

Geochemistry of groundwater from Graciosa Island (Azores): A contribution to the hydrothermal system conceptual model

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Graciosa island is located in the Azores Archipelago, along the so-called Terceira Rift, a major tectonic structure that makes the NE boundary of the Azores Plateau. In general terms, it includes a basaltic platform on the NW and a silicic poligenetic volcano with caldera on the SE, the Graciosa Caldera Volcano. This volcano has produced significant tephra falls, pyroclastic flows, lahars, and lava flows, both of basaltic s.l. and trachitic s.l. composition.

The hydrothermal system shows fumarolic emissions inside the volcano caldera and thermal springs located along the shoreline. This system is exploited in a thermal building through shallow and deep (110 m) boreholes, near the coast.

In Graciosa two types of Na-Cl groundwater systems can be identified: 1) a cold one emerging at springs and exploited by wells for public water supply, and 2) a hydrothermal system with temperatures around 40-44 °C. The cold groundwaters have pH higher than 7 and different degree of mineralization, according to the proximity to the sea. The thermal waters show mixing with seawater, pH varying between 6.20 and 6.94, 166 mg/L of SiO₂, and significant concentration of metals, such as Mn, Fe, Co, Ni, Cu and Zn. The thermal water mineralization varies strongly, showing EC from 8.87 mS/cm (shallow water) to 47.4 mS/cm (deeper water). The higher mineralized water is rich in CO₂(g), with 2130 mg/L of total dissolved CO₂. Geothermometers application reveals aquifer temperature ≈ 167 °C and immature/mixed waters, not reaching complete equilibrium with reservoir rock.

The geochemistry of the thermal waters indicates the occurrence of seawater/host rock interaction processes at high temperature and slightly acid conditions, favored by CO₂(g) input, and a different degrees of mixing with cold and shallow groundwaters.

Geochemistry of S-type granitic rocks from the Valongo area (Northern Portugal)

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Variscan peraluminous granitic rocks crop out at the eastern limb of the Valongo anticline, located about 18 km east of Oporto, in the Dúrico - Beirão region, northern Portugal and Central Iberian Zone of the Iberian Massif.

The medium- to coarse-grained porphyritic biotite>muscovite granite (G1) intruded Ordovician and Silurian metasediments and produced a contact metamorphic aureole. The medium-grained porphyritic biotite ≈ muscovite granodiorite (G2) intruded the earlier granite and the contact is by faulting. The fine-grained porphyritic biotite>muscovite granodiorite (G3) intruded the other two granitic rocks. Granite G1 and granodiorite G2 are late-D3, whereas granodiorite G3 is post-D3. The U-Pb ages for zircon and monazite, obtained by ID-TIMS, are 309.6±1.0 Ma for G1, 307.0 ± 3.2 Ma for G2 and 305.1± 0.4 Ma for G3 and 587 Ma for inherited zircon cores from G2 and G3. Variation diagrams show that G3 has higher TiO₂, total FeO, MgO, CaO, Zr, Ba, Th, Ce contents and lower SiO₂, Li, Rb contents than G1 and they define independent trends. G2 is not related to G1. Granite G1 and granodiorite G3 have similar (⁸⁷Sr/⁸⁶Sr)_i of 0.7085, εNd_T -6.64 (G1) and -6.92 (G3) and δ¹⁸O 11.36 ‰ (G1) and 10.90 ‰ (G3). Therefore, they are derived by partial melting of the same metasedimentary materials, containing Neoproterozoic detritus, but G3 results from a higher degree of partial melting than G1. Granodiorite G2 results from a distinct granitic magma and is derived by partial melting of metasedimentary materials containing Neoproterozoic detritus, as it has (⁸⁷Sr/⁸⁶Sr)₃₀₇ of 0.7080, εNd₃₀₇ of -7.06 and δ¹⁸O of 11.31 ‰. The three granitic rocks are of S-type.