NEW INSIGHTS ON THE ANDEAN-RELATED SUBCONTINENTAL LITHOSPHERIC MANTLE AND EVIDENCE OF Sr-Nd DECOUPLING

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INTRODUCTION

The subcontinental lithospheric mantle, assumed to be the portion of the lithosphere below the Mohorovicic discontinuity and above the asthenosphere, can be defined in terms of its chemical, thermal, seismic and/or mechanical properties. Simple petrological and chemical models have been suggested for the bulk composition and mineralogy of the oceanic lithospheric mantle (Ringwood, 1982). However, for the understanding of the subcontinental lithospheric mantle composition and mineralogy, difficulties have arisen due to its long-term evolution and processes responsible for continuous changes of its composition (McDonough, 1990). Some of these processes have been described as metasomatism. Metasomatism is defined as the percolation of fluids or melts through the mantle inducing its compositional, and in some cases mineralogical, modifications. The metasomatic agent has been attributed to products derived either from the asthenosphere underneath or from the subducted crust in compressive regimes. In both cases, and in a simple constrain, the isotopic composition of a lithospheric mantle, initially characterized by depletion of incompatible elements, must change due to incorporation of more radiogenic Sr, but less radiogenic Nd once this mantle undergone es a metasomatic event. This simplistic model assumes that the metasomatic agent will be mixed to the depleted mantle lithosphere by "two-end member simple mixture process" and do not consider chromatographic process that could take place due to the different mineralogy with different partition coefficients related to Sm and Rb. Some authors, however, have been calling attention to this possibility (Navon & Stolpler, 1987; Bedini et al., 1997; Hauri, 1997).

Spinel- and/or garnet-bearing ultrabasic mantle xenoliths brought to the Earth's surface by intraplate alkaline basalts provide direct information on the nature and processes involved in the modifications of the subcontinental mantle lithosphere, such as mantle metasomatism. These xenoliths have been used to identify processes involved in the growth of the continental lithosphere, constrain the tectonic setting of its formation and provide an estimate of the primitive mantle composition. Additionally, geochemical and isotopic studies have been done on these xenoliths in order to provide further insights on the composition of magmas. These studies, however, are based on the hypothesis that some magmas, such as ultrapotassic, kimberlites and some rinds of basalts, could be derived from the lithospheric mantle. This assumes that this part of the mantle is able to melt, in spite of its refractory characteristic, to generate basalts or mantle derived magmas.

Problems in studying mantle xenoliths and processes responsible for the changing of its pristine composition arise from several areas. After the exposition of the xenoliths to the surface, supergenic processes could change its isotopic composition increasing radiogenic Sr and depleting radiogenic Nd. Infiltration of the host material (in general alkali basalts and kimberlitic melt) into the xenoliths will tend to equalize xenoliths isotopic characteristics to the host magma isotopic composition. In general, such evidence has been wrongly used by some authors to argue that the host magma could be generated from a mantle with the same characteristic of the mantle xenoliths included in them. The discrimination of these secondary processes (supergenic and magma infiltration) from the primary processes (depletion event and possible metasomatic events) must be carefully done. The characteristic, origin and how metasomatic agent proceed in the xenoliths must be determined therein.

SOUTH AMERICAN LITHOSPHERIC MANTLE AND THE STUDIED XENOLITHS

The western part of the South American plate is a natural laboratory for petrological investigations of the subcontinental lithosphere due to the complex tectonic arrangement of the Andes. This complexity has its basis on the configuration of an active continental margin in which two oceanic plates (Nazca and Antarctic) with different velocities subduct under a continental margin formed by several events of accretion. Besides that, variation on the subduction angles along the active margin and the presence of seismic and asseismic ridges help to define four distinctive zones of active volcanism (Ramos, 1999): the Northern, Central, Southern and Austral Volcanic Zones (NVZ, CVZ, SVZ and AVZ,

Figure 1. Present geodynamic configuration of the South American continent. Circles indicate localities of studied samples: M – Mercaderes, A – Agua Poca, C – Chile Chico, G – Gobernador Gregores (Lote 17), R – Cerro Redondo. Modified after Ramos, 1999.

respectively, Fig. 1). Flat-slab segments without evidence of volcanism separate these zones, except the SVZ and AVZ that are separated by the subduction of the Chile Seismic Ridge, which comprehend the limit between the Nazca and Antarctic plates. Spinel- and/or garnet-ultrabasic mantle xenoliths are frequently described in all zones associated to alkaline basalts, except in the CVZ where crust appear to be thicker.

