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Obsidian resource use from the Jomon to Okhotsk period on Rebun Island: An analysis of archaeological obsidian

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ABSTRACT

Hokkaido obsidian sources have been widely exploited by hunter-gatherer groups in Northeast Asia since the Upper Paleolithic (~30,000 cal. BP). Rebun Island is located 50 km from the northwest tip of Hokkaido in the Sea of Japan. Given that obsidian does not occur naturally on Rebun Island, all obsidian materials found there are the result prehistoric transportation of these resources. Examination of 133 obsidian artifacts collected from excavations on Rebun Island employing portable X-ray fluorescence (pXRF) provides data for assessment of obsidian resource use during the Middle Jomon, Epi-Jomon, and Okhotsk periods on Rebun Island. Previously published data are also consulted for the Late and Final Jomon, and Epi-Jomon period on Rebun Island. The findings of this study suggest that the most prevalent changes in obsidian resource use on Rebun Island occur between the Middle and Late Jomon periods, and the Late Jomon and Okhotsk periods. These results demonstrate that variation in obsidian resource use during these periods is closely associated with patterns of culture change, in Hokkaido, and on Rebun Island.

1. Introduction

Hokkaido, the most northern of the four main Japanese islands, is situated on two volcanic arcs between the Sea of Japan, the Sea of Okhotsk, and the Pacific Ocean (Izuho and Hirose, 2010). The use of Hokkaido obsidian for lithic tool production began by approximately 30,000 cal. BP (Imamura, 1996; Izuho and Sato, 2007; Kikuchi, 1986; Kobayashi, 2004; Mizoguchi, 2002). At this time, obsidian gravels from the Shirataki source located in northeastern Hokkaido were utilized by early hunter-gatherers (Izuho and Hirose, 2010). There are 21 known sources for obsidian in Hokkaido (Fig. 1), with the most widely exploited being Shirataki and Oketo sources (Ferguson et al., 2014; Hall and Kimura, 2002; Izuho and Sato, 2007; Wada et al., 2014). Obsidian from Hokkaido has been recovered from archaeological sites in Amur River Basin, Sakhalin Island, and throughout the Kuril Islands (Gjesfjeld and Phillips, 2013; Ferguson et al., 2014; Phillips, 2010, 2011; Phillips and Speakman, 2009; Kuzmin, 2006, 2010, 2011, 2012; Kuzmin and Glascock, 2007; Kuzmin et al., 2002; Kuzmin et al., 2013). Despite the presence of locally available lithic materials in these regions, the high quality obsidians found in Hokkaido were likely important resources for facilitating and maintaining exchange networks, and for the production of lithic tools (Fitzhugh et al., 2004; Kuzmin et al., 2002; Kuzmin and Glascock, 2007; Phillips, 2011). Therefore, the distribution of Hokkaido obsidian into neighbouring geographic regions indicates the long-standing use and transportation of these resources by prehistoric hunter-gatherers. Obsidian provenance research in Hokkaido has slowly grown since the early 2000′s. However, few provenance studies have been conducted on obsidian artifacts found on Rebun Island (Tomura et al., 2003).

Rebun Island is located approximately 50 km west of the northernmost tip of Hokkaido, and approximately 95 km south-southwest of Sakhalin Island. Despite the peripheral location of Rebun Island to these larger islands, hunter-gatherers are suspected to have occupied Rebun Island since approximately 20,000 BP (Sakaguchi, 2007a, 2007b). Obsidian does not occur naturally on Rebun Island. Therefore, all obsidian found on Rebun Island is the result of the transportation of these resources to Rebun, via direct procurement, or through exchange with local groups in Hokkaido.

In this study, the provenance of 133 obsidian artifacts, including finished tools and debitage, is determined using portable energy dispersive X-ray fluorescence (pXRF). These artifacts are derived from Middle Jomon, Epi-Jomon and Okhotsk period sites found on Rebun Island. Geological reference samples of obsidian collected from primary and secondary deposit in Hokkaido were also analyzed by pXRF to determine artifact provenance. Additionally, the results of this study are compared with the findings from earlier research in order to examine how culture change in Hokkaido may have influenced obsidian resource use on

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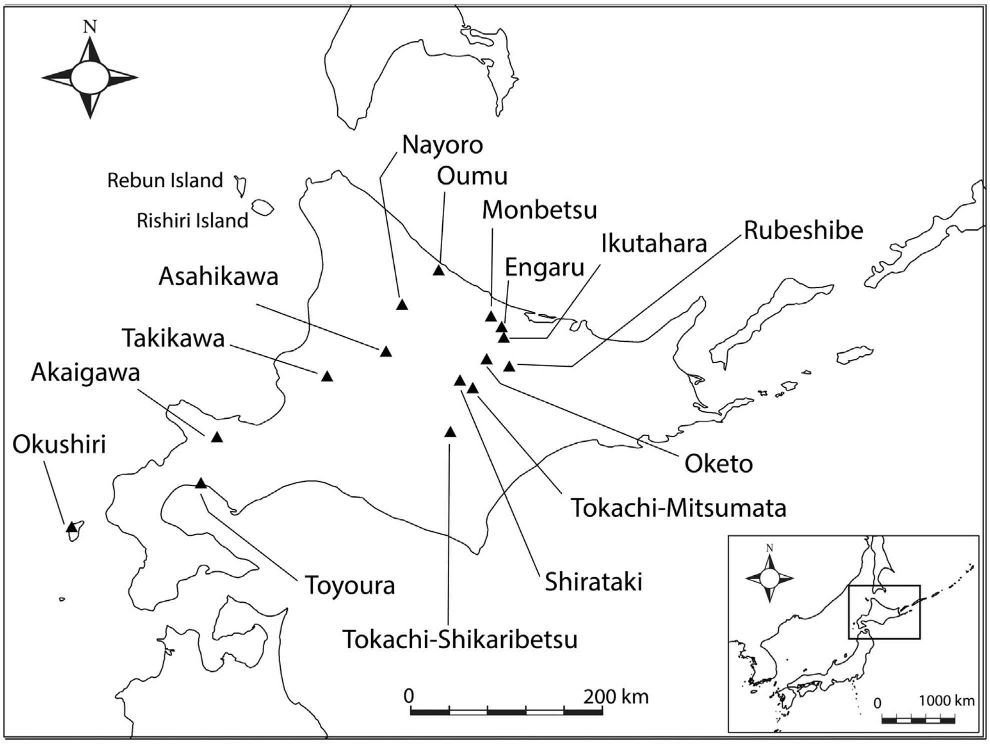

Fig. 1. Map of analyzed obsidian source in Hokkaido. The triangles indicate the approximate location of the obsidian source.

Rebun Island. These results shed new light on the lithic raw material industry of hunter-gatherers on Rebun Island for the Middle Jomon, Epi-Jomon and Okhotsk periods.

1.1. Archaeological context of Hokkaido and Rebun Island

The archaeological record of Hokkaido is unique when compared to the rest of Japanese archipelago. This is uniqueness is attributed to the perpetuation of hunter-gatherer life-ways in Hokkaido after wet-rice agriculture, brought by the immigrating Yayoi culture from the Korean peninsula by approximately 2800 BP, became widespread in western Japan (Aikens and Higuchi, 1982; Crawford, 2008, 2011; Habu, 2004; Hudson, 2004; Matsui and Kanehara, 2006; Okada, 1998a; Okada, 1998b; Yamaura, 1998). Current archaeological, genetic, and osteological evidence have further distinguished the prehistoric inhabitants of Hokkaido from their contemporaries found in western Japan (Akazawa, 1986; Befu and Chard, 1964; Chisholm et al., 1992; Fukase et al., 2012; Ishida, 1996; Minagawa and Akazawa, 1992; Okada, 1998a; Okada, 1998b; Sato et al., 2007; Temple and Matsumura, 2011; Yamaura, 1998). During the Holocene, the hunter-gatherer groups of Hokkaido included the Jomon: Incipient, Early, Middle, Late and Final phases (14,000–2700 cal. BP), Epi-Jomon (2700–1500 cal. BP), Okhotsk (6th–10th cent. CE), Satsumon (7th–13th cent. CE), and Ainu (13th–19th cent. CE) (Weber et al., 2013). During these cultural periods, elaborate exchange networks facilitated the movement of obsidian, jade, bitumen, ceramics, and shells between Hokkaido, western Japan, and Northeast Asia (Hall and Kimura, 2002; Hudson, 2004; Kato et al., 2008; Kuzmin et al., 2013; Oxenham et al., 2006).

