
Use-wear traces : processes of development and post-depositional alterations

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RÉSUMÉ

Cet article présente des recherches sur les surfaces lithiques polies après usage, observées au microscope optique et au MEB. Des surfaces naturellement polies observées dans des conditions postérieures au dépôt anthropique ont aussi été étudiées. Ces travaux ont été inspirés par les résultats décevants de la « tracéologie à forts grossissements » sur des outils de différents âges et de sites variés qui suggèrent que l'apparence seule des « polis » d'usage ne permet pas de diagnostiquer le matériau travaillé. Ils ont, en outre, montré que certains processus du sol affectaient négativement la surface du silex qu'elle soit polie par l'usage ou non. Pendant ces travaux, les surfaces lithiques ont été polies dans des conditions contrôlées, employant plusieurs matériaux pour en étudier les processus de polissage plutôt que pour répliquer les activités des préhistoriques.

ABSTRACT

This is a report on research carried out to investigate (with Optical and Scanning Electron Microscopy) the polished surfaces which appear optically on the edges of flint tools after use. Naturally polished surfaces also appear optically on flint under some depositional conditions, and the project investigated both this natural polishing and its possible effects on the polishing produced by use. This research was prompted by « high power microwear analysis » of implements from several sites of different ages which cast doubt on the distinctive appearance of « polish » on flint and furthermore suggested that post-depositional processes negatively alter the surface of flint implements and degrade the polished surfaces. In this work flint surfaces were polished under controlled conditions using different materials, to investigate the processes involved in the formation of polished edges rather than to replicate tasks which prehistoric people are likely to have carried out.

This is a report about the research carried out to investigate the processes of « polish » formation on flint surfaces. In particular the aim was to

ascertain whether the « polish » observed optically after use can be attributed to the phenomenon of plastic deformation alone (which would suggest

wear by a mechanical action) or whether silica gel (through hydrolysis) is formed as well. Plastic deformation almost always means the formation of a layer of somewhat amorphous silica because the atoms on the flint surface are no longer ordered in the same way as in unpolished flint. Amorphous silica is to be distinguished from silica gel, which is hydrolysed amorphous silica produced as the result of a one to one combination of silica and water (see fig. 1 for definitions of terms).

In experiments published previously, water was shown to greatly enhance polish formation and development. To test whether it was the water as H_2O which was initiating a process of hydrolysis or rather its presence as a liquid medium, hexane was used. It is a hydrocarbon oil not known to cause the dissolution of silica and is very different chemically from water in terms of polarity (fig. 1). Experiments were also carried out to monitor the role certain variables play in the development of polished surfaces on flint edges. The factors considered important in the appearance of « polish » such as abrasives, water, other fluids and edge angle were varied and the results observed microscopically.

Flint was polished, by hand and mechanically, under different conditions and with different organic and inorganic materials.

Amorphous silica : Regions of atomic order of crystals of extremely small size, which do not have the usual arrangement of silica molecules.

Plastic deformation : Occurs when you « increase the tensile strength until there is permanent shape change » (Anderson *et al.*, 1985 : 155-156).

Polar liquids : The electrons in such liquids are fairly evenly shared between the component atoms making the bonds between carbon and hydrogen very strong. Hydrogen is not free to ally itself with silica as occurs in water. This is true hexane and all non-polar liquids.

Polish : As used in microwear is more correctly : a polished surface.

Silica gel : Can be found only in the presence of water producing a chemical reaction between silica and water through hydrolysis yielding $SiOH$. It can be said to be hydrolysed amorphous silica.

Wear : As defined in tribology is « the progressive loss of substance from the operating surface of a body occurring as a result of relative motion at the surface » (Oecd, 1969 in Dowson, 1979).

Fig. 1. Definitions of terms used in text.

« Polish » formation

Friction, wear, lubrication, and adhesion are a group of mechanical surface interactions involved in the formation of polished surfaces which are

studied together. They are well known but the relative importance of each is not well understood.

The theory has first been put forward by Witthoft (1967 : 385) and supported by many others until recently that during use silica in flint reaches a semi-molten state or is transformed into gel by the presence of localized high temperatures and water. A molten layer, however, would indicate that very high temperatures were reached over the whole surface during the polishing process whereas generally « this consists of a moderate temperature rise over the contacting bodies, and superimposed on this there are higher flash temperatures at the junctions. » Rabinowicz (1966). A hydrolysed layer would furthermore presuppose that water interacted chemically with the flint (as silica dissolves very slowly in water).

It was further suggested that residues such as phytoliths from plants can be trapped in such a layer during its « amorphous gel » (Anderson, 1980 : 184). In order to trap phytoliths, the thickness of such a layer would have to be measurable in microns as phytoliths are 11-44 microns in length (Ollendorf, 1987 : 457) and in fact Anderson (*ibid.*) suggested a layer of at least 10 microns had formed in her experiments. A considerable mass of silica would have to be dissolved and precipitated to give such a thick layer on a sickle blade whose

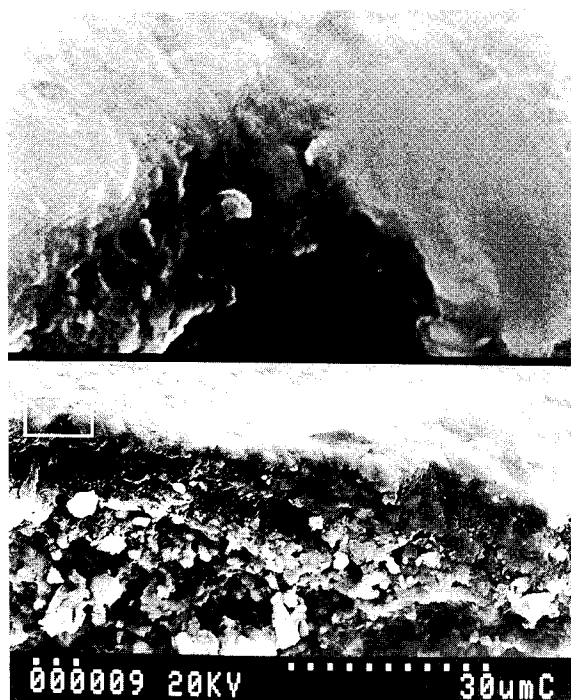


Fig. 2. Thickness of deformed layer on Neolithic sickle blade, 2 000x.

dorsal and ventral surfaces are glossy along the whole edge up to 20 mn inland.

In none of the experiments carried out in this was any evidence of such a thick layer found under the SEM. The examination of a Neolithic sickle blade from the site of Far'ah (fig. 2) at 2 000x magnifications illustrates clearly that the polished or deformed layer is in the region of a micron or less in thickness. The top picture shows part of the bottom picture magnified ten times.

Experiments 1

The details of the following series of experiments were published elsewhere (Levi Sala, 1988), so only the results will be illustrated and discussed here. Wood was grooved with flakes removed from the same core of medium grained Israeli flint with water, hydrocarbon oil, and talcum powder used separately. The degree to which the flint surface was polished was the same both when water and oil were used. When the water-wet wood was used, however, the polished area was of greater distance from the edge suggesting a deeper penetration of the wood by the tool (fig. 3 and 4).

The « polish » observed optically on a flake with a 45 degrees edge angle had many striations while on a burin-edge of 80 degrees no striations appeared in spite of the presence of talcum as an abrasive in both cases : compare figures 5 and 6. This suggests that flint particles from edge scarring and elsewhere are responsible for some of the striations optically observed on the polished surface. They need not necessarily be the only cause.

Experiments 2

As the next set of experiments have not been reported before, I will describe and discuss them in some detail. They were carried out to polish flint with dust-free hides in order to elucidate the abrasive factor (which seems bound to be present) when flint surfaces are polished by soft materials such as damp hide.

