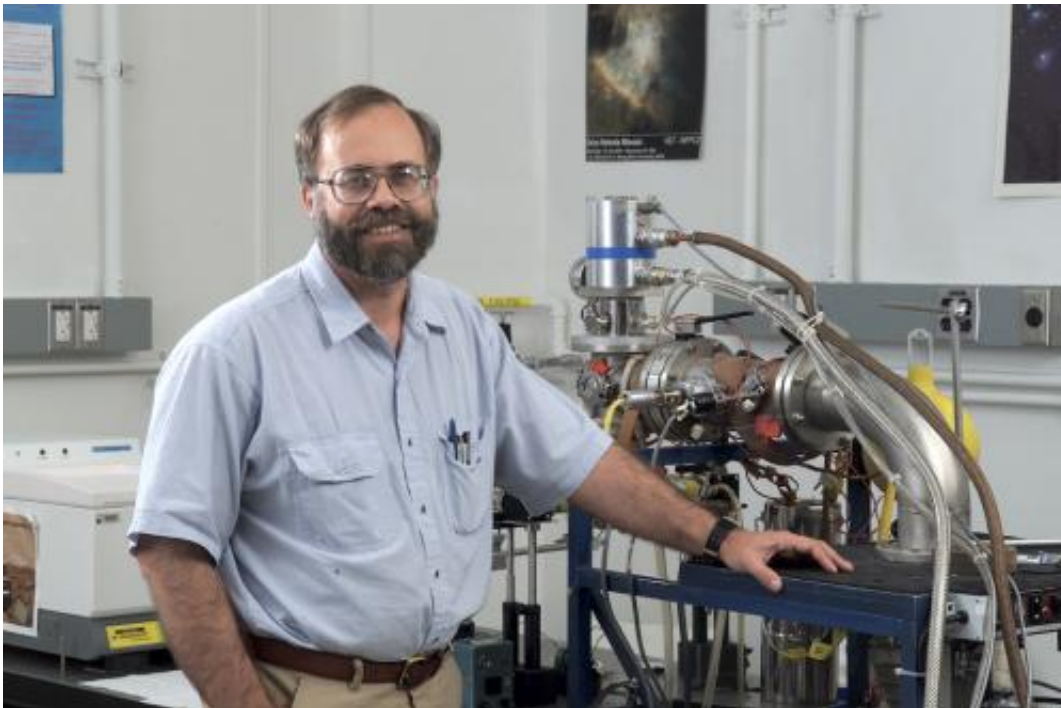


Contamination of impacted meteorites can happen quickly

December 18 2014, by Andrew Williams, Astrobio.net



Scott Sanford next to a cryovacuum systems that helps reveal the chemistry that produces organic compounds of astrobiological interest. Credit: NASA Ames/Sanford

A team of scientists has published the results of an investigative survey into the Sutter's Mill meteorite that landed in California in 2012.

The results reveal that the meteorite contained a number of features associated with minerals such as olivines, phyllosilicates, carbonates, and

possibly pyroxenes, as well as organics.

However, a key conclusion of the paper, and one that is likely to be of keen interest to astrobiologists, is confirmation that meteorites can become contaminated by Earth-based organics very quickly. That means scientists must be extra vigilant in identifying and assessing the effects of terrestrial organic contamination of meteoritic samples.

Infrared Spectroscopy

The paper, "Mid-infrared Study of Stones from the Sutter's Mill Meteorite," was published online in the March, 2014 issue of the journal *Meteoritics and Planetary Science*. It provides a detailed overview of the mineral composition of the meteorite, which fell in northern California on April 22, 2012.

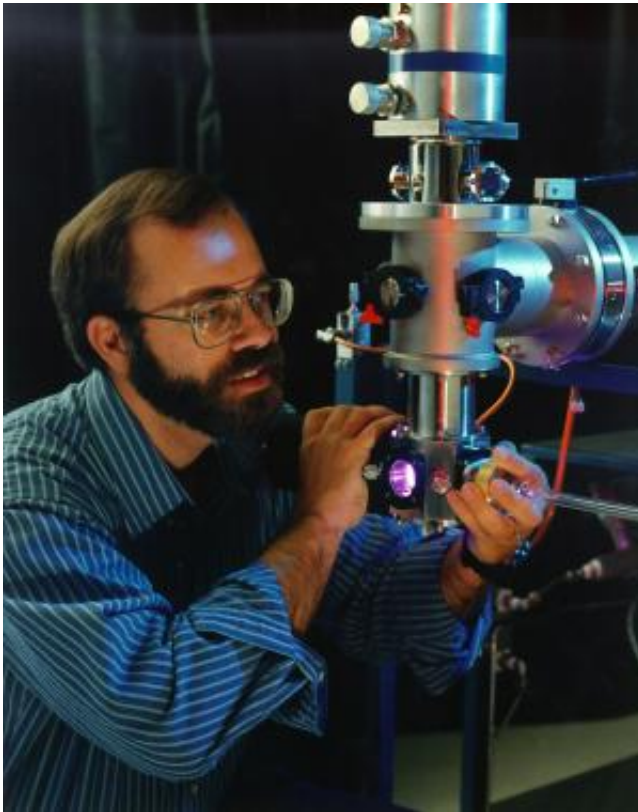
Several fragments of the meteorite were recovered, four of them shortly after the fall, and others several days later after a heavy rainstorm. The research team used [infrared spectroscopy](#), employing several different analytical devices to obtain spectra from very small samples. The spectra from the samples were then compared those of "standard materials," which refer to previously identified and characterized mineral standards. For example, the spectra of the carbonates in the Sutter's Mill meteorite samples were compared against the spectra of "mineral standards" of the carbonates calcite and dolomite.

