Metamorphic P-T Conditions and Deformational Microstructures of Chloritoid and Kyanite-bearing Metapelites from the Southeastern Veporicum, Western Carpathians (Slovakia)

Branislav LUPTÁK[1], Marian JANÁK[2] and Dušan PLAŠIENKA[2]

[1] *Department of Mineralogy and Petrology, Faculty of Sciences, Comenius University, Mlynská dolina, 842 15 Bratislava, Slovak Republic*
[2] *Geological Institute, Slovak Academy of Sciences, Dúbravská 9, 842 26 Bratislava, Slovak Republic*

Kyanite and chloritoide from the south and south-eastern Veporicum margin were first investigated by Mišík (1953) and Vrána (1964). These minerals occur in the Late Palaeozoic (Permian) metasediments at the boundary between the Veporicum and Gemericum.

The aim of our study were the Late Palaeozoic chloritoid and kyanite-bearing schists from the south-eastern Veporicum, near Hanková, which belong to the Permian Rimava formation. A characteristic mineral assemblage in these rocks is: quartz + white mica (muscovite-phengite-paragonite) + chloritoid + kyanite + chlorite±ilmenite±rutile. Such an assemblage is dependent on Al-rich bulk rock composition, thus Al-rich schists are less abundant in this area. However, they are very important for the evaluation of P-T conditions of the Alpine metamorphism in the Permo-Mesozoic cover sequences of the Veporicum.

Based on observed microstructures, chloritoid is growing parallel to foliation planes. In a later stage of deformation, it was reoriented and rotated into shear planes which are of an extensional character indicating top-to-the E movements.

Metamorphic P-T conditions were calculated by geothermobarometry, using activities-compositions relationships of mineral end-members based on microprobe analyses, and internally-consistent thermodynamic data. For the mineral assemblage chloritoid-chlorite-kyanite-quartz-water in the FMASH system, we estimated the temperature and pressure of 456 - 459°C and 8.2 - 9.3 kbar (PTAX - Berman, 1988); or 471 - 477°C and 5.6 - 7.2 kbar (THERMOCALC - Holland and Powell 1990). For these rocks, the Si p.f.u. content of around 6.4 in phengite is characteristic.

The estimated P-T conditions are in agreement with petrogenetic grids for metapelites (Bucher and Frey 1994; Spear and Cheney 1989). The presence of kyanite and the absence of pyrophyllite indicate an overstep of the pyrophyllite stability curve. On the other hand, the upper boundary of chloritoid stability, i.e. the breakdown of chloritoid to garnet and/or staurolite was not reached, in accordance with petrographic observations and calculated P-T conditions.

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Lithological and Petrofacies Analyses of some Palaeozoic Clastics from Sudetes, Poland: Implications for the Geotectonic Position of Source Rocks

Lubomír MAŠTERA

Czech geological survey, Leitnerova 22, 658 69 Brno, Czech Republic

Several samples of greywackes and arcoses from the west Sudetic Palaeozoic complexes were petrographically analysed in detail by the method of Dickinson and Suczek. The samples from the Góry Sowie Culmian, Depression of Swiebodzice, Intrasudetic Depression and Góry Bardzkie Palaeozoic reflect by their composition and by its petrofacial evaluation substantial differences from the eastern Sudetes of Poland and from the Moravian-Silesian Culmian. The source of detritus in the

west Sudetian clastics can be interpreted as low-grade metamorphosed schists of the recycled orogen with a variable amount of remnants of acid volcanism. Partly exposed parts of the craton should be taken into account as well.

The East Sudetic Culmian in Poland which is a continuous part of the Moravian-Silesian Culmian is characterised by a higher amount of magmatic material and of mesozonal metamorphites.

Variscan Thrusting and Extensional Collapse in the Karkonosze-Izera Massif, West Sudetes: Tectonic, Sedimentary and Magmatic Record

Stanislaw MAZUR

Institute of Geological Sciences, University of Wrocław, pl. Maksa Borna 9, 50-204 Wrocław, Poland

The Karkonosze-Izera Massif in the Western Sudetes comprises the Karkonosze granite pluton together with its metamorphic envelope. The latter consists of three crystalline nappes characterised by contrasting metamorphic paths (Kryza and Mazur 1995, Mazur and Kryza 1996). From base to top these are: Izera-Karkonosze, South Karkonosze and Leszczyniec units. A complete section across the three nappes is exposed in the Rudawy Janowickie metamorphic complex along its boundary with the Intra-Sudetic Basin. In general, a medium pressure (MP) Izera-Karkonosze unit is tectonically overlain by two high pressure (HP), South Karkonosze and Leszczyniec, units.

