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Wacław RYKA

Crystalline basement of the Polish part of the Baltic Sea

New geophysical data and the results of the petrographic investigation of the rocks derived from boreholes performed in the Polish area of the southern Baltic Sea enabled to compile the schematic geological map of the crystalline basement surface. In the south-western part the basement is probably composed of Presvekofenno-Karelian granitoids whereas in the north-eastern part of rapakiwi-like granitoids. North of Rozewie — Hel Spit the Presvekofenno-Karelian folding zone represented by enderbites and pyroxene gneisses is jutting out into the sea is quite probably that the Polish rapakiwi-like granitoids are southern domain of the Trans-Scandinavian granitic-porphyry belt of southern Sweden. The very young age the Gothian charnockitization, migmatization and anatexis having been hard to justify thus far may be explained by the Halland quasi-orogeny. In turn, the reactivation of the Pregothian meridional faults can be elueidated by the Grenville rotation of the Baltic Shield and its collision with the Laurentian Shield.

INTRODUCTION

The boundary of the East-European Platform identified with the Teisseyre-Tornquist Zone is running through Poland to the north-western direction and slightly west of the Gardno Lake entering the sea. Then it by-passes Bornholm from the west and breaks off in Scania. Apart from various very important regional implications the Teisseyre-Tornquist Zone is of great significance for the Precambrian because it has thus far determined the physical border for surveying the crystalline basement of the East-European Platform. The investigation of the Precambrian basement on the Polish territory commenced just after the World War II (1954), but the first boreholes primarily located close to the eastern state boundary because of the thin sedimentary cover overlying the crystalline basement. Fifteen years later first boreholes were drilled in the Gdańsk Pomerania and in the region of Koszalin. The drillings were primarily performed for identifying geological setting and elucidating hydrocarbons accumulations as well as for collecting as much the relevant information on lithology and stratigraphy of rocks as possible. In the years 1969–1974 in the Pomerania area embracing the zone to 50 km up-land nine boreholes achieved the crystalline basement. The obtained drill cores allowed to perform the systematic investigation of the crystalline basement rocks and the correct interpretation of the results of the regional gravimetric and magnetic survey. The received data enabled to elaborate the uniform geological map of the examined area taking into account the fact that the up-land mapping had been performed earlier.

In the years 1970–1972 the magnetic survey was carried out in the southern Baltic Sea including the Polish coastal waters 50 sea miles wide. Based upon the obtained results the first uniform sketch geophysical maps were elaborated making it possible for A. Dąbrowski and A. Uhrynowski (1976) to prepare the geological map of the crystalline basement. The method of determing the boundaries of the lithological units of the rocks assigned to the crystalline basement top was elaborated by K. Karaczun et al. (1975). It has been further applied in the consecutive modifications of the geological map of the Precambrian basement belonging to the Polish part of the East-European Platform (H. Pendias, W. Ryka, 1984).

A. Dąbrowski and A. Uhrynowski (1976) distinguished on the magnetic map of the active crystalline basement, scale about 1:2 500 000, three lithological units, i.e. granitoids, Karelian (Svekofenno-Karelian) metamorphic rocks and norite-anorthosite complexes. The granitoids are prevailing (approximately 75% of the entire surface), the metamorphic rocks are less spread (approximately 20%) whereas the norite-anorthosite complexes are occupying the area of about 5%. The described map is the essential step into identifying the geological structure of the crystalline basement top and its accuracy can be appreciated now considering the fact that the authors had not had at their disposal neither the new results of the geophysical investigation nor the analyses of rocks derived from the boreholes performed by W. O. Petrobaltic much later. The crucial progress in geological prospecting the crystalline basement of the Baltic Sea started from drilling the boreholes by the aforementioned company in 1980. The drillings had been proceded by the geophysical investigation. The petrographic examination of the crystalline rocks derived from these boreholes was carried out by the author together with M.Sc. E. Krystkiewicz whereas the isotopic investigation by Dr. J. Lis respectively. These works were performed on the basis of the order placed by W. O. Petrobaltic.

The author wants to express his thanks to the management of W. O. Petrobaltic for making it possible to carry out the investigation of the crystalline basement of the southern Baltic Sea and for publishing the summary based upon the abundant data.

PRESVEKOFENNO-KARELIAN UNITS

In the Pomerania the surface of the crystalline basement assigned to the platform margin is generally lowering toward the south-west from 2300 to 7000 m and the isohypses are running parallel to the Teisseyre-Tornquist Zone. The isohypses within the Baltic Sea retain at first the same pattern but before Bornholm the crystalline

