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Magnetic polarity of Masol 1 Locality deposits, Siwalik Frontal Range, northwestern India

Étude des polarités magnétiques des dépôts de la localité de Masol 1, chaîne frontale des Siwaliks, Nord-Ouest de l'Inde

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ABSTRACT

The Mio-Pleistocene Siwalik formations have been known worldwide since the 19th century for their fossil hominoids. Numerous paleomagnetic studies have contributed to build the chronological framework of the Siwalik Group subdivided into Lower, Middle and Upper Siwalik Subgroups. Our study concerns the Tatrot Formation (Late Pliocene) of the Upper Siwalik Subgroup located at Masol in the Chandigarh Siwalik Frontal Range (India), and is accessible by the Patiali Rao River. At Masol (district Mohali, Punjab), the erosion of the anticline structure has formed an inlier and exposed paleontological assemblages characterizing the Late Pliocene "Quranwala fossiliferous zone". Since 2008, the Indo-French research program, "Siwaliks", has conducted surveys in the Masol inlier and has collected stone tools on the surface of the outcrops among fossilized bones, a few with cut marks. The first cut-marked bone was discovered in 2009 at Masol 1 (M1). The study of the magnetic polarities of some stratigraphic units of M1 revealed that the deposits recorded a normal polarity. According to the paleontology and the previous magnetostratigraphy of the Patiali Rao, it appeared that the deposits of Masol 1 are older than the Gauss-Matuyama reversal, dated to 2.58 Ma.
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Mots clés :
Siwalik supérieur
Chaîne Frontale des Siwaliks
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Zone fossilifère Quranwala
Inversion géomagnétique Gauss-Matuyama
Traces de boucherie

RÉSUMÉ

Les formations mio-pléistocènes des Siwaliks sont mondialement connues depuis le XIXe siècle pour leurs hominoïdes fossiles. De nombreuses études paléomagnétiques ont contribué à établir le cadre chronologique du groupe Siwalik (du Miocène au Pléistocène moyen). Notre étude porte sur la formation Tatrot (Pliocène supérieur) du sous-groupe Siwalik supérieur affleurant à Masol, une localité située dans la chaîne frontale des Siwaliks proche de Chandigarh (piémonts himalayens du Nord-Ouest de l'Inde), accessible par la

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rivière Patiali Rao. La structure anticlinale et l'érosion ont formé une boutonnière donnant accès à des vertébrés fossiles terrestres et d'eau douce, caractéristiques de la fin du Pliocène supérieur (zone fossilifère Quranwala de la formation de Masol, Tatrot final). Depuis 2008, le programme de recherche franco-indien « Siwaliks » prospecte cette boutonnière et collecte des outils lithiques en surface des affleurements parmi des fossiles dont certains portent des traces de boucherie. Le premier fossile avec des traces de découpes a été découvert à Masol 1 en 2009. L'étude des polarités magnétiques des unités lithostratigraphiques de cette localité (M1) indique une polarité normale et intermédiaire. Compte tenu des nombreuses données biochronologiques de la zone Quranwala dans laquelle s'inscrivent les fossiles aux traces de découpe, d'une part, et des analyses magnétostratigraphiques bien connues du Patiali Rao, d'autre part, les dépôts concernés sont attribués à la magnétozone de Gauss et à la fin du Pliocène.

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1. Introduction

The Masol inlier (district Mohali, Punjab) is known for its fossiliferous deposits belonging to the "Quranwala zone", which is rich in vertebrate species characterizing the Late Pliocene of the Siwaliks (Sahni and Khan, 1964, 1968). The Indo-French program, "Siwaliks", was conducting prehistoric research in this sector since 2008 (Dambricourt Malassé, 2016; Dambricourt Malassé et al., 2016a), collecting stone tools (Gaillard et al., 2016) and numerous fossils (Moigne et al., 2016) among which a few bovid bones show cut marks made by sharp edges of artefacts in quartzite (Dambricourt Malassé et al., 2016b). Considering the geological map of Sahni and Khan (1964, 1968), the magnetostratigraphy (Ranga Rao et al., 1995), the fossils collected in the Quranwala fossiliferous zone (Moigne et al., 2016) and the long field experience of the Indian team in this area, it clearly appears that the deposits belong to the Tatrot Formation (Pliocene). Its uppermost part coincides with the Gauss/Matuyama magnetic reversal (Ranga Rao, 1993; Ranga Rao et al., 1995) dated to 2.58 Ma (Cande and Kent, 1995). The cut marks on the bones reveal anthropic activities on the Asian continent slightly older than the earliest ones known so far in Africa at Kada Gona in Ethiopia (Coppens, 2016; Dambricourt Malassé, 2016; Semaw, 2010) and in Asia at Longgupo Cave (South China) dated to the very beginning of the Pleistocene (Han et al., 2015). The paleomagnetic study presented in this article is integrated into the pluridisciplinary Indo-French program 2008–2014 (Abdessadok et al., 2016; Chapon Sao et al., 2016; Dambricourt Malassé et al., 2016a, b; Gaillard et al., 2016; Gargani et al., 2016; Moigne et al., 2016; Tudryn et al., 2016), and was undertaken to confirm that the deposits of Masol 1 are below the Matuyama/Gauss geomagnetic reversal.

