Proceedings

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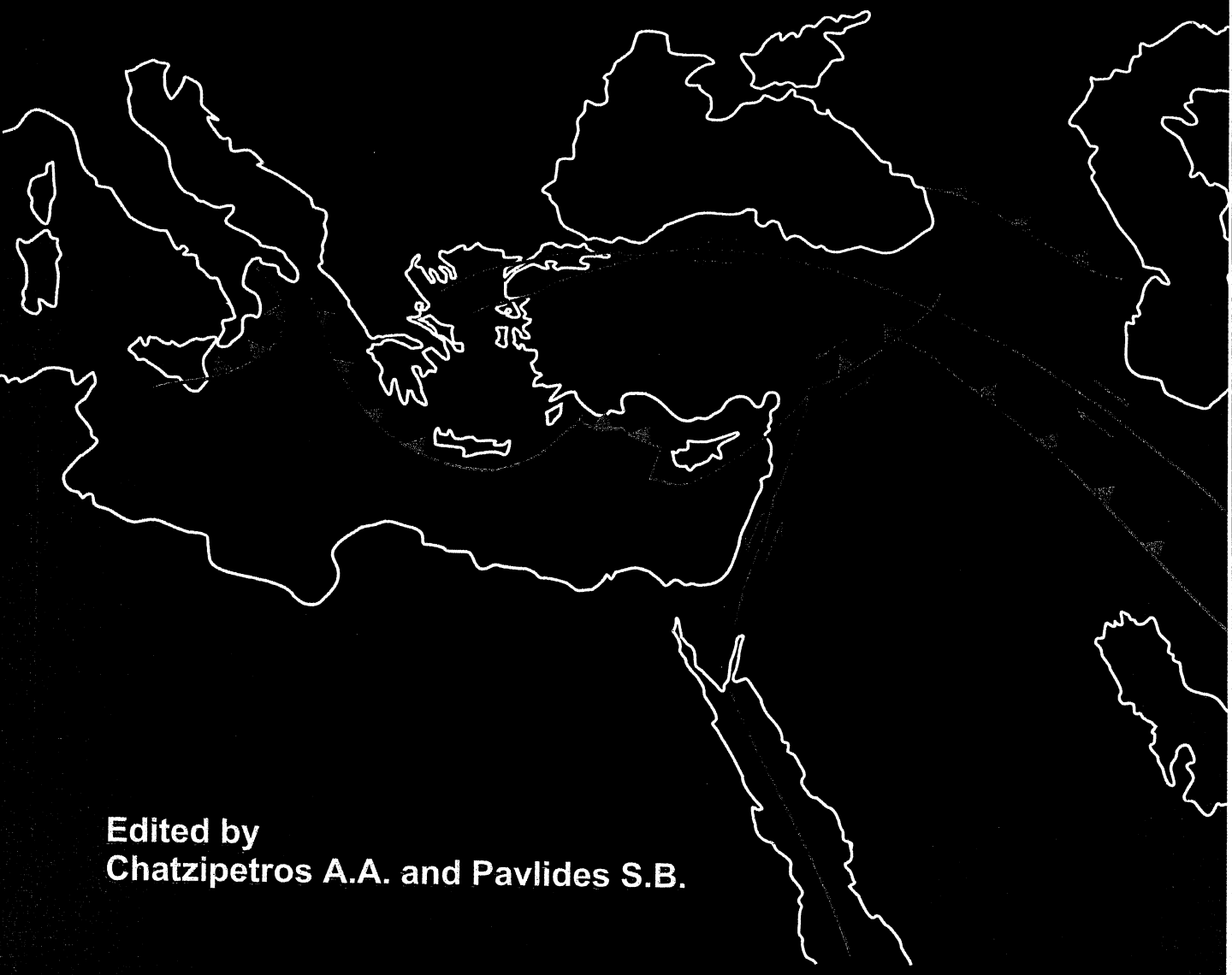

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Volume 2

The disaster at the tailing pond of the Sasa lead and zinc mine and contamination of surface and underground waters

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Introduction

The Sasa lead and zinc mine is situated in the central part of the Osogovo massif in the north-eastern part of FYR Macedonia (fig. 1).

