The mineralogical composition of dark dunes in Martian craters and updated results of the consolidation analysis

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Introduction

We study the Martian fine-grained dark material by focussing on a global selection of 68 impact craters, based on MarsExpress HRSC data [1]. These craters are interesting because the material frequently accumulates on their floors into huge dune fields such as barchan or transverse dunes. The mineralogical composition was analysed by using near infrared spectra of MarsExpress OMEGA data [2].
For the analysis of the dune surface conditions, i.e. a possible dune surface consolidation, we used the thermal inertia because it is the key surface property controlling the diurnal and seasonal temperature oscillations and is most closely related to the thermal conductivity of a surface. Therefore, it can be used to determine several physical properties of a surface, comprising the grain size, the degree of induration, abundance of rocks and exposure of bedrock [3,4,5].

Compositional Analysis

The mineral detection was done using an IDL routine that applies a rationing technique on the geometrically and atmospherically corrected spectral data as described by [6]. For every crater we analysed the presence of pyroxene, olivine (forsterite and fayalite), hydrated minerals. The absorption depths in the spectra determine the amount of the respective components. The global distribution of olivine, pyroxene and hydrated minerals in the crater deposits was visualised by using a GIS.

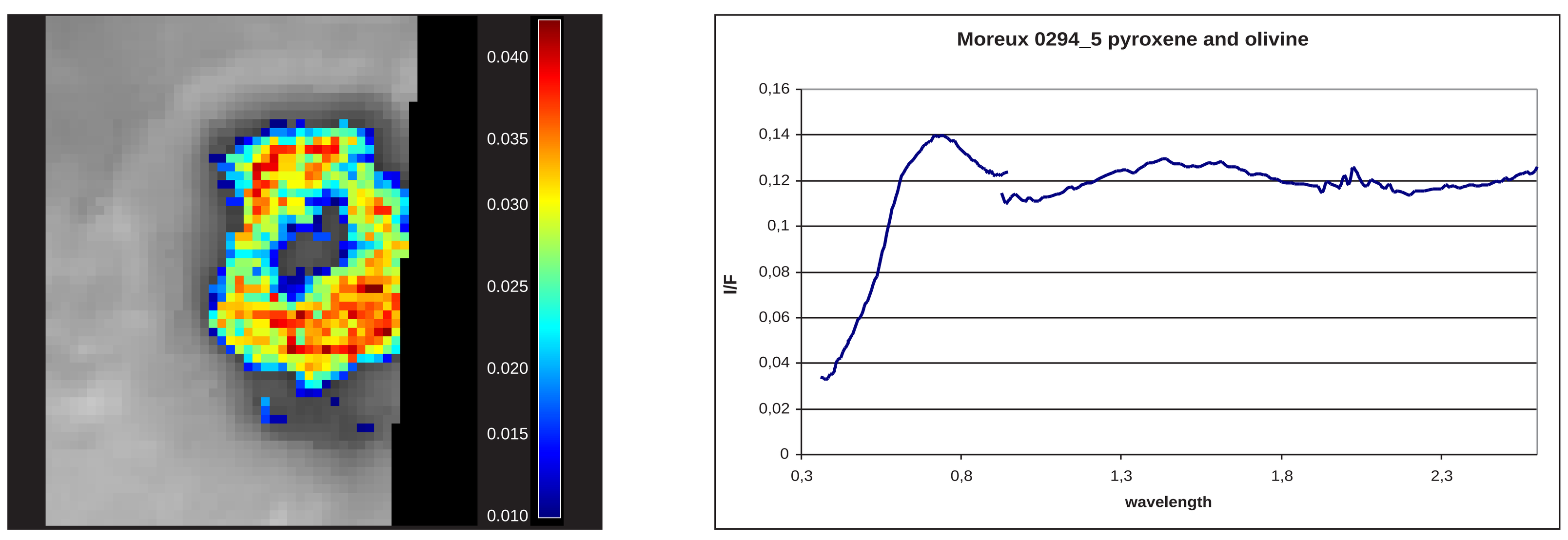

Fig. 1: Detection of pyroxene in Moreux Crater.
left: pyroxene absorption band depths in OMEGA Orbit 0294_5 right: OMEGA reflectance spectrum (note that there is also the presence of olivine detectable).

