

in terms of Ae of fishes; (ii) intensive investigations on PPS resulting in maximum Ae for a given species; (iii) inclusion of more sources of PPS to enhance total N and DCP; (iv) intensive research on PPS, which results in better Ae in more fishes; (v) partial substitution of non-protein N and animal proteins to enhance Ae; (vi) development of inexpensive methods for removal/inactivation of ANFs; (vii) special methods for removal of enzyme inhibitors, and (viii) supplementation of essential amino acids.

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N. KRISHNANKUTTY

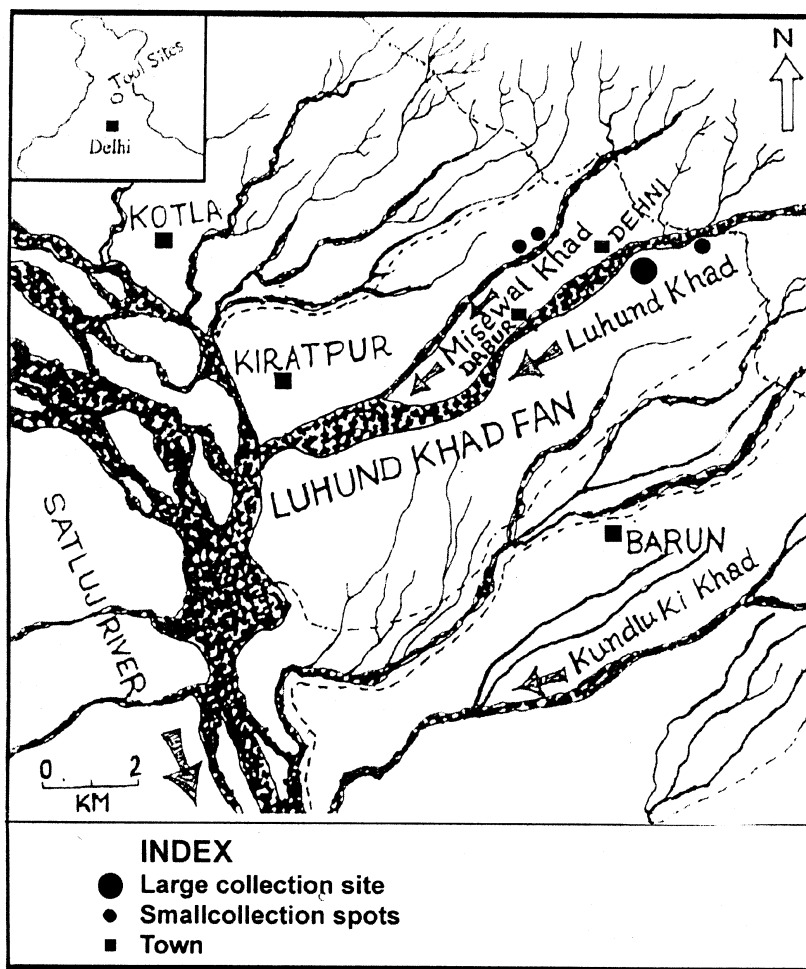
PG Department of Zoology,  
Madura College,  
Madurai 625 011, India

## Palaeolithic tools from the surface of optically stimulated luminescence dated alluvial fan deposits of Pinjaur Dun in NW sub-Himalayas

For a long time, the Sohan-type palaeolithic tools found from the river terraces of NW sub-Himalayas had been relatively dated on the basis of alpine glaciations chronology, suggested by De-Tera and Patterson<sup>1</sup>. Later workers<sup>2–6</sup> in the Indian part of the subcontinent continued research based on the same approach, and the late-Sohan stone tools found by some workers<sup>4,5</sup> from Pinjaur Dun and its adjoining regions were also assigned dates pertaining to the then-accepted third glacial or third inter-glacial stages of terrace formations. Naturally, such tools were thus thought by them to have been manufactured much before 70 ka BP (the tentative date of the onset of the last phase of glaciations, according to the alpine glaciations chronology). However, now we know that the relative chronology of the sub-Himalayan river terraces, as suggested

by De-Tera and Paterson, is not being considered as true since the number of Pleistocene glaciations greatly exceeded<sup>7</sup> the number of river terraces that were earlier identified and accepted by almost all researchers<sup>1–6</sup>. We therefore need to search for new evidence that may be available for working out a true chronology of the Sohan type tools and their sites, particularly in the absence of absolutely datable material. If in some cases, the absolute age of the surface on which some stone tools are found is known, it will certainly provide us with a lower limit to the date of fabrication/use of these tools. Recently, Suresh *et al.*<sup>8</sup> have dated the deposition of alluvial fan surface of Pinjaur Dun using optically stimulated luminescence (OSL) method, in which the age of sedimentation of the uppermost terrace of Luhund Khad (a rivulet incising

