DETECTION OF HYDRATED MINERALS ON FLUIDIZED EJECTA LOBES FROM OMEGA OBSERVATIONS: IMPLICATIONS IN THE HISTORY OF MARS.

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Introduction: Martian ejecta blankets exhibits single layers and double layer ejecta that are likely the result of emplacement by fluidized processes, either from impact into and vaporization of subsurface volatiles (Barlow et al., 2000) or by ejecta entrainment by the thin Martian atmosphere (Barnouin-Jha and Schultz, 1998).

One of the main goals of the MarsExpress mission is the detection of volatile materials by means of OMEGA imaging spectroscopy, of radar sounding (MARSIS) and high resolution images of the surface (HRSC camera). It has been proposed that fluidized ejecta lobes would originate from the melting of ice rich permafrost or from the vaporization of water or volatiles (Carr et al., 1977, Gault and Greeley, 1978, Schults, 1994). The detection of potential hydrated minerals would comfort such hypotheses. In that context, we have used the OMEGA data to analyze the surface composition of fluidized ejecta lobes. The data acquired during the first two years of the mission already reveal only a few examples of lobate ejecta with hydrated minerals. Here we discuss their geological context and their implications for Martian climate and subsurface volatiles.

Background: The OMEGA investigation on board MarsExpress is currently mapping the surface composition of Mars at a 0.3 to 5 kilometer resolution by means of visible-near-infrared hyperspectral imagery (Bibring et al, 2005). The data already acquired reveal a diverse surface mineralogy with the identification of large deposits of phyllosilicates mainly associated with Noachian outcrops consistent with an early active hydrological system (Poulet et al., 2005). The presence of sulfates results from a more acidic environment.

Identification of hydrated minerals on ejecta : Impacts are natural probes into planetary surfaces and expose underlying lithologies. The rims and ejecta blankets of relatively fresh impact craters consist of a mixture of particles excavated from different depths that are ideal for visible-near-infrared hyperspectral analysis. From OMEGA data, hydrated minerals are observed on some lobate ejecta blankets. The database includes a few tens of impact craters with diameter from 3 to 30 km mostly in the equatorial latitudes. We identify hydrated minerals in ejecta deposits in the south of Gangis (-11.4°S, 308.5°W), in the south of Isidis (-12.7°S, 83.5°W), and west of Hellas (-25°S, 50°E).

Interpretations: Post-impact processes as wind erosion and/or dust deposition affect the spectral signature of hydrated minerals. The detection of hydrated minerals from OMEGA data occurred only on dust-free surfaces (based on the Thermal Inertia Map from TES/Mars Global Surveyor). Moreover, nighttime THEMIS IR images of ejecta blanket surfaces are consistent with an erosional and dust-free surface (Fig. 1). These observations suggest that the detection of hydrated minerals in some ejecta blankets reflects the composition of underlying materials. The most stricking result of the identification of hydrated minerals on fluidized ejecta lobes is their correlation with Noachian units. Most of the hydrated minerals on lobate ejecta are mostly found in the ancient highlands, which exhibit the highest channel densities (Carr, 1977). These old dentritic patterns of the cratered uplands suggest a relatively warm and wet climate. The spatial correlation between hydrated minerals on ejecta blankets and Noachian units suggests a thick layer of weathered materials formed during the Noachain epoch (see Poulet et al., 2005; this volume).

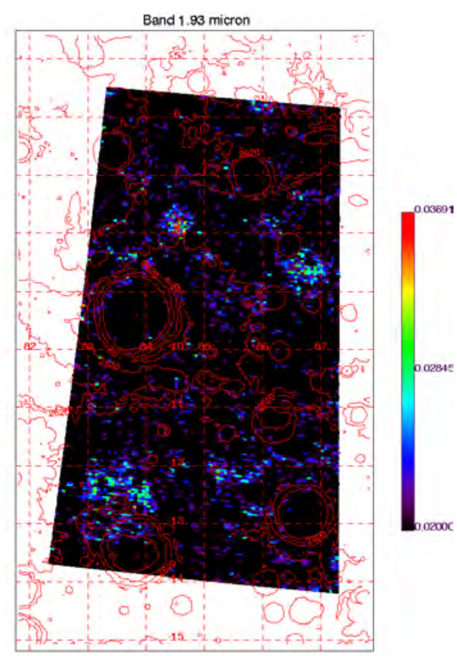

Fig. 1 Detection of hydrated minerals on fluidized ejecta lobes in the south of Isidis.

