Geoheritage elements of millstone manufactory, Tokaj Mountains, Hungary

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Abstract

The changes in the exploitation of natural stones emphasize the continuous changes of cultural landscapes. The widespread Miocene rhyolite tuffs of The Tokaj Mountains usually intensively silicified increasing the hardness of the material. The grinding of cereals and ores required high quality, long lasting millstones from the mining industry. The hardest, silicified varieties were carved from the 15th century until 1970 years. The quarries are scattered throughout the mountains; amongst them three sites were selected for detailed assessment. The geoconservation value of the historical quarries is well illustrated by the exposed special geological features and remnants of historical stones. So, the silicified tuffs demonstrate that anthropogenic landforms could have significant geoconservation roles, and these geodiversity elements might enhance geotourism activities.

Introduction

Geoheritage is a generic but descriptive term applied to sites or areas of geological features with significant scientific, educational, cultural, or aesthetic value (Brilha 2016). The anthropogenic landforms of mining (including quarries, underground adits, open pits, etc.) have also a fundamental importance in geoheritage studies (e.g Kubaliková 2017, Prosser 2019) providing valuable resource for recreation and geotourism. The Tokaj Mountains (TM) are made of Miocene intermediate (andesite) and silicic (dacite, rhyolite) volcaniclastics and volcanic rocks providing exceptional geodiversity which has attracted the earth scientist from the 18th century. The volcanism is associated with continuous circulation of hydrothermal fluids causing physico-chemical changes in volcanic rocks and resulted in different types of alteration (silicification, potassic, argillic, etc.) (Pécskay and Molnár 2002). The exploitation of primary and altered rocks has thousands of years of history. At the different levels of social and technical development more and more raw materials were placed in the centre of interest from the early Neolithic obsidians. The silicified zones of volcaniclastics and subordinate sedimentary deposits were suitable for high quality millstones. After the first mentioning from the 15th century, the silicified materials were the most popular and important products for more than six centuries (Hála 2003). Technological and market changes indicated development and evolution in quality and quarrying techniques from the handmills to the grindstones used by precious metal ore grinding at Telkibánya. The silicified deposits are usually associated with clay minerals supporting famous ceramic industry, which had a golden age in the 1800s. Data on ancient quarries were registered in the early national geological mining inventory (1904) and also in recent databases (Atlas of European Millstone quarries, Historic Quarries) highlighting the continuous national and international interest for the special industry of the cultural landscape. These emphasize that the abandoned quarries are important elements of geodiversity but there was no comprehensive research on their current condition. The present paper describes three quarry sites including geological conditions, geography of the cultural landscapes involving their additional natural and anthropogenic values which are important from geoconservation and geoeducation points of view.

Site selection, data collection and filedwork

The inventory and assessment of geodiversity is essential for the preservation of geoheritage. The study of these specific mining landforms follows the steps discussed in various papers (e.g. Kubaliková 2017, Szepesi *et al.* 2017). First, the revision of the literature includes the overview of geology, mineralogy, historical geography and industrial history papers. After compiling a preliminary inventory (*Fig 1.*), three quarry sites were chosen for detailed study with collection of available data and field description.

