

## Long-term denudation rates of limestone surfaces: an application of in-situ-produced cosmogenic Cl-36 in calcite

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This study quantified the long-term subaerial denudation of bare limestone surfaces by using in-situ-produced cosmogenic Cl-36 in calcite. Limestone samples for the analysis were collected from the topmost 5 cm of about 1 m-high pinnacles at several karst areas in subtropical to subarctic regions in Japan. Concentrations of the Cl-36 in calcite were determined with accelerator mass spectrometry, and were converted to the rates of total (i.e., sum of chemical and physical) denudation rate of the limestone surfaces. The results showed that the nuclide concentrations were of the order of  $10^5$ - $10^6$  atoms  $g^{-1}$ , corresponding to the denudation rates of  $10^{-2}$  mm  $yr^{-1}$  (averages over  $10^4$  yr timescales). The denudation rates were lowest in the central part of Japan, correlating with the climate factors such as mean temperature, precipitation rate, and annual freezing index. This tendency indicates the shift in relative importance of chemical (dissolution) and physical (frost shattering) processes depending on the site climates for the denudation of karst landform.