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CHARACTERISTICS OF STONE RAW MATERIALS IN MEDIEVAL CHURCHES IN KOŁBASKOWO COMMUNE

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Abstract. The article presents the characteristics of rock material used as a building material in medieval stone churches. Macroscopic petrographic analysis showed that the rock blocks used for the construction of medieval churches in the Kołbaskowo commune were generally made of material available on site. They were rocks originating from Fennoscandia but extracted from sediments deposited by ice sheets that had advanced in from the north. The obtained results were compared against macroscopic analyses of the petrographic composition of Scandinavian erratic boulders in the area and accumulations of raw material in megalithic objects. The results of petrographic observations made it possible to distinguish the basic types of rock materials used in the construction of the churches. The most commonly used materials were: granitoids, gneisses, rhyolithoids, sandstones and quartzites. All the churches built in the 13th century within what is today Kołbaskowo commune show a predominance of granitoids.

Key words: macroscopic petrographic analyses, erratics stones, churches, megalithic tombs, granitoids, gneisses

Introduction

The study aims to characterise the rock material from Scandinavian erratics used as a building material in medieval stone churches located in the Kołbaskowo commune, Police poviat, West Pomeranian Voivodeship (Fig. 1). In addition, the obtained results were compared against macroscopic analyses of the petrographic composition of Scandinavian erratic boulders in the area. They were also compared against the rock material observed in erratics over a larger area and to accumulations of raw material in megalithic objects. The results of the petrographic observations made it possible to separate the basic types of rock materials used for the construction of churches and those found in the Kołbaskowo commune. Detailed marking of the rock material may indicate the place of obtaining this raw material.

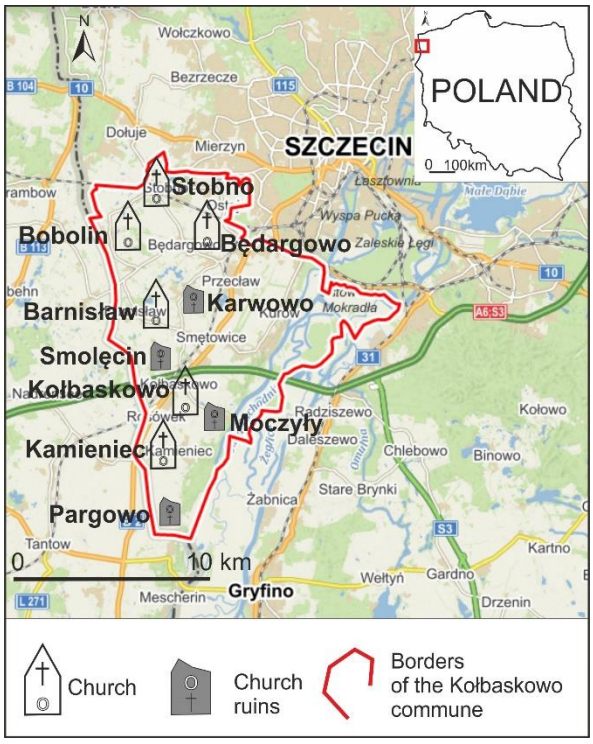

Fig.1. Location of stone churches in the Kołbaskowo commune
Cartographic base from: mapy.cz (Map Service 2023)

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Methodology

A petrographic analysis of the rock materials used for the construction of the churches was carried out. Due to the historic nature of the structures, the analysis was limited to macroscopic petrographic marking. The macroscopic analysis covered all visible rock material, in both external and internal walls (available for observation in the case of ruins). The rock materials used in the constructions were divided into groups. There are twelve types of rocks comprising four groups: plutonic igneous rocks, volcanic igneous rocks, sedimentary rocks and metamorphic rocks. Due to the exclusively macroscopic nature of the precipitates, the recommended simplified classification of rocks was adopted (Manecki, Muszyński 2008). Within the plutonic igneous rocks, the following were distinguished: granitoids, syenitoids, dioritoids, gabbroids and diabases. The volcanic igneous rocks include: rhyolithoids, trachitoids and basaltoids. Sedimentary rocks consist almost exclusively of sandstones. However, isolated occurrences of limestone and flint have been recorded. The following metamorphic rocks were observed: gneisses, amphibolites and quartzites. Minor occurrences of migmatites (which were classified as gneisses), mica schists and granulites were recorded. For each church, a percentage list of identified rocks was drawn up. The rock material of Scandinavian erratic boulders from nearby occurrences was used for comparative analyses. Only erratics with dimensions of the longer axis exceeding 50 cm were taken into account, due to the fact that the rock material in churches is most often shaped cuboid blocks of sides exceeding 30 cm. Analyses were made for 23,962 rock fragments in stone churches, 943 erratics from the area and 799 erratics in existing megalithic tombs. No interpretation of the origin of the rock material based on reference erratics was performed.

Geological conditions of origin of rock material

In terms of physical geography (Kondracki 2002), the Kołbaskowo commune is located in the area belonging to the Szczecin Heights and Lower Odra Valley mesoregions.

Geologically, the area of the Kołbaskowo commune is located in the north-western part of the Szczecin Basin (Piotrowski 2015). The oldest deposits exposed on the surface were accumulated in the Lower Oligocene. These are the so-called septaria loams, appearing as glacial floes or glacial xenoliths in glacial Quaternary formations – mainly within the younger tills from the upper stadial of the Vistulian glaciation. Together with clays, also in the form of floes, Upper Oligocene quartz sands and Miocene sands and muds with brown coals are exposed. Septaria loams are most widespread in the northern and central parts of the Kołbaskowo commune (Bobolin, Będargowo, Smolecin and Przecław), where their outcrops cover large areas. Quaternary sediments cover the entire study area with a layer of variable thickness from 30 to 150 m (Piotrowski 2015). The most widespread formations in the Kołbaskowo commune are glacial formations of the North Polish glaciation. The profile of the Quaternary formations consists of a variety of glacial, fluvioglacial and lacustrine series.

Among the formations of the Vistulian glaciation, the largest areas are occupied by boulder clays with numerous Scandinavian erratics (Fig. 2).

