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Tectonics and Correlation of Upper Kaimur Group Sandstones by their Palaeomagnetic Study

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ABSTRACT

The Upper Kaimur Group rocks of the Vindhyan Supergroup are represented by sandstones all over the Vindhyan basin. These have been quite widely sampled for palaeomagnetic studies from Baghain Sandstone (Panna), Dhandraul Sandstone (eastern Son valley), Diken Sandstone (Rajasthan) and Dudauni Sandstone (Guna-Shivpuri) etc. in order to understand their contemporaneity and tectonics associated with them. Palaeomagnetic signatures from the Dhandraul Sandstone and Dicken Sandstone Formations were recovered from oriented samples collected by using laboratory alternating field and thermal demagnetization studies. Results of these studies are presented in this paper in detail that helps identify the ChRM vectors in these formations. The Dhandraul Sandstone from the Son valley revealed both normal and reverse magnetic directions with upward and downward inclinations and the Diken Sandstone from Rajasthan revealed only normal magnetic direction with downward inclination. The remanent magnetic signatures in the Dhandraul Sandstone imply two reversals of the geomagnetic field and indicate shallow northern and southern palaeolatitudinal positions for the Indian subcontinent during Neoproterozoic period similar to that of the Baghain Sandstone of the Panna region. The Dicken Sandstone revealing similar ChRM directions as that of the Malani Rhyolite result in intermediate northern palaeolatitude. Thus the results of our palaeomagnetic studies on the Dhandraul Sandstone and Dicken Sandstone of the Upper Kaimur Group correlate well giving a clear tectonic movement of the Indian subcontinent from intermediate northern hemisphere to the shallow southern hemisphere position during the Neoproterozoic times.

INTRODUCTION

The Vindhyan Basin is a very large intra-cratonic sedimentary basin of Meso-Neo Proterozoic eras in Central India exposed between Sasaram in Bihar in the east to Chittaurgarh in Rajasthan in the west occupying an area of 1,04,000 sq. km. It contains a sequence of sandstone-shale-limestone deposited in several sub-basins over a period of nearly 1Ga (Soni, Chakraborty & Jain 1987). Correlation of contemporaneous rocks in these basins is a difficult task. A number of properties of these rocks are used for correlation such as lithological similarities, radiometric dates, fossil presence, primary sedimentary features, tectonic evidences etc. These have been broadly divided in to four major groups namely the Semri, Kaimur, Rewa and Bhander based on lithological similarities (Auden 1933) and in to Lower and Upper Vindhyans on the basis of major tectonic (major unconformity) evidences (Mallet 1869). There is another property of these rocks that can be used in their correlation. It is the remanent magnetic signatures of the rocks that is acquired at the time of their deposition. Magnetic minerals in rocks align themselves along the direction of the Earth's magnetic field and this alignment is retained even after consolidation throughout the geological time. This would serve as a record of the geomagnetic field that can be made use of in correlation of the rocks formed at a particular period of time in their history as well as in understanding the tectonics of the region (Irving 1964; McElhinny 1973). This remanent magnetic record in the Kaimur Group rocks of Vindhyan Supergroup is made use of in correlating them from far apart regions in the east and west of the Vindhyan Basin in this study. On the basis of palaeomagnetic signatures in the Upper Kaimur Dhandraul Sandstone in Son valley and Dicken Sandstone in Rajasthan are examined for their possible correlation that provide an excellent technique and proved to be very useful. Remanent magnetic signatures of these rock formations are also used to understand the drift

