Srivastava[5] opines that the contamination of mantle-derived magmas must have led to the formation of alkaline magmas of SRC.

It can, therefore, be concluded that U, Th, Nb, Sn, Pb, Y, Be and LREE rich peralkaline, agpaitic granitoid dykes, so far recorded only from the eastern half of the inner granite ring of Siwana Ring Complex, represent the last pegmatitic stage fractionates of such parental alkaline magma of SRC. In view of the anomalous abundances of these strategic elements in them, these dykes and the remaining western half of the granite ring needs further detailed investigations to evaluate their trace element potential and economic feasibility for possible exploitation in future.

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Alkaline nature and taphrogenetic affinity of felsic volcanic rocks of St. Mary Islands, off Mangalore coast

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The St. Mary Islands located off the Mangalore coast is an isolated patch of volcanic rocks presumed by some of the earlier workers to be related to the Deccan Trap volcanism. Geochemical analysis of the rocks of the islands reveals their essentially felsic but alkaline nature which indicates a possible relation with continental rift. In the light of the available age-data (of 93 Ma) and their location in the reconstructed Gondwanaland, the genesis of the St. Mary Islands volcanics can be related to the crustal thinning preceeding the Indo-Madagascar rift which predates Deccan volcanism significantly. This study necessitates identifying such expressions of rift-related magmatism of pre-Deccan age from other areas of the western margin of the Indian subcontinent.

THE St. Mary Islands, situated within a distance of 4 km from the mainland, off the Mangalore coast (between 74°40′13″–74°4′ E and 13°19′30″–13°23′10′ N) is well known for the occurrence of spectacular columnar joints in the rocks of the islands. Detailed field and petrographic studies by earlier workers[1,2] indicated that the rocks of the islands are essentially felsic volcanic rocks like rhyolite, rhyodacite and dacite. Geochronological studies have indicated an age of 93 Ma for them[3]. Here we present the results of the geochemical analysis – carried out by the rapid methods of silicate analysis outlined by Shapiro and Brannock[4] – and the interpretation of the data along with the already available chemical data on these rocks. Though the data are of preliminary nature, they are sufficient enough to decipher the magmatic affinities and petrogenetic aspects and to discuss their tectonic setting in relation to Plate Tectonics. Petrographically, the rocks are fine-grained with phenocrysts of feldspar and commonly showing small xenoliths – mostly having a diameter of 1 to 2 mm – of mafic nature made up essentially of augite and plagioclase.

Table 1 presents results of the chemical analysis of the volcanic rocks. The felsic nature of the rocks is reflected by their high silica content and low magnesia content, except in samples with significant presence of mafic xenoliths. When plotted in the SiO_2 vs $(N_2O + K_2O)$ diagram for the nomenclature of volcanic rocks they fall in the fields of trachydacite, rhyolite and dacite (Figure 1). Compared to the chemistry of average rhyolite, the rhyolites of the islands possess higher TiO_2

Table 1. Chemical analyses of felsic volcanic rocks from St. Mary Islands (Sl. Nos. 6 and 7 are from Naganna, 1966)

Sl. No.	1	2	3	4	5	6	7
Sample No.	S1	S2	S3	S4	S5	D	RD
SiO_2	72.80	63.80	67.88	70.42	65.85	69.90	70.14
Al_2O_3	11.06	10.71	10.71	8.64	12.24	13.11	14.08
TiO_2	1.10	0.82	0.55	1.10	0.55	0.64	0.74
Fe_2O_3	1.43	0.78	0.37	0.99	1.57	4.60	5.13
FeO	2.16	2.52	2.88	2.16	1.80	1.43	1.00
CaO	0.40	0.45	2.10	2.10	2.10	1.84	1.71
MgO	1.04	6.54	5.10	6.15	6.17	1.40	0.70
MnO	0.04	0.03	0.04	0.04	0.02	0.19	0.18
P_2O_5	0.03	0.04	0.03	0.02	0.03	Tr.	Tr.
Na_2O	4.97	5.72	5.73	4.97	5.81	3.29	3.35
K_2O	2.86	3.98	2.48	2.48	2.25	2.93	2.77
LOI	1.00	2.65	0.56	0.57	0.98	–	–
H_2O	0.94	1.93	0.41	0.31	0.13	0.60	0.41
ALK*	1.54	2.70	1.96	1.59	2.07	1.36	1.33
AGP**	1.02	1.28	1.12	1.38	0.97	0.655	0.60

*ALK: Alkali index = $(Na_2O + K_2O/(SiO_2 - 43 \times 0.17$.
**AGP: Agpaitic index = Mol · $(Na_2O + K_2O)/Al_2O_3$.

