

GEOCHEMISTRY OF RARE ELEMENTS IN RECENT METALLIFEROUS GAS-AND-VAPOR SYSTEMS

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A gas-and-vapor metalliferous system of Kudryavyi, Kurile Islands, is anomalous in temperature. Sublimates of rare metal (Re, In, Ge, Mo, and Bi) sulfides are formed at fumaroles as a result of gas-rock interaction. Our in situ experiments using natural and synthetic scavengers (zeolites, activated coal, Al_2O_3) revealed the formational constraints on the sublimates and their metal loading. The metal discharge rate is quantified. Chloride and carbonyl clusters similar to crystalline sulfides and carrying 2 or 3 metal atoms are the major metal species transported by the gas flow. The metal yield of the Kudryavyi's gas flow is estimated (t/yr): 1—10 Ag, Au, 20—50 Re, In, Ge, Bi, and 100 Cd and Mo. At 350—700 °C deposition of sublimates depends solely on temperature. The formation temperatures for sulfides are (°C): 600—700 Mo, Ge, 400—600 Re, 300—500 Cd, In, and 350 Bi. Morphology of sulfides deposited from the gases onto scavengers is established. Kinetic constraints on the sublimate formation are defined. These are the temperature gradient at the crystallization surface, the gas flow rate, and density of the active centers on the surface. Natural zeolites are the fastest scavengers: the anion active centers are densely packed and well-ordered here. At 350 °C, formation of sulfides is additionally controlled by $f\text{O}_2$; Re is transported as oxides (e.g., Re_2O_7); hence its dispersal in the environment. A model of the vertical geochemical zoning of the volcanic-hydrothermal sequence is developed, along with the extraction method for Re (10 t/yr) and other metals.