Origin of Felsic Migmatites by Ductile Shearing and Melt Infiltration

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The Gföhl migmatite-gneiss complex forms the largest anatectic unit of the Variscan orogenic root domain. The origin of this migmatitic unit was classically attributed to the anatexis and the different degree of migmatitization explained by the variable degree of partial melting.

A new petrogenetic model of an origin of this felsic migmatites is proposed on a basis of the microstructural and petrological study. The detailed observation reveals that the migmatites originated by melt infiltration and contemporaneous shearing of the banded orthogneiss in a crustal scale shear zone. They are marked by gradual transition from the high-grade solid state banded orthogneiss with distinctly separated monomineralic layers via the migmatitic gneiss, the gneissic migmatite characteristic by disappearance of monomineralic layering to sheeted foliation parallel bodies of the granitic gneiss with no relicts of gneissosity. The disintegration sequence is characterized by: (i) progressive destruction of well equilibrated banded microstructure of the high-grade orthogneiss by a crystallization of new interstitial phases (Kfs, Plg and Qtz) along the feldspar boundaries and by a resorption of relict feldspars and biotite, (ii) variations of modal proportion of felsic phases reflecting the increasing amount of melt in the originally mono-mineralic aggregates, (iii) systematic grain size decrease of all felsic phases together and crystal size distribution curves (CSD) indicating increase of the nucleation rate coupled with preferential removal of large grains for all felsic phases with the increasing melt proportion. This evolutionary trend is connected with a decrease in grain shape preferred orientation (SPO) of all felsic phases, an increase of regular grain boundary distribution (dominance of unlike boundaries) and a decrease of grain boundary preferred orientation (GBPO) of unlike boundaries.

Melt topology reveals well oriented melt seems and pools at low melt fraction consistent with dislocation to diffusion creep regimes. At high melt fractions the absence of preferred orientation of melt patches corresponds to the distributed granular flow associated with a breakdown of rigid skeleton close to rheological critical melt percentage (RCMP).

SEM images show plagioclase zoning displaying non-diffusive 2–10 μm more sodic rims (An0-10) around oligoclase cores (An10-30). The whole textural sequence displays continuous increase of Na content in plagioclase cores and rims, increase of XFe in biotite and garnet coupled with decreasing Ti content in biotite towards the granitic gneiss. The increasing amount of discrete albite rims and complete disintegration of original banded texture are compatible with melt infiltration into progressively deformed rock. Additionally, the petrological observations indicate that the melt infiltration is connected with crustal exhumation along retrograde pressure and temperature path.

The Role of Melt Infiltration in the Formation of Migmatitic Orthogneiss

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The Gföhl orthogneiss is a widespread lithology in the Moldanubian orogenic root domain of the Bohemian Massif. Its apparent textural variations were classically attributed to the variable degree of anatexis, however, a recent textural study interprets some of the variations to be due to different degrees of melt infiltration. In this contribution, we describe mineral and bulk rock chemical changes from the original banded orthogneiss (textural type I) to granite-looking gneiss (type IV) and determine equilibration P-T conditions. We characterize what sort of fluid is involved, calculate its composition and deduce how it interacts with the original rock.

The mineral assemblage in all the rock types is garnet-biotite-sillimanite-K-feldspar-plagioclase-quartz. As muscovite is absent, the infiltrating fluid must be a melt and not an aqueous fluid. Garnet in the studied sequence displays the following changes: $alm_{75=>94}py_{17=>0.8}grs_{2.5=>1.2}sps_{2=>11}$; X_{Fe} 0.80=>1, and biotite X_{Fe} increases (0.45 => 0.99). Plagioclase in the original aggregates has higher anorthite content ($An_{25=>5}$) than interstitial grains or films tracing the K-feldspar boundaries and plagioclase rims ($An_{18=>0}$). In an AFM diagram, the assemblage garnet-biotite-sillimanite is divariant, in the presence of quartz, K-feldspar and melt, a systematic increase in X_{Fe} of the phases indicating a decrease in equilibra-

tion temperature. The compositional isopleths in pseudosections also point to temperature decrease, corroborated by average PT calculations (800 => 650 °C/6kbar).

There is no direct evidence of the composition of involved melt, apart from the mineral compositions with which it equilibrated. A melt composition that is in equilibrium with plagioclase-K-feldspar-quartz-sillimanite-garnet-biotite in the NCKFMASH system can be calculated if X_{An} and the P-T conditions are fixed. With a melt composition derived in this way we calculated T-x pseudosections for a bulk composition line between K-feldspar (or plagioclase) and melt in order to understand bulk composition changes. When in a K-feldspar layer, plagioclase starts to crystallize above the temperature of muscovite stability only if melt: rock is 9:1. Similarly, in the plagioclase layer, the K-feldspar crystallizes if more then melt: rock is 8:1. Such a high melt proportion is reasonable only if the edges of grains of solid phases are considered to be in equilibrium with melt covering the grain boundaries. Thus, a small proportion of melt is present in the whole rock at one time. In order to change the whole rock composition in such a way, a large, but currently unidentified quantity of melt must have passed through the rocks along the grain boundaries.

The observed compositional changes in individual layers as well as bulk rock chemistry changes are driven by equilibration with large quantities of infiltrating haplogranitic melt of unknown source. Such a process of a large quantity of melt passing through rocks at grain scale without any important signs of segregation might be an important mechanism for melt transport in a migmatitic crust. As the Gföhl gneiss appears as hundreds of km^2 bodies, the process of penetrative melt flow through the orogenic crust would be a crucial process for crustal differentiation and also for crustal rheology during orogeny.

New Seismo-Tectonic Activity near Zakopane (Poland) – Events Recorded by Broad-Band Stations Operated by IPE

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During the end of the year 2004, the seismo-tectonic activity in the Polish part of the Vysoké Tatry region was newly detected. This activity continued also during the year 2005. The broad-band stations operated by the IPE (Institute of Physics of the Earth, Masaryk University, Brno – stations JAVC, KRUC, MORC and VRAC) in the eastern part of the Czech Republic registered 25 events with local magnitude ML from 1.1 to 4.6.

The new exhibitions of the seismo-tectonic activity have started by the strongest event (local magnitude ML = 4.6) on 30. 11. 2004, which was macroseismically observed. The historical macroseismic observations are known in this region. But during about ten years long continuous registration of broad-band stations operated by the IPE, before 30. 11. 2004, these stations had not recorded any tectonic event with epicentre situated in the Polish part of the Vysoké Tatry region. In contrast to situation before the strongest event, the significant seismo-tectonic activity was observed during first three days of the December 2004 (13 recorded events with local magnitude ML from 1.1 to 3.5). Less intensive activity continued up to the August 2005 (11 recorded events with local magnitude ML from 1.5 to 3.4).

Using other stations operated by Polish, Slovak, Czech and Hungarian seismological institutes, 13 events were reliably located by program LocSAT. In the case of other 12 events, only approximate locations were possible due to small number of reliable records by accessible broad-band stations. Epicentres are situated near Zakopane, on the northern margin of the Central Western Carpathians. This region represents the NE prolongation of the significant seismoactive zone passing from the Mur-Mürz fault system in the Eastern Alps through the southeastern part of the Vienna basin into Western Carpathians and continuing along the Pieniny Klippen Belt to NE.

Seismo-Tectonic Activity in the NE Part of the Bohemian Massif – New Records in the Period 2004–2005

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In the NE part of the Bohemian Massif, the weak recent seismo-tectonic activity occurs. Micro-earthquakes are concentrated in numerous epicentral areas. During the period 2004–2005, more than 250 tectonic events were detected (more than 60 events were located)