# Palaeolithic landscape of extraction: flint surface quarries and workshops at Mt Pua, Israel

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*The authors report on investigations at quarrying sites on Mount Pua, Israel. they suggest that the area shows a degree of industrial organization from the late Lower Palaeolithic with a resultant impact on the landscape.*

*Key words*: flint extraction, workshops, Lower–Middle Palaeolithic, handaxes, Levallois technique

A complex Late Acheulian–Early Mousterian quarry landscape was discovered during reconnaissance of prehistoric communities in the central Dishon Valley, Northern Israel (FIGURE 1). The site is on the flat, narrow summit of Mt Pua, where numerous flint nodules of various sizes are exposed within the limestone outcrops (Barkai & Gopher 2001). The summit is studded with hundreds of tailings (quarry debris heaps), each covered with flint nodules and prehistoric artefacts (tested nodules, cores, roughouts, tools, blanks and knapped lithic waste material). Preliminary mapping revealed approximately 1500 tailing heaps (FIGURE 2), varying in size from <1 to >15 m in diameter and from <0·3 to >3 m in height (FIGURE 3).

## Geological controls on quarry development

Quarry activities at Mt Pua were concentrated at higher elevations, where the nearly flat-lying limestone beds (karrens) form a series of steps. These locations were preferable to lower elevations for practical reasons, most importantly the enhancement of master joint systems (regular networks of near-vertical fractures in the bedrock) by solution weathering. Accelerated dissolution of the limestone along the master joints enabled easier prying-away of the limestone to reach the desired flint nodules. The master joints at Mt Pua rarely intersect flint nodules, so the thick limestone beds were crushed and broken along joints before the flint was extracted from the limestone matrix. Large, homogeneous limestone blocks were apparently used as hammerstones. These are rectangular to sub-rounded masses of dense limestone derived from the local outcrops and are simply joint-bounded blocks with crushed edges, sometimes slightly modified for use in quarry extraction (FIGURE 4).

The summit area also provided room for manoeuvre of extraction debris as the outcrops were quarried and enabled the development of a large-scale quarry complex. In contrast, lower elevation locations have master joint systems that are still tightly sealed (owing to a less advanced state of weathering) and only one face of the outcrops would have been visible, making it more difficult not only to extract the flint but even to assess just how much flint was available to be quarried. Furthermore, preliminary geological reconstruction seems to indicate that sources at lower elevations might not have been exposed during the Middle Pleistocene (Ronen *et al.* 1974; Yair 1962). The importance of solution-enhanced master joint systems to the Paleolithic quarrying process is apparent at other locations in Israel (personal observations by the authors), where extensive Palaeolithic quarry landscapes have developed in limestone formations.

## Surface quarrying at Mt Pua

Most, if not all the extraction debris heaps lie adjacent to limestone outcrops containing flint nodules. Numerous nodules have eroded from the outcrop owing to natural weathering processes. However, specific breakage patterns and impact marks observed on the outcrops de-

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scribed above, as well as massive hammerstones bearing impact marks, indicate human exploitation of the flint nodules by 'surface quarrying' (e.g. Claris & Quartermaine 1989). Preliminary reconstruction of the extraction techniques applied at the site reveals that Palaeolithic hominids took advantage of master joints in the limestone outcrops, by expanding the joints using massive hammerstones, smashing the limestone blocks and extracting the flint nodules, heaping the extraction waste close to the extraction front. The large quantities of broken blocks found in the waste heaps are thus products of this surface quarrying. Test pits excavated at two different heaps indicate that the tailing heaps overlie exhausted flint sources. Finer-scale flint debris interspersed between the blocks indicates that flint-working took place on top of these heaps throughout all stages of their 'construction'. We interpret this as related to the organization of flint procurement and exploitation strategies practised at the site, in that expended flint sources were intentionally covered as potential sources were exposed for future manipulation. This pattern of heaping extracted waste and working flint on top of the heaps is visible at other recently discovered Lower–Middle Palaeolithic quarry sites in Israel (personal observations by the authors), as well as at the Early Bronze Age workshop at Mt Haruvim (Shimelmitz *et al.* 2000). It seems, therefore, that this strategy may have been employed in general wherever flint nodules are embedded within rocky outcrops (karren).

