An overview and future prospects of Croatian geotechnological heritage

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Review scientific paper

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Abstract

Industrial heritage plays an important role in the economical, historical, and cultural identity of contemporary European society. A significant part of the industrial heritage consists of historical buildings which have remained after mining and petroleum exploitation. Moreover, industrial heritage can be also nurtured in countries in which mining and petroleum activities are not fully developed. It is inevitably associated with geological heritage. Furthermore, geological heritage is essential for a better understanding of nature, its wider appreciation and better protection. Mining has always played a significant industrial role, but it has recently lost its significance due to increasing environmental requirements regarding the European green deal and transforming the economy for a sustainable future. However, old mining and petroleum heritage sites can become attractions and they can contribute to the development of tourism and the community itself. A new term "geotechnological heritage", presented in this paper, is related to mining, geological and petroleum heritage due to their significant interaction. This paper presents the used and unused touristic potential of heritage on selected sites in the Republic of Croatia. In addition, an analysis of the Croatian undervalued geotechnological heritage has been performed after the exploitation of stone and other nonmetallics, coal, metals, and petroleum. Unlike Croatia, the potential of geotechnological heritage has been recognized and exploited in most European countries. Therefore, Croatia has a great opportunity to develop heritage based on the experience of more successful members of the European Union.

Keywords:
geotechnological heritage; mining heritage; geological heritage; petroleum heritage; industrial heritage

1. Introduction

According to UNESCO, heritage is our legacy from the past. We live with it today and pass it on to future generations. Our cultural and natural heritage are both irreplaceable sources of life and an inspiration that we should cherish, protect, and learn about. There are one hundred and eighteen protected mining related properties located in sixty-three countries which are inscribed on the UNESCO World Heritage List. Protected areas are classified into three categories with sixty-six of them being in cultural, forty-two in natural and ten in mixed categories. There are forty-one mining properties located in seventeen European countries (**URL1**).

In addition to the UNESCO World Heritage List from the end of the 1980s, the Council of Europe has initiated a project called the European Cultural Route. Its aim is to make the Europeans aware of their cultural identity and encourage them to preserve and protect heritage as a source of social, economic, and cultural development of the places in which they live. At the same time, the purpose of the project is to stimulate places involved in cultural tourism to retain sustainable development. Croatia is represented with four non-mining related sites on the European Route of Industrial Heritage – ERIH (**URL2**). Although Croatia has a very long mining tradition and its potential places are shown in this paper, unfortunately mining related properties are not on the ERICH list. In addition, the project that needs to be mentioned is "MineHeritage: Historical Mining – Tracing and Learning from Ancient Materials and Mining Technology". Old mining sites in eleven European countries including Croatia will be listed and described (**URL3)** in the referred project.

Mining as an important factor of economic and social development has played a crucial role in Europe's industrial history over the centuries. If raw materials, such as stone, metals (copper, iron, silver), salt, coal, petroleum and others, were not extracted, the development path of the continent would have looked completely different. However, the modern world is constantly changing in economic, social, ecological, and/or cultural directions. These changes represent complex processes that cities, specific regions, and governments across the civilized

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world are currently facing and that affect the mining industry. For example, in the former socialist countries of Central and Eastern Europe, the regime change in 1989/90 brought about a radical turning point. When the system collapsed, many industries faced ruin and mining was not an exception (**Wirth et al., 2012**). The consequences of the social and civilizational progress once caused by the use of coal, and in today's world by oil, should not be neglected in industrial heritage research (**Freese, 2006**). In addition, the history of the European and Croatian oil and gas industry, similarly, has an impact on local, as well as on global political events, economic constraints, and personal endeavours of individual geoscientists, as much as it does on the development of technologies and regional geology. The establishment of petroleum as a tradable commodity, as well as a natural resource, has greatly changed the history of civilization, thus introducing a new set of values, opportunities and forces. It has also had a great impact on science, technology, energy production and consumption, and it has improved living standards throughout the world (**Craig et al., 2018**).

Accordingly, given the fact that many mineral resources were once exploited in Croatia, the main goal was to present the wealth of mining and petroleum industrial heritage that remains after extensive historical exploitation. In addition, there is a lack of distinctive nomenclature that unites and refers only to mining and petroleum heritage and connected geological heritage. The term industrial heritage covers a wider range of historical activities associated with various industries that ordinarily do not retain common links. There is a need for one specific name that would refer to the heritage associated with mining and petroleum exploitation and geology. This would contribute to greater visibility and tourism branding for this type of heritage. Therefore, in this paper, we have introduced a new term, "geotechnological heritage," which covers mining, petroleum and geological heritage.

2. European geotechnological heritage

There are many examples of the successful conservation and revitalization of mining heritage sites in the European Union. In some classical cases, old mines formerly used for the extraction of salt have been revitalized. Traditionally, this is the case of Saltzburg or the famous Wieliczka salzmine near Krakow (see **Figure 1**). Wieliczka is the most popular visitor mines in the world and one of the most visited tourist attractions in Poland. It is marked as the first of the mining objects and regions in the world on the UNESCO World Heritage List (**URL1**). Comparing the number of visitors, it ranks higher than the Austrian Hallstatt, which is probably the oldest salt mine in the world. The history of salt mining dates back to the Middle Bronze Age and it is related to the Swedish Falun (which once belonged to the most important copper mining areas in the world), and the Columbian Zipaquirá, which is the largest salt deposit in the world (**Rybár and Hronček, 2017**).

Figure 1: Salt mine entrance in Wieliczka (by Briševac, Z.)

Zloty Stok Gold Mine (Poland) is one of the abandoned mines which was revitalized by local people further to the revitalization plan from 1991. Today, this old mining site offers numerous attractions to tourists. The most interesting attraction is an underground mine route, the Museum of Mining and Metallurgy and Medieval Technology Park. Similarly, volunteers have played an important role in the revitalization process of the King Edward Mine Museum in Cornwall (United Kingdom). There they restored a tin processing mill from 1900 to full working order. This mill is the only one of that kind. In addition, local communities and civil societies can have an important role in the revitalization of old mining sites such as La Tortilla Mine in Linares (Spain) (**Kaźmierczak et al., 2019**). A great example of how cooperation and a joint effort between mine owners and local authorities have contributed to the revitalization process of old mining sites is the Lousal Mine in Portugal, where the Mining Museum and the Science Centre are open for visitors (**Inácio et al., 2013**). Furthermore, Europe's largest open pit mine is the Parque de Minero de Riotinto and it presents a rich mining history of that part of Spain.

In some cases, mining heritage is only a part of industrial facilities, as in case of the Styrian Iron Road in Austria and the Lavrion Technological and Cultural Park in Greece. Lavrion is an example of a once over-industrialized city, which has recovered and adapted to new standards of modern development since the local industry ceased to dominate in 1989. Industrial heritage has contributed to the reusage and development of museum

Table 1: List of petroleum and gas museums in Europe (**Kruczek and Kruczek, 2016**)

Museum	Country	Established	Exhibition
National Museum of Oil Industry, Ploesti	Romania	1957	A collection of machines and tools.
Museum of Oil and Gas Industry, Bóbrka	Poland	1961	A collection of objects and documents connected with the oldest oil petroleum mine.
Museum of the Hungarian Oil Industry, Zalaegerszeg	Hungary	1969	Machines connected to the extraction of crude oil.
Musée du pétrole de Merkwiller-Pechelbronn	France	1967	A collection of documents, photos, models, exhibits and oil industry equipment.
German Petroleum Industry, Wiese	Germany	1970	A collection including derricks, valves, pumps and the 'nodding donkeys' used to extract crude oil.
Scottish Shale Oil Mines Light Railway, Almond Valley Heritage Centre, Millfield	UK	1983	Exhibits presenting the history of the petroleum industry, and the starting point for a heritage trail that passes through shale-working villages.
Oljeon. Analberg, Oil island in Lake Amannigen	Sweden	1986	A refinery dating from the first years of the petroleum industry, preserved at Angelsberg on Oljeon (oil island) in Lake Amannigen.
Museum of the Petroleum Industry, Stavanger	Norway	1999	An exhibition presenting the technology of oil exploration and the way of life of those who worked on the platforms.
Oil Shale Museum Kaevanspark, Jaama	Estonia	2001	A collection of oil paintings of mines, and a display of equipment which includes Esku, a 50-tonne bucket.

premises which coexist with new scientific and research premises (**Cheirchanteri, 2019**).

Not only mining heritage, but also museums, memorials, and other historical buildings have contributed to the importance of the petroleum industry in European culture. For example, several European countries, such as France, Germany and Italy, cherish petroleum heritage, which is abundant in inventions and technology, although the referred countries have never achieved significant levels of conventional oil production (**Craig et al., 2018**). Nowadays, these sites have become important tourist attractions together with a geotechnological heritage. This refers to abandoned oil fields, workshops, buildings, construction, vehicles, machines, tools, scientific instruments, documentation, etc. The production and processing of petroleum was added to the ERIH system of tourist routes which are connected with energy. The most important oil and gas exploration and production museums established in Europe are presented in **Table 1** (**Kruczek and Kruczek, 2016**).

The most successful example of using an old petroleum site is the German petroleum museum grounds which consist of an area of 18 000 m^2 and represent the former oil field placed near the city of Hanover. At the end of the production era, the Petroleum Museum Wiese was established by the Deutsche Erdöl AG (DEA), which re-opened as a public museum in 1970. There are over sixty-five known wells on the site (**Douet, 2019**).

3. Croatian geotechnological heritage

Many mineral raw materials were exploited in Croatia during the past, with a special emphasis on stone quarrying. Today, stone (natural building or dimension stone and aggregate) represents the most important raw material in Croatia. Besides stone, gravel pits or clay pits are very often places of surface mining. Intensive exploitation of metal ores was recorded in the Middle Ages. In addition, there has been a significant exploitation of coal as a fossil material for energy, which has been replaced by the petroleum industry and has had a long tradition in Croatia as well. Geotechnological heritage is based on the tradition of exploitation, and the places of preserved Croatian geotechnological heritage are shown in **Figure 2**.

3.1. Stone quarrying and the excavation of industrial minerals

Stone quarrying and utilization can be characterized as the oldest human activities known in ancient civilizations around the world. Croatia is not an exception in that field. It has a very long tradition of stone exploitation where sedimentary rocks, mostly limestone, have been exploited. Consequently, natural building stone represents the most important mineral raw material in Croatia, not only today, but also during history since the ancient times, through the Middle Ages, and to this day (**Crnković and Jovičić, 1993; Fio Firi and Maričić, 2020**). Today, forty-four different varieties of natural stone are exploited in Croatia in the shape of marketable stone blocks or slabs (**HRN EN 12440, 2017**).

