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Orthogonal Dykes around the Cuddapah Basin - A Palaeomagnetic Study

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ABSTRACT
The dyke swarms surrounding the Palaeo-Meso Proterozoic intracratonic Cuddapah Basin in the south Indian peninsular shield are considered to be the result of thermal events responsible for its initiation and development. The stress fields control the joint pattern with unidirectional and orthogonal fissures, which in turn provide channels for the dyke emplacements. Often the orthogonal joints are considered to be simultaneous in their development. Whenever there is dyke emplacement it acquires a magnetization parallel to the ambient geomagnetic field and therefore, a study of the magnetic expression of these intersecting dyke systems will reveal the nature of stress fields and their emplacement periods so as to constrain the tectonic evolution of the basin. Intersecting dyke sets were noticed at several locations in the N, NW, W, SW and S portions of the Cuddapah Basin and their magnetic signatures are critically examined in this study to understand the nature of stress fields. The palaeomagnetic signatures of these dykes revealed magnetic directions in unidirectional and orthogonal dyke sets indicating development of fractures due to operation of stress fields along these directions simultaneously as well as in phases. Further, it is also evident from the magnetic signatures of these dykes that there are multiple phases of dyke emplacement throughout the Proterozoic era confirming the available radiometric data on these dykes around the Cuddapah Basin.

INTRODUCTION

The dyke swarms surrounding the Cuddapah Basin are quite complex with several intersecting units that were emplaced over a protracted period between 2068 and 656 Ma, and they have variable chemistry (Murthy et al. 1987). By contrast the McKenzie Dyke Swarm of Canada that intruded at 1212 Ma with uniform chemical composition is extremely linear without intersecting dyke swarms (Fahrig & Jones 1969; Fahrig & West 1986; Fahrig 1987). There are several other dyke swarms in the Canadian shield (Abitibi, Franklin, Matachewan, Sudbury etc.,), which run for several hundreds of kilometers, exhibiting extreme linearity with uniform chemical composition within them. Dykes are usually also known to faithfully record the geomagnetic field direction whenever they are emplaced. Therefore, the magnetization history of the intersecting dykes surrounding the Cuddapah Basin will form an interesting subject for study in understanding the role of events of stress regimes in the evolution and development of this intracratonic sedimentary basin. The dyke swarms around the Palaeo-Meso Proterozoic Cuddapah Basin in the South Indian Peninsular shield are considered to be the result of various phases of thermal events around the Cuddapah Basin that are ultimately responsible for the evolution of this sedimentary basin (Bhattacharji & Singh 1984). A palaeomagnetic study is made on several intersecting dykes with different trends, ages and chemistry to bring in to light several phases of dyke intrusion and their emplacement history. Results of these studies are presented in this paper.

DYKE EMPLACEMENT MECHANISM

Most of the world's ancient cratons were intruded by dyke swarms during the Proterozoic era. Emplacement of these dyke swarms is dependent on several factors such as regional stress fields, joint patterns, crustal heterogeneity, nature of magma and its depth of origin etc. Normally dyke emplacements occur due to the tensile forces developing unidirectional fissures which will be subsequently filled with doleritic material. A further aspect of dyke geometry is that where two dyke trends are present, they are commonly orthogonal to one another or with in about 30^0 of orthogonality. In general the two trends represent intrusive events separated by several million years but in some cases the pattern is interlaced and thus appears to result from a single episode of magma intrusion (McGlynn 1972; Escher et al. 1976; Halls 1982; Tokarski 1990). The frequent near orthogonality of dyke swarms may relate to a pattern of preexisting fractures, or dyke swarm emplacement may change the stress pattern to ultimately favour near orthogonality of the next phase of dyke intrusion. Again the dyke pattern may arise from some systematic change in the underlying processes that creates swarms in the first phase. The dyke emplacement mechanism suggests intrusion into the preexisting joints and joints that develop during the intrusion in the country rock. There are three types of joints; namely joints, which 1) predate the dyke intrusion, 2) joints generated during the dyke intrusion and 3) joints that post date the intrusion of dyke.

GEOLOGY AND SAMPLING

The south Indian peninsular shield consists mainly of crystalline basement comprising granites and gneisses of different types and ages. These basement rocks are intruded by a number of dyke swarms in all the major orientations. Some such swarms can be noticed surrounding the Palaeo-Meso Proterozoic intracratonic Cuddapah Basin in South Indian Peninsula (Karunakaran 1971; Halls 1982; Drury 1984; Murthy et al. 1987). While studying the structure and evolution of the Cuddapah Basin one cannot ignore the role of these dyke swarms surrounding it. Several aspects of these dyke swarms have been studied by several workers (Balakrishna, Rao & Venkatanarayana1979; Kumar & Bhalla 1983; Suryanarayana & Anjanappa 1975; Halls 1982; Drury 1984; Murthy et al. 1987; Murthy 1987).

