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ANDRZEJ PRINKE, JANUSZ SKOCZYLAS

STONE RAW MATERIAL ECONOMY IN THE NEOLITHIC OF THE POLISH LOWLANDS

GOSPODARKA SUROWCAMI KAMIENNYMI W NEOLICIE NIŻU POLSKIEGO

This article comprises results achieved during the realization of the authors' own program of archaeological and petrographic studies of the raw material differentiation in Neolithic stone processing. Methodical assumptions, objectives and cognitive possibilities of this program have been presented in PA 26:1978, 43 ff. Disposing of identifications of stone material from numerous series of Neolithic stone implements from Mid-western Poland, the authors obtained a quantity of new data concerning the means of their exploitation, distribution and use. Among other problems, the authors discussed the origin of these raw materials (selection of erratic material, transport from distant, original deposits and the exploitation of local quarries in the Lowlands), problems concerning the choice of appropriate raw material depending on the function of implements and technique of their production as well as the regional differentiation of the raw material structure of the stone industry, which have been examined on the basis of statistical tests. Results concerning the investigated region were compared as a whole with the present state of knowledge of the relevant problem in Central Europe. Finally, an attempt was made to reconstruct the practical petrographic knowledge of ancient stone workers, seen as an index of the degree of adaptation of particular Neolithic societies to the natural environment of the Lowlands.

INTRODUCTION

This work was realized as the result of a research program, the objectives and methods of which were presented in a separate publication (Prinke, Skoczylas 1978). The authors indicated there the highly unsatisfactory state of knowledge relating to problems of Neolithic stone industry (here including processing of raw materials other than flint) on an all-European scale (with the exception of Great Britain) with particular emphasis on Poland. This situation clearly contrasts with the actual, comprehensive and quickly developing knowledge concerning the exploitation of flint raw materials in the Neolithic, also including Poland (I. a. Balcer 1975; Dzieduszycka-Machnikowa, Lech 1975; Schild 1971; 1976; Schild, Królik, Mościbrodzka 1977). This is comprehensible considering the disregard of even basic data relating to petrography and mineralogy in respect to prehistoric stone artefacts.

Researchers of the Neolithic stone industry have hitherto used usually erroneous or too extensive definitions of types of stone raw materials without considering expert evidence (e.g., Smoczyńska 1953) or have, more often, completely resigned from differentiating any types of stone raw material and are content with a general term "stone artefacts" as opposed to "flint artefacts".

These shortcomings produced in practice a reduction of studies of Neolithic stone artefacts to almost exclusively morphological deliberations, which ruled out the possibility of reconstructing Neolithic stone industry as a whole, seen as an important branch of economy of those times. Unsolved are in particular such leading aspects as the provenance of particular raw materials exploitation methods, the existence of possible exchange, inflow of imports of high quality raw materials from southern Poland and adjacent rock bearing regions to Polish Lowlands, further, the influence of the type of raw material on techniques used in its processing, links between the raw material and the function of the implement, proportions between local and imported raw materials used in Lowland areas etc.

We owe the recognition of most of relevant problems relating to Neolithic flint industries, primarily to the fact that researchers of these questions took under consideration the internal raw material differentiation within the group of flint artefacts and endevoured to synchronize finds of these artefacts with original layers of raw material. The latter task was realized due to the close cooperation between archaeologists and geologists (Krukowski 1920; 1922; Samsonowicz 1923; 1925).

The relevant program of archaeologic-petrographic studies of the Neolithic (Prinke, Skoczylas 1978) is based on the assumption that petrographic methods allow to undertake aforesaid problems. The general raw material structure of stone industry will be described first for the Neolithic as a whole (on the basis of sums of achieved determinations) and next for its successive periods — on the basis of artefacts which can be classified more thoroughly as regards chrono-cultural aspects. It is possible to reproduce in this manner lists of types of raw materials exploited in stone industries of particular Neolithic cultures (Prinke, Skoczylas 1978, 52, Table 1). The territorial division of an assemblage will facilitate the comprehension of possible local differences in the exploitation structure of stone raw material. Finnally, a linking of these two sub-sections will create a detailed raw material structure, characterized in time and space for the entire Neolithic and the whole area of research. This will be, therefore, a three aspectual construction (space — time — raw material; cf. Tugby 1971). Its interpretation involves the recognition of factors which — in successive periods and in particular areas — influenced the shaping and changes of the relevant structure. To this end, it is necessary to analyze both petrographic properties (i.e., physical and technical characteristics of stone raw material, the distribution of deposits on a particular area and adjacent regions) and archaeological properties (stone industry traditions, the assortment of produced implements, their function, applied processing methods).

An attempt at interpreting the previously reconstructed raw material structure — on the basis of achieved results — in categories of a Neolithic stone worker's attempts at a rational and optimal use of available raw material resources, represents the final stage of the discussed program. These studies should result in the reconstruction of the practical petrographic knowledge utilized by Neolithic makers of stone implements.

As already stated, the so far available knowledge concerning relevant problems in the Central European scale, above all Poland, is still very insufficient. Hence, studies here discussed were necessarily of a reconnaissance character. It is obvious that factographic results obtained hitherto did not exhaust the entire range of problems formulated in this program in a maximum scale. The complete lack of appropriate comparative materials from adjacent territories constituted the main barrier. This situation necessitated the fulfilment of an additional, methodical objective of undertaken studies. They included an initial examination of problems of Neolithic stone industry as a whole, the comprehension of problems requiring further, more thorough studies, the elaboration of an appropriate approach to particular questions, an examination of the usefulness of selected methods and the definition of the approximate range of their application.

Out of many forms concerning the use of stone raw materials, appearing in the Neolithic of the investigated region, the authors have chosen as the object of discussed archaeologic-petrographical research the production of stone implements (perforated axes, flat axes, hoes, hammers, hammer-axes, mace-heads chisels etc.) made from stone raw material in the strict sense. Flint artefacts have been left out due to the completely different research procedure, based upon dissimilar treatment techniques of this raw material and a still insufficient knowledge of the petrography of its types and, on the other hand, because of the incomparably better knowledge on problems concerning Neolithic flint production based on simple macroscopic descriptions (e.g., Schild 1971). In addition to quoted types of implements, the lithic inventory of Neolithic cultures includes still other forms. But these play a marginal role in our deliberations since they have not been sufficiently differentiated as regards morphology and raw material (for example, quern-stones, grinding-stones, polishers), or because they appear in much smaller quantities (e.g., stone ornaments).

The territory embraced by our study comprises about a dozen physico-geographical regions of Mid-western Poland (Bartkowski 1970; Kondracki 1968), belonging to four macroregions. The largest part of the chosen area belongs to the Great Polish (Wielkopolska) Plain, which has been included almost entirely (except its western and southern borderlands). Researches have also encompassed the Chełmno-, East- and South-Pomeranian Lake Districts and Żuławy (cf. Prinke, Skoczylas 1978, maps 1–5)*.

From the formal point of view the chronological framework ranges from the Early Neolithic horizon of the oldest stone implements of the Danubian Cycle to the level of "Epi-Corded Ware" implements (mainly perforated axes and hammer-axes) from the turning-point of the Neolithic and the Bronze Age (certain forms continued into the second period of the Bronze Age). The absolute chronology of a thus defined section of prehistory can be specified, on the basis of radio-carbon data from this area, to the years 4500–1700 B.C. (Bakker, Vogel, Wiślański 1969a; 1969b).

The twofold character of accepted source foundations results from the above-mentioned objectives. On the one hand, these are archaeological data relating to Neolithic polished implements produced from lithic raw materials, on the other — petrographic information on the type of these raw materials, where and how they appear, their physical and technical characteristics etc.

Polished stone implements appear, as a rule, as stray

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* Those maps illustrate the raw material differentiation of Neolithic stone implements of the Danubian Cycle (map 1), of Funnel Beaker Culture and Globular Amphorae Culture (map 2), of Corded Ware Culture (map 3), of the cultural groups from the turn of the Neolithic and the Early Bronze Age (map 4) and of chrono-culturally unidentified artefacts (map 5) in Mid-western Poland.

finds. This makes a precise specification of their chrono-cultural provenance more difficult and decreases their value in classificational studies. Nonetheless, our objective is not to elaborate new determinations of this type but to make a division of the examined assemblage of implements into several possibly exactly defined but extensive chrono-cultural groups, on the basis of hitherto used classification systems. This division will enable the reconstruction of dynamics of the process of utilizing stone raw material in the Neolithic, for we assume that the basic changes in the way of utilizing rocks, constituting a phenomenon from the sphere of economic activity, were neither sudden nor short-lasting but embraced longer periods, certainly exceeding the duration of a single phase of a particular culture. It should be added that the prevalence of stray finds, being deficient category of sources, represents a typical difficulty in studies of Neolithic stone implements and does not result from local specific conditions concerning their appearance nor the state of research on the selected area (cf. Vencl 1960, 4, 23, 40; Brandt 1967, 6). In our opinion, this phenomenon should be treated rather as an objective effect of the appearance of most pieces belonging to this category outside compact assemblages: its negative influence on research results can be diminished only by intensifying studies of the classification type, instead of treating this group of sources as subordinate in the cognitive sense — often observed in works carried out so far.

The present study comprises 1557 artefacts from Central-western Poland, including 1480 (95.05%) stray finds. Only 31 artefacts (2%) derive from excavated sites and convey, therefore, a well defined cultural context. The intermediate category is made up of 46 artefacts (2.95%) constituting a part of a homogenous assemblage discovered during surface surveys; co-appearing pottery allowed, sometimes, to define more exactly the chronology of sites.

Two groups of information can be distinguished in collected petrographic data. The first includes identifications of the type of lithic material used for the production of particular implements. They represent the basis for a characteristic of the raw material structure of the entire assemblage. They were obtained by a macroscopic method controlled by a series of 45 microscopic analyses carried out by the thin slices method. Detailed questions concerning the use of the two methods and the assessment of the reliability of results thus achieved have already been discussed (Prinke, Skoczylas 1978, 47–51). Results of a planimetric (micrometric) analysis, embracing 23 pieces, previously defined as basalt by the thin slices method, constitute a separate category in this group of petrographic sources. This procedure allowed a further specification of the mineral composition of raw material, necessary at attempts referring particular types of implements to single stone ledges[1].

The second group of petrographic sources includes informations taken from literature of this discipline. They relate to a whole range of more general problems linked with lithic raw material whose presence has been determined in the examined archaeological material. Analyzing relations occurring between the type of implement and the raw material used in its production, authors took into account data concerning physical and technical properties of rocks (Wojno, Pentlakowa 1956; 1957; Kamieński 1957; Kozłowski 1975). At the determination of the origin of particular raw materials a decisive role was played by data on distribution, the type and accessibility of deposits and the mineral specificity of prevailing rocks (among others: Małkowski 1923; 1926; 1927; 1931; 1933; 1934; Kamieński 1929; 1957; Śliwa 1971; 1977; Śliwa, Oberc 1973). It was also essential to get at characteristics of the raw material structure of erratic rocks, elaborated by petrographers and geomorphologists, although not completed so far (Hesemann 1936; 1975; Korn 1927; Dudziak 1961; 1970; Nunberg 1971).

The adopted research procedure has been based on the use of three groups of methods: a — the petrographic (macro- and microscopic methods including the thin slices analysis, and the micrometric analysis); b — the archaeological (typological and cartographic) method; c — the statistical (non-parametric tests: chi-square and Smirnov's). The role of petrographic and statistical methods has been characterized more extensively in the previous publication (Prinke, Skoczylas 1978, 53 ff.). We shall now give a summary of archaeological methods. The typological method has been used at the initial stage of analysis, devoted to the chrono-cultural classification of the examined assemblage of implements. Considering the prevalence of stray finds, the only possibility to carry out this classification was to base it on typological systems, involving morphological traits and the technique of producing implements[2].

Accepting the relevant classification procedure, we

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[1] Microscopic examinations were executed by the late Doctor Z. Śliwa, Department of Mineralogy and Petrography of Wrocław University, and B. Wojnar, M. A., Laboratory of the Old Structures Geology, Department of Geological Sciences of the Polish Academy of Sciences, Wrocław. Comprehensive consultations concerning the identification of erratic raw materials were given by Doctor J. Nunberg, Laboratory of Quaternary Geology, Department of Geological Sciences of the Polish Academy of Sciences, Warsaw, and, concerning the differentiation of basalts — by Professor Doctor M. Mišik and Doctor M. Šimova, Geological Department of Charles University, Bratislava. The authors express special gratitude to all these scholars.

[2] The following typological systems were taken into account in present study: Brandt 1967 and Vencl 1960, concerning cultures of the Danubian Cycle; Åberg 1918; Jażdżewski 1936 and Herfert 1962, concerning the Funnel Beaker Culture; Wiślański 1966 for the Globular Amphorae Culture; Glob 1945, Struve 1955 and Machnik 1966 for Corded Ware Culture; Schroeder 1951 and Kośko 1976 for the „Epi-Corded Ware" groups from the turn of the Neolithic and Bronze Age.

were aware that the types of lithic implements cannot always be referred to a particular culture or period in an explicit manner as may be done with leading forms of pottery. The appearance of single pieces in contemporary or younger compact assemblages of other cultures has occurred even when a particular implement was considered to be a cultural determinant. Hence, the here distinguished chrono-cultural groups represent rather equivalents of technological complexes (or adaptation systems; D. Clarke 1968, 333 ff.; Schild 1975, 165).

The cartographic method enabled, in turn, the spatial analysis of phenomena such as affluence of imports of raw materials (mainly basalt) of southern origin to the examined part of Polish Lowlands, regional differences in the utilization of local raw material resources, the range and manner of distributing raw material from original Lowland deposits (variegated Poznań loam), the localization of Lowland stone workshops (by preparing index lists of semi-manufactured implements) and regional differences in the general raw material structure of Neolithic implements as well as in the utilization of particular raw materials. These problems have been investigated on a set of maps to 1:300,000-scale, prepared in relation to chrono-cultural, typological and raw material aspects (Prinke, Skoczylas 1978, maps 1–5).

Further presented is a systematic review of so far achieved results of studies relating to the Neolithic stone raw material economy on Polish Lowlands. The sequence of particular problems is discussed in accordance with the course of activities comprising Neolithic stone industry. The entire problem is presented in three groups: a — exploitation (problems concerning the origin of particular types of stone raw material, selection of erratic resources for stone industry requirements, exploitation of original deposits in moutain, sub-moutain and Lowland areas, etc.); b — distribution (for example, the appearance of stone raw material imports in the Lowlands, regional differences in the distribution of particular raw materials); c — utilization (differences in the raw material structure of successive Neolithic cultures in the same area, relations between the type of raw material and types of produced implements, the selection of raw material used in Lowland stone workshops — in accordance with the raw material structure of semi-manufactured pieces, links between the type of raw material and applied processing techniques, on the example of the empty and full drill techniqe).

I. THE EXPLOITATION OF LITHIC RAW MATERIALS

Considering the almost complete lack of material remains from Neolithic stone mining, preserved in situ, the origin of particular types of stone raw materials has been acknowledged as the key problem in subsequent studies of relevant problems. Other aspects of acquiring raw material, such as applied exploitation methods etc., will be discussed in the final part of this work.

The starting point in determining the manner in which Neolithic communities inhabiting Lowlands acquired stone raw material has been based on the assumption that all of 109 types of raw material, distinguished in the representative series of 1557 polished implements are divided into three groups (in relation to their provenance): 1 — local erratic pieces from Fennoscandic rocks, which appeared on the investigated area on the surface or in secondary deposits (moraines or river valleys); 2 — raw material imported from rock-bearing areas south of the Lowlands (in relevant studies this includes southern Poland and adjacent regions); 3 — rocks from original Lowland deposits (mainly siliceus variegated Poznań loam)[3].

1. ERRATIC RAW MATERIALS

As regards this group of raw materials, the character of geomorphological and petrographic elaborations at our disposal restricts in advance attempts of more specific determinations since hitherto conducted studies of erratic rocks have been pursued from a different angle. Erratics were most frequently regarded as determinants of directions of the Scandinavian icesheet movement (Konieczny 1956; Dudziak 1970; 1974a; Nunberg 1971) and the range of glaciation (Kreutz, Głowińska 1932; Gołąb 1933; Milthers, Milthers 1938; Krygowski 1948; Dudziak 1961). This is why petrographic classification embraces only a small part of the examined sample of erratic material, including rocks known from Scandinavia. Konieczny (1956, Table 1 and 7), for example, denoted only 9 per cent of the examined material, Nunberg (1971, Table 5 and 11), specified 23.8 and 19.5 per cent of collected erratics. Attempts to link erratic materials with particular Scandinavian stone quarries have not led to satisfactory results so far. This synchronization was successful only in relation to 5 per cent of all erratics petrographically determined (Dudziak, 1974b, 30; He-

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[3] For the full list of raw material types, cf. Prinke, Skoczylas 1978, pp. 50 f.

semann 1931), and pertinent results have shown considerable divergences (Konieczny 1956; Dudziak 1970; Nunberg 1971).

The lack of a complete structure of erratic raw material was the consequence of this concept of geomorphological research. Whereas archaeologists, studying the utilization of erratic rocks in prehistory, are not at all interested in localizations of original Scandinavian deposits of examined materials, the presented situation considerably limits possibilities of comparing the petrographic composition of Neolithic stone implements with the structure of erratics making up the initial quantum for their prehistoric users. Conceivable divergences arising from this comparison would define the degree and course of selection concerning local resources of stone raw material and, hence, the scope of practical petrographic knowledge of Neolithic stone workers.

Considerable vacillations in the raw material structure of erratics, depending on the analysed fraction, are an additional inconsistency in the use of geomorphological data. Most works are based on the examination of small diameter shingles (2.0–2.5 mm, Gołąb 1933) and 1.0–10.0 centimetres (Dudziak 1974a, b; Konieczny 1956), and only recently 7.0–20.0 centimetres (Nunberg 1971), a fraction considered as the most representative, also because of the assumed absence of disturbances linked with economic activities of Holocene men). In our deliberations, however, the bigger fraction (beginning with 20–30 cm) is essential and its raw material composition can be quite different from the previously referred to. Nevertheless, despite indicated limitations and possibilities of a distortion of results, we shall try to carry out the outlined comparison, being aware of its initial and indicatory nature. For this reason, we shall turn our attention only to general tendencies, observed in collected comparative materials, concerning erratics and recurring regardless of fraction, the place from which the sample was obtained or details linked with the method of conducting examinations.

Six petrographic structures of erratics from studies conducted by W. Skalmowski (1937), F. Krawiec (1938), J. Dudziak (1961; 1970), D. Czernicka-Chodkowska (1977), H. Krawczyńska-Grocholska and W. Grocholski (1978) were chosen for comparison. The first of these authors, who conducted his studies from the aspect of the practical use of erratic stones for road building, supplied, unfortunately, no data concerning the fraction or origin of the investigated series of boulders. J. Dudziak's work from 1961 concerns shingles of a diameter over 40 cm from southern Poland, an area between Cieszyn and Przemyśl, the work prepared by H. Krawczyńska-Grocholska and W. Grocholski deals with fractions of a 0.5–4.0 m, all the other works — with boulders of a diameter exceeding 5 m from the entire area of Poland. Despite certain, sometimes considerable differences (principally concerning quantity) between relevant structures of erratics, we were able to observe a common trait — essential for our studies — relating to the decisive predominance of acidites, principally from the granite group (i.e., acidite igneous and abyssal rocks). The structure of raw materials utilized in the Neolithic of Mid-western Poland is presented in a generalized arrangement embracing 38 most frequent types (Table 1). Included raw materials have been examined as regards their frequency in the investigated series of erratics, on the one hand, and in the assemblage of Neolithic implements, on the other. Six groups of raw materials have been differentiated:

1. Rocks appearing only in erratic materials (E): dolomite, granulite, cataclasite, metasandstone, mygmatite, mylonite, quartzite sandstone, piterlite, tonalite and other undetermined crystallic rocks. Their absence in the archaeological assemblage indicates a negative selection, brought about by disadvantageous technical properties of these rocks.

2. Raw material appearing exclusively in the examined archaeological material (A): aplite, Poznań loam, other loams, leptite, amphibole schist, melaphyre, nephrite, serpentinite, tuffite and greenstone. Their absence in quoted series of erratics can be explained threefold: a — aplite erratics have been probably enclosed by authors of quoted geomorphological works together with sandstones; b — the major part of remaining rocks from this group certainly comprises raw material imported from the South and — without doubt — absent among erratics; this concerns primarily nephrite of which rich despoits may be found in the area of Jordanów Śląski (cf. Geschwendt 1931); amphibole schist may also have been imported; c — the absence of remaining types of rock in erratic structures may have resulted from the shortage in comparative materials, namely petrographic denotations of only a part of pieces of examined samples.

3. Amphibolite and diorite are raw materials appearing in similar proportions in the two examined assemblages (=). Considering the technical characteristics of these two minerals, they can be considered as relatively attractive erratic raw materials.

4. Raw materials occurring considerably (at least twice) less frequent among Neolithic implements than in erratic materials (-+): granite, granitogneiss, granitoide, lydite, pegmatite, pyroxenite, porphyry and syenite (the number of times the first frequency is smaller than the second is shown in brackets; if data relating to frequencies of erratics varied — the lowest value was accepted). This concerns the phenomenon of a partial negative selection; raw materials in this group were obviously treated as deficient and played a complementary role in general raw material resources, they were used more extensively only in the production of particular implements; granite, for example, for the production

Table 1. Comparison of the raw material structure of the erratics from Poland with that of the examined series of the Neolithic polished stone implements.

