Effect of vibro-impact exposure on intensity of geodynamic events in rock mass

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Abstract. Effect of vibrational impacts on rockburst-hazardous iron ore body and enclosing rocks is experimentally studied using the microseismic, electromagnetic, acoustic and electrometric methods. The nature of the change in the intensity of electrical resistance, and in electromagnetic and acoustic signals in a series of impacts is determined. The variation in the amplitude dispersion of spectral components of signals at different frequencies is described.

Iron ore mining operations in Gornaya Shoria are scheduled for the transition to levels below 1000 m below ground surface in the nearest future. As a result of mining, for instance, at Tashtagol deposit, large areas of subsoil are changed quantitatively and technologically altered rock masses are generated. As a consequence of different rate of destruction, such altered rock masses contain zones where properties of rocks and, thus, geomechanical behavior differ from the initial conditions [1, 2].

In deeper level mining, it becomes important to understand geodynamics of rocks under induced factors since blasting and stoping result in restructuring of rock mass and, accordingly, in accumulation of energy of such external influences. In this connection, it is necessary to analyze rock mass behavior with regard to the nature and rate of the technological impact with the purpose of predicting and preventing rock burst toward safety of mines [3]. At the same time, it is of the current concern to study the influence exerted by long weak dynamic shock actions on stress-strain state of rock mass with subsequent reduction in the shock action intensity in the influence zone of mining operations, or at the redistribution of impacts deeper inside rock masses [4–6].

The experimental studies were carried out at Level –350 m in cross drift 8 at a depth of 800 m below the ground surface in Vostochny site of Tashtagol deposit (Figure 1). Vostochny site ore body is composed of magnetite with the admixtures of quartz, calcite, chlorite, epidote and other minerals. The horizontal thickness of the ore body is 15 to 60 m and more. The dip angle varies from 70 to 90°. B the dynamic source of P-waves is a compression vacuum percussion machine (CVPM). The specification of the machine is given in the tale below, while Figure 2 shows its physical view.

The details of the machine operation in the experiments [7], and trials of CVPM machines are described in [8, 9].
Figure 1. Arrangement of cross drift 8 at Level –350 m: 1—ore; 2—syenite; 3—skarn; 4—fault; 5—fractures; 6—dykes; 7—geological exploration wells.

At the location site of CVPM, dynamic impact recording used the methods of microseismicity and electrometry, and electromagnetic an acoustic emission. It was found that the percussion action induced shocks within the classes of energy from 2 to 2.4 in cross drifts 9 and 10 (center).

Table 1. Specifications of CVPM

| Description                                      | Characteristics                  |
|--------------------------------------------------|----------------------------------|
| Power drive:                                     | CVPM 1 model                    |
| –basic                                           | Electric                         |
| –power, kW                                       | Original                         |
| –weight, kg                                      | 2                                |
| Process chamber                                  | 4                                |
| Compression and vacuum unit air lines used to    | Vacuum                           |
| generate impacts                                 |                                  |
| Body material                                    | Polyethylene                     |
| Elastic reverse                                  |                                  |
| Length of power stroke of hammer, mm             | 1300                             |
| Inner diameter of the body, mm                   | 200                              |
| Hammer weight, kg                                | 40                               |
| Unit blow energy, J                              | to 300                           |
| Blows per minute                                 | 50–60                            |
| Control mode                                     | Automatic                        |
| Percussion angle, deg                            | –90°                             |
| Weight, kg                                       | 56                               |
Figure 2. General view of compression vacuum percussion machine CVPM.

Figure 3. Variation in EME and AE under series of impacts. The first three peaks are obtained under percussive treatment of rock without sandy gravel; the last two peaks—rock with a sandy gravel layer 1 cm thick (particles to 10 mm in sizes).

Concurrently with vibro-treatment, electrometric sounding was carried out in rocks mass. The electrometric measurement at a depth of 2 m showed electrical resistance of 0.35 Ω·m before the vibro-treatment and 31 Ω·m after the treatment. The electrical resistance increased owing to “opening” of cracks. However, due to low energy of blows, no considerable increase was recorded at all measurement point (an average increase in the electrical resistance made 1.8 and 3 times).

The percussive excitation of electromagnetic signals was modeled physically. The aim of the modeling was to find variations in the intensity of EME under continuous acoustic excitation pulses generated by initiation, growth and manifestation of geodynamic events. At the level above (~280) m, neither blasting, no first or second mining was performed. The percussion machine had blow energy of 300 J and frequency 1 Hz. The electromagnetic signal recording used EM detector REMS-1 with the EM signal amplitude averaged to 1 s and REMAS-1 with the EM signal amplitude averaged to 10 ms.
EME was received using induction pickups. Figure 3 illustrates EME and AE intensity by the data of detector REMS-1 during a series of hammer blows in rocks.

Initially a series was not less than 20 blows. Specific number of blows is seen in Figure 4.

![Figure 4](image-url)

**Figure 4.** The last 8th expanded fragment of measured dispersion in the amplitude of spectra of electromagnetic signals in rocks at the frequencies of 1 (1) and 13 (2) kHz in the first series of hammer blows.

Analysis of the electromagnetic and acoustic emission measurements and dispersion of amplitudes of the selected spectra of electromagnetic signals generated by a series of hammer blows reveals an interesting pattern. In the beginning of the series, the amplitudes of EME and electromagnetic signals grows (Figure 4), then distribution of the amplitude takes place to a certain value and is sustained over the whole time period of the blow series. It is highly probable that subsequent blows (or shocks) excite new electromagnetic response in rocks and the previous blows maintain the emitting rock excited, and the level of amplitudes of electromagnetic signals lowers against the background of residual excitation field.

The dispersion of amplitudes is measured in the selected spectra of electromagnetic signals at the frequencies 1 and 13 kHz from the records obtained by detector REMAS-1 with the amplitude averaging at 10 ms.

Thus, the vibro-percussion treatment has an influence on initiation and manifestation of geodynamic events in the form of shocks with an energy class from 2 to 2.4, variation in the electrical resistance from 1 to 31 Ω·m and dispersion of amplitude of electromagnetic signals at the frequencies of 1 and 13 kHz with the amplitude averaging to 10 ms.

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