A New View: First U.S. Magnetic Anomaly Map

The United States finally has its magnetic survey data on a single map, making some large features apparent for the first time

The first magnetic anomaly map of the United States, constructed through laborious handwork from hundreds of different surveys, presents a new view of the upper 20 kilometers or so of the crust that will complement other methods for the study of the continent.

The construction of the new map* was no simple task. In 1976, a committee of the Society of Exploration Geophysicists (SEG), the professional group that cooperated with the U.S. Geological Survey (USGS) in the compilation of the map, recommended that new data be acquired. That would mean ferrying a sensitive magnetometer back and forth across the whole country by plane along parallel tracks only a few kilometers apart. The catch: a $100-million price tag. The committee's last choice, the approach eventually used, was to compile all of the available piecemeal surveys into a single composite map. Isidore Zietz of the Phoenix Corporation in MacLean, Virginia, who had independently begun compilation of such a national map some years ago while with the USGS, directed its completion under the USGS-SEG cooperative effort.

Splicing together hundreds of different magnetic surveys, each having different specifications, would have been impossible without some common observations to tie them together. To start, the compilers of the map, using only hand and eye, selected contour lines within each survey that connected magnetic anomalies of equal amplitude. (Variations of hundreds of nanoteslas, due to magnetized crustal rock, remain after subtraction of Earth's magnetic field of about 50,000 nanoteslas.) They reduced these contour maps to a common scale and transferred them to a single map of the conterminous United States. Then they had to join contours from adjacent surveys which, because of differing standards, did not necessarily meet.

The key to linking the individual surveys was a single study that covered the entire country, the National Uranium Resource Evaluation (NURE). As part of NURE, the Department of Energy flew a radiation detector along flight paths having 5- to 10-kilometer spacing, in order to locate new regions that might contain uranium deposits. A magnetometer went along with the detector as a piggyback experiment. This broadly spaced but uniform national survey provided the common link between the contours of adjacent surveys. "Without NURE," says Zietz "it wouldn't be a good map." The Project Magnet survey by the U.S. Naval Oceanographic Office provided an independent check at each degree of longitude. It agrees with the new map within 100 nanoteslas, according to the compilers.

"Never before have we had a map that showed the magnetics all the way across the U.S.," says Robert Hatcher of the University of South Carolina. "Now you can sit down with it and think about what it all means." The 1:2,500,000 scale of the map (which makes it about 2 by 1.3 meters in size) aids contemplation of the big picture. The scale is the same as that of maps of the geology, gravity, basement rock, and geologic structure of the conterminous United States that have been published by the USGS and professional societies over the past 20 years. In addition, some surveys, including some made by oil and mineral firms, appear for the first time anywhere.

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The new magnetic anomaly map reveals some large-scale features that had gone unrecognized in the narrower views of individual surveys. One is a 400-kilometer-wide pattern of magnetic lows and highs, a vague band of reds and pinks (the highs) and blues and greens (the lows). It parallels and is bounded on the south by the gravity low discovered recently in computer-processed gravity anomaly maps (*Science*, 5 March 1982, p. 1220). This pattern runs southeast-northwest across Missouri, through Nebraska, and into South Dakota, Zietz says. What caused the crust to produce these geophysical anomalies is unclear. The gravity low indicates that the crustal rock there is less dense than the surrounding rock. Magnetic lows and highs reflect the varying crustal content of magnetic minerals such as magnetite, but there are no hard-and-fast rules correlating rock type and magnetic properties. Speculation on the underlying cause centers around a stretching of the crust into a rift or a tearing along a shear zone.

Researchers have also used the new map to divide parts of the country into large, coherent blocks of crust. Before the map became available, M. E. Bickford and Randall Van Schmus of the University of Kansas believed that, because a large area of the central United States (Indiana, Illinois, Missouri, Ohio, southern Kansas, Oklahoma, and the Texas panhandle) is underlain by apparently identical volcanic rocks, the entire crustal block was added to the continent at the same time. But the map's patterns of anomalies differ across the area, suggesting that there are actually two blocks. Southwest Missouri appears to be on the edge of one and southeast Missouri on the edge of the other. Dating of volcanic basement rocks from outcrops and drill holes supports this division of otherwise identical rocks, Bickford says. The block to the southwest is about 1380 million years old, and the other is about 1480 million years old.

Another mapping problem that researchers have faced is locating the boundary between North America and the fragment of Africa left behind when the Atlantic opened about 180 million years ago. Zietz and Michael Higgins of the USGS in Atlanta believe that they can pinpoint the suture formed when Africa jammed against North America between 225 and 250 million years ago. On the basis of the magnetic anomaly map and gravity data, they say that the suture cuts off the southern end of the Appalachians and runs across Mississippi, Alabama, and Georgia to Savannah.

Because much of the crust is blanketed by nonmagnetic sediments, magnetic mapping should be a popular approach to sorting out the long and involved history of the continental crust. "Until we had the magnetic map," Bickford says, "we had no way to guide overselves." The guide is not without its pitfalls. The text accompanying the map cautions that varying specifications between adjacent surveys may give a false impression of contrasting anomaly patterns.

—**Richard A. Kerr**

*Available in black and white as U.S. Geological Survey Open-File Report 81-766 (1981). The recently released color version is U.S. Geological Survey Map GP-954A.

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