Porównanie struktury surowcowej materiałów narzutowych z terenu Polski ze strukturą surowcową badanego zbioru narzędzi neolitycznych

Item Lp.	Raw material Rodzaj surowca	Erratics after — Eratyki wg												Neolithic polished stone implements Narzędzia neolityczne		Comparison Porównanie
		Skalmowski 1937		Krawiec 1939		Dudziak 1961		Dudziak 1970		Czernicka-Chodkowska 1977		Krawczyńska-Grocholska, Grocholski 1979				
		quant. egz.	%	quant. egz.	%	quant. egz.	%	quant. egz.	%	quant. egz.	%	quant. egz.	%	quant. egz.	%	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1.	Amphibolite Amfibolit	29	9,7	—	—	3	2,0	1	0,5	3	0,6	12	12,0	300	20,0	=
2.	Amphibole schist Łupek amfibolowy	—	—	—	—	—	—	—	—	—	—	—	—	21	1,4	A
3.	Aplite — Aplit	—	—	—	—	—	—	—	—	—	—	—	—	6	0,4	A
4.	Basalt — Bazalt	—	—	—	—	1	0,7	—	—	—	—	—	—	187	12,4	X (17,7)
5.	Cataclasite Kataklazyt	—	—	—	—	—	—	—	—	6	1,2	—	—	—	—	E
6.	Diabase — Diabaz	4	1,4	—	—	1	0,7	1	0,5	1	0,2	—	—	169	11,3	X (8,1)
7.	Diorite — Dioryt	2	0,7	1	1,1	2	1,4	1	0,5	—	—	1	1,0	24	1,7	=
8.	Dolomite Dolomit	1	0,4	—	—	—	—	—	—	—	—	—	—	—	—	E
9.	Gabbro — Gabro	5	1,7	—	—	1	0,7	—	—	1	0,2	—	—	242	16,0	X (9,4)
10.	Gneiss — Gnejs	61	20,3	36	39,1	4	2,7	57	27,1	128	28,0	13	13,0	163	10,8	Z
11.	Granite — Granit	115	38,3	42	45,6	117	80,1	68	31,4	201	43,9	33	33,0	23	1,6	+ (−19,6)
12.	Granitogneiss Granitognejs	—	—	—	—	—	—	68	31,4	72	15,9	10	10,0	1	0,1	+ (−100,0)
13.	Granitoide Granitoid	—	—	8	8,7	—	—	—	—	—	—	—	—	18	1,2	+ (−7,2)
14.	Granodiorite Granodioryt	—	—	—	—	—	—	—	—	—	—	12	12,0	3	0,2	+ (−60,0)
15.	Granulite Granulit	1	0,4	—	—	—	—	—	—	—	—	—	—	—	—	E
16.	Greenstone Zieleniec	—	—	—	—	—	—	—	—	—	—	—	—	8	0,5	A
17.	Leptite — Leptyt	—	—	—	—	—	—	—	—	—	—	—	—	163	10,8	A
18.	Lydite — Lidyt	—	—	—	—	3	2,0	—	—	—	—	—	—	14	0,9	+ (−2,2)
19.	Melaphyre Melafir	—	—	—	—	—	—	—	—	—	—	—	—	2	0,1	A
20.	Metasandstone Metapiaskowiec	—	—	1	1,1	—	—	—	—	—	—	7	7,0	—	—	E
21.	Mygmatite Migmatyt	—	—	—	—	—	—	4	1,9	1	0,2	—	—	—	—	E
22.	Mylonite — Mylonit	—	—	—	—	—	—	4	1,9	—	—	—	—	—	—	E
23.	Nephrite — Nefryt	—	—	—	—	—	—	—	—	—	—	—	—	2	0,1	A
24.	Other crystalline rocks — Inne skały krystaliczne	—	—	—	—	—	—	—	—	33	7,4	—	—	—	—	E
25.	Other (crystaline) schists — Inne łupki (krystaliczne)	—	—	—	—	—	—	—	—	2	0,4	—	—	45	3,0	X (7,5)
26.	Other loams Iły inne	—	—	—	—	—	—	—	—	—	—	—	—	19	1,4	A
27.	Pegmatite Pegmatyt	11	3,7	—	—	—	—	5	2,3	5	1,0	5	5,0	1	0,1	+ (−10,0)
28.	Porphyry — Porfir	23	7,7	—	—	3	2,0	—	—	—	—	6	6,0	7	0,6	+ (−3,3)
29.	Poznań loam Ił poznański	—	—	—	—	—	—	—	—	—	—	—	—	26	1,7	A
30.	Pyroxenite Piroksenit	1	0,4	—	—	—	—	—	—	—	—	—	—	1	0,1	+ (−4,0)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
31.	Pyterlite — Piterlit	—	—	—	—	—	—	—	—	1	0,2	—	—	—	—	E
32.	Quartzite Kwarcyt	—	—	—	—	10	6,8	1	0,5	—	—	—	—	13	0,9	Z
33.	Quartzite sandstone Piaskowiec kwarcytowy	—	—	2	2,2	—	—	—	—	1	0,2	—	—	—	—	E
34.	Sandstone Piaskowiec	29	9,7	—	—	1	0,7	2	1,0	1	0,2	—	—	29	1,9	Z
35.	Serpentinite Serpentynit	—	—	—	—	—	—	—	—	—	—	—	—	11	0,7	A
36.	Syenite — Sjenit	—	—	2	2,2	—	—	—	—	—	—	—	—	5	0,3	+ (−7,1)
37.	Tonallite — Tonalit	—	—	—	—	—	—	—	—	2	0,4	1	0,1	—	—	E
38.	Tuffite — Tufit	—	—	—	—	—	—	—	—	—	—	—	—	2	0,1	A
	Sample size Wielkość próbki	300		92		146		210		458		100		1557		

Explanations to the last column — see text, pp. 47, 49.
Objaśnienia do ostatniej rubryki — patrz tekst, s. 47, 49.

of tools lacking distinct points, mainly mace-heads and hammers (cf. point III 2).

5. Of the highest interest to us is the group of raw materials representing a strong positive selection, namely these, which are at least twice more numerous in archaeological materials than in the erratics samples(X). The multiplicity of this prevalence is shown in brackets; if there is a divergence in geomorphological data, the highest value was taken as the basis for calculations. It is remarkable that this group included most types of rock, most frequently utilized in the Neolithic (except leptite, which has not been distinguished in the quoted erratic material, and amphibolite), containing basalt (17.7), diabase (8.1), gabbro (9.4) and crystallic schist (7.5). The high index of basalt should be explained by the only vestigal appearance of this rock in erratic material; most of the basalt artefacts were most probably produced from imported raw materials. This will be elucidated on the basis of microscopic research results. The considerable use of diabase and gabbro should be discussed separately. Their frequence in erratic materials is often quite vestigal. The combined share of the four types in erratic materials amounts to 1.5–4.2 per cent, while it reached 41.1 per cent in archaeological assemblages, that is at least 9.7 times more.

6. The remaining three raw materials: gneiss, quartzite and sandstone, make up a separate category. Their common characteristic is the clearly unequal frequency among erratics, as has been calculated by particular researchers. As a result, it is higher in some cases and lower in others than in the archaeological assemblage (Z).

Summing up the analysis devoted to the utilization of erratics we have found that: a — the use of erratic materials, which were a relatively valuable, differentiated and most easily accessible source of stone raw material for the Neolithic inhabitants of the Lowlands, was of a rational and highly selective type; this indicates a close adaptation of those communities to local natural conditions; b — the most useful and, consequently, most generally utilized erratic rocks were gabbro and diabase, although they appear in minimal amounts in erratic materials (respectively: 0–1.7 and 0–1.4%). They were used in the production of all types of implements in the Neolithic; c — a certain group of rocks more numerous among erratics but characterized by less useful technical features (for example granite) was used in a specialized manner, namely in the production of implements lacking distinct edge (mainly mace-heads and hammers).

2. RAW MATERIALS IMPORTED FROM THE SOUTH

In contrast to the remaining assemblages, all information concerning this group of raw materials, far exceeds the importance of problems of the stone industry itself. If it were possible to reproduce in the future a complete list of types of imported rocks, the roads of their inflow to the Lowlands, and to define approximately the intensity and form of this process, it would certainly constitute a factor speeding up research on cultural relations as a whole, existing in this region in the Neolithic and also on more extensive problems of Neolithic economy, particularly questions of goods exchange. Keeping in mind this far-reaching objective, we have devoted particular attention to this group of raw material, using the most precise of available methods to determine petrographic characteristics.

The method of defining the origin of imported raw materials is presented in detail in discussions on methodological assumptions of the program (Prinke, Skoczylas

Table 2. Comparison of the mineral structure of the basalt raw material of the Neolithic polished implements (after the authors) with those from the Berestowiec (after Kamieński 1929) and Janowa Dolina (after Viktorov 1951) basalt quarries.
Porównanie ilościowego składu mineralnego bazaltów, z których wykonane zostały neolityczne narzędzia kamienne (wg autorów), ze składem bazaltów z wystąpień w Berestowcu i w Janowej Dolinie

Minerals — Minerały	In Neolithic implements W narzędziach neolitycznych		In basalts from the Volhynian quarries W bazaltach z wychodni wołyńskich	
	Jerzykowo	Smolniki	Berestowiec	Janowa Dolina
Plagioclase — Plagioklaz	47,195	52,738	38,5	22–41
Pyroxene — Piroksen	24,511	29,140	29,0	14–19
Magnetite — Magnetyt	19,926	9,714	6,5	7–8
Basalt glass — Szkliwo	6,544	5,866	18,0	0–42
Seladonite — Seladonit	1,824	1,760	—	—
Zeolites — Zeolity	—	0,782	—	—
Chlorite substance — Substancja chlorytowa	—	—	8,0	0–19
Postolivine pseudomorphoses (iddingsite) — Pseudomorfozy po oliwinie (idyngsyt)	—	—	—	0–9

1978, 54–59). It has been proved, at the same time, that basalt, which fulfils requirements of the program to the utmost, has been particularly suitable for such determinations. Further, due to a considerable differentiation of the mineral composition of the basalt group, it became possible to distinguish variants of Scandinavian origin (plagioclase and nepheline basalts) from raw material of West Sudetian (of an intermediate — plagioclase-nepheline — variant) and of Volhynian origin (olivineless type). In certain cases this differentiation even allows to indicate the origin of basalt raw materials exact to a concrete deposit.

On the basis of results of laboratory studies we have ascertained the existence in the Neolithic of importation of plagioclase-nepheline basalt from its deposits in the West Sudeten to Mid-western Poland (Prinke, Skoczylas 1979b). A detailed comparison of the mineral composition of three Neolithic implements from the Piła region (northern part of Great Poland) with several appearances of Sudeten basalts indicated a deposit at Leśna, near Lubań Śląski, as the most probable source of the examined raw material (Prinke, Skoczylas 1978, 56, Fig. 6).

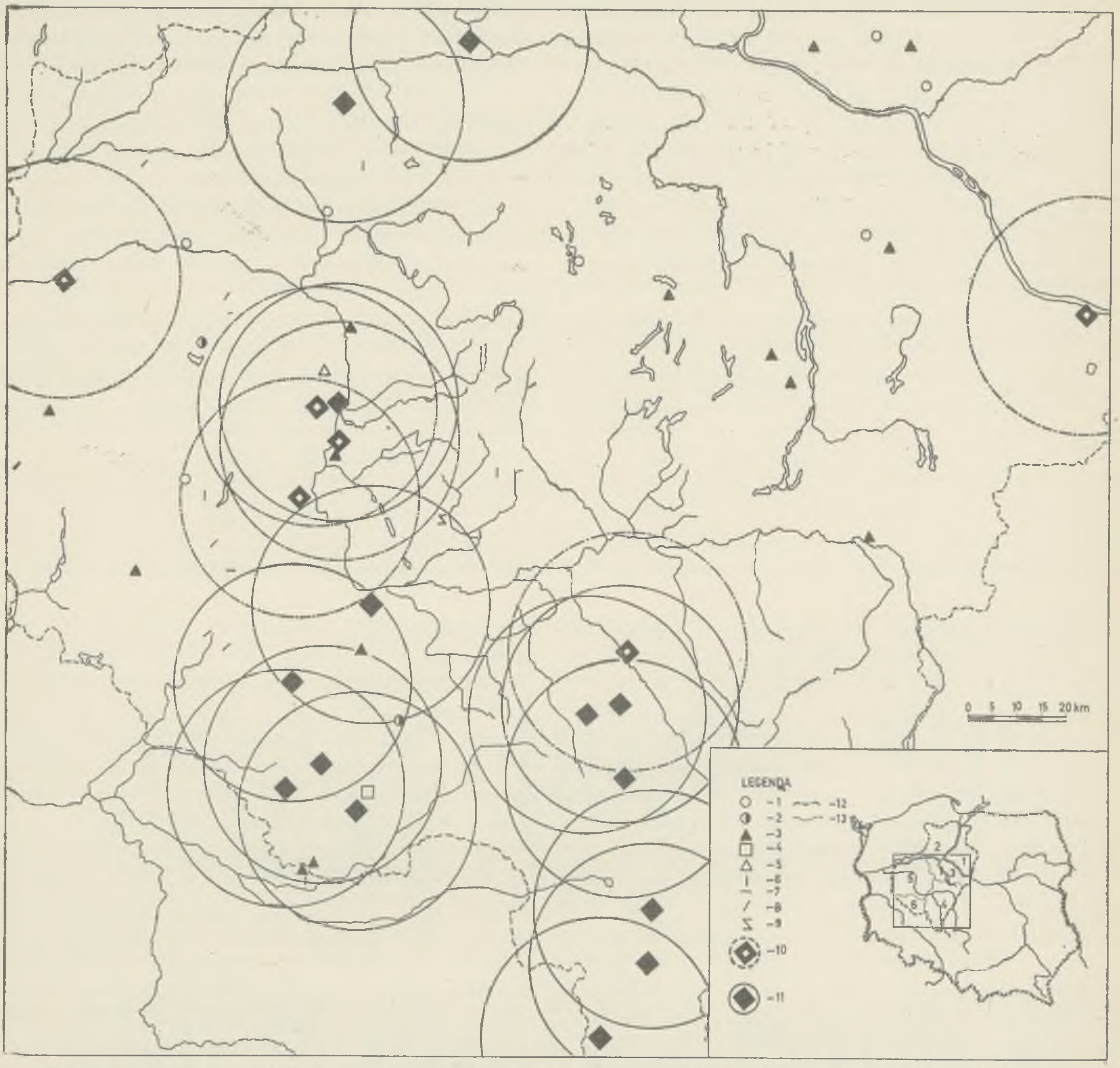
These determinations can be supplemented with the following synchronization carried out between two pieces of lithic implements (from Jerzykowo near Mogilno and Smolniki near Szubin, both woj. Bydgoszcz) and olivineless basalts from the area of Równe in Volhynia (Ukrainian SSR). The existence of a far-reaching transport of basalt raw materials from this region to Kujawy was suggested already by previous results of thin slices analyses (Prinke, Skoczylas 1978, 59, Fig. 8); this assumption was recently corroborated by results of a planimetric analysis, presented in Table 2.

Basalt was not the only rock of southern origin imported in the Neolithic to Polish Lowlands. A few finds of nephrite artefacts were of a similar type. Despite the lack of detailed petrographic studies, pieces from Mid-western Poland can be with great probability referred to deposits of this raw material at Jordanów Śląski (Geschwendt 1931; 1944; Zotz 1934). The origin of the remaining raw materials from southern rock-bearing areas — not found in erratic materials (cf. Table 1) — is less certain. This concerns primarily amphibole schist, serpentinite and tuffite. Their deposits have been investigated to a smaller degree and their mineral composition is less differentiated than basalt; nor are there any systematic petrographic studies — with the exception of macroscopic denotations of the type of raw material. At present, there exist only general premises indicating the origin of serpentinite, appearing in Lowland Neolithic materials from Lower Silesia, probably from the Ślęża massif. This would be substantiated by a concentration of finds of artefacts produced from this mineral in the northern part of Lower Silesia, which constituted the supply area of an apparent exploitation centre (Wojciechowski 1966; 1970), and by traces indicating the prehistoric exploitation of Ślęża deposits (Geschwendt 1931: Smutek 1950).

We must also consider the probability of imports of these rocks which appear in minimal quantities among erratics, but are quite frequent in southern rock-bearing areas in the form of original deposits. These rocks include primarily diabase and gabbro; their high share in Neolithic assemblages (11.3 and 16.0%) indicates a great demand for these raw materials. It is unlikely that a rock so often represented could have originated only in very poor, local erratic resources of these raw materials (diabase: 0–1.4% and gabbro: 0–1.7% of all erratics). The closest gabbro deposits — in relation to the examined area — are also in the Ślęża range. The proposed hypothesis could be verified by the same procedure which was used in the case of basalt, since the Ślęża gabbro differs in its mineral composition from the gabbro of northern (erratic) origin.

3. RAW MATERIALS FROM ORIGINAL LOWLAND DEPOSITS

In addition to erratic materials and imports from the south (their provenance described above), Neolithic stone workers in Mid-western Poland used — though to a much smaller degree (45 pieces — i.e., 3.1% of the examined assemblage) — also materials extracted from local stone ledges. These are exclusively sedimentary rocks from the loam group, of a relatively high internal differentiation (mostly according to the degree of silica content). A particular type in this group are variegated Poznań loams, relatively numerously represented in examined archaeological materials (26 pieces — i.e., 57.8% of the group of loam artefacts). The utility value of loams are quite different from properties dominating among implements produced from the most popular types of erratic rocks (amphibolite, diabase, gabbro, gneiss, leptite). Loams differ primarily as regards their much lower hard-



Map 1. The distribution of Neolithic stone implements produced from raw materials derived from original local deposits (loams).

1–5 — Poznań loams: slightly siliceous (*2*), siliceous (*3*), strongly siliceous (*4*), with predominating kaolin (*5*); *6–9* — other loams: slightly siliceous (7), siliceous (*8*), with predominating kaolin (*9*); *10, 11* — loam deposits: Poznań (*10*), others (*11*),; *12, 13* — boundaries: of the investigated area (*12*), of the region (*13*). The background areas of particular deposits in the radius of 25 kilometres are marked for orientation.

Rozprzestrzenienie neolitycznych narzędzi kamiennych, wykonanych z surowców, pochodzących z miejscowych złóż pierwotnych (iłów)

1–5 — ił poznański: lekko skrzemionkowany (*2*), skrzemionkowany (*3*), silnie skrzemionkowany (*4*), z przewagą kaolinu (*5*); *6-9* — iły inne: lekko skrzemionkowane (*7*), skrzemionkowane (*8*), z przewagą kaolinu (*9*); *10, 11* — złoża iłów: poznańskich (*10*), innych (*11*), *12, 13* — granice: badanego obszaru (*12*), regionu (13). Dla orientacji oznaczono najbliższe zaplecze poszczególnych złóż o średnicy 25 km ness, although their hardest, diagenesed and often silicified variant (claystone) was chosen as a rule for the production of implements. Characteristic of claystones is their pelitic structure and dense texture (Kunkel 1975, 11). To define the exploitation of deposits of relevant raw materials situated on the area of our research, we have prepared a map showing the distribution of Neolithic loam implements in relation to known natural quarries of these rocks (Map 1; *Katalog* 1964; Kunkel 1975; Błaszak 1977).

Finds of artefacts have been marked in accordance with differences in types achieved by means of macroscopic determinations. Only deposits covered by a layer not thicker than 1.5 m have been considered. This allowed to assume the possibility of their exploitation in the Neolithic. The occurrence of loam deposits is linked with the range of the Pliocene lake which covered almost the entire area of the Polish Lowlands (Aren 1957). Three out of six Poznań loam deposits mentioned by A. Kunkel (1975), are in the closest vicinity of Poznań. Although implements produced from this raw material form no distinct concentrations, we can distinguish areas on which these artefacts are regularly distributed (ziemia chełmińska and the central part of Great Poland along the meridional course of the Warta River), and areas on which they do not appear at all (the south-eastern part of the investigated area: the eastern part of Great Poland). Only the concentration of deposits near Poznań tallies to a degree with finds. It is astounding, however, that rich deposits of diagenesed Poznań loam at Dobrzyń, woj. Włocławek (Gajdówna 1952; Łyczewska 1961), particularly easy to exploit considering their wide-spread exposition (a 300 m long section of the high bank of the Vistula), were, probably, neither known nor exploited in the Neolithic, since the nearest finds of this material were made more than 35 kilometres away. These deposits are, at the same time, the closest to ziemia chełmińska where several implements from Poznań loam were found. A comparison of deposits of ,,other loams" with corresponding finds led to the following conclusions:

1. Neolithic finds of "other loams" did not appear east of the Wyrzysk—Gniezno—Rawicz meridional line, none have been found on the entire ziemia chełmińska, in Kujawy and eastern Great Poland.

2. The appearance of "other loams" deposits, which, in theory, should be accessible in the Neolithic to exploitation in quarries tallies, in general, with the occurrence of corresponding artefacts. The only exception is South-eastern Great Poland, where — within a distance of about 70 kilometres — there are six deposits of this type, in the far-reaching neighbourhood of which there appeared no implements produced from the relevant material. This fact suggests that local Neolithic inhabitants were completely unaware of these deposits.

II. THE DISTRIBUTION OF NEOLITHIC STONE RAW MATERIALS ON POLISH LOWLANDS

Just like the Neolithic exploitation of stone raw materials, their distribution belongs to the most neglected problems in our entire knowledge on the economy of that epoch[4]. Due to the lack of previous elaborations which could be used as reference points, we shall begin our presentation by introducing a general picture resulting from our own researches on Neolithic stone production in Mid-western Poland. It comprises all (macro- and microscopic) petrographic denotations, systematized according to spatial differentation, and includes a chrono-cultural division. Considering the limited scope of the work, we shall present only a generalized version of this approach based on a concise list of raw material types. It comprises 25 types of rocks of the highest frequency among 109 previously recognized types (variants of the same raw material have been included, every time, in a common category; Prinke, Skoczylas 1978, 50–52).

The simplified chrono-cultural division links the original 28 categories of into 5 extensive groups: 1 — the cycle of Danubian cultures (DC), 2 — The Funnel Beaker and Globular Amphorae Cultures (FBC), 3 — the Corded Ware Culture (CWC), 4 — "Epi-Corded Ware" groups from the turning-point of the Neolithic and Bronze Age (N/Br), 5 — Neolithic implements of undetermined chrono-cultural provenance (?). Local differences in the utilization structure of lithic raw materials will be investigated on the basis of the thus defined system of co-ordinates. To this end, the investigated area was divided into 6 zones of a rank close to mesoregions: 1 — a part of the area of research situated east of the Vistula (mainly ziemia chełmińska); 2 — the area situated north of the Noteć River, of a marginal character, embracing the southern border of Central Pomerania; 3 — Kujawy; 4 — Eastern Great Poland (woj. Kalisz and woj. Konin); 5 — Mid-western Great Poland; 6 — South-western Great Poland (woj. Leszno; position of regions — cf. Prinke, Skoczylas 1978, maps 1–5). Not all of them are culturally and geomorphologically compact, because the purpose of the division presented here was only to examine changes in ways and the intensity of utilizing particular types of lithic raw material in specific chrono-cultural groups. First of all we particularly intended to study possible differences in the flow of raw materials imported from southern areas.

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[4] The present position of research on this and related problems were presented in: Skoczylas, Prinke 1979b.

1. THE REGIONAL DIFFERENTIATION OF RAW MATERIAL STRUCTURE

The regional differentiation in the distribution of lithic raw materials is illustrated by two tables (3 and 4). They represent a transposition of the summaric initial table, operating with frequencies expressed in the number of implements (see Prinke, Skoczylas 1979a, table 1), in relative percentage. Table 3 indicates to what extent a particular raw material was utilized in specific regions and successive chrono-cultural groups. Assuming a complete lack of regional differentiation in the utilization intensity of particular raw materials, each segment of the diagram in Fig. 1 would comprise six equal parts and connecting broken lines would run horizontally. Distinct differences have been observed, however, on particular chrono-cultural planes, including both qualitative (the absence in a particular region of implements from defined raw material) and quantitative differences (a different share of implements from various regions in series of implements from a specific raw material).

