

## Stop 6-4 (Day 6). Peridotite and Pyroxenite Boudins in the Bory Granulite, Horní Bory

Coordinates: N49°25'28.6" E16°02'28.2"

Lukáš ACKERMAN<sup>1,2</sup>, Emil JELÍNEK<sup>3</sup>, L. Gordon MEDARIS Jr.<sup>4</sup>

<sup>1</sup> Institute of Geology v.v.i., Academy of Sciences of the Czech Republic, Rozvojová 269, 165 00, Praha 6, Czech Republic

<sup>2</sup> Czech Geological Survey, Geologická 6, Praha 5, 150 00, Czech Republic

<sup>3</sup> Institute of Geochemistry, Mineralogy and Mineral Resources, Faculty of Science, Charles University, Albertov 6, 128 43, Praha 2, Czech Republic

<sup>4</sup> Department of Geoscience, University of Wisconsin-Madison, WI 53706, USA

The Bory granulite is part of the Gföhl unit and contains numerous boudins of peridotite pyroxenite, and eclogite, which range from centimeters to meters in size (Fig. 1) (Mísař and Jelínek, 1981; Mísař et al., 1984). The granulite is characterized by a layered structure defined by the alternation of light-colored (biotite-poor) and dark-colored (biotite-rich) layers, which are isoclinally folded and parallel to the metamorphic foliation. The ultramafic boudins are concentrated along several horizons that are parallel to the predominant trend of granulite foliation, but internal structures of the boudins have variable orientations with respect to metamorphic foliation in the granulite, ranging from approximately parallel, to oblique, to perpendicular, i.e. parallel to remnants of an older vertical foliation in granulite (Hrouda et al., 2009). The ultramafic boudins consist of a variety of lithologies, including dunite, harzburgite, wehrlite, lherzolite, websterite, olivine pyroxenite, and eclogite, most of which are garnetiferous. All boudins have biotite- and amphibole-rich reaction rims of variable thicknesses at contacts with granulite, reflecting the chemical incompatibility between phases in the ultramafic boudins and granulite.

Based on mineralogy and geochemistry (Fig. 2), three types of ultramafic boudins have been distinguished (Medaris et al., 2005; Ackerman et al., 2009): (1) Mg-lherzolite with Mg-numbers from 91 to 89, (2) Fe-dunite/wehrlite with Mg-numbers from 88 to 81, and (3) pyroxenite with Mg-numbers from 77 to 85. The Mg-lherzolite is a strongly serpentinized, five-phase peridotite, consisting of variable proportions of olivine (61–78 %), orthopyroxene (13–23 %), clinopyroxene (5–13 %), Cr-spinel (3 %), and garnet (5–7 %). Spinel occurs as discrete, intergranular grains and as inclusions in garnet, indicating the stable coexistence of spinel and garnet (Fig. 3). Garnet is extensively replaced by kelyphite Fe-dunite/wehrlite is the predominant type of ultramafic boudin in the Horní Bory quarry. It has a slightly foliated, equigranular texture and, locally, a layered aspect due to thin layers of clinopyroxene in dunite and wehrlite. The Fe-dunite/wehrlite consists of olivine (83–88 %), orthopyroxene (0–5 %), clinopyroxene (4–11 %) and spinel+garnet (2–7 %). In contrast to Mg-lherzolite, Fe-dunite/wehrlite contains abundant ilmenite (Fig. 4) and thin veins of secondary clinopyroxene, tremolite, carbonate, and chlorite (after phlogopite) parallel to foliation and layering. Some Fe-dunite/wehrlite boudins have a composite structure with interlayering of Fe-dunite/wehrlite and pyroxenite on a scale of 1 to 6 cm.

