# $^{40}Ar/^{39}Ar$ geochronology of the Sylhet Traps, eastern India and their relationship to the Kerguelen plume related magmatism

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## Introduction

The Rajmahal-Bengal Traps of eastern India form part of a Large Igneous Province (LIP) that includes rifted margin basalts in southwest Australia (Bunbury, Naturaliste Plateau), and lavas forming the central and southern Kerguelen Plateau *(e.g., Davies et al., 1989; Kent et al., 2002)* (Fig. 1). This LIP is generally believed to be related to Kerguelen hotspot activity that began during the early Cretaceous *(e.g., Frey et al., 2000; Kent et al., 2002)*. The oldest volcanism attributed to the Kerguelen plume are the 132 and 123 Ma old Bunbury Basalts *(e.g., Coffin et al., 2002)* and the ~118 Ma old Rajmahal-Bengal Traps *(Kent et al., 2002)*. Although the extent of the latter in space and time is unknown, it has been postulated that the magmatic activity in the eastern India was contemporaneous with the oldest activity on the southern Kerguelen Plateau *(Kent et al., 2002)*. The lesser-known Sylhet Traps of eastern Indian state of Meghalaya, exposed ~400 km east of the Rajmahal Traps (25.5°N, 91.8°E; Fig. 1), are also considered to be a part of the above LIP *(e.g., Baksi, 1995)* despite limited geochronological evidence. In an attempt to test the hypothesis of their contemporaneity we dated the Sylhet Traps by $^{40}Ar/^{39}Ar$ incremental heating technique.

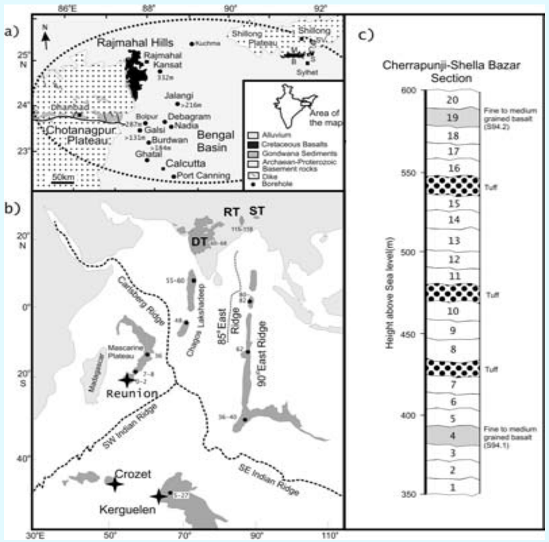


**Fig. 1: a)** Geological map of Eastern India showing the present outcrops of Rajmahal and Sylhet Traps together with the locations of exploration wells drilled in the western Bengal basin *(modified after Kent et al., 1997)*. The minimum thickness of the lava flows in meters is indicated for each drill site. The dotted ellipse marks the probable spatial spread of the Rajmahal-Bengal-Sylhet igneous province in which the dikes occurring in the Gondwana sediments to the west and southwest of the Rajmahal hills are included. M-B refers to Mawsynram-Balot section, C-S to Cherrapunji-Shella Bazar section and SV represents the 107 Ma old Sung valley complex *(Ray et al., 1999)*.
**b)** Map of the Indian ocean, bordering landmasses and hot-spot traces. The numbers alongside ● are measured ages (Ma) of volcanic activity along the Reunion and Kerguelen hotspot tracks *(modified after Duncan, 1991)*. - ✦ -hotspots. DT - Deccan Traps, RT - Rajmahal Traps and ST- Sylhet Traps. The age (Ma) ranges for DT and RT are also shown.
**c)** Litholog of the Cherapunji-Shellabajar section showing twenty lava flows (numbered) and three tuff horizons. The samples analyzed in this work were collected from flow 4 and flow 19 (shaded).

## Samples and Method

Samples were collected from a well exposed section along the Cherrapunji-Shella Bazar highway. Two fresh samples, with little alteration, of fine to medium grained massive tholeiitic basalt from flow 4 (ST94-1) and flow 19 (ST94-2) of the section (Fig.1c) were selected for $^{40}Ar$-$^{39}Ar$ analysis by the conventional step-heating method *(Pande et al. 2001)*. About 500mg each of ultrasonically cleaned whole rock sample powder was irradiated along with the flux monitor standard Minnesota Hornblende (MMhb-1). An age of 523.2 ± 0.9 (1σ) Ma *(Spell & McDougall, 2003)*, the latest recommended value for MMhb-1, has been used in this work. For each sample argon was extracted in a series of steps of increasing temperature starting at 450°C until fusion with increments of 50°C. We define a plateau as comprising four or more contiguous steps in an apparent age spectra that overlap with the mean at the 2σ level of error excluding the error contribution from the error in *J* values with a total minimal $^{39}Ar_K$ release of 60%. The procedure for the calculation of plateau age and associated error is given in *Pande et al.(2001)*. The isochron and inverse isochron ages were determined using ISOPLOT3 *(Ludwig, 2003)* through the selected step gas composition using the $^{40}Ar/^{36}Ar$ vs. $^{39}Ar/^{36}Ar$ and $^{36}Ar/^{40}Ar$ vs. $^{39}Ar/^{40}Ar$ isotope correlation diagrams. The plateau age spectra along with the inverse isochron plots are presented in Fig. 2 and 3.

