

A GEOLOGICAL MODEL FOR MARTIAN GROUNDWATER BASED ON WATER-FORMED FEATURES WITHIN DEEP BASINS Francesco Salese^{1,2*}, Monica Pondrelli², Adrian Neeseman³, Gene Schmidt² and Gian Gabriele Ori^{2,4}, ¹ Faculty of Geosciences, Utrecht University, Princetonlaan 8a, 3584 CB, Utrecht, The Netherlands; ² International Research School of Planetary Sciences, Università Gabriele D'Annunzio, Viale Pindaro 42, Pescara, Italy; ³ Freie Universität Berlin, Institute of Geological Sciences, Planetary Sciences and Remote Sensing Group, Malteserstr. 74-100, 12249 Berlin, Germany; ⁴ Ibn Battuta Centre, Université Cadi Ayyad, Marrakesh, Morocco. * e-mail: f.salese@uu.nl

Introduction: The extent and variation of water in the Martian subsurface throughout the planet's history is a topic of ongoing debate. Sedimentary systems thought to have been formed from groundwater upwelling have been observed globally and may serve as indicators of the amount of water present in the past. Many craters and basins in the northern equatorial regions display signs that large volumes of water may have existed on Mars at a planet-wide scale. Within several basins in the northern equatorial regions, features such as Gilbert and sapping deltas fed by sapping valleys were observed and may be evidence of groundwater upwelling events followed by long term periods of standing bodies of water. On Earth, sapping valleys occur not only in unconsolidated sediments, but in basalt bedrock as well [1,2]. A hypothesis which considers the elevation differences between the observed morphologies and the assumed basal groundwater level is presented and described as the "dike confined water" model. The deepest craters observed, with floors deeper than -4000 m in elevation, exhibit evidence of groundwater fluctuations and reached the zone of saturation. These craters were observed planet-wide, strongly suggesting that the proposed Martian ocean [3] and various configurations of sedimentary deposits formed by groundwater fluctuations during the Hesperian period are linked. These water-formed deposits and erosional features are attractive locations to search for the presence of biosignatures, possibly buried amongst the sediment, and will be important for future missions searching for evidence of geologic conditions that support life.

Methods: The investigation area is located in the northern hemisphere of Mars, between 0°N and 37°N. A variety of orbital data was used including the HiRISE, CTX and HRSC. DTMs were produced from HRSC and MOLA data. Deep craters with diameters of 28 to 114 km, depths of 1.4 to 3.1 km and floor elevations between -4215 m and -5770 m were identified using a crater database [4] and then inspected individually. An emphasis is placed on the northern hemisphere due to the large amount of groundwater upwelling predicted to have occurred there [5]. We selected craters with floor depths deeper than -4000 m and located south of 37°N to limit ice noise or associated deposits related to the north polar cap, as well as to avoid ambiguity between landforms that are morphologically similar to terrestrial glacial and perigla-

cial landforms present in the mid-latitudes, between approx. 35°N and 60°N. The location of a subpermafrost groundwater table below the subsurface melting isotherm estimated by Clifford and Parker [2001] (<5 km, 30° latitude) was also taken into account. We looked for evidence of intra-crater fluvial activity and lacustrine deposits, particularly in locations where evidence of aqueous activity was present in the crater, but absent in the terrain outside the crater (i.e. the crater was not fed by surface drainage, excluding short sapping valleys). The study was restricted to areas determined to be of Noachian to Early Hesperian age to investigate craters that most likely formed during episodes of groundwater upwelling, prior to the Amazonian and Late Hesperian.

Results: The studied basins show evidence of water-related landforms below -4000m Mars datum.

In the deepest basins, groundwater upwelling would have resulted in the formation of clastic-dominated fluvio-lacustrine depositional environments (with related sub-environments), as also demonstrated by the presence of Gilbert delta, while in the shallower basins/plains evaporitic deposition would have predominated. These observations suggest that only the deepest basins, those with floors deeper than -4000m below the Mars datum, intercepted this deep water-saturated zone. Furthermore, they point towards the existence of a putative planet-wide groundwater table between -4000m and -5000m during the past Martian history. These evidences fully or partially support the models proposed by [5,6], which predicted regional to global groundwater upwelling and the existence of water saturated zone around -4000m below Mars datum respectively. Basins with bases deeper than -4000m below Mars datum intercepted the water-saturated zone predicted by the model of [6] and exhibit evidence of groundwater fluctuations. The range of water level variations that we estimated from several geological observations is of the same order of magnitude as the one estimated by the model of [7] for Gale crater. The formation of sapping valleys at higher elevation than the groundwater basal level could have been possible due to the presence of the "dike confined water" that can make the groundwater level shallower than the basal one, this concept is introduced in the Martian geology by the proposed conceptual model (we can't show the model figure because, at the time of writing the abstract, the paper is in the final phase of

revisions in JGR Planets and the submitted images are subject to copyright.).

References:

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