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Article

Geochemical analysis of heavy metals in soils of the Yamasaki archaeological site, Hikimi River, Masuda, Japan

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Abstract

Geochemical study of soils was carried out at the Yamasaki archaeological site in Masuda city for evaluation of human activities during the earliest to late Jomon age. Abundances of P_2O_5, Cu, Zn, I, TS (total sulfur), Sr, Br and F show variations in vertical profiles in four trenches. These elements are good indicators of habitation sites and pottery manufacture. In contrast, concentrations of TiO_2, Fe_2O_3, MnO, CaO, As, Pb, Ni, Cr, V, Nb, Zr, Y, Th and Sc show no significant change in the profiles. This may be related to provenance of the area, and indicates lack of active metal production or smelting.

Key words: Yamasaki archaeological site, Masuda city, geochemistry, heavy metals, human activities, Jomon age, Yayoi age

Introduction

Past human habitation can significantly affect the chemical compositions of soils. Habitation can lead to enrichments and depletions of certain elements in the formation of archaeological soils (Oonk *et al.,* 2009). High values of heavy metals in soils at numerous archaeological sites have been well correlated with past human habitation and actions (Aston *et al*., 1998; Entwistle *et al*., 1998; Wilson *et al*., 2008). This is possible because these human activities left specific chemical fingerprints in the soils, and chemical elements are retained by soils and sediments. However, anomalous levels of elements are not always related to past human activities, and natural processes primarily influence the total geochemical composition of soils (Middleton and Price, 1996; Wilson *et al*., 2008). Background concentrations are linked to differences in geology, soils, and hydrology, and these factors together can result in patterns of elemental concentration that are not connected to the archaeology.

The Hikimi area is located in the southwestern end of Shimane Prefecture, and in southwest Japan is well known for the number of archaeological sites present (Editorial Board of Hikimi town, 2007). Fragments of pottery belonging to the Jomon period (14.500-300 BC) have recently been discovered at the Yamasaki site for the first time. The aim of this report is to present data obtained by X-ray fluorescence analysis (XRF), and give a brief description of the general variations of elemental abundances at the Yamasaki site. More extensive and specific discussion will be published at a later article.

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Study area

The Yamasaki site is located along the Hikimi River, in the Hikimi district. Many river terraces were formed along the Hikimi River, and these terrace plains have been inhabited from ancient times to the present. Three locations of past human settlements were recognized at this archaeological site, according to the age of unearthed artifacts. Earliest Jomon pottery fragments (c. 8000 BC) were found in trench NST-1 in the northern part of the site (Fig. 1). These fragments record the oldest record of human activity at the Yamasaki site. Pottery fragments of the Late Jomon period were unearthed from the western and eastern trenches (EWT-3 and EWT-1) in the southern part of the site (Fig. 1), which was in use for human settlement around 3500-3000 BC (Agency of Education of Hikimi town. 2011a, b, c).

Geology and Pedology

Jurassic pelitic mélange of the Kanoashi Group is widely distributed in the Hikimi area, and Cretaceous felsic volcanic rocks of the Hikimi Group are exposed in the southern part of the district (EBGMSP, 1997). The development of the valleys is related to the trend of NE-SW faults. At present the Hikimi area is mostly covered by forest, and lower regions of the tributaries lie above 100m elevation, and higher regions more than 800m.

Two terrace plains can be distinguished at the Yamasaki site as upper and lower terraces (by locality-northern and southern part), due to their topography, soil texture, structural aspects, and soil horizon successions (Fig. 2). The soil stratigraphy of trenches EWT-1 and EWT-3 are similar, and are located at the same altitude in the southern part of the site. Black soil layers (Guro-1 and Guro-2) were identified in these southern EWT trenches, where Guro-1 is archaeologically modified and is rich in pottery fragments. These black soils may have formed during the climatic