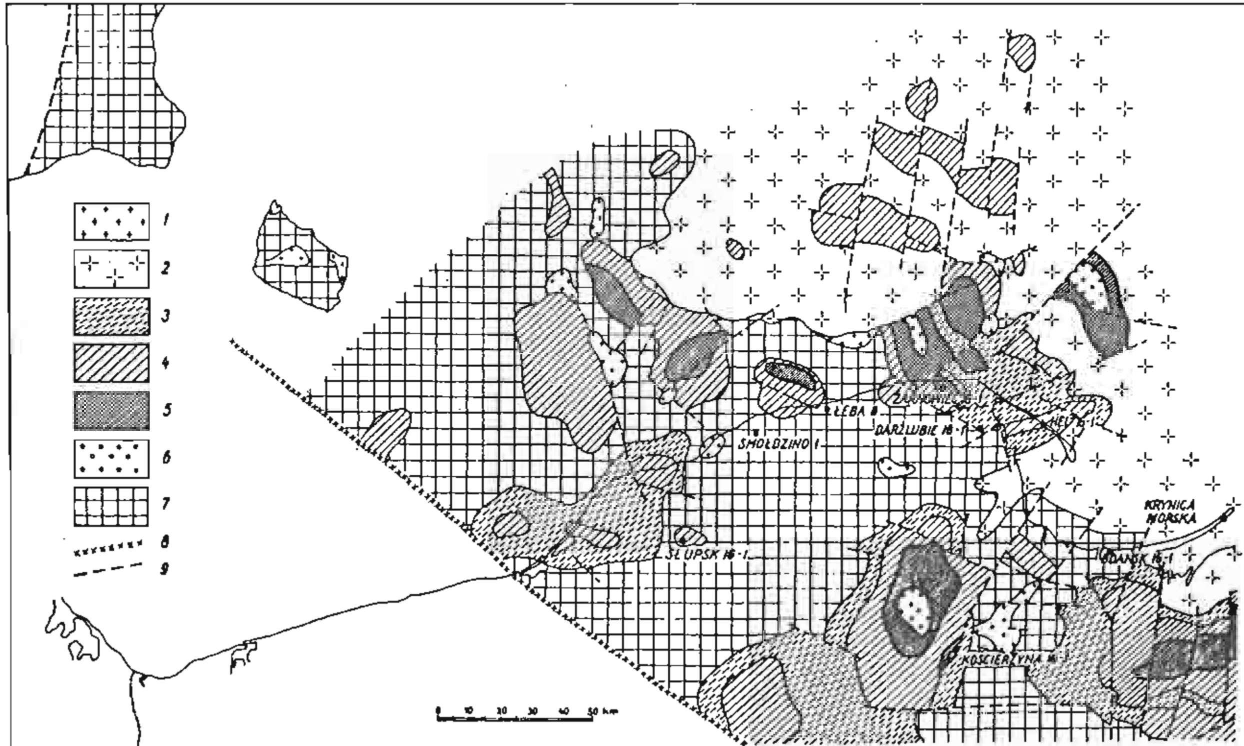

Fig. 1. Geological map of the crystalline basement top of the southern Baltic area

1 — anatectic and rheomorphic granitoids; 2 — rapakiwi-like granitoids; 3 — migmatites; 4 — gneisses and crystalline schists; 5 — gneisses and amphibolites; 6 — enderbites and charnockites; 7 — granitoid massifs; 8 — Teisseyre-Tornquist Zone; 9 — faults

Mapa geologiczna stropu podłoża krystalicznego obszaru południowobałtyckiego

1 — granitoidy anatektyczne i reomorficzne; 2 — granitoidy rapakiwipodobne; 3 — migmatyty; 4 — gnejsy i łupki krystaliczne; 5 — gnejsy i amfibolity; 6 — enderbity i charnockity; 7 — masywy granitoidowe; 8 — strefa Teisseyre'a-Tornquista; 9 — uskoki

basement is uplifting rapidly emerging on the island. North of the Łeba Elevation (–3500 m) the crystalline basement is raising somewhat toward the Baltic Shield (A. Dąbrowski, A. Uhrynowski, 1976).

The division of the crystalline basement into the main tectonic-structural units (W. Ryka, 1985) has been proved within the structure of the Precambrian basement of the southern Baltic area (Fig. 1). The division of the Polish part of the East-European Platform into the six main units has been recorded: Prekarelian granitoid massifs[1], Prekarelian folded zones, Karelian metamorphic-magmatic complex, Gothian metamorphic-magmatic complex, Subjotnan-Jotnian quasi-platform complex, platform intrusions.

In the Pomerania and southern Baltic area the rocks of the Presvekofenno-Karelian granitoid massifs, Presvekofenno-Karelian folded zones and rapakiwi-like granitoids assigned thus far to the Gothian metamorphic-magmatic complex have been ascertained. The rocks of the remaining units have not been identified what does not mean that they are not present here. It may be assumed that the metamorphic formations occurring west and north-west of Słupsk as well as the rocks situated south-west of Kościerzyna belong to the Svekofenno-Karelian crystalline schists. The assumption made by A. Dąbrowski and A. Uhrynowski (1976) on the occurrence of the norite-anorthosite intrusion in the Baltic basement along the fault striking north--east of Słupsk seems to be correct.

The Presvekofenno-Karelian granitoids are forming the Pomeranian Massif which is connected in the vicinity of Gdańsk with the Dobrzyń Massif of the Presvekofenno--Karelian age in turn being probably the main tectonic-structural unit. Thus the assumption regarding the continuity of the Pomeranian Massif within the Baltic Sea toward Bornholm and Scania has been confirmed. The south-eastern border of the Pomeranian Massif is being determined by the Presvekofenno-Karelian fold zone — the Kaszuby complex located east of Kościerzyna and running toward Rozewie — Hel Spit (boreholes Darżlubie IG 1, Żarnowiec IG 1, Hel IG 1) and farther about 40–60 km in the northern direction getting stuck finally in the rapakiwi-like granitoid complex. On the boundary of the Pomeranian Massif with the rapakiwi-like granitoids numerous large metamorphic structures probably being the remains of the deep--eroded branch of the Kaszuby complex are occurring.

