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Lithic raw material exploitation and circulation in Préhistory. A comparative perspective in diverse palaeoenvironments
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2.5. Obsidian exploitation and circulation in Late Pleistocene Hokkaido in the northern part of the Japanese Archipelago

Résumé
L'obsidienne était la matière première la plus importante à la fin du Pléistocène à Hokkaido au nord de l'archipel japonais. Des 21 sources archéologiques d'obsidienne à Hokkaido, 8 ont été employées au Paléolithique supérieur (35-10 ka cal BP.). Dans notre étude nous nous sommes intéressés à reconstruire l'histoire de l'exploitation de l'obsidienne au Paléolithique supérieur en examinant les analyses publiées sur l'approvisionnement en obsidienne et en les comparant aux proportions d'obsidiennes dans les diverses sources actuelles dans les assemblages archéologiques de 6 régions à Hokkaido.

Durant toute la période du Paléolithique supérieur, les sources d'obsidienne les plus utilisées se trouvaient à proximité des sites ; l'exploitation des autres sources variait selon la période et l'industrie lithique. Parmi les quatre sources principales d'obsidienne, Shirataki, Tokachi, Oketo et Akaigawa les deux premières (Shirataki et Tokachi) étaient largement utilisées sur place à partir de l'E.U.P. (35-25 ka cal BP). Par contre les deux dernières approvisionnaient les sites voisins durant l'E.U.P. et eurent une grande diffusion à l'L.U.P. (25-10 ka cal BP). La quantité d'obsidiennes de ces dernières sources était moins importante que celle des deux premiers. L'utilisation de l'obsidienne d'Oketo et de Akaigawa semble avoir été complémentaire. En fonction de la proportion des différents types d'obsidienne trouvés dans les assemblages, il semble que le changement dans les stratégies d'obtention ne corresponde pas à la transition de l'E.U.P. vers l'L.U.P. – période de l'apparition de l'industrie sur microlame – mais à la transition de l'industrie ancienne sur microlame (sous-phase 1 : 25-21 ka cal BP) à l'industrie tardive sur microlame (sous-phase 2 : 19-16 ka cal BP), ce qui coïncide aussi avec l'apparition cette méthode d'obtention à Yubetsu à Hokkaïdo. Durant la période tardive de l'industrie sur microlame (sous phase 3 : 16-10 ka cal BP) il apparaît que les industries lithiques spécifiques sont associées à des sources spécifiques. Nos résultats sur les modèles d'exploitation des sources de l'obsidienne confirment les résultats des recherches de Kimura (1995) et Yamada (2006) sur le rapport entre résidence et mobilité. Cependant la taille des échantillons analysés est assez restreinte et c'est pourquoi nous aimerions augmenter nos analyses pour augmenter notre compréhension des modalités d'exploitation de l'obsidienne.

Abstract
Obsidian was the main lithic raw material in Late Pleistocene Hokkaido, in the northern part of the Japanese archipelago. Out of 21 archaeological obsidian sources in Hokkaido, 8 were used during the Upper Palaeolithic (35-10 ka cal BP). In our study we are interested in producing a history of Upper Palaeolithic obsidian exploitation by looking at published obsidian sourcing analyses and comparing them to the proportions of obsidian from the various sources present in archaeological assemblages from 6 areas in Hokkaido.

Throughout the Upper Palaeolithic the obsidian sources mostly used where the ones nearest to the sites. The exploitation of the other sources varied depending on the period and lithic industry. Among the four major obsidian sources, Shirataki, Tokachi, Oketo and Akaigawa, the former two used widely from the Early Upper Palaeolithic (35-25 ka cal BP) on ward. In contrast, the latter two supplied the sites in their vicinity during the Early Upper Palaeolithic, and in the Late Upper Palaeolithic (25-10 ka cal BP) their use expanded widely. The volume of Oketo and Akaigawa obsidian used was less than that of the other two sources. The use of Oketo and Akaigawa obsidian seems to have been complementary.

In terms of the proportions of different types of obsidian found in the assemblages, it seems that the change in procurement strategies does not correspond to the transition from the Early to the Late Upper Palaeolithic –a time when we witness the appearance of microblade industries— but to the transition from the early Early Microblade Industry (Subphase 1: 25-21 ka cal BP) to the late Early Microblade Industry (Subphase 2: 19-16 ka cal BP), which coincides also with the appearance of the fully developed Yubetsu method in Hokkaido. During the Late Microblade Industry (Subphase 3: 16-10 ka cal BP), it appears that specific lithic industries are associated with specific sources. Our results on the obsidian source exploitation patterns confirm the research results of Kimura's (1995) and Yamada's (2006) residential mobility approach. However, the sample sizes of the materials analyzed are still quite small, therefore we would like to stress how important it is to increase our data in order to increase our understanding of obsidian exploitation strategies.

Keywords: Obsidian, Late Pleistocene, Hokkaido, Upper Palaeolithic, Microblade,Shirataki, Oketo, Tokachi, Akaigawa

1 – Introduction

In recent years obsidian sourcing has been a burgeoning field yielding valuable data for the prehistory of the Circum-Japan Sea area (e.g. Kuzmin and Popov 2000; Kuzmin and Glascock 2010). Consequently, our increased knowledge of the exploitation of each obsidian source has allowed us for the first time to engage in meaningful discussions on crucial topics such as the emergence of modern human behavior in the Japanese archipelago, the human adaptation to the environment, and the networks in place for the circulation of lithic raw materials. For instance, we now know that on the island of Honshu very distant obsidian sources were used and these were exploited already from the beginning of the Upper Palaeolithic (Kunitake 2009). Another example would be the research conducted on the Kozushima obsidian source located on a remote island in the Pacific Ocean, which we know with certainty was an island during the Palaeolithic as well. Kozushima obsidian was used intensively from the Early Upper Palaeolithic (hereafter EUP) onwards, and its exploitation is a clear indication of the seafaring skills modern humans must have had in order to navigate the Japanese archipelago and reach this remote island (Shimada 2009; Shimada and Ikeya 2011).

These early modern humans of the Circum-Japan Sea area practiced long distance mobility and used blade and microblade industries for their subsistence needs; the preferred raw material for their tools became obsidian. Several obsidian sources were known in the Russian Maritime Provinces, the middle Amur River and the border between China and North Korea (Kuzmin and Glascock 2010), making obsidian source analysis central in revealing interaction and circulation networks in the region. For example, it is well known that obsidian from the Shirataki source was transported to Sakhalin in the UP (Kuzmin et al. 2002). In contrast, obsidian from Hokkaido never made its way to the continental region of the Russian Far East (Sato 2004a; 2011b). The microblade industries of Hokkaido, for which obsidian was primarily used, are characterized by a high degree of specialization and standardization of microblade core types in comparison to those of neighboring regions (Sato 2010). In considering the possible reasons behind such a contrast, it is necessary to evaluate the quality and size of obsidian nodules from each of the sources, the distance between the sources, and whether there is a correlation between sources and lithic industries.

In order for us to maximize the precision of obsidian source analysis, we examined the chemical composition of each obsidian source using Instrumental Neutron Activation Analysis (INAA), Electron Probe Micro-Analyzer (EPMA), and Energy Dispersive X-ray Fluorescence (EDXRF). By using these techniques we were able not only to analyze excavated obsidian artifacts, but also to investigate the geological formation process of the obsidian sources. Since such studies have recently started to increase (e.g. Izuho et al. 2008; Wada and Sano 2011), we think it will be useful to provide in this paper a review of the obsidian sourcing studies published thus far, in an effort to compile a diachronic overview of obsidian exploitation for every region, industry and site on Hokkaido.

2 – Materials and Methods

A – Materials

The obsidian sourcing data for the UP Hokkaido published up to April 2012, comprise 6,368 samples from 83 sites, analyzed mainly using X-ray fluorescence (XRF). Those samples that yielded inconclusive results have been excluded from the present analysis, leaving us with 5,323 samples from 80 sites in total (Tab.1). The lithic raw materials used in UP Hokkaido were siliceous shale, chert, agate, chalcedony and andesite, with obsidian consistently comprising the majority of any given assemblage. At present, we are aware of 21 obsidian sources that were used in prehistory (Izuho et al.2008), out of which only 8 were used in UP Hokkaido (Tab.2). Among them 4, namely Shirataki, Tokachi, Oketo, Akaigawa are the major sources, while others, such as Keshomappu, Chikabumidai, Nayoro, and Toyoizumi are considered to be minor. Although thus far a vast plethora of obsidian artifacts have been unearthed in archaeological excavations, only

very few were made available for sourcing analysis. The number of Palaeolithic sites in Hokkaido as of February 2010 was 861 (Japanese Palaeolithic Research Association 2010); out of these only 80 sites have produced sourcing data amounting to a mere 9.3 % of the whole. Even though the results of our study are based on a fraction of the sites, we are confident that the general trends in UP Hokkaido can be safely deduced from this sample.

B – Chronology, industries and areas where used obsidian

During the Late Pleistocene the Japanese archipelago was very different from today both geomorphologically and ecologically, mainly due to the drop of sea level during the glacial period. The present-day islands Honshu, Shikoku and Kyushu were once one single island mass, the so-called Palaeo-Honshu Island, whereas Hokkaido was part of the Palaeo-Hokkaido Peninsula, which was connected to the continent along with Sakhalin and the southern part of the Kuril Islands (Sato et al. 2011; Iwase et al. 2012) (Fig.1). Accordingly, the periodization of the UP in Hokkaido is different from that of Honshu and the South. In Hokkaido, the UP is divided into two periods: the Early Upper Palaeolithic (EUP) (35-25 ka cal BP) which consists of various lithic industries (microblade technology has not yet appeared), and the Late Upper Palaeolithic (LUP) (25-10 ka cal BP) consisting of various microblade industries and other industries with points, stemmed points and boat-shaped (also known as 'naviform') tools[1] (Sato2003) (Tabl.3).