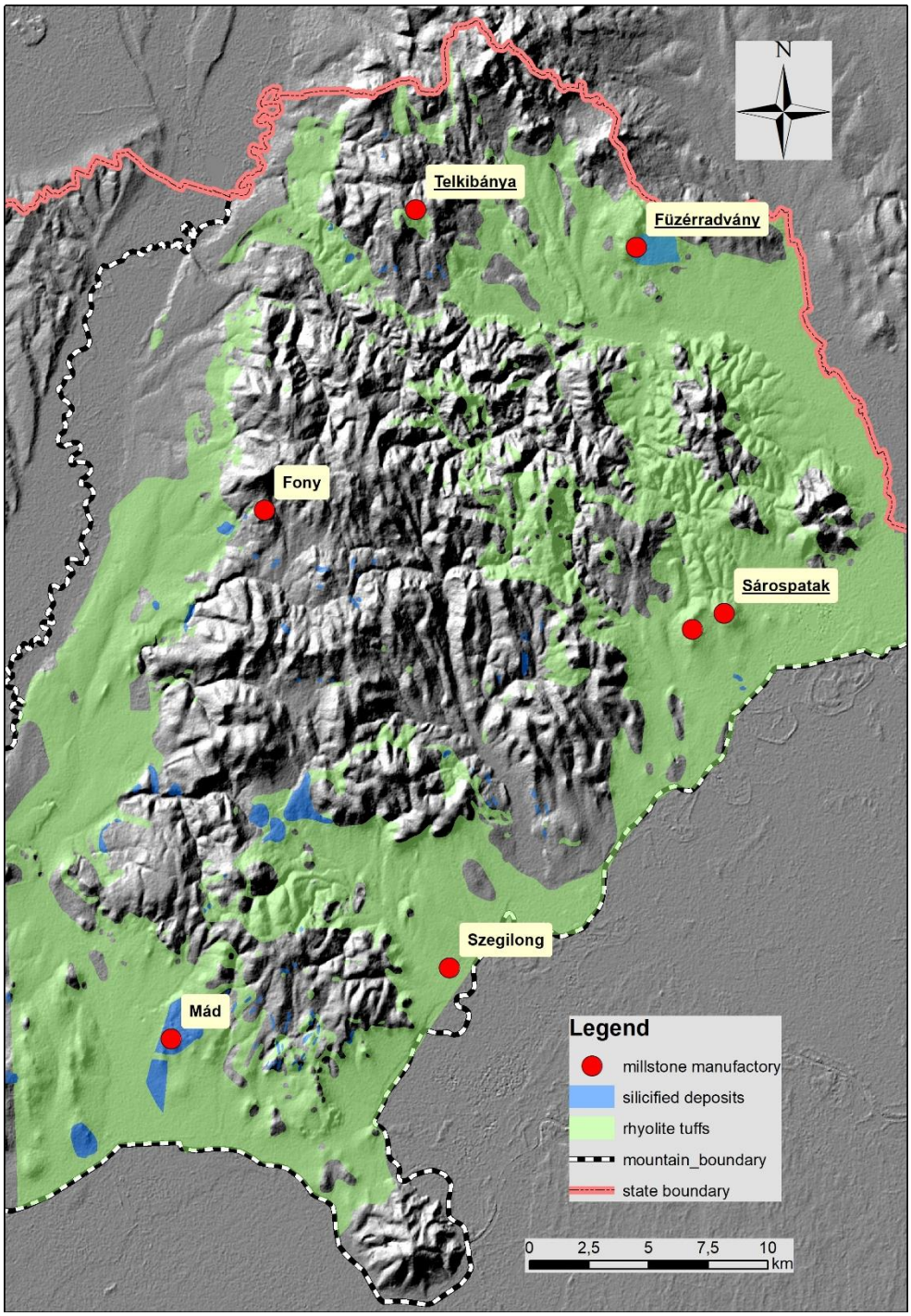

Figure 1. Miocene rhyolitic tuffs in Tokaj Mountains and inventory of the millstone manufactories. The selected sites are underlined.

The selected sites are situated in the northern and the eastern parts of the mountains and also represent current use in geotourism. Megyer Hill with a lake in the quarry is the most spectacular anthropogenic

object in the mountains. Füzérradvány was the most important site for illite mining. Telkibánya was famous for gold mining for centuries.Due to the mineral stock, scientific research has a long history at all three locations. Beside the detailed geological and mineralogical studies (e.g. Széky-Fux 1970, Pécskay and Molnár 2002, Szepesi and Ésik 2015) mining and industrial history were also published (Hála 2003, Benke 2009,). Detailed description of the sites includes general information with maps and photographs, brief summary of geological settings, additional natural and anthropogenic values. The final assessment defined suggestions on site management regarding geoconservation and geotourism development.

Geological setting and mining history

The areal distribution of rhyolitic tuff and hydrothermal materials in the TM demonstrate the role of explosive volcanism and postvolcanic alterations (*Fig. 1*). Variable silicified deposits have been utilized as quality millstone resources for several centuries as demonstrated by large numbers of abandoned quarries (*Fig. 1*). The inventory and description of the three quarries are compiled in Table 1-3.

The three quarry sites are important geoheritage elements which achieved a very high scientific, historical, cultural value in the region. They represent very similar geological settings; the silicified zones are easily recognized as resistant outcrops at higher elevation which surrounded by argillic rocks. The quarries excavated silicified rhyolitic lapilli tuffs. The additional sandstone, conglomerates and rhyolites were also altered in Telkibánya. Depending on hydrothermal zonation the clays were also mined as raw material (*Table 1*). The largest stocks developed at Füzérradvány area and were extracted almost to present day, but important excavation occurred at the other two locations, too. Telkibánya was the predecessor of the famous Hollóháza porcelain factory.

