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EXPLORATION OF STONE RAW-MATERIALS IN STONE INDUSTRY OF LATE-NEOLITHIC COMMUNITIES OF LOWLAND POLAND (NIŻ POLSKI). PROSPECTS FOR FURTHER PETROARCHAEOLOGICAL STUDIES IN THE KUJAWY REGION*

Recent petrological and archaeological studies on the stone industry of late Neolithic communities of the Kujawy region have made it possible to establish that for the production of tools and weapons the communities in question made use of not only varied but also carefully selected set of stone raw-materials and that the relevant raw material was used selectively in relation to the function of a final product. The choice of the raw material for stone production among the communities was not thus accidental but intentional and depended, among other things, on physical and technical properties of individual rocks to be used. Manifestations of the selection of the most suitable raw material for a final product have been distinguished in a specific selection of raw materials used by the contemporary stone workers in production of virtually all kinds of tools. The presented relationships between the function of the choice and the type of the material used for their production fully justify the assumption that late Neolithic communities of the region had a high level of practical knowledge about the available rock raw material.

KEY WORDS: petroarchaeology, rock raw material, utilisation, Lowland Poland, early Stone Age

INTRODUCTION

Advances and developments in pre-historical studies are nowadays, unlike other fields of science that deal with the history and culture of mankind, dependable on the possibilities and achievements in natural science as well as in physics and chemistry. The branches of science supporting studies in prehistory, especially in relation to taxonomic research, and in particular chronology establishment as well as the selected aspects of economy and some production (processing) issues have been found of the well-established usefulness.

Studies on the reconstruction of the environmental conditions of the existence of pre-historical and early-historical communities have also gathered momentum in their significance. The contribution of the relevant studies to the knowledge of manifold and complex manifestations of the activities of man and the surrounding nature in which he shaped his presence appears to be unshakeable and by no means unimportant.

Geological sciences are given the ever-increasing interest in the studies upon the economy of prehistorical and early-historical communities of the river-basin of the Vistula and Odra rivers, especially when it comes to the methods used in petrography. The co-operation between archaeologists and geologists encompasses the increasing number of joint research subjects, which illustrates well the phenomenon of pursuing new fields of interests currently taking part in the contemporary pre-history studies. This tendency is also exemplified by the scientific description of the origins and utilisation of stone raw material in the past which is labelled as petroarchaeology.

Petroarchaeology can be thus placed within the study of the phenomena characteristic for modern science, which lead to a creation of new study areas, in this case of natural science, and the sciences which deal with material remains of the past (made of stone or minerals). The research issues formulated within the interests of petroarchaeology must be then solved by way of the complementary use of research methods proper for geology, especially petrography, and archaeology.

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Petroarchaeology is thus an interdisciplinary branch of science placed somewhere between the sciences whose primary interest lay upon the earth's crust and those which focus their attention on products (objects of stone or minerals) of man's activity in the pre-historical past. Such a point of view and understanding of petrography, presented by A. Prinke and J. Skoczylas (Prinke, Skoczylas 1974; 1978; 1980a; 1980b; Skoczylas 1990; 1991; Skoczylas, Prinke 1979) referred, to a great extent, to the definition put forward by J. Štelcl and J. Malina (1975) and has been recently repeated in Przegląd Geologiczny (Majerowicz, Skoczylas, Wójcik 1999).

A conception of the actual placement of petroarchaeological studies – in terms of its formal and cognitive status and the scope and subject of its application – was presented essentially by P. Chachlikowski (1989; 1991; 1992; 1994a; 1994c; 1996; 1997; 2000). The presentation of the "research space" of petroarchaeology outlined in the works allows us to understand better the placement of the said studies within the "archaeology of stone and mineral raw material" as well as the complexity of its methodical and theoretical position within the sciences dealing with man's development in the past. Petroarchaeology is thus understood as a separated field of knowledge, as regards the necessity of the application of geological knowledge (science) and, simultaneously as regards the specific character of the subject of the research, questions that arise in the course of the studies and formulated concepts in justifications being subjected to interpretations proper to the humanities.

Stone raw material, primarily of all siliceous rocks and other non-siliceous rocks, found application in those lines of production whose source manifestations represent those which are best documented in archaeological material (ceramics, pottery, stone industry products, mortar, building materials). In the case of older epochs they form, basically, the only relics of the history of the past. Thus the range of potential petroarchaeological studies appears to be wide enough and includes a number of different economic activities of man – in relation to, primarily, pottery, flint tools production, and stone production, i.e. those activities which were very important to create foundations for the basic spheres of existence of the pre-historical and early-historical communities.

Stone and mineral raw-materials, along with their importance in satisfying material conditions of living, were also valuable for the production of items that indicated status, prestige or wealth of their owners, viz. amber-processing, glass making, jewellery, architecture and others.

This wide, sometimes even disputable, range of application of methods used normally in geology, petrography, mineralogy, geochemistry and sedimentology, in studies upon rock and mineral raw material in prehistory was proposed by M. Pawlikowski (1992). However, Pawlikowski leaves out one of the most important spheres of interests in petroarchaeology, namely, the issue of the use of non-siliceous rocks which were a basic raw material used for the production of items of every-day use, or used as building material.

I. PETROARCHEOLOGICAL STUDIES IN THE KUJAWY REGION. AN OUTLINE OF THE RESEARCH PROJECT

The questions concerning acquisition, mining and processing of rock raw material (non-siliceous, traditionally described as stone raw material) by the early Stone Age communities still belong to those issues of prehistory which have not been fully discussed in recent research, or research into which has not been carried out at all (the above opinion refers both to Polish and European research studies and projects). This sphere of activity of pre-historical man which, after all, was closely connected with the utilization of one of the basic raw materials in tool-making industry for production of tools and weapons, still needs further investigation being extremely poorly represented in pre-historiography (Chachlikowski 1997, 10-17). Until quite recently the knowledge of stone industry of the Neolithic communities was identified only with the studies in the raw material structure of stone tools in the chronological, cultural and functional aspects, with particular emphasis on the objects more culturally distinctive. The main reason for the above is the fact that the studies on production of stone tools in the Holocene of the Stone Age have not been properly approached methodologically yet and have not been fully described properly by research projects documented by source material.

An attempt at a broader application of geology in studies on stone material was made within the study project on exploration, exploitation and the use of stone raw-materials in pre-historical commu-

nities of the Kujawy region (Kuiavia). Such studies in relation to the Kujawy region were possible to be taken up thanks to the long-term relevant field research concentrated on specific issues (Fig. 1). As a result of the research, rich and varied source material has been gathered which testifies to the local treatment of stone (Chachlikowski 1989; 1991; 1992; 1994b, 31-43, 152-158; 1994c; 1996; 1997; 1998; 2000). The research work on the pre-historical stone industry done in the area that forms a part of the Polish Lowland (Niż Polski) in Kuiavia is an attempt at showing a new approach, both methodological and conceptual, to the studies in pre-historical relics unearthed in the region.

In the hitherto existing published results of the petroarchaeological research in the region, relatively much space have been devoted to stone raw materials used in early Middle Ages (Jochemczyk, Skoczylas 1988; 1991a; 1991b; Skoczylas 1990; 1994), while the results of the researches carried at the turn of the 1980s into the stone material used by earlier communities, have been seriously neglected (Prinke, Skoczylas 1978; 1980a; 1980b; Skoczylas, Prinke 1979). The objective of the present archaeological and petrographical research in the area is to fill the existing gap in that part of the studies as extensively as possible.

The subject for the petroarchaeological studies introduced in the Kujawy project is the activity of human settlements documented in the sphere of exploitation and utilisation of non-siliceous rock raw material (Chachlikowski 1991; 1992; 1994b, 152-158; 1994c; 1996; 1997; 1998; 2000). The stone production activity is studied here through a comprehensive analysis of the sources testifying to the whole of the manifestations of practices linked with this particular sphere of human economic activity. In the analysis, a vast array of stone findings with the established intentionality, including the sources so far left out or disregarded in the syllabuses for petroarchaeological studies, is taken into consideration. Thus, not only final products are put into investigation, as has been a normal practice so far, but also natural rock concretions, production waste, and unfinished products. All these sources are subjected to a complex analysis from the point of view of the ways of the exploration of the raw materials, differentiation in their types and kinds, used techniques in stone processing, sizes and assortments of the production and of the range of the forms of organisation of the activities in relation to exploration and processing of the stone raw material. Furthermore, additional research is done aimed at distinguishing and describing the preferences that were used in the selection of raw material in relation to the kinds of tools to be produced.

