

Origin of methane within a subduction related high-temperature hydrothermal system and its role in risk evaluation

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Introduction

The origin of methane within subduction related high-temperature hydrothermal systems (abiogenic vs thermogenic) and its role in risk evaluation is still a matter of debate. In order to address these questions we present a combined approach where fumarolic gas discharges from Nisyros volcano, Greece, are both investigated for their chemical and isotopic composition.

Discussion of results

With varying relative amounts of CH₄ and CO₂ carbon isotopic composition of both gases stays constant implying an origin from a single source. Apparent temperatures derived from carbon isotope partitioning between CH₄ and CO₂ are around 350°C and correlate well with temperatures measured directly for a deep aquifer (330-340°C, as known from two geothermal drillings). Apparent temperatures inferred from compositional data using the H₂O - H₂-CO₂-CO-CH₄-geothermometer (Chiodini & Marini, 1998) show a much larger spread, but highest temperatures again coincide with measured deep aquifer temperatures. Molar ratios of CO₂, CH₄, H₂ and H₂O at fumarolic outlet are in agreement with formation after Fischer-Tropsch CO₂ + 4H₂ = CH₄ + 2H₂O in the liquid phase, followed by adiabatic boiling and local quenching of the liquid into the vapor phase.

Conclusions

A pure inorganic reaction seems to be responsible for CH₄-formation within the high-temperature hydrothermal system of Nisyros. CO₂ and CH₄ within the deep aquifer are initially in chemical and isotopic equilibrium. Local discrepancies between the chemical and isotopic composition observed at fumarolic outlet are caused by secondary re-equilibration phenomena, such as reaction of CO to CO₂ during the ascent of the gases. These do not affect carbon isotope partitioning between CO₂ and CH₄. Since rates of isotopic exchange between dissolved CO₂ and CH₄ are unknown, the role of the carbon isotope geothermometer in monitoring volcanic-hydrothermal activity remains speculative.

References

Chiodini, G. & Marini, L. (1998) *Geochim. Cosmochim. Acta* 62, 2673-2687.

Distribution of ²³⁰Th and ²³¹Pa off SW-Africa

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The North Atlantic is one of the key areas for the formation of newly formed deep water masses (e.g. North Atlantic Deep Water (NADW)) which ventilate the world ocean basins. Changes of the formation rates are believed to influence the world climate significantly. Therefore one of the key issues in paleoceanography is the investigation of changes in the production rate of NADW in the geological past. Based on ratios of the natural radioisotopes ²³⁰Th (T_{1/2} = 75.2 ky) and ²³¹Pa (T_{1/2} = 32.2 ky) preserved in the sediments it was proposed that NADW formation rates did not change during the last glacial maximum compared to recent times. This suggestion was based on a mass balance of ²³⁰Th and ²³¹Pa for the Atlantic Ocean. Since these radioisotopes are particle reactive, areas with high particle flux, e. g. the upwelling area off SW Africa, may have an important effect on this balance.

During Meteor cruises M48/4 (2000) we investigated the distribution of ²³⁰Th and ²³¹Pa in the water column and surface sediments in the Angola and Kap basins. At 11 locations covering near shore sites as well as the open ocean, surface sediments as well as water samples (total and particulate) were obtained in up to 10 depth levels. In the Angola basin a gradual increase of ²³⁰Th concentrations with depth was observed comparable to the ²³⁰Th water-column distribution in most ocean basins. In general, concentration-depth gradients are similar in the Angola and in the Kap basins; but at the near-shore sites in the Kap basin ²³⁰Th concentrations were reduced indicating a boundary scavenging effect which is probably related to high particle flux caused by the upwelling environment off the Namibian coast. In the western Kap basin a drastic increase in ²³⁰Th concentrations of up to a factor 3 was observed in the Antarctic Bottom Water which fills the Kap basin in > 4000m water depth. It is proposed that these ²³⁰Th enriched water masses were advected from areas like the Weddell Sea where export of ²³⁰Th enriched water masses was previously observed. Both water masses and boundary scavenging control ²³⁰Th/²³¹Pa ratios preserved in the surface sediments in the area investigated. The upwelling area off Namibia seems to be an unimportant sink for ²³⁰Th and ²³¹Pa.