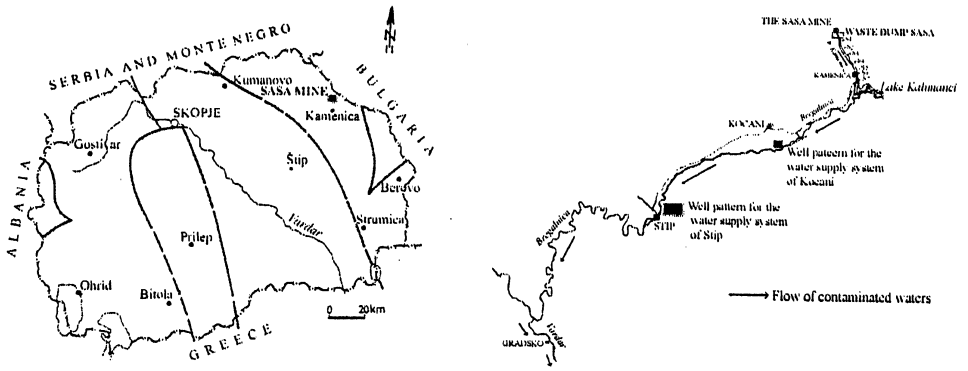

Figure 1. Map of the Sasa mine and the tailing pond, the distribution of wells for the water supply systems of the towns of Stip and Kocani, sampling sites and the course of contaminated waters.

The relief surrounding the mine is mountainous and abundant in forests. The mine and the tailing pond are situated some 1 700 meters above sea level. The main river is Kamenicka with its tributaries Svinja and Kozja. The springs of the two rivers (situated in the same place as the mineral deposit) empty into the River Kamenicka. On 30 August 2003 a disaster occurred at the waste dump of the Sasa mine damaging part of the drainage canal of the river that passes beneath the waste dump. The flotation waste that flows into the tailing pond amounting to 150 000 m^3 entered River Kamenicka (fig. 2). The waste made a 300 meter wide and 50 meters deep hole.

Flotation process

Mineral processing at the Sasa mine is carried out with collective flotation producing lead and zinc concentrate. A number of agents that are toxic and harmful for the environment are used in the flotation process. Flotation waste is dumped in the pond located beneath the mine. The liquid phase contains highly mineralised waste with large amounts of wastewater with sulphates, heavy and toxic metals, phenols and other toxic materials.

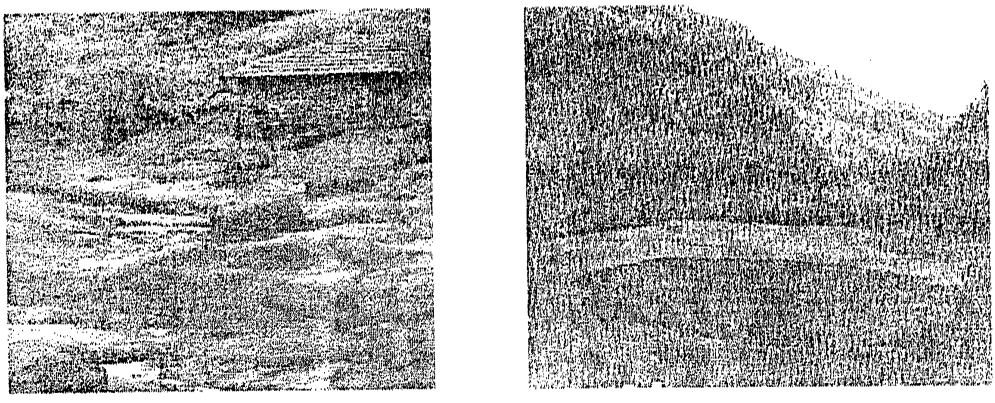

Figure 2. Flotation waste material covering the Kamenicka riverbed and the hole in the tailing pond.

Contamination of surface waters

The collapse of part of the drainage canal made possible the direct outflow of toxic materials into the river. The waste material mixed with the waters of the river flowed in the riverbed and emptied into Lake Kalimanci some 10 km far from the waste dump. Part of the heavy fraction settled on the sediments along the river edges and most of it went into the lake and settled in sediments on the bottom of the lake. A small part entered the Rivers Bregalnica and Vardar. It is important to say that the water of the lake is used for irrigation of Kocansko and Ovce fields.

