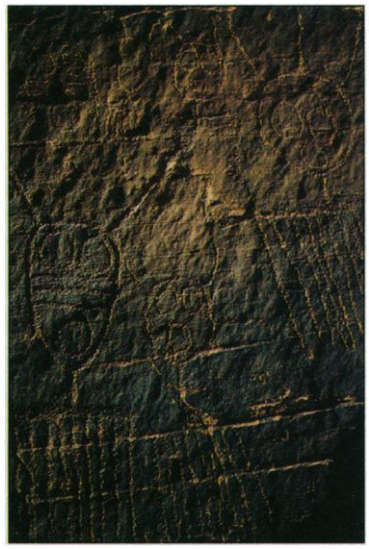
CARBON DATING

Rock Dates Thrown Into Doubt, Researcher Under Fire

When amateur rock art enthusiast Ekkehart Malotki discovered ghoulish human and animal carvings in isolated sandstone cliffs in the Arizona desert in 1993, he suspected that they were among the oldest he had ever found. So he was elated in 1996 when Ronald Dorn, a prominent geoscientist at Arizona State University (ASU) in Tempe, agreed to date the carvings. Using a technique he developed, based on measuring tiny amounts of carbon trapped beneath rock varnish, Dorn concluded that the carvings were perhaps 4800 years old, making them some of Arizona's oldest scientifically dated petroglyphs. An archaeology journal accepted a paper by the two men announcing the discovery. "I was honored that this world-renowned rock art dater had done this for me," recalls Malotki, a linguist at Northern Arizona University in Flagstaff.



E. MALOTKI

Center of controversy. Charges and countercharges swirl around the dating of these Arizona petroglyphs.

Now, however, Malotki says his elation has given way to anguish, and the age of his find—and of hundreds of petroglyphs, stone tools, and rock surfaces around the world—is in doubt. On page 2132, Malotki and seven co-authors, including several prominent geologists, challenge the validity of Dorn's technique. They report that rock samples Dorn processed contain microscopic granules of coal and charcoal, which, they say, render the dating results meaningless. If so, then many of Dorn's results—with implications for such debates as the peopling of the Americas—may be in jeopardy.

The findings also raise the specter of scientific misconduct by Dorn, who says the researchers are accusing him of manipulating samples. The *Science* Technical Comment, whose lead author is geoscientist Warren Beck of the University of Arizona, Tucson, stops short of accusing Dorn of fraud. "We do not intend to use the 'f' word with any reporters," says Beck, who, like Dorn, has consulted with attorneys in this matter. But the paper reports that the carbon granules do not appear in samples processed by other researchers. Those close to the case say that the National Science Foundation (NSF) and ASU are reviewing the possibility of misconduct.

In a lengthy response, Dorn acknowledges that his technique is flawed and produces "ambiguous" results. But he writes that the suggestion of tampering is "utterly false" and that the carbon granules are naturally occurring; he offers detailed technical explanations of why Beck and colleagues could not reproduce his results. This "controversy not only threatens my reputation but sidetracks a very important body of scientific research," he told *Science*.

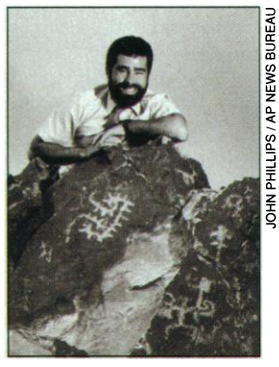
The controversial technique relies on accelerator mass spectrometry (AMS) radiocarbon analysis, one of several rock-surface dating methods pioneered since the 1980s by Dorn, a tenured professor who earned his Ph.D. at the University of California, Los Angeles (UCLA), and was hired by ASU in 1988. The method assumes that microscopic quantities of carbon-rich organic material, such as the remains of plants or bacteria growing on the rock's surface, become trapped beneath a thin layer of natural varnish. Although some scientists doubt the trapped material can be accurately dated, Dorn has argued—beginning with a 1986 *Science* paper—that it holds measurable quantities of radioactive carbon-14, which decays at a known rate. To date a rock, Dorn scraped organic material from beneath the varnish and extracted it with acid, then sent samples to one of the dozen AMS facilities around the world.

In June 1996, Dorn sent samples from Malotki's petroglyphs to Beck's AMS lab. Noticing unusual color variations, Beck says he examined the samples under a microscope and discovered that in addition to mineral grains, they contained two kinds of black granules. One type was identified by an independent expert as coal and the other appears to be charcoal, as the Technical Comment explains. Using radiocarbon dating, Beck and colleagues found that the coal averaged about 28,000 years old and the charcoal 4000 years. The different ages, says Beck, mean that the sample "will not yield a reliable radiocarbon age."

