodified materials. Thus, bringing down medium-sized animals most likely involved the making and use of spears. To make spears for these purposes, stone tools are essential. In Australia, saplings for spears were cut, trimmed and roughly pointed using simple unifacial choppers (figure 1) similar to those expediently made by the Ova Tjimba and Western Desert Australian Aborigines [1,2,13]. Little if any debitage or tools were left at these procurement sites. The saplings were then transported back to the main camp where several different types of spears could be made from them including simple pointed spears, spears with barbs (either attached or carved into the heads), spears with separate wood points hafted to the main shaft and heavy fighting spears. In all cases, the

Figure 1. A simple flake chopper used to cut down a sapling in order to make a spear. Cundeelee, Western Australia. Photo by B. Hayden.

Figure 2. A thick unretouched flake being used to scrape down the shaft of a spear. Note the high edge angle. Papunya, Northern Territory. Photo by B. Hayden.

shafts of the spears were regularized with flake tools in order to remove asperities that might catch on the skin of the hand during a thrown release (figures 2 and 3). Most of the flakes used were simple unretouched flakes. However, on occasion, some flakes were retouched with semi-abrupt scraper type of retouch or notch/denticulate types of retouch [2]. Of particular note was the common use of naturally occurring or broken right angle edges (similar to modern woodworking metal 'scrapers' or the side edges of archaeological burins) that were highly effective in removing wood and creating very smooth finished surfaces (figures 4 and 5). In this regard, it is of interest to note that a recent usewear analysis of simple whole quartz and quartzite flakes from Kanjera (*ca* 2 Ma) revealed that over half the recognizably worn edges were identified as having been used on wood

Figure 3. A large unretouched flake used to scrape down the shaft of a spear. Papunya, Northern Territory. Photo by B. Hayden.

Figure 4. A flake with a right angle break used to smooth and sharpen the tip of a spear. Papunya, Northern Territory. Photo by B. Hayden.

Figure 5. A flake with a right angle edge used to smooth the shaft of a spear. Note that a simple barb has been carved into the end of the spear using simple unretouched flakes with low edge angles enabling them to 'saw' in from the sides. Papunya, Northern Territory. Photo by B. Hayden.

or 'medium hard materials' [14, p. 21]. Broken edged flakes are rarely, if ever, examined for indications of tool use in traditional lithic archaeological analysis nor were they examined in Lemorini *et al.*'s [14] study.

In the Australian Western Desert, barbs were important additions to spears for their effective use, i.e. in preventing the spear from simply falling out of the body of a wounded animal allowing the animal to escape unencumbered. Barbs could be fashioned as separate pieces that were attached to the blade tip with sinew, or they could be carved into the

Figure 6. Heating a spear shaft in hot coals and sand prior to straightening. Papunya, Northern Territory. Photo by B. Hayden.

blade of the spear tip. When carved into the blade, choppers were first used to make a nock or series of nocks along the blade of the tip. After this, I only saw simple unretouched primary flakes being used for sawing out the details [2]. The tip of the spear was treated with some attention and carefully honed into an effective piercing wooden point using simple flake tools, almost all of which were unretouched. None of these can be described as complex technological operations. In essence, the creation of spears with stone tools was a two-step process: creation of a sharp edge on a stone followed by using the stone to chop or scrape the end of a stick or sapling to a point with the removal of relatively little wood. Creating a spear does not entail many steps, does not require much skill, does not involve the creation of complex shapes or any composite elements. After spears were shaped and smoothed, they were then straightened in the hot sands of a fire using various types of fulcrums depending on what was available (figures 6 and 7); however, this part of the process would not likely have been followed in the Oldowan, where undisputable evidence of fire control is missing as yet.