The pyroxenite boudins are clinopyroxenite and websterite, which contain clinopyroxene, orthopyroxene, garnet, and small

or accessory amounts of olivine, ilmenite, rutile, phlogopite, and secondary amphibole. The clinopyroxenite has a porphyroclastic texture, in which large clinopyroxene porphyroclasts are set in a fine-grained equigranular matrix of clinopyroxene, orthopyroxene, and garnet. Locally, clinopyroxene porphyroclasts contain garnet and orthopyroxene lamellae, as well as ilmenite rods, that are oriented parallel to the (100) planes of the porphyroclasts (Sanc and Rieder, 1981; Faryad et al., 2009.)

Modeling of Mg-Fe exchange between Mg-lherzolite and Fe-rich melt reveals that the modal and chemical compositions of the Fe-dunite/wehrlite suite can be produced by melt-rock reaction between Mg-lherzolite and SiO<sub>2</sub>-undersaturated melts of basaltic composition at melt/rock ratios ranging from 0.3 to 2 (Ackerman et al., 2009). The Fe-rich suite is significantly enriched in large-ion lithophile elements (LILE), depleted in high field strength elements (HFSE) and has radiogenic <sup>87</sup>Sr/<sup>86</sup>Sr ratios (Fig. 5), all of which point to a significant component of subducted(?) crustal material. Following this model, the pyroxenites could represent crystal cumulates (± trapped liquid) from melts migrating along conduits, and reacting with, peridotite in a mantle wedge above a Variscan subduction zone.

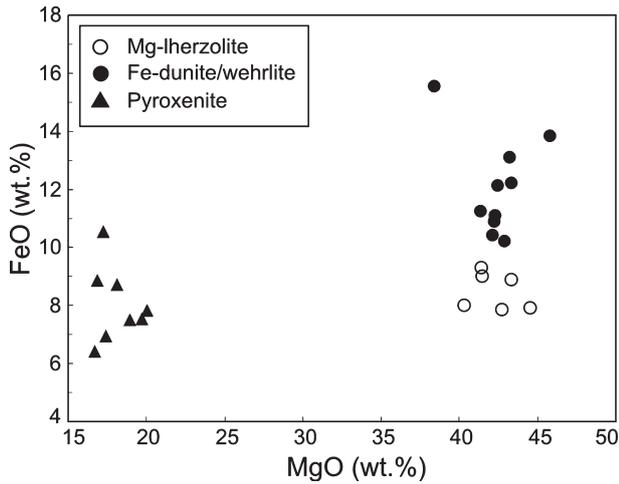
P-T conditions were calculated for peridotites by using the olivine-garnet Fe-Mg exchange geothermometer of O'Neill and Wood (1979) and O'Neill (1980) and the Al-in-Opx geobarometers of Brey and Köhler (1990) and Nickel and Green (1985). Mg-lherzolite yields an average P-T estimate of 905 °C, 37.7 kbar, and two samples of Fe-dunite/wehrlite yield 885 °C, 28.7 kbar and 965 °C, 25.5 kbar (Fig. 6). For one sample of clinopyroxenite, Faryad et al (2009) provided analyses of an exsolved clinopyroxene host and its orthopyroxene and garnet lamellae, the reintegrated clinopyroxene porphyroclast, which contains 18.25 wt% CaO and 5.87 wt% Al<sub>2</sub>O<sub>3</sub>, and matrix orthopyroxene, clinopyroxene, and garnet. The clinopyroxene porphyroclast likely crystallized at ~1400 °C, 23 kbar (Fig. 6), by comparison of its reintegrated composition with the thermodynamic model of Gasparik (2000). Note however, that this P-T estimate is semi-quantitative, because it is unlikely that the clinopyroxene porphyroclast was in equilibrium with orthopyroxene and garnet at the time of its crystallization, which is required for direct application of the Gasparik model. P-T conditions for the exsolved and matrix phases in clinopyroxenite were obtained from application of the Fe-Mg exchange geothermometers for Opx-Grt (Halley, 1984) and Cpx-Grt (Powell, 1985), three 2-Px geothermometers (Brey and Köhler, 1990; Bertrand and Mercier, 1985; Taylor, 1998) and the Al-in-Opx



