THE CASE FOR LARGE-SCALE SPRING DEPOSITS ON MARS: LIGHT-TONED DEPOSITS IN CRATER BULGES, VALLES MARINERIS AND CHAOS. A. P. Rossi[1], G. Neukum[2], M., Pondrelli[3], T. Zegers[1], P., Mason[4], E. Hauber[5], G. G. Ori[2], F. Fueten[6], J. Oosthoek[4], A. Chicarro[1], B. Foing[1]. [1]RSSD of ESA. ESTEC, NL Noordwijk, The Netherlands, arossi@rssd.esa.int. [2]Institut für Geologische Wissenschaften, Freie Universität Berlin, Germany. [3]IRSPS, Università d'Annunzio, Pescara, Italy. [4]Utrecht University, Faculty of Geosciences, Utrecht, The Netherlands. [5]Institute of Planetary Research, DLR, Berlin, Germany. [6]Brock University, Canada.

Introduction: Light-toned deposits (LTD) crop out in several areas on Mars, including crater bulges, Valles Marineris interior layered deposits (ILD) and chaotic terrains (e.g. Iani, Aureum) (Fig. 1A). Interior layered deposits in Valles Marineris have been interpreted in various ways [e.g. 1,2], including a variety of processes, both sedimentary and volcanic.

Spring deposits have been proposed to exist on Mars by various authors [e.g. in 3, 4], mostly for small to medium scale features, with a scale comparable to terrestrial counterparts, typically of several hundreds of m.

Moreover, hydrated minerals have been detected in a variety of locations on Mars [5]. Several of these locations coincide with the presence of bright (more or less) layered deposits in chasmatas, chaotic terrains or crater bulges (Fig 1B).

In the present work, we propose that light-toned, often layered material occurring at various locations on Mars (Fig. 1A) could have a common origin as large-scale spring deposits.

Common features: ILD in Valles Marineris appear as light-toned deposits and they show extensive presence of hydrated minerals, vastly dominated by sulfates [6]. Bright deposits occur in various locations within chaotic terrains [e.g. 6, 7], showing mound-like layered morphologies, and presence of hydrated minerals as well. Crater bulges: thick, massive to well stratified deposits are occurring in several areas on Mars, mostly at low latitudes and heights [e. g. 8].

Several of these deposits have common features: light color, association with hydrated minerals [5] or high H_20 content derived from Mars Odyssey GRS [9] (Fig. 1C), topographic low setting, bulge-like morphologies, also in apparently flat and tabular bodies, such as LTD in Aram Chaos, e.g. Fig.2, with some correlation between thickness distribution and structural trends, suggesting a link among them.

Terrestrial Spring deposits can also have a variety of morphologies, and facies association and internal architectures [10], producing a wide range of bodies, from tabular to mound-shaped.

Discussion: Large-scale spring deposits on Mars would have to mainly rely on endogenic resources (e.g. hydrothermal activity) and supply of water. There would be no need for strong climatic differences from current conditions on Mars; therefore they could have formed even when fluvio-lacustrine deposits were not possible to form anymore. In addition, several of the deposits in crater bulges are not associated with other major water-related morphologies and deposits, pointing for example against a merely lacustrine origin. Valles Marineris ILD are also often showing bedding planes dipping outwards consistently with a draping/mound morphology [11] (similarly to Fig. 3).

Internal unconformities and evidence of large temporal hiatus (e.g. in Gale crater bulge) are consistent with an intermittent or multistage process, e.g. supply of water from the subsurface. In this hypothesis, the presence of interbedded eolian deposits could not be excluded locally.

LTD in chaos, bulges and Valles Marineris occur in relative low-lying areas, where higher hydrostatic pressures are likely to drive groundwater more efficiently. Given the lower gravity, it is reasonable to expect spring mounds sensibly bigger than on Earth, similarly to what happens for volcanic constructs. Moreover, especially in the case of Valles Marineris the possible long-lasting role of Tharsis bulge heating of subsurface fluids would also concur to the eventual deposition of large bodies of spring deposits.

The presence of spring deposits at various locations on Mars would also be consistent with groundwater/ground fluids presence, movement and diagenetic activity [12, 13]. A once active subsurface hydrologic system, more or less [4] related to hydrothermal activity, would fit with the presence of underground pathways for fluids and possibly cavernous systems [14]. A part of the "upstream" portion of the spring deposits forming process could also involve pseudokarst or pseudokarst-like mechanisms, as invoked for Valles Marineris [15]. In general, large collapses and likely subsurface mass transfers are linked to the formation of chaotic terrains too [e.g. 14].

The erosion level and cratering record of these deposits is variable, suggesting variable ages. As an example Gale Crater [8] shows a clear hiatus in the formation/deposition of its central bulge. Different erosion and cratering levels suggest that these deposits, regardless their origin, have formed during a variable amount of time. It has also to be said that several of these light-toned deposits appear to be easily eroded away.

Conclusions: Given availability of groundwater, available time and energy source (e.g. hydrothermal circulation), spring deposits would be a viable explanation to several discretely positioned layered deposits on Mars, which could be interpreted in this view as chemically precipitated sedimentary rocks. A possible role in the buildup of physical processes, such as serpentine mud volcanism [e.g. 16] is also under evaluation. If our working hypothesis is correct, we tentatively predict more detection of hydrated minerals in correspondence with crater bulges and other LTD of variable size with high resolution imaging spectrometers.

