TITHONIUM CHASMA DOMES: A RESULT OF SALT DIAPIRISM BY MEANS OF THIN-SKINNED EXTENSION?

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Introduction: Tithonium Chasma (TC) is part of the western troughs of Vales Marineris (VM), constituting the northern trench, stretching about 850 km between 75-91°W. A wider opening is characterizing the western part (130 km) becoming narrower as it is advancing eastward, forming another Chasma like depression just before the emerging trenches connect it to Chandor Chasma. VM's origin has long been debated and currently two ideas of formation are accepted: tectonism-rifting and collapse; the rifting process was decisive in choosing the work path for our study, although evidences show that both processes might have been active in the area. The characteristic features in each depressional area of TC are the high albedo deposits at both ends of the trough commonly referred throughout VM as ILD. The outcrops in TC have unique dome shape morphology amongst the VM magnesium hydrates salt bearing deposits, having an elongated attitude parallel to main tectonic lineation (the same of the trough) and an almost symmetric position in respect with Chasma walls. These deposits were previously mapped as AHvm geologic unit [1] of late Amazonian age, and subsequently proven to bear magnesium sulfate [2], salts which are commonly believed to form in the presence of water. This situation calls for the presence of water in large amounts up to recent geologic periods which may actually contrast the actual evidences on Mars [2]. We tested the hypothesis that the domed salt bearing outcrops was the result of diapirism upraise in conditions of thin-skinned extension from a previously deposited salt layer subsequently covered by volcanic activity material (units Hf and Hsu [1]) and the implications of such process to the configuration and the evolution of the area.

Salt and diapirism: Rift-faulting and salt deposits produce a series of reciprocal triggering events, amongst these salt diapirism and gravitational gliding are the commonest [2], [3], [4]. All these processes require a simple stratigraphic stack in which a thick salt layer is overlain by a sequence of material deposition that is commonly referred to as overburden. The underlying salt would have a lower density than the overburden, constituted by various units that accumulated and lithified above the evaporite layer. This leads to a density inversion, causing Rayleigh-Taylor (RT) instabilities between the buoyant fluid layer and the denser overburden. Although density inversion is a common case in various setting in which diapirism occurs, it has been proven [6] that it is not a determinant requirement for diapirism, which can be triggered only by the rheological behavior of the salt and the overburden lithostatic pressure. Upraise is started when the evenly distributed pressure in a pressurized fluidized material (salt) overlain by the overburden is disrupted by various processes, amongst which extensional graben faulting formation. In case of TC this tectonic requirement is fulfilled considering rifting as main formational process. The stratigraphic requirement can be satisfied if salt is deposited before Hsu and Hf geologic units generally considered as volcanic material from Tharsis volcanic activity, hence before Valles Marineris opening. This can also solve the debate of who underlies who started for ILD deposits in different areas [5], [6] favoring to a salt ILD older hence underlying the wall rock material.

Geologic setting and evolution: TC presents a rather simple geologic setting display in which the depositional processes are represented by the units Hsu and Hf. The other geomorphic units were classified [1] as erosional or mass wasting processes results. The study is focused on the establishment of the process(es) that could have emplaced the salt domes, considering unsatisfactory the current interpretation and geologic classification of the units. Each possible candidate mechanism of formation was considered from those synthesized in [5]. Among these processes we considered the lacustrine and dry deposition as best counter candidates for our working hypothesis, capable of depositing magnesium salts. Both fail to explain the current distribution and morphology of salt bearing deposits in the area: (i) in case of a lacustrine environment that would invade the troughs of VM after its opening, and in the eventuality of precipitation of salts, this