Goat hide was washed with ammonia-free detergent and brushed with a nylon brush as free of dust and dirt as possible. Separate clean squares were then used to cover a soft wool buffing wheel.



Fig. 3. Polished edge from grooving birch w/water 3 000 strokes, 200x.

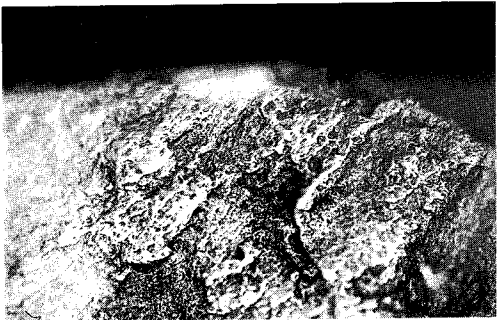


Fig. 4. Polished edge from grooving birch w/oil 3 000 strokes, 200x.



Fig. 5. Striations from grooving wood with low-angled edge using soft abrasive, 200x.

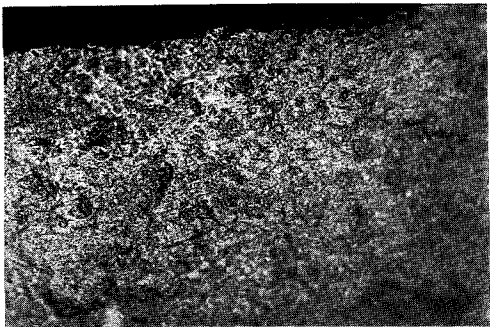


Fig. 6. No striations from grooving wood with high angled edge using soft abrasives, 200x.

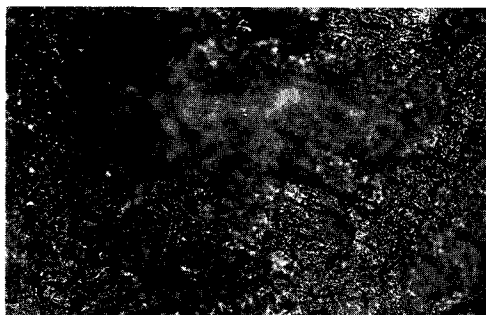


Fig. 7. Unused goat hide ; optical, 200x.



Fig. 9. Flint surface polished by buffing with wet hide macroscopic « gloss » like bright spots, 400x.

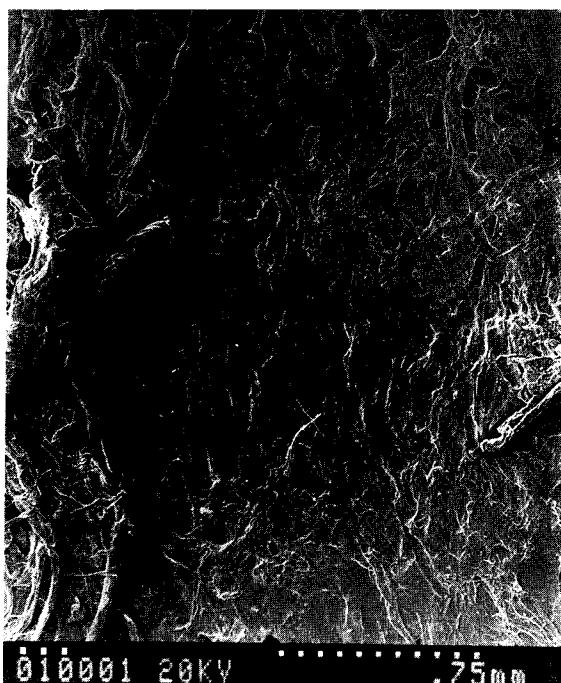


Fig. 8. Unused cow hide ; SEM, 80x.

To avoid microchips from the edge of the artefacts coming between the hide and the flint, no contact was allowed between the buff and the edges of the flakes. Fingers were used to protect the edge, and the hide touched only a previously circled area of flint. Figures 7 and 8 show the hide squares before use optically and with the SEM respectively.

Two fine Brandon flint flakes were buffed for 45 minutes. One flake was repeatedly dipped in distilled water to remove hide particles from its surface during work. There was no apparent increase in temperature probably due to the frequent immersions in water. The other flake was buffed with dry hide. During work the flake became barely warm to the touch.

On both artefacts a discrete surface was polished as seen in figures 9 and 10 in the presence of



Fig. 10. Lesser smoothing of the surface on artefact buffed with dry hide, 200x.

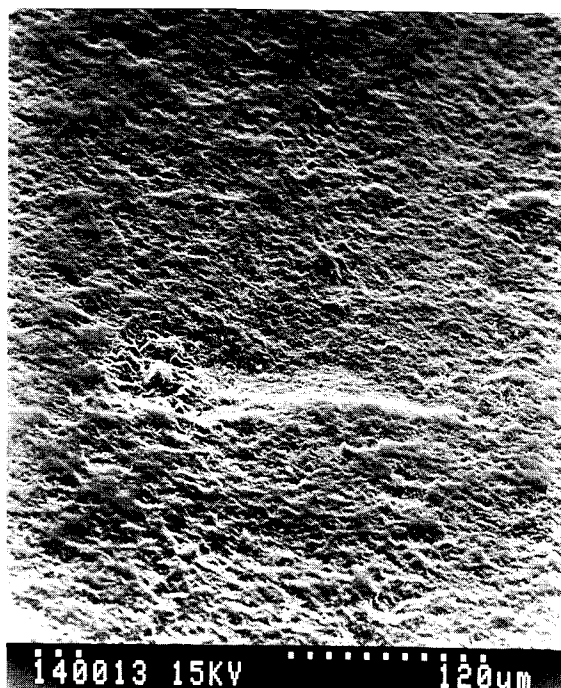


Fig. 11. Smoothed « tail » on « comet-tail » striation on flint polished by dry hide, 500x.

water ; however, the « gloss » was visible with the naked eye. Minute « comet tail pits » were visible optically. With dry hide, a small area of was totally



Fig. 12. Goat hide used wet speckled with flint particles, 200x.

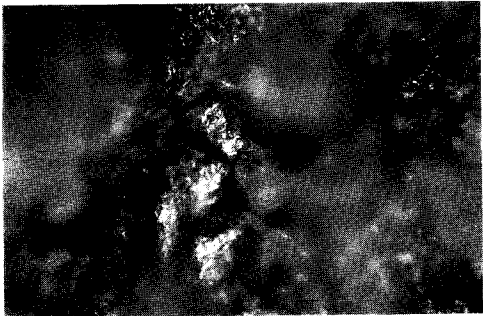


Fig. 13. Goat hide after use speckled with flint particles, 200x.

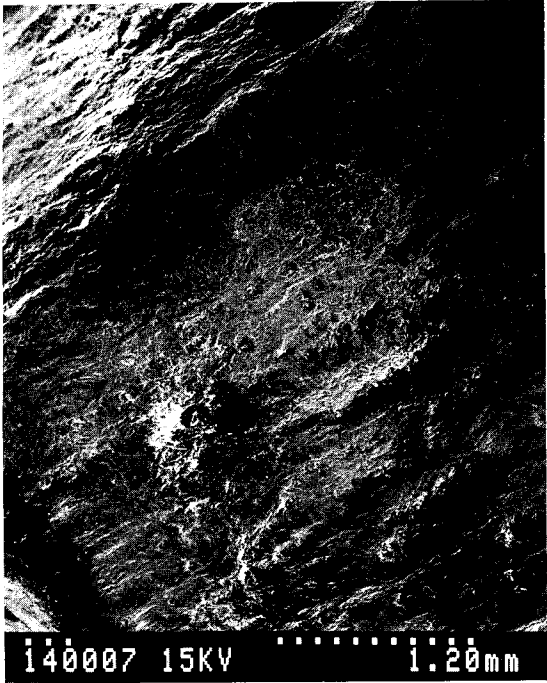


Fig. 15. Flint particles embedded in goat hide used dry ; SEM, 50x.