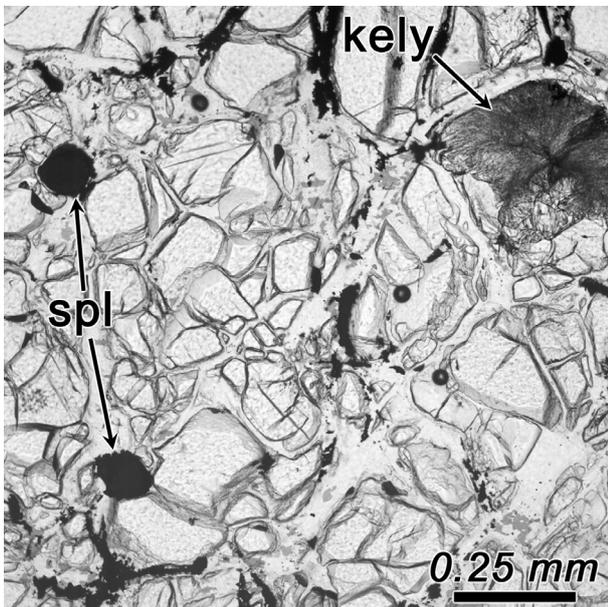
■ **Fig. 1.** Large boudin of layered Fe-dunite/wehrlite and pyroxenite in granulite, Horní Bory quarry.

geobarometers of Brey and Köhler (1990) and Nickel and Green (1985). The average P-T estimate for clinopyroxene host and its orthopyroxene and garnet lamellae is 830 °C, 24.0 kbar, similar to that for Fe-dunite/wehrlite, and for matrix clinopyroxene, orthopyroxene, and garnet is 830 °C, 13.5 kbar (Fig. 6).

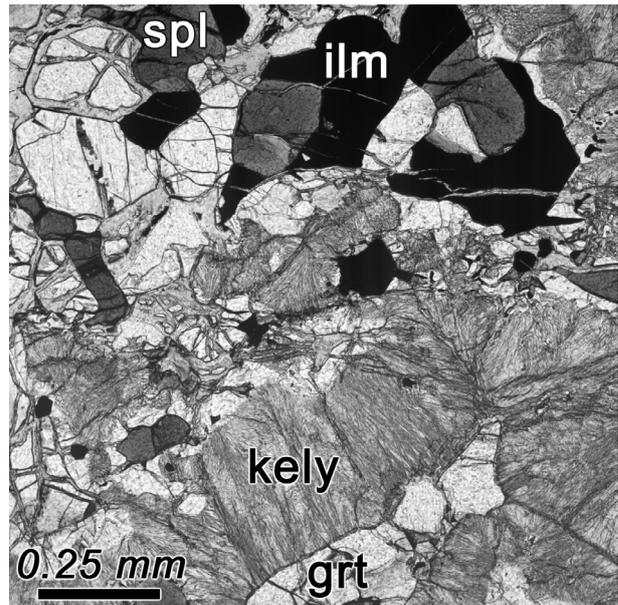
The geochemical and P-T characteristics of ultramafic boudins in felsic granulite in the Horní Bory quarry are consistent with their derivation from a suprasubduction mantle wedge. The Mg-lherzolite may represent deeper portions of the wedge that were brought to shallower levels, where transient melts, origi-



