A geoarchaeological approach for estimating last glacial temperatures using coupled isotopic analyses of fossil snails and stalagmites from limestone caves in Okinawa, Japan

*Ryuji Asami[1], Rikuto Hondo[2], Ryu Uemura[3], Masaki Fujita[4], Shinji Yamasaki[5], Chuan-Chou Shen[6,7], Chung-Che Wu[6,8], Xiuyang Jiang[9], Hideko Takayanagi[1], Ryuichi Shinjo[10,11], Akihiro Kano[12], Yasufumi Iryu[1]

1. Graduate School of Science, Tohoku University, 2. Faculty of Science, Tohoku University, 3. Graduate School of Environmental Studies, Nagoya University, 4. Department of Anthropology, National Museum of Nature and Science, 5. Okinawa Prefectural Museum & Art Museum, 6. Department of Geosciences, National Taiwan University, 7. Research Center for Future Earth, National Taiwan University, 8. Department of Chemistry and Applied Biosciences, ETH Zurich, 9. College of Geography Science, Fujian Normal University, 10. Research Institute for Humanity and Nature (RIHN), 11. Faculty of Science, University of the Ryukyus, 12. School of Science, the University of Tokyo

We applied a new geoarchaeological method with two carbonate archives, which are fossil snails from Sakitari Cave and stalagmites from Gyokusen Cave, on Okinawa Island, Japan, to reconstruct surface air temperature variations over the northwestern Pacific Ocean since the last glacial period. Oxygen isotope ratios of modern and fossil freshwater snail shells were determined to infer annual and seasonal air temperature variations. The observational and analytical data confirm that oxygen isotopic values of fluid inclusion waters in the stalagmite can be regarded as those of spring waters at the sites where snails lived. Our results indicate that the annual mean, summer, and winter air temperatures were lower by 6–7 ˚C at ca. 23 thousand years ago (ka) and 4–5 ˚C at ca. 16–13 ka than those of the present day. Our reconstruction implies that surface air cooling was possibly two times greater than that of seawater around the Ryukyu Islands during the Last Glacial Maximum, which potentially enhanced the development of the East Asian summer monsoon during the last deglaciation. Considering the potential uncertainties in the temperature estimations, the climatic interpretations of this study are not necessarily definitive due to the limited number of samples. Nevertheless, our new geoarchaeological approach using coupled isotopic determinations of fossil snails and stalagmite fluid inclusion waters can be useful for reconstructing snapshots of seasonally resolved time series of air temperatures during the Quaternary.

Keywords: archaeological cave, stalagmite, fluid inclusion water, freshwater snail, oxygen isotope composition, last glacial temperature