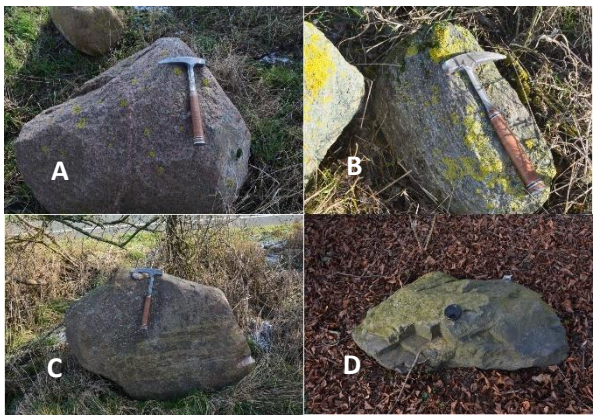

Fig. 2. Scandinavian erratics (*photo by B. Cedro 2023*)
A – granitoid, B – gneiss, C – sandstone, D – amphibolite

Results

Currently, stone churches have been preserved in the towns of: Będargowo, Kamieniec, Kołbaskowo, Barnisław, Bobolin and Stobno. The ruins of stone churches can be found in the towns of: Karwowo, Pargowo, Moczyły and Smolecin. In the 20th century, stone churches in the towns of: Kurów, Przecław, Siadło Górne, Ustowo and Warzymice were demolished (Łuczak 2013). In total, there were fifteen such objects in the Kołbaskowo commune.

Będargowo

The church in Będargowo was built around 1220 (Łuczak 2013). It was rebuilt many times in the 17th, 18th and 19th centuries. The building was founded on a rectangular plan with dimensions of 18.6×12.0 m. The walls were built mainly of regular and hewn erratics with average dimensions of the longest side of 32 cm. The walls of the church nave were built up in 23 layers. Only the visible rock material of the outer walls was analysed (Fig. 3). There are 4966 pieces of rock fragments visible. They include plutonic igneous rocks, including: 2090 granitoids, 101 syenithoids, 60 dioritoids, seven gabbroids and two diabases. From the area of volcanic igneous rocks, the following were distinguished: 915 rhyolithoids, 12 trachitoids and eight basaltoids. The sedimentary rocks consist of 315 pieces of sandstone. Metamorphic rocks include: 1264 gneisses, 138 quartzites, 37 amphibolites, 12 granulites and four mica shales. The percentage content of the components is shown in Figure 4.

Fig. 3. Church in Będargowo (*photo by B. Cedro 2021*)

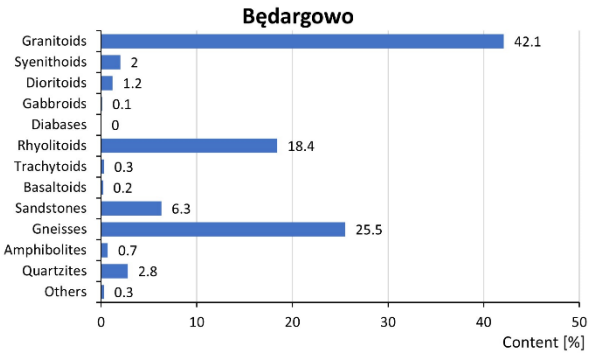

Fig. 4. Percentage content of rock raw materials of the church in Będargowo

Kamieniec

The church in Kamieniec was erected in the 13th century (Świechowski 1950). The building was rebuilt at the end of the 17th century, at the beginning of the 18th century and at the end of the 19th century (Łuczak 2013). It was built on an irregular polygonal plan with dimensions of 16.5× ×10.65×15.7 m. The tower measures 12.1×8.4 m. The walls were built mainly of regular and profiled erratic stones with an average size of the longest side of 32 cm (Fig. 5). The nave of the church was built in 18 layers, and the tower in 23 layers. Only the visible rock material of the outer walls was analysed. There are 4595 pieces of rock fragments visible. The petrographic composition is mainly of plutonic igneous rocks, which include: 1903 granitoids, 205 syenithoids, 92 dioritoids, 18 gabbroids and 10 diabases. The volcanic igneous rocks include: 606 rhyolithoids, 28 trachitoids and 11 basaltoids. Sedimentary rocks consist of 338 sandstones. Metamorphic rocks are represented by: 1056 gneisses, 272 quartzites, 44 amphibolites and six granulites. The percentage of components is shown in Figure 6.

Fig. 5. Church in Kamieniec (*photo by B. Cedro 2021*)

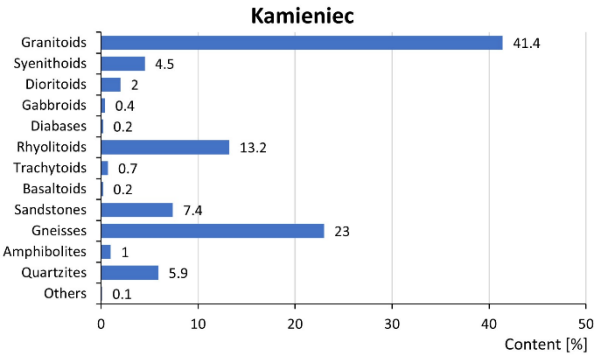

Fig. 6. Percentage content of rock raw materials of the church in Kamieniec

Karwowo

The church in Karwowo was built in the middle of the 13th century (Fig. 7; Świechowski 1950). In the 19th century, the church was rebuilt and a neo-Gothic tower was added (Fig. 8; Łuczak 2013). It was built on a rectangular plan with dimensions of 14.7×8.5 m. At present, it is in ruins. The walls of the nave were built in 17 layers, mainly of regular, worked erratics and irregular erratics with an average size of the longest side of 33 cm. The tower was built on a square plan with a side of 4 m from irregular and processed rock blocks with an average size of 57 cm (maximum 1.2 m).