The identification of microblades, microcores and tanged points from Rebun Island suggest the earliest occupations of Rebun Island occurred during the Late Paleolithic (20,000 to 11,000 cal. BCE) (Sakaguchi, 2007a). However, the first long-term occupations of Rebun Island are dated to the Middle Jomon period (2950 cal. BCE) (Sakaguchi, 2007a). Well-established occupations of Rebun Island did not occur until the Late Jomon period (2470 cal. BCE) (Sakaguchi, 2007a, 2007b). Archaeological sites Uedomari 3, Kafukai 1, and Hamanaka 2 (Fig. 2) were selected given the availability of archaeological obsidian samples suitable for pXRF analysis (i.e., ≥5 mm thick and ≥10 mm wide, with relatively flat surfaces).

The Middle Jomon site Uedomari 3 was excavated in 1984 by the Hokkaido Archaeological Resources Center (Keally, 1990: 21). The site has been dated to approximately 2950–2470 cal. BCE, and included 5 dwelling pits, 14 small pits, 1 stone-encircled hearth, 57 fireplaces and 2 refuse areas (Keally, 1990:21; Sakaguchi, 2007a). Large flame-rimed pots typical of the Jomon period were recovered from Uedomari 3. The ceramic styles identified at Uedomari 3 are associated with the Ento Upper and Rouletted styles found in Hokkaido (Keally, 1990). The Ento Upper style is typically associated with Middle Jomon of southwestern Hokkaido, and is seldom found further north than Sapporo (Kobayashi et al., 1992). The Rouletted style is generally associated with Middle Jomon groups found in northeastern Hokkaido (Keally, 1990; Kobayashi et al., 1992).

Kafukai 1 contains archaeological remains from the early to late phases of the Okhotsk culture (1500–800 cal. BP). The site was excavated from 1968 to 1971 by members of the Research Institute for the Study of North Eurasian Culture on Rebun, Faculty of Literature, Hokkaido University (Ohyi, 1981: 711). The Okhotsk complex at Kafukai 1 contains semi-subterranean hexagonal and rectangular pit-houses typical of Okhotsk residential sites, as well as human burials, and lithic, ceramic, metal artifacts, and midden deposits containing shellfish, fish, and sea mammal remains (Ohyi, 1981). Juvenile bear crania recovered from four of the six house pits at Kafukai 1 indicate contact between Hokkaido and Rebun Island during this period, given that bears are not native to Rebun Island. Mitochondrial DNA analysis of these bear remains revealed that the lineages of three of these animals were derived from central, and southwestern Hokkaido (Masuda et al., 2001).

Hamanaka 2 is a multi-component shell-midden site spread between various locations in the village of Hamanaka (Sakaguchi, 2007a: 29). Excavations at Hamanaka 2 have been carried out by Japanese archaeologists consistently since the 1990's. The oldest deposits at Hamanaka 2 date to the Late Jomon (2470 to 1250 cal. BCE) and Final Jomon periods (880 to 790 cal. BCE) (Nishimoto, 2000, Sakaguchi,

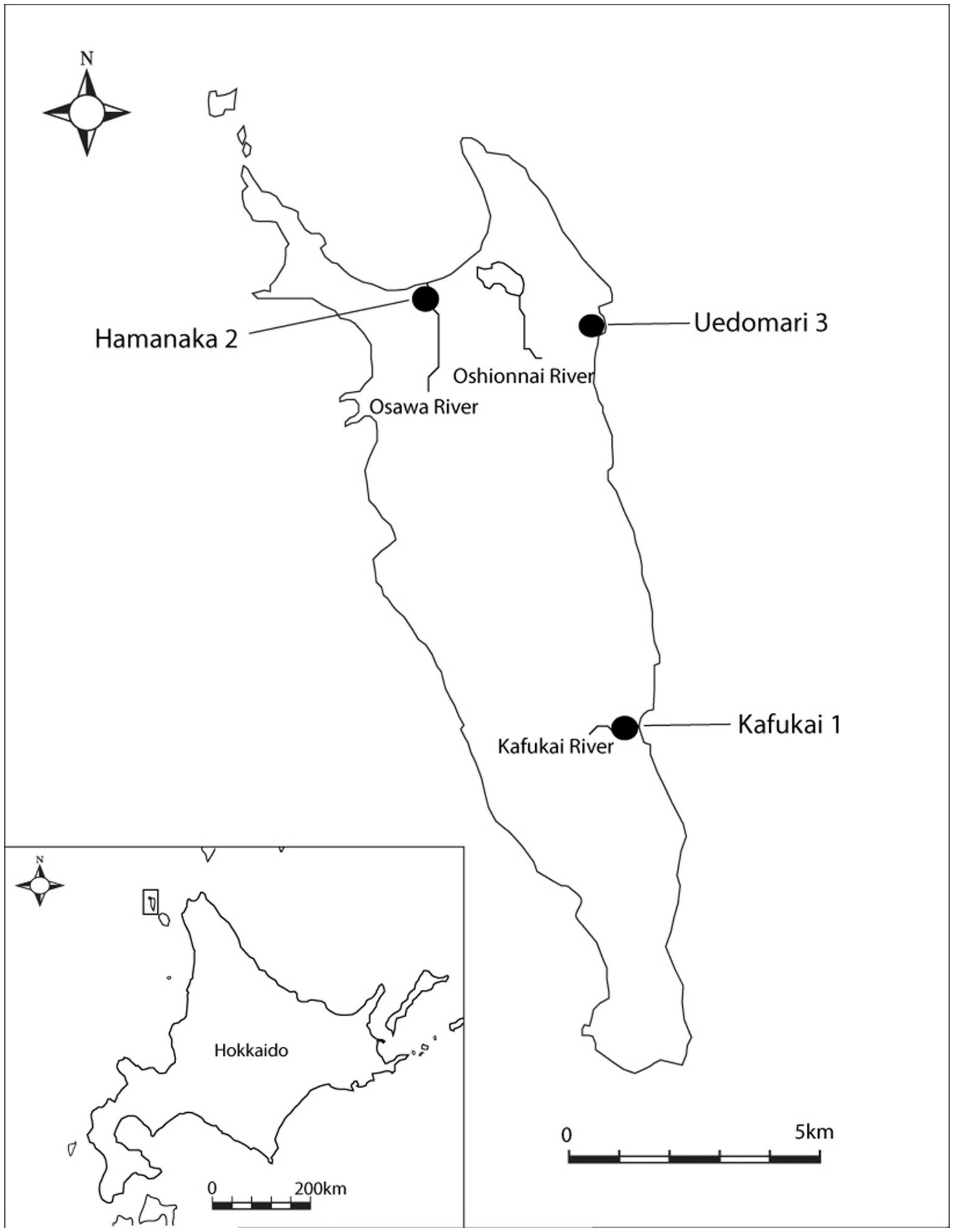

Fig. 2. Map of examined archaeological sites on Rebun Island. The dots indicate relative location of the examined archaeological sites.

2007a, 2007b). However, only Okhotsk and Epi-Jomon materials collected during the 2011 and 2013 excavations by the Baikal-Hokkaido Archaeology Project (BHAP) were used for this study. These layers have yet to be dated by the BHAP, however earlier research at Hamanaka 2 has dated Epi-Jomon occupation from 200 to 100 BCE, and the Okhotsk occupation from 500 CE to 1000 CE (see Sakaguchi 2007b). The Okhotsk layer features a well-stratified shell-midden, deposited on a sand dune formation, and contained human and dog burials, ceramic and lithic materials, as well as an abundance of sea mammal, fishes and shellfish remains. The Epi-Jomon layer excavated by the BHAP at Hamanaka 2 is found below the Okhotsk shell-midden layer in an intact sand dune formation. The Epi-Jomon layer lacks a shell-midden, but contains, lithic artifacts, cord-marked ceramics, concentric hearth features, and dog butchering areas. Excavation of Hamanaka 2 by the BHAP is ongoing.