The millstone manufactories were founded in the Middle Ages and the last one worked until the 1970s. Based on the geological characteristic and quarrying techniques different styles of stones can be identified. The manufactory started with monolithic stones. The size depended on the type of utilization (hand or water mills). These one-piece stones could be found recently in the quarry yard of Megyer Hill (*Fig. 2a*) and Füzérradvány (*Fig. 2b*). Unfinished or broken ones are observable in all three sites (e.g. *Fig. 2c*, Telkibánya). Ore processing required different, mortar-like stones from the harder quartzite exhibited in the courtyard of Telkibánya Museum as an ex-situ geoheritage (*Fig. 2d*). During the 19th century the milling technique was changed with faster rotation (power mills), and long-lasting stones from harder rock were required. The “French-style” millstones were made from cemented pieces (12-16 tiles). Production has become easier and more productive and replaced the monolithic types. The famous Sárospatak millstone won the First-Order Medal of the 1862 World Expo in London, and due to production of this millstone the prices were reduced by half compared to the original French market (e.g. La Ferté sous Jouarre, Atlas of Millstone Quarries). The expansion of steel rolling mills heavily influenced the manufacturing in the 20th century. After a continuous decrease in productivity Megyer Hill ceased to operate in 1906. Stones from Király Hill were ordered and delivered even during World War II (Hála 2003). The last millstone was taken in 1979, when excavation in the Király Hill quarry terminated.

	1. Megyer Hill, Sárospatak	**2. Korom Hill, Füzérradvány**	**3. Kánya Hill, Telkibánya**
General information	280-300 m a.s.l., three-level quarry with picturesque lake	398 m a.s.l., single yard quarry	500 m a.s.l., periglacial block processing only without surface excavation
Geological settings	silicified lapilli tuff with variable alteration zones (alunite/kaolinite, illite/montmorillonite, potassic (adularia)	silicified lapilli tuff with illite dominated alteration lenses, covering lacustrine clay and silica deposits	silicified lapilli tuff sandstone and conglomerate on hydrothermally altered andesite

Geo-morphology	semicircular range with basin opening to south, the quarries opened in the silicified cap	uplifted morphological unit (200 m above the valleys) surrounded by Hegyköz basin	erosional surface of tuff and conglomerate covered andesite, periglacial block meer on the steep slopes
Additional geodiversity features	Király Hill quarry, Zsolnay clay quarry, Botkő quartzite quarry,	underground illite excavation in the quarry yard, further mines nearby (Borai, András, Hármas)	gold-silver mining objects Veresvíz open pit field, Lipót shaft, millstone at Telkibánya museum (ex-situ geoheritage)
Scientific value	internationally important site, with detailed research on hydrothermal activity	regionally important site with detailed research on hydrothermal activity and mining (clay, Au)	regionally important site with detailed research on mining (Au,Ag)
Biodiversity	Maple-oak woods (Aceri tatarico-Quercetum), aquatic plants in the lake (Lemnaminor)	beech forest (Fagus sylvatica), sessile oak (Quercus petraea), pioneer species in the quarries: birch (Betula pendula), poplar (Populus tremula), protected bat colony	hornbeam oak forest (Querco petreae-Carpinetum). rocky slopes, turkey oak (Quercetum petra-cerris) and linden (Mercuriali-Tilietum).

Table 1. Inventory and detailed description of the millstone quarry sites: general information, geo- and biodiversity features

Figure 2. The quarry sites. a) Three yards of Old millstone quarry, Megyer Hill; the first level is under water. b) The canyon-like road cut carved for lake drainage and transportation. c) An unfinished millstone with central hole as first phase of shaping; Telkibánya, Kánya Hill. d) Vertical walls of Korom Hill quarry; the underground hole from where illite was excavated (at the right side of the photo) today is a protected bat habitat.

