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A note on palaeomagnetic evidence to show tectonic deformation in the Deccan Volcanic Province of Saurashtra, western India

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A long curved dyke with peculiar vertical layering, in the Deccan Volcanic Province of Saurashtra, was palaeomagnetically investigated. Palaeomagnetic measurements clearly indicate that the curved character of the dyke is due to some kind of tectonic drag deformation. Such deformation could have possibly developed in case the Saurashtra Peninsula has moved northwards along the Cambay Basin fault. There is a possibility that the horst in the southern part of Saurashtra may have been originally the continuation of the Satpura horst.

IN the central and south-eastern parts of Saurashtra, there are a large number of prominent dykes that often stand out as ridges. Majority of the dykes are dolerites, although an ankaramite dyke and a stock-like body of essexite have also been encountered in the area between Rajkot and Amreli. South of Amreli, in addition to the dolerite dykes there are a few rhyolitic quartz porphyry dykes. The dykes north of Amreli trend E–W, while south of Amreli they trend NE–SW. One prominent dyke (Figure 1) north of Amreli (68 km from Rajkot on road to Bhavnagar) trends E–W and can be traced for more than 50 km along the length and has a width of 10 to 15 m. This dyke is distinctly curved in the eastern part of the outcrop to trend NW–SE and has a T-shaped extension (penetration of the magma along an intersecting fracture) that can be traced for 15 km in length trending NE–SW. Petrography and petrochemistry of this dolerite, along with layering seen in this dyke, have been described earlier[1]. Dextral displacement of the dyke along N–S fractures can be observed at various places along the length of the dyke, but such displacements have been considered earlier as possibly due to intrusion along *en echelon* fractures[1]. Palaeomagnetic study was carried out on this dyke to ascertain whether the curved nature of the dyke is due to intrusion along a curved fracture or the curving is a later tectonic phenomenon.

The curved dyke was sampled at five different places along the length of the dyke. Sample locations are shown in Figure 1. Samples S II and S III were collected from the western straight part of the dyke. At both these locations four separate oriented samples were collected. Similarly, samples S IV and S V were collected from the eastern curved part of the dyke. At each of these latter locations three oriented samples were collected. S VI was collected from the ‘T’ branch of the dyke at the eastern end, where four separate oriented samples were collected. The oriented samples were mounted in cement and core specimens of 2.5 cm diameter and about 2.2 cm length were prepared for each sample. Three to fourteen specimens were prepared for samples of each locality.

The NRM measurements were made for all the specimens using the astatic magnetometer (LAM-24 manufactured by Geofyzika n.p. Brno, Czechoslovakia). Alternate field demagnetization was carried out starting at 50 Oe and going up to 1000 Oe, in increments of 25, 50, 100 and 200 Oe, on two to three pilot specimens for each of the locations. Similarly, thermal cleaning was carried out on a pilot basis starting at 100°C, going up to 600°C, in increments of 50 to 100°C. Thermal cleaning was carried out in a magnetic vacuum using MAVACS (magnetic vacuum control system).

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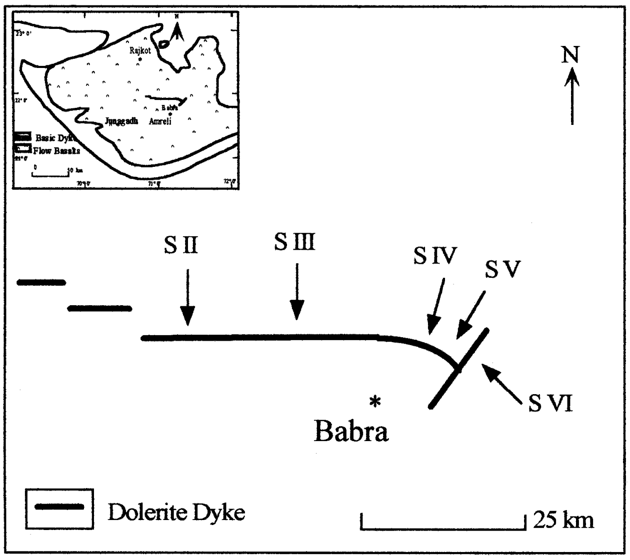

Figure 1. T-shaped major dyke with the sample locations marked. (Inset) Location of the dyke.

