FLINT KNAPPING TECHNIQUE AND MICRO-WEAR ANALYSIS

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Conceptual Background

The development of human behaviour is not unilateral rather multi-structural, multilateral and spiral in time and space. At a more pragmatic level, it implies that there is some complex structural thinking process which links the possible visual patterns. An increasingly complex mixture of interdisciplinary knowledge has been required to keep pace.

One of the aims of archaeology has had been to understand dynamic context of archaeological context in time and space. Vico had rightly opined that we can know history because man created history. Most of the Philosophers of the history have opined that the development of history is towards progress of human society to achieve complete freedom and/ or communalism. It is also believed that history is a continuous process and moreover an unending dialogue between the past and the present. A basic question obviously comes to our mind - why all societies and communities in time and space could not progress and prosperous equally and simultaneously. Some societies even today are in primitive stage, if we accept division of the history with reference to development of societies from remote times as suggested by a number of social scientist. Does this support the well known theory of 'Challenge and Response' propounded by Toynbee? The fundamental question here is - how to develop dialogue with archaeological evidence?

Commonly, archaeological materials make life difficult for archaeologists that they are fragmentary or their quantity does not have an obvious meaning. Before we can create meaningful complications of lithic artifacts, pottery or floral and faunal remains, for example, we need to decide what unit or units of analysis we will use. Will we simply count tool types, potsherds or bone fragments, or try to estimate the number of pots or animals and or make attempt to understand mind or cognitive map of their creators?

During the 1960s Franc¸ois Bordes and Don Crabtree brought flint-knapping to the attention of lithic artifact researchers. Thereafter, many archaeologists became flint-knappers. Unfortunately, because much of that production variability was not systematically controlled in experiments, replication studies were criticized as nonscientific. The more controlled experiments shifted the emphasis of analysis away from the finished products of lithic tool production to the by-products of production. As a result of this shift, lithic replication experiments gained new acceptance in the archaeological community as controlled scientific experiments that could provide important behavioral information to lithic analysis. Additionally, refitting or conjoining studies of excavated lithic assemblages have supported the findings of replication analysis associated with lithic tool reduction sequences.

In many sciences, research designs are based on experiments. The experiment may attempt to hold several factors constant, and vary one, to see what, if any, effect that factor may have on some variable of interest. Most archaeological analysis cannot control or manipulate things that happened in the past. Only in experimental archaeology which typically involves attempting to replicate or simulate some past process such as flint-knapping or use-wear on tools edges, making of clay objects like potteries, terracotta, we can impose and vary experimental controls.

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Above all a basic question is why man made tools? Indeed, until and unless we are able to know the function of the lithic tools it would be difficult to construct prehistoric economy and cognitive map of an archaeological period in the region. Micro-wear study can provide attributes to synthesize not only function of the tools but may also enlighten us on the instrument and gears used to exploit material culture in the region during a particular archaeological period.

There is always some meaning behind normal human action and to understand rationale behind his/ her action one should understand the process of cultural constructs through contextual archaeological evidence in time and space. This understanding may be accomplished through experimental archaeology.

Typo-technological and metrical studies of ceramic and lithic industries especially in Indian context urgently require standardization. Single analyst cannot analyse all assemblages recovered from different parts of India using one analytical design; and without comparing and understanding variability against standardized scale of typo-technological classification, we cannot, perhaps, formulate and reconstruct cultural past on scientific grounds.

Flint Knapping Techniques:

Longest period of human behavioral and cultural history has had been documented on lithics, the most abundant form of artifacts. Because of their physical properties they have withstood the inroads of environmental and human perturbation, such as erosion, decay, and landscape development and finally resulted into what archaeologist usually designate archaeological landscape. Moreover, they symbolize in many parts of the world the only form that signifies presence of hominines and his activities. Obviously, lithic artifacts represent one of the most important clues to understand prehistoric lifeways, behavioral development and cognitive process that would have led to the development of cognitive ecosystem.

