RELATIONSHIP BETWEEN ASTEROID 1 CERES AND CHONDRITE METEORITES ON THE BASIS OF MINERALOGY AND UV-VISIBLE SPECTROSCOPY.

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Introduction: Asteroid 1 Ceres is the largest body of the main asteroid belt. As one of the oldest bodies in the Solar System, it represents information about processes taking place at the very early stages of planetary evolution. NASA's Dawn mission, launched in September 2007, has now arrived close to the vicinity of Ceres. Dawn carries a visible and infrared spectrometer (VIR) targeting the mineral composition of surface materials. Although infrared spectra of meteorites, some of which are likely to originate from Ceres, have been extensively studied, fewer studies have examined their UV-visible spectra. This study builds a systematic library of shallow UV-visible spectra of CI, CM, CR, and ungrouped carbonaceous chondrite meteorites in context of petrography and mineralogy.

Methods: An FEI Quanta 200 3D SEM characterized sample petrography using an accelerating voltage of 20.05 kV, beam current of 0.6 nA, spot size of 4-6 µm, working distance of 15 mm and magnifications up to 5,000×. A Cameca SX-100 EPMA with five wavelength-dispersive spectrometers performed chemical analyses on Fe,Ni-metal, sulphides, oxides, silicates, and phosphates using an accelerating voltage of 15 keV, beam current of 20 nA, and beam diameter of 1 to 5 µm. In Fe,Ni-metal, sulphides, and oxides, elements Mg, Al, Si, P, S, Cl, Ca, Ti, Cr, Mn, Fe, Co, Ni, Cu, and Zn; in silicates, elements Na, Mg, Al, Si, P, S, Cl, K, Ca, Ti, Cr, Mn, Fe, and Ni; and in phosphates elements F, Na, Mg, Si, P, S, Cl, Ca, Mn, Fe, Ce, and Yb were analysed. All measurements utilised standards from The Open University standard collection. Spectra of sample areas of 2 x 2 µm in the range of 200-800 nm were collected using a Craic Technologies optical microspectrophotometer system in reflectance mode. This is based on a Leica DMR microscope, with the regular objective lenses removed and fitted with Cassegrain reflecting mirrors. Samples were illuminated by a 75 W xenon light source. Measured reflectance spectra were corrected for dark current resulting from the production of thermal electrons and sensitivity variations at different wavelengths.

Results: *Petrography.* Modal mineral phases widely described in the literature were characterised spectroscopically and in petrographic context: phyllosilicates represent the main component of carbonaceous chondrite matrix; while calcium-aluminium-rich inclusions, including perovskite-dominated CAIs with interstitial spinel, as well as chondrules, Fe,Ni-metal, sulphide, and oxide grains of variable size and composition are embedded in the matrix. A unique 5×15 µm fluorine-rich phosphate grain directly surrounded by isopachous zones dominated by phyllosilicate, oxide-admixed Fe,Ni-sulphides, another phyllosilicate layer and Fe,Ni-sulphides was newly recognized in the Cold Bokkeveld CM2 carbonaceous chondrite.

Spectroscopy. 300 spectra of carbonaceous chondrite grains containing mineralogical information and 50 reflectance spectra of terrestrial mineral analogue grains were collected and will be presented.

Discussion and conclusions: The F:Cl ratio of ~15:1 of the unusual phosphate assemblage discovered is unprecedented among chondrite meteorites and is not simply consistent with conventional interpretations of the origin of apatite (volcanic vs hydrothermal) based on volatile content [1]. The assemblage either represents a refractory grain originating from a body with active igneous activity or documents fluorine-rich hydrothermal fluids on the CM parent body. Further investigation must address the paragenetic relationships within this grain in order to further unravel the complex geological evolution of the CM chondrite parent body.

Once Dawn spectral data become fully accessible, they can be compared to our spectral library using principal component analysis in order to find a meteorite group or groups originating from Asteroid 1 Ceres. Based on currently available spectral data of Ceres, none of the studied CI, CM, CR, and ungrouped carbonaceous chondrites are likely to be meteoritic analogues to Ceres. However, it is important to emphasise two points: (i) our sampling of the asteroid belt only represents a fraction of the asteroid population and may lack meteorites originating from certain bodies and (ii) the physical and chemical processes acting on the surface of Ceres could have changed its mineralogical make-up and, consequently, its spectral signature could have changed significantly over the last 4.6 billion years. The important implication of these points is that we might only have a very limited number of meteorites, if any, originating from asteroid 1 Ceres. Those separated from Ceres during early stages of Solar System evolution might not reflect its current mineralogical composition.

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References: [1] McCubbin F.M. and Jones R.H. 2015. *Elements*, 11:183–188.