2. Materials and methods

In total, 133 obsidian artifacts from Rebun Island were analyzed for this study: Uedomari 3 (n = 51), Kafukai 1 (n = 49), and Hamanaka 2 (n = 33). From the Hamanaka 2 assemblage, 18 specimens are derived from the Epi-Jomon period layer, while the remaining 15 specimens are derived from the Okhotsk layer. The analysis focused on finished tools such as projectile points and scrapers, but also included flake debitage. Reference samples from Hokkaido obsidian deposits, and sub-deposits, were analyzed at the Asahikawa City Museum, Hokkaido. These samples were collected from the known primary and secondary deposits.

All archaeological and geological specimens were analyzed with a Bruker AXS Tracer III-SD hand-held X-ray fluorescence spectrometer. Artifacts and reference materials were analyzed at 40 kV, 30 μA, with the Bruker AXS “green” filter (0.3047-mm aluminum, 0.0254-mm titanium, 0.1523-mm copper), for 300 s. X-ray counts are converted to parts per-million (ppm) concentrations using the Bruker Obsidian Calibration. This calibration contains the concentration values of some 40 obsidian sources that have been well characterized by instrumental neutron activation analysis (INAA), inductively coupled plasma mass spectrometry (ICP-MS) and laser ablation ICP-MS (Speakman, 2012). The samples used in this calibration provide a spectrum of element concentrations from low to high energy elements, with an emphasis on elements which are typically well quantified by XRF (Speakman, 2012). The elements quantified by the Bruker Obsidian calibration include manganese (Mn), iron (Fe), zinc (Zn), gallium (Ga), thorium (Th), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr) and niobium (Nb) (Speakman, 2012).

Trace elements Rb, Sr and Zr are often unique to individual obsidian deposits, given that as large ions, they are incompatible with crystalizing solids (Tykot, 2004; Speakman, 2012). As a magma chamber transforms overtime by melting and absorbing crustal materials, the concentrations of these trace elements continue to change until obsidian producing lavas are erupted (Tykot, 2004). This is why a single obsidian source location may contain multiple chemically distinct obsidian deposits. These trace elements have been successfully characterized in previous obsidian studies via pXRF, and have allowed researchers to differentiate obsidian materials and source artifacts (Craig et al., 2007; Ferguson et al., 2014; Nazaroff et al., 2010; Phillips and Speakman, 2009; Reimer, 2015). Therefore, these elements were used to differentiate the obsidian materials analyzed in this study.

The statistical package MURRAP created by members of the Missouri University Research Reactor (MURR) Archaeometry Laboratory, designed for the GAUSS program was used to aid in the differentiation of artifacts and geological reference materials. Bivariate plots comparing ppm concentrations of Rb, Sr and Zr were used to group the artifacts within source groups for each cultural period. Concentrations for Rb, Sr and Zr determined for individual artifacts were compared to the source materials analyzed in this study, as well as previously published geochemical data to attribute the artifacts to individual sources (see Kuzmin et al., 2013; Kuzmin and Glascock, 2007; Ferguson et al., 2014). Several of the analyzed artifacts are fall outside two standard deviations of element concentrations established for the Hokkaido obsidian deposits analyzed in this study. This is particularly apparent for the artifacts we attribute to the Oketo-Tokoroyama/Oketo-Kitatokoroyama deposit/sub-deposit. This is possibly a result of the limited chemical variability determined for individual sources based on the geological source samples analyzed in this study. However, these results may represent greater variation in currently established element concentrations of individual deposits and sub-deposits in Hokkaido. Additionally, uneven surfaces are known to impact X-ray generation and detection (Ferguson, 2012; Ferguson et al., 2014). As a result, an artifact's surface morphology can impact the detection and quantification of individual elements (Lynch et al., 2016).

3. Results

The concentration values for the analyzed geological source materials are provided in Table 1. These results represent the average of up to three analyses on Hokkaido source materials. Despite the limited number of geological samples available for analysis at the time of this study, these results are in generally good agreement with previously published values for Hokkaido sources (see Ferguson et al., 2014; Hall and Kimura, 2002; Kuzmin et al., 2013; Phillips and Speakman, 2009). Given that standard reference materials such as those produced by the United States Geological Survey (USGS) or the National Institute of Standards and Technology (NIST) were not used to verify instrument precision and accuracy in the field, an obsidian sample derived from the Shirataki-Akaishiyama deposit, later named JPN-1, was reanalyzed 28 times during the analysis of all source materials and artifacts. The reanalysis of JPN-1 demonstrates a high level of instrument precision for the quantified elements based on the low relative standard deviation (RSD), Table 2. To evaluate the accuracy of the pXRF results, sample JPN-1 was reanalyzed by INAA at the University of Alberta SLOWEPOKE-II Nuclear Reactor Facility and by ICP-MS at the University of Alberta, Department of Earth and Atmospheric Sciences. A comparison of the results of these three techniques demonstrate good agreement for elements Rb, Sr and Zr, Table 3 (Lynch et al., 2016). These results verify the accuracy of the pXRF device used in this study, and demonstrate the suitability of this technique for obsidian provenance studies in Hokkaido (Lynch et al., 2016). Published data for obsidian deposits located in Kamchatka, Primorskii Krai, and Honshu were consulted to determine if any of the artifacts were derived from sources outside of Hokkaido (see Glascock et al., 2011; Grebennikov et al., 2010; Suda, 2012). However, all artifacts analyzed in this study are determined to be derived from Hokkaido sources.

The Middle Jomon assemblage from Uedomari 3 is found to contain five sources: Akaigawa, Shirataki-A, Shirataki-B, Rubeshibe-Iwayama

Table 1
pXRF results in ppm concentrations for the Hokkaido obsidian deposits analyzed in this study. Concentration results are rounded to the nearest whole number where possible.

Deposit	Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
Shirataki-A Summit Lava (n = 3)	590 ± 46	9490 ± 464	66 ± 3	35 ± 1	21 ± 1	149 ± 6	31 ± 2	32 ± 0.4	80 ± 3	13 ± 1
Shirataki-A Upper Lava (n = 3)	580 ± 21	9140 ± 322	65 ± 3	35 ± 1	21 ± 1	145 ± 2	30 ± 1	32 ± 0.3	79 ± 2	14 ± 1
Shirataki-B Horoka-Yubetsu (n = 3)	681 ± 51	9753 ± 474	65 ± 3	35 ± 1	21 ± 1	170 ± 7	16 ± 0.4	37 ± 1.6	72 ± 2	15 ± 1
Shirataki-B Tokachi-Ishizawa (n = 3)	665 ± 5	9176 ± 146	63 ± 2	35 ± 1	20 ± 2	171 ± 6	19 ± 9	34 ± 0.3	72 ± 4	15 ± 1
Asahikawa-Syunkodai (n = 3)	736 ± 92	12,930 ± 959	75 ± 2	37 ± 2	22 ± 1	122 ± 6	95 ± 4	29 ± 2	93 ± 2	13 ± 0.1
Asahikawa-Higashitakasu (n = 3)	810 ± 49	16,680 ± 1063	81 ± 9	35 ± 2	20 ± 1	114 ± 5	128 ± 5	28 ± 1	107 ± 0.3	13 ± 0.4
Takikawa (n = 3)	751 ± 54	7764 ± 289	57 ± 3	34 ± 1	27 ± 1	148 ± 2	57 ± 0.3	32 ± 0.3	95 ± 0.5	14 ± 1
Akaigawa (n = 3)	774 ± 46	9472 ± 673	59 ± 3	35 ± 6	28 ± 2	132 ± 6	51 ± 3	31 ± 2	89 ± 2	14 ± 1
Nayoro (n = 2)	471 ± 19	11,640 ± 362	64 ± 2	34 ± 2	22 ± 1	120 ± 1	87 ± 1	24 ± 0.1	113 ± 1	12 ± 1
Engaru-Sanabuchi (n = 3)	692 ± 31	12,200 ± 367	82 ± 5	36 ± 0.5	20 ± 1	120 ± 5	48 ± 1	45 ± 1	135 ± 2	16 ± 0.4
Oumu (n = 3)	351 ± 11	10,555 ± 175	69 ± 2	35 ± 3	20 ± 2	141 ± 9	45 ± 1	48 ± 2	119 ± 6	14 ± 2
Okushiri (n = 3)	1019 ± 51	6160 ± 686	54 ± 2	33 ± 1	26 ± 2	178 ± 9	118 ± 15	22 ± 1	67 ± 1	14 ± 1
Tokachi-Mitsumata (n = 3)	607 ± 10	8885 ± 110	63 ± 3	35 ± 2	21 ± 1	136 ± 3	49 ± 0.3	36 ± 1	89 ± 4	14 ± 1
Tokachi-Shikaribetsu (n = 3)	532 ± 23	11,705 ± 150	67 ± 2	35 ± 1	22 ± 2	123 ± 4	90 ± 1	29 ± 0.2	91 ± 1	13 ± 0.1
Ikutahara-1 (n = 3)	467 ± 18	13,740 ± 527	81 ± 5	35 ± 5	21 ± 4	159 ± 7	48 ± 1	43 ± 0.2	201 ± 12	13 ± 2
Ikutahara-2 (n = 3)	473 ± 14	14,760 ± 52	87 ± 4	41 ± 1	25 ± 1	161 ± 1	50 ± 1	46 ± 1	205 ± 2	15 ± 0.3
Rubeshibe-Iwayama (n = 3)	687 ± 12	14,550 ± 291	78 ± 3	38 ± 1	20 ± 0.3	124 ± 4	97 ± 6	32 ± 0.2	112 ± 4	14 ± 0.3
Rubeshibe-Kayokozawa (n = 3)	733 ± 35	16,070 ± 449	80 ± 1	36 ± 2	20 ± 0.4	115 ± 4	113 ± 3	31 ± 1	123 ± 3	14 ± 1
Toyoura (n = 3)	731 ± 4	9745 ± 118	57 ± 2	31 ± 1	20 ± 0.3	90 ± 3	88 ± 3	29 ± 1	110 ± 4	13 ± 0.3
Monbetsu (n = 3)	429 ± 56	10,120 ± 2081	62 ± 7	34 ± 2	20 ± 2	128 ± 2	61 ± 2	39 ± 2	89 ± 4	13 ± 0.5
Oketo-Oketoyama (n = 3)	574 ± 39	11,500 ± 187	65 ± 1	34 ± 2	18 ± 1	97 ± 1	74 ± 1	28 ± 1	126 ± 1	14 ± 0.3
Oketo-Tokoroyama (n = 3)	557 ± 54	9460 ± 172	57 ± 2	35 ± 2	23 ± 1	136 ± 4	64 ± 1	29 ± 1	102 ± 1	14 ± 1
Oketo-Kitatokoroyama (n = 3)	540 ± 26	9340 ± 300	58 ± 4	34 ± 0.4	22 ± 1	135 ± 2	62 ± 2	28 ± 1	102 ± 1	13 ± 0.3