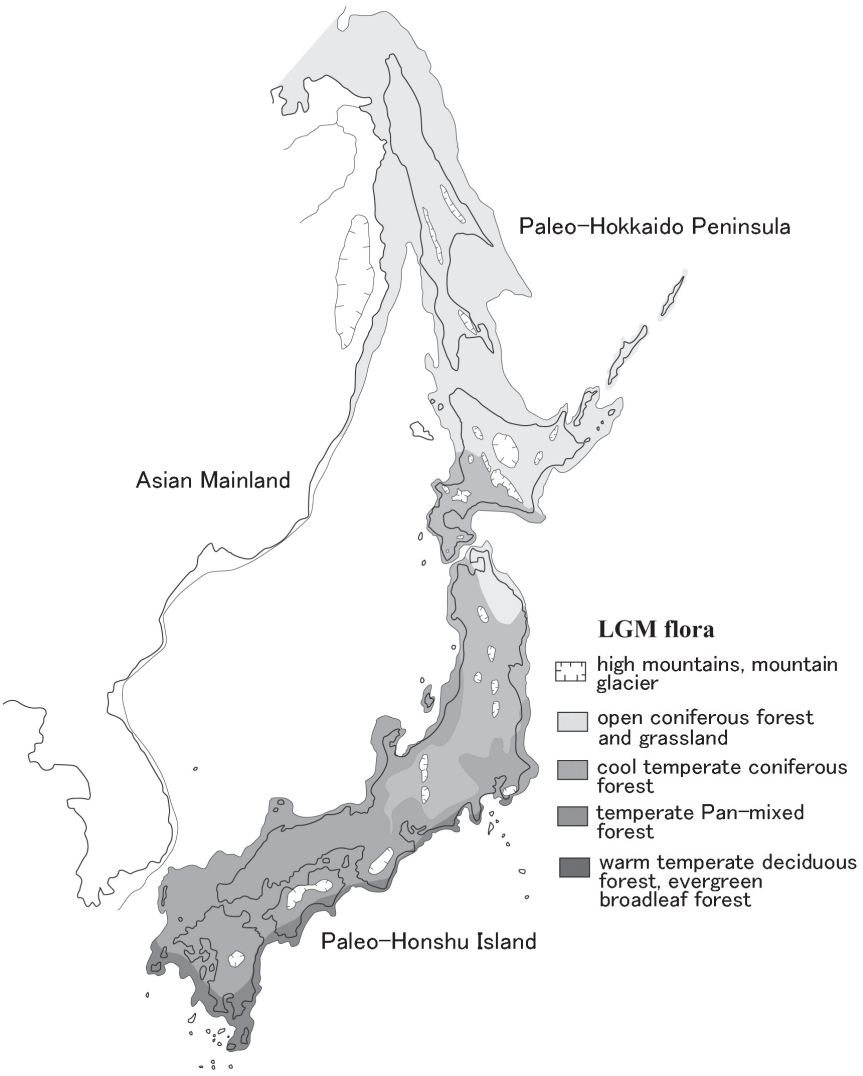


Figure 1 – Physiographic features of Late Pleistocene in the Japanese Archipelago (Iwase et al. 2012)

Although the EUP can be further subdivided, in this paper we treat it as one period. The LUP is subdivided to 3 phases; the early Early Microblade Industry (25-21 ka cal BP), the late Early Microblade Industry (19-16 ka cal BP), and the Late Microblade Industry (16-10 ka cal BP). The early Early Microblade Industry (Subphase 1) includes the Rankoshi, Tougeshita 1 and Pirika type microblade industries. The Late Early Microblade Industry (Subphase 2) includes the Sakkotsu and Tougeshita 2 type microblade industries. The Late Microblade Industry (Subphase 3) includes the Shirataki, Oshorokko 1 and 2, Hirosato, Momijiyama microblade industries and non-microblade industries such as the small boat-shaped tool types 1 and 2, and industries with points and stemmed points (Fig.2). The abovementioned industries constitute the chronological markers used in our analysis (Yamada 2006). Hokkaido was divided into six areas, namely Tokachi, Kitami, Shirataki, Kamikawa, Ishikari Lowland and Southern Hokkaido, according to the distribution patterns of archaeological sites and geological environments (Fig.3).

3 – A diachronic perspective of obsidian exploitation patterns in Palaeo-Hokkaido Peninsula

A – Early Upper Palaeolithic 35 - 25 ka cal BP

The majority of obsidian used in EUP sites comes from the sources nearest to the sites. Specifically, at the sites located in the Shirataki, Kitami, and Tokachi areas, we find obsidian coming from the Shirataki, and Oketo and Tokachi sources respectively,

Area	No.	Site	Industry	Number of analyzed material	Number of excavated materials	Shirataki	Oketo	Tokachi	Akaigawa	Minor sources	Unknown
Shirataki	1	Hattoridai 2	1	3	7	2				K1	
			2-B-2	3	Unknown	2			1		
			2-C-1	3	Unknown	3					
			2-C-3	5	1022	5					
			2-C-4	1	Unknown	1					
			2-C-5	6	10173	6					
			2-C-8	23	30959	14	6	1		K2	
			2	27	67747	20	3		3		1
			1 and 2	7		3	2			K1	1
	2	Shirataki hattoridai	2-B-2	8	31693	7					1
			2-C-1	67		61	1			N1	4
			2-C-5	9		9					
			2-C-8	2		1	1				
			2	78		73					5
			1 and 2	1905		1509	11	3	1	N7, K3	371
	3	Okushirataki 1	1	9	1289	8				K1	
			2-C-3	15	2706	15					
			2-C-8	28	58020	19	6		1		2
			1 and 2	8	29939	4	2	1		K1	
	4	Kamishirataki 2	2-B-1	5	5888	5					
			2-C-2	3	1799	2	1				
			2-C-5	2	5766	2					
			2-C-8	5	35538	5					
	5	Kamishirataki 5	2-B-1	3	94	3					
			2-C-5	27	9758	21	3			K3	
			2-C-8	14	11315	14					
	6	Kamishirataki 6	2-C-8	6	1343	6					
	7	Kamishirataki 7	1	54	2339	54					
			2-C-8	11	1987	11					
	8	Kamishirataki 8	1	41	60818	41					
			2-A-1	1	Unknown	1					
			2-A-2	10	26522	9				K1	
			2-A-3	1	Unknown	1					
			2-C-4	6	2788	3	1				2
			2-C-5	3	28783	3					
			2-C-8	15	65023	8	3	2		K2	
			2	17	206818	17					
			1 and 2	12	215783	4	6		1	K1	
	9	Shirataki 3	2-C-5	33	1009	32		1			
			2-C-8	4	41271	4					
			2	5		3				K2	
			1 and 2	16		11	1			K4	
	10	Shirataki 8	2-B-2	5	138	5					
			2	4	4030	4					
	11	Shirataki 18	2-C-8	41	23331	41					
	12	Shirataki Loc. 30	2-B-2	2	6085	2					
			2-C-5	4	4835	4					
			2-C-6	1	1109					K1	
			2-C-8	3	8954	2	1				
			2	11	71249	5	1			K4	1
			1 and 2	8		3				K4	1
	13	Horokazawa I	2-C-4	3	2185	3					
			2-C-8	2	10237	1		1			
			2	20	115574	19	1				
			1 and 2	7		7					
	14	Kitashiyubetsu 4	2-C-8	2	6559		2				
	15	Kyushirataki 5	1	4	32731	4					
			2-A-2	15		14				K1	
			2-C-2	1		1					
			2	44	261571	41			1	K1, C1	
			1 and 2	7		7					
	16	Kyushirataki 15	2-A-1	7	12961	3				K4	
			2-B-2	5	10079	5					
			2-C-4	13		11		2			
			2-C-7	1						K1	
			2-C-8	3	12318	2	1				
			2	5	35541	5					
			1 and 2	13		1	2	4		K6	
	17	Kyushirataki 16	1	7	1807	2				K5	
Kitami	18	Motomachi 2	2	140	148	45	71	1		K1	22
	19	Midori 1	2	119	653	58	30	5		K3	23
	20	Toyooka 7	2-C-7	107	>114		83	2		K1	21
	21	Hirosato 8	1	13	14218	1	11				1
			1 and 2	7			7				
	22	Hirosato maruyama	2-C-2	10	276		10				
	23	Kitakamidaichi	2-C-7	40	40	1	30	1			8
	24	Kitakami 4	2-B-2	21	3055		17	4			
			2-C-4	4	380		4				
			2-C-8	5	153		5				
			2	20	1095	1	18	1			
	25	Rankokubashi	2	5	(3232)		5				
	26	Kawahigashi 16	2-B-2	3	(32889)		1			K1	1
			2-C-2	1			1				
			2-C-4	2			1	1			
			2-C-7	2			1				1
			2	75		4	60	1		K6	4
	27	Kawahigashi 3	2-B-2	1	(26639)		1				
			2-C-5	13		3	7	3			
			2	43		12	24	2		K5	

Area	No.	Site	Industry	Number of analyzed material	Number of excavated materials	Shirataki	Oketo	Tokachi	Akaigawa	Minor sources	Unknown
Kitami	28	Hokushin	2-A-2	120	2126	10	85	5			20
	29	Momijiyama	2-C-3	106	2185	2	70			K34	
			2-C-5	6		6					
			2	13		2	5			K6	
	30	Yoshiizawa Loc.B	2-C-7	10	1157		7	1			2
		Yoshiizawa Loc.UT	2-C-7	22	13694	3	15			K3	1
	31	Oketoazumi	1	14	>40,000		11	2			1
			2-B-1	18		2	14				2
			2-C-1	17		1	14	1		K1	
			2-C-2	9			7				2
			2-C-3	10			5	5			
			2-C-4	3		1		2			
			2	24		3	18	2			1
			1 and 2	377		5	279	17	1	K3	72
Tokachi	32	Yukuepira chashiato	2-C-1	1	Unknown					K1	
	33	Shimohororo 15	2-C-8	1	2			1			
	34	Hokuto	2-C-8	1	1484	1					
	35	Oribe 16	2-C-5	2	2124			2			
			2	4				4			
	36	Oribe 17	2-C-6	12	29549			12			
	37	Kukominami A	1	2	30	1		1			
	38	Kukominami B	2-B-2	3	898			3			
	39	Wakabanomori	1	6	9701			6			
	40	Ozora	2-C-6	5	3997	1	1	2	1		
	41	Inada 1	1	7	163			7			
			1 and 2	3	43		3				
	42	Kawanishi C	1	14	19326		4	10			
			2-C-4	6	608			3	2		1
	43	Minamimachi 1	2-C-5	14	30227		1	11			2
	44	Minamimachi 2	1	6	2228			5			1
			2-B-1	4	574	4					
			2	4	652			2	2		
	45	Akatsuki	2-B-1, 2-B-2	70	>14186	30	10	30			
			2-C-2	1			1				
	46	Ochiai	2-C-5	22	7069	6		16			
	47	Satsunai N	1	7	589			7			
			2-C-8	10	51084		8	2			
	48	Satsunai K	2-C-5	14	1055		4	10			
			2	2	95			2			
	49	Nisshin F	2	3	478			3			
	50	Kamiitaira	1	3	39			3			
			2-B-1	30	488	16		14			
	51	Seo	2-C-4	1	419			1			
	52	Kagawa	2-C-7	25	3092		1	24			
	53	Kitafushiko 2	2	8	974	6		2			
	54	Kyouei 3	1	33	1539			33			
			1 and 2	5	1086		1	4			
Kamikawa	55	Higashirokugo 1	2-C-8	79	2744	3	14	17			45
			2-C-4	1	1						1
	56	Higashirokugo 2	2-C-6	123	4603	101					22
	57	Sakuraoka 5	2	5	468	5					
	58	Arashiyama 2	2-C-7	32	1750	25	2			C3	2
	59	Nitto	2-C-2	20	2708	1	11				8
	60	Higashimachi	2-B-2	1	2	1					
	61	Nisshin 2	1	13	1324	2	2	2	3	C1	3
			2-B-2	12		10					2
			1 and 2	62		36	2	3	2	N11	8
Ishikari Lowland	62	Kamihoronaimoi	2-B-1	134	1412	8		112	1		13
	63	Bibi 4	1	1	1			1			
			2	2	10			2			
	64	Shukubai sankakuyama	1	12	211	2			10		
	65	Kashiwadai 1	1	13	29213	4			8	T1	
	66	Ankarito 7	2-B-2	3	23	3					
			2-C-2	12	2030				12		
	67	Oruika 2	2-B-1	5	2671	2		1			2
	68	Kiusu 5	2	15	494				14		1
	69	Kiusu 7	2-B-2	16	396			13	1		2
	70	Osatsu 16	2-B-2	12	2260	5		4	3		
			2-C-7	8	32266				8		
	71	Yukanboshi E10	2-B-2	14	43				14		
	72	Yukanboshi C15	1	3	3	2		1			
Southern Hokkaido	73	Miyako	2	10	5173				10		
	74	Sakaemachi 5	2-C-8	1	1				1		
	75	Obarubetsu 2	1	1	127				1		
			2-A-1	3	4305				3		
	76	Pirika 1	2-A-1	3	63412				3		
			2-C-5	8	4832	1			6		1
			2	107	110316	8	4	1	92		2
	77	Kamioka 2	1	1	1466				1		
			2-C-4	4	6229	1		1	1		1
	78	Ishikawa 1	2-C-1	6	8781	6					
	79	Shinmichi 4	2-A-2, 2-A-3	26	23263				12		14
	80	Yunosato 4	1	1	ca.20,000				1		
			2-B-2	105		12		52	3		38
			2-C-8	1		1					
Total				5323	>1,589,808	2678	1041	501	224	139	740

