PIXE for the provenance study of obsidian artefacts from Paleolithic sites in Korea

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1. Introduction

We have collected obsidians from several Upper Paleolithic sites in Korea, with radiocarbon dates in the range of 15000~25000 yrs. BP. The prime concern in the field of Upper Paleolithic study is microlithic industry, of which many were made of obsidians . The provenance of obsidians may be valuable for tracing the beginning and the propagation of microlithic tools. The general belief is that the obsidians in Korean archaeological sites are introduced through two major sources: one from northern part of Korean Peninsula, mostly from Paektusan volcano, the other from Japan.

PIXE measurements were carried out on obsidian artifacts for the provenance study,using Seoul National University 3 MV Tandetron AMS facility. In addition, we also made some comparisons with results from other analytic methods such as neutron activation analysis.

2. Status of source studies

Source obsidians are the most important part in the provenance study of the archaeological obsidians. In the following, we give the present status of studies on Paektusan sources and Japanese sources relevant to Korean obsidian archaeology.

2-1. Paektusan sources:

Paektusan obsidians were extensively studied by Kuzmin et al.(Kuzmin et al. 2002:741-749, Kuzmin et al. 2002:505-515].

More recently, the same group, Popov et al. 2005 has identified three different types of Paektusan volcano obsidians : namely,Paektusan volcano-1[PNK1], Paektusan volcano-2[PNK2] and Paektusan volcano-3[PNK3], by analysing geological rocks collected in field trips to Paektusan, combined with studying archaeological obsidians from southern Primorye region .

Also some additional obsidians related to Paektusan source are analysed by PIXE in our laboratory (see section 4) : Two obsidians claimed to be brought from an Early Iron age site in Hunchun, China and two obsidians from a Neolithic site in Chungjin, the coastal city of North Korea, 100 km south east from Pectusan (Hong 2005).

2-2. Japanese sources:

Source obsidians of Hokaido area, namely, Shiradaki-A, Shiradaki-B, and Oketo volcano have been previously studied by Kuzmin et al. 2002.

We have also procured some Japanese source obsidians from Japan: 2 Koshidake from Kyushu, 2 Shiradaki from Hokaido, and 2 Hariojima obsidians. Our PIXE analyses for the Shiradaki obsidians were in good agreement with those of Kuzmin et al. 2002.

3. PIXE analyses

An external beam PIXE system was constructed on the 15 deg. exit port of the multipurpose beam line of the Seoul National University AMS Tandetron accelerator (Kim et al. 1999). Proton beams of 2 MeV energy were extracted through a 10 mcm thick Kapton window and were used to bombard obsidian samples. The samples were accurately positioned using crossed laser beams. X-rays were detected using a Si[Li] detector. PIXE measurements of obsidian samples are attractive since it is nondestructive. However, One should bear in mind that the method allows only the surface part of the sample and this surface measurements induces some errors in two respects. First error will be associated with the surface weathering. The weathered surface might change its chemical composition of certain elements by effects of ion exchange mechanism with surrounding environments such as moisture ,alkalinity/acidity etc.. The second error will be the geometry for the X-ray absorption, the curved surfaces of obsidians causes angular uncertainties for thebeam impinging on the target , thereby bringing about additional errors in measurements. Low energy X-rays from elements such as Si, Cl, K, and Ca are to be affected more sensitively by this angular effect. For this reason, we have confined our measurements, by using low energy X-ray absorber, to heavier elements such as Zn, Fe, Mn, Rb, Sr, Zr, and Nb. We have measured a sum of 50 obsidians: 30 [in waste flake form] from the Hopyung Paleolthic site, 10 [waste flakes form] from the Samri Paleolthic site, and 10 from Shinbuk Paleolthic site. And we have also measured additional 4 obsidians of the Paektusan related source materials and 6 obsidians as references for Japanese source .

4. Results and discussions

Table 1 summarizes results of the present study of provenances by characterizing obsidians from Paleolithic sites in Korean peninsula. From total number of 75 obsidians studied in the present work, 64 obsidians are of Pectusan origin and the rest is 4 obsidians from Japan and 7 obsidians of unknown origin. If we take only identified ones into our consideration, all the Paleolithic sites in Korean peninsula produced only Paektusan obsidians with a sole exception of the Shinbuk ,where a few Japanese obsidians were also found. To show the capability of our PIXE results for the source discrimination, we have made a two dimensional plot of Zr/Fe vs. Rb/Fe for the obsidians of Hopyung, Samri, and Shinbuk sites in Fig.1. This figure shows clearly separated 4 islands: in counter clockwise order from the top of the figure, Paektusan 2 origin, Japan origin, Paektusan 1 origin, and a group of unknown two obsidians in the far right side. Shinbuk results are very interesting in two respects; The first is that the finding of three Pectusan obsidians in this site, which is located in the southern end of Korean peninsula, proves a very long distance travelling of ~800 Km. About the same distance of travelling of Pectusan obsidians has been sighted in Russian Far East Primorye region site (Kuzmin et al. 2002: 505-515).

