Discharge of Tectonic Stresses in the Earth Crust by High-power Electric Pulses for Earthquake Hazard Mitigation

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Abstract

An effect of high-power electromagnetic pulses of magneto-hydrodynamic (MHD) generator on the seismic regime over the Northern Tien Shan and Pamir regions has been studied. An increased level of seismic activity was observed within 3 to 6 days after the MHD generator firing runs. It was suggested that electromagnetic pulses result in discharge of energy accumulated by the Earth crust due to tectonic deformation processes. The energy discharges in the form of series of relatively weak earthquakes instead of one catastrophic event. During series of experiments with the pulsed MHD generator relative portion of more weak seismic events, its clustering, and seismic activity of the region increase. For verification of field results and to clear a possible mechanism of interaction of electromagnetic field with rocks under stressed conditions various laboratory experiments have been performed. The experiments were carried out under the biaxial compression in models composed of sand and cement. At different stages of loading of the models series of measurements of acoustic activity (AE) were conducted, each of them included repeated cycles of electric actions, applied to the model. The two modes of electrical action were realized: repetitive pulse train with pause between and single electrical pulse. It was established that electrical impact results in increase of AE in both cases. All results obtained by field and laboratory experiments pointed to a possibility of application of electromagnetic pulses for earthquake control by regulation of seismic flow and release of energy accumulated in the Earth crust in the form of weak seismic events.

Keywords: *tectonic stress discharge, earthquake control*

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1. Introduction

Today there are many patterns of seismicity triggered by various natural and man-made impacts like lunar-solar tides, strong earthquakes, magnetic storms, liquid injection into faults, oil field development, and underground nuclear/chemical explosions [1, 2]. Both natural and man-made triggered seismicity results in release of tectonic stresses accumulated in the Earth crust and change of natural seismic flow. Recently a new phenomenon of earthquake triggering by electromagnetic pulses generated by magneto-hydrodynamic (MHD) power system has been discovered [3, 4]. In combination with natural triggering factors this phenomenon may be considered for managing the seismic activity and prevention of catastrophic seismic events. The controlled electromagnetic (EM) discharges have the obvious advantage over another triggering/control tools like high-power explosions, vibrations, etc., because they are easy to manage and more environment-friendly.

2 Field experiments on electromagnetic monitoring of the Earth crust

The institutes of Russain Academy of Sciences (Joint Institute for High Temperatures, Institute of Physics of the Earth, and Research Station in Bishkek, Kyrghisia) performed electromagnetic monitoring of the Earth crust in the areas of Garm (Tadjikistan) and Bishkek (Kyrghisia) geophysical proving grounds for reveal of earthquake precursors based on variation of electrical parameters of rocks before strong seismic event (Fig. 1). The high-power electromagnetic pulses of 2-10 s duration were produced by MHD generators (Fig. 2) and injected into emitting dipole, which has electrodes embedded into the earth at a distance of about 4 km. Generated electric current of MHD power system "Pamir-2" in the electric dipole achieved 2.5 – 3.5 kA.

An effect of high-power electromagnetic pulses of magneto-hydrodynamic (MHD) generator on the seismic regime over Pamir (Fig. 2) and the Northern Tien Shan (Fig. 3) regions has been discovered [5]. It was found that occurrence of local earthquakes after firing runs of MHD generator became higher than before them. An increased level of seismic activity was observed within 3 to 6 days after the firing runs. It was suggested that electromagnetic pulses result in discharge of energy accumulated in the Earth crust due to tectonic deformation processes. The energy discharges in the form of series of relatively weak earthquakes instead of one catastrophic event. Detailed analysis of seismicity of the Northern Tien Shan shows that the electromagnetic impact of MHD generator pulses results in deep and prolonged alteration of seismic process in the region under study and adjacent territories. During series

of experiments with the pulsed MHD generator relative portion of more weak seismic events, its clustering, and seismic activity of the region increase.

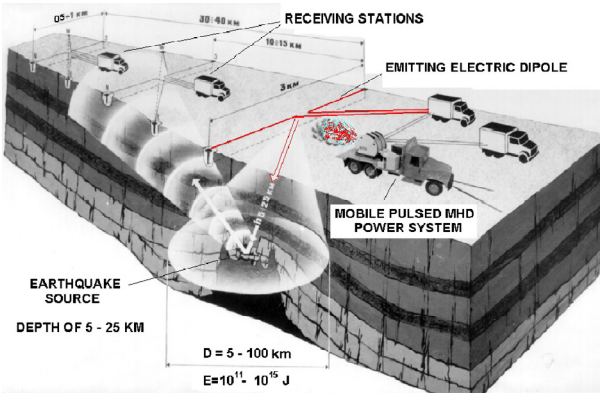

Fig. 1. Diagram of the Earth crust electromagnetic monitoring with application of pulsed MHD generators. (Earthquake Prediction Program, Pamirs mountains, Northern Tian Shan, 1978-1990).