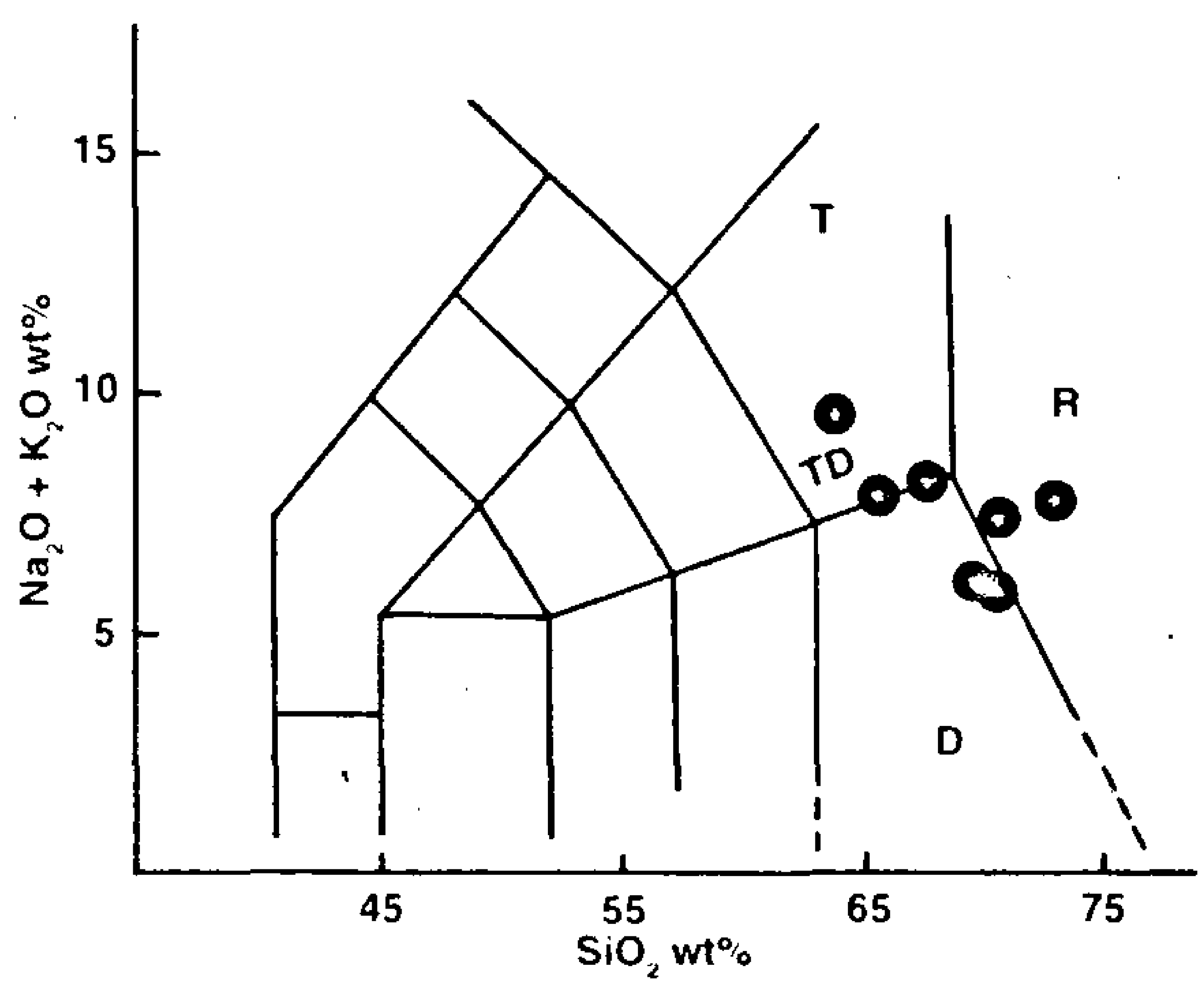

Figure 1. St. Mary Islands rocks plotted in the diagram showing the fields of volcanic rocks in terms of alkalies and silica. R, rhyolite; D, dacite; TD, trachydacite and T, trachyte.

