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The composition of M-type asteroids: Synthesis of spectroscopic and radar observations

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Abstract

This work updates our and expands our long term radar-driven observational campaign of 27 main-belt asteroids (MBAs) focused on Bus-DeMeo Xc- and Xk-type objects (Tholen X and M class asteroids) using the Arecibo radar and NASA Infrared Telescope Facilities (IRTF). Seventeen of our targets were near-simultaneously observed with radar and those observations are described in companion paper (Shepard et al., 2010). We utilized visible wavelength for a more complete compositional analysis of our targets. Compositional evidence is derived from our target asteroid spectra using three different methods: 1) a χ^2 search for spectral matches in the RELAB database, 2) parametric comparisons with meteorites and 3) linear discriminant analysis. This paper synthesizes the results of the RELAB search, parametric comparisons, and linear discriminant analysis with compositional suggestions based on radar observations. We find that for six of seventeen targets with radar data, our spectral results are consistent with their radar analog (16 Psyche, 21 Lutetia, 69 Hesperia, 135 Hertha, 216 Kleopatra, and 497 Iva). For twenty out of twenty-seven objects our statistical comparisons with RELAB meteorites result in consistent analog identification, providing a degree of confidence in our parametric methods.

1. Background

In this paper, we present updated results from our long-term survey of the X-complex asteroids. We initially began this work in 2003, targeting the Tholen M-types. Since that time, taxonomy has evolved and our targets have been newly classified according to the Bus-DeMeo system. In the Bus-DeMeo system, our targets are now called Xc- and Xk-types, however some of them are designated Xe or X-types. These asteroids have a notable lack of strong spectral features, and their near-infrared slopes range widely from flat to red. This paper presents new observations, several methods of data analysis, and a synthesis of all the work we have conducted to date. This paper directly follows and builds on our previous results (Shepard et al., 2010; Ockert-Bell et al., 2010).

2. Analysis

In order to determine possible mineralogies for our targets, three methods comparing spectral properties of our targets with those of meteorites were employed.

We used the publicly available RELAB spectrum library, in addition to spectra of meteorites presented in Cloutis et al. (2010, 2009). For each spectrum in the library, filters were applied to find relevant wavelengths and brightness at 0.55 μm that were within 7% of the asteroid's albedo. We normalized our asteroid and meteorite spectra to 1.0 at 0.55 μm and calculated the χ^2 value for each RELAB sample in the filtered list. The lists of RELAB spectra were sorted according to χ^2 and then visually examined for dynamic weighting of spectral features. A best match meteorite was selected for each asteroid based on the χ^2 value and the visual examination.

The values of six parameters (albedo, VIS slope, NIR1 slope, NIR2 slope, Band 1 center, and Band 2 center) of the asteroids can be compared with those of the meteorite classes suggested as analogs in the published literature. We conducted parametric comparisons using three methods. The first method was a parameter range comparison in which we counted the number of times an asteroid's parameter value was within the range of parameter values for a given class. The meteorite class that matched the greatest number of parameters is called the best match class for that asteroid.

The second method was to determine a distance between an asteroid's parameter value and the value of a meteorite class. The class with the smallest distance is the best match class. Three different

distance calculations were used to determine three possible best match classes; average, mean, and median. The average distance was calculated by summing the differences of an asteroid's parameter value and each meteorite's parameter value in a particular class, and dividing by the number of meteorites. The mean distance was calculated by the difference between an asteroid's parameter value and the mean parameter value of a meteorite class divided by the standard deviation of the class. The median distance is given by the difference between an asteroid's parameter value and the median parameter value of a meteorite class.

The final method used to establish a best match class linear discriminant analysis. Coefficients of a linear function of the meteorite parameter values are determined by minimizing the covariance between classes. This linear function was then used to predict group membership of our target asteroids. Assuming that parameter values within each meteorite class are normally distributed, probabilities of membership of each class are assigned to an asteroid. The class with the highest probability was determined to be our best match.

3. Figures

Shown in Figure 1 are three examples of asteroids which all methods used resulted in consistent matches. 21 Lutetia is well determined to be an enstatite chondrite type meteorite, 69 Hesperia is well determined to be an iron meteorite, and 55 Pandora is well determined to be a stony iron meteorite.

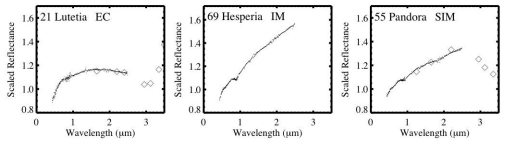

Figure 1: Three example spectra with their best match class given.

4. Tables

Shown in Table 2 are the summary results for all 27 asteroids.

Table 1: Best match class based on all methods

Name	Spectral analog	Radar analog
21 Lutetia	EC/IM	EC/CH
97 Klotho	IM	EC/CH
16 Psyche	IM	IM/CB
22 Kalliope	IM	CH/EC
69 Hesperia	IM	IM
77 Frigga	EC	-
129 Antigone	IM	CB
135 Hertha	EC	CH/EC
136 Austria	EC	-
224 Oceana	IM	EC/CH
250 Bettina	IM	-
336 Lacadiera	EC	-
441 Bathilde	EC	-
497 Iva	EC/SIM	SIM/CH
678 Fredegundis	IM	SIM/CB
771 Libera	IM	SIM/CH
792 Metcalfia	IM	-
872 Holda	IM	-
1214 Richilde	IM	-
55 Pandora	SIM	-
110 Lydia	SIM	CB/CH
216 Kleopatra	IM	IM
337 Devosa	IM/SIM	-
347 Pariana	SIM	IM/CB
758 Mancunia	SIM	IM/CB
779 Nina	SIM	IM/CB
785 Zwetana	SIM	IM/CB

References

[1] Clark, B.E. and 13 colleagues, 2010. Spectroscopy of B-type asteroids: Subgroups and meteorite analogs. J. Geophys. Res. 115, E06005. doi: 10.1029/2009JE003478.

[2] Cloutis, E.A., Hardersen, P.S., Bish, D.L., Bailey, D.T., Gaffey, M.J., Craig, M.A., 2010. Reflectance spectra of iron meteorites: Implications for spectral identification of their parent bodies. Meteorit. Planet. Sci. 45, 304-332.

[3] Ockert-Bell, M.E., Clark, B.E., Shepard, M.K., Isaacs, R.A., Cloutis, E.A., Fornasier, S., Bus, S.J., 2010. The composition of M-type asteroids: Synthesis of spectroscopic and radar observations. Icarus 210, 674-692.

[4] Shepard, M.K. and 19 colleagues, 2010. A radar survey of M- and X- class asteroids II: Summary and synthesis. Icarus 208, 221-237