MODELS OF HECATE CHASMA, VENUS AND IMPLICATIONS FOR ACTIVE(?) EXTENSION. S. E. Smrekar[1], E.R. Stofan[2], P. Martin[3], T. Hoogenboom[3], and W. R. Buck[5], and, [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, USA; ssmrekar@jpl.nasa.gov; [2]Proxemy Research, 20528 Farcroft Lane, Laytonsville, MD 20882, USA; ellen@proxemy.com; [3]Dept. of Earth Sciences, Durham University, South Road, Durham DH1 3LE, UK; paula.martin@durham.ac.uk; [4]ExxonMobil, Gravity-Magnetics Group, 233 Benmar St., Houston, TX 77060, USA; trudi.hoogenboom@exxonmobil.com; [5]Lamont-Doherty Earth Obs., 61 Route 9W; PO Box 1000, Palisades, NY 10964, USA; buck@ldeo.columbia.edu).

Introduction: Hecate Chasma is an approximately 7000 km long extension zone, and may be relatively young based on the concentration of dark halo craters [1]. What drives this extension in the absence of plate boundary forces? The long wavelength geoid shows no evidence of active, broad scale upwelling. However, the majority of coronae, likely to be formed through small scale upwelling, occur in association with rifts. What is the genetic relationship between rifting and upwelling? We begin to address these questions by applying a simple model of uniform extension and show that it is consistent with the observed rift characteristics (width, fracture style) in Hecate Chasma.

Modeling: We use a simple model of uniform lithospheric extension [2] to determine if observations are consistent with the observed style of rifting and estimated lithospheric properties. [2] describes the change in crustal thickness, thermal gradient, and strength of the lithosphere as extension progresses and causes the crust to thin and heat up relative to the surrounding lithosphere. The compositional buoyancy force created by the thicker crust exterior to the rift opposes rifting while the thermal buoyancy force in the thinned crust favors rifting. If the strength of the rifted lithosphere is less than that of the surrounding lithosphere, the rift will remain narrow. If extension causes the lithospheric strength to increase with time relative to the surrounding lithosphere, wide rifting is predicted. For example, if the crust is thinned appreciably, the lithospheric column will be stronger due to a large thickness of mantle material.

We assume a dry diabase for the crustal and dry olivine for the mantle [3]. Mantle heat flux is varied over a range of 10-50 mWm^{-2} and we examine a range of crustal thickness (Zc) from 10 to 110 km. We assume a crustal heat production of 6.4e^{-7} Wm^{-3} and a surface temperature of 460°C.

The predicted thermal gradient is translated to an elastic thickness (Te) value by assuming that the brittle-ductile transition occurs at 700°C. For terrestrial mantle material, the brittle-ductile transition is around 600-800°C, and up to 450°C for the crust [4]. Dry diabase is closer in strength to the terrestrial mantle than the crust, so 700° is chosen as plausible value for comparison to Te estimates. We examine extensional strain rates of 0.01 and 0.1 cm/yr, based on the assumption that strain rates will be low without plate tectonics.

Results: Predicted styles of rifting are shown in Figure 1 for two extensional velocities and a range of crustal and elastic thicknesses. Unless the crustal thickness is small or the elastic thickness is large (low heat flow), the predicted style is wide rifting. The assumed high strength of the crust, as well as the relatively small crust-mantle density difference, favors wide rifting in most cases. Although a 'core complex' regime is predicted, this regime is unlikely since it requires rapid crustal flow.

Figure 1 also shows estimates of the crustal and elastic thickness for different regions of Hecate Chasma. These values are found by modeling the admittance between the Magellan gravity and topography. The admittance was calculated using a spatio-spectral method with spectra centered at 1° by 1° grid points across Hecate Chasma. The admittance curves are classified into like shapes and fit using models of elastic flexure with top and bottom loading to obtain the best fit elastic and crustal thickness [5].

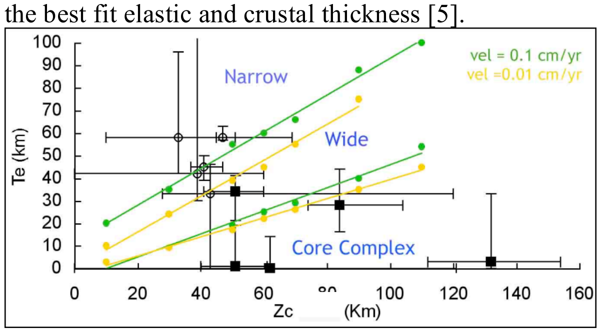

Figure 1. Predictions of rift style as a function of variations in crustal thickness and elastic thickness. Points show fits and uncertainties for admittance classes.

We use the spatial distribution of the admittance classes and their associated estimates of elastic and crustal thickness to map out the predicted regions of narrow versus wide rifting at Hecate Chasma (Figure 2). We compare the measured widths of rift to the model prediction, and find that rifts that occur in regions predicted to be narrow from the extensional model and estimates of the elastic and crustal thickness are nearly all <125 km in width. Those rifts predicted to be wide are mostly all >125 km in width (Figure 3).

