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The origin of enriched mantle beneath North China block: Evidence from young carbonatites

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ABSTRACT

A swarm of Late Triassic (220 Ma) carbonatite dykes is emplaced into the deformed southern margin of the North China block (NCB) at Lesser Qinling, discontinuously extending for about 10 km. The carbonatites are volumetrically minor, and their formation is related to collision between the South China block (SCB) and Qinling orogen, which led to the amalgamation of the NCB and SCB. The carbonatites are intruded into different Archean and Mesoproterozoic wall-rocks, but are characterized by remarkably similar isotopic compositions [$(^{87}Sr/^{86}Sr)_i = 0.7048–0.7057$; $\varepsilon_{Nd} = -4.3$ to -10.1; $^{207}Pb/^{206}Pb = 0.878–0.889$ and $^{208}Pb/^{206}Pb = 2.136–2.160$], which approach, and trend toward slightly less radiogenic Sr and Nd values than, the enriched mantle component EM1. Proterozoic oceanic crust recycled through deep mantle is interpreted to be the principal source of carbon for the Lesser Qinling carbonatites. In comparison with most other young carbonatites (<200 Ma) emplaced in a rift setting, the Lesser Qinling suite contains appreciably lower ε_{Nd} and higher $^{207}Pb/^{206}Pb$ and $^{208}Pb/^{206}Pb$ values, which suggest the presence of an isotopically distinct additional component in its mantle source. The Pb isotopic signature of these carbonatites is significantly distinct from that of the Precambrian rocks in the North China block, but is similar to that of basement rocks in the South Qinling. On the basis of the available isotopic, geophysical and tectonic constraints, we suggest that the southern margin of the North China block was underthrust by crustal material derived from the South Qinling during their collision. The underthrusting contributed to thickening of the lower crust beneath the North China block and its conversion to dense eclogite. This process culminated in brittle delamination of the eclogitized material into the mantle and its metasomatic reworking by carbonate-rich melts derived from the EM1-type recycled Proterozoic crust. Carbonate metasomatism could produce an enriched sub-continental lithospheric source capable of yielding a variety of magma types.

1. Introduction

Carbonatites have been found on all continents and at two oceanic localities, and are the products of low-degree partial melting of a carbonate-bearing metasomatized mantle source. Carbonate melts play an important role in mantle metasomatism and consequently, are intimately tied in with, and can be used to monitor, the secular evolution of the sub-continental mantle (Bell et al., 1982; Bell and Blenkinsop, 1987a; Bell and Rukhlov, 2004; Halama et al., 2008). The overwhelming majority of some 530 known carbonatite occurrences are confined to intraplate rift environments such as the East African Rift (Bell and Tilton, 2001) or Kontozero Graben in northwestern Russia (Bell and Rukhlov, 2004), although some are undoubtedly linked to collisional processes and possibly, recycling of oceanic crust (e.g., Chakhmouradian et al., 2008). Owing to their generally high Sr and REE concentrations (Bell and Blenkinsop, 1987b; Nelson et al., 1988) and low viscosities (Treiman, 1989), ensuring rapid ascent to the surface (Williams et al., 1986), carbonatitic magmas effectively preserve the isotopic signature of their source(s).

In the past 50 years, the study of radiogenic isotope variations in carbonatites has progressed tremendously, providing an excellent understanding of the conventionally used isotopic systems (e.g., Sr–Nd–Pb: Bell, 1998; Bell and Simonetti, 2010; Nelson et al., 1988; Ray, 2009; Tilton et al., 1998), as well as some preliminary constraints on other systems (e.g., Re–Os: Pearson et al., 1995; Lu–Hf: Bizimis et al., 2003). It has been demonstrated that in terms of their isotopic budget, carbonatites share many similarities with ocean island basalts, suggesting similar sources for both rock types. The HIMU, EM1 and FOZO mantle components appear to be involved in the generation of most young (<200 Ma) carbonatites. However, the ultimate sources of parental carbonatitic melts remain the subject of debate, being alternatively viewed as entirely lithospheric, sub-lithospheric, or formed

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by mixing between a lithospheric and sub-lithospheric sources. Also debated is the extent of involvement of subducted crustal material in the generation of metasomatized mantle sources capable of producing primary carbonatitic melts.