Studies on the origin of the stone raw materials used by the inhabitants of the region in the past form a significant part in the research project (Chachlikowski 1991, 162-166, 173; 1992, 182-183; 1994b, 152-155; 1994c; 1996; 1997, 141-181, 256-262; 2000, 404; Skoczylas, Jochemczyk, Chachlikowski 1992). The objective of the studies is to sum up the size and the degree of utilisation of the local raw materials (of erratic origin) and imported raw materials (from outside Polish Lowland) in stone production of the local communities. To achieve the above, the currently conducted research aims at: i. evaluation of the structure of the erratic resources within the selected trial areas (in terms of assortment and frequency), and ii. qualification of the assortment of stone material used in the relevant production, especially the structure of the imported raw material.

As it was pointed out earlier the Kujawy research project represents, both in terms of methodological and conceptual approach, a new tendency in the studies on acquisition, mining and processing of stone raw materials in the past. An attempt has been made to construct new methodological and conceptual norms, i.e. to create a new base in defining sources for stone industry (the rules for their discrimination and documentation), and also to form preliminary assumptions as to the taxonomy of the findings within the group of raw materials and to define the methods of their analysis (Chachlikowski 1989, 52-63; 1991, 156-171; 1992, 167-186; 1994b, 31-43, 152-158; 1994c; 1997, 22-44; 2000). In particular, a clear definition of the rules of filing the stone products in question was needed which would be primarily helpful in defining the stone "source" of the product, i.e. in identifying traces of intentional activities pertaining to the findings that presented no evident features of any intentional treatment or usage. At the same time, other proposals, often in opposition to the hitherto existing formulations, have been put forward in relation to formulating justifications of interpretations of manifold and complex manifestations of practices linked with acquisitions and utilization of non-siliceous raw materials among pre-historical communities of Polish Lowland (Chachlikowski 1991; 1994a; 1994c; 1996; 1997).

II. THE GENERAL CHARACTERISTICS OF STONE SOURCES OF LATE-NEOLITHIC COMMUNITIES OF THE KUJAWY REGION

The archaeological excavations carried out in the Kujawy region have unearthed rich and varied source material, which proves the use of a series of production practices followed by the pre-historical inhabitants of the region (Fig. 1). They have also revealed the whole of variety and complexity of the activities connected with exploration and utilisation of stone raw-materials in the communities (Chachlikowski 1989, 1991; 1992; 1994b, 31-43, 152-158; 1994c; 1996; 1997; 1998; 2000).

The present description sums up a certain stage of works conducted within the presented research project. It concentrates specifically on a particularly important period in the stone industry of the early agrarian communities in the Kujawy region, i.e. the period of the intensification of all the activities relating to the acquisition and utilization of stone raw materials among late-Neolithic communities of Funnel Beaker culture (FBC) and Globular Amphorae culture (GAC). As the result of the processes, the stone industry of the time achieved its peak development unprecedented in the history of the whole Neolithic period in the region (Chachlikowski 1991; 1992; 1994b, 152-158; 1994c; 1997; 2000).

Some of the presented aspects of the archaeological and petrological studies of the region deal with the problem of the application of stone raw materials in the stone production of both of the late-Neolithic cultures. In the present approach, the establishments of the previous research conducted from the point of view of the identification of the dependencies between the function (appropriation – purpose) of a product and the kind of rock used for its production have been stressed and emphasised. The results of the research indicate preferences the late-Neolithic inhabitants of the region had in the selection of stone raw material used in the production of the specific kinds of tools.

Base source for the present study is the stone material obtained in the course of the excavation works conducted at 31 sites (Fig.1). Only materials with established intentionality (of localization, treatment or utilisation) and those, which may have been linked, either factually or at least potentially, with the manifestations of the stone industry of just one culture (either FBC or GAC), i.e. the inventories relatively homogeneous have been included. In sum, 66 stone inventories, including 23 that document stone production of FBC settlements and 43 of those of GAC, were put to investigation. Eventually, 1,753 items were ascribed to FBC, while 778 objects were documented as representing GAC. The total weight of 2,531 stone products under scrutiny was 800.35 kg (Chachlikowski 1991; 1992; 1994b, 31-43; 1994c; 1997; 2000)

The overwhelming majority of the sites where the researched material came from is situated within Eolithic forms – dunes or forms capped with a layer of covering sands of Eolithic origin (Chachlikowski 1991; 1992; 1994b; 1997; 2000). In terms of geological context of the places of the findings, the interpretation of these findings as components of natural sediments building up the forms in question is highly improbable. Eolithic forms, from nature, lack rock fractions – stone macroliths – which are suitable for stone tools production in terms of their size. Moreover, the bulk of the studied material was characterised, beyond any reasonable doubt, by clearly identified intentional man's activity represented by traces of different processing techniques or by their use.

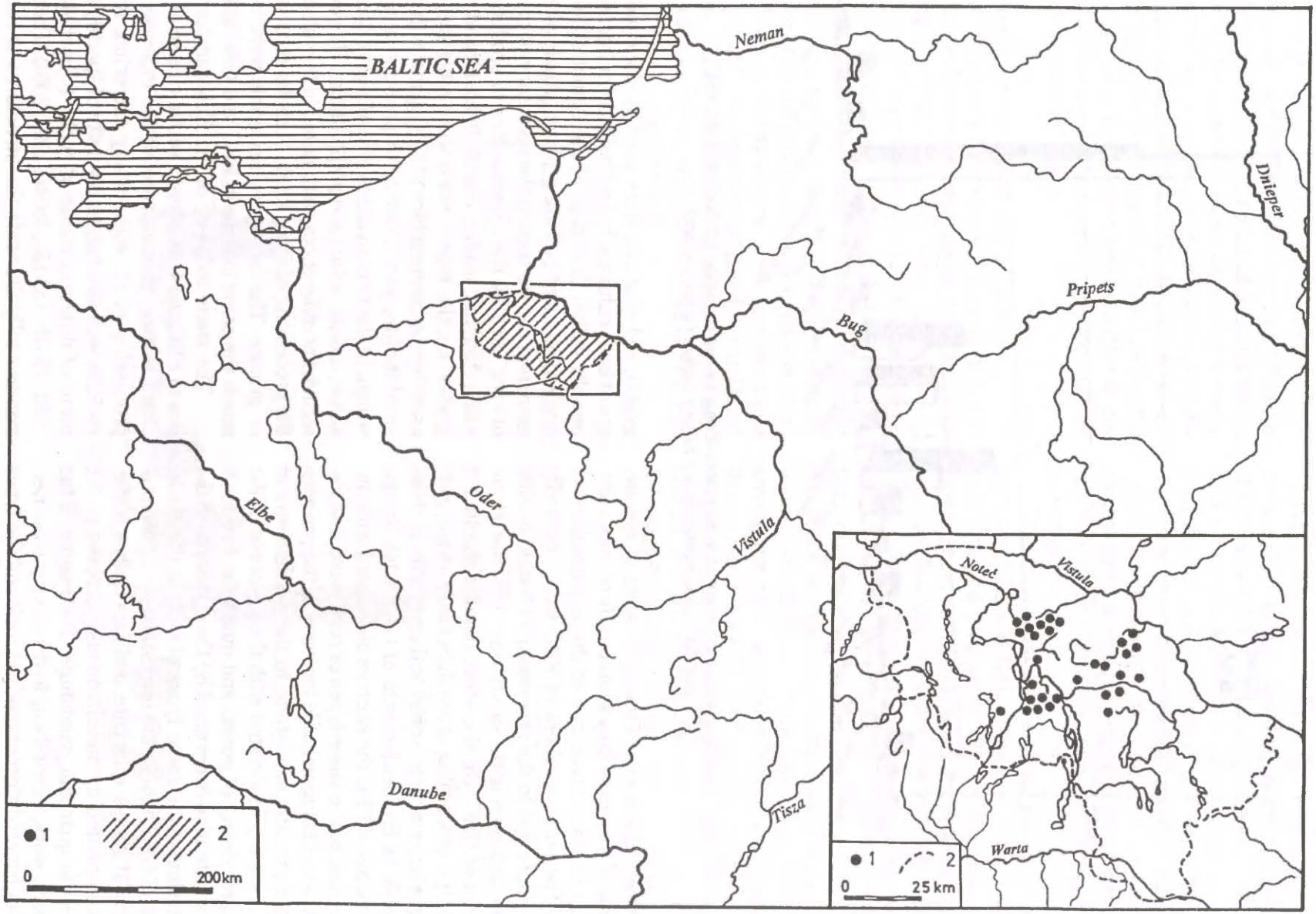
1. Structure of the raw materials of stone sources

In late Neolithic period the communities of the region used in their stone industry a variety of assortment of stone raw material (Fig. 2, see also Table 1). Among the stone raw- materials used by these communities 21 types of individual types of rocks have been recognised. Quartzitic sandstone, gneiss, granite and quartzite were most frequently used for the production of weapons and tools. All in all, they constituted 78.66 per cent of all the stone raw-materials which were used in the stone production of the FBC and GAC communities in the region (1991 articles out of the total number of 2531).

