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On the sources of the obsidian flakes from some Late Palaeolithic Sites in southern part of Central Primorye, Far East Russia

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I Introduction

On September in 2001, the writers had investigated into two Late Palaeolithic sites in southern part of Central Primorye (Fig. 1), as the International co - work. As to the purpose of this co - work, the research for the obsidian rocks in Primorye was carried out in order to clarify the sources points of the raw obsidian rocks as wll as the obsidian fragments excavated from the Palaeolithic sites. The two sites are entered in the site - cadaster in Russia, and they are given the following names respectively ; Novovarvarovka - 1 , and Maladozhunaya (Gorvatka - 5) Sites. The localities of these Palaeolithic Sites are shown in Fig. 2 .

Novovarvarovka - 1 Site is situated at the outskirt area of Novovarvarovka, where is about 6 km distant towards westside from Anuchino. Anuchino is seen at the junction point of Arsenievka and Muraveyka Rivers. Novovarvarovka - 1 Site is found on the left side terrace along Arsenievka River (Fig. 1). As to the vestiges from Novovarvarovka - 1 Site, the large stone implements as such as follows ; blade, core, spoll, scraper, graver, micro - blade. These stone implements were reported by N.A.KONONENKO (1998, 2001). The most of the large stone implements were made from diabasic rocks, on the contrary the small pebble sized obsidian gravels, that could be collected easily from river beds near the site, were used for the small stone implements (N.A.KONONENKO, 1998 ; 2001).

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キーワード：Late Palaeolithic Site（後期旧石器遺跡）Obsidian Flakes from Site（遺跡出土の黒曜岩剥片）
Central Primorye, Russia（ロシア・沿海州）Source of Obsidian Rocks（黒曜岩の原産地）

Fig. 1 Index Map

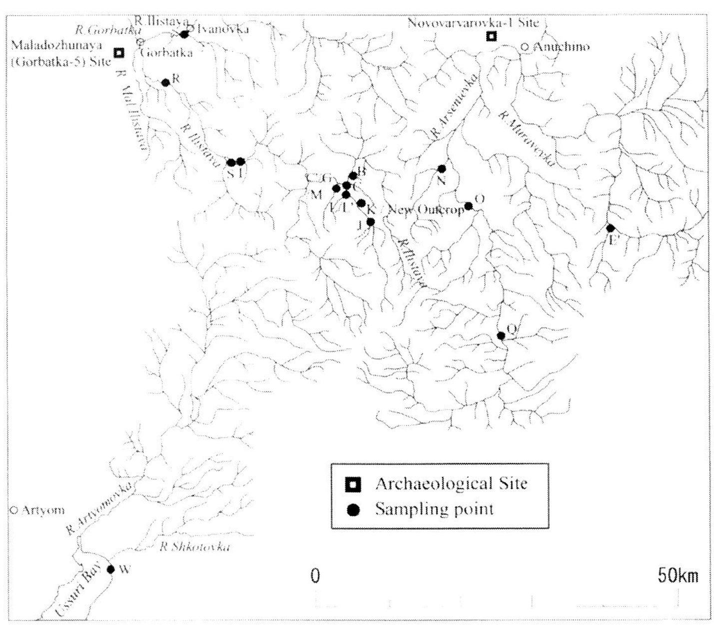

Fig. 2 The Points of Obsidian Samples and The Sites

Maradozhunaya (Gorbatka - 5) Site is found at the western suburbs of Gorvatka, where is situated at the junction of Ilistaya and Mala - Ilistaya Rivers. This site is found on the terrace having about 150 m above the sea level. N. SAKANASHI (2001) had reported on the excavated stone implements from this site. According to this thesis, it can be clarified that these stone implements were mainly made from obsidian rocks (54.2%), and also andesites (37.0%).

The writers had collected some obsidian flakes from above mentioned two Late Palaeolithic Sites in order to search for the sources of these obsidian flakes based on the chemical data. After then, these obsidian flakes were chemically examined in Japan.

