can be converted to estimates of mechanical plate thickness and thermal gradient [6]. Using parameters appropriate for Venus [7] we obtain thermal gradients values of about 12–25 K/km for Tepev Mons and about 25 K/km for 10°N, 275°E. These gradients are in the range expected if Venus loses most of its internal heat by conduction through a globally continuous, if laterally heterogeneous, lithospheric shell [7].

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PANCAKELIKE DOMES ON VENUS. Dan McKenzie[1], Peter G. Ford[2], Fang Liu[2], and Gordon H. Pettengill[2], [1]Institute of Theoretical Geophysics, Bullard Laboratories, Madingley Road, Cambridge CB3 OEZ, UK, [2]Center for Space Research, Massachusetts Institute of Technology, Cambridge MA 02139, USA.

The shape of seven large domes on the plains of Venus, with volumes between 100 and 1000 km^3, is compared with that of an axisymmetric gravity current spreading over a rigid horizontal surface. Both the altimetric profiles and the horizontal projection of the line of intersection of domes on the SAR images agree well with the theoretical similarity solution for a newtonian fluid, but not with the shape calculated for a rigid-plastic rheology, nor with that for a static model with a strong skin. As a viscous current spreads, it generates an isotropic strain rate tensor whose magnitude is independent of radius. Such a flow can account for the randomly oriented cracks that are uniformly distributed on the surface of the domes. The stress induced by the flow in the plains material below is obtained, and is probably large enough to produce the short radial cracks in the surface of the plains beyond the domes. The viscosity of the domes can be estimated from their thermal time constants if spreading is possible only when the fluid is hot, and lies between 10^{14} and 10^{17} Pa s. Laboratory experiments show that such viscosities correspond to temperatures of 610°–690°C in dry rhyolitic magmas. These temperatures agree with laboratory measurements of the solidus temperature of wet rhyolite.

These results show that the development of the domes can be understood using simple fluid dynamical ideas, and that the magmas involved can be produced by wet melting at depths below 10 km, followed by eruption and degassing.

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GROUNDBASED NEAR-IR OBSERVATIONS OF THE SURFACE OF VENUS. V. S. Meadows[1], D. Crisp[2], and D. A. Allen[3], [1]University of Sydney, Sydney, Australia, [2]Jet Propulsion Laboratory, Pasadena CA, USA, [3]Anglo-Australian Observatory.

Near-infrared observations of the nightside of Venus have revealed thermal emission from the lower atmosphere in relatively transparent regions of the spectrum centred on 1.0, 1.1, 1.18, 1.27, and 1.31 µm [1,2,3]. The emission in these windows is believed to originate from the very lowest scale heights of the atmosphere and from the surface. Recent groundbased work in the 1.0-µm window [4], and measurements made at 1.18 µm by the Galileo NIMS during its 1990 flyby [3], indicate that the Venus surface topography produces contrasts in the thermal emission. These contrasts are believed to be caused primarily by surface temperature differences associated with differences in surface elevation. A similar correlation of reduced emissivity with altitude has been seen in 17-cm radio maps [5], although these contrasts are not consistent with topographically related temperature differences alone, and are postulated to be the result of increased reflectivity due to the presence of conducting materials in the highland surfaces. As well as providing information about the surface, observations in the near infrared can be used to obtain estimates of the optical depth of the lower atmosphere at these wavelengths and to constrain the water abundance in the lower atmosphere.

