Nature and Provenance of Exotic Rock Types from Lower Carboniferous Conglomerates (Eastern Bohemian Massif)

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Conglomerates of Late Visean flysch – molasse of the Drahany Uplands (eastern Bohemian Massif) contain a variety of rocks in pebbles/boulders potentially useful for provenance and geotectonic studies. Apart from the abundant migmatized biotite gneisses, the Luleč conglomerates include rather frequent garnet-bearing leucogranulites and biotite-muscovite to biotite granites (cf. Eisgarn type). Mica schists, porphyric subvolcanics and quartzites are less abundant, orthopyroxene-bearing granulites, intermediate cordierite-bearing granulites, durbachites (melagranites), tourmaline-bearing granites, hybrid granites and nebulitic migmatites locally with cordierite, amphibole-bearing granite, amphibolite, gabbro, calcite marbles, graphitic quartzites and calc-alkaline andesites to rhyolites are rare.

Granulites from pebbles display specific features distinguishing them from the granulites from outcrops in the Bohemian Massif:

1) scarcity of alumosilicate in felsic types.
2) presence of highly peraluminous dark cordierite-bearing granulite types with prismatic sillimanite having no equivalent at present erosional level.
3) extensive MP-LP/HT overprint.

Restricted mineral assemblages and a strong lower-pressure overprint complicate derivation of peak P-T conditions for granulites. Garnet-rich ($Alm_{50-53}Grs_{3-6}Prp_{43-46}Sps_{1}$) granulite of granodiorite composition with rare sillimanite yielded peak pressures of 12 kbar (GASP barometry) for minimum temperatures of 820 °C (2fs thermometry, preliminary). These conditions and observed textures are indicative of possible original stability of kyanite later pseudomorphosed by sillimanite. Calcium depletion at garnet rim along with Ca increase at Pl rim are consistent with a significant decompression to about 7 kbar for 800 °C (sillimanite stable).

Orthopyroxene-bearing granulite (Grt-Opx-Bt-Q-Afs-Pl) contains garnet with composition $Alm_{60-65}Prp_{23-27}Grs_{6-12}Sps_{2}$. The sample yielded pressures of 6–8 kbar (Al-in-Opx, GAES, cores) for 750 °C (Grt-Opx, cores), consistent rather with the retrograde conditions for comparable granulites from the outcrops. Mineral zoning towards the rim – Grs ± Prp decrease in garnet, certain Al_2O_3 and CaO decrease in Opx (X_{En} = 52−54) and An increase in Pl – is consistent with a P and T decrease from the peak to retrograde metamorphic assemblage. Broad homogeneous cores of Grt may reflect an extensive diffusional reequilibration resulting into obliteration of any possible evidence of higher-grade conditions (just low-T values).

Dark intermediate highly peraluminous granulites with prismatic sillimanite show extensive development of complex symplectites around garnets. These symplectites consist of Crd + Opx with variable relative proportions and composition. They reflect operation of a reaction Grt + Qtz = Opx + Crd, which is characteristic of the isothermal decompressional (ITD) evolution of the rocks.

ITD evolution is consistent with a rapid exhumation of the rocks, as suggested by geochronological data (Kotková et al. 2000). Neo-Variscan U-Pb zircon ages of ~ 338 Ma for granulites and close ages of the conglomerate sedimentation (Upper Visean, goniatite zone Gog, V3A microfauna in limestone pebbles – Špaček and Kalvoda 2000) leave a very short interval for the exhumation which must have been of the order of several mm/yr. Very high exhumation rate is also indicated by the overlap of the monazite ages from granulites and from pegmatites post-dating the nappe emplacement (Novák et al. 1998).

Marbles were identified as calcitic with mineral assemblage Cal + Phl + Qtz + Gr + Ttn + Py similar to marbles in the Olešnice group of the Moravian zone. They do not show any signatures of the late HT metamorphic overprint typical of the Variegated unit of the Moldanubian zone in the Třebíč massif surroundings. On the other hand, mineral assemblage and chemical composition of a pebble of graphitic quartzite containing V-bearing muscovite are comparable to similar rocks of Variegated unit west of Třebíč in Želetava surroundings. Durbachites are of different character than the Rastenberg granodiorite. Some durbachite types can be correlated with light-coloured varieties from the Třebíč Massif. However, some other types have no equivalent on the present-day surface and, on the contrary, the typical mafic durbachites are missing in the spectrum of pebbles from Luleč conglomerates.

