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FORECASTING AND ASSESSING EUROPE'S
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WP7 Historic Mine Sites revisited

Case Study

The Trepca mine tailings, Kosovo

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(photo: Henrike Sievers, BGR)



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1 Introduction

Kosovo has a long history in lead and zinc mining, dating back as far as Roman times, when deposits were mined for silver and gold. Within the last decades, lead and zinc have been the main commodities mined in Kosovo. Modern mining of Pb and Zn dates back to 1930 when the British company Trepca Mines Limited (established 1927) first started exploiting the Pb/Zn-deposit Stan Terg.

After WWII, Trepca was nationalized and further mines came into production in 1953 (Pb/Zn-mines Kishnica, Hajvalia, Badovc, Belo Berdo and Crnac).

During Yugoslavian times the territory of Kosovo was a major contributor to the country's raw material production: especially with lead and zinc from mines of the Trepça state combine. During the 1980s, Trepça had assets all around Yugoslavia and employed 20,000 workers. At its height, Trepça generated a considerable amount of the total regional industrial production and was one of Yugoslavia's top exporters. It was the leading mining company in the Balkans for lead and zinc production and produced more than 100,000 t refined Pb, 50,000 t refined Zn and 12 t of Ag in 1980. The Trepca combine also included the subsequent production steps of concentrating and smelting, semi fabrication as well as the production of batteries.

Ore from Stan Terg was concentrated in the Tuneli i Pare concentration plant, while ore from the mines Kishnica, Novo Berdo, Hajvalia and Badovc was sent to the concentrator in Kishnica. The plant in Leposavoc treated ore from Crnac and Belo Berdo. After milling and flotation, the Pb- and Zn- concentrates were refined in the smelters in Mitrovica (Zn) and Zvečan (Pb). Refined Pb and Zn metal as well as chemical products were further manufactured by Yugoslavian companies or sold on the free market. Continued financial problems, a lack of investment and rising political and ethnical tensions led to a decline of the production towards the end of the 1980's.

During the Kosovo war, the production was halted in most of Trepça's mines. Today the mines Stan Terg, Belo Berdo and Artana (Novo Berdo) are operating, while the other mines were flooded during the conflict and never have been restored. Today three concentrators, Tuneli i Pare, Leposavoc and Badovc, produce Zn and Pb concentrates for the export.

In 2016 the Trepca Law was signed and the company was converted into a stock company – the Trepca Sh. A., with 80% held by the government and 20% belonging to the employees. The new law divided Trepca into 3 divisions:

- a. Stan Terg mine and flotation plant (Tuneli i Pare)
- b. Artana mine and Badovc flotation plant
- c. Belo Berdo mine and Leposavoc Flotation plant

