論文内容の要旨

A study on aridification of the Atacama Desert, South America using in-situ terrestrial cosmogenic nuclides

（岩石中に生成する宇宙線照射生成核種を用いた南米アタカマ砂漠における乾燥化の研究）

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In-situ terrestrial cosmogenic nuclide (TCN) dating technique has developed over the last 20 years. TCNs accumulate with time in the upper several m of exposed surfaces due to interaction with secondary cosmic rays. TCN concentrations on a target surface allow us to estimate erosion rates and exposure ages of landforms directly. The detectable time ranges of TCNs depend on their half-lives. Therefore, TCNs with long-lives (^{10}Be; 1.36 Myr and ^{26}Al; 0.75 Myr) allow us to quantitatively understand landform evolution at mid-latitude areas at million-year time scale.

Today, deserts are distributed across all the three continental mid-latitude areas in the Southern Hemisphere (The South America, Africa and the Australian continents). Recent results of a study based on in-situ TCNs conducted at a mid-latitude Australian dune field and the Namib Desert, Africa indicate that the onset of enhanced aridity may have occurred at ~ 1 Ma, during the Mid Pleistocene Climate Transition (MPT) with a gradual global cooling. However, it is not known whether aridification occurred though the mid-latitude Southern Hemisphere during the MPT.

The Atacama Desert in northern Chile, South America, located adjacent to the eastern Pacific, is one of the most hyper-arid areas in the world. At present, hyperaridity with less than 10 mm precipitation per year is maintained in the Atacama Desert by the Andean rain shadow effect that prevents moisture from Amazon, and the strength of cold Humboldt Current along the Pacific coast. However, the timing of the present-day aridification of the Atacama Desert is poorly understood because previous studies using TCN dating method reported various ages due to older landforms such as alluvial fans reflecting older timings of aridification. It has not been decided which landforms should be selected to sample in order to determine the timing of the aridification.

In this study, in order to determine which landforms suitable are as an indicator of the timing of present-day aridification, landforms from large-hill scale (several km long) to small-hill scale (several hundred long) were investigated. Samples were collected from the summits, hillsides and bottoms of each site. This sampling strategy, in which samples are collected on several elevations and several landform settings such as flat or steep, has not been conducted before.

The results show that surface ages of the higher elevation sites are older than those of the lower elevation sites, at both the large-hill- and small-hill-scale. The surfaces of flat tops exhibit the oldest ages. Therefore, the flat landforms located at higher altitudes are the best geomorphological settings to determine the timing of the present-day aridification. The results reveal that the present-day aridification started at 0.88 - 1.24 Ma, which is deduced from the flat surfaces located at higher altitudes. This study represents the first reporting of the onset of the present-day aridification based on high accuracy measurements of TCNs in this study.

The result suggests that aridification in the mid-latitude Southern Hemisphere during the MPT with global cooling is a hemispheric event based on TCN dating. Together with other climatic proxy data reported previously from deep-sea sediment cores, aridification in the mid-latitude Southern Hemisphere during the MPT may have been controlled by the northward migration of ITCZ.

Finally, the results in this study confirmed that TCN dating is able to use as an indicator of determining timings of aridification on million-year time scale. Also, this study determined that the most suitable landforms for determination of present-day aridification timings are the flat surfaces located at higher altitudes.