Biotitic gneiss, amphibolite, gabbro, syenite, diorite, basalt, pegmatite, diabase and porphyry were used less frequently. The processing of the remaining number of 8 kinds of rocks took place on a much smaller scale (Fig. 2, see also Table 1).

Despite the far-reaching standardization of the structure of raw material of the stone industry of FBC and GAC , we can notice distinctive varieties among the products clearly distinguishable not only within the range of the size but also in the degree of the use of particular type of rock. And for example, in the material which is associated only with the stone industry of FBC, the processing of andesite and, possibly, mudstone, has been certified, and in the inventories of GAC we can document a signifi-

Fig. 1. Distribution of the settlements-sites of FBC and GAC populations in the Kujawy region the sources included in the present work refer to



Legend: 1 – settlement-sites; 2 – ranges of the Kujawy settlement and cultural mesoregion

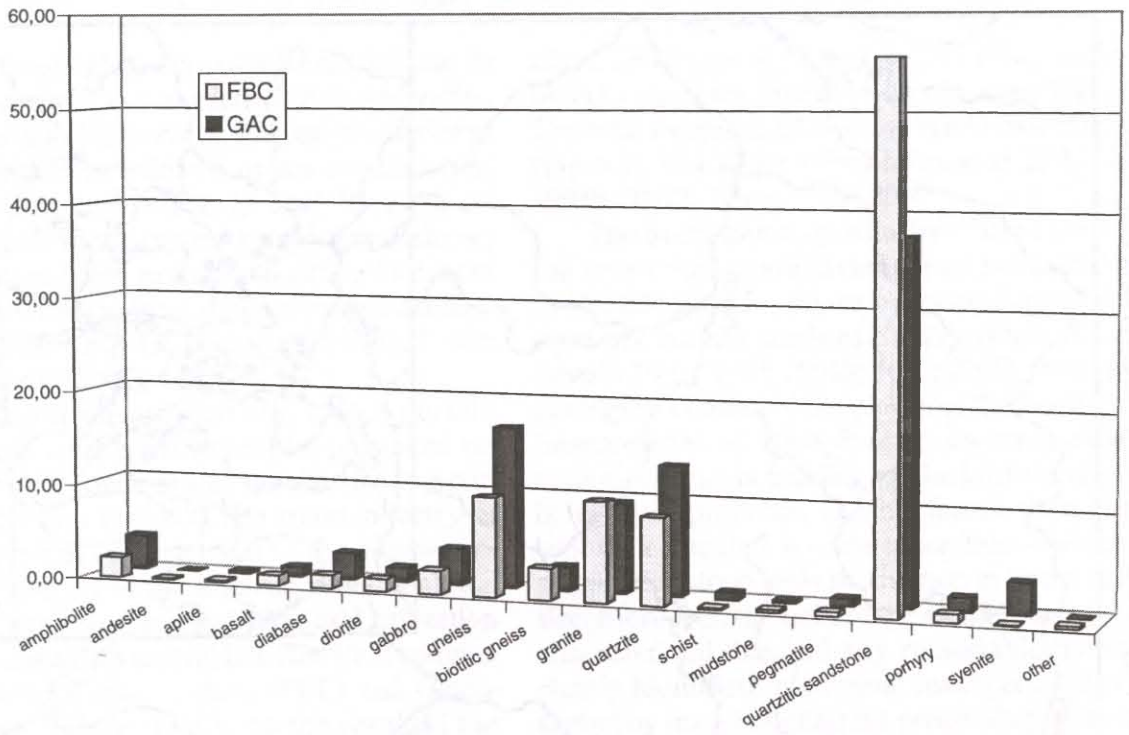


Fig. 2. Comparison of the share of stone raw-materials among the stone production of the FBC and GAC communities in the Kujawy region (in percentage)

cant share of sources of the processing of syenite, the type of rock used only sporadically or even missing in the stone inventory of the communities of FBC. The stone workers of FBC were decidedly more interested in the processing of basalt, biotitic gneiss and quartzitic sandstone than the stone workers of GAC. On the other hand, a significant role of the processing of amphibolite, diabase, gabbro, gneiss, quartzite, schist and pegmatite is clearly visible in the settlements of GAC while in the settlements of FBC the sources associated with the processing of the latter types of rock were less frequent. The distinguishable increase of the processing of quartzitic sandstone in the settlements of FBC is clearly associated with the decrease in the local processing of gneiss and quartzite. Precisely reverse situation is certified by the remnants of the processing of the same types of rock in the settlements of GAC, where the intensification of the processing of gneiss, quartzite, and especially syenite, is accompanied by simultaneous decrease in the interest in quartzitic sandstone. The results of the research work, carried out to discover the connections between different types of rock and the types of tools produced by the communities of FBC and GAC (cf. III), indicate that quartzitic sandstone, gneiss, and quartzite were used by stone tool makers of both cultures, but with different intensity, especially within the range of the output of "milling" implements and polishing plates. Analogous phenomenon can be seen in the inventory of the types of rock used by the communities to produce tools with retouched blades, mainly in basalt and biotitic gneiss, i.e. the types which were most frequently used, by the communities of FBC along with gneiss, amphibolite, and gabbro, to produce axes, and which, in the communities of GAC, gave way to diabase, diorite, schist and amphibiolite. However, no significant differences were noted in the intensity of the processing of other kinds of rocks such as aplite or granite. The latter raw materials were used to much the same degree in FBC and GAC alike.

The stone industry of the Kuiavian communities of FBC and GAC shows with a course of time a characteristic phenomenon of the increase in the processing of all, without any exception, types of rock, as well as a bigger diversity of specific assortment of different kinds of rocks (Chachlikowski 1991; 1994b, 152-158; 1994c; 1997; 2000). These phenomena fully illustrate the structures of rock raw material used by the communities of FBC at the times of Late Beaker horizon, and especially in the

phases IIIC/IVA-IVB FBC, and in the "classic-Amphorae" horizon (i.e. phases IIb-IIIa GAC). In those periods of the development, the communities of FBC and GAC not only used the most versified collection of raw material in terms of its assortment, but also the processing of those types of rock reaches its peak time in an unprecedented way in comparison to the older phases (FBC, GAC), and to the earlier phases of the development (GAC), when the stone processing in the communities evidently decreased and a decidedly modest collection of raw material was used.

2. Structure of the tools of stone sources

The Kuiavian FBC and GAC communities produced basically similar assortment of stone products (Fig.3, see also Table 1). Stone production of FBC and GAC communities in the Kujawy region was primarily targeted at the production of multifunctional tools of every-day use, which were used in households. In the settlements of these communities the processing of rock raw materials in order to produce polishing plates, hammerstones and polishers, mill tools (querns and grinders) and hand axes was clearly dominant. The production of adzes or hammers among the communities of FBC was done on a much smaller scale.

The stone industry of the FBC and GAC communities under investigation is then characterized by a relatively uniform functional profile of the production. The ascertained differences concern only slight frequential diversity of the same type of products among the whole of the number of tools produced by the peoples in question (Fig. 3). The production of adzes, polishing plates and polishers was more intensified with FBC communities while GAC communities were more engaged in the treatment of the available raw material for hand axes, querns and grinders.

