THE DETECTION OF METHANOL AND DIAMONDS IN DENSE MOLECULAR CLOUDS

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In this abstract we report on the detection of solid state methanol (CH_3OH) and 'micro-diamonds' in dense interstellar molecular clouds. The work reported here is an extension of that previously reported at the 54th Annual Meteoritical Society Meeting held in Monterey, California (1).

Until recently, the presence of solid state methanol in these clouds had not been as well established (2). However, the position, width, and profile of an absorption band near 1470 cm^{-1} (6.8 μm) in the infrared spectra of many dense molecular clouds strongly suggests that solid methanol is an important component of interstellar ices (second only to H_2O). This identification is not unique, however, and other identifications have also been suggested (2). To better constrain the presence of methanol we have begun a program to search for other characteristic absorption bands of solid state methanol in the spectra of of objects known to produce the 1470 cm^{-1} (6.8 μm) band. Three such features at 2825, 2600, and 2540 cm^{-1} (3.54, 3.85, and 3.94 μm) have been unambiguously identified in the spectra of several dense molecular clouds. The positions, widths and profiles of these bands fit well with those of laboratory H_2O:CH_3OH ices (Figures 1 and 2). Thus, the presence of solid state methanol in many dense molecular clouds is confirmed. Where it is observed, methanol is the second most abundant component of the ice (only H_2O is more abundant).

In all of the spectra in which the new 2825 cm^{-1} (3.54 μm) methanol feature was detected, and in a number of spectra in which the feature was not detected, a second, unexpected band was discovered near 2880 cm^{-1} (3.47 μm) (Figure 3). This position is characteristic of the C-H stretching vibrations of 'tertiary carbon', i.e. carbon atoms bonded to one hydrogen and three other carbons. The strength of this feature, and the simultaneous lack of nearby features due to primary (-CH_3) and secondary (-CH_2-) carbons, places severe constraints on the molecular geometry of the carrier. After consideration of the position, width, and profile of the new band, we tentatively identify 'micro-diamonds' to be the source material causing most of the new absorption feature. It is likely that this material is related to the meteoritic diamonds that carry interstellar isotopic signatures (3). This feature is seen in virtually all the high-quality spectra of dense clouds we have obtained to date in this spectral region and its strength suggests that micro-diamonds contain as much as 10% of the cosmic carbon contained in some clouds. Presently available spectra of dust in the diffuse interstellar medium do not address the question of whether this material also resides in the diffuse, inter-cloud medium. Comparisons do show, however, that the presence of diamonds in the diffuse medium is not precluded.

The apparent ubiquity of the new feature and the abundance of its carrier suggests that this material is produced in a relatively common interstellar environment. This suggests that the formation site of the majority of the meteoritic diamonds need not *necessarily* be the same as the exotic environments responsible for the isotopic anomalies with which they are associated. A more detailed description of this work will soon appear in the literature (4).

REFERENCES:

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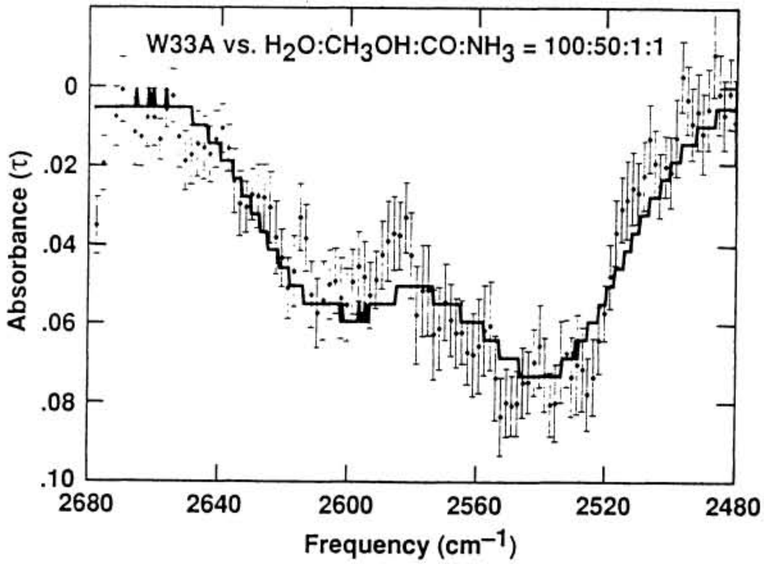