Fig.7. Ruins of the church in Karwowo
(photo by B. Cedro 2021)

Fig. 8. Ruins of the church tower in Karwowo
(photo by B. Cedro 2021)

Only the visible rock material of both the external and internal walls of the nave of the church and the external walls of the tower was analysed. There are 2506 pieces of rock fragments visible in the nave. They consist of plutonic igneous rocks, including: 1059 granitoids, 45 syenithoids, nine dioritoids and three gabbroids. From the area of volcanic igneous rocks, the following were distinguished: 322 rhyolithoids, nine trachitoids and six basaltoids. Sedimentary rocks consist of 298 sandstones. Metamorphic rocks are represented by: 629 gneisses, 98 quartzites, 25 amphibolites and two granulites. The percentage of components is shown in Figure 9.

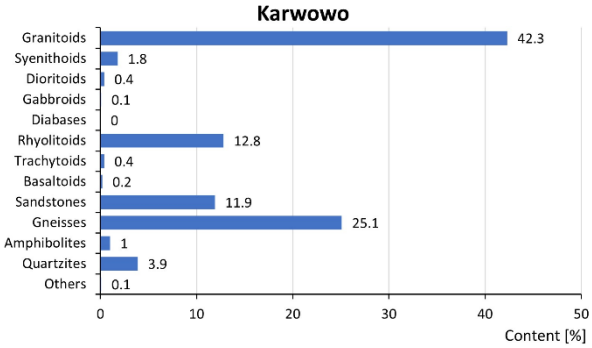

Fig. 9. Percentage content of rock raw materials of the church ruins in Karwowo

There are 263 rock fragments visible in the tower. The material used to build the tower consists mainly of metamorphic rocks, including 121 gneisses and 14 amphibolites. Plutonic igneous rocks include: 87 granitoids, 13 syenithoids, nine dioritoids and two gabbroids. From the area of volcanic igneous rocks, nine rhyolithoids and four basaltoids were identified. No sedimentary rocks were found. The percentages of the components are shown in Figure 10.

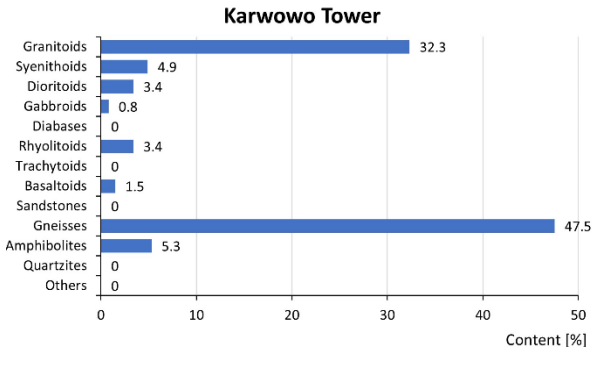

Fig. 10. Percentage content of rock raw materials in the ruins of the church tower in Karwowo

Pargowo

The church in Pargowo was built at the end of the 13th century (Łuczak 2013). The building was founded on a rectangular plan with dimensions of 19.1×10.9 m. At present, it is in ruins (Fig. 11). The walls were built mainly of irregular and regular and profiled erratic stones in 15 layers with an average size of the longest side of 33 cm. Only the visible rock material of both the outer

Fig. 11. Ruins of the church in Pargowo
(photo by B. Cedro 2021)

and inner walls was analysed. There are 5161 pieces of rock fragments visible. They include, among others, plutonic igneous rocks, including: 2206 granitoids, 191 syenithoids, 98 dioritoids, 12 gabbroids and six diabases. From the area of volcanic igneous rocks, the following were distinguished: 602 rhyolithoids, 15 basaltoids and 12 trachitoids. Sedimentary rocks consist of 481 sandstones. Metamorphic rocks are represented by: 1301 gneisses, 199 quartzites, 35 amphibolites and three granulites. The percentages of the ingredients are shown in Figure 12.

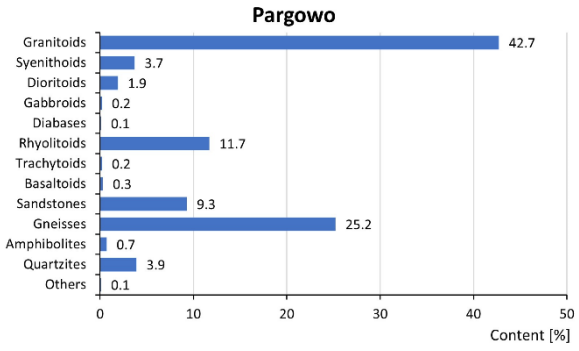

Fig. 12. Percentage content of rock raw materials of the church ruins in Pargowo

Kołbaskowo

The church in Kołbaskowo was built at the end of the 13th century (Świechowski 1950). The building was erected on a rectangular plan with dimensions of 17.5×9.0 m. In the middle of the 18th century, a tower was added on the western side (Łuczak 2013). The walls were built mainly of irregular erratics and regular, profiled erratic stones of various sizes, averaging 36 cm (the longest side reaching 50 cm). Only the visible rock material of the outer walls was analysed (Fig. 13).

Fig. 13. Church in Kołbaskowo
(photo by B. Cedro 2021)

There were 1797 rock fragments distinguished. The petrographic composition is mainly of plutonic magmatic rocks, consisting of: 736 granitoids, 49 syenithoids and 12 dioritoids. Of volcanic magmatic rocks, the following are distinguished: 141 rhyolitoids, 24 trachitoids and 11 basaltoids. Sedimentary rocks consist of 241 sandstones. Metamorphic rocks are represented by: 424 gneisses, 136 quartzites, 19 amphibolites and four schists. The percentage content of the components is shown in Figure 14.