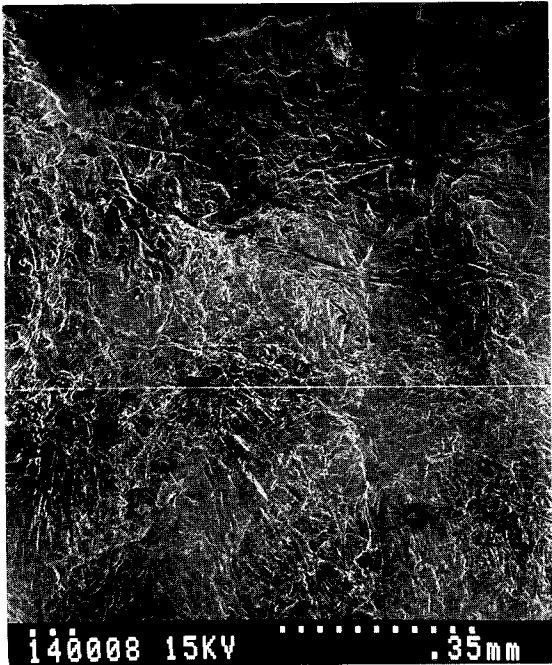


Fig. 14. Flint particles embedded in goat hide used wet ; SEM higher magnification of figure 12, 170x.

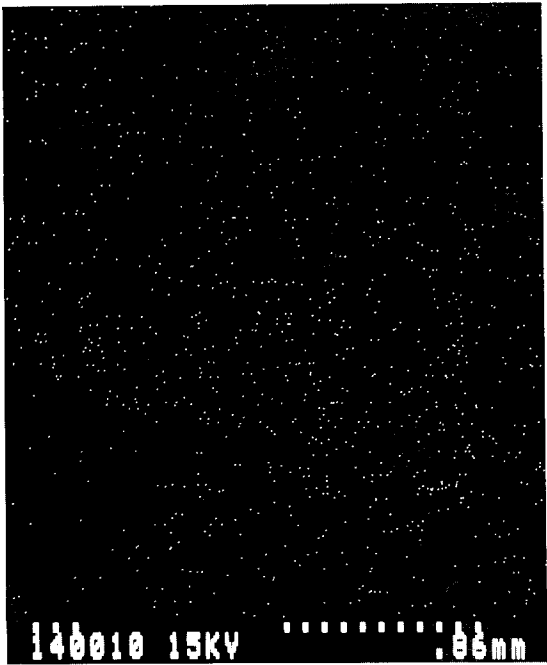
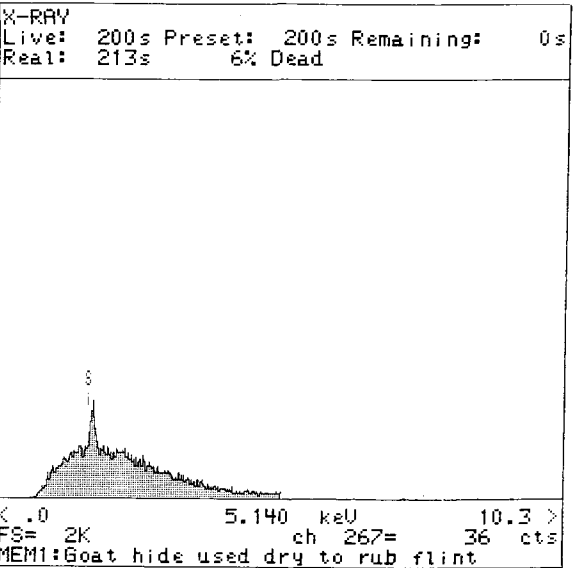
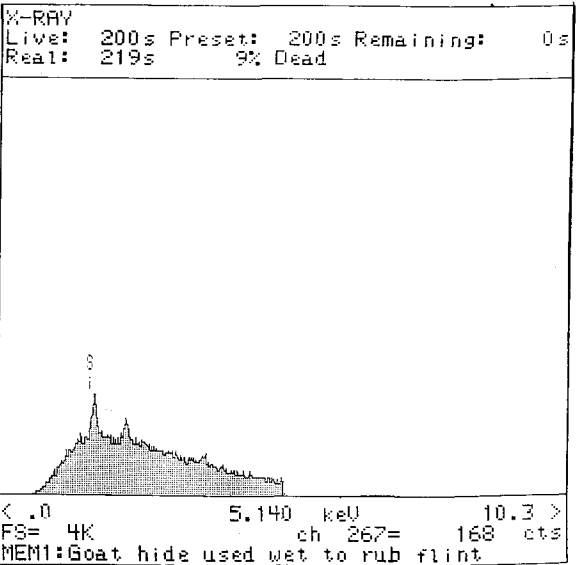
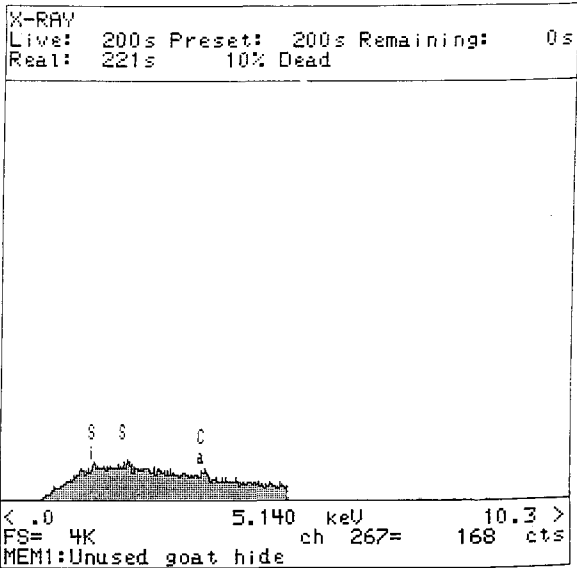


Fig. 16. X-ray dot mapping of silicon distribution on hide in figure 12, 70x.

polished with a « comet tail pit » on a prominent point on the microtopography observed by the SEM (fig. 11). Figures 12 and 13 show optically

the goat hide surface after both experiments, suggesting that flint particles have become embedded in the hide. The same appears on the



← Opposite, from top to bottom :

Fig. 17. X-ray spectrum of elements on unused goat hide.
Fig. 18. X-ray spectrum of elements on goat hide showing increase in silicon on hide used wet.
Fig. 19. X-ray spectrum of elements on goat hide showing increase in silicon on hide used dry.

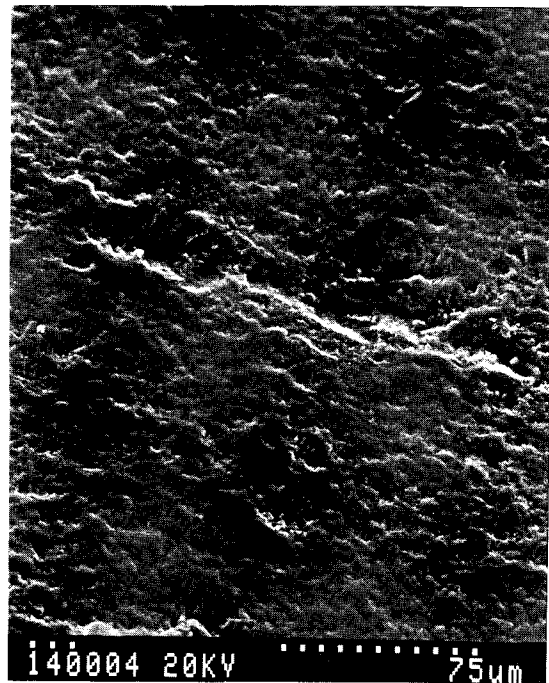


Fig. 20. Striation as a groove in the surface smoothed by goat hide, 800x.