Dyke swarms occurring around the Cuddapah Basin are given by Murthy et al. (1987). Major orientations of the dyke are E –W, WNW to NW, NE to ENE and N – S. E – W oriented dykes are predominant in the south while in the south western part the dykes trend along NW and NE directions with some E – W dykes. In the western part the dominant trend is WNW to NW with some NE dykes. In the north, there are two major trends of WNW and N-S with minor dykes along NE orientation also (Murthy et al. 1987; Mallikarjuna Rao et al. 1995).

Majority of the dyke swarms are dolerites and gabbros whereas peridotite, amphibolite, syenite and granophyric varieties also occur. These dykes are fine to coarse grained and ophitic to subophitic or granular. They rarely exhibit flow or vesicular texture and have tholeiitic and alkaline composition. Ar – Ar and K – Ar ages were reported on a number of dykes by Murthy et al. (1987), Padma Kumari & Dayal (1987) and Mallikarjuna Rao et al. (1995) outside the Cuddapah Basin and these are listed in Table 1. An examination of these dyke ages reveal three major phases of dyke emplacements between 1900 – 1000 Ma (1900 – 1700 Ma, 1500 – 1300 Ma and 1200 – 1000 Ma) and a minor youngest event at 650 Ma. It is generally observed that dykes trending in the E-W and NW direction with tholeiitic composition are older than 1700 Ma. Dykes between 1700 and 1000 Ma are both tholeiitic and alkaline in nature with a peak activity between 1400 – 1300 Ma forming conjugate sets along the NW and NE directions. Alkaline emplacements younger than 1000 Ma are also seen. From the field, petrographic, geochemical and isotope age studies it is suggested that dyke emplacement surrounding the Cuddapah Basin took place in about three distinct phases.

In order to study the palaeomagnetic directions of these dyke swarms, oriented samples from a number of dykes were collected from the northern, western, southwestern and southern regions surrounding the Cuddapah Basin (Poornachandra Rao 1992). Only those dykes that form orthogonal sets are considered

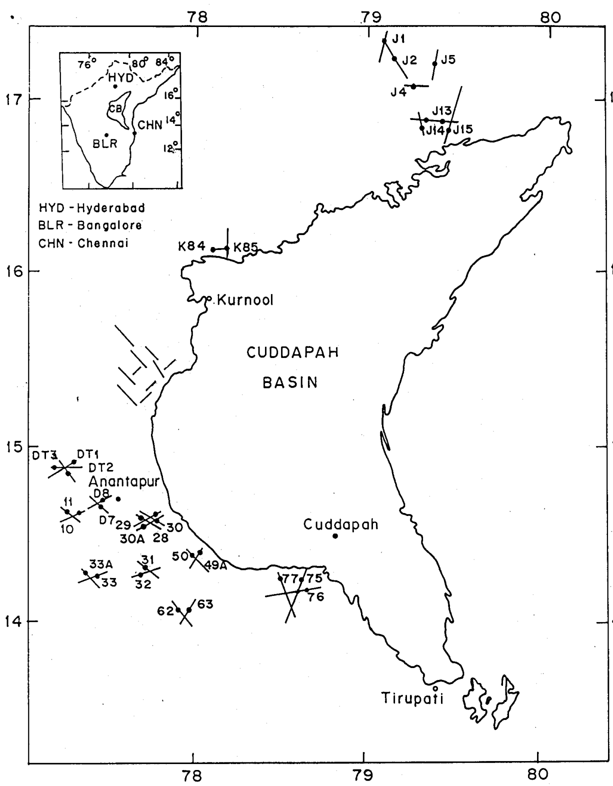

Figure 1. Map of the Cuddapah Basin in South Indian Peninsular Shield showing intersecting dykes out side the basin selected for palaeomagnetic analysis. Numbers refer to dykes investigated in the present study.

Table 1. Ar-Ar and K-Ar ages of some dykes surrounding the Cuddapah Basin.

Sl.No	Dyke No.	Orientation	Age in Ma	Remarks
1	DOL	NE	1884 ± 40	3
2	D8A	EW	1879 ± 05	2
3	J22	NE	1854 ± 40	3
4	DIII	NE	1748 ± 35	3
5	DIV	NE	1734 ± 26	3
6	K33	NE	1730 ± 38	3
7	D76	EW	1713 ± 65	1
8	DII	EW	1518 ± 37	3
9	K88	NW	1489 ± 05	2
10	J2	NW	1486 ± 40	3
11	J9	NS	1480 ± 50	3
12	D38	NE	1475 ± 52	1
13	K122	NW	1471 ± 54	1
14	K72	NW	1454 ± 56	1
15	DI	EW	1437 ± 40	3
16	D75	NE	1414 ± 52	1
17	K104	NS	1387 ± 30	3
18	D77	NW	1371 ± 04	2
19	D28	NE	1367 ± 49	1
20	D49A	NE	1355 ± 49	1
21	D88	EW	1348 ± 48	1
22	K110	NE	1335 ± 49	1
23	D84	EW	1333 ± 04	2
24	J15	NE	1326 ± 47	1
25	D89	NW	1280 ± 47	1
26	D30	NW	1212 ± 05	2
27	K34	NE	1157 ± 41	3
28	DV	NW	1124 ± 35	3
29	LI	NE	1086 ± 23	3
30	K64	NW	1084 ± 24	3
31	D86	EW	1073 ± 45	1
32	D83	NW	935 ± 34	1
33	D47	NE	646 ± 23	1
34	J19	NW	644 ± 18	3

1: K-Ar data by M/S Kruger Enterprises Inc, Geochron Laboratories, Cambridge, U.S.A.

