CLEOPATRA PATERA, A CIRCULAR STRUCTURE IN MAXWELL MONTES, VENUS; VOLCANIC OR IMPACT? A.R. Peterfreund, J.W. Head, R.A.F. Grieve, Dept. Geol. Sci., Brown Univ., Providence, RI 02912, D.B. Campbell, Arecibo Obs. Arecibo PR 00612.

The large circular structure on the eastern edge of Maxwell Montes, Cleopatra Patera (Fig. 1), is an enigmatic feature in one of the most geologically interesting regions on Venus. Since the structure was first observed in Arecibo radar observations [1,2], a familiar debate has occurred regarding whether the structure is volcanic or impact in origin. Improved spatial resolution of the structure has recently been obtained by Arecibo radar at 12.6 cm [3], allowing for a more detailed characterization of the region. The objective of this study is to describe Cleopatra from radar images and available Pioneer-Venus (PV) data (res. ~ 60km) in order to constrain its origin.

Maxwell Montes is one of the most prominent structures observed on Venus from both Earth-based and spacecraft radar [4,5,6]. The elevation of Maxwell Montes is at least 11 km above datum (6051.0 km radius) with a very steep slope on the western side and a more gradual slope to the east; Cleopatra is located on the more gradual eastern slope. Earth-based and PV observations show Maxwell to be one of the roughest regions on the planet at scales of cm to m. The high reflectivity of Maxwell observed from PV data has been interpretted to indicate surface materials incorporating appreciable proportions of high-dielectric materials [7]. Arecibo backscatter images show that Maxwell contains the following features: 1) well-defined, sub-parallel bands that extend across the length of the main massif; 2) broad regions of high backscatter, particularly in the north and south; 3) localized patches of low backscatter; and 4) the circular region of low backscatter (Cleopatra) [2,6]. Radar characteristics of Maxwell have been used to infer numerous geologic processes, including a fault-bounded massif of volcanic origin [5], and a domed or folded uplift [2,8]. In each of these models an explanation incorporating Cleopatra remains problematic.

Figure 1 shows backscatter cross-section per unit area at a spatial resolution of ~1 km. Brightness is proportional to surface roughness at scales of 0.1 to 1.0 m. The four rings defined in figure 2 are based on discontinuities in relative backscatter, and backscatter structure and texture. For illustration, the rings are shown as circles with all but the inner ring concentric.

The inner ring, A (radius = 19 km), is defined by a discernable contrast in backscatter from a dark interior to a brighter exterior. Its center is offset from the other rings by ~ 10km. In detail ring A is polygonal with the NE and SW sides aligned with the regional structural trend, as defined by the backscatter structure. The SE and NW sections of ring A are highly segmented. PV radar measurements of this general area, limited to a single set of measurements, show an anomalously low (by 0.5 to 1.5 km) elevation, smooth roughness and moderate reflectivity. Partially surrounding ring A (S and E) is a narrow band (width <10 km) of relatively higher backscatter. The second ring, B (radius = 48 km), is the best defined ring based on a strong contrast in backscatter. The ring shape is polygonal, elongated in a NNE-SSW direction, and has an eccentricity of ~1.3. Only the NE side appears to be aligned with the regional structural trend. PV measurements centered between rings A and B show no distinct deviation from the broad regional slope, but do show the area to be exceptionally high in reflectivity and, to a lesser degree, high in roughness. A band of high backscatter (width = 10 to 20 km) surrounds ring B. The third ring, C (radius = 123 km), is subjectively defined on the basis of a change in backscatter texture as well as absolute magnitude. Ring C is elongated in the NW-SE direction and is poorly defined in many sections. Within ring C, regional bands appear segmented and slightly more irregular in direction. Part of ring C encompasses the low backscatter region to the NE. This region has much lower backscatter than the rest of the area bounded by ring C, but texture and structure of the backscatter is similar to that in the rest of the area. PV data for the area between rings B and C, as well as between C and D, also show no break in regional slope, and moderately high roughness and reflectivity values. The outer ring, D (radius = 168 km), is defined primarily on the basis of structures coincident with the ring. Particularly striking is the set of bands in the SW that coincides with ~70° of arc of ring D. A set of bands to the NE, in the low backscatter region, is coincident with ~40° of arc at nearly the same radius. To the NW and SE, a slight change in texture is observed. The zone between rings C and D is, for the most part, indistinguishable from the surrounding region.

Interpretation of the radar characteristics of Cleopatra involves a number of assumptions, including: 1) that a link exists between radar backscatter, roughness, and large-scale surface morphology, and 2) knowledge about the characteristics of venusian impact craters and volcano-tectonic structures. Experience with #1 is limited, and understanding of #2 is embryonic. However, the characteristics described above warrant some discussion. If Cleopatra is a volcanotectonic structure, then the number and concentric pattern of the rings, its location on the eastern flank of Maxwell, and a possible relationship between Cleopatra and the banded terrain must be accounted for. Volcanic analogs on other planets are exceedingly rare due primarily to the size of the Cleopatra structure. Perhaps the best analog may be Alba Patera on Mars, which has a caldera of comparable size to ring B and a surrounding structural pattern produced by tectonic deformation. Unfortunately, radar data are not available for direct comparison with Cleopatra.

