The Geology of Whales

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David Leveson once wrote that "with the geologist lies the special responsibility and opportunity of revealing the earth in all its beauty and power." An awesome task indeed, rivaled only by the geologist's fortitude in accepting it. Puzzling solemnly and enthusiastically over their charge – that is, to piece together the story of our planet --- these rock-hounds manage somehow to glean an entire history from disparate minutiae, obscure fragments, and ambiguous traces of the earth's tarnished and broken record. And from their meager evidence they compose an epic drama. They are masters of coherence. They turn science into storytelling. As a result, their field represents one of the more eclectic and peculiar branches of natural history.

If there is any other scientific group that faces a similarly lofty charge, or an equally daunting subject, it would have to be the cetologists: the whale scientists. What geologists do for the "beauty and power" of the earth, cetologists must do for its life. They study animals that are at the surface less than ten percent of the time. And when they *are* at the surface, only about ten percent of their bodies is visible. Do the math: 99% of the whales' lives remain an inevitable mystery. Like geologists, whale scientists are reconstructing a natural history based on the few, patchy, discontinuous, and surface-deep records to which they have access.

As a result of these challenges, studies in both fields are often plagued with data deficiencies, forced into conjecture, and even accused, on occasion, of pseudo-science. Geology is too speculative, cetology too sexy, the field work for both too much fun. Authority in these fields is based too much on the bronze of one's tan, not enough on the immaculate press of one's lab coat. And yet their most robust sampling methods are often deemed too distant, too remote, and too entrenched in theoretical modelling to be of serious significance. It seems both fields fall inexorably on either side of the scientific standard, for many of the same reasons.

But the bonds of their connection -- this curious union between geology and cetology -- go much deeper than shared methodological adversity. Its roots extend throughout every facet of the two disciplines, deep into every joint and movement of their subjects, down to the very bedrock, as abyssal as a sperm whale's dive. More extensive than we care to admit, it is a vast and underrated kinship. It is time someone called attention to it. So. Preliminary investigations into The Geology of Whales:

To begin, consider a curious pattern: Think of the best places in the world for watching whales, and chances are there's some cool geology nearby.

Take, for example, the primo place in the continental United States to see humpback whales, the tip of New England's Cape Cod. Look underwater, and you will see why: a massive, isolated plateau, known as Stellwagen bank, sculpted by glaciers and meltwater erosion from Pleistocene ice ages.

The pattern holds for most whale-watching hotspots. One of the best places to see sperm whales is off the coast of Kaikoura, a hamlet on New Zealand's South Island. It is no coincidence that Kaikoura sits atop a massive triple-fault system, or that a transverse fault along it brings a mile-deep canyon right up to Kaikoura's beach.

Using this correlation, areas of active whale research can serve as indicators of geologic anomaly. Look to the world's premiere localities for blue whales studies, and the connection becomes obvious: close at hand, always, is a glacier, trench, or volcano. Or stake out the migratory thoroughfares of any large whale, and you'll find yourself at a subduction arc, rift valley, or coastal fault zone.

The pattern is so extensive that it spills out of the oceans: the river dolphins all live high upstream in the fluvial outflows of the earth's largest mountain chains – the Amazonian drainage of the Andes, the Indian and Pakistani rivers fed by the Himalayas, and the Chinese drainages of the same orogeny.

It spills, even, back into the depths of time. The major radiations in the history of cetaceans coincide with hallmarks of the tectonic record: from the early Cenozoic's itinerant closures of the Tethys Sea, as ancestral archaeocetes on its shores were first getting their feet wet, to the break up of Gondwana and the establishment of Antarctica's circumpolar current, just as the whale's lineage broke up as well, fissuring into its two suborders (toothed and baleen whales). It is a deep, profound partnership, a history of camaraderie preserved in the annals of the fossils and strata, in the distribution and diversity of modern whales.

Or work the other way. Think of any geologic anomaly in the world's oceans, and you can bet there is a population of whales close at hand. Look to the areas of the world where geologic processes are at their most dynamic and ostentatious: the subduction zones of tectonic plate boundaries, the arcs and seamounts of active volcanoes, or the zones of recent or ongoing glaciation. In all these geologic palimpsests, whales are there, lurking.

Again, the humpback serves as a prime example. Each year, all over the world, humpback whales migrate remarkable distances between geologic showcases. In the abundance of summer, when it is time to feed, they are attending the geologic marvels of higher latitudes – the fjords, ice sheets, and reclusive polar basins. In the sterility of winter, they return to their tropical breeding waters among the volcanoes and seamounts. From geologic monument to geologic monument, and back again. Rocks. Whales. It is a partnership that spans ocean basins and transcends deep time. A geoleviathanic phenomenon.

