

Karoo large igneous province: Brevity, origin, and relation to mass extinction questioned by new $^{40}\text{Ar}/^{39}\text{Ar}$ age data: Comment

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Jourdan et al. (2005) present new age data from the Karoo large igneous province (LIP) on 38 samples from Botswana and the Lebombo region of South Africa. Such a contribution is of immense value to workers on LIPs, as robust geochronology covering a large regional extent of any province is often lacking. The new ages, in combination with existing $^{40}\text{Ar}/^{39}\text{Ar}$ and U-Pb data, have allowed them to demonstrate that Karoo magmatism had a duration of at least 8 m.y., and that there is an indication of migration from south to north. Based on these new data, Jourdan et al. (2005) propose that (1) an alternative should be sought to the plume model for the Karoo flood basalts and (2) the prolonged duration of magmatism would have had only a minor impact on global climate, explaining the absence of a major mass extinction event at the Pleinsbachian–Toarcian boundary. We contend that these inferences are not strongly supported by the data.

DURATION OF LIPS AND MANTLE PLUMES

We do not support the view that the duration of a LIP can be used to demonstrate if it is linked to a mantle plume.

The duration of magmatism in other Phanerozoic continental flood basalt provinces has also received much attention, and there is ample evidence from many provinces of extended magmatism linked to a mantle plume. The Paraná–Etendeka event (Jerram and Widdowson, 2005; Thompson et al., 2001), the North Atlantic igneous province (NAIP) (Jerram and Widdowson, 2005) and the Siberian Traps (Ivanov et al., 2005) all have periods of continuous magmatism (6–10 m.y.). The magmatism of the Siberian Traps, which has a duration of at least 6 m.y., has been linked by several authors to a mantle plume (e.g., Saunders et al., 2005). The Paraná–Etendeka event has a period of continuous magmatism (~10 m.y.; Jerram and Widdowson, 2005) and the extensive melt production of the province is widely attributed to the thermal input from the Tristan mantle plume (e.g., Thompson et al., 2001). The NAIP has a duration of ~12 m.y. (Jerram and Widdowson, 2005) and also has clear plume links (Lin and van Keken, 2005). Even the Deccan province, which has a major outpouring at 65 Ma, has a duration between 68 and 64 Ma (Jerram and Widdowson, 2005) and a widely supported plume association.

A model of extended magmatism has already been proposed for the Antarctic portion of the Karoo LIP by Riley et al. (2005), who identified age peaks of 190 and 178 Ma in dike swarms of Dronning Maud Land, coupled with a main lava extrusion peak of 182 Ma (Duncan et al., 1997). Dike ages from elsewhere in Dronning Maud Land (e.g., Zhang et al., 2003) verify the ages of Riley et al. (2005) and testify further to a prolonged episode of Karoo magmatism. Jones et al. (2001) also confirmed a duration of at least 5 m.y. for the Karoo LIP, based on $^{40}\text{Ar}/^{39}\text{Ar}$ age data from Zimbabwe.

FERROPICRITES

In the cases of the Siberian Traps and Paraná–Etendeka, as well as continental flood basalt provinces elsewhere (e.g., North Atlantic,

Deccan), the association of a mantle plume with a specific LIP is not based on geochronology alone, but is used in combination with the style, volume, and geochemistry of the erupted or intruded magmas. The identification of ferropicrites in the Etendeka Province (Gibson et al., 2000) and in the Siberian Traps (Wooden et al., 1993) is genuine evidence of anomalously hot temperatures in the mantle. However, it is not just their occurrence but also their timing that matters. Thompson et al. (2001) predict that some of the first formed melts of a mantle plume starting head should be ferropicritic. This is also true in the Karoo where Riley et al. (2005) have identified a suite of ferropicrite dikes at 190 Ma, predating the main eruption event by 8 m.y.

MIGRATION OF VOLCANISM

We would urge caution over the south-north migration of Karoo magmatism proposed by Jourdan et al. (2005), which was mostly based on the absence of evidence for magmatic ages younger than 180 Ma in the ‘south.’ However, several areas within the ‘south’ of the province have yielded ages younger than 180 Ma. The major Rooi Rand dike swarm of the southern Lebombo has been dated at 173.9 ± 0.6 Ma (Jourdan et al., 2004), while the Antarctic (Dronning Maud Land) portion of the Karoo LIP, which lies to the south and east of southern Africa in Gondwana reconstructions, has age peaks at 190, 182, and 177 Ma (Duncan et al., 1997; Zhang et al., 2003; Riley et al., 2005).

DISCUSSION AND MASS EXTINCTIONS

In the Karoo, and other LIPs, there is a general pattern of prolonged and continuous magmatism over several million years (typically > 8 m.y.), with a major outpouring at some point in the history of the province. This occurred in the Karoo at ~183 Ma, when ~ 10^6 km³ of magma were erupted in a time interval of < 1 m.y. (Duncan et al., 1997). This event was almost certainly instrumental in the significant Pleinsbachian–Toarcian extinction event (Pálffy and Smith, 2000). The impact of flood volcanism on the environment is a major area of research, and simple calculations of magma erupted versus duration do not provide the necessary information to assess the global impact. Even during peak eruption episodes there can still be a significant hiatus between major fissure and/or flow eruptions, which can allow a recovery of atmospheric SO₂ and CO₂ levels.

A feature common to almost all of the Phanerozoic LIPs is the prolonged duration of magmatism, which may be punctuated by one, two, or more major outpourings of lava (e.g., Karoo: Lesotho lavas and Shadi-Shadi lavas). These features, typical of LIPs, are predicted by recent plume models (e.g., Lin and van Keken, 2005), which demonstrate that flood volcanism can extend over >10 m.y. with petrochemical variations.

This comment is not intended as a debate concerning the presence or absence of a mantle plume in the petrogenesis of the Karoo province, but it is intended to address the issue that the duration of magmatism cannot be considered a reliable indicator of the involvement of a mantle plume or an associated mass extinction event.

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