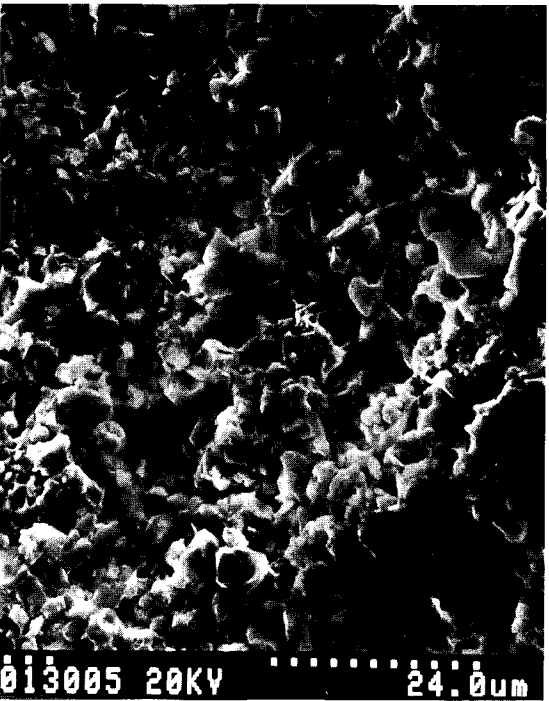


Fig. 21. Unused flint Potters Bar, 2500x.

SEM (fig. 14 and 15). Figure 16 shows a dot mapping by energy dispersive X-ray analysis of the distribution of silicon on the hide surface in figure 14. An X-ray spectrum of elements present on the goat hide surface was taken before use (fig. 17). New spectra show after use the increase of silicon on the surface of the hide (fig. 18 wet hide and fig. 19 dry hide).

Discrete areas of the flint surface have been smoothed by the high speed contact with the hide : compare figure 20 with figure 21 of unused flint. The smoothness, however, is restricted to more localised areas on the surface than in scraping hide by hand where the edge is involved as in figure 22.

The degree of contact which occurs and the amount of pressure exerted, when the edge is used, are likely to be greater than in rubbing even at the high speeds involved with a mechanical buff (fig. 22 hand scraping). The edge is generally more vulnerable as its particles are free standing on at least one aspect, hence more easily removable.

As expected, the edge characteristics and the flint microtopography affect the distribution and linking up of polish. On the artefact which was frequently dipped in water it is doubtful that any significant heating could have occurred. Very well developed macroscopic « polish » or « gloss » formed nonetheless.

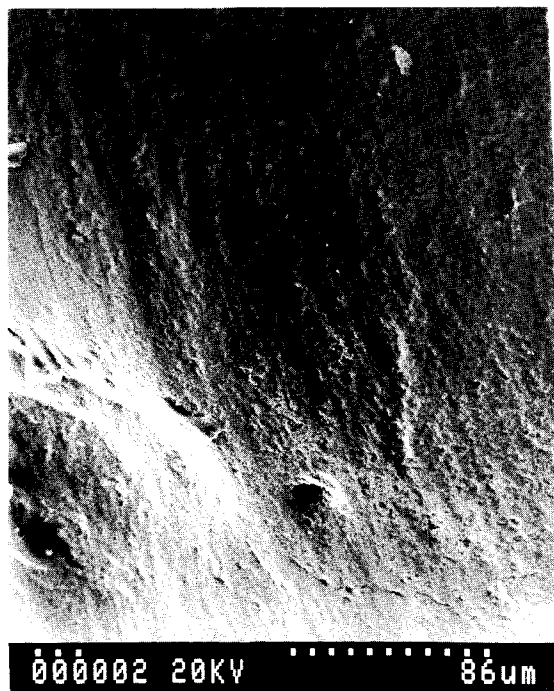


Fig. 22. Very smooth surface on edge of flint used to scrape hide by hand, 700x.

Experiment 3

Another series of experiments was carried out by hand scraping raw damp hide for twenty minutes per artefact, using ochre both unsifted and sifted in measured grain sizes, several types of flint, and two hide types : cow and goat. The hide was lying on a board covered with thick plastic. Working angle and direction were kept constant. Edge angles were recorded as variables. For comparison experiments were also carried out with hydrocarbon oil instead of water and scraping hide without ochre. The polished edges were examined optically and by SEM and the following are only the more significant results :

1. The edges were polished to the same extent whether water or oil was used (fig. 23 and 24).
2. The coarseness of the hide fibres affected the development of the polish. The finer the grain of the hide the more area was polished and *vice versa*. In one case (fig. 25 and 26) the same ochre grain sizes (between 212 and 300 microns) and the same flint type produced vastly differing stages of polishing according to whether goat or cow hide was being scraped. The same observation was

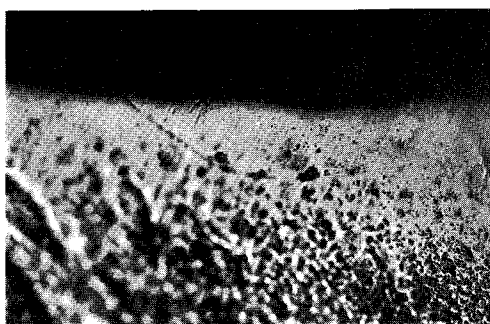


Fig. 23. Highly polished edge on fine flint scraping hide with water and ochre, 200x.

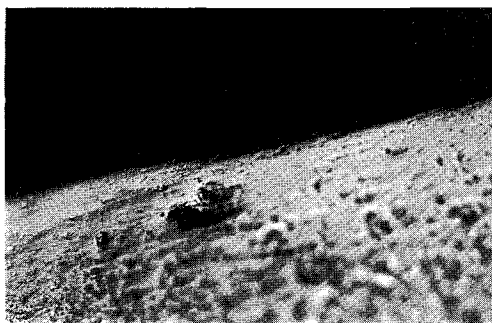


Fig. 24. Highly polished edge scraping hide with hexane and ochre, 200x.

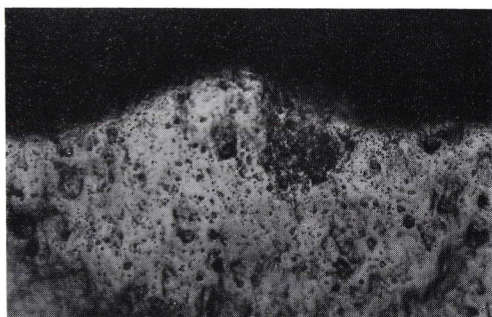


Fig. 25. Highly polished and rounded edge scraping deer hide with ochre, 200x.

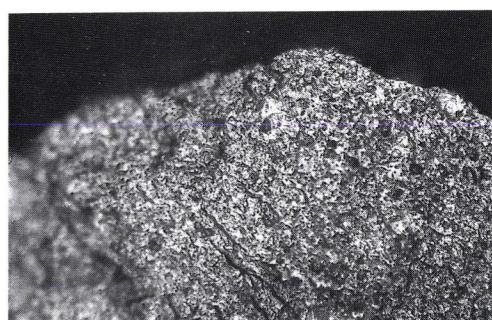


Fig. 26. Very slightly polished edge scraping cow hide with ochre, 200x.

