MONITORING AND DOCUMENTATION OF FLAKING-OFF PHENOMENA IN THE HISTORICAL JERONÝM MINE

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ABSTRACT
The medieval Jeroným Mine is a mine working in which places of various degrees of rock mass disintegration are there. Time-lapse recording, which has been performed in the Jeroným Mine since the year 2009, was induced by a necessity of documenting both areas of flaking-off and caved areas owing to an increased rate of occurrence of flaking-off phenomena in mine workings – rooms K3 and K4 of this mine. The methodology of recording, which uses as a basis repeated recording in time in the framework of geotechnical measurements carried out quarterly, is based on the principle of maintenance of not only parameters of images themselves, but also of location of a photo device used for documentation provision. This process is followed by the creation of information sheets of areas of flaking-off and caved areas and their classification. The method of recording was used owing to a high degree of disintegration of the rock mass in selected mine workings, a possibility of extension of caved areas and also the high rate of occurrence of subsidence phenomena occurring above those workings and even sporadically reaching the mine workings. Time-lapse recording is thus performed primarily in mine workings with reduced stability, situated very close to the surface. With regard to the principle of this method, results will be known only in further years.

KEYWORDS: visual monitoring, Jeroným Mine, flaking-off, caved areas

Note 1:

Documentation and monitoring is considered as the documentation of flaking-off phenomena (pasportization) and their monitoring, because of the sizeof decline, vastness falls and the high degree of distress of the mountain massif. With regard to the spatial situation in the underground the monitoring phase of the works was initiated. Due to the destruction of mine workings, in which the mountain massif is reeling and ceilings are very surcharged the failure of retaining pillars in so far stable parts of the mine may occur.

INTRODUCTION

One of the methods of visual observation used in the observation of time and space changes in the rock mass of Jeroným Mine is the method of time-lapse recording. The time-lapse recording method itself consists in the repeated recording of an object of interest in time with the maintenance of constant parameters of a photograph. This method makes high demands on the accuracy of recording because it is desirable to create identical images.

The basis of this method is the installation of a fixed stand mounted on the ground in a way excluding any change in position due to fastening the photo device and other manipulation. The device is equipped with a three-way head for the precise grab of a camera, enabling the adjustment of the camera (front and side angles) in small steps with a possibility of reading the adjusted position values. The camera itself will be equipped with a sled assembly for possible attachment of an external flash. A precondition is also the provision of unvarying lighting of the given space. The position of light sources will be, in consideration of light source output, a subject of primary test measurements for ensuring unvarying lighting and avoiding image degradation due to different illumination (plasticity effect). As well, to prevent reflection on the lens, it is desirable for subsequent recording to define exactly a distance between the light source and the camera.

A precondition for this method is necessary hardware and software as given below.

HARDWARE

- A ground-mounted fixed stand with a possibility of fastening of a tripod head
- A three-way head for the grab of a camera
- A high-resolution camera enabling the creation of viewports at quality preservation, with a possibility of manual mode setting and external flash attachment

Fig. 1 A cross line laser in room K4.

- A remote shutter trigger
- A 1000 W, or 2000 W lighting system with a possibility of regulation of light output, e.g. a 500 W halogen reflector DUO Telestativ
- Cross line laser level with plumb function (Fig. 1)
- Digital laser rangefinder
- A stereo adaptor for the stereophotography method
- 3D goggles
- Tools and equipment for the production of the fixed stand (bars, angular grinder, extension cables, level tube, and others).

SOFTWARE

- **Photo-editing software** with a possibility of format editing and conversion **RAW** (e.g. **Digital Photo Professional** from the company Canon)
- software for image comparison by image information, not by parameters, **Exif** (*Exchangeable image file format – metadata embedded into a photograph by a digital camera)* contained in each image, e.g. **Image Comparer** or software based on **MUFIN** (Multi-Feature Indexing Network), **CBIR** (Content Based Image Retrieval), **SIMPLIcity** (Semantics-Sensitive Integrated Matching for Picture LIbraries), and other technologies.
- software for spatial image (anaglyph) creation, e.g. **Anaglyph Maker.**

PRINCIPLE OF IMAGE COMPARISON METHOD

From the point of view of photography, image creation itself consists in the maintenance of the following parameters:

- focal length
- aperture
- exposure time
- sensitivity (ISO)
- exposure mode
- angle towards the recorded object (roof, fissure, etc.).

