EXPLORING THE POSSIBLE RELATIONSHIP BETWEEN MARTIAN METEORITES AND THARSIS-RELATED LAVA FLOWS.

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Introduction: Martian meteorites, or SNCs (shergottites-nakhlites-chassignites), provide a means for unraveling the geologic evolution of Mars. However, the location of SNC source region(s) remains an intriguing question. Associating Martian meteorites with their source regions is critical for (1) placing the meteorites into a geologic context [e.g., 1], (2) fully utilizing the information obtained from the SNCs, and (3) establishing calibration points for Martian crater chronology. SNCs have mafic to ultramafic compositions and, with the exception of ALH 84001, have relatively young crystallization ages ranging from approximately 1.3 Ga to 165 Ma [2]. These characteristics have led to hypotheses that Martian meteorites are sourced from either the Tharsis or Elysium volcanic provinces [2], an idea bolstered by the recent identification of rayed craters as putative launch sites in both regions [3]. However, until now it has not been possible to determine the composition of Tharsis flows for comparison with those of the SNCs.

The purpose of this study is to begin testing the hypothesis that the Tharsis province is a SNC source region. Specifically, we use Thermal Emission Spectrometer (TES) data from the Mars Global Surveyor mission to compositionally constrain a suite of Arsia Mons-sourced lava flows that appear from underneath the regional dust cover in south Tharsis. We then compare the compositions of these flows with Martian meteorite compositions.

Regional Geology: Arsia Mons and associated flow deposits characterize the southern portion of the Tharsis volcanic province. Lava flows radiate from Arsia Mons in all directions with some flow material having traveled southward from the construct for distances greater than 1500 km. This extensive south-trending flow material appears as a bright (warm) surface in THEMIS nighttime thermal infrared images and embays local basement materials associated with the cratered highlands. Geologic mapping of the distal portions of this flow material reveals at least six distinct flow units (Figure 1). The surfaces of at least four of these flows (the flows that extend south of the yellow line in Figure 1) measure greater than 0.968 on the Dust Cover Index (DCI) [4], demonstrating that some Tharsis-related flow material appears from underneath the regional dust cover and can be analyzed using spectroscopic techniques. Interestingly, the rayed crater Zumba [3] occurs on one of the flows that extends from underneath the dust cover (unit fc), which enhances the intriguing possibility of a link between these lava flows and Martian meteorites.

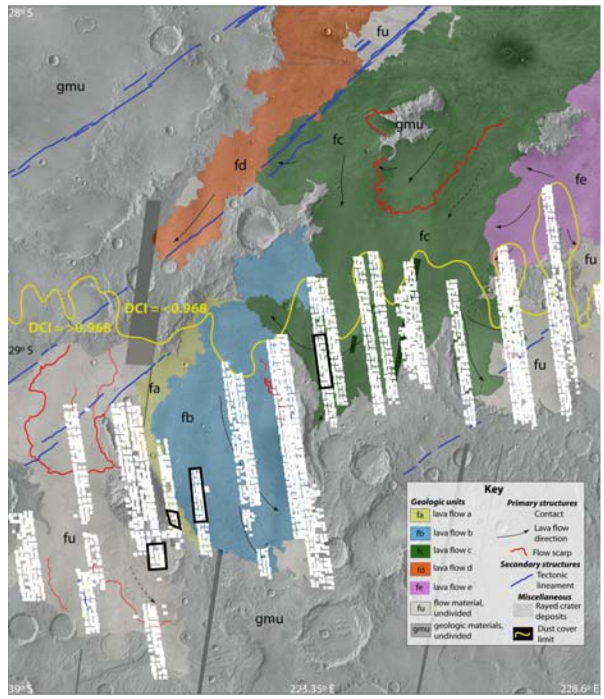

Figure 1: *Simplified geologic map of the distal portions of the south Arsia Mons flow field.*

Methodology: To test for a possible link between these Tharsis-related flows and Martian meteorites, we performed linear deconvolution analyses [5] on the four 'dust-free' flows. In each deconvolution, we used end members from four published spectral libraries [6-9] in order to estimate uncertainties in subsequent chemical classifications. Deconvolutions provided mineral percentages (vol.%), which were converted to wt.% oxides allowing us to chemically classify the lavas. In converting to oxide abundances, we used only the deconvolved minerals that we interpreted as representing primary constituents. When collecting the spectra to be used in our deconvolution analyses, we followed the methodologies and cautions outlined in [9]; in Figure 1, white boxes denote TES data for the relatively 'dust-free' portions of the flows in the map area with the TES pixels used in the deconvolution outlined in black.

