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Preliminary Study on the Provenance Interpretation of Obsidian Artifacts using Neutron Activation Analysis

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1. Introduction

Obsidian is a glassy rock formed by rapid cooling of silica-rich rhyolitic magma [1], and it had been used as a tool material during the prehistoric time. In the previous studies, the provenance of the obsidian artifacts has been estimated by comparing their geochemical compositions with those of the presumed source rocks. In the case that the obsidian artifacts are treated as a prehistoric cultural property, we cannot analyze them using destructive analytical methods. In this study, we compared geochemical data obtained by NAA with that by the other method, and examined the applicability of the NAA method to interpret the provenance of the obsidian artifacts.

2. Materials and Methods

2.1 Obsidians

Obsidian occurrence is spatially restricted to the volcanic area. According to the recent researches, the provenance of the obsidian artifacts in South Korea could be mainly divided into two groups. The first group is composed of the obsidian artifacts from the southern part of South Korea, which has genetic similarity to the Kyushu obsidians (Wolsoengdong, Dongsamdong, Tongyeong, Yeosu site in Fig. 1)[2,3,4]. The second one is of those from the central parts, which has similar features to the Baekdusan obsidians (Neulgeori, Tonghyeonri, Millakdong, Hahwagyeri, Hopyeongdong, Jangheungri, Suyanggae site in Fig. 1)[5,6,7,8].

2.2 Neutron Activation Analysis

Neutron Activation Analysis(NAA) is a very sensitive, powerful technique for identifying characteristics of many elements through performing both qualitative and quantitative analysis in samples [9]. NAA has strength in terms of no matrix effect, no need of chemical-preparation process, and high sensitivity.

The reference values and the NAA results for both geostandard samples of USGS (U.S. Geological survey) and GSJ (Geological Survey of Japan) were compared with each other to check the validity of neutron activation analysis. Also, we analyzed the obsidian samples from the North Korean side Baekdusan and Kyushu Koshidake, Japan. NAA was carried out at DALAT Nuclear Research reactor in Vietnam and analytical conditions are presented in Table 1.

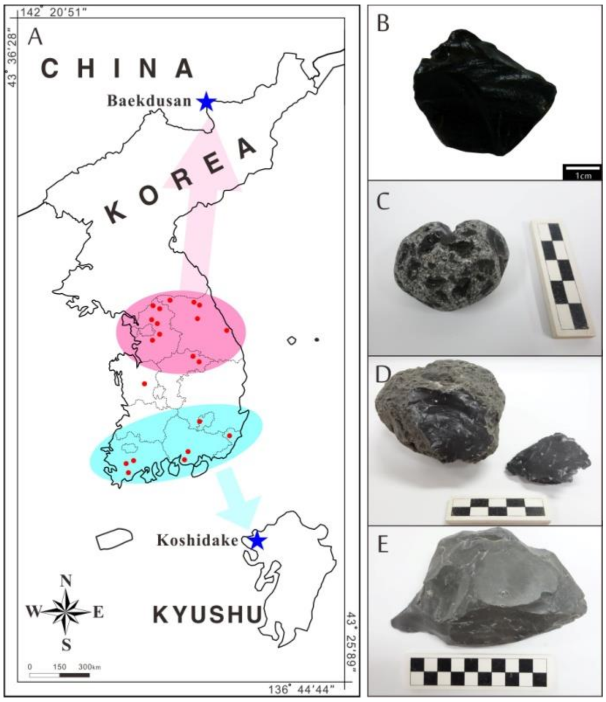

Fig. 1. A; Major prehistoric sites where obsidian artifacts excavated in South Korea, B~E; obsidian samples for NAA, B; Baekdusan obsidian, C,D,E; Kyushu obsidians.

Table 1. Analytical condition of NAA.

weight	Neutron Flux	Irradia-tion time	Decay time	Counting time	Elements
~100 mg	Rotary Rack (~3.5 x 10^{12} n/cm^2.s)	10 h	2-3 d	1 h	Na, K, As, La, Sm,
			20-30 d	3-5 h	Sc, Cr, Fe, Co, Zn, Rb, Cs, Ba, Ce, Eu, Tb, Yb, Hf, Ta, Th

3. Result and Discussion

Fig. 2 shows the NAA values relative to the reference values for geostandard samples according to the characteristic gamma-ray energy. In addition we compared the geochemical data obtained by NAA with those by the other analytical method (LA-ICP-MS; Baekdusan data from [10], Kyushu data unpublished), and applied it to the provenance interpretation of the obsidian artifacts from various origins.

