A FIRST-ORDER MODEL FOR IMPACT CRATER DEGRADATION ON VENUS; Noam R. Izenberg, Raymond E. Arvidson, and Roger J. Phillips, McDonnell Center for the Space Sciences, Department of Earth and Planetary Sciences, Washington University, St. Louis, MO 63130
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A first-order impact crater aging model is presented based on observations of the global crater population of Venus. The total population consists of 879 craters found over the ~98% of the planet that has been mapped by the Magellan spacecraft during the first three cycles of its mission. The model is based upon three primary aspects of venusian impact craters: 1) extended ejecta deposits (EEDs); 2) crater rims and continuous ejecta deposits; and 3) crater interiors and floors.

Assumptions

The primary assumptions of the model are: 1) all or most impact crater events on Venus generate EEDs during their formation. 2) parabolic EEDs are thin deposits (several cm thick) of fine-grained particles [1,2]; 3) halo-like components of EEDs are composed of larger ejecta particles and/or ground blasted or otherwise affected by the shock of impact [3,4,5]; and 4) Craters form with continuous ejecta and crater floors with a high radar backscatter cross section due to the large size (meter scale and larger) and blocky character of their materials [3,5]. Crater floors may start out with low emissivities relative to the surrounding terrains perhaps due to excavated materials not being at chemical equilibrium with the atmosphere. Figure 1a is a sketch of a typical impact crater at time = 0, defined as the initial time where modification of the crater occurs primarily at the geologic timescale.

Observations

A global survey of the total crater population was conducted to identify craters with EEDs and the superpositional relationships of EEDs with respect to surrounding materials. Craters were also examined for tectonism, exterior modification (embayment by external volcanic sources), and interior modification of crater floors (e.g., dark floors of indeterminate origin). Results are as follows:

EEDs: 1) Between 61% and 73% of all craters have EEDs. The spread is due to craters for which SAR data are not clear enough to confirm the presence of an EED.

2) The occurrence of EEDs decreases to 40% for craters above the 6053km planetary radius (1.2 km above the mean planetary radius), to 34% for tectonized craters, and to 23% for volcanically embayed craters. Simple binomial distribution tests indicate a low probability (<.01) that these lower percentages are random.

3) The occurrence of EEDs also decreases for the population of craters with dark floors (i.e., floors with low radar backscatter relative to the rim and continuous ejecta). This part of the survey is still incomplete and reliable statistics are not yet available.

4) Parabolic EEDs are found around less than 10% of the crater population.

5) Partial parabolic and halo-like EEDs have been observed. About 17% of EEDs have been modified by tectonic activity, embayed by lavas from sources outside the crater, or by subsequent nearby impacts. Mottled EEDs, and EEDs modified by wind and possibly affected by high altitude atmosphere surface chemistry have been observed, but not yet quantified.

Rims and Continuous Ejecta: Backscatter properties of crater rims and continuous ejecta do not appear to vary as a function of preservation state, except for severely tectonized craters or craters that have been embayed by external volcanic sources. That is, extraction of backscatter cross sections of continuous ejecta materials for a number of craters of different sizes and characteristics reveal no significant or systematic variations.

Crater Interiors and Floors: 1) About 54% of all impact craters have floors with lower backscatter cross sections than their continuous ejecta. Differences of 5-10 dB are common.

2) Only 36% of craters with parabolic EEDs have at least some dark material on their floors.

3) Of the 95 craters with modified EEDs (i.e., craters whose EEDs have been clearly modified by tectonism, volcanism, or subsequent impact events) as many as 70 have dark floors. This occurrence is 10% to 20% above the planetary average.

Implications

The observations imply that impact craters and associated ejecta deposits degrade in a characteristic way. Figure 1b-e shows sketches of the hypothesized process. Parabolic EEDs are interpreted to be easily removable by surface winds over a geologic timescale (figure 1b), so the 8-10% of craters with parabolas are likely to be the youngest 8-10% of the crater population [1,2]. This possibility is supported by association of wind streaks with many parabolas, the relative paucity of dark floors in craters with parabolic EEDs, and examples of partial parabolic EEDs, which may show parabolas in the process of disappearing. The halo-like components of EEDs are interpreted to be harder to remove by wind. As halos age, they may become mottled, degraded in appearance (losing backscatter contrast with surroundings), or become tectonized or embayed by lavas. Heavily modified impact craters may have their EEDs totally obliterated, but some will remain observable even at this stage (figure 1c - 1e).

