TECTONIC ANALYSIS OF FRACTURING ASSOCIATED WITH OCCATOR CRATER. D.L. Buczkowski[1], J.E.C. Scully[2], P.M. Schenk[3], O. Ruesch[4], I. von der Gathen[5], R. Park[2], F. Preusker[5], R. Jaumann[5], C.A. Raymond[2], C.T. Russell[6]. [1]JHU-APL, Laurel, Maryland, USA; [2]NASA JPL, California Institute of Technology, Pasadena, California, USA; [3]LPI, Houston, Texas, USA; [4]GSFC, Greenbelt, Maryland, USA;, [5]DLR, Berlin, Germany; [6]UCLA, Los Angeles, California, USA.

Introduction: On board NASA's Dawn spacecraft [1], captured into Ceres orbit on March 6, 2015, was the Framing Camera (FC) [2], which provided the first images of Ceres' surface. Observation of these FC data discovered that "Bright Spot 5", originally identified in Hubble Space Telescope data [3], is actually comprised of multiple bright spots on the floor of Occator crater.

A 92 km diameter crater located at 19.8°N, 239.3ºE, Occator is one of several floor-fractured craters (FFCs) observed on Ceres [4]. The floor of Occator is cut by multiple sets of linear fractures, while concentric fractures are found on both the crater floor, the crater walls, and in the ejecta [4]. The bright spots now named the Vinalia Faculae are noticably associated with floor fractures [4], although the brightest spot, Cerealia Facula, is associated with a central pit [5].

Data: Geologic analysis was performed using Framing Camera (FC) mosaics from late Approach (1.3 km/px), Survey (415 m/px), the High Altitude Mapping Orbit (HAMO - 140 m/px) and the Low Altitude Mapping Orbit (LAMO – 35 m/px) orbits, including clear filter and color images and digital terrain models derived from stereo images.

Fracture Sets: Occator crater has several sets of fractures associated with it, including: 1) Concentric floor fractures at the base of the crater wall; 2) Cross-cutting fractures in the lower part of the southwestern wall; 3) Linear fractures associated with the Vinalia Faculae; 4) Concentric and radial fractures around the central pit; 5) Linear fractures extending from the cross-cutting set, toward the central pit; 6) Concentric fractures high on the crater wall, near the crater rim; and 7) Circumferential fractures in the ejecta blanket. We have performed a tectonic analysis of each of these sets of fractures, and have determined that they each almost certainly have a different formation mechanism.

Concentric floor fractures at the base of the crater wall: Models for fracture formation in lunar FFCs invoke a piston-like uplift of the entire crater floor as the last stage of magmatic intrusion beneath the crater [6]. This localizes bending stresses at the periphery of the intrusion, which results in concentric fracturing and faulting adjacent to the crater wall [6]. This orientation is similar to what is observed in the Occator fractures.

Cross-cutting fractures in the SW wall: A pattern of fractures found at the base of the SW Occator wall are located in the region of concentric floor fractures, but are more consistent with formation due to asymmetrical domal uplift [e.g. 7]. These fractures show apparent broad outer arc extension, with at least two central peaks. Topographic profiles across these fractures show local highs associated with these loci of fracturing. A transition to radial faulting with distance from the center is consistent with the change in stress orientation that occurs at the edge of a dome.

In lunar FFCs, magma can take advantage of the concentric fractures at the base of the crater wall to travel to the surface [6]. It is possible that something similar is happening on Ceres, although more likely involving cryomagma or salt, resulting in this localized doming event.

Linear fractures associated with Vinalia Faculae: While much of the southern floor of Occator is covered by relatively flat, knobby to smooth material that could very well be impact melt [5], in NE Occator is a morphologically distinct floor material. This material has distinct lobate margins extending away from the center of the crater [4], and has been interpreted to be a cryovolcanic flow [8]. The surface of the flow has a ropy, hummocky texture somewhat similar to what is observed on the floor of Class 4 Ceres FFCs [4, 9, 10], and is highstanding compared to the immediately surrounding floor. Linear fractures cross the lobate material at its highest points, suggesting that they formed due to bending stresses as the floor was uplifted.

These fractures are associated with the Vinalia Faculae, high-albedo deposits with wispy margins that are composed of sodium carbonate [11]. Pyroclastic deposits can be associated with fractures in lunar FFCs [6]. If cryomagmatic fluids utilized the fractures to reach the surface, the fluids would have evaporated [12], leaving behind the carbonate salts.

