Detailed Petrological Characterization of Asteroid 1459 Magnya.

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Introduction: The recent discovery of a basaltic asteroid, 1459 Magnya, in the outer regions of the main asteroid belt [1] suggest that significant heating in the earliest epoch of the solar system reached further heliocentric distances than previously anticipated [2,3,4]. Although relatively few (<~50) main-belt asteroids have been mineralogically characterized to give relatively precise inferred thermal histories [5], research into the heating pattern in the main asteroid belt can be attempted and is continuing [6,7]. 1459 Magnya represents a potentially very important data point to advance our understanding of the actual heating pattern that occurred.

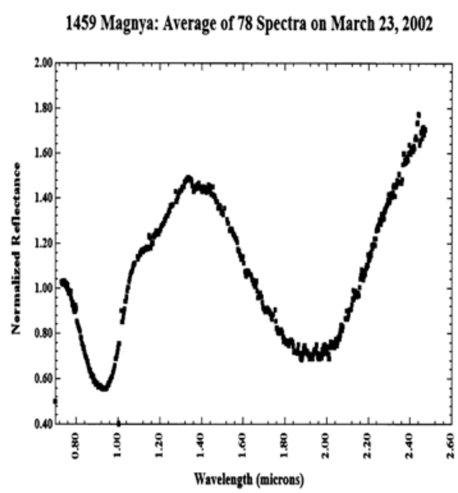
In addition to the thermal work, other issues concerning 1459 Magnya include its potential similarity with the HED meteorites and its possible genetic linkage to asteroid 4 Vesta and its associated fragments [8,9]. The resolution of these issues depends on detailed observations of 1459 Magnya that extend the wavelength coverage of this asteroid beyond at least 2.4 µm so that the pyroxene chemistry of the asteroid can be constrained.

Background: 1459 Magnya (*D* ~ 30 km) has a semimajor axis of 3.14 AU, with a perihelion of 2.39 AU and an aphelion of 3.89 AU. It orbits the Sun in a relatively eccentric orbit (*e* = 0.24), has an orbital inclination of 17°, and an orbital period of 5.56 years [1,10]. No rotation period has been determined for this asteroid.

Lazarro *et al.* suggest a basaltic composition for 1459 Magnya based on spectral similarites (from ~0.4 to ~1.7 µm) with 4 Vesta, 3657 Ermolova and the eucrite Bereba [1]. These researchers also suggested that 1459 Magnya is *not* genetically related to 4 Vesta because of implausibly high escape velocity requirements necessary to transport this asteroid to its current location [1]. 1459 Magnya is also known to orbit nearby several mean-motion and secular resonances that may have dispersed much of the presumed parent body of this asteroid [1].

Observations: We undertook observations of 1459 Magnya on March 23, 2002, using the SpeX instrument [11] at the NASA Infrared Telescope Facility (IRTF) on Mauna Kea, Hawai'i. The asteroid had a visual magnitude of 15.74 during data acquisition. Eighty spectra were acquired over a time period of four and one-half hours; all but two were eventually used. Weather conditions were clear with an inversion layer present on the mountain. All spectra were subsequently reduced using IRAF and the PC-based SpecPR [12] spectral processing program that has been modified and recently upgraded by M.J. Gaffey for use on Windows-based personal computers [13].

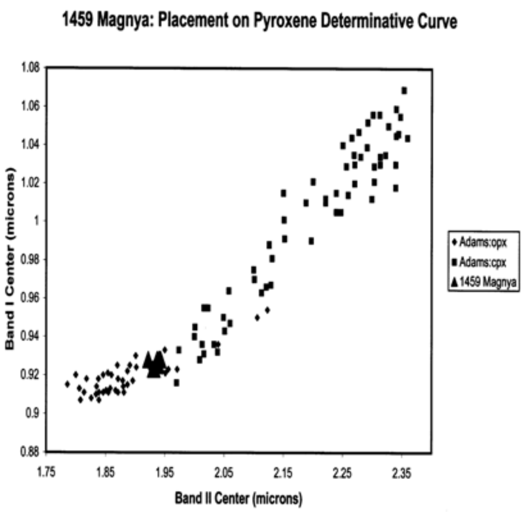
Results: An average spectrum of 78 observations of 1459 Magnya is displayed in Fig. 1 below.



