

## Retrospective monitoring of changes in the areas of mine-affected lands under the Klochkivskiy Quarry based on analysis of various space images

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### SUMMARY

The authors carried out field studies of the current state and production of the Klochkivskiy quarry (Mukachevo district, Zakarpattia area). It was studied the constant change in landscape of an area due to the excavation and movement of rocks in course of mining. To study trends and rates of change in the terrain, it is important to establish the dynamics of their development. Retrospectively monitored changes in the area of land disturbed by mining operations based on the analysis of time-lapse space images was carried out.



XIV International Scientific Conference “Monitoring of Geological Processes and Ecological Condition of the Environment”

10–13 November 2020, Kyiv, Ukraine

## Introduction

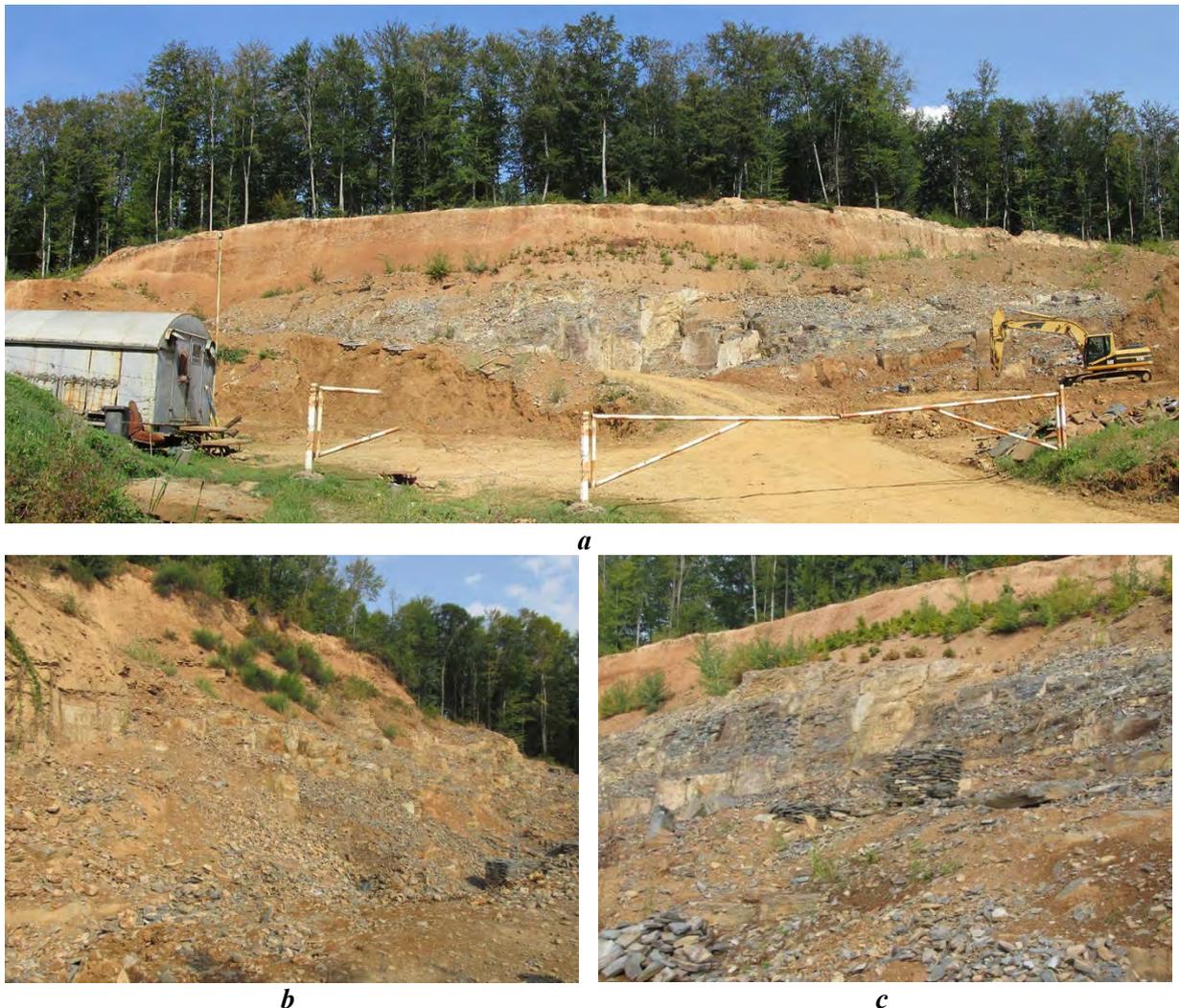
The modern state of the mining industry is characterized by significant volumes of exploration of useful minerals by open pit mining method.