Fractures around the central pit: Lunar FFCs frequently have both radial and concentric fractrures around their central peaks, thought to form due to doming of the crater center due to laccolith formation beneath the crater [6]. Occator crater does not have a central peak, but rather has a 9 km diameter, 1 km deep central pit with an uplifted dome on its floor [5]. There is an extensive set of concentric fractures around this central pit, as well as a smaller number of radial fractures. While these could be a result of increased bending stresses due to floor uplift [6], it is also possible that they formed due to the formation of the pit itself.

Many of the large (>60 km) craters on the icy moons Ganymede and Callisto have central pits instead of central peaks. It is thought that their icy composition is a factor in pit formation [13], which is consistent with the observation of similar pit craters on icy Ceres [5]. Proposed formation mechanisms for these pits include surface collapse into a void left by the release of volatiles due to impact into an ice-rich target or the drainage of impact melt into sub-crater fractures [14]. Either method of pit collapse would result in radial extensional stresses which could trigger the concentric fracturing we see around Occator's central pit.

Other linear fractures on the crater floor: A set of linear fractures on the Occator floor occur between the SW wall fracture set and the central pit. It is possible that these linear fractures are simply linkages of those fractures radial to the SW dome and those fractures radial to the central pit.

Concentric fractures high on the crater wall, near the crater rim: The wall of Occator is heavily terraced [4], features that are interpreted to form due to downward movement along a series of concentric faults that formed during impact crater formation during the collapse of the the transient crater [15]. The concentric fractures high on the Occator wall are all above the wall terraces. We suggest that these fractures also formed during transient crater collapse, but without downward motion along their faces to form terraces.

Circumferential fractures in the ejecta blanket: Fractures in the Occator ejecta are circumferential to the crater rim. However, in a region where the topographic data suggests that there is a completely buried crater, the ejecta fractures instead follow this smaller crater rim. This is consistent with ring graben formation on Mars, which occurs due to the differential compaction of a volatile-rich overburden [16].

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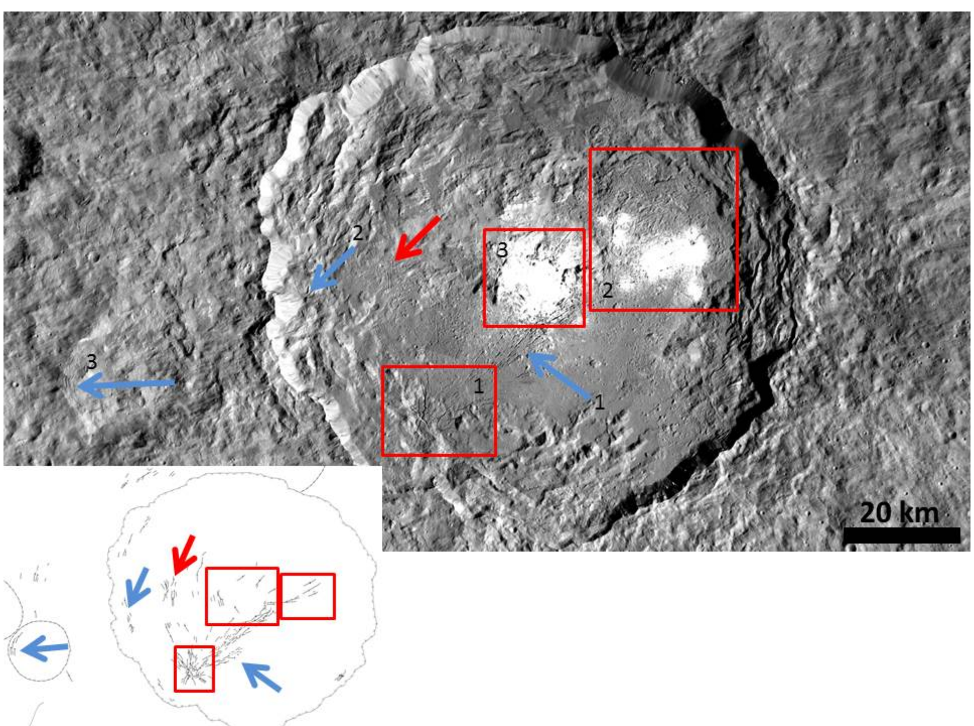

Figure 1. LAMO mosaic of Occator crater, and associated fracture map. Red arrow points to concentric fractures at the base of the crater wall. Red box 1 shows location of crosscutting fractures in SW wall, red box 2 shows location of fractures associated with the Vinalia Faculae, and red box 3 shows location of fractures associated with the central pit. Blue arrow 1 shows location of other linear fractures on the crater floor, blue arrow 2 shows location of high wall fractures, and blue arrow 3 shows location of ejecta fractures.