Revisiting I-Xe systematics, an early solar system chronometer

M. OZIMA[1], Y. N. MIURA[2], AND F. A. PODOSEK[3]

[1] Department of Earth and Planetary Science, University of Tokyo, Tokyo 113-0033, Japan (EZZ03651@nifty.ne.jp)
[2] ERI, University of Tokyo, Tokyo 113-0032, Japan
[3] Washington University, St. Louis, MO 63130-4899, USA

Xe, and other chronometers based upon short-lived activities, can provide valuable information about early solar system chronology. The objective of this paper is to reexamine I-Xe systematics concentrating on the composition that is implied for trapped Xe in meteorites. We show that the latter information is very useful in understanding elemental fractionation in proto-solar nebula, and also bears far-reaching implications on the age of the Earth.

Several workers have noted that there exists a negative correlation between the initial $^{129}I/^{127}I$ ratio and the $^{129}Xe/^{132}Xe$ ratio in a trapped Xe component in chondrules – hereafter called an I – R plot (Initial – Ratio) (e.g.,1, 2). Swindle et al. (2) interpreted that this negative trend was due to the decay of extinct nuclide ^{129}I in pre-chondrule environment. Swindle (3) further pointed out that if the pre-chondritic environment were of a closed system, the negative trend should be a straight line with a slope corresponding to I/Xe ratio in the pre-chondrule environment. Although the negative trend is apparent in Chainpur chondrules (2) and also supported by new Xe isotopic data on dark inclusions in Allende meteorite (4), the observed slope matches neither the solar I/Xe ratio nor values commonly observed in meteorites. We show that the characteristic features of Xe isotopic data seen in an I - R plot are consistently explained by assuming that Xe has been fractionated from I in the solar nebula that was dissipating exponentially with time

From the model, we also infer that the primordial $^{129}I/^{127}I$ and $^{129}Xe/^{132}Xe$ ratios are considerably smaller than the values deduced from meteorites, although the estimation of the primordial ratios involves large uncertainties. We note that some chondrules have the $^{129}Xe/^{132}Xe$ ratio of a trapped Xe as low as 0.9, well below the solar Xe ratio and even the least radiogenic $^{129}Xe/^{132}Xe$ ratio (Novo Urei meteorite). The new data on Allende dark inclusions (4) also support this smaller primordial $^{129}Xe/^{132}Xe$ ratio. If the primordial $^{129}Xe/^{132}Xe$ ratio were indeed as small as 0.9, this bears far reaching implications on early solar chronology. For example, the currently estimated value of the initial $^{129}I/^{127}I$ isotopic ratio of about 10^{-6} in the Earth (5) would become larger, and reduce the puzzling gap in an initial $^{129}I/^{127}I$ ratio (about 10^{-4} in meteorites) or in a formation age interval between the Earth and meteorites.

References

(1) Podosek F.A. (1970) G.C.A. 34, 341-365.
(2) Swindle T.D. et al. (1991) G.C.A. 55, 861-880.
(3) Swindle T.D. (1998) Met. Planet. Sci. 33, 1147-1155. (4) Hohenberg C.M and Pravdivtseva O. (personal. com.).
(5) Ozima M. and Podosek F.A. (1999) JGR 104, 25,493-9.