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Corundum-bearing garnet peridotite from northern Dominican Republic: A metamorphic product of an arc cumulate in the Caribbean subduction zone

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ABSTRACT

Garnet peridotite in oceanic subduction complexes has been reported only in two locations in the world. One of these examples occurs in the late Cretaceous to early Tertiary subduction complex in northern Dominican Republic. The garnet peridotite (wehrlite and olivine-bearing clinopyroxenite) occurs as large (≤4 m) boulders together with boulders of eclogites and serpentinites along a narrow (<10 m) stream of the Rio Cuavas in the southern part of the Rio San Juan Complex. The peridotite is composed of garnet, diopsidic clinopyroxene (partially altered to magnesiohornblende), olivine (extensively altered to serpentine), Al-spinel and minor corundum; the latter two are mostly enclosed in garnet. Coarse-grained garnet also encloses small grains of early-formed garnet that contain Ca- and Al-rich cores and Mg-rich rims.

The garnet peridotite contains low Cr, Ni, and Ir-group platinum group elements in bulk rock compared to primitive mantle values, low Mg (Mg#; 0.74–0.83) and NiO (<0.1 wt.%) in olivine, and elevated concentrations of fluid-mobile elements (Sr, Pb and U) in clinopyroxene and bulk rock. Combined with the rare earth element data of bulk rocks and clinopyroxene, these data suggest that the peridotite originally solidified as a plagioclase-bearing cumulate of an arc melt at a shallow depth, <35 km, in the mantle wedge. The cumulate was later dragged by mantle flow from the subarc mantle towards the subduction plane. Subsequent downward movement along the subduction plane resulted in the crystallization of corundum and Ca- and Al-rich garnet at the expense of plagioclase, at a depth of ~50 km. The garnet peridotite continued to be subducted to a depth of ~120 km, causing a progressive increase in pressure and temperature that resulted in the crystallization of Mg-rich garnet. The garnet periodotite was then exhumed in the serpentinite subduction channel. These events likely took place during the very early stages of the subduction system, where a strong mantle corner flow was likely produced by poor lubrication along the interface between the subducting plate and the overlying Caribbean Plate.

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1. Introduction

Occurrences of garnet peridotite are reported in many continental collision zones, such as in the Western Gneiss Belt of Norway and the Sulu ultra-high pressure (UHP) belt of China (e.g., Brueckner and Medaris, 2000; Zhang et al., 2003), but it is very rare in oceanic subduction zones. So far only two examples have been reported in the interior of an oceanic subduction zone: in the Sanbagawa belt in southwestern Japan (Enami et al., 2004; Hattori et al., 2009) and in the Rio San Juan Complex of northern Dominican Republic (Abbott et al., 2005, 2006, 2007; Fig. 1a). In both locations, garnet peridotite occurs in close spatial association with eclogites in high grade parts of these metamorphic terranes. Garnet peridotite in the Dominican Republic is unique in containing minor amounts of corundum, Al_2O_3. Corundum is rare in mafic–ultramafic complexes and reported only from a few locations; the Beni Bousera massif of northern Morocco (Kornprobst et al., 1990), the Ronda massif of southern Spain (Morishita et al., 2001), the Horoman peridotite complex in northern Japan (Morishita and Arai, 2001; Morishita et al., 2007), and Cabo Ortegal Complex in Spain (Girardeau and Ibarguchi, 1991). Corundum in these mafic–ultramafic complexes occurs in mafic layers and lenses, but corundum in the Rio San Juan Complex occurs within peridotite and clinopyroxenite. Therefore, the presence of corundum and garnet makes the peridotite in northern Dominican Republic a rare example of an ultramafic rock in