The thick cover of the sedimentary rocks in the Pomerania and the southern Baltic Sea and the predominant position of the granitoids obliterating the differentiation contrast of the geophysical survey do not favour the tracking of fault tectonics. Small amount of the interpreted faults in the area west of Łeba did not bring the essential elements for identifying the tectonic style nor for elucidating the tectonic relations of

[1] There is the lack of the normalized and stabilized terminology in the Scandinavian literature. The similar meaning is given to the names Svekofenno-Karelian and Sveko-Karelian. G. Gaál and R. Gorbatschev (1987) have found no evidence in distinguishing the Sveko-Karelian orogeny and suggest reviving the concept of the old division into the Svekofennides and Karelides but on the grounds of the plate tectonic theory. The term Karelian complex was applied in the previous works concerning the Polish Precambrian (W. Ryka, 1984, 1985). The aforementioned term was used as structural unit not the genetic meaning. It implies that the Karelian (Svekofenno-Karelian) complex overlies the old Prekarelian (Presvekofenno-Karelian) one, i.e. the granitoid massifs and greenstone belts.

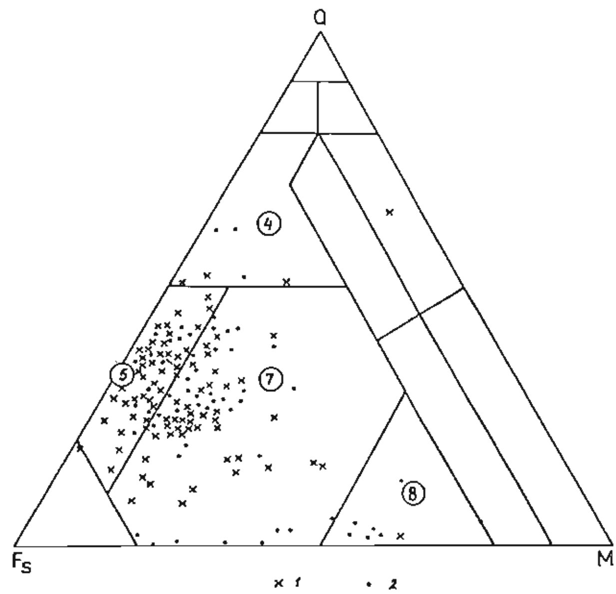

Fig. 2. Classification projection of metamorphic rocks according to Austrian petrologists (*Ein Symposion*, 1962)

Q — quartz; Fs — feldspars; M — mafic minerals; classification fields in circles: 4 — quartz gneisses, 5 — quartz-feldspar gneisses, 7 — gneisses, 8 — mica gneisses; projection points: 1 — gneisses and migmatites from the Pomerania, 2 — gneisses and migmatites from the southern Baltic area

Projekcja klasyfikacyjna skał metamorficznych według petrografów austriackich (*Ein Symposion*, 1962)

Q — kwarc; Fs — skalenie; M — minerały maficzne; pola klasyfikacyjne w kółkach: 4 — gnejsy kwarcowe, 5 — gnejsy kwarcowo-skalcniowe, 7 — gnejsy, 8 — gnejsy łyszczykowe; punkty projekcyjne: 1 — gnejsy i migmatyty z Pomorza, 2 — gnejsy i migmatyty obszaru południowobałtyckiego

the tectonic units present there. Somewhat more information was obtained from the survey of the Kaszuby complex fragment situated north of Rozewie — Hel Spit (Fig. 1). The style of the discontinuous tectonics is being marked by the directions approximated the meridional occasionally parallel ones and is typical for the Mazury complex. The described fault system was formed after the Svekofenno-Karelian movements but before the Gothian rapakiwi-like granitoids. It was consecutively regenerated after the Gothian movements (W. Ryka, 1984).

The Prekarelian rocks of the granitoid massif are occurring in the south-western part of the southern Baltic area (Fig. 1). They occupy the larger area (27.4%) which was not penetrated by boreholes. Thus the continuity of the Pomeranian Massif within the Baltic Sea was inferred on the basis of the regional geophysical survey. According to the data obtained thus far the granitoid massifs display the complicated structure and origin (S. Kubicki, W. Ryka, 1982). These units were frequently regenerated during the younger tectonic-magmatic alterations. They contain numerous traces of the Presvekofenno-Karelian structures which underwent such strong transformations

Table 1

Results of chemical analyses of enderbites and rapakiwi-like granitoids (in weight percent)

