Sampling strategy for finding radioactive pollutants in floodplain

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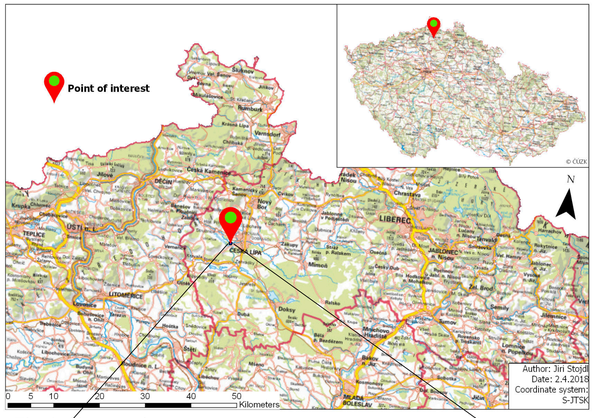

Fig. 1: Site overview map.

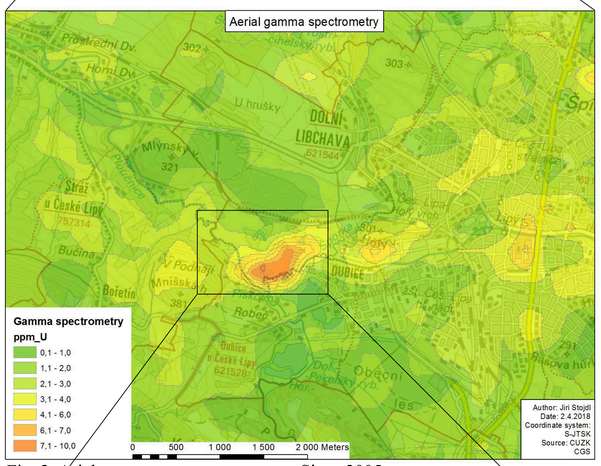

Fig. 2: Arial gamma spectrometry map. Since 2005.

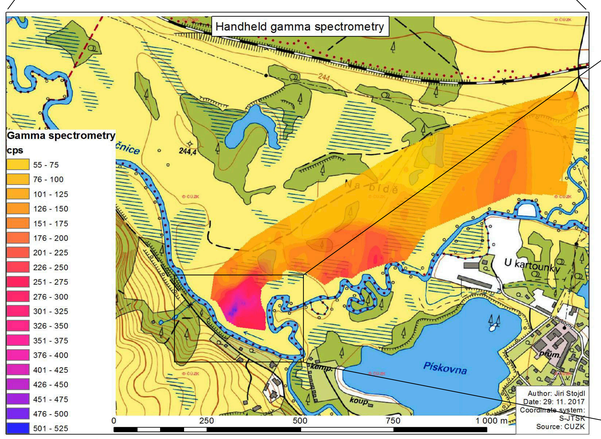

Fig. 3: IDW interpolation of handheld gamma spectrometry.

Introduction

Uranium ore was mined in the area of Ralsko, northern part of the Czech Republic in the last century (Fig. 1). One of environmental problems of mining was the discharge of mine waters to the Ploucnice River and consequent deposition of the contamination in floodplain. Another way of the transfer of mining waste into floodplain was a "radioactive" flood in 1981, which washed away a settling pond in the mining area. Finding the hotspots of contamination by uranium and other heavy metals in floodplain was a challenge for us.

Aerial gamma spectrometry

The first step in the hotspot imaging was examination of a historical low-resolution map based on aerial gamma spectrometry covering the entire mining area and the Ploucnice River catchment (Fig 2). Spatial resolution of the interpolated gamma activity raster was about 25 m, but the distance between individual neighbouring measurement points was about 250 m.

Handheld gamma spectrometry

After selecting potential pollution hotspots in that low-resolution map, we visited those sites to perform field survey using handheld gamma spectrometer connected with GPS. The output of this mapping was a net of points with about 11 m steps which was interpolated by *inverse distance weight* (IDW) method (Fig.3). Interpolated raster was cliped by outer points of measurement. The place close to river cannot be measured because in this place was inpenetrable willow (*Salix*).

Gamma spectrometry itself cannot be used to reliable localization of the subsurface contamination for two reasons. In the first place, this method don't measure radioactive uranium directly but measure ^{214}Bi as products of radioactive decay of uranium (called *equivalent of uranium* - eU). And ^{214}Bi is after radon (^{222}Rn) in decay chain(Fig. 4). ^{222}Rn has a half-life of 3,8 days as inert gas can move as component of soil gases or as dissolved in groundwater. In our case, we used *Total count* which is weighted sum of K, eU and eTh (*equivalent of thorium)*. We used it because our instrument cannot storage individual components with gps informations.

Secondly, the contamination was stored in variable depths and the surface activity was attenuated if the pollution was deeper than a few decimetres. Therefore, the third step of work was drill coring followed by in-situ chemical analysis using handheld X-ray fluorescence spectrometer (XRF).

