A Search for 3-µm Features on Nominally Anhydrous Main Belt Asteroids

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Abstract

We are conducting a survey to search for 3 µm absorption features on nominally anhydrous Main Belt asteroids using the LXD short mode on the SpeX instrument at the NASA Infrared Telescope Facility (IRTF). Previous observations from our complementary survey of near-Earth objects with similar compositions show evidence of these 3 µm features. Our primary goals of the survey are the spectroscopic detection (or non-detection) of the 3 µm OH/H$_2$O absorption feature and an assessment of the processes responsible for the delivery of any detected OH/H$_2$O to these surfaces. The combination of the observations of Main Belt asteroids with our NEO observations will enable studies of the processes responsible for this feature (e.g., solar wind implantation) and any correlations (e.g., heliocentric distance, composition) that might exist.

1. Introduction

Studies have shown that several airless bodies previously thought to be devoid of OH/H$_2$O, such as the Moon and Vesta, show evidence of these materials on their surfaces. One indicator is a broad absorption feature near 3 µm. There are three proposed hypotheses for the presence of a 3 µm feature on airless bodies: 1) Solar wind implantation is the leading hypothesis to explain the 3 µm features on the Moon. Solar wind implantation leads to trapping of H+ ions in oxygen-rich regoliths to form isolated OH groups [1]. Temporal variations in the 3 µm absorption over the lunar diurnal cycle are consistent with this mechanism [2]. 2) Some Main Belt asteroids have 3 µm features whose strength and shape are more consistent with abundant native phyllosilicates [3]. Radioactive heating via $^{26}$Al and $^{56}$Fe would be adequate to aqueously alter asteroid parent bodies, if they accreted quickly [4]. 3) The dark hydrous material on Vesta is hypothesized to originate from low velocity impacts of carbonaceous material [5]. The effectiveness of these processes and retention of the products on the surface is likely dependent on several parameters. In particular, the effects of solar wind implantation may be dependent on surface composition. Laboratory studies indicate that temperature has a strong effect on the chemical reactions from solar wind implantation [6, 7], and temperature likely also affects the stability of hydrated carbonaceous material. Given that the processes responsible for this feature are likely to be active in near-Earth space, we hypothesized that spectra of nominally anhydrous near-Earth objects (NEOs) should also show a 3 µm feature. Observations of these NEOs have demonstrated that spectra of these objects can contain a 3 µm feature (McGraw et al, this conference). To complement these NEO observations, we extended this investigation of OH/H$_2$O on nominally anhydrous asteroids to include Main Belt Asteroids (MBAs). The MBA observations are intended to provide additional constraints for understanding the effects of heliocentric distance, temperature, and silicate mineralogy on delivery and implantation of OH/H$_2$O by solar wind implantation and carbonaceous impactors.

2. Observations

We are using the LXD short mode (1.7-4.2 µm) on the SpeX instrument [8] at the NASA Infrared Telescope Facility (IRTF) to observe nominally anhydrous (S- and V-complex) Main Belt Asteroids (MBAs) in order to investigate the volatile (OH/H$_2$O) content of these surfaces. Our survey began in 2017 and we have observed 22 MBAs as of 6 May 2019. We plan to observe ∼30 S- and V-complex MBAs to match the sample size of our NEO observations. Our primary goals are the spectroscopic detection (or non-detection) of the 3 µm OH/H$_2$O absorption feature and an assessment of the processes responsible for the delivery of any detected OH/H$_2$O to these surfaces. Few Main Belt objects (we estimate <15 outside of this survey) of these spectral types have been observed in these wavelengths. Our targets were selected to sample a
range of object sizes, compositions, and heliocentric distances.

3. Conclusions

Our observations show that some nominally anhydrous objects have 3 \( \mu \)m bands that can be associated with an OH/H\(_2\)O absorption feature. We will discuss what fraction of our sample contains these bands, the range of band depths observed, and compare our results with those of our NEO 3 \( \mu \)m survey.

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References