SCIENCE VISION
Volume 2026, Issue 1, pages 27–37
31 Mar 2026
https://doi.org/10.33493/scivis.26.01.05

ORIGINAL RESEARCH

Magnetostratigraphic study of the Bhuban Formation (Surma Group) in Midum Kham, Aizawl, Mizoram

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Magnetostratigraphic analysis was conducted on a ~380 m thick succession of the upper Bhuban Formation (Surma Group) exposed between Thiak and Sumsuih villages in Aizawl District, Mizoram. The study section yielded three normal and two reverse magnetozones, with GPTS-correlated ages ranging from ~9.308 Ma at the base to ~8.699 Ma at the top, spanning a total duration of ~0.609 Ma. The average sediment accumulation rate (SAR) is approximately 24.305 cm/ka, the lower part of the section exhibits a peak of 46.8 cm/ka prior to ~9.65 Ma. The subsequent decline in SAR to 11.02 cm/ka at approximately 9.45 Ma suggests a potential hiatus in the upper part of the succession that warrants further investigation.

Keywords: Bhuban Formation, Magnetostratigraphy, Mizoram, Surma

Received 10 Mar 2026
Accepted 31 Mar 2026

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Introduction

The Bengal Basin, positioned between the Indian Plate and the Indo-Burman Ranges, comprises three distinct tectonic provinces: the Stable Shelf and the Central Deep Basin (encompassing the Sylhet and Hatia Troughs), and the Chittagong-Tripura Fold Belt (CTFB)[1], which are more conspicuous in the Paleogene succession than in the Neogene. Mizoram lies in the Chittagong Hill Tracts (or is bordered by them). Mizoram predominantly characterized by Neogene sedimentary rocks, roughly N-S trending fold belt specifically from the Miocene to Pliocene epochs. While older Paleogene sediments (Barail Group) exist, the vast majority of the exposed rock formations in Mizoram belong to the Neogene, comprising the Surma and Tipam groups. In recent Years, many researchers in Mizoram have expanded significantly—covering petrography and heavy mineral analysis,[2,3] and structural frameworks[4]. Furthermore, although the fossil record of the Mizoram molasses has been extensively documented through body fossils[5,6,7], microfossils[8,9], and ichnofossils[10-17] fossilised tree resin[18] there is still a notable lack of modern geochronological studies focusing on definitive age dating

Magnetostratigraphy serves as a robust, independent tool for stratigraphic correlation, bypassing the limitations often found in traditional lithological methods. Over the past two decades, magnetostratigraphy has provided reliable chronological constraints for long continental sequences in the Himalayan foreland basin spanning Pakistan, India, and Nepal.[19-30] In Mizoram magnetostratigraphy has been work out by some researcher.[31-36] The high-resolution, continuous sedimentation rates in this region ensure uninterrupted magneto-zone records, aiding in precise time-scale establishment.

While Mizoram has been the subject of extensive multidisciplinary research, a definitive

ISSN 0975-6175 (print) /2229-6026 (online) | CODEN SVCIC9

geochronological age for the entire region remains elusive. While previous paleoenvironmental reconstructions of Midum Kham[37] is work out and has been identified the area as an intertidal, shallow-shelf depositional environment, its precise geochronology remains insufficiently explored. To address this gap, the primary objective of this study is to establish the magnetostratigraphy of the approximately 380-meter-thick Upper Bhuban succession at Midum Kham, located between Thiak and Sumsuih villages.

Study Area

The study is carried out in Midum Kham. The Midum Kham lies within latitudes 23°27′55″ N to 23°28′10″ N and longitudes 92°44′20″ E to 92° 44′30″ E, between Thiak and Sumsuih village Mizoram. This section comprises of about ~380 m characterized by Sandstone alternating with silt and shale exposed along the World Bank Road (see Figure 1).

Neogene Surma Basin, featuring a series of elongated, N-S trending folds that form an arc with westward convexity.[38,39] This fold belt aligns nearly parallel to the Arakan Yoma subduction suture zone[37,38,40] The Surma Group (Lower to Middle Miocene) is the state's dominant sedimentary succession, covering approximately 75% of its territory[41] Following the classification[42] which is based on sand-shale ratios, the group is divided into the Boka Bil and Bhuban subgroups—the latter of which is further split into Lower, Middle, and Upper formations (Figure 2).