2. Geological context of the Siwalik Group

The Siwaliks are continental molasse deposits that extend from the North of Pakistan to Assam in Northeast India along the Himalayan Range. The Siwalik Series have been known worldwide since the 1830s for their Neogene and Quaternary fossil vertebrates, especially in the Upper Indus Basin, with special attention paid to the human origins in this area of the Indian sub-continent (e.g., Dennell, 2010, see review of the history in Dambricourt Malassé et al., 2016a). The 6000 meter thick Siwalik Series is divided into three subgroups: Lower, Middle and Upper Siwalik (see Patnaik, 2013 for a review; Stidham et al., 2014) and further into zones or formations based on Mammalian fauna, called faunal zones (Pilgrim, 1913). These biostratigraphic subdivisions are named Kamlial and Chinji for the Lower Siwalik, Nagri and Dhok Pathan for the Middle Siwalik, Tatrot, Pinjor and Boulder Conglomerate for the Upper Siwalik. Unfortunately, the paleontological record is spatially unequally distributed, and the deposits are characterized by lateral facies variations complicating the regional correlations (Nanda, 2002). To ease this difficulty, a well-developed chronostratigraphic framework was established based on studies of magnetic polarity (Barry et al., 1982, 2012; Keller et al., 1977; Opdyke et al., 1979), coupled with fission track dating of volcanic tuffs (Johnson et al., 1982).

The type locality of the Tatrot Formation is described in the Potwar Plateau, Pakistan, and the type locality of the Pinjor Formation in a northeastern area of the Chandigarh anticline, near the Pinjaur Township (Fig. 1). Numerous fossil species were exhumed from several localities of the Tatrot and Pinjor Formations (Badam, 1973; Barry et al., 1982, 2012; Gaur and Chopra, 1984; Nanda, 1973; Patnaik, 2003, 2013; Raghavan, 1990; Sahni and Khan, 1964, 1968; Sahni and Mitra, 1980; Stidham et al., 2014). Four tuffaceous mudstones have been discovered in the Pinjor Formation near the Ghaggar River (Tandon and Kumar, 1984), but only one was dated by fission tracks, providing an age of 2.14 ± 0.5 Ma (Mehta et al., 1993). Thus, this tuffaceous layer became a chronological benchmark to correlate the magnetostratigraphy of the Pinjor Formation with the geomagnetic polarity time scale (GPTS) (Gradstein et al., 2004; Kumaravel et al., 2005; Tandon et al., 1984).

In other Upper Siwalik localities in Pakistan and India, the chronostratigraphic and paleontological results showed that the uppermost part of the Tatrot Formation provides a paleontological assemblage with new species, especially *Equus sivalensis*, emerging during the very Late Pliocene (Upper Tatrot Formation) and developing over the Pleistocene (Pinjor Formation) (Nanda, 1994, 2002). This paleontological assemblage is called "transitional fauna" (Sahni and Khan, 1968; Sahni and Mitra, 1980). At Masol, the top of this transition coincides with the

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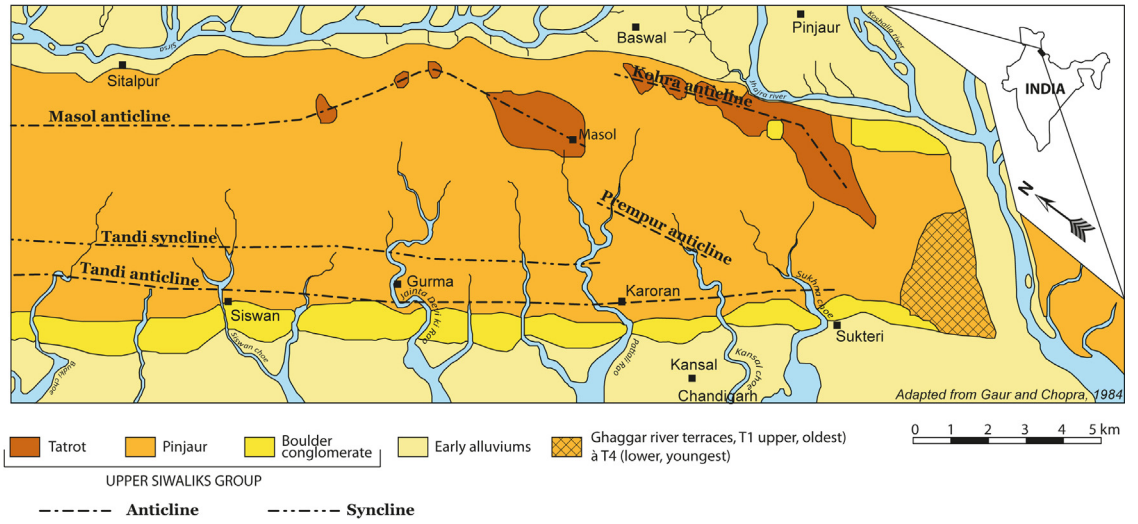


Fig. 1. Geological map of the Chandigarh anticline in the Siwalik Frontal Range.
Fig. 1. Carte géologique de l'anticlinal de Chandigarh dans la chaîne frontale des Siwaliks.
Adapted from Gaur and Chopra (1984).

Gauss-Matuyama reversal, dated to 2.58 Ma (Cande and Kent, 1995; Ranga Rao, 1993).

3. Geology of the Masol inlier and previous magnetostratigraphic results

The studied area is located in the Siwalik Frontal Range (SFR) near Masol village about ten kilometers north of Chandigarh. The structure of the SFR is an anticline parallel to the sub-Himalayan foothills (Fig. 1). The Patiali Rao, a seasonal river, cuts them perpendicularly from north to south, and this fluvial incision exposes a transect showing inclined strata of the Upper Siwalik Subgroup from the source upstream to the Punjab Plain downstream (for more details, see Gargani et al., 2016).

