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2014 年オークニー地震（ML5.5）の震源破壊過程
Source Process of the 2014 ML5.5 Orkney earthquake, South Africa

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An earthquake occurred at 12:22:33 SAST (10:22:33 UT) on 5 August, with the epicenter near Orkney town near gold mines in the Klerksdorp district in the North West province of South Africa. The Council for Geoscience (CGS) in South Africa reported that the magnitude was M_L5.5. As a quick preliminary report, USGS estimated a left lateral fault mechanism and a focal depth of 5.0 km. CGS revised its depth to 4.7 km using the dense cluster network data. CGS also reported 84 aftershocks on 5 August and 31 aftershocks on 6 August, with magnitudes of 1.0 to 3.8 on the Richter scale. According to the CGS, this earthquake was the biggest recorded earthquake in the gold mining districts in South African history.

In this study, we analyzed the main shock waveforms and aftershock distribution to understand the rupture process of this earthquake. At the time of the 2014 Orkney earthquake, 17 strong motion surface stations were in operation and continuous acceleration seismograms were obtained with 24-bit and 200 Hz sampling. First, we picked P and S wave arrival times of the main shock and found two sets of phases in those seismograms. One belongs to a smaller event that occurred at a depth of 4.1 km (5.6 km below ground surface; BGS) with a magnitude less than 3. The other event started 0.3 seconds later with a larger magnitude slightly (1 km) north of the first one and at a depth of 4.2 km depth (5.7 km BGS). It seemed appears that the smaller initial rupture was leading led to a larger main rupture. According to the S wave velocity structure of in the Klerksdorp area, the S wave of the initial rupture can would have been able to reach to get to the hypocenter of the main rupture hypocenter, just in time. Thus, it seems that appears as though the initial rupture's S wave had initiated the main rupture.

Next, we applied hypoDD (Waldhauser & Ellsworth, 2000), the Double-Difference earthquake location algorithm, to P and S wave arrival times of the aftershocks, as well as to the initial and main ruptures of the main shock. We found spatial gaps in the deep parts of the aftershock distribution. These seem to correspond to the initial and main rupture hypocenters. We also found a horizontal seismic gap at a depth of 3.5 km BGS. Shallow events located above this seismic gap may have been caused by the M_L5.5 coseismic stress change and the existence of high mining rock stress. These might not be aftershocks since the gold mine leaf reaches up to a depth of 3.5 km.

According to Matsuda's law (Matsuda, 1975), the extent of a M_L5.5 earthquake fault can be 2-3 km (maximum for unidirectional rupture), main rupture could reach 2.5 km BGS. However, the existence of the horizontal seismicity gap and rupture extension at the same depth may imply that the main rupture did not reach 3.5 km BGS.

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