ROCKS OF ANDESITIC COMPOSTION AT THE MARS PATHFINDER SITE: WHAT DO THEY MEAN? H. Y. McSween, Jr., J. P. Greenwood, and A. Ghosh, Department of Geological Sciences, University of Tennessee, Knoxville TN 37996-1410 (mcsween@utk.edu).

Preliminary APXS analyses (X-ray mode only) of five rocks at the Mars Pathfinder landing site define nearly linear arrays on multi-element diagrams, with soils plotting at one end [1]. The most straightfoward interpretation of these arrays is that they are mixing lines between a single rock composition and soil (either adhering dust or a soil-like weathering rind), an inference supported by a correlation between the sulfur contents of the rocks and their red (750mm) to blue (440 mm) spectral ratios [2]. Because the solubility of sulfur in magmas at reasonable oxidation states is very low, extrapolations of regression lines in plots of oxides versus sulfur to zero sulfur give the composition of the rock [1] if it is igneous. A provisional C.I.P.W. norm for the sulfur-free rock consists primarily of hypersthene, diopside, feldspars, and quartz, and the relative proportions of these phases are consistent with those of common terrestrial volcanic rocks. Even if the Pathfinder rocks are conglomerates, as might be suggested by some textural observations [3], their compositions may mimic those of their igneous protolith. Based on a silica versus alkalis diagram used for classification of volcanic rocks [4], the sulfur-free rock plots within the field of andesite. The rock also conforms to the definition of andesite given by [5]: "a hypersthene normative volcanic rock with 53-62 wt % silica calculated on an anhydrous basis."

The interpretation of the Pathfinder rocks as andesites may seem inconsistent with the apparent absence of a ~1 mm pyroxene absorption band in the IMP spectra of relatively dust-free rocks. In rocks containing high-calcium and low-calcium pyroxenes, the absorption bands overlap. The compositions of normative hypersthene and diopside in the sulfur-free rock (which would presumably be represented in the real rock by pigeonite and augite, respectively) are exceptionally rich in iron, and the position of the composite absorption band for such iron-rich pyroxenes appears to fall at a wavelength slightly greater than 1 mm [6]. Thus it might lie outside the IMP spectral range.

The composition of the sulfur-free rock is distinct from terrestrial andesites occurring at destructive plate margins, which have relatively high alumina and often define calc-alkaline differentiation trends. The Pathfinder rocks, like SNC meteorite liquids, are clearly tholeiitic with high iron and low aluminum abundances. The closest compositional matches for the sulfur-free rock among terrestrial volcanic rocks are anorogenic andesites (commonly called "icelandites"), which have lower Al_3O_3 and higher FeO^* at a given SiO_2 content [5], relative to orogenic andesites.

A comparison of the sulfur-free rock composition with fractionated icelandites from the Galapagos Spreading Center and the experimentally determined Galapagos liquid line of descent [7] demonstrates their similarities. Only TiO_2 differs markedly, suggesting that the

Pathfinder andesites could also have formed by simple fractional crystallization of a ferrobasalt magma. We have also estimated the liquid line of descent for the Shergotty intercumulus melt (a Martian ferrobasalt), to ascertain if shergottite-like liquids could have been parental to the andesite. Calculations using the MELTS program indicate that fractionation of shergottite liquids apparently cannot generate the Pathfinder andesite composition.

The Pathfinder location was originally selected, in part, on the premise that it might be a "grab bag" site containing ancient crustal rocks carried by floods from the southern highlands. However, the 800-kilometer distance to the highlands boundary, the recognition that terrestrial floods do not carry rocks great distances, and the angularity of many boulders all suggest that rocks at the Pathfinder site may have been locally derived. A more plausible explanation for these rocks is that they formed by fractional crystallization of a basaltic magma, possibly represented by rocks of the Hesperian ridged plains unit that dominates the local bedrock. There is no need to argue that these andesites imply an important role for water in their petrogenesis, or for the existence of Martian plate tectonics.

Comparisons of liquid lines of descent suggest that the parental basaltic magma for the Pathfinder rocks would have had a higher alumina content than SNC melts, more akin to that of MORB. This may indicate a more primitive mantle source, one that had not yet been depleted in Al_2O_3 by partial melting [8]. Given that Mars differentiated very early [9], this may imply an ancient age for the Pathfinder rocks. Perhaps they are samples of Noachian crust that may underlie the Hesperian ridged plains unit at the Pathfinder site.

References: [1] Rieder R. et al. (1997) *Science , 278,* 1771. [2] Bridges N. et al. (1997) *EOS* 78, F402. [3] Matijevic J. et al. (1997) *Science , 278,* 1765. [4] Le Bas et al. (1986) *J. Petrol. , 27,* 745. [5] Gill J. (1981) *Orogenic Andesites and Plate Tectonics*, Springer-Verlag. [6] Cloutis E.A. and Gaffey M.J. (1992) *J. Geophys. Res. , 96,* 22, 809. [7] Juster T.C. et al. (1989) *J. Geophys. Res.* , *94,* 9251. [8] Longhi J. et al. (1992) *Mars*, 184. [9] Lee D.C. and Halliday A. N. (1997) *Nature , 388,* 854.