plications for the upper mantle seismic anisotropy. *J. Geoph. Res.*, 105: 7893-7908.
VAUCHEZ A. and GARRIDO C., 2001. Seismic Properties of an Asthenospherized Lithospheric Mantle: Constraints from the Lattice Preferred Orientation of Peridotite Minerals in the Ronda Massif, *Earth Planet. Sci. Lett.*, 192: 235-249.

Metabasites of the Nove Mesto Group, West Sudetes: a Rift-Related Bimodal Sequence Incorporated in a Variscan Nappe Structure

Izabella NOWAK and Andrzej ŻELAŹNIEWICZ

Instytut Nauk Geologicznych PAN, Podwale 75, 50-449 Wrocław, Poland

The westernmost flank of the Orlica-Śnieżnik Dome (OSD), West Sudetes, is formed by the Nové Město Group (NMG). The NMG is composed of low-grade to mid-grade metamorphosed metapelites and metagreywackes extensively accompanied by bimodal metavolcanic rocks and diorite to granodiorite intrusions (Opletal et al., 1980). Although still no age data are available, the NMG has customarily been assigned to the Late Proterozoic, less commonly to the Cambrian–Silurian interval (see review in Opletal et al., 1980), and interpreted as a mantle to the ca. 500 Ma gneissic core of the OSD.

Based on geochemical studies, Domečka and Opletal (1980) and Opletal et al. (1990) identified in the NMG subalkalic tholeiites interpreted as ocean floor basalts and co-magmatic calc-alkaline felsic volcanites, apparently different from (meta)basites of the Stronie Group at the OSD core (Domečka and Opletal 1980, Opletal et al. 1990). Floyd et al. (1996, 2000) classified the NMG mafic rocks to MORB-like tholeiites and included to the West Sudetes Main Series metabasites of Early Palaeozoic age. They paid no attention to the NMG felsic members and considered the mafites as astenosphere-derived basalts modified by mixing of depleted (MORB-like) and enriched (OIB-like) plume sources.

Our studies show that the NMG metabasites, conforming in general to the main series tholeiites of Floyd et al. (1996, 2000), are diversified enough to be subdivided into 3 different types: dominant within-plate tholeiites (WPT), less common MORB-like tholeiites, and scarce Ti-tholeiites. The distinguishing element ratios are: Zr/Y, Ti/Y, Ti/V, Zr/Nb, $(La/Yb)_N$, $(La/Sm)_N$ and abundances of HFSE and REE. Although the three types display some overlaps, they are persistently discriminated on various diagrams. In the field, the WP-tholeiites (Zr/Y ca. 3.57–5.70; Ti/Y ca. 290–450) and MORB-like tholeiites (Zr/Y < 3.5; Ti/Y < 320) form roughly parallel belts concordant with the regional meridional strike of the main lithological boundaries and that type of their distribution continues E-ward to the Stronie Group. Both the WPT and MORB-like metabasites, irrespective of their position in the observed belts, display fairly uniform isotopic signature $\varepsilon Nd(500)$ ~5–7 suggestive of similar mantle source and possibly weak contamination with crustal material. $(La/Yb)_N$, $(La/Sm)_N$ and Zr/Nb ratios indicate that the WPT might come from an enriched mantle source as compared with a N-MORB source, whereas the MORB-like tholeiites might originate from a MORB source transitional between N-MORB and E-MORB. A N-MORB-like source might possibly be mixed with an enriched OIB-like source (plume). For the WPT, both the isotopic and characteristic elemental ratios may also point to mild contamination due to some crustal admixtures.

The Ti-tholeiites (Ti/Y ca. 600–860; Ti/V ca. 50–100) differ from the two previous types. They are uniquely characterized by positive Eu and Sr anomalies which might be due to plagioclase cumulation in a depleted yet Ti-rich magma source (cumulated Ti-phases). These cumulate-like basites on most discriminant diagrams plot in the WPT area.

Field evidence shows that only the WP tholeiites and Ti-tholeiites are accompanied by the NMG felsic volcanites which injected the former. Also the MORB-like tholeiites intruded other mafites. These observations make a crude template of evolving magmatism in the NMG.

The observed field relationships of the cumulate-type mafic and the felsic to intermediate volcanites (rhyolites to trachyandesites) suggest their origin from the same magma chamber, which is corroborated by Eu-anomalies shown by the two lithologies. This suggestion is consistent with the results of geochemical studies conducted by Opletal et al. (1990), who concluded that the NMG bimodal magmatic rocks were derived from the same magma source.

The bimodal magmatism recorded in the NMG likely developed in a rift-related (probably back-arc) setting which reached the stage of new oceanic crust production. Palaeogeographic assignment of the rift basin needs dating of its sedimentary-volcanogenic infilling. U-Pb dating of the NMG rocks is under way.

