SPECTRAL VARTIATIONS OF D-TYPE ASTEROIDS AT DIFFERENT HELIOCENTRIC DISTANCES.
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Introduction: D-type asteroids present one of the most complex puzzles in asteroidal science. Their origin, dynamic evolution, and mineralogical makeup remain unknown. Due to their low albedos, they are difficult to detect and observe from Earth. No spacecraft has ever visited one and there are no missions planned. We have no confirmed samples of D-types in the terrestrial meteorite collection. They may or may not be related to comets, Trans Neptunian Objects (TNO), or Kuiper Belt Objects (KBO). Many D-types may be virtually unchanged compositionally since their formation and could be rich in primordial organics. They could have pure crystalline water-ice beneath their dark, opaque crusts. We just do not know.

Research Focus & Methodology: The purpose of this work is to understand how D-type asteroids differ spectrally in the infrared at varying heliocentric distances. The effort began with an extensive review of literature related to asteroidal physical characteristics, mineralogy, taxonomy, asteroid spectroscopy, analysis of asteroidal spectra, compositional modeling of asteroidal surfaces, connections between asteroids and meteorites as related to D-types, and possible relationships between D-types and other small Solar System bodies. The review included a synopsis of previous ground based observations of D-types, including the results of those observations and their significance.

A program begun in late 2017 will, over the next year, use near-infrared reflectance spectroscopy from 0.7 to 2.5μm to examine ~50 D-types to develop identification of surface minerals and establish correlations between physical characteristics and location. A subset of these targets will be examined in the visible and TIR wavelengths. Laboratory comparisons of the newly obtained D-type spectra to known meteorite types will be used to establish a possible connection between D-types and terrestrial samples. Mathematical compositional modelling will be applied to the obtained spectra to estimate possible surface mineralogical composition of D-types. Finally, a model of spectral gradient by heliocentric distance will be developed and interpreted. While several theories regarding the relationship between spectral variations of D-types and geophyisical properties have been submitted over the years none have been conclusively validated. Successful results from this study will provide new significant constraints that can increase our understanding of D-types and may establish basic understanding of the variables responsible for spectral distinctions at different heliocentric distances.

D-Type Asteroids: The term D-type asteroid originates from taxonomic classification of observed characteristics. Taxonomic definitions of D-types are consistent across the major asteroid classification schemes of Tholen [1], Bus & Binzel [2], DeMeo et al [3] and Carvano et al [4]. D-types are characterized by low albedos and steep, red spectral slopes. D-type spectra do not exhibit a discernable absorption feature at 1μm [4], although some spectra exhibit a slight kink at 1.5μm [3]. Modeling estimates suggest D-type asteroids dominate the asteroid population beyond 3.5AU, with a large cluster at the Jupiter trojan points, and another between ~3.0 - 3.2AU [4]. There are estimates of several hundred D-types in the middle and inner asteroid belt [4, 5], as well as several dozen in near-Earth orbits [6].

Spectral properties. Spectroscopic surveys of D-types confirm steep red spectra with virtually no discernable absorption features [5, 7-17]. Spectral reddening in D-type asteroids appears to increase with increasing heliocentric distance [4, 9, 17-19], extends through the wavelength range for D-type spectra [8], may correlate directly to formation location [9], and may be inversely correlated to material strength [20]. Spectral reddening of D-types may be the result of contamination of water ice by carbon and/or tholin [21, 22] or the result of Titan tholin processing of silicates [8] or some other darkening agent.

Mineralogical Hypotheses. Multiple studies [8, 23, 24] were unable to find direct spectral evidence of silicates on the surface of D-types. If silicates are present on the surface they could be impact deposits [18], depleted in iron [25], or space weathered [9]. Although there are intimations surface material on D-types may be similar to CM2 chondrites [14] or certain iron meteorites [26], only two specific meteorite samples WIS91600 [27] and Tagish Lake [28] are suggested, but not confirmed, to originate from D-type parent bodies. Samples from the Tagish Lake Meteorite have spectral similarities to D-types in near-Earth space [29], and multiple regions of the asteroid belt [28, 30].

Possible Connections to Other Solar System Bodies. D-types represent between ~66-84% of the Jovian Trojan population and multiple workers have discerned similarities between D-types and Trojans in formation location, albedo, material strength, and

spectral reddening correlated with increasing distance, as well as decreasing diameter [9, 12, 31, 32]. Similar comparisons have been drawn between D-types and comets regarding spectral [12, 18] as well as dynamic properties [33-35], and formation location [36]. Similarities between the dark material covering D-type surfaces resemble material observed on smaller satellites of Jupiter and Saturn as well as TNO's and KBO's [37-42].

Potential Significance of This Research: If a relationship exists between spectral characteristics of D-type asteroids and their current heliocentric locations it may provide clues to understanding how and where D-types formed along with their compositional and dynamical relationship to other Solar System objects. The absence of such a relationship may also be significant.

If the number of proposed spectra are obtained, and mineral absorption features are not revealed, mathematical modeling of a hypothetical D-type surface composition is still possible. In addition to constraining surface composition, the discovery of mineral absorption features in D-type spectra and the development of a viable compositional model of surface material may help better explain the paucity of D-type meteorite samples in the terrestrial collection and establish spectral links to potential parent bodies for the few analog D-type samples on hand.

References:

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