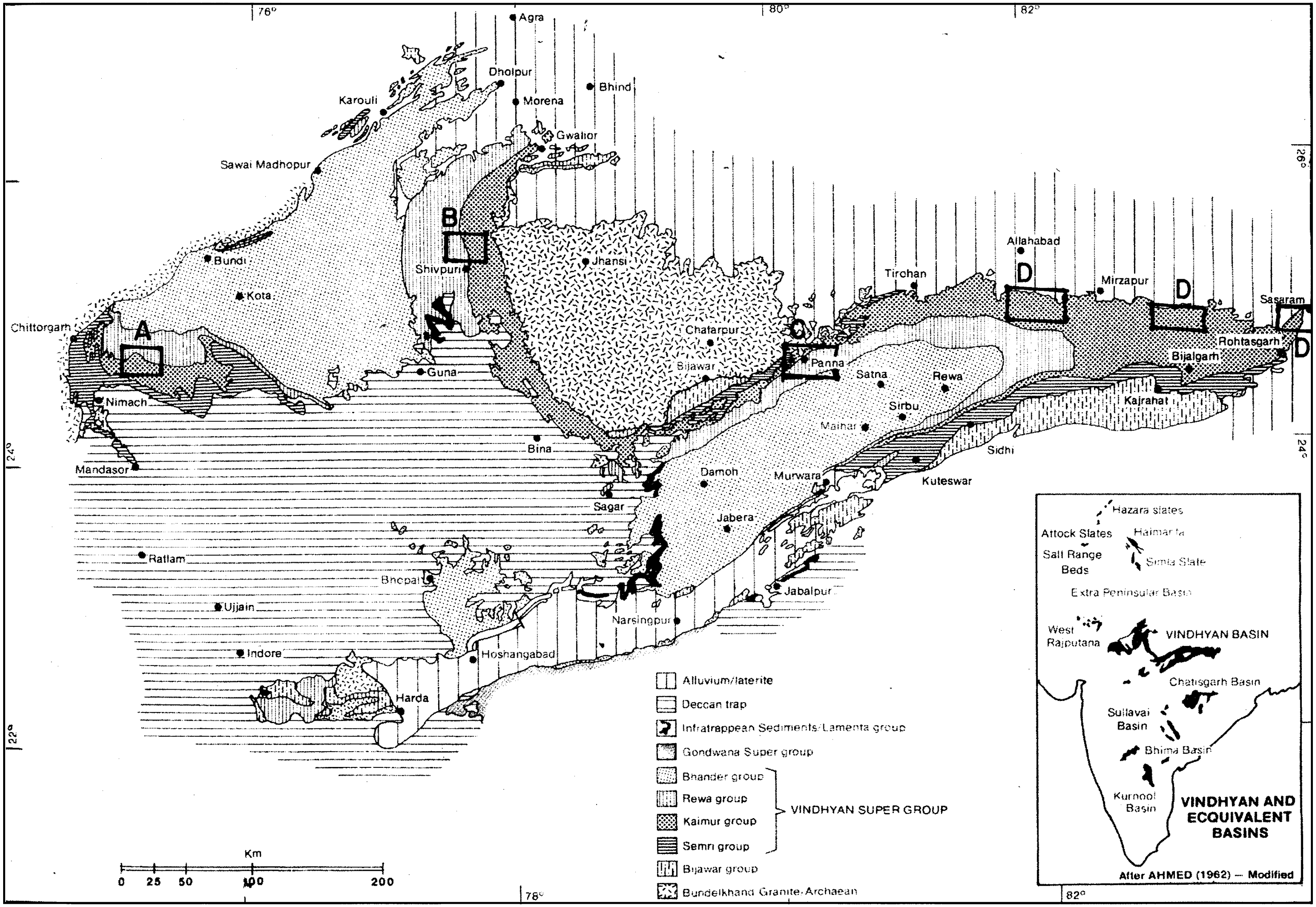

Figure 1. Geological map of the Vindhyan basin (after Soni et al. 1987) also showing the adjacent formations such as Bijawars, Bundelkhand Granite Massif and Deccan Traps. The rectangles from west to east denote A) Dicken Sandstone, B) Dudauni Sandstone, C) Baghain Sandstone and D) Dhandraul Sandstone Formations.

history of the Indian subcontinent during the period of deposition of these sediments and fill the gap in the data for this time interval.

GEOLOGY AND SAMPLING

The Vindhyan basin in Central India is an intra-cratonic sedimentary basin with sandstone-shale-limestone sequences. It covers a very long period of 1600-400 Ma during Meso-Neo Proterozoic eras and exposed over 1,04,000 sq. km in the states of Bihar, Uttar Pradesh, Madhya Pradesh and Rajasthan with a total thickness of 4000-5000 m (Soni, Chakraborty & Jain 1987). Geology of the Vindhyan Basin is shown in Fig.1. The Vindhyan Supergroup of rocks are mainly divided in to Semri, Kaimur, Rewa and Bhander Groups both in the Son valley in the east and Rajasthan in the west on the basis of lithological similarities. The stratigraphy of the Vindhyan Supergroup rocks in the Son valley, Guna-Shivpuri and Rajasthan regions is given in Table 1 (after Soni, Chakraborty & Jain 1987).

In the absence of distinct and conventional faunal / floral assemblage the Vindhyan Supergroup rocks are estimated to range between lower Riphean to Carboniferous period and exact period of sedimentation in this basin remained an enigma. Soni, Chakraborty & Jain (1987) suggest that the Vindhyan sedimentation took place between 1400 – 400 Ma taking in to account all the available fossil and radiometric dates in to consideration till then. Some glauconitic rich rocks belonging to the Semri Group have been dated using K-Ar methods whereas the other groups are devoid of any suitable material for radiometric dating. The K-Ar dating by Vinogradov et al. (1964) and Tugarinov et al. (1965) of Semri and Kaimur Groups of rocks indicated an age between 1400-910 Ma. The Khairmalia Andesite, at the base of the Semri Group in Chittorgarh area, has been dated at 1250 Ma by Crawford & Compston (1970). The Majhgawan kimberlite intruding the Upper Kaimur Dhandraul Quartzite / Baghain Sandstone has been dated to be of 1140 ± 12 Ma (Crawford & Compston, 1970), 1130 ± 20 Ma Lovering (cited in Grantham 1969) and 1120 ± 45 Ma (Paul, Rex & Harris 1975). Azmi (1998) reported small shelly fossils of Cambrian affinity from the Rohtasgarh Limestone in Son Valley that spurted radiometric dating of several Semri Group rocks in recent years. Several Rb-Sr and U-Pb dating of Semri Group rocks yielded ages around 1600 Ma for the initiation of sedimentation in the Vindhyan basin (Kumar, Gopalan & Rajagopalan 2001; Ray et al. 2002; Ray, Veizer & Davis 2003; Rasmussen et al. 2002). A palaeomagnetic study of Khairmalia Andesites by Poornachandra Rao et al. (2004) extend the initiation of Vindhyan sedimentation to 1650 Ma on the basis of ChRM isolated from them. In the light of these evidences it is considered that the Vindhyan sedimentation lasted for a very long period of time of 1650 – 400 Ma.

The Upper Kaimur rocks are named as Dhandraul Sandstone in eastern Son valley, Dudauni Sandstone in Guna-Shivpuri and Dicken sandstone in Rajasthan. In Panna region these are referred to as Bhaghain Sandstone and as Binder sandstone in Bhopal inlier (Soni, Chakraborty & Jain 1987). We have collected 76 oriented block samples from 14 sites of upper Kaimur formations from eastern Son Valley, Guna-Shivpuri and Rajasthan (Fig. 1). The sampling details are as follows.

Region	Formation	Sites	Samples
Son Valley	Dhandraul Sandstone	6	40
Guna-Shivpuri	Dudauni Sandstone	3	15
Rajasthan	Dicken Sandstone	5	21

Cylindrical specimens of standard dimension 2.5 cm diameter and 2.2 cm long were prepared from these samples to investigate remanent magnetic direction in these samples. The Dudauni Sandstone from Rajasthan could not be cored and cut in to cylindrical specimens as they are more quartzitic in nature. In order to core these samples special diamond core drill bits were imported and studies on them would be taken up at a later stage. Therefore, we describe the results of remanent magnetization of Dhandraul Sandstone and Dicken Sandstone only and compare them with that of Baghain Sandstone from Panna region (Poornachandra Rao et al. 1997) and Malani Rhyolites (Athavale, Radhakrishnamurty & Sahasrabudhe 1963; Klootwijk 1975; Torsvik et al. 2001) to examine their correlation and other tectonic implications.

