ATOC program, said that the program would allow scientists to gather broad average area temperatures of the Pacific. By measuring temperatures in the ocean's interior, about 1 km deep, the variability of the ocean's surface temperatures would be avoided.

The Kauai and Point Sur sites were chosen for several reasons. "Rather than finding a marine mammal desert, we were advised by marine mammologists to choose sites without a resident population but [which have] a transient population of migrating animals," Forbes said.

The Point Sur site offers a good acoustic view of the southern ocean and the Kauai site is effective for measuring temperature in the northern ocean. The narrow continental shelves there allow the researchers to run the minimum amount of cable to the speakers from land: 10 miles at Kauai and 25 miles at Point Sur.

Another advantage is that the sites offer buildings, computer racks, and an array of deep hydrophones that were originally used by the Navy to search for submarines during the Cold War. The presence of these facilities makes the experiment more cost effective.

If the pilot program is successful, ATOC will seek permission to run it for an additional 10 years. A decade of measurements are necessary to detect warming on a small scale, while about 100 years worth of data would be needed to detect long-term warming. The program would also be extended to the other oceans, to gain a global understanding of the changes in ocean temperature.

Effects on the Animals

Much of the controversy stems from the many unknowns about how noises affect animals in the water. There is little hard data on the impact of such noise on marine mammals.

Linda S. Wellgart, a professor of whale studies at Dalhousie University, Halifax, Canada, says that "there is practically no research on the effects of such sound on marine mammals." She said, "the risks range from comparably harmless effects to changes in reproduction, mortality, and growth rates, which could translate into potentially devastating effects to already stressed marine mammal populations."

Wellgart emphasized that sound is absolutely essential to marine mammals, and that little is known about the hearing sensitivity and diving ability of great whales.

The species most likely to be affected, she says, are those that use low sounds to communicate, such as the finback, blue, and whalebone whales, as well as those that dive to great depths to feed, including the sperm and beaked whales and elephant seals.

"The deep ocean is an ecosystem we know less about than the surface of the Moon," Wellgart said.

While the project involves an effort to monitor the effects on maine mammals, some whale experts object that the monitoring program cannot assess damage to the animals.

"Dramatic, obvious effects, such as whales floating to the surface will be detected, but some effects will be too subtle—such as changes in reproduction, mortality, and growth rates," Wellgart said.—*M. Catherine White*

Rock Magnetism Linked to Human Brain Magnetite

PAGES 178–179

This piece was written to help inform science teachers, students, and journalists about some of the latest developments in the geophysical sciences. It will also appear in Earth in Space, *published by AGU.*

Magnetite has a long and distinguished career as one of the most important minerals in geophysics, as it is responsible for most of the remanent magnetization in marine sediments and the oceanic crust. It may come as a surprise to discover that it also ranks as the third or fourth most diverse mineral product formed biochemically by living organisms, and forms naturally in a variety of human tissues [*Kirschvink et al.*, 1992].

Magnetite was discovered in teeth of the Polyplacophora mollusks over 30 years ago, in magnetotactic bacteria nearly 20 years ago, in honey bees and homing pigeons nearly 15 years ago, but only recently in human tissue.

Research in the somewhat obscure geophysical field of rock magnetism led to many of these more recent discoveries, as many of the instruments and techniques developed for these studies lend themselves directly to the problem of finding ferromagnetic materials in tissue samples.

Most recently, extension of these rock-magnetic techniques to biological materials has pointed to the presence of a biological surprise: a new cell type loaded with crystals of biogenic magnetite, which we have dubbed "magnetocytes."

Several important clues concerning the organization of magnetite crystals in the human brain were present in our original magnetic data, which in fact led to the discovery of these new cells. Over the past 20 years, geophysicists working in the field of rock magnetism have developed sensitive techniques to determine whether the magnetic crystals within a sample are close to each other. It turns out that the magnetic field of one crystal upon its neighbor will cause distinctive shifts in the coercivity spectrum of a sample. This inhibits the acquisition of an isothermal remanent magnetism (IRM) but aids in its demagnetization [e.g., *Cisowski*, 1981].