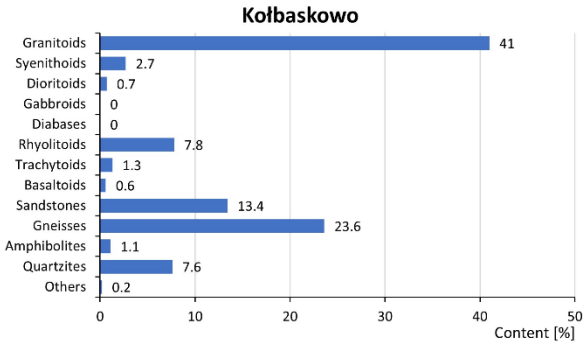

Fig. 14. Percentage content of rock raw materials of the church ruins in Kołbaskowo

Moczyły

The church in Moczyły was built at the end of the 13th century (Świechowski 1950). It was rebuilt in the 17th century (Łuczak 2013). The building was founded on a rectangular plan measuring 14.4×9.4 m. It is currently in ruins (Fig. 15). The walls were built mainly of irregular and regu-

Fig. 15. Ruins of the church in Moczyły
(photo by B. Cedro 2021)

Fig. 17. Ruins of the church in Smolęcin
(photo by B. Cedro 2021)

lar, profiled erratic stones of various sizes (the longest side reaching 60 cm). Only the visible rock material of both the outer and inner walls was analysed. There are 1,849 pieces of rock fragments visible. From the plutonic magmatic rocks, the following were distinguished: 694 granitoids, 40 syenithoids, 11 dioritoids, one gabbroid and one diabase. From the area of volcanic magmatic rocks, the following have been identified: 159 rhyolitoids, 11 trachitoids and eight basaltoids. The sedimentary rocks consist of 236 sandstones. Within the metamorphic rocks, the following were observed: 530 gneisses, 131 quartzites, 21 amphibolites, four schists and two granulites. The percentage content of the components is shown in Figure 16.

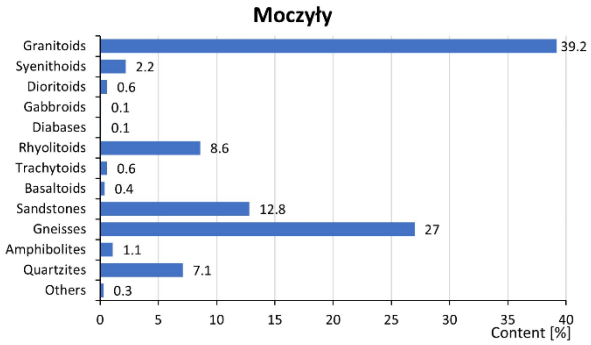

Fig. 16. Percentage content of rock raw materials of the church ruins in Moczyły

Smolęcin

The church in Smolęcin was built at the beginning of the 14th century (Łuczak 2013). It was founded on a rectangular plan measuring 15.6×9.2 m. It is currently in ruins (Fig. 17). The walls were built mainly of irregular erratic stones of various sizes (the longest side reaching 60 cm). Only the visible rock material of both the outer and inner walls was analysed. There are 2080 rock fragments visible. From the plutonic magmatic rocks, the following were distinguished: 822 granitoids, 51 syenithoids and 30 dioritoids. From the area of volcanic magmatic rocks the following were distinguished: 248 rhyolitoids, ten basaltoids and ten trachitoids. The sedimentary rocks consist of 179 sandstones and one of flint. Metamorphic rocks are represented by: 596 gneisses, 96 quartzites, 29 amphibolites and eight mica schists. The percentage content of the components is shown in Figure 18.

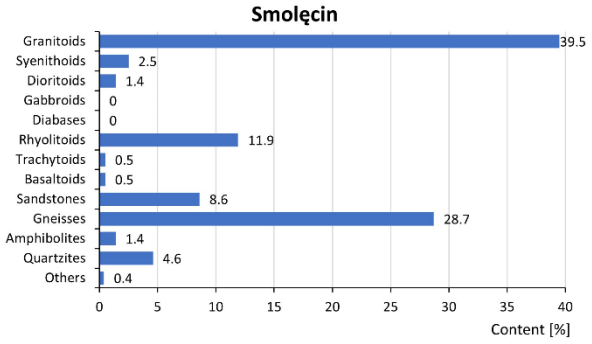

Fig. 18. Percentage content of rock raw materials of the church ruins in Smolęcin

Barnisław

The church in Barnisław was erected at the beginning of the 14th century. The building was rebuilt in the second half of the 19th century (Łuczak 2013). It was founded on a rectangular plan measuring 16.8×8.4 m. The walls were built mainly of regular and profiled erratic stones with average dimensions of the longest side from 28 to 35 cm (Fig. 19). Only the visible rock material

Fig. 19. Church in Barnisław
(photo by B. Cedro 2021)

Fig. 21. Church in Bobolin
(photo by B. Cedro 2021)

of the outer walls was analysed. There were 3929 rock fragments visible. The petrographic composition is mainly of plutonic magmatic rocks, consisting of: 1351 granitoids, 80 syenithoids, 72 dioritoids, seven gabbroids and three diabases. Of the volcanic magmatic rocks, the following are distinguished: 396 rhyolitoids, 52 trachitoids and ten basaltoids. The sedimentary rocks consist of 437 sandstones and the occurrence of pyroclastic rocks was distinguished, represented by three ignimbrites. The metamorphic rocks are represented by: 1141 gneisses, 306 quartzites, 51 amphibolites, ten schists and ten granulites. The percentage content of the components is shown in Figure 20.

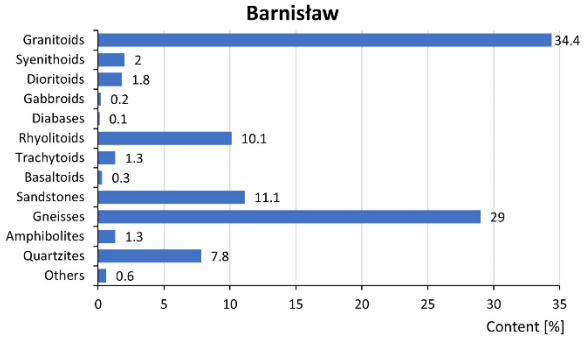

Fig. 20. Percentage content of rock raw materials of the church in Barnisław

Bobolin

The church in Bobolin was built at the end of the 15th century (Łuczak 2013). It was founded on a rectangular plan measuring 17.0×9.0 m and ended with a pentagonal apse (Fig. 21). The walls are built of irregular erratic stones of various sizes (the longest side reaching 90 cm). Only the externally visible rock material was analysed. There are 1,476 pieces of rock fragments visible. Plutonic magmatic rocks are represented by: 459 granitoids, 31 syenithoids, 29 dioritoids, four gabbroids and one diabase. From the area of volcanic magmatic rocks, 103 rhyolitoids, eight trachitoids and one basaltoid were distinguished. Of the sedimentary rocks, 164 sandstones were recorded. The metamorphic rocks consist of: 546 gneisses, 72 amphibolites, 45 quartzites and 12 schists. The percentage content of the components is shown in Figure 22.

