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Computation of time-dependent subsurface pore pressure variations and stresses due to time varying water loads at the Itoiz reservoir (Northern Spain), and their relation with near seismicity

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In this work we study the seismicity produced near the newly constructed Itoiz reservoir in the western Pyrenees (northern Spain). We computed the evolution of the stress changes in the subsoil due to the time water load distribution and relate it with the main seismicity occurred after the beginning of impoundment in 2004. We also computed the pore pressure variations produced around Itoiz dam using a hybrid technique which take into account the time varying water loads in the reservoir. In this methodology, two different techniques are joined to calculate each one of the partial solutions evolved: the pore pressure diffusion term is obtained by using the Green functions of the problem, whereas the second term due to stress time changes is computed with a Finite Difference Method (FDM). We pay special attention to the pore pressure changes at the hypocenter location of the mainshock (with magnitude mb = 4.6) occurred on September 2004, 8 months after the beginning of its impounding. After this, we compute the coseismic and postseismic stress changes produced by the main events of the seismic series and study its influence on the triggering of the aftershocks by means of the Coulomb Failure Stress criterion (CFS).
Results show that at the time of occurrence of the main earthquake the pore pressure change was of about 1000 Pa at the hypocenter. However, the pore pressure variation exceeded 1000 Pa at other earlier times and at many different positions near Itoiz dam without the occurrence of earlier earthquakes. Thus, the origin of the September 18, 2004 earthquake (mb = 4.6) can be explained when considering the pore pressure perturbation at a pre-existent fault in the hypocenter location with more aptitude to fail than other sites, together with the assumption of regional pre-existing stress field. At last we found, a large positive influence over most of the aftershocks of the seismic series due to the stress changes produced by the largest events.