Experimental study on hydrogen production through hydrothermal alteration of komatiite glass

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Since their discovery in the late 1970s (Corliss et al., 1979), deep-sea hydrothermal systems have been considered as likely candidates for the origin of life on the Earth. The most probable candidate for the most primitive life is methanogen, which utilizes the metabolic energy of hydrogen oxidation. Therefore, hydrogen is a key element for eco-system in the early Earth. Serpentinization of peridotite has been well studied experimentally and theoretically (e.g., McCollom, 2007; McCollom and Bach, 2009). Interaction between such serpentinizatin of peridotite and primitive microbial communities was found in the modern hydrothermal systems in the Kairei and Raibow fields (Takai et al., 2004; 2006). In the Archean ocean, komatiite magmatism produced ultramafic rocks and possibly provided the environments to support methanogenesis-based ecosystem in the early Earth.

To test this hypothesis, we conducted an hydrothermal experiment of komatiite using a Dickson-type batch hydrothermal apparatus with flexible gold-cell. Synthetic komatiite glass powder was reacted with pure water at 300°C and 50 MPa. Komatiite glass was prepared by remelting of an ultramafic Al-depleted komatiite from the Barberton Greenstone Belt, South Africa, using an atmospheric furnace at 1600˚C, regulating oxygen fugacity under QFM buffer. Hydrogen generation was confirmed ~500 hrs after the start of experiment, and reached at a level of approximately 1 mM after 640 hours. Hydrogen generation persistted and progressively increased even after 640 hrs.

Due to the widespread distribution of komatiite in the Archean Earth, its hydrothermal alteration in shallow subseafloor regime has been potentially a significant source of hydrogen for the earliest biosphere.

Astronomical oxygen isotopic evidence for supernova pollution of the solar system birth environment

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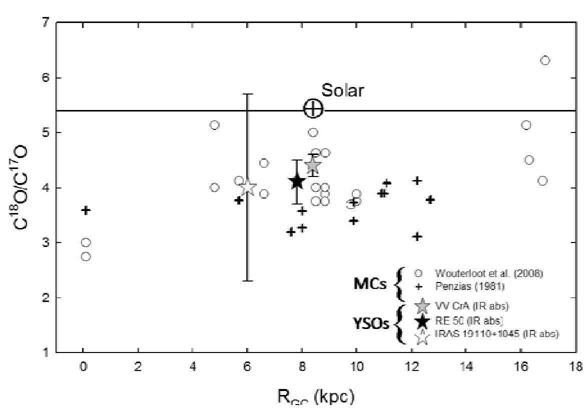
We present newly obtained ratios among $C^{16}O$, $C^{17}O$ and $C^{18}O$ from young stellar objects (YSOs) and compare these with molecular cloud data and the oxygen isotopic composition of the solar system. This new analysis suggests that the solar system is indeed unusual in its $^{18}O/^{17}O$ compared with the present-day Galaxy. Galactic chemical evolution (GCE) models suggest that $^{18}O/^{17}O$ is independent of time. The disparity between present-day Galactic and solar $^{18}O/^{17}O$ requires that either our understanding of the GCE of oxygen is incorrect or that the solar system was born in an environment polluted by low-mass supernovae.

Our survey of oxygen isotopologues of CO in YSOs is consistent with molecular cloud radio emission data in showing that typical Galactic $^{18}O/^{17}O$ is near 4 (the $C^{18}O/C^{17}O$ values for three YSOs are 4.0 ± 0.4, VV CrA; 4.4 ± 0.2, RE 50; and 4.0 ± 1.7, IRAS 19110+1045) compared with the solar system value of 5.2. These data show that the difference between solar $^{18}O/^{17}O$ and typical Galactic $^{18}O/^{17}O$ cannot be attributed to heterogeneity on the scale of individual stars. Our data allow us to now exclude systematic errors in the molecular cloud data as the cause of the difference.



Pollution from low-mass type II supernovae (SNe II) on the order of 1 % by mass can account for the enhancement in $^{18}O/^{17}O$ of the birth environment of the solar system compared with normal Galactic values. Statistical analysis shows that pollution by low-mass SNe II progenitors requires that the parental molecular cloud of the solar system was proximal to a cluster composed of order 500 stars. This cluster predated the solar system by ~ 10 to 30 million years.