SURFICIAL DEPOSITS AND ACCESS TO MATERIALS WITH KNOWN GEOLOGICAL CONTEXT ON VENUS.

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Introduction: Landing on Venus and geochemical investigations of Venusian materials either in-situ or with returned samples are thought to be of the highest priority in future scientific robotic exploration of Venus. Harsh conditions at the surface strongly limit mobility and operations at the landing sites, as well as the total number of different samples that can be analyzed. This makes it especially important that the samples are taken from known and pre-planned geological situation; for example, it would be desirable to understand, how to reliably get unaltered igneous material, altered material form a known source, etc. This is not easy, because remote sensing of Venusian surface is principally limited due to thick layer of clouds. Here I summarize relevant current knowledge on Venusian surface layer and apply it to analysis of accessibility of materials with known geological context. I consider here typical terrains in the vast Venusian plains and do not consider the exotic materials at high elevations.

Volcanic units seen in SAR images. Information about geology and surface properties has been obtained mostly with microwave remote sensing techniques. Imaging with the synthetic-aperture radar (SAR) on the Venera-15,-16 Venus orbiters, then from the Earth with the Arecibo radar facility, and, finally, by the Magellan orbiter has revealed a spectacular surface dominated by extensive volcanic deposits and deformed by abundant tectonic features. The generally pristine appearance of the volcanic morphologies indicates a very low rate of exogenic resurfacing during the recent half-a-billion years long geologic history. This pristine morphology gives a good chance that the original volcanic material is preserved, but it would be wrong to assume that it is accessible immediately at the surface. The sharp lava flows outlines seen as pristine morphology in the SAR images (the best resolution is ~200 m) can be preserved even if the original flow surface is heavily reworked or covered by meters of secondary surficial deposits. A number of lines of evidence show that this is the case in many locations on the planet.

Dust deposits: There are about a thousand of impact craters on Venus. Impact process inevitably produces at least some fine dust, which was inevitably suspended in the dense atmosphere and could be redistributed and deposited regionally or globally. Such dust can contaminate the surface with altered materials from distal sources. Thin (a centimeter or thinner) dust does not have any unique signature in the microwave remote sensing data. Deposits of fine dust under the Venusian conditions will sinter. It is probable that it will be difficult to distinguish between sintered dust and rinds of altered local material, if we try to do this with panoramic or microscopic images. In any geological situation at the landing site, least some digging and/or rock abrasion capability is needed to be sure that samples are local materials rather than altered dust deposits from unknown source.

Surficial deposits at Venera landing sites: The morphology of the surface seen in the panoramas taken by Venera landers is not consistent with unaltered lava flows. Two of four panoramas contain soil. Rocks seen in the panoramas were reported to be similar to indurated sediments [1,2] or degraded lava flows [3]. Some lander data also indicate low density and mechanical weakness of the surface material [e.g., 4, 5]. Surface at the landing sites perhaps contains altered and/or nonlocal material.

Surficial deposits seen in the SAR images: Magellan SAR images revealed a number of eolian features: different types of wind streaks, two large fields of dunes and a few occurrences of unresolved microdunes [e.g. 6, 7]. It is not known , if such features form due to eolian reworking of local material or there is regional or global transport. Additional analysis of available remote sensing data may give some additional information on this.

A significant part of the surface is covered by extended crater-related diffuse features, including parabolas [e.g., 8, 9]. Several independent lines of evidence suggest that these features are mantles of microwave-transparent material with flat upper surface. The most important of such observations are: observation of a linearly polarized component in the Arecibo dual-polarization radar imaging experiment [10], the absence of decameter-scale topographic asymmetry [11], and low decameter-scale roughness. These observations are consistent with commonly accepted interpretation of the parabolas as airfall deposits of loose material ejected by impact events and moved westward by atmospheric superrotation. Pristine parabolas can give easy access to material from known source. This material can be altered, but alteration conditions in this case are well understood.

Indirect indication of surficial deposits from microwave remote sensing. Observations of backscattering anisotropy in the Magellan radar altimeter experiment indicate ubiquitous asymmetry of surface topography at the scales of decameters [12, 11]. This asymmetry has been attributed to the presence of decameter-scale eolian bedforms. In [13] similar ubiquity of meter-scale asymmetric features has been found from analysis of left- and right-looking Magellan SAR images. These observations clearly indicate that loose material reworked by wind is much more abundant than would be deduced from observations of eolian features with SAR mosaics. It is not known, if these eolian bedforms are active now or if they recorded wind action in the geological past. It is possible that all eolian activity occurred only during short periods of atmospheric disturbance caused by large meteoritic impacts. It is also unclear, if eolian activity is / was able to move material for long distances to produce global material mixing, or the bedforms reflect only local reworking of the material. However, it is clear that some surficial deposits are present almost everywhere.

Some crater-related parabolic features seen in the microwave emissivity maps [14] are invisible in the SAR mosaics; probably, such features represent thin deposits. Emissivity maps as well as Aresibo dual-polarization SAR maps [10] and Magellan bacscattering anisotropy maps [11] show that the spatial extent of the smooth-surface mantle is significantly wider than the dark parabolas and halos seen in the SAR mosaics [15]. This again shows the presence of surficial deposits in places where they are unseen in the SAR mosaics.

Stratigraphically older surfaces usually display lower contrasts in radar cross-section than the young surfaces, which points to some processes of surface aging [16]. This is naturally explained by accumulation of the surficial materials, which replace the originally varying backscatter signature of volcanic units with uniform properties of eolian deposits.

From analysis of the Magellan radiometry results together with SAR images it was found [17] that locally older volcanic units tend to have relatively lower dielectric permittivity of surface material. This shows that some kind of surface aging occurs. The nature of this process is not known: it can be either progressive local chemical weathering or progressive accumulation of eolian deposits. Patchiness of occurrence of dielectric permittivity contrasts between volcanic units points to the latter option. The patches, where such contrasts are observed, perhaps have less extensive coverage with recent surficial deposits; stratigraphically younger units in such regions are places where original volcanic rocks can be easily accessible. Additional studies involving all available remote sensing data are necessary to find good candidate areas and quantify the depth at which bedrocks can be reliably accessible.

Fresh volcanic rocks: The observations mentioned above suggest that volcanic units with the highest dielectric permittivity (the lowest microwave emissivity) are places with the least contamination with eolian material, places where original volcanic material can be readily accessible at the surface. The highest dielectric permittivity of lava flows at low elevation (the peculiar material at high latitudes is not considered here) is about 10 - 12. This has been thought to be too high for unaltered volcanic rocks and the transient presence of pyrite has been involved for explanation [18]. This, however, is not necessary, because at Venusian high temperatures the dielectric permittivity of materials is higher than at laboratory temperatures. On Venus, bedrocks of mafic Fe-rich composition can have dielectric permittivity as high as 10 - 12.

Conclusions:

(1) Mixed dust of ambiguous source and alteration history can contaminate the surface (everywhere) and shallow subsurface (almost everywhere).

(2) If we avoid parabolas, dune fields, etc. and want to get an unaltered sample from a given volcanic unit seen in Magellan SAR mosaics, then a few meters drilling capability is needed.

(3) It is probable that there are regions, where unaltered volcanic bedrock can be reached at the depth of a few decimeters or less. Additional analysis of the available data sets is needed to make an inventory of such regions and reliably estimate the depth.

(4) There are a few small (tens of km) areas, where there is a good chance to access unaltered lavas just at the surface (< 1 cm deep).

(5) Crater-related parabolas give easy access to material ejected by from known site.

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