ICE CAVES IN HEBRUS VALLES: A TARGET LOCATION FOR THE FIRST HUMAN MISSION TO MARS. D. Schulze-Makuch[1,2], A. Davila[3], A.G. Fairén[4], A.P. Rodríguez[5], J. Rask[6], J. Zavaleta[6]. [1]Technical University Berlin, Berlin, Germany; [2]Washington State University, Pullman, WA (dirksm@wsu.edu); [3]SETI Institute, Mountain View, CA (adavila@seti.org); [4]Centro de Astrobiologia, Madrid, Spain (agfairen@cab.inta-csic.es); [5]Planetary Science Institute, Tucson AZ (alexis@psi.edu); [6]NASA Ames Research Center, Moffett Field, CA (jon.c.rask@nasa.gov; jhony.r.zavaleta@nasa.gov).

Introduction: Caves are an ideal target for the exploration of Mars as they provide shelter, more benign temperatures, and are interesting sites for astrobiological investigations [1]. Of special interest are ice caves or permafrost caves, because they provide an opportunity to explore possible remnant water ice and protected subsurface environments, which are critical resources for the establishment of long-term human settlements. Thus, we suggested Hebrus Valles as a suitable target location at NASA´s First Human landing site, at which close to 50 sites were suggested as possible landing sites for an anticipated human mission (http://www.nasa.gov/feature/mars-human-landing-site-workshop-presentations).

Geological setting: The suggested candidate landing site and Exploration Zone (EZ) are located in the middle reaches of Hebrus Valles (Fig 1, centered at 20º05' N, 126º38' E). An important fraction of the science and exploration efforts at this site would focus on the characterization of an extensive subsurface cavern network, and its scientific, engineering and in-situ resource utilization.

The proposed EZ occurs within a broad outflow channel system in western Elysium Mons that dissects boundary plains materials along the southwest perimeter of the Utopia Impact basin. The lower reaches of the channels dissect into the Vastitas Borealis Formation (VBF), a possible remnant of a Late Hesperian ocean. This geologic formation exhibits widespread evidence for recent periglacial resurfacing, which along with fluvial bedforms, are not buried by aeolian mantles.

The VBF consists of a sedimentary deposit 30 to 170 m thick, formed during the Late Hesperian/Early Amazonian when sediment-laden water effluents of the outflow channels ponded in the northern lowlands, rapidly froze solid and sublimed [2,3].

Hebrus Valles is an intricate system of individual pits, pit chains, troughs and channels that extends for ~500 km in a NW direction. The troughs and channels have been tentatively identified as outflow channels carved by large, catastrophic floods due to melting of subsurface ice [3]. At some locations within and around the EZ, features interpreted as mud volcanoes cluster into linear ridges, and are further indicators of liquid water activity at regional scales [4]. Hence, the EZ includes recently extruded water-rich sediments with geochemical signatures indicative of aqueous or groundwater/mineral interactions that could date back to the ocean's emplacement, freeze over and evaporation histories.

The lower reaches of Hebrus Valles consists of pits and troughs, interpreted as apertures that captured the catastrophic floods into networks of caverns [4]. The total extent of partially collapsed cavern sections in the Hebrus region include ~2400 km of troughs, and ~3600 km as indicated by the pattern of aligned sinkholes. Both the fluvial features with their associated sediments, the remnants of water ice, and the subsurface caverns have a high preservation potential for evidence of past habitability and fossil biosignatures.

A ~900 m deep (15 km diameter) crater located in the eastern portion of the EZ would provide access to explore subsurface materials, likely composed of Hesperian deposits buried beneath the VBF sediments. The stratigraphic contact between these units can be used for relative age determinations.

Engineering merit: The suggested landing site has also high engineering merit and is located in the middle of the EZ, between two large fluvial features (Fig 1). Dissected near surface VBF materials in the EZ likely consist of desiccated permafrost and bouldery outwash materials (a few meters/tens of meters thick) overlying massive ice (tens/hundreds of meters thick). If confirmed, the presence of near surface massive ice would be a key resource for humans. Regionally, there are abundant, small and shallow craters that appear to be partially infilled.

