

Global volcanic emissions of SO₂, halogens and trace metals, 1998 - 2005

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We have quantified annualised global volcanic emission rates based on a compilation of measurements at 60 active volcanoes, for the years 1998 – 2005. The global mean emission rate is 16 Tg SO₂/yr, of which 9 Tg/yr (56%) is emitted by non-explosive activity. Corresponding mean annualised halogen emissions are ca. 4 Tg HCl/yr; 0.3 Tg HF/yr and 0.6 Tg HBr/yr.

There is, as expected, a large interannual variability, with measured global volcanogenic SO₂ emissions varying between 13.3 Tg/yr in 1998 to 21.3 Tg/yr in 2000; most of this variability was due to sustained emissions from two persistently degassing volcanoes (Popocatepetl and Miyakejima). There were no major explosive eruptive sources (no eruptions of VEI 5 or larger; 1 eruption of VEI 4) during this period. Extrapolation to account for the un-measured emissions at a further 58 active volcanoes may extend the annual average SO₂ emission rate to ca. 20 Tg SO₂/yr for the period 1998-2005.

Using this global volcanic sulphur emissions inventory as a basis, and combined with appropriate field measurements, we can now extend the analysis to make well constrained projections of the fluxes of other important volatiles (H₂O, CO₂); volcanic nano-particles, and volatile trace metals (e.g. Hg) to the troposphere, and thereby evaluate the importance of persistent volcanic degassing to global geochemical budgets. Considerable uncertainty remains over the trace gas and trace metal emissions to the stratosphere associated with explosive volcanic eruptions, due to a lack of appropriate measurements.

Geochemistry and genesis of the Qibaoshan gold-copper deposit in Shandong Province, eastern China

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The Qibaoshan is a medium-sized Cu-Au deposit located in a caldera near the east of Yishu deep fault zone. This deposit consists of two parts, the upper part is a gold-containing breccia pipe, and the lower part is a copper-bearing stockwork.

The caldera covers an area of 10-12 km² and rocks around it are distributed in ring shape. The inner ring consists of subvolcanics, such as pyroxene monzonite, quartz monzonite porphyry, and trachyandesite porphyry; the outer ring comprises predominantly of trachyte, trachyandesite and minor rhyolite. In southeast of the central intrusive body, there is a cryptoexplosive breccia pipe which develops gold and copper mineralization.

Mineral association of this deposit displays a clear vertical zoning, i. e., from 0 to -20 m, the dominant mineral is gold-bearing specularite; main minerals are commonly specularite, manganosiderite, quartz and minor amounts of pyrite and chalcocopyrite from -20 to -70 m; and pyrite and chalcocopyrite from -70 to -120 m. Wall-rock alteration is widespread in the ore district. Main alteration types are phyllic alteration, silicification and carbonatization, and in the deep part of the pipe there also develops potassic alteration.

Fluid inclusion studies show that the homogenization temperatures range predominantly from 250°C to 350°C. The estimated salinities of ore-forming fluids vary between 10.6 and 32.6 wt% equiv. NaCl. The main compositions of ore-forming solutions are characterized by enriched in Ca²⁺, Na⁺, Cl⁻ and depleted in Mg²⁺, K⁺, F⁻. The F⁻/Cl⁻ ratios of hydrothermal fluids increased obviously from the main mineralization stage to late mineralization stage, indicating that the ore materials were transported predominantly as chloride complexes.

The δ¹⁸O_{H₂O} values of ore-forming fluids during main mineralization stage range from 3.05‰ to 5.77‰, and δD_{H₂O} from -78.6‰ to -48.1‰. In late mineralization stage, the δ¹⁸O_{H₂O} and δD_{H₂O} values are -7.77‰ and -73.4‰ respectively, indicating a major meteoric water component. The δ³⁴S values of sulfides vary between 0.30‰ and 3.59‰, with a δ³⁴S_{SS} value of 2.80‰. Overall, the H, O and S isotopic data suggest that the ore-forming fluids and materials might be originated mainly from magmatic source.

This study was financially supported by the National 973 Project of the Chinese Ministry of Science and Technology (grant no. 2006CB403508) and the Natural Science Foundation of China (grant no. 40221301).