Times-Standard
Times-Standard / Humboldt Beacon

Not My Fault: How does a plate die – with a bang or a whimper?

Lori Dengler/For the Times-Standard
Posted June 13, 2021
https://www.times-standard.com/2021/06/13/lori-dengler-how-does-a-plate-die-with-a-bang-or-a-whimper/

Eastern Africa is a lesson of how plates are born (Not My Fault 6/6/21). What happens at the other end of a plate's life cycle? Can plates "die"? Last week, my attention was on how plates begin. The earth is not expanding and there is no trend of plates getting smaller. If new plates form, something must happen to the older ones.

The fate of a plate depends on whether it includes continental material or not. Once a plate is set in motion as a new spreading center forms, it continues to move outward from the ridge, driven by the heat that created it. As it moves further and further away, the older parts cool and thicken, providing an additional gravitational pull.

The Red Sea, the Gulf of Aden, and the Atlantic Ocean provide snapshots in time of the process. The opening of the Red Sea and the Gulf of Aden began around fifty million years ago. But like the present rifting in Africa, it happened in fits and starts as the Arabian plate rotated away from Africa. The Red Sea opening has been slower and oceanic crust is just beginning to form along the spreading axis. The more rapidly spreading Gulf of Aden has produced oceanic sea floor nearly from shore to shore.

The Atlantic is a mature ocean. Rifting began with the breakup of Pangaea more than 150 million years ago and the gap has widened ever since. Some of the oldest oceanic crust anywhere in the world is found on its edges. Today's Atlantic is about 3,000 miles wide and is bounded by what geologists call "passive margins." The seafloor – continent connections are not broken by faults and have changed little since the supercontinent breakup. A common school introduction to plate tectonics is a cut and paste matching of the continental margins to reconstruct Pangaea.

The Atlantic is still growing at the rate of an inch or so a year and will continue to spread until the gravitation tug on the oldest oceanic crust and uppermost mantle becomes too heavy to bear. All oceans eventually get to the point where the weight of older and colder portions exceeds the strength of the underlying mantle and begin to founder and sink, forming a new subduction zone. The physical expression of the process is a depression or trench. Subduction zones can also spread from one ocean to another as plate geometry changes.

Once subduction zones form, an ocean will eventually contract. Some scientists hypothesize subduction zones are already beginning to form along the Atlantic margin. A study published in 2013 by a group from the University of Lisbon examine what they call an embryonic subduction zone off the coast of Portugal beginning a process they propose could consume the entire Atlantic in about 200 million years.

Plates don't sink quietly. The process of subduction creates stress, friction, and chemical changes, resulting in the majority of the world's volcanoes and earthquakes. Subduction zones also evolve with time as the global geometry, the composition, and age of the descending slab change.

The biggest changes occur when a bit of continental crust or a ridge hits the subduction zone. The world's current plate geometry consists of about 12 major plates and a few dozen small ones depending on how one defines a plate boundary. Some plates like the Philippine plate are entirely composed of oceanic crust and upper mantle, but most include both oceanic and continental material.

Interesting things happen when a chunk of continental material hits a subduction zone. Continental crust is too light to be subsumed into the subduction zone. If the chunk is small, it gets slapped onto the continental margin in a process called accretion. We owe much of the present-day geography of the US West Coast to this process. Read John McPhee's "Assembling California" for an engaging and readable account.

When the chunk is continental in size, the collision is truly monumental. The Indian subcontinent broke away from the supercontinent Gondwanaland (the southern half of Pangaea) 180 million years ago. For more than 125 million years, it peacefully drifted across what we now call the Indian Ocean. But about 45 to 55 million years ago, the subcontinent made contact with Asia and the two have been colliding ever since, producing the Himalayas and the Tibetan Plateau, the highest plateau on the globe.

There are interesting consequences of a spreading ridge hitting a subduction zone as well. And those consequences are important to every Californian. The Pacific Ocean is the largest body of water on the planet accounting for 28% of the earth's surface, but it was once even larger. Unlike the Atlantic, almost every part of the Pacific is bordered by subduction zones. These active margins are nibbling away at the edges of the ocean at rates of inches per year, consuming close to two tenths of a square mile every year.

This plate consumption will eventually bring the ridge that created the plate into contact with a subduction zone. Several times in these columns I've recommended Tanya Atwater's terrific animation of the plate tectonic evolution of the US West Coast (https://www.youtube.com/watch?v=SfO_6g0SMpA). It is well worth watching again.

The giant subduction zone system that once spanned the entire west coast of both North and South America has been cut into segments as different parts of the ridge made contact with the trench. There is no strength across the two sides of a spreading center. That means once the ridge meets the subduction zone, the subduction zone dies.

The Cascadia subduction zone is the largest remaining section of the once giant west coast subduction system along the North American coast. Extending from Cape Mendocino to Vancouver Island, Canada, the Gorda and Juan de Fuca ridges will also meet the trench and cease to be at some point in the future. Today's plate geometry in Northern California and the Pacific Northwest is a lesson in how plates die.

More next week.

Lori Dengler is an emeritus professor of geology at Humboldt State University, 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/resources and may be reused for educational purposes. Leave a message at (707) 826-6019 or email rctwg@humboldt.edu for questions and comments about this column, or to request a free copy of the North Coast preparedness magazine "Living on Shaky Ground."