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

Redox cycling in the Cadagno Lake

Contact persons

Two people (one has to be professor/MER)

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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. This project will seek to quantify redox flows in a spectacular alpine lake.
Lago Cadagno is perched in the Swiss alps, and is unique because the continuous supply of sulfate by rivers draining the neighboring rocks sustains a very active sulfur cycle in the water column and uppermost layers of the underlying sediment. In addition, the lake is highly stratified, leading to very distinctive redox transitions through the water column and sediments. Those transitions have been evidenced so far using a range of isotopic and bulk sediment characterizations.

Aims and Methods

Our goal with this project is to advance our understanding of redox flow considering S, Fe and C in Lago Cadagno. To this end, the student will measure the redox capacity at discrete intervals of the sediment core. The student will learn novel laboratory technics, and will use the data to reconstruct the pathways of oxidant exchanges between S (sulfides, elemental S), C (organic matter) and Fe (sulfides). One of the goal is to determine whether the sediment column can be considered as a closed ''redox'' system, maintaining its overall redox capacity downcore. Alternatively, one may find that the continuous redox reactions between the various redox active phases leads to progressive loss of redox capacity, e.g. through release of light hydrocarbon molecules (CH_4, H_2S) to the pore fluids and to the overlying water. The student will be involved in complementary approaches involving pyrolysis to shed light on the redox dynamics of this unique alpine lake. This lake may also, under certain conditions, serve as a modern analogue for primitive, euxinic conditions of the Proterozoic ocean. The work will therefore have a wide range of implications and provide new understanding on how the ocean may have evolved before the ocean and atmosphere oxygenated.
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