

Fig. 1.

in cycle 3. Some 98% of the planet will be mapped at the end of mission cycle 3.

Planned observations in the fourth mission cycle from mid-September 1992 through mid-May 1993 will emphasize high-resolution gravity observations of the equatorial regions of Venus. A second Orbit Trim Maneuver (OTM) at the beginning of this mission cycle will lower periapsis to below 200 km to improve the gravity resolution. Magellan, with its large antenna and X-band radio system, will also improve upon the venusian gravity maps obtained from the Pioneer-Venus spacecraft. These new gravity observations when coupled with superb radar images will provide valuable insights to the interior processes occurring on Venus.

Scientific reports for the project include the "45 Day Report," which was published as a single issue of *Science* in March 1991. A "6-Month Report" will also be published as a special issue of the *Journal of Geophysical Research (JGR) Planets* in the summer of 1992. A "Geophysics Report" on the 360° of gravity observation in cycle 4 will be one or more scientific articles submitted for publication in the summer or fall of 1993.

Magellan data products, the SAR images, altimetry data and radiometry data, are available as analog photographs and digital compact disks (CD-ROMs) at the National Space Science Data Center (NSSDC) at the NASA Goddard Space Flight Center (GSFC) in Greenbelt, Maryland. As of May 1, 1992, over 500 radar mosaics, as well as the altimetry and radiometry data for the first mission cycle, are available. In addition, some 250 photographs have been released and are available to the public. The altimetry and radiometry data for cycle 1 produced by the Massachusetts Institute of Technology (MIT), as well as the cartographic products produced by the U.S. Geological Survey (USGS), are being released to the science community.

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ATLA REGIO, VENUS: GEOLOGY AND ORIGIN OF A MAJOR EQUATORIAL VOLCANIC RISE. D. A. Senske and J. W. Head, Department of Geological Sciences, Box 1846, Brown University, Providence RI 02912, USA.

Introduction: Regional volcanic rises form a major part of the highlands in the equatorial region of Venus. These broad domical uplands, 1000 to 3000 km across, contain centers of volcanism forming large edifices, and are associated with extension and rifting. Two classes of rises are observed: (1) those that are dominated by tectonism, acting as major centers for converging rifts such as Beta Regio and Atla Regio, and are termed tectonic junctions [1]; and (2) those forming uplands characterized primarily by large-

scale volcanism forming edifices, Western Eistla Regio and Bell Regio, where zones of extension and rifting are less developed. Within this second class of features the edifices are typically found at the end of a single rift, or are associated with a linear belt of deformation [1,2]. In this paper, we examine the geologic characteristics of the tectonic junction at Atla Regio, concentrating on documenting the styles of volcanism and assessing mechanisms for the formation of regional topography.

Topographic and Geologic Characteristics of Atla Regio: Atla Regio is a 1000-km × 1000-km highland centered near 4°N, 200° and is a broad rise reaching an elevation of 3.0 km (all elevations are referenced to a planetary radius of 6051.0 km) (Fig. 1). The relationship between chasmata (rifts) and volcanic features forms a pattern similar to that observed at Beta Regio, distinguishing Atla as a major tectonic junction [3,4,5]. In addition, Pioneer Venus gravity data show this highland to have a substantial gravity anomaly, centered at Ozza Mons, along with a corresponding large apparent depth of isostatic compensation (>200 km) [6,7]. Interpretations from these data suggest that like Beta Regio, Atla Regio is most likely a site of mantle upwelling.

Magellan altimetry data provide the first detailed coverage of the topography of Atla Regio (Fig. 1). The regional rise has gentle slopes (0.1° to 0.2°), reaching its highest point at Ozza Mons, a 7.5-km-high peak. In plan view the central part of the highland is triangular shaped with its apex pointing to the north where it intersects the north-south-trending rift valley Ganis Chasma. The legs of the triangle correspond to Dali Chasma (southwest/northeast orientation) and Parga Chasma (southeast/northwest orientation). The more distal parts of all three rifts curve, are aligned along a more east-west orientation, and form a "pinwheel" pattern centered on Ozza Mons. At a point just to the south of where Dali Chasma intersects Ozza Mons a second volcano, Maat Mons, is located on the western edge of the rift and rises to an elevation of 9.2 km. To the northwest of central Atla is a second gentle topographic rise (elevation of 2.0 km) on which is located Sapas Mons, a 4.0-km-high volcano that has a substantial gravity anomaly (+25 mgal at a spacecraft altitude of 200 km) (8). The presence of broad domical topography, the large gravity anomaly, and the presence of large-scale volcanism suggests that Sapas is the site of second thermal anomaly.

