of varying amounts of ancient, highly radiogenic, light REE-enriched crust by melts from a depleted mantle [*Borg et al.*, 1997; *McSween*, 2002]. The assimilated material was similar in many respects to the lunar KREEP component. Alternatively, these correlations could indicate mixing of materials from complementary enriched and depleted reservoirs within the Martian mantle [*Wadhwa and Grove*, 2002; *Borg et al.*, 2003]. In this case, the depleted and enriched regions must have been isolated by an early differentiation event, possibly creating a shallow, enriched mantle and a deep, depleted mantle. A correlation between the degree of geochemical contamination and magmatic oxidation state [*Wadhwa*, 2001; *Herd et al.*, 2002] is consistent with crustal assimilation, although recent evidence shows that the depleted source region for nakhlites could also be derived from an oxidized mantle reservoir [*Wahdwa and Grove*, 2002].

[14] For the moment, let us assume that the assimilant was crust. Can we use the composition of this component to constrain the nature of the ancient crust through which the shergottites erupted? Unfortunately, it is easier to determine the isotopic and trace element compositions of this component than its major element abundances or petrologic identity. It is not even clear if this component was actually rock or a fluid that either metasomatized the shallow mantle or scavenged solutes from the crust. If rock was assimilated, the ancient crust probably has a basaltic composition; assimilation of andesite would have increased the silica contents of the resulting contaminated magmas. Figure 3a shows silica abundances in shergottite melts plotted versus La/Yb (a proxy for the abundance of the assumed crustal component). Although most shergottites show a positive correlation, as would be expected if the assimilant were silicic rock, the Los Angeles shergottite is inconsistent with this model. If the ancient crust can be represented by the Mars Pathfinder dust-free rock (see below), incorporation of this component should also have resulted in lower MgO/Al_2O_3 (Figure 3b), which is not observed. (Note: La/Yb for the Pathfinder rock is unknown but is assumed in Figure 3 to be high, as appropriate for fractionated crust.)

2.3. In Situ Chemical Analysis of Martian Crustal Rocks

[15] The Mars Pathfinder rover analyzed five rocks using an alpha proton X-ray spectrometer (APXS). Preliminary X-ray mode analyses of rocks at the Pathfinder site [*Rieder et al.*, 1997] have now been revised [*Waenke et al.*, 2001; *Foley et al.*, 2003], owing to the inclusion of alpha mode data and to differences in conditions under which laboratory calibrations and Mars measurements were made. Element concentrations plotted versus sulfur in rocks yield straight lines, with soils clustering at the sulfur-rich ends of the rock arrays. These trends are interpreted as mixing lines between the compositions of rock and dust. Imagery indicates that rocks at the Pathfinder site are partly coated with red dust, and a correlation between sulfur content and the red/blue (750/440 nm) reflectance spectra ratio of APXS-analyzed rocks [*McSween et al.*, 1999] reinforces the conclusion that rock analyses are contaminated by sulfur-rich dust. Extrapolation of the mixing lines to low sulfur (*Waenke et al.* [2001] used 0.3 wt.% S, based on basaltic shergottite sulfur contents) yields the dust-free rock composition.

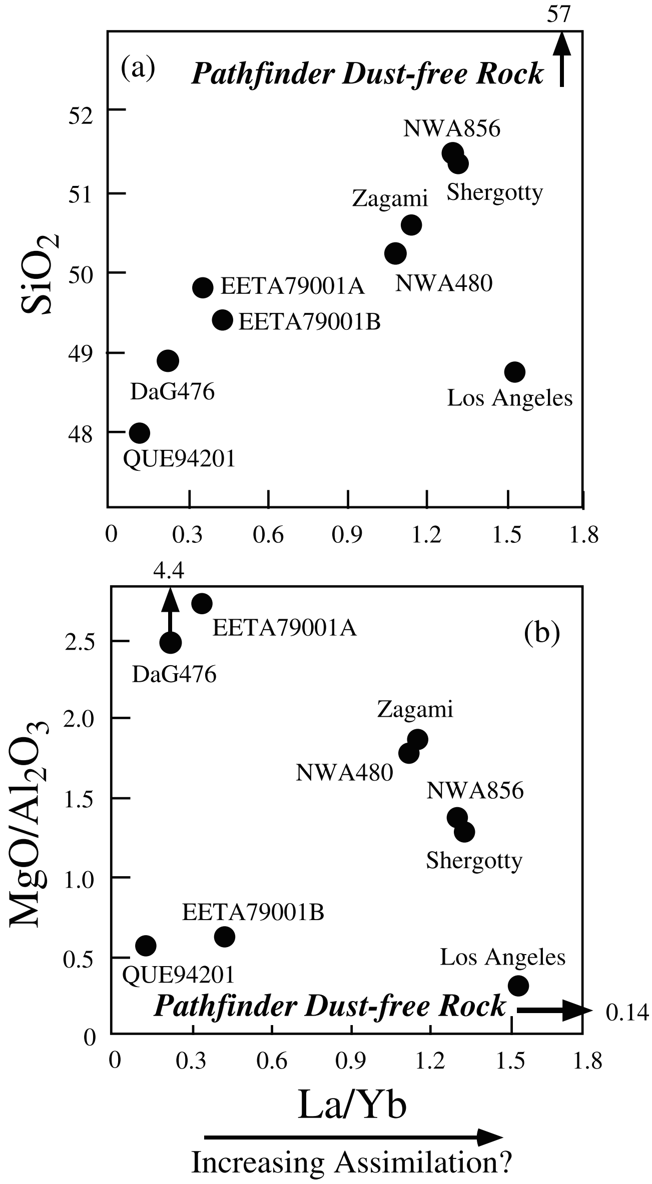

Figure 3. Major element compositions for basaltic/olivine-phyric shergottites appear to be decoupled from trace element (La/Yb) data, the latter interpreted to reflect varying degrees of assimilation of light REE-enriched crust. Silica contents for NWA480 and NWA856 are calculated by difference from the sum of other analyzed oxides. Assimilation of the Mars Pathfinder dust-free rock composition (57% SiO_2, 0.14 MgO/Al_2O_3, presumed to have high La/Yb) would elevate SiO_2 and lower MgO/Al_2O_3. Data sources as in Figure 2.

[16] The SiO_2 concentration (57 ± 6 wt.% from *Waenke et al.* [2001]; 57.7 ± 1.5 wt.% from *Foley et al.* [2003]) for the Pathfinder dust-free rock plots on the low-silica boundary of the andesite field in a classification diagram (Figure 2). The preferred interpretations of this rock composition are that it is volcanic, or is a clastic sedimentary rock composed of volcanic fragments [*McSween et al.*, 1999; *Waenke et al.*, 2001]. However, *McSween et al.* [1999] also considered the possibility that the dust-free rock composition