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FLINT MINING AMONG THE EARLY FARMING COMMUNITIES OF CENTRAL EUROPE

This paper discusses the main deposits of the siliceous rocks in Central Europe and its vicinity, and the methods of their exploitation among the earliest farming communities. The meaning of the terms "deposit", "mine", and "mining" in the context of studies of the primitive communities is considered. The methods of extracting the raw materials, from the simple stholes to underground galleries, are distinguished and they are illustrated with examples of the mining workings. The chronology of mining of the siliceous rocks in Central Europe, based on ^{14}C dates, is presented and compared with ^{14}C dating for other regions of prehistoric mining in Europe. It is shown that the beginnings of mining of the early farming communities are connected with LBK (Danubian I) in the second half of the 5th Mill.b.c. The development of mining of the siliceous rocks lasts through the 4–3 Mill.b.c. and its decline takes place around the middle of the 2nd Mill.b.c.

INTRODUCTION

When in 1933 Grahame Clark and Stuart Piggott published their famous article — *The Age of the British Flint Mines* — they mentioned almost 40 flint mines for the whole of Europe. But no mine from Central Europe is among them, not even the one at Krzemionki Opatowskie which was already known (Radwan 1926; Stelmachowska 1927; J. Żurowski 1929) nor the mines at Krasnoye Selo (Szmit 1926) in Poland or Mauer near Vienna in Austria (Bayer 1930). The nearest to this area were the mines at Rijckholt—St.Geertruid in the Dutch Limburg and in the region of Malmo in Sweden. Although today we know much more about the prehistoric flint mining in Central Europe, as a result of the work of archaeologists from many countries, the results of those studies are not very well known because of the language barriers and the difficulties with getting the literature. These difficulties were stressed lately by E. Schmid (1973a, 15). It is one of the reasons why I have prepared this article.

The second reason arises from the need to discuss certain problems connected with the oldest European flint mining. We must include here the meaning of such terms as "deposit", "mine" and "mining". The problem of typology of methods of obtaining siliceous rocks among primitive communities is connected with that. Another interesting field is linked with the social aspects of prehistoric mining, based on the archaeological sources. It seems that twenty years after the publication of the well known work by M. Jahn — *Der alteste Bergbau in Europa* — we can look at some problems of flint mining in prehistoric Europe in a different way.

I. DEPOSITS

Mineral resources form in the earth crust natural agglomerations suitable for mining if they meet certain quantitative and qualitative requirements (Gruszczak 1972, 11). In such cases they are called "deposits". Agglomerations which do not fulfil such conditions are called "outcrops". In the Atlantic and Subboreal periods the need for flints were directly shaped by the constant demand connected with permanent wearing out of tools made of this raw material in every-day work, and by the cultural tradition which controlled their method of production. The abilities and technical knowledge in the field of flint treatment were important. They allowed, to a certain degree, adaptation of the material to the existing patterns. The value of demand was also influenced by the population numbers and its density. Taking things theoretically each mineral or rock agglo-

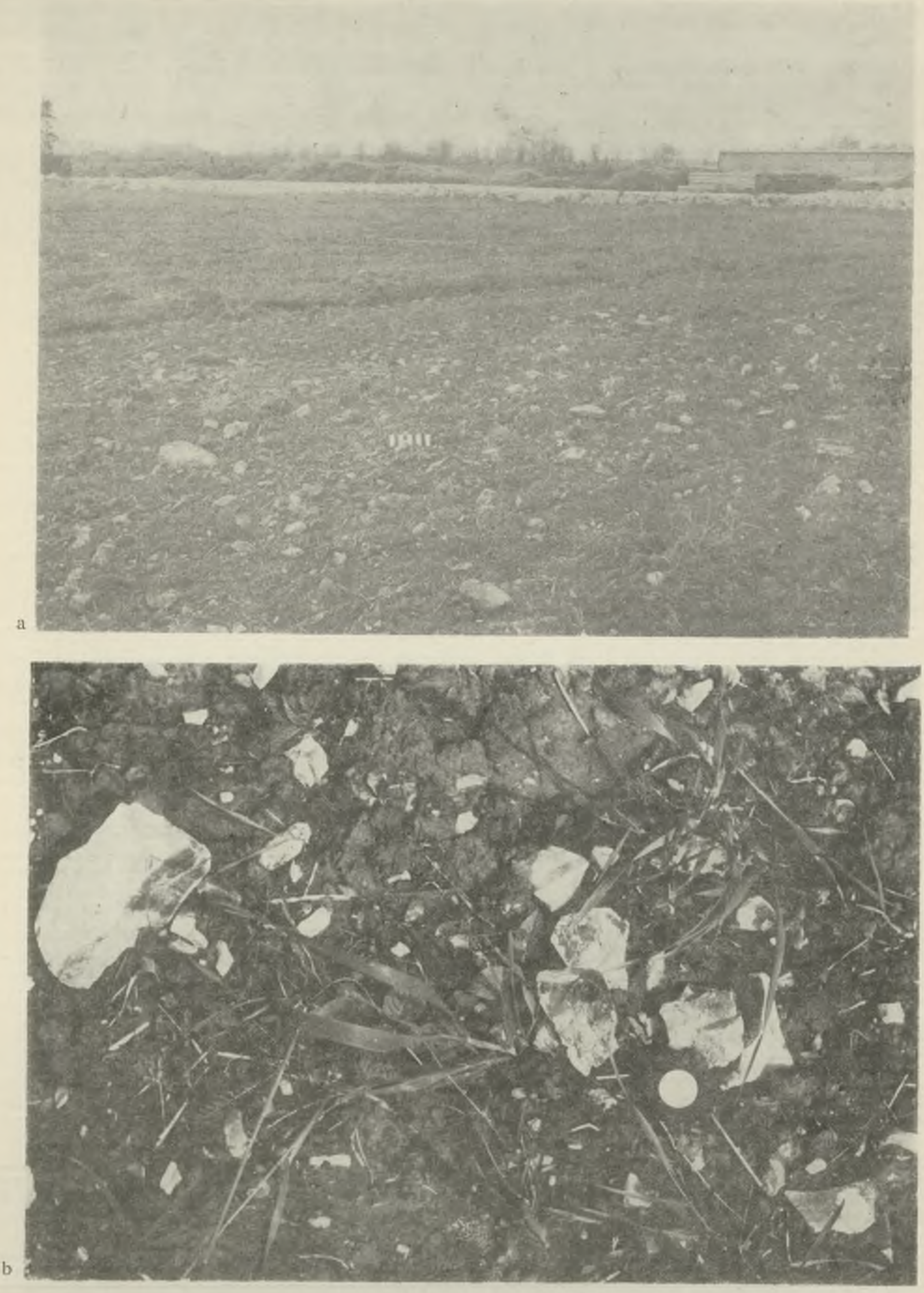


Fig. 1. Surface appearance of sites categorised as "points of raw material exploitation"

a — Wierzbica „Zele", Radom dist. Scale 20 cm; b — Czajowice, Cracow dist. Diameter of white circle 3 cm

Photo by J.Lech

meration in the earth crust could be recognized as a deposit. In practice, natural, economical-technical factors are decisive for distinguishing "the deposits" (Gruszczak 1972, 12). As a result, the meaning of the term "deposit" is strictly conditioned historically and it should be always related to the period under discussion.

The development of mining among prehistoric communities resulted from the fact that obtaining the proper amount of flint, of the right kind was a technological and economic necessity as well. This situation can be already observed in certain areas of Central Europe in the late Pleistocene (Schild 1976a, 162–170; 1976b, 98 f.), and next in the early Holocene. The great development of the flint mining in Central Europe takes place with the appearance of the earliest farming communities.

The recognition which of the flint rock agglomerations in the given region can be considered as a deposit in the prehistoric research and which as an outcrop should be based on the archaeological criteria. In prehistory it depended on geological knowledge, technical and organization possibilities, and on the needs of the human communities. An additional element was the contemporary pattern of contacts and divisions, both cultural and political ones. Current studies on the prehistoric flint mining in Europe give in this respect several convincing examples. Often, especially in the mines extracting the raw materials from the Cretaceous layers in North-Western and Western Europe, a phenomenon of drilling the shafts through other layers of flint to the right exploitation horizon can be observed. Such cases are the mines at Grime's Graves and Easton Down in England, Rijckholt—St. Geertruid in Holland, Spiennes in Belgium, and in Poland the mines at Krzemionki Opatowskie and at Świeciechów (Armstrong 1923, 114; Stone 1931, 354; T. Żurowski 1960; 1962; P. J. Felder, Rademakers 1971, 39–45; Balcer 1975, 52, 149–157; Hubert 1978, 8–22). A typical example is the rarity of the local Striped flint of Krzemionki type among the Danubian communities, although was commonly used in the Funnel Beaker culture (TRB) in the Little Poland (Małopolska). And the other way round, chocolate flint commonly utilized by the Danubian communities was only exceptionally found in the materials of the Funnel Beaker culture communities in South Poland.

The basic criterium for the definition of the raw material deposits is the discovery of the traces of their mining exploitation or systematic processing, finding its expression in the existence of the flint workshops. In the surface survey they take the form of so-called raw material exploitation points. This name is given to the archaeological sites which do not have any visible remains of a mining landscape but are characterized by the presence on the surface of the large amounts of flint industrial waste from the preliminary phases of the processing, damaged pieces and the waste raw material etc. (Fig. 1). This category of sites covers flint mines and flint workshops which are in the vicinity of the deposit (Schild 1971, 5 f.; Lech 1975a, 145 f.).

II. RAW MATERIALS

Various raw materials used in the flint industries of the early farming communities occur in Central Europe (Fig. 2). They are not evenly distributed over the whole area. The research is complicated by the different degrees of their recognition in the particular regions. We know best the raw materials from Poland, Bavaria, the northern Rhine and Limburg, relatively less about those from Bohemia, Moravia, West Ukraine and West White Russia, and least of all from GDR, Slovakia, Hungary and Austria.

In recent years, much attention was given to the Cretaceous flints from the territory of Limburg, Aldenhovener Platte and adjacent areas — the region of Maastricht—Liège—Aachen by the Dutch and German scientists (I *Symposium*, II *Symposium*, Löhr 1975; Löhr, Zimmermann, Hahn 1977, 151–160; W. M. Felder et alii 1979). The Rijckholt flint exploited from the Lanaye chalk of the Gulpen Maastrichtien formation is the most important one in this region (Fig. 3). It was extruded from the territory of the known Rijckholt—St. Geertruid mine, situated on the right bank of the Maas river near Maastricht. The siliceous mass of the nodule is black, in some places dark grey; the cortex — white, sometimes thick. Among 23 flint layers in the Lanaye chalk (Fig. 4), at Rijckholt mine the layer No 10 and at a smaller range No 5 and 6 were the subject of the exploitation (Löhr, Zimmermann, Hahn 1977, 157 f.; W. M. Felder et alii 1979, 51–64 — where further literature is cited).

Another typical flint for this area is that from Rullen. It is honey coloured, with a hard, thick white cortex. It occurs in the region of Rullen and Banholt (Fig. 5; Löhr 1975, 95 f.; Löhr, Zimmermann, Hahn 1977, 156 f.; W. M. Felder et alii 1979, 69–72).

The third recently discovered centre of prehistoric flint mining is in the region of Valkenburg, Cadier en Keer and Cronsveld. Flint extruded there is most frequently coloured light grey to blue grey and is describ-

1 — Krasnoye Selo
2 — Karpovcy
3 — Polovla
4 — Gorodok, Višnevaya Gora
5 — Studenica, Belaya Gora
6 — Orońsko
7 — Tomaszów
8 — Wierzbica „Zele"
9 — Polany Kolonie
10 — Polany
11 — Gliniany
12 — Krzemionki
13 — Ruda Kościelna
14 — Borownia
15 — Korycizna
16 — Ożarów
17 — Świeciechów
18 — Sąspów
19 — Jerzmanowice-Dąbrówka
20 — Bębło
21 — Wołowice
22 — Maków
23 — Vienna-Mauer
24 — Tata-Kálváriadomb
25 — Sümeg-Mogyorósdomb
26 — Tušimice
27 — Bečov
28 — Lengfeld
29 — Kleinkems, Kachelfluh
30 — Lousberg, Aachen
31 — Löwenburg
32 — Olten
33 — Rijckholt—St.Geertruid
34 — Jandrain-Jandrenouille
35 — Spiennes
36 — Mesvin
37 — Veaux-Malaucène
38 — Kvarnby
39 — Aalborg
40 — Grime's Graves
41 — Cissbury
42 — Harrow Hill
43 — Church Hill
44 — Blackpatch
45 — Easton Down
a — Novoselký
b — Muravica
c — Listvin
d — Brzoskwinia
e — Vienna-Lainz
f — Skršín
g — Kozákov
h — Sv. Sidonie
i — Poznań-Starołęka
j — Gorzów Wielkopolski-Chwalęcice
k — Abensberg
l — Asch, Borgerhau
m — Eitensheim-St.Salvator
n — Haunsheim, Im Glind
o — Ochsenhart
p — Inching
q — Ochsenfeld-Tempelhof
r — Baiersdorf
s — Seulohe-Südwest
t — Sangen, Valkenburg
u — Geböschke, Valkenburg
v — Banholt
w — Mheer
x — St.Pietersvoeren
y — Rullen
z — Remersdaal

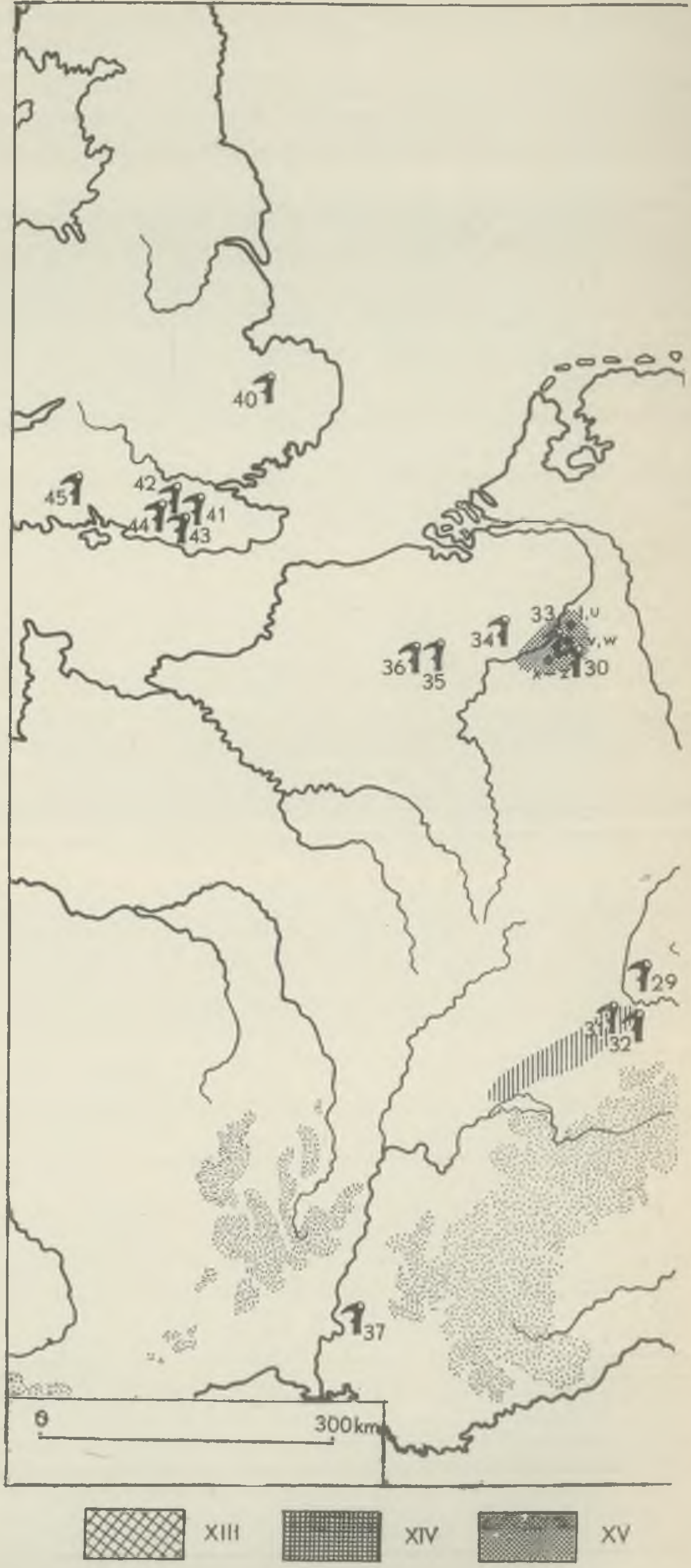
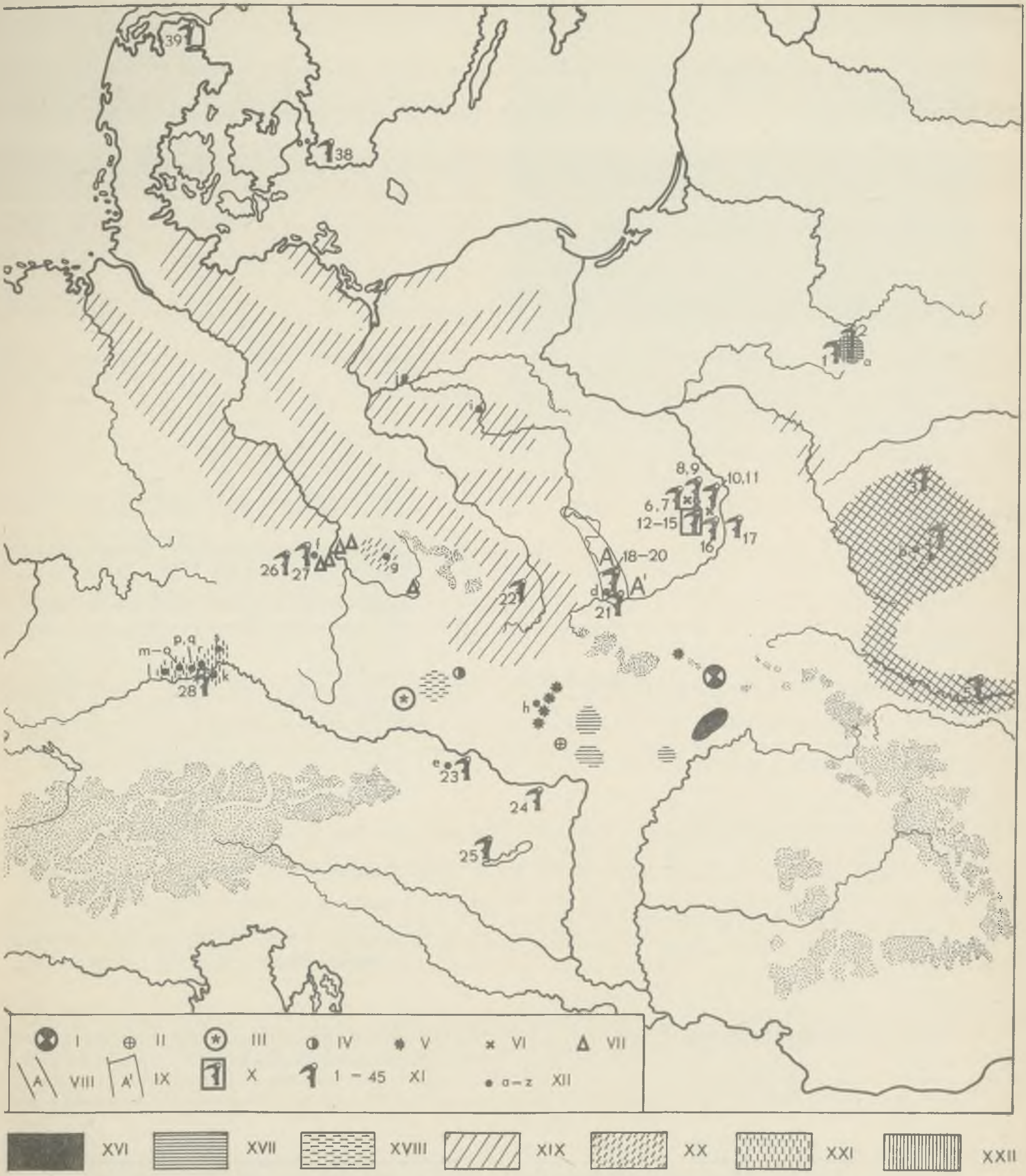


Fig. 2. Map showing occurrence

I — opal jasper in the northern part of the Slanské Vrchy Mountains
II — withe hornstones from the Tribeč Mountains
III — „the Boskovštejn plasma type"
IV — Upper Jurassic Oxford flints and hornstones of Stranská skala type
V — radiolarite deposits in the White Carpathian Mountains and in the upper basin of the River Poprad
VI — "chocolat" flints in the nort-east fringes of the Holy Cross Mountains
VII — porcelanites from Bohemia
VIII — Upper Jurassic flints from the Polish Jura



of chief siliceous rocks, mines and probable mines in Central Europe and neighbouring territories

IX — Jurassic-Cracow flints in the Cracow region, south of the Polish Jura
X — Upper Jurassic striped flint of the Krzemionki type
XI — mines
XII — probable mines
XIII — zone of Cretaceous Volhynian and Dnestr flints
XIV — Cretaceous flint of the Roś type
XV — Cretaceous flints from the region of Maastricht—Liège—Aachen
XVI — Obsidian in the Tertiary volcanic rocks of the Zemplin Uplands
XVII — "limnoquarzits" in the Kremnické vrchy, Vtačnik and Štiavnicke vrchy Mountains in Slovakia, and in the region of Miscolc in Hungary
XVIII — hornstones of Moravský Krumlov type
XIX — Cretaceous erratic Senonian flints (Baltic Flints)
XX — jaspers in the region of Turnov and the Jizerské hory Mountains
XXI — Upper Jurassic flints and hornstones in the south part of Frankische Alb, around the Danube in Bavaria, in the region of Ingolstadt, Kelheim and Regensburg
XXII — flints of the Swiss Jura

Fig. 3. Quarry ENCI, Sint Pietersberg near Maastricht. Section of the Gulpen-Maastricht Formation with many layers of flint nodules

Photo by J.Lech

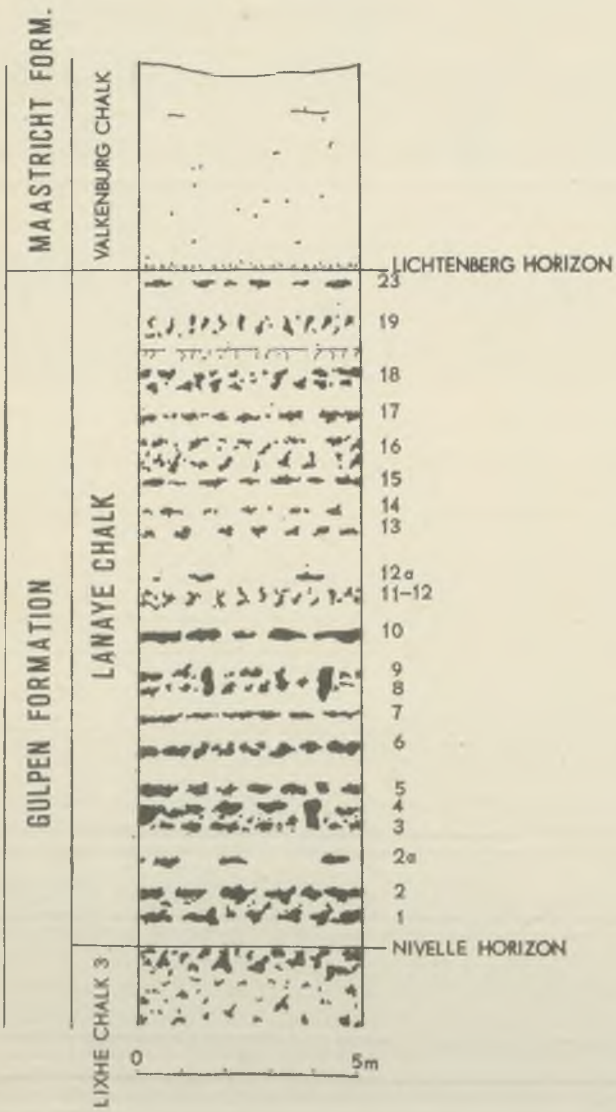


Fig. 4. Rijckholt—St.Geertruid near Maastricht. Lithological section of the Lanaye Chalk

After W.M.Felder et alii

ed as the Valkenburg flint. It originates from the Cretaceous formation of Maastricht (W. M. Felder 1975; Löhr 1975, 96; W. M. Felder et alii 1979, 46–50).

The easternmost point for Cretaceous flint exploitation is situated at Lousberg near Aachen (Fig. 6). The characteristic flint with brown and bluish stripes was extruded there. It originates from the Cretaceous Maastricht formation (Löhr 1975, 96; Löhr, Zimmermann, Hahn 1977, 157; W. M. Felder et alii 1979, 65–67).

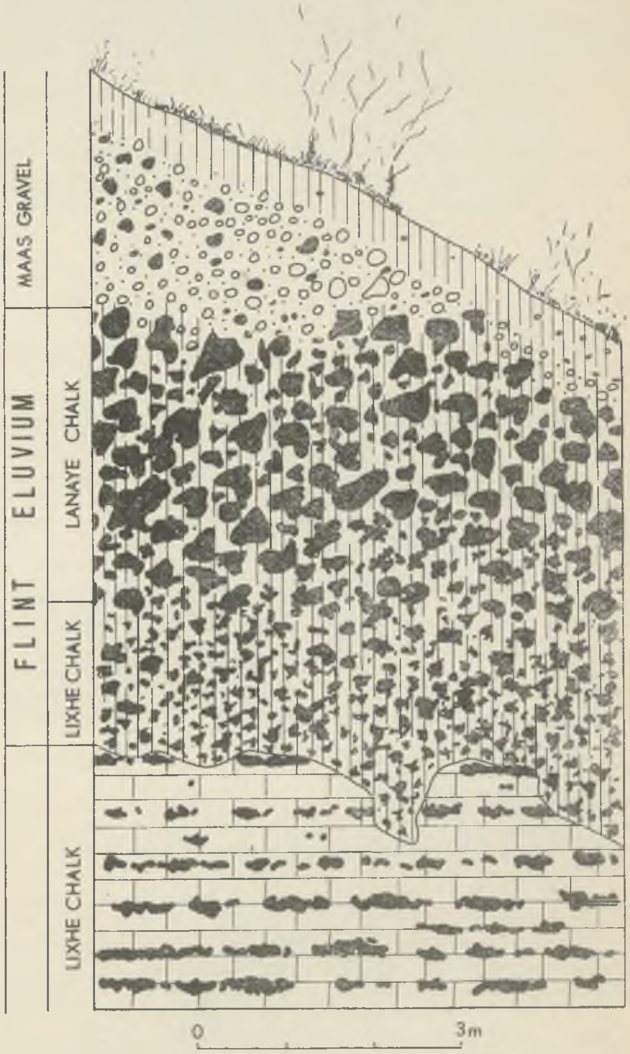


Fig. 5. Banholt and Mheer near Maastricht. Schematic section of the flint occurrences in the flint eluvium at the Neolithic flint mine and workshops

After W.M.Felder et alii

All of the above flint types, and Rijckholt flint in particular, occur in the Pleistocene gravels of this area as well. These secondary deposits are sometimes several km away from the points of their occurrence in the bed rock. The state of flint preservation is much poorer there, and the cortex frequently torn off. Certain changes in the colour in comparison with the raw material from the bed rock are visible (Löhr, Zimmermann, Hahn 1977, 158–160).

