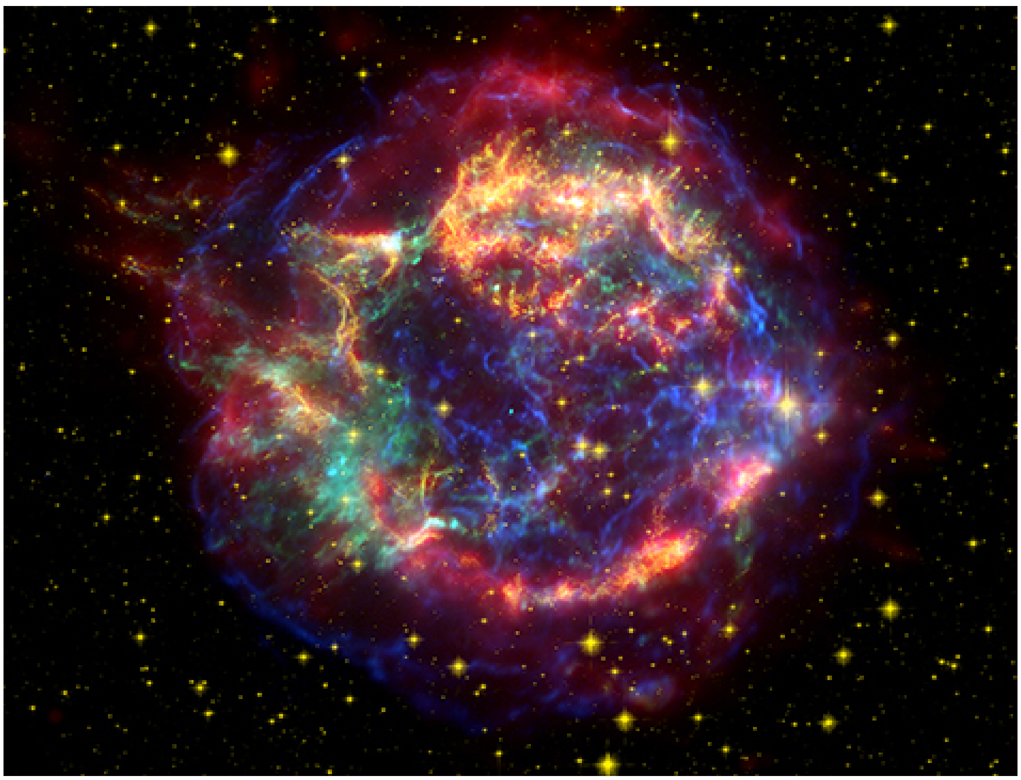
# Grains of sand from ancient supernova found in meteorites

April 19 2013, by Diana Lutz



In 2007 NASA's Spitzer space telescope found the infrared signature of silica (sand) in the supernova remnant Cassiopeia A. The light from this exploding star first reached Earth in the 1600s. The cyan dot just off center is all that remains of the star that exploded. Credit: NASA/JPL-Caltech/ O.Krause (Steward Observatory)

(Phys.org) —It's a bit like learning the secrets of the family that lived in your house in the 1800s by examining dust particles they left behind in cracks in the floorboards.

By looking at specks of dust carried to earth in meteorites, scientists are able to study stars that winked out of existence long before our solar system formed.

This technique for studying the stars – sometimes called astronomy in the lab—gives scientists information that cannot be obtained by the traditional techniques of astronomy, such as telescope observations or computer modeling.

Now scientists working at Washington University in St. Louis with support from the McDonnell Center for the Space Sciences, have discovered two tiny grains of silica (SiO2; the most common constituent of sand) in primitive meteorites. This discovery is surprising because silica is not one of the minerals expected to condense in stellar atmospheres—in fact, it has been called 'a mythical condensate.'

Five silica grains were found earlier, but, because of their isotopic compositions, they are thought to originate from AGB stars, red giants that puff up to enormous sizes at the end of their lives and are stripped of most of their mass by powerful stellar winds.

