Hypanis: A deltaic-lacustrine system at the edge of a Chryse sea?

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Thanks Jim Bell² for presenting!

¹Olde Englanders
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Source of Hypanis

- Hypanis fan system is fed by a very extensive bedrock valley – Hypanis Vallis – several hundred kilometres long (?), ~75 m deep

- Valley network is very different to drainages sourced from crater rims cf. Gale crater fan and other crater-rim fed fans

- Hypanis is a much bigger system

- Hypanis and Sabrina deltas are located at margin of Chryse escarpment – abrupt transition from erosional to depositional realm

- Timescale of fluvial erosion
  - Valley form is different to outflow channels
  - Narrow width, sinuous valley form
  - Suggests long-lived erosion – not instantaneous or short-lived erosion
Scales of deltas

Jezero

Eberswalde

Hypanis
Hypanis has a large catchment!

- Chryse escarpment
- Sabrina delta
- Hypanis delta system
- Entry point of fluvial system into basin
- Xanthe Terra
- Hypanis Vallis
Location of possible ellipses relative to delta

Primary

Secondary

Hypanis delta system

Entry point of fluvial system into basin

10 Km
Hypanis – why is it a delta and not an alluvial fan?

- In an alluvial fan, sedimentation occurs at entry point and builds a semi-circular deposit with the avulsion node fixed at the entry point.
- In deltas we can see channel-lobe transitions and avulsion nodes downstream of entry point.

Channel-lobe transition occurs basinward of entry point:
- Lobe deposition has shifted abruptly basinward.
- Difficult to do in alluvial fan.

Older lobes

Avulsion node?

Entry point of Hypanis Vallis into basin

10 km

Inverted channels

Lobe

Channel-lobe transition
Channel-lobe body extends basinward of lobe to west.

Erosional ‘front’ of lobe.

Late stage incision after lobe deposition.

~5 km
Large-scale geometry of the Hypanis system

- Hypanis system comprises multiple depositional lobes

- Individual lobes appear to cross-cut each other

  => we observe temporal variation in deposition – lobes are shifting sideways through time – this is classical behaviour - called compensation cycles

- Channel-lobe features appear to shift basinward
  - System progrades basinwards...

- In eastern part of ellipse, we observe long, inverted channel system extending beyond termination of central lobe
  - Does this indicate further basinward progradation of fluvial systems?
  - Maybe an overall progradational system.. Would prograde over finer-grained basinal lower energy deposits
Age of Hypanis deposits

Nick Warner + students at SUNY Geneseo
Crater Counts on Deltas?

- Crater counting directly on deltas in Xanthe Terra (e.g. Hypanis Delta) has major limitations.


- Area of typical deltas = $10^1 – 10^2$ km$^2$, too small for accurate crater counting given (1) crater resurfacing and (2) the spatial variability of cratering as a random process.

- Deltas in this region show evidence for significant resurfacing (inverted landforms, isolated layered mesas and buttes, degraded craters) and do not preserve craters well.

- Another more regional method of dating is required.
Crater "15 N" continuous ejecta covers headwaters of Hypanis Vallis.
Crater 15N Ejecta Crater Count

200 – 500 m, slope lower than SFD (poor preservation)

Fit is to 500 m to 1 km

3.7$^{+0.0}_{-0.0}$ Ga

Epochs: Mars, Michael (2013)
Pf: Mars, Ivanov (2001)
CF: Mars, Hartmann & Neukum (2001)
Hypanis Vallis Relative Age

Hypanis Valles older than crater 15N

- Ejecta crater count = 3.7 Ga
- Crater degradation data: 15N is 80% from pristine d/D (≤ 3.6 Ga)
- Hypanis Valles is likely Early Hesperian or older
Orbital mineralogy – very limited data

Orange box indicates area of CRISM observation in Hypanis deltaic region
Deltaic deposits.
FRS0003157E

BD1900

- 1.9μm due to bound molecular H₂O
- Remnants of delta material.
- Signal on order of highest amplitude noise, but is spatially significant.
- Signal aligns with geologic units and appears to occur at different phase angles, therefore not just correlation with illumination conditions.

Ongoing analysis to statistically quantify spatial correlation with geologic units.
CRISM Summary

3157E

- Limited data near ellipses
- Hydration in northern reaches of Hypanis delta material, at contact between delta edge (De) and delta top (Dt) units.
- Detailed analysis ongoing to reconcile spatial alignment of signal with stratigraphy.

EXTRA

3134F - outside ellipse but in region

- Indicates Fe/Mg-phyllosilicates in ‘Le’ unit near Magong crater rim.
- Spatially coincident with fractured surface texture.
HYPANIS ROIs
Due to the large area occupied by the Hypanis delta, two 16 x 14 km ellipse placements are presented. They represent primary and secondary choices, but both share 3 common types of ROI.

**Ellipse centers**

Primary : 314.641°E 11.907°N  
Secondary : 314.323°E 11.848°N
Major Units

Sm - Smooth pervasive layered basin floor material representing lacustrine/pro-delta

De/Dt - Finely layered deltaic units

Rb/Dc - Rounded buttes, dark cap: remnants of mostly removed overburden.
# Meeting Mars 2020 Science Criteria

<table>
<thead>
<tr>
<th>Objective</th>
<th>Relevant ROIs</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: Characterize geology of astrobiologically relevant area.</td>
<td>1-3</td>
<td>Sedimentological and geochemical analyses of distal delta deposits and pro-delta material in multi-episodic fluvial system with extensive source region.</td>
</tr>
<tr>
<td>B: Determine habitability and biosignature preservation potential.</td>
<td>1-3</td>
<td>Recent removal of overburden material, preserving exhumed deposits laid down in near-neutral aqueous environment. Phyllosilicates in basin floor material and hydration in delta deposits.</td>
</tr>
<tr>
<td>C: Caching of scientifically selected and compelling samples.</td>
<td>1,2</td>
<td>Potential samples:</td>
</tr>
</tbody>
</table>
ROI type 1: Basin floor material/lacustrine pro-delta

Key to ROI types:

1 - Layering in smooth plains unit exposing lacustrine/pro-delta stratigraphy.