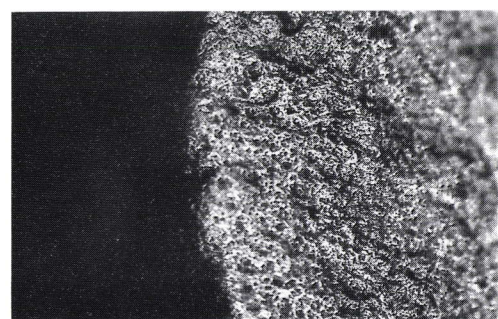


Fig. 27. Polished and rounded edge scraping deer hide and unsifted ochre, 200x.

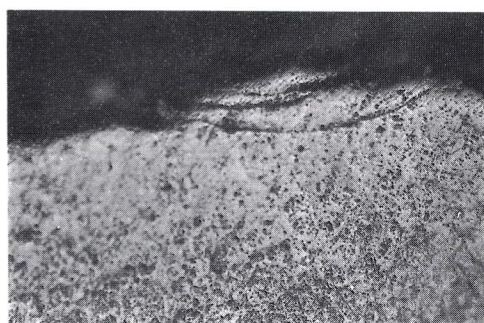


Fig. 28. Highly polished edge scraping hide with fine ochre, 200x.

made when cow and goat hides were scraped with Brandon flint without ochre.

3. The finest ochre correlated with the greatest polished area (fig. 27 and 28). On these artefacts all the variables were the same except ochre grain size.

Striations did not correlate directly with ochre grain size as a variety of striations appeared with all sizes.

Experiments 4

Although the following experiments were published elsewhere (Levi Sala, 1988) I would like to summarise the results here as they have a direct bearing on the understanding of the process of polish formation.

Extremely well developed « polish », similar in optical appearance and SEM observation to « sickle gloss », was produced by polishing several flint artefacts ; some with a rotating turntable covered with 1/4 micron diamond paste ; others with a similarly coated woollen buff ; always without water (fig. 29).



Fig. 29. Totally polished surface from buffing flint with 1/4 micron paste, 100x.

Conclusions

Deposition vs. Abrasion

The high silica content of grasses has been thought by many to be the main cause for the development of the macroscopic gloss on Neolithic sickles. However, none of the experimental blades discussed above had come in contact with any external source of silica, the diamond grit being pure carbon. This argues very strongly against any

depositional theory and suggests that the silica in plants acts as an abrasive in the same way as the carbon in the diamond grit does, which leads to a smoothing of the flint surface.

Time

Scraping hide for the same length of time produced vastly differing polishing stages. It is obvious that the amount of « polish » observed optically on an implement is the result of the interaction of many variables the most important of which are, in this case : flint types, hide type, and the presence of an abrasive. Fluids are also crucial but were kept constant in these experiments, which were all carried out on damp hide.

It would seem, therefore, incorrect for functional analysts to reconstruct the length of time a prehistoric artefact was used, on the basis of the amount of « polish » observed optically on the edge when many of the variables are unknown.

Smoothing of the surface (« polish »)

In the experiments buffing flint with hide no edge-flaking was allowed to occur, the abrasive element in this experiment had to come exclusively from the asperities removed from the flint surface itself. « Comet tail pits » developed, in association with a totally polished surface. The presence of striations documented optically and with the SEM in the absence of dust, dirt and added abrasives suggests that the asperities of the flint are themselves being dragged across the surface. The flint particles embedded in the hide have seemingly been acting as fine abrasive causing a macroscopic gloss to develop.

Water

Several series of experiments, carried out on a variety of used materials, have shown that the role water plays is not ESSENTIAL to the formation of very well polished flint surfaces since they were obtained either in the presence of non-polar liquids or in the total absence of liquids.

Water promotes the polishing process by softening the worked material and making contact

and adherence between the two surfaces more intimate. The materials softened by water may also retain removed flint asperities more readily than the hard dry ones, hence promoting greater attrition. In other words the enhancement of the polishing process is due to the presence of a liquid medium acting as a lubricant, as in the case of a whetstone, rather than to the chemical properties of water as opposed to any other fluid.

Hydrolysis

Regarding the theory of a silica gel layer forming in flint during use as a result of localised high temperatures and water, the experiments mentioned above suggest that even if high temperatures develop in localised areas the total amount of heat involved is far short of that required to produce melting over any significant proportion of the surface. It is highly unlikely that increases in temperature during use could be of such a magnitude as to melt or even soften the flint since neither the cloth (on the rotating turntable) nor the woollen buff were singed. Being in intimate contact with the flint, similar heat would be dissipated in them as that suggested to be responsible for melting the flint. On the other hand, for a silica gel to form, temperatures have to stay moderate at all times, for gel would decompose at higher temperatures.

As flint surfaces are being polished in the absence of water, hydrolysis does not seem to be the mechanism by which the polishing occurs. There is some water, no doubt, in the flint structure and the hide fibres. More water would be required in the composition of a gel than would be available from these sources and yet in the experiments where surfaces were macroscopically polished no additional water was used.

A process of dissolution and redeposition of the silica in flint might occur under certain circumstances. In such cases, however, substantial quantities of water would presumably be necessary as was shown in the PDSM experiments described below (the solubility of silica being very low), yet none whatsoever was used in any of the above experiments. A large quantity of silica would have to go in solution and be redeposited in order to obtain a blade as glossy as some Near-Eastern Neolithic « sickles » are.

Striations

The experiments carried out in this work suggest that striations (in the sense of grooves in the polished surface as opposed to linear features) are formed principally by microchips removed from the used edge during work. This is suggested in view of the absence of striations where very high angled edges were used on wood.

In the hide scraping experiments striations formed even on edges which were either naturally high angled or made so through retouch. This may be due to removed asperities from the flint surface. Ochre particles will be blended in the slurry formed by the surface asperities, thus increasing abrasion and causing a higher number of striations to form.

Under the SEM the striations that Mansur-Franchomme (1983) aptly described as « fern-like » formed on an artefact used on hide with ochre. These striations illustrate the process by which they are formed, namely the removal of surface particles which are dragged across the surface and the consequent smoothing of their path (fig. 30). The fern-like appearance may be due to micro-cracks formed on either side of the main track by drag.

Some features which were perceived as straight striations optically were seen under the SEM to have been the result of two different processes. In some cases it is clear that a groove in the polished surface was formed by the removal of one or more crystals leaving unsmoothed crystals at its bottom and smoothed edges (fig. 20) while in others the straight « striation » observed optically was seen as a rather big surface asperity which instead of being removed has been smoothed down (fig. 31). It is a property of the flint microstructure that some asperities have particular shapes (e. g. cigar shaped rather than spherical) which might be misleading.

In another instance a feature very similar optically to a « comet tail pit » on a Neolithic sickle blade revealed itself by SEM to be a cigar-shaped natural hollow in the flint surface whose edges had been polished during use (fig. 32). In this case, in fact, the direction of the « striation » was not in the direction of use.

