Strong variations of geomagnetically induced currents in the conductive seismogenic faults as a possible trigger of earthquakes

Novikov V.A.

Joint Institute for High Temperatures of Russian Academy of Sciences, Moscow, Russia

e-mail: novikov@ihed.ras.ru

Despite a fairly large number of publications on the possible relationship between geomagnetic and seismic activity, this issue is still debatable. In the cases where the authors statistically found a positive relationship between these phenomena, it should indicate a possible triggering impact of geomagnetic field variations on the earthquake source. The attempts of a phenomenological explanation of the possible mechanisms of this impact have not yet clarified their physical nature, which casts doubt on their real existence. In this paper, we consider a hypothesis on a possible triggering effect of telluric currents generated in the crust faults by strong variations in the geomagnetic field. The hypothesis is based on the results of laboratory experiments and field observations obtained earlier, which demonstrated that electric current pulses supplied to the Earth crust from artificial power sources can cause an increase in fracture formation in rocks, trigger weak earthquakes, and result in a spatiotemporal redistribution of the regional seismic activity.

It is known that one of the most significant manifestations of space weather is geomagnetically induced currents (GIC) excited in the surface layers of the Earth and conductors during abrupt changes in the geomagnetic field. Since GIC is a hazard for pipelines, main cable lines, high-voltage power lines, railway equipment, marine and land communication cables, this phenomenon is currently well studied for conductive technical objects of developed infrastructure. Practically unexplored are GIC in conductive fault zones of the Earth crust, as well as their effect on the crust deformation processes. It should be noted that due to the saturation of the crustal faults with highly mineralized fluids or the fault graphitization (the formation of thin graphite films on the fault walls as a result of previous earthquakes), its conductivity can exceed the conductivity of host rocks by several orders of magnitude. Previously, calculations showed [Sorokin et al, 2017] that during strong geomagnetic field disturbances of $\sim$102 nT, the density of telluric currents in a conducting fault can reach 10-6 A/m2, which is an order of magnitude higher than the current density generated in earthquake sources by artificial pulsed power sources of DC supplied to the crust through a grounded electric dipole. Thus, under certain conditions (the level of the fault stress-strain state, the fault conductivity and orientation), GIC excited in the faults by sharp variations in the geomagnetic field can trigger earthquakes. This assumption is confirmed by a statistical analysis of the effect of strong geomagnetic storms on the reduction of the recurrent period of weak repeating earthquakes at the San Andreas Fault, California. It is shown that if a geomagnetic storm with Kp$\geq$8 occurs at the end of the recurrent period, then it leads to its reduction, which is additional confirmation of an existence of electromagnetic triggering of seismic events by strong geomagnetic storms.

The reported study was funded by RFBR and NSFC, project number 21-55-53053.