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HOT-SPOT TECTONICS OF EISTLA REGIO, VENUS: RESULTS FROM MAGELLAN IMAGES AND PIONEER VENUS GRAVITY

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Introduction. Eistla Regio is a broad, low, discontinuous topographic rise striking roughly EW at low northern latitudes of Venus. Some 2000x7000 km in dimension, it is the third largest rise in planform on Venus after Aphrodite Terra and Beta-Phoebe Regiones. These rises are the key physiographic elements in a hot-spot model of global tectonics [1] including transient plume behavior [2]. Since Eistla Regio is the first such rise viewed by Magellan and the latitude is very favorable for Pioneer Venus gravity studies, we attempt to test some of the predictions of a time-dependent hot-spot model here. We define western Eistla Regio as the rise including Gula and Sif Mons and central Eistla Regio as that including Sappho Patera. Superior conjunction prevented Magellan from returning data on eastern Eistla Regio (Pavlova) during the first mapping cycle.

Regional Tectonic Patterns. The largest tectonic feature viewed by Magellan in western Eistla Regio is a 700-km long anastomosing set of radar-bright lineaments extending SE from Gula Mons. The strike of individual elements varies from NW to N; indeed, some strike N and are arrayed en echelon to the NW. This region appears to be a rift zone, as many of the lineaments are troughs and most lie within a larger linear depression flanked by local highs. This depression can be traced 400 km further along the saddle joining western and central Eistla, where it joins with N- and NW-striking troughs. The rift zone is truncated by flows on the lower flank of Gula Mons; after a short switch to a northeasterly strike along the volcano's summit, graben-like lineaments continue northwesterly from Gula Mons. Two parasitic domes (coronae?) along this trend further suggest that it is a locus of extension, mantle upwelling, and partial melting. Regional tectonic fabrics are less evident at Sif Mons, but again a NW-trending band of troughs, often en echelon, extends from the NW for several hundred km although the pronounced topographic trough is absent. NW-striking lineaments also appear to the SE of Sappho Patera, but their regional importance is yet unresolved due to the small imaged area available. In summary, the regional tectonic fabric of central and western Eistla Regio is dominated by NW-striking rift zones, approximately centered on the axis of the rise, which both cut and are buried by volcanic edifices.

Impact Crater Density. Within the 3.4×10^6 km² of western Eistla Regio above the mean planetary radius, Magellan images show 5 probable impact craters (Class 1), 2 possible impact structures (Class 2), and 2 additional circular features of unknown origin (Class 3). The areal density of impact craters for this region is then $1.5/10^6$ km² for Class 1 alone and $2.1/10^6$ km² for Classes 1 and 2 together. The latter value is consistent with the mean density of $1.9 \pm 0.2/10^6$ km² for Classes 1 and 2 over the first 15% of the planet surveyed by Magellan. The surface age of western Eistla Regio does not appear to be significantly different from the mean age of the surface as a whole. Two of the nine potential impact craters on the rise actually lie on the volcanic constructs, approximately the expected number for the area of these edifices. One, a doublet of 5-km diameter structures at 20N, 350E, is doubtful, but the other, a crater 20 km in diameter at 20N, 355E (provisional name De Lalande) is a strong impact candidate. Since there are not enough craters for reliable statistics within the region, impact crater density alone cannot distinguish between the alternative hypotheses: (1) the edifices are younger than the rise, or (2) the rise and the edifices are contemporaneous. By contrast, no impact craters are visible in a 5×10^6 km² area around Sappho Patera; since it is highly unlikely that this would occur by chance, central Eistla Regio is distinctly younger than the planetary mean.

Gravity. A linearized inversion procedure [3] was used to produce a map of vertical gravity at 300-km altitude from Pioneer Venus line-of-sight accelerations over the area 10S-40N, 30W-30E. The apparent depth of isostatic compensation (ADC), derived from the correlation between gravity and topography, is 190 ± 30 km over the entire region. However, significant variations are present within this area: the ADC is 200 ± 20 km at western Eistla (15-30N, 15W-5E), but falls to 110 ± 20 km over central Eistla (5-20N, 10-25E). The ADC of central Eistla Regio is only slightly larger than those of western Aphrodite Terra, whereas the ADC of western Eistla Regio is more comparable to those of Atla and Bell Regiones.

Discussion. The presence of NW-oriented rift zones all along the topographic axis of west-central Eistla Regio indicates some crustal stretching in a NE-SW direction, either due to active mantle uplift or passive extension perpendicular to the principal axis of the rise. The crater-free surface of central Eistla Regio is consistent with the terminal stages of transient plume ascent [2], wherein the lithosphere is penetrated by a plume head and massive flood volcanism occurs [4]. Intermediate (~ 100 km) ADCs are associated with this stage. Larger ADCs such as those of western Eistla Regio are held to be associated with deep plumes that have uplifted the surface, perhaps with some advance volcanism, but without widespread resurfacing. These conditions would be satisfied if Sif and Gula Mons are younger than the rise as a whole (hypothesis 1). If, however, the volcanic edifices are as old as the rise (hypothesis 2), then the mantle plume must be long-lived rather than transient, although not much volcanism has been produced in recent geologic time. In this latter scenario, central Eistla is experiencing the effects of extensive partial melting in a transient plume head while western Eistla has entered a steady-state (plume tail) phase [6]. These same considerations should apply to Beta Regio, which has an impact crater density similar to western Eistla Regio [5], a large ADC, and contemporaneous linear rift zones and volcanic edifices.

Conclusion. The western and central portions of Eistla Regio, while part of the same broad topographic rise and tectonic framework, have distinctly different surface ages and gravity signatures. The western rise, including Gula and Sif Mons, is the expression of deep-seated uplift with volcanism limited to the individual large shields. The eastern portion, including Sappho Patera, has been widely resurfaced more recently by shallower thermal anomalies in the mantle.

References. [1] R.J. Phillips and M.C. Malin, in *Venus*, (eds. D.M. Hunten et al.), Univ. Ariz., 159, 1983; [2] Herrick and Phillips, *GRL*, 17, 2129, 1990; [3] Grimm and Phillips, *JGR*, in press, 1991; [4] R. White and D. McKenzie, *JGR*, 94, 7685, 1989; [5] D.B. Campbell et al., *Science*, 246, 373, 1989; [6] M.A. Richards et al., *Science*, 246, 103, 1989.