Very rich deposits of flint of various colours and of Upper Jurassic hornstones (malm) occur in the south part of Frankische Alb, around the Danube in Bavaria, in the region of Ingolstadt, Kelheim and Regensburg. So-called *Plattensilex* or *Plattenhornsteine* is another typical raw material from this area, besides flint nodules. The colour of the hornstones and flints is usually from grey to blue. Pieces coloured yellow or brown also occur. Rarer is the greenish or bluish to black colour. Platy striped hornstones constitute another characteristic group. Stripes of various colours and width are parallel to the cortex surface. The thickness of the striped hornstones layer and of *Plattensilex* is frequently of about 10 mm (Reisch 1973; 1974; Davis 1975, 19–23; Moser 1978 – where further literature is cited). Farther eastwards from Regensburg dark, flat or kidney-shaped hornstones occur in deposits around Ortenburg and Vilshofen (Davis 1975, p. 21 f.).

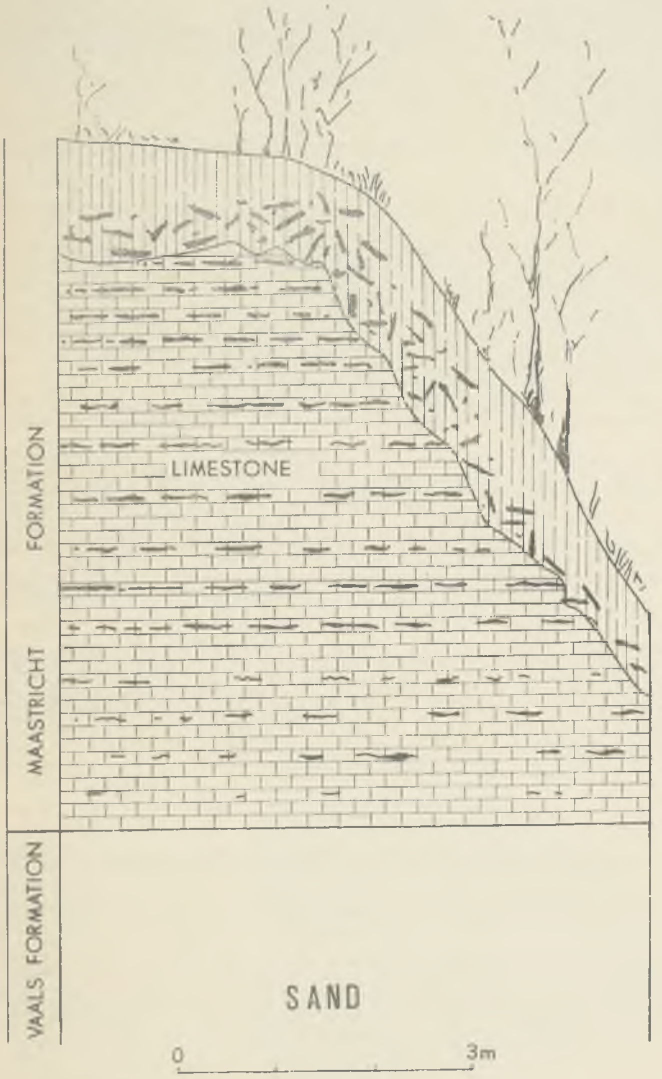


Fig. 6. Lousberg near Aachen. Schematic section of the flint occurrences in the limestone and slope deposits at the flint mine and workshops on the highest part of the site

After W.M.Felder et alii

Fig. 7. Tušimice. Chomutov dist. Quartzite nodules in the mother sandstone rock in the roof of gallery No. 1

After E.Neustupný

In Bohemia quartzites are the best raw materials and they occur in the north-western part of the country, in the foreland of Krušné hory. Three types of quartzites can be distinguished.[1] The Tušimice type originates from the deposits directly to the east of Kadaň (Fig. 7). The rock mass consists of fine sand grains cemented together and which have a yellowish, or more rarely a whitish or bluish colour (Neustupný 1963; 1966). The Bečov type of quartzite usually has a more coarse-grained structure than the Tušimice quartzite type and the colour varies from whitish through bluish and on to grey. In the archaeological literature it was discussed by K. Žebera (1966) and J. Fridrich (1972). The Skršín type of quartzite has quite a smooth surface, and is of a grey colour with characteristic red stripes (which are not present on each flake). Quartzite deposits of Bečov and Skršín type are found north-east of Most.

Another raw material frequently met in Bohemia is porcellanite. The region of its occurrence is in České středohoři, between Louny and Česka Lipa. Porcellanites in the region of Pardubice, and also at Bylany, originate from the local deposits in Kunětická hora, north of Pardubice. At the beginning when the tool is first made the porcellanite gives a sharp edge. It is also easy to process. In contact with water it becomes soft. For

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[1] All basic information on raw materials from Bohemia I owe to Dr.Slavomil Vencl C.Sc. of the Institute of Archaeology ČSAV in Prague; compare also Vencl 1971.

that reason all prehistoric tools made of porcellanites are soft when discovered, with mealy surface, reminiscent of chalk. Their most characteristic feature is water absorption. It is because of their chemical structure and origin.

In Bohemia, north-east of Mladá Boleslav, in the region of Turnov and the Jizerské hory Mountains, jasper occurs (Pleslová-Štiková 1959). From the macroscopic point of view it is often very similar to radiolarites. In such cases it can be distinguished only with the help of the microscope. In the microsection the radiolarians are visible, which are missing in jaspers. Some jaspers have a red-brick colour unkown in radiolarites. Some semiprecious stones, rock crystal and hornstones (usually of very bad quality) are important locally in the flint industry in Bohemia.

Fig. 8. Polany, Radom dist. "Chocolate" flint nodules originating from Tertiary eluvial clays. Scale 20 cm

Photo by J.Lech

It is very difficult to estimate the importance of various stone raw materials from Moravia in the tool production of early farming communities. The most important ones were hornstones of Moravský Krumlov type occurring in southern Moravia. They are found in the secondary deposits in the form of pebbles in the Tertiary sandy deposits of Neogene date. Most often their surface is smooth and black. They have no cortex. Their fracture is uneven, and their colour from blue to grey.

Further south, north-west of Znojmo, in the region of Jevišovice, a kind of opal (the so-called plasma) occur in the degraded serpentine marbles.[2] This name is used for the opal containing in its mass the relicts of the rock from which it originated; in this case these were serpentine marbles from the Proterozoic age. The process of "plasma" creation was taking place in the degraded serpentine marbles in the Tertiary. In the archaeological materials honey-brown coloured "plasma" occurs most frequently. Because of its common presence at the site in Boskovštejn,[3] I will describe it as "the Boskovštejn plasma type". It is possible that in future other name originating from the site of its mining exploitation would appear more proper. Škorpion hill (421 m above sea level) close to Boskovštejn could be such a site.

Flints and Upper Jurassic Oxford hornstones, of Stranská skala type constitute the third kind of stone raw materials in Moravia. Their deposits are in the suburbs of Brno. The siliceous mass has a grey and sometimes slightly brown colour. Its surface is dull and slightly rough. The cortex is usually rather thick and hard.

On the border of Moravia and Slovakia, in the White Carpathian Mountains, along the middle course of the Vah river there are radiolarite deposits. Currently, the only currently localized region of their exploitation is in the Vlara river basin, in east Moravia, eastwards from the town of Slavičin.[4] A large number of raw material exploitation points as well as processing workshops were found there (Vencl 1967). The second region where radiolarite occurs is in the upper basin of the River Poprad (Bárta 1979).

The two most important regions with flint deposits which were exploited in prehistoric times are in Poland in the upper Vistula river basin. They are in the vicinity of the Holy Cross Mountains (Góry Świętokrzyskie) and in the southern part of the Polish Jura (in other words the Cracow-Częstochowa Upland).

In the north-east fringes of the Holy Cross Mountains between the place called Gliniany, on the right bank of the Kamienna river, and Chronów Kolonie — south-west of Radom — there are numerous types of "chocolate" flint present in a band 70 km long and 3–5 km wide (Schild 1971; 1976a). They were exploited from the roof of the Upper Jurassic platy limestones of Kimmeridgian date and from eluvial clays (Fig. 8). These flints have a uniform siliceous mass and the colour varies from honey to black. But the most common are varieties of chocolate colour. The line cortex, hard and even, has thickness from approx. 1 mm to approx. 1 cm, depending on the place of the nodulus and deposit.

Not far away from Ostrowiec Świętokrzyski, in the region of Krzemionki Opatowskie, Ruda Kościelna, Borownia and Korycizna there are deposits and mines of Upper Jurassic striped flint (Fig. 9). After the famous mine they are described by the common name (as the Krzemionki type), but it should be stressed that varieties

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[2] Information on "plasma" geology and geology of other siliceous rocks in Moravia I owe to Dr.Antonín Přichystal from the Geological Institute in Brno.

[3] Collection of the Moravian Museum in Brno.

[4] I obtained information on radiolarites from the area of the White Carpathian Mountains, and from the region of the Vlara river in particular, from Dr. Jiři Pavelčik C.Sc. of the Branch of the Archaeological Institute ČSAV in Opava.

Fig. 9. Krzemionki Opatowskie near Ostrowiec Świętokrzyski, Kielce dist. Striped flint

Photo by S.Biniewski

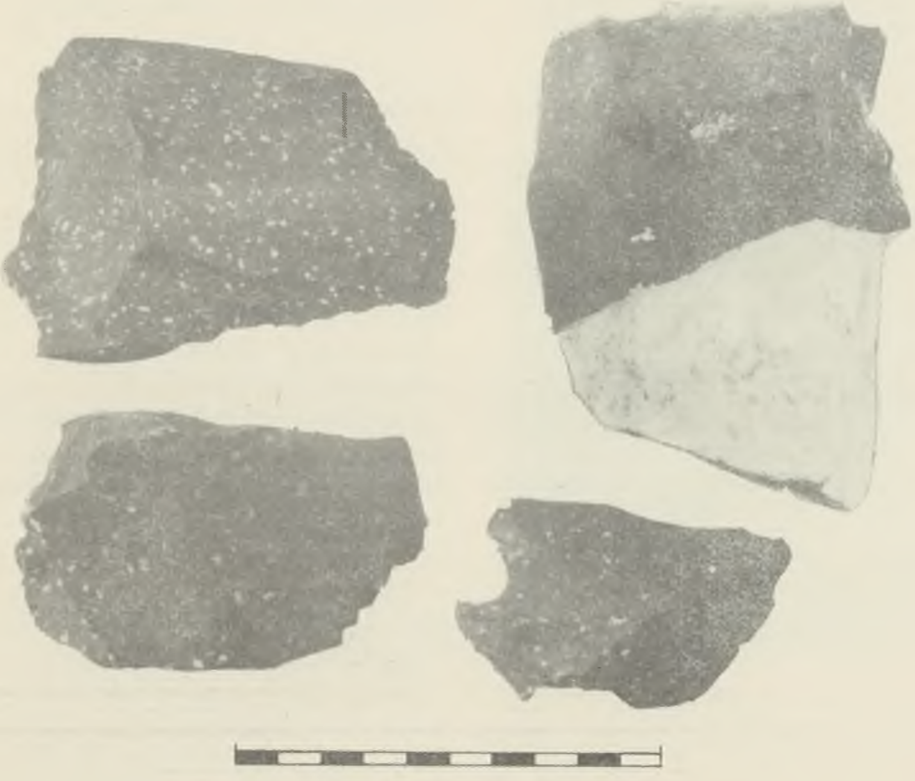

Fig. 10. Świeciechów, Tarnobrzeg dist. Greywhite spotted flint. Scale 10 cm

Photo by S.Biniewski

of the raw material characteristic for particular mines can be distinguished. Varieties of striped flint occur in various regions of Central Europe. Striped varieties are found among Jurassic-Cracow flints, Cretaceous erratic flints (Baltic ones) and Volhynian flints, as well as flints and hornstones from Bavaria. Among them, striped flint of Krzemionki is the most decorative one, which can be clearly distinguished in this respect from all other European flints.

In the region of the Holy Cross Mountains grey white spotted flint was exploited at the Świeciechów mine on a big scale. Świeciechów is located on the right bank of the Vistula river close to Annopol (Balcer 1975, 46–52; 1976, 179–186). The cortex is white, soft, and of various thicknesses (Fig. 10). White platy Turonian marls are the bed rock of Świeciechów flint. But their eluvial deposits were the first ones to be exploited. Flint from Ożarów similar to Świeciechów flint was of the local significance (Krzak 1970).

In the Cracow region, south of the Polish Jura, Upper Jurassic flints called Jurassic-Cracow flints were commonly exploited. They occur *in situ* in the Oxford malm limestones. But there is no evidence to show that they were exploited there in prehistoric times. The biggest Jurassic-Cracow flint agglomerations are known from the Tertiary eluvial deposits, from the area of the Paleogene surface of plantation in the southern part of the Polish Jura (Lech 1980). In some deposits of Karstic clays, flints constitute approx. 50% of the whole formation (Fig. 11). Jurassic-Cracow flints occur as nodules of various sizes, sometimes forming a hornstone layer up to 3 m long. The most frequently exploited deposits in the eluvial clays provided nodules from a few centimetres to approx. 30 cm (Fig. 12). The colour of the siliceous mass is most often from brown to black, frequently grey, less frequently blue and more seldom whitish. Some varieties of this raw material, after exposure on the surface for a few years, change in colour from dark brown to grey. The surface becomes duller. The cortex of the Jurassic-Cracow flint is usually uneven, spiked with the thickness from approx. 1 mm to a few millimetres. Some varieties of the Jurassic-Cracow flints popular among early farming communities have brown, chocolate colour identical with some varieties of "chocolate" flints. Clearance (a kind of suspension), gloss and the kind of cortex are the criteria allowing them to be distinguished by megascopic method.

Cretaceous flint and cherts occurring in the Cracow region had little significance there (Kaczanowska, Kozłowski 1976, 207 f.).

In the whole area of the North European Plain, from the Vistula river basin at the east to the Rhine and Maas at the west, Cretaceous erratic Senonian flints are found. Towards the south they appear in the upland

Fig. 11. Sąspów, Cracow dist. Deposits of nodules of Jurassic-Cracow flint in Tertiary red eluvial clay, lying on a bedrock of limestone. Scale 20 cm

Photo by J.Lech

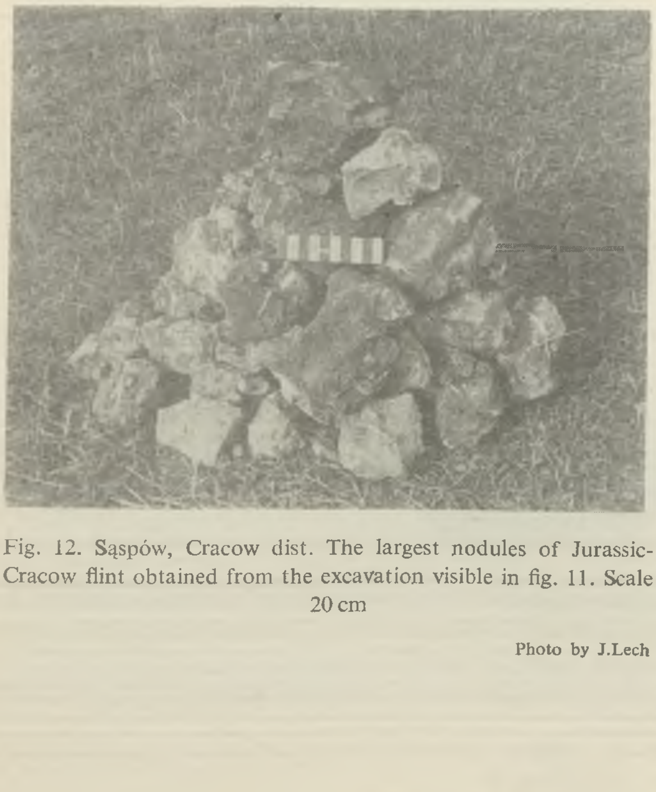

Fig. 12. Sąspów, Cracow dist. The largest nodules of Jurassic-Cracow flint obtained from the excavation visible in fig. 11. Scale 20 cm

Photo by J.Lech

Fig. 13. Gorzów Wielkopolski-Chwalęcice. Kłodawka river gap at moraine of Würm glaciation. Flint exploitation point
Photo by J.Lech

zone. This raw material originates from the primary deposits in the Cretaceous formations of the south Baltic Sea rim, from West Pomerania to Schleswig-Holstein (Ginter 1974, 11). In the west it originates from the Cretaceous deposits of the Maastricht—Liège—Aachen area (Löhr, Zimmermann, Hahn 1977, 151–153, 158–160). In most cases they were eroded from their primary deposits in the Cretaceous formations and were transported to the places of their present occurrence by the inland ice, mainly of Riss glaciation (Ginter 1974, 11). Erratic flints are found most often in the moraines (Fig. 13), gravel trains and fluvioglacial sands and the outcrops frequently occur in the river-gaps (i.e. Poznań-Starołęka — Kobusiewicz 1967). The colour of the erratic flints changes so that within one nodule in some places are black and in others grey. Sometimes the blend of both colours occurs. Additionally, brown, russet, grey, bluish and yellowish flints are known. Some varieties are striped. The fracture surface of some is dull and of others glossy. The cortex as a rule has traces of the glacial transport in the form of smoothings or sometimes is even completely torn off. Secondary deposits differ from the point of view of nodules site and their industrial values (Fig. 14). Recent research indicates the possibility of making distinctions between raw materials from different deposits (Bagniewski 1979; Cyrek 1979). Erratic raw materials from the local deposits played an important role in the flint industries of early farming communities in western Poland, from Pomerania to Upper Silesia, in the region of Opava and in the whole of northern Moravia, in Meklenburg, Brandenburg, Saxony, Thuringia and further west in Lower Saxony. Rügien island and the neighbouring continental shores were an important centre of their exploitation and distribution (Wiślański 1969, 236–238), as well as the region of Racibórz in Upper Silesia (Balcer 1977, 7 f., and the region of Poznań-Starołęka (Kobusiewicz 1967). There was probably a similar region of rich occurrence and exploitation of the erratic flint deposits (Baltic ones) in Saxony. Numerous long blades made of this raw material in north-west Bohemia, from the region of Chomutov and Teplice to Prague could be a proof[5].

Fig. 14. Gorzów Wielkopolski-Chwalęcice. "Baltic" erratic chalk flint nodules
Photo by J.Lech

Stone raw materials from Slovakia are little known.

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[5] For example, compare the blades from the graves in the Corded Ware culture cemetery at Vikletice near Chomutov. They are now in the collection of the Branch of the Archaeological Institute ČSAV in Most; see: BUCHVALDEK, KOUTECKÝ 1970.

Fig. 15. Sečovce, Trebišov dist. Obsidian nodules from workshop

After V.Budinský-Krička

The analysis of the archaeological materials from the settlements indicates that they were very rich. Approximate regions where siliceous rocks occur (which are described by the Slovak archaeologists as limnoquartzit) are in the Kremnické vrchy Mountains, Vtačnik and Štiavnicke vrchy in western Slovakia. In the northern part of the Slanské vrchy Mountains, to the north-east from Košice, opal jaspers are found. White hornstones from the Tribeč Mountains were used locally in the upper Žitava river basin, in the vicinity of the town of Zlaté Moravce[6].

Obsidian was an important raw material for the early farming communities of the eastern part of Central Europe. It occurs on the eastern border of Slovakia and Hungary, in the Tertiary volcanic rocks of the Zemplin Uplands (Zemplinske vrchy and Zempléni Hegység). The region of their occurrence is between the rivers Bodrog and Hornad, to the south-west starting from the place where the river Latroica joins the river Ondava forming the Bodrog. Abundant obsidian workshops of the early farming communities are known from the area around the villages of Cejkov, Kašov, Malá Toroňa, dist. Trebišov in Slovakia (Janšák 1935, and the collection of the Slovak Ethnographical Museum in Martin). Obsidian occurs in the weathering waste of the local volcanic rocks in the form of round or oval nodules. The surface of the nodules is black, uneven, glossy or grey-black, dull with numerous small hollows sometimes with the structure similar to purnice and with a very thin layer of the surrounding rock sunk into the tektite, forming a kind of cortex (Fig. 15). Obsidian from the Zemplin Uplands is black, translucent and glossy. Utilized obsidian nodules vary in diameter from approx. 1 cm to a dozen or so centimetres.

In Hungary, in the region of Miscolc, there are *Limnoquarzit* deposits (Vértes 1964, 210). On the north-west border of the Transdanubian Central Mountains (Dunantul), in the region of Tata, the layers of liver-brown Zpper Dogger radiolarian chert (flint) occur in the Jurassic limestones (Fülöp 1973; 1975). Further to the south-west in the central Transdanubian Mountains, close to Sümeg, dark-grey radiolarian flints occur in the limestone marls of the Cretaceous period (Vértes 1964; Fülöp 1975).

In Austria the radiolarites deposits described by some scientists as hornstones occur in the limestones forming Jurassic Klippes in the region of Vienna. The Vienna-Mauer mine is a known exploitation site (Kirnbauer 1958; Ruttkay 1970). Dark-red, violet and greenish-brown radiolarites were extruded there.

Abundant flint deposits in a small area of Chalk occur in White Russia, in the region of Volkovysk, on the river Roś (left-bank tributary of the Niemen). Local chalk layers were pushed here from the north by the glacier. Roś flint was exploited in a few mines (Gurina 1976). The best known one is at Krasnoye Selo. The chalk surface is covered by the moraine formations. Their thickness differs. In particular cases the thickness is so small that the chalk comes to the surface when the soil is ploughed or dug. In other places the capping is 1.5 m thick. Flint nodules of the Roś type occur in the chalk irregularly, in separated agglomerations or in the parallel and oblique layers described by N. N. Gurina

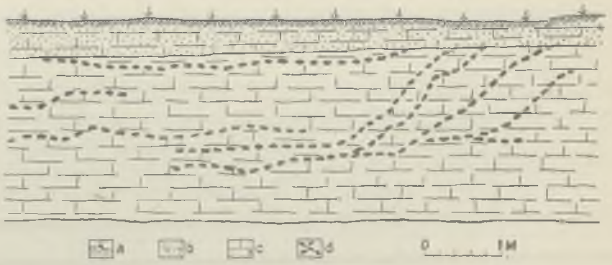

Fig. 16. Krasnoye Selo, Volkovysk dist. Position of layers of flint in chalk — "chains"

a, *b* — soil and subsoil; *c* — chalk; *d* — "chains" of flint nodules

After N.N.Gurina

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[6] I thank Dr.Ladislav Baneš C.Sc., Dr.Juraj Barta C.Sc. and most especially Dr.Juraj Pavúk C.Sc. of the Institute of Archaeology SAV in Nitra, for their help in getting acquainted with the differentiation of the siliceous raw materials in Slovakia. An attempt at recognizing the main siliceous raw materials of Slovakia was undertaken recently by Dr.Małgorzata Kaczanowska at the Archaeological Museum in Cracow (in press).

as "chains" (Fig. 16). Very big nodules (approx. 40 cm) are very rare just as are the very small ones (under than 10 cm). Nodules often have an irregular form with numerous outgrowths (Gurina 1976, 34–39). The nodules' siliceous mass is black with some parts of a grey or white colour. The cortex is white.

On the eastern fringe of the Vistula river basin, on the upper Bug, a vast zone of Cretaceous Volhynian and Dnestr type flint starts. They are also called Bug flint and originate from the Turonian (Kovnurko 1963, 238 f.; Svešnikov 1969, 114). Its main deposits are in the Volhynian Upland, in the north part of the Podolian table-land, and in the upper and middle Dnestr river basin. The Volhynian flint occurs in the form of big nodules (Fig. 17). Nodules with the diameter of up to 50 cm were exploited[7]. The cortex of the Volhynian and Dnestr flints is usually thin (up to 1 mm), and smooth. The colour of the siliceous mass is black, dark grey, in some places greyish; sometimes concentric stripes occur in the nodules. The deposits of black flints in the western Ukraine belong to the biggest and the most abundant ones in Europe. They were easily accessible and provided raw materials of the best quality. Besides them, other varieties of flint occur there. They were grey, brown, and black white spotted in colour. The Volhynian and Dnestr flints have good transparency, while the others cannot be seen through and have a dull surface. They were of local significance.

Fig. 17. Vel'ké Raškovce, Trebišov dist. Large Volhynian or Dnestr flint nodule placed in grave No 37. Length of nodule 26.5 cm; width 17 cm

After J.Vizdal

This review of the most important siliceous rock deposits exploited by the early farming communities in Central Europe is not comprehensive. We can expect that further studies will discover data on new deposits and their geology, as well as their role in prehistory.

III. AGENTS REVEALING THE EXISTENCE OF THE DEPOSITS IN PRIMEVAL CONDITIONS

With the primeval vegetation and lack of the anthropogenic transformations in the natural environment, the number of the exposed deposits or siliceous rock outcrops must have been much smaller than today. The majority of exposures observed today, whether in road cuttings or on hill slopes and valley edges, or in quarries, is the result of the processes which sometimes started many centuries ago following deforestation and other human activities.