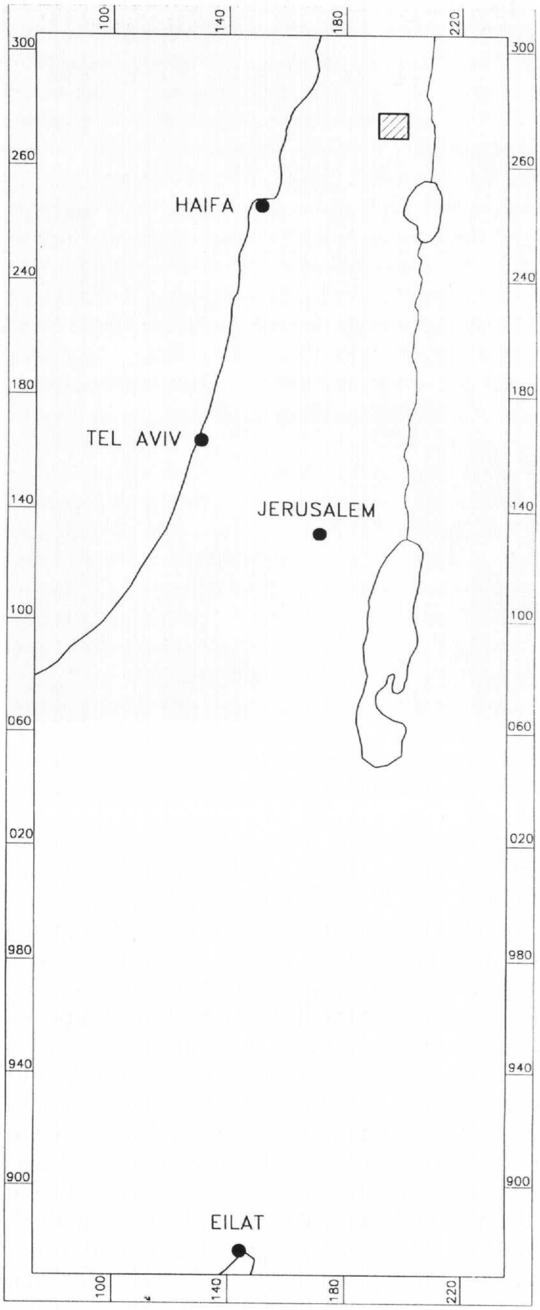



FIGURE 1. *Location map of Mt Pua.*

## Lithic assemblages at the Mt Pua site

The tailing heap assemblages generally include all stages of the lithic reduction sequence (nodules, cores, waste and tools). While some of the individual heaps have similar tools and lithic debris, others contain only specific stages — mainly nodules and tested nodules, with no evidence of more advanced reduction stages.

A test pit excavated at one of the large-scale stone heaps revealed, among thousands of waste lithic artefacts found between the limestone blocks, two flint caches deposited over the exhausted extraction front, almost a metre below the present heap surface. The caches include mainly large blanks and cores and a detailed technological and typological analysis of these caches is currently under way. The following notes deal with the two most conspicuous components of the lithic assemblage — Levallois cores and handaxe roughouts.

Levallois cores form an important component of the lithic industry at Mt Pua (FIGURE 5). Various Levallois core reduction strategies

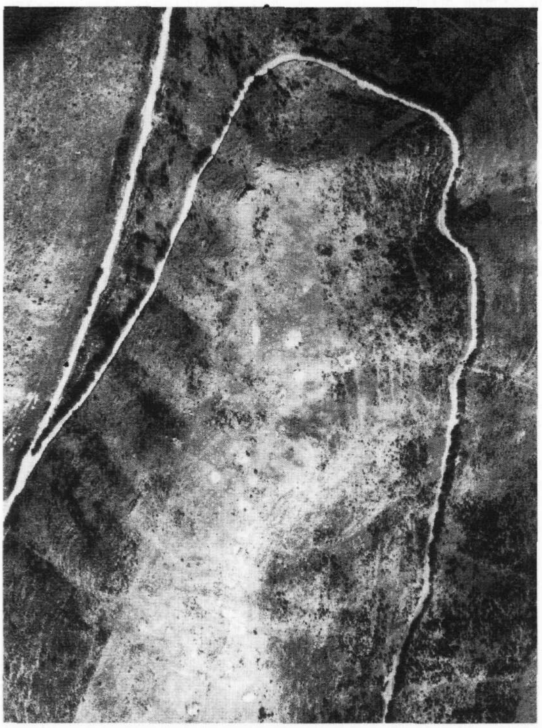


FIGURE 2a. *Air photo of the extraction landscape at Mt Pua in 1969 (white spots are debris heaps).*

