# Methodical Concepts and Assumptions Underlying Research Methods for Studies on the Erratic Raw Material of the Polish Lowland. Geology versus Archaeology

Piotr Chachlikowski

Institute of Archaeology, Adam Mickiewicz University in Poznan, Umultowska 89D Street, 61–614 Poznan, Poland
e-mail: piocha@amu.edu.pl

**Abstract**: Inadequate levels of identification of glacial resources of raw materials in the Polish Lowlands areas and unreliable geological determinations of the assortment and frequency of local Fennoscandian erratics have established the opinion among archaeologists of alleged shortages in appropriate petrologically differentiated material necessary for stone industry in glacial areas. The claim has been made that raw material shortages were supplemented by massive imports of exogenous rocks from areas of their natural deposits. Yet a long study undertaken by the author on the Lowland inventory of erratics has proved that they constituted an extremely abundant and lithologically diversified source of raw materials. In the study, relatively large numbers of boulders and pebbles have been examined, regardless of their so-called indicating usefulness and with their appropriate overall measurements parameters taken into consideration. The exceptional abundance of local glacial 'deposits' effectively balanced the deficit in imported rock raw material for the local stone worker and inhibited the demand for imports.

Keywords: Fennoscandian erratics, research methodology, the Polish Lowland, prehistoric stone industry

## Introduction

Due to its geological structure, the area of the Polish Lowland essentially lacks natural deposits of most significant types of non-flint raw materials that were procured and exploited by man in the prehistoric past. Similarly to other areas covered by the last Pleistocene continental glaciation, glacially deposited rock material identified in the area[1] and transported away by ice sheet from distant source regions, not only accounted for an easy reservoir of raw material close at hand for prehistoric inhabitants of the area, but also constituted the primary source, and until early historical times the only one, for stone acquisition. It is not surprising then that existing scholarly knowledge and interpretation generally assume that the societies inhabiting the great valley belt of the Polish Lowland in the past, and more generally the population of the early glacial landform areas, procured raw material for stone production primarily by exploiting local resources of erratic rocks (cf. Chachlikowski 1991, 1994, 1997, 2000, 2007, 2010 and 2013; Chachlikowski and Skoczylas 2001a, 2001b and 2001c; Szydłowski 2011; Pomaniowska 2012; further references therein).

The inhabitants of these areas also utilised rock materials, though on a decidedly smaller scale, that was gained by way of the procurement of exogenous raw materials, i.e. 'imports' from areas rich in stone deposits, generally located south of the Polish Lowland areas. It has been scientifically established that the utilisation of exogenous rock materials, i.e. non-endogenous and from outside the Polish Lowland, by the local population was a phenomenon not only inconsistent[2] but also, and what is particularly important, with just a marginal significance for the stone raw material industry in early agrarian societies of the Polish Lowland. Research to date on imports of raw materials used in the Polish Lowland in the Neolithic and early Bronze Age has shown that the 'imports' did not include all stone raw materials available in areas of their natural deposits and located outside the Lowland. The phenomenon of the procurement of exogenous material by the contemporary population was limited to just those types of rock that were used for the production of a relatively narrow assortment of products, predominantly forms that were more culturally characteristic – in particular those with a cutting edge. Moreover, even within this category of products, the share (and contribution) of imported raw materials was only incidental. The exceptions are products related to the early Neolithic stone industry and, to a lesser degree, tool implements made by the middle Neolithic colonists of the Polish Lowland that represented cultures that spread from the Danubian region.[3]

[1] For erratic rock materials (synonymous to erratic boulders or pebbles) mapped in glacial deposits in Poland, the areas of relevant corresponding resources to their natural origin (source regions) are: Scandinavia with the Baltic states and the Baltic Basin, i.e. the area of the so-called Baltic Shield (or the Fennoscandian Shield). Fennoscandian erratic pebble assemblages in the Polish Lowland represent all types of rocks, i.e. igneous, metamorphous and sedimentary (see: Konieczny 1956; Dudziak 1970; Nunberg 1971; Meyer 1983; Lisicki 2003; Woźniak 2004; Czubla *et al.* 2006; Górska-Zabielska 2007, 2008a, 2008b and 2010; Górska-Zabielska and Zabielski 2010; Czubla 2011, 2015).

[2] With regard to both the assortment composition of raw material and the areas of their provenance and the intensity or chronology of the reception of the 'import' in prehistoric societies of the Lowlands.

[3] From among the exogenous raw materials exploited at the time by

The key issue in the study of the origin and utilisation of stone raw materials, i.e. the so-called stone industry of the societies that inhabited the vast plains between the Oder and Vistula rivers in prehistory (but also in early historical times), is to distinguish and evaluate the local resources of erratic raw material – glacially deposited rocks that rest on the area following the activity of the last Pleistocene Scandinavian ice sheet. The question of a proper evaluation of the raw material inventory in the Lowland in lithic material constitutes in fact an extremely important, though still underestimated and not adequately addressed scientifically, research area of the archaeology of the Middle European Plain.

Meanwhile, the recognition and evaluation of the structure (in terms of assortment and frequency) of erratics from the Polish Plain as well as the evaluation of the local resources of glacial rocks belonged until quite recently to these issues of prehistory that were not addressed by scholarship at all or only addressed inadequately. The above opinion applies to the research practice both at home as well as in other Central European countries. This sphere of man's activity in the remote past, related to the procurement and use of one of the basic raw materials by the population that inhabited the Polish Lowland, still remains inadequately scholarly researched and meagerly elucidated in prehistoriography. Although this unsatisfactory state of knowledge on erratic stone raw materials of the Polish Lowland slowly improves, things as they are indicate that these issues still remain somewhat marginal in terms of dedicated areas of research and research initiatives and projects, both for prehistoric and early historic archaeology. This state of affairs has primarily resulted from a lack of appropriately methodologically approached field surveys, (with strict research agenda and properly documented in sources), that would be aimed at evaluating the inventory of rock raw materials – Fennoscandian erratics.

