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Petrography and Geochemistry of Granitoids from South Part of Strzelin Crystalline Massif (SW Poland)

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The Strzelin Crystalline Massif represents an isolated fragment of the Variscan basement exposed in the southern part of Fore Sudetic Block (SW Poland). The igneous rocks represented by granodiorites, quartz diorites and tonalites, biotite granites (347 ± 12 Ma) and two mica granites (of 330 ± 6) form small bodies, mostly stocks and flat dykes within metamorphic rocks (Oberc-Dziedzic, 1991, Oberc-Dziedzic et al., 1996). Crystalline rocks usually occur as small exposures therefore many important information about history of the Massif must be obtained from borehole material. This paper focuses on rocks from five boreholes in southern part of the Massif.

Several types of granitoids were distinguished according to drill documentation. Detailed observation led to simplified division into three types of granitoids: (1) granodiorites (dominating type) and subordinate (2) tonalites and (3) two mica granites.

Granodiorites are medium- to coarse-grained and locally exhibit parallel alignment of minerals. They consist of quartz, plagioclase, K-feldspar, biotite, amphibole and accessory apatite, titanite and zircon. Plagioclases are commonly normally zoned (45% An in the core to 25% An in the rim) with slight oscillations. Inner parts of the cores are often strongly altered. Small inclusions of biotite occur in the mantles. Several grains exhibit different zonation style with reversly zoned cores (30% An in the inner core and 51% An in outer core) and constant anorthite content in the mantle (27%–30% An). Mafic minerals (biotite and amphibole) occur as aggregates or as individual grains. Biotite is characterized by slight decrease of Al^{IV}, Ti and $Mg/(Mg+Fe^{tot})$ from the cores towards the rims. Amphibole grains consist of Fe-hornblende and Mg-hornblende cores and thin actinolite rims.

Tonalites are fine- to medium-grained, consist of plagioclase, quartz, biotite, amphibole, K-feldspar and apatite, titanite and zircon as accessories. Large grains of plagioclases are characterized by complex zonation. The poor in anorthite (29–33%) cores are surrounded by mantles richer in anorthite (43%). Anorthite content decreases again towards the rim to 28%. Small plagioclases are normally zoned from 39% An to 33% An. Biotites form large aggregates up to 4 mm. Al^{IV} in biotites increases from the cores to the rims by 0.2 in average. Slight increase in Ti content is also noted in the same direction. Amphiboles consist of Fe-hornblende cores, Mg-hornblende mantles and strongly enriched in Mg-hornblende rims.

The granites are fine-grained and consist of quartz, K-feldspar, plagioclase, muscovite and biotite.

Investigated granitoids are mostly calcic, metaluminous with positive correlation between aluminium saturation index (molar $Al_2O_3/(CaO+K_2O+Na_2O)$ and SiO_2 (% wt) content. They show 'normal' variation trends of decreasing MgO, Fe_2O_3, CaO, MnO, TiO_2 and P_2O_5 with increasing SiO_2. K_2O increasing together with SiO_2, whereas Na_2O and Al_2O_3 show a relatively large scatter with no evident trends. Granitoids have relatively high abundances of Yb, low abundances of Sr and low values of Sr/Y, Sr/Nd, Zr/Y and $(Tb/Yb)_N$. Negative correlation is noticeable between SiO_2 and V, whereas SiO_2, Sr, Ba and Y content are not mutually dependent. There is also positive correlation between SiO_2 and Rb.

Chondrite-normalized rare earth element (REE) patterns are characterised by moderate concave-upward shapes with relatively low negative Eu anomaly. The magnitude of the negative Eu anomaly is not dependent on the SiO_2 content.

Conclusions

Only scarce contacts between granodiorites and tonalites were found but structural characteristics of both rocks together with previously described relationships (Oberc-Dziedzic personal communication) indicate that tonalite forms veins crosscutting granodiorite. Two-mica granite crosscuts granodiorite and is supposedly the youngest rock type as it was described from field relations and dating in other parts of Strzelin Crystalline Massif (Oberc-Dziedzic et al., 1996, Oberc–Dziedzic, 1999).

Normal zonation in type I plagioclases from granodiorite and crystallization of biotite and amphibole after plagioclase (structural evidence) indicates their crystallization in steadily cooled magma body progressively enriched in water (e.g. Naney, 1983). Occurrence of second scarce type of plagioclase grain with reversly zoned cores suggests different, more complex origin of their formation, and then mixing of two types of grains in one magma reservoir.

