THE 3:1 KIRKWOOD GAP AND THE MARIA FAMILY: GENETIC FAMILY MEMBERSHIP AND PLAUSIBLE SOURCE BODY OF MESOSIDERITES.

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Introduction: Since their initial discovery by [1], asteroid families have commonly been considered to be fragments from the collisional breakup and dispersion of their parent bodies. [2] drew attention to the distinction between asteroid families identified on the basis of their clustered similar orbital elements (dynamical families) and genetic families derived from a parent body breakup. To be considered a genetic family, the members of a dynamical family must be shown to be compositionally compatible with a common parent body.

Historically, taxonomy has been used to test the genetic nature of dynamical families and to identify potential interlopers within dynamical families. A number of investigators [3-7] have used taxonomic classifications to test family memberships. Other investigators have used a spectral curve matching approach and CCD spectra to test family memberships [e.g., 5, 7-10].

Using taxonomy as a tool to derive or imply mineralogy and to test genetic relationships whether asteroid-to-asteroid or asteroid-to-meteorite is fraught with ambiguity, both because most asteroid taxonomies are not based on compositionally diagnostic criteria [e.g. 11] and because the diversity of asteroid space weathering processes introduces an unconstrained variable into the taxonomic classification process [e.g. 12]. Additionally, most asteroid taxonomies are based on spectral data with limited wavelength coverage, typically ~0.4–1.0 µm, which lacks the near-infrared spectral coverage normally required to establish the true mineralogical nature of an asteroid.

Similarly, comparison of CCD spectra between members of a putative family is suggestive, but not definitive. It is likely to identify interlopers with significantly different compositions than the members of a genetic family. However, the limited spectral coverage does not allow actual mineralogical characterizations needed to assess genetic relationships. For example, two S-type spectra may have nearly identical CCD spectra, but show significant mineralogic (and genetic) differences when a full ~0.4 – 2.5 µm spectrum is analyzed. In the case of asteroid taxonomic types, classification of asteroids into different taxons almost guarantees that those asteroids have different compositions, but classification into the same taxon is no assurance that they have similar compositions. A similar statement can be made with respect to CCD spectra; different spectra generally indicate different compositions, but similar spectra do not assure similar compositions.

The Maria asteroid family (MAF) examined in this paper borders the chaotic zone of the 3:1 Kirkwood gap. These locations are capable of contributing to the terrestrial meteorite flux, as well as a possible source region for the giant NEAs such as (433) Eros and (1036) Ganymed [13]. [14] further investigated the possibility of a relationship between (433) and (1036) using spectral coverage extending from 0.4-2.5 µm. Results indicated they were not genetically related and not derived from the same family. This study extends that research to the MAF to determine if the MAF could be a possible source of either (433) or (1036).

This study investigated thirteen Maria dynamical family members: (292), (652), (695), (714), (787), (875), (897), (1158), (1215), (2089), (3066), and (3637). The present research uses NIR spectra to identify possible links between MAF adjacent to the 3:1 resonance and meteorites in the terrestrial collections.

Observations and Data Reduction: NIR spectral observations of MAF members were obtained between 2000-2009 at the NASA IRTF using the SpeX instrument[15] in the low-res spectrographic mode. Asteroid & local standard star observations were interspersed to allow modeling of atmospheric extinction. Data reduction was done using procedures outlined by [11,16].

The spectra of the MAF members characteristically exhibit an overall reddish spectral slope with two absorption features located near 1 and 2 µm which are typical of anhydrous mafic silicate assemblages. The band centers (BCs) and the band area ratios (BAR) are diagnostic of the abundances and compositions of mafic silicates [e.g., 11, 17-24]. The BCs and BAR for each spectrum are measured relative to a linear continuum fitted tangent to the spectral curve outside the absorption feature [e.g.19]. The error was estimated from several polynomial fits, sampling different ranges of points within the Band I and II spectral intervals. The error was determined as half of the difference between the minimum and maximum error calculated from the polynomial fits.

Analysis: BCs were plotted on the Band I vs. Band II plot [17,25] (Fig. 1). The MAF either plot within or very close to the HED regions of the Band I vs. Band II plot and either on or slightly above the OPX region of the pyroxene the trend line. Within the error bars, these values indicate a silicate assemblage containing abundant orthopyroxene. Using equations outlined by [11], the composition of the average pyroxene on the surface of MAF members were calculated. Within the uncertainties, the MAF members average pyroxene chemistries appears consistent with the chemistries of pyroxenes in the HED meteorite group. Spectrally neutral phases such as feldspar could also be present, but remain undetected. The alternate spectral calibration of [23,26] were also used to derive the mineralogies of the pyroxenes for each asteroid. The results using the [23,26] calibration and the [11] calibrations are within each others, increasing our confidence in the derived mineralogies.

The location of MAF members on the Band-Band plot would indicate that olivine is either rare or absent. However, on the Band I center vs. BAR plot (Fig. 2), MAF members plot within the S(IV), S(VI), and basaltic achondrite zones of the S-Asteroid sub-types defined by [20] . Two plot within the S(IV) region, four plot within the S(VI) region, and six plot within the basaltic achondrite region. Olivine appears to be a component of the silicate assemblage in the S(IV) and S(VI) regions. The surface assemblage of these MAF members appear to be enriched in metal with ultramafic pyroxene and olivine clasts.

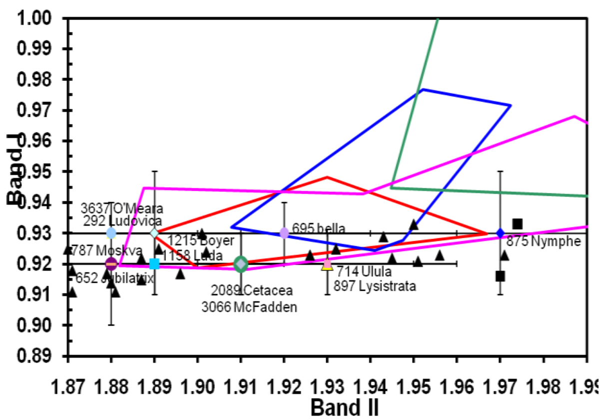

Figure 1

Conclusions: Our spectral data and analyses indicates that the MAF located adjacent to the chaotic region of the 3:1 Kirkwood gap appears to be a true genetic family composed of assemblages analogous to mesosiderite-type meteorites. Dynamical models by [27] predicts this region should supply meteoroids into Earth-crossing orbits. Thus, the MAF may be the source of some or all of the mesosiderites in our meteorite collections. One of the Maria dynamical family members investigated, (695), was found to be unrelated to the genetic MAF. The parameters of (695) indicate an H-chondrite assemblage, and that (695) may be a sister or daughter of 6 Hebe.

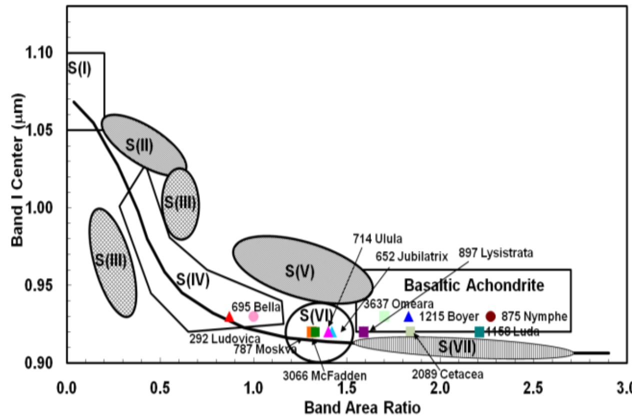

Figure 2

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