Inadequate levels of recognition of glacial Scandinavian erratics that rest on the areas once covered by the last Pleistocene glaciation have prevented researchers from performing an insightful and truly reliable profile of the available glacial lithic reservoir of this area. Let us recall that it was the only accessible source for the local stone industry of the inhabitants of the Polish Lowland in prehistory. Shortages of interdisciplinary field surveys and accompanying research output, as well as methodical shortcomings of heretofore incidental research projects,[4] have limited to the minimum any attempts to approach erratic raw materials from the perspective of the evaluation of the participation of local lithic resources in satisfying the demand for rock raw materials for the local population.

## 1. Outline of the geological questionnaire for research on Fennoscandian erratics and its consequences for rock raw material archaeology

It should be recalled at this point that despite obvious shortcomings (from the perspective of requirements of the archaeology of rock raw materials) of a geological questionnaire of research on petrography of glacial erratics in the areas within the reach of the Scandinavian glacial, an attempt has nevertheless been made. Its authors, Andrzej Prinke and Janusz Skoczylas (1978, 1980: 46–49), in order to assess the frequency and assortment inventory for glacial stones (erratics), used all the available results of geological research on the petrography of erratics that rest in glacial deposits in areas of early glacial landforms.

It turns out, though, that the relevant geological studies available to Prinke and Skoczylas at the time, and used by both researchers to characterize the petrographic composition, frequency and number count of Fennoscandian erratics in the Polish Lowland, cannot be treated as sufficiently representative and reliable sources of knowledge on the real abundance of erratics in the local raw material reservoirs of this area. The above reservations notably apply to determinations of the diversity of the assortment of the local rock material, in particular those relative to the frequency of particular lithological rocks available in the resources of erratics in the Polish Lowland.

In the opinion of the author, doubts and uncertainties as to comprehensiveness and authoritativeness of the determinations of the existing geological research on the characteristics of the erratic resources in the

the local population, the following have been identified more thoroughly: amphibolite, basalt, schist of different types and serpentinite from the Sudety Mountains, the Bohemian Massif and of Volhynian provenance (see: Prinke and Skoczylas 1980a, 1980b; Majerowicz *et al.* 1981, 1987a and 1987b; Chachlikowski 1996, 1997, 2013; Skoczylas *et al.* 2000; Chachlikowski and Skoczylas 2001b; Krystek *et al.* 2011).

[4] Existing studies of the assortment and frequency of glacial erratics of the Polish Lowland are burdened by vagueness and a great number of methodical shortcomings. They mainly refer to applied criteria for delimitation of erratic samples indicated for lithological surveys (Skoczylas 1989, 1990: 80–84; Grygiel 2004: 127–132; Szydłowski 2011: 296–302; Pomianowska 2012). The cited studies define the rules for a determination of the petrographic composition adopted in the relevant analysis of selected rock material for examination in a very imprecise way, or even do not include them at all. The criteria adopted and described by the above cited authors on more than one occasion do not satisfy the requirements for proper sample delimitation, namely those concerning their sufficient size and overall measurements, i.e. those related to appropriate shapes and dimensions of rock concretions submitted for scrutiny. As a result, one can discover significantly dissimilar criteria for a delimitation of glacial erratic samples identified for archaeological and petrographic examination than those adopted in research studies on erratics of the Polish Lowland written by the author (mostly with reference to the methods for their acquisition, their count and measurements). For more on the subject, see Chachlikowski 2013: 28–37, 138–145.

Lowland stem from fundamentally different research goals involved, as well as from the relevant construction of methodical standards formulated in geological studies and surveys[5] and in the author's own research plan for the archaeology and geology of the Polish Lowland (see: Chachlikowski 1991, 1994, 1996, 1997, 2000, 2007, 2010 and 2013; Chachlikowski and Skoczylas 2001a, 2001b and 2001c).

These doubts come primarily from the fact that a geological questionnaire for research comprises a relatively small part of the erratic rocks resting in the area, or, more precisely, limited exclusively to glacial erratics. These analyses were nevertheless limited exclusively to erratics that had a strictly defined the so-called indicating usefulness that allowed these rocks to be identified with their natural deposits, i.e. the so-called indicator rock types and erratics with limited indicating significance. Erratics were selected for research studies mainly to indicate corresponding Fennoscandian source regions and, at the same time, to establish the direction of transgression of the ice sheet to the place of the deposition of sediments, or to reconstruct the probable course of the tracks of the long-range glacial transport and the ranges of successive Pleistocene ice cap. The usefulness of an analysis of petrographic composition of erratic rocks for the stratigraphic distribution (lithostratigraphy), or, should need arise, a determination of the age of quaternary glacial sediments that contained them (chronostratigraphy), was also considered (see: Konieczny 1956; Dudziak 1970; Nunberg 1971; Meyer 1983; Czerwonka and Krzyszkowski 1994; Czerwonka 1998; Lisicki 2003; Woźniak 2004; Zabielski 2004; Czubla *et al.* 2006; Górska-Zabielska 2007, 2008a, 2008b and 2010; Czubla 2001, 2015; Rutkowski 2007; Górska-Zabielska and Zabielski 2010).

Meanwhile, in the opinion of geologists, and generally accepted by all, examinations of the petrographic composition of erratics routinely conducted in studies on the geology of the Pleistocene and the Quaternary comprise only about 40–50% of all rocks occurring in glacial erratics of early glacial areas. From that number 10% include indicator erratics, whereas a further 30–40% of the total amount of boulders and pebbles deposited in the area are the so-called indicator erratics (e.g. Meyer 1983; Czubla *et al.* 2006; Górska-Zabielska 2007, 2008a, 2008b, 2010). All the remaining Fennoscandian glacial erratics, i.e. rock varieties that do not have any indicating usefulness, are consistently omitted in the practice of research on the petrography of sediments that contributed to the land formation of the early glacial landscape (glacial tills and fluvio-glacian sediments). Thereby, over half, in fact as much as 50–60%, of the total number of glacial raw materials in the Polish Lowland, still lies beyond any register of the geological questionnaire. This fact was not, and understandably remains, irrelevant to the correct and reliable determination of glacial rock resources needed for prehistorical stone workers in the areas of the great plains between the Vistula and Oder.