PALAEOMAGNETISM

Remanent magnetic directions and intensities of the specimens were measured using a Schonstedt spinner magnetometer (Model DSM-2) and Susceptibilities by Bartington Susceptibility System (Model MS2). The magnetic character of the rocks has been established by AF method on an AF demagnetizer similar to that described by Creer (1959) and by thermal method using a Schonstedt thermal demagnetizer (Model TSD-1). Natural Remanent Magnetic (NRM) directions of specimens from the 6 sites of Dhandraul Sandstone show varying amounts of groupings. One

Table 1. Stratigraphy of Vindhyan Supergroup in Son Valley, Guna-Shivpuri and Rajasthan (after Soni, Chakraborty & Jain. 1987)

Group	Son Valley	Rajasthan	Guna-Shivpuri
	Maihar Sandstone	-	Upper Bhander Sandstone
	Sirbu Shale	-	Sirbu Shale
Bhander	-	Tilsava Sandstone	Lower Bhander Sandstone
	Nagod Limestone	Singoli Limestone	Bhander Limestone
	Simraval Shale	-	Ganurgarh Shale
	Gahadra Sandstone	Umar Sandstone	Sanwara Sandstone
Rewa	Jhiri Shale	Ratangarh Shale	Kolaras Shale
	-	Dehpur Sandstone	-
	-	Deopura Shale	-
	Dhandraul Sandstone	Dicken Sandstone	Dudauni Sandstone
Kaimur	Bijaigarh Shale	Panoli Shale	Balabehat Shale
	-	Morwan Sandstone	Sumen Sandstone
	Hinauti Limestone	Suket Shale	-
	-	Nimbahera Limestone	-
	-	Bari Shale	-
	-	Jiran Sandstone	-
Semri	-	Khori-Malan Conglomerate	-
	Deonar Porcellinite	Palri Shale	-
	-	Sawa Sandstone	-
	Kuteswar Limestone	Bhagwanpura Limestone	-
	Kanwar Shale	Bandki Shale	-
	Deoland Sandstone	Khardeola Sandstone	-
	-	Khairmalia Andesite	-

site (Site 7) shows only normal magnetic direction with downward inclination and two sites (Site 8 and 21) show both normal and reverse magnetic directions with downward and upward inclinations. Of the remaining, two sites show (Site 9 and 24) only normal magnetization with both downward and upward inclination and another site (Site 6) shows scattered directions with upward and downward inclinations . These NRM directions are shown in Fig. 2a site-wise. The Dicken Sandstone from Rajasthan reveal only normal magnetization with steep downward inclination with varying amounts of scatter and are shown in Fig.2b. NRM intensity (Jn) and Susceptibility (K) of the Dhandraul Sandstone and Dicken Sandstone formations are as follows:

	Jn x mA/m	K x 10^{-3}SI Units
Dhandraul Sandstone	0.1——23.0	1.0——20.0
Dicken Sandstone	1.4——19.3	0.3—— 4.0

Selected specimens from each site of Dhandraul Sandstone and Dicken Sandstone representing all groups of NRM directions were subjected to laboratory demagnetization using AF and thermal fields to study their magnetic and thermal history and recover the ChRM from each site. The specimens were subjected to stepwise demagnetization in increasing alternating magnetic fields (AF) at intervals of 5-10 mT up to a peak field of 100 mT and measured their remanent magnetic direction after each step of demagnetization. Since haematite is the carrier of remanence in the sandstone samples, these samples do not show much decay in intensity (Irving 1964; McElhinny 1973) while retaining the NRM vector till the maximum peak field that is applied to these samples. Typical examples of response of remanent vector to AF fields from these formations are shown in Figs 3a and b as Zijderveld (1967) diagrams. Peak fields of 20-30 mT have been selected for demagnetization of these samples to recover the ChRM vector from these samples.

Table 2a. Dhandraul Sandstone

Site No.	N (n)	Dm	Im	K	α_{95}	λp	Lp	δp	δm	λm
					GROUP – A					
6	4 (13)	355	+66	10.31	21.8	66.3	75.8	35.6	29.1	48.3
7	6 (22)	352	+30	15.14	14.69	78.6	305.6	16.3	9.0	16.1
8	6 (20)	2	+37	512.15	2.53	85.2	239.6	3.0	1.7	20.6
8	2 (5)	183	-44	490.76	4.47	87.2	157.9	5.6	3.5	25.8
9	4 (7)	14	+50	7.97	24.79	76.3	143.5	19.5	13.0	30.8
9	1 (3)	158	-65	-	-	61.8	49.3	-	-	47.0
21	2 (9)	8	+31	18.12	23.26	79.4	214.1	26.1	14.6	16.7
21	6 (20)	178	-39	26.71	11.06	87.2	301.7	13.2	7.9	22.0
24	7 (10)	27	+9	40.88	8.28	57.4	203.6	8.4	4.2	4.5
Mean	**Sites 8**	**5**	**+42**	**14.04**	**13.21**	**-**	**-**	**-**	**-**	**25.8**
					GROUP – B					
6	3 (10)	353	-48	15.5	20.53	35.5	271.6	26.8	17.5	-29.0
6	2 (7)	210	+49	431.01	4.77	28.0	237.7	6.3	4.2	-29.9
9	3 (10)	25	-45	30.59	14.61	33.2	235.3	18.5	11.7	-26.6
24	7 (7)	17	-17	29.15	9.80	53.2	232.0	10.1	5.2	-8.7
Mean	**Sites 4**	**16**	**-41**	**17.89**	**16.55**	**-**	**-**	**-**	**-**	**-23.5**

Table 2b. Dicken Sandstone

Site No	N (n)	Dm	Im	K	α_{95}	λp	Lp	δp	δm	λm
35	6 (17)	357	+51	8.75	19.32	82.5	55.1	26.1	17.7	31.7
36	5 (19)	355	+50	30.17	11.40	82.5	40.2	15.2	10.2	30.8
37	5 (17)	352	+73	90.13	6.60	55.7	67.7	11.8	10.5	58.6
38	5 (16)	5	+75	78.96	7.05	52.8	77.4	12.9	11.7	61.8
Mean	**4 Sites**	**356**	**+62**	**35.10**	**11.82**	**70.9**	**66.9**	**18.4**	**14.3**	**43.6**

N = Number of samples,
Dm = Mean Declination;
K = Precision Parameter;
λp = Latitude of VGP,
δp = Semi-major axis of ellipse of confidence;
λm = Palaeolatitude of reference town (Nagpur)
n = Number of specimens;
Im = Mean Inclination;
α_{95} = Radius of Circle of Confidence;
Lp = Longitude of VGP,
δm = Semi-minor axis of ellipse of confidence;

