Lithos 109 (2009) 209–222

Contents lists available at ScienceDirect

Lithos

journal homepage: www.elsevier.com/locate/lithos

Serpentinised peridotites from an ultrahigh-pressure terrane in the Pohorje Mts. (Eastern Alps, Slovenia): Geochemical constraints on petrogenesis and tectonic setting

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ARTICLE INFO

Article history:
Received 31 January 2008
Accepted 19 May 2008
Available online 3 June 2008

Keywords:
Pohorje
Serpentinite
Harzburgite
Mantle melting
Metasomatism
Continental subduction

ABSTRACT

The Slovenska Bistrica ultramafic complex (SBUC; Eastern Alps, Slovenia) occupies the south-easternmost part of the Pohorje Mountains, which represent an exhumed piece of continental crust subducted during the Cretaceous Eo-Alpine orogeny. The SBUC is composed of serpentinised harzburgites with local occurrences of garnet lherzolite, and is the only known occurrence of ultramafic rocks within the high- to ultrahigh-pressure nappe system apart from a few small dismembered pieces in the near vicinity. The harzburgites are highly depleted following melting within the spinel stability field, as exemplified by high whole-rock MgO contents (41.5–44.3 wt.%), low Al_2O_3 (0.7–1.2 wt.%), low Lu_N (0.1–0.7), and high Cr# of Cr-spinel (ca. 0.5). Fluid-immobile incompatible trace elements (Ti, Sc, V, Zr, HREE, Th) correlate well with MgO, consistent with a melt depletion trend. Other incompatible elements (Ba, Sr, LREE) show little correlation and are probably modified by the serpentinisation process or later metamorphic overprint. However, comparable LREE enrichment of all samples and absence of negative Nb and Th anomalies suggests that this piece of mantle was already metasomatised by melts or fluids before serpentinisation.

Garnet lherzolite in the SBUC recorded an UHP stage (4 GPa, 900 °C) not visible in the harzburgites. Because of the evidence of an earlier lower pressure stage within the spinel stability field, the SBUC represents a piece of subducted mantle. The protolith of the harzburgites is probably oceanic mantle, considering the high degree of melt depletion yet the lack of a subduction-zone signature. It therefore most likely represents a part of previously subducted Meliata oceanic mantle, which was part of a deeper section of the hanging wall along which subduction of the continental crust that is now exposed in Pohorje took place. Alternatively, it may represent mantle depleted and metasomatised in a continental rift zone, which was later incorporated in the hanging wall of the subduction zone and subsequently dragged down to UHP conditions.

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1. Introduction

Ultramafic rocks are a small but common component of continental crust that has gone through a subduction and exhumation cycle (e.g., Scandinavian Caledonides, Medaris and Carswell, 1990, Ravna et al., 2006; Dabie-Sulu terrane, Liou and Zhang, 1998, Yang and Jahn, 2000; Bohemian Massif, Medaris et al., 1990). Petrologically the rocks vary widely from pyroxenites to lherzolites to harzburgites, include garnet and spinel-bearing varieties and occur as boudins and lenses or as larger orogenic bodies within the continental crust.

Most of these ultramafic rocks are interpreted to be derived from the overlying mantle wedge, and may have been incorporated at great depth and high pressure, but also at lower pressure and subsequently subducted together with the down-going continental plate (Medaris, 2000; Brueckner and Medaris, 2000). Alternatively, the ultramafics may have been present in the continental crust before subduction.

The significance of these ultramafic rocks is manifold. If garnet-bearing they provide independent proof of a high to ultrahigh-pressure stage of the rocks (e.g., Carswell, 1986; Janák et al., 2006). Their former tectonic setting and melt depletion ages may provide important clues as to the tectonic history of the region before the subduction stage (e.g., Spengler et al., 2006; Yuan et al., 2007) and put constraints on the subduction process itself. They also may provide information about metasomatic processes before and during

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doi:10.1016/j.lithos.2008.05.006

subduction, and, if serpentinised, may facilitate exhumation of subducted rocks (Guillot et al., 2000).

The Pohorje Mountains in Slovenia, part of the Eastern Alps, have recently been established as a terrane with peak metamorphic conditions within the coesite stability field, i.e., ultrahigh-pressure (UHP) conditions (Janák et al., 2004), and associated with eclogite UHP localities several outcrops of garnet peridotites have been found (Janák et al., 2006; Vrabec, 2007). The largest ultramafic body is strongly serpentinised, comprising the south-easternmost extension of the Pohorje Mountains (Hinterlechner-Ravnik et al., 1991a), and has previously been suggested to be a former layered gabbro (Visona et al., 1991). Janák et al. (2006) investigated UHP garnet peridotites from within and nearby the ultramafic body and proposed that these could have been derived from depleted mantle rocks that were subsequently metasomatised by melts and/or fluids either in the plagioclase-peridotite or the spinel-peridotite field.

In this paper we focus on the serpentinised ultramafic body and aim to reconstruct its geological and tectonic history. Albeit strongly serpentinised, the body retained a signature of extensive melt depletion, either in a continental rift or an oceanic ridge environment. It therefore probably represents a sliver of overlying mantle tectonically emplaced in the continental crust during subduction. UHP metamorphism was recorded locally in garnet peridotites.