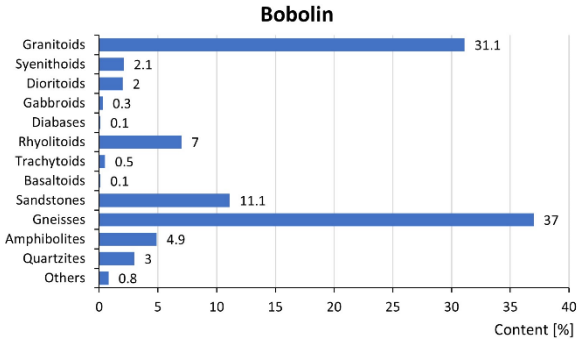

Fig. 22. Percentage content of rock raw materials of the church in Bobolin

Stobno

The church in Stobno was built in the 15th century (Płotkowiak 2019). It was founded on a rectangular plan with dimensions of 16.0×10.0 m, ended with a semicircular apse. It has a tower on a square plan with sides of 5 m. The walls are made of irregular erratic stones of various sizes (the longest side over 1.0 m) with the addition of bricks (Fig. 23). Only externally visible rock material

Fig. 23. Church in Stobno *(photo by B. Cedro 2021)*

was analysed. There are 1056 rock fragments visible. The group of plutonic igneous rocks consists of: 275 granitoids, 25 syenithoids, 25 dioritoids, three gabbroids and one diabase. In the area of sedimentary rocks, 165 sandstones and one limestone specimen were distinguished. Metamorphic rocks include: 397 gneisses, 45 amphibolites, 13 quartzites and ten mica schists. The percentage content of the components is shown in Figure 24.

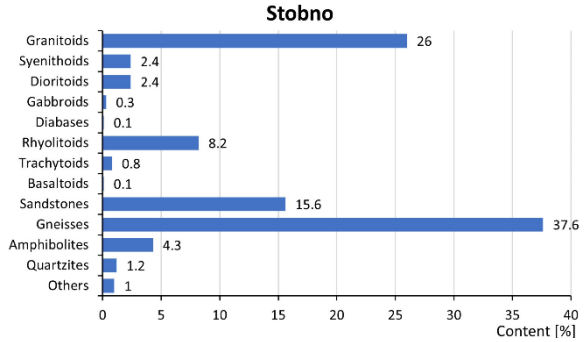

Fig. 24. Percentage content of rock raw materials of the church in Stobno

Rock raw materials

A macroscopic petrographic analysis of erratics available for observation (transported from the surrounding fields) currently lying next to the Kołbaskowo–Kamieniec bicycle path was carried out. In the 1.5-km section, 455 erratic boulders with sizes of the longest side exceeding 50 cm were analysed. The presence of 221 granitoids, 14 syenithoids, four diorites, three gabbroids and two diabases was found within the plutonic igneous rocks. Of the volcanic igneous rocks, 34 rhyolithoids, four trachitoids and two basaltoids were distinguished. The sedimentary rocks consisted of 28 pieces of sandstone and five fragments of limestone. Metamorphic rocks were represented by: 185 gneisses, 23 quartzites and 19 amphibolites. The percentages of the components are shown in Figure 25.

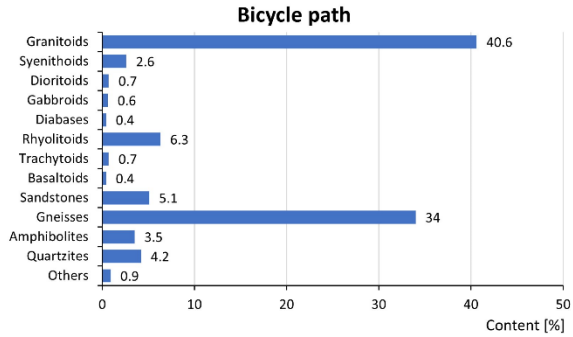

Fig. 25. Percentage of individual types of erratic rocks located along the Kołbaskowo–Kamieniec bicycle path

In 2004, with the participation of the author, a study of erratics lying in the Woliński National Park in the Międzyzdroje–Wisełka beach section was carried out. At that time, the records and petrographic characteristics were subject to specimens with sizes exceeding 1.0 m. A total of 488 erratic boulders were found in this area. They consisted of, among others, plutonic igneous rocks, where the following were distinguished: 202 granitoids, 16 syenithoids, five dioritoids, six gabbroids and four diabases. From the area of volcanic igneous rocks, the following were distinguished: 31 rhyolithoids, one trachitoid and four basaltoids. Sedimentary rocks consisted of 31 sandstones and ten limestones. Metamorphic rocks were represented by: 159 gneisses, 15 amphibolites and four quartzites. The percentage content of the components is shown in Figure 26.

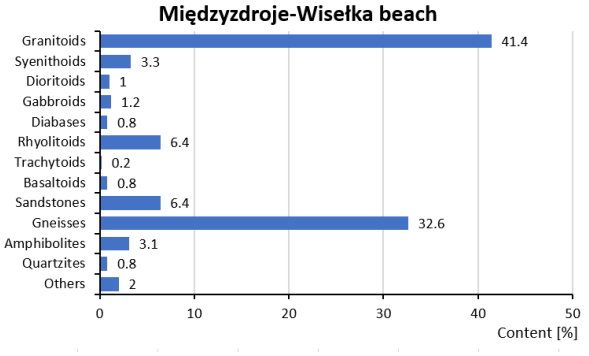

Fig. 26. Percentage content of individual types of erratic rocks located on the Międzyzdroje–Wisełka beach section

The analysis of the Fennoscandian erratics showed that most of them are plutonic igneous rocks – mainly granitoids and less numerous gabbroids, syenithoids, dioritoids and diabases. On the other hand, within the volcanic igneous rocks, mainly rhyolithoids were recorded, with smaller amounts of trachitoids and basaltoids. The sedimentary rocks are dominated by sandstones and, to a lesser extent, limestones. Metamorphic rocks are the second most abundant group after igneous plutonic rocks with the dominant role of gneisses. The presence of quartzites and amphibolites has been recorded less frequently.

