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Palaeomagnetic Polarity of the Deccan Basalt Lava Flows, Exposed Around Eastern Part of Amravati City, Central India: Implications of N-R Sequence

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Abstract

Basalt preserve palaeomagnetic record, essential for the correlation of the lava flows which is important to establish flow stratigraphic sequence. The present study encompasses, palaeomagnetic polarity of the Deccan basalt lava flows, exposed in Chhatri Talao hill (part of Pohra hill ranges), due east of Amravati city, Maharashtra State, India. During the present study, flow mapping was carried out with collection of basalt rock samples for palaeomagnetic investigation. Geological field results indicate exposure of three basalt lava flows between altitude of 365 to 435 meter (amsl), which are (i) lower flow-I: fine to medium grained, mafic plagioclase microphyric basalt; (ii) middle flow-II: coarse grained, mafic plagioclase phyric basalt and (iii) upper flow-III: fine to medium grained, mafic plagioclase microphyric basalt. Results also indicate, 'Normal' polarity of upper two lava flows (flow-II and flow-III), exposed at an altitude of 427-440 meter and 398-427 meter (amsl), and 'Reverse' palaeomagnetic polarity by the lower flow (flow-I) at an altitude of 380-398 meter (amsl). Thus, present study, can be useful to correlate eastern basalt lava flows with other parts of the Deccan basaltic terrain. This study can be useful to determine the palaeo-latitudes of eastern Deccan basalt lava flows.

Keywords: Deccan basalt; Lava flows; Palaeomagnetism; Flow stratigraphy.

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1. Introduction

The Deccan Volcanic Province (DVP) is well exposed and spread over 5 00,000 km^2 area of central and western India, which records vast accumulation of basalt in a relatively short time span in the Cretaceous/Paleogene boundary (KPB) [1,2]. The Deccan volcanic activity initiated prior to the KPB, however, main episode occurred at ~300 ka prior to or at the KPB itself [1]. This was the most outstanding catastrophic event in the geological history of India with outpouring of an enormous quantity of lava that flowed over hundreds of kilometres to form a major part of the Deccan Plateau [3]. The flows are thick tabular sheets

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having large general extent. They are mostly horizontal, and form flat-topped hills with step like terraces produced by differential weathering and erosion [3]. In the Western Ghats, Deccan volcanism took place during a reverse magnetic epoch [4,5]. The upper 'Normal' sequence of Mahabaleshwar formation was later established [6]. Also, the palaeomagnetic studies in eastern part of Satpura hill ranges was carried out to establish detail magnetostratigraphy [7,8]. Alternate normal and reverse sequence was also observed, South of Narmada river [9]. The palaeomagnetic studies by Geological Survey of India along Indore-Buldana section mentioned that south of Narmada, faulting has caused repetition of the N-R boundary [10,11]. Aim of the present research was to carry out flow mapping and palaeomagnetic study of the of the Deccan basalt lava flows, exposed around eastern part of Amravati district, central India.

2. Study Area

The area under present investigation covers eastern part of Amravati city, Maharashtra State, India which is covered by the Survey of India topographic map 55 H/13, with coordinates 77°.46'.00" E longitude and 21°.54'.00" N latitude (Fig. 1). This area is covered by small hillocks of 30 to 100 meter altitude above mean sea level. The area is entirely covered by the basalt lava flows of Upper Cretaceous to Lower Eocene Age.

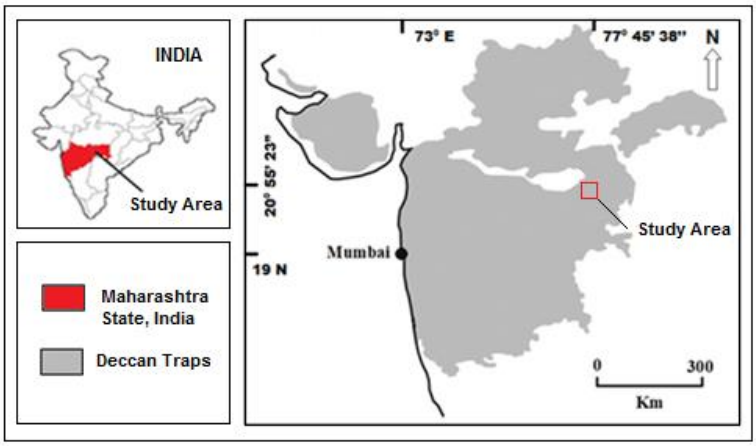

Fig. 1. Location map of the study area.

