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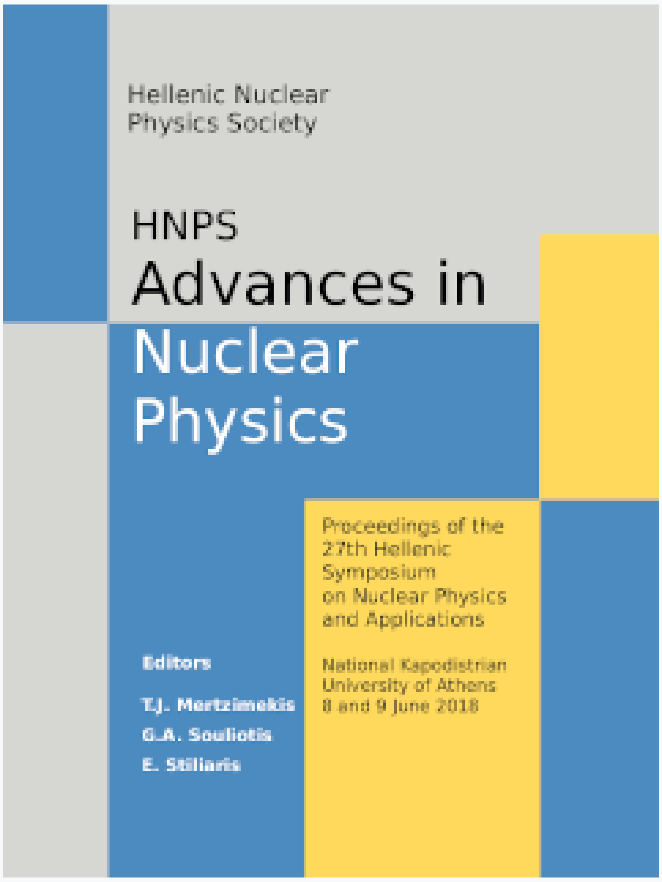

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Gamma spectroscopy studies of the underwater hydrothermal vent field of the Methana Peninsula

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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 ^{238}U and ^{232}Th decay series, as well as ^{40}K 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

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INTRODUCTION

Methana, a peninsula of approximately 44 km^2 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.

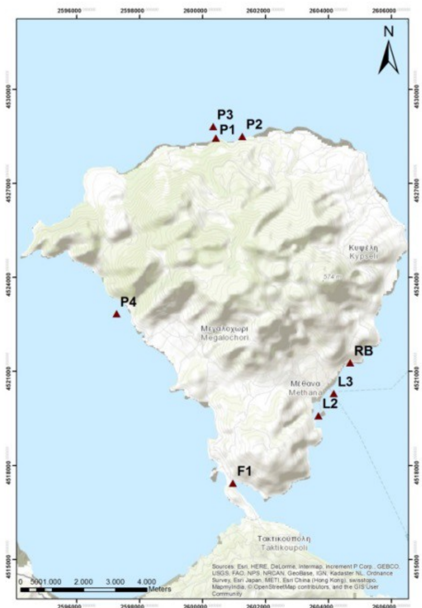

Figure 1. The Methana Peninsula and the sampling locations

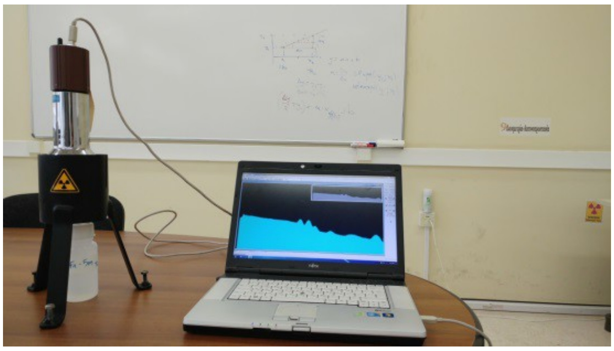

Figure 2. AMESOS during data recording

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].

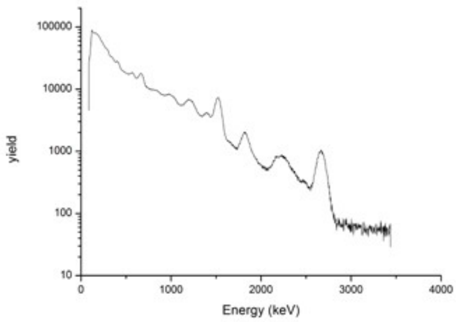

Figure 3. A typical spectrum from this study

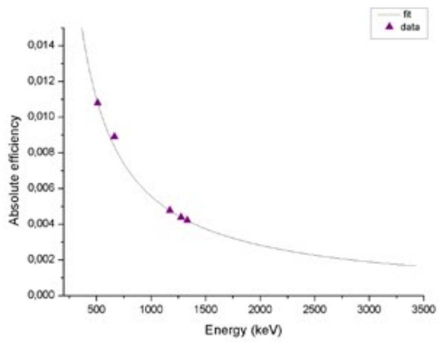

Figure 4. AMESOS' absolute efficiency curve

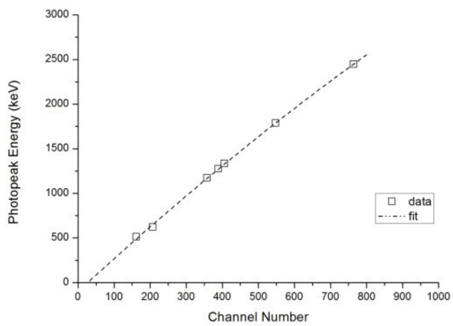

Figure 5. AMESOS' linearity

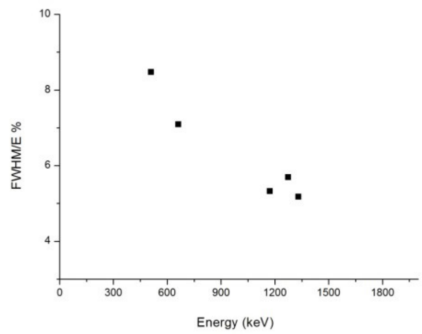

Figure 6. AMESOS' energy resolution (FWHM)

