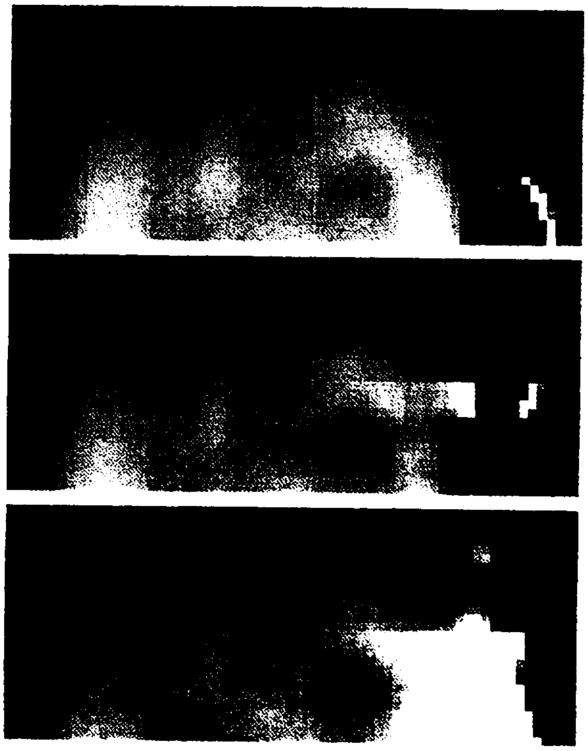

Fig. 1. Data taken on the 27th of July 1991. These are, from the top, images taken in the 1.18-, 1.1-, and 1.0-µm windows. Beta Regio can be seen on the lower right near the crescent. Its apparent contrast with respect to the surrounding plains increases with decreasing wavelength. This feature is not detected in the 1.28- and 1.31-µm windows.

lowest scale height of the atmosphere. More comprehensive surface-atmosphere radiative transfer models are being used to determine whether the observed emission contrasts are consistent with surface elevation-related temperature differences or require surface emissivity variations as well.

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MAGELLAN STEREO IMAGES AND VENUSIAN GEOLOGY.

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Areas of Venus imaged by Magellan radar with multiple viewing conditions provide unique data that will contribute to the solution of venusian geologic problems and provide a basis for quantitative comparison of venusian landforms with those on other planetary bodies. Three sets of images with different viewing conditions have been acquired: (1) left-looking with variable incidence angles (cycle 1 profile), (2) right-looking with nearly constant incidence angles (cycle 2 profile), and (3) left-looking with variable incidence angles that are almost always smaller than those in (1) (cycle 3 profiles).

The unique data provided by paired images of the same scene with different incidence angles arises from image displacements caused by the relief of individual landforms at scales comparable to the ground-range and azimuth resolutions of the images [1]. There are two aspects of the data: (1) Stereopsis achieved by simultaneous viewing of paired left-looking images of the same scene permits three-dimensional perception and interpretation of the morphologies of landforms at resolutions much finer than the altimetry footprints. (2) Measurements of differences of image displacements (parallax) on paired images with known imaging geometries provide quantitative estimates of the relief and shapes of landforms. The potential scientific contributions of the data can be grouped into two interrelated classes: (A) geologic mapping, analysis, and interpretation and (B) topical studies that involve topographic measurements.

A. Stereopsis, without quantitative measurements, enhances geologic mapping, analysis, and interpretation of the rock units of Venus to a degree that cannot be overestimated. In geologic mapping, assemblages of landforms, assessments of backscatter and variations in backscatter, and fine-scale topography are used to define and characterize geologic map units that represent laterally continuous deposits or rock units. Stereopsis adds the important dimension of local relief for characterization of geologic units at a scale that is not possible with Magellan altimetry or products derived from the altimetry. Relative ages of the geologic units are determined using the well-known principles of superposition and intersection. Here, the perception of relief is invaluable because superposition relations among the geological units are more readily and clearly established. The recognition of folds, faults, and fault systems, regardless of their orientations, is facilitated with stereopsis so that sequences of deformation of the geologic units can be determined and structural analyses vastly improved. Shapes of landforms are readily perceived so that they can be properly interpreted. The end result of the mapping, analyses, and interpretations is a geologic history of Venus that includes the sequences of formation and deformation of various geologic units.

B. Measurements of relief at the finest scale possible are necessary for numerous topical studies. Standard altimetry will provide the necessary information on the relief of most large landforms, but it tends to underestimate the relief of small landforms [2] and distorts their shapes. Although special processing of the altimeter echoes improves the estimates of the relief and shapes of some landforms [3], there are uncertainties in the interpretations of the echoes [2]. Examples of topical studies requiring measurements of relief are given below.

Impact Craters: Impact craters are ubiquitous landforms on terrestrial planets and moons. They range in diameter from 1.5 to 280 km on Venus. The shapes and dimensions of venusian craters are important for their interpretation and for comparisons with those on other planets and bodies [4–7]. Two of these dimensions are crater depth and rim height.

Small Volcanic Landforms: Small volcanic edifices and craters are important landforms on most planetary bodies because they indicate certain aspects of the style of volcanism. On Venus, small volcanic landforms include domes, "ticks," cratered cones, rilles, and so forth [8]. Relief of edifices and depths of craters are among the dimensions used to classify volcanic landforms and compare them among the various planetary bodies [9–12].

