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Hydrothermal mercury inputs from the Kolumbo Submarine Volcano

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Mercury (Hg) is a pervasive environmental pollutant with neurotoxic effects, accumulating in marine food webs and posing risks to marine life and humans. Its contribution from submarine volcanoes, particularly through hydrothermal emissions, is poorly understood and likely underestimated. Kolumbo submarine volcano, with its constraining geometry, located northeast of Santorini in the Aegean Sea at a depth of 500 m, provides a unique setting for studying Hg cycling in hydrothermal systems.

Our research during four oceanographic cruises from September 2013 to October 2023 (SANTORY project) aims to understand Hg concentrations, distribution, and dynamics across vent fluids, plumes, and the water column. In Kolumbo, distinct water layers clarify Hg dynamics: the seawater up to 200 m depth reflects typical Eastern Mediterranean characteristics with tHg at 1.7 ± 0.15 pM(n =25) and MeHg at 0.15 ± 0.04 pM (n =24). The crater water from 200 to 500 m, isolated from external influences, shows tHg levels between 600 to 10,000 pM due to trapped hydrothermal emissions. Contrary to the expected anoxic conditions typical of the Eastern Mediterranean, the oxygenated waters within Kolumbo's crater indicate a water turnover mechanism, influencing mercury speciation and biogeochemical interactions. Fluids from the vents exhibit exceptionally high Hg levels, with tHg reaching up to 200,000 pM and MeHg at 1.2 pM, surpassing other studies (German et al., 2016). We utilized temperature increases monitored by the SANTORY underwater observatory after a convection event to quantify hydrothermal inputs more accurately, estimating Kolumbo’s hydrothermal Hg input at 33.3 ± 7.6 kg/year—high compared to other shallow vent systems. Metagenomic analysis identified abundant mercury resistance genes in microbial mats on active vent chimneys. The degassing of CO2-dominated gases with 3He/4He as high as 7 Ra (Rizzo et al., 2019), confirm strong mantle influences correlating with the high Hg levels, providing additional proof for the stratification in the water column. This study not only challenges existing models of marine Hg sources but also underscores the urgent need for enhanced monitoring and regulation to mitigate potential local food chain contamination risks.

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