Components	Test number			
	1	2	3	4
SiO_2	51.42	47.94	71.34	72.88
TiO_2	0.61	1.33	0.47	0.53
Al_2O_3	13.42	17.30	13.70	12.95
Fe_2O_3	3.08	3.99	0.30	0.39
FeO	6.39	7.54	2.78	1.66
MnO	0.26	0.22	0.08	0.08
MgO	7.61	6.61	0.76	0.72
CaO	11.28	6.52	0.71	2.35
Na_2O	3.47	3.78	3.29	2.80
K_2O	1.20	3.20	4.83	4.25
P_2O_5	0.09	0.36	–	–
S	0.06	0.13	–	–
CO_2	0.00	0.00	–	–
H_2O^+	0.64	0.66	–	–
H_2O^-	0.24	0.22	–	–
Loss on ignition	–	–	1.38	1.15
Total	99.77	99.80	99.64	99.78

Explanations: 1 — enderbite, borehole B–2, depth 2941.5 m; 2 — enderbite, borehole B–2, depth 2942.4 m; 3 — rapakiwi-like granitoid, borehole B–4, depth 1458.5 m; 4 — rapakiwi-like granitoid, borehole B–4, depth 1506.8 m; samples 1 and 2 were tested by W. Sulkowska (Dolnośląski Branch of the Polish Geological Institute) whereas samples 3 and 4 were tested by E. Kotlarski (Świętokrzyski Branch of the Polish Geological Institute)

that deciphering of the primary character is practically impossible. The granitoid massifs are consisted mainly of orthoclase (microcline) reddish granites with minor admixture of quartz, oligoclase, muscovite and biotite rarely cordierite, sillimanite, common hornblende and sporadically pyroxene. Their petrographic composition conforms with the β-granites and granodiorites seldom α-granites. They are featured by the variable texture and structure as well as monotonous chemical composition.

The small area of the southern Baltic zone is taken up by the rocks of the Presvekofenno-Karelian folded structures (16.8%). According to the lithostratigraphic division patterned upon the Podlasie complex (S. Kubicki, W. Ryka, 1982) the aforementioned unit is composed of two groups — the older (granulite) and the younger (plagiogneiss). The granulite group comprises charnockites (older), two-pyroxene granulites, enderbites as well as gneisses and amphibolites whereas the plagiogneiss group sillimanite-andalusite, hornblende, biotite and garnet gneisses as well as amphibolites respectively. The accurate classification of the Presvekofenno-Karelian gneisses is not always possible because of the considerable degree of hypergenic and hydrothermal alterations of the rocks of the Baltic crystalline basement which is drilled sporadically at shallow depths.

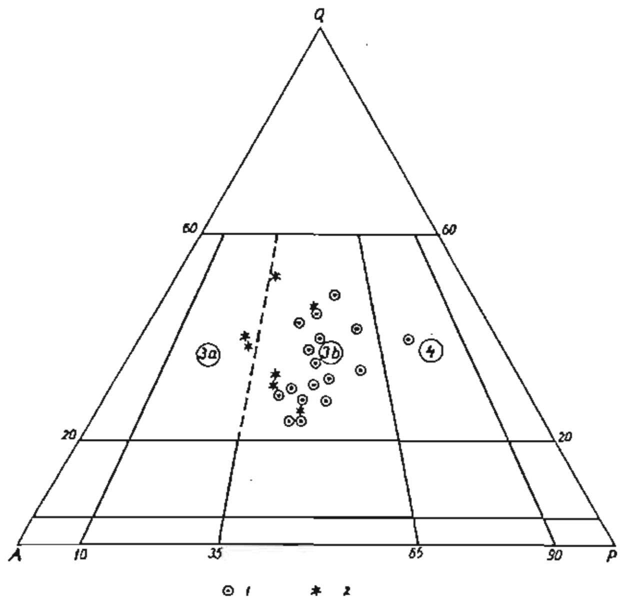

Fig. 3. QAP classification projection of rapakiwi-like granitoids

Q — quartz; A — K-feldspars; P — plagioclase; classification fields in circles: 3a — granite α, 3b — granite β (monzogranite), 4 — granodiorite; projection points: 1 — granitoids from the Pomerania, 2 — granitoids from the southern Baltic area

Projekcja klasyfikacyjna QAP granitoidów rapakiwipodobnych

Q — kwarc; A — skalenie potasowe; P — plagioklaz; pola klasyfikacyjne w kółkach: 3a — granit α, 3b — granit β (monzogranit), 4 — granodioryt; punkty projekcyjne: 1 — granitoidy z Pomorza, 2 — granitoidy obszaru południowobałtyckiego

In the Pomerania the rocks of the granulite groups were encountered in boreholes Kościerzyna IG 1 and Żarnowiec IG 1 whereas in the Baltic Sea north of Żarnowiec — Hel Spit. In the southern Baltic area the enderbites and pyroxene gneisses were ascertained. The plagiogneiss group is apparently represented here by the hornblende and biotite gneisses. The systematic division of these rocks was depicted on Figure 2. The projection show that rocks derived from the Pomeranian and southern Baltic areas are forming one point pattern which includes the quartz-feldspar gneisses (field 5) and gneisses (field 7) occasionally mica gneisses (field 8) and quartz gneisses (field 4). In addition, along the projection base (feldspars-mafic minerals) the amphibolites are occurring. The projection points of the Presvekofenno-Karelian metamorphic rocks along with the projection points of the migmatites concentrated primarily in the quartz-feldspar gneisses field have been presented. The aforementioned rocks have not been divided because the Presvekofenno-Karelian rocks generally underwent the migmatization and metasomatism of various degree hence determing the boundary in-between would require the removal of most parametric points which could distort

