
Postdepositional changes on surfaces of flint artifacts as observed under a scanning electron microscope

*Jolanta KAMINSKA**
*Elzbieta MYCIELSKA-DOWGIALLO***
*Karol SZYMCZAK**

Résumé

Les surfaces de trois séries d'artefacts en silex provenant de sites sablonneux ont été examinées au microscope électronique à balayage pour l'identification de divers types d'endommagements naturels. On a reconnu trois facteurs principaux responsables de telles détériorations : le gel (climat périglacial), le facteur éolien et le facteur chimique (corrosion par les acides du sol).

Abstract

The surfaces of three series of flint artifacts coming from sandy sites were scrutinized under a scanning electron microscope in order to observe various types of natural damages. Three main factors were recognized to be responsible for such damages : frost (periglacial climate), eolian, and chemical (etching of soil acids).

Between the moment of discarding a flint artifact by its producer or user in prehistoric times and the moment of recovering it by archaeologists, a very long period of time elapses – a period of thousands of years. During this period the surface of a flint artifact is exposed to the action of various climatic and environmental factors which damage and transform it. Some of these transformations can be seen even with the naked eye (polishing, smoothing, glosses, changes of color) while others can be observed only with the use of smaller or greater magnifications. The scanning electron mi-

croscope is one of the instruments which can be used to make such observations.

The studies of traces mentioned above can allow the reconstruction, in part at least, of the history of an artifact and changes of its nearest environment. Research with very similar aims concerning the surfaces of sand quartz particles from various sediments and soils in different climatic zones is being done by sedimentologists and pedologists. The primary results of this research are very encouraging (Mycielska-Dowgiallo (ed.), 1988 ; Kowalkowski, 1988 ; Gozdzik, Mycielska-

Dowgiallo, Bezowska, Makowski, 1988 ; Whalley, 1978 ; Smart, Tovey, 1981).

We could enumerate at least three kinds of advantages deriving from studies of differentiation of flint artifacts' surfaces changed by natural factors. Firstly they give a possibility to settle or check the homogeneity of flint assemblages. This very important problem often arises especially in cases of dune or sandy sites, common in European lowlands. Secondly they can give some additional data for establishing the relative chronology of assemblages of different ages found on one site and mixed together, allowing at the same time reconstruction of some environmental factors. Thirdly, they form the essential background for studying the changes of the flint tools' surface connected with the functions of such tools, making it possible to distinguish and to correctly interpret various types of traces and damages of different origins.

In this article we introduce three examples of using a scanning electron microscope to study postdepositional changes on the surfaces of flint artifacts. The analysed assemblages come from Late Pleistocene and Early Holocene sandy sites in the Polish lowland. All studied artifacts are made of the same kind of raw material : the Cretaceous erratic flint, common in the area. None of the artifacts bore any visible traces of fire, frost or any other kind of natural damage.

The samples to be observed under the scanning electron microscope need special preparation. Initially small flat flakes (4-6 mm²) are taken from the artifact. They should be cleaned by immersion in distilled water, then in 10 % HCl solution for 24 hours and again in distilled water, and finally they should be rinsed in pure alcohol to be dehumidified properly. As we were not sure about the influence of HCl on the flint surfaces we prepared a parallel series of samples immersed only in acetone instead of HCl but during the observation it appeared that the way of cleaning the surfaces has no effect on their microscopic images, at least where natural damages are concerned.

The cleaned samples were glued to specially adapted metal discs (« stages ») 10 mm in diameter, and uniformly sputter-coated with gold.

All the arrangements described above are the routine treatment of samples which are to be viewed under a scanning electron microscope.

Our samples were observed in the Geological Institute in Warsaw. The costs were paid from the funds of the RPBP-III-35 project.

All specimens were scrutinized mainly at magnifications ranging from 400 to 4 000 times. Each of the appearing images was described in detail, and the most important and interesting parts were photographed. The selection of photographs presented in this article is only a very small part of the whole documentation.

