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Not My Fault: Blame geology for unrest in the Middle East

Lori Dengler for the Times-Standard
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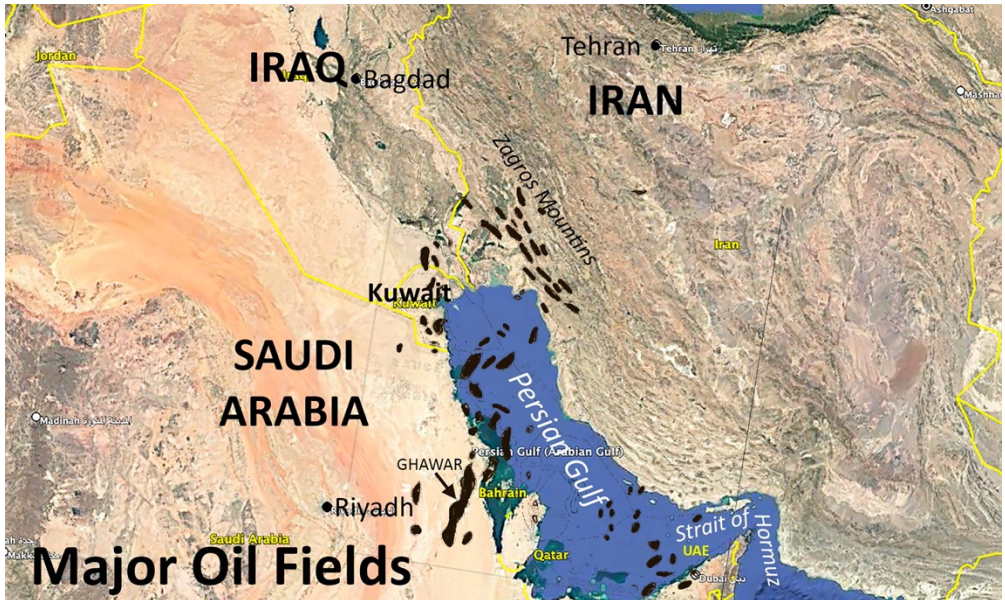

Map showing some of the major oil fields of the Middle East superimposed on Google Earth imagery. Note the difference between the western side of the Persian Gulf, where the landscape is relatively flat, and the Iranian side, where the crust is deformed into sharp folds. Most of Iran's oil and gas fields are in the Zagros Mountains in the NW part of the country.

In August of 1990, Iraq invaded Kuwait, leading to the first Gulf War. The conflict had its origins in decades of disputes in the region and Saddam Hussein's need to fill his drained financial coffers from massive war debts. Kuwaiti oil reserves were clearly Saddam's objective and when the U.S. sent in troops and the war raged on, I became obsessed with the origin of that oil.

Alas the region is no more peaceful today and although the Persian Gulf is no longer the largest supplier of hydrocarbons on the planet, it still provides over 20% of the global oil and liquid natural gas. While petroleum products aren't the only reason for outside interest in the region, there is no question that the history in the region over the last 75 years would have played out very differently if there were no oil reserves.

The Fertile Crescent, a region spanning the Persian Gulf countries, and modern-day Lebanon, Palestine, Israel, Jordan, and parts of Turkey, has played a pivotal role in human civilization that extends much further back than the petroleum era. Sites in Syria and Palestine dating back nearly 12,000 years contain evidence of the oldest human agricultural sites outside of China.

Dubbed the “Cradle of Civilization” by many scholars, it’s where hunter gatherer societies first shifted to permanent settlements.

Geology shaped the fertile valleys of the Tigris and Euphrates rivers and tributaries. Many animal species including humans traversed this zone between the uninhabitable Saharan desert and the Mediterranean. This key juncture between Africa and Eurasia, its mid-latitude location and varied geographic terrain increased biodiversity with many edible plants, the wild progenitors of what became the foundation crops of the Neolithic Revolution.

Just as geology created the conditions for human habitation in the Fertile Crescent, those same tectonic movements created the stage for today’s hydrocarbon-based conflicts. How did a region comprising less than a percent of earth’s surface end up with a substantial share of its gas and oil reserves? This question haunted me back in 1991. I submerged myself in the origins of the Persian Gulf (also called the Arabian Gulf) reserves. The answer was straight forward – it has been blessed (or cursed) with exactly the right set of circumstances to create, concentrate, preserve hydrocarbons.

Producing hydrocarbons on our planet is not difficult. Many sedimentary deposits in marine environments start out with a supply of organic material, the basic building block of petroleum products. They all begin as the remains of plankton and algae that died and accumulated on the sea floor over many millions of years. Sand, silt, and clays from land bury the organic detritus, compacting the material. If everything just stayed on the sea floor, nothing much else would happen. To produce oil or gas, the organics need to be buried and “cooked” at just the right temperature and pressure.

