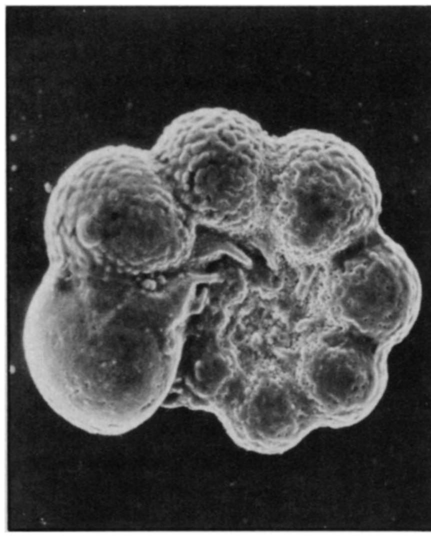
Of Life and Death and Magnetism

Old fossils and a new theory are the latest inputs to the mysterious question of whether the behavior of earth's magnetic field has had major effects on life on the planet

BY JONATHAN EBERHART



Photos: Barbara Keating/Univ. of Texas at Dallas

G. yaucoensis: 70 million years dead.

It is a dramatic scenario, beside which earthquakes and tidal waves pale into mere local thrashings. Gradually (by human reckoning), the magnetic field of the earth weakens, shrinks, shifts, reverses, finally growing back to renewed strength millennia later. In the wake of the ponderous pulsing, whole species of living organisms vanish, perhaps thousands of them, driven to extinction by invisible yet deadly forces on a global scale.

The earth's magnetic field certainly goes through changes. Numerous living species have certainly been wiped from the face of the planet. But is there a connection? Have the periodic weakenings of the field had repeated catastrophic consequences for life on earth? The evidence, virtually every step of the way, is circumstantial or deductive, but it would not be the first time that the scientific method has had to advance along the lines of courtroom procedure.

One early speculation appeared in 1963 in NATURE (198:143) as a brief paper, shorter even than this article, by Robert J. Uffen of the University of Western Ontario. Uffen cited paleomagnetic data to the effect that "the geomagnetic field intensity must have been reduced to zero for intervals of several thousand years," thus removing the field's shielding effect and allowing the earth's surface to be bathed in incoming cosmic radiation. This, Uffen suggested, led to "the resulting occurrence of intermittent high mutation rates and the consequent effect on the evolution of organisms at the surface or in shallow seas."

Since Uffen's work appeared, other researchers have calculated that the increased radiation dosages would be too small to have an appreciable effect on population levels. Alternative links have also been proposed—geomagnetic effects on climate (a whole separate can of research worms in its own right) and even direct magnetic effects on living organisms (SN: 10/30/71, p. 300). But an agreed-upon mechanism seems little, if any, closer.

Whatever the mechanism, the whole scenario hinges, of course, on whether species can be shown to have become extinct at the times of magnetic field reversals, or at least weakenings. In 1970, James D. Hayes of Lamont-Doherty Geological Observatory reported the finding, in deep-sea sediment cores, of eight species of radiolaria that became extinct in the last 2.5 million years (SN: 11/21/70, p. 392). "Six of the eight species," as he later reported in the GEOLOGICAL SOCIETY OF AMERICA BULLETIN (82:2433, 1971), "disappeared in close proximity to magnetic reversals recorded in the sediment."

Now a second group of correlations has been found, this time in far older sediments from the oceanic record. Looking back through samples from Legs 21 and 40 through 43 of the Deep Sea Drilling Project, Barbara Keating, Emile Pessagno and Charles Helsley of the University of Texas at Dallas, have discovered seven species of planktonic foraminifera, all of which became extinct at the time of the same geomagnetic field reversal about 70 million years ago. Although the data are still unpublished, Keating has told SCIENCE NEWS that the seven species, which became extinct during an event known as the *Globotruncana gansseri* Subzone Reversal, had been in existence for 10 million to 20 million years previously. The seven species are *Globigerinelloides prairiehillensis*, *G. yaucoensis*, *Archaeoglobigerina blowi*, *A. cretacea*, *Globotruncana austinensis*, *G. bulloides* and *G. rosetta*.