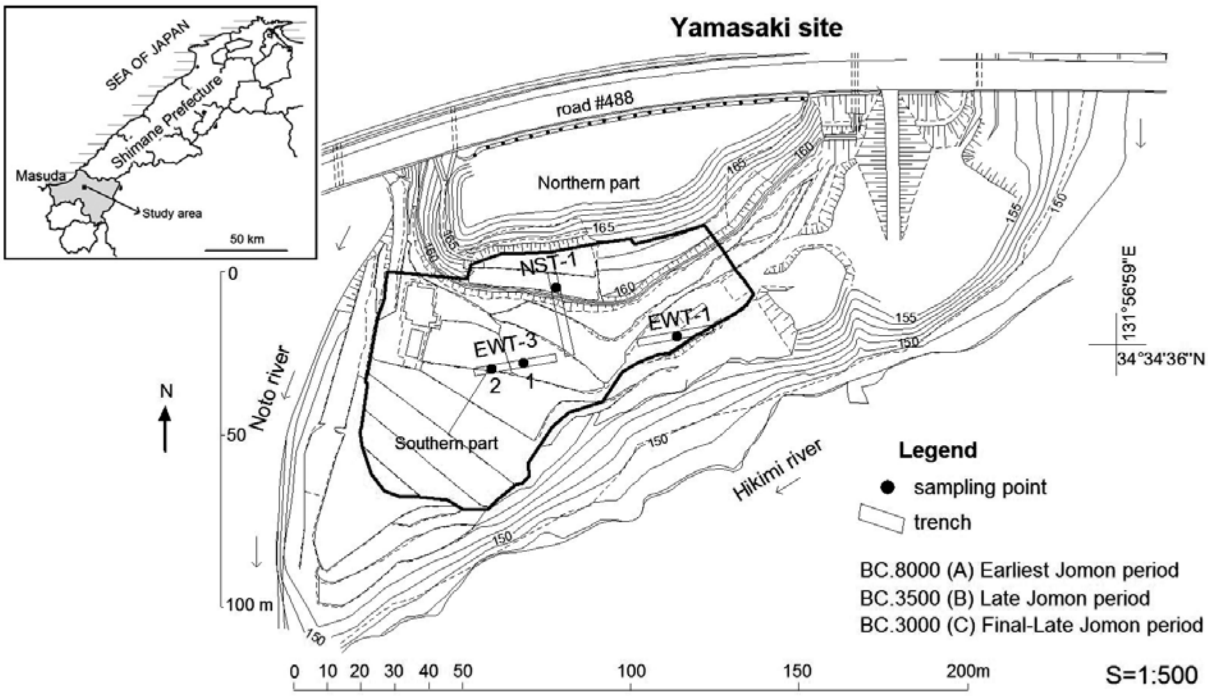

Fig. 1 Sample location map at the Yamasaki site, Hikimi, Japan.

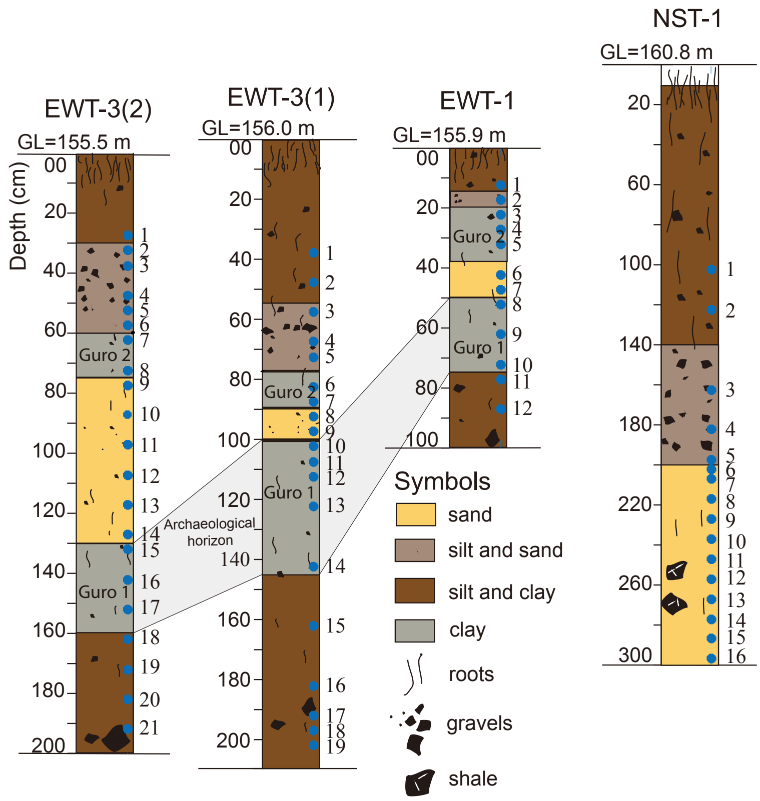

Fig. 2 Soil stratigraphy of trenches NST-1, EWT-1, EWT-3(1) and EWT-3(2) at the Yamasaki site.

warming in the Holocene that caused the sea level rise known locally as the Jomon transgression.

The base of trench NST-1 is located at the highest altitude in the site. The lowermost section of NST-1 consists of sands. This unit is overlain by a gravel layer (Gravel bed 2) which contained some of the oldest pottery fragments. An old trace of the Hikimi River was found in this northern part, as represented by occurrence of imbricated rounded boulders. This river trace was deposited after formation of the highest terrace.