Clearly, there is something going on here. Everywhere we turn, stone and cetacean seem indelibly linked, as if the earth's biggest forces were magnetically attrracted. For me, it was not until two enlightening research seasons, on two fjorded coasts a hemisphere apart, that The Geology of Whales became grave and apparent, a story worth telling.

Each summer, deep within the fjords of British Columbia's glacier-gouged coast, hungry humpback whales are present in remarkable, outlandish concentrations. Using the notorious spectacle of bubble-net feeding, groups of ten or more band together to break their migratory fast. And they are not alone. Fin whales and orca take advantage of this region's geology as well, riding tides through its steep-walled chutes of granite and taking sanctuary in its labyrinthine corridors, all scars of a thoroughly glacial past.

Of all the world's many geologic clues for where to find whales, perhaps the most promising is the world's fjord systems. These U-shaped, submerged valleys are known as some of the most majestic, breathtaking places on earth. And even within these breathtaking glacial troughs, here too will you find whales, often in surprising numbers.

Accordingly, one of the best places on the coast to witness this spectacle is Caamano Sound, a vast, remote, and beautiful expanse in the heart of the Gitga'at First Nation. It lies at the crossroads of several fjord valleys, whose glaciers all converged here and plowed out into the open Pacific as a single "super-glacier". If we could drain Caamano Sound, we would see a magnificent amphitheatre of hanging valleys, a deep-water Yosemite, each funnelling, upwelling, and mixing nutrients into a giant, bio-productive cauldron, each summer attracting herring by the millions. The perfect recipe for attracting whales: a steaming, teeming humpback's brew. A manifestation, dramatic and jaw-dropping, of The Geology of Whales.

But wait -- couldn't I argue the same point for any faction of Earth's biota? After all, geology is the literal bedrock of all life, the groundwork for all natural history, be it whale, person, plant, or bacteria. Ecologically speaking, the connection between rocks and whales is not even that direct. There are several tiers of intermediate steps. Geologically sculpted seafloor features divert currents, which leads to nutrient mixing, which leads to spikes in primary productivity. These blooms become the foundation of marine food webs. Miniscule invertebrates and fish thrive on the planktonic harvest, and whales, among others, thrive on them. It appears that the ecological roadmap of The Geology of Whales -- from geologic hotspots, to productivity hotspots, and finally, at long last, to whale hotspots – could apply to most any species. In fact for some, like krill, there are far fewer degrees of separation. Yes, there is some truth to all that, I must admit. Although I maintain that the myriad examples mentioned above make the whale a special case, I must concede that this objection holds some merit. So why dwell on whales? Why preoccupy ourselves with *their* geologic affiliations? Why not krill, person, or plant?

The reason became glaringly obvious to me – gloriously obvious -- during my season in Chilean Patagonia. The revelation came not through the particulars of the study area (though it was both glaciated and cradled by two subduction zones), but as a result of the study's subject: the blue whale.

Think, for a moment, about the largest animal ever to have lived. She weighs as much as a town of two thousand people. Every day, she eats more than a ton of food. Her heart, which is the size of a Volkswagen Beetle (that's two tons), pumps sixty gallons of blood per beat. A child could swim through her central arteries. The surface of her tongue is sixty-four square feet in area, and weighs over two tons! Her tongue! This is what the blue whale does to the human mind, gets it figuring in tons and towns, automobiles and synecdoche, but all to no avail. Even with such illustrative measurements, little can be done to convey such scale.

The very same, it turns out, can be said for the geological forces that govern this planet. Geologists also grapple day-to-day with the unfathomable. In both fields, numbers fail to convey the vastness of their subjects. Attempting to comprehend either the scale of the blue whale or that of geologic time both result in the same awestruck paralysis. For our meager minds, it is all just too big to mean anything.

Geologists and cetologists are both engrossed in nature's superlatives. The former is concerned with its most destructive, eruptive, unyielding, and transformative forces. As living, breathing hyperboles, cetaceans are superlative in a similar sense. Whales are the geologic analogs of the biosphere. Their breath is a volcanic eruption. Their calls are as deep and ominous as mid-ocean earthquakes. Many writers have cut right to the chase and described whales as landmasses. Dan Bartolloti even referred to the blue whale as the "Everest of Whales."

Seeing her in person and up close is all one needs to get it. The waves that break along her mottled, blue shores give the whale a geographical aspect. There are not pictures of blue whales, only maps. Geology and whales, *Lithos* and *Cetus*, polarized ultimacies, the *alpha* and the *omega* of natural history.

