COMPOSITIONAL SPECTRAL MIXING MODELS OF S-TYPE ASTEROIDS: 243 IDA AND 951 GASPRA;

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INTRODUCTION: We use the Hapke spectral reflectance model to calculate best-fit model compositions for each of 45 telescopically observed S-type asteroids [1,2,3]. The goal is to quantify uncertainties resulting from poorly constrained model parameters, and to produce sets of model compositions which we can analyze for trends that can be related to what we already know about S-asteroids and the meteorites proposed to be derived from them. The endmembers used for this study are low-iron orthopyroxene and clinopyroxene, nickel-iron metal from the Mundrabilla meteorite, troilite, and forsteritic olivine. All endmember spectra were measured at RELAB [4,5,6,7]. Currently accepted S-class meteorite analogs are the stony-iron and anomalous achondrites and possibly the ordinary chondrites [8,9], all of which are composed mainly of these materials. Each endmember comes in three different grain size ranges: < 45 microns, 45 - 75 microns, and 75 - 125 microns. Fits were calculated with each grain size range, and the fit with the lowest residual errors was selected for the model set. At first report [10], model determinations with albedo constrained were presented. Now we present two different approaches to the selection of the albedo input parameter and discuss the resulting differences in model compositions. First we constrain the input spectrum albedo using the IRAS listing [11]. Next, changing nothing else, we normalize spectra and model fits and tabulate the model-derived albedos. Similar grain sizes, albedos, and composition patterns in terms of silicate/metal and olivine/pyroxene ratios were determined regardless of albedo approach. We suggest, therefore, that the two resulting sets of model compositions can be used to set limits on endmember abundances. This study hinges on the assumption that we have chosen appropriate endmember minerals.

RESULTS: We find that 43 of 45 models from the two different albedo approaches agreed on the model-determined grain size. The breakdown in grain size is heavily slanted toward the intermediate size range, with 23 of the best fit model compositions. The largest size range was best for 7 of the asteroids, and the smallest grain size was best for 13. Residual errors were consistently higher for the albedo constrained case, but were substantial in both cases. Table 1 shows the correlations in model parameters between our two different albedo approaches. A correlation coefficient value greater than 0.7 indicates a correlation, and values between 0.5 and 0.7 indicate a trend.

243 IDA AND 951 GASPRA: We can learn more about mixture modeling systematics and the significance of our model derived parameters if we take an in-depth look at some specific examples. We select two asteroids, 243 Ida and 951 Gaspra, and we explore parameter space within and between each albedo approach. The program is run 20 times for each asteroid, and the ten best fits are selected for calculation of statistics. Both asteroids were best fit with the intermediate grain size range, and the composition results are listed in Table 2. There are several interesting things to note; 1) In the albedo constrained cases, most of the model variations are with the olivine and Fe,Ni metal abundances, hence these are the most uncertain parameters, 2) In the albedo unconstrained cases olivine and Fe,Ni metal are less uncertain and orthopyroxene seems to be very tightly defined, and 3) Olivine/pyroxene ratios for the entire S-type class ranged from 1 to 20; Ida is at the low end (~4) and Gaspra is at the high end (~18). Similarly, silicate/metal ratios for the entire S-class ranged from 0.5 to 4; Ida is at the low end and

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Gaspra is at the high end (~4). Changes in endmember ratios which occur with change in albedo approach have also been calculated. Encouragingly, in only one case does a parametric ratio change by more than a factor of 2, and that is the familiarly uncertain olivine/Fe,Ni metal ratio.

CONCLUSION: In conclusion, we have compositionally modeled 45 S-type asteroid spectra using the Hapke spectral reflectance theory, and have calculated statistical significance of model abundances for asteroids 243 Ida and 951 Gaspra. The largest single source of potential error in this mixing model analysis is in the choice of endmember minerals [12,13,14]. Residual errors are comparable to those found by other compositional modeling attempts, and furthermore tend to be located in the same spectral regions. These are: 1) 0.4-0.7 microns, where the UV drop-off in the asteroid spectra is steep, and 2) 1.5-2.5 microns, where the IR continuum of the asteroid spectra goes flat. We believe these systematic problems to be compositional information, as yet uninvestigated. The technique presented here may therefore be most useful in conjunction with other spectral deconvolution methods.

ACKNOWLEDGEMENTS: I thank Taki Hiroi, Jess Sunshine, Dan Britt, Paul Lucey, Tim McCoy, Jeff Bell, Steve Pratt, Fraser Fanale, Mark Robinson, Ellen Howell, Tom Burbine, Deborah Domingue & Chuck Claver.

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TABLE 1	
PARAMETER	CORRELATION COEFFICIENT
ALBEDO	0.68
CPX	0.63
OPX	0.96
OLI	0.77
FE,NI	0.69
TROI	0.65
CPX+OPX	0.87
FE,NI+TROI	0.80
OLI/FE,NI	0.13
OLI/OPAQUES	0.67
SILICATES/ OPAQUES	0.79
OLI/PYX	0.92
OLI/OPX	0.52
FIT	0.91

TABLE 2	ALBEDO CONSTRAINED	UNC.	ALBEDO UNCONSTRAINED	UNC.
243 IDA				
CPX	10.84	0.78	10.39	1.35
OPX	8.55	0.64	9.46	0.67
OLI	33.44	9.37	40.38	3.07
FE,NI	39.52	9.84	29.53	2.58
TROI	7.64	0.71	10.23	3.80
ALBEDO	24.00	0.00	25.98	2.60
FIT	0.0320	0.0010	0.0317	0.0005
951 GASPRA				
CPX	17.54	0.50	13.51	1.38
OPX	2.99	0.54	3.63	0.58
OLI	58.06	2.85	64.46	2.23
FE,NI	6.67	3.91	3.15	3.77
TROI	14.74	0.25	15.25	2.31
ALBEDO	22.00	0.00	25.22	1.74
FIT	0.0590	0.0004	0.0611	0.0010