The stone has been quarried along the Adriatic coast from Istria through Dalmatia to Dubrovnik, especially on the islands of Brač and Korčula, as well as in the inland near Varaždin and on Medvednica Mt. (**Crnković and Jovičić, 1993; Donelli et al., 2009; Parica, 2014;**

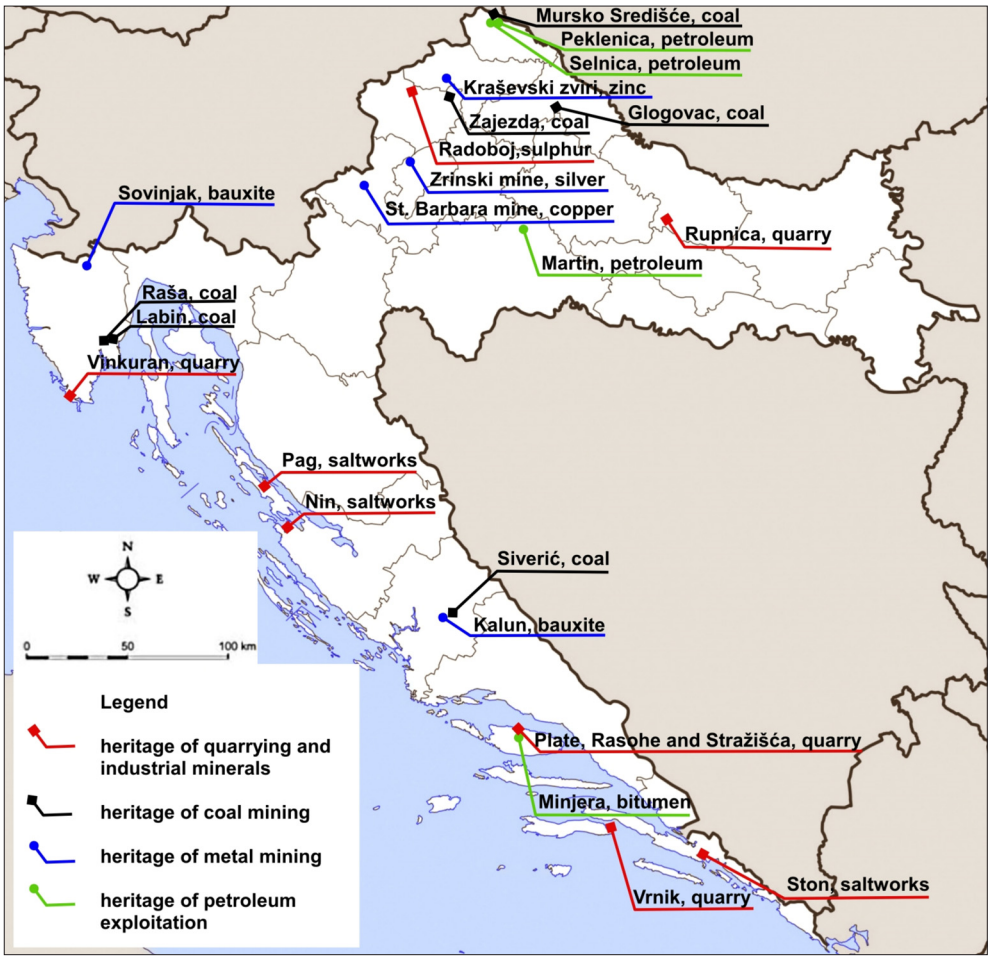

Figure 2: Map of Croatian geotechnological heritage

Figure 3: Old quarry fronts in Vinkuran quarry (by Maričić, A.)

Kovačević Zelić et al., 2020). The knowledge of quarrying activity in ancient Histria and Dalmatia lies within larger economic and cultural centers of the referred provinces. Highly developed construction and artistic techniques from that time have been used today. On the eastern Adriatic coast, we come across antique monuments built of local stone. Stone from each individual quarry has its own characteristics and quality (**Buzov, 2009**).

Due to a famous and long tradition of stone exploitation and stonemasonry, today there are an extremely large number of abandoned natural stone quarries in Croatia. These old mining sites are often neglected although many of them could be revitalized and used as potential tourist sites, especially for geo-tourist purposes. Their excavation history and used technology, the cultural heritage they are associated with, but also their different and unique geological features could be presented to visitors as part of a geo-tourist tour (**Mileusnić et al., 2019**).

Unfortunately, there are only a few examples of good practice in Croatia where old, abandoned quarries could be revitalized and used in a new way (**Mileusnić et al., 2019**). One of the rare examples of such good practice is the old quarry Rupnica near Voćin. Rupnica quarry was declared to be the first protected geological heritage monument in Croatia in 1948. Nowadays, it is a part of Papuk Geopark and was designated as part of UNESCO Global Geoparks (**Žeger Pleše and Zwicker Kompar, 2020**). Another good practice example is Vinkuran quar-

ry (see **Figure 3**) near Pula in Istria. Vinkuran is also called "Cavae Romane" because it was the oldest quarry in Istria, which was active during ancient times. Upper Cretaceous rudist limestone was quarried and used for construction of the outer mantle of the Arena in Pula (**Crnković, 1991**).

Traces of old exploitation with hand tools or chisel marks that looks like a "fish bone" are visible on open quarry fronts. For that reason, Vinkuran quarry nowadays represents an open-air monument of human mining activity (**Mileusnić et al., 2019**). In addition, the quarry is easily reachable and well maintained. Because of its vicinity to the town of Pula, it used as a stage for various performances and concerts.

Apart from the above referred quarries, the oldest ones from Roman times are on the island of Brač, at locations in Plate, Rasohe and Stražišća, located near the villages of Škrip and Splitska (**Didolić, 1957**). In the Rasohe quarry, there is a relief of Hercules which is carved into a rock front and in the Plate quarry, a covenant altar was found with an inscription that mentions the soldier Valerius Valerianus (**Cambi, 2013**). In these quarries, handmade toolmarks on quarry-faces and separation trenches called "pasharins" have been preserved (**Russell and Glicksman, 2015**) for the extraction of large blocks. Today there is a 2 km long path arranged and managed by the local community for visitors to reach the Rasohe quarry and to enjoy in the view of the Hercules relief. Apart from the island of Brač, the long tradition of mining and stonemasonry on the island of Korčula and especially the Lumbarda area should be emphasized. Exceptionally high-quality stone varieties have been quarried on the nearby islets called Vrnik (see **Figure 4**), Sutvara, Kamenjak and others since antiquity and used in the old towns of Korčula and Dubrovnik (**Gjivoje, 1970; Russell and Glicksman, 2015; Mileusnić et al., 2019**).

In addition to quarried stone, salt as a non-metallic mineral was also produced on the Adriatic coast. The Ston saltwork is the oldest in Europe and the largest preserved in the history of the Mediterranean. The diocese of Ston is mentioned in 877, so it is assumed that it is the oldest diocese of the Croatian ethnic area (**Bogdan, 2018**). Besides Ston saltworks, the most intensive tradition of salt extraction is present on the island of Pag, which dates back to the 8th and 9th centuries (**Brgles, 2014**). Today, three saltworks still produce salt, Ston (see **Figure 5**), Pag, as well as Nin saltwork (**URL4**).

In addition, sulfur of excellent quality was being extracted in Radoboj in the past. The sulfur mine was opened in 1811 (**Bićanić, 1951**). Many plant fossils, insects and fish were found there, and they all represent an exceptional ex-situ geological heritage (**Mileusnić et al., 2019**). Among many fossils it is important to mention the famous and the oldest found leaf of a vine (Vitis teutonica) and many fossil insects, such as ants, flies, and leaf bugs (**Kozina, 2014**). Additionally, a sulfur refining machine known as the "Radoboj machine" was invented and used for the first time in Radoboj (**Kišpatić, 1878**) which has contributed to the importance of the mining heritage. Today, this sulfur mine does not exist anymore (see **Figure 6**). Therefore, only old documents and an essential fossil collection prove the importance of the geological and mining heritage of this area. Due to the exceptional importance of mining and sulfur exploitation in the Radoboj area, the Radboa Museum was opened (**URL5**). The museum was partly funded by European funds and represents a good example of connect-

Figure 4: Remains of the old quarry on the Vrnik islet near Lumbarda (by Maričić, A.)

Figure 5: Saltworks in Ston (by Briševac, Z.)

Figure 6: Marking of the place where the sulfur mine was (by Briševac, Z.)

ing mining and geoheritage with the European perspective of energy efficiency and educational contents.

3.2. Coal mining

In Croatia, coal was being periodically and to a lesser extent extracted in many places, but intense exploitation took place in Istria, Zagorje, Bilogora, Međimurje and in some places in Dalmatia.

Coal mining in Istria ceased in the early 1990s. The local community still has a strong memory of this industry, and many of its historical artefacts have remained on the peninsula. Some towns like Labin (see **Figure 7**) are heavily marked by them.

Figure 7: Mine shaft in Labin (by Briševac, Z.)

The first known coal mining concession dates back to 1626 and it was issued in the vicinity of the town of Labin. The bituminous coal type was used then to coat the underwater parts of ships. Continuous production started in 1785 at the "Pegola Nera" mine above Krapno (**Vujec, 1997**). Later, a hard coal type was found, and its intensive exploitation developed. The coal has been generally known under the name of Raša coal. It is an exceptional coal from a global point of view due to its high content of organic sulfur, which can be up to 14% (**Medunić et al., 2016**). Raša coal was also known for its increased radioactivity. The activity of U-238 was 500-1200 Bq/kg in the 1970s, and 250-300 Bq/kg in the 1980s, which was 10-15 times higher than the average of other types of coal in the world (**Marović et al., 2004**).

When the exploitation of coal finished in Labin, the "Art Association Labin Art Express" (**URL6**) began to operate successfully, presenting its ideas for the revitalization of the mine for many years. It is recognized as such and it has participated as a partner in many European projects. The local city authorities of the town of Labin have been involved in three significant projects related to the former mines: KOVA Mining Heritage Conversion Project (**URL7**), MIN-HER (**URL8**) and MINE TOUR (**URL9**).

The future project Memorial Center Karlota in Raša (**URL10**) can be included in the spatial revitalization and presentation plan of the entire mining area around the town of Labin. With regard to the authenticity of the architectural and urban heritage of the mining town of Raša, the concept of the Memorial Centre of European Totalitarisms, situated in the nearby abandoned quarry of Karlota (see **Figure 8**), is based upon the idea of presenting the "spirit of the place" (lat. genius loci), or the identity of place, through a new complex with a specific architecture and urban design. The abandoned quarry Karlota has proven to be an ideal location for many reasons. It is situated in the immediate area surrounding Raša, on an elevated terrain with great views over the town's historical structures. There is a plateau amidst the rock wall with a surface area of about 13 900 m^2, which meets all the requirements for the complex disposition.

Figure 8: Memorial center Karlota in Raša, architectural visualization (by "Arhitektonsko-građevinski atelje" d.o.o.)

The complex can be easily connected with the abandoned coal mine which was in operation between 1928 and 1966. The team of authors consisting of Vladi Bralić, Arsen Čupev and Luka Ilić, has designed the complex as a certain symbiosis of the cultural and commercial sector. Different educational facilities dedicated to studying European totalitarian regimes would be joined with a number of various commercial facilities in a single architectural envelope. A highly aesthetic synergy of cultural and educational elements has been achieved through this center, but also a variety of shops, gastronomy, and design.

According to the Croatian Encyclopedia (**URL11**), the first coal mine in the Zagorje region was the Straža mine near Krapina, which opened in 1857. The Ivanec Coal Mine opened in 1867 and had operated efficiently

since the 1890s. It was one of the oldest and largest lignite coal mines in the local area (**Petrić, 2013**). Today, mining buildings together with industrial remains such as a mining separator, have a huge potential for revitalization. There have also been some initiatives and actions, but many of them are going to be taken into account by the Tourist Office Ivanec (**Jagetić Daraboš, 2017**) within next steps of the revitalization process. On the opposite side of Ivanec, namely in the southern part of the mountain Ivančica, the Konjščina basin coal mines were equally developed. A representative monument of the mine is set in Zajezda (Budimština municipality) and it is located next to the chapel of St. Barbara (see **Figure 9**). The local mine in Zajezda existed from 1928 to 1967. The inspiration for the construction of the mine in the Technical Museum Nikola Tesla in Zagreb stems from the Konščina mine.

