arctic regions until 30,000 years ago.

So the team that redated the site has looked for other methods. But Diring Yuriakh lacks the charcoal, volcanic materials, or teeth needed for other techniques, and Forman's attempts to use OSL failed, because the sediments had been buried too long and all the OSL electron traps had been filled long ago. "So you're left with nothing except TL," says Forman. "Yes, it's experimental. Yes, it's developing, but what else do you do?"

Buzz word

Caution is the best advice that Wintle and others can offer to archaeologists eager to use luminescence methods. They advise forming an interdisciplinary team that can scrutinize the geology of the site, such as how the sediments were laid down, particularly around the object being dated, and detect signs of trouble in the lab (such as poor bleaching or a signal that fades because the traps have leaked electrons before the sample was dated). "Above all, the ultimate test of a date is whether it can be reproduced by an independent lab with access to the original site, because reassessment of the geological context is critical," adds geologist Jack Rink of Canada's McMaster University.

New luminescence strategies may also help. Roberts and his colleagues, for example, have now dated some of the most spectacular rock art in Australia by extracting single grains of quartz from mud-wasp nests on the rock face (*Nature*, 12 June). Wasp nests are common at rock art sites in Australia and elsewhere, and the mineral grains they harbor should have been well bleached at the time the nests were built—and sealed off from light since then. And because the nests are often right on top of the pigment, and in some cases have been partially painted over, they can provide minimum and maximum dates for the art. In another advance, Spooner and the University of Wales's Geoff Duller are borrowing a tool from astronomers' telescopes for detecting the luminescence—a charge-coupled device, capable of detecting the dimmest signals.

In the end, high-profile controversies at sites like Jinmium may speed the transformation of luminescence sediment dating from showy upstart into a reliable standby. "My job is luminescence dating," says Roberts. "I can't afford to have the field look inept."

–Ann Gibbons

ASTRONOMY

Probing a Star's Heart of Crystal

Looking into a crystal ball is not what you'd expect an astronomer to do. But Don Winget and his colleagues will give it a try next year. Their hope is not to predict the future, but to unravel the past. And their crystal ball isn't on a magician's table; it is a pulsating white dwarf star at a distance of tens of light-years in the southern constellation Centaurus.

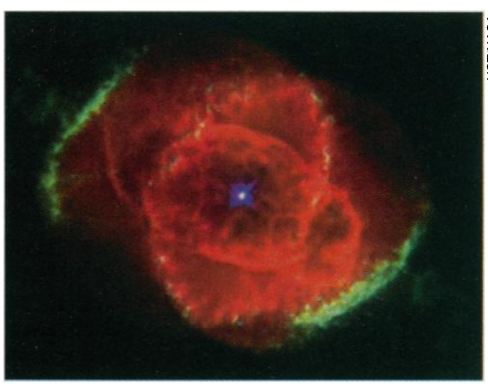
Winget and his colleagues have identified this star, called BPM 37093, as an ideal laboratory for studying how material inside white dwarfs—ancient stellar embers—crystallizes as they age. Depending on what the researchers find, "the ages of white dwarf stars in the disk of our galaxy might have to be revised upward, from 9 billion to 11 billion years or so," says Winget, who is at the University of Texas, Austin. That could spell trouble for cosmologists, who believe the universe as a whole is only about 11 billion years old.

Compact stars with a mass comparable to the sun, but a diameter not much larger than Earth's, white dwarfs are the remains of sunlike stars that shed their outer layers into space at the end of their lives. The cores, which no longer have any fuel left for nuclear fusion, slowly cool and fade. The coolest white dwarfs should thus be relics of the first stars to form in the galaxy.

Determining a white dwarf's age from its temperature isn't simple, however. In the early 1960s, theorists predicted that the atomic nuclei inside a cooling, compacting white dwarf would arrange themselves in a rigid lattice structure. The formation of this crystal ball, like the freezing of water, would release energy, slowing the cooling rate and making the star look younger than it really is.

Just how big an effect the crystallization has on the star's cooling rate depends on whether the carbon and oxygen nuclei that make up most of the white dwarf crystallize as an "alloy"—which would limit the effect—or separate into a core of pure oxygen and a carbon-oxygen mantle. "If [this] phase separation takes place," says white-dwarf specialist Gilles Fontaine of the University of Montreal, "you have additional energy release, and the cooling of the white dwarf is slowed down [further]." The delay would add 2 billion or 3 billion years to the age determined from temperature alone.

Astronomers have had a technique that could settle the question—but until now, no suitable star. The technique is asteroseismology: observing pulsations at a star's surface to deduce its internal structure, much as geologists study earthquakes to learn about the interior of our planet. Pulsating white dwarfs are scarce, however, and known pulsators are too hot to be crystallized.


HST/NASA

Birth of a white dwarf. Planetary nebulas like this one form when an aging star flings off its outer layers, exposing its hot, dense core.

In the 1 October issue of *The Astrophysical Journal*, Winget and his colleagues Mike Montgomery (also at the University of Texas) and Kepler de Souza Oliveira Filho, Antonio Kanaan, and Odilon Giovannini (at the Universidade Federal do Rio Grande do Sul in Brazil) identify BPM 37093 as an exception. They point out that this particular pulsating white dwarf is massive enough (about twice the mass of an average white dwarf) to have a crystallized interior, despite its relatively high surface temperature of over 11,000 degrees Celsius. Asteroseismology of this star "promises to provide us with the first empirical tests of the theory of crystallization," say the researchers.

In March 1998, Winget and his colleagues will begin studying the star's pulsations, observable as tiny brightness variations over periods of about 10 minutes, with the Whole Earth Telescope. WET is a collection of medium-sized telescopes all over the world, working in tandem to ensure that the star is never lost from sight. The observations will continue for nearly 2 weeks, yielding data that Winget hopes will settle the issue of whether phase separation takes place.

"That would be a fabulous achievement," says Huib Henrichs, a University of Amsterdam astronomer who uses asteroseismology to study giant stars. But Fontaine argues that poorly known features of the star such as its internal convection and the mass of the external hydrogen layer could make the results hard to interpret. Says Fontaine: "A lot of hard work will be necessary to untangle the various effects" that could mimic the signature of crystallization.

Winget agrees but says additional, ultraviolet (UV) observations of his crystal ball, to be made next year by the orbiting Hubble Space Telescope, will help sort out these effects. In the UV images, he says, it should be possible to distinguish the confounding effects from glimpses of a real crystal ball.

–Govert Schilling

Govert Schilling is an astronomy writer in Utrecht, the Netherlands.