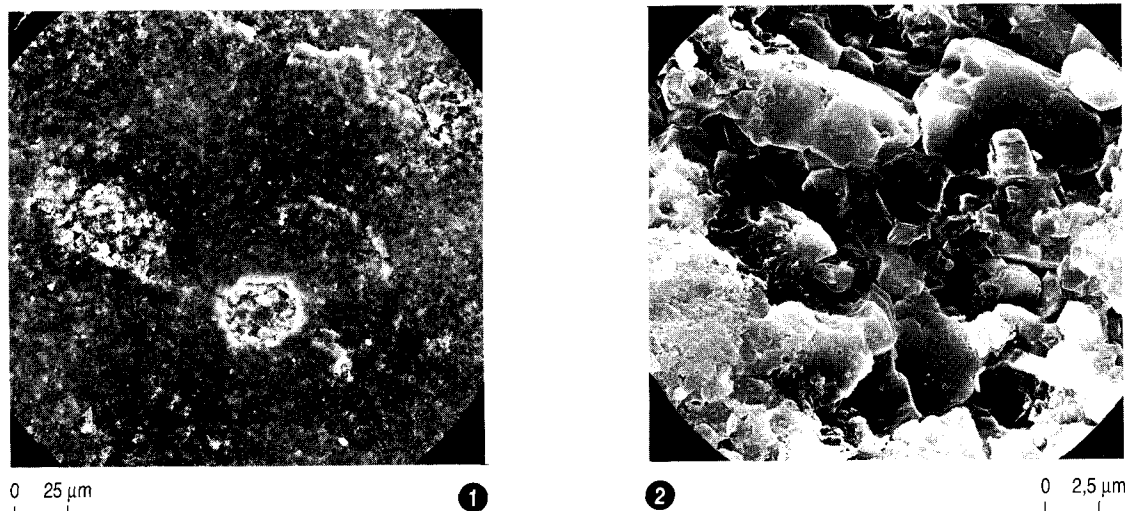
As we have already mentioned all three series of flint artifacts are made of this same kind of flint raw material. To better understand the changes in the artifacts' surfaces we examined first the images of freshly chipped fragments of this type of flint.

The surface of freshly chipped Cretaceous erratic flint viewed at 400x magnification is characterized by grainy texture on which the elongated edges of zones of higher splinting of the siliceous substance of the nodule can be seen (pl. I : 1). More or less regular depressions (holes) are also present (pl. I : 1). They are created most probably by water washing out less solid mineral or organic inclusions. In such holes secondary crystallization frequently follows (pl. I : 1, 2). At 4 000x magnification the siliceous background is rather uniform, monotonous, smooth and dull.

Calowanie, Warsaw voiv

The site in Calowanie yielded the detail stratigraphical sequence of at least six Late Pleistocene and Early Holocene settlement levels. All the levels were comprehensively examined not only in archaeological terms but also with absolute chronology (¹⁴C dates) ; geomorphology, geology and soils are all assessed (Schild, 1975 : 194-199). The results of these studies are very significant for the interpretation of the features observed under the scanning electron microscope. A series of flakes from each settlement level were chosen to be examined (levels I, III, IV, V, VI, VII-VIII – see : Schild, 1975 : 198-199).

The surfaces of the flint artifacts from level I when viewed at 400x magnification are characterized by relatively small foci or clusters of damage on the dull, lustreless, close-grainy background (pl. II : 1). On the same surface magnified 4 000x



Pl. I, 1, 2. The surface of freshly chipped Cretaceous erratic flint.

it was noted that in cluster-like damaged parts the surface is exfoliated. Scales forming a sort of cover or crust are partly separated from their bedding and often displaced (pl. II : 2). In some places the less damaged parts form island-like features (pl. II : 2). The exfoliation of the surface of the artifact and the displacement of the scales testify that it was exposed to mechanical damage done by sand particles moved by wind (eolian damage) while the characteristic focii and island-like features bear out the presence of permanent heavy frost in periglacial climate.

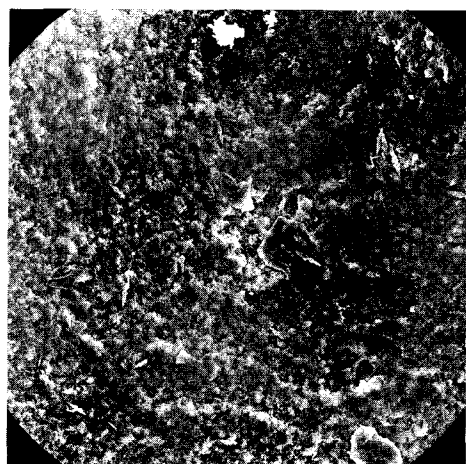
The artifacts from level III viewed at 400x magnification are characterized by dull, close-grained texture (pl. II : 3). Sometimes typical eolian edges can also be seen (pl. II : 3). On the same surface viewed at 4 000x magnification exfoliation can be observed. Also in this case the scales which form the crust are displaced (pl. II : 4). Very deep punctual etching also occurs (pl. II : 4). The features of the observed surfaces indicate that in this case we are dealing with the distinct traces of eolian factor (edges, displaced scales), but in addition we also have the traces of humic acids' etching (deep punctual holes) which prove that the artifact lied in active soil for a long time.

