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Geochemistry of volcanic and hydrothermal gases of Mutnovsky volcano, Kamchatka: Evidence for mantle, slab and atmosphere contributions to fluids of a typical arc volcano

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We report chemical compositions (major and trace components including light hydrocarbons), hydrogen, oxygen, helium and nitrogen isotope ratios of volcanic and geothermal gases of Mutnovsky volcano, Kamchatka. Several aspects of the geochemistry of fluids are discussed: chemical equilibria, mixing of fluids from different sources, evaluation of the parent magmatic gas composition and contributions to magmatic vapors of fluids from different reservoirs of the Kamchatkan subduction zone. Among reactive species, hydrogen and carbon monoxide in volcanic vapors are chemically equilibrated at temperatures > 300°C with the SO2-H2S redox-pair. A metastable equilibrium between saturated and unsaturated light hydrocarbons is attained at close to discharge temperatures. Methane is disequilibrated. Three different sources of fluids from three fumarolic fields in the Mutnovsky craters can be distinguished: (1) magmatic gas from a large convecting magma body discharging through Active Funnel, a young crater with the hottest fumaroles (up to 620°C) contributing $\sim$ 80% to the total volcanic gas output; (2) volcanic fluid from a separate shallow magma body beneath the Bottom Field of the main crater (96-280°C fumaroles); and (3) hydrothermal fluid with a high relative and absolute concentrations of CH4 from the Upper Field in the main crater (96-285°C fumaroles). The composition of the parent magmatic gas is estimated using water isotopes and correlations between He and other components in the Active Funnel gases. The He-Ar-N2 systematics of volcanic and hydrothermal fluids of Mutnovsky are consistent with a large slab-derived sedimentary nitrogen input for the nitrogen inventory, and we calculate that only $\sim$ 1% of the magmatic N2 has a mantle origin and «1% is derived from the arc crust.