1.1. Geological background

Ultramafic rocks occur in the south-easternmost part of the Pohorje Mountains. Near Slovenska Bistrica (Fig. 1) they form a body of ca. 6 × 1.5 km size, which is termed the "Slovenska Bistrica ultramafic complex" (SBUC; Janák et al., 2006). The main protoliths of the SBUC were described as harzburgites and dunites by Hinterlechner-Ravnik et al. (1991a). Because of extensive serpentinisation, only a few less altered garnet peridotites, garnet pyroxenites and coronitic metatroctolites are preserved (Hinterlechner-Ravnik et al., 1991a; Janák et al., 2006). The ultramafics include numerous lenses, boudins and bands of eclogites. The country rocks enclosing the SBUC consist of a typical continental crust assemblage of high-grade metamorphic rocks, such as ortho- and paragneisses, micaschists, amphibolites and marbles

Table 1
Sample locations and description.

Sample	Type[a]	Location	GPS	Description
GP-VI01	SLh	Visole	46.408°N 15.524°E	Garnet lherzolite, partly serpentinised with relics of Gt, Ol, Opx, Cpx, Cr-spinel and sulphides (see Janák et al., 2006, for a detailed description)
SH-123	SHz	Markuž quarry	46.404°N 15.493°E	Serpentinised harzburgite with relics of Opx, Ol and Cr-spinel. Exsolutions of Cpx and Cr-sp from Opx. Amphiboles (hornblende, tremolite, anthophyllite) replacing serpentinised mantle minerals.
SH-NO2	SHz	Novak[b]	46.418°N 15.529°E	Strongly serpentinised harzburgite with relics of Cr-spinel, some amphibole (hornblende, tremolite)
SH-1-1	SHz	Near Visole	46.408°N 15.534°E	Serpentinised harzburgite with relics of Ol, Cr-spinel and Opx.
SH-VO1	SHz	Same as SH-1-1	Same as SH-1-1	Coarse-grained serpentinised harzburgite with abundant relics of Ol, Opx and Cr-spinel. Amphiboles (hornblende, tremolite, anthophyllite). Sulphide-bearing. Cr-spinel exsolutions in Opx.

[a] SLh = serpentinised garnet lherzolite, SHz = serpentinised spinel harzburgite.
[b] Along road, not in situ.

(Mioč and Žnidarčič, 1977; Hinterlechner-Ravnik et al., 1991a,b; Janák et al., 2004; Miller et al., 2005). These rocks form a strongly foliated matrix around elongated lenses and boudins of eclogite and ultramafics, including the SBUC. Abundant eclogites record peak pressures from 2.4 to 3.2 GPa (Sassi et al., 2004; Janák et al., 2004; Vrabec, 2004, 2007), with the highest values in the southeast near the SBUC (Janák et al., 2004), whereas garnet-bearing peridotites and pyroxenites record peak pressures of up to 4 GPa (Janák et al., 2006).

1.2. Tectonic history

The region has a complicated tectonic history, which was reconstructed by Schmid et al. (2004 and references therein). A short summary is given here. The current Austroalpine nappes of the Eastern Alps were part of a continental block called Apulia that

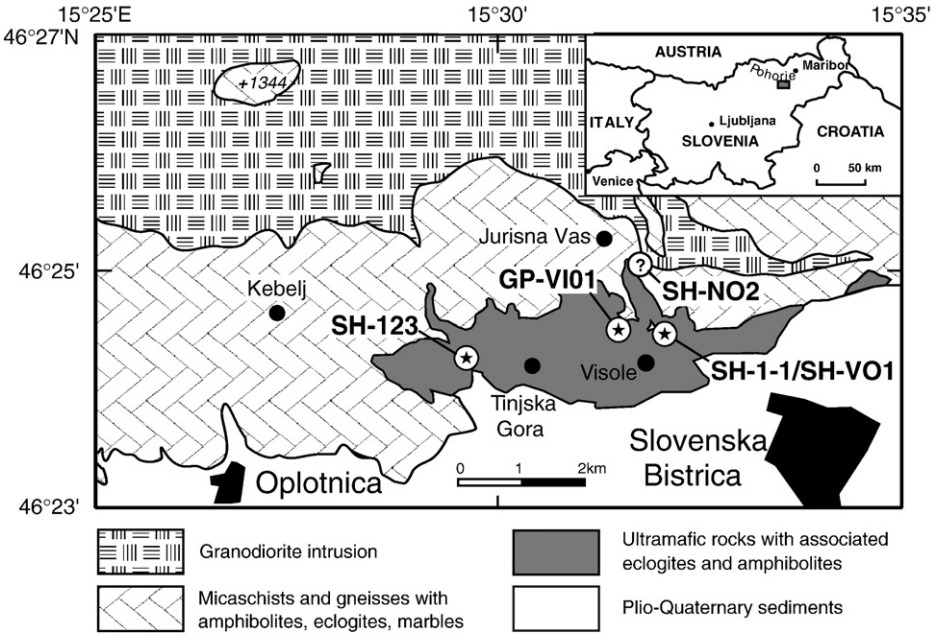

Fig. 1. Simplified geological map of the southwest corner of the Pohorje Mountains (modified from Mioč and Žnidarčič, 1977, with updates by F. Kirst and S. Sandmann, University of Bonn) showing the location of the Slovenska Bistrica Ultramafic Complex (SBUC) and sampling localities. Inset shows location of Slovenia and Pohorje Mountains; gray rectangle represents geological map area.

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