SURFACE COMPOSITION AND CHEMISTRY OF MERCURY: HAPKE MODELING OF MESSENGER/MASCS REFLECTANCE SPECTRA. J. Warell[1], A.L. Sprague[2], R.W. Kozlowski[3], J. Helbert[4], [1]Dept. of Physics and Astronomy, Uppsala University (Box 515, SE-751 20 Uppsala, Sweden, johan.warell@fysast.uu.se), [2]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ, USA, [3]Susquehanna University, Selinsgrove, PA, USA, [4]DLR Institute for Planetary Research, Berlin, Germany.

Introduction: The NASA MESSENGER spacecraft [1] has made two flybys of Mercury, providing the first close-range surface reflectance spectra using MASCS [2] as well as new imagery of nearly the global surface with MDIS [3]. We present results of modeling of published MASCS/VIRS [4] reflectance spectra from the first Mercury flyby using Hapke's photometric model [5-7] to derive quantitative information on mineral types, abundancies and chemistries, including the effects of maturation by microphase iron.

Model: Our implementation of Hapke's radiative transfer theory uses absorbance (*k*-) spectra of silicate minerals calculated from laboratory reflectance spectra of powders of varying compositions and grain sizes, similar to the method of [8]. The derived *k*-spectra are averages of the optical properties of carefully selected mineral suites from the RELAB [9] and USGS [10] spectral libraries. For opaque minerals we tie grain size variations to reflectance by employing single scattering albedo (*w*-) spectra. The following minerals with chemical or grain size ranges are presently included: plagioclase feldspar (An# 10-100), clinopyroxene (Mg#50-95), orthopyroxene (Mg#50-90), olivine (Fo# 0-90), ilmenite (gs 1-100 μm), troilite (gs 1-125 μm), metallic iron (gs 1-125 μm), rutile (gs 1-125 μm). Maturation effects of the matured regolith are calculated with unrestricted abundances of microphase iron [nomenclature as suggested by 11], hereafter termed "mpFe", distributed in grain rims and present in equal relative amounts among model silicate members. Matured intimate mixtures of regolith spectra containing any number of minerals with varying compositions and grain sizes may be modeled, practically restricted only by computation time. The fit between measured and modeled spectra is evaluated in reflectance or *w*-space.

Application: We present here results from models of the 400-850 nm range of the equatorial average bidirectional reflectance spectrum obtained by MASCS/VIRS. The range is limited compared to VIRS full coverage as the near-UV range is not fully implemented in the present model and the MESSENGER spectral calibration of the NIR sensor is not yet completed. Average grain size was set to 30 μm according to [12-14]. The VIRS spectrum was fit to 455686 models containing up to three silicates (CPX, OPX and OLI) plus ilmenite, throughout their full compositional ranges and with abundance increments of 5 wt%. Abundance of microphase iron was varied between 0 and 0.1 wt%. Ilmenite is a possible dark neutral component of Mercury's regolith [3, 15], though rutile was recently indicated from linear thermal reflectance modeling [16]. The model fit to the measured spectrum is considered satisfactory if the root-mean-square (RMS) value is equal or less than the RMS of a best-fit multi-order polynomial function to the spectrum.

Results: In Fig. 1, modeling results for the equatorial VIRS spectrum are shown. All twenty displayed models have RMS values $<3.3\times10^{-4}$. Plagioclase is always the dominant silicate with abundance in the range 65-75 wt% and composition from An#10 to 90 with a dominance for intermediate values, i.e. labradorite. Clinopyroxene is present in all models at 5-15 wt% abundance with a range of Mg#50-90 but with a predominance for the higher values, i.e., diopsidic. Olivine is present in only a minority of the models at a maximum abundance of 15%, and the chemistry is basically unconstrained. The opaque component ilmenite is present in all models and is well determined at 15-20 wt% in abundance. The abundance of smFe is well determined at 0.06 wt% in all models.

Discussion: Naturally, as there are no absorption features clearly present within the VIRS wavelength range except in the near-UV, the mineral abundances are not accurately constrained, and the compositional ranges are even less determined. Microphase iron is however fundamental in setting the general reflectance and is thus well determined in abundance. The opaque component ilmenite, having a dark and spectrally neutral continuum, is fundamental in balancing the matured red slope introduced by mpFe towards the slightly less sloped average spectrum shown by Mercury.

The derived composition of the equatorial MASCS spectral scan across Mercury is consistent with previous analyses based on ground-based spectra. The abundance of mpFe is somewhat smaller here however (a value of arund 0.2 wt% was determined by [13] from a disk-integrated spectrum), due to the less red slope of the spectrum as seen in the VIRS range. Carich clinopyroxene has previously been reported from modeling [13] and from the identification of a shallow absorption band in the north and south mid-latitude regions near longitude 170 W [17]. None of the models contain appreciable amounts of olivine, consistent with previous Hapke modeling of ground-based VISNIR reflectance spectra [13] and linear thermal reflectance modeling [16].

Conclusions and outlook: Very good fits to the VIRS spectra are provided already at this early stage. The major results of previous modeling and analysis of ground-based reflectance and thermal emittance spectroscopy are confirmed. Results will be more discriminative and accurate when the full MASCS wavelength range has been calibrated and made publically available, and, particularly, when higher signal-to-noise, higher spatial resolution data from the orbital mission becomes available. Also, the wavelength range of all model mineral optical constant spectra, including glass with varying FeO and TiO_2 chemistry, need to be extended down to 320 nm to exploit fully the spectral reflectance effects of various opaque minerals and the effects of maturation, which are strongest in the near-UV. A full exploration of the effects of varying the mineral components and their chemistries will be conducted for all of the MASCS spectra from the first flyby.

Acknowledgements: This research was conducted under contract with the Swedish National Space Board.

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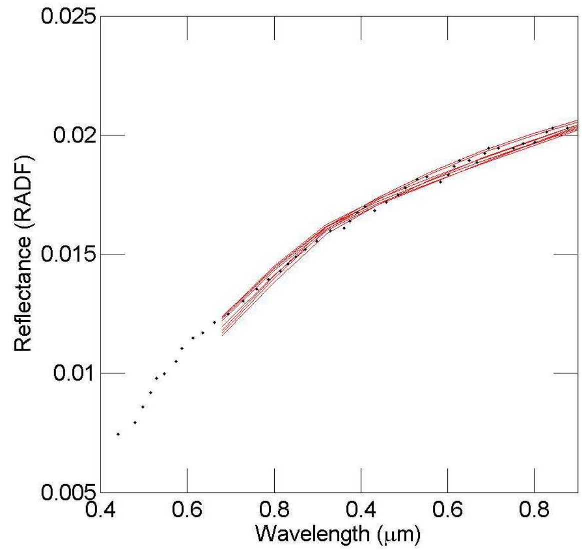

Fig. 1. Results of modeling the MESSENGER MASCS/VIRS "Equatorial average" reflectance spectrum (dots) of [2] with our Hapke radiative transfer code. The twenty model spectra (lines) have RMS values <0.033% with respect to the measured spectrum. The models are based on four-component mixtures of minerals of differing types, abundances, and chemistries, matured by microphase iron.