MEANDER LOOPS AND POINT BAR SEQUENCES: EVIDENCE OF A STABLE DELTA PLAIN ENVIRONMENT IN JEZERO CRATER. S. C. Schon[1], C. I. Fassett[1], and J. W. Head[1] [1]Department of Geological Sciences, Brown University, Box 1846, Providence, RI 02912; Samuel_Schon@brown.edu

Introduction: Unambiguous deltaic geomorphology has only recently been identified on Mars [1,2]. Studies of Eberswalde delta have highlighted the multi-lobe morphology of this deposit as evidence for a long-lived lacustrine system [e.g., 3,4]. In 2005 Fassett & Head [5] discovered two deltaic deposits in a 45-km crater (Jezero) in the Nilli Fossae region associated with valley networks draining a 15,000 km^2 watershed. Jezero crater also has an incised outlet channel approximately correlative with the deltaic deposits [5]. We analyze new data, and compare observations with terrestrial deltaic processes. We focus on fluvial sedimentary features, especially meander loops, scroll bars, and point bar sequences, to help constrain the depositional style and evolution of the deltas. These new observations point to a deltaic environment characterized by prolonged periods of steady discharge and stable baselevel, which has significant implications for the Noachian climate system.

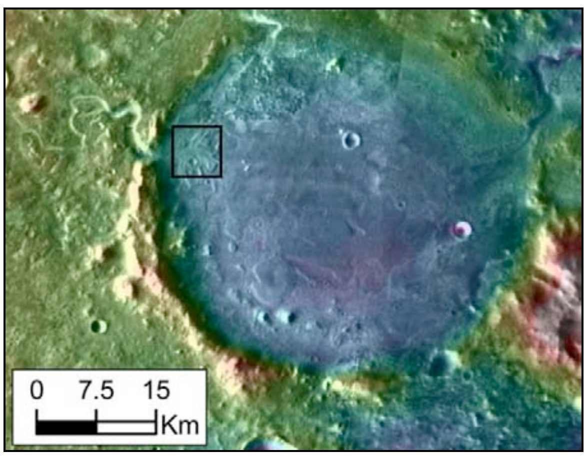

Figure 1: Jezero Crater (18°25' N, 77°40'E), near Nili Fossae northwest of the Isidis Basin, is a paleo-lacustrine lake system with two deltas and an outlet channel. The western delta is highlighted [5].

Delta Architecture: Terrestrially, tidal range, wave energy, sediment supply, longshore drift, and tectonic factors all control overall delta architecture (Figure 2). These factors can be considered primarily fluvial/constructive (sediment supply and composition) or marine/destructive (waves, tides, and longshore drift) processes [6]. Both Jezero deltas are sediment-dominated, lobate-to-elongate, Gilbert-type deltas. The western and northern deltas are morphologically similar; however, the western delta is larger (commensurate with the more extensive drainage) and presently affords better exposures.

A tripartite subdivision of terrestrial deltas includes delta plain (landward, fan-shaped, low relief, many distributaries), delta front (sloping transitional regime, site of rapid deposition during progradation) and pro-delta (furthest offshore, fine-grained deposition) environments [7]. No clear evidence of pro-delta environments is observed in Jezero – we hypothesize that deflation, erosion, and volcanic resurfacing have effectively obscured remnants of this depositional regime. Discontinuous mesa-like features indicate that the delta was once more extensive and has subsequently eroded back, making the over-steepened delta front that is observed an erosional, rather than depositional, feature. The putative delta plain environment is composed of finely layered sediments that contain among the best examples of deltaic fluvial geomorphology on Mars.

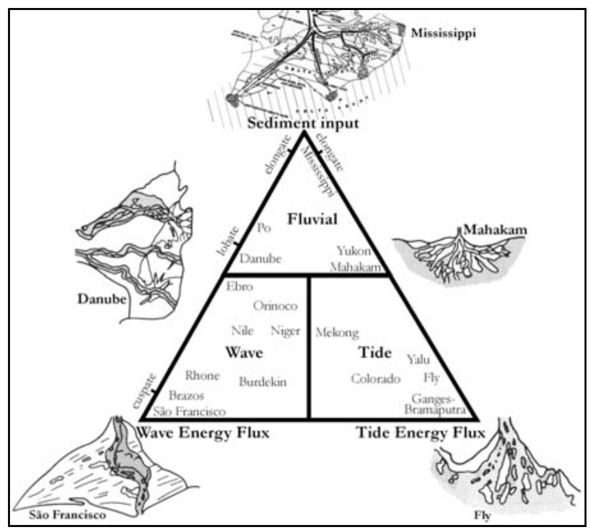

Figure 2: A ternary diagram classification of delta morphology illustrates dominant controls and the continuums of morphology that exist between endmembers. Jezero crater delta deposits are lobate to elongate, characteristics of the fluvial regime [after 6].