Thermal history of the samples has been investigated by subjecting them to stepwise thermal demagnetization in increasing temperatures of 100, 200, 300, 400, 450, 500, 550, 580, 625, 650, 675 and 680 °C on a pilot basis. The specimen remanent intensity remains constant throughout the heating treatment and drops suddenly at 680°C indicating their blocking temperature due to haematite. The remanent vector does not show much change indicating their stable character. Some specimens, which are away from the ChRM direction, move towards the mean ChRM direction in successive heating steps. Typical behaviour of these samples to pilot thermal study is shown in Figs 4 a and b as Zijderveld (1967) diagrams. At temperatures between 500-600 °C the specimens indicate very good grouping and the specimens were treated at these temperatures to recover the ChRM direction from these samples. Peak AF fields and temperatures were selected by a study of the pilot specimen demagnetization spectra using Kirschvink (1980) methods in isolating the ChRM vectors from these rocks. In Fig.5 the ChRM directions of

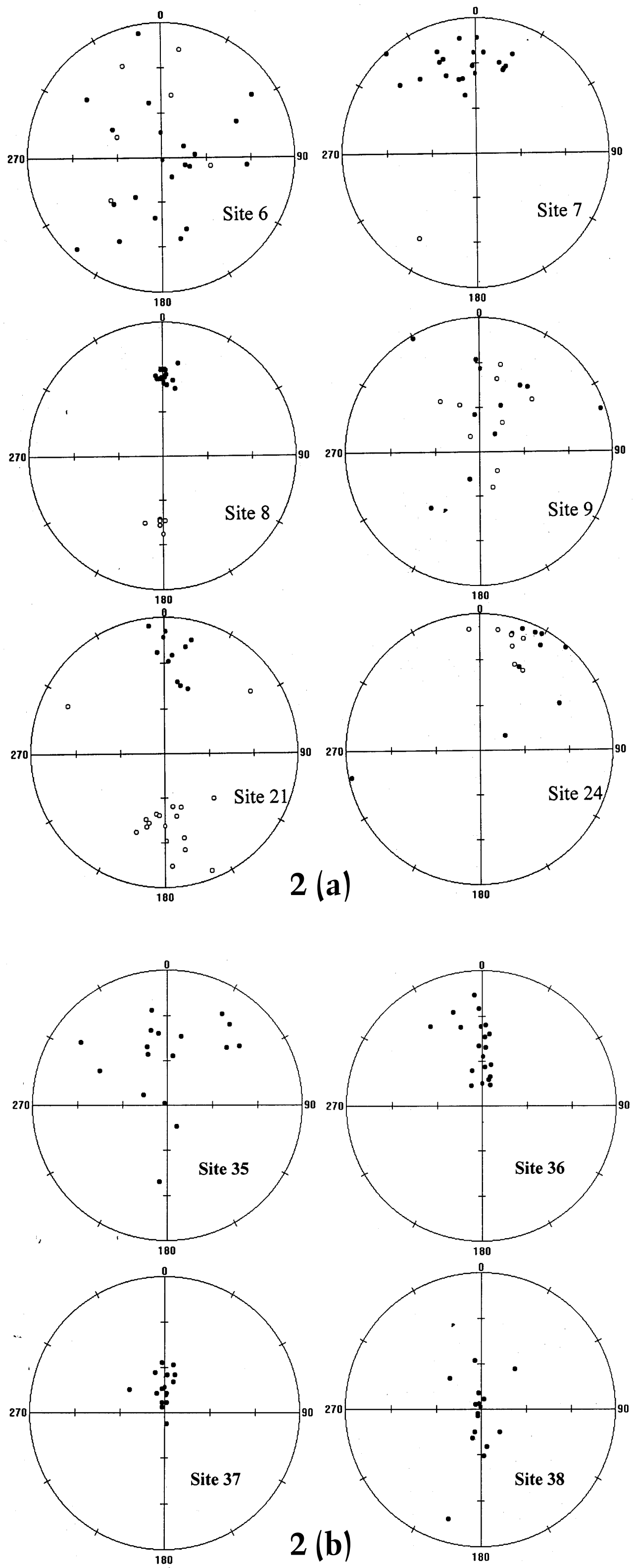

Figure 2. Stereographic plots of site-wise NRM directions of (a) Dhandraul Sandstone and (b) Dicken Sandstone Formations. Solid (open) circles denote downward (upward) pointing inclinations.

Dhandraul Sandstone and Dicken Sandstone are shown site-wise that are obtained as a result of laboratory demagnetization of these samples.

The ChRM directions recovered from each specimen by AF and thermal demagnetization were averaged using Fisher (1953) statistical methods to get sample and site mean directions. The site mean ChRM directions of Dhandraul Sandstone and Dicken Sandstone are shown in Figs 5a and b and listed in Table 2. The Dhandraul Sandstone at two sites (8 & 21) exhibit normal and reverse magnetic directions with downward and upward inclinations respectively and normal magnetization with downward inclination at one site (7). Of the remaining sites, two sites (6 & 9) exhibit normal magnetization with both downward and upward inclinations and reverse magnetization with downward inclination. Another site (24) shows normal magnetization with downward and upward inclinations (Fig.5a). The magnetic directions of samples from all sites are divided in to A and B Groups exhibiting normal and reverse magnetization with downward and upward inclinations respectively and vice-versa. These Groups are thus having mean ChRM directions of A) Dm = 5, Im = +42 (K = 14.04, α_{95} = 13.21), λm = 25.8 °N and B) Dm = 16, Im = -41(K = 17.89, α_{95} = 16.55), λm = 23.5 °S. The magnetization of samples from all 4 sites of Dicken Sandstone are normal with steep downward inclination, except two samples from site 38 also showing reverse magnetization with steep downward inclination (Fig. 5b). The mean ChRM direction of Dicken Sandstone is Dm = 356, Im = +62 (K = 35.1, α_{95} = 11.82). This ChRM direction results in a VGP at λp = 70.9 °N, Lp = 66.9 °E and a palaeolatitude of (λm) 43.6 °N.