Moreover, depending on the size classes of erratic stone samples identified for scrutiny, the results of available geological studies, including those cited by Prinke and Skoczylas, differ in assessing the reservoir of erratics occurring in the Polish Lowlands, not only in terms of their petrographic composition, but also, and which is particularly important, in terms of the estimations of the number of recognized varieties of rock. At the same time, none of these findings are based on the analysis of rock fractions useful for archaeological considerations, i.e. they do not cover these erratic concretions that were useful, in terms of their overall dimensions, to prehistoric stone implement production. In other words, the existing studies of the petrography of Lowland erratics ignore rock blocks that would meet the strict archeometric criteria. This would refer to those specimens which – due to their shape and size – would have been perfect for all kinds of products that were produced by the stone industry in the Lowland in prehistory. But then the findings of geological investigations show that the petrographic composition, or more exactly the frequency of certain varieties of raw materials present among erratics, is not irrelevant when it comes to the fraction of the selected research material.

A choice of erratics for a lithological survey based on specifically and strictly established routine archeometric criteria, that is on one that would include only those specimens that have their shapes and dimensions appropriate for use in prehistoric stone production, has a very specific, and at the same time very important justification. At this point, one should refer to past experience in geology studies conducted over petrography of Lowland Fennoscandian erratics. We can see, therefore, that numerous studies on the petrographic composition of erratics resting in the sediments of glacial and fluvio-glacial accumulations of the last Pleistocene glaciation attest to the indisputable relationship between the composition of the inventory of erratics types of rocks and the fractions identified for examination. It turns out that, along with the increase in the size of analysed erratic concretions, there are significantly increased shares of the so-called crystalline rocks (specifically igneous rock, mainly granite, and, to a lesser extent, metamorphic rocks, mainly gneiss) at the expense of sedimentary rocks,

[5] Notwithstanding, it seems absolutely obvious that from the point of view of questions to be posed in geological research on Scandinavian erratics, the selection (assortment) and range of applied methods has undoubtedly been, and still remains, correct, while the results achieved in this way are by all means reliable and authoritative.

such as sandstones and quartzites (e.g. Konieczny 1956; Dudziak 1970; Nunberg 1971; 1974; Czubla 2001, 2015; Rutkowski 2007; Górska-Zabielska 2008a, 2010; Górska-Zabielska and Zabielski 2010). This means that the larger the size fraction of erratics selected for petrographic examination are, the more numerous will be the igneous and metamorphic rocks in the analysed sample, whereas the frequency of sedimentary rocks will decrease.

Meanwhile, let us recall that earlier studies on Fennoscandian erratics in the Polish Lowland conducted by geologists, and on a larger scale, in areas covered by the last Pleistocene glaciation, predominantly take into account rock fractions that were generally useless to the prehistoric stone industry in the area, on account of their dimensions. Ultimately, most of the petrographic studies of Lowland glacial and fluvio-glacial deposits included an identification of lithological types of rocks among those erratics that either had a very small size (unconsolidated rock fragments – gravel medium and coarse fraction), or were boulders with dimensions in excess of a few, ten, or even several tens of meters in diameter (see: Skalmowski 1937; Konieczny 1956; Dudziak 1970, 1974; Numberg 1971; Meyer 1983; Czubla 2001, 2015; Lisicki 2003; Woźniak 2004; Czubla *et al.* 2006; Górska-Zabielska 2007, 2008a, 2008b, 2010; Rutkowski 2007; Górska-Zabielska and Zabielski 2010). It was also the size classes identified for the analysis of erratics that primarily influenced the results for the assessment of the resource of erratic raw materials – in terms of their overall diversification in the assortment (petrographic composition) and, what is vital, the number of particular varieties of rocks. The vast majority of existing geological analyses, though, ignore and exclude the analysis of these erratic fractions that would have been potentially useful – on account of their overall dimensions – in the production of all known products of stone implement manufacture in the Polish Lowland in prehistory.[6]

We already know that the stone production communities in the Polish Lowland in prehistory applied two basic techniques for handling rock blocks. Generally speaking, a method for manufacturing stone products depended on the shape and dimensions of rock nodules (concretions, lumps of stone material) that were selected as a raw material for tool implement production. The first method involves a technique of morphometric adaptation of rock blocks (straight on the natural lump of raw material), while the other is a technique based on their significant morphometric transformation (see: Chachlikowski 1991, 1997, 2000, 2007, 2010 and 2013; further literature therein).

For obvious reasons, gravel fractions of erratics, especially those small in size (i.e. with a diameter of less than 6mm), remained beyond the interest of the prehistoric stone worker. On the other hand, boulder fractions and boulders with very large dimensions were also of marginal use in the contemporary stone production. In the light of current knowledge of the methods for the production of stone products in the Polish Lowland areas in prehistory, the stone production of these societies was dominated by the morphometric adaptation technique (directly on the lump of source material). This technique was based on an appropriate selection of rock mass that, by its very nature, best matched the morphometry of a final product, i.e. had the most matching shape and dimensions to their expected future application and purpose.[7] Even in the case of the application of the other processing technique for concretions of local stone products, i.e. the technique of so-called morphometric transformation),[8] half-raw material was used, which was obtained from pebbles or lumps of source material that were not so much larger in overall dimensions than the desired final product, e.g. using boulders with dimensions exceeding the size in diameter by several or even several tens of meters.[9]

[6] It should not be forgotten, however, that from the perspective of the requirements of the methodology of geological research on Fennoscandian erratics, the choice of fractions (boulders and pebbles) marked off for analysis so far is the most adequate, while the range and scope of the analysis is undoubtedly competent.

[7] This way of making stone products required only minimal (or even no) corrections in the practice of lithic reduction to a natural lump of source material from which given tools were to be made. Typically, the processing of such rock concretions was limited to chopping and rounding off their rough shapeless, or uneven, surfaces and then the final shaping of the morphometric variations of a desired product by way of grinding and then the smoothening (or, should the need arise, polishing) of the surface of the final product.

[8] This technique was based on the exploitation of stone blocks much larger than the desired product (requiring therefore appropriate transformations of shapes and sizes). This process allowed a single or even several blocks of half-raw material to be formed (i.e. those blocks that, due to their dimensions, were suitable for manufacture of certain types of tools).

