Fluid induced fracture of rock in laboratory as model of triggered seismicity

Ponomarev A.V. (1), Smirnov V.B. (1, 2), Patonin A.V. (3), Mikhailov V.O. (1), Stroganova S.M. (1), Potanina M.G. (1, 2), Bondarenko N.B. (1, 2), Fokin I.V. (1), Shikhova N.M. (3), Arora K. (4), Chadha R. (4), Davuluri S. (4), Raza H. (4)

(1) Schmidt Institute of Physics of the Earth of the Russian Acsdemy of Sciences, Moscow, Russia

(2) Lomonosov Moscow state university, Faculty of Physics, Moscow, Russia

(3) Geophysical observatory «Borok» - the branch of Schmidt Institute of Physics of the Earth of the Russian Acsdemy of Sciences, Borok, Yaroslavski district, Russia

(4) National Geophysical Research Institute - CSIR, Hyderabad, India

e-mail: avp46@mail.ru

It is widely accepted at present that the infiltration pore pressure plays a controlling role in reservoir triggered seismicity. When water from a reservoir infiltrates into the rock mass at the depth of several kilometers, the increasing pore pressure reduces the effective stress, thereby lowering the shear strength of a potential seismogenic fault in the vicinity. This may initiate a crack, which would propagate and trigger an earthquake. The complex mechanisms of RTS are not yet well understood due to the very limited knowledge of the rheology of crustal material and groundwater movement under high pressures and high temperature conditions in the hypocenter region. Therefore, in the absence of instrumental data directly from the hypocentral zone, laboratory experiments on interactions of fluid infiltration, pore pressure and acoustic emissions of selected samples can provide vital insights on processes which take place in the crust.

We have used dry cylindrical samples (length 60 mm, diameter 30 mm) of granite from boreholes in the Koyna-Warna area, western India for our laboratory experiments, which were carried out under two different

confining pressures, 10 to 40 MPa, with pore pressures varying between 1 and 15 MPa. In the sample, a "fault zone" was first formed, which qualitatively simulated the general fault zone along which, according to the assumption, fluid diffusion occurred. Then, under uniaxial loading at constant confining pressure, water was injected through the sample end face. The pore pressure jumps caused an increase in acoustic emission, the maximum of which was reached with delays relative to the moment of the pore pressure jump. This delay in the initiation of failure during fluid propagation in a dry medium turned out to be several times larger than when the diffusion front of pore pressure in a saturated medium propagates. Thus, the results of the experiments at a qualitative level confirm the assumption about the nature of reactivation of seasonal seismicity in the south of the Koyna reservoir, which we attributed to the different velocity of the primary irrigation waves and subsequent pore pressure fronts caused by the Koyna reservoir.

It was found that pore pressure steps caused both induced acoustic activity with a sharp front and gradual relaxation to the background level, as well as activation of the "swarm" type. The latter, as a rule, is realized at relatively small pore pressure values, of the order of 1 MPa or less. Finally, in a number of experiments, the effect of a noticeable, in tens of seconds and more, delay of the acoustic response peak relative to the moment of supply of pore pressure was revealed. Note that in real conditions, induced seismicity in the Koyna-Varna area is also characterized by both a fast and delayed response to the filling of reservoirs, and the delay mechanism remains unclear.