Mystified by how grains of such disparate ages were incorporated into the same thin slice of rock surface, Beck and Malotki collected and processed new samples from Dorn's original site. They report that none of the new samples contained the carbon granules. Concerned, Malotki says he immediately withdrew the paper on his treasured find.

Meanwhile, similar observations had been made by geochemist Wallace Broecker and his colleague Tanzhuo Liu at Columbia University's Lamont-Doherty Earth Observatory in Palisades, New York, who wanted to use rock varnish to date geologic events. According to Broecker, samples Dorn processed for them contained the granules, but samples they prepared themselves did not. Liu, a former graduate student of Dorn's, then returned to ASU in August 1996 especially to receive training in sample preparation from Dorn. Samples that Liu prepared in Dorn's lab contained the granules; those he processed at Columbia did not, says Broecker. Beck says he has examined more than 50 other samples prepared by Dorn and other investigators since the mid-1980s and found the same pattern: "The bottom line is that we found one or both of these materials in virtually every sample that was processed by Ron Dorn, and [we were] unable to find them in any sample that anyone else had processed," he told *Science*.

Dorn counters, however, that faulty technique explains why Beck, Broecker, and Liu couldn't find the grains. He adds that the presence of two different carbon grains on some, but not all, rock surfaces is well documented. "I and other scientists have found both of these materials associated with rock varnish samples from a wide variety of locations, and the literature abounds with those findings," he told *Science*. He cites two other researchers who have found the grains in independently processed samples: a former graduate student in his lab, and geologist Ramon Arrowsmith, an associate professor at ASU. Arrowsmith says his unpublished study, designed to look for the two kinds of grains, did reveal them in varnished rock samples from Arizona. He did not date the grains and says "it



JOHN PHILLIPS / AP NEWS BUREAU

Rocky road. One of Ron Dorn's rock art dating methods is under attack.

is a bit of a mystery" how they got into the rock.

As further argument against the tampering charge, Dorn claims that doctoring samples with different-aged contaminants would make it difficult to consistently bias results and "would be insane" if cheating were his intent. Finally, he cites a 1995 double-blind test in which he and geologist Alan Watchman of James Cook University in Townsville, Australia, independently dated Portuguese rock art using varnish-trapped organics—and got similar results. However, they concluded that the art was about 4000 years old—and most archaeologists put it at about 18,000 years old. Dorn says that the Portuguese results, and his realization that his samples held different-aged materials, made him recognize "fatal flaws" in his method.

But Dorn and his challengers differ on the timing of this admission. Dorn says he began to have concerns about the method as early as mid-1995; David Whiteley, a colleague from Dorn's UCLA days and now a consulting archaeologist with W & S Consultants in Simi Valley, California, confirms that Dorn discussed the problems with him then. "My impression was that he was attempting to broadcast his doubts widely," says Whiteley. In mid-1996, Dorn says he sent a note about the method's flaws to *Nature*; after it was rejected, he published an article in the December 1996 issue of *La Pintura*, the newsletter of the American Rock Art Association. It details "critical mistakes on the radiocarbon dating of organic matter associated with rock varnish. Enough data has accumulated to put the brakes on the use of this technique." He sounded a narrower cautionary note in a March 1997 *Antiquity* paper, which described "fundamental problems in the use of radiocarbon dating" at the Portuguese sites.

Beck and Broecker, however, say Dorn began publicly backing away from his technique only after he learned of Beck's concerns in August 1996. And Malotki says that Dorn didn't warn him of problems with the method even though Malotki was preparing their paper in the spring and summer of 1996. Dorn flatly contradicts this and says that he did indeed tell Malotki that the paper needed revision. Finally, in September 1996, Broecker says he forwarded the team's preliminary findings to the NSF Inspector General's office. NSF responded to him in late 1997, asking for a list of researchers qualified to review the issue. And in April, ASU moved ahead with its own inquiry, asking Beck to testify before a review committee.

Some researchers who know Dorn say that they don't believe the charges of tampering. Whiteley, for example, calls them "absurd." Ken Hedges, editor of *La Pintura* and an archaeological curator at the San Diego Museum of Man in California, says that "most of us who know Ron don't think they hold any water."

