Isotopic evidence of the double beta decay of 100Mo

Hiroshi Hidaka[1]

[1] Earth and Planet. Sys. Sci., Hiroshima Univ.

http://www.geol.sci.hiroshima-u.ac.jp/~geochem/geochem.html

Double beta decay (DBD) is one of the rarest nuclear reactions in nature, and the half-life ranges from 10^17 to 10^24 yr. There are mainly two methods for the detection of DBD phenomenon; (1)direct observation of emitted particles by counting method, and (2) geochemical detection of decay products as isotopic excesses in geologically old minerals. Direct counting method is extremely difficult and uncertain because of the small count rates from DBD. On the other hand, geochemical approach has the advantage of geological time for the accumulation of detectable amount of the decay product in the minerals. Here I report isotopic evidence of the DBD of 100Mo, and the estimation of its half-life.

Previous works of geochemical approaches for DBD were mainly focused on noble gas analyses to search for isotopic excesses of 82Kr, 128Xe and 130Xe decayed from 82Se, 128Te and 130Te, respectively. These approaches show great successes to detect DBD products, because the initial contents of noble gasses in geological materials are extremely low. However, the results of the half-lives estimated from individual measurements show a variation probably due to imperfect retentivity of noble gasses in the minerals.

Besides the noble gas isotopic studies, Mo isotopic measurements in old zircon ($ZrSiO_4$) were previously reported to study 96Mo decayed from 96Zr. Zircon has a merit for the DBD study, because it is a physico-chemically stable mineral to retain decay products in the lattice structure and easy to determine the formation age by U-Pb system. On the other hand, spontaneous fission of 238U affects the Mo isotopic compositions, because zircon generally includes significant amount of U. Therefore, correction of accumulated fissiogenic isotopes is required to find DBD evidence in zircon.

In this study, two molybdenites (MoS_2) from Mt. Mulgine and Osbourne, Australia were treated. It is generally known that molybdenite initially contains little Os relative to Re. Therefore, Re-Os chronometry has been successfully used to determine precise formation age of molybdenite. Re-Os ages of the molybdenites used in this study show 2.902 Ga for Mt. Mulgine, and 1.051 Ga for Osboourne. As expected from the chemical similarity of Ru with Os, initial contents of Ru in the samples show extremely low around a few tens ppt level. Therefore, significant isotopic excesses of 100Ru were detected from both of two samples. Estimated half-life from the 100Ru isotopic excesses of two molybdenites with different Re-Os ages show a consistency with each other, which provides 2.0x10^18 yrs. There has only been one geochemical determination of the 100Mo-100Ru half-life, which only resulted in a lower limit (1 x 10^18 yr). This is the first report to determined the DBD half-life of 100Mo from the geochemical approach.