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Mesoproterozoic kimberlites in south India: A possible link to ∼1.1 Ga global magmatism

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Abstract

Precambrian kimberlites are relatively rare in the geological record and yet those that do exist tend to form in relatively narrow windows of geologic time. We report new age information for three Proterozoic kimberlites from two distinct clusters in the Eastern Dharwar craton, India: a U–Pb perovskite age of 1124 + 5/−3 Ma for Wajrakarur Pipe-2, a Rb–Sr phlogopite age of 1102 ± 23 Ma for Wajrakarur Pipe-6 and a Rb–Sr phlogopite–whole rock composite isochron age of 1093 ± 4 Ma based on two samples from the recently discovered SK-1 kimberlite pipe at Siddanpalli. These new age results are identical to a number of previously reported kimberlite emplacement ages (1085–1099 Ma) from several clusters in the Eastern Dharwar craton, India and contribute to a growing database that documents extensive kimberlite magmatism encompassing an area of more than 30,000 km^2 within this province alone.

Coeval ∼1.1 Ga kimberlite/lampröite/carbonatite magmatism in central India (Majhgawan) about 1000 km north of the Eastern Dharwar craton kimberlite clusters, and in North America, Greenland, Scandinavia, Southern Africa, Liberia, and Australia confirms a significant period of global ultrapotassic and alkaline magmatism at this time. The timing of this Mesoproterozoic kimberlite magmatism coincides with the development of several Large Igneous Provinces and attendant intracontinental rifting; such as those formed in the intervals 1109–1086 Ma in Laurentia (Midcontinent Rift), 1112–1102 Ma in the Kalahari craton (Umkondo), and 1079–1070 Ma in west central Australia (Warakurna). The association of wide spread contemporaneous ultrapotassic, alkaline and mafic magmatism at ∼1100 Ma may be linked to a global period of enhanced short-lived mantle plume activity and/or a major change and re-organization of the mantle convection regime at this time.

Keywords: Kimberlites; Magmatism; Mesoproterozoic; Geochronology; India

1. Introduction

The majority of kimberlites on Earth (>80%) are Mesozoic/Cenozoic (200–50 Ma) and are often associated with periods of continental rifting and formation of ocean basins. For example, most of the Cretaceous kimberlite and related magmatism in Southern Africa spans about 70 Ma from 125 to 55 Ma (see compilation in Heaman et al., 2003) and closely follows the opening of the South Atlantic Ocean initiated at about 130 Ma. Similarly, alkaline magmatism on the opposite side of the South Atlantic Ocean in Brazil spans about 50 Ma from 125 to 75 Ma (Davis, 1977; Gibson et al., 1995; Bizzi et al., 1995; Sgarbi et al., 2004). The spatial and temporal association of kimberlite magmatism with major episodes of Mesozoic continental extension and rifting is clear but whether this kimberlite magmatism is linked to focused upwelling of asthenosphere or passage of one or more mantle plumes is unclear. The timing and spatial distribution of kimberlites should provide some evidence

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to distinguish between these two hypotheses. Kimberlites formed along mantle plume hotspot tracks would be expected to follow a linear trend with a resolvable age progression whereas those linked to upwelling asthenosphere during continental extension might form along corridors and failed arms but would not be expected to show any age progression trend. For example, the majority of Jurassic kimberlites in eastern North America were emplaced during the initial opening of the North Atlantic Ocean (200–140 Ma) but the southeastward younging of kimberlite magmatism along a corridor between Rankin Inlet and Kirkland Lake that coincides with the continental extension of the Great Meteor Hotspot track has been interpreted to indicate that much of this magmatism was triggered by the passage of one or more mantle plumes through this region (Heaman and Kjarsgaard, 2000).

