Next Stop....



MSL Site: Eberswalde Deltaic Complex

Jim Rice Assisted by Juergen Schieber and Ralph Milliken J. Dickson, K. Edgett, and M. Minitti

October 23, 2007

Outline

- Evidence that Eberswalde contains a Delta and comparisons with terrestrial deltaic complexes
 Eberswalde lake duration
 Science Objectives
 Tour of Landing Ellipse (HiRISE and CRISM)
- 5. Safe Haven Site
- 6. Summary

Background Fundamentals:

Deltaic systems have long been studied qualitatively and quantitatively as the cradle of early faunal and floral evolution along terrestrial prehistoric shorelines.

EBERSWALDE CRATER

- Location: 23.8.S,326.7E
- Diameter: 65 km
- Elevation: -1.480km
- Geology: Numerous channels cut western rim of Eberswalde.
 Distributary multi lobate fan (115 km²) composed of layered sediment, meandering channels, inverted channels, meander cutoffs and scrolls, cross cutting channels



Eberswalde Delta

Series of valleys drain highland area of 4800 km² (5 orders of tributary branching)

Preserved delta 10 X 25 km, volume 20 to 30 km³
 1. Prograded from NE, located along western margin of Eberswalde crater
 2. Frosional remnant of larger thicker paleodeltaic

2. Erosional remnant of larger thicker paleodeltaic complex

Delta may have extended up to 45 km from apex



Series of valleys drain highland area of 4800 km² (5 orders of tributary branching)

Preserved delta 10 X 25 km, volume 20 to 30 km³

- 1. Prograded from NE, located along western margin of Eberswalde crater
- 2. Erosional remnant of larger thicker paleodeltaic complex

Delta may have extended up to 45 km from apex



<u>Channels</u> record complex history of migration, avulsion and bifurcation

Meandering Channels prime evidence for on-going, persistent flow of water



Is this a Delta or Alluvial fan?

Distributary channel development and Bifurcation are well documented and recognized as fundamental delta building process in a fluvially dominated prograding Delta (Welder, 1959; van Herdeen and Roberts, 1980).

The Eberswalde deposit clearly exhibits distributary channel architecture typical of distributary deltaic systems. Distribution of distributary channel widths similar to pattern seen in terrestrial deltas:

Eberswalde delta 86% of distributary channels are 100-240 meters wide, compared to 62% and 44% of distributary channels in the Atchafalaya and Wax Lake Deltas of Louisiana, which are of similar size to the Eberswalde delta.

Channel Sinuosity

Sinuosity is measure of channel length divided by length measured down axis of meander belt. Terrestrial channel sinuosities are highly studied and influence channel morphology and sediment load (Schumm, 1987).

Eberswalde channels exhibit sinuosities ranging from 1.1 to 1.8 (indicates prolonged periods of water flow).

Atypical for channels on alluvial fans, alluvial fan channels tend to be straight and braided and have (much lower sinuosities) and tend to lack meander bend migration and point bar development.

Preponderance of Evidence: Eberswalde depost is a Delta

Channels have evidence of chute cut-offs, meander bend migration, point bars, numerous incised cross cutting channels, inverted channels.

Distribution of distributary channel widths and channel sinuosities similar to pattern seen in terrestrial deltas.

Two styles (leaf and tongue shaped) of deltaic lobe development.

Eberswalde Delta

- 1. Cross-cutting distributary relationships and compensated depositional lobes are clearly visible
- 2. Delta composed of six separate depositional lobes
- 3. Channel sinuosities between 1.2 and 1.8 define low- to moderate-sinuosity systems typical of the type transporting bed or mixed-grain-size loads.
- 4. Channel systems increase in sinuosity as they get older.
- 5. Eberswalde delta 86% of distributary channels are 100 to 240 m wide, compared to 62% and 44% of distributary channels in the Atchafalaya and Wax Lake Deltas of Louisiana, which are of similar size to the Eberswalde delta.
- 6. The volume of the material in Eberswalde deposit suggests long periods of sediment deposition. Sinuosity indexes, meander-bend migration, and ridge-and-swale point-bar topography suggest periods of stable discharge on the delta surface.



- Multiple Delta Lobes

- up to 150 m of sediment
- 30 km³ sediment volume

 minimum duration estimates, 10's to 100's of years (JeroImack et al., Lewis & Aharonson)

 by comparison to terrestrial analogs, sedimentary record more likely ranges from 150, 000 years to several million years (Bhattacharya et al.)

Eberswalde Crater: Long Lived Lake

1. Closed Basin

2. No outlet channels

Lake Life estimates range from ~100 years to 150,000 years, possibly millions of years

(Jerolmack et al, 2004) 100 to 10,000 years duration Assumptions: Continuous flow But if flow had typical terrestrial intermittency (humid to sub humid climate) formation would increase by factor of 20 (2,000 years duration) and for arid to hyperarid climates increase by factor of at least 100 (10,000 years duration). (Bhattacharya et al, 2005) 150,000 years to millions of years Assumptions:

11 avulsion events, avulsion event periods of a few hundred years, transitions from straight to meandering channels, sedimentation rate of 1 mm/yr

However the Eberswalde delta has been highly eroded and may be exhumed, we don't know maximum thickness and areal extent of deposit. So the lake may have lasted much longer or may have had several episodes of lake formation over time.