Materials and Methods

The archaeological surveyed site at Yamasaki has an area of about 5700 m^2, as shown by the bold line in Figure 1. Terrace sediment samples were collected from three trenches NST-1 ($n = 16$), EWT-1 ($n = 12$), and from two sections in EWT-3 (EWT-3(1), $n = 19$; EWT-3(2), $n = 21$) in January and February 2011. The samples were packed in zip-lock bags and stored in a cooler box at 4 °C for transport. Approximately 50 g of each sample were dried in an oven at 160 °C for 48 hrs. The dried samples were then ground for 20 min in an automatic agate pestle and mortar grinder. The powdered samples were compressed into briquettes using a force of 200 KN for 60s. Abundances of selected major elements TiO_2, Fe_2O_3 (total iron), MnO, CaO and P_2O_5 and the trace elements As, Pb, Zn, Cu, Ni, Cr, V, Sr, Y, Nb, Zr, Th, Sc, F, Br, I and TS (total sulfur) were determined by XRF in the Department of Geoscience, Shimane University, using a Rigaku RIX-2000 spectrometer. Average errors for all elements are less than ±10% relative.

Results

Major and trace element abundances of individual samples from trenches NST-1, and EWT-1, EWT-3(1) and EWT-3(2) in the Yamasaki site are given in Tables 1 and 2, respectively. Average chemical compositions and ranges in each trench are given in Table 3. Significant differences in chemical compositions are seen between the northern and southern trenches. Abundances of most of the elements analyzed are higher in the southern EWT trenches (EWT-1, EWT-3(1) and EWT-3(2)), except for Y, Nb, Zr and Th, which are slightly higher in northern trench NST-1, as shown in Table 3. However, abundances of CaO and the high field strength TiO_2, CaO, Sc Y, Nb, Zr, Th and Sc generally do not differ between the two parts.

Sampling concentrated on the Guro-1 horizons in the EWT trenches, because they contained the most archaeological remains. Data for the Guro-1 horizons in the EWT-1, EWT-3(1) and EWT-3(2) trenches were combined because they can be correlated from their similar soil stratigraphy and structures (Fig. 2).

Multivariate statistical analysis was used to identify geochemical associations of the Guro-1 archaeological horizon (Fig. 3). The elements can be divided into two main groups. Group I contains three sub groups: (P_2O_5-Cu), (Zn-I-TS) and (Sr-Br-F), respectively. These elements clearly showed higher concentrations in the Guro-1 relative to detrital background in the lowermost unit, as shown in Table 4. These enrichments seem to be related to anthropogenic effects such as habitation sites and firing pottery using wood as a fuel.

Table 1 Major and trace element compositions in trench NST-1 at the Yamasaki site, Hikimi River, Masuda, Japan.

Sample number	Depth (cm)	Horizon	Soil*	Major oxides (wt%)					Trace elements (ppm)																
				TiO_2	CaO	MnO	Fe_2O_3	P_2O_5	As	Pb	Zn	Cu	Ni	Cr	V	Sr	Y	Nb	Zr	Th	Sc	F	Br	I	TS
NST-1-1	102	Uppermost	sl/cl	0.74	0.97	0.26	8.52	0.38	35	88	154	33	39	71	168	56	33	13	158	18	15	102	17	28	495
NST-1-2	122	Uppermost	sl/cl	0.71	0.95	0.32	8.44	0.33	35	120	163	29	40	66	152	66	34	12	152	17	12	206	25	42	609
NST-1-3	162	Gravel bed 1	sl/sd	0.51	0.92	0.22	5.68	0.18	28	64	136	21	20	35	82	77	34	11	148	13	9	36	13	28	494
NST-1-4	182	Gravel bed 1	sl/sd	0.52	0.91	0.20	5.52	0.14	30	59	135	23	19	33	76	76	35	11	163	13	9	64	8	22	499
NST-1-5	197	Gravel bed 1	sl/sd	0.50	0.90	0.17	5.32	0.15	30	54	132	25	18	32	63	74	36	11	165	13	9		12	24	479
NST-1-6	202	Sand bed	sd	0.49	0.92	0.16	5.15	0.13	30	53	132	25	17	27	63	75	38	12	160	13	9	115	14	24	389
NST-1-7	207	Sand bed	sd	0.45	0.92	0.14	4.98	0.12	30	50	126	25	16	25	63	75	39	12	159	13	9	48	12	24	330
NST-1-8	217	Sand bed	sd	0.44	0.91	0.13	4.80	0.10	31	44	108	21	12	25	59	77	37	12	171	12	9		9	22	278
NST-1-9	227	Sand bed	sd	0.43	0.90	0.11	4.64	0.08	31	43	99	20	12	23	55	77	34	12	166	13	6	9	5	15	259
NST-1-10	237	Sand bed	sd	0.39	0.88	0.11	4.48	0.07	31	42	92	18	8	18	49	77	33	11	158	13	6	9	2	14	247
NST-1-11	247	Sand bed	sd	0.40	0.90	0.11	4.55	0.07	33	41	93	18	8	23	54	78	32	12	153	13	9	23	2	14	252
NST-1-12	257	Sand bed	sd	0.43	0.93	0.14	5.25	0.07	37	47	105	17	12	24	62	74	32	11	150	15	9	2	2	14	270
NST-1-13	267	Sand bed	sd	0.43	0.93	0.14	5.26	0.07	37	46	107	18	13	27	71	74	31	11	145	14	10	20	2	14	268
NST-1-14	277	Sand bed	sd	0.50	0.91	0.17	5.68	0.07	41	49	112	23	19	32	80	66	31	11	144	14	10		2	12	264
NST-1-15	287	Sand bed	sd	0.59	0.88	0.23	6.30	0.07	42	59	123	31	28	49	102	56	30	11	141	14	11	222	1	10	259
NST-1-16	297	Sand bed	sd	0.59	0.86	0.21	6.19	0.06	42	58	123	32	31	52	105	53	32	11	145	12	11	22	1	12	255

