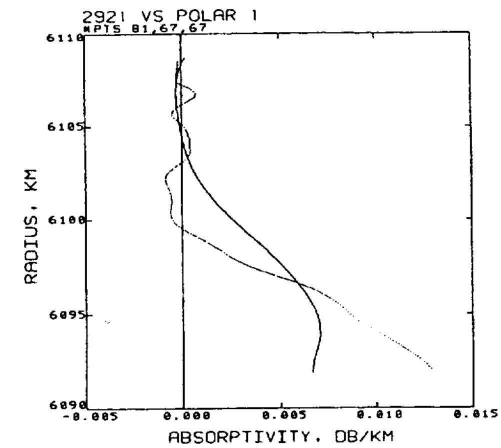

Fig. 1. Absorptivity profiles for near-polar PVORO experiments from 1979 (dotted line) and 1986 (solid line). Since $H_2SO_4(g)$ is the dominant 13-cm absorber in the Venus atmosphere, this plot suggests that the abundance of $H_2SO_4(g)$ decreased form 1979 to 1986 in the high northern latitudes.

ents in those planetary atmospheres. However, the reduction of amplitude data from such experiments to determine abundance profiles requires the application of the inverse Abel transform (IAT) and numerical differentiation of experimental data. These two operations preferentially amplify measurement errors above the true signal underlying the data. A new technique for processing radio occultation data has been developed that greatly reduces the errors in the derived absorptivity and abundance profiles. This technique has been applied to datasets aquired from Pioneer Venus Orbiter radio occultation studies and more recently to experiments conducted with the Magellan spacecraft.

While primarily designed for radar studies of the Venus surface, the high radiated power (EIRP) from the Magellan spacecraft makes it an ideal transmitter for measuring the refractivity and absorptivity of the Venus atmosphere by such experiments. Two transmitter frequencies were used: 2.3 GHz and 8.4 GHz (13 cm and 3.6 cm, respectively), and the measurements were made during spacecraft ingress on three consecutive orbits on October 5, 1991. Since the stability of the spacecraft transmitted frequencies is critical for accurate retrieval of atmospheric properties from the signals recorded on Earth, the spacecraft transmitter was locked to a 2.1-GHz uplink from DSS-43 (Tidbinbilla, Australia), which also received the signals. Because of the high gain of the spacecraft antenna, and the large ray bending in the deep Venus atmosphere, a spacecraft tracking maneuver was designed to keep the spacecraft antenna pointed in the direction of the refracted ray path back to Earth. This tracking maneuver, plus the high EIRP of the Magellan transmitter, yielded 3.6-cm refractivity and absorptivity profiles down to altitudes below 36 km, and 13-cm profiles to altitudes below 34 km (above a radius of 6052 km). These experiments probed much deeper in the atmosphere than previous radio occultation experiments conducted with the Pioneer Venus Orbiter, which reached altitudes of 54 km at 3.6 cm, and 40 km at 13 cm.

The longevity of the Pioneer Venus Orbiter has made it possible to study long-term changes in the abundance and distribution of sulfuric acid vapor, $H_2SO_4(g)$, in the Venus atmosphere between 1979 and 1992. The abundance of $H_2SO_4(g)$ can be inferred from vertical profiles of 13-cm absorptivity profiles retrieved from radio occultation experiments [1]. Data from 1979 and 1986–87 suggest that the abundance of $H_2SO_4(g)$ at latitudes northward of 70° decreased over this time period (see Fig. 1). This change may be due to a period of active volcanism in the late 1970s followed by a relatively quiescent period, or some other dynamic process in the Venus atmosphere. While the cause is not certain, such changes must be incorporated into dynamic models of the Venus atmosphere.

Potentially, the Magellan spacecraft will extend the results of Pioneer Venus Orbiter and allow the continued monitoring of the abundance and distribution of $H_2SO_4(g)$ in the Venus atmosphere, as well as other interesting atmospheric properties. Without such measurements it will be difficult to address other issues such as the short-term spatial variability of the abundance of $H_2SO_4(g)$ at similar latitudes in Venus atmosphere, and the identities of particles responsible for large-scale variations observed in NIR images [2].