2: Ar-Ar measurements by Prof. York, Department of Physics, University of Toronto, Canada.

3: K-Ar measurements by Padma Kumari & Dayal 1987.

here for the present study. A total of thirteen such intersecting dyke sets are available for this purpose. In eight of the interesting dykes, two dykes are involved, whereas in the rest of them three to four dykes are involved. These are shown in Figure 1. Oriented samples were collected at least from one site on each of these dykes and at some dykes more than one site were also sampled. From each site a minimum of 5 – 6 samples were oriented using both Solar and Brunton compasses. The sites from these intersecting dykes are several kilometers apart and therefore, there is no possibility of remagnetization of the older dykes during the emplacement phase of younger dykes. A total of 198 oriented block samples collected at 36 sites from these 32 dykes and cored and cut into cylindrical specimens of 25 mm in diameter and 22 mm in length in the laboratory for their remanent magnetic study.

PALAEOMAGNETISM

Natural Remanent Magnetic (NRM) direction and intensity (Jn) of the specimens were measured on astatic and spinner (Schonstedt, USA, Model – DSM 2) magnetometers. Stability of the NRM vector was estimated using AF demagnetizer similar to that described by Creer (1959) and Thermal demagnetizer (Schonstedt, USA, Model TSD - 1). Susceptibility was measured using a Hysteresis and Susceptibility Apparatus (Likhite & Radhakrishnamurty 1965). NRM directions of specimens from all samples from almost all the dykes show very good grouping. Sample NRM directions of all the dykes show scatter. These are distributed over the entire stereonet with both upward and downward inclinations. The observed inclinations of these dyke samples vary from very shallow to very steep values. NRM intensity of the samples vary over three orders between 0.035 and 37.04 A/m and susceptibility over two orders between 0.9 and 49.1 x 10^{-3} SI Units. The characteristic remanent magnetic vector of these dykes was determined by laboratory demagnetization studies using AF and Thermal methods as described below.

A F Demagnetization

To determine the characteristic remanent magnetic vector in these dykes at least two specimens from each site from each dyke were selected and subjected to pilot AF study in progressively increasing alternating fields. The specimens were demagnetized at increasing peak fields in steps of 2.5, 5, 10, 15, 20, 30, 40, 60, 80 and 100 mT and the remanent magnetic vector was measured after each step of demagnetization. Most of

