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Pulsed Electric Processing of the Seismic-Active Fault for Earthquake Hazard Mitigation

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Previous field and laboratory investigations performed in Russia (1999-2008) showed a possibility of application of high-power electric current pulses generated by pulsed MHD power system for triggering the weak seismicity and release of tectonic stresses in the Earth crust for earthquake hazard mitigation. The mechanism of the influence of man-made electromagnetic field on the regional seismicity is not clear yet. One of possible cause of the phenomenon may be formation of cracks in the rocks under fluid pressure increase due to Joule heat generation by electric current injected into the Earth crust. Detailed 3D-calculaton of electric current density in the Earth crust of Northern Tien Shan provided by pulsed MHD power system connected to grounded electric dipole showed that at the depth of earthquake epicenters ($>$ 5km) the electric current density is lower than 10^{-7} A/m^2 that is not sufficient for increase of pressure in the fluid-saturated porous geological medium due to Joule heat generation, which may provide formation of cracks resulting in the fault propagation and release of tectonic stresses in the Earth crust. Nevertheless, under certain conditions, when electric current will be injected into the fault through the casing pipes of deep wells with preliminary injection of conductive fluid into the fault, the current density may be high enough for significant increase of mechanic pressure in the porous two-phase geological medium. Numerical analysis of a crack formation triggered by high-power electric pulses based on generation of mechanical pressure in the geological medium was carried out. It was shown that calculation of mechanical pressure impulse due to high-power electrical current in the porous two-phase medium may be performed neglecting thermal conductance by solving the non-stationary equation of piezo-conductivity with Joule heat generation. For calculation of heat generation the known solution of the task of current spreading from spherical or elliptic electrode submerged into unbounded medium is used. Pressure increase due to electric current is determined by voltage of the current source and the medium parameters, and it does not depend on the electrode radius. The pressure increase is proportional to parameter $\eta\sigma/r^2$, where η is viscosity factor, σ is electric conductivity of fluid in pores, r is average radius of capillaries. This parameter may vary for different media and fluids in the pores by many orders of magnitude. The pressure increase for water is insignificant. If a high-mineralized fluid (e.g. sludge) is injected into the medium, the pressure may be increased by several orders. In that case the pressure may obtain tens kilobars, and an intergrowth of cracks will be possible in the medium exposed to high-power electric current. An estimation of parameters of portable pulsed power system for electric processing of the fault was performed, when the current is injected into the fault through the casing tubes of deep wells with preliminary injection of conductive fluid into the fault between the wells.

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