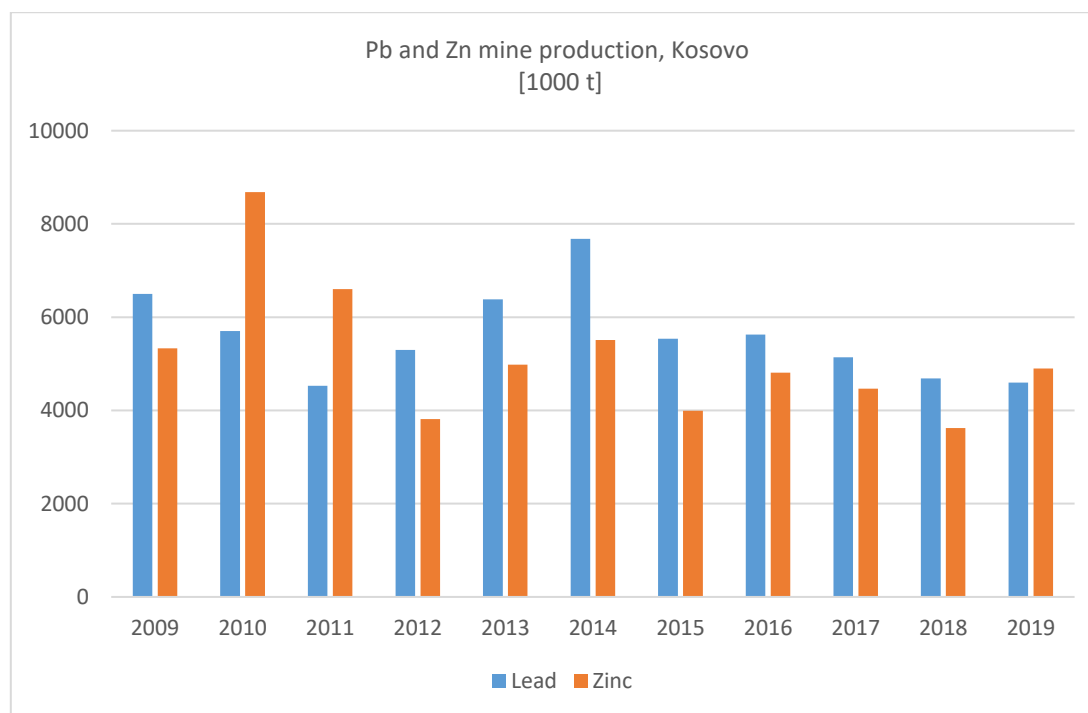


Figure 1: Mine production of lead and zinc in Kosovo since 2009 (source: BGR database)

The long period of mining and ore processing lead to an enormous amount of tailings that have been deposited at several sites. Most of these tailings ponds are inactive today, but the sites Badovc, Kelmendi and Bostaniste are still in use.

1 Active mines

1.1 Stan Terg Mine

Stan Terg, the most important mine of the Trepca company, is located about 7 km north of Mitrovica. The underground mine had been in production continuously since the 1930's, when its activities were halted in 2000 after the Kosovo conflict. The mine has been on care and maintenance from 2000 to 2004 before resuming production in 2005.

The Stan Terg deposit is located within the Vardar zone of the Dinarides. The structure of the deposits is generally described as an anticline, plunging 40° NW, which consists of Triassic carbonates in the core and is surrounded by sericite schists. The hinge of the anticline hosts a



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volcanic breccia. The deposit itself is a carbonate replacement type deposit. In the vicinity of Stan Terg mine several further ore deposits are known.

According to Hyseni et al. (2010) the economically important massive sulphide ore forms continuous, columnar shaped ore bodies, which are located along the carbonate-schist contact and dip parallel to the plunge of the anticline. Large ore bodies occur in contact with the volcanic breccia pipe. Hyseni et al. (2010) state that the ore bodies along this contact extend about 1.200 m along a strike. According to mine geologists the deposit has been explored to a depth of 925 m below the surface (level 13). The deposit's extension along strike and in depth could not been terminated, yet and needs more exploration and research.

The main ore minerals at Stan Terg are pyrite, pyrrhotite, sphalerite and galena. Lower grade skarn type ore bodies occur along paleo karst features. Palinkas et al. (2013) conclude from their investigations that the structurally and lithological controlled mineralization was formed in an early prograde closed-system and a later retrograde open-system stage. Phreatomagmatic activity led to the transition from the prograde to the retrograde stage.



Figure 2: Addit of the Stan Terg Mine (photo: H. Sievers, BGR)



Historically Pb, Zn, Ag and Bi have been produced from Stan Terg mine. Today the ore mined is transported to the Tuneli i Pare concentrator, where a Pb (65-70 % Pb content) and Zn (48-50 % Zn content) concentrates are produced and then exported to Bulgaria. The table below shows the chemical composition of a Zn concentrate sample. It contains 50% of Zn and less than 1 % Pb. Au and Ag are enriched in the Pb concentrate. Their values in the Zn concentrate are about 14 ppm Ag and around 250 ppb Au. The concentrate also contains 60 ppm In and 0.74 % Mn, but also 0.17 % As and 0.18 % Cd as punishing elements.

Table 1: Results of geochemical analysis of Stan Terg Zn-concentrates.