The Qinling orogenic belt, located in Central China and linked to the Dabie–Sulu ultra-high-pressure metamorphic belt to the east (Fig. 1), separates the North China block (NCB) from the South China block (SCB), and is critical for unraveling the tectonic history of East

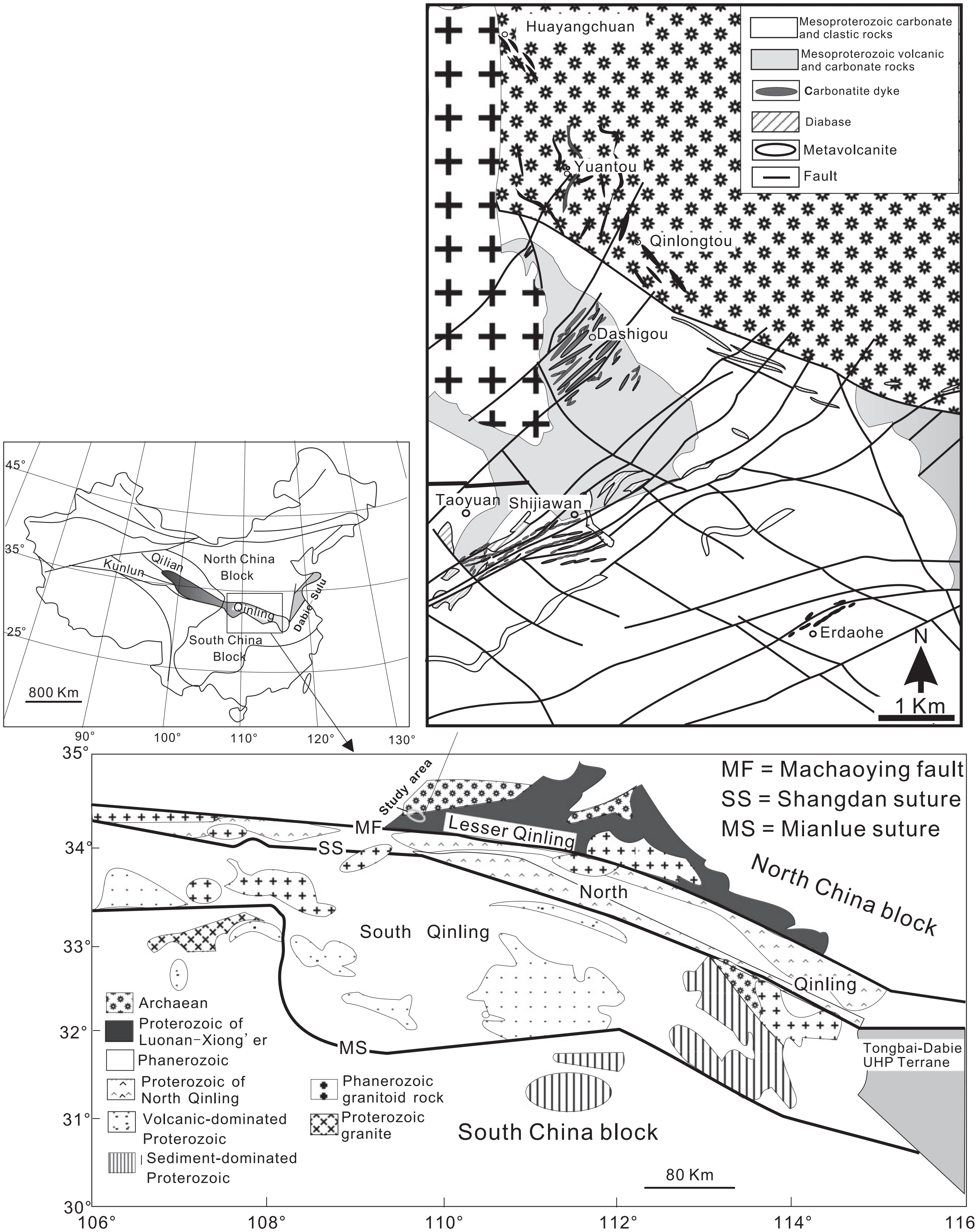

Fig. 1. Schematic geological setting of the Lesser Qinling carbonatites.
Modified after Gao et al.(1996)and Xu et al.(2007, 2010).