	1. Megyer Hill, Sárospatak	**2. Korom Hill, Füzérradvány**	**3. Kánya Hill, Telkibánya**
millstones	Full circle or broken stones in quarry yard	Full circle or broken stones in quarry yard	unfinished stones at manufactory sites, millstone collection with large mortars at the museum
geohistorical importance	old quarry:15th-1907 Király Hill: 1835-1994 Zsolnay: clay quarry: 1900-1955	millstone quarry: 15-20th century, illite quarries: Borai, Hármas: 1950-90 András: 1972-2000	millstone: n.d. open pits: 12-15th century Veresvíz adit, Lipót shaft: 15-19th century

other specific features	miners house in quarry yard French style millstone won "1st order medal" in 1862 World Expo, London	small lakes at surface, the water accumulates in mining induced surface subsidence	Veresvíz (red water) indicate dissolved iron in the drain water, according to legend, this is the blood of miners who died in a collapse in 1443
aesthetic aspects, view points	picturesque lake in the quarry yard, high vertical walls (10-30 m) in three levels: 1. Óbánya with lake, 2nd level 5-6 m above lake 3rd level with mining houses circular hiking path with several different viewpoints, large road cut (a former) open a view at lake surface	millstones at the entrance, high (10 m) vertical walls with subvertical fractures,	block meer with large boulders of conglomerate and sandstone, scattered millstones between the boulders

Table 2. Inventory and detailed description of the millstone quarry sites: historical, cultural and aesthetical characteristics

Figure 3. Millstones from a) Megyer Hill; b) Korom Hill; c) Kánya Hill; and d) millstones (rhyolite tuff, conglomerate, rhyolite) and quartzite mortars for Au-Ag ore processing in Telkibánya museum as ex-situ geoheritage

Geoconservation and geotourism issues

Anthropogenic landforms are attractive landscape features and usually included in natural and cultural heritage as well (Kubalíková 2017, Prosser 2019). Geoconservation aspects are summarised in Table 2. Megyer Hill is a well-known nature conservation area in Hungary, where the geological, landscape, cultural, and ecological values defined a complex geosite. The amazing 1.1 ha quarry yard with the area of Megyer Hill was listed as a natural reserve in 1977, which became a nature conservation area of national interest in 1997. The quarry is an important cultural landscape element and also part of UNESCO World Heritage Site (Tokaj Wine Region Historic Cultural Landscape) (Szepesi *et al.* 2017). The other sites are unprotected but they have been surveyed for further geoconservation action in 2018-

2019 to establish new natural monuments. The degradation risk of the sites depends on the tourism flow. Megyer Hill is one of the most visited sites in the TM which caused trail degradation and larger amount of communal waste problems. The Telkibánya area is famous for mineral collecting activities. The surrounding area of the mining site listed in national collectors' database (geomania.hu) as location of quartz variants and sulphide minerals.

		1. Megyer Hill, Sárospatak	**2. Korom Hill, Füzérradvány**	**3. Kánya Hill, Telkibánya**
Geoconservation aspects	protection	Natural Reserve (1977)	unprotected conservation survey under act 55/2015	unprotected conservation survey under act 55/2015
	degree of disturbance	large number of visitors, via ferrata track construction in 2019	no human activity induced degradation after abandonment	mineral collecting in pit holes
	degradation risks	vegetation growth, rock falls hiking trails degradation	vegetation growth, rock falls, hiking trails degradation	vegetation growth, hiking trails degradation
Geotourism aspects	current use	hiking trails, educational trail focused on millstone manufactory via ferrata trail (2019) suspension bridge over the lake (planned)	hiking trails, additional self-guided educational trail focused on geodiversity and mining heritage	educational trail focused on mining heritage,
	tourist facilities	marked pathway, information panels	marked pathway self guided trail with published booklet	marked pathway, information panels
	number of visitors	high (over 1000/year)	moderate (under 1000/year)	moderate (under 1000/year)

Table 3. Inventory and detailed description of the millstone quarry sites: Geotourism and geoconservational aspects

The preliminary assessment of the regional geodiversity summarizes the current state of geotourism in the TM (Szepesi *et al.* 2017). The importance of geoheritage is recognized by the establishment of geo-educational trails. The first self-guided path (*Fig. 3a*) was created in Füzérradvány (Kiss et al 1999) but trail facilities are currently degraded and need renewal. The „Millstone" Nature Trail was established in 2001 by a civil initiative to demonstrate the most important natural and cultural-historical interests. The trail was partially renewed in the quarry (2015). The improved information panels (Fig. 3b) focused on quarrying and mining history. The city of Sárospatak received additional funds for further development of the lake environment. The via ferrata route around the wall completed (2019, Fig 4c.). The development will be finished in the near future with a museum, a lookout tower and a suspension bridge. The development of the Telkibánya area was a complex PHARE cross border activity including Hungarian-Slovakian (University of Miskolc, Local Authority of Telkibánya, and Technical University of Košice, respectively). A new educational trail ("Gold miners walk", established in 2011, Fig 4b.) connects the mining heritage objects (underground adits, open pit field, buildings, etc.). The establishment of an educational centre was another important area of development supporting field practice of university and high school education.