DISCUSSION

The Vindhyan Supergroup rocks are exposed in a crescent shaped basin in an area of over 1,04,000 sq. km. in central India. These are divided in to four groups namely Semri, Kaimur, Rewa and Bhander and these have been correlated on the basis of major tectonic, structural and lithological basis among several sub-basins. We are using yet another property of the formations in the Vindhyan Supergroup for their correlation. This property is their remanent magnetic signature and the horizon is the Upper Kaimur Group. The Upper Kaimur rocks at different places in several sub-basins are differently named. These are Dhandraul Sandstone in the Son valley, Baghain Sandstone in Panna region, Dudauni Sandstone in Guna-Shivpuri region and Dicken Sandstone in Chittaurgarh (Rajasthan) (Fig.1 D, C, B & A). Poornachandra Rao

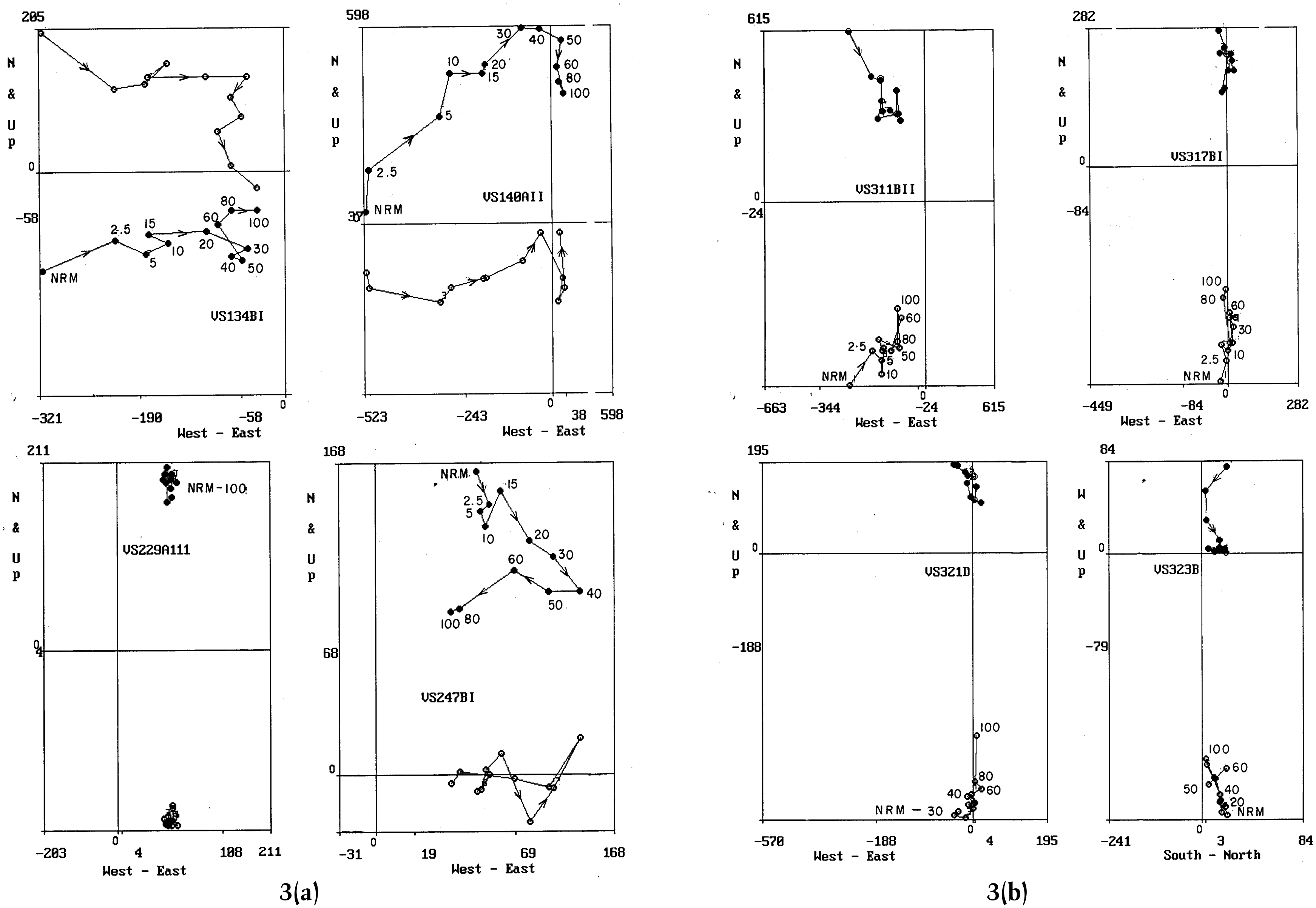

Figure 3. Zijderveld (1967) plots of pilot specimen behaviour to AF demagnetization of (a) Dhandraul Sandstone and (b) Dicken Sandstone. Solid circles denote projection of the endpoint of remanent magnetic vector on the E-W horizontal plane and open circles on N-S vertical plane. Numbers refer to peak alternating field and all intensities are in mA/m.

