SCIENCE NEWS of the week

Squeezing Hydrogen to Molecular Metal

By peering through diamond windows at tiny samples of hydrogen under tremendous pressure, two research groups have caught tantalizing glimpses of what may be the long-sought metallic form of molecular hydrogen. When the pressure reaches 1.5 megabars (roughly 1.5 million times atmospheric pressure), both groups see evidence for sharp changes in certain properties of solid, molecular hydrogen. Those changes signal a phase transition – possibly the shift from an electrically insulating form of solid hydrogen to a conducting one.

At temperatures near absolute zero and atmospheric pressure, hydrogen exists as a transparent, insulating solid, in which the two-atom hydrogen molecules sit in an orderly arrangement. Theorists predict that sufficiently high pressures would free electrons, allowing them to roam throughout the material as they would in a metal. At even higher pressures, the molecules themselves would break up into individual atoms, producing an atomic metal. In the laboratory, researchers can now achieve the necessary pressures to reach a metallic state by squeezing hydrogen samples between two gem-quality diamonds.

Last year, Ho-kwang Mao and Russell J. Hemley of the Carnegie Institution of Washington (D.C.) reported that at pressures greater than 2.5 megabars, solid hydrogen turns opaque (SN: 5/27/89, p.327). Because semiconductors and metals absorb light, the darkening suggests that the hydrogen has become a metal – perhaps an atomic metal – at such pressures, Mao and Hemley say.

However, changes in the optical properties of diamonds at these high pressures make the observations difficult to interpret. Furthermore, no one knows how to measure the electrical conductivity of tiny samples under such extreme conditions.

"At very high pressures, wild things happen to the diamonds," says Arthur L. Ruoff of Cornell University in Ithaca, N.Y. "It's a tough environment for experimental measurements. We have to worry about the diamond window closing." Ruoff chaired a session at this week's American Physical Society meeting in Anaheim, Calif., that covered the latest findings on metallic hydrogen.

Mao and Hemley also reported evidence last year for a phase transition of some kind at a lower pressure of 1.5 megabars. New, more precise measurements show that the pressure at that transition seems to force major changes in the properties of solid, molecular hydrogen, although the material remains transparent.

"These measurements suggest the crystal structure probably is not changing much across this transition, but there's a spontaneous weakening of the [molecular] bonds," Hemley says. "That would be consistent with losing some electrons from the bonds to conduction states, but that remains to be proved."

In separate work, Isaac F. Silvera and his co-workers at Harvard University have studied the pressure-dependent characteristics of solid hydrogen at temperatures ranging from 5 to 150 kelvins. Using such low temperatures, they can make critical measurements needed to test for metallization, Silvera says.

Silvera's group discovered several new solid-hydrogen phases, in which molecules settle into a variety of different arrangements. One of those phases is associated with the sharp transition at 1.5 megabars. That transition leads to a unique molecular-hydrogen phase that exists only at pressures greater than 1.5 megabars. Other data suggest the phase may well be metallic, Silvera says.

If this high-pressure molecular hydrogen is metallic, it has interesting properties, Hemley says. "It's completely transparent at visible wavelengths."

Although the Harvard and Carnegie groups obtained consistent results, many details remain uncertain. "There clearly is a phase transition at 1.5 megabars," Ruoff says, "but there's no real evidence yet of metallic hydrogen."

Anyone interested in using metallic hydrogen as a compact fuel for nuclear fusion reactors, or in exploring the possibility that metallic hydrogen may even be a superconductor, will have to wait until researchers can further untangle the remarkable complexity of this simplest of all elements. *– I. Peterson*

Amazon forest unlikely to rise from ashes

Adding extra urgency to the topic of tropical deforestation, simulations with a new breed of computer models suggest that the Amazonian rain forest, once destroyed, probably would not regrow.

Cutting the entire forest would severely alter the climate in the Amazon basin, causing temperatures to rise and precipitation levels to fall – a shift that would severely hinder development of a new rain forest, report Jagadish Shukla and Piers J. Sellers of the University of Maryland in College Park and Carlos Nobre of the Brazilian Space Research Institute in São José dos Campos. "These results suggest that a complete and rapid destruction of the Amazon tropical forest could be irreversible," they write in the March 16 SCIENCE. At the present rate of deforestation, the forest might disappear in 50 to 100 years, they say.

Shukla and his colleagues tested the climate effects of deforestation through simulations on a computer model that couples a high-resolution model of the global atmosphere with a biosphere model accounting for vegetation and soil effects. Many scientists in the past have simulated tropical deforestation, but only within the last few years have researchers designed realistic biosphere models that mimic the effect of trees, Shukla says.

The investigators ran a pair of simulations covering one year: a control case using a forest-covered Amazon, and a deforestation case that replaced the rain forest with pasture. The tests predicted the deforested Amazon would have surface and soil temperatures about 1°C to 3°C higher than the forested. On average, precipitation dropped by 26 percent in the deforested Amazon and evaporation decreased by 30 percent. These results match the findings of a similar study, reported in the Nov. 23, 1989 NATURE, that examined a pair of three-year-long simulations on a coupled atmosphere-biosphere model with coarser resolution.

Scientists have long assumed that cutting the rain forest would decrease local evaporation, which provides about half the rainwater in the Amazon basin. But without computer simulations, they could not predict how deforestation would affect the atmospheric circulation patterns that bring in the remaining half of the Amazon's rainwater from outlying regions. The new results indicate complete deforestation would lower by 18 percent the net amount of moisture entering the basin from outside, says Shukla.

The precipitation drop would lengthen the Amazon's dry season – an effect likely to prevent rain forest regrowth, says Shukla. The model results do not indicate how much climate change would follow a partial deforestation, nor do they apply to other rain forests.

Robert E. Dickinson of the National Center for Atmospheric Research in Boulder, Colo., who ran earlier computer simulations of deforestation, says the two new studies appear to establish strong links between rainfall and the forest. However, he adds, these models will achieve real credibility only when future studies prove they can simulate the large year-to-year shifts in Amazonian rainfall that result from El Niños and other ocean changes. *– R. Monastersky*