Qualitative analysis of the spectrum in Fig.1 shows two broad absorption features in the ~1 and ~2 µm regions, along with an inflection in the ~1.2 µm region. The two deep (~40% and ~70%) absorption features are indicative of pyroxene and the inflection is suggestive of the presence of abundant plagioclase feldspar [14].

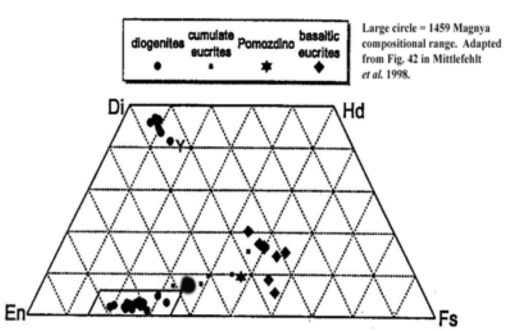
Quantitative analysis of the 10 spectral sets of 1459 Magnya (one all-night average, one set of the 50 best spectra and eight individual sets spread through the observing period) show that the Band I center wavelength ranges from 0.923-0.928 µm and the Band II center wavelength ranges from 1.922-1.943 µm. Isolation of the plagioclase feldspar feature produces a band center (~ 10% deep) at 1.17 µm for the average of the 50 best spectra of 1459 Magnya.

Pyroxene Calibrations: The change in band center positions for pyroxenes of differing compositions has been extensively investigated [15,16]. Using the latest pyroxene calibrations from [5], the chemistry of the pyroxenes on 1459 Magnya vary little around the determination for the all-night average, which is $Wo_{7-9}Fs_{36}En_{55-57}$. This composition would classify these orthopyroxenes as enstatite, but with a significant amount of Fe. Placing the band centers of 1459 Magnya on the corrected pyroxene calibration curve of Adams [15,16], the data points for 1459 Magnya lie in a tightly clustered zone directly on the pyroxene calibration curve. These data points are located near the right end of the calibrated orthopyroxene data points and at the beginning of the calibrated clinopyroxene data points. See Fig.2 below.



Comparison with HED Meteorites: Spectrally, 1459 Magnya is consistent with a eucrite-like assemblage due to the strong plagioclase feldspar feature present along with the pyroxene absorption bands. Comparison with the spectral parameters of basaltic achondrites in the terrestrial collection [8] shows that 1459 Magnya's assemblage is not currently represented in the terrestrial meteorite collection.

Mineralogically, the strength of the plagioclase feldspar feature suggests a plag/py ratio of ~0.59 [17]. This would also suggest a eucrite-like assemblage on 1459 Magnya. See Fig.3 in the lower left column for the position of 1459 Magnya pyroxenes (large dot to upper right of boxed diogenite field) on the pyroxene quadrilateral from Mittlefehldt et al. [18].



Comparison with 4 Vesta: The average spectrum of 4 Vesta from [8] produces band centers at 0.936±0.001 µm and 1.969±0.005 µm. This equates to an average composition ($Fs_{46}Wo_8$) for Vesta that is most similar to the howardite and polymict eucrite meteorites [8]. By comparison, 1459 Magnya has ~10 mole% less Fe compared to that of Vesta.

In addition, Vesta exhibits some surface compositional heterogeneity [8], while 1459 Magnya does not, except in the potential case of it having a very long rotation period. This may be due to the small size of 1459 Magnya that would represent a relatively small portion of the original basaltic crust of Magnya's parent body.

Conclusions: Based on dynamical considerations by [1] and our compositional work, we do *not* consider 1459 Magnya to be genetically related to 4 Vesta. Differences in pyroxene chemistry and feldspar abundance suggest that 1459 Magnya is either a fragment from a relatively reduced parent body compared to that of 4 Vesta or similar to basalts near one extreme end of the cumulate eucrite zone. The eucrite-like assemblage is unique and is not currently represented among any of the basaltic achondrites in the terrestrial meteorite collection.

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