« Comet tail pits » were observed on two separate artefacts buffed by dust-free hide. They appear to owe their shape to the asperities from the flint surface being plucked from one spot forming the head and then dragged against the surface forming the tail. As no abrasives were used in the experiment (in which the hide was kept free of ambient dust

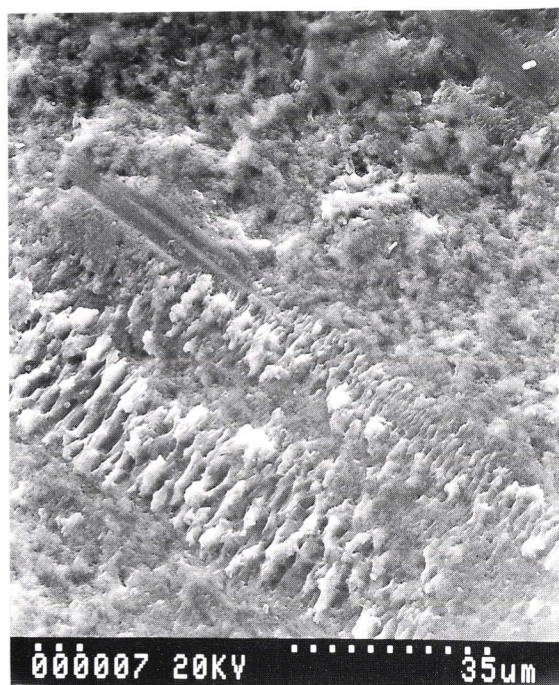


Fig. 30. Fern-like striation from scraping hide with ochre, 1 700x.

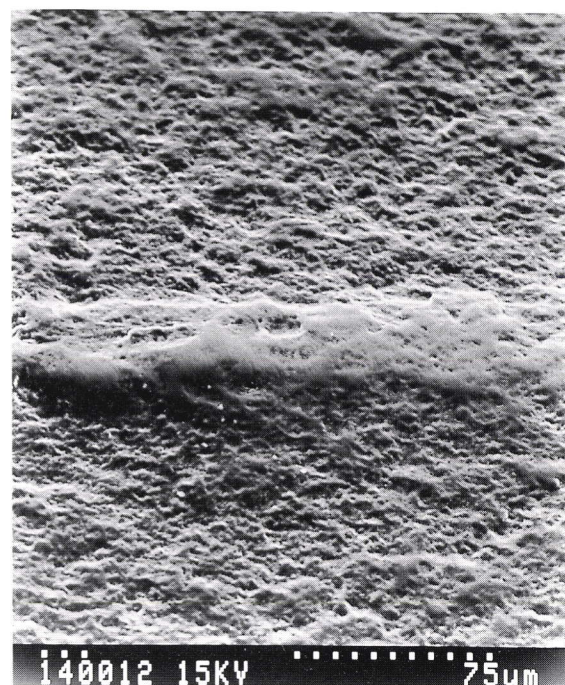


Fig. 31. Linear feature, probably large asperity plastically deformed, 800x.

as possible), it is suggested that this illustrates one of the mechanisms of the polishing process. The smoothed surface of the « tail » is often quite apparent suggesting that the asperities removed from the head of the pit had rubbed against the « tail » area smoothing it (fig. 11). Figure 33 is of another « comet tail pit » clearly showing at a much higher magnification where the crystal(s) have been removed leaving behind the unpolished flint which forms the head of the pit. In spite of the higher magnification, the « tail » area does not seem to have been smoothed as much as in figure 11. This may be due to the fact that there was a difference in the pressure when the removed asperities had rubbed against the area of the « tail ».

In conclusion, these experiments suggest that what appears optically as « polish » is a smoothing of the flint surface produced by wear causing the removal of surficial asperities which are sometimes dragged across the surface flattening it. Some removed asperities can become embedded in a soft worked material to act as abrasives. Water seems to be a useful medium rather than an essential variable, while use-induced heating does not appear to be crucial to the development of the polished surface.

« Comet tail pits », as seen on the SEM, need not be indicative of contact with plant silica since they appear whenever a surface has been very well polished. They have been observed on polished flint produced by diamond paste, hide, and wool as shown above. Their shape is probably only apparent when the surrounding surface is very well smoothed. On the SEM they appear to be a type of striation in the sense of a groove on the flint surface. Striations in general seem to be caused by crystals being dragged across the surface grooving the flint. « Comet tail pits », on the other hand, seem to occur when larger crystals or groups of crystals have been displaced.

The same kind of smooth surface seen on the SEM (which optically appears as a macroscopically glossy polish) can also be produced by 1/4 micron diamond paste on a soft wool buff, by reaping silica rich plants and by scraping hide. The appearance of optically observed « polish » would seem, therefore, not to be specific to the worked material.

The function of flint artefacts can be reconstructed, nonetheless, from the distribution

of the polished areas on the edge suggesting the direction of movement, from the edge scarring, when present, and the distribution of the polished spots on the microtopography hinting at the hardness of the worked material.

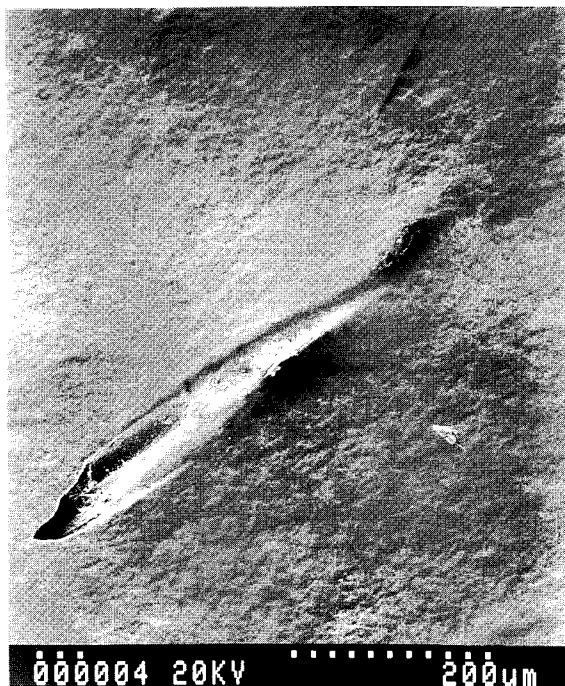


Fig. 32. Cigar-shaped hollow on Neolithic sickle blade, 300x.

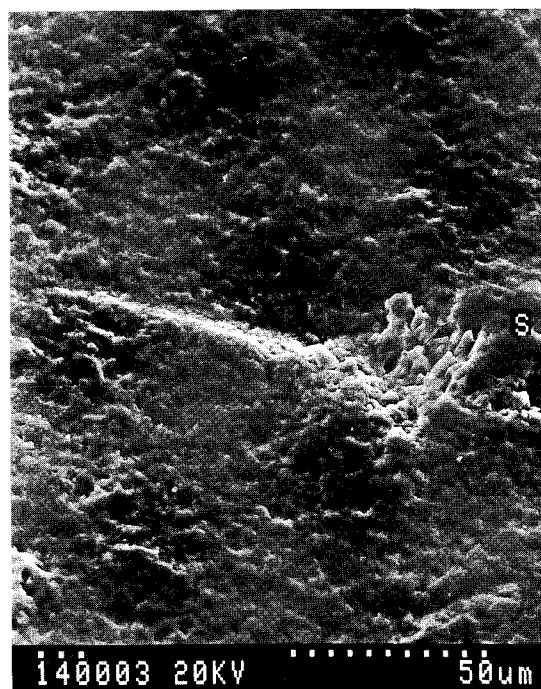


Fig. 33. Comet-shaped striation in surface smoothed by wet goat hide, 1 200x.

Post-depositional surface modification

The following experiments were carried out to study the processes involved in post-depositional alteration of flint artefacts and their effect on use-wear traces. Assemblages from many sites in various countries have been found to be affected by post-depositional surface modification (PDSM) and were consequently unsuitable for analysis by microwear at high magnifications. Most of these implements, when not patinated, had a macroscopic sheen or frequent bright spots.

The ubiquity of these alterations prompted the investigation of the processes of their formation. The hypothesis that some are due to mechanical processes was previously tested and published elsewhere (Levi Sala, 1986). Chemical processes were subsequently investigated to test which phenomena they were responsible for.

