

Thermomineral waters of Greece: geochemical characterization

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Many geothermal areas of Greece are located in regions affected by Miocene or Quaternary volcanism and in continental basins characterised by elevated heat flow. Moreover, the majority of them is found along the coast as well as in islands of the Aegean Sea and thus, thermal water is often brackish to saline due to marine intrusion into costal aquifer.

In the present study, almost 300 thermal and cold mineral water samples were collected along the Hellenic territory with their physicochemical parameters (temperature, pH, electrical conductivity and Eh) and the amount of bicarbonates (titration with 0.1N HCl) being determined in situ. Additionally, gases, found either in free or dissolved phase, were sampled. Both water and gas samples were analysed at the INGV-Pa laboratories for major ions (Ion Chromatography), silica (Inductively Coupled Plasma - Optical Emission Spectrometry), chemical composition of free and dissolved gases (Gas Chromatography) water isotopes (O and H) and carbon and helium isotopes of free and dissolved gases (Mass Spectrometry).

The temperature of the investigated waters ranges from 6.5 to 98°C, pH from 1.96 to 11.98, whilst Total Dissolved Solids (TDS) from 0.06 to 43 g/L. Based on the temperature parameter, waters can be divided into four groups: i) cold (< 23 °C), ii) warm (23 - 40 °C), iii) thermal (40 - 75 °C) and iv) hyperthermal (> 75 °C). In terms of pH, most results vary from 5.5 to 8; few springs show either very low pH (< 4) suggesting interaction with H₂S-rich gases or very high pH values (> 10) proposing serpentinization processes.

Regarding TDS concentrations, collected waters can be subdivided into low salinity (up to 1.5 g/L), brackish (up to 20 g/L) and saline (up to 43 g/L). The medium - high salinities can be justified by mixing with sea water and/or strong water-rock interaction processes. Isotope composition of O and H ranges from -12.7 to +2.7 ‰ SMOW and from -91 to +12 ‰ SMOW respectively and is generally comprised between the Global Meteoric Water Line and the East Mediterranean Meteoric Water Line. Only few water samples show a positive shift for δ¹⁸O possibly related to high temperature water-rock interaction processes.

Carbon dioxide (18 - 997,000 μmol/mol) or N₂ (1100 - 989,000 μmol/mol) or CH₄ (< 0.5 - 913,000 μmol/mol) are the prevailing gas species found in the studied sites. The δ¹³C_{CO₂} values ranged from -20.1 to +8.5 ‰, whilst the isotope ratio of He from 0.21 to 6.71 R/RA.