This study comprises a synthesis of the observations on 19 ultrabasic mantle xenoliths that came from 5 separate alkaline basalt centers in the Cenozoic to Recent volcanoes from the Andes (infra and back-arc volcanoes in convergent plate areas). Nine of them came from Mercaderes (1° 45' N, 77° 3' E) - Colombia (NVZ), in which 2 samples are spinel-lherzolites and 7 samples are garnet-lherzolites and harburgites. Three samples from Agua Poca (67° 07' W, 37° 01' S), and one sample from Chile Chico (46° 20' S and 71°50' W) came from the SVZ. The other seven samples are spinel-lherzolite and harburgite from the AVZ. They correspond to six samples from Cerro Redondo (70°08' W, 49°07' S), and one sample from Gobernador Gregores (48.5° S, 70.2° W). Fine-grained texture veins filling fractures cutting crystals and matrix indistinctly are ubiquitous in Cerro Redondo xenoliths. Geothermobarometry suggests that these xenoliths crystallized under 1100° to 1200° C and 3 to 4 GPa (grt-peridotites – based on Mercaderes xenolith Weber, 1998) and 815° to 1226°C and 1 to 2 GPa (sp-peridotite - based on data from Cerro Redondo – Schilling, 2002).

Sr AND Nd ISOTOPES

Sr-Nd isotopic data are illustrated in Figure 2a-c. In addition to our results, data from the literature have also been included: basalts and veined- and unveined-, garnet- and/or spinel-xenoliths from Pali Aike (Stern et al., 1990, 1999); basalts and metasomatized (apatite and phlogopite present) xenoliths from Gobernador Gregores (Gorring & Kay, 2000); and anhydrous xenoliths from Mercaderes (Weber, 1998). For comparison, OIB, MORB, BSE and CPB (continental plate basalts) isotopic data are also illustrated.

Tests of basalt contamination into the xenoliths were carried out based on the two-end member mixing (Schilling et al., this symposium). In Figure 2, the samples with evidence of this contamination were drawn with dashed lines. Samples not affected by infiltration of basalts are drawn with solid lines. All xenolith samples contaminated by the host basalts are displaced along the same trend of the mantle-derived magmas from all Andean volcanic zones (Fig. 2a), and in the MORB-OIB-

BSE trend. However, samples not affected by the host basalt plot within or outside these trends. The ones plotted outside the MORB-OIB-BSE trend show enrichment in radiogenic Sr without expressive changes in the Nd isotope ratio (Fig. 2c).

DISCUSSION AND CONCLUDING REMARKS

Our data suggest that isotopic data of mantle xenoliths of the South America plate subcontinental lithosphere plot outside the MORB-OIB-BSE trend. This configuration seems to characterize some kind of mantle process that ends up in enrichment of Sr radiogenic composition, without dramatically changing the Nd isotopic characteristic of the mantle. Such process could be considered as one kind of metasomatic process that involves interaction between a depleted mantle and a metasomatic agent. Carbonatitic melts have been used as a relevant metasomatic agent due to their high Nd/Sr ratios (ranging from 0.01 to 0.18) similar to the ratio observed in some metasomatised xenoliths (around 0.05). However, xenoliths with well-known infiltration of carbonatitic melts from South America are represented in the Figures 2a-c by the xenoliths from Gobernador Gregores and some samples of Pali Aike peridotite. Gobernador Gregores samples usually plot to the left of the MORB-OIB-BSE trend in spite of the carbonatite influence, while one sample from Pali Aike plots to the right side. The Gobernador Gregores sample analyzed in this study does not show any vestiges of modal metasomatism characterized by the crystallization of carbonate. However, it plots far right in the diagram (Fig. 2). This observation demonstrates that the influence of carbonatitic melts as metasomatic agent result in a different isotopic signature of the whole rock peridotite, enriching or not the Sr radiogenic composition and that it could not be considered a general process.

The understanding of the metasomatic process requires more than two-end member mixing processes does. Our data suggest that metasomatism in these peridotites resulted in some kind of Sr and Nd decoupling that occurred possibly due to different Rb and Sm partition coefficients of some minerals present in the xenoliths, such as clinopyroxene, orthopyroxene and garnet. Samples from Eastern China (Tatsumoto et al., 1992) and the North Atlantic region (Ionov et al., 2002) are also displayed on Figure 2c (a and b fields) for comparison. These samples present model metasomatism characterized by phlogopite and/or amphibole crystallization and also plot to the right side of the MORB-OIB-BSE trend. To explain this behavior, several authors as Navon & Stolper (1987), Bedini et al. (1997), and Hauri (1997) also suggest the Nd-Sr decoupling in the course of metasomatism. A better understanding of this process is required in order to constrain it.

