ICDP DSeis: the FY2023 activity of the drilling into seismogenic zones of M2.0-5.5 earthquakes in South African gold mines

*Hiroshi Ogasawara[1], DSeis Team

1. Faculty of Science and Engineering, Ritsumeikan University

We overview our activity in FY2022 in the project ” Drilling into Seismogenic zone of M2.0-5.5 earthquakes in South African gold mines (DSeis; Ogasawara et al. Afrirock 2017)” . In 2016, International Continental Scientific Drilling Program (ICDP) approved this project, which, in 2018, accomplished drilling and downhole logging (Ogasawara et al. Deep Mining 2019; ICDP Thrill to Drill). In 2019, we imported the critical section (a hundred and several tens of meters in total length) to Kochi Core Center.

Six papers were published in five peer-reviewed journals and one international conference proceeding. Ogasawara et al. (2022) and Yabe et al. (2022) have successfully attempted to constrain the 3D stress field using drilled cores recovered from the stress concentration zone ahead of the mining front at the Cooke 4 mine and the Mw 2.2 seismogenic field at the Mponeng mine, respectively. By 2018, two drill holes from 2.9 to 3.4 km below the surface had intersected the upper margin of the aftershock zone of the 2014 Orkney M5.5 earthquake, and a total of 1.6 km of continuous core samples were recovered from three drill holes, including the two holes, with successful downhole logging; Mngadi et al. (2022) and Miyamoto et al. (2022) carried out the mineralogical and chemical analysis for the recovered material, who revealed more than 20 wt% talc along with amphibole and biotite from the altered lamprophyre dike that hosted the aftershock zone. Miyamoto et al. also reported that the friction coefficient of powdered dry gouge was small and velocity-strengthening; Nkosi et al. (2022) summarized the main mechanical properties of the country rocks (felsic sedimentary metamorphic rocks; Vp slightly less than 6 km/s, density about 2.7 g/cm3) and the mafic and ultramafic sill-dyke complex (some with Vp>6.5 km/s and density>3 g/cm3); Nkosi et al. also reported that the lampropyre dike in the complex was the host structure for the aftershock zones, and that the acoustic impedance ratios of the sill-dike complex and host rocks were consistent with the 3D reflection survey data; Nisson et al. (2022) discovered a hypersaline brine vein in a different dyke than the lamprophyre dyke described above, and through further isotopic and chemical analyses of the dissolved material and host rock, they found the residence time of the hypersaline brine (1.2 billion years), and the interaction with the host rock, and several groundwater events from the green schist metamorphic phase to present 55˚C.

In JpGU 2023, Ogasawara et al. (S-CG47) detail the occurrence of mineral assemblage through EPMA and SEM-EDS analyses for the section containing talc that follows up Oba et al. and Fujita et al. (2022 JpGU SGG46). Yabe et al. (S-SS06) report on the frictional test for the gouge in wet condition that contains talc.

It should be also noted that we could resume our activities in the drilled holes that reached the vicinity of the aftershock zone of the M5.5 earthquake. In January and October-November 2022, we were able to log borehole magnetic susceptibility, water temperature and electrical conductivity in the borehole. This was the first time in three years, which had been suspended due to COVID. Water temperature and hydraulic conductivity showed a significant increase compared to the logging results in 2018, immediately following the completion of drilling.

The DSeis team consists of seismologists, geologists, geomicrobiologisits, rock mechanists, mining engineers from Japan, South Africa USA, Switzerland, Germany, India, and Australia. The DSeis project is

built on JST-JICA SATREPS project and Kakenhi (21224012) and is supported by ICDP, JSPS Core-to-Core Program, Ritsumeikan University, MEXT 2nd Earthquake and Volcano Hazard Reduction Research, Kochi Core Center, and Kyoto University.

Keywords: Seismogenic zones, ICDP drilling, Altered mafic/ultramafic intrusives