In the course of open mining, the integrity of the geological environment is disturbed, soil and vegetation cover is removed within the limits of mining allotment sites, the aquifers are disturbed and became prone to contamination. It is also observed the landscape transformation, the dumps of overburden and technical reservoirs are created, that result in a number of negative geo-environmental impacts both within the mine drainage area and within the adjacent areas (Regulation act #96, 2013).

Mining is always accompanied by excavation and movement of rocks, and therefore a constant change of landscape. To study trends and rates of change in the terrain, it is important to establish the dynamics of their development. This opportunity opens up the use of multiple space images.

## Method and/or Theory

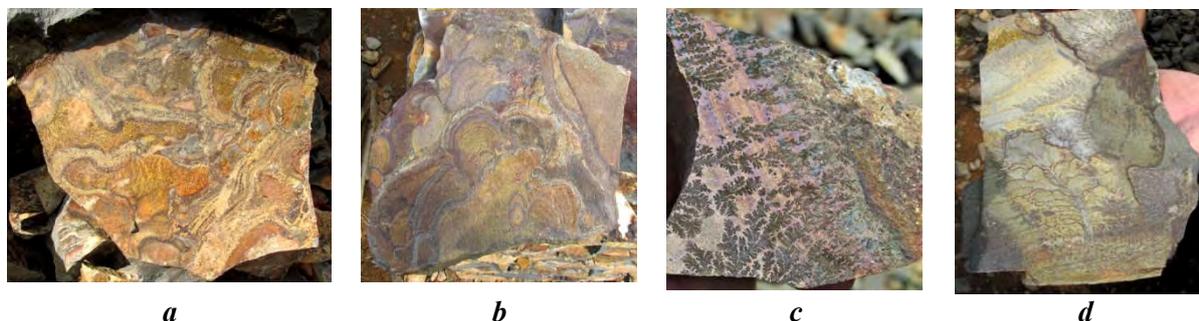
The object of the study is the Klochkivsky field of andesite-basalt, which is located in the northeast suburb of the Klochky village (Mukachevo district, Zakarpattia region, Ukraine) and belongs to the Enterprise «Emerald» (Fig. 1).



**Figure 1** Klochkivsky deposit of andesite-basalts (a) with detail of structure (b, c). Photo by M. Kovalchuk



The products of the deposit are used as facing and paving slabs, borders, paving stones, and rubble stone. Iron dendrites are widely developed in the plate-bearing andesite-basalts, which form beautiful aesthetic «landscape paintings», which significantly increases the value of rocks as a facing stone (Fig. 2).



**Figure 2** Plate-bearing andesite-basalts with patterned iron dendrites. Photo by M. Kovalchuk

It was used the Earth remote sensing data to solve the applied problems of monitoring the change of area affected by open-cast mining.

In particular, remote sensing data of the Earth in the form of images from the Google Earth system was used to determine the trend of changes in the area of the quarry, which allowed GoogleEarthPro software to analyze the change in the area of the granite quarry for the period from 2004 to 2018 (<https://earth.google.com>).

Career vectorization was carried out according to the images of 2004, 2012, 2014, 2015, 2016, 2017, 2018.

For this purpose we used "Tool" - "Show images in time". On the graduated scale with the dates of receipt of space images, which appeared at the same time, we chose the first image of 2004. Applying an instrument to "Add a polygon" in a table that was opened, entered the name of object - "Klochkivsky Quarry 2004" and set the style and color of the line (blue), and in the column "Areas" set the parameter "Contours". Then select the option "Units" and put in the column "Perimeter" - meters, and in the column "Area" - square meters. Then, using the mouse, clicking on the appropriate points, creates a polygon around the perimeter of the quarry. Automatically, the "Units" option in the "Area" column highlights the results of the quarry area measurement.

Using the movable indicator of the Add Polygon tool, find another date for receiving the space image (in particular 2012). A new space image for the date appears on the screen. In the table of the Add Polygon tool, change the name according to the date the space image was received. Using the Style, Color tool, we change the color of the line (in the case of 2012 to yellow) and repeat the operation of vectorizing the quarry and calculating its area. In this way, the quarry was vectorized and its area was calculated for other years.

### Conclusions

The highlighted algorithm for express determination of the area of objects (in our case, the quarry) from different time space images allows approximately to define the area of the object under study and establish the trend of its change over a period of time.

The use of multiple satellite images allowed us to study the dynamics of changes in the area affected by the mining of Klochkivskiy quarry. The dynamics of changes in the area of disturbed geological environment due to the extraction of andesite-basalts during 2004-2018 are presented in Figures 3 and 4 and in the table.