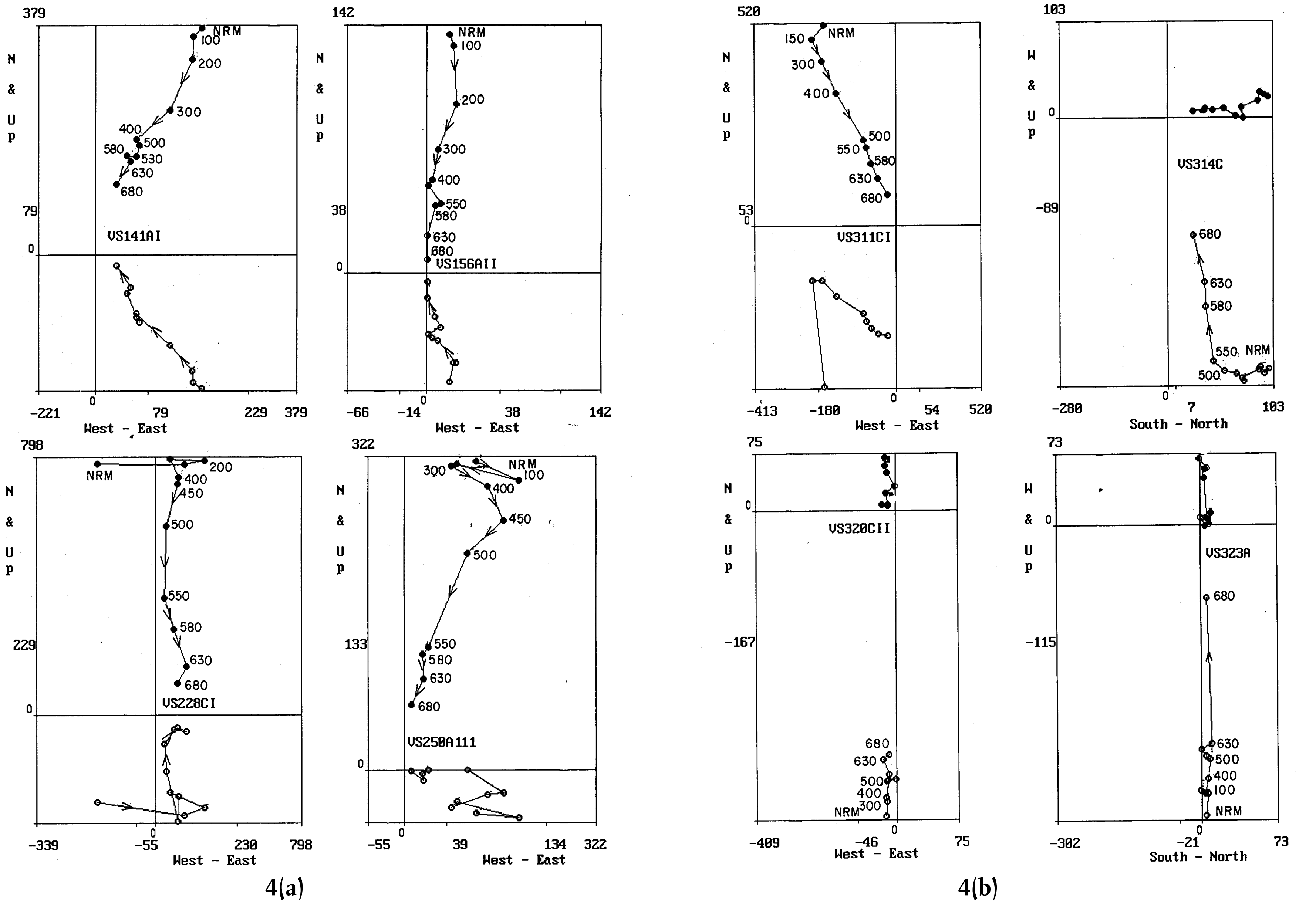

Figure 4. Zijderveld (1967) plots of pilot specimen behaviour to thermal demagnetization of (a) Dhandraul Sandstone and (b) Dicken Sandstone. Solid circles denote projection of the endpoint of remanent magnetic vector on the E-W horizontal plane and open circles on N-S vertical plane. Numbers refer to peak temperature and all intensities are in mA/m.

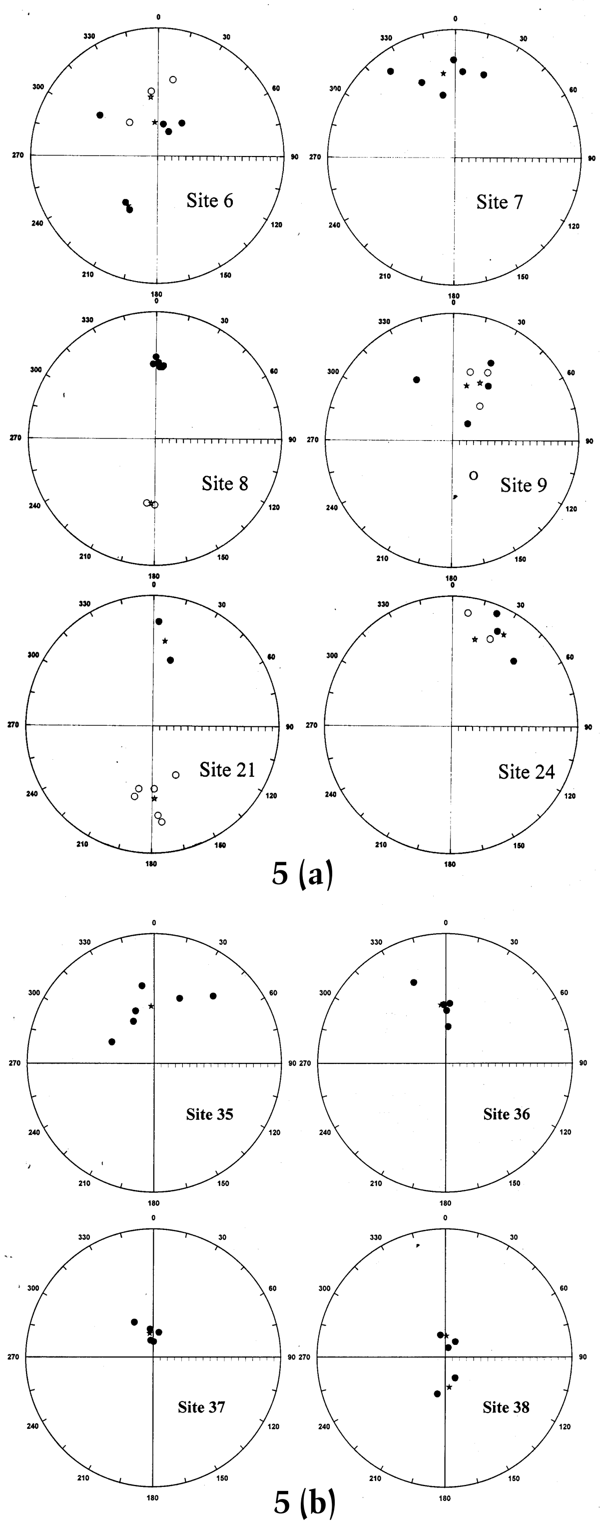

Figure 5. Stereographic plots showing sample mean ChRM directions site-wise for (a) Dhandraul Sandstone and (b) Dicken Sandstone Formations. Solid (open) circles denote downward (upward) pointing inclinations. Stars indicate mean vector for each group sample mean vector at each site.

et al. (1997) have published the palaeomagnetic results on Baghain Sandstone from Panna region. These results reveal both normal and reverse magnetic directions with upward and downward inclinations. This implies two reversals of the geomagnetic field and result in palaeolatitudes of 18.4 °N and 28.4 °S indicating migration of the Indian sub-continent from northern to southern hemisphere between Malani Rhyolite and Rewa Sandstone periods.