and higher alkali content, especially Na_2O. The alkaline nature of the rocks is reflected in their calculated alkali and agpaitic indices (Table 1) and according to the definition of Shand[5] some of them are 'peralkaline'. When plotted in the K_2O vs Na_2O diagram for classifying alkalic magma series, the present samples fall in the fields of Na-series as well as K-series and close to the boundary between the two fields (Figure 2).

The limited variation of silica and other major element oxides of the rocks can be attributed to their origin by way of simple petrogenetic processes like fractional crystallization or partial melting. However, the absence of significant amounts of rocks of intermediate or mafic

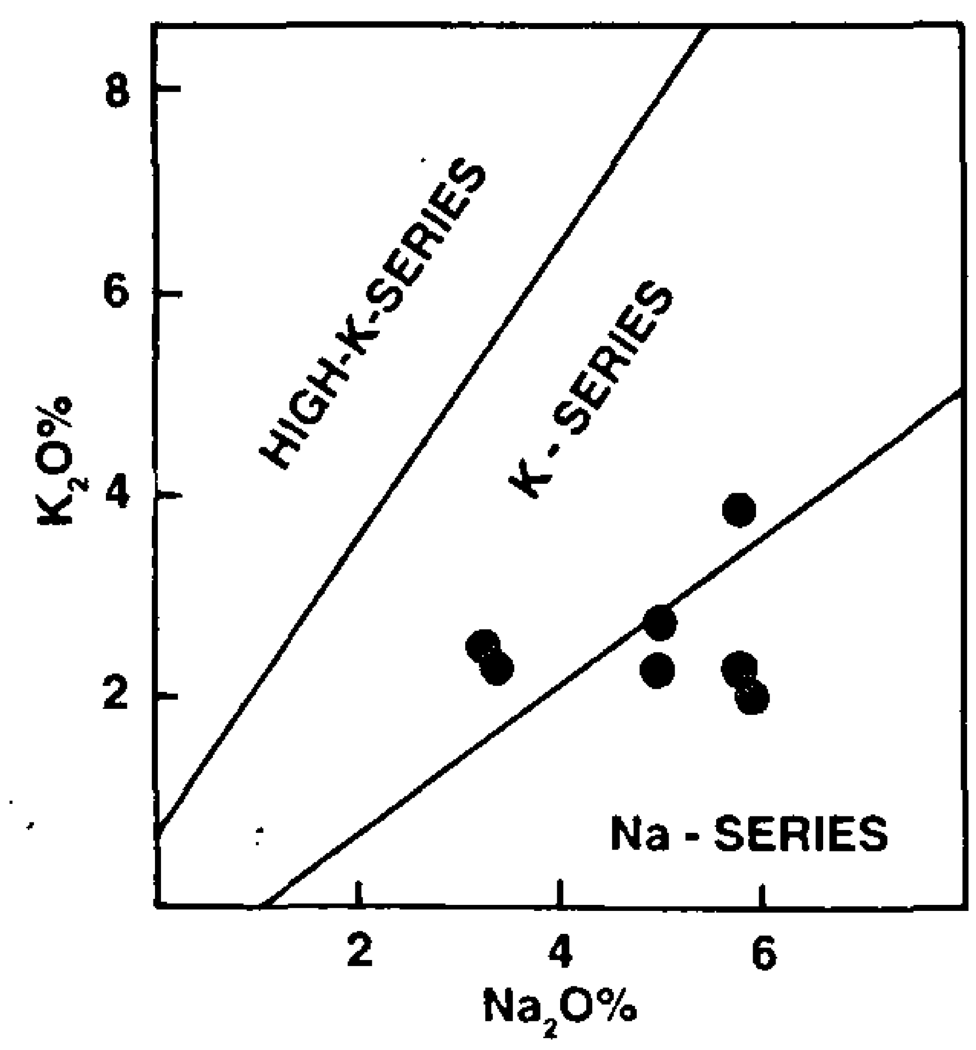

Figure 2. St. Mary Islands rocks plotted in the diagram showing subdivisions of alkali-magma series[9].

compositions seen either associated with them or in the proximal region precludes them being members of a differentiated sequence and probably represent low-level melting of crustal or subcrustal rocks.

