Preliminary investigation of cosmogenic radionuclides in Mukundpura (CM2) Carbonaceous chondrite

A.D. Shukla[1], D. Ray[1], A. Dutta[2], D. Raychaudhuri[2] and A. Bhattacharya[2], [1]Physical Research Laboratory, Ahmedabad 380 009, India (anilds@prl.res.in). [2]Geological Survey of India, Kolkata 700016, India

Introduction: The cosmogenic radionuclides in meteorites are produced due the interaction of the target element's atom present within the meteorite to the galactic cosmic radiation (GCR) after the separation from large parent body. These nuclides provide important clues towards our understanding of the sojourn of the meteorite between parent body to the Earth. We at Physical Research Laboratory, Ahmedabad have been studying this aspect for the past two decades on freshly fallen Indian meteorites using a well-established γ-ray spectrometer counting system. The Mukundpura chondrite is the new carbonaceous meteorite fall in India [for details of the fall see 1]. The fall took place near Jaipur, Rajasthan, India on June 6, 2017 at 5:15 IST. According to eyewitness, the meteorite was a single fall and got fragmented into several pieces after hitting the ground. This meteorite is characterized and classified as carbonaceous chondrite as CM2 based on its chemistry and petrography [1, 2]. The main mass was kept in Geological Survey of India (GSI) repository, Kolkata and petrography and mineralogy results are reported elsewhere in this volume [3]. We focus here on the preliminary results of cosmogenic radionuclides in the Mukundpura meteorite.

Analytical Techniques: Several fragments were collected from GSI for non-destructive analysis of cosmogenic radionuclides. The meteorite fragments were counted in fixed geometry sample container for cosmogenic radionuclides using ultra low back ground hyper pure germanium (HPGE) planar co-axial detector. The germanium crystal has active volume of $148cc^3$ with relative efficiency of 25.6% and housed within a 10 cm thick lead shield at the ground floor in Physical Research Laboratory, Ahmedabad, India. The background in the ^{40}K channel is <0.023 counts per minute. The gamma ray spectrometry experiments were started four-month aftermath the fall. The typical error is ~10% which includes mostly due to counting errors and the sample processing.

Results: Though efforts are given for measuring the majority of the cosmogenic nuclides, we were able to analyze only ^{22}Na, ^{54Mn}, and ^{26}Al. The radioactivity levels of these isotopes were estimated on considering the homogeneous distribution of K within the meteorite. K concentration measured following ^{40}K gamma ray spectrometry, estimated to be ~200ppm. In a fixed circular box geometry where a few fragments were packed and counted for two-week time. The preliminary results derived from these fragments for ^{54}Mn, ^{22}Na and ^{26}Al isotopes, to be estimated as 39±5 (dpm/kg), 45±5 (dpm/kg) and 38±7 (dpm/kg) respectively.

Discussion: The estimated activities of the cosmogenic nuclides are consistent with earlier observed activities in various meteorites. The ^{22}Na activity found to be lower than the Sutter's Mill CM2. This may be due to the differences in the time of fall relative to the solar activity. We found Mukundpura is chemically similar in composition to Sutter's Mill CM2 meteorite, which fell on April 2012 [4] at peak activity of solar cycle 24, while Mukundpura fell at the declining phase of the current solar cycle 24. The effect of solar activity is well demonstrated by the cosmogenic nuclides specifically for radionuclides with lower half life. Most significantly the ^{22}Na/^{26}Al ratio is modulated due to interplay of galactic cosmic rays and solar activities independent of irradiation history in the interstellar space [5] looks consistent with the solar behavior of current solar cycle 24. This is further supported by the low activity of ^{54}Mn in Mukundpura in comparison to Sutter's Mill also indicate that its production is controlled by solar cosmic rays which is get modulated due to interaction of galactic cosmic rays. The observed activities of long lived ^{26}Al found to be quite higher than Sutter's Mill (<23 dpm/kg) [4] indicates that the Mukundpura meteorite might yield an older cosmic ray exposure age.

Additionally, the neutron capture reaction produced nuclide ^{60}Co is absent or not measurable. This might correspond to smaller size of its parent body in interstellar space as the production of ^{60}Co related to the thermal behavior of neutrons during its interaction with the meteorite. Hence it might be possible that the sample available from shallow shielding depth or its production could not take place due to the smaller size of the parent body. Further investigation is under progress.

Conclusion: The preliminary results shows the observed activities are consistent with their production mechanism. The detailed analysis still under progress and will be presented during the annual meeting.

References: [1] Meteoritical Bulletin no. 107 (2018) *MAPS* (in preparation). [2] Ray D. and Shukla A.D.(2018) *Planet. Space Sci*. 151:149-154. [3] Ray D. and Shukla A.D. (2018) this conference. [4] Hamajima Y. et al. (2012) *MAPS Supplement:* 5354. [5] Bhandari N. et al. 1994. *Meteoritics* 29(4): 443-444.

.