There are several climatic zones prevailing in Europe and the area under discussion belongs to the west Central European configuration. It is in the zone of deciduous forests. They were the prevailing plant communities, other than the mixed forests which occur on a smaller scale (Odum 1963, 383–386, 393–395; Medwecka-Kornaś 1972, 37). In this biom the layer of herbs and shrubbery is usually well developed. In spite of the differences between contemporary climate and the climate of the Atlantic and Subboreal periods. we know that in prehistoric times Central Europe was covered by rich and varied deciduous forests. Finding the deposits of the raw material in such conditions was not simple (Figs. 18 and 19).

Primeval agents revealing and exposing the deposits of siliceous rocks were somewhat different from ones today. They also had different range and the scale of influence. They cover:

1. Rain water.
2. Seas, rivers and streams.
3. Rockfall and slumping of juvenile slopes, with angles between 45°–90°.
4. Soil creep and landslides on mature slopes with angles ranging from some 2° to 45°.
5. Uprooting of trees.
6. Ground movements due to freezing and thawing.

These processes had a different significance depending on the type of deposits. From this point of view the siliceous rock agglomerations can be divided into three groups:

I. Siliceous rocks on the primary or secondary deposits in the massive rock — Jurassic and Cretaceous limestones, chalk, sandstones, marls and puddingstones.

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[7] Part of information on the Volhynian type of flint and other flints from the West Ukraine I owe to the kind information of Dr. Sc. A.P.Černyš and to Dr. Sc. I.K.Svešnikov from the Archaeological Department of the Social Science Institute UAN in Lvov.

Fig. 18. Ojców National Park near Cracow. Korytania ravine. Searching for flint in conditions approximating to primeval

Photo by F.M.Stępniowski

Fig. 19. Ojców National Park. Korytania ravine. Large, weathered Jurassic-Cracow flint nodule, eroded by stream which at times flows along the bottom of the ravine

Photo by F.M.Stępniowski

II. Siliceous rocks in the Tertiary eluvial deposits.

III. Siliceous rocks in the Quaternary glacial tills, glacifluvial sands and grits and in other loose lithological formations (Tertiary and older ones) as well as on the sea shores and in the Holocene wash.

Abundant and terrential rainfall is the most important agent exposing and revealing the siliceous rock deposits (Armstrong 1926, 101). In the Atlantic period it was greater than at present. We can imagine that the morphological action of the torrential rain had a vast effect on the deposits from the Atlantic period, since we have a good contemporary knowledge of this type of process (Kondracki 1937; Starkel 1967, 491, 493).

The erosive action of sea waves, of divagating rivers and streams, was exposing in some places all the deposits of the siliceous rocks mentioned so far. Those agents were of special significance for the exposure of the deposits in the massive rocks. To a certain extent they could release them, leading to the formation of loose rock as screes, which were then transported further by water.

The tectonic faults, first of all in the Jurassic limestones, had some influence on the accessibility of the raw materials in the massive rocks. Rockfall and slumping due to the weathering could in some places release flints, hornstones and radiolarites gathering together with the Calcerous debris at their foot (Alexandrowicz 1956, 11 f.; Gerlach 1976, 94).

All varieties of siliceous rock deposits in the condition of the primeval vegetation were revealed in the result of soil creep and landslides on mature slopes with angles ranging from 2° to 45°. Those processes under natural conditions are more unusual than in landscape which has been effected by man (Bukowy 1956, 46 f., Tyczyńska 1968, 51–54; Gerlach 1976, 83 f.). In the Atlantic and Subboreal periods they were probably only accompanying phenomena to the action of rain waters, seas, rivers and streams.

A more important role should be attributed to the process of so-called "uprooting of trees" connected with the wind action on the territories covered with forests or single trees (Gerlach 1976, 46, 88). It means pulling out together with roots of falling trees of considerable amounts — sometimes several m^3 — of soil and its bedrock. These phenomena occur most often on slopes. The material pulled out by the roots was translocated and placed at a small distance from the place where the tree grew. In the place of extraction, small depressions approx. 60 cm deep and up to 4 m across are found. Falling trees could bring into daylight the siliceous rocks, whereever they occurred near the soil surface. That would be one of the most important ways of revealing the presence of flint raw material, taking into account the primeval forest vegetation on the territory of Central Europe. A. L. Armstrong drew attention to this at the mines of Grime's Graves in England (1926, 101).

Soil and ground movements due to freezing and thawing were equally important, and brought to the surface siliceous rocks found in the loose Tertiary eluvial or Quaternary deposits (Bac 1951, 52).

These agents were interrelated and often it would be difficult to state which of them were primary and which secondary. We can assume that the mining of some raw materials, and the lack of interest in others was most frequently due to a deliberate choice, depending on the technical features of the given raw material, on the type of deposit, and the cultural tradition. Exploitation of only certain flint raw materials in the region of the Holy Cross Mountains or in the Cracow Upland, and the complete lack of interest in others can serve as an example. Exploitation of particular flint layers at the Rijckholt—St.Geertruid and Krzemionki Opatowskie mines has similar significance. The interest in a specific deposit did not stop people occasionally gathering suitable rocks, that they found chance.

IV. REMARKS ON THE TERMS "MINE" AND "MINING" IN THE RESEARCH ON PRIMITIVE COMMUNITIES

Deposits are the objectives of mining exploitation. Although the existence of mining of various siliceous rocks in prehistory can be judged from the features of a given raw material and the area of its distribution, such judgements are hypotheses. Identification of the deposits and the characterization of flint exploitation points basing on surface collection is usually sufficient to show the existence of mining (Krukowski 1939-1948, 101 f., 106 f.; Kowalski, Kozłowski 1958, 349 f., Krzak 1965; 1970; Schild 1971; Ginter 1974, 9–13; Lech 1975a; W. M. Felder 1975; W. M. Felder et alii 1979, passim). The discovery of workings decides finally in favour of the existence of a mine in a given place because in areas of rich deposits not every "point of raw material exploitation" is a mine — vide: the Polish Jura or the north-east fringes of the Holy Cross Mountains. But where we find evidence of the flint processing and workings, we can talk about mines and thus about mining.

Such an understanding of the terms "mine" and "mining", which originates in Polish archaeological literature with the pioneer studies by S. Krukowski (1939, passim; 1939-1948, 101–112) has been treated with reserve by other scholars. These doubts found their expression in the classical work by M. Jahn which was devoted to the oldest European mining (1960, 7, 11) or in the book by S. Tabaczyński which discussed the economic bases of the early farming communities in Central Europe (1970, 270). Some other terms also awake doubts. M. Jahn is against the use of the term "open pit mine" — *Bergwerk mit Tagebau*, and "quarry" — *Steinbruch* — to describe the places where prehistoric communities exploited the deposit through pits dug down to depth of a few metres. The author stresses that, now, the term "mine" has quite different meaning (1960, 10 f.). Here M. Jahn tackles the essential problem faced by all researchers of prehistoric mining. On one hand we deal with the activities which are quite clearly in line with modern mining forms. On the other hand prehistoric exploitation units are sometimes very modest in comparison with what in every day life is understood under the terms "mine" and "mining". I exclude here the biggest and the most complex mines where there was full underground exploitation of deposits.

It seems that one should act here as in the case of the word "deposit". When we talk about "mines" and "mining" connected with the activities of the primitive communities we must, first of all, take into account the cultural context and the meaning of the phenomenon in its own remote epoch. In this way the identity of modern mining and of prehistoric stone raw material exploitation is obvious. The significance of this in the economy of prehistoric communities has been raised in the archaeological literature many times (Krukowski 1939, 50–55, 84–107; 1939-1948, 101–112; Childe 1954, 101–103; 1963, 61; Clark 1957, 212–217, 287–302; Piggott 1954, 36 f.; Jahn 1956, passim; Wiślański 1969, passim; Tabaczyński 1970, 263–282; Balcer 1975, passim). In the light of C. Lévi-Strauss' ideas in *La pensée sauvage* it is worth drawing attention to its significance in man's intellectual development.

For the definition and understanding of the meaning of flint mining in prehistory, the differentiation between "manufacture" and "production" is essential. This was made by L. Vértes for the stone age in his work on the Sümeg-Mogyorósdomb mine (1964, 205 f.). He stressed the importance of knowledge, observation, planning and preliminary activity, which were connected with obtaining the raw material, all quite separate from mining. F. Kirnbauer, while working out the Vienna-Mauer mine (1958, 126), and lately B. Ginter (1974, 13) also drew attention to this aspect of primitive mining. In the light of archaeological sources we are clearly dealing with such planned mining activity from the Late Pleistocene, and probably as early as the upper Palaeolithic period (Krukowski 1939-1948, 101–112; Vértes 1964, 206; Kozłowski 1967, passim; Ginter 1974, passim; Schild 1975, 324–332; 1976a, 163–170; 1976b, 98 f.). The formation and systematic development of seasonal mining exploitation with organizational variants, processing and distribution for the mass production of tools takes place all together with the appearance of the first farming communities.

V. METHODS OF RAW MATERIAL EXPLOITATION

Many investigators of prehistoric mines never paid too much attention to the systematics of methods of stone raw material exploitation. The interests of archaeologists usually concentrated on the workings which they had found. The range of comparison was generally limited to single sites or to short notes about other regions of prehistoric mining without attempting any generalization (Nougier 1950; Vértes 1964; Kasymov 1972; Mirsaatov 1973; Gurina 1976). The small number of units which have been examined, and their general likeness has not promoted the comparative studies. As a result we have four major divisions for the methods of obtaining raw materials in prehistoric Europe. We include here A. L. Armstrong's typology worked out on the base of many years excavation works at Grime's Graves (1926), the scheme of M. Jahn based on the carefully collected literature on the subject (1960) and its expansion — "systematic classification of flint obtaining methods" by E. Schmid (1973a). As a fourth typology we can treat the scheme of the division of sites which were connected with stone raw material exploitation and processing by N. N. Gurina (1970, 589; 1976, 5). The classification adopted here is an adaptation and expansion of Schmid's typology. An attempt is also made to define more precisely these exploitation systems.

Methods of obtaining stone raw materials among primitive communities:

A. Natural collecting.
B. Mining:
  1. Systematic extraction from sea-shore slides, glacifluvial and alluvial gravel trains, glacial tills and Karatic clays together with casual local turning up of the soil.
  2. Surface pits.
  3. Open shafts.
  4. Open shafts with underground side workings.
  5. Underground shafts with niches.
  6. Underground shafts with galleries and stalls.
  7. Drift mining.
  8. Horizontal mining changing into drift mining.
C. Quarrying.

In the proposed classification the basic difference between natural collecting and mining consists in the fact that the deposit is the objective of mining exploitation. Natural collecting is limited to the casual gathering of rocks coming from different sources, mainly from outcrops. Only in this way can we sensibly distinguish systematic extraction connected with turning up of the soil in sea-shore slides, postglacial and Holocene river gravel trains, which were the raw material deposits, from casual collecting of all siliceous rocks mainly from the outcrops or the surface rather than systematically exploited deposits. We cannot ignore the significance of natural flint collecting which provided prehistoric communities with their raw material. The border line between the conscious exploitation and casual collecting should follow L. Vértes' definition (1964, 205 f.). In this way for example sporadic appearances of Świeciechów and "chocolate" flint in the middle and upper Palaeolithic period at considerable distances from the deposits (Kozłowski 1958, 355–357; 1967, 22; 1972, 62 f., 91 f.; Balcer 1971, 24; Schild, 1971, 40) is only a proof of obtaining the raw material through natural collecting while the occurrence of flint workshops based on the raw material eroded in moraines or originating from river gravel trains would be a sufficient to show mining exploitation, planned earlier and realized in the simplest of all possible ways. In such a formulation, the natural collection of raw material means something different than in E. Schmid's conception. It refers only to picking up raw material from outcrops and the casual collecting on the area of deposits.

1. MANIFESTATIONS OF THE SIMPLEST MINING

We can talk about mining exploitation at the moment when the existence of systematic utilization of a deposit finds its reflection as flint workshops which processed raw materials. As a rule, the last activity was accompanied by at least simple extractive work. It consisted in turning up the soil and removing the material without any industrial value. Such activities were already ascertained among others in some traditional Central-European cultures in the Upper Palaeolithic period (Kozłowski 1967), and for the later periods at the gorge of the Warta valley through the Poznań High Plain, in the region of Poznań-Starołęka (Kobusiewicz 1967, 60–65). From this area we know flint workshops of Mesolithic food-gathering and hunting communities, and of the TRB communities. A similar system of exploitation was ascertained for the Danubian communities in the region of Kraków-Nowa Huta (Kaczanowska 1971, passim).

The best example of the exploitation unit which was connected with the systematic extrusion of the Volhynian flint from glacial tills or Karatic clays was provided by I. K. Svešnikov, who studied the hill Višnevaya Gora, in the village of Gorodok, dist. Rovne (1969, 114 f.). It was well preserved because the ground had been covered with a layer of loess flowing down the slope. The depth of the exploitation pit was 10–30 cm, the diameter 180–200 cm (Fig. 20). It was accompanied by a waste heap, 56 cm high on the edge of the pit and approx. 2 cm on the opposite extremity. On one side of this small exploitation unit there was an agglomeration of useless nodules with negatives of single strikings, flakes and waste (Fig. 21). In the place where the flint bearing layer was washed away by rain water, a runnel formed on the slope of Višnevaya Gora. Strong erosion could have been the result of a single catastrophic rainfall in the conditions of the primeval vegetation. The erosive action of such a rainfall was described for the Ojców National Park in the Polish Jura near Cracow by J. Kondracki (1937). Anthropogenic devastation of the natural environment could have been another reason of finding the deposit. The pit that we here mentioned was situated on

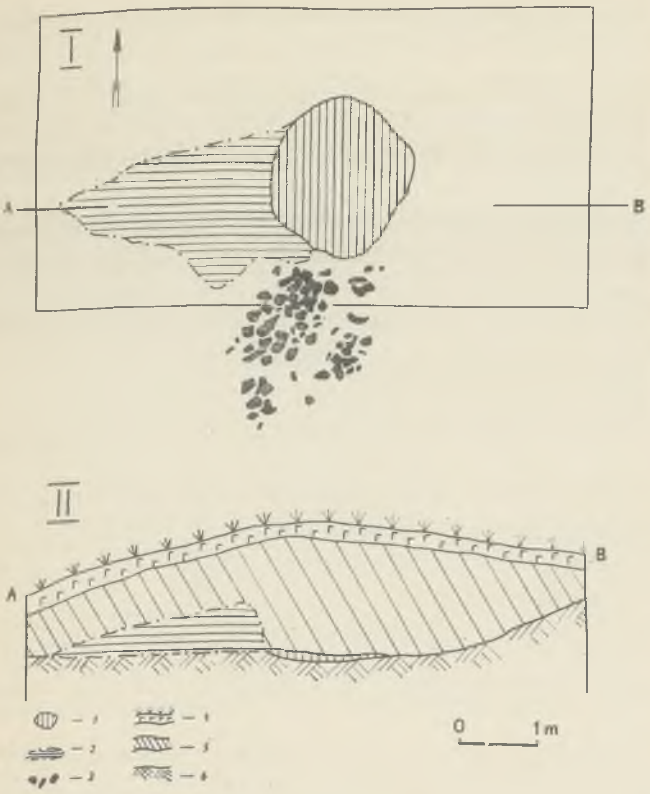

Fig. 20. Gorodok, Rovne dist. Višnevaya Gora site

I — Plan of the exploitation unit and waste-heap; *II* — Section of exploitation unit and waste-heap on axis A—B: *1* — pit, *2* — waste-heap, *3* — flint workshop, *4* — soil, *5* — loess, *6* — bed-rock

After I.K.Svešnikov

Fig. 21. Gorodok, Rovne dist. Višnevaya Gora site. Filnt workshop from plan in fig. 20, Scale 20 cm

Photo by I.K.Svešnikov

the edge of the Corded Ware settlement at the foot of Višnevaya Gora. Preliminary prepared nodules were taken there. Stone retouchers and hammerstones, spherical flint hammerstones, fragments of antler mining tools and semiproducts of flint axes and sickles come from the settlement. At a distance of between one half km to 5 km from Višnevaya Gora more than 20 other settlements of the Corded Ware Culture have been discovered. Some of them provided antler tools for mining works (Svešnikov 1969, 118).

The facts ascertained by I. K. Svešnikov i.e.: the presence of local turning up of the soil with waste heaps accompanying them and workshops of preliminary processing as well as typical mining tools, which allowed him to characterize the unit from Višnevaya Gora as a manifestation of the simplest mining. As the abundant comparative materials indicate, the kind of works in the whole prehistoric Europe depended first of all on the deposits' geological situation, and was not determined culturally, and secondly we can assume the existence of similar extractive units in other regions.

2. SURFACE PITS

Surface working consisted in digging shallow, small pits with a depth from tens to the maximum approx. 1.5 m and with a bigger diameter not usually exceeding 2 m. Such workings, from the beginning to the end, could have been dug and exploited by one man. From the point of view of working them, obtaining flint from the pits did not require the participation of any more people. The right kind of planning, the knowledge of deposit and of mining field were the only things necessary.

Typical units of this sort were found on the terri-

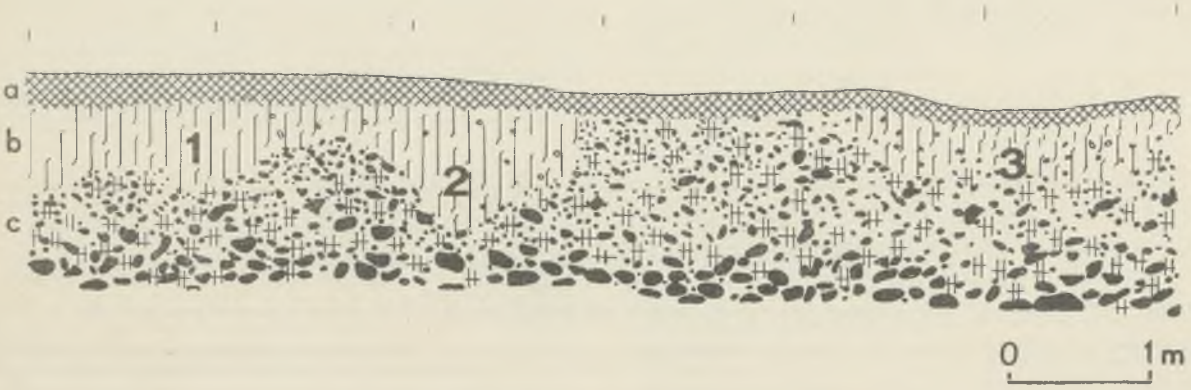

Fig. 22. Bębło, Cracow dist. Surface pits (*1–3*)

a — soil; *b* — loess containing artefacts and a small admixture of eluvial clay which filled in the pit; *c* — eluvial clay with flints tory of the flint mine at Bębło near Cracow (Fig. 22). The excavated depth of No 1 was 60 cm below ground level; object No 2 — 80 cm (Fig. 23) object No 3 — 40 cm, all very similar in this respect to the exploitation unit from Višnevaya Gora. The original depth of pits at Bębło was bigger in some places, probably by several tens of centimetres, as a result of the erosion of the loess layer. In the cutting, No 1 was more than 160 cm wide, but its through section disappeared under part of the flint floor which was unexcavated. No 2 is 120 cm wide and No 3 — 180 cm. None of the full pit outlines of the three workings was exposed.

Fig. 23. Bębło, Cracow dist. Pit No 2. Scale 20 cm

Photo by J. Lech

In the deposit there are places of bigger concentration of nodules and the others almost without them. That is why in the case of surface workings the shape of each one was so very dependent on the casual discovery of flint agglomerations, and was variable for that reason. Because the workings were shallow the side extension of exploitation units was technically easy and fully justifiable from the point of view of work economics. Also safety was no obstacle here. As no border line between pits 1 and 2 was found, we cannot exclude the possibility that we are dealing with such a case. We would then have a working with a diameter exceeding 3 m, with very rugged turned up bottom, similar to the adjacent pit No 3 but bigger. Both the cross sections indicate the great density of shallow workings in this part of the mining field. It is interesting that the exploitation was limited only to the upper layer of Karstic clay. Where the intensity of bigger nodules increased, the pits were not dug any deeper. This was undoubtedly due to the image of the deposit that the people had. Observations of flint deposits in this part of the Polish Jura, where the mines at Bębło and Sąspów are situated, show considerable differences in the number of big nodules in the deposits. In the case of the pits at Bębło, the people were not aware that deeper down lay the bigger nodules. No deep probe into the deposit was undertaken, because it was much easier to dig in the thin loess layer in some other place than to decide in favour of much more laborious, and uncertain boreing through compact eluvial clay with flints. For this reason we find a more "wasteful" exploitation system (Lech 1981).

Raw material exploitation from the deposit at Bębło demanded a more complicated organization than the workings at Višnevaya Gora. The location of the mine at Bębło beyond the region of permanent settlements, and the greater depth of the workings demanded increased efforts. Shallow units at Bębło could also have been sunk by one man. The deepest workings of this category demanded a certain amount of cooperation. As the mine was at a distance from the settlements utilizing it, one can assume that only a few persons would be in the flint mining groups there. In case of bigger workshops, even the transport of blade blanks required groups of several persons (Lech 1971, 119–122; Dzieduszycka-Machnikowa, Lech 1976, 123 f.).

Exploitation of the deposit by the system of shallow pits was the normal way of obtaining the raw material at the mine of Świeciechów (Fig. 24). B. Balcer has leaned

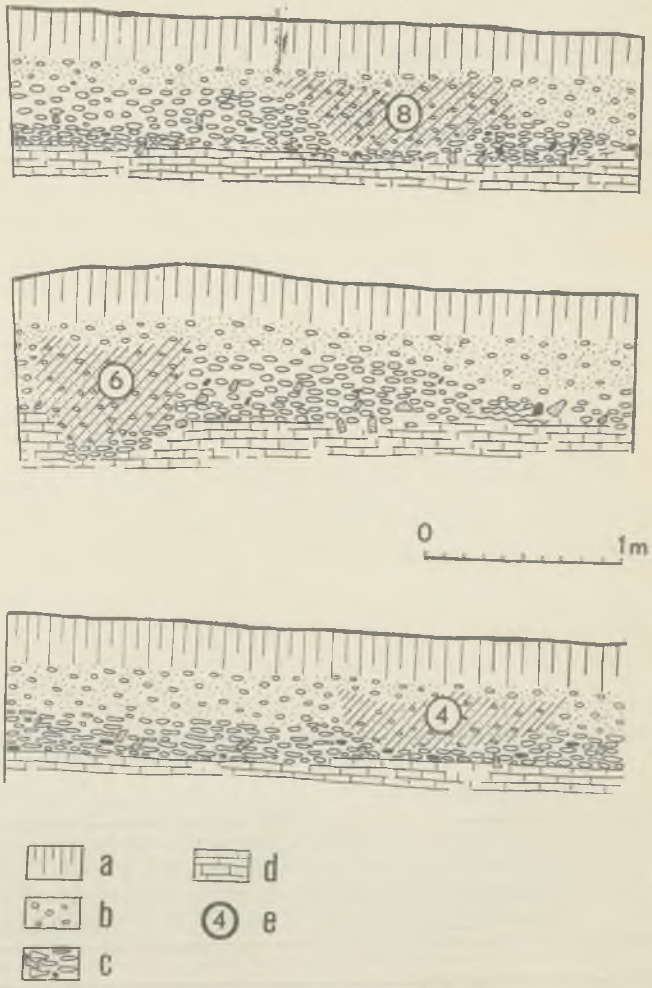

Fig. 24. Świeciechów, Tarnobrzeg dist. Surface pits Nos 8, 6 and 4

a — soil; *b* — subsoil with fine calcerous rubble; *c* — large pieces of chalk rubble with grey-white spotted, and black flints; *d* — platy chalk marl; *e* — surface pits

After B. Balcer

towards this view recently (1971, 120 f.; 1975, 162). As can be seen from the publication by F. Kirnbauer (1958) and N. N. Gurina (1976), this kind of raw material exploitation also occurred on a small scale at the mines on Vienna-Mauer and Krasnoye Selo. The volume of extruded raw material and waste rock was usually from 1 to 5 m^3 approx. Surface pit exploitation differs clearly from the extraction of raw material from sea-shore slides, eluvial or glacial clays, or river gravel trains. As we shall see in further considerations, it is also clearly different from open shaft exploitation of the deposit; in other words it is primitive in A. L. Armstrong's classification or *Mardellen Grubenbau* of M. Jahn and E. Schmid.

3. OPEN SHAFTS

Open shafts exploitation required much more work with the participation of at least two people, better knowledge, and more mining experience. In such workings knowledge, and more mining experience. In such workings, a kind of communication step was often left to lift flint and waste material to the surface. The volume of extruded material ranged from 3 to 80 m^3, taking into account the known workings from Central Europe. Open shafts are the most common form of exploitation unit of the early farming communities. Among others we know the hornstone mine at Lengfeld (Reisch 1974), quartzite mines at Tušimice and Bečov (Neustupný 1963; 1966; 1976; Kruta 1966; Fridrich 1972), the radiolarian chert mine at Tata-Kálvária Hill (Fülöp 1973; 1975) and partly at Sümeg (Vértes 1964; Bácskai 1976), Jurassic-Cracow flint mines at Sąspów and Jerzmanowice-Dąbrówka (Lech 1972; 1975b; 1981), and "chocolate" flint mines at Tomaszów and Polany II in the north-eastern fringes of the Holy Cross Mountains (Chmielewska, Lech 1973; Lech 1975a, 143 f.; Schild 1975; 1976a, 158–161). Open shafts occur side by side with other types of shafts on the territory of the mines at Rijckholt—St.Geertruid (W. M. Felder et alii 1979, 56 f.), Krzemionki Opatowskie (Krukowski 1939, 11–13) and at Krasnoye Selo (Gurina 1976, 132–163).

Among this category of workings we can observe a clear division into two groups: narrow shafts and wide shafts. They often occur side by side at the same mines — for example at Lengfeld and Tomaszów. At Lengfeld the shafts were sunk through a layer of loess, gravel trains and clay with rounded Calcerous rubbish and numerous flint nodules, down to the roof of the limestone rock (Reisch 1974, 33–35, Beilage I). One of the shafts (*Schacht* I) was 95 cm wide at the mouth, directly below the soil floor. It was 225 cm deep (Fig. 25). The second shaft (*Grube* II) was about 4 m wide at the mouth, and 2 m in depth (Fig. 26). At Tomaszów, distr. Radom the shafts were cut through sands, washed down formations and cryo-turbated deposits of the Middle and Upper Würm periods. Flint nodules were extruded from the Karstic clays which lay below. The shafts were from 1.2 m to more than 3 m wide and from 3.5 to 4.5 m deep (Schild 1975, 17; 1976a, 158–161).

