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POLYSTAGE MAFIC PLUTONISM WITHIN AMCG MAZURY COMPLEX - THE SEJNY IG-1 BOREHOLE, NE POLAND

Abstract: This paper presents new geochemical and U-Pb geochronological data from the mafic Sejny intrusion of NE Poland. Three stages of mafic plutonism, differing in age and chemical characteristics have been recognized. Mingling was recognized as main process leading to formation of several types of hybrid rocks, present as mosaic of fine and medium grained portions of not homogenized mafic magma, mainly at the upper part of this intrusion.

Key words: jotunite, gabbro, U-Pb geochronology, mingling, AMCG magmatism

INTRODUCTION

Mafic composite plutons are usually formed by a series of more or less discrete pulses of magmas of different composition and age. They might be of the same source, resulting from fractionation or might be formed by pulses of magmas of heterogeneous origin. In this paper we try to present a model of the polyphase mafic intrusion, cut by Sejny IG-1 well.

GEOLOGICAL SETTING

Mesoproterozoic Mazury Complex, composed of rapakivi-type granitoids (ca 1.56 Ma), with an AMCG affinity, is a westernmost fragment of the East-European Craton. This Precambrian rock complex is covered by 1000-3500 m thick sedimentary Phanerozoic sequences (Dörr *et al.* 2002, Skridlaite *et al.* 2002) Among the granitoid rapakivi-type complex, three anorthosite-gabbro-norite intrusions have been distinguished: Ketrzyn, Suwalki and Sejny. The Sejny gabbroidic intrusion (Fig. 1) is the smallest one and contain only few meters of anorthosite at the highest depth and small concentrations of Fe-Ti mineralization. This body has been recognized by 2 boreholes up to 1180 metres.

EXPERIMENTALS

Microprobe analyses of minerals were performed in Inter-Institution Laboratory of Microanalyses of Minerals and Synthetic Substances, located at the Warsaw University, on CAMECA SX-100 electron microprobe. Whole rock analyses of main and trace elements were carried out by XRF analytical method at Geochemical Laboratory at the University of Liege in Belgium. Chemical composition of the zircon crystals, ion-exchange separation of U and Pb and mass spectrometric measurements were performed in the Isotope Laboratory of Institute für Geowissenschaften und Lithosphärenforschungen (University of Giessen). Isotopic ratios were determined using Finnigan MAT 261 multicollector solid-source mass spectrometer in the static mode, with ²⁰⁴Pb measured with a previously calibrated axial secondary electron multiplier in ion counting mode.

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MINERALOGY AND PETROLOGY OF THE SEJNY MASSIF

Sejny IG-1 well cuts coarse-grained anorthosites, locally with megacrysts at the bottom, showing transitions to the overlying coarse- to medium-grained gabbro. Both rock-types are cut by jotunite dykes. In the upper part of the profile a hybrid zone is observed, composed of the fine-grained and very fine-grained gabbro portions mingled with the medium and coarse grained gabbroic matrix. Locally the small veins and segregations of meladorite are present. The whole mafic complex is cut by the youngest veins (up to 1.5 m) of fine grained granites and their pegmatites.

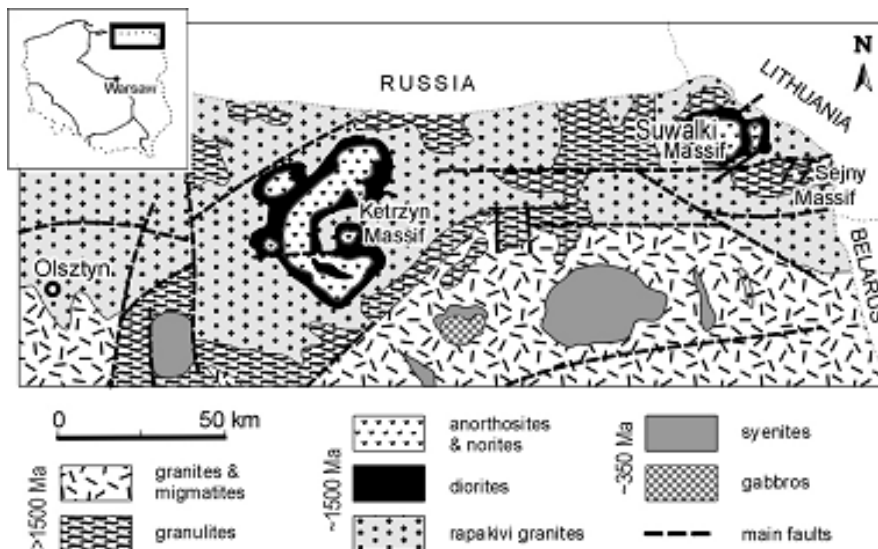


Fig. 1. Geologic map of the Mazury Complex (Kubicki, Ryka 1982, modif. Wiszniewska *et al.* 2000)