Table 1: *Average wt.% oxides for the four measured Arsia Mons lava flows*

Oxide	*Unit fu*	*Unit fa*	*Unit fb*	*Unit fc*
SiO_2	51.51	50.86	51.51	51.41
TiO_2	0.83	0.68	0.83	0.73
Al_2O_3	13.03	12.33	13.03	12.44
FeO	7.38	7.15	7.38	7.18
MnO	0.11	0.11	0.11	0.11
MgO	10.49	12.61	10.49	11.12
CaO	13.63	13.13	13.63	14.00
K_2O	0.28	0.26	0.28	0.27
Na_2O	2.50	2.40	2.50	2.41
Cr_2O_3	0.01	0.01	0.01	0.01
P_2O_5	0.07	0.06	0.07	0.06

Preliminary Results: Deconvolutions of the four relatively 'dust-free' flows show that each unit is dominated by mafic primary mineralogies. Conversion to bulk rock chemistries (Table 1) and subsequent plotting onto a total alkali versus silica diagram with other Martian rocks (Figure 2) illustrates that these flows plot between the basaltic end of Surface Type 1 and the basaltic shergottites and nakhlites; as a side note, using both the primary and secondary mineralogies in the conversion to wt.% oxides moves the Arsia flows into the dacite field.

The compositions of basaltic shergottites and nakhlites are further compared to Arsia flows in Figure 3, a diagram used to classify SNCs. However, examination of the deconvolved weight percent oxides in Table 1 reveals that the Al_2O_3 content is too high and the FeO content is too low for these Tharsis-related flows to be directly related to the SNCs. But could these flows represent the liquid compositions of nakhlites and/or basaltic shergottites? Specifically, could the removal of cumulus pyroxenes from the bulk rock compositions result in compositions similar to the lava flows? Petrochemical modeling suggests not. Although removal of cumulus pyroxenes can increase the Al_2O_3 contents of residual liquids to that of the lava flows, the FeO contents of the liquid remain too low. This suggests that there is no robust correlation between these Arsia Mons-sourced lava flows and Martian meteorites. Therefore, at least this part of Tharsis is apparently not a SNC source region.

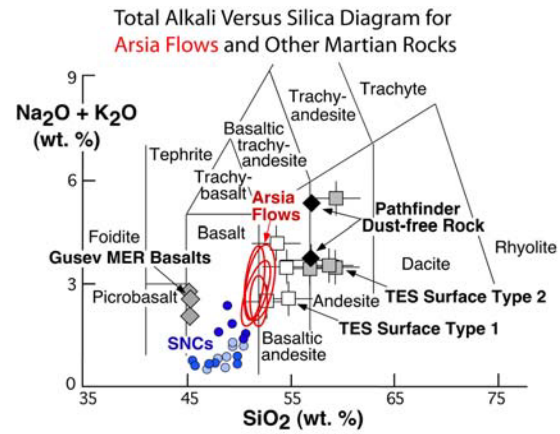

Figure 2: *Chemical classification of Arsia flows in relation to other Martian rocks (red ellipses encompass deconvolutions using four spectral end member libraries, to illustrate compositional uncertainties).*

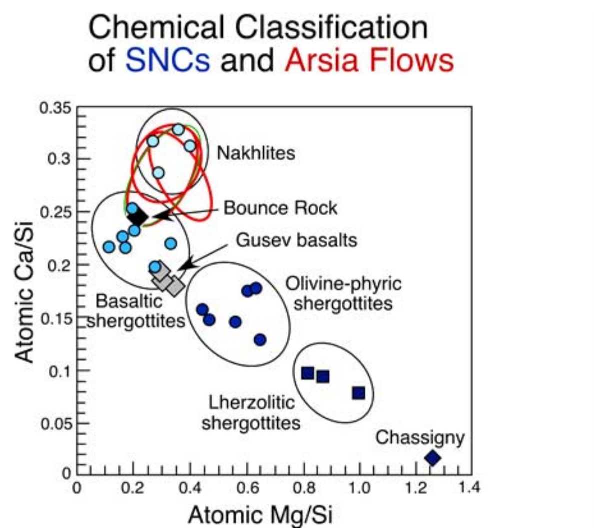

Figure 3: *Chemical classification of the Arsia flows (red ellipses) in relation to Martian meteorites.*

References: [1] Hamilton, V.E., et al. (2003) *Meteorit. Planet. Sci., 38*, 871-885. [2] McSween, H.Y. (2002), *Meteorit. Planet. Sci., 37*, *Nr 1*, *7-25*. [3] Tornabene, L.L., et al. (2006), *JGR*, 111, 10.1029/2005JE002600. [4] Ruff, S.W. and Christensen, P.R. (2002), *JGR*, 107, 10.1029/2001JE001580. [5] Ramsey, M.S. and Christensen, P.R. (1998), *JGR*, 103, 577-596. [6] Christensen, P.R., et al. (2000), *JGR*, 105, 9609-9621. [7] Wyatt, M.B. and McSween, H.Y. (2002), *Nature*, 417, 263-266. [8] McSween, H.Y., et al. (2003), *JGR*, 108, 10.1029/2003JE002175. [9] Rogers, A.D., et al. (2005), *JGR*, 110, 10.1029/2005JE002399.