II Obsidian Flakes from the Sites

For the purpose of researching the source of obsidian rocks found in Palaeolithic Sites in Primorye, the obsidian flakes were collected from above mentioned two sites, i.e., Novovarvarovka - 1 and Maradozhunaya Sites. These sites had been already excavated, so large majority of the sampled obsidian flakes were small ones in size, and small amounts of samples were gathered. Among these flakes, the specimen which can be used for the chemical analyses were very few. The obsidian specimen of being used for experiments are given as follows :

Novovarvarovka - 1 Site : Specimen No. RNB-1, RNO-1 Total 2 samples.

Maradozhunaya Site : Specimen No. RMA-1 ~ 7, RMO-1 ~ 4 Total 11 samples.

These obsidian samples were, of cause, collected from the excavated vestigeses of sites. Among these samples, three samples, i.e., RMA-1 ~ 3, are rather big in size, however the rest of them are small. The obsidian samples from the sites exhibit very hard and dark blueish gray in colour, and they have high indecies. They seem to be basaltic glasses in compositon. Any person can not find out the obsidian rocks showing these distinctive features in Japanese Islands at all.

Table 1 Some Components of JG-1

	Na_2O (wt%)	K_2O (wt%)	CaO (wt%)	T-Fe_2O_3(wt%)	Rb (ppm)	Sr (ppm)
J G - 1	9.38	3.98	2.20	2.18	182.00	184.00

Ⅲ Chemical Experiment and Results

As to the obsidian samples from the sites in Primorye, they were reduced to pulverized specimen in 200～300 mesh in size by use of W—C mortar, in order to analyze these specimen chemically. For the chemical experiments, the following apparatus were used ; Wave Dispersive X - Ray Fluorensence Spectrometer (WDX) and Energy Dispersive X - Ray Fluorensence Spectrometer (EDX). As the other apparatus, Electron Probe Microanalyzer (EPMA) and Atomic Pile were sometimes used in case of need.

The chemical compositions of the obsidian specimen were decided by using standard material such as JG-1 (powdered granodiorite specimen), of being arranged by Geological Survey of Japan. By the way, some chemical elements of JG-1 are given in Table 1.

The chemical analyses data, as the results of experiments through WDX and EDX, are given inTables 2 and 3. Here, as for the accuracy of the chemical experiments, measurement error will be counted within ± 5 %, and the error range shows normal distribution. Accordingly any statistics deduction methods will not be necessary. Based on the chemical analyses results, the mutual relation between Rb and Sr contents by means of WDX method is shown in Fig. 3.

Judging from the interrelation between Rb and Sr contents, the specimen can be divided into three groups. The specimen, numbered RMA-2, is constituted one group independently. And the rest of these specimen, i.e., 10 specimen from Maradozhunaya Site are divided into two groupes (Fig. 3).

Besides, owing to the relationship between Ba and Sr contents by EDX method, the osidian specimen are able to be divided into 5 types as shown in Fig. 4, such as Type Ⅰ～Ⅴ. Among the obsidian specimen from Maradozhunaya Site, 8 specimen, RMA-4 ～ 7 and RMO-4, belong to Type Ⅰ, and as to the other specimen, RMA-1 is classified to Type Ⅲ, RMA-2 to Type Ⅳ, RMA-3 also to Type Ⅴ. Besides, RMO-1 ～ 3 constitute to Type Ⅱ. Furthermore, the two specimen, that are RNB-1 and RNO-1 collected from Novovarvarovka - 1 Site, belong to Type Ⅱ. Here, the three specimen, RMA-1 ～ 3, were reduced to powdered ones from more large obsidian flakes.

The results of the examination of WDX and EDX are some what different with each other. Especially Ba contents are shown severally, however the reason why Ba contents have such diversities will be not able to be clarified without field surveys in details.

Thereupon, the writers had taken raw obsidian samples at the basin of Ilistaya River as shown in Fig. 2. These samples were also examined for chemical analyses as same as the flakes. The chemical composition data of the raw obsidian samples are given in Tables 4 and 5.