A number of analytical procedures having different perspectives and approaches have been developed and followed in different parts of the world to understand meaning behind prehistoric lithic artifacts. Mention may be made of typological procedure, technological procedure, typo-technological procedure functional procedure, *chaine opratoire* (operational chain), provenance procedure and statistical procedure. A holistic approach to these analytical procedures, indeed has had been helpful to construct prehistoric society.

It is important, perhaps, to conceptualize why man made tools, unlike his close cousins? Evolutionary advance, however, alienated men from other animals. Anatomically, man was built neither to match the speed nor the strength of other animals. He did not possess even their sharp aggressive appendages and, therefore, had to depend entirely on his cunning for survival.

The advantages the vertical body position provided and two well-developed forelimbs made it possible for the ancient anthropoid apes to make use of such objects as stones, bones, etc, more and more frequently in defending themselves from their terrible enemies, in hunting and searching for food. As the digging have shown man's primitive ancestors hunted small animals and killed them with heavy objects, using stones to crack the shells of turtles and crabs. The systematic use of natural tools eventually caused man's ancestors to try to adapt objects at hand to their needs and, later, to fashion tools for various tasks, to approach conscious application of gained skill. In the process of their conscious efforts, these men modified objects found in nature into implements which served their needs. The fashioning of even most simple tools distinguishes man from the animal world, for no animal is capable of conscious activity, no animal can fashion even the simplest tools.

The transition from using tools found in nature (sticks/antler, jaws and stones) to the conscious fashioning of tools is the greatest leap in natural development and marks the transition from anthropoid ape to man. As a result of natural development, man's ancestors acquired the ability to work initially for food like other animals but more than animals for the defence. All his efforts, in turn, influenced the development of man and his biological development as well.

Generally, scholars believe that man made tools for hunting and got success because increased cranial capacity or intelligence (Dart 1953; Washburn and Lancester 1968). If we analyse these questions keeping in perspective the differences in anatomy like brain, limbs, dentition, etc. between man and animals and variations in archaeological records in given time and space and the vertical body position, then perhaps we may begin to work out some of these puzzling problems. Such issues have been discussed in detailed elsewhere and suggested that *plausibly, his first need would have been means to defend himself and his children and* that *he made artifacts on stone, firstly to protect and defend, and not for hunting* (Sinha 1994, 1999, nd.).

It is difficult to describe precisely how man started making lithic tools. Indeed, the idea of making/flaking stone pieces might well have come to him due to interaction with the environment and learning through observation about happenings in the surroundings. He might have observed that when a stone boulder/block fell to the ground from a height it often got broken when it landed on hard rock or another boulder. He might also have observed that when he threw a stone at an animal and his missile missed the mark and, instead, struck another hard material it often gets broken. When he looked at the chipped pieces he might have noticed that they usually have sharp lateral edges, which are good to cut meat or plants. These are some of the possibilities which could have played an instrumental role in giving man the idea of breaking stones to produce tools.

Lithic technology, like other crafts, is a combination of two factors. The first is the method, i.e. the use of the mind, and the second is technique, i.e. the use of the hand. A change or variation in either or both usually causes variability in the assemblage(s) and or site. Experiments and ethno-archaeological data have demonstrated that there are primarily two techniques, percussion and pressure. But prior to getting down to making any tool or artifact, its morphological features and the technique that can be adopted to shape them must be conceived in the mind, otherwise, one would not be able to make the desired tool type or artifact. Thus, before making something, there is present in the mind, the shape of the tool and the technique to be adopted. Therefore, if one is making a particular tool type it means that one wants to use the tool for some particular end.

