The birth and death of oceans: what ancient Pangea has to say about future supercontinents

John Waldron (left) with graduate students Shawna White (middle) and Ryan Lacombe (right) examining sea-floor sediments formed during the closing of the Iapetus Ocean, now uplifted and exposed at the foot of the steep cliffs of the Port au Port Peninsula, western Newfoundland.

Pangea, the supercontinent that contained most of the Earth's landmass until about 180 million years ago, endured a rather apocalyptic undoing during the Jurassic period - when the Atlantic Ocean opened up. This is well understood.

But what is less clear, is how Pangea came into being in the first place.

Earth and Atmospheric Sciences professor John Waldron in the University of Alberta's Faculty of Science, along with three colleagues in Atlantic Canada and the United Kingdom, has recently described a new model for the events that led to the closing of ancient oceans and the formation of Pangea. The scientists outline their findings in in their paper, “How was the Iapetus Ocean infected with subduction?” in the journal Geology, published by the Geological Society of America.

According to Waldron and fellow authors, the answers may be found in the best known of the ancient oceans, Iapetus, which lay between the ancient core of North America and parts of what are now Europe, Africa, and South America.

Sedimentary rock exposed by wave action on the coast of Newfoundland near the town of Stephenville. Formed on the bottom of the sea along the margin of the Iapetus Ocean during the early Ordovician Period about 480 million years ago as the ocean closed. As they were formed, they were caught, squeezed and folded as a subduction zone collided with the edge of the North American Continent about 10 million years later.

The Iapetus Ocean opened up around 600 million years ago by rifting between these continents. However, the mechanism by which oceans transition from opening to closing is a long-standing unsolved problem in tectonics.

"Most geologists have assumed that the ancient Iapetus Ocean stopped getting wider and started to shrink when subduction somehow spontaneously started up along its margins. Looking at the history of the oceans formed since Pangea, we think that just doesn't happen. It's much more likely that a small plate, like the modern Caribbean, came into the Iapetus from the east, bringing with it many small continental fragments.

This helps to explain many odd features of the Appalachian and Caledonide mountain belts that are otherwise very difficult to understand," explains Waldron.

Using the modern Caribbean Sea as an analogy, Waldron and his co-authors have observed that at its eastern edge, the Caribbean Plate is overriding the floor of the Atlantic Ocean in a process known as subduction, which produces a zone of earthquakes and volcanoes extending from Barbados to Haiti. In another example, the zone between South America and Antarctica is also overriding Atlantic Ocean floor.

Waldron and his colleagues suggest that the Iapetus Ocean contained a region that looked like a mirror image of the Caribbean. They have named this the Sea of Exploits, after the Bay of Exploits in Newfoundland, where fragments of this plate are preserved. A subduction zone along its edge advanced westward into the Iapetus Ocean overriding its ocean floor producing earthquakes and chains of island volcanoes.

Once "infected" with subduction, the floor of the Iapetus Ocean was progressively consumed, leading to collisions between the surrounding continents that built the Appalachians of North America and the Caledonide Mountains of Scotland and Norway, and the assembly of Pangea.

Fragments of these ancient island volcanoes are preserved in Atlantic Canada and the British Isles, with folded and faulted sedimentary rocks squeezed by the ensuing collisions, which Waldron has worked on with a succession of graduate students since the 1990s.

The modern Atlantic may be similarly doomed to close, in the distant future. If subduction zones like those around the Caribbean Plate continue to consume the floor of the Atlantic Ocean, eventually the continents around the Atlantic may collide to form a mountain range and a new supercontinent. However, the process is likely to take perhaps another 100 million years, so we may not be around to check it out.

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