Combining palaeontological and geochemical data to reconstruct environmental gradients, a case study from the Jurassic Sundance Seaway

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Environmental gradients are among the primary drivers of change in ecological communities through time and space. However, what is rare are combined data sets of community composition and the environmental factors that may have caused ecological turnover, largely because many environmental variables are difficult to measure in the stratigraphic record. In this study we integrate quantitative abundance estimates of benthic macroinvertebrates with a multivariate dataset of geochemical proxies to potentially estimate the environmental drivers of faunal change through the 13 m.y. history of the Middle–Late Jurassic Sundance Seaway, western United States.

Faunal counts of macroinvertebrates were obtained from marine rocks of the Gypsum Spring, Sundance and Twin Creek formations at 19 localities in Wyoming, Montana and South Dakota. From the same localities, calcitic shells of selected species (Gryphaea planoconvexa, Gryphaea nebrascensis, Gryphaea sp., Liostraea strigilecula, Deltoideum sp.), were analysed for stable isotope (carbon and oxygen) and elemental (Mg/Ca, Sr/Ca, Na/Ca, Ba/Ca) geochemistry. The studied interval was subdivided into seven third-order depositional sequences representing carbonate ramp, wave-dominated, siliciclastic shelf, siliciclastic tidal coast, and mixed evaporite-siliciclastic desert systems. Of these, five depositional sequences were fossiliferous.

Ordination plots (nMDS) of the two palaeoecological and geochemical datasets are very similar (procrustes correlation: 0.75, p: 0.0001). Vector fitting of geochemical data on the palaeoecological ordination shows that a main faunal turnover event, corresponding to the shift from carbonate to siliciclastic deposition at the Middle–Late Jurassic transition, correlates with an increase in productivity (increase of δ¹³C) and a decrease in temperature (decrease of Mg/Ca ratio) through time. Position of fauna in the seaway (craton vs. foredeep) correlates instead with variations of δ¹⁸O and Ba/Ca ratio, suggesting a strong salinity gradient, with decreasing salinity moving from the craton towards the foredeep. A critical discussion of these results will also include factors that could potentially affect temporal changes of proxy data, such as species-specific vital effects.