In the percussion technique either the object or the hammer is in motion; in the pressure technique neither is in motion. However, in archaeological literature a number of techniques have been mentioned such as anvil technique, free hand-held technique, bipolar technique, inverse technique, clactonian technique, levalloisian technique, mousterian technique, grinding technique, fluted core technique, micro-bruin technique, flake-cleaver technique, etc. All these are innovations and improvisations on basic tool techniques. Besides technique *per se*, other factors also play a significant role in fabricating tools, such as the types of manufacturing tools, the raw material, and the degree of skill with which the fabricator can coordinate hand, fingers, thumb and brain. Man had been perfecting his technology through experience, empirical knowledge. When he noticed that the stone hammer created deep scars because of pointed impact he changed to antler / wood/bone hammers. With the help of such types of tools, commonly known as soft hammers in archaeological literature, he started getting diffused scars on the flakes and fabricated tools which ultimately helped him to fabricate still finer artifacts with nearly straight working edges.

The percussion technique requires a fabricator or hammer which can impart sufficient force to exceed the elastic limits of the stone and cause fracture. The application of the percussion technique can be executed by both types of hammers, hard and soft. The hard or soft hammer controls the interval of contact. If the hammer is of antler, wood or bone (soft hammers) then the interval of contact is prolonged while with the stone hammer (hard hammer) it is shortened. Relatively, soft hammers contact a larger area than hard hammers. This causes the cone of force to have a larger truncation and the flakes to have a diffused bulb of percussion. Percussion technique can be of either the hard hammer or the soft hammer type. All of the diverse variations of this technique will probably never be known, but it prevailed during the entire Stone Age until metal implements became common. However, one of the most important variants of this technique is known as the *indirect percussion technique* or *punch technique*. In this technique, a punch is placed on a well-prepared platform of a core and the hammer imparts the force through a punch, hence indirectly. Because of this variant, the former percussion technique is usually referred to as *direct percussion technique*. Indirect percussion technique is more accurate than direct percussion and detaches straighter and more uniform flakes and blades with small platforms. The *punch* is a semi-pointed or blunt rod-like object of tenacious stone, bone, antler, horn, ivory or hard wood. For good results, two persons are required for working the punch technique, one to hold the stone tool or core and the other to hold the punch and deliver the blow. However, the maker can also hold the working object between his feet leaving his hands free for holding the punch by one hand and give the blow by the other.

In the pressure technique, blades/flakes can be removed from a core by using the chest or shoulder crutch or a staff held in both hands. The main feature which distinguished the pressure technique from the percussion and especially from the indirect percussion technique is that the hammer remained in direct contact with the stone core or flake and was pressed hard till a narrow blade or flake was detached. Thus a constant forte for a longer duration was involved in this case in contrast to the swings of the hammer in the percussion technique. Generally, pressure flakes/blades are small and thin as compared to those made by percussion or indirect percussion techniques. For obvious reasons, this technique would have been used more in making tools through retouching and backing techniques than in manufacturing blades/flakes.

Besides these basic techniques, there are some specialized techniques or core preparation or pre-planned – visualizing final end product. Mention may be made of most common specialized techniques like Levalloisian, flake-cleaver, Mousterian, Fluted Core, Backing, micro-burin, etc.

Primarily, lithic technology is a reductive process, unlike other prehistoric technologies such as pottery production or house construction. Stone is always removed to produce a tool and never added. Cores are also systematically reduced to produce usable blades or flakes. Lithic technology, however, may be classified as a reductive process until composite tools or gears are not made. The function of artifact may change as the artifact form is changed. The form, size and other technical attributes of lithic artifacts may change or modified because of a number of factors like heat treated objective stone, prolong use, abundance or scarcity of raw material close to the site, reutilization, retouching, etc. Hence, the dynamics of stone tool morphology is essential for lithic analysts to understand.

