HALDANE -- A MULTI-RINGED LUNAR CALDERA IN MARE SMYTHII.

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Mare Smythii, on the eastern limb of the Moon, is one of the oldest circular mare basins. Terra material which has been interpreted as mostly Crisium basin ejecta (1), occupies most of the basin and mare basalts continuously fill only the northeastern quadrant of the basin. Within the intrabasin terra unit, basalts occur as isolated patches which are intimately related to several unusual multi-ringed craters. These craters are in a belt oriented N-S and have been described as volcanic collapse calderas (2) and as endogenically modified impact craters (1,3). The most prominent of these multi-ringed craters, Haldane, was selected for detailed study because it is structurally the best developed and it alone contains examples of all material units associated with these craters. Haldane was mapped geologically at the scale of 1:250,000 (Figure 1, reproduced approximately to 1:500,000) using Apollo 15-17 metric and panoramic photographs, and a base of LTO's 81B1 and 81B2.

The topography of Haldane is not that of a typical impact crater; most notably, the innermost rim at places is higher than the main rim and the elevation of the central massifs exceeds that of the surrounding terrain. The crater has sharp rim crests and steep inner walls, but there is no evidence of hummocky rim deposits. The northwest rim of Haldane is breached and much of the floor is flooded by basalt. The elevation of these flows, however, is 200-400 meters higher than that of the adjoining depression which is also flooded by basalt.

In addition to crater materials of Imbrian through Copernican age, the Haldane area contains, from oldest to youngest, the following material units. Mantled terra (mt), which surrounds most of Haldane, is heavily cratered and nearly as high in albedo as the highlands adjacent to the Smythii basin. On a fine scale the mantled terra has a smoothly rolling surface. The crater wall (cw) unit of Haldane forms the high albedo, mostly smooth, steep walls of the crater. The outer ring of Haldane exhibits these characteristics only inward from the rim crest; the inner ring is entirely composed of wall materials. The central massif (cm) material, characterized by its very high albedo, forms a cluster of steep, rounded hills in the center of Haldane. The crater floor (cf) unit here undivided, consists of the relatively flat, moderate to high albedo material inside the crater walls. Parts of this unit resemble the mantled terra. The mare materials, mare basalt (m) and dark mantle (dm) are distinguished from the other units by their smoothness and relatively lower albedo, and from each other by the very low albedo of the dark mantle material. Where these two units are in contact, no clear stratigraphic relationship is discernable as in the Taurus-Littrow region.

In addition to the regional pattern of N-S trending fractures in western Mare Smythii there are two systems of faults associated with Haldane, one arcuate and one radial-tangential. Faults of the arcuate system bound

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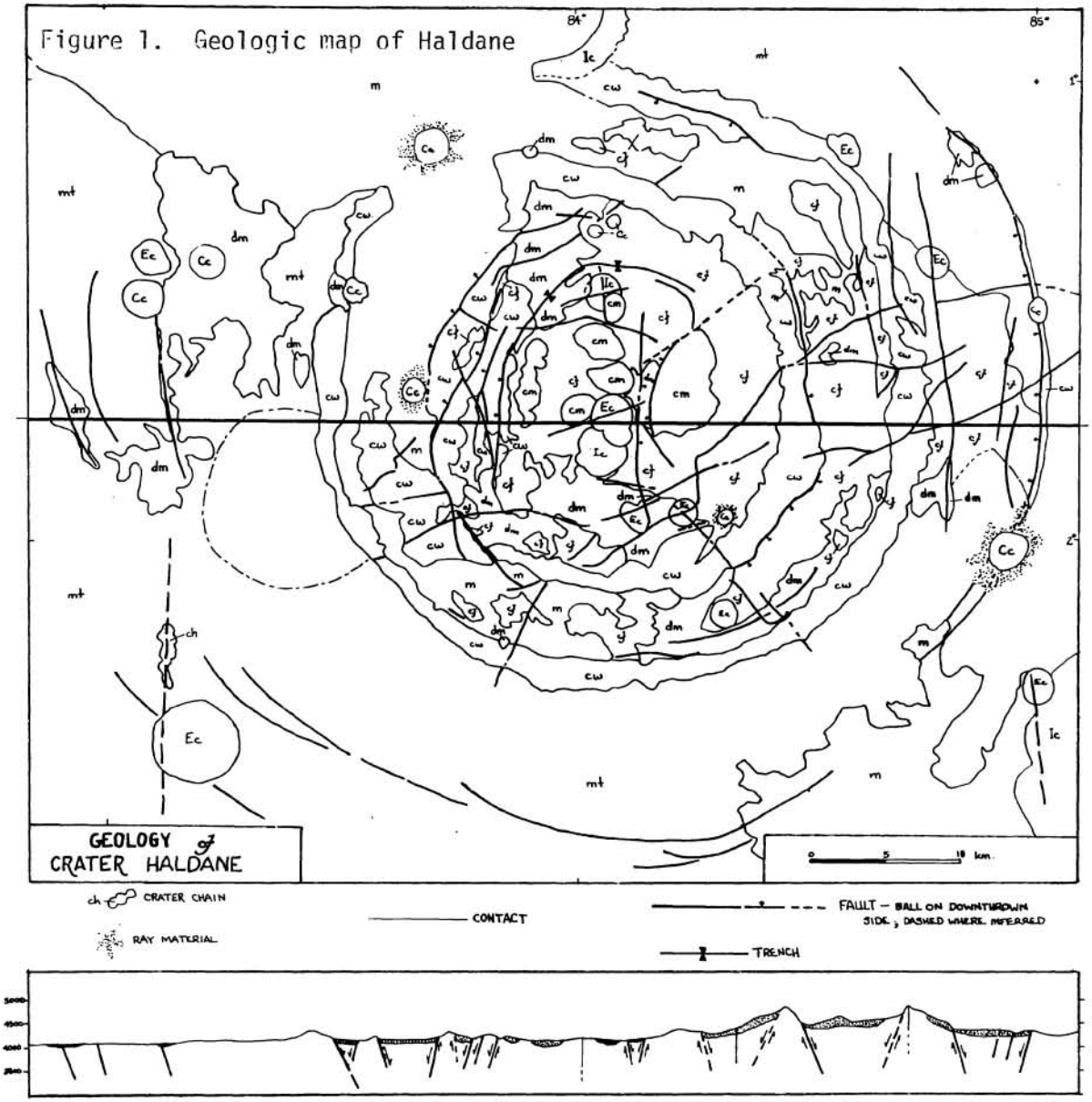
Figure 1. Geologic map of Haldane