References are omitted
In the column of "Minor sources", K: Keshomappu, C: Chikabumidai, N: Nayoro, T: Toyoizumi

Legend

1	Early Upper Paleolithic	2-A-3	Pirika type microblade industry	2-C-1	Shirataki type microblade industry	2-C-5	Small boat-shaped tool 2 type industry
2	Late Upper Paleolithic	2-B	late Early Microblade Industry	2-C-2	Hirosato type microblade industry	2-C-6	Oshorokko1 type microblade industry
2-A	early Early Microblade Industry	2-B-1	Sakkotsu type microblade industry	2-C-3	Momijiyama type microblade industry	2-C-7	Oshorokko 2 type microblade industry
2-A-1	Rankoshi type microblade industry	2-B-2	Tougeshita 2 type microblade industry	2-C-4	Small boat-shaped tool 1 type industry	2-C-8	bifacial point or stemmed point industry
2-A-2	Tougeshita 1 type microblade industry	2-C	Late Microblade Industry				

Sources	Areas	Scale	Names among researchers (integrated in this study)
Shirataki	Shirataki	major	Akaishiyama, Shirataki I・II, Hachigousawa, Hakudonosawa, Akaishiyama I・II, Akaishiyama A・B, Horokazawa, Ajisaitaki, Tokachiishizawa A・B, Tokachiishizawa : aj, na
Tokachi	Tokachi	major	Tokachimitumata, Biman, Tokachi I・II, Kamishihoro・Biman A
Oketo	Kitami	major	Oketoyama, Tokoroyama, Kitatokoroyama, Tokoroyama III
Akaigawa	Southern Hokkaido	major	Akaigawa
Keshomappu	Shirataki	minor	Rubeshibe I・II, Kouwa forestry area 49, Keshomappu group 1・2
Chikabumidai	Kamikawa	minor	Chikabumidai
Nayoro	Kamikawa	minor	Nayoro A
Toyoizumi	Ishikari Lowland	minor	Toyoizumi
Unknown			Tokorogawa group 4
			KS artifact group : Kiusu 4 site A-R area
			HS1, 2 artifact group : Hokushin site
			FR1, 2, 3 artifact group : Higashirokugo 1, 2 site
			Sapporo K19 artifact group : K39 site

Table 1 (Left page) – List of obsidian source analyses published in Hokkaido – Each number correspond to the number of the site shown in Fig. 3 -7, 11-14

Table 2 – Name of obsidian sources mentioned in this article

Table 3 – LChronology of the Upper Palaeolithic of Hokkaido

Early Upper Paleolithic (35 - 25 ka cal BP)		Trapezoid
		Hirosato type pointed tool
		Pointed blade tool with retouched base
		Kawanishi C type blade
		Shimaki type
Late Upper Paleolithic (25 - 10 ka cal BP)	1. early Early Microblade Industry (25 - 21 ka cal BP)	Rankoshi Microblade
		Tougeshita 1 Microblade
		Pirika Microblade
	2. late Early Microblade Industry (19 - 16 ka cal BP)	Sakkotsu Microblade
		Tougeshita 2 Microblade
	3. Late Microblade Industry (16 - 10 ka cal BP)	Shirataki Microblade
		Hirosato Microblade
		Momijiyama Microblade
		Oshorokko 1 Microblade
		Oshorokko 2 Microblade
		Point and stemmed point
		Small boat-shaped tool, type 1
		Small boat-shaped tool, type 2

whereas in the Ishikari Lowland and southern Hokkaido we mostly find obsidian from the Akaigawa source (Fig.4). However, there are exceptions to these trends; such is the case of the Kyushirataki 16 site in Shirataki where obsidian from the Keshomappu source, which is generally considered a minor source, was used more than that from the major Shirataki source (Ibutsu Zairyo Kenkyujo 2009). Unlike obsidian from other minor sources, the Keshomappu obsidian was used complementarily in the Shirataki area throughout the UP, except for the phase of the late Early Microblade Industry.

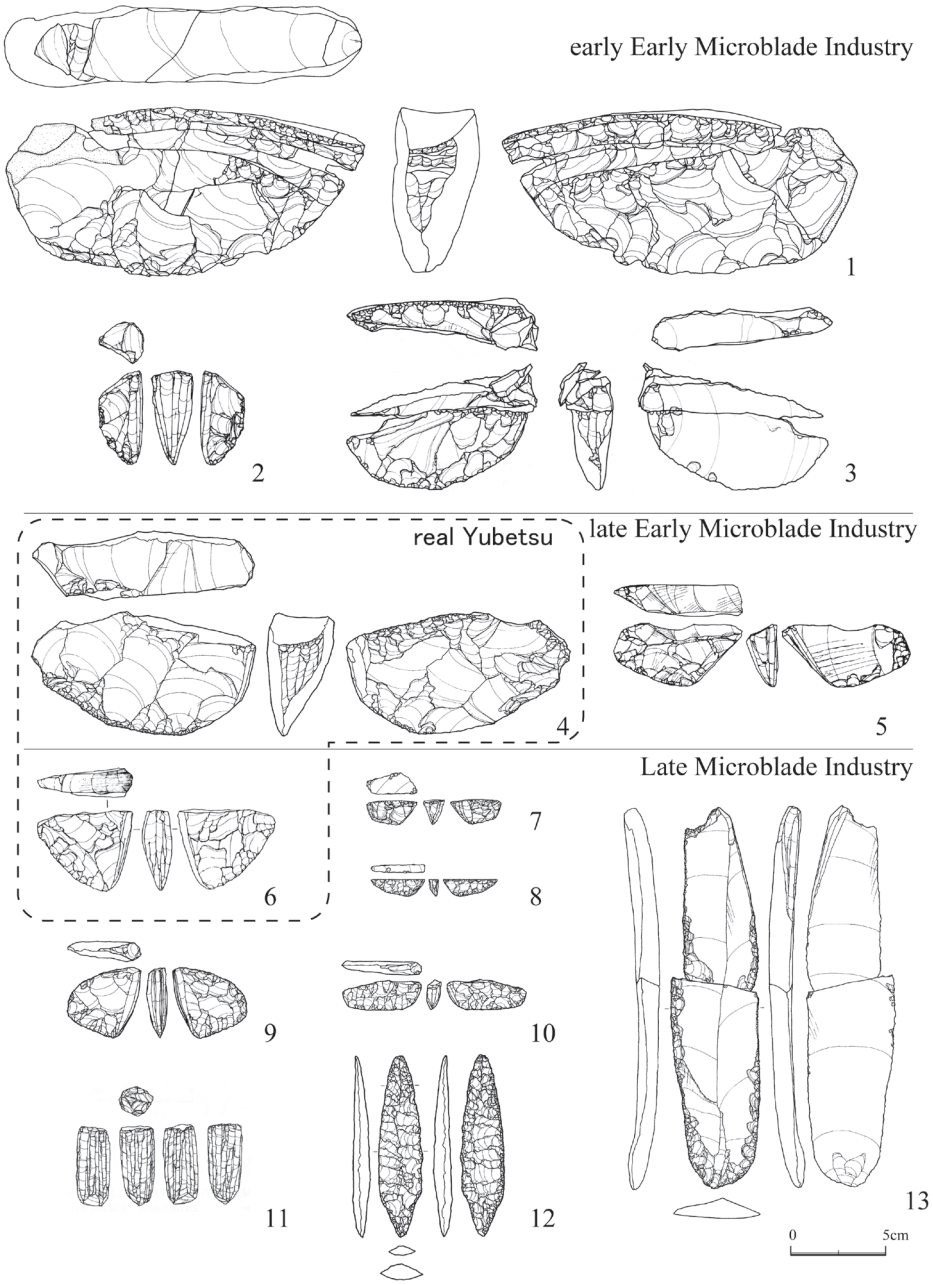
The Ishikari Lowland presents us with a unique case: the Akaigawa source, which was mostly used in the area is located relatively close to the Ishikari Lowland, but it was not the only source used. Quite distant from the Ishikari Lowland, the Eastern Hokkaido sources such as the Tokachi and Shirataki (150 km and 170 km away, respectively, in a straight line) were also used, albeit as secondary sources. The most probable explanation why both types of obsidian were brought into this area already from the earliest phase was because the Ishikari Lowland is equidistant from the two sources. As for correlations between specific sources and industries, there seem to be none. A characteristic trait of this period seems to be the transportation of obsidian over long distances. For example, Tokachi obsidian was found at the Bibi 4 site in the Ishikari Lowland, which is a long 150 km journey (in a straight line) through some major geological barriers such as the Hidaka Mountains (Kondo 1985). This is undoubtedly one of the earliest examples of long distance transportation of obsidian in Hokkaido.