Stan Terg (Zn concentrate)			
		Zn concentrate Sample 1	Zn concentrate Sample 2
[%]	Cu	0,224	0,22
	Fe	11,6	11,6
	Zn	50,5	49,9
	Pb	0,81	0,71
	S	31,8	33,1
[ppm]	Ga	5,1	5,2
	Ge	< 0.7	< 0.7
	In	61	59,1
	Ag	13,9	13,8
	Co	2,6	2,6
	Cr	< 1	3
	Ni	3,1	2,1
	Sn	128	123
	Mn	7420	7440
	Cd	1790	1800
	As	1660	1700
	Sb	42,3	39,7
	Te	0,1	< 0.1
	Tl	0,58	0,6
	Bi	12,2	12,3
[ppb]	Au	266	229
	Hg	790	870



1.2 Artana Mine

Artana (often also referred to as Novo Berdo) is a small, active underground Pb/Zn mine about 22 km west of Pristina and belongs to the Trepca company. In the middle ages, the town of Novo Berdo was famous for its silver production from surrounding mines.

The deposit is located within the Artana metamorphic belt, which comprises Paleozoic metamorphic rocks the Dardanian massif, schists and ultrabasic rocks. Younger Cretaceous sediments overly the metamorphic units. Tertiary volcanic rocks, mainly andesites, are present, too. The ore bodies occur in the contact of at the metasomatically altered contact between the metamorphic rocks and tertiary volcanics. The mineralization is controlled by at NNW-SSE trending faults. Most of the ore is hosted in marbles and the mineralized zones are generally steeply dipping to the west (40-60°). Artana represents a metasomatic replacement deposit.

The thickness of the ore bodies varies from a few meters to up to 60 m and the extension along strike is between 150 m and 400 m (ICMM, 2011). The bodies show an irregular shape and are fault controlled. According to Hyseni (2010b) several different styles of mineralization are found in Artana:

- Replacement mineralization along tectonic contact of triassic and cretaceous carbonates with vulcanoclastics as well as serpentinites.
- Vein-type mineralization as a quartz-carbonate-sulphide vein of a length of about 400 m
- Skarn-type mineralization mainly in the cretaceous carbonate

The Artana mine comprises the deposits Perroi i Ngjyrosur, Kalterina and Perroi i Tharte, of which only the first one is currently exploited. The latter two are neither mined nor explored. Within the license area of Artana an old, exhausted manganese open pit mine exists.

Today the Artana mine maintains ore production at a very limited level, due to a lack of modernization in the mine infrastructure during the last decades and environmental issues. Currently Artana produces about 65,000 t of ore annually with a metal content as following: 13 % Pb and Zn combined, 136 g/t Ag, and 1 g/t Au. Durmishaj et al. (2012) present contents of 4.36 % Pb, 5.45 % Zn, 126.07 g/t Ag, 0.01 % Bi, 0.18% Cu, 0.05% Cd, 0.54 % As and 0.21 %Sb.

According to ICMM (2011) the total resources amount to 2.7 Mio t of ore with 4.4 % Pb, 5.4 % Zn, 141 g/t Ag and 1.0 g/t Au. Durmishaj et al. (2012) calculate a higher amount of resources, but lower grades: 9 Mt of ore reserves with an average content of 2.3 % Pb, 2.5 % Zn and 92 gr/t Ag. The mine itself says, that reserves are about 6 Mio t and reserves were calculated to about 20 Mio t of or for all orebodies in the license area.



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Figure 3: Artana Mine entrance (photo: H. Sievers, BGR)

The ore from Artana is transported by road to the Badovc concentrator for flotation and the production of Pb and Zn concentrate. Samples taken at the concentrator show a Zn content in the Zn concentrate is ca. 43-45%. The Zn concentrate also contains about 6% Pb, while the Pb concentrate contains as much as 78-79 % Pb and only 0.5 % Zn. These values show a more effective concentration of valuable metals than e.g. values revealed in a study by BRGM in 2009 (Feraud & Deschamps, 2009). This study stated values of only 32 % Zn in the Zn concentrate and 48 % Pb in the Pb concentrate. The newly taken samples show lower Au values compared to Feraud & Deschamps (2009), which are below 0.2 ppm in the Pb concentrate, but where nearly 4 ppm in the Pb concentrate sample analysed by BBRGM (Feraud & Deschamps, 2009). High Ag content in the Pb concentrate is another difference to the earlier study. Samples analysed for this study showed values of 2600 ppm Ag, while the BGRM study measured 1000 ppm Ag. The reason causing these differences cannot be investigated here, but might be due to changed process parameters or ore composition.