The Oil Natural Gas Commission (ONGC) began a geological survey in 1956; it divided the Upper Siwalik Subgroup of the Chandigarh anticline into five units based on the lithology, which are, from the oldest to youngest: Masol Formation, Rupar Formation I, II, III and IV (Ranga Rao, 1993; Ranga Rao et al., 1995). Referring to its paleontological assemblage, the Masol Formation was correlated with the Quranwala faunal zone defined by Pilgrim (1913) into the Tatrot Formation, while Rupar I, II and III have been linked with the Pinjor Formation. The conglomeratic unit Rupar IV was correlated with the Boulder Conglomerate. Later, Sahni and Khan (1964, 1968) discovered numerous faunal remains in the Masol Formation and confirmed their attribution to the Tatrot fauna. This collection was next enriched by the paleontological findings of Badam (1973, 1979), Gaur (1987) and Nanda (1994) (see a review in Moigne et al., 2016).

Ranga Rao (Ranga Rao, 1993; Ranga Rao et al., 1995) investigated the lithostratigraphy and magnetostratigraphy of the deposits all along the Patiali Rao and made a synthesis of his results with those of the studies initiated in 1956 in the Chandigarh region (Azzaroli and Napoleone, 1982; Tandon et al., 1984; Yokoyama, 1981). After all these geological and paleontological investigations, the first terminology of the subdivisions was then replaced by that of Tatrot (Masol Formation), Pinjor (Rupar I, II, III Formations) and Boulder Conglomerate (Rupar IV). Table 1 displays the stratigraphic correlations between these different terminologies used for the Chandigarh anticline.

Table 1
Subdivisions of the Upper Siwalik Subgroup in the Chandigarh anticline.
Tableau 1
Les subdivisions du sous-groupe Siwalik supérieur dans l'anticlinal de Chandigarh.

Faunal zone of Pilgrim (1913) in Upper Siwalik Subgroup	Masol stratigraphy from ONGC (Ranga Rao et al., 1995)	Conventional stratigraphy of Masol (Ranga Rao et al., 1995)
Boulder Conglomerate	Rupar IV	Boulder conglomerate
Pinjaur	Rupar III Rupar II Ruparl	Pinjaur
Tatrot	Masol Formation	Tatrot

The 1296-m-thick sequence observed along the Patiali Rao shows alternations of sandstones and claystones easily attributed to Tatrot, then thick benches of sandstone belonging to Pinjor, and finally Boulder Conglomerate on the southern edge of the anticline (Ranga Rao, 1993; Sahni and Khan, 1964, 1968). Structurally, the Masol 1 locality is located at the top and in the center of the anticline where the oldest layers of the Tatrot Formation outcrop are unearthed. For the magnetostratigraphy study, Ranga Rao (1993) selected fifty-two sites along the Patiali Rao transect. In the laboratory, he cut several 2.5 cm cubes extracted from 3–4 oriented blocks collected from each site. These samples were demagnetized by alternating field and measured using an astatic magnetometer. Ranga Rao et al.

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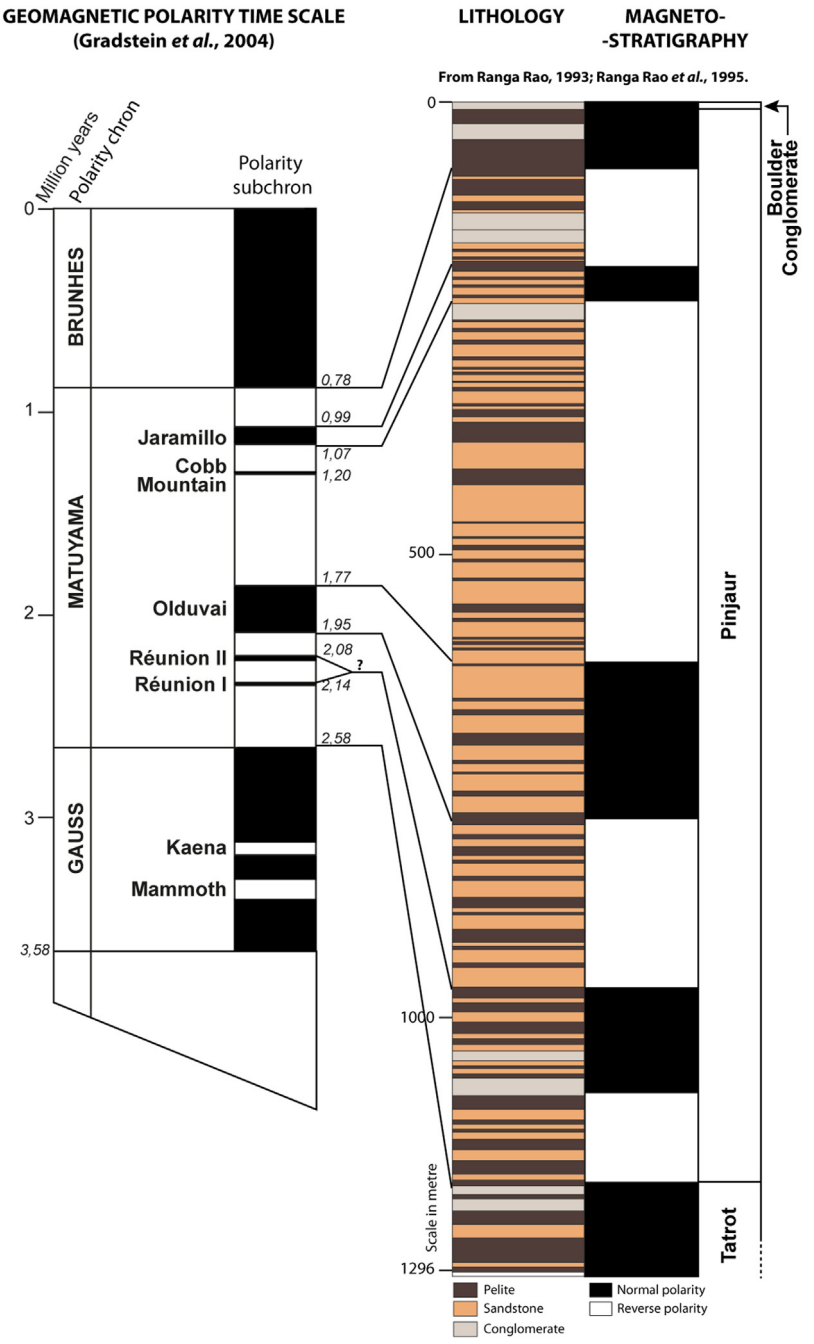


