THE GEOLOGY AND EVOLUTION OF HECATE CHASMA, VENUS, Victoria E. Hamilton, Department of Geology, Arizona State University, Tempe, AZ 85287; Ellen R. Stofan, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109.

Hecate Chasma is an 8000 km long approximately linear to sinuous zone of extensional deformation and volcanism extending from Atla Regio through Asteria Regio and ending at Beta Regio. Previous work has established that the development of a distinctive chain-like concentration of coronae associated with Hecate Chasma is closely linked to processes of the trough's formation [1-3]. Coronae in this chain do not display any clear age progression or systematic variation in topography and morphology, and are therefore not believed to be indicative of terrestrial-style hotspot activity [3]. We have examined the structural, morphologic, and spatial characteristics of the corona chain, associated coronae, the chasm, and regional volcanism in order to evaluate models of the formation of Hecate Chasma. We find that the predominance of features related to upwelling and extensional tectonism strongly favor an extensional/rifting origin for this region.

Regional setting. The geomorphic units surrounding Hecate Chasma appear to be mostly radar-dark volcanic flood plains with some mottled plains, both of which lie roughly 0.5 to 1 km above mean planetary radius (MPR). The source areas of both plains units are difficult to identify. Thousands of volcanic domes greater than 2 km in diameter may mark source vents for the plains units; additional material may have been supplied by corona-related volcanism or flows related to extensional tectonics. Twelve of the 17 impact craters in this region have been tectonically modified and two have been modified by volcanism [4, 5]. The number of modified craters indicates that there has been recent, significant geologic activity involving tectonism and less commonly, volcanism.

The sinuous southwest/northeast trending corona chain associated with Hecate Chasma is distinguished by a series of coronae partially linked by irregular fractures. Several deviations from this trend occur where peripheral "arms" of the chain diverge to the north, east, and southeast. The trace of the chain roughly corresponds to the trace of the trough defining Hecate Chasma. The density of complex fracturing along the chain and chasm decreases significantly 150-200 km away from the axis of the trough, indicating that fracture formation is closely related to trough-forming processes.

Volcanism. Volcanic activity in Hecate Chasma is represented by different types of plains units and edifices, including fracture-associated flows and large volcanic rises. Based on crosscutting relations, it is apparent that volcanism in the area has overlapped in time with tectonic activity as local volcanism may be younger or older than tectonic deformation. Flows associated with the linear fracture zones are generally digitate and flow down current topographic gradients, perpendicular to the local trend of deformation. As this type of flow and geometry is almost always present at known rift zones, the flows of Hecate Chasma are interpreted to indicate that a component of extensional tectonism is present. Three major volcanoes in the region are Ozza Mons in Atla Regio and two unnamed volcanoes in Asteria Regio. Ozza Mons marks a regional tectonic junction where several zones of linear deformation (Hecate, Parga, Ganis, and Dali Chasmata) terminate [14]. None of these fracture zones cuts completely across Ozza Mons. Both volcanoes in Asteria Regio are cut by regional normal faulting (some graben) and record a history of concurrent volcanism and tectonism.

Structures. Lineaments in the Hecate Chasma region are primarily associated with coronae and the trough. Graben, normal faults, and compressional fractures/wrinkle ridges are observed. Graben are usually associated with and trend parallel to the deepest portions of the chasm and also occur at volcanic centers. Diffuse sets of graben tend to occur on the flatter plains areas and at volcanic centers, while denser groupings are preferentially located in and along the chasm. Radially oriented graben sets are typically restricted to the interiors of coronae as predicted by models of corona formation [3, 6, 7, 11, 12], but may extend out beyond the corona annulus. Normal faults are found throughout the Hecate Chasma region, distinguished by radar-bright scarps. These faults are most prevalent near the volcanoes in Asteria Regio and Atla Regio, and in east-central Hecate near 18.5°N, 255°E. Compressional features occur preferentially at the annuli of coronae and at higher elevations associated with more intense deformation; they are more likely to be present further away from the trough than are graben. Compressional lineaments are almost always irregular and sinuous in planform, may anastomose, and tend to parallel the chasm, even when crossing/intersecting a corona.

Coronae. Coronae in the Hecate chain are typical of most coronae in that they are generally circular to elongate in planform, may be associated with extensive volcanism, and display tectonic features indicative of extension, compression, or both [3]. Coronae are generally between 200 and 350 km in diameter and display heavily fractured annuli of concentric or arcuate lineaments. Interiors may contain radial fractures, apparently random deformational features, or an absence of deformation (typically in flooded interiors). Additionally, many coronae are characterized by pervasive, throughgoing fractures that do not appear to be deflected by the coronae's deformation (or vice versa). In many cases, it is difficult to establish the temporal relation between these fractures and the associated coronae. Topographic profiles display considerable diversity ranging from domical features to plateaus with interior lows and annular moats. The distinctive topographic profiles, patterns of radial and

concentric fracturing, and other general characteristics of coronae suggest formation by mantle upwelling or mantle diapirs [3, 6-12]. Of the 51 coronae identified along the Hecate Chasma chain, 5 are interpreted to be fresh to intermediate in development, 9 are classified as intermediate, 15 are intermediate to degraded, and 22 are considered significantly degraded [3, 13]. The freshest/youngest coronae are randomly located throughout the area and do not appear to be spatially related.

Hecate Chasma. Magellan topography data show that the chasm is asymmetric with a reversal in the sense of asymmetry across a corona straddling the chasm at 16N, 252. To the southwest of this corona, the highest topography is on the northern side, and to the northeast of the corona it is on the southern side. The deepest portions of the chasm reach 3-4 km below MPR, and the rims of the trough reach elevations of up to 3-4 km above MPR: total relief in some localities is up to 6 km, often over relatively short horizontal distances. Profiles across the trough primarily display consistent patterns of inward facing, downward-stepping slopes consistent with normal faulting and extensional tectonism. Profiles of topography and emissivity are generally anti-correlated at high elevations as expected [15] except in two areas which show the base and the north side of the trough roughly correlating with emissivity. We are examining these areas to establish whether low emissivities at low elevations and high emissivities at high elevations can be related to geologically recent subsidence and volcanism, respectively.

Conclusions. Complex geologic processes have taken place in the Hecate Chasma region. We have found evidence for a variety of volcanic and tectonic activity, with dominant styles relating to upwelling and extension. Volcanism in the region includes flows emanating from fractures interpreted to have an extensional origin, and large volcanic edifices at the ends of the chasm. Extensive tectonism has resulted in a dominant pattern of fractures and a deep trough. Based on the unusual asymmetry of the chasm, the stair-stepped, inward-facing slopes, and associated graben, we believe the processes that have formed the trough to be extensional in nature. Coronae along Hecate Chasma are inferred to form due to processes of upwelling; most do not appear to be sites of subduction or retrograde migration [16-18] based on the continuity of radial and other features beyond the corona annului. Further studies of local variations in emissivity with topography may provide more insight into recent geologic processes along the trough. Continuing studies concentrate on constraining trough formation and the relationship of Hecate Chasma to Parga Chasma and similar trough/corona chains.

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