Monitoring Stress-Induced Seismic Velocity Changes At SAFOD Using Crosswell Continuous Active-Source Seismic Monitoring (CASSM)

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Monitoring of in-situ, stress-induced, seismic velocity change provides an increasingly important contribution to the study of the earthquake nucleation process. Continuous Active-Source Seismic Monitoring (CASSM) with borehole sources and sensors has proven to be a very effective tool to monitor seismic velocity and to identify its temporal variations at depth. Since June 2017, we have been operating a crosswell CASSM field experiment at the San Andreas Fault Observatory at Depth (SAFOD) where a previous CASSM experiment identified the two seismic velocity reductions approximately 10 and 2 hours before micro-earthquakes.

The ultimate goal of our experiment is to continuously monitor tectonic stress for the San Andreas Fault near seismogenic depth. Our active-source experiment makes use of two boreholes drilled at the SAFOD project site. A piezoelectric source and a three-component accelerometer have been installed in the SAFOD pilot and main holes, respectively, at about 1 km depth. A seismic pulse is generated by the piezoelectric source four times per second, and waveforms are recorded with a 48 kHz sample rate, with recordings summed for 1 to 10 minutes to capture seismic velocity changes at a high-temporal resolution.

Since deployment in June 2017, and as of July, 2019, local seismicity has not been above our current threshold of detection. However, we have identified a velocity reduction at the SAFOD site (0.5 microsecond change in crosswell travel time, measured in a coda window) possibly induced by dynamic stress changes from the distant 6 July 2019 M 7.1 Ridgecrest earthquake, California. We will characterize and report the co-seismic change and post-seismic recovery process for this remotely triggered velocity change. We will also report on the overall status of this unique CASSM experiment.

Keywords: Stress-induced velocity change, Active source, Borehole seismic monitoring