[9] A different suggestion is proposed by Marcin Szydłowski (2011: 296–301), though we think it is not substantiated enough to make such a claim. This concerns the procurement of the so-called Mszczonów sandstone by societies of the Trzciniec culture, who inhabited a settlement at Site 1 at Polesie (Łowicz district, Łódź voivodeship). The sandstone was exploited by quarrying one of the largest erratic boulders in Poland, located near Mszczonów, Żyrardów district, within the distance of about 30km from the settlement. Undoubtedly, the hypothesis of such an early exploitation, because dating from as early as the Bronze Age the Mszczonów boulder is intriguing as a research question, however it is supported by merely a single find of a splinter from this sandstone boulder. Moreover, no archaeological context of its discovery can be reliably supplied. Even if Szydłowski's hypothesis is plausible, it is very unlikely that the local societies of Trzciniec culture exploited Mszczonów sandstone to satisfy *in extenso* the demand for raw materials for stone industry, which is claimed by the researcher, while the boulder from Mszczonów can be treated exclusively as an outcrop of raw material exploited by open-pit mining (Szydłowski 2011: 301). In my opinion, the hypothesis of the author of the study on the stone monuments from site 1 in Polesie completely ignores a totally different aspect of the interest in the Mszczonów boulder within the local population in prehistory, generated by its extra-utilitarian function of the valorisation of landscape in the cultural space of the then inhabitants of the area (Chachlikowski 2013: 31–32).

All in all, the dependencies demonstrated between the fraction of erratic samples selected for petrographic scrutiny and their assortment frequency (lithological composition of rocks) for obvious reasons cannot be irrelevant in any correct evaluation of the resource of erratic rock useful for stone industry of the societies inhabiting the Polish Lowland in prehistory. For these reasons, it is clear that only a proper archeometric delimitation of Fennoscandian erratics selected for an investigation based on the lithological analysis of carefully selected rock blocks (those that have their sizes and shapes suitable for the execution of the full stone instrumentation used by the population) can provide a reliable and credible evaluation of the raw material potential in meeting the demand for stone production in the societies inhabiting the area in the past. No less important for the correct estimation of the resource of the local erratic rocks available for use by the local stone production remains the number (size) of erratic samples taken into consideration in the studies cited by Prinke and Skoczylas (1978, 1980: 46–49), and yet none of them meets the requirements of proper statistical representativeness.

The inadequate state of research on the archaeology of glacial resources of stone raw materials in the Polish Lowland, as well as the unreliable existing geological determinations of the range and frequency of Fennoscandian erratic blocks, challenge previous claims regarding the lack of certain types of rocks, or their low frequency, among the local erratics. The available research studies, in particular the publication by Prinke and Skoczylas (1978, 1980: 46–49), have contributed significantly towards establishing this particular approach (among archaeologists in particular) to the supposed shortcomings of early glacial areas in terms of sufficiently numerous raw materials, and, above all, in appropriately diversified material in terms of its assortment. In this way, the claim that the alleged raw material shortages in Lowland environments were supplemented in the past through a mass take-up and use of exogenous rocks – imports from areas of natural stone deposits – has been validated. The phenomenon of raw material imports among early agrarian communities inhabiting the Polish Lowland was primarily to involve these types of rocks that were commonly used for the production of tool molds with a separated cutting edge (e.g. axes, adzes and the like), namely amphibolite, basalt, diabase, diorite, gabbro, and biotitic gneiss (see: Prinke and Skoczylas 1980b; Chachlikowski 1991, 1997, 2000, 2007, 2010 and 2013; Chachlikowski and Skoczylas 2001a, 2001b; further literature therein), i.e. those raw materials that were believed until quite recently to be nonexistent or rare among Fennoscandian erratics in the areas covered by the last Pleistocene glaciation (Prinke and Skoczylas 1978, 1980: 46–49).

It should be remembered, then, that the authors of the recently cited works on the origin and use of rock raw materials in the Polish Lowland in the Neolithic formulated the exploration questionnaire for imported raw materials among the products of the local stone production solely on the basis of geological evidence (Prinke and Skoczylas 1978: 54–61, 1980: 46–49). The researchers assumed that a sufficient condition for a qualification of provenance from beyond the Lowland of raw materials was the lack, or a scant trace, of the share of certain types of rocks, especially of raw materials with high technical parameters and utility (mainly basalt), in the local inventory of erratics. These are, in fact, correct premises and provide a relatively accurate identification of the 'import', provided, however, that the classification of these raw materials as hypothetical imports will be based on a credible assessment of the rock resources available in the Polish Lowland, which the archaeology of that time had not yet had.

In light of the above conclusion, the far-reaching translocation of exogenous rock materials to the Polish Lowland area in the past was inspired only by action triggered by a necessity to balance deficits (i.e. a lack, or low frequency, of local material) of some high-quality types of rocks among the local Fennoscandian erratics. This hypothesis, widely accepted today in academic circles (mostly by archaeologists), leads, in my opinion, to a controversial hypothesis that the main reason for the take-up and use of raw materials imported by local societies in prehistory was the supposed inadequacies of local resources of glacial rocks appropriate for stone tool production and, consequently, a tendency of Lowland tool producers to have the most attractive (in terms of technical characteristics and utility) stone raw material at their disposal. In other words, the phenomenon of the 'import' is treated in this approach as a manifestation of activities related fully to the acquisition of raw materials of appropriate quality for stone production, caused by deficiencies in the number of types of petrographic rocks with high-quality varieties among the available erratics in the Polish Lowland. The authors, as well as supporters, of this hypothesis assume then that communities living in the areas of the Polish Lowland did not have a sufficient number of rock raw materials properly diversified in terms of their assortment needed for the production of stone tools at home, which meant that shortages were supplemented with imported raw materials. From this perspective, the main reason for a long-distance circulation of rock raw materials in the past would have been of exclusively utilitarian and economic nature. Utilitarian and economic argumentation for the majority of the manifestations of the practice of importing exogenous raw materials in the Polish Lowland in the Neolithic, hitherto commonly accepted in the research community, explains, however,

neither the reasons for the chronologically uneven influx of imported raw materials to the area, or the significant differences observed in the composition of the assortment, or provenance, of the rock then 'imported'.[10]

**2. Outline of the archaeological questionnaire for research on the resources of Fennoscandian erratics**

The indicated limitations and shortcomings in the proper recognition of the resource of raw materials in the Polish Lowland, as well as the controversy surrounding the issue of the supposed scarcity of a local reservoir of glacial rocks in the material suitable for stone production, could have been overcome only by means of interdisciplinary field works and surveys dedicated exclusively to this problem. The results of several-year-long interdisciplinary studies (both field work and the following research output) on the stone erratic raw materials in the areas of the great plain belt between the Odra and Vistula rivers are widely discussed by the author (more on that in: Chachlikowski 2013). The results of field research conducted from this angle, with accompanying study work, justify the pursuit of a more comprehensive, yet reliable, assessment of Lowland Fennoscandian erratics, and, more precisely, of those that were available in Pojezierze Lubuskie (Lubuskie Lakeland) and the Kujawy region. The output of these studies is not only the general characteristics of non-flint rocks occurring among the local erratics, but also multi-faceted estimations of the resources of local lithic erratic raw materials.

