ASTEROID 6 HEBE: SPECTRAL EVALUATION OF THE PRIME LARGE MAINBELT ORDINARY CHONDRITE PARENT BODY CANDIDATE WITH IMPLICATIONS FROM SPACE WEATHERING OF GASPRA AND THE IDA-DACTYL SYSTEM. Michael J. Gaffey, Dept. of Earth and Environmental Sciences, Rensselaer Polytechnic Institute, Troy, New York 12180-3590.

No large mainbelt asteroid has yet been confirmed as an ordinary chondrite parent body. However a number of plausible candidates have been identified based on dynamical considerations and/or spectral evidence. The leading candidate is 6 Hebe which is the fifth largest member of the S-asteroid class with an IRAS diameter of 185 km and an IRAS albedo (0.268) in the upper range of the albedos of the S-type objects. Hebe is located in the inner asteroid belt (a=2.426 AU, i=14.8°, e=0.203) near the chaotic zones associated with both the 3:1 proper motion resonance with Jupiter at 2.50 AU [1] and with the ν_6 (or g=g_6) secular resonance (located near i=15-16° at a=2.426 AU). Moderate ejection velocities of a few hundred meters per second can deliver relatively large amounts of Hebe fragments into either of these chaotic zones where they can rapidly be transferred into Earth-crossing orbits suggesting that Hebe is a significant source of meteorites [2,3]. Based upon the relative efficiency of impact ejecta delivery to these "escape hatches", Hebe could contribute about 10% (with an uncertainty factor of about 10) of the meteorite flux reaching the Earth and this asteroid could be the source of one of the major ordinary chondrite groups [3]. Calculations of the subsequent orbital evolution of fragments ejected by many asteroids located near the ν_6 resonance have confirmed that Hebe should be an important contributor to the terrestrial meteorite flux [4].

Based upon mineral compositions derived from the analysis of spectral survey data, the S-asteroid class was divided into seven mineralogical subtypes [5]. Hebe was classified as a member of subtype S(IV). This subtype exhibits surface silicate assemblages that are either undifferentiated (i.e., chondritic) or only slightly differentiated (i.e., the partially differentiated primitive achondrites). The S(IV) subtype was identified as the only subgroup among the S-asteroids which might include ordinary chondrite parent bodies. It is important to note that this conclusion does not constitute identification of S(IV) objects as ordinary chondrite assemblages, but only allows for that possibility.

Thus asteroid 6 Hebe is the best potential candidate for one of the long sought large mainbelt ordinary chondrite parent bodies. It appears to be a major mainbelt contributor to the terrestrial meteorite flux and it also exhibits a surface assemblage which allows (or more precisely, does not exclude) an ordinary chondrite affinity. An analysis of the rotational spectral variations exhibited by an asteroid provides a sophisticated test of whether or not any particular S(IV)-object is a viable ordinary chondrite parent body. To first order, the chondrites have a very limited compositional range, so that their suite of mineralogies is a function of their oxidation state [6]. In such a constrained system, the compositions and abundances of individual mineral species are strongly correlated [7,8]. For available spectral data and interpretive procedures, the most diagnostic test utilizes the inverse correlation between the 2 μm band center (BII, a function of the iron content of the pyroxene) and the ratio of the area of the 2 μm absorption feature to that of the 1 μm feature (BII/BI, a function of the pyroxene/olivine abundance ratio) in undifferentiated (chondritic) assemblages [9].

It has long been established that Hebe exhibits rotational color variations (Δu-v~0.02 mag) [10]. Recent observations indicate a relative variation of ~25% in the polarization in the V filter with rotation of Hebe [11]. Both of these data sets indicate the presence of surface heterogeneities, but cannot establish their compositional significance. Visible and near-infrared spectra were obtained in April 1978 (0.33-1.1 μm, 30 observations) and June 1979 (0.33-1.0 μm, 139 observations) using a two-beam filter photometer on the University of Hawaii 2.24 meter telescope atop Mauna Kea. These data exhibited consistent variations in the intensity and shape of the 1 μm absorption feature indicating mineralogical variations across the surface of Hebe. However, attempts to extend the rotational spectral coverage to include the critical 2 μm spectral feature were repeatedly frustrated until February 1989, when these data (0.83-2.55 μm) were obtained with the double CVF spectrometer on the NASA Infrared Telescope (IRTF) on Mauna Kea.

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The lightcurve of Hebe has a relatively low amplitude (<0.18 mag) and exhibits a complex structure which varies considerably with the phase angle and the ecliptic coordinates (subearth latitude on Hebe) of the observations. The lightcurve exhibits three maxima and three minima, their relative amplitudes varying with the observing geometry so that sometimes one or more of these maxima and/or minima are absent. This has presented some potential ambiguity in matching the rotational phase of the 0.33-1.0 μm and the 0.83-2.55 μm data sets. This ambiguity has been reconciled and results of the analysis of the full data set will be discussed.

If the rotational spectral variations of 6 Hebe are consistent with an undifferentiated silicate assemblage, there still remains the mismatch in the overall spectral slope and band intensities which has been a major topic of discussion. It has been recently suggested that the results from the Gaspra and Ida-Dactyl encounters establish that space weathering causes this discrepancy. It is observed that the lower albedo regions have a weaker 1 μm absorption feature and a steeper spectral slope [12]. It was concluded that these observations plus the deep band depth of Dactyl relative to the high albedo regions on Ida indicates the action of a lunar-style space weathering process (which attains a lesser degree of maturity) on asteroid surfaces. If this were the case than the steeper spectral slope and weaker absorption features of undifferentiated S(IV)-type asteroids could be reconciled with ordinary chondrite substrates.

However, there are several inconsistencies in this simple picture which leaves the issue in considerable doubt. Firstly, while the band depth for Dactyl is about twice that of the dark background terrain on Ida, their albedos are nearly equal. This is not consistent with the "weak lunar space weathering" model, and suggests that lithological differences are confusing the issue. Secondly, among the S(IV) asteroids there is a general positive correlation between band depth and spectral slope while any "lunar-style space weathering" would produce a negative correlation. Thus while the presence of a space weathering process on Ida and Gaspra appears well established by the contrast of bright craters to their surrounding terrain, there still remain considerable uncertainty concerning its nature and ability to spectrally modify ordinary chondrites to match the slope and band depths of S-asteroids.

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