Regions 4 (Eastern Great Poland) and 6 (South-western Great Poland) are the most clearly differentiated in the DC group, in respect to differences in quality. No implements made from diabase, amphibole schist or sandstone have been found among them. As regards the quantitative aspect, our attention was drawn to certain specific features of region 5 (Mid-western Great Poland). They related to a considerably higher, than in remaining regions, share of Poznań loam and schists (except amphibole schist) and an considerably less frequent use of diabase. In respect to the FBC group we dispose, so far, of no sufficiently numerous series from regions 2 and 4. Our conclusions concern, therefore, only the remaining 4 areas. Qualitative differences were observed in relation to Poznań loam (not found in region 1), schists (except amphibole schist, also absent in regions 1 and 3) and sandstone (not found in regions 5 and 6). As regards quantity, a particularly low frequency of basalt artefacts appeared in region 6, and a high number of gneiss artefacts in region 1. The quantity of Poznań loam implements was also relatively high in region 6 — 78.4 per cent of implements. We had to omit regions 1 and 2 when discussing the CWC group because of negligent quantity of the two samples. A distinct quantitative difference was noted in regions 4 and 6, where only amphibolite was found. In regard to considerable quantitative differences, we have noted an exceptionally high frequency of implements from basalt, gneiss and leptite in region 3 and from diabase in region 5. As regards the N/Br group, our conclusions omit the poorly represented region 2. The most characteristic in this group is the structure of region 6, where there were no artefacts from diorite, gneiss, leptite and schists (except amphibole schist). All implements from diorite, however, are concentrated in region 3.

We shall additionally investigate the geographical differentiation of the group of Neolithic implements of an undetermined chronology (group?). The different character of region 6 was noted again — no diabase, diorite, Poznań loam, amphibole schist and sandstone imple-

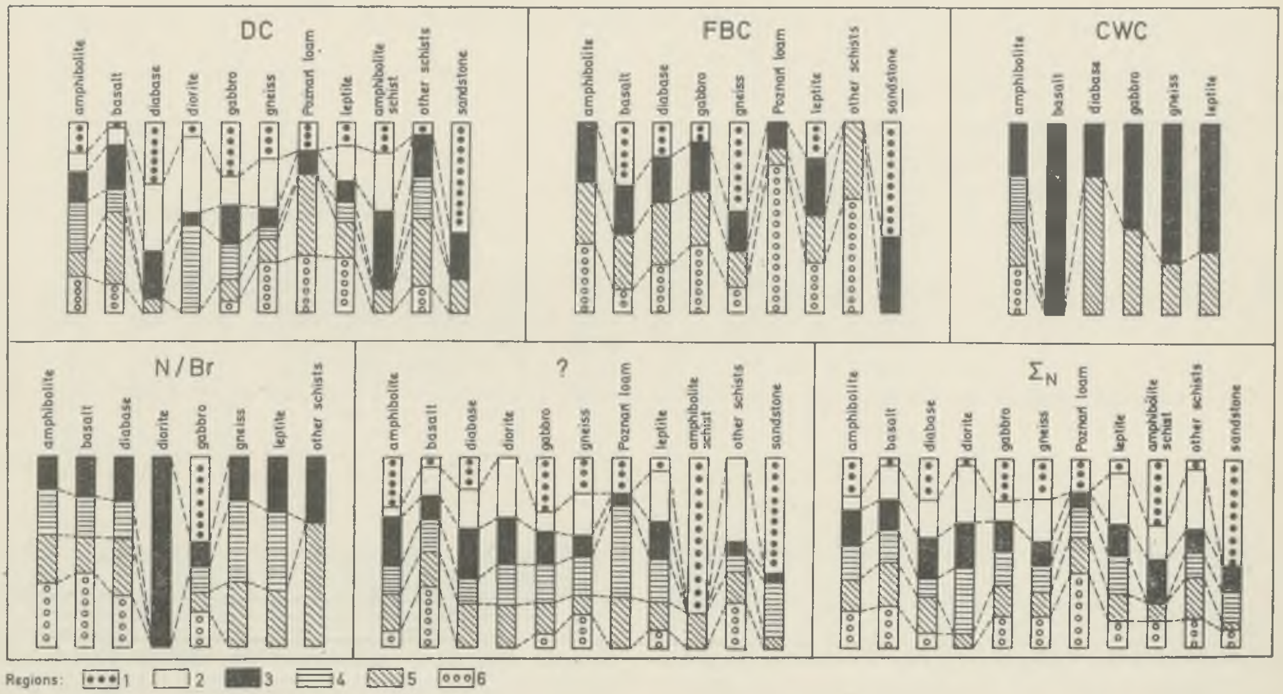

Fig. 1. The regional differentiation of the intensity of utilizing particular stone raw materials in the chrono-cultural aspect.

Regionalne zróżnicowanie intensywności użytkowania poszczególnych surowców kamiennych w aspekcie chronologiczno-kulturowym

Table 3. Regional differentiation of occurrence of the Neolithic implements from respective rocks in Mid-Western Poland in chrono-cultural
Regionalne zróżnicowanie występowania narzędzi neolitycznych z poszczególnych surowców kamiennych w Polsce środkowo-zachodniej
procentowe)

Chrono-cultural group Grupa chronologiczno-kulturowa	Region	Amphibolite Amfibolit		Amphibole schist Łupek amfibolowy		Basalt Bazalt		Diabase Diabaz		Diorite Dioryt		Gabbro Gabro		Gneiss Gnejs	
		quant. egz.	%	quant. egz.	%	quant. egz.	%	quant. egz.	%	quant. egz.	%	quant. egz.	%	quant. egz.	%
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Danubian Cycle	1	27	15,8	3	16,1	1	1,8	15	32,1	1	6,8	20	28,0	20	18,8
Cykl naddunajski	2	3	9,7	1	30,4	1	10,4	3	35,5	1	40,1	2	15,4	5	26,0
(DC)	3	32	15,6	9	40,9	15	23,2	14	24,8	1	6,1	18	21,0	13	10,2
	4	7	26,9	—	—	1	12,1	—	—	1	47,0	2	18,4	1	6,1
	5	19	13,0	2	12,6	17	37,4	3	7,6	—	—	7	11,6	11	12,2
	6	8	19,0	—	—	2	15,1	—	—	—	—	1	5,6	7	26,7
	1–6	96	100,0	15	100,0	37	100,0	35	100,0	4	100,0	50	100,0	57	100,0
Funnel Beaker	1	—	—	—	—	2	33,5	1	17,9	—	—	1	10,3	5	47,1
Culture	3	8	31,4	—	—	7	26,3	6	24,1	—	—	11	25,4	10	21,0
Kultura pucharów	5	12	32,7	—	—	11	28,7	12	33,5	—	—	18	29,0	13	19,1
lejkowatych	6	3	35,9	—	—	1	11,5	2	24,5	—	—	5	35,3	2	12,8
(FBC)	1–6	26	100,0	—	—	22	100,0	23	100,0	1	—	36	100,0	30	100,0
	3	14	26,7	—	—	6	26,1	3	27,1	—	—	9	55,0	4	73,3
Corded Ware Culture	4	4	25,5	—	—	—	—	—	—	—	—	—	—	—	—
Kultura ceramiki	5	16	23,3	—	—	17	73,9	11	72,9	—	—	10	45,0	2	26,7
sznurowej	6	4	25,5	—	—	—	—	—	—	—	—	—	—	—	—
(CWC)	1–6	41	100,0	—	—	23	100,0	16	100,0	—	—	27	100,0	6	100,0
"Epi-Corded Ware"	1	—	—	—	—	—	—	—	—	—	—	5	45,3	—	—
Groups	3	5	16,6	—	—	9	20,4	3	23,5	5	100,0	12	12,8	4	23,4
Grupy "episznurowe"	4	3	24,1	—	—	4	22,1	1	19,9	—	—	5	12,9	3	43,0
(N/Br)	5	12	25,4	—	—	13	18,8	6	29,9	—	—	16	10,9	9	33,6
	6	3	33,9	1	—	5	38,7	1	26,7	—	—	5	18,1	—	—
	1–6	23	100,0	1	—	33	100,0	11	100,0	5	100,0	44	100,0	17	100,0
Chrono-culturally	1	22	26,7	4	82,6	6	6,1	14	18,2	—	—	24	29,6	14	19,8
unidentified Neoli-	2	1	4,8	—	—	4	16,2	4	20,6	1	33,3	2	9,8	4	22,5
thic implements	3	38	26,7	—	—	21	12,4	35	26,4	5	24,6	23	16,4	13	10,6
Okazy neolityczne	4	5	14,6	—	—	7	17,3	4	12,4	1	20,2	7	20,8	6	20,3
bliżej nie określone	5	19	19,8	1	17,4	19	16,8	20	22,4	3	21,9	15	15,9	8	9,7
pod względem chro-	6	1	7,4	—	—	5	31,2	—	—	—	—	1	7,5	2	17,1
nologiczno-kulturowym (?)	1–6	86	100,0	5	100,0	62	100,0	77	100,0	10	100,0	72	100,0	47	100,0
Total	1	55	20,6	7	35,4	9	4,9	34	22,9	1	3,7	52	22,7	39	21,7
Ogółem	2	5	7,6	1	19,5	8	17,5	7	19,1	2	30,9	6	10,6	10	22,7
	3	97	19,3	9	23,2	58	16,5	61	21,5	12	24,3	73	16,6	44	12,9
	4	21	17,8	—	—	14	16,9	7	10,4	4	34,6	19	18,5	11	13,6
	5	78	16,0	3	8,5	77	22,9	52	19,1	3	6,5	66	15,6	43	13,1
	6	19	18,7	1	13,4	15	21,3	4	7,0	—	—	14	16,0	10	16,0
	1–6	275	100,0	21	100,0	181	100,0	165	100,0	22	100,0	230	100,0	158	100,0

ments were found there. But most basalt artefacts were centred in that area. A summing up of the entire assemblage (without considering chrono-cultural aspect) has indicated, among others, a lack of implements from diorite in region 6 and from amphibole loam in region 4. Most Poznań loam artefacts appeared in region 6, sandstone ones — in region 1.

A univocal interpretation of observed local differences is not quite possible at the present, initial stage of research. Our analysis proved only the existence of numerous and deep differences on various chronological levels. It seems that subsequent relevant studies should be directed at solving the problem whether these differences were caused by natural (above all, the varied

aspect (generalized, proportional version)
w aspekcie chronologiczno-kulturowym (zgeneralizowane ujęcie

Leptite Leptyt		Other schists Łupki inne		Poznań loam Ił poznański		Sandstone Piaskowiec		Sample size Wielkość próbki
quant. egz.	%	quant. egz.	%	quant. egz.	%	quant. egz.	%	
17	18	19	20	21	22	23	24	25
7	12,4	2	6,7	2	14,7	4	58,5	105
2	19,4	—	—	—	—	—	—	19
8	11,6	8	22,3	2	12,4	2	24,6	126
1	11,5	1	21,9	—	—	—	—	16
8	16,6	9	35,7	5	43,5	1	16,9	89
4	28,5	1	13,4	1	29,4	—	—	26
30	100,0	21	100,0	10	100,0	7	100,0	381
1	19,3	—	—	—	—	1	59,7	13
7	30,3	—	—	1	12,7	3	40,3	58
8	24,1	3	40,4	1	8,9	—	—	83
2	26,3	1	59,6	2	78,4	—	—	19
23	100,0	6	100,0	4	100,0	4	100,0	173
6	67,4	—	—	—	—	—	—	47
—	—	—	—	—	—	—	—	14
4	32,6	1	—	—	—	—	—	64
—	—	—	—	—	—	—	—	14
18	100,0	1	—	1	—	1	—	150
—	—	—	—	—	—	—	—	—
7	29,5	1	35,1	—	—	—	—	51
4	41,0	—	—	—	—	—	—	21
11	29,5	3	64,9	1	—	—	—	80
—	—	—	—	—	—	—	—	15
23	100,0	4	100,0	1	—	—	—	180
6	7,8	—	—	2	19,8	10	61,8	103
5	25,8	3	45,0	—	—	—	—	26
28	21,0	3	6,6	1	6,2	1	3,8	178
7	21,9	1	9,0	2	48,0	2	29,3	43
14	15,6	5	16,4	3	26,0	1	5,1	120
1	7,9	1	23,0	—	—	—	—	17
61	100,0	13	100,0	8	100,0	14	100,0	487
14	7,7	3	5,7	5	17,8	15	56,8	243
12	26,0	4	31,7	—	—	—	—	60
56	16,1	12	12,3	4	8,0	7	13,8	464
18	21,9	3	12,8	2	16,1	2	16,5	109
46	13,6	21	22,3	10	19,6	2	3,7	445
10	14,1	3	15,2	4	38,5	1	9,2	93
156	100,0	46	100,0	25	100,0	27	100,0	1414

petrographic composition of erratic materials in particular regions) or cultural factors (for example, the tradition of using certain types of raw material in certain regions or because a particular area was within the range of a far-reaching exchange of raw materials). The second possibility may be linked with geographic differences in the appearance of imported raw materials, mainly including basalt.

The proportional compilation in Table 4 allows to determine the presence and kind of regional differences in raw material structures between particular chrono-cultural groups. The representative qualities of the examined assemblage appeared to be only fragmentary also in this sphere. A relatively complete picture of the relevant problem was achieved for regions 3 and 5; three areas are represented by only some categories, whereas the frequency of all chrono-cultural groups from region 6 was too low to consider this zone in our deliberations.

We have also found several quantitative and qualitative differences between compared regions. In region 3 (Kujawy) the raw material structure of all chrono-cultural groups included almost no Poznań loam. Neither were there any schist (except in the DC group) or diorite artefacts (except in the N/Br group). As regards quantitative characteristics, we should like to mention the maximum use of amphibolite in the DC and CWC groups, gabbro in N/Br and gneiss in FBC. The N/Br group is also characterized by a numerous series of basalt implements. Investigated raw material structures from Mid-western Great Poland (region 5) included almost no diorite and amphibole schist, and (with the exception of DC) Poznań loam.

Numerous dependences between raw material structures of particular chrono-cultural groups and regions, noted in the two Tables, were subsequently statistically verified[5]. The Smirnov's Test was used in elaborating data in Tables 3 and 4. The matrix in Fig. 2 presents an image of statistically significant differences between the distribution of each of principal lithic raw materials in particular regions (Table 3). This allows to supplement and verify the above formulated conclusions.

The highest regional differences in utilization intensity in DC group relate to diabase (threefold on the 1% level), next comes basąlt (twice — 1% and once — 5%). As regards basalt, observed differences have been caused probably by the already mentioned zonal inflow of this raw material to the Lowlands from rock-bearing southern areas. Differences noted in the remaining chrono-cultural groups are too random to play an essential role in our deliberations; the reason being their low frequency in studied systems. Attention should be directed, however, to the strongly accentuated (level of 1%) difference in the appearance of gabbro and basalt implements. Only the whole assemblage reflects a wider range of raw materials. It proves the already noticed separateness of diabase and of sandstone whose geographical distribution differs from all other raw materials.

The second matrix (Fig. 3) relates to Table 4 and con-

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[5] About the aim and method of execution of the statistical verification in present research, cf. PRINKE, SKOCZYLAS 1978, p. 53 f

Table 4. Raw material differences of the respective chrono-cultural groups of Neolithic implements from Mid-Western Poland in regional aspect (generalized proportional version)

Zróżnicowanie surowcowe poszczególnych grup chronologiczno-kulturowych neolitycznych narzędzi kamiennych z terenu Polski środkowo-zachodniej w aspekcie regionalnym (zgeneralizowane ujęcie procentowe)

Region	Chrono-cultural group Grupa chronologiczno-kulturowa		Amphibolite Amfibolit	Amphibole schist Łupek amfibolowy	Basalt – Bazalt	Diabase – Diabaz	Diorite – Dioryt	Gabbro – Gabro	Gneiss – Gnejs	Leptite – Leptyt	Other schists Łupki inne	Poznań loam Ił poznański	Sample size Wielkość próbki
1	2		3	4	5	6	7	8	9	10	11	12	13
1	DC	quant.	27	3	1	15	1	20	20	7	2	2	105
		%	25,7	2,9	1,0	14,3	1,0	19,0	19,0	6,6	1,9	1,9	100,0
	FBC	quant.	—	—	2	1	—	1	5	1	—	—	13
		%	—	—	—	—	—	—	38,5	—	—	—	100,0
	N/Br	quant.	—	—	—	—	—	5	—	—	—	—	6
		%	—	—	—	—	—	83,3	—	—	—	—	100,0
	?	quant.	22	4	6	14	—	24	14	6	—	2	103
		%	21,3	3,9	5,8	13,6	—	23,3	13,6	5,8	—	1,9	100,0
2	DC	quant.	3	1	1	3	1	2	5	2	—	—	19
		%	—	—	—	—	—	—	—	—	—	—	100,0
	?	quant.	1	—	4	4	1	2	4	5	3	—	26
		%	3,8	—	15,4	15,4	3,8	7,7	15,4	19,2	11,5	—	100,0
3	DC	quant.	32	9	15	14	1	18	13	8	8	2	126
		%	25,4	7,1	11,9	11,1	—	14,3	10,3	6,3	6,3	—	100,0
	FBC	quant.	8	—	7	6	—	11	10	7	—	1	58
		%	13,8	—	12,1	10,3	—	19,0	17,2	12,1	—	—	100,0
	CWC	quant.	14	—	6	3	—	9	4	6	—	—	47
		%	29,8	—	12,8	—	—	19,1	—	12,8	—	—	100,0
	N/Br	quant.	5	—	9	3	5	12	4	7	1	—	51
		%	9,8	—	17,6	—	9,8	23,5	—	13,7	—	—	100,0
	?	quant.	38	—	21	35	5	23	13	28	3	1	178
		%	21,3	—	11,8	19,7	2,8	12,9	7,3	15,7	—	—	100,0
4	DC	quant.	7	—	1	—	1	2	1	1	1	—	16
		%	43,7	—	—	—	—	—	—	—	—	—	100,0
	N/Br	quant.	3	—	4	1	—	5	3	4	—	—	21
		%	—	—	—	—	—	23,8	—	—	—	—	100,0
	?	quant.	5	—	7	4	1	7	6	7	1	2	43
		%	11,6	—	16,3	—	—	16,3	13,9	16,3	—	—	100,0
5	DC	quant.	19	2	17	3	—	7	11	8	9	5	89
		%	21,3	—	19,1	—	—	7,9	12,3	9,8	10,1	5,6	100,0
	FBC	quant.	12	—	11	12	—	18	13	8	3	1	83
		%	14,4	—	13,2	14,4	—	21,7	15,7	9,6	—	—	100,0
	CWC	quant.	16	—	17	11	—	10	2	4	1	—	64
		%	25,0	—	26,6	17,2	—	15,6	—	—	—	—	100,0
	N/Br	quant.	12	—	13	6	—	16	9	11	3	1	80
		%	15,0	—	16,2	7,5	—	20,0	11,2	13,7	—	—	100,0
	?	quant.	19	1	19	20	3	15	8	14	5	3	120
		%	15,8	—	15,8	16,7	—	12,5	6,7	11,7	4,2	—	100,0
6	DC	quant.	8	—	2	—	—	1	7	4	1	1	26
		%	30,8	—	—	—	—	—	26,9	—	—	—	100,0
	FBC	quant.	3	—	1	2	—	5	2	2	1	2	19
		%	—	—	—	—	—	—	—	—	—	—	100,0
	N/Br	quant.	3	1	5	1	—	5	—	—	—	—	15
		%	—	—	33,3	—	—	33,3	—	—	—	—	100,0
	?	quant.	1	—	5	—	—	1	2	1	1	—	17
		%	—	—	29,4	—	—	—	—	—	—	—	100,0

			DC							FBC		CWC	N/Br		?						Total								
			amphibolite	basalt	diabase	gabbro	gneiss	leptite	schists	gabbro	gneiss	amphibolite	basalt	gabbro	amphibolite	basalt	diabase	gabbro	gneiss	leptite	amphibolite	basalt	diabase	gabbro	gneiss	Poznań loam	leptite	schists	sandstone
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
DC	amphibolite	1		—	⊗	—	—	—	—	×	×	×	—	×	—	—	×	—	—	—	—	—	—	×	×	—	—	×	⊗
	basalt	2			⊗	⊗	×	—	—	—	⊗	—	—	⊗	—	—	×	×	×	×	—	—	⊗	—	⊗	—	—	⊗	⊗
	diabase	3				—	⊗	⊗	⊗	⊗	—	⊗	⊗	×	⊗	⊗	×	⊗	⊗	⊗	⊗	⊗	×	⊗	⊗	⊗	⊗	×	—
	gabbro	4					—	—	—	⊗	—	⊗	⊗	—	—	×	—	—	—	—	—	⊗	—	—	—	×	—	—	—
	gneiss	5						—	—	×	—	⊗	⊗	—	—	—	×	—	—	—	—	×	—	×	—	—	—	—	⊗
	leptite	6							—	—	—	—	—	×	—	—	×	—	—	—	—	—	—	—	—	—	—	—	⊗
	schists	7								×	×	×	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	⊗
FBC	gabbro	8									×	—	—	—	⊗	—	⊗	⊗	⊗	⊗	⊗	—	⊗	⊗	⊗	—	⊗	⊗	⊗
	gneiss	9										⊗	⊗	—	—	⊗	—	—	—	⊗	×	⊗	—	—	—	×	⊗	—	—
CWC	amphibolite	10											⊗	⊗	⊗	—	⊗	⊗	⊗	⊗	⊗	—	⊗	⊗	⊗	—	⊗	⊗	⊗
N/Br	basalt	11												⊗	⊗	—	⊗	⊗	⊗	×	×	—	⊗	⊗	⊗	—	⊗	⊗	⊗
	gabbro	12													—	⊗	×	—	—	⊗	×	⊗	—	×	×	—	⊗	—	—
?	amphibolite	13														×	—	—	—	—	—	⊗	—	—	—	×	×	—	×
	basalt	14															—	×	—	×	—	—	×	—	×	—	×	⊗	⊗
	diabase	15																—	—	—	×	⊗	—	—	—	⊗	⊗	—	⊗
	gabbro	16																	—	—	—	⊗	—	—	—	—	×	—	—
	gneiss	17																		—	—	—	—	—	—	—	—	—	×
	leptite	18																			—	—	—	—	—	—	—	—	⊗
Total	amphibolite	19																				⊗	⊗	—	⊗	—	×	—	⊗
	basalt	20																					⊗	⊗	⊗	—	×	⊗	⊗
	diabase	21																						—	—	⊗	×	—	⊗
	gabbro	22																							—	—	×	—	⊗
	gneiss	23																								×	—	—	⊗
	Poznań loam	24																									—	×	×
	leptite	25																										—	⊗
	schists	26																											×
	sandstone	27																											

Fig. 2. A matrix illustrating the statistical significance of differences between the utilization of particular stone raw materials in specific chrono-cultural groups (Smirnov's Test; cf. Table 3).

⊗ — statistically significant differences on the level 0.01; × — on the level 0.05; — — no statistically significant differences.