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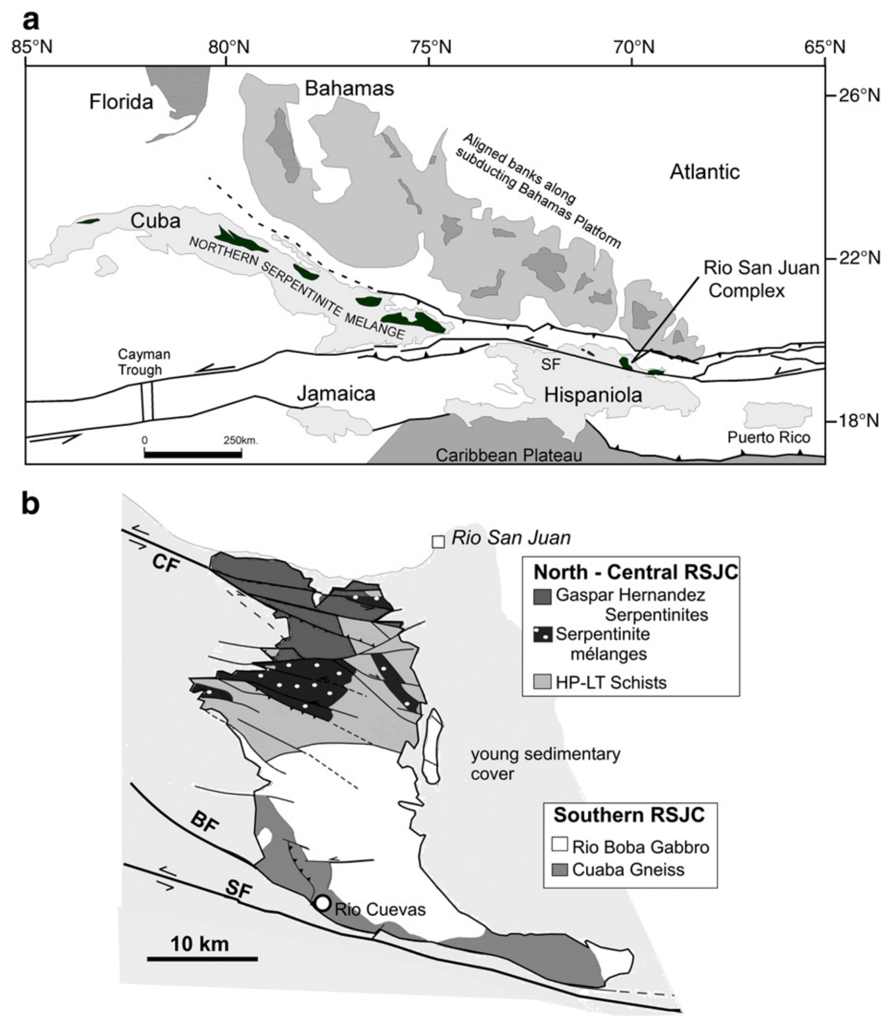

Fig. 1. Location map of the study area. (a) The map is modified after Dolan et al. (1998). The central dark area in the box is shown in panel b. (b) Geological map of the Rio San Juan Complex. BF = Bajabonico fault, CF = Camú fault, SF = Septentrino fault, Map modified from Lewis et al. (1990); Draper and Nagle (1991).

the subduction complex. Thus, this unit may contain information relevant to deep processes in oceanic subduction zones.

Previous study has been conducted on the mineralogy and major element mineral chemistry of the Dominican Republic garnet peridotite (Abbott et al., 2005, 2006, 2007), but the trace elements of the bulk rocks and minerals have not been investigated. Trace element compositions of igneous rocks may provide information relevant to the origin of the parental magmas. This paper presents the compositions of bulk rocks and minerals including the trace element concentrations of clinopyroxene in the corundum- and garnet-bearing peridotites in northern Dominican Republic and discusses their origin.

2. Geological setting

Dominican Republic is in the eastern half of Hispaniola, located on the northern margin of the Caribbean plate (Fig. 1a). Until the Mid to Late Cretaceous, this region was above the NE-dipping Farallon oceanic plate of the Pacific Ocean (Pindell et al., 2005). There was a major change in the plate configuration at ~120 Ma when the subduction complex moved from the Pacific Ocean side to the Atlantic Ocean side, and the North and South American continents diverged (Pindell et al., 2005). The NE move of Hispaniola to its current position was accommodated by a polarity reversal of subduction, and subduction of the Proto-Caribbean oceanic lithosphere below this moving Caribbean plate. This subduction of the Proto-Caribbean oceanic lithosphere produced the Caribbean arc on the northern margin of the Caribbean plate. The subduction lasted until the middle Eocene, when the oceanic lithosphere was consumed by the subduction and the Caribbean Plate collided with the Bahamas Platform, which is the southern margin of the North American plate (Goncalves et al., 2000; Fig. 1a). This oblique collision produced left-lateral strike-slip faults in northern Hispaniola (Fig. 1), the Septentrional and Camú faults (Goncalves et al., 2000). The strike-slip displacement along the Septentrional fault is greater than 200 km, and is still active with 6 to 12 mm/year strike movement (Prentice et al., 2003).

At present, the northern part of Dominican Republic is mostly covered by young sedimentary rocks ranging in age from late Eocene to Quaternary, and subduction-related rocks are exposed only in isolated stratigraphic windows (or inliers) (Draper and Nagle, 1991; Fig. 1b). The Rio San Juan Complex (~30 × ~30 km), the largest inlier in the area (Fig. 1b), is composed of three juxtaposed parts (Fig. 1b): the Gaspar Hernandez Serpentinites in the northern part, HP metamorphic rocks and tectonic mélanges in the central part, and the Cuaba Gneiss and the Rio Boba Gabbro in the southern part. Garnet peridotite occurs close to the Septentrional fault in the southern extreme of the southern part of the Rio San Juan Complex (Fig. 1b).

The Cuaba Gneiss in the southern part of the Rio San Juan Complex is a metamorphosed oceanic gabbro of the Proto-Caribbean lithosphere (Draper and Nagle, 1991). It is composed of amphibole + quartz + plagioclase ± rutile ± ilmenite ± chlorite ± epidote, and has undergone retrogression under amphibolite facies conditions. The unit, which is well exposed along rivers and on roads, contains

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