



The abandoned surface mining sites in Czech Republic: Mapping and creating the database with GIS web application

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Abstract. Based on the vectorization of the 55-volume book series *The quarry inventories of the Czechoslovak Republic/Czechoslovak Socialist Republic*, published in the years 1932-1961, a new comprehensive database was built comprising 9958 surface mining sites of raw materials, which were active in the first half of the 20th century. The mapped area covers 40.9% of the territory of the Czech Republic. For the purposes of visualization, a map application *The Quarry Inventories Online* was created that enables the data visualization.

1 Introduction

The sites of former surface winning of mineral raw materials mirror a notable part of the heritage of every nation. They provide an overview of cultural, economic and industrial history, they enable to study architecture and arts and they reflect development and maturity of technologies. Finally, they represent remarkable objects from the point of view of landscape ecology (Raška et al., 2011). Especially town or village small quarries used to be left for natural succession and nowadays they represent important refuges of biological diversity.

2 History of the surface mining sites in the Czech Republic

The registration of surface mining sites on the territory of the Czech Republic has a long tradition ranging to the turn of the 19th and 20th centuries. The catalogue *Österreichs Steinbrüche*, written in German, seems to be the oldest comprehensive list of surface mining sites in the territory of the Austro-Hungarian Empire. It mentions 1502 quarries, from that 625 located in the today's Czech Republic (436 in Bohemia, 86 in Moravia, 103 in Silesia) (Hanisch and Schmid, 1901).

In 1918, after the establishment of the independent Republic of Czechoslovakia, the distinguished Czech scientist, geologist and contemporary head of the Czech Geological Survey (formerly the State Geological Survey of the Republic of Czechoslovakia, later renamed to the Central Geological Institute) Cyril Purkyně (*1862 – †1937) started an extensive project *The quarry inventories of the Czechoslovak Republic/Czechoslovak Socialist Republic* (in Czech *Soupisy lomů ČSR/ČSSR*, hereinafter referred as “Quarry Inventories”). The main object of the mapping was to create a cumulative catalogue of the occurrence of both abandoned quarries and locations where the mining was still going on. It should have



given a view of the occurrence, approximated quality, presumption of the deposit thickness and possibilities of resource utilization. Further, it should have enabled to estimate the areal extension of the needed raw materials in the given area, to assess the traffic accessibility and so on. Aside from the quarries, other types of surface mining sites were also objects of interest, e.g. clay pits, loam pits, sand pits and gravel pits. The newly established “quarry department” of the State Geological Survey was entrusted with mapping and with the formation of the “Quarry Inventories” (Purkyně, 1933).

5 The “Quarry Inventories” project can be divided into two periods. The publications were elaborated according to the area of the former administrative districts in the years 1932 – 1951. Thirty-nine of them were mapped (Gotthard, 1932; Vachtl, 1933, 1934a, b, 1935, 1947, 1949a, b; Kratochvíl and Zabloužil, 1934; Urban, 1935; Procházka, 1939; Soukup, 1940; Tuček, 1940; Vavříňová, 1940, 1946, 1948a, 1949, 1950; Žebera, 1941; Hejtmán, 1942; Rost, 1942; Polák, 1946a, b, c, 1948a, b,

10 1949; Pauk, 1947; Pokorný, 1947, 1948, 1950; Hejtmán, 1948a, b; Prokop, 1948, 1949a, b; Kalášek and Polák, 1950; Šob, 1950; Prokop and Vachtl, 1951), for next two districts separate supplements were published (Pauk, 1948; Vavříňová, 1948b) and one district belongs to the Slovak Republic nowadays (Fiala, 1934).

The area of interest in the frame of single volumes of the “Quarry Inventories” was unified according to map sheets in the scale 1:75000 in the period 1947 – 1961, whereas in sporadic cases duplicate mapping of already processed area happened.

15 In such cases the data were updated in the new volume – for instance when the quarry was not any longer functioning, or when a newly opened mining site was detected next to an already known object, or when new details on mining were obtained. In this period, 13 map sheets were mapped and published (Polák, 1951a, b, 1956; Vavříňová, 1951, 1952, 1961; Frejčková, 1952; Kalášek, 1952; Prokop, 1952; Vavříňová and Líbalová, 1959; Líbalová, 1961a; b; Fajst and Holásek, 1961).