sd - sand; sl - silt; cl - clay

Table 2 Major and trace element compositions in trenches EWT-1, EWT-3(1) and EWT-3(2) in Yamasaki site, respectively, Hikimi River, Masuda, Japan.

Sample number	Depth (cm)	Horizon	Soil*	Major oxides (wt%)					Trace elements (ppm)																
				TiO_2	CaO	MnO	Fe_2O_3	P_2O_5	As	Pb	Zn	Cu	Ni	Cr	V	Sr	Y	Nb	Zr	Th	Sc	F	Br	I	TS
EWT-1-1	12	Uppermost	sl/cl	0.58	0.90	0.12	5.56	0.19	46	130	365	34	25	41	91	61	28	12	139	12	11	115	7	18	602
EWT-1-2	17	Gravel bed 2	sl/sd	0.50	0.90	0.28	10.81	0.20	122	177	348	44	12	35	115	62	28	10	138	13	10		8	15	629
EWT-1-3	22	Guro-2	cl	0.46	0.93	0.49	7.09	0.18	57	57	311	42	15	25	82	70	30	10	141	12	8	12	8	38	628
EWT-1-4	27	Guro-2	cl	0.44	0.92	0.20	8.27	0.16	57	43	272	28	11	23	81	69	29	10	133	11	5	89	8	29	577
EWT-1-5	32	Guro-2	cl	0.42	0.95	0.25	6.29	0.15	37	42	305	25	14	37	75	74	30	11	136	11	7	89	9	37	562
EWT-1-6	42	Sand bed	sd	0.43	0.92	0.20	5.27	0.16	32	54	345	33	16	24	68	74	32	10	127	13	9	11	15	43	672
EWT-1-7	47	Sand bed	sd	0.42	0.93	0.17	5.24	0.20	32	56	356	33	19	25	63	75	32	10	129	13	10	140	20	36	593
EWT-1-8	52	Guro-1	cl	0.42	0.93	0.20	5.20	0.25	34	61	385	39	20	29	68	74	33	10	127	13	10	208	28	26	495
EWT-1-9	62	Guro-1	cl	0.42	0.94	0.21	5.18	0.26	30	51	394	39	17	26	70	74	34	10	128	13	8	115	26	22	484
EWT-1-10	72	Guro-1	cl	0.42	0.95	0.16	5.05	0.23	30	42	376	28	15	27	64	76	33	11	141	13	8	315	21	21	412
EWT-1-11	77	Lowermost	sl/cl	0.45	0.95	0.15	5.01	0.23	31	42	382	24	14	28	59	78	34	10	136	14	8	142	16	21	424
EWT-1-12	87	Lowermost	sl/cl	0.43	0.95	0.14	4.92	0.20	32	39	345	23	15	23	60	78	33	10	133	13	9	130	14	17	379
EWT-3(1)-1	37	Uppermost	sl/cl	0.56	0.92	0.13	4.85	0.32	31	101	351	33	27	50	79	65	28	11	134	11	8	89	6	20	822
EWT-3(1)-2	47	Uppermost	sl/cl	0.60	0.88	0.10	5.93	0.28	50	145	348	33	25	52	98	62	27	11	138	11	8	188	4	13	658
EWT-3(1)-3	57	Gravel bed 2	sl/sd	0.59	0.89	0.17	7.60	0.23	77	177	367	38	25	49	106	58	28	10	134	12	9	63	4	11	532
EWT-3(1)-4	67	Gravel bed 2	sl/sd	0.56	0.94	0.23	4.71	0.26	54	271	441	38	29	45	80	68	26	11	137	12	10	12	4	22	466
EWT-3(1)-5	72	Gravel bed 2	sl/sd	0.56	0.86	0.18	8.29	0.20	81	165	409	33	22	44	108	61	28	10	139	11	8	62	3	14	502
EWT-3(1)-6	82	Guro-2	cl	0.51	0.91	0.30	8.71	0.20	75	55	312	36	22	39	103	66	31	10	128	12	8	220	5	20	559
EWT-3(1)-7	87	Guro-2	cl	0.49	0.94	0.20	6.69	0.17	49	45	363	30	22	38	85	72	30	10	133	13	7	48	6	24	431
EWT-3(1)-8	92	Sand bed	sd	0.54	0.93	0.52	7.48	0.18	51	51	433	35	22	37	95	69	32	11	138	12	8	194	6	24	521
EWT-3(1)-9	97	Sand bed	sd	0.57	0.91	0.26	6.09	0.20	40	57	448	39	25	42	99	68	32	11	140	12	9	49	10	28	516
EWT-3(1)-10	102	Guro-1	cl	0.58	0.91	0.25	6.10	0.21	38	61	448	37	29	49	98	64	32	10	141	12	12	198	13	34	494
EWT-3(1)-11	107	Guro-1	cl	0.57	0.91	0.27	6.14	0.24	37	64	440	38	28	48	93	63	31	10	139	12	10		13	32	508
EWT-3(1)-12	112	Guro-1	cl	0.53	0.91	0.29	6.13	0.25	39	65	420	39	31	50	99	63	31	10	132	12	10	117	15	28	506
EWT-3(1)-13	122	Guro-1	cl	0.59	0.91	0.30	6.16	0.27	37	68	360	41	33	52	105	62	33	11	134	11	10	24	13	26	485