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VARIATIONS IN LITHOSPHERIC THICKNESS ON VENUS. C. L. Johnson and D. T. Sandwell, Scripps Institution of Oceanography, La Jolla CA 92093–0208, USA.

Recent analyses of Magellan data have indicated many regions exhibiting topographic flexure [1,2,3]. On Earth, flexure occurs at oceanic trenches and around seamounts. On Venus, flexure is associated predominantly with coronae [1,3] and the chasmata within Aphrodite Terra [2,3]. Modeling of these flexural signatures allows the elastic and mechanical thickness of the lithosphere to be estimated. In areas where the lithosphere is flexed beyond its elastic limit the saturation moment provides information on the strength of the lithosphere. Modeling of 12 flexural features on Venus has indicated lithospheric thicknesses comparable with terrestrial values. This has important implications for the venusian heat budget.

Model: Flexure of a thin elastic plate due simultaneously to a line load on a continuous plate and a bending moment applied to the end of a broken plate is considered. The mean radius and regional topographic gradient are also included in the model. Features with a large radius of curvature were selected so that a two-dimensional approximation could be used. Comparisons with an axisymmetric model were made for some features to check the validity of the two-dimensional assumption. The best-fit elastic thickness was found for each profile crossing a given flexural feature. In addition, the surface stress and bending moment at the first zero crossing of each profile were also calculated.

Results: Flexural amplitudes and elastic thicknesses obtained for 12 features vary significantly. Three examples of the model fitting procedure are shown in Fig. 1, where the solid line is the data and the dashed line the best-fit model. The lowest elastic thickness was obtained at Nishtigri Corona (8–12 km) where the flexural amplitude is low (0.4 km). Nightingale Corona was typical of several other areas with elastic thicknesses in the range 18–25 km and a flexural amplitude of about 0.8 km. At W. Dali Chasma the lithosphere appears very thick (25–40 km) and the flexural amplitude is large (3 km); a similar result was obtained for other areas in Aphrodite Terra. However, the amplitude of the flexure at Artemis and Latona Coronae and at the chasmata of Aphrodite Terra is extremely large and it is likely that in these areas the lithosphere is flexed beyond its elastic limit. In some regions of extreme curvature it was not possible to model the topography to the base of the flexural moat (e.g., W. Dali Chasma, Fig. 1); this is probably due to extensive faulting. SAR images of several areas exhibiting flexure

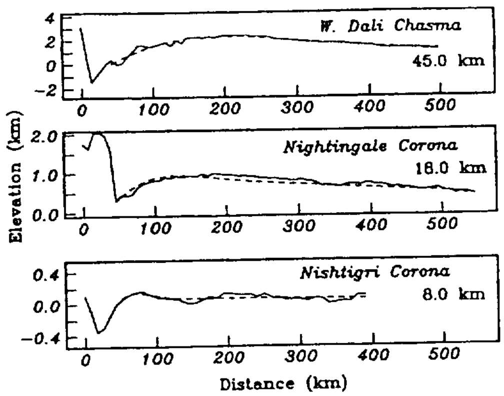

Fig. 1. Profiles (solid lines) and best-fit models (dashed lines) for three flexural features on Venus. The best-fit elastic thickness for each profile is indicated. Note the difference in vertical scales in each case. Elevation is relative to a datum of 6051.0 km.

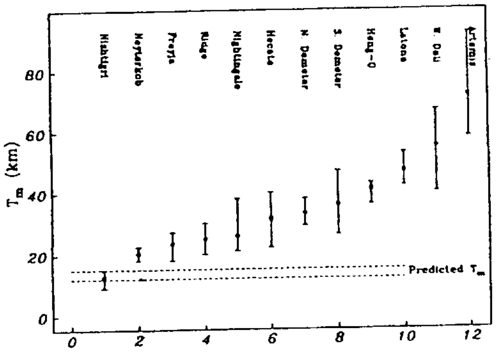

Fig. 2. Mechanical thicknesses obtained for 12 flexural features on Venus. Only Nishtigri Corona gives a lithospheric thickness compatible with that predicted (see text). The very high values obtained for Arcemis Corona and W. Dali Chasma are a result of the lithosphere being flexed beyond its elastic limit at these locations.

reveal circumferential fractures on the flexural outer rise, roughly coincident with the predicted location of high surface stresses.