The Surma Basin is a complex sedimentary sink that collected diverse materials from the Himalayas, the Indo-Myanmar Range, and the Shillong Plateau. Its Miocene-Pliocene history is recorded in the thick sediment piles of the Surma Group, which is divided into the Bhuban and Bokabil Formations. Researchers have interpreted these formations as shifting between deltaic, brackish, and shallow marine environments[1] Various methods, including sand-shale ratios[42], heavy mineral analysis, and

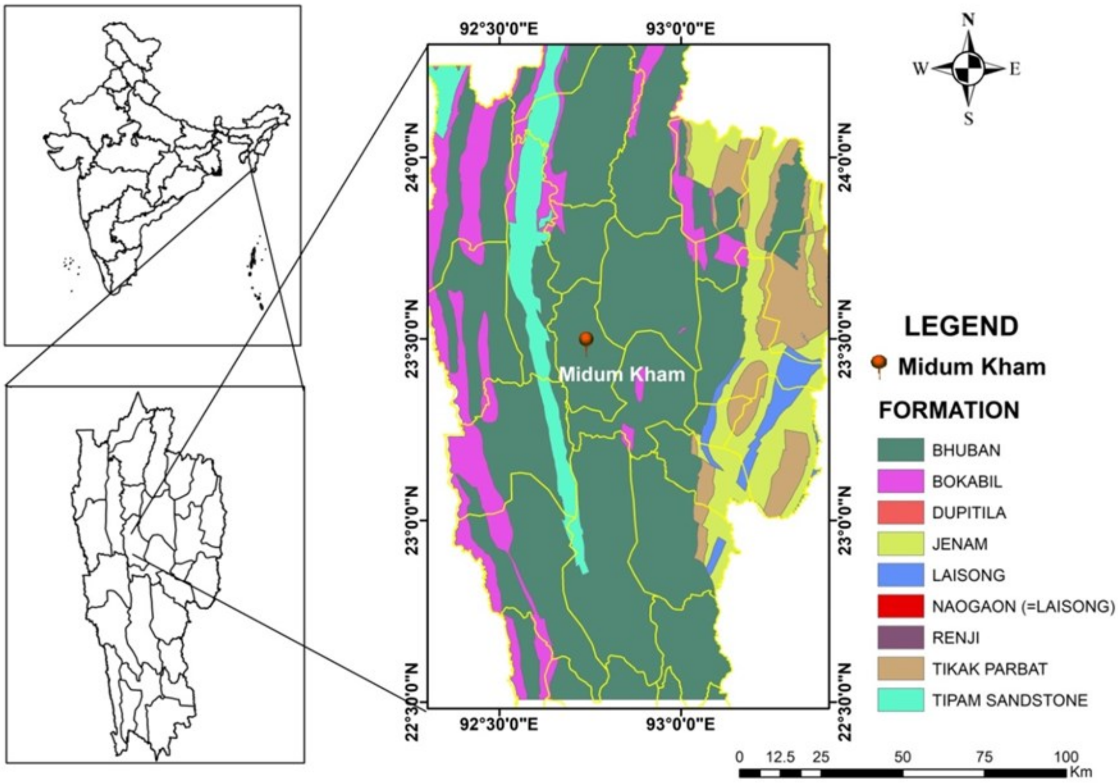

Figure 1. Location of the study area. (Source Geological Survey of India (GSI) Bhukosh portal. https://bhukosh.gsi.gov.in/Bhukosh/Public

Geology of the study area

Mizoram is geologically situated within the

fossil-based biozones[10-18,43-49] and paleoenvironmental reconstruction of Midum Kham was carried out[36] have been used to classify these sections. Magnetostratigraphic data suggests