Study of the plutonic and metamorphic rocks from outcrops led to discovery of an ultra-high-temperature event in the Moldanubian zone (Leichmann et al. 2000). Some intermediate cordierite-garnet-sillimanite granulite clasts from Luleč Conglomerates (Vrána and Novák 2000) can be of a similar character. Zircon and monazite U-Pb ages for these dark granulites are neo-Variscan, excluding the possibility of derivation of these rocks from an older shield area.

Presence of the exotic rock types (intermediate cordierite-bearing granulites, calc-alkaline andesites to rhyolites), not known from present erosional level, scarcity of evidence of HP/HT metamorphism and the extensive HT/MP-LP overprint on granulite assemblages in pebbles are indicative of a partial derivation of the material from a higher level of the Moldanubian nappe pile, not anymore exposed on the present surface. High-pressure assemblages (if originally present) were likely to be overprinted due to the high temperatures at medium to low pressures.

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Subsidence History and Tectonic Control During the Development of the Western Carpathian Neogene Basins.

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Based on subsidence history data and model of tectonic activity during the development of the Vienna, Danube and East Slovakian Basins, some common 3rd order stages of the Western Carpathian intramontane basins formation can be distinguished (Horváth 1993; Kováč et al. 1997; Bada 1999).

Initial rifting stage – from the Carpathian till Early Badenian (17.5–15 Ma) is characterized by opening of pull-apart type depocentres in all the mentioned Western Carpathian intramontane basins (Royden 1988; Csontos et al. 1992; Fodor 1995; Kováč et al. 1995; Hrušecký 1999). The onset of the basin formation, associated with extrusion of the ALCAPA lithospheric fragment from the Alpine domain, accelerated by subduction pull in front of the Carpathian orogene. The initial rifting stage was followed by filling up of the basin depocentres till the end the of Early Badenian.

Synrift stage of the basin development, which lasted till the Late Miocene (15–10.5 Ma) was controlled by diapiric mantle uprise in the back-arc domain (Tari et al. 1992; Horváth 1993; Lankreijer et al. 1995; Kováč et al. 1997). The generally slowing subsidence, accompanied by the whole-lithospheric extension was several times interrupted by phases of increased tectonic activity reflecting an accelerated roll-back effect of the individual segments (microslabs) of the subduction zone in front of the Carpathians.

Middle Badenian extesional phase (15–14 Ma) led to graben and halfgraben-type depocentres development. High rate of the tectonic subsidence can be documented in the Danube and East Slovakian Basins. This extensional event reflects most probably a partial rifting at the mantle diapir margin. The Late Badenian sedimentation (14–13 Ma) ended by filling up of the most sedimentary basins and represented time of the crust thermal relaxation.

Early Sarmatian extensional phase (13–12.5 Ma) can be traced in the northern part of the Vienna Basin and the East Slovakian Basin. The opening of new depocentres reflects the partial rifting at the mantle diapir margin but also the active tectonic elongation of the Western Carpathians due to subduction roll-back in the front of the Eastern Carpathians (Csontos 1995). The Late Sarmatian to earliest Pannonian (12.5–10.5 Ma) represents time of the crust thermal relaxation during the synrift filling up of the sedimentary basins.

Early Pannonian extesional phase – the second, late rifting stage (10.5–9.5 Ma) can be observed only in the Danube Basin, e.g. in the area of back-arc uprise of the mantle (Lankreijer 1998).

Stage of thermal postrift subsidence (9.5–1.8 Ma) is represented by the Late Pannonian to Quaternary deposition in the Pannonian Back-arc Basin System (Horváth 1993; Kováč et al. 1997). Similarly to the stage of synrift subsidence, the postrift sedimentation also shows phases of an accelerated subsidence.

Pliocene extensional phase (5.6–1.8 Ma), documented by development of flexural sag basins during the late rifting and following thermal relaxation of the crust, is known only in the Danube Basin. In the Vienna and East Slovakian basins, a Pliocene relief inversion took place during this time (Lankreijer et al. 1995; Baráth et al. 1997; Hók et al. 1999).

Quarternary extensional phase (1.8–0 Ma) can be observed in the Vienna Basin (Zohor – Plavec graben) and Danube Basin (Gabčikovo depression) and lasted till present time.

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