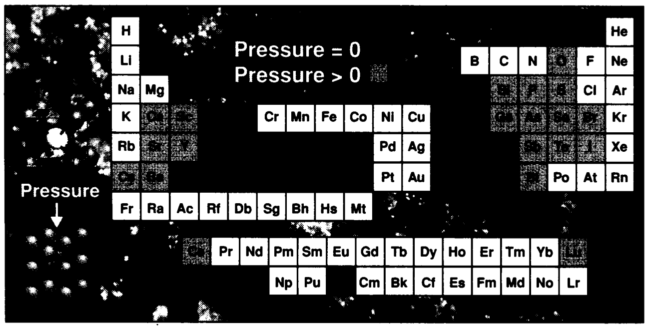

Super under pressure. Cesium iodide, a white crystalline salt (left) with a cubic structure in its low-pressure "normal" state (yellow, cesium; dark red, iodine), transforms to a "hexagonal close-packed" metal on compression (atoms have similar electronic cores, orange) and is a superconductor (*4*). At right are the superconducting elements found by pressure application.

imparting a driving force for dissociation, and this could be promoted by shear stresses. So is CsI the superconductor, or is one of the possible breakdown products responsible? Pure iodine has a transition temperature (T_c) of ~1 K measured at 28 to 74 GPa; the differences could be due to different states of crystallization or a pressure effect on T_c (*9*). Notably, SnI_4 is also a superconductor with a maximum T_c of 2 K in a crystalline state formed from its amorphous form (*10*), suggesting that a related transformation might also be considered for this material.

But the alternative interpretation of elemental superconductivity is in itself significant. Already 20 new elemental superconductors have been found at high pressure, increasing the number of known superconducting elements to at least 49 (see figure). The Osaka group has also made the extraordinary finding of superconductivity in oxygen at 100 GPa with a T_c of 0.6 K (*11*). This followed observations of superconductivity in sulfur at a similar pressure (*12*, *13*); higher pressure studies of sulfur by magnetic susceptibility showed that T_c reaches 17 K at 160 GPa, the record T_c for an element (*13*). The chalcogenide family of elements is in fact a family of superconductors with a wide range of T_c values. Notably, some of the results confirm reports of metallization and T_c from the early, crude diamond-indentor studies, which were discredited because of the lack of sample control and measurement of pressure (*3*).

With these recent experiments, more and more substances are giving up their "normal" state status as gases and liquids, and as insulators and semiconductors, to join the growing list of superconducting materials under pressure. Moreover, these "new" high-pressure superconductors may embody new mechanisms (*14*). Thus, understanding the origin of T_c in these materials, together with other new, but more well-known, ambient pressure superconductors—high T_c cuprates, fullerites, and borocarbides—represents a serious challenge to theory.

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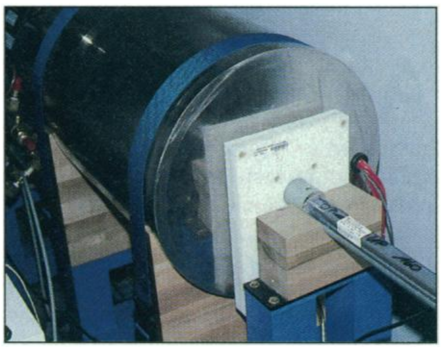
PERSPECTIVES: PALEOMAGNETISM

Faster Is Better

Kenneth L. Verosub

Think of a laboratory procedure that requires 1 hour of intensive labor to measure each sample. Now imagine the impact on any field of a new instrument that can measure 150 samples in 2 hours, without the presence of an operator. Such is the case with the automated, long-core cryogenic magnetometer, which has started to revolutionize the way that paleomagnetists study the magnetic properties of rocks, sediments, and soils. The data obtained by this new instrument are having a profound effect on studies of the behavior of Earth's magnetic field and on our understanding of climatic and other environmental processes.



New tool. With improved instruments such as this automated long-core magnetometer, samples can be processed much faster.

Traditionally, paleomagnetic samples have been collected as discrete, oriented cores or cubes of material with dimensions on the order of a few centimeters. Each sample is subjected to a magnetic cleaning procedure, known as demagnetization, which systematically removes secondary magnetizations that might be masking the primary signal. A typical 10-level demagnetization takes 1 hour and involves repeated manual transfer between the demagnetizer and the magnetometer, the instrument that actually measures the magnetization. With the new long-core cryogenic magnetometers (see figure), all of the processes are automated and incorporated into a single instrument. Samples are loaded onto a track that moves them between a set of demagnetization coils and a measurement region. Seven discrete samples can be measured at once, and a 10-level demagnetization of seven samples can be done in 20 minutes, which represents a 20-fold increase in throughput and productivity.

But that is not the end of the story. In recent years, scientists have been turning to sediment cores from the marine and continental realms to obtain information about paleoclimatic and other environmental processes. These cores can be sampled for paleomagnetic study with plastic u-channels, which, despite their name, have a square cross section, 2 cm across, and a length of up to 1.5 m. The u-channel is pushed upside-down into the flat face of a sediment core that has been split lengthwise. Monofilament fishing line is then used to free the u-channel and its sediment sample from the core. Once free, the u-channel is covered with a tight-fitting cap, and the ends are sealed to prevent desiccation of the sample. The entire procedure can take as little as 5 minutes.