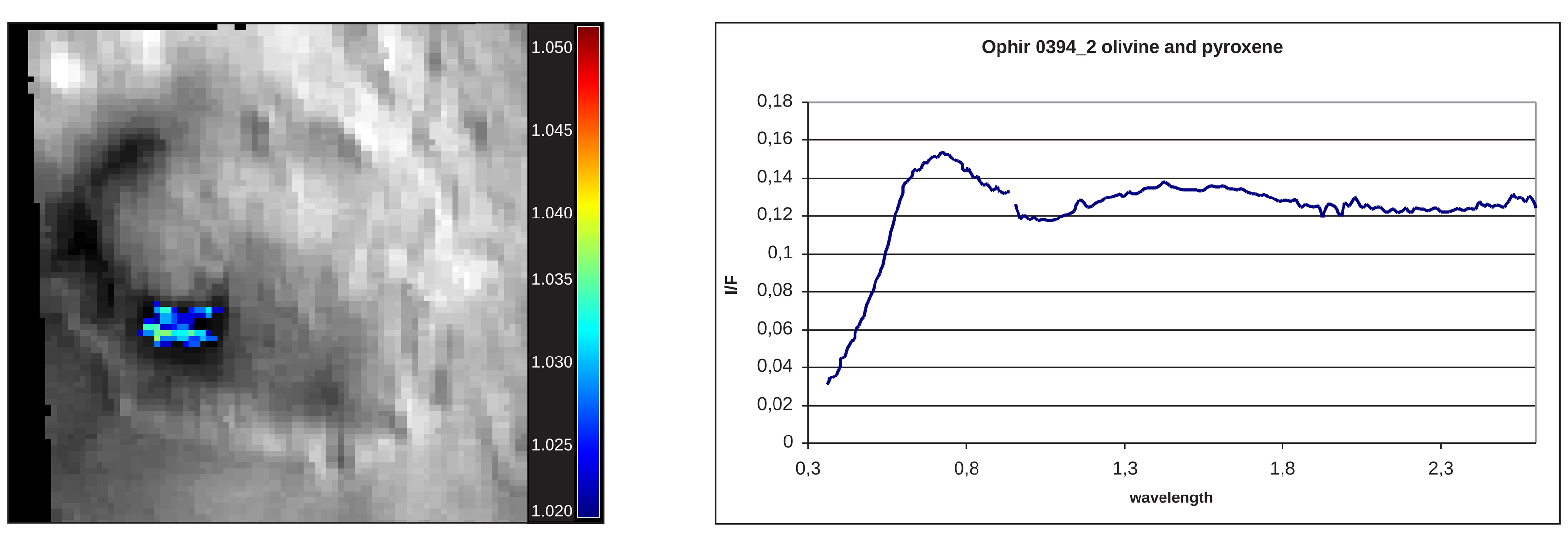

Fig. 2: Detection of olivine in a crater at 3°S, 308°E (Ophir Planum).
left: absorption band depths in OMEGA Orbit 0394_2 right: OMEGA reflectance spectrum (note that there is also the presence of pyroxene detectable).