Sheen has been referred to in the microwear literature as « glossy patina », « gloss patina », « surface sheen », and « soil sheen ». There is often some sort of soil sheen on the most pristine artefacts. Some researchers have considered that it could be attributed to mechanical or to chemical polishing of the flint surface. It appears optically uniform over the whole surface though microscopically it tends to be more concentrated on edges and prominent parts of artefacts. It varies in degree of intensity from very faint to very glossy (fig. 34 at 37). Plisson and Mauger (1988) have mentioned the problems this sheen creates for microwear analysts and investigated chemical alterations of microwear polish.

Contrary to my experience, however, they feel confident that it is possible to analyze function on artefacts bearing chemically altered polished surfaces. Some experiments will be described here which produced sheen on experimental artefacts by chemical processes. In some cases sheen appears optically as a polished surface concentrated on the useful edges like use-wear.

Bright spots occur very frequently on archaeological artefacts of a variety of ages and provenances (fig. 38 : A and B). Semenov (1964), Bordes (1950) and Shepherd (1972), amongst others, noted them and made varying hypotheses about their origin. They are a highly reflective polished surface (« gloss ») on flint, varying in size from a pin point

to the whole artefact being glossy, occurring singly and in clusters on edges, ridges and flat areas of archaeological flint tools. They do not have a systematic relation to the probable used edges and can generally be excluded as use-wear, especially when isolated, flat and large, but they do often mask large stretches of edge (fig. 39). Bright spots vary : some appear as an extreme and localised smoothing of the surface within the area of occurrence (fig. 38 to 40) but others are not so localised with an appearance and a distribution on the flint topography mimicking use-wear (fig. 41 and 42).

The work described here has shed light on the processes of their formation having shown how bright spots can also be formed by chemical processes (see Levi Sala, 1986, for bright spots formed by mechanical processes).

The correlation between bright spots and sheen on the same pieces has been noted both on archaeological and experimental pieces suggesting a similarity in the processes responsible for the two phenomena.

In an experiment where artefacts were immersed in peat, leaves decaying in water, urine and calcium carbonate, a solution around pH 7.30/8, the following was observed : on one of the artefacts a microscopic alteration occurred like a smoothing of the lower-lying points of the microtopography (fig. 43). A slightly more polished surface was observed when grooving wood with talc (fig. 3) and after a trampling experiment (fig. 44). This polishing on the low points seems to occur when the abrading substance, or in this case the dissolution, affects both the protruding asperities and the low-lying crevices of the flint surface. It has been noticed both with chemical polishing and with use when soft abrasives are involved and is often observed on archaeological artefacts (fig. 36).

Experiments were carried out to study the effect on flint surfaces of artefacts suspended in a heated solution of calcium carbonate and water. In laboratory conditions heat of about 80 degrees centigrade was recommended by Rottlaender (1976) to obtain results within a relatively short time. This combination could freely occur in nature though probably at lower temperatures.

Bright spots (fig. 45 and 46) formed on the finer Brandon flint after 25 days but patination soon followed, so no macroscopic sheen appeared. The

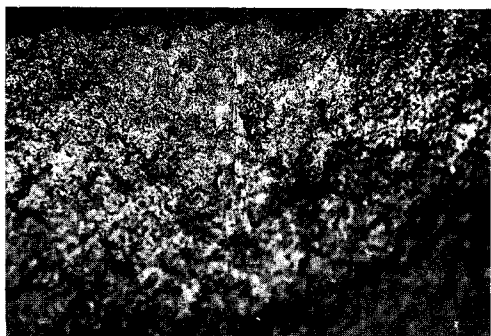


Fig. 34. Sheen on archaeological artefact mimicking the distribution observed in use-wear, 100x.

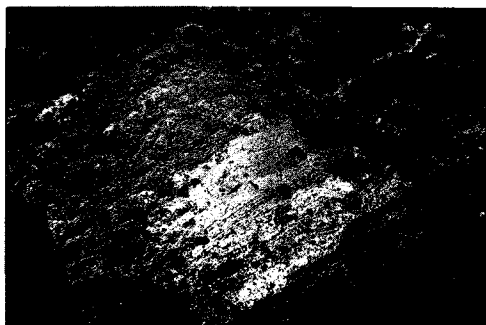


Fig. 38. A. Bright spot on archaeological artefact, 50x.

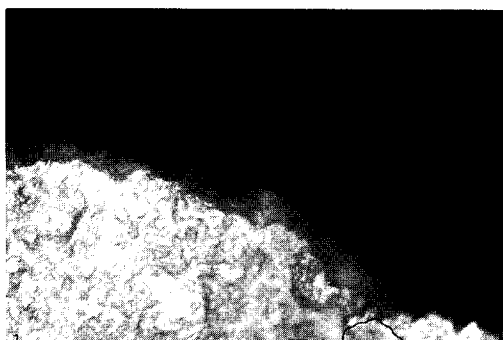


Fig. 35. Sheen on archaeological artefact appearing « glossy », 200x.



Fig. 38. B. Bright spot produced by rubbing flint on flint with water for 2 minutes (cf. fig. 38 : A), 200x.



Fig. 36. Sheen on archaeological artefact faintly developed, 100x.

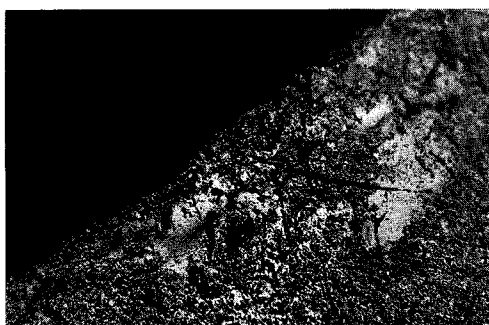


Fig. 39. Bright spots with striations on edge of archaeological artefact, 100x.

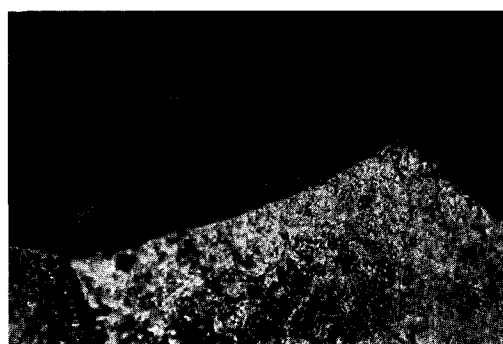


Fig. 37. Sheen on archaeological artefact restricted to edge, 100x.



Fig. 40. Bright spots as localized smoothing, cf. fig. 38 : A and B, 200x.



Fig. 41. Bright spots mimicking use-wear, 100x.

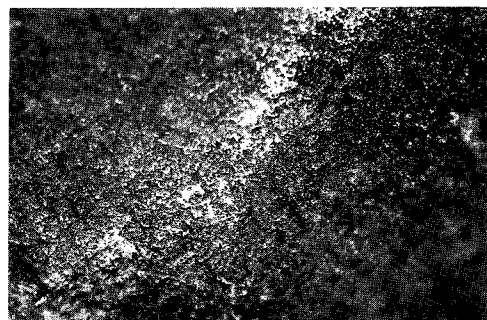


Fig. 45. Bright spots on fine flint in a line after 25 days in CaCO_3 , 100x.

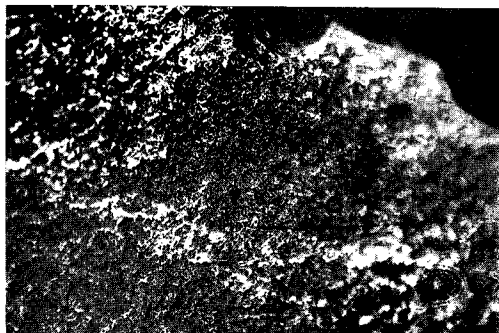


Fig. 42. Bright spots similar to use-wear in distribution, 100x.