Table 2 The Chemical Composition of The Obsidian from The Sites (WDX). Oxisides are presented in wt%

Specimen No.	Na_2O	K_2O	CaO	T-Fe_2O_3	Rb (ppm)	Sr (ppm)
RMA-1	2.625	0.291	7.958	11.102	17	212
RMA-2	2.995	0.405	7.216	10.197	18	281
RMA-3	2.489	0.404	7.831	11.521	21	231
RMA-4	2.778	0.215	7.775	10.732	18	203
RMA-5	2.761	0.271	7.949	10.921	21	201
RMA-6	3.041	0.367	7.382	10.416	19	234
RMA-7	2.651	0.412	7.669	10.686	19	228
RMO-1	2.801	0.373	7.174	10.141	21	241
RMO-2	2.741	0.401	7.311	10.304	22	236
RMO-3	2.677	0.431	7.356	10.431	21	243
RMO-4	2.687	0.423	7.387	10.374	21	243
RNB-1	2.765	0.435	7.299	10.537	22	241
RNO-1	2.702	0.348	7.198	10.111	21	242

Table 3 The Chemical Composition of The Obsidian from The Sites (EDX). Oxisides are presented in wt%

Specimen No.	T-Fe_2O_3	MnO	Rb	Sr	Zr	Y	Ba	Type
RMA-1	4.731	0.075	73.1	205.1	95.9	23.2	211.4	III
RMA-2	4.694	0.073	77.6	235.9	100.1	23.5	299.9	V
RMA-3	5.087	0.077	79.7	216.1	101.3	24.2	323.8	IV
RMA-4	4.841	0.073	72.6	204.2	94.1	23.1	206.3	I
RMA-5	4.854	0.076	75.6	203.3	95.8	23.3	294.7	I
RMA-6	4.488	0.071	74.4	207.8	94.7	22.9	279.6	I
RMA-7	4.777	0.076	76.1	212.1	96.2	23.2	281.4	I
RMO-1	4.625	0.071	74.4	211.5	94.7	23.5	233.5	II
RMO-2	4.874	0.074	74.4	219.5	96.8	23.8	241.8	II
RMO-3	4.775	0.072	74.9	210.1	94.7	23.3	241.3	II
RMO-4	4.751	0.072	74.7	212.1	96.5	23.6	296.9	I
RNB-1	4.503	0.067	74.9	208.2	95.4	22.5	295.2	I
RNO-1	4.611	0.071	73.5	210.2	95.1	23.4	290.7	I

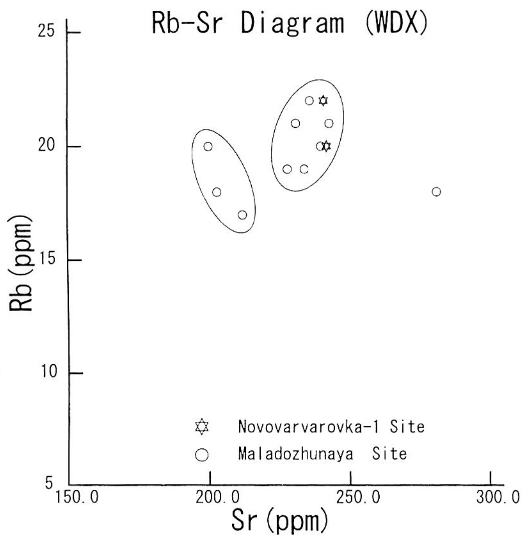

Fig. 3 The Rb-Sr Diagram (WDX)

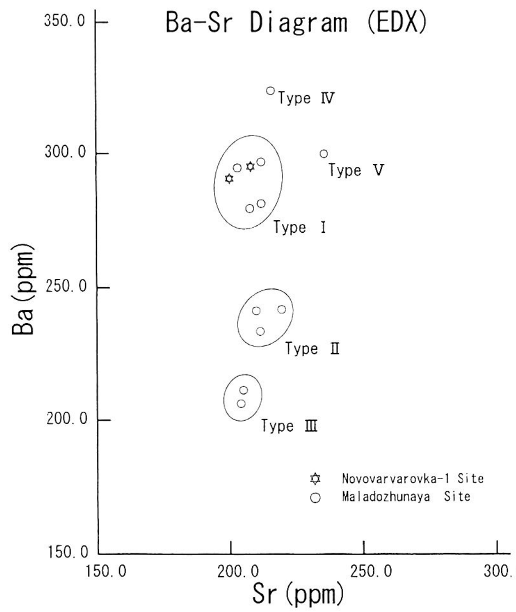

Fig. 4 The Ba-Sr Diagram (EDX)