Other basic, extremely simple shaft tools such as throwing sticks (for bringing down small animals and birds) and digging sticks followed the same simple manufacturing sequence and involved the same basic types of tools. A notable alternative woodworking technique was used by women in manufacturing digging sticks (figure 8). If a suitably flat and coarse-grained boulder was available, the coarsely shaped blade of a digging stick could be ground to a smooth, more effective digging contour by grinding it [2]. This technique was also recorded among the Tasmanian Aborigines by Roth [15, p. 70]. Interestingly, d'Errico & Backwell [16] report the evident use of grinding that created pointed ends on bones from Swartkrans (*ca* 1.0–1.8 Ma) which they interpret as having been used for digging purposes similar to the ethnographic use of digging sticks. A similar case was reported among modern chimpanzees by Hernandez-Aguilar *et al*. [17, p. 19 213].

In all my observations in Australia, the finishing of spears resulted in relatively small amounts of debitage together with a minimal number of discarded flake 'tools' (mostly unmodified [1]). These lithic scatters were often associated with a hearth and/or fulcrum for straightening the shaft. Spears

Figure 7. Straightening a heated spear shaft using a tree stump for leverage. Rocks were also sometimes used as fulcrums for straightening, and feet were sometimes used to put pressure on sections to be straightened. Papunya, Northern Territory. Photo by B. Hayden.

Figure 8. Flat slabs of coarse-grained stone were sometimes used by women to roughly shape or sharpen the tips of their digging sticks. Papunya, Northern Territory. Photo by B. Hayden.

were generally made of hard desert mulga wood and tips did not require any fire hardening.

Thus, spears, digging sticks and throwing sticks are of the utmost simplicity to make (arguably within the cognitive

Figure 9. Use of a 'handaxe'-shaped chopper to remove wood from the inside of a winnowing bowl by a women in Papunya, Northern Territory. The use of this morphology for wood removal may indicate a possible auxiliary use of handaxes in the Palaeolithic. Photo by B. Hayden.

abilities of early hominins in terms of conceptualization, foresight, planning and anticipated future results), and they provided access to major quantities of resources. In fact, in terms of *food procurement technology*, spears, digging sticks and throwing sticks were the *only* tools that Tasmanian Aboriginals made or used aside from stone butchering tools, although they also made simple clothes, fire sticks and rafts [15]. Given the extreme simplicity of these woodworking tools and the wooden products together with the major food procurement benefits that they would have provided, it is difficult for me to imagine that they would not have been made and used at least from Oldowan times onward, especially given the previously noted archaeological indications of hunting and butchering small-to-medium-sized mammals [7–12,18] and the use of digging tools [16]. If early hominins were making such wooden tools, the optimal designs of the stone tools for making wooden shaft items must have been constrained to a considerable degree due to the force required to cut through 2–4 cm of wood. Thus, the size of the stone tools needed for procuring the wood would have had to be of chopper dimensions, just as it was among ethnographic groups.

Western Desert Aborigines also made and used slabs of wood for shields, winnowing troughs or bowls for water, and spear throwers [2]. Chopping implements were the predominant type of stone tool used to manufacture these items with some finishing or decoration added with hafted flake tools (adzes). It is far less certain that shields, troughs, bowls or spearthrowers were being made during the Lower or Middle Palaeolithic, although I saw a core tool resembling a handaxe being used in Australia for removing wood from the inside of a winnowing trough (figure 9)—perhaps a fortuitous resemblance, but one that emphasizes the potential multifunctionality of handaxes, e.g. for heavy butchering or woodworking as well as finer wood scraping, and for producing thin, razor sharp billet flakes useful in cutting into hides. The procurement and manufacture of these slab types of wooden items often resulted in substantial amounts of debitage left at activity loci including a number of chopping implements, especially those obtained and made expediently

from suitably coarse-grained stones obtained in the immediate vicinity (see also [4]).

(b) Butchering tools

While Toth and co-workers ([11, pp. 130, 153–154]; [19, p. 163]; [20, p. 55]; [21]) view the larger Oldowan artefacts as simple cores for the production of flakes to be used in skinning and butchering scavenged dead animals, the above observations portray a very different picture of early *Homo*. In my view, most stone tools were almost certainly used to make a variety of wooden implements to be used for procuring various food resources, and the stone tool morphologies largely reflect this. Nevertheless, if early *Homo* were hunting, or even if they were simply scavenging, Toth [21] is correct in maintaining that they would have required some sharp flakes for opening up ventral cavities and penetrating often thick skins in order to access meat. Thus, the production of flakes for skinning and butchering should be of considerable interest for prehistorians.

