

Finite-Fault Model of the 2016 Gyeongju, South Korea Earthquake and its Implication for the Subsurface Fault Structure

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The 2016 Gyeongju earthquake (M_L 5.8) occurred in the southeastern part of the Korean peninsula on September 12, 2016. This is the largest earthquake ever instrumentally recorded in Korea. The mainshock was preceded by foreshock activity including the largest foreshock with M_L 5.1 which occurred approximately 50 minutes before the mainshock. The epicenters were close to the Yangsan fault, however the trend of the foreshock and aftershock seismicity was oblique to the surface trace of the Yangsan fault. And, the depths of the hypocenters of the mainshock and the foreshock are 12.8 and 13.9 km, respectively (Son et al., 2017), which are relatively deep as crustal earthquakes. This earthquake was paid attention by public, not only because of the greatest magnitude in the country, but also due to the strong seismic shaking felt all over the country and the epicenter locations close to the nuclear power plant.

Finite-fault slip inversion analyses

In order to quantify the source process of the mainshock and the largest foreshock, we performed the finite-fault slip inversion analyses. The use of the empirical Green's function technique employing an M 3.8 event enabled us study seismograms at higher frequencies. We set two parallel faults for each of the mainshock and the largest foreshock, as the foreshock and aftershock distribution (Son et al., 2017) implied. The obtained slip models fitted the observed seismograms well.

High Stress Drop

The average of the stress drop in the area with the positive stress drop were 23 and 15 MPa for the mainshock and the largest foreshock, respectively. These are higher than the typical values such as 1-10 MPa (Kanamori & Anderson, 1975). The high stress drop values are consistent with short pulse widths of the observed seismograms.

Rupture Directivity

The models indicated NNE-ward directivity for the mainshock and SSW-ward one for the largest foreshock, whereas the epicenter of the mainshock is located just south of that of the largest foreshock. Although our result for the mainshock contradicts the result of Kim et al. (2017), we have confirmed our result by a simple deconvolution analysis.

Implications

Our result suggests that the parallel faults were ruptured by each of the mainshock and the largest foreshock and their rupture propagation directions were opposite to each other. Based on this suggestion, we hypothesize the right-stepping fault system (see Figure). This is consistent with the right-lateral strike-slip mechanisms in this region. Then, the stress concentration in the fault jog would

overcome the high fault strength, which is consistent with the hypocenter locations of the mainshock and the largest foreshock in the fault jog. If this hypothesis is the case, there may exist normal faulting events in the fault jog, although such events have not been found so far.

The detail of this abstract is described in our recent paper (Uchide and Song, 2018).

Acknowledgement

We used the seismic data from KIGAM and KMA. We also used the relocated earthquake catalog from Minkyung Son, Chang Soo Cho, and Jin Soo Shin.

References

Kanamori, H., & Anderson, D. L. (1975). Theoretical basis of some empirical relations in seismology. *Bull. Seismol. Soc. Am.*, 65(5), 1073-1095.

Kim, Y., He, X., Ni, S., Lim, H., & Park, S. C. (2017). Earthquake source mechanism and rupture directivity of the 12 September 2016 M_w 5.5 Gyeongju, South Korea, earthquake. *Bull. Seismol. Soc. Am.*, 107(5), 2525-2531. <https://doi.org/10.1785/0120170004>

Son, M., Cho, C. S., Shin, J. S., Rhee, H.-M., & Sheen, D.-H. (2017). Spatiotemporal distribution of events during the first three months of the 2016 Gyeongju, Korea, earthquake sequence. *Bull. Seismol. Soc. Am.*, 108(1), 210-217. <https://doi.org/10.1785/0120170107>

Uchide, T., Song, S. G. (2018). Fault rupture model of the 2016 Gyeongju, South Korea, earthquake and its implication for the underground fault system, *Geophys. Res. Lett.*, 45. <https://doi.org/10.1002/2017GL076960>

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Map View
(depth ~ 12 km)

Right-lateral
Stress Loading