The assortment of tools produced in the settlements of FBC and GAC communities did not basically changed throughout the whole period of the development of the two communities in the Kujawy region (Chachlikowski 1991; 1992; 1994b, 152-158; 1994c; 1997; 2000). And though the inhabitants of all the verified FBC and GAC settlements produced basically similar set of stone products, still the intensity of the production in subsequent chronological phases was different. Thus, the stone production among the FBC communities reached its peak in the period of "Late Beaker" horizon, mainly among the group of the Mątwy settlement of the phase IIIC (IIIC/IVA-IVB). Also, in the communities of GAC the biggest number of stone tools was produced in

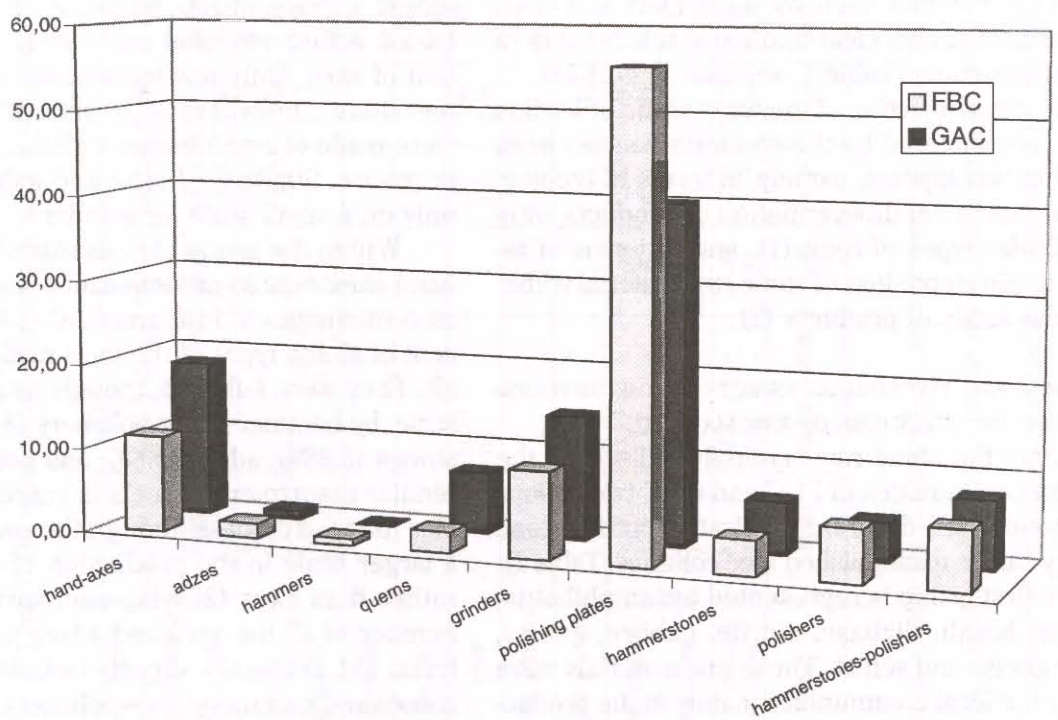


Fig. 3. Comparison of the share of the articles made from stone among the products of the stone industry of the FBC and GAC communities in the Kujawy region (expressed in percentage)

the period of „classic-Amphorae" horizon (phases IIb-IIIa), predominantly however, in the phase IIIa. Much smaller in the number and much modest in assortment was the output of stone tools in the settlements of FBC in the phase IIIA and in the settlements of GAC in the phases IIa and IIIb.

The increase in the stone production of the Late Beaker groups of FBC and „classic-Amphorae" of GAC includes all kinds of tools used by the communities. It is most visible, however, in the production of axes, querns and grinders, polishing plates, hammerstones and polishers, and, in the case of the stone industry of FBC, also in the production of adzes. The remnants of the production of a specific form of a tool which served as a drop-hammer – hammers with a flat base and surrounding groove to fix a handle are connected with the stone industry of the Late Beaker stage of the development of FBC communities (Chachlikowski 1997, Fig. 15:1, 196, 198, 267; 2000, Fig. 1:4, 396). The bulk of the findings of hammers unearthed so far was located in the Kujawy region which may suggest that they represented the kind of tool which had been used predominantly among FBC communities of the area. However, in the settlements of the "classic-Amphorae" settlements of GAC, manifestations of the production of "working" adzes which, formally, were connected with the output of Late Band Pottery cultures (LBPC) or similar to the forms produced by the FBC communities, have been also documented (Chachlikowski 1991, 172, Fig. 1:6, 2:8; 1997, Fig. 37:4, 45:7, 238-239; 2000, 404-405). The inventories of the Kuiavian sources at the same time seriously question the opinion that the stone industry of GAC in the Polish Lowland did not include stone adzes produced independently but it was limited only to adoption and use of forms of other than GAC provenience (LBPC, FBC, Corded Ware culture-CWC). However, the opinion that the local groups of GAC settlements were not able to produce an ingenuous form of an adze still remains in power.

III. THE USE OF ROCK RAW MATERIAL IN THE KUJAWY REGION IN LATE NEOLITHIC PERIOD IN THE TYPOLOGICAL, FUNCTIONAL AND CULTURAL ASPECTS

A distinct relationship between the function (appropriation – purpose) of a product and the kind of rock used for its production has been recorded among the products of the stone production of the late-Neolithic period. Apparently, the structure of stone raw material used by local FCB and GAC communities shows clear and close relationship to the tool structure (Table 1, see also Figs. 4-11).

The reconstruction of the ways of the utilisation of rock raw material by the communities has been viewed in two aspects, namely, in terms of typological and functional differentiation of products within particular types of rock (1), and in terms of assortment differentiation of stone raw material within particular kinds of products (2).

1. Formal and typological aspects of the differentiation of the structure of raw material

Within the stone raw-materials utilised by the Kuiavian communities of FBC and GAC two groups with pronounced different application in the stone industry can be distinguished (see columns, Table 1).

The first group is represented by: amphibolite, andesite, basalt, diabase, diorite, gabbro, gneiss, biotitic gneiss and schist. These raw materials were used by the local communities mainly in the production of tools with retouched blade (with secondary trimming or shaping applied to stone implements), i.e. with hand axes and adzes. Andesite, basalt, biotitic gneiss, and schist were used at the same time exclusively for the production of these types of products. However, most probably, when not only axes but also adzes were made of amphibolite, diabase, diorite, gabbro, gneiss, biotitic gneiss and, possibly, basalt; schist was used exclusively for the production of axes. Only few tools which served as hammerstones, polishers or hammerstones-polishers were made of amphibolite, diabase, diorite, gabbro or gneiss. Similarly, diorite and gabbro were used only on a small scale for grinders.

Within the group of tools made of amphibolite, hand axes were in predominance among the Kuiavian communities of FBC and GAC (a little over 70 per cent of all the types of the tools made of the material). They were followed, though on a much smaller scale, by hammerstones-polishers (8.83%), hammerstones (5.88%), adzes (5.88), and polishers (2.94%). Similar assortment of tools is represented by articles made of diabase, though the rock was used on a larger scale in the production of adzes (25.00%) rather than axes (20.84%) and, what is more, the number of all the axes and adzes made of the material (54.17%) only slightly outnumber hammerstones and hammerstones-polishers (in all 45.83%).

Among the Kuiavian communities of late Neolithic period the following raw-materials were

Table 1. The characteristics of the use of stone raw-materials in stone industry of the communities of the region in late Neolithic times (in percentage)

Type of raw material / Type of product	Amphibolite	Aplite	Basalt	Diabase	Diorite	Gabbro	Gneiss	Biotitic gneiss	Granite	Quartzite	Schist	Mudstone	Pegmatite	Quartzitic sandstone	Porphyry	Syenite	Other	Total
Hand-axes	70,59 *13,71*	- -	85,71 *6,86*	20,84 *2,86*	33,34 *3,43*	52,63 *11,43*	39,26 *36,57*	80,49 *18,86*	- -	- -	100,00 *2,86*	50,00 *1,14*	- -	- -	14,29 *1,14*	- -	50,00 [a] *1,14*	*100,00*
Adzes	5,88 *10,00*	- -	- -	25,00 *30,00*	11,11 *10,00*	15,79 *30,00*	0,61 *5,00*	7,32 *15,00*	- -	- -	- -	- -	- -	- -	- -	- -	- -	*100,00*
Axes/adzes	5,88 *11,76*	- -	14,29 *11,76*	8,33 *11,76*	- -	2,63 *5,89*	3,68 *35,30*	9,75 *23,53*	- -	- -	- -	- -	- -	- -	- -	- -	- -	*100,00*
Hammers	- -	- -	- -	- -	- -	- -	0,61 *14,28*	- -	2,22 *42,86*	2,17 *42,86*	- -	- -	- -	- -	- -	- -	- -	*100,00*
Querns	- -	- -	- -	- -	- -	- -	12,89 *42,00*	- -	17,04 *46,00*	- -	- -	- -	- -	0,15 *2,00*	- -	35,72 *10,00*	- -	*100,00*
Grinders	- -	33,33 *0,67*	- -	- -	22,22 *2,67*	7,90 *2,00*	20,86 *22,67*	- -	41,48 *37,33*	7,25 *6,67*	- -	- -	71,44 *3,33*	3,90 *17,33*	21,43 2,00	57,14 *5,33*	- -	*100,00*
Querns-grinders	- -	- -	- -	- -	- -	- -	3,07 *55,56*	- -	2,96 *44,44*	- -	- -	- -	- -	- -	- -	- -	- -	*100,00*
Polishing plates	- -	- -	- -	- -	- -	- -	- -	- -	- -	63,04 *13,06*	- -	- -	- -	86,81 *86,94*	- -	- -	- -	*100,00*
Hammerstones	5,88 *3,28*	33,33 *1,64*	- -	12,50 *4,92*	22,22 *6,56*	5,26 *3,28*	5,52 [b] *14,75*	- -	14,81 *32,79*	7,97 [b] *18,03*	- -	- -	14,28 *1,64*	0,30 *3,28*	35,70 [b] *8,19*	- -	25,00 [c] *1,64*	*100,00*
Polishers	2,94 *1,35*	- -	- -	- -	- -	- -	6,14 [b] *13,51*	2,44 *1,35*	5,19 [d] *9,46*	9,42 [d] *17,57*	- -	50,00 *2,70*	- -	5,70 [b] *51,36*	14,29 [b] *2,70*	- -	- -	*100,00*
Hammerstones-polishers	8,83 *3,19*	33,33 *1,06*	- -	33,33 *8,51*	11,11 *2,13*	15,79 *6,39*	7,36 *12,77*	- -	16,30 *23,41*	10,15 *14,89*	- -	- -	14,28 *1,06*	3,14 *22,34*	14,29 *2,13*	7,14 [e] *1,06*	25,00 [c] *1,06*	*100,00*
Total	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	

In Rows: in terms of the differentiation of the assortment of stone raw-materials within individual types of products.

