3-µm SPECTROSCOPY OF WATER-RICH METEORITES AND ASTEROIDS: NEW RESULTS AND IMPLICATIONS

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Introduction: Ground-based observations of water-rich asteroids are important to constrain many questions related to the abundance and distribution of volatiles in the early Solar System, and to the evolution of many diverse Solar System bodies. Recent studies have revealed that several airless bodies, including the Moon and asteroid Psyche ([1], [2], [3], [4]), show spectral indications of hydration on their surfaces. Absorption features at ∼3.0 µm are particularly indicative of aqueous alteration. These absorptions are likely due to hydroxyl and/or water- bearing materials (OH/H_2O) (e.g.,[5] , [6]), but could also be due to surficial OH implanted from solar wind or exogenic sources like those seen on Vesta [7]. We are observing and studying 60 new water-rich asteroids in the 3-µm region using NASA Infrared Telescope Facility (IRTF) and Gemini North telescopes, in addition to the 45 water-rich asteroids previously observed by [6] and [8]. We are also stuyding additional carbonaceous chondrite meteroites (e.g., CI, CM, CO, CV, CR, CH, and CB) by measuring their 3-µm spectra under asteroid-like conditions to determine their mineralogical and spectral indicators. Applying these spectral analyses of carbonaceous chondrites to water-rich asteroids in the 3-µm region has been challenging because chondrite spectra have generally been acquired in ambient terrestrial environments, and hence are contaminated by atmospheric water. In this work, however, chondrite reflectance spectra are measured under dry conditions (i.e., vacuum and asteroid-like conditions) to minimize the adsorbed water that affected previous analyses. This investigation is important for matching the observed water-rich asteroids to specific chondritic groups for better understanding of the origin and evolution of our Solar System. Results from this work will also help analyze and characterize the returned carbonaceous samples from asteroids Bennu (OSIRIS-REx's target) and Ryugu (Hayabusa2's target), putting these returned samples into a wider perspective and broader context.

Methodology: Ground-based spectra of water-rich asteroids were measured using the longwavelength cross-dispersed (LXD: 1.9-4.2 µm) mode of the SpeX spectrograph/imager at the NASA IRTF and the cross-dispersed mode of the Near InfraRed Spectrograph (GNIRS) spectrometer at Gemini North, following the methodology of [6]. Additional 3-µm bi-directional reflectance spectra (*incidence* = 15°, *emission* = 45°, *phase angle* = 60°) of carbonaceous chondrites have been collected at the Johns Hopkins University Applied Physics Laboratory (APL) under vacuum-desiccated conditions, following the methodology used in [9].

Results: [8] found that CM (and CI) chondrites are possibly the meteorite analogs for water-rich asteroids with the sharp 3-µm band, attributed to phyllosilicates. The sharp spectral group contains asteroids that are located in the $2.5 < a < 3.3$ AU region. No meteorite match was found by [8] either for the rounded group, Ceres-like group, or asteroid Europa-like group. These three spectral groups are located farther from the Sun ($3.0 < a < 4.0$ AU). Here we present new 3-µm spectra of water-rich asteroids, including 212 Medea, 690 Wratislavia, 372 Palma, 259 Aletheia, 114 Kassandra, 701 Oriola, 360 Carlova, 747 Winchester, 386 Siegena, 356 Liguria 233 Asterope, 135 Hertha, and 142 Polana. Asteroid Polana, which is the main asteroid in the New Polana Family [10], is thought to be the probable source of primitive near-Earth asteroids including Bennu and Ryugu [11]. The new 3-µm spectra are grouped according to the classification scheme of [6]. We will also present new 3-µm spectra of carbonaceous chondrites, which will be used to interpret ground-based, as well as space-based, spectra of water-rich asteroids. We will then compare the new spectra of meteorites and asteroids to determine new possible matches on the basis of the 3-µm band.

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