Age	Group	Formation	Unit	Generalized Lithology
Recent	Alluvium			Silt, clay and gravel
---Unconformity---				
Early Pliocene to Late Miocene	Tipam (+900 m)			Friable sandstone with occasional clay bands
---Conformable and transitional contact---				
Miocene to Upper Oligocene	SURMA (+5950 m)	Bokabil (+950 m)		Shale, siltstone and sandstone
		---Conformable and transitional contact---		
		BHUBAN (5000 m)	Upper Bhuban (1100m)	Arenaceous predominating with sandstone, shale and siltstone
			---Conformable and transitional contact--	
			Middle Bhuban (3000m)	Argillaceous predominating with shale, siltstone-shale alternations ans sandstone
			---Conformable and transitional contact--	
			Lower Bhuban (900m)	Arenaceous predominating with sandstone and silty-shale
---Unconformity obliterated by faults---				
Oligocene	Barail (+3000 m)			Shale, siltstone and sandstone
---Lower contact not seen---				

Figure 2. Stratigraphic succession in Mizoram

significant tectonic activity and basin subsidence during the Late Miocene. However, despite these extensive studies, a complete understanding of the basin's evolution remains elusive.

Lithostratigraphy

The Midum Kham Section features a ~380 metre exposure of the Upper Bhuban Formation (Figure 3), dating from the Early to Middle Miocene. The sequence begins with 30 metres of ripple-marked grey siltstone, followed by a middle section of mixed sand and silt containing diverse structures like flaser bedding, herringbone cross-stratification, and soft-sediment deformation. The top 10 metres consist of massive, buff-coloured sandstone that coarsens upward. The Midum Kham features hard, compact rocks with a high clay content, consisting primarily of fine grey sandstones and occasional buff-coloured layers. Sedimentary structure like cross and parallel lamination, lenticular, wavy, lentisoid body, flaser bedding, clastic dykes, ripple marks and tidles bundles are present. These deposits contain foraminifers (*Ammonia* sp.) and a variety of ichnofossils (such as *Skolithos* and *Thalassinoides*), suggesting a shallow shelf or sub-tidal environment with fluctuating wave energy.

Materials and Methods

Following a field reconnaissance we selected Midum Kham section for its well-exposed, relatively undisturbed 380 m thick succession of the Bhuban unit, situated on the southern limb of the Aizawl anticline. Detailed litholog was prepared in order to understand the lithofacies variations and plan the magnetostratigraphic sampling. Oriented samples were primarily collected from siltstones, sandstones, and shales using a gasoline-powered

