Provenance study of excavated amber by the observation of boson peak

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Amber is one of the materials used to buried cultural property that has been excavated from numerous archaeological sites dating from the Jomon, Kofun, Nara, and Heian periods. In Japan, the producing regions of amber are limited, and the physical properties of amber differs from region to region. Therefore, clarifying the provenance of excavated amber by the scientific analysis is important data in the study of ancient distribution and exchange network. Mainly, the previous study has used FT-IR and thermal analysis to estimate the provenance of ancient ambers. On the other hand, the provenance of ancient ambers was studied by archaeological approach. However, there are many differences between the results of archaeological and natural scientific studies. In particular, there have been many negative opinions on the results of scientific analysis that the amber was transported from the Tohoku region to the Kinki region. Therefore, it is essential to establish a more accurate scientific characterization method of ancient ambers for clarifying the ancient distribution and exchange network.

In this study, we attempt to estimate the provenance of amber by neutron inelastic scattering experiments as a new method. The new method is estimated by observation of boson peaks that comparing the peak positions of excavated artifacts with modern samples from each producing region. Amber is fossilized tree resin by the polymerization of terpenes that are 100 million to 10 million years old. Each producing region has different geological formation ages and source plants. The material density of amber will reflect the differences of producing regions. On the other hand, it is reported that the boson peak position and intensity are affected by density [1]. Thus, the producing region of excavated amber will be clarified by measuring the boson peak position as material density.

The neutron scattering study at 5, 100 and 300 K were performed with modern amber from 5 producing regions. Figure 1 shows the differences of neutron scattering spectra at 100K. The boson peaks were observed at around 1 meV, and peak positions were different. Each samples peak position and geological time are shown below.

Choshi:	1.06meV,	110 - 130 Ma
Nakagawa:	1.13meV,	113 - 125 Ma
Kuji:	1.27meV,	83 - 89 Ma
Kitakyushu:	1.23meV,	23 - 65 Ma
Mizunami:	1.20meV,	10 - 16 Ma

It is clear that the boson peak position of each sampling region is different, so that identification can be from measuring boson peak. However, correlation was not found between peak positions and geological age, which is an issue for further study.

[1] H. Nakagawa *et al.*, Biophysical journal, **117**, 229-238 (2019)

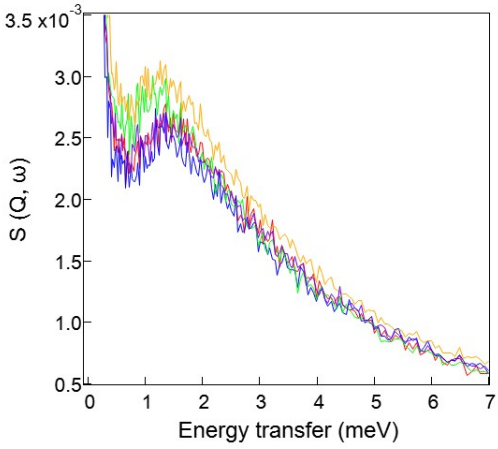

Fig. 1 Inelastic neutron scattering spectra of amber, *green*, *yellow*, *red*, *purple* and *blue* show Choshi, Nakagawa, Kuji, Kitakyushu and Mizunami amber, respectively.