P09

Coseismic and Postseismic Deformation of the 2016 Central Tottori Earthquake and its Slip Model

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1. Introduction

The San-in Shear Zone (SSZ) is a right-lateral shear zone in southwestern Japan with a 30-50 km width, where active seismicity and high strain rates have been observed (Nishimura and Takada, 2017). In the past century several large earthquakes have occurred within the SSZ, such as the 1943 Tottori earthquake (M7.2) (e.g. Kanamori, 1972), the 1983 Central Tottori earthquake (M6.2) (e.g. Oike, 1987), and the 2000 Western Tottori earthquake (e.g. Ohmi et al., 2002), showing that the SSZ is seismotectonically active.

On October 21, 2016 a Mj 6.6 earthquake occurred in central Tottori Prefecture, within the SSZ. This event was recorded by a dense GNSS network, composed of GEONET sites and 13 continuous GNSS stations constructed by the Disaster Prevention Research Institute (DPRI), Kyoto Univ. in 2014 around Tottori and Okayama Prefectures to monitor deformation in the SSZ. To monitor postseismic deformation of this event, DPRI deployed 2 additional sites immediately after the 2016 earthquake (Fig 1). We analyze these data in combination with K-net data and available ALOS2 InSAR images to clarify the developments of crustal deformation associated with the 2016 Central Tottori earthquake.

2. Observed displacement

Coseismic displacement is observed at GNSS stations around the epicentral region of the 2016 Central Tottori earthquake (Fig 1a). The largest displacement is observed at station KRNS where horizontal displacement to the southeast of 9 cm and vertical subsidence of 4 cm is observed.

Strong ground motion observed at K-net stations during the 2016 Central Tottori earthquake, as well as line of sight displacement from interferograms generated with data of ALOS-2, are in agreement with GNSS observations. Clear coseismic displacement is observed at the stations near to the epicenter of the 2016 earthquake. Largest displacement from K-net data was observed at station TTR005 (Fig 1a), where horizontal motion of 5 cm to the southeast and subsidence of approximately 3 cm was observed. SAR data indicates coseismic displacement concentrated 20 km from the epicentral area. Smooth patterns are observed further from the source, indicating that coseismic slip occurred at shallow depths.

We analyzed postseismic displacement during 7 months after the earthquake based on GNSS data (Fig 1b). Displacement is restricted to stations near to the source region of the event, which suggest shallow afterslip as the dominant mechanism of crustal deformation in the postseismic period. The largest displacement is observed very close to the epicenter at one of the stations deployed after the earthquake (MSJH). Maximum horizontal displacement to the northwest of 5 cm is observed.

3. Deformation modeling

We estimated the coseismic and postseismic slip distribution of the 2016 Central Tottori earthquake by performing a linear inversion of available data sets (Nishimura, 2009). Coseismic slip distribution inversion included the previously described InSAR, strong motion and GNSS displacement data, while postseismic distribution was only assessed using GNSS data, due to limited resolution of the InSAR data in the postseismic period.

We first performed a non-linear inversion of only the GNSS data to search for the optimal geometry of the fault (Matsu'ura and Hasegawa, 1987). Then, the obtained fault model was extended along the strike and the dip directions, in order to assess the extent of the coseismic and postseismic slip by linear inversion of the observations. The fault area was divided into 72 rectangular sub-faults of 1.57 km x 1.57 km dimensions. The slip angle was not fixed for the inversion. Model displacement was calculated by assuming a homogeneous elastic half space (Okada, 1985).

4. Results and Discussion

4.1 Coseismic slip

A large slip region with a maximum estimated slip of 1.34 m extends to the northwest of the rupture source, without reaching the surface (Fig 1c). Estimated slip errors ranged from 3 cm to 20 cm, and are smaller in the shallow region. Rupture process estimated from strong motion waveforms indicated the existence of areas of concentrated slip on the fault plane (e.g. Kubo et al. 2017), but such distribution is not recovered from the the inversion of geodetic data and static coseismic displacement from K-net data. The total seismic moment in the model region was 2.34 x 10^{18} N·m (M_w 6.18), assuming a rigidity of 30 GPa. This seismic moment release is in agreement with the moment magnitude provided by moment tensor analysis of F-net solutions (M_w 6.2).

Comparison of the model and observed displacements used for this inversion shows that the general characteristics of the deformation pattern are reproduced by the current model (Fig 1a). The aftershock slip area shows little to no overlap with the main shock slip (Fig 1c).

4.2 Postseismic slip

Distributed afterslip in the shallow portion of the source fault, above the area of coseismic slip, is found (Fig 1b). Maximum afterslip of 14 cm was observed near to the surface, with virtually no slip at depths greater than 6 km (Fig 1d). Estimated slip errors are between 3 to 10 mm. The total seismic moment release in the postseismic period in the model region was 2.54 x 10^{17} N·m (Mw 5.54). This means that ~11 % of the seismic moment released by the mainshock was released in the form of afterslip. Complementary spatial pattern between the coseismic and postseismic slip indicates afterslip driven by coseismic stress change.

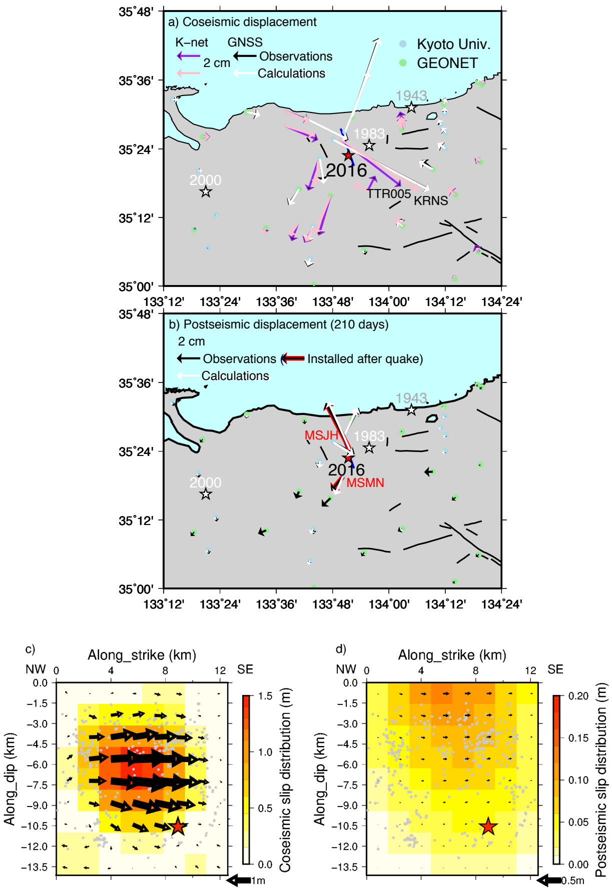

Fig 1. Coseismic (a) and postseismic (b) displacement of the 2016 M6.6 Central Tottori earthquake (black and purple arrows) at GNSS and K-net stations, and model displacement (white and pink arrows) associated with slip distribution inferred from data inversion (c and d). Map view and cross section of the fault are shown. Grey dots represent aftershocks on the fault plane (thick blue line) within 2 km from the fault (Iio et al. 2017). Red star denotes the mainshock.