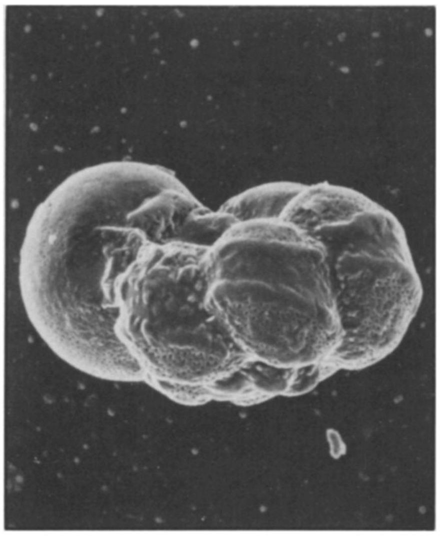
Keating and her colleagues are also studying evidence from an even earlier reversal, the Turonian, which took place about 85 million years ago. This is an unusual event, Keating says, because it is so far the only major reversal known to have occurred during a vast span from more than 100 million to about 75 million years ago called the Cretaceous Quiet Period. There are plainly visible extinctions of both microfossils and "megafossils" (about 10 percent of the then-extant mollusc species disappeared) in ocean sediment samples covering the event, and traces are now being sought in certain on-land samples from Colorado.

Still farther back, at the Permian-Triassic boundary about 225 million years ago, even greater numbers of species extinctions are known, Keating points out. As many as 40 percent of living species at the time perished from the earth, she says, but the geomagnetic record of the time has not been known for long enough or in enough detail to yet yield firm correlations with field reversals. The same is true, she adds, for the Cretaceous-Tertiary boundary at the end of the Quiet Period, when about a third of the known species apparently died out abruptly.

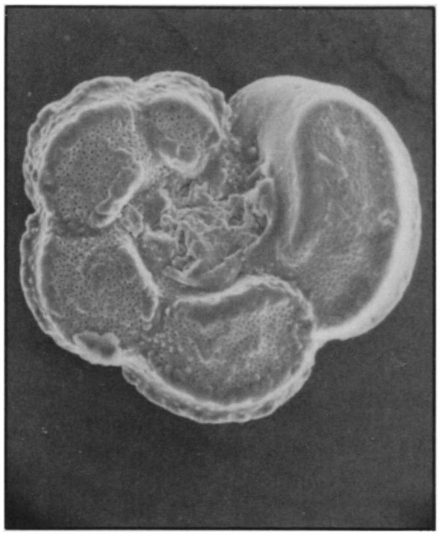
The species extinctions are not in question. When examining a core sample, Keating says, the sudden absence of some species "is like night and day," and other researchers have made similar comments, even though continuous sediment records through the Cretaceous-Tertiary boundary are rare. There is some disagreement, however, as to whether vertical mixing in the sediment layers confuses time scales enough to prevent precise matching of extinctions with times of weak field strength. Keating maintains that mixing in seafloor sediments typically blurs the dating by about 10,000 years, and says that it is not critical even at the sample sites from the *Globotruncana gansseri* reversal, where the uncertainty is about 60,000 years, since the weakened field accompanying some reversals can last as long as a million years.

Other researchers are not so sure. Ian K. Crain of the Australian National University, who has advocated biomagnetic effects as a possible connection (GEOLOGICAL SOCIETY OF AMERICA BULLETIN, 82:2603, 1971), cited a maximum estimated duration for a weakened field of only 13,000 years. Geophysicist Allan V. Cox of Stanford University maintains that the major portion of the field, the dipole, remains at its weakest level (about 20 percent of its usual intensity, he says) for from 5,000 to 20,000 years.

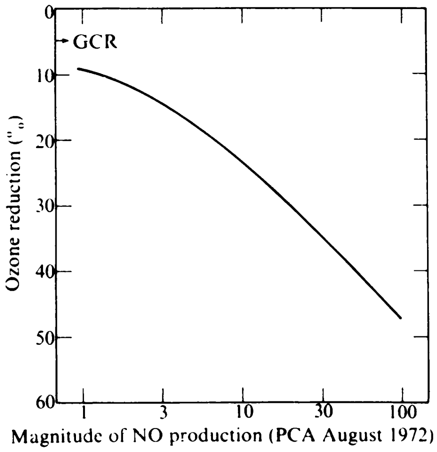
Cox, however, goes a step further. He suggests that even if the dipole, which can amount to four-fifths or more of the total



A. cretacea: Another magnetic victim?



G. bulloides: Dead to the last foram.



George C. Reid

The effect on the ozone layer, in the absence of a geomagnetic field, of solar proton events larger than Aug. 1972.

field strength, were to vanish completely, the total reduction in shielding would be only 10 to 12 percent, since the majority of the shielding comes not from the field at all but from earth's atmosphere. This means, he says, that taking away the dipole field completely would produce no greater irradiation than moving from the equator to Alaska, where the field lines are close to the earth, or to Denver where the atmosphere is thin.

