THE EFFECT OF THIN COATINGS OF DUST OR SOIL ON THE BULK APXS COMPOSITION OF THE UNDERLYING ROCKS AT THE PATHFINDER LANDING SITE.

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Geochemical trends of the rocks and soils at the Pathfinder landing site, monochrome lander and rover camera images, and red/blue ratio lander camera images all indicate that the rocks at the Pathfinder landing site are probably contaminated to varying degrees by coatings of soil or dust [1,2,3]. Even if we can unravel the dust and soil signature from the Alpha Proton X-ray Spectrometer (APXS) analyses, we may not recover a pristine igneous composition. The lack of diagnostic rock textures found so far in Pathfinder images means we cannot rule out the possibility of a sedimentary, metamorphic, or igneous origin or the possibility that the rocks are strongly altered, possibly throughout [4]. However, it is still worth investigating the possible chemical effects of a thin coating of dust.

Standard linear mixing models can be used to unravel dust and underlying rock composition for bulk analyses made on rock surfaces that are covered primarily by patches of no dust and patches of thick dust (thicker than the APXS sampling depth of approximately 100 micrometers). Here the problem is primarily an areal mixing one, and the bulk analysis is a combination of exposed rock and dust, each weighted according to its area percentage. For rock faces having a dust coating that is in most places less than 100 micrometers thick, a bulk APXS measurement is not a simple linear mixture of dust and underlying rock.

The geometric arrangement of dust on the surface of the rocks at the Pathfinder landing site is unknown at the 10 to 100 micrometer scale. Most rocks are rough at that scale and the dust, or varnish if there is a varnish, is likely to be more concentrated in nooks and crannies rather than forming a coating of even thickness. The physics of scattering and absorption add even more complexity to the measurement of thinly coated rocks by the APXS. Despite all of these issues, it is likely that the percentage of dust component in a bulk APXS analyses is higher for the lighter elements than for the heavier elements because the x-rays for the light elements are absorbed by the sample more than they are for the heavy elements. The sampling depth for light elements like sodium is approximately 10 to 20 micrometers, and for heavy elements like iron it is approximately 50 to 100 micrometers [Economou and Rieder, pers. comm.]. The APXS does not measure absolute amounts; rather, the sums of the oxides or elements must be renormalized to 100% or some chosen value. Thus, the bulk APXS analysis of a rock with a thin dust coating is a combination of dust and rock, each weighted so that the fraction of dust rises with atomic weight from sodium to iron, and then the total is renormalized. These weightings cannot be known because of the unknown dust and rock surface geometry, but the relative order of weighting from Na to Fe does provide a constraint and if a composition is assumed for the dust, a range of reasonable mixtures can be assessed. Although not all possible weighting combinations can be examined, ones that do fit the constraint (order of weighting) can demonstrate the possible difference from a simple linear mixing.

Two of the five Pathfinder rock analyses reported in [2] are andesitic in composition with 59-61% SiO_2 (Shark and Barnacle Bill), and sulfur contents of 0.3 and 0.9 wt% S, respectively. The other three (Half Dome, Wedge, and Yogi) are higher in sulfur (1-1.6 wt% S) and have bulk compositions that are comparable to a basaltic andesite (52-55 % SiO_2). The linear trends in composition and the unusually high sulfur contents suggested the possibility that the APXS analyses of rocks are contaminated by dust and/or soil, with sulfur a direct indicator of the degree of contamination [2]. An extrapolation of the linear trends to zero sulfur suggested the underlying rock has an andesitic composition with 62% SiO_2 [2], similar to Shark.

An approach using arbitrary weighting schemes but maintaining the order of weighting with atomic number provides some alternatives to the composition of the underlying rock. The primary result is that the underlying rock does not have to be more or less silica rich as that predicted by the linear mixing model. For instance, assuming a dust coating similar to the A-5 soil in which the contribution of dust to the bulk composition varies from 48% (Na) to 10% (Fe), the underlying rock for Wedge could have a normal sulfur content (0.1 % S) and a silica content of 56%. An example of a higher silica substrate is provided by a dust coating of A-10 composition on Yogi, in which the contribution of dust varies from 65 (Na) to 50% (Fe). In this case, the underlying rock could be 66% dacite.

Although the examples here use soil compositions as the dust cover, the fallout dust may not have the same composition. Separate calculations could be done on speculative dust compositions. This same modelling approach could be used to examine the possible effects of thin varnish or weathering rinds and should be kept in mind when using bulk APXS rock analyses. If coatings are suspected to be between 10 and 100 micrometers thick, or compositional zonation with depth is expected on that scale, then a simple linear mixing model is not strictly valid.

REFERENCES

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[4] Parker, T.J., et al., this volume.