the alluvial fans and joining the river Satluj near Kiratpur–Punjab) is determined to be around 20 ka BP. Like thermoluminescence (TL) dating, OSL dating is also related to the absorption of nuclear energy by minerals. Here, by exposure of certain minerals to sunlight<sup>9</sup>, there is optical bleaching during the pre-depositional transportation of the sediment. Following burial, natural minerals start acquiring fresh luminescence from the radioactive minerals present in the sediments. The time elapsed since deposition can be determined by calculating the ratio of the acquired luminescence to the annual rate of its acquisition since burial. Hence the time elapsed since the last exposure to sunlight is determined giving an absolute age to the sediment deposition. An exploration done by the present authors on these dated terrace surfaces was successful and a number of



**Figure 1.** Locality map of the stone age tool-sites. The tools were collected from the surfaces of the topmost and next to topmost terraces of Luhund and Misewal rivulets.

artifacts made on quartzite cobbles/pebbles were found from the top surface of the alluvial fan. This surface constitutes the proximal part of the alluvial fan of Luhund Khad which is almost planar and is spread up to about 3 kilometers on either side of the Khad near the villages Bagheri and Dehni. Opposite to village Dehni, on the left bank of Luhund Khad (Figure 1), 28 humanly worked quartzite pebbles and cobbles were found spread over a nearly 200 m<sup>2</sup> area of a ploughed field. During subsequent visits, when a search was made in the adjoining fields covering another area of 400 m<sup>2</sup> or so, the total number of tools or humanly worked quartzite stones recovered from that site went up to 96. On the right side of this Khad and across one of its tributaries, the Misewal Khad (Figure 1), the same top surface of the fan continues and a search on this surface yielded 18 more tools of same typology as were found from the site on the left

bank of Luhund Khad. On these surfaces, a high intensity of angular and rounded cobble or pebble clasts of tertiary sandstone were found strewn mixed with loose matrix of sandy clay, but there was no naturally occurring quartzite stone on the topmost terrace or even on the surfaces of two lower terraces or in the bed of the rivulet. Obviously the fabricators of these tools had brought the raw material for their tools from distant places. The uppermost conglomerate sandy-clay mixed layer forms the highest terrace of the rivulet and is quite thick. This conglomerate bed (although with varying thickness) continues up to mid section of the fan, where it is underlain by a sandstone layer that has been OSL dated<sup>8</sup> to 24 ± 4.5 ka BP. The thick conglomerate bed was laid down in a very short span of time due to debris flow<sup>8</sup> so it may not add much to the date of deposition of the sandstone layer below it. Next to the topmost terrace

of Luhund Khad at village Bagheri, there is a second terrace about 9 m below the topmost one. The remnant parts of this next to the topmost terrace found on both sides of Luhund Khad, are now known to have been deposited nearly 15 ka BP (OSL dated as per private communication by N. Suresh), after the culmination of the last glacial maximum<sup>8</sup> (20 to 16 ka BP). Some artifacts of the above-mentioned typology were also found from this second terrace of Luhund Khad as well as from the similar terraces of the adjoining Misewal Khad which has incised the same alluvial fan, making a total collection of 122 artifacts from these dated terrace surfaces. Table 1 shows the type-wise categorization of these artifacts.

The assemblage is dominated by partially flaked cores but chopper/chopping-tools are nearly non-existent (only 2 artifacts can be graded into them). Cores and tools on cores are nearly 50% while flakes

