Distant Deposits Hint at Huge Eruption

By linking volcanic deposits on either side of the Atlantic Ocean, a team of geologists has found evidence for what they suggest is the largest known eruption in the last half billion years.

The clues for such a large eruption 454 million years ago come from layers of soft rock called bentonite that appear frequently in deposits from Earth's Ordovician period. Geologists regard bentonite as the remains of volcanic ash that blanketed the ground after an eruption and was later transformed into a clay-like rock. The prevalence of Ordovician bentonite beds in North America and northern Europe has caused many researchers to wonder whether these deposits came from a common volcano or group of volcanoes.

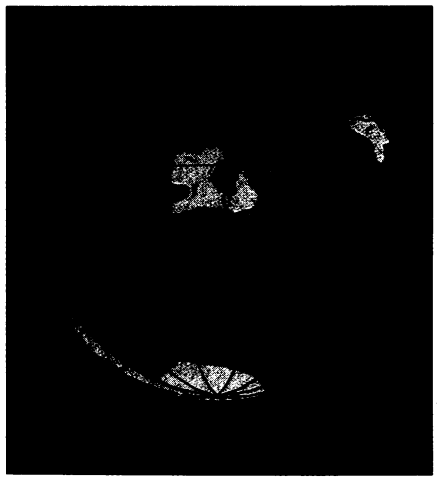
"The beds were there and people have known about them for decades. But nobody had ever tried any systematic effort to see if they could be related to each other," says Warren D. Huff of the University of Cincinnati. "What we have done is bring together all the pieces of evidence we could muster on that question."

In the October GEOLOGY, Huff and his colleagues now present evidence relating two major bentonite beds on the two continents. Not only did these deposits hail from the same volcano, they also originated during the same eruption, the researchers propose.

To link the distant beds, Huff and his coworkers used a form of chemical fingerprinting that compares the relative concentrations of six rare elements in the bentonites. This method suggests that a thick Scandinavian layer called the Big Bentonite is the same as a major North American bed called the Millbrig. The fingerprinting can also distinguish the two big layers from others at the same locations, showing that the others erupted at different times, Huff says.

In North America, the Millbrig bed spreads from western Iowa to Quebec and northern Alabama. Averaging about 1 to 2 meters in thickness, the bed is thickest in the Appalachian region, which would have been the North American coastline during Ordovician times. In Europe, the Big Bentonite bed extends from north-central Sweden to the Baltic region and northern Poland. During the time of the eruptions, the ancestral North American continent lay across a small ocean from the Baltoscandian continent, which carried present-day Scandinavia, the Baltics, and eastern Russia. The beds apparently came from a volcano located off the eastern coastline of North America.

From the aerial extent of the Big Bentonite and Millbrig deposits, the researchers calculate these layers contain 340 cubic kilometers of ash. A much larger


Huff/GEOLOGY

Gray shows ash thickness on early North American and Baltoscandian continents.

amount of ash must have fallen in the ocean that separated the two continents. Using the presumed location of the continents at the time, Huff and his colleagues estimate that at least 800 cubic km disappeared in the water. The total of 1,140 cubic km represents the largest known ashfall.

Although the blast would have created a globe-circling dust cloud, it apparently did not cause any major extinctions, the researchers report. This finding, they say, casts doubt on the idea that a cloud from a meteorite impact caused the dinosaurs and other creatures to die out 65 million years ago.

While the new report has intrigued some geologists, many remain skeptical about the proposed correlation between the two beds. "They may be right, they just haven't demonstrated it yet," says Scott D. Samson of Syracuse (N.Y.) University.

