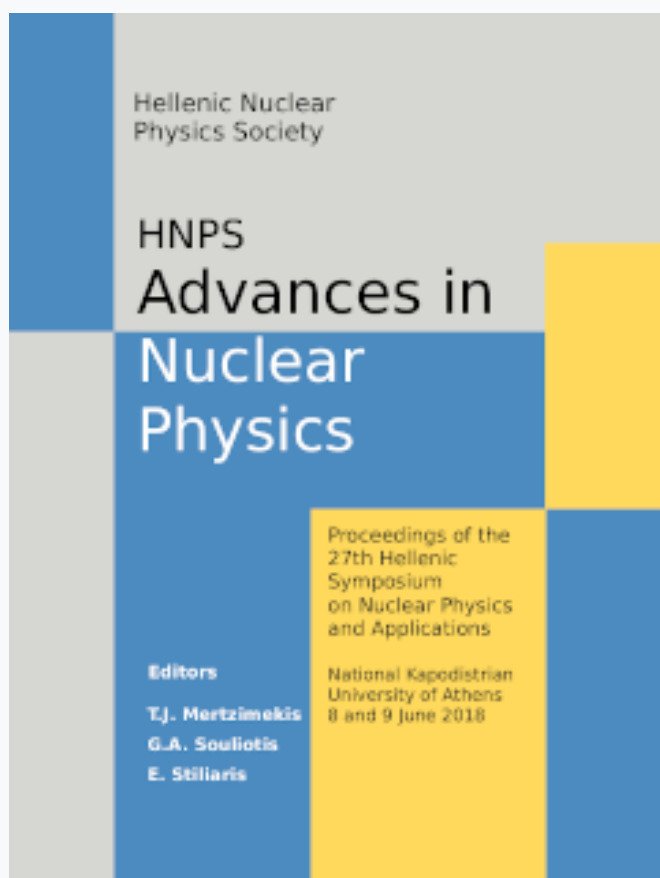


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Gamma spectroscopy studies of the underwater hydrothermal vent field of the Methana Peninsula

V. Papakosta¹, T.J. Mertzimekis², M. Triantafyllou¹

¹ *Department of Geology and Geoenvironment, University of Athens, Zografou Campus, GR-15784 Athens, Greece*

² *Department of Physics, University of Athens, Zografou Campus, GR-15784 Athens, Greece*

Abstract A preliminary study of natural radioactivity was conducted on the thermal spas in Methana Peninsula. To carry out this research, a collection of 17 water samples were taken from thermal springs around and underwater of the volcanogenic Peninsula at depths ranging 0–5 m. The Methana peninsula belongs to the Hellenic Volcanic Arc and is characterized by hydrothermal vent activity. A NaI(Tl) scintillator (AMESOS) was used to carry out gamma-ray counting of the samples to deduce the activity concentrations of the natural radionuclides of the ²³⁸U and ²³²Th decay series, as well as ⁴⁰K in spa waters. Results are expected to provide information on the geological setting of the Methana peninsula. The impact of naturally occurring radioisotopes to human health has also been assessed in terms of the radiation dose risk corresponding to the measured activities.

Keywords Methana Peninsula, thermal spa, hydrothermal activity, gamma-ray spectroscopy

INTRODUCTION

Methana, a peninsula of approximately 44 km² at the NE coast of Peloponnesus in Greece, is the western most dormant, but geodynamically and hydrothermally active volcanic system of the south Aegean volcanic arc. Methana is part of the Saronic gulf area, a neotectonic basin that is considered to be seismically active and that contains active fault systems. These tectonic lineaments are the preferential paths for the present day geothermal fluid leakage and could also be potential sites for magma uprising. Hydrothermal vent fields are sources of hydrothermal fluids, which are often show elevated concentration of naturally occurring radioactive material (NORM).

In the present work, a preliminary study of natural radioactivity was conducted in the thermal spas in Methana Peninsula.