These two grains are thought to have come instead from a core-collapse supernova, a massive star that exploded at the end of its life.

Because the grains, which were found in meteorites from two different bodies of origin, have spookily similar isotopic compositions, the scientists speculate in the May 1 issue of *Astrophysical Journal Letters*, that they may have come from a single supernova, perhaps even the one whose explosion is thought to have triggered the formation of the solar system.

A summary of the paper will also appear in the Editors' Choice compilation in the May 3 issue of *Science* magazine.

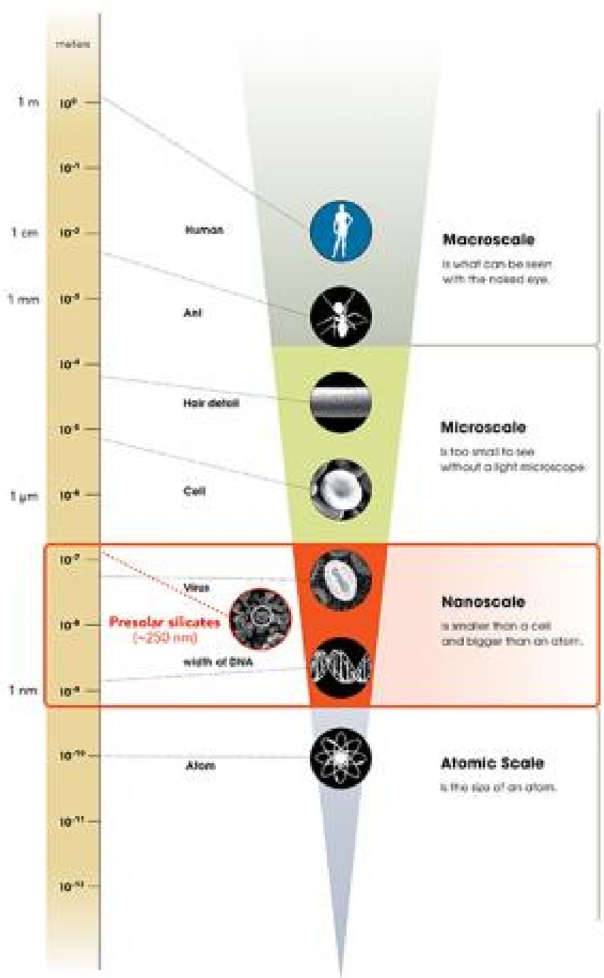
## The first presolar grains are discovered

Until the 1960s most scientists believed the early solar system got so hot that presolar material could not have survived.

But in 1987 scientists at the University of Chicago discovered miniscule diamonds in a primitive meteorite (ones that had not been heated and reworked). Since then they've found grains of more than ten other minerals in primitive meteorites.

Many of these discoveries were made at Washington University, home to Ernst Zinner, PhD, research professor in Physics at Washington University in St. Louis, who helped develop the instruments and techniques needed to study presolar grains (and the last author on the paper).

The scientists can tell these grains came from ancient stars because they have highly unusual isotopic signatures. (Isotopes are different atoms of the same chemical element that have a slightly different mass.)




How small is small? Presolar silicates typically run 250 nanometers in diameter, slightly larger than a virus — and nowhere near visible. Credit: Nanoscale informal science education network

Different stars produce different proportions of isotopes. But the material from which our solar system was fashioned was mixed and homogenized before the solar system formed. So all of the planets and the Sun have the pretty much the same isotopic composition, known simply as "solar."

Meteorites, most of which are pieces of asteroids, have the solar composition as well, but trapped deep within the primitive ones are pure samples of stars. The isotopic compositions of these presolar grains provide clues to the complex nuclear and convective processes operating within stars, which are poorly understood.

Even our nearby Sun is still a mystery to us; much less more exotic stars that are incomprehensibly far away.

Some models of stellar evolution predict that silica could condense in the cooler outer atmospheres of stars but others predict silicon would be completely consumed by the formation of magnesium- or iron-rich silicates, leaving none to form silica.