Level III in Calowanie has an uncalibrated ^{14}C date of $9\,430 \pm 95$ BC, while the date for level I was calculated to about 9 600 BC (beginnings of Allerod period). However, the conclusions derived from microscopic studies do not seem to be in full agreement with this chronology. All this has changed

with a newly obtained ^{14}C date for level III in Calowanie which is 9 700 BC (inf. Schild). It could also mean that the date for level I should be moved back to about 9 900 BC – the period of Dryas II, not Allerod. The newly established chronology for the bottommost levels in Calowanie is in accordance with the types of traces and damages found on the surfaces of flint artifacts coming from these levels.

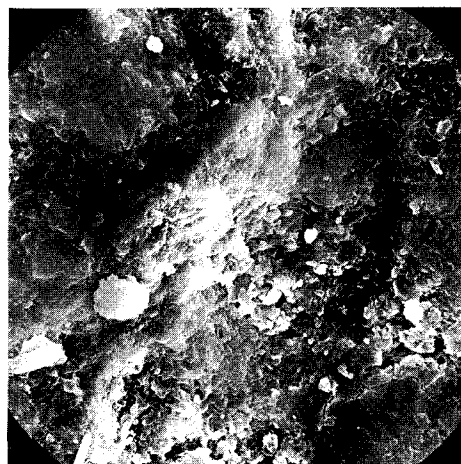
The surfaces of artifacts from level IV viewed at 400x magnification are characterized by fairly monotonous, close-grained texture (pl. II : 5). The parts with direct damage are also present, especially well seen in depressions (pl. II : 5). At 4 000x magnification inside the damaged depressions very deep punctual etching appears (pl. II : 6). Such damage can have the shape of deep slits with edges covered with a uniformly smooth siliceous crust (pl. II : 6). In depressions exfoliation sometimes occurs but the scales are not displaced from their bedding (pl. II : 6). Such images are very characteristic for the surfaces etched chemically by humic acids. Indeed, the assemblages from level IV come directly from the well preserved soil of Uesselo type dated to between $9\,240 \pm 65$ and $8\,790$ BC (Schild, 1975 : 198, 223).

The surfaces of the artifacts from level V viewed at 400x magnification are characterized by fine-grained texture and small focii of damage (pl. III : 1). At 4 000x magnification heavy exfoliation of the surface can be seen. The scales are often displaced



