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Geomorphology of Ceres: first observations by Dawn

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Abstract

First observations from the Dawn mission [1] enable the derivation of Ceres' shape, facilitate investigations of the surface geology and provide the first evidence from Dawn for Ceres' geological evolution. At the time of abstract submission data had been acquired during approach to Ceres providing a set of images obtained for optical navigation and rotation characterization with resolutions of up to 3.6 km/pixel (8 times better than Hubble observations), good enough to identify large scale geological features resembling impact, tectonics and probably cryo-processes.

Introduction

Ceres is an oblate spheroidal body with a mean diameter of 950 km, a mass of $(9.43\pm0.05)\cdot10^{20}$kg, a density of about 2077kg/m^3, a rotation period of ~9 hours and an orbital period of 4.6 years [2,3]. The physical properties of Ceres are consistent with a rocky core and a thick outer mantle of water ice and possibly even an ocean of water beneath [3]. Its surface temperatures vary with latitude from 130K at the poles to 180K at the equator, reaching a maximum of 235K [4,5]. This is greater than any creep temperature for known icy compositions, implying Ceres' icy shell to be in hydrostatic equilibrium. Surface albedo determined by HST varies from ~0.07 to ~0.09 [5]. Ceres is classified according to spectral observations as a C- or G- type asteroid, sharing similarities with carbonaceous chondrites. Models constrained by the thermal and compositional conditions demonstrate that Ceres almost certainly differentiated, involving processes such as the formation of a silicate core, a liquid water mantle and a solid ice crust and crustal evolution by tectonics and probable cryovolcanism [3,4]. The Dawn spacecraft [6] reached Ceres March 6th 2015.

Major Geologic Features

Ceres exhibits smooth and rugged topography ranging from about -9 km to 8 km relative to a best-fit ellipsoidal shape with 481x481x447 km (Fig. 1). Ceres' topography has a much greater range in elevation relative to its ellipsoidal dimensions (3.2%) than the Moon and Mars (1% and 0.9%) or Earth (0.3%) but is lower compared to Vesta (15%) [7]. It is comparable to the icy satellite Iapetus (3.6%) but significantly higher than the other icy satellites of Jupiter and Saturn (< 1.8%). The topography of Ceres indicates a rigid crust manifesting a range of processes at large and small scales in the course of its geological evolution

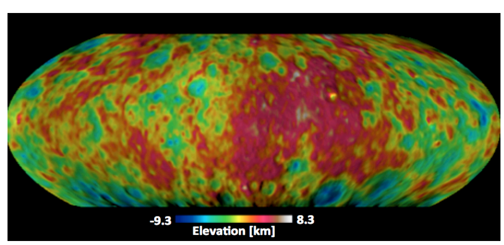

Fig 1: Large-scale topography of Ceres

Ceres's surface is characterized by impact craters, basins of > 250 km in diameter, central peaks and rings and a variety of ejecta blankets (Fig. 2 and 3), as well as lineaments, apparent infills and distinctive bright spots.

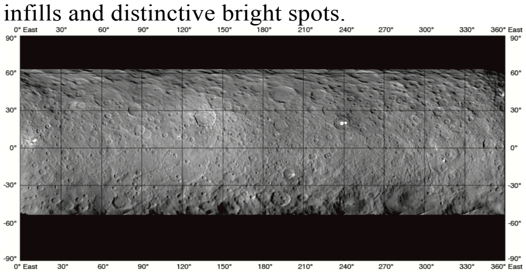

Fig 2: Mosaic of the surface of Ceres (resolution 4 km/pixel)

Impact craters range from fresh to highly degraded, comparable to that of various icy satellites, the Moon and Vesta, indicating an intensive cratering history over the age of the solar system (Fig. 3) as indicated by surface units of different ages. Some craters show upwelling dome-like structures on the crater floor.

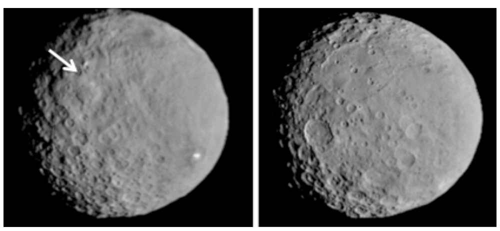

Fig 3: Impact structures and dom-like features

Bright spots occur at different locations correlated with impact structures and significantly higher albedo than the surrounding terrain. These spots seem to be independent of topography (Fig. 4) and indicate material differences and possible time variable effects related to cryo-processes either volcanic or glacial.

Trough-like features and polygonal impact crater rims indicate crustal stress that compensates by tectonic processes (Fig. 5)

According to the relatively high topography to radius ratio steep slopes and possible mass wasting is expected and observed (Fig. 6)

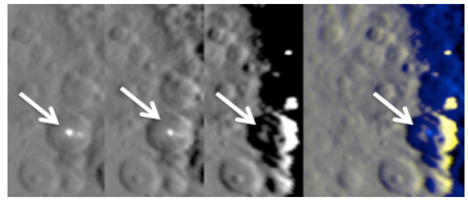

Fig 4: Sequence of rotational observations shows the bright spot at the terminator (right) to be offset of the craters' central peak.

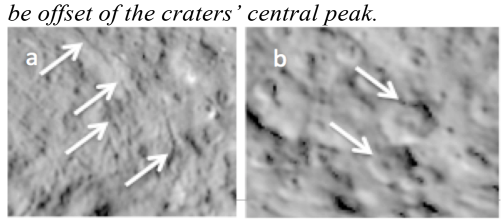

Fig 5 Crustal stress: a) trough-like lineaments, b) polygonal crater rims.

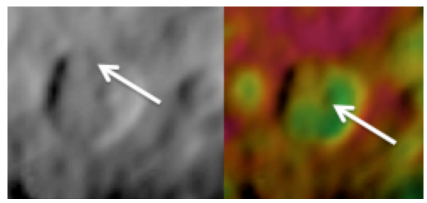

Fig 6 Possible mass wasting on Ceres.

In general, Ceres exhibits various surface features and units that indicate geological activity over time due to impact cratering, tectonics, relaxation, mass displacement and possible cryo-volcanic and/or cryo-glacial processes.

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References: [1] Russell, C.T., Raymond, C., 2011, Space Sci. Rev., 163, p3-23, DOI 10.1007/s11214-011-9836-2; [2] Thomas, P.C. et al., 2005, Nature 437:224-226; [3] McCord, T.B., Sotin, C., 2005, J Geophys Res 110:CiteID05009; [4] Castillo-Rogez, J.C., McCord, T.B., 2009, Icarus: doi:10.1016/j.icarus.2009.04.008. [5] Li, J.-Y., et al., 2006, Icarus 182,143-160; [6] Russell, C.T., et al., 2007, Earth, Moon, and Planets 101,65-91; [7] Jaumann R. et al. (2012) *Science, 336*, 687.