Interesting values of other elements in the concentrates are around 240 ppm In in the Zn concentrate and up to 2,000 ppm Sb and an average of ca. 3,300 ppm Bi in the Pb concentrate.



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Two known deposits being connected to Artana are Kaltrina and Perroi I Tarthe. According to Dvorani et al. (2012) they are located SW of Artana mine and are believed to be an extension of the Artana deposit. Kaltrina is hosted by the same tectonic structure as Artana. The mineralization occurs between amphibolite schists and a tectonic breccia. The ore body has a thickness of ca. 50 m. Reserves are estimated to about 1.3 Mio t of ore with 4.37 % Pb, 4.52 % Zn and 129 g/t Ag. (Dvorani et al., 2012)

Exploration results from the 1980s show contents of up to 8.7 % Pb and 29 % Zn in drill cores of the deposit Perroi I Tharte. Reserve numbers are not known. The deposits are both accessible through an underground corridor in the Artana mine, but are not being mined ore explored currently.



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Table 2: Results of geochemical analysis of Artana Zn- and Pb- concentrates from the Badovc plant

		Artana (concentrate)			
		Zn concentrate	Zn Concentrate	Pb concentrate	Pb concentrate
		Sample 1	Sample 2	Sample 1	Sample 2
[%]	Cu	0.415	0.396	0.167	0.159
	Fe	12.7	12.4	1.3	1.32
	Zn	44.5	42.9	0.46	0.49
	Pb	6.36	6.14	79	78
	S	33.5	33.7	15.8	15.8
[ppm]	Ga	28.7	29.2	0.9	0.8
	Ge	< 0.7	< 0.7	< 0.7	< 0.7
	In	241	246	4.3	4.3
	Ag	237	238	2,600	2,630
	Co	6.7	5.8	1.3	1.4
	Cr	< 1	8	8	< 1
	Ni	9.9	8.6	3.1	3.1
	Sn	149	154	238	228
	Mn	5,300	5,370	133	145
	Cd	2,280	2,340	130	125
	As	595	598	454	441
	Sb	278	274	1,990	2,000
	Te	1.9	1.7	4.5	6.9
	Tl	15.1	13.4	13.1	12.5
	Bi	297	258	3,410	3,240
[ppb]	Au	205	288	143	171
	Hg	2,340	1,950	630	630



2 Tailings from processing of Pb/Zn-ores

Decades of mining and processing of ores in Kosovo produced huge amounts of tailings. Generally, most of the tailings are related to Pb/Zn mining and ore processing and several sites related to Trepca mining activities are known, like Artana, Bostanishte, Kelmendi, Zvecan and Kishnica. Some of the sites have been covered, but others are still in use. Further tailings are known from the recovery of Ni in Drenas and of chromite in Deva. This chapter will describe tailings sites from Pb/Zn mining of Trepca mines.

Generally, these tailings ponds from Pb/Zn mining contain material from the last decades, which sometimes derived from processing ore from several mines. Thus, the tailings represent a mixture of sources, processing technologies and time of production. The composition of the tailings thus can be very heterogeneous within one site.

With the onset of modern mining at Stan Terg in the 1930s, the deposition history of tailings started as well. The first concentrator of the Trepca company was located at Zvecan and operated from the 1930s until 1985. The plant processed ore from Stan Terg and from Belo Brdo. After the Crnac mine started production in 1967 ores from Crnac were also processed in Zvecan. Tailings from this plant were deposited in the Gornje Polje tailings pond until 1962 and subsequently at the Zitkovac tailings pond north of Zvecan. In 1972, a new concentration plant was built at Leposavic, processing ore from Belo Brdo and Crnac as well from the newly opened mines Zuta Prlina and Koporic. Tailings from this plant were deposited at the sites Bostaniste and Tvrdanski Do.

The Artana mine had its own concentration plant, the Marevc concentrator, until 1978, which led to the deposition of tailings at the tailings sites at Artana South and later at Artana North.

In 1985, a new concentrator plant commenced operation to process the ore from Stan Terg: the Tuneli Pare concentrator. From 1985 on tailings mainly from Stan Terg are contained in the Kelmendi tailings pond (alternative name: Zarkov Potok), which still is in use today.

