RESULTS OF SEISMIC STUDY ON THE UPPER PART OF THE SECTION AT SEMIPALATINSK TEST SITE AREA (FOR OSI PURPOSES)

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Underground nuclear explosions (UNEs) forming the areas of enclosing geological media disintegration with different size and configuration (Figure 1) caused dead cavity (radius 10÷13.6 m/kt), zone of rock fragmentation (to 24÷34 m/kt), zone of intense fracturing (to 50÷85 m/kt), zone of block fracturing (to 65÷100 m/kt), and spill zone which is observed at epicentral distances to 100÷200 m and on depth 10÷20 m (Murashkin and Spadil, 2014). Table 2 presents the results of the seismic study of one of above mentioned zones—spall zone, marked by red color on Figure 1. The spall zones, as usual, form for all the UNEs, conducted in standard technical-geological conditions. All spall zones are simple to reveal because of their shallow depth and visible by the human eye, so, they could be one of the main target objects during OSI fulfillment. In 1997 a seismic first-arrival method of observation was applied at a UNE area in Semipalatinsk Test Site (STS) in order to study velocity properties of the geological environment of the spall zone. Seismic observations were conducted on the site 6000 ÷ 3900 m of size, consisting of eight parallel profiles (Figure 2). The distance between the profiles was 500 m, and shot point and observation interval was 125 m. For the purposes of seismic energy injection, chemical explosions with the charge of up to 40 kg were used.

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Seismic waves' rays by the travel time curve segments of tracing in the surroundings of first arrivals [Belyashov et al., 2013]. As a result, layered-gradient models have been obtained, with lateral changes of velocity in the isolated layers, which are observed in narrow zones, emphasising the spall structure. Low velocity zone (LVZ) has a velocity of 1.4 km/s (interval between seismic receivers of 125 m does not allow obtaining the data on velocity at LVZ) in all profiles and its thickness is increasing from 5 to 125 m. At the beginning of the profiles the velocity slowed down to 3.0 km/s corresponds to soft Jurassic deposits, bordered by spillage fault from carbonaceous deposits of Paleozoic basement.

Figure 3. 3D velocity sections along the seismic profiles. Projections of emplacement boreholes are shown for the profiles with borehole number and point on explosion in Kt. Red color denotes the borehole distant from the profile no more than 450 m, blue – at 450÷900 m. Thin lines represent velocity discontinuities (km/s), thick lines - seismic boundary.

The building of constructed sections is determined by sharp changes of the apparent velocity, correlated along the profiles whereas the gradient – by the regions of the travel time curve segments and tracing in the surroundings of first arrivals [Belyashov et al., 2013]. As a result, layered-gradient models have been obtained, with lateral changes of velocity in the isolated layers, which are observed in narrow zones, emphasising the spall structure. Low velocity zone (LVZ) has a velocity of 1.4 km/s (interval between seismic receivers of 125 m does not allow obtaining the data on velocity at LVZ) in all profiles and its thickness is increasing from 5 to 125 m. At the beginning of the profiles the velocity slowed down to 3.0 km/s corresponds to soft Jurassic deposits, bordered by spillage fault from carbonaceous deposits of Paleozoic basement.

According to experimental data it is known that the thickness of spall zones is proportional to the yield of underground explosions. In this connection it is of great interest to study this correlation based on obtained seismic data, which will confirm the justification of the solution of spall layer. Data in this respect is presented in Figure 6, where a high-level correlation is characteristic of the domain number of data. However, the data on seismic boreholes sharply deviates from such a correlation. Basement rocks uncovered by the boreholes with deviating values are characterized by anomalous strength parameters (Young modulus, tension and compression capacity) that impact the thickness of spall areas. Hence, the obtained trend can be considered as reasonably sufficient and it can be used when assessing seismic thickness of spall zones at other regions of the Semipalatinsk Test Site.

Figure 4. Examples of comparison of velocity values based on laboratory measurements on the samples from boreholes prior to explosions (black dashed line) with the results of seismic observations (red lines).

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Figure 5. Maps of spall layer thickness (a) and distribution of velocity values at its base (b). Red stars denote UNE boreholes. Black diamond shows deviant values.

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Figure 6. Dependency of spall area thickness on the charge weight. Black diamond shape denote anomalous (with the number of a borehole) ones. Black line represents approximating curve segments of tracing in the surroundings of first arrivals [Belyashov et al., 2013].