Figure 9: Chapel of St. Barbara and the Monument to the Zajezda Mine (by Briševac, Z.)

The oldest mining shaft in the mountain range of Bilogora is in Glogovac. In 1869, the Hawthorn Coal Mining Association was founded, and it received official concessions from the state in 1874. Since then, exploitation was being conducted with more or less success until 1970, and when the production stopped, the mines were also shut down. Attempts of revitalization in the first part of the 1980s were not successful (**Feletar, 1986**). There has been a major economic change in the Bilogora region, which is still nostalgic about the mining and miners. The memory of better days has remained. Nowadays, Glogovac is empty and even neglected in some parts (**Horvat, 2014**).

Remains of mining buildings such as a loading bunker (see **Figure 10**) are reminiscent of the former mine. In 2008, the Tourist Board of the Koprivnica-Križevci County planned a cultural and educational evaluation of the mine in Glogovac. However, a mining sign and multilingual panel have not been set up thus far.

Some historical details have shown that the first underground coal mine in Međimurje was opened in Peklenica on June 5, 1870 (**Mesarić, 2015**). The exploitation of coal has also been recorded in the village of Dragoslavec since 1918. The founder of the mine was Juraj Brlek (**Požgan et al., 2019**). In addition, it is known, for certain, that coal was mined in that region at the end of the First World War. A significant industrial exploitation of coal by open pit mining had been initiated by the entrepreneur Karlo Vargazon in Peklenica in 1919. After the Second World War, the socialist regime started to exploit coal. The mines were nationalized and merged into one company that was eventually called Međimurje Coal Mines. In the middle of the 20th century, the company was one of the largest coal producers in Croatia (**Kalšan, 2006**). Međimurje Coal Mines stopped working in 1972, and the company changed its activity (**Požgan and Posedi, 2019**). Anthropogenic relief form elevations (locally called "halde") and depressions (locally called "grabe") were created due to many years of mining activity in a larger area of Mursko Središće (**Mesarić, 2015; Buntić, 2020**). Although the city itself was called the City of Miners, the actual management of mining geoheritage is insufficient today. The greater number of "haldes" situated near villages are endangered due to unrecognized values and a significant anthropogenic impact. The conservation of geomorphological sites within the framework of the Nature Protection Act is a prerequisite for their physical protection, restoration, tourist benefits and their contribution to the sustainable development of the region (**Mesarić, 2015**).

Figure 10: Remains of a coal loading bunker in Glogovac (by Briševac, Z.)

Coal was also mined outside of three dominant regions, for example, in Dalmatia in the area of Siverić and Drniš. The exploitation of coal dates back to the Venetian Republic, but mining achieved remarkable value during the Austro-Hungarian Empire. There are still some individual traces in the form of forgotten tracks, like an abandoned devastated workshop, masonry shells of the substation and barely noticeable, mostly unmarked, and unprotected entrances to the once famous pits, even named after imperials and royals. However, mining is being gradually erased from the memory of today's generations because it is not a part of their life. Mining has been neglected. Additionally, the facts about it are overshadowed by human negligence and further desecrated in the Croatian war of independence in the end of the 20th century (**Tarle, 2016**).

Lignite was also explored and exploited in the last half of the 19th century and in the first half of the 20th century near Kravarsko and its wider surroundings, the hills of Vukomeričke Gorice until the end of the Second World War. At that time, the mine and its equipment were devastated. The only trace of the mine has been preserved in the evidence related to the purchase of the mine, namely in the Purchasing Contract, government acts and other documentation, mining permits, mining profiles, etc. (**Šebečić, 2010**).

3.3. Metal mining

Although Croatia does not have any metal extraction site today, it is worth mentioning that the roots of mining and metallurgical traditions lie deep in the past. The first traces of copper casting in Croatia were recorded nearly 6 000 years ago, and they are related to the artefacts of the Vučedol civilisation in the vicinity of the town of Vinkovci. The Celts had a significant impact on mining in Croatia since they initiated the production of iron after the town of Sisak had been established in the Pannonian part of Croatia. After the Roman conquest, mining and metallurgy had been significantly developed (**Fabijanec and Vasiljević, 2017**). In the Middle Ages, many Croatian aristocratic families had built their wealth on the intensive exploitation of metal ores, but this activity stopped at the beginning of the industrial age due to the unprofitable nature of small deposits.

In the past, there was a considerable extraction of metals due to the mining of silver, lead, zinc, copper, iron and aluminum. However, there are no potential metal ore deposits today. Amongst old underground mining sites, only two have been revitalized to some extent and presented as a part of cultural and mining heritage sites to visitors and have been used in geo-tourism. These old mines, where local people used to mine precious metals in the past, are the St. Barbara copper and iron mines in Rude village near Samobor and the silver mine Zrinski located on Medvednica. Mines were partially revitalized by the local community and different associations or public institutions. The main aim of revitalization was the preservation of old mining traditions. St. Barbara mine is maintained by the local community and the Croatian Folklore Ensemble Oštrc (**URL12; Vrkljan, 2019)**. The old Zrinski mine is maintained by the Nature Park Medvednica (**URL13; Vrkljan, 2019)**. There is one interesting old mine with a potential for revitalization by the local community in cooperation with the Tourist Office and it is called Kraševski zviri. This old mine is near Ivanec, where zinc was mined (**Jagetić Daraboš, 2017**).

In addition, the rich history of mining is especially evident in the whole area of Trgovska gora, where metal mining was first recorded during the Roman and Illyrian times. Today, the remains of the blast furnace from the 19th century still exist in Bešlinec. The blast furnace that was closed in 1942 represents industrial heritage today.

The mining of iron and copper, as well as lead-silver ores, was exceptionally active during the Middle Ages and the reign of the family Zrinski that built the fortress Gvozdansko (named after iron) in 1488. The same family was affiliated with the Zrinski mine on Medvednica Mt. (**Laszowski, 1944; Šebečić, 1998; Šebečić, 2000**).

Bauxite was also mined in Croatia. The first bauxite mines in the world were opened in the first half of the 16th century in the Croatian area of Istria, namely in the valley of the river Mirna below Sovinjak castle. The first scientific description of bauxite ore was written in 1808 about Sovinjak bauxite (**Turini, 1808**). The centre of this mining area is the Minjera site, which could be of worldwide importance in the future, in terms of marking the exploitation of bauxite (**Marušić et al., 1993**). In the area of Drniš, the Kalun bauxite mine was the deepest bauxite mine in the world during the cessation of exploitation. The exploitation ceased in 1963 because the mine was filled with underground water (**Tarle, 2016**).

3.4. Petroleum exploitation

The first records of petroleum utilization in Croatia date back to the early Middle Ages. Dubrovnik's merchants already mentioned tar in the 12th century. The physician Pietro Andrea Mathioli from the city of Gorizia, published the book "Commentarii in sex libros Pedacii Dioscoridis Anazarbei de Medica materia" in Venice in 1565 with the most important details. Oil digging near the island of Hvar, in Panonia and not far from the Neretva River was mentioned in the book as well. The travelogue of Albert Fortis in his book "Viaggio in Damazia" published in 1774 describes the bitumen mine on the island of Čiovo and the site near Škrip on the island of Brač, later known as Minjera mine (**Kanajet et al.,1995 and Šebečić, 1995),** around Vrgorac and near Sinj. The first exploration permits were granted as early as 1855, and an organized oil production with a valid permit was recorded in 1856. Count Juraj Feštetić started with legal oil production in several shallow wells (4 to 10 meters deep) in the Međimurje area.

Due to a long tradition of oil exploitation, Međimurje can be considered as one of the oldest oil exploitation areas in the world. The most significant oil deposits in history were the oil fields in Peklenica and Selnica. These well sites have recently been transformed into heritage parks (see **Figure 11** and **Figure 12)**.

Almost simultaneously, research has begun in the area of Voloder, Mikleuška in the Moslavina region (Central Croatia), Paklenica near Novska and in Baćindol near Nova Gradiška (**Žgaljić, 1984**).

In the middle of the 19th century, the Polish pharmacist Ignaz Lukasiewicz discovered the kerosene lamp. Lighting with kerosene lamps was introduced in the cities of the Austro-Hungarian monarchy of which Croatia was also a part of at that time. The first major mining facility built in the Moslavina region was the Martin pe-

Figure 11: Peklenica petroleum heritage park (by Brkić, V.)

Figure 12: Selnica petroleum heritage park (by Brkić, V.)

troleum shaft (**Velić et al., 2012**), from which oil was being extracted in the period from 1854 to 1943 (see **Figure 13**). The 72-meter-deep Martin shaft was once the largest in the Austro-Hungarian Empire. Oil was even used to illuminate the city of Vienna (**Novak-Zoroe, 2013**).

Figure 13: Martin petroleum shaft (by Brkić, V.)

In the area between the Drava and the Sava rivers, the remains of exploration and production have been recorded at a dozen localities, mostly in places where natural oil spills have been observed earlier (**Križ et al., 2008**). An intensive growth in the exploration and production of oil and gas in the Republic of Croatia was initiated in 1952 in the Pannonian basin.

The historical outline of oil and gas exploration and production, which also had an impact on Croatia, would not be complete without mentioning Antun Lučić, the most famous Croatian oil expert who worked in the United States of America. At the beginning of the 20th century, he made a revolution in petroleum engineering by introducing rotary drilling, drilling mud (drilling fluid) and other innovations. In 1936, the American Institute for Geological and Metallurgical Investigations awarded the Gold Medal Prize named after Anthony F. Lucas for development in the field of oil and gas exploration and production. A museum with a granite obelisk was built in honor of the explorer Lučić, with the following inscription: "A new era in the civilization began on this spot on the tenth day of the twentieth century" (**McBeth, 1998**).

4. Discussion

This paper has addressed a wide area related to the history of the mining and petroleum industry. If we want to connect mining, petroleum, and geological heritage, then the term "geotechnological heritage" can be used. The expression is related to a permanent bond between mining, petroleum and geology. It stems from the Greek word "geo" (i.e. earth), "tekhne" (i.e. skill, mastery, ability, or craft) and "logia" (i.e. knowledge, science). Although such an expression has not been mentioned yet in literature, and it is used for the first time in such context, there has not been a justified argument for its non-use in terms of preserving the specific industrial heritage. In Croatia, the expression "geotechnological heritage" can be used because it is recognizable in our circumstances. However, each part of the heritage has its own unique characteristics, so they should be taken into account.

The broadest segment of geotechnological heritage is a geological one because it presents the natural structure of the underground. The mining and petroleum industry would not exist without geology, which represents a fundamental science. In addition, through mining activity, the underground geological nature becomes more visible and accessible. This indicates a direct connection between mining and the necessary knowledge of nature and geology. The connection is also visible from the UNESCO World Heritage List (**URL1**). It is essential to emphasize that mining, and geological heritage are mutually interconnected, but they are also linked with cultural heritage in general. Croatia has nurtured an old tradition of raw material exploitation (particularly quarrying). Many old quarries, mines or industrial remains still exist in traditionally mining regions like Istria or on the islands of Brač and Korčula.