The characteristics of the structure (assortment and frequency) of erratic stone raw materials in the Polish Lowland is based on an analysis of boulders and pebbles that are to be found in Lubuskie Lakeland and the Kujawy region. In total, twelve samples of Fennoscandian erratics sampled in both areas, overrun by the last Pleistocene glaciation, were examined. The bulk of the samples, involving as many as eleven samples, represents stone material sorted out for analysis from among erratics deposited in the Kujawy region, whereas the remaining single sample is composed of rocks deposited in Lubuskie Lakeland (Chachlikowski 2013: 19–27, 40–128).

The erratic material chosen for relevant archaeological and petrological examination was sorted out mainly from piles (cairns) of so-called fieldstones located within the Kujawy area. The stones that had been selected for examination came from a number of anthropogenic alignments that suggested human intervention and manipulation of the environment, i.e. rock block assemblages, numerous in this area, of different fraction, piled up in clearance cairns. This group consisted of boulders that had been previously removed by farmers from local arable fields and collected into mounds or cairns. In this way, i.e. from these piles of boulders, ten samples of erratics were selected for further analysis (Chachlikowski 2013: 60–97). The further two samples were selected from rock concretions forming the so-called moraine pavements, i.e. natural accumulation of boulders and pebbles of different size embedded in glacial deposits (residuals) near Torzym, Sulęcin district, in the Lubuskie Lakeland and Strzelce-Krzyżanna, Mogilno district, on Pakoskie Lake in the Gnieźnieńskie Lakeland (Chachlikowski 2013: 40–59, 97–106). In all, 37,529 glacial erratic blocks were petrographically determined. For the samples collected in the Kujawy region, a determination of the constituting raw material was performed for 23,759 boulders and pebbles, whereas from the erratics from Lubuskie Lakeland, selected from the glacial pavement near Torzym, the affinity of rocks was established for 13,770 specimens (Chachlikowski 2013: 19–27, 106–128).

From among the twelve samples of glacial boulders considered in the study, ten, mentioned above, represent rock material marked off from the piles of fieldstones located in the Kujawy region, or, more precisely, in the area of five of the so-called sample diagnostic surfaces (areas) included in the project of the detailed field survey. The characteristics of erratic raw material occurring in the area of the Kujawy sample surfaces selected for the study was based in every instance on the results of the analysis of two cross-verified samples of erratics, always selected for careful examination from two separate heaps of stones. The aim was to achieve the most thorough and reliable overview of the structure of erratic stones embedded there in the glacial past of the region.

It was only in the case of a single heap of stones, from among the total number of ten heaps of erratics in the Kujawy region, that a lithological survey was carried out for all of the stones piled up in the heap. As far as the remaining heaps are concerned, the analysis involved boulders and pebbles that formed a given part of the whole of the heaps. The selection of erratics for lithological scrutiny according to precisely pre-defined archeometric criteria for only parts of these heaps of stones was imposed by the inability to perform expert examination for all fieldstones in the heaps, simply because there were too many of them. Besides, petrographic characteristics for the total number of analysed rock erratics forming the piles of stones would have been substantively unjustified (cf. further comments below). Decisions on which fragment of the heaps should be separated for archaeopetrographical

[10] More criticism of this type of justification based on the proposed interpretation of the phenomenon of 'imported' rock among Lowland prehistoric societies is undertaken in: Chachlikowski 1996, 1997: 172–181, 256–262, 2013: 9–14, 265–281.

inspection was made on an *ad-hoc* basis. In general, boulders and pebbles were selected from one edge of a pile, but in every case the rock blocks selected for archeometric and lithological inspection were removed consistently from the same part of the heap, once it had been selected for examination. Erratic samples extracted from moraine pavements were delimited in a different way. In the case of the pavement discovered in Torzym, appropriate examinations were performed for the vast majority of boulders and cobbles collected from 1,150 square meters of the top surface of the sample area (unit of area equal to 100 $m^2$), whereas the sample of erratics extracted in Strzelce-Krzyżanna is represented by stones selected within an area of about 300 square meters.

The petrographic examination included only those concretions that met strictly defined dimension conditions. The guiding principle was to choose only those rock blocks that, due to their shape and size, could be a potentially useful reservoir of raw material and were suitable for their further processing in the stone industry of prehistoric societies of the Polish Lowland. Specifically, petrological examination was carried out for specimens with the length of the longer axis not less than 5cm, and suitable, due to their shape, for the production of all forms of tool implements that we know to be have been produced by this population (e.g. Prinke and Skoczylas 1980b; Chachlikowski 1991, 1997, 2000, 2007, 2010 and 2013; Chachlikowski and Skoczylas 2001b, 2001c; further literature therein). The above archeometric criteria were applied during the examination of all samples of erratics, i.e. those that had been selected for scrutiny from both heaps of fieldstones and the samples selected from the available pool of boulders and pebbles that formed the residuals unearthed at Torzym and Strzelce-Krzyżanna.

