

Denudation rate of karst surfaces in Japan: estimates from cosmogenic Cl-36

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This study quantified the long-term denudation of bare limestone surfaces by using in-situ-produced cosmogenic ^{36}Cl in calcite. Limestone samples for the analysis were collected from the topmost 5 cm of exposed pinnacles at several Japanese karst areas under subtropical to subarctic environments. Concentrations of Cl and ^{36}Cl in calcite were determined by isotope dilution using ^{35}Cl spike and accelerator mass spectrometry at UTTAC (University of Tsukuba Tandem Accelerator Complex). Concentration of Ca and abundances of neutron absorption nuclei were determined by prompt gamma-ray analysis with JRR-3M (Japan Research Reactor No. 3) to calculate ^{36}Cl production rate in calcite. The nuclide concentrations were of the order of 10^5 - 10^6 atom g^{-1} , and these data were converted to the rate of total denudation that averages over 10^4 - 10^5 yr-timescales of chemical and physical processes on the limestone surfaces. The denudation rates range from 5 to 20 $\text{mg cm}^{-2} \text{yr}^{-1}$ (20 to 70 mm kyr^{-1}), being lowest under temperate climate conditions in the central part of Japan, higher in subarctic northern areas and subtropical southwest areas in Japan. Modeling of this tendency with climate factors at each site indicates a shift in relative importance of chemical (dissolution) and physical (frost shattering) processes in the denudation of karst landforms, depending on mean temperature, annual precipitation, and annual freeze-thaw days.