EWT-3(1)-14	142	Guro-1	cl	0.56	0.91	0.33	5.97	0.27	33	61	323	45	33	48	93	64	34	10	132	13	10	26	8	22	387
EWT-3(1)-15	162	Lowermost	sl/cl	0.56	0.94	0.36	6.11	0.36	32	59	193	50	32	47	102	65	34	10	128	11	9	61	9	22	386
EWT-3(1)-16	182	Lowermost	sl/cl	0.59	0.95	0.36	5.92	0.35	29	59	174	50	35	51	98	64	33	10	132	10	10	50	8	21	371
EWT-3(1)-17	192	Lowermost	sl/cl	0.55	0.96	0.33	5.89	0.31	32	59	173	47	33	46	92	66	33	11	138	11	11	146	11	16	363
EWT-3(1)-18	197	Lowermost	sl/cl	0.56	0.96	0.31	5.95	0.29	41	57	170	47	33	47	101	65	33	11	132	11	10		10	20	361
EWT-3(1)-19	202	Lowermost	sl/cl	0.52	0.95	0.30	5.94	0.26	40	56	172	42	34	47	94	65	33	11	136	11	9		8	14	331
EWT-3(2)-1	27	Uppermost	sl/cl	0.56	1.04	0.15	5.18	0.30	32	125	402	50	41	102	128	62	27	11	164	11	10	243	5	7	1013
EWT-3(2)-2	32	Gravel bed 2	sl/sd	0.56	0.97	0.22	7.48	0.23	63	127	387	37	29	62	120	66	28	11	139	12	9	185	5	11	632
EWT-3(2)-3	37	Gravel bed 2	sl/sd	0.57	0.93	0.30	9.28	0.22	91	146	402	35	30	54	124	59	27	10	136	10	7	220	4	3	606
EWT-3(2)-4	47	Gravel bed 2	sl/sd	0.58	0.93	0.18	5.59	0.20	45	168	416	38	33	53	101	60	28	11	147	12	10	62	5	14	582
EWT-3(2)-5	52	Gravel bed 2	sl/sd	0.55	0.90	0.15	7.36	0.17	78	219	394	35	31	47	112	59	27	11	139	11	9	89	4	8	496
EWT-3(2)-6	57	Gravel bed 2	sl/sd	0.55	0.96	0.20	8.76	0.17	81	120	365	36	30	44	126	63	30	11	137	11	10	102	4	9	508
EWT-3(2)-7	62	Guro-2	cl	0.47	1.09	0.15	8.06	0.16	73	64	291	36	18	32	94	77	31	10	138	12	9		4	15	412
EWT-3(2)-8	72	Guro-2	cl	0.48	1.08	0.41	5.96	0.19	53	81	337	49	24	29	81	79	32	11	144	13	7	258	7	25	474
EWT-3(2)-9	77	Sand bed	sd	0.45	1.01	0.17	5.45	0.15	41	60	343	38	17	28	73	81	31	10	137	12	9	115	9	25	478
EWT-3(2)-10	87	Sand bed	sd	0.53	0.98	0.24	5.89	0.16	41	69	307	36	27	46	95	71	31	10	136	12	9	156	7	25	436
EWT-3(2)-11	97	Sand bed	sd	0.52	0.96	0.25	5.93	0.14	38	60	279	34	28	44	100	67	30	11	135	11	9	47	6	18	390
EWT-3(2)-12	107	Sand bed	sd	0.54	0.93	0.27	6.15	0.15	39	58	294	35	30	49	99	65	31	11	144	13	11	37	7	18	400
EWT-3(2)-13	117	Sand bed	sd	0.58	0.94	0.31	6.51	0.16	42	63	284	38	33	47	110	62	34	11	140	13	11	139	7	19	390
EWT-3(2)-14	127	Sand bed	sd	0.64	0.98	0.34	6.74	0.20	42	68	289	42	35	48	114	62	36	12	147	13	10	47	10	19	428
EWT-3(2)-15	132	Guro-1	cl	0.60	0.99	0.33	6.69	0.22	40	64	274	37	36	47	114	62	35	12	140	13	11	75	14	19	429
EWT-3(2)-16	142	Guro-1	cl	0.62	1.00	0.33	6.67	0.23	39	64	274	40	35	52	114	62	33	11	139	13	13	102	14	18	430
EWT-3(2)-17	152	Guro-1	cl	0.63	0.98	0.33	6.69	0.22	41	70	266	40	36	50	120	61	33	12	138	13	12	89	13	17	409
EWT-3(2)-18	162	Lowermost	sl/cl	0.58	0.94	0.32	6.56	0.19	42	72	208	40	35	49	108	61	33	11	138	12	10	9	14		366
EWT-3(2)-19	172	Lowermost	sl/cl	0.58	0.95	0.30	6.47	0.20	43	77	195	40	42	49	109	61	32	11	133	12	10	157	8	14	380
EWT-3(2)-20	182	Lowermost	sl/cl	0.59	0.94	0.31	6.61	0.19	44	73	203	41	37	50	115	61	33	11	140	13	11	183	8	13	383
EWT-3(2)-21	192	Lowermost	sl/cl	0.51	1.06	0.28	6.20	0.15	42	56	188	33	37	46	103	61	27	10	114	12	10		2	13	293

