Mapping of Natural Radioelements Using γ-Ray Spectrometry: Veneto Region Case of Study

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INTRODUCTION

The main source of terrestrial gamma-ray radiation exposure to humans comes from ^{238}U, ^{232}Th decay chains and ^{40}K decay. γ-ray spectrometry is a consolidated methodology extensively utilized by many nations for investigating and mapping of natural radioelements [1].

The territory were investigated through γ-ray spectrometry implying measurements utilizing laboratory [2], portable and airborne instruments [3,4] in order to realize the thematic maps of radioactivity content and in particular of the abundances of eU , eTh: these concentrations by weight are determined indirectly from ^{238}U and ^{232}Th daughter products (^{214}Bi and ^{208}Tl respectively), that are assumed to be in equilibrium with their parent isotope) and ^{40}K.

The Veneto region has 18000 km^2 with around 50 different lithological formations and 40% of its territory is covered by mountains and hills while the remaining 60% has a plain geomorphology. Therefore, the survey program was planed taking into consideration the geological, geographical and morphological variability of the territory under investigation and divided in three approaching scales undertaking laboratory, in-situ and airborne measurements following the IAEA guidelines [1].

The Legnaro National Laboratory (LNL) is the national leader for the design and realization of high-resolution γ-ray spectrometers, portable and massive NaI(Tl) detectors. The MCA-Rad γ-ray spectrometry system [2] was designed and built up at LNL for measuring large amount of samples with a minimum wait: these features fit perfectly with the requirements of this project. This system is able to measure any type of materials (solid, liquid, gas), and due to the high efficiency and its geometric symmetry, absolute activity measurements are possible with systematic errors below 5%.

MATERIALS AND METHODS

The sampling strategy was planed on geological arguments: the homogeneous units are recognized by low density of samples, permitting to focus a high density of samples on the heterogeneous areas. The informations collected during the sampling are organized in a geo-database (VenDB). The two operators working on field fill the VenDB with GPS coordinates and the main information about the state of outcropping, the weather conditions and the geological features (unit, formation, lithology). More than 500 samples of rock and soil are already collected and measured in laboratory by using the MCA-Rad system [2]. The surface area already covered by the sampling procedure is shown in figure 1 and the northeast part will be covered in spring and summer 2012.

The samples collected are crushed, sieved and then placed in a drying oven at temperature 60°C in order to remove the moisture. The 200 cm^3 cylindrical polycarbonate containers filled with the ground rock are weighted and labeled with a barcode. Finally they are stored and kept sealed for 38 days in order to reach the radioactive secular equilibrium between ^{226}Ra and ^{222}Rn (10 half- lives of ^{222}Rn). The MCA-Rad output (counts, specific activity and abundance) it is adapted in order to easily fill the VenDB permitting an user-friendly management of the data. This procedure is designed to minimized the human errors and optimize the manpower. The specific activity of ^{238}U and ^{232}Th was calculated under the assumption of secular equilibrium, using the gamma transitions of energy, 609.3 keV for ^{214}Bi (eU) and 583.2 keV for ^{208}Tl (eTh), while for ^{40}K was calculated through the gamma transition of energy 1460.8 keV. The achieved minimum detection activity (MDA) calculated following [5] were 0.2 Bq/kg for ^{214}Bi, 0.3 Bq/kg for ^{208}Tl and 1.8 Bq/kg for ^{40}K.

RESULTS AND CONCLUSIONS

During the 2011 sampling campaign 421 rock samples have been collected and 302 were already analyzed. In Table 1 we report the preliminary results of the activity (in Bq/kg) of geological formation with at least 10 samples already collected and measured with the MCA-Rad system. In 2012 we have planned a subsequent sampling campaign in order to complete the measurements of all rock formations of the Veneto region.

The formations reported in Table 1 are sampled in the area between the Garda Lake and the Belluno region and

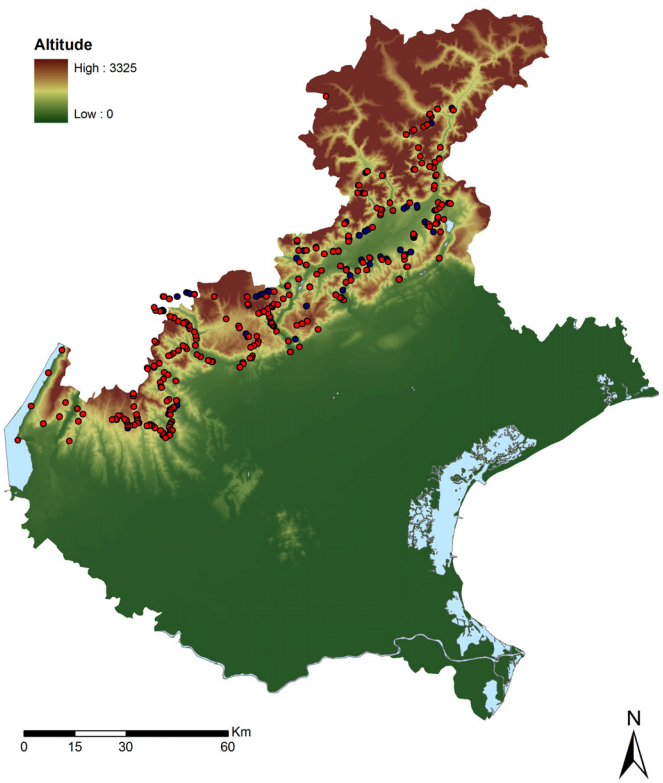

Fig. 1. The distribution of sampling of rocks (light grey points) and soils (dark gray points) in the Veneto region. The map shows the all 421 samples already collected. The region of the Colli Berici and Euganei and the north part of the Veneto Alps will be covered during 2012.

Table 1. Activity measurements of rock formations with at least 10 samples already analyzed.

Formation	N. samples	Bq/kg
Biancone	44	66^{+55}_{-30}
Calcari Grigi	42	44^{+30}_{-18}
Dolomia Principale	61	44^{+33}_{-19}
Rosso Ammonitico	25	56^{+26}_{-18}
Scaglia Rossa	24	108^{+120}_{-57}
Sequenza Metamorfica di Recoaro	10	1184 ± 463

they are made mainly by sedimentary rocks. With the exception of the Sequenza Metamorfica di Recoaro all other formation report a low activity level with respect with the average on the Earth (around 460 Bq/kg). The Sequenza Metamorfica di Recoaro contains both metamorphic rocks derived from protolitic sedimentary and volcanic rocks which are characterized by a higher activity.

FINAL NOTES AND REFERENCES

The authors would like to thank Enrico Bellotti, Giuseppe Di Carlo, Pirro Altair, Luigi Carmignani and Riccardo Vannucci for useful suggestions and invaluable discussions. This work is supported by the Italy INFN and Fondazione Cassa Di Risparmio di Padova e Rovigo and Centro di Geotecnologie dell'Università di Siena and Tuscany region founding.

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