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The Composition Of The Dwarf Planet Ceres

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Abstract

While Ceres has been observed for centuries, and we have been obtaining reflectance spectra for decades, we have only recently gotten a sense of the ways in which its composition is like and unlike carbonaceous chondrites. Spectral features from brucite and carbonates suggest pervasive aqueous alteration but critical pieces of the puzzle are still mysterious, awaiting further data from Dawn and future telescopic observations.

1. Introduction

Ceres, the largest object between Mars and Jupiter, is not easily classified. Its low density suggests a significant ice fraction, like the Galilean and other satellites. It is too warm for ice to remain stable over much of its surface, but may maintain ice at a depth of a few meters [1,2]. It is large enough to be in hydrostatic equilibrium, but is probably differentiated rock from ice rather than the metal-rock separation seen in the planets [3,4]. It is also too small to have had a large disruptive effect on the orbits of its neighbors, disqualifying it from planethood in the current IAU scheme.

2. What we know

What we know about Ceres has to this point been determined via remote sensing. The first observations of Ceres were made in the visible-near IR (0.4-2.5 µm) spectral region, and established an overall similarity to carbonaceous chondrites based on a low albedo and relatively flat spectrum. Its visible spectum places it within the C class, which dominates the middle of the asteroid belt [5,6].

Positive identifications of absorptions have been rare in this spectral region, beyond a decrease in reflectance shortward of 0.4 µm due to oxidized iron. A broad band centered near 1.1 µm is consistent with magnetite, which is also found in some carbonaceous chondrites [7]. Longer wavelengths have provided more quantitative identifications. A series of absorptions in the 3-4 µm region have been interpreted most recently as due to brucite and carbonates [8-11]. Mid-IR (8-13 µm) observations have inconsistently found evidence for carbonates, but on the whole are consistent with the 3-4 µm observations [12,13]. A list of identified and yet-unidentified [14,15] absorptions in Ceres' spectrum

Mineral	Wavelengths	Reference
Carbonates	~3.3-3.4, ~3.9, ~11.3? µm	10,11
Brucite	3.06 µm	11
Magnetite?	~1.1 µm	7
??	~0.25 µm	14,15
Silicates	~10 µm	12,13

is presented in Table 1.

Table 1: Identified spectral features on Ceres, current interpretations, and their first references.

In addition to these identified species, the possibility of near-surface ice on Ceres combined with a low obliquity and resultant low temperatures at high latitudes leads to the prospect of polar caps, undetected in our low spatial resolution data but observable from orbit. The possibility of solar wind-created OH and impactor contamination on Ceres' surface, as has been suggested for the Moon and Vesta [16,17], also needs to be considered when considering in detail what Dawn may find.

Over the last 35 years, astronomers and geologists have pieced together our ideas of Ceres' surface composition, which along with modeling and laboratory efforts leads to our overall interpretation of this body. We will present our current synthesis of Ceres research as it stands in the pre-Dawn era.

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