After creation of images or series of them (images can also be created electronically using a notebook and data can be compared in situ (this function must be supported by the digital camera), we shall proceed to the **check of images on a computer** according to Exif information (sensitivity, exposure time, focal length, flash use information, and focusing distance) to be sure of maintenance of all parameters as in previous image creation. In the case of different parameters, we shall edit the image in RAW editor (digital exposure compensation (image brightening or darkening): +/-2 EV in 0.1 EV step, white balance, contrast, colour saturation, colour hue, sharpness, colour space), but on the assumption that the focal length and the angle towards the recorded object are maintained. If not, the image is excluded from comparison.

After completing the check of image parameters, the check of images by software instruments using the method of comparison by observing changes in image information, follows, then image subsequent evaluation and large format printing regardless of the fact whether or not images from previous photography measurements are identical. If the images are not identical we shall proceed to a backward check of the images by means of large-format photographs. If the analysis of these images confirms that the recorded objects (caved materials, flaked-off

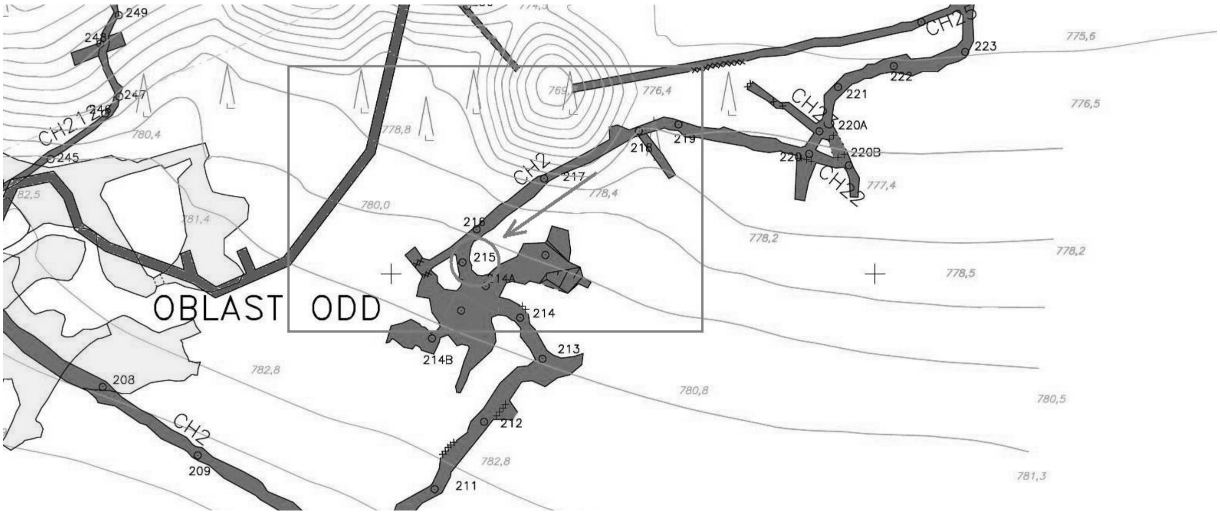

Fig. 2 Caved area in the passage CH2.

Fig. 3 Impassable caved area near the measuring point No. 215.

materials) differ in spatial layout, the places concerned will become a subject of metric, convergence and other accompanying measurements.

STEREOPHOTOGRAPHY

When observing the time and space changes concerning places with reduced stability (pillars), the **stereographic** method, namely the photographic technique that makes it possible to capture spatial sensations, can be applied (Boháč, 2009). In the framework of this method, anaglyphs will be created – a stereoscopic technique making it possible to perceive images spatially. This method utilises the decomposition of images for both the left and right eye into colour components, and the overlapping of them into one photograph.

The principle of the method is identical with that of the method mentioned above. A difference consists in the use of stereo adaptor and the double number of images, because this method requires the other image to be shifted in the horizontal plane in relation to the recorded object by about 6 cm.

DESCRIPTION OF PLACES OF INTERESTS IN THE JERONÝM MINE

In the Jeroným Mine there are several places that will be the subject of visual observation and subsequent study. They are the places in which occurs a considerable amount of materials flaked off from the roof (Žůrek et al., 2008) and/or materials caved in, which are expected to be eluted by the influence of intercepted water; for description see below (description of places is made from the adit level to the uppermost parts of Jeroným Mine).