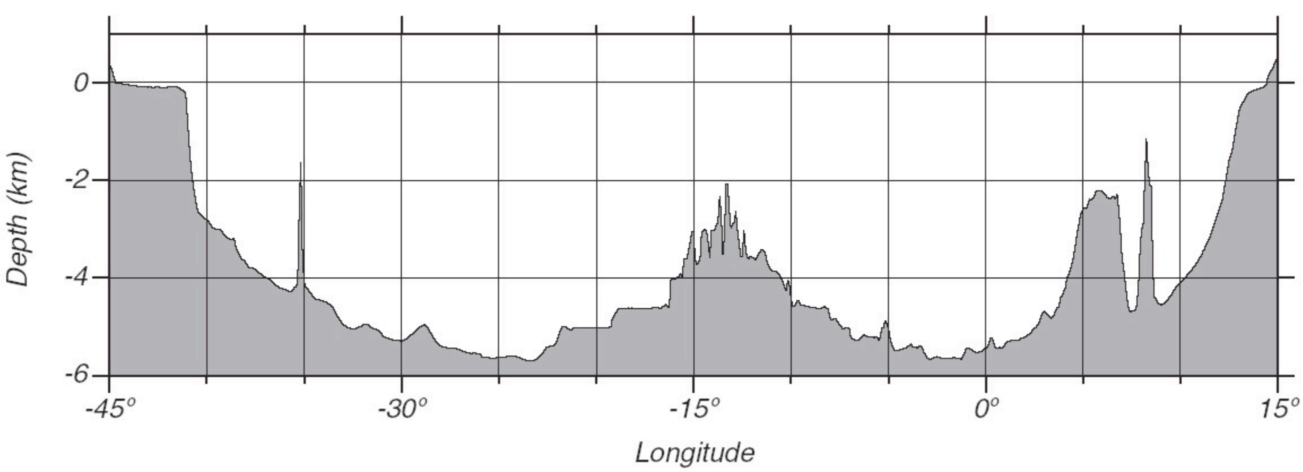
So yes, there *is* something geological about the whale, even if the ecological connection between the two is not the most intimate. This is because such estrangement is easily overcome by just how far *beyond* ecology their convergence goes. After all, human meaning and fancy are not incorporated into ecology's equations, and that is precisely where the connection is strongest. It is the whale *as an idea* that trembles our world, quakes our foundations, fissures our worldview, and cuts to our core. And it is there, in the realm of human curiosity, that the two are inextricably entwined.

Rocks. Whales. Big, glaring question marks. There is an alarming amount about the earth and its whales that we may never understand, so much that is so hard to learn. But this is as exciting as it is daunting, for wherever there is mystery, you are bound to find discovery. Just as wherever there are geologic marvels, you are bound to find whales.

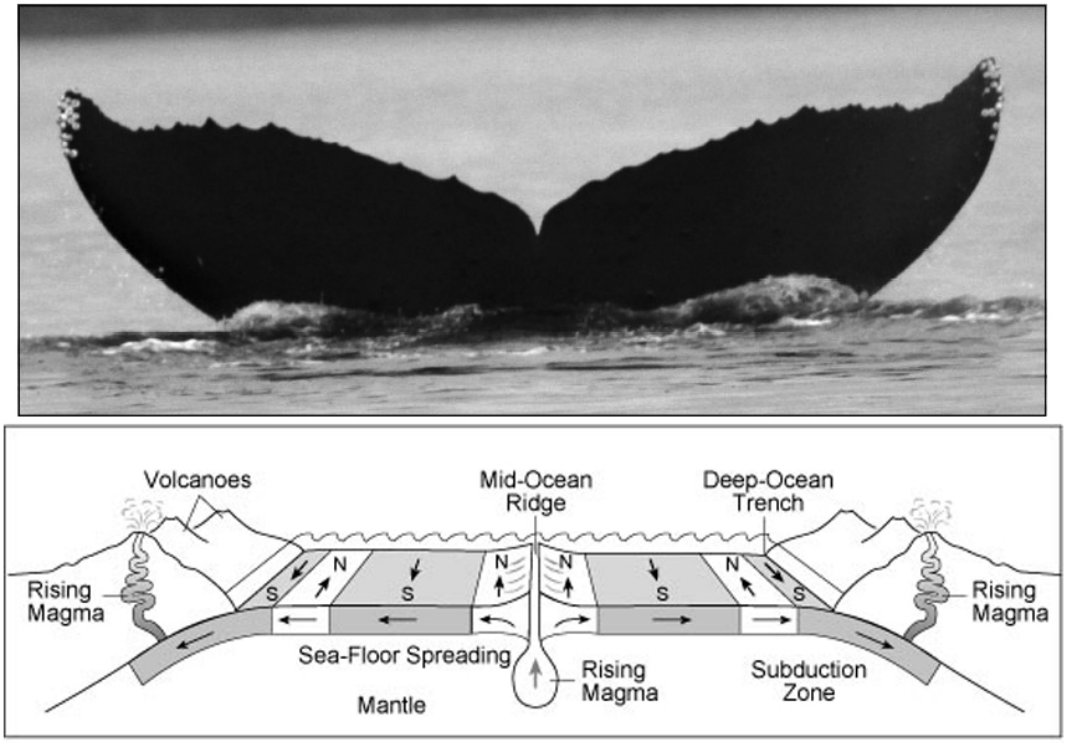
Both branches of science are trying to bring coherence to subjects that, by their very nature, lie well beyond our comprehension. You have to hand it to those that grapple with such daunting unknowns. In their endeavor, they remind us that there must always remain a place in the scientific process for imagination, for adventure, and -- above all -- for wonder.

