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Improving 14C-based chronologies of non-annually resolved sediment series by assessing the biogenic fraction flux instead of sedimentation rate

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The last decade was a period of unprecedented development of annually-resolved natural archives of past environmental conditions, such as speleothems, varve lake sediment, ice core or corals. Nevertheless, such geosystems are not present everywhere in the world and the interest for non-annually resolved natural archives remains important in the aim of reconstructing past climatic and environmental condition, both in marine and continental areas. In particular it has been shown that sediment – from lakes, fjords, or continental margins – which are made of a mixture of biogenic and detrital fractions, may be used to reconstruct past detrital discharge and thus hydrological patterns. Thanks to the recent developments in core logging geochemical techniques – XRF core scanning – such sediment sequences are susceptible to deliver highly resolute climatic of environmental signals, provided they may be accurately dated. In this paper we present a new method, applied to the establishment of age-depth relationships of two of such sequences taken in Lake Bourget, NW French Alps. Our method is classically based on 14C ages, but those ages were stratigraphically placed as a function of "biogenic carbonate accumulation" instead of depth below lake floor, which is classically done.

Lake Bourget is a fjord-type lake in which river Rhône, one of the main European Alps rivers, sporadically enters during its major floods. Such events bring a silicate-rich detrital fraction which dilutes the biogenic carbonates constituting the main sediment fraction in normal conditions.

Two long cores covering most of the Holocene period were retrieved in Lake Bourget and sampled for 14C dating following a sampling-step of less than 1000 years. Using high resolution XRF core scanning results calibrated by 150 major elements discrete measurements, we assessed carbonate and detrital fraction contents following a 5mm- to 1cm-step. We also assessed the evolution of dry density as a function of depth by measuring the dry weight of volume-known samples. Combining those information we were able to compute the weight of carbonate accumulation above each depth per surface unit (carbonate accumulation depth). 14C ages were subsequently replaced as a function of this "carbonate accumulation depth". It then appeared that all the ages were aligned along a linear curve. On the contrary, the age-depth relationship presents many disruptions due to changes in detrital flux. We hence demonstrate that biogenic carbonate flux varies of one order of magnitude less than total sediment flux. We finally applied a classic age-depth modelling to take account of low amplitude change in carbonate accumulation and thus establish an independent chronology of each sediment sequence. The chronology hence obtained takes account of instantaneous changes in detrital supply and is thus more accurate than classic age-depth relationship. The agreement of detrital signals as a function of time in our two independently dated sequences argues for the accuracy of our method. Such a method should improve age-modelling of any non-annually laminated sediment sequence which is made of a mixture of biogenic (carbonate, diatoms, organic matter etc.) and detrital fractions, whatever it is of freshwater or marine origin.