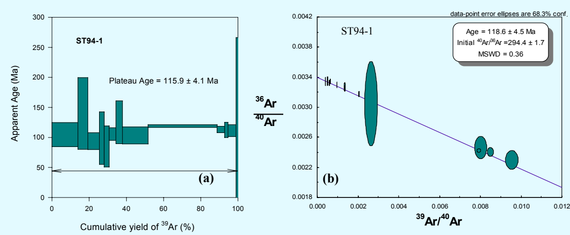


**Fig. 2:** Age spectra and inverse isochron diagrams for ST94-1. **(a)** Whole rock step heating age spectra. The vertical width of the individual steps indicates 2σ error calculated without propagating the error on *J*. Plateau age with the corresponding 2σ uncertainty is calculated using the isochron defined initial $^{40}Ar/^{36}Ar$. **(b)** $^{36}Ar/^{40}Ar$ vs. $^{39}Ar/^{40}Ar$ correlation diagram (inverse isochron) for the plateau steps showing 2σ error envelops and the best-fit regression line.

## References

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## Results

Both the samples yield good plateaus and inverse isochrons (Fig. 2 and 3). The sample ST94-1 yields a 13-step plateau age of 115.9 ± 4.1 Ma with 100% of $^{39}Ar$ released (Fig. 2a). Its inverse isochron age is 118.6 ± 4.5 Ma with initial argon value indistinguishable from atmospheric argon and MSWD of 0.36 (Fig. 2b). The second sample ST94-2 yields a 9-step plateau age of 115.5 ± 5.4 with 100% of $^{39}Ar$ released. Its inverse isochron age is 119.0 ± 10 Ma with initial argon value also indistinguishable from the atmospheric argon with MSWD value of 0.25. The samples do not show any indication of $^{39}Ar$ recoil redistribution within the rocks. For both the samples the plateau, isochron and inverse isochron ages agree within the limits of analytical uncertainty at 2σ. The concordant plateau, isochron and inverse isochron ages, the large amounts of released $^{39}Ar_K$ for the plateau steps, atmospheric value of the trapped $^{40}Ar/^{36}Ar$ component and acceptable MSWD values for the isochrons imply that these ages represent crystallization ages. More importantly, the ages for the two samples are indistinguishable at 2σ implying eruption of the Sylhet lava flows at 115.8 ± 3.2 Ma, the weighted mean of the plateau ages.

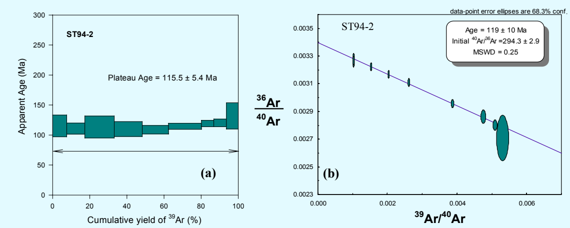


**Fig. 3:** Age spectra and inverse isochron diagrams for ST94-2. **(a)** Whole rock step heating age spectra. The vertical width of the individual steps indicates 2σ error calculated without propagating the error on *J*. Plateau age with the corresponding 2σ uncertainty is calculated using the isochron defined initial $^{40}Ar/^{36}Ar$. **(b)** $^{36}Ar/^{40}Ar$ vs. $^{39}Ar/^{40}Ar$ correlation diagram (inverse isochron) for the plateau steps showing 2σ error envelops and the best-fit regression line.

## Summary and Conclusions

- The age of eruption of the Sylhet Traps of eastern India has now been determined to be 115.8 Ma.
- This age falls within the range of ages (118-115 Ma) reported for various groups of volcanic rocks in the Rajmahal-Bengal province, thereby forms a part of the Kerguelen plume generated large igneous province.
- It also suggests that flood basaltic activity in eastern India during early Cretaceous had a large spatial extent, covered an area in excess of $\sim 2\times 10^5$ $km^2$.
- The age of Sylhet Traps and other alkaline activities suggest that the Kerguelen plume related magmatism in this part of India continued well beyond the major tholeiitic pulse at ~118 Ma.
- Our results combined with existing gechronological and gechemical information support the proposal that the Kerguelen hotspot was located close to the eastern Indian margin just after 120 Ma *(Kent et al., 2002)*.