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Preliminary Rock and Palaeomagnetic Results from the (Neoproterozoic) Bhima Basin, India

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ABSTRACT
Palaeomagnetic and rock magnetic results of the samples from Lower Bhima Group are reported here. Magnetic cleaning by different techniques give an impression that these rocks are remagnetized. IRM studies indicate that the magnetic carrier in the lower and upper Sedam Subgroup of Bhima Group is hematite and magnetite respectively. Possibly this is also an indication of remagnetization of Bhima Group of rocks by Deccan lava flows.

INTRODUCTION

Out of the eight Proterozoic sedimentary basins, only Vindhyan and Cuddapah basins were palaeomagnetically studied (Athavale, Asha Hansraj & Verma 1972, Klootwijk 1973, McElhinny, Cowley & Edwards 1978, Sahasrabudhe & Mishra, 1966, Poornachandra Rao et al., 1994, Williams & Schmidt, 1996 and Prasad et al., 1987). Bhalla & Asha Hansraj (1974) had reported the palaeomagnetic results of Bhima Group of rocks which states that the middle and a part of lower Bhima rocks are normally magnetized while the lower formations are reversely magnetized. No palaeomagnetic work has been carried out on the rest of the basins. The most striking aspect of the Proterozoic Palaeomagnetic results from India is the record of both normal and reversed magnetizations such as in Banganapalli Quartzite of Kurnool Group (Goutham et al., 2006) and Baghain Sandstone of Kaimur Group (Vindhyan Supergroup) (Poornachandra Rao et al., 1997). Based on the similarity in magnetization directions and their pole positions they were stratigraphically correlated (Goutham et al. 2006). This correlation makes the Kurnool Group slightly older in stratigraphy, though this is a topic of debate, than formerly believed with its base possibly equivalent to the upper part of Kaimur Group of the Vindhyan Supergroup. This correlation is different from the model based on geological consideration (Krishnan 1983). In the literature of Indian geology, Bhima Group and Kaladgi Supergroups are correlated with Kurnool Group and Cuddapah Supergroup respectively. Therefore, it is possible to identify the marker horizon of mixed magnetic polarity that was recorded in Kurnool Group, in the Bhima Group also based on palaeomagnetic study. It is with this background palaeomagnetic work on Kaladgi and Bhima Basins is taken up and preliminary palaeomagnetic work that has been done on Bhima Group is reported here. This paper is intended to highlight the remagnetization effect of Deccan lava flows on these rocks.

GEOLOGY AND SAMPLING

The 'z' shaped Bhima Basin covers an area of 5,000 km2 in parts of Gulbarga and Bijapur districts of Karnataka, and Mahboobnagar and Ranga Reddy district of Andhra Pradesh with a maximum thickness of 150 m, consisting more or less alternating clastic and chemogenic sediments which could broadly be divided into two cycles of deposition (Mishra et al., 1987). The Bhima Basin is exposed on the northeastern margin of the Dharwar Craton and is the smallest of all the Purana Basins of the Indian Peninsula (Kale & Phansalkar 1991). The thickest sedimentary pile at any place in the basin is less than 70 m and therefore implies that the entire sedimentation in the basin is a short-lived transgressive event. The main lithology of the Bhima Basin is horizontal to near horizontal sediments and predominantly of limestone. The exposures of Bhima Group are sandwiched between Eastern Dharwar Craton in the south and the late Cretaceous-Palaeocene Deccan Traps in the north. Outline geological map of Bhima and Kaladgi Basins is shown in Fig.1 and the lithostratigraphy of the Bhima Basin is given in Table 1.