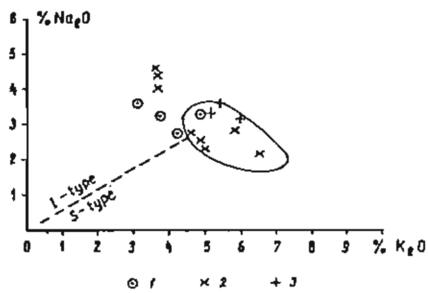

Fig. 4. K_2O:Na_2O diagram with marked field of projection points occurrence of Finnish rapakiwi granites (I. Haapala et al., 1987) along with division into fields of I-type and S-type granitoids

Projection points of rapakiwi-like granitoids: 1 — southern Baltic area, 2 — Pomerania, 3 — Mazury complex

Diagram K_2O:Na_2O z zaznaczonym polem występowania punktów projekcyjnych fińskich granitów rapakiwi (I. Haapala i in., 1987) oraz podziałem na pola granitoidów I-typu oraz S-typu

Punkty projekcyjne granitoidów rapakiwipodobnych: 1 — obszar południowobałtycki, 2 — Pomorze, 3 — kompleks mazurski

the real picture of the differentiation of the rocks assigned to the crystalline basement top.

In the southern Baltic area the Presvekofenno-Karelian rocks are strongly altered due to the metasomatism, mylonitization and recrystallization as well as the hydrothermal and hypergenic processes. The rocks weakly affected by alteration are rare. That is why the enderbites from borehole B2–1/80 which reveal the following mean values of the sixteen point counter analyses should be highlighted here. They are (in percent): quartz — 1.8, plagioclase (40% An) — 46.2, antiperthite — 3, pyroxenes (hypersthene, augite, diopside-augite) — 11.9, common hornblende (after pyroxenes) — 26.9, biotite — 3.9, muscovite — 0.1, opaque minerals — 3.8, apatite — 0.3, zircon — 0.1 and chlorite, carbonates and sericite. According to the international classification of charnockites the examined rocks may be identified as hypersthene diorite in which the antiperthitization process has been constrained to the initial phase and the typomorphic paragenesis of andesine with hypersthene and augite along with small admixture of quartz make it possible to include these rocks into the enderbites. The characteristic chemical composition of the enderbites is presented in Table 1. High content of magnesium and bivalent iron as well as calcium should be emphasised here. The amount of the calcium may be locally lowered in the strongly microcline-enriched rocks, for instance in sample no. 2 as compared to sample no. 1 (Tab. 1).

The Presvekofenno-Karelian gneisses are much worse preserved and the accumulation of the secondary products of alterations is locally of such degree that it enables the correct identifications, though both the structure and texture remain unobliterated. The pyroxenes, even those which resisted to the metamorphosis, were subsequently affected by the hydrothermal and hypergenic alterations. After these minerals only rims and particularly the accumulations of secondary titanium minerals within the skeleton of the diallage lattice have been preserved. The common hornblende and especially biotite were more resistant to these alterations. The plagioclase is represented by the oligoclase revealing the variable content of the anorthite molecule (8–14% An and 25–27% An). The perthite intergrowths and occasionally advanced microclinization are commonly known. Other minerals like titanite, zircon, allanite, apatite and opaque minerals are frequently encountered.

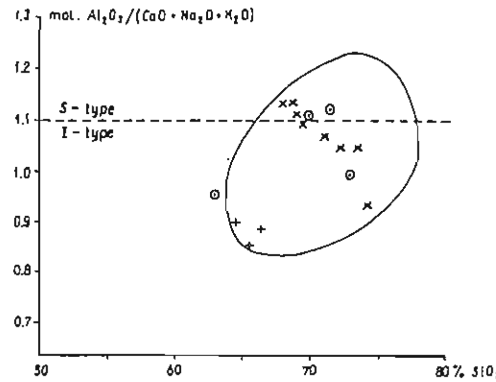

Fig. 5. SiO_2:Al_2O_3/($CaO+Na_2O+K_2O$) projection (in weight percent:molar percent) with marked field of Finnish rapakiwi granites (I. Haapala et al., 1987) along with division into fields of I-type and S-type granitoids

For more details on projection points of rapakiwi-like granitoids refer to Figure 4

Diagram SiO_2 (% wag.):Al_2O_3/ /($CaO+Na_2O+K_2O$) (% mol.) z zaznaczonym polem fińskich granitów rapakiwi (I. Haapala i in., 1987) oraz podziałem na pola granitoidów I-typu i S-typu

Objaśnienia punktów projekcyjnych granitoidów rapakiwipodobnych jak na fig. 4

PROBLEM OF THE RAPAKIWI-LIKE GRANITOIDS

In the north-eastern part of the southern Baltic Sea about 50% of the crystalline basement area is occupied by rapakiwi-like granitoids (Fig. 1). The migmatites take up the area of about 4% mainly in the vicinity of Hel and Żarnowiec. The anatectic and rheomorphic granitoids are in turn rarely present (0.5%). The rapakiwi-like granitoids are forming the great structural unit stretching from Suwałki through Gołdap and Bartoszyce (Mazury complex) to Vistulan Spit and farther the Baltic Sea toward to Sweden. As for the structure as well as mineral and chemical composition these rocks are not homogenous.

