

# Mafic alkaline intrusions in the Damodar Valley, India: the micaceous kimberlite - lamproite connection revisited

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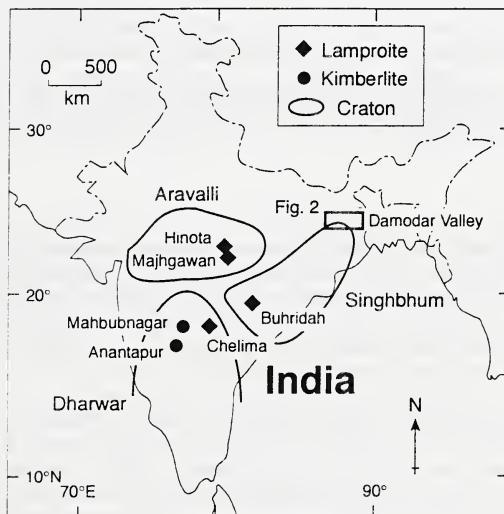
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## Introduction

Small-volume mafic alkaline igneous rocks in India have received little attention during this century, perhaps being overshadowed by their diamond-rich counterparts in Australia, Botswana, Russia, the Congo and South Africa. In recent years, there has been renewed interest in India as a region for diamond exploration, prompted by discoveries of diamondiferous rocks at Raipur, Madhya Pradesh, and in the Mahbubnagar district, Andhra Pradesh. Less well known is a suite of early Cretaceous micaceous kimberlite ('orangeite')-like rocks that crops out in the Damodar Valley, Bihar-West Bengal (Fig. 1). These rocks resemble South African micaceous kimberlites in mineralogy and geochemistry, and mafic alkaline intrusions from Brazil (the Alto Paranaíba province) and Russia (Archangelsk) in Nd-Sr isotopic composition (Kent *et al.*, 1998a, b). The Damodar Valley rocks are unusual also in their mode of occurrence, cropping out as thin dykes and sub-horizontal cylindrical sills within coal seams (e.g. Kent *et al.*, 1992). This paper outlines the distribution, age and nomenclature of the Damodar Valley mafic alkaline rocks.



**Fig. 1.** Map showing the location of lamproites and kimberlites in India and their relationship to Archaean cratons (modified from Chalapathi Rao *et al.*, 1996). The Damodar Valley alkaline province lies on the northern margin of the Singhbhum craton.

## Distribution and age

The Damodar Valley alkaline province lies on the northern margin of the Singhbhum craton, within a Proterozoic mobile belt (the >1.4 Ga Chotanagpur plateau; Fig. 2). The number of alkaline intrusions is greatest (several hundred) in the eastern part of the Damodar Valley, notably in the Bokaro, Jharia and Raniganj basins (e.g. Middlemost *et al.*, 1988; Rock *et al.*, 1992; Basu *et al.*, 1997). The location of the intrusions appears to have been controlled by the east-west-trending Damodar Valley extensional fault system, which may be the surface manifestation of a deep basement shear zone (Mazumdar, 1988).

The Damodar Valley alkaline rocks have K-Ar (biotite and whole-rock) ages of 113-105 Ma (Sarkar *et al.*, 1980). In a recent study, Kent *et al.* (1998a) obtained an  $^{40}\text{Ar}/^{39}\text{Ar}$  total-fusion isochron age of  $113.5 \pm 0.5$  Ma (1s error) on phlogopite separated from a Damodar Valley mafic alkaline rock. This age was interpreted as being close to the true crystallisation age. Two other phlogopite separates gave  $^{40}\text{Ar}/^{39}\text{Ar}$  laser ablation ages of  $116.6 \pm 0.8$  Ma and  $109.1 \pm 0.7$  Ma (1s errors), respectively; these ages appear to reflect partial alteration of the phlogopite grains. Coincidentally, the age of the Damodar Valley samples is similar to that of most South African micaceous kimberlites (Rb-Sr ages of 125-110 Ma, with several 'outliers' having ages of >130 Ma; Skinner, 1989).

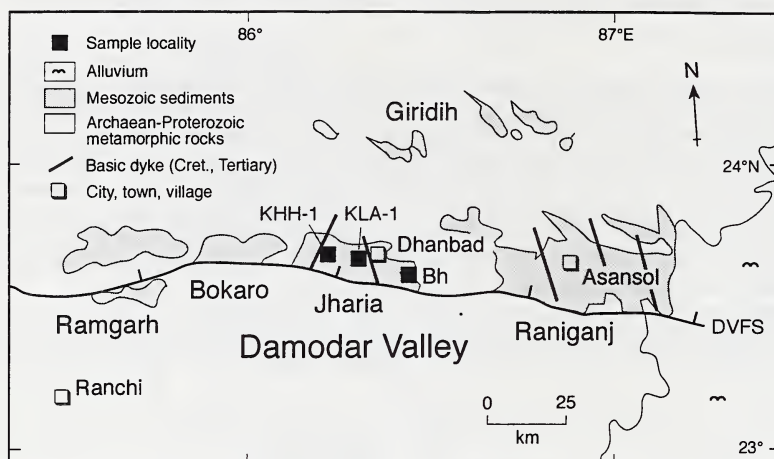


Fig. 2. Map of the eastern Damodar Valley, Bihar/West Bengal, eastern India, showing selected sample localities in the Jharia and Raniganj basins. Basic dykes are shown schematically. Key: Bh = Bhowrah, DVFS = Damodar Valley Fault System.