Concurrently to the “Quarry Inventories” project, primarily targeted on the Bohemian part of Czechoslovakia, 20 map sheets

20 named *Map of the Building Materials in the Czechoslovak Republic* (in Czech *Mapa stavebných hmôt Československé republiky*) were edited in Slovakia by - at that time still independent - State Geological Institute in Bratislava. Only a part of this set of 20 map sheets were printed in form of explanatory text as that of the “Quarry Inventories” (Katyk, 1949, 1950a, b, 1951a, b, c, d, e; Zorkovský, 1951), the rest are deposited as author manuscript map sheets at ČGS – department Geofond.

Single volumes of the “Quarry Inventories” project were published in form of sewn bound, hardbound or paperback booklets

25 in A5 size (or similar). In the exordium, basic data concerning the geology of the mapped area and the history of preceding research in the area of interest are briefly summarized. Listings of surface mining sites represent the central part of each volume. The listings are aligned according to appropriate cadastral areas and they describe about 20 characteristic of the mining site, using a unified template. Mentioned are owner of the site, mileage to the nearest railway station, form of the access road, petrographic name of the rock, geological period, color, granularity, porosity, hardness, polishability, method of

30 mining, size of the site, number of employees, annual cut etc. Listing of remarkable buildings where constructional materials from the site were used is an important but not always mentioned category.

The volumes have separate appendices – schematic or topographic maps of former districts or map sheets. Some of the volumes of the “Quarry Inventories” also contain attached sections that - in lesser scale - illustrate selected parts of the surveyed area with higher density of mining sites.



At the beginning of the sixtieth, the “quarry department” of the State Geological Survey was abolished and the project “Quarry Inventories” was terminated without having mapped the whole territory of Czechoslovakia. We may presume that the reason of the shutdown was the fact that for the statism of communist Czechoslovakia - where the proprietorship of raw material deposits was suppressed – running small local quarries was non-profitable while new large opencasts were opened up (Peterková, 2015).

Disregarding the fact that the “Quarry Inventories” project had not been finalized, the 40.9% of the territory of contemporary Czech Republic in 55 published volumes was processed.

3 Methods of georeferencing, vectorization and building the database

Map attachments of the published “Quarry Inventories” were digitized by a large format scanner into the form of a non-compressed raster in tiff format. In ArcGIS 10.2, control points – identical both in the referential background map and in the embedded raster - were identified and created by means of the function “Add control points”. Georeferencing was done by the function “Update Georeferencing”, the geographical grid system S-JTSK_Krovak_East_North was used (see Fig. 1).

After georeferencing of all raster data a punctual vector layer file with a table of attributes was created, containing columns for a follow-up adding of text information (type, extent, character of the wining site, serial number in the published volume, district). The metadata database creation allowed sorting the mining sites by their type, size and main used technology (see Tab. 1, 2). The consecutive hand-made vectorization of opencast objects from raster maps was the most time-consuming activity.

In single cases, when the volume of the “Quarry Inventories” was published without a map supplement, original manuscripts were used for vectorization (Polák 1951a, b, 1956; Prokop, 1952; Kalášek, 1952). At three volumes, auctorial maps were not preserved. In these cases the localization and consecutive vectorization of surface mining sites was made based on a written description only (Frejková, 1952; Vavřínová, 1951, 1952).

In all, 9958 objects have been vectorized. The standard deviation of the vectorization accuracy is up to 150 meters because of the inconsistent quality of graphic processing and preservation of map supplements of the “Quarry Inventories”.

For the purpose of spatial analyses, the vector layer in form of polygons was being generated which should be instrumental for recording the area of particular districts and map sheets. The calculation of areas was done by means of the function “Calculate Geometry” (see Fig. 2).

In order to enable the on-line visualization of generated data, the GIS project was appended with metadata (title, summary, description, and tags), then the project with all vector layers was saved by means of the function “Create Map Package”, and uploaded to the mapping cloud platform ArcGIS Online. Herein a web map composition and lastly a final web map application in form of the hosted feature service *The Quarry Inventories Online* was created and configured, accessible at <http://mapserver.ujep.cz/seminarky/bp-peterkova/> (see Fig. 3). The GIS software users can display all layers as web map



service sublayers (WMS) based on the client-server principle at http://195.113.140.12/arcgis/services/Projekty/Soupis_lomu_BP_Peterkova/MapServer/WMServer.