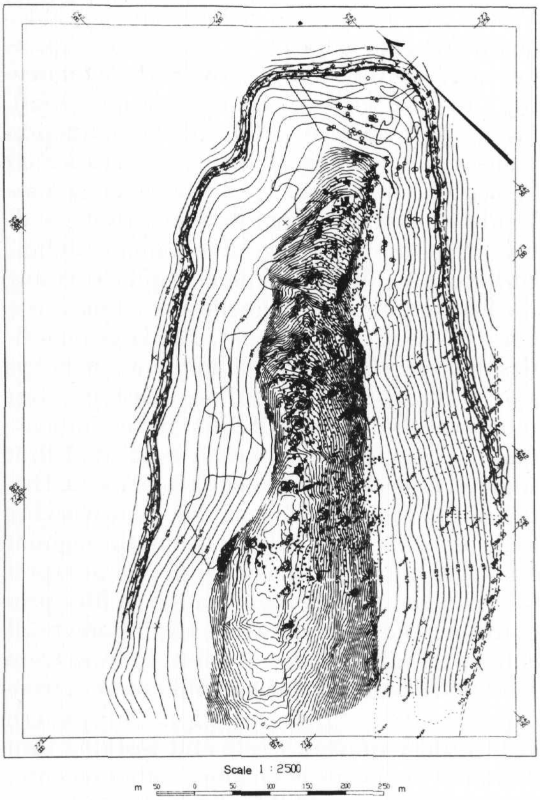



FIGURE 2b . *Topographic map of the extraction landscape at Mt Pua (black spots are debris heaps).*

(unipolar parallel, bipolar, centripetal, unipolar convergent) were employed at the site, although very few Levallois blanks are present. Another component of the industry is roughouts of large bifacial tools, mostly representing early stages of handaxe manufacture (FIGURE 6). However, the bulk of the flint assemblage comprises large numbers of non-Levallois cores (FIGURE 7), many cortical elements, flakes, chunks and chips as well as a small quantity of blade cores and blades. (The presence of blade cores from Late Acheulian-Early Mousterian context was recently indicated in layer E at Hayonim cave (Bar Yosef & Kuhn 1999: figure 4) and from Rosh Ein Mor (Marks & Monigal 1995).) Small numbers of completed tools were found at Mt Pua, and most are rejects owing to failure during manufacture. The artefacts and debris composition suggest that selected blanks and preshaped tools were transported from the workshops. Few chopping tools are worthy of note (FIGURE 8).

The presence of Levallois cores and debitage, as well as handaxe roughouts and chopping tools, suggests that the quarrying at Mt Pua is related to the later phase Acheulian complex of the Lower Palaeolithic period (e.g. Goren 1979; Goren-Inbar 1985), or perhaps the early stages of the Mousterian complex of the Middle Palaeolithic period. Archaeological assemblages from other periods were not identified at the site. (Isolated, stray, bifacial tools present on site could be attributed to the Neolithic or Chalcolithic periods, but these probably indicate late, random visits of local Neolithic-Chalcolithic inhabitants to the Palaeolithic site.) Our preliminary observations suggest that the site of Mt Pua as a whole was in use mainly during Palaeolithic times. The extraction activities we have identified, as well as some aspects of the lithic industry, could indicate late Lower Palaeolithic stages of stone procurement strategies. Early Palaeolithic examples for stone procurement are known from Africa and southern Asia, such as the MNK chert factory site at Olduvai Gorge (Stiles 1998; Stiles *et al.* 1974) and the Acheulian Isampur quarry in India (Petraglia *et al.* 1999; Paddayya *et al.* 2000;

