Pb isotope fractionation during evaporation

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Pb isotopes are an important tracer widely used in many fields including cosmochemistry and archaeology. During processes of the solar nebula evolution and the bronze-making, Pb has been subjected to evaporation and/or condensation. Here we report the results of experimental study on Pb isotope fractionation during evaporation.

Analytical gade Pb metal was sealed inside quartz glass tube after vaccummcation. The sealed tubes were inserted partly into furnaces heated to 650°C. The Pb vapor condensed at the cold ends of the tubes. 10 experiments were run with duration ranging from 2 to 135 minutes and the degree of evaporation from 9 to 83%. Both Pb residues and condensations were totally collected

Pb isotopes were measured on a Nu Plasma HR MC-ICPMS using Tl doping method. The Tl isotope ratio used for instrumental mass discremination correction standard reference material NBS 982, and the instrument working conding was callibrated using NBS 981.

For all experimental runs, the Pb isotope compositions in condensates are systimaticlly lighter than the original Pb, whereas the residues heavier. Overall, they are mass ballanced, and the differences between condensates and residues are constant and follow mass fractionation law. The averaged mass fractionations between the residues and condensates are 2.8, 5.8, 5.8, 11.5 ε units for $^{207}Pb/^{206}Pb$, $^{208}Pb/^{206}Pb$, $^{206}Pb/^{204}Pb$, $^{208}Pb/^{204}Pb$, respectively. These results defined a mass fractionation factor $\alpha_{res\text{-}conden} = 1.0003$ per amu for Pb isotope at ca. 650°C.

The results demonstrate that significant mass fractionation occurs during Pb evaporation. It should be emphsysed that these results are obtained in close system. The mass fractionation could be much larger in open systems. Therefore, the effects of mass fractionation during evaporation/condensation must be considered when Pb isotopes are used to addtress issues such as the sources of Pb used in bronze, and processes occurred during early Solar System evolution.

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