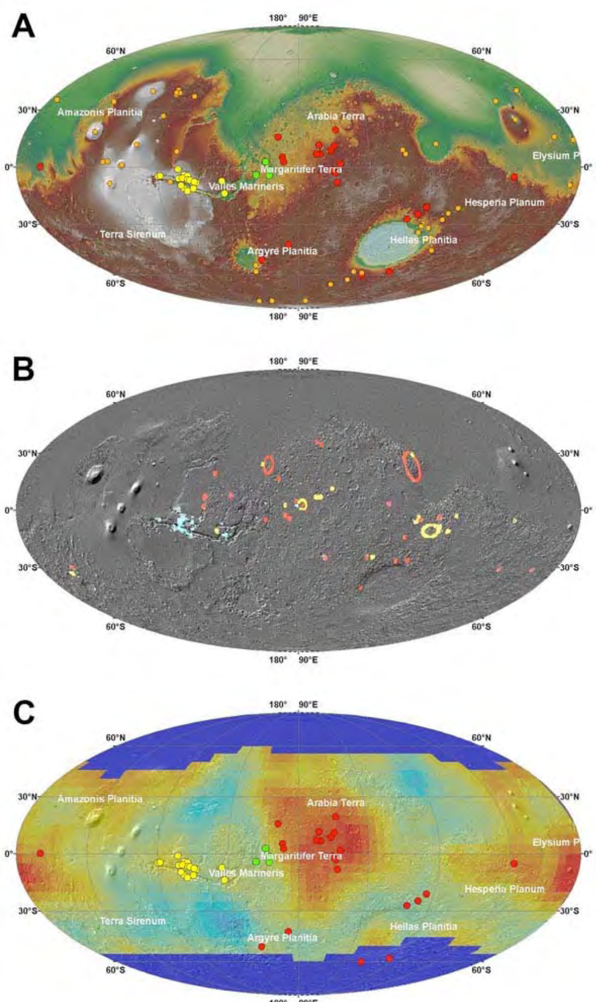

Figure 1: A. Global distribution of Crater bulges (red), Valles Marineris ILD (yellow) and LTD in chaotic terrains (green), compared with volcanic edifices (orange). B. Location of hydrated minerals, as in [5]. (red: phyllosilicates, blue: sulfates, yellow: generic hydrated minerals). C. Strong correlation (red) between the distribution of bulges in Arabia and high GRS H_20 content, data from [9] (dark blue: no data in present grid). Point color codes as in Fig. 1A.

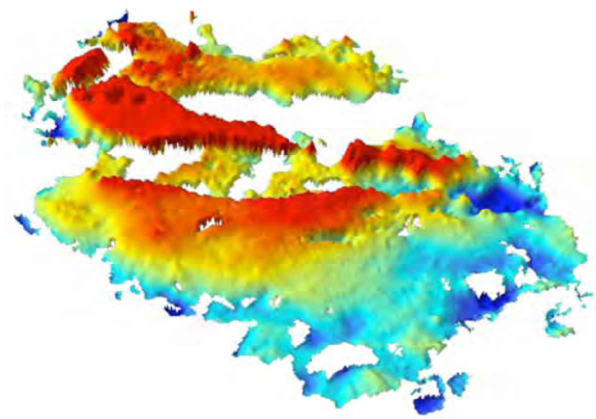

Figure 2: 3-D view of the isopach (max thickness ~400 m) map of bright deposits in Aram Chaos: LTD are slightly bulged and not sub-horizontal. North is towards the upper left corner.

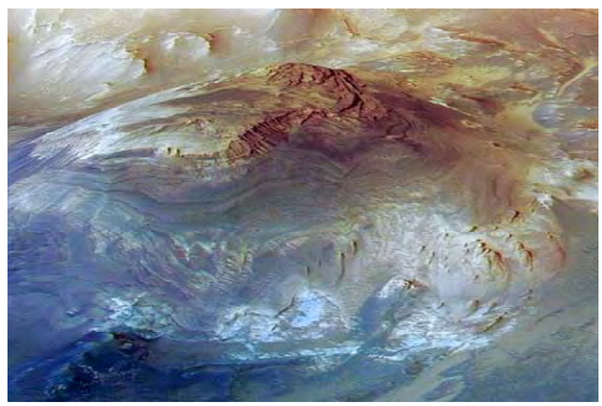

Figure 3: Layered deposits in Melas Chasma showing draping geometry [12] (HRSC color image draped on HRSC stereo-derived DTM, orbit 2039.

References: [1] Lucchitta B. et al. (1992) *Mars*, University of Arizona Press, 453-492. [2] Chapman, M. G, Tanaka, K. L. (2001) *JGR* 106, 10087-10100. [3] Ori G. G. and Baliva A. (1999) *LPS XXX*, #1758. [4] Crumpler L. S. (2003) *Sixth int. Mars Conf.*, #3228. [5] Bibring J.-P. et al. (2006) *Science*, 312, 400-404. [6] Gendrin A. et al. (2005) *Science*, 307, 1587-1591. [7] Oosthoek J. et al., *this conference*. [8] Rossi A. P. et al., *this conference*. [9] Feldman W. C. et al. (2004) *JGR*, 109, doi:10.1029/2003JE002160. [10] Pentecost A. (2005) *Travertine*, Springer, p. 445. [11] Fueten F. et al. (2006) *GRL* 33, doi:10.1029/2005GL025035. [12] Chan et al. (2004) *Nature*, 429, 731-734. [13] Ormo et al. (2004) *Icarus*, 429, 731-734. [14] Rodriguez J. A. P. et al. (2003) *GRL*, 30, doi:10.1029/2002GL016547. [15] Tanaka K. L. and MacKinnon D. J. (2000) LPS XXXI #1780. [16] Fryer P. (2002) *Chem. Erde*, 62, 257-302.