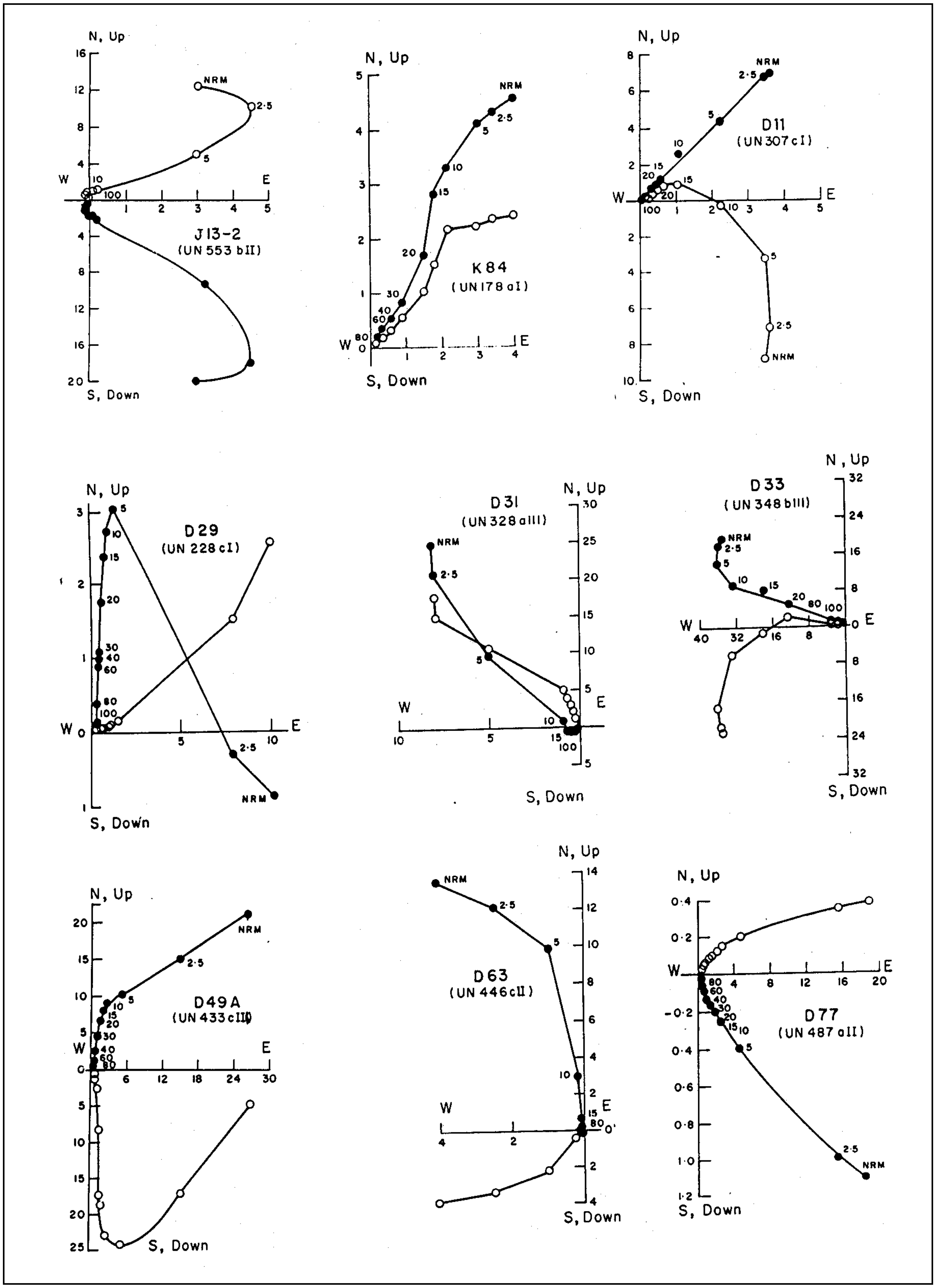

Figure 2. Response of remanent magnetic vector of dolerite dykes surrounding the Cuddapah Basin subjected to pilot study using AF demagnetization method. Orthogonal plots of horizontal component plotted along the E-W plane and vertical component along the N-S plane. Solid (open) circles denote the plot of horizontal (vertical) component. Numbers refer to the peak alternating fields in mT and intensities in units of A/m (10^{-3} emu/cc).

the dykes exhibit removal of a weak viscous overprint in low AF fields of the order of 5 – 15 mT. The remanent magnetic vector has been found to move towards the characteristic remanent vector during successive demagnetization from all the dykes. In case of some specimens there is not much change in the remanent magnetic vector (which is ChRM itself) during the successive steps of demagnetization (J4, K84). Specimens from dykes J13 – 2, K85, D8, D29, D33, D33A, D50, D63, D75, D77, DT1 and DT2 after removal of weak viscous components in low fields of about 5 - 15 mT the remanent vector reaches the characteristic remanent vector position by exhibiting stable end points. In case of some other dykes the specimens change the remanent inclination from downward to upward in varying fields between 5 – 15 mT and reach the ChRM position with a stable end point retaining the changed inclination (J2, J5, J15, K85, D8, D11, D30, D33, D33A, D49A, D63 and DT3). Specimens from dykes D32 and D49A exhibit downward inclination retain it without any change. Typical examples of these characteristics of the remanent vector in these dykes to the pilot AF study are shown as orthogonal plots (Zijderveld diagrams) in Figure 2 that depict the remanent vector variation and intensity decay pattern at successive intervals of demagnetization treatment.

NRM intensity drops rapidly to 10 – 15% during the initial demagnetization between 5 – 10 mT and thereafter remains almost constant till the end of the entire demagnetization treatment up to 80 – 100 mT without much change in its magnetization vector after reaching its stable position. Some specimens reveal removal of weak viscous magnetic components at these low fields of 5 – 10 mT. It has been found that AF demagnetization is quite effective in revealing characteristic magnetization in these dyke samples. In these Zijderveld diagrams, the remanent magnetic vector ultimately reveals presence of single component after demagnetization between 5 – 10 mT and passes through the origin indicating stable nature. Removal of weak viscous components, presence of single remanent vector, change in magnetic inclination etc. are clearly depicted in these diagrams (Fig. 2).

