Garnet peridotite in the Moldanubian Zone in the Czech Republic – a heat source for Variscan metamorphism?

(3 figs)

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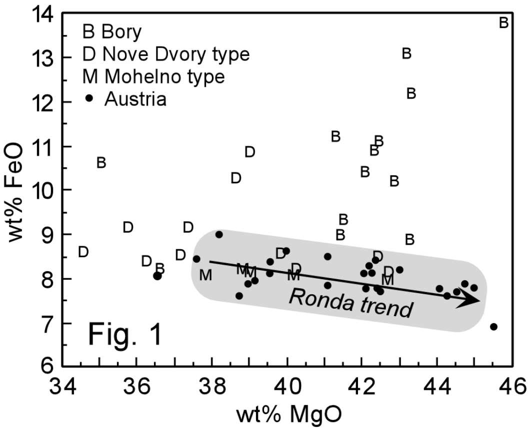
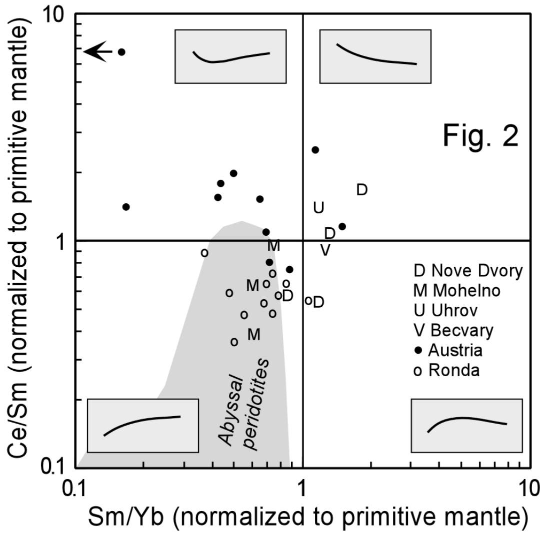
Introduction

Different types of peridotite occur in the Gföhl Nappe in southwestern Moravia: the Nové Dvory type is allochthonous to surrounding migmatitic orthogneiss, contains layers of eclogite and garnet pyroxenite, and consists predominantly of garnet peridotite; the Mohelno type has concordant contacts with associated granulite, is devoid of eclogite or garnet pyroxenite layers, and is mostly spinel peridotite, in which garnet (with spinel inclusions) occurs only at the margins of the body (Medaris et al., 1990); and the Bory type consists of abundant boudins of peridotite, pyroxenite, and eclogite in granulite. The Mohelno type of peridotite has been proposed as a source of advected heat for high-temperature metamorphism and crustal melting during culmination of the Variscan orogeny (Brueckner – Medaris, 1998).

Geochemistry Many garnet peridotite bodies in the Czech and Austrian (Becker, 1996) segments of the Gföhl Nappe show a negative correlation of FeO (Fig. 1), TiO_2, Al_2O_3, CaO, and Na_2O with MgO, similar to the „depletion trend" of the well-studied Ronda Massif (Frey et al., 1985). However, some peridotites of the Nové Dvory type and peridotite boudins in the Bory quarry show considerable scatter in major element composition (Fig. 1), probably reflecting the effects of cumulate or metasomatic processes.