Table 1. Lithostratigraphy of Bhima Group (after Mishra et al.1987)

Group	Subgroup	Formation	Member	Thickness
Bhima Group	Andola Subgroup	Harwal-Gogi Formation		5-10 m
		Katamdevarahalli Formation		10-40 m
		Halkal Formation	Fissile Sh.	
			Orthoquartzite	
			Chert Pebble Conglomerate	
	~~ Para-unconformity ~~~~~~~~~~~~~			
	Sedam Subgroup	Shahabad Formation	Flaggy, dark-grey and argillaceous	4-6 m
			Massive, dark grey and bluish grey	8-20 m
			Veriegated and Siliceous/cherty	20-80 m
			Blocky, light grey to bluish grey	10-15 m
			Slabby and Flaggy	4-8 m
		Rabanpalli Formation	Purple Shale	2-40 m
			Green/Yellow Sh.	5-15 m
			Siltstone	3-4 m
			Quartzitic S.St.	5-15 m
			Conglomerate/Grit	1-2 m

A total of 75 oriented block samples were collected from 15 sites from the Sedam Subgroup of the Bhima Group. A minimum of 3 separately oriented samples were collected from each site. Out of 75 samples collected 55 samples are from Shahabad Formation and 20 are from Rabanpalli Formation of Sedam Subgroup (Lower Bhima Group). 55 samples of Shahabad Formation include slabby & flaggy and blocky, bluish grey members and 20 samples from Rabanpalli Formation include Quartzitic Sandstone and purple shale. A detailed note on the geology, sedimentation history and structure of the Bhima Group is given by Kale & Peshwa (1995).

METHODOLOGY

All the samples collected in the field were reoriented in the laboratory using standard techniques and drilled out to obtain a total of 610 specimens. Natural Remanent Magnetizations (NRMs) were measured using JR6 magnetometer of Agico make (Chezeck Republic). Stability of NRM directions was examined by subjecting the specimens to progressive thermal demagnetization and to Alternating Field demagnetization (AFD) using TDMD 800 thermal demagnetizer and AF demagnetizer of Molspin make respectively. For the identification of magnetic minerals representative specimens were subjected to IRM studies, using Pulsed field instrument of Molspin make. Susceptibility of the samples was measured using Bartington Susceptibility apparatus (MS2). Statistical parameters were calculated by using Fisher (1953) statistics. Remanence components were determined by Principal Component Analysis (Krischvink 1980).

RESULTS

By and large, NRM directions of the Bhima Group show a normal magnetization with northwesterly declination with low to moderate inclinations (Fig.2). There is a very good grouping within the samples and