FIGURE 3a. *A large extraction heap (note scale — people and trees).*

FIGURE 3b. *A small extraction heap (note scale — 50 cm.).*

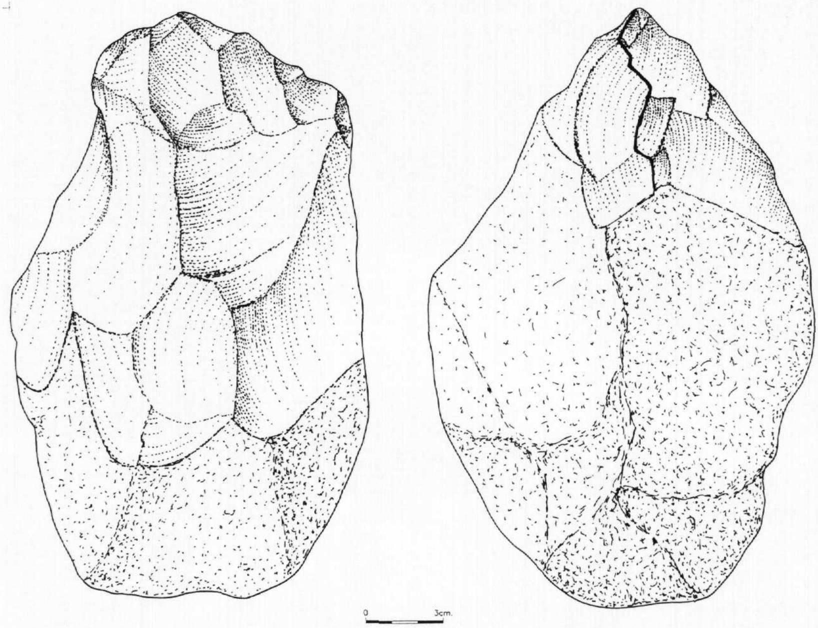



FIGURE 4. *Crushed-edged extraction tool made of limestone.*

Blackwell *et al.* 2001). Extensive Middle Palaeolithic flint extraction sites were recently studied in Egypt (Vermeersch *et al.* 1990; 1995; 1998; Vermeersch & Paulissen 1997).

**Summary**

An extensive quarry landscape was developed at Mt Pua in the central Dishon Valley, upper Galilee, Israel, during the late Lower Palaeolithic to early Middle Palaeolithic, as indicated by the presence of handaxe preforms, chopping tools and Levallois cores and debitage. Late Acheulian sites found at the Yiron and Bara'm plateaus, very close to the Dishon valley and to Mt Pua, were studied by Ohel (1986; 1990). The lithic assemblages of these sites are similar to finds described above from the quarry site of Mt Pua and thus a possible connection between these two complexes can be suggested. Other Late Acheulian sites in Israel are characterized by the presence of both handaxes and Levallois products (e.g. Goren 1979; Goren-Inbar 1985). Acheulian lithic assemblages from Europe and Africa, including both handaxes and Levallois technology, have been recently reported (Rolland 1995; Tuffreau 1995; Monnier 2000) and a technologial and conceptual link between handaxe manufacture and the Levallois technology has been suggested (DeBono & Goren-Inbar 2001; Tuffreau 1997; Roe 2000).

At present we thus can not determine the exact cultural assignment of the site. The prominent role of Levallois technology in the lithic assemblages of Mt Pua points to the Mousterian, but it seems to us that since the site was in use for very long time periods, one can not rule out the possibility that it was visited during both Late Acheulian and Early Mousterian times. Geological characteristics inherent in the bedrock, such as rock fabric, controlled the distribution and development style of the quarries; such controls are common to Palaeolithic quarries at other sites in Israel as well as at Isampur, India (Petraglia *et al.* 1999). However, the increasingly advanced degree of quarry organization from Isampur (quarry activity but no sense of maintenance) to Mt Pua (possible task subdivision and evidence for maintenance) suggests that quarrying may also have been influenced by changes in cultural traditions during the Acheulian and the Mousterian. Our research thus suggests that the development of large-scale quarry landscapes bearing signs of task subdivision and maintenance began during the late Lower Palaeolithic.

