PUBLICATIONS

Not Written in Stone. Plate tectonics at 50

"Published PT teaching is complacent. It should adapt to emerging data, include multiple working hypotheses and enable students to think and choose"

Keith James
Consultant geologist /Institute of Geography and Earth Sciences of Aberystwyth University in Wales, UK.

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The Plate tectonic paradigm – "the unifying theory of geology" – has just turned 50.

In 2017, the Geological Society of London's William Smith Meeting celebrated this historical occasion, perhaps with a touch of self congratulation, but with little discussion of alternative ideas.

Plate tectonics (PT) is an enormous topic with a convoluted history. This article highlights some problems, some old ideas, emerging data and some different possibilities.

Supercontinent Pangaea began to fragment in the Triassic. PT holds that from the Jurassic onward, mid-ocean ridges (MORs) generated new seafloor that separated continents. Here, magnetic stripes record reversals of Earth's magnetic field and spreading progress.

This crust is consumed by subduction, which creates blueschists and new continental crust below volcanic arcs. Collision raises mountains.

PT's predecessor theory, continental drift, used the fit of South Atlantic coastlines and fossil distributions as basic arguments for the former connection of South America and Africa (see figure 1). Mantle convection distributed continents.

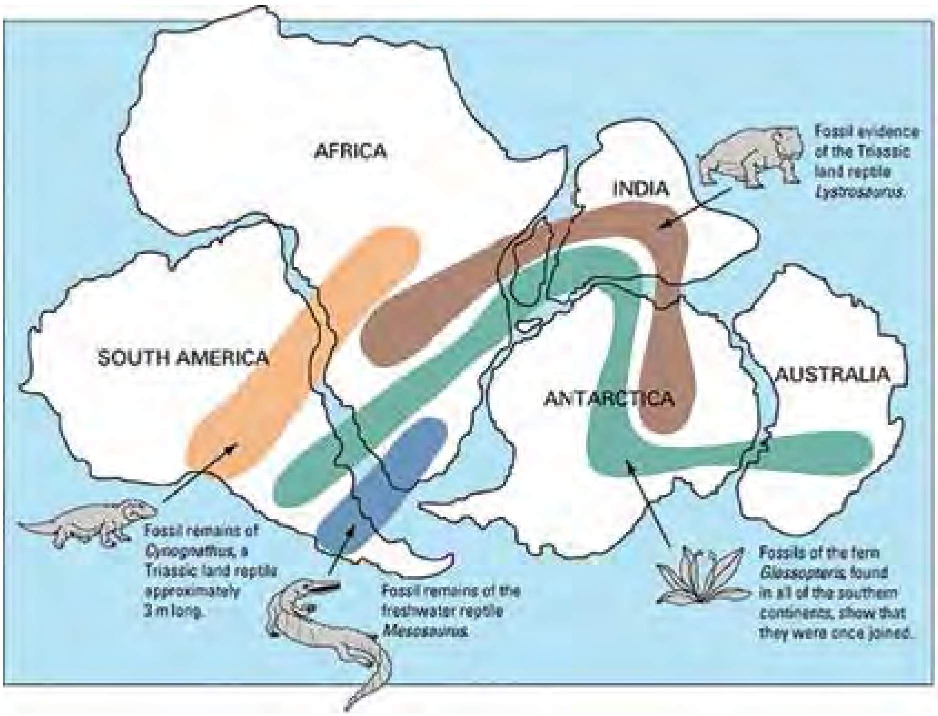
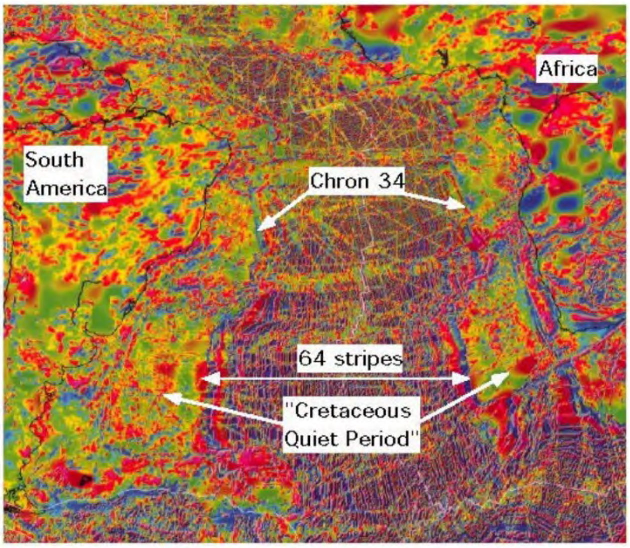


Figure 1. As noted by Snider-Pellegrini and Wegener, the locations of certain fossil plants and animals on present-day, widely separated continents would form definite patterns (shown by the bands of colors), if the continents are rejoined. Image courtesy of the United States Geological Survey.