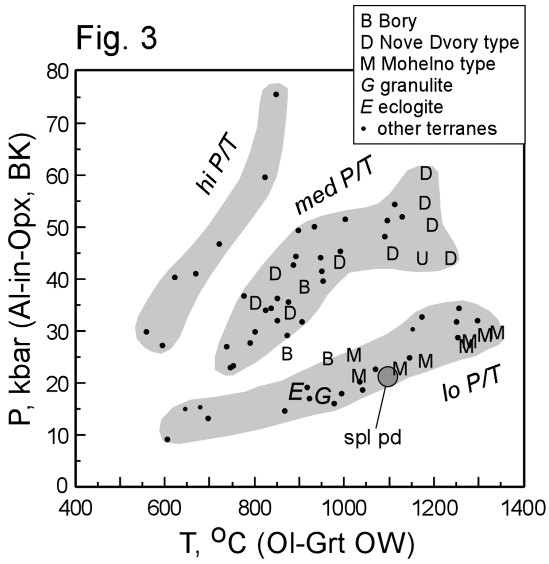
The wide range of REE patterns for peridotite in the Gföhl Nappe is illustrated in a plot of Ce/Sm vs. Sm/Yb (Fig. 2). The Mohelno peridotite and two Austrian peridotite samples lie in the „depleted" quadrant of the figure, as do the Ronda peridotite and abyssal peridotites. Most of the Nové Dvory type and Austrian peridotites have values of Ce/Sm >1, most likely due to cryptic metasomatism originating from the associated garnet pyroxenite and eclogite layers.



Thermal characteristics

Application of the ol-grt Fe-Mg exchange geothermometer and the Al-in-opx geobarometer to garnet peridotite from eleven Eurasian HP and UHP terranes defines three distinct P/T domains at high, medium, and low ratios of P/T (Fig. 3; Medaris, 1999). The three different arrays do not represent geotherms, but, rather, are equivalent to metamorphic field gradients associated with different tectonothermal settings.

Garnet peridotite of the Nové Dvory type lies within the medium P/T field, over a wide range of conditions from 800 to 1200 °C and 33 to 60 kbar. Garnet peridotite of the Mohelno type lies within the low P/T field at



temperatures from 1000 to 1350 °C and pressures from 20 to 29 kbar. P-T estimates for Gföhl granulite (Carswell – O'Brien, 1993) and an eclogite boudin in granulite (Medaris et al., 1998) also fall within the low P/T array. This simple, twofold P/T division of garnet peridotites in the Gföhl Nappe is complicated by three garnet peridotite boudins surrounded by granulite in the Bory quarry, one of which lies in the low P/T field, one in the medium P/T field, and one in between!

Locally, garnet grains in granulite and eclogite preserve prograde compositional zoning (O'Brien – Vrána, 1995; Becker, 1997; Medaris et al., 1998). Diffusion modeling demonstrates that prograde zoning could not have survived for more than 14 m.y. in a garnet grain of 2 mm radius at 1000 °C. In garnet peridotite of the Mohelno type, diffusion modeling of retrograde compositional zoning in garnet adjacent to olivine inclusions yields a bilinear cooling history, with initial rapid cooling of 2000–2500 °C/m.y. from >1100 °C to ~700 °C, followed by slower cooling of 1–10 °C from ~700 to 550 °C. Such results require that the high-temperature (~1000 °C) and high-pressure (~20 kbar) metamorphism in the Gföhl Nappe at 335–345 Ma must have been a short-lived event, involving both rapid heating and rapid cooling.

Discussion

Based on their geochemical and thermobarometric characteristics, the Nové Dvory type of peridotite represents lithospheric mantle, and the Mohelno type, shallow asthenospheric mantle. The Mohelno type may have originated as the result of lithospheric thinning and marginal basin development in Devonian time, allowing hot asthenosphere to ascend to relatively shallow levels. High-temperature and high-pressure metamorphism in the Gföhl Nappe may be ascribed to Carboniferous compression and closure of the marginal basin, accompanied by subduction and imbrication of Mohelno type peridotite and continental crust. Sufficient advected heat may have been provided by hot slabs of peridotite to account for the elevated metamorphic temperatures and, perhaps, to promote partial melting of associated crust, resulting in high-pressure granulite melts. Rapid exhumation of the Gföhl terrane may have been driven by buoyancy forces, following slab break-off. An explanation for the association of Nové Dvory and Mohelno types of peridotite in the Gföhl terrane and the large pressure gap between them is problematic, but incorporation of the Nové Dvory type may be related to exhumation processes.

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