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Laminated sediments of the Garbyang palaeolake, Kumaun Tethys Himalaya -preliminary magnetic results

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The Quaternary history and geomorphology of the Himalaya is a result of the complex interaction between exceptionally active and accelerating Cenozoic tectonism sufficient to lift several massifs during the Quaternary Period. The Quaternary times have witnessed disruption of widespread areas resulting in the formation of broad valleys and blockade of several drainage basins forming the lakes. One such lake basin in Kumaun Tethys Himalaya at Garbyang (30� 5′–30� 10′ N, 80�50′–80� 55′ E) lies in a transitional zone between dry steppe (Tibetan plateau) and the sub-humid (Himalayan) climate zone. The SW monsoon is the dominant source of precipitation. Moisture laden SW winds enter into the basin through the narrow valley in Garbyang during June-September which account for 80% of total precipitation, and part of it falls as snow over the glaciers. During November to February, the winter monsoon contributes remaining 20% of the precipitation. The sediment sequence is about ~134 m thick (Fig. 1& 2) and is comprised of varves (clays, sands and gravels). The varve facies overlie other sediments with an erosional base and are laterally continuous for several hundreds of meters. The varve consists of clay and silty clay laminae arranged in a rhythmic pattern giving rise to dark and light couplets. The clays form the dominant part and range between 50% and 80%, whereas, the silt fraction varies by 20% to 50%. The thickness of the individual clay laminae ranges between 0.1 mm and 0.3 mm, whereas, the silty clay laminae are coarser. The silty clay laminae exhibit development of small-scale ripple structures. Often associated with the varve facies are the carbonaceous mud, wood/charcoal fragments and angular clasts. Deformational structures such as convolutes, flames, pseudo nodules and small- scale faults are present in the varve sediments.

The rhythmic deposition of clay and silty clay laminae is a characteristic of a glacial lake setting. The individual couplet of the dark clay and lighter silty clay laminae perhaps represents an annual sedimentation event, termed as 'varve'. Massive gravel units exhibiting definite imbrications and with a thickness of about 3-15 m are an important part of the profile. This facies consists of moderately to poorly sorted,poorly graded and imbricated gravel-boulder clast supported gravel. These imbricated Gm facies occur as independent and with erosional or sometimes having sharp contacts with the underlying sediments. The general imbrication pattern observed is NNW-SSE. These imbricated massive gravel units are laterally continuous, observed as lensoid for several hundred meters. Massive sand facies comprise of structureless, ungraded to poorly graded and medium to very coarse-grained sands. The thickness of these units varies from 0.4 to 1.4 m and they are often marked by the presence of outsized angular to subroundedclasts ranging between 1 and 10 cm. These Sm beds are lensoidal and persist laterally for several tens of metres The Sm facies lack development of primary sedimentary structures.

The massive sands interbedded within the massive clays or varve layers exhibit deformation structures such as pseudo nodules, ball and pillows and dykes are observed. Facies Sm is attributed to the deposition by subaerial hyperconcentrated flows or subaquous high-density turbidity currents. Massive sand may be deposited due to turbulent suspension giving insufficient time for the bedform development. This may be the reason for the absence of sedimentary structures and presence of outsized clasts in the massive sand. The development of the penecontemporoeus sediment structures may be either due to rapid deposition of the sands over the clays or as a result of the ground shaking movements during the occurrence of earthquakes. Massive clay (Fm) facies is composed of ungraded and massive or poorly laminated clays with a thickness of 10-30 cm. Individual Fm beds have non-erosional bases and extend laterally for several tens of meters. These are generally associated with the Gh, Sh and Sm facies. The massive mud facies is interpreted as deposits of subaerial waning flood flows. These may have been deposited due to waning flood flows or from suspension fall out. Their association with the Gh, Sh, Sm facies may be suggestive of deposition by low density sheet flow processes. The clast supported breccia units are 1-3 m thick and are laterally persistent for several hundreds of metres. The gravel unit comprises of angular-subangular, poorly graded and poorly sorted, striated gravel-boulder sized clasts. The clast size ranges from 2-40 cm but occasionally some of the outsized clasts of 1-3 m size are also observed. The angular unsorted and ungraded nature of the deposit suggests its transport from the adjacent mountain slopes and emplacement as debris flows. The lateral continuity of more than 10 km may argue towards deposition of the breccia unit from the mountain derived debris. The striated and angular-subangular nature of the clasts may suggest that these may have firstly transported by glaciers and later deposited as melt water product having very less time to clast accretion resulting in the angularsubangular nature of the clasts. Two radiocarbon dates obtained on the bulk organic matter show that the top of the sequence belongs to Holocene. Preliminary palaeomagnetic results of the profile indicate the normal polarity except at the bottom (ca. 3-6 m from the base). Considering the sediment accumulation rate in such a terrain and avoiding the gravels while estimating the rate of sedimentation, we assume that the base of the Garbyang profile is Upper Pleistocene. At the moment, the preliminary studies can not firmly assign the reversed polarity chron to any specific time period.The susceptibility measurements do not show any major departure in the values except for the medium to coarse grained sands. The detailed analysis and interpretation is being carried out.