Thermal Demagnetization

In order to evaluate the characteristic remanent magnetic vector in these dykes, at least two specimens from each site were also subjected to pilot study by thermal demagnetization method. The specimens were heated in increasing temperatures in steps of 100, 200, 300, 400, 450, 500, 550, 580 and 600 ^{0}C and in some cases up to 630 and 680 ^{0}C and the remanent vector was measured after cooling to room temperature after each heat treatment. It has been observed that during these studies the vector shows similar behaviour in general as observed during AF demagnetization. In case of some dykes the remanent vector shows no change during successive heating steps accompanied by slow drop in intensity until their blocking temperatures of 580 to 680 ^{0}C (J1, J4, J5, K84, DT1, DT3, D30, D62 etc.). In case of few other dykes the vectors move during each step of heating reaching their characteristic magnetization position accompanied by intensity decay (K85, D30A, D31, D33A, D50, D49A, D63, D75) where the intensity drops below the detection level. Specimens from dykes (J2, J13, J14, J15, D8, D11, D32, D33, D50, D76) show large migration after heating to beyond 580 ^{0}C. Typical examples of the above behaviour is shown as orthogonal plots (Zijderveld diagrams) in Figure 3. The Zijderveld diagrams of pilot study reveal removal of soft viscous components at low temperatures upto 300 – 400 ^{0}C and thereafter reveal single component as can be seen from the remanent vector passing through the origin. The samples exhibit a continuous movement of the remanent magnetic vector towards the origin without any superimposed components. After removal of the superimposed viscous components some samples exhibit change in inclination from positive to negative (D30A, D49A, D63). With regard to the intensity fall, during the thermal demagnetization the intensity fall is seen beyond 580 ^{0}C indicating magnetite to be remanent carrier in these dolerites.

From the pilot study behaviour of these dolerite dyke samples to A.F. and thermal demagnetization studies, effective peak AF fields and temperatures were determined for each site to isolate the characteristic remanent magnetization following Zijderveld (1967) and Kirschvink (1980). Thus the remaining specimens were demagnetized at selected peak fields of 15 – 30 mT and 450 – 580 ^{0}C and the remanent vector was measured. Specimen and sample mean vectors were averaged to obtain sample and site mean vectors by the use of Fisher (1953) statistical analysis. Site mean vectors of the several intersecting dykes under study are shown with their circles of confidence in Fig.4. The mean vectors, VGP's corresponding to these vectors and other parameters are listed in Table 2.