**Table 1.** Type-wise categorization of artifacts

Artifact type	Count	% of total
Anvil	1	0.82
Hammers	5	4.1
Cylindrical hammer	1	0.82
Semi-flaked hammer stones with battered end/ends	3	2.46
Nosed elongate hammer stone	1	0.82
Cores/tools on cores	56	45.9
Battered/un-battered nosed cores	19	15.57
Partly flaked battered small cobbles	12	9.84
Cores with sharp edges	8	6.56
Sub-rectangular cores	4	3.28
Semi-flaked cobble having a thick blunt edge on one end and a sharp edge each on its adjoining and on its opposite end	1	0.82
Chopper-like specimen having a bulging flaked face with a sub-peripheral blunted edge	1	0.82
Battered sub-spherical cores	3	2.46
Small chopping-tool with oval working edge	1	0.86
Cores as borers	2	1.64
Irregular flake/blade cores	4	3.28
Blade-core/burin	1	0.86
Flakes/flake-tools	55	45.1
Sharp-edged flakes with cortical strip	9	7.38
Retouched first flakes with prominent bulbs of percussion	4	3.28
Flake-borers	7	5.74
Points/pointed flakes	6	4.92
Non-cortical thick flakes	2	2.46
Flakes with cortical back having plane striking platform	7	5.74
Small rectangular flakes	3	2.46
Thick flakes with tangs	3	2.46
Backed blade-like flakes	3	2.46
Backed and pointed knives	2	1.64
Parallel sided chisel	1	0.86
Push plane on a thick flake	1	0.86
Burins/flakes with burin edges	7	5.74
Artifacts on sandstone clasts	5	4.1
Burins	2	1.64
Point	1	0.86
Backed blade-like specimens	2	1.64

122

**Table 2.** Abrasion and rounding of artifacts

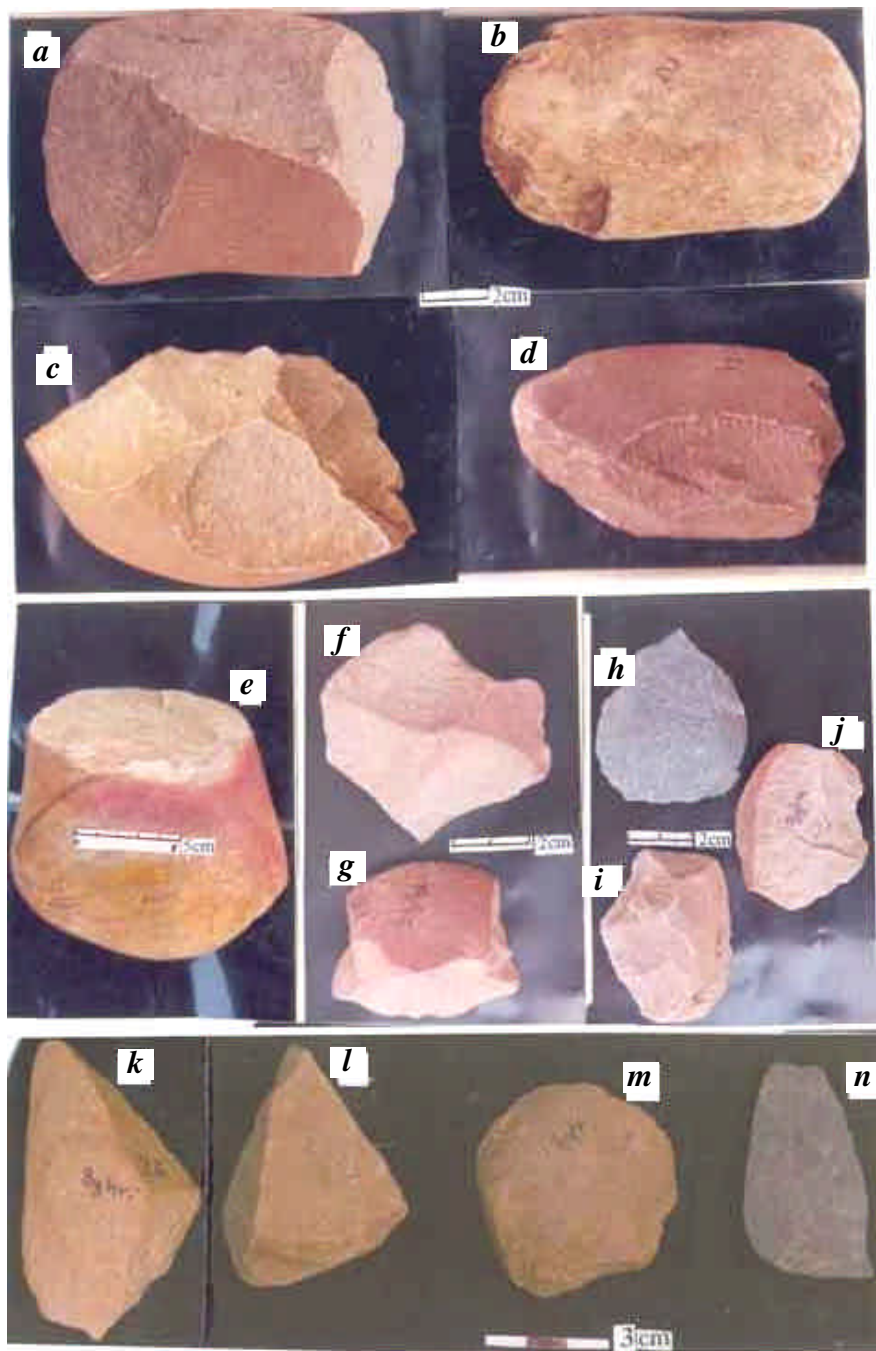
Artifact type	% Abraded	% Rolled	% With patina
Cores	40	0	0
Flakes	20	0	0