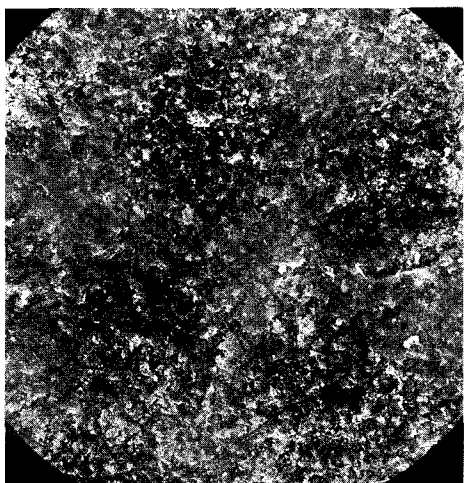
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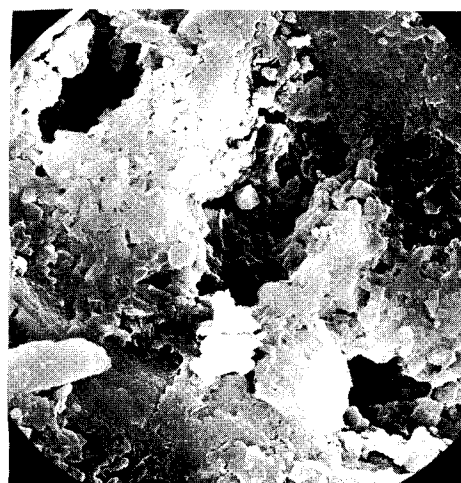
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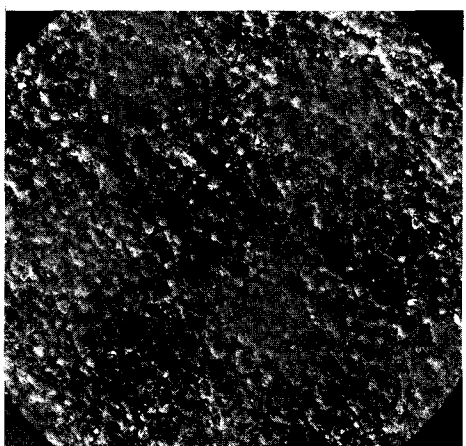
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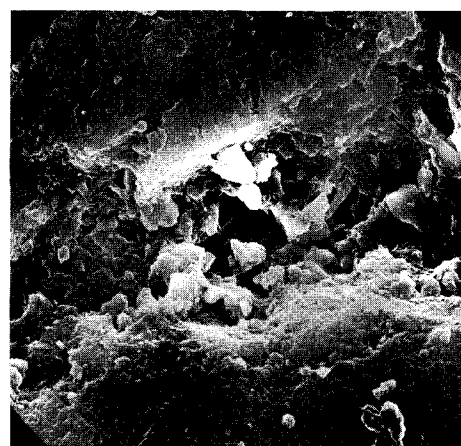
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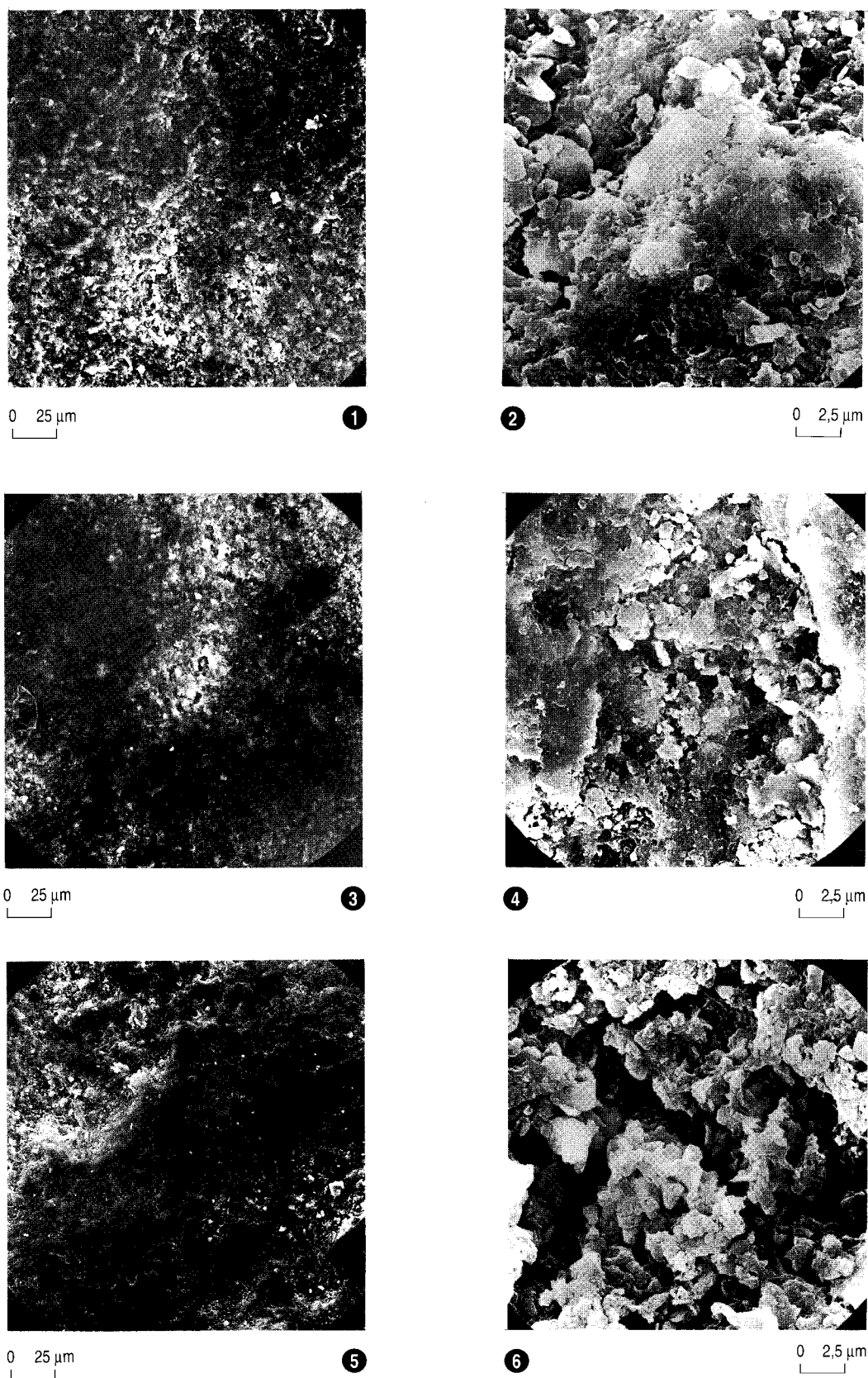
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Pl. II. The surface of artifacts from Calowanie. 1, 2. Level I. 3, 4. Level III. 5, 6. Level IV.