In Columns: in terms of the differentiation of the assortment of products (product range) within individual types of rocks.

Note: [a] Andesite and lydite; [b] One of the products also used as a base-plate; [c] Granite-gneiss; [d] Two of the products also used as a base-plates; [e] Products used as a base-plate

utilised on a larger scale: diorite, gabbro, gneiss and porphyry (see columns, Table 1). These raw materials were utilised not only in the production of hand axes, adzes or hammerstones, polishers or hammerstones-polishers but also in the production of mill tools, i.e. querns (gneiss) and mainly grinders (diorite, gabbro, gneiss and porphyry). However, at the same time, diorite and gabbro were used in a more versatile way by the communities of FBC, which utilised these materials in the production of all kinds of these tools, except querns, while the GAC communities used diorite and gabbro for the production of axes (66.68% and 73.34% of all the tools made of the materials, respectively), while in the production of grinders (16.66% and 13.33%, respectively), and hammerstones (16.66% and 13.33%, respectively) used them only sporadically. It is also worth noticing that only among articles made of gabbro and gneiss the forms with retouched blade are in preponderance over the remaining kinds of tools (a little over 71% and nearly 44% of all the kinds of tool produced from the materials, respectively), whilst the frequency of hand axes, adzes, querns and grinders as well as hammerstones and polishers among diorite and porphyry is similar.

However, among the late-Neolithic communities of the Kujawy region, the production of tools made of gneiss had the most functionally diversified range (see columns, Table 1). With the stone workers of FBC and GAC gneiss was commonly used in the production of all kinds of tools except polishing plates. Gneiss was most frequently used in the production of hand axes (39.26%) but querns and grinders (33.75%), hammerstones and hammerstones-polishers (19.02%) followed in the number. Adzes and massive hammers which were used as drop-hammers (pile-drivers) were the least frequent. It is worth remembering at this point, however, that this particular raw-material was, along with quartzitic sandstone, most frequently used in the stone production of the region in the late Neolithic period (cf. Fig. 2).

Articles made of aplite, granite, granite-gneiss, quartzite, mudstone, pegmatite, quartzitic sandstone and syenite represent totally different functional assortment (production range) of tools (see columns, Table 1). The then inhabitants of the region did not use the aforementioned raw materials in the production of articles with retouched blades, i.e. hand axes and adzes, at all. However, these raw-materials were used in the production of large quantities of querns and grinders, polishing plates as well as tools that served as polishers, hammerstones or base-plates.

Among the products made of granite, querns and grinders were represented most frequently (61.48% of all the tools), while hammerstones-polishers (16.30%), hammerstones (14.81%), and polishers (5.19%) were less frequent. Hammers were least numerous (2.22%) within the range of products made of granite. Similarly, a wide range of utilisation in the stone production of the Kuiavian communities of FBC and GAC went to quartzite and quartzitic sandstone though they were used primarily for making polishing plates (63.04% of all the tools made of quartzite and 86.81% made of quartzitic sandstone, respectively). Products made of pegmatite and aplite, scarce in number, represented a relatively narrow scope for production range in the production of tools. The former was represented primarily by grinders (71.44%) and, sporadically by hammerstones and hammerstones-polishers (14.28% each). The latter was used by the inhabitants of the settlements under investigation for the production of grinders, hammerstones and hammerstones-polishers alike. On the other hand, the production of tools made of syenite was very limited in terms of its production range and, basically, limited to the settlements of GAC communities, and was represented exclusively by querns and grinders only with one exception of a single base-plate. Mudstone, on the other hand, was mainly used in the production of polishers. What still remains unanswered is the possible use of mudstone in the production of hand axes in the late-Neolithic communities of FBC (Chachlikowski1997, 202-203; 2000, 405-408).

2. Raw material aspect of the differentiation of the tool structure

FBC and GAC communities of the region used in their stone production not only a relatively diversified but also carefully selected set of raw-materials which were used selectively depending on the function of the final product (see rows, Table 1 and Figs. 4-11).

A strong and marked preference in the selection of raw materials is to be observed in the production of polishing plates (see rows, Table 1 and Fig. 8). For their production only two types of stone were used: quartzitic sandstone, which was absolutely dominant (86.94% of all the polishing plates were made of the material), and quartzite, used on a much smaller scale (13.06%). Similarly with hammers, we can detect a relatively limited assortment

of stone raw materials, which were used for the production of the tools. The most frequent raw materials used for their production were granite and quartzite (42.86% each), sporadically gneiss (14.28%).

Narrow selection is also visible in the selection of raw-materials for the production of hand axes (see rows, Table 1 and Fig. 4). And though for the production of the tool local communities used more diversified set of stone raw-materials (eleven types of individual rocks have been distinguished), still axes made of gneiss (36.57% of all the axes), biotitic gneiss (18.86%), amphibolite (13.71%), gabbro (11.43%), or basalt (6.86%) were the most frequent. Diorite (3.43%), diabase (2.86%) and schist (2.86%) were less frequently used here and porphyry, andesite and, possibly, mudstone, were used only sporadically (in total 3.42%). In the production of adzes, diabase and gabbro were most frequently used (60.00% of all the adzes) and were followed, on a much smaller scale, by biotitic gneiss, amphibolite, diorite and gneiss (see rows, Table 1 and Fig. 5).

For the production of querns, granite (46.00% of all the querns) and gneiss (42.00%) were mainly used and, on a much smaller scale, syenite (10.00%) and, only sporadically, quartzitic sandstone (see rows, Table 1 and Fig. 6). With grinders, a strong predominance of articles made of granite (37.33%) as well as gneiss (22.67%) and quartzitic sandstone (17.33%) over the remaining stone raw-materials, i.e. quartzite, syenite, pegmatite, diorite, porphyry, gabbro and aplite, is easily distinguishable (see rows, Table 1 and Fig. 7).

An extremely differentiated assortment of stone raw-materials was used by the inhabitants of the Kujawy region of the late-Neolithic period in the production of multifunctional tools which served as hammerstones and polishers but especially for the production of articles which combined the function of a hammerstone with that of a base-plate (see rows,Table 1 and Figs. 9-11). A much broader range of raw-materials was used in the case of the hammerstones and hammerstones-polishers production than in the case of polishers and base-plates. With hammerstones for example, there were 12 different kinds of individual rocks. Granite, quartzite, and gneiss were most frequently used (65.57% of all the hammerstones); diorite, porphyry, diabase, amphibolite, gabbro and quartzitic sandstone were less frequent. The remaining raw-materials, i.e. aplite, pegmatite, granite-gneiss were represented, in each instance, only by a single specimen of the tools. In the production of hammerstones-polishers, granite