Macierz ilustrująca istotność statystyczną różnic między użytkowaniem poszczególnych surowców kamiennych w kolejnych grupach chronologiczno-kulturowych (test Smirnova; por. tab. 3)

⊗ — różnice statystycznie istotne na poziomie 0,01; × — na poziomie 0,05; — — brak różnic statystycznie istotnych

cerns differences appearing in particular chrono-cultural groups from the regional approach. Our assemblage investigated on this plane is much more uniform. Only two series are clearly distinguishable: DC implements from region 6 (7 statistically significant differences including 4 on the 1 per cent level) and CWC implements from region 5 (12 differences including 8 on the 1% level). The structure of the first of these series is dominated by amphibolite (over 30%) and gneiss (almost 30%), the second comprises primarily amphibolite and basalt (ca. 25% each), followed by diabase and gabbro (above 15% each).

				Regions														
				1		2	3					4	5					6
				DC	?	?	DC	FBC	CWC	N/Br	?	?	DC	FBC	CWC	N/Br	?	DC
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Regions	1	DC	1		—	—	—	—	—	—	—	—	—	—	⊗	—	—	⊗
		?	2			—	—	—	—	—	—	—	—	—	⊗	—	—	×
	2	?	3				—	—	—	—	—	—	—	—	⊗	—	—	—
	3	DC	4					—	—	—	—	—	—	—	×	—	—	⊗
		FBC	5						—	—	—	—	—	—	×	—	—	—
		CWC	6							—	—	—	—	—	—	—	—	—
		N/Br	7								×	—	—	—	⊗	—	—	—
		?	8									×	×	—	—	—	—	⊗
	4	?	9										—	—	⊗	—	—	—
	5	DC	10											—	⊗	—	—	—
		FBC	11												×	—	—	×
		CWC	12													⊗	×	⊗
		N/Br	13														—	—
		?	14															×
	6	DC	15															

Fig. 3. A matrix illustrating the statistical significance of differences between raw material structures of particular chrono-cultural groups in each region of Mid-western Poland (Smirnov's Test; cf. Table 4).

Macierz ilustrująca istotność statystyczną różnic między strukturami surowcowymi poszczególnych grup chronologiczno-kulturowych w każdym z regionów Polski środkowo-zachodniej (test Smirnova; por. tab. 4).

Legend: see Fig. 2 — Legenda patrz ryc. 2

2. IMPORTS OF BASALT OF SOUTHERN ORIGIN TO THE POLISH LOWLANDS

Since the employed range of petrographic methods is not complete, we can only generally maintain that basalt raw materials were transported in the Neolithic from the Western Sudeten and Volhynia to Polish Lowlands. This has been proved by petrographic arguments (cf. p. 49 f.). It should also be kept in mind that quarries of basalt which was utilized on the Lowlands need not have been situated only on indicated areas but could have also lain in present-day Czechoslovakia and East Germany or even on areas situated further west.

It may be assumed that the technical properties of basalt — definitely surpassing those of all other erratic raw materials accessible on the Lowlands — were the main reason for the conducting of these forms of economic activity. A detailed analysis of the production process of polished stone artefacts has indicated that the utilization properties most in demand among Neolithic stone workers, and deciding the selection of appropriate lithic material, undoubtedly included a considerable air-tightness (i.e., minimum porousness) and a related low degree of absorption ensuring a satisfactory resistance to frost and decay; furthermore, a high specific gravity allowing to achieve a great stricking force with implements of limited size; a good cleavability facilitating the treatment of raw materials, and a relatively high density (considering the durability of tools), but not so high as to make treatment difficult (Prinke, Skoczylas 1978, 60; 1979b). Since basalt shows all these advantages, it was the closest to the ideal, exemplary raw material among stones used for the production of implements in the Neolithic on Polish Lowlands. This fact decided its attractiveness despite a considerable distance from deposits. The distance between the probable quarries of examined basalts and sites where relevant artefacts were found was about 250 kilometres for West Sudeten deposits and about 700 kilometres for Volhynian quarries.

The mass macroscopic denotations of the type of raw material relating to lithic artefacts from Mid-western Poland, collected by the authors, allow to define general proportions of the inflow of basalt raw materials from the south to the Lowlands. The share of basalt in the entire Neolithic assemblage amounts to 12.4 per cent; among DC implements — 9.1 per cent, FBC — 11.5 per cent, CWC — 16.5 per cent, N/Br — 16.3 per cent and implements not precisely defined as regards culture — 12.6 per cent (Prinke, Skoczylas 1978, 52, Table 1). Considering the fact of a complete absence or, according to other authors, a minimal share of basalt in erratic materials (cf. Table 1; Cohen, Deecke 1891; Skalmowski 1937), we may assume that approximately all Neolithic basalt implements found on the area referred to, were produced from southern imports. If this assumption is correct, the discussed phenomenon must have been of a mass character and lasted throughout the entire Neolithic with no significant fluctuations. A complete verification of this hypothesis will require further microscopic analyses of more numerous than hitherto series of basalt implements.

III. THE UTILIZATION OF STONE RAW MATERIALS IN NEOLITHIC CULTURES OF POLISH LOWLANDS

1. THE CHRONO-CULTURAL ASPECT

Results collected in the cource of our research allow to reproduce a general image of two aspects concerning raw material economy in Neolithic stone industry: the chrono-cultural and typological situation.

The chrono-cultural aspect shows differences appearing in raw material structures of stone industry in particular chrono-cultural groups. As may be seen from the summarized compilation of frequencies of the entire Neolithic (Prinke, Skoczylas 1978, 52, Table 1) the six most numerous raw material categories (amphibolite, basalt, diabase, gabbro, gneiss and leptite) include 75.3 per cent of the examined assemblage (Fig. 4). Already this basis makes it possible to formulate a conclusion that there existed a strong tendency to select out of all available raw materials (this availability may be seen in the presence of artefacts from 109 types of rock) only a small group of rock types, which Neolithic stone workers considered to be the most suitable for the production of implements.

Following a generalization, we have achieved a simplified but still relatively precise and, at the same time, clear picture of the raw material structure of the examined assemblage in relation to both the entire Neolithic (structure of the entire assemblage) and particular, principal groups of that epoch (Fig. 4). We have also considered the raw material structure of the undetermined (?) group, which has often proved useful for comparative purposes as being partly representative

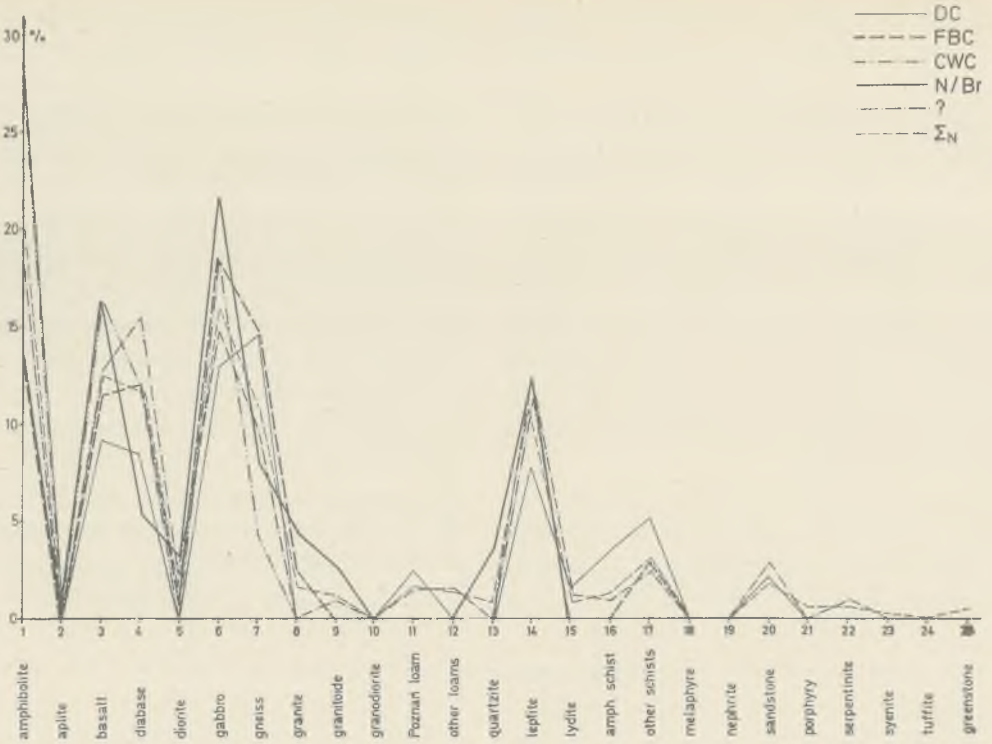

Fig. 4. A diagram of the proportional raw material composition of Neolithic stone implements from particular chrono-cultural group in Mid-western Poland (generalized).

Wykres procentowego składu surowcowego neolitycznych narzędzi kamiennych z poszczególnych grup chronologiczno-kulturowych w Polsce środkowo-zachodniej (ujęcie zgeneralizowane)

lor the stone industry of the Middle and Late Neolithic[6].

A detailed comparison of data from the Table quoted above (Prinke, Skoczylas 1978, 52, Table 1), allow to make an initial assumption concerning the existence of several trends in the utilization intensity of certain stone raw materials in successive Neolithic periods. We have taken into account only the most numerous raw material categories. Assuming that the sequence of chrono-cultural groups accepted in the relevant Table reflects in general their succession in time, we have found that three out of six quantitatively dominating categories (basalt, gabbro and leptite) indicate a clear increase in frequency in cource of time, whereas in respect to the group of gneiss implements, we have observed an opposite tendency: a gradual decline of the share in the entire raw material structure. Changes in the frequency of amphibolite and diabase are not linked in a consequent and uniform way with the temporal factor. Comparing raw material structures of the stone industry of four principal cultural groups we have found no decisive differences in quality. In each of these industries the first six positions are taken by the same types of raw material which dominate in the entire assemblage (amphibolite, basalt, diabase, gabbro, gneiss and leptite). Divergences — quite substantial, as may be seen — have been of a rather quantitative character (a different share of main types of rock in particular structures). Qualitative differences relate only to the presence or absence of secondary raw materials; but it is they which decide the raw material specificity of a particular industry.

The verification of statistical results concerning the chrono-cultural aspect of raw material differentiation included a double testing of attained data. The frequency values expressed in whole numbers (cf. columns of particular chrono-cultural groups, in: Prinke, Skoczylas 1978, 52, Table 1) were examined by the chi-square test, whereas analogical proportional assessments — by the Smirnov's Test. As regards the first test, it was necessary to carry out a further generalization of raw material categories in relation to the quoted table, caused by a too low frequency of a part of raw materials. We have taken into consideration the frequency of six principal raw materials, and have treated the remaining rocks as a whole. We have found a high level of substantial differences considerably exceeding boundary values (0.001 —

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[6] This group includes mainly loose finds of symmetric flat axes occurring in almost all Neolithic groups outside the Danubian Cycle. The authors considered also these perforated axes which show only loose morphological links with types referred to defined cultures. It seems, that due to the particularly characteristic style of Danubian Cycle implements, all related pieces, including loose finds, have been correctly classified to the DC group. We may conclude, therefore, that group? comprises uncharacteristic forms which probably derived from remaining groups represented in the investigated assemblage and concerns, therefore, the middle and late Neolithic.

i.e., 0.1%). An identical result was achieved by using the same test for an analogical proportional approach (Prinke, Skoczylas 1978, 52, Table 1).

The Smirnovs' Test was used to link discovered differences with defined relations. Although this test does not measure the strength of links appearing in the assemblage (in our studies this function is fulfilled by the chi-square test), it has the advantage of specifying the synthetic image of links between particular elements of the assemblage. As regards problems of interest to us, the result of the first test allows to determine with great probability considerable differences appearing in the raw material composition of stone industries of principal Neolithic groups in Mid-western Poland.

The interpretation of results achieved in this way is more complex. The presented matrix (Prinke, Skoczylas 1978, 54, Fig. 5) includes several arguments to support the hypothesis of the difference between the raw material structure of the lithic inventory of the Danubian cycle and cultures genetically linked with Central European Lowlands. The group of DC implements is quite distinct in this respect (1% level of confidence) compared with the remaning groups of a more specific chrono-cultural characteristics. At the same time, however, Lowland groups also differ considerably (on a 1% level) between each other. Similarities have been found only between FBC and N/Br groups. The most distinguished raw material structure of CWC implements stands apart from all remaining groups, including the summarized composition of the entire Neolithic. It seems that the sample supporting this statement is sufficiently numerous (almost 11% of the assemblage) to depict real conditions. The specific composition of the CWC group involves the lack of implements from granite and other granitoides, further, loams, schists and sandstone, and also a low frequency of basalt implements.

2. THE TYPOLOGICAL ASPECT

The successive approach to the examined assemblage of implements concerns a typological differentiation in a general meaning. Its purpose has been to determine whether in the stone industry of the here investigated Neolithic cultural groups, there occurred dependences between the type of implement and the type of raw material used for its production. It should be assumed that such dependences appeared wherever tool makers achieved a high level of petrographic knowledge and, in particular, a good acquaintance with the physical and technical properties of particular rocks. These would have enabled them to correctly choose raw material from the aspect of employed processing technology and the intended function of the implement. It must be emphasized, that the assumed knowledge of types of lithic material must have been good enough to allow a consequently repeated selection among all available raw maerials, both erratic and imported, and the use of spectfic types of rock of parameters considered as optimal. The detection of sought regularities would, therefore, iprove that stone industries of particular groups applied strict rules to the use of lithic raw materials, rules of a rank of cultural patterns or cultural behaviour.

To perceive appropriate dependences between examined characteristics of stone artefacts — their typological nature and the type of raw material — it was necessary to carry out certain changes in numeral data in the initial Table (Prinke, Skoczylas 1979a, Table 3), in a manner identical to that used in previous systems (Prinke, Skoczylas 1979a, Table 4). Tables 5 and 6, based on relative percentages, resulted from this transformation. Converted data represent the frequency ratio which appeared in a particular raw material category, divided by the magnitude of the sample (i.e., the typological category within the framework of a specific chrono-cultural group) from which it was obtained.

These data have been transformed twofold. The share of implements produced from particular raw materials in successive typological categories of each of the chrono-cultural groups was calculated first. This approach requires ahorizontal reading of the typological initial table (Tugby 1971, 638). It shows the raw material structure of each category. Only the 17 most numerous out of the 38 previously considered typologic-cultural categories were taken under consideration. This was dictated by requirements concerning the size of samples to which statistical tests could be applied. Only data thus prepared are suitable for a more detailed analysis, which ought to elucidate eventual links between types of implements and types of lithic raw material.

The arrangement in Table 5 illustrates the raw material structure of particular typological categories compiled within the framework of chrono-cultural groups. In this manner, we can determine in which groups the selection of raw materials depended on the type of produced implement. A series of flat axes, perforated axes and hoes were examined from this point of view in the DC group. The flat axes in this group were produced most often (almost one fourth of implements) from amphibolite. Besides this material, there appeared in almost equal proportions: basalt, diabase, gabbro, gneiss and schists (except amphibole schist). The raw material structure of perforated axes is shaped in a similar way (the same raw materials but different amounts). More seldom occur basalt, diabase and schists implements, more frequently — gabbro and gneiss tools. Also here amphibolite takes the first place. The series of hoes embraces only four types of rock with amphibolite again prevailing; the remaining pieces are in equal amounts from gabbro, gneiss and leptite. Taken together, particular typological categories of the DC group show, as regards the examined problem, no essential divergences; noted differences are only of a quantitative nature.

Clearly different are the raw material compositions of FBC flat axes and perforated axes. Most frequent among flat axes are amphibolite and diabase, slightly less appear gneiss, leptite and schists (except amphibole schist). While among perforated axes more than one fifth of pieces are made from gabbro, followed by gneiss and leptite. In this chrono-cultural group basalt was used three times more often for the production of perforated axes than for flat axes. Schist was avoided in their production in this group much more than was the case in DC. Considering the shortage of source materials relating to CWC, only perforated axes were considered in the discussed problem. They were produced from already mentioned six most popular raw materials headed by amphibolite. As regards hammeraxes in the N/Br group, we have found a small share of amphibolite and basalt — so common among perforated axes — whereas diorite (a raw material practically absent in others, previously discussed series of perforated axes) played an important role in the production of hammeraxes.

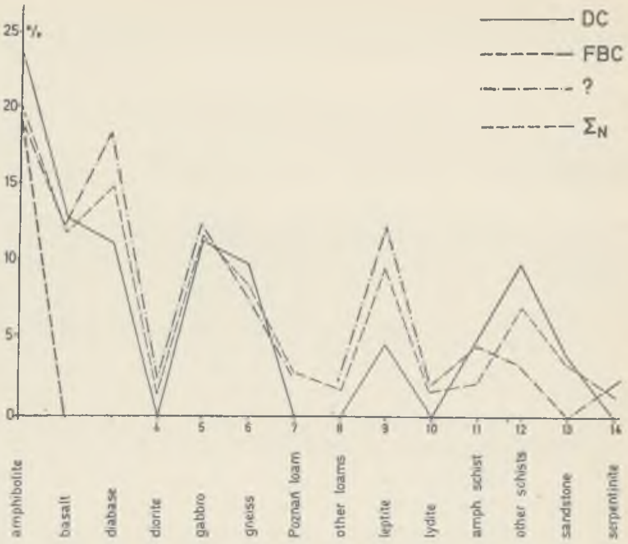


Fig. 5. A diagram of the proportional raw material composition of Neolithic stone flat axes from particular chrono-cultural groups in Mid-western Poland (generalized; cf. Table 5).

Wykres procentowego składu surowcowego neolitycznych siekier kamiennych z poszczególnych grup chronologiczno-kulturowych w Polsce środkowo-zachodniej (ujęcie zgeneralizowane; por. tab. 5)

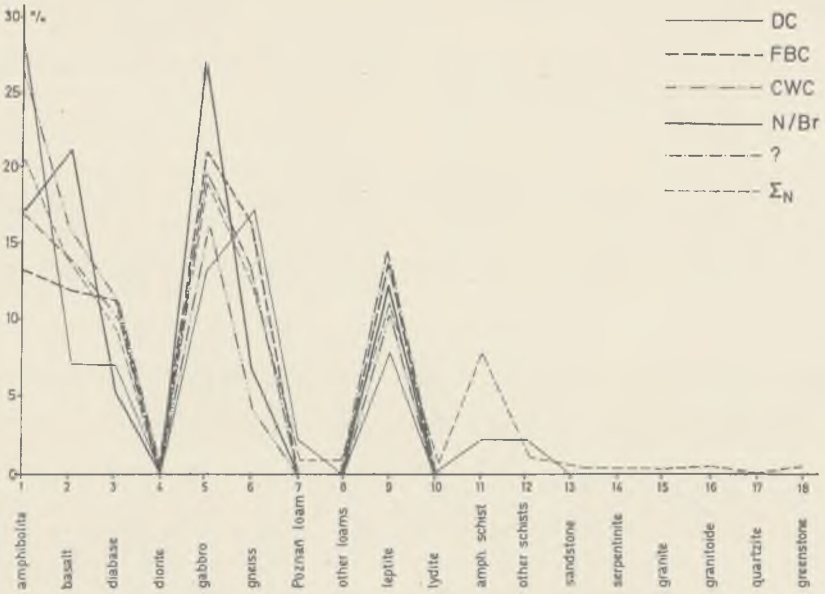


Fig. 6. A diagram of the proportional raw material composition of Neolithic stone perforated axes from particular chrono-cultural groups in Mid-western Poland (generalized; cf. Table 5).

Wykres procentowego składu surowcowego neolitycznych toporów kamiennych z poszczególnych grup chronologiczno-kulturowych w Polsce środkowo-zachodniej (ujęcie zgeneralizowane; por. tab. 5)

Of less significance are observations concerning chrono-culturally unidentified implements. Examined raw material structures of flat axes and perforated axes of this group indicate a general similarity with the exception of schists — used only for the production of flat axes. This proves out previous observations of the FBC group. A new element in the summarized picture concerning dependences between the type of implement and the type of raw material relating to the Neolithic is the raw material structure of mace-heads, quite different from all remaining types of products. They are characterized by a decisive dominance of granite and quartzite — rocks which practically played no role in the production of other implements. Mace-heads are, therefore, an example of a complete dependence of the selection raw material from the type of produced implements.