The MP Izera-Karkonosze unit is composed mainly of the Upper Cambrian - Lower Ordovician (Oliver et al. 1993) Izera granite (in most part subsequently deformed into the Izera gneiss) and of mica schists representing remains of its envelope. The mica schists are, locally, intercalated with variegated metavolcanic rocks of within-plate geochemical signature (Winchester et al. 1995). In the east and south, the Izera granite-gneiss, together with the Upper Proterozoic (?) mica schists of its envelope, are tectonically overlain by (1) the Lower Palaeozoic metasedimentary-metavolcanic sequence of the HP South Karkonosze unit and (2) the Lower Ordovician (Oliver et al. 1993) metabasalts and bimodal igneous rocks of the HP Leszczyniec unit. The igneous rocks of the both units geochemically correspond to magmas of an evolved rift setting (Kryza et al. 1995, Winchester et al. 1995).

The tectonic evolution of the Karkonosze-Izera Massif involved two main events, related to contraction and subsequent extension of the crust (Mazur and Kryza 1996). The contractional event, probably Late Devonian in age, comprised pervasive reverse-displacement shearing, associated with a NW-directed thrusting and concomitant progressive metamorphism, which resulted in tectonic juxtaposition of the MP and HP units. The D_1 event produced widespread deformational fabric consisting in the main foliation S_1 and mostly NW-SE trending stretching lineation with local presence of top-to-the NW shear criteria. The orientation of L_1 stretching lineation in the Leszczyniec unit is NNE-SSW and it differs from the general trend of L_1 in the neighbouring units. Petrological data from the envelope of the eastern contact of the Karkonosze granite (Mazur and Kryza 1995) indicate that Izera gneiss experienced MP metamorphism, generally below the amphibolite facies, whereas the overlying tectonic units were subjected to HP metamorphism prior and partly during D_1 under the blueschists (South Karkonosze unit) and epidote-amphibolite (Leszczyniec unit) facies conditions. The lower time limit of the nappe stacking is constrained by the age of phengites from mafic blueschists of the South Karkonosze unit dated at about 360 Ma (Maluski and Patočka 1997). The upper limit corresponds to the age of the late- to post-tectonic Karkonosze granite estimated at ca. 330 Ma (Duthou et al. 1991).

The subsequent extensional event, probably of Early Carboniferous age, comprised normal to wrench-normal shearing related to ESE-directed extensional collapse (Mazur and Kryza 1996). This event produced stretching lineation L_2, locally oblique to L_1. The extensional displacements were localised in a several kilometres wide dip-slip shear zone along the eastern margin of the Karkonosze-Izera Massif. This N-S trending zone corresponds to the Rudawy Janowickie metamorphic complex outcrop zone which defines a narrow belt between the Karkonosze pluton and the Intra-Sudetic Basin. The deformation changes across this zone from ductile shearing in the foot wall to brittle-ductile and brittle displacements in the rocks adjacent to the hanging wall. The hanging wall of the shear zone corresponds to the western portion of the Intra-Sudetic Basin separated from the Rudawy Janowickie complex by brittle normal faults. A deposition of 5-7 km thick sequence of coarse-clastic sediments in the Intra-Sudetic Basin provide evidence of rapid subsidence during the Visean. The MP unit of the Rudawy Janowickie complex, structurally the lowermost one, is exposed in the innermost part of the foot wall. This unit was subjected to a LP/HT metamorphic event, coeval with the extensional shearing, and was intruded by the granite pluton. The emplacement of the Karkonosze granite was accompanied by regional doming which resulted in reorientation of D_1 structures on flanks of the dome. The age of the extensional event corresponds to the age of the greenschist facies metamorphic overprint dated in blueschists from the Rýchory Mts. at ca. 340 Ma (Maluski and Patočka 1997).

Generally, the Karkonosze granite bears no evidence of solid state deformation. Nevertheless, WNW-ESE trending, non-penetrative lineation, defined by alignment of feldspar megacrysts was recognised in the granite by Cloos (1925). Recent studies of magnetic fabric (Diot et al. 1995) provide evidence of WNW-ESE trending magnetic lineation in the Karkonosze granite. This lineation is interpreted to reflect the direction of magmatic flow. The magnetic lineation of the granite parallels the feldspar lineation of Cloos (1925) and the stretching lineation in the adjacent metamorphic rocks. The parallelism of the lineations developed in the pluton and within its metamorphic envelope indicates a relationship between the granite emplacement and the final phase of extensional collapse. Furthermore, the granite has recorded evidence of a top-to-the ESE sense of shear, indicated by tilting of feldspar megacrysts, characteristic of the extensional deformation event.