Typo-technological Procedure

The term 'culture' in archaeology has had been in currency with very restricted meaning unlike the definition and or meaning usually understood in social sciences and humanities. Indeed, there no one definition or meaning of 'culture' in social sciences and humanities. Archaeology mainly deals with cultural material and on that basis archaeologists identify sites in time and space. Similarities and dissimilarities in assemblage (s) play a crucial role in constructing archaeological time scale both in spatial (facets) and temporal dimensions (periodization). To meet this requirement archaeologist tagged assemblage of cultural material with some reasonable name, on its first discovery, primarily based on some special morphological features of cultural material, including their medium and uses the word culture as suffix to the name. For example, sites or assemblages of Lower Palaeolithic culture, Upper Palaeolthic culture, Painted Grey Ware Culture, Northern Black Polished Ware culture, etc. only denote similarities in morphological features no more, no less. Similarities in the assemblages usually treated as belonging to similar period while dissimilarities may refer to spatial and / or temporal changes. Typological procedures of classification of archaeological lithic assemblages are primarily based similar presumptions.

Shape, size, technique of manufacturing- hard / soft hammer, percussion/ pressure, direct/ indirect percussion; nature of retouching, class of retouching, invasiveness of retouching, primary form of artifacts are some of the variables usually considered in analyzing lithic assemblages under typo-technological procedure.

The *Chaîne Opératoire*

The *chaîne opératoire* or 'operational chain' or 'sequence' refers to the range of processes by which naturally occurring raw materials are selected, tested, transported, knapped and reduced into a shaped tool and or transformed into usable cultural products. This procedure can contribute to the reconstruction of the dynamic context of archaeological landscapes, both natural and social. This goal-oriented activity can be considered as a structured and generative interplay between mental and material possibilities, involving planning and decision-making as well as more tacit or routine reactions (Keller and Keller 1996; Schlanger 1996).

Provenance Procedure

A good understanding and identification of lithic raw material exploited by prehistoric man are not only required to know factors that would have caused variability in shape and size of prehistoric lithic artifacts and modification in methods and techniques of manufacturing artifacts but also to know their source of location. Knowledge about source of raw material in the region may provide data on social and economic aspects such as catchment area, range of mobility, exchange network, etc. Although macroscopic techniques can be helpful for provenance studies, their precision is subject to greater degrees of error than geochemical techniques. However, since many of the rock types used for chipped stone tools have as much variation within a source location as between source locations, even geochemical techniques are subject to error. Geochemical techniques of stone analysis are used to determine the elemental composition of lithic artifacts. By matching the elemental composition of artifacts to raw material from various source areas the provenance of raw material used to make artifacts can be determined. Stone is composed of elements classified into one of three groups: (1) major elements (those that make up 2% or more of the sample); (2) minor elements (from 2% to 0.1% of the sample); and (3) trace elements (those in concentrations less than 0.1%). Geochemical techniques frequently focus on trace elements to determine provenance. There are several different techniques of geochemical analysis, mention may be made of – X-ray fluorescence spectrometry, Particle induced X-ray emission analysis, Electron microprobe analysis, Instrumental neutron activation analysis, inductively coupled plasma emission spectroscopy and Atomic absorption spectroscopy.

