
Chemostratigraphy: Potential and Limitations

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Abstract

Sedimentary geochemistry has long been used to understand the paleoenvironmental conditions during deposition. Since the late 1980s, stratigraphic geochemical variations have increasingly been applied to define specific geochronological or lithostratigraphic boundaries and since then have become a powerful stratigraphic tool.

Carbon isotopes measured on marine whole-rock carbonates have been shown to have the greatest potential for chemostratigraphic correlation, especially when recrystallisation and cementation have occurred in a closed diagenetic system (e.g. micritic carbonates). However, remineralisation of sedimentary organic carbon during diagenetic stabilisation can add isotopically light carbon (open system) and thus obscure the primary signal. The carbon isotopic composition of sedimentary organic carbon can be used as a complementary proxy, especially in carbonate-poor successions, but the taxon-specific and $p\text{CO}_2$ -dependent carbon isotope fractionation during photosynthesis and admixture of isotopically heavier terrestrial organic carbon can complicate the correlation with inorganic carbon isotope records. Records from epeiric seas may differ in absolute carbon isotope values and amplitudes of isotope excursions when compared to more open marine records (aquafacies). However, the relative changes in carbon isotope values generally allow chemostratigraphic correlations to be made between sections from different environments.

Strontium and oxygen isotopes are more sensitive to diagenetic resetting and should only be measured on pristine carbonate shells or biogenic apatite. Sr has a long ocean residence time of ~ 2.4 Ma, so Sr isotope records are of limited use for high-resolution stratigraphy (10 - 100 kyr), but long-term variations in the Sr isotope record can be used for both stratigraphic correlation and dating. Instead, oxygen isotopes, which reflect changes in seawater temperature and global ice volume are a prime tool for high-resolution chemostratigraphy (e.g. Pleistocene benthic foraminiferal oxygen isotope record). In deep time, the use of oxygen isotopes measured on shallow-water fossil remains appears to be problematic because local sea surface water temperatures and salinities will result in spatial and latitudinal differences in oxygen isotope values. Nevertheless, oxygen isotopes are a useful chemostratigraphic tool during periods of global climate change.

Uranium isotopes in marine carbonates represent a new proxy for average global-ocean paleoredox conditions with secular variations in carbonate $^{238}\text{U}/^{235}\text{U}$ being interpreted in terms of changing proportions of anoxic versus oxic sinks for seawater U. A promising and newly developed indicator of ancient global weathering rates is represented by lithium isotopes derived from sedimentary carbonates. Due to the long residence time of both U and Li in the ocean, the ocean is well mixed in its uranium and lithium isotopic composition. Both

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proxies therefore have potential for chemostratigraphic correlation.

Carbon and oxygen isotopes have so far been successfully used for high-resolution correlation in Phanerozoic marine successions, whereas the relatively new proxies such as uranium and lithium isotopes have only been reported for specific time intervals. Proxy records used for chemostratigraphy must be calibrated by bio- or magnetostratigraphy and, importantly, checked for diagenetic overprinting. Trends or excursions in the geochemical signals should be documented by continuously increasing and/or decreasing values. Correlations of single data point excursions (wiggle matching) are not meaningful and need to be corroborated by additional analyses of samples collected at higher resolution.

Keywords: Chemostratigraphy, carbon isotopes, strontium isotopes, oxygen isotopes