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Table 2
Results from the multiple pXRF analyses of specimen JPN-1 (based on results from Lynch et al., 2016).

pXRF results	Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
JPN-1 average (n = 28)	598	9300	65	35	22	146	31	33	78	14
Standard deviation	26	200	3	1.4	1	3	1	0.7	1	0.5
RSD (%)	4.4	2.1	4.6	4.0	4.50	2.3	3.1	2.2	1.4	3.9

and Takikawa (Tables 4 and 5, Fig. 3). A majority of the analyzed artifacts from this assemblage are attributed to the Shirataki-A and Shirataki-B deposits located in northeastern Hokkaido, and the Akaigawa deposit, located in southwestern Hokkaido. Three sources were identified in the Epi-Jomon assemblage from Hamanaka 2: Shirataki-A, Akaigawa, and Oketo-Tokoroyama/Oketo-Kitatokoroyama (Tables 5 and 6, Fig. 4). A majority of the artifacts analyzed from the Epi-Jomon assemblage are attributed to the Shirataki-A deposit. In total, four sources were identified from the Okhotsk assemblage from Hamanaka 2: Shirataki- A, Shirataki-B, Akaigawa, and Oketo-Tokoroyama/Oketo-Kitatokoroyama (Tables 5 and 6, Fig. 5). From this assemblage a majority of the artifacts are attributed to the Shirataki-B obsidian deposit. In total, five sources are represented in the analyzed Okhotsk assemblage from Kafukai 1: Shirataki-A, Shirataki-B, Oketo-Tokoroyama/Oketo-Kitatokoroyama, Akaigawa and Toyoura (Tables 5 and 7, Fig. 6). Materials from the Shirataki-A and Shirataki-B deposit are found to compose a majority of the analyzed assemblage from Hamanaka 2. While material from Oketo-Tokoroyama/Oketo-Kitatokoroyama represent a smaller proportion, materials from the southwestern deposits Akaigawa and Toyoura represent a minimal proportion of the analyzed artifacts the Kafukai 1 see Table 8.

Several Hokkaido obsidian deposits, and sub-deposits are known to have overlapping chemical signatures (see Hall and Kimura, 2002; Izuho and Sato, 2007; Ferguson and Izuho, 2013; Ferguson et al., 2014; Kuzmin and Glascock, 2007). In particular, the overlapping concentrations between Akaigawa and Tokachi-Mitsumata for trace elements Rb, Sr and Zr pose a challenge for obsidian provenance studies in Hokkaido due the difficulty in separating the concentrations of these two sources. INAA permits differentiation of these deposits given the greater number of major, trace, and rare-earth elements which can be characterized and compared by this technique (see Kuzmin and Glascock, 2007). However, many of these elements cannot be detected by pXRF as they are beyond the energy excitation levels and detection capabilities of these devices. Based on the pXRF results alone, the artifacts attributed to Akaigawa could equally be attributed to Tokachi-Mitsumata. Therefore, additional research exploring the occurrence of obsidian from Tokachi-Mitsumata in the Hokkaido archaeological record must be considered in addition to the pXRF data. Kuzmin et al. (2013) noted that none of the obsidian artifacts analyzed from the years of obsidian provenance research on Sakhalin Island are attributed to the Tokachi-Mitsumata deposit. Furthermore, Kuzmin et al. (2013) suggest that the use of this resource within Hokkaido during prehistory was limited. Given these assertions, it is possible that obsidian from Tokachi-Mitsumata was not transported to Rebun Island, given the proximity to Sakhalin Island. Additionally, previous obsidian provenance research on Rebun Island, and the neighbouring island of Rishiri, also sports this claim, as none of the artifacts analyzed in these studies are attributed to the Tokachi-Mitsumata deposit (Tomura et al., 2003; Wada et al., 2006). Given these findings, the authors of this study are confident in their attribution of artifacts to the Akaigawa deposit.

4. Discussion

The results presented here demonstrate that the use of specific obsidian resources varied from the Middle Jomon, Epi-Jomon, and Okhotsk periods on Rebun Island at both the source and sub-source level (e.g., Shirataki-A and Shirataki-B). Obsidian resources from several Hokkaido deposits were used by Middle Jomon, Epi-Jomon, and Okhotsk groups on Rebun Island through either direct procurement, or exchange with other groups from Hokkaido. However, the availability of these materials likely varied over time as a result of accessibility, exchange networks, or knowledge of these locations. Tomura et al. (2003) conducted an INAA analysis of 83 obsidian artifacts collected from Late and Final Jomon, and Epi-Jomon period layers at Hamanaka 2. Their research also identified changes in the use of specific obsidian deposits from the Late Jomon to the Epi-Jomon period at Hamanaka 2. The findings of Tomura et al. (2003) and additional archaeological literature from the surrounding region are integrated into the current study to aid in the examination of obsidian resource use on Rebun Island from the Middle Jomon to Okhotsk period.

In this study, the Middle Jomon inhabitants of Uedomari 3 are demonstrated to have had access to obsidian materials from both northeastern and southwestern Hokkaido. The proportion of artifacts attributed to obsidian sources in western and southwestern Hokkaido may indicate the growing centralization of Hokkaido Jomon culture in the southwest during this time. However, the proportion of obsidian derived from northeastern Hokkaido, as well as the presence of Ento Upper and Rouletted series ceramics at this site suggests that Middle Jomon inhabitants of Uedomari 3 were incorporated in exchange systems situated in northeastern and southwestern Hokkaido. No direct correlation was found between obsidian deposit and tool type in the examined Uedomari 3 materials. Several of the obsidian artifacts demonstrate wear on their ventral and dorsal surfaces consistent with transportation damage (Odess and Rasic, 2007); suggesting that these artifacts were moved to Rebun Island from Hokkaido as finished tools.