IV Discussion and Conclusion

As shown in Fig. 2, the writers had collected the raw obsidian rocks at the upper reaches basin of Ilistaya, Arsenievka and Muraveyka Rivers. These samples were also chemically analyzed for pursueing their chemical composition data. The experimental results are given in Tables 4 and 5 as already mentioned. The interrelationships between Rb and Sr contents (WDX), and also Ba and Sr (EDX) are diagrammed in Figs. 5 and 6. Here, as for the specimen RW-1, its point can not find in Fig. 5, because its Sr content is very high and its point scales out of the range in Fig. 5.

In order to specify the source points of the obsidian rocks which were materials of the flakes from the sites, the chemical features of both of raw obsidian samples and the obsidian flakes are examined. As illustrated in Table 3 and Fig. 5, it can be clarified that the original source points of the obsidian flakes from the sites, with the excepting of RMA-1 ～ 3, are found in the upper reaches basins of Ilistaya, Arsenievka and Muraveyka Rivers.

As previously described, the obsidian specimen such as RMA-1 ～ 3 were arranged in order to analize chemically from the more large obsidian flakes than the the others. Therefore as N.SAKANASHI (2001) pointed out, it can be estimated that these above mentioned three obsidian flakes were made from big raw obsidian rocks that had been brought in from some where excepting of basin of Ilistaya River in Primorye region, where basaltic rocks are distributed in,

Table 4 The Chemical Composition of Raw Obsidian (WDX). Oxisides are presented in wt%

Specimen No.	Na_2O	K_2O	CaO	T-Fe_2O_3	Rb (ppm)	Sr (ppm)
RIR-1	2.904	0.366	7.056	10.266	19	254
RIR-2	2.916	0.349	7.262	10.259	18	237
RB-1	2.839	0.368	7.295	10.342	19	238
RC-1	2.982	0.369	7.271	10.302	21	237
RC'-1	2.914	0.344	7.164	10.205	21	241
RC'-2	2.886	0.355	7.191	10.254	19	242
RE'-1	2.715	0.425	7.822	10.561	20	239
RG-1	2.867	0.354	7.124	10.399	18	234
RG-2	2.878	0.365	7.239	10.302	19	236
RJ-1	2.731	0.443	7.409	10.481	21	247
RK-1	2.931	0.399	7.187	10.206	22	287
RK-2	2.931	0.354	7.094	10.193	19	259
RL-1	2.751	0.443	7.317	10.471	21	243
RL-2	2.787	0.365	7.165	10.275	20	237
RL'-1	2.748	0.413	7.275	10.411	20	242
RM-1	2.833	0.381	7.253	10.372	21	239
RM-2	2.728	0.461	7.427	10.568	21	243
RN-1	2.651	0.261	7.756	10.808	20	196
RN-2	2.624	0.249	7.796	10.782	18	198
RO-1	2.463	0.425	7.928	11.241	22	227
RQ-1	2.463	0.321	7.751	11.104	19	208
RQ-2	2.449	0.445	7.865	11.325	22	230
RR-1	2.577	0.431	7.145	10.741	21	237
RR-2	2.774	0.349	6.931	10.953	18	233
RS-1	2.708	0.425	7.291	10.486	21	241
RS-2	2.741	0.428	7.325	10.446	20	243
RT-1	2.764	0.418	7.302	10.484	20	240
RW-1	2.483	0.575	7.556	10.865	21	367
RUI-4	2.362	0.414	6.969	11.352	21	246

Table 5 The Chemical Composition of Raw Obsidian (EDX)
Oxisides are presented in wt%