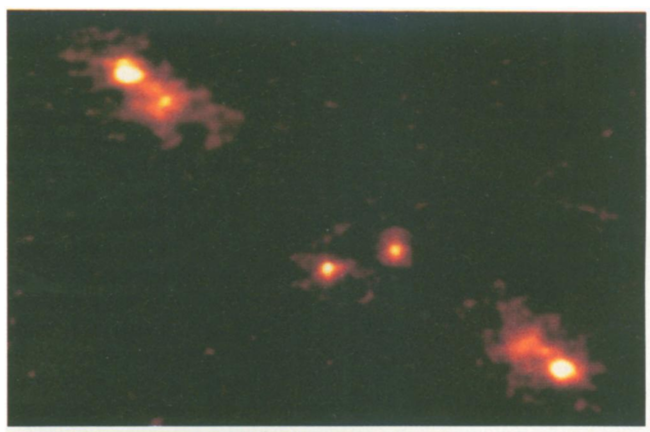
Michael R. Rampino of New York University questions the analogy between a volcanic dust cloud and one from an impact. The latter carries much more energy and may have lofted material higher in the atmosphere, he says.

Huff says his group is currently conducting a more refined type of fingerprinting on the bentonite beds, which could resolve some of the remaining questions. Later this month, researchers will hold a session on the Ordovician bentonites at a meeting of the Geological Society of America. *– R. Monastersky*

Gravity's lens: Hubble gets sharpest image

Examining a distant cluster of galaxies, the Hubble Space Telescope has produced the sharpest picture ever of a cosmic mirage called gravitational lensing. Researchers say that as Hubble takes more of these high-resolution images, they will yield a more accurate estimate of the universe's dark matter — material that can't be observed like ordinary matter.

Richard S. Ellis of Durham University in England and his colleagues weren't searching for a gravitational lens when they began analyzing a Hubble image, taken last November, of a remote galactic cluster called AC114. But graduate student Ian Smail spotted two unusual structures on opposite sides of the Hubble picture. The objects were nearly mirror images of each other, indicating that dark matter in the cluster, which lies 4 billion light-years from Earth, acts as a giant lens. The gravity field of the unseen material had bent starlight from a more distant body, much as a distorted glass lens might create multiple images from a single light source.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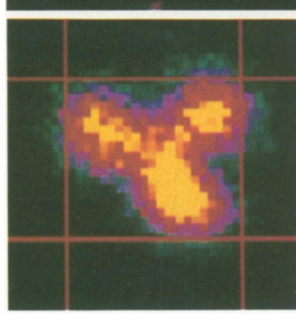

Above: Highest-resolution picture ever taken of gravitational lensing. Arrows show mirror images of a background galaxy distorted by dark matter in the galactic cluster AC114; objects in the center are material from the cluster. Left: The Extreme Ultraviolet Explorer detected a quasar-like body, PKS 2155-304, 2 billion light-years beyond the Milky Way.

This gravitational illusion, based on the principle that gravity distorts the path of light, was first proposed by Albert Einstein in 1916, and astronomers have seen the handiwork of gravitational lenses with ground-based telescopes since the late 1970s.

But in previous images, both those captured on the ground and those made by Hubble, the lensed objects appear as blurs. Ellis says that the unprecedented sharpness of the new Hubble picture, which shows L-shaped structures at the edges of the lensed images, enabled him to determine more accurately the concentration and mass of the material in AC114 that acted as a lens. His team has identified a third lensed image of the same distant galaxy in the Hubble photograph, he adds.

Assuming that the gravitational lens coincides with the center of the cluster and obeys similar laws of physics, Ellis calculates that the hidden material has 50 to 100 times the mass of visible material in the cluster and is much more densely concentrated. He reported the findings last week at a press conference in Washington, D.C.

The results match estimates of the amount of dark matter in galactic clusters made by observing lensed images from the ground. But J. Anthony Tyson of AT&T Bell Laboratories in Murray Hill, N.J., likens the impact of Hubble's single set of high-resolution lensed images to the diagnostic power of a single brain scan: One or two images may reveal only limited detail. He asserts that the blurrier but far more numerous lensed images seen from Earth still provide the best estimates of the amount of dark matter.

While Ellis disagrees, both scientists say the real revolution in the way astronomers calculate dark matter will come once Hubble begins to record many more gravitationally lensed objects.

Astronomers first postulated the existence of dark matter because the observed mass of the universe is too small to bind large objects gravitationally. The total amount of dark matter may determine the universe's fate – whether the cosmos has the gravitational power to collapse in on itself or will expand forever.

