$^{87}Sr/^{86}Sr$, $\delta^{13}C$ and $\delta^{18}O$ evolution of Phanerozoic oceans

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A total of 2117 calcitic and phosphatic shells, mainly brachiopods with some conodonts and belemnites, were measured for their $\delta^{18}O$, $\delta^{13}C$ and $^{87}Sr/^{86}Sr$ values. The data set covers the Cambrian to Cretaceous time interval. Where possible, these samples were collected at high temporal resolution, up to 0.7 Ma (1 biozone), from the stratotype sections of all continents but Antarctica and from many sedimentary basins. Palaeogeographically, the samples are mostly from palaeotropical domains. The SEM, petrography, cathodoluminescence and trace element results of the studied calcitic shells and the CAI data of the phosphatic shells are consistent with an excellent preservation of the ultrastructure of the analysed material. These datasets are complemented by extensive literature compilations of isotope data for analogous skeletons.

The oxygen isotope signal exhibits a long-term increase of $\delta^{18}O$ from a mean value of about -8 ‰ (PDB) in the Cambrian to a present mean value of about 0 ‰ (PDB). Superimposed on the general trend are shorter term oscillations with their apexes coincident with cold episodes and glaciations. The carbon isotope signal shows a similar climb during the Palaeozoic, an inflexion in the Permian, followed by a sudden drop and subsequent fluctuations around the modern value. The $^{87}Sr/^{86}Sr$ ratios differ from the earlier published curves in their greater detail and in less dispersion of the data.

The means of the observed isotope signals for $^{87}Sr/^{86}Sr$, $\delta^{18}O$, $\delta^{13}C$ and the less complete $\delta^{34}S$ (sulphate) are strongly interrelated at any geologically reasonable (1 to 40 Ma) time resolution. All correlations are valid at the 95 % level of confidence, with most valid at the 99 % level. Factor analysis indicates that the $^{87}Sr/^{86}Sr$, $\delta^{18}O$, $\delta^{13}C$ and $\delta^{34}S$ isotope systems are driven by three factors. The first factor links oxygen and strontium isotopic evolution and the second one $^{87}Sr/^{86}Sr$ and $\delta^{34}S$. These two factors explain up to 63 % of the total variance. The last factor weakly links the carbon and sulphur isotopic evolution. A tentative interpretation identifies the first two factors as tectonic, and the third one as a (biologically mediated) redox linkage of the sulphur and carbon cycles. On geological timescales ($\geqslant$ 1 Ma), we are therefore dealing with a unified exogenic (litho-, hydro-, atmo-, biosphere) system driven by tectonics via its control of (bio)geochemical cycles.

References

http://www-ep.es.llnl.gov/germ/evolution/Veizer/seawater-isotopes.html