PI. III. The surface of artifacts from Calowanie. 1, 2. Level V. 3, 4. Level VI. 5, 6. Level VII-VIII.

from their bedding (pl. III : 2). Also present are the smoothed island-like features incised on one of their sides (pl. III : 2). The similar surfaces are shaped mainly by the eolian factor (displaced scales and incisions). These observations fit well with the chronology of this level, which is earlier than $8\,870 \pm 90$ and $8\,710 \pm 100$ BC – beginnings of Dryas III (Schild, 1975 : 198).

The surfaces of the artifacts coming from level VI viewed at 400x magnification are characterized by the smoothness of their convex parts and very heavy damage of the depressed parts (pl. III : 3).

At 4 000x magnification the wear of the convex parts displayed punctual etching and deeply etched slits (pl. III : 4). In the more damaged depressed parts, heavily and deeply cracked siliceous crust and a net of polygonal cracks can be observed (pl. III : 4). Also the traces of deep punctual penetration of humic acids could be recognized (pl. III : 4). Cracking of the crust can be explained by the presence of the freezing and thawing processes of a cold climate, however not excluded is the fact that the process of moistening and drying of the surfaces can give similar features. The majority of observed surfaces, however, were shaped by chemical etching via humic acids (damage of chemical type). This interpretation does not contradict the chronology of level VI in Calowanie – the turn of Pleistocene and Holocene (Schild, 1975 : 199).

The surfaces of the artifacts from level VII-VIII viewed at 400x magnification are characterized by very wide focii of damage in depressions and a fairly monotonous, smooth surface of convex parts (pl. III : 5). At 4 000x magnification it can be seen that the smooth parts are covered with crust which in this case is most probably not siliceous but carbonate. The crust is distinctly and deeply cracked (pl. III : 6). The statement that the crust is of carbonate origin can be attested by the fact that it could be partly dissolved in HCl. The cracks could be a result of changes in temperature as well as of changes of moisture in the nearest environment. The lower parts at the same magnification are extremely heavily exfoliated and cracked. The slits of such cracks are very deep (pl. III : 6). Thus, in this case, we have the heavy chemical etching together with accumulation of the carbonate crust on the artifacts' surfaces which is probably connected with soil processes. These observations correspond with the Boreal chronology of level

VII-VIII in Calowanie (Schild, Marczak, Krolik, 1975 : 59-60).

Burdeniszki, Suwalki voiv., site 4

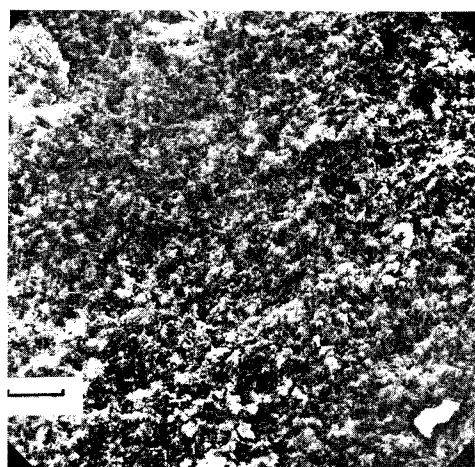
The flint inventory from site 4 in Burdeniszki is mechanically mixed, as are the majority of the Stone Age sandy sites in European lowlands. On a typological basis we could isolate from it the Late Palaeolithic elements (connected with the cultural groups with tanged points), Mesolithic elements (connected with Kunda culture) and Neolithic elements (connected with Globular Amphor culture – Kaminska, 1987 : 16-44, 52-58). For microscopic studies we have chosen the artifacts representing all these elements : 2 burins, an end-scraper, the combined tool (end-scraper + burin), tanged point – Late Palaeolithic, little end-scraper, blade insert of Borki type – Mesolithic, and 4 wide rectangular inserts – Neolithic.

