Marine Algal Revolution and trace metals: comparing metal acquisition strategies

QIONG ZHANG [1], BRUNO NEVADO[2], JOSEPH T. SNOW[1], DMITRY A. FILATOV[2], ROS E. M. RICKABY[1]

[1]Department of Earth Sciences, University of Oxford, UK
[2] Department of Plant Science, University of Oxford, UK

200 Mya the algal lineages that dominated the open ocean underwent a revolution which had major implications for the entire marine ecosystem. The red algal lineage, previously limited to coastal waters, has took over the open ocean that was dominated by green algae, and at the same time developed abundant mineralisation strategies which led to a major change in ocean chemical buffering. Here we investigate whether different strategies for trace metal acquisition could have contributed to this major shift in the algal community structure of the ocean by systematically identifying metal transporter families. We determine likely metal maintenance strategies for various algal species based on finding the genes of well annotated metal transporters from a number of model organisms in the genome of 27 species of phytoplankton. We also test the strategies phytoplankton utilise when maintaining their metal stoichiometry under differing environments (toxicity vs limitation) with a set of experiments, aiming to link the physiology responses of algae to their element homeostasis stoichiometry. In general, the results show that the green lineages have a more efficient strategy for maintaining metal homeostasis than red lineages, especially for essential elements, so they are generally more tolerant to metal toxicity at high levels. Meanwhile, red lineage phytoplankton have more non-specific metal transporters, which allow them to take up nutrients at higher rates under nutrient limiting conditions and have more interplacement of metal cofactors in metalloproteins. The difference of metal transporters may date back to the endosymbiosis event when red and green lineages first diverged and may be emphasised with the changes of elemental composition in the ocean associated with the changes of redox conditions over geological time. Such differences may relate to the transition from the green to red algae in the open ocean, which occurred at the Paleozoic-Mesozoic period, and may also be related to the distinct distribution of these two lineages of phytoplankton in the modern environment.