B – Late Upper Palaeolithic, 25 - 10 ka cal BP: Overview

The EUP pattern of exploiting the major obsidian source closest to the site does not change during the LUP. Compared to the EUP, however, there is more obsidian arriving from different sources at the sites during this period (Fig.5). Moreover, the second most used obsidian was not always from the second closest source. It should

Figure 2 – Microblade cores and tools of each Late Upper Palaeolithic industry from Hokkaido

1. Pirika type microblade core (hereafter MC) (Naganuma 1985); 2. Rankoshi type MC (Fukui and Koshida 1999); 3. Tougeshita 1 type MC (Onuma et al. 1988); 4. Sakkotsu type MC (Naganuma and Suzuki 2001); 5. Tougeshita 2 type MC (Sato and Kitazawa 1985,); 6. Shirataki type MC (Sugihara and Tozawa 1975); 7. Small boat-shaped tool type 1 (Kitazawa 2000); 8. Small boat-shaped tool type 2 (Yamahara 1999); 9. Oshorokko 1 type MC (Oya 2001); 10. Oshorokko 2 type MC (Oshima 1997); 11. Momijiyama type MC (Oda 2009); 12;.Stemmed point, (Naganuma and Suzuki 2001); 13. Hirosato type MC (Naganuma and Suzuki 2001)



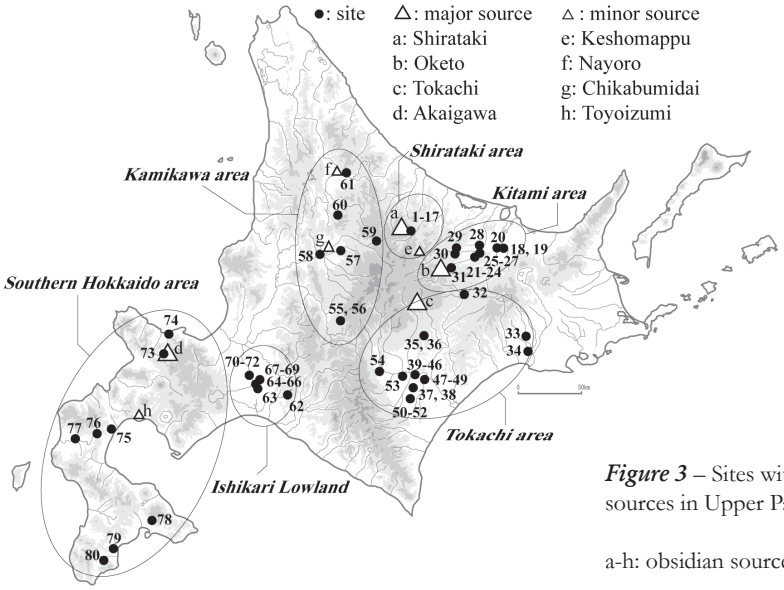


Figure 3 – Sites with obsidian sourcing data, archaeological areas, and obsidian sources in Upper Palaeolithic Hokkaido

a-h: obsidian sources (site number corresponds to those in Tab.1)

be noted that obsidian from minor sources, such as the Chikabumidai and Nayoro sources, was used in the Kamikawa and Shirataki areas, showing that the minor sources were starting to be exploited.

Looking at long-term developments, we see that the exploitation of secondary sources in the Shirataki and Kitami areas varies from one phase to the next, and also that the use of the primary sources in Tokachi similarly varies. It is worth noting that the obsidian mostly used at the Ishikari Lowland during the late Early Microblade Industry was not from the nearest Akaigawa source, but from the Tokachi source. In the areas of Kamikawa and southern Hokkaido, it is difficult to talk about change in the LUP due to the very limited sourcing analysis undertaken in these areas. Since the obsidian exploitation patterns during the LUP exhibit specific trends that vary according to chronological phases and specific industries, we have decided to outline them in detail below.

Subphase 1: early Early Microblade Industry, 25 - 21 ka cal BP

Obsidian sourcing studies were carried out only in the areas of Shirataki, Kitami, and in southern Hokkaido. Although archaeological sites of this phase have been found in the Ishikari Lowland, and the Kamikawa and Tokachi areas, sourcing analyses have not yet been undertaken. The basic trend was that obsidian from the nearest major source was primarily used, making obsidian from other sources quite scarce. It is noteworthy that Tokachi obsidian was used little throughout Hokkaido during this phase (Fig.6). The sites in the Tokachi area have yielded Tougeshita 1 type microblade industry, but unfortunately no obsidian sourcing study has yet been conducted (Yamada 2006). Tokachi obsidian is also used at the Hokushin site located in Kitami adjacent to the Tokachi region, which leads us to assume that Tokachi obsidian would have been used near the Tokachi source, but not widely elsewhere.

Comparing the trends of obsidian exploitation of this phase with those of the entire LUP (Fig.5), it is evident that fewer sources were exploited during this subphase, a trend that seems rather similar to that of the EUP. The greatest peculiarity of this phase and the EUP is that obsidian is not transported often over longer distances.

Subphase 2: late Early Microblade Industry, 19 - 16 ka cal BP

In the late Early Microblade Industry the obsidian exploitation patterns changed drastically. Even though the preference towards the nearest major source did not change significantly, we see at the same time that obsidian from the major sources is now circulating more widely, and that diversity of the sources used in each site is much more increased (Fig.7). The main trends of this phase are that minor sources are no longer used whereas the major ones are used almost exclusively. No correlations between sources and industries have been observed during this phase.

Shirataki obsidian was extensively used in Tokachi, Kamikawa and Ishikari Lowland beyond the Shirataki area. In southern Hokkaido a certain amount of Shirataki obsidian was used at the site Yunosato 4, located 350 km in a straight line away from the Shirataki obsidian source (Warashina and Higashimura 1985). Tokachi obsidian was used not only in the nearby areas of Kitami and Shirataki, but also in Ishikari Lowland and southern Hokkaido. Tokachi obsidian was used predominantly at some of the sites in these areas. Obsidian from the Shirataki and Tokachi sources, located in eastern Hokkaido, were transported already before this period all the way to western Hokkaido across the Backbone Range. In contrast, obsidian from the Akaigawa source in western Hokkaido was used only at the EUP site Nisshin 2 in Kamikawa (Koshimizu 1988a). In the late Early Microblade Industry Akaigawa obsidian was used for the first time at Shirataki, across the Backbone Range, but was not used in eastern Hokkaido before this period. The Keshomappu source, a minor source near the Shirataki source, was used secondarily in all periods but this one. Obsidian from Oketo, one of the major sources, was used mainly in the nearby Kitami area, and only slightly used in Tokachi until the late Early Microblade Industry.

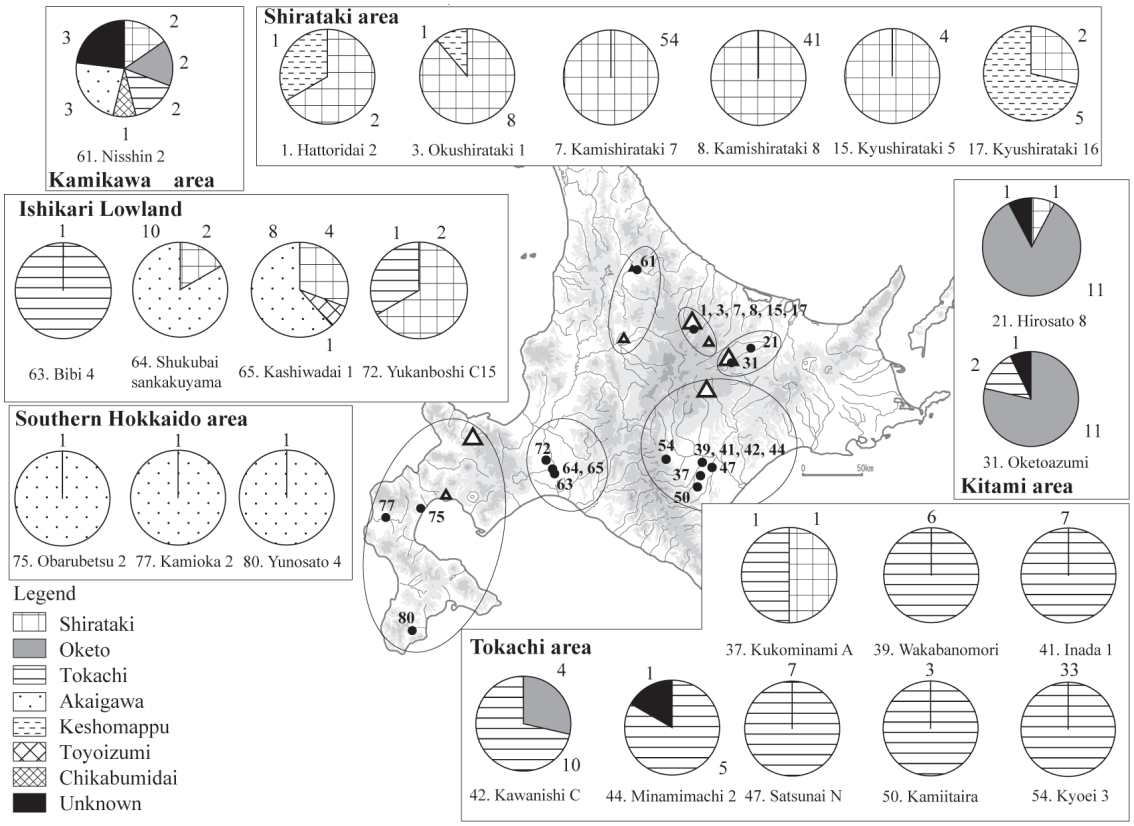
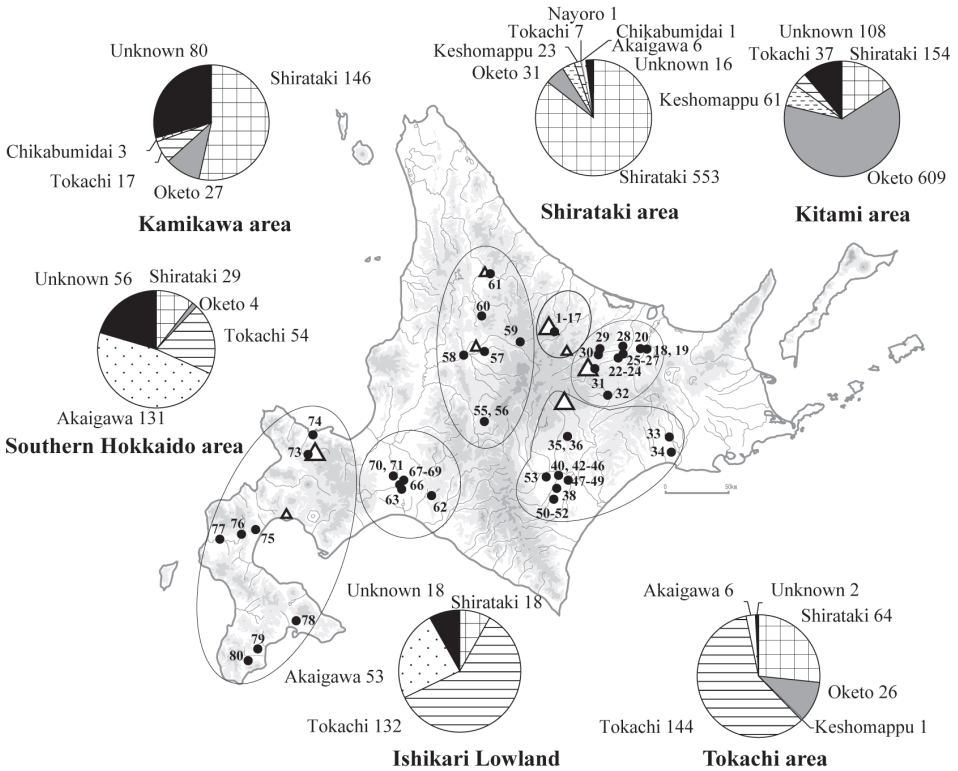


