proposed by Izenber et al. [3]. They suggested that the observations can be explained by a random distribution of small volcanic events.

Strom et al. [8] have pointed out that a global resurfacing event that ceased about 500 MYBP is consistent with the results given by Arkani-Hamed and Toksoz [1]. These authors carried out a series of numerical calculations of mantle convection in Venus yielding thermal evolution results. Their model 4 considered crustal recycling and gave rapid planetary cooling. They, in fact, suggested that prior to 500 MYBP plate tectonics was active in Venus and since 500 MYBP the lithosphere has stabilized and only hot-spot volcanism has reached the surface. Thus they suggested that the transition to a near pristine lithosphere was the result of the secular cooling of the planet.

In this abstract we propose an alternative hypothesis for the inferred cessation of surface volcanism on Venus. We hypothesize that plate tectonics on Venus is episodic. Periods of rapid plate tectonics result in high rates of subduction that cool the interior resulting in more sluggish mantle convection. With a cool viscous interior the surface lithospheric plate stabilizes and plate tectonics cease. The stable lithosphere thickness increases with time reducing the surface heat flow. As a result the interior temperature increases leading to an increase in the plume flux. Eventually the lithosphere is sufficiently thick and its gravitational instability initiates an episode of global subduction.

This hypothesis is illustrated qualitatively in Fig. 1. During a period of about 500 m.y. the lithosphere is globally stable and no plate tectonics occurs. During this period the lithosphere thickens, the surface heat flow decreases, and the mantle temperature increases. As the lithosphere thickens it becomes gravitationally unstable. Eventually this instability leads to a catastrophic global subduction event. In the model illustrated in Fig. 1 this event occurred 600 MYBP. At the time of the global lithospheric instability the mantle on Venus is expected to be considerably hotter and less viscous than on the Earth so that rapid subduction would occur. Without a lithosphere, vigorous mantle convection would lead to extensive volcanism, vigorous plate tectonics, a high surface heat flow, and a rapid cooling of the mantle. As the mantle cools the mantle convection and its surface manifestation, plate tectonics, become less vigorous. Eventually the global lithosphere stabilizes and plate tectonics ceases. In the model illustrated in Fig. 1 this occurs at 500 MYBP. The lithosphere thickens, the surface heat flow decreases, and the cycle repeats.

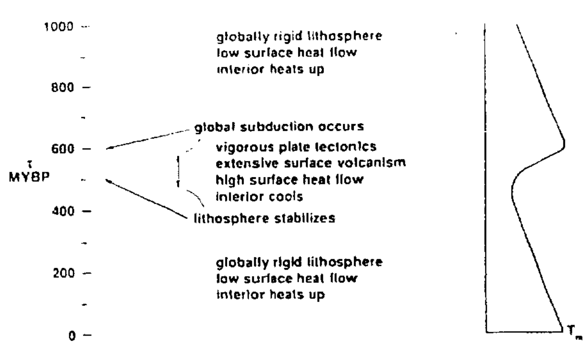

Fig. 1. Illustration of episodic tectonics on Venus for the last 1000 Ga. Also shown is the qualitative behavior of the mean mantle temperature T_m.

Assuming that the venusian lithosphere stabilized 500 MYBP, it is easy to determine its thermal structure, assuming no basal heating from mantle plumes and no partial delamination. After 500 m.y. the depth to the 1475-K isotherm is 290 km, the depth to the 1275-K isotherm is 180 km, and the depth to the 1125-K isotherm is 120 km. The corresponding depths for a venusian lithosphere with steady-state conductive heat transport are 34, 26, and 19 km respectively. The transient cooling of the lithosphere results in much greater thicknesses, almost an order of magnitude. Such a thick lithosphere is consistent with the large observed topographic and gravity anomalies.

McKenzie et al. [4] have argued that the perimeters of several large coronae on Venus, specifically Artemis, Latona, and Eithinoha, resemble terrestrial subduction zones in both platform and topography. Artemis chasma has a radius of curvature similar to that of the South Sandwich subduction zone on the Earth. Sandwell and Schubert [6] have shown that the morphologies of several coronae are in good agreement with the lithosphere flexure models that have been successful in explaining the sea floor morphology at ocean trenches on this planet. Their flexural profiles yield elastic lithosphere thicknesses of 37 km for Artemis, 35 km for Latona, 15 km for Eithinoha, 40 km for Heng-O, and 18 km for Freyja. These values are consistent with a thick conductive lithosphere. The presence of incipient subduction zones may be an indication of the onset of another episode of active plate tectonics.