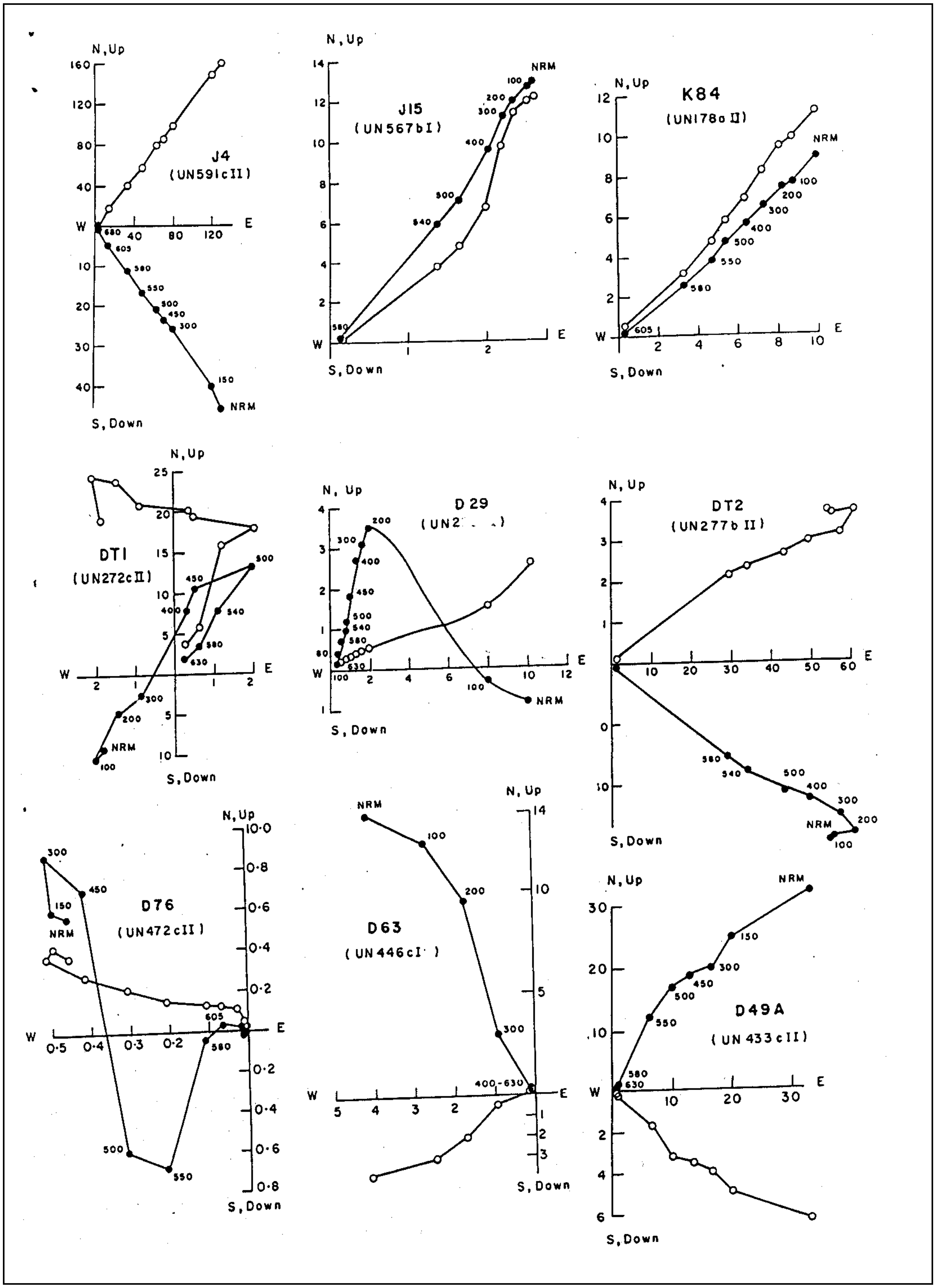

Figure 3. Orthogonal plot of response of remnant magnetic vector of dolerite dykes out side the Cuddapah Basin subjected to pilot study using thermal demagnetization method. Horizontal component plotted along the E-W plane and vertical component along the N-S plane. Solid (open) circles denote the plot of horizontal (vertical) components. Numbers refer to the peak temperatures in degrees Celsius and intensities in units of A/m (10^{-3} emu/cc).

Table 2. Palaeomagnetic data of some intersecting dykes surrounding the Cuddapah Basin

	Dyke	Strike	N	n	Dm	Im	K	α_{95}	λ_p	Lp
				Simultaneous Emplacement						
1.	J1	N 15 E	5	28	53	-67	39.1	10.2	9 N	228 E
	J2	N 15 W	5	30	32	-54	18.8	14.4	30 N	229 E
2.	K84	N 80 E	5	29	20	-66	25.9	13.7	23 N	244 E
	K85	N-S	6	32	350	-62	26.0	11.2	29 N	266 E
3.	D10	N 60 E	10	45	357	-54	6.3	18.6	40 N	261 E
	D11	N 40 W	6	31	22	-72	34.4	9.7	15 N	240 E
4.	D28	N 50 W	5	33	70	-57	11.3	18.6	6 N	209 E
	D29	N 50 E	5	28	50	-66	19.9	15.7	13 N	226 E
	D30	N 50 W	8	50	51	-64	22.3	11.2	14 N	223 E
	D30A	N 50 E	5	37	51	-46	30.1	11.4	25 N	208 E
5.	D33	N 50 E	15	93	237	-69	142.9	6.8	31 N	295 E
	D33A	N 65 W	5	30	222	-73	20.5	13.8	37 N	282 E
6.	DT1	N 55 E	5	40	54	-69	26.6	12.1	8 N	228 E
	DT2	E-W	5	39	76	-34	14.8	16.3	8 N	189 E
	DT3	N 25 W	5	44	49	-65	11.8	18.3	14 N	225 E
				Multiple Emplacements						
1.	J4	N 70 W	4	23	108	-65	20.6	17.8	25 S	214 E
	J5	N 15 E	5	30	28	-36	13.6	17.0	44 N	222 E
2.	J13-1	E-W	6	34	22	-65	8.7	21.2	23 N	243 E
	J13-2	E-W	5	30	146	-48	13.0	17.0	33 N	295 E
	J14	N 15 W	12	71	218	-62	5.1	18.0	48 S	302 E
	J15	N 20 E	6	36	40	-66	26.5	11.1	16 N	233 E
3.	D7	N 50 W	6	41	339	-77	70.1	7.5	9 N	266 E
	D8	N 70 E	6	39	69	-48	72.4	6.7	10 N	201 E
4.	D31	N 35 W	5	32	191	-70	13.9	16.8	49 S	268 E
	D32	N 80 E	5	30	258	+57	10.2	19.6	0	27 E
5.	D49A	N 25 E	6	33	79	+33	17.4	13.7	15 N	133 E
	D50	N 50 W	5	25	273	-69	32.9	12.2	10 S	296 E
6.	D62	N 50 W	7	41	1	-65	16.8	12.9	29 N	257 E
	D63	N 25 E	6	36	241	-78	117.0	7.5	24 S	280 E
7.	D75	N 10 E	7	42	316	-28	15.5	14.5	38 N	316 E
	D76	N 85 E	7	39	255	-55	9.6	17.1	21 S	315 E
	D77	N 60 W	5	21	109	-55	6.3	32.2	24 S	201 E

N = No. of Samples; n = No. of Specimens;
Dm = Mean Declination; Im = Mean Inclination
K = Precision Parameter; α_{95} = Radius of Circle of Confidence;
λ_p = Latitude of the VGP; Lp = Longitude of the VGP

DISCUSSION

The Cuddapah Basin is considered to be one of the best studied Precambrian intracratonic basins in the world. The tectonics of the Cuddapah Basin is considered to be most complicated and remarkable. Several studies carried out by various workers such as King (1872), Narayanaswami (1966), Balakrishna, Christopher & Ramana Rao (1967), Sen & Rao (1967), Kaila & Bhatia (1981), Kaila & Tewari (1985), Kaila et al. (1987), Murthy et al. (1987), Venkatakrishnan & Dhothiwala (1987) among others have greatly enhanced our understanding of the tectonics of the basin. It has been emphasized that igneous activity surrounding the basin played a dominant role in the development of this basin (Bhattacharji & Singh 1984). Therefore, a thorough understanding of the phases of these thermal expansion events in the form of dyke swarms will throw more light on the development stages. One property, which can record these events, is their magnetization that can be seen in terms of different directions of magnetization.