Specimen No.	T-Fe_2O_3	MnO	Rb (ppm)	Sr (ppm)	Zr (ppm)	Y (ppm)	Ba (ppm)	Type
RIR-1	0.317	0.074	76.4	223.3	98.9	23.6	291.5	I
RIR-2	4.531	0.071	75.6	213.6	95.6	22.9	219.7	II
RB-1	4.535	0.071	76.1	209.7	96.2	23.4	282.3	I
RC-1	4.649	0.072	75.2	213.4	95.3	22.9	203.7	II
RC'-1	4.718	0.074	75.5	216.9	97.4	23.5	292.2	I
RC'-2	4.412	0.069	74.2	208.7	93.8	22.9	275.2	I
RE'-1	4.759	0.076	77.1	216.8	96.8	23.3	241.6	I
RG-1	4.563	0.073	74.2	213.7	96.8	23.2	286.9	I
RG-2	4.652	0.074	76.5	213.9	96.9	24.1	224.7	II
RJ-1	4.628	0.073	73.9	213.6	95.4	22.4	242.2	II
RK-1	4.378	0.071	75.2	224.3	98.2	22.8	227.8	II
RK-2	4.519	0.072	74.8	218.9	97.1	23.1	286.5	I
RL-2	4.609	0.073	74.9	216.1	96.9	23.3	239.6	II
RL'-1	4.668	0.071	77.1	216.8	95.8	23.6	233.9	II
RM-1	4.515	0.072	77.2	212.1	98.1	23.8	297.3	I
RM-2	4.799	0.068	73.5	222.1	97.7	23.3	298.9	I
RN-1	4.815	0.069	71.4	200.8	93.7	23.1	215.9	II
RN-2	4.832	0.071	73.2	205.8	92.7	22.9	223.7	II
RO-1	4.659	0.069	74.3	204.8	94.9	22.4	291.4	I
RQ-1	4.709	0.069	72.1	198.4	95.1	23.1	252.5	III
RQ-2	4.914	0.069	77.4	214.5	98.4	23.5	244.4	II
RR-1	4.844	0.071	78.1	218.9	95.7	23.2	295.9	I
RR-2	4.911	0.073	74.3	213.6	96.4	23.2	244.5	II
RS-1	4.814	0.071	75.7	218.5	98.2	23.1	304.3	I
RS-2	4.521	0.071	74.9	210.8	96.9	22.3	234.2	II
RT-1	4.559	0.068	73.4	212.6	95.2	22.9	289.2	I
RW-1	4.513	0.067	77.1	250.3	102.9	23.1	324.5	VI
RUI-4	10.467	0.093	27.5	239.1	77.2	17.7	159.9	VII

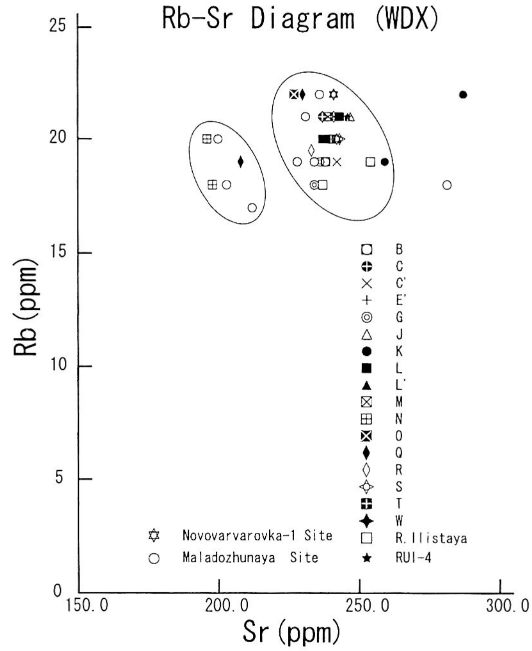

Fig. 5 The Rb-Sr Diagram (WDX)

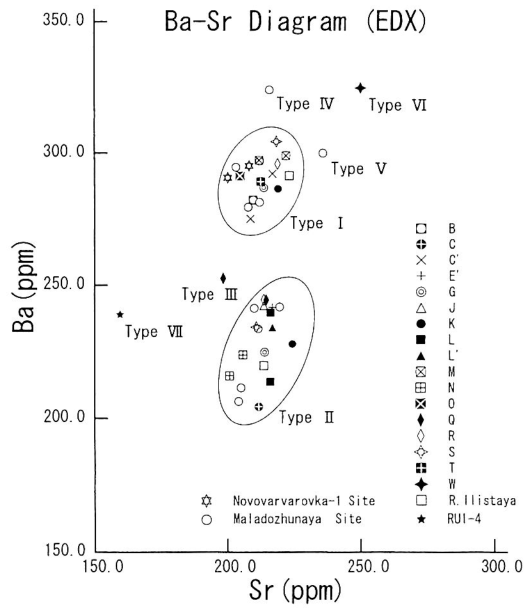

Fig. 6 The Ba-Sr Diagram (EDX)

furthermore these obsidian flakes showing basaltic composition. It may be offered that the other obsidian flakes were made from small raw obsidian gravels that could be taken easily from river beds near sites.

