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RESEARCH ARTICLE

Presence and implications of petrogenic organic carbon in High Himalayan Crystalline lake sediment

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Abstract

Twelve lacustrine sediment samples from a relict lake in the Kalla Glacier valley were co-dated using AMS radiocarbon (^{14}C) and infrared stimulated luminescence (IRSL) dating methods. In general, the radiocarbon ages of bulk organic matter were older by a minimum of 1500 years compared to (age depth) modeled luminescence ages after fading corrections. This is observed for the first time in the lake sediments of High Himalayan Crystalline zone. A combination of lipid *n*-alkane data, Raman spectra and geochemical proxies suggested that this was due to ancient organic carbon ($OC_{ancient}$) that is a mixture of pre-aged ($OC_{pre\text{-}aged}$) and petrogenic (OC_{petro}) organic carbon within older glacial moraine debris that served as sediment source to the lake. Raman spectra suggest the presence of moderate to highly graphitized OC_{petro} in all the profile samples. The OC_{petro} contributed $0.064 \pm 0.032\%$ to the sediment and the lake stored 2.5 ± 0.7 Gg OC_{petro} at variable rates during the last 16 kyr, with the mean burial flux 160 kg OC_{petro} yr^{-1}. This study implies (1) employing another independent dating method in addition to radiocarbon method using bulk sediment organic matter, if the carbon content is low, to observe any discrepancy, and (2) a need to investigate on the fate of OC_{petro} as many such small lakes become relict in this region.

Introduction

The radiocarbon chronology of lacustrine sediment in the High Himalayan Crystalline (HHC) zone at ~4000 m msl (above the treeline) has been, mostly, based on the bulk sediment organic matter (bSOM) (Beukema et al. 2011; Bhushan et al. 2018; Juyal et al. 2004; Kumar et al. 2020; Kusumgar et al. 2016; Srivastava et al. 2017). If any "old" carbon either of rock derived petrogenic or biospheric pre-aged is mixed with the lake sediment, the radiocarbon composition in the bSOM gets diluted and thus overestimate the radiocarbon age. The petrogenic organic carbon (OC_{petro}) that stored in source rocks of the catchment is liberated during physical erosion and transported by the melt water to the lake. The biospheric pre-aged organic carbon ($OC_{pre\text{-}aged}$) represents all other particles of organic carbon which are neither of contemporary vegetation (both terrestrial and aquatic), OC_{bio} nor of petrogenic (Galy et al. 2008). If OC_{petro} is defined as infinitely old organic carbon i.e., > 60 kyr or $F_{mod} = 0$ (Galy et al. 2008) and OC_{bio} as contemporaneity between the sediment depositional event and the vegetation in and around the lake, the age of $OC_{pre\text{-}aged}$ is between that of OC_{bio} and OC_{petro}.

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