A large number of dyke swarms surrounding the Cuddapah Basin were investigated by Murthy et al. (1987) for their petrography, geochemistry, geochronology, field relationship etc., to identify the phases of dyke emplacements. These studies resulted in three to four episodes of dyke intrusions in these swarms. Among these dykes intersecting dyke sets at thirteen places have been noticed. At most of these intersections the dykes strike nearly NW – SE and NE – SW and at two places there are dykes striking ENE to E – W orientation also as shown in Figure 1. The characteristic remanent magnetic directions obtained after magnetic field (AF) and thermal demagnetization of these intersecting dykes are listed in Table 2 along with their strikes, VGP's and other statistics.

Doubts were expressed about the acquisition of magnetization by dykes (Strangway 1961). However, studies by Evans (1968, 1987) provided evidence by the agreement of palaeomagnetic poles of dykes with sills and sediments as well as dykes and baked contacts. Hence we can consider that the dykes faithfully record the magnetic field at the time of their emplacement. Therefore, it is possible to know whether there is simultaneous emplacement of dykes or not of the intersecting orthogonal sets by a study of their magnetic signatures. An examination of Table 2 and Figure 4 will reveal among the dykes surrounding the Cuddapah Basin with intersecting dykes, there is evidence for both simultaneous and periodic emplacement of dyke emplacements in these intersecting dykes.

At Five of these intersecting dyke sets striking mostly along NW - SE and NE - SW (J1 – J2, D10 – D11, D28 – D29, D33 – D33A) and N – S and E – W (K84 – K85) directions reveal identical characteristic directions of magnetization indicating simultaneous emplacement of dykes along both the orientations (Fig. 4a). Whereas in the remaining intersecting dyke sets scattered directions of magnetization from one another (J4 – J5, J13 – J14 –J15, D7 – D8, D31 – D32, D49 – D50, D62 – D63, D75 – D76 – D77 and DT1 – DT2 – DT3) indicating multiple phases of dyke emplacement (Fig. 4b). At some intersections involving more than two dykes both simultaneous and periodic emplacements are evident. In an intersection involving four dykes D28 – D29 – D30 – D30A with NE and NW striking dykes there is simultaneous emplacement revealed by identical directions of magnetization with intersecting circles of confidence as shown in Figure 4a.

In the J13 – J14 – J15 intersecting dyke set, there are two sites on dyke J13 striking E – W and one site each from dyke J14 (NNW) and dyke J15 (NNE). There is simultaneous dyke emplacement along J13 – 1 and J15 and periodic emplacement again along J13 – 2 and J14. Therefore, it appears in total there are three phases of dyke intrusions in this set. In two other dyke sets involving three dykes each i.e. DT1 – DT2 – DT3 and D75 – D76 – D77 there are two and three phases of dyke emplacements respectively. While there are simultaneous emplacements along dyke DT1 (NE) and dyke DT3 (NW) in the DT1 – DT2 – DT3 intersection with DT2 (E – W), there are three phases of dyke intrusions in the D75 – D76 – D77 intersection. The field relations here reveal that DT2 cuts both the NE (DT1) and NW (DT3) trending dykes. The ChRM directions of these dykes are shown in Figure 4b.

From the dyke map of the Cuddapah Basin (Murthy et al. 1987) it appears that dykes J4 and J13 are to be same striking approximately in the same direction but the remanent magnetic directions indicate that these dykes belong to two phases of dyke intrusions in the same direction at different periods. Similar situation was also noticed in Karimnagar swarm striking NE – SW further north of Cuddapah Basin (Rao, Rao & Patil 1990) where two different directions of magnetization and both positive and negative anomalies were observed during their magnetic survey over the swarm (Subba Rao & Radhakrishna Murthy 1985). The dykes from the western margin of the Cuddapah Basin itself are good examples for this phenomenon. Here there are two sets of dykes along NW and NE orientation forming conjugate sets. There are two directions of magnetization in dykes striking NW while there are