Most of the available petrographic studies of glacial and fluvioglacial sediments included the identification of lithological types of rocks among small-sized erratics, i.e. most often the gravel fraction (Czubla 2001; Górska 2003; Czubla, Forysiak 2004; Górska-Zabielska 2008, 2010; Górska-Zabielska, Pisarska-Jamroży 2008; Czubla *et al.* 2010). The results of these analyses do not correspond to the size of the fraction of the material that was used to build the churches. Depending on the adopted fraction size range, the results of the analyses may differ significantly. As an example, the results of the analysis of the 60–128-mm fraction on the test section of Międzyzdroje–Wisełka beach that was performed by Lityński (2018) can be presented. Of the analysed 805 pebbles of the 60–128-mm fraction, granitoids were most abundant of the analysed population at 21.1%, followed by gneissses (18.6%) and sandstones (14.9%). Limestones (11.8%), quartzites (11.2%) and rhyolithoids (9.6%) also had large shares. The other identified genera are: basaltoids (6.1%), syenithoids (2.9%), trachitoids and amphibolites (1.5% each), gabbroids (1.4%) and dioritoids (0.5%). Noteworthy is the significantly higher frequency of limestones and quartzites in the analysed range of fractions in relation to specimens of over 1.0 m marked on the Międzyzdroje–Wisełka beach presented above.

In 2023, the author carried out a petrographic analysis of the nearest available megalithic tombs (Wiślański 1977; Matuszewska 2023) at Krępcewo (Stargard County), Karsk (Pyrzyce County) and Wollschow (Uckermark County, Germany). Erratics larger than 50 cm were used for analysis. At Krępcewo (Fig. 27), out of a total of 98 pieces of observable rock fragments, the following were distinguished: 49 granitoids (50.0%), 27 gneisses together with migmatites (27.6%), 12 rhyolitoids (12.2%), four syenithoids (4.1%), two quartzites and two sandstones (2.0% each), and one amphibolite and one dioritoid (1.0% each).

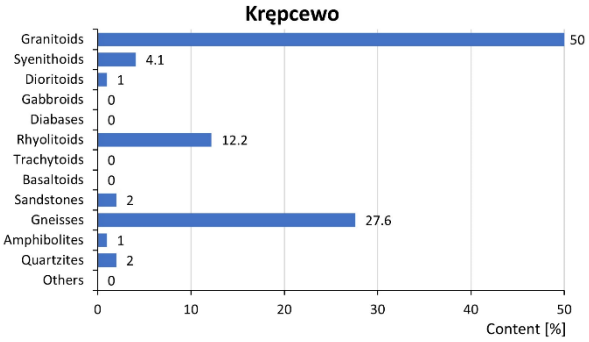

Fig. 27. Percentage content of erratic rocks components used in the construction of the megalithic tomb in Krępcewo

In the vicinity of the village of Karsko, the stone enclosings of two megalithic tombs are available for observation. In the first of them (Fig. 28), the following were distinguished: 231 erratics consisting of 111 granitoids (48.1%), 69 gneisses (29.9%), 23 rhyolithoids (10.0%), seven quartzites and seven syenithoids (3.0% each), six sandstones (2.6%), four amphibolites (1.7%), two dioritoids (0.9%) and one diabase and one trachitoid (0.4% each).

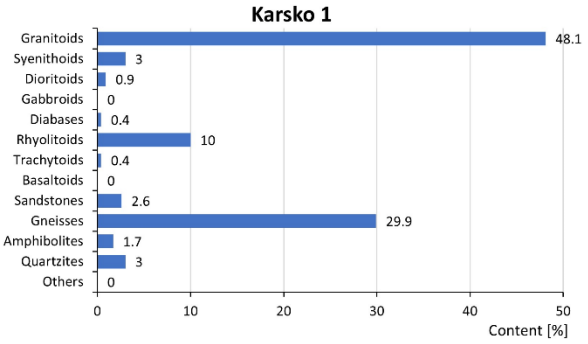

Fig. 28. Percentage content of erratic rocks components used in the construction of the megalithic tomb in Karsko 1

In the second tomb (Fig. 29), 354 erratics were analysed and distinguished: 190 granitoids (53.7%), 102 gneisses (28.8%), 33 rhyolitoids (9.3%), eight quartzites (2.3%), six syenitoids (1.7%), five amphibolites (1.4%), four sandstones (1.1%) and two each of diabases, dioritoids, trachitoids (0.6% each).

From the megalithic tomb complex located in a forest near the village of Wollschow (18 km

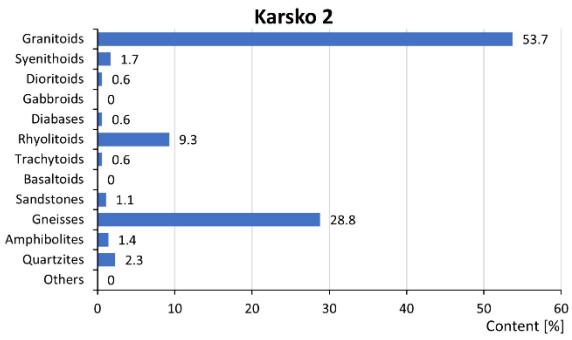

Fig. 29. Percentage content of erratic rocks components used in the construction of the megalithic tomb in Karsko 2

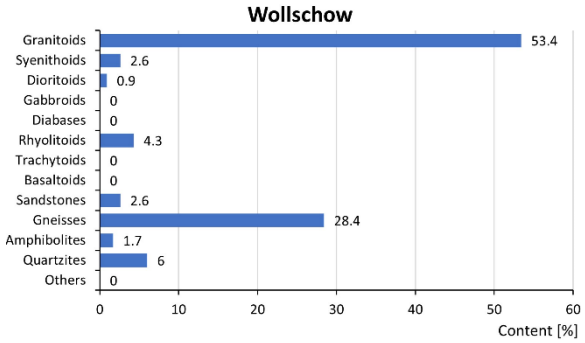

Fig. 30. Percentage content of erratic rocks components used in the construction of the megalithic tomb in Wollschow

north-west of Kołbaskowo), the stone enclosure of the only trapezoidal tomb in the area was analysed (Fig. 30) (Schuldt 1974). There, 116 erratics were found that were available for observation; these consisted of 61 granitoids (53.4%), 33 gneisses (28.4%), seven quartzites (6.0%), five rhyolitoids (4.3%), three each of sandstones and syenithoids (2.6% each), two amphibolites (1.7%) and one dioritoid (0.9%).