EXPERIMENTAL DETAILS

A collection of seventeen (17) water samples were taken from thermal springs around and underwater of the volcanogenic Peninsula (Fig. 1) at depths ranging 0–5 m. At the greater depths, Niskin bottles were used to extract the water. Samples were weighed and sealed for a month to reach radioactive equilibrium.

The mobile AMESOS Spectrometer (Fig. 2) was used to carry out γ -ray counting of the samples to deduce the activity concentrations of the natural radionuclides. AMESOS consists of a 3''x3'' NaI(Tl) detector with a USB DigiBase and a portable PC equipped with Maestro Software. The detector bias remained fixed at 700 V during the 24 h-long measurements.

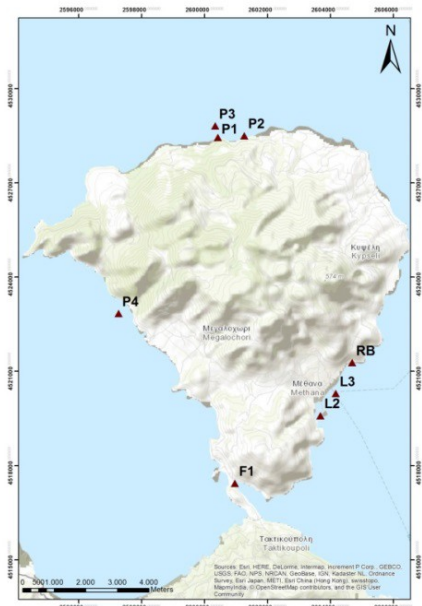


Figure 1. The Methana Peninsula and the sampling locations

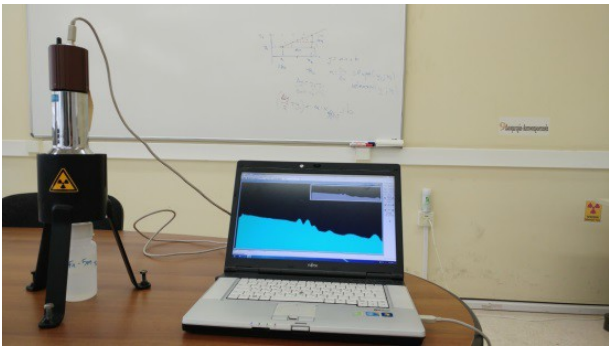


Figure 2. AMESOS during data recording

Spectra were analyzed using SpectrW [1] (Fig. 3). Focus was given on naturally occurring ^{40}K , ^{238}U (determined via its daughter ^{214}Bi) and also on ^{232}Th (determined via its daughter ^{208}Tl). Prior to measurements, the absolute efficiency was obtained (Fig. 4) along with detector linearity checks (Fig. 5) and photopeak resolution (Fig. 6) by using standard point-like sources (^{22}Na , ^{60}Co , ^{137}Cs) of known activities [2–5].

