COMPARISON OF THE ALIPHATIC C-H ABSORPTIONS IN INTERPLANETARY DUST AND CERES.

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Introduction: The Visible and InfraRed Mapping Spectrometer on the Dawn spacecraft identified localized regions of aliphatic organic material on the surface of Ceres [1] having a spectrum quite different from the spectrum of the surface of comet 67P/Churyumov-Gerasimenko obtained by the Visible, Infrared and Thermal Imaging Spectrometer on the Rosetta spacecraft [2]. With respect to the organic matter the major difference is the presence of an absorption consistent with aromatic C-H in the comet spectrum but below the detection limit in the Ceres spectra.

De Sanctis et al. [1] suggest two possibilities for the localized organic matter detected on Ceres: exogenous delivery of organic matter or endogenous production. They note the similarity of the spectrum in the organic-rich areas of Ceres to that of insoluble organic matter extracted from carbonaceous meteorites, but suggest that organic matter delivered to the surface of Ceres by meteorites or Jupiter Family Comets might be modified or destroyed by the heat generated in the impact. This leaves delivery by interplanetary dust particles (IDPs) as the likely exogenous source.

We previously compared the spectra of more than 50 anhydrous and hydrous IDPs with the published spectra of 67P/Churyumov-Gerasimenko and found only one hydrous IDP was a good match [3]. Since Vernazza et al. [4] have proposed that the anhydrous IDPs sample the surfaces of the C-, P-, and D-type asteroids, and Vernazza et al. [5] suggest that the surface of Ceres has been partially contaminated by enstatite-rich anhydrous IDP material, a comparison of the organic spectra of the IDPs to the spectra of the organic-rich regions of Ceres seems appropriate.

Organic Matter in IDPs and Ceres: The organic signature we measured in more than 50 anhydrous and hydrous IDPs exhibits no detectable aromatic C-H and the aliphatic C-H absorption features are generally similar to the feature reported for Ceres. However, in almost all of the anhydrous and the hydrous IDPs we have examined by infrared spectroscopy the aliphatic $-C\text{-}H_2$ absorption is significantly stronger than the aliphatic $C\text{-}H_3$ absorption [6] (Figure 1), which is different from the spectra of the organic-rich regions on Ceres where $-C\text{-}H_2$ and $C\text{-}H_3$ are equal.

Although we detected N in IDP organic matter by x-ray absorption near-edge structure spectroscopy [7], none of our IDP spectra show the strong absorptions of NH_4 and CO_3 present in both the organic-rich and organic-poor spots on Ceres, consistent with the suggestion by De Sanctis et al. [1] that the ammonia and carbonate are endogenous.

De Sanctis et al. [1] express the concern that aliphatic C-H is unstable, citing laboratory measurements by Kebukawa et al [8] who derived kinetic parameters for Murchison meteorite organic matter that indicated aliphatic C–H is lost within 200 years at 100 °C and 100 Myr at 0 °C. Observation of the degredation of Murchison organic matter to produce methane when exposed to ultraviolet light [9] raises a similar concern about long-term stability. However, the detection of solar flare tracks and solar wind noble gases in many ~10 µm IDPs demonstrates that they spent tens of thousands of years with their present surfaces exposed in space. Our detection of abundant aliphatic C-H in these IDPs demonstrates that neither the temperature these IDPs experienced in space nor exposure to Solar ultraviolet radiation resulted in the loss of this aliphatic organic matter, and these effects should be less severe on Ceres.

Conclusions: IDPs are a viable exogenous source of the aliphatic organic matter detected on the surface of Ceres. However, if the current IDP population is responsible for the aliphatic organic matter detected on Ceres, the higher ratio of $C\text{-}H_3$ to $C\text{-}H_2$ absorption in the spectra of Ceres compared to those of most IDPs requires some modification to the IDP organic matter either during accretion onto or residence on Ceres.

References: [1] De Sanctis et al. (2017) *Science*, 355, 719-722. [2] Capaccioni et al (2015) *Science*, 447, id. aaa0628. [3] Flynn, G. (2016) *Geophysical Res.,* Abst. 18, EGU2016-1804. [4] Vernazza, P. M. et al. (2015) *Astrophys. J.,* 806, id. 204. [5] Vernazza, P. M. et al. (2017), 153, article id. 72. [6] Flynn, G. J. et al. (2003) *Geochim. Cosmochim. Acta,* 67, 4791-4806. [7] Flynn et al. (2008) *Proceed. IAU*, V 4, Symp. S251, 267-276. [8] Kebukawa, Y. et al. (2010) *Meteoritics Planet. Sci.*, 45, 99-113. [9] Schuerger, A. C. et al. (2012) J. Geophys. Res. 117, E08007.

Figure 1: Infrared spectrum of an anhydrous IDP, L2008R16, dominated by coarse-grained enstatite and forsterite and showing aliphatic CH_2 and CH_3 absorption features, but no detectable NH_3 or CO_3 absorptions. As with most IDPs we measured, the $C\text{-}H_3$ absorption is much weaker than the $C\text{-}H_2$ absorption.