Figure 4 – Obsidian exploitation patterns during the Early Upper Palaeolithic, 35 – 25 ka cal BP

Δ; utilized source,
▲; non-utilized source (hereafter same)

Figure 5 – Obsidian exploitation patterns in Late Upper Palaeolithic, 25 – 10 ka cal BP



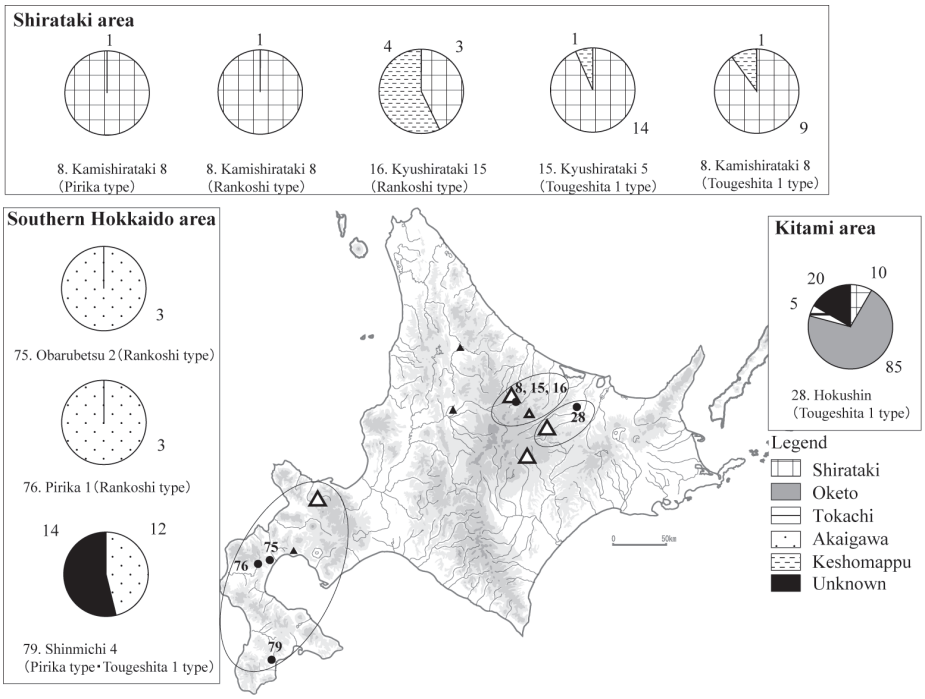


Figure 6 – Obsidian exploitation patterns in the subphase 1 of early Early Microblade Industry, 25 – 21 ka cal BP

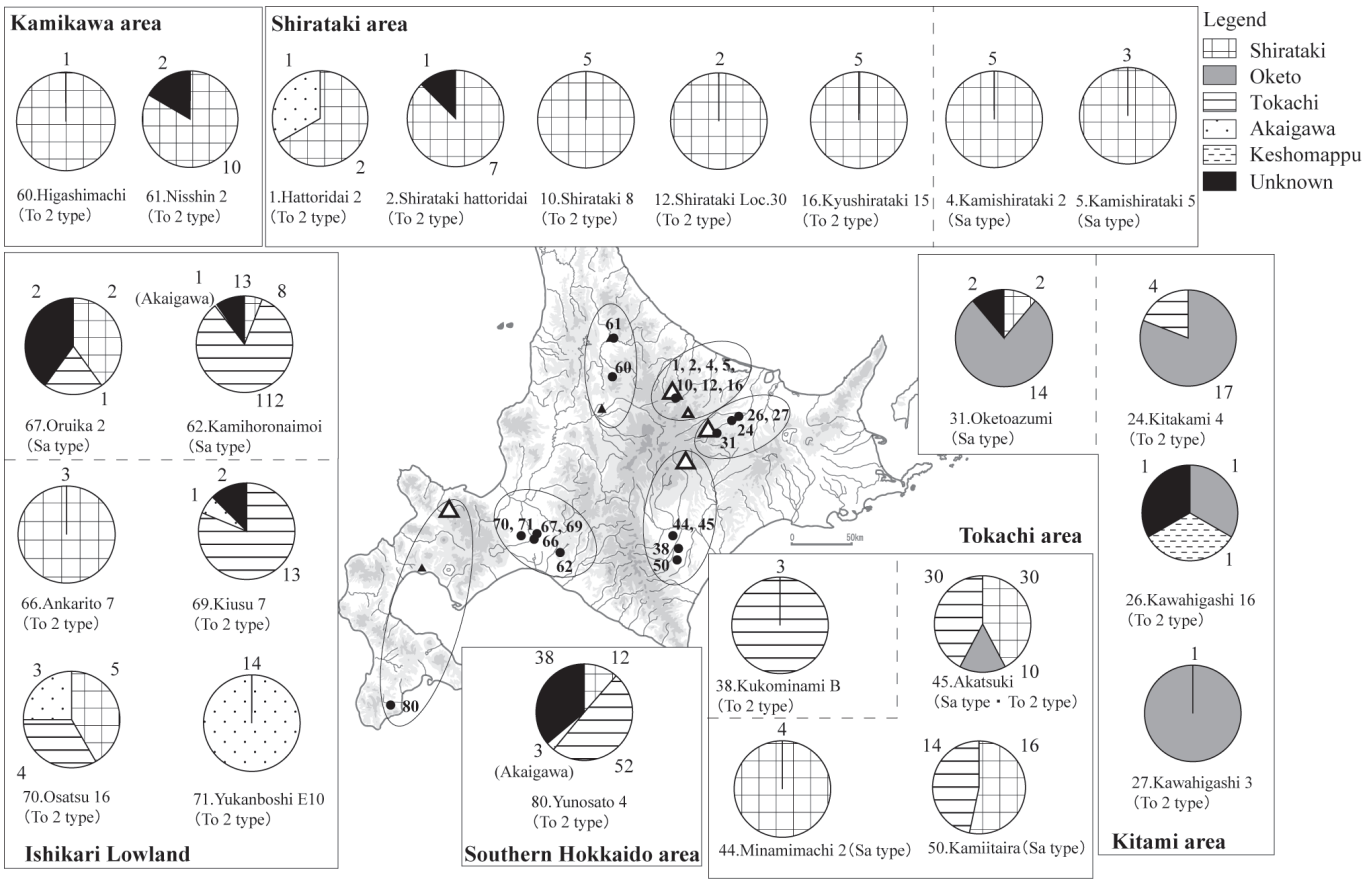


Figure 7 – Obsidian exploitation patterns in the subphase 2 of late Early Microblade Industry, 19 – 16 ka cal BP

Sa; Sakkostu type, To2; Tougeshita 2 type

Comparing the proportions of obsidian from different sources used in each area, we notice that the nearest major sources were mostly used in Shirataki, Kitami and Kamikawa. On the other hand, in Ishikari Lowland obsidian from Tokachi (170 km away) was predominantly used, while the nearby Akaigawa source was exploited much less. It is well known that at some sites in Ishikari Lowland, Shirataki obsidian was strongly preferred for the production of the Sakkotsu type microblade industry (Akai 2009); this trend seems to hold up in our research as well, with the exception of the Kamihoronaimoi site (Fig.7). We analyzed the chemical composition of 83 Sakkotsu type microblades from Kamihoronaimoi which yielded the following results: 92% were made of Tokachi obsidian, 7% of Shirataki obsidian, and only 1% of Akaigawa. The Sakkotsu type microblade industry was usually made of Shirataki obsidian, therefore Kamihoronaimoi is unique and different from other sites producing Sakkotsu type microblade industries (Fig.8). In the Ishikari Lowland Akaigawa obsidian, which is the nearest major source, was mainly used throughout the UP, although during the late Early Microblade Industry we witness an increased use of Tokachi obsidian.

In southern Hokkaido the Tokachi source was the mostly used one, after which come the Shirataki, and the Akaigawa sources. An exception to this trend is the Yunosato 4 site which yielded Tougeshita 2 type microblade industry (Warashina and Higashimura 1985). Microblades made of Shirataki obsidian are usually assumed to have come from Sakkotsu type microblade cores on the basis of morphological criteria (Terasaki 2005; Yamada 2006). This shows the strong correlation between the Sakkotsu type microblade cores and Shirataki obsidian, and between the Toigeshita 2 type and Tokachi obsidian or obsidian from other local major sources.

In the Tokachi area the ratio of sources used is clearly different for every industry. Shirataki obsidian was mainly used at the sites with Sakkotsu type microblade industries, whereas Tokachi obsidian was preferred for the Tougeshita 2 type microblade industry. In the Akatsuki site the Sakkotsu type microblade cores were made entirely of Shirataki obsidian (n=14), whereas Tougeshita 2 type microblade cores were made of obsidian from Tokachi (n=18), Oketo (n=4), and Shirataki (n=1) (Kitazawa 1996) (Fig.9). This result demonstrates that the preference to Shirataki obsidian for the production of the Sakkotsu type microblade industry exists in eastern Hokkaido as well (Shirataki, Kitami, and Tokachi areas).