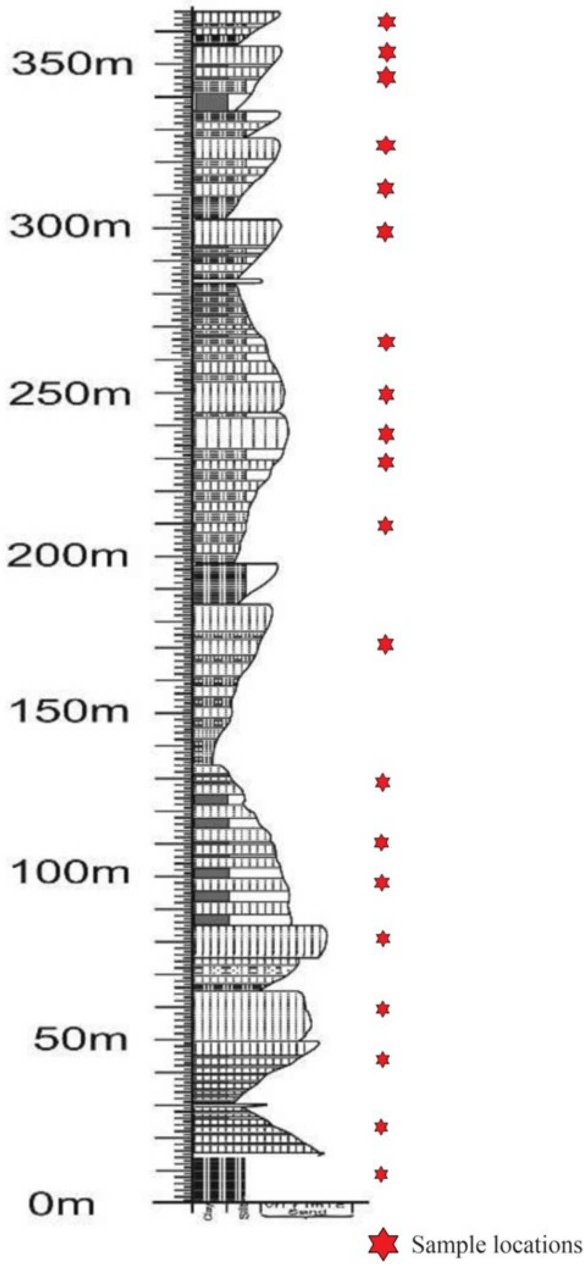

Figure 3. Lithocolumn of the study area

portable drill and orientation fixture. For softer sediments, manual sampling techniques were employed following Collinson[50]. Each core was processed into 2.2 cm cylindrical specimens using a dual-blade saw equipped with non-magnetic blades, then thoroughly cleaned while maintaining their original field orientations. For the magnetostratigraphic analysis, two initial batches of representative specimens underwent high-resolution demagnetization. Thermal demagnetization was performed using an MMTD-80 (Magnetic Measurements, UK), while alternating field (AF) demagnetization utilized an Agico LDA-3A, both conducted within shielded chambers with internal fields below 10 nT. The magnetic remanence intensity and direction were measured using an Agico JR-6A spinner magnetometer (sensitivity: 2×10^{-6} A/m). To interpret the results, Zijderveld plots and intensity decay curves were generated using Agico's Remasoft software. Based on these initial findings, the remaining sample batches were processed using the established thermal and AF protocols.

Results and Discussion

The section between Thiak and Sumsuih villages on World Bank Road, south of Aizawl, is a ~380 m-thick sequence, represented by 20 oriented sites, each collecting 8-10 specimens. Partial demagnetisation was performed to determine the remnant component assemblage and obtain ChRM directions. Stepwise Thermal demagnetisation was performed at 100, 200, 250, 300, 350, 400, 450, 500, and 580°C with partial NRM measurements. The alternating field demagnetisation was performed at steps of 10, 20, 30, 40, 50, 60, 70, 80, and 90 mT. After the rejection of the noisy samples, rest of the samples exhibit 90% of the intensity steadily decaying to 400° C. Simultaneously, a gentle rise and fall in decay indicate the acquisition of soft secondary components removed at 20 mT. The secondary components are demagnetised at field strengths below 50 mT, followed by plateau-like behaviour and good clustering. Most specimens were thus assigned stable ChRM values below 80 mT. The thermal demagnetisation shows single or double heating steps in the range 500 °C–580 °C within demagnetisation below 25 minutes, revealing the ChRM direction for the samples. Due to constant heating across the complete spectrum of Thermal demagnetisation, a few samples showed scattering and were rejected.

Zijderveld plots and the corresponding intensity decay curves of the representative samples depict the vector behaviour during demagnetization (Figure 4). The site-mean direction (after bedding/tilt correction), resultant vector (R), precision parameter (k), angular dispersion(s), and confidence limit (-95) for each bed are presented. The vector behaviour during Thermal and alternating-field demagnetisation is presented.

The VGP latitude of each horizon is plotted against the measured litho-column to reconstruct the local magnetic reversal pattern. A total of 3

