FLUID ESCAPE FEATURES IN THE EQUATORIAL REGIONS OF MARS: LANDING SITE POTENTIAL AND CONSTRAINS OF EARLY MARS HYDROLOGY. F. Franchi[1], A.P. Rossi[2], M. Pondrelli[3], B. Cavalazzi[4], [1] ISMAR, CNR, Bologna, via Gobetti 101, 40129 Bologna, ITALY (fulvio.franchi@bo.ismar.cnr.it), [2] Jacobs University Bremen, Campus Ring 1, 28759 Bremen, Germany, [3] IRSPS, Università D'Annunzio, Viale Pindaro, 65127, Pescara, Italy, [4] BiGeA, University of Bologna, via Zamboni 67, 40129 Bologna, Italy.

Introduction: Candidate landing sites that were deemed of sufficient merit for the oncoming missions should have peculiar morphology indicative of fluids circulation or possible exobiological markers. This implies the actuation of a holistic research strategy to warrant collection of orbital and analytical (through terrestrial analogues) data to assist in evaluation of their astrobiological potential. Presence of past fluid water would be a proof of astrobiological potential and is strongly dependent from climate and atmospheric conditions in Early Mars. Martian climate began to shift toward colder and more arid conditions towards the Noachian-Hesperian transition [1]. Climate changes resulted in deposition of thick succession of layered deposits (ELDs) in the Martian equatorial regions [2]. Outcrops of ELDs were observed throughout much of Arabia Terra and Meridiani Planum. The abundant and varied aqueous morphologies, such as furrows, ridge-and-trough and mounds (Fig. 1) that is observed within and nearby this area, likely represents diverse geologic settings and it was probably formed in situ [3]. The Arabia Terra exposed section might represent some of the most pervasive and long-term habitable periods and regions on Mars.

Methods: Multidisciplinary data base on terrestrial mounds was implemented with bibliography and laboratory data (e.g. RAMAN). The NASA Context Camera images form the framework for targeted high-resolution HiRISE imagines of equatorial landforms. This data set was implemented with low to mid-resolution topographic data and DEM starting from MOLA and HRSC data sets. Mars regolith was discretized starting from the published megaregolith theory [4] and eventually implemented with radar data. The hydrological problem was preliminary tackled with finite elements CAD software.

Results and Discussion: In the study area the ELDs are characterized by presence of diffused conical mounds with asymmetric shape and steep flanks some of which have well-rounded apical holes. Previous research demonstrated that these mounds are not consistent with aeolic origin [5]. Mound clusters were described aligned along the crater rims and often settled along straight kilometer-long faults and fractures. These fractures were linked with a deep tectonic structures system generated in the impact and could have acted as preferential ways for fluids upwelling [6]. These kind of mounds were described throughout Mars equatorial lowland and were considered evidence for spring activity and/or mud volcanism [2-3, 5-6].

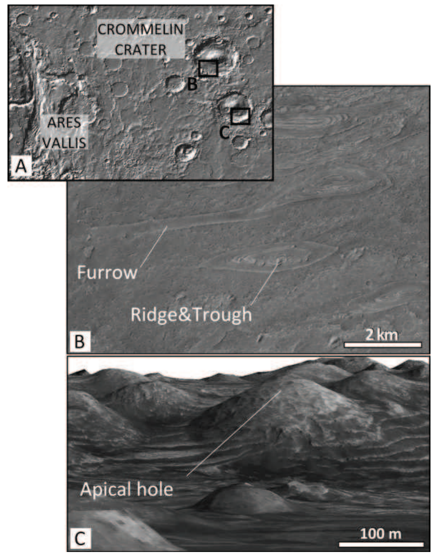

Figure 1: Aqueous morphologies within ELDs in Crommelin crater area (A): furrows ending in ridge-and-trough structures (B) and conical mounds (C).

ELDs in Arabia Terra and Meridiani Planum appear to have experienced diagenetic modification in the presence of a fluctuating water table, but are those places of groundwater upwelling? Planetary scale hydrological models predicted zone of groundwater upwelling in the Mars equatorial lowland [3, 5].

