POLSKIE TOWARZYSTWO MINERALOGICZNE – PRACE SPECJALNE
MINERALOGICAL SOCIETY OF POLAND – SPECIAL PAPERS
Zeszyt 24, 2004; Volume 24, 2004

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MELT INCLUSIONS AND EVOLUTION OF PARENTAL MAGMA OF THE KARKONOSZE GRANITE

Abstract: Two processes governed the evolution of parental magma of Karkonosze pluton: mixing and fractional crystallization. Two steps of the evolution are noticeable. Melt inclusions study has been done in quartz phenocrysts, being the product of early magma crystallization. The obtained data point to homogeneous, water-rich hybrid magma.

Keywords: melt inclusions, parental magma, phenocrysts, Variscan granite, Karkonosze

INTRODUCTION

The parental magma for granitic body is seldom generated by a single, crustal source. Within granite plutons products of hybridisation are easy to recognize. Karkonosze pluton, especially porphyritic granite facies, shows many examples of hybrids, from wide zones till small enclaves (Słaby *et al.* 2002, Słaby, Götze 2004). Some of them are evidence of homogenisation of the mixed components, some of them present mingling. Taking both processes under consideration, an essential question arises, whether Karkonosze porphyritic granite crystallized from homogeneous or not-homogeneous melt. The granite formation is also influenced by fractional crystallization (Słaby *et al.* 2003). The composition of the parental melt, evolved by fractional crystallization is not known. The granite formation was at least two-step process. Products of the first step are phenocrysts, mainly alkali feldspar megacrysts, less frequent plagioclases and quartz (Borkowska 1966, Słaby *et al.* 2002). Groundmass crystals could be assigned to the second step. The aim of the research work was to investigate melt inclusions trapped in quartz phenocrysts, therefore to look for the initial melt composition giving rise to porphyritic granite crystallization.

MELT INCLUSION STUDIES

The investigated samples of granite were collected in four outcrops within the ranges of the Karkonosze massif: granite quarry at Michałowice, granite quarry at Szklarska Poręba Huta, rocks near the Samotnia tourist hostel and the abandoned pegmatite quarry at Czarne near Jelenia Góra. The investigated quartz grains were euhedral to subhedral hexagonal bipyramids from 4 to 7 mm in size.

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The preparations were doubly polished ~0.5 mm thick slices cut through the centre of the quartz grains. Homogenization temperatures were measured by means of the quenching method (Kozłowski 1981 2003) with the accuracy of ±5ºC at temperatures close to 1000ºC. Careful approaching to the homogenization temperature was necessary to avoid water loss from the inclusions during heating at high temperatures (Kozłowski 1985).

The studied inclusions occurred in the central parts of the quartz grains, and contained crystal phases (potassium feldspar, plagioclase, quartz, biotite and mixture of fine grains of these minerals) and bubble of volatiles (water and CO_2) During heating the first signs of melting were discernible at ca. 600ºC. Usually total melting of the daughter crystals in inclusion appeared at temperature less than 20ºC below temperature of bubble disappearance, and the last melting crystal was potassium feldspar (Fig. 1). The same quartz grains contained in the outer rims melt inclusions, which did not yield consistent data (homogenization temperatures and melt compositions) till present. Some of them were probably trapped aggregates of small mineral grains rather than true melt inclusions.

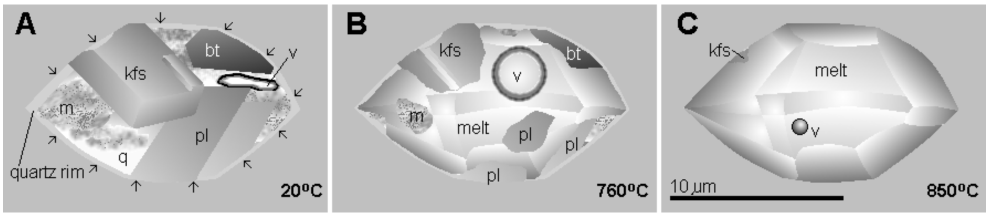

Fig. 1. Melt inclusion in quartz from the Samotnia granite before heating (A) and at elevated temperatures (B and C). Note the rim of quartz that crystallized from the inclusion volume, outlined by arrows, and the presence of small portion of the potassium feldspar (image C), which melted completely at temperature few degrees below homogenisation temperature of the inclusion (876ºC); kfs – potassium feldspar, pl – plagioclase, q – quartz, bt – biotite, v – volatile bubble, m – mixture of fine grains of silicates.