The results of the planimetric analyses of the rapakiwi-like granitoids were presented on Figure 3. The parametric points of these rocks have been clustered in the β-granite (monzogranite) field and while retaining the somewhat predominant position of the K-feldspar over plagioclase they are marked by the great variation of the quartz content. In general, the rapakiwi-like granitoids are featured by much greater variation of the mineral composition than the β-granites and granodiorites and even quartz monzonites or quartz monzodiorites. Apart from the main components the rapakiwi-like granitoids contain in minor quantities common hornblende (to 9%), biotite (to 11%) and additionally apatite (to 4%), opaque minerals, zircon, titanite, fluorite and commonly encountered minerals of secondary alterations. Among the aforementioned minerals the K-feldspar — primarily younger microcline and sporadically older orthoclase should be strongly highlighted here. The orthoclase and microcline are overgrown by the albite-oligoclase rims (often affected by sericitization), for instance in the rocks derived from borehole B–1/81. The results of the chemical analyses of these rocks are presented in Table 1 (analyses 3 and 4).

In the rapakiwi granitoids K_2O usually prevails over Na_2O and the ratio of these two constituents does not generally exceed the statistically defined boundaries. Based upon this (Fig. 4) I. Haapala et al. (1987) marked the field of the occurrence of the Finnish rapakiwi granites. The rapakiwi granitoids resembling those from the Polish part of the East-European Platform reveal the higher content of Na_2O as compared to the Finnish rapakiwi granitoids and therefore the cluster field of the projection

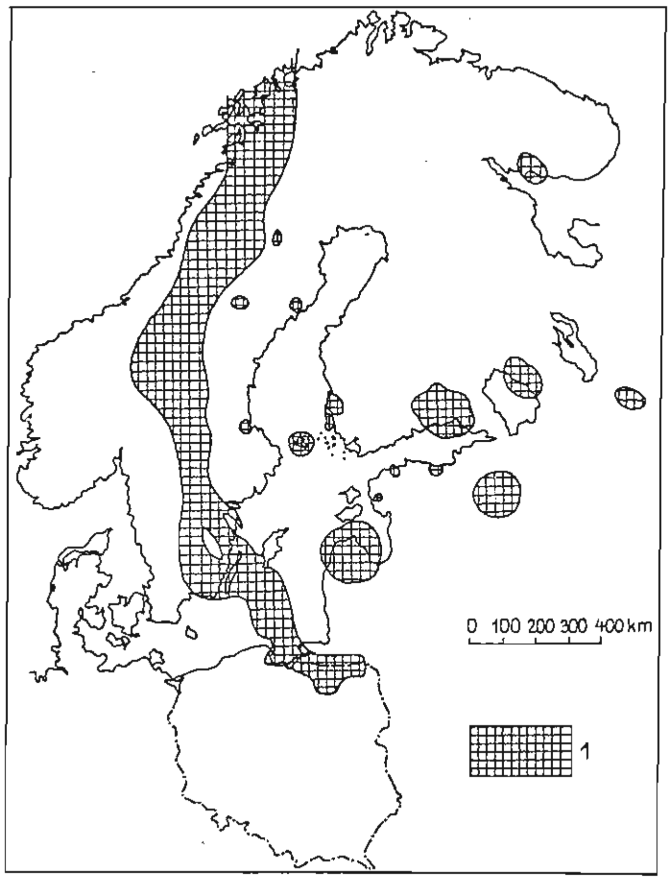

Fig. 6. Extent of Trans-Scandinavian belt of granites and rapakiwi massifs; schematic diagram after R. Gorbatschev and G. Gaál (1987) supplemented by the author

1 — rapakiwi granites and granitoids

Przebieg transskandynawskiego łańcucha granitów i masywów rapakiwi; schemat R. Gorbatscheva, G. Gaála (1987) uzupełniony przez autora

1 — granitoidy i granity rapakiwi

points is somewhat different. The parameters of the chemical analyses of the rapakiwi-like granitoids are forming systematic pattern with the K_2O/Na_2O ratio of 3 to 2. The similarly shaped though more simplified is the pattern of the Finnish repakiwi granites.

The division boundary into I- and S-types granites (Fig. 4) have been presented after B. W. Chappell and A. J. R. White (*fide* I. Haapala et al., 1987). This boundary can indicate the relation of the rapakiwi-like granitoids with the magma source (I-type). It may be applied particularly to the rocks derived from the southern Baltic

