CORRESPONDENCE OF SHERGOTTITES AND MARTIAN FINES. Benton C. Clark, Planetary Sciences Laboratory, Martin Marietta Denver Aerospace, Denver, Colorado 80201

New results in the analysis of the elemental composition of fine material at the Viking landing sites (1) and of newly discovered Shergottite meteorites (2,3) can be applied to the question of a possible chemical correspondence between the two (4-8). Taking as the most representative composition of Martian fines the deep, duricrust-free samples (Table 3 of ref. 1), and following (8) to find the "silicate fraction", the composition in Table I is calculated. This is interpreted as the average composition of the one or more major igneous rock units which contributed to the make-up of the fine-grained regolith.

Characteristics of the Silicate Component. In the broad geochemical context, the high FeO content of about 20% is noteworthy. Values of FeO above 15% are rarely encountered in terrestrial igneous rocks. Such materials are almost always magnesium-rich and contain TiO_2 in the range 1 to 5%. It is difficult to match the Martian silicate fraction to any common igneous type on earth.

Two types of extraterrestrial igneous materials do often contain about 20% FeO: (a) lunar basalts and (2) basaltic achondrites. The Apollo 11 and 12 samples are too Ti-rich, Si-poor, Ca-rich, and in most cases Al-rich to mimic Mars. Some samples from Apollo 15, including green glass, are closer. Lunar samples usually have one or more of Sr, Y, and Zr well above 100 ppm, whereas these trace elements are 30-100 ppm on Mars.

Among basaltic achondrites, Eucrites are a good match, except for high Ca and a somewhat higher Al/Si ratio. Howardites are low in Ti and too high in Mg/Fe (the same can be said for terrestrial Komatiites). Nakhlites have much too low Al/Ca. Most Shergottites are close except (Mg+Ca) is invariably too high.

A Correspondence Criterion. Up to 10^6 different compositions are identifiable in principle. Prior to the Viking landings, an algorithm was selected for searching a data base of known geological materials by calculating the distance between a measured composition (w_{im}) and any reference composition (w_i) in n-dimensional space (corresponding to the n measured elements). Axis units are concentration divided by estimated measurement error (see ΔW, Table I). Mathematically,

$$(\text{distance})^2 = \sum_i \frac{(w_i - w_{im})^2}{(\Delta w_i)^2}$$

This algorithm allows an objective evaluation, with results shown in Figure 1. From 10^3 cases, the more interesting are plotted, with meteorites above and terrestrial and lunar data below the bar. Basaltic achondrites provide the closest matches. Of the well known ones, Shergotty and Kapoeta match best.

Differences from Shergottites. Martian fines are distinctly lower in CaO, by about 30%, than either Shergotty, lithology B of EETA79001, or inferred intercumulus liquid. Calculations show mineralogic starting composition can be similar if pigeonite increases at the expense of augite (constant total pyroxene). The inferred composition is then consistent with all 10 measured elements (Mg, Al, Si, K, Ca, Ti, Fe, Sr, Y, Zr) bearing on this question. An alternative explanation for Ca-deficiency is chemical weathering to produce insoluble sulfate deposits.

Implication for Mars. If shergottites indeed originated on Mars, the geochemical coherence among three distinct sites (two Vikings and one shergottite source site) implies this rock type is dominant on Mars, or is significantly more susceptible to comminution into fines than other rock types. No data yet disproves the null hypothesis that the Martian lithosphere is geochemically uniform and S-rich (cf. to moon and earth).

Additional Geochemical Links. It is technologically feasible to make more accurate measurements of both rock and soil from a future Mars lander. Orbital measurements are less likely to improve the geochemical evidence for linkage. Alternatively, it is conceivable that minor bits of regolith fines were entrained into a shergottite during the impact maelstrom. An element which could serve as a tracer for such material is chlorine. Compositional similarity to the regolith (S, Cl, Ca) would strengthen a Mars connection.

Lunar vs. Martian Meteorite Sources. Recovery of meteorites from the moon may be less likely for the following reasons. "Finds" are intrinsically unlikely for planetary surface materials because of similarity with typical terrestrial material, requiring detailed laboratory verification. Many meteorites have been thrown away. Collection of "falls" has been available only in the last 10^2 years. But lunar ejecta is undoubtedly swept up by the earth-moon system on a short time scale since ejecta orbits are either slow earth crossers, or escape. Unless an important lunar impact event has occurred near this 10^2 collection interval, witnessed falls are unlikely. Martian, asteroidal, and cometary fragments can be temporarily stored as non-

earth crossers, or as fast crossers, so that the flux available today includes 10^6 or more years of original creation events.

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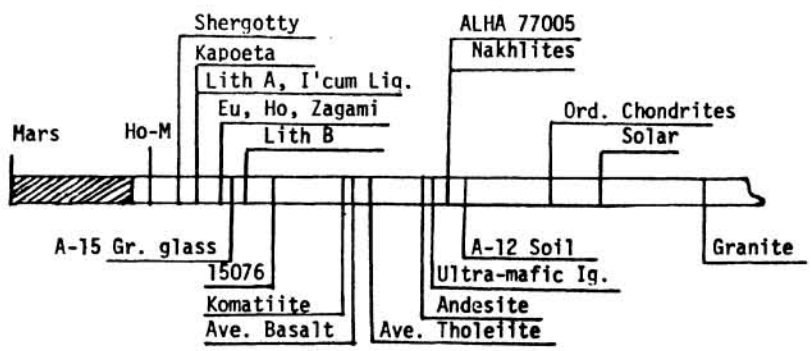

Fig. 1. Plot of hyperspace distance between nominal Mars silicate fraction (left end of bar) and selected compositions. Shaded area denotes range allowed by one error bar (ΔW).

Table I.	MgO	Al_2O_3	SiO_2	K_2O	CaO	TiO_2	"FeO"
Mars silicate fraction	7.2	8.8	53.1	0.50	6.9	0.7	20.0
Shergotty (9)	9.4	6.7	50.1	0.16	10.0	0.9	20.8
Sherg. Intercumulus liq. (5)	5.1	9.5	50.1	0.25	10.0	1.1	20.0
ΔW	±3.0	±2.5	±3	±0.50	±1.0	±0.25	±2.0