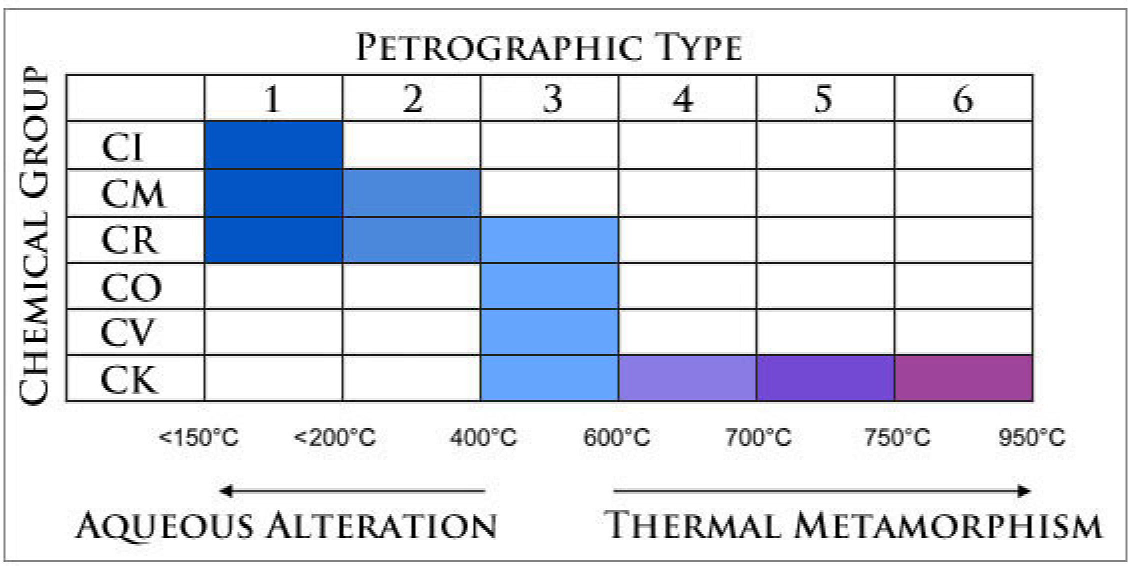
Explaining CO_2 Inside the Snowline

Orbital spectral data (e.g. from NASA's historic ***Galileo Mission***) confirmed the existence of the ***volatile*** carbon dioxide (CO_2) in the non-ice materials on the surfaces of the moons of Jupiter. Because CO_2 transforms from solid to gas (***sublimates***) inside the CO_2 ***snowline***—places such as the icy satellites of Jupiter and Saturn—researchers have been faced with the question: What process is acting to stabilize and retain CO_2 molecules under conditions too warm for CO_2 ice to exist in the outer Solar System?

In pursuit of answers, a team of researchers performed CO_2 gas adsorption experiments on different groups of ***carbonaceous chondrites***. These meteorites are some of the most chemically primitive and can serve as analogs for the non-ice materials on the surfaces of the satellites of Jupiter and Saturn.

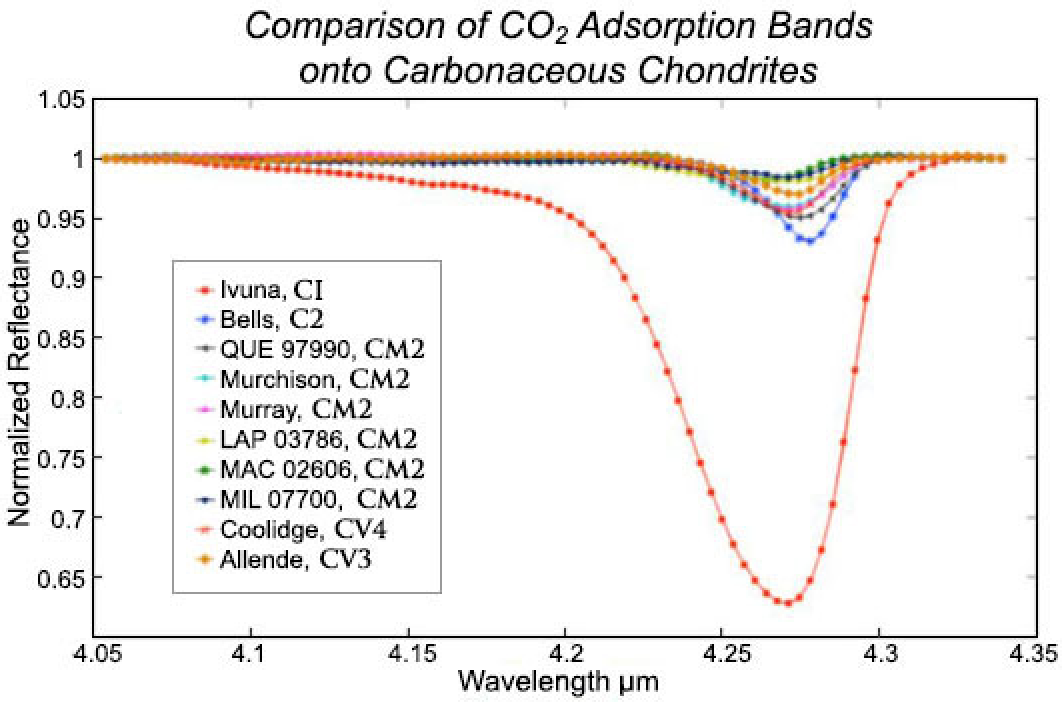
Classification of Carbonaceous Chondrites



