Geochemistry of metasedimentary sequences in the Krkonoše-Jizera Terrane, West Sudetes, Bohemian Massif: Palaeotectonic and stratigraphic implications

J. A. WINCHESTER[1] – V. KACHLÍK[2] – F. PATOČKA[3] – M. MELZER[1] – C. NAWAKOWSKI[1] – Q. G. CROWLEY[4] – P. A. FLOYD[1]

[1] School of Earth Sciences and Geography, Keele University, Staffs ST5 5BG, England
[2] Department of Geology and Palaeontology, Charles University, Albertov 6, 128 43 Prague 2, Czech Republic
[3] Institute of Geology, Academy of Sciences of the Czech Republic, Rozvojová 135, 165 02 Prague 6, Czech Republic
[4] NERC Isotope Geosciences Laboratory, Kingsley Dunham Centre, Keyworth, Notts NG12 5GG, England

The Krkonoše-Jizera Terrane (KJT), in the West Sudetes (northern Bohemian Massif), is currently interpreted as a Variscan NW-directed orogenic wedge, which developed between the orogenic root of the Orlica-Snieźnik lower to middle crustal complexes in the E, and autochthonous (Cadomian) Lusatian foreland to the NW. Chaloupský *et al.* (1968, 1989) distinguished four lithostratigraphic groups in the metasedimentary and metavolcanic sequences in the KJT: (a) low- to medium-grade Middle Proterozoic metasedimentary Velká Úpa Group, associated with and probably intruded by the Izera and Krkonoše (Kowary) granitoid gneisses exposed in the core of the KJT antiform, (b) very low-grade Late Proterozoic metagreywackes of the Machnín Group, (c) low-grade end-Proterozoic to Early/Middle Cambrian Radčice Group, comprising metasedimentary and metavolcanic sequences including the Železný Brod and Rýchory metavolcanic complexes, and (d) Late Ordovician to Silurian Poniklá Group, consisting of a low-grade metasedimentary sequence with subordinate metavolcanic rocks. Only the latter sequence was palaeontologically dated (e.g. Chlupáč 1993). Minor metagranitoid gneiss bodies occur in all the abovementioned lithostratigraphic groups (Kachlík *et al.* 1999, 2002).

This scenario now needs revision because the distinctions between sequences on published maps (e.g. Chaloupský *et al.* 1968; Chaloupský 1989) may be questioned by recent studies. The metasedimentary Poniklá and Radčice Groups comprise similar metapelite-dominated lithologies and are difficult to distinguish lithologically, partly because deformation and metamorphic growth of albite have obscured original sedimentary structures. They contain many extensive mylonitic zones, suggesting that stratigraphic repetition by ductile thrusting is likely, although difficult to prove as preserved fossils are scarce. These groups are chemically indistinguishable and we propose that they should be combined in a single Vrchlabí Group of Cambro-Ordovician to Siluro-Devonian age, containing two facies distinguished by the abundance of either metavolcanic rocks or intercalations of marbles and quartzites. This Vrchlabí Group is coeval with comparable metasedimentary sequences in the Kaczawa and Rudawy Janowickie Complexes of Poland.

Compared to metapelites in the Velká Úpa Group, those of the Vrchlabí Group have higher Fe/Mg and lower Na/Rb, are enriched in LILE relative to mantle compatible elements, in LREE relative to HREE, and with a negative Eu anomaly. These geochemical differences indicate that the protoliths of the Velká Úpa Group were derived from calc-alkaline intrusives emplaced in a former active continental margin, whereas those of the Vrchlabí Group indicate deposition in a Palaeozoic extensional passive margin setting. In this palaeotectonic scenario the Velká Úpa Group, previously assumed on slender grounds to be Mesoproterozoic by Chaloupský *et al.* (1989), is interpreted to be younger than the only KJT metasedimentary sequence of verified Proterozoic age, the Neoproterozoic Machnín Group (e.g. Gehmlich *et al.* 1997).

The chemistry permits two possible relationships between these two groups. Either (1) the Vrchlabí Group sedimentation postdated that of the Velká Úpa Group, and there was a change from active continental margin to passive margin settings, indicated by the differing chemistries of the metapelites of the two groups, or (2) the two groups were Palaeozoic rocks deposited in different areas with differing source material which have since been tectonically juxtaposed, with the Velká Úpa Group deposited proximal to the source area, and the more distal Vrchlabí Group sediments mixed with volcanogenic material.

Recent field studies of the quartzites helps resolve this problem. Locally conglomeratic quartzite bodies contain abundant blue quartz pebbles derived from the KJT Cambro-Ordovician gneisses and metagranites (Kachlík *et al.* 1999). Velká Úpa Group conglomeratic quartzites from the Malé Labe Valley contain pebbles of dark quartz-tourmaline hornfelses known also from basal Ordovician quartzites in Lusatia, interpreted there as pebbles derived from the contact aureole of the Cadomian Lusatian Pluton (e.g. Chaloupský 1963). Ar-Ar isotope geochronology on detrital white micas from quartzite intercalations from Vysoké nam Jizerou and Železný Brod (in the Vrchlabí Group) shows cooling ages of 564 Ma and 465 Ma, respectively (Marheine *et al.* 1999). Thus the blue quartz pebbles, contact hornfels clasts and the

Ar-Ar data on detrital micas, taken together, suggest that the quartzite source area comprised meta-igneous rocks of Neoproterozoic to Ordovician age, and hence the age of deposition of much of the Velká Úpa and Vrchlabí Group quartzites was no older than Ordovician.

This sedimentation age of the quartzite precursors fits within the Cambro-Ordovician to Siluro-Devonian time span of accumulation of the Vrchlabí Group, shown by palaeontological and geochronological dating. If the quartzites are also primary members of the Velká Úpa Group, their age implies that both of the KJT groups are broadly coeval. However, the presence of numerous mylonitic zones and ductile thrusts in the KJT shows that tectonic imbrication of rocks from both groups occurred. Such imbrication may also have brought rocks with different protolith ages into contact, while on the larger scale the Velká Úpa and Vrchlabí Groups were probably juxtaposed by ductile thrusting, analogous to that proposed along the Kowary and Kaczorów shear zones by Seston *et al.* (2000).

Hence, on the basis of both the geochemistry of the metapelites and the presence of blue quartz and hornfels clasts in the locally conglomeratic quartzites, the Velká Úpa Group must be broadly coeval with the Vrchlabí Group: both are Palaeozoic (Cambrian to Silurian ± Devonian?) in age (Kachlík – Patočka 1999; Hladil et al. 2003) and mostly postdate intrusion of the late Cambrian Izera and Krkonoše (Kowary) granitoid gneisses. In this scenario the Velká Úpa Group sediments were more proximal, perhaps derived from less deeply dissected part of the source area comprising a former active continental margin of Neoproterozoic age, and hence generally display chemical characteristics more typical of ACM-type clastic sediments, despite also being deposited in an Early Palaeozoic extensional setting that presaged the fragmentation of the northern margin of the Gondwana supercontinent (e.g. Crowley *et al.* 2000; Dostal *et al.* 2001; Winchester *et al.* 2002).

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