Unexpected Young Fault Found in Oklahoma

Geologists had thought that the Meers fault was long dead, but they now see that it recently slipped and could produce another large earthquake

Regulators seeking geologically quiet sites at which to build high dams or nuclear power plants, places as far as possible from faults that might generate damaging earthquakes, have followed a guideline that has served them well—if a fault visible at the surface has no current or historical earthquakes associated with it, then it is in all likelihood inactive and not a threat. Recent studies of the Meers fault in southwestern Oklahoma have shown that guideline to be unreliable in at least one case.

For 40 years geologists saw the Meers fault as merely an ancient scar on the land, an inactive relic of hundreds of millions of years ago when deep forces wrenched the crust apart. But instead of being seismically inactive for millions of years, the Meers fault has probably slipped during an earthquake within the past 10,000 years and perhaps within the past few thousand years. The question now is how many other quiet but possibly deadly faults lurk elsewhere.

The Meers fault is one of many northwest-southeast-trending faults in southwestern Oklahoma lying in a belt between the low Wichita Mountains to the south and the 12-kilometer-deep, sediment-filled Anadarko Basin to the north. The basin apparently formed when the crust split open but failed to form a true ocean basin. As the failed rift deepened, the crust had to give and it yielded at the basin's edge along near-vertical faults like the Meers fault. Geologists inspecting the straight, 26-kilometer-long crease in the land where the Meers cuts the surface therefore assumed that because the basin was old and no longer growing, the fault was also dead.

Once Charles Gilbert of Texas A&M University looked at the Meers fault—really looked at it—it seemed distinctly peculiar to him for an ancient fault. Whether it was cutting through soft, easily eroded rock or hard, resistant rock, the offset created by the fault looked about the same. The side of the fault that is uplifted to form a steep slope or scarp is about equally eroded along its length. If the fault were geologically old, the scarp cut in the resistant rock should stand out and the scarp in softer rock should be much less pronounced or even obliterated. It is not.

Once Gilbert was able to see the fault for what it is and now what it was supposed to be, the evidence of its youthfulness could be seen everywhere. "Anyone looking at it now sees that it is young," he notes. When the uplifted side of the fault slipped farther up during the recent geologic past, notes Richard Madole of the U.S. Geological Survey (USGS) in Golden, Colorado, streams crossing the fault cut new, narrow channels in order to return to their original inclination. That left terraces along their valleys on the upper block and deposited eroded debris in fans at the base of the scarp. David Slemmons of the University of Nevada reports that horizontal motion along the fault, which moves the opposing blocks past each other, has obviously offset ridges crossing the fault by about 20 meters. And Kenneth Luza of the Oklahoma Geological Survey reports that fault motion has cut through a sediment deposit that is no older than 2 million years.

S. Brocoum

The not-so-old Meers fault

A stream offset at the 5-meter-high Meers fault suggests geologically recent lateral movement.

The Meers fault looks relatively young, but exactly how young is it? Madole has found three deposits of alluvium, one of which was washed down from the upthrown fault block, that suggest that the fault last slipped within the past few thousand years. The oldest deposit has a preliminary carbon-14 age of about 9000 years, and it appears to be at least that old to judge from the relatively mature soil that has formed in it, Madole says. The next oldest deposit has a weakly developed soil and has a preliminary carbon-14 age of about 2000 years. This deposit buried the older one, probably when the upthrown block last moved, which would have forced the stream crossing it to cut a new channel and drop the debris downstream. The third deposit is the youngest of all because it cuts through the other two. Its preliminary carbon-14 age is about 500 years.

Thus, according to these analyses, the fault last moved no more recently than about 500 years ago but no earlier than about 2000 years. The still tentative carbon-14 dating aside, the obvious youthful appearance of this and other features requires movement within the past 10,000 years, Madole says.

With an eye toward going beyond subjective estimates of youthfulness, Slemmons has applied a technique to the Meers fault that can be used to estimate the age of a fault-created feature by gauging the degree to which erosion has modified it. As soon as the vertical movement of the fault during an earthquake creates a steep, step-like fault scarp, erosion begins to wear it back into a progressively more gentle slope. The heavier the precipitation and the weaker the surface material, the faster the scarp is beveled back toward the horizontal.

On the 5 to 6 meters of vertical relief created by movement on the Meers fault, Slemmons finds three distinct surfaces. One has a slope of about 25 degrees. Farther from the fault, there is a slope of 12 to 15 degrees, presumably created by greater erosion of a scarp formed by an older movement. An even gentler and thus even older slope can also be recognized, Slemmons says.