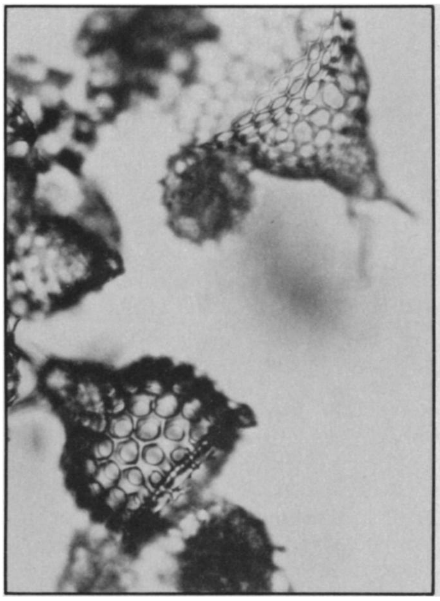
The latest proposed link between geomagnetic events and species extinctions meets this head-on, in a sense, by suggesting that when the field weakens, the atmosphere itself becomes more vulnerable to having its own shielding ability reduced. The key: the ubiquitous ozone layer. According to George C. Reid, Ivar S.A. Isaksen and Paul J. Crutzen of the National Oceanic and Atmospheric Administration's Environmental Research Laboratories and Thomas E. Holzer of the National Center for Atmospheric Research, both in Boulder, Colo., the absence of a geomagnetic field would allow freer access to protons from solar flares. This would increase the formation of nitrous oxide (NO), which catalytically destroys ozone, thereby subjecting the earth to an increased dose of solar ultraviolet radiation.

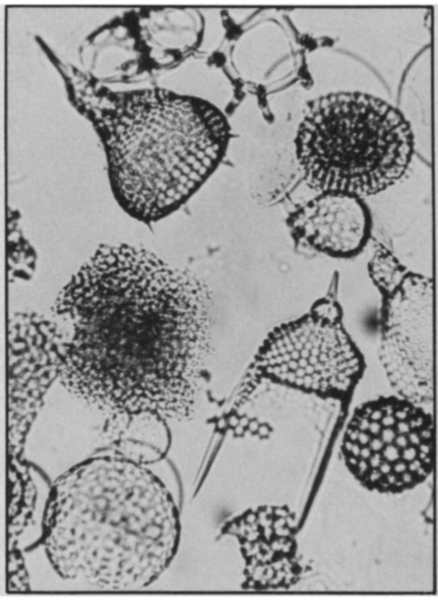
The researchers mention rock magnetization studies (apparently different from those cited by Uffen) indicating "that the field intensity does decrease by an order of magnitude during polarity reversals, but that it does not completely disappear." The remainder, however, consists largely of nondipole components, and, they report in NATURE (259:177, 1976), "it is likely . . . that nondipole fields will allow freer access than would dipole fields of similar strength."

The largest solar proton event known in the 20 or so years that they have been studied, according to the authors, took place in August 1972. Though this event would have produced only a 10 percent ozone reduction in the absence of a protecting geomagnetic field, they calculate, "it does not seem that events 1 or 2 orders of magnitude [10 to 100 times] more intense . . . can be ruled out when the observation period is lengthened to more than 1,000 years." By the same calculations, this could destroy nearly 50 percent of the stratospheric ozone layer, and it would take nearly 10 years—presumably a long time for simple, short-lived organisms—for the resulting ultraviolet "window" to reclose completely. The researchers estimate that an event 100 times larger than the August 1972 solar eruption would increase the dose of 270-to-320-nanometer UV radiation by 160 percent.

How much damage can an overdose of ultraviolet light at such wavelengths (called UVB) really do? At a 1974 conference on the U.S. Transportation Department's Climatic Impact Assessment Program, John Calkins of the University of Kentucky described a study in which a variety of freshwater microorganisms—bacteria, yeast, protozoans, rotifers and flatworms—were exposed to varying amounts of simulated solar UVB. He found indications that "the majority of the microorganisms found in any particular habitat are near the limit of solar UVB which they can tolerate." Furthermore, he said, "increasing UVB levels by 25 to 300 percent would profoundly disturb the microorganism ecology."

So the link may be ultraviolet. Or it may be climatic, or biomagnetic, or via galactic cosmic rays. Some say it doesn't exist at all. Cox, for one, leans in that direction, but he admits that it is an intriguing subject for research. "If you hit it," he says, "you've hit it big." At least, unlike a number of other exotic scientific posers of recent years, the question seems to be receiving thoughtful, conscientious study. This may mean that the answer will be a long time coming, but it is also likely to mean that the process of finding that answer will yield valuable knowledge about the overall development of life in the world. □





Photos: James D. Hayes/Lamont-Doherty

Clathrocyclas bicornis and Pterocanium prismatium, says Hayes, died near a reversal.