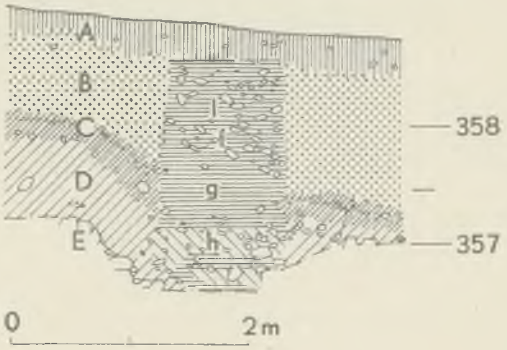

Fig. 25. Lengfeld, Kelheim dist. Narrow open shaft

A — soil; *B* — loess; *C* — layer of fine gravel; *D* — eluvial clay with lime rubble and raw material; *E* — mother rock or waste weathering; *f*–*h* — sediments in secondary position: lime rubble with loess (*f*) loess (*g*); eluvial clay with lime rubble (*h*); I — shaft

After L.Reisch

Only big, wide shafts are known from the territory of the flint mine at Sąspów. The natural stratigraphy there is as follows: top soil, subsoil, loess, karstic clay, limes waste and Upper Jurassic calcerous bedrock. In

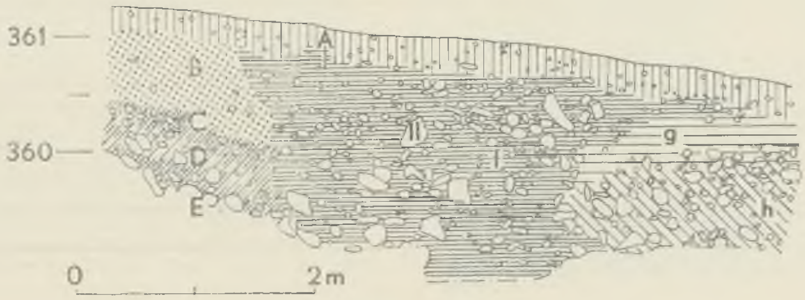

Fig. 26. Lengfeld, Kelheim dist. Wide, open shaft.

Key as for fig. 25; II — shaft

After L.Reisch

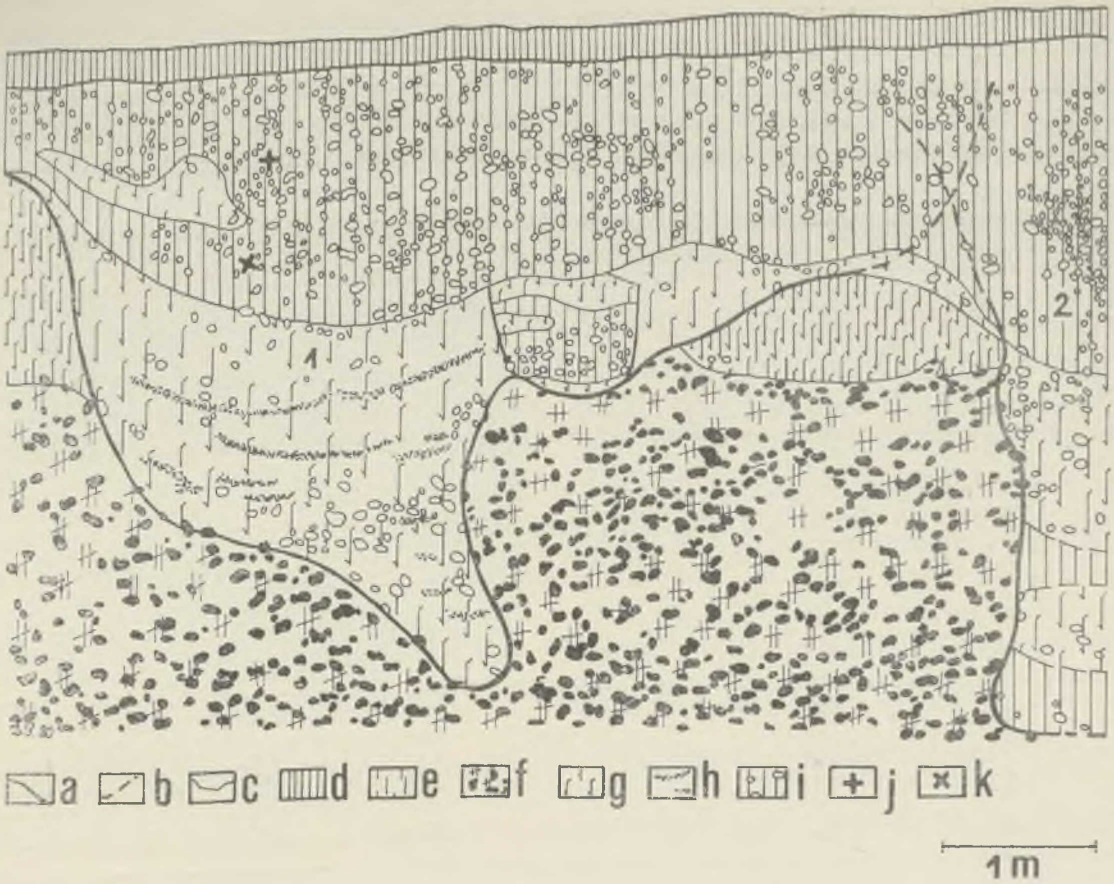

Fig. 27. Sąspów, Cracow dist. Cross section of shaft No 1 and portion of Shaft No 2

a — shaft walls; *b* — reconstructed shaft walls; *c* — limits of layers; *d* — soil and subsoil; *e* — loess; *f* — Karstic clay with flint nodules; *g* — loess with artifacts, flint nodules and fragments; *h* — grey-bluish loess loam; *i* — Karstic clay with loess, artifacts, flint nodules and fragments; *j* — location of collected charcoal sample for ^{14}C dating — (Bln-1461) 3345±60 b.c.; *k* — location of collected charcoal sample for ^{14}C dating (GrN-7052C) 3375±90 b.c.

order to reach the flint rich Karstic clay, shafts were sunk right through the loess layer. Shafts in their top part had an oval shape. Shaft No 1 was 8 m diameter at the mouth, and narrowed to 5 m. This leads me to believe. that the shafts were sunk over a relatively large area As soon as the top of the Karstic clay layer was reached at about 2–2.5 m deep, the size of the shaft was reduced. As a result, a shelf was formed (Fig. 27). It allowed the workman to lift flint nodules and waste to the surface. All communication within the shaft — getting in, and out, as well as moving the rock — was directed through this place. Probably between the surface and the shelf there was an additional step. Shafts were usually sunk in the flint bearing layer to 2–3 m (Fig. 28), seldom less. The depth of shaft No 1 reaches 4.3 m below the present ground level, which means approx. 4 m below the ground surface in the prehistoric period. The depth of shaft No 2 amounted to 4.8–5.1 m, the width of its top part was of approx. 5×4 m. The depth of shaft No 8 amounted to approx. 5 m and the width to approx. 5.5×4 m. The smallest of the workings at Sąspów — shaft No 7 — was 3.5 m deep with a mouth 4×3.5 m in diameter. Generally speaking, the Sąspów shafts are 3–5 m deep, with the diameter of the top part varying between 6 and 4 m. On the basis of this work, we can say that the method adopted in working shaft No 1 and No 2 was by no means the only one. The various sizes and shapes of shafts suggest the existence of some differences in the methods of working (Lech 1971; 1972; 1975b; 1981).

Fig. 28. Sąspów, Cracow dist. Boundary of filling in shaft No 1 with layer of eluvial clay containing flint nodules. Scale 2 m

Photo by J.Lech

Similar workings to these occur on the territory of other mines. Shafts at Tušimice were sunk through the loam layers to sandstone. Quartzite was extruded from the sandstone. Shaft No 5 (Fig. 29) was approx. 3.25 m deep and the width of its top part was approx. 2.25 m (Neustupný 1963). In its close vicinity two other shafts — Nos. 2 and 3 occurred. Shaft No 3 was about 2.5 m deep with a mouth width about 4.9 m. Another shaft No 4 was 2.1 m deep and approx. 3.6 m wide (Neustupný 1976). Similar workings were also sunk on the territory of the quartzite mine at Bečov. Their depth varied between 2–3 m. Shaft No 1 was 2.2 m deep and 2.5 m wide (Kruta 1966). In the Vistula river basin apart from the mine at Sąspów, open shafts with a wide mouth are known from the mines at Jerzmanowice-Dąbrówka I (Lech 1981) and Polany II (Chmielewska, Lech 1973). Shapes of the shafts from the mine at Polany were similar to pits Nos 2 and 3 at Tušimice and to the shaft at Bečov. They were sunk in sand and glacial tills mixed with Karstic clays, to reach eluvial clays. At the shaft bottoms, the roof of the Upper Jurassic limestones was disturbed (Fig. 30). Flint was exploited from the layer of Karstic clays and the roof of the limestone. Shafts at Polany were usually about 3 m wide at the top and the depth was not much more than 2 m (Fig. 31).

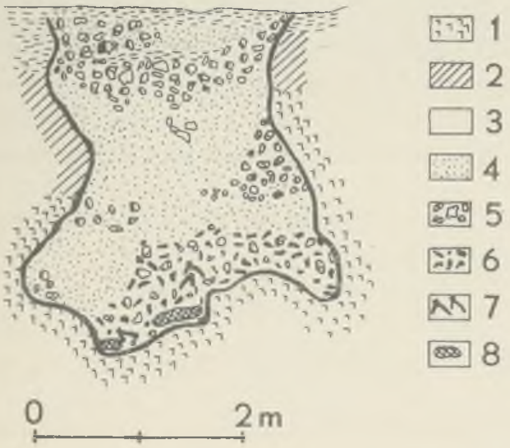

Fig. 29. Tušimice, Chomutov dist. Section of shaft No 5
1 — mother sandstone with quartzite nodules; *2* — grey loams; *3* — black loam; *4* — loam in filling in of shaft on secondary position; *5* — sandstone rubble; *6* — quartzite industrial waste; *7* — antler picks; *8* — fire-place

After E.Neustupný

Fig. 30. Polany, Radom dist. Fragment of bottom of shaft No. 1. Bodkin shows place where charcoal samples for ^{14}C dating were taken (BM-1235) 1541±81

Photo by J.Lech

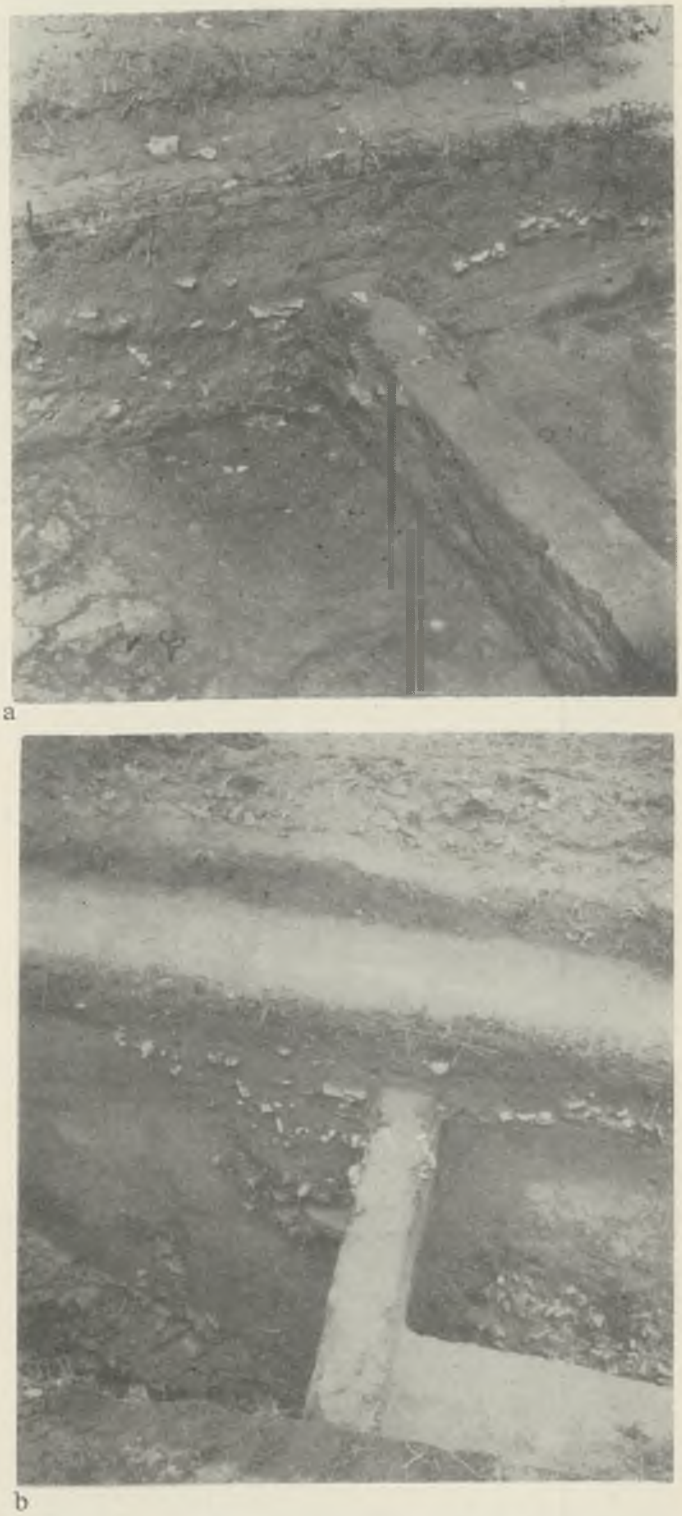

Fig. 31. Polany, Radom dist. Shaft No 3. Width of excavatoni 2 m. Distance between bodkins 1 m

Photo by J.Lech

Similar workings to these are known at the mine at Vienna-Mauer (Fig. 32). Some open shafts up to 8 m

Fig. 32. Vienna-Mauer. Radiolarite mine. Cross section of shaft No 1 in wall of quarry

After E.Ruttkay

deep had characteristic niches under the side walls (Kirnbauer 1958, 129 f.; Ruttkay 1970; Fig. 33).

A specific kind of open shaft was discovered at the mine on Kálvária Hill in Tata, in the north-west of Hungary, near the Danube. A dip in the geological strata of about 15–20° caused the characteristic inclination of the bottom of the exploitation units (Fülöp 1973; 1975, 77). Here, the bottom was like a steep ramp, so that people could go in and out with their loads of raw material and waste. The deepest point at Kálvária Hill occurs in the place where the bottom follows a dip in the strata (Fig. 34). These shafts have irregular outlines. Their depth is around approx. 1.5 m to 2.25 m (Pit I and II). The inclination of the layers suggests that besides deeper workings linking with open shafts (Pit II), surface pit exploitation could have occurred here too.

This type of exploitation unit very often had niches under the side walls — shafts Nos 1 and 8 from Sąspów, shaft No 5 from Tušimice and the shafts from Vienna-Mauer (Fig. 33).

The differentiation within this category of workings has two causes. The sinking of narrow shafts side by side with a wide shafts mouth was caused by the system of working (number of people working together at the same time), and by the strength of the demand for the flint. Characteristically, the different type of workings at Kálvária Hill was caused by the geological situation of the deposit.

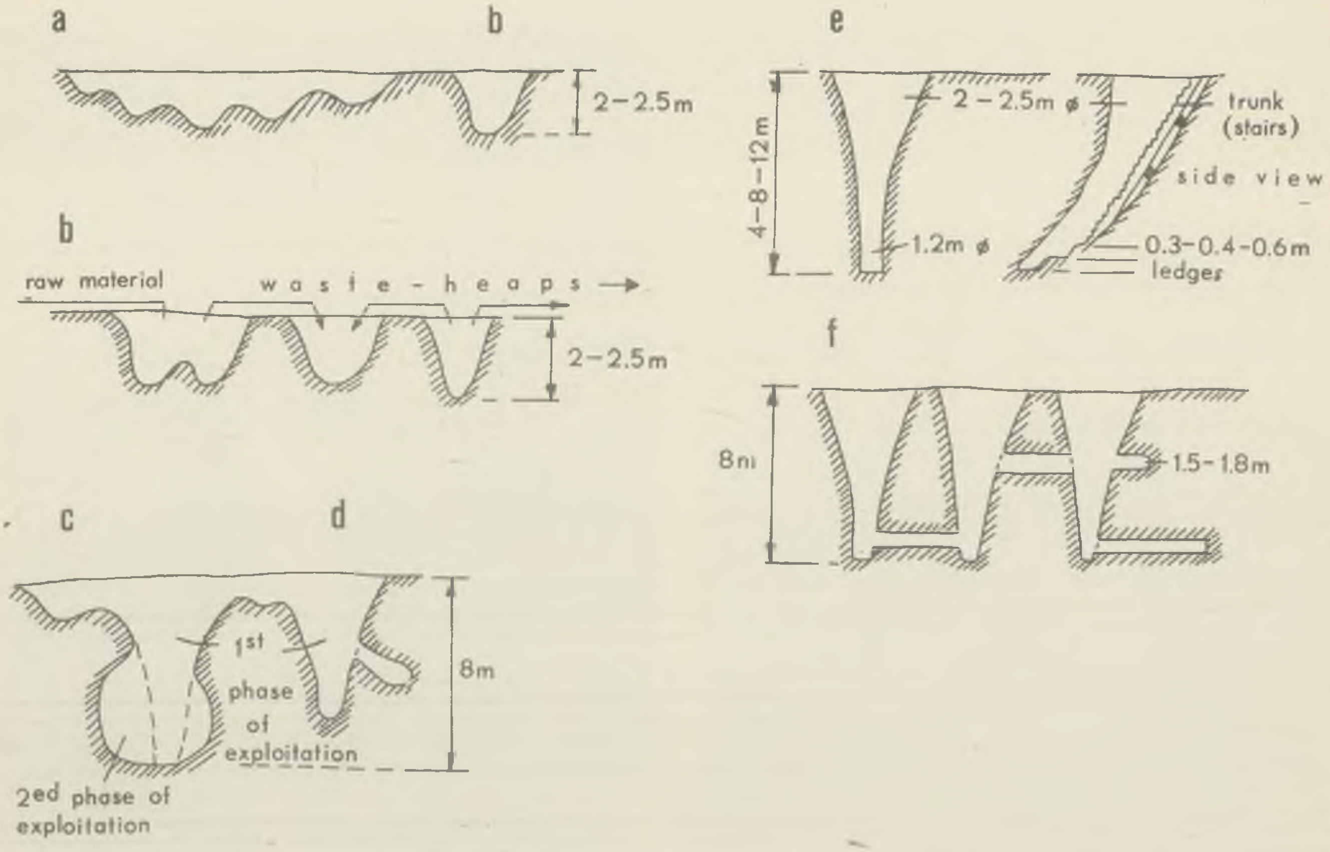

Fig. 33. Vienna-Mauer. Types of shafts

a — surface pits, and open shafts; *b*, *c*, — open shafts; *d*, *e* — open shafts with side workings; *f* — underground exploitation by shafts with gallery workings

After F.Kirnbauer

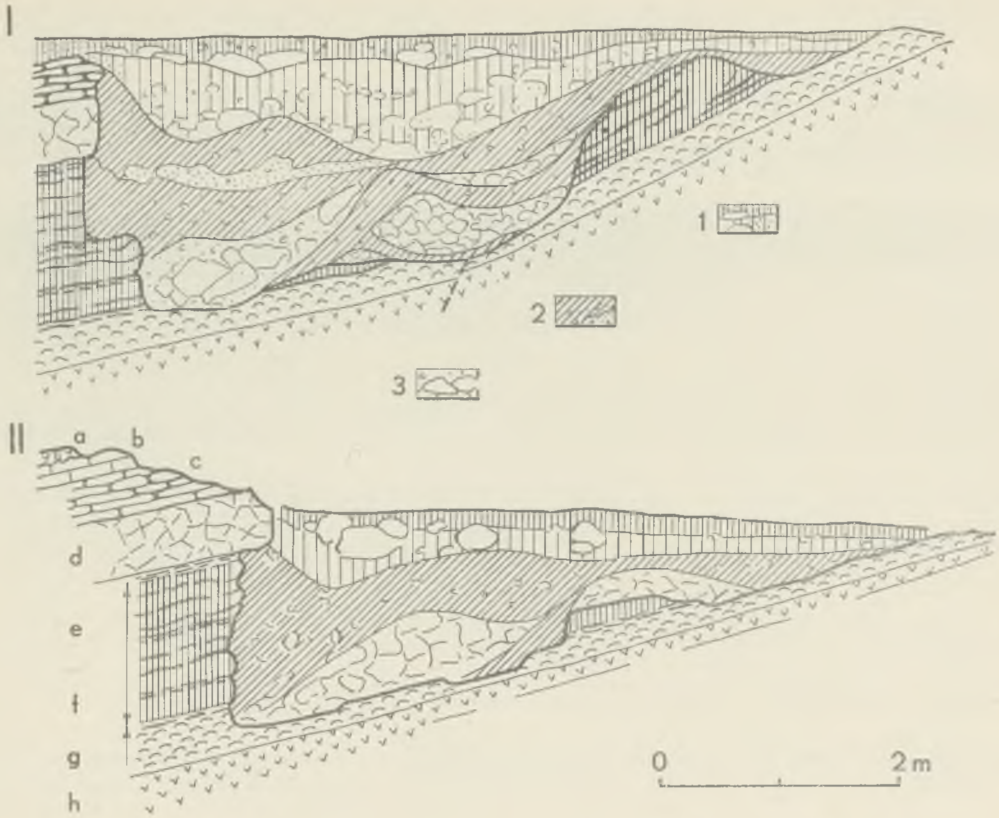

Fig. 34. Kálvária Hill. Tata. Section of shaft 2

I — from the South; *II* — in centre; *1* — mixed level of debris, abowe humus, below calcareous; *2* — red argillaceous filling, sporadically arenaceous, predominantly with small pieces of flint; *3* — coarse-grained debris of limestone and flint; *a* — aptian grey limestone with *Crtnoids*; *b* — tithonian limestone with *Cephalopods*; *c* — kimmeridgian red nodular argillaceous limestone; *d* — Oxfordian brecciated limestone; *e* — callovian-bathonian flint (chert); *f* — lower bathonian *Crinoidea*; *g* — *Posidonia*; *h* — limestone

After J.Fülöp

4. OPEN SHAFTS WITH UNDERGROUND SIDE WORKINGS

Open shafts with underground side workings are a transitional category to the underground shafts. They are differentiated in exploitation units with a narrow shaft and ones with a wide shaft. Good examples of the first group are at the mine at Krasnoye Selo on the river Roś, and of the second group at the mine at Polany Kolonie.

Certain conditions at Krasnoye Selo caused an unusually wide range of workings, much wider than on territories of other European mines. Depths of exploitation units at Krasnoye Selo were also different. In some places workings which could be included as surface pits or open shafts occur there. Various types of shafts with underground exploitation constitute a separate group. Open shafts with the elements of underground exploitation in the form of short galleries, shallow niches and the like are a transitional category. The maximum depth of the shafts at Krasnoye Selo usually did not exceed 5 m, and only in some regions of the mine, where the cap-rock of moraine formations and top soil was 1.5 m thick, did they reach as far as 6 m. The shafts' width was 1.5–1.6 m, and occasionally approx. 2 m and more (Fig. 35). Bigger dimensions could sometimes occur just under the surface in moraine formations. Then the shaft in that part had a funnel shaped section. All the shafts had a vertical section with a diameter less than 2 m (Fig. 36, and Gurina 1976, 41). It indicates that at least in this section they were sunk by one man. In some cases, in the preliminary phase of work as well as in the niches and galleries at the shaft bottom, two people could have worked together. Galleries and exploitation fronts went in various directions to follow the flint nodules and the dip of their strata (Fig. 37). The height of exploitation fronts rarely exceeded 1.5 m, and the diameter of the galleries was around 60 cm. Exploitation fronts and niches always narrowed at the end, frequently to the size of the flint layer found there.

Shafts No 2 from cutting I, No 20 from cutting III and No 124 from cutting IV are the examples of open shafts with single underground exploitation fronts in the mine at Krasnoye Selo. Shaft No 2 had an irregular outline with a diameter 2.2 m. The depth of the working was 2.8 m (Fig. 38). Walls of the shaft from the north, north-east and east side were sunk straight down to

Fig. 35. Krasnoye Selo, Volkovysk dist. Fragment of the mining field after removal of soil and subsoil with wokshops

After N.N.Gurina

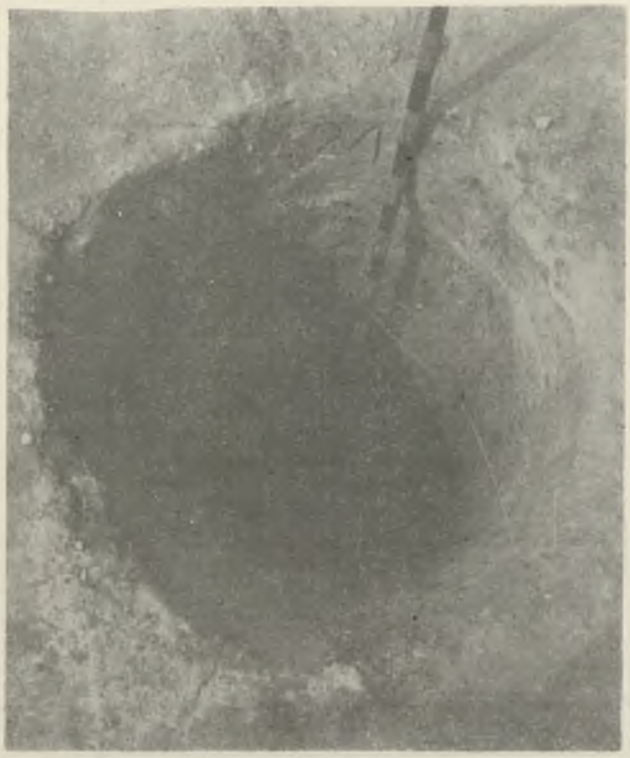

Fig. 36. Krasnoye Selo, Volkovysk dist. Narrow shafts. Typical mple of diameter of shaft opening. Graduation on scale of 10 cm

After N.N Gurina

Fig. 37. Krasnoye Selo, Volkovysk dist. Differentiated siting side-workings of the shaft. Z.Szmit's excavations 1925(?)

