Contamination of roads in Klatovy by natural radionuclides from waste rock dumps of the former uranium mine Ustaleè

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ABSTRACT: Contamination by natural radioisotopes was detected in the road network of the town Klatovy (Czech Republic). The extent and distribution of the contamination were studied using automobile and portable gamma ray spectrometers. Samples of the roadway were taken for a mineralogical and petrological study at two localities. Processes of redistribution of uranium in the road and its surroundings were studied.

1 INTRODUCTION

The Faculty of Science at Charles University organised in 1999 and 2000 courses of geochemical mapping in Klatovy and neighbouring villages. During these courses an anomalous content of uranium was found in the roads at 15 locations in the town and other 14 in close villages. Because of this fact, an automobile gamma ray research was proposed to be used to find out more about the extent of the contamination. The automobile gamma research was carried out in the spring 2001 by PICODAS s.r.o. About 100 kilometres of the road network of Klatovy (practically all the roads in the town) were measured and maps of K, U and Th content and a map of total gamma activity were constructed. In 2001 a detailed geophysical and geochemical research in the streets Macharova, Nuderova and U Pazderny was carried out, using field and laboratory gamma ray spectrometry, sieve analysis, X-ray diffraction, optical and electron microscopy.

2 GEOLOGICAL SETTING

The town Klatovy lies near the contact of two big tectonic units: the Middle bohemian unit, which is represented by the upper proterozoic rocks of the Barrandian, and the Moldanubian unit, represented by the Central Bohemian pluton and the Moldanubicum of the Šumava mountains. The town itself lies in the area, which is built of magmatites of the Central Bohemian pluton (biotite to amphibole-biotite granite to granodiorite of the Klatovy type). The neoproterozoic of the barrandian in surroundings of Klatovy consists of low grade metamorphosed greywackes and shales with extended bodies of lydite. The local part of the Šumava moldanubicum is made of biotite gneiss and layered migmatises.

3 FIELD RESEARCH

3.1 Selection of localities

The information from the radiometric maps made by PICODAS, was used to select 3 localities with a high content of uranium for a detailed research. Parts of streets Macharova, Nuderova and U Pazderny show a normal content of K and Th and high content of U. It is a typical sign of contamination by a mine waste from an uranium mine.

3.2 Field Gamma Ray Spectrometry

The three selected areas were measured in detail in a regular 2x2m grid with a portable gamma ray spectrometer DISA 400A with 75x75mm NaI(Tl) detector. (Measuring period 120 s.) Measured contents of radioisotopes: 3 - 80 ppm eU, 7 - 28 ppm eTh, 1 - 6%K. Dose rate: 72 - 582 nGy/h.

3.3 Beta rays activity measuring

All the points of the grid were also measured by a radiometer RP 12 with a beta probe to find out the presence of radioisotopes on the surface of the road. The probe consists of Geiger-Müller tubes. Every point was measured with steel shading of GM tubes (while only gamma rays can be detected) and without it. The difference corresponds to beta rays activity. With the use of a calibration coefficient, planar activity of beta rays can be obtained. The detection of beta rays proved the presence of radioisotopes on the surface in the street Macharova and U Pazderny (over 4 kBq/m²). In the street Nuderova it was less than 1.5 kBq/m².

4 LABORATORY RESEARCH

4.1 Roadway Sampling

The roadways were sampled by handmade holes reaching the underlier. About two kilogram samples of asphalt, road metal and underlying soil were taken. The loose material lying on the road was sampled in 1m² areas. All the loose material was taken from these areas.
4.2 Sieve analysis

Before the sieve analysis, bitumen had to be removed from the samples of asphalt by Soxhlet extraction. All the samples of the roadway materials and loose material from the surface were separated into three categories by sieving: dust (smaller than 0.063 mm), sand (from 0.063 to 2 mm) and rubble (over 2 mm). The dust (which is usually the most radioactive) creates about 4% in the layer of road metal, 6.5% in asphalt cover and 7 to 15% in loose material.

4.3 Laboratory Gamma Ray Spectrometry

Sieved samples of asphalt, crushed stone and underlying soil from the holes and samples of the loose rock material, lying on the street surface were analyzed by a gamma ray spectrometer CANBERRA series 10 with 75x75 mm NaI(Tl) detector. K, U, Ra and Th content was determined. Contents of radionuclides vary from 0.9 to 3.7% K, from 1.4 to 158.6 ppm U, from 3.3 to 699.3 ppm eU Ra and from 4.1 to 30.3 ppm Th.

5 PETROLOGY

The rock material from the road metal and from the waste dumps of close former uranium mines in Ustaleè and Dlažov and also from the quarry in Svèrovec was studied to try to find the origin of the contamination. The broken stone from the roads consists of paragneiss, granitised paragneiss and carbonate veinstone (sometimes containing uraninite). It is similar to the samples from waste dump in Ustaleè. Samples from Dlažov were found to be different from those from the roadways.

6 MINERALOGY

6.1 Primary uranium mineralisation

In all studied samples, primary uranium containing mineral is uraninite, usually occurring together with pink or white carbonate and sometimes also with pyrite, limonite, chlorite, quartz or chloritized paragneiss.

6.2 Secondary uranium containing phases

On the surface of samples of uraninite, yellow and green phases were found. 4 samples of these phases from the street Macharova and one from Nuderova were studied; using X-ray diffraction and electron microscope and microprobe. By the X-ray diffraction schröckingerite (NaCa3(UO2)(CO3)3(SO4)F*10H2O), \( a = 9.632(10) \), \( b = 9.641(12) \), \( c = 14.388(10) \), \( \alpha = 91.453(63)^\circ \), \( \beta = 94.13(76)^\circ \), \( \gamma = 120.229(56)^\circ \), liebigite (Ca2(UO2)(CO3)3*10H2O) \( a = 16.711(10) \), \( b = 17.552(17) \), \( c = 13.711(10) \), \( V = 4021.7(3.61) \) and uranophane Ca(UO2)2(SiO3)(OH)5*H2O were detected, two another phases were found amorphous, consisting of uranium (over 10 wt.%), calcium (over 1 wt.%) and Na, Al, Si, Fe, Pb (less than 0.1 wt.%).

7 CONCLUSIONS

The results of the petrological study indicate that contamination by uranium originates at the former uranium mine in Ustaleè. Radiogeochemical study proved migration of uranium out from the roads. The values of the coefficient of radioactive equilibrium are 83% and 190% at samples of asphalt, 117% and 441% at road metal, and 32 and 48% at underlying soil. Construction materials show depletion in uranium, while underlying soil is enriched with it (figure 1). And together with the occurrence of newly-formed uranium mineral phases, it gives an evidence of the uranium being leached out from the contaminated roads. Uraninite seems to be a non-stable mineral. Its decomposition and dissolving produce radioactive dust and cause contamination of the underlying soil. The external irradiation at studied areas is not of a serious health risk. However, the radioactive dust, lying on the surface of old damaged roads could be more dangerous.

Figure 1: Schematic roadway profile, graph of dependence of coefficient of radioactive equilibrium on the depth of sampling.

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REFERENCES

