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The influence of the impoundment of Three Gorges Reservoir on the M5.1 Badong earthquake

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The Three Gorges Reservoir constructed on Yangzi River is the world's largest power station on installed capacity ($39.3\times10^9 m^3$), it extends 660km from the western part of Hubei province and eastern part of Chongqing municipality. It is a major concern if it can trigger reservoir earthquakes. After the impoundment of the Three Gorges Reservoir since 7 June 2003, there were many micro-earthquakes in the head segment of the reservoir area including Badong area. The prior researches had suggested the micro-seismic activity will be weak as time goes on, even disappear, and the maximum magnitude of earthquake triggered by the reservoir should not be more than M5.5. However, ten year later, a moderate M5.1 earthquake happened around BaDong Country on 16 December 2013, after the annual highest water level. The epicenter was about 5.5km away from the Yangzi River and nearly 100km from the Three Gorges Reservoir dam. The focal depth of this earthquake was about 5km and the focal mechanism solutions show the NNW-striking thrust seismogenic fault (www.ceic.ac.cn). So, if this earthquake was related to the impoundment of the Three Gorges Reservoir? Would this pose an important impact on the earthquake triggered by the Three Gorges Reservoir? In order to quantitatively analyze these considerations, a three-dimensional fully coupled poroelastic finite element model is proposed in this study by taking the consideration of the realistic observation data, such as the high resolution topography, water level fluctuation, flood zone boundary and water depth variation, fault parameters and etc. The change of Coulomb Failure Stress (ΔCFS) in correspondence to elastic stress and pore pressure change induced by fluid diffusion is calculated. Meanwhile, the elastic strain energy accumulation in reservoir region due to the water-filling load is obtained. Our primary results indicate that both pore pressure and coulomb stress on the hypocenter gradually increases with the respect of time while the water level variations. The magnitude of pore pressure can reach 16kPa when the diffusion coefficient was selected as $0.2 m^2/s$, which was according to the distribution of small foreshocks. The maximum surface deformation beneath the of Three Gorges Reservoir is up to 3.6cm when the water level 135m and the surface deformation near the Badong area is 1.35cm, which well accordance with the GPS measurement. Although the total elastic strain energy accumulation caused by the impound water load is around 7.3×10^{11}J, the energy density is still insignificant compared to the vast reservoir inundation area, as it is only less than 3.5 percent of the total seismic wave energy released by the M5.1 earthquake, which confirms that the tectonic stresses is the major source for the earthquake and weak fault zone and impoundment of the reservoir triggered earthquakes. We expect that the pore pressure diffusion in the future may increase deeper fault instability, therefore reservoir earthquake may still occur instead of disappear, although the maximam magnitude of triggered earthquakes by the Three Gorges Reservoir may not exceed M5.5 as suggested by previous researchers.