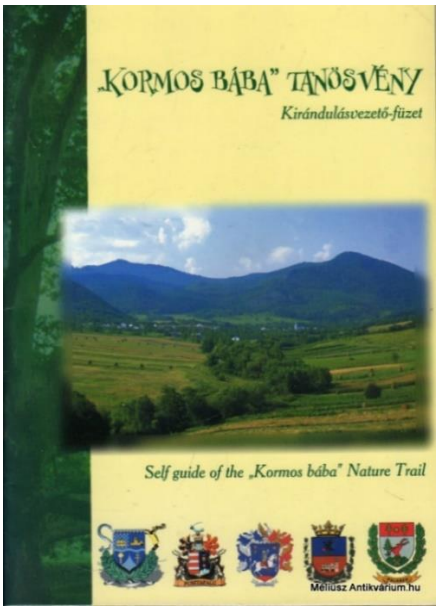



Figure 4. Regional geotourism a) Self-guided nature trail booklet, Korom Hill, Füzérradvány; b) Information panel, Megyer Hill; c) Ropes of the new via ferrata trail above the lake, (Megyer Hill)d) signpost on the Gold miners educational trail, Kánya Hill, Telkibánya

Conclusions

The manufacturing of natural stones represents well the impact of geology on the society, and illustrates clearly how culture may influence geoheritage perception and use through centuries. All quarry sites represent high significant scientific, educational, cultural, and/or aesthetic values. These criteria determine the perception and exact value of geoheritage and define geosites. Megyer Hill has highest reputation and is a nationally well-known geosite. The picturesque lake in the abandoned quarry was selected as Hungary's most beautiful natural attraction in 2011. The other sites have regional tourism relevance with moderate tourism flow. Further improvement in site management includes geoconservation and geotourism activities. After the geoconservational survey of Füzérradvány and Telkibánya sites, the declaration of protection would ensure the preservation of the geoheritage. It would be important to have an organized control over the minerals collecting activity. The quarry walls need continuous vegetation removal for better visibility. The new tourism development (Sárospatak) and further involvement of universities can provide seasonal geo-guided walks of public interest. These activities can contribute to maintain a better image of the sites and more efficient use of geotouristic and geoeducational potentials in a sustainable way.

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References

Atlas of European Millstone quarries. http://meuliere.ish-lyon.cnrs.fr/en/Heritage.htm

Benke I. 2009. The History of the mining of Telkibánya. Publ. Univ. Miskolc, Ser. A, Min., 78, pp.7-26.

Brilha J. 2016. Inventory and Quantitative Assessment of Geosites and Geodiversity Sites: a Review. Geoheritage 8, pp. 119–134. https://doi.org/10.1007/s12371-014-0139-3

Hála J. 1993. A sárospataki "francia malomkő" (French Millstones of Sárospatak) Yearbook of Hermann Otto Museum 30-31 (1) pp. 485-511.

Kiss G., Szepesi J., Oláh T., Barkó O., Szépvölgyi Á., Kalenyák E., Proksa K., Tomor T. 1999. "Kormos Bába" Tanösvény Kirándulásvezető-füzet. (Self guide of the „Kormos bába" Nature Trai p. 46.

Kubalíková, L. 2017. Mining Landforms: An Integrated Approach for Assessing the Geotourism and Geoeducational Potential Czech Journal of Tourism 2. pp. 131-154.

Pécskay Z., Molnár F. 2002. Relationships between volcanism and hydrothermal activity in the Tokaj Mountains, Northeast Hungary. Geologica Carpathica, Bratislava 53 pp. 303-314.

Prosser C.D. 2019. Communities, Quarries and Geoheritage—Making the Connections Geoheritage https://doi.org/10.1007/s12371-019-00355-4 pp. 1-13.

Szepesi J., Ésik Z. 2015. Megyer Hill: Old Millstone Quarry In: Lóczy D (ed) Landscapes and Landforms of Hungary Springer Science pp 227-235.

Szepesi J., Harangi S., Ésik Z., Novák T., Lukács E., Soós I. 2017. Volcanic Geoheritage and Geotourism Perspectives in Hungary: a Case of an UNESCO World Heritage Site, Tokaj Wine Region Historic Cultural Landscape, Hungary. Geoheritage. 9: 329-349

Széky-Fux V. 1970. Mineralization Telkibánya and its intra-Carpathian connections Academic Press, Budapest 1-266 (in Hungarian)