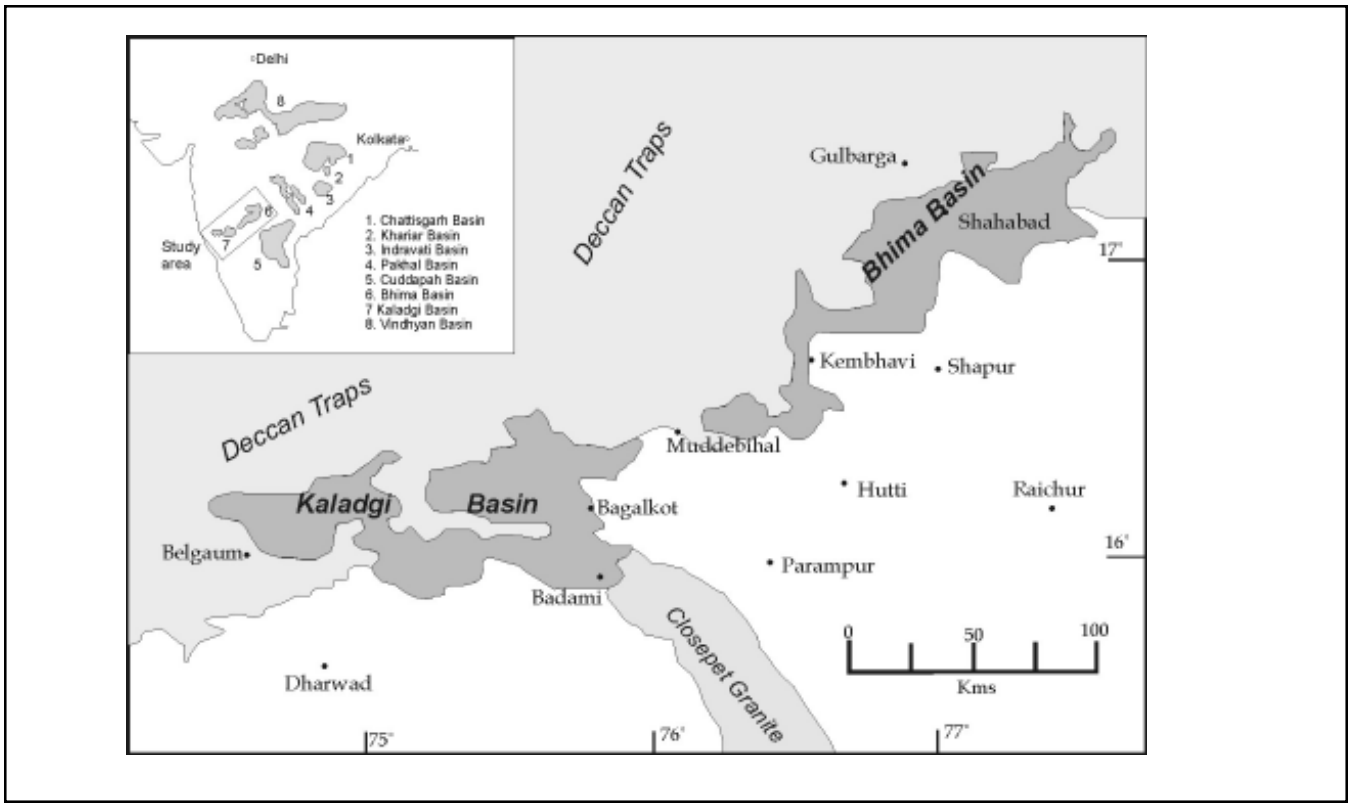

Figure 1. Outline Geological map of Kaladgi and Bhima Basins. Inset: Proterozoic sedimentary basins of India.

