ECOLE LEMANIQUE DES SCIENCES DE LA TERRE
DES UNIVERSITES DE GENEVE ET DE LAUSANNE

Redox cycling in archean shales

Contact persons

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Context

Redox processes, those involving exchanges of electrons between different compounds at the surface or within the Earth interior, are essential controls on the evolution of the oxygen cycle on our planet on a variety of timescales. Those processes connect the geological cycles of O, C, Fe, and S. Assessing the net result of redox exchanges between sediment layers, or between rock units, is however challenging. There are two complementary tools that can be used to quantify the redox state of geological material. On the one hand, one may consider assessing the redox potential, that is the ability of a sample to oxidize/reduce another one at a given condition. The redox ''potential'' is a thermodynamic variable, and it informs on whether a sample is ''reducing'', or not, independently of the actual amount of reduced/oxidized elements in the sample. Yet, to quantify redox flows, one needs to quantify the amount of both reductants and oxidants, and how this composition varies over time and space. Over the last years, we have developed a method to quantify the redox capacity of a variety of samples. We propose to apply this technique to assess the redox processes using Proterozoic organic-rich shales from South Africa. Shales serve as precious source of paleoenvironmental information. However, much remains to be done to understand how those rocks formed, and the redox cycling of C, S and Fe during burial.

Aims and Methods

Our goal with this project is to advance our understanding of redox flow between S, Fe and C in a well characterized series of Archean/Proterozoic shales from South Africa. To this end, the student will measure the redox capacity using samples available at UNIL. The student will learn novel laboratory techniques, and will use the data to reconstruct the pathways of oxygen exchanges between S (sulfides, elemental S), C (organic matter) and Fe (sulfides). This work will be complemented by a detailed petrographic study of the redox phases using optical microscopy, as well as Raman and scanning electron microscopy at UNIL. One of the objective is to assess the structural and chemical state of the organic material, determine the details of the redox reactions, and evaluate the reliability of those ancient organic-rich material as paleoenvironmental archive.

The student is expected to have an inclination for rigorous and quantitative laboratory work, but prior experience in laboratory experiments is not necessarily required.

References

Galvez, M. E., & Jaccard, S. L. (2021). Redox capacity of rocks and sediments by high temperature chalcometric titration. Chemical geology, 564, 120016.

Berg, J. S., Michellod, D., Pjevac, P., Martinez-Perez, C., Buckner, C. R., Hach, P. F., ... & Kuypers, M. M. (2016). Intensive cryptic microbial iron cycling in the low iron water column of the meromictic Lake Cadagno. Environmental microbiology, 18(12), 5288-5302.

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Prerequiste Indicate if the student must take some course or module