After Z.Szmit

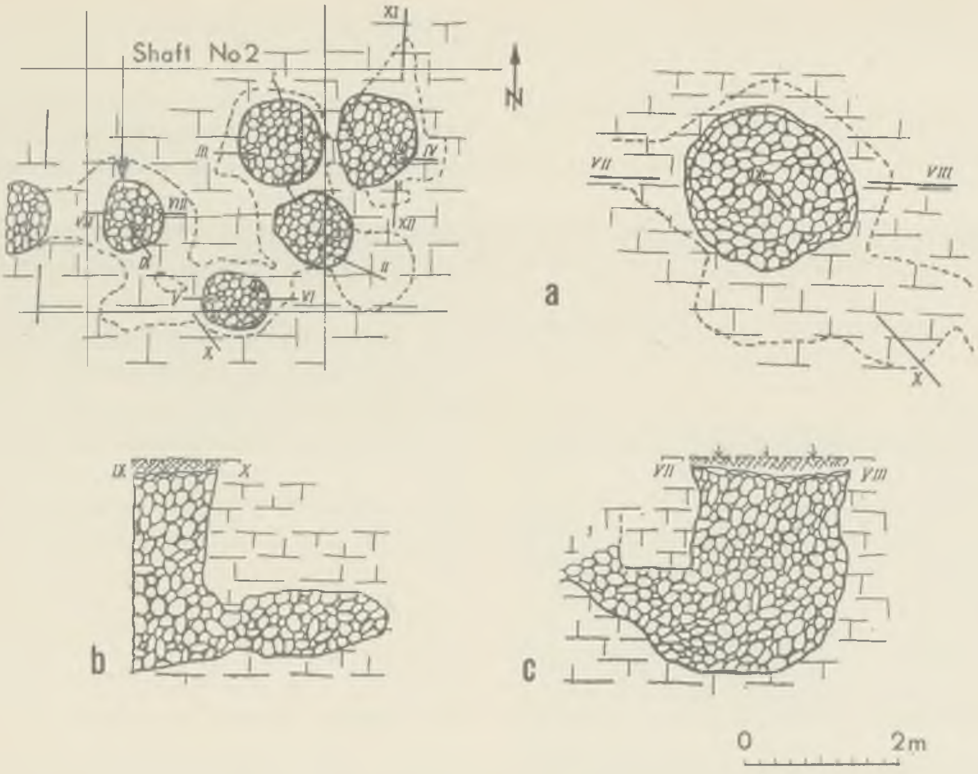

Fig. 38. Krasnoye Selo, Volkovysk dist. Shaft No 2 from excavation I

After N.N.Gurina

the bottom. In the southern part of the shaft there was an exploitation front 1.1 m long, 1.3 m wide with a height 75–80 cm (Fig. 38b). The base of the exploitation front was 70 cm below the shaft bottom. From the east, the exploitation front and the adjacent short gallery were divided by Cretaceous rocks which were not extracted. The shaft wall on the west was widened further on into a gallery. It connected shaft No 2 with shaft No 1. The length of this exploitation front was approx. 1.4 m, the width at the exit from shaft No 2 — 80 cm, the height — 90 cm. The passage from the gallery to shaft No 1 was circular in section, and 70 cm diameter. Its bottom rose steeply in the direction of shaft No 1 (Fig. 38c). The shaft walls were formed by relatively strongly weathered Cretaceous rocks (Gurina 1976, 137).

Shaft No 20 was adjoining from the west shaft No 44, from the north shaft No 21 and from the north-east shaft No 13 (Fig. 39). The opening was oval with a diameter 1.1–1.7 m. The larger measurement ran from the west to the east. The shaft was 2.7 m deep. The shaft walls from the west, north and south are relatively even. In the eastern part of the shaft there was an exploitation front 1 m long, 1.2 m high and 1 m wide (Gurina 1976, 150). Its presence was decisive for including the shaft in our category of mine workings.

Shaft No 124 had 1.5 m diameter and was 2.2 m deep. The vertical part of the shaft was surrounded by

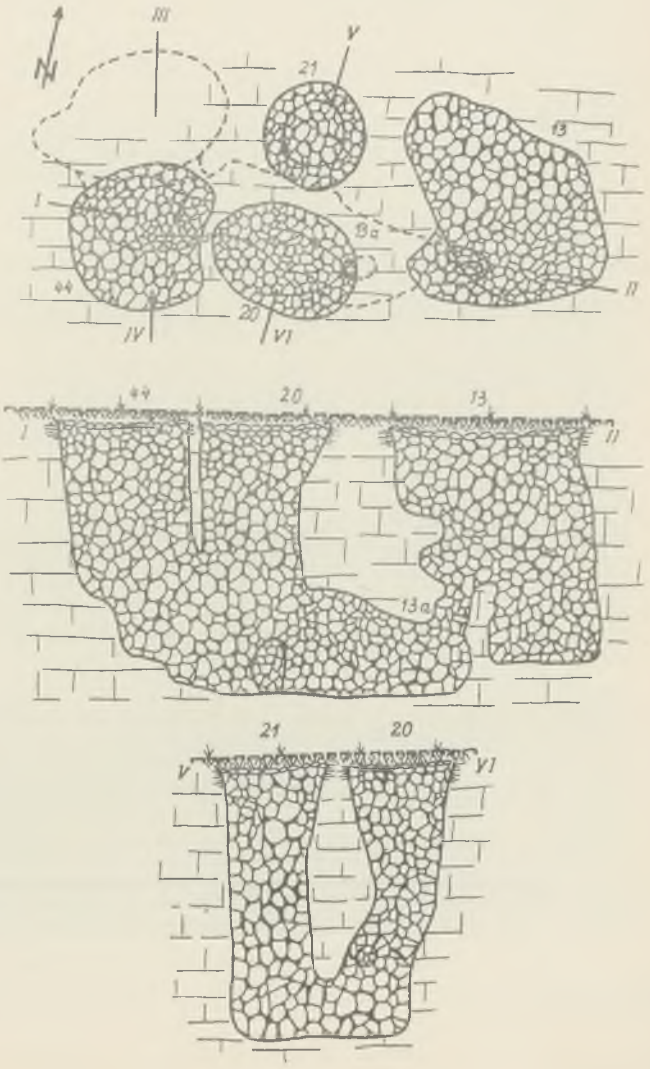

Fig. 39. Krasnoye Selo, Volkovysk dist. Shaft No 20 from excavation III

After N.N.Gurina

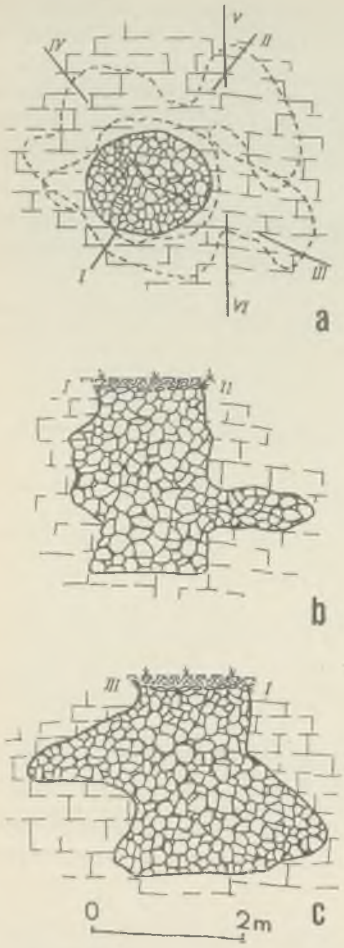

Fig. 40. Krasnoye Selo, Volkovysk dist. Shaft No 124 from excavation IV
After N.N.Gurina

exploitation fronts (Fig. 40). Two of them, along with a few smaller ones, allow us to treat this working as an open shaft with underground exploitation fronts. On the SSW wall there was a shallow exploitation front sinking to 30 cm. It started at a depth of 35 cm and was 1.2 m high. The exploitation front in the NNE was at a depth of 1.4 m, its length was 1.1 m, its greatest width 1.8 m, its height 50 cm (Fig. 40b). Its lowest part was 60 cm above the shaft bottom. The SSE exploitation front was 1.4 m long, with the biggest width 80 cm. The roof of this exploitation front dipped from 1.1 m to 30 cm. The lowest part of the exploitation front was 1.1 m above the shaft bottom. Underneath this exploitation front, near the shaft bottom there was another small one on the side (Fig. 40c). It was sunk into the shaft wall at 30 cm; its width was 40 cm and its height 35 cm (Gurina 1976, 161 f.).

Open shafts with underground side workings (exploitation fronts) also occurred on the territory of the radiolarites mine at Vienna-Mauer. Shaft holes usually had diameters from 2.5 m to 3 cm. Lower down they narrow to about 1 m (Kirnbauer 1958, 129). In places where there were layers of good raw material, hollows or short galleries were sunk (Fig. 33 d, e).

Some shafts from Sąspów and Tušimice also had single underground workings. Shaft No 3 from Sąspów was probably once a large funnel pit about 4.5 m deep (Lech 1972, 42; 1981). It reached a depth of 3 m, in the

Fig. 41. Sąspów, Cracow dist. Fragment of cross-section of shaft No 3, with gallery visible at bottom of excavation. Graduation on scale of 10 cm

Photo by J.Lech

archaeological excavation at its edge (Fig. 41). From there the bottom dipped again towards the south. In the section below the bottom lay Karstic clay with lots of flint nodules. Underneath, a fragment of a collapsed side working was found (Fig. 42). The dimensions of this were deformed because clay had fallen away from the roof and side walls. The prehistoric height of the working was some tens of centimeters, the width approx. 1.5 m, and the length 2–3 m.

During the rescue excavations at Tušimice, E. Neustupný discovered 19 workings as well as three galleries (1976). Unfortunately, it is not possible to connect them with the known shafts. The published gallery in Tušimice (Fig. 43, 44) was about 2.6 m long and its height ranged from 40 cm to 1 m (Neustupný 1963). The workings at from Tušimice show that all three galleries could be treated as elements of open shafts with single underground workings. In spite of the different geological situation in both mines, the similarities of gallery No 1 from Tušimice and the gallery of shaft No 3 from Sąspów attract our attention. Shaft No 1 from the mine at Polany Kolonie should be included to the group of open shafts with underground side workings (Schild, Królik, Mościbrodzka 1977, 34–44). Its depth amounted to 2.4 m, the shape at the mouth was slightly oval with dimensions 3.3 × 3 m. For this reason the shaft belongs to the category with wide mining holes (Fig. 45). The shaft was sunk through a rubble layer to the top part of the thin-platted Jurassic limestones with flints. At the bottom the shaft was surrounded by short side workings — niches and short corridors, with a length up to 1.1 m beyond the shaft (Fig. 46).

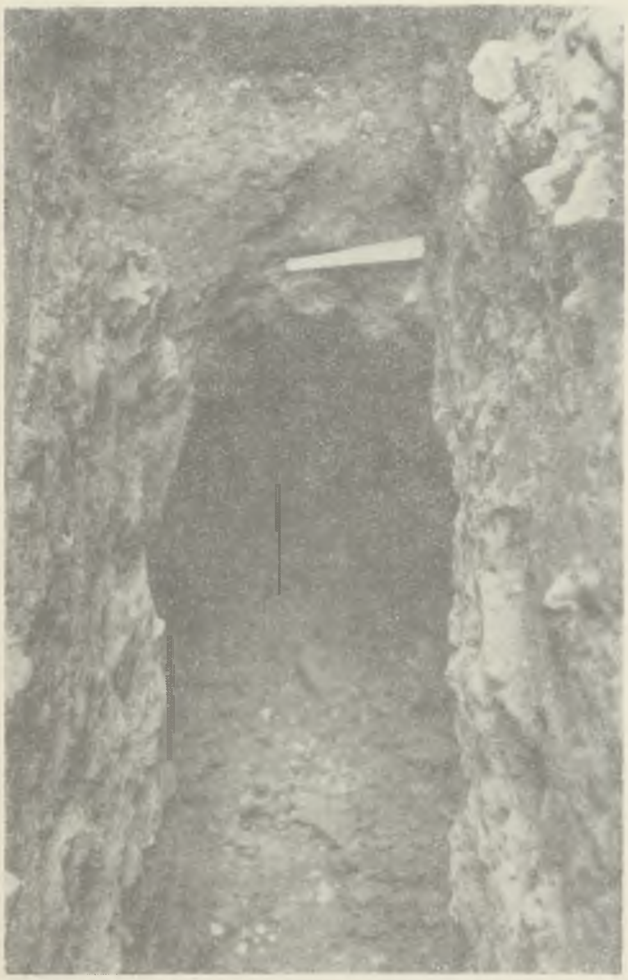

Fig. 42. Sąspów, Cracow dist. Shaft No 3. Gallery. Scale 20 cm

Photo by J.Lech

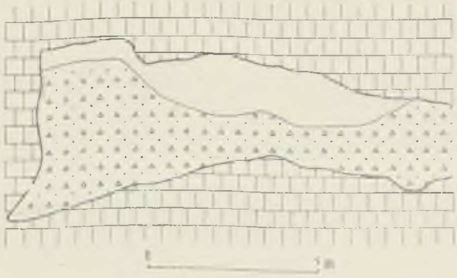

Fig. 43. Tušimice, Chomutov dist. Cross-section through gallery No 1

After E.Neustupný

Fig. 44. Tušimice, Chomutov dist. Gallery No 1

After E.Neustupný

Because of the occurrence of underground galleries and workings in open shafts, the problem is how we can usefully separate this kind of exploitation unit from open shafts, or from shafts with underground exploitation. Workings where the main mass of raw material was obtained within the actual shaft hole can be included in open shafts without underground exploitation. The raw material from the recesses in the shaft walls an arm's reach away from the bottom should be included there. It is characteristic for open shafts with underground exploitation that part of the raw material was obtained in a typical underground work. But generally, raw material was taken from the actual shaft hole and from short workings. This can be shown by the floor surface or by

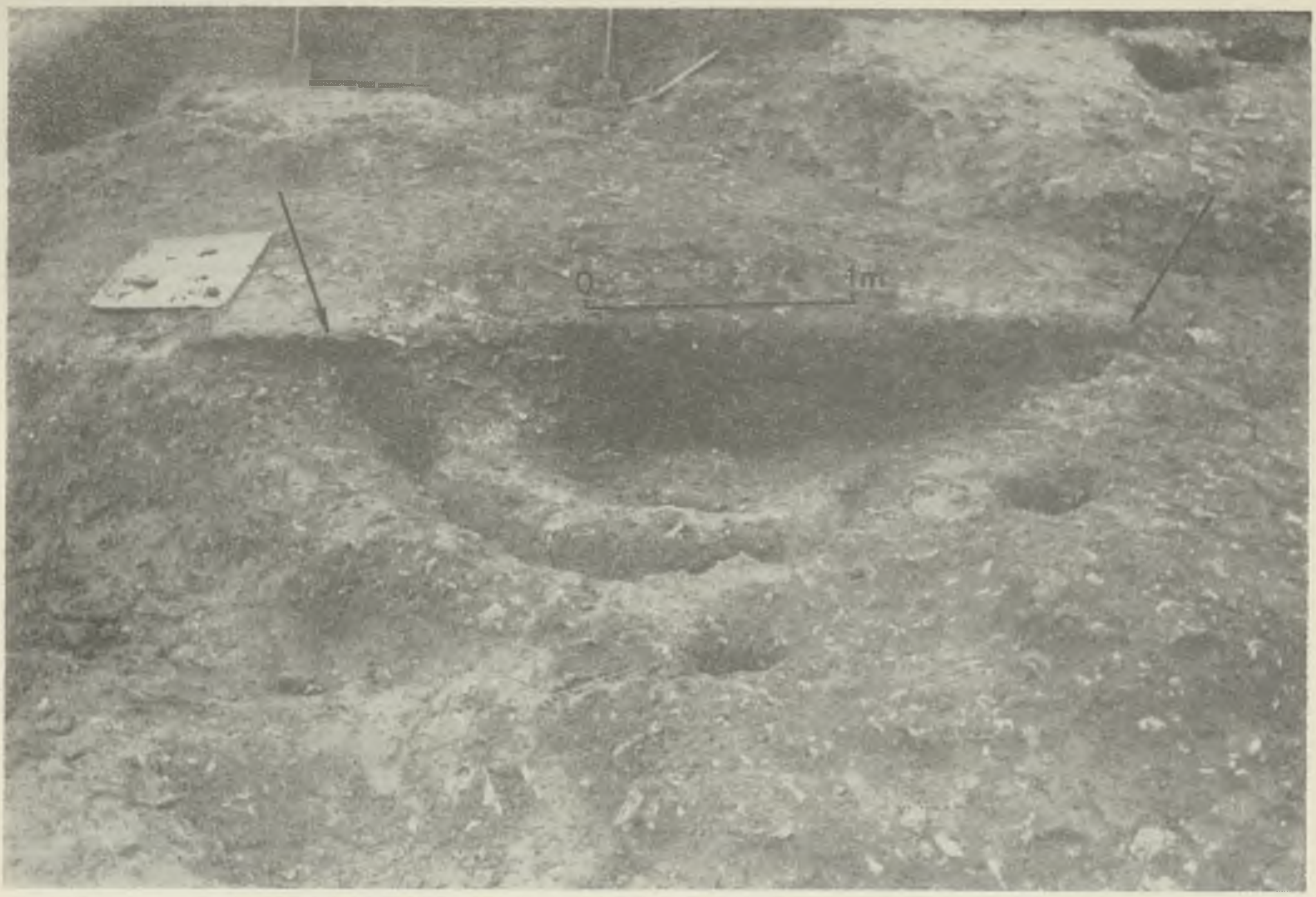

Fig. 45. Polany Kolonie, Radom dist. Fragment of the mining field after removal of soil and subsoil. Arrows mark opening of shaft No 1 Excavations 1972 by R. Schild et alii

Photo by J.Lech

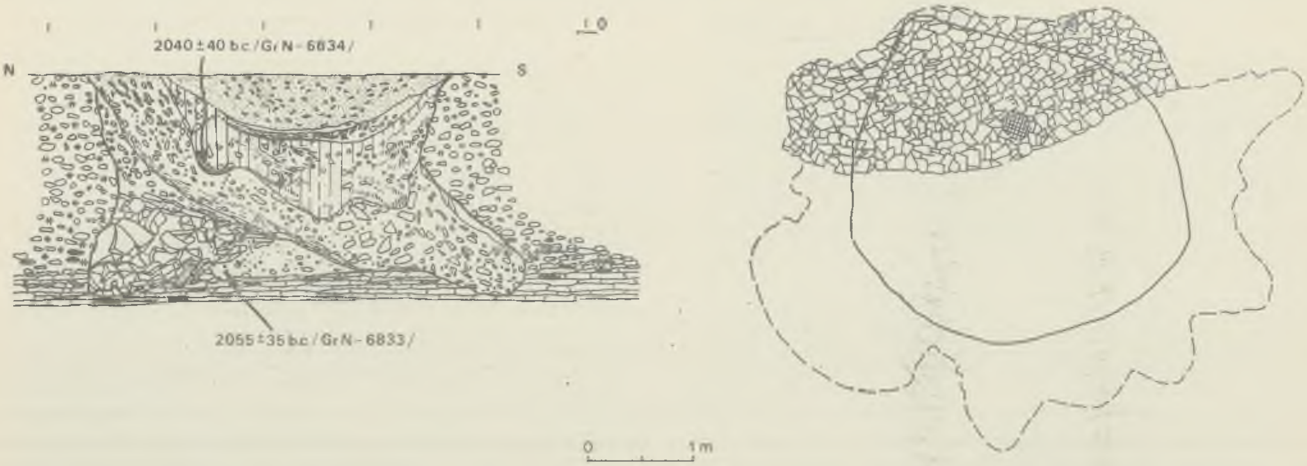

Fig. 46. Polany Kolonie, Radom dist. Cross-section and map of shaft No 1

Dotted line indicates maximal extent of workings, continuous line shows opening of the shaft; limestone masonary schematically indicated in the northern section together with the flints cache (black dots), and hearth on shaft floor (hachured areat)

After R.Schild et alii

the amount of raw material extruded within the shaft in comparison with the similar parameters for underground workings. The examples of shafts from Krasnoye Selo, Vienna-Mauer, Sąspów, Tušimice and Polany Kolonie constitute a separate transitional category between open shafts and full underground shaft exploitation with niches, galleries and stalls.

5. UNDERGROUND SHAFTS WITH NICHES

Underground shafts with niche workings are known at Krzemionki Opatowskie and Krasnoye Selo. The presence at the bottom of the shaft of high, wide niches which diminish in size the longer they are, is a characteristic of this exploitation system. As the shafts of this kind from Krzemionki Opatowskie are known only from brief reports and schematic drawings (Fig. 47). we shall limit ourselves to describing shafts with niches from Krasnoye Selo. Shafts Nos 5, 9 and 127, all from the cutting IV are typical examples.

Shaft No 5 had the hole diameter 1.6–1.9 m and was 3.9 m deep (Fig. 48). The chalk in which it was sunk was very hard. In the north part, at the bottom there was a small side working, cut into the wall to 60 cm and 50 cm high. In the south-west part of shaft, at a depth of 1 m,

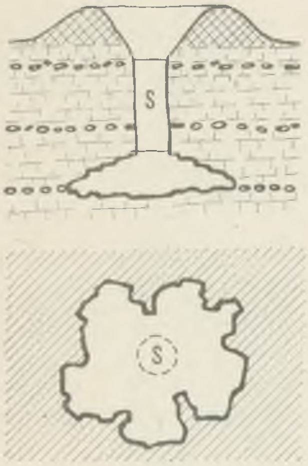

Fig. 47. Krzemionki Opatowskie, near Ostrowiec Świętokrzyski. Schematic cross-section and plan of schaft with niche workings

After T.Żurowski

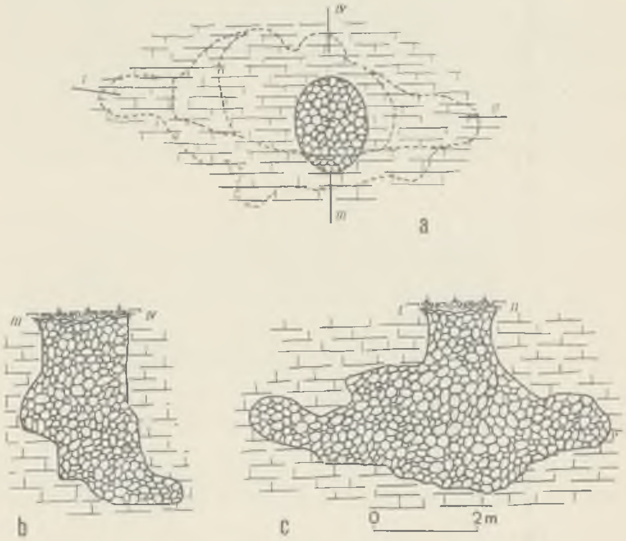

Fig. 48. Krasnoye Selo, Volkovysk dist. Shaft No 5 from excava tion IV

After N.N.Gurina

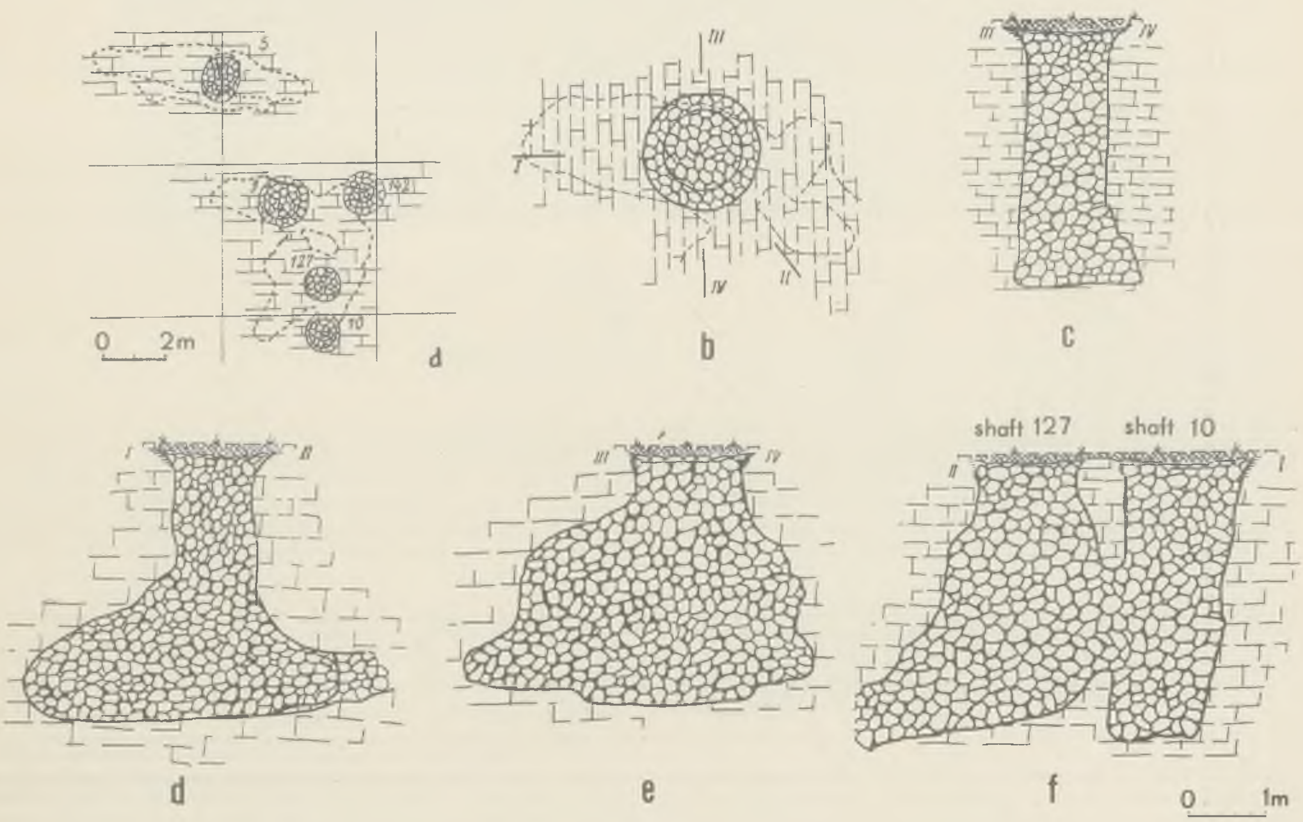

Fig. 49. Krasnoye Selo, Volkovysk dist. Shafts No 9, 10 and 127 from excavation IV

After N.N.Gurina

there was a small working in the form of a niche with a dipping roof. Its maximum height was 1 m, and the depth 40 cm. Further down, the wall became vertical again. Then the shaft narrowed to a step 50 cm wide. Below the step the wall reached the bottom (Fig. 48b). In the west shaft wall, at a depth of 1 m a two part niche had been started. Its biggest height from the shaft bottom was 2.35 m (Fig. 48c). This height was carried 1.6 m into the niche. Further on the roof dipped and the floor rose. In this way the height decreased 70 cm. The complete length of this niche was 3.4 m (Gurina 1976, 158). The third niche occurred in the east shaft wall (Fig. 48c). To the depth of 1 m the wall was vertical, then it widened to form a niche. At a depth of 1.8 m from the surface the niche took a horizontal direction. At the end there was rather striking narrowing 1 m high. The niche floor was 80 cm above the shaft floor. The complete length of the east niche was 2.2 m. Because both niches — east and west — were situated opposite to each other, the maximum width of the shaft in the lower part amounted to 7 m. The bottom was very uneven.