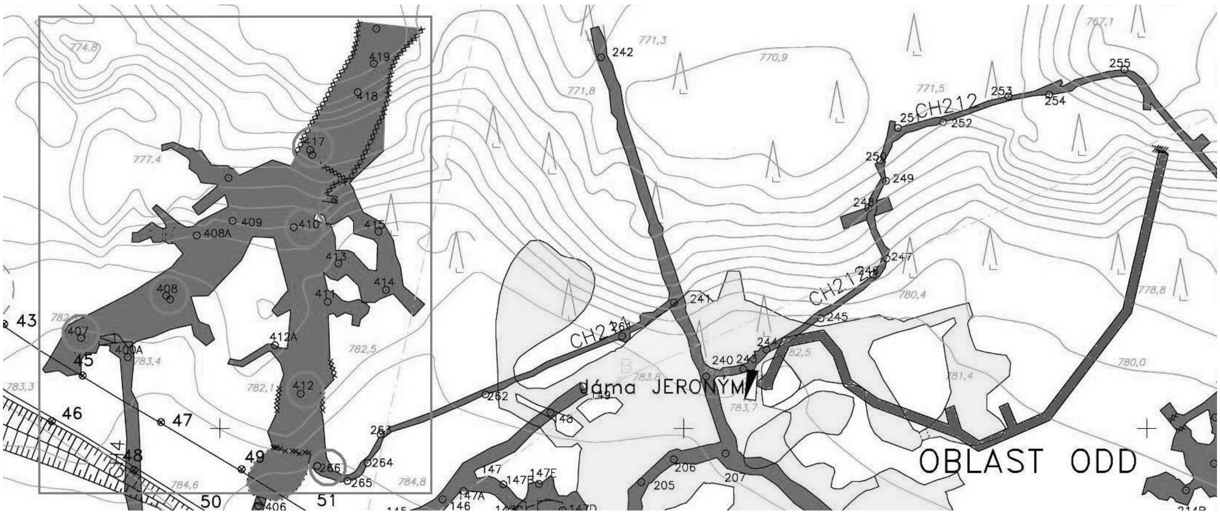

Fig. 4 Room K3.

Fig. 5 Flaked off material in room K3.

1. *CAVED AREA IN PASSAGE CH2*

A large caved area with a considerable amount of caved materials in the right wall of passage CH2 (Fig. 2). It is probably the case of a caved room. In the passage CH2, after the observation point, a caved area and intercepted water are there (Fig. 3). From the caved area to the measuring point No. 215, a small amount of material flaked off from the roof can be found. The caved area in the passage CH2 will be documented, because eluting the caved material by the influence of intercepted water cannot be excluded. The area concerned is situated in places of marked disintegration of the rock mass, which manifests itself in numerous subsidence phenomena on the surface (Kukutsch and Stolárik, 2008). To the most significant of them, a surface depression above the passage CH25 belongs; in case of caving of the passage, the caved area in the passage CH2 may be significantly affected as well.

2. *ROOM K3*

The room K3 (Fig. 4) in the Jeroným Mine together with the room K4 are ranked among the rooms with the frequent occurrence of flaking-off and caving phenomena. The room K3 is a mine working driven upwards, in the case of which communication with the surface cannot be excluded (Kukutsch, 2008). In the part between the measuring points No. 266 and No. 412, local roof flaking-off and partially sidewall flaking-off can be seen. In K3 towards the measuring point No. 417, extensive flaking-off can be observed. The largest amount of flaked off materials along the

