Crustal recycling of nitrogen to the atmosphere: Preliminary melt inclusion results

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The crust represents a major reservoir for nitrogen, and models that seek to describe the global nitrogen cycle include crustal processes such as sedimentation, biological fixation, and continental weathering. However, little is known about the recycling of crustal nitrogen back to the atmosphere through volcanism. This study presents preliminary results on calibrating Secondary Ion Mass Spectrometry (SIMS) for nitrogen, as well as initial analyses of nitrogen contents in quartz-hosted melt inclusions from large rhyolitic eruptions.

While SIMS is rarely used for nitrogen analyses in geological studies, it is routinely utilized in the semiconductor industry. We calibrated the nitrogen ion yield (as Relative Sensitivity Factors, RSF) in various geologic matrices, including natural and synthesized glasses, as well as minerals. These RSFs were determined through depth profiles of nitrogen-implanted samples of rhyolite, basalt, and other phases testing a variety of instrumental parameters. In general, the analyses detecting N^+ using primary O_2^- beams show higher sensitivity than with O^-, with the decrease in sensitivity being more pronounced in relatively oxygen-poor matrices. The detection of CN^- with a positive Cs^+ primary ion beam, while requiring a high mass resolution power of ~6500, yields higher signals than N^+, if sufficient carbon is in the sample. These implanted samples are allowing us to develop a variety of standard materials containing known H, C, and N contents.

Preliminary results of Bishop Tuff quartz-hosted melt inclusions show variability with formation units, but yield a pre-eruptive maximum concentration of nitrogen near 300 ppm. Other large eruptions show pre-eruptive nitrogen contents around 10x lower. Due to the large volume of these eruptions, they can have a significant impact on the atmospheric nitrogen content on short time scales, relative to weathering and sedimentation.