No matter how the NSF and ASU inquiries turn out, Dorn agrees that dates included in more than 20 of his publications over the last dozen years must now be viewed with skepticism. However, many archaeologists have long been skeptical of rock art dating anyway, notes archaeologist Benjamin Swartz Jr. of Ball State University in Muncie, Indiana. Thus, although Dorn estimated some southwestern rock art to be more than 15,000 years old—implying an early peopling of the Americas—"his dates weren't any better than any others," Swartz says. "The general consensus remains that the earliest [North American] rock art is about 12,000 years old."

The controversy is likely to cast a cloud over rock-varnish science, says geologist Fred Phillips of the New Mexico Institute of Mining and Technology in Socorro, who published a number of papers with Dorn. Says Phillips: "I would not submit any type of proposal involving rock varnish at this point."

–David Malakoff

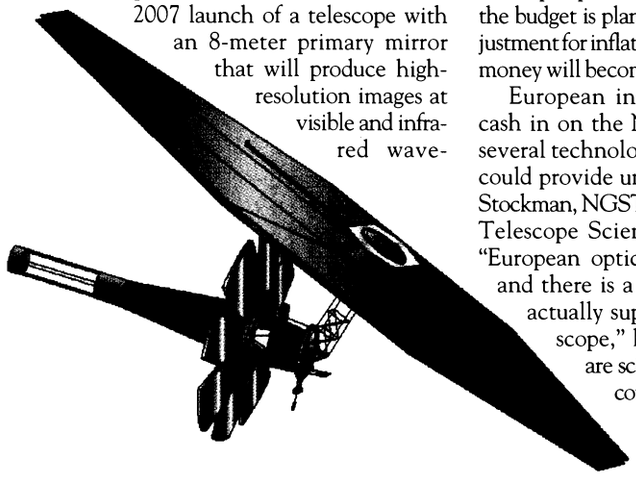
David Malakoff is a writer in Bar Harbor, Maine.

ASTRONOMY

ESA Commits to Hubble's Successor

The prospect that the United States and Europe will collaborate on building the Next Generation Space Telescope (NGST)—the successor to the Hubble Space Telescope—moved a step closer last week. During a meeting in Liege, Belgium, European and American astronomers and space scientists honed their plans for the $900 million instrument, and Roger Bonnet, director of science at the European Space Agency (ESA), announced that the agency has earmarked about $200 million from its science budget to collaborate on the NGST. Bonnet said ESA will soon start discussing the collaboration with NASA.

Current plans for the NGST call for the 2007 launch of a telescope with an 8-meter primary mirror that will produce high-resolution images at visible and infrared wavelengths. Its sensitivity will be several orders of magnitude greater than that of ground-based telescopes. Rather than orbiting Earth as Hubble does, it will observe space from Lagrangian point L2, a position on the Earth-sun axis about 2 million kilometers further from the sun than Earth. Compared to a similar meeting held at NASA's Goddard Space Flight Center in Greenbelt, Maryland, last year, the scientific goals of the mission were much more focused this time, reports Piero Benvenuti, NGST project scientist at ESA's European Coordination Facility for the Space Telescope in Garching, Germany. The NGST will serve to "discover the first galaxies and the first star-formation processes in the so-called 'dark ages' of cosmology, and also star formation in our galaxy," he predicts.



NASA

The next Hubble. Will it have European optics?

ESA's contribution to the NGST will put a severe strain on the science program's already stressed budget. ESA hopes to save money by putting two future astronomy missions—the FIRST and Planck telescopes, which will survey space at infrared and millimeter wavelengths—on a single launcher around 2007, but future prospects still look grim. No increase in the budget is planned, and there will be no adjustment for inflation. "We cannot say when this money will become available," says Benvenuti.

European industry, however, hopes to cash in on the NGST program. "There are several technological areas where Europeans could provide unique assistance," says Peter Stockman, NGST project scientist at the Space Telescope Science Institute in Baltimore. "European optics manufacturing is superb, and there is a serious possibility they can actually supply the optics for this telescope," he says, adding, "other areas are science instrumentation and, of course, the Ariane 5 launcher."

European astronomers also hope to reap rewards, just as they have done in the Hubble collaboration in which ESA contributed instruments for the telescope. For the Europeans, "the minimum agreed return on Hubble is 15%, but we are getting over 20%," says Benvenuti. The current collaboration agreement between NASA and ESA on the Hubble will end in 2001. Bonnet said at the meeting that the continuation of this agreement is now linked with the NGST.

–Alexander Hellemans

Alexander Hellemans is a science writer in Naples, Italy.