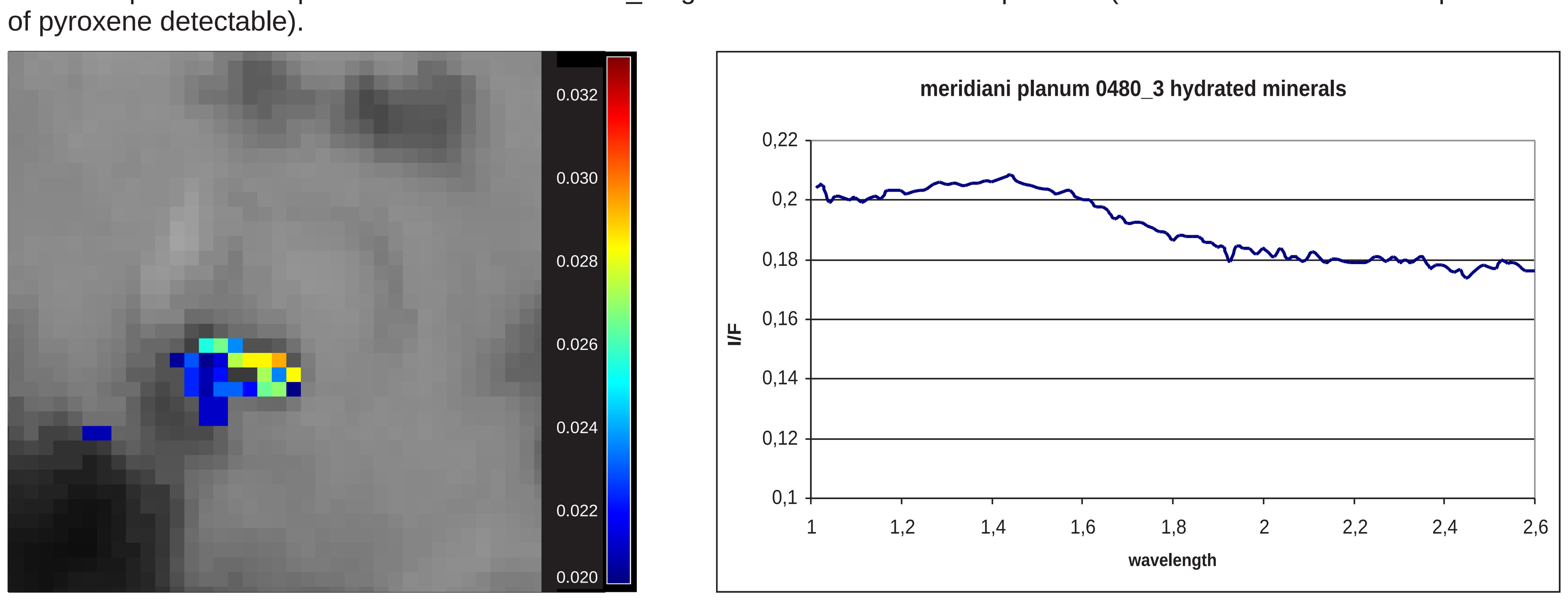

Fig. 3: Detection of hydrated minerals in a crater at 5°N, 0°E (Meridiani Planum).
left: absorption band depths in OMEGA Orbit 0480_3 right: OMEGA reflectance spectrum