On the examined series of flint artifacts from Burdeniszki three main types of surface damage were recognized :

1. The frost induced damage – viewed at 400x magnification, is characterized by highly damaged surface featuring focii or clusters of more intense scaling in the form of « lichens » (pl. IV : 5). The surface of such a « lichen patch » viewed at 4 000x magnification exhibits severe exfoliation. The resultant forms have an uneven irregular surface of the depression bottom and jagged edges (pl. IV : 6).

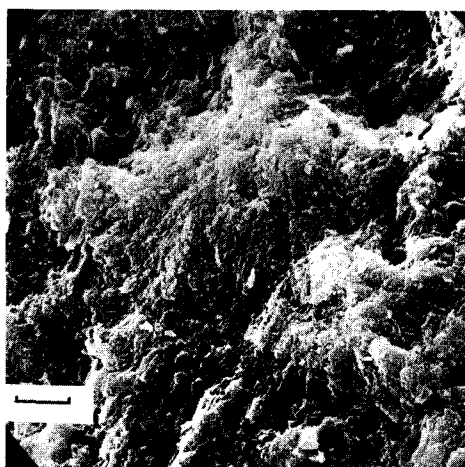
2. The eolian damage – viewed at 400x magnification, is strongly transformed from its uniformly grainy texture (pl. IV : 1). The same surface magnified 4 000x features incisions and exfoliation of all convex parts. The scales are displaced in relation to the bedding often forming a kind of crust (pl. IV : 2).

3. The chemical damage viewed at 400x magnification, also gives a close-grained image of the surface similar to the one affected by eolian factors (pl. IV : 3). The differences only become apparent at 4 000x magnification, which reveals deep irregular depressions and slits separated, most probably along the crystallographic net of the flint nodule, by the outermost forms partly connected with the siliceous background. These features are most probably the result of humic acids etching the surface of the artifact (pl. IV : 4).



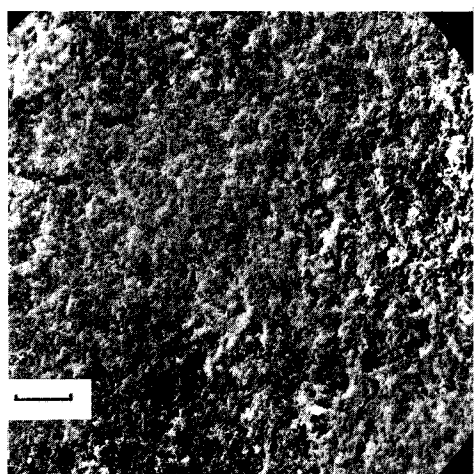
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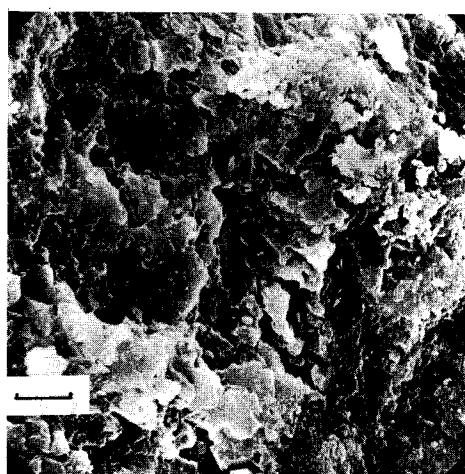
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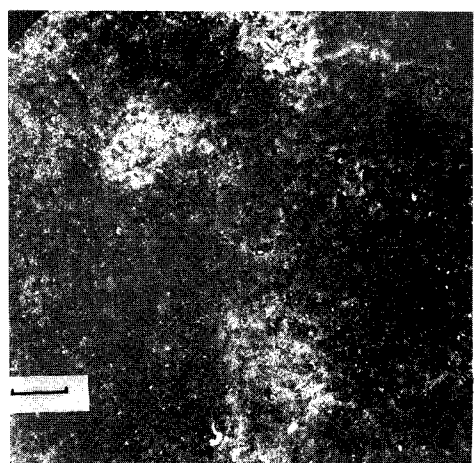
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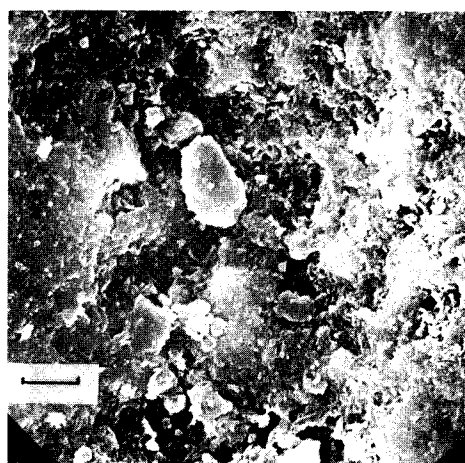
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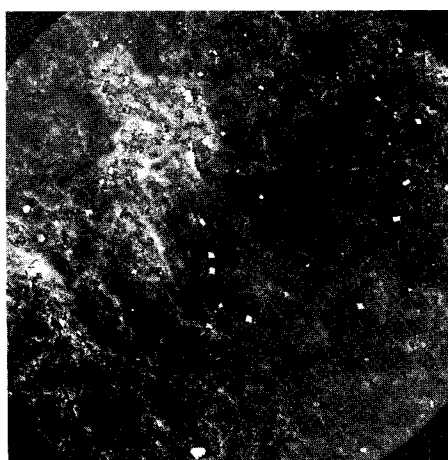