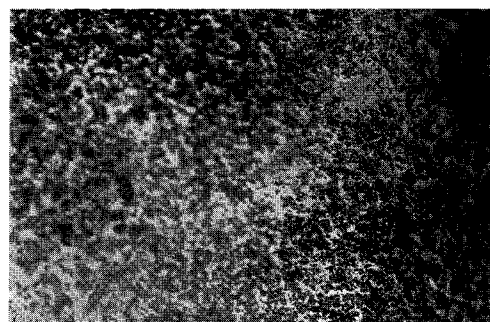


Fig. 46. Flat patches of bright spots on same artefact, 200x.

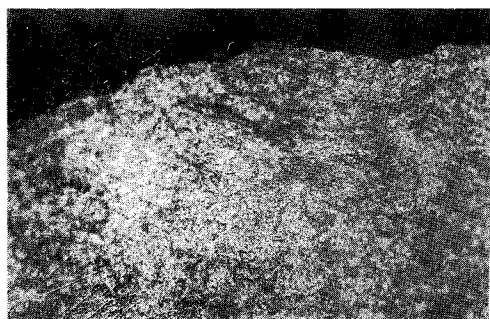


Fig. 43. « Polished » surface after 14 weeks in heated compost, 200x.

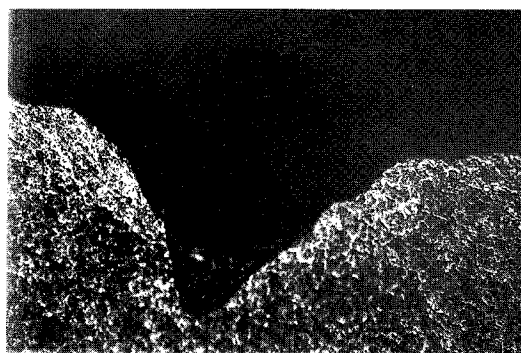


Fig. 47. Macroscopic sheen after 1 month on edge of coarser flint artefact (cf. fig. 45), 100x.

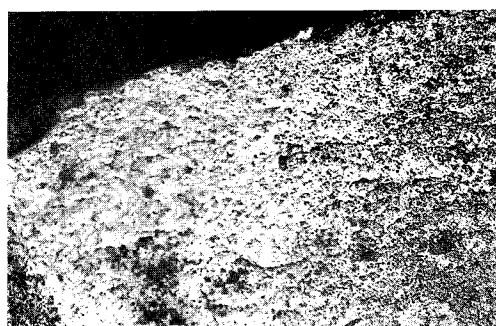


Fig. 44. « Polish » from trampling experiment at Klithi similar to fig. 3, 200x.

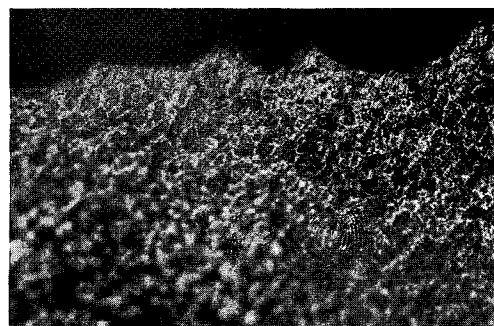


Fig. 48. Macroscopic sheen after 5 weeks on same artefact as in fig. 47, 200x.

less homogeneous Brandon flint developed « macroscopic » sheen first on the edges then inland and some bright spots (fig. 45 and 48) but did not start to patinate even after 50 days in the same solution.

An Israeli flint which is macroscopically very homogeneous but microscopically very different from Brandon flint had after two months just started to develop some microscopic alteration to its surface but no macroscopic gloss (fig. 49).

Although no marked weight loss occurred on the artefacts in these experiments, soil sheen, bright spots and patination seem to be surface modifications which are the result of silica dissolution and redeposition from the flint surface as suggested by Rottlaender (*ibid.*).

Alkaline conditions, and « abundant » water seem to be necessary for the process to occur. Presumably, in nature, temperatures of 25 degrees are sufficient to produce the same results over a much longer period of time than in the laboratory. Flint structures seem to influence the speed at which the process occurs and probably the type of alteration which will occur. The different diagenesis and resulting microstructure of Israeli flint might be responsible for the difference in results. It takes a very long time to polish the surface of this flint during use-wear experiments as well. The obstacles posed by the microstructure when a flint surface is being smoothed are the same whether the processes are chemical (as in PDSM) or mechanical (as in use-wear). It is possible that in these experiments the flint surface was being smoothed by some of the dissolved silica being redeposited in the interstices as suggested by Rottlaender (1976 : 56), who uses the expression « glossy patina » to describe what microwear analysts refer to as « soil sheen ». His explanation is worthy of being reported in full :

« Glossy patination occurs, if the concentration of the chemical agents are too weak to penetrate into the holes and the fissures of the flint. So they just remove the prominences of the flaked surfaces, because of their higher potential energy. Since the fissures and holes have a significantly lower potential energy than the normal surface, they act as pitfalls for silica acid occurring free in solution. By this mechanism the surface is smoothed and polished. »

Another experiment was carried out in which Sodium Carbonate Na_2CO_3 was used in an attempt

to patinate flint. Macroscopic sheen developed before the patination stage (fig. 45 and 51). The sheen developed much faster on Brandon flint than it did on Israeli flint. In the above-mentioned experiments sheen occurred in the early stages on the useful edges of tools mimicking use-wear.

This should serve as a word of caution to functional analysts to ascertain that traces they are analyzing on archaeological artefacts are without doubt the result of use. Sheen and bright spots are present on artefacts of all ages and provenances

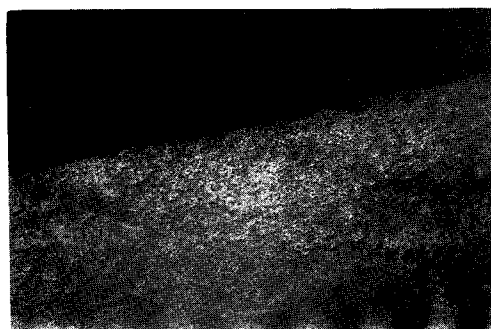


Fig. 49. Macroscopic sheen on very coarse flint after 2 months, 100x.

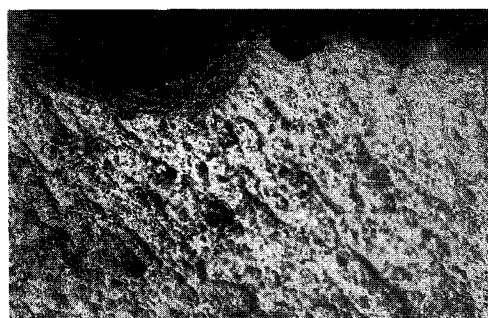


Fig. 50. Sheen similar to PDSM as in figure 51, 200x.

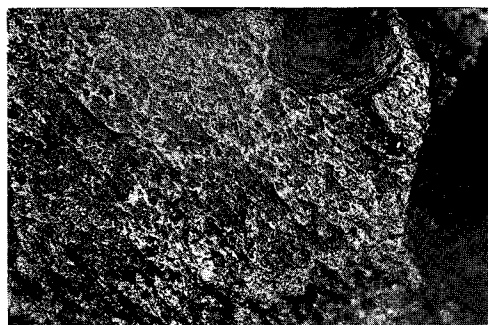


Fig. 51. PDSM on archaeological artefact similar to figure 50, 200x.

and use-wear studies should not be carried out on such implements as it is impossible generally to

isolate the real use-wear when this other smoothing of the surface is also present.

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