Earth Sciences

Richard Monastersky reports from Baltimore at the spring meeting of the American Geophysical Union

Where mountains once stood

Wind and water can gradually remove almost all signs of once-splendid mountain peaks. But erosion cannot erase everything. Often, the roots of ancient mountains survive beneath what looks like unimpressive landscape. Using such buried evidence, a group of researchers has identified the remains of a previously unknown mountain belt that stretched over 1,000 kilometers across northwest Canada.

Frederick A. Cook and his colleagues from the University of Calgary in Alberta discovered these roots primarily from seismic profiles recently released by oil companies. Using seismic waves almost like a radar, geophysicists can identify structures in underground rock. Profiles for the region between Canada's Great Bear Lake and the Beaufort Sea show that huge faults and folds run through the basement rock. These structures indicate that long ago, tectonic forces from the east and west squeezed the crust, causing mountains to grow along a north-south line. Similar folds and faults form the roots of the modern Appalachians and Rocky Mountains, says Cook.

The researchers cannot pinpoint when the mountain belt grew, but evidence suggests it happened sometime between 1.2 billion and 0.9 billion years ago. Cook says a collision between North America and another, unknown land mass created the tremendous forces that raised the mountain belt.

Earth as egg: Hard-boiled or raw?

Most cooks know that a hard-boiled egg spins much faster than a raw or partially cooked egg. This difference often serves as a test for doneness. On a more global level, it may also illustrate one reason why Earth's magnetic field has sporadically switched direction in the past, according to a controversial theory proposed by Richard Muller and Donald Morris at the Lawrence Berkeley Laboratory in Berkeley, Calif.

Most geophysicists think the geomagnetic field arises from currents of liquid iron flowing in the planet's outer core. But this is only a general theory. Scientists disagree over many details, including why the magnetic field sometimes weakens and then switches direction. Some have suggested that meteorites hitting the Earth might turn the field around, but this theory has gained little support in recent years.

Now Muller and Morris are reviving it. They suggest that impacts or volcanic eruptions could loft dust into the atmosphere and suddenly cool the Earth to a point where great ice caps would develop over the polar regions. Like an ice-skater accelerating a spin by pulling her arms toward her body, the movement of water toward the poles would speed the Earth's rotation.

At this point, the difference between hard-boiled and raw eggs becomes important. Like the contents of a raw egg, the liquid portions of the inner Earth are not firmly attached to the solid parts, so the entire core will not accelerate at the same time. As the crust and mantle speed up, friction and electromagnetic forces accelerate the outermost portions of the liquid core, but deeper regions of the core should lag behind for several hundred years, says Muller.

It is this shearing between regions in the outer core that causes the reversals, he proposes. Spin-up "scrambles" the flow patterns and weakens the geomagnetic field. When the entire core finally reaches speed, the field rejuvenates itself. But starting from a weak state, the field has an equal chance of pointing north or south. Not all reversals would occur in this way, but sudden cooling could explain some, Muller says.

So far, the physicists have few data or calculations to prove their ideas, although they say the theory offers several predictions that scientists can test. Other researchers remain extremely skeptical. In particular, some say it will take the entire core only a few years to reach speed.

Space Sciences

Where did AMPTE's ions go?

In 1984 and 1985, an unusual family of satellites called the Active Magnetospheric Particle Tracer Explorers (AMPTE) produced a series of "artificial comets" by releasing barium and lithium atoms into Earth's magnetic field, so that the atoms would be ionized by the sun's ultraviolet light and behave like the tails of natural comets. The experiments produced glowing, comet-like clouds as expected (SN: 7/27/85, p.54), but scientists were puzzled when one of the satellites sent along specifically to sample the ions farther down the "tails" failed to detect any.

In the May 1 Journal of Geophysical Research, researchers describe their attempt to understand where the missing ions went, based on a hypothesis they first proposed a year ago. John B. Cladis and William E. Francis of the Lockheed Palo Alto (Calif.) Research Laboratory suggest the ions from the first of two barium releases were carried along and across the lines of Earth's magnetic field into the shape of a narrow corridor that brought them no closer to the satellite than about twice Earth's radius. The second ion supply, they say, got no closer than three Earth radii.

As for the lithium, those atoms take much longer to become photoionized, so they expanded into a very large volume, and the ions were detected within this volume over a broad time interval. The slow ionization, however, provided enough time for the lithium cloud to become extremely rarefied. Unfortunately, the satellite's most sensitive detector had stopped working by that time, and the numbers of lithium ions had gotten too low to be measured by the detectors that were still operating.

Scientists plan a similar but more elaborate experiment with the NASA/Air Force Combined Release and Radiation Effects Satellite, carrying barium, lithium and other materials.

Uranus' signature in a radio signal

Less than a week before Voyager 2 flew past Uranus in 1986, two of the craft's instruments detected bursts of radio signals in an extremely narrow band of frequencies. They seemed to be the first signs of radio emissions from the planet, making them the first clear evidence that Uranus has a magnetic field (SN: 2/1/86, p.72). However, the frequency band was so narrow — the emissions showed up in one of the instruments' channels but not in an adjacent one — that scientists initially wondered whether these signals might be not from Uranus at all, but instead due to electronic noise created when the instruments were periodically "cycled" through their operating ranges.

Now three scientists involved with the Voyager mission report that the data may have been confusing because the "instrument cycling periods" used before the flyby were based on a Uranian day then assumed to be 15.57 hours long. They conclude that the narrowband bursts reflect the planet's actual 17.24-hour rotation period, a sign that they are indeed "planetary in origin." Michael D. Desch and Michael L. Kaiser of the NASA Goddard Space Flight Center in Greenbelt, Md., with William S. Kurth of the University of Iowa in Iowa City, describe the work in the May 1 Journal of Geophysical Research.

In addition to the narrowband bursts detected just before Voyager flew past Uranus, the researchers have since identified another batch from about three weeks earlier — in other words, a total of two major episodes, each about 10 days long. Comparing the timing of the burst episodes with Voyager's solar-wind measurements near Uranus indicates, they say, that "the radiated power [of the radio emissions] is greatly enhanced when the solar-wind density is enhanced. When the density is very low, few if any narrowband bursts are emitted." The two "bursty" periods thus provide what the scientists call the first evidence of "solar-wind-driven control" of Uranus radio emissions.