



The geochemistry of Oceanic Anoxic Events:

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Oceanic Anoxic Events (OAEs) record profound changes in the climatic and palaeoceanographic state of the planet and represent major disturbances in the global carbon cycle. OAEs that manifestly caused major chemical change in the Mesozoic Ocean include those of the early Toarcian (Posidonienschiefer Event, T-OAE, ~183Ma), early Aptian (Selli Event, OAE 1a, ~120Ma), early Albian (Paquier Event, OAE 1b, ~111Ma) and Cenomanian–Turonian (Bonarelli Event, C/T OAE, OAE 2, ~93Ma). Currently available data suggest that the major forcing function behind OAEs was an abrupt rise in temperature, induced by rapid influx of CO₂ into the atmosphere from volcanogenic and/or methanogenic sources. Global warming was accompanied by an accelerated hydrological cycle, increased continental weathering, enhanced nutrient discharge to oceans and lakes, intensified upwelling, and an increase in organic productivity transmitted to the sedimentary record as black shales. An increase in continental weathering is typically recorded by transient increases in the seawater values of ⁸⁷Sr/⁸⁶Sr and ¹⁸⁷O/¹⁸⁸O ratios acting against, in the case of the Cenomanian-Turonian and early Aptian OAEs, a longer term trend to less radiogenic values. This latter trend indicates that hydrothermally and volcanically sourced nutrients may also have stimulated local increases in organic productivity.

Increased flux of organic matter favoured intense oxygen demand in the water column, as well as increased rates of marine and lacustrine carbon burial. Particularly in those restricted oceans and seaways where density stratification was favoured by palaeogeography and significant fluvial input, conditions could readily evolve from poorly oxygenated to anoxic and ultimately euxinic (i.e sulphidic), this latter state being geochemically the most significant. The progressive evolution in redox conditions through phases of denitrification/anammox, through to sulphate reduction accompanied by water-column precipitation of pyrite framboids, resulted in fractionation of many isotope systems (e.g., N, S, Fe, Mo) and mobilization and incorporation of certain trace elements into carbonates, sulphides and organic matter. Sequestration of CO₂ in organic-rich black shales and by reaction with silicate rocks exposed on continents would ultimately restore climatic equilibrium, but at the expense of massive chemical change in the oceans and over timescales of tens to hundreds of thousands of years.