© Lunar and Planetary Institute • Provided by the NASA Astrophysics Data System

Cleopatra shares common traits with suspected venusian impact craters (i.e. radar smooth interior and rough exterior) [1,5,9,10,11] and with impact structures on other planets. Estimates of depth-diameter ratios for a crater the size of Cleopatra are comparable to the PV data [11]. Relative size relationships between crater rim crests and central peak ring diameters have been shown to be independent of gravity [12,13]. Assuming the crater rim crest coincides with ring B, then ring A is within 10% of the predicted size of a central peak ring. A rim crest diameter of ~100km is relatively small for a peak ring basin [14]. It is, however, consistent with values for terrestrial ring structures [15]. The asymmetry of ring A may be a problem for an impact hypothesis. Asymmetric peak rings, however, are observed on the Moon, although their origin is poorly understood. Ring C and D may represent structural zones associated with the initial crater. The area within zone C may be related to ejecta effects or have been heavily fractured and responded to subsequent deformational forces in a manner different from the surrounding terrain. Ring D may be a tectonic ring fracture that also was uniquely involved in subsequent deformation. Finally, in any hypothesis for the origin of Cleopatra, the processes responsible for the bands in Maxwell most likely occurred, at least in part, subsequent to the formation of the feature. If these processes are deformational in nature [2], these observations could provide limits on the amount of compression in this region.

Clearly, confirmation of any hypothesis of the origin of Cleopatra will require higher resolution data. In the meantime, we would argue that designation of Cleopatra as a Patera (i.e., an irregular or scalloped-shaped crater), which generally implies a volcanic origin, may be premature.

References: 1) D.B. Campbell and B.A. Burns (1980) JGR, 85, 8271. 2) D.B. Campbell et al. (1983) Science, 221, 664. 3) D.B. Campbell et al. (1983) Bull. Am. Astro. Soc., 15, 818. 4) R. Jurgens (1970) Radio Sci., 5, 435. 5) H. Masursky et al. (1980) JGR, 85, 8232. 6) J.W. Head et al. (1982) LPSC, XIII, 291. 7) G. Pettengill et al. (1982) Science, 217, 640. 8) G. McGill et al. (1983) Venus, Chpt. 6, 69. 9) G.G. Schaber and J.M. Boyce (1977) Impact and Explosion Cratering, Pergamon, 603. 10) J.A. Cutts et al. (1981) Icarus, 48, 428. 11) R.A.F. Grieve and J.W. Head (1981) LPSC, XI, 285. 12) J.W. Head (1978) LPSC, IX, 485. 13) S.K. Croft (1981) Proc. Multi-Ring Basins, 227. 14) C. Wood and J.W. Head (1976) PLSC, 7, 3629. 15) R.A.F. Grieve et al. (1981) Proc. Multi-Ring Basins, 37.

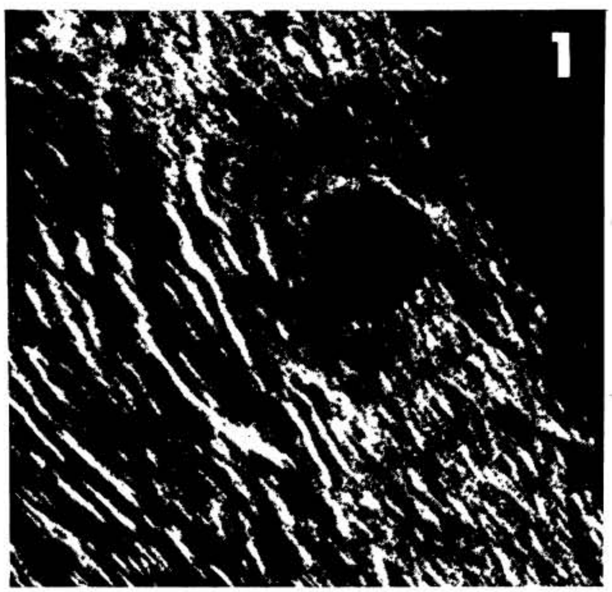

Figure 1. Arecibo radar image (12.6 cm) of Cleopatra (66°N, 7°E) obtained in 1983 at ~1 km resolution. Image is in Mercator projection with north at top. Resolution is 50 pixels/degree latitude.

Figure 2. Arecibo radar image of Cleopatra obtained in 1982. Image is in an equal area projection (3 km/pixel). Circles are referred to in text as rings A, B, C, and D, and have radii of 19, 48, 123, and 168 km, respectively.

© Lunar and Planetary Institute • Provided by the NASA Astrophysics Data System