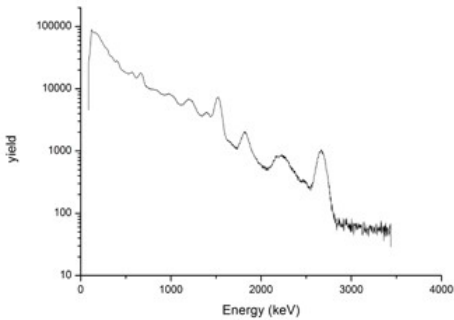


Figure 3. A typical spectrum from this study

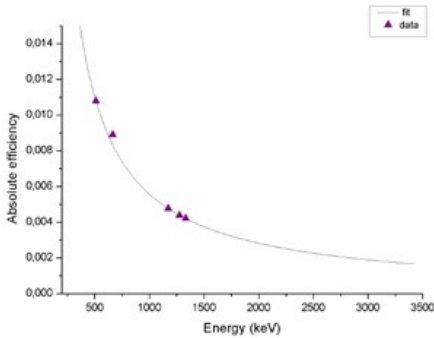


Figure 4. AMESOS' absolute efficiency curve

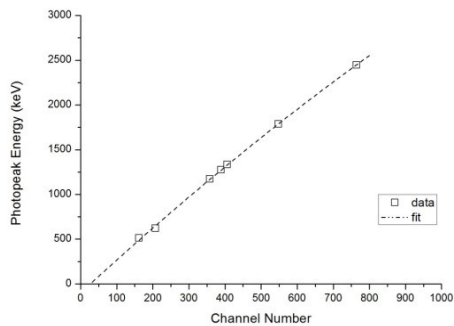


Figure 5. AMESOS' linearity

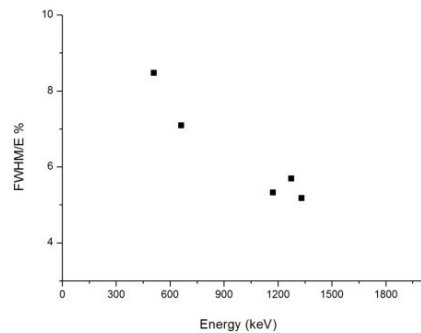


Figure 6. AMESOS' energy resolution (FWHM)