3. Methodology

The detailed flow mapping of eastern part of Amravati city was carried out by using Survey of India's topographic maps 55 G/15 and 55 K/3 (scale 1:50,000) (which served as the base map for study). Geological mapping was carried out from top to bottom of the hill ranges, covering 70 meter thick basaltic lava pile between 435 meter (highest point) to the 365 meter (lowest point). The rock samples were collected at frequent interval for petrological and palaeomagnetic study. The physiographic breaks were carefully plotted, as they may

indicate change in flow. The lava flows are separated on the basis of mineral content, structure, texture, presence of phenocryst and physiographic breaks in topography. The palaeomagnetic rock samples were collected (from top to bottom of the hill) with flat top and vertically exposed two adjacent sides. These samples were mounted in a cement base in the laboratory and used to obtained small core samples, after drilling. For palaeomagnetic measurements, thermal and alternating field demagnetization cleaning techniques were applied to the rock cores, in the palaeomagnetic laboratory at Department of Geology, Sant Gadge Baba, Amravati University, Maharashtra State, India.

4. Geology

The Deccan basalt has not been studied in detail regarding palaeomagnetic properties, especially due north and east part of its extension. Most of the investigations carried out by previous researchers were confined to thick lava piles of the Western Ghats. The lava flows exposed due East of Amravati city are designated as Karanja Formation (Sahyadri Group) by the Geological Survey of India [12]. The flows are exposed in hilly area and most of the flows are of simple type, with alternate vesicular and massive units. A detailed traverse along Chhatri Talao ('Chhatri Talao' is a lake present due east of Amravati city at about 3 km. distance) reveals an exposure of total 3 lava flows, with different colour appearance, mineralogy, grain size characteristics and physiographic breaks at places. The lower most flow (Flow-I) is fine to medium grained, mafic plagioclase microphyric basalt which is dark grey coloured with extremely fine grained plagioclse feldspar, embedded in fine grained ground mass consists of clinopyroxenes. This flow is overlaid by (Flow-II), a coarse grained, mafic plagioclase phyric basalt which is grey in colour and composed of large size plagioclase feldspar laths and coarse grained clinopyroxene groundmass. This flow is characterized by vesicles on the upper portion of the flow. The topmost flow (Flow-III) is dark grey coloured, fine to medium grained, mafic plagioclase microphyric basalt, with extremely fine grained plagioclse feldspar, embedded in fine grained ground mass of clinopyroxenes (Table 1; Fig. 2). All the 3 lava flows are divided into two different formations and classified as B and C formations, based on the field characteristics and palaeomagnetic polarity (Figs. 2 and 3).

Table 1. Field characteristics of the basalt lava flows, exposed near Chhatri Talao, eastern part of Amravati city, central India.

Sr.No.	Lava Flow	Flow Altitude (m, amsl)	Field Characteristics	Flow Type
1	Flow-III	427-440	Fine to medium grained; grey coloured; hard and compact	Mafic plagioclase micropheric basalt
2	Flow-II	398-427	Coarse grained; Plagioclase feldspar laths; grey coloured; spheroidal weathering	Mafic plagioclase phyric basalt
3	Flow-I	380-398	Fine to medium grained; dark grey coloured; hard and compact	Mafic plagioclase micropheric basalt

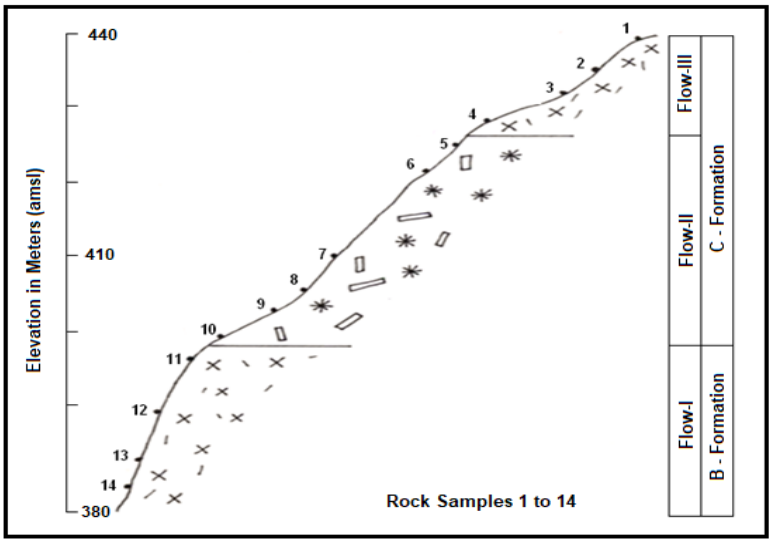

Fig. 2. Deccan basalt lava flows, exposed in Chhatri Talao section, Amravati district.

