AIAA's position that the ban is “consistent with U.S. laws” is incorrect, says Marc Brodsky, executive director of the American Institute of Physics (AIP), which has pushed hard to assure open communication with scientists in the embargoed countries. “There is no law or regulation I know of that requires AIAA to take the actions it has announced,” he says. “Certainly it hurts our security to bury our head in the sand and not learn about what scientists and engineers are doing in the countries the institute has targeted.”

In December, the Treasury Department’s Office of Foreign Assets Control (OFAC) clarified that publications did not need the government’s permission to edit and print papers from anywhere in the world (Science, 24 December 2004, p. 2170). That decision, which reversed an earlier ruling requiring journals to obtain a license in order to edit papers from embargoed countries, came after AIP and other publishers filed a lawsuit against OFAC in October 2004 alleging that the agency was violating freedom of speech. The suit cited a 1988 legal amendment that exempts information from trade embargoes.

AIAA did not institute the ban “in response to a specific legal constraint,” institute Executive Director Robert Dickman told Science in an e-mail. Dickman said the board “is balancing our responsibilities as a professional society to foster open exchange in scholarly, scientific, and engineering information with our social responsibility to avoid assisting a nation such as North Korea in its efforts to develop nuclear weapons and the capability to deliver them.”

One of the first victims of that policy was Masoud Darbandi, an aerospace engineer at Sharif University of Technology in Tehran, who received a note from Dickman on 26 May that AIAA had withdrawn his paper on high-temperature irradiance from a forthcoming issue of the Journal of Thermophysics and Heat Transfer. “It was a basic science paper, and I am not involved with any military projects,” he says. “If the paper had been about a military application, the U.S. would actually benefit from our publication; what better way to get inside information about Iran’s military?”

The policy has triggered internal dissent, according to some AIAA staff members who requested anonymity. “We’re hopeful that it will be reversed,” says one.

—YUDHIJIT BHATTACHARJEE

New Geochemical Benchmark Changes Everything on Earth

Whether you’re navigating the expanse of the Pacific or Earth’s 6370-kilometer-deep interior, it’s best to have a star to guide you. Geochemists exploring the dark realms of the planet’s rocky mantle and iron core depend on the elemental and isotopic composition of magmas, which have risen from the deep interior, and meteorites, which were the building blocks of the rocky planets. Their pole star has been an assumption about the composition of Earth’s rock—until now.

Far from done. New isotopic data suggest that the rock of the accreting Earth soon separated into two layers.

According to a paper published online this week by Science (www.sciencemag.org/cgi/content/abstract/1113634), for decades researchers have been following the wrong star. New, more-precise measurements of the neodymium isotope composition of meteorites show that geoscientists have been using an incorrect composition of the rocky Earth as a benchmark to infer everything from mantle compositions to the amount of interior heat being generated by radioactive decay.

“It’s a fantastic paper,” says geochemist Stanley Hart of Woods Hole Oceanographic Institution in Massachusetts. “This is going to change the way we think about the interior of the Earth. There are so many things this is going to impact.” For starters, either Earth was made from only one part of an inexplicably lumpy primordial pudding, or very different rock unlike anything sampled so far settled to the bottom of the mantle early on and has been altering the behavior of the rest of the planet ever since.

A key to the geochemical benchmarking of Earth has been the ratio of the isotopes neodymium-142 to neodymium-144 (Nd/144Nd), which can be used to trace geologic processes. In the early 1980s, researchers measured this ratio in both chondritic meteorites—which are made of the same primordial rock that formed Earth—and a variety of terrestrial rocks. The ratio was the same on Earth and in meteorites, within the error of the analyses. So everyone assumed that the average Nd/144Nd ratio of terrestrial rock had not been changed since Earth formed. Any chemical processing in the first several hundred million years—such as partial melting of rock or crystallization of magma—would have tended to separate samarium-146—whose radioactive decay produces neodymium-142—from neodymium-144, altering the Nd/144Nd ratio seen today.

No one seriously tested the result until geochemists Maud Boyet and Richard Carlson of the Carnegie Institution of Washington’s Department of Terrestrial Magnetism in Washington, D.C., used a markedly improved mass spectrometer to measure the Nd/144Nd ratio of a variety of chondrites. Their value fell in the range published 25 years ago, but their much more precise analytical technique revealed that Nd/144Nd is 20 parts per million lower in chondrites than in terrestrial rocks.

Boyet and Carlson think that the meteorite–Earth difference most likely arose just 30 million years after Earth formed. Some process—perhaps the progressive crystallization of Earth’s early “magma ocean”—may have concentrated certain elements in the remaining melted rock, the way frozen seawater loses most of its salt to the sea. Such an “enriched” part of the interior has never shown up in volcanic rocks. If it’s there, geochemists have calculated the composition of the rocky Earth
from samples of “depleted” rock, with misleading results.

Boyet and Carlson suggest that the enriched rock ended up at the bottom of the mantle. To judge by other isotopic and chemical data, this enriched region could make up as much as 30% or as little as 5% of the whole mantle. At the low end, it would be small enough to fit into the 200-kilometer-thick D′ (pronounced “D double prime”) layer, a mysterious region seismologists have spotted at the bottom of the mantle, hard against the molten-iron core.

