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Chemical and isotopic relationships between peridotite xenoliths and mafic–ultrapotassic rocks from Southern Brazil

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Abstract

Peridotite xenoliths from the late-Cretaceous Alto Paranaíba and Goiás mafic–alkalic magmatic provinces of central and southeast Brazil reveal the existence of compositionally and temporally distinct lithospheric mantle beneath these areas. Garnet and spinel–lherzolites and spinel–harzburgites from the Alto Paranaíba province are generally depleted in Ca, Al and Re, which indicates that they are residues of melt extraction. Old Re-depletion model ages (average 2.4 Ga) for these peridotites show that this area is underlain by the early-Proterozoic to late-Archean melt-depleted lithospheric mantle of the São Francisco Craton. In contrast, spinel–lherzolites from the Goiás alkalic province, located 500–600 km northwest of the Alto Paranaiba province, have major- and trace-element compositions similar to modern fertile mantle. Most Goiás peridotites have fertile mantle $^{187}Os/^{188}Os$ (0.1261–0.1292), but two samples with lower $^{187}Os/^{188}Os$ define Re-depletion model ages of ~1.2 Ga.

The compositional distinction between the lithospheric mantle samples is mirrored in the kamafugitic rocks of these two provinces, which suggests that the composition of these magmas was strongly influenced, or determined entirely, by the lithospheric mantle. Most of the kamafugitic rocks have $^{187}Os/^{188}Os$ higher than observed for peridotite, which suggests that the source of these magmas is a mixture of lithospheric peridotite of varying age, veined and/or interlayered with various olivine-poor components. The relatively limited range in Sr, Nd, and Hf isotopic composition of the mafic–alkalic magmas indicates that the olivine-poor component was added regionally, overprinting the incompatible-element characteristics of the lithospheric mantle beneath these provinces. The age of metasomatism in the lithospheric mantle of this area is poorly constrained, but the isotopic characteristics of the mafic–alkalic magmatism suggest that this event may have occurred during the mid- to late-Proterozoic assembly of the Brasília mobile belt.

Keywords: Radiogenic isotopes; Xenoliths; Lithospheric mantle; Alkalic volcanism; Brazil; Igneous geochemistry

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1. Introduction

The largest kamafugite (Wooley et al., 1996) province in the world occurs in Minas Gerais and Goiás States in southern Brazil (Gaspar and Danni, 1981; Danni, 1985; Danni and Gaspar, 1992, 1994; Gibson et al., 1995a,b; Sgarbi and Valenca, 1995; Carlson et al., 1996; Sgarbi et al., 1998; Araujo et al., 2001a,b; Sgarbi and Gaspar, 2001). The kamafugites, along with other silica under-saturated rock types, such as kimberlite and carbonatite, are found in a number of provinces (Fig. 1) on the northern and western margins of the Paraná Basin of southern Brazil, the eruption sight of ~800,000 km^3 of flood-basalt lavas between 138 and 129 Ma (Peate, 1997). Subsequent alkalic magmatism, with an age range between 90 and 55 Ma (Bizzi, 1993; Gibson et al., 1995a; Thompson et al., 1998) post-dates the flood-basalt activity, but shares some important chemical and isotope characteristics with the flood basalts. Among these are: (i) the presence of low- and high-Ti compositional groups in both the flood basalts (Mantovani et al., 1985; Piccirillo et al., 1989; Peate et al., 1992) and the mafic–alkalic magmas (Gibson et al., 1995b, 1997) and (ii) similar Sr, Nd and Pb isotopic compositions between the high-Ti Paraná basalts (Mantovani et al., 1985; Piccirillo et al., 1989; Peate et al., 1992), high-Ti mafic–alkalic magmas (Gibson et al., 1995b; Carlson et al., 1996; Gibson et al., 1997; Araujo et al., 2001a), and the lavas of the Rio Grande Rise, Walvis Ridge (Richardson et al., 1982; Gibson et al., 2005) and the central Atlantic island Tristan da Cunha (O'Nions et al., 1977), the current location of the mantle plume proposed as the source of the Paraná flood basalts.

Whether or not flood-basalt magmas originate from melting of continental lithospheric mantle (Hawkesworth et al., 1992) or upwelling mantle plumes (White and

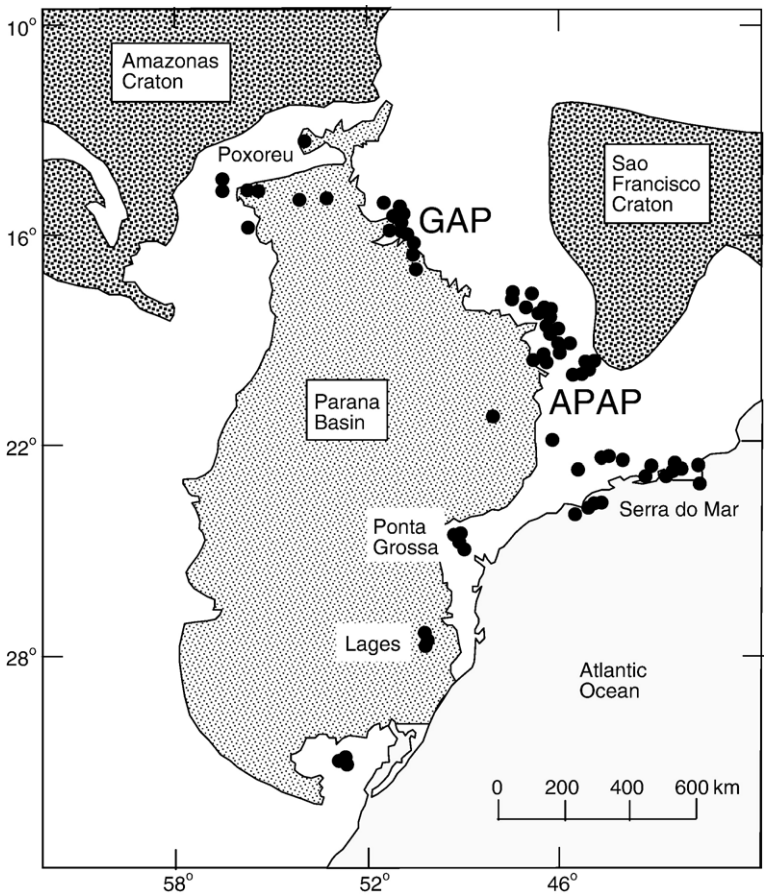

Fig. 1. Geological map of central and southern Brazil showing the location of the many late-Cretaceous mafic–alkalic magmatic provinces (large black circles) in relation to the two nearby Archean cratons and the Paraná basin. Both the Alto Paranaíba alkalic province (APAP) and Goías alkalic province (GAP) intrude the Mesoproterozoic Braziliano belt basement at the margin of the Paraná basin. Map modified from Gibson et al. (1997).