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Miranda's Inverness Corona Interpreted as a Cryovolcanic Complex

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High resolution Voyager images of Uranus' miniscule satellite Miranda revealed three "coronae" of relatively dark terrain with very complex surface topography and albedo patterns (1). Inverness Corona (the "trapezoid" of ref. 1) is the best imaged of the three, the only one seen in its entirety with its regional geologic setting. Interpretations of the structure and origin of the coronae constitute important components of Miranda's geologic and thermal history. An analysis of Inverness Corona is given here.

Geologic Structure and Setting: A geologic sketch map of Inverness is shown in figure 1. The coronal material is generally darker and of crisper texture than the rolling cratered terrain. Superposition relations and crater densities indicate the coronal material to be younger than the cratered terrain (2). The corona is bound by elevated scarps to the east and west, a deep canyon and bounding scarp to the north, and a rugged strip of horst-and-graben at a slightly lower mean elevation to the south. The corona itself consists of a complex of geologic units of distinct albedo and structure. Unit A (see fig. 1) is stratigraphically the lowest and most extensive unit. It has medium-dark albedo and is characterized by undulating "ripples." The strike of the ripples' crests generally parallel the edge of the unit on all four sides, being parallel to the bounding scarps on the east and west and approximately perpendicular to the local down-slope on the north and south. There are exceptions: paired ridges with smaller transverse ripples between them run roughly downslope in the NE corner (feature #1); there is also a roughly concentric set of ripples around a dome (#2) in the SW. The edge of the unit is a convex lip several hundred meters high with lobate projections into topographic hollows (esp. #3) around the N, W, and S sides. Along the E side, the unit appears to extend over the bounding ridge (#4) in places and includes convex deposits "perched" on the uppermost topographic steps of the 340° Chasma. In one place, the unit extends down the face of several steps to "pool" in a crater and on the chasma floor (#5). Unit B, the "chevron," is a high albedo unit again bounded by a convex lip. Ripples are well developed in the north and are generally perpendicular to the local down-slope. The ripples fade to the south with only a single prominent ridge extending the length of the unit. The C units (stipple) are a series of smaller, darker, individual units superposed on unit A. Several different structures are apparent: a "D" shaped patch (#6) has ripples like units A and B and a distinct topographic boundary. Several ripples on the A unit continue into #6 unit as subtle undulations, suggesting unit D is fairly thin at the edges and has overridden rather than replaced preexisting topography. #7 appears to consist of a central dome surrounded by concentric ripples. #8 is an elongated dome $\sim$ 2 km high with a concentric albedo pattern and possibly a summit pit. #9 is a dark ridge 2-3 km high extending into the 340° Chasma and appears to have a chain of elongate craters along its crest. Finally, the D units are irregular high-albedo deposits with no apparent topographic expression. Underlying topography and albedo patterns show through in a manner analogous to the polar hood on Ganymede, implying the deposits are a light "dusting" of material rather than a continuous layer.

Interpretation: The corona is interpreted as an enormous cryovolcanic complex. The albedo variations, superposition relations, and surface morphologies appear to preclude a

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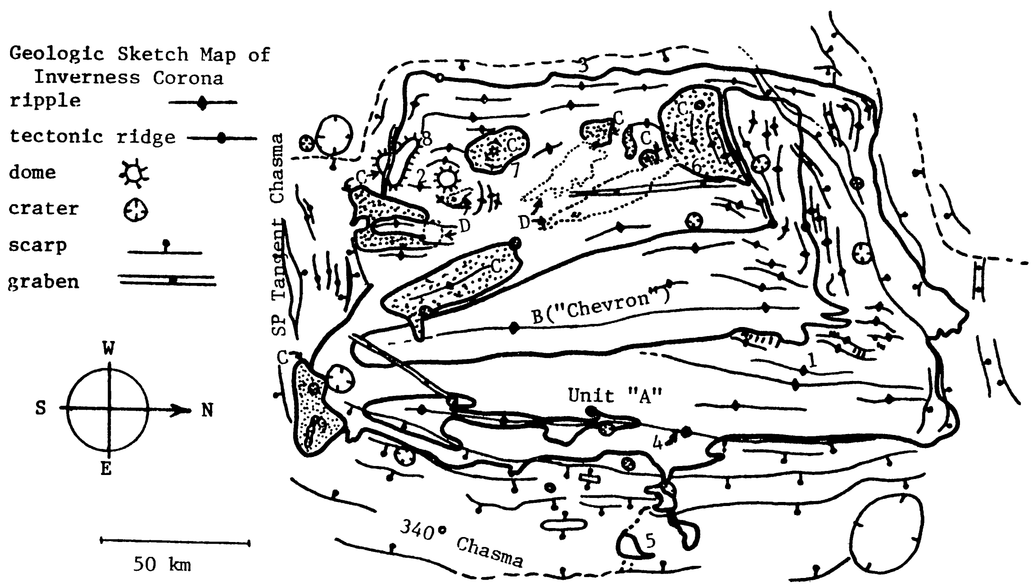
purely tectonic origin. The ripples and troughs of the coronal units are morphologically distinct from the fault terraces in the 340° Chasma, the ridges in the SP Tangent Chasma, and the grabens that cross the corona obliquely in the NW and SE. Several features are similar in morphology and gravity-scaled size to features found in terrestrial lava flows: ripples parallel corda found transverse to downslope flows and parallel to bounding obstructions, paired ridges with transverse flows are found in both andesitic and basaltic terrestrial flows, the domes and ridges are comparable to terrestrial volcanic domes and cinder cones, and several of Invernesses' units seem to have flowed viscously over previously existing structures. Given the volcanologic interpretation, several conclusions may be made: the flows (with the possible exception of domes 2 and 7) originate from large fissures a few tens to about one hundred kilometers in length. These lengths are not unreasonable from the point of view of the theory of magma migration in fluid-filled cracks. Fissure orientations parallel the two major pre-existing fracture directions (2). Assuming the ripples are true corda, the ripple dimensions and apparent flow thicknesses may be used to estimate viscosities (3) of 10^8 to 10^9 poise and Bingham yield stresses (4) of 10^{-2}-10^{-1} bars. These values are consistent with each other and are intermediate between values for terrestrial basalts and andesites. In particular, the implied viscosities are logarithmically midway between the viscosities of the solid ($\sim 10^{15}$ poise) and liquid (~ 10 poise) forms of the molecular materials ($NH_3 \cdot H_2O$, CH_4, etc.) of which the flows presumably consist. Thus the Inverness flows were apparently emplaced as partially congealed melts rather than as some type of solid-state diapir flow. It is speculated that the differences in albedo between the various units are due to minor differences in composition and that the "D" units may represent some form of fumarolic activity.

The cyrovolcanic interpretation of Inverness suggests that: 1) the origins of ripple-like structures on Ganymede and Enceladus need to be reconsidered as possible volcanic rather than tectonic phenomena; and 2) volcanism on icy satellites is comparable to terrestrial volcanism in its complexity and multifold morphologic expressions. **References** 1. Smith, B.A., *et al.* (1986) *Science* **233**, 43. 2. Croft, S.K. (1988) *Icarus*, submitted. 3. Fink, J. (1980) *Geology* **8**, 250. 4. Hulme, G. (1974) Geophys. J.R. Astr. Soc. **39**, 361.



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