Middle Pleistocene hominids used the natural resources at Mt Pua extensively over a long time-span, in recurring visits. The site can be regarded as a Palaeolithic 'industrial area' representing large-scale resource extraction and

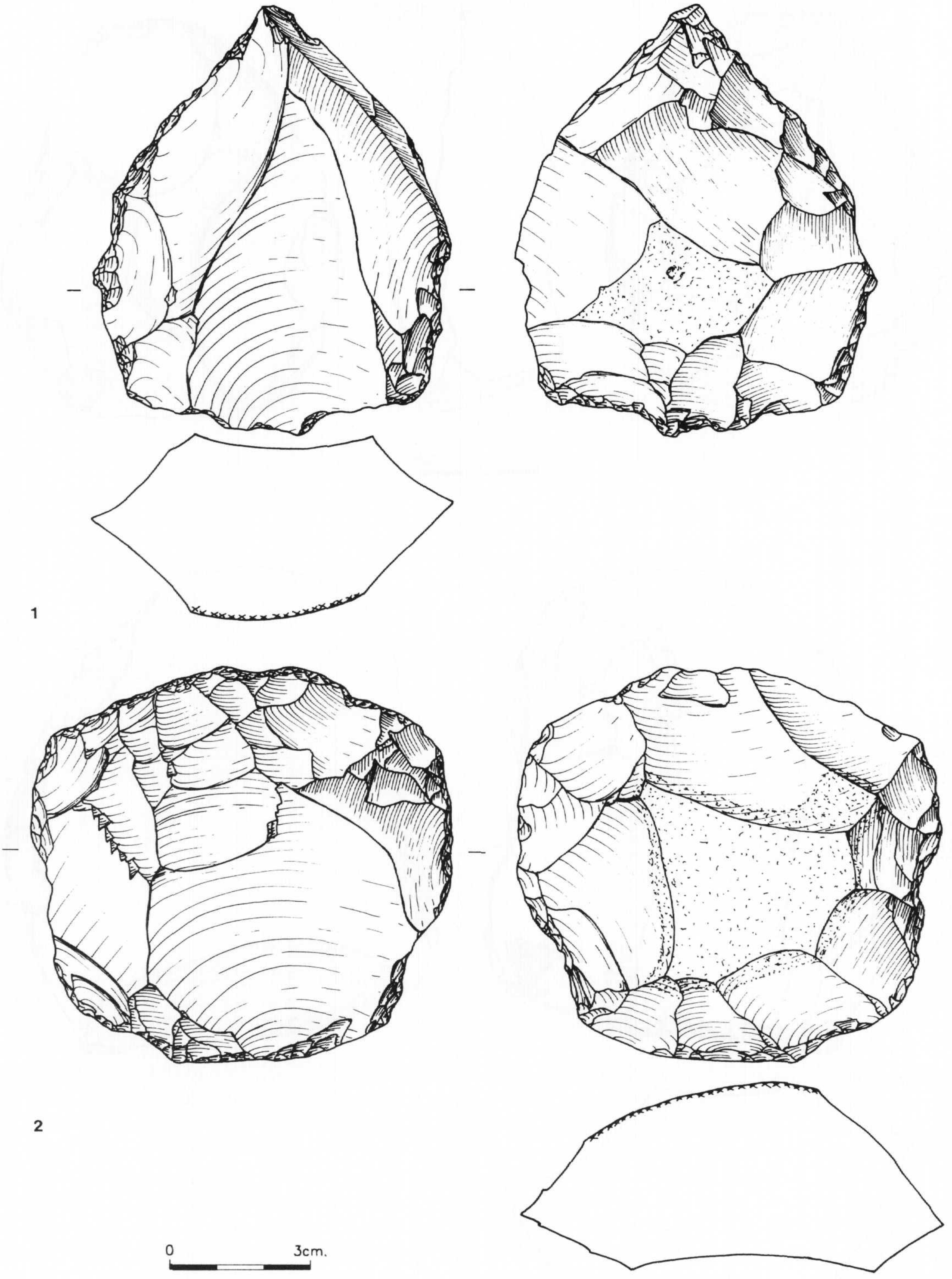
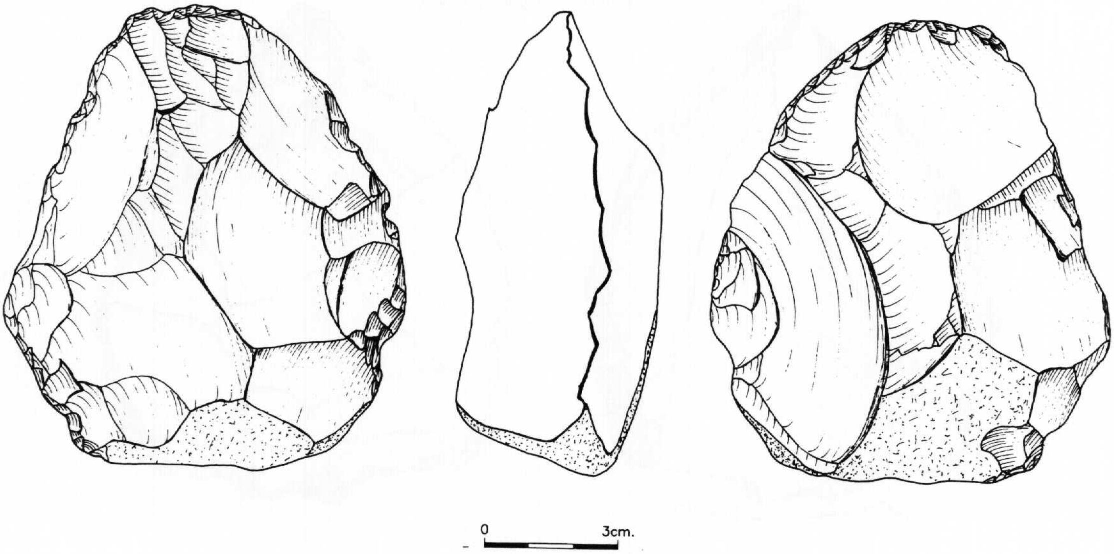



