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Fine-grained Antarctic micrometeorites and weathered carbonaceous chondrites as possible analogues of Ceres surface: implications on its evolution.

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Abstract

IR spectra of several micrometeorites (MMs) and Antarctic weathered carbonaceous chondrites (AWCCs) have been acquired and compared to Ceres spectra. We propose these samples as possible analogues of Ceres. This allowed us to define a more precise composition of Ceres and to suggest a possible evolution of this body.

1. Introduction

Ceres is an icy body with a surface composition close to the carbonaceous chondrites (CCs) [1] that suffered aqueous alteration [2] and geothermal activity [3]. It has been proposed a composition dominated by phyllosilicates, NH_4-phyllosilicates and carbonates plus organic material and opaque minerals [1]. Nevertheless no certain analogue has been found yet in the meteorite collections. For this reason we analysed CCs that suffered strong weathering in Antarctica, possibly the closest terrestrial environment to the surface of Ceres, and fine-grained MMs collected in the Transantarctic Mountains since [4] suggest that they represent C-type asteroid regolith.

2. Results

We selected 5 samples that have NIR spectra close to the average NIR spectra of an area in the Fejokoo quadrangle (Figure 1) labeled as: 5.29; 18c.11; 19b.7; 6.14 and 18c.13. All the MMs analyzed show the 3.3 µm band but only MMs 6.14 and 18c.13 have evident absorptions at 3.9 µm, related to carbonates, and MM 19b.7 has a weak absorption at around 4 µm. MMs 5.29 and 18c.11 show sharp absorption bands at 3.09-3.1 µm, which on Ceres have been attributed to the presence of NH_4-phyllosilicates [1]. Mineralogically MMs 5.29 and 18c.11 are dominated by Ca-Fe pyroxenes often associated with andradite, jarosite and minor olivine. MMs 19b.7, 6.14 and 18c.13 are more weathered and are mainly made of jarosite plus Fe-carbonates and Fe-K sulfides. All of these samples show the constant presence of carbon compound, which can be poorly graphitized C. Phyllosilicates are rare. For what concerns the AWCCs we found the CM2 sample GRA 98005 with weathering grade Ce that had one side exposed to the Antarctic environment, and is thus heavily altered, and one side that has been preserved with a pristine composition. Spectra on the pristine side are flat and almost featureless. On the contrary spectra of the weathered side tend to have a shape close to the average Ceres spectra. This meteorite, on the weathered side, is dominated by Fe-oxides, Ca-Fe carbonates, anidrite and gypsum plus enstatite and forsterite.

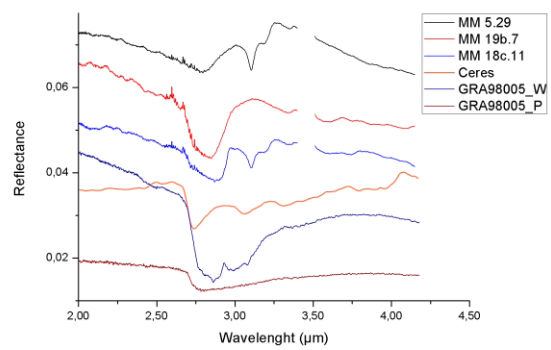

Figure 1: Spectra of MMs and AWCCs compared to Ceres. (GRA98008_W is the weathered side, GRA98005_P is the pristine side).

3. Summary and conclusion

MMs 5.29 and 18c.11 have a composition that is the result of relatively low temperature aqueous alteration <300°C [5], while the other MMs and GRA 98005 show a composition that is mainly the result of rock-ice interaction [6]. On our samples matching the spectra of Ceres, we didn't find any ammoniated phyllosilicates associated to the 3.1µm band so far. This might suggest that this band can be due to ion-irradiated organics mixed with ice as proposed by [7] or brucite [1]. Nonetheless we cannot rule out the presence of ammonia on Ceres. To better understand the nature of this absorption band further analysis are needed. In addition the analysed samples have low abundances of phyllosilicates compared to what expected on Ceres, probably due to a dehydration caused by heating during entry in atmosphere [4]. In this scenario we can assume that MMs 5.29 and 18c.11 represent products of Fe-alkali-halogen metasomatism that affected and started from the interior of Ceres and expanded very close to the surface as also proposed by [8]. MMs 19b.7, 6.14 and 18c.13 and GRA 98005 are instead representatives of the crust of Ceres that suffered minor hydrothermal activity and suggest that the crust underwent an alteration process similar to the Antarctic weathering. As also stated by [9], the interior of CCs parent bodies (and thus Ceres) were heated up to dehydration temperatures creating H_2 gas that migrated to the surface through cracks and fractures and created vents even with explosive processes [10]. The result is that part of the water sublimated into space and part froze within the crust of Ceres leaving the interior without hydrated minerals. This process may have also depleted the core of some of the main long-term radiogenic sources such as K and enriched the crust with these mobile elements [11]. This heat source on the crust in addition to minor impacts may have melted the water that altered the regolith of Ceres and partially rehydrated materials coming from the underlying layers.

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