As the conclusion, the obsidian flakes collected from two Late Palaeolithic Sites were made from two kinds of raw obsidian rocks ; one was small gravels of being taken very easily from river beds near the Sites and the others were rather large obsidian rocks carried from somewhat distant region in Central Primorye. Furthermore, both of the obsidian flakes and the raw rocks, they show basaltic in composition without exception. The experimental results for chemical composition of the raw obsidian rocks and the flakes collected in southern part of Central Primorye, are never contradictory to the data mentioned in the data - book (Far Eastern Geological Institute, 2000).

Some one ever had pointed out that the obsidian fragments from some Palaeolithic Sites in Primorye had been brought in from Hokkaido, Japan (MORI, 1989). For reference, chemical composition data of the obsidian, of being sampled from the typical sources in Hokkaido such as Shirataki and Akaigawa are given in Tables 7. Besides, the interrelationship between Rb and Sr contents of the obsidian rocks sampled from both southern part of Central Primorye and

Table 6 The Chemical Composition of The Obsidian from Hokkaido (WDX)
Oxisides are presented in wt%

Specimen No.	Na_2O	K_2O	CaO	$T\text{-}Fe_2O_3$	Rb (ppm)	Sr (ppm)
Akaigawa — 1 Group						
HAK-1	3.513	4.345	0.745	1.017	141	54
HAK-1W	3.591	4.311	0.753	1.024	141	53
HAK-1B	3.438	4.439	0.745	1.012	139	55
HAK-2	3.532	4.341	0.751	1.022	138	56
HAK-3	3.572	4.285	0.747	1.032	139	55
HAKR-1-1	2.998	4.247	0.723	1.007	136	55
HAKR-1-2	3.051	4.208	0.729	1.009	135	56
HAKR-1-3	3.038	4.183	0.731	1.017	138	55
HAKR-1-4	2.995	4.221	0.729	1.019	137	54
HAKR-2-1	3.036	4.174	0.729	1.017	137	53
HAKR-2-2	3.031	4.178	0.731	1.014	138	55
HAKR-2-3	2.973	4.204	0.731	1.007	137	54
HAKR-2-4	3.111	4.171	0.729	1.017	136	54
HAKR-2-5	3.014	4.187	0.727	1.019	138	54
HAKR-3-1	2.846	4.081	0.721	1.014	136	54
HAKR-3-3	3.036	4.174	0.727	1.024	138	55
HAKR-3-4	2.973	4.157	0.723	1.035	137	56
HAKR-4-1	3.005	4.123	0.725	1.022	139	55
HAKR-4-2	3.058	4.234	0.729	1.027	138	54
HAKR-4-3	3.008	4.166	0.731	1.029	137	54
HAKR-4-4	2.998	4.166	0.727	1.027	137	55
HAKR-4-5	3.005	4.187	0.725	1.032	138	55
HAKR-2-1	3.017	4.221	0.723	0.994	139	53
Akaigawa — II Group						
HAKR-3-2	2.791	3.931	0.763	1.047	142	97

Specimen No.	Na_2O	K_2O	CaO	$T\text{-}Fe_2O_3$	Rb (ppm)	Sr (ppm)
Shirataki — I Group						
HSHH-1	3.841	4.328	0.465	1.146	186	5
HSHU-1-1	3.881	4.264	0.467	1.136	184	6
HSHU-1-2	3.847	4.319	0.467	1.134	182	4
HSHU-2-1	3.901	4.332	0.467	1.103	185	4
HSHU-2-2	3.672	4.336	0.465	1.073	183	6
HSHU-2-3	3.841	4.345	0.469	1.116	183	5
HSHB-2	3.941	4.439	0.463	1.041	188	6
HSH-2	3.909	4.443	0.467	1.027	187	6
HSH-3	3.806	4.469	0.467	0.994	185	6
HSH-4	3.681	4.289	0.475	1.078	186	4
HSH-6	3.706	4.281	0.473	1.047	184	7
HSH-7	3.759	4.319	0.475	1.017	184	4
HSHK-1	3.891	4.447	0.469	0.986	191	5
HSHK-2	3.843	4.464	0.463	1.042	187	4
HSHN-1	3.828	4.434	0.461	0.986	187	4
HSHK-2	3.887	4.392	0.465	1.004	188	4

