Researchers find building seismic strain in Azerbaijan

June 14 2012, by Jennifer Chu

The Caucasus mountains in Azerbaijan funnel from the west, into the Caspian Sea, a major oil-producing source. According to new MIT research, the region is ripe for a future earthquake that could have devastating effects for the country's capital, Baku, situated on the small outcrop jutting into the sea. Image: NASA

In 1859, a devastating earthquake ripped through what is now central Azerbaijan, destroying the capital city of Shemakha. Damage from the quake was so extensive that the capital was subsequently relocated to Baku, a coastal city on the Caspian Sea. Since then, Baku has grown into a thriving metropolis, fueled by vast offshore oil reserves. Rapid development of the city's housing, infrastructure and foreign trade has made Azerbaijan one of the fastest-growing economies in the world.

But new research shows that the region may be ripe for another devastating earthquake of a magnitude similar to the one that leveled the country's previous capital in 1859. Scientists at MIT and the Azerbaijan National Academy of Sciences analyzed more than 10 years' worth of GPS data from Baku and surrounding regions, discovering a large buildup of tension in the land. This geological deformation could lead to an earthquake, threatening Baku's population, petroleum reserves and the health of the Caspian Sea.

"It doesn't take a gigantic earthquake," says Robert Reilinger, principal research scientist in MIT's Department of Earth, Atmospheric and Planetary Sciences (EAPS). "It just takes bad luck. And this is an area where they can't afford it. It's an extremely vulnerable area in terms of the density of the people, the density of oil infrastructure, and the potential environmental impact regionally, not just in Azerbaijan."

Reilinger and his colleagues have published their findings in the *Journal of Natural Hazards*.

A shaky history

Azerbaijan has had a tumultuous geologic history. The country's earthquakes have mainly struck along the Caucasus Mountains, which extend from the Black Sea to the Caspian Sea. Over millions of years, the mountain range rose up from the collision of two tectonic plates: the southern Arabian plate and the northern Eurasian plate. As each massive plate pushes against the other, tension builds, occasionally releasing in the form of earthquakes along the boundary of the plates.

Michael Floyd, a postdoc in EAPS and the paper's co-author, likens the continental collision to a car crash. "If you have two cars coming together, you end up getting this crumple zone where things get distorted and damaged," Floyd says. "The backs of the cars stay intact, but the

hoods are completely busted. And that's what the mountains are here."

Finding a fault

Reilinger and Floyd set out to determine the tectonic strain near Baku using data obtained from a system of GPS monitoring stations throughout the area. Each station, equipped with an antenna and solar panels, records its position every 30 seconds relative to other monitoring stations. The researchers compiled measurements from multiple stations over the last 10 years, averaging a daily position measurement for each station during that time.

After crunching the data, the researchers generated a velocity map that illustrates how the region's geography has shifted over time. The team found that the region south of Baku is pushing steadily northward against the Eurasian plate. From their measurements, the researchers calculated that this tectonic convergence is occurring at a rate of 12 millimeters per year near Baku — twice the rate at which the convergence is occurring further west along the Caucasus in central Azerbaijan and Georgia, where a powerful earthquake occurred in 1991.

Floyd says the numbers indicate a significant geologic deformation, or strain, near Baku — raising the question of how this strain is being accommodated. If faults or fractures in the Earth are stressed, they may break, causing an earthquake in Baku that may ripple into the Caspian Sea.

The group suspects there are two major fault systems in the region with the potential to snap under the tectonic strain. But Floyd says there are currently not enough monitoring stations in the area to know "what faults may be active and are the most dangerous and likely to rupture."

Eric Sandvol, an assistant professor of geological sciences at the

University of Missouri at Columbia, says the tectonic strain revealed by the group will likely continue to push up the mountains in Azerbaijan, with potential side effects. “There will continue to be earthquakes in this region,” says Sandvol, who was not involved in this research. “The maximum size and location is difficult to say, but clearly, hazard mitigation is definitely needed in this important oil-producing country.”

Reilinger and Floyd are appealing to officials in Azerbaijan to set up additional GPS stations to record seismic activity and surface motions around Baku and in the Caspian Sea. For example, Reilinger says scientists, with support from the government, may erect stations on small islands or abandoned oil platforms. More data, he says, may help planners steel the city against an impending earthquake — perhaps through better building codes and innovations in oil pipeline design.

However, he admits that more data doesn’t always guarantee a conclusive outcome, as evidenced by recent events.

“Look at Japan, for instance,” Reilinger says. “It has one of the longest histories of earthquake records on the planet, maybe a couple thousand years. Using that record, they didn’t expect a magnitude 9 earthquake off of the Tohoku region. And yet we got one. So it’s a tricky business — the Earth is a fickle homeland for us.”

This research was supported in part by the National Science Foundation.