The rocks when plotted in the normative Q–Or–Ab diagram (Figure 3) fall on the low-pressure side of the eutectic and thus they could be products of low-pressure and high-temperature melting when compared with the position of experimental anatectic melts generated at 720 and 760°C. It may be noted that higher temperatures of equilibrations – of the order of 700 to 900°C – of the minerals were obtained from mineral chemical studies[2].

Alkaline or peralkaline rocks have in general been supposed to be associated with continental rifting. The alkaline nature of St. Mary Islands rocks and their inferred high-temperature low-pressure evolution suggest their generation in rift-related setting. The high TiO_2 content, even in samples with low MgO, further confirms the taphrogenetic affinity of these rocks (*cf.* MgO–TiO_2 diagram for tectonic discrimination of rhyolites of Condie and Shadel[6]).

The Phanerozoic magmatism in the Indian subcontinent is essentially centred around Deccan Trap volcanism and Rajmahal volcanism, of which the former is more dominant and had given rise to one of the most voluminous Continental Flood Basalt provinces. Contrary to the earlier workers' contention of a longer duration for the Deccan Trap volcanism it is now apparent that it is confined to a short span around 65 Ma (ref. 7). The available geochronological data[3] for the St. Mary Islands rocks – whole-rock K–Ar mean age of 93.1 ± 2.4 Ma – much predates the Deccan Traps eruption. While the Deccan activity postdates the fragmentation of the Gondwanaland, the formation of St. Mary Islands volcanics probably predates or coincides with it. Their geographic location, age and inferred tectonic setting are in agreement with the origin of St. Mary Islands