The exploitation of mines and raw materials has played an important role in the economy of some Croa-

tian regions. Nowadays, they do not play an essential role in the economy, but their remains still exist. However, there has always been a negative perception of the exploitation of mines due to terrible working conditions in the past, but also due to its negative impact on the environment in modern times (**Petlovanyi et al. 2019**). Heritage in terms of adopting certain patterns of behavior is also worth preserving and protecting. Socially isolated miners had always been exposed to various dangers in order to ensure a better standard of living for society. They had also built a type of solidarity, much like soldiers in a war (**Freese, 2006**). As time goes by, people who used to work in mines pass away and thus solidarity with former mining areas also weakens. Therefore, efforts regarding the collection and writing down of verbal stories about the life of miners are very precious (**Horvat, 2014**).

There are various approaches to the revitalization of mining heritage, as can be seen in the case of the town of Labin. After the mine was closed, the "Art Association Labin Art Express" was established and it has come up with the idea of building an "Underground City" with all of the facilities normally found in a city. Lately, the town administration of Labin has initiated the projects KOVA, MIN-HER and MINE TOUR, which are primarily cultural projects, but none of these projects have been realized so far. However, the cultural and commercial aspects of the projects must be harmonized. It is easier for a local administration to take into account a cultural aspect, but it should not be overrated. On the other hand, commercial facilities are equally relevant because the population must earn for living. The primary challenge is to achieve synergy between all the stakeholders in the revitalization of geotechnological heritage. Clear legislation would help overcome these challenges.

In Croatia, examples of the protection and local utilization of mining, petroleum and connected geological heritage are not widely known compared to European ones. If regions and types of mineral resources are taken into account, most elements of cultural heritage are present in coastal regions and are related to the extraction of natural building stone, which was used for building old cities along the Adriatic coast, monuments and cultural heritage buildings. In historical regions where coal was exploited, such as Istria, Zagorje, Međimurje and Bilogora, there are also places where mining cultural elements can be found. Furthermore, there are several places near Zagreb where metal ore was exploited during the Middle Ages, such as the St. Barbara mine near Rude, the Zrinski mine on Medvednica Mt. and also Trgovska gora.

Freese (**2006**) points out, "When we think of oil, it associates us with sudden wealth, while coal associates us with poverty and disappointment." So, petroleum heritage has a different perception because it did not require difficult working conditions as in mines where the predominantly poor population had been worked. Unfortunately, Croatia has not had any petroleum museum yet. The Croatian company INA Plc. has rich archives with plenty of equipment and documentation related to oil and gas exploration and production, which could become a part of a museum exhibition. Therefore, a Petroleum museum in Ivanić Grad is planned to be found as a first petroleum museum in Croatia, which should present a centenarian cultural and monumental heritage of the oil industry.

The research which was done for the purpose of making this paper has also shown the existence of identical names for remote locations. In coastal area, these names are of Italian origin "pegola nera" (which means black resin) and "Minjera" (which means mine). There is Minjera on the island of Brač as a former bitumen mine and Minjera in Istria, which was a bauxite mine. A similar thing is with the name "Peklenica" near Mursko Središće and "Paklenica" near Novska. The word "Pekla" means an oil outgrowth. This is very interesting, but it must be taken into account because the same name cannot be used in the process of branding and increasing the web visibility of a site. The same names can confuse potential foreign visitors.

The world and way of living are constantly changing, but these changes are often connected with raw materials, including hydrocarbons and its mining from the Stone Age to the Modern Age. In addition, mining may be considered as a temporary activity in some places, and the possibility of the reuse of old mines, oil and gas fields once they are closed, must be taken into account. Some of them may represent a precious heritage whether they have cultural and historical, or maybe geological or industrial (mining and petroleum) significance.

In terms of presenting industrial heritage, and thus geotechnological heritage, the ERIH organization has contributed a lot in that respect. ERIH has placed industrial heritage on the tourist map of Europe for better recognition. The tourist potential in Croatia is still unrecognized and insufficiently appreciated. It is essential to follow the example of other European countries (France, Poland, Germany, etc.) which are more oriented to their tourist attractions in various forms of tourism. Thus, geotechnological heritage has a great potential that must be recognized and used once mining activity has ceased. The site itself is the basis for further tourist activity and education. The key thing in terms of geotechnological heritage in Croatia is investment. Investment in projects that will be recognized, investment in advertising and promotion of geotechnological heritage and investment in sites that already represent good grounds for further progress.

5. Conclusion

The main emphasis in this paper is the review of Croatian geotechnological heritage. Such a term could be used for better recognition of mining, geological and petroleum heritage within the broader concept of industrial

heritage. The most promising segment of geotechnological heritage is geological heritage that can be developed in areas with the old tradition of raw material exploitation, particularly quarrying and also in the field of nature protection.

One of the important problems identified that influences revitalization processes is lacking clearer legislation. Clear legislation would help in overcoming the challenges of various concepts of protection and revitalization and would encourage synergy of all stakeholders in the revitalization of geotechnical heritage.

Due to the unjustified but real negative perceptions of mining and post-industrial landscapes in general, the cultural preservation of mining heritage should also be based on intangible potentials such as mining traditions, customs, and unique local identities. Efforts to collect and write down verbal stories about the mining life need to be stepped up because people who have been involved in mining pass away and their testimonies disappear with them.

As the European experience and some of our cases show, these geotechnological heritage potentials can be carefully turned into cultural objects, historical events, local museums, industrial tourist routes or trails and many other examples of good practice. In addition, Croatia should present the cultural and monumental heritage of the oil industry in a unique thematic museum due to the long tradition in oil and gas production.

Croatia is recognized as a country with a relatively large number of sites where geotechnological heritage could be adequately presented. All places where mineral resources are now exploited could one day become places of protection and presentation of geotechnological heritage. One of the proposals to the Republic of Croatia, as a member of the European Union, is to make the most of the available funds for financing mining, geological and petroleum heritage to achieve more recognition in Central and Western Europe. It must be strongly emphasized that geotechnological heritage is more recognized and used in Europe than in Croatia.

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Author's contribution

Zlatko Briševac (1) (Ph.D. in mining engineering, Assistant Professor at the Faculty of Mining, Geology and Petroleum Engineering, University of Zagreb) assembled and analyzed data of European heritage and collected historical data for description of the mining heritage. He wrote a chapter on Croatian coal mining. He contributed to discussion and conclusion. **Ana Maričić (2)** (Ph.D. in geological engineering, Assistant Professor at the Faculty of Mining, Geology and Petroleum Engineering, University of Zagreb) studied Croatian and European geological heritage sites, wrote about Stone quarrying and excavation of industrial minerals and metal mining, contributed to the discussion, and conclusion chapters. **Vladislav Brkić (3)** (Ph.D. in petroleum engineering, Asocciate Professor at the Faculty of Mining, Geology and Petroleum Engineering, University of Zagreb) analyzed Croatian and European petroleum heritage and contributed to the discussion and conclusion chapters**. Vladi Bralić (4)** (mag.ing.arh. director in Arhitektonsko-građevinski atelje d.o.o.) described the Memorial center Karlota in Raša and provided a graphic figure of project.

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Sažetak

Industrijska baština važan je segment u ekonomskome, povijesnome i kulturnome identitetu suvremenoga europskog društva. Znatan dio industrijske baštine čine objekti koji su ostali nakon rudarenja mineralnih sirovina ili eksploatacije nafte. Štoviše, zemlje koje nemaju jako razvijenu rudarsku i naftnu djelatnost ipak njeguju tu vrstu industrijske baštine. Geološka baština bitna je za razumijevanje naravi prirode, njezina većeg vrednovanja te njezine bolje zaštite. Rudarska je djelatnost uvijek imala važnu gospodarsku ulogu, ali njezina se percepcija u modernome društvu promijenila zbog sve većih zahtjeva za očuvanjem okoliša vezanih za europski zeleni plan i prilagodbu europske ekonomije održivoj budućnosti. Međutim, rudarska baština ne mora biti negativno prihvaćena u javnosti, ona danas itekako može postati atrakcija koja pridonosi razvoju turizma te na taj način čuva tu vrstu nasljeđa za dobrobit cjelokupne zajednice. U ovome se radu pojašnjava prvi put korišten pojam „geotehnološka baština" kao novi pojam koji spaja rudarsku, geološku i naftnu baštinu zbog njihove prirodne međusobne povezanosti i isprepletenosti. Pored toga, dan je pregled nedovoljno cijenjene hrvatske geotehnološke baštine u eksploataciji kamena i drugih nemetalnih mineralnih sirovina, ugljena, mineralnih sirovina za proizvodnju kovina i u eksploataciji nafte. Za razliku od Hrvatske potencijal geotehnološke baštine prepoznat je i iskorišten u većemu dijelu Europe. S obzirom na to Hrvatska ima dobru priliku za razvoj toga tipa baštine na temelju iskustva uspješnijih članica Europske unije.

Ključne riječi:
geotehnološka baština, rudarska baština, geobaština, naftna baština, industrijska baština

1. Uvod

Prema UNESCO-u baština je naša ostavština iz prošlosti s kojom živimo u sadašnjosti i koju prenosimo na buduće generacije. Naša kulturna i prirodna baština nezamjenjivi su izvori života i inspiracije koje trebamo njegovati, štititi i učiti iz njih. Na UNESCO-ovu popisu svjetske baštine nalazi se 118 zaštićenih mjesta povezanih s rudarstvom koja su smještena u šezdeset i tri zemlje. Zaštićena mjesta razvrstana su u tri kategorije, od kojih 66 pripada kulturnoj, 42 prirodnoj i 10 mješovitoj kategoriji. U Europi se nalazi 41 zaštićeno mjesto u 17 zemalja povezano s rudarstvom (**URL1**).

Uz UNESCO-ov popis svjetske baštine krajem 1980-ih Vijeće Europe započelo je s provedbom projekta pod nazivom Europska kulturna ruta (European Cultural Route). Cilj mu je bio osvijestiti Europljane o vlastitome kulturnom i građanskom identitetu te ih poticati na očuvanje i zaštitu baštine kao izvora društvenoga, ekonomskoga i kulturnoga razvoja mjesta u kojemu žive. Cilj je ujedno i poticati mjesta s razvijenim kulturnim turizmom da zadrže načela održivoga razvoja. Hrvatska je zastupljena na Europskoj ruti industrijske baštine (European Route of Industrial Heritage – ERIH) s četirima lokacijama koje nisu povezane s rudarstvom (**URL2**). Iako Hrvatska njeguje vrlo dugu rudarsku tradiciju i ima potencijalno zanimljiva mjesta, koja će biti opisana u radu, nažalost, na ERIH-ovu popisu nema mjesta povezanih s rudarstvom. Uz to, potrebno je spomenuti i projekt „MineHeritage: Historical Mining – Tracing and Learning from Ancient Materials and Mining Technology". U okviru toga projekta opisat će se stara rudarska nalazišta u jedanaest europskih zemalja, među kojima je i Hrvatska (**URL3**).