5. Magneto-Stratigraphy

An understanding of the nature and magnitude of magma generation, storage, and transport in flood basalt provinces requires knowledge of the stratigraphic and geo-chemical relationships between lava sequences in different regions of any given province and for most of the provinces, including the Deccan Traps of India, such knowledge is still fragmentary [13]. The +2000 m thick pile exposed in the Western Ghat Escarpment (WGE) displayed reverse polarity with a small capping sequence of normal polarity [13]. This Reverse-Normal sequence may be equated with the magnetic Chrons 29R and 29N respectively [14,15] and provided the paleomagnetic and geochronological validation of the linkage of the DVP with the K-Pg Boundary [16]. The real problem across the DVP is the fact that while the western sequence has been well studied and replicated by multiple workers over the years, paleomagnetic data from the other sub-provinces is sparse [16].

The Geological Survey of India carried out palaeomagnetic studies along 40 sections in the Deccan Traps, which revealed that the section along the Western Ghats, display only one reversal boundary, a reversed pile at bottom and normal sequence above [3]. But multiple reversals are observed in the sections in central and eastern part of the Deccan Traps [11,17]. Also, previous detail palaeomagnetic study was carried out in Rajura-Indla area of Amravati district (adjacent to present research site), also reported the exposures of three basalt lava flows [18]. This study was carried out with the help of five different traverses, one traverse from Rajura area, three traverses from Indla area and one traverse from Mardi area [18]. Detail magneto-stratigraphy of the Wadali basalt of Pohra area (adjacent to current research area) exhibit similar Normal-Reverse sequence [19] (Table 2, Fig. 3). Similarly, present palaeomagnetic investigation of eastern part of Amravati city

reveals exposure of three basalt lava flows, exhibiting 'Normal' and 'Reverse' palaeomagnetic polarity. The lower most mafic plagioclase micropheric flow exhibit Reverse polarity, middle mafic plagioclase phyric flow exhibit Normal polarity and topmost mafic plagioclase micropheric flow exhibit Normal polarity, indicating N-R sequence in the area (Fig. 4). The magnetic declination and inclination of upper Normal flows are D = 322° and I = - 37, and lower Reverse flow exhibit D = 133° and I = + 51 [19].

Table 2. Rock magnetic and palaeomagnetic data of the basalt lava flows, adjacent to the present study area [19].

Flaw No.	Sample No.	Wt. in g	Jn x 10^{-4} emu/ g	Ji x 10^{-4} emu/ g	Qn	Rs (196/ 250K)	K	Magnetic State	Grain compo-sition	D°	I
III	Px/1.2a	17	19.94	3.28	3.03	0.083	6.56	SP	TM_{60} + X	116	-11
	Pv/15.1a	19.08	19.91	0.81	24.73	0.21	1.61	SP + SD	TM_{49} + X	289	-65
II	Px/8.2a	30.32	44.93	0.54	81.69	-	1.09	-	-	-299	31
	Piv/10.1a	15.98	5.61	1.25	4.47	0.39	2.51	SP + SD	TM_{40} + X	355	61
I	Piii/1.1a	17.48	15.76	0.82	19.10	0.19	1.65	SP	TM_{52} + X	171	71
	Pxix/13.1b	29.10	25.00	0.76	30.26	0.22	1.56	SP + SD	TM_{49} + X	91	32

(Wt.: Weight in g; SD: Single domain; Jn: Natural remanent magnetic intensity x 10^{-4} emu/gm; CD: Cation deficient; Qn: Koenigsberger ratio (Jn/Ji); MD: Multi domain; K: Magnetic susceptibility x 10^{-4} emu/gm; SP: Super paramagnetic; RS: Relative susceptibility at 77k/300k; TM: Titanomagnetite; Peak: Peak susceptibility at 120k/300k; X: Unidentified component; D: Declination, I: Inclination).

