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Spatiotemporal evolution of foreshock-mainshock-aftershock sequence in northern Taiwan

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Stress and pore pressure changes both play important roles in development of fractures and successively generate different seismicity patterns during seismogenic processes. Based on hydromechanics theory, seismicity may propagate in space with the square root of time if the earthquakes were triggered by pore pressure changes. On the other hand, we may see a gathered or dispersed ruptures at the same time if the earthquakes were triggered by stress changes. We observed both seismicity patterns in Central Range of northern Taiwan, which is an area characterized by orogeny-parallel syn-collisional extension in the upper crust. It is a 7-month-long foreshock-mainshock-aftershock earthquake sequence, with a 2013 M 5.87 Nanshan mainshock. We relocated earthquakes recorded by Central Weather Bureau (CWB) using waveform cross-correlation relocation, and analyzed the spatiotemporal evolution of the earthquake sequence. The spatiotemporal distribution of relocated earthquakes presents several NNW trending normal fault segments dipping to southwest with a focal depth of 4-12 km. One foreshock sequence propagated away from an M 4.56 earthquake with the square root of time, which can be considered to be triggered by pore pressure changes. 74 days later, the main shock occurred. The migration of the mainshock-aftershock sequence can be subscribed as the hydromechanics equation which relates to the square root of time and diffusivity. The earthquakes migrate bilaterally to the north and south respectively, with a northward diffusivity of 0.42 m^2/s and the southward diffusivity of 0.6 m^2/s. We divided the foreshock sequence into three clusters, and analyze their migration behavior. Two of them appear to be stress-driven, causing 1.5*2 $km^2$and 2*2km^2 fractures, respectively. The third one is likely to be fluid-driven, with a linear seismicity pattern propagating with 3 m^2/s diffusivity toward northwest. We also divided mainshock-aftershock sequence into four clusters. Three of them indicated stress-driven, causing 3*4 km^2, 1*1 km^2, and 4*4 km^2 fracture respectively. Only one of them showed migration with about 6 m^2/s diffusivity. The factors of stress and fluid-driven pore pressure changes may act together on the activations of the 2013 Nanshan earthquake sequence.