Rudarstvo je u prošlosti bilo važan čimbenik gospodarskoga i društvenoga razvoja i znatno je pridonijelo razvoju industrije u Europi. Bez eksploatacije mineralnih sirovina poput kamena, metala (bakra, željeza, srebra), soli, ugljena, nafte i drugih sirovina, razvojni put kontinenta izgledao bi izrazito drugačije. Međutim, moderni se svijet neprestano mijenja, bilo u ekonomskome, socijalnome, ekološkome i/ili kulturnome smjeru. Te promjene predstavljaju složene procese i izazov su za gradove, određene regije i vlade širom civiliziranoga

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svijeta te utječu na sudbinu rudarske industrije. Primjerice, u bivšim socijalističkim zemljama srednje i istočne Europe promjena režima 1989./1990. donijela je radikalnu prekretnicu. Tada se sustav srušio i mnoge su industrije bile suočene s propašću, a rudarstvo nije bilo iznimka (**Wirth i dr., 2012**). Posljedice društvenoga i civilizacijskoga napretka nekad uzrokovane uporabom ugljena, a danas je to nafta, ne smiju se zanemariti u istraživanjima industrijske baštine (**Freese, 2006**). Povezano s tim povijest europske i hrvatske naftne i plinske industrije slično odražava i lokalne i globalne političke događaje, ekonomska ograničenja i osobna nastojanja pojedinih naftnih geoznanstvenika te razvoj tehnologija i geologije podzemlja u regiji. Uspostavljanje nafte kao trgovačke robe i prirodnoga resursa pokrenulo je pomak paradigme u povijesti civilizacije uvodeći novi skup vrijednosti, mogućnosti i prednosti, oblikujući tijek raznovrsnih društvenih pothvata kao što su znanost, tehnologija, proizvodnja i potrošnja energije, što dovodi do povezanih poboljšanja životnoga standarda u cijelome svijetu (**Craig i dr., 2018**).

S obzirom na to da se u Hrvatskoj nekoć eksploatiralo puno mineralnoga bogatstva, glavni je cilj rada predstaviti obilje rudarske i naftne industrijske baštine koja je preostala. Pored toga, uočen je i nedostatak specifičnoga naziva koji bi zajednički objedinio i odnosio se samo na rudarsku, naftnu i s njima povezanu geološku baštinu. Pojam industrijske baštine obuhvaća širi spektar povijesnih aktivnosti povezanih s raznim industrijama koje obično nemaju zajedničkih veza. Dakle, potrebno je jedno određeno ime koje bi se odnosilo na baštinu povezanu s rudarstvom i eksploatacijom nafte te geologijom. To bi pridonijelo većoj uočljivosti i izgradnji identiteta ove vrste baštine. Zbog toga je u radu uveden novi pojam „geotehnološka baština" koja obuhvaća rudarsku, naftnu i s njima povezanu geološku baštinu.

2. Europska geotehnološka baština

U Europskoj uniji može se uočiti puno primjera uspješne zaštite i revitalizacije rudarske baštine. U nekim klasičnim slučajevima revitalizirani su stari rudnici u kojima se eksploatirala zanimljiva mineralna sirovina poput soli. To je tradicionalno slučaj u Salzburgu ili poznatome rudniku soli Wieliczka u blizini Krakowa (**slika 1**). Wieliczka je upravo među posjetiteljima najpopularniji rudnik na svijetu, a ujedno je i jedna od najposjećenijih turističkih atrakcija u Poljskoj. Na UNESCO-ovu popisu svjetske baštine zabilježena je kao prvi rudarski objekt i rudarska regija (**URL1**). Više posjetitelja posjećuje Wieliczku nego austrijski Hallstatt (koji je vjerojatno najstariji rudnik soli na svijetu, gdje se povijest rudarenja soli proteže do srednjega brončanog doba), švedski Falun (nekada na svjetskoj razini iznimno bitan rudnik bakra) i Colombian Zipaquirá (najveće ležište soli na svijetu) (**Rybár i Hronček, 2017**).

Slika 1: Ulaz u rudnik soli Wieliczka (Briševac, Z.)

Mnogi napušteni rudnici uspješno su revitalizirani. Treba spomenuti rudnik zlata Zloty Stok (Poljska), gdje je lokalno stanovništvo započelo s planovima revitalizacije 1991. godine. Danas to staro rudarsko mjesto nudi turistima brojne atrakcije, među njima i podzemnu rutu kroz rudnik, muzej rudarstva i metalurgije te srednjovjekovni tehnološki park. Slično tome, uključenost volontera kao važnoga faktora procesa revitalizacije vidljiva je i na primjeru Muzeja rudarstva kralja Edwarda u Cornwallu (Velika Britanija). Tamo su volonteri restaurirali postrojenje za oplemenjivanje kositra iz 1900. godine koje je jedinstveni primjer te vrste. Uz lokalnu zajednicu civilna društva mogu imati važnu ulogu u revitalizaciji starih rudarskih mjesta kao primjer rudnika La Tortilla u Linaresu (Španjolska) (**Kaźmierczak i dr., 2019**). Sjajan primjer kako suradnja i zajednički napor vlasnika rudnika i lokalnih vlasti mogu pozitivno doprinijeti procesima revitalizacije starih rudnika jest Lousal u Portugalu, gdje danas posjetitelji mogu posjetiti Muzej rudarstva i znanstveni centar (**Inácio i dr., 2013**). Isto tako, najveći površinski kop u Europi ima park rudarstva Parque de Minero de Riotinto i uspješno prezentira bogatu rudarsku povijest toga dijela Španjolske. U nekim je slučajevima rudarsko nasljeđe samo dio industrijskih kompleksa poput Štajerskoga željeznog puta u Austriji i Tehnološkoga i kulturnoga parka Lavrion u Grčkoj. Lavrion je primjer industrijskoga grada koji je nakon dugoga kriznog razdoblja, od zatvaranja rudnika 1989. godine, uspio ući u razdoblje oporavka i prilagodbe novim prioritetima suvremenoga razvoja. Industrijska baština i uspostava muzejskih prostora koji koegzistiraju s novim znanstvenim i istraživačkim prostorima Lavrionu su omogućili oporavak nakon razdoblja krize (**Cheirchanteri, 2019**).

Uz rudarsku baštinu mnogi muzeji, spomen-obilježja i druge povijesne ustanove obilježavaju doprinos naftne industrije europskoj kulturi. Nekoliko europskih zemalja, kao Francuska, Njemačka i Italija, njeguju naftno nasljeđe izumima i tehnologijom iako nikada nisu postigle globalno bitne razine konvencionalne proizvodnje nafte (**Craig i dr., 2018**). Danas ta mjesta koja njeguju geotehnološku baštinu predstavljaju turističku atrakciju. To uključuje napuštena naftna polja, radionice, zgrade, postrojenja, vozila, strojeve, alate, znanstvene instrumente, dokumentaciju itd. Proizvodnja i prerada nafte dodana je u sustav ERIH-ovih turističkih ruta koje su tematski povezane s energijom. Popis najvažnijih muzeja vezanih za istraživanje nafte i plina u Europi prikazan je u **tablici 1** (**Kruczek i Kruczek, 2016**).

Ogledni je primjer naftne baštine muzej Wiese u Njemačkoj, koji se prostire na površini od 18 000 m^2 i zauzima prostor nekadašnjega naftnog polja smještenoga blizu grada Hannovera. Nakon završetka proizvodnje tvrtka Deutsche Erdöl AG (DEA) osnovala je naftni muzej koji je 1970. godine postao javni muzej. Na otvorenome muzejskom prostoru nalazi se preko 65 bušotina **(Douet, 2019)**.

Tablica 1: Popis Europskih muzeja nafte i plina (**Kruczek and Kruczek, 2016**)

Naziv muzeja	Zemlja	Osnovan	Izložba
Nacionalni muzej naftne industrije, Ploesti	Rumunjska	1957.	zbirka opreme i alata
Muzej naftne i plinske industrije, Bóbrka	Poljska	1961.	zbirka predmeta i dokumenata vezanih za najstarije mjesto naftnoga rudarstva
Muzej mađarske naftne industrije, Zalaegerszeg	Mađarska	1969.	oprema povezana s vađenjem sirove nafte
Muzej nafte Merkwiller-Pechelbronn	Francuska	1967.	zbirka dokumenata, fotografija, modela, eksponata i opreme naftne industrije
Njemačka naftna industrija, Wiese	Njemačka	1970.	kolekcija koja uključuje dlijeta, ventile, sisaljke i njihalice koje su se koristile za vađenje sirove nafte
Uskotračna željeznica rudnika uljnoga škriljevca u Škotskoj, Centar baštine doline Millfield	Velika Britanija	1983.	izloženi predmeti koji predstavljaju povijest naftne industrije, polazište za rutu koja prolazi selima koja obrađuju uljni škriljevac
Oljeon, Analberg, naftni otok na jezeru Amannigen	Švedska	1986.	rafinerija iz pionirskih godina naftne industrije, sačuvana u Angelsbergu u Oljeonu (naftni otok) na jezeru Amannigen
Muzej naftne industrije, Stavanger	Norveška	1999.	izložba koja predstavlja tehnologiju istraživanja nafte i način života radnika koji su radili na platformama
Muzej uljnoga škriljavca Kaevanspark, Jaama	Estonia	2001.	zbirka uljanih slika rudnika i prikaz opreme koja uključuje Esku, kantu od 50 tona

3. Hrvatska geotehnološka baština

U prošlosti su se u Hrvatskoj eksploatirale mnoge mineralne sirovine s posebnim naglaskom na vađenje kamena. Danas je kamen (prirodni ili arhitektonsko-građevni i tehničko-građevni) najvažnija čvrsta mineralna sirovina u Hrvatskoj. Osim kamenoloma, šljunčare ili glinokopi često su mjesta površinskih kopova. U srednjemu vijeku zabilježena je i intenzivna eksploatacija metalnih ruda. Eksploatacija ugljena kao energetske sirovine također je bila važna, no s vremenom je jenjavala i ustupila mjesto naftnoj industriji koja također ima dugu tradiciju u Republici Hrvatskoj. Geotehnološka baština utemeljena je na tradiciji eksploatacije, a mjesta očuvane hrvatske geotehnološke baštine prikazana su na **slici 2**.

Slika 2: Karta hrvatske geotehnološke baštine

3.1. Vađenje kamena i eksploatacija nemetala

Eksploatacija i upotreba kamena može se okarakterizirati kao jedna od najstarijih i vrlo važnih ljudskih aktivnosti čija prošlost seže do davnih civilizacija širom svijeta. Hrvatska nije iznimka zbog svoje vrlo duge tradicije eksploatacije kamena. U povijesti su eksploatirane sedimentne stijene, uglavnom vapnenci. S obzirom na to, prirodni arhitektonsko-građevinski kamen predstavlja najvažniju čvrstu mineralnu sirovinu u Hrvatskoj, ne samo danas već i u prošlosti (**Crnković i Jovičić, 1993; Fio Firi i Maričić, 2020**). Danas se u Hrvatskoj eksploatiraju 44 različita varijeteta prirodnoga kamena u obliku tržišnih kamenih blokova ili ploča (**HRN EN 12440, 2017**).

Arhitektonsko-građevni kamen vadio se duž cijele jadranske obale od Istre preko Dalmacije do Dubrovnika, a posebno na otocima Braču i Korčuli, kao i u unutrašnjosti u okolici Varaždina te na Medvednici (**Crnković i Jovičić, 1993; Donelli i dr., 2009; Parica, 2014; Kovačević Zelić i dr., 2020**). Znanje o kamenolomima u drevnoj Histriji i Dalmaciji povezano je s većim gospodarskim i kulturnim središtima. Iz njih se saznaje o visokorazvijenim građevinskim i umjetničkim tehnikama koje su se tada koristile. Na istočnoj obali Jadrana nailazi se na antičke spomenike izgrađene od lokalnoga kamena. Kameni varijeteti iz svakoga pojedinačnog kamenoloma pokazuju svoja obilježja i kvalitetu (**Buzov, 2009**).