Fig. 2. Magnetostratigraphy of the Patiali Rao section from Ranga Rao (1993) and Ranga Rao et al. (1995).
Fig. 2. Magnétostratigraphie de la séquence stratigraphique du Patiali Rao d'après Ranga Rao (1993) et Ranga Rao et al. (1995).

(1995), hence, revealed three normal and four reversed magnetozones in the sequence (Fig. 2).

Referring to the biostratigraphic data, the lowest magnetic reversal was assigned to the Gauss-Matuyama reversal, and the highest to the Matuyama-Brunhes. With a calculated sedimentation rate of 0.63 m/1000 years between both magnetic limits (based on the ages of LaBrecque et al., 1977), Ranga Rao (Ranga Rao, 1993; Ranga Rao et al., 1995) identified the Reunion, Olduvai and Jaramillo magnetozones and, thus, highlighted a continuous sequence ranging from 2.7 Ma to 630 ka.

4. Masol 1 stratigraphy

The Masol 1 stratigraphic sequence, 30 m thick, was completed with the sequence of the neighboring Masol

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2 locality. The composite stratigraphy correlates with the uppermost part of the Tatrot Formation, and begins before the Quranwala faunal zone. It is characterized by the alternation of claystone, siltstone and sandstone (Fig. 3) (Chapon Sao et al., 2016). The lithostratigraphic sequence from unit F (lower) to unit A (upper) is composed as follows: unit F: sandy silts, grey in color, 2.40 m thick; unit E: red wine silts, 2 m thick; unit D: orange silts, 1 m thick; unit C: sandstone with white mica, light-grey in color, 1.20 m thick; unit B: coarse sandstone with gravels and clay lenses, cross-bedded, 2.40 m thick; unit A: brown silts, 0.80 m thick (Fig. 3). Unit B sandstone corresponds to the "Elephant sand" (Chapon Sao et al., 2016) and the Masol 1 sequence is equivalent to units c3 through s4 defined by Tudryn et al. (2016).

The bovid tibia shaft with cut marks was discovered on the slopes of a cliff formed by the outcrop of units B to E, less than 10 m below the top of the cliff. The yellow color of the cortical bone, similar to other fossils collected on the same surface of unit D and the fine micaceous sandy crust that covers it, allows researchers to conclude that its lithostratigraphic origin is very likely the yellow claystone D, near the micaceous sandstone C (Dambricourt Malassé et al., 2016b).

5. Methods

Referring to the previous works (Ranga Rao, 1993; Rendell et al., 1987), the sandy sediments of Tatrot are generally too weakly magnetized to yield reliable paleomagnetic data. Thus, only the finer sediment units were sampled (Fig. 3). Besides sedimentological loose sampling, rectangular prism-shaped blocks were taken as samples from the Masol 1 section with a hammer and chisel. Before separating the blocks from the outcrop, they were coated with plaster bands for consolidation and to avoid fracturing during the transport. Each block was meticulously oriented

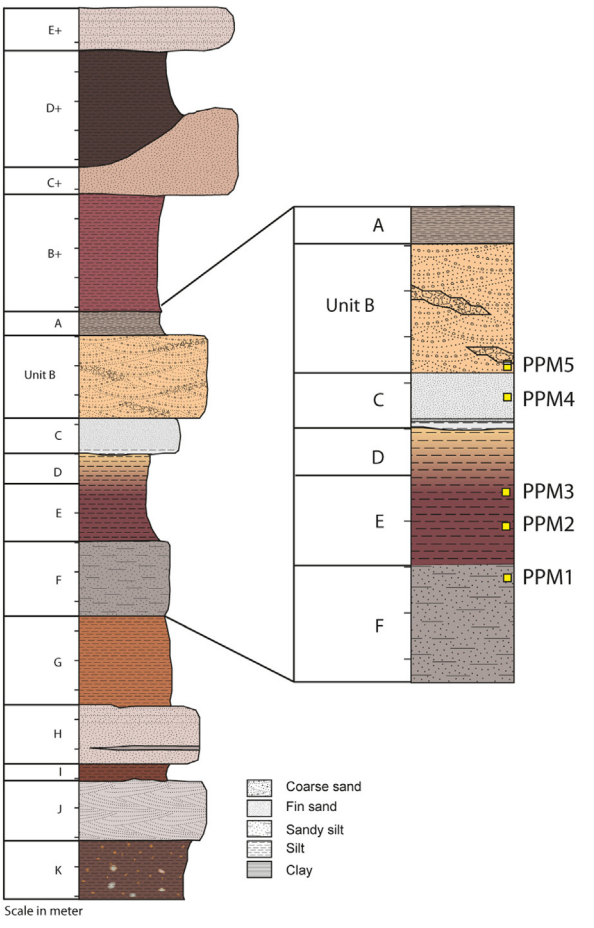


Fig. 3. Lithostratigraphy of the Masol 1 locality and location of the block-shaped samples.
Fig. 3. Lithostratigraphie de la localité de Masol 1 et emplacement des prélèvements sous forme de blocs.

