SULFATE-RICH DEPOSITS IN WEST CANDOR CHASMA. N. Mangold[1], A. Gendrin[2], C. Quantin[1], B. Gondet[2], J.-P. Bibring[2], V. Ansan[1], Ph. Masson[1], G. Neukum[3], and the OMEGA and HRSC Co-Investigator Teams (1) IDES-Orsay, UMR 8148, CNRS and Université Paris-Sud, Bat. 509, 91405 ORSAY Cedex, France, Nicolas.Mangold@u-psud.fr, (2) IAS, Université Paris-Sud, France (3) FU, Berlin.

Introduction: Sulfates are identified with the spectral data OMEGA onboard Mars Express on many areas of the Valles Marineris region, with broad outcrops in the Candor Chasma region [1]. Sulfates require the presence of liquid water in their formation. Sulfates in layered deposits have been interpreted either as deposition through evaporitic processes or alteration through groundwater circulation [1] but many issues remain open concerning their formation. Coatings and duricrust formation are locally able to explain sulfates on Earth. How can we exclude this possibility on Mars? What is the exact nature of layered deposits? We use all geological data available here to show the correlations between geology and mineralogy.

OMEGA Analysis: Six OMEGA orbits (360, 581, 1224, 1235, 1462, 2116) have been studied in the West Candor Chasma area providing a full coverage at low resolution (2 km/pixel), locally reaching 300 m/pixel for orbit 2116. The match between the spectra and the spectrum of kieserite is excellent between 1.4 and 2.5 µm, with three main absorption bands at 1.6, 2.1 and 2.4 µm. These bands are due, in monohydrated sulfates, to the single, strongly hydrogen bonded, water molecule. A second group of minerals is detected in West Candor with absorption bands at 1.4 and 1.9 µm and a drop at 2.4 µm. Such associations are observed in spectra of polyhydrated sulfate minerals. Additionally, a drop between 1 and 1.3 micron suggests the frequent occurrence of iron oxides close to the locations where sulfates are detected. Notice also that sulfates might not be the only minerals present, especially if the rocks contain minerals that are spectrally neutral in the NIR wavelengths (halite salt or silica for example). Finally, pyroxenes signatures are also present in the canyon and are studied in comparison.

West Candor Chasma characteristics: Five Mars Express orbits (360, 1235, 2116, 2138, 2149) are used in this study with nadir image spatial sampling between 12 and 30 meters. A mosaic of these images has been completed at 30 m/pixel in the region of interest. A DEM mosaic using these orbits has been computed with 30 m of spatial grid and about 30 m of vertical accuracy. West Candor Chasma lies in the central area of the Valles Marineris canyon system (Fig. 1). It is closed on three sides measuring about 200 km long from West to East and over 150 km long from North to South. The HRSC mosaic and context map shows the main units found in the canyon. Interior Layered Deposits (ILD) are widespread in the West Candor Chasma canyon covering about half of the canyon interior. Layered deposits are mainly composed of two units, a narrow mesa to the east and a more developed area in the rest of the canyon. Locally, the top of these layered deposits mesas is covered by a dark cap unit. The floor of the canyon is darker and smoother. The difference in elevation from the floor to the plateau is of about 8 km, from –5 km for the lowermost floor at the SE edge of the canyon to 4.3 km on the plateau. The top of the western mesa lies at about 3.6 km above datum, thus only 700 m below plateau level. Assuming a subhorizontal layering for the overall interior layered deposits, the difference of elevation found in West Candor Chasma corresponds to a thickness of layered deposits of about 7 to 8 km; a thickness consistent with estimations made using Viking data [2].

Comparison between mineralogy and geology: The most striking result of the identification of sulfates is their systematic correlation with interior layered deposits (ILD) which cover more than half of the West Candor Chasma surface (Fig. 1) [1,3]. They are found over elevations from –3.6 km to +3.1 km, thus over much of the layered deposits sequence. Sulfates signatures are mostly developed on the scarp of mesa, and some other escarpments as seen from the superimposition with the MOLA slope map. When we eliminate all sulfates detected on slopes of more than 5°, about 90% of sulfates are removed. Only a few outcrops remain visible showing that the sulfates are found on sloping outcrops mainly. In contrast, pyroxene is found mainly in the low lying areas of dark tone and a few areas at higher elevations such as the top of the eastern mesa. These areas correspond to dark sand dunes, never to ILD. Thus, sulfates and pyroxene do not follow the same overall distribution. Iron oxides are found mainly in geographic association with sulfates, but they extend out of the sulfates areas.