Zbog poznate i duge tradicije eksploatacije kamena i klesarstva danas je u Hrvatskoj iznimno velik broj napuštenih kamenoloma prirodnoga kamena. Stari kamenolomi često su zanemareni iako bi se mnogi mogli revitalizirati i koristiti kao potencijalna turistička mjesta, posebno u geoturističke svrhe. Povijest vađenja kamena i korištena tehnologija, kulturna baština s kojom su povezani, ali i njihove različite i jedinstvene geološke značajke mogli bi se predstaviti posjetiteljima kao dio geoturističke ponude (**Mileusnić i dr., 2019**).

Nažalost, u Hrvatskoj je samo nekoliko primjera dobre prakse kako se stari napušteni kamenolomi mogu revitalizirati i iskoristiti na nov način (**Mileusnić i dr., 2019**). Jedan je od rijetkih primjera stari kamenolom Rupnica kod Voćina koji je 1948. godine proglašen prvim zaštićenim spomenikom geološke baštine u Hrvatskoj, a danas je dio Geoparka Papuk koji je uvršten u mrežu svjetskih parkova UNESCO-a (**Žeger Pleše i Zwicker Kompar, 2020**). Drugi primjer dobre prakse jest kamenolom Vinkuran (**slika 3**) u blizini Pule u Istri.

Vinkuran je jedan od najstarijih kamenoloma u Istri koji je bio aktivan u antici te se naziva i Cavae Romane. Gornjokredni vapnenci vađeni su i korišteni za izgradnju vanjskoga plašta Arene u Puli (**Crnković, 1991**).

Slika 3: Vidljive stare otkopne fronte u kamenolomu Vinkuran (Maričić, A.)

Na otvorenim frontama kamenoloma vidljivi su tragovi stare eksploatacije ručnim alatom, odnosno tragovi dlijeta koji izgledaju poput riblje kosti. Iz toga razloga kamenolom Vinkuran danas predstavlja spomenik rudarske djelatnosti na otvorenome. Uz to, kamenolom je lako dostupan i održavan je. Zbog blizine Pule često se koristi kao pozornica za razne predstave i koncerte.

Najstariji kamenolomi iz rimskoga doba na otoku Braču jesu Plate, Rasohe i Stražišća smješteni u blizini sela Škrip i Splitska (**Didolić, 1957**). U kamenolomu Rasohe u stijenu je urezan reljef Herkula, a u kamenolomu Plate pronađen je žrtvenik s natpisom koji spominje vojnika Valerija Valerijana (**Cambi, 2013**). U tim su kamenolomima vidljivi tragovi ručnih alata kao i kanali zvani „pašarini" za odvajanje i vađenje velikih blokova (**Russell i Glicksman, 2015**). Kako bi posjetitelji mogli doći do kamenoloma Rasohe i uživati u pogledu na reljef Herkula, lokalna je zajednica uredila stazu dugačku dva kilometra. Osim otoka Brača treba izdvojiti i dugu tradiciju rudarstva i klesarstva na otoku Korčuli, a posebno na području Lumbarde. Na obližnjim otočićima zvanim Vrnik (**slika 4**), Sutvara, Kamenjak i dr. vadili su se iznimno kvalitetni kameni varijeteti od antike, a koristili su se u starome gradu Korčuli i Dubrovniku (**Gjivoje, 1970; Russell i Glicksman, 2015; Mileusnić i dr., 2019**).

Slika 4: Vidljivi ostatci stare eksploatacije na otočiću Vrnik, blizina Lumbarde (Maričić, A.)

Druga bitna nemetalna mineralna sirovina koja se eksploatirala na jadranskoj obali jest morska sol. Najstarija solana u Europi, a ujedno i najveća koja je sačuvana na Mediteranu, jest stonska solana. To je poznato jer se stonska biskupija spominje 877. godine te se pretpostavlja da je to najstarija biskupija hrvatskoga etničkog područja (**Bogdan, 2018**). Osim stonske solane najintenzivnija tradicija vađenja soli prisutna je na otoku Pagu, a vjerojatno seže u 8. i 9. stoljeće (**Brgles, 2014**). Tri solane, u Stonu (**slika 5**), Pagu te Ninu (**URL4**), i danas proizvode sol.

Slika 5: Solana Ston (Briševac, Z.)

Uz prethodno navedene sirovine tijekom povijesti u Radoboju se vadio sumpor izvrsne kakvoće. Rudnik sumpora otvoren je 1811. godine (**Bićanić, 1951**). U Radoboju su pronađeni mnogi fosili biljaka, kukaca i riba, što predstavlja iznimno *ex situ* geološko nasljeđe (**Mileusnić i dr., 2019**). Među pronađenim fosilima posebno treba istaknuti najstariji pronađeni fosil vinove loze (*Vitis teutonica*) te mnoge fosile kukaca kao mrave, mušice, lisne stjenice (**Kozina, 2014**). U Radoboju je izumljen te prvi put korišten radobojski stroj za preradu sumpora (**Kišpatić, 1878**), što doprinosi važnosti mjesta u smislu rudarske baštine. Danas rudnik sumpora ne postoji (**slika 6**), tako da stari dokumenti, zapisi i iznimno važna fosilna zbirka svjedoče o geološkoj i rudarskoj baštini toga područja. Uz ostalo i zbog iznimnoga utjecaja rudarstva i eksploatacije sumpora na području Radoboja otvoren je Muzej Radboa (**URL5**). Muzej je djelomično financiran iz europskih fondova i dobar je primjer povezivanja rudarstva i geobaštine s europskom perspektivom energetske učinkovitosti i obrazovnih sadržaja.

Slika 6: Lokacija u Radoboju na kojoj je bio rudnik (Briševac, Z.)

3.2. Eksploatacija ugljena

Ugljen se u Hrvatskoj povremeno i u manjoj mjeri vadio na mnogim mjestima, ali prava eksploatacija odvijala se u Istri, Zagorju, Bilogori, Međimurju i na nekoliko mjesta u Dalmaciji.

Eksploatacija ugljena u Istri prestala je početkom 1990-ih. No i danas unutar lokalne zajednice postoji snažno sjećanje na ovu industriju, a mnogi su njezini povijesni artefakti ostali na cijelome poluotoku. Neki gradovi poput Labina jako su obilježeni ostatcima nakon eksploatacije (**slika 7**).

Slika 7: Rudarsko okno u Labinu (Briševac, Z.)

Prva poznata koncesija za vađenje ugljena datira iz 1626. godine, a izdana je za okolicu Labina. Bitumenozni tip ugljena bio je korišten za premazivanje dijelova brodova. Kontinuirana proizvodnja započela je 1785. godine u rudniku Pegola Nera iznad Krapna (**Vujec, 1997**). Nakon što je pronađen kameni ugljen, razvilo se njegovo intenzivno iskorištavanje. Ugljen je općenito poznat pod nazivom raški ugljen. Izniman je u svjetskim okvirima zbog visokoga sadržaja organskoga sumpora koji može biti i do 14 % (**Medunić i dr., 2016**). Raški ugljen također je karakterizirala povećana radioaktivnost. Aktivnost U-238 bila je 500 – 1200 Bq/kg u 1970-ima, a 250 – 300 Bq/kg u 1980-ima, što je 10 – 15 puta više od prosjeka ostalih vrsta ugljena u svijetu (**Marović i dr., 2004**).

Kad je eksploatacija ugljena u Labinu završila, započela je s radom „Umjetnička udruga Labin Art Express" (**URL6**), koja je dugi niz godina uspješno predstavljala svoje ideje za revitalizaciju rudnika. Kao takva je i prepoznata te sudjeluje kao partner u mnogim europskim projektima. Lokalne gradske vlasti grada Labina sudjelovale su u trima važnim projektima povezanim s bivšim rudnicima: Projekt prenamjene rudarske baštine KOVA (**URL7**), MIN-HER (**URL8**) i MINE TOUR (**URL9**).

Budući projekt Memorijalni centar Karlota u Raši (**URL10**) može se uvrstiti u plan prostorne revitalizacije i prezentacije cijeloga rudarskog područja oko grada Labina. S obzirom na autentični kontekst graditeljske i urbane baštine rudarskoga grada Raše, projekt Memorijalnoga centra europskih totalitarizama, smještenoga u

obližnjemu napuštenom kamenolomu Karlota (**slika 8**), temelji se na ideji da se izrazi duh mjesta (lat. *genius loci*) ili identitet mjesta kroz novi kompleks specifične arhitekture i urbanoga dizajna.

Slika 8: Memorijalni centar Karlota u Raši, arhitektonska vizualizacija (Arhitektonsko-građevinski atelje d.o.o.)

Napušteni kamenolom Karlota pokazao se idealnim mjestom iz mnogo razloga. Smješten je u neposrednoj blizini grada Raše. Nalazi se na povišenome terenu s prekrasnim pogledom na povijesne građevine grada, a zaravan usred kamenoloma ima površinu od oko 13 900 m^2 što udovoljava svim zahtjevima za smještajem kompleksa. Kompleks bi se lako mogao povezati s napuštenim rudnikom ugljena koji je bio u funkciji između 1928. i 1966. Autorski tim, koji su činili Vladi Bralić, Arsen Čupev i Luka Ilić, projekt kompleksa zamislio je kao određenu simbiozu kulturnoga i komercijalnoga sektora. Različiti obrazovni sadržaji posvećeni proučavanju europskih totalitarnih režima bili bi povezani s nizom različitih komercijalnih objekata u jednome arhitektonskom omotaču. Unutar takva centra postiže se visokoestetska sinergija kulturnih i obrazovnih elemenata, ali i raznovrsna kombinacija trgovine, gastronomije i dizajna.

Prema Hrvatskoj enciklopediji (**URL11**) prvi rudnik ugljena u Zagorju bio je rudnik Straža kraj Krapine koji je otvoren 1857. godine. Rudnik ugljena Ivanec otvoren je 1867. godine, ali je efikasno djelovao od 1890-ih godina te je bio jedan od najstarijih i najvećih rudnika lignita na lokalnome području (**Petrić, 2013**). Danas rudarska zgrada zajedno s industrijskim ostatcima – rudarskim separatorom ima ogroman potencijal za revitalizaciju. Već postoje neke realizirane inicijative i akcije. Također, Turistički ured Ivanec planirao je mnoge akcije u sljedećim koracima revitalizacije (**Jagetić Daraboš, 2017**). Na suprotnoj strani od Ivanca, na južnoj strani planine Ivančica, podjednako su bili razvijeni rudnici ugljena takozvanoga konjščinskog bazena. Reprezentativni spomenik rudniku postavljen je u mjestu Zajezda (općina Budinščina), a nalazi se uz kapelu svete Barbare (**slika 9**). Lokalni rudnik u Zajezdi postojao je od 1928. do 1967. godine. Inspiracija za izgradnju rudnika u zagrebačkome Tehničkom muzeju Nikola Tesla potječe iz rudnika konjščinskoga bazena.

Slika 9: Kapela sv. Barbare i spomenik rudniku Zajezda (Briševac, Z.)