Elastic thickness and curvature can be used to obtain mechanical thickness if the yield strength envelope for the lithosphere is known [4]. For features that are flexed beyond the elastic limit (i.e., moment saturated) an alternative approach is to calculate the thermal gradient directly from the saturation moment. Results from both these methods will be presented. Figure 2 shows the mechanical thicknesses obtained for Venus, assuming a dry olivine rheology, brittle behavior in the upper lithosphere, and ductile flow in the lower lithosphere [5]. Error bars are calculated from the range of best-fit elastic thickness for a given feature. The horizontal dashed lines are upper and lower bounds on the mechanical thickness expected for Venus, based on heat-flow scaling arguments [6]. It is evident that only one location studied gives a lithospheric thickness compatible with that predicted (15 km). The mechanical thickness at most other features is in the range 20–45 km. This implies mean heat flow values in the range 20–46 mW m^{-2}, much less than the predicted 74 mW m^{-2}. On Earth lithospheric thickness is related to age. Variation in lithospheric thickness obtained from different coronae on Venus may indicate relative ages and therefore provide a constraint on coronae evolution.

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IGNEOUS AND TECTONIC EVOLUTION OF VENUSIAN AND TERRESTRIAL CORONAE. J. S. Kargel and G. Komatsu, Lunar and Planetary Laboratory, University of Arizona, Tucson AZ 85721, USA.

A great variety of tectonic and volcanic features have been documented on Venus. It is widely appreciated that there are close spatial associations among certain types of tectonic structures and some classes of volcanic flows and constructs. Coronae are endowed with a particularly rich variety of volcanism [1,2,3]. It is thought that coupled tectonic and volcanic aspects of coronae are cogenetic manifestations of mantle plumes. An outstanding feature of most venusian coronae is their circular or elliptical shape defined by peripheral zones of fracturing and/or folding. Some coronae are composite, consisting of two or more small coronae within a larger enclosing corona, suggesting complex histories of structured diapirism analogous in some ways to salt dome tectonics [4]. Coronae range widely in size, from smaller than 100 km to over 1000 km in diameter [3].

Volcanic features associated with venusian coronae are further documented in Figs. 1–4. These include lunarlike sinuous rilles, thin lava flows, cinder cone-like constructs, shield volcanos, and pancake domes. Several types of volcanic features are often situated within or near a single corona, in many instances including landforms indicating effusions of both low- and high-viscosity lavas. In some cases stratigraphic evidence brackets emplacement of pancake domes during the period of tectonic development of the corona, thus supporting a close link between the igneous and tectonic histories of coronae. These associations suggest emplacement of huge diapirs and massive magmatic intrusions, thus producing the tectonic deformations defining these structures. Igneous differentiation of the intrusion could yield a range of lava compositions. Head and Wilson [5] suggested a mechanism that would cause development of neutral buoyancy zones in the shallow subsurface of Venus, thereby tending to promote development of massive igneous intrusions.

Large igneous intrusive complexes are common on the modern Earth, especially in magmatic arcs associated with subduction zones. Extensive igneous evolution occurs in magma arc batholiths [6], yielding compositionally diverse magmas. Large terrestrial layered basaltic intrusions, usually not associated with subduction zones, also have been common through Earth history. Some of these, including the famous Skaergaard Intrusion, have undergone considerable igneous differentiation without involving processes directly related to plate tectonics [7].

Although coronae are especially numerous and varied on Venus, Earth also has coronalike structures [8]. Whether terrestrial coronalike analogues truly involved the same tectonic processes responsible for venusian coronae is uncertain, but development of these struc-