CHINA EARTHQUAKE CAUSED BY RESERVOIR?

Since the Sichuan earthquake struck southwestern China in May 2008, killing more than 68,000 people, many geologists have focused on the Zipingpu Reservoir as a possible trigger. Now, a new study shows that the filling of the reservoir may have indeed created the stress that caused a fault in the Longmen Shan fault zone to slip, tens to hundreds of years before it otherwise would have quaked.

The Zipingpu Dam and reservoir, completed in 2006, is one of China's modern irrigation engineering feats. But pressures from the reservoir may have triggered the May 2008 earthquake.

Jian Guo Liu

The epicenter of the magnitude-7.9 quake was about 20 kilometers west of the reservoir, which formed in 2005 after the construction of the 156-meter-high dam on the Min River, a tributary of the Yangtze. The area is riddled with faults and prone to seismic activity due to the collision of the Indian and Eurasian plates. The Longmen Shan fault zone experiences earthquakes of this magnitude roughly every 2,000 years.

The idea that a large reservoir can precipitate an earthquake — by some combination of the weight of the water and changes in the pore pressure to the underlying rock — is not new. Scientists have speculated about reservoir-induced seismicity since tremor activity increased around the newly built Hoover Dam in the 1940s. And after the Sichuan event, many scientists analyzed the relationship between the Zipingpu Reservoir and the quake. Furthermore, anecdotal accounts from a nearby town told of increased seismicity after the dam was built, although no known data support this.

In fall 2008, Christian Klose, a geophysicist then at Columbia University in New York, suggested that the quake might have been advanced by a mass imbalance on Earth's surface near the fault, although he did not specifically address the reservoir. Such "mass changes can come from natural processes like erosion, like sedimentation," says Klose, now a senior research scientist at Think GeoHazards, an environmental risk-management firm based in New York and California. But mass changes can also come from larger "human activities," he says, thereby shifting "a huge amount of mass."

Other studies have considered the reservoir directly, looking to see how the forces due to the weight of the reservoir affected stress on the fault. These studies suggested the reservoir could in fact inhibit seismic activity by compressing the fault. But Shemin Ge, a geologist at the University of Colorado at Boulder, and colleagues looked at an additional factor: the pore pressure, or the pressure groundwater beneath the reservoir exerts on the rock.

When the team took into account both the weight of the water and changes in the pore pressure below the reservoir, they found that the Coulomb stress near the fault increased between 0.01 and 0.05 megapascals since the reservoir was filled, they reported in Geophysical Research Letters. Coulomb stress is a measure of the difference between the stress a fault experiences and the strength the fault has. "So if you have a Coulomb stress change in the positive direction, it means that the stress changed in a direction that the strength might not be able to endure," Ge says. Increases of 0.01 megapascals are enough to trigger an earthquake.

It's the pore pressure that made all the difference. "Think of a swimming pool," Ge says. "If you go to the bottom of a really deep swimming pool, you feel the pressure on top of you. So the deeper the reservoir, the higher the pressure at the bottom of the reservoir." With an average depth of 100 meters, the pore pressure beneath the reservoir increased by about 0.98 megapascals.

Still, Ge says, it's important not to conclude that the reservoir was the sole cause of the earthquake. "The reason we say 'potentially hastened' the earthquake is because this region is an earthquake-prone region. Earthquakes are going to happen regardless, and the difficult thing is to figure out where exactly and when exactly they're going to happen," she says. "It's a complex issue with many factors at work. The scientific implication of our calculation is that the reservoir might have sped up the earthquake that's going to happen anyway."

Bernard Langer