As mentioned above, except for the Ishikari Lowland, Sakkotsu type microblade cores were made of Shirataki obsidian in all areas. On the contrary, the Tougeshita 2 type microblade industry tends to be made of obsidian from the nearest major source in eastern Hokkaido (Fig.10).

As Yamada (2006) has shown, the Sakkotsu type microblade industry requires large nodules of high quality, which would make its preparation at the primary sources necessary, therefore making Shirataki the most suitable source for the procurement of such raw material. On the other hand, in the Tougeshita 2 type microblade industry, which also makes use of round pebbles and small debris or angular nodules, we expected that it would be popular in the Tokachi and Ishikari Lowland areas, in which high quality large obsidian nodules are relatively scarce. The results of this study confirm Yamada's (2006) hypothesis. Furthermore, our results are consistent with the hypothesis that Sakkotsu type microblade cores were transported over a long distance with uniting to Shirataki obsidian, whereas the Tougeshita type microblade cores were made of obsidian available near the sites (Kimura 1995).

Subphase 3: Late Microblade Industry, 16 - 10 ka cal BP

This phase is characterized by the increased exploitation of the minor sources compared to the previous phases. Moreover, the most characteristic trait of this phase is that all industries show peculiarities in the way they use obsidian. As in previous phases, the tendency of using the nearest major sources persists in the Late Microblade Industry as well.

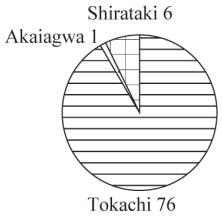


Figure 8 – Obsidian source ratios from Kamihoronaimoi site in the Ishikari Lowland in the subphase 2

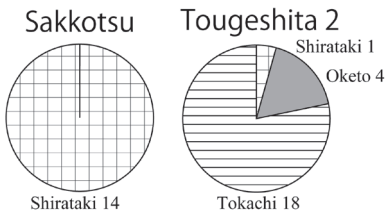


Figure 9 – Obsidian source ratios of Sakkotsu and Tougeshita 2 type microblade cores found at the Akatsuki site in the Tokachi area in the subphase 2

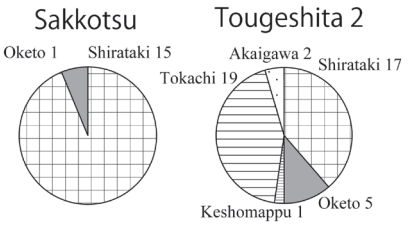


Figure 10 – Obsidian source ratios of Sakkotsu and Tougeshita 2 type microblade cores in whole Hokkaido in the subphase 2

For example, in the Oshorokko 1 and 2 type microblade industries (Fig.11) and the points and stemmed points industry (Fig.12) the nearest major obsidian sources were used mainly, however, at the same time the minor source of Chikabumidai also started being used. Obsidian nodules from such minor sources are usually small and scarce, but they were nevertheless used often much later, in the Jomon period (Tomoda 1996). This is the beginning of new exploitation strategies by the sedentary hunter-gatherers of Holocene Japan, which start at the Jomon period and continue after this period. In eastern Hokkaido the types of obsidian used for the Oshorokko 2 type microblade industry vary, whereas in western Hokkaido (Ishikari Lowland and southern Hokkaido areas) the picture seems to be simpler. It is quite difficult to explain this pattern, as only a few sourcing analyses have been conducted thus far; what we can say however, is that this tendency is largely different from the previous phase of the late Early Microblade Industry, when even western Hokkaido witnesses the use of a variety of obsidian sources. Moreover, an important common trait is the transportation of obsidian from the various sources in the form of finished tools (e.g., points, bifaces etc.) or cores (e.g., microblade cores). For instance, in the microblade industry Oshorokko 1 of the Tokachi area the cores are made of obsidian from a distant source and then brought to the area (Fig.11: Ozora site [Higashimura and Warashina 1995; Kitazawa 1993]). In the Oshorokko 2 type microblade industry of the Shirataki area, one flake refitted to a microblade core was analyzed and showed that its provenance was from the Keshomappu minor source (Fig.11: Kyushirataki 15 site [Ibutsu zairyo kenkyujo 2012a, Naoe 2012]). In the Tokachi area an Oshorokko 2 type microblade core made of Oketo obsidian was recovered during excavations (Fig.11: Kagawa site [Ibutsu zairyo kenkyujo 2012b; Murata et al. 2012]). Similarly, in the points and stemmed points industry, stemmed points are made of obsidian from distant sources and are often transported into the Shirataki area.

Akaigawa obsidian was transported into the Shirataki and Tokachi areas in the form of Tougeshita 2 type microblade industry of the late Early Microblade Industry phase; this tendency is also common in the Late Microblade Industry including the Oshorokko 1 type microblade industry and the points and stemmed points industry. This characteristic is especially evident in the small boat-shaped tool type 1 and 2 industries (Fig.13). These examples of Akaigawa obsidian being transported into eastern Hokkaido are incompatible with the general tendency to exploit nearby sources which prevails in this period.

Similarly to the previous period, some industries seem to be made of specific types of obsidian. For example, the Oketo source, which is not the nearest major source for the Tokachi and Kamikawa areas, was the obsidian mostly preferred for the production of Hirosato type microblades (Fig.14). Even though Oketo obsidian was less frequently transported into distant areas, we see however, that it was brought to these areas exclusively for the purpose of producing this industry. The Hirosato type microblade industry made on high quality fine-grained raw material such as obsidian or shale, it is found in the Kitami area where the Oketo obsidian source is located. It is known that this industry is also found around the Ustinovka shale zone in the Russian Maritime

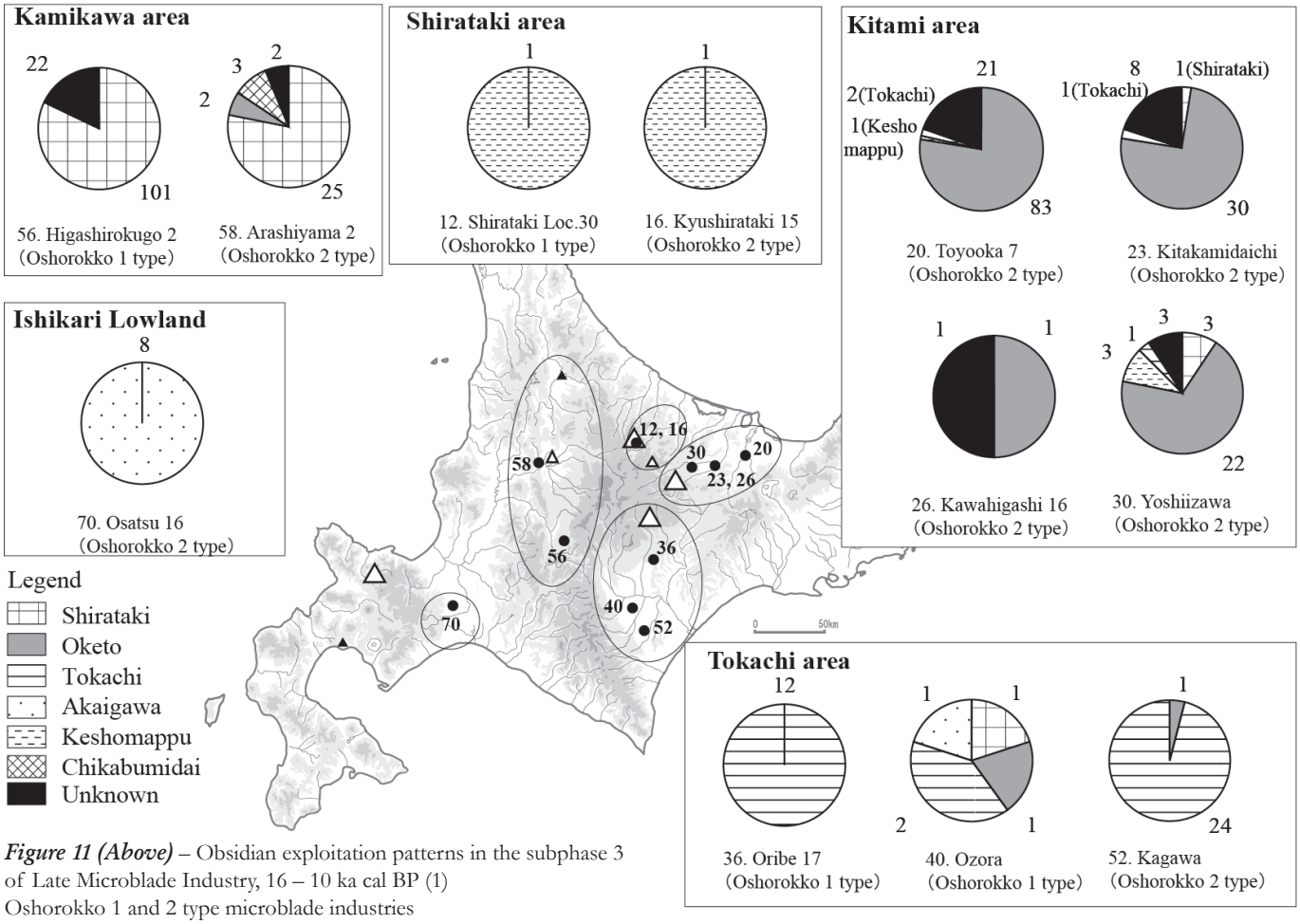


Figure 11 (Above) – Obsidian exploitation patterns in the subphase 3 of Late Microblade Industry, 16 – 10 ka cal BP (1)
Oshorokko 1 and 2 type microblade industries