The ChRM directions recovered from the Dhandraul and Dicken Sandstones formations are shown in Figs 5 a and b. It can be seen from this Figure 5a that there is very good similarity of site mean ChRM vectors of both Dhandraul and Baghain Sandstone (Fig. 4, Poornachandra Rao et al. 1997). The Dicken Sandstone shows only normal magnetic direction with steep downward inclination (Fig. 5b). From these ChRM directions it appears that the Upper Kaimur sedimentary rocks in the four sub-basins (regions) with identical remanent magnetic directions appears to have deposited simultaneously. In the Baghain Sandstone also there are some sites with normal and reverse magnetic directions, some sites with only normal magnetic directions with both upward and downward inclinations and some sites with reverse magnetic directions with downward inclinations (Fig.4, Table 2, Poornachandra Rao et al. 1997). Therefore, it is evident that these two formations (Dhandraul and Baghain Sandstone) with identical ChRM vectors from different sub-basins (regions) can be correlated. The ChRM directions of the Dhandraul Sandstone can be classified in to two groups as Group A and Group B. The Group A and Group B ChRM directions of the Dhandraul Sandstone with distinct magnetic signatures yield palaeolatitudes (λm) of 25.8 °N and 23.5 °S identical to that of the Baghain Sandstone with palaeolatitudes of 18.4 °N and 28.4 °S respectively. This also confirms the drift of the subcontinent from northern hemisphere to the southern hemisphere during their deposition in the Upper Kaimur period (~750 Ma). These palaeolatitudinal positions of the sub-continent are shown schematically in Fig.6 covering most of the Vindhyan period. Indian Precambrian palaeomagnetic data indicate that during most of the time it remained in the equatorial latitudes making rotational movements (Klootwijk 1976, 1979). Therefore, in the light of these data, the Upper Kaimur Group formations namely the Dhandraul Sandstone from the Son valley and the Baghain Sandstone from the Panna region may be correlated having deposited during the same time.

The Dicken Sandstone from Chittaurgarh area in SE Rajasthan revealed normal magnetic direction with steep downward inclination at all the 4 sites. Though these Dicken Sandstone also considered being of Upper Kaimur period, exhibit steeper inclinations than those of the Dhandraul and Baghain Sandstone formations. Dicken Sandstone is having similar ChRM directions and VGP data as that of the Malani Rhyolite at Jodhpur in northwestern Rajasthan. Dicken Sandstone is having a mean ChRM of Dm = 356, Im = +62 with a VGP of λp = 70.9 °N, Lp = 66.9 °E and a palaeolatitude (λm) of 43.6 °N. The mean ChRM of Malani Rhyolites from three independent studies (Athavale, Krishnamurty & Sahasrabudhe 1963; Klootwijk 1975; Torsvik et al. 2001) is Dm = 358, Im = +58 (K = 111.7, α_{95} = 7.65) with the corresponding VGP at λp = 76.7 °N, Lp = 66.6 °E and palaeolatitude of 43 °N. Thus the palaeomagnetic data of Dicken Sandstone and Malani Rhyolites suggest their correlation and the radiometric data of the Malani Rhyolite also help in dating the Dicken Sandstone to be of 750 Ma, an additional advantage of their correlation and assigning their age.

Further, the Dicken Sandstone shows a palaeolatitude of 43.6 °N and the Dhandraul Sandstone yield two palaeolatitudes of 25.8 °N and 23.5 °S. In case of a southward drifting Indian subcontinent the palaeolatitude of the Dicken Sandstone is more northward than that of the Dhandraul Sandstone and is comparable with that of Malani Rhyolite (Fig. 6). Therefore, from the palaeolatitudinal positions of the subcontinent it appears that the deposition of the Dicken Sandstone is earlier than the Dhandraul Sandstone and hence the Dicken Sandstone might be few million years older than the Dhandraul Sandstone.

The important assumption in palaeomagnetic study is that the observed magnetic field of the Earth recorded in rocks is bipolar in nature with an imaginary axis connecting the poles (axial geocentric dipole field). As per this assumption, one can understand the movements of the crustal blocks on the surface of the Earth. In addition to this the direction of magnetization in rocks can be used to infer about the polarity of the palaeomagnetic field in terms of normal and reverse and a polarity time scale can be developed during the period back in to geological time. A well-constrained polarity time scale may be useful in correlation of rock strata of unknown satratigraphic position and assigning approximate period of its formation. The Vindhyan sedimentation took place for nearly a billion years of time during the Meso-Neo Proterozoic era and the geomagnetic field recorded in these rocks is very useful in understanding the movement of the subcontinent and nature of the geomagnetic field polarity during this period.

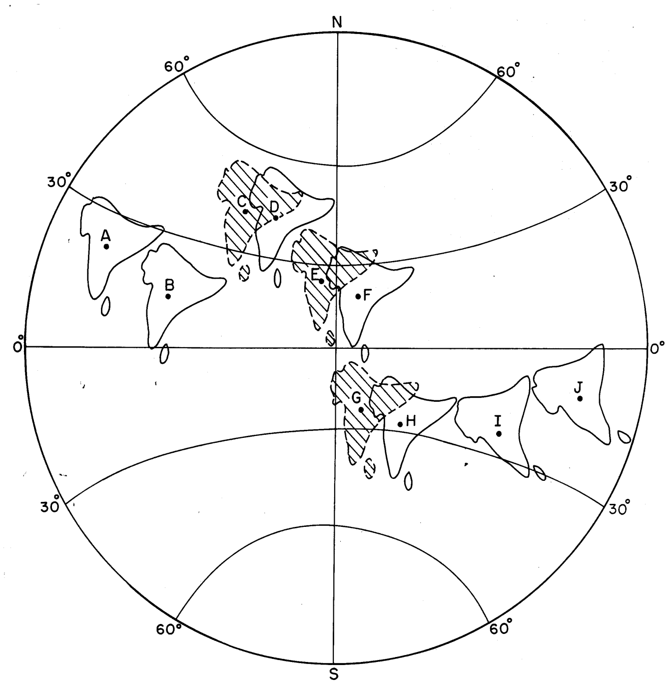

Figure 6. Schematic diagram showing the palaeolatitudinal positions of Indian subcontinent during the Vindhyan period. Dashed lines denote palaeolatitude positions obtained from the Dicken Sandstone and Dhandraul Sandstone (Group A and Group B) in the present study. A – Pandwafall Sandstone, B – Kaimur Quartzite, C – Dicken Sandstone, D – Malani Rhyolite, E – Dhandraul Sandstone (Group A), F – Baghain Sandstone, G- Dhandraul Sandstone (Group B), H – Baghain Sandstone, I – Rewa Sandstone and J – Bhander Sandstone.

