

MINING TRENDS AND THE POTENTIAL SPATIAL DEGRADATION IN THE EAST PLANNING REGION IN REPUBLIC OF MACEDONIA

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ABSTRACT

The East planning region of the Republic of Macedonia has a great mining history. As a result, there is a great quantity of waste and significant impact on the environment. Lately the region is facing a trend of opening new mines, that will affect the economic and social activities in the region. The increased impact on the environment and the lack of positive remediation experiences were the motive for analysis of the correlation between proposed mining activities and environmental protection.

The analysis consists of confronting the value of the locations (natural heritage, settlements, hydrological elements) and the impact on the environmental media.

The analysis showed that only several locations may be exploited without major spatial degradation consequences.

Keywords: spatial planning, environment, mining, pollution

INTRODUCTION

The environmental protection in the past was not as important as the economic benefit of the industry. The outdated technologies used in most of the capacities over time resulted in 16 contaminated sites around the country, where the presence of soil contamination is well recognized [6]. The seriousness of possible effects on the ecosystems and people's health is such that remedial measures are required. Although there is some progress in the maintenance of the contaminated sites, after all these years none has been totally remediated, according to the environmental indicators of the Ministry of environmental and physical planning. The analysis of the type of the contaminated sites show that there are 5 mines among them [3].

The East planning region (EPR) in the Republic of Macedonia has a great mining history. As a result, 99,98% of the waste generated from the mining industry and stone extraction is concentrated in the East planning region, which has had enormous negative environmental impact [13]. Lately, the region is facing a trend of opening new mining sites, that will affect the economic and social activities in the region, as well the environmental values. This paper is analyzing the potential impact on the spatial values from the planned concession sites, especially from environmental and social viewpoint.

AIMS AND OBJECTIVES

The main aim of the paper is to offer sustainable approach through the process of location selection for a geological research concession site, with minimal environmental and social impact, having in mind that these sites later, become exploitation fields.

The objectives of the paper are:

- Analysis of the locations given as concession sites for geological research in the EPR;
- Environmental aspects of the national legal framework regarding the selected locations;
- Suggested sustainable approach for the best possible location selection for mining activities with minimum environmental impact.

THEORETRICAL BACKGROUND

Water quantities for the needs of industry and mining sector in the Republic of Macedonia are mostly provided from surface waters (watercourses, reservoirs and lakes). The use of water from springs, needed for supply in the industry and mining sector has risen from 8% in 2010 up to 51% in 2015. The underground water remains the least used source for water supply in the industry and mining sector with around 1-2% [2]. Comparing to other regions in the country, the East planning region has major water use in the industry and mining sector [7].

The national statistical data show that less than 1% of the wastewater generated in the industry and mining sector is treated before it is discharged [2]. Furthermore, almost the whole untreated wastewater from industry and mining sector in 2015 was discharged in the watercourses, reservoirs and the soil (99,6%). Less than 1% was discharged in the public sewers. Comparing to other regions, the greatest share of the unpurified wastewater from the industry and mining sectors is discharged in the East planning region [7].

The current water protection issues against pollution in industry and mining and the amount of waste generated from the mining industry in the East Planning Region, as well as the present natural values, were the motive for the research analysis presented in this paper.

METHODOLOGY

The qualitative methodological approach was used for the assessment of the spatial potential of the selected locations. The concession sites were analyzed through several criteria: the distance from the surrounding populated areas, nearby natural heritage, environmentally polluted areas and existing nearby water basins. The collected data, organized in a geodatabase, using a GIS methodology and tools, were then used for the analysis, which resulted in several important points presented in the conclusion of the research paper.

STUDY REGION

The East Planning Region, determined according to the nomenclature of the territorial units for statistics NUTS-3 [8], is in the eastern part of the Republic of Macedonia. It is bordered by the Vardar, Northeast and the South-East Planning Regions. It mainly covers the catchment area of the river Bregalnica and covers 13.76% of the territory of the Republic of Macedonia.