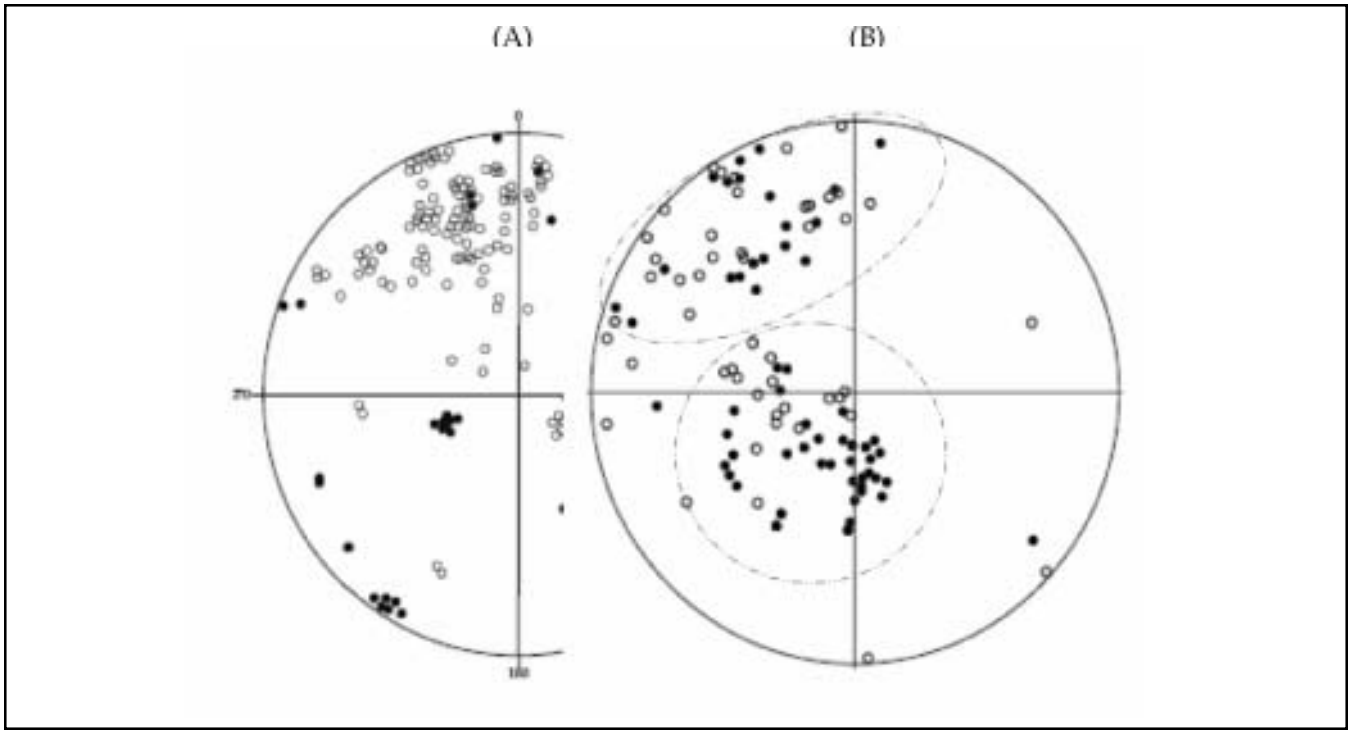

Figure 2. A) NRM directions of Shahabad and Rabanpalli Formations of Bhima Group. B) After magnetic cleaning. Equal area Projection-lower hemisphere.