Continental Reconstruction

Magnetic data (see figures 2 and 3) suggest an intriguing alternative to coastlines/bathymetric contours for Pangaean reconstruction. Large areas without magnetic stripes below the South Atlantic adjacent to South America and Africa supposedly record the Cretaceous Quiet Period, when magnetic field reversals paused for 40 million years.



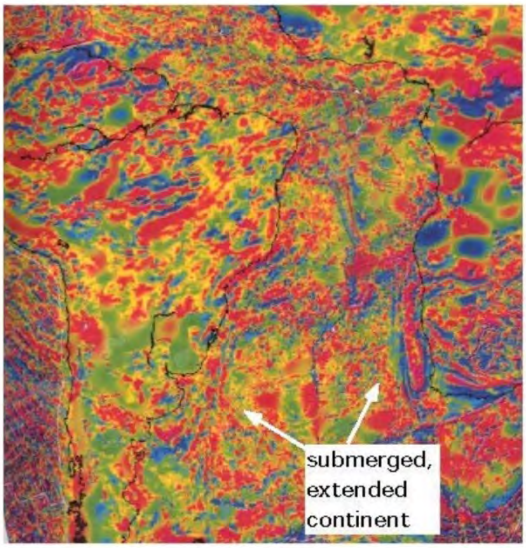


Figure 3 (left). Removal of striped crust indicates reconstruction of much larger Pangaean Africa and South America, with significant implications for occurrence of continental material on the ocean floor, fossil distributions and exploration possibilities.
Figure 4 (right). This gravity map of northern South America indicates dynamic, eastwardmigrating, deep (blueschist conditions) foreland basins pursued by inverted, overriding uplifts exposing metamorphic rocks.

Alternatively, a similar signature suggests they are foundered parts of adjacent continents. They reconstruct well (see figure 3). A similar signature appears off eastern North America where seafloor fractures that continue onshore to Palaeozoic/older Appalachian offsets indicate ancient, continental origins.

In today's PT, paleontology takes a back seat. A new book published by the Geological Society of London, "Crustal Evolution of India and Antarctica: The Supercontinent Connection," edited by N.C. Pant and S. Dasgupta, relates India to Antarctica using geochronological data/petrology. Fossil data relate India to neighboring Eurasia. Dinosaurs, freshwater snails, catfish, cichlid fish, angiosperms, flightless birds and manatees evidence communication between supposedly long-separated areas. Monkeys and rodents travelled 2,600 kilometers from Africa to South America (early Cretaceous separation) in the Oligocene. Mammals migrated between Africa and Madagascar (Jurassic separation) as recently as the Eocene-Miocene. Explanations offered include swimming, rafting or island hopping.

Foundered continental areas are an interesting alternative.

Convection and Sea Floor Magnetic Stripes

Today's PT maintains that subduction slab pull is the major driver of spreading. This seems to be a non-starter – no spreading, no pull, and vice-versa. 2-D models of mantle convection cells rising at MORs, diving below subduction zones and carrying continents apart are still alive but could they be segmented in the third dimension? MOR offsets up to several hundreds of kilometres along fractures surely rule them out.

A major pillar of PT is that sea floor magnetic stripes, sometimes attributed to magnetic field reversal, others to high versus low intensity, record spreading. They also occur in continental rifts.

Moving ever further offshore, seismic surveys reveal lightly stretched continental crust followed by thinning from 30 kilometers to less than 10 kilometers, and thence to highly extended crust, presumed continent-ocean boundaries and "oceanic" crust. The crust is being stretched. That seems to rule out ridge push as a spreading driver.

Extended crust carries asymmetric basins, between 60 and 200 kilometers wide and up to 25 kilometers deep, where reflections, some with sedimentary architecture (truncation, onlap), dip toward bounding faults (seawarddipping reflections, or SDRs). Here, magma rises to intrude sills and extrude basalt.

Stretching also results in serpentinization (with magnetite) of exhumed peridotite, generating magnetic anomalies unrelated to MOR spreading.

Could they explain seafloor magnetic stripes?

Deep sea drilling aimed at calibrating increasing age of oceanic crust away from MORs encountered basalts assumed to be "basement," but some contained sediment clasts and some deeper basalts were interbedded with sediments. Perhaps "oceanic" crust includes extended continent basins far offshore. Is there any evidence?