A qualifying condition for the heaps of so-called fieldstones considered in the surface survey to be included in the archaeological and petrographic examination was the appropriate number of the composing boulders and pebbles. Therefore, in making a selection of stone heaps for examination in the Kujawy region, an assumption was made that each of the heaps of stones selected for the study should involve a sample that would include at least 1000 appropriate, in terms of their shape and size (cf. the remarks above), rock blocks. The same criteria were adopted during the delimitation process for erratic rock samples selected from the glacial pavements at Torzym and Strzelce-Krzyżanna. The minimum number of each of the twelve samples selected for the analysis was then more than 1000 boulders and pebbles, determined in view of their petrographic properties that would meet precisely defined criteria concerning their shape and size. Therefore, I believe that the samples of the Scandinavian erratics considered in the study and extracted from the heaps of fieldstones and moraine pavements sufficiently satisfy the requirements for the proper number count in a sample, i.e. the statistical representativeness of a sample size for a survey (more on that in: Chachlikowski 2013: 32), as well as the condition of representing appropriate archeometric parameters in relation to size and form.

Analysis of the petrographic characteristics of the erratic raw materials was carried out for all boulders and pebbles, selected from the stone heaps and from the erratics forming moraine pavements, that were suitable in terms of their size and shape, and known to have been used in the production of all tool implements created in the Polish Lowland in the remote past. The petrographic survey included then all the selected stone samples that satisfied all the criteria for the delimitation of a sample (shape, size and number), regardless of the indicator usability, a particularly important point here, of the analysed material. Let us remember that this indicator usability belongs to the canon of a geological study on Scandinavian erratics (cf. Section 1 of the article). It was then the whole number of erratics, irrespective of their raw material affiliation, that made an indication of their corresponding Fennoscandian source regions possible. The thing is that their petrographic evaluation was applied to all erratic rocks included in the stone samples marked off for examination, therefore not only to the so-called indicator erratics that, as we know, embrace only about 40–50% of the whole of the erratic raw materials occurring in the areas covering the last Scandinavian glaciation.

The lithological scrutiny of erratics in the samples of stones examined in Lubuskie Lakeland and the Kujawy region was carried out with the application of macroscopic scrutiny of the raw material of all boulders and pebbles (extracted from heaps and moraine pavements) that satisfied the required archeometric conditions. Proper raw material designation of erratics was always performed on the basis of a physical examination of a fresh, i.e. not eroded or weatherbeaten, split pieces of rock, as only these samples prevent us from making an erroneous petrographic classification. The application of macroscopic identification of the stone samples considered in the study can be thus justified by the fact that a naked eye examination (supported by a magnifying glass) makes it possible to recognize properly enough a petrographic classification of the majority of Fennoscandian erratics occurring in the Polish Lowland.[11] It should be stressed at this point that macroscopic core descriptions (designations) were not undertaken to identify types of rock associated with known indicator erratics, but

[11] For more on the subject, see Chachlikowski 2013: 34–35, and cited references therein.

the exclusive task of applied petrographic examination was to determine a type of given rock in the analysed stone samples, without indicating any corresponding Fennoscandian source regions.[12] Such identification of erratic raw materials, i.e. with topogenetic references to corresponding source regions missing, which are useless for archaeology,[13] was relatively easy to perform (visual testing with just the naked eye and magnifying glass) in relation to the absolute majority of boulders and pebbles selected for petrographic survey.

The adopted procedure of petrographic identification for Fennoscandian erratics ensures a reliable raw material classification for all erratics included in the examination, because macroscopic petrographic scrutiny makes it possible to identify correctly all lithic types occurring among Fennoscandian erratics and, in most cases, determines them with high precision, identifying a variety of a given type of rock, for example – biotite gneiss, quartzitic sandstone and others (cf. Chachlikowski 2013: 36–38).

To sum up, it should be stated that the samples of glacial rocks examined in the area of Lubuskie Lakeland and the Kujawy region represent (in terms of assortment and frequency) a structure that is typical for those local environments in the Polish Lowland. This statement can be validated by the fact of the selection of a relatively large number of boulders and pebbles for examination, regardless of their so-called identifying usability, with the simultaneous application of the necessary archeometric criterion taken into account. The inclusion of all the above conditions, which was applied during the delimitation process of the erratic samples examined in the Lubuskie Lakeland and Kujawy region, is a sine qua non condition for reliable archaeological and petrological studies on the resources of glacial erratics that were available to the societies inhabiting the Polish Lowland in the remote past.

[12] In contrast to the geology of the Pleistocene, and specifically the questions posed in the research on erratics occurring in the Polish Lowland, in terms of archaeology the identification of Fennoscandian source regions for analysed samples of glacial erratics, just as for erratic rocks recognized among the products of the local stone tool implement industry in the remote past, is absolutely irrelevant. The case here is that we are dealing with natural imports of raw material to the area of the Middle European Plain, as a result of the movement of the Scandinavian ice sheet, as opposed to the 'imports' that resulted from exploitation of exogenous raw material (in this case, of provenance from outside the Polish Lowland) by local inhabitants.

[13] We do encounter reports of archaeological investigations that include surveys on raw materials of stone specimens annotated with corresponding Scandinavian source regions. I do not think that there is anything improper in this practice, and, undoubtedly, the resulting information has some measure of research merit, but from the point of view of archaeology it hardly has any scientific dimension or research value.

**Conclusions**

The characteristics (assortment and frequency) of Fennoscandian erratics occurring in the Polish Lowland, and, in particular, the multifaceted existing evaluations of the inventory of erratic rocks with regard to their assortment and overall dimensions in prehistoric stone industry, are convincing enough to claim that the local boulders and pebbles constituted an exceptionally rich and diversified source of raw material that satisfied the needs of the local stone industry. For the prehistoric inhabitants of these areas, these sources formed exceptionally abundant inventories of stone raw material, indeed almost inexhaustible, in terms of both the count (number) of available types of rock and their petrographic diversity.

The structure of the examined erratic blocks from Lubusz Land and the Kujawy region proves the existence of nearly all the raw materials needed for prehistoric stone tool production in the local lithic resources. At the same time, it gives us a credible basis (especially if we put it within the context of our knowledge on the petrography of erratic blocks in the Polish Lowland hitherto obtained) for assuming that the share of these types of rocks, that until recently were believed to have been unknown to the area, was surprisingly high. This is in strong opposition to the established opinion and theories which claim that they occurred only incidentally, or that were virtually non-existent among the local erratics (notably amphibolite, basalt, diabase, diorite, gabbro and biotitic gneiss).