In shaft No 5 all niches were clearly above the shaft bottom. Niches in shaft No 9 were situated at its bottom (Fig. 49a–d). Shaft No 9 was 1.6 m diameter and was 3.4 m deep (Gurina 1976, 159). The north shaft wall was even and almost vertical to the bottom. The south one had a small niche at the bottom (Fig. 49c). The height of the south niche was 1.2 m. The length of the niche, measured along the shaft bottom, was 50 cm. There was a big niche in the west part of shaft. The roof became lower with the increase in the distance away from the centre. The bottom was at the same level as the shaft. The depth of the niche was 1.8 m, its biggest height 1.8 m, the smallest one 60 cm (Fig. 49d). The niche in the south-east part of the shaft started at a depth of 2 m. It was 1.4 m high there. Further on it changed into a gallery 70 cm high. At the end there was an oval leading to shaft No 127 (Fig. 49d).

Shaft No 127 also had niche workings (Fig. 49e, f). The diameter at the surface was 1.2 m and the depth was 3 m. In the north wall there was a shallow niche (50 cm), 1.8 m high (Fig. 49e). A much deeper niche (2 m) of the same height — was in the south-west part (Gurina 1976, 159). In the north-west part of the shaft a niche 1 m high gradually changed into a gallery 70 cm in diameter, leading to shaft No 9. In the north part of the shaft there was also a working forming the passage to shaft No 142. On the south side the shaft bottom rose and its depth was reduced to 2.2 m. The passage to shaft No 10 went through that place. The thickness of the wall dividing both shafts was 40 cm (Fig. 49f).

6. UNDERGROUND SHAFTS WITH GALLERIES AND STALLS

Underground shafts with galleries and stalls are known from the mine at Krzemionki Opatowskie and from the mine at Rijckholt-St.Geertruid, near the west border of the area under discussion. At Krzemionki Opatowskie the shafts are wide (Fig. 50), while at Rijckholt-St. Geertruid they are narrow (Fig. 51). Long, narrow horizontal workings are described as galleries (Fig. 52). Stalls are most commonly formed through widening the galleries to extract the raw material over a larger surface (Fig. 53). Sometimes stalls formed as a result of

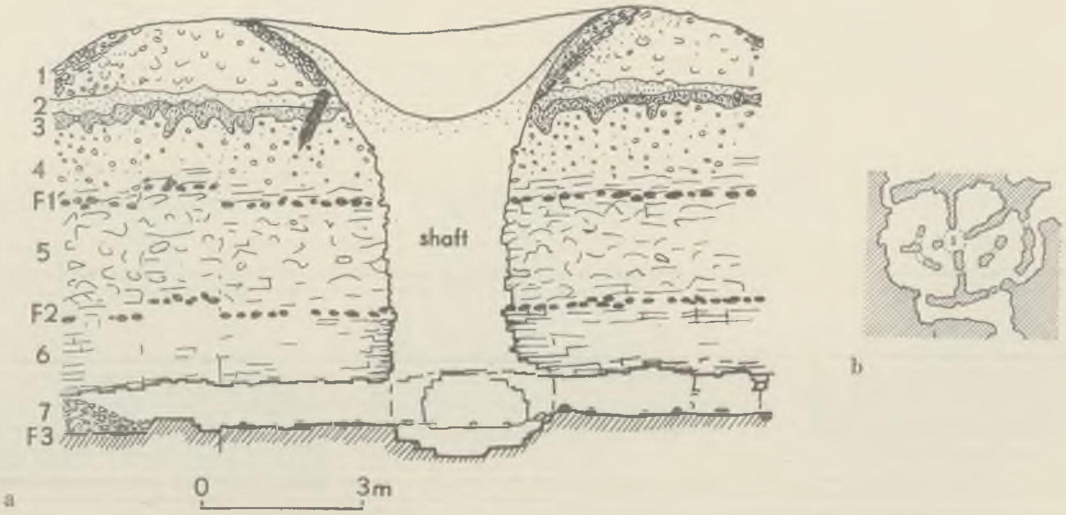

Fig. 50. Krzemionki Opatowskie. Cross-section of shaft and plan of workings

a — cross-section through shaft and waste-heap; *1* — waste-heap, *2* — soil with sand, *3* — brown clay, *4* — clay with admixture of limestone, *5* — limestone rifted in blocks, *6* — limestone rifted in plates, *7* — galleries, F1, F2, F3 — layers of flint; b — plan of the fully-developed exploitation system with stalls and galleries

After T.Żurowski

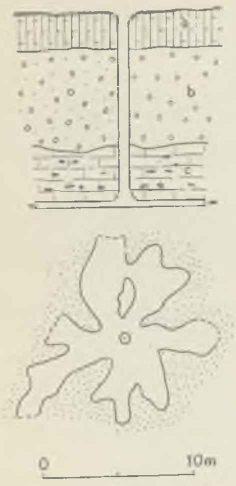

Fig. 51. Rijckholt–St.Geertruid, Maastricht dist. Schematic section of flint mine with narrow shaft

a – loess; *b* – sand with gravel; *c* – calcareous rock with layers of flint nodules

After W.M.Felder et alii

Fig. 52. Rijckholt–St.Geertruid, Maastricht dist. Gallery

After P.J.Felder and P.C.M.Rademakers

Fig. 53. Krzemionki Opatowskie. Shaft No 4. Fragment of cleaned stall. Scale of range pole on right 20 cm; scale in background 20 cm

Photo by J.Lech

connecting the workings of adjacent shafts. Stalls were the same height as galleries, or a little higher. Sometimes pillars were left in them.

Shafts at Krzemionki have 3–10 m in diameter in their upper parts, which narrowed after reaching the roof of the limestone rock. In the rock, at the bottom, their diameter was approx. 2.5–3 m × 3–3.5 m. The depth varied from approx. 4 m to 10 m (Krukowski 1939, 13–24; T. Żurowski 1960, 269–271; 1962, 37–43). Shaft galleries were about 60 cm high (Fig. 54). Flint was exploited from the floor of galleries and stalls (Fig. 55). Flint exploitation from other levels was rare at Krzemionki. In such cases it was caused by a fault or irregularity in the deposit. In the mine shafts Nos 2 and 3 the length of the galleries varied from 2 to 5 m. Also, stalls could have been up to 5 m in diameter. Larger and smaller stalls are also known. Sometimes galleries of adjacent

Fig. 54. Krzemionki Opatowskie. Entrance from shaft to gallery – stall (?). In entrance original height of roof visible; in foreground, effects of weathering on roof after abandonment of shaft. Scale 20 cm

Photo by J.Lech

Fig. 55. Krzemionki Opatowskie. Shaft No 4. Negatives after extrusion of striped flint nodules from floor of stall

Photo by T.Biniewski

Fig. 56. Krzemionki Opatowskie. Original state of unexamined gallery, several metres long and not filled in with limestone debris, in the region of shafts Nos 2 and 3. Scale 20 cm

Photo by J.Lech

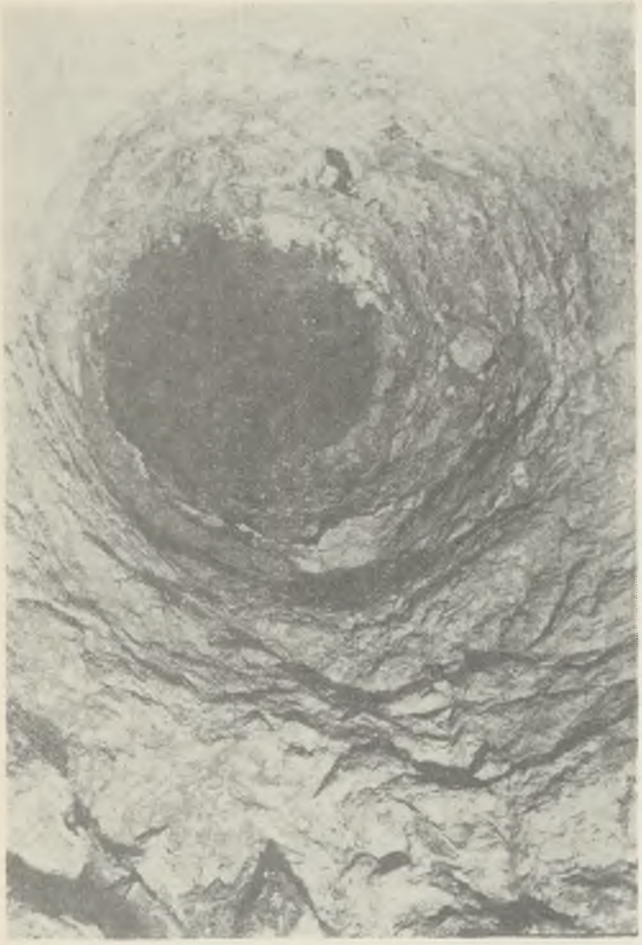

Fig. 57. Rijckholt—St.Geertruid. View of shaft No 18
After P.J.Felder, P.C.M.Rademakers

shafts were deliberately connected to form passages, which were not filled with waste rock (Fig. 56). In some places pillars with square or triangular section were left. Shafts examined by S. Krukowski and T. Żurowski were about 7 m away from each other.

At Rijckholt—St.Geertruid the shaft hole diameters were only about 1 m (Fig. 57). Their depth varied from 4 to 16 m, but the most common were shafts with a depth from 8 to 12 m (P. J. Felder, Rademakers 1973; Bosch 1975; W. M. Felder et alii 1979, 51–64). The system of widening galleries or making them into stalls was used to exploit the deposit. The area of underground exploitation from one shaft covered a range from 15 m^2 to 50 m^2, and was clearly increasing with the depth of the shaft. In 4 m deep shafts the most remote workings were 2 m from the pit (Fig. 58). With a depth of 6 m the maximum distance of deposits exploitation was increased to 5 m. In shafts 10 m deep the most remote workings were from the hole. The exploited flint layer was always in the middle of the workings.

Galleries occurred in some shafts of the Vienna-Mauer mine (Fig. 33) and stalls are found sporadically at Krasnoye Selo. For that last mine N. N. Gurina describes the shaft with a single stall and a niche (shaft No 17 from the cutting IV) and the case of stall formation as a result of connecting the workings of three adjacent shafts (shafts Nos 17, 19 and 20 from the cutting I). In the upper part, the section of shaft No 17 had an oval outline measuring 1.4×1.8 m. It was 3.4 m deep. In the south-west part of the shaft, at a depth of 1.6 m, a relatively narrow stall was started. It was 4 m long and approx. 1 m high. The stall was situated 65 cm above the shaft bottom (Fig. 59). At the back, the stall widened and divided into two separate workings. Its width there amounted to 2.2 m. The north stall ended in a small oval hole, 50 cm in diameter which connected shaft No 17 with shaft No 133. Additionally, in shaft No 17 a niche and a working occurred (Gurina 1976, 160). In the case where workings from three shafts at the cutting I (Nos 17, 19 and 20) were connected together a stall measuring 4.2×4 m was formed (which also takes into account the shaft hole surface). The diameters of three shafts varied from 1 m to 1.4 m (Gurina 1976, 140).

Underground shafts with galleries and stalls required the most complex organization, geological knowledge, and the participation of several people. The presence of narrow and wide shafts indicates essential differences in the methods employed, which we have discussed for open shafts and shafts with niches.

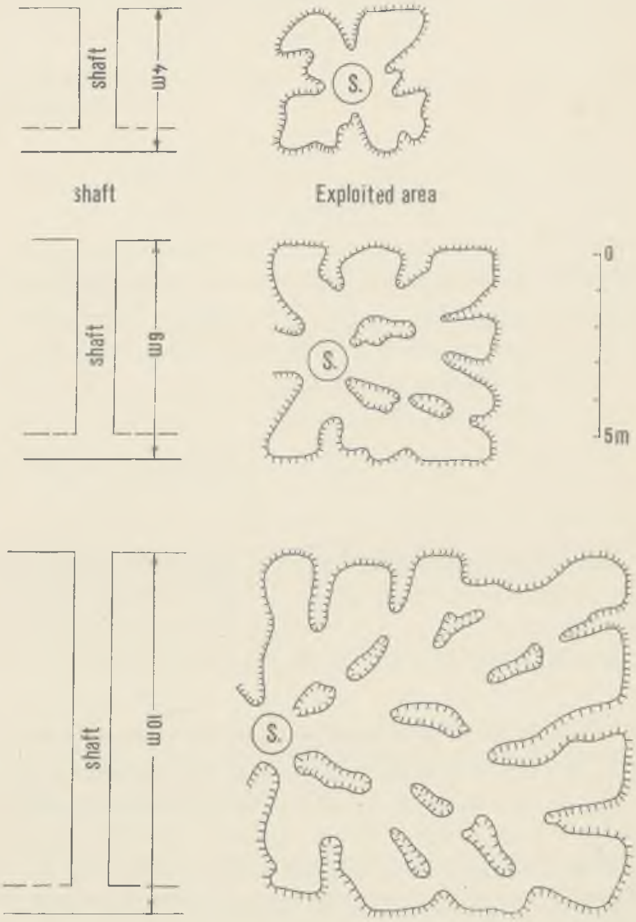

Fig. 58. Rijckholt—St.Geertruid. Schematic view of methods of exploitation at different depths
After W.M.Felder et alii

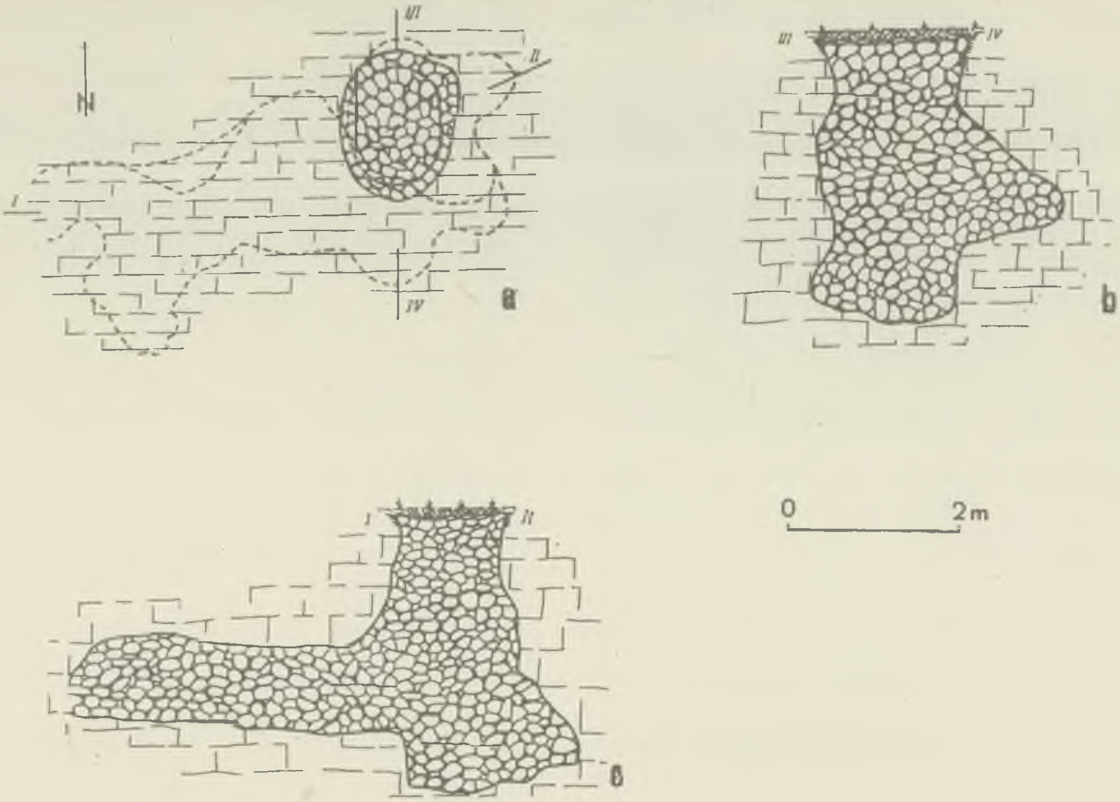

Fig. 59. Krasnoye Selo, Volkovysk dist. Shaft No 17 from excavation IV

After N.N.Gurina

7. OTHER WORKINGS

Other methods of obtaining raw material to meet needs of the flint industry among early farming communities, i.e. drift mining, horizontal mining changing into drift mining and quarrying, are not known yet from the area of Central Europe. For that reason, there is no need to discuss them here. They have been studied by M. Jahn and E. Schmid. Poorly known discoveries of mines with drift exploitation come from the territory of Ukraine — region of Kamieniec Podolski in the basin of the middle Dnestr and the region of Donieck. They have been discussed lately by N. N. Gurina who cite earlier literature on the subject (1976, 102 f.).

VI. THE PROBLEM OF THE SIZE OF THE MINING FIELD

It has been a difficult task, for most of the investigators of prehistoric flint mines, to quantify the size of the exploitation area; in other words — the mining field (Krukowski 1939, 11 f., 130). The surface of the mining field covers the territory occupied by exploitation units i.e. workings formed in the deposit itself. In the primeval conditions, a mining field was marked by hollows from old workings and heaps of waste rock. In addition, there were sometimes partly filled hollows which had once been workshops for processing the flint. The levelling processes which went on for thousands years almost completely obliterated the primeval landscape on most mines (Lech 1971, 117; 1975a). Only a few prehistoric mines in Europe preserved visible traces of their former use. Among the better preserved ones are Krzemionki (Fig. 60). Borownia, Korycizna and farther away Grime's Graves and Cissbury. That is why it is not possible to characterize the size of prehistoric flint mines using only sites from Central Europe. It is necessary to include the mines from more distant territories.

Even in these lucky cases where elements of the primeval landscape from the period of raw material exploitation are preserved, they do not necessarily reflect the real size of the mining field. This is shown by unmistakable investigations at Grime's Graves (Armstrong 1923, 117; 1926, 121; Clarke 1971, 12; Sieveking et alii

1973, 185–187) and observations made by S. Krukowski at Krzemionki Opatowskie (1939, 108–111). Attempts at defining the former size of mining fields basing on obliterated remains of exploitation units and of surface workings are becoming ever more difficult. This is true of all the mines we have discussed until now.

After complete levelling of the territory, the area of the mining field is marked only by flint materials — the mixture of natural waste and industrial specimens (Lech 1975a, 142–144). This criterion, in most cases the only possible one to use, does not eliminate the mistake resulting from the fact that flint workshops and encampments were located in the vicinity of the mine but beyond the area of the mining field. Such a situation is illustrated best by W. H. Holmes' investigations carried out at the beginning of the last decade of the 19th century on the territory of very well preserved chert mine at Peoria, at the border line of Missouri and Kansas — U.S.A (1894, 7 f.). It was exploited by local Indian tribes in the 18th and at the beginning of the 19th century. Holmes' research showed that the mining field covered not more than 1/3 part of the whole site. The rest of territory was covered by numerous processing workshops. In case of a completely levelled surface it would be impossible to distinguish the area with shafts, from the areas occupied by workshops.

This conclusion is confirmed by R. Schild's investigations at the Polany Kolonie mine. Using systematic surface collection one would have thought that the mining field covered about 1.5 ha (Schild 1971, 31). Archaeological excavations showed that the mine territory was much smaller. Just after finishing the investigations R. Schild qualified its area as smaller than 0.5 ha with about 50–70 shafts, but after more analysis he stated more precisely that the size of the mining field was about 0.2 ha (1973, 39; 1976a, 153).

The views on the size of the mining field at Grime's Graves mine changed in the opposite direction. For many years it was thought, after A. L. Armstrong, that the mine area covered about 14 ha (1926, 91). This information was quoted among others by J. G. D. Clark (1957, 212) and R. R. Clarke (1971, 12). Meanwhile the latest investigations show that the mining field at Grime's Graves is much bigger, and its biggest part was completely levelled. The whole site area is presently calculated to cover more than 37 ha (Sieveking et alii 1973, 184). As a result we should assume that to define the surface of a mining field we must treat each site individually, taking into account its geographical and geomorphological situation, recognition of the exploited deposit, types of workings and the range of site destruction. The result is always more or less approximative.

Among roughly one hundred and fifty stone mines of primitive communities known today (compare Holmes 1919, 155–240; Reisch 1974, 75–86; Engelen 1975; Lech 1975a; Gurina 1976, 101–108; Moser 1978), we have at our disposal data of various qualities on the sizes of mining fields for a dozen or so sites. Apart from that, in the archaeological literature there are sometimes contradictory data on the size of some mines. This can arise partly from the variety of criteria used by various researchers or by the same researchers in various works (compare T. Żurowski 1960, 250, 277; 1962, 83). A comparison of flint mine sizes in primitive communities in various regions of the world, suggests a four-group division.

Fig. 60. Krzemionki Opatowskie. Fragment of the mining field on the main survey line (former point No 38). Survey rods and arrows mark hollows left by shafts, that are visible today

Photo by J.Lech

The first group covers small ones with a surface up to 1 ha. This would include the mines at Polany Kolonie — about 0.2 ha (Schild 1976a, 153), Tušimice — about 0.2 ha (Neustupný 1976), Burły 3 localized south of the Aral Sea and to the east from the lower course of Amudarya, on the fringe of the Kyzyl-kum Desert — 0.3 ha (Vinogradov 1968, 126 f.), Vienna-Mauer — about 0.5 ha (Kirnbauer 1958, 132) and Učtut, north-east from Buchara — about 1 ha (Kasymov 1972, 38, 53).

Mines of medium size with a surface from 1 ha to 5 ha constitute the second group. The mine at Sąspów (4–5 ha) and probably the mines at Tomaszów and Wierzbica "Zele" (Schild 1971, 34–36) belong to it. The Indian mine at Peoria (1.5–2 ha) is also placed in this group (Holmes, 1894, 9).

Mines with a large surface constitute the third group in our division. Their size ranges from 5 to 20 ha. The mines at Rijckholt—St. Geertruid (Bosch 1975, 8), Easton Down (Stone 1931, 350), Krasnoye Selo (Gurina 1976, 130), and Bębło (Lech 1981).

Ones with a mining field bigger than 20 ha constitute the last group of very large mines. The mines at Grime's Graves, Krzemionki Opatowskie and Świeciechów (Sieveking et alii 1973, 184; Balcer 1975, 150–152; Bąbel 1975) are among them.

VII. SURVEY OF WORKING TOOLS

The researchers of prehistoric mines face numerous problems but working tools of the oldest "miners" have always aroused great interest for over 120 years. It is well seen even in the report by Canon W. Greenwell on the first excavations at Grime's Graves, presented during the meeting at The London Ethnological Society in 1871.

Tools or their working fragments made of various kinds of rocks, antler and bones survived until the present day. As with the majority of archaeological sites, tools and elements made of wood, skin and similar organic materials did not survive, although their utilization in mining need not be doubted (Krukowski 1939, 35, Fig. 21; T. Żurowski 1962, 44; Schmid 1973b, 26 f.; 1974, 16 f.). The hafting marks visible on picks and hammers testify to the mass utilization of wood and other organic materials. We know single flint tools from the oldest flint mines connected with the activities of early farming communities (the LBK and later Danubian cultures) such as Tomaszów, Sąspów, Bębło and Jerzmanowice-Dąbrówka. In this way we can be sure that tools made of organic materials — antler, wood, skin and bone were dominant. In an unfavourable chemical environment of eluvial clays (highly acid) even antler tools do not survive. In one case — the mine at Sąspów — the visible outline of cutting within shaft No 1 (Fig. 27), shows the utilization of a tool resembling a wooden spade. Antler hoes discovered among the materials of the camp in the cave Bębłowska Dolna (Fig. 61), about 1000 m away from the mine at Bębło could have served to dig the loess, clay and sand (Rook 1963).

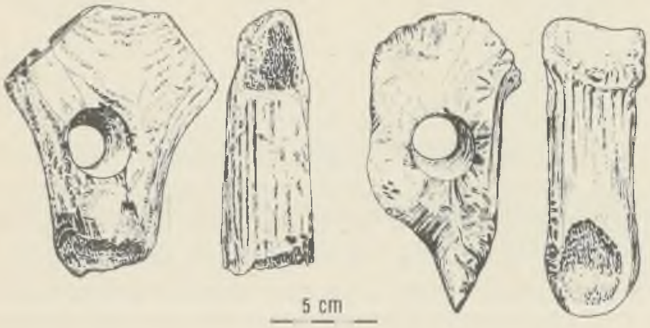

Fig. 61. Bębło, Cracow dist. Bębłowska Dolna Cave. Antler hoes
After E.Rook

A single flint pick — 90 mm long — from the mine shaft at Jerzmanowice-Dąbrówka (Fig. 73b) and a few similar specimens from the Lengyer-Polgar settlements situated in the vicinity of the Jurassic Cracow flint deposits could be proof that this tool was used on a small scale in the Vistula river basin in the 4th Millennium b.c.

