Journal of Environmental Radioactivity 213 (2020) 106156

Contents lists available at ScienceDirect

Journal of Environmental Radioactivity

journal homepage: http://www.elsevier.com/locate/jenvrad

Radiocarbon measurements using new automated graphite preparation laboratory coupled with stable isotope mass-spectrometry at Birbal Sahni Institute of Palaeosciences, Lucknow (India)

Rajesh Agnihotri [a,*], S.K.S. Gahlaud [a], N. Patel [a], R. Sharma [b], Pankaj Kumar [b], S. Chopra [b]

[a] BirbalSahni Institute of Palaeosciences, 53 University Road, Lucknow, 226007, Uttar Pradesh, India
[b] Inter-University Accelerator Centre, ArunaAsaf Ali Marg, New Delhi, 110067, India

ARTICLE INFO

Keywords:
Graphitization
Stable isotopes
Radiocarbon dating

ABSTRACT

Conventional beta counting technique based radiocarbon dating facility at Birbal Sahni Institute of Palaeosciences- Lucknow was established in 1974 (Rajagopalan,1978). In 2017–18, BSIP received an upgrade with installation of an Automated Graphitization Equipment (AGE) coupled with an Elemental Analyser, a Carbonate Handling System (CHS) along with an *in-line* stable isotope mass-spectrometer (IRMS). Using this combo, stable Carbon (C), Nitrogen (N) and Sulfur (S) isotopic measurements could be carried out in both organic and inorganic type samples followed by graphite preparation (~1 mg) for ^{14}C measurement by Accelerator Mass Spectrometry (AMS). This communication addresses details of pre-processing, processing, and quality checks adopted for achieving acceptable and demonstrable accuracy and precision of measured $\Delta^{14}C$, $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ measurements. Information regarding chemical preparation of samples for aforesaid stable and radio isotopic analysis is provided in succinct manner. Overall, average coefficient of variation determining precision of our graphite powders for ^{14}C measurements is ~2.4%. The mean age of blank (anthracite) processed using established EA-IRMS-AGE unit comes as 42,100 ± 300 years.

1. Introduction

Geo-environmental studies involving complex biogeochemical processes occurring on earth require key knowledge of timing, source identification, and transformation pathways. To achieve this intricate task, natural stable and radioactive carbon isotopic abundances (^{13}C and ^{14}C) serve as reliable proxies. Radiocarbon (^{14}C; abundance ~10^{-12} with respect to most abundant ^{12}C atoms) is produced in the upper atmosphere by interaction of thermal neutrons with atmospheric nitrogen (N_2) (Libby, 1946; Anderson et al., 1947). Following its production in the upper atmosphere, ^{14}C atoms get incorporated in atmospheric carbon monoxide (CO) and then by incorporation in atmospheric carbon dioxide ($^{14}CO_2$), which eventually becomes a part of the carbon cycle and is removed from atmosphere by gas-exchange processes. Thus, concentration of ^{14}C atoms in geological realm would depend on (i) its production, (ii) mixing processes, (iii) exchange between various reservoirs, (iv) removal by scavenging processes and (v) radioactive decay. $^{14}CO_2$enters the oceanic waters through gas exchange and solubilisation, while in fresh water systems through its participation in chemical weathering. ^{14}C measurements have been extensively used to derive ocean circulation timescales, deep water ages and rates of its recharge (Stuiver et al., 1983). In addition, half live of ^{14}C (5730 ± 40 year) also make it ideal to use it as an absolute chronometer to date terrestrial and marine sediments deposited during the late-Quaternary (~45–50 ka). Besides this, precise measurements of $^{14}C/^{12}C$ ratios in variety of archaeological samples (e.g. habitational soil-sediment, macro--botanical (agricultural) remains, teeth, bone etc.) greatly help in ascertaining chronologies of ancient cultures.Similarly ^{14}C abundance plays key role in hydrology (dating ground waters) and climate change studies. ^{14}C measurements in rapidly depositing geological archives such as tree rings, corals, and varved sediment have shown significant variability in past few tens of thousands years, indicating variations in cosmic ray flux and production of ^{14}C atoms in upper atmosphere. In fact, variations in Sun's internal activity (sunspot activity) influencing strength of solar cosmic rays may modulate galactic cosmic rays reaching the earth's atmosphere are known to impact ^{14}C activity in earth's repositories (Dutta, 2016 and references therein). It is noteworthy that solar activity prior to the period of direct solar observation

* Corresponding author.
E-mail address: rajagni9@gmail.com (R. Agnihotri).

https://doi.org/10.1016/j.jenvrad.2019.106156
Received 7 October 2019; Received in revised form 31 December 2019; Accepted 31 December 2019
Available online 7 January 2020