Delta formations associated with high-frequency (annual?) lake-level fluctuations: An example from the uppermost Pleistocene Gokarna Formation, Kathmandu Valley, Nepal

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The Kathmandu Valley, one of the intermontane basins in the lesser Himalayan Belt, is filled with fluvio-lacustrine deposits dating from the Pliocene. After 5 ka BP, sediments in the central part of the basin occur as depositional terraces (Patan, Thimi and Gokarna terraces), the formation of which has been interpreted as being related to lake-level changes (Yoshida et al. 1984). The uppermost Pleistocene Gokarna Formation, which forms the Gokarna Terrace, has been interpreted as forming in conjunction with long-term lake-level rises associated with basin plugging and lake-level falls caused by lake water out-bursts at the basin outlet (Sakai et al. 2000). This formation is composed of small stacked Gilbert-Type delta successions, the thickness of each is up to 10 m. Small-scale, high-frequency lake-level fluctuation is especially recorded in the delta front deposits of the lower part of the formation that accumulated between ca. 50-35 ka. Based on the large number of fluctuations seen even in small outcrops, Sakai et al. (2001) inferred that these high frequency cycles were formed by annual lake-level changes. Our recent work has detected at least 21 cycles in a 40-m wide outcrop. Previous work was limited to the delta front, and broad scale stratigraphic architecture associated with the short-term fluctuations was thus unclear. Here we describe lateral facies changes of delta deposits formed in association with short-term lake-level changes and discuss their processes of formation.

Two types of delta deposits, juxtaposed in the same stratigraphic horizon, were identified in the lower part of the Gokarna Formation. Delta front deposits of the first type (type 1) are represented by 0.5-3 m thick, tabular cross-stratified sand and silt beds. The silt beds are continuous with prodelta deposits. Most of the silt beds pinch out near the top of the delta front, but some extend beyond the delta front and cover the delta plain sand beds deposited prior to the silt beds. Delta plain deposits of this type are characterized by lenticular, epsilon cross-stratified fluvial channel fill sand and silt beds and flood plain silt beds. Silt beds in the channel fill deposits continue into the surrounding flood plain silt beds in many cases. Delta front deposits of the second type (type 2) are characterized by thick, steeply dipping (ca. 30°) foreset sand beds. Thicknesses commonly reach 5-10 m. Small sand wedges (up to 1 m thick and 2-3 m wide) are frequently attached to the lower part of the foreset slope, and small gullies are developed in the upper part. The wedges contain tabular cross-stratification, are flat-topped, and are covered by thin trough cross-stratified fluvial channel fill deposits which are, in turn, overlain by delta front deposits prograded after sand wedge formation. In some delta front sand beds, inclined foreset beds tend to be flat to the up-dip direction and grade into trough cross-stratified sand beds with sheet-like geometry (up to 1 m thick), which are of braided stream origin.

The interbedded silt beds in the type 1 delta front deposits that continue from the prodelta and extend onto the delta plain deposits and those in the fluvial channel fill deposits spreading into the surrounding flood plain deposits suggest that they accumulated when the delta plain was inundated and delta progradation occurred during lake-level lowstand. The attached small delta wedges in the type 2 delta front topped by fluvial channels represent temporary deltas formed when lake level fell. This also indicates that type 2 delta progradation occurred mainly during lake-level highstand. Transition from delta front to braided stream deposits on the delta plain indicates some of the type 2 delta deposits accumulated during lake-level rise, when sediment accumulation on the delta plain was synchronized with lake-level rise. The differences in level of the tops of the delta front deposits and those of the attached sand wedges show that the amplitude of lake-level fluctuations was 6 m at most (average ca. 3 m). Changes in fluvial style from meandering (type 1) to braided streams (type 2) can be explained by alternating, possibly annual, wet and dry periods. In the lowstand phase (dry period), meandering streams0could develop due to lower water discharge. During lake-level rise (i.e. wet period), larger water discharge together with enhanced sediment supply could then produce braided streams.

The high-frequency lake-level fluctuation described above does not occur in the upper part of the Gokarna Formation. One possible explanation for the absence of cyclicity in this part of the succession is that the lake could then have been more extensive: if lakes are wider, larger volumes of water are required to produce fluctuations in level. Climate change is another possibility. Our age measurements show that the upper part of the Gokarna Formation was deposited at about 17 ka BP, indicating that accumulation occurred around the last glacial maximum. Both climate change and more extensive lake area may thus contribute to the absence of sediment cycles in the upper part of the Gokarna Formation.

References

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