## Classification

The nomenclature of mafic alkaline igneous rocks is confusing to specialists and non-specialists alike. In attempting to classify the Damodar Valley alkaline rocks, Kent *et al.* (1998a) followed the mineralogical-genetic nomenclature of Mitchell (1995, p.10-14), using his definition of micaceous kimberlites (orangeites) as "a clan of ultrapotassic peralkaline volatile-rich ... rocks, characterised by the presence of phlogopite macrocrysts and microphenocrysts ... groundmass micas" and, commonly, rounded olivine macrocrysts.

We observe that the Damodar Valley alkaline rocks contain microphenocrystal and groundmass phlogopite-tetraferriphlogopite, microphenocrystal apatite, rutile and prismatic crystals of K-triskaidecatitanate ( $\text{K}_2\text{Ti}_{13}\text{O}_{27}$ ; Mitchell, 1995). Macrocrystal olivine (usually serpentinised) and primary microphenocrystal and groundmass diopside or aegirine are present in some samples. Damodar Valley alkaline rocks also contain sanidine, K-richterite, perovskite, monazite, ilmenite and a varied assemblage of carbonates, including one or all of calcite, ferroan dolomite, strontianite, breunnerite and strontian witherite (cf. Rock *et al.*, 1992). Thus, these rocks conform to Mitchell's (1995) mineralogical definition of orangeite. Evolved varieties from our sample collection, which resemble sanidine richterite lamproites (*sensu* Mitchell and Bergman, 1991; see also Tainton and Browning, 1991), can be termed 'richterite sanidine orangeites'. The latter suggest a mineralogical convergence of differentiated members of the orangeite clan with lamproitic rocks.

The only 'flies in the ointment' are that our Damodar Valley samples are not usually peralkaline (most have molar  $(\text{K}_2\text{O} + \text{Na}_2\text{O})/\text{Al}_2\text{O}_3 < 1$ ) or perpotassic (most have molar  $\text{K}_2\text{O}/\text{Al}_2\text{O}_3 < 1$ ). The Indian rocks also differ from most South African orangeites in Nd-Sr isotopic composition (Fig. 3; for data and discussion, see Kent *et al.*, 1998b). Our samples resemble isotopically the anomalous Prieska orangeites of South Africa, mafic alkaline igneous rocks from the Alto Paranaíba province, Brazil, and samples of 'micaceous kimberlite' and 'olivine lamproite' from Archangelsk, northeast Russia.

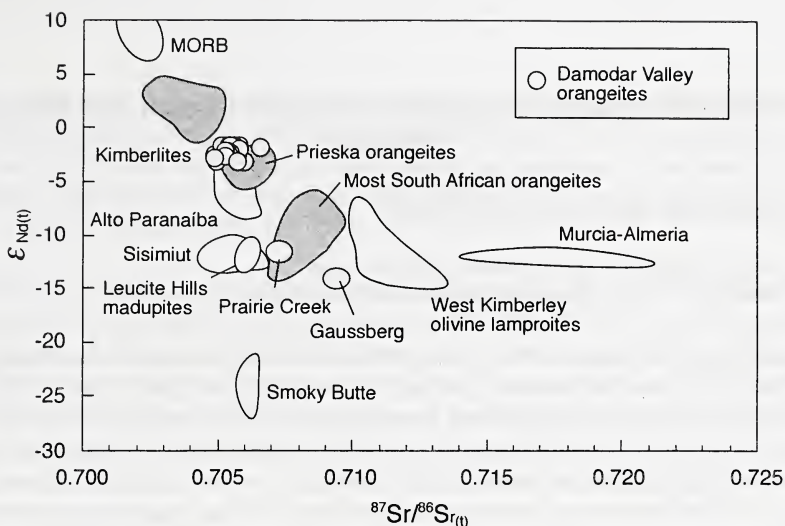


Fig. 3: Nd-Sr isotope diagram showing the compositions of Damodar Valley micaceous kimberlites (orangeites) relative to other mafic alkaline igneous rocks. Data for the Damodar Valley rocks is from Middlemost *et al.* (1988), Rock *et al.* (1992) and Kent *et al.* (1998b).

## Summary and conclusions

Early Cretaceous mafic alkaline igneous rocks cropping out in the Damodar Valley, Bihar, India, can be classified as micaceous kimberlites (orangeites). Highly-differentiated varieties are mineralogically similar to sanidine richterite lamproites, suggesting a convergence between the orangeite and lamproite clans. The Damodar Valley micaceous kimberlites are potentially diamondiferous; however, diamond grade is yet to be established.

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