Regional Geology of Atla Regio: In order to understand the relationships between regional tectonism and volcanism, we examine the geology of the central part of the Atla, concentrating on Ozza Mons and Maat Mons. Geologic mapping of this area (Fig. 2) shows it to contain five general units, the most abundant of which are radar-dark plains. Plains to the northwest of Ozza Mons contain pervasive sinuous ridges (spacing of 10 to 25 km) with a general orientation of N 30°E, parallel to the trend of Ganis Chasma, and are interpreted to be compressional in origin [5]. These structures may have formed by the relaxation of topography or may represent surface deformation linked to large-scale flow in the mantle [5]. To the north of Ozza Mons the plains are disrupted by faulting and fracturing forming a 150- to 250-km-wide rift, Ganis Chasma. Features mapped as edifices correspond to the volcanos Sapas Mons, Maat Mons, and Ozza Montes. An additional volcanic center with a corresponding large gravity anomaly (+35 mgal) is located on the southwest edge of Ganis Chasma (15°N, 195°). This region is located along a chain of gravity highs stretching the length of Ganis Chasma. Lava flows from the volcanic center lie on the edge of the rift, being deposited to the southwest, apparently down the rift flanks and do not appear to contribute to any rift infilling. A number of isolated regions of

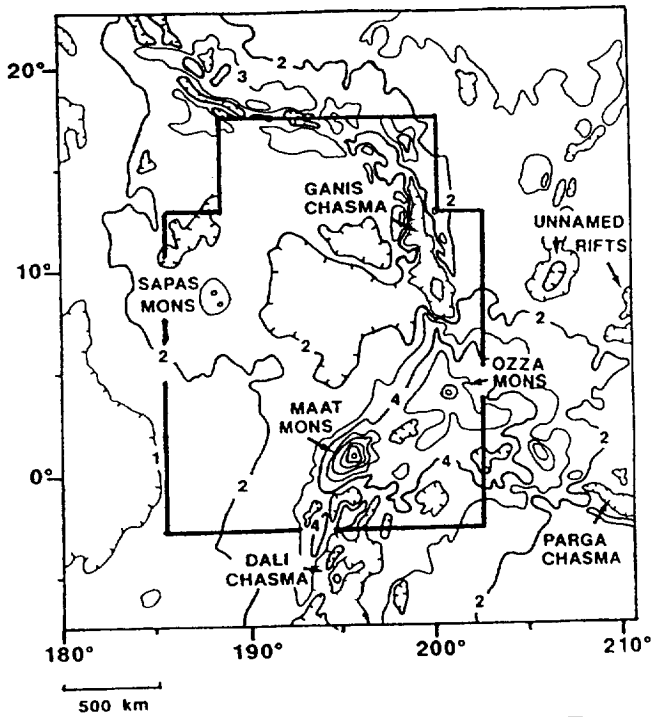


Fig. 1. Magellan topography of Atla Regio contoured at 1.0-km intervals and referenced to a planetary radius of 6051.0 km. The rifts Dali Chasma, Ganis Chasma, Parga Chasma, and two unnamed rifts trending to the northeast are topographically distinct depressions reaching depths of up to 3.0 km. The two highest features, Maat Mons and Ozza Mons, reach elevations of 9.2 km and 7.5 km respectively. The area outlined by the solid line corresponds to the region shown in Fig. 2.

