Powerful appeal of Mars' 'missing' field

Planetary scientists disagree about whether Mars generates its own "intrinsic" magnetic field, as do Earth and most of the solar system's other planets. Some researchers believe Mars once had such a magnetic field, and a far stronger one than any that may exist there today. Now Jayanta Kar of India's National Physical Laboratory in New Delhi proposes in the newly released February GEOPHYSICAL RESEARCH LETTERS that the weakening of a strong magnetic field could have had significant influences on the planet, ranging from the evolution of its atmosphere to the possible development of life.

An intrinsic field is one produced in a planet's molten core by circulation patterns caused by rising heat (convection), which create essentially a dynamo like an electric motor. U.S. and Soviet spacecraft sent to Mars in the 1960s and 1970s with instruments to measure such a field failed to find unambiguous evidence of intrinsic magnetism.

The U.S. Viking spacecraft in the late 1970s did detect an "induced" magnetic field above the planet, formed where the sun-spawned ions called the solar wind strike the top of the Martian atmosphere. Any intrinsic field other than a very weak one, however, would act as a shield, keeping most of the solar wind from ever getting close to the atmosphere.

Some scientists have calculated that if Mars does have an intrinsic field, it is no more than four ten-thousandths as strong as Earth's. On the other hand, Steven A. Curtis of NASA's Goddard Space Flight Center in Greenbelt, Md., and Norman S. Ness of the University of Delaware in Newark suggested in 1988 that the field present early in Mars' history was about 16,000 times stronger than any magnetic field Mars may have now. The field's weakening seems to have happened at least 1.3 billion years ago, they noted, when the dynamo was "switched from its on to its off state." They based this estimate on studies of certain meteorites found on Earth whose rock apparently crystallized on Mars about that time, whose magnetic characteristics indicate the planet's interior may by then have cooled enough to weaken or shut off the dynamo.

Earth is a larger planet than Mars and so it more thickly blankets its core and retains its interior heat. The giant outer planets — Jupiter, Saturn, Uranus and Neptune — have kept their heat sources going by compression due to their own gravity. Mars and the sun, however, may have engaged in a sort of shoving match, in which the planet's magnetic field once held the solar wind at bay.

There is no direct evidence for the strength of the solar wind during the period when the Martian dynamo was active, Kar says. However, he adds, observations of stars similar to the sun but at different stages in their evolution can give astronomers an idea.

Studies addressing the sun's early evolution suggest it was then about 25 percent dimmer than now, says Kar, and that the sun's continual loss of its mass was about 25 percent slower than its present rate. Furthermore, the scientist says, investigations of Apollo moon rocks reveal that the average solar wind velocity may have been only three times greater about 3 to 4 billion years ago than it is now, with a pressure at any given distance from the sun of about 2.25 times its present amount. "Clearly, therefore, the pressure of the intrinsic magnetic field in early Mars would exceed the solar wind dynamic pressure," according to Kar, leaving Mars wrapped in a magnetosphere of ions that could not penetrate that magnetic barrier.

The shoving match may not always have gone that way, however. Some astrophysicists believe that the sun spent the first 50 million years of its life in an energetic period called the "T-tauri" phase. At that time, says Kar, mass could have been leaving the sun and heading toward Mars at as much as a million times the present rate, so that even the initially strong Martian magnetic field would not have been able to balance it.

The shoving match after that, however, could have played a role if life were trying to evolve on the Martian surface. Kar notes that some species that became extinct on Earth in the last 2.5 million years did so near reversals in its magnetic field. These reversals may have been accompanied by periods when the whole field was weaker, possibly allowing more ultraviolet radiation from the sun to reach Earth's surface. "It appears," reports Kar, "that the shielding effect of the Martian magnetosphere would have helped sustain biological species until about 1.3 billion years ago," if any ever developed. *— J. Eberhart*

Imagined pictures possess 3-D properties

A vivid passage in a book often prompts a reader to paint a mental picture of the scene. Now a study in the March JOURNAL OF EXPERIMENTAL PSYCHOLOGY: GENERAL suggests these mental paintings are spontaneously rendered on a three-dimensional canvas. Moreover, objects lying in certain directions are easier to uproot from memory when a person searches an imagined landscape.

People mentally construct an imaginary space around themselves based on three dimensions, or axes, report Nancy Franklin of the State University of New York at Stony Brook and Barbara Tversky of Stanford University. For an upright observer, imagined objects above or below the body run along a vertical axis from the head to the feet and are easiest to recall, followed by objects in front or behind the body running along one horizontal axis and objects to the left or right running along a second horizontal axis.

"It looks like this is a powerful [mental strategy] to organize space that we use whenever we can," Franklin says.

The data contradict two theories of memory for three-dimensional information. One asserts memory is equally fast for objects in all directions, when the distance of each object from the observer is the same. The other theory holds that memory is quickest for objects in front of an observer, with more time needed as objects move to the sides and to the back.

Franklin and Tversky had 77 college students read narratives in which five objects are located around the reader along the three landmark axes. In one narrative, "you are standing next to the railing of a wide, elegant balcony" and objects are described above, below, in front, behind and to the right of the reader. The narrative was then presented again, one sentence at a time, on a computer screen. The computer periodically instructed the students to shift their orientation in the scene — say, turn 90 degrees to the right — and identify object locations by pushing specific numbers on the keyboard.

After discarding the few errors the study participants made on this task, the researchers found students were fastest to locate objects above or below the imagined observer, slower to locate objects in front of or behind the observer, and slowest to locate objects to the left or right. If the students imagined themselves reclining, rather than standing, the directional bias shifted, with objects in front and behind recalled faster than those along the head-to-foot axis, which were recalled faster than objects to the left and right.

For an upright observer, Franklin notes, the vertical dimension is defined by the environment — the ground and the sky — and objects remain "above" or "below" as the observer moves about. The horizontal dimensions depend on more arbitrary reference points, thus creating some confusion when the body's orientation shifts. The reclining observer is not aligned along the vertical axis, so visible, easy-to-reach objects in front of the body and behind are easier to recall, Franklin maintains.

This research may spur the redesign of airplane cockpits to improve pilot performance and offer strategies to rewrite textbooks on subjects requiring the visualization of accompanying diagrams, such as physics, Franklin says. *—B. Bower*