Specimen No.	Na_2O	K_2O	CaO	$T\text{-}Fe_2O_3$	Rb (ppm)	Sr (ppm)
Shirataki — II Group						
HS-⑧-1-1	3.497	4.545	0.525	1.185	165	28
HS-⑧-1-2	3.731	4.259	0.533	1.205	162	28
HS-⑧-1-3	3.859	4.328	0.535	1.205	161	28
HS-⑧-1-4	3.641	4.413	0.525	1.221	163	27
HS-⑧-1-5	3.575	4.554	0.525	1.192	165	28
HS-⑧-1-8	3.173	4.127	0.525	1.136	161	32
HS-⑧-1-9	3.011	4.302	0.527	1.129	161	31
HS-⑧-2-1	3.769	4.285	0.531	1.154	161	31
HS-⑧-2-2	3.728	4.251	0.529	1.146	162	31
HS-⑧-2-3	3.737	4.277	0.531	1.169	165	29
HS-⑧-2-6	3.239	4.191	0.533	1.124	163	31
HS-⑧-3-1	3.778	4.255	0.531	1.136	164	29
HS-⑧-3-2	3.601	4.234	0.527	1.141	162	28
HS-⑧-3-3	3.825	4.268	0.529	1.083	163	31
HS-⑧-3-12	3.204	4.144	0.531	1.029	158	29
HS-⑧-3S-1	3.713	4.341	0.531	1.146	162	28
HS-⑧-3S-2	3.706	4.285	0.533	1.185	161	28
HS-⑧-3S-3	3.703	4.259	0.529	1.154	163	31
HS-⑧-4-1-1	3.644	4.272	0.531	1.141	163	27
HS-⑧-4-1-2	3.635	4.371	0.527	1.124	161	28
HS-⑧-4-1-3	3.048	4.242	0.523	1.051	159	29
HS-⑧-4-2-1	3.797	4.277	0.533	1.073	163	29
HS-⑧-4-2-2	3.688	4.242	0.533	1.057	162	28
HS-⑧-4-2-11	3.949	4.089	0.529	0.976	157	29
HS-⑧-4-3-1	3.851	4.281	0.533	1.111	163	27
HS-⑧-C-1	3.778	4.255	0.531	1.141	162	26
HS-⑧-C-2	3.819	4.268	0.529	1.032	163	29
HS-⑧-C-3	3.703	4.247	0.531	1.116	159	31
HSHU-1-3	3.675	4.238	0.529	1.221	161	27
HSHU-3-1	3.142	4.328	0.491	1.403	156	24
HSHB-1	3.859	4.401	0.533	1.108	161	28
HSH-1	3.688	4.379	0.531	1.116	163	29
HSH-5	3.563	4.231	0.537	1.116	161	27
HMO-1-1	3.472	4.823	0.529	1.103	161	28
HMO-1-2	3.631	4.665	0.531	1.091	161	29
HMO-1-3	3.511	4.673	0.523	1.078	161	31
HMO-2-1	3.868	4.413	0.531	1.055	163	28
HMO-2-2	3.706	4.383	0.529	1.121	164	28
HMO-2-3	3.925	4.401	0.529	1.045	162	28
HMO-2-4	3.497	4.242	0.535	1.136	161	27
HMO-2-5	3.535	4.306	0.535	1.113	159	27

Hokkaido is shown in Fig. 7 . Owing to these analyses data, any person can not found the obsidian rocks, as like as the ones in southern part of Central Primorye, carried from Japanese Islands, especially from Hokkaido at least.

