



Resolution of Lead-210 Chronologies in Lake Sediments: problems of Mid-core fluctuations in Lead-210/Radium-226 Ratios

Robert Haworth (1) and Henk Heijnis (2) (1. Department of Geography and Planning, University of New England, Armidale NSW 2351) (2. ANSTO, Menai NSW 2234)

With a range in excess of 150 years under optimum conditions, Lead-210 dating represents a valuable tool for studying recent human impacts on the environment, particularly the effects of European settlement in Australia. It is therefore also useful for establishing the start of the pre-European record in a sediment profile. Despite these advantages, there are some unresolved problems that prevent the full potential of an atmospherically-derived Lead-210 profile being extended as far into the past as the activity signal allows.

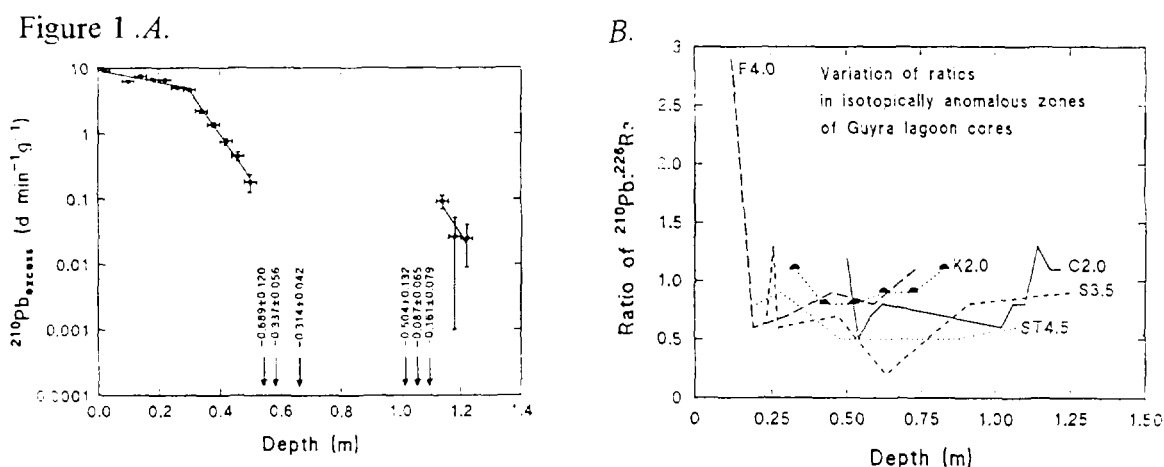
Lead-210 does not give an absolute date but must be applied using one of two models, or mixtures of both. Lead-210 is part of the natural decay chain of Uranium-238, which decays through a series of intermediaries to Radium-226. Radium-226 is almost universally present in earth material, and decays in turn to Radon-222, a short-lived inert gas that diffuses into the atmosphere from the lithosphere and is distributed globally. This in turn decays via a series of short lived daughters to Lead-210. Lead-210 has a half-life of 22.26 years, and a capacity to precipitate and be adsorbed by terrestrial material, particularly lake and marine sediments. This out-of-phase (or unsupported) Lead-210 thus returns to a specific terrigenous location where it is added to the Lead-210 formed continuously *in situ* from the local Radium-226 (equivalent to supported Lead-210). Dating is based on the measurement of the decline of this unsupported Lead-210 against the equilibrium ratio of *in situ* Lead-210: Radium-226.

Use of Lead-210 activity in sediment dating depends firstly on the assumption that there has been a steady supply of unsupported Lead-210 at the site over the time being studied. Unsupported Lead-210 accumulates in the sediment, is isolated from further input or removal by burial, and the buried activity then decays exponentially at a predictable rate. Comparison of unsupported Lead-210 at different depths in a sediment column allows the calculation of a sediment chronology. As well as the development of this initial assumption by the two main dating models (Constant Initial Concentration [CIC] and Constant Rate of Supply [CRS] of unsupported Lead-210), there is the equally important but often overlooked assumption that supported Lead-210 and its grandparent Radium-226 will be in equilibrium throughout the sediment column, with only minor deviations. When it was found that downcore Radium-226 activities might vary, even by quite large amounts, Robbins and Edgington (1975) suggested using a smoothing operation utilising the mean of all downcore Radium-226 activities, perhaps excluding a few top activities where radon leaking may have occurred. They conceded that calculating unsupported Lead-210 values by using an averaged value for Radium-226 would produce significant error where levels of unsupported Lead-210 activity are low. This error would occur deep in the sediments, at the limit of the chronology, where in the Australian case an ultimate date would be most useful in separating the commencement of the pre-European sediment regime and its valuable archaeological information.

Variations in the Radium-226 side of the ratio tend to swamp the weak unsupported Lead-210 signal at these lower depths. If some way other than statistical smoothing could be found to account for Radium-226 fluctuations at these depths, the small unsupported Lead-210 profile could be rescued. The chronology could then be extended using the less intensive (and therefore less expensive) CIC model. One problem in assuming automatic equilibrium between *in situ* Lead-210 and Radium-226 is that they represent two chemically dissimilar elements, in two different chemical families. The behaviour of the isotopes may be quite different in transit to a site through water and sediments, or within a buried profile. For instance, Lead-210 adheres preferentially to organic material, while there is evidence to suggest that Radium-226 is preferentially scavenged by silicates (Koide *et al.*, 1973). The silicate-rich products of granite may therefore be expected to have greater Radium-226 activity than silicate-poorer basalt products. Cation exchange capacity on montmorillonite clays may also favour concentration of Radium-226. When different erosion products are mixed in sediments local conditions may therefore favour a concentration and locking up of Radium-226, and perhaps an escape of Lead-210.

Some of these possibilities were tested against sedimentary evidence from five sediment profiles from three northern New South Wales lakes which had exhibited mid-core isotopic inversions of their Lead-210: Radium-226 ratios (Fig. 1 B). In one CRC-model dated core (Fig. 1 A), the date of inversion was definitely fixed to the period of extreme catchment soil destabilisation immediately following European settlement, and in other CIC dated cores this was the most likely date of the inversions. As subsoil-derived material diminished deeper in the core, Lead-210 increased in activity and in some cases resumed its exponential downcore decline.

Figure 1 .A. Unsupported ^{210}Pb activity from a core at Little Llangothlin Lagoon, Guyra, northeast New South Wales, showing anomalous 'kink' associated with enhanced catchment erosion. B. Comparison of the downcore fluctuation of the $^{210}\text{Pb}/^{226}\text{Ra}$ activity ratio of five dated sediment profiles from three separate lakes in northern New South Wales.



Koide M., Bruland K.W. and Goldberg E.D. 1973. Th-228/Th-232 and Pb-210 geochronologies in marine and lake sediments. *Geochim. et Cosmochim.*, 37, 1171-1187.

Robbins J.A. and Edgington D.N. 1975. Determination of recent sedimentation rates in Lake Michigan using Pb-210 and Cs-137. *Geochim. et Cosmochim.*, 39, 285-304.