EVALUATION AND ZONING OF GROUND INSTABILITY RISK IN SALT MINING AREAS (OCNA DEJ CASE STUDY)

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Introduction

The instability phenomena generated by salt mining provide in time strong economical and social impact in the mining areas, sometimes having hazard potential: water infiltration in active or abandoned mining works, landslides, geomechanical interaction between old and contemporary works, underground or/surface subsidence, sometimes with spectacular subsidence effects due to sudden falling of the roofs. Large sinkholes formed at the surface determine afterwards their natural or artificial backfilling or generate salt lakes. These phenomena affected both salt mining and the environment and also human activities in the influence zones.

The Ocna-Dej salt deposit has a tabular shape with some variation in thickness. The salt formation (middle Badenian) with a breccia at its upper limit lies between the Dej Tuff (lower Badenian) and an upper Badenian sedimentary complex consisting of marls, clays, and thin intercalations of tuffs. The first mining works for salt in the Ocna-Dej region date from the Dacian-Roman period (100-200 a. C.), but the industrial scale mining of salt started in the 17th century, when new mining methods were adopted, with large, bell-shape exploitation rooms, reaching 100 m height and 45-50 m in diameter. Due to the geometry of such rooms and in accordance with the geomechanical parameters of the salt and the geomechanical conditions in the location area, most of the voids determined by the mining works were preserved until present time. Some of these rooms were flooded by the intrusion of the water from an aquifer located at the salt floor and/or were filled by anthropic and natural filling. Beginning with the 19th century the mining was performed by square rooms and pillars method and the new mining works often intersected those operated in earlier times. To evaluate and classify the ground instability risk, diagnosis and then prognosis of the instability phenomena are proposed as main tools.

1. Diagnosis of the instability phenomena

1.1. Geomorphologic elements

- Subsidence depressions and sinkholes: Stefan mine sinkhole (Fig. 1), past lake, now backfilled with sterile, Mina Mare sinkhole lake Fig. 2), Iosif mine depression, past swimming pool, now backfilled, Ferdinand (23 August)-Ciciri sinkhole (Fig. 3), still in evolution from 1998.
- Landslides: were evidenced by geomorphological features, like minor scarps, transverse ridges, radial cracks, crumpled topography, isolated swamps or ponds and by electrometric measurements. These phenomena are located generally between Ferdinand and Mina Mare mines, being determined by the ground morphology and the mining subsidence in the area (Fig. 4).

1.2. Tectonic elements
An intense fracture zone has been revealed in the gallery 1 Mai, between meters 520-640, vertical and N-S oriented. This major element has been confirmed by electrometric measurements. Other fracture lines have been cited in the documentations of the mines Stefan and Iosif.

1.3. Instability elements deduced by geoelectric and seismic measurements
- Linear ruptural elements. These elements represent planar ruptural elements, determined by the interpretation of planar anomalies (anomal gradients) from maps and sections of apparent resistivity, correlated with the seismic data. They are oriented mainly NW-SE and are both tectonic elements, or subsidence plans.
Circular ruptural elements. They represent electrometric and seismic anomalies, interpreted as local structural modification of the salt massif due to denivelations on the salt back or due to collapse of the roof of the old bell-shaped mines, not always reflected by the ground morphology (Georgescu et al., 2000, Marunteanu et al., 2002).

The localized underground openings have been confirmed by geoelectric measurements and besides, at least two unknown old mines have been localized by the geoelectric mapping: Old mine 4 and Old mine 6 (confirmed by the drilling L7-IGG) (Fig. 5).

Fig. 5. Map of the ground instability due to mining subsidence.

2. Prognosis of the instability phenomena and effects on the environment and human activities

2.1. Instability in evolution, high risk zone (A). The zone of mines Ferdinand and Ciciri, with the sinkhole "Ciciri" (Fig. 6) and developing subsidence, water infiltration and landslides.

2.2. Partially stabilized zone, but with potential risk of subsidence and collapse (C, D).

- The area of the old mines Mina Mare, Stefan, Vechi 1, 2 and 3 (zone C) is characterized by the backfilling of the mine Stefan and the developing of the lake Mina Mare. The risk of subsidence, hidden sometimes by the surface slidings, including the potential collapse of the old mines, even colmatated, the risk of landsliding and the risk of water infiltration, increased by the presence of the lake, are the main risks of the area. Any construction or elements on risk must be prohibited.
- The area of the administrative buildings and old mines Iosif and Vechi 4, 5 and 6 (zone D) is characterized by the flooding and partial filling of the mine Iosif (one bell-shaped and large rooms openings). This situation and the oldness of the mine (the XVIII-XIX century) make any construction not allowed in this zone. The other old mines (with circular contour) represent a certain risk for developing constructions due to their approximately location or even their unknown existence (see the mine Miron, affecting partially by differential settlement the main building of the salt mine Ocna Dej). The extension of the buildings is allowed after a deep exploration (by geophysical methods and drillings) of the ground.

2.3. Stable zone but with long term instability potential (B). The zone of the mine 1 Mai and gallery Transilvania is defined by a thicker salt roof and sterile cover comparing with the other zones. However, some instability phenomena (fractures and deformations, water infiltration) have been revealed in the mine and at the surface by mining, geoelectric and displacements measurements. The area is habitated and the displacement monitoring must continue.

References