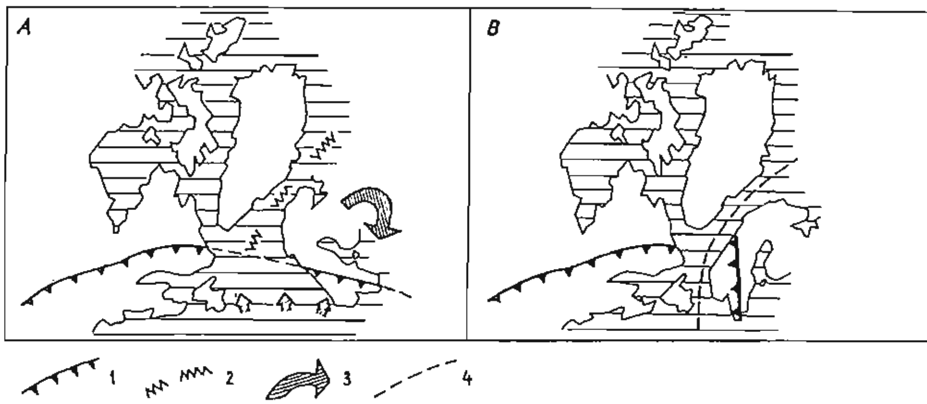

Fig. 7. Reconstruction of Sveko-Norwegian (Grenville) continent according paleomagnetic data (J. E. F. Stearn, J. D. A. Piper, 1984)

Arrow indicates the rotation direction of the Baltic Shield against the Laurentian Shield during 1190–1050 million years: A — at the beginning of the Grenville orogeny, B — during later period of the Grenville orogeny; 1 — Grenville front, 2 — rift zone, 3 — subduction area, 4 — collision zone

Rekonstrukcja sveko-norweskiego (grenwillskiego) kontynentu według danych paleomagnetycznych (J. E. F. Stearn, J. D. A. Piper, 1984)

Strzałką pokazano kierunek rotacji tarczy bałtyckiej wobec tarczy laureatyjskiej w czasie 1190–1050 mln lat: A — na początku orogenezy grenwillskiej, B — w późnym okresie orogenezy grenwillskiej; 1 — grenwillski front, 2 — strefa ryftu, 3 — obszar subdukcji, 4 — strefa kolizji

Sea and Mazury complex areas. They are abundant in magnetite and titanite also frequently encountered in the granitoids from the Pomerania; the heavy minerals characteristic of the I-type granite. The parameters of the anatectic granitoids assigned to the Polish part of the crystalline basement have clustered below the field of the Finnish rapakiwi granites in the area determined by the K_2O and Na_2O contents of 3–6 and 1.5% per weight respectively. The projection points of the Finnish postorogenic microcline granites are quite differently arranged overlapping the Finnish rapakiwi granites on Figure 4 or clustering in the center of the projection field of these rocks on Figure 5.

Based upon the data obtained thus far the geotectonic position of the rapakiwi granitoids cannot be unequivocally established. The rapakiwi granitoids are commonly considered the anorogenic. Nonetherless the cluster of the chemical analyses of the Polish rapakiwi-like granitoids and Finnish rapakiwi granites (Figs. 4 and 5) is concentrated at the boundary of the I-granites (synorogenic) and S-type granites (lateorogenic and migmatites). The S-type rapakiwi granites may be then the pattern for elucidating the origin of the Polish rapakiwi-like granitoids.

As for the Polish rapakiwi-like granitoids the application of the heavy minerals such as magnetite and titanite being the indicators for identifying I-type granites seems to be of doubtful value. The analysis of the chemical composition of the crystalline basement rocks assigned to the Polish part of the East-European Platform revealed the characteristic variation of some chemical elements during its evolution. The steady increase of the mean content of titanium from the Presvekofenno-Karelian granitoid massifs (mean value of TiO_2 is 0.5%) to the young Proterozoic platform intrusions (TiO_2 in ijolites averages up to 9% whereas in syenites 0.7–1.7% respectively) has been among others ascertained. The titanium having occurred at first in the disseminated form amidst aluminosilicates, differentiated at the turn of the Proterozoic in form of oxides (titanomagnetite and ilmenite) or silicates (titanite). The last-mentioned is particularly abundant in the syenites and frequent in the rapakiwi-like granitoids (TiO_2 content reaches 1.2%).

The analysis of the crystalline rocks from the southern Baltic Sea has revealed numerous elements yielding the more detailed information on the evolution of the Precambrian basement. The strong development of the hydrothermal and hypergenic alterations precluded drawing more new data on the conditions of the metamorphic alterations and mineral transformations. More important was the lithostratigraphic identification of the crystalline basement within the southern Baltic Sea which created the basis for the comparison with the Precambrian of southern Sweden.

The Presvekofenno-Karelian (Karelian) fold zones called in the Pomerania the Kaszuby complex enter the sea where they were identified by means of boreholes. The presence of the enderbites, pyroxene gneisses of the granulite group as well as the hornblende gneisses and biotite gneisses of the plagiogneiss group was proven here. The attempts of determing the isotopic age of the common hornblende from the enderbites applying the $^{40}K/^{40}Ar$ method was performed by Dr. J. Lis. The obtained results were: 1685, 1544 and 1550 million years. However, the age values mentioned above refer to the alteration of the pyroxene which relics are sometimes ingrained in the hornblende. The transformations of the pyroxene into hornblende took place then during the Gothian alterations in southern Sweden, i.e. 1800 through 1500 million years ago. The aforementioned age overlapped the formation in the Scandinavian — the Trans-Scandinavian granite-porphyry belt (Fig. 6). Based upon the obtained results confirming the continuation of the rapakiwi-like granitoids from the Mazury complex through Vistulan Spit and farther toward the Baltic Sea it may be assumed that there is younger structural domain with connection of the older granite Trans-Scandinavian granite-porphyry belt.