A geochemically enriched bottom layer “explains a lot of things,” says Carlson. One might be Earth’s missing heat. The average Earth rock—as previously calculated—didn’t contain enough radioactive, heat-generating uranium, thorium, and potassium to account for half of the heat seeping out of the planet. But an enriched layer would contain 43% of all heat-producing elements. From the bottom of the mantle, a hot, enriched layer could help drive the core’s geodynamo, which generates Earth’s magnetic field. And the hot layer could also produce rising plumes of hot mantle rock that feed volcanic hot spots such as Hawaii and Iceland.

“It’s a very exciting result,” says geochemist Stein Jacobsen of Harvard University, who co-authored the 1980s papers on the first 142Nd/144Nd measurements. “I don’t doubt their measurements at all, and the interpretation is reasonable. But at this early stage, I don’t think it’s the only one.” Boyet and Carlson acknowledge that the Earth-meteorite difference might have arisen when the planets formed. Perhaps the primordial disk of gas and dust differed in composition from place to place. True enough, says planetary physicist David Stevenson of the California Institute of Technology, but such heterogeneity “is not an attractive idea. There is no obvious physical reason why it would be so.” Wherever the truth lies, “this is going to create an incredible hum and a lot of work,” says Hart.

—RICHARD A. KERR

MOLECULAR BIOLOGY

Nucleosomes Help Guide Yeast Gene Activity

If traffic lights aren’t precisely coordinated, accidents and traffic jams result. Likewise, for an organism to develop and remain healthy, cells need to turn their genes on and off at exactly the right times. Numerous proteins known as transcription factors assist in this task, settling in on regulatory sequences in DNA and activating or inactivating associated genes as needed. But genetic material is more than just strands of DNA. It also includes complexes of proteins arranged with the DNA in beadlike structures called nucleosomes. Recently, studies have suggested that these chromosomal beads also contribute to gene regulation.

The latest example comes from Oliver Rando and his colleagues at Harvard University. In a paper published online this week by Science (www.sciencemag.org/cgi/content/abstract/1112178), they describe a technique that has allowed them to determine the exact positions of all the nucleosomes over large stretches—roughly 500 kilobases—of the yeast genome. The work, which cell biologist Bradley Cairns of the University of Utah in Salt Lake City calls “a technical tour de force,” suggests that nucleosomes help direct transcription factors to the regulatory sites of their target genes.

For many years, researchers thought that nucleosomes were distributed more or less evenly along a chromosome’s DNA. However, examination of a few genes revealed that their promoters, regulatory regions that contain binding sites for transcription factors, lacked nucleosomes. Then, last year, two groups, one led by Jason Lieb of the University of North Carolina, Chapel Hill, and the other by Bradley Bernstein and Stuart Schreiber of Harvard University, reported that this seemed to be the case for promoters throughout the yeast genome.

The Rando team has now provided the most detailed look yet at nucleosome positioning in the yeast genome. The researchers first treated yeast DNA with a DNA-digesting enzyme that removes the regions that connect one nucleosome bead with the next. The nucleosomal DNA itself survives because it is protected by associated proteins called histones.

After isolating the nucleosomal DNA and labeling it with a green fluorescent dye, they mixed it with digested fragments of total genomic yeast DNA labeled with a red fluorescent dye. The researchers then applied the mixture to a microarray chip covered with thousands of overlapping 50-base DNA sequences that covered the length of chromosome 3, a span of nearly 500 kilobases. These probes latched onto the corresponding fluorescently labeled fragments of yeast DNA. By plotting the green-to-red ratio for each spot on the chip, Rando’s team could determine the exact position of nucleosomes along chromosome 3.

This analysis showed that most—nearly 70%—of nucleosomes occupy the same chromosomal locations in every yeast cell. This was indicated by the fact that the green-to-red ratio peaks indicating their positions were sharp and not smeared out across the DNA. That finding was surprising. “If nucleosomes were left to their own devices, they would be pretty happy [thermodynamically] sitting almost anywhere,” Rando says.

In keeping with the previous results, those positions are outside the promoter-containing regulatory sites for most genes. Indeed, nucleosomes usually flanked those sites, creating what Lieb calls “helicopter landing pads” for transcription factors.

A question that remains is whether those promoter sites are nucleosome-free all the time, or whether transcription factors push nucleosomes out of the way so they can land. There is some evidence for the first idea. Rando and his colleagues found that the regulatory site for a gene turned on by heat and other stresses lacked nucleosomes even before the stress was applied. The promoter sites may be held open, Rando says, because they contain stretches of adenine-thymine nucleotide pairs, which tend to incorporate poorly into nucleosomes because of their rigidity. However, other work, including that of the Lieb and Bernstein-Schreiber teams, indicates that gene activation leads to shifts in nucleosome positioning.

Lieb suggests that the Rando team’s finding may help explain other phenomena in addition to gene regulation. He points out that chromosome exchanges during meiosis and the insertion of moveable elements called transposons both tend to occur just before the beginning of genes—regions now known to often lack nucleosomes. Nucleosome positioning could “provide a structural basis for a broad range of observations,” Lieb predicts.

—JEAN MARX