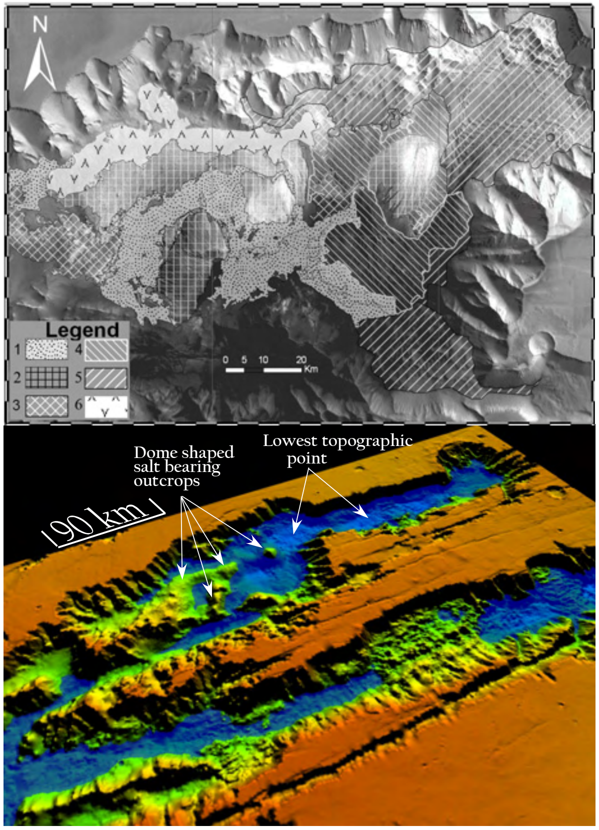

Figure 1 (a) Figure 4.5 Geomorphologic map of Tithonium Chasma west. 1) sand-dust sheet; 2) salt bearing domed outcrops; 3) salt deposits covered by sand and/or dust; 4) hummocky material; 5) landslide deposits; 6) undivided material.(b) MOLA topography of W Ius-Tithonium troughs. Water was "added" up to an arbitrary level 0 of MOLA datum to test the possibility of salt precipitation from lacustrine environment. Salt would precipitate from concentrating brine in the center in the lowest topographic point leveling by dissolution the W Chasma domes.

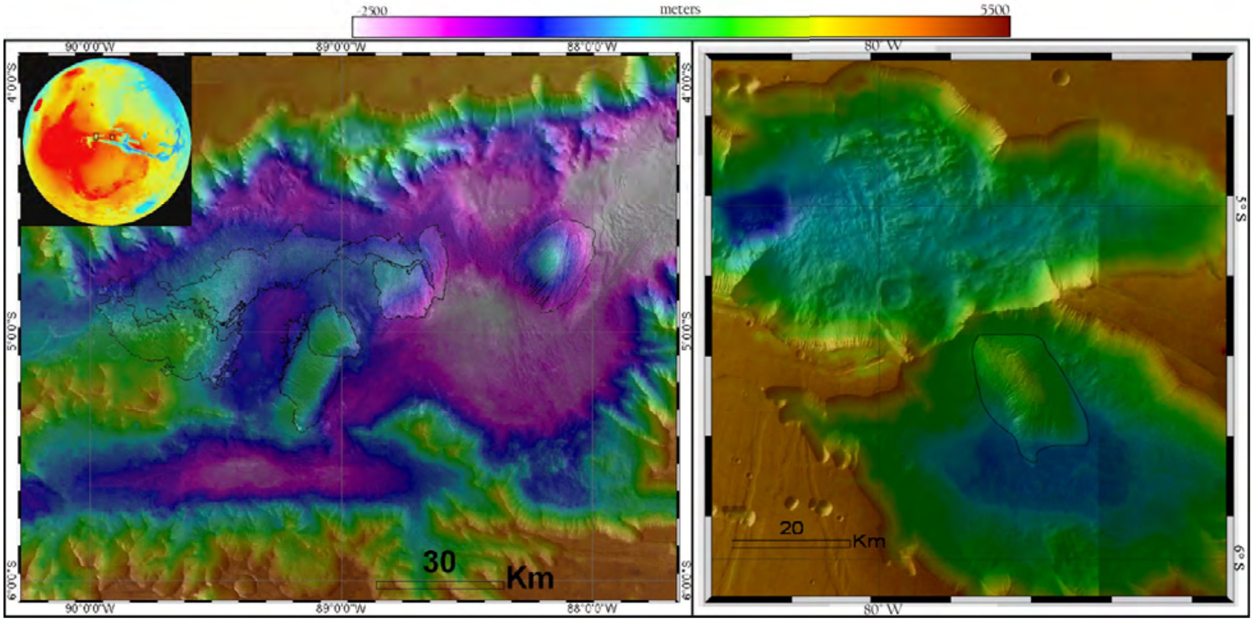

Figure 2 Topography of TC areas, derived from HRSC orbits 420 and 442 for W Tithonium and orbits 71 and 887 for E Tithonium. The contours follow exactly the surficial limit between domes and other geomorphic units.

