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Near infrared imaging of the surface of Venus and implications for crustal composition

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Venus Express is an ESA spacecraft orbiting Venus since April 2006. The instrument VIRTIS acquires multispectral images in the range from 0.2 to 5 μm wavelength. An analysis of VIRTIS images at the wavelengths of the atmospheric window at 1.02 μm shows evidence for variation of surface emissivity on the southern hemisphere [Mueller et al. 2008]. Inferred surface emissivity is correlated to some extend with morphological units identified from radar images of the NASA/JPL Magellan mission [Tanaka et al. 1997]. Alpha and Phoebe Regios are highlands mostly composed of tessera terrain, which is defined as a region strongly deformed by compressive and extensional tectonism in at least two directions. In comparison to lowland plains and other less tectonized highlands, these regions generally emit less thermal radiation, which implies lower emissivity. A recent analysis of NIR data from the Galileo fly-by in 1990 finds, that highland regions on Venus on average have a lower emissivity than lowlands [Hashimoto et al. 2008]. As a significant part of Venus highlands in the area observed by Galileo is composed of tessera, this observation is consistent with the observation of Mueller et al. [2008].

In situ measurements by the Venera and Vega landers are at most places consistent with basaltic surface composition. The hypsometry of Venus is unimodal. Inferred lava viscosity of most volcanic features is low, consistent with basaltic composition. All these observations hint towards a crust mostly composed of basalt [Basilevsky et al 1997]. However, no landing site was on tessera terrain, tessera are hypsometrically elevated and the morphology is dominated by tectonic deformation. Among other arguments this leads to the hypothesis that tessera highlands crust is more abundant in feldspar and silica, comparable to lunar highlands or continents on Earth [Nikolaeva et al., 1992]. NIR mapping supports this hypothesis, although other interpretations of the NIR data can not be ruled out.

Generation of felsic crust is unlikely under the current climatic and tectonic regime on Venus. The lunar highland crust is believed to be a remnant of an magma ocean [Taylor 1974]. Enrichment in silica as in the continental crust of Earth requires recycling of water into the mantle [Campbell and Taylor 1984]. The surface of Venus is extremely dry and Venus and crustal recycling by plate tectonics does not operate at present. Any crust with felsic bulk composition had to be created during the early history of the planet. In a stratigraphic analysis tessera terrain predates all units it is in contact with [Ivanov and Head 1996]. Tessera terrain is defined by an extensive history of tectonic deformation. Assuming that tessera highlands indeed represent less dense crustal blocks created early in the history of Venus, implications arise from their persistence on the surface of Venus regarding resurfacing mechanism, crustal recycling and thermal evolution. If tessera highlands are enriched in silica relative to basalt this implies existence of a primordial ocean on Venus [Hashimoto et al. 2008]. In either case Venus would even more closely resemble the Earth-Moon system than previously assumed, making Venus an excellent subject for general studies of earth-like planets.

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