DISCOVERY, MAPPING AND ANALYSIS OF HYDROUS SILICATE-BEARING DEPOSITS IN NORTHERN PLAINS OF MARS.
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Introduction: The discovery of hydrous silicates on Mars has greatly improved our understanding of the planet’s early surface environment. Data collected from the OMEGA and CRISM imaging spectrometers has led to the identification and analysis of hundreds of sites over the southern cratered highlands of Mars (e.g. [1-7]). However, hydrated silicates had not yet been detected in the northern Amazonian plains.

In this abstract we report the first detection of phyllosilicates and low-grade metamorphic/hydrothermal products in several northern plain craters. Using CRISM high resolution observations, we present an overview of the mineralogical diversity and geological settings in 9 craters.

Survey: Our survey include 162 high-resolution CRISM observations. Available data on northern plain craters with diameters greater than 30 km were systematically analyzed, and a number of smaller craters down to 4 km in diameter have also been included in our survey. Craters mantled by seasonal CO₂/water ice have been discarded.

Method: In order to find hydrous mineral exposures we built spectral parameter maps from near infrared surface reflectance data. These parameters are spectral ratios that test each spectrum for absorption bands at key wavelengths around 1.4, 1.9, 2.2 and 2.3-2.4 µm. Once maps have indicated possible sites of interest, we recover the spectral signatures and compare them to laboratory spectra of hydrous minerals. It is important to note that the signal to noise ratio of the spectral data is usually smaller than that found in the mid-latitude regions because the atmosphere usually has greater or more variable aerosol opacity.

Spectral discrimination between the minerals pumpellyte, prehnite and some chlorites is not always straightforward. All 3 species have absorption bands in the 1.4, 2.25 and 2.32-2.35 µm regions. Prehnite however can be uniquely discriminated thanks to a shift towards longer wavelengths in the 1.4 µm band at 1.48 µm. Pumpellyite and chlorites have slightly different overall spectral continuum shapes.

Results: We have identified 9 craters with hydrated mineral signatures including: Lyot, Kunowsky, Stokes, Santa Fe and Bamberg craters. The remainder are unnamed. They are found at a wide range of latitude and longitude, namely in Chryse, East Acidalia, Elysium, Arcadia and Isidis Planitia (Fig. 1). We have excluded from this study a small number of hydrated craters found at the dichotomy boundary.

Morphology and age. All 9 craters are found in late Hesperian / Amazonian plains [8], range in diameter from 20 to 60 km (210-km Lyot crater excluded), and have distinguishable inner crater features and rims. Some are complex craters, others have a single central mound. Lobate ejecta can be seen around 4 craters. The preservation state of the crater varies greatly from one site to another, some are well preserved while others have been heavily mantled and resurfaced, presumably by periglacial processes.

Figure 1. Locations of 9 hydrous silicate exposures in northern plain craters (MOLA – USGS background).

Mineralogy. Three lower latitude craters have spectral signatures in their central mound consistent with altered olivine with a Fe/Mg-rich clay (at the 18m/pixel resolution of the CRISM instrument). Alternatively, they may be sub pixel scale spatial mixtures of olivine and clay. All remaining 6 sites exhibit chlorite signatures. In addition, at least 4 sites have prehnite signatures, and 3 sites have a chlorite-prehnite assemblage identifiable through band shape around 2.35 µm and the presence of two distinct shallow bands at 1.4 and 1.48 µm (Fig 2.). Prehnite and chlorites are hence the most common hydrous minerals here, while Fe/Mg smectites-vermiculites are found in 3 out of 6 sites, and Al-rich phyllosilicates (e.g. montmorillonite, muscovite, kaolinite) are only found at Stokes crater.

Geological settings. Hydrous minerals are encountered within crater central mound structures, with the exception of Lyot crater which shows signatures over its inner and outer rims. There is no clear geological context so as to their local setting. Some are found in bulky outcrops or knobs while others are associated with mobile material. Polygonal terrains have also been observed, and some exhibit signatures of these hydrated
phases. The same mineral specie may be found in these different settings at a given crater site. In addition to hydrous minerals, most craters have strong olivine signatures both in bedrocks and dunes and in the vicinity of the hydrated mineral deposits, and on rare occasions have small pyroxene-bearing outcrops near the central uplift.

Fig. 3 presents the case of Kunowsky crater (350.5°E, 56.9°N). Using a spectral parameter based on the 2.32 µm absorption band, we have mapped two distinct hydrous species in the vicinity of the central mound. The first unit (north) is a chlorite-prehnite bearing assemblage which appears to be mobile material overlying polygonal terrain. The second unit (south), is Fe/Mg-smectite or vermiculite-bearing. It is found in a somewhat bulkier unit and shows no sign of aeolian displacement. It is in close occurrence with bright olivine outcrops.

**Origin of the hydrated material:** The hydrated mineral assemblages could result from excavation of buried material from the ancient crust. All the sites reported here are large enough to have excavated Noachian material in the fractured central uplifts and/or rims [9, 10]. Alternatively, an impact-induced hydrothermal system could have provided suitable pressure, temperature and water availability settings for phyllosilicate formation. Recent impact hydrothermal models [11, 12, 13] for Mars indicate lifetimes no longer than 10^6 yrs for craters 10s-km in size, capable of forming a variety of hydrous mineral species depending on the water/rocks ratio. We will discuss these two possible scenarios. However, olivine is a mafic material readily altered under an aqueous environment. We have detected olivine in dozens of northern plain craters, sometimes juxtaposed to the hydrated minerals, but found it to be altered in only 3 sites. This suggests that the alteration after impact was very rare. Prehnite forms at high temperatures (200-350°C) only attainable in the crust or within the central uplift of large craters (>50 km) [6, 11, 12, 13] The presence of prehnite in central peaks and rims leads us to favor the excavation scenario. Finally, some of the observed minerals (such as smectites and chlorites) have been detected using CRISM and OMEGA in the highland craters [6, 14, 15]. The geological contexts of these detections being less degraded than those in the northern plains, point to a formation from aqueous altera-