Preliminary remanent magnetism results from the Jurassic sediments of Kachchh, India

Oriented block samples were collected from two sections, Ler (23°10′N, 69°50′E) in Mainland Kachchh and Kantkote (23°30′N, 70°45′E) east of the Mainland at a random interval to test the stability of remanent magnetism in these sediments (Figure 1). The stratigraphic levels sampled (Figure 2) were otherwise already precisely dated with ammonoids[1–7] as also excellently correlated with composite ammonoid-magnetochronologic standard of the European Tethyan Margin (ETM)[8,9]. The Ler and Kantkote sections (Figure 2) include sediments of Chari Formation and the conformably overlying Katrol Formation of late Middle Jurassic Callovian to late Late Jurassic Tithonian age. The lithology in the studied sections mainly comprises alternation of argillaceous and aranaceous sediments. Medium-to-coarse-grained, earthy, yellowish-brown, cream-to-maroon sandstones, siltstones and shales are exposed in these sections in multiple cyclic patterns.

Oriented block samples (K2, K3, K11.1, K11.2, K9.1, K9.2, K9.3, K21, K26, K32, KD1, K14, K16, KX and KXVII) were cored and cut into standard specimen (25 mm diameter, 22 mm length). A total of 80 such specimens was obtained from both the sections, including a dyke sample from Kantkote section (Figure 2). Natural remanent magnetization (NRM) of all the specimens was measured on a Digital Spinner Magnetometer (Model DSM-2), Schonstedt, USA. The sensitivity of the spinner magnetometer is $< 2.5 \times 10^{-7}$ emu total moment. Susceptibility measurements were done on a Bartington Susceptibility System (Model MS-2). The NRM intensity of the sediments ranges from 0.5 to 50 mA/m, and decays to about less than 5% of the total NRM intensity after thermal demagnetization at 680°C. Specimens were selected systematically and subjected to alternating field demagnetization (AFD) at various field steps from 2.5 to 100 mT using the AF demagnetizer described by Creer *et al.*[10]. More than 70% of the intensity remains in the specimens even up to 100 mT, which shows that this method is unable to remove the secondary magnetizations. Thermal demagnetization technique proved to be the best tool to isolate the characteristic remanent magnetization directions of Jurassic sedimentary rocks elsewhere[11]. Hence, another batch of specimens was subjected to progressive thermal demagnetization at different temperatures in multiple intervals using a Thermal Demagnetizer (MMTD-80). Figure 3 shows a graphical representation of the behaviour of thermal demagnetization[12]. From Figure 3 one can see that at initial steps the secondary component of weak viscous magnetization gets removed and at later steps it is confirmed that the remanent carrier in these sediments is haematite as the intensity of the specimens (Figure 3 *c*) decays to less than 5% of the total NRM intensity at 680°C. Based on these pilot results, the rest of the specimens were subjected to batch thermal demagnetization at 585°C. Site/sample (minimum of five specimens from each sample) means were calculated using Fisher's statistics[13]. Palaeolatitudes of the Virtual Geomagnetic Pole (VGP) positions were computed for each site. It

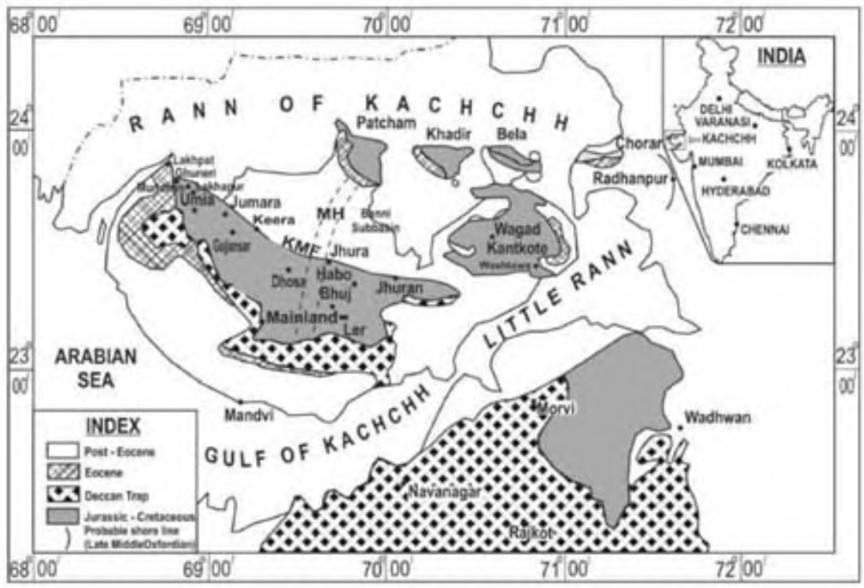

Figure 1. Simplified geological map of Kachchh (modified after Krishna and Ojha[1]).