Continent Below Oceans
PT overlooks numerous samples of continental material dredged from ocean floors, some with trilobites and graptolites, (e.g., Bald Mountain, 80 kilometers-cubed of Proterozoic granite, and King´s Trough in the North Atlantic).

Rocks as old as 2 billion years occur on the Mid-Atlantic Ridge Peter and Paul's islands. Proterozoic-Paleozoic zircons occur in gabbros on the Mid-Atlantic Ridge.

Continental isotopes are widespread in Indian Ocean basalts. Proterozoic zircons in lavas on Mauritius suggest ancient basement, newly christened "Mauritia" in 2013, below the island and adjacent Mascarene Plateau. Magnetic data indicate a large submerged continental area to the east.

In the South Atlantic, granite was in 2013 discovered on the northwest-to-southeast Rio Grande Ridge (outer edge of South America's magnetic extension). Basalts on the "conjugate" Walvis Ridge show continental signature. Both are seen as migration tracks over the same Tristan da Cunha hot spot but they are oblique to seafloor fractures (flowlines). Both ridges are associated with those large extensions of neighboring continents and SDRs are present.

Precambrian-Devonian zircons have just been reported in lavas of the Galapagos Islands, a 20 million-year-old supposed hotspot 1,000 kilometers west of South America. Mesozoic zircons occur on Iceland, 13-15 million years old, on the Mid-Atlantic Ridge.

In 2017, Zealandia was nominated as a newly recognized continent. This fragmented, largely submerged area between Australia and New Zealand is the size of India. It explains plant and animal distributions in the South Pacific. There is much more, however. Magnetic data indicate very large extensions to the north and east. Permian-lower Cretaceous sandstones in New Zealand's eastern Torlesse Terrane, 3,500 kilometers long, 300 kilometers wide and 30 kilometers thick, came from here.

Pangaean Reconstructions and Earth Size
Proliferating models of Pangaea, its breakup and dispersal show Increasing complexity, recognizing ever more small terranes and their migrations, but they overlook important data.

One objective, to model paleoclimate and thence source rock presence, requires knowledge of ocean currents. Mid-Jurassic/Miocene shallow-water deposits and subaerially weathered rocks, now 1 – 7 kilometers deep, in Deep Sea Drilling Project sites in the Atlantic, Indian and Pacific Oceans must have been influenced by these, but reconstructions do not show them. Those large subsided continental masses need to be taken into account as well.

Reconstructions show oceanic crust east of Japan and New Zealand, and west of South America. But Japan received sediments from the east in the Palaeozoic- Paleogene and a million cubic kilometres of Devonian micaceous sediments in Bolivia and Argentina came from the west. Geological, geophysical and dredge data evidence Precambrian, younger continental crust under northwest Pacific abyssal plains. It subsided below deep sea at the end of the Jurassic, but you can still see it on the magnetic map.

The reconstructions use constant size Earth. There are 75,000 kilometers of “spreading” ridges and only 30,500 kilometers of trenches and 9,000 kilometers of collision zones. Production of more crust than consumption implies that the Earth is expanding.

Space-geodetic data show that the solid Earth expanded about 0.24 millimeters annually in recent decades.

Growth increments on fossil corals and brachiopods show that days per year declined from 424 in the Middle Cambrian to 365 today – like a pirouetting ballerina extending her arms, Earth grows and slows.

How?

Serpentinization of shallow mantle peridotite results in up to 40-percent volume increase and release of heat. Is this responsible for elevation of MORs, with their black smokers? Does radial growth contribute to continental separation, extension and subsidence?

Origin of Continental Crust
Intra-oceanic volcanic arcs are characterized by high silica andesite (named from the Andes of South America).

This cannot derive from subducting slab low-silica basalt so we have an “andesite problem.” For PT, the rock reflects “new” continental crust formed by complex partial melting of sediments, the slab, the mantle or the mantle wedge (or combinations of these) in “subduction factories.” This is where continental crust forms.

Recently discovered Precambrian and Palaeozoic zircons produced by the volcanoes of and continental seismic velocities below island arcs Izu-Bonin, Luzon, Vanuatu, Solomon Islands, East Java and the Lesser Antilles show they are underpinned by original continent. There is no andesite problem and subduction factories are not required.