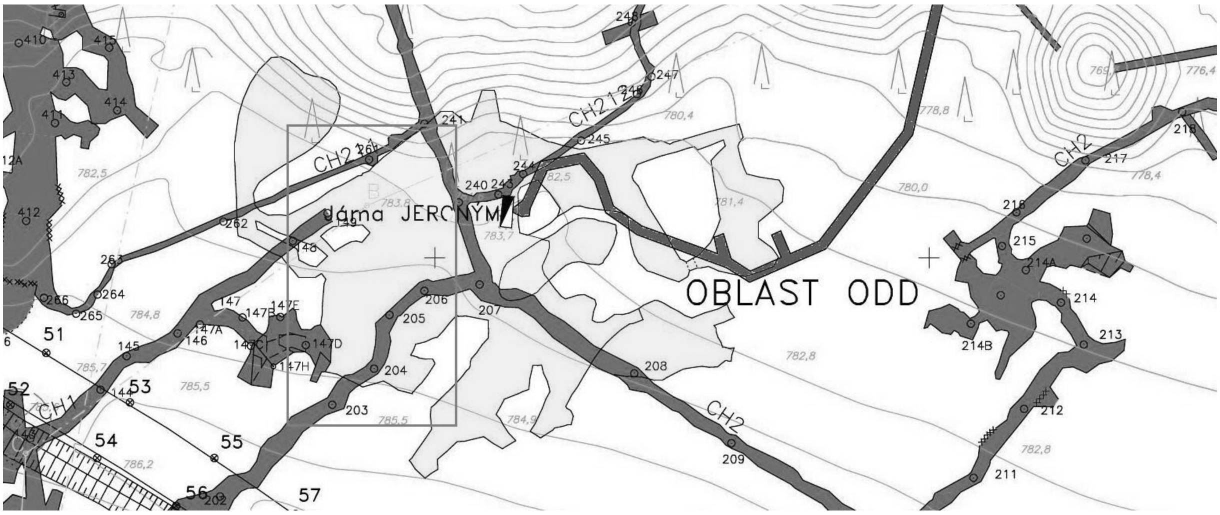

Fig. 6 NW and SE parts of room K1.

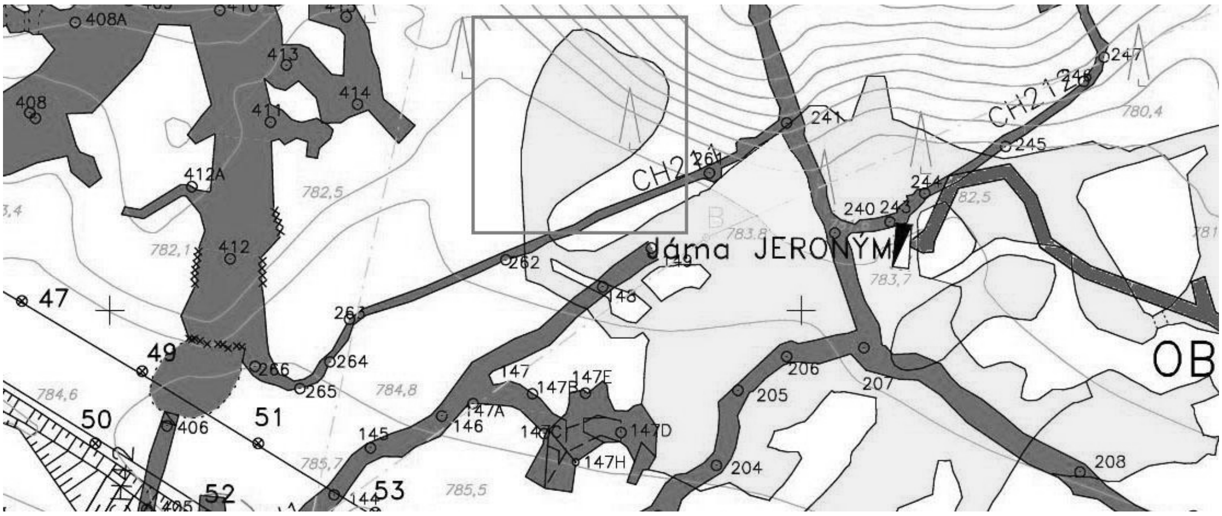

Fig. 7 Room K4.

tectonic fault can be found in the section between the measuring points No. 408 and No. 410 (Fig. 5). In the section between the measuring points No. 407 and No. 408, flaked off materials occur merely sporadically.

3. *ROOM K1*

The roof of north-west part of room K1 (Fig. 6) is damaged along the subhorizontal tectonic fault, and slabs are thus formed. The thickness of a slab is about 50 cm; that of a crack is 5 cm as a maximum. In the south-east part of room K1, a considerable amount of materials flaked off especially from roofs and parts of walls mostly along the subhorizontal tectonic fault is there. The roof parts of room K1 are, from the point of view of flaking-off, considerably instable.

4. *ROOM K4*

Into the space of room K4 (Fig. 7), two caved areas (Fig. 8) containing the gneissic material reach. This is an unmistakable sign of collapse of roofs in the mine workings situated higher that are connected with the room K1. One can assume that it is a case of caved areas that may extend as far as the surface.

With regard to the close proximity of the road No. II/210, it would be suitable to make an attempt to verify, e.g. by surface borehole exploration, the extent of expected caved areas and the possible existence of large-space mine workings not backfilled and/or not caved.