References: [1] Arkani-Hamed J. and Toksoz M. N. (1984) *PEPI, 34*, 232–250. [2] Ghail R. and Wilson L. (1992) *LPSC XXIII*, 409–410. [3] Izenber N. K. et al. (1992) *LPSC XXIII*, 591–592. [4] McKenzie D. et al. (1992) *JGR*, submitted. [5] Parmentier E. M. and Hess P. C. (1992) *LPSC XXIII*, 1037–1038. [6] Sandwell D. T. and Schubert G. (1992) *LPSC XXIII*, 1209–1210. [7] Schaber G. G. et al. (1992) *LPSC XXIII*, 1213–1214. [8] Strom R. G. et al. (1992) *LPSC XXIII*, 1279–1380.

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SCATTERING PROPERTIES OF VENUS' SURFACE. G. L. Tyler, R. A. Simpson, M. J. Maurer, and E. Holmann, Center for Radar Astronomy, Stanford University, Stanford CA 94305-4055, USA.

Radar backscatter functions $\hat{\sigma}_0(\phi)$ for incidence angles between $0 \le \phi \le 4°–10°$ have been derived from Magellan altimetry radar echoes. The procedure includes constrained solution of a system of simultaneous equations for which the echo spectrum and echo time profile are inputs. A practical and workable set of constraints has been applied; optimization and improved results are expected as the analysis matures. The scattering functions yield information on small-scale surface structure (tens of centimeters to tens of meters) but averaged over hundreds of km^2. RMS surface slopes derived from fits of analytic functions to the $\hat{\sigma}_0(\phi)$ results have been converted to map form and show patterns similar to those reported using other techniques. While all three forms are found on Venus, fit residuals imply that an exponential scattering function matches data better than either the Hagfors or gaussian form in most areas, although the Hagfors function may be a better descriptor at some sites. Limited study of image data indicates that average backscatter cross section, and possibly its slope, can be derived at oblique angles ($17° \le \phi \le 45°$). Offsets of the echo peak in altimetry spectra are surprisingly common and are loosely correlated with Venus topography, but no cause for this phenomenon has yet been identified.

The observation that rms slopes obtained from direct inversion of the altimetry data are consistent, at least in a general way, with values derived from template fits [1] provides some confidence that both these procedures are reliable. Since the recovered functions from inversion $\hat{\sigma}_0(\phi)$ do not depend on *a priori* specification of an analytic function, we expect to find differences between our results and those obtained via the template method as our analysis proceeds.

Our result that an exponential scattering function can provide better agreement with data than the widely used Hagfors function is significant in terms of its implications for the surface. Although the difference is not large, it is convincing. A gaussian surface model is derived by assuming that the surface is gently rolling. A Hagfors surface must have at least a few flat segments and some "edges" in order to justify use of an exponential autocorrelation function. The degree to which a fresh planetary surface has been turned over and smoothed may be expressed in the degree to which its scattering is described by gaussian functions rather than Hagfors functions. The exponential function requires that there be more or larger flat-lying segments than even the Hagfors function requires. We note that while the exponential law works best for Venus, just the opposite is the case for the Moon [2]. It seems likely this difference reflects underlying differences in processes of erosion and deposition and of materials on the two bodies.

Our results from SAR image analysis to date are limited. We have found a smooth region (in altimetry data) east of Alpha Regio where SAR backscatter cross section is lower than predicted by the Muhleman function, suggesting that the same scattering mechanisms apply at both nadir and at $\phi \approx 30°$ and 35°. East of Maxwell, SAR backscatter is above average, but our estimates of rms slopes and those derived from template fitting [3] indicate that this is an "average" region in its nadir backscatter. The difference could be accounted for by the presence of small-scale roughness that is not apparent to the altimeter but scatters relatively strongly at oblique angles.