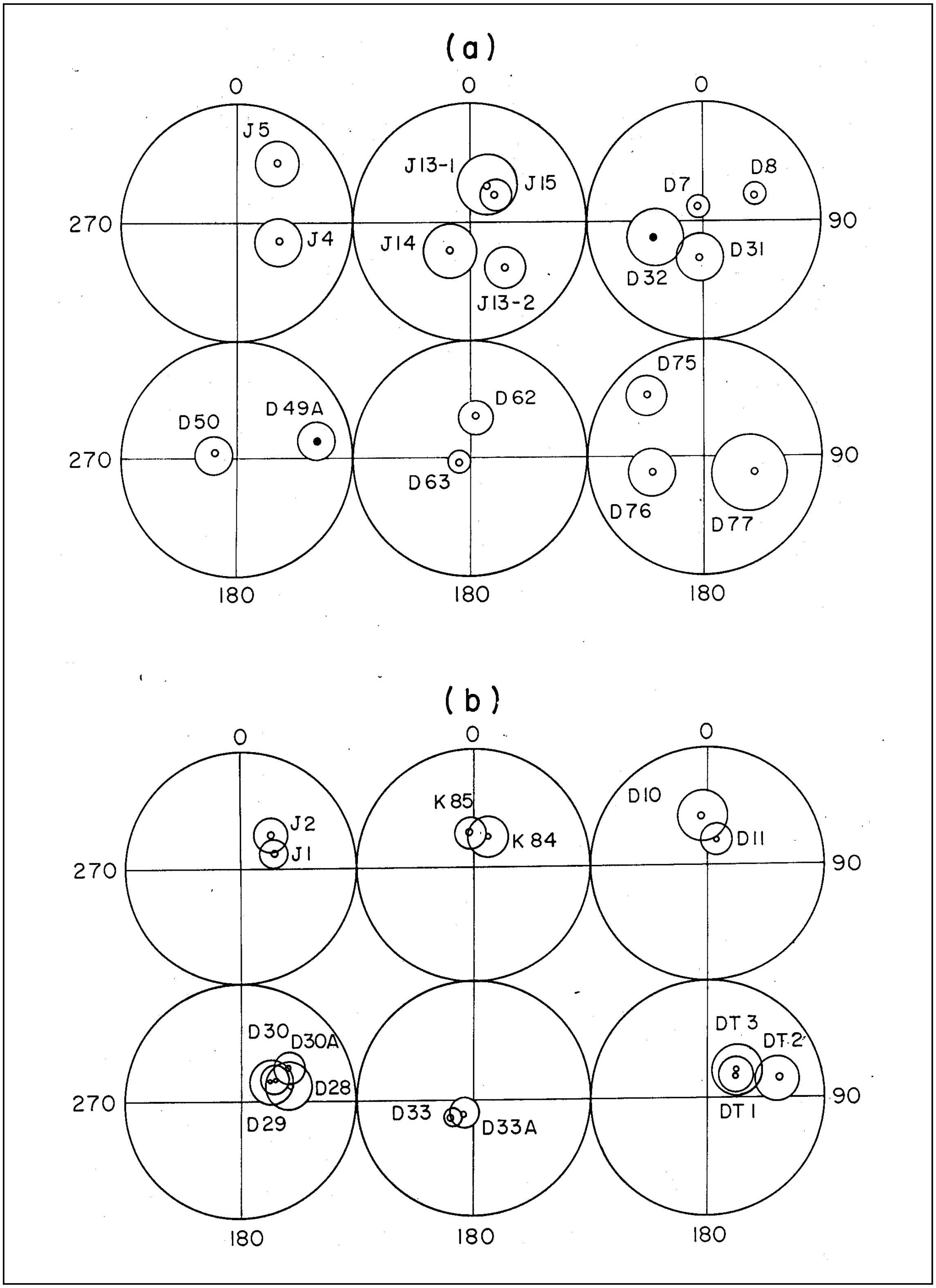

Figure 4. Stereographic plot of dyke mean characteristic remanent magnetic (ChRM) directions recovered after the AF and thermal demagnetization treatment. Solid (open) circles denote downward (upward) pointing inclinations. Circles around the ChRM directions denote circle of confidence. (a) for simultaneously emplaced dykes and (b) for dykes emplaced at different periods.

identical directions of magnetization in dykes forming conjugate sets along NE – SE (Poornachandra Rao 1992). These examples also confirm the possibility of dyke emplacement mechanism of simultaneous and multiple dyke phases suggested above.

CONCLUSIONS

Available isotopic dates of the dyke swarms around the Cuddapah Basin range between 2068 ± 79 and 656 ± 29 Ma. On the basis of these age data three major phases of dyke intrusions between 1900 – 1000 and a minor phase at 650 Ma have been suggested. This is in conformity with the worldwide dyke activity from a number of plates. The palaeomagnetic studies on the Cuddapah dyke swarms also reveal three to four major ChRM directions in agreement with the age data on them. The dyke emplacement mechanism suggests both intrusion into the preexisting joints and joints that develop during the intrusion in the country rock. There are three types of joints namely joints which predate the dyke intrusion, joints generated during the dyke intrusion and joints that post date the intrusion of dyke. The third type of joints will provide vents for the next intrusion. The present investigation of nature of magnetization in intersecting dykes surrounding the Cuddapah Basin confirms the above jointing pattern. In some orthogonal dyke systems there is simultaneous emplacement of dykes and in some others there are more than two phases of dyke intrusions. Two phases of dyking in joints along the same orientation is also noticed.

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