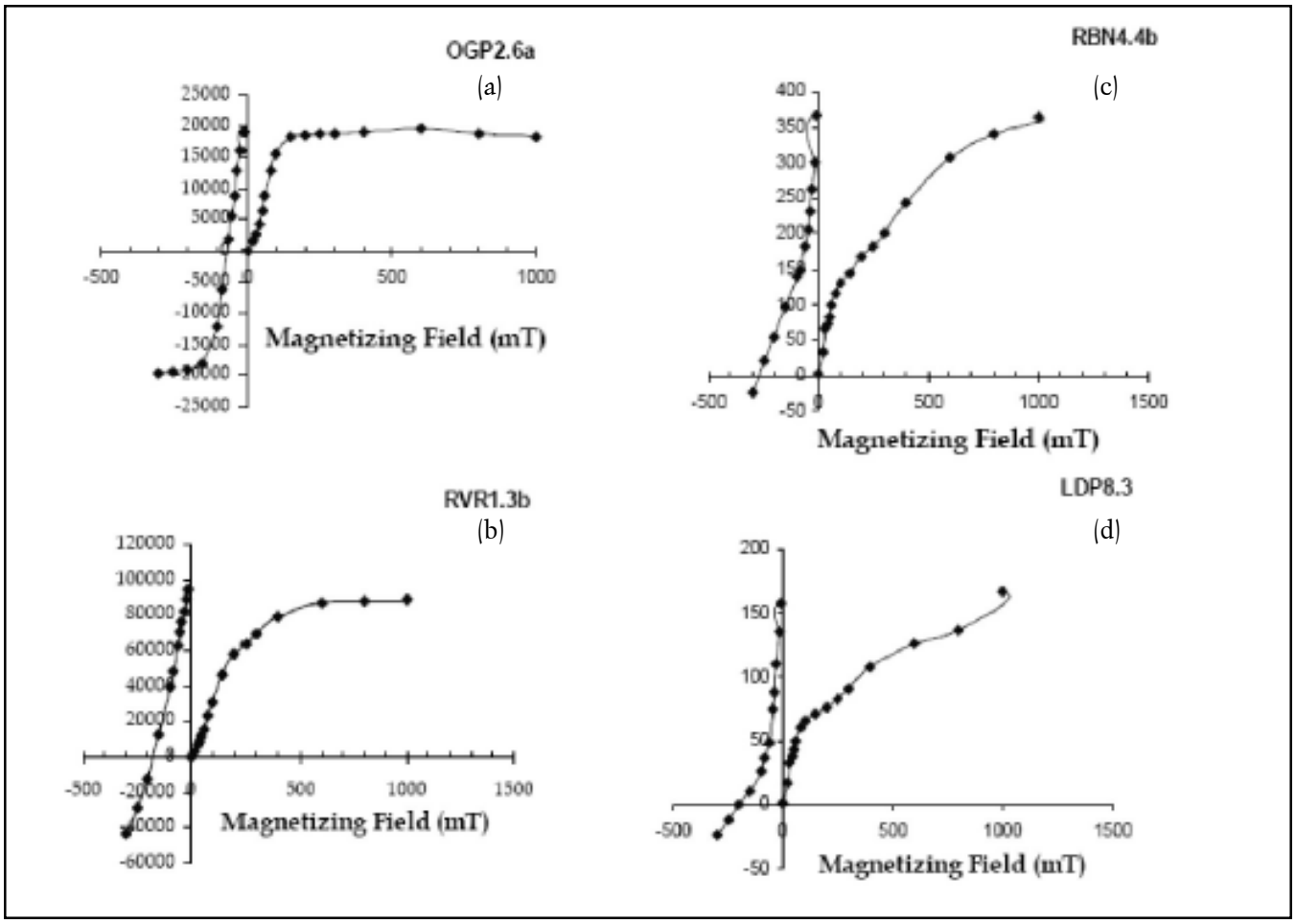

Figure 3. Typical examples of IRM acquisition in Bhima Group Samples.

within site. To test the stability of NRM directions and to resolve ChRM directions, a pilot study on two batches of specimens, each containing 16 specimens representing all the sites, were subjected to progressive thermal demagnetization at 100º, 200º, 300º, 350º, 400º, 450º, 500º, 550º, 580º, 600º, 650º, 680º and 700ºC temperature. Further another batch of specimens were subjected to AF demagnetization in increasing field at 36, 50, 75, 100, 150, 200, 250, 300, 350, 400, 500, 600, 800 and 1000 mT. These magnetic cleaning slightly improved the sample and site mean directions though it looks scattered (Fig.2). It is interesting to observe the grouping in the SE quadrant which resembles the Deccan direction (D/I=154º/46.7º - Vandamme et al 1991). It appears that the Bhima Group of rocks is partially remagnetized by the Deccan Lava Flows. However, it is premature at this moment to comment on this aspect as more number of samples from the upper horizons of Bhima Group as well as Deccan Traps is needed to confirm this remagnetization effect.

The intensities of initial remanent magnetization (Jn) were found to vary in the range from 0.324 to $16x10^{-3}$ mA/m; and susceptibility (χ) has a range from 1.2 to 26.9 x 10^{-5} SI units. To ascertain the magnetomineralogy, a batch of 16 specimens were subjected to Isothermal Remanent Magnetization (IRM) studies in the magnetic fields of 20, 30, 40, 50, 60, 80, 100, 150, 200, 250, 300, 400, 600, 800 and 1000 mT and the induced magnetization acquired by the specimens is measured after each step of induction. Then the specimens were subjected to opposite field to get the coercivity of remanence. Typical examples of IRM studies are shown in Fig. 3.

In the above figure, 3a and 3c are of Shahabad Limestone and 3b and 3d are of Rabanpalli Quartzitic Sandstone member. From Fig 3a it is observed that the coercive force is ~80mT and the saturation field is around 300mT. This is indicative of the presence of magnetite as the carrier of magnetization in this sample. The coercive force in Fig.3b is around 175mT and saturation field is more than 300mT. Probably

this is an indication of presence of hematite in single domain character and magnetite in small proportion. Figures 3c and 3d show no sign of saturation even after 1000mT field and the coercivity remanence is very high and therefore in the Rabanpalli Quartzitic member the magnetic carrier appears to be hematite. Intensity decay curves from thermal demagnetization results (reported elsewhere) also show similar results as in IRM studies

CONCLUSIONS

So far the palaeomagnetic results of Bhima Group of samples give an impression that they are partially remagnetized by the Deccan lava flows. Rockmagnetic studies indicate that the magnetic carrier in the lower Sedam Subgroup of Bhima Group is hematite and the same in the upper part is magnetite. Possibly, this is also an indication of remagnetization. However, to establish the said remagnetization effect study on a larger set of samples from the rest of the basin (Andola Subgroup) as well as Deccan lava flows is needed.

