A MODEL SCENARIO FOR KIESERITE-DOMINATED EVAPORITES IN JUVENTAE CHASMA, MARS.
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Introduction: Juventae Chasma, located north of Valles Marineris, stretches for approximately 150 km east-west and 250 km north-south. The basin floor lies ~ 5 km and more below the surrounding surface and shows a smooth topography. A large dune field covers the bottom of the basin. Juventae Chasma contains several interior layered deposits (ILD). The four most distinctive deposits have been named from south to north mound A-D by [1, 2]. Several articles have been published discussing the origin and history of mono- and polyhydrated sulphate deposits within Juventae Chasma [1-7] based on studies of OMEGA and CRISM data. Formation theories range from a volcanic origin as a result of sub-ice volcanic eruptions [1], lake deposits, delta-deposits [4] and spring deposits [5], to mention a few. The composition of these sulphate bearing mounds has attracted the attention of many scientists because it still hides the information about a paleo-hydrogeological history. Based on the spectral observations of [7] our study presents an additional contribution to the ongoing discussion about the origin of the sulphate deposits within Juventae Chasma with kieserite ($MgSO_4 \cdot H_2O$) as the predominant mineral.

If we postulate that the mounds mainly consist of the characteristic measured monohydrated sulphate kieserite, only water is able to deliver this huge amount of minerals. On Earth, seawater represents the largest reservoir of solute salt and the largest kieserite deposits are marine evaporitic deposits [9].

Mound B was chosen for this study due to its characteristic morphology. Detailed maps are needed to correlate hyperspectral data obtained from CRISM with geologic and geomorphologic units, hence, a geologic and geomorphologic mapping of Mound B was carried out (Figure 1). Taking evaporation as a prerequisite, we measured the “stairstep” - morphology and the volume of mound B to model the mineral assamblage to reconstruct the amount of water needed to form mound B in its composition as measured by CRISM and OMEGA.

Methods: For the determination of mean layer thicknesses we used an HRSC digital elevation model (DEM) with a spatial resolution of 50 m/px superimposed by the corresponding HRSC image data. In order to avoid thickness errors related to the structural attributes of the geologic layer, we took into account the layer attitudes of the measured layers, i.e. dip and strike, instead of simply obtaining height differences

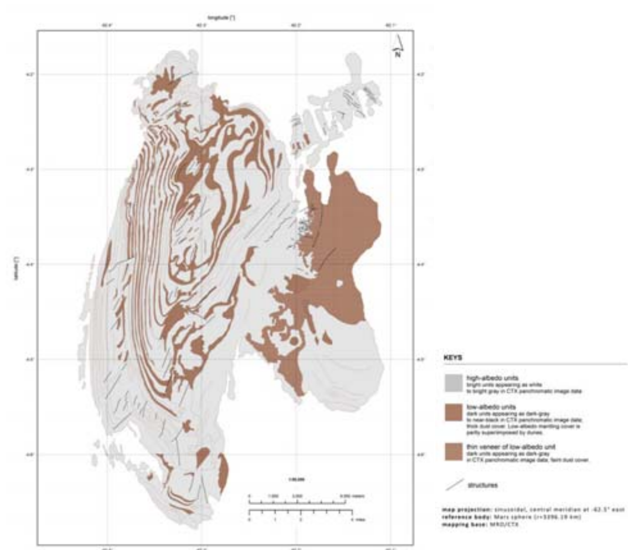

Figure 1: Geologic/ geomorphologic map of mound B, Juventae Chasma. Mapping was carried out at a scale of 1:90,000 MRO/CTX orbit.

between layer boundaries along a straight topographic profile. For this purpose, we determined dip and dip-direction values for each individual layer which could be distinctly identified. These measurements have been done using the LayerTools extension for ESRI’s ArcGIS as described by [8]. The basic concept of this software is to combine xy-coordinates of measurement points along an outcrop of a geologic layer with their according z-coordinates (elevation values) determined from an underlying DTM. Afterwards, the LayerTools software performs a one-degree polynomial fit in order to define the best-fitting plane. Using this interpolated plane, mean strike and dip values of the geologic layer can be obtained. Afterwards, the measurement of individual layer thicknesses was performed in strike direction, which avoids elevation distortion caused by the dip of the layer. Finally, all performed thickness measurements were averaged in order to determine a mean layer thickness which has been used for modeling of the sulphate precipitation.

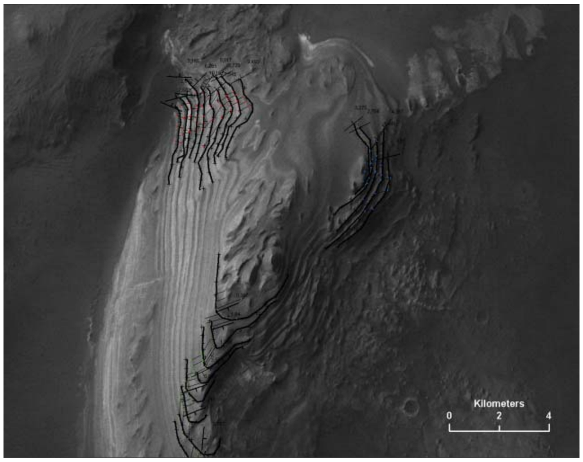

Figure 2: HRSC image H1070 showing dip and strike location at the flanks of mound B. Measurements of the individual layer thickness was performed in strike direction.

Conceptual model and model approach: It is the aim of our hydrogeochemical modeling to calculate the amount of water (the total height of a water column; footprint of 0.0001 m^2) which enables the formation of kieserite by evaporation

Our modeling scenario considers a simple batch model. The generic initial solution of the PHREEQC input file for our scenario is based on the wateq4f.dat database. Additional phases from the pitzer database, such as kieserite, leonhardite, leonite and pentahydrate were added to the input file. Modeling was conducted under low temperature conditions (25°C) with a starting pH of 7. The initial acid input contains 0.01 mol of H_2SO_4, 0.01 mol of H_2SO_3, 0.001 mol of H_2CO_3 and 0.001 mol of O_2 under the constant acid supply of 2.0 mol in 10 steps. The basaltic and ultramafic rock's primary mineral assemblage equilibrates with pure but, acidified water with a water to rock ratio of 2500.

Until the solution reaches a pH of 4.5, 548000.0 mol H_2O (equivalent to 99,953 liter) of pure water are evaporated.

Results: The calculated mean layer thickness is approximately 106 m (-48/+63). The volume of mound B is up to 205 km^3. Acidic aqueous weathering of basaltic or ultramafic rocks (at 25°C) and subsequent almost complete extraction of water from these solutions (> 99.9% by evaporation plus precipitation of hydrous minerals at 25°C) leads to the formation of evaporitic mineral assemblages, which are dominated by kieserite and contain minor amounts of anhydrite and bloedite or glauberite.

197 mol kieserite are stored within a representative evaporitic rock column, which displays a total thickness of 106 m and a footprint of 0.0001 m^2.

150 to 180 mol kieserite precipitate from 10,000 liter of groundwater, which occupy a water column displaying a footprint of 0.0001 m^2 and a total height of 100,000 m

Each layer (106 m thick) of the observed evaporitic deposits must have been formed via multiple flooding (100 to 10,000 times) with water formed via acidic weathering of ultramafic and/or basaltic rocks.

That leads to the conclusion that a volume of 205 km^3 material (mound B) needs up to 20,000 km^3 solution to evaporite.

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