tent (Prp_{70} Alm_{15} Grs_6 Uv_7). Orthopyroxene, clinopyroxene, and olivine show weak zoning. Core-to-rim grains of ? orthopyroxene show an increase in Al and Mg and a decrease of Cr, and clinopyroxene exhibits a decrease in Na from (Jd_8) to (Jd_5). Olivine has forsterite content 0.89. Spinel has X_{Al}=Al/(Cr+Al+Fe^{3+}) ratio 0.37. PT conditions, calculated based on garnet-olivine (O'Neill & Wood, 1980; O'Neill, 1981), two-pyroxene (Brey and Kohler, 1990; Taylor, 1998) thermometry, and Grt-Opx (Brey and Kohler, 1990), Cr-in Cpx (Nimis and Taylor, 2000) are in the range 1080–1115 °C at 2.9–3.0 GPa.

References

BREY G.P. and KÖHLER T.P., 1990. Geothermobarometry in 4-phase lherzolites. 2. New thermobarometers, and practical assesment of existing thermometers. *Journal of Petrology,* 31: 1353–1378.

NIMIS P. and TAYLOR W.R., 2000. Single clinopyroxene thermobarometry for garnet peridotites. Part I. Calibration and testing of a Cr-in-Cpx barometer and an enstatite-in-Cpx thermometer. *Contributions to Mineralogy and Petrology,* 139: 541–554.

O'NEILL H.S.C., 1981. The transition between spinel lherzolite and garnet lherzolite, and its use as a geobarome. *Contribution to Mineralogy and Petrology,* 77: 185–194.

O'NEILL H.S.C. and WOOD B.J., 1980. An experimental study of Fe-Mg partitioning between garnet and olivine and its calibration as a geothermometer. *Contribution to Mineralogy and Petrology,* 70: 59–70; *erratum in Contribution to Mineralogy and Petrology*, 72: 337.

TAYLOR W.R., 1998. An experimental test of some geothermometer and geobarometer formulations for upper mantle peridotites with application to the thermobarometry of fertile lherzolite and garnet websterite. *Neues Jahrbuch fuer Mineralogie Abh.*, 172: 381–408.

Stop 5-1 (Day 5). Granulite and Garnet Peridotite, Plešovice Quarry, 5 km NNE of Český Krumlov

Coordinates: N48°55′25.20″, E14°20′28.10″

Martin SVOJTKA[1], Takao HIRAJIMA[2], Stanislav VRÁNA[3] and Kosuke NAEMURA[2]