2 - Deltaic deposits.

3 - Mounds/rounded buttes, interpreted as mostly removed overburden.
ROI type 1: Basin floor/lacustrine pro-delta material

Exposed beds in layered material infilling ancient craters.

Primary

Secondary

HiRISE: ESP_036517_1920

HiRISE: ESP_037651_1920
ROI type 2: Deltaic deposits

Layered delta remnant

HiRISE: ESP_037651_1920

HiRISE: ESP_036277_1920

Primary

Secondary
ROI type 3: Rounded buttes/overburden material

Determine origin of 2 superficially different overburden units.
Deltaic deposits.

Resistant layered deposits
Forming smooth crater plains unit

Deltaic deposits.

Deltaic deposits.

Primary Ellipse
Key to ROI types:

1 - Layering in smooth plains unit exposing lacustrine/pro-delta stratigraphy.

2 - Deltaic deposits.

3 - Mounds/rounded buttes
Deltaic strata directly overlie basin-floor material.
Detail of centre-east ellipse: Evidence of Recent Exposure?

Eroding layers on basin-floor - lacustrine deposits?

Retreating scarp
Beautiful layered deltaic deposits nearby, between the two ellipses

~20 m high mesa
1.5 km long

Hirise image and dtm
2 x vert. exag.
Deltaic deposits.

Resistant layered deposits
Forming smooth crater plains
Unit - ancient lacustrine deposits?

Deltaic deposits.
Hypanis – key points 1

• Late Hesperian aged, sedimentary rocks throughout the area
  ➢ Therefore, lots of science targets
• Clear fluvio-deltaic context
  • Excellent aqueous geological setting
• Sourced from extensive fluvial system – likely long duration of activity and samples extensive geologic units
• Likely downstream association with low energy fine-grained pro-delta and lacustrine layered deposits
  ➢ High rates of sedimentation
  ➢ Good biomarker preservation potential
Hypanis – key points 2

• Extensive layered sedimentary rocks associated with geomorphic features

• One of several deltaic systems in the region – this could be a representative example of widespread, ancient deltaic systems at Chryse basin margin

• No downstream topographic boundary – what created the basin – a large Chryse lake/sea???

Potential to investigate and cache a large variety of sedimentary rocks from an ancient aqueous environment. Possible volcanic rocks as float?
What is the bath-tub that ponded water?

Was the Chryse basin the bathtub?
**HYPANIS:**
A large, enigmatic deltaic-lacustrine system

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**Mars 2020 Mission and Decadal Priority Science Factors**

<table>
<thead>
<tr>
<th>Environmental Setting for Biosignature Preservation and Taphonomy of Organics</th>
<th>Type 1A &amp; 1B Samples: Aqueous Geochemical Environments indicated by Mineral Assemblages</th>
<th>Type 2 Samples: Igneous</th>
<th>Context: Martian History Sampled, Timing Constraints</th>
</tr>
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<tbody>
<tr>
<td>Deltaic or Lacustrine (perennial)</td>
<td>Recent exposure</td>
<td>No diagenetic overprinting</td>
<td>Crustal phyllosilicates</td>
</tr>
<tr>
<td>Lacustrine (evaporite)</td>
<td>Sedimentary clays</td>
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</tr>
<tr>
<td>Hydrothermal (&lt;100°C) subsurface</td>
<td>Al clays in stratigraphy</td>
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</tr>
<tr>
<td>Pedogenic</td>
<td>Carbonate units</td>
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<tr>
<td>Fluvial/Alluvial</td>
<td>Sulfate sediments</td>
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<td>No diagenetic overprinting</td>
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<td>Acid sulfate units</td>
<td>Pre- or Early-Noachian</td>
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<tr>
<td>Silica deposits</td>
<td>Megabreccia</td>
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<tr>
<td>Forte Ox/Forero clays</td>
<td>Oldest stratigraphic constraint</td>
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<td>Igneous unit</td>
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**Hypanis**

- Delta deposits in ellipses; likely pro-delta deposits cover ellipse
- Fluvio-deltaic deposits exposed in ellipse and at ellipse edge
- Hydration signature from CRISM nearby in deltaic sediments (1.9 micron water signature)
- Igneous clasts in deltaic sediments?
- Based on Fluvio-deltaic deposit formed in early Hesperian
- Based on crater retention ages
- Well-defined stratigraphy mapped in basin
- Possible ash beds outside ellipse?

**TRN required? No**
Backup
Why is Hypanis a delta system?

- Hypanis – why is it a delta and not an alluvial fan?
- In an alluvial fan, sedimentation occurs at entry point and builds a semi-circular deposit with the avulsion node fixed at the entry point.
- In deltas we can see channel-lobe transitions and avulsion nodes downstream of entry point.
East Hypanis – inverted channels
Deltaic strata
Basin-floor materials
Deltaic strata