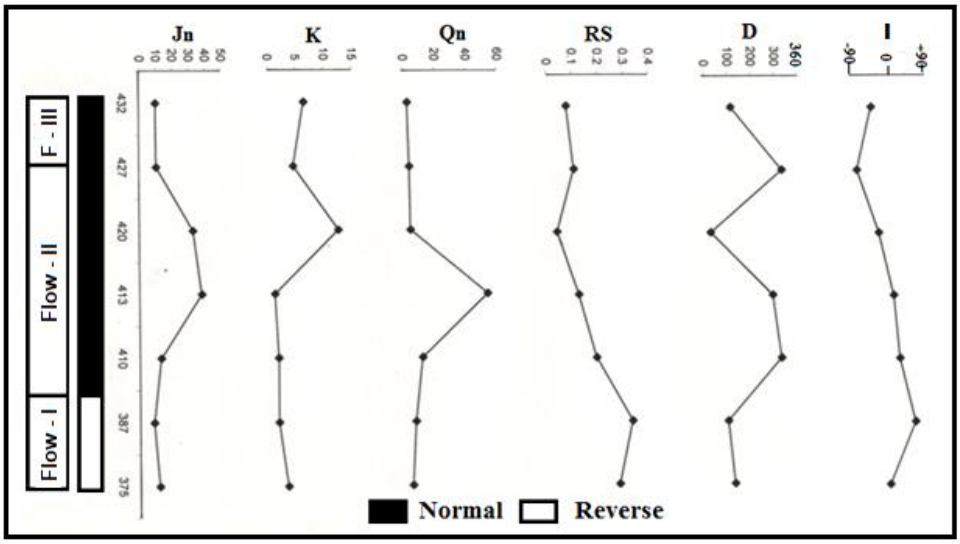

Fig. 3. Magneto-stratigraphy of the Wadali basalt (Pohra area), central India [19].

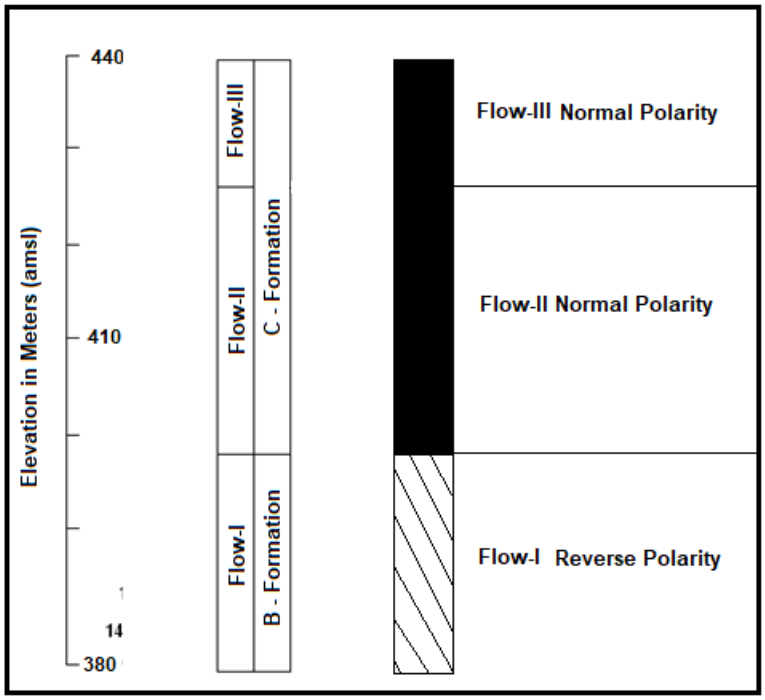

Fig. 4. Basalt lava flows and their corresponding palaeomagnetic polarity, Chhatri Talao section, Eastern part of Amravati district, central India.

6. Conclusion

Discussion about the palaeomagnetic polarity and magnetostratigraphy of different parts of the DVP reveals big gap over this basaltic terrain. Present study incorporates flow mapping, along with the papalemagnetic measurements of basalt lava flows exposed in the eastern part of Amravati city, central India. This study was very crucial to fill the existing gap of palaeomagnetic polarity between Western and eastern part of the Deccan Traps. The basalt lava pile of 70 meter thickness was divided into three basalt lava flows, between an altitude of 365 to 435 meter (amsl). The flows are differentiated as: lowermost flow-I: fine to medium grained, mafic plagioclase micropheric basalt; middle flow-II: coarse grained, mafic plagioclase phyric basalt and upper flow-III: fine to medium grained, mafic plagioclase micropheric basalt. The palaeomagnetic results indicate Normal-Reverse polarity of the basalt lava flows, with ‘Normal’ polarity exhibited by the upper two lava flows (viz. flow-II and flow-III) and ‘Reverse’ polarity indicated by lower flow (flow-I). The established flow sequence and magneto-stratigraphy can be further useful for correlation the Deccan lava flows and determination of palaeo-latitudes.

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