THE HYPANIS FLUVIAL-DELTAIC-LACUSTRINE SYSTEM IN XANTHE TERRA: A CANDIDATE EXPLORATION ZONE FOR THE FIRST HUMAN LANDING ON MARS, S. Gupta[1], E. Sefton-Nash[2], J. Adler[3], M. Rice[4], P. Fawdon[5], N.H. Warner[6], P. Grindrod[2], J. Davis[7], M. Balme[5], J.F. Bell III[3], C. Stetson[4], J. Richard[8], [1]Dept. of Earth Science & Engineering, Imperial College, London, UK (s.gupta@imperial.ac.uk), [2]Dept. of Earth and Planetary Sciences, Birkbeck, University of London, UK, [3]School of Earth and Space Exploration, Arizona State University, Tempe, AZ, USA, [4]Western Washington State Univ., Bellingham, WA, USA, [5]Dept. of Physical Sciences, The Open University, Milton Keynes, UK, [6]Dept of Geological Sciences, SUNY Geneseo, USA,[7]Dept. of Earth Sciences, University College London, UK. [8]Deltion Innovations Ltd, Capreol, Ontario, Canada.

Introduction: The human exploration of Mars is a major future goal of Solar System exploration. Here we propose a region of Xanthe Terra at the edge of the Chryse basin that harbors a major deltaic sedimentary system – the Hypanis delta - that likely fed into a major lacustrine basin, even potentially a Chryse sea, as an Exploration Zone (EZ) for a future human mission to Mars. We propose that this site has high potential for major scientific discoveries in terms of: the habitability of ancient Mars and the opportunities for preservation of fossil biosignatures, the history of aqueous processes and climate evolution on Mars, relative stratigraphic reconstruction, and the exploration of Noachian and Hesperian crustal units that have potential to contain rock units dateable by radiometric methods. The Hypanis Exploration Zone also fulfills the ISRU and Civil Engineering (CE) requirements for a human mission to Mars.

Overview: The Hypanis EZ in northern Xanthe Terra is situated on the dichotomy boundary. Our study area includes fluvio-deltaic deposits at the termini of Sabrina Vallis and Hypanis Vallis [1, 2]. Mapped Sabrina terminal deposits are constrained to within the buried crater, Magong. The Hypanis deltaic system is more extensive, with multiple mapped depositional lobes extending to the north and east (Fig. 1) [1]. Onlapping relationships with superposing deposits and crater ejecta reveal that both deltaic formations occupy the lowest stratigraphic position in the study area.

Significant aeolian modification has occurred since formation, with crater counts on both Sabrina [2, 3] and Hypanis [4] delta units revealing crater-retention ages of < 100 Ma, supported by the presence of ubiquitous aeolian features and suggesting recent exhumation from overburden. The large crater population classifies the study area as mid to late Noachian terrain [5]. Cross-cutting relationships of channels and crater ejecta blankets in the headwaters demonstrate that Hypanis Vallis formed >3.7 Ga ago in the Early Hesperian [6].

Landing and trafficability: Closely-spaced transverse aeolian ridges (TARs) on top of delta units (Fig. 1) prevent landing directly on upper delta material, because TAR morphology produces adverse slope conditions for EDL and rover locomotion. However, extensive smooth plains units, are less hazardous for landing and traversing, and occupy a significant areal fraction of the ellipse.

Science ROIs: An extensive array of science ROIs are present in the 100 km EZ (Fig. 1):

1. *High Preservation Potential Deposits:* ROIs with high preservation potential for past habitability and fossil biosignatures are provided by deltaic sediments from two systems: the Hypanis and Sabrina deltas. Downstream and laterally to their margins are extensive exposures of finely-layered likely sedimentary materials that may represent ancient lacustrine deposits that have high preservation potential for organics if ever they were present. These form compelling science targets because they formed in low energy depositional environments caused by suspension sediment fallout downstream of deltas.

2. *Aqueous Mineralogical Signatures:* There are two full-resolution short (FRS) CRISM hyperspectral observations within the study area. FRS0003157E shows a 1.9 μm hydration signature that spatially aligns with exposed strata in eroded deltaic sediments, indicating putative hydrated minerals in discrete layers A spectral unit in FRS0003134F just east of the rim of Magong crater is defined by the combined presence of the 1.9 μm absorption plus a strong 2.3 μm dropoff in reflectance, indicative of the presence of Fe/Mg-phyllosilicates. These spectral signatures spatially correspond to fractured areas within polygonally ridged terrain. The unit is between, but not immediately adjacent to, the Sabrina or Hypanis deltas, perhaps indicating that extensive ancient fluvial activity has influenced mineralogy throughout the region. Extensive CRISM coverage of the Sabrina Vallis delta deposits in Magong crater also indicates a weak Fe/Mg-phyllosilicate signature that is consistent with the presence of nontronite, verminculite or saponite in delta sediments [3, 4].

3. *Pertinent/Regional Stratigraphic Contacts.* The fluvial-deltaic units provide abundant stratigraphic contacts that would enable reconstruction of the aqueous evolution of the region and provide relative age constraints. In the southern part of the EZ, valleys

that cross-cut the Noachian bedrock units along the dichotomy provide excellent opportunities to characterize the stratigraphic relationship between Highland Plains and Lowland Plains units. These rocks potentially contain ash beds and lava flows, the ages of which might be constrained by radiometric dating methods. In the northern part of the EZ, extensive large crater rims preserve examples of fine scale layering and complex crater rim topography with highly interesting geologic relationships.