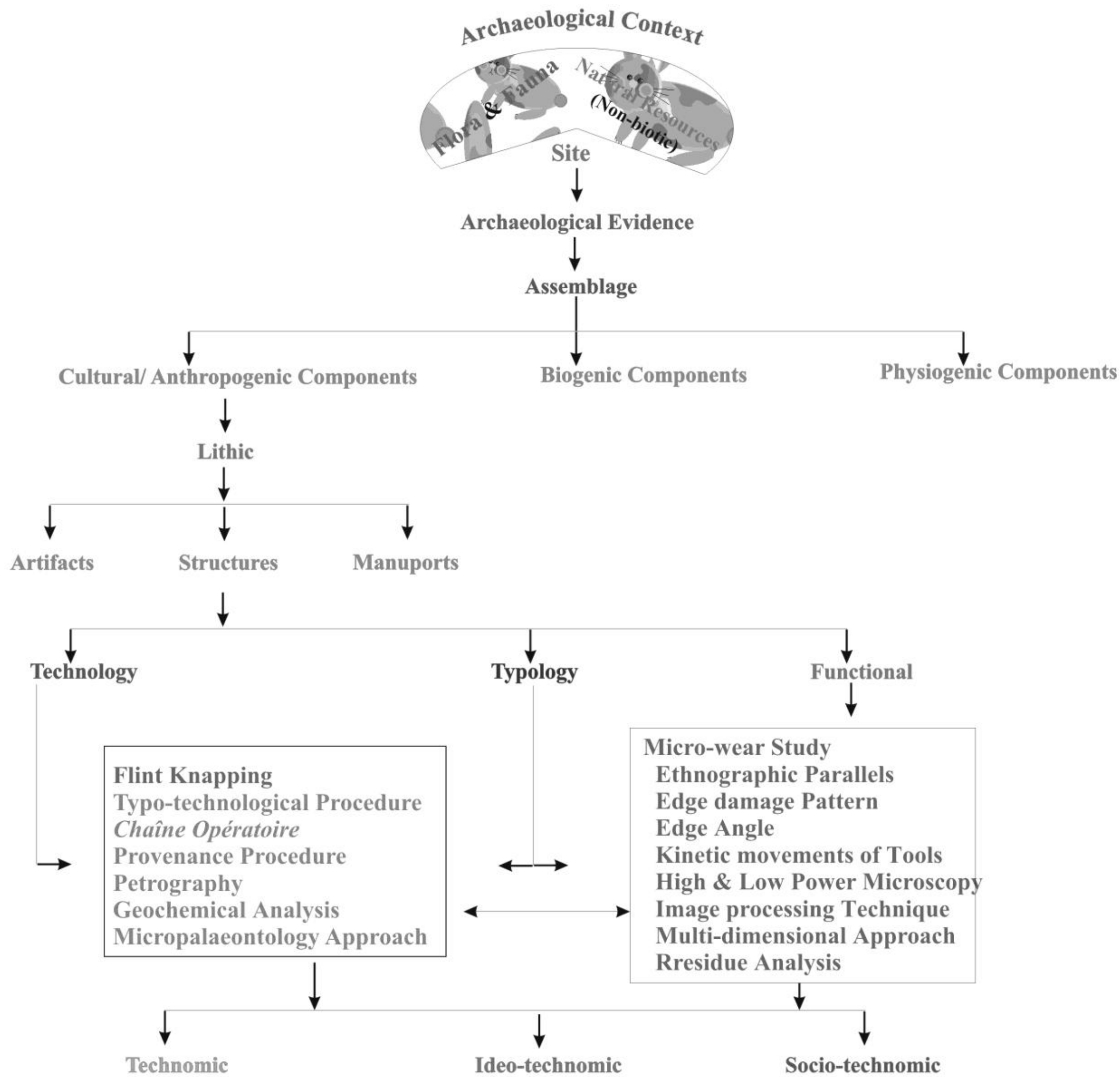
Micropalaeontology Approach

Besides geochemical techniques, micropalaeontology approach is being also followed to study sources of lithic. A rather different focus is taken in micropalaeontological approaches. Here the interest shifts from constituent elements to fossils, most notably foraminifera in materials like flint and chert. It is argued that consistent relationships can be identified between the presence and relative frequency of fossil species, and the source of flint and chert.

Petrography

One of the more established approaches, petrography is the characterization of stone in terms of its mineralogy and structure (Kempe and Harvey 1983). The technique involves removing a small piece either by sawing a section or drilling a core. Though the former has a long history, the latter is increasingly common as it has less impact on artifacts that we are reluctant to damage for aesthetic or other reasons. The ends of a core can be used to plug the hole left by sampling.

Petrography can characterize a range of raw materials, and has proved valuable in determining the distribution of tools, sculpture and building materials away from their geological sources (Olsen and Alsaker 1984). Whilst this technique has been successful on these materials, it is of limited value with others, such as flint.



