Under the volcano: Lava in the lab

Heat is the engine of the earth. As it escapes from the core, heat has made mountains, driven volcanos and churned up the earth's mantle, from which the atmosphere, oceans and continents were derived. One way to learn about the history of the planet as it cools from its rather hot beginnings is to study how magmas, or molten rocks, are formed in the mantle before they are spewed out onto the surface. But duplicating mantle conditions in the laboratory has been hampered by a lack of equipment capable of simultaneously subjecting large rock samples to high temperatures and high pressures.

After a decade of development, several Japanese researchers now have such equipment at hand. And one of the first important fruits of their labors is a report in the June 13 NATURE on the melting of natural rocks to form komatiite, a very hot, magnesium-rich lava that erupted on the earth 2.5 billion to 3.8 billion years ago during the Archean eon (the oldest time from which rocks still exist) and, with one exception, has not erupted since.

The recent experiment, performed at Okayama University by Eiichi Takahashi and Christopher M. Scarfe, has shown that komatiite can be created at much higher pressures—and hence depths in the earth—than was commonly believed. As such, it has considerable bearing on the makeup and evolution of the Archean mantle, about which there is much speculation but few known facts.

Most scientists believe that the upper mantle today is made of peridotite, a magnesium-rich mineral. Different magmas, distinguished in part by their magnesium content, can be generated by melting peridotite under various conditions. Since komatiites were discovered in 1969, the prevailing theory held that they formed, like the basalt lavas common today, at shallow depths and low pressures. The major problem with this idea, says Claude T. Herzberg at Rutgers, The State University, in New Brunswick, N.J., is that it requires that the peridotite melt almost completely and in such a way that the solid crystals remain in contact with the liquid phase. In practice, the solid bits tend to fall away from the liquid, so Herzberg and others have proposed instead that komatiites could come from peridotite with only a small degree of melting but at very high pressures.

This is just what Takahashi and Scarfe confirmed experimentally. Their study, using a 5,000-ton press, produced komatiites from natural peridotite rocks subjected to temperatures of almost 2,000°C and pressures up to 14 billion Pascals (GPa) — three to four times greater than the pressures of past experiments, in which the first drops of liquid produced were lower-magnesium magmas like basalt.

Since pressures increase with depth in the earth, "this is very strong evidence that melting in the Archean took place at much greater depths than it is taking place today," says Herzberg. "The reason there are no komatiites erupting today is that the depth of melting is not great enough; as the earth has cooled, the depth at which melting takes place has progressively moved toward the surface."

The recent experiment also supports another of Herzberg's predictions by showing that the "melting interval" of peridotite decreases with increasing pressure. The melting interval is the difference between the temperature at which crystals start to form in a cooled liquid and the temperature at which the first drop of liquid appears in a heated solid. For peridotite at the surface, this interval is about 600°C. Takahashi and Scarfe showed that it dropped to about 100°C at 10 GPa.

Herzberg thinks the melting interval will drop to 50°C or so and then start to increase again with increasing pressure. "And when that happens the mineral that first crystallizes as the temperature drops will change," he says. At low pressures this mineral is olivine, but no one knows what it will be at high pressures. "It's one of the exciting things that has to be done...that's going to tell us something about the mineralogy of the lower mantle," he adds.

Scarfe, on sabbatical from the University of Alberta in Edmonton, says he and Takahashi are planning more experiments this summer that will extend the pressure range to 20 GPa. With some care, their equipment can go up to 30 GPa.

Meanwhile, researchers at the State University of New York (SUNY) at Stony Brook are in the process of acquiring a system almost identical to that of Takahashi. According to SUNY's Robert Liebermann, the new equipment will be ready for experiments in 1986 and will be the first of its kind in North America.

—*S. Weisburd*

An open airing of the gene-splice debate

"Not to live in the cellar because we fear a tornado, but rather to keep a hurricane watch" was the goal of a meeting of geneticists and ecologists in Philadelphia last week, as described by the opening speaker, Peter R. Day of the Plant Breeding Institute in Cambridge, England. The geneticists are eager to proceed with small-scale field tests of several engineered microorganisms (SN: 5/4/85, p. 280), while the ecologists are generally more reluctant to see such bacteria released into the environment.

The intent of the meeting was stated most concretely by Susan Gottesman of the National Institutes of Health in Bethesda, Md.: "We want some sense of the minimal information needed before small-scale field tests are begun, and also the minimal information needed from such tests before there is any commercial use."

Last week's gathering, the largest multidisciplinary meeting to be focused on this issue, was organized by the American Society for Microbiology, in collaboration with seven other organizations of biologists, and it received funding from a variety of federal agencies that either support research in genetic engineering or expect to play a part in its regulation.

In the meeting's discussion, Philip J. Regal of the University of Minnesota in Minneapolis and other ecologists charged that genetic engineers are employing outdated theories in their analyses of the potential impact of new organisms on the environment. For instance, the argument that every genetic combination has at some time been employed already in nature is not valid, Regal says, because the number of combinations in complex animals is far too great. Another argument cited by geneticists is that because mutations disrupting genes generally reduce an organism's ability to survive in nature, any genetic engineering, including the adding of genes, also will decrease survival potential and reduce the chance of any adverse environmental impact. Regal says, "That is like saying stepping on someone's lunch is the same as adding a banana to it."

The greatest objections come to the idea of "the balance of nature" — that communities of organisms are so well adapted to each other and their physical environment that no novel organism would be likely to disturb the balance. "Most ecologists don't refer to niches any more. ... It is really an antiquated concept," Regal says. "There is no reason at this point to believe a species is so highly perfected that nothing can replace it."

"The lesson from ecology," says Regal, "is that one must be careful not to oversimplify what to expect from nature." Beyond this sense of caution, however, ecology today does not offer general principles that would allow geneticists to predict what will happen to an organism that is released. But ecologist Daniel Simberloff of Florida State University in Tallahassee says "there is no reason why [ecology] couldn't provide lots of specific predictions. ... Understanding [a specific environmental situation] is very accessible to detailed research, work about the equivalent of a Ph.D. thesis."

A case-by-case analysis of proposed field tests of genetically engineered organisms was much lauded by both ecologists and geneticists, although some still held out for more general rules. Henry Miller of the Food and Drug Administration says, "Case-by-case analysis is a totem receiving much reverence but little reflec-