Najstarijim rudarskim oknom na Bilogori smatra se ono u Glogovcu. Već 1869. godine osnovano je Udruženje rudnika ugljena Glogovac koje je od države dobilo službenu koncesiju 1874. Od tada se eksploatacija, s manje ili više uspjeha, nastavlja do 1970. godine, kada je proizvodnja prestala, a rudnici su bili zatvoreni. Pokušaji revitalizacije u prvome dijelu 1980-ih nisu bili uspješni (**Feletar, 1986**). Iako se dogodila velika promjena, u gospodarstvu regije Bilogora još se uvijek osjeća nostalgija i uspomena na rudarstvo i rudare. Ostalo je sjećanje na bolje dane, a Glogovac je danas prazan i uspavan, pa čak i zanemaren u nekim dijelovima (**Horvat, 2014**). Ostatci rudarskih zgrada poput utovarnoga bunkera (**slika 10**) podsjećaju na nekadašnji rudnik. Turistička zajednica Koprivničko-križevačke županije još je 2008. godine planirala kulturno-obrazovnu valorizaciju rudnika u Glogovcu, no do sada nisu postavljene čak niti oznake rudnika niti višejezične informativne ploče.

Slika 10: Ostatci utovarnog bunkera za ugljen u Glogovcu (Briševac, Z.)

Neki povijesni podatci navode kako je prvi podzemni rudnik ugljena u Međimurju otvoren u Peklenici 5. lipnja 1870. (**Mesarić, 2015**). Eksploatacija ugljena zabilježena je i u selu Dragoslavec od 1918. godine. Osnivač rudnika bio je Juraj Brlek (**Požgan i dr., 2019**). No, sigurno je da se u toj regiji ugljen počeo kopati krajem Prvoga svjetskog rata. Znatno industrijsko iskorištavanje ugljena površinskim kopom započeo je poduzetnik Karlo Vargazon u Peklenici 1919. godine. Nakon Drugoga svjetskog rata započelo je socijalistički planirano iskorištavanje ugljena. Rudnici su nacionalizirani i spojeni u jednu tvrtku koja se na kraju nazvala Međimurski rudnici ugljena. Sredinom 20. stoljeća bili su jedni od najvećih proizvođača ugljena u Hrvatskoj (**Kalšan, 2006**). Međimurski rudnici ugljena prestali su s radom 1972. godine, a tvrtka je promijenila djelatnost (**Požgan i Posedi, 2019**). Uslijed dugogodišnje rudarske aktivnosti na širemu području Murskoga Središća stvoreni su antropogeni reljefni oblici uzvisina (lokalno nazvani „halde") i udubina (lokalno nazvani „grabe") (**Mesarić, 2015; Buntić, 2020**). Iako se sam grad zvao Grad Rudara, trenutačno upravljanje rudarskim nasljeđem nije zadovoljavajuće. Veći broj „haldi" smještenih u blizini obližnjih sela ugrožen je zbog neprepoznatih vrijednosti i znatnoga antropogenog utjecaja. Očuvanje geomorfoloških nalazišta u okviru Zakona o zaštiti prirode preduvjet je za njihovu fizičku zaštitu, obnovu, uključivanje u turizam i doprinose održivomu razvoju regije (**Mesarić, 2015**).

Ugljen se kopao i izvan triju dominantnih regija, na primjer u Dalmaciji na području Siverića i Drniša. Počeci sežu u doba Mletačke Republike, a najveću važnost rudarstvo je imalo za vrijeme Austro-Ugarske. Još uvijek postoje pojedinačni tragovi poput napuštene devastirane radionice, zidanih ostataka trafostanica i jedva primjetnih, uglavnom neoznačenih i nezaštićenih ulaza u nekada poznate jame carskih i kraljevskih imena. Međutim, rudarstvo postupno nestaje iz sjećanja i osjećaja sadašnjih generacija jer ono danas nije dio njihovih života. Činjenice o njemu zasjenjene su ljudskim nemarom i dodatno oštećene u nedavnome ratu (**Tarle, 2016**).

Lignit je također istraživan i eksploatiran u drugoj polovici 19. stoljeća i prvoj polovici 20. stoljeća, sve do kraja Drugoga svjetskog rata u blizini Kravarskoga i u široj okolici brežuljkastih Vukomeričkih gorica. Na kraju su rudnik i oprema bili devastirani, a jedini spomen od toga ostao je u sačuvanoj dokumentaciji, ugovoru o otkupu rudnika, vladinim aktima i drugim doku-

mentima, poput karte rudnih polja, rudarskih dozvola, rudarskih profila itd. (**Šebečić, 2010.**)

3.3. Eksploatacija kovina

Iako se danas u Hrvatskoj ne eksploatiraju metalne mineralne sirovine (kovine), rudarska i metalurška tradicija sežu daleko u prošlost. Prvi tragovi lijevanja bakra u Hrvatskoj zabilježeni su prije gotovo 6 000 godina, a povezani su s pronađenim artefaktima iz vučedolske civilizacije u blizini grada Vinkovaca. U panonskome dijelu Hrvatske Kelti su znatno doprinijeli rudarstvu; nakon osnutka Siska započeli su s proizvodnjom željeza, a nakon rimskoga osvajanja započeo je znatan razvoj rudarstva i metalurgije (**Fabijanec i Vasiljević, 2017**). U srednjemu vijeku mnoge su hrvatske aristokratske obitelji temeljile svoje ekonomsko bogatstvo na intenzivnome iskorištavanju metalnih ruda. Vađenje kovina prestaje početkom industrijskoga doba zbog neisplativosti eksploatacije manjih ležišta.

Iako danas nema potencijalno iskoristivih ležišta metalnih ruda, u prošlosti je proizvodnja metala bila velika s obzirom na to da su se eksploatirali srebro, olovo, cink, bakar, željezo i aluminij. Među starim rudnicima samo su dva rudnika u određenoj mjeri revitalizirana i otvorena posjetiteljima kao dio kulturne i rudarske baštine u geoturističke svrhe. Stari rudnici u kojima su mještani nekada vadili plemenite metale jesu rudnik bakra i željeza *Sv. Barbara* u selu Rude kod Samobora i rudnik srebra *Zrinski* na Medvednici. Rudnici su djelomično revitalizirani snažnim angažmanom lokalne zajednice i različitih udruga ili javnih institucija s ciljem očuvanja stare rudarske tradicije. Rudnik *Sveta Barbara* održavaju lokalna zajednica i Kulturno umjetničko društvo Oštrc (**URL12; Vrkljan, 2019)**, a stari rudnik *Zrinski* održava Park prirode Medvednica (**URL13; Vrkljan, 2019**). Jedan zanimljivi stari rudnik s potencijalom za revitalizaciju, u suradnji turističke zajednice i lokalne uprave, jest rudnik Kraševski zviri kod Ivanca, u kojemu se kopao cink (**Jagetić Daraboš, 2017**).

Uz to, bogata povijest rudarstva posebno se očituje na cijelome području Trgovske gore, gdje je vađenje metala prvi put zabilježeno tijekom rimskih i ilirskih vremena. U Bešlincu i danas postoje ostatci visoke peći iz 19. stoljeća. Visoka peć, koja je prestala s radom 1942. godine, danas predstavlja industrijsko nasljeđe.

Vađenje željeza i bakra kao i olovno-srebrnih ruda bilo je iznimno aktivno tijekom srednjega vijeka i vladavine obitelji Zrinski koja je 1488. godine izgradila tvrđavu Gvozdansko nazvanu po željezu. Ista je obitelj bila povezana s rudnikom *Zrinski* na planini Medvednici (**Laszowski, 1944; Šebečić, 1998; Šebečić, 2000**).

Treba napomenuti da su prvi rudnici boksita na svijetu otvoreni u prvoj polovici 16. stoljeća na hrvatskome području Istre, u dolini rijeke Mirne ispod dvorca Sovinjak. O tome je boksitu napisan i prvi znanstveni rad (**Turini, 1808**). Središte je ovoga rudarskog područja nalazište Minjera koje bi u budućnosti moglo imati svjetsku ulogu u smislu obilježavanja eksploatacije boksita (**Marušić i dr., 1993**). Na području Drniša rudnik boksita Kalun bio je najdublji rudnik boksita na svijetu u trenutku prestanka eksploatacije. Eksploatacija je prestala 1963. jer se rudnik napunio podzemnom vodom (**Tarle, 2016**).

3.4. Eksploatacija nafte

Prvi zapisi o korištenju nafte u Republici Hrvatskoj datiraju iz ranoga srednjeg vijeka. Dubrovački trgovci spominjali su katran već u 12. stoljeću. Liječnik Pietro Andrea Mathioli iz grada Gorice objavio je u Veneciji 1565. godine knjigu pod nazivom „Commentarii in sex libros Pedacii Dioscoridis Anazarbei de Medica materia" s najvažnijim podatcima. Autor je u knjizi spomenuo vađenje nafte u blizini otoka Hvara, nedaleko od rijeke Neretve i u Panoniji. Putopis Alberta Fortisa u knjizi pod nazivom „Viaggio in Dalmazia", objavljenoj 1774., godine opisuje rudnik bitumena na otoku Čiovu i nalazište kod mjesta Škrip na otoku Braču, kasnije poznato kao rudnik Minjera (**Kanajet i dr.,1995; Šebečić, 1995**), te oko Vrgorca i kod Sinja. Prve dozvole za istraživanje izdane su već 1855. godine, a organizirana proizvodnja nafte s valjanom dozvolom zabilježena je 1856. godine. Grof Juraj Feštetić započeo je s legalnom proizvodnjom nafte u nekoliko plićih bušotina (dubine od 4 do 10 metara) na području Međimurja. Zbog duge tradicije eksploatacije Međimurje bi se moglo smatrati jednim od najstarijih područja eksploatacije nafte na svijetu. Najvažnija nalazišta nafte u povijesti na spomenutome području bila su naftna polja u mjestima Peklenica i Selnica. Nedavno su prostori s bušotinama uređeni kao parkovi naftne baštine na tome području (**slika 11 i slika 12**).

Slika 11: Park naftne baštine Peklenica (Brkić, V.)

Slika 12: Park naftne baštine Selnica (Brkić, V.)

Gotovo istovremeno započela su istraživanja na području Volodera i Mikleuške u Moslavini (središnja Hrvatska), Paklenice kod Novske i u Baćindolu kod Nove Gradiške (**Žgaljić, 1984**).

Sredinom 19. stoljeća poljski ljekarnik Ignaz Lukasiewicz izumio je petrolejsku svjetiljku. Rasvjeta petrolejskim svjetiljkama uvodi se u gradove Austro-Ugarske Monarhije kojoj je u to vrijeme pripadala i Republika Hrvatska. Prvi veći rudarski objekt izgrađen je u Moslavini, naftno okno Martin (**Velić i dr., 2012**), iz kojega se vadila nafta od 1854. do 1943. godine (**slika 13**). Martinovo okno duboko je 72 metra i nekoć je bilo najveće u Austro-Ugarskoj Monarhiji. Nafta je korištena čak za rasvjetu grada Beča (**Novak-Zoroe, 2013**).

Slika 13: Naftno okno Martin (Brkić, V.)

Na području između rijeke Drave i Save zabilježeni su ostatci istraživanja i proizvodnje na desetak lokaliteta, uglavnom na mjestima gdje su prije bili uočeni prirodni izdanci nafte (**Križ i dr., 2008**). Znatan porast

istraživanja i proizvodnje nafte i plina u Republici Hrvatskoj započeo je 1952. godine u Panonskome bazenu.