Particularly rich sources of stone raw material for extraction and exploitation for the societies inhabiting the Polish Lowland in the remote past were boulders and pebbles that formed the so-called moraine pavements overridden by the Fennoscandian ice sheet in numerous land formations of the early glacial stage. The results of the study on the structure and frequency of the local moraine pavements indicate that they were fairy abundant, and at the same time diversified in terms of their petrographic composition, and constituted rich reservoirs of raw material providing an abundance of first-rate raw material for the prehistoric stone industry.

The assessment of the Lowland resources of glacial erratics fully confirms the validity of claims about the extraordinary richness of local early glacial environments in raw materials necessary for the production of stone tool implements. The local glacial 'deposits' represent remarkably abundant sources for raw material, both in terms of the number of available rock nodules and the variety in the assortment of rocks required for this production. The abundance of erratic blocks available in the Polish Lowland clearly exhibits the significance of the local assemblages of erratic

blocks in satisfying the demand for raw material among the local prehistoric societies. It is worth noting that this significance of the Lowland reservoir of erratics has been grossly underestimated so far.

Prehistoric societies of the Polish Lowland and, within a broader context, the general population inhabiting the areas covered by the last Pleistocene glaciation, procured raw material for stone production through intensive exploitation of local resources of boulders and pebbles. In stone production, raw materials that had to be 'imported', i.e. rocks of exogenous provenance imported from the areas of their natural stone deposits lying south of the Lowland, were used on a decidedly smaller scale.

The local raw material inventory – represented by early glacial environments extremely abundant in stone assemblages – largely reduced the deficit of imported raw material demanded by local stone workers. This extremely high abundance of assemblages of lithic relics (highly diversified in terms of their raw material potential) of the glacial past of the region (or, more broadly, that of the Middle European Plain) effectively limited the necessity to import rock blocks from areas of their natural deposits. What follows, then, is a consideration that involves a change in perspective that challenges the earlier accepted theories and interpretations of most of the manifestations of the long-range displacement of exogenous raw materials in the Polish Lowland in the remote past as manifestations of a sustained regular practice of the time effected by supposed shortages of local resources of raw material in these types of rock that were most appropriate for the local stone industry.

*Translated by Tomasz Olszewski*

**References**


Chachlikowski, P. 1991. Stone industry of the Globular Amphorae people in Kuiavia. In A. Cofta Broniewska (ed.), New Tendencies in studies of Globular Amphorae culture: 155–200. *Archaeologia Interregionalis 14. Warszawa-Kraków-Poznań,*

Chachlikowski, P. 1994. Późnoneolityczne wybierzysko surowców skał niekrzemiennych w miejscowości Goszczewo, gm. Aleksandrów Kujawski, woj. Włocławek, stanowisko 13. *Folia Praehistorica Posnaniensia* 6: 59–121.

Chachlikowski, P. 1996. Ze studiów nad pochodzeniem i użytkowaniem surowców importowanych w wytwórczości kamieniarskiej społeczności wczesnorolniczych Kujaw. In A. Kośko (ed.), *Z badań nad genezą regionalizmu kulturowego społeczeństw Kujaw*: 121–153. Poznań–Kruszwica–Inowrocław.

Chachlikowski, P. 1997. *Kamieniarstwo późnoneolitycznych społeczeństw Kujaw*. Poznań.

Chachlikowski, P. 2000. Kamieniarstwo społeczności kultur późnoneolitycznych. In A. Kośko (ed.), *Archeologiczne badania ratownicze wzdłuż trasy gazociągu tranzytowego. Tom III, Kujawy, cz. 4. Osadnictwo kultur późnoneolitycznych oraz interstadium epok neolitu i brązu: 3900–1400/1300 przed Chr.*: 393–409. Poznań.

Chachlikowski, P. 2007. Przetwórstwo i użytkowanie surowców kamiennych. In A. Kośko and M. Szmyt (eds), *Opatowice – Wzgórze Prokopiaka. Tom III. Studia i materiały do badań nad późnym neolitem Wysoczyzny Kujawskiej*: 315–338. Poznań.

Chachlikowski, P. 2010. Kamieniarstwo społeczności pradziejowych i wczesnośredniowiecznych Kotliny Kolskiej. In J. Bednarczyk, J. Kabaciński and A. Kośko (eds), *Osadnictwo Kotliny Kolskiej. Archeologiczne badania ratownicze na trasie autostrady A2*: 617–626. Poznań.

Chachlikowski, P. 2013. *Surowce eratyczne w kamieniarstwie społeczeństw wczesnoagrarnych Niżu Polskiego (IV–III tys. przed Chr.).* Poznań.

Chachlikowski, P. and Skoczylas, J. 2001a. Exploration of stone raw-materials in stone industry of late-neolithic communities of Lowland Poland (Niż Polski). Prospects for further petroarchaelogical studies in the Kujawy region. *Przegląd Archeologiczny* 49: 17–34.

Chachlikowski, P. and Skoczylas, J. 2001b. Pochodzenie i użytkowanie surowców kamiennych spoza Niżu Polskiego w neolicie i wczesnej epoce brązu na Kujawach. *Fontes Archaeologici Posnanienses* 39: 163–190.

Chachlikowski, P. and Skoczylas, J. 2001c. Neolithic rock raw materials from the Kujawy region (Polish Lowland). *Slovak Geological Magazine* 7: 381–392.

Czerwonka, J. A. 1998. Litostratygrafia glin lodowcowych: uwagi metodyczne. *Biuletyn Państwowego Instytutu Geologicznego* 385: 113–126.

Czerwonka, J. A. and Krzyszkowski, D. 1994. Pleistocene stratigraphy and till petrography of the central Great Poland Lowland, western Poland. *Folia Quaternaria* 65: 7–71.

Czubla, P. 2001. *Eratyki fennoskandzkie w Polsce Środkowej i ich znaczenie stratygraficzne. Acta Geographica Lodziensia, Volume 80.* Łódź.

Czubla, P. 2015. *Eratyki fennoskandzkie w osadach glacjalnych Polski i ich znaczenie badawcze*. Łódź.

Czubla, P., Gałązka, D. and Górska, M. 2006. Eratyki przewodnie w glinach morenowych Polski. *Przegląd Geologiczny* 54 (4): 352–362.

