Carbon-, sulphur- and strontium-isotope trends of high- and low-latitude Permian brachiopods

C. KORTE[1]*, U. BRAND[2], H. STRAUSS[3] AND J. VEIZER[4]

[1]Institut für Geologische Wissenschaften, Freie Universität Berlin, Malteserstr. 74-100, 12249 Berlin, Germany (*correspondence: korte@zedat.fu-berlin.de)
[2]Department of Earth Sciences, Brock University, St. Catharines, Ontario L2S 3A1, Canada
[3]Geologisch-Paläontologisches Institut, Universität Münster, Corrensstrasse 24, 48149 Münster, Germany
[4]Ottawa-Carleton Geoscience Centre, University of Ottawa, Ottawa, Ontario K1N 6N5, Canada

Calcareous shells of articulate brachiopods are frequently utilised to decode variations in carbon, sulphur and strontium isotope values of Phanerozoic seawater [1, 2]. New $\delta^{13}C$, $\delta^{34}S$ and $^{87}Sr/^{86}Sr$ results from extensively screened high-latitude Australian Permian brachiopods were used to generate improved low- [1-4] and high-latitude [5] datasets. High-latitude $\delta^{13}C$ values vary for most of the Permian between 3 and 5 ‰ confirming the general low-latitude trend. For the high-latitudes a distinct positive $\delta^{13}C$ excursion up to 8 ‰ occurs during the late Kungurian, a critical time interval with sparse low-latitude data. This positive shift is slightly later than a positive $\delta^{18}O$ excursion recently interpreted as a cooling episode [6]. The $^{87}Sr/^{86}Sr$ of both high- and low-latitudes show similar trends with high values of up to 0.7082 in the lowermost Permian followed by a gradual decrease below 0.7067 during the middle Capitanian and a slight rise in the Late Permian to values of 0.7072. Most of the high- and low-latitude sulphate sulphur isotopes of Early, Middle and early Late Permian brachiopods vary between 11 and 13 ‰. For the higher part of the Late Permian bulk rock $\delta^{34}S$ data from micritic carbonates [7] show an increasing trend to values of 18 ‰ at the P–Tr boundary; suggesting increased sulphate reduction. This reduction effect might be triggered (1) by enhanced nutrient supply due to continental weathering (supported by $^{87}Sr/^{86}Sr$) or, more likely, (2) by upwelling of anoxic deep oceans waters.

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Chemical fluxes and heat fluxes at mid-ocean ridge hydrothermal systems: Temporal and spatial variability and approaches of quantification

ANDREA KOSCHINSKY

Jacobs University Bremen, School of Engineering and Science, D-28759 Bremen, Germany (a.koschinsky@jacobs-university.de)

Along seafloor spreading axes, seawater circulates through oceanic crust, cooling and altering the crust and exchanging with it chemically [1]. Hydrothermal fluids produced at ridge axes have high temperatures of up to >400°C and are chemically significantly altered when they re-enter the oceanic water column compared to ambient seawater. On ridge flanks, these processes place at much lower temperatures. Although the overall flux from off-axis sites can be significant, much less is known so far about their contribution to global hydrothermal fluxes.

Understanding how energy and mass fluxes by hydrothermal circulation take place is important because it enables us to estimate geochemical mass fluxes between the oceanic crust and the ocean, and how they influence the composition of the seawater and the formation of hydrothermal deposits around vent sites. Fluxes from the crust into the ocean via hydrothermal plumes vary on different time scales and spatial scales. Differences between vent sites at different locations are mostly related to the type of country rock, water depth and temperature. Significant long-term changes of fluxes are related to the temporal variability of the fluid emanations, which themselves are driven by changes in volcanic and magmatic activity.

Quantification of heat and material fluxes requires knowledge on distribution of hydrothermal vent systems, the specific compositions of their fluids, and flux rates. While fluid sampling and *in situ* measurements of physico-chemical parameters allow for short-term records of these systems, other proxies may serve to estimate fluxes on intermediate to longer time-scales. Hydrothermal precipitates record fluxes and temporal changes over the lifetime of the hydrothermal systems, while hydrothermal fauna such as mussels may be useful proxies for elemental fluxes in diffuse-flow areas. Modelling tools allow to extrapolate measured data in both space and time. Examples will be shown from the German SPP 1144 program on the Mid-Atlantic Ridge, during which different approaches have been used.

[1] German & Von Damm (2003) in: *Treatise on Geochemistry* (Turekian & Holland, eds.), Vol. **6**, 181-222.