In the deserts of Nevada, where Robert Wallace of the USGS in Menlo Park first developed the technique, an initial 35-degree fault scarp slope would erode to 25 degrees in only a few thousand years. In southwest Oklahoma, however, there are 75 centimeters of precipitation per year versus Nevada's 16 centimeters per year. There are also soil differences, so that the calibration of slope steepness in Nevada cannot be used rigorously in Oklahoma. But Slemmons believes that the last movement on the Meers fault must have been "a matter of a few thousand years ago" to have left such a steep slope.

Earthquakes on the Meers fault seem to have occurred in the geologically recent past, but determining their magnitudes is more difficult than estimating their ages. Magnitude depends on the amount of fault movement during each earthquake. Five meters of vertical movement is evident at the fault scarp and both Slemmons and Gilbert detect signs of at least three earthquakes contributing to that movement. How much horizontal movement has occurred of the sort that the San Andreas experiences is more controversial. Gilbert sees about an equal amount of vertical and horizontal slippage whereas Slemmons favors 4 meters of horizontal movement for every meter of vertical movement.

If only three events contributed to the present height of the scarp and the motion was predominantly vertical, each event could have had a magnitude as high as 7, Slemmons says. Those would have been damaging though moderate earthquakes. If there was in addition considerable horizontal motion, the magnitudes might have been as high as 7.5, which is larger than all but one of the California earthquakes since the great San Francisco earthquake.

Unlike the situation in the American West, the cause of the activity on the Meers fault is unclear. It lies within the "stable" central region of North America thought to be old enough and far enough from a plate boundary such as the San Andreas to remain relatively quiet. But the region is still subject to certain strains. Measurements show that the central United States is being compressed in a roughly east-west direction, perhaps by the drag of the North American plate across the mantle. Whatever its origin, this compression could reactivate a fault oriented so that the present strain could drive movement on it. Such reactivation of an ancient rift seems to have produced the three great earthquakes near New Madrid, Missouri, in 1811–1812.

The Meers fault is an awkward new phenomenon for those searching for the sites of future damaging earthquakes. "The astonishing thing about it is that there seems to be essentially no seismicity" associated with the fault, says Stephan Brocoum of the Nuclear Regulatory Commission in Silver Spring, Maryland. Neither regional nor recently installed local seismograph networks have detected even microearthquakes directly on the fault, and historical records contain no events that can be confidently placed on it. Should regulators be more cautious than to depend solely on seismicity? The Meers fault could help provide some answers.—**Richard A. Kerr**

The Taung Baby Reaches Sixty

Sixty years ago the first australopithecine fossil was found in South Africa; prejudiced against it, the establishment did not want to know

Innocent, unbiased observation is a myth.—Sir Peter Medawar

When Sherwood Washburn said recently that "Molecular biology has settled the problems of human relations," meaning the shape and chronology of our family tree, he touched on a raw spot for most comparative anatomists.

It is the comparative anatomists, afterall, who are supposed to be able to infer phylogenetic relations—that is, genetic distance—from morphological difference. It is they who traditionally have enjoyed a virtual monopoly on reconstructing family trees. Molecular biologists—neophytes in this long established business—wield new and unproven techniques, it is held, which yield only an uncertain key to the past. For their part the molecular biologists view comparative anatomy as having proved to be wrong too often and the molecules as offering for the first time an unbiased measure of relationship. This is a bit of an exaggeration, of course, but not too far from the truth.

Washburn was speaking at a gathering of paleoanthropologists in various guises, called together to celebrate 60 years since the first discovery of an australopithecine, prehuman, fossil.* That fossil—the Taung child, which goes by the name *Australopithecus africanus*—received a distinctly negative reception when in February 1925 its discovery was announced, a mixture of indifference and scorn. Its discoverer, Raymond Dart, was considered to be, at best, misguided. Like the data of molecular biology today, said Washburn, the Taung child fell outside the mainstream of palaeoanthropology, which was bad enough, but also implied answers that fell outside established patterns of belief, which was worse. Such is the nature of science and of this science in particular.

The Taung Diamond Jubilee, which was organized by Phillip Tobias, successor to Dart in the Department of Anatomy at the University of The Witwatersrand, Johannesburg, was in part an opportunity to view the modern science of paleoanthropology through the lens of that early discovery and controversy.

At the time of the Taung fossil's announcement, theories of human origins flourished lustily, relatively unconstrained by actual fossil evidence. The Taung fossil was so firmly rejected by the establishment, simply because it did not fit with current theories. With the subsequent discovery of many hundreds of similar fossil hominids, the harnessing of scores of sophisticated techniques, and the increase in enthusiasm for the discipline as a science, particularly in the United States, the human element in

*Taung Diamond Jubilee International Symposium, 27 January to 4 February, University of The Witwatersrand, Johannesburg, and University of Bophuthatswana, Mmabatho.