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Subsurface seismogenic fault geometry estimated based on faulting mechanics

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Identifying geometry of seismogenic faults is the most fundamental aspect in earthquake hazard assessment, which is normally conducted by investigation on fault traces exposed to ground surface. However, identifying subsurface faults in tectonically stable regions is often difficult mainly because small-scale faulting activities that may not always be exposed to the surface. The goal of our study is to investigate how much similarity exists in a tectonically stable and thus slowly deforming region, southeastern part of Korean Peninsula between subsurface fault planes deduced from earthquake focal mechanism solutions and surface traces of faults. The southeastern part of Korean Peninsula is located at eastern edge of Eurasian plate, away from plate boundary, and thus characterized seismically by relatively low magnitude earthquakes (M<5), although two main events (2016 M5.8 Gyeongju and 2017 M5.4 Pohang) occurred recently. There are a family of major faults in NNE strikes, some segments of which were activated in Quaternary time. We determine subsurface fault planes from earthquake focal mechanism solutions using the instability method, in which the nodal plane in a focal mechanism solution exhibiting higher shear instability under the given tectonic stress condition is considered as fault. To validate the shear instability method, we first apply the method to known Quaternary faults in the study area by adding artificial conjugate sets and building data similar to focal mechanism solutions. The method predicts 75% of the Quaternary faults correctly. Having that predictability of the method, we then apply it to contemporary earthquake focal mechanisms in attempts to identify the attitudes of present-day seismogenic faults. We find that several subsurface faults, whose orientations are known independently from associated aftershocks, are correctly predicted by the method. Surprisingly, however, the majority (>50%) of the determined subsurface fault planes are not consistent with the orientations of surface traces of faults. Only 44% are similar and compatible to surface traces. This result demonstrates that subsurface 3D fault network may be much more complicated than what we can infer from surface 2D projection of the fault system.