Results obtained and discussions

In order to determine the effects of the disaster on the contamination of surface and underground waters, a number of macro and micro components as well as elements of the heavy and toxic metals were studied in seven samples of water taken from the river. Samples were taken from the layer beneath the waste dump and along the course to Lake Kilamanci (fig. 1). The results obtained are shown in Table 1. The contents of heavy and toxic metals that are hazardous for the health were compared with the maximum allowed concentrations after the classification of waters of 1999 (Table 1). The results indicate that the contents of heavy and toxic metals Zn, Pb, Cd, Mn, Fe, and P in all samples are several times higher than MKD for the waters of I, II, III and IV class. This indicates that the disaster in the waste dump contaminated the waters of River Kamenicka with heavy and toxic metals. There is great possibility the contaminated waters of the river and the flotation waste to contaminate the waters of the River Bregalnica that flows out of the lake.

The possibility of contamination of underground waters

The contamination of underground waters in the aquifers located close to the Rivers Kamenicka and Bregalnica is very likely since they are recharged by those rivers. Contamination also depends on the hydrogeological characteristics of the terrain around the rivers where the aquifers are formed. Based of the structural type of porosity of the terrain in which the rivers flow there are boundary, fracture and karst type of aquifers. The waters in the boundary type of aquifers in the Quaternary alluvial sediments near Rivers Kamenicka and Bregalnica are most likely to contaminate. Less likely are other types since they possess weaker filtration characteristics or the rivers flow in a smaller area. Alluvial sediments are made up of sands, gravels, marls and sandy clays and clays. Their yield is from 0.1 to 10 l/s and the filtration coefficient is Cf = > $10^{-2} - 10^{-3}$ sm/s. It is worth mentioning that the waters of these aquifers are extensevly used from wells or well systems located in alluvial sediments in close proximity to the River Bregalnica. The major concern, however, is the use of the water for the supply systems of Kocani and Stip (fig. 1).

	S 1	S2	S 3	S4	S 5	S 6	S 7	MDK I-II *	MDK III-IV*
As	<0.005	<0.005	0.007988	0.016479	<0.005	<0.005	0.026436	0.03	0.05
Ag	<0.001	<0.001	<0.001	<0.001	0.000893	<0.001	0.000896	0.002	0.02
Al	0.142	0.945	0.358	0.264	0.640	0.346	0.255	1.5	1.5
Sr	0.355	0.323	0.516	0.346	0.341	0.354	0.279		
Ca	77.53024	73.44871	100.2374	81.84994	72.82457	74.16318	61.45047		
Ba	0.036	0.043	0.044	0.050	0.051	0.049	0.049	1	4
Ni	0.006916	<0.001	0.011088	0.002474	0.001153	<0.001	0.003704	0.05	0.1
Mn	1.768843	1.835308	3.262381	2.191312	1.602682	1.524377	0.922378	0.05	1
Fe	0.560322	3.415278	1.383956	1.399822	1.995152	0.991777	0.686856	0.3	1
Cr	0.004265	0.00338	0.005687	0.006751	0.003117	0.003675	0.002745	0.05	0.1
Mg	17.85236	17.66972	22.12332	17.37153	16.87869	17.24318	13.66026		
Na	3.26841	2.981708	4.095873	4.135614	3.407503	3.519629	3.160542		
P	0.025976	0.101754	0.071462	0.048508	0.048584	0.054312	0.050497	0.00001	0.0001
Zn	2.494334	3.175835	4.396024	2.485961	3.195373	2.621796	1.705374	0.1	0.2
Cu	0.005558	0.009675	0.008692	0.002732	0.023039	0.001303	0.00376	0.01	0.05
Pb	0.150922	0.665873	0.399618	0.345596	0.466092	0.240151	0.170631	0.01	0.03
Cd	0.014744	0.017889	0.020835	0.00973	0.015493	0.012668	0.006891	0.0001	0.01
Co	0.00056	<0.0001	<0.0001	<0.0001	<0.0001	0.001865	0.000692	0.1	2
K	1.544943	1.279981	1.620976	2.344438	1.36523	1.303021	1.18782		

Table 1. Results of analyses of waters of the River Kamenicka obtained with AES-ICP method (the laboratory of the Faculty of Mining and Geology Stip. Samples were taken on 20 September 2003). (mg/l).

Sampling sites: S1 - at the outflow of River Kamenicka from the tailing pond; S2 - the River Jagodina site; S3 - Cerska Stanica site; S4 the Razdol site in the village of Mostica; S5 - the outskirts of Kamenica, Donevi Trli site; S 6 - Coach station in Kamenica; S 7 - the flow of River Kamenicka into Lake Kamenicko.

Maximum allowed concentrations of harmful and hazardous materials after the classification of waters of 1999.

* *MKD I-II, for first and second class of waters,*

* *MKD III-IV, for waters of the third and fourth classes.*

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