The Badovc concentration plant started operation in 1968 to process ores from the mines Kishnica, Hajvalia and Badovc and after the closure of the Marevc plant also ore from Artana. Tailings were deposited at the Kishnica tailings site and later at the Badovc tailings pond, which today still serves as disposal site for tailings derived from the processing and flotation of ore from Artana.

The following list (in alphabetical order) gives an overview over the location and main characteristics of the tailings sites resulting from processing Pb/Zn ores.



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Artana North



(map source: Google maps)

Location	42.640437 21.437336
Type	flotation tailings
Status	inactive
Size	4 ha
Tonnage	2 mio t
Metal concentration	Pb 0.4 %; Zn 0.02 %; As 0.1 %
Commodity mined	Pb/Zn
Time of operation	closure 1978

Artana South



(map source: Google maps)

Location	42.634479 21.429288
Type	flotation tailings
Status	inactive
Size	2 ha
Tonnage	0.35 mio t
Metal concentration	Pb 1.4 %; Zn 0.2 %; As 0.3 %
Commodity mined	Pb/Zn
Time of operation	Closure 1978



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Badovc



(map source: Google maps)

Location	42.604181 21.227158
Type	flotation tailings
Status	active
Size	9 ha
Tonnage	8 mio t
Metal concentration	Pb 0.6 %; Zn 1.1-1.5 %; As 0.3 %
Commodity mined	Pb/Zn
Time of operation	since 1978

Bostaniste



(map source: Google maps)

Location	43.107310 20.785595
Type	flotation tailings
Status	active
Size	19 ha
Tonnage	3.7 mio t
Metal concentration	No data
Commodity mined	Pb/Zn
Time of operation	since ca.1985 (?)



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Gornje Polje



(map source: Google maps)

Location	42.907101 20.857227
Type	flotation tailings
Status	inactive
Size	57 ha
Tonnage	12 mio t
Metal concentration	Pb 0.4-1.1 %; 0.1-0.2 % Zn; 0.7 As
Commodity mined	Pb/Zn
Time of operation	1932-1962 (?)

Kelmendi



(map source: Google maps)

Location	42.907669 230.874654
Type	flotation tailings
Status	active
Size	23 ha
Tonnage	3.6 mio t
Metal concentration	Pb 0.5-0.6 %; Zn 0.6 %; As 1.6-2.0 %
Commodity mined	Pb/Zn
Time of operation	since 1975



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Kishnica



(map source: Google maps)

Location	42.605194 21.210272
Type	flotation tailings
Status	inactive
Size	47 ha
Tonnage	11 mio t
Metal concentration	Pb 0.3 %; Zn 0.3-0.5 %; s 0.4-0.5 %
Commodity mined	Pb/Zn
Time of operation	Closure 1968

Trvdanski Do



(map source: Google maps)

Location	43.110809 20.788289
Type	flotation tailings
Status	inactive
Size	9 ha
Tonnage	2.7 mio t
Metal concentration	No data
Commodity mined	Pb/Zn
Time of operation	1972-1985 (?)



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Zitkovac



(map source: Google maps)

Location	42.922780 20.831166
Type	flotation tailings
Status	inactive
Size	29 ha
Tonnage	10 mio t
Metal concentration	No data
Commodity mined	Pb/Zn
Time of operation	1962-1974



2.1 Tailings around Zvecan

2.1.1 Gornje Polje

The Gornje Polje is located southeast of Zvecan east of the river Ibar. From the beginning of mining at Stan Terg in the 1930's until 1962 Gornje Polje was Trepca's only tailings site in operation. Tailings deposited at Gornje Polje stem from the mines Stan Terg and Belo Brdo.

According to the Kosovo Environmental Protection Agency (2011), the tailings cover an area of about 50 ha and consist of ca. 12 mio t of material. The tailings at Gornje Polje have been covered and vegetated to protect them from erosion. As the thin cover is not densely vegetated, the tailings would still be accessible for remining.

Gornje Polje tailings are located next to the former lead smelter of the Trepca combine. Metallurgical slag from the smelter has been deposited on top of the tailings.