Words: 1,960

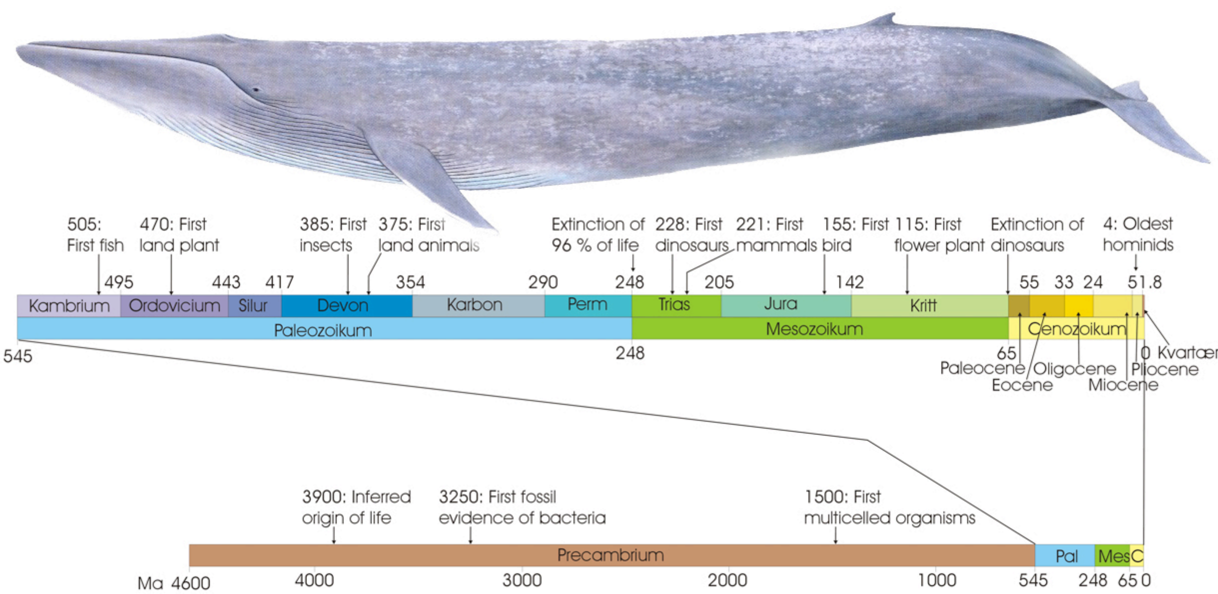
Figures



1. A Geoleviathanic Phenomenon: The compressed scale of this cross-section of the South Atlantic basin illustrates just how varied ocean topography is: mid-ocean ridges, sea mounts, basins, ranges, slopes, shelves, etc. And it is to such remarkable seafloor features that whales gravitate and congregate. From Robert Stewart's *Introduction to Physical Oceanography*, 2008.



2. The geology of whales: Even their body parts, like the fluke of this humpback whale, are corporeal manifestations of geologic principles – monstrous diagrams of our dynamic earth. Photograph by Janie Wray, *North Coast Cetacean Society*, 2009.



3. "Attempting to comprehend either the scale of the blue whale or that of geologic time both result in the same awestruck paralysis." Blue whale illustration by Jorge Ruiz, of *Centro Ballena Azul*, Chile. Time scale by Bjarne Rafaelsen, 2003.