CRYSTALLIZATION PATH OF K–FELDSPAR MEGACRYSTS FROM MT. PAPUK, CROATIA

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Abstract: Two K-feldspar megacrysts from Mt. Papuk, (Croatia) were studied by X-ray powder- and selected area electron diffraction, transmission electron microscopy and wavelength dispersive X-ray spectroscopy. Based on microstructure vein filling megacryst was formed below 460˚C as triclinic microcline whereas pocket forming megacryst near to but above 460˚C, at eutectic composition as orthoclase which underwent further transformation to microcline.

Key Words: K-feldspar, microcline, microstructure, thermal history, Mt. Papuk (Croatia)

Mt. Papuk belongs to the Slavonian Mountains in Croatia, at the southern part of the Tisa Megaunit. A comprehensive review of the geological setting of this area is given by Jamičić & Brkić (1987), Jamičić (1988) and Korolija & Jamičić (1989). Vragović (1965) made a detailed petrographic description of the granitoids and their pegmatites. Pamić & Lanphere (1991) and Pamić et al. (1996) studied the origin and formation of granitoids and metamorphic rocks occurring in Slavonia and gave the geodynamical model for the prealpine evolution of geological processes based on geochemical and isotope data.

The goal of this paper is to characterise microstructures and deduce the crystallisation path of alkali feldspar megacrysts and give solid evidences for their origin. Since, the submicron scale mineralogy of the abundant alkali feldspar megacrysts from the Mt. Papuk is not known, we provide the first description and genetical interpretation of their microstructure.

The studied samples are from two localities, their sizes are about 5x3x1.5 cm. Pakra Creek megacrysts are pink. They were found in a 10 cm wide vein which crosses the porphyric granitoid body with no sharp boundary and we selected one for this study. Sloboština Creek pale grey megacryst is from a pegmatitic pocket in the migmatite host.

We measured the chemical and structural inhomogenities using petrographic microscopy, a scanning microscope for electron probe microanalysis (EPMA) and transmission electron microscopy (TEM). The X-ray powder diffraction (XRPD) measurements were performed on a SIEMENS D500 powder diffractometer (analogous registration). Quantitative chemical analyses were carried out on a JEOL JCXA-733 wavelength dispersive (WDS) electron microprobe equipped with three spectrometers operating at 15 kV and 36 nA, using ZAF correction. The following standards were applied: albite for Si, Al and Na; wollastonite for Ca, and orthoclase for K. The samples for TEM observations were obtained by grounding the sample under ethanol and mounted a drop from suspension onto a Cu-grid covered by amorphous carbon supporting film. The selected area electron diffraction (SAED) patterns and the images were obtained with a JEOL JEM 100U microscope operating on 100 kV.

Beside minor quartz the samples proved to be maximum microcline on the basis of their XRPD patterns. Among the microcline reflections low-albite peaks appear separately. Using the calculation introduced by Goldschmidt & Laves (1954) the value of triclinity is 0.9312 and 0.8087 for Pakra Creek sample and Slobostina Creek sample, respectively.

Under petrographic microscope Pakra Creek megacryst shows 10-50 μm sized albite patches, which tend to form layers in microcline. Separated albite grains extinct simultaneously whereas microcline shows inhomogeneous undulatory extinction. No twins were observed in this sample. Besides feldspar components, nontextured, isometric quartz grains also occur. The results of modal analysis are: microcline 82%, albite 15% and quartz 3%.

The Sloboština Creek sample is different from the above. The albite grains are about 10 μm in size, with rather isometric or tabular forms. The quartz shows no graphic texture, but the host is a microcline-twinned potassic feldspar showing cross-hatched extinction pattern. The results of modal analysis are: microcline 88%, albite 9% and quartz 3%.

The local composition was measured by microprobe. The composition ranges of the microcline and albite for the two samples are Or_{91-96} $Ab_{8-4}An_{0-4}$ and $Ab_{99-97}Or_{0-1}An_{0-2}$, respectively.

TEM studies revealed no traces of exsolution neither twinning in the albite but continuous modulation in the microcline along the (010) and $(11\bar{1})$ planes. Streaking parallel to **b*** of microcline is observable e.g. on $<\bar{1}0\bar{1}>$ zone patterns (Figure 1). However, this diffraction geometry remind one to the albite-twinning but the observed geometry and streaking exclude this interpretation. The albite-twinning requires mirror symmetry for doubled reflections, but the $<\bar{2}0\bar{2}>$ axes incline to the **b*** with different angles (87.6 and 90.6˚, respectively). These angles are close to the same value of the maximum microcline (88.1˚, calculated from data of Blasi et al., 1984). The $d(020)/d(\bar{2}0\bar{2})$ ratios match well with the same structural data.

Both the pocket forming and vein filling occurrences forming by segregation of a melt would require an eutectic composition and texture for microcline-quartz-albite system. The solid phase segregation of quartz component from an eutectic potassic feldspar system produce a vermicular or spherical texture as a function of undercooling (Baker and Freda, 2001). The lack of graphic, vermicular or spherical textures with quartz and uniform distribution of albite in the microcline host exclude the formation of megacrysts from a melt, so we concluded that the studied megacrysts formed from fluids at low temperature. The intergrain boundaries between albite and potassic feldspar do not show crystallographic interrelations. The simultaneous extinction of the albite patches in Pakra Creek sample support epitaxially oriented intergrowth of the two crystalline substances. This type of intergrowth is not observable in Sloboština Creek sample, which contains albite patches in random orientation distribution. These strongly suggest simultaneous crystallisation of albite and potassic feldspar by heterogeneous nucleation.

The two-feldspar geothermometer of Stormer (1975) gives a solid evidence for the low temperature formation of megacrysts. The albite contents of coexisting plagioclase and potassic feldspars in the two samples are 99.6 and 99.5%, respectively. The extrapolated crystallisation temperatures are below 400˚C, which is probable an underestimated value (Parsons and Brown, 1984). However, this temperature and composition definitely exclude the homogeneous crystallisation followed by exsolution processes.

The phase diagram of alkali feldspars (Smith, 1974; modified by Brown, 1981; in Griffen, 1992) also allows us to conclude thermal histories of samples. The sequences of ordering states and coexisting compositions for albite and potassic feldspars reflect the paths of their formations.

In the case of Pakra Creek the fine scale modulation and the diffuse streaks in SAED patterns are the consequence of kinetically controlled slow Al/Si ordering in microcline at low temperature. Based on the lack of perthitic exsolution and microcline-twinning, heterogeneous nucleation below 460˚C seems to be evident. However, a slightly different origin can be concluded for the Sloboština Creek sample. It has a near eutectic composition ($Or_{90}Ab_{10}$). The lack of perthitic exsolution and the presence of microcline-twinning suggest a precipitation temperature near to but above 460˚C at eutectic composition as orthoclase, which underwent further transformation to microcline (Laves, 1950; McLaren, 1984).

As a consequence of the low diffusion rates at these time/temperature paths (Putnis, 1992) the complete transformation to the maximum microcline state is impeded. The resulting inhomogeneous Al/Si ordering is reflected by the fine scale variation of the cell parameters, however the average value of triclinity is high for both samples.

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