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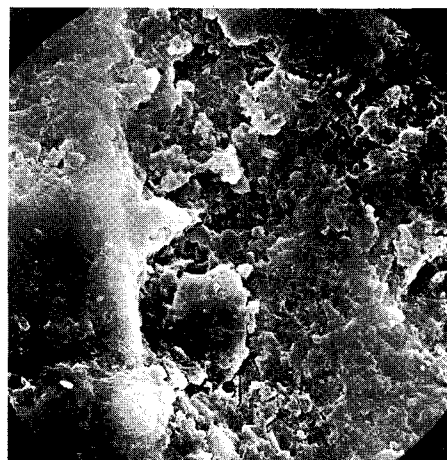
Pl. IV. The surfaces of artifacts from Burdeniszki 4.

1, 2. The eolian type of damage. 3, 4. The chemical type of damage. 5, 6. The frost type of damage.



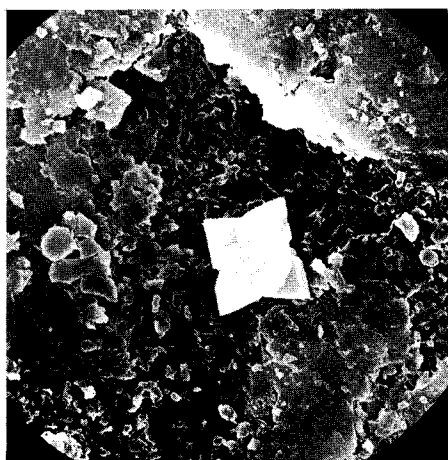
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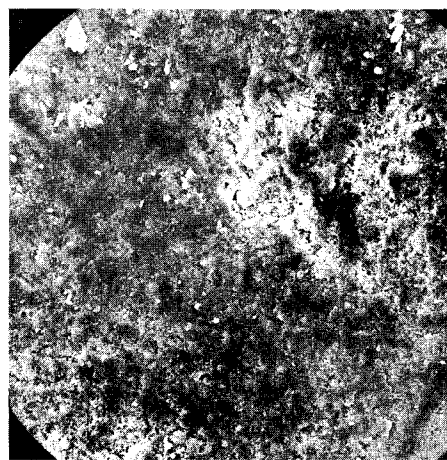
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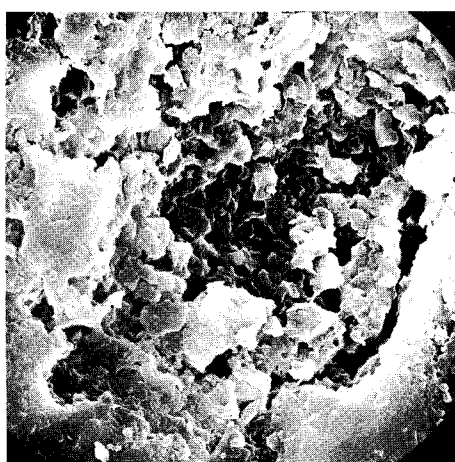
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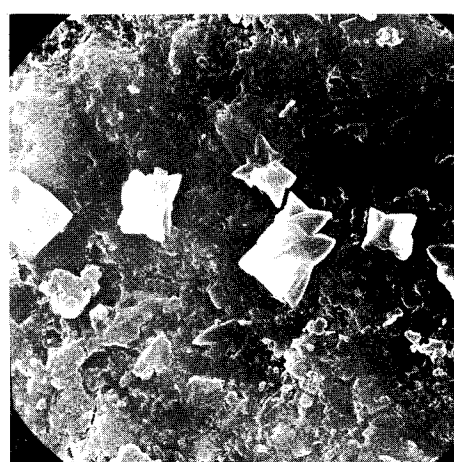
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Pl. V.– The surfaces of artifacts from Nowodworce. 1, 2, 3. The upper layer. 4, 5, 6. The lower layer.