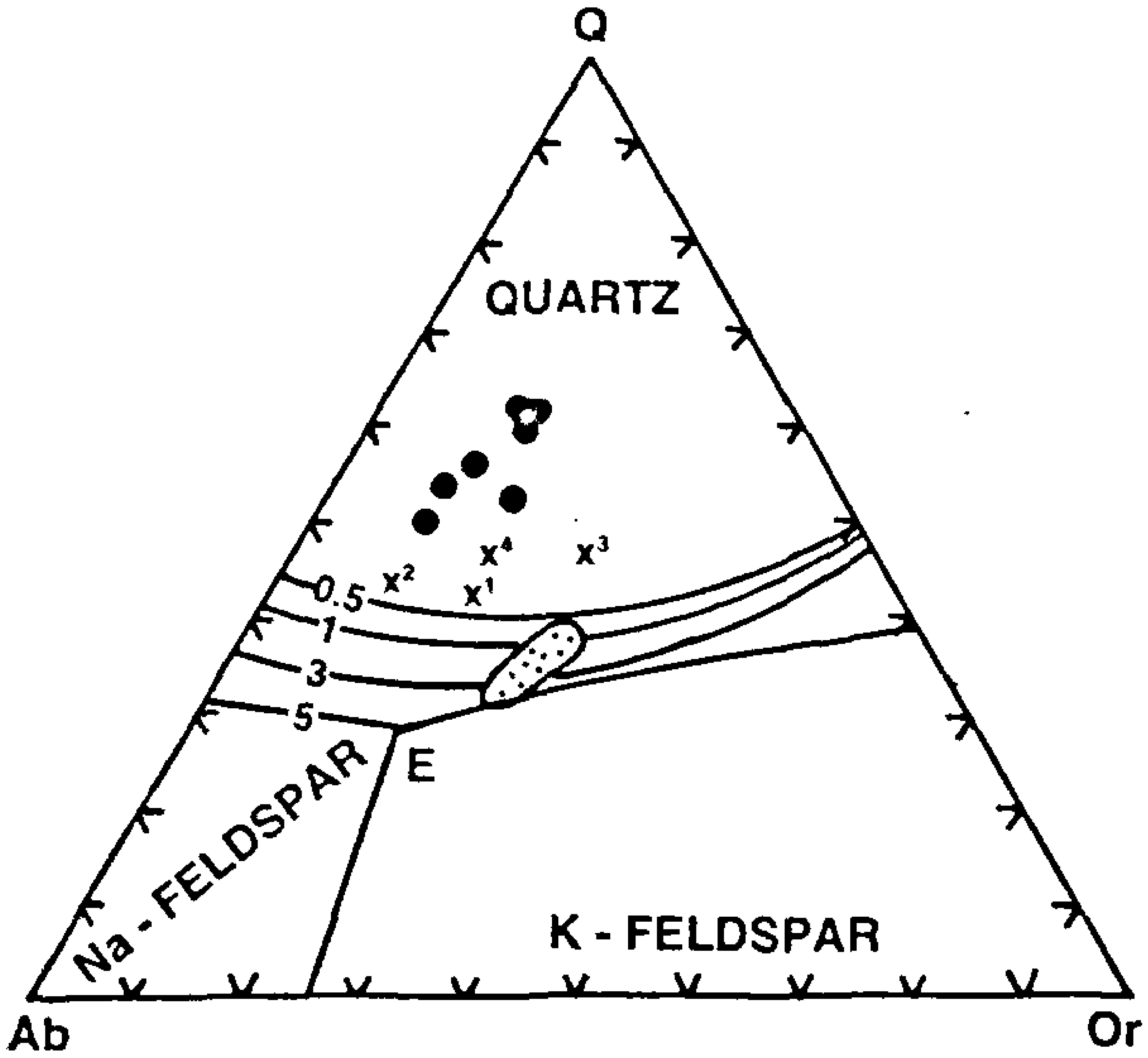

Figure 3. St. Mary Islands rocks plotted in the normative quartz–orthoclase–albite diagram. Lines indicate curves for water-saturated liquids in equilibrium with quartz and alkali–feldspar at confining pressures of 0.5, 1, 2 and 5 kilobars and stippled area indicates field of granites after Tuttle and Bowen[10]. Also shown are the compositions of experimental anatectic melts at temperatures of 720°C and (crosses 1 and 2) and at 760°C (crosses 3 and 4) after Winkler[11]. See Appendix for normative values.

Appendix. Calculated CIPW norms of the analysed samples in Table 1.

Norm	S1	S2	S3	S4	S5	D	RD
Q	30.90	11.50	16.98	25.00	11.34	33.60	35.10
Or	16.70	23.40	14.50	14.50	13.30	17.20	16.70
Ab	40.90	33.01	41.40	30.90	49.30	27.80	28.30
An	–	–	–	–	0.56	9.17	8.60
Lu	–	–	–	–	–	–	–
Ne	–	–	–	–	–	–	–
Co	–	–	–	–	–	–	2.35
Ac	0.92	2.30	0.92	2.80	–	–	–
Di	2.27	3.84	5.65	5.13	4.65	–	–
Wo	–	–	–	–	–	–	–
Hy	4.86	3.46	4.39	1.84	0.91	0.35	0.18
Mt	1.60	–	–	–	2.32	2.78	2.26
Ht	–	–	–	–	–	2.72	–
Il	0.61	1.50	1.06	2.13	1.06	1.22	1.37
Ap	0.06	0.92	0.06	0.04	0.06	–	–
Ns	–	2.93	1.34	1.83	–	–	–

volcanics being associated with the lithospheric thinning preceeding the Indo-Madagascar rifting.

The volcanic sequence of the east coast of Madagascar like the volcan de l'Androy with a mean age of 87.6 ± 0.6 Ma has recently been related to Marion hot-spot and the break-up of Madagascar with India[8]. The St. Mary Islands volcanics possibly represent the Indian counterpart of this rift-related magmatism, as illustrated in Figure 4.

