Abstract No: A-100

CELLULOSE OXYGEN ISOTOPES OF PEAT AS A TOOL OF PALEOCLIMATE RECONSTRUCTION; APPLICATIONS IN RISHIRI AND BORNEO PEATS

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SUMMARY

Technique of cellulose oxygen isotope analysis was applied to the peats from the Rishiri Island, Japan, in the Sea of Japan. Sphagnum remains were carefully separated and their cellulose was purified by lipid extraction and subsequent lignin decomposition processes. The purified cellulose was analyzed by pyrolysis isotope ratio monitoring mass spectrometry to measure its $\delta^{18}O$. The 4000-year record of $\delta^{18}O$ showed millennial scale variation with maxima around 2,500 years ago and the last several centuries. The periods showing heavier $\delta^{18}O$ corresponded to those of the intensified Tsushima Warm Current in the Japan Sea (Koizumi *et al.,* 2006), suggesting that changes in the vapor source affected the oxygen isotopes of precipitated water in the Rishiri Island.

Keywords: *peat, cellulose, oxygen isotopes, paleoclimate, Rishiri Island, Japan*

INTRODUCTION

The oxygen isotope composition of precipitation is sensitive to the atmospheric dynamics. The tree-ring cellulose $\delta^{18}O$ is thus increasingly used for paleoclimate reconstruction of the recent centuries (e.g., Anderson *et al.*, 1998; Roden *et al.*, 1999; Nakatsuka *et al.*, 2004; Sternberg, 2009). Peat contains sphagnum and plant remains, and their $\delta^{18}O$ values are potentially used for long-term climate reconstruction (e.g., Hong *et al.*, 2000). Because the cellulose $\delta^{18}O$ is discriminated in different tissues in a single plant, and the value is also different among different species in a same location, the cellulose $\delta^{18}O$ of a bulk peat sample has a mixed signal of environmental, physiological, biochemical, and ecological conditions, resulting in a complex interpretation on the paleoclimate.

In this study, the difference of $\delta^{18}O$ in different remains in peat samples and reconstructed paleoclimate records from sphagnum and plant tissue cellulose $\delta^{18}O$ in the peats from the Rishiri Island, Japan, in the Sea of Japan were examined.

SAMPLES AND METHODS

Cores MHWL-1 (4.6 m long) and MHWL-3 (4.0 m long) were taken from the Minamihama Swamp developed in a volcanic crater, south of Rishiri Island in the Sea of Japan by a Russian peat sampler on June 2013.

Sphagnum remains and other plant remains were carefully separated by hand picking. Their cellulose was purified by lipid extraction and subsequent lignin decomposition processes (Nakatsuka *et al.*, 2004). The purified cellulose was analyzed using a Finnigan DELTAplus pyrolysis isotope ratio monitoring mass spectrometry to measure its $\delta^{18}O$.

RESULTS

In MHWL-1 core, six different stems, four different roots, and sphagnum moss were separated for 37 samples. In MHWL-3 core, five different stems, four different roots, and sphagnum were separated for 38 samples. Plant tissue remains, i.e., stems and roots, and sphagnum remains show different $\delta^{18}O$ variations. The $\delta^{18}O$ values of plant tissues were generally higher than those of sphagnum. The amplitude of variation was larger in sphagnum (12 permil) than in plant tissues (5 permil). Depth variation of sphagnum $\delta^{18}O$ showed higher values in top 1 m and at around 2.5 m. According to a preliminary age model (Takada *et al.*, 2005; Igarashi, 2006), the former interval corresponded to the last several centuries, while the latter interval corresponded to around 2,500 years ago.

DISCUSSION

The higher $\delta^{18}O$ in plant tissues than in sphagnum is attributed to the condensation of isotopically heavier water molecules in plant body by transpiration via stromata. The transpiration of sphagnum might be limited when the surface of sphagnum is covered by water, resulting in smaller fractionation. Thus, the $\delta^{18}O$ of sphagnum reflects more directly that of precipitated water.

