Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

SSS33-10 Room:315 Time:April 30 11:30-11:45

The detection of crustal deformation associated with earthquake swarm in Tanzania observed by SAR

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The East Africa Rift Valley is one of the divergent plate boundaries can be seen on the land surface. The area undergoes middle-class earthquakes and eruptions due to the existing faults and volcanoes.

An earthquake swarm occurred in the Northern Tanzania in July 2007 including the largest earthquake with Mw5.9 and lasted for approximately two months. According to the Global CMT solution, eight M>5 earthquakes occurred during the earthquake swarm and all of them were reported to be caused by normal fault. One week after the start of the swarm, an effusive eruption began at Mt. Oldoinyo Lengai located near the epicentral region, and a major ash eruption was observed by the time when swarm was terminated.

Biggs et al. (2009, 2013) also detected the crustal deformation associated with the earthquake swarm and Mt. Oldoinyo Lengai eruption, using mainly ENVISAT/ASAR C-band SAR data. In these interferograms, however, the ground displacements at some deforming areas were uncertain because of the difficult of phase-unwrapping. Also, these datasets were acquired only along the descending track, and the 3D deformation fields were unclear. Therefore, we used the L-band ALOS/PALSAR data obtained at both ascending and descending track to detect the detailed crustal deformation.

The purpose of this paper is to elucidate the mechanism of crustal deformation associated with the earthquake swarm in Tanzania in 2007 by interferometric synthetic aperture radar (InSAR).

By using InSAR data for ascending and descending track and the azimuth-offset data, we determined the 3D displacement. The results show a subsiding region along the NE-SW direction that are sandwiched by two horizontally deforming regions toward NW and SE directions. These spatial variation patterns are consistent with the expected direction, where the East Africa Rift Valley is expanding. In addition, the azimuth-offset data reveals slightly southward displacement in sediment area.

The ground at the subsiding region indicated ˜62 cm subsidence and ˜33 cm horizontal displacement toward SSE. The two-lobe pattern in eastern and western half each moved several centimeter upward and ˜50 cm in NW-SE direction horizontally.

In order to describe the ground displacement in detail, we estimated a fault source model assuming slip distribution in a homogeneous elastic half-space. Considering the complexity of the fault geometry, we derive a non-planar fault source model with triangular dislocation elements. Based on the result captured by InSAR and the observed area is in tension field, we propose two fault segments. The model indicates dip-slip and strike-slip displacement with maximum slip of about 1 m and 75 cm at 2-4 km depth.

Derived slip distribution can well explain the spatial variation pattern acquired by InSAR. The amount of moment release inferred from the model (Geodetic Moment: GM) exceeds that of the earthquake swarm (Seismic Moment: SM), and the ratio (SM/GM) is 37.2 percent. The ratio indicates that significant aseismic crustal deformation contributes to GM.

Some interferograms also detected the crustal deformation associated with Mt. Oldoinyo Lengai eruption during the earthquake swarm. We will also discuss the relationship between the earthquake swarm and the volcanic eruption of Mt. Oldoinyo Lengai.

Keywords: InSAR, Crutal deformation, East Africa rift valley, Earthquake swarm, Continental techtonics, Tanzania