Numerical simulation study on the stress evolution and the scenaro earthquake in Taiyuan basin, China

*Ping en Li[1]

1. Institute of Geophysics, China Earthquake Administration

The 3-D viscoelastic finite element model of Shanxi seismic zone including Taiyuan basin is built in this paper. In addition, the difference of regional geological structure, the main active fault zone, the irregular topography and layered lithosphere structure synthetically, as well as the seismic velocity structure of the crust and mantle are considered when building the model. Moreover, the present tectonic background stress field in the research area is reconstructed by the constraint of the observed values of the rate of the crustal horizontal movement and the direction of the maximum principal compressive stress. On these bases, the historical strong earthquake sequences with M≧7 in Shanxi seismic zone and with M≧6 in Taiyuan basin since 512 AD are simulated, respectively. From the viewpoint of the equivalent stress and the maximum shear stress, the evolution process of the stress field in Shanxi seismic zone, the interation between strong earthquakes, and the relationship between present stress state and seismic activity as well as seismic potential of Shanxi seismic zone are investigated, respectively. The results show that the most historical strong earthquakes in Shanxi seixmic zone were advanced by the combined effects of their preceding strong earthquake sequence and the long-term tectonic stress loading. The 1989 Yanggao M6.1 earthquake is mainly affected by the long-term tectonic stress loading, and its precedingr earthquake sequence has little influence on it. The long-term tectonic stress loading has obvious promoting effect on the historical strong earthquake, thus its influence cannot be ignored. The results also indicate that the seismic activity in Shanxi seismic zone is obviously controlled by the regional present stress level. The distribution of stress field variation on the main active fault zones in Taiyuan basin may be related to the seismic potential of this region.
Based on the above research results, using the curved grid finite-difference method, we develop dynamic spontaneous rupture models of earthquakes on Jiaocheng Fault (JF) near Taiyuan, the capital and largest city of Shanxi province in North China, and then model the wave propagation and strong ground motion generated by these scenario earthquakes. A map of seismic hazard distribution for the potential earthquake with magnitude of M7.5 is given based upon dynamic rupture and true 3D modeling. The tectonic initial stress fields derived from inversion of focal mechanisms of history earthquakes, non-planar fault, and rough surface are considered in the dynamic rupture simulation. Due to geological structure at Taiyuan basin, the normal faulting with a dipping angle of 60 degree is implemented for the scenario earthquake simulations. The uncertainty of the potential earthquake happened on JF is the hypocenter. We set up four cases to nucleate the earthquake at different locations.With these dynamics rupture sources on JF, we further simulate and analyze the seismic wave generated by the scenario earthquake and then the strong ground motion. It is found that the low-velocity media at the Taiyuan basin redistribute the ground motion well. The effects of regional stress fields on dynamic rupture and hazards distributions are investigated and discussed further. Moreover, a scenario earthquake which can shake Taiyuan City with great damage is modeled and analyzed.

Keywords: Taiyuan basin, stress filed evolution, historical strong earthquake, scenario earthquake, dynamic spontaneous rupture, strong ground motion