The separate diagrams of the three most important

Table 5. Raw material structure of the respective types of Neolithic stone implements from Mid-western Poland in chrono-
Skład surowcowy poszczególnych rodzajów neolitycznych narzędzi kamiennych z terenu Polski środkowo-zachodniej w aspekcie

Chrono-cultural group Grupa chronologiczno-kulturowa	Type of implement Rodzaj narzędzia	Amphibolite Amfibolit	Amphibolite schist Łupek amfibolowy	Aplite — Aplit	Basalt — Bazalt	Diabase — Diabaz	Diorite — Dioryt	Gabbro — Gabro	Gneiss — Gnejs	Granite — Granit	Greenstone Zieleniec	Leptite — Leptyt	Lidite — Lidyt	Other granitoids Granitoidy inne	Other loams Iły inne
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
DC	Flat axes — Siekiery	23,9	5,2	—	12,7	11,2	—	11,2	9,7	—	—	4,5	—	—	—
	Perforated axes Topory	27,8	2,4	—	8,3	8,3	1,9	13,6	17,6	—	—	8,3	1,9	—	1,4
	Hoes — Motyki	26,5	6,1	—	6,1	4,1	—	14,3	16,3	2,0	—	16,3	2,0	—	—
FBC	Flat axes Siekiery	19,2	—	—	3,8	15,4	—	7,7	11,5	3,8	—	11,5	—	—	7,7
	Perforated axes Topory	13,6	—	—	12,3	11,7	—	21,6	16,7	—	1,8	14,2	—	1,8	—
CWC	Perforated axes Topory	26,8	—	—	16,5	11,6	1,2	17,7	4,3	1,8	—	11,0	1,2	1,2	—
N/Br	Perforated axes Topory	17,5	—	—	21,9	5,8	—	27,7	7,3	—	—	13,1	—	—	2,2
	Hammeraxes Siekieromłoty	7,5	—	5,0	7,5	5,0	15,0	17,5	10,0	7,5	—	12,5	—	5,0	—
?	Flat axes Siekiery	18,3	0,7	—	12,1	16,6	2,1	12,4	7,6	0,7	—	12,1	1,7	0,7	2,1
	Perforated axes Topory	16,3	1,2	—	14,4	10,8	2,4	19,9	13,8	—	1,2	14,4	—	1,8	1,2
Total Razem	Flat axes Siekiery	19,8	2,1	—	11,8	15,0	1,3	11,6	8,4	0,9	—	9,9	1,3	0,6	1,7
	Perforated axes Topory	20,7	0,8	—	14,0	9,7	1,3	19,4	12,3	0,6	0,6	12,0	0,7	0,9	1,2
	Hoes — Motyki	25,4	5,4	—	5,4	7,3	—	12,7	14,5	—	—	18,2	—	—	—
	Mace-heads Buławki	4,3	—	—	4,3	4,3	4,3	4,3	4,3	26,1	—	—	—	17,4	—
	Hammers Młoty	11,5	—	7,7	7,7	3,8	—	11,5	15,4	15,4	—	3,8	—	3,8	3,8
	Hammeraxes Siekieromłoty	7,5	—	5,0	7,5	5,0	15,0	17,5	10,0	7,5	—	12,5	—	5,0	—
	Other — Inne	7,4	3,8	—	14,8	29,5	—	22,1	7,4	—	—	—	—	—	—

typological categories; flat axes, perforated axes and hoes, provide a graphic picture of data from Table 5 (Figs. 5–7). They represent differences in the raw material composition of particular implements in different chrono-cultural groups. The curves of the raw material composition of flat axes (Fig. 5) are approximately similar. Differences in quality are due to a shortage of artefacts produced from lydite and loams other than Poznań loam in the group of DC flat axes. The most important of quantitative differences is the individual feature of the DC group in comparison with other groups (a lower share of diabase and leptite and a rather high share of schists). In a comparison of the series of perforated axes (Fig. 6), a distinct presence of loams and schists was noted only in the DC group. Considerable differences have occurred in regard to quantity: extremely opposite raw material structures are represented by series of DC and N/Br perforated axes. The first embraces the lowest share of basalt and gabbro, while in the N/Br group these rocks achieve their maximum. The opposite takes place as regards amphibolite and gneiss. Considerable divergences may also be seen in the appearance of leptite perforated axes (most frequently in the unidentified and FBC group and most seldom in DC group.

cultural aspect (generalized proportional version)
chronologiczno-kulturowym (zgeneralizowane ujęcie procentowe)

Other schists Łupki inne	Porphyry — Porfir	Poznań loam Ił poznański	Quartzite Kwarcyt	Sandstone Piaskowiec	Serpentinite Serpentynit	Syenite — Sjenit	Other rocks Skały inne	Together — Razem
17	18	19	20	21	22	23	24	25
9,7	—	3,0	—	3,7	—	—	5,2	100,0
2,4	—	2,4	—	1,0	1,4	—	1,3	100,0
2,0	—	—	—	4,1	—	—	0,2	100,0
11,5	—	—	3,8	3,8	—	—	0,3	100,0
1,8	1,8	1,2	—	—	—	—	1,5	100,0
1,2	—	—	—	—	—	1,2	4,3	100,0
—	—	—	—	—	1,2	—	3,3	100,0
—	—	—	5,0	—	—	—	2,5	100,0
4,5	—	2,4	—	3,1	1,7	—	1,2	100,0
—	—	—	—	1,2	—	—	1,4	100,0
6,9	—	2,6	0,6	3,2	1,1	—	1,2	100,0
1,3	0,4	1,3	0,4	0,7	0,7	0,5	0,5	100,0
—	—	—	—	5,4	—	—	5,7	100,0
—	4,3	—	21,4	4,3	—	—	0,7	100,0
—	3,8	—	—	11,5	—	—	0,3	100,0
—	—	—	5,0	—	—	—	2,5	100,0
3,8	—	7,4	—	3,8	—	—	—	100,0

The series of hoes including almost exclusively implements from the DC group comprises four types of raw material with amphibolite predominant (Fig. 7).

The second group of data, shown in the initial table of the typological aspect (Prinke, Skoczylas 1979a, Table 4) allows to answer the question for what purpose particular raw materials were used in the Neolithic production of stone implements (Table 6). This Table defines, therefore, the typological composition of artefacts in relation to raw materials, investigated in a chrono-cultural stratification. It includes eleven most numerous raw material categories (generalized; Fig. 8). It must be emphasized that presented data are only partly comparable. This is caused by an objective factor (differences in the lithic inventory of particular cultures) and by previously mentioned difficulties encountered by the chrono-cultural classification of raw material (e.g., the impossibility of separating adequately numerous series of implements in certain typological categories). Considering the latter difficulties, we have omitted in the table and diagram the implements of the CWC group among which only perforated axes could be distinguished. Nonetheless, the achieved picture facilitates the observation of several most important regularties. Above all, we can again see the separateness of the six most popular raw materials which have appeared in all investigated chrono-cultural groups. As regards quality, they have the same typological composition and occurring quantitative differences are not striking. These raw materials were used in the production of all types of implements known to a particular culture in more or less approximate proportions. A considerable typological separateness may be seen, however, among remaining raw materials, represented only in certain chrono-cultural groups. Diorite was principally used in the production of hammer-axes, whereas mace-heads were made almost exclusively from granitoides. Sandstone and schists, perceptible in greater quantities only in the DC group, are of a non-uniform typological structure, indicating a greater universality of their use.

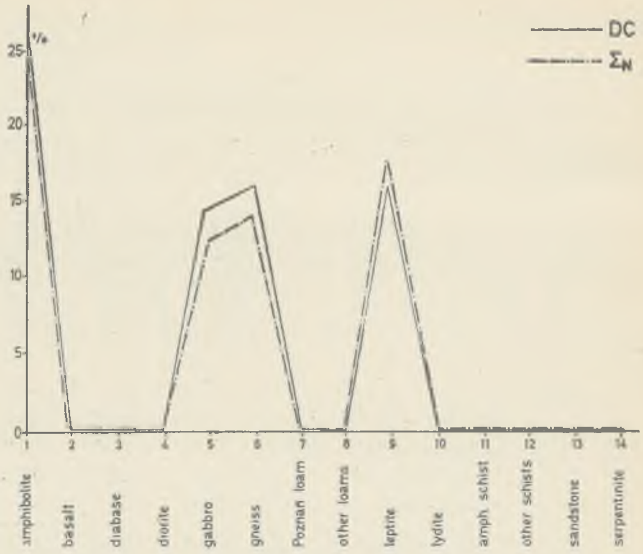


Fig. 7. A diagram of the proportional raw material composition of stone hoes from particular chrono-cultural groups in Mid-western Poland (generalized; cf. Table 5).

Wykres procentowego składu surowcowego motyk kamiennych z poszczególnych grup chronologiczno-kulturowych w Polsce środkowo-zachodniej (ujęcie zgeneralizowane; por. tab. 5)

This analysis of typological factors concerning raw material differentiation presented in Tables 5 and 6 and in Fig. 5, was next verified and extended by statistical methods leading to final conclusions. Internal relations be-

Table 6. Typological structure of the Neolithic implements from Mid-western Poland, made of respective rocks, in chrono-cultural aspect (generalized proportional version)
Struktura typologiczna neolitycznych narzędzi z terenu Polski środkowo-zachodniej, wykonanych z poszczególnych surowców kamiennych, w aspekcie chronologiczno-kulturowym (zgeneralizowane ujęcie procentowe)

Chrono-cultural group Grupa chronologiczno-kulturowa	Type of implement Rodzaj narzędzia	Amphibolite Amfibolit	Basalt — Bazalt	Diabase — Diabaz	Diorite — Dioryt	Gabbro — Gabro	Gneiss — Gnejs	Granitoids Granitoidy	Loams — Iły	Leptite — Leptyt	Sandstone Piaskowiec	Schists — Łupki
1	2	3	4	5	6	7	8	9	10	11	12	13
DC	Flat axes — Siekiery	19,6	47,3	47,9	—	19,5	15,9	—	18,7	15,5	42,7	40,5
	Perforated axes — Topory	22,3	30,2	34,7	—	23,3	28,3	—	24,4	28,3	11,2	12,9
	Hoes — Motyki	21,3	22,5	17,4	—	24,7	26,4	—	56,9	56,2	46,1	22,1
	Other — Inne	36,8	—	—	—	32,5	29,4	—	—	—	—	24,5
	Total — Razem %	100,0	100,0	100,0	—	100,0	100,0	—	100,0	100,0	100,0	100,0
	Quant.	107	37	34		52	59		13	31	9	35
FCB	Flat axes — Siekiery	58,5	21,3	40,4	—	21,0	34,0	—	—	44,7	—	—
	Perforated axes — Topory	41,5	69,2	30,6	—	61,9	49,4	—	—	55,3	—	—
	Other — Inne	—	9,5	29,0	—	16,0	16,6	—	—	—	—	—
	Total — Razem %	100,0	100,0	100,0	—	100,0	100,0	—	—	100,0	—	—
	Quant.	27	24	25		38	31			26		
N/Br	Perforated axes — Topory	59,7	51,7	38,4	—	51,4	24,1	—	—	34,0	—	—
	Hammeraxes Siekieromłoty	25,6	17,7	33,1	—	32,5	33,0	—	—	32,3	—	—
	Other — Inne	14,7	30,6	28,5	—	16,1	42,9	—	—	33,7	—	—
	Total — Razem %	100,0	100,0	100,0	—	100,0	100,0	—	—	100,0	—	—
	Quant.	28	36	11		47	17		—	26	—	—
?	Flat axes — Siekiery	34,2	32,4	29,1	46,7	27,0	25,8	—	71,4	38,0	25,0	57,1
	Perforated axes — Topory	30,4	38,7	18,9	53,3	43,5	46,7	—	38,6	45,1	9,7	13,2
	Other — Inne	35,4	28,9	52,0	—	29,5	27,5	—	—	16,9	65,3	29,7
	Total — Razem %	100,0	100,0	100,0	100,0	100,0	100,0		100,0	100,0	100,0	100,0
	Quant.	87	63	77	10	74	48		16	61	14	18
Total Razem	Flat axes — Siekiery	18,2	19,5	22,4	6,2	12,7	11,8	2,2	25,0	17,0	12,6	39,0
	Perforated axes — Topory	19,2	23,1	14,4	6,2	21,3	17,1	2,2	14,5	20,5	2,7	9,1
	Hoes — Motyki	23,5	9,1	10,9	—	13,9	20,3	2,6	—	31,3	21,6	31,6
	Hammeraxes Siekieromłoty	6,9	12,3	7,4	71,4	19,2	13,9	18,1	—	21,5	54,1	—
	Mace-heads — Buławki	12,7	16,9	10,3	16,2	15,1	24,0	74,9	19,8	5,8	—	—
	Other — Inne	19,5	19,1	34,6	—	17,8	13,0	—	40,7	3,9	9,0	20,3
	Total — Razem %	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
	Quant.	296	187	169	24	242	163	41	45	163	29	66

tween examined factors (Table 5) were verified in accordance with the Smirnov's Test, which rendered a matrix (Fig. 9).

Let us begin with comparing relations between typological categories within the framework of a particular chrono-cultural group, as substantially more important. Outstanding within the DC group is a series of perforated axes which — as regards raw material composition — differs both from flat axes and from hoes in this group (a 5% level of confidence). The structural specificity of this series involves a tendency to a more frequent use of amphibolite and gneiss (Table 5). In the FBC group, however, despite apparently strong divergences, the Smirnov's Test has shown no statistically significant differences between the composition of flat axes and perforated axes. In turn, considerable deviations have been noted in the N/Br group, in which perforated axes and hammeraxes categories were examined. The statistical analysis confirmed results obtained from procedures based on traditional methods. Hammeraxes include few pieces from

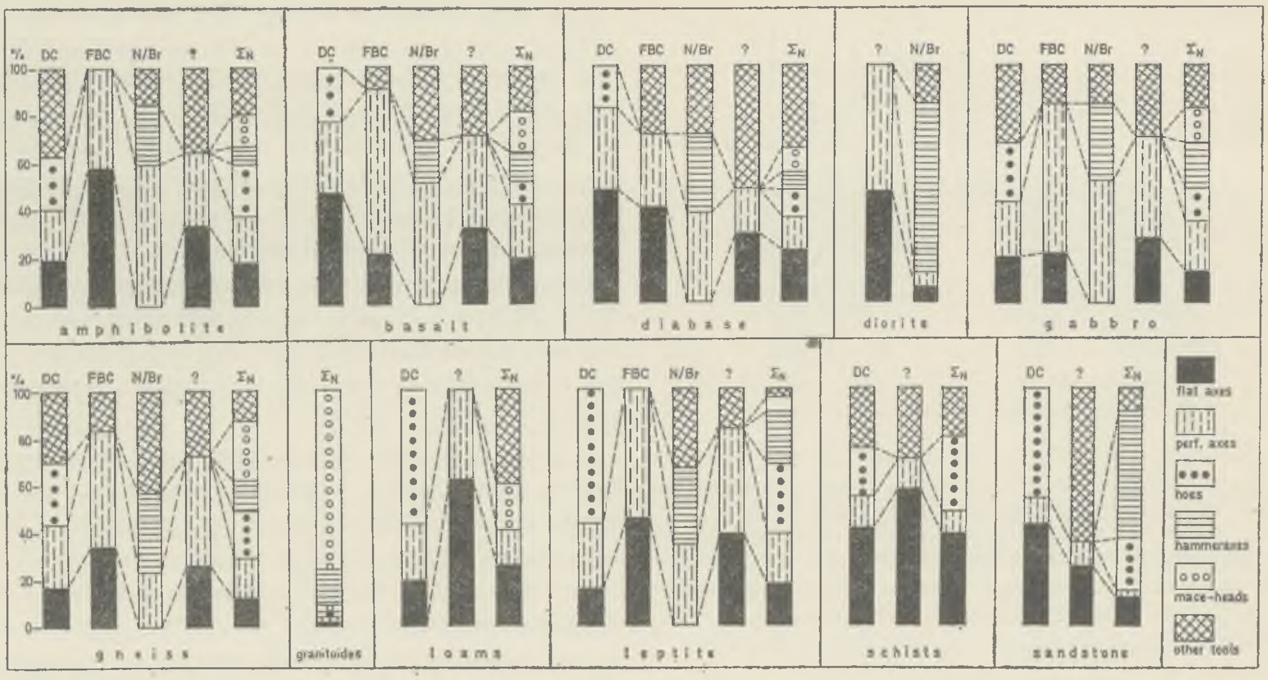
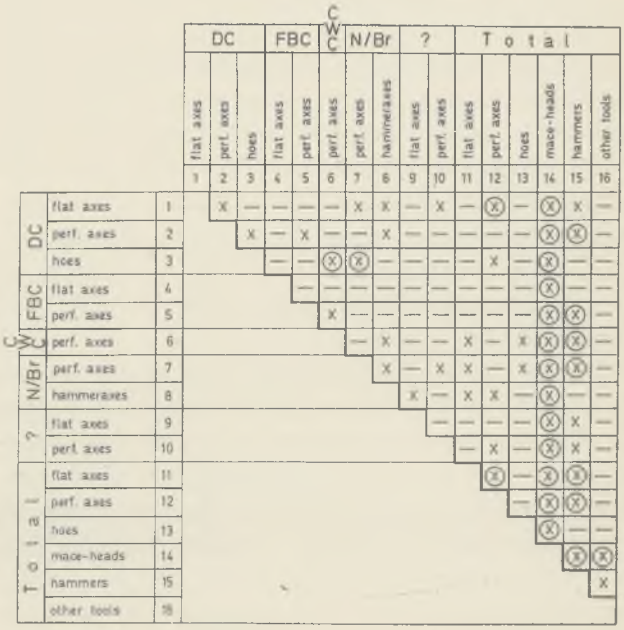


Fig. 8. Differences in the utilization of particular stone raw materials in successive chrono-cultural groups (cf. Table 6).
Różnice w sposobie użytkowania poszczególnych surowców kamiennych w kolejnych grupach chronologiczno-kulturowych (por. tab. 6)

amphibolite, basalt and gneiss — raw materials persistently appearing in series of perforated axes of this and other chrono-cultural groups; they are replaced by frequently represented diorite, which was not used at all in the production of perforated axes. Results of the discussed test, concerning the entire assemblage of implements, are also essential. Appearing differences are particularly significant (except one case, all are on the 1% level of confidence). The most striking is raw material separateness of mace-heads which differ highly — by a 99 per cent probability — from remaining typological categories. An almost equally high distinction may be seen in the series of hammers, where the absence of statistically significant differences appeared only at comparisons with hoes. This phenomenon is due to a completely different function of these implements. Decisively different from each other (on the 1% level) are also the summarized raw material compositions of flat axes and perforated axes in the entire Neolithic. Since such tendencies were previously not found in any of the groups, however, we must omit this difference, because it could have resulted from the summing up of several statistically insignificant differences.

We would like to point out an interesting arrangement of differences between series of perforated axes from particular groups among relations between typologically uniform categories but of a diverse chrono-cultural provenance. DC-perforated axes differ essentially from FBC ones, and these, in turn, from CWC-



			DC			FBC		CWC	N/Br		?		Total					
			flat axes	perf. axes	hoes	flat axes	perf. axes	perf. axes	perf. axes	hammeraxes	flat axes	perf. axes	flat axes	perf. axes	hoes	mace-heads	hammers	other tools
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
DC	flat axes	1		x	—	—	—	—	x	x	—	x	—	ⓧ	—	ⓧ	x	—
	perf. axes	2			x	—	x	—	—	x	—	—	—	—	—	ⓧ	ⓧ	—
	hoes	3				—	—	ⓧ	ⓧ	—	—	—	—	x	—	ⓧ	—	—
FBC	flat axes	4					—	—	—	—	—	—	—	—	—	ⓧ	—	—
	perf. axes	5						x	—	—	—	—	—	—	—	ⓧ	ⓧ	—
CWC	perf. axes	6							—	x	—	—	x	—	x	ⓧ	ⓧ	—
N/Br	perf. axes	7								x	—	x	x	—	x	ⓧ	ⓧ	—
	hammeraxes	8									x	—	x	x	—	ⓧ	—	—
?	flat axes	9										—	—	—	—	ⓧ	x	—
	perf. axes	10											—	x	—	ⓧ	x	—
Total	flat axes	11												ⓧ	—	ⓧ	ⓧ	—
	perf. axes	12													—	ⓧ	ⓧ	—
	hoes	13														ⓧ	—	—
	mace-heads	14															ⓧ	ⓧ
	hammers	15																x
	other tools	16																

Fig. 9. A matrix illustrating the statistical significance of differences in the raw material structure between particular types of Neolithic stone implements in Mid-western Poland from the chrono-cultural aspect (Smirnov's test; cf. Table 5).

Macierz ilustrująca istotność statystyczną różnic w strukturze surowcowej między poszczególnymi rodzajami neolitycznych narzędzi kamiennych z Polski środkowo-zachodniej w aspekcie chronologiczno-kulturowym (test Smirnova; por. tab. 5)

Legend: see Fig. 2 — Legenda patrz ryc. 2

			DC								
			amphibolite	basalt	diabase	gabbro	gneiss	loams	leptite	schists	sandstone
			1	2	3	4	5	6	7	8	9
DC	amphibolite	1		⊗	⊗	—	—	—	⊗	—	—
	basalt	2			—	x	x	—	x	—	—
	diabase	3				⊗	⊗	—	x	—	—
	gabbro	4					—	—	x	—	—
	gneiss	5						—	—	—	—
	loams	6							—	—	—
	leptite	7								—	—
	schists	8									—
	sandstone	9									

Fig. 10. A matrix illustrating the statistical significance of differences between particular raw material categories of implements from the Danubian Cycle (Smirnov's Test; cf. Table 6).

Macierz ilustrująca istotność statystyczną różnic między poszczególnymi kategoriami surowcowymi narzędzi cyklu naddunajskiego (test Smirnova; por. tab. 6)

Legend: see Fig. 2 — Legenda patrz ryc. 2

perforated axes. There is, hovever, no corroboration concerning the significance of differences in the relation: DC-perforated axes — CWC-perforated axes (Figs. 6 and 9). A considerable extension of the internal division of Table 6 (19 horizontal and 11 vertical columns) rendered impossible the use of the chi-square test since an eventual generalization of data would obliterate the significance of results. The statistical verification was, therefore, confined to the Smirnov's Test. Only two out of five columns in Table 6 (the FBC and ?-groups) contain identical typological categories (flat axes, perforated axes and "other implements"). This fact made a common examination possible (Fig. 11). In all other instances the relevant question was analyzed separately, within the framework of each group.

Due to results of the Smirnov's Test, it was possible to resolve which of the perceptible quantitative differences are of a non-accidental nature. Several essential differences in appropriation of particular types of raw material for the production of various types of implements appeared in the DC group (Fig. 10). The highest difference was indicated by diabase (threefold on the 1% level and once on the 5% level), next was basalt and leptite (threefold 5% and once 1%), almost 60 per cent of the latter raw material was devoted to hoes. No significantly characterstic divergences were found in FBC group (Fig. 11). But, as regards the simultaneously examined unidentified (?) group, we have observed a marked separateness in the appropriation of diabase (52% of implements in this series includes "other" implements), loams (more than 70% falls to flat axes) and sandstone (more than 65% are "other" implements, principally hammers).

The separateness of diabase was caused by an accidentally formed, numerous group of closer unidentified fragments of implements, most of which were probably remains of flat and perforated axes, this induced us to pass by the result as substantially insignificant. Implements from N/Br group, divided into 6 principal raw material categories, have shown no significant differences in the typological system (Fig. 12). This was different in the assemblage of implements as a whole, the overall majority of examined differences (46 out of 55) was statistically significant and almost all were on the 1 per cent level (Fig. 13). It is difficult, however, to resolve at present, whether they are also substantially significant, or whether they emerged due to an accumulation of several smaller, accidental divergences. Summing up the internal analysis of the entire assemblage of Neolithic stone implements from Mid-western Poland, we have found, that the relevant conclusion and next a closer characteristic, elucidated the real (not accidental) raw material differentiation from all examined — geographic, chrono-cultural and typological — aspects. The range of these comparisons (greater on the last two levels) has been limited by the almost general prevalence of six raw materials (amphibolite, basalt, diabase, gabbro, gneiss and leptite). Their general use in the Neolithic was decisive in a considerable standardization of the raw ma-

			FBC						?									
			amphibolite	basalt	diabase	gabbro	gneiss	leptite	amphibolite	basalt	diabase	diorite	gabbro	gneiss	loams	leptite	schists	sandstone
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
FBC	amphibolite	1		—	—	x	—	—	x	—	⊗	—	x	x	—	—	—	⊗
	basalt	2			—	—	—	—	—	—	⊗	—	—	—	x	—	—	⊗
	diabase	3				—	—	—	—	—	—	—	—	—	—	—	—	—
	gabbro	4					—	—	—	—	⊗	—	—	—	⊗	—	—	x
	gneiss	5						—	—	—	⊗	—	—	—	—	—	—	x
	leptite	6							—	—	⊗	—	—	—	—	—	—	⊗
?	amphibolite	7								—	—	—	—	—	x	—	—	—
	basalt	8									—	—	—	—	x	—	—	—
	diabase	9										—	—	—	⊗	⊗	—	—
	diorite	10											—	—	—	—	—	x
	gabbro	11												—	x	—	—	—
	gneiss	12													x	—	—	—
	loams	13														—	—	⊗
	leptite	14															—	⊗
	schists	15																—
	sandstone	16																

Fig. 11. A matrix illustrating the statistical significance of differences between particular raw material categories of stone implements of the Funnel Beaker Culture and group? (Smirnov's Test; cf. Table 6).