We present images of the nightside of Venus taken in the near-infrared windows at 1.0, 1.1, 1.18, 1.28, 1.31, and 2.3 µm with the new infrared camera/spectrometer IRIS on the Anglo-Australian Telescope. These data were taken in spectral-mapping mode. This technique involves scanning the telescope perpendicular to the slit, while collecting spectra at successive slit positions across the planet. We produce data cubes with one spectral and two spatial dimensions. The spectra have a resolution $\lambda/\Delta\lambda \sim 400$. Images can be extracted over any wavelength regions. Each image has square pixels of 0.8" resolution. Spectral image cubes were obtained on a total of eight days during July, September, and October 1991. The July cubes cover the spectral region 0.820–1.511 µm and the September and October cubes 1.135–1.317 µm. We reduced the scattered light from the sunlit crescent in images extracted from each window by subtracting images taken on either side of the window, where the Venus atmosphere is opaque. Unlike the short wavelength windows, which reveal thermal contrasts that originate primarily from the surface and deep atmosphere, the emission in the 2.3-µm window is produced at much higher altitudes (30–40 km). Emission contrasts seen near 2.3 µm are associated with horizontal variations in the cloud optical depths, and have rotation periods of about six days [2]. These cloud contrasts fade at shorter wavelengths as the cloud deck becomes steadily more transparent, but are still present and must be removed to distinguish the surface emissivity contrasts.

We detect large contrasts in infrared emission (20–40%) across the disc of Venus in the 1.0-, 1.1-, 1.18-, 1.28-, and 1.31-µm images. Contrasts at these wavelengths may be due to a combination of variations in the optical depths of the overlying sulfuric acid clouds and differences in surface emission. Comparison with the 2.3-µm images show that the patterns seen in the 1.28- and 1.31-µm windows are consistent with cloud optical depth variations alone and require no contribution from the surface. However, images at 1.0, 1.1, and 1.18 µm from July 1991 show a dark feature having a contrast that increases with decreasing wavelength (Fig. 1). This behavior is contrary to that expected of cloud absorption. Images taken on three successive days in October show another dark feature that is stationary with respect to the surface. These regions of lower emission correspond closely to the high-altitude surface regions of Beta Regio and Aphrodite Terra.

The images can potentially reveal the near-infrared emissivity of the surface of Venus, thereby complementing Magellan radar reflectivity and groundbased radio emissivity measurements. The contrast ratio between highlands and plains is much smaller than would be expected for blackbody radiation from the surface alone. Unlike at radio wavelengths, where the atmosphere is essentially transparent, at near-infrared wavelengths the atmosphere emits, absorbs, and scatters radiation, and can modify the observed topographically induced contrasts. The additional radiation from the atmosphere reduces the contrast, and further modification would be expected if terrain at different altitudes has different emissivities. A fit to our data therefore requires, and may constrain, a model of the

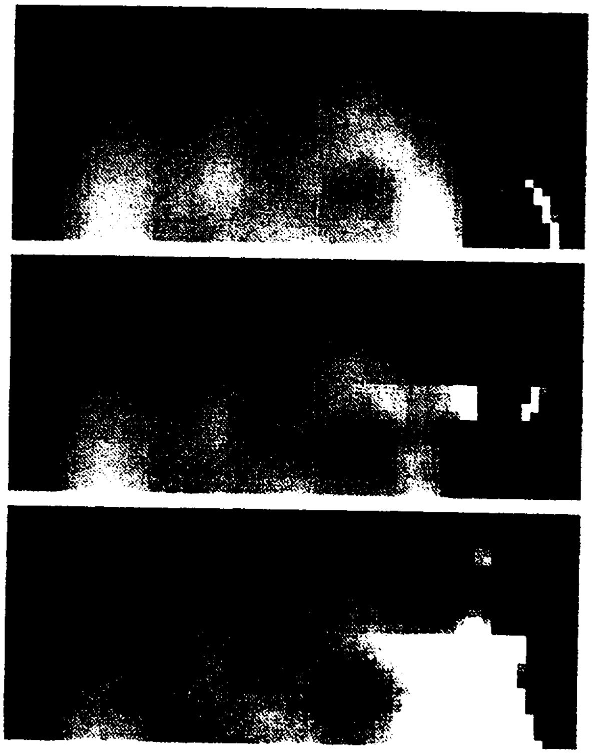

Fig. 1. Data taken on the 27th of July 1991. These are, from the top, images taken in the 1.18-, 1.1-, and 1.0-µm windows. Beta Regio can be seen on the lower right near the crescent. Its apparent contrast with respect to the surrounding plains increases with decreasing wavelength. This feature is not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