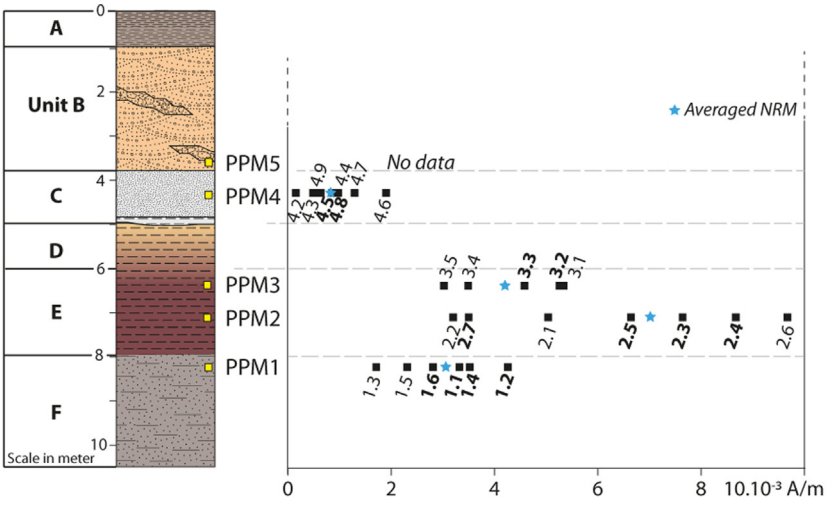


Fig. 4. Natural remanent magnetizations recorded in the cubic samples of the Masol 1 sediments. In bold, the selected samples for both demagnetizations (AF and thermal).
Fig. 4. Aimantations rémanentes naturelles mesurées dans les échantillons cubiques de la localité de Masol 1. En gras, les échantillons sélectionnés pour les désaimantations.

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by marking on the plaster coating the north and vertical lines. As the sampling took place at the top of the anticline, the stratigraphic strata are horizontal. Unit A was discarded from the paleomagnetic study, for its stratigraphic position corresponded to a sub-structural surface exposed to hazards of climatic variations and biological factors (plants, animals, shepherds). The middle and the upper parts of unit B were not sampled because they contained medium or coarse-grained sandstone. Finally, the thick unit E composed of silts was sampled with a first block in the lower part (PPM2) and a second in the upper part (PPM3).

All the paleomagnetic samples were exported to France to be analyzed in the paleomagnetic laboratory of the UMR 7194 CNRS, Department of Prehistory, National Museum of Natural History, located in the Institut de Paléontologie Humaine, Paris. After drying in an oven at 30 °C for one month, the sediment blocks were carefully cut with an amagnetic saw and knife to obtain at least four 8 cm^3 cubes per block. The fine sandstone lenses of unit B were too brittle to allow the sampling of an 8-cm^3 cube. Twenty-six cubes were made, but 12 were selected: four samples in unit F, six in unit E, and two in unit C.

The magnetic measurements furnace (MMTD 80) were used for the thermal demagnetization at 13 temperature steps, 100, 200, 300, 360, 400, 440, 460, 500, 520, 540, 560, 600 and 660 °C. The Molspin shielded alternating field demagnetizer enabled the removal of the natural remanent magnetization (NRM) by applying 15 steps, 2.5, 5, 7.5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 90 and 100 mT.

Before beginning the demagnetizations, the NRM of each cubic sample was measured with a high-sensibility, low-speed spinner magnetometer JR6 Agico. To determine the stability of the magnetization recorded in the sediment blocks, selected specimens were subjected to alternating field (AF) and thermal demagnetizations. However, as the sediment from the upper unit E and unit C were characterized by a soft magnetization, only the thermal demagnetization that was more effective was used.

The demagnetized data were analyzed using the REMASOFT 3.0 software developed by Chadima and Hrouda (2006).

6. Results

6.1. Intensity

The natural remanent magnetizations (NRM) were relatively weak overall. The maximal value of 9.10^{-3} A/m was recorded within the lower unit E (Fig. 4). The intensity of the NRM was stronger in the lower part of unit E than in its upper part, even though there were no lithofacies variations; the averages were, respectively, 7.10^{-3} A/m and $4.5.10^{-3}$ A/m. The NRM of unit C (PPM4) was less variable than in the lower units. Sediments from unit C were weakly magnetized, and the intensity of NRM for unit C subsamples averaged around 862.10^{-6} A/m. The fluctuation in NRM intensity along the stratigraphy (Fig. 4) most probably represented variations in the type and concentration of magnetic minerals.