Macierz ilustrująca istotność statystyczną różnic między poszczególnymi kategoriami surowcowymi narzędzi kamiennych grup episznurowych z przełomu neolitu i epoki brązu (test Smirnova; por. tab. 6)

Legend: see Fig. 2 — Legenda patrz ryc. 2

terial structure of the entire assemblage in its various sections. This was why most of the statistically corroborated divergences were of a quantitative and not qualitative nature. The presupposition of our analysis was only to make an initial examination of a hitherto completely unknown problem concerning raw material used in Neolithic stone industry. Research procedures embraced only the most numerous of previously differentiated categories, and this is why the achieved results concern only leading characteristics of the examined phenomena. We shall further try to find out to what degree they answer questions asked at the outset.

The most significant phenomenon, which emerged during researches of the geographical aspect, was the characteristic appearance of basalt implements, which became gradually more scarce towards the north. We were also able to define the territory of the more intensive utilization of Poznań loam, confined to South-western Great Poland.

As regards conclusions concerning chrono-cultural differentiation we have found clearly outlined trends in the shaping of the intensity of utilizing the majority of the most popular raw materials: basalt, gabbro, leptite — increase, gneiss — decrease in the frequency in successive Neolithic periods.

In respect to the typological aspect we have achieved several determinations relating to the problem whether the selection of the type of stone raw material was linked in the Neolithic to the kind of produced implements. A quantitative separateness in the raw material structure appeared in the DC group, and there was a significant qualitative divergence between perforated axes and hammer-axes in the N/Br. It seems, that the technological factor was of a decisive significance in the second case — diorite, never used more extensively in the production of perforated axes, was in that period devoted to the much less complicated production of hammeraxes (no perforation). The greatest raw material deviation was noticed in mace-heads and hammers, what was linked with their functional separateness in relation to cutting implements (perforated axes, flat axes, chisels, hoes, flake axes). It was also found that each of the considered cultural groups utilized different sets of raw materials for the production of the same typological category; this phenomenon was fully documented in regard to perforated axes, particularly numerous in the examined assemblage. The dominant influence of the cultural factor was revealed there (in the future, it will probably be identified with cultural behaviour or cultural patterns). In this case, it outnumbered other factors, above all the influence of the natural environment. This was so because all previously mentioned groups developed on the same territory and had, in theory, the same access to raw material resources.

			N/Br					
			amphibolite 1	basalt 2	diabase 3	gabbro 4	gneiss 5	leptite 6
N/Br	amphibolite	1		—	—	—	—	—
	basalt	2			—	—	—	—
	diabase	3				—	—	—
	gabbro	4					—	—
	gneiss	5						—
	leptite	6						

Fig. 12. A matrix illustrating the statistical significance of differences between particular raw material categories of stone implements of the „Epi-Corded Ware" group from the turn of the Neolithic and Bronze Age (Smirnov's Test; cf. Table 6).

Macierz ilustrująca istotność statystyczną różnic między poszczególnymi kategoriami surowcowymi narzędzi kamiennych kultury pucharów lejkowatych oraz grupy bliżej nie określonej (test Smirnova; por. tab. 6)

Legend: see Fig. 2 — Legenda patrz ryc. 2

			Total										
			amphibolite 1	basalt 2	diabase 3	diorite 4	gabbro 5	gneiss 6	granite 7	loams 8	leptite 9	schists 10	sandstone 11
Total	amphibolite	1		—	x	⊗	x	—	⊗	⊗	⊗	x	—
	basalt	2			x	⊗	—	—	⊗	x	⊗	⊗	x
	diabase	3				x	⊗	⊗	⊗	—	⊗	⊗	⊗
	diorite	4					⊗	⊗	⊗	⊗	⊗	⊗	—
	gabbro	5						—	⊗	⊗	⊗	⊗	—
	gneiss	6							⊗	⊗	⊗	⊗	x
	granite	7								⊗	⊗	⊗	⊗
	loams	8									⊗	⊗	⊗
	leptite	9										x	x
	schists	10											⊗
	sandstone	11											

Fig. 13. A matrix illustrating the statistical significance of differences between particular raw material categories of the investigated assemblage of stone implements (Smirnov's Test; cf. Table 6).

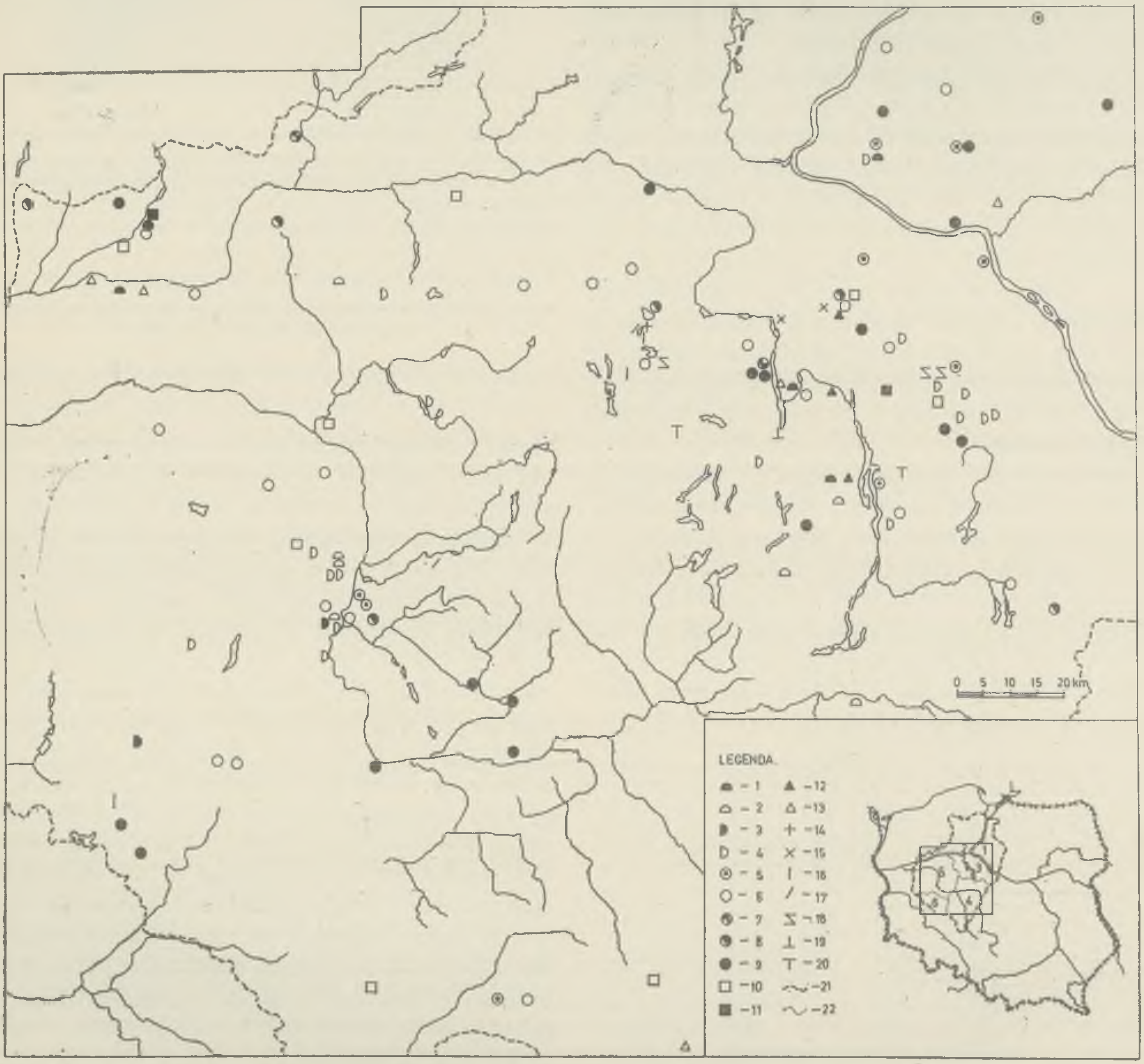
Macierz ilustrująca istotność statystyczną różnic między poszczególnymi kategoriami surowcowymi badanego zbioru narzędzi kamiennych (test Smirnova; por. tab. 6)

Legend: see Fig. 2 — Legenda patrz ryc. 2

Following this general characteristic of utilization methods of raw materials in Neolithic stone industries, we shall devote attention to two detailed technical problems emerging from this background: problems concerning the raw material structure of semi-manufactured stone implements and possible dependences between the type of utilized raw material and the perforation technique employed at the production of an implement.

3. THE RAW MATERIAL STRUCTURE OF A SEMI-MANUFACTURED IMPLEMENT ASSEMBLAGE

Criteria qualifying a piece to the group of semi-manufactured implements include: a) an incompletely shaped outline of an implement; b) the absence of a perceptible head or cutting edge; c) an unifinished perforation or its absence in relation to perforated implements. We shall endeavour to find out whether and how far the raw material structure of the semi-manufactured group departs from the petrographic composition of the entire investigated assemblage of implements. We have assumed that semi-manufactured implements found on the examined area are of local origin. These deliberations are based on Map 2 which illlustrates the distribution of semi-manufactured implements from Mid-western Poland. The differentiation of its contents relating



Map 2. The distribution of Neolithic semi-manufactured stone implements in Mid-western Poland

1–4 — flat axes: of the Danubian Cycle (*1*), of the Funnel Beaker Culture (*2*), of the „Epi-Corded Ware" groups (*3*), chrono-culturally unidentified (*4*); *5–9* — perforated axes: of the Danubian Cycle (*5*), of the Funnel Beaker Culture (*6*), of the Corded Ware Culture (*7*), of the „Epi-Corded Ware" groups (*8*), chrono-culturally unidentified (*9*); *10, 11* — hoes: of the Danubian Cycle (*10*), chrono-culturally unidentified (*11*); *12* — chisels; *13, 14* — mace-heads: of the „Epi-Corded Ware" groups (*13*), chrono-culturally unidentified (*14*), *15* — hammer-axes of the „Epi-Corded Ware" groups; *16, 17* — hammers: of the „Epi-Corded Ware" groups (*16*), chrono-culturally unidentified (*17*); *18* — plugs; *19, 20* — other implements: of the Globular Amphorae Culture (*19*), chrono-culturally unidentified (*20*); *21, 22* — boundaries: of the investigated area (*21*), of the region (*22*).

Rozprzestrzenienie półfabrykatów neolitycznych narzędzi kamiennych w Polsce środkowo-zachodniej

1–4 — siekiery: cyklu naddunajskiego (*1*), kultury pucharów lejkowatych (*2*), grup episznurowych (*3*), bliżej nie określone (*4*); *5–9* — topory: cyklu naddunajskiego (*5*), kultury pucharów lejkowatych (*6*), kultury ceramiki sznurowej (*7*), grup episznurowych (*8*), bliżej nie określone (*9*); *10, 11* — motyki: cyklu naddunajskiego (*10*), bliżej nie określone (*11*); *12* — dłuta; *13, 14* — buławki: grup episznurowych (*13*), bliżej nie określone (*14*); *15* — siekieromłoty grup episznurowych; *16* — młoty grup episznurowych; *17* — młoty bliżej nie określone; *18* — czopy; *19, 20* — inne narzędzia: kultury amfor kulistych (*19*), bliżej nie określone (*20*); *21, 22* — granice badanego obszaru (*21*), regionu (*22*) to chrono-cultural aspects, it also shows the position of local centres of stone industry throughout consecutive Neolithic periods.

In respect to the raw material structure the examined collection of 118 semi-manufactured implements resembles in its general outline of the entire assemblage of implements. Only amphibole schist is absent among rocks included in the list of raw material used for semi-manufactured pieces (we have also eliminated several other rocks of a vestigal frequency below 1% of the assemblage). Quantitative differences, however, are sometimes considerable. Raw materials of a much higher share in the assemblage of implements than among semi-manufactured pieces, include: amphibolite, basalt, diabase, gabbro. The reverse was noticed in the frequency relation of diorite, gneiss, granite, granitoides, quartzite and leptite in the two assemblages; this may indicate that these raw materials were used only in local centres of stone industry on the Lowlands (hence the great number of semi-manufactured implements from these rocks on the examined area). As divergences increase to the advantage of the frequency of a particular rock in the assemblage of implements, there grows the probability of its inflow to the Lowlands in the form of finished products.

4. THE PETROGRAPHIC ASPECT OF DIFFERENCES IN DRILLING TECHNIQUES

The numerous series of semi-manufactured implements distinguished above provides an opportunity to determine eventual links between the type of lithic raw material and the use of specific drilling techniques for perforations. For this purpose, we have taken into account those semi-manufactured articles in which perforation traces allow explicitly to define the type of empolyed technique (full or hollow drill). In all, this condition was met by 43 pieces, including 27 perforated axes, 5 hoes, 5 hammers and 6 mace-heads. Additional information concerning the hollow drill technique is supplied by stone plugs (3 pieces in our assemblage). The picture achieved as a result of an analysis of these semi-manufactured implements is shown in Table 7.

Table 7. Relation between type of raw material and type of drilling technique in Neolithic stone implements.

Zależność między rodzajem surowca a typem techniki wiercenia otworu w neolitycznych narzędziach kamiennych

Type of raw material Rodzaj surowca	Prefabricates with traces of use of drilling technique Półfabrykaty ze śladami stosowania techniki wiertła	
	of empty drill pustego	of full drill pełnego
Amphibolite — Amfibolit	1	2
Basalt — Bazalt	2	1
Diabase — Diabaz	2	1
Gabbro — Gabro	4	2
Gneiss — Gnejs	8	1
Granite — Granit	2	1
Granitoide — Granitoid	1	2
Granodiorite — Granodioryt	1	—
Leptite — Leptyt	3	2
Lydite — Lidyt	1	—
Metamorphic rock — Skała metamorficzna	2	—
Porphyry — Porfir	1	—
Quartzite — Kwarcyt	2	1
Schists — Łupki	—	1

Table 8. Presence of type of drilling technique in Neolithic stone implements in chrono-cultural aspect.

Występowanie typu techniki wiercenia otworu w neolitycznych narzędziach kamiennych w ujęciu chronologiczno-kulturowym

Chrono-cultural group Grupa chronologiczno-kulturowa	Number of prefabricates with traces of use of drilling technique Liczba półfabrykatów ze śladami stosowania techniki wiertła	
	of empty drill pustego	of full drill pełnego
Danubian Cycle	6	4
Funnel Beaker Culture	7	5
"Epi-Corded Ware" Groups	5	1
Late Neolithic to Lusatian Culture	2	—
?	10	4

Table 8 presents the distribution of the examined assemblage in relation to chrono-cultural aspects.

These two compilations denied the existence of direct, distinct dependences between types of perforation techniques, on the one hand, and the type of raw material and the chrono-cultural attachment, on the other. In most of the examined petrographic and, next, chrono-cultural categories, we found pieces from the two distinguished technological groups. Although the initial analysis, embracing only semi-manufactured perforated axes, suggested the use of the full drill technique only within the FBC group (5 pieces), after extending the field of observation to semi-manufactured types of other implements, we found that traces relating to the use of this technique also appeared on implements of the DC group (4 pieces) and the N/Br group (1 piece).

5. THE INFLUENCE OF PHYSICAL AND TECHNICAL PROPERTIES OF ROCKS ON THE SHAPING OF THE RAW MATERIAL STRUCTURE OF NEOLITHIC STONE INDUSTRY

The most appropriate technical (utilitary) properties of raw material are those which meet processing requirements imposed by technical possibilities and the intended function of an implement. It should be noted that these two factors are almost opposite to each other, the first assuming a maximum simplicity of treatment, the second presupposing a high effectiveness and durability of the finished product. An analysis of the technical characteristics of raw materials of the highest frequency in the examined assemblage will make it possible to find out to what degree these implements fulfilled conditions desired by their makers. The correct selection of raw material will, therefore, be scrutinized as a part of the general adaptation of Neolithic communities to Lowland conditions.

A CHARACTERISTIC OF THE TECHNOLOGY EMPLOYED AT THE PRODUCTION OF NEOLITHIC STONE IMPLEMENTS

On the whole, stone implements were produced in the Neolithic by polishing and sawing or coring techniques (cf., for example, Cabalska 1960, 239). The first method was used in the Danubian Cycle, the second was linked with most Lowland cultures in Central Europe. The production technique of Danubian implements was exhaustively described by H. Quitta (1955, 23–26) and S. Vencl (1960, 6–10). The first production stage involved the shaping of the future implements by chipping and cutting. Angular pieces of required size were separated from lumps of rock in a possibly economic manner (usually by notching and breaking off). The sawing technique was known in Czechoslovakia already during the early phase of the Linear and Stroke Ornamented Pottery (Vencl 1960, 6, note 15). This method became most popular in the later stages of this culture, particularly at the production of flatiron heater shaped hoes (*Plättbolzen*). The sawing shortened working time and saved raw material, it also reduced the possibility of damaging semi-products and increased the accuracy of treatment. It is, however, difficult to find such traces on source materials, because they were obliterated by consequent polishing, sharpening or the use of the implement. It may be noticed clearly only on semi-manufactured pieces or bigger Danubian implements, the surface of which was, as a rule, polished only in part (Semenov 1964, 71). The apparently archaic method of chipping used in the initial processing stage together with or instead of sawing, was employed throughout the entire Neolithic.

The next proceeding — surface polishing — was practiced sporadically already in the Upper Palaeolithic (Kostienki, site IV). It was generalized, however, only in the Early Neolithic. This phenomenon was explained by S. A. Semenov (1964, 71) by the mass use of wood which began in that period and was linked with a change for a settled way of life, causing a demand for more permanent housing, water transport facilities and effective tools for grubbing up trees to make the land arable. Due to the method of polishing resistance produced by the edge at work was significantly reduced and the effectiveness of the implement increased (Nietsch 1939, 70). The labour-consuming activity of polishing may be seen in its being limited to the edge only in the Early Neolithic. But this factor depends considerably on the type of raw material, thus, for example, the polishing of a flint axe took three times longer than of an analogical implement from diorite. Consequently, many flint axes were polished only towards the edge in contrast with implements made from crystallic rocks which, as a rule, were finished by polishing the whole surface. In relation to perforated implements, polishing was done either before or after the hole was made, while the latter method was certainly more rational (drilling threatened with cracking). Sandstone plates or hard base-plates with strewn sand were used for polishing. First coarse-grained and then fine-grained polishers from various types of rock were used for the final polishing of the implement. Sandstone was particularly useful for polishing since its coarse surface does not silt up but regenerates constantly due to the separation of grains during friction. The fact that these loose grains replace strewn sand was an additional advantage. A particular manner of surface forming was the piquage (pick) technique, applied only to the treatment of granular, very dense raw materials of a complex mineral composition (granite, gabbro, diorite, basalt and diabase).

The beginnings of the stone perforation technique and of polishing date back to the Palaeolithic. At the beginning it was applied at the production of ornaments. This ability was generalized in the Neolithic due to the invention of bow and disk drills (Semenov 1964, 74, 78).

The invention of the hollow drill technique was a long step towards the rationalization of drilling. To make a perforation, it was necessary to drill through only 30–40 per cent of its surface, the rest was taken by the plug (Semenov 1964, 80). The predominance of this variant over the full drill technique and borers was proved by experiments conducted by A. Rieth (1958, 101). Stone workers of Danubian Cultures, who used this method since the beginnings of the Linear and Stroke Ornamental Pottery, have a considerable share in the development of the hollow drill technique. Considering these facts, it seems odd that the remaining, less effective drilling methods have been employed for such a long time, throughout the entire Neolithic, also by cultures who knew the hollow drill.

The final, not always applied operation in the relevant production process, was the polishing of the surface until lustre was obtained. This was possible with certain raw materials, and was dictated not only by aesthetic reasons but also by endeavours to protect implements against decay. Certain researchers have advanced the hypothesis that — to attain this objective — the surface of the implement was additionally smeared with fat and ash. This assumption was supported by the fact, detected during the taking of samples for our microscopic examination — that certain implements were saturated with fat.

The core technique of producing stone implements was distinguished by chipping off flakes from lumps of raw material, using the circular core method. This meant the taking over of the flint processing technology (employed in the Mesolithic at the production of axes) and employing it at the treatment of other raw materials. This assumption has been proved by observations at the Graig Lwyd (South Wales) stone workshop, specializing in the production of axes with thin and sharp heads, where — during the process of chipping off flakes from raw material lumps — there originated entire series of pseudo-Palaeolithic forms (including a great number of flakes of the Levallois type; Piggott 1954, 289). Two types of coring techniques can be distinguished in the Central European Neolithic stone industry: a) the eastern, where flaking off was linked with edge chipping; b) the western, where the initial angular form was processed by edge and surface chipping until a finished implement was obtained. The eastern type has been considered as a less precise but quicker and more effective method. It appears in the comprehensively perceived Baltic area. This method was used in the production of most axes of the Pit and Comb Pottery Culture and the Corded Ware Culture. Its characteristic feature was dihedral cross-section of the implement. The western method was used in the north and north-eastern part of the territory occupied by the Funnel Beaker Culture (Cabalska 1960, 239).

PHYSICAL AND TECHNICAL PROPERTIES OF LITHIC RAW MATERIALS INFLUENCING THE PROCESS OF IMPLEMENT PRODUCTION

The above presented characteristic of the technology of producing stone implements in the Neolithic made it possible to particularize several physical and technical properties of raw materials, which shall be investigated further because of their role in the production process, and next, the utilization of relevant implements. Our deliberations are based on works by T. J. Wojno and Z. Pentlakowa (1956; 1957) and S. Kozłowski (1975).

The principal physical property of a rock is its density described in g/cubic centimetres in two formulations. Specific density concerns only the volume unit of a particular raw material without considering its porousness, whereas the bulk density also includes rock fissures. These indexes indicate the relation between the mass of the rock and its volume, essential for our deliberations, since this factor directly influences the kinetics of work with a particular implement. The next two properties: air-tightness and porousness, characterize the internal spatial structure of rocks. By air-tightness we understand this part of raw material volume which embraces the compact mass of rock, by porousness — the sum of the volume of fissures to one unit of rock volume. Among stone materials utilized in the Neolithic a large range was shown in this respect by sandstone and, slightly less by limestone. Granites, diabases and basalts are of a very compact structure (among the last two rocks there appear types of a zero coefficient of porousness). Rock absorption defines closer the type of occurring porousness. It expresses the amount of water which may be absorbed by a unit of rock volume in specific conditions. The highest absorption coefficient relates to strongly porous rocks with very fine fissures — a feature involving capillarity. The other two factors include the frost resistance of rocks, described here, for example, as complete, incomplete or absent. Completely frost resistant as a rule are rocks with a porousness coefficient below 0.5 per cent.

Shearing resistance, expressed in kG/square centimetre, denotes tightness corresponding to the force which crushes a particular rock sample. This index denotes the limit at which rock resistance is overstepped. Investigations of resistance are carried out, with the aid of oil presses, in two ways: the first concerns rock samples in air-dry condition and after saturation with water; the second includes rocks in which absorption exceeds 0.5 per cent. Fine-grained rocks are generally more resistant than the coarse-grained material, particularly in the case of even granulation. The rock with the highest index of pressure resistance is basalt, particularly its evenly fine-crystalline and non-porous form. Very high values have been achieved by diabase, quartzite and some sandstones; high values — granite, syenite, diorite; medium values — fine-crystalline limestones, the remaining sandstone and gneiss; the lowest values, by pegmatite and tuff.