OTHER POSSIBILITIES OF UTILISATION OF TIME-LAPSE RECORDING

As far as mine water is concerned, methods of time-lapse recording can be utilized here as well. Into abandoned mine workings, besides those mine workings that are not flooded although they demonstrably reach deep below the level of flooded mine workings, flooded mine workings are included. In addition to the mine workings, in which the amount of water is minimum, mine workings with high water inflows exist (Žůrek et al., 2009). In this case, the system of time-lapse recording can serve for the recording of current state of mine water level and for the confrontation between this state and data furnished by the continuous measurement system (Knejzlík, 2006; Kaláb et al., 2009). By combination

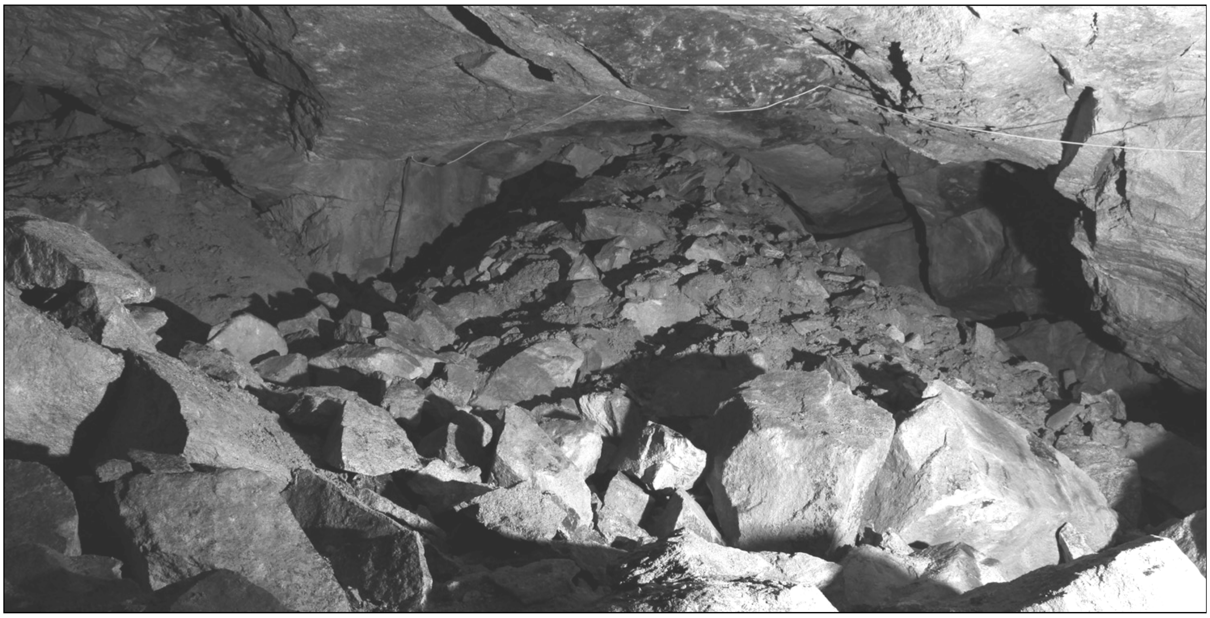

Fig. 8 Caved material in the room K4.

and evaluation of the data we obtain integrated information (image and data) on the level of flooding of a mine working.

CONCLUSION

The reason for the application of visual methods is the proper creation of information sheets and the registration of areas of flaking-off and adjacent caved areas. Here, this method seems to be applicable and very practical, because it enables the long-term observation of condition of areas of flaking-off and caved areas. A criterion for the finding of a suitable method was also the spatial layout and the extent of areas of flaking-off and also caved areas. *Based on the above criteria 9 position points were installed and the 1. series of images was made.*

The objective of the method of time-lapse recording is the development of a methodology for time data collection and the long-term observation of places with reduced stability (rooms K3, K4). This is connected with the regular provision of documentation on areas of flaking-off and that on chosen caved areas and other specific phenomena (e.g. documentation on mine water level fluctuation). If any communication of caved areas in the NW part of K1 and K4 is found, it will be necessary to document in more detail the concerned area of mine workings and to look for possible relationships, because the problems of relatively extensive caved areas above and also below accessible mine workings should not be underestimated.

Results of recording and measurements made will be included into the model of Jeroným Mine being created.

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