Fluvial Geomorphology: HiRISE data provide high-resolution (~25 cm/pixel) outcrop-scale views of the delta morphology that were not available when the deposits were first interpreted [5]. These data contain evidence of migrating distributary channels, which indicate that a significant portion of the delta plain sediment was deposited via lateral accretion in meander belts (Figures 3 and 4).

Meander loops. Unconstrained alluvial stream system channels occur in boundary materials that have been deposited by, and can be eroded by, the stream. They develop sinuous, braided, and anabranching forms which have been classified by [8]. Sinuous streams are characterized by meanders, which form as a result of helicoidal flow. Meander loops (one bend of a meander) increase in amplitude and migrate downstream in an active system. The migration record of meander loops is preserved by scroll bars on laterally accreted deposits [9].

Point bar sequences. Point bar sequences are prograding, diachronous, time-transgressive, laterally continuous, fining upward (channel lag → gravel → sand → silt/clay) sequences that form at the inner bank of meanders and produce distinctive lateral accretion topography (scroll bars and intervening swales). Therefore, while in general deltas are composed of coarsening upward sediments, cross-laminated finest-grained materials top point bar sequences [7].

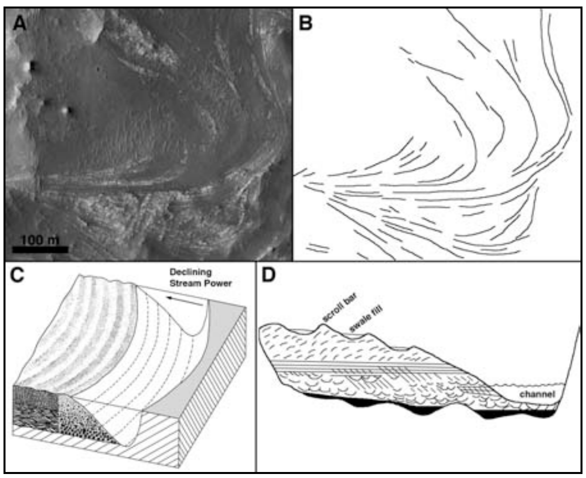

Figure 3: A) Lateral accretion topography preserved in the delta plain environment of the western delta in Jezero crater. Lateral accretion topography indicates a succession of point bar deposition (prograding, diachronous, time-transgressive, laterally continuous, fining upward sequences) formed by channel meandering; HiRISE PSP_002387_1985. **B)** Sketch map of A highlighting scroll bars and multiple episodes of point bar migration. **C)** Block diagram of active meander and point bar deposition system; dashed lines indicate lines of constant stream power. **D)** Cross-section of a point bar; swale fill is dark sand in A.

Scroll bars. Point bar progradation forms lateral accretion topography topped by elongate ridges termed scroll bars. These concentric ridges and intervening swales record the migration of the system. Scroll bars originate from elongate bars on the accretion surface that migrate to "bank-full" positions on the point bar [10].

Epsilon Cross-bedding. Lateral accretion of point bars leads to epsilon cross-bedding, also known as lateral accretion surfaces. Terrestrially these beds mark depositional surfaces of point bars and are observed commonly in lateral accretion deposits, such as deltaic sections within the Book Cliffs, Utah [11].

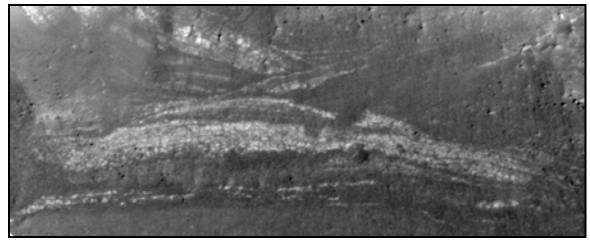

Figure 4: An ~1km crater provides exposure of epsilon cross-bedding in the wall. Accretion is to the left in the lower portion and to the right in the upper portion (220m across, PSP_002387_1985).

Conclusions: The recognition of point bar sequences and significant deposition by lateral accretion in the delta plain environment of the western Jezero delta provides constraints on the fluvial activity of the lacustrine system and points toward a *multiple distributaries* delta architecture. For terrestrial alluvial systems to migrate extensively, stable baselevel is required. If the baselevel of the system is falling, depositional environments will be shifted distally (basinward) and the channel will downcut. If baselevel is rising, the fluvial system will become sediment starved and transgressive lags will form as deposition shifts proximally.

Therefore, the formation of extensive meander belts in the delta plain environment implies a significant period of stable baselevel in the Jezero lacustrine system while these sediments [12] were being deposited. Baselevel could have been maintained via the outlet channel, which is approximately correlative with the current delta surface [5]. Also, given the size of the watersheds drained by the dendritic valley networks, sustained fluvial activity appears to be required, suggesting a comparatively temperate climate interval for at least some period of time during the Noachian. The terminal stage of the system is not constrained by these specific fluvial geomorphic features.

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