The entire u-channel can be placed on the track of a long-core cryogenic magnetometer. At the usual sampling interval of 1 cm, the magnetometer can do a 10-level demagnetization of a u-channel in about 2 hours. This is equivalent to 150 individual paleomagnetic samples and represents the equivalent of a 75-fold increase in through-

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put and productivity, compared with sampling in a discrete mode. Furthermore, an operator needs to be present only for the 5 minutes that it takes to change the u-channel sample. Under these circumstances, it is not difficult to process 10 m of sediment a day, and it becomes feasible to undertake paleomagnetic studies that involve many tens of meters or even a few hundred meters of core.

As with other major technological advances, the revolutionary capabilities of the long-core cryogenic magnetometer are the result of a series of incremental steps involving improvements in the design and operation of cryogenic magnetometers (*1*), development of the u-channel sampling technique (*2*, *3*), and careful validation of the scientific results (*4*). The latest new magnetometers can impart different types of laboratory-induced magnetizations to a demagnetized sample. The demagnetization of the new magnetizations provides additional information about the nature of the magnetic carriers (*5*, *6*).

There are two main areas for which these capabilities are particularly useful. The first is for studies of the behavior of the geomagnetic field. Sediments contain the most continuous record of geomagnetic field behavior, but in earlier studies the time involved in making measurements compromised the number of samples and the closeness of those samples. With long-core magnetometers, one obtains a complete, continuous record of geomagnetic field behavior so that one can see the field evolve as it changes direction.

More importantly, long-core magnetometers are leading to an appreciation of the vector nature of the paleomagnetic signal. Until quite recently, the focus of most paleomagnetic studies was on the directional record of the geomagnetic field. Except for time-consuming studies that were specifically designed to determine the absolute paleomagnetic intensity, little attention was paid to the intensity of magnetization of individual samples. Recently, there have been substantial advances in methods for determining the relative paleointensity record in sedimentary sequences (*7*, *8*). The basic approach is to use measurements of laboratory-induced magnetizations to separate the variations in magnetization intensity that are due to concentration from those that are due to actual intensity variations of the original geomagnetic field. The new methods are particularly suited for studies involving u-channels, and considerable attention is currently focused on this area. Although some of the results are quite controversial, there is certainly more interest now in the vector nature of the geomagnetic field than there has been since the inception of paleomagnetism almost 50 years ago. Moreover, there is growing evidence that certain changes in the directional record of the geomagnetic field are coupled to changes in the intensity record (*9*–*11*), making it all the more important to deal with the paleomagnetic signal as a fully three-dimensional vector.

The second area of application for long-core measurements of u-channels is environmental magnetism, a new and rapidly evolving field that makes use of the influence of environmental processes on the size and nature of the magnetic carriers (*12*). The advantages of this approach are that the methods are relatively rapid, simple, nondestructive, and inexpensive and that they can be used to address problems that may be inaccessible with other techniques. The methods of environmental magnetism have been applied to studies of catchment areas, sediment transport, diagenesis, paleoseismology, paleoclimate reconstruction, and various types of pollution. Before the development of the long-core magnetometer, the limiting factor in many environmental magnetic studies was the time required to make a wide range of magnetic measurements on a large number of discrete samples. With the time constraint removed, the field is capable of reaching its full research potential.

Of course, every technological advance creates new problems and challenges. Long-core magnetometers are capable of creating enormous databases. In one study in my laboratory, we have already amassed over 1 million vector measurements. Standard methods for display and analysis of paleomagnetic data, developed for studies that might involve at most a few thousand measurements, are clearly inadequate for the new databases, and more advanced computer graphics techniques need to be developed. These methods will probably lead to insights about the use and interpretation of paleomagnetic data that, in turn, will spur additional advances in paleomagnetic technology.

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PERSPECTIVES: APOPTOSIS

Death by Crowd Control

Michael Hengartner

Animals use apoptosis, or programmed cell death, to eliminate extraneous or dangerous cells. The muscle of this controlled cellular deconstruction is provided by the caspase family of cysteine proteases, which cleave key targets in the cell [(*1*), see page 1312]. Caspases normally exist in cells as inactive proenzymes; proteolytic processing at a few specific sites unleashes their latent enzymatic activity and triggers cell destruction.

So how is this proteolytic activation brought about? There are many caspases in mammals (13 at last count), and even more ways to kill a cell, which initially raised the specter of a vast army of caspase-activating mechanisms. Thankfully, recent work by a number of groups, including a report by Yang *et al.* in this issue of *Science* on page 1352 (*2*), suggests that the cell uses only a limited number of strategies, which are mined over and over. One of these is the use of "apoptotic chaperones," which herd together inactive proenzymes to increase their local concentration and ease them into conformations that promote their activation.

Caspases can be activated by two distinct mechanisms. Because all caspases have similar cleavage specificity, the simplest way to activate a procaspase is to expose it to a previously activated caspase molecule. This "caspase cascade" is used extensively by cells for the activation of the downstream effector caspases: caspase-3, caspase-6, and caspase-7 (*1*).

The second strategy, "induced proximity," was first observed in caspase-8, an initiator caspase that acts downstream of the Fas/CD95 death receptor [(*3*), see page 1305]. Upon ligand binding, Fas receptor molecules aggregate into a membrane-bound complex. This signaling complex recruits, via the receptor-bound adapter protein FADD, several procaspase-8 molecules, resulting in a high local concentration of procaspase-8. Under these conditions, the low protease activity inherent to procaspases is sufficient to drive intermolecular prote-

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