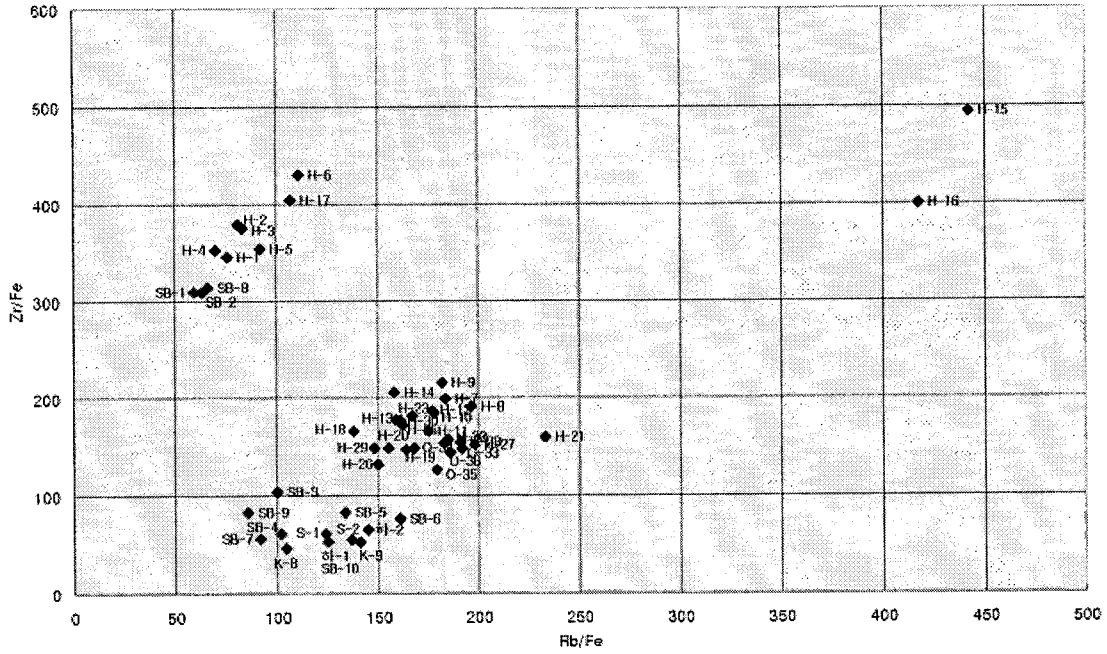

Fig. 1 Two dimensional plot of Rb/Feand Zr/Fe for the obsidians from the Hopyung [H], Samri [S], Shinbuk[SB] Paleolthic sites. Also plotted are source obsidians from Koshidake[K], Chungjin-Hunchun[O]. See the text for the source group assignment.

Table 1: Summary of source identifications

	n	Pectusan #1	Pectusan #2	Japan	Unknown	method[lab.]
Hahwageri	6	1	5			NAA[Missouri][1]
Suyangge	8	6	2			NAA[KAERI][2]
Sangmuyongri	21	19			2	NAA[KAERI][3]
Hopyung	20	11	7		2	PIXE[present]
Samri	10	10				PIXE[present]
Shinbuk	10		3	4	3	PIXE[present]
Total	75	47	17	4	7	

1. Choi and Yu 2005 2. Lee et al. 2004:37-50 3. Cho et al. 2005

The second is that Shinbuk is the only Paleolithic site in Korean peninsula which produced Japan originated obsidians so far. The presence of 4 Japanese origin obsidians in this site could be regarded as a direct evidence of contact between Korean peninsula and Japanese archipelago at the time of as early as ~20000 BP.

This paper is the first report of finding abundant Paekusan obsidians in Korean peninsula, albeit. There was a report of Kuzmin et al.(Choi et al. 2005) on Hahwageri obsidians.

The present analyses shows that from 3 kinds of Paektusan obsidians of PNK1, PNK2 and PNK3, only PNK1 and PNK2 had been used for the tool making by the Paleolithic people in Korean peninsula and it is known (Popov et al. 2005) that the material property of PNK1 is the best for the tool making and that of PNK3 is not suitable for the tool making . Maybe, this is why PNK1 is most populously excavated from the archaeological sites. However, previous researchers failed to identify this Paektusan obsidians in archaeological site in Korean Peninsula and this was soley due to not being able to find any source outcrop, in particular, of PNK1. While it seems that there still need to be more field works for the PNK sources, one could wonder what is the reason that the most abundant obsidians in 20000 yrs. old archaeological sites are difficult to find their outcrops in Paektusan area at the present day. one plausible expanation will be the catastrophic eruption of recent Paektusan volcano in ca. 1000 AD. This huge volcanic event-approximately 25 km^3 of magma was erupted which is much larger than the Pinatubo volcano [ca. 7 km^3] in 1991 AD (Horn and Schmincke 2000)- may be attributed to the difficulty or absence of outcrops of Pectusan type 1 obsidian at the present day.

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