Blueschists (high-pressure/lowtemperature metamorphism) are seen as classic indicators of fossil subduction zones, involving descent of material to 40–80 kilometers over millions of years, metamorphism, and then unexplained resurrection. However, some radiometric data suggest metamorphism only slightly younger than predecessor rocks. There are no blueschists in the Central American or Lesser Antilles subduction arcs. Along the north and south Caribbean margins, metamorphism increases and highpressure/low-temperature rocks occur close to strike-slip faults. Some are even interbedded with sedimentary equivalents.

How Do Mountains Form?
While normal faults might involve tens of kilometers of displacement and thrusts up to several hundreds, strike-slip displacements can be many hundreds. These latter, primordial faults form a conjugate northwest and northeast global pattern. Transtention/transpression within this generates secondary north-trending extension and east-trending compression. The polygonal blocks these define are repeatedly shuffled within this global fabric.

Africa supposedly converged 2,000 kilometers with Eurasia, pushing up the Alps. Yet there is no uplift along the same boundary to the west in the Atlantic. The Alps and Carpathians carry European brachiopods. There is nothing African present. India is supposed to have migrated 7,500 kilometers north across the Indian Ocean to push up the Himalayas, but fossils relate India to Eurasia. Head-on collision of far travelled continents is not indicated. Perhaps strike-slip plays a role.

There is an interesting, dynamic, natural strike-slip laboratory along northern South America (see figure 4). Right-lateral offset generates eastward-younging foreland basins followed by inversion into overriding uplifts. The 200 milligal negative gravity anomaly, the world’s largest at sea level, over the eastern, Maturín Basin suggests a root without a mountain. Major hydrocarbon reserves occur here. Industry data (sediment thickness, overpressures, low heat flow) point to blueschist conditions at depth.

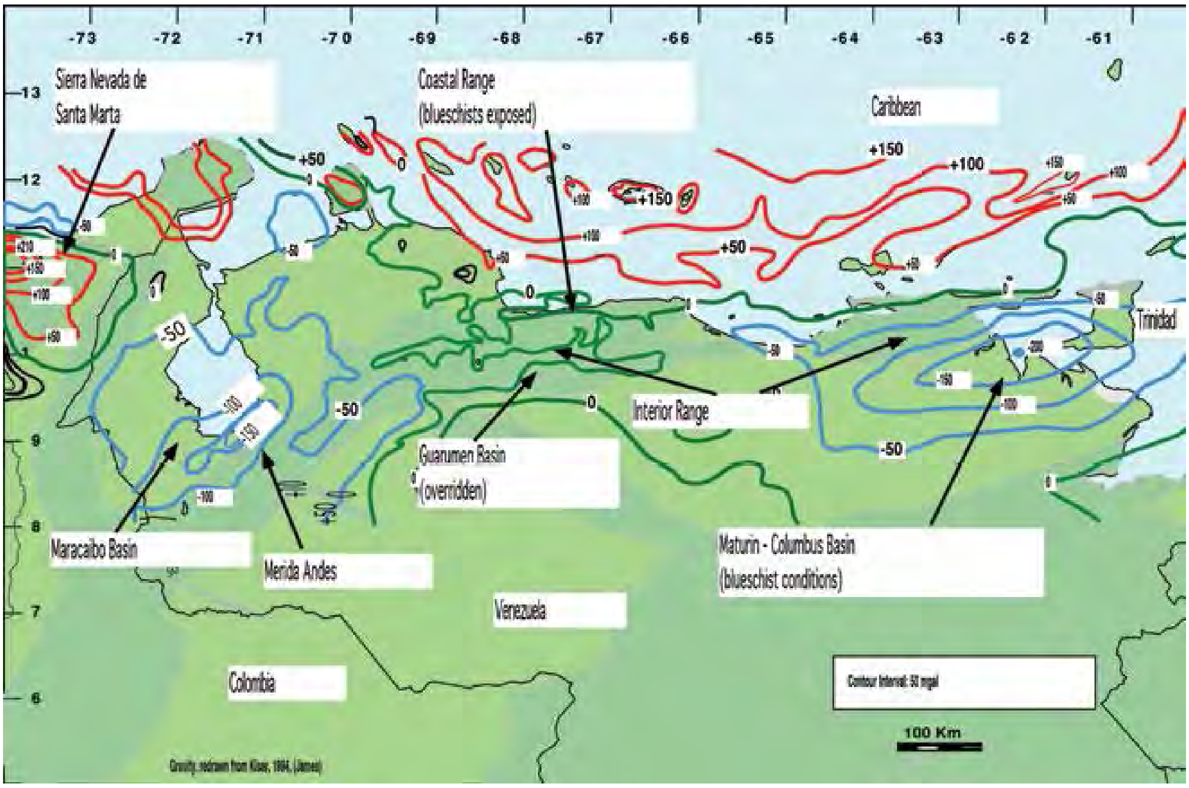


Figure 4. This signature of non-striped submarine crust similar to adjacent Africa and South America suggests subsided, extended continent. Image extracted from the Magnetic Anomaly Map of the World by J.V. Korhonen of the Commission for the Geological Map of the World in Paris.

