Mineral and Lithologic Mapping of Martian Low Albedo Regions Using OMEGA Data. M. Zhu1,2, H. Xie2, H. Guan3, R.K. Smith4, 1Research Center of GIS and RS, East China Institute of Technology, Fuzhou, Jiangxi 344000, China, mzhu@ecit.edu.cn, 2Earth & Environmental Science, University of Texas at San Antonio, San Antonio, TX, 78249, USA, Hongjie.Xie@utsa.edu

Introduction: Since January 2004, OMEGA/Mars Express data has revealed a diverse and complex Martian surface mineralogy [1]. The important findings, together with Thermal Emission Spectrometer (TES), Thermal Emission Imaging System (THEMIS), and in-situ observations from Mars Exploration Rovers, include but not limited to (1) hydrated sulfates [1, 2, 3, 4, 5, 6, 7]; (2) iron oxides and oxhydroxides [2, 3, 5, 8, 9, 10, 11, 12, 13]; (3) hydrated alteration phyllosilicates [4, 2, 3]; and (4) mafic and ultramafic rocks containing pyroxene and olivine [1, 11, 13, 14, 15, 16]. These results are improving our knowledge regarding the Martian surface mineralogy and lithology, and the geological history of Mars. OMEGA imagery as noted above provides efficient and satisfactory hyperspectral information. It can be used not only to map individual minerals, but also their corresponding lithologic units.

The purpose of this study was to identify the mineral and lithologic units using the OMEGA imagery. The minimum noise fraction (MNF) method was applied to derive the lithologic endmember units and then three spectral matching methods, spectral angle mapper (SAM), spectral feature fitting (SFF), and binary encoding (BE), were used to match minerals and lithologies. Three low albedo areas, Meridiani Planum, Ophir-Candor Chasma, and Syrtis Major, were chosen for this study. Meridiani Planum is Opportunity Rover’s landing site, Minerals such as pyroxene, hematite, jarosite, and phyllosilicates and lithologies such as basalt have been identified [2, 3, 11, 12]. The hydrated sulfates (kieserite and polyhydrated sulfates) on light-toned layered terrains at the Ophir and Candor Chasmas have been detected [1, 5]. Syrtis Major is dominated by basalts, but with little olivine [13, 17]. These are available for testing results of this study.

Dataset: OMEGA acquires spectrum in 352 contiguous bands covering 0.35 to 5.1 µm with a spatial resolution of 0.3 to 4 km/pixel and spectral resolution of 7 to 20 nm [1]. The spectral range and resolution have been chosen to allow for identification of major surface and atmospheric species by their diagnostic spectral absorption feature [1]. OMEGA data for three selected areas were downloaded from the ESA’s Planetary Science Archive. In this study, we mainly examined the spectral range from 0.4 to 2.5 µm. The data was pre-processed using a modified IDL program initially provided by ESA to a relative reflectance image (I/F), which was then utilized for atmospheric corrections using a LLEE model developed by Guan et al. [18].

Method: The atmospherically corrected image was then processed using ENVI for image classification and mineral and lithologic identification. The MNF method, conducted twice principal component analysis, was first run to produce noise-free principal components. The MNF band1 mostly contains the albedo information, but the MNF bands 2, 3, and 4 mainly contain the mineral and lithologic information, which can be used to produce a false-color endmember map (Fig.1). Spectra of these endmembers were then processed to match with the various standard spectral libraries from the USGS, John Hopkins University, and Brown University. Three spectral matching methods (SAM, SFF, and BE) were applied based on both spectra and/or continuum removal spectra for scoring individual minerals and lithologies from libraries with each endmember. The highest scores for the matched minerals and lithologies were then recorded for each endmember.

Results: ORB0529-3 (Maridiani Planum) consists of 8 lithologic endmembers (Fig.1-a). (1) The green endmember on Fig.1-a match best with basalt and basaltic andesite. Comparable minerals include chalcopyrite, hematite, and pyroxene. The diagnostic spectral absorption bands in continuum-removed curves are 0.47 µm, 0.96 µm, and 1.91 µm. These compositions are more comparable to the Noachian highland basaltic rocks detected by TES [15, 17], named the Crater Unit and Dissected Unit of the Plateau Sequence on USGS geologic maps. (2) The purple endmember, which includes the Opportunity landing site, matches best with the minerals chalcopyrite, hematite and jarosite. The shape of this purple colored area is counterpart to hematite-bearing material mapped by TES [8] and THEMIS [10]. It should be noted that chalcopyrite has yet to be reported however. Lithologies showing the
best matches include basalt, sandstone, and andesite. This may infer that the rock type is basaltic sandstone or sand. However, the spectral absorption bands 0.5 µm, 0.9 µm, 1.91 µm, and 2.2 µm, respectively in continuum-removed curves match well with micasandstone (Fig.2-a). The existing sandstone or sand most likely came from the erosion of the south highlands basalts. The Opportunity Rover has proved that the soil consists of fine-grained basaltic sand and a surface lag of hematite-rich spherules; the finely laminated rocks, silicate sediments, contain abundant sulfate salts with embedded hematite-rich spherules [3]. (3) The pink endmember, north of the purple unit to the mid-east portion of the area, matches very well with the minerals barite, jarosite and hematite. The most compatible lithologies for this area are basalt and micasandstone. This indicates that the basaltic rich sediments are well developed in the layered and etched terrains. (4) The yellow unit matches garnet (almandine) and hematite, while the lithology matches basalt as well as felsic granite. This suggests the presence of more feldspar in this endmember. (5) The red, blue, and gray endmembers occur in the northwest region of the Opportunity landing site is mainly basaltic sandstone or basaltic sand, though the etched terrain, as well as the portion to the north and west, found more barite and gypsum in addition to hematite. (2) Two different lithologic groups are identified in Ophir-Candor chasma. The lithology on the Chasma floor, with low albedo, is basalt or norite, and the matched minerals are monticellite, pyroxene, hematite, and covellite. The second lithology (i.e. Slide Materials and Highly Deformed Terrain Material) is basaltic andesite, with the presence of orthoclase and hematite. Regions of the light-toned layered terrain are dominated by monticellite, anhydrite, and gypsum. (3) Rocks in low albedo areas of Syrtis Major are basalts and possible diabase. The mineralogy includes pyroxene, monticellite, Garnet (uvarovite), hematite, and thenardite. This is the first time that the thenardite is reported to occur on the surface in Martian surface based on its diagnostic spectral absorption bands at 1.17 µm, 1.42 µm, 1.91- 2.01 µm, 2.11 µm, and 2.47 µm.

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