For the Late Jomon period, Tomura et al. (2003) determined that obsidian from the Akaigawa deposit represents the greatest proportion of the analyzed artifacts from Hamanaka 2. However, by the Final Jomon and Epi-Jomon periods, obsidian from the Shirataki and Oketo sources are represented in greater proportions. Nishimoto (2000) suggests that Late Jomon groups from southwestern Hokkaido traveled seasonally to Rebun Island for seal hunting and producing ceramics on local clays. Therefore, it can be expected that obsidian tools and materials were also transported to Rebun Island for hunting and processing sea mammals. Nishimoto's (2000) hypothesis serves to explain the high proportion of Akaigawa obsidian in the Late Jomon assemblage

Table 3
Geochemical results of JPN-1 from pXRF, INAA and ICP-MS (based on results from Lynch et al., 2016.

Geochemical method	Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
pXRF (n = 28)	598 ± 26±	9300 ± 200	65 ± 3	35 ± 1.4	22 ± 1	146 ± 3	31 ± 1	33 ± 0.7	78 ± 1	14 ± 0.5
INAA (n = 3)	390 ± 7	8353 ± 76	34 ± 1	ND	11.5 ± 0.1	151 ± 1	28 ± 2	ND	84 ± 2	ND
ICP-MS (n = 3)	360 ± 9	8000 ± 274	26 ± 0.6	16 ± 0.3	15 ± 1	152 ± 2	28 ± 2	25 ± 1	64 ± 1	7 ± 0.3

ND not determined.

Table 4
Uedomari 3 Middle Jomon artifact concentration value list in ppm.

Sample	Lithic Type	Source	Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
UEDO1	Projectile Point	Shirataki-B	715	9652	66	39	23	180	17	38	75	17
UEDO2	Projectile Poin	Shirataki-A	614	8727	74	37	25	157	33	34	81	14
UEDO3	Projectile Point	Shirataki-A	685	10,271	84	40	23	169	35	35	85	16
UEDO4	Projectile Point	Shirataki-B	716	9656	65	36	22	172	16	37	72	16
UEDO5	Projectile Point	Shirataki-B	724	9709	74	35	23	175	17	38	72	14
UEDO6	Projectile Point	Akaigawa	763	9469	55	35	28	132	51	31	91	14
UEDO7	Projectile Point	Akaigawa	732	8768	65	35	27	129	50	31	85	14
UEDO8	Projectile Point	Akaigawa	768	9543	60	35	28	131	52	29	88	15
UEDO9	Projectile Point	Akaigawa	754	9242	61	38	27	130	51	31	87	14
UEDO10	Knife	Shirataki-A	613	9701	67	35	22	147	30	33	81	14
UEDO11	Projectile Point	Shirataki-A	594	9791	66	36	23	147	30	31	80	14
UEDO12	Knife	Shirataki-A	607	9539	63	35	20	147	32	33	85	14
UEDO13	Scraper	Akaigawa	767	9403	65	35	28	133	53	31	89	15
UEDO14	Scraper	Akaigawa	693	8827	53	26	22	138	52	29	88	10
UEDO15	Scraper	Akaigawa	727	9485	62	37	28	131	50	30	86	15
UEDO16	Projectile Point	Akaigawa	778	9757	62	38	27	135	54	32	90	15
UEDO17	Projectile Point	Akaigawa	755	9254	64	36	26	132	51	31	86	14
UEDO18	Projectile Point	Akaigawa	739	9542	58	36	29	135	51	31	90	15
UEDO19	Projectile Point	Shirataki-A	648	10,807	66	35	21	154	32	33	81	14
UEDO20	Projectile Point	Rubeshibe-Iwayama	513	11,633	66	39	23	125	94	28	118	14
UEDO21	Projectile Point	Shirataki-B	650	9503	68	37	22	171	17	38	73	16
UEDO22	Projectile Point	Rubeshibe-Iwayama	483	11,919	66	38	24	126	92	27	118	13
UEDO23	Projectile Point	Shirataki-A	614	10,294	69	38	23	152	33	35	81	16
UEDO24	Projectile Point	Shirataki-A	639	10,605	72	40	23	157	33	34	84	16
UEDO25	Projectile Point	Shirataki-A	595	10,347	64	36	23	154	33	33	80	14
UEDO26	Projectile Point	Shirataki-B	715	9889	68	37	21	173	16	37	73	16
UEDO27	Projectile Point	Akaigawa	752	9474	57	35	28	130	50	29	92	15
UEDO28	Projectile Point	Akaigawa	690	9299	54	33	28	132	51	32	89	14
UEDO29	Projectile Point	Rubeshibe-Iwayama	447	12,119	65	37	24	127	92	27	116	13
UEDO30	Projectile Point	Akaigawa	793	9690	69	35	30	135	52	32	90	15
UEDO31	Scraper	Akaigawa	780	9865	64	35	27	133	52	31	91	15
UEDO32	Scraper	Akaigawa	786	9526	59	36	26	132	51	31	87	15
UEDO33	Projectile Point	Shirataki-A	627	10,030	72	37	21	155	32	34	80	14
UEDO34	Projectile Point	Shirataki-A	583	9906	64	35	22	150	33	32	79	14
UEDO35	Projectile Point	Akaigawa	737	9311	58	34	25	132	51	30	88	15
UEDO36	Biface Frag.	Shirataki-A	636	9725	65	34	21	145	32	32	79	14
UEDO37	Projectile Point	Takikawa	680	10,343	71	45	25	154	56	40	95	17
UEDO38	Projectile Point	Shirataki-A	587	9646	94	41	22	146	32	33	85	15
UEDO39	Projectile Point	Shirataki-B	725	9506	63	38	22	180	18	39	75	16
UEDO40	Projectile Point	Akaigawa	757	9562	61	39	29	138	53	32	91	16
UEDO41	Projectile Point	Shirataki-B	746	9705	65	41	21	175	18	38	73	16
UEDO42	Projectile Point	Shirataki-A	632	10,174	67	41	25	153	34	35	81	15
UEDO43	Projectile Point	Shirataki-B	696	9547	64	37	22	169	16	37	71	15
UEDO44	Biface Frag.	Shirataki-A	632	9518	61	37	21	149	32	34	79	14
UEDO45	Scraper	Shirataki-A	635	10,412	63	36	22	152	32	35	83	14
UEDO46	Biface Frag.	Shirataki-A	616	10,130	72	37	22	152	33	33	79	14
UEDO47	Biface Frag.	Shirataki-A	579	9537	66	35	23	144	32	32	80	14
UEDO48	Biface Frag.	Shirataki-A	594	9881	68	38	22	151	33	32	77	15
UEDO49	Biface Frag.	Shirataki-A	671	10,413	70	37	23	152	33	34	83	14
UEDO50	Projectile Point	Akaigawa	716	8984	57	36	25	128	50	30	88	15
UEDO51	Projectile Point	Shirataki-A	640	10,453	65	38	24	155	33	33	79	13

analyzed by Tomura et al. (2003). Additionally, the Late Jomon culture in Hokkaido is suspected to have been centralized in southwestern portion of the island, near modern-day Sapporo (Ikawa-Smith, 1992; Sakaguchi, 2011). Therefore, the presence of a high proportion of obsidian from Akaigawa is to be expected on Rebun Island, if groups from southwestern Hokkaido traveled seasonally to Rebun Island.

As Jomon culture in Honshu and Hokkaido began to decline and decentralize during the Final Jomon period, exchange networks and social ties dissolved, and were replaced by new networks. The Final Jomon assemblage analyzed by Tomura et al. (2003) contains materials predominantly from the Shirataki and Oketo deposits, and fewer from Akaigawa. These findings are significantly different from those determined for the Late Jomon period at Hamanaka 2. Thus, alterations to the socio-political dynamics in Hokkaido, due to the immigration of the Yayoi culture in western Japan, and spread of wet-rice agriculture, possibly resulted in the restructuring of exchange networks for the Final Jomon inhabitants of Rebun Island.

Table 5
Number and percentage of artifacts attributed to each source for each cultural period examined. Artifacts from Kafukai 1 and Hamanaka 2 are added together for the Okhotsk Period. Oketo-Toko/Oketo-Kita refers to Oketo-Tokoroyama/Oketo-Kitatokoroyama.

