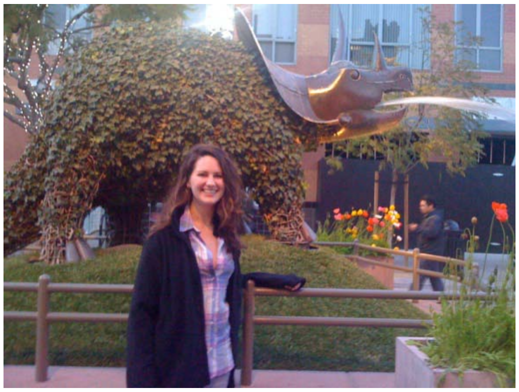

Emily Wooton is a Ph.D. student at The University of California-Riverside and is interested in resolving problems of community restructuring and environmental perturbation during the Late Devonian Mass Extinction events, the most enigmatic series of biotic crises of the “Big 5” Phanerozoic mass extinctions. Her advisor is Dr. Mary Droser.

One of the five largest biodiversity crises in Earth’s history occurred at the Frasnian-Famennian (F-F) boundary in the Late Devonian period, around 367 Ma. This extinction is thought to be a series of stepwise events, broadly the Kellwasser events, which eliminated more than half of all genera (Sepkoski 1986, Jablonski 1991). While the crisis was undeniably global, it disproportionately affected the biota of the tropics and shallow seas, and the faunal turnover strongly impacted the reef ecology of the Devonian world (McGhee 1996). The Late Devonian Mass Extinction was also fundamentally different from the other mass extinctions in that all higher-level taxonomic groups recovered after the extinction pulse, but marine communities, especially reefs, underwent a complete ecological restructuring. The F-F boundary is characterized in the geologic record by ubiquitous sequences of black shale, a sedimentary facies indicative of anoxic or dysaerobic conditions. Evidence of anoxia is common throughout the geologic record, however, and anoxic conditions alone are unlikely to be able to fully account for the extinction.

The potential causes for the extinction event range from the bolide impact hypothesis (McLaren 1970) to climate change triggered by a combination of tectonic, sea level, and productivity cycles (Fischer 1977, Johnson 1974, Buggisch 1991). Though it is clear that environmental perturbation is key to this crisis, the breadth of postulated causes indicates how little we understand the actual extinction mechanisms and highlights the need for the collection of data of new types and at a new scale, specifically investigating the nature of the characteristic low oxygen facies.

The purpose of my project is to correlate biomarkers, trace fossils, and body fossils to provide a more accurate reconstruction of the Late Devonian environment (with respect to oxygen, initially) in order to constrain possible causes of the mass extinction. To this end, I will conduct extensive microstratigraphic analyses at Frasnian-Famennian boundary locations, beginning at black shale locations that typify Late Devonian successions. My study will differ from those previously-conducted on the late Devonian because 1) I will be collecting integrated sedimentological, paleontological and geochemical data on a millimeter to centimeter scale, which is necessary for revealing environmental changes up to and through the mass extinction horizon, and 2) I will be collecting and analyzing geochemical data, specifically biomarkers, that have not previously been applied to such an environmental investigation.

I will begin this summer in central and western New York State by examining paleo-oxygen tracers in well-exposed black shale units. I will strive to illuminate the extent of the impact of anoxia/euxinia as a contributor to the Devonian biotic crises by logging and correlating high-resolution chemo- and bio-stratigraphic evidence of a variety of data, from paleobiology (body fossils), paleoecology (ichnofabrics), isotope geochemistry, and molecular geobiology (lipid biomarkers). Biomarkers, in particular, provide insight into the nature of anoxia like no other tracer, because they can detect the influence of primary producers through lipid molecular fossils, and consequently identify periods of euxinia. A robust biomarker study is crucial to testing the hypothesis that productivity cycles were integral to the sedimentation process of the Devonian black shales.

I will approach the problem of changing oxygen conditions during the Late Devonian-period of ecological restructuring by sampling approximately one meter above and below the Kellwasser events, and, in localities where applicable, between the Kellwasser events. I will sample at eight different localities in upstate New York: Irish Gulf, Eighteen Mile Creek, Point Gratoit/Dunkirk Beach, Walnut Creek, Beaver Meadow Creek, Glade Creek, Perry Farm, and Pipe Creek. In these localities, the F-F boundary crops out as a minor disconformity in the Hanover Shale, underlain by the black Pipe Creek Shale Member and overlain by the petroliferous Dunkirk Shale. The Hanover Shale Member is comprised of light gray, silty shale interbedded with dark gray, organic-rich silty shale. Initial biomarker assays reveal high levels of extractable organics from all three shale members, and maturity assessments suggest they fall within the early to peak oil window; this range of maturity is optimal for biomarker studies.

Each section will be continuously sampled across the extinction horizon, and shale samples will be meticulously wrapped and labeled. In lab, each slab will be cut, polished, wet-scanned, and reconstructed in their proper stratigraphic relationship to-scale on Adobe Photoshop, following a previously well-tested methodology. The to-scale stratigraphic section will be analyzed for trace fossil changes correlating with oxygen facies changes, according to the ichnofabric index created by Droser and Bottjer (1986). This will allow for identification of fine-scale oxygen-level changes. These samples will be simultaneously assessed for body fossils, whose appearance or absence will aid the construction of an overall picture of oxygen patterns in the Late Devonian epeiric seas.

Each section will also be sampled in close lateral proximity for material for geochemical analyses. Because of processing constraints, it is impossible to sample a continuous sequence for biomarkers, as is possible for ichnofabric assessments, but samples of <5 cm will be collected at adjacent intervals a meter above and below the extinction horizons. This distribution of biomarker data at <5 cm intervals is at an extremely fine scale for geochemical analyses and will provide much higher resolution of changes in primary production than has heretofore been attempted. The primary biomarkers I will be looking for are those for Green Sulfur Bacteria (GSBs), specifically the diagenetic product of its diagnostic membrane lipid molecule, isorenieratane. The presence of biomarkers for GSBs is evidence for photic zone euxinia, an important indicator of the extent of water column oxygenation.

The end goal of this first leg of my dissertation field work is to produce a high-resolution picture of the stratigraphic fluctuations in oxygen up to and across the Upper Kellwasser event/F-F and, where available, the Lower Kellwasser event. The knowledge gained from this endeavor will contribute to our understanding of the anoxia that contributed to both the deposition of the characteristic Devonian black shales and also the environmental changes that perturbed the ecological communities of the Late Devonian reef systems. Biomarker analyses, because of their relative novelty in application to investigations of earth history, also inherently contribute to the body of organic geochemical technical knowledge and, as such, indirectly aid innovation in the energy industry.

This project will be done in collaboration with Dr. Diana Boyer (SUNY Oswego) who has been investigating low oxygen facies through trace metal concentrations and other geochemical and paleontological proxies.

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