Table 1. Details of samples collected from Ler and Kantkote sections, Kachchh

Stratigraphic section	Sample number	Ammonoid-based age	Magnetic polarity in Kachchh	Magnetic polarity in European standard
Ler	K2	Late Early to early	Normal	Normal
Ler	K3	Middle Callovian	Normal	Normal
Ler	K11.1	Late Early to early	Normal	Normal
Ler	K11.2	Middle Oxfordian	Normal	Normal (?)
Ler	K9.1	Late Late	Normal	Normal
Ler	K9.2	Kimmeridgian	Normal	Normal
Ler	K9.3		Normal	Normal
Ler	K21	Middle Early	Normal	Normal (?)
Ler	K26	Tithonian	Normal	Normal (?)
Ler	K32	Late Tithonian	Normal	Normal
Kantkote	KD1	Latest Maestrichtian	Reverse (?)	Reverse
Kantkote	K14	Late Middle	Normal	Normal
Kantkote	K16	Oxfordian	Normal (?)	Normal
Kantkote	KX	Late Oxfordian	Mixed	Mixed
Kantkote	KXVII	Early Kimmeridgian	Normal	Normal

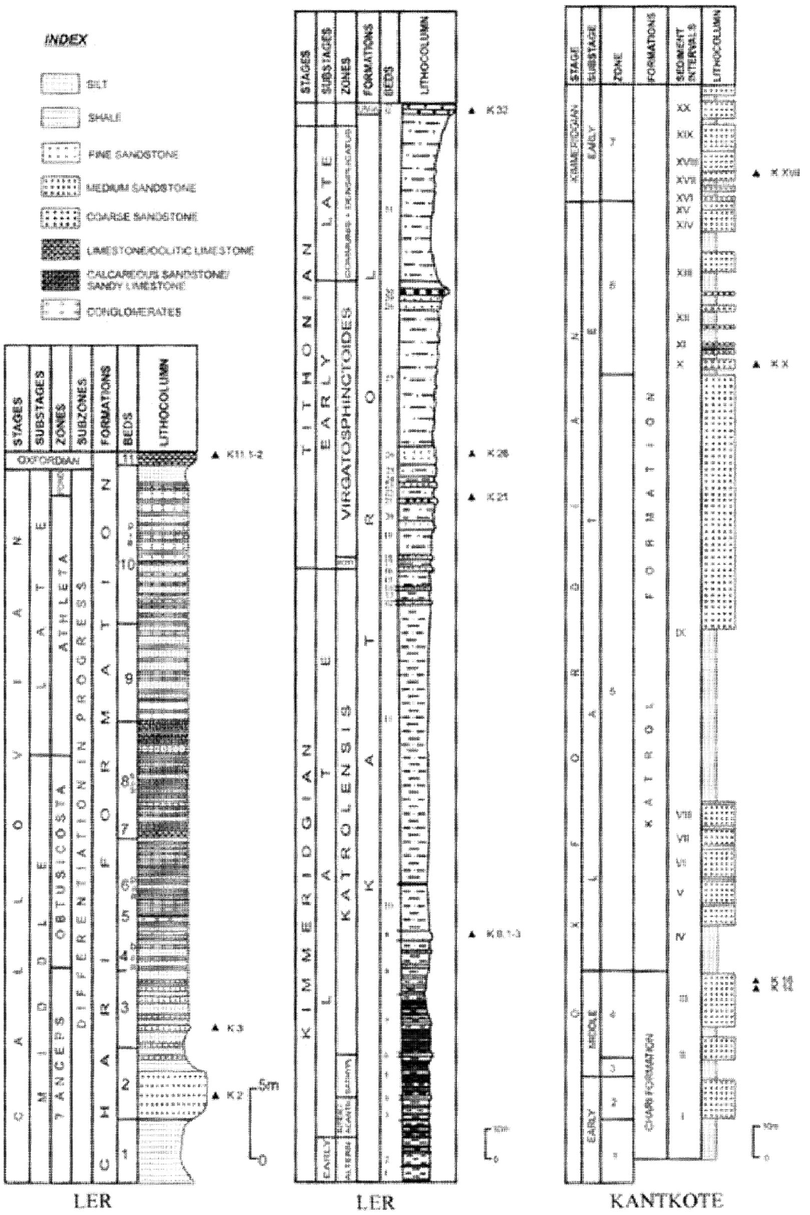

Figure 2. Geological litholog of Ler and Kantkote sections along with the position of the samples collected.