These effects are present in virtually all vertebrate tissues examined to date, including the human brain, implying that the human magnetite crystals are not isolated from each other.

Calibration studies of these interaction effects done with bacterial magnetites and the more sensitive techniques of anhysteretic remanent magnetization (ARM) [e.g., *McNeill and Kirschvink*, 1993] indicate the magnetite crystals in the brain are present in clumps with a minimum of 50 or more particles per clump. Hence, rather than one crystal per 100 brain cells, there is less than 1 cell in 5000 with one of these magnetite clumps.

Unfortunately, the rock magnetic data do not place an upper limit on the number of crystals present per cluster—something on the order of at least 50 is needed, but it could just as well be 10,000.

More recent work suggests that the upper number may be more correct. Recently, we have found that pellets of the Jurkat strain of human T-lymphocytes have peculiar magnetic dipole patterns when viewed with three-dimensional magnetic resonance imaging (MRI) microscopy [*Ghosh et al., 1993*]. The number density of these patterns, along with the magnetite concentrations measured with SQuID magnetometry, implied the presence of between 1000 and ~10,000 magnetite crystals per dipole pattern.

We also have evidence that magnetocytes are naturally present in tissues, rather than formed as some bizarre differentiation product in the cell cultures. In collaboration with our group, M. H. Nesson of Oregon State University has disaggregated normal mouse brain tissue with multiple freeze-thaw cycles and used our "magnetic finger" technique to pull out magnetic objects. This technique allows cell fragments only a few microns across to be extracted, and these fragments contain hundreds of single-domain magnetite crystals nearly identical to those in the human brain. The close packing arrangement is precisely what is needed to produce the magnetic interaction effects noted above.

The biological function of these magnetocytes is as yet unknown. They are definitely not used to detect the geomagnetic field, as they do not contain the linear chains of crystallographically aligned magnetite crystals as do magnetotactic bacteria, protozoans, migratory fish, and birds.

At the risk of engaging in speculation, our best guess is that the magnetite crystals are important for biochemistry. The lipid-bilayer membranes surrounding the magnetite crystals in bacteria contain several hundred distinct proteins of unknown function. It is easy to show that these proteins reside in a local, static magnetic field that ranges from 0.2 to 0.5 T (2000 to 5000 Gauss) produced by the enclosed magnetite crystal.

Although these field strengths are probably too weak to produce significant magneto-mechanical orientations in diamagnetic molecules, which need fields approaching 1 T, they are well within the range needed to produce dramatic effects on the electronic spin states of reaction intermediates. Controlling the decay path of a triplet state, for example, only requires magnetic fields on the order of

~10 mT or 100 Gauss [e.g, *McLaughlin*, 1989].

As magnetite biomineralization evolved nearly 2 b.y.a. [*Chang and Kirschvink*, 1989], evolution has had ample opportunity to incorporate magnetically mediated reactions into biochemistry. Rock magnetism may yet induce another field of study.—*Joseph L. Kirschvink, California Institute of Technology, Pasadena, Calif.*

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New Map for Climate Change, Ecosystems Researchers

PAGE 180

A new map of the land cover regions of the conterminous United States and its accompanying digital data set can provide scientists with a new tool for investigating the ecosystem effects of climate change.

The map combines satellite imagery, digital elevation, ecoregion, and climate data sets to build a database containing 159 separate land cover regions across the lower 48 states. Each of the map's regions has a unique combination of vegetation and land cover types. Typical vegetation or land cover patterns commonly found in each region are listed in the map's legend.

Additional small-scale maps depict the length of vegetation greenness, the onset of greenness, and peak greenness.

The map, "Seasonal Land Cover Regions," is available for $3 from USGS Map Distribution, Box 25286, MS 306, Denver Federal Center, Denver, CO 80225; the complete digital data set and documentation for the map are available on CD-ROM for $32 from Customer Services, EROS Data Center, Sioux Falls, SD 57198.

