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Garnet hornblendites of the Niedźwiedź Massif (SW Poland): the remnants of Variscan volcanic arc roots

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The Niedźwiedź Massif is poorly exposed, few kilometres in diameter, series of amphibole-dominated rocks occurring in SW Poland. It consists of garnet hornblendites with subordinate garnet clinopyroxenites, both with abundant accessory titanite, and of leucotonalite schlieren containing igneous epidote. The garnet-hornblende assemblage records peak metamorphic conditions at 12 – 13 kbar and temperature 790 ºC (Puziewicz & Koepke 2001, Neues Jahrbuch für Mineralogie Montashefte 2001: 529-547). The hornblendites and clinopyroxenites are intermingled with products of their metamorphic retrogression under amphibolite, epidote-amphibolite and pumpellyite-actinolite facies conditions (Puziewicz 2006, Neues Jahrbuch für Mineralogie Abhandlungen 183: 1-11).

The hornblendites whole-rock trace and REE patterns are typical for tholeiites. Locally, the remnants of magmatic layering in the centimetre-scale occur. Primary hornblende has the composition of Si-rich tschermakite (mg# 0.49 – 0.56) and is characterised by (primitive mantle normalised) bell-shaped REE patterns, depleted in LREE and HREE, with MREE close to 1. Part of hornblende grains exhibits igneous zonation with mg# decreasing outwards. Garnet cores are rich in intergrowths of titanite and solidified melt inclusions consisting of quartz + plagioclase $\pm$ hornblende $\pm$ epidote, whereas the rims are free of inclusions. The primary garnets show little chemical variation and have the composition close to Alm50Sp2Py17Gr31 with mg# 0.22 – 0.26. The garnets are depleted in LREE and enriched in HREE relative to primitive mantle; the analysed LREE contents varies because of contamination by intergrowths of titanite and melt in core regions of the grains. The tonalite schlieren contain unzoned and weakly normally or reversely zoned plagioclase An23 - An19 and igneous epidote. Clinopyroxenites consist of (aluminian, sodian) diopside, garnet, subordinate plagioclase and hornblende and accessory titanite. The diopside is chemically homogeneous. It is slightly depleted in REE's relative to primitive mantle, its REE patterns are bell shaped (impoverished in LREE and HREE) or flat with slight LREE depletion. The other minerals are similar to those occurring in the garnet hornblendite.

The mineral assemblage of Niedźwiedź garnet hornblendites is typical of high-pressure crystallization of wet andesitic/tholeiitic magma. The crystallized melt inclusions as well as the layering suggest that the hornblendites are cumulates of evolved andesitic or tonalitic magma. Part of the grains occurring in the Niedźwiedź garnet hornblendite preserved primary igneous features (magmatic zonation and REE patterns of amphibole, crystallized melt inclusions in garnet and titanite, occurrence of magmatic epidote in tonalitic schlieren). Many of the grains record high P/T metamorphism which might be due to in-situ cooling of cumulates and which overprints the igneous features. This was followed by retrogressive metamorphism and foliation development during exhumation of the rocks. The grain-size reduction in the leucotonalite schlieren is much greater than in the hornblendites, suggesting that the schlieren were the 'soft" element and accommodated most of the strain. In conclusion, the garnet hornblendites and garnet clinopyroxenites originated in a deep-seated evolved andesitic magma chamber in the supra-subduction environment.