Distribution of aqueous morphologies described from Mars equatorial lowland depend from topography. In the study area furrows, ridge-and-trough and mounds are clustered in the southern regions where sediments package is thicker. The topography may have also influenced the long-term regional groundwater flow that induced groundwater upwelling and the deposition of layered deposits in the Mars equatorial lowlands [3, 5]. ELDs are considered the exhumed part of the deposits that once covered this vast area of the Martian equatorial surface comprising Arabia Terra (Fig. 1), Meridiani Planum and surrounding lowlands [e.g. 3]. Preliminary hydrological models, starting from isotropic conditions, confirmed a groundwater discharge increase toward the main depressions such as craters where ELDs were described. These sediments, and associated depositional landforms therein, experienced interaction with fluids and could be thus compared with analogues situations from the terrestrial record. Particularly those originated by long wavelength groundwater upwelling driven by faults and fractures. Examples of these morphologies were described in the Dalhousie region (Fig. 2) [e.g. 6].

Mars hydrology: Water circulation in the subsurface is governed mainly by the hydrogeological properties of the aquifer and by the climatic conditions. Recently proposed global hydrological models predict a fluctuating water table, producing sub-planar deposits with consistent dip directions toward the north, within the Martian equatorial region [3]. Within a modeled aquifer [4] the volumetric flux of water depends from the hydraulic conductivity (m/s) of the aquifer and is driven by the hydraulic head (m). In the area concerning this study a positive hydraulic gradient oriented northward should have been maintained as long as a water table was present on Mars. The conductivity of the system, resulting from the presence of fractures beneath an impact crater, is determined by the fractures frequency and compressional state. Fractures frequency, increasing at the impact crater, could be inferred by superficial evidence of fracture systems, eventually coupled with subsurface preliminary analyses.

Concluding remarks: The results of detailed morphological analyses point towards a regional groundwater flow as main control for fluids upwelling within Mars lowlands. This upwelling was identified as the main process that fuelled the spring processes that formed ELDs and the morphologies therein. Depressions such as the craters in Arabia Terra and Meridiani Planum would have reached by water due to the migration of the groundwater flow from the highlands (south) to the lowlands (north). Due to the regional northward dipping topography of Arabia Terra, the likely rising point of the fluids flowing through the north should have been in the southern sector of each crater. Here the deep fractures induced by the impact could have acted as preferential pathways for fluids migration. This is consistent with proposed models [e.g. 3] and preliminary results of finite elements analysis. This theory is also endorsed by observations carried on terrestrial analogues of Arabia Terra morphologies. Terrestrial mounds are often settled along faults or fractures breaching anticline structures (e.g. Dalhousie spring mounds) that acted as preferential ways for fluids expulsion (Fig. 2).

ELDs occur exclusively within the equatorial lowlands and throughout this region they present analogue morphologies that might be considered as triggered by analogues geological genetic factors. These features are evidences of a groundwater upwelling widespread in the equatorial lowlands that, therefore, might be considered within the same hydrological model.

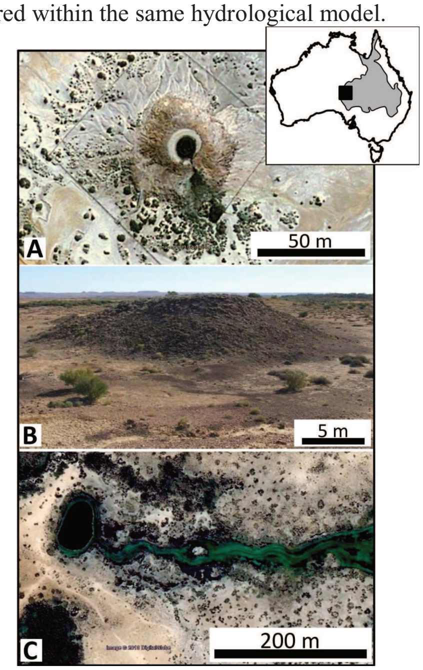

Figure 2: Spring morphologies in the Dalhousie region (square in the inset), Great Artesian Basin (grey in the inset), Australia. A, B) Examples of mounds and furrows (C).

Future work: Hydrological modeling may be integrated with detailed study of Martian regional and shallow structures (anticline, faults, etc.) coming from radar data sets. Size and frequency of the fractures network beneath each crater may substantially influence the water table behavior. Moreover a parameterization of Mars climate during ELDs deposition might be proposed for an evaluation of ice melting and water circulation. Mars climate during the late Noachian may be estimated using the model developed by the Laboratoire du Météorologie Dynamique (Université Paris VI) [7] considering an obliquity of 25°-45°, a thick CO_2 atmosphere and average heat fluxes between 45-65 mW/m^2 [8] and varying these parameters.

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