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REFERENCES

Athavale, R.N., Asha Hansraj & Verma, R.K. 1972. Palaeomagnetism and age of Bhander and Rewa Sandstone from India, Geophys. Jour. Roy. Astr. Soc., 28, 499-509.

Bhalla,M.S. & Hansraj, A. 1974. Palaeomagnetism of Bhima Series : Precambrian formations of India, Jour. Ind. Geophys. Union, 12, 1-12.

Fisher, R.A., 1953. Dispersion on a sphere, Proc. R. Soc.Lond. A217 1953 295-305

Goutham, M.R., Raghubabu, K., Prasad, C.V.R.K., Subbarao, K.V. & Damodara Reddy, V. 2006. A Neoproterozoic Reversal from the Kurnool Group, India and Implications for stratigraphic correlation and formation of Gondwana, J. Geol. Soc. Ind., 67, 221-233.

Kale & Phansalkar, 1991. Purana Basins of Peninsular India:A Review, Basin Research, 3, 1-36

Kale & Peshwa 1995. Bhima Basin, Geol. Soc. Ind. 142p.

Klootwijk, C.T., 1973. Palaeomagnetism of Upper Bhander Sandstone from Central India and implications for a tentative Cambrian Gondwanaland reconstruction. Tectonophysics., 18, 123-145.

Krishnan, M.S., 1983. Geology of India and Burma, CBS Publ., New Delhi, 562p.

McElhinny, M.W., Cowley, J.A. & Edwards, D.J., 1978. Palaeomagnetism of some rocks from Peninsular India. Tectonophysics, 50, 41-54.

Mishra, R.N., Jayaprakash, A.V., Hans, S.K. & Sundaram, V., 1987. Bhima Group of Upper Proterozoic- A stratigraphic puzzle, Mem. Geol. Soc. Ind. No.6, 227-237.

Krischvink, J.L., 1980. The least-squares line and plane and analysis of palaeomagnetic data, Geophys. J.R. Astro. Soc., 45, 699-718.

Poornachandra Rao, G.V.S., Rao, J.M., Asha Hansraj & Subrahmanyam, K., 1994. Palaeogeography of the Indian landmass from the Lower Vindhyan Pandwafall sandstones, Proc. 30th Annual Convention of the Indian geophysical Union. 50-55.

Poornachandra Rao, G.V.S., Mallikarjuna Rao, J., Chako, S.T. & Subrahmanyam, K., 1997. Palaeomagnetism of Baghain Sandstone Formation, Kaimur Group. Jour. Geophys. Union, 1, no.1, 41-48.

Prasad, C.V.R.K., Pulla Reddy, V., Subbarao, K.V. & Radhakrishnamurty, C., 1987. Palaeomagnetism and the crescent shape of the Cuddapah Basin. Purana Basins of Peninsular India, Mem.Geol Soc. Ind., no.6, 331-347.

Sahasrabudhe, P.W. & Mishra, D.C., 1966. Palaeomagnetism of Vindhyan rocks of India, Bull., NGRI., 4, 49-55.

Vandamme, D., Courtillot, V., Besse, J. & Montigney, R., 1991. Palaeomagnetism and age determinations of the Deccan traps India: results of a Nagpur-Bombay traverse, and review of earlier work. Review of Geophysics 29, 159-190.

Williams, E. G. & Schmidt, P.W., 1996. Origin and Palaeomagnetism of the Mesoproterozoic Gangau tilloid basal Vindhyan Supergroup, Central India. Precambrian Research, 79, 307-325.

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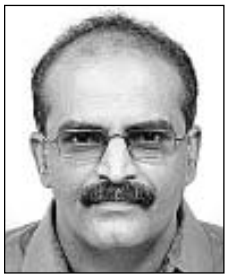

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