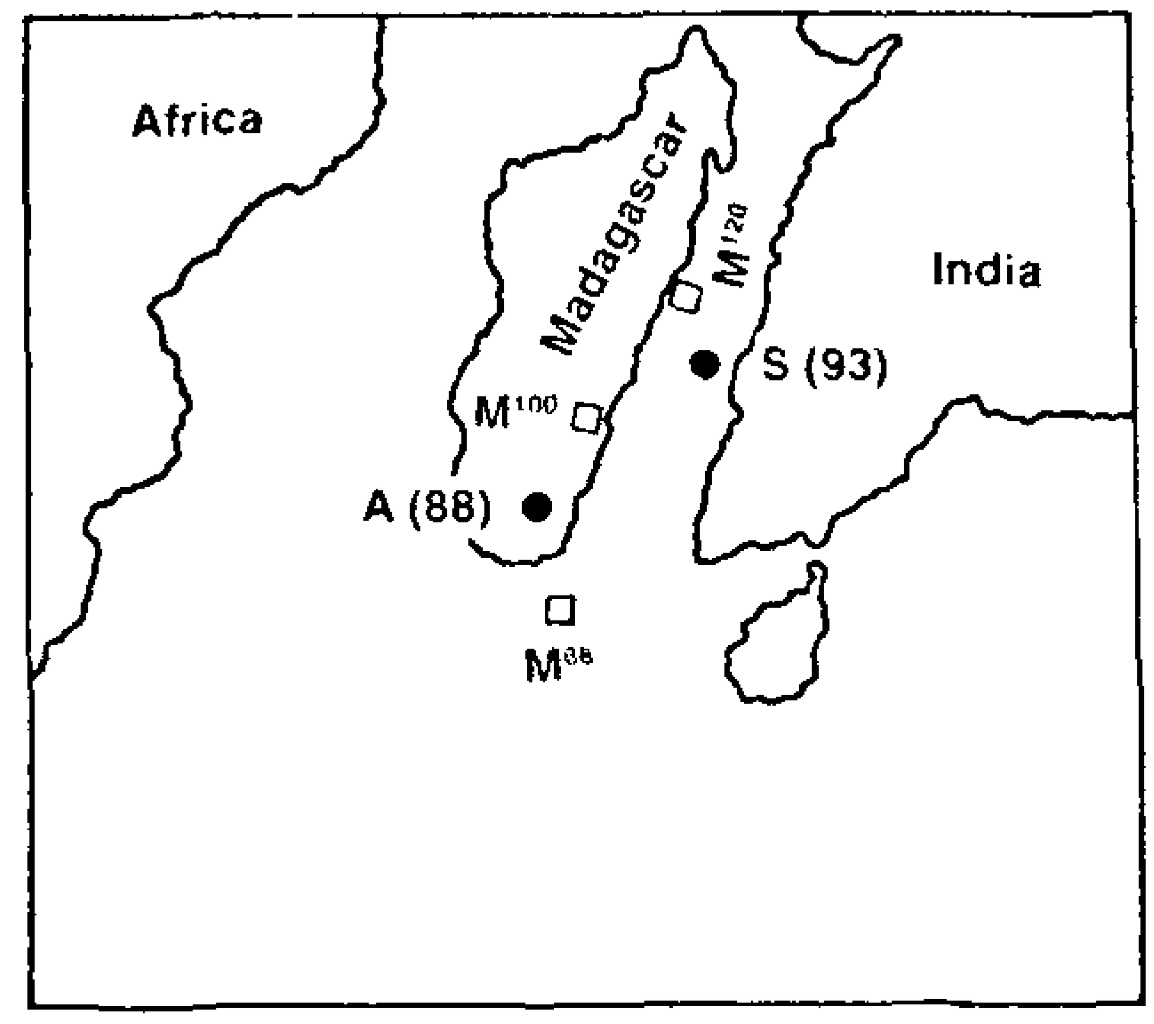

Figure 4. Plate reconstruction for 88 Ma (simplified from Storey *et al.*[8]) showing the relative positions of India, Madagascar and Africa and the palaeopositions of Marion hot-spot at 88, 110 and 120 Ma (M^{88}, M^{110} and M^{120}). Open circles indicate the locations of St. Mary Islands (S) and Volcan de l'Androy (A) with age in Ma in parentheses.

It is probable that earlier expressions of this plume activity are represented by some of the felsic/alkaline rocks seen spatially associated with or such rocks concealed beneath the Deccan Traps. For a better understanding of the tectonomagmatic evolution of the region, this rift-related, pre-Deccan magmatism should be delinked from the Deccan Trap volcanism.

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