A most important factor from the technical point of view is the cleavability of particular rocks, namely its capacity for splitting along certain faces (face of cleavage). This has been described as perfect cleavability, very good cleavability etc. The density of rocks, i.e., their resistance to blows, is not univocal with the above mentioned shearing resistance or their hardness, since basalt, for example, with a high contents of glaze, is resistant to pressure and, at the same time, easily splintering. The density of rocks depends on the existence of internal structural stresses which originated during their shaping. The porousness of rocks reduces the effect of strokes. Density is defined in degrees in accordance with Page's scale.

One of the methods of determining the hardness of lithic raw materials is the calculation of the abrasiveness coefficient. It is expressed in centimetres, which means a hight loss of the examined sample subjected to abrasion on Böhme's disk in defined conditions, or is expressed proportionally, showing loss of mass during abrasive action in Deval's rotary cylinder (Böhme's and Deval's method — respectively).

During the production of perforated implements (perforated axes, hoes, mace-heads, hammers) an important role was played additionally by the resistance of a raw material to drilling. In general, this is greater in the case of fine-grained than coarse-grained rocks and also in the case of raw material of a fibrous texture compared with granular rocks.

CONCLUSIONS

Comparing the course of the process in the production of lithic implements with a characteristic of principal physical and technical properties of rocks, we have endeavoured to distinguish these traits of lithic raw materials which were most desired by Neolithic stone workers and, hence, probably decided the applied selection of raw material. The most sought after features of an exemplary, ideal raw material were, undoubtedly, a great air-tightness and, consequently, a low absorption, and, therefore, a great resistance to frost and decay. We have noticed an intensive use of raw materials of a maximum air-tightness coefficient in the investigated assemblage of implements from Mid-western Poland. The high specific density was in demand because of the possibility of a great striking force of the implement while its size was limited. The outstanding importance of a good cleavability of raw material (provided, it is correctly used by the producer) has already been pointed out. The domination of cleavable rocks in the petrographic structure of implements has been recorded, among others, in Saxony (Herrmann, Schüller 1952, 112–114) and Czechoslovakia (Štelcl, Malina 1975, 180).

These facts impair former views that the schistic texture rules out the usefulness of a particular rock as raw material for the production of implements (Kandler 1924, 56 ff.). Despite an obvious schistic structure these raw materials, particularly prasinite, have certain structural properties which ensure their hardness, namely cross bonds of minerals in rosette texture (Herrmann, Schüller 1952, 114–115). Uncleavable raw materials (aplite, granite, quartzite) were used almost exclusively in the production of mace-heads. They required a special type of treatment, most frequently the use of the piquage technique. The resistance of raw materials to shearing was less important since implements — during production and then utilization — were not exposed to greater influence of this type. It is more difficult to define the influence of the degree of density on the production technology and utilization value of implements. A great density of rocks constituted considerable difficulties for producers, on the other hand, once overcome, it produced a durable and functional tool. An example here may be nephrite, the exceptional density of which excluded its use in the production of perforated axes (lack of appropriate processing technique), but a measure of the high quality of flat axes from this raw material was their widespread distribution throughout several European regions.

S. A. Semenov (1964, 35) refers to the high degree of hardness as one of the principal features in the selection of stone material in the Neolithic. The suppleness of rocks to polishing was probably a secondary factor. This characteristic appears only in certain dense (i.e., very fine-grained) rocks, generally in these which include component parts of related degree of hardness (Wojno, Pentlakowa 1956, 129). Well suitable for polishing are granite, syenite, diorite — raw materials found in small numbers in the investigated assemblage of implements, while basalt has no permanent and strong lustre. The discussed property could have played a significant role only in relation to more representative implements (e.g., battle-axes), where aesthetical factors were important. We assume that the preservative function of polishing the surface of implements (preservation against decay), and the chemical suppleness to decay and resistance to the action of water and acids had no influence on the selection of raw materials since implements at issue were effectively protected by means of special, already mentioned procedures.

Summing up this part of our deliberations, we may conclude that almost all properties considered advantageous appear in several types of rock. They include mainly basalt and diabase, in part also gneiss — types which, at least in Mid-western Poland, were among the most intensively used raw materials. This conclusion proves the purposeful and to a high degree appropriate choice of raw material by Neolithic stone workers, producers of polished implements, and may serve as an argument supporting the thesis of the high level of their petrographic knowledge.

IV. THE NEOLITHIC STONE RAW MATERIAL ECONOMY IN MID-WESTERN POLAND AGAINST A COMPARATIVE BACKGROUND

The last part of our deliberations will include a summary of all previous determinations. Considering the highly unsatisfactory state of knowledge on this issue, the following generalization should be treated only as an outline of a future interpretation model of Neolithic stone raw material economy (cf. Schild 1975, 161). It includes an extensive comparative background sometimes exceeding Central Europe. It concerns, above all, rich achievements of many years of research on raw material differentiation pertaining to Neolithic stone industry, which have been carried out in Great Britain.

1. THE RAW MATERIAL SPECIFICITY OF MID-WESTERN POLAND

A comparison of petrographic denominations of raw material types as supplied by various authors often includes a risk or is quite impossible. As regards a part of these denotations found in archaeological literature, there exist substantial objections whether they were determined in a competent and methodologically correct manner. A typical example of rather problematic raw material identifications is the recent work by D. Kaufmann (1976), which represents a monographic elaboration of the Stroked Pottery Culture in the Elbe and Saale region. The author defined the raw material structure of elaborated lithic implements but limited this task to the specification of only two types of rock: amphibolite and siliceous schist, and the only considered criterion was the colour of the implement's surface (Kaufmann 1976, 54).

It seems that problems concerning the raw material aspect of stone industry generalized in this way falls short of supplying pertinent data to any deliberations of an economic nature. Equally generalized specifications may be found in the catalogue of Corded Ware Culture relating to Thuringia (Loewe 1959) and in a general outline of the Neolithic in Elbe and Saale River-basin (Behrens 1973, 192). Necessary expert opinion lacked also in these cases. This may be noticed in the identification of only siliceous schist and hornblende schist; in relation to other minerals, the authors contented themselves with describing their colour. Similar objections can be made in relation to some Polish works devoted to Neolithic stone implements (e.g., Smoczyńska 1953) a fact already mentioned in the first part of this work. We have no guarantee, moreover, whether definitions taken from various sources were based on similar methods of identifying rocks and whether results were formulated within the framework of the same taxonomic system. We particularly object to the term "greenstone" often applied too widely and not uniformely, particularly by certain English and Scandinavian researchers (e.g., Malmer 1962, especially 543–563). It seems, they embraced by this term several various types of rock, which have been separately examined in the present work, e.g., diabase and diorite (cf. Semenov 1964, 34). The term "greenstone" was used only in relation to these materials in our studies which represent metamorphized effusive rocks of the diabase type. In our concluding comparative deliberations we shall consider only information arousing no objections, for example items of knowledge which resulted from direct co-operation between archaeologists and petrographers. Despite all this, since we cannot fully prove the comparative value of data referred to above, we shall confine ourselves to careful conclusions, which may provide directions for future, detailed studies.

GENERAL QUALITATIVE DIFFERENCES

We shall begin the search for differences in the raw material structure between particular, so far petrographically identified areas of Neolithic Europe from principal peculiarities of the qualitative type. Considering the lack of sufficient data we have beforehand given up more detailed quantitative determinations. A comparison of available information should be subordinated to the question concerning causes of registered differences. The influence of two factors can be theoretically assumed: the natural environment (raw material resources of a particular area) and cultural traditions (the raw material structure of stone industry on previous development stages of a particular cultural group and adapted techno-utilization rules). A particularly perspicuous example of the dominating influence of the latter factor comes from Wessex. Although this area is based on a flint-bearing chalk bed, petrographic studies have proven extensive imports of implements from other than flint raw materials, which originated at well known and distant rock quarries (G. Clark 1965). This situation — untypical and difficult to comprehend in categories of natural attempts of Neolithic men to create optimum conditions in stone industry production — can be explained only by a strong pressure of tradition, since the early farming culture from the beginnings of the Neolithic in this area did not use flint axes. The British investigations have also supplied an opposite example which illustrates an almost complete determination of the raw material structure on a large area by local resources. This situation existed in the early and middle Neolithic Windmill Hill Culture; it embraces the area of South-eastern England, also characterized by a flint-bearing chalk bed, which explains why most implements in the lithic assemblage were made from flint (Piggott 1954, 45). Moreover, the prevailing use of local raw materials was the reason why this culture knew no forms of perforated axes (except several, single pieces obtained from imports), the production of which necessitated the use of non-flint raw materials.

The few elaborations relating to the raw material composition of stone implements of the entire Neolithic have been confined to the area of Thuringia, Trier, Brittany and Great Britain. Amphibolite decisively prevails in a precisely defined series of implements from Thuringia (Scholz 1968), although the scantiness of this assemblage (44 pieces) prevents a reaching of detailed conclusions concerning its frequency (68.2%). The assemblage from the Trier area is even less numerous (40 pieces) and is not classified either from the chronological or the cultural aspect; it includes three types of raw material: quartzite, sandstone and diabase (Schmitt, Dehn 1938). More reliable data on quantitative proportions could be obtained from French researches based on numerous materials (3060 pieces), were it not for methodological shortcomings in petrographic analyses (there are only macroscopic denotations) and, as in the previous case, the lack of internal chrono-cultural differentiation (Cogné, Giot 1952; 1954; 1957; Giot 1951; 1964). These facts require, nevertheless, a critical survey of published results of these researches. They include a general composition of raw materials from Brittany's Neolithic (Giot 1951, 228). The prevailing epidiorite has been termed by these authors as greenstone or dolerite (Giot 1964, 26).

The best documented as regards petrography and, hence, the most suitable for our studies is the list of principal stone raw materials from Great Britain, exploited in great quantities for the requirements of several workshops of stone implements (mainly flat axes). It was prepared on the basis of numerous series from various regions of the country (several thousand pieces), examined by the thin slices method. It includes the following raw materials (Shotton 1971): 1 — fine-banded epidotized andesitic ash, 2 — compact Ordovician volcanic ash, 3 — epidotized micro-granodiorite, 4 — gabbro, 5 — fine-grained rhyolithic ash, 6 — picrite, 7 — preselite (also known as spotted dolerite), 8 — sandstone, 9 — quartz dolerite, 10 — coarse-grained volcanic ash. The standard value data from British researches allow to recognize the thus acquired quantitative picture of particular regions in Great Britain as reliable and approximating real conditions. For the purpose of comparison with conditions in Mid-western Poland we have chosen the quantitative raw material structure of eastern England which, as regards natural resources, closely resembles the Central European Lowlands (an area embraced by several glaciations and, hence, abundantly covered with erratic material). The structure referred to is based on a series of 406 pieces (McClough, Green 1972, 108 ff.).: ash — 34.0 per cent; greenstone — 22.9 per cent; dolerite (preselite) — 10.1 per cent; quartz dolerite — 10.1 per cent.

Referring this information to the raw material structure of the examined assemblage from the Polish Lowlands, we have found significant qualitative differences increasing proportionally to the distance separating the compared series. In the two mentioned German regions, already belonging to the upland zone, there still prevail single types from the group of six raw materials most intensively utilized in Mid-western Poland (Thuringia — amphibolite, Trier — diabase). There are no analogic examples concerning raw materials from Brittany, whereas in the raw material structure from Great Britain the main position goes to various types of volcanic tuffs, almost completely absent in the assemblage analyzed above; gabbro was the only raw material playing a significant role in the two compared areas. A characteristic feature of Neolithic stone industries in Western Europe was, moreover a more frequent (than, for example, in Poland) use of sandstone, despite the indicated not very advantageous technical features of this rock.

An attempt at indicating these raw materials which played a leading role in the economy of particular areas was based on a group of four criteria advanced by B. Balcer (1975, 208), concerning the role of the Świeciechów flint in the Funnel Beaker Culture: 1 — technical properties and the use in production of the investigated raw material compared with assemblages utilized by communities of a particular culture; 2 — the assortment and functional range of implements produced from this raw material; 3 — the frequency of finds from this raw material; 4 — the distribution of implements.

An initial assessment indicates the leading role of basalt in Mid-western Poland, of epidiorite (perhaps dolerite, since this category includes several related types of rock) in Brittany and a group of tuffs in Great Britain. In the light of available data these raw materials fulfil requirements referred to.

THE CHRONO-CULTURAL ASPECT

Relatively numerous but mostly marginal and deficient remarks, made in the monographs concerning particular cultural groups, supply the basis for a comparative examination of raw materials in the first of three detailed aspects. Another shortcoming of these remarks is the fact that they do not represent in an equal degree all groups considered in this analysis. The utilization of raw materials on areas adjoining Danubian cultures has been relatively best characterized, but there is a complete lack of comparative materials on the Funnel Beaker Culture and the Corded Ware Culture.

Data on the prevalence of implements made from amphibolite (Vencl 1960, 7) and amphibole schist (Štelcl, Malina 1970; 1975) were obtained from the initial area of Danubian cultures in Czechoslovakia. The share of other types of schist, generally defined as green or greenish schist has also been large (Vencl 1960, 7). The actinolite-amphibole schist was a raw material of a high technical value, often used particularly in the younger Moravian Neolithic (Moravian Painted Pottery Culture; Štelcl, Kalousek, Malina 1970). Principally basalt, together with greystone and siliceous schists, were recognized in the rich stone assemblage of an early Neolithic settlement of the Danubian Cycle at Köln-Lindenthal (Buttler, Habersay 1936, 143). Data from Saxony mention only a high prevalence (90%) of "greenstone" including prasinite and green schist. These determinations were carried out only by the macroscopic method (Quitta 1955, 26). We reached the conclusion that the analyzed series of DC implements shows structural traits appearing both in Czechoslovakia (predominant share of amphibolite and an extensive group of schist with amphibole schist prevailing) and in Rhineland (intensive use of basalt).

The only available analogies concerning the Globular Amphorae Culture are from the area of Kujawy discussed in our work; six flat axes included in this group have been defined macroscopically as diorite (Wiślański 1966, 39). A far-reaching unification of raw materials took place in Silesia at the decline of the Neolithic. This was caused by the exploitation of local serpentinite deposits in the Ślęża range (Geschwendt 1931, 46). Perforated axes of the Ślęża type produced from this raw material have been linked with the Marszowice and partly with the Únetice Cultures (Smutek 1950, 158), or with older Lower Silesian groups of the Corded Ware Culture (Machnik 1970). Excavation works carried out in recent years questioned the monopoly of the late Neolithic population of the mass use of this raw material and proved its considerable role already during the younger (IV) phase of the Funnel Beaker Culture in Lower Silesia, among others at Tomice near Dzierżoniów, woj. Wałbrzych (Romanow 1973). According to achieved data, the unification referred to was at the end of the Neolithic of a local nature, limited to Lower Silesian supply deposits of serpentinite, because there existed a clear raw material differentiation in those time in Mid-western Poland.

Discussing the chronological factor in the shaping of the raw material structure, we must not pass by the interesting phenomenon of the rapid, inter-cultural spreading of certain types of raw materials over relatively extensive areas. Since this expansion usually did not last very long, we may speak of certain chronological horizons determined by products uniform as regards raw material. At least two examples of the discussed type have appeared in the European comparative material. The first concerns the output of a porcellanite axes workshop at Tievebulliagh near Clyde in Great Britain (Piggott 1954, 173, 184). The short period of its activity has been dated to the turning-point of the Atlantic and Sub-Boreal periods (ca. 3500 B.C.). The second example was supplied by votive axes from the so called Wida-schist, which represent an inter-cultural chronological horizon and appear mainly in the Bernburg Culture, furthermore also in the Walternienburg, Schönfeld, Elbe-Havel, Salzmünde and Globular Amphorae Cultures (Toepfer 1957, 213 ff.). Three workshops of these implements have been discovered so far. We have found no traces of these implements in areas embraced by our researches.

THE TYPOLOGICAL ASPECT

Most examples of correlation between forms of implements and types of raw material have been noticed among flat axes. The inter-cultural type of axes with sharp, narrowing heads, which appear almost throughout the entire Neolithic (from Danubian cultures to the Bell Beaker Culture), have been usually linked with precious raw materials, principally jadeite and nephrite (Behrens 1973, 153). A significant correlation of relevant factors has been observed among flat axes of the Vogtland type from Northern Bavaria, Vogtland and Saxony (Neumann 1930). The majority of these axes was produced from very soft, gray argillaceous schist. All of several dozens of miniature axes discovered at Tomice (phase IV of FBC) were made from serpentinite; this was explained by the nearness of deposits situated 20 kilometres from the site (Romanow 1973, 92).

As regards the group of perforated axes, examples almost uniform in relation to raw material have been found only in Lower Silesia. They included the already mentioned Ślęża type axes produced from serpentinite (Smutek 1950). The low degree of hardness of this raw material practically eliminated its use in the production of implements. In Great Britain perforated axes were produced almost exclusively from erratic raw materials. This was due to the chronological position of this form which appeared in larger quantities only in allochtonic Beaker Cultures, the representatives of which either were not in contact with local stone workers who exploited rock deposits, or arrived in Great Britain after activities at their workshops declined (Piggott 1954, 301). In relation to hoes, we have noted K. H. Brandt's observation (1967, 11), that none of the *Plättbolzen* was produced from schists, so popular in the Danubian Cycle, and that all implements from Lower Saxony and Brunswick (35 pieces) analyzed by this author, represented "various types of greenstone". Marble, a raw material very seldom used in the Neolithic production of implements, was utilized for producing disk mace-heads by the Rössen Culture in the river basin of the middle Elbe and Saale (Behrens 1973, 53).

More general formulations concerning links between the form and raw material of implements have been supplied by results of studies conducted in Great Britain. The regularity discovered there was based on an approximately equal increase in raw material and typological differentiation (Evens, Smith, Wallis 1972, 248). A differentiation in the assortment produced by stone industry workshops took place but in the third phase of their activity (about 2000–1500 B.C., according to S. Piggott; cf. Evens et al. 1962, 234), when there appeared the first mace-heads and early forms of battle-axes. Flat axes were produced earlier in this area almost exclusively. On the other hand, all raw material groups distinguished in British studies, indicated a considerable typological differentiation (Stone, Wallis 1951, 130).

THE GEOGRAPHICAL ASPECT

The purpose of comparing dependences between the type of raw material of lithic implements and their geographical occurrence is to determine spatial factors which decided the shape of the raw material structure of the Neolithic stone industry. Specific local conditions were most often influenced by local deposits of correspondingly attractive rocks. In certain periods, stone industry was based almost completely (more than 90%) on local deposits, e.g., prasinite from the Döbeln area (Herrmann, Schüller 1952, 109–112), serpentinite from Ślęża (Smutek 1950), or fibrolite from central Brittany (Giot 1964). Less obvious (only quantitative) differences in utilization proportions of the same lithic raw materials in various areas might reflect the degree of their distance from deposits (e.g., the distribution of basalts in Mid-western Poland, cf. Fig. 1) or, in the case of erratics — differences in stone industry traditions.

2. MEANS OF SUPPLYING LITHIC RAW MATERIAL

Frequently, it is possible to determine whether a particular raw material was of erratic origin, or whether it was obtained directly from deposits, only after several complicated laboratory procedures. It is still more difficult to determine whether a particular piece of raw material was extracted by Neolithic men from solid layers or whether it was a piece selected from river bed deposits, where it was brought due to erosion processes of layers or by river transport. This problem emerged, for example, in connection with lithic raw materials at the Köln-Lindenthal settlement. Although raw materials distinguished there appear among local gravel in the Rhine Valley, the large size of implements produced from these materials indicate links with original, more distant rock deposits (e.g., the closest quarries of siliceous flint in the upper Lahn river basin ; Buttler, Haberay 1936, 143).

ERRATIC RAW MATERIAL

Erratic rocks, carried to the Central European Lowlands during successive Scandinavian glacier transgressions, constituted in this area a basic, locally accessible raw material source for the stone industry. It has already been mentioned, however, that only some types of rock, relatively most seldom appearing among erratics, were suitable for this purpose (Prinke, Skoczylas 1978, 54–56). The apparent ease of acquiring raw material must have been complicated to Neolithic producers, considering the necessity to select (as regards defined physical and technical characteristics) required types of rock from among many others more abundant types in the erratic material. Certain facts indicate, that a careful selection concerned only raw material devoted to the production of most important implements of which considerable functional efficiency was expected — i.e., principally large polished implements used for cutting (flat and perforated axes, etc.). Other lithic implements, used for simple activities (e.g., quern stones, chipping stones, grindstones and polishers) were produced in the Lowlands from easier accessible raw materials, i.e., those types of rock which were most frequently represented in glacial deposits (mainly granite and quartzite). This situation was found, among others, in the settlement of Linear Pottery Culture at Zalęcino, woj. Szczecin (T. Wiślański, personal communication).

The utilization of erratic materials by Neolithic men living in the Lowlands was undoubtedly dictated by necessity, namely the considerable distance from original rock deposits, which sometimes prevented them from meeting in full demands for lithic raw materials by means of imports. Besides theoretical circumstances (it is easier to treat freshly broken stones; cf. Dehn 1938, 135), this was also manifested by a gradual decline in the share of erratics in the raw material structure as the distance to rock-bearing piedmont and mountainous areas grew shorter. The rich series of implements from the Döbeln area includes only few pieces made from erratic material, this indicates their complementary role in relation to high quality raw materials from nearby quarries (Herrmann, Schüller 1952, 116). As regards areas further south, we dispose of data concerning Czechoslovakia, where — at least in respect to implements of Danubian Cultures — no semi-manufactured implements produced from erratic or valley pebbles have been found (it is much more difficult to find traces of natural transport on finished pieces; Vencl 1960, 6).

RAW MATERIAL FROM ORIGINAL DEPOSITS

In addition to erratic materials, raw materials from rock quarries situated in piedmont and mountainous areas have also been used in Central European Lowlands. The share of this group of rocks depended on the degree of intensity of raw material exchange carried out by the population inhabiting rock-bearing areas, or on the frequency of independent trips to obtain raw material organized by lowlanders. An exact reproduction of the full share of imported raw materials in Neolithic stone industry in the Lowlands requires detailed petrographic analyses of a large number of stone implements. At the present stage of researches, it is possible to particularize raw materials which undoubtedly come from original deposits situated south from the area of our studies, and a group of rocks appearing both in upland-mountainous quarries and in erratic material. Raw material of the first type includes basalt, serpentinite and nephrite. Basalt deposits have been discussed in section II 2.