Table 1. Average declination, inclination and other palaeomagnetic parameters for the curved dyke

Site no.	*N*	*n*	*D*	*I*	*a*95	*K*
S II	3	7	154.7	39.1	12.2	25.5
S III	4	12	151.2	40.7	07.4	35.1
S IV	3	14	182.0	48.8	13.7	82.0
S V	3	3	185.1	83.1	06.0	424.8
S VI	4	7	195.3	40.7	20.4	09.7

N, No. of oriented samples collected; *n*, No. of specimens measured; *D*, Declination; *I*, Inclination; *a*95, Radius of circle of confidence; *K* Precision parameter.

Based on the Zijderveld plots, vector migration plots and intensity decay curves, the rest of the specimens were cleaned by alternate field demagnetization at 175 to 300 Oe. The mean magnetic declination and mean inclination of the stable NRM and other parameters are given in Table 1.

From Table 1 it is obvious that the dyke shows reversed polarity at all the five locations from where the samples were collected. The VGPs calculated from the locations at S II to S VI nearly match with the Deccan Trap poles, as well as the pole derived from dyke intrusions[2,3]. However, the average declination for the straight part of the dyke is 153°, while it is 187° on the curved part and the T-shaped segment of the dyke. Since the inclination values are the same, the anomaly can be explained only when it is assumed that the dyke is rotated clockwise by about 35°, after it was magnetized. It can be seen from Figure 1, that the dyke has been 'dragged' approximately through 35°, which is the same amount calculated palaeomagnetically.

Palaeomagnetic studies on the flows and dykes of the Deccan Volcanic Province, including those of the Narmada–Tapti rift zones, carried out over the last 2 to 3 decades, opened a new field in establishing the stratigraphic order of sequences of lava flows. The study has also helped in correlating sequences of lava flows that are separated, and postulations of regional significance have been based on normal-reverse polarity[4,5]. Pre-existing tensional or shear fractures controlled the emplacement of dykes; or step faulting with differential movement and changes in the polarity of the dykes have been discussed in specific and general cases[6–8].

The west coast tectonics are intertwined with the Narmada–Tapti faults with the intervening Satpura horst, the west coast fault and the Cambay graben, the triple junction or the four-armed Khambat junction; and the Deccan volcanism[9–12]. The similarities of major geomorphic features on the Saurashtra Peninsula to those of the Narmada–Tapti zone on the mainland of India have been alluded[7,10,13,14].

In the present study, the clockwise rotation of reverse polarity on the curved part and the T-shaped segment of the dyke (the latter was almost N–S at the time of intrusion), combined with the observed structural drag is inferred to be the result of tectonic disturbance of regional significance, subsequent to the emplacement. Also, in the present study it is noted that north of Amreli (Figure 1), the lava flows are practically horizontal and form a flat peneplain type of topography with only few isolated hills. In contrast, the area south of Amreli has a more rugged topography, with dipping lava flows forming southerly plunging antiformal structure. It is therefore inferred that the area south of Amreli forms a horst-like structure (Saurashtra horst) which is bounded on either side by ENE trending faults.

The possibility of the ENE trending Narmada Rift Zone (NRZ) extending into the Saurashtra Peninsula has also been postulated earlier and that the reactivation of NRZ from time to time brought out several geological changes in western India[7]. Assuming that the observed polarity at the T-shaped segment of the dyke is due to regional tectonics related to Saurashtra Peninsula and the NRZ, a postulation is made here. The ENE trending fault north of the Saurashtra horst (see also Figures 1 and 2 in ref. 7), in Amreli area mentioned above, is possibly a continuation of the Narmada fault. Thus the Saurashtra horst bounded by two faults could be equated with the Satpura horst bounded by the two faults (Narmada and Tapti faults of the NRZ). A careful examination of the structural map of India reveals that there would be approximately a movement of 50 km northward for the Saurashtra peninsula relative to the mainland of India. It will be necessary to do a more detailed palaeomagnetic study to confirm the possibility that the Saurashtra Peninsula has moved northwards. Also, chemical stratigraphy has to be carried out for the correlation of the lava flows of Saurashtra with those of the Satpura range and those occurring north of the Narmada fault.

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