CHARACTERISTICS OF CALDERAS ON IO: SURFACE MORPHOLOGY, SIZES, AND DISTRIBUTION.

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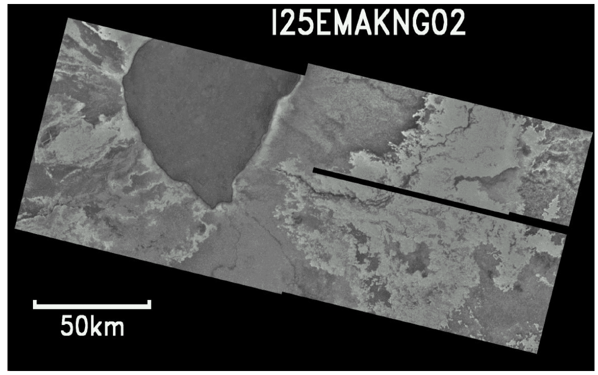
Calderas are roughly circular volcanic depressions created by collapse associated with subsurface magma movement, and have been identified on Earth, Venus, Mars, and Io (and possibly Triton). Calderas are defined to be larger than 1 km and range to greater than 200 km in diameter. There are close to 300 known calderas on Io, and some of the largest calderas in the solar system are found on this body. About half of these features have dark floors; thermal observations indicate that most or all dark areas on Io are currently or were very recently active.

Calderas probably mark the main silicate volcanoes on Io, and are critical to how Io removes her prodigious tidal energy.

Calderas on Io are intriguing because they bear some similarities to calderas known and studied on Earth; yet calderas on Io have unique aspects which do not appear to have terrestrial comparisons. Most calderas on Io have a steep, gently curved morphology to their walls, similar to terrestrial basalt shield calderas [1]. Many of this type of caldera on Earth appear to have undergone multiple stages of collapse, while this is slightly more rare in Io calderas. For example, Prometheus caldera has gently curving, steep walls with evidence of only one collapse event; however this could also be the result of previous calderas being filled up with lava . In the region of Tvashtar Catena in the high latitudes, two small, steep-walled depressions reside within an elongate, larger depression, which may be evidence of multiple episodes of collapse. Many Io caldera walls have one side which is completely straight, while the rest of the caldera is gently curved, a characteristic present in Prometheus, Loki, and Tupan calderas, and unique to Io calderas. Thus, the locations and shapes of the calderas are largely controlled by tectonic faults and fractures [2]. The volume of lava erupted from the Moon-sized Io is so great that it is possible that at times lava fills up a caldera, overtops the walls, and flows out over the surface, such as at Prometheus and Emakong calderas. In addition, there may be evidence of large lava lakes at Pele and Loki calderas, lakes which are an order of magnitude larger than any similar feature seen on Earth. Figure 1, a Galileo mosaic by David Williams of Emakong Caldera, shows lava flows emerging from the caldera walls. Also evident is the relatively straight southeastern wall.

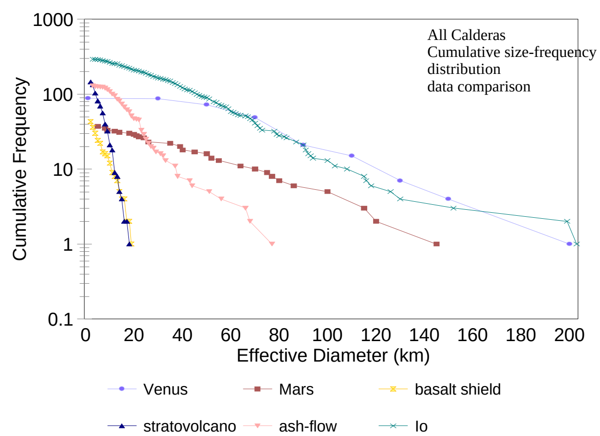
Because of their great sizes, Io calderas are often compared with the largest type of terrestrial caldera, the ash-flow caldera, which forms as a result of the eruption of copious amounts of silicic magma from a long-lived near-surface magma chamber. On Io, evidence for high-T, Mg-rich lavas from the mantle suggests little differentiation (although the presence of OPX indicates some differentiation or crustal contamination), as must occur in a long-lived magma chamber, so it may be that caldera formation on Io occurs by a fundamentally different process than this. In fact, if these are collapse features, their great sizes present a problem in missing magma and crust volume. The question must be addressed of whether the missing magma drained back into the mantle or was erupted, either near the caldera or in a remote vent region. It could also be that the missing volume is created by extensional tectonics, as caldera morphologies indicate tectonic influence.



An analysis of 292 calderas measured on Io yields the following information about their sizes: the calderas range from 2.5 km to 203 km in diameter and the mean diameter is 40 km. The mean for identified calderas of both Mars and Venus is also close to 40 km, but the mean for terrestrial ash-flow calderas is a much smaller 18 km diameter. Despite several large calderas, such as the 200 km diameter Loki, the mode is still a fairly low 5.7 km. Thus the calderas on Io show their peak in number at the smallest diameters, then drop off exponentially in number toward the highest diameters. This is true for both basalt shield and stratovolcano calderas on Earth, while there is a lack of small diameter terrestrial ash-flow calderas, a peak at close to 10 km diameter, and then an exponential drop in number toward higher diameters [3]. A comparison of the cumulative size-frequency distributions for calderas of Mars, Venus, and the three separate terrestrial caldera types is shown with Io calderas (Figure 2). The gentle slopes of the distributions for calderas of Io, Mars, and Venus indicate greater numbers of large calderas in comparison to terrestrial calderas.

Calderas on Io may also vary in size with latitude and longitude. Voyager data [4] found fewer but larger calderas in the south polar region, and Galileo has also seen some large calderas in the north polar region, such as Tvashtar Catena. The size distribution is uniform with longitude to first order [5], but there may be very subtle variations in this pattern [6].

Consideration of all of these characteristics of Io calderas, their surface morophologies, sizes and distributions, will provide background for study of how these unique calderas form.



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