POSTGOTHIAN EVOLUTION OF THE CRYSTALLINE BASEMENT

During the formation of the Trans-Scandinavian belt of the alkaline-calcium granites within the Svekofenno-Karelian craton the masses of rapakiwi originated. The isochronous age of the Polish rapakiwi-like granitoids has been determined to be 1470 million years being somewhat younger the anorogenic granitoids assigned to the Trans-Scandinavian granite-porphyry belt (R. Gorbatschev, G. Gaál, 1987; K. Sundblad, 1991). In turn, the isochronous age of the granitoid veins cutting the migmatites and metasomatic granitoids amounts to 1340 million years, that can indicates: 1 — the backward age of the Gothian alterations in the marginal part of the East-European Platform in Poland, Lithuania and Byelorussia — and such view has so far been represented (W. Ryka, 1985); 2 — the existence on the East-European Platform of the unknown episode reflecting strong events evidenced by the charnockitization (younger), migmatization and anatectic granites. Recording the Halland quasi-orogeny in the vicinity of Varberg in south-western Sweden induces to reexamine the view on the backward development of the Gothian events in Poland (F. H. Hubbard, 1975). The coincidence of the scale of alteration processes such as charnockitization (younger) in the range of amphibolite facies, migmatization and anatexis as well as nearly the same time of alterations, i.e. 1500–1400 million years in the vicinity of Varberg and 1400–1340 million years in Poland seems to indicate that the backward transformations of the Gothian phasis in Poland are the Halland quasi-orogeny.

The metamorphic evolution of the Polish part of the crystalline basement seems to have continued during the Sveko-Norwegian (Grenville) orogeny dated back to 1250–900 million years. In the Polish territory its impact is evidenced by the granite veins of 1250 million years cutting the granitoid massifs. The younger period of the magmatic activity in south-western Sweden (about 1200 million years) revealed by ijolite-syenite intrusions, granites, great amounts of mafic dykes and basic eruptive rocks is quite significant. That is why it appcars reasonable to refer to the Polish analogues of the platform intrusions, i.e. lamprophyres and basic eruptive rocks.

The analysis of the discontinuous tectonics of the crystalline basement assigned to the Polish part of the East-European Platform has revealed the presence of two fault systems, i.e. NW–SE — parallel to the Teisseyre-Tornquist Zone and NE–SW — parpendicular to the aforementioned. The second fault system displays often developed N–S and rare W–E directions, and is connected with the occurrence or direct proximity of the Gothian rocks (W. Ryka, 1984). The meridional and parallel faults have been confirmed within the Mazury complex, Żuławy branch, the Pomerania and north of Rozewie — Hel Spit. In southern Sweden numerous long-lived meridional faults along which the intrusions were placed many times have also been ascertained. One of the most long-lived is the meridional protogenic zone in southern Sweden separating the Trans-Scandinavian granite-porphyry belt from the South-Scandinavian domain. The protogenic zone played important role during the Sveko-Norwegian (Grenville) orogeny. It was at that time the front of subduction and then, after the rotation of the Baltic Shield 1190–1050 million years ago (J. E. F. Stearn, J. D. A. Piper, 1984) and its collision with the Laurentian Shield, was strongly deformed, regenerated and intruded (Fig. 7). In the Polish territory the Pregothian meridional faults were apparently rejuvenated, and particular blocks of the crystalline basement pushed apart at the distance of 5 km. It is quite possible that in the southern Baltic area the distance between the meridional faults is greater and increases toward the west. Both the parallel and particularly the meridional faults were reactivated many times in the younger epochs of the geological development of the Polish territory.

Having been particularly active the protogenic zone extends within the Odra — Nysa Łużycka zone along which centers of the postvolcanic autometasomatosis were located in the Rotliegendes (W. Ryka, 1981).

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Zakład Petrografii i Geochemii
Państwowego Instytutu Geologicznego
Warszawa, ul. Rakowiecka 4
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Wacław RYKA

PODŁOŻE KRYSTALICZNE POLSKIEJ CZĘŚCI POŁUDNIOWEGO BAŁTYKU

Streszczenie

Nowe materiały geofizyczne i wyniki badań petrograficznych skał z wierceń wykonanych na polskim obszarze południowego Bałtyku umożliwiły zestawienie schematycznej mapy geologicznej powierzchni fundamentu krystalicznego. W południowo-zachodniej części krystalinik składa się prawdopodobnie z granitoidów presvekofenno–karelskich, a w części północno-wschodniej — z granitoidów rapakiwipodobnych. Na północ od Rozewia — Mierzei Helskiej wychodzi w morze presvekofenno– karelska strefa fałdowa reprezentowana przez enderbity i gnejsy piroksenowe. Stwierdzono, że polskie granitoidy rapakiwipodobne utworzyły południową domenę transskandynawskiego pasa granitowego południowej Szwecji. Trudne dotychczas uzasadnienie bardzo młodego wieku „gotyjskiej" charnockityzacji, migmatytyzacji i anateksis tłumaczy się quasi-orogenezą hallandzką. Natomiast odnowienie pregotyjskich uskoków południkowych wyjaśnia się grenwillską rotacją tarczy bałtyckiej i jej kolizją z tarczą laurentyjską.