	Shirataki-A	Shirataki-B	Akaigawa	Rubeshibe-Iwayama	Takikawa	Oketo-Toko/Oketo-Kita	Toyoura	Total
Middle Jomon	21 (41.7%)	8 (15.6%)	18 (35.29%)	3 (6%)	1 (1.96%)	–	–	51 (100%)
Epi-Jomon	16 (88.8%)	–	1 (5.5%)	–	–	1 (5.5%)	–	18 (100%)
Okhotsk	16 (25.0%)	35 (54.6%)	3 (4.6%)	–	–	9 (14.0%)	1 (1.5%)	64 (100%)
Total	53 (39.8%)	43 (32.2%)	23 (17.2%)	3 (2.25%)	–	10 (7.5%)	1 (0.75%)	133 (100%)

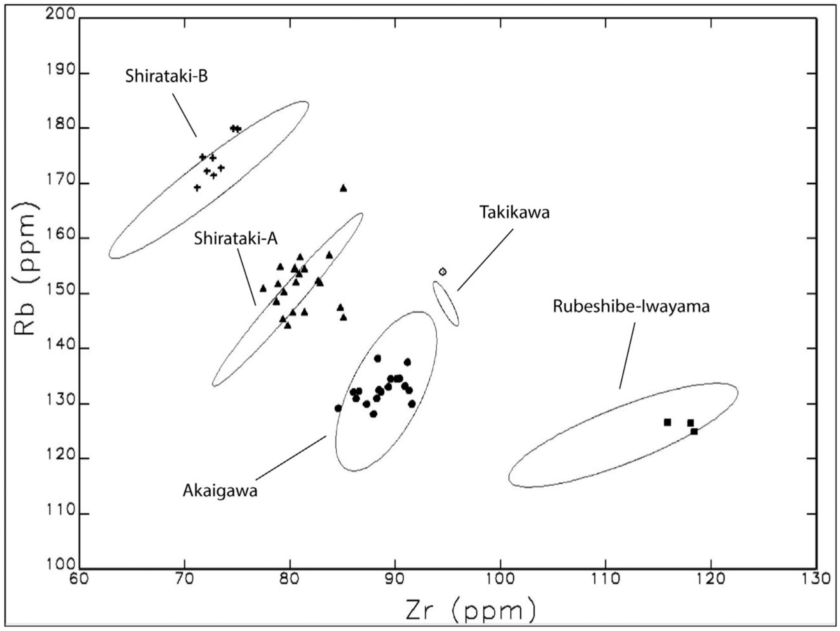

Fig. 3. Uedomari 3 artifact bivariate plot of Zr vs. Rb. Confidence ellipses are drawn at a 95% confidence interval accounting for $\pm 2\sigma$.

The Epi-Jomon assemblage analyzed by Tomura et al. (2003) is composed of obsidian from Shirataki, Oketo deposits, Akaigawa and Asahikawa (Tomura et al., 2003). Although, materials from Shirataki and Oketo compose a majority of materials (Tomura et al., 2003). Wada et al. (2006) examined 76 obsidian artifacts collected from Epi-Jomon period site on Rishiri Island, located approximately 10 km southwest of Rebun, using electron microprobe analysis. Their work demonstrated that a majority of the Epi-Jomon artifacts were derived from the Shirataki and Oketo deposits, while fewer artifacts were attributed to Akaigawa, Asahikawa, and Rubeshibe deposits. These findings agree with those presented by Tomura et al. (2003) and the authors of this study. The elevated proportions of Shirataki obsidian suggest that Epi-Jomon groups on Rebun Island may have acquired this resource directly, or had well established exchange networks with northeastern Hokkaido (Wada et al., 2006).

The Epi-Jomon artifacts analyzed in this study also demonstrate a connection to both northeastern and southwestern Hokkaido given the presence of Shirataki, Oketo, and Akaigawa obsidian. The limited presence of Akaigawa materials in this assemblage may indicate that access to these materials was restricted, or perhaps less significant relative to materials from the Shirataki region, as both sources yield high quality materials for the production of stone tools. Conversely, these materials could be the result of a palimpsest effect, with the Epi-Jomon population at Hamanaka 2 recycling materials left by Late and Final Jomon groups that previously occupied Rebun Island. Alternatively, Epi-Jomon people may have engaged in exchange for these materials with other groups in Hokkaido. Given the identification of southwestern Hokkaido obsidian materials from the Epi-Jomon assemblages analyzed by Tomura et al. (2003), and Wada et al. (2006), it is likely that these resources were also available to Epi-Jomon groups. Additionally, the presence of bipolar flakes in the Epi-Jomon assemblage at Hamanaka 2 suggests that these lithics were produced on site from obsidian raw materials, or pre-shaped cores, rather than brought to Rebun as finished tools.

In this study the Okhotsk materials from Hamanaka 2 and Kafukai 1 contain a high proportion of obsidian from the Shirataki outcrops in northeastern Hokkaido. Similarly, few artifacts from the Okhotsk materials are attributed to sources in southwestern Hokkaido. During its early stages, the Okhotsk culture was limited to the peripheral areas of Hokkaido, as well as Rebun and Rishiri Island, while Epi-Jomon populations were still well established in central and southern Hokkaido

Table 6
Hamanaka 2 Epi-Jomon artifact concentration value list in ppm. Oketo-Toko/Oketo-Kita refers to Oketo-Tokoroyama/Oketo-Kitatokoroyama.

Sample	Lithic type	Source	Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
HA2-01	Bipolar Flake	Shirataki-A	569	9731	76	34	20	148	32	32	78	14
HA2-02	Bipolar Flake	Shirataki-A	597	9948	75	36	20	146	31	33	79	14
HA2-03	Bipolar Flake	Shirataki-A	603	10,226	74	34	21	151	31	32	79	15
HA2-04	Bipolar Flake	Shirataki-A	563	10,100	70	38	20	155	33	33	89	14
HA2-05	Bipolar Flake	Shirataki-A	608	10,720	82	39	22	155	33	32	82	15
HA2-06	Bipolar Flake	Shirataki-A	602	10,048	77	37	20	160	33	34	83	14
HA2-07	Bipolar Flake	Shirataki-A	598	9701	73	39	20	159	33	32	82	14
HA2-08	Bipolar Flake	Shirataki-A	668	11,288	89	41	23	162	36	35	83	14
HA2-09	Bipolar Flake	Shirataki-A	712	11,052	81	42	22	167	36	35	85	16
HA2-10	Bipolar Flake	Shirataki-A	590	10,652	82	42	24	160	34	34	83	16
HA2-11	Bipolar Flake	Shirataki-A	718	12,621	98	47	23	189	39	36	92	17
HA2-12	Bipolar Flake	Shirataki-A	638	10,717	80	34	20	159	32	33	82	13
HA2-13	Bipolar Flake	Shirataki-A	633	10,216	79	39	21	161	33	33	81	14
HA2-14	Bipolar Flake	Shirataki-A	614	9814	71	34	21	149	31	31	79	14
HA2-15	Bipolar Flake	Shirataki-A	638	11,014	85	43	23	171	35	36	87	16
HA2-16	Flake	Shirataki-A	654	11,239	84	44	23	169	37	35	91	16
HA2-17	Bipolar Core Frag.	Akaigawa	716	9743	68	33	27	131	51	32	86	13
HA2-18	Bipolar Flake	Oketo-Toko/Oketo-Kita	512	9806	67	39	21	148	68	31	109	14

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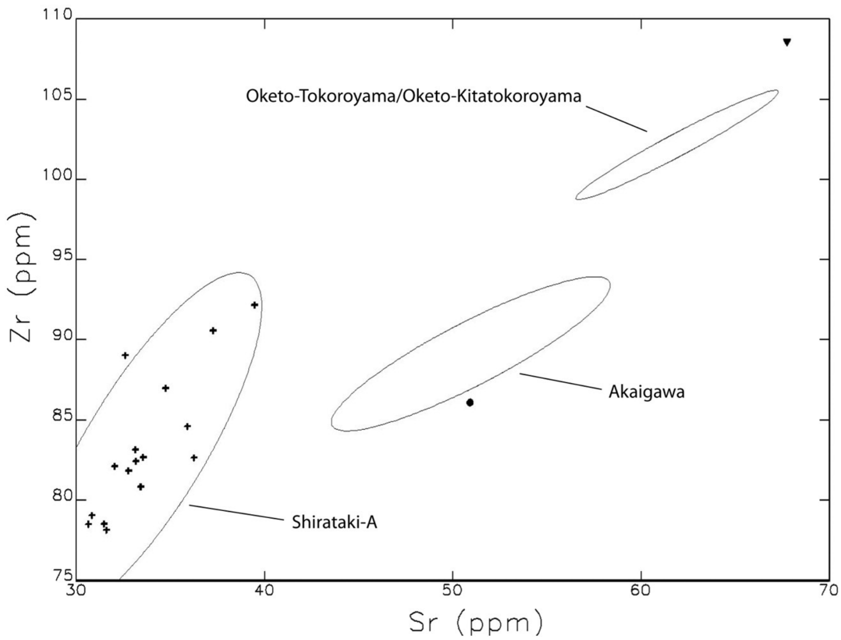

Fig. 4. Hamanaka 2 Epi-Jomon artifact bivariate plot Sr vs. Zr. Confidence ellipses are drawn at a 95% confidence interval accounting for $\pm 2\sigma$.

