

Timing of Chemical Weathering with U-decay Series Measured in Rivers

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Introduction

The role of lithology, relief, runoff and climate on chemical weathering has been the subject of a hot debate in the recent years. Consequently, it is crucial to find reliable indicators for chemical weathering of continent. The ²³⁸U decay series nuclides (e.g. ²³⁸U, ²³⁴U, ²³⁰Th and ²²⁶Ra) may be a particularly powerful tool for studying recent continental weathering since the U-series is in secular equilibrium before the inception of weathering. The greater ability of radium and uranium to be leached to the aqueous phase compared with thorium, and the α -recoil effects, both induce radioactive disequilibria during chemical erosion of continental rocks. Weathering-induced ²³⁴U-²³⁸U, ²³⁸U-²³⁰Th, and ²²⁶Ra-²³⁰Th fractionation imply a wide range of half-lives (from 1620yr to 248000yr), which should help to determine chemical weathering timescales in both recently and formerly eroded regions.

Results

The dissolved and solid phases of the major rivers of the Mackenzie basin, located in the NW of Canada watershed, were collected in August 1996. The suspended sediments display (²³⁸U/²³⁰Th) and (²²⁶Ra/²³⁰Th) activity ratios lower than 1 (secular equilibrium) and the dissolved phases are enriched in U and Ra relative to Th (Figure 1). This is consistent with a preferential leaching of U and Ra while Th is mainly retained in the particulate phase. Similarly, the preferential leaching of ²³⁴U caused by recoil effects is displayed by (²³⁴U/²³⁸U) lower than 1 in the particles and greater than 1 in filtered waters.

Discussion

As shown in Fig. 1, particles and dissolved phase are complementary with respect to the secular equilibrium value for pristine rocks. Nevertheless, simple mass balance calculations show that the amount of U released for each watershed is greater than what would be expected from a steady-state regime of erosion. This discrepancy can be explained either by an excess of dissolved U, from enhanced chemical erosion, or by a lower flux of suspended particles. We have developed an open-system model that describes the leaching of particles while they reside in soils. This model takes into account the leaching rate of Ra and U relative to Th, based on dissolved phase ²²⁶Ra-²³⁰Th and ²³⁸U-²³⁰Th data. For the Mackenzie

river, the best-fit solution yields a time of 11500 yr (± 500 yr). This time represents the inception of the leaching process in the basin, and coincides with the last glaciation ranging between about 9000 and 15000 years ago. This supports the idea that in this region, the last glacial maximum has reduced chemical erosion relative to physical denudation. Moreover, this time is much smaller than residence times estimated with mean thicknesses for basin soils (=40 000 yr). This conclusion supports evidence for a recent change of the watershed erosion regime, and confirms, as already suggested above, that the ratio of chemical over physical denudation rate is higher now. Ten thousand years after the last glacial maximum, the erosional regime of the Mackenzie basin is still in a transient state. This implies that the present-day charge of world-wide rivers may not be representative of interglacial climatic conditions (Gwiazda R. H. and Broecker S., 1994).

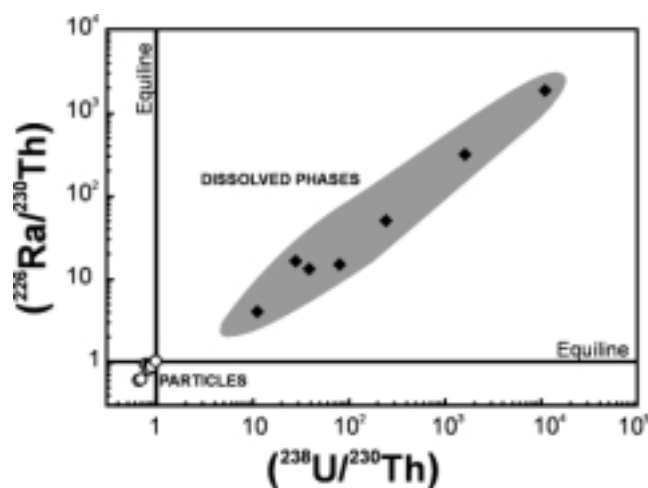


Figure 1: ²²⁶Ra-²³⁰Th and ²³⁸U-²³⁰Th disequilibria measured in the dissolved phases and suspended sediments for the Mackenzie basin rivers.

Gwiazda RH, Broecker WS, *Glob. Biogeochem. Cycles*, **8**, 141-155, (1994).