Catchment-wide denudation rates from the Murrumbidgee River, Murray-Darling Basin, SE Australia, using *in situ* cosmogenic ^{10}Be

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Abstract

The Murray-Darling Basin (MDB) is a large inland basin in southeast Australia (draining one seventh of the continent), and is by far the most important agricultural centre of the country. Sustainable use of the basin resources is a significant national agenda where the balance between two contrasting aspects - ecological preservation and industrial/agricultural development - has been long-debated. To evaluate the impact of human land use, it is required to understand the natural response of the basin to various external forcing such as climate and CO_2 fluctuation. This study is the first part of a larger investigation on the behavior of different river systems within MDB in response to past climate changes. Here, we present a study of the Murrumbidgee River catchment for the estimate of catchment-wide denudation rates using *in situ* cosmogenic-nuclide measurement in sediments. The Murrumbidgee River is among the longest (length ~1485 km) of the MDB rivers. Four stages of paleo-channel systems were identified and dated previously by thermoluminescence [1]. The paleo-denudation rates were calculated from the measured ^{10}Be corrected for post-depositional nuclide production. Results show remarkably constant nature of catchment-wide denudation rate (12-15 m/Ma) for the last 100 ka. The average rate of 14 ± 1 m/Ma (n = 8) is much slower than the global mean ^{10}Be-based basin denudation rate of 218 ± 35 m/Ma (n = 1149) [2]. At such low rate, time-averaging of denudation rate estimate is c. 50-70 ka, and our data integrate over the entire glacial or interglacial period. Overall, our results suggest that catchment-wide denudation in the Murrumbidgee River catchment has not been changed dramatically for the last two glacial-interglacial cycles. The result here is somewhat in contrast to U-series comminution ages of the same deposits, where interglacial sediments exhibit relatively longer residence time (c. 100-500 ka) over sediments deposited during the glacial periods (<50 ka) [3], which implies changes in weathering or erosion regimes between the two periods. Finally, response to certain climatic conditions may have been significantly different between rivers within the MDB, and our ongoing project will address this issue by comparing temporal variations in fluvial activity, denudation rates, and sediment residence times between different catchments within the basin.

[1] Page *et al*. (1996) *Journal of Quaternary Science* **11**, 311-326. [2] Portenga and Bierman (2011) *GSA Today* **21**, 4-10. [3] Dosseto *et al*. (2010) *Geology* **38**, 395-398.

Monitoring microbially induced calcite precipitation in the subsurface

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Microbially induced calcite precipitation (MICP) has gained interest for a number of subsurface applications, such as contaminant remediation, flowpath modification for energy resource recovery and management, and improvement of soil shear strength. A specific example is the immobilization of the radionuclide ^{90}Sr by co-precipitation in calcite, where calcite precipitation is accelerated by microbial ureolysis. Previous work has shown that ureolytically driven calcite precipitation can be mediated by indigeneous subsurface microorganisms at numerous sites, and that nutrient addition can accelerate the process and thereby increase Sr partitioning. A critical need for the further development of this approach into a field-ready technology is the ability to verify and track the progress of the relevant biogeochemical processes.

Recently we have been conducting field experiments of MICP and testing various approaches for monitoring the effects of our perturbations of the subsurface biogeochemical environment. In an experiment at the Integrated Field Research Challenge site in Rifle, Colorado, USA, we injected urea and molasses into groundwater for 12 days, with a continuous recirculation system between two wells located approximately 4 meters apart. During the recirculation, water samples were withdrawn at various locations within and outside of the recirculation zone for analysis of chemical and isotopic (^{13}C) composition and of microbial ureolytic potential (cell counts, urease gene quantitation, and/or ureolysis rate estimations), and incubated solids were sampled for evaluation of the attached microbial community. Cross borehole geophysical data were collected prior, during, and after the amendment addition. Followup water sampling occurred periodically for almost a year after active recirculation. Ten months after the cessation of nutrient injection, core was collected from within the recirculation zone.

The urea and molasses treatment enhanced *in situ* ureolytic activity as evidenced by increases in *ureC* gene copies and estimated urea hydrolysis rates, as well as long-term observations of ammonium in the injection, extraction and downgradient monitoring wells. Isotopic analyses showed a decrease in the δ^{13}C of the dissolved inorganic carbon in the recirculated water, consistent with hydrolysis of the isotopically light urea. Permeability changes and increases in the calcite saturation indexes in the well field suggest that mineral precipitation occurred; core samples are being examined for evidence. Joint interpretation of radar, seismic and electrical data suggest that these techniques can track the spatiotemporal progress of the urea hydrolysis and calcite precipitation processes.