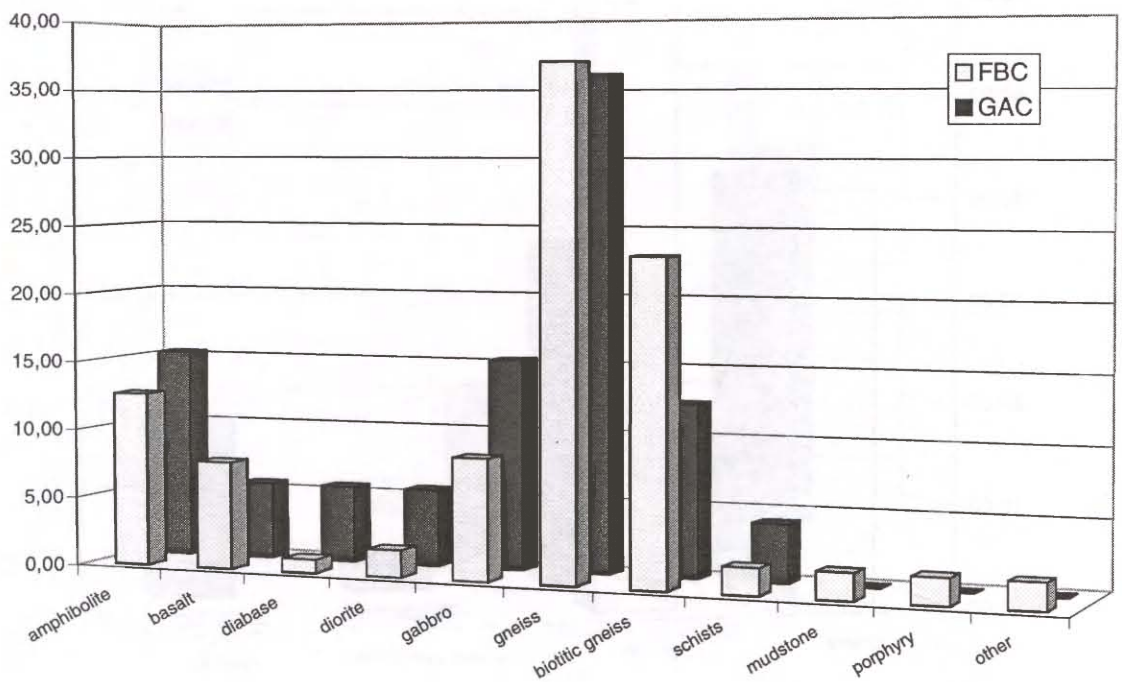


Fig. 4. Comparison of the share of stone raw-materials among hand axes of FBC and GAC communities of the region (in percentage)

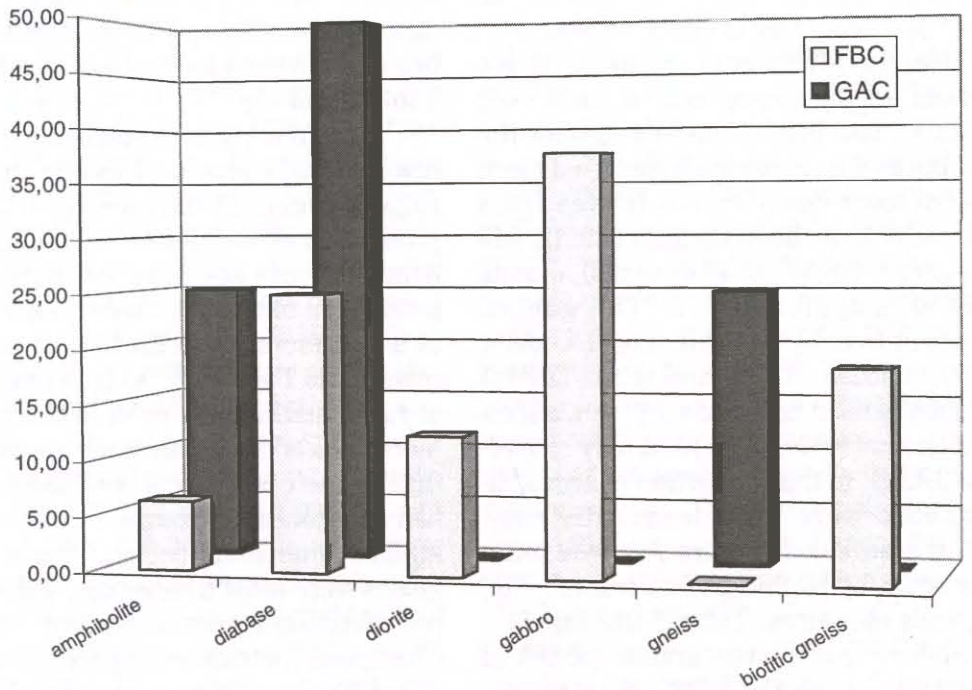


Fig. 5. Comparison of the share of stone raw-materials among adzes of FBC and GAC communities in the region (in percentage)

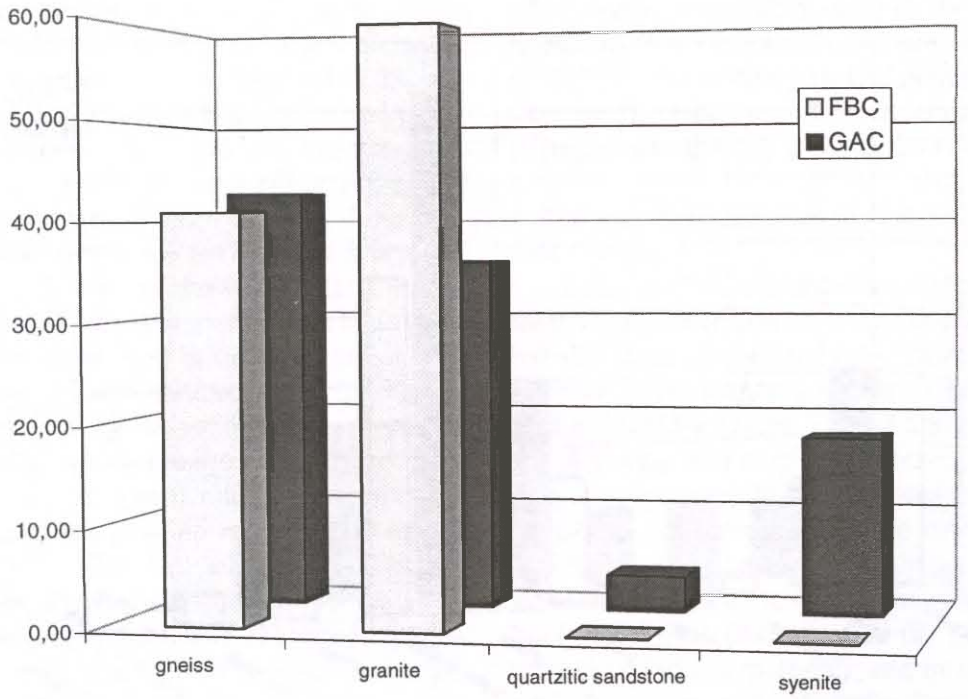


Fig. 6. Comparison of the share of stone raw-material among querns of FBC and GAC communities in the region (in percentage)

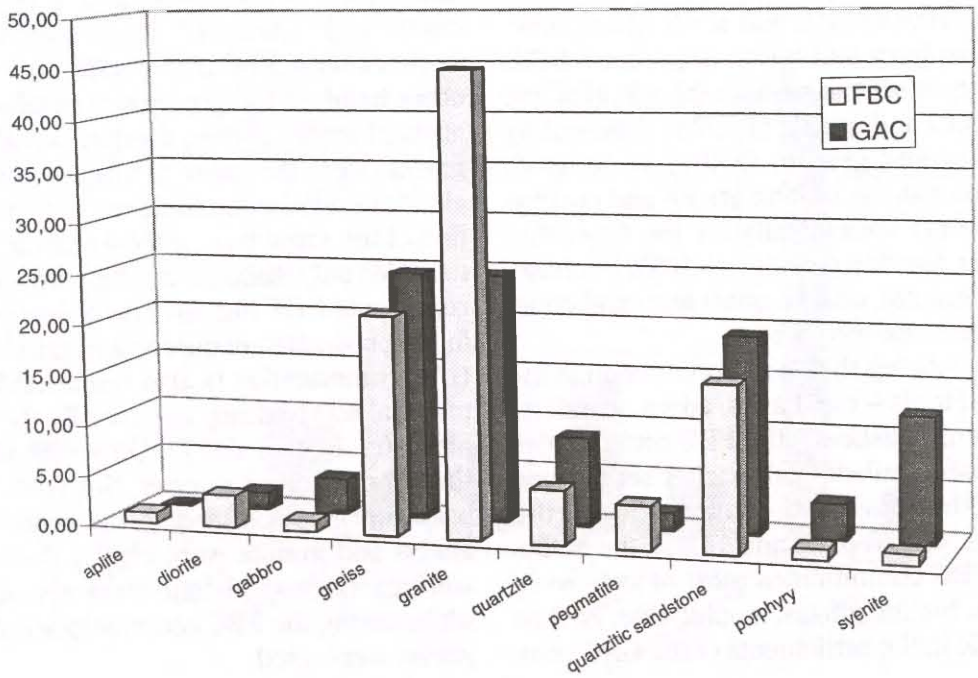


Fig. 7. Comparison of the share of stone raw-material among grinders of FBC and GAC communities in the region (in percentage)

