Development of the Gföhl Migmatites through Partial Melting and Textural Annealing of High-Grade Orthogneiss

Pavlína HASALOVÁ, Karel SCHULMANN, Ondrej LEXA and Jakub HALODA

Charles University in Prague, Institute of Petrology and Structural Geology, 128 43 Prague 2, Albertov 6, Czech Republic

The Gföhl gneiss forms an important lithological unit of the most deeply buried part of the Moldanubian root domain. The detailed observation reveals gradual transition from porphyritic orthogneiss via high-grade mylonites to entirely molten rock during polyphase tectonic evolution connected with thrust-related exhumation of the lower crust. The question arises, whether the whole volume of the felsic medium-grained migmatites originated through partial melting of orthogneiss protolith or whether the whole migmatitic domain was originally formed by melting of fertile metasediments rich in hydrous minerals.

Several outcrops were investigated from the structural, textural and petrological point of view. The earliest structures are represented by steep solid state high-grade foliations (S1) in strongly sheared orthogneisses marked by alternation of monomineralic K-feldspar, plagioclase and quartz layers separated by bands of biotite. This fabric is folded and transposed by thrust-related flat foliation (S2) associated with the development of gneissic migmatites rich in sillimanite and garnet. This gneiss alternates with felsic leucosomes and tens centimetre thick layers of leucocratic melts. Finally, the gneissic migmatites are completely dissipated in leucocratic granitic magma. Stable whole rock chemistry shows that the Gföhl orthogneisses – migmatites – granite sequence is an ideal example of closed chemical system, where textural modifications can be studied in terms of in situ partial melting and crystallization.

Basing on detail microstructural analysis and field studies we have distinguished four stages of orthogneiss fabric disintegration: I = banded orthogneiss, II = migmatized gneiss, III = gneissic migmatite and IV = leucocratic granite. The first stage is represented by fine-grained banded orthogneiss with distinctly separated monomineralic layers. A polygonal mosaic consists of well-equilibrated plagioclase, quartz polycrystalline ribbons and The K-feldspars layers of K-feldspars grains with straight boundaries. Rounded inclusions of quartz occur mostly at tripple points of feldspar aggregates. Biotite flakes, locally overgrown by sillimanite (<1%), form bands separating quartz and plagioclase layers. Small garnets are associated with biotite aggregates. The second and third stages (gneissic migmatites) are characteristic of continuous decrease of grain size, disappearance of monomineralic layering and increase in modal content of sillimanite and garnet. The fourth stage is a granite with no relics of gneissosity, composed of almost equivalent amount of plagioclase, K-feldspar and quartz, biotite and atoll garnet.

Quantitative microstructural and textural study, including grain-size analysis, grain shape and orientation and grain boundary analysis, was done using Arc-View GIS PolyLX extension and Poly-LX Matlab toolbox (Lexa, 2000) on the main phases (Plg, Kfs, Qtz and Bt) through the whole sequence. Grain-size statistics show continuous decrease of median grain size coupled with decrease in standard deviation from mylonitic orthogneiss towards granite. This evolution points to dissolution of original large grains, significant nucleation of new small grains at high surface energy sites with ongoing melting. Grain shape preferred orientation of all phases is strong in all stages. Grain contact frequency analysis shows strong regular distribution of K-feldspars (dominated by unlike-unlike contacts) corresponding to many intersticial phases of quartz and plagioclase in all stages. Plagioclase and quartz show original random distribution of like-like contacts evolving towards regular distribution in stage IV. The grain boundary orientation analysis shows strong preferred orientation of plagioclase-biotite and weak alignment of felsic mineral like-like and unlike boundaries. Boundary preferred orientation is disintegrated in textural stage II. The stage III. exhibits again an increase of grain boundary orientation. The stage IV is marked by a strong increase of preferred orientation of like-like boundaries of plagioclase and K-feldspar.

Mineral chemistry of plagioclase shows systematic decrease of anorthite component towards the granite stage from An_{20} to $An_{0.5}$. The plagioclase is also characterized by important mineral zoning in the III and IV stages. 5μm wide rims of pure albite develop along contacts of oligoclase with K–feldspar. Garnets show also important mineral evolution marked by decrease in Mg, Ca and increase of Fe and Mn from stage I to IV. This evolution is coupled with decreasing Mg content in biotite.

The textural analysis shows important contribution to dissolution of feldspars and their nucleation at high energy positions marked by grain size decrease and disintegration of aggregate distributions. This process of K feldspar dissolution is coupled with crystallization of albite mostly at plagioclase-K-feldspar boundaries. All textural changes are truly dynamic as documented by grain shape and grain boundary preferred orientations, which remain high for all textural stages