

# Rapid lithification masks the Venus sedimentary cycle

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## Abstract

Venera lander data are usually assumed to indicate basaltic lavas but a significant fraction of the rock material must be volatiles, such as sulphur, implying at least strongly weathered basalts. The lander images most closely resemble sedimentary material, with layered strata (which may be pyroclastic in origin) that are sometimes broken into cobbles and fine grained sediment. The Magellan SAR was relatively insensitive to loose fine-grained material under Venus surface conditions but the reprocessed data reveal a range of weathering processes, particularly at higher elevations, and mass wasting of steep slopes. Mean wind speeds are strongly altitude dependent and are able to erode and transport material throughout the highland regions. In some areas, this material is deposited on adjacent plains where, under the extreme Venus surface conditions, lithification is an apparently rapid process. Thus the largely featureless plains may not be igneous at all but sedimentary in origin. The settling out and lithification of sedimentary material is consistent with observed crater degradation, in which low-lying crater floors are infilled first.

## 1. A Sedimentary Landscape

These detailed observations of surface processes challenge accepted views about Venus and reveal a much more complex and active geological picture, with evidence for a complete sedimentary cycle and significant exchange of materials, particularly volatiles, between the interior and atmosphere.

Ten spacecraft, all Soviet, have successfully operated on the Venus surface, including the first ever successful landing on another planet. With the possible exception of Venera 8, the X-ray fluorescence and  $\gamma$ -ray spectrometry data obtained by a number of these landers were all interpreted to indicate weathered basalts (Barsukov et al., 1982),

consistent with the extensive volcanism evident in Magellan imagery. However, the four landers to successfully return surface images, Veneras 9, 10, 13 and 14, show little in common with basaltic flows on other planets.

The simplest interpretation is that while the surface materials are geochemically basaltic in origin, the primary igneous rocks were weathered, transported and deposited as wind-blown sands that lithified into sandstones. From their appearance, chemistry and mechanical properties the rocks might best be described as lithic arenites. Some time after lithification, these rock were jointed, perhaps by tectonic processes, weathered and then disaggregated into well graded gravels, with any fines removed by wind, presumably to be deposited elsewhere in a repeat of the cycle.

## 2. Mass Wasting

Further evidence for a sedimentary cycle is apparent in Magellan imagery (Figure 1). Venera 9 is inferred to have landed on a talus slope. Small-scale steep slopes are very common on Venus, most often associated with normal faulting and graben, and mass wasting is an equally common and probably frequent occurrence (Malin, 1992). At higher elevations, these materials appear to be strongly affected by surface winds but counterintuitively the mass wasted slopes have reflectivity characteristics consistent with lithified sediments, not loose accumulations. The low resolution of the altimeter (from which the density of surface materials is derived) of course implies a mixed signal—the red areas may well be a mixture of high dielectric (highland) material and sediments, while the green areas to the east may likewise be a mixture of talus and volcanic rock—but even relatively large areas of streamlined material have the signature of lithified sedimentary rock rather than loose regolith. Lithification must therefore be

relatively rapid, as might be expected under the supercritical PT conditions of the Venus surface.

### 3. Conclusions

The Venus landscape consists mainly of sedimentary materials, with little evidence of volcanic rocks, in stark contrast to the global picture of a planet dominated by volcanism. Geochemical data imply that the sedimentary materials were of volcanic origin and subsequently weathered and transported. Rather than an absence of sediment supply, the lack of extensive regolith may be a consequence of

relatively rapid lithification in the supercritical fluid atmosphere, with carbonate (calcite) and/or sulphate (anhydrite) the most likely cements.

### References

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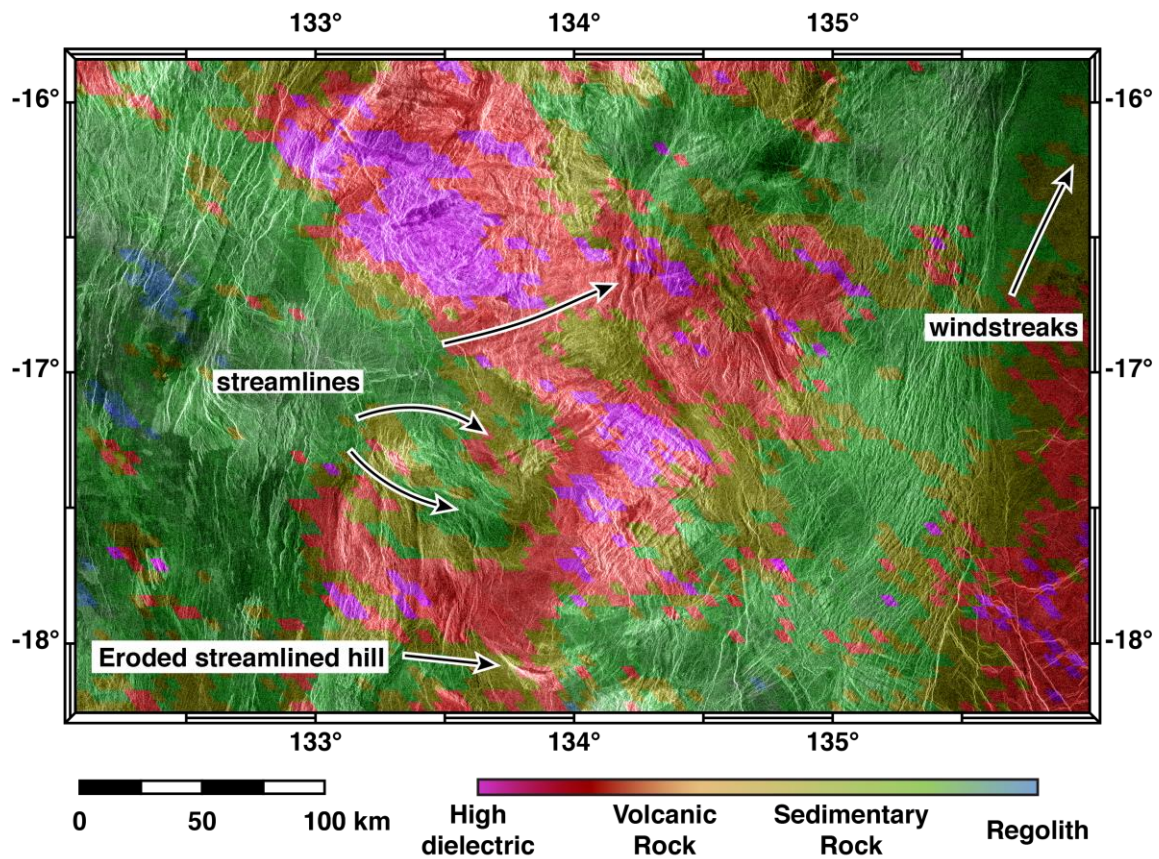


Figure 1: Windblown sediments in south east Thetis Regio shown on derived surface materials.