Evaluation of acid leaching methods for high precision meteorite Pb-Pb chronology

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The U-Pb system offers high-precision chronometer for early solar and earth systems because of having two decay chains. Pyroxenes are common in ancient mafic rocks including meteorites and ideal targets for high-precision Pb-Pb chronology because of its high U/initial Pb. Yet, their low U abundances require collection of many grains for single Pb isotopic analysis and efficient removal of contaminated non-radiogenic Pb components. While multi-step acid leaching procedures using various acids have been extensively utilized for effective removal of non-radiogenic Pb, the detailed mechanism of the acid leaching has not been investigated. Recently, moreover, it has been shown that acid leachates and residues yielded scattered Pb isotopic data when using highly reactive acids such as HF, leading some to argue that measurable Pb isotopic fractionation occurred during the acid leaching. If this is the case, then acid leaching results in inaccurate and imprecise Pb-Pb dating. Here we have conducted textural observation of acid leached samples and chemical analysis for acid leachates and residues to understand the elution process of non-radiogenic Pb components and to evaluate whether acid leaching caused Pb isotopic fractionation.
Our results revealed the following pictures as to elution of non-radiogenic Pb components; (i) weak acids (0.5 M HNO_3) remove the most of non-radiogenic Pb components hosted by metal/sulfides, together with radiogenic Pb component hosted by phosphates, (ii) leaching with more intense acid (6 M HNO_3 and HCl) results in removal of non-radiogenic Pb by dissolution of anorthitic plagioclase, whereas albitic plagioclase cannot dissolved by this step, (iii) leaching with diluted HF can dissolve albitic plagioclase enriched in non-ragiogenic Pb and pyroxenes enriched in radiogenic Pb. The detailed observation further revealed that exsolution lamellae in pyroxenes dissolved heterogeneously at HF attack: high-Ca lamellae were preferentially dissolved relative to low-Ca lamellae. Combining these observations with the results of modeling of Pb isotope evolution in each lamellae, we indicate that preferential dissolution of pyroxene lamellae gives an explanation for scattered Pb isotopic data found in previous work that was considered as evidence for Pb isotopic fractionation during acid leaching.

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