Atmospheric Information Available on Gopher

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The Atmospheric Sciences Department at the University of Illinois, Urbana-Champaign, is opening a new full-scale World Wide Web (WWW) server, The Daily Planet. This environmental information server will continue the work started with the university's Weather Machine and offers new and useful capabilities to the atmospheric sciences community.

The server features current weather information, lists of other weather servers and sources of weather data, atmospheric sciences community information, information about the university's department, plus a look at some online hypermedia instructional modules for atmospheric sciences under development.

Weather World is accessible from The Daily Planet menus, and it offers over 170 current images, 600 archived images, and 60 MPEG animations. Many are updated hourly and others twice daily, including current satellite imagery, surface maps, upper air maps and plots, and forecast maps. The text products currently found in the Weather Machine gopher server also will be available soon. To get to Weather World, access The Daily Planet by feeding the following to a WWW client:

http://www.atmos.uiuc.edu/

Access "Weather Data" and then pick "Weather World."

Please direct all inquiries to webmasters @ www.atmos.uiuc.edu.

FROM THE ARCHIVES

PAGE 179

This column, which celebrates AGU's 75th anniversary year, offers a look back at research published in previous years.

The following is excerpted from "Some Observations of the Peruvian Coastal Current" by Milton J. Lobell, which appeared in *Transactions, American Geophysical Union* in 1942. The excerpt gives an early account of the El Niño phenomenon.

There is mention made of variations in oceanography. These observations have been reported by a number of investigators and the general picture is as follows:

(1) Local fishermen and some local writers claim that the Humboldt Current swings offshore in the north of Peru. A current of hot water of low salinity from the Equatorial Counter-Current then is reported to flow southward and this affects markedly the inshore water conditions and the coast. They know this current as El Niño (the child) because it appears shortly after Christmas time.

(2) The existence of El Niño is confirmed by numerous workers. *Schott* [1931] says it is caused by northerly winds.

(3) While El Niño has been reported as far south as Pisco, this is doubtful and its usual southward extension is little south of Slaverry.

(4) El Niño is most prevalent from January to March.

(5) Torrential rains, thunderstorms, above-average air temperatures, and humidity occur.

(6) Birds desert the Guano Islands, thousands die, anchovy schools vanish, and hammerhead sharks and manta rays appear.

(7) A condition known as aguaje often appears during or after El Niño and causes death of myriads of fish which are cast up on beaches and remaining in the water cause discoloration of paintwork on ships.

GEOPHYSICISTS

Honors

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Richard E. Orville, director of the Cooperative Institute for Applied Meteorological Studies at Texas A&M University, has been named the 1994 recipient of the Charles Franklin Brooks Award for Outstanding Service to the Society. Orville was honored "for superb leadership as a Commissioner for more than a decade." He has published more than 80 papers and more than 100 conference papers on the subject of the physics and meteorology of lightning. While serving as chair of the American Meteorological Society (AMS) Commission on Education and Human Resources, he assisted in the initiation of the Board on Women and Minorities, and while serving as chair of the AMS Commission on Publications, he was instrumental in the reorganization of the AMS journals. He also served as AGU's president-elect and president of the Atmospheric Science Section from 1986–1990. Currently, his research focuses on the use of lightning information in association with meteorological information from Doppler radars to improve the understanding of severe storms.

Paul L. Stoffa of the University of Texas at Austin and **Richard Sternberg** of the University of Washington have been selected as fiscal year 1994 Office of Naval Research Ocean Science Educators. This award recognizes scientists with outstanding records of research and education in the ocean sciences, introduces recently graduated scientists from other disciplines to the ocean sciences by supporting outstanding postdoctoral fellows to work with the ocean science educator, and improves interactions between the academic community and Navy laboratories. Stoffa is currently the Carlton Centennial Professor of Geophysics in the Department of Geological Sciences and the Associate Director of the Institute for Geophysics at the University of Texas at Austin.