Ellis notes that the spectra of the lensed galaxy, recorded from Earth, suggest the galaxy lies 8 to 12 billion light-years away.

In a separate report at the press conference, C. Stuart Bowyer of the University of California, Berkeley, announced that another space-borne observatory, the recently launched Extreme Ultraviolet Explorer, detected a quasar-like object about 2 billion light-years from Earth. Researchers had thought the observatory would detect few, if any, sources outside our galaxy because of the patchy fog of hydrogen that bathes the stars and absorbs extreme-ultraviolet radiation (SN: 5/23/92, p.344). *– R. Cowen*

Gene-spliced rice resists stripe virus

In the Japanese language, the terms "rice" and "a good meal" are synonymous, reflecting the importance of the white grain to both the diet and the culture of Japan. Accordingly, the Japanese regard anything that threatens their rice crop as Public Enemy Number One.

A group of Japanese agricultural researchers has now made an advance that takes aim at one of the most serious rice scourges. Takahiko Hayakawa of the Plantech Research Institute in Yokohama and his colleagues have developed two genetically engineered rice varieties that resist infection by the rice stripe virus.

The rice stripe virus destroys millions of dollars' worth of rice harvests each year in Japan, Korea, China, Taiwan, and the former Soviet Union. An insect pest called the brown planthopper transmits the virus as it eats rice plant leaves. Rice stripe virus stunts the growth of rice seedlings, causes yellow stripes to develop on the leaves of mature plants, and reduces the amount of seed produced.

To foil the disease, Hayakawa's group turned to a modern-day adaptation of a classical agricultural technique: viral cross-protection. This strategy, which farmers worldwide have used for decades, involves inoculating young plants with relatively benign viruses in order to prepare them to fend off subsequent infection by more destructive viral strains.

In the mid-1980s, plant biotechnologists refined the technique by using genetic engineering to create plants whose cells make their own, benign bits of otherwise virulent invaders. Roger N. Beachy of Washington University in St. Louis and his colleagues demonstrated in 1986 that tobacco plants containing the gene that directs the production of the outer, or coat, protein of the tobacco mosaic virus can resist later infection by the virus.

Since then, the U.S. Department of Agriculture has approved 70 proposals by nearly two dozen research teams to grow outdoor test plots of plants containing genes for viral coat proteins. These field tests have included evaluations of tomatoes resistant to tomato mosaic virus, potatoes resistant to potato leaf-roll virus, and cantaloupe and squash resistant to cucumber mosaic virus (SN: 8/19/89, p.120). None of the gene-spliced vegetables has yet reached the market.

In the new report, published in the Oct. 15 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES, Hayakawa's group describes the first successful use of the viral-coat-protein strategy in a cereal crop. Working with clumps of immature rice-plant cells taken from two Japanese varieties of rice, the researchers inserted a gene that directs the production of the rice stripe virus' coat protein. They found that the clumps grew into young plants that made the coat protein.

Hayakawa/PNAS

A rice seedling infected with rice stripe virus (right) displays stunted growth and reduced grain yield compared with a genetically engineered seedling (left) that contains a gene conferring resistance to the virus.

To test whether the coat protein would allow the genetically engineered plants to resist infection by the rice stripe virus, Hayakawa and his colleagues placed virus-infected brown planthoppers onto 31 rice plants containing the coat protein and onto 17 control rice plants lacking the protein. They found that while 80 percent of the controls developed viral symptoms, only 20 to 40 percent of the genetically engineered plants did.

Moreover, the plants that did not display the viral symptoms also lacked a second protein marker of rice stripe virus infection, says Plantech researcher Ko Shimamoto, a member of Hayakawa's team. Shimamoto says the group plans to grow outdoor test plots of the genetically engineered rice plants next year.

Sivramiah Shantharam, a microbiologist at the USDA's Division of Biotechnology, Biologics, and Environmental Protection in Hyattsville, Md., says Hayakawa's team has taken steps toward solving a significant agricultural problem. However, he adds, "the exact mechanism of protection is not really known.... The coat protein might interact with an incoming viral particle, preventing its replication, but we really don't know how it works." *– C. Ezzell*