	MARE UNITS	HIGHLAND UNITS	CRATER UNITS
COPERNICAN			Cc MATERIALS of BRIGHT RAYED CRATERS
ERATOSTHENIAN			Ec MATERIALS of RELATIVELY OLDER CRATERS
IMBRIAN	m MARE BASALT; dm DARK MANTLE MATERIALS	cm MATERIAL of CENTRAL MASSIF; mt MANTLED TERRA OUTSIDE MAIN WALL (RING)	cf FLOOR MATERIALS, MOSTLY WITHIN MAIN RING; cw WALL MATERIAL THAT FORMS THE RINGS (MOSTLY INWARD FROM RIM CREST); Ic MATERIAL of OLD CRATERS

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the two major rings of the crater and nearly encircle the crater at a radius of 1.5 times that of the outer ring. A 45° arc of the outermost fracture has been down-faulted to produce a portion of a third crater ring. The center of Haldane is uplifted along arcuate faults to form the central massifs. As in Alphonsus (4), the distribution of dark mantle material is structurally controlled with nearly all of the mantle associated with the arcuate faults. No motion is evident on the radial-tangential system of fractures.

There is no definitive evidence that Haldane was originally an impact crater; therefore an alternative, endogenic model for the origin and development of Haldane is presented here. The arcuate system of fractures formed in response to regional tumescence associated with magma intrusion (Fig. 2-a). With subsequent ring-fracture volcanism (Fig. 2-b) (perhaps related to the mantling of the terra) and depletion of the magma chamber, collapse occurred along the arcuate faults to form the two major rings of Haldane (Fig. 2-c). A renewed build-up of magma pressure (Fig. 2-d,e) caused the center of the crater to be uplifted along arcuate faults in the manner of resurgent calderas (5) and produced the radial-tangential system of fractures. Eruption of mare materials (Fig. 2-d,e), which began with and continued beyond resurgence, partially flooded Haldane and adjacent depressions. After the cessation of volcanism, minor movements on the system of arcuate faults occurred (Fig. 2-f).

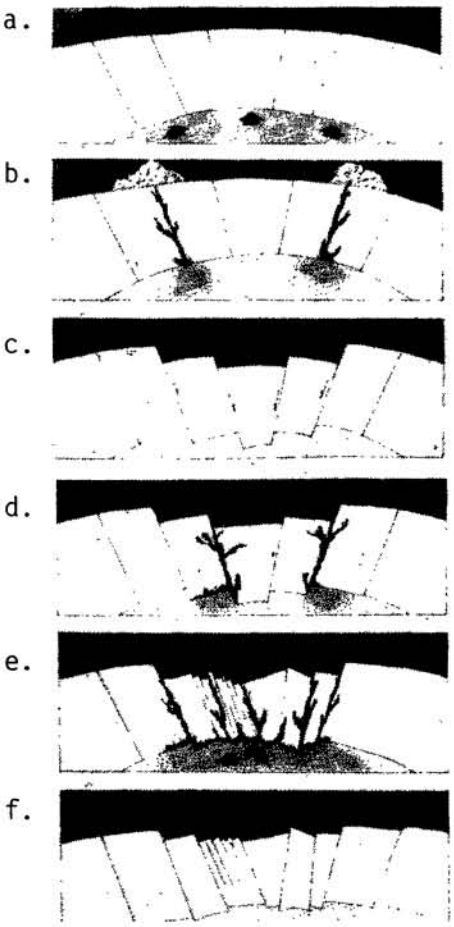

Fig. 2. Model for the origin and evoluation of Haldane.

References

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