RADIATIVE TRANSFER MODELING OF MESSENGER VIRS SPECTRA OF MERCURY: DETECTION AND MAPPING OF SUBMICROSCOPIC IRON AND CARBON. D. Trang1, P. G. Lucey1, and N. R. Izenberg2, 1Hawai‘i Institute of Geophysics and Planetology, University of Hawai‘i at Mānoa, Honolulu, HI (dtrang@higp.hawaii.edu), 2Applied Physics Laboratory, The Johns Hopkins University, Laurel, MD.

Introduction: Mercury exhibits a low albedo and a red-sloped featureless visible-to-near-infrared reflectance spectrum. Studies suggest that these characteristics are due to the presence of opaque minerals and space weathering products in a silicate matrix [1–3]. Radiative transfer modeling proved effective in reproducing the major properties of Mercury’s spectra obtained by MESSENGER VIRS (Visible and Infrared Spectrograph) instrument (spectral range is from 0.3–1.45 µm) with the inclusion of the optical effects of submicroscopic iron. However, small scale structures in the spectral fits are imperfect, suggesting the presence of other components.

The recent possible detection of carbon on Mercury [4] and the discovery that carbon-bearing compounds can produce Mercury-like products in impact experiments [5] prompted us to investigate the ability of nanophase and microphase carbon to provide a better fit to the spectra of Mercury.

Methods: We used the radiative transfer equations from [3,6,7] to make spectral models of transparent host minerals containing various combinations and abundances of submicroscopic particles. The host mineral had an assumed grain size of 20 µm [8]. The submicroscopic particles consisted of nanophase and microphase particles composed of iron, amorphous carbon, and/or graphite.

Results: We found that the best spectral matches relied on model spectra derived from iron and amorphous carbon in nanophase and iron in microphase particles in combination. Maps of the distribution of nanophase and carbon and microphase iron are shown in Fig. 1.

Discussion: The spatial distribution of microphase iron abundance is consistent with Ostwald ripening [9]. Because Mercury is in a 3:2 resonance, at perihelion, the regions at 0° and 180° longitude, called hot poles, always face the Sun. As a result, these regions experience maximum temperatures of ~700 K, whereas the surfaces at 90°W and 90°E are <600 K [10]. Similarly the geographic poles are consistently 100s of degrees colder than the equatorial regions. The surface temperatures at the equatorial and hot poles are great enough that metallic iron particles will enlarge by diffusion.

The modeling abundances are consistent with the results from other interpretations, which used instruments such as, the Gamma-Ray Spectrometer (GRS), the X-Ray Spectrometer (XRS), and MASCs (Mercury Atmospheric and Surface Composition Spectrometer). The XRS result shows that the Fe abundance in the southern hemisphere is ~1.5 wt.% [11] The GRS results for Fe and C abundances north of 20°S is 1.9 and 1.4 wt.%, respectively [12,4]. Within the same region as the GRS data, our Fe abundance (i.e., total nanophase and microphase wt.% Fe) is 1.7±0.5 wt.% and C abundance is 1.4±0.3 wt.%. The predicted nanophase iron abundance based upon the strength of the OMCT (oxygen-metal charge transfer) is 0.2–0.3 wt.% [13]. Our global nanophase iron abundance is 0.3±0.1 wt.%.


Fig 1: Space weathering maps a) nanophase iron, b) microphase iron, c) nanophase amorphous carbon map. The graphs are longitudinal and latitudinal averages.