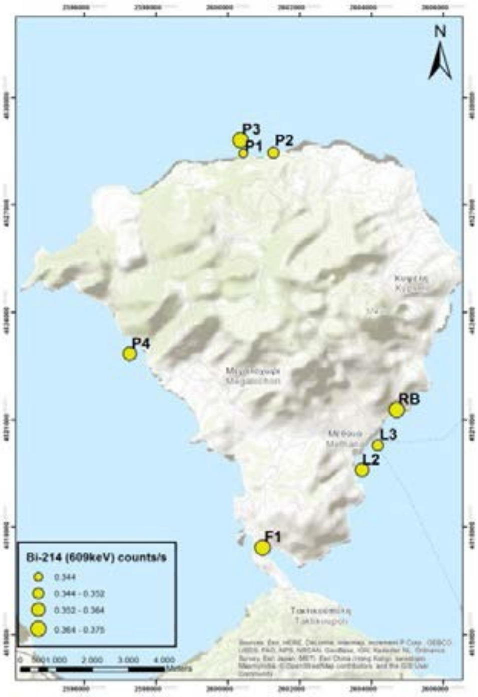

Figure 7. ^{238}U (609 keV) map

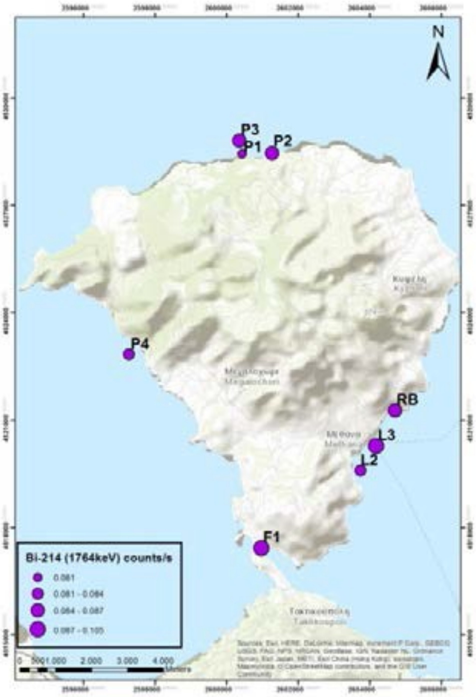

Figure 8. ^{238}U (1764 keV) map

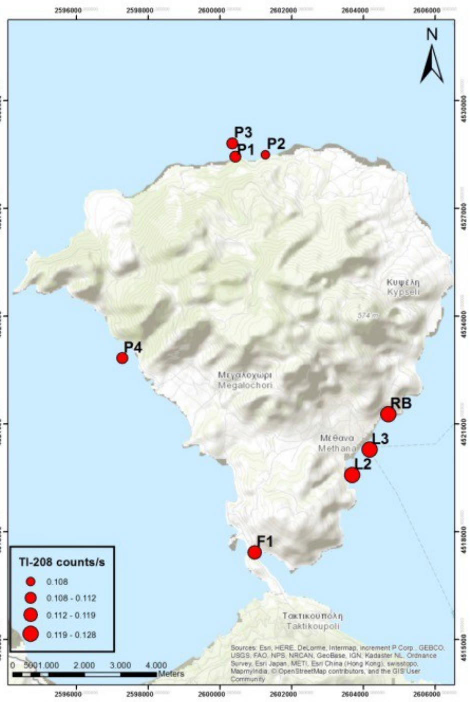

Figure 9. ^{208}Tl map

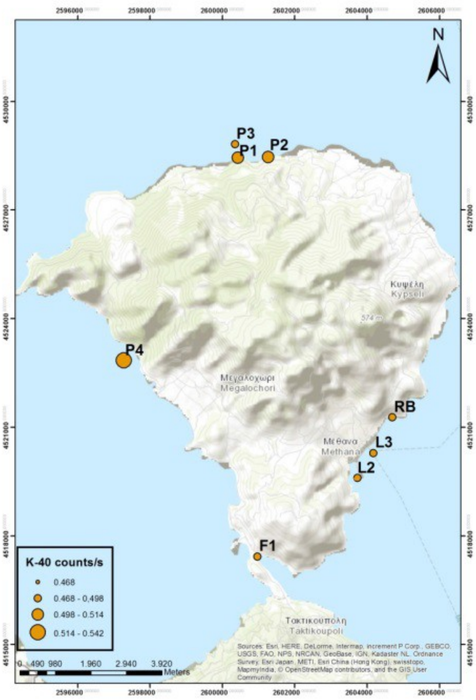

Figure 10. ^{40}K map

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_{ex} <1.

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

Table 1. Dose estimation factors

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