Table 1 shows the chemical composition of samples taken from the tailings at Gornje Polje and Kelmendi. Results for Gornje Polje show Zn concentration of up to 1.5 %. The concentration of Pb varies in the two samples taken for this report between 0.4 % and 1 %. Arsenic values are much lower than the results obtained for Kelmendi. Here As values are below 0.73 %.



Figure 4: Sampling tailings from in Zvecan, Gornje Polje (inactive tailings pond)



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Figure 5: Location of tailings near Zvecan derived mainly from Stan Terg mine and metallurgical slag from the former Pb- smelter in Zvecan: inactive tailings site Gornje Polje and the currently active tailings pond Kelmendi.(map source: Google maps)

2.1.2 Zitkovac

The Zitkovac tailings site is located approximately 1 km north of Zvecan on the bank of the river Ibar. The site was used for tailings from the Zvecan concentrator in the 1960s and 1970s. According to the Kosovo Environmental Protection Agency (2011) the surface of the landfill is approximately 26 ha and contains around 3 mio t of material.

2.1.3 Kelmendi

Today the Kelmendi tailings pond is the actively used tailings storage for tailings deriving from the processing of ore from Stan Terg in the Tuneli i Pare concentrator. The tailings pond became operational after the closure of Zitkovac in 1975 and has the capacity to store tailings for another 40 years. The main amount of the tailings originates from Tuneli i Pare flotation plant, which came into operation in 1985.



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According to the Kosovo Environmental Protection Agency (2011) the surface the landfill surface is approximately 18 ha and Feraud & Deschamps (2009) estimate that it contains 9 to 11 mio t of material.

Table 19 shows the chemical composition of samples taken from the tailings at Gornje Polje and Kelmendi. At Kelmendi the tailings still contain up to 0.6 % Zn and 0.58 % Pb. Up to nearly 2 % As in the tailings where measured, which would be negative for a potential future metal extraction and also bears potentially an environmental and health risk. Feraud & Deschamps (2009) report somewhat lower As levels (0.5 % As). They also analysed for Au and Ag and report values of 10 g/t Ag and 0.2 g/t Au. The study by BRGM also reports 1.3 % Zn in the Kelmendi tailings, which is considerably higher than the analysis presented in this report. This indicates a heterogenic tailings composition, certainly varying over time and depending on ore mineralogy and technical details of ore processing.



Figure 6: Currently active Kelmendi tailings pond with tailings from the Stan Terg mine



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Figure 7: Front of the dam of the Kelmendi Tailings pond

Table 3: Chemical composition of Gornje Polje and Kelmendi tailings

Gornje Polje and Kelmendi tailings				
	Gornje Polje (sample 1)	Gornje Polje (sample 2)	Kelmendi (sample 1)	Kelmendi (sample 2)
[%]				
SiO₂	27,95	20,02	7,94	7,33
TiO₂	0,096	0,070	0,020	0,024
Al₂O₃	1,45	1,00	0,40	0,38
Fe₂O₃	29,26	25,07	51,05	48,60
MnO	0,439	0,291	4,912	4,663
MgO	0,55	0,02	0,46	0,41
CaO	10,050	13,930	8,222	8,716
Na₂O	<0.01	<0.01	<0.01	<0.01
K₂O	0,254	0,203	0,064	0,061
P₂O₅	0,012	0,015	0,008	0,008
(SO₃)	9,30	15,93	5,39	5,93
(Cl)	<0.002	<0.002	<0.002	<0.002
(F)	<0.05	<0.05	<0.05	<0.05
[ppm]				
(As)	7260	6533	16370	19820
Ba	125	458	<65	<65



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Bi	34	140	196	115
Ce	<56	<58	<59	<58
Co	<13	<13	24	21
Cr	326	48	<12	<12
Cs	<69	<73	<69	<69
Cu	146	306	573	457
Ga	<6	<6	<8	<8
Hf	<24	<26	<31	<31
La	<42	<44	<42	<42
Mo	<9	<9	<10	<10
Nb	3	15	<3	<3
Nd	<42	<43	<49	<48
Ni	117	<9	<12	<12
Pb	4088	10640	5755	5050
Rb	23	25	15	14
Sb	155	471	157	186
Sc	<25	<27	<25	<25
Sm	<60	<60	<76	<74
Sn	<36	105	<37	<37
Sr	40	58	23	26
Ta	<15	<15	<20	<20
Th	<11	<11	16	<13
U	<11	<12	<14	<14
V	24	<17	<17	<16
W	65	202	286	135
Y	<11	<12	<13	<13
Zn	1259	1510	5960	5642
Zr	16	48	<12	<12