FIGURE 5. *Levallois cores from Mt Pua.*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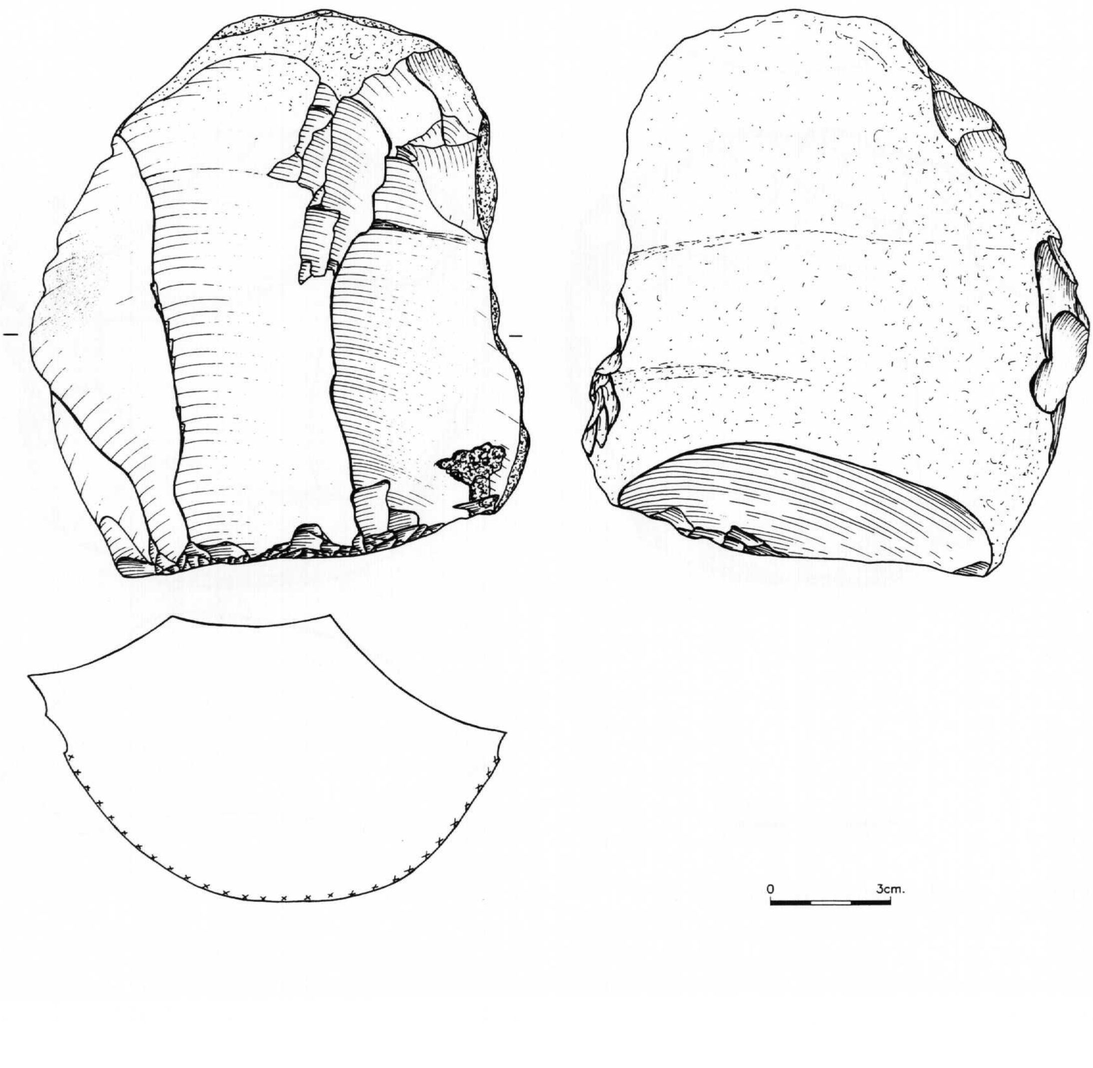
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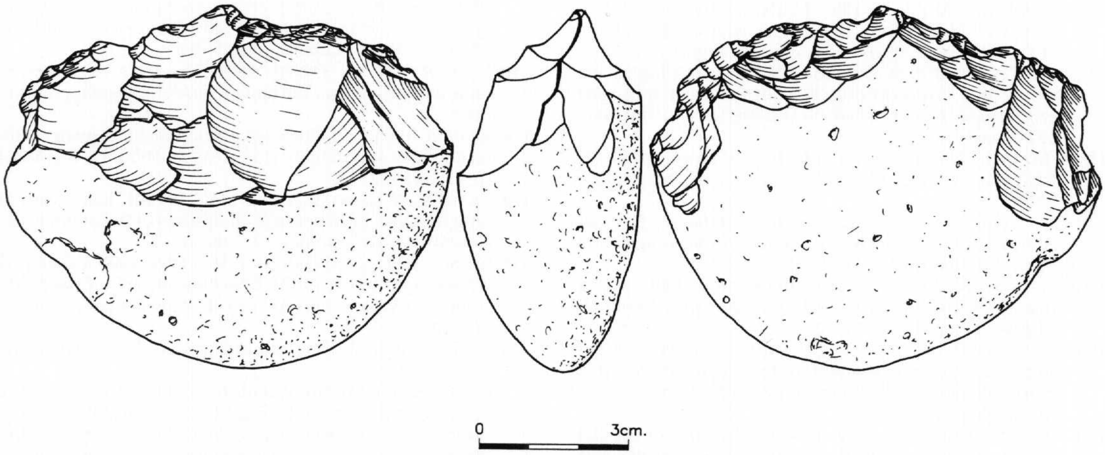


FIGURE 8. *A chopping tool from Mt Pua.*

unprecedented human impact on ancient environments. Mt Pua must have been exploited by generations of foragers and thus represents a monumental landmark in the Palaeolithic landscape. This new aspect of Middle Pleistocene human behaviour is evidence of complex, large-scale environmental manipulation by early hominids. This may suggest new insights into the man–environment relationship and the capabilities of Pleistocene hunter–gatherers to alter nature.

Further investigation of this extensive Lower–Middle Palaeolithic industrial complex will permit a better reconstruction of the Late Acheulian–Early Mousterian lithic *chaîne opératoire.* It will also contribute more generally towards a better understanding of raw material procurement and exploitation strategies, land use patterns and early human impact on the environment and landscape, in a region that represents the crossroads of the ancient hominid world.

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FIGURE 6 (opposite, above). *Handaxe roughout from Mt Pua.*

FIGURE 7 (opposite, below). *Non-Levallois core from Mt Pua.*

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