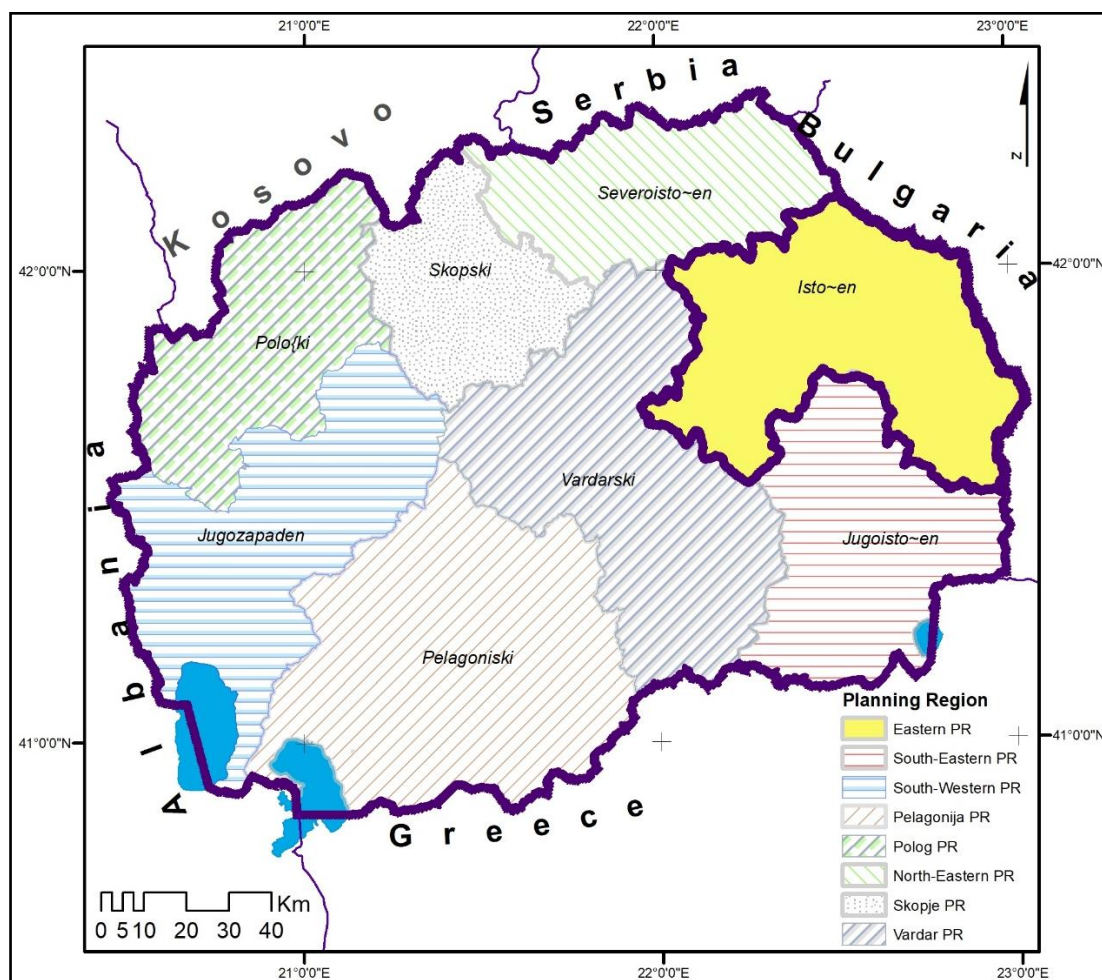


Figure 10. Statistical Planning Regions in the Republic of Macedonia with the position of the study region (East Planning Region)

The EPR is comprised of 11 municipalities: Berovo, Pehchevo, Delchevo, Kochani, Makedonska Kamenica, Vinica, Zrnovci, Probishtip, Cheshinovo-Obleshevo, Karbinci and Shtip, with a total area of 353,813.82 *ha*. The number of settlements is 217, of which 8 are urban settlements and 209 are rural. Regarding the total number of settlements in the country, the Region participates with 12%, and in the total number of the population with 9%.

Geologic-petrographic characteristics

The geological structure of Eastern Macedonia includes rocks of metamorphic and complex Rhodope type, consisting of rocks of varying degrees of crystallinity-crystalline shales, Mesozoic and Tertiary sediments, magmatic and quaternary formations [1].

These rock masses are included in the following geological formations:

- Complex of Precambrian metamorphic rocks;
- Complex of old Paleozoic rocks and magmatites;
- Hercic-young Paleozoic magmatic rocks and sediments;
- Mesozoic sedimentary rocks and magmatites;
- Sedimentary rocks and volcanics of Tertiary and
- Quarter rocks and volcanics.

The main characteristic of this area is its location in two geotectonic units on the Balkan Peninsula: the Serbian-Macedonian mass and the Vardar zone, each of which is characterized by its specific geological structure.