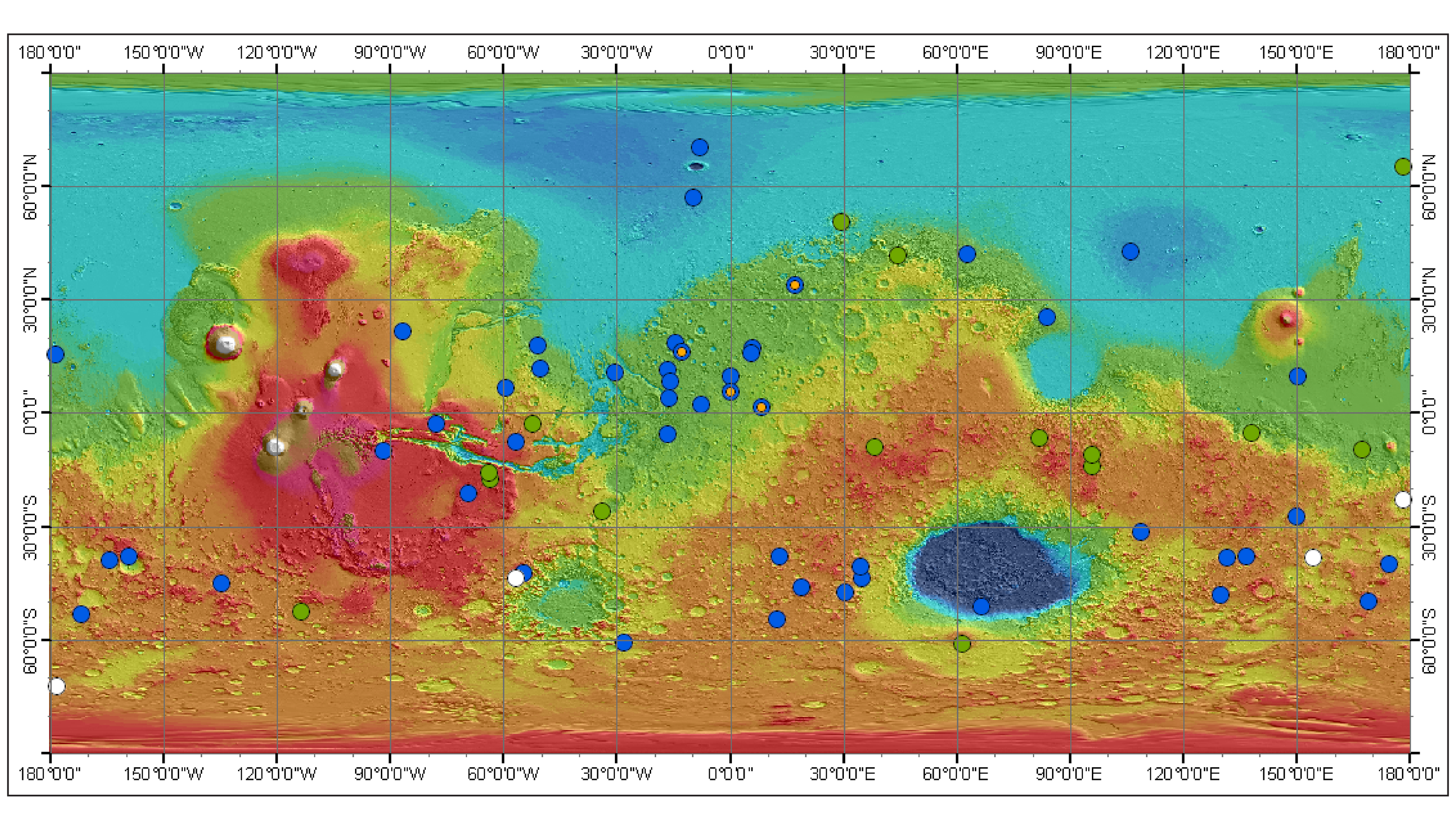

Fig. 4: Global distribution of pyroxene and/or olivine composed dark dunes with occurrences of hydrated minerals

Analysis of surface consolidation

The thermal inertia (TI) values for every crater were derived by using TES data [7] with a spatial resolution of 3 km. Gaining this information pointing to the grain size it should be assessed which dunes could be unconsolidated and thus might be active and which dunes could be covered by an indurated surface and thus might be inactive. In general, unconsolidated fines (i.e. dust, fine sand) will have low thermal inertia values, sand-sized particles result in intermediate TI values, and rocks, duricrusts and exposed bedrock will have high TI values [8]. Regarding this basis, those dunes, that show intermediated TI values and corresponding particle sizes ranges are supposed to be unconsolidated and dunes showing higher TI values corresponding to duricrust are supposed to be consolidated.