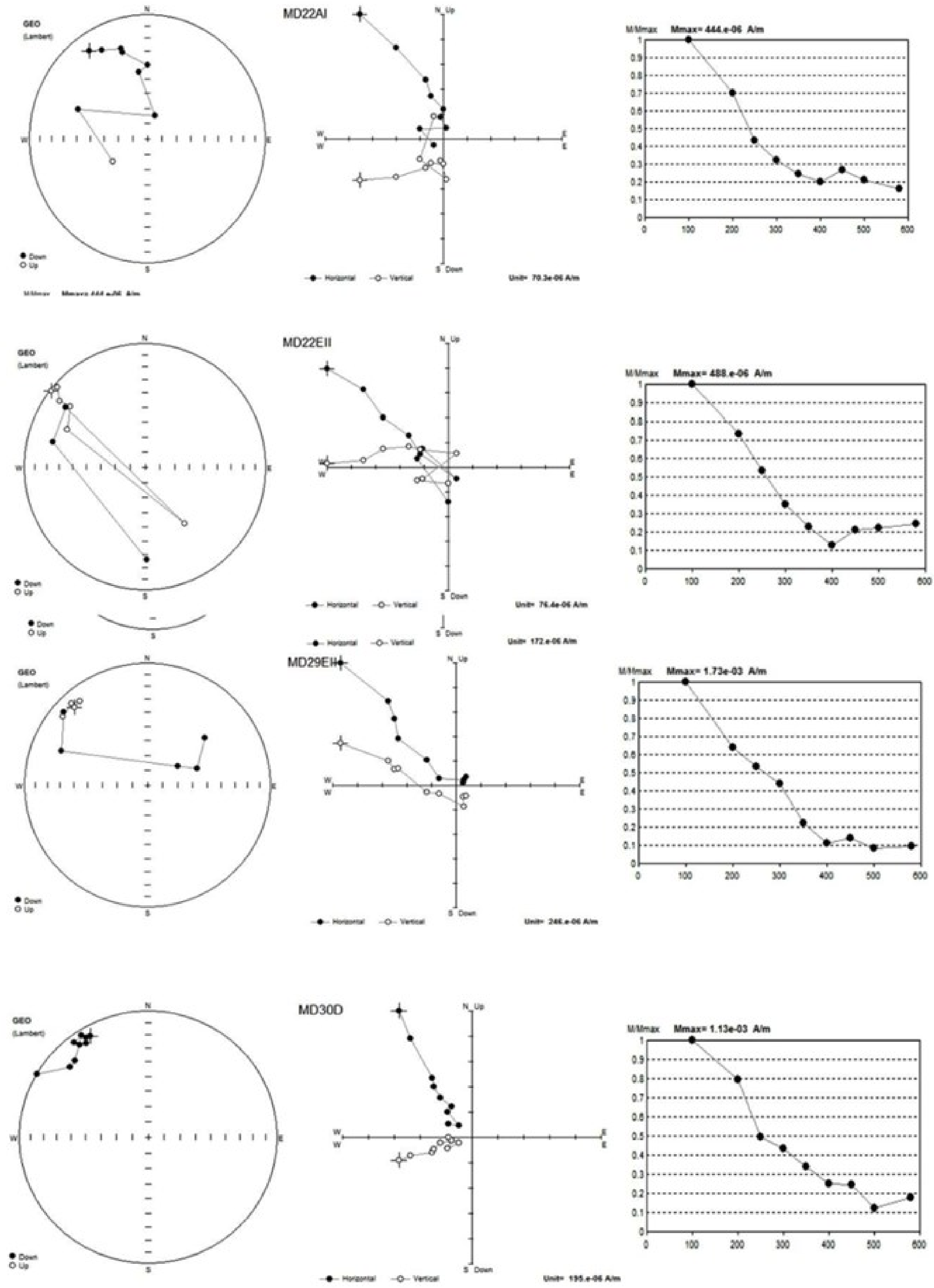

Figure 4. Zijderveld plots and the corresponding intensity decay curves of the representative samples depict the vector behaviour during demagnetization.

Table 1. Stratigraphic succession in Mizoram

Site	DM	IM	ALPHA 95	VGP LAT	VGP LONG	DP	DM2	PALEO-ALTITUDE	COMP. HEIGHT
MK33	39.8	19.6	45.5	44.8	189.8	25	48	11.2	380
MK30	260.6	-2.2	66.1	8.8	184.7	33	66	-1.3	360
MK29	258.1	-12.5	71.4	11.6	181.1	36	72	-5.75	345
MK27	282.1	-18.7	36.3	-11.5	172.8	18	36	-4.1	320
MK25	307.3	1.3	46.1	36.6	353.1	23	47	6.6	302
MK24	256.3	-0.9	43.8	-12	10.1	21	43	2.11	285
MK23	304.2	-27.9	25.4	-28.5	157.5	13	26	-8.6	264
MK22	268.2	20.8	51.4	-0.8	22	32	58	17.5	254
MK20	197.4	4.7	57.5	62.7	231.8	28	57	-1.8	233
MK18	201	-24	35.7	67	192.1	22	40	-17.6	203
MK15	15.3	11.8	59.9	67.2	229.6	30	60	5.94	185
MK14	257.6	-26.5	62	16.7	174	67	-14	-14	170
MK12	209.62	26.4	59.8	-42.8	51.6	64	13.9	13.9	145
MK11	313.68	15.0	95.2	42.9	350.7	91	7.6	7.6	135
MK3	315	-1.2	32.3	-40.2	160.2	32	0.61	-0.61	115
MK2	322.7	-29.5	30.3	-36.5	139	33	15.8	-15.8	105
MK1	50.16	-34.1	41.6	25.1	39.3	47	-19.3	-19.3	88
MKN4	29.3	50.0	44.4	30.1	25.7	37	55	30.8	60
MKN3	130.77	-62.7	80.7	44.9	42.3	99	126	-44.1	52
MKPN2	95.06	39.9	68.4	19.5	43.1	83	107	44.1	44