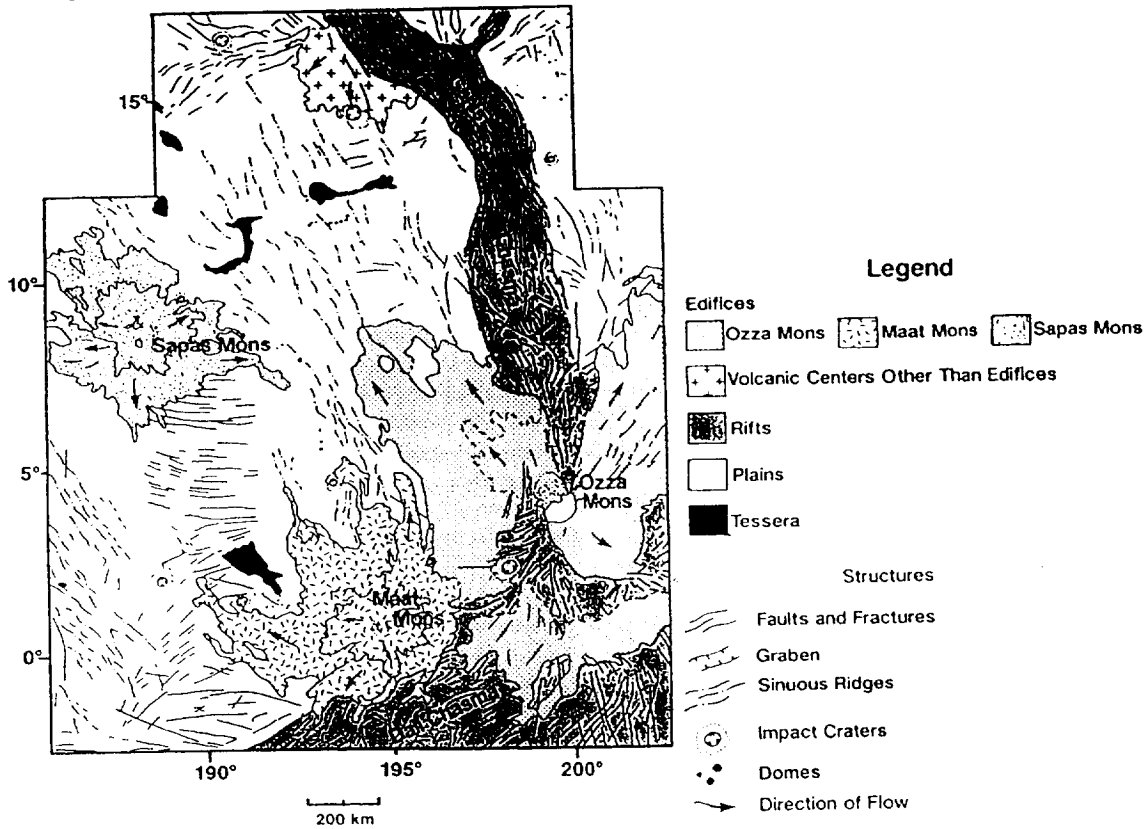


Fig. 2. Sketch map of the central part of Atla Regio. Ozza Mons is located at the point where Ganis Chasma, Dali Chasma, and Parga Chasma converge, while Maat Mons is located astride the western flank of Dali Chasma.

highly deformed terrain are mapped as tesserae. Unlike Beta Regio, tesserae does not appear to be a major unit Atla [9].

Ozza Mons forms the central part of Atla and is located at the point where Ganis, Dali, and Parga Chasma intersect. The relationship between Ganis Chasma and Ozza Mons is examined along with the general stratigraphic relationships between assemblages of volcanic units. The rift valley, Ganis Chasma, is unique in that it is relatively devoid of infilling from volcanism and sedimentary material. The exception to this trend is evident where it merges with the volcano. At the point where the rift intersects Ozza it narrows from a width of 225 km to 125 km and deformation is confined to a trough on the flank of the volcano. The primary area of disruption is a zone of scarps associated with normal faulting that is offset from the main trend of the rift, changing orientation from a strike that is just west of north to one that is just east of north. Additional scarps with a relatively uniform spacing of 5 km are arrayed with a northeast/southwest orientation on the eastern flank of the edifice and are associated with an unnamed rift aligned to the northeast. The Ganis rift terminates at the summit of Ozza, a radar-dark oval plateau (100 km × 60 km) that rises to an elevation of 1.5 km above its surroundings and contains numerous pits and collapse structures (diameters of 0.5 to 7.0 km). To the north of the summit, just below the plateau, lies a dome field (domes 10 km in diameter) covering an area 80 km × 100 km. Deposits along the eastern edge of the dome field are superposed on faults and fractures from Ganis Chasma, indicating that at this location volcanism postdates faulting and contributes to partial infilling of the rift. Further to the north, where the rift narrows, other lava flows both superpose and are cross cut by faults, indicating that rifting and the deposition of volcanics occurred concurrently.

