REANALYSIS OF MGS-TES DATA WITH DETECTED/KNOWN MINERALS AND ITS IMPLICATIONS FOR GEOLOGIC EVOLUTION OF MARS CRUST. S. Gou, K. Di, Z. Yue, J. Wang. Institute of Remote Sensing Applications, Chinese Academy of Sciences, Beijing, China 100101 (gousheng@irsa.ac.cn)

Introduction: After MGS (Mars Global Surveyor) was launched to Mars in 1996, many other orbiters (e.g., MEX and MRO) and landers/rovers (e.g., Phoenix and MERs) were also sent to the red planet. Spectrometers were usually used on these spacecrafts to detect the mineral composition of the Martian surface. While the repeated observations by orbital spectrometers provide macroscopic information about the global composition, the in-situ analysis can provide detailed local surface composition, which can be used as ground truth. With the Thermal Emission Spectrometer (TES) data from MGS, Bandfield [1] interpreted that the Martian surface is mainly composed of basalt on the southern older surfaces while andesite on the northern younger plains. However, with the same data, Wyatt [2] proposed that the northern surface was probably altered basalt instead of andesite. The varying interpretation is caused by different endmembers used in deconvolving the spectra data. For example, Dunn [3] found that alkalic mineral endmembers have a significant effect on the determination of Mars surface composition. In this research, we try to deconvolve the TES spectra with known or detected minerals by complementary use of orbital spectrometer observations and in-situ chemical analysis results. We think our results can greatly optimize the interpretation, and have potential implications to the Mars crust evolution.

Data: The TES data used in this research was acquired under single scan observation mode and has been atmospherically corrected. To use the high-quality data, we selected the data with the orbit count keeper (ock) of 1583-7000, Ls of 104°-352°, emission angles less than 30°, incidence angle less than 80°, surface temperatures greater than 250K, water ice and dust extinctions less than 0.1 and 0.18 respectively. In addition, the spectra data was also rejected if their dust cover index (DCI) is less than 0.96 [4].

The endmembers used in the deconvolution include carbonates, sulfates, iron oxides, olivine, a series of silicates such as smectite, serpentine and common rock-forming materials such as pyroxenes and plagioclase feldspars. They had been mainly confirmed by the in-situ analysis and a few were detected with the spectrometer data from OMEGA and CRISM. The reference spectra and their bulk chemistries of these endmembers are obtained from Arizona State University spectral library [5].

Method: The reference spectra are first resampled to TES resolution of 10 cm^{-1}, and then the linear spectral unmixing model is applied on each TES spectrum over channels 9-35 and 65-100. The mineral abundance of each endmember and a RMS error value can be derived from this model, and those minerals with the abundance less than 10% are considered unreliable and rejected [6, 7]. The bulk rock chemistries of the Martian surface are dervied by multiplying the abundance with their bulk chemistries [8-12]

Results: The unmixing results show that the overll mineral distribution trend is consistent with previous work [1, 6]. Plagioclase feldspars are distributed mainly on the near equatorial regions and high latitude regions of southern hemisphere (Figure 1a). Pyroxenes are distributed mostly on the middle latitude regions of the southern hemisphere and Syrtis Major (Figure 1b). Silicates are mainly distributed on the near equatorial and high latitude regions of both hemispheres (Figure 1c). Other minerals (e.g. carbonates, sulfates and olivine) are below the detection limits, and the maximum RMS error is less than 0.5% (Figure 1d). The derived SiO_2, Alkali ($Na_2O + K_2O$), Al_2O_3, CaO, MgO, FeO, K_2O and Na_2O are shown in Figure 2. The global enrichment in SiO_2 is a refectence of higher modeled silicates (Figure 1c and Figure 2a), Al_2O_3 and CaO are enriched in high latitude regions of both hemisphere (Figure 2c and 2d), while MgO and FeO is enriched in near equatorial regions and Syrtis Major (Figure 2e.and 2f). The distribueon of K_2O, Na_2O and Alkali do not show a local enrichment trend (Figure 2b, 2g, 2h). The statistics of these derived Martian surface chemistries are also calculated (Table 1, Figure 3 and Figure 4).
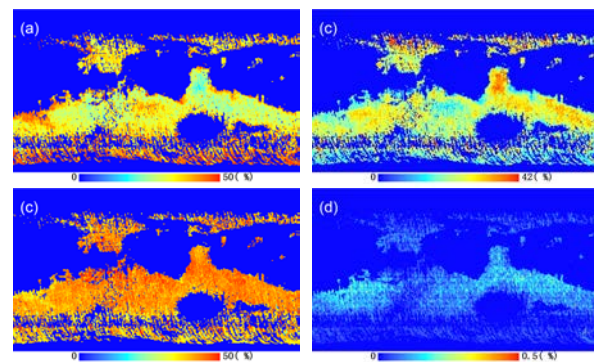

