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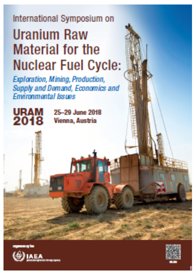

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The Test of new UAV Gamma-ray Spectrometer at a Real Uranium Anomaly

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INTRODUCTION

Localization of size-limited gamma-ray objects plays a fundamental role in uranium prospecting and environmental studies. Unmanned Aerial Vehicle (UAV) mini-airborne measurements have been applied for many environmental issues, including radiation protection and nuclear accident monitoring [1-6]. The instrument reported by Sanada and Tori [5] was based on LaBr3:Ce scintillator, which is not appropriate for measurement of natural radiation due to the inherent contamination of the crystal by 138La. Instruments employed by MacFarlane et al. [1], Martin et al. [2-4] and Falciglia et al. [6] have very good energy resolution, but they are not suitable for radioactive ore prospecting due to their small volume and insufficient sensitivity for the not very intense natural radiometric anomalies.

The instrument suitable for prospecting of radioactive geological objects and used in this project was the Georadis D-230A, a newly developed gamma-ray spectrometer specially designed for UAV and equipped with two BGO scintillation detectors. The objective was to assess this equipment for localization of a size limited U mineralization. The possibility of anomaly detection depends on its size, shape and gamma-ray intensity and on the instrument sensitivity, flight speed and flight altitude [7].

The mini-airborne gamma-ray spectrometer Georadis D 230A, having two 51 mm × 51 mm BGO scintillation crystals, provides the sensitivity of 0.55 cps (counts per second) per 1 ppm eU on the ground. The sensitivity of a standard 76 mm ×76 mm NaI(Tl) scintillation detector is approximately 0.33 cps per 1 ppm eU [8]. The sensitivity of Georadis D-230A is about 300 times greater than the sensitivity of the 1 cm3 CZT detector, which was used for many previous UAV surveys in environmental applications [1-4].

METHODS

A uranium mineralization near the village of Třebsko, five km to the south from the town of Příbram, Central Bohemia, Czech Republic, served as a test site for the performance of the Georadis D-230A gamma-ray spectrometer. The spectrometer was attached to a powerful hexacopter. The radiation anomaly at the test site is related to an outcropping U mineralized vein.

Concentrations of radionuclides at the anomaly were assessed by a detail ground measurement with a portable gamma-ray spectrometer GS-256 equipped with a 76×76 mm NaI(Tl) scintillation detector. Calibration of the GS 256 spectrometer was performed at the calibration facility in the Czech Republic, in conformity with the standard procedures as recommended by the IAEA [8]. Registered field data were interpolated by the kriging method and the U contour map of the anomaly was compiled.

The hexacopter by Robodrone Industries (Czech Republic), type Kingfisher, was used as an airborne platform. It was a powerful hexacopter with up to 5 kg payload capacity, dimensions 120×140×22 cm, maximal endurance 45 min., endurance with attached 4 kg instrument was 16 min, maximal speed was 70 km/h and wind resistance 10 m/s [9]. The navigation could be manual or autonomous. The autonomous mission was specified by waypoints given by GPS coordinates and the flight altitude as the third coordinate. The system measures the altitude by a barometric pressure sensor MS5611-01BA03 [10]. The atmospheric pressure altimeter is calibrated to zero height on the ground before each flight.

Mini-airborne 1024 channel gamma-ray spectrometer Georadis D 230A (Czech Republic) with two Bismuth Germanium Oxygen (BGO) scintillation detectors of the volume 103 cm3 each has an automatic spectrum stabilization using energy lines of natural radionuclides. The instrument energy resolution 13.6 % at 662 keV was determined experimentally. The instrument weight was approximately 4 kg including rechargeable battery and dural holder fixing the instrument under aircraft.

Mini-airborne measurement was carried out on three 100-m-long parallel lines NW –SE perpendicular to the longer axis of the anomaly (NE –SW). The separation between profiles was 10 m. The data recording time interval was 1 second. Each of the three profiles was flown at eight altitudes from 5 m to 40 m above the ground with the vertical step of 5 m. Flight velocity was 1 m/s. The navigation was performed in the autonomous GPS flight mode. The result of flight operation were 1s interval 1024 channel gamma-ray spectra, which were processed to U concentration and TC count rate.

RESULTS AND DISCUSSION

The resulting U contour map obtained from the ground assaying shows the size of the anomaly approximately 80 m by 40 m with average U concentration of 25 ppm eU, which locally attains 700 ppm eU.

The results show the significant dependence of the recorded anomalous gamma-ray field converted to TC data and apparent U concentrations on the flight altitude.

The anomaly was recognized at all profiles and flight altitudes. Recorded maxima of count rates exceed the N + 3S level [8] at all cases.

A comparison between sensitivities and data quality of a standard airborne survey and the mini-airborne survey is illustrative. Grasty and Minty [11] reported U sensitivity of an airborne spectrometer at 80 m flight altitude approximately as 8 cps per 1 ppm eU. The flight speed of the aircraft is about 50-60 m/s for fixed-wing surveys [8]. The Georadis D-230A has U sensitivity on the ground 0.55 cps per 1 ppm eU. Uranium sensitivity at the altitude of 40 m is approximately 50% of the sensitivity on the ground [11, 13], which means about 0.25 cps per 1 ppm eU. Flight speed of the UAV multicopter can be slowed down to 1 m/s. Theoretically, a standards airborne survey at flight altitude of 80 m over 100 m long profile with unit uranium concentration 1 ppm U will generate in U energy window 16 counts while for the Georadis D-230A at a flight altitude of 40 m and attainable speed 1 m/s 25 counts will be recorded. It is obvious that UAV mini-airborne survey can, due to low speed and lower flight altitude, collect data with comparable quality, on a detailed scale, as standard airborne survey.

CONCLUSION

The presented issue deals with the methodology and potential of mini-airborne gamma-ray spectrometric survey for radioactive ore prospecting using unmanned aerial vehicles. The research has shown real operational possibilities of the tested mini-airborne system with a progressive BGO gamma-ray spectrometer with relatively large volume detector.

Experimental measurement profiles over a size limited U anomaly at flight altitudes from 5 m to 40 m showed the rapid decrease of the gamma-ray field with increasing flight altitude. Flight altitude is an important setting for mini-airborne survey. Based on our results, the flight altitude for mini-airborne surveys can be up to 40 m and take into account all important conditions like size and intensity of an assumed anomaly, detector sensitivity, flight speed and vegetation character.

A detailed ground gamma-ray spectrometry investigation of the U anomaly enabled analysis and comparison with airborne data. A small UAV can fly at low altitudes and enables detection of size-limited radiation objects which are undetectable by conventional airborne gamma-ray spectrometry at standard flight altitude of about 80 m. In this sense UAV systems fill a gap in technical possibilities between ground and conventional airborne measurement.

The UAV mini-airborne instrument can collect the same number of counts per unit distance on a profile as a standard airborne survey, due to low speed and lower flight altitude. The main limitations of mini-airborne gamma-ray spectrometry are short operational time and slow survey speed causing the method to be not applicable for regional surveys.

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