Tracers in the Sea Now and Then

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Very few books ever shaped the core concepts of an entire community the way *Tracers in the Sea* by Broecker and Peng did. The understanding of ocean chemistry, water-column and sedimentary processes, and interactions between ocean and atmosphere, was completely and quantitatively overhauled when a textbook that would train generations of oceanographers went to the Lamont press. I will try to modestly follow Broecker's path and apply his approach to the terrestrial waterworld which covered the surface of our planet until the Great Oxygenation Event at 2.4 Ga. The modern thermohaline circulation, Broecker's conveyor belt, is made possible by the dominantly meridional trend of continents in the Atlantic. In contrast, geological evidence and Sr isotopes in carbonates indicate that pre-GOE subaerial expanses represented only a small fraction of the modern surface area of continents. The submarine character of most continents imposed a dominantly zonal circulation regime, with vertical mixing achieved by wind friction and internal gravity waves. Inorganic precipitation of magnetite from Fe(II)-rich seawater as Banded Iron Formations entails that CO_2 was the major electron acceptor and that CH_4 was the dominant form of atmospheric carbon. Ocean chemistry was tightly controlled by mid-ocean ridge hydrothermal activity and alkalinity regulated by the fate of dissolved Fe(II). The role played today by carbonate precipitation was assumed back then by iron oxides. Biological activity was severely limited by the lack of phosphorus sources and confined to scant shorelines. The atmospheric haze formed by methane photochemistry under oxygen-free conditions partially condensed as broad oil slicks at the surface of the ocean leaving only the shoreline free for carbonate precipitation. Although the pre-GOE ocean-atmosphere system may have shared many features with modern Titan, the role of liquid water remains what made Earth's evolution unique and the emergence of life possible.