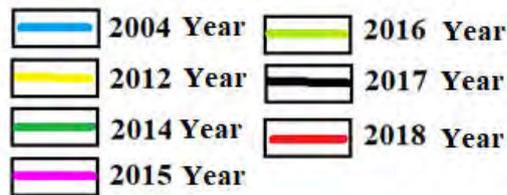
The largest increase in the area of quarry occurred between 2014 and 2015 (+6273 m<sup>2</sup>). At the period of time from 2017 to 2018, there again has been detected an upward trend in the area enlargement affected by the extraction of mineral resources (+946 m<sup>2</sup>).

In total, the area of the Klochkivskiy quarry due to the extraction of mineral resources increased by 1389 m<sup>2</sup> between 2004 and 2018.



**Figure 3** Dynamics in change of area of disturbed geological environment due to extraction of andesite-basalts during 2004-2018 for space images

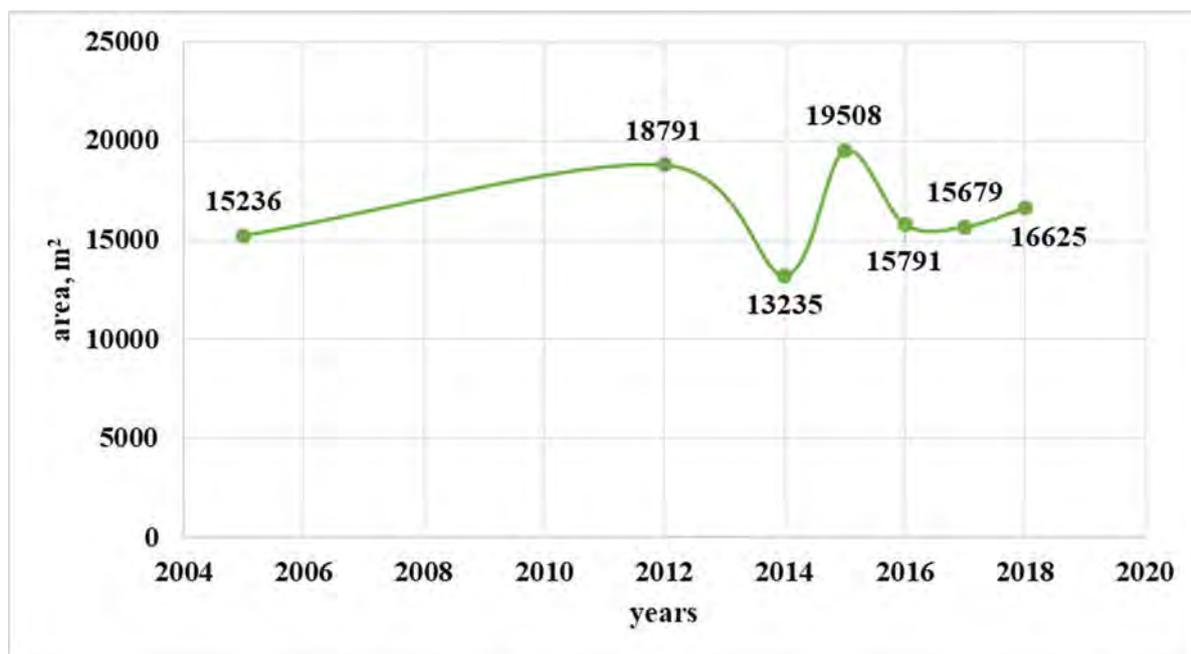
Legend:



**Table 1** Dynamics of change in area of disturbed geological environment due to extraction of andesite-basalts

Year	Area,m <sup>2</sup>	Increase in area, m <sup>2</sup>
2004	15236	0
2012	18791	+ 3555
2014	13235	- 5556
2015	19508	+ 6273
2016	15791	- 3717
2017	15679	- 112
2018	16625	+ 946





**Figure 4** Dynamics of change in area of disturbed geological environment due to extraction of andesite-basalts

The trend of increasing the area of the quarry is still observed, as new territories within the land allotment are involved in the operation.

It should be noted that during the years of quarry development, after working off of a certain area, recultivation of disturbed lands was carried out, which was reflected in variations in the area of the quarry.

Studies have shown the effectiveness of the use of different time space images for rapid monitoring of changes in the area of land disturbed by mining in an open way.

#### Reference

Regulation on monitoring and scientific support of subsoil use: approved by the Ministry of Ecology and Natural Resources of Ukraine 11.03.2013 No. 96. (2013). Ministry of Ecology and Natural Resources of Ukraine. (in Ukrainian)

<https://earth.google.com/>



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