Figure 1. Global mineral abundence distribution on Martian low albedo regions. High albedo regions with DCI less than 0.96 are masked and shown as blue. (a) plagioclase feldspars; (b) pyroxenes; (c) silicates; (d) RMS error.
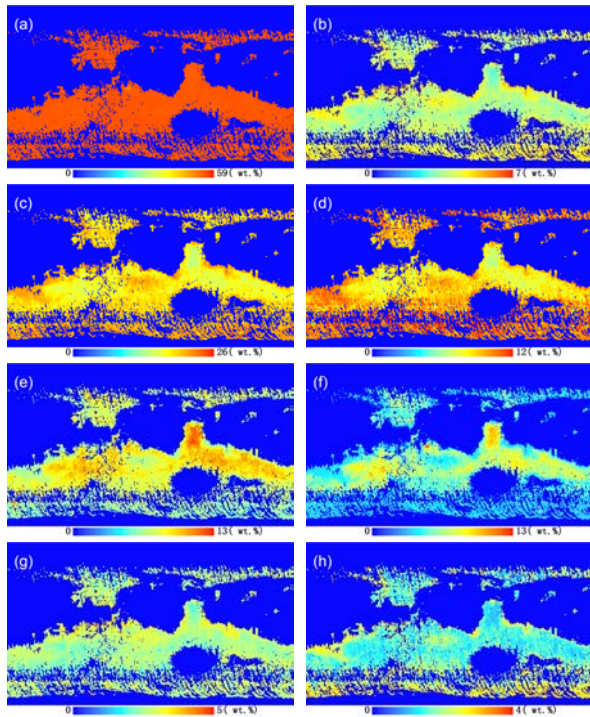
Figure 2. TES derived bulk chemistries of Martian low albedo regions in weight percent (wt. %). High albedo regions with DCI less than 0.96 are masked and shown as blue. (a) SiO_2; (b) Alkali ($Na_2O + K_2O$); (c) Al_2O_3; (d) CaO; (e) MgO; (f) FeO*, FeO* means total iron as FeO; (g) K_2O; (h) Na_2O.

Table 1. Statistics of TES derived Martian surface bulk rock chemistries in weight percent (wt. %).

Items	SiO_2	Na_2O	K_2O	CaO	Al_2O_3	FeO*	MgO	TiO_2
Max	59.1	3.9	4.3	11.5	25.7	12.2	12.6	0.4
Mean	54.1	2.0	2.3	7.1	19.2	4.2	6.9	0.2
Min	47.7	0.1	0.1	3.0	11.8	1.0	2.0	0.1

Conclusion and Discussion: According to the total alkali silica (TAS) classification diagram, the Martian surface is chiefly subalkaline, with dominant basaltic andesite dominant, and a small portion belonging to basaltic trachyandesite and just a little part being classified as basalt and andesite. The FeO*/MgO-silica diagram indicates that the Martian surface is made of calc-alkaline rock. This homogeneity of Martian crust suggests it was formed in the same period. Further study is necessary to determine wheather the present observered mineral diversity was formed by magmatic differentiation and fractional crystallization in the crust's formation stage or was the result of later weathering and alteration. In addition, the refinement of the unmixing algorithms will be carried out in the future with joint investigation of hyperspectral spectrometer

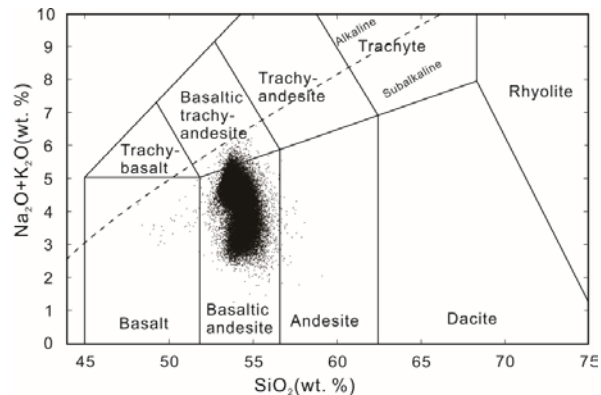data, rover in-situ observations and bulk analysis of Mars meteorites.

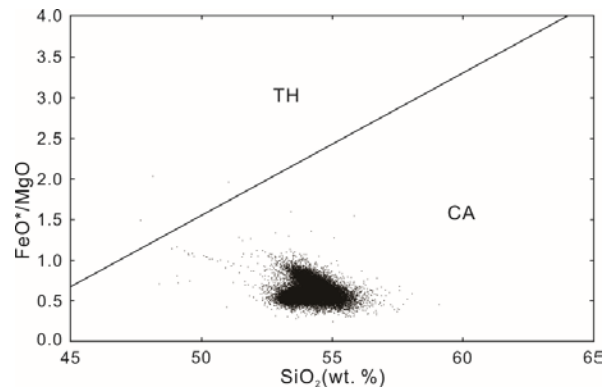Figure 3. TAS plot of Martian surface chemistries.

Figure 4. Discrimination diagram of Martian surface for calc-alkaline (CA) and tholeiitic (TH) rock.

References: [1] Bandfield, J.L. et al. (2000) *Science*, *287*, 1626-1630. [2] Wyatt, M.B. and McSween H.Y. (2002) *Nature, 417*, 263-266. [3] Dunn, T.L. and McSween Jr H.Y. (2006) *LPSC XXXVII,* Abstract #1291. [4] Ruff, S.W. and Christensen P.R. (2002) *JGR, 107* (E12), 10.1029/2001JE001580. [5] Christensen, P.R., et al. (2000) *JGR, 105,* 9735-9739. [6] Bandfield, J.L. (2002) *JGR, 107* (E6), 10.1029/2001JE001510. [7] Kirkland, L.E. et al. (2003) *JGR, 108* (E12), 10.1029/2003JE002105. [8] Hamilton, V.E. and Christensen P.R. (2000) *JGR, 105*, 9717-9733. [9] Wyatt, M.B., et al. (2001) *JGR, 106,* 14711-14732. [10] Hamilton, V.E. et al. (2001) *JGR, 106,* 14733-17766. [11] Wyatt, M.B. et al. (2004) *LPSC XXXV* Abstract #1887. [12] McSween H.Y. et al. (2009) *Science, 324,* 736-739.