Oxygen Isotope Study of Earth and Space Materials

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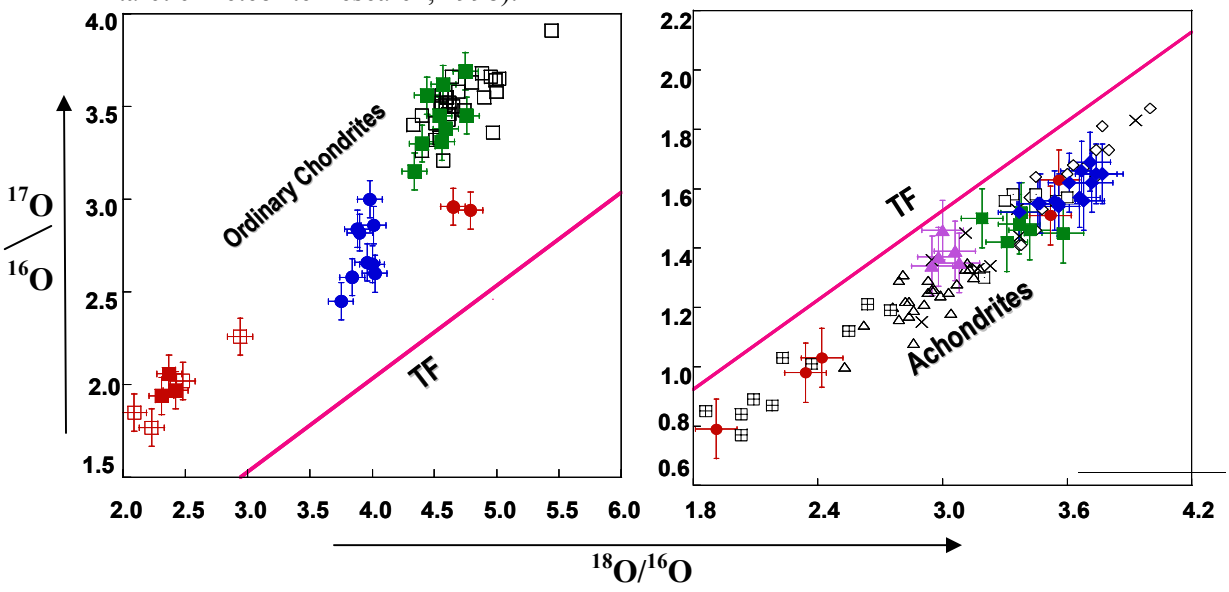
Universe is greater than our imagination. Studying about our planet earth and the space surrounding out there is intriguing and exciting. Geo-Cosmo chemistry is one of the sciences through which one can peep into the space. Oxygen isotope geo-cosmo chemistry is the only system which can tell about the whereabouts of the space materials falling on earth. It has three stable isotopes O^{16}, O^{17} and O^{18} with natural abundances of 99.762%, 0.038% and 0.200% respectively. These isotopes are subject to the mass dependent fractionations in both equilibrium and kinetically produced processes. It can have mass independent fractionations nucleosynthetic processes, chemical reactions. The relative abundances of oxygen isotopes indicate the different composition of universal bodies.

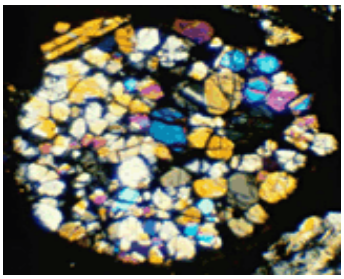
On a three isotope plot of oxygen all the terrestrial (earth) samples fall on a slope ½ line which is designated as Terrestrial Fractionation (TF) line. This line is the basis for the study of all the extraterrestrial (space materials excluding earth) bodies. Earth has a distinct ratio of the three isotopes of oxygen. Similarly all other planets and asteroidal bodies have their own distinct isotopic compositions. Therefore, on a three isotope plot of oxygen different space bodies have their specific places either above or below the slop ½ TF line. In Japan a CO_2 laser extraction fluorination system was established in 1996 at the Institute for Study of Earth's Interior (ISEI), Okayama University. A terrestrial fractionation line is designed using 23 different mineral and whole rock samples taken from different earth locations (Jabeen and Kusakabe, Chemical Geology, Isotope Geoscience, 1997).

