EVALUATING THE RESIDUAL LIFE OF SALT PILLARS

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Introduction

A massive cave-in occurred on January 5, 1995 in worked-out chambers of the Second Solikamsk Mine of the Verkhnekamsk Potassium-Salt Deposit — the largest such deposit in Europe. The area of the cave-in was 0.3 km². A crater up to 5 m deep was instantly formed on the surface, and open cracks were formed at the crater's edges. Seismic stations — the closest of which was 400 km away — recorded the event as an earthquake with a magnitude of M-3.8.

The underground mining of water-soluble ores requires that measures be taken to prevent water from entering the workings, since that can lead to the destruction of potassium and salt mines. Worldwide, there have been more than 80 such mines that have been inundated when water located above the salt deposit accidentally entered the excavation. To ensure the integrity of the water-confining pillar, i.e., the water-protective stratum (WPS), a chamber system of mining in which "rigid" or "compliant" pillars are left in the mine is usually used in salt and potassium deposits. "Rigid" pillars retain their load-carrying capacity for the entire life of the mine, while "compliant" pillars are destroyed with the transition to the supercritical regime of deformation.

Two productive seams had been fully mined and three seams partially mined on the section where the cave-in occurred, with "rigid" pillars having been left between the chambers after mining operations. The widths of the chambers and pillars was 11 and 16 m, respectively. The total thickness of the bed that can be mined is 9 m with two-seam excavation and 14 m with three-seam excavation. Stoping on the given section of the mine area was done over the period 1976-1991.

The massive cave-in was the largest in the 60-year history of the mine. Never before had such significant subsidence of the ground surface been observed in that area, much less subsidence of that magnitude that took place instantaneously. Naturally, the first problem that had to be addressed after the accident was eliminating its consequences. Experts in various fields were dispatched to the site to analyze the change in the condition of the WPS layers, evaluate the extent of their fracture as a result of instantaneous strains of the rock mass, and determine the next sections where the excavated space should be filled. With these goals in mind, studies were made of the load-carrying capacity of the pillars on a section immediately adjacent to the region of the cave-in.

1. Measurement of the Stresses Acting in the Pillars. To estimate the load-carrying capacity of the pillars and evaluate the change in their stress state with increasing distance from the boundaries of the cave-in, we chose three experimental sections on sylvinite bed AB in northeast panel II (Fig. 1).

The first section (chamber 103) was located near the site of the accident (95-100 m from the boundary of the cave-in). Fractures were observed in the sylvnite and the clay projections from the roofs of the rooms. Intensive swelling accompanied by the formation of subvertical cracks occurred in the floor. The walls of the pillars were subdivided by cracks, which indicates that these walls (or at least their end regions) had undergone the transition to the supercritical state.

The second section (chamber 120) was located a distance from the cave-in roughly equal to the depth of the productive seams (about 300 m). Most of the pillars between the chambers were fractured, and layers of rock had separated from isolated areas of the roof. There were no visible fractures in the pillars between the passageways.

The third section chosen for study (chamber 137) was a substantial distance (more than 500 m) from the boundary of the cave-in region. No visible changes were seen in the condition of the workings after the accident. The pillars between the chambers were in satisfactory condition.

The stresses in the inter-chamber pillars were measured by two methods: compensation and slit unloading. The compensation method entails reconstructing the strains in the contour region of a previously unloaded rock mass [1]. This is one of the "direct" methods used for stress determination, making it unnecessary to use model assumptions when changing over from measured unloading strains to acting stresses.

Partial unloading of the rock mass was done using a plane horizontal slit made in the wall of the pillar (Fig. 2). We reconstructed (compensated for) the acting stresses by loading the surfaces of the slit with plane hydraulic jacks. The level of the reconstructed stresses was determined by the magnitude of the unloading strain that had to be compensated for during the loading of the slit. The pressure in the hydraulic system of the jacks corresponded roughly to the stresses in the contour rock before unloading [1].