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Sulfur Isotope Chemostratigraphy as a Potential Tool for Correlation in Paleozoic Dolomite
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Narrative Report 2018

Research Progress

Work continued on the diagenetic history of the Upper Ordovician dolostones from the Great Basin and coeval limestones from Anticosti Island. This component of the project advanced in collaboration with Anne-Sophie Crüger Ahm and John Higgins (Princeton University). The team developed a quantitative model of fluid-buffered and rock-buffered diagenesis for the strata based on the elemental and isotopic composition of Ca, Mg, C, O, and Sr. This model is validated by parallel measurements of the modern Bahamas platform. Model results are consistent with the Hirnantian carbon isotope excursion representing changes in $\delta^{13}C$ of aragonite-producing shallow water carbonate platforms, rather than global seawater. These preliminary results were presented at the Geological Society of America's annual meeting in October, 2017 (Figure 1). Ongoing work seeks to incorporate the sulfur isotope record into the numerical model, using $\delta^{34}S$ data from the Ely Springs Dolostone produced in the first two years of the project. We completed sulfur isotope analysis of the Ely Springs Dolostone in the 2017-2018 project year, including measuring isotope ratios of sulfur in pyrite.

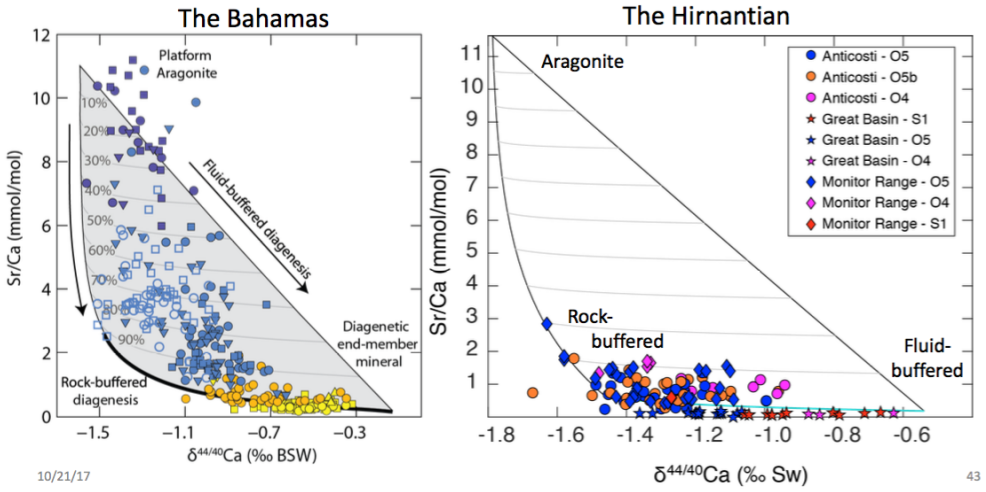

Figure 1. Quantitative model of rock-buffered and fluid-buffered marine diagenesis through the lens of Sr and Ca elemental and isotopic geochemistry. From Ahm et al. (2017).

In parallel, work has advanced on the geochemistry of the Bighorn Dolomite samples collected in summer 2017. This work will be completed during project year 2018-2019.

In order to further constrain the sulfur isotope record of correlative undolomitized rock unit, work proceeded on measurement of sulfur isotope ratios in sulfate from a very high resolution sample set from the west end of Anticosti Island, Quebec. These samples, provided by André Desrochers (University of Ottawa), represent what may be the most complete and stratigraphically expanded succession of Hirnantian carbonate rocks. Using the published carbon isotope curve and biostratigraphy (Achab et al., 2013; Mauviel and Desrochers, 2016) for correlation with our dolostone units from the Great Basin and Bighorn Mountains, we have generated a high-resolution $\delta^{34}S$ record for upper Katian and lower Hirnantian strata. Work continues on the Hirnantian and Llandovery strata and will be complete by the end of the current project year.

Because a key interpretative framework of the sulfur isotope data involves considerations of changing marine redox states, a portion of the work in 2017-2018 focused on a project examining whether sedimentary mercury (Hg) concentrations may be reliable indicators of paleoredox changes. This work, in collaboration with Sara Pruss (Smith College), focuses on a Cambrian interval characterized by a large positive carbon isotope excursion (the SPICE

event), much like in the Hirnantian. By measuring Hg concentration, organic carbon content, and clay mineralogy, we suggest that there are conditions under which redox fluctuations may lead to enhanced sequestration of Hg in the sedimentary rock record. We will submit a manuscript reporting on these results in the 2018-2019 project year.

Another offshoot of the main project has been following up on the Hg data presented in Jones et al. (2017) for Hirnantian strata. In 2018-2018 we began to develop detailed Hg records from Anticosti Island in order to document further the extent of Hirnantian Hg enrichments and test competing hypotheses of volcanism and anoxia as potential causes of the Late Ordovician mass extinction.

Looking forward to the final year of the project, the results will likely be published in the form of two manuscripts. The first will report on the sulfur isotope geochemistry of Hirnantian rocks from the Great Basin and Anticosti Island. This will include some of the discussion of the motivating questions of the project regarding the use of sulfur isotope chemostraigraphy for correlation in dolomitized rocks. The second manuscript will present the Ca and Mg isotope data from the same suite of samples. This manuscript will consider the depositional and diagenetic conditions under which sulfur isotope correlation is possible and attempt to elucidate how we might know that through the quantitative diagenetic model.

Impact on PI

The grant supported the PI for a portion of Summer 2018. The PI was able to retain all three students from the previous year as well as recruit a new cadre of undergraduate students to work on the project for extended periods during the summer and in the academic year. The grant also facilitated collaboration between the PI and five collaborators, David Fike (Washington University in Saint Louis); André Desrochers (University of Ottawa); Sara Pruss (Smith College); and John Higgins and Anne-Sofie Crüger Ahm (both Princeton University).

Impact on Undergraduate Students

During the 2017-2018 academic year, eight students worked in the PI's geochemistry laboratory at Amherst College. Three students who had participated in Summer 2017 field work were involved with preparing samples collected on that trip for carbon, oxygen, and sulfur isotope ratio analysis. These three students took geology courses in both semesters of the 2017-2018 year, and all three declared geology majors in the spring of 2018.

Five new students were recruited to work on the project in 2017-2018. Their work focused mostly on developing new geochemical records from a sample set supplied by André Desrochers (University of Ottawa). These five students participated in a three-week internship in the PIs geochemistry lab, supported by the project. During the internship, students worked individually or in teams of two on aspects of the research project. Two of the students were rising sophomores, and three were rising juniors. The internship involved training in laboratory techniques, graphical presentation of data, reading primary literature, and giving brief oral reports. All five students are continuing project work in the 2018-2019 academic year.

References

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