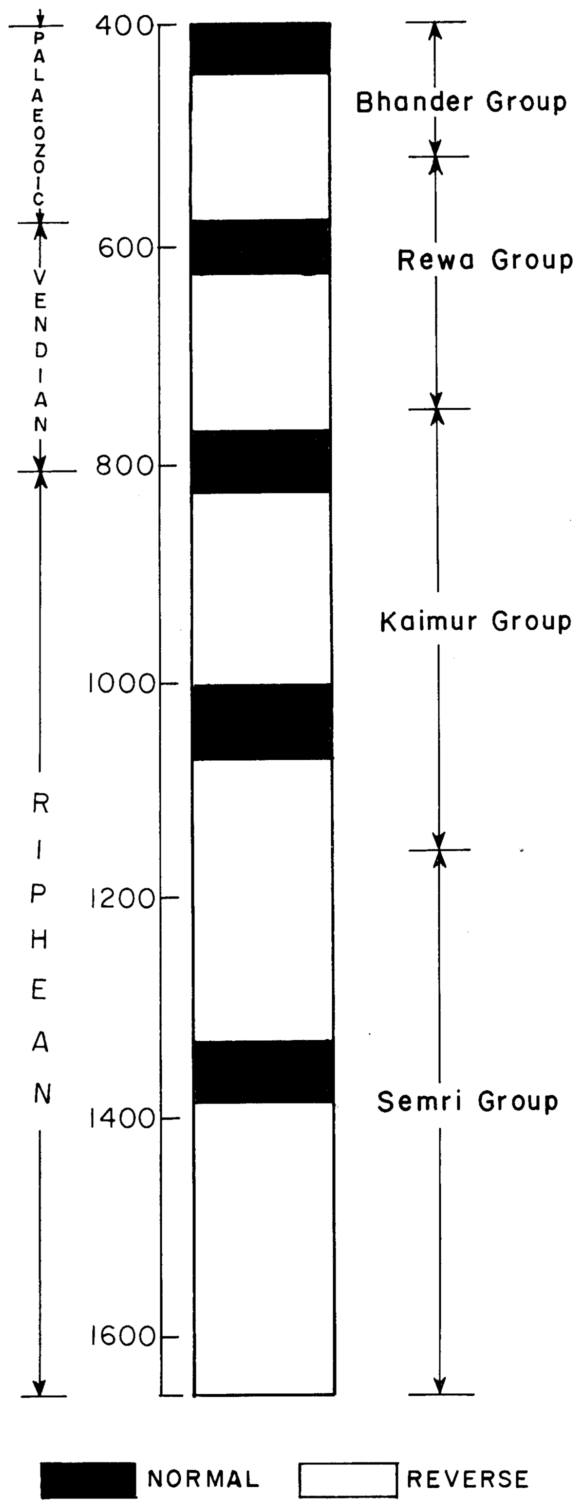

Figure 7. Geomagnetic Polarity Time Scale (GPTS) denoting the polarity changes observed from the Vindhyan Formations palaeomagnetic data. The time interval covered is Meso-Neo Proterozoic to lower Palaeozoic (1650 – 400 Ma) as per the available geological and radiometric data of the Vindhyan Supergroup rocks.

Though the Vindhyan rocks are exposed over a very large area in central India, not many of them have been studied for their palaeomagnetic signature. Only limited studies are available from all the major groups. These are the lower Semri Pandwafall Sandstone (Poornachandra Rao et al. 1994) and Gangau Tilloid (Williams & Schmidt 1996), lower Kaimur Quartzite (Sahasrabudhe & Mishra, 1966) and upper Kaimur Baghain Sandstone (Poornachandra Rao, 1997), upper Rewa Sandstone (Athavale, Asha Hansraj & Verma 1972; McElhinny, Cowley & Edwards 1978) and upper Bhander Sandstone (Athavale, Asha Hansraj & Verma 1972; Klootwijk, 1973; McElhinny, Cowley & Edwards 1978). Results of these studies reveal both normal and reverse polarity implying at least one inversion of the geomagnetic field during their deposition. The rocks investigated belonging to the Kaimur period reveal a minimum of three polarity inversions, one during the lower Kaimur period and two during the upper Kaimur period. A summary of these results is presented elsewhere (Poornachandra Rao & Bhalla 1996; Poornachandra Rao et al. 1997; Pooranachandra Rao, Mallikharjuna Rao & Bhalla 2000). The Dhandraul Sandstone of the present study also revealed two inversions of the geomagnetic field during the upper Kaimur period. These polarity changes are similar to those that are already observed in Baghain Sandstone from Panna region with which the Dhandraul Sandstone are correlated. Similar polarity inversions were also reported by Goutham et al. (2001) in Banganapalle Quartzite in Cuddapah Basin far away from the Vindhyan Basin.

It is also inferred that the Dicken Sandstones also belonging to the Upper Kaimur period (~750 Ma) with normal polarity conform to the normal polarity zone in the Upper Kaimur period. A geomagnetic polarity time scale constructed by using the palaeogeomagnetic field signatures from the Vindhyan formations for the Vindhyan period (1650-400) is shown in Figure 7. The Geomagnetic Polarity Time Scale (GPTS) for the Riphean period available from the Russian platform indicate domination of reverse polarity with intermittent normal polarity zones (Khramov 1987). These reverse magnetozones are of 100-200 Ma duration and the normal polarities in any of these reverse magnetozones serve as a very good marker horizons for correlation purpose. Therefore, more weightage is given to reverse magnetozones in constructing the polarity time scale during the Vindhyan sedimentation time shown in this figure. When the palaeomagnetic signatures from all the Vindhyan rock formations are available it gives a good opportunity to correlate several lithological units among several sub-basins across the entire Vindhyan basin.

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