Anorthosites are almost monomineral, composed of plagioclases (An_{55-58}), locally antyperthitic, with accessory pyroxene ($En_{55}Fs_{43}Wo_2$), Ti-magnetite and ilmenite. Anorthosites show relatively high Al_2O_3 content (19-28 wt %) and positive Eu anomaly ($Eu/Eu^* = 1.76-2.27$; Wiszniewska 2002).

Jotunites are fine- and very fine-grained variety (with chilled margins found against the contact with gabbro). They are composed of zoned plagioclase ($An_{54}-An_{74}$), two types of pyroxenes: Opx ($mg\# = 56-59$; $Wo = 0.89-0.78\%$) and Cpx ($mg\# = 73-75$; $Wo = 49-47$), apatite, and Fe-Ti oxides. Dispersed plagioclase porphyrocrysts (An_{51-61}) are concentrated in the border zones of the jotunite sills, underlying the oriented fabric of the rocks. Secondary biotite is enriched in Ti (0.53-0.58 a.p.f.u) with $mg\# = 0.60-0.62$. Jotunites are enriched in TiO_2 (1.3-1.5 wt %) and poor in silica. Eu/Eu^* and Sr content dramatically drop with the growing SiO_2 content. The medium REE fractionation is expressed by $(Ce/Yb)_N$ ratio in the range of 3.52-9.32. $(Ce/Yb)_N$ parameter and TiO_2 content show the strong negative correlation while $(Yb)_N$ parameter show positive correlation with TiO_2 . Such features suggest that the jotunite melt fractionation was governed by plagioclase crystallisation while the HREE fractionation was driven by the crystallisation of (Fe-Ti) oxides (and secondary biotite) as the main Ti (and consequently HREE) carriers. More primitive samples with the smallest Eu-anomaly show the highest REE concentrations ($\Sigma REE = 92.02$ ppm and 102.9 ppm respectively).

Gabbros are heterogeneous in texture and mineral composition. They are mainly medium- to coarse grained, with locally developed oriented texture. Their main mineral

components are orthopyroxenes ($mg\# = 0.62-0.68$, $Wo = 0.0-0.02$) showing the ilmenite exsolutions (Wiszniewska et al. 2002), overgrown by amphibole rims, zoned plagioclases (An_{83-50}) and ilmenite. Abundant secondary biotite shows high Ti content (0.57-0.34 a.p.f.u.) and $mg\#$ in the range 0.62-0.72, suggesting the chemical inheritance after decomposed pyroxene and ilmenite. Gabbros are characterised by SiO_2 content in the range of 52-53 wt %. Their REE patterns (total REE = 20.6-72 ppm) varied from less fractionated samples with $(Ce/Yb)_N \sim 3$ to higher fractionated ones with $(Ce/Yb)_N \sim 10$. Gabbros show a positive correlation between Eu/Eu^* and Sr, what suggest plagioclase fractionation as the main process. Weak negative correlation between Yb_N and TiO_2 and lack of any relationship between $(Ce/Yb)_N$ and TiO_2 point out the late, post-magmatic processes influencing strongly the crystallization patterns.

Hybridic rocks, occurring in the upper part of the composite pluton are heterogeneous, composed of the patchy portions of fine grained gabbroic material (“clasts”), cemented by medium- to coarse-grained gabbro to gabbro-norite. Amphibole rims around clinopyroxene are frequent, as well as Ti-rich biotite crystallizing around ilmenite. Plagioclase crystals contain numerous mineral inclusions and irregular distribution of An content. SiO_2 content in hybrids differ from 48.8 to 57.8 wt.%, (from jotunitic gabbro to diorite) and total REE content in the narrow range: 40.3-48.7 ppm (one exception = 22.7 ppm). Both rock-components are characterised by positive Eu anomaly (Eu/Eu^* in the range 1.41 – 2.33) and no distinguished chemical trends.