Implements of the other two raw materials (serpentinite and nephrite) have not been subjected to laboratory analyses during present studies; this is why we must assume — only hypothetically at present — that they originated at known Lower Silesian deposits of these raw materials, which were the closest to Mid-western Poland (serpentinite — at the foot of the Ślęża massif; cf. Geschwendt 1931; Smutek 1950; nephrite in the area of Jordanów Śląski, cf. Zotz 1934). No finds are available which could directly elucidate methods of extraction and distribution of raw materials from stone quarries.

G. Clark (1965; cf. Briggs 1976), comparing the Neolithic culture in Europe with present-day tribal cultures of Australia, New Guinea, Melanesia and New Zealand, found several analogies in relation to stone industry, particularly methods of obtaining raw material. Both archaeological and ethnographic data indicate that principally loose materials (pebbles) covering river beds were used. This was possible wherever raw material lumps, eroded by rivers in their upper course from their original deposits, were carried by water down the valley. These raw materials were easier accessible than those obtained from cohesive rocks. If they were sufficiently big and not decayed, they were not inferior as regards utilization value. Evidence of such exploitation, not yet up to mining standards, was found in Thuringia (Scholz 1968). Cohesive rock deposits were exploited only when it became necessary to get fresh, not decayd rock (G. Clark 1965). This was proved, among others, by the fact that in the thoroughly investigated — in this respect — area of Great Britain, where several sites of Neolithic exploitation of stone deposits were discovered, only one (Mynydd Rhiw) represented a typical open pit, but even there, exploitation reached not far underground (G. Clark 1965, 1 ff.). The procurement of raw material from rock waste usually found near quarries was noted in all other cases.

On certain areas researchers recorded an indirect form of exploitation involving the digging up of loose lumps deposited in a layer of waste constituting the upper, eroded part of the rock deposit. This was practised wherever the erosion process was not advanced far enough to destroy the utilization value of rocks. Open pit mining activities of this type were noted, among others, on slopes of the Ślęża. Excavation research carried out in 1929 (Geschwendt 1931, 47) revealed funnel-like mineshafts from which dense but loosely distributed lumps of serpentinite were excavated — a fact which facilitated exploitation; the raw material, covered by a layer of soil, was still suitable for treatment despite decay (Smutek 1950, 158). Quartzite deposits at Bühren near Göttingen were exploited in a similar manner. Raw material consisting of lumps was extracted from layers of waste and Tertiary sand. Funnel-like mineshafts reaching to a depth of 0.8 metres were discovered there. The breaking of cohesive rock was noted only in few cases. The selection of deposits of a possibly small thickness facilitated their exploitation. In addition to the Mynydd Rhiw quarry, we also know one in Czechoslovakia (Vencl 1960, 5) — the Bily Kamen site belonging to the Danubian Cycle. Quartzite at Nalkkila near Askola in Finland (Luho 1956, 52, 116), where ledges 2–10 centimetres thick and 1 metre wide were cleaved with large chipping-stones, was exploited in a similar manner. The beginnings of this quarry have been dated to the Early Mesolithic Askola Culture of the pre-Boreal period.

It is not always possible to determine the manner a deposit was exploited. Sometimes, a contemporary quarry destroyed the closest environment of the prehistoric exploitation site, and the Neolithic mining activity is reflected only in remains of initial treatment of excavated raw materials or in stone workshops. Thus, for example, vaguely defined Neolithic exploitation activities embraced deposits of amphibolite and crystalline limestone deposits, lying in the Sázava Valley in Czechoslovakia. They were utilized during late phases of the Danubian Cycle (Žebera 1939, 51). As regards exploitation methods of cohesive stone deposits, there exist only loose suggestions supported by few finds remaining from mining activities and single pieces of excavation implements. On the basis of ethnographic analogies S. A. Semenov assumes that in the Neolithic stones were broken by fire or wooden wedges were forced into cracks, next water was poured over and the wedges — swelled — split the rock. A similar effect could be achieved in winter by filling cracks in ledges with water. Typical assemblages used for the exploitation of stone include pickaxes made of antlers or stone, stone hammers and wooden or bone wedges.

The exploitation of raw materials from stone ledges is linked with the problem of their initial treatment at workshops, known from various European regions. They have been localized in the close vicinity of exploited deposits or at a considerable distance from permanent settlements (some scores of kilometres). It seems, that these differences in the position of workshops reflect a different production organization of each of the two groups. An appropriate ethnographic model includes certain interpretation guide lines in this respect (G. Clark 1965). According to this researcher, particularly valuable and at the same time very hard raw materials (e.g., nephrite and jadeite), which could be treated only with the use of time-consuming sawing or grinding techniques, were transferred to settlements in the form of crude lumps. Cleavable rocks were initially treated at the extraction site to avoid transport of heavy loads. Only the final polishing of implements was done at workshops. But as regards analogical objects from the Neolithic, there were — in addition to technical features of the raw material, the localization of workshops and their distance to deposits — other decisive and so far unknown factors. Workshops situated on supply areas of rock quarries are known from the Ślęża (Smutek 1950, 158; numerous semi-manufactured implements in various processing stages discovered near a channelled extraction site), the Trier district (Schmitt, Dehn 1938; a diabase flat-axes workshop situated directly at deposits of this rock) and at Bühren in Lower Saxony (Jünemann 1959, 2 ff.). Of a different character were workshops in the region of Döbeln (Herrmann, Schüller 1951, 115–116) and all known objects of this type linked with the Danubian Cycle in Czechoslovakia. A distance of about 20–50 kilometres from rock deposits which supplied raw material was determined in each case. The transports of raw material have been proved by large finds of lumps of rock, roughly hewn to rectangular pieces, board-like plates found together with semi-manufactured stone implements. They weigh up to 12 kilograms (the Abtlöbnitz hoard in Saxony; Quitta 1955, 51; see also Vencl 1960, 6, note 11).

Despite the discovery of several objects of this type, there are still no systematically and comprehensively investigated, representative stone workshops from the area of Central Europe. The best preserved and, hence, most interesting workshop has been described only in a brief note (Höckner, Reinhold 1936). It was discovered at Reinwald near Altenberg (Erzgebirge) and was linked with the Danubian Cycle. It included, among others, a working "bench" from a hewn block of porphyry and traces of a secondary utilization of damaged pieces as raw material for the production of new implements.

Stone workshops were sometimes quite extensive. Out of a dozen or more production centres in Great Britain (the discovery of some of them represents the main achievement of long-term petroarchaeological researches) some yielded great amounts of finished products, semi-manufactured implements and waste, indicating a large scale production. It suffices to mention that Knowles (who discovered porcelanite axes at Tievebulliagh) found on the surface more than 2500 semi-products (Piggott 1954, 289), and Warren (who carried out researches at the Graig Lwyd workshop) based his interpretation on stone material weighing 3 tons (Warren 1919; 1921; 1922). Great Britain also supplied data on the upper chronological limit of the functioning of stone workshops. A part of them were still in existence in the Early Bronze Age (Wessex Culture I and II, 1500–1400 B.C.) when they gave way to generalized metal tools (Evens et al. 1962, 233; cf. Cummings 1974).

Stone implements, above all perforated axes and flat axes, have been considered by many researchers as objects of Neolithic trade exchange. To substantiate this view, a range of implements of the same characteristics (G. Clark 1965) and assemblages comprising these implements (Štelcl, Kalousek, Malina 1970; Quitta 1955) have been mentioned. The second of these arguments does not seem convincing and has been impaired in relevant literature (G. Clark 1965), whereas the first was additionally corroborated by results of petroarchaeological studies, which considerably increased its evidential strength. Due to the isolation of implements of uniform petrographic characteristics which were found at known production centres, it was possible to reproduce the authentic range of products from particular workshops, in contrast to previous works based exclusively on morphological characteristics of implements and, therefore, embraced also implements made from other raw materials (and perhaps on other areas). Due to more precise data, a rich and highly probable image of Neolithic exchange, linked with stone implements from the British Isles, was achieved. The most astonishing result relating to the British program of petroarchaeological studies was the discovery of exchange contacts between Northern Ireland (flat axes workshop) and Southern England (receivers of products), and links of a small workshop at Stake Pass, Lake District (Warren 1921; 1922) and its products found at the Thames (Keiller, Piggott, Wallis 1941, 68). These determinations have provided valuable guide lines inclining to a further study of these links on the basis of remaining categories of archaeological sources.

A typical characteristic of the entire exchange involving stone implements in Great Britain was its substantial connection with the sea coast (Fell 1964, 41). All hitherto discovered stone workshops were localized at a small distance from the sea, which solves the question concerning the type of employed transport. The thesis concerning the distribution of implements from production centres by sea has been proved by their disposition (e.g., some porcelanite axes from Ulster have been discovered on the Hebrides and in the vicinity of London). The only exception were implements produced in workshops in Cornwall; their range indicates land transport and a possible partial use of rivers. Consequently, the role of these centres was considerably limited (G. Clark 1965). A far-reaching exchange of stone raw materials existed also in other parts of Europe and in the Near East. A relevant classical example was the transport of flint over a distance of ca. 500 kilometres, discovered at Jarmo, an early Neolithic settlement in Iraq (Tabaczyński 1970), and the obsidian trade in the Mediterranean area (Cann, Renfrew 1964). The so-called Olonec green schist, extracted in the middle and late Neolithic from deposit in the Petrozavodsk region (north-eastern bank of the Onega Lake), was also distributed over wide areas (ca. 900 km from the source). This was certainly a result of exchange, since glacier transport of this raw material quite impossible (Foss, Elnitskij 1941, 182–191).

The lack of thorough petrographic examinations of stone industry products in Central Europe makes it impossible at present to determine more exactly the type and scale of raw material exchange. We can hope, on the basis of theoretical assumptions, to find in future studies traces relating to the distribution of lithic materials and finished stone implements in the following forms: 1 — exchange of raw material lumps, semi-manufactured artefacts and finished stone implements for their equivalents in other products; 2 — exchange limited to finished products — if there existed stone workshops producing implements for market, a fact indicating professional specialization (cf. Fell 1964, 41); 3 — far-reaching trips to obtain stone raw material from its deposits, organized by particular societies which utilized this material. This thesis is based on ethnographic analogies (mainly relating to Australia; cf. Spencer, Gillen 1904, 175 f.) but is difficult to prove by means of archaeological sources.

In regard to Poland, achieved results (the presence of raw materials imported from the South during the entire Neolithic) contradict the self-sufficiency thesis of particular Linear Pottery Culture settlements in relation to rock raw materials, with the exception of certain types of flint (Kulczycka-Leciejewiczowa 1970, 74). They speak rather for the correctness of the opposing concept that a widely understood exchange of goods was a permanent characteristic of early farming cultures, because economic self-sufficiency occurred in none of these groups in Central Europe (Tabaczyński 1970, 263–282). Another indication we have obtained concerns the existence in the late Neolithic a far-reaching exchange between Mid-western Poland and Volhynia. Traces of Volhynian influences have already been recognized in the late Neolithic in Poland in the form, among others, of large imports of Volhynian flint, Sokołówek type pottery indicating links with the Dniepr-Donets Culture (Kempisty 1970, 288–292), white-painted Złota-Volhynian type pottery and flint daggers of the Strzyżów type (Wyszomirski 1974, 92, Fig. 5). Basalt raw material, from deposits in the Horyń River basin was recently included in these materials (cf. Prinke, Skoczylas 1978, 59, Fig. 8).

Still unsolved remains the question of equivalents to raw materials or finished stone implements constituting objects of exchange. T. Wiślański proposes to explain the phenomenon of the much wider range of appearance of Danubian Cycle implements than its compact settlements by the exchange of these products for food, which was to have taken place during periods of bad crops (Wiślański 1969, 223). This is quite probable if we consider that early agricultural societies, as a rule, achieved smaller surplus of food than neighbouring hunting-gathering communities. The major part of products used as equivalents, however, cannot be disclosed in archaeological materials (cf. Balcer 1975, 267).

3. AN ATTEMPT AT DEFINING THE SCOPE OF PRACTICAL PETROGRAPHIC KNOWLEDGE IN THE NEOLITHIC

Deliberations concerning the level of knowledge of prehistoric men are among the most difficult problems in archaeology since they result only indirectly from available source material, and this leads often to the possibility of different interpretations (cf. Schlette 1966). The manner of using stone raw materials constitutes an important element in the adjustment system of Neolithic societies to the occupied natural environment. This concerns in particular Central European Lowlands where, generally, there existed unfavourable conditions for the development of stone industry. As was indicated in previous parts of this work, stone raw materials occurring in the Lowlands were quite abundant, but most of them lacked physical and technical properties required in the production process and the utilization of implements. This is why, producers, who used local, postglacial material, had to carry out a careful and limited selection of erratics, which required considerable empirical knowledge on the identification of lithic materials. Raw material shortages had to be met by imports from rock-bearing upland and mountainous areas lying in the south. This situation gave the local Lowland population a stimulus to develop practical petrographic knowledge to acquire supplies of raw materials for the production of basic types of implements and weapons in the most economic manner.

Despite these difficulties, relatively great research possibilities concerning the discussed problem are created by observing in archaeological materials links between physical and technical characteristics of utilized rocks and applied processing methods. A maximum use of the structural features of rocks during the shaping of implements has been noted already on implements from the early Neolithic (incl. a settlement of the Linear Pottery Culture at Bylany). Thus, for example, implement points were situated as a rule, vertically to the level of the rock's cleavability, which ensured a high resistance to mechanical deformation (Štelcl, Kalousek, Malina 1970; Štelcl, Malina 1970, 40–43; 1975, 212–215).

The level of practical petrographic knowledge can be also seen in the exploitation of rock deposits. Both data from Central Europe and from Great Britain indicate that deposits intended for exploitation were carefully selected and pertinent decisions taken in this respect are recognized as correct even today if they are verified on the basis of contemporary knowledge of raw material resources of a particular territory. It has been found in Great Britain that Neolithic stone workers avoided quarries which contained heterogeneous raw materials. This conclusion was reached by comparisons of greenstone and finished products from this mineral. The structure of this rock is particularly diverse (even within the same implement), a fact caused by its discontinuous structure. But, among examined implements, this changeability was much smaller than in most deposits of this raw material (Evens, Smith, Wallis 1972, 239). A similar raw material situation was found in the area of Döbeln. Decisively prevalent there (more than 90%) were prasinites, also described as epidote and amphibole schists. Their deposits, very rare in the whole of Saxony and Thuringia, occur only in the Deckenschollen Mountains near Frankenberg. The discovery of these raw material deposits and the recognition of their technologically advantageous characteristics required of Neolithic stone workers exceptional knowledge and long-lasting searches (Herrmann, Schüller 1951, 115 f.). Interesting observations of British researchers also indicate a good knowledge of local raw material resources. They have noticed regularities in the situation of the oldest excavation points of copper and zinc ore in North-western England in the direct vicinity of earlier exploited deposits of lithic raw materials (Evens et al. 1962, 237). The beginnings of empirical knowledge concerning mineral mining are linked, according to theoretical premises, with casual observations made by prehistoric men during earth works (digging hunting pits etc.; cf. Jahn 1960, 6).

As we have already said, the knowledge of lithic raw materials fulfilled a particularly important role in the utilization of erratics. In getting supplies of raw material directly from original deposits the problem of selecting a particular type of rock occurs only once — at the moment a ledge is chosen for exploitation. If this choice was correct — and this was decided by results of the processing and utilization of the first implements produced from this material — the quarry became for a long period the source for required raw material. The use of raw material resources of erratic origin was linked, however, with the necessity of a constant selection of types of rocks acknowledged within the framework of a particular technocomplex as suitable for the production of a defined type of implement. We can assume on this basis that Lowland inhabitants out of necessity represented a higher level of practical petrographic knowledge than inhabitants of piedmont and mountaineous areas, who had easier access to rock quarries.

The high level of knowledge concerning Neolithic raw materials was linked with problems of an eventual professional specialization in stone industry production. This social aspect of the development of petrographic knowledge has been variously viewed in relevant literature. We shall successively examine facts speaking for and against such specialization. A comprehensive approach to this problem in relation to older Danubian Cultures may be found at H. Quitta (1955, 23, 51 f.) and D. Kaufmann (1976, 57). These authors, speaking for specialization, advance the following arguments: 1 — a much smaller number of semi-manufactured pieces from crystallic rocks are found in settlements than similar pieces from flint and bone; 2 — compared with other implements, the time of labour at implements from crystallic rocks was very high; 3 — their utilization value is also higher and, therefore, also their attractiveness as exchange objects; 4 — when leaving settlements, flint implements easy to produce were often abandoned, but implements from other stone materials were taken along. Those in favour of specialization also refer to the extraordinarily skillful use of physical and technical properties of rocks, which could prove that the producers of these implements must have worked with these raw materials for a long time and not only casually (Eibner 1971, 10; Kaufmann 1976, 58; Scholz 1968, 292). A similar but more comprehensive argument was advanced by S. Vencl (1960, 10). In his opinion, it is necessary to accept the thesis of an at least partial specialization, since the obtaining, transport and treatment of rock raw materials embraced several complex and time-consuming activities requiring, moreover, extensive specialistic knowledge.

At the same time, however, there appear in this image of Neolithic stone industry several factors speaking against this thesis. One concerns a fact noted in several cases: the separation of activities involving initial treatment (flaking off) and finishing procedures (polishing of the surface of the semi-manufactured implement). The first was executed in workshops at the material supply area, the second — in settlements. According to G. Clark

(1965), this indicates an only seasonal engagement in stone treatment; if this were not so, the entire production process would have taken place in the exploitation zone.

There are still not enough source materials to solve this question explicitly. These materials can be obtained only by means of systematic researches at exploitation points of rock deposits and stone workshops with a comprehensive consideration of their petrographic context. But B. Balcer's conclusion about the risk of a too hasty settlement of the question concerning professional specialization, which — according to this author is the most difficult in the entire problem of stone industry, may be referred to many of the above quoted views, since it is directly linked with the complicated problem of the development level of production and exchange relations. The appearance in the early Bronze Age of individual specializations, developed under the influence of the Near Eastern model of metallurgic production, has been better substantiated (Balcer 1975, 271).

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PA — Przegląd Archeologiczny, Poznań, Wrocław.
PPS — Proceedings of the Prehistoric Society, London.
RPTG — Rocznik Polskiego Towarzystwa Geologicznego, Warszawa.
WA — Wiadomości Archeologiczne, Warszawa.

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GOSPODARKA SUROWCAMI KAMIENNYMI W NEOLICIE NIŻU POLSKIEGO

Streszczenie

Skróty:
DC — cykl naddunajski (KCW)
FBC — kultura pucharów lejkowatych (KPL)
CWC — kultura ceramiki sznurowej (KCS)
N/Br — grupy episznurowe z przełomu neolitu i epoki brązu
? — grupa neolitycznych wyrobów kamiennych bez bliższej przynależności chronologiczno-kulturowej

Artykuł zawiera wyniki uzyskane podczas realizacji własnego programu badań archeologiczno-petrograficznych nad zróżnicowaniem surowcowym kamieniarstwa neolitycznego (założenia metodyczne, cele i możliwości poznawcze tego programu przedstawiono w poprzednim tomie ,,Przeglądu Archeologicznego"; A. Prinke, J. Skoczylas 1978). Dysponując oznaczeniami rodzaju surowca licznych serii neolitycznych narzędzi kamiennych z Polski środkowo-zachodniej, uzyskano szereg nowych danych, dotyczących sposobów ich eksploatacji, rozprzestrzeniania i użytkowania. Omówiono m. in. kwestię pochodzenia tych surowców (selekcja materiału eratycznego, dalekosiężny transport ze złóż pierwotnych oraz eksploatacja lokalnych wychodni na Niżu), dalej — zagadnienie doboru odpowiedniego surowca w zależności od funkcji narzędzia względnie techniki jego obróbki, a także — regionalne zróżnicowanie struktury surowcowej kamieniarstwa, które rozpatrzono przy zastosowaniu testów statystycznych. Całość wyników z badanego terenu porównano z obecnym stanem znajomości omawianego problemu w Europie Środkowej. W zakończeniu podjęto próbę rekonstrukcji poziomu praktycznej wiedzy petrograficznej ówczesnych kamieniarzy, rozumianego jako jeden z mierników stopnia adaptacji poszczególnych społeczności neolitycznych do środowiska naturalnego Niżu.

The authors' addresses:
Dr Andrzej Prinke, Poland
Muzeum Archeologiczne
61-781 Poznań, ul. Wodna 27

Dr Janusz Skoczylas, Poland
Katedra Geologii Uniwersytetu im. Adama Mickiewicza
60-780 Poznań, ul. Grunwaldzka 6

ERRATA

do artykułu A. Prinke, J. Skoczylas, Z metodyki badań nad użytkowaniem surowców kamiennych w neolicie, „Przegląd Archeologiczny", t. 26: 1978

Strona 46:

Ryc. 1. Dąbrowa Biskupia, woj. Bydgoszcz. Topór kultury ceramiki sznurowej, wykonany z kwarcytu sfelszpatyzowanego

a — wygląd zewnętrzny, *b* — obraz mikroskopowy surowca (pow. ok. 58×).

Perforated axe of the Corded Ware Culture, made of feldspar quartzite

a — external view, *b* — microscopic picture of the raw material (magnification c. 58 ×)

Strona 48:

Ryc. 3. Smolniki, woj. Bydgoszcz. Topór cyklu naddunajskiego, wykonany z bazaltu bezoliwinowego (tefroidu)

a — wygląd zewnętrzny, *b* — obraz mikroskopowy surowca (pow. ok. 189 ×).

Perforated axe of the Danubian Cycle, made of olivineless basalt (tephroide)

a — external view, *b* — microscopic picture of the raw material (magnification c. 189×)

Strona 47:

Ryc. 2. Palmierowo, woj. Bydgoszcz. Topór kultury pucharów lejkowatych, wykonany z amfibolitu

a — wygląd zewnętrzny, *b* — obraz mikroskopowy surowca (pow. ok. 58×).

Perforated axe of the Funnel Beaker Culture, made of amphibolite

a — external view, *b* — microscopic picture of the raw material (magnification c. 58×)

Strona 49:

Ryc. 4. Mokronosy, woj. Piła. Topór cyklu naddunajskiego, wykonany z gnejsu hornblendowego

a — wygląd zewnętrzny, *b* — obraz mikroskopowy surowca (pow. ok. 58 x).

Perforated axe of the Danubian Cycle, made of hornblende gneiss

a — external view, *b* — microscopic picture of the raw material (magnification c. 58 x)

Mapy pod opaską:

Map 1. Distribution of polished stone implements of the Cycle of Danubian Cultures in Mid-western Poland with regard to their raw material differentiation

Map 2. Distribution of polished stone implements of the Funnel Beaker Culture and of the Globular Amphorae Culture in Mid-western Poland with regard to their raw material differentiation

Map 3. Distribution of the perforated stone axes of the Corded Ware Culture in Mid-western Poland with regard to their raw material differentiation

Map 4. Distribution of polished stone implements of the cultural groups from the turn of the Neolithic and the Early Bronze Age with regard to their raw material differentiation

Map 5. Distribution of Neolithic stone implements of not exactly determined chronological and cultural status, in Mid-western Poland with regard to their raw material differentiation