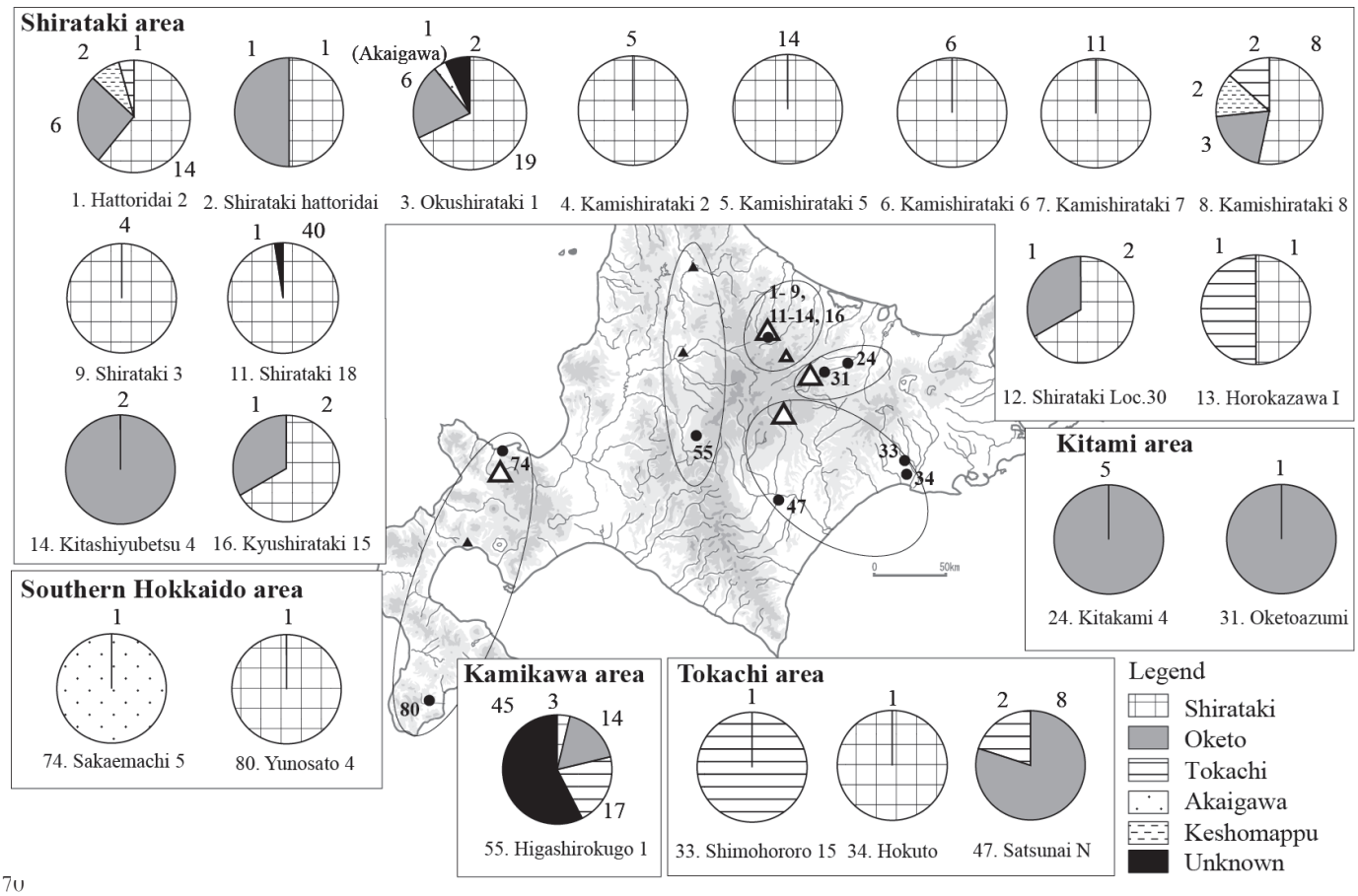


Figure 12 (Below) – Obsidian exploitation patterns in the subphase 3 of Late Microblade Industry, 16 – 10 ka cal BP (2) – Industry with points and stemmed points

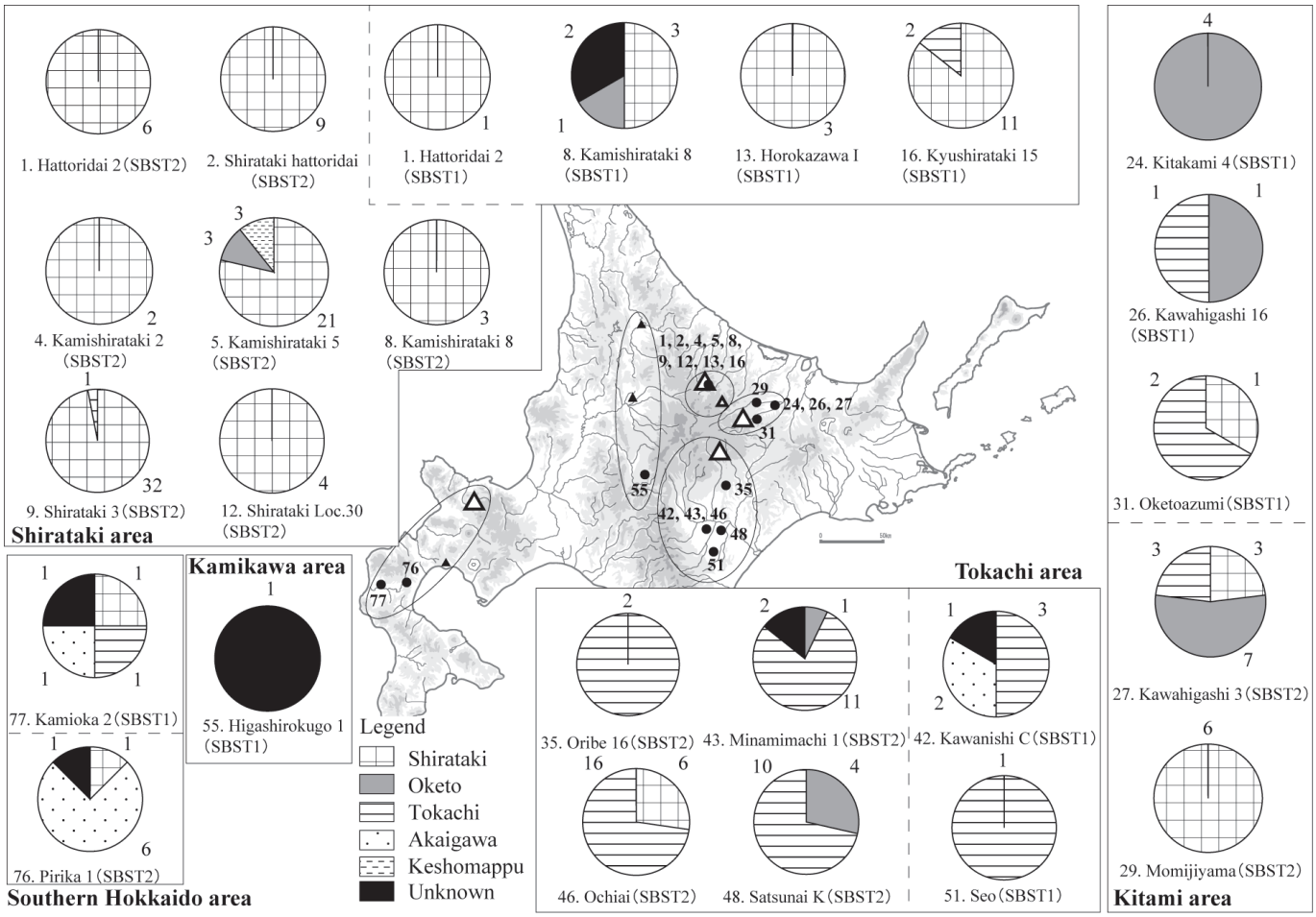
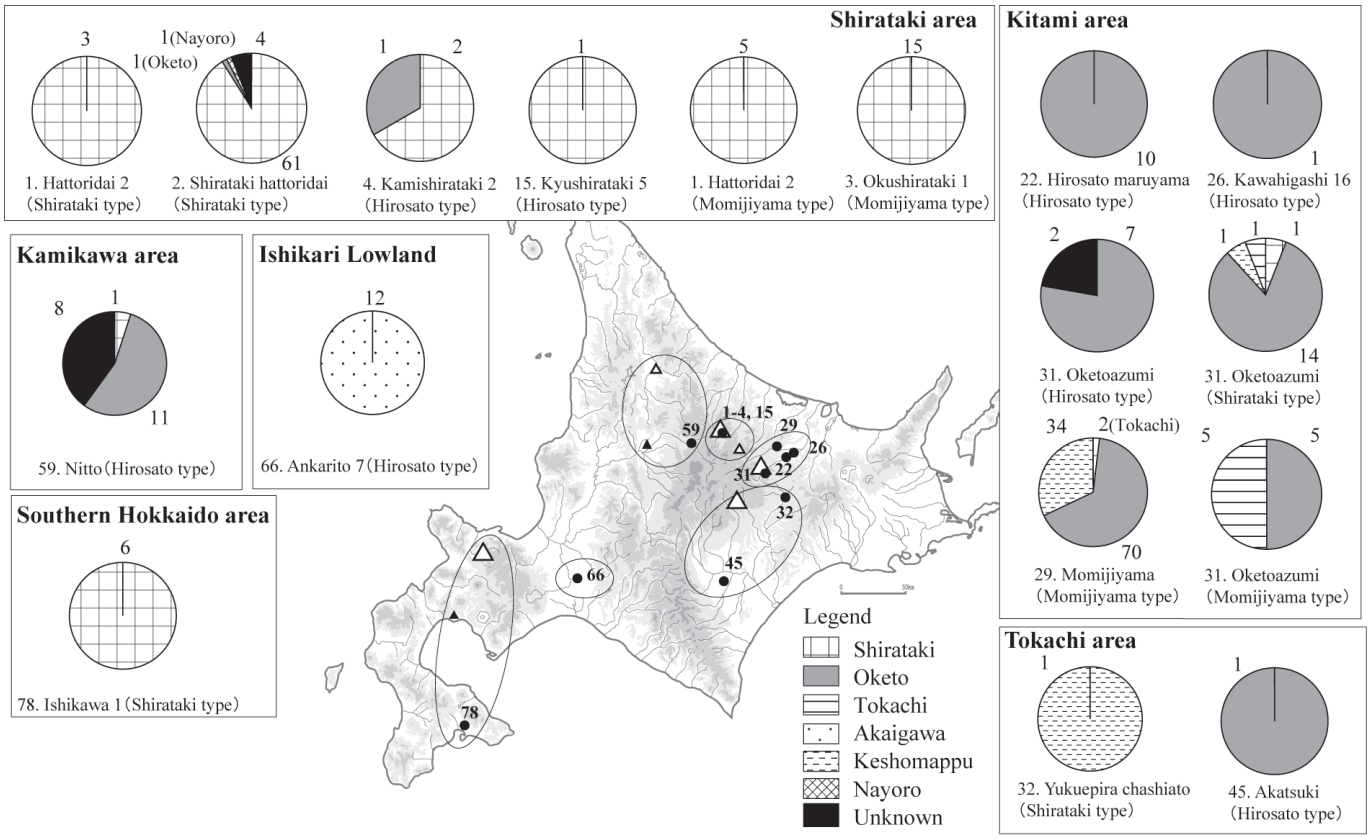


Figure 13 (Above) – Obsidian exploitation patterns in the subphase 3 of Late Microblade Industry, 16 – 10 ka cal BP (3)
Small boat-shaped tool type 1 and 2 industries – SBST1; small boat-shaped tool, type 1 industry – SBST2; small boat-shaped tool, type 2 industry
Figure 14 (Below) – Obsidian exploitation patterns in the subphase 3 of Late Microblade Industry, 16 – 10 ka cal BP (4) – Shirataki, Hirosato and Momijiyama type microblade industries



Provinces and the Baekdu Mountain obsidian source (Sato 2004a; 2004b). In the Ishikari Lowland however, this industry was made exclusively of Akaigawa obsidian. In southern Hokkaido, which is a long way from the obsidian sources but has abundant shale, it was shale that served as a raw material for the Hirosato type microblade industry. As mentioned already, it seems that in western Hokkaido (Ishikari Lowland and southern Hokkaido), the raw material procurement strategies were different from those in eastern Hokkaido. Nevertheless, the Hirosato type microblade industry in Hokkaido was made of obsidian from the Oketo source.