The Doppler offset observations appear to be real and a manifestation of a geophysical or geological state of the surface. They show global patterns that include a great circle at equatorial latitudes (roughly following the band of equatorial highlands that includes Aphrodite Terra, Eistla Regio, and Beta Regio) and at least part of another (constant latitude) circle at 40°–50° N. Large-scale surface slopes from Pioneer Venus topography [4] correlate to some extent, but are inadequate by themselves to cause the displacements observed. Small-scale "shingles" or other asymmetric scattering surfaces (for example, sand dunes [R. A. Arvidson, personal communication]) could contribute, but acquiring independent confirming data will be difficult. Local slopes of 0.3° on kilometer scales may also be important [P.G. Ford, personal communication], but more needs to be learned of their distribution. A concentration of negative offsets between Sapas Mons and Rusalka Planitia, where the large-scale surface gradient is perpendicular to the Magellan track, indicates that this phenomenon need not be associated with large-scale slopes. Global-scale "zones of disruption" [5] may have led to surface modification, which is expressed in small-scale surface features but does not necessarily show up in the large-scale topography.

References: [1] Ford P. G. and Pettengill G. H. (1992) *JGR*, submitted. [2] Simpson R. A. and Tyler G. L. (1982) *IEEE Trans., AP-30*, 438–449. [3] Tyler G. L. et al. (1991) *Science, 252*, 265–270. [4] Sharpton V. L. and Head J. W. (1985) *JGR, 90*, 3733–3740. [5] Schaber G. G. (1982) *GRL, 9*, 499–502.

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LOW-EMISSIVITY IMPACT CRATERS ON VENUS. C. M. Weitz[1], C. Elachi[1], H. J. Moore[2], A. T. Basilevsky[3], B. A. Ivanov[4], and G. G. Schaber[5], [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena CA 91109, USA, [2]USGS, Menlo Park CA 94025, USA, [3]Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences, Moscow, 117975, Russia, [4]Institute for Dynamics of Geospheres, Russian Academy of Sciences, Moscow, 123810, Russia, [5]USGS, Flagstaff AZ 86001, USA.

Procedure: An analysis of 144 impact craters on Venus has shown that 11 of these have floors with average emissivities lower than 0.8. The remaining craters have emissivities between 0.8 and 0.9, independent of the specific backscatter cross section of the crater floors. These 144 impact craters were chosen from a possible 164 craters with diameters greater than 30 km as identified by Schaber et al. [1] for 89% of the surface of Venus. We have only looked at craters below 6053.5 km altitude because a mineralogical change causes high reflectivity/low emissivity above this altitude [2]. We have also excluded all craters with diameters smaller than 30 km because the emissivity footprint at periapsis is 16 × 24 km and becomes larger at the poles [3].

On the SAR images, rectangular boxes were chosen on the crater floor that avoided central peaks and inner rings. Backscatter cross sections were calculated from the average DN values within the boxes for the incidence angle for the crater latitude. Emissivity values were taken from the datasets produced by MIT [3]. A rectangular box was selected inside each crater floor and the average DN was then converted to emissivity. In Fig. 1, while the majority of crater floors lie between 0.8 and 0.9 in average emissivity independent of backscatter cross sections, 11 craters fall below this range.

We also found all craters that had any emissivity values on their floors below or equal to 0.8 because several craters had variations across their floors. After doing this, we found five more crater floors with emissivity values below or equal to 0.8. Table 1 lists the 16 craters and the lowest emissivity values found on their floors. The 16 craters represent a minimum number of craters with low emissivities on Venus because craters with diameters smaller than the footprint of the radiometer may have low emissivities that will not be detected.

Results: A study of backscatter and emissivity for impact craters associated with parabolic-shaped features by Campbell et al. [4] indicates that the majority of these craters have high specific

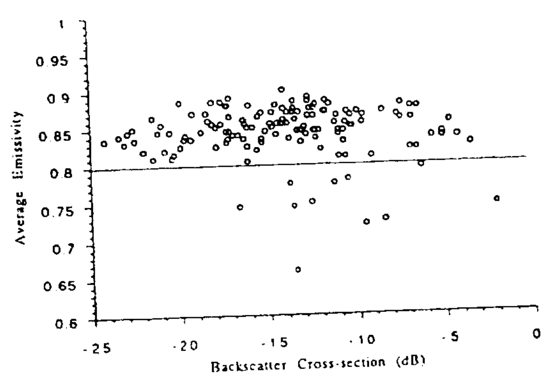

Fig. 1. Emissivity and specific backscatter cross section for 144 craters on Venus.