



## **Hydrothermal fluids vented at shallow depths at the Aeolian islands: relationships with volcanic and geothermal systems.**

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Scuba diving investigations carried out over the last two decades at the Aeolian islands revealed the existence of submarine magmatic and late-magmatic hydrothermalism at all the islands, despite the absence of on-shore activity at some of the islands.

The results gained by diving activities provided useful information to evaluate the volcanic and geothermal activity and to manage the volcanic crisis occurred on November 2002 off the island of Panarea. Scuba diving investigations carried out from middle 80's, had shown that despite the absence of on shore volcanic manifestations, submarine hydrothermal activity is recognizable at shallow depth around all the Aeolian islands related either to volcanic and geothermal activity.

The sampled gases are CO<sub>2</sub>-dominated with low amounts of oxygen and reactive gases (H<sub>2</sub>, CO, CH<sub>4</sub> and H<sub>2</sub>S) with concentrations ranging from a few ppm to some mole percent. Sometimes significant N<sub>2</sub> amount are detectable together with high helium contents. Samples having low CO<sub>2</sub> content, besides relevant N<sub>2</sub> and He amounts, are the consequence of CO<sub>2</sub> dissolution in sea-water due to gas-water interactions (GWI) occurred before the sample collection.

The high CO<sub>2</sub> solubility (878 ml/l, T=20°C, P=1bar) may, in fact, decrease the CO<sub>2</sub> content in the venting gases thus increasing the concentrations of the less soluble species (e.g. He 8 ml/l, CO 23 ml/l and CH<sub>4</sub> 33.8 ml/l) in the gas mixture. Such a process might occur at any level, however, because of the slow water circulation in deep sediments, CO<sub>2</sub> is able to saturate the circulating sea-water.

The isotopic composition of carbon displays a small range of values while helium isotopes are in the range of 4.1<math>R\_{ac}</math>7. Despite the gases come from both active and extinct Volcanoes, their chemical composition is similar. Contrastingly the isotope composition of helium shows a large heterogeneity with the highest isotopic ratios surprisingly measured at the extinct volcanic islands in the western sector, and much lower values detected in venting gases from active volcanoes (e.g. Vulcano and Panarea).

The explanation of such a difference is not related to the volcanic activity at all, but to the parent mantle that in the western side looks to be less contaminated compared to the eastern side. Crustal contamination has been invoked by several authors as the main factor that caused the dramatic 3He/4He decrease. Although the parent mantle produced magmas with different isotopic signature, the gas phase looks similar. To explain the results of the chemical analyses it is proposed that similar deep boundary conditions (pressure, temperature, oxidation level) act as buffers for the chemical composition of the venting gases. With the aim of investigating their origin, estimations of the deep equilibration conditions have been carried out.

The reactive compounds detected in the sampled gases, largely used for geothermometric and geobarometric considerations of hydrothermal fluids were used in a system based on the CH<sub>4</sub>-CO-CO<sub>2</sub> contents assuming the presence of a boiling aqueous solution. The equilibrium constants of the adopted reactions are a function of temperature and oxygen fugacity, being the latter buffered by the mineral assemblage of the host rocks. Due to the similarity in the chemical composition of the gases vented at all the islands, a theoretical model developed to interpret the chemical composition of the gases released at Panarea during the last volcanic crisis is here applied. The results have shown that geothermal boiling systems are detectable at all the islands with temperatures up to 350°C. The adopted geo-thermobarometric system is more sensitive to the contents of CO and CH<sub>4</sub> than that of CO<sub>2</sub>, implying that although GWI induce modifications in the chemical composition, the estimated equilibrium temperatures do not change very much for variations of the CO<sub>2</sub> content in the range of several volume percent, thus, whether or not the gaseous mixture underwent GWI. Moreover, the slow reaction kinetics of CO and CH<sub>4</sub>

allow them to keep the deep equilibrium conditions during uprising and the similar solubility does not alter their abundance ratios.