4. *Other ROIs:* A fresh, complex impact crater in the southeastern EZ preserves an ejecta blanket and rays, exposes bedrock units and allows an opportunity to study cratering mechanics. Finally, the northern EZ allows access to wrinkle ridges that extend to the north, covering Hesperian lava plains.

Resource ROIs: In-situ water resources are potentially provided by the extensive aeolian dune sands. Observations by MSL of atmospheric water adsorbed in dune sands [7] and 3-6 wt. % H_2O in sands at Rocknest [8] show potential for mining sands within the EZ for water resources. Within a 5 km radius of the proposed landing site, there areal extent of TAR sand deposits is roughly 23.5 km^2. The absence of crater retention indicates that the TARs are weakly indurated and could be easily mobilized to a processing facility constructed on adjacent, level bedrock.

The presence of Fe-Mg clays also offers the potential to recover water from hydrated mineral resources. These deposits, together with silicon and metals in mafic minerals, would also provide metal and silicon resources. TAR sands would provide important building materials. In addition, abundant overhanging ledges in the deltaic stratigraphy would provide habitation construction with radiation shielding.

Summary: The Hypanis site displays clear evidence for the long-lived action of water in the Early Hesperian across the Martian dichotomy boundary. Low-energy depositional environments that formed downstream of prominent delta bodies may have concentrated any potential biosignatures. A variety of Resource ROIs are also present that together with the diverse Science ROIs make Hypanis a compelling future human EZ.

References: [1] Gupta, S. et al., (2014), ExoMars 2018 First Landing Site Selection Workshop (LSS WS#1), ESAC, Spain. [2] Platz, T. et al., (2014) First Mars 2020 Landing Site Workshop, Crystal City, VA, USA. [3] Hauber, E. et al., (2015) 2nd Mars 2020 Landing Site Workshop, Pasadena, CA, USA. [4] Hauber, E. et al., (2009), *Plan. Space Sci.* 57, p. 944-957. [5] Werner (2014) *Pers. Comm.* [6] Eckes et al. (2015) GSA Annual Meeting abs. [7] Meslin et al., *Science*, 2013. [8] Leshin et al., *Science*, 2013.

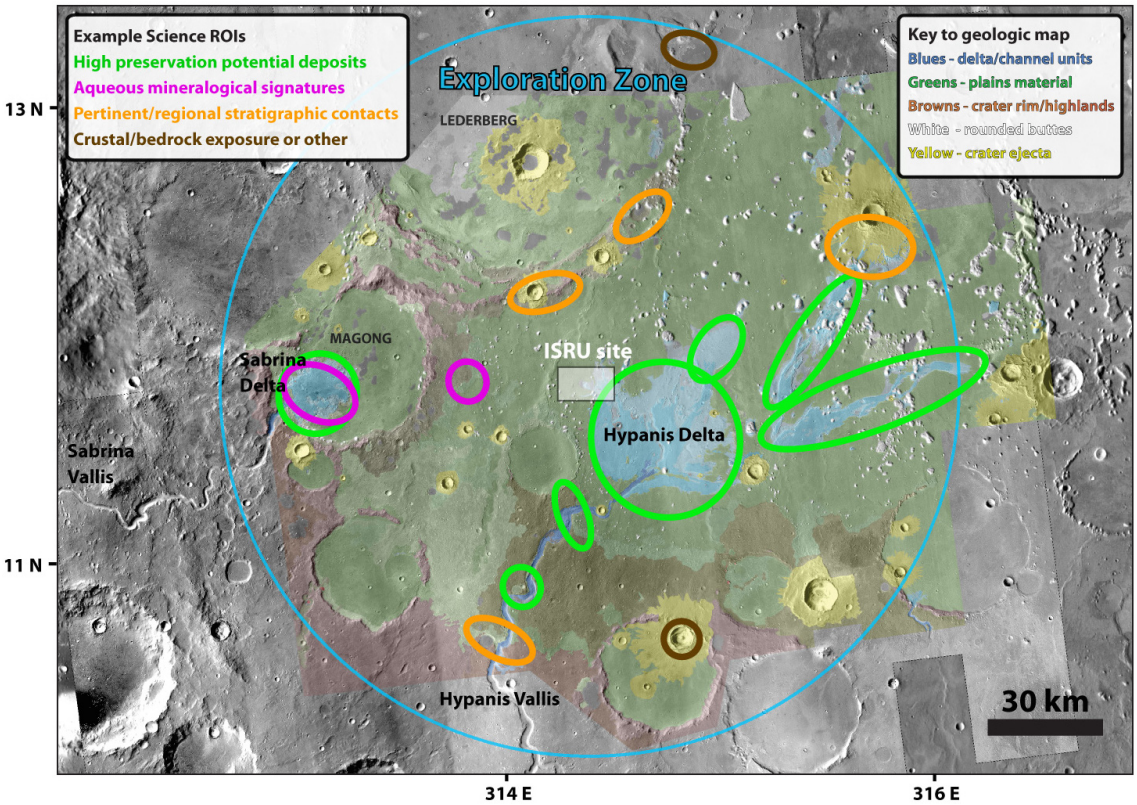

Figure 1. Exploration Zone (EZ) map of the Hypanis region in Xanthe Terra with key regions of interest (ROIs).