Natural ^{32}Si as environmental tracer

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There is a pressing need for an effective dating tool to cover the historical past. Cosmogenic ^{32}Si, with a half-life of ca. 140 years, is ideally suited to provide time information in the range 50-1000 years. Detection of ^{32}Si is, however, very difficult due to extremely low natural concentrations and isotopic ratios. The difficulties of setting up extremely low background systems, and the need for large samples have previously deterred wider use of ^{32}Si. At GNS we have developed improved methods for radiometric detection of natural ^{32}Si [Morgenstern et al., 2001] and, in collaboration with Australian National University, have succeeded in measuring natural ^{32}Si by accelerator mass spectrometry (AMS) [Morgenstern et al., 2000]. For AMS the necessary sample size can be reduced by a factor of ca. 1000, making it suitable for analysing ice core samples of only ca. 1 kg .

The global distribution of ^{32}Si was poorly known for a long time. However, assessment of all published Northern Hemisphere ^{32}Si precipitation data, and comparison with recent data from New Zealand shows that ^{32}Si exhibits similar latitude and seasonal variation to other well-investigated cosmogenic radionuclides. Compared with Northern Hemisphere data, ^{32}Si concentrations in rain water from Kaitoke (near Wellington) are about a factor two higher, and in snow from NZ glaciers are higher by a factor of 5.

^{32}Si has been considered as a tool for groundwater dating since its first detection. In a number of studies, the conservative behaviour of ^{32}Si as a tracer has been questioned, but some promising results have also been obtained, including the detection of ^{32}Si in ground waters with mean residence times of some hundreds of years, and a regularly decreasing ^{32}Si concentration with aquifer depth. To test ^{32}Si as a tracer suitable for dating groundwaters, we measured ^{32}Si in a young river-recharged confined gravel aquifer system with well-established ages from tritium dating. We found that ^{32}Si is nearly lost from the groundwater after 20 years. However, previous results do indicate that ^{32}Si behaves conservatively in sandstone aquifers.

We have also applied ^{32}Si measurements to a sediment core from the Bangladesh continental shelf and were able to establish a chronology beyond other dating methods [Morgenstern et al., 2001]. This suggested a relatively constant sedimentation rate from 50 to 400 years, and a significantly increased sedimentation rate over the past fifty years.

Projects for dating deep ocean glass sponges and glacier ice cores via AMS measurement of ^{32}Si are underway.

References

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XAS monitoring of Arsenic (Bio-)Oxidation and Immobilisatio in Soils and Acid Mine Drainage.

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Arsenic contamination of waters, sediments and soils, from both natural and anthropogenic sources, represents potential risks for water quality and food chain. Mobility and bio-availability of this toxic contaminant are controlled by its oxidation state and by solid/solution interactions that can be monitored in situ by X-ray Absorption Spectroscopy (XAS).

We studied the molecular-scale mechanisms of arsenic retention in soils and Acid Mine Drainage (AMD), at several field sites chosen by French and European Community research programs to evaluate the risks related to arsenic contamination [1-4]. Particular attention was paid in assessing the role of micro-organisms in controlling arsenic speciation.

In the natural and polluted soils studied, XAS analyses indicate that, after crystalline As-bearing species have dissolved, arsenic immobilisation is mainly achieved by complexation onto iron oxy-hydroxide mineral surfaces [*2*].

In heavily contaminated AMD studied, microbial oxidation of Fe(II) and the subsequent co-precipitation of arsenic with crystalline and amorphous ferric oxy-hydroxide mineral phases is the dominant process. XAS data show that the oxidation state of arsenic in these precipitates is controlled by seasonal variations of the activity of bacteria able to oxidise As(III) [*3-4*].

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