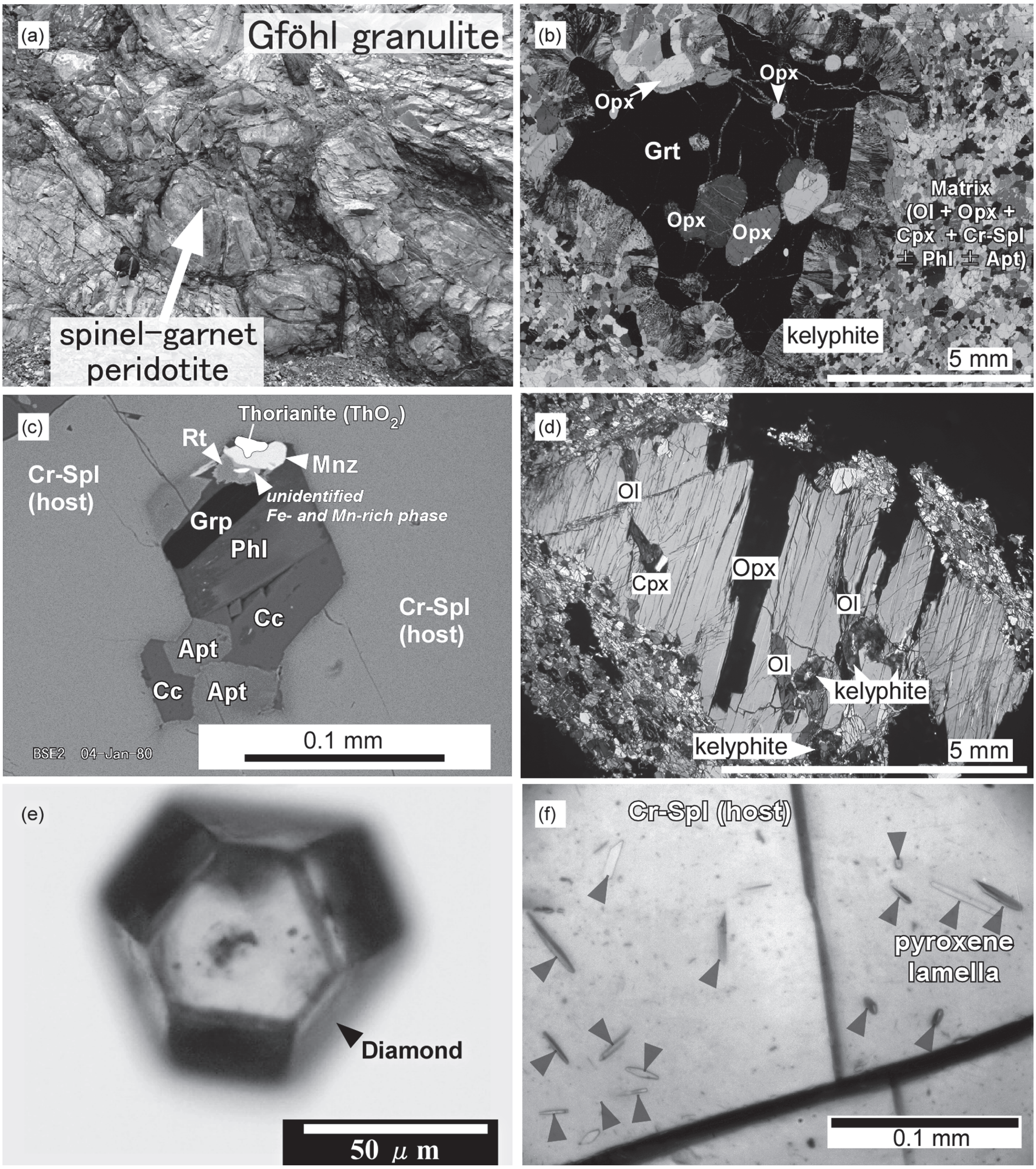
[1] Institute of Geology, Academy of Sciences v.v.i, Rozvojová 269, 165 00 Prague 6, Czech Republic
[2] Department of Geology and Mineralogy, Graduate School of Science, Kyoto University, Kyoto 6069-8502, Japan
[3] Czech Geological Survey, Klárov 3, 118 21 Prague 1, Czech Republic

The main rock types in the Plešovice quarry are felsic granulites and granulitic gneisses, similar to those at stop 4-1, but minor amounts of garnetiferous perpotassic granulites and veins of aplites and pegmatites also occur. Garnet peridotite occurs as an isolated boudins in the granulites. The highly potassic granulites (with K_2O content up to 13 wt.%) occur in foliated layers up to 2 m thick, which are concordant with the predominant felsic calc-alkaline granulites (Vrána, 1989; Janoušek et al., 2007; for description of the predominant felsic granulites – see the Post-Conference Excursion Guide, Day 1). Perpotassic granulites consist of K-feldspar (up to 93%), quartz and pyrope-rich (~30 molar%) garnet with accesory zircon (up to 1 000 ppm Zr), apatite and monazite. Characteristic are high concentrations of Cs, Rb, Ba and U and variable enrichments in Zr and Hf (Vrána, 1989; Janoušek et al., 2007). The perpotassic granulites are interpreted as the product of non-eutectic melt (Vrána, 1989; Janoušek et al., 2007), possibly derived from the protolith of the adjacent felsic granulites in the BLGM (Janoušek et al., 2007).