Tectonic Structures: The crust of Venus exhibits a host of landforms that indicate remarkable variations in style and intensity of deformation [13]. Landforms with relief include scarps of normal faults, ridges of reverse faults, horsts, graben, and nappes. Knowledge of the relief and planform dimensions of these landforms at the fine-scale will help provide estimates of magnitudes of strains involved in the deformations [14,15].

Surface Processes: Surface processes include eolian, mass wasting, and other processes [16]. Examples where measurements of relief will be useful include (1) analyses of erosion-deposition patterns behind obstacles [16], (2) slopes of erosion-deposition environments, (3) slope stability analyses, and (4) estimates of landslide volumes.

Rheological Analyses: There is a host of applications of relief measurements to the analyses of the rheological properties of venusian flow associated with volcanism [8], impact cratering [7], and debris flows [17]. These applications include flow thicknesses and relations between the flows and the adjacent topography. Lava flow thickness as large as 100 to 700 m have already been measured using parallax [18]. According to Magellan altimetry, bright outflows from impact craters flow up slopes, and flow margins may be 100 m or so above the centers of the outflows. If true, these relations have important implications about the kinematics and rheology of the outflows. Relations between the relief and runout may reveal the rheological properties of venusian landslides [17,19].

Backscatter Functions: A better understanding of the relations between backscatter cross sections and incidence angles can be gained by analyses of given classes of landforms and terrains with variable slopes and sufficient relief for stereometric analyses. Multiple viewing conditions are essential in understanding (1) the forms of the scattering laws, (2) the dielectric properties, (3) the contributions of conducting materials to scattering behaviors, (4) the fine-scale roughnesses, and (5) the contributions of quasispecular and diffuse echoes to average backscatter cross sections of tesserae, impact craters, and volcanic edifices, craters, and flows [20]. An understanding of the above will assist in geologic interpretations of tesserae, impact cratering, and volcanism.

Radarclinometry and Shape from Shading: Once the backscatter functions of the various classes of landforms are established, shape from shading can be used to refine the topography of landforms with stereo-relief data [21], and radarclinometry can be used to estimate the relief and shapes of landforms of the same class where there is no stereoscopic coverage and where the landforms are too small for stereo-parallax measurements.

Topographic Analyses: Radargrammetric reduction of stereoscopic models and radarclinometry (shape from shading) [21] may provide information on the topography of venusian surfaces at slope lengths smaller than those achievable with Magellan altimetry and larger than those obtained by analyses of quasispecular echoes from level surfaces with surface tilts smaller than the image resolution [22]. Derived topographic information includes slope probabilities, power spectral densities, and fractal dimensions.

Altimetry: Radargrammetric reduction of stereoscopic models can confirm, refute, or supplement Magellan altimetry where problems with the altimetry exist. The current problem of the steep slopes of Maxwell Montes is an example, but there are others.

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FLEXURAL MODELS OF TRENCH/OUTER RISE TOPOGRAPHY OF CORONAE ON VENUS WITH AXISYMMETRIC SPHERICAL SHELL ELASTIC PLATES.

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Magellan altimetry has revealed that many coronae on Venus have trenches or moats around their peripheries and rises outboard of the trenches [1,2]. This trench/outer rise topographic signature is generally associated with the tectonic annulus of the corona. Sandwell and Schubert [3,4] have interpreted the trench/outer rise topography and the associated tectonic annulus around coronae to be the result of elastic bending of the Venus lithosphere (though the tectonic structures are consequences of inelastic deformation of the lithosphere). They used two-dimensional elastic plate flexure theory to fit topographic profiles across a number of large coronae and inferred elastic lithosphere thicknesses between about 15 and 40 km, similar to inferred values of elastic thickness for the Earth's lithosphere at subduction zones around the Pacific Ocean. Here, we report the results of using axisymmetric elastic flexure theory for the deformation of thin spherical shell plates [5] to interpret the trench/outer rise topography of the large coronae modeled by Sandwell and Schubert [3,4] and of coronae as small as 250 km in diameter. In the case of a corona only a few hundred kilometers in diameter, the model accounts for the small planform radius of the moat and the nonradial orientation of altimetric traces across the corona. By fitting the flexural topography of coronae we determine the elastic thickness and loading necessary to account for the observed flexure. We calculate the associated bending moment and determine whether the corona interior topographic load can provide the required moment. We also calculate surface stresses and compare the stress distribution with the location of annular tectonic features.

The model lithosphere is a spherical elastic shell buoyantly supported by a dense internal fluid. Although the model includes membrane stresses, for a planet the size of Venus the buoyant support provides the dominant reaction to the load. The load is modeled as either an axisymmetric disk (uniform loading) or a ring (peripheral loading). Other load geometries may be achieved by superposition. The wavelength of the flexural feature depends only on the thickness of the plate and not on the details of the loading, allowing a unique determination of the elastic thickness from the best-fitting model. Vertical strains are not included so that the vertical displacement at the top of the lithosphere is the same as that at the bottom where the buoyancy forces are acting. This model includes the effects of a distributed load and a continuous lithosphere that are absent in two-dimensional models and that become important when the radius of the load is reduced to a few flexural wavelengths.

The models are fit to the topography using least squares fitting and the relevant parameters are determined from the best-fitting model. For the corona Latona (diameter = 800 km) we reproduce Sandwell and Schubert's [3] value of approximately 30 km for the