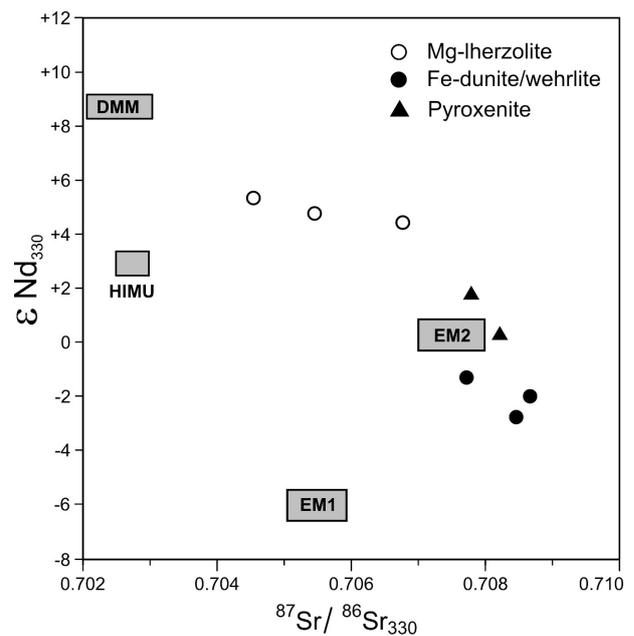
■ Fig. 2. Plot of MgO (wt. %) vs. FeO (wt. %), illustrating the compositional differences among ultramafic rock types in the Horní Bory quarry.



■ Fig. 3. Photomicrograph of Mg-lherzolite (plane polarized light). This view illustrates mostly olivine, with kelyphite (kely) after garnet and interstitial spinel (spl).



■ Fig. 4. Photomicrograph of Fe-dunite/wehrlite (plane polarized light), illustrating mosaic-textured olivine (unlabelled), spinel (spl), ilmenite (ilm), and garnet (grt) partly replaced by kelyphite (kely).



■ Fig. 5. εNd vs. <sup>87</sup>Sr/<sup>86</sup>Sr<sub>330</sub> of clinopyroxenes from Horní Bory peridotites and pyroxenites. Abbreviations: DMM, depleted MORB mantle; EM1, enriched mantle 1; EM2; HIMU, high Mu mantle. Data from Ackerman et al. (2009).

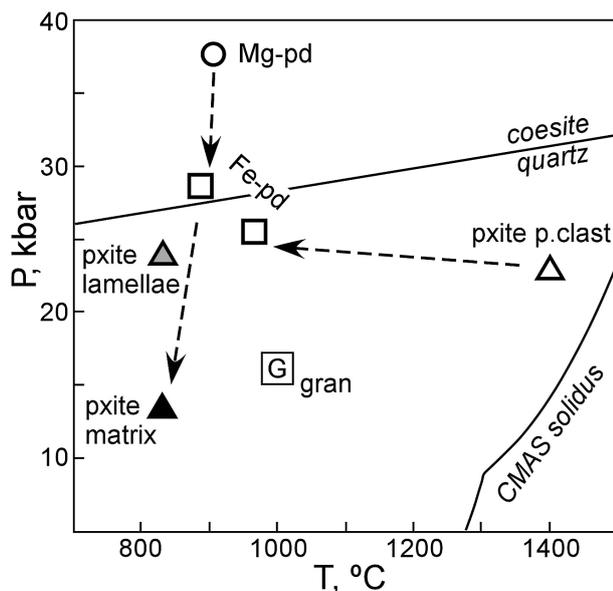
nating from the subduction zone, intruded and reacted with Mg-lherzolite to produce the Fe-dunite/wehrlite suite and associated pyroxenite dikes (now layers). Such reaction was accompanied by extensive recrystallization, which continued at lower pressures during entrainment by granulite and subsequent exhumation of the entire lithologic package.

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■ **Fig. 6.** P-T estimates for Mg-lherzolite (circle, Mg-pd), Fe-dunite/wehrlite (squares, Fe-pd), reconstituted clinopyroxene porphyroclast in pyroxenite (open triangle, pxite p.clast), orthopyroxene and garnet lamellae and host clinopyroxene in pyroxenite (gray triangle, pxite lamellae), and matrix orthopyroxene, clinopyroxene, garnet in pyroxenite (filled triangle, pxite matrix), and Gföhl felsic granulite (G, gran). See text for methods and discussion.

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