Four major classes of volcanic deposits are identified on Ozza Mons; the first two are made up of the radar-dark material on the summit and the adjacent dome field. The others correspond to flow units mapped on the distal parts of the volcano, bright flows and mottled bright flows. Bright flows have a relatively uniform texture, with no apparent source regions for the deposits observed. In many places the unit is cut by faults and fractures, deformation associated with rifting. In comparison, it is possible to identify numerous apparent source regions for mottled bright flows. These originate mainly from vents on the outer flanks of the volcano. Like the bright flow unit it is possible to identify places where the mottled bright flows are cross cut by faulting. The boundaries between the units typically form an embayment relationship, with some of the mottled bright flows being channeled down graben, suggesting that they are stratigraphically the younger of the two units. In general the dome field and the mottled bright flows appear to be most recent units.

Maat Mons: Located 600 km southwest of Ozza Mons and lying on the northwest edge of Dali Chasma is Maat Mons. In plan view, this volcano is elliptically shaped (195 km × 120 km) with its major axis oriented in a northeast/southwest direction. Its summit region differs from that of Ozza Mons in that it contains a 25-km-diameter caldera with additional smaller nested pits and collapse structures (diameters between 1.0 and 5.0 km), indicating multiple episodes of magma emplacement and withdrawal. Unlike Ozza Mons, this volcano is not disrupted by faulting, but instead, along its southeast flank, appears to be filling the rift.

Volcanic deposits mapped on Maat range from bright to mottled dark. The most abundant flows have a bright homogeneous texture, are found on the more distal flanks of the volcano, and are interpreted to be associated with the large-scale effusion of lava. Mottled bright flows have a range of textures on the scale of tens of kilometers and are found mainly in the area where the rift is being

filled in. The central part of Maat contains deposits with mottled dark textures that are arrayed in a pattern radial to the summit. In several locations the dark material has a diffuse boundary, suggesting the presence of a mantling deposit. One example corresponds to a cluster of domes (diameters ranging from 5 to 10 km) located in a 2.0 km deep depression 250 km to the north of the summit (3.2°N, 194.9°) and mapped as a dome field. The terrain associated with this area appears etched and is covered by a dark diffuse deposit, suggesting the possible presence of an air fall deposit associated with pyroclastic activity. In general the boundaries between the different flow units are gradational, making stratigraphic relationships difficult to determine.

Summary and Conclusions: Atla Regio is a complex region of converging rifts and volcanism. The largest (areally extensive) volcanic center corresponds to Ozza Mons and has characteristics similar to Theia Mons in Beta Regio [5]. Stratigraphic relationships at Ozza suggest that both the deposition of volcanics and rifting have occurred concurrently. Maat Mons is broadly similar to volcanos identified in Western Eistla Regio (Sif Mons) and contains a well-defined summit caldera. On the basis of regional stratigraphic relationships and the analysis of geophysical data, Atla is interpreted to be a site in which a mantle plume, centered near Ozza Mons, has uplifted plains causing faulting and rifting and volcanic construction at Ozza Mons and Maat Mons.

In addition to Ozza Mons, Sapas Mons, Ganis Chasma, and the area mapped as a volcanic center (separate from the large volcanos), all have substantial positive gravity anomalies. Sapas is interpreted to be a second site of upwelling adjacent to Atla. On the basis of its large gravity anomaly and a corresponding large apparent depth of compensation (>200 km) [7] the zone of extension and rifting at Ganis is interpreted to be linked to mantle dynamics. This array of surface features separate from those at central Atla (Ozza and Maat) may be associated with multiple upwellings, or possibly a single large plume that has produced smaller instabilities [10].

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THE GEOLOGIC MAPPING OF VENUS USING C-1 FORMAT: SHEETS 75N254, 60N263. I. V. Shalimov, Lomonosov Moscow University, Moscow, Russia

The results of geologic mapping of Venus, produced on the base of Magellan images, are presented. We submit two C-1 format geologic maps with the appropriate legend.

The mapping territory has been taken from Venera 15 and 16 missions and geologic maps have been composed by Sukhanov et al. [2] and Kotelnicov et al. [1]. Magellan images allow us to divide some types of the plains units to determine the lava flow direction and to map with better accuracy.

C-1 sheets 75N254 and 60N263 are shown in Figs. 1 and 2. The correlation of the mapped units is shown in Fig. 3. We regret the difficult perception without the color legend.

References: [1] Kotelnicov V.A. et al. (1989) *Atlas of Venus*, GUGK, Moscow (in Russian). [2] Sukhanov A.L. et al. (1989) *Atlas*