

Radiometric Survey of Vromos Bay, Black Sea

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Abstract

Vromos Bay on the Black Sea was contaminated with heavy sulfidic ore minerals and radionuclides from the flotation factory of the copper mine Rosen between 1954–1977. Vromos beach went through recultivation after the closure of the mine in 1998, the deep sediments covering the bottom of the bay however remained there. The goal of the survey is to evaluate the current radioactivity state of the bay and the potential environmental risk that it poses.

Vromos Bay is a small bay at the southern end of the Gulf of Bourgas, situated between two rocky capes: Atia to the West and Akin to the East (Fig. 1). The area of 203 944 sq. m stretching between them is occupied by a nearly 3 km long sand beach of Vromos. Located 22km south of Burgas and 16 km north of Sozopol, just west of town of Chernomorets the Bay of Vromos was used as a landfill for the tailings from the flotation factory for copper concentrate of the near mine Rosen (Fig. 2). The mineral paragenesis of the copper ore in the hydrothermal deposits consists over 100 minerals including minerals of the copper, nickel, molybdenum, cobalt-nickel and iron sulfides, mineralized uranium, iron oxides and rock-forming minerals (quartz, feldspar and zeolites) etc.

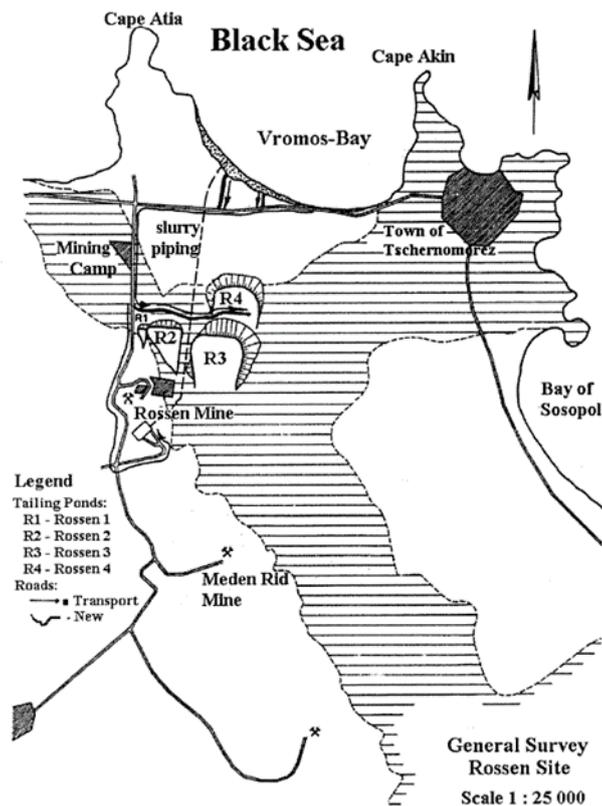


Fig. 1 Plan of the Rossen Mine and Vromos Bay (Bley, 2003).

From 1954 to 1977 the total amount of flotation tailings discharged there was about 8 000 000 t that covered the beach between Cape Atia and Chernomorets (Fig. 1) extending the coast about 150 m into the sea. Most of the refuse (about 6 000 000 t) have been carried far into the sea building a thick layer of slime that covers the bottom of the bay. The rest was redeposited on the beach or used in the fundamental construction of the Port of Bourgas-West. The heavy iron sulphides and oxides, copper, and uranium minerals have been chiefly deposited in the surf area and right on the beach area forming a field about 2,3 km long, up to 150 m wide, and 2,3 m thick (Bley, 2003). The field included about 10% of the total amount of flotation refuse, but with copper, iron, and uranium contents several times higher (Eremenko, 2000). As a result of the combined influence of

sea waves and other processes the beach was encircled with refuse of height 2 to 3 m and single dunes up to 5 to 6 m in height were formed in the central, widest parts of the beach (Bley, 2003). The black color of the sand on Vromos beach was not natural, but resulted mainly from the magnetite and hematite brought by the tailings as well as the rock-forming materials (Rojdestvensky, 1979). The uranium minerals in the ore enriched the contents of ^{238}U and ^{226}Ra (Dimitrov et al., 1994) and increased specific activity of radionuclides (Surguchev, 2011).

The mine and the flotation factory was exploit for 50 years between 1945 and 1995 with a total yield of 7563 t ore with 1,02 % copper concentration or 77912 t metal copper (Ivanov, 2006)

In 1998, after the closure of the mine, the Vromos beach went through recultivation financed by EU Phare-Ecology Program. The layer of sand contaminated with heavy sulfidic ore minerals as well as minerals consisting radionuclides was removed and replaced with non-contaminated layer of sand. The recultivation was targeted only to the surface area of the beach which left the sediments in the deeper parts of the bay contaminated with heavy mineral ores containing the typical elements for the mineral paragenesis of the hydrothermal deposits of mine Rosen such as arsen, copper, barium, iron etc. and potentially radionuclides of uranium, radium and lead.

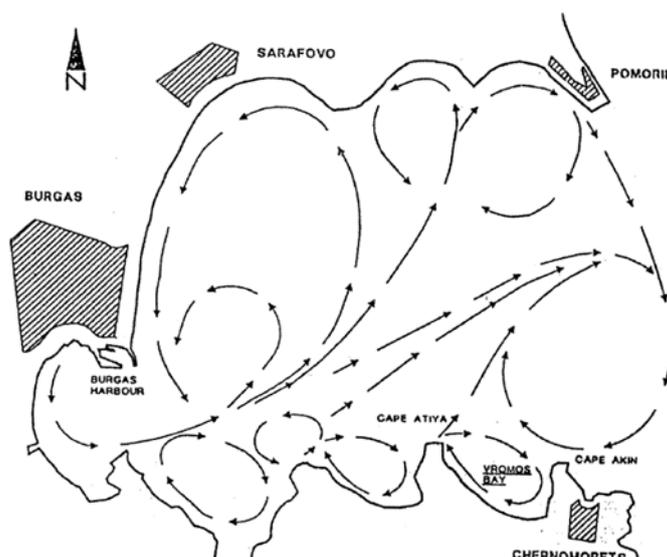


Fig. 2 Bourgas Gulf and Black Sea currents (Bley, 2003).

