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Origin and evolution of the fluids emitted along the "Sperchios Basin – Evoikos Gulf" Graben (Central Greece)

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The study area is a 130 km long fast spreading graben in Central Greece bordered by active faults. Its complex geodynamical setting includes the presence at depth of a subduction slab responsible for the recent (Quaternary) volcanic activity in the area which possibly represents the northward continuation of the South Aegean active volcanic arc. To the area belongs also the western termination of the North-Anatolian fault a tectonic lineament of regional importance. The high geothermal gradient of the area is evidenced by the presence of many thermal springs with temperatures from 19 to 82 °C, issuing along the normal faults bordering the graben.

In the period 2004-2012 more than 60 gas and water samples have been collected and their chemical and isotopic analysis revealed a wide range of compositions.

Going from west to east the gas composition changes (Fig. 1) from CH_4- to CO_2-dominated passing through mixed N_2-CH_4 and N_2-CO_2 compositions, while at the same time the He isotopic composition goes from typical crustal values (0.02 R/R_a) up to 0.87 R/R_a (corrected for air contamination), showing in the easternmost sites a small but significant mantle input (up to ~ 10%). Isotopic composition of CH_4-C indicates a thermogenic origin for the CH_4-rich samples ($\delta^{13}C$ from -50 to -37 ‰) and hydrothermal origin for the remaining samples (> -25‰). Positive $\delta^{15}N$ values (around +2 ‰) indicate a contribution of crustal derived nitrogen for the N_2-rich samples.

The most pristine values of $\delta^{13}C(CO_2)$ refer to the most CO_2-rich samples. These values (~ -3 ‰) point to a mixed mantle-marine carbonate source. Lower δ13C values (-10 ÷ -5 ‰) of the other sites can be explained by loss of CO_2 due to dissolution processes.

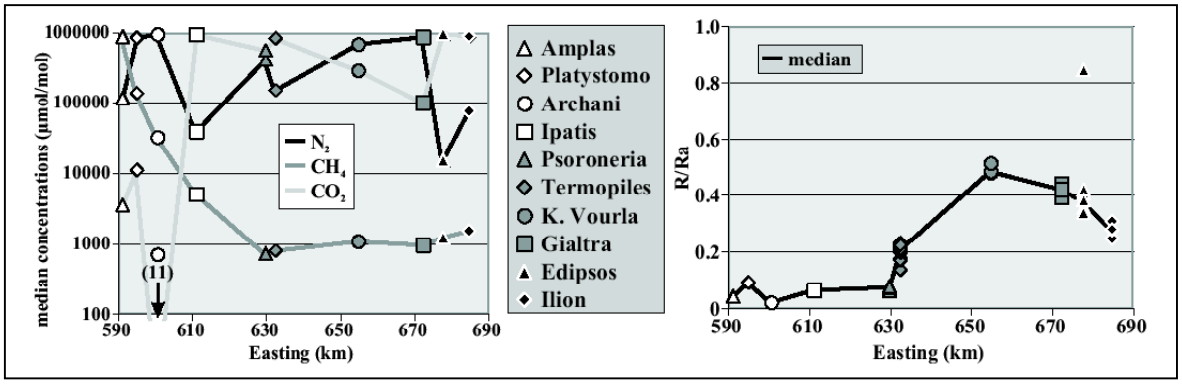

Fig. 1: West-east variations of the major chemical components and of the He isotopic composition of the gases collected along the "Sperchios Basin – Evoikos gulf" graben. CO_2 concentration at Archani is 11 µmol/mol.

Also temperature and salinity of the waters shows differences along the graben increasing from west to east (Fig. 2). Two main groups can be separated on the basis of the total dissolved salts (TDS). The first, represented by dilute waters (TDS < 500 mg/l), is found in the westernmost sites characterised by the presence of CH_4-rich and mixed N_2-CH_4 gases. The remaining waters display higher salinities (TDS from 9 to 35 g/l) due to the mixing with high salinity waters.

The water composition can be explained by mixing of two end-members, one with low salinity of meteoric origin and the other with high salinity of marine origin. The mixing can be evidenced in Fig. 2. Low salinity waters show low chloride contents and their light water isotope composition overlaps the field of the cold groundwaters of the area confirming their meteoric origin. High salinity waters are aligned along the mixing line between the cold groundwaters and the seawater confirming the contribution of marine component.

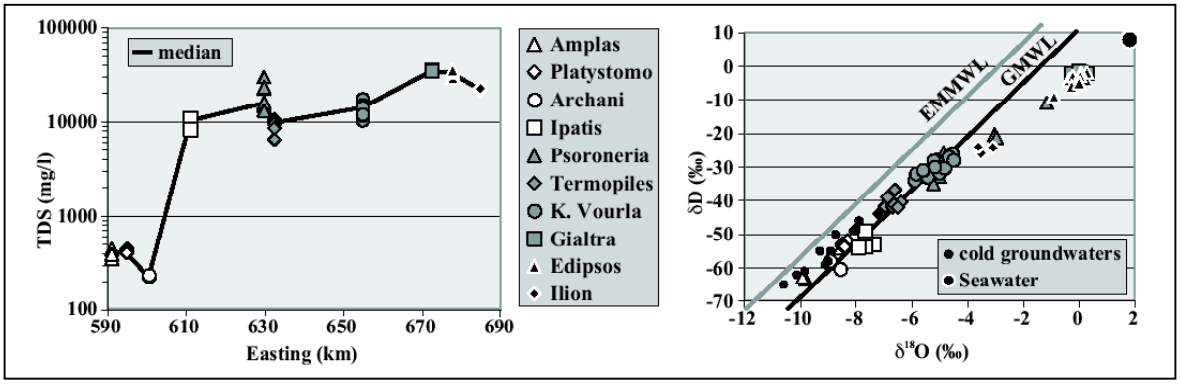

Fig. 2: West-east variations of the TDS of the thermal waters collected along the “Sperchios Basin – Evoikos gulf” graben (left) and isotopic composition of the waters (right). GMWL = global meteoric water line; EMMWL = Eastern Mediterranean meteoric water line.

Most of the water compositions in the triangular graph of Giggenbach fall in the field of the non equilibrated waters being therefore unsuitable for geothermometric estimations. Only the easternmost sites (Gialtra, Ilion and Edipsos) falling the field of the partially equilibrated waters yield estimated temperatures in the range 150-170 °C. Silica geothermometers confirm these estimations.

This study revealed that the complex geodynamic setting of the area is clearly reflected in the wide compositional range of the gases collected in the area that evidence contributions from different end-members (atmosphere, crust, mantle and hydrothermal systems). Water chemistry can be explained mainly from the mixing of a meteoric low-salinity end-member with a high-salinity marine end-member partially modified by hydrothermal water-rock interactions. The highest estimated temperatures in the hydrothermal reservoirs are in the range 150-170 °C.