The spinel-garnet peridotite (Fig. 1), which has been studied in detail, occurs as an elongated lens (20 m × 5 m), which is exposed in the western part of the present-day fifth level of the quarry. The peridotite has an inequigranular texture, in which large spheroidal garnet grains (extensively kelyphitized) are set in a fine-grained matrix of olivine (Ol), orthopyroxene (Opx), minor clinopyroxene (Cpx), and Cr-rich spinel (Spl). The large spheroidal garnet grains locally enclose Ba- and Sr-rich phlogopite and apatite (Ap) inclusions (Naemura et al., 2008). Thorianite (ThO_2) occurs as a member of multiphase solid inclusions, consisting of phlogopite + carbonates + apatite + graphite + rutile + monazite + thorianite, in chromian spinel. The CHIME U-Th-Pb dating of the thorianite yielded a weighted mean age of 333.8 ±4.5 Ma (2 sigma, Table 1), which is the

analyses no.	UO_2 [wt%]	ThO_2 [wt%]	PbO [wt%]	ThO_2* [wt%]	Age ± 2σ [Ma]
1	17.628	77.210	1.889	134.714	331.3 ± 6.6
2	18.094	76.910	1.918	135.942	333.3 ± 6.6
3	17.758	77.240	1.927	135.193	336.7 ± 6.7
4	18.836	75.730	1.938	137.183	333.8 ± 6.6
weighted average					333.7 ± 5.5

■ **Tab. 1**. Results of electron microprobe dating of thorianite from the Plešovice peridotite. From Naemura et al., 2008.



■ **Fig. 1.** (a) The spinel–garnet peridotite outcrop within prevailing felsic granulite in the Plešovice quarry; (b) A large garnet (Grt) with rounded orthopyroxene inclusions (Opx), the fine-grained matrix is composed of olivine (Ol) + orthopyroxene (Opx) + clinopyroxene (Cpx) + Cr-spinel (Cr-Spl). Phlogopite (Phl) and apatite (Apt) are present as accesories. Crossed polarized light; (c) Backscattered electron image of a multi-phase solid inclusion within chromian spinel (Cr-Spl). Inclusion consists of phlogopite (Phl), calcite (Cc), apatite (Apt), graphite (Grp), rutile (Rt), monazite (Mnz), thorianite and unidentified Fe- and Mn-rich phase; (d) Orthopyroxene (Opx) megacryst (approximately 6 mm in diameter) with olivine (Ol) and clinopyroxene (Cpx) inclusions. Crossed polarized light; (e) Microphotography of diamond crystal from the Plešovice peridotite. Plane polarized light; (f) Detail of the core of large chromian spinel (Cr-Spl) inclusion in kelyphitized garnet. Note that there are many lamellae in the Cr-Spl, which were identified as diopside crystals with minor clino-enstatite. Plane polarized light.

same within error as the age of HP metamorphism determined for felsic granulites in southern Bohemia (Naemura et al., 2008, see the text above).

Naemura et al. (2009) described three equilibrium stages for the Plešovice peridotite. The temperature of Stage I was estimated to be 1020 ± 15 °C, using the Al-Cr orthopyroxene thermometer (Witt-Eickschen and Seck 1991) for orthopyroxene megacrysts. Stage II is defined by the spinel-garnet lherzolite assemblage in the matrix, and equilibrium conditions were estimated to be 23–35 kbar and 850–1030 °C, based on the application of two-pyroxene and Grt-Cpx thermometry, Grt-Opx and Grt-Cpx barometry, and an empirical Spl barometer for Spl-Grt lherzolite. Stage III is defined by the presence of aluminous ortho- and clinopyroxene, aluminious spinel, and amphibole and phlogopite in kelyphite. Temperature conditions for stage III were estimated to be 730–770 (±27) °C at 8–15 kbar. The mineral assemblage in the multiphase solid inclusions (MSI) in chromian spinel is composed of phlogopite, dolomite, apatite and calcite with minor amounts of chlorite and magnesiohornblende. Crystallization conditions of the MSI assemblage were at relatively low-P and low-T (T < 750 °C; P < 16 kbar). The timing of crystallization of MSI appears to predate the stage II, as most MSI are completely enclosed by the host chromian spinel, which formed during stage II. These relations suggest that the Plešovice peridotite experienced cooling after Stage I and was transformed to spinel-garnet peridotite by subsequent subduction processes (Naemura et al, 2009).

