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Nitrogen and Argon in Volcanic and Geothermal Fluids. Constraints on the Output from Subduction Zones

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Nitrogen, argon and other air components are inevitably recycled from the subducted oceanic lithosphere to the surface by magmatism and accompanying volcanic and hydrothermal activity. A part of N and Ar are of the "old" atmosphere origin, and a significant fraction of N can be derived from the subducted organic-rich sediments, appearing as "excess nitrogen" in volcanic and geothermal gases. However, excess nitrogen can be released also from the continental sedimentary organics or metamorphic rocks, with the same isotopic characteristics (δ^{15}N $\geq$ +5‰) and the same high N_2/Ar ratio in the gas discharge. On the other hand, gas with the N_2/Ar ratio close to the ASW (air-saturated water) values (40-80), δ^{15}N $\sim$ 0 and ^{40}Ar/^{36}Ar $\sim$ 296 can be released also from the altered basalts of the subducted oceanic plate, poor in pelagic sediments. A complex interplay between δ^{15}N, ^{40}Ar/^{36}Ar, N_2/Ar and absolute concentration of N_2 in a surface thermal manifestation has different issues for the volcanic and geothermal vents within different subduction zones. The excess nitrogen in volcanic fumaroles as a rule has a deep origin and, if exists, correlates well with fraction of magmatic water; whereas, the excess nitrogen in "meteoric-hydrothermal" systems as a rule has crustal origin and correlates positively with the methane content.

Volatile outputs from volcanoes and geothermal systems of a subduction zone are comparable. ($3.1 \cdot 10^{10}$ mol/a of CO_2 by volcanoes vs $2.3 \cdot 10^{10}$ mol/a by geothermal systems in Kamchatka). However, direct estimations of the gas discharge from a bubbling thermal spring sometimes impossible. A simple method based on the phase equilibrium is designed for the calculation of the total gas content exclusively from the gas analysis. The same approach helps to constrain ranges of absolute concentrations of N_2 and Ar in a free gas phase of thermal ASW with an external source of CO2. The method is applied to the estimation of the “net” output of subducted nitrogen and argon from the Kamchatka-Kuriles volcanic arc