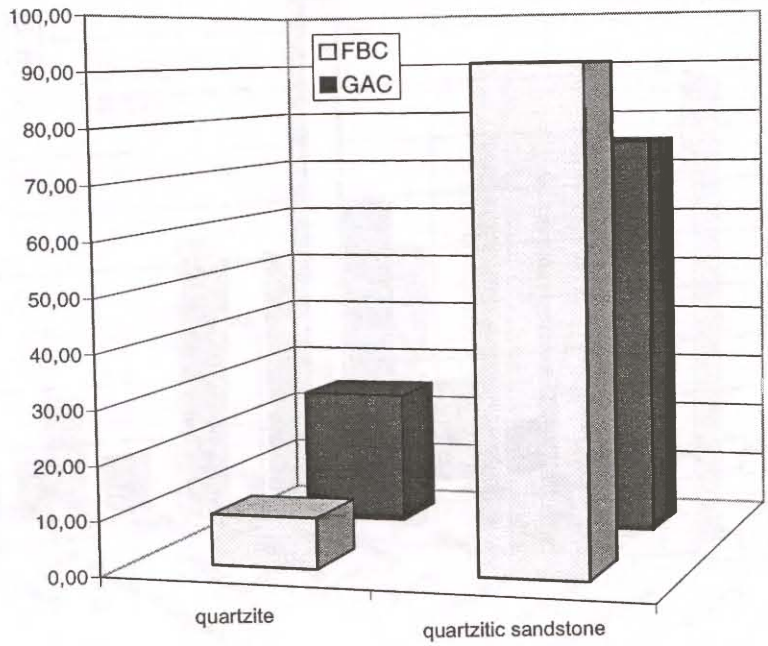


Fig. 8. Comparison of the share of stone raw-material among polishing plates of FBC and GAC communities in the region (in percentage)

(23.41%), quartzitic sandstone (22.34%) and quartz (14.89%) were used and, to a lesser degree, gneiss, diabase and gabbro (together 27.67%). The least number of this kind of tools was made of amphibolite, diorite, porphyry and aplite (together 8.51%). For polishers, quartzitic sandstone (51.36% of all the tools in question) and quartz (17.57%), followed by gneiss (13.51%) and granite (9.46%) were used. Amphibolite, mudstone, biotitic gneiss and porphyry were used only sporadically for the tools that served a similar function (together 8.10%). For baseplates, gneiss, granite, quartz, quartzitic sandstone, porphyry and syenite were used.

It is worth noticing that in the production of the widest range of tools – hand axes, adzes, grinders, hammerstones or polishers – the FBC communities of the region used a substantially richer set of stone raw-materials than the GAC communities of the region (cf. Figs. 4, 5, 7, 9, 10 and 11). In the settlements of the FBC communities most of axes were made of gneiss, biotitic gneiss, amphibolite, gabbro and basalt, while in the settlements of the GAC communities more axes were made of gabbro and amphibolite than of biotitic gneiss. The GAC communities used in the production of the tool diabase, diorite and schist on a larger scale than the stone workers of the FBC communities (cf. Fig. 4). On the other hand, in the production of adzes, gabbro, diabase, biotitic gneiss, diorite, possibly basalt and gneiss, were the most commonly used raw-materials in the FBC communities, while for the production of the same type of tools among the GAC communities only diabase, amphibolite and gneiss were represented (cf. Fig. 5). The occurrence of syenite in the production of querns and grinders among the GAC communities is also remarkable as this raw-material was basically not used by the FBC communities (cf. Figs. 6 and 7). Only with the instance of the production of querns, the GAC communities used more varied in type raw-materials. Though gneiss and granite were clearly dominant, syenite and quartzitic sandstone were also distinguished, while among the FBC communities only granite and gneiss were used.

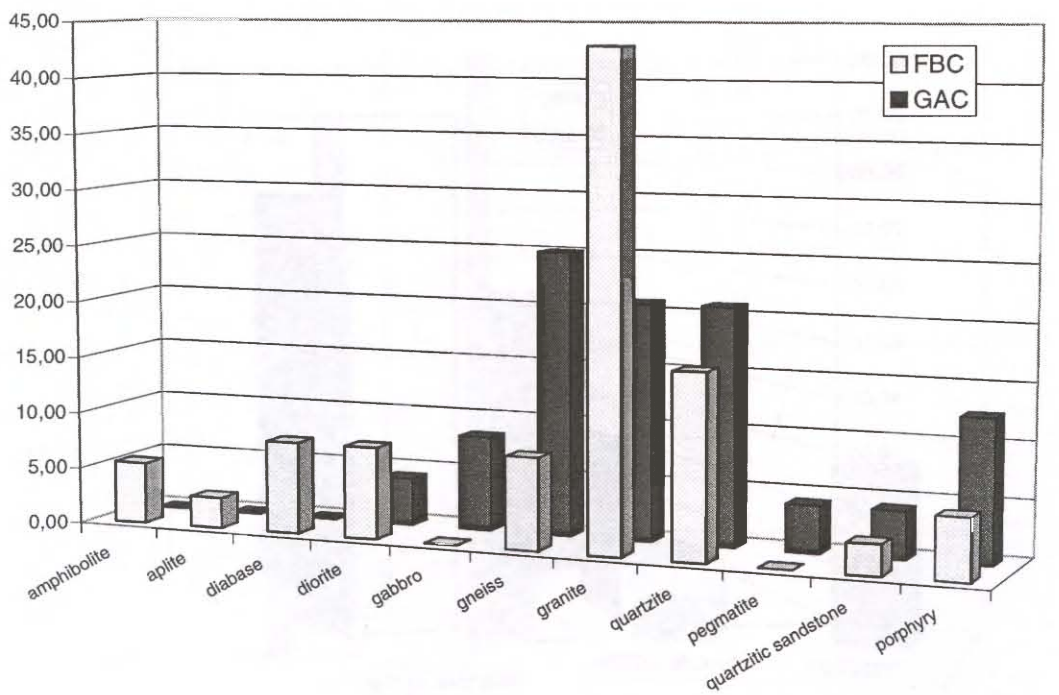


Fig. 9. Comparison of the share of stone raw-material among hammerstones of FBC and GAC communities in the region (in percentage)

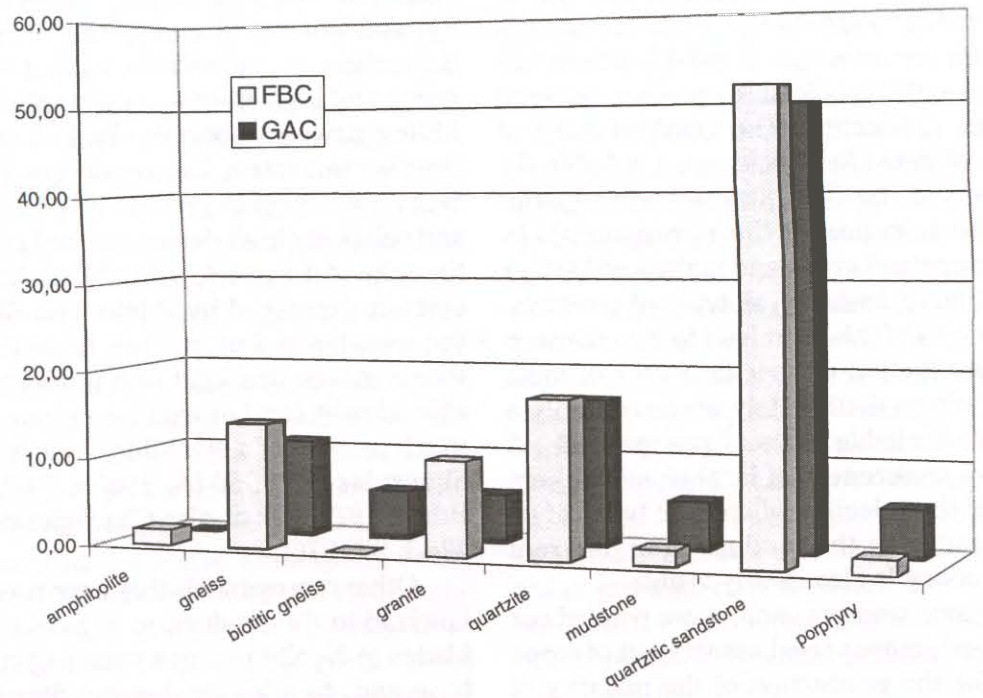


Fig. 10. Comparison of the share of stone raw-material among polishers of FBC and GAC communities in the region (in percentage)