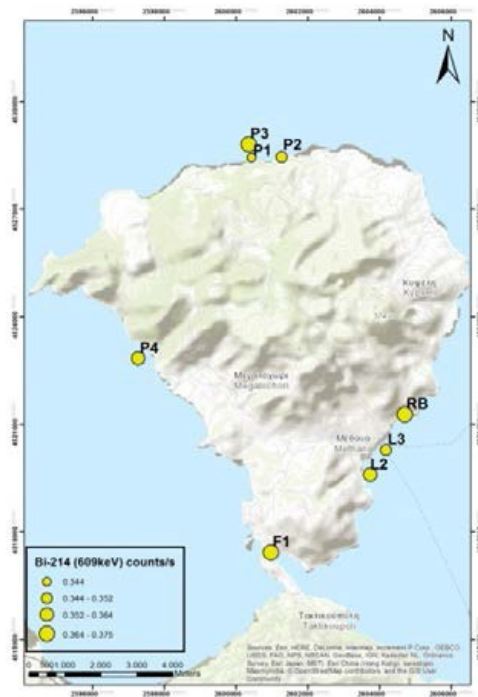


Figure 7. ^{238}U (609 keV) map

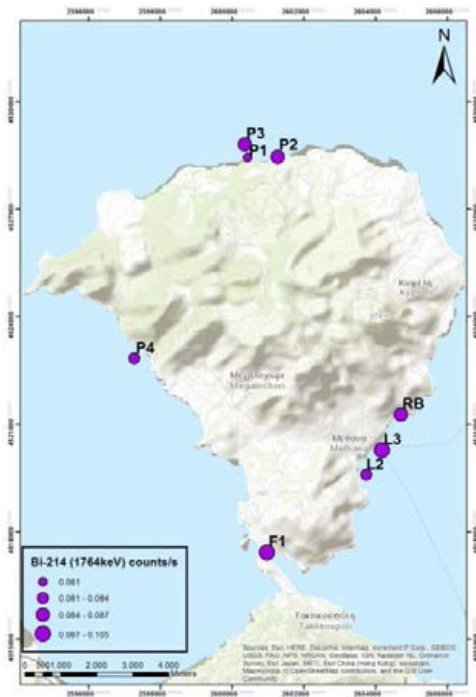


Figure 8. ^{238}U (1764 keV) map

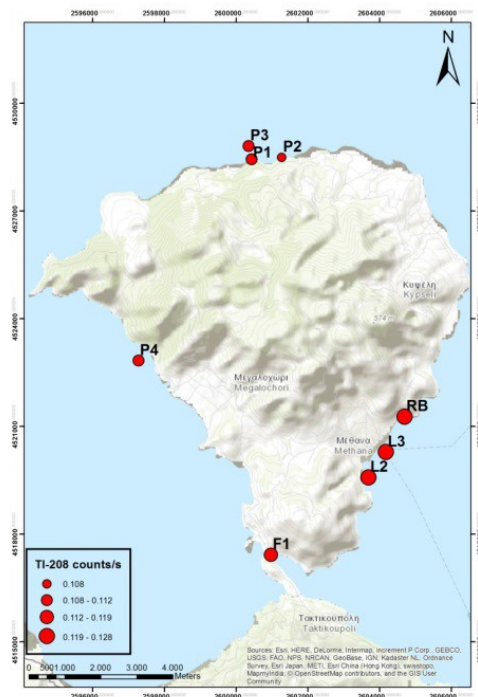


Figure 9. ^{208}Tl map

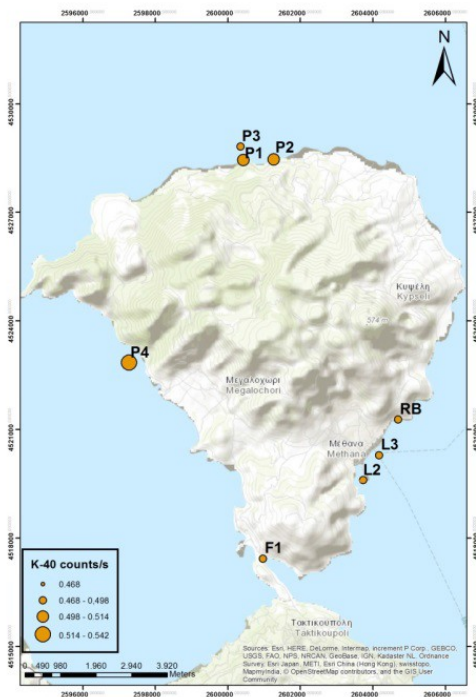


Figure 10. ^{40}K map

RESULTS AND DISCUSSION

- ^{238}U specific activities were extracted from ^{214}Bi (609 and 1764 keV). All but one value (at sampling location F1), seem to be rather similar (Fig. 7 & 8).
- ^{208}Tl levels are higher in L2, L3, RB (Fig. 9)
- ^{40}K levels are similar in all sampling points, with a slightly higher value in P4 (Fig. 10)
- Dose rates in nGy/h were calculated according to UNSCEAR [6] (Table 1). The risk of radiation is negligible to human health since $H_{\text{ex}} < 1$.

| <i>Samples</i> | <i>D</i> (nGy/h) | <i>AEDE</i> ($\mu\text{Sv/y}$) | <i>Ra eq</i> (Bq/kg) | <i>Hex</i> |
|-----------------|---------------------|-------------------------------------|-------------------------|------------|
| <i>P1-0m</i> | 73 | 90 | 171 | 0.463 |
| <i>P1-2m</i> | 66 | 81 | 155 | 0.418 |
| <i>P1-5m</i> | 69 | 85 | 161 | 0.434 |
| <i>P2-0m</i> | 67 | 82 | 157 | 0.423 |
| <i>P2-5m</i> | 69 | 85 | 162 | 0.436 |
| <i>P3-0m</i> | 71 | 87 | 165 | 0.445 |
| <i>P4-0m</i> | 70 | 86 | 162 | 0.439 |
| <i>F1-2m_#1</i> | 76 | 93 | 176 | 0.476 |
| <i>F1-2m_#2</i> | 75 | 92 | 176 | 0.474 |
| <i>F1-5m_#1</i> | 73 | 89 | 169 | 0.457 |
| <i>F1-5m_#2</i> | 75 | 92 | 176 | 0.474 |
| <i>L2-2m_#1</i> | 77 | 94 | 179 | 0.484 |
| <i>L2-2m_#2</i> | 77 | 94 | 180 | 0.485 |
| <i>L3-3m_#1</i> | 75 | 92 | 174 | 0.471 |
| <i>L3-3m_#2</i> | 81 | 99 | 189 | 0.511 |
| <i>RB-0m_#1</i> | 80 | 98 | 186 | 0.501 |
| <i>RB-0m_#2</i> | 78 | 96 | 182 | 0.493 |

Table 1. Dose estimation factors

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