(Adapted from Sephton, M. A. (2002) *Nat. Prod. Rep.*, v. 19, p. 292-311. doi: 10.1039/b103775g)

Carbonaceous chondrites are classified by their bulk chemical composition, which places them into groups (CI, CM, etc.), and by the amount of aqueous alteration (petrographic types 1 and 2) and heating without much water (3 through 6). Colored boxes show the groups identified in meteorite collections. Darker blue colors represent more aqueous alteration and redder colors represent increased thermal metamorphism. Berlanga and coauthors used powders of CI, CM, and CV meteorites as analogs for non-ice materials on the surfaces of the satellites of Jupiter and Saturn.

Genesis Berlanga (previously at Johns Hopkins Applied Physics Laboratory and now at the University of Hawai‘i), Charles Hibbitts (APL), Driss Takir (U.S. Geological Survey, Flagstaff), M. Darby Dyar and Elizabeth Sklute (both at Mount Holyoke College), examined and compared adsorption of CO_2 and quantified the spectral characteristics of the adsorbed CO_2 on ten powders of CI, CV, and CM chondrites. Under the experimental conditions of ultra-high to high vacuum (~1.0×10^{-8} to 1.0×10^{-7} Torr) and 150 K they examined the spectral signatures from ~1.66 to 5.55µm, which includes the 4.268µm band of CO_2. The figure below shows a comparison of CO_2 adsorption bands for the ten powders used in the experiments, listed in order from greatest to least CO_2 adsorption.



(From Berlanga, G. *et al.* (2016) *Icarus*, v. 280, p. 366-377. doi: 10.1016/j.icarus.2016.06.020)

Average CO_2 adsorption bands plotted for ten meteorite powders that retained CO_2 for several hours when dosed with gas and held at ~150 K in the experiments by Berlanga and coauthors. Meteorites are listed in order from greatest to least CO_2 adsorption.

The grain sizes and elemental compositions of the powders were determined with a scanning electron microscope. The abundance and valence state of the iron in the samples were determined with Mössbauer spectroscopy.

Berlanga and coauthors' research shows that CO_2 adsorption does not correlate with OH (water), organic, or carbonate abundances. They found that finer-grained samples and those containing complex clays with significant micro-porosity and high abundances of total FeO (oxyhydroxides) correlate with greater CO_2 adsorption. This is strikingly evident in the figure that shows the Ivuna CI meteorite powder [**Data link** from the Meteoritical Bulletin] adsorbed significantly more CO_2 than the other samples. The team suggests that the adsorption of CO_2 onto carbonaceous chondrites is analogous to adsorption onto the non-ice materials on the surfaces of the satellites of Jupiter and Saturn. And that more broadly, adsorbed CO_2 may have been retained and transported around the early Solar System on carbonaceous chondritic asteroids.

See Reference:

· Berlanga, G., Hibbitts, C. A., Takir, D., Dyar, M. D., and Sklute, E. (2016) Spectral Nature of CO_2 Adsorption onto Meteorites, *Icarus,* v. 280, p. 366-377, doi: 10.1016/j.icarus.2016.06.020. [**abstract**]

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