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The Apr 2013 earthquake swarm and dyke intrusion in the Okinawa trough

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In April 2013, a shallower earthquake swarm occurred in the Okinawa trough, 50 km NNE of Yonaguni Island, following more than 10 yrs of seismically quiet period in the area. The major seismic activity decayed within a week. During the period, 28 earthquakes of Mw >4.5 (max Mw 5.2) occurred. The sum of all seismic moments is equivalent to Mw 5.7. GPS data from seven stations from GEONET and three from Taiwan are used over a sufficient long interval of dataset. During the active period, crustal displacements reached 4.7 cm in SSW direction on Yonaguni Island, 1cm in the E direction on Iriomote, sub-cm on Ishigaki and other islands and no noticeable displacements at stations in Taiwan.

A kinematic GPS analysis of theses data reviles that this deformation started at the time of the earthquake swarm and slowly continued over two days. During the period no step-like movements exceeding a threshold level occurred, suggesting the absence of sudden slips at the earthquake source area. We propose two source models to interpret these GPS data, 1) a normal fault of Mw 7.0 and 2) a magma intrusion with the thickness of 3 m. These models cannot be distinguished from the GPS data alone.

Prior to the earthquake swarm, the GPS velocity vector at Yonaguni is 6.5 cm/yr in the SSE direction but that increases at 8.4 cm/yr after the earthquake swarm and furthermore 9.5 cm/yr throughout 2014. The long-lasting and accelerating GPS displacements suggest a strong preference for the dyke intrusion model.

A question may arise whether such magma intrusion causes the rifting of the Okinawa trough and hence the southward migration of the Ryukyu arc. To solve the question, the data from the baseline of Iriomote and hateruma islands is critical. This baseline is aligned perpendicular to the general trend of the western Ryukyu trench. The baseline of 40 km between the two islands shows a constant extension of 1 mm/yr from 2001 to 2015. The long-term and steady extension of the baseline suggests that rifting of the Okinawa trough is caused by the retreat of the Ryukyu trench due to a rollback of the Philippine Sea plate in the western Ryukyu trench.

Keywords: earthquake swarm, normal fault, Okinawa trough, back-arc rifting, dyke intrusion, Ryukyu trench