Crater rims and continuous ejecta remain pristine in SAR appearance until heavy modification by tectonism and/or embayment by lava flows (figure 1e). While a crater may be tectonized or embayed early in its lifetime, the likelihood and degree of the modification increase with time.

Crater interiors may be darkened by several processes, which are not necessarily mutually exclusive. Impact melt ponding and cooling may darken some craters' floors at the outset. Infilling of the crater floor by volcanic material originating beneath the crater may occur over the crater's lifetime. As the crater ages, the likelihood of lava infilling may increase (figure 1d). It is unlikely that dark interiors are the result of a surface/atmosphere chemical reaction, since rims and continuous ejecta are not likewise darkened over time. Low emissivity signatures of craters may be removed by infilling and/or possibly by equllibration of excavated materials with the atmosphere.

References

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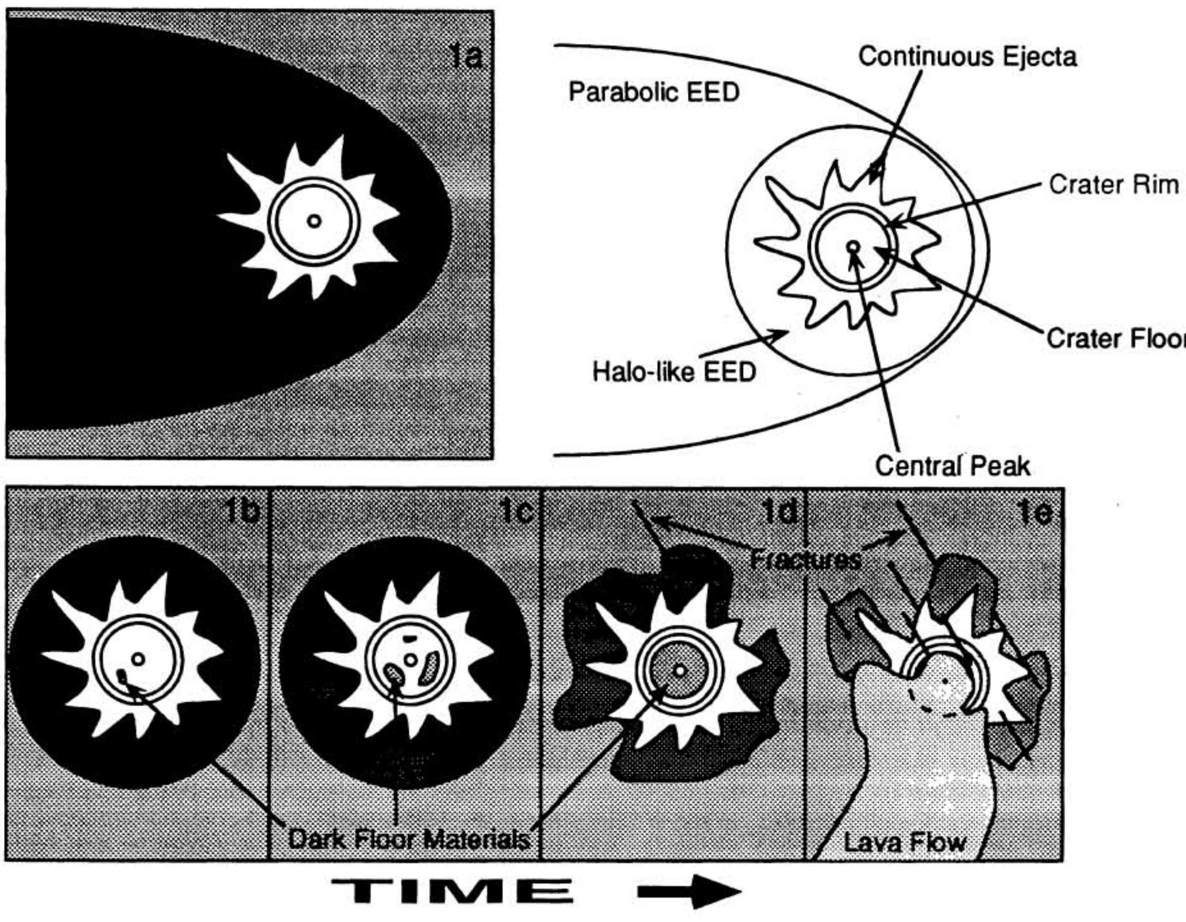

Figure 1. A simplified schematic of crater degradation on Venus. A central peak crater (20-40 km diameter on average) is used. Letters **a** to **e** denote increasing time.