Povijesni prikaz istraživanja i proizvodnje nafte i plina, a koji je imao utjecaj i na Hrvatsku, ne bi bio potpun bez spomena Antuna Lučića, najpoznatijega hrvatskog naftaša koji je radio u Sjedinjenim Američkim Državama. Početkom 20. stoljeća pokrenuo je revoluciju u naftnome inženjerstvu uvodeći rotacijsko bušenje, isplaku (fluid) za bušenje i druge inovacije. Američki institut za geološka i metalurška istraživanja 1936. godine osnovao je nagradu pod nazivom „Anthony F. Lucas Zlatna medalja" za dostignuća u području istraživanja i proizvodnje nafte i plina. U čast istraživača Lučića izgrađen je muzej s granitnim obeliskom na kojemu je zapisano: „Na ovom je mjestu desetog dana dvadesetog stoljeća započelo novo razdoblje u civilizaciji," (**McBeth, 1998**).

4. Rasprava

Ovaj rad pokriva prošireno područje povezano s prošlošću rudarstva i naftne industrije. Ako bi se ujedinila rudarska, naftna i geološka baština, mogao bi se koristiti pojam geotehnološka baština. Pojam zbog neraskidive poveznice objedinjuje rudarstvo, naftu i geologiju. Izraz je kovanica od grčkih riječi *geo* (Zemlja), *tekhne* (vještina, majstorstvo, sposobnost ili zanat) i *logia* (znanje, znanost). Iako takav pojam još nije prisutan u literaturi i prvi put se koristi u takvu kontekstu, ne postoje valjani argumenti za njegovu neupotrebu u smislu očuvanja specifične industrijske baštine. U Hrvatskoj se može koristiti pojam geotehnološka baština jer je prepoznatljiv u našim okolnostima. Međutim, svaki segment baštine ima svoje jedinstvene karakteristike, što se ne smije previdjeti.

Najširi segment geotehnološke baštine jest onaj geološki jer prezentira prirodnu strukturu podzemlja. Bez geologije kao temeljne znanosti ne bi bilo rudarske i naftne industrije. Kroz rudarske aktivnosti geologija podzemlja postaje vidljivija i dostupnija. To upućuje na izravnu vezu između rudarstva i potrebnoga znanja o prirodi i geologiji. Povezanost je vidljiva i u UNESCO-ovu popisu svjetske baštine (**URL1**). Potrebno je naglasiti da su rudarska i geološka baština međusobno povezane, no povezani su i s kulturnim nasljeđem općenito. Posebno se u Hrvatskoj njeguje stara tradicija eksploatacije sirovina s naglaskom na vađenju kamena. Mnogi stari kamenolomi, rudnici ili industrijski ostatci ostaju vidljivi u tradicionalno rudarskim regijama poput Istre ili otoka Brača i Korčule.

Eksploatacija mineralnih sirovina bila je važan dio lokalnoga gospodarstva nekih regija u Hrvatskoj. Danas to nije toliko važno, ali ostatci te eksploatacije i dalje postoje. Međutim, eksploataciju su uvijek pratile negativne percepcije zbog teških radnih uvjeta u prošlosti, a u moderno doba i zbog negativnoga utjecaja na okoliš (**Petlovanyi i dr., 2019**). Baština u smislu usvajanja određenih obrazaca ponašanja također je vrijedna očuvanja i zaštite. Socijalno izolirani rudari bili su u stalnome kontaktu s iznenadnim opasnostima, a sve kako bi društvu osigurali viši životni standard. Pri tome su razvili dubok osjećaj solidarnosti, sličan vojnicima u ratu (**Freese, 2006**). Kako vrijeme prolazi, ljudi koji su radili u rudniku umiru, pa solidarnost u bivšim rudarskim područjima također slabi, stoga su vrijedni napori prikupljanja i zapisivanja usmenih priča o rudarskome životu (**Horvat, 2014**).

Postoje različiti pristupi u načinu revitalizacije rudarske baštine. To se može vidjeti u slučaju grada Labina. Tamo je nakon zatvaranja rudnika počela djelovati „Umjetnička udruga Labin Art Express" koja je konceptualno osmislila ideju „Podzemni grad" sa svim gradskim sadržajima. U novije vrijeme gradska uprava teži rješenjima kroz projekte KOVA, MIN-HER i MINE TOUR koji imaju izrazitu kulturnu svrhu. Nijedna koncepcija do sada nije u potpunosti ostvarena. No očito mora postojati odgovarajuća ravnoteža između kulturnih i komercijalnih sadržaja. Lokalnoj je upravi lakše uspostaviti kulturne sadržaje, ali ne bi ih trebalo predimenzionirati. S druge strane, komercijalni objekti jednako su potrebni jer stanovništvo ima potrebu za zaradom, tj. radnim mjestima. Primarni je izazov kako postići sinergiju između svih dionika u revitalizaciji geotehnološke baštine. Jasno zakonodavstvo pomoglo bi u prevladavanju ovih izazova.

Primjeri zaštite i lokalnoga korištenja rudarske, naftne i s njima povezane geološke baštine u Hrvatskoj nisu svjetski poznati kao slični primjeri u Europi. Gledano po regijama i vrstama mineralnih sirovina, većina elemenata kulturne baštine nalazi se u obalnim regijama. Većinom su povezani s vađenjem arhitektonsko-građevnoga kamena koji je korišten za izgradnju mnogih starih gradova i spomenika kulturne baštine duž jadranske obale. U povijesnim regijama u kojima se eksploatirao ugljen, poput Istre, Zagorja, Međimurja, Bilogore, postoje mjesta na kojima se mogu naći rudarski kulturni elementi. Nadalje, postoji nekoliko mjesta u blizini Zagreba u kojima se tijekom srednjega vijeka eksploatirala ruda metala, kao rudnik *Sv. Barbara* kod Ruda, rudnik *Zrinski* na Medvednici te cijelo područje Trgovske gore.

Freese (**2006**) ističe: „Kad razmišljamo o nafti, to nas povezuje s iznenadnim bogatstvom, dok nas ugljen asocira na siromaštvo i razočaranje." To znači da se drugačije shvaća naftna baština jer ona ne iziskuje otežane uvjete rada kao rudnici u kojima je pretežno radila siromašnija populacija. Nažalost, Hrvatska još nema muzej posvećen eksploataciji nafte. Hrvatska tvrtka INA d.d. u svojoj bogatoj arhivi ima mnoštvo opreme i dokumentacije vezane za istraživanje i proizvodnju nafte i plina, što bi moglo postati dijelom muzejske izložbe. Prvi naftni muzej planira se otvoriti u Ivanić-Gradu te bi u Hrvatskoj predstavljao stoljetnu kulturnu i spomeničku baštinu naftne industrije.

Istraživanje koje je obavljeno u svrhu izrade ovoga rada rezultiralo je i zanimljivim saznanjem o identičnim imenima udaljenih lokacija. U primorju su to imena talijanskoga podrijetla *pegola nera* (što znači 'crna smola') i Minjera (što znači 'rudnik'). Na Braču postoji Minjera

kao nekadašnji rudnik bitumena, a postoji i Minjera u Istri koja je bila rudnik boksita. Slična je stvar s imenom Peklenica kod Murskoga Središća i Paklenica kod Novske. Riječ *pekla* znači 'izdanak nafte'. To je zanimljivo, ali se mora uzeti u obzir da se ne može koristiti potpuno isti naziv u procesu izgradnje identiteta i povećanja vidljivosti mrežnih stranica različitih mjesta. Isti nazivi mogu zbuniti strane potencijalne posjetitelje.

Svijet i način života neprestano se mijenjaju. Te su promjene često povezane s eksploatacijom mineralnih sirovina uključujući i ugljikovodike od kamenoga do modernoga doba. Uz to, rudarstvo se može smatrati privremenom djelatnošću na nekome mjestu pa se uvijek mora razmotriti mogućnost korištenja rudnika ili naftnih i plinskih polja nakon prestanka rada. Neki od njih mogli bi predstavljati vrlo vrijednu baštinu bez obzira na to imaju li kulturno-povijesno, geološko ili industrijsko (rudarsko i naftno) značenje.

U prezentaciji industrijske baštine, a time i geotehnološke baštine, najviše je učinila organizacija ERIH. ERIH je svojim radom industrijsku baštinu smjestio na turističku kartu Europe i turistima približio tu baštinu. Takav turistički potencijal u Hrvatskoj osim što nije još uvijek prepoznat, nedovoljno je valoriziran. Potrebno je slijediti primjere dobre prakse drugih europskih zemalja (Francuska, Poljska, Njemačka itd.) koje u svojoj turističkoj ponudi imaju i geotehnološku baštinu. Geotehnološko nasljeđe nudi potencijal koji treba prepoznati i iskoristiti jer nakon prestanka rudarske djelatnosti ostaje prostor kao dobra osnova za daljnje turističke aktivnosti i obrazovanje. Ključna stvar u pogledu budućnosti geotehnološke baštine u Hrvatskoj jesu investicije, odnosno ulaganje u projekte koji će biti prepoznati te ulaganje u oglašavanje i promociju geotehnološke baštine kao i investicije u rudarska mjesta koja već nude dobru osnovu za daljnji napredak.

5. Zaključak

U članku se prikazuje geotehnološka baština Hrvatske. Pojam geotehnološke baštine mogao bi se koristiti za bolje prepoznavanje rudarske, geološke i naftne baštine u širokome konceptu industrijske baštine. Dio geotehnološke baštine s najvećom perspektivom jest ona geološka, te se takav tip baštine može razvijati u područjima s tradicijom u eksploataciji mineralnih sirovina, posebno u vađenju kamena, a također i u području zaštite prirode.

Jedan od bitnih problema uočenih prilikom revitalizacije jest nedostatak jasnijega zakonodavstva. Jasnije zakonodavstvo pomoglo bi prevladati izazove različitih koncepcija zaštite i revitalizacije geotehološke baštine te bi potaknulo sinergiju svih sudionika u tome procesu.

Zbog neopravdane, ali realne negativne percepcije rudarstva i postindustrijskoga krajobraza općenito, kulturno očuvanje rudarske baštine trebalo bi se temeljiti na nematerijalnim potencijalima kao što su rudarska tradicija, običaji i jedinstveni lokalni identiteti. Stoga treba što prije pojačati napore u prikupljanju i pisanju priča o rudarskome životu jer sve je manje ljudi koji su se nekada bavili rudarstvom, a svjedočenja i usmena predaja njihovom smrću nestaje.

Europsko iskustvo, ali i neki od naših primjera pokazuju da se potencijali geotehnološke baštine mogu sadržajno i smisleno pretvoriti u kulturne znamenitosti, povijesne događaje, lokalne muzeje, industrijsko-turističke staze i mnoge druge primjere dobre prakse. Hrvatska bi trebala predstaviti i kulturnu i spomeničku baštinu naftne industrije u jedinstvenome tematskom muzeju zbog duge tradicije u proizvodnji nafte i plina.

Hrvatska je prepoznata kao zemlja koja ima relativno velik broj lokacija na kojima može adekvatno predstaviti svoju geotehnološku baštinu. Sva mjesta na kojima se mineralne sirovine sada eksploatiraju mogla bi jednoga dana postati mjesta zaštite i prezentacije geotehnološke baštine. Jedan od prijedloga Republici Hrvatskoj, kao članici Europske unije, jest da maksimalno iskoristi raspoloživa sredstva za financiranje rudarske, geološke i naftne baštine kako bi postigla dodatnu prepoznatljivost u srednjoj i zapadnoj Europi. Mora se naglasiti kako je geotehnološka baština više prepoznata i korištena u Europi nego u Hrvatskoj.