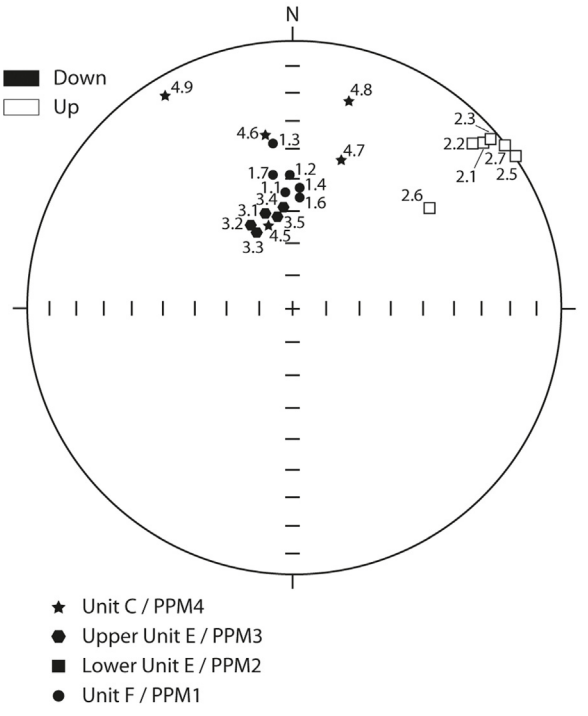


Fig. 5. Stereographic projection before the thermal and alternating field demagnetization of the whole cubic samples.
Fig. 5. Projections stéréographiques avant les désaimantations thermiques et sous champ alternatif pour tous les échantillons cubiques.

6.2. Directions

Stereographic projections of the magnetic declination and inclination for all studied samples before their demagnetization highlighted two groups of data (Fig. 5). For samples from the upper part of unit E and from unit F, the measured directions showed values close to those known at present in the Masol area. Directions for the lower part of unit E were different because inclination displayed negative values (Fig. 5).

6.2.1. Unit F

Four subsamples from unit F were processed by applying steps of the thermal and alternating field demagnetization (AFD). For each sample, magnetization, stereographic projection of magnetic directions and the Zijderveld diagram, which is a plot of magnetization vector projected on two orthogonal planes, were presented (Fig. 6). The thermal demagnetization (samples 1.4 and 1.6) was more effective than the AF demagnetization (samples 1.1 and 1.2) to remove the magnetization. In both cases, directions of the magnetization remained stable. After thermal demagnetization, the Zijderveld diagram showed that the last component stayed close to the origin. The persistence of a weak magnetization after the AF suggested the presence of goethite in the sediment, whereas the thermal demagnetization curve showed preferentially the hematite. Such thermomagnetic behavior was already noted for specular hematite in the Middle Siwalik Red Beds (Tauxe et al., 1980). The demagnetization curves and the

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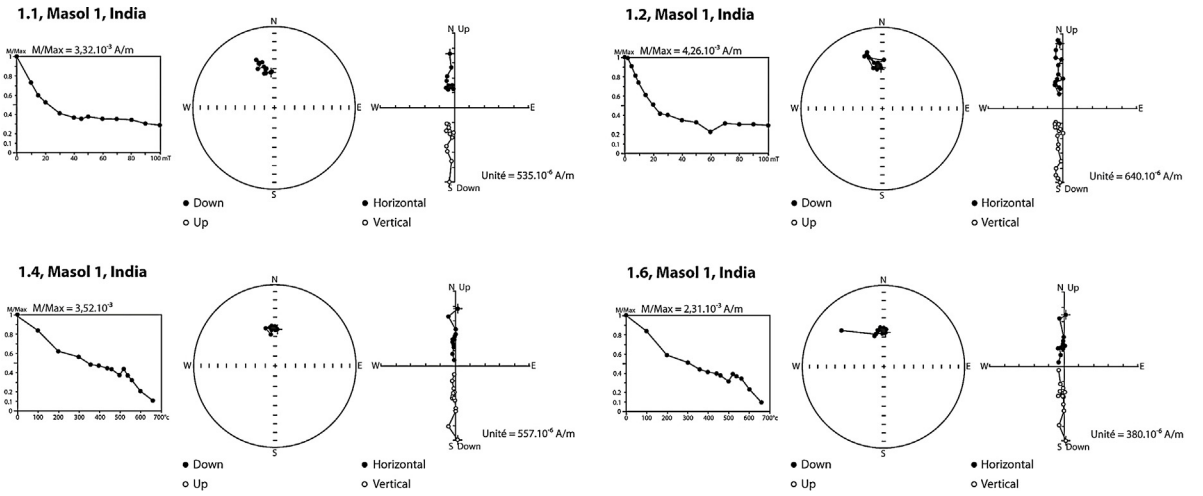


Fig. 6. Thermal and alternating field demagnetization for four samples from the Masol 1 Unit F (PPM1 block): change of the magnetization, stereographic projection, Zijderveld diagram.
Fig. 6. Diagramme de désaimantations thermique et sous champ alternatif des quatre échantillons de l'unité F de Masol 1 (block PPM1) : diagramme de désaimantation, projections stéréographiques, diagramme de Zijderveld.