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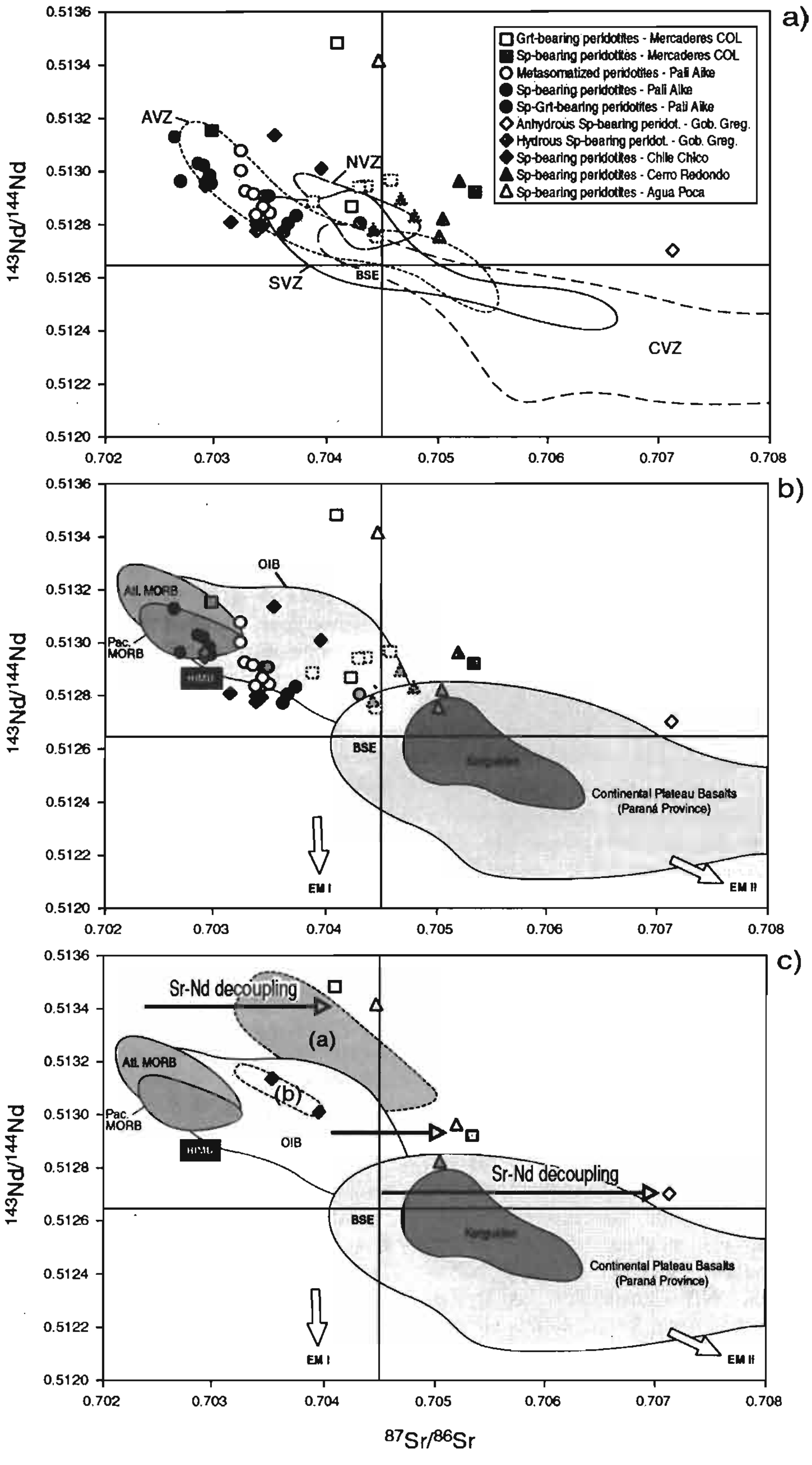

Figure 2. Isotope data (this work and from literature) for South American lithospheric mantle xenoliths. Samples with basalt contamination are drawn with dashed lines. NVZ, CVZ, SVZ and AVZ refer to volcanic areas of South America. Tectonic setting fields are compiled from "http://georoc.mpch-mainz.gwdg.de/". OIB-field draw using Hawaii, La Palma, Azores, St. Helena, Easter and Ascension islands. In figure 2c, fields a and b correspond to Eastern China (Tatsumoto et al., 1992) and North Atlantic (Ionov et al., 2002), respectively. Pali Aike-field drawn from Stern et al. (1999), and Gobernador Gregores-field (hydrous xenoliths) from Gorring & Kay (2000).