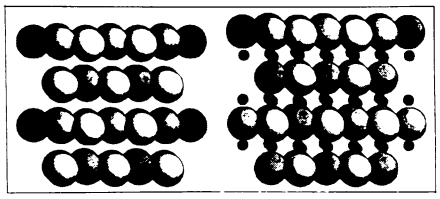
Iron swells up when squeezed with hydrogen



Compressed iron atoms form alternating layers of hexagons. But adding hydrogen atoms (black) causes the iron atoms to shift so that some alternating layers no longer line up.

Intense pressure usually makes a material shrink. But when three geophysicists recently subjected iron and hydrogen to a pressure of 35,000 atmospheres, their sample expanded by 17 percent.

This phenomenon, reported in the July 26 SCIENCE, also expands current thinking about the composition of the Earth's core. The discovery that iron hydride can exist under very high pressure adds weight to the suggestion that its presence may account for the lower-than-expected density of the core, say John V. Badding, Russell J. Hemley and H.K. Mao of the Carnegie Institution of Washington (D.C.).

From calculations of the thermodynamics required for the formation and stability of iron hydride within the Earth, the researchers conclude that the compound could result from water reacting with iron in the core. "There could be a large amount of hydrogen in the core," Hemley told SCIENCE NEWS.

"They have given us a totally new class of observations," comments geophysicist Raymond Jeanloz at the University of California, Berkeley. "If we can show there is hydrogen down there, then it has some serious implications for the earliest history and atmosphere of the Earth."

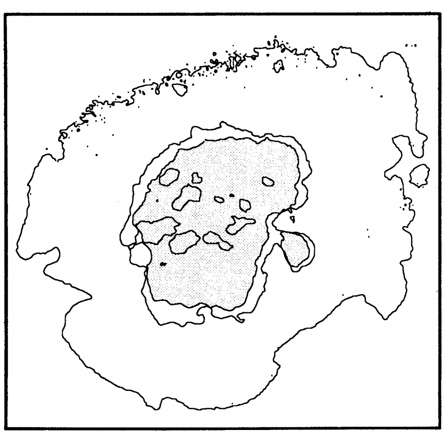
For their experiments, the researchers first placed a small sample of iron into a diamond anvil cell, then filled the cell with hydrogen gas and squeezed the sealed sample between the tips of the anvil's two diamonds until the iron suddenly expanded. "It puffed up like a sponge absorbing water," says Hemley. At the same time, the sample's smooth surface became rough and grainy.

The team then shined synchrotron radiation through the diamonds to study the deformed iron's structure under pressures of up to 620,000 atmospheres.

Normally, iron atoms subjected to intense pressure form closely packed layers of hexagons. The atoms in one layer line up with those two layers away, creating a simple pattern of alternating alignments. But when hydrogen works its way into the metal lattice, the iron hexagons shift, says Hemley. One layer of iron atoms still lines up with the atoms two layers away, but the layers sandwiched in between match up with atoms four layers away.

The researchers think the hydrogen settles into octahedral spaces between the iron atoms, altering their bonds and causing the sample to swell. The iron sops up so much hydrogen that there is almost one hydrogen atom for every iron atom. "That's an awful lot of hydrogen," Hemley says. The added hydrogen makes the material much less dense.

The impetus for this work, he says, came from a side effect seen during an earlier study of hydrogen's behavior. The Carnegie researchers noticed that the stainless steel gaskets in their diamond anvil cell reacted with the hydrogen they had used. When forced by pressure into a metallic element, hydrogen can make the metal brittle, so the steel in the anvil tended to flake and crack, Hemley says. The team has begun replacing the stainless steel with rhenium, which seems to hold up better, he adds. *– E. Pennisi*



Illustrations: Badding et al./SCIENCE

Shaded area represents iron before compression. Squiggly line just beyond the shading shows how much the sample swelled when squeezed together with hydrogen. The gas itself extends to the outermost border.

Maleness gene may be a master gene switch

The recently discovered gene for maleness appears to serve as a master control switch with the ability to turn on or off other genes involved in sexual development, according to research presented this week.

Peter Goodfellow, one of the British geneticists who first reported the discovery of this maleness gene (SN: 7/28/90, p.61), says his team now has evidence the gene makes a protein that binds to specific regions of DNA. If the maleness gene – named *SRY* for the sex-determining region of the Y chromosome – makes such a DNA-binding protein, it could control the expression of secondary genes involved in determining gender.

"The SRY protein has a region that binds to DNA," Goodfellow told the Short Course in Medical and Experimental Mammalian Genetics, held at the Jackson Laboratory in Bar Harbor, Maine. "I think we've stumbled onto a family of [gene-reading] factors that are used quite widely during development."

Goodfellow, who works at the Imperial Cancer Research Fund in London, collaborated with a group at the British Medical Research Council (MRC) National Institute for Medical Research to track down the smallest bit of DNA responsible for making a male. In the May 9 NATURE they reported identifying a comparatively short stretch of DNA on the Y chromosome that could turn a female mouse embryo into a male mouse capable of copulating with females. That stretch of mouse DNA, which they dubbed *Sry*, resembles the human *SRY* gene.

Mouse and human embryos start out female. Even trained experts cannot tell the difference between male and female mouse embryos until the twelfth day of development, when squiggly sperm ducts become detectable in the tissue destined to become testes. Once testes arise, they churn out hormones that govern the development of other male features.

Goodfellow and his colleagues theorized that the maleness gene must be active at the time of the testes' differentiation in order for it to direct male sexual development. To prove it, they searched for the protein produced by the gene in mouse embryonic gonads. Interestingly, the gene only directed protein production for the two days preceding testis development, then shut down until the male mouse reached sexual maturity.

To see if the maleness gene was sufficient to make a male, the team then spliced the mouse version of the gene into 158 fertilized mouse eggs. Eleven of the resulting mice were genetically female – bearing two X chromosomes – but also contained the spliced-in maleness gene. Three of these genetically female mice developed as males, the other eight as females.

"We have shown that [the maleness gene] ... is sufficient for sex-reversal," Goodfellow says. He surmises that the maleness gene spliced into an inappropriate site in the chromosomes of the eight mice who failed to become males.

In an editorial accompanying Goodfellow's paper in NATURE, Anne McLaren with MRC's Mammalian Development Unit agrees that the gene "must be part of that cascade" that makes a male.

The converted females were sterile, however, a fact that Goodfellow says demonstrates that additional genes are needed to produce a fully functional male. His group is now searching for those genes, using as their detector the newly discovered DNA-binding properties of the SRY protein. *– C. Ezzell*