Dudziak, J. 1970. *Studia nad kierunkami transgresji lądolodu plejstoceńskiego. Studia Geologiczne, Volume 66. Warszawa.*

Dudziak, J. 1974. Zależność składu głazowego od frakcji w osadach glacjalnych zlodowacenia Południowopolskiego. *Rocznik Polskiego Towarzystwa Geologicznego* 44: 577–590.

Górska-Zabielska, M. 2007. Narzutniaki skandynawskie – metodyka i interpretacja. In E. Mycielska Dowgiałło and J. Rutkowski (eds), *Badania cech teksturalnych osadów czwartorzędowych i wybrane metody oznaczania ich wieku*: 75–82. Warszawa.

Górska-Zabielska, M. 2008a. *Fennoskandzkie obszary alimentacyjne osadów akumulacji glacjalnej i glacjofluwialnej lobu Odry*. Poznań.

Górska-Zabielska, M. 2008b. Obszary macierzyste skandynawskich eratyków przewodnich osadów ostatniego zlodowacenia północno-zachodniej Polski i północno-wschodnich Niemiec. *Geologos* 14 (2): 55–73.

Górska-Zabielska, M. 2010. Analiza petrograficzna osadów glacjalnych – zarys problematyki. *Landform Analysis* 12: 49–70.

Górska-Zabielska, M. and Zabielski, R. 2010. Petrographic analyses and indicator erratics of gravels of the Odra Lobe. *Studia Quaternaria* 27: 17–25.

Grygiel, R. 2004. *Neolit i początki epoki brązu w rejonie Brześcia Kujawskiego i Osłonek, Tom I, Wczesny neolit. Kultura ceramiki wstęgowej rytej*. Łódź.

Konieczny, S. 1956. *Z badań nad rozmieszczeniem eratyków krystalicznych zlodowacenia plejstoceńskiego w Zachodniej Polsce. Prace Komisji Geograficzno-Geologicznej PTPN, Volume 2 (1). Poznań.*

Krystek, M., Młodecka, H., Polański, K. and Szydłowski, M. 2011. Neolityczne narzędzia z metabazytów typu Jizerské Hory (Masyw Czeski) na obszarze Polski. Biuletyn *Państwowego Instytutu Geologicznego* 444: 113–124.

Lisicki, S. 2003. *Litotypy i litostratygrafia glin lodowcowych plejstoceny dorzecza Wisły. Prace Państwowego Instytutu Geologicznego, Volume 177. Warszawa.*

Majerowicz, A., Prinke, A. and Skoczylas, J. 1981. Neolityczny import amfibolitu i serpentynitu na teren Wielkopolski. *Fontes Archaeologici Posnanienses* 32: 4–8.

Majerowicz, A., Prinke, A. and Skoczylas, J. 1987a. Neolityczny import surowców skalnych na obszar Wielkopolski w świetle badań petroarcheologicznych. Acta Universitatis Wratislaviensis No788. *Prace Geologiczno-Mineralogiczne* 10: 69–89.

Majerowicz, A., Skoczylas, J. and Wiślański, T. 1987b. Aus den Studien über die Steindistribution bei den frühneolithischen Kulturen auf der Polnischen Tiefebene. *Przegląd Archeologiczny* 34: 83–91.

Mayer, K. D. 1983. Indicator pebble and stone count methods. In J. Ehlers (ed.), *Glacial deposits in North-West Europe*: 275–287. Rotterdam.

Nunberg, J. 1971. *Próba zastosowania metod statystycznych do badań zespołu głazów fennoskandyjskich występujących w utworach glacjalnych północno-wschodniej Polski.* Studia Geologica Polonica 37. Warszawa.

Pomianowska, H. 2012. Petrograficzna badania neolitycznych narzędzi kamiennych z okolic Bocienia (Pojezierze Chełmińskie). *Acta Universitatis Nicolai Copernici, Archeologia* 32: 193–199.

Prinke, A. and Skoczylas, J. 1978. Z metodyki badań nad użytkowaniem surowców kamiennych w Neolicie. *Przegląd Archeologiczny* 26: 335–342.

Prinke, A. and Skoczylas, J. 1980a. O neolitycznym imporcie surowca bazaltowego na teren Polski środkowo-zachodniej. *Acta Archaeologica Carpathica* 20: 229–250.

Prinke, A. and Skoczylas, J. 1980b. Stone Raw Material Economy in the Neolithic of the Polish Lowlands. *Przegląd Archeologiczny* 27: 43–85.

Rutkowski, J. 2007. Petrografia żwirów – możliwości badawcze i podstawy interpretacji wyników. In E. Mycielska-Dowgiałło and J. Rutkowski (eds), *Badania cech strukturalnych osadów czwartorzędowych I wybrane metody oznaczania ich wieku:* 45–74. Warszawa.

Skalmowski, W. 1937. *Naturalne materiały kamienne w budownictwie drogowym ze szczególnym uwzględnieniem materiałów krajowych*. Warszawa.

Skoczylas, J. 1989. Budowa geologiczna i surowce mineralne regionu Jeziora Lednickiego. *Studia Lednickie*, Volume I: 209–224.

Skoczylas, J. 1990. *Użytkowanie surowców skalnych we wczesnym średniowieczu w północno-zachodniej Polsce.* Poznań.

Skoczylas, J., Jochemczyk, L., Foltyn, E. M. and Foltyn, E. 2000. Neolithic serpentinite tools of west-central Poland and Upper Silesia. *Krystalinikum* 26: 157–166.

Szydłowski, M. 2011. Zabytki kamienne (niekrzemienne) ze stanowiska Polesie 1, gm. Łyszkowice, woj. łódzkie. In J. Górski, P. Makarowicz and A. Wawrusiewicz (eds), *Osady i cmentarzyska społeczności trzcinieckiego kręgu kulturowego w Polesiu, stanowiska 1, woj. łódzkie, Volume I. Tekst:* 284–305. Łódź.

Woźniak, P. 2004. Przydatność analizy litologicznej glin morenowych w badaniach geomorfologicznych stref marginalnych ostatniego zlodowacenia. *Przegląd Geologiczny* 52 (4): 336–339.

Zabielski, R. 2004. Jakie cechy składu petrograficznego żwirów glin lodowcowych mogą być przydatne w litostratygrafii. *Przegląd Geologiczny* 52 (4): 340–346.