Modeling the excavation depth: The hypothesis concerning the excavation of hydrated materials formed before the impact event in the Noachian epoch is investigated in more details. Hydrated minerals are found in craters ranging from 3 km to 30 km in diameters. A Z-model approach presented in [8] is used to discuss the thickness and depth of the layers which contains hydrated minerals (see Fig. 2). The smallest craters containing hydrated minerals constrain the thickness of the non-hydrated upper layer. The larger craters with hydrated minerals constrain the thickness of the hydrated layer. Assuming that hydrated minerals can be detected for a proportion greater than 20% and that the hydrated layer contains 50% of hydrated minerals (JUSTIFICATION?), we roughly estimate the occurrence of an hydrated layer at 100 meters depth down to 1 km, suggesting the existence of large amounts of weathered material. These values depends on the detection, decreasing the thickness of the upper layer and increasing the thickness of the hydrated layer for a value lower than 20%. Assessing the mineralogical abundance is thus essential to discuss the sub-surface composition through impact crater. High-resolution studies will be also essential to investigate possible radial variations of abundances of hydrated minerals related to the mixing of the sub-surface stratigraphy as predicted by impact cratering models (Fig. 2).

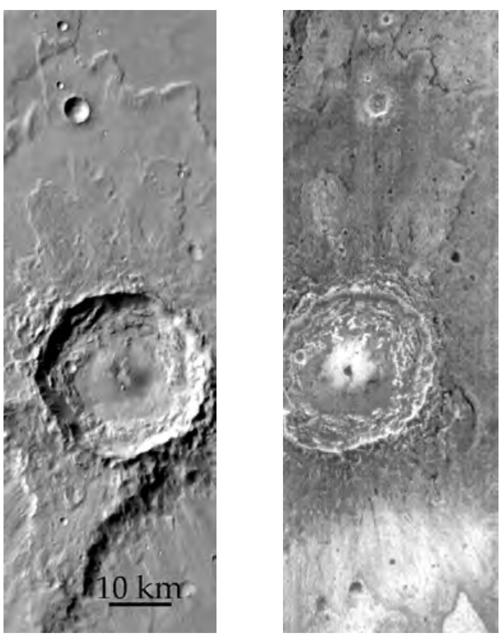

Fig. 2~~1~~ : Day time and night time THEMIS images of a crater (12.7°S 83,5°E) where hydrated minerals have been detected on lobate ejecta. I02456002 and I14208004 images.

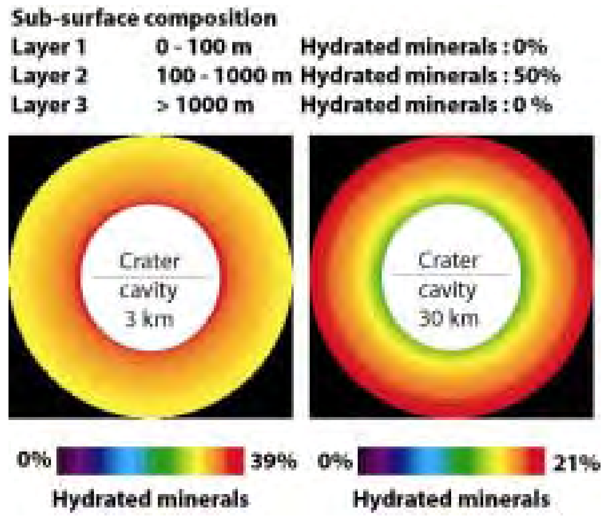

Fig. 3~~2~~: Abundances of hydrated minerals in the ejecta layer from Z-modeling. The 3 km crater constrains the thickness of the non-hydrated upper layer, and the 30 km crater constrains the thickness of the hydrated layer.

Conclusion: The detection of hydrated minerals on lobate ejecta suggests relatively high alteration rate on early Mars. This observation in the ancient highlands suggests Earth-like conditions before 3.5 to 4 billion years ago. The current association with Noachain unit shows that water may have played a major role in the formation of weathered minerals in the surface and subsurface of Mars during that primitive epoch.

At the present stage, there is no clear evidence of correlation with the hypothetized permafrost and young hydrothermal systems related to impact event into ice-rich layers. Direct measurements of the main water/ice discontinuity at depth from MARSIS experiment will be helpful to evaluate a possible correlation with the detection of hydrated minerals in the ejecta blankets.The spectral signature of hydrated materials as seen by OMEGA also depends on many other factors (albedo, particle size, viewing geometry…). Further studies are needed to assess the proportion and nature of hydrated minerals within the ejecta layer and demonstrate their exact origin.

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