PRF# 58926-UR8: Testing Links Between Marine Anoxia and Mercury Enrichments During the late Cambrian SPICE Event

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Scientific Progress

The Cambrian Period is characterized by large shifts in the carbon isotopic record of carbonates (Maloof et al., 2005; Smith et al., 2016), beginning at the Proterozoic-Cambrian boundary (e.g., Kirschvink et al.,1991, Amthor et al., 2003). The SPICE event (Steptoean positive isotopic carbon excursion) is perhaps the best known and most studied of the Cambrian excursions (Saltzman et al., 1998; Gill et al. 2011), with much of its initial foundational work happening in sections in the western United States (e.g., Saltzman et al., 2004). Our primary goal in our research was to create parallel carbon isotopes records with mercury abundances (Hg) to see how Hg abundances correspond to the onset, duration and termination of the SPICE excursion.

PI Pruss began work on this project in YR 1 which ran from May 2018 to August 2019. Initially, Pruss and co-authors worked to finish data gathering and analyses from samples collected in Scotland, and that resulted in our first publication from this work (Pruss et al., 2019). In this initial paper, we detail that Hg abundances increase during the SPICE, along with glauconite abundances, but that before and after, Hg abundances are at baseline around zero. This provided an initial set of hypotheses to test by examining other sections of the SPICE.

During our first field season, per my grant proposal, I led 2 field seasons in support of this work. The first was to tackle well-known carbonate-rich sections in the western US that preserve the SPICE event. Our initial plan was to resample the Shingle Pass section in eastern Nevada, and as with all good plans, a few days before we were scheduled to leave for the field, the Shingle Pass region was predicted to receive 10" of snow. In 48 hours, we shifted our entire focus to sections in eastern Utah that also preserve the SPICE event (Lawson's Cove and the House Range). Although this was a change of plans, we were delighted to see different sections reflect the SPICE event within reasonably close proximity, and we sampled both sections at higher resolution than Saltzman et al (1998). In both Lawson's Cove and the House Range, Hg abundances show some fluctuations, but the levels are overall much lower than in Scotland. This suggests that in settings with comparably high sedimentation rates, the Hg may accumulate differently, so our interpretations must incorporate depositional environment.

Our second field excursion was to western Newfoundland to resample the SPICE event documented by Saltzman et al. (2004). Here, we are satisfied that we captured the onset of SPICE but we did not fully capture its return. This might require an additional trip to sample higher in the stratigraphy and fill in this gap. In the meanwhile, we generated Hg abundances for the portion of the section that we have, and Hg abundances tend to be enriched during the onset of SPICE. Taken as a whole, our data suggest that the SPICE event co-occurs with local redox changes that are manifested differently in our various sections around the world. This will be an important contribution to how we interpret Hg in deep time: absent intense volcanism, Hg is likely a reliable proxy for local redox changes.

Impact on PI

This work has been hugely impactful on me because it has enabled me a chance to move into a new area, understanding a poorly understood geochemical proxy, while building a significant new collaboration with D. Jones at Amherst College. He and I worked closely in the writing of the initial SPICE/Hg paper that was published this year (Pruss et al., 2019), and we co-led all field excursions this last summer. As a result, I have furthered my understanding of Hg in sedimentary systems and generated numerous projects for undergraduate students (more on that below). The work has been productive and generative, and I am excited about the additional work we will do with support from this grant.

Impact on Undergraduate Students

In total, 7 students were involved in the field research this summer. Five undergraduate women from Smith were supported in their field work, including 2 students who had just completed their first years, and one student who is from a group underrepresented in Geosciences. Two others accompanied us in the field from Amherst College. These students worked together as a team and collaborated on all aspects of the field collection and further analysis. All of the data were created by undergraduate students. They were involved in every aspect of the work, from the field collection, the cutting and powdering of the rocks, to the analysis of Hg abundances on our in-house Hydra C. Three of these projects are generating semester-long research projects, and 2 of them will turn into theses. The students reflected very positively on their field experiences – from the days-long learning with their professors and peers to the sense of community that happens when people travel and live together. In this way, undergraduate students were incredibly well-served by this grant.

Juliet Ramey-Lariviere, now a sophomore, is continuing work on ooid-rich samples collected this field season. She learned how to measure and sample in the field, and she is excited to continue her work as my STRIDE student at Smith. She is currently enrolled in my Paleo class. Ginny Svec generated all of the data from Lawson's Cove, including cutting,

powdering and measuring the Hg. She is a senior and plans to do 2-semesters worth of work on these samples. She will analyze the TOC and hopefully generate some mineralogical data on our XRD. She is currently a TA for my Paleo class. Amelia Olsen was an incredibly productive student in the field and in the lab. She generated all of the data from the House Range, and she also managed to dissolve all of her samples this summer. She is abroad in the Fall, but she will continue this work for a semester-long special studies and then a thesis in 2020-21. Ashley Rivas, a first-generation college student, originally from Venezuela, took her first trip in the field this summer after spending her first year in my research lab. She excelled in the field, made excellent observations, and worked very hard. Now as a sophomore, she is focusing on Ordovician samples we collected about the SPICE and is now considering pursuing Geosciences as a major. I plan to keep her as a research student in the lab as long as she wants to be here. She is also currently enrolled in my Paleo class. Amy Hagen, a junior, worked on the SPICE samples from western Newfoundland. She generated the carbon isotope profile, the Hg data, and dissolved all of her samples for TOC. She will next work on the XRD to gather mineraological data from her sections. She will be abroad in the Spring but will return to do a thesis in 2020-21, pairing with Amelia in this work. She is also a TA for my Paleo class.

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Products to date:

Pruss, S. B., Jones, D. S., Fike, D. A., Tosca, N. J., and Wignall, P. B., 2019, Marine anoxia and sedimentary mercury enrichments during the Late Cambrian SPICE event in northern Scotland, Geology, v. 47 (5): 475-478.

Pruss, S. B., Jones, D. S., Fike, D. A., Tosca, N. J., Wignall, P. B., and Faggetter, L., 2018, Does marine anoxia explain Hg enrichments during the SPICE event? New evidence from the Cambro-Ordovician Durness Group, northern Scotland, Keynote lecture, AGU Fall Meeting, Washington D.C.