The 210 milligal positive anomaly over Colombia's 5,800 meter Sierra Nevada de Santa Marta, the world's highest ocean-side mountain, indicates a mountain without a root, overriding the Caribbean.

The Mérida Andes, also strike-slip related, lie halfway over the 150 milligal negative gravity anomaly in the southern Maracaibo Basin – the mountain is arriving over its root. It has already covered the Guarumen Basin and inversion further north exposes blueschists in the Coastal Range. Graphitic rocks record former hydrocarbon systems.

Unlike the Atlantic, the Pacific is markedly asymmetric – the East Pacific Rise (EPR) approaches South America and converges with North America. Magnetic data indicate large areas of extended, subsided continent west of the Rise but none to the east. Yet large amounts of conglomerates/sandstones in the Andes came from the Pacific. Crustal thicknesses here up to 70 kilometer speak of merger.

Since the EPR hit the trench Pacific/ North America strike-slip motion has occurred along the San Andreas Fault.

From Alaska to Mexico the North American Cordillera carries far travelled (hundreds of kilometers) distal/oceanic thrust sheets, detached from subducted Pacific crust to overly Precambrian-Mesozoic shelf sequences.

Extended/thinned continental crust is perhaps easily thrust onto continental margins. Paleozoic and Mesozoic troughs in Peru, with steep western boundaries and gentle eastern slopes, contain 10-12 kilometer thick prisms of shallow deepwater deposits (upward concave SDR reflections possibly indicate basinward velocity decline). Bounding growth faults acted as volcanic conduits. They resonate with those asymmetric basins seen on deepwater seismic.

These "vanished continents" once linked North America, southeast Asia, Australia and South America.

They explain plant and animal fossil distributions.

Obviously, many will disagree. That's fine, discussion is good. But don't overlook those large areas of subsided continent remaining to be recognized. They could carry huge reserves. Someone will eventually lay claim to them. Meanwhile, published PT teaching is complacent. It should adapt to emerging data, include multiple working hypotheses and enable students to think and choose. If not, the writing in stone might eventually read "RIP."

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Searching for the Catastrophe Signal: The Origins of The Intergovernmental Panel on Climate Change Paperback – November 21, 2017

by Bernie Lewin (Author)

Available from Amazon. https://www.amazon.com/Searching-Catastrophe-Signal-Origins-Intergovernmental/dp/0993118992/ref=sr_1_1?s=books&ie=UTF8&qid=1516221935&sr=1-1&keywords=searching+for+the+catastrophe+signal . Paper back, U$16.00; Kindle, U$7.34

In 1973, excited by the first Earthday, I received a research assistantship to study human impacts on weather and climate. I enrolled in what I believe to be the first course in climate change taught in the US. One of the instructors was a new PhD. Roger Pielke. We covered the effect on weather and climate of changes to the albedo and heat capacity of the earth surface and the effect of aerosols. What about CO2 and the greenhouse effect? One of the instructors dismissed them with a calculation showing that if all the coal known were burned, we would get a temperature rise less than 1 degree Kelvin.

There was little money at the time to pursue this, so I went on to other things. Later, in the 80's and 90's, when climate change became a hot topic, I was thinking about returning to climate change. After many inquieries, it became apparent that the only effect being funded was global warming (not changes in regional temperature or extremes in temperature change, etc.) What I was reading in the recent research baffled me. It contradicted everything I knew up until then.

In 1991, a student brought me a handful of recent papers by Michael Mann and Phil Jones, debunking the role of land use and land cover in climate change. I couldn't believe they were published. It was obvious that they were working toward an answer. I then started looking at what was happening a lot closer. I formed my own opinion about the motivation of these and other researchers.

Years later, after green house effect morphed into global warming and then to climate change, everyone had an opinion on it; but it didn't seem that many agreed with me. So I am more than happy that Bernie Lewin wrote "Searching for the catastrophic signal .... ". What he describes is what I lived through. In short, many but not all researchers were working toward a cause that would lead to a particular solution that would benefit a particular industry. I reccommend the book without reservation.

Martin Kokus
martinkokus@yahoo.com