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Spectral parameters to distinguish CC groups using Dawn FC Ceres data

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Abstract

We identified spectral parameters based on 118 laboratory spectra to distinguish carbonaceous chondrite (CC) groups by using seven color filters of the Dawn Framing Camera (FC), which we intend to apply on Ceres data after Dawn's arrival in 2015.

1. Introduction

The reflectance spectrum of Ceres in the VIS/NIR range has been linked to CCs by asteroid taxonomy in the past [1 and references therein]. Ceres spectra are best fitted in the 0.3-2.4 µm range by a mixture of two unusual carbonaceous chondrites Y-82162 and Y-86720 [2] and a CK4. The unusual ones are assigned to a special group of aqueous altered and thermal metamorphosed CCs (ATCC), spectrally described by [3]. On the other hand [4] show that the 3 µm region of Ceres does not match with a number of known CCs but with a mineralogy that can originate from aqueous alteration.

Evolution models of Ceres result in a range between an undifferentiated porous agglomeration of CC material [5] and a highly differentiated case with a silicate core and a hydrosphere [6, 7]. Considering incremental accretion of asteroids and magnetization in CCs, due to a core dynamo, [8, 9 and references herein] suggest a differentiated interior and a chondritic outer shell as a series of inward increasing thermal metamorphosed chondrites.

In March 2015 the Dawn spacecraft will reach Ceres. We intend to apply the FC seven filter color data in the 0.4-1.0 µm range to detect different chondritic material on the Ceres surface. This will gain information about the thermal metamorphism and aqueous alteration on Ceres. Furthermore we can get hints in which way in situ CC material on the Ceres surface could be different from the meteorite analogues. High spatial resolution of FC clear filter data of up to 35 m/pixel and color filter data of 130 m /pixel can reveal related surface processes.

2. Approach

The used data base contains 118 laboratory spectra of different CC groups from RELAB, including 2 CI, 49 CM, 8 CK, 13 CR, 11 CO, 10 CV, and 25 ATCC. These CCs are a selection from CCs that were spectrally investigated in detail in a series of publications starting with [10]. For our investigations we chose only powder spectra with grain sizes < 75 µm and < 125 µm, and equal viewing geometry (30º/0º).

We deconvolved the laboratory spectra to FC band passes and tried to find spectral parameters to distinguish between different CC groups. An investigation of the laboratory spectra led to an approach to distinguish CC groups by their differences in spectral slope in the 438 to 749 nm range, the shape in the 749 to 965 nm range and the band depth of the 749 nm filter (examples are shown in Figs. 1 and 2). The parameter band depth at 749 nm has also been applied by [11] for detecting serpentine in dark material sites on Vesta in FC data.

3. Discussion

We can show a coarse separation of CK, CR (excluding 3 outliers), CO and CM by plotting the spectral ratios 829/965 and 555/438 (Fig. 1). CM and ATCC are the most variable groups in our parameter space (and represent the largest population).

The band depth plotted versus ratio 749/965 shows a distinct separation of the CI and the CK group from the other groups (Fig. 2). The 749 nm absorption feature indicated by values > 2 is shown only in CM and ATCC (except of one CR).

Overlaps of CC groups in the parameter space can be explained by overlapping mineralogy. Furthermore classical CC grouping is predomenantly based on texture and matrix/chondrule abundance. Apart from that we have to consider that our investigations do not base upon an equal basic population for every CC group and therefore the full range of spectral characteristics is not equally covered for every group.

4. Outlook

In our recent plots the CCs are arranged only by their groups. For future investigations we will refine the arrangement by petrologic subtypes and will also consider more detailed classification schemes [12, 13] for aqueous alteration types in the CM group.

Individual CC groups do not reveal specific absorption features. Therefore it is challenging to separate these groups by spectral parameters. We will develop a decision tree approach combining spectral parameters to reduce overlaps between the groups. We intend to expand our data basis spectra of minerals produced by a serpentinization process and CC constituent minerals, and apply future investigations on aqueously altered CC material.

Regarding the abundance of water ice as volatile phase indicated by the low density of Ceres and the concept of the buried snowline suggested by [14], as well as implications for primordial ice abundance in CV chondrites [15], we plan to consider chondritic material or alteration products mixed with water ice for further spectral investigations.

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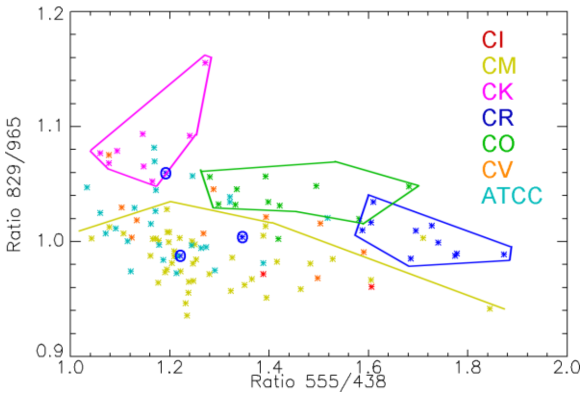

Figure 1: Scatterplot of spectral ratio 829/965 versus spectral ratio 555/438 nm.

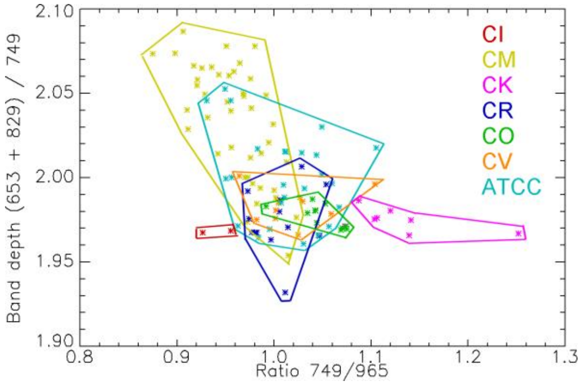

Figure 2: Scatterplot of band depth at 749 nm versus spectral ratio 749/965 nm.