The Shirataki type microblade industry was analyzed only in 4 sites. The results show that Shirataki obsidian was almost exclusively used for this industry, with the sole exception of the Oketoazumi site, which lies very close to the Oketo source. Shirataki obsidian was transported for the production of this industry at the Ishikawa 1 site at the southernmost part of Hokkaido (Koshimizu 1988b), therefore showing that this industry is so strongly associated with Shirataki obsidian that it would be transported especially for this purpose over a very long distance.

The Shirataki type microblade industry in this period employs the fully developed Yubetsu method; together with the Sakkotsu type microblade industry of the previous period, the late Early Microblade Industry, they share some common characteristics with the wedge-shaped microblade industry, which is widely distributed over Northern Eurasia (e.g., in Siberia). Almost all of the microblade industries in Hokkaido were scantly distributed in the Palaeo-Hokkaido Peninsula; a plausible explanation for that would be that the UP socio-cultural boundary was defined by the Tsugaru Strait between the Palaeo-Hokkaido Peninsula and the Palaeo-Honshu Island during the Pleistocene. The Sakkotsu type and the Shirataki type microblade industries however, are found all over northeastern Japan and even in the South across this boundary. We have made a case elsewhere that the morphology of the lithic technology was dictated by the long distance mobility strategy which we regard as the determining behavioral factor for the choices the UP peoples made (Sato 1993, 2000, 2005, 2010, 2011b); this is further attested by the fact that both industries strongly depend on Shirataki obsidian, which the present study also showed.

4 – Discussion

A – Characteristics of the obsidian procurement and circulation pattern of the major sources

It seems there is a difference in the way the major sources Shirataki, Tokachi on one hand and Oketo and Akaigawa one the other, were exploited throughout the Palaeolithic period. Obsidian from Shirataki and Tokachi was transported to distant areas already from the EUP, and was intensively used throughout Hokkaido during the LUP. Shirataki obsidian was used mostly locally throughout the Upper Palaeolithic; during the EUP it was transported to the Ishikari Lowland, but during the LUP, it is found even in the distant southern Hokkaido. It should also be noted that a small amount of Shirataki obsidian was transported to the nearby Kitami area where the Oketo source is the nearest major source. During the EUP the circulation of Tokachi obsidian was limited to the local areas of Tokachi and Kamikawa or the Ishikari Lowland located relatively near Tokachi area, after the LUP, however, this type of obsidian is found over the entire area of Hokkaido. It is noteworthy that obsidian from other areas was not transported into the Kitami area, apart from Oketo obsidian.

In contrast, Oketo and Akaigawa obsidian can be found at sites near the two sources during the EUP, and later, in the LUP, their distribution seems to have expanded widely. However, unlike the Shirataki and Tokachi obsidian, their use was relatively limited. A small amount of obsidian from Shirataki was transported to Kitami, whereas larger amounts of obsidian from the Oketo source in Kitami were transported to the Shirataki area. The use of Akaigawa obsidian expanded remarkably after the LUP. During the EUP it was mainly used in the west Kamikawa areas, and specifically in the Ishikari Lowland and southern Hokkaido, but after the LUP, Akaigawa obsidian is

found all the way to the Shirataki and Tokachi areas in eastern Hokkaido. Throughout the LUP, a relatively large amount of obsidian from eastern Hokkaido (Shirataki and Tokachi sources) was transported into western Hokkaido (Ishikari Lowland and southern Hokkaido), while the amount of Akaigawa obsidian transported into eastern Hokkaido (Tokachi, Kitami, Kamikawa and Shirataki areas) was quite small. This might be explained by the limited quantity of Akaigawa obsidian available.

Compared with other major sources, Oketo obsidian was mainly used locally in Kitami, and rarely used in other areas. In the Ishikari Lowland this obsidian is barely used, except for the production of the Hirosato type microblade industry. The procurement and use of Akaigawa obsidian in southern Hokkaido and Oketo obsidian in eastern Hokkaido seem to be complementary to each other. On the island of Sakhalin only Shirataki obsidian was used during the LUP, whereas Oketo obsidian was not used there until the Neolithic period (Kuzmin et al. 2002).

B – Comparison with studies for residential mobility and behavioral strategy

Kimura (1995) suggested that obsidian was transported over long distances during the period that microblade industries flourished, but before and after that period, local raw materials were mainly utilized. Yamada (2006) modeled the residential mobility system of the prehistoric people that used microblade industries according to the scheme of residential and logistic mobility. Although the results of our study corroborate these hypotheses, we appreciate that the dynamics of behavioral strategies are much more complicated than what this kind of studies can hypothesize, which explains in part why so many questions remain still unresolved.

C – Cultures, ecosystems and obsidian source analysis

We have written extensively on the undoubtedly strong relationship between human cultures on one hand, and vegetation, fauna, landscape and palaeoclimate on the other, in an attempt to map the historical process of socio-ecological and cultural change in the northern Circum-Japan Sea Area through the lens of cultural ecology (Sato 2008, 2009, 2011a, 2012; Sato et al. 2011). The emergence of microblade industries in Hokkaido at the beginning of the early Early Microblade Industry coincides with the transition from Marine Isotope Stage 3 to 2 (MIS3 to MIS2). The Last Glacial Maximum (LGM) also began during this period, while the mammal resource structure changed radically from the southern *Palaeoloxodon-Sinomegaceroides* complex to the northern mammoth fauna. It must be noted however, that the ratios of obsidian from different sources present at each site did not change significantly during this time, implying that it is possible that the behavioral strategy during the early Early Microblade Industry did not change immediately to adapt to the changes in the resources.

In other words, the diversification of obsidian sources used and the relation between specific sources and industries were not seen until the transition from the early to the late Early Microblade Industry. Therefore, the changes in the obsidian exploitation patterns did not necessarily coincide with the changes in technology, subsistence, residential mobility and behavioral strategies caused by the introduction of the microblade technology. Rather, it seems that the obsidian exploitation patterns changed in the late Early Microblade Industry at the same time the fully developed Yubetsu technique appeared, the famous microblade knapping technique of northern Eurasia. The prehistoric people of the late Early Microblade Industry developed a long distance mobility strategy suitable for hunting large fauna, such as mammoth and giant deer, which in turn meant organizing efficiently the production of microblade industries, which is also reflected in the manner in which obsidian sources were exploited. It is generally assumed that the extinction of large mammals in Hokkaido occurred about 18 ka cal BP (Takahashi 2007; 2011). If this assumption is correct, it corresponds to the middle of the late Early Microblade Industry. Consequently, the game gradually became smaller in size, which brought about the various obsidian procurement strategies pertaining to each industry in the Late Microblade Industry.

The first human occupation in Hokkaido dates back to the beginning of the Upper Palaeolithic, and obsidian remained the main lithic raw material from this time until the end of the Palaeolithic period. At present no sites have been found dating to the period between early and late Early Microblade Industry (21-19 ka cal BP). Unfortunately, radiocarbon dates for Palaeolithic sites in Hokkaido are very few; hence, it is difficult to determine whether this lack of sites is due to a population decrease caused by extreme environmental conditions, such as severely cold climate similar to the one during the LGM, or simply because we are lacking securely dated Palaeolithic sites.

5 – Summary and concluding remarks

There are 21 obsidian sources archaeologically in Hokkaido, out of which only 8 were used during the UP. Throughout the UP, the sites located in the vicinity of the major obsidian sources Shirataki, Tokachi, Oketo and Akaigawa, tended to use these primarily for the procurement of obsidian; however, the obsidian sources that are deemed secondary show different exploitation patterns depending on the period and industry. In Kamikawa and the Ishikari Lowland, where no major obsidian sources exist nearby, the ratios of obsidian from different sources vary among periods and industries. In particular, the Ishikari Lowland is 70 km away in a straight line from the Akaigawa source, 150 km from the Tokachi source, 170 km from the Shirataki source, and 180 km from the Oketo source. Knowing which sources were used for which industry is crucial to our understanding of raw material procurement strategies as well as the process of creating territorial boundaries.

Among the four major sources, Shirataki, Tokachi, Oketo and Akaigawa, the former two were distributed widely from the beginning of the EUP, while the latter two were used in sites near them in the EUP, and were not widely distributed until the LUP. Even during the LUP, the amount of obsidian circulated from Oketo and Akaigawa was relatively small. We should also note that Oketo and Akaigawa obsidian were complementary to each other.

From the perspective of ratios of different types of obsidian, the turning point for the obsidian exploitation strategies did not coincide with the appearance of microblade industries during the transition from EUP to LUP, but with the development of the fully developed Yubetsu technique during the transitional period from the early to the late Early Microblade Industry. The Sakkotsu type microblade industry in this period was strongly tied to Shirataki obsidian; Oketo and Tokachi obsidian were used in the Kitami and Ishikari Lowland areas respectively. In contrast, the contemporaneous Tougeshita 2 type microblade industry tends to be made of local obsidian from nearby sources. During the Late Microblade Industry, the relationship between specific sources and industries became more pronounced. Apart from the Sakkotsu type microblade industry, Shirataki obsidian was also used for the production of Shirataki type microblade industries knapped using the fully developed Yubetsu technique. Oketo obsidian was not used much throughout the UP, but it was the preferred raw material for the Hirosato type microblade industry. Exploitation of minor sources such as Chikabumidai and Nayoro is characteristic of the LUP. The obsidian exploitation patterns we explore here are generally consistent with the residential mobility system studies of Kimura (1995) and Yamada (2006), but we should note once again that the scant sourcing data create a bias that needs to be addressed to further our understanding. The more we increase the number of sourced obsidian artifacts, the more precise our interpretations can be about the circulation of obsidian and the exploitation of every obsidian source.

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Note (1) – Palaeolithic in the Palaeo-Honshu Island is divided into Early Upper Palaeolithic (38-29 ka cal BP), Late Upper Palaeolithic (29-18 ka cal BP) and Final Upper Palaeolithic (18-16 ka cal BP). In particular, please notice that the subphases of the EUP and LUP in Hokkaido are different from those of the Palaeo-Honshu Island.

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