MINERALOGY ON VENUS AND AREAS OF HIGH FRESNEL REFLECTION COEFFICIENT DETECTED BY MAGELLAN RADAR; J. A. Wood and K. B. Klose, Harvard-Smithsonian Center for Astrophysics, Cambridge MA USA

Radar surveys of Venus by orbiting spacecraft have yielded several different types of image. *SAR images* are synthesized from the signals returned after bursts of radar pulses are fired at a ground area, from a side-looking perspective, and the pulses are scattered by the roughness of the target area. *Emissivity images* are based on the amount of background microwave energy passively emitted by the target area and received by the SAR antenna at times when it is not firing pulses or receiving reflections. SAR images, which have higher resolution and display differences in slope and roughness, are useful for defining landforms. Emissivity images are more strongly affected by differences in the material properties of targets; in some circumstances inferences can be made about surface mineralogy [1,2]. (To greatly oversimplify, emissivity can be related to the Fresnel reflection coefficient [ρ] of the material, and this to its bulk dielectric constant [ε]. High values of ρ and ε appear to require that the surface material has a >~10% component of an *electrically conductive mineral.*)

Areas of the Venus surface reflective enough to (apparently) require an electrically conductive mineral were found by the Pioneer Venus radar mapper experiment [1,2]. In particular, elevated regions (Maxwell, Theia, Atla, Ovda) are highly reflective. Additionally, however, many lower-lying areas were found to display abnormally high reflectivity. [3] found from high-resolution ground-based radar studies of selected plains areas on Venus that low-reflectivity surface material appears to be locally underlain by high-reflectivity material. Magellan emissivity images have confirmed the Pioneer Venus observations, and extended them [4]. The improved resolution of Magellan emissivity images (~70 km) allows estimation of the altitudes above which surface material displays high Fresnel reflection coefficients. These are highly variable. Gula and Sif Mons have enhanced reflectivities above ~6054 km (planetary radius), but Maxwell Montes, the highest mountain on Venus, becomes highly reflective only above ~6058 km. Maxwell also displays a remarkable reversion to low reflectivities at the very highest elevations (Fig. 1).

Conductive minerals that have been proposed as constituents in Venus surface material which could account for locally high ρ and ε are pyrite (FeS_2) [5] and ilmenite ($FeTiO_3$) [6]. Measurements by S. D. Nozette, cited by [2], showed that rock containing 8 vol. % pyrite has a bulk dielectric constant of ~20, approximately what is called for by the high-ρ areas of Venus. In a companion abstract in this volume [7] A. Hashimoto and I show that under different conditions of temperature-- a function of altitude-- and atmospheric composition, chemically weathered basalt can contain pyrite (~8 vol. %), pyrrhotite ($Fe_{0.877}S$, ~7%), or magnetite (Fe_3O_4, ~5%). All are conductive minerals, but the effect of the last two in enhancing ρ of their host has not been measured. Magnetite is a ferromagnetic mineral, and its dielectric and magnetic loss tangents may be large enough to make it ineffective in this role.

The Magellan observations are not readily interpreted in the context of the phase diagram (Fig. 1) of [7]. Setting aside the possibility that each area with distinctive reflectivity represents an eruption of lava with suitably specialized mineralogy, two general models can be entertained.

1. Primary Venus basalt, like terrestrial basalt, does not contain a large enough component of conducting minerals, especially pyrite, to have a high value of ρ. With time it weathers in the Venus atmosphere to the stable mineral assemblages shown in Fig. 1 of [7], which include pyrite or pyrrhotite at high altitudes. This crudely accounts for the radiometric observations of high-ρ mountaintops, but it predicts that the changeover should occur at a uniform altitude, corresponding to a phase boundary in Fig 1. [6058.5 or 6060 km], which is not observed. Further, it does not account for surface and subsurface high-ρ material in the plains [3], or the reversion to low-ρ properties at the crest of Maxwell Montes.

2. Fresh Venus basalt contains a mineral, probably pyrite, that enhances ρ. This endures at high altitudes, but is destroyed by weathering at low elevations. Most of the same objections can be raised to this model as to 1., above. The existence of subsurface high-ρ material in the plains is accounted for, but not the persistence there of high-ρ ejecta [3].

The reversion to low-ρ properties of material at the crest of Maxwell Montes does not occur at a uniform altitude, nor does it correlate well with slope. The low-ρ band in Fig. 1 does closely follow an elongated ridgeline which forks at the north, suggesting that it may be due to a geometric effect in the data reduction rather than a change in material properties.

1. P. G. Ford & G. H. Pettengill (1983) *Science* ***220***, 1379. 2. G. H. Pettengill *et al.* (1988) *JGR* ***93***, 14881. 3. R. F. Jurgens *et al.* (1988) *Science* ***240***, 1021. 4. G. L. Tyler *et al.* (1991) Electrical and physical properties of Venus' surface from Magellan radar and radiometric observations. *Science*, in press. 5. G. H. Pettengill *et al.* (1982) *Science* ***217***, 640. 6. J. B. Garvin *et al.* (1985) *JGR* ***90***, 6859. 7. J. A. Wood and A. Hashimoto (1991) Weathering on Venus: Dependence of mineralogy on altitude and atmospheric composition. *LPS XXII*, this volume.

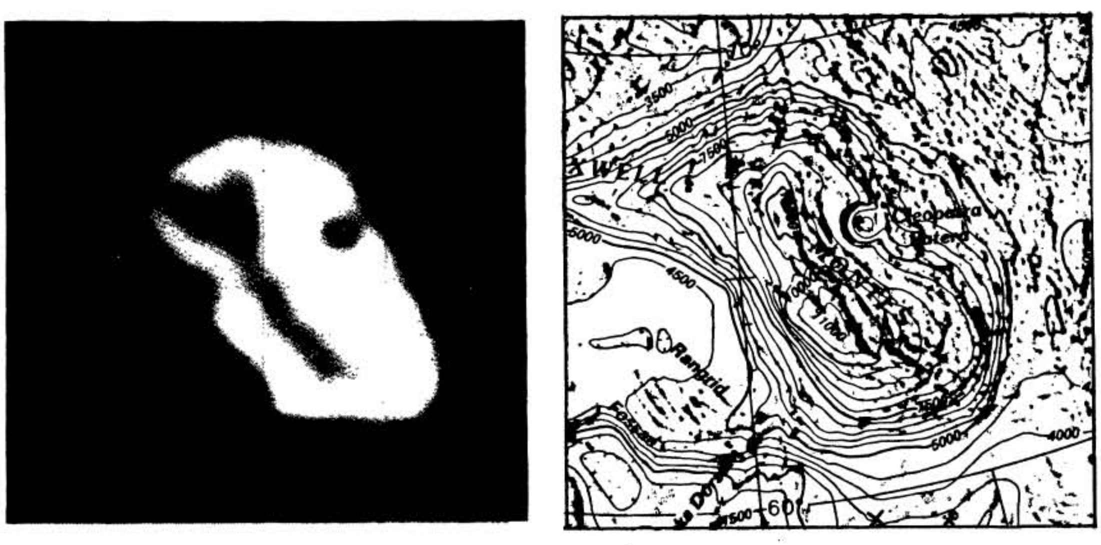

Figure 1. Maxwell Montes: Fresnel reflection coefficient (bright areas on left) and topography (right). The match in scale and projection between frames is not perfect. Width of frame, ~1200 km.