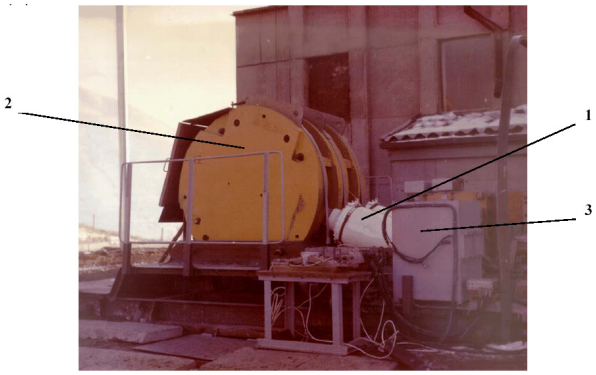

Fig. 2. Pulsed MHD generator installed at Bishkek geophysical proving ground (Kyrgysia, Northern Tien-Shan); 1 – solid propellant plasma generators; 2 – magnet system; 3 – electric switching equipment

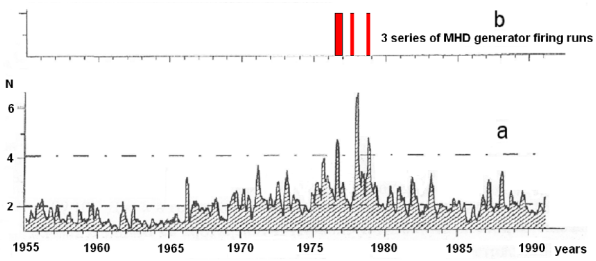

Fig. 3. Correlation of earthquake number per day with three series of firing runs of MHD generator at Farm geophysical proving ground (Pamirs mountains)

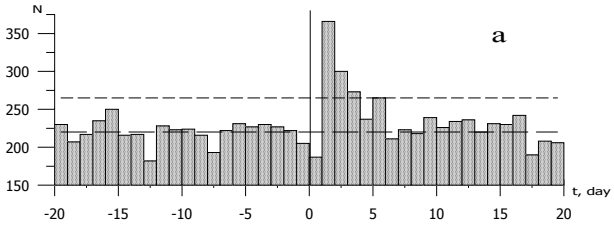

Fig. 4. Variation of average daily earthquake number of Northern Tien Shan and adjacent areas before (t<0) and after (t>0) MHD generator firing run at Bishkek proving ground.

3 Laboratory experiments

For verification of field results and to clear a possible mechanism of interaction of electromagnetic field with rocks under stressed conditions various laboratory experiments have been performed. The experiments were carried out under the biaxial compression of halite (Fig. 5), granodiorite (Fig. 6), and Westerley granite (Figs. 7-8) samples [6, 7]. At different stages of loading of the rock samples series of measurements of acoustic emission (AE) were performed, each of them included repeated cycles of electric actions applied to the tested sample. Two modes of electrical action were realized: repetitive pulse train with pause

between the pulses and single electrical pulse. It was found that electrical impact results in increase of AE in both cases.

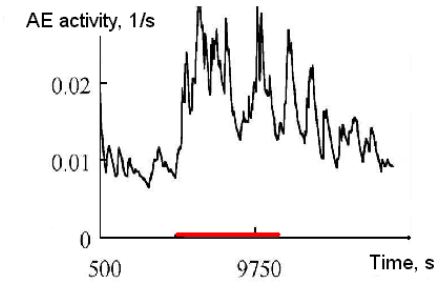

Fig. 3. Acoustic emission of halite sample for action of rectangular electric pulses during 4800-10800 s (shown by red color). Pulse amplitude 60 V, duration 5 μs, frequency of pulse repetition 2 kHz.

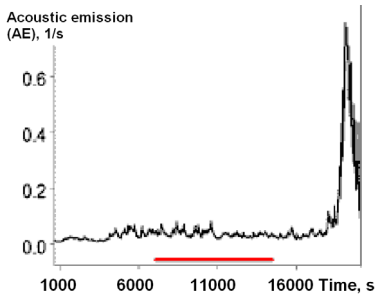

Fig. 4. Acoustic emission of granodiorite sample for the following parameters of electric action: frequency 2 kHz, pulse duration 5 μs, amplitude 60 V, action duration 7000-14200 s (shown by red color).

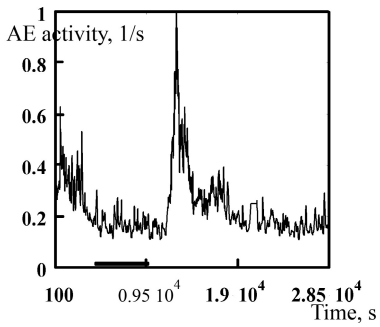

Fig. 5. AE activity of Westerly granite. Solid line denotes period of action of magnetic field (frequency of pulses 4 kHz, magnetic filed ~ 10^{-2} T).

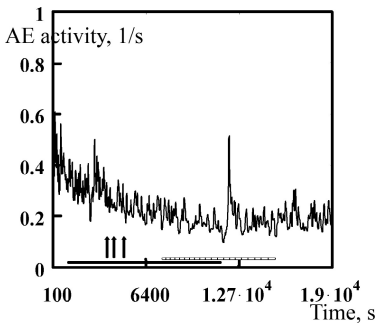

Fig. 6. Test conditions see in Fig. 6. Dotted line denotes action by unidirectional pulses of frequency 2.9 kHz and amplitude 100 V. Application of electrical discharges are shown by arrows (amplitude up to 1 kV).

All results obtained by statistical analysis of field experiments and laboratory testing pointed to a possibility of application of high-power electromagnetic pulsed for earthquake control by regulation of seismic flow and release of energy accumulated in the Earth crust in the form of large number of not dangerous seismic events.

4 Conclusions

- Analysis of seismic activity of Garm and Bishkek geophysical proving grounds shows an influence of high-power electric pulses on seismic flow.

- Laboratory experiments prove as well an impact of electric pulses on intensity of acoustic emission of rock samples under metastable state.
- Energetic estimations provide a basis of assumption of trigger mechanism of impact of electric pulses.
- For determination of physical nature of the discovered phenomenon additional laboratory and field experiments are required.
- The obtained results may be used as a background for development of technology of earthquake hazard mitigation based on release of tectonic stresses by physical actions on the Earth crust.

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