Recently, Naemura et al. (in press) reported the presence of carbon phases in garnet(?), including micro-diamond that suggests ultra-deep conditions (~6 GPa) for garnet in the precursor of the Stage I(?) garnet peridotite. Synchrotron X-ray fluorescence analysis indicated that this diamond contains Fe-Ni metal (taenite) and Cu-Zn-rich phases (possibly sulfide) as inclusions. In particular, the latter phase supports the natural origin of this diamond, although the aggregation state of nitrogen in the diamond is very similar to that in synthetic diamond. Raman spectroscopy shows that graphite crystals included in garnet show upward displacements of the G-band up to 1600 cm^{-1}. Such upward displacements are most likely due to internal pressure, supporting the high-pressure origin of graphites. Another line of evidence for ultra-deep conditions is revealed by pyroxene lamellae developed in coarse-grained chromian spinel grains. EBSD analysis indicates that the pyroxene lamellae could be formed by exsolution from a high-pressure polymorph of spinel (Ca-ferrite and/or Ca-titanite structure), which may be stable under very high pressures (>12.5 GPa). The diamond-bearing Plešovice peridotite is interpreted to represent a fragment of asthenosphere (> 200 km) that was transported to relatively shallow levels by a diapiric plume and then incorporated into the Moldanubian orogenic root shortly before or during the Variscan continent-continent collision at ca. 340 Ma.

References

JANOUŠEK V., KRENN E., FINGER F., MÍKOVÁ J. and FRÝDA J., 2007. Hyperpotassic granulites from Blanský les (Moldanubian Zone, Bohemian Massif) revisited. *Journal of Geosciences*, 52: 73-112.

NAEMURA K., HISASHIMA H., HIRAJIMA T. and SVOJTKA M., 2009. An ultra-high-pressure metamorphic condition and isothermal decompression path obtained from a garnet-pyroxenite in the Horni Bory granulite of the Bohemian Massif. *Journal of Mineralogical and Petrological Sciences*, 104(3): 168-175.

NAEMURA K., YOKOYAMA K., HIRAJIMA T. and SVOJTKA M., 2008. Age determination of thorianite in phlogopite-bearing spinel-garnet peridotite in the Gföhl Unit, Moldanubian Zone of the Bohemian Massif. *Journal of Mineralogical and Petrological Sciences*, 103: 285-290.

NAEMURA K., IKUTA D., KAGI H., ODAKE S., UEDA T., OHI S., KOBAYASHI Y., SVOJTKA M., HIRAJIMA T., (2011, in press). Diamond and other possible ultra-deep evidence discovered in the orogenic spinel-garnet peridotite from the Moldanubian Zone of the Bohemian Massif, Czech Republic, In: L. DOBRZHINETSKAYA, S.W. FARYAD, S. WALLIS and S. CUTHBERT (Editors), UHPM: 25 year after discovery of coesite and diamond, Elsevier.

VRÁNA S., 1989. Perpotassic granulites from southern Bohemia. A new rock type derived from partial melting of crustal rocks under upper mantle conditions. *Contrib. Mineral. Petrol.,* 103: 510-522.

WITT-EICKSCHEN G. and SECK H.A., 1991. Solubility of Ca and Al in orthopyroxene from spinel peridotite: an improved version of an empirical geothermometer. *Contrib. Mineral. Petrol., 106:* 431-439.

Garnet-Rich Gneisses (Kinzigites) of the Lhenice Shear Zone

Martin SVOJTKA[1], Tomoyuki KOBAYASHI[2,3] and Takao HIRAJIMA[2]

[1] Institute of Geology, Academy of Sciences v.v.i, Rozvojová 269, 165 00 Prague 6, Czech Republic
[2] Department of Geology and Mineralogy, Graduate School of Science, Kyoto University, Kyoto 6069-8502, Japan
[3] Department of Earth Sciences, Graduate School of science, Chiba University, 1-33 Yayoi, Inage, Chiba 263-8522, Japan

The garnet-rich gneisses form a ~15 km long, north-south trending, discontinuous belt having up to 100 m in thickness, which forms part of the Lhenice shear zone (Rajlich et al., 1986). The Lhenice shear zone separates the Blanský les granulite massif to the east from the Prachatice and Křišťanov granulite massifs to the west. Rajlich et al. (1986) determined that