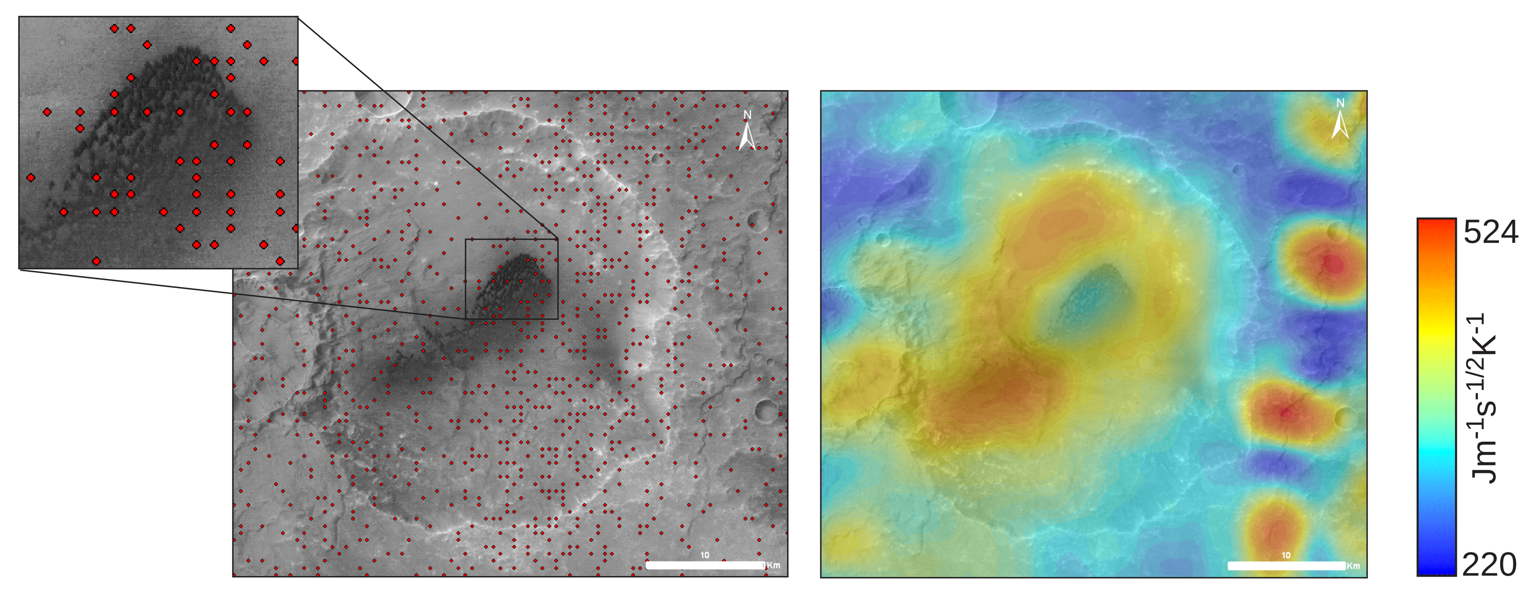

Fig. 5: TES TI of a crater at 14°S, 96°E.
left: ungridded TES single point measurements overlain onto HRSC. right: gridded TES data overlain onto HRSC.
The TI values for the dune field range from 295 to 305, corresponding to unconsolidated medium to coarse grained sand.

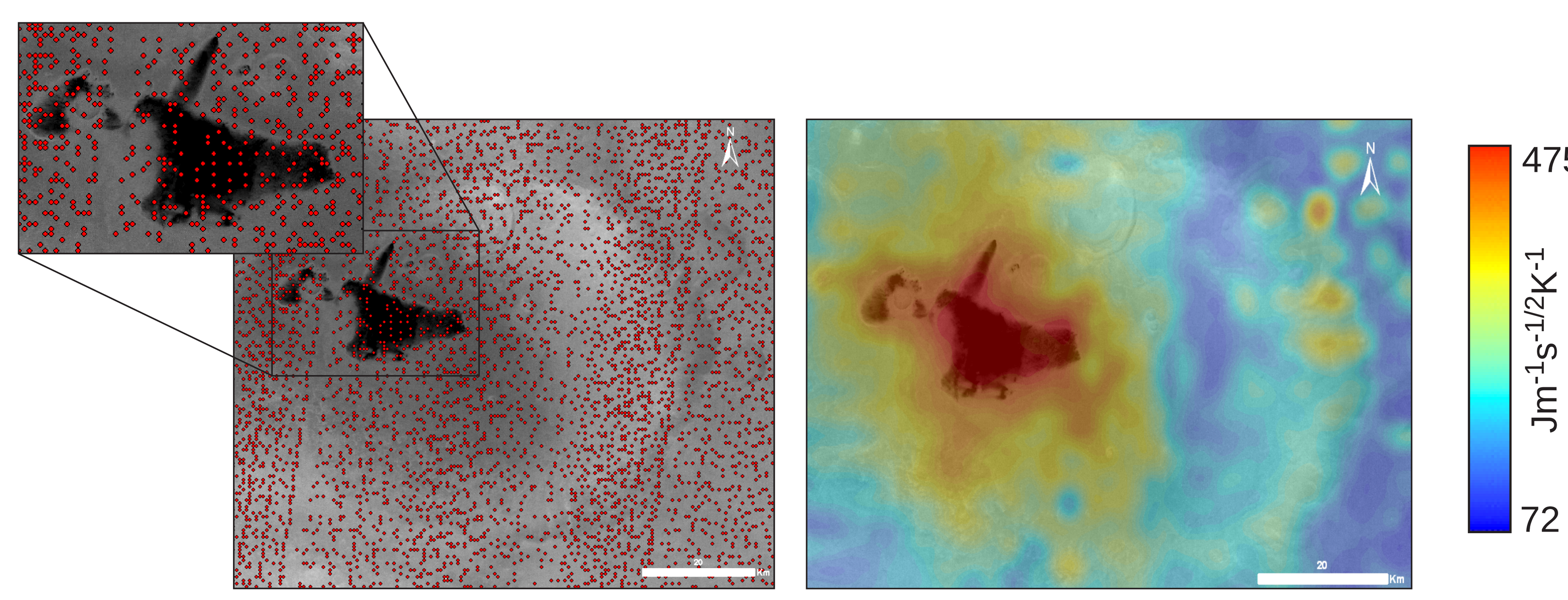

Fig. 6: TES TI of the crater at 17°N, 6°E.
left: ungridded TES single point measurements overlain onto HRSC. right: gridded TES data overlain onto HRSC.
The TI values for the dune field range from 411 to 475 corresponding to rocks, bedrock or duricrust.