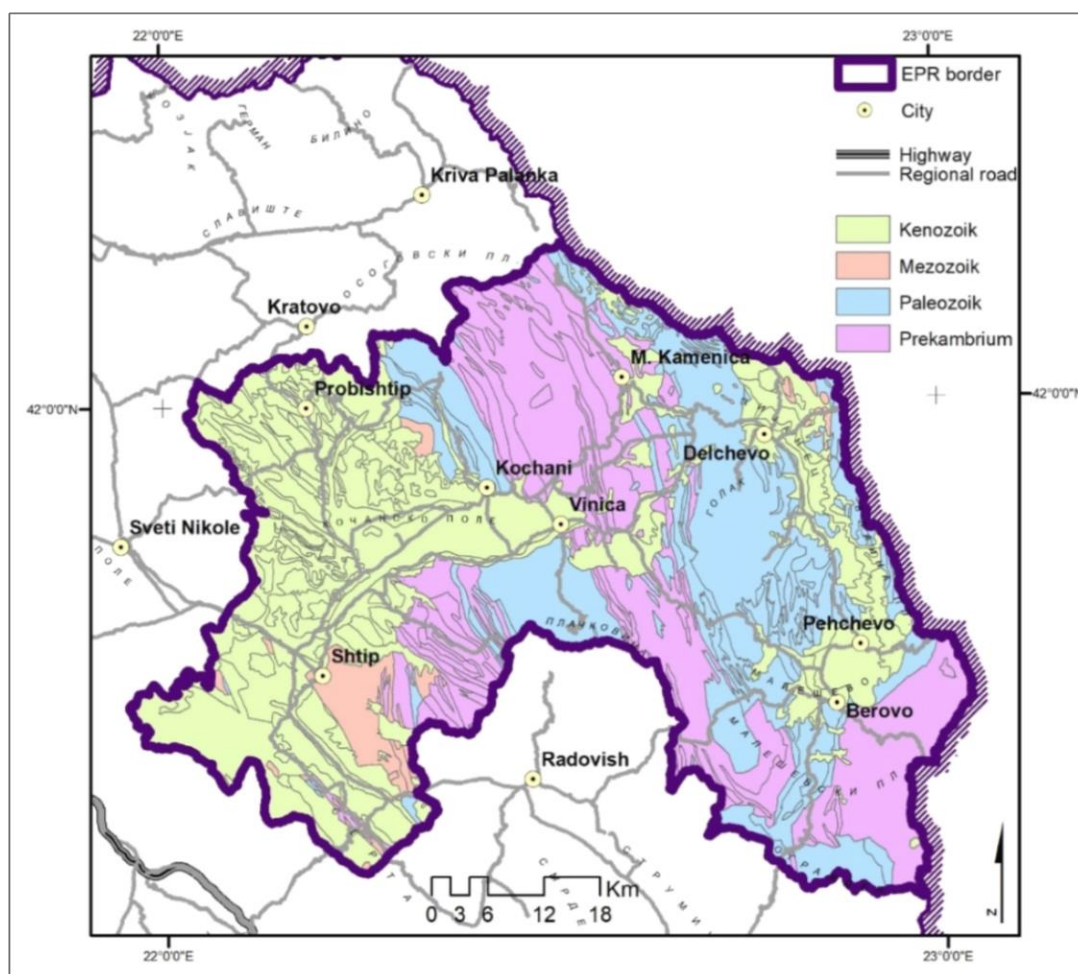


Figure 11. Geological formations

MINING IN THE STUDY REGION

Exploitation of mineral raw materials is regulated by issuing concessions. Concessions are issued for the exploration of mines and mining. Metallic, non-metallic, energy mineral resources, as well as water and geothermal water sources are found in the East Planning Region [1].

Table 1. Number of localities in EPR by type of mineral and status

Type of mineral	Exploitation	Research	Grand Total
Energy	2	1	3
Metallic	4	8	12
Non-metallic	31	10	41
Water	6	3	9
Grand Total	43	22	65

Metallic mineral resources

Metallic mineral resources represent the most significant resource and have a direct impact on the overall economic picture of the region. This is due to the presence of significant metallogenetic zones within which several major sites (mines) for *Pb*, *Zn*, *Cu* and *Au* are determined.

From the existing concessions for exploitation of metallic mineral resources, the most significant, from the economic point of view, are the sites (mines): "Sasa" - Municipality of Makedonska Kamenica, "Dobrevo" and "Plavica" - Municipality of Probishtip. Of these mines, opened during the sixties and seventies in the last century, active exploitation is done in Dobrevo and Sasa, while in the "Plavica" additional geological explorations are ongoing for determining additional ore reserves and re-starting the mine.

Energy minerals

Regarding the representation of energy mineral resources, significant zones in the Region are: Probishtip basin and Berovo-Pehchevo-Delcevo basin.

Technogenic mineral resources

These mineral resources are in fact raw materials that can be used in the process of exploitation of the primary mineral resource.

Also, as a technogenic mineral resource, part of the slag from the mines for metallic mineral raw materials can be used, where with new techniques and technologies additional extraction of the remaining content of metal in the slag is possible.

Non-metallic mineral raw materials

Significant are the occurrences of construction-technical stone, quartz, clay, opal breccia and tuff.

As subclass of the non-metallic mineral raw materials architectural-ornamental and architectural-construction stones are represented by: ignimbrites, limestones, andesites, sandstones etc.

Water

There are findings of mineral, thermo-mineral, thermal and mineral/CO₂ gas waters in the EPR. From the aspect of hydrothermal zoning, the following zones are distinguished: Kocani valley - Kocani-Istibanja, near the village Krupiste; granite massif in the surroundings of Stip (Stip granites) - the Kezhovica bath in the Stip area.