process would very probably occur in the lowest topographic parts of the Chasma and not the intermediary topographic position that outcrops occupy figure 1 and 2; and (ii) a dry deposition from atmosphere precipitation from combined processes of SO_2 photochemical conversion and interaction with icy particles in the atmosphere [5] fail to explain the dome morphology of the outcrops and would produce an evenly distributed layered deposit on the Chasma floor. The diapirism process seems to explain the symmetric emplacement as well as the morphology of the outcrops, which bear a remarkable resemblance to analogue models [3], [4], [5], [8].

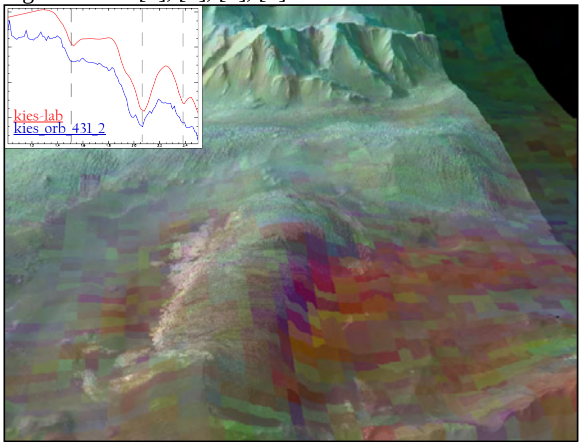

Figure 3 Kieserite distribution in TC around transversal dome shows an accumulation at the base of the dome slope with a best fit on the eastern side. This shows that kieserite source is the dome but this was possibly only wrapping the dome, exposing the internal minerals by mechanical erosion that may also have a water origin (e.g. halite) but is IR neutral for OMEGA channel C, situation similar to Riedel mine diapir [9]. Also kieserite could be traced intimately mixed with the sand sheets on each side of the transversal dome. (Warm colors = best fit of the library spectra).

Mineralogy: Mineralogic mapping was performed to establish the distribution of water related mineralogy with respect to the outcrops. The outcrops in west TC were divided in two according to the main orientation with respect to the trough: a longitudinal and a transversal one. The main water related mineral identified with OMEGA imager is kieserite. Its distribution is distributed as in figure 3.

Conclusion: Here we propose a plausible mechanism of emplacing the saline bearing outcrops in TC avoiding the problems generated by other possible mechanisms of formation. This explains the mineralogy and morphology of these deposits permitting the time evolution reconstruction presented in figure 4.

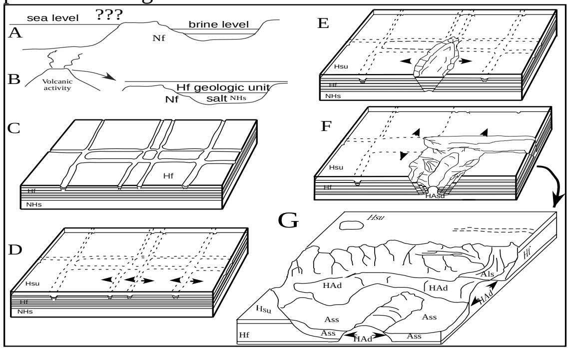

Figure 4 Evolution time line for west Tithonium. "A" stage is a highly speculative but very likely setting as source of saline deposition similar to Earth Permian saline-giants deposits in North Europe. Salt accumulated in tectonic trap from brines most probably supported by Nf geologic unit, being subsequently covered by geologic units Hf and Hsu B, C, D. The salt source supplied the diapirs as soon as the conditions were met as VM started to open E, F. G represents the present situation.

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