(personal communication with T. Amano, 2013). This serves to explain the limit amount of obsidian derived southwestern Hokkaido sources in the Hamanaka 2 and Kafukai 1 assemblages. Later, the Okhotsk culture expanded along the west coast of Hokkaido and the Sea of Japan (Okada, 1998a). During these migrations, the Okhotsk likely contacted remaining Epi-Jomon populations in southwestern Hokkaido. As mentioned, the DNA analysis of three juvenile bears interred at Kafukai 1 has been linked to lineages from central and southern Hokkaido. These findings along with the obsidian provenance data from this study align with Masuda et al. (2001) proposition that Okhotsk peoples exchanged goods with the Epi-Jomon in southern Hokkaido for these animals.

The Okhotsk of Rebun Island are suspected to have acquired a bulk of their obsidian resources through seasonal migrations to northeastern Hokkaido along the Sea of Okhotsk (personal communication with T. Amano, 2013). Ohyi (1981) notes the limited number of lithic materials in the Okhotsk assemblage at Kafukai 1, suggesting that the Okhotsk culture likely began to incorporate the use of other materials such as metals into their toolkits making stone implements obsolete. However, the use of obsidian, as well as other locally available lithic materials by the Okhotsk people demonstrates the continued need for these resources despite the growing use of metal tools. Therefore, obsidian may have been used to facilitate interactions between neighbouring Okhotsk groups, or other contemporary cultures in Hokkaido, such as the Epi-Jomon. It was previously thought that the limited number of foreign artifacts recovered from Okhotsk sites demonstrated limited exchange between the Okhotsk and other contemporary cultures (Befu and Chard, 1964; Ohyi, 1975, 1981). However, perishable items

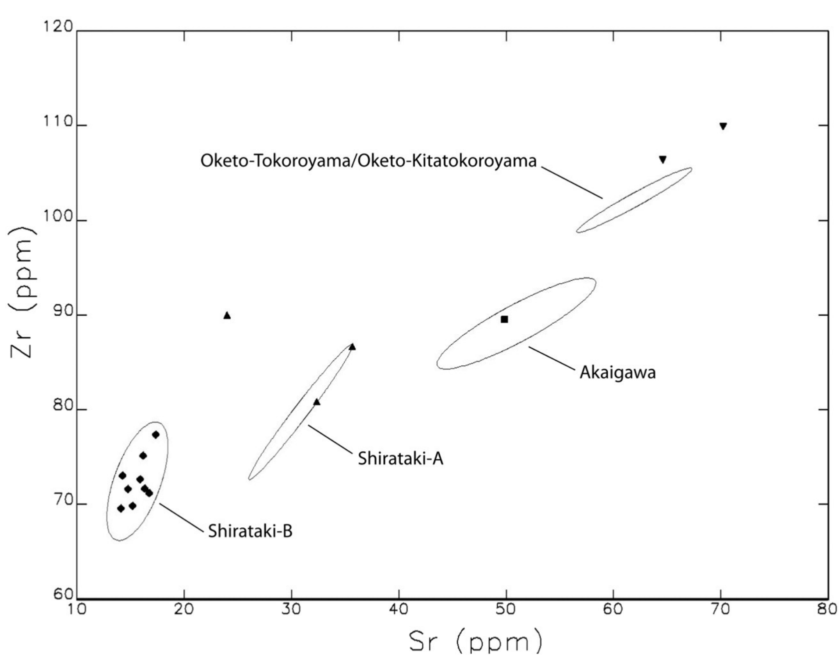

Fig. 5. Hamanaka 2 Okhotsk artifact bivariate plot Sr vs. Zr. Confidence ellipses are drawn at a 95% confidence interval accounting for $\pm 2\sigma$.

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Table 7
Hamanaka 2 Okhotsk artifact concentration value list in ppm. Oketo-Toko/Oketo-Kita refers to Oketo-Tokoroyama/Oketo-Kitatokoroyama.

Sample	Lithic type	Source	Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
HA2-19	Bipolar Flake	Shirataki-B	695	9658	67	34	22	174	14	39	73	14
HA2-20	Bipolar Flake	Shirataki-B	706	9504	63	37	21	173	16	39	73	16
HA2-21	Bipolar Flake	Shirataki-B	686	9590	68	35	20	178	16	38	72	14
HA2-22	Flake	Shirataki-B	714	9954	64	39	21	176	17	38	71	16
HA2-23	Flake	Oketo-Tokoro/Oketo-Kita	492	9710	56	37	22	139	65	29	106	14
HA2-24	Bipolar Flake	Akaigawa	739	9482	66	36	30	132	50	31	90	14
HA2-25	Bipolar Flake	Shirataki-B	764	11,038	88	46	23	192	17	41	77	18
HA2-26	Bipolar Flake	Shirataki-A	637	11,446	87	42	23	171	36	37	87	14
HA2-27	Bipolar Flake	Shirataki-B	715	10,235	73	41	23	191	16	40	75	16
HA2-28	Bipolar Flake	Shirataki-B	662	9366	72	33	19	171	14	39	70	13
HA2-29	Projectile Point	Shirataki-A	668	10,529	82	43	20	179	24	40	90	15
HA2-30	Bipolar Flake	Shirataki-A	583	10,028	76	37	21	149	32	34	81	15
HA2-31	Bipolar Flake	Shirataki-B	681	9640	71	37	20	173	15	37	72	15
HA2-32	Bipolar Flake	Shirataki-B	658	9327	70	37	19	171	15	37	70	15
HA2-33	Bifacial Thinning Flake	Oketo-Toko/Oketo-Kita	539	10,141	69	39	22	154	70	32	110	14

including plant and animal materials may have been exchanged between Epi-Jomon and Okhotsk people; however, these materials are poorly represented in the archaeological record due to poor preservation (Yamaura, 1998). No correlation between lithic type and obsidian deposit were identified in the Hamanaka 2 and Kafukai 1 artifacts. However, the presence of bipolar core fragments and bipolar flakes suggests Okhotsk peoples transported obsidian raw materials to Rebun Island, and later formed these materials into tools.

5. Conclusion

The analysis of archaeological obsidian from Rebun Island suggests that culture change in this region had an impact on the use and availability of obsidian resources during prehistory. The representation of multiple obsidian material types in examined assemblages from the Middle Jomon to Okhotsk period demonstrates the availability of non-local obsidian materials from northeastern and southwestern Hokkaido during these periods. Based on the findings of this study and previous provenance research, the use of specific obsidian deposits is suspected to have varied between each cultural occupation of Rebun Island.

During the Middle Jomon period at Uedomari 3, it is possible that we see the beginnings of the Jomon centralization in southwestern Hokkaido given the almost equal proportion of obsidian materials derived from southwestern and northeastern Hokkaido examined in this study. This growing centralization in southwestern Hokkaido, then came to fruition during the Late Jomon period, and is demonstrated by the high proportion of materials derived from Akaigawa deposit in southwestern Hokkaido (Tomura et al., 2003). During the Final Jomon period, a new resource procurement structure was created due the collapse of mobility and exchange patterns established during the Late Jomon period. This is represented by the higher proportions of northeastern Hokkaido obsidians in the Final Jomon assemblage analyzed by Tomura et al. (2003). Epi-Jomon resource use may indicate similar level of interaction with southwestern Hokkaido as the proceeding Final Jomon culture, based on the comparable proportions of obsidian derived from northeastern and southwestern Hokkaido during this period (Tomura et al., 2003; Wada et al., 2006). For the Okhotsk period, the limited number of southwestern obsidian source materials analyzed from Hamanaka 2 and Kafukai 1, supports the notion that the immigrating Okhotsk cultures likely had limited knowledge or access to these locations prior to decline of the Epi-Jomon culture, and the Okhotsk expansion south along western Hokkaido. The higher proportions of obsidian derived from northeastern Hokkaido in the Hamanaka 2 and Kafukai 1 assemblages supports this notion.

