

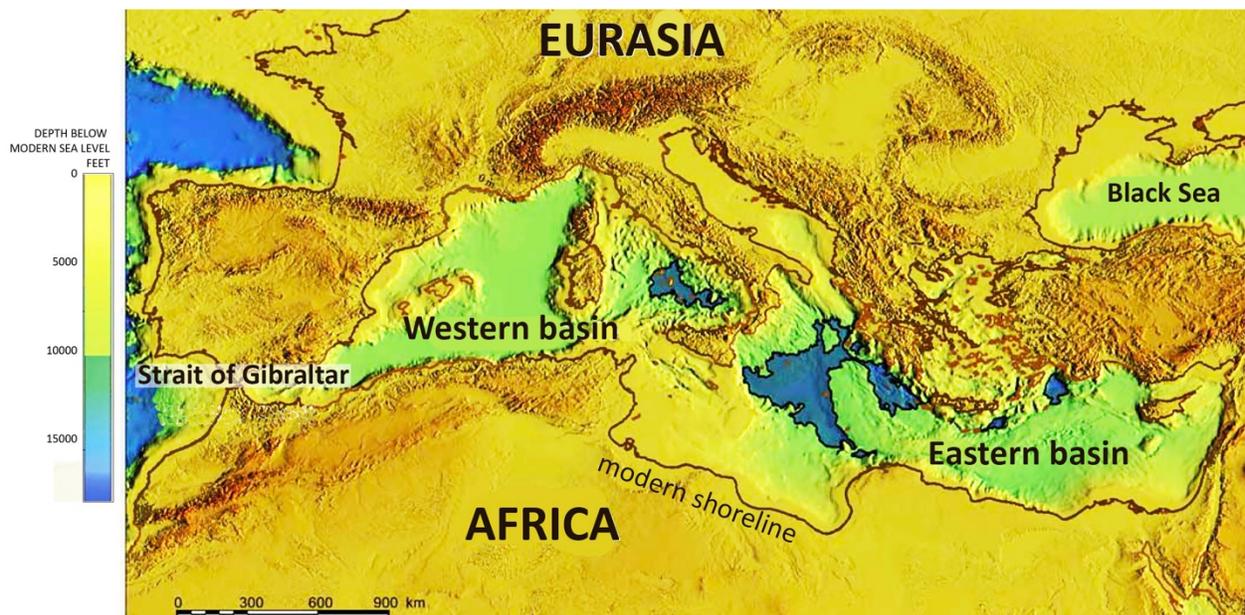
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Not My Fault: The Mediterranean has been a Place of Drought and Deluge

Lori Dengler for the Times-Standard

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This map shows a reconstruction of the Mediterranean Sea about 6 million years ago at the peak of the salinity crisis, when the sea was reduced to two small, extremely brackish waters shown by the blue areas in the eastern and western parts of the modern basin and the Strait of Gibraltar was closed to the Atlantic. The modern shoreline is shown by the darker line, modified from Anzeidi et al, 2014.

Last week, my attention was on oil in the Persian Gulf region and the problem of the Strait of Hormuz, the narrow passageway that ships need to transit to reach world markets. The situation has not improved in the last week. As I write, transit of tankers in the Gulf has essentially stopped resulting in the worst disruption to the global energy supply since the oil crisis in the 1970s, something none of us can ignore when we fill the gas tank.

The Strait of Hormuz is not the only narrow marine choke point to play an important role in global affairs. The Suez Canal, Panama Canal, the Strait of Malaca (between Sumatra and Malaysia), the Turkish Straits, Bab el-Mandeb separating Yemen and Djibouti at the southern end of the Red Sea, and the Strait of Gibraltar have all created havoc at one time or another in human affairs. Narrow passageways bordered by belligerent states are prime points for conflict with the potential to disrupt maritime trade.

I became interested in the Strait of Gibraltar over a dinner conversation with my son a few weeks ago. He was telling us about the computer game UBOAT where players attempt to sneak past British patrols and get through the Strait into the Mediterranean Sea. The game includes

not only eluding British defenses but a realistic simulation of the current fluctuations. Flow is complicated between the Atlantic and the Mediterranean with a two-layer system of counter currents affected by tides, salinity contrasts (the Mediterranean is saltier), winds, and internal waves generated by local features and my son assures us that the game includes these factors.

Gibraltar was a crucial choke point during World War II and has been the setting for many films. The memorable scene in *Das Boot* where the *U-96* attempts to transit the Strait was probably part of the motivation behind the *UBOAT* game. But Gibraltar's role in human affairs goes back much further. Called the Pillars of Hercules by the Greeks, it was heavily used by ancient peoples as a trade route. It's played a strategic military role for millennia, becoming one of the most densely fortified and contested spots in Europe.

