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Sulphide globules and their impact on sulphur degassing budget: the case of Grímsvötn volcano, Iceland.

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Volcanic eruptions are known to contribute sulphur to the atmosphere. Two different methods allow estimation of sulphur mass loading: remote satellite measurements and the petrologic method. Sulphur emission at subduction-related volcanoes is often underestimated by the latter method relative to the former whereas a fair agreement is found for hot spot-related volcanoes. The Grímsvötn 2011 eruption allows further comparison between these two methods.

Grímsvötn is a basaltic subglacial volcano located under the Vatnajökull ice cap, above the Iceland mantle plume and the Mid-Atlantic Ridge. The May 2011 eruption lasted one week and took place inside the composite caldera of the volcano. During the first 24 hours, the column reached a height of more than 20 km and bulk of the magma was emitted. The basaltic tephra has quartz-normative tholeiite composition with 1-5% plagioclase, clinopyroxene, olivine, FeTi-oxide crystals and, noteworthy, sulphide globules present in the groundmass glass.

Sulphur concentrations of twenty eight melt inclusions (MIs) were measured in plagioclase, clinopyroxene and olivine crystals extracted from the tephra produced during the most explosive phase. The difference between the mean sulphur content of both MIs and groundmass glass multiplied by the magma mass erupted, yields 0.73 $\pm$ 0.18 Tg of liberated sulphur. This is four times the estimated sulphur degassing by satellite measurements (0.19 $\pm$ 0.06 Tg).

The contributions of different sulphur sinks were quantified. The geothermal system harvests approximately 0.037 Tg (5%), which are liberated during jökulhlaups. Sulphur adhering to the volcanic ash is approximately 0.12 Tg (15%). Added to the satellite measurements of sulphur entering the stratosphere, half of the S estimated by the petrologic method is still missing.

Sulphur immiscibility forming sulphur globules in the magma chambers appears the most probable explanation for the missing 50% of sulphur. Due to elevated density of sulphide globules, they preferentially separate from the magmatic liquid at depth.

This study clearly shows that estimations of S emissions in low fO_2 basalts from older eruptions must take into account the potential sulphide immiscibility and, consequently, the storage of sulphur at depth.