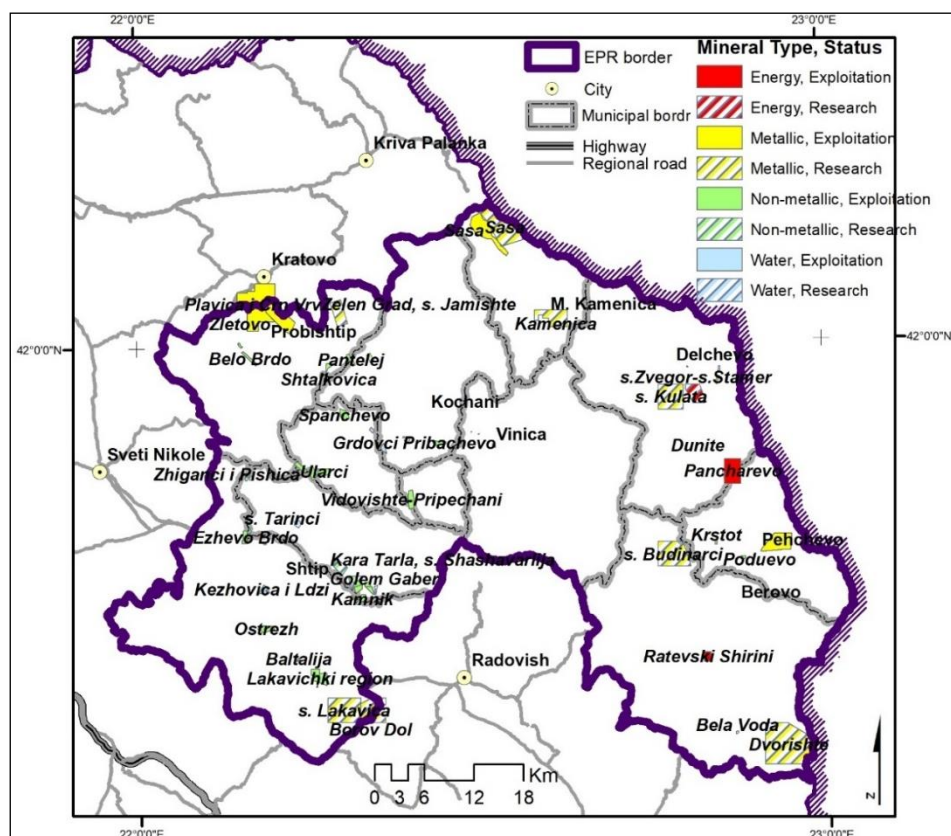


Figure 12. Localities with mining and research concessions, by mineral type

Table 2. Exploitation of minerals by type in the region (Area in hectares)

Mineral	Type of the mineral				Exploitation Total
	Energy	Metallic	Non-metallic	Water	
Basalt			82.30		82.30
Ceramic Clay			341.62		341.62
Clay			26.89		26.89
Coal	689.10				689.10
Copper		600.67			600.67
Copper, Gold and Silver		1,688.18			1,688.18
Gabbro			53.18		53.18
Geothermal water				59.97	59.97
Groundwater				0.27	0.27
Lead		595.50			595.50
Lead and zinc		642.30			642.30
Limestone			214.53		214.53
Limestone and Rapeseed Limestone			90.20		90.20
Marble limestone			12.35		12.35
Opal Breccia			98.24		98.24
Quartz			373.47		373.47
Quartzites			16.39		16.39
Rapeseed limestone			76.31		76.31
Sand and Gravel			6.53		6.53
Slate			42.50		42.50
Thermo-mineral water				93.19	93.19
Tuff			60.31		60.31
Tuff, Gabbro, Monzonite			42.50		42.50
Grand Total	689.10	3,526.64	1,537.32	153.43	5,906.49

Table 3. Research of minerals by type in the region (Area in hectares)

Mineral	Type of the mineral				Research Total
	Energy	Metallic	Non-metallic	Water	
Andesite			35.17		35.17
Basalt			14.30		14.30
Coal	403.59				403.59
Copper		769.40			769.40
Copper and gold		2,837.72			2,837.72
Geothermal water				55.24	55.24
Groundwater				7.39	7.39
Limestone			312.64		312.64
Metallic		5,032.39			5,032.39
Quartz			46.64		46.64
Sand			1.94		1.94
Slate			31.67		31.67
Grand Total	403.59	8,639.51	442.36	62.63	9,548.08

The largest share in the areas intended for exploitation and exploration of mineral resources have metallic minerals (79%), followed by non-metallic (13%), energy (7%) and water (1%). The exploitation of the metallic ore is underground, but the impact of the technology used for exploitation on the environment is significant. Non-metallic minerals are extracted in quarries; therefore, the impact is mainly on the landscape and air quality. Water exploitation has the least visible impact on the environment. Still care must be taken regarding the long-term balance of underground waters in the Region.

SUSTAINABLE APPROACH

The process of sustainable spatial planning is essential for determination of the best possible use of the land use categories in the future. Thus, there is need to view the spatial potential from all aspects, before making a decision for future development of the planned area. The fact that some spheres of interest are forced towards rapid use without taking into account the spatial potential of the other spheres of interest is unsustainable.

The locations of the concession sites for geological research in this paper were analysed by their spatial potential through four criteria: populated areas, natural heritage, environmental values and water sources.

The distance between the concession site and the populated areas is very important since the geological research, and later the exploitation, will have environmental consequences which may result in health issues of the nearby population. Thus the nearby population will be mostly affected.

The second criterion was: the presence of nearby water bodies, since the mining activities will affect the life in them; the planned water supply systems, which will affect the population health through the quality of the drinking water and the planned irrigation systems, which will affect the nearby agricultural land, and consequently the population that will consume those products.

The third criterion was the distance from the natural heritage. The concession sites located in protected or proposed for protection natural heritage will affect the natural values in a long term, so the heritage will lose its designated values.

The distance from waste disposal sites is also important, since there might be indications for pollution of the underground water designated for exploitation.