A summary of the percentages of all identified rock fragments is presented in Table 1.

Table 1

A summary of the percentage of all identified rock fragments for each site

Sites	Granitoids	Syenithoids	Dioritoids	Gabbroids	Diabases	Rhyolitoids	Trachytoids	Basaltoids	Sandstones	Gneisses	Amphibolites	Quartzites	Others
Będargowo	42.1	2.0	1.2	0.1	0	18.4	0.3	0.2	6.3	25.5	0.7	2.8	0.3
Kamieniec	41.4	4.5	2.0	0.4	0.2	13.2	0.7	0.2	7.4	23.0	1.0	5.9	0.1
Karwowo	42.3	1.8	0.4	0.1	0	12.8	0.4	0.2	11.9	25.1	1.0	3.9	0.1
Karwowo Tower	33.2	4.9	3.4	0.8	0	3.4	0	1.5	0	47.5	5.3	0	0
Pargowo	42.7	3.7	1.9	0.2	0.1	11.7	0.2	0.3	9.3	25.2	0.7	3.9	0.1
Kołbaskowo	41.0	2.7	0.7	0	0	7.8	1.3	0.6	13.4	23.6	1.1	7.6	0.2
Moczyły	39.2	2.2	0.6	0.1	0.1	8.6	0.6	0.4	12.8	27.0	1.1	7.1	0.3
Smolęcin	39.5	2.5	1.4	0	0	11.9	0.5	0.5	8.6	23.8	1.4	4.6	0.4
Barnisław	34.4	2.0	1.8	0.2	0.1	10.1	1.3	0.3	11.1	29.0	1.3	7.8	0.6
Bobolin	31.1	2.1	2.0	0.3	0.1	7.0	0.5	0.1	11.1	37.0	4.9	3.0	0.8
Stobno	26.0	2.4	2.4	0.3	0.1	8.2	0.8	0.1	15.6	37.6	4.3	1.2	1.0
Bicycle path	40.6	2.6	0.7	0.6	0.4	6.3	0.7	0.4	5.1	34.0	3.5	4.2	0.9
Międzyzdroje––Wisełka beach	41.4	3.3	1.0	1.2	0.8	6.4	0.2	0.8	6.4	32.6	3.1	0.8	2.0
Krępcewo	50.0	4.1	1.0	0	0	12.2	0	0	2.0	27.6	1.0	2.0	0
Karsko 1	48.1	3.0	0.9	0	0.4	10.0	0.4	0	2.6	29.9	1.7	3.0	0
Karsko 2	53.7	1.7	0.6	0	0.6	9.3	0.6	0	1.1	28.8	1.4	2.3	0
Wollschow	53.4	2.6	0.9	0	0	4.3	0	0	2.6	28.4	1.7	6.0	0

Discussion

Macroscopic petrographic analysis showed that the material available locally was generally used to produce the rock blocks used to build the medieval churches in the Kołbaskowo municipality. These were rocks of Fennoscandian origin, but extracted from sediments deposited by the advancing ice sheets from the north. Rocks of local origin are commonly identified as the primary material for stone churches (Skoczylas 1990, 1995; Mrożek 2005; Górska-Zabielska 2016).

The use of erratic boulders found in large numbers in the fields was common. Scandinavian granitoids were the basic raw material used in the construction of churches. At the same time, the term granite squares is often used in earlier studies (Świechowski 1950; Wiliński 1952) or contemporary studies (Janisio-Pawłowska 2011; Łuczak 2013; Płotkowiak 2019) as the only term for the material from which churches were built. All churches built from the 13th century to the 14th century in the area of the present municipality of Kołbaskowo show a predominance of granitoids. Accordingly, granitoids represent: 42.7% of the rock material in the case of the ruins of the church in Pargowo, 42.3% of the ruins of the church in Karwowo, 42.1% of the church in Będargowo, 41.4% of the church in Kamieniec, 41.0% of the church in Kołbaskowo, 39.5% of the ruins of the church in Smolęcin, 37.5% of the ruins of the church in Moczyły, 34.4% of the church in Barnisław, 32.3% of the ruins of the church tower in Karwowo, 31.1% of the church in Bobolin and 26.0% of the church in Stobno.

The raw material structure changes and in churches built from the 15th century, gneisses prevail. A similar regularity was also noticed by Skoczylas (2009) for the area of the Central Poland. It is particularly visible in the case of the church tower in Karwów, which was built in the 19th century. The largest share is represented by gneisses as a building material and amounts to: 47.5% in the case of the ruins of the 19th century church tower in Karwów, 37.6% in the church in Stobno and 37.0% of the church in Bobolin. A similar content of gneisses was found in analyzes of erratics from the bicycle path (34.0%) and boulders from Międzyzdroje–Wisełka beach (32.6%). In the case of other churches, the content of gneissses ranged from 23.0% (the church in Kamieniec) to 25.0% (the church in Będargowo), only in the case of the 14th century churches in Barnisław and Moczyły, the content of gneiss exceeded 27.0%. Thus, the preference of lighter colored rock materials by the builders of earlier churches is evident. This also applies to the content of brighter volcanic rocks, especially rhyolithoids, the largest amounts of which can also be noted in the 13th century churches in Będargowo (18.4%), Kamieniec (13.2%), Karwowo (12.8%), Smolęcin (11.9%) and Pargowo (11.7%). In the case of other churches, the content of rhyolithoids rarely exceeds 10.0% (the church in Barnisław) or oscillates around 8.0% (churches in: Moczyły, Stobno, Kołbaskowo and Bobolin). A similar content of rhyolithoids was also recorded in the case of erratics from the vicinity of the bicycle path (6.3%) and Międzyzdroje–Wisełka beach (6.4%).