Every year our earth is showered by thousands of chunks of space materials. These chunks are called meteorites. Mostly these are coming from the inner planets and the asteroidal belt between the inner and outer planets of our solar system. A mere examination of these meteorites do not differ them from a simple stone of our earth. The oxygen isotope analyses of such chunks reveal their significant positions in the solar systems. Among these meteorite types there are ordinary chondrites, achondrites and carbonaceous chondrites. The oxygen isotope exploration of many different kinds and types of ordinary chondrites, achondrites study is done and added many new and outstanding data on the three isotope plot of oxygen (Jabeen et al., Meteoritics, 1998a; Antarctic Meteorite Research, 1998).



Among all meteorites the carbonaceous chondrites have diversifying oxygen isotopic signatures as compared to the ordinary chondrites and achondrites. The oxygen isotopes from these chondrites fall on slope 1 line on a three isotope diagram. This different behavior of meteorites of carbonaceous chondrite type stress that the nebular processes might not be that homogeneous. It further stressed the need for exploration of the isotopic signatures in different mineral fragments of different types of carbonaceous chondrites. Two meteorites of carbonaceous chondrite types Allende and Murchison are best known for variety of hidden isotopic signatures. These meteorites have rounded nodules like bodies called chondrules. Chondrules have bunch of minerals with varying isotopic compositions. Also these chondrules are of different types depending on the major mineralogy. Recent times require a thorough understanding of the nebular and post accretion processes to explain the signatures found among such chondrites. The chondrules are the key to such understanding. A number of Allende chondrules are studied to clarify the oxygen isotopic behavior to investigate whether these chondrules preserve the primary signatures or not during early nebular processes. It is observed that chondrules from Allende possess the primary as well secondary signatures in various kinds and types of chondrules (Jabeen et al., Meteoritics, 1998b; Antarctic Meteorite Research, 1998). The small size of the mineral fragments within the chondrules and other fragments of carbonaceous chondrites require the in-situ study for the oxygen isotope exploration within the carbonaceous chondrites.

Allende meteorite



A chondrule

The Earth and Planetary Science department of the University of Tokyo has well maintained SIMS-SEM system for such studies. Very systematic SEM-EDS analyses, Cathodoluminescence (CL) imaging and in-situ SIMS analyses of oxygen isotopes mineral olivines from chondrules and matrix of Murchison carbonaceous chondrites is carried out. This in-situ study reveal that even within a single mineral of a single meteorite we have a variety of oxygen isotopic compositions. It gives a hint towards their origin and formation in different compositional regions of the solar nebular and show the distribution of oxygen isotopes (Jabeen and Hiyagon, Lunar Planetary Science, 2003; Earth Planetary Science, 2003). Attempts are underway to expand such study to other types of carbonaceous chondrites to solve the mystery of oxygen isotope anomalies of our solar system and eventually the mystery of our solar system formation itself

Pakistan is still far behind in the space science studies. In order to uplift Pakistan in such studies, it is suggested that a systematic approach should be followed as 1) introduction and recognition of such studies in Pakistan; 2) addition of Planetary Science section in the Earth Science sector of Pakistan; and 3) exploitation of the sources and resources in Pakistan in the light of International Standards. Japan is one of the developed countries which have well established systems for space studies. Pakistan should collaborate with Japanese scientists, universities and institutions in this regard. It would open a complete new era of understanding and knowledge sharing between these two great nations and would provide a very intriguing subject for our young researchers to explore.