The outcome from the analysis of the concession sites for geological research in the East Planning Region, by these criteria is presented for each municipality below:

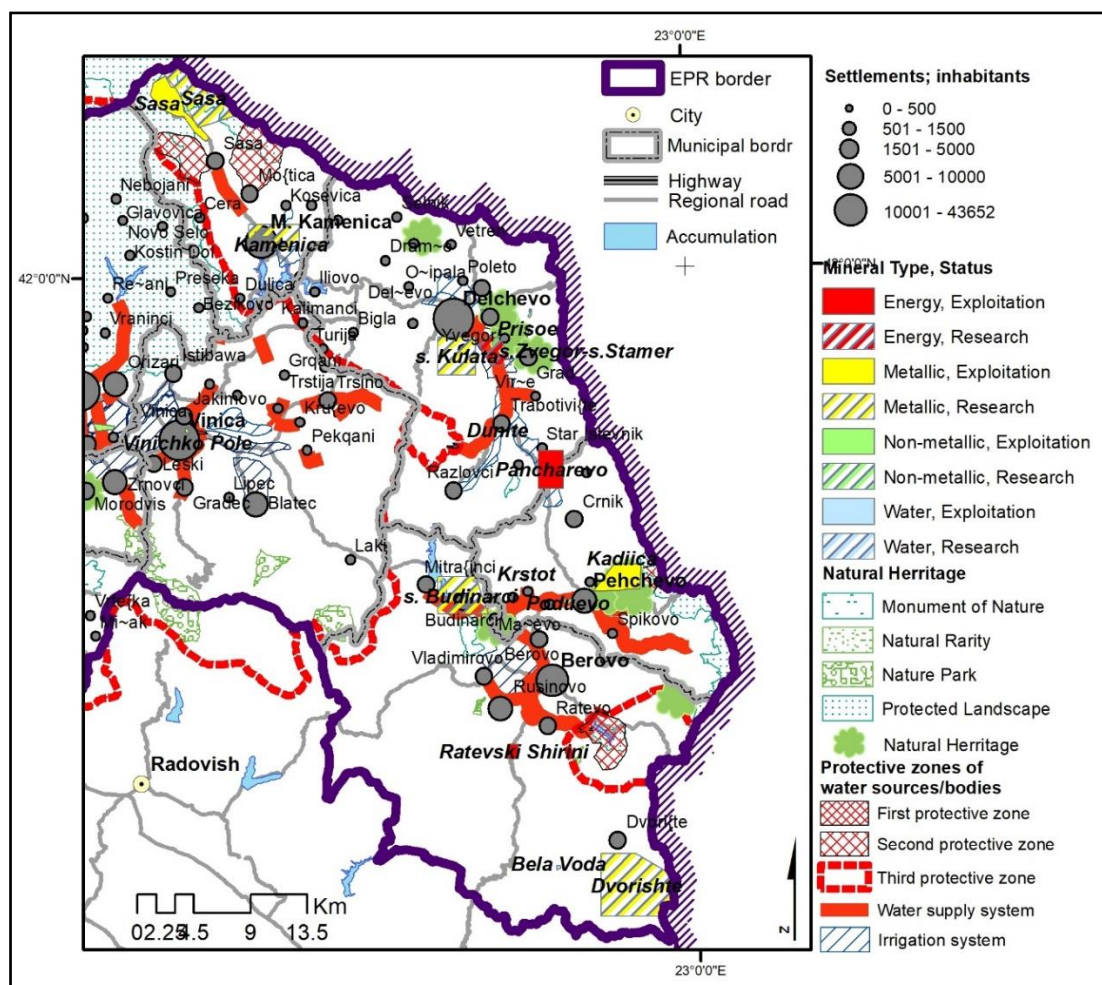


Figure 13. Localities with mining and research concessions in municipalities of Berovo, Pehchevo, Delchevo, M. Kamenica and Vinica

Table 4. Spatial potential of the concession sites for geological research in municipality of Berovo

Research site	Spatial potential	
Dvoriste Copper and gold Area: 2452 ha	Populated area	<i>The concession site is located near the national border with Republic of Bulgaria. Nearest populated area in the Republic of Macedonia is Dvoriste, located less than 1 km from the concession site.</i>
	Surface water	<i>There are several watercourses and flows crossing through the concession site: Bukovkracka River, Sredocka River, Elenska River, Crkvicka River and Zabelski, Gramadnicki and Drshanski flow.</i>
	Natural heritage	<i>The concession site is located in representative area Ograzden proposed to be managed for species conservation.</i>
	Environment	<i>Wild dump is located 0,7 km from the concession site.</i>

Budinarci Metallic minerals Area: 1050 ha	Populated area	<i>The concession site is partially entering the populated area Budinarci. The populated area Machevo is located at 0,4 km distance from the concession site. The populated area Mitrashinci is located 0,75 km from the concession site.</i>
	Surface water	<i>Water supply sistem is located in the borders of the concession site. There are several watercourses crossing through the concession site: Bregalnica, Davalica, Kamenica, Golem Dol, Lenishka River, Roshul and Selska River. The concession site is partially entering in the planned accumulation Razlovci. The irrigation system Ratevska Reka and Chiflic is located on 0,8 km distance from the concession site.</i>
	Natural heritage	<i>The concession site is located 0,1 km from the proposed natural heritage, Machevo, monument of the nature.</i>
Bela Voda Underground water Area: 7,39 ha	Surface water	<i>The River Bela Voda is passing by the concession site. The Prevedenska River is passing by the concession site on a 0,3 km distance.</i>
	Natural heritage	<i>The concession site is located in representative area Ograzden proposed to be managed for species conservation.</i>

Table 5. Spatial potential of the concession sites for geological research in municipality of Delchevo