But in the absence of any evidence, few modelers even bothered to discuss the condensation of silica in stellar atmospheres. "We didn't know which model was right and which was not, because the models had so many parameters," said Pierre Haenecour, a graduate student in Earth and Planetary Sciences, who is the first author on the paper.

## The first silica grains are discovered

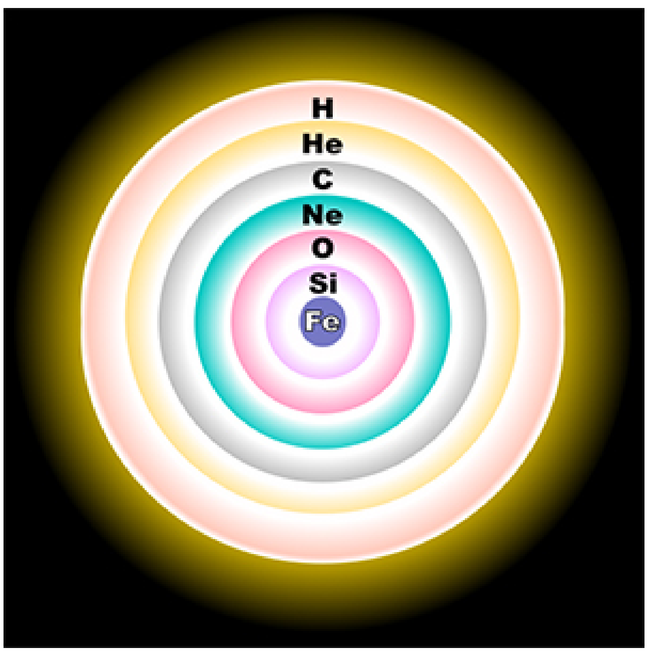
In 2009 Christine Floss, PhD, research professor of physics at Washington University in St. Louis, and Frank Stadermann, PhD, since deceased, found the first silica grain in a meteorite. Their find was followed within the next few years by the discovery of four more grains.

All of these grains were enriched in oxygen-17 relative to solar. "This meant they had probably come from red giant or AGB stars" Floss said.

When Haenecour began his graduate study with Floss, she had him look at a primitive meteorite that had been picked up in Antarctica by a U.S. team. Antarctica is prime meteorite-hunting-territory because the dark rocks show up clearly against the white snow and ice.

Haenecour found 138 presolar grains in the meteorite slice he examined and to his delight one of them was a silica grain, But this one was enriched in oxygen-18, which meant it came from a core-collapse supernova, not a red giant.

He knew that another graduate student in the lab had found a silica grain rich in oxygen-18. Xuchao Zhao, now a scientist at the Institute of Geology and Geophysics in Beijing, China, found his grain in a meteorite picked up in Antarctica by the Chinese Antarctic Research Expedition.




A massive star that will explode at the end of its life, a core-collapse supernova has a layered structure rather like that of an onion. Credit: Wikipedia

With two specks to go on, Haenecour tackled the difficult problem of calculating how a supernova might have produced silica grains. Before it explodes, a supernova is a giant onion, made up of concentric layers dominated by different elements.

Some theoretical models predicted that silica might be produced in massive oxygen-rich layers near the core of the supernova. But if silica grains could condense there, Haenecour and his colleagues thought, they should be enriched in oxygen-16, not oxygen-18.

They found they could reproduce the oxygen-18 enrichment of the two grains by mixing small amounts of material from the oxygen-rich inner zones and the oxygen-18-rich helium/carbon zone with large amounts of material from the hydrogen envelope of the supernova.

In fact, Haenecour said, the mixing needed to produce the composition of the two grains was so similar that the grains might well come from the same supernova. Could it have been the supernova whose explosion is thought to have kick-started the collapse of the molecular cloud out of which the planets of the solar system formed?

How strange to think that two tiny grains of sand could be the humble bearers of such momentous tidings from so long ago and so far away.

**More information:** AJL paper: iopscience.iop.org/2041-8205/768/1/L17/

Provided by Washington University in St. Louis