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Drilling into seismogenic zones of M2.0 – M5.5 earthquakes in deep South African gold mines (DSeis)

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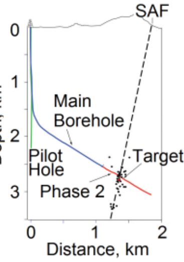
Several times a year, small (M2) mining-induced earthquakes occur only a few tens of meters from active workings in South African gold mines at depths of up to 3.4 km. The source regions of these events are accessible with short boreholes from the deep mines, and provide a very cost-effective method to directly study the earthquake sources. Recently, the largest event (M5.5) recorded in a mining region, took place near Orkney, South Africa on 5 August 2014, with the upper edge of the activated fault being several hundred meters below the nearest mine workings (3.0 km depth). This event has rare detailed seismological data available both from surface and underground seismometers and strainmeters, allowing for a detailed seismological analysis. Drilling into the source area of this earthquake while aftershocks are still occurring will enable important near-field seismological observations as well as a rare opportunity to study possible presence of H_2 that is important for microbiological activity.

We intend to drill several tens of holes into and around seismogenic zones to study the rupture details and scaling of both small (M2.0) and larger (M5.5) earthquakes. An advantage of the relatively low cost of drilling is that multiple holes can be drilled. Past fault zone drilling projects have been limited to 1 or 2 boreholes, severely limiting the ability to resolve spatial variability. The value of the project will be maximized if we combine results from a number of boreholes drilled into the source area of the M5.5 seismogenic zone, and also compare with boreholes in source regions of small earthquakes in other mining horizons. Additionally, the combination of logging, fault sampling, and earthquake monitoring, will be enhanced in some cases by the direct visual observations of exhumed faults, leading to a unique complete picture of the earthquake source.

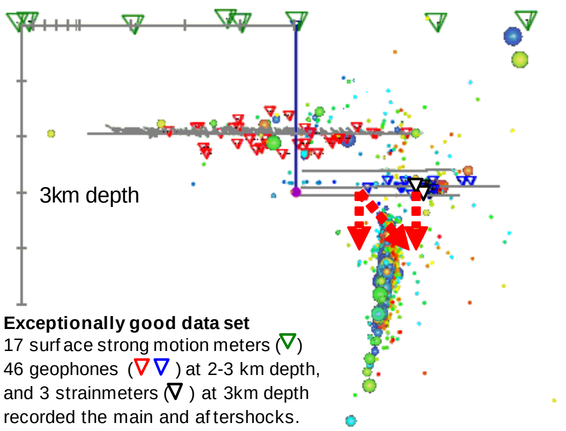
In seismogenic zones in a critical state of stress, it is difficult to delineate reliably local spatial variations in both the directions and magnitudes of principal stresses (3D full stress tensor). We have overcome this problem and can numerically model stress better, enabling orientations

San Andreas Fault Observatory at Depth (SAFOD)



http://www.earthscope.org/science/data/data-access/safod-data/

DSeis



Exceptionally good data set
17 surface strong motion meters (▽)
46 geophones (▽▽) at 2-3 km depth,
and 3 strainmeters (▽) at 3km depth
recorded the main and aftershocks.
We can reach the M5.5 fault
within 1 km from a tunnel at 3 km depth.
The spatial coverage provides us the

Seismic data courtesy of Anglogold Ashanti (AGA) Station data courtesy of of boreholes that minimize stress-induced damage during drilling and overcoring. We can also reliably measure the full 3D stress tensor even when stresses are as large as those expected in seismogenic zones. Better recovery of cores with less stress-induced damage is also feasible. These studies will allow us to address key scientific questions in earthquake science and deep biosphere activities.