Research site	Spatial potential	
Zvegor and Stamer Coal Area: 403,59 ha	Populated area	<i>The concession site is located 1,7 km from Delchevo. Planned gas line is passing through the concession site.</i>
	Surface water	<i>The Bregalnica River and some other small watercourses are passing through the concession site. Grashtica River is passing by near the concession site. Irrigation system Delchevsko Pole is passing through the concession site. Water supply system Delchevo is passing through the concession site. Wastewater system is passing on 0,9 km distance from the site.</i>
	Natural heritage	<i>The concession site is located 0,4 km from the proposed natural heritage for protection, Stamer - natural rarity, 1,6 km from the Cave Konjska Dupka – monument of nature. The concession site is located 2 km from the protected natural heritage Zvegor – natural rarity.</i>
	Environment	<i>Wild dump is located 0,7 km from the concession site.</i>
Kulata Metallic minerals Area: 900 ha	Populated area	<i>The populated area Chiflic is entering in the concession site. Planned gas line is passing at 0,5 km distance from the concession site.</i>
	Surface water	<i>The Bregalnica River and some other small watercourses are passing through the concession site. Irrigation system Delchevsko Pole is passing through the concession site. Water supply system Delchevo is passing at 0,3 km distance from the concession site. Wastewater system is passing at 0,7 km distance from the concession site.</i>
	Natural heritage	<i>The concession site is located 2,4 km from the proposed natural heritage for protection, Stamer - natural rarity.</i>

Odzov Chukar Non-metallic minerals: sand Area: 1,94 ha	Populated area	<i>The nearest populated area Zvegor is located at 0,4 km distance from the concession site.</i>
	Surface water	<i>The concession site is partially entering in the irrigation system Sandanski. The Gabrovska River is passing by the concession site on a 0,5 km distance, and the river Zvegor is passing by on a 0,6-0,7 km distance.</i>
	Natural heritage	<i>The concession site is located at 0,9 km distance from the protected natural heritage Zvegor – natural rarity.</i>
R'zacki Kamen Limestone Area: 11,82 ha	Populated area	<i>The nearest populated area Zvegor is located at 2 km distance from the concession site.</i>
	Natural heritage	<i>The concession site is is located 1,7 km from the proposed natural heritage for protection, Stamer - natural rarity.</i>

Table 6. Spatial potential of the concession sites for geological research in municipality of Makedonska Kamenica

Research site	Spatial potential	
Sasa Metallic minerals Area: 1272,67 ha	Populated area	
	Surface water	<i>Kozja River, Svinja River, Petrova River and some other small watercourses are passing through the concession site. The Kamenica River is passing near by the concession site.</i>
	Natural heritage	<i>The concession site is entering the proposed natural heritage Osogovski planini [5]. The concession site is entering the proposed natural heritage Crvena Reka.</i>
Kamenica Metallic minerals Area: 620 ha	Populated area	<i>The populated area Lukovica is entering the concession site. Makedonska Kamenica is located on 0,1 km distance from the concession site.</i>
	Surface water	<i>Kamenica, Lukovicka Reka and some other small watercourses are passing through the concession site. The planned irrigation system Lukovicka River is entering the concession site. The planned accumulation Lukovica is entering the concession site. The concession site is located on 0,7 km distance from the protection zone of the accumulation Kalimansko Ezero.</i>
	Environment	<i>There are installations near by the concession site that have had negative environmental impact in the near past.</i>

