Project #13114 "Fine-scale organic thermal maturity along the Punchbowl Fault "
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Abstract
The aim of this project was to collect samples from the Punchbowl Fault, CA for analysis of thermal maturity of biomarkers on smaller structures within gouge zones. Biomarker thermal maturity has shown to be an effective indicator of earthquake slip, and here we employ it to determine differential heating on the scale of mm-cm thick structures. Samples were successfully collected, and the analytical tests necessary to run small volume samples have been conducted. Samples will be analyzed using Gas Chromatograph-Mass (GC-MS) Spectrometry shortly.

Technical Report
Field sampling occurred in September 2013 at the Punchbowl Fault, southern California, an ancient strand of the San Andreas Fault (Chester). Our sampling team, including PI Savage and members of her lab (including postdoc, grad student, and undergraduate) collected samples from within the various gouge layers within the fault core of the Punchbowl Fault (Figure 1). The structure of the Punchbowl Fault was described in detail (Chester and Chester 1998), including a brown and black ultracataclasite that is separated by a principle slip zone that accommodated several kilometers of fault slip.

Figure 1. Outcrop of the Punchbowl Fault sampled for this study. This particular location was comprised of several different fault rocks, ranging in color, fabric and induration.

We sampled the fault at three outcrops, and identified localization structures within two locations. Samples were taken by hammering small metal tubing into the outcrop, so that individual fine-scale layers could be sampled without contamination from the surrounding rocks. These samples are stored in the lab at Lamont awaiting finalization of the analytical methods.

In parallel to the sample collection, we have worked to greatly increase the sensitivity of our laboratory analyses for biomarker thermal maturity. We have significantly reduced sample size requirements using selected ion monitoring (Fig. 2) and are working on large-volume injection (LVI) methods that will further reduce the sample size. Typically, samples contain at least 1,000 picograms of each biomarker compound we are analyzing (and often much more) and can be detected with standard GC-MS operating conditions. Using selected ion monitoring we have been able to analyze down to ~60 pg of biomarker molecules, however further reductions are needed. The Punchbowl Formation and Punchbowl fault rocks have lower concentrations of biomarker molecules that is exacerbated by the small size of the samples we will analyze. We have purchased the gas chromatograph parts needed for the LVI injections that will facilitate even lower analytical limits by allowing us to inject a much greater proportion of our sample (50% compared to the typical 5-10%). Due to unforeseen demand on our GC-MS we have not yet been able to test the LVI methods. This will require some trial-and-error work as there are no pre-set methods for this type of injection. Once method development is complete we will analyze the samples collected in September. We expect this to occur in the next two months.

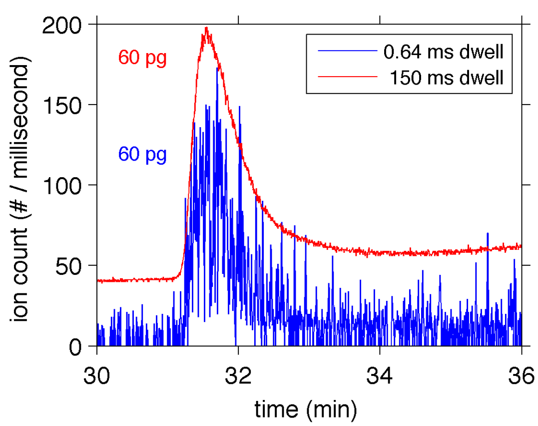

Figure 2 – GC-MS chromatogram showing enhanced signal/noise for 60 picograms of an aromatic standard used for methylphenanthrene quantification (1-1'- binaphthalene). Typical scan acquisitions (blue) have short dwell times that increase noise making quantification of small chromatogram peaks uncertain. Selected ion monitoring (red) greatly increases the dwell time, reducing noise and lowering quantification limits. Combined with large volume injections (LVI) this should reduce our sample size requirements at least 20-fold and perhaps more.

Intellectual Merit & Broader Impacts

The intellectual merits of this proposal include the refinement of a method, biomarker thermal maturity, for detection of earthquake slip in exhumed faults or drill cores through fault zones. This project represents the first time that sampling and analysis was attempted on the scale of localized slip zones within gouge layers. The variation in temperature rise across a fault zone will aid our understanding of the earthquake rupture process.

The broader impacts of this work includes the participation of undergraduate and graduate students in the field, as well as a deepening of our understanding of seismic activity along ancient faults.

Publications

No publications have resulted from this work at this time.