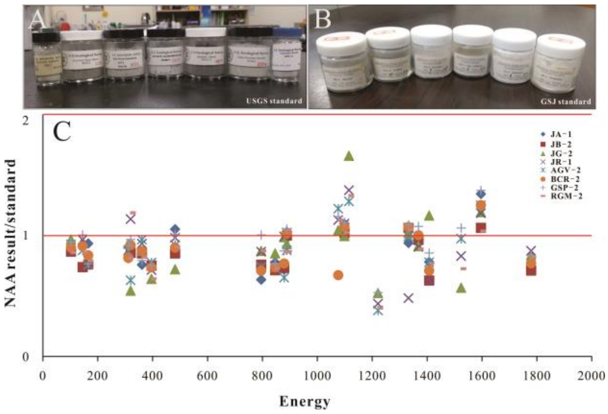

Fig. 2. A; USGS geostandard samples, B; GSJ geostandard samples, C; Relative ratios of two data with elemental energy.

The NAA values of some trace elements for the obsidians are listed in Table 2 and shown in Fig. 3. Both the NAA and the LA-ICP-MS data show a general similarity in elemental variation. In particular, it is possible to distinguish Baekdusan obsidians from Kyushu obsidians. This kind of contrast between the Baekdusan and the Kyushu obsidians would reflect the different magma composition at the different tectonic and geologic settings. In general the geochemical composition of obsidian is closely related to the accompanied volcanic rocks. For more detailed estimation of obsidian provenance, we should use the geochemical compositions of obsidians as well as volcanic rocks.

Table 2. Element contents (ppm) of the Baekdusan obsidians and the Kyushu obsidians, Japan.

	Baekdusan		**Kyushu, Japan**
	NK	**baekdu**	**K11-A**
Yb	3.5±4.9	7.2±2.7	1.5±6
Rb	267.6±4.5	382.9±2.7	166.9±3.8
Sm	10.36±1.2	39.09±0.4	3.623±1.0
Co	0.5±12.7	0.6±7.5	0.8±5.8
Th	26.0±1.2	36.9±0.7	14.2±1.1
Cs	3.7±3.4	4.1±2.4	8.9±1.2
Ce	130.6±1.3	388.5±0.5	59.9±1.4
Tb	1.5±3.2	4.2±1.5	0.5±5.4
	Kyushu, Japan		
	K14	**K14-C**	**K15-2**
Yb	1.2±7.3	1.2±6.4	1.4±5.7
Rb	150.8±4.0	139.4±4.2	189.2±3.3
Sm	3.166±2.4	3.01±1.6	2.8±1.5
Co	-	0.6±6.8	0.6±6.7
Th	14.1±1.1	13.5±1.1	14.4±1.0
Cs	5.2±1.5	5.4±1.6	9.7±1.1
Ce	55.2±1.4	53.7±1.4	38.5±1.8
Tb	0.2±17.7	0.4±7.9	0.54.7

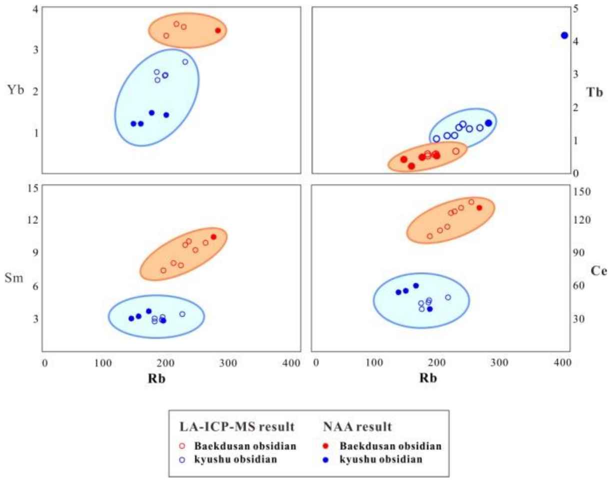

Fig. 3. Bivariate plots of trace elements variation.

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