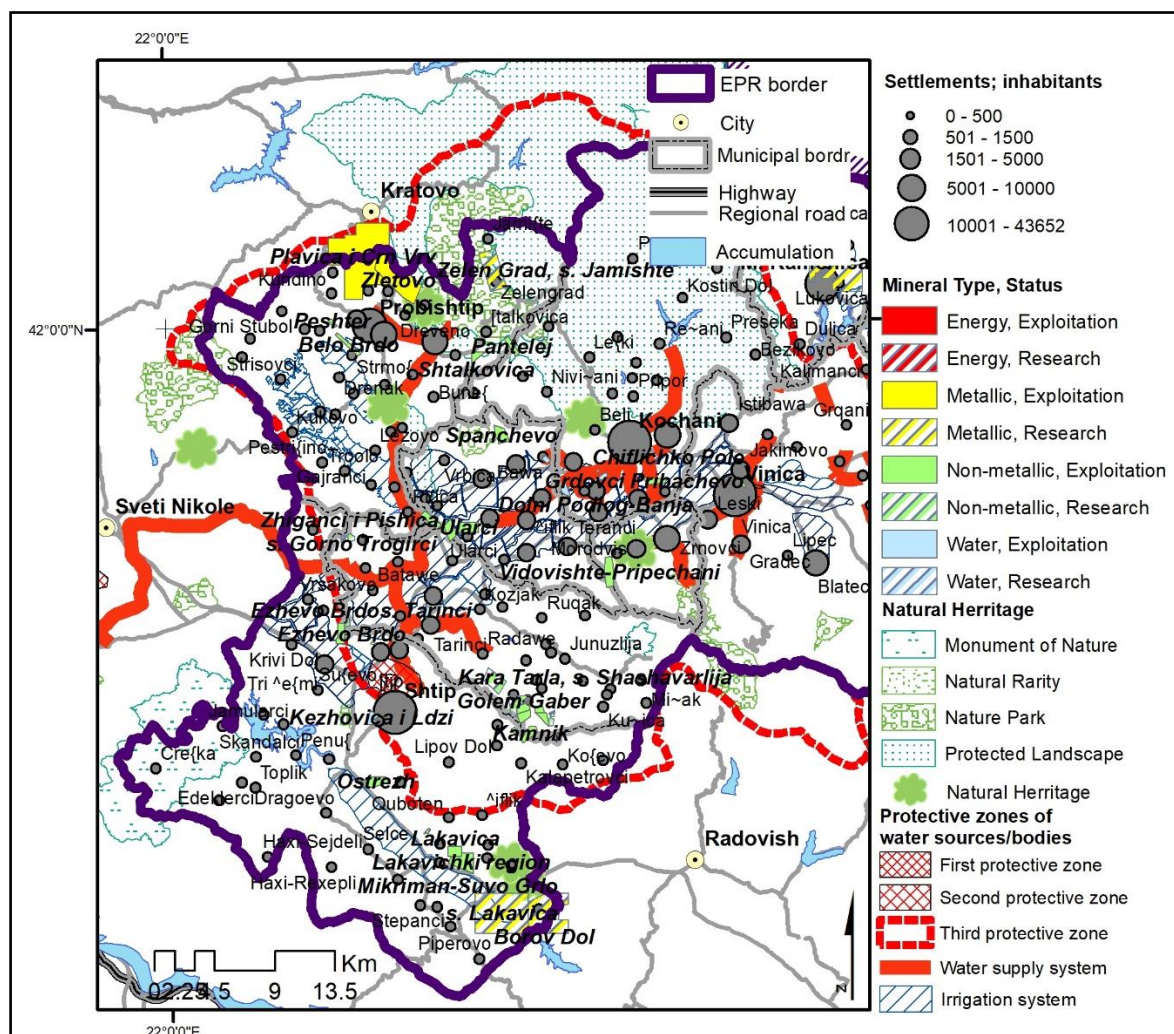


Figure 14. Localities with mining and research concessions in municipalities of Kochani, Zrnovci, Probishtip, Cheshinovo-Obleshevo, Karbinci and Shtip

Table 7. Spatial potential of the concession sites for geological research in municipality of Kocani

Research site	Spatial potential	
Przhiti Quartz Area: 46,64 ha	Surface water	The concession site is entering in the third protection zone from the wells in Stip.
	Natural heritage	<i>The concession site is entering the proposed natural heritage Osogovski planini.</i> <i>The concession site is partially entering the proposed natural heritage and Zletovska Reka - Ratkova Skala.</i>
Vinicka Vada Geothermal water Area: 2,34 ha	Populated area	<i>Kochani is located on 1,1 km distance from the concession site.</i>
	Surface water	The concession site is near by the Kochanska River. <i>The concession site is partially entering the planned water supply sistem Kocani.</i> The concession site is entering in the third protection zone from the wells in Stip.
	Environment	Wild dump is located on 0,3 km from the concession site.

Table 8. Spatial potential of the concession sites for geological research in municipality of Probishtip

Research site	Spatial potential	
Zelen Grad Coper and Goleo Area: 385 ha	Populated area	<i>The populated area Zelen Grad is entering the concession site. The concession site is located near by the populated area Jamishte.</i>
	Surface water	<i>The concession site is entering the first and second protection zones of the river Zletovica. The concession site is entering in the third protection zone from the wells in Stip.</i>
	Natural heritage	<i>The concession site is entering the proposed natural heritage Osogovski planini. The concession site is partially entering the proposed natural heritage and Zletovska Reka - Ratkova Skala.</i>

Table 9. Spatial potential of the concession sites for geological research in municipality of Karbinci

Research site	Spatial potential	
Gorno Trogerci Andesite Area: 13,13 ha	Populated area	<i>The nearest populated area Gorno Trogerci is located on 1 km distance from the concession site.</i>
	Surface water	<i>The concession site is entering in the third protection zone from the wells in Stip. The concession site is located on a 2 km distance from the planned water supply system Varshakovo.</i>
	Natural heritage	<i>The concession site is entering in the proposed natural heritage for protection – Mangovica [5].</i>
Ezevo Brdo Basalt Area: 14,30 ha	Populated area	<i>The nearest populated area Sarcievo is located on 2 km distance from the concession site.</i>
	Surface water	<i>The concession site is entering in the third protection zone from the wells in Stip. The concession site is located on a 0,3 km distance from the planned water supply sistem Balvan.</i>
Gorno Trogerci Andesite Area: 22,05 ha	Populated area	<i>The nearest populated area Gorno Trogerci is located on 0,4 km distance from the concession site.</i>
	Surface water	<i>The concession site is entering in the third protection zone from the wells in Stip. The concession site is located on a 2 km distance from the planned water supply sistem Varshakovo.</i>
	Natural heritage	<i>The concession site is entering in the proposed natural heritage for protection – Mangovica [5].</i>
Golem Gaber Limestone Area: 131,44ha	Populated area	<i>The concession site is near by the populated areas Golem Gaber and Mal Gaber.</i>
	Surface water	<i>A watercourse is entering in the concession site.</i>
Kara Tarla, Shashavarija Limestone Area: 169,38 ha	Populated area	<i>The nearest populated area Radanje and Golem Gaber are located on 0,8 km distance from the concession site.</i>
	Surface water	<i>The concession site is located near the Radanjska River. The concession site is entering in the third protection zone from the wells in Stip. The concession site is located on 1,5 km southeast from the water supply sistem Vinica Stip.</i>