Slope at the LS is <1º and surface materials have relatively low thermal inertia (<200 J m-2 K-1 sec-1/2), pointing to loose, fine surface dust and very few rocks. Practically no boulders larger than 1 m are observed near the landing site area in HIRISE images at 24 cm/pixel resolution, satisfying safety constrains for EDL operations.

The inferred magnitude of floodwater infiltration in the EZ points to the existence of structurally stable caverns that were largely evacuated of fluids and sediments prior to Hebrus Valles outflow channel activity [5]. The predicted typical mean annual surface temperature for the EZ investigated latitudes is -60ºC [6]. At these temperatures, permafrost could have a mechanical strength close to that of limestone [7, 8], which could have stabilized evacuated caverns. Chemical precipitation from circulating brines in terrestrial cold springs can produce cements along the periphery of feeder conduits, thereby enhancing their overall structural stability [9]. Cements developed in association with cold water circulation include calcite, aragonite, Fe-Mn oxides, sulfides and sulfates [10,11]. On Earth, caverns are known to occur in ice-welded sediments such as in association with networks of ice wedges in permafrost [12] and ice-welded moraine deposits [13]. Some glacier caverns are known to have remained stable over decades [14]. Subsurface caverns and steep walls in Hebrus Valles might represent natural terrain features that can be adapted for construction purposes. Hence, infrastructure could be emplaced or constructed at the suggested landing site.

Summary: The suggested Hebrus Valles land EZ fulfills a significant number of minimum Resource of Interest (ROI) requirements, and also represents a diverse setting with multiple geological contacts and layers. Further, it provides an opportunity to explore possible remnant water ice and protected subsurface environments, which are critical resources for the establishment of long-term human settlements, and present ideal targets for exobiological exploration.

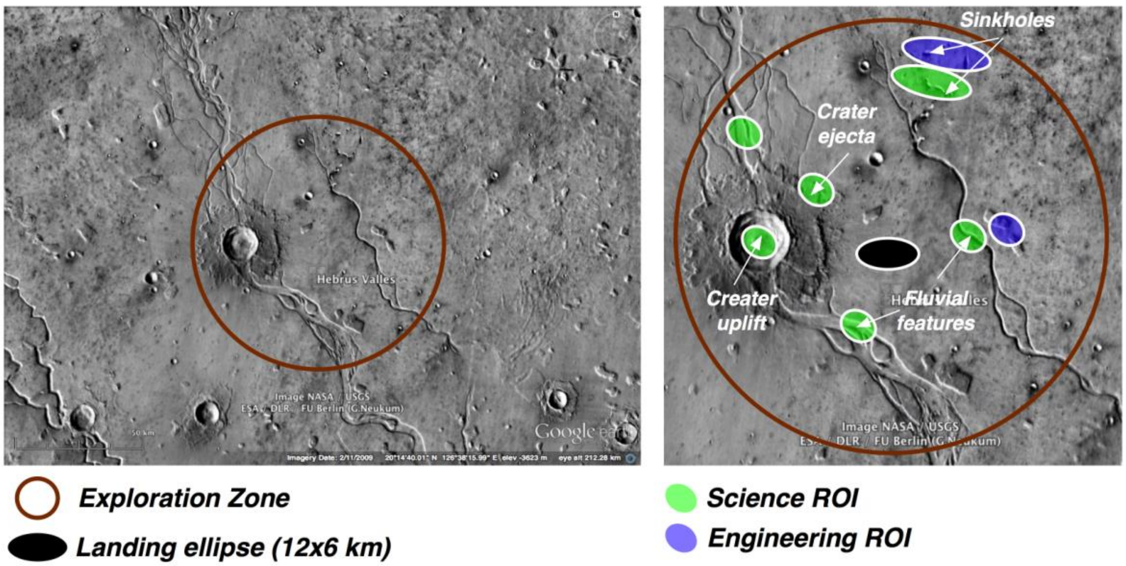

Figure 1. Proposed landing site, Exploration Zone and ROIs in the Hebrus Valles region.

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