Chemical compositions of minerals from tonalite (increase in An content towards the mantles in plagioclase, increase in Al^{IV} and Ti in biotites) indicate crystallization event in differentiating magma prior to emplacement into granodiorite sequence.

Geochemical compositions of granodiorites and tonalites indicate mafic sources of derived magma (I-type granitoids in the sense of Chappell and White, 1974). Trace element signatures preclude the involvement of substantial amounts of garnet either in the residue during partial melting or as a part of the fractionating assemblage during an AFC process (DePaolo, 1981). Amphibole and plagioclase have to be considered as major fractionating phases during magma genesis (Altherr et al., 1999)

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Geochemistry and Geochronology of the Javornik Granodiorite and its Geodynamic Significance in the Eastern Variscan Belt

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The Złoty Stok – Skrzynka shear zone (ZSSsz) is situated in the West Sudetes, immediately north of the Orlica-Śnieżnik dome. ZSSsz is made up of late Proterozoic-early Paleozoic sedimentary and volcanic rocks which have undergone multiple deformation and medium- to low-grade matamorphism during Early and Late Paleozoic time. Numerous granitoids sills and dykes intruded the shear zone and commonly form sheeted-bodies parallel to the regional tectonic foliation in the host rocks.

Jawornickie granitoids are broadly calc-alkaline with relatively high alkali (Na_2O+K_2O) content, ranging from5.8 to 9.2 wt. %, and Na_2O/K_2O ratios of 1.05 to 3.56 consistent with orogenic granitoid rocks (Maniar and Piccoli, 1989) and typical of I-type granitoid rocks (Chappell and White, 1974). They are generally weakly metaluminous to mildly peraluminous, (except for one sample wich is strongly peraluminous - A/CNK=1.5) with alumina saturation indices in the range from 0.92 to 1.1, and ASI is poorly correlated with SiO_2. The primitive-mantle trace element spider diagram for Jawornickie granitoids, shows an obviously negative anomaly, features considered typical of crustal-derived granite. Chondrite-normalized REE patterns are all moderately fracionated and have LREE enrichment $(La/Yb)_N$ ranging from 9.2 to 21.7 and negative Eu anomaly in the range from 0.55 to 1.27. REE concentrations decrease regularly as a function of increasin SiO_2 content, and the size of Eu anomaly decrease irregulary with increasing SiO_2.

Oxygen isotope data for Jawornickie granitoids include 6 quartz, 3 biotite, 2 muscovite and 1 amphibole analyses. Results are systematic and demonstrate that, in general, isotopic partitioning varies from high to low $\delta^{18}O$ in the sequence quartz> muscovite> amphibole> biotite.Quartz was mineral selected for comparison between different lithologic type because it resistance to post-crystallization exchange and alteration. Oxygen isotopic composition of quartz separates cluster between +9.3 and +11.4 ‰. $\delta^{18}O$ values for muscovite are between +9 to +10, for biotite are in the range from 3.3 to 6.1, and for amphibole has $\delta^{18}O$ of 6.6 ‰. The equilibrium fractionation of ^{18}O and ^{16}O between coexisting minerals is a function of temperature but is independent of pressure. Accordingly, obtained data would allow the estimation of temperatures of igneous crystallization or later subsolidus alteration. The temperature obtained with the Qz-Ms pair ranged from 727 to 776 °C, with the Qz-Bt pair tepmeratures ranged from 463 to 577. The single quartz-amphibole pair yields a nominal temperature of 719 °C.

The geochemical chracteristic and $\delta^{18}O$ values of quartz are consistent either with primitive metasedimentary source rocks or with meta-igneous source rocks, such as amphibolites.

The geochemistry of igneous rocks bear a close relationship to their tectonic settings of formation. Jawornickie granitoids samples plotted in the field of syn-collision granitoids on discrimination diagram by Batchelor et al. (1985) and cluster in the syn-collision/volcanic-arc fields on Pearce et al. (1984) diagrams. On the Rb-Hf-Ta digram (Harris et al., 1986) Jawornickie granitoids data fall between volcanic arc and late- to postcollisional granitoid fields, indicative of an evolved I-type magmatic system.

Two granite varieties were dated – hbl+bt granite and bt+ms granite. Four mineral aliquots and associated flux monitors