sd - sand; sl - silt; cl - clay

Table 3 The range and mean chemical compositions of the northern and southern trenches of the Yamasaki site, Hikimi River, Masuda, Japan.

trenches	NST-1		EWT-1		EWT-3(1)		EWT-3(2)	
	mean	range	mean	range	mean	range	mean	range
Major elements (wt%)								
TiO_2	0.51	0.39-0.74	0.45	0.42-0.58	0.56	0.49-0.60	0.56	0.45-0.64
Fe_2O_3	5.67	4.64-8.52	6.16	4.92-	6.35	4.71-8.71	6.68	5.18-9.28
MnO	0.18	0.11-0.32	0.21	0.12-0.49	0.27	0.10-0.52	0.26	0.15-0.41
CaO	0.91	0.86-0.97	0.93	0.90-0.95	0.92	0.86-0.96	0.98	0.90-1.09
P_2O_5	0.13	0.06-0.38	0.20	0.15-0.26	0.26	0.17-0.36	0.19	0.14-0.30
Trace elements (ppm)								
As	34	28-42	45	30-122	45	29-81	50	32-91
Pb	57	41-120	66	39-177	88	45-271	91	56-219
Zn	121	92-163	349	272-394	334	170-441	305	188-416
Cu	24	17-33	33	23-44	39	30-50	38	33-50
Ni	20	8-40	16	11-25	28	22-35	32	17-42
Cr	35	18-71	28	23-41	46	37-52	49	28-102
V	82	49-168	75	59-115	96	79-108	108	73-128
Sr	71	53-78	72	61-78	65	58-72	65	59-81
Y	34	30-39	31	28-34	31	26-34	31	27-36
Nb	12	11-13	10	10-12	10	10-11	11	10-12
Zr	155	141-171	134	127-141	135	128-141	139	114-164
Th	14	12-18	13	11-14	11	10-13	12	10-13
Sc	10	6-18	9	5-11	9	7-12	10	7-13
F	68	2-222	124	11-315	97	12-222	122	9-258
Br	8	1-25	15	7-28	8	3-15	8	2-14
I	20	10-42	27	15-43	22	11-34	15	3-25
TS	353	247-609	538	379-672	484	331-822	473	293-1013

Table 4 Average values in stratigraphic units in three EWT trenches, for comparison of enrichments of selected elements (Fe_2O_3, P_2O_5, As, and Zn) (Fig. 4).