The NMG metabasites originated form dolerites and gabbros that underwent polymetamorphic transformations when practically all primary magmatic minerals have been replaced by metamorphic ones. The oldest recognizable and most distinct foliation of the metabasites dipping to SW/W/NW is defined by the assemblage tschermakite–plagioclase (An_{28-36}). It developed syntectonically in a contractional regime with E/SE directed tectonic transport under the metamorphic peak conditions at T= 615–680 °C and P ~ 6 kbar (geothermometer of Holland

and Blundy 1994), or at T=530–550 °C and P = 5–8 kbar (geothermobarometer of Plyusnina 1982). This event was followed at lower P-T conditions by porphyroblastesis of low-Al hornblende and less calcic plagioclase at low to very small deviatoric stress. Further deformation turned porphyroblasts to porphyroclasts. The deformation paths for the metabasites consist then of oblique to strike-slip dextral shearing and mylonitization along the main foliation planes followed by normal regime due to late orogenic collapse. Asymmetric folds with radially disposed SW/W/NW vergence are accompanied by numerous shallowly to moderately dipping shear zones with similar kinematics. Both the dextral shear planes and axial plane zones to these folds developed under decreasing P-T conditions marked by a retrograde assemblage (low-Al Hbl–Act–Chl–Olg $_{(An15)}$ Ab$_{(An4)}$) developing at T = 480–510 °C and P = 4 kbar (geotherm. Holland and Blundy 1994).

Modeling of deformation of metabasites prior to metamorphic peak has been proved impossible. Deformation at the peak conditions was clearly contractional and generally E-vergent which led to crustal stacking. Younger fold deformation was apparently related to the formation of the OSD. The NMG rock series were stacked over the OSD core then were subjected to gravitational collapse and radially outward gliding down the slopes of the OSD core units during final stages of Variscan collision.

References

FLOYD P.A., WINCHESTER J., CIESIELCZUK J., LEWANDOWSKA A., SZCZEPAŃSKI J., TURNIAK, 1996. Geochemistry of early Palaeozoic amphibolites from the Orlica-Śnieżnik dome, Bohemian massif: petrogenesis and palaeotectonic aspects. *Geol. Rundschau*, 85: 225-238.

FLOYD P.A., WINCHESTER J., SESTON R., KRYZA R. and CROWLEY Q.G., 2000. Review of geochemical variation in Lower Palaeozoic metabasites from the NE Bohemian Massif: intracratonic rifting and plume–ridge intercation. *Geol. Soc.Lond., Spec. Publ.*, 179: 155-174.

OPLETAL M., DOMEČKA K., ČECH S. et al., 1980. Geology of the Orlické hory Mountains. Academia, Praha, pp.1-202.

OPLETAL M., JELÍNEK E., PECINA V., POŠMOURNY K. and POUBOVA E., 1990. Metavolcanites of the SE part of the Lugicum, their geochemistry and geotectonic interpretation. *Sbor. geol. věd , Geologie*, 45: 37-64.

The Early Miocene Olistostromes and “Old Styrian Overthrusting” in the Polish Western Carphatians

Nestor OSZCZYPKO and Marta OSZCZYPKO-CLOWES

Jagiellonian University, Institute of Geological Sciences, Oleandry 2a, 30-063 Kraków, Poland

The Lower Miocene, autochthonous deposits from the basement of the Flysch Western Carpathians in Poland have been known since the late 1970’s. The deposits were documented in the following deep boreholes: Bielsko 4, Sucha IG 1, Zawoja 1, Lachowice 1, 2, 3a, 7, Cieszyn IG 1, Bielowicko IG 1 and Zebrzydowice 13 (see Oszczypko and Oszczypko-Clowes 2003, Ślączka and Oszczypko 1987, and bibliography therein). The oldest known deposits of the Zawoja Fm. probably belong to the Oligocene (Egerian). In the middle part of this formation a 43 m strongly, folded flysch olistostrome (Palaeocene-Middle Eocene) was pierced.

The Sucha Formation, which was identified in the given boreholes, overlaps the Zawoja Fm.: Sucha IG 1, Zawoja 1, Lachowice 1, 2, 3a, 7 and Stryszawa 1K. This formation is an olistoplaque of up to 370 m thick and composed of Lower Cretaceous to Paleocene flysch olistholiths from the Subsilesian and Silesian units with an Early Miocene matrix. This formation is mainly covered by coarse, clastic, Stryszawa Fm. deposits of up to 566 m thick. The conglomerates, derived from the erosion of the Carpathian Flysch belt and the Paleozoic basement, contain carbonate and gypsum cement. From this formation Ottnangian-Karpatian, calcareous nannoplankton (NN 4) was also reported as well as recycled Lower Cretaceous – Early Miocene foraminifera. These deposits became transgressively overlapped by Dębowiec Conglomerates (Late Karpatian/ Early Badenian).

In the Cieszyn area between the Zebrzydowice Fm. (Eggenburgian-Ottnangian) and the Dębowiec Conglomerate, a 25–150 m thick, flysch olistoplaque (Zamarski Mb.), composed of elements of the Subsilesian Unit were discovered. This olistoplaque is also known as the „Old Styrian overthrust” from Northern Moravia. All of the buried flysch outlayers probably developed during Ottnangian-Karpatian as an olistoplaque or a gravitational nappe, which slid from the front of the contemporaneous, Flysch Carpathians. The geological results of the boreholes drilled in the Andrychów- Zawoja –Żywiec- Cieszyn enable us to propose the following paleotectonic scenario:

The Egerian-Ottnangian period of the marine deposition in the Carpathian foreland basin was followed by the Intra-Burdigalian folding (Late Ottnangian), the uplift and overthrust of the Outer Carpathians onto the foreland platform. At the turn of Ottnangian the front of the Outer Carpathians was located about 50 km south of the present-day position. The load of the growing, Carpathian accretionary wedge caused a bending of the platform basement and the development of the moat-like flexural depression of the Carpathian inner foredeep (Oszczypko 1998), filled with molasee deposits. This was accompanied by the development of large-scale slides (olistoplaques and gravitational nappes) along the front part of the Sub-Silesian Nappe. In the Cieszyn area this overthrust reached more or less the