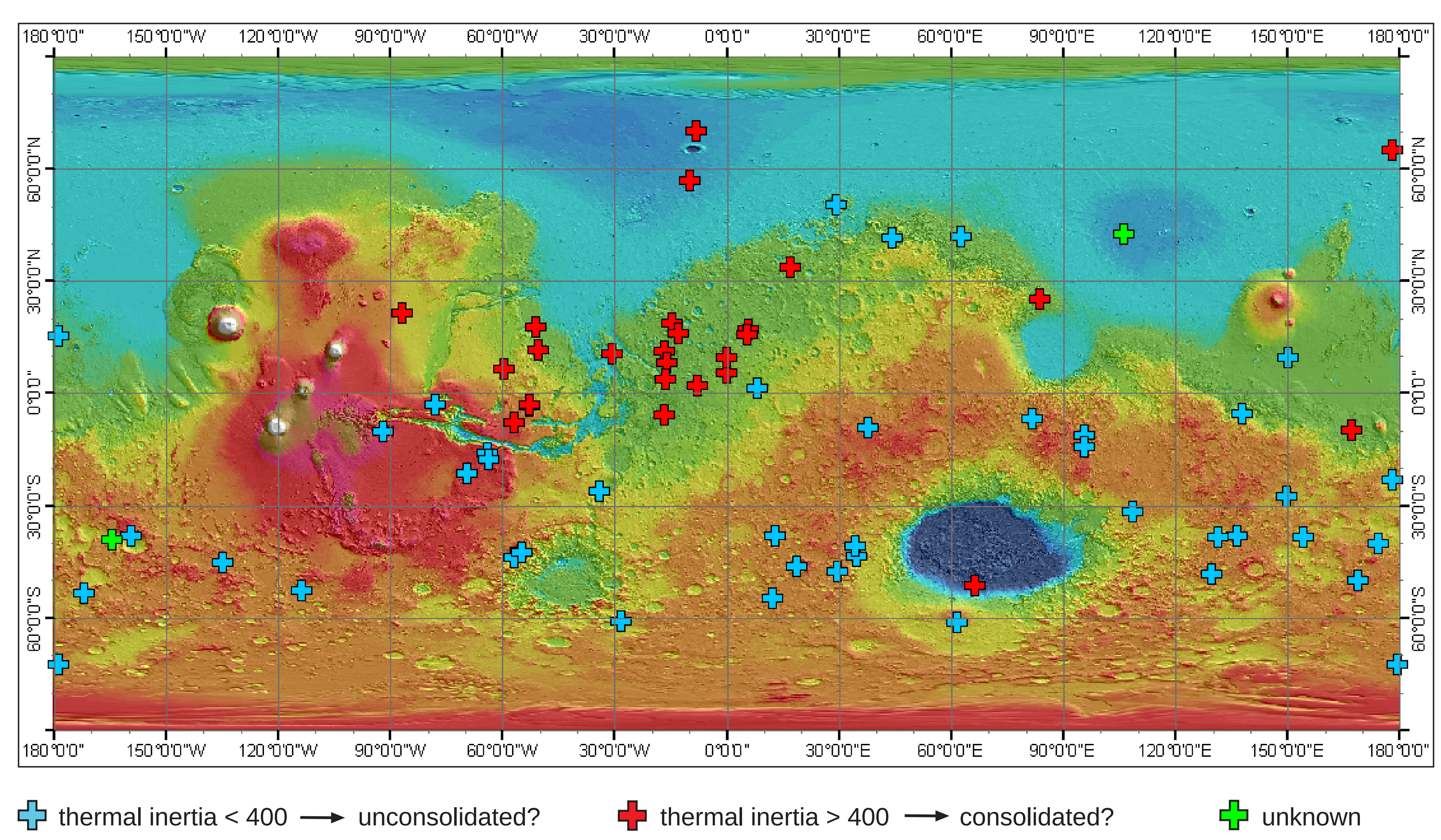

Fig. 7: Global distribution of probably consolidated and unconsolidated dark dunes in Martian craters

Discussion

The global consideration of unconsolidated and consolidated dunes still shows a slightly correlation between consolidated dunes and lower elevations (northern lowlands) and between unconsolidated dunes and higher elevations (southern highlands). The process of consolidation is unknown yet. Until this point, no mineralogical difference between unconsolidated and consolidated dunes could be identified. There is also no correlation between the mineralogical composition and the geographical location of the dunes recognisable, except of the hydrated mineral abundance at Meridiani Planum. We can confirm the report of [9] that a portion of the dark material shows absorption bands of hydrated minerals, indicating that the material has underlain a chemical alteration process. However, for the bulk of the material, the mafic composition suggests that it is the result of mechanical weathering only [10].

References:

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