regular and 2 reverse magneto-zones are obtained from the Midum Kham section (Figure 5). The GPTS -correlated ages of the MC section range from ~9.308 Ma (at the base) to ~8.69 Ma (at the top). It estimates a total duration of ~0.618 Ma for the accumulation of a 350 m-thick sedimentary pile in this section. Consequently, this magnetostratigraphic correlation is considered preliminary, relying on a combination of iterative matching and field-based geological knowledge.

Sediments Accumulation Rates (SAR)

A change in Sediment Accumulation Rate (SAR) is one of the significant information on basin tectonic inferences using magnetostratigraphic data. However, its correlation needs careful examination since the SAR can vary with location (distal to proximal), tectonic settings or any other local influence for the given section within the basin. The Midum Kham section shows a deposit of high sedimentation (Figure 6). The average rate of sedimentation is ~24.305 cm/Ka. At around ~9.23 Ma at the height of about 70 m the rate of sedimentation is 46.80 cm/Ka then the rate decreases to 11.02 cm/Ka at about ~8.69 Ma. From the lithocolumn study of the area as well as by the results of biostratigraphy shows high sediments deposits. This abrupt changes in SAR demonstrate that the depositional environment to be inferred as near shore environment.

Conclusion

A total of 3 normal and 2 reverse Magnetozone are delineated within ~380 m thick Bhuban succession exposed along Midum kham, Aizawl, Mizoram. These match fairly well with the corresponding magneto-zone available on GPTS. The GPTS correlated ages of Midum kham falls between ~9.308 Ma (at the base) to ~8.669 Ma (at the top). A total of ~0.609 Ma duration has been