horizons	Uppermost (UM)			Gravel bed (GB2)			Guro-2 (G2)			Sand bed (SB)			Guro-1 (G1)			Lowermost (LM)		
trenches	EWT-1	EWT-3(1	EWT-3(2	EWT-1	EWT-3(1	EWT-3(2	EWT-1	EWT-3(1	EWT-3(2	EWT-1	EWT-3(1	EWT-3(2	EWT-1	EWT-3(1	EWT-3(2	EWT-1	EWT-3(1	EWT-3(2
n*	1	2	1	1	3	5	3	2	2	2	2	6	3	5	3	2	5	4
TiO_2	0.58	0.58	0.56	0.50	0.57	0.56	0.44	0.50	0.48	0.43	0.56	0.54	0.42	0.57	0.62	0.44	0.56	0.57
CaO	0.90	0.90	1.04	0.90	0.90	0.96	0.93	0.93	1.09	0.93	0.92	0.97	0.94	0.91	0.99	0.95	0.95	0.97
MnO	0.12	0.12	0.15	0.28	0.19	0.20	0.31	0.25	0.28	0.19	0.39	0.26	0.19	0.29	0.33	0.15	0.33	0.30
Fe_2O_3	5.56	5.39	5.18	10.81	6.87	7.28	7.22	7.70	7.01	5.26	6.79	6.11	5.14	6.10	6.68	4.97	5.96	6.46
P_2O_5	0.19	0.30	0.30	0.20	0.23	0.21	0.16	0.19	0.17	0.18	0.19	0.16	0.25	0.25	0.22	0.22	0.32	0.18
As	46	41	32	122	70	65	50	62	63	32	45	40	31	37	40	32	35	43
Pb	130	123	125	177	204	151	47	50	73	55	54	63	51	64	66	41	58	69
Zn	365	350	402	348	406	394	296	337	314	351	441	299	385	398	271	363	176	198
Cu	34	33	50	44	36	38	31	33	42	33	37	37	35	40	39	24	47	38
Ni	25	26	41	12	26	32	14	22	21	17	23	28	17	31	35	14	33	37
Cr	41	51	102	35	46	60	28	39	31	24	39	43	27	49	50	25	48	48
V	91	88	128	115	98	118	79	94	87	65	97	99	67	97	116	60	97	109
Sr	61	63	62	62	63	61	71	69	78	75	69	68	74	63	61	78	65	61
Y	28	28	27	28	27	28	30	30	32	32	32	32	33	32	34	34	33	31
Nb	12	11	11	10	10	11	10	10	10	10	11	11	10	10	12	10	10	11
Zr	139	136	164	138	137	144	136	131	141	128	139	140	132	136	139	134	133	131
Th	12	11	11	13	12	11	12	12	12	13	12	12	13	12	13	13	11	12
Sc	11	8	10	10	9	9	7	7	8	9	9	10	9	10	12	8	10	10
F	115	139	243	nd	46	150	63	134	258	76	122	90	213	91	89	136	86	116
Br	7	5	5	8	4	5	8	5	6	17	8	8	25	12	13	15	9	8
I	18	16	7	15	16	9	35	22	20	39	26	21	23	28	18	19	19	13
TS	602	740	1013	629	500	640	589	495	443	633	519	420	464	476	423	402	362	356

n*=number of samples

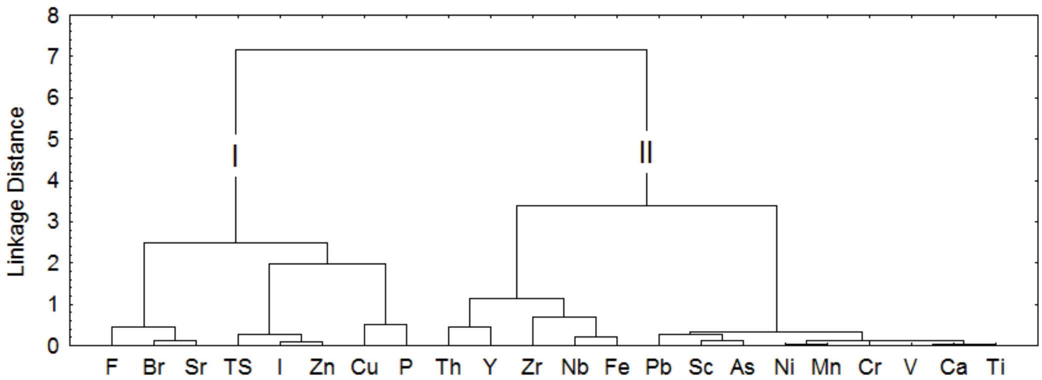

Fig. 3 Dendrogram of chemical analyses for the Guro-1 horizon in the southern EWT trenches, Yamasaki site.

