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EXTENSIONAL TECTONICS OF THE SATURNIAN SATELLITES: Jeffrey M. Moore, Department of Geology, Arizona State University, Tempe, Arizona, 85287

The saturnian satellites were imaged by the Voyager spacecraft at sufficient resolutions to reveal landforms that indicate histories of extensional tectonics for several of these bodies. The relationships among landforms on various satellites imply that extensional tectonism is a consequence of several different energy sources. Case histories of several satellites will be discussed to illustrate the interaction of various phenomena associated with extensional tectonism.

Mimas

Long, linear, sub-parallel troughs on Mimas (satellite diameter 390 km) are interpreted to be graben formed by global-scale fracturing induced by the impact that formed the 130 km diameter crater Herschel(1). This suggestion is similar to one proposed for the formation of troughs or grooves on the martian satellite Phobos by its crater Stickney(2). It should be noted, however, that the troughs on Mimas do not obviously radiate from Herschel the way grooves do on Phobos from Stickney.

Tethys

A somewhat more complex relationship between impact and extension can be observed on Tethys (1060 km diameter). Ithaca Chasma, an enormous trough system extending at least 270^o around Tethys, is narrowly confined to a zone which lies roughly along a great circle that is concentric to the 400-km-diameter Odysseus impact basin(3,4). It was originally suggested that if Tethys was once a sphere of liquid H_2O covered with a thin solid crust, freezing the interior would have produced expansion of the surface comparable to the area of the chasm(3). This hypothesis failed to explain why the chasm occurs only within a narrow zone. Expansion of the satellite's interior should have caused fracturing to occur over the entire surface in order to effectively relieve stresses in a rigid crust(4). The Odysseus impact may have caused Tethys to become temporarily oblate if the satellite was composed of a brittle shell overlying a plastic interior. Forcing Tethys into an oblate spheroid could have induced near-surface tensional fractures along the intersection of the satellite's surface with a plane that is normal to a planetary radius from the center of impact(4). Alternatively, it has been recently proposed that the grabens composing the Ithaca Chasma were formed some time after the impact in response to stresses induced by viscous flow associated with the restoration of Odysseus' floor to match Tethys' geoid(1).

Dione and Rhea

Linear troughs and coalescing-pit chains observed on Dione (1120 km diameter) and Rhea (1530 km diameter) have been interpreted as evidence for episodes of extensional tectonics in these satellites' past(3,5,6,7,8). The globally widespread distribution of these features implies that they were formed by surface-layer tensional stresses created by the volumetric expansion of the satellites' interiors. Theoretical models suggest an early but relatively long-lived period of increasing volume resulting from thermal expansion and/or phase-density changes of H_2O (and hydrates) driven by the rise and fall of output from radionuclide energy sources (9,10).

The location and orientation of some extensional features on Dione may have been controlled by deep-seated fractures established by large impacts and later exploited by endogenic stresses(5,7). Additionally a loss of oblateness due to tidal despinning or orbital recession may have influenced global, extension-related lineament orientation(7). The orientation of extensional features on Rhea are not random. However, they do not form a pattern that can be explained by existing models for lineament trends(8).

Enceladus

The youngest and most tectonically modified surface observed in the saturnian system is that of Enceladus(3). Bands of parallel, alternating troughs and ridges (similar to "grooved" terrain of Ganymede), fissures, and coalescing-pit chains compose a suite of landforms on Enceladus thought to be due to extensional tectonics. Small fissures and troughs probably form initially as tension fractures or graben. Trough-ridge sets may be akin to horst and graben terrains. The morphology of these landforms has probably been significantly modified by the effects of viscous creep and mass wasting thus complicating the identification of the details of their formation. Like similar landforms on Ganymede, the mechanisms by which extensional features are formed on Enceladus is poorly understood(1).

The geological vigor of Enceladus is remarkable in that its diameter is 500 km, only a little larger that Mimas and less than half the diameters of Tethys, Dione, and Rhea. Like the Galilean satellite Io, it is probably heated by the tidal-torque flexing of its interior(11,12). Tidal heating joins large basin-forming impacts and radionuclide decay to form the three identified energy sources for extensional tectonics on the saturnian satellites.

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