The Strait of Gibraltar today is the 35-mile-long channel between Spain and Morocco. At its narrowest, only 9 miles separates the two countries. The 2.6 square miles of land adjacent to the Strait has been under British rule since the Treaty of Utrecht in 1713, a result of the War of Spanish Succession. The surface geography only tells a small part of the story. Beneath the water lies a great chasm, nearly 3000 feet deep. Outside of the Strait in the Gulf of Cadiz, the Atlantic continental shelf averages only 700 feet and once passing through to the Mediterranean into the Alboran Sea on the eastern side, it shallows again.

The Strait is named after the Rock of Gibraltar, a symbol of strength and permanence. The rock is a great limestone monolith on the Spanish side of the Strait whose name is derived from its Arabic name Jabal Tarik. But the Strait has by no means been permanent and its evolution has profoundly shaped the entire region. The Mediterranean as we know it today is a relative newcomer on the earth's surface. It is the last remnant of the vast Tethys Ocean that persisted for roughly 500 million years. As the Gondwana supercontinent broke apart, Africa was sent on a northern trajectory slowly moving towards Eurasia.

A subduction zone formed with the Tethys slowly diving beneath Eurasia, building the Alps and Carpathian mountains, and creating a deep basin. The two landmasses first met at Gibraltar, and it has been a complex relationship ever since. Roughly 6 million years ago the collision closed what is now the Strait, completely cutting off the flow of water between the Atlantic and what had been the Tethys Ocean.

Once the Tethys basin was cut off from the Atlantic, water quickly began to evaporate. Called the Messinian salinity crisis, almost all of the water had probably dried up in less than 10,000 years within closing the Strait. The two remaining water bodies in the deepest parts of the eastern and western parts of the basin likely resembled the Dead Sea, surrounded by thick layers of salt, gypsum, and other minerals formed by the evaporation of sea water. It was a catastrophic extinction event. A 2024 paper in *Science* argues that only about 10% of species survived the abrupt degradation of habitat.

Plates move and sea levels change. About 5.3 million years ago, the Atlantic suddenly breached the Strait of Gibraltar producing arguably the greatest flood we have direct geologic evidence for. Imagine the setting at that time – the Atlantic perched about 6000 feet above the nearly dry basin that would become the Mediterranean, a drop 30 times greater than Niagara falls. Named the Zanclean flood, modeling studies suggest peak discharge 1,000 times greater than the largest Amazon floods, with water flowing at upwards of 80 miles per hour.

It would have taken up to two years to fill the entire basin, the blink of an eye in geologic terms. Refilling likely happened in stages. The geometry of the Mediterranean region is complex and the Malta escarpment south of Sicily may have blocked the flow for some time. Whether a separate western sea persisted for months or centuries is not clear, but a group of scientists published a 2023 paper in the journal *Sedimentology* found evidence for what happened when the Malta escarpment was breached.

Led by Van Dijk from Utrecht University, the group studied sandstones on the south coast of Sicily dated between 5 and 6 million years ago. This unit was perched in exactly the right position atop a gypsum unit from the period during the salinity crisis when the basin was dry and marl, a mixture of calcium carbonate and silts that is only formed in wet conditions. They examined the sandstone unit carefully and found fossilized current ripples that could only be produced by rapid water flow. Analysis showed the water was deep and currents rapidly traveled from west to east in an area where such currents could not exist in the present Sea. Their paper proposes this unit was the result of the moment waters in the western part of the basin finally began flowing into the eastern basin.

Geologists use the Messinian salinity crisis and Zanclean flood to delineate units in the geologic time scale. The Neogene period extends from 23 million years to about 2.5 million years ago and is the last period before the ice ages began. It was a time of general cooling, grassland expansion and rapid evolution of mammals. But conditions were by no means constant during that time, and the Neogene is subdivided further into Epochs (Miocene and Pliocene) and Stages. The Messinian marks the last part of the Miocene when conditions were dry, defined by the evaporites in the Mediterranean and Zanclean is first stage of the Pliocene when conditions became much wetter. Both names come from ancient cities in Sicily where much of this work on the history of the Mediterranean were conducted.

The Strait of Gibraltar will eventually close again as Africa continues to encroach upon Eurasia. At the present rate of movement, the Mediterranean basin will be cut off from the Atlantic in 20 million years. The environmental impacts are likely to repeat the salinity crisis of 6 million years ago, but the closure will be permanent and 50 million years from now, all that will remain of the Mediterranean's history will be in the contorted rocks of a much greater great Alpine – Carpathian mountain chain.

Visit <https://www.youtube.com/watch?v=0xQeEgPhSfl> for an animation of the Zanclean flood.

Lori Dengler is an emeritus professor of geology at Cal Poly Humboldt, and an expert in tsunami and earthquake hazards. The opinions expressed are hers and not the Times--Standard's. All Not My Fault columns are archived online at <https://kamome.humboldt.edu/taxonomy/term/5> and may be reused for educational purposes. Leave a message at (707) 826-6019 or email Kamome@humboldt.edu for questions and comments about this column or to request copies of the preparedness magazine "Living on Shaky Ground."