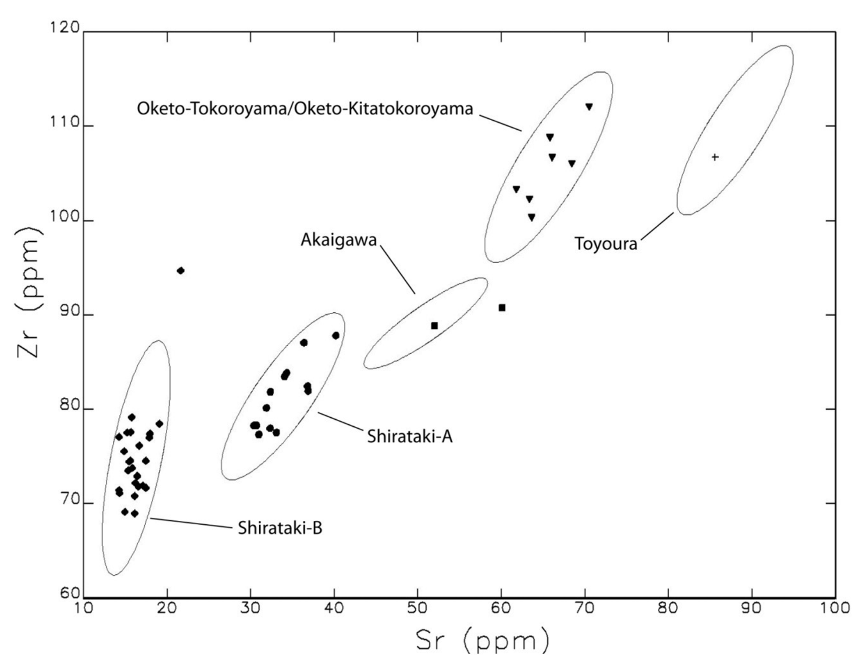

Fig. 6. Kafukai 1 artifact bivariate plot of Sr vs. Zr. Confidence ellipses are drawn at a 95% confidence interval accounting for $\pm 2\sigma$.

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Table 8
Kafukai 1 Okhotsk artifact concentration value list in ppm. Oketo-Toko/Oketo-Kita refers to Oketo-Tokoroyama/Oketo-Kitatokoroyama. Biface Frag. refers to biface fragment. Core-RF refers to core reduction flake.

Sample	Lithic Type	Source	Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
KAF01	Scraper	Shirataki-A	606	9347	64	35	22	147	30	32	78	13
KAF02	Projectile Point	Shirataki-B	733	9792	70	40	22	176	17	39	72	15
KAF03	Projectile Point	Shirataki-B	786	10,461	75	41	21	190	18	42	77	17
KAF04	Projectile Point	Shirataki-B	724	9800	71	43	22	186	16	41	79	16
KAF05	Projectile Point	Shirataki-B	793	10,335	72	42	22	186	16	41	78	16
KAF06	Projectile Point	Shirataki-B	759	10,802	81	45	23	194	18	40	77	17
KAF07	Projectile Point	Shirataki-B	796	11,004	78	44	22	199	19	40	78	18
KAF08	Projectile Point	Shirataki-B	697	10,202	72	40	21	184	15	39	78	16
KAF09	Projectile Point	Shirataki-A	655	10,615	80	43	22	163	37	35	82	17
KAF10	Projectile Point	Shirataki-B	802	10,348	73	43	22	182	17	39	75	17
KAF11	Projectile Point	Shirataki-A	656	10,631	74	39	23	158	36	32	87	15
KAF12	Projectile Point	Oketo-Toko./Kita.	555	10,231	64	43	25	151	71	30	112	15
KAF13	Biface Frag.	Oketo-Toko./Kita.	517	9403	53	37	22	138	62	29	103	14
KAF14	Projectile Point	Shirataki-B	683	9512	69	34	20	167	22	38	95	14
KAF15	Scraper	Shirataki-A	616	9933	67	37	21	152	32	32	82	14
KAF16	Projectile Point	Shirataki-B	717	9868	68	39	22	183	16	40	73	15
KAF17	Projectile Point	Shirataki-B	702	9929	68	39	22	178	16	39	72	15
KAF18	Scraper	Shirataki-B	679	9804	70	39	21	178	17	37	72	16
KAF19	Projectile Point	Shirataki-B	717	10,147	72	44	21	184	17	39	76	16
KAF20	Biface Frag.	Shirataki-B	733	9702	73	40	20	178	17	38	72	16
KAF21	Projectile Point	Shirataki-B	685	9522	64	36	20	172	15	36	69	16
KAF22	Scraper	Shirataki-A	604	9798	71	36	21	151	32	33	80	14
KAF23	Projectile Point	Shirataki-A	982	13,184	99	47	27	187	40	39	88	16
KAF24	Scraper	Shirataki-A	620	10,039	67	35	22	145	31	32	77	15
KAF25	Projectile Point	Oketo-Toko./Kita.	597	10,090	57	42	23	142	66	30	109	14
KAF26	Projectile Point	Oketo-Toko./Kita.	595	10,058	61	40	23	141	66	30	107	14
KAF27	Scraper	Toyoura	711	9645	56	32	20	87	86	29	107	14
KAF28	Scraper	Oketo-Toko./Kita.	533	9023	57	34	23	135	63	28	102	14
KAF29	Point	Shirataki-B	704	9673	68	35	21	170	16	38	74	16
KAF30	Bipolar Flake	Shirataki-A	595	10,069	84	35	21	144	33	32	78	14
KAF31	Bipolar Flake	Akaigawa	785	9755	62	38	27	136	52	31	89	15
KAF32	Bipolar Flake	Shirataki-B	655	9425	63	33	21	175	15	38	76	14
KAF33	Core Fragment	Shirataki-B	634	9348	58	34	20	171	14	36	77	16
KAF34	Core-RF	Shirataki-B	696	9388	66	37	23	177	15	38	74	15
KAF35	Bipolar Flake	Shirataki-B	617	9420	69	38	19	176	14	37	71	15
KAF36	Core-RF	Shirataki-B	700	9133	59	35	18	168	14	36	71	15
KAF37	Core Fragment	Shirataki-B	699	9261	64	36	22	170	16	37	75	16
KAF38	Core-RF	Oketo-Toko./Kita.	561	9533	63	34	22	138	68	30	106	13
KAF39	Bipolar Flake	Shirataki-A	618	9691	65	37	21	150	32	32	78	14
KAF40	Core Fragment	Shirataki-A	592	8929	65	37	22	146	31	33	78	14
KAF41	Bifacial Thinning Flake	Shirataki-A	603	9729	69	38	22	158	34	34	83	15
KAF42	Bipolar Flake	Shirataki-B	720	9633	63	36	22	173	16	36	71	16
KAF43	Thinning flake	Shirataki-A	631	8757	68	38	22	157	34	35	84	15
KAF44	Core Fragment	Akaigawa	809	10,153	67	32	26	133	60	29	91	13
KAF45	Bipolar Flake	Shirataki-B	695	9837	63	38	23	171	16	36	69	16
KAF46	Core Fragment	Shirataki-B	753	10,033	66	38	21	179	16	38	73	15
KAF47	Core Fragment	Shirataki-B	708	9536	68	35	20	173	15	37	74	14
KAF48	Core-RF	Oketo-Toko./Kita.	596	9233	61	33	21	131	64	28	100	14
KAF49	Core-RF	Shirataki-A	688	11,032	78	39	23	152	37	35	82	15

It is thought that the peripheral location of Rebun Island made prehistoric communities sensitive to changes in exchange networks over broad regions. Therefore, determining the provenance for obsidian artifacts recovered from Rebun Island is found to be useful for studying changes in resource procurement patterns over time. Additional research needs to be conducted for the early and late phases of each of these cultures to pinpoint when changes obsidian resource use, and exchange networks occurred. To do this, closer examination of the stratigraphic layers, as well as radiocarbon dates for these phases are needed. Furthermore, subsequent analyses of overall lithic assemblage size and material type will help explore the significance of local and non-local lithic resources during the Jomon, Epi-Jomon, and Okhotsk periods on Rebun Island.

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