Analytical Procedure

Micro-wear Study:
The aim of microwear studies is to reconstruct as completely as possible, the primary economic activities and behavior of prehistoric groups. Following systematic procedure of microwear analysis scholars have not only inferred the functions of lithic tools and thus least rather more about prehistoric economics.
Microscopic study of wear pattern on humanly made artifacts is microwear analysis. These wears may be due to various factors such as alteration in the course of manufacturing artifacts, technical wears; alteration due to use, use-wear and alteration caused by natural agencies, natural wears. Distinguishing them and identifying use-ware is the job of micro-wear analysts. It would be, therefore, better to designate such microscopic study as micro-wear analysis instead of generally used term, lithic use-wear analysis.
After eliminating technical wear and natural wear features, a use-wear (functional) analysis is primarily based on various microscopic features. Some of important features are the study of (i) Edge-wear pattern: (a) types of micro-scars, (b) location of micro-scars, (c) depth of micro-scars; (ii) Striation: (a) types of striations, (b) location of striations, (c) orientation of striations; (iii) Polish: (a) types of polish, (b) location of polish, (c) distribution of polish; (iv) Raw material of artifacts; (v) Used edge angle of artifact; (vi) Morphological features of artifact.
The study of lithic technology, indeed contributed a lot in understanding prehistoric lithic artifacts, but unless and until we know the function of these lithic tools it would be hard to reveal dynamics of tools and the systematic context of the sites. Analytical procedures based on ethnographic parallels, edge damage pattern, edge angle, kinetic movements of tools, high & low power microscopy, image processing technique, multi-dimensional approach and residue analysis have contributed significantly in this direction.
Ethnographic Parallels
The development of the analysis of the function of stone tools began by the use of analogy with ethnographic tools. The main problem, apart from assuming a direct correlation between form and function, is that many prehistoric tools have no ethnographic analogues, notably hand axes and burins.
Edge Damage Pattern
Gould, Koster and Sontz (1971) observed that the wear traces on Australian Aboriginal adzes (purpuna), used for planing hard wood, appeared similar to those on Quina scrapers, and therefore inferred that the Quina scrapers were used on hard wood.Typologically, both concave and convex scrapers are classed in the same group of tools, but they could not have been used in the same way because the two kinds of edges are not mechanically useful for the same task.
Edge Analysis
Wilmsen (1968) measured 2,139 artifact edge angles and he claimed that the analysis showed there to be 3 modes: 26-35 degrees, 46-55 degrees and 66-85 degrees. Wilmsen interprets the activities that these edge angle modes represent as follows: 26-35 degree angled edges were used for cutting, 46-55 degree angled edges were used for hide scraping/heavy cutting and the 66-75 degree angled edges were used for wood and bone working. White and Thomas then went on to derive a classification of the prehistoric material based on such attributes as edge angle. This procedure constitutes one of first attempts to produce a functional classification.
Kinetic Movements
After the translation of Semenov's *Prehistoric Technology* in 1964 the emphasis in use-wear analysis centered on the use of microscopy for studying the effects of use on the edges of tools.

At first this was mainly concerned with low power (i.e. <100 magnifications) looking principally at edge wear. Low power microscopy (up to 80x) was used mainly to ascertain how the edge angle changed during use.In the paper by Tringham et al. (1974) experiments were carried out to test the following hypothesis: "A tool made of a specific raw material, whose edge is activated in a specific direction across a specific worked material will develop a distinctive pattern of edge damage of a kind that is recognizable on the edges of prehistoric tools". Odell and Odell (Odell and Odell-Vereeken,1981) accepted that the technique is limited to identifying the hardness of the material rather than specific materials.

Fracture Analysis

A major aspect of low power micro-wear analysis is the classification of fractures. Kamminga (1982) devised 6 types of fractures in his classification scheme.