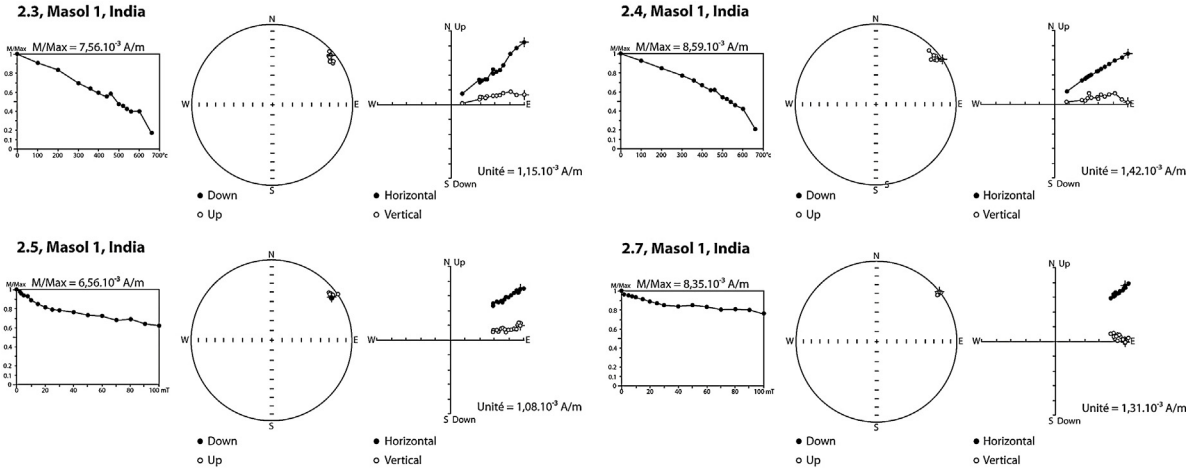


Fig. 7. Thermal and alternating field demagnetization for the four samples from the Masol lower unit E samples (PPM2 block): change of the magnetization, stereographic projection, Zijderveld diagram.
Fig. 7. Désaimantation thermique et sous champ alternatif des quatre échantillons de l'unité E inférieure de Masol 1 (block PPM2) : diagramme de désaimantation, projections stéréographiques, diagramme de Zijderveld.

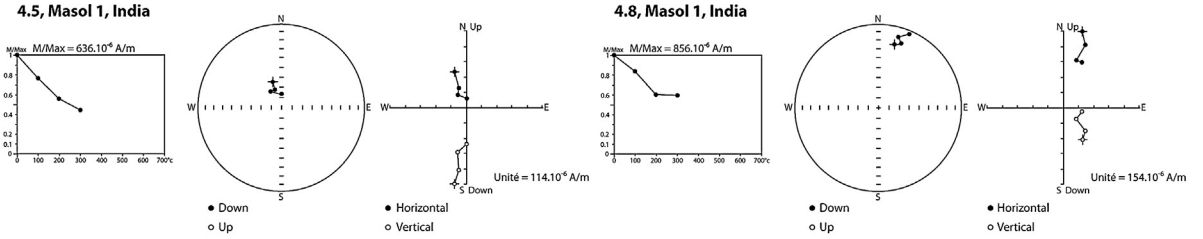


Fig. 8. Thermal demagnetization for the two Masol upper Unit E samples (PPM3 block): change of the magnetization, stereographic projection, Zijderveld diagram.
Fig. 8. Désaimantation thermique de deux échantillons de l'unité E supérieure de Masol 1 (block PPM3) : désaimantation, projections stéréographiques, diagramme de Zijderveld.

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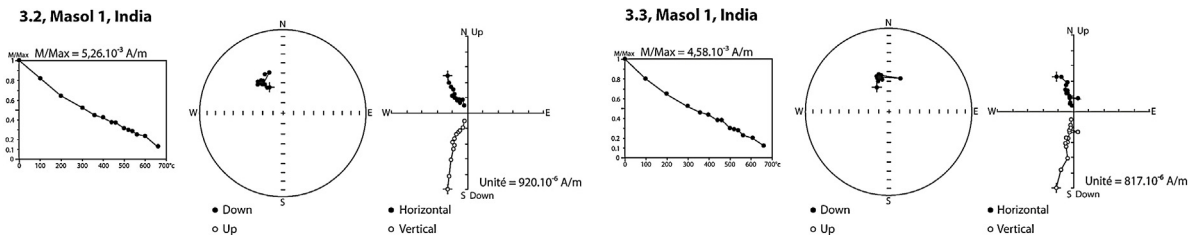


Fig. 9. Thermal demagnetization for the two Masol Unit C samples (PPM4 block): change of the magnetization, stereographic projection, Zijderveld diagram.
Fig. 9. Désaimantation thermique des deux échantillons de l'unité C (PPM4 block) : désaimantation, projections stéréographiques, diagramme de Zijderveld.

Table 2
Fisher statistical results for block samples from the Masol 1 locality in Masol inlier.
Tableau 2
Résultats statistiques de Fisher pour les prélèvements en blocs issus de la localité 1 dans la boutonnière de Masol.

Unit	Block sample	Declination	Inclination	N	R	k	α_{95}
C	PPM4	179.3	42.8	2	1.36	2.61	1.58
E							
Upper	PPM3	333.9	55.55	2	1.94	1.46	2.19
Lower	PPM2	52.5	−6.6	4	3.99	883.79	1.57
F	PPM1	351.9	49	4	3.99	266.02	1.58

similar directions obtained for the four cubes revealed a homogenous magnetization in the block. The results for the four subsamples showed a normal polarity.

6.2.2. Unit E

In the lower part of unit E, the thermal demagnetization of cubes from the PPM2 block was progressive and linear and was effective at removing the NRM, which was contrary to the AF demagnetization (Fig. 7). The Zijderveld diagrams for all the samples indicated that there was no secondary component, and the stereograms showed that the magnetization directions remained very stable (Fig. 7). The recorded negative inclination was very weak and indicated a transitional direction. The thermal demagnetization curves, similar to the Red bed specular hematite noted in the Middle Siwalik (Tauxe et al., 1980), indicated that the remanence was principally carried by hematite, but the persistence of a weak magnetization after AF demagnetization suggested the presence of goethite in the sediment.

