ANDESITES ON MARS: IMPLICATIONS FOR THE ORIGIN OF TERRESTRIAL CONTINENTAL CRUST. Paul D. Lowman Jr., Mail Code 921, NASA Goddard Space Flight Center, Greenbelt MD 20771, USA.

The Alpha Proton X-ray Spectrometer (APXS) on the Mars Pathfinder rover (Rieder et al., 1997) produced analyses in the X-ray mode of 5 rocks with chemical compositions (62.0$\pm$2.7% SiO2 "soil-free rock") corresponding to andesite. The APXS soil analyses resemble those from the Viking landers, providing a field comparison. Furthermore, the Mariner 9 mission in 1972 had produced thermal emission spectra of suspended dust indicating a composition averaging 60$\pm$10% SiO2, corresponding to "an intermediate igneous rock"(Hanel et al., 1972a,) and implying "substantial geochemical differentiation of Mars." An identical instrument on a Nimbus satellite had previously produced similar dust spectra over Africa (Hanel et al., 1972b), which,if representative of the surface, support the similarity between the terrestrial and martian crusts. Viewed in historical context, and in light of martian geology, the APXS results can be considered both accurate and reasonably representative of the composition of the highland crust of Mars.

An andesitic composition for the martian highland crust was predicted as a test of a general theory for the origin of continental crust (Lowman, 1989). The Pathfinder data provide the first tentative confirmation of this prediction. The present paper discusses the implications of the Pathfinder results, and other post-1989 findings, for the Earth's continental crust.

The general stages of crustal evolution in Mars (Fig. 1) have been clear for two decades (Lowman, 1976). The Pathfinder data confirm the felsic "first differentiation" and indicate that, as predicted, magma generation under hydrous conditions (Yoder, 1976; Morse, 1986) produced andesite, in contrast to the basalt and differentiation products thereof (e.g., anorthosites) making up the lunar highland crust. A basaltic "second differentiation" in Mars has been confirmed by the SNC meteorites. Unlike the Earth, this evolutionary path has not involved plate tectonics, beyond the initial crustal fragmentation indicated by the Valles Marineris and similar features.

The bulk chemical composition of the crust of Venus is not known, although basalts have been found by two Soviet landers. However, the unimodal topography of Venus, and the typically continental tectonic style revealed by the Magellan radar (Solomon et al., 1992), are consistent with global differentiation, but as for Mars, without the involvement of plate tectonic processes.

Collectively, these discoveries imply that silicate planets can undergo early global differentiation by igneous processes not depending on sea-floor spreading and subduction. This concept runs counter to prevailing views on the origin of the Earth's continental crust, which is widely believed to have been formed by long-term andesitic volcanism and terrane accretion. There is no doubt (Marsh, 1976;Wyllie, 1988) that most Phanerozoic andesitic volcanism is subduction-related, but this is probably not the dominant process by which continental crust has over geologic time been extracted from the mantle. An intermediate composition for much of the lower continental crust granulites, and other geologic evidence (Lowman, 1984, 1989), points to formation of most continental crust in the earliest Archean (Armstrong, 1981), by andesitic volcanism accompanying outgassing of the primordial mantle. It is impossible to show that this early crust was global, other than by analogy with the global first differentiation on other planets (notably Mars), but the mafic/sialic crustal dichotomy of the Earth may be the eventual result of major impacts corresponding to the basin-forming impacts on the Moon and Mars (Frey, 1980). Formation of the Moon by a large impact on the primordial Earth may also have contributed to disruption of the earliest crust.

This theory for the origin of continental crust is a radical but testable one, and has so far passed "the most significant" (Lowman, 1989) test. Further exploration of Mars with *in situ* analyses will permit additional evaluation. Even if disproved, the theory illustrates the value of comparative planetology in throwing new light on the crustal evolution of the Earth.

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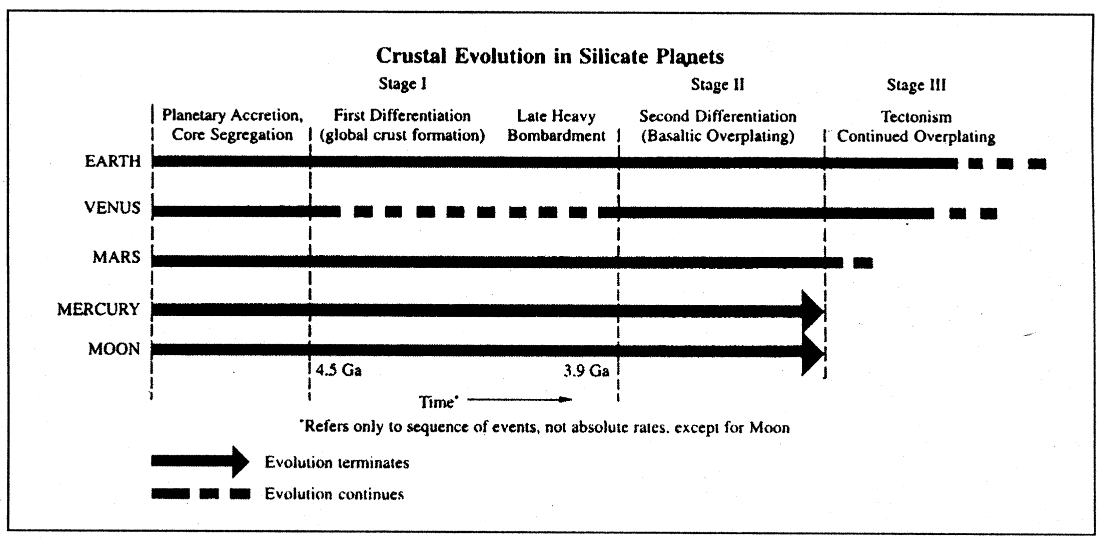

Fig. 1. Crustal evolution in silicate planets.