In situ cosmogenic-nuclide method in Australian Earth Sciences

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Incoming cosmic-ray particles to the Earth's atmosphere create a cascade of high-energy secondary cosmic rays dominantly neutrons and muons, those of which arrive at the Earth's lithosphere in turn produce a series of rare nuclides via interactions with elements in the surface substances [1,2]. So called, *in situ* cosmic-ray-produced (= cosmogenic) nuclides are accumulated in rocks, sediments and soils at the Earth's surface, and their concentrations in various landscape components can be used to probe the timing and rates of landscape changes. The accumulation of *in situ* cosmogenic nuclides is controlled by exposure times of substances to cosmic rays (= surface residence time), removal rates of materials at the surface (= surface erosion rates), and, if it is radioactive, decay rates. Depending on the half-lifves of nuclides, the *in situ* cosmogenic-nuclide method can be used to determine exposure ages in the timescale at the order of thousands to millions of years and erosion rates as low as decimeters per million years. With its wide range of capability in measuring ages and rates of landscape changes, and due to the lack of other suitable methods with such capability, the *in situ* cosmogenic-nuclide method has become indispensable in Earth Sciences for the last two decades. At significantly low rates of their production at terrestrial surface environment, at the order of magnitude of 1–100 atoms per gram of substance per year, only highly-sensitive mass-spectrometric techniques, such as accelerator mass spectrometry (AMS) and high-sensitivity noble-gas mass spectrometry, can detect those nuclides at a level of 10^4-10^8 atoms. In this paper, I present a brief review of the principle of the *in situ* cosmogenic-nuclide method and its application in Australian Earth Sciences since the development of AMS systems at the two Australian premier accelerator facilities in ANSTO and ANU.

[1] D. Lal, *Earth and Planetary Science Letters* **104**, 424 (1991).
[2] J.C. Gosse and F.M. Phillips, *Quaternary Science Reviews* **20**, 1475 (2001).