

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

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INTRODUCTION

Riley et al. (2006a) question our interpretations of $^{40}\text{Ar}/^{39}\text{Ar}$ data obtained on the Karoo flood basalts (Jourdan et al., 2005). We believe their arguments are partially based on (1) poorly reliable $^{40}\text{Ar}/^{39}\text{Ar}$ age data (e.g., analyses of whole rocks that might have suffered hardly detectable alteration, recoil, etc.), and (2) mis-interpretation of the reliable geochronological data available on Karoo and other continental flood basalts (CFBs).

DURATION OF LIPS, MANTLE PLUMES, AND FERROPICRITES

Riley et al. argue that the duration of the Karoo province is comparable to some of the other Phanerozoic CFBs that are classically considered to be plume related.

A duration of ~10 m.y. for the Paraná-Etendeka CFB is mainly based on $^{40}\text{Ar}/^{39}\text{Ar}$ data obtained by Turner et al. (1994) with laser spot experiments on whole rocks with strong alteration overprint. With this approach, it is impossible to distinguish data affected by alteration or excess ^{40}Ar , and therefore the proposed duration of 137–127 Ma cannot be considered as valid. Instead, the published age data demonstrate that the peak of the magmatic activity is unambiguously at 131–133 Ma (e.g., Renne et al., 1992). The main volume of the Siberian traps was emplaced at 250–251 Ma (cf. compilation of Ivanov et al., 2005). The Deccan traps are mostly emplaced at 65.5 ± 1 Ma (e.g., Hofman et al., 2000). In conclusion, the available robust age data on these CFBs are in agreement with a brief bulk basaltic activity, though much less voluminous dispersed events might have occurred over 5–10 m.y. This feature is completely different from the magmatic activity of the Karoo Province, for which the available selected age data (Jourdan et al., 2005; Jones et al., 2001; Duncan et al., 1997) show the emplacement of large volumes of magmas persisting over ~5–6 m.y. without any unique and dominant peak activity.

Therefore, according to available age data, the Karoo CFB appears different from most of the other provinces which, as mentioned by Riley et al., have been related to mantle plumes. Although our data do not rule out the mantle plume hypothesis, the persistence of large magma production over several million years suggests that a different process may have occurred (e.g., a strong contribution of the lithospheric mantle?).

When Riley et al. refer to their ages at 190 Ma on Dronning Maud Land (including ferropicrites; Riley et al., 2005), we must outline that these data were obtained on whole rocks that are highly sensitive to ^{39}Ar recoil and alteration processes. Riley et al. present strongly disturbed tilde- and/or saddle-shaped (demonstrating the existence of ^{40}Ar excess, recoil process, and alteration) spectra profiles associated with mean square weighted deviate (MSWD) values ranging from 6.5 to 110. We strongly recommend discarding these whole rock ages to correctly define the history of the Karoo province.

MIGRATION OF THE MAGMATISM

Riley et al. question the south to north migration of the magmatism based on one reliable age of the Rooi Rand dike swarm (174 Ma; Jourdan et al., 2004) and other $^{40}\text{Ar}/^{39}\text{Ar}$ ages in Antarctica (Zhang et al., 2003; Riley et al., 2005; Duncan et al., 1997).

Our goal was mainly to emphasize that the emission of magma occurred at different places and at different times in the history of the province. Recent plagioclase $^{40}\text{Ar}/^{39}\text{Ar}$ ages obtained on dikes from western South Africa seem to suggest that a younger activity (~176 Ma; Riley et al., 2006b) occurred in the south, but include only a few dikes representing a negligible volume. Concerning the Rooi Rand dike swarm, it must be mentioned that these rocks are chemically specific and display an enriched mid-oceanic ridge basalt-like composition, and do not represent a genuine Karoo flood-basaltic event. The only truly reliable ages published concerning Dronning Maud Land are five dates (Duncan et al., 1997; Zhang et al., 2003) that are not sufficient to discard our interpretation based on 55 plateau ages in southern Africa.

DISCUSSION AND MASS EXTINCTIONS

The probability density distribution diagram of Jourdan et al. (2005) shows that there was no brief peak of magmatism for the Karoo province, but several discontinuous eruptions distributed over ~6 m.y. (for the main volume of magma). On the contrary, other CFBs do show an acme of magmatism of ~1 m.y. and are associated with drastic mass extinctions. Compared to these examples, the Karoo shows a lower rate of eruption and might “allow a recovery of atmospheric SO_2 and CO_2 levels” (Riley et al., 2006a, p. e109), providing an explanation for the absence of a major mass extinction synchronous with the Karoo magmatism.

In conclusion, we agree with Riley et al. that the long duration of the Karoo province, rather than a brief peak of magmatism, cannot by itself rule out a mantle plume origin. However, as the Karoo eruption timing is atypical compared to well-established plume-derived CFBs, a different origin is not so unlikely.

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