Research site	Spatial potential	
Tarinci Geothermal water Area: 52,9 ha	Populated area	<i>The populated area Tarinci is located on 0,2 km distance from the concession site.</i> <i>The populated area Karbinci is located on 0,6 km distance from the concession site.</i>
	Surface water	<i>The concession site is located on 0,4 km distance from Bregalnica River.</i> <i>The concession site is partially entering the planned water supply sistem Karaorman.</i> <i>The concession site is located on a 0,6 km distance from the planned irrigation system Argulica.</i> The concession site is entering in the third protection zone from the wells in Stip.
	Environment	The concession site is located near the landfill in municipality of Karbinci.

Table 10. Spatial potential of the concession sites for geological research in municipality of Shtip

Research site	Spatial potential	
Lakavica Metalic Minerals Area: 1189,72 ha	Populated area	<i>The populated area Novo Selo is entering the concession site.</i> The concession site is located on 1,5 km distance from the populated areas Piperovo and Leskovica.
	Surface water	<i>Some small watercourses, wich later on are entering in the Mantovo accumulation, are passing through the concession site.</i> The concession site is located on 1 km distance from the accumulation Mantovo. The concession site is entering the water supply sistem Lakavica.
	Natural heritage	The concession site is located on a 0,6 km distance from the proposed natural heritage Pilav Tepe [5].
Borov Dol Copper Area: 769,40 ha	Populated area	<i>The concession site is located on 0,5 km distance from the populated areas Dolna Vrashtica, Gorna Vrashtica, Damjan and Novo Selo.</i>
	Surface water	<i>Some small watercourses, wich later on are entering in the Mantovo accumulation, are passing through the concession site.</i> The concession site is located on 0,4 km distance from the accumulation Mantovo.
	Natural heritage	The concession site is located on a 1,3 km distance from the proposed natural heritage Pilav Tepe [5].
Mal Gaber Slate Area: 12,79 ha	Populated area	The concession site is located on 1,7 km distance from the nearest populated area Mal Gaber.
	Surface water	<i>Small watercourse is passing by the concession site.</i> The concession site is entering in the third protection zone from the wells in Stip.
Mal Gaber Slate Area: 18,88 ha	Populated area	The concession site is located on 2 km distance from the nearest populated area Mal Gaber.
	Surface water	<i>Small watercourse is passing by the concession site.</i> The concession site is entering in the third protection zone from the wells in Stip.

Regarding the information from the available literature used for preparation of this paper, there were no existing concession sites for geological research in municipalities of Cheshinovo-Obleshevo, Pehcevo, Vinica and Zrnovci [11].

CONCLUSIONS

The overall analysis shows that when issuing concessions for exploitation (and research) of minerals, priority, if not exclusivity, is given to the economy. Environmental issues and impact on the health of the people living in the areas where mining is to be present are not well elaborated. This should be changed especially if we have in mind the trends present in the EU.

Over several decades the EU's coal mining activity has been in decline due to competition from coal imports and the substitution of other fuels to produce electricity, the latter stimulated in part by efforts to reduce emissions [9].

The experience from mining of metallic minerals in other countries shows that even in very small amounts, metals can be toxic to humans and wildlife. Metals are particularly problematic because they do not break down in the environment. They settle to the bottom and persist in the stream for long periods of time, providing a long-term source of contamination to the aquatic insects that live there, and the fish that feed on them. Carried in water, the metals can travel far, contaminating streams and groundwater for great distances. The impacts to aquatic life may range from immediate fish kills to sublethal, impacts affecting growth, behaviour or the ability to reproduce [4].

The mining activities in the protected areas or areas proposed for protection will irreversibly affect the landscape diversity and may result in loss of sceneries of great importance. They are noted as risks to natural heritage in the National Strategy for heritage protection, as well [12]. It should be noted that IUCN's members adopted a recommendation at the World Conservation Congress in Amman, Jordan in October 2000, which suggested that mining should not take place in IUCN category I–IV protected areas. Recommendation 2.82 includes a section that: "State members to prohibit by law, all exploration and extraction of mineral resources in protected areas corresponding to IUCN protected area management categories I–IV". The recommendation also includes a paragraph relating to category V and VI protected areas: "in categories V and VI, exploration and localized extraction would be accepted only where the nature and extent of the proposed activities of the mining project indicate the compatibility of the project activities with the objectives of the protected areas" [10]. Republic of Macedonia, as a country member in the IUCN, should review these recommendations and implement them in the national legislation.

There are several examples in the EPR where the concession sites intersect with the limits of the settlements. Also, there are many watercourses which are entering different concession sites.

The contemporary approach would consist of several measures:

- Modernization of existing technologies and strict emission control in active mines;
- Economic vs environmental, with the emphasis on the health Estimate of the overall effect of the population prior to issuing concessions for opening of new mines;
- Choosing priorities in a strategy for development at the state level based on the principles of sustainable development and strengthening the role of spatial planning and strategic assessment of the impact on the environment.

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