and flake-tools make about 45% of this collection. Some 4% of the tools were also fabricated on non-quartzite but locally available hard tertiary sandstone clasts, probably because of the paucity of the quartzite raw material in near-vicinity of the site. The industry represented by this collection does not belong to the chopper/chopping tool tradition nor can we say that the flakes in this industry are just necessary accompaniments of chopper/

chopping tools (it is at variance with what had been earlier<sup>2,5,6</sup> inferred for all Sohanian tools), it is a flake and core industry in which many blanks are retouched into tools. Partially or fully worked and occasionally battered cores/cobbles found here in large numbers were most probably used for hammering purposes.

This assemblage may be assigned a semi-primary context as the artifacts displaced from their original positions could

not have been disturbed by more than a few feet by even repeated use of the terrace sites for agricultural purposes. There is no patina on any of the artifacts and all are unrolled. Abrasion and rounding of the selective edges is seen on majority of the cores (battering is also there), most of which could obviously be due to their prehistoric use. The abrasion is quite less on flakes (Table 2), and it might have partly occurred due to trampling, etc.



**Figure 2.** Some of the tool types collected from the dated surfaces: *a*, Boldly flaked rectangular cobble with one battered/blunted and two sharp edges. *b*, Cylindrical hammer-tool. *c*, Chopper-like step-flaked cobble with quite an abraded convex edge. *d*, Core as hammer with an abraded nose. *e*, Abraded and battered large anvil. *f*, Flake/blade core cum burin. *g*, Core as a push-plane/scraper with slightly conchoidal ventral surface. *h*, Leaf-shaped Levalloisian point. *i*, Thick cortical flake with two adjoining sharp edges. *j*, Blade-flake with a cortical strip. *k*, Backed and pointed knife. *l*, Triangular burin on local sandstone clast. *m*, Positive bulb of percussion of a first flake with retouched edges. *n*, Parallel-sided chisel with sharp distal edge.

It may not be out of context to mention here the assemblage of the flake industry excavated, by Rendell *et al.*<sup>7</sup>; which has been dated by them to be nearly 45 ka old. In that assemblage, some tools like

points, backed blades/knives, burins, etc., are not represented which are present in our collection from the alluvial fan surfaces, which are of later date. Some crudely manufactured flakes and core-tools were

reported<sup>10</sup> from Nepal sub-Himalayas, some two decades ago, but the true chronology and typology of those artifacts was un-determinable as mentioned by the authors<sup>10</sup>.

Because of the preponderance of small and medium size artifacts in our collection and the dominance of flake tools among them, the typology of this assemblage may be assigned to that late-Sohan period which appears to have continued in this region from late upper Pleistocene to early Holocene. This notion is supported by the fact that there are present in the assemblage quite a good number of upper palaeolithic tool types which, unlike those found in central India, are fabricated on quartzite material commonly found in the region.

Figure 2 depicts a few of the tools from this assemblage. All these tools possess some degree of cortex on their surfaces except a leaf shaped point which is a dark grey Levalloisian flake, one dirty white coloured thick circular plate, and one rectangular flake, which are all non-cortical. This assemblage cannot be an assorted conglomeration of tools of different ages since the typology of the collected tools is almost uniform and appears to belong to one industry. Further, the presence of an anvil along with some hammer stones leads to the inference that these fan-top

surface sites were used as working sites by the pre-historic man after the culmination of the fan sedimentation (some 20 ka BP) and to some extent even after laying down (about 15 ka BP) of the next to topmost terraces within the incised streams which dissected the fan surface.

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ANUJOT SINGH SONI  
VIDWAN SINGH SONI\*

444/I Urban Estate,  
Patiala 147 002, India

\*For correspondence.

e-mail: vidwansoni@rediffmail.com