On some of the artifacts the presence of more than one affecting factor could be observed but always one predominated.

In majority the artifacts of Late Palaeolithic character bear the traces of frost type damage which could agree with their probable chronology in Dryas III. The Early Mesolithic artifacts have their surfaces damaged mainly by the eolian or eolian-frost factor while on the Neolithic inserts the chemical or eolian-chemical damage dominates.

Nowodworce, Białystok voiv., site 1

On site 1 in Nowodworce in trench I, two layers of the Holocene settlement were found: the upper layer which is Late Mesolithic, dated on typological grounds to the second half of Atlantic period, and the lower layer connected with post-Late Palaeolithic traditions, dated using thermoluminescence and confirmed by the results of geological, geomorphological and soil analysis for the Boreal period (Nowak, 1981: 361, 364-365, 368; Szymczak, 1983: 6, vol. II).

Two flint flakes from both layers found in the same square metre of trench I were chosen to be scrutinized under a scanning electron microscope.

The surface of the artifact from the upper layer observed at 400x magnification is monotonously smooth in its convex parts, showing only a few foci of damage (pl. V: 1). The edges marking zones of natural splintering of the flint nodule are distinctly smoothed (pl. V: 1, 2). The heaviest etching can be seen in small depressions which sometimes take the shape of elongated directed slits (pl. V: 1, 2). White dots seen on plate V: 1, are the crystals of calcite which are the result of secondary precipitation on the artifacts' surface.

The same surface viewed at 4 000x magnification is smoothed in convex parts, especially clearly on the edges (pl. V: 2, 3). The punctual etching is faintly marked. At the same time in depressions the process of accumulation can be observed (pl. V: 3). Some of the accumulated substances could be recognized (for instance crystal calcite) while the others are rather hard to qualify solely by their microscopic image.

The surface of the artifact from the lower layer viewed at 400x magnification is characterized in its convex parts by an extremely smooth surface, even smoother than the one on the previous sample. However, the zones of damage in the depressions seem to be considerably vaster (pl. V: 4).

At 4 000x magnification the convex parts of the same surface are smooth and not exfoliated but the traces of punctual etching are more intensive than on the artifact from the upper layer. In depressions only the traces of secondary accumulation of siliceous substances were observed. These parts were heavily cracked and exfoliated and some of the scales are moved from their primary bedding (pl. V: 5). Also here punctual etching is visible. Secondary precipitated calcite crystals are much more numerous. In some cases they even can be sunk into the bedding (pl. V: 6).

The images of the scrutinized artifacts differ from one another. Though in both cases the traces of chemical etching dominate, on the artifact from the upper layer mainly the process of accumulation appears, while on the artifact from the lower layer the most important feature is deep punctual etching. Also on the surface of the former the traces of eolian damage and cracks are absent while they are clearly visible on the surface of the latter artifact.

To summarize the results of the present investigations we can say that they are able to give archaeology some additional data to solve the problems of homogeneity, chronology and environmental studies of Stone Age sites. We are well aware that our results require some better confirmation and further analysis. Undoubtedly such research should be widened to incorporate other types of sites, not only sandy ones, and also different types of flint raw material. It should be repeated that studies of this type are necessary in order to distinguish properly the traces of purely functional origin on the flint tool surfaces observed under a scanning electron microscope.

* *Institute of Archaeology, Warsaw University,
00023 Warsaw, Poland.*

** *Institute of Geography, Warsaw University,
00023 Warsaw, Poland.*

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