In the upper part of unit E, the thermal demagnetization and the Zijderveld diagram showed the removal of a viscous component at 200 °C. The magnetization vector trajectories moved toward the origin, indicating predominance of a single component (Fig. 8). The directions remained very stable and similar to those of unit F. The sediments recorded a normal polarity. As in the lower part of unit E (PPM2), the magnetic mineral carrying the NRM was hematite.

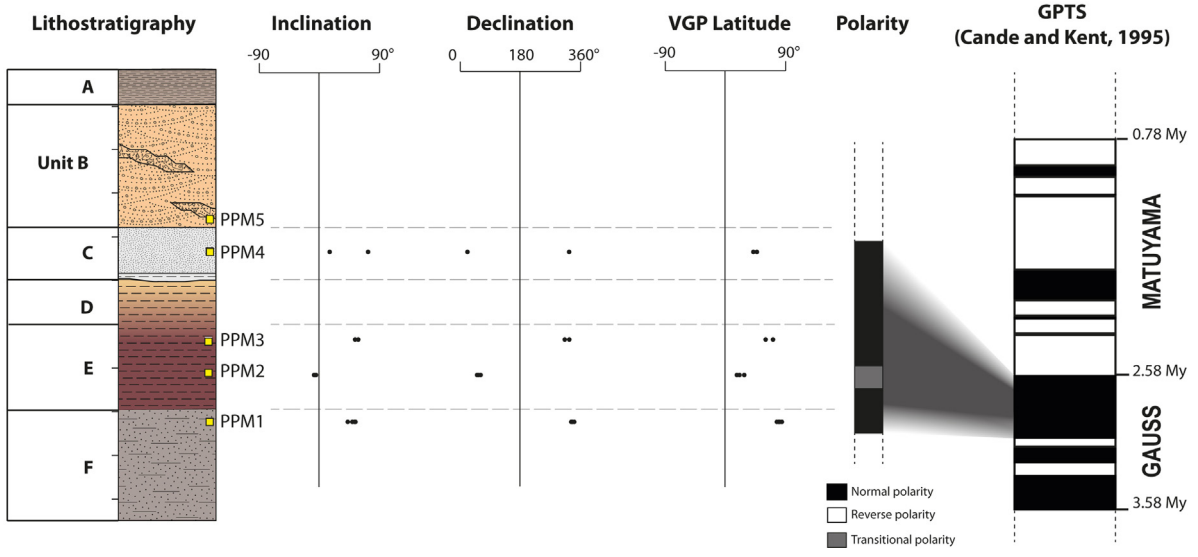


Fig. 10. Lithostratigraphy and magnetostratigraphy of the Masol 1 section.
Fig. 10. Lithostratigraphie et magnétostratigraphie de la coupe de Masol 1.

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6.2.3. Unit C

After thermal treatment up to 300 °C, the average intensity was of 465.10-6 A/m (Fig. 9). This NRM intensity value was close to the intrinsic noise level of the measuring instrumentation. That is why the NRM measurements were stopped at 300 °C. However, the first directions were stable and oriented toward the origin, which might indicate the existence of a single component showing a normal polarity.

7. Discussion

The intensity of the magnetization was weak but provided reliable data, further strengthened by Fisher statistics (Table 2). For samples from all units, the thermal demagnetization was more effective than the AF demagnetization. No unstable secondary component was highlighted in this study, whereas Ranga Rao (1993) noted the presence of a secondary component, which was removed after 20 mT. The measurements showed that the sediments from the three lithostratigraphic units F, E and C were deposited during a normal magnetozone and recorded a transitional polarity in the lower part of unit E (Fig. 10). This transitional polarity was between two samples recording a normal polarity. The magnetostratigraphy of Ranga Rao (1993) did not reveal this transitional polarity.

The identification of the collected fauna (Moigne et al., 2016) allowed us to correlate the studied sediments with the Quranwala fossiliferous zone (Sahni and Khan, 1964) and, thus, with the upper part of the Tatrot Formation. Any indication to explain the transitional polarity in the lower unit E was missing. By reference to the biostratigraphic data (Moigne et al., 2016) and to the stratigraphic studies (Chapon Sao et al., 2016; Tudryn et al., 2016), the sediments of the three units presented in this study were deposited during the Gauss magnetozone. Thus, the sediments can be considered older than the Gauss-Matuyama reversal, dated to 2.58 Ma (Cande and Kent, 1995; Gradstein et al., 2004).

8. Conclusion

Many paleomagnetic studies have been performed in the Upper Siwalik Subgroup in Pakistan and India aiming to build a chronological framework for the paleontological sites and, therefore, establish correlations between them. The latest prehistoric discoveries in the Masol inlier (district Mohali, Punjab) led to the launch of a multidisciplinary program of research. The new magnetic polarity studies of samples selected from the four stratigraphic units at the Masol 1 locality allowed us to precisely locate the stratigraphic position of these discoveries in relation to the Gauss-Matuyama reversal. During the sampling process, the thermal demagnetization was more effective than the AF demagnetization and provided reliable results. Our study demonstrated that the deposits mostly recorded a normal and a transitional polarity. In addition, with data from the paleontological assemblage, these results showed that the investigated sequence was, therefore, older than the Gauss-Matuyama reversal, dated to 2.58 Ma.

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