Survey Summary

The conducted radiometric survey had two phase: Phase I - evaluating the current radioactivity state of Vromos beach. Phase II - evaluating the current radioactivity state of deep sediments in Vromos Bay.

Phase I

The survey was performed with scintillation counters used as radiometers measuring the beach on profiles parallel to the coast line indented from the sea to the shore. According to the results of the radiometric survey there are no indications for dangerous gamma radiation in the beach area (Fig. 3). The values of the ionizing radiation dose do not exceed the norm and varies between 0,12 and 0,39 $\mu\text{Sv/h}$. The highest values are concentrated in the western part of the beach. This feature of the observed values distribution probably is related to the local marine currents of Vromos bay (Fig. 2). This leads to the conclusion that in the western area of the beach it will be appropriate to carry out periodic measurements in order to monitor the radioactivity of the sands accumulated by the sea currents onshore.

Phase II

The monitoring of the deep sediments was made on profiles with sensor device connected to a radiometer boarded on a boat. For every measurement the sensor was stuck about 10-15 cm into the bottom slim, the measuring points were localized with differential GPS and the relative depth of the investigation was recorded. The values of the ionizing radiation dose range from 0,12 to 1,4 $\mu\text{Sv/h}$, the latter exceeding the norm over three times and may pose an eventual health risk (Fig. 3). The obtained results clearly localize a deep zone with

higher gamma radiation when the highest value of $1,4 \mu\text{Sv/h}$ is measured at a depth of 19 m in the central part of the bay. The map of the radioactivity distributions also confirms the conclusion of the phase I making the western part of Vromos beach exposed to a risk of further contamination mainly because of the sea currents.

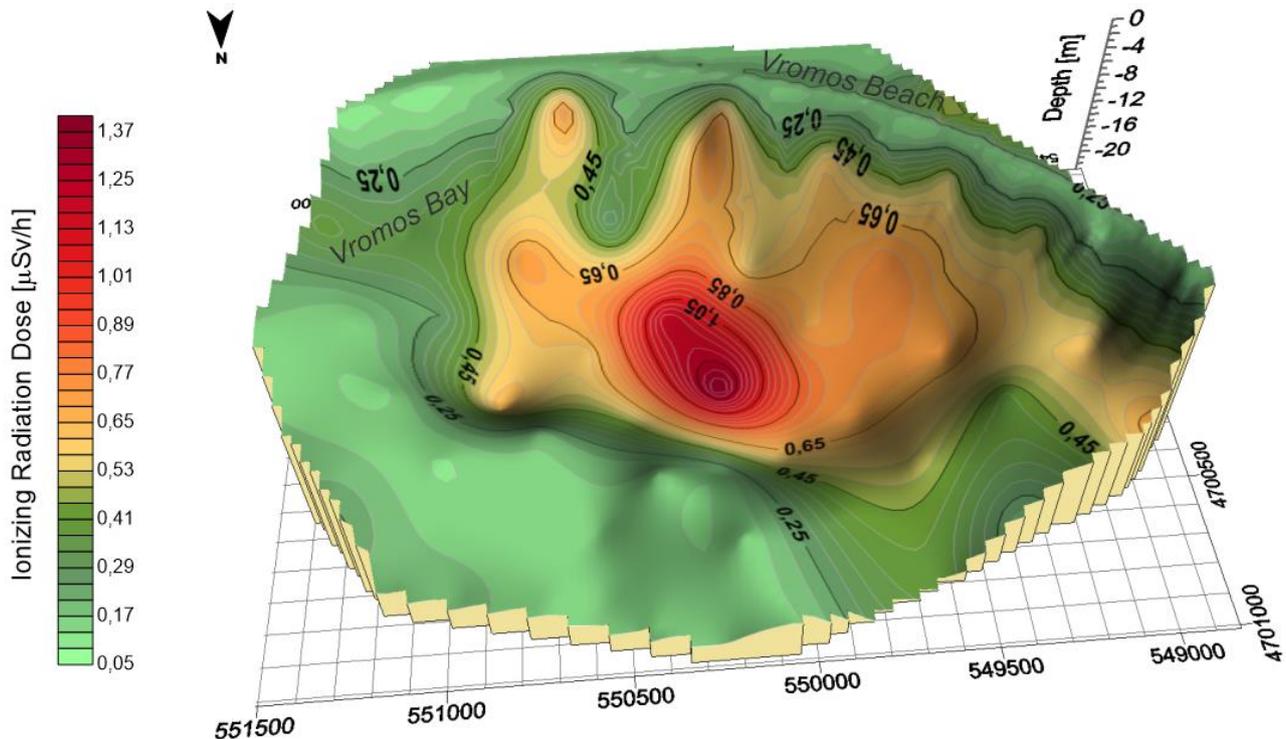


Fig. 3 Results of the radiometric survey of Vromos Bay.

Conclusion

The results of the survey show that the deep sediments of the Vromos Bay remain radioactive which requires periodic monitoring of the beach due to the sea dynamics and the natural process of enrichment of the sand with heavy minerals from the bottom.

Acknowledgements: The study was supported by Field Camp program of SEG Foundation и TGS.

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