2.1.4 Artana North and South tailings

Through ore mining and processing from the Artana mine two tailings ponds were created close to the mine. The older site is located just next to the mine (Artana tailings South), while a newer site is found about 500 m to the NE (Artana tailings North). Both sites are directly adjacent to the Kriva River. These two tailings ponds are inactive, as the ore from Artana is sent to the flotation plant in Gracanica and today tailings are deposited at the Badovc tailings pond. Artana used to have its own small concentrator plant, which produced the tailings. Artana tailings South and North were both closed in 1970.



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According to UNDP (2010) works on capping and containment of Artana tailings sites have been completed until 2010. During these works the tailing were capped and the river protected from further erosion of tailings into the riverbeds. Nevertheless, future access of the tailings for preprocessing is still possible as the capping can be removed easily.



Figure 8: Sampling at old tailings from Artana mine (Artana tailings North)

According to the Kosovo Environmental Protection Agency (2012) the older tailings site close to the mine contains about 350.000 t of material and covers an area of ca. 2 ha. The second site contains about 2 Mio t of tailings and covers an area of about 4 ha. The report states that the metal content of these dumps is heterogenic, but in averages about 1-1.56 % Pb, 1.76-3.22 % Zn, 20-110 gr/t Ag and 2-2.59 gr/t Au. The content of FeS_2 is 60-70%.

Samples analyzed for this report showed Pb values of 1.4 % for Artana South and 0.42 % at Artana North. Zn grades were considerably lower than stated by the report mentioned above, which supports the assumption of the heterogeneity of the tailings material. High As values point to potential environmental risks of these sites, if not monitored carefully.



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Table 4: Composition of Artana Tailings (XRF analysis by BGR, 2019)

		Artana tailings South	Artana tailings North
[%]	SiO ₂ _SI	25,01	24,69
	TiO ₂	0,178	0,148
	Al ₂ O ₃	2,48	2,18
	Fe ₂ O ₃	39,44	28,93
	MnO	0,061	0,014
	MgO	0,11	0,05
	CaO	1,130	9,586
	Na ₂ O	0,02	0,11
	K ₂ O	0,539	0,819
	P ₂ O ₅	0,085	0,002
	(SO ₃)	1,73	9,40
	(Cl)	<0.002	<0.002
	(F)	<0.05	<0.05
[ppm]	(As)	2591	1021
	Ba	547	215
	Bi	58	38
	Ce	<53	<55
	Co	<14	<13
	Cr	31	<11
	Cs	<64	<68
	Cu	526	49
	Ga	<7	<6
	Hf	<28	<23
	La	<39	<41
	Mo	<9	<8
	Nb	16	3
	Nd	<42	<41
	Ni	<10	<9
	Pb	13970	4222
	Rb	26	33
	Sb	188	156
	Sc	<23	<25
	Sm	<65	<59
	Sn	123	41
	Sr	24	38
	Ta	<17	<15



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Th	<12	11
U	<12	<11
V	22	17
W	71	45
Y	<13	<10
Zn	2433	188
Zr	58	40

2.2 Badovc and Kishnica tailings

The Badovc tailings pond is located close to the beneficiation and floatation plant at Badovc. The site today serves as active tailings pond for ore mined at Artana mine and concentrated at the concentration plant at Badovc concentrator. Ore extracted at the mines Kishnica, Hajvalia and Badovc used to be processed at the Badovc concentrator and subsequently deposited at the Badovc as well between 1970 and 1999, when the mines ceased production. The Kishnica tailings pond was used until 1970.

The tailings at Kishnica and the tailings dam at Badovc have been part of a remediation program and were covered, but not vegetated.



Figure 9: Location of Badovc and Kishnica tailings and flotation facilities.



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The Badovc tailings cover a surface area of about 1 ha and contain approximately 8 Mio t of material. The Kishnica tailings cover an area of 5 ha and contain about 11.5 Mio t of tailings (Feraud & Deschamps, 2009).