Tools used to extrude raw material from Calcerous rocks or chalk are the best known. Various sets of tools were used to break limestones into pieces and to work the soft or hard chalk. Different kinds of mining hammers — "bucking hammers" of those days — of the fist size or bigger, were made most commonly of volcanic rocks, metamorphic rocks or quartz pebbles (Fig. 62). They were the most important tools wherever limestone was worked. The shape of mining hammers is usually elongated and the section oval (Schmid 1973b, 26). Traces of utilization are various. Sometimes chips and smashes are visible only at one end. But usually both ends are smashed. Pebble hammers were used to strike in such a way as to form a scratch reaching rather deep into the limestone. In this way the loosened waste rock was removed with the help of other tools.

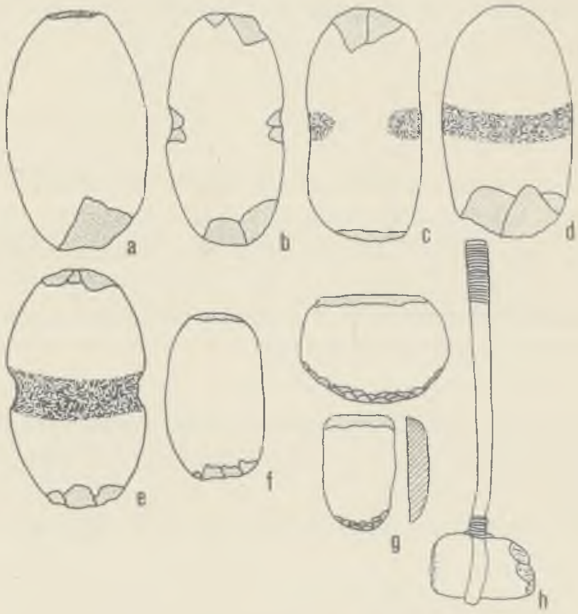

Fig. 62. Pebble mining hammers and similar tools
a–f — various types of pebble mining hammers used with handle (*b, c*) or without handle (*a, f*); *g* — "navette" — stone tool for more precise work; h — method of fitting handles to pebble mining hammers
After E.Schmid

Cigar-shaped picks and mining pick-hammers, up to a dozen or so centimetres long, made of crystalline rocks were also used to work in limestone, They are known from the mine at Krzemionki Opatowskie (Krukowski 1939, 33–36, 39, Fig. 19). One end is formed into a conical spike or short point, slightly flattened and rounded; the other one is transversely "cut", for use as a hammer (Fig. 68c). These tools, unlike the pebble hammers, are usually prepared and finished with great care, in the first phase through chipping off flakes, and then by grinding (Krukowski 1939, 35). Hammers and pick-hammers adapted from stone axes also occur. They have a hole drilled through, to fit a handle (Ruttkay 1970). At Krzemionki, pick-hammers were used to work in poorly stratified limestones and with rare joint cracks. This rock is easy to crush and groove (Krukowski 1939, 39–41). Flint picks were used more seldom to work the Calcerous rocks.

Deposit exploitation in damp and soft chalk, where the waste rock could be removed by scraping and jerking, created different requirements. Picks with a sharp edge, made of flint, were most suitable for such work. Pebble hammers, cigar-shaped pick-hammers as well as flint picks, often had a wooden handle. This is illustrated by ethnographic analogies (Krukowski 1939, 35; Schmid 1973b, 27). On the other hand, experiments by T. Żurowski in underground shafts at Krzemionki show that pick-hammers and flint picks could have been efficiently used also without any handle (1962, 47).

Antler belonged to the materials most commonly used to produce mining tools. Most of necessary raw material was obtained by collecting shed antlers. Antlers were divided into parts depending on the size and the number of branches. Picks, axes, hoes, hammers, levers, rabblers, wedges and point-picks were hafted and made in a simple way by adapting separate antler fragments. The most commonly used picks came from the piece of antler rod with the rose (Fig. 63). The brow tine next to the rose was left as acting part and the ones above were removed (Schmid 1973b, 28). Other antler fragment, with or without preparation, then were used as separate tools. Antler tools were used in many flint mines. Antlers of elk, roe-deer, and horns from aurochs were much more rarely used than red deer antler (Krukowski 1939, 33, 37; T. Żurowski 1960, 266; 1962, 48; Fülöp 1973, 23; 1975, 73; Schmid 1975, 79).

The shovel-spade made from the shoulder blade of aurochs, deer, ox or swine by trimming the protruding spine belong to the most interesting of mining bone tools (Stone 1934, 227; Curwen 1954, 100). The efficiency of such a spade was not much better than bare hands. It was probably important in protecting the miners' hands against injury. It was most suitable for sweeping up loose material. We can assume that similar wooden tools were more effective than trimmed animal bones (Lane Fox 1876, 383; Coles 1973, 73 f.). Nor can we exclude the utilization of hand bone picks, made from the long bones of oxen, or bones of other big mammals (Armstrong 1923, 121 f.).

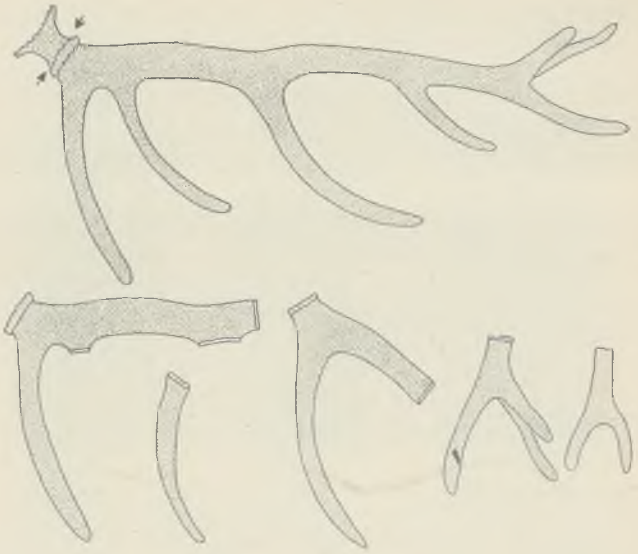

Fig. 63. Plan showing the division of antler for different kinds of tools for mining work. If the antler ends below the rose (arrows) this is a shed antler

After E.Schmid

We know of pebble hammers from the mine at Löwenberg in the Swiss Jura sited 25 km. to the south-west of Basel (Schmid 1975, 78 f.). They were usually 20 cm long. They were used without any hafts beside antler picks, hammers or rabblers. This is similar to the mine at Veaux-Malaucène in the lower course of the Rhône close to Avignon, where pebbles were brought from bigger distances perhaps up to 10–20 km from the site, and then used there. Various kinds of mining hammers (some of them stone axes used for that purpose), flint axes and antler tools were used at Vienna-Mauer (Ruttkay 1970). Pebble mining hammers were used on a mass scale in some mines outside Central Europe. Many hundreds of hammers with and without grooves come from the mine at Veaux-Malaucène. They are made of elongated quartz pebbles 15–20 cm long. The most carefully made hammers have a groove in the middle a $\frac{1}{3}$ of the way along. It was used to fit the handle. In some cases it is carefully hammered, in others it is like a strips (Schmid 1974, 15 f.). The weight of hammers from Malaucène often exceeds 10 kg (Phillips 1975, 130). No traces of deer antler or bones were found during the investigations at the mine. Perhaps they have not survived. E. Schmid suggested that the removal of mined limestone was done with wooden tools.

In underground mining, in the soft chalk rocks of Limburg, Brabant and Hainaut, flint picks in wooden hafts were the basic tool. About 15,000 of them were found during excavations at Rijckholt—St.Geertruid (P. J. Felder, Rademakers 1973; Bosch 1975, 9). They were made either of natural flint pieces, or of reused blade cores and unsuccessful semiproducts of axes (Fig. 64). Flint picks were also basic tools for working in the

Fig. 64. Rijckholt—St.Geertruid. Flint picks

Photo by J.Lech

chalk at Spiennes and the Jandrain- Jandrenouille mine. In recent years F. Hubert devoted more attention to their typology (1974, 30–41; 1978, 24–32). In Central Europe, picks are not commonly found on mine territories. At present they are known only from a few mines in the Vistula river basin. A few specimens of this tool come from Krzemionki Opatowskie (Krukowski 1939, 35; T. Żurowski 1962, 45), Świeciechów (Balcer 1971, 114), Polany Kolonie (Schild, Królik, Mościbrodzka 1977, 65). A single specimen comes from the mine at Jerzmanowice-Dąbrówka (Fig. 73 b) and from the grave goods in the settlement at Kraków-Pleszów — pit 937 (Kaczanowska 1977, 38–41, 47 f.). Picks were used relatively often at the mine of Polany (Chmielewska 1973). They were never the basic tool, but rather an accompanying one.

Antler tools are known from many mines in Central Europe. They constitute the most important mining equipment from the mines at Sümeg-Mogyorósdomb and Tata-Kálvária Hill (Fig. 65), Tušimice, Lengfeld, Polany Kolonie, Krasnoye Selo (Fig. 66) (Vértes 1964, 190–205; Reisch 1974, 45 f.; Gurina 1976, 50–62; Neustupný 1976; Schild, Królik, Mościbrodzka 1977, 67–76). At Sümeg, Tata and Tušimice stone hammerstones were used additionally to divide radiolarite and quartzite from mother rock. Among antler tools, picks, levers, antler axe points with handles of other material, hoes and hammers

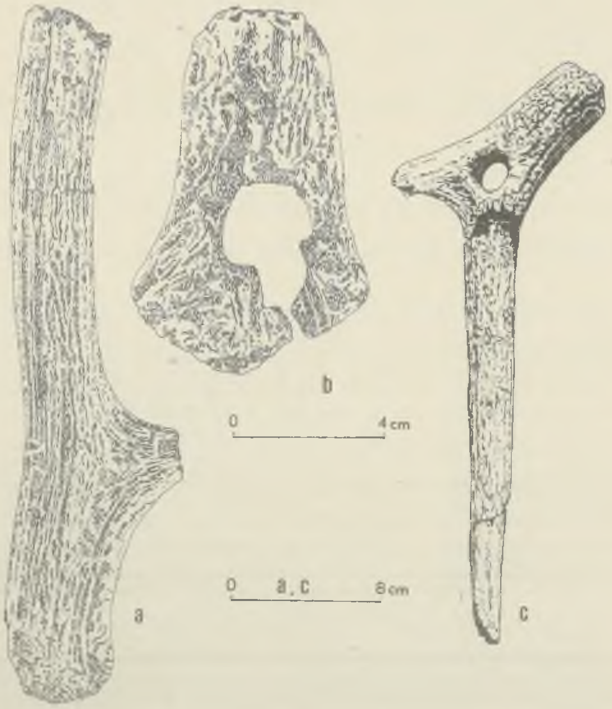

Fig. 65. Antler tools from Hungarian mines: Tata, Kálvária Hill (*a*, *b*) and Sümeg-Mogyorósdomb (*c*)

a — maul; *b* — hammer-head with trapezoidal shaft hole; *c* — pierced mining implement;

After J.Fülöp

Fig. 66. Krasnoye Selo. Various types of antler tools

After N.N.Gurina

Fig. 67. Krzemionki Opatowskie. Various types of tool made of dear antler

Photo by J.Lech

were most common. Red deer antler was the basic raw material. Antlers of elk, roe-deer, aurochs and goat were used occasionally. In none of the Central European mines, do antler tools appear as frequently as they do at Grime's Graves. Over many years' work, hundreds of very similar antler picks were found there (Greenwell 1871, 426–429; Armstrong 1934, 391; Sieveking et alii 1973). Single specimens of this type of antler pick are known from Krzemionki Opatowskie (T. Żurowski 1962, 52), Polany Kolonie (Schild, Królik, Mościbrodzka 1977, 73), and Polany, as well as from Krasnoye Selo (Gurina 1976, 51). Antler tools were also more common than pebble hammers in the mine at Löwenberg (Schmid 1975, 79).

In many mines groups of tools occur together at the same time, while in others there is one absolutely dominant type. Particularly varied mining tools were found at Krzemionki (Figs. 67 and 68). In this respect, this mine belongs to the most interesting in Europe. S. Krukowski mentions and describes, and in some places also

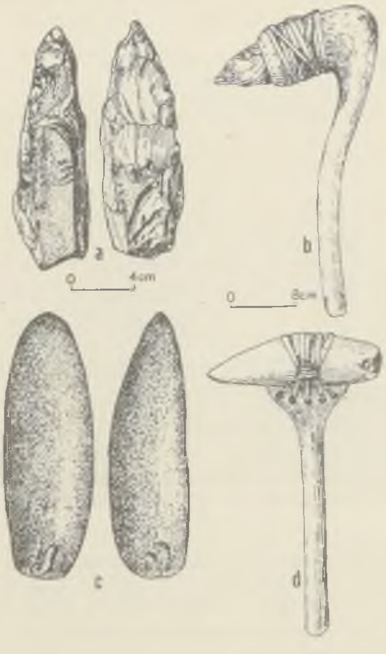

Fig. 68. Krzemionki Opatowskie. Mining tools

a, b — flint pick with reconstructed handle; *c, d* — stone pick with reconstructed handle

After S.Krukowski

Fig. 69. Vienna-Mauer. Antler tools

After E.Ruttkay

Fig. 70. Vienna-Mauer. Stone axes with hole for fitting handle, used for mining work

After E.Ruttkay

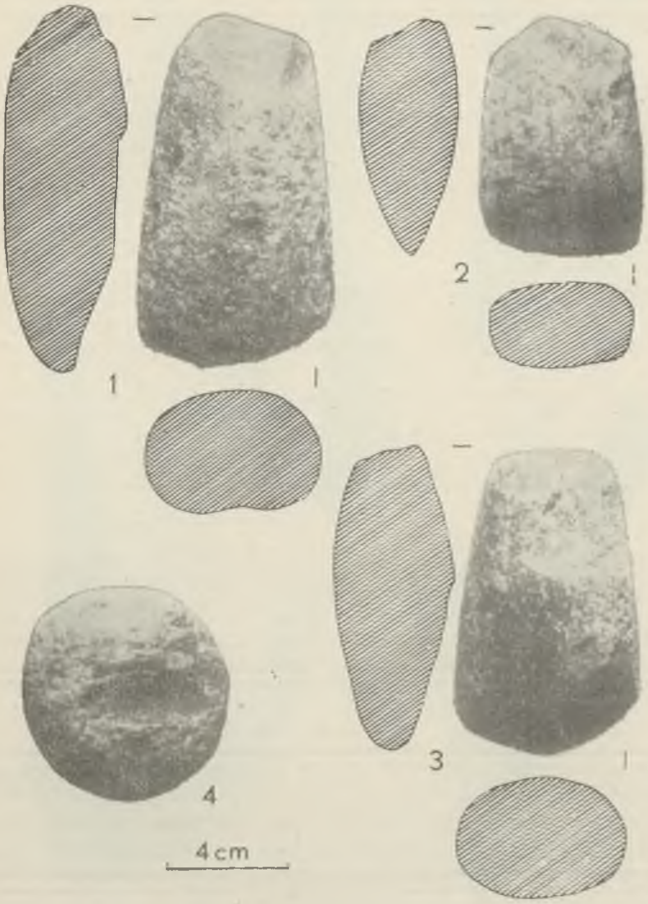

Fig. 71. Vienna-Mauer. Stone axes (*1–3*) and hammer-stone (*4*), used in the area of the mine

After E.Ruttkay

illustrates stone picks, pick hammers, rabbler picks, hoes made from crystalline rocks. Among flint tools, picks and hoe points were found. Picks, hammers and bits were made of antler (Krukowski 1939, 33–39). Similar tools occurred in further publications by T. Żurowski (1954, 281; 1960, 266 f.; 1962, 44–52). In the mine at Krzemionki deer antlers, and also a few elk, roe-deer and auroch antlers were utilized (Krukowski 1939, 33, 37; T. Żurowski 1960, 266). In 1953 the remains of a wooden tool were found, but it was impossible to recognize its shape (T. Żurowski 1954, 281; 1960, 263; 1962, 44).

Parts of deer antlers served as tools at the Vienna-Mauer mine (Fig. 69). They were used as levers and hammers. Various kinds of stone axes, mentioned earlier, were used to work the rock (Figs. 70 and 71). Hammers made of diabase, hand axes of greenstone and hammerstones of Danubian flint and quartz were also used (Kirnbauer 1958; Ruttkay 1970). Investigations at Polany mine showed that until the middle of the 2nd Millennium b.c. flint and antler picks (and perhaps levers) were used to exploit flint from Karstic clay and from the roof of the platy limestone.

Excavations at Polany Kolonie flint mine discovered a specific set of tools dated to the end of the 3rd Millennium b.c. Antler levers were the commonest tools and they served to pull both flint nodules and limestone slabs out of the walls and the shaft bottom (Schild, Królik, Mościbrodzka 1977, 67–76). This is shown by distinct utilization traces (Fig. 72). Four fully preserved specimens measured from 268 to 317 mm in length. In addition, a pick, a hammer, and a double ended lever or a digging stick were found, all made of red deer antler. Picks occur among flint mining tools. In addition there are also some specially made flint tools (Fig. 73c,e), which can be defined as bihorned pieces (in Polish *dwurogacz*) known from the flint mine Polany Kolonie and from many other "chocolate" flint exploitation points. We must agree with the view of R. Schild that bihorned pieces were linked with flint mining and were probably used to trim branches into usable wooden poles with a round section.

Macrolithic side scrapers and end scrapers were probably used to clean the clay or the soft chalk off the extruded nodules and they are known from many raw material exploitation points where the deposits are situated in eluvial clays or glacial formations (Fig. 73a,d). They could also have been used in digging the mine shaft and preparing the mining tools on the site. C. J. Becker (1951, 147) found traces of work of such tools on the flint cortex of the material originating from the chalk deposits at the Aalborg mine, in the north part of the Jutland Peninsula, as did B. Balcer (1975, 61 f.) on some specimens from the Świeciechów mine.

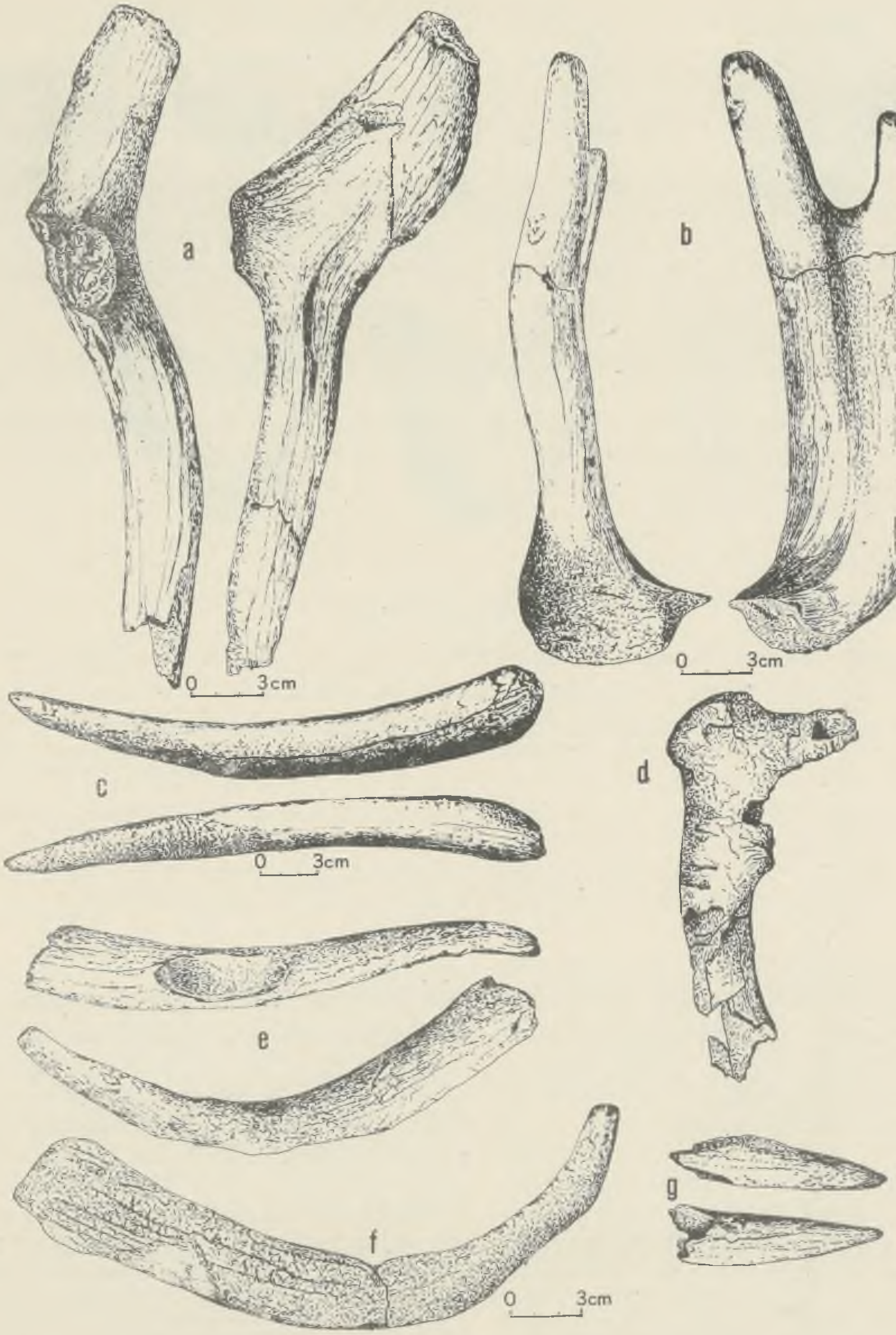

Fig. 72. Polany Kolonie, Radom dist. Antler tools for mining work

a — hammer; *b* — spade-shaped lever or digging stick; *c, e, f* — levers; *d* — antler pick; *g* — fragment of broken lever

After R.Schild et alii

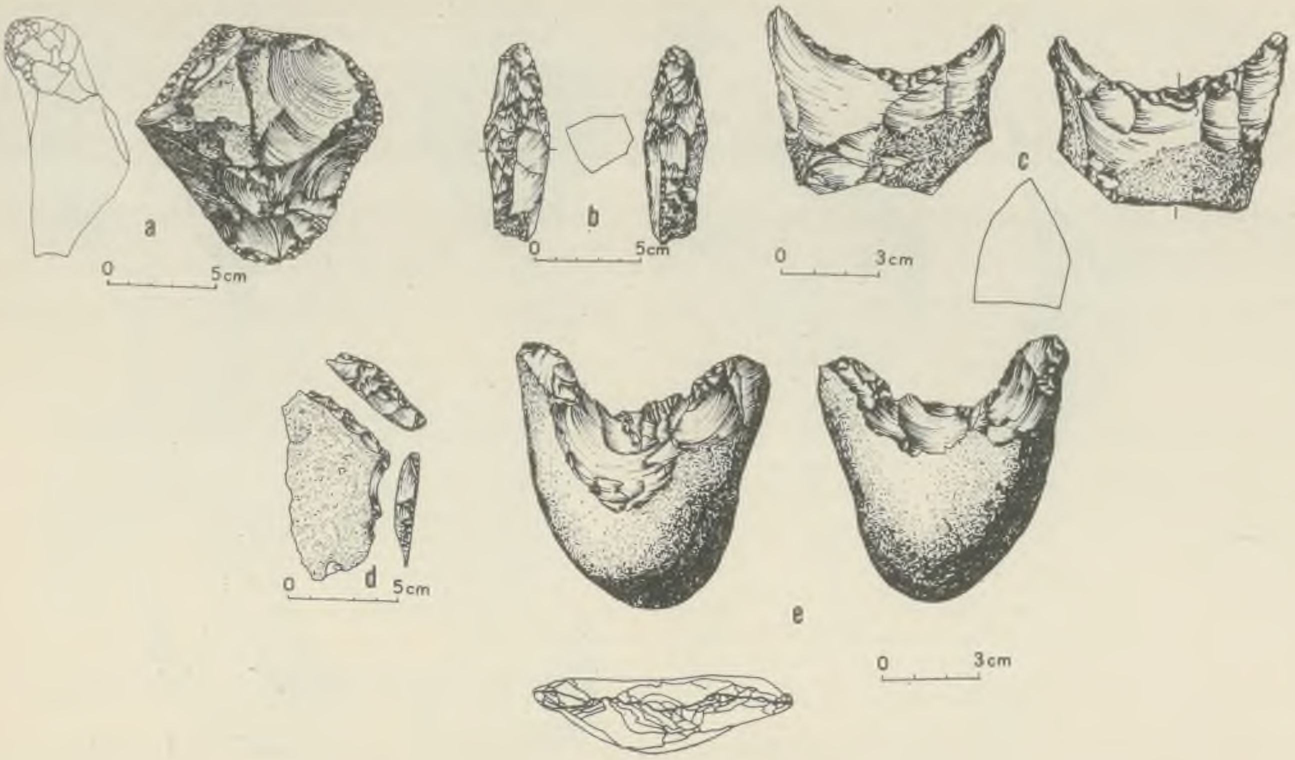

Fig. 73. Flint tools from mines in Polish territories

a — macrolithic side-scraper (Sąspów); *b* — pick (Jerzmanowice-Dąbrówka); *c*, *e* — bihorned pieces — dwurogacz (Polany Kolonie); *d* — scraper (Sąspów)

After J.Lech (a, b, d), R.Schild et alii (c, e)

VIII. THE DATING OF FLINT MINING

Dating flint mines has been very difficult until quite lately. It is typical that mines, workshops and raw material exploitation points all over Europe have very few datable features. Defining the links between mines and settlements utilizing them is usually a separate problem. Sometimes it is even difficult to discover them.

The character of the archaeological materials from the mines and the structure of workshop assemblages is a result of their function and for that reason they are the same, even in different cultural traditions. For example, some semi-finished tools from the Eneolithic or Early Bronze Age are morphologically identical with tools or cores from the Middle Palaeolithic period. Such a state of affairs is reflected in the history of research on the oldest mining.

The classification of mine shafts made by A. L. Armstrong was closely connected with his views on the age of Grime's Graves. The author used typological arguments and agreed with the opinions of H. Breuil, R. Smith and others who thought that many palaeolithic products were made of mined flint. He pointed out features from the Mousterian industry on the site of High Lodge, and its likeness to the flint from the main exploitation level at Grime's Graves (Armstrong 1926, 95). His division of exploitation units was supposed to have chronological value. In this view, he linked the oldest workshops processing mined flint with the pure Levallois industry (floor 85c). The latest mining activities, confirmed among others by Greenwell's shaft were supposed to finish in the Early Neolithic Age, in the "pre-dolmen" period (Armstrong 1926, 121–123). The three shaft types that he distinguished were supposed to correspond with different mining tools and separate workshops. The error of such an idea and the need to return to Greenwell's dating (1871) was pointed out in 1933 by J. G. D. Clark and S. Piggott. ^{14}C dates (Table 2) prove in the clearest way that most of the shafts at Grime's Graves are of Late Neolithic and Early Bronze Age date. In this way the chronological value of A. L. Armstrong's typology fell into disuse.