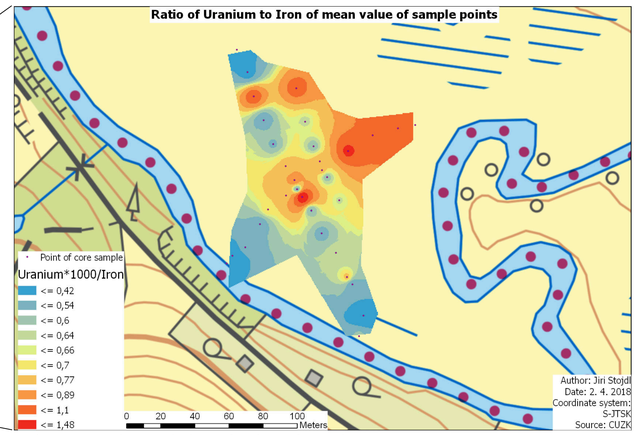

Fig. 6: IDW interpolation of ratiou of Uranium to Irone.

Sampling system

We call our system called "double – half" (Fig. 5). The core 1 is drilled and analysed in a local maximum of the surface gamma activity. Then core 2 is drilled in the distance of the half of the radius of the gamma activity hotspot measured by handheld gamma spectrometer. The next point of drill coring (core 3) is placed in double distance from the core 1 in the same direction as the core 2, if contaminants in core 2 are present (3a), or in the half of distance between cores 1 and 2, if contaminants are absent in the core 2 (3b). Then proceeding with same system to finding border of contamination. Last step of sampling is concentration of points in interested places (terrain inequality, sedimentary bodies, change of plants...). This approach systematically allows minimizing the number of samples without contamination and thus time and money are saved.

We are using soil core sampler and depth of sampling is limited by presence of contaminant which is analysed by handheld X-ray fluorescence spectrometer.

Postprocessing

The last step was a more accurate analysis of uranium and other heavy metals in laboratory. Standard process of sample processing involves drying, milling and analysis by laboratory X-ray fluorescence spectrometer. In the last picture (Fig. 6) you can see interpolation of uranium concentration normalized by iron. Values in drill hole were averaged. Interpolation method was Inverse distance weight (IDW).

The evaluation of spatial distribution of contamination from drill coring may be supported by electromagnetic imaging (EMI) of the pollution hotspot or electrical resistivity tomography (ERT) in the line of samples.

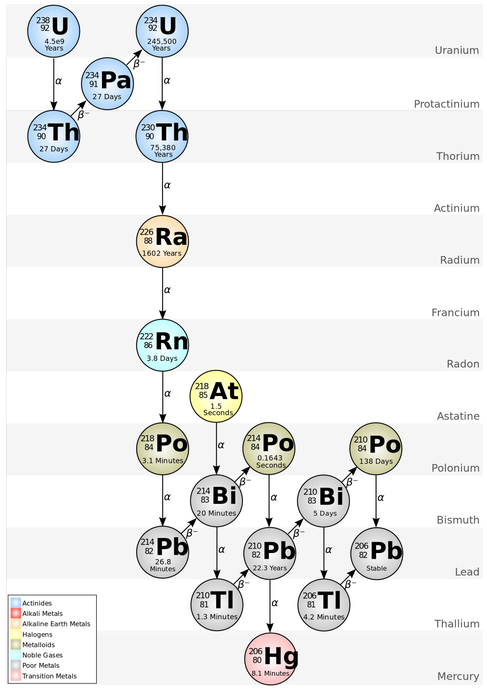

Fig. 4: Uranium decay chain.

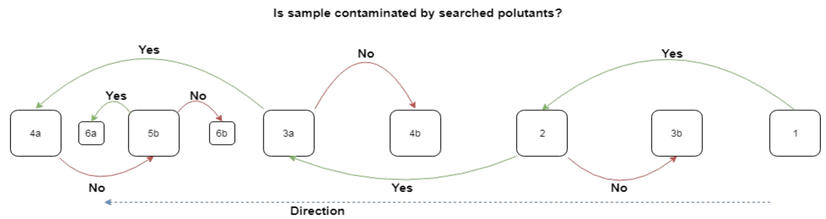

Fig. 5: Diagram of sampling strategy.

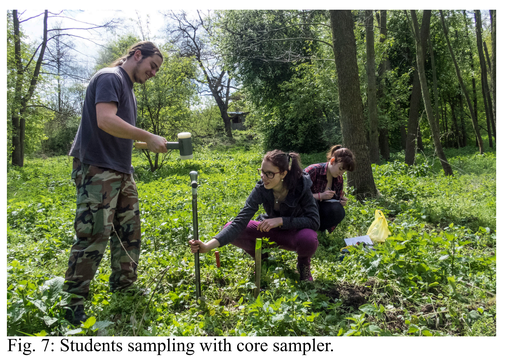

Fig. 7: Students sampling with core sampler.

Fig. 6: Ing. Hošek with handheld gamma spectrometry on locality.

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