SEDIMENTARY PROCESSES AND LITHOFACIES IN LAKE-MARGIN GROUNDWATER-FED WETLANDS IN EAST AFRICA

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ABSTRACT: Groundwater-fed wetlands are common features of many lake margins, and they may leave characteristic deposits that record hydrologic conditions at their time of formation. Geomorphic and sedimentologic observations of wetland complexes on the margins of Lakes Eyasi, Makat (Ngorongoro Crater), and Natron, Tanzania, show that clastic, chemical, and biological processes in the wetlands produce discernible lithofacies variation. Five distinct sets of lithofacies are identified: sands and gravely sands (S and Sg), silty to sandy muds (Sm), bioturbated muds (Mb), alkaline muds (Ma), and organic-rich rootmats, peat, and clay (R, P, C). Several wetland depositional subenvironments can be defined on the basis of lithofacies associations, including drainage channels (facies S, Sg, Mb, Ms), marshes (R, P, C, Mb, Sm), hippopotamus flats (Co, Mb, Ms), pools (S, Sm, Mb), and alkaline flats (Ma, Co). Sediment supply, aqueous geochemistry, activity of large mammals, and composition and distribution of vegetation are the primary controls on sedimentation. Sediments in these subenvironments are generally thin (< 1 m), but they are thicker where large mammals like Hippos watermarkus generate deep (> 1.5 m) bioturbation zones. Recognizable lithofacies are found up to ~ 1 km basinward from the sources of spring waters, with down-gradient sediment fining. Very strong evaporatively driven geochemical gradients are seen as well, with increasing salinity and alkalinity downstream and laterally. Wetland sediments are laterally restricted to only a few tens of meters, and they abruptly interfinger with sediments from adjacent fluviolacustrine environments. In all three basins, these recent deposits overlie a regressive disconformity or hiatus that signifies a drop in lake level, recording the onset of regional aridity during the late Holocene. Such wetland sediments can be important paleohydrological indicators, generally indicating a fluctuation that led to subaerial exposure and colonization of lake flats by wetland vegetation.

INTRODUCTION

Wetlands associated with groundwater discharge are common features of closed-basin lakes in the East African Rift, especially in drylands where minerotrophic mires develop on exposed mudflats (Hardie et al., 1978). Laterally extensive sheets of fine-grained sediment may accumulate in these settings, although they have not been widely recognized in the sedimentary record, and there are few reports of modern facies (Hamilton and Taylor, 1986; Quade et al., 1995). These deposits typically comprise multiple lithofacies, and are found within larger sedimentary systems. The depositional context in which the wetland sediments form may be perennial lacustrine (Hardie et al., 1978; Renaut et al., 1986), playa (Hay et al., 1986; Quade et al., 1995), or fluvial (Haynes, 1985; Holliday, 1995).

Wetland deposits have been difficult to recognize in the sedimentary record for several reasons. First, wetlands are usually small features relative to their sedimentary basins. Their deposits, therefore, can be expected to be limited in areal extent (Quade et al., 1995). Second, because many biotic, chemical, and hydrologic processes are active in spring systems, many lithologies can form. This complexity is due in part to their close proximity to environments, like alluvial fans or lakes, that may overprint or destroy the sedimentary record of a spring. Third, the fine grain size and organic-rich composition of wetland sediments can be similar to those of lacustrine deposits. Fourth, the familiar image of spring deposits as travertine mounds or siliceous sinters has focused attention on laterally restricted chemical precipitates. Some styles of groundwater discharge do indeed favor chemical precipitation, especially those with thermal ground waters, and substantial evaporative concentration of waters can induce authigenic mineralization even at ambient temperatures. However, a volumetrically more significant component of sedimentation can occur over a much larger area around springs, and in pools, marshes, and other wetlands (Hay et al., 1986; Holliday, 1995; Quade et al., 1995; Deocampo, 1997).

Significant relief in wetland systems is usually found only adjacent to spring discharge that is associated with fault conduits (Haynes, 1985; Quade et al., 1995), mounds formed of spring deposits (e.g., Roberts and Mitchell, 1987), or spring-sapping features (Baker et al., 1990). The preservation of wetland sediments is therefore enhanced in low-gradient lake-margin settings.

In the playa-margin groundwater-fed wetlands of the Great Basin, U.S.A., Quade et al. (1995) recognized four main depositional subenvironments: (1) an upslope alluvial fan or plain, (2) a sand/phreatophyte flat, (3) a wet meadow, and (4) marshes with spring pools. These late Quaternary deposits were useful in reconstructing paleo-water table fluctuations, and demonstrated the importance of groundwater-fed wetlands as a depositional environment (Quade et al., 1995; Quade et al., 1998).

Chemical precipitates can also constitute a significant volume of spring deposits, and these reflect groundwater and surface-water chemistries. Chemical sedimentation is dominant at spring heads (Hardie et al., 1978) and in playa lakes (Rosen, 1994), and also may occur in associated marshes (Hay et al., 1986; Deocampo and Ashley, 1999a). Precipitation at spring heads, typically carbonate travertine and tufa, is perhaps the most diagnostic deposit of a spring, but spring mounds form only where calcium carbonate supersaturation is achieved.

Wetlands associated with ground-water or surface-water discharge are an important component of hydrologically closed basins, such as those in the East African Rift. In these settings, stratigraphic relationships between marginal lacustrine wetland deposits and lake sediments could provide high-resolution, potentially datable evidence for paleoenvironmental and paleo-