Earth Sciences

Stefi Weisburd reports from Reno, Nev., at the Geological Society of America meeting

Bugs in a bubble?

Keith E. Bargar was studying fluid inclusions in pieces of quartz taken from a drill hole in a hydrothermal region of Yellowstone National Park when he noticed tiny specks scooting around inside the pockets of liquid. Upon closer inspection, Bargar, Robert O. Fournier and Ted G. Theodore at the U.S. Geological Survey in Menlo Park, Calif., discovered that the micron-long particles were rod-shaped and looked remarkably like bacteria. If the particles are indeed bacteria — and that remains to be proved — they will join the ranks of other microorganisms discovered at hydrothermal vents in the Pacific Ocean and elsewhere that thrive, unexpectedly, at high temperatures or pressures.

Fournier's group was originally looking at fluid inclusions to learn about the effects of a large sheet of ice that geologists believe moved into the area 14,000 to 45,000 years ago. By heating the inclusions taken from rocks at various depths and noting the temperature at which the vapor phase disappears and only liquid remains, the researchers can estimate the temperature of the fluid when it was trapped.

At 102 meters deep, where most of the particles were discovered, Fournier's group found entrapment temperatures ranging from 190°C to 280°C, well above the boiling point of water at that depth. This confirms the glacier idea, says Fournier, because the weight of the ice sheet would have increased the pressure at buried layers, thereby preventing boiling of fluids at higher temperatures. This also means that the specks were captured during the last glacial period.

The researchers spot the particles by their movement, which is due to thermal agitation, not because the specks are alive. Of the 200 quartz crystals examined, 10 percent contained particles in numbers from one to several hundred per inclusion. Bargar says that similarly shaped specks have been found in inclusions formed near geysers in northern California. Scanning electron micrographs of particles from both regions show that many are segmented and some give a hint of a cell wall. But the ultimate proof that these are bacteria, says Bargar, will have to wait for transmission electron microscope studies to probe their internal structure. "If we can really substantiate that these are indeed bacteria, it will be icing on the cake," adds Fournier. "If not we will have shown that something funny is going on that has to be taken account of somewhere."

Breakup date of a supercontinent

It is believed to be a geologic fact of earth life that continents, embedded in plates that drift like rafts over the molten mantle, periodically ram into one another and sometimes form one large supercontinent. The best-documented and most recent supercontinent was Pangea, thought to have begun rifting apart some 250 million years ago into, eventually, all the continents that exist today.

Before Pangea, there is some evidence — based on the magnetic signatures of rocks — that another supercontinent existed in the Proterozoic eon, more than 600 million years ago. Measurements of the radioactive decay of rocks extruded at the time of rifting place the breakup of this supercontinent between 520 million to 800 million years ago (Ma). Fossil ages have narrowed down the end of rifting to 545 to 650 Ma.

Now Gerard C. Bond, Peter A. Nickeson and Michelle A. Kominz at Lamont-Doherty Geological Observatory in Palisades, N.Y., present a new body of data that supports the supercontinent notion and pinpoints the time of separation a bit more. The researchers devised a method to infer the cooling rates of rocks at ancient margins, or rifting lines. When continents are torn apart, the crust thins and is heated by magma that upwells in ridges to form new ocean floor. After the breakup, when the plates start to drift away from the ridges, the crust begins to cool and in so doing, subsides, or settles downward. This enables sediments to accumulate. Bond's group can relate the thickness of these sedimentary deposits to the amount of subsidence of the underlying crust, and from this, calculate a crustal cooling rate. Using a theoretical model, they then project back to the time in which cooling began, that is, the time when rifting ceased and the land masses separated.

By obtaining the so-called subsidence curves for old margins in North America, Argentina, the Middle East and Australia, the researchers conclude that the major phase of the breakup took place no earlier than 625 Ma and no later than 555 Ma. The essentially simultaneous formation of over 18,000 kilometers of margins strongly supports the idea that a supercontinent existed prior to that time, says Kominz. The new data also show that the breakup was fairly rapid.

The scenario painted by Bond's group is consistent with other geological evidence that points to a sea level increase and subsequent flooding over large portions of land more than 500 Ma. The sea level rise, say the researchers, would have occurred about 70 million years after the breakup when the hot protruding ridges displaced much of the water in the newly formed ocean basins.

In a paper to be published in Earth and Planetary Science Letters, the researchers also present their version of the supercontinent mosaic at just before breakup. The biggest difference from other such constructions is that South America is jammed between North America and Africa, and the whole supercontinent sits at a pole.

Fossils of fabrics and fibers

Few of the silks, feathers, leathers and other finery inhumed in ancient burial sites survive decomposition. But in some cases, the form and texture of a fabric has been preserved in enough detail to tell an archaeologist about the textile technologies of an ancient culture, or even, perhaps, the types of birds (in the case of feathers) that were prevalent at the time. These so-called fabric pseudomorphs — minerals that have crystalized in the shape of the decaying fabric threads — are also revealing to scientists how fossils are formed.

J. Hatten Howard III and Kathryn A. Jakes of the University of Georgia in Athens and Lucy R. Sibley, now at Ohio State University in Columbus, believe that pseudomorphs form when water soaks through a burial site, oxidizing the copper contained in buried metal objects like weapons or jewelry. At the same time, water molecules invade the fabric, and in the case of silk, pry apart the long chains of amino acids that make up the threads. Copper ions close to the fabric can then nestle in and adhere to amide, amine and carboxyl groups within the fiber. Pseudomorphs arise as minerals — typically malachite or tenorite — precipitate in a shape mimicking the structure of the decaying silk. This differs from the usual fossil model, in which each organic molecule is replaced by a metal one, says Howard.

Howard and Jakes have studied this process in the laboratory by degrading silk in the presence of copper. By monitoring the acidity and oxidation potential of the solution, the researchers have predicted theoretically that malachite and tenorite are indeed the minerals most likely to form. The researchers have yet to make a complete fabric fossil, but they can see little crystallites of malachite forming in their silk-copper solutions. Howard doesn't think the fossilization process should take very long; when the researchers add silk to a copper solution, the mixture turns green immediately and within a few days is green-black.

The researchers are also studying the mineralization of other fabrics such as linen and cotton and are exploring how dyes or the composition of the surrounding soils affect the development of pseudomorphs.