system survivability (in war environments), studies of nuclear weapons' effects on other weapons and communications systems, the design of systems to simulate nuclear weapons' effects (such as electromagnetic pulse) and analyses of supercomputer capabilities.

Graham has chaired the General Advisory Committee on Arms Control and Disarmament, under an appointment from Reagan, and is an executive member of the Washington, D.C.-based Committee On The Present Danger, a private, nonprofit group that studies issues relating to the U.S.-Soviet military balance.

— J. Raloff

Altamira cave art: Low-vent district?

The Altamira cave near Santander, Spain, is famed for its "Paintings Room," a chamber decorated with Stone Age paintings from more than 10,000 years ago. The cave was closed to visitors in 1977, however, due to deterioration of the artworks presumably caused in some way by the constant stream of tourists.

Scientists at the University of Santander now report that the wearing away of paleolithic paint and its limestone backing may have been promoted by carbon dioxide exhaled by people inside the chamber. Carbon dioxide buildup can lead to the dissolution of limestone. An initial charting of natural ventilation in the Paintings Room indicates it is weak and thus allows carbon dioxide to collect even without humans present, write physicist P. L. Fernández and his colleagues in the June 5 NATURE.

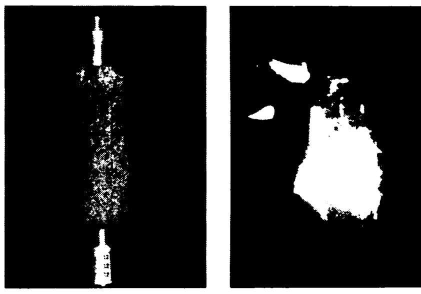
The researchers measured the concentration of radon gas in the chamber three times per week from February 1983 through January 1984. This, they say, is the best available means to assess ventilation. Radon escapes to the atmosphere through cracks in the earth, they note, and concentrates in the air of places with little ventilation. While ventilation of radon is weak throughout the year in the Paintings Room, it is lowest in May and peaks in July.

Furthermore, say the researchers, the carbon dioxide concentration in the Paintings Room, which originates from gas dissolved in underground waters, is at its lowest during July, August and September, and peaks in May and November. Taking into account the estimated average volume of carbon dioxide exhaled by one person, the scientists calculated the maximum number of people who could visit the cave for one hour each day in the summer months without raising the carbon dioxide level beyond the peak seen in May: 43 in July, 74 in August and 80 in September. The number of daily visitors in the summer was considerably greater before the cave was closed. *— B. Bower*

The light side of rock fractures

For centuries, miners have dreaded the occasional, mysterious flashes that would erupt from rock faces to light up underground diggings. The air would feel electrified as in a thunderstorm, and bits of paper and straw would jump about. Too often, these effects would presage a major rock collapse.

Although long a part of mining lore, these emissions have only recently been studied in the laboratory. Reporting in the May 29 NATURE, Brian T. Brady and Glen A. Rowell of the Bureau of Mines in Denver suggest that as rocks fracture, they eject electrons, which in turn excite surrounding air molecules to produce light.



Brady & Rowell

Left: A sample of granite, about 2 inches tall and 1 inch in diameter, during breakup. Right: Light emission from a fracturing granite sample.

"This is the first laboratory investigation of this problem," says Brady. The experiments provide a possible explanation for light and electrical emissions associated with rock fracture not only in mines but also during earthquakes. Reports of "earthquake lights" have a long history, and scientists have proposed several hypotheses to account for this effect (SN: 6/5/82, p. 375).

In their experiments, Brady and Rowell compress cylindrical samples of granite, basalt, coal, marble and other rocks. When the pressure is high enough, the rock samples fracture explosively. Within milliseconds, a dust cloud of fine rock particles is ejected and light flashes appear. In general, however, only an observer in darkness with night-adapted vision can see this light.

By fracturing samples in diffrent atmospheres and by examining the spectra of emitted light, the researchers found that the light comes not from the rocks but from the ambient gas. Moreover, the spectra show distinct lines rather than a continuous range of wavelengths. A continuous spectrum would be seen if the effect were due to heat generated by friction within the rock.

Even more surprising is the finding that when the tests are done in water, the water glows and hydrogen is produced. The ejected electrons appear to have enough energy to cause the dissociation of water, says Brady. Thus, the fracturing process, in the presence of water, could promote a variety of chemical reactions.

"We believe that insufficient consideration has been given to the role of rock fracture in fluid- and gas-saturated rock masses in promoting molecular dissociations," the researchers say, "and the role of this process in initiating chemical reactions of geological and biological interest." That may include reactions contributing to the formation of natural-gas deposits or to the origin of life on earth.

Brady and Rowell are now studying the details of these effects. They speculate, for instance, that electron emission within fracturing coal masses may cause the dissociation of methane, leaving pockets of potentially explosive hydrogen gas.

This research also provides the first plausible explanation for the observation of earthquake lights at sea. Previously, says John S. Derr of the U.S. Geological Survey in Denver, "it was not possible to explain earthquake lights at sea, except by invoking the help of legions of excited, phosphorescent plankton."

And, says Derr, the overall results show that under the right conditions, even the smallest earthquakes can produce light. This fits Derr's own observations of luminous phenomena that seem to be associated with very small quakes (SN: 12/24 & 31/83, p. 412).

However, there is a great difference in scale between a laboratory sample and a major earthquake. Although the work of Brady and Rowell is a significant step toward finding one possible geological mechanism for light production, Derr says, ". . . investigations in other areas are still required because we may be looking at several phenomena which sometimes share a common appearance and name."

Also not settled, says electrical engineer Stuart A. Hoenig of the University of Arizona in Tucson, is the question of how the breakup of rock generates free electrons. "Why does the rock give off electrons when it breaks?" he asks. "How do the electrons escape?"

Nevertheless, the fact that electrons are emitted is quite certain, says Hoenig. This electrical activity and its related chemical effects — possibly causing changes in the air's ion concentration — may account for the unusual behavior of some animals before an earthquake, he says.

Says Derr, "A new, challenging area of geophysics is just opening."

— I. Peterson