The $\delta^{18}O$ of precipitated water in Rishiri Island was ~2 permil heavier in summer than in winter (Yuta Tsuzuki, unpublished data), but this seasonal variation was not sufficient to explain the changes in sphagnum $\delta^{18}O$. The periods showing heavier $\delta^{18}O$ of sphagnum corresponded to those of the intensified Tsushima Warm Current in the Japan Sea indicated by diatom records (Koizumi *et al.*, 2006). This suggests that changes in the vapor source affected the oxygen isotopes of precipitated water in the Rishiri Island. The intensified Tsushima Warm Current carried warm water to the area of Rishiri Island and may have enhanced evaporation. The shorter transportation of water vapor may have decreased the degree of fractionation of $\delta^{18}O$ in residual water vapor, resulting in higher $\delta^{18}O$ of precipitated water.

The difference of $\delta^{18}O$ between plant tissues and sphagnum indicates the degree of transpiration of plants, which depends on relative humidity. Large difference implies a dry condition. Its difference was larger when the Tsushima Warm Current was weaker. This correspondence suggests that the intrusion of Tsushima Warm Current is a key factor determining precipitation amount and resultant relative humidity in Rishiri Island.

CONCLUSIONS

Our results suggest that sphagnum cellulose $\delta^{18}O$ is useful to understand the $\delta^{18}O$ of precipitated water, while the difference of $\delta^{18}O$ between plant tissues and sphagnum can be used to understand relative humidity. This technique was applied to the reconstruction of hydrological history of Rishiri Island, showing a linkage between the intensity of the Tsushima Warm Current and the precipitation in Rishiri Island. We try to apply this method to Borneo peats. We retrieved peat cores from Marudi and Timbarap areas. We plan to generate paleoclimate records from Borneo peatlands.

REFERENCES

1. Anderson, W.T., Bernasconi, S.N., McKenzie, J.A., 1998. Oxygen and carbon isotopic record of climatic variability in tree ring cellulose (*Picea abies*): An example from central Switzerland (1913-1995). Journal of Geophysical Research 103, 31625-31636.
2. Hong, Y.T., Jiang, H.B., Liu, T.S., Zhou, L.P., Beer, J., Li, H.D., Leng, X.T., Hong, B., Qin, X.G., 2000. Response of climate to solar forcing recorded in a 6000-year d18O time-series of Chinese peat cellulose. The Holocene 10, 1-7.
3. Igarashi, Y., 2006. Late Holocene vegetation history in Minamihama wetland and Numaura wetland, Rishiri Island, Hokkaido. Rhishiri Kenkyu 25, 71-82 (in Japanese).
4. Koizumi, I., Tada, R., Narita, H., Irino, T., Aramaki, T., Oba, T., Yamamoto, H., 2006. Paleoceanographic history around the Tsugaru Strait between the Japan Sea and the Northwest Pacific Ocean since 30 cal kyr BP. Palaeogeography, Palaeoclimatology, Palaeoecology 232, 36–52.
5. Nakatsuka, T., Ohnishi, K., Hara, T., Sumida, A., Mitsuishi, D., Kurita, N., Uemura, S., 2004. Oxygen and carbon isotopic ratios of tree-ring cellulose in a conifer-hardwood mixed forest in northern Japan. Geochemical Journal 38, 77-88.
6. Roden, J.S., Lin, G., Ehleringer, R., 1999. A mechanistic medel for interpretation of hydrogen and oxygen isotope ratios in tree-ring cellulose. Geochimica et Cosmochimica Acta 64, 21-35.
7. Sternberg, L.S.L.O, 2009. Oxygen stable isotope ratios of tree-ring cellulose: the next phase of understanding. New Phytologist 181, 553–562.
8. Takada, M., Kosugi, K., Nogawa, H., Sato, M., 2005. Peat stratigraphy of Minamihama mire and Tanetomi Mire, Rishiri Island, Hokkaido. Rishiri Kenkyu, 24, 49-64 (in Japanese).