

【Grant-in-Aid for Scientific Research (S)】

Broad Section A



Title of Project : Quantification of the climate-productivity-population history in Japanese archipelago by refinement of oxygen isotope dendrochronology

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Keyword : Dendrochronology, Oxygen isotope ratio, Japanese archipelago, climate, productivity, population, history

【Purpose and Background of the Research】

Before Medieval period, there were only few quantitative documentary records on productivity and population in Japanese archipelago, limiting our understanding on the dynamics of past human society. Although we can obtain quantitative data on numbers of archaeological remains, it was impossible to convert them to the numbers per a year because Japanese archaeology is principally based on relative dating of pottery typology.

Dendrochronology has a potential to change this situation. It provides us of “histogram of yearly emergence of wooden artefacts in farmlands and villages” related to past productivity and population. On the other hand, it realizes “simulation of agricultural productivity and population” by reconstructing of air temperature and precipitation, the key factor of agriculture productivity. In short, it plays two roles, “proposal” and “verification” of hypotheses on past productivity and population. In the US Southwest where dendroarchaeological studies have been carried out for a long time, climate variations and related changes in agricultural productivity and regional population have been clarified for more than a millennium. However, in Japan, only large conifer woods could be dated using the tree-ring width and it was difficult to reconstruct summer climate that influences agricultural productivity directly.

Recently, we have improved the situation drastically. The establishment of 5000-year length of master chronologies on tree-ring cellulose oxygen isotope ratio over Japan has enabled us to date many hardwoods and small woods and reconstruct past summer climate at annual time resolution. As the result, we have found the tight relationship between climate variation and Japanese history. Hence, the purpose of the research is to create a new quantitative research strategy on human history by integrating of two advantages of oxygen isotopic dendrochronology, “the massive dating of numerous wooden artefacts” and “the simulation of productivity and population”.

【Research Methods】

We can make “histogram of yearly emergence of wooden artefacts” someday as well as US southwest using the oxygen isotopes. However, in this study, we will accelerate the whole procedure by making the intra-ring (seasonal) master chronology, more informative than the interannual one, on cellulose oxygen isotope ratios. We will apply the intra and inter-annual master chronologies of cellulose oxygen isotope ratio to date many small wooden artefacts with only 10-20 year rings which have never been dated

even using oxygen isotope ratios and reconstruct past summer climate at monthly or weekly time resolution, comparable with individual flood and drought events, helpful for precise simulations of past productivity and population.

In order to establish the intra-ring master chronology on the cellulose oxygen isotope ratio, we must collect many big woods with plenty of wide rings from various periods in the past. But it is quite time-consuming. Therefore, at first, we will focus on some important periods, such as Late Yayoi, Early Kofun and Late Kofun periods where the enhanced multi-decadal climate variability might have induced political regime shifts and many big woods have been already collected. For these periods, we will integrate “histogram of yearly emergence of wooden artefacts” and “simulation of productivity and population” to elucidate variations in human societies quantitatively. In this study, we will utilize numerous wooden artefacts like those discarded in the circular trench around village as the indicator of variation in past human activity. At the same time, we will conduct 2D (horizontal) simulations of productivity and population using data on regional differences in climatic and geomorphological conditions to clarify the human migration due to climate changes.

【Expected Research Achievements and Scientific Significance】

From the responses of human societies to climate changes in the past, we can learn important lessons for adopting to on-going global changes. The new quantitative research strategy on history must contribute to the improvement of historical researches. By introducing the analytical skill of oxygen isotope dendrochronology for many related people, we can support sustainable development of investigation of buried cultural properties in Japan and world.

【Publications Relevant to the Project】

- Nakatsuka, T.: “Oxygen Isotope Dendrochronology: Editing Calendar Ages and Weather in Prehistorical and Ancient Eras” Dosei-Sha, Tokyo, 232pp. 2021. (ISBN 9784886218674) in Japanese.
- Nakatsuka, T., M. Sano et al. (2020) : A 2600-year summer climate reconstruction in central Japan by integrating tree-ring stable oxygen and hydrogen isotopes. *Climate of the Past*, **16**, 2153–2172.

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