More findings about life on the Red Planet

If Martians could look down on Earth, they might be amused. Ever since a startling report last August, Earthlings have hotly debated whether a potato-shaped meteorite contains fossil evidence of primitive life on the Red Planet.

Some of the controversy focuses on whether carbonates found in the meteorite were formed at low temperatures, in an environment hospitable to life, or at much higher temperatures. Speaking to a standing-room-only crowd last week at NASA's Goddard Space Flight Center in Greenbelt, Md., David S. McKay, a leader of last August's discovery team, disputed a recent report arguing for a high-temperature origin for material in the meteorite.

He also presented new evidence that the rock, dubbed ALH84001, contains fossils of primitive bacteria from Mars.

McKay, of NASA's Johnson Space Center in Houston, countered criticisms that the tiny, wormlike structures thought to be microfossils in the meteorite could not, in fact, have been formed by a living organism (SN: 12/14/96, p. 380). John P. Bradley of MVA in Norcross, Ga., and the Georgia Institute of Technology in Atlanta and his colleagues had reported evidence that the apparent microfossils in ALH84001 are elongated, whiskerlike crystals of magnetite.

The whiskerlike shape has been associated with high-temperature activity, which cannot support water-based life, near volcanic vents. Bradley and his colleagues also found that some of the magnetite crystals contain structural defects that are not known to be produced in a biological environment. One of them, a spiral defect, typically occurs when atoms crystallize from a high-temperature vapor. In the other defect, known as twinning, atomic lattices that are mirror images of each other join at a common boundary.

Although McKay continues to assert that his team has not seen the whiskerlike shapes or the defects in microfossils from ALH84001, he also cites two older reports, previously overlooked, demonstrating that tiny bacteria can produce both whiskers and twinning.

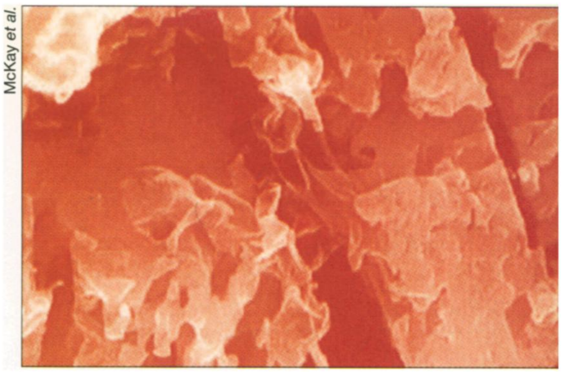
"Two out of three of [Bradley's] arguments are completely out the window," asserts Joseph L. Kirschvink of the California Institute of Technology in Pasadena. Bradley notes, however, that McKay's team had originally claimed that the apparent microfossils were and should be flawless if they were produced by living material. No one has yet demonstrated that bacteria can produce the spiral defect, he adds.

During his talk, McKay displayed intriguing micrographs that show what appear to be filmy coatings around carbonate globules in the meteorite. McKay suggests that the coatings, which survived even after the carbonates were etched away by acid or ions, are either a clay mineral or a protective, biological layer known as a biofilm. Modern colonies of bacteria can produce biofilms.

In a report to be given in March at the annual Lunar and Planetary Science Conference in Houston and already posted on the Internet, Kirschvink's team argues that ALH84001 hasn't been heated to more than 110°C since 4 billion years ago, long before any bacteria could have infiltrated the rock. The researchers found that two tiny, adjacent pieces of the meteorite showed dramatically different responses to an applied magnetic field. Exposure to high temperatures would have erased any such differences, they assert.

These results also provide a hint that ancient Mars had a magnetic field. That's good news for proponents of life on Mars, because the field would have steered away charged particles, belonging to the solar wind, that would otherwise have eroded the planet's atmosphere. An eroding atmosphere, with its large climate variations, could have proved catastrophic for life on the Red Planet. — *R. Cowen*

McKay et al.



Colorized photo of acid-etched fragment of ALH84001 shows a coating that could be a biofilm.

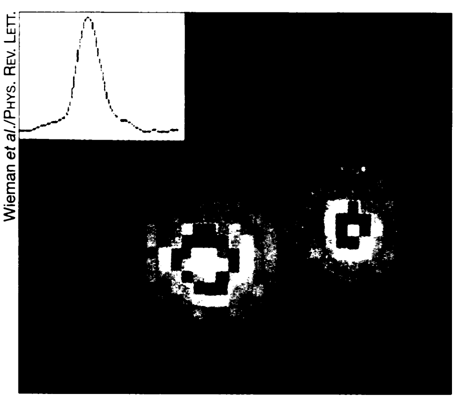
Frigid atoms settle into surprising states

When poet Robert Service wrote of the "strange things done in the midnight sun" of the frigid Arctic, he wasn't referring to atoms chilled to temperatures near absolute zero. Nonetheless, such atomic assemblages turn out to display a host of surprising characteristics.

In the latest twist in the saga of the coldest atoms, researchers have discovered a way to cool a single cloud of rubidium atoms in a magnetic trap so that each atom ends up in either of two subtly different quantum states. Unexpectedly, the two sets of atoms spontaneously separate into barely overlapping clouds.

Eric A. Cornell, Carl E. Wieman, and their coworkers at the University of Colorado and the National Institute of Standards and Technology, both in Boulder, report their findings in the Jan. 27 PHYSICAL REVIEW LETTERS.

Wieman et al./Phys. Rev. Lett.



This false-color image shows two atomic clouds representing the different quantum states created simultaneously during the cooling of rubidium atoms to temperatures below 250 microkelvins. Inset: Cross section of cloud on left shows concentration of coherent atoms.

"This is the first time that anybody has gotten two condensates of different types in the same trap," Wieman says.

Atoms that have been cooled to a sufficiently low temperature collectively enter the same quantum state and behave as a single unit. They are known as a Bose-Einstein condensate. Recently, a group at the Massachusetts Institute of Technology demonstrated that the array's atoms are coherent and constitute an atom laser (SN: 2/1/97, p. 71).

The Colorado-NIST team has now developed a cooling technique and a new type of apparatus that allows them to create condensates of neutral atoms in distinct atomic states. The two states differ by whether the electrons and nucleus of each atom spin in the same or opposite directions.

"What's surprising is that there's so little overlap of the two clouds in the case we studied," Wieman says. "Instead of mixing like normal gases, they separate like oil and water."

The new cooling method opens up the possibility of studying mixtures of two Bose-Einstein condensates. Theorists have already predicted a rich variety of interesting behaviors in such combinations.

In the Oct. 14, 1996 PHYSICAL REVIEW LETTERS, Tin-Lun Ho and V.B. Shenoy of Ohio State University in Columbus showed theoretically that overlapping mixtures of two different condensates would, under certain conditions, display vortices and other structures that occur when liquids become superfluids.

"The current experiments have already produced surprises," Ho says. With further improvements in the techniques, "one has a chance to see a new kind of superfluidity." — *I. Peterson*