Tectonic movements provide the forces that maintain and deepen marine basins. As the sediment sinks, it warms in the deeper parts of the crust. Just how hot it gets depends on the geothermal gradient, the rate at which temperature increases with depth. To produce oil, burial depth must be roughly between 3,000 and 15,000 feet. Heavy crude is produced at the upper range, shifting to a mix of lighter oil and natural gas as temperatures increase at greater depths. Eventually a depth is reached where only natural gas is created. At much greater depths, like an oven left on too long, no useful organics will remain. It’s easier to produce and extract natural gas because fields are more widespread, easier to recover, and reservoirs are more long lasting. The Thompkins Hill field that supplies natural gas to Humboldt County is an example.

Hydrocarbons are being produced all the time and in much of the planet. To become of use to people, two more critical pieces are needed, porous rocks to allow the hydrocarbons to move and accumulate and a geologic structure or ‘trap’ and contain the gas and oil from just bubbling to the surface. Oil and gas are lighter than the surrounding rock or water and will move upwards in the absence of any barrier. Petrolia near Cape Mendocino in Humboldt County got its name from the many spots where oil oozes up to the surface. It was tantalizing enough to make Petrolia the site of California’s first oil well in 1865. That well looked promising in the first few days after drilling as oil gushed to the surface. Unfortunately, it quickly died out, a victim of triple junction geology that sheared our gas-bearing rocks into inadequate-sized reservoirs.

The ideal reservoir rock is a porous sandstone with pore spaces between the grains large enough to hold large amounts of gas and oil and allowing for easy flow to the surface once tapped by an oil well. There are techniques nowadays such as hydrofracturing that allow

recovery from less porous rocks like shale, but these are more expensive and were not available in the latter half of the 20th century when the Gulf region rose to prominence in global petroleum production.

Searching for suitable geologic traps has kept many geologists gainfully employed. First step is identifying cap rocks, very fine-grained or crystalline rocks that stop the gas and oil from moving upwards. Evaporites like salt and gypsum that are formed when sea water dries up are perfect candidates. A marine basin not too far from land is the ideal setting, providing plenty of sand to become reservoirs in wetter times and capping these sand layers with impermeable evaporites during dry conditions. The last step is adding a little faulting or folding to further concentrate the oil and gas.

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 abundant marine life and circulation conditions that preserved their voluminous remains. Climate changes during this period caused fluctuating water levels, sometimes becoming completely dry and forming thick impermeable caps of salts and gypsum. Coring deep beneath the surface reveals a layer cake pattern of sandstones and evaporites.

Continental masses are constantly rearranging themselves as heat flow and gravity cause them to coalesce and break apart. What we now call the Arabian plate spent most of its geologic history firmly attached to Africa. About 25 million years ago rifting began, rotating the Arabian plate towards Asia, and slowly closing the gap between the two. This convergence formed the Persian Gulf and began to crumple the rocks on both sides. On the Arabian side of the Gulf the forces were relatively weak, resulting in large, gentle folds. The largest oil field in the world is Saudi Arabia's giant Ghawar, discovered in 1948. It measures 19 by 174 miles in size and still produces nearly 4 million barrels of oil a day.

Iran on the Asian side of the plate convergence, suffered a very different fate. The landscape is crumpled in the elaborate northwest – southeast oriented texture of the Zagros mountains. The folds are tight and small. Oil and gas have migrated upwards into the crests of the folds, producing more than 300 known reserves, of which about 80 are currently active. The largest Iranian oil field is Ahvaz, producing less than 20% of Ghawar.

Almost all of the petroleum products in the region must travel through the Gulf to get to market. A gas pipeline connects some of Iran's natural gas production to Turkey, Iran has established one oil terminal south of the Persian Gulf, and a pipeline ships some of Ghawar's light oil to the Red Sea, but the vast majority of petroleum products must pass through the Strait of Hormuz. Only 35 miles wide, the Strait separates Iran from Oman and the United Arab Emirates and is arguably the most important choke point in today's world. While governed by international agreement, Iran exerts considerable control. Insurance companies are unwilling to cover the risk of attack and today almost no ships are traversing the Strait.

Plate tectonics will eventually change the geographic landscape and destroy the oil reservoirs of the Gulf region. The Arabian plate is swinging into Asia at a speed of just under an inch per year, closing the Strait of Hormuz and will turn the Gulf into an inland sea in another three or so million years. That same collision will grow the Zagros chain much higher and contort the Saudi Arabian side of the Gulf into complex folds and faults. The increasing temperatures and

pressures will completely erase any vestiges of the once vast petroleum reserves. But in the meantime, our dependence on fossil fuels and political instability in the region pose problems with no clear solutions.

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