A separate archaeological culture — the so-called Campignien culture formed from the Pyrenees to the Urals was distinguished in the prehistory of Europe. As a result of closer studies it is now known that the Campignien culture consists of many mining sites or sites connected with the raw material processing, having no common cultural tradition. Many years ago, J. K. Kozłowski showed that there was no reason to distinguish it in Upper Silesia (1960). Lately, L. Reisch's research on macrolithic industries in Bavaria produced a similar result (1973; 1974). The so-called Jurassic culture from the Fränkische Alb, placed between the end of the Palaeolithic period and the beginning of the Neolithic Age (Jurakultur) was distinguished in 1932 by K. Gumpert, and appeared to be linked with obtaining and processing of raw materials, probably of quite different culture groups. As L. Reisch has shown, they all belong to the Late Neolithic, and in some cases to even later periods (1973, 410; 1974, 68–81). Even in the late 1960's similar difficulties were still met in dating the morphological features of flint industries from the exploitation points of the "chocolate" raw material, in the north-east fringes of the Holy Cross Mountains (Schild, Królik, Mościbrodzka 1977, 56 f.). These experiences showed clearly that morphology is not sufficient to date mines, points of raw material exploitation and workshops. Although such attempts are still made (Kasymov 1972, 18–36), they are methodologically unsound. Only a chronology based on ^{14}C, studies of chipped stone industries, on the distribution of settlements and raw materials together allow us to look afresh at siliceous rock mining among early farming communities.

Flint mining had already appeared in Central Europe among the LBK communities. We do not have enough data to link its origins with the mining of the hunting and gathering groups, which existed earlier in the Holocene. The first farming communities mined the "chocolate" and Jurassic-Cracow flints from the Vistula river basin, hornstone of the Moravský Krumlov type, quartzite of Tušimice type and probably two other types of quartzites from the north of Bohemia (Bečov and Skršín), probably also the obsidian from the eastern border between Slovakía and Hungary, flint of Rijckholt type in the west, and probably flint of Volhynian type to the east of our study area. Most of the data supporting the mining of these raw materials has an indirect character, but recently exploitation units dated to this period have been discovered at Tomaszów.

Studies of flint inventories from the LBK settlements (Danubian I) suggest that "chocolate" flint from Tomaszów occurs at Brześć Kujawski, sites 3 and 4, Radziejów Kujawski, sites 5 and at Niemcza, as well as the deposits exploited at Wierzbica "Zele" — whose materials are known from the settlements at Brześć Kujawski site 4, Pietrowice Wielkie (Balcer 1977, 8). This is an important indirect argument, because R. Schild at Tomaszów discovered shafts most probably connected with the LBK communities. Even at that early period, the units belonging to the open shafts category — were quite big. Shaft No 1 at Tomaszów had a circular mouth, about 2 m in diameter and was 3.8 m deep. There is a communication step left in the shaft like the ones in the Sąspów shafts. Shaft No 1 was abandoned before reaching the deposit which here ran deeper. A ^{14}C date (GrN-7050) 3950±40 b.c. was obtained for the last stage of the filling (Schild 1976a, 161). This is the oldest published ^{14}C date for any mine shaft in Europe (Tables 1 and 2). Shafts Nos 6 and 10 from Tomaszów, not yet published, date from the end of the 5th Mill. b.c. (personal information of Prof. R. Schild), corresponding with the Žaliezovce phase of the LBK in the Cracow region.

Mining exploitation of the Jurassic-Cracow flint from the music note and Želiezovce phases is testified by the abundant materials from the settlement at Kraków-Olszanica. More than 42,000 flints were discovered there (Kozłowski, Kulczycka 1961; Milisauskas 1976). The nodules were of good quality, with a fresh cortex and a black coating of iron or manganese compounds, all very characteristic of the specimens found locally in the eluvial clays. Taking into account all these points, as well as the primeval forests in this area in the Atlantic period, it is likely that this flint was mined from the deposits in the eluvial clays. A series of ^{14}C dates obtained for Kraków-Olszanica settlement (Milisauskas 1976, 32) and the dates for the settlements at Niemcza and Strachów in Lower Silesia (Kulczycka-Leciejewiczowa 1979, 63), all making use of the mined Jurassic-Cracow flint, show that the start of mining in the LBK groups in the Cracow region also goes back to the second half of the 5th Mill. b.c. No exploitation units linked with this early flint mining in the Polish Jura have been discovered yet. Because of the similar geology of the "chocolate" flint deposits and of the Jurassic-Cracow one, shafts from the mine at Tomaszów point out the type of workings which probably also occurred in the Polish Jura from the beginning of the LBK mining.

Very abundant materials from the settlement at Vedrovice-Zábrodvice, Znojmo dist. show mining exploitation of the Moravský Krumlov hornstone at the same early stage of agricultural development in Central Europe (Ondruš 1976). More than 20 thousand of the chipped stone pieces come from there. This intensity is similar to that on the settlement at Kraków-Olszanica. Hornstone pebbles of Moravský Krumlov type, from the smallest ones to those up to 50 cm in diameter, occur in great abundance in the Tertiary sands close to the settlement[8]. Small pebbles a few centimetres in diameter were the object of exploitation and processing. Considering the geological condition of the deposit we can suppose that simple methods of collecting and surface pit exploitation were used to obtain the raw material. Those activities are connected with the middle phase of the LBK development in Moravia.

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[8] Personal information from Dr.Vladimir Ondruš of the Moravian Museum in Brno.

Table 1. Radiocarbon dates for prehistoric flint mines in Central Europe and its vicinity

Serial number	Mine, laboratory number and material of the sample	Place from which sample was taken	b.c.	±	Literature
	I. Tomaszów, Poland				
1.	GrN-7050 — charcoal	Shaft 1	3945	40	Schild 1976a, p. 159, p. 161
	II. Sąspów*, Poland				
2.	GrN-7692 — charcoal	Shaft 3	3750	135	unpublished
3.	GrN-7693 — charcoal	Shaft 7	3625	75	unpublished
4.	Bln-1462 — charcoal	Workshop 3/1970	3375	60	unpublished
5.	GrN-7052C — charcoal	Shaft 1	3375	90	Lech 1975b
6.	Bln-1461 — charcoal	Shaft 1	3345	60	unpublished
7.	BM-1128 — charcoal	Workshop 2/1970 and Shaft 6	3096	102	Burleigh 1975, p. 91
	III. Krasnoye Selo, White Russian SSR				
8.	LE-637 — charcoal	Shafts 15, 21, 56	3350	300	Dolukhanov, Romanova, Semyontsov 1970, p. 132
9.	GIN-164 — charcoal	Shafts 3, 11, 18	3100	25	Cherdyntsev et alii 1968, p. 437
10.	GIN-148 — charcoal	Shaft 13	2360	45	Cherdyntsev et alii 1968, p. 437
11.	LE-799 — charcoal	Shaft 125	1640	150	Semyontson et alii 1972, p. 336
12.	LE-915 — charcoal	—	1560	110	Gurina 1976, p. 127
13.	LE-680 — charcoal	Shaft 12	1420	50	Dolukhanov, Romanova, Semyontsov 1970, p. 132
14	LE-636 — charcoal	Shafts 2, 3, 12	1240	60	as above
	IV. Löwenburg, Switzerland				
15.	B-2601 — charcoal		3260	100	Schmid 1975, p. 79
16.	B-2050 — charcoal		3070	100	Schmid 1975, p. 79
17.	B-2057 — charcoal		2990	240	Schmid 1975, p. 79
	V. Rijckholt—St.Geertruid, Netherlands				
18.	GrN-5962 — charcoal	Shaft 9 — near the bottom	3140	40	Burleigh 1975, p. 91
19.	GrN-4544 — charcoal	Gallery between Shafts 3 and 4	3120	60	Vogel, Waterbolk 1967, p. 124; Burleigh 1975, p. 90
20.	GrN-5549 — charcoal	Shaft 23 — near the bottom	3050	40	Vogel, Waterbolk 1972, p. 83; Burleigh 1975, p. 90
	VI. Kvarnby, Sweden				
21.	BM-410 — antler	—	2900	115	Barker, Burleigh, Meeks 1971, p. 184
	VII. Tušimice, Czechoslovakia				
22.	Bln-239 — charcoal	Hearth 1 — Shaft No.5? — at the bottom	2818	100	Kohl, Quitta 1966, p. 38
	VIII. Sümeg-Mogyorósdomb, Hungary				
23.	A-246 — charcoal	—	2570	160	Dawon, Long 1962, p. 247 f.
	IX. Valkenburg, Netherlands				
24.	GrN-6782 — antler	Sangen — Quarry	2390	60	W.M. Felder 1975, p. 84
25.	GrN-6783 — antler	Geböschke-Surface site	2240	45	W.M. Felder 1975, p. 84
	X. Polany Kolonie II, Poland				
26.	GrN-6833 — charcoal	Shaft 1 — at the bottom, hearth	2055	35	Schild 1976a, p. 154–156
27.	GrN-6834 — charcoal	Shaft 1 — second phase of filling up	2040	40	Schild 1976a, p. 154–156
28.	Gd-133 — charcoal	Shaft 1 — third phase of filling up	1550	90	Mościcki, Zastawny 1976, p. 55
	XI. Tata-Kálvariádomb, Hungary				
29.	Hv-1770 — charcoal	—	1860	65	Fülöp 1975, p. 77
	XII. Polany II*, Poland				
30.	BM-1235 — charcoal	Shaft 1 — at the bottom	1541	81	unpublished
	XIII. Karpovcy, White Russian SSR				
31.	LE-914 —	—	1540	70	Gurina 1976, p. 127
32.	LE-913 —	—	1400	80	Gurina 1976, p. 127
	XIV. Bečov, Czechoslovakia				
33.	Bln-552 — charcoal	Shaft 5	1530	80	Kohl, Quitta 1970, p. 403
34.	Bln-553 — charcoal	Shaft 1	1455	80	Kohl, Quitta 1970, p. 403

* I would like to express my great gratitude to Dr I.Longworth and Mr R.Burleigh from the British Museum, Dr W.G.Mook from Natuurkundig Laboratorium der Rijks Universiteit, Groningen and Dr H.Quitta from Akademie der Wissenschaften der DDR, Zentralinstitut für Alte Geschichte und Archäologie in Berlin for carrying out analyses of the charcoals from the mines at Sąspów and Polany.

Table 2. Radiocarbon dates from other areas of prehistoric flint mines in Europe

Serial number	Mine, laboratory number and material of the sample	Place from which sample was taken	b.c.	±	Literature
	I. Spiennes, Belgium				
1.	GrN-4674 — charcoal	"Camp-à-Cayaux" hearth No 2431b	3470	75	Vogel, Waterbolk 1967, p.132
2.	BM-289 — antler	"Petit-Spiennes"? — col. ca 1855 by D.Tolliez	2280	130	Barker, Burleigh, Meeks 1971, p. 158
	II. Mesvin 2, Belgium				
3.	Lv-216 — charcoal	"Sans Pareil", Shaft 1 — gallery	3390	150	Gilot, Ancion, Capron 1966, p. 253; Lefrancq, Moisin 1965, p. 13–18
4.	Lv-65 — charcoal	"Sans Pareil", Shaft 1 — fill	3270	170	Deumer, Gilot, Capron, 1964, p. 165; Lefrancq, Moisin 1965, p. 13–18
5.	BM-417 — antler	"Sans Pareil" Shaft 1 — base	3181	123	Barker, Burleigh, Meeks 1971, p. 158
	III. Church Hill, England				
6.	BM-181 — antler	Gallery	3390	150	Barker, Burleigh, Meeks 1969, p. 285
	IV. Blackpatch, England				
7.	BM-290 — antler	Gallery	3140	130	as above, p. 286
	V. Harrow Hill, England				
8.	BM-182 — antler	Gallery	2980	150	as above, p. 285
	VI. Cissbury, England				
9.	BM-185 — antler	Shaft No. 6 — gallery	2780	150	as above, p. 286
10.	BM-183 — antler	Gallery	2770	150	as above
11.	BM-184 — antler	Harrison's pit — gallery	2700	150	as above
	VII. Easton Down, England				
12.	BM-190 — antler	Gallery	2530	150	as above
	VIII. Grime's Graves, England				
13.	BM-97 — antler	Shaft 12 — fill	2340	150	Barker, Mackey 1963, p. 106
14.	BM-87 — antler	Shaft 15 — fill	2320	150	Barker, Mackey 1961, p. 41
15.	BM-377 — antler	Shaft 12 — fill	2300	130	Barker, Burleigh, Meeks 1969, p. 286
16.	BM-944 — antler	Gallery (cf.BM-777)	2203	64	Burleigh 1975, p. 91
17.	BM-943 — antler	Shaft floor (cf. BM-776)	2154	55	Burleigh 1975, p. 91
18.	BM-88 — antler	Shaft 15 — fill	2100	150	Barker, Mackey 1961, p. 41
19.	BM-945 — antler	Gallery (cf.BM-775)	2084	88	Burleigh 1975, p. 91
20.	BM-99 — antler	Shaft 14 — fill	2030	150	Barker, Mackey 1963, p. 106
21.	BM-93 — antler	Shaft 10 — fill	1920	150	Barker, Mackey 1963, p. 106
22.	BM-775 — charcoal	R.Mercer's shaft — gallery 3	1865	60	Sieveking et alii 1973, p. 201
23.	BM-291 — antler	Greenwell pit — gallery 3	1860	130	Barker, Burleigh, Meeks 1969, p. 286
24.	BM-776 — charcoal	R.Mercer's shaft — floor	1839	60	Sieveking et alii 1973, p. 201
25.	BM-778 — charcoal	R.Mercer's shaft — fill	1831	60	Sieveking et alii 1973, p. 201
26.	BM-777 — charcoal	R.Mercer's shaft — gallery 1	1814	60	Sieveking et alii 1973, p. 201
27.	BM-103 — antler	Shaft 11 — fill	1750	150	Barker, Mackey 1963, p. 106
28.	BM-276 — antler	Shaft 12 — fill	1600	150	Barker, Burleigh, Meeks 1969, p. 286
29.	BM-109 — antler	Shaft 8 — fill	1340	150	Barker, Mackey 1963, p. 106
	IX. St.Mihiel, France				
30.	Ny-285 — charcoal	Hearth	2220	70	Burleigh 1975, p. 91
31.	MC-573 — charcoal	Hearth	2110	50	Burleigh 1975, p. 91

The beginnings of the common utilization of the Tušimice quartzite type are also connected with the LBK (Neustupný 1966). In settlements located close to the deposits — for example at Čachovice, Chomutov dist., middle LBK phase[9] — traces of this raw material processing occur on a large scale. Considering the vast distribution of Bečov and Skršin quartzites in Bohemia, it is likely that their mining exploitation is connected with the LBK too.

Flint of Rijckholt type is the next raw material exploited and mined in the LBK. In spite of the fact no exploitation units were discovered from this early period, features of the raw material discovered on settlements make such mining a likely possibility (Newell 1970, 145; Löhr 1975, 95; Löhr, Zimmermann, Hahn 1977, 151–165).

The view for the possible existence of Volhynian flint mining, and the obsidian mining too, in this period, is based on the features of the raw materials from the settlements (Kotovanie, for example. Svešnikov 1954), and on their vast distribution.

Eacher information than this is fragmentary. However, we can probably assume the existence of mining among the LBK groups in the whole of Central Europe.

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[9] Unpublished materials from the excavations of Dr.Z.Smrš of the Branch of the Archaeological Institute ČSAV in Most, and I thank him for enabling me to have access to them.

This should be dated to the last centuries of the 5th Mill. b.c. In the 4th Mill. b.c. flint mining was already common over the whole of Europe (Table 1 and 2). At least for several hundred years, the deposits at Sąspów were exploited at that time. At the same time some other mines were functioning, such as the ones at Bębło and Jerzmanowice-Dąbrówka in the Polish Jura and in the zone of the "chocolate" flint deposits — at Tomaszów (personal information of prof. R. Schild) and at Wierzbica "Zele". ^{14}C date confirms the exploitation of flint deposits in the Swiss Jura — i.e. the mine at Löwenberg, and in the Dutch Limburg — i.e. the mine at Rijckholt—St.Geertruid. Three dates obtained for the last one (Table 1) are connected with underground shaft mining with gallery workings. The existence of older exploitation units is shown not only by Rijckholt flint in the LBK settlements but also by its presence in the Rössen culture (Löhr 1975, 95). Dated shafts represent fully developed exploitation units. They were sunk to the well defined flint nodule layer, with the full practical knowledge of the deposit's geology. Generally, it indicates the existence at Rijckholt—St.Geertruid of older mining phases than those confirmed by the present ^{14}C dates. The dates for this area correspond to the Michelsberg culture. Rijckholt flint utilization reaches its peak in the settlements of this culture (Löhr 1975, 95).

By the 4th Millennium b.c. all deposits used earlier by the LBK were being exploited in Central Europe. In addition, in this period exploitation of the Bavarian striped hornstone deposits and the quartzite of Bečov type increases. This is well seen in the materials from Bohemia and Moravia. Radiolarite deposits in the Vlara river basin in the White Carpathian Mountains were exploited in the 4th Mill. b.c. in the east Moravia (Vencl 1967). In the second half of this millennium, in the Lengyel IV horizon, the mine at Vienna-Mauer (connected with the Brodzany—Nitra group) was functioning (Ruttkay 1970, 77 f.). At the same time, as there was an increasing demand for long blades, the importance of Volhynian flint increases.

The series of dates from the mine at Krasnoye Selo (Table 1) represents a very wide range. From them we can see that the mine was utilized for about 2000 years, since two of the dates are from the last centuries of the 4th Mill. b.c. But N. N. Gurina stresses that these are less sure than the rest, because of their small samples size (1976, 127). The rest of the dates correspond with the Late Neolithic and Bronze Age. Two dates from the nearby mine at Karpovcy are similar to the late dates from Krasnoye Selo. Both mines were about 6 km apart N. N. Gurina connects the shafts from Krasnoye Selo and Karpovcy with the late Niemen culture and the Corded Ware culture (1976, 130).

At the end of 4th Mill. b.c. and at the beginning of the 3rd Mill. b.c., the *Plattensilex* or *Plattenhornstein* from Bavaria becomes very important. It was exploited by the Aichbühl, Horgen, Altheim and Pfyn groups (Winiger 1971; Moser 1978). At the same time exploitation of two important new raw materials develops in the Vistula river basin. We mean here the flints from the great mines at Krzemionki Opatowskie and Świeciechów. There are no ^{14}C dates for these mines. In spite of this we can date them relatively precisely using dates obtained from the settlements which were using their flints. From this point of view the most important dates are a series from the TRB settlement at Ćmielów, dist. Tarnobrzeg (Bakker, Vogel, Wiślański 1969, 12–14):

GrN-5087	2825±40 b.c.
GrN-5090	2750±40 b.c.
H 566-592	2725±110 b.c.
GrN-5036	2700±40 b.c.
GrN-5088	2665±40 b.c.

The settlement at Ćmielów is located close to the mine at Krzemionki Opatowskie, which lies 9 km away. The community at Ćmielów was processing striped flint, and making axes on a large scale. Among 38,411 analyzed flint pieces from the settlement 62.1% were made of striped flint, and 37.9% of Świeciechów flint type (Balcer 1975, 329). Most of this was production waste. Tools only constituted 1.48%. Świeciechów flint come from the mine more than 29 km away from the settlement. This is reflected in the smaller amount of waste flint. Nevertheless, their number is conspicuous. The origin of both types of flint is not in doubt. Similar data come from a few other TRB settlements in the Vistula river basin. Using these facts we can assume that both mines were in operation from the beginning of the 3rd Mill. b.c. But we cannot exclude the possibility that mining Świeciechów flint could have begun as much as 1000 years earlier. But for this, we lack reliable data for the moment.

From that time striped and Świeciechów flints were exploited until the Early Bronze Age. They are known from the settlement at Mierzanowice, dist. Tarnobrzeg (Balcer 1977, 205 f.). The Mierzanowice culture is dated by the series of ^{14}C dates from Iwanowice, dist. Cracow, to around 1750–1600 b.c. (Machnikowie 1973,153; Machnik 1977, 80 f.).

In the 3rd Mill. b.c., raw materials utilized in the earlier periods were still exploited. Among them Volhynian flint and other flints from the areas of the upper and middle Dnestr became very significant. Mines and workshops existed there but their most intensive activities are connected with Tripolye culture (Černyš 1967; Gurina 1976, 102–107). Some of them were already functioning in the second half of the 4th Mill. b.c. The great period of their use was in the 3rd Mill. b.c. and at the beginning of the 2nd Mill. b.c. After the decline of the Tripolye culture, mines and workshops from the west Ukraine were connected with the communities of Corded Ware culture. Local deposits of Baltic Cretaceous erratic flint became very significant in the European Lowlands, on Rügien island, on the adjacent shores, in Upper Silesia, in Opava Silesia, and in north-west Moravia. Jasper exploitation, connected with the communities of TRB, Řivnač and Globular Amphore culture, develops in north-east Bohemia[10]. Among the new deposits, but of less significance, was the radiolarian flint from the mine at Sümeg-Mogyorósdomb in Hungary, and in Moravia it was the flint of Stranská skala type. Using the Pécel pottery fragments (Fülöp 1973; 1975), on the mine at Tata-Kálvária Hill, we can date the beginnings of the local radiolarian chert exploitation back to the last centuries of the 3rd Mill. b.c.

The decline of the oldest mining in Central Europe is dated much better than its beginnings (Table 1). Studying the mines at Polany, Bečov, Krasnoye Selo and Karpovcy, we can assume that the decline of siliceous raw materials mining, to meet needs of the chipped industries took place in the 15th century b.c., and in some regions probably even later (Krasnoye Selo, Karpovcy). Discoveries from the west Bohemia tumuli show that exploitation of Bavarian striped hornstone and of quartzite of Tušimice type was carried on until the Middle Bronze Age (Čujanová-Jílková 1970). Blades and tools made of Bavarian striped hornstone are found in the museum of Pilsen, in the materials from the graves at Pilsen Nova Hospoda site — grave 49; Zelené site — graves 15 and 25; Stáhlavy site — graves 12 and 48 both Pilsen-South distr. An end scraper and a borer made of Tušimice type quartzite were found in grave No 1 at the Zákava site, dist. Pilsen-South. The prevalence of tools rather than waste flint in the grave materials suggests their utilization up to that time, and this argues against the theory that flints found casually were put into graves according to the older cultural tradition without practical meaning. This agrees with ^{14}C dates for some flint mines in Central Europe, for Bečov in particular. Dates obtained for shafts No 1 and 5 correspond with the Tumulus culture from the Middle Bronze Age (Fridrich 1972, 250).

Comparing ^{14}C dates for the mines in Central Europe and its neighbourhood (Table 1) with the dates for the rest of the European mines (Table 2) we can see some general similarities. Certain differences are the result of too few carbon 14 dates. Flint mining is very clearly confirmed for the second half of the 4th Mill. b.c. both for the region of Spiennes "Camp-a-Cayaux" site and Mesvin 2 mine "Sans Pareil" and for the south of England — mines at Church Hill and Blackpatch (Sussex). It is true that we do not have dates from the end of 5th and from the first half of the 4th Mill. b.c., but indirect data ever more strongly confirm our thesis about the beginnings of flint mining among the early farming communities in north-west Europe, and their links with the LBK culture and Danubian cultures in general (Lech, 1975b, 71).

At the moment underground forms of mining in West Europe have earlier dates than in Central Europe. Except for the mine at Rijckholt—St. Geertruid, this is shown by the dates for the mines from the area of Cissbury: Church Hill, Blackpatch, and Harrow Hill (all in Sussex). On the other hand we should remember that there have been fewer investigations on the mining sites in Central Europe than in the West. This also applies to the mine at Krzemionki Opatowskie, for which we do not have ^{14}C dates. There are no data indicating that the mining at Krzemionki was earlier than the dates for the settlement at Ćmielów. It is even probable that underground mining was later and that the first phase of exploitation was connected with open shafts.

A series of ^{14}C dates for the mine at Grime's Graves is in agreement with late dating of flint mining in Central Europe. It should be emphasized that this mine was still fully working in the period I×II at Stonehenge, for instance. Dates for Stonehenge I are: 2180±105 b.c. (I-2328) for the ditch construction and 1848±275 b.c. (C-602) for the Aubrey Hole 32 (Smith 1974, 136). Meanwhile, the dates for the big shaft with galleries, about 14.5 m deep which was investigated by R. Mercer, and for Canon Greenwell's shaft which had galleries too, correspond with the 19th century b.c. (Table 2). Both demanded very complicated work organization, and the effort of many people to sink them (P. J. Felder 1979). Radiolarian chert in the mine at Tata-Kálváriádomb was exploited at the same time (Table 1)[11].

Translated by Anna Urban

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Abbreviations

AAC — Acta Archaeologica Carpathica, Kraków

AP — Archeologia Polski, Wrocław—Warszawa—Kraków

AR — Archeologické rozhledy, Praha

PA — Przegląd Archeologiczny, Poznań, Wrocław

PPSEA — Proceedings of the Prehistoric Society of East Anglia, London

SA — Sprawozdania Archeologiczne, Wrocław—Warszawa—Kraków

I Symposium — *Eerste Internationale Symposium over Vuursteen, Maastricht 26—29 April 1969*, ,,Grondboor en Hamer", 3.

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[10] Personal information from Dr.Emilia Pleslová-Štiková C.Sc. from the Institute of Archaeology ČSAV in Prague, and PLESLOVÁ-STIKOVÁ 1959.

[11] I am very grateful to my friend Dr.Richard J.Harrison from the University of Bristol, who was kind enough to undertake the stylistic revision of the English translation.

II Symposium — *Tweede Internationale Symposium over Vuursteen, 8–11 Mei 1975 — Maastricht*, Staringia No 3, Nederlandse Geologische Vereniging.

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Z badań — *Z badań nad krzemieniarstwem neolitycznym i eneolitycznym*, ed. J.K.Kozłowski, Kraków 1971.

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