"This sort of spectral matching is a way to identify an unknown," says Scott Sandford, a co-author of the paper and a space scientist at the NASA Ames Research Center. "Good spectral matches suggest possible identifications, while bad matches eliminate them. Most of the spectra are dominated by minerals that are consistent with the identification of this meteorite as a carbonaceous chondrite."

Carbonaceous chondrites are counted amongst the most primitive of all known meteorites and comprise about 3 percent of all the meteorites collected on Earth. They are of particular importance to astrobiologists because of the insights they provide into the early history of the Solar System.

Indigenous Organics

The research team hoped that the analysis of the [meteorite samples](#) would detect the spectral features of the "indigenous organics" that arrived with the original meteorite, as opposed to organic contaminants that got onto the samples after they landed on the ground. Although the team saw "clear" evidence of contamination on some of the samples, Sandford says there were a few places where it was "possible" that the team detected "organics original to the meteorite," but admits that the matter is "in no way proven by the data."



Scott Sandford of NASA's Ames Research Center looks into the sample chamber of one of the cryovacuum systems to study the chemical processes that can happen in space. Credit: NASA Ames/ Sandford

"[M]uch of the discussion in our paper associated with organics is devoted to addressing the caution that must be applied to searching for organics in this meteorite using spectral techniques, since the presence of organic contamination and abundant [carbonate minerals](#) makes spectral searches very difficult," adds Sandford.

For him, this difficulty was caused by a combination of two different factors. To begin with, even though some of the team's samples were collected fairly rapidly, there was evidence that bacterial contamination was present "in at least one of the samples."

Secondly, many of the samples contained abundant carbonate minerals, which made it much more difficult to detect the spectral signatures of certain types of organic materials.

As Sandford explains, this is because carbonate minerals produce a series of characteristic bands in the infrared spectrum, some strong, some weak. Some of these weak bands happen to land right on top of one of the spectral positions where particular types of organic compounds, known as aliphatic hydrocarbons, also typically produce features. Aliphatic hydrocarbons include molecules such as ethane, propane and butane.

"This is unfortunate, since it can cause considerable spectral confusion that makes it difficult to detect organics if they are present," adds Sandford.

A Note of Caution

In Sandford's view, both of these points serve as "cautionary items" for the astrobiology community.

The photon energies associated with the part of the infrared spectrum investigated by the team are generally not large enough to excite individual electrons, but are often high enough to induce the vibration of highly stable covalently bonded atoms and groups.



Scott Sanford on an Antarctic expedition to collect meteorites. Credit: NASA Ames/Sanford

One way of thinking about this is to picture the covalent bonds in molecules not as stiff rods or poles of the type found in molecule construction kits, but rather as rigid springs that can be bent or stretched. These types of vibrations, or vibrational modes, are often assigned descriptive names, including bending, scissoring, rocking, wagging, twisting and stretching. The research team analysing the Sutter's Mill meteorite concentrated on one such mode, known as the C-H stretching mode.

"Because of the structure of carbonate minerals, one of their vibrational modes can be mistaken for organics if only the C-H stretching region is examined and you're not cautious," he says.

Sandford adds:

"I'd say that use of IR spectroscopy in the C-H stretching region clearly needs to be used with caution, particularly in samples that may contain carbonates."



The recover team of the Stardust comet sample return mission collects the recovered capsule, which has been bagged to minimized contamination of the returned samples. Sandford is on the far right. Credit: NASA Ames/Sandford

Constant Vigilance

In light of the investigations carried out by the team, Sandford concludes that the broader astrobiological community "must always be vigilant" when assessing the effects of terrestrial contamination of any samples collected.

Although he is pessimistic about the prospects of astrobiologists ever finding signs of extinct life in meteorites, he believes that studies of this kind will continue to be a fruitful area of research into the detection of prebiotic organics.

"I don't think that there are many people who are trying to detect life in meteorites. Most of us are trying to detect prebiotic [organics](#) in meteorites—that is, molecules that may have played a role in helping life get started on Earth. While there are some folks that think they've detected signs of extinct life in meteorites, I have not so far found their arguments to be very compelling," he says.

More information: Nuevo, M., Sandford, S. A., Flynn, G. J. and Wirick, S. (2014), "Mid-infrared study of stones from the Sutter's Mill meteorite." *Meteoritics & Planetary Science*, 49: 2017–2026.
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