Figure 1 - A fit between the 2680-2480 cm^{-1} (3.73-4.03 μm) spectrum of the protostellar object W33A (points) and the spectrum of a H_2O:CH_3OH:CO:NH_3 = 100:50:1:1 laboratory ice. Note the good fit to both the 2600 and 2540 cm^{-1} (3.85, and 3.94 μm) methanol features. [W33A data provided courtesy of T. Geballe, UKIRT].

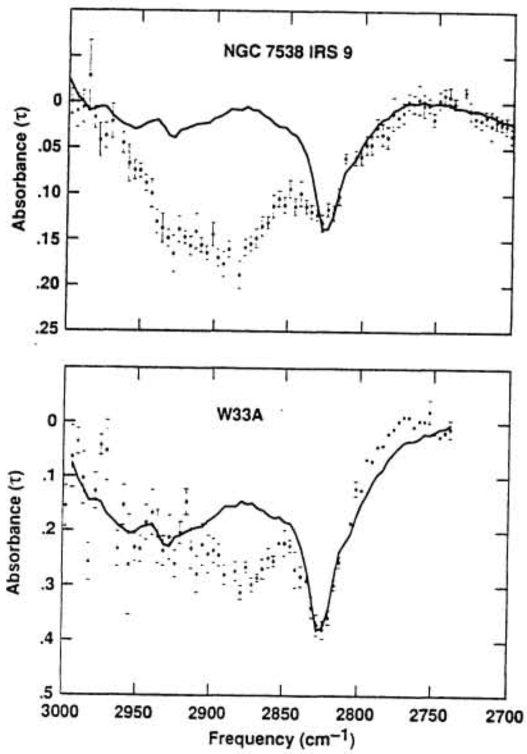

Figure 2 - A fit between the 3000-2700 cm^{-1} (3.33-3.70 μm) spectra of the protostellar objects NGC 7538 IRS 9 and W33A (points) and the spectrum of a H_2O:CH_3OH:CO:NH_3 = 100:50:1:1 laboratory ice. Note the good fit to the 2825 cm^{-1} (3.54 μm) methanol feature.

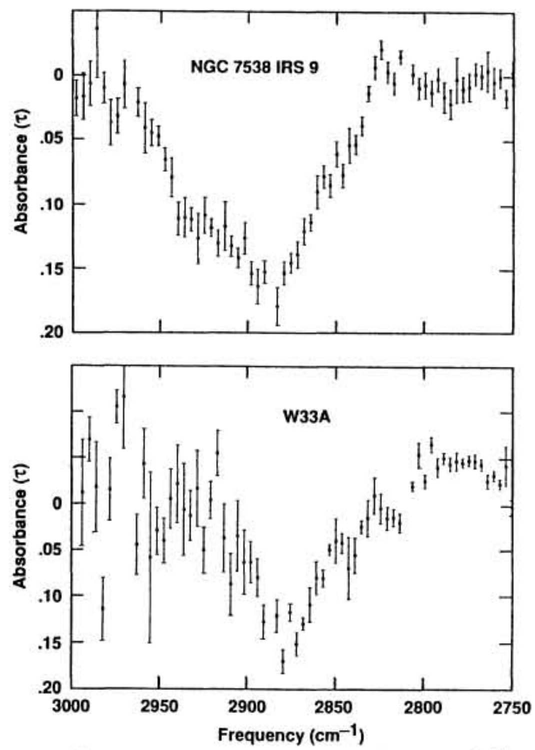

Figure 3 - The spectra of the objects NGC 7538 IRS 9 and W33A (points) after the methanol contributions shown in Figure 2 are removed. The spectral position of the residual feature (2880 cm^{-1}; 3.47 μm) is characteristic of tertiary carbon and is thought to be due to 'micro-diamonds.'