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One Year of Observations of Dawn at Ceres: Composition as seen by VIR

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NASA's Dawn spacecraft [1] arrived at Ceres on March 5, 2015, and has been studying the dwarf planet. The Dawn mission is observing Ceres' surface with its suite of instruments [1] including a Visible and InfraRed Mapping Spectrometer (VIR-MS) [2]. VIR-MS is an imaging spectrometer coupling high spectral and spatial resolution in the VIS (0.25-1-micron) and IR (0.95-5-micron) spectral ranges. Ceres' surface is very dark, but small localized areas exhibit unexpectedly bright materials. Since the first approach data, near infrared spectra revealed a dark surface, with a strong and complex absorption band in the spectral region around 3 microns [3]. Near-infrared spectroscopic analyses confirmed previous observation of bands at 3.1, 3.3-3.5, 3.9 micron but have clearly identified a band at 2.72 micron. This characteristic narrow feature is distinctive for OH-bearing minerals, while H_2O-bearing phases, show a much broader absorption band that is a poor match for the Ceres spectrum. Water ice does not fit the observed spectrum. The 3.05–3.1 μm band is also visible in Ceres' ground-based spectra, and has been previously attributed to different phases including water ice, hydrated or NH4-bearing clays and brucite [4,5,6]. We find here that the best fit is obtained with ammoniated phyllosilicate added to a dark material (likely magnetite), antigorite and carbonate [7]. These different components, including ammoniated phases, occur everywhere across the surface although with different relative abundances [8]. Particularly interesting are the bright materials present in some craters like Occator, Haulani and Oxo that show different proportions of the components of the mixture [8]. However, the distribution of the band depths are not always linked to morphological structures. The retrieved mineralogy and composition indicates pervasive aqueous alteration of the surface, processes that are expected to be favored on large bodies like Ceres [9]. Furthermore, Ceres' low density and the presence of OH-bearing minerals, suggests a high content of water inside the body, consistent with extensive differentiation and hydrothermal activity, and possibly even a present-day liquid subsurface layer [10]. However, we note that large amounts of water ice are unlikely on the surface due to the instability of this phase at Ceres' surface temperatures [11]. On the other hand, the presence of ammoniated clays (ammonia ice is extremely volatile) together with the low density, may indicate that Ceres retained more volatiles than objects represented in the meteorite collection, or that it accreted from more volatile-rich material typical of the outer solar system [3].

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