Biological objectives:

- 1. Determine the nature and inventory of organic carbon compounds
- 2. Inventory the chemical building blocks of life (carbon, hydrogen, nitrogen, oxygen, phosphorous, and sulfur)
- 3. Identify features that may represent the effects of biological processes

Geological and geochemical objectives:

- 4. Investigate the chemical, isotopic, and mineralogical composition of the martian surface and near-surface geological materials
- 5. Interpret the processes that have formed and modified rocks and soils

Planetary process objectives:

- 6. Assess long-timescale (i.e., 4-billion-year) atmospheric evolution processes
- 7. Determine present state, distribution, and cycling of water and carbon dioxide

Surface radiation objective:

8. Characterize the broad spectrum of surface radition, including galactic cosmic radiation, solar proton events, and secondary neutrons

Studying Eberswalde will provide

Goodies for Everyone: For the Sedimentologists

- Sedimentary Rocks, aqueous environment. Rainfall & sustained flow. Soil and clay formation
- □ Standing Body of Water, accumulation of fines likely.
- Heterolithic Succession, (softer intervals mudstones)
- Point bar and deltaic shallowing upwards successions; Types & associations of sedimentary features; Prodelta mudstones
- Microbial mats in sandy/muddy deposits on delta platform?



Studying Eberswalde will provide

- **Goodies for Everyone:** For the Exobiologist
- Aqueous environment
- □ Standing Body of Water
- Noachian in Age



- If life was present, remains should have been buried in prodelta deposits
- Good preservation of organic matter & biomarkers because of rapid burial in prodelta muds
- Potential for preserving microbial mats in sandy and muddy deposits on delta platform

Tour of Landing Ellipse

Eberswalde: 25x20 km Ellipse

Even within the ellipse many valuable targets:

- Escarpments of layered rocks, likely sedimentary
- Inverted channels that may protect softer (clay-rich) sediments from erosion
- Exhumed anastomosing and branching channels (association with fine grained sediments; Extended fluvial history)
- Light toned deposits that may be clay-bearing (by analogy with light toned deposits in the delta lobes)
- Light toned deposits with polygonal cracks (like in delta lobe escarpments)

Eberswalde: *25x20 km Ellipse*

Multiple Areas of Interest, Examples (many more)





HiRISE: Center of Ellipse (PSP_005556_1560)



HiRISE: Center of Ellipse (PSP_005556_1560)



Eberswalde: *25x20 km Ellipse*

Examples of Interesting Areas: A



Eberswalde: *25x20 km Ellipse*

- Exhumed channels (relief inversion)
- Mesa with layered rocks exposed on slopes
- Low relief bedrock outcrops



Eberswalde: *25x20 km Ellipse*

• HiRISE detail: light toned layered rocks on slopes

• Clays P



Eberswalde: 25x20 km Ellipse

• HiRISE detail: light toned layered rocks with polygonal cracks

• Clays P



Eberswalde: *25x20 km Ellipse*

- HiRISE detail: light toned layered rocks
- meter-scale polygonal cracks
- Clays P
- Multiple exposures in ellipse area



Eberswalde: *25x20 km Ellipse*

Examples of Interesting Areas: B



Eberswalde: *25x20 km Ellipse*

- Sinuous Exhumed channels (arrows)
- Low relief bedrock outcrops



Area B:

Eberswalde: 25x20 km Ellipse

• HiRISE detail: Exposures of Mega-Breccia blocks

 Opportunity to sample wide variety of older strata



Eberswalde: *25x20 km Ellipse*

Examples of Interesting Areas: C



Eberswalde: 25x20 km Ellipse

• Exhumed small delta - or - Anastomosing Channels (red arrows)

- High suspended load? - Clays? – prior to main delta?

Bedrock escarpments (yellow arrows) and low relief bedrock exposures



Eberswalde: *25x20 km Ellipse*

Examples of Interesting Areas: D



Eberswalde: *25x20 km Ellipse*

- "Etched Terrane" style bedrock exposures
- Light toned layered rocks exposed in mesa escarpment, clays? (yellow arrows)
- Contiguous with light toned deposits south of ellipse
 distal delta deposits ? condensed section? clays and preserved organics ?



Eberswalde: *25x20 km Ellipse*

Examples of Interesting Areas: E



Area E:

- Exhumed channels
- Anastomosing and/or branching (red arrows)
- Light toned layers - clays ?

Eberswalde: *25x20 km Ellipse*



Eberswalde: *25x20 km Ellipse*

Examples of Interesting Areas: F



Eberswalde: *25x20 km Ellipse*

- "bona fide" delta deposits 1-2 km from edge of ellipse (red arrows)
- Light toned layers clays ?









The Smoking Gun: Eberswalde Deltaic Complex

- persistent fluvial activity
- extended time periods of rainfall
- into standing body of water
- definitely deposited by flowing water
- No plausible alternative scenario