However, contrary to Toth's and others' reconstructions, I suggest that using direct percussion to produce flakes from cobble cores (often of coarse-grained basalts) is far from the optimal solution for the production of flakes used in butchering. A much more likely effective and economical strategy would have been to produce flakes using bipolar reduction on smaller, more ubiquitous raw materials, especially pebbles of quartz or highly metamorphosed quartzite [3]. Bipolar reduction is essentially a battering technology. Its distinctiveness as a reduction strategy was initially brought to the attention of archaeologists by White [22] using ethnographic observations from New Guinea, but has since been prehistorically documented on all inhabited continents. It consists of placing a core (usually a large pebble or small cobble) on a hard surface or anvil and striking with a hammerstone from above (usually repeatedly) to produce flakes that have distinctive characteristics including low edge angles which are especially suited for cutting hides [23]. This technique is more effective than standard hard hammer removal of flakes from hand-held cores because the flakes produced (at least from pebble-sized cores) are often very flat and even lack pronounced bulbs of percussion. The edges therefore tend to be thinner and correspondingly sharper than standard core flakes [23]. The use of bipolar technology is more economical than standard core reduction because it can use much smaller pieces of raw material for the production of flakes, down to the size of pebbles. In Australia, such material, especially quartz, is much more widespread over the landscape and more easily available than the large pieces of raw material required for standard core reduction, besides which quartz can produce cutting edges second in sharpness only to obsidian. In addition, very little skill is required for bipolar reduction in contrast to at least a modicum of skill required to get a very sharp-edged flake off a standard core. However, not only is bipolar production of flakes for butchering the optimal theoretical strategy on the basis of mechanical considerations, it was also reported as the actual technique used for butchering by Ova Tjimba hunter-gatherers in South West Africa [13].

In view of these observations, I think that bipolar reduction provides a critical link between the nut processing technologies of chimpanzees (who use a hammerstone and stone anvil in a bipolar fashion to crack open large nuts, sometimes even inadvertently producing stone flakes [24] and the emergence of relatively sophisticated Oldowan flaked stone technology replete with core tools, flake tools and bipolar products. I believe that bipolar reduction is *the* missing link in the development of Lower Palaeolithic stone technology. In terms of early kinematics, bipolar reduction would have been by far the easiest reduction technique to master given the probable nut-cracking abilities of early hominins. Bipolar reduction is also documented in a number of Oldowan and, now, even pre-Oldowan assemblages ([25,26]; [27, pp. 243, 245]), although not all lithic analysts distinguish bipolar reduction from other types of reduction as emphasized by Moore [28, p. 66], who claims that archaeologists often fail to recognize up to 85–90% of bipolar products. In its earliest stages of development for butchering purposes, bipolar reduction would have been even more difficult to recognize archaeologically due to sporadic use at widely separated kill or butchering locations producing few pieces of debitage and no modified flakes or core tools per event. I think that it was initially a pre-Oldowan technology that may eventually prove to extend back another 1 or 2 Myr before the beginning of the Oldowan as the Dikika cutmarked bones *ca* 3.39 Ma seem to indicate [5], and as most recently claimed for a pre-Oldowan assemblage dated to 3.3 Ma [25].

It might be added that, in addition to using bipolar techniques to produce effective flakes for butchering, bipolar techniques have also been reported as having been used by ethnographic hunter-gatherers for other activities, including the insertion of very large thin pieces of stone into cuts in trees for use as wedges to create splits in the wood in order to remove slabs of wood for shields or spear throwers. These stone wedges were hammered with cobbles at the proximal ends and battered creating distinctive damage (similar to the inferred bipolar use of *pièces esquillées* as wedges for breaking scored pieces of bone or antler [2,23]). Bipolar techniques were also used by some hunter-gatherers to split quartzite cobbles in order to produce large spall tools for scraping or stretching hides [29]. While Oldowan technology may not have made use of bipolar techniques to produce slabs of wood, spall scrapers, or as wedges, the kinematics were essentially the same and it is worth at least considering the possibility that these activities might have been within the realm of Oldowan capabilities.