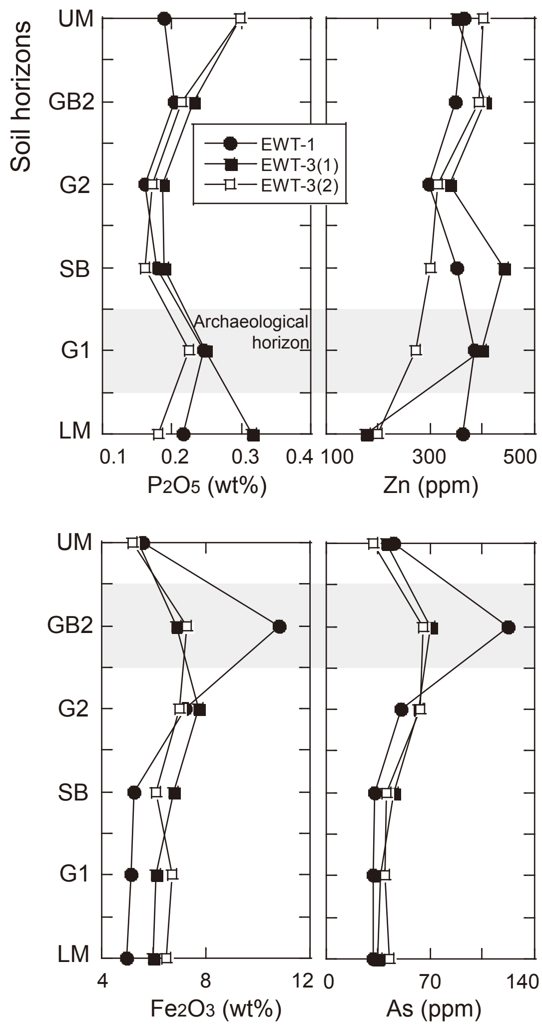

Fig. 4 Distribution of mean Fe_2O_3, P_2O_5, As, and Zn abundances in soil horizons in trenches EWT-1, EWT-3(1) and EWT-3(2) at the Yamasaki site.

Group II consisted of two main sub-groups: (TiO_2-CaO-V-Cr-MnO-Ni) and (As-Sc-Pb) which show no apparent enrichment in the Guro-1 horizon (Table 4). These associations are probably related to sediment provenance. The geochemical behavior of As and Pb are similar in the soil profiles, and diverge only in the GB2 horizon where they are enriched at the same depth as Fe_2O_3 (Fig. 4). Two other sub-groups (Fe_2O_3-Nb-Zr) and (Y-Th) show constant concentration patterns along the profiles, except for Fe_2O_3. No group II elements show any significant variations in the Guro-1 archaeological horizon. They are mainly related to felsic rock provenance of the sediments, and indicates lack of active metal production or smelting in the area.

Conclusions

Mean abundances of major and trace elements differ between the northern and southern parts of the Yamasaki site. Highest values in the southern trenches [EWT-1, EWT-3(1) and EWT-3(2)] occur in the horizon where most archaeological artifacts were found. The three EWT trenches are located at the same altitude and have similar soil stratigraphy. Archaeological artifacts were mainly unearthed only from the Guro-1 horizon of the EWT trenches, indicating an early settlement site of pre-historic people. Multivariate statistical elemental analyses allowed the identification of geochemical signatures related to the geochemical behavior of elements in the Guro-1 archaeological horizon. Higher concentrations of P_2O_5 and Zn coincided with the archaeological horizon, and these elements are also well correlated with Cu, TS, Sr, Br, I and F. Several other elements (TiO_2, Fe_2O_3, MnO, CaO, As, Pb, Ni, Cr, V, Nb, Zr, Y, Th and Sc) are grouped together, and show no significant enrichments in the archaeological layer, suggesting their abundances are linked solely to sediment provenance. This further suggests lack of active metal production or smelting in the area at the time of deposition of the Guro-1 horizon.

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（要　旨）

Banzragch Dalai・石賀裕明，2011．益田市匹見川の山崎遺跡の土壌の重金属の地球化学的分析．島根大学地球資源環境学研究報告，30，57-63.

益田市の縄文前期から後期にかけての山崎遺跡の土壌について地球化学的研究を行い，人間活動の影響を評価した．P_2O_5, Cu, Zn, I, TS（total sulfur），Sr, Br と F 等の元素は検討した４つのトレンチで垂直変化を示し，生活面や土器製造のよい指標となる．これに対して TiO_2, Fe_2O_3, MnO, CaO, As, Pb, Ni, Cr, V, Nb, Zr, Y, Th と Sc などは垂直断面では大きな変化は示さず，後背地の地質に関係すると考えられる．