It is interesting to compare to the few results of analyses of rock material used for the construction of megalithic tombs, including those made by Skoczylas (1973) and presented by Wierzbicki (2020) from the Łupawa area. Out of a total of 63 analysed rock blocks used in the construction of the megalithic tomb at site 15 in Łupawa, the presence of 22 pieces of granites and feldspar-quartz pegmatites (34.9%), 20 pieces of gneisses and granitogneisses (31.8%), eight pieces diorites (12.7%), five pieces of porphyries (7.9%), three pieces of syenites (4.8%) and one piece each of: quartzite (1.6%), amphibolite with quartz veins (1.6%), quartz-feldspar breccia (1.6%), feldspar-quartzite foliated breccia (1.6%) and granite vein in amphibolite gneiss (1.6%). The absence of the use of rock blocks made of limestone is notable.

Unfortunately, detailed data on the use of raw materials for the construction of megalithic tombs are very scarce (Górska-Zabielska 2017; Pawlikowski *et al.* 2020), which results in a small comparative base and makes it necessary to perform such detailed analyzes in the future. The research carried out by the author for megalithic tombs from the Pyrzyce region shows a clear advantage of granitoids (often with a content exceeding 53.0%) over gneiss, whose content reached a maximum of almost 30.0%. Rhyolithoids with a maximum content exceeding 12.0% were in third position. Thus, the ratio of the content of leucocratic to melanocratic rocks recorded in the case of megalithic tombs from the area of Krępcewo or the Karsko site is clearly visible.

This is understandable if we consider the preference for the choice of rock material for making stone tools. The vast majority of tools such as:

radicles, axes, hatchets, chisels or hammers were made from materials such as: amphibolites, gabbros, diabasalts, basalts or gneisses (Szydłowski 2017; Bartz *et al.* 2023), which undoubtedly belong to melanocratic rocks. The choice of these rocks as a raw material for the production of tools was determined by the properties and mineralogical composition of individual rocks. Amphiboles show special properties in this respect, which most often have a staminate and fibrous habit, creating a dense network of intertwined needles and threads. This creates a very strong, impact-resistant structure. The best example in this respect is nephrite (Gunia 2000). Therefore, we will not encounter this type of rocks (with a high content of amphiboles and other dark minerals) in the area of megalithic tombs, because they were too valuable raw material for the production of tools.

Also, a comparison to the characteristics of stone raw materials present in the settlement inventories from the Kuyavia area used by representatives of the Funnel Cultures and the Amphora Cultures compiled by Chachlikowski (2013) shows the raw material structure of the material used for stone tool production. It shows that sandstones, present in this structure in the amount of 34.7%, were the most frequently used; gneisses are also a very numerous group in the amount of 25.5% and granites, representing 15.9% of the raw material base; quartzites, in the amount of 8.8%, are also numerously represented. The remaining components do not exceed 4% and in the order of population we can distinguish: gabbros (3.2%), amphibolites (3.1%), diorites (1.4%), porphyries (1.4%), pegmatites (1.4%), basalts (1.2%), diabasalts (1.2%), syenites (1.1%), other raw materials make up 1.0%.

For aesthetic or other reasons, rocks with an interesting structure or colouration may instead have been preferred in the construction of tombs (Brink 2015). Such rocks include, among others, volcanic rocks that have a porphyry structure. Here, rhyiolitoids and trachitoids play a dominant role. The increased content of rhyolithoids in the stone churches may indicate the source of the rock material. Such a source could undoubtedly have been megalithic tombs (of the Kuyavia type), the presence of which has been found in many areas of Western Pomerania (Wiślański 1977; Jankowska 2005; Matuszewska, Szydłowski 2012; Król 2016, Przybyła 2020; Matuszewska 2023). At the same time, there are currently no such sites in the area of the municipality of Kołbaskowo, despite the existence of the Funnel Cultures (KPL) functioning in this area (Siuchniński 1958; Dziewanowski 2011, 2014, 2015; Dziewanowski, Pyżewicz 2016), which built such forms of tombs. In areas of KPL functioning, tombs were often built in groups of several or even a dozen (Czebreszuk 2009).

Conclusions

– The coverage of the entire analysed territory by Pleistocene glacial sediments gave access to very different types of rock raw materials.
– There were stone churches (15 sites) in almost all the villages in the area of the municipality of Kołbaskowo.
– The stone churches in the area of the present municipality of Kołbaskowo were built from local raw material – most commonly granitoid erratics, less frequently gneisses and rhyolits.
– A similar composition of rock content was found in the existing and partly preserved megalithic tombs, where there is a clear predominance of granitoids over gneisses and rhyolithoids.
– The medieval churches built in the 13th century are dominated by granitoids. In those built later (from the 15th century onwards), gneisses predominate.
– In the raw material composition of stone churches from the 13th century, there is a clear predominance of leucocratic rocks over melanocratic rocks, and similar proportions were recorded for megalithic tombs. The lower content of darker rocks in the tombs (gabbros, diabas, basaltoids and amphibolites) may have been due to the fact that stone tools were often made from them.
– A large proportion in some churches (Będargowo, Kamieniec, Pargowo, Karwowo and Smolęcin) have rocks with characteristic structures (porphyries) or (and) colouration (red in various shades). Similar proportions have been recorded in the preserved megalithic tomb enclosures from Krępcewo and Karsko.
– There is a high probability that raw material for the construction of churches (especially those built in the 13th century) was obtained from megalithic tombs which may have existed at that time. At present no megalithic tombs have been recorded in the area of the municipality of Kołbaskowo, nor, for example, in the 19th century, despite the existence in this area of traces of cultures to which such objects could be linked.

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