Samples taken at Badovc and Kishnica tailings have been analyzed for this report. The samples from the Badovc tailings pond contain 1.1 to 1.5 % Zn and around 0.6 % Pb. According to Feraud & Deschamps (2009) tailings at Badovc contain ca. 2.5 g/t Au and 19 g/t Ag. Kishnica tailings reveal lower values for Zn and Pb (0.25-0.3 % Pb, 0.3-0.5 % Zn).

Arsenic is a penalizing element in the case of potential reprocessing of the tailings. Arsenic values vary between 0.26-0.31 % in Badovc and 0.41-0.5 % in Kishnica tailings.



Figure 10: Active Badovc tailings pond of the Artana mine (View from E to W)



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Table 5: XRF analysis of samples from Kishnica and Badocv tailings (for sample location see figure 9.)

		Kishnica tailings (Sample 1)	Kishnica tailings (Sample 2)	Badocv tailings (Sample 1)	Badocv tailings (Sample 2)
[%]	SiO ₂ _SI	32.39	29.92	24.70	22.27
	TiO ₂	0.326	0.305	0.282	0.266
	Al ₂ O ₃	5.98	5.87	5.83	5.48
	Fe ₂ O ₃	21.70	22.95	38.17	39.30
	MnO	1.803	2.753	0.297	0.276
	MgO	2.96	3.17	0.72	0.70
	CaO	5.777	5.816	2.907	3.278
	Na ₂ O	0.08	0.05	0.17	0.22
	K ₂ O	0.876	0.909	1.072	0.985
	P ₂ O ₅	0.065	0.052	0.059	0.091
	(SO ₃)	4.79	5.60	0.86	1.24
	(Cl)	<0.002	<0.002	<0.002	<0.002
	(F)	<0.05	<0.05	<0.05	<0.05
[ppm]	(As)	4,934	4,063	2,548	3,084
	Ba	119	103	208	228
	Bi	13	19	37	29
	Ce	<54	<55	<53	<54
	Co	28	41	39	33
	Cr	626	534	40	43
	Cs	<66	<66	<65	<65
	Cu	326	310	418	395
	Ga	7	10	10	22
	Hf	<22	<23	<26	<27
	La	<40	<41	<39	<40
	Mo	<8	<8	<9	<9
	Nb	5	3	5	6
	Nd	<40	<41	<42	<42
	Ni	369	499	46	47
	Pb	2,447	3,084	6,138	6,477
	Rb	47	47	48	46
	Sb	162	145	98	171
	Sc	<24	<24	<23	<24
	Sm	<54	<56	<64	<65
	Sn	<35	<36	<35	<36
	Sr	51	52	37	61



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Ta	<15	<15	<17	<18
Th	12	11	12	14
U	<11	<11	<12	<12
V	64	66	56	47
W	38	38	87	71
Y	19	24	14	<12
Zn	2,932	4,815	11,140	14,590
Zr	57	51	54	45



Figure 11: Active Badovc tailings pond of the Artana mine (view W to E)



Figure 12: Kishnica talings



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Figure 13: Flotation plant at Kishnica

3 Conclusions

Samples were taken at six tailings ponds: Badovc, Kishnica, Kelmendi, Gornje Polje, Artana North and Artana South. The amount of tailings deposited in these ponds add up to about 37 Mio t of material, still containing considerable amounts of Pb and Zn. Generally the content of potential CRM analyzed in this study is low and would not be of economic interest on its own.

Zn concentrates from the processing plant in Badovc show elevated levels of In of ca. 240 ppm. According to Féraud (2009) zinc concentrates originating from Stan Terg ore contain about 45-70 ppm In. While the ore mined contains 6,8 g/t, tailings showed values of 3,3 g/t In (Féraud, 2009). Differences in the In content of ores from Trepca deposits would make it necessary to systematically sample ores and tailing sites to assess a possible In potential, especially as tailings ponds have served as disposal facilities for more than one mine.

Pb and Zn values in the samples taken vary greatly and to assess the full metal potential of the tailings originating from is decades of Pb/Zn mining further sampling and geochemical analysis would be needed.



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