High Power

High power microwear analysis was developed by Keeley from Semenov's work (1964). High power microscopy involves using magnifications of 100 plus, normally characterising use-wear traces at 200 magnifications, but occasionally using up to 400 magnifications. The extra information gained through the use of higher magnifications centers on polishes of worked material. Keeley carried out a series of experiments using various tools and he claims to have recognized that specific materials produce distinctive polishes, so that we have bone polish, wood polish, hide polish, etc.

Keeley originally stated that these polishes are distinctive when certain variables are controlled, in particular the raw material of the tools, so that a prerequisite of any microwear study is an experimental programme using simulation experiments with similar stone, preferably from the same source as that of the archaeological material. The main problem with high power microwear analysis is that the descriptions of the distinctive polishes are subjective and largely unusable by independent workers.

Image Processing Techniques

The quantification of microwear polishes would facilitate their classification by mathematical criteria, rather than by individual expertise, and any microwear analysis so classified would be comparable with any other. This quantification has been carried out with the use of image processing techniques like Confocal Laser Scanning Microscope (CLSM), Laer Induced Breakdown Spectroscopy (LIBS), UBM (Ulrich Breitmeier Messtechnik) Laser Profilometry, etc.

Multi-Dimensional Approach

In response to the fundamental doubts that have been raised about the accuracy and usefulness of microwear analysis as it is currently practiced, a new approach, multi-dimensional approach which attempts to standardise the methodology of microwear analysis and to test the limits of its interpretations has been used. These include the morphology of the working edges, utilization damage, the orientation of striations and the location and extent of micro-wear polishes.Correlations between the variables then allow the analyst to eliminate some of the possible functions of a tool until the most probable function is isolated.

Residue Analysis

For the last one decade, some scholars are working hard to infer function of stone tools on the basis of extraction and identification of organic materials from the edges of stone tools.But such studies only limited to infer probable worked material.To infer kinetic movements / activities carried out by archaeological tools, edge damage pattern, direction and nature of striations are required variables /attributes and that can be obtained by high power microscopy.Moreover, one should take all precautions and care while inferring the function of tools on the basis of organic residues alone for obvious reasons.

Micro-Wear and Phytolith Analysis: A new sets of experiments

High power microscopy is primarily based on experimental catalogue of worked material. Analysis of phytoliths from archaeological soil samples of concerned site may give clue for vegetal material present and or exploited by inhabitants. Hence experimental catalogue may be developed accordingly.

Mould-Replication Procedure

This procedure is being developed. However, it was initiated by Straus and Walker in the year 1978. If developed successfully, it will not only an economical procedure for micro-wear analysis as micro-traces could be observed under normal binocular and / or stereo microscopes but will also open the scope of comparative study among analysts.

Applications of Micro-wear Analysis

- The variability between assemblages in terms of activities that took place at the sites, then edge analysis can group the tools into types having similar functional capabilities.
- That is, groups of tools are held to be associated with a particular activity, but without necessarily specifying exactly what that activity is.
- Therefore, one can construct a functional typology that can be quantitatively compared with other assemblages in order to ascertain the similarities or differences in activities represented at different sites.
- Another way in which use-wear analysis can be used on whole assemblages is to attempt to interpret the function of a site as a whole, in terms of the range of activities that were carried out at the site.
- Knowing the range of activities would help to interpret the function of the site as a home base, kill site, hunting station, specialist activity site (such as a hide processing site) etc
- The kind of analytical process described above could be applied to an assemblage in order to interpret the subsistence strategy associated with a particular site.
- The separation of the tools into those used on soft or hard materials would give an estimation of the importance of vegetable resources as opposed to hunting resources.
- A second area in which use-wear analysis can be profitably utilised is to approach specific problems associated with a particular tool type.
- Use-wear analysis should not be seen as a technique that is intended to supplant existing methods of lithic analysis but to supplement lithic analysis as a whole.