5 Conclusions

The project of vectorization of the surface mining sites, rising from the collection of volumes of *The quarry inventories of the Czechoslovak Republic/Czechoslovak Socialist Republic*, maps the stand of objects which were active in the first half of the 20th century mainly. Thus, its scope in time is deeper than other similar projects in the Czech Republic – such as *Stones, sandpits and limestone quarries in the Czech Republic* mapping the currently quarried raw materials sources used especially for renewal of cultural heritage (Koutník, 2015) or the equally specialized application *Decorative Stones* (Dudíková-Schulmannová and Skarková, 2010; Paleček et al., 2014). Historical sites of opencast mining of raw materials in a wider European space are mapped by the project *Historic Quarries* which covers - aside from several locations in the Czech Republic – mainly the territory of Slovakia, Poland, Hungary, Austria and Ukraine (Uhlir and Schaller, 2008-10; Uhlir et al., 2013). On-line available, in form of a database without map application, are the services *Italithos* (Giampaolo et al., 2000-13) and *Stone Quarries Database* (Russell, 2010), specialized mainly in raw materials mining in the era of the Roman Empire.

The map application “Quarry Inventories” represents with its almost 10,000 entries the most comprehensive survey of abandoned surface mining sites of raw materials on the territory of one state. Most occurred were categories of small and middle sized stone quarries with an area up to 10,000 m² (5512 in total) and small sand quarries with an area up to 1,000 m² (455 in total). Only 194 mining sites can be defined as large, covering an area over 10,000 m². In relation to the used mining technology, the shelf quarries prevailed over the pit quarries (71.8%, 19.7%, 8.5% - no data), see Tab. 1, 2.

Considering the fact that in the frame of the published volumes of the “Quarry Inventories” less than a half of the Czech Republic (40.9%) was mapped, the real number of active quarries in the first half of the 20th century can be estimated at c. 20,000 - 25,000. It corresponds to the average distributions of the quarries per each 3-4 km² (Peterková, 2015).

In time to come, therefore, a widening of the database is planned in several steps. First, data will be processed from similarly specialized manuscripts written after the publishing of the “Quarry Inventories” had been terminated (theses, paper card indexes etc.). In areas where no inventory analyses have been done, air photos from the years 1937 – 1970 will be utilized (SINE 2010).

The final and most time-consuming phase will be a field survey focused both at verification of existing entries and at completely new and still unmapped objects.



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Table 1 Size characteristics of the mining sites. Small = up to 1,000 m², medium = 1,000-10,000 m², large = above 10,000 m². Note: "---" = the category of mining sites was not classified in detail.

	small	middle	large	no data	Σ
stone quarry	3498	2014	184	1017	6713
gravel pit	4	10	0	51	65
combined gravel pit + sand quarry	0	2	0	33	35
sand quarry	455	27	1	1465	1948
loam pit	0	7	8	585	600
clay pit	---	---	---	228	228
loam or clay pit (unspecified)	1	2	0	334	337
combined loam pit + sand quarry	0	2	1	2	5
kaolin pit	---	---	---	17	17
unspecified raw material	---	---	---	10	10



Table 2 Mining sites sorted by main used technologies. Note: "---" = the category of mining sites was not classified in detail.

	pit quarry	shelf quarry	no data	Σ
stone quarry	1586	5043	84	6713
gravel pit	35	10	20	65
combined gravel pit + sand quarry	11	24	0	35
sand quarry	226	1417	305	1948
loam pit	47	232	321	600
clay pit	31	126	71	228
loam or clay pit (unspecified)	18	292	27	337
combined loam pit + sand quarry	1	4	0	5
kaolin pit	2	0	15	17
unspecified raw material	---	---	10	10



Figure captions

Figure 1 Georeferenced raster maps of the “Quarry Inventories” project in the Czech and Slovak Republic.

5 Figure 2 Areal extents of the districts and the map sheets processed in the published “Quarry Inventories” project volumes.

Figure 3 Example of the mining sites distribution in the map sheet of the special map 1:75 000 Horšovský Týn 4150.

Figure 4 Example of the mining sites distribution in three districts (Jičín - bottom, Semily – top, Nová Paka – right).

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Figure 5 Screenshot of “The Quarry Inventories Online” web map application.