At MOC scale, the surface texture of bright deposits displays flutes and yardangs typical of eolian erosion in weakly consolidated material. They are also devoid of small impact craters (<100 m), which does not mean that the layers formed recently, but that they were exhumed recently. When compared to albedo and thermal inertia, sulfates are detected over terrains significantly bright (albedo: 0.15-0.25) and with thermal inertia of 250-450 USI showing the lack of dust and a relative induration of the material.

A detailed look to the eastern mesa shows a pile of layers reaching more than 3 km over which sulfates are present. We observe that kieserite is present with deep band on steep slopes (> 15°). In order to quantify this observation we compared the relative proportion of kieserite-rich areas relative to ILD mapped from images. This histogram shows a continuous increase in the relative proportion of kieserite with the increase of the slope. At 20 to 25° of slope, kieserite cover 60 to 80% of the ILD unit whereas only 20% at 5°. This effect is not observed for the polyhydrated sulfates showing this is not a statistical bias. The effect of steep slopes is mainly to provide more freshly eroded material at outcrops. The increasing presence of kieserite there is thus an evidence that kieserite is directly present in the bedrock and does not come from surface interactions.

Conclusion: The detailed study of West Candor Chasma shows that sulfates are located in the outcrops of layered deposits over a large thickness with kieserite more frequent on freshly eroded bright scarps. Duricrust is not able to explain such preference for fresh surfaces. In order to form sulfates, liquid water should have reached, either at surface or in aquifers, the elevation of 3100 m to explain the presence close to the summit of the two mesas.

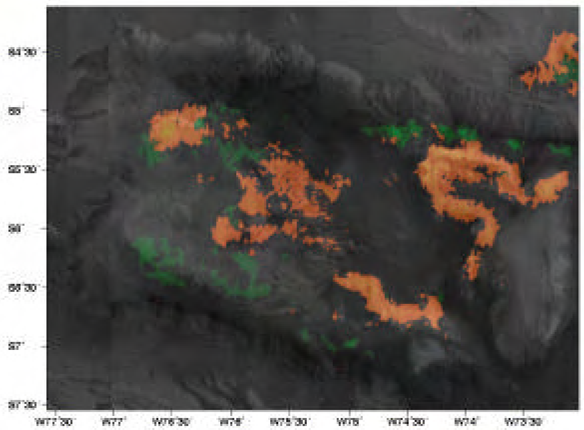

Fig. 1: Identification of kieserite (red) and polyhydrated sulfates (green) by OMEGA/MEX in West Candor Chasma. The brighter red corresponds to deeper depth of the main absorption band at 2.1 micron for kieserite.

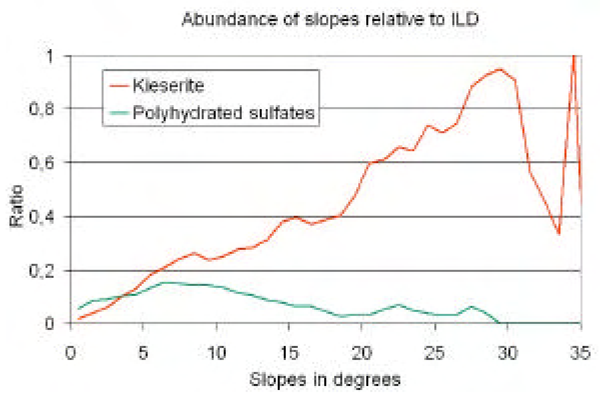

Fig. 2: Proportion of each sulfates ratioed by the total proportion of ILD versus slope (1 means kieserite on all ILD outcrops mapped from geology). Kieserite becomes more and more frequent as the slope increases. Strong variations for slopes >30° are due to statistical unsampling of slopes of such steepness.

References: [1] Gendrin et al, Science, 307, 1587-1591, 2005. [2] Lucchitta, JGR, 1994. [3] Quantin et al, Workshop on sulfates on Mars, Houston, 2006.