

## **Not My Fault: Of earthquakes, tectonics and oil in the Middle East**

Lori Dengler/For the Times-Standard

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There is a new leader in a grim race. On Sunday, a magnitude 7.3 earthquake struck along the border region between Iraq and Iran. As I write this column, it is estimated that more than 530 people died and at least 8000 were injured, easily surpassing last September's Mexico earthquake. Deadly earthquakes are not unusual in this part of the world. Twenty-seven earthquakes in the area we now call Iran have claimed more than 10,000 lives, and the 856 AD Damghan earthquake is the 6th deadliest of all time with a death toll estimated at 200,000. Compared with past earthquakes, the impacts of this most recent one are relatively modest.

Why so many deadly earthquakes? The modern Iran – Iraq political border is less than a century old but nearly coincides with a far older geologic one. For nearly 40 million years, the Arabian Plate has been slowly rotating towards Asia, opening the Red Sea and the Gulf of Aden and compressing the Persian Gulf. It is a great place to watch plate tectonics in action.

Look at a physical map of the Middle East or zoom in with Google Earth. Match up the shorelines of the Red Sea and the Gulf of Aden and imagine what this area looked like before the rift formed. Now shift your view east to the Persian Gulf. Unlike the Red Sea, the two shorelines look very different - the flat, nearly featureless desert of Saudi Arabia to the west and the highly convoluted surface of Iran's Zagros Mountains to the east. Each year the Arabian Peninsula moves a little closer to Asia gradually shrinking the ocean that once lay between them and crumpling the edge of the Asia plate into a multitude of ridges and valleys.

With compression comes earthquakes and Sunday's quake was a direct response to these tectonic forces. It was located near the northern end of the Zagros chain along a thrust fault at a depth of about 12 miles beneath the surface. The relatively shallow depth, the population density and the type of construction all contributed to the damage. Over a million people lived in areas that experienced very strong shaking. We may never know the exact death toll or the details of the damage as access to the region for outside experts is limited. But the outlines of the story are fairly clear. The earthquake

happened at night when most people were in their homes, many of which had not been designed to resist earthquake shaking.

Earthquakes are not the only result of this tectonic collision. It is no random accident that nearly half of the world's known hydrocarbon reserves reside in this region. This first hit home for me back in 1990 during the first Gulf War. Persian Gulf oil was clearly a major factor in the war and I became obsessed with the question of how so much oil and gas had ended up in a corner of the world covering less than 1% of its area.

So I read books and papers, talked to colleagues and sent emails and slowly learned about the unique set of circumstances that produce hydrocarbons. They need an enormous supply of organic rich material, conditions to preserve and bury that material, the appropriate temperatures and pressures to "cook" and convert the organics to gas or oil, porous and permeable reservoir rocks to collect the gas and oil, and finally a trap to keep the hydrocarbons from merely seeping upwards and out of the ground.

All of those conditions have coincided to make the Persian Gulf the Goldilocks zone for oil and gas. For at least 60 million years this region was a shallow corner of the Tethys Sea with circulation conditions that preserved the voluminous remains of marine life that rained down on the sea floor. Sometimes the Sea dried up completely forming thick impermeable caps of salts and gypsum.

As Arabia began to rotate into Asia, the sedimentary layers were folded. On the Iran side, the folds were tight and small. Oil and gas migrated upwards into the crests of the folds and were trapped by the impermeable layers, producing more than 300 known reserves.

Folding occurred on the Arabian side of the Gulf as well, but resulted in much larger and gentler folds than in Iran. Eight oil fields in Saudi Arabia currently contain more than a billion barrels. At the top of the list is giant Ghawar – 19 by 174 miles in size and producing in the neighborhood of 5 million barrels a day.

For our time, earthquakes and hydrocarbons will continue to be a fact of life in the Persian Gulf region. But as the Arabian Peninsula continues to plow into Asia, the Gulf will eventually disappear and the temperatures and pressures will become too great for hydrocarbon production and preservation. So a few million years from now, we won't need to fight over the Middle Eastern oil supply.

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