Geophysical Research Abstracts
Vol. 17, EGU2015-3579-1, 2015
EGU General Assembly 2015

Strontium and barium incorporation into freshwater bivalve shells

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Despite strong vital control, trace elements of bivalve shells can potentially serve as proxies of environmental change. However, to reconstruct past environments with the geochemical properties of the shells and determine the degree to which the element levels are biologically influenced, it is essential to experimentally determine the relationship between environmental variables and the element composition of the shells. In particular, the trace element geochemistry of freshwater bivalve shells has so far received little attention.

Here, we present a controlled laboratory experiment that aimed at providing a better understanding of the influence of changing environmental variables on the incorporation of trace elements into freshwater bivalve shells. Under controlled conditions, Asian clams *Corbicula fluminea* were reared for 5 weeks in three sets of experiments: (1) different water temperature (10, 16, and 22˚C) and different food levels (an equally mixed *Scenedesmu quadricanda* and *Chlorella vulgaris* at rations of 0.4, 2, 4, and 8×10^4 cells ml^{-1} d^{-1}); (2) different water temperature (10, 16, and 22˚C) and different element levels (Sr, Ba); (3) five sediment types (sand, slightly muddy sand, muddy sand, slightly sandy mud and mud). In the first set of experiments, shell Sr/Ca showed a significantly negative correlation with temperature, where Sr/Ca decreased linearly by about 1.6 to 2.1% per 1˚C, but responded far more weakly to food availability. On the other hand, temperature and food availability affected shell Ba/Ca ratios, which potentially confounds the interpretation of Ba/Ca variations. Moreover, shell Sr/Ca and Ba/Ca exhibited a clearly negative dependence on shells growth rate that varied significantly among combinations of temperature and food availability. In the second set of experiments, shell Sr/Ca and Ba/Ca were positively and linearly related to water Sr/Ca and Ba/Ca for all temperatures. However, significantly negative effects of temperature on shell Sr/Ca and Ba/Ca were also detected. Considering the freshwater element composition is highly variable, great caution should be taken in the interpretation of these proxy data. Specifically, partition coefficients of Sr and Ba were much lower than 1, confirming the existence of strong vital effects on the incorporation of Sr and Ba into shells. However, the influence of sediment on shell Sr/Ca and Ba/Ca can be negligible at 22 ˚C. Levels of these environmental variables manipulated in our study encompassed the broad range of natural conditions that *C. fluminea* may experience in the wild and hence, the data presented here provide a realistic test for validating factors influencing trace element incorporation into shells. Furthermore, our results highlight the potential of shell Sr/Ca of *C. fluminea* shells as a paleothermometer, while the interpretation of shell Ba/Ca must remain very cautious.