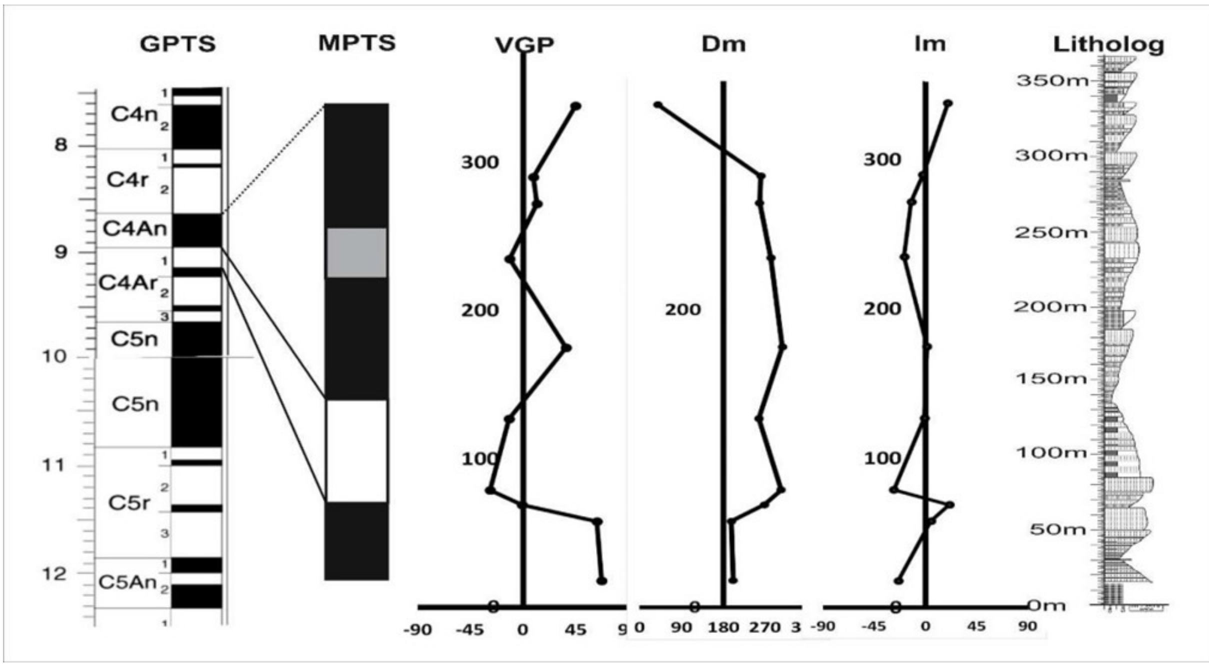

Figure 5. VGP latitudes and magnetic polarity correlation to GPTS (Cande and Kent[5]) for the Midum section

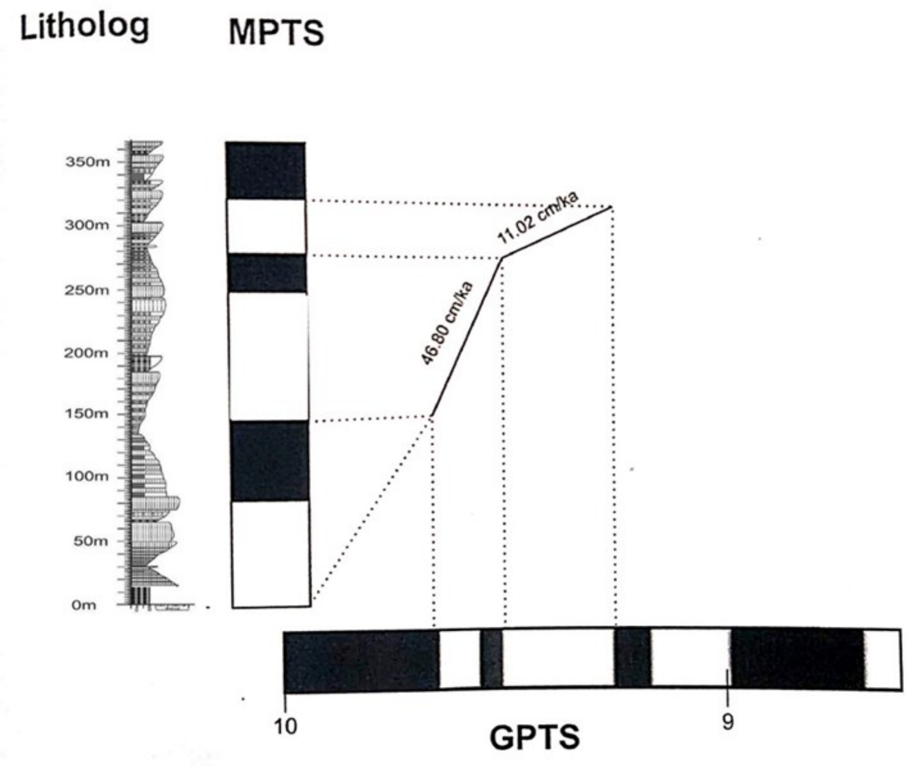

Figure 6. Estimation rate of sedimentation of Midum Kham

estimated for the accumulation of 380 m thick sedimentary pile in this section.

The average sediment accumulation rate for this section is 24.305 cm/Ka. At around ~9.23 Ma at the height of about 70 m the rate of sedimentation is 46.80 cm/Ka then the rate decreases to 11.02 cm/Ka at about ~8.699 Ma. Overall, the SAR is higher in the lower part of the section with the spike of 46.86 cm/Ka at <9.308 Ma. The deposits of the Bhuban show sedimentation rate between 11.02 – 46.80 cm/ka without major hiatus. This might has permitted the preservation of uninterrupted magneto-zone records. Therefore magnetic polarity stratigraphy of Surma sediments may form a robust tool for correlation of the Cenozoic sequence in the Northeastern region.

Acknowledgement

The authors are thankful to the Department of Geology, Mizoram University, Tanhril, India, for expanding laboratory capabilities to extending facilities for this research work.

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