

Giant Plagioclase Basalts, eruption rate versus time

Response to Sheth's comments and some additional thoughts

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I welcome Sheth's comments on a more intriguing aspect of my paper, namely, the calculation of age of the Deccan lava pile in the Western Ghats (type section) using sizes of the "giant" plagioclase crystals in "Giant Plagioclase Basalt (GPB)" lava flows. I found the GPB lavas to be very interesting because in some cases they clearly mark the boundary between Formations (Hooper *et al* 1988; Subbarao *et al* 1988; Khadri *et al* 1988). They also seem to have erupted over bole beds, each of which possibly represents a hiatus between eruptive activities (Sen 2001). In my view, the latter aspect still needs to be proven with solid field work.

Sheth correctly points out that typically eruption rate is expressed in terms of some sort of unit volume as a function of time. I did not do this because I am not sure that we know the volumes of individual lava flows all that well. It is clearly something that we need to know by mapping out individual flows in the field. That is why I chose to estimate a "one dimensional eruption rate," a practice that is not uncommon in experimental and modeling studies. I was initially encouraged by Sheth's new (and correct) eruption rate calculations based on my approach, suggesting that the Western Ghats section span a time of 4.4 m.y. He notes that this range coincides very well with the $^{40}\text{Ar}/^{39}\text{Ar}$ dates obtained by Venkatesan *et al* (1993) and thus in a way validates my approach. I have had some more thoughts on this issue and have strong reservations about Sheth's conclusion on the eruption rate.

First, the available constraint from $^{40}\text{Ar}/^{39}\text{Ar}$ dates obtained most recently by Hofmann *et al* (2000) from the Western Ghats is quite stringent and cannot be ignored. In my opinion, Hofmann *et al* (2000) presented convincing new data on plagioclase separates as well as whole rocks to argue that the entire Western Ghats section erupted at 65.5 ± 1 Ma. This date coincides with many previously published dates (references in Sen (2001) and Sheth's comment) but the age range is at variance with that reported by Venkatesan *et al* (1993). While Venkatesan *et al* argued for a 4–5 m.y. duration of the eruption of Western Ghats basalts, Hofmann *et al*'s work suggests that the eruption did not last more than 1 m.y. Additionally, Hofmann *et al* (2000) critically evaluated the $^{40}\text{Ar}/^{39}\text{Ar}$ dates published by all authors, and demonstrated that the *longer age range reported by Venkatesan et al (1993) from whole rock analysis is likely due to ^{39}Ar loss and is therefore incorrect.* Interestingly, Sheth chose to use only the Venkatesan *et al* age range and completely ignored the more modern study by Hofmann *et al*.

The fact that we have no idea about the originally erupted volume of the Western Ghats section prevents me from attempting the sort of calculation carried out by Sheth but it is clear that the true eruption rate was greater than the one estimated by Sheth. Any further attempt to calculate an average eruption rate by this scheme will require a detailed mapping of individual flows and age calculation of lavas from phenocrysts.

Keywords. Deccan Trap; Giant Plagioclase Basalts; eruption duration.

Second, plagioclase crystals in a GPB lava are more anorthitic than the groundmass plagioclase in the same flow but are as anorthitic as the phenocrysts in lavas that erupted below within the same formation (refs. in Sen 2001). Also, GPB lavas are generally the most differentiated within a given formation (Hooper *et al* 1988). This suggests to me that within a formation, the last erupting giant crystals may have been in existence in the chamber throughout the time while the chamber was erupting all the other lavas that constitute the formation including that particular GPB flow. *That is, the crystals in a GPB flow represent the total age of the formation and not just the GPB flow.* A detailed study of isotopic transects within individual giant crystals can help us evaluate the validity of this important inference made from major elements. If an individual GPB crystal were found to record the time span of an entire formation then the implication is even more interesting. In the case of Kasubai subgroup, for example, it would mean that the magma chamber that fed the Igatpuri Fm., with its Kashele GPB at the top, erupted over 3200 years. By similarly carrying out crystal size measurements and isotopic transects through individual crystals we may some day be able to have a true independent estimate of the

Deccan eruptive period and unravel a detailed history of the magma chambers.

In sum, I believe that the approach that I put forward has tremendous potential. However, I believe that we are not yet in a position to calculate “proper” eruption rates using my approach.

References

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