Meladiorites are fine grained rocks with aplitic fabric, composed of plagioclase, amphibole, rare remnants of pyroxene, accessory quartz, K-feldspar and secondary biotite. All primary mineral constituents are intimately intergrown. Meladiorites are characterised by negative Eu anomaly ($Eu/Eu^* = 0.499$), steep REE fractionation patterns ($[Ce/Yb]_N = 43.42$) and relatively high Zr content (85 ppm).

Granitoids are present as fine-grained pinkish veins, from several cm to 1.5 m in thickness, cutting discordantly all the mentioned rock types. They are composed of perthitic K-feldspar, plagioclase, biotite. Granitoids are enriched in Th, Zr and depleted in Sr and TiO_2 . They show negative Eu anomaly ($Eu/Eu^* = 0.18-0.25$) and high REE fractionation ($Ce/Yb = 48.39$ and 21.55). They have geochemical features of late orogenic – post-collisional association.

U-Pb GEOCHRONOLOGY

Rocks from mingling zone were selected for U-Pb ID-TIMS zircon dating. Zircon crystals from all rocks show typical fine oscillatory magmatic zonation. A single zircon from **jotunitic**, with the lowest U content of 60 ppm, plots on the concordia, at 1549 ± 5 Ma, that could be interpreted as the crystallization age during quick cooling process (Wiszniewska et al. 2002). Fine grained **gabbroic chilled margin** contain concordant zircon crystals at 1526 ± 1 Ma which is interpreted as chilled margin formation. Uranium poor single zircons from the same sample define a discordia line with an upper intercept age at $1542 +9/-2$ Ma, which is interpreted as inheritance from older plutonic processes. The zircons from medium grained **gabbro-norite** are rich in U (289-1070 ppm) and define a discordia line, with the upper intercept at $1519 +17/-12$ Ma and lower intercept at 416 Ma. The upper intercept may be interpreted as crystallization age.

TYPE OF PROCESSES ACTING AND THEIR AGE

Jotunites (an equivalent of hyperstene monzodiorite) are usually interpreted as the parental magma for anorthosites (Duchesne 1990) and consequently they coexist with them

in the described profile. Jotunite dykes cut both anorthosite (present at the bottom of borehole) and overlying gabbro. The U-Pb age of zircons from jotunite (1549 Ma) could be interpreted as an age of jotunite magma exsolutions and/or intrusion into not completely consolidated anorthosite and gabbro with the Re-Os age determination of 1559 Ma (Morgan *et al.* 2000, Wiszniewska 2002). In the uppermost part of the pluton, chilling processes occurred (1526 Ma), forming the fine-grained variety of the gabbro. Subsequently, the residual fractionated melt intruded in the upper part of the massif. As a result, the zircon age from medium-grained gabbro to gabbro-diorite, forming the “cement” in the hybrid zone in the upper part of the profile (1519 Ma) could be a record of the “brecciation” of the old chilled margin and formation of the hybrid zone. Both magmas did not homogenized chemically and the process of hybridisation could be described as mingling. Fine-grained meladiorite dykes and segregations represent the younger, less fractionated magmatic episode. Later fine-grained granite dykes are the source of post-magmatic fluid and potassium necessary to crystallize biotite. Late, secondary Ti-rich biotite crystallize at the cost of pyroxene and ilmenite in all rock types and is chemically identical with the biotite present in granites.

CONCLUSIONS

Polyphase mafic magmatism, which started at 1559 Ma with anorthosite – gabbro magma intrusions (Wiszniewska 2002), developed further as a consequence of the intrusion and chilling of an exsolved jotunite magma (1549 Ma), gabbroic chilled margins formation (1526 Ma) and fractionation of residual gabbro to gabbro-norite melt (1519 Ma). At all these stages magma fractionation occurred, driven by plagioclase and Ti-Fe oxides crystallisation. Fine-grained amphibole-rich meladiorite was the late products of magma differentiation. The granitoid veins were the source of potassium for the pervasive biotite crystallization. In the nearby Boksze drill core zircons from granitoid veins show discordant ages with upper intercept at 1512±1.1 Ma (Dörr *et al.* 2002).

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