Discussion: *Fracture style.* In addition to correspondence between the model prediction for narrow vs. wide rifts and the average rift width, there is also general agreement between the model predictions and the style of rifting seen in the Magellan radar data. [6] mapped two primary types of rifts in Hecate Chasma: 1) diffuse fractures, which are dominated by graben and lineaments, and 2) trough dominated fractures, which are intensely fractured, often with graben sets. Diffuse fractures occur predominantly in areas predicted to be zones of narrow rifting, while trough-dominated fractures occur primarily in predicted zones of wide rifting. Thus the wider, better-defined rifts are seen in areas that are expected to have undergone greater extension.

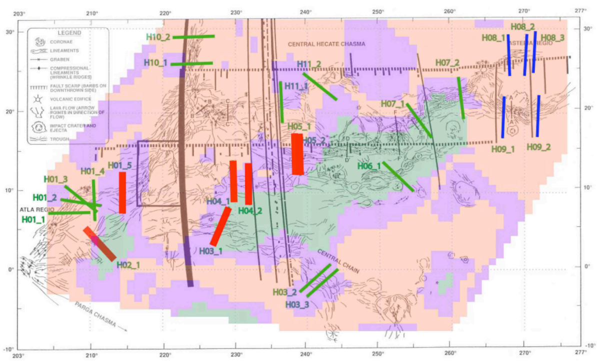

Figure 2. Map of predicted rift zones of narrow (orange), wide (purple) and undetermined (green) using an extensional velocity of 0.1 cm/yr. Locations of measured rifts zones are shown as colored bars: red (> ~125 km width), green (~<125 km) and blue (special location: Asteria Regio, a possible hotspot).

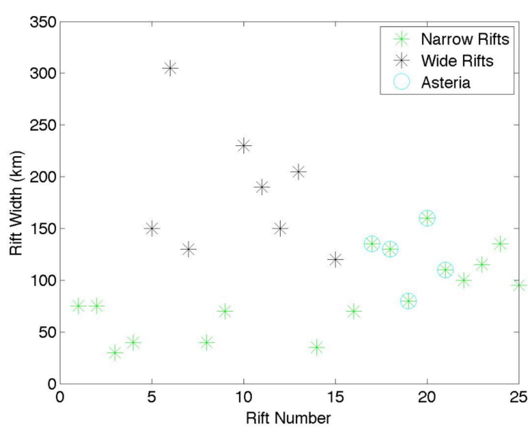

Figure 3. Width of the rift locations in Figure 2, from H01_1 to H11_2. Color indicates regional rift model prediction at the location of each rift: green (narrow), black (wide). Circled points occur in Asteria Regio, a likely hotspot and thus a different geologic setting.

Comparison to Parga Chasma. We also attempted to apply this model to Parga Chasma. However, there the admittance classes and thus the estimates of elastic and crustal thickness and the associated rift model predictions do not correspond to major sections of the rift. Additionally there are 131 coronae at Parga Chasma, compared with 50 at Hecate. In a companion study [5] we find that the characteristics of the corona populationsat the two chasmata differ. We interpret the smaller coronae at Parga to be due to possible late stage, diapirc melting driven by extension due to their 1) occurrence in chains, 2) stratigraphically young age relative to the rift, 3) relatively low amounts of volcanism, and 4) smaller diameter. Hecate Chamsa may lack this population of coronae. Certain types of extension driven melting are predicted in the late stages of extension on Earth [7,8]. Additionally analysis of dark halo crater degradation and statistics suggests that Hecate Chasma is relatively young [1].

Conclusions: The agreement between model predictions for the style of rifting and a difference in both rift style and widths, with a transition at ~125 km demonstrates that: 1) a model of uniform extension is applicable at Hecate Chasmata, 2) the extensional velocity is at least 0.1 cm/yr, 3) the transition width between narrow and wide rifts on Venus (~125 km) and Earth (~100 km) are similar, 4) a combination of elastic and crustal thickness, not either parameter individually, must be used to predict rifting style, and 5) this model does not fit the data at Parga Chasma. This fact along with differences in the coronae populations suggest that Parga is in a later, possibly inactive stage of evolution, while Hecate may still be active. **References:** [1] Phillips, R.J. and N. Izenberg (1995) *GRL, 22,* 1417-1520. [2] Buck, W.R. (1991) *JGR, 96*, 20,161-20,178. [3] Mackwell, S.J. et al. (1998) JGR, 103, 975-984. [4] Chen. W.P., and P. Molnar (1983) JGR, 88, 4183-4214. [5] Smrekar, S.E. et al., submitted, JGR-P, 2009. [6] Hamilton, V. E. and E.R. Stofan (1996) *Icarus, 121,* 171-194. [7] Hernlund, J.W. et al. (2008) *JGR, 113*, doi:10.1029/206JB004862. [8] Hernlund, J.W. et al. (2008) JGR, 113, doi:10.1029/206JB004863.