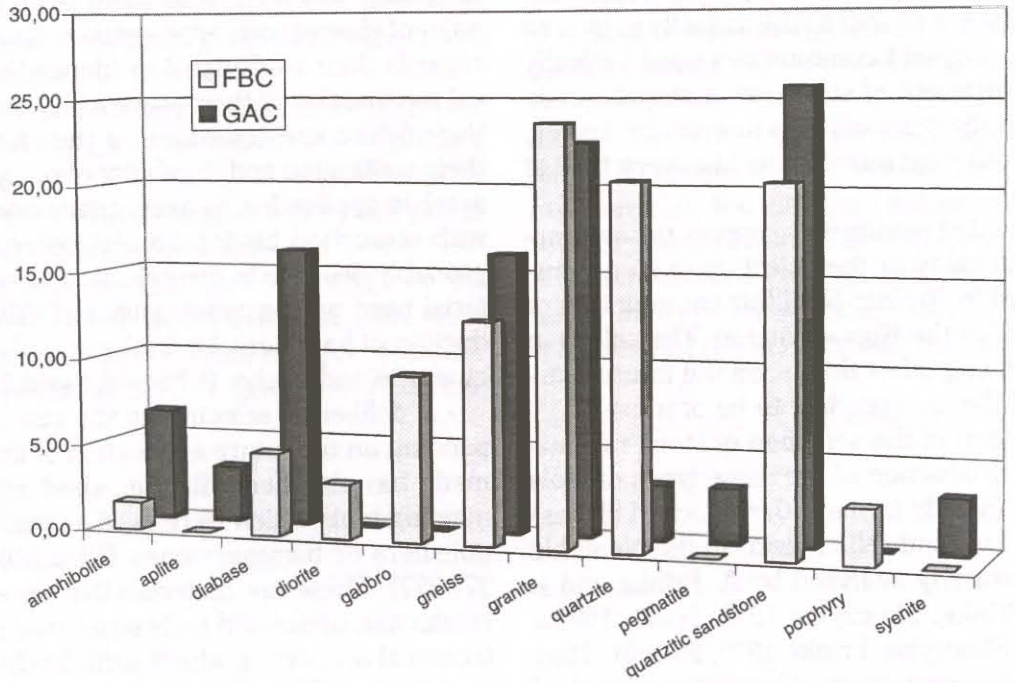


Fig. 11. Comparison of the share of stone raw-material among hammerstones-polishers of FBC and GAC communities in the region (in percentage)

DISCUSSION AND CONCLUSIONS

It is evident from the presented detailed investigation that the structure of the stone raw-materials used in the region in late Neolithic times was closely related to the profile of the product range of the local stone production. The manifestations of the selection of individual rocks most suitable for the production of the final product were distinguished in the selection of the raw-materials in terms of their type and grade and in their utilisation in the production of, basically, all types of products. The dependencies of this kind lead to a conclusion that for the production of specific forms of tools local stone workers deliberately preferred only a selection of the available types of raw-materials. A concurrence in preferences of local stone workers in the range of the selection of specific types of individual rocks used in the production of different tools and weaponry is also clearly visible.

The FBC stone workers used, as we pointed out earlier in the text, more varied assortment of stone raw-material for the production of the majority of tools. However, the most important differences among the communities of FBC and GAC deal only with the volume of the utilisation of some of the individual types rocks in the production of the same articles, predominantly hand axes, adzes and mill tools. But for the production of multifunctional tools of everyday use such as polishing plates, hammerstones or polishers as well as the majority of querns and grinders, the said communities used basically the same assortment of stone raw-materials, making use of specific types of rocks to a similar degree, though with different intensity within every type of the tools.

The presented results may support the assumption of intentionality in the selection of stone raw-materials used by the late-Neolithic communities of FBC and GAC in the Kujawy region. The selection was based, among other things, on the future function of the of the final product to be produced.

The question of the selection of stone raw-materials in the production of the same types of tools and weapons (mostly forms with retouched blades) in the Polish Lowland (Niż Polski) in the Neolithic period was formerly analysed by A. Prinke and J. Skoczylas (Prinke, Skoczylas 1978, 56-60; 1980a; 1980b, 70-72; Skoczylas, Prinke 1979, 98-105). They believed that the most sought-after features that had decided on the selection of specific types of rocks in the production of the said articles was for the local stone workers: high tightness (minimal porosity) and low absorbability, which secured substantial resistance to physical effects of frost and weathering, and high specific weight which allowed high hitting power despite the limited size of the tool. Another important feature was good fissility, which was very helpful in processing of the raw material, and relatively high denseness and compactness for the sake of the article's durability. According to the opinion expressed by Prinke and Skoczylas all of the mentioned features are to be found in basalt which makes this kind of trap rock the most suitable, almost ideal or exemplary raw material, very much in need of a Neolithic stone worker (Prinke, Skoczylas 1978, 56-59; 1980b, 71-72; Skoczylas, Prinke 1979, 105; cf. also Chachlikowski 1996; 1997, 42-43, 275-276).

Other raw materials that were used in the Polish Lowland in the production of tools with retouched blades in Neolithic times such as amphibolite, diabase and, to a lesser degree, diorite, gabbro or gneiss possess similar physical properties to basalt (Chachlikowski 1997, 276-277). It is then proper to assume that the said raw materials were carefully and accurately selected by the stone workers of FBC and GAC from among other types of rocks at their disposal in the available erratic material. The next step was to choose them from carefully the point of view of their appropriation (purpose), i.e. as regards their workmanship (depending on technical possibilities of their processing) and as regards their future use (considering the effectiveness of their application and durability of ready-made products) in application to axes, adzes and other tools with retouched blades. Similar criteria were most probably decisive in the selection of stone raw material used by the communities of FBC in the production of hammers, i.e. in the selection of granite, quartzite and gneiss (Chachlikowski 1997, 276).

A deliberate selection in the raw materials depending on the future application of the tools to be made has also been distinguished among the remaining tools which were used as polishing plates, polishers or hammerstones (Chachlikowski1997, 276-277). These raw materials that were used in the production of the said tools possessed physical and technical properties which sufficiently met the expectations of their users. And it was polishing plates that were represented exclusively by quartzitic sandstone, less frequently by quartzite which have

high grinding and polishing properties. On the other hand, for hammerstones and other tools which combined the function of a hammerstone and a polisher, raw materials were selected that were distinguished not so much by their good polishing or grinding properties but also by a high degree of hardness and high compactness (which was decisive in the resistance of the rock material to blows or hits).

The whole of the remarks described hitherto confirms the feasibility of the assumption that the choice of stone raw materials in the stone production of the FBC and GAC communities of the region was not accidental but intentional and depended on the function of the final product. The dependencies of this kind were distinguished in the choice of the types of raw material used by the local stone workers in the production of, basically, all types of functional tools (see Table 1 and Figs. 4-11).

In keeping with the above assumption is the reasoning that the preferences of the local stone makers in the selection of local raw materials were shaped not only by cultural factors, i.e. symbolic and communicative factors, but also by technological and utilitarian criteria. The thing is that physical and technical properties of specific raw materials were decisive in the choice made in their selection for special purposes in the production of specific tools and weapons. It was because of those specific properties of different types of rocks that a narrow selection of stone raw materials took place. The selection was targeted functionally, i.e. in relation to the available assortment.

The shown relationships between the function of a tool and the type of rock used for its production prove beyond any doubt that the late-Neolithic inhabitants of the Kujawy region had a high practical knowledge on stone raw material in the Lowland. They also prove that the knowledge on the erratic raw material of the area that the local stone workers possessed allowed them to repeat a specific choice, always the same, of a given assortment of individual rocks. It is worth remembering here though that because of the geological conditions of Kuiavia, basic source of raw material for its inhabitants in Neolithic times were local erratic blocks, i.e. foreign to the surrounding strata and transported from their original sites by glacial action. The utilization of local erratic blocks in the stone industry of the FBC and GAC communities was absolutely common regardless the type of a final product to be produced from the raw material. Geological specificity of the Lowland which lacks natural deposits of the majority of stone raw material used in the Neolithic stone industry required the local stone workers to possess an advanced empirical knowledge of the local resources of erratics. The exploration of stone raw materials for the production of tools and weapons by the exploitation of local erratic blocks was linked with the necessity of continual selection of certain kinds and types of stone raw-materials (believed to be of better suitability in the production of specific articles) among other available Lowland erratics. Quite different condition had been formed in the areas rich in stones, where the problem of selection of raw material occurred just once, i.e. at the time of the selection of a deposit for further exploitation.

The increase in the demand of the stone raw material recorded in Kuiavia in late Neolithic also required from stone workers good knowledge of geology of secondary deposits of local raw material (moraine pavements), mainly in identifying potentially available areas of natural assemblages of erratics, especially those which were rich in sufficiently numerous and varied rock material. One may well arrive at a conclusion that the choice of raw materials for the stone industry depended on the cultural tradition of the late-Neolithic communities and on the type of the final product. The availability of particular suitable kinds of stone raw material among the erratics was only marginal.

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