3. Stone tool morphologies

If Oldowan core tools were actually used for woodworking rather than simply serving as cores to produce flakes, one might expect comparable morphologies and edge angles to core tools that were ethnographically used for woodworking. Although there is quite a range of variability in both Oldowan and Australian core tools, a comparison of core tools (choppers) used for woodworking in Australia shows some remarkable morphological similarities to Oldowan core tools [3].

In addition, the edge angles of both the Australian chopping tools and the estimated edge angles of the Oldowan tools are almost identical. Similarly, the thicknesses of chopping tools in Australia almost exactly correspond to the thicknesses of Oldowan specimens. Lengths of Oldowan chopping tools are somewhat smaller than the Australian examples, perhaps because the Australian examples were

not usually used to the point of exhaustion, but perhaps also due to smaller hand sizes of early *Homo*.

Thus, the following different types of data support the interpretation of Oldowan choppers and flake tools being used for the production of simple wooden tools minimally, including spears, throwing sticks and digging sticks. First, evidence for hunting implying the use of spears ([7–9]; [10, pp. 659, 662]; [11, p. 146]; [12,18]); second, usewear studies that indicate that most flakes were used on wood or medium hard materials; third, ethnographic analogies of stone tool use for making wooden tools in general and chopper morphological forms in particular; fourth, similar edge angles and sizes of Oldowan choppers to ethnographic tools used for making wooden tools; and fifth, ethnographic and logical observations indicating that the optimal lithic reduction strategy for butchering is to use bipolar reduction rather than large cores (as discussed in §2b).

4. Conclusion

Because of the fundamental similarities in environments, subsistence, mobility, tool design constraints and stone technology characteristics, it is useful to compare semi-desert modern hunter-gatherers with early Stone Age hominins. This analysis has focused on Central Desert Australian Aboriginal technologies and South West African technologies to generate models of stone tool use in Oldowan times. While some flakes were undoubtedly produced and used to skin and butcher animals, whether scavenged or hunted, the vast majority of flake and core stone tools were probably used in woodworking activities. Ethnographically, these tools were used to produce spears, throwing sticks, digging sticks, winnowing troughs, bowls and shields. The first three of these (spears, throwing sticks and digging sticks) are such simple and effective means of enhancing subsistence that it is difficult to imagine that early *Homo* would not have produced them with their stone working abilities. Indeed, there are crude versions of spears and digging sticks used to access small mammals, termites and geophytes made even by extant non-human primates [17,30]. Morphological, edge angle and size comparisons of Australian choppers and Oldowan variants confirm that the Oldowan tools were likely used in woodworking activities. It seems unrealistic to maintain that they would not have been.

By contrast, the manufacture of flakes for cutting into hides or tendons and butchering has been shown by Ova Tjimba groups to be most effectively carried out with bipolar reduction strategies [13,23]. While this observation supports Leakey's [31] original interpretation of the Oldowan toolkit, this is in marked contrast to more recent archaeological interpretations of Oldowan 'core tools' as having been used primarily, if not exclusively, for producing butchering flakes (e.g. [21]). Although frequently overlooked by lithic analysts as a distinctive type of reduction, bipolar cores and flakes are definitely represented in a number of Oldowan assemblages [27, pp. 243, 245], and bipolar reduction arguably provides a critical link between early primate nut-cracking stone technologies and the first intentionally flaked stone technologies. Such bipolar reduction events probably occurred before the Oldowan and were probably used to cut through scavenged or hunted (small-scale) animal hides and tendons. As such they would be scattered over the landscape at kill or scavenge sites, leaving only a few dispersed, unretouched flakes at event locations. As proposed by Panger *et al*. ([32], also [18]), these pre-Oldowan (and Oldowan) small lithic scatters would be exceedingly difficult to identify archaeologically, and even more difficult to date unless they occurred in favourable stratigraphic contexts. However, just such an assemblage has been recently reported by Harmand and associates from West Turkana [25].

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