Table 2. Details of virtual geomagnetic pole latitudes

Sp. No.	*Dm*	*Im*	α95	VGP Latitude
K2	352	46	19.40	81.60
K3	339	34	8.68	69.90
K11.1	344	45	9.28	75.10
K11.2	357	33	5.23	84.11
K9.1	329	21	6.57	58.00
K9.2	338	47	17.47	69.58
K9.3	2	60	3.84	72.20
K21	338	44	3.93	69.83
K26	323	38	6.40	55.80
K32	341	17	6.21	66.74
K14	329	39	9.22	62.20
K16	328	60	4.45	58.07
KX	272	–64	11.24	–15.48
KXVII	357	25	8.44	79.16

is observed that all the sites from both the sections exhibit normal polarity. These polarities are correlated to the European standard[14] (Table 1).

Table 1 gives details of the sampling, corresponding ages, polarities and equivalents of the European standard. Table 2 shows the details of site mean and the corresponding VGP latitudes. It is encouraging to note that the corresponding age equivalent levels in Europe also belong to normal polarity (Table 1), which validates our preliminary pilot studies. Yet, definite evidence would only be complete when the intervening levels planned to be sampled during the next field

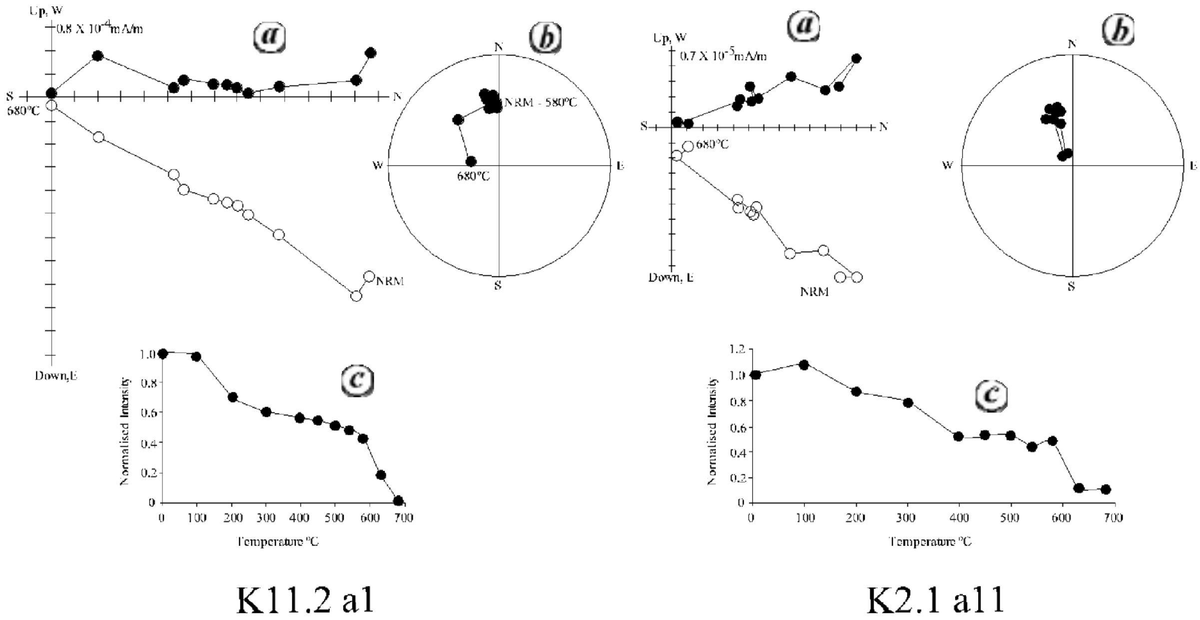

Figure 3. Graphical representation of thermal demagnetization of specimens from Kachchh. ***a***, Vector end point diagram. Solid circles represent horizontal plane and open circles represent vertical plane. ***b***, Vector migration diagram. ***c***, Intensity decay curve.

season yield reverse polarity as well, and also match well the European ammonoid-magnetochronologic scale. The preliminary results call for further detailed remanent magnetism investigations to throw light upon palaeolatitudinal displacement of India as a constituent of Gondwanaland in the pre-drift rifting-cum-sliding history along transform boundaries on either side of India during the geologically eventful Jurassic. The results are considered significant, being among the first few from precisely dated stratigraphic intervals. Our studies thus mark the initiation towards developing an ammonoid-magnetochronologic integration in the Indian Jurassic.

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