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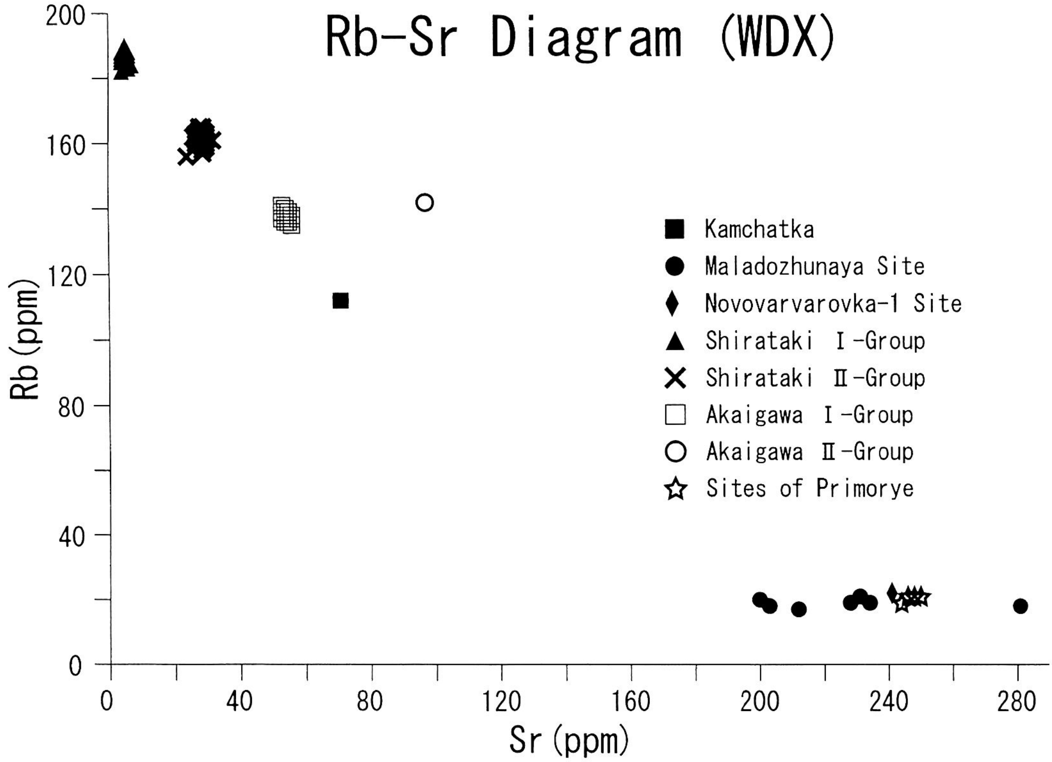

Fig. 7 The Rb-Sr Diagram (WDX) of Chemical Composition of Obsidian Rocks in Hokkaido and Far East Russia

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ロシア・中部沿海州の南部地域に分布する後期旧石器遺跡から採集された黒曜岩フレイクの原産地について

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2001年に国際共同調査として，中部沿海州の南部地域に存在する2つの既に発掘された後期旧石器遺跡を調査し，そこから黒曜岩フレイクを採集した。これらのフレイクの原材である黒曜岩の原産地を，化学分析に基づいて求めるためである。

黒曜岩フレイクを粉末試料に調整し，蛍光X線分析装置を，また必要に応じてX線マイクロアナライザーや原子炉を用いて分析を行った。分析結果によって黒曜岩試料は，Rb–Sr含有量3つのタイプ（図3）に，またBa–Sr含有量では5つのタイプ（図4）に分けられることが明らかにされた。さらにイリスタヤ川，アルセーニェフカ川およびムラヴェイカ川の上流地域で，黒曜岩の原石を収集した。これらの原石の多くは河床礫である。黒曜岩原石についても分析を行った。

黒曜岩原石はRb–Sr含有量で4つのタイプに，またBa–Sr含有量で5つのタイプに分類されることが明らかにされた。黒曜岩のフレイクも原石も共に玄武岩質の組成を示しており，日本列島ではまったく見出せないものである。

黒曜岩フレイクの原材である原石の原産地は，遺跡に近い川の河床礫であると言うことが明らかにされた。しかし，遺跡で得られたやや大きな黒曜岩原石は，沿海州のどこかすこし離れた場所からもたらされたものであると，推論された。