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Water content, speciation and isotopic composition in volcanic glass: an open window on magma degassing processes or paleoclimate?

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The content, speciation and isotopic composition of water in volcanic glass have been used for decades as recorder of magma degassing or late glass rehydration processes. Magmatic or paleoclimate information are derived depending on the primary (magmatic) or meteoric (secondary) origin of water. In this study, we attempt to discriminate residual magmatic from secondary meteoric water in volcanic glass. Using samples from different geological settings and different climatic conditions, we show that the H-isotope composition and water content measured via a TC/EA–MAT253 system in volcanic glass alone are not always sufficient to provide clear distinction between magmatic and meteoric origin. However, it is quite easy to resolve δD evolution during post-deposit rehydration by meteoric water from magma degassing when volcanic glass have a δD <-100‰ or >-50‰ and [H_2O]tot >1.5-2wt.%. Water speciation inferred from near-infrared spectroscopy also provides valuable information complementary to isotopic and total water measurements. During magma degassing (typically with [H_2O]tot decreasing from 6wt.% to ~0wt.% water) H_2O/OH is expected to decrease from 2 to close to 0. However, our dataset shows the opposite trend with an increase of H_2O/OH from 2 to ~5. We interpret it as post deposit rehydration of the volcanic glass.

Overall our results show that the discrimination of the water origin is essential to discuss magma degassing processes or paleoclimatic reconstitutions. The present study of hydrous glass supports the use of H-isotopes of volcanic glass to discuss paleoclimate reconstitution in a specific region. To this purpose, the volcanic glass has to be almost fully rehydrated in order to fingerprint the isotopic composition of the rehydration water. A sharp time constrain can be obtained if the full rehydration occurs quickly after the eruption. This is most likely to occur in meters thick volcanic pyroclast deposits that undergo slow cooling rates and thus can stay at few hundreds °C for a time long enough to ensure complete chemical reaction (few to hundreds of years) after the eruption but still short on a geological scale.