Introduction: We investigate the mineralogy, morphology and stratigraphy of sulfate-bearing light-toned interior layered deposits (ILDs) at mound B in Juventae Chasma using multiple datasets from the CRISM, HRSC, CTX and HiRISE instruments onboard Mars Reconnaissance Orbiter and Mars Express. Our recent study [1] shows that Mound B features the most varied sulfate mineralogy and morphology among the Juventae Chasma ILD mounds. This study builds on an earlier one [2] and enables the determination of kieserite and starkeyite as the most common sulfate minerals. We also conducted numerical modeling to compare evaporation under martian conditions with the mineralogy observed in the Juventae Chasma ILDs. Precipitation of mineral assemblages was estimated using thermodynamic calculations in “Geochemist’s Workbench,” with input for the concentrations of aqueous species derived from dissolution experiments on several rock and mineral samples [3].

Methods: Stereo HRSC images [4] with 12.5 m per pixel were used to create digital terrain models (DTMs) [5,6] with a resolution of 50 m per pixel. CTX DTMs were created using NASA’s Open Source ‘Ames Stereo Pipeline’. The data were incorporated into a Geographic Information System (GIS)-project using the ESRI ArcGIS software. Processed HRSC nadir data and DTMs, geometrically corrected CTX image data [7], and CRISM [8] spectral parameter maps were displayed in ArcScene to determine stratigraphy of specific geologic units. CRISM targeted observations FRT00009C0A, FRT0001484D, and FRT00009C0A provide 20 m/pixel high-resolution coverage, whereas mosaicked CRISM 200 m/pixel multispectral mapping data in MRDR (Multispectral Reduced Data Record) tile T0934 provide overall mineralogic context in Juventae Chasma.

Observations: Mound B contains a combination of poyhydrated sulfates (PHS) and monohydrated sulfates (MHS) (Figure 1), whereas the other mounds are dominated by MHS (Figure 2). The PHS is observed to overlie the MHS: at two locations PHS appears to have slumped downhill. Terraces are observed at the upper elevations of mound B that contain PHS on their steeper slopes but appear to be covered with eolian sediment on their shallower slopes (Figure 3). Eolian dust exhibits a characteristic ferric signature, whereas
sand consists mostly of mafic material. Outcrops of intact mafic basement materials are found at the base of the mounds and in the chasma wall rock [2,9]. Spectra were collected from several locations marked by S.

Figure 3: a) CRISM FRT00009C0A MTRDR image with RBD920, G BD2100, B SINDEX draped over an HRSC image with CTX elevations (two-fold vertical exaggeration). Spectra were extracted from sites marked by arrows. b) Selected mound B spectra compared to lab spectra of sulfates.

Analyses and Interpretation: Band positions and shapes were evaluated for numerous spectra collected from the TRR3 images [1] and the MTRDR image ([1], Figure 3). The majority of MHS exhibits a kieserite (MgSO$_4$•H$_2$O) signature (S3), except a small region on the western flank (S9) is consistent with a mixture of szomolnokite (Fe$^{2+}$SO$_4$•H$_2$O) and kieserite. The most typical PHS signature (S5) most closely matches starkeyite (MgSO$_4$•4H$_2$O), although a few horizontal units could be amaranthite (Fe$^{3+}$SO$_4$OH 3H$_2$O) or a mixture of starkeyite with ferric oxides.

Stratigraphic analysis from Figure 3 and morphology from HiRISE views [1] suggest that MHS-bearing material was deposited first on the canyon floor, followed by PHS-bearing material.

Figure 4: Mineral precipitation predicted from evaporating 1L of a brine based on leaching experiments with olivine [3].

Modeling of evaporation, based on olivine leaching experiments with sulfuric acid (pH 1.3) [3], show the formation of Mg sulfates almost at the end of the reaction path calculated at temperatures of 75°C and 150°C in an extreme acidic environment [1]. The PHS hexahydrite could form at 75 °C from olivine (Figure 4), while the MHS kieserite requires higher temperatures. Because kieserite appears to have formed first at Juventae Chasma, followed by PHS later, the solution temperature may have decreased over time.

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