Homogenization temperatures were between 825 and 920ºC, what agrees with the data for quartz from granitoids published elsewhere (*e. g.* Sobolev, Kostyuk 1975). Electron microprobe analyses of the homogenized and next quenched melt in the inclusions in quartz grains (made by means of Cameca sx100 device in the Inter-Institution Laboratory of Microanalysis of Minerals and Synthetic Substances at the Faculty of Geology of the Warsaw University, the analysts L. Jeżak and Dr. P. Dzierżanowski) yielded totals of ca. 94–96%, indicating 4–6 wt. % of volatiles. The melts contained 60.9–68.4 SiO_2, 0.2–0.5 TiO_2, 13.7–16.1 Al_2O_3, 3.1–5.3 total FeO, 0.6–2.1 MgO, 1.3–4.8 CaO, 3.2–3.9 Na_2O, 2.6–4.5 K_2O and 0.1–0.2 P_2O_5 (in wt %).

THE PARENTAL MELT POSITION ON HARKER DIAGRAMS

The estimated melt composition has been plotted on Harker diagrams. Silica has been chosen as a differentiation index. The silica content recognized in melt inclusions is by far lower, than the silica content estimated for host granite samples. The positions of major element concentrations in the melt inclusions show some differences against granite (including hybrids: granodiorites, enclaves) *liquid* *line of descent* (LLD), presented for the same elements. Three cases of mutual elements behaviour could be noticed. The melt composition projection points fall below the LLD, however, they may be interpreted in the context of this trend.. They form two populations within the same outcrop group, where one of them fit to LLD and the other is placed below the LLD. The first case is illustrated by Fig. 2, and besides TiO_2 it is complied with MgO, FeO. The second condition is fulfilled by Al_2O_3, K_2O, Na_2O. Calcium and phosphorus spread into two trends.

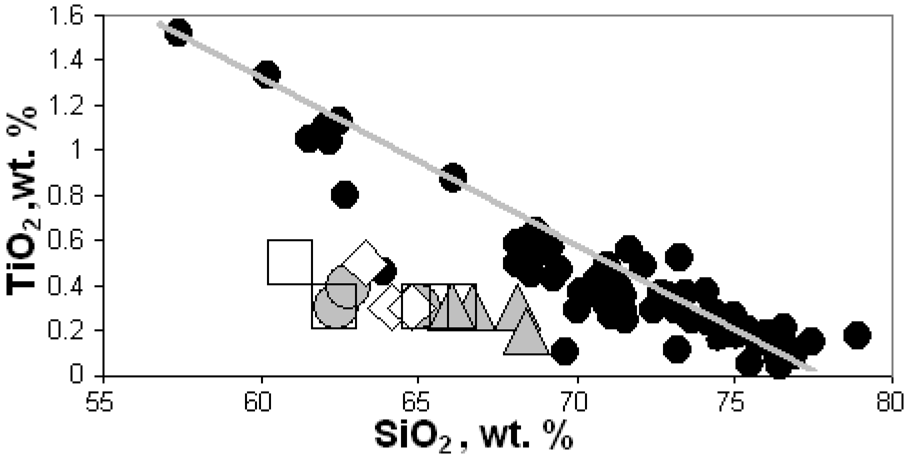

Fig. 2. Melt inclusion composition on the TiO_2 vs SiO_2 plot. Explanations: black dots – granite composition (including hybrids), grey line – LLD; melt inclusions: empty squares – Czarne near Jelenia Góra, grey circles – Michałowice, grey triangles – Szklarska Poręba Huta, white diamonds – Samotnia.

DISCUSSION AND CONCLUSIONS

Melt inclusions provided information of special value for Karkonosze granite petrogenesis. The melt composition probably doesn't reflect the initial composition responsible for porphyritic granite evolution. Its composition could be correlated with the first step of hybridised magma crystallization. The melt appears as homogeneous and water-rich. Its intermediate composition is placed close to that found in Karkonosze hybrids. This conclusion is corroborated by Wenner and Coleman (2001) experiments. Hybrids composed from mafic-like and crustal-like components could be homogeneous if the mafic magma is water-rich. The magma chamber has been recharged with hybrid impulses of various compositions (noticed in calcium and phosphorus variation).

Deflection of the melt inclusion composition from LLD is well known effect (see for comparison Danyushevsky *et al*. 2002). Usually it is explained by delay in the element diffusion in the melt or by competition effect close to crystallizing phase. We would rather explain differently the effect. The melt inclusions are trapped in course of differentiation. The moment of inclusion emplacement into crystallizing quartz could reflect the particular stage of magma evolution i.e. particular moment of mineral separation from the melt. The melt composition seems to point to prior cumulate separation. It also indicates that some of the main phases like alkali feldspars were in course of crystallization. Investigations of alkali feldspar megacrysts (Słaby, Götze 2004) assigned their formation to hybridised melt under thermal conditions close to 900°C (Borkowska 1966, Słaby *et al*. 2002). The melt inclusion study strongly supports these conclusions.

The research work was supported by the grants of the Faculty of Geology of the Warsaw University No. BW 1567/18 and BSt. 977/4.

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