The association of kimberlite and related magmatism to continental extension and rifting is not restricted to Mesozoic kimberlite fields and provinces. Older periods of kimberlite magmatism can also be linked to major episodes of continental rifting. As an example, a large proportion of kimberlites and affiliated ultramafic lamprophyres in Labrador, Quebec, West Greenland and Scandinavia were emplaced in the period 630–560 Ma (Doig, 1970; Scott-Smith, 1989; Heaman et al., 2004; Tappe et al., 2004) and are therefore both spatially and temporally linked to Eocambrian opening of the Iapetus Ocean. This example also demonstrates the contemporaneous association of kimberlite magmatism, rift basin development and the emplacement of large igneous provinces. For example in eastern North America, Neoproterozoic kimberlite and ultramafic lamprophyre magmatism coincides with significant continental extension and development of the St. Lawrence and Lake Melville rift systems (Kumarapeli, 1985; Gower et al., 1986), including eruption of the 554 + 4/−2 Ma Tibbet Hill volcanics in Quebec (Kumarapeli et al., 1989), associated alkaline complexes (Gittins et al., 1967; Doig, 1970; e.g. the 577 ± 1 Ma Callander Complex; reported in Kamo et al., 1995) and the emplacement of two large igneous provinces; the 590 + 2/−1 Ma Grenville dyke swarm (Kamo et al., 1995) and the 615 ± 2 Ma Long Range diabase dyke swarm (Kamo et al., 1989; Kamo and Gower, 1994).

One of the oldest prolific periods of Precambrian kimberlite magmatism occurs during the Mesoproterozoic at about 1.1 Ga. This includes the ∼1180 Ma Premier kimberlite in Southern Africa, some ∼1.1–1.2 Ga ultramafic lamprophyres in west Greenland (Scott-Smith, 1989) and Finland (O'Brien et al., 2005), a large number of Mesoproterozoic kimberlite occurrences in the vicinity of the Lake Superior region of North America, including ∼1.07 to 1.14 Ga ultramafic lamprophyres and kimberlites (Queen et al., 1995; Kaminsky et al., 2000), the 1070 Ma Kyle Lake kimberlite cluster in the James Bay Lowlands (Heaman et al., 2004) and the ∼1.1 Ga Le Tac (Bachelor Lake) kimberlite in Quebec (Alibert and Albarede, 1988).

In addition to this, there are a large number of Mesoproterozoic kimberlites and lampröites that occur in India (Fig. 1); in the Bastar (Tokapal and Raipur kimberlites), Bundelkhand (Majhgawan lampröite) and Dharwar (over 85 kimberlites and lampröites) cratons. While the Bastar kimberlite ages are still unknown, previous Rb–Sr and K–Ar whole rock and $^{40}Ar/^{39}Ar$ phlogopite age estimates on the Majhgawan lampröites and the Dharwar kimberlites vary between 840 and 1630 Ma (Paul et al., 1975; Paul, 1979; Basu and Tatsumoto, 1979; Chalapathi Rao et al., 1999). More recent Rb–Sr phlogopite isochron ages, however demonstrated that all these pipes were emplaced during the Mesoproterozoic and that most of the kimberlite magmatism occurred close to 1100 Ma, perhaps within a time span of less than 20 Ma (Kumar et al., 1993, 2001).

During the last few years, extensive exploration in several parts of India has led to the discovery of many new kimberlite and lampröite bodies. Recently, three kimberlite pipes were discovered near Siddanpalli (Sridhar et al., 2004) in the Dharwar craton about 75 km from the nearest previously reported kimberlites (Fig. 1). In this paper, we report a new U–Pb perovskite age for Wajrakarur Pipe-2, a Rb–Sr phlogopite age for Wajrakarur Pipe-6 and a pooled Rb–Sr isochron age for acid-leached phlogopite macrocrysts and whole rocks for two separate samples from the a newly discovered SK-1 kimberlite near Siddanpalli. In addition, we discuss the regional extent of the Mesoproterozoic kimberlite activity in the Indian subcontinent and the significance of this apparent global period of ∼1.1 Ga kimberlite magmatism and their coincidence with lampröites, carbonatites and large igneous provinces.

2. Distribution of kimberlites and lampröites in south India

The Dharwar craton in south India hosts most of the kimberlite and lampröite occurrences in India. The geology of the Dharwar craton can be broadly subdivided into ∼2.51 Ga granulites in the south (Southern Granulite Terrane: SGT) and a low-grade granite-greenstone terrain in the north. The granite-greenstone terrain com-