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# Impact-induced extreme Cl isotopic fractionation and volatile loss: Insights from Chang'e-5 glass beads

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The Moon shows the largest range of $\delta^{37}Cl$ (-4‰ to +81‰) in the solar system, in contrast to ~0‰ of bulk Earth. This large range is widely believed to be related to the loss of chlorine during the formation and evolution of the Moon. The lunar chlorine isotopic system can help to understand the mechanisms of volatile loss during planetary processes. In this study, we used CAMECA NanoSIMS 50L to analyze F and Cl contents, as well as $\delta^{37}Cl$ values of the impact glass beads from Chang'e-5 (CE5) samples. These glass beads can be divided into two groups: homogeneous and heterogeneous ones according to the morphological features with back-scatter electron images. The homogeneous glass beads have lower F and Cl contents but higher $\delta^{37}Cl$ compared to the heterogeneous glass beads. The relationships between F and Cl contents behave differently in homogeneous and heterogeneous glass beads. The glass beads also have the largest $\delta^{37}Cl$ variation observed to date, from -0.7 ‰ to +119 ‰. The $\delta^{37}Cl$ was roughly negatively correlated with the Cl abundance. We further calculated the fractionation of different chlorides (e.g., HCl, NaCl, KCl, $FeCl_2$, and $ZnCl_2$) during degassing and condensation processes. The comparison of analytical results and calculated data implies that HCl and NaCl degassing during impact events may be the primary Cl isotopic fractionation mechanism to elevate $\delta^{37}Cl$ values in glass beads, and more than 50% of Cl has been lost during these processes. Furthermore, the formation of these glass beads may have incorporated the previous condensates. These findings can contribute to constrain the impact-induced degassing of volatiles on airless celestial bodies.