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Major and trace element analyses of Cretaceous to Miocene sedimentary rocks from the Shimanto terrane, Kii Peninsula, SW Japan

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Abstract

The Cretaceous-Miocene Shimanto terrane of southern Japan is well-known geologically, but comparatively few geochemical studies have been made and comprehensive whole-rock data are scarce. This report contains whole-rock XRF analyses of 100 sandstones and mudstones spanning the stratigraphic range of the Shimanto sequence in Kii Peninsula, Wakayama Prefecture. Data include major elements and 19 trace elements (As, Ba, Ce, Cr, Cu, Ga, La, Nb, Ni, Pb, Rb, Sc, Sr, Th, U, V, Y, Zn and Zr). Seven analyses of post-Shimanto sediments (Tanabe and Kumano Groups) are also included. Interpretation of the data in terms of provenance and evolution of the terrane will be published elsewhere.

key words: Shimanto terrane, geochemistry, Cretaceous, Paleogene

Introduction

The Cretaceous-Miocene Shimanto terrane of southern Japan is one of the world's best known accretionary prisms, comprising a voluminous sequence of trench-fill and forearc basin-fill sediments deposited at the Japan Pacific margin (Kimura 1997). Outcrop length is some 1400 km, extending from the Kanto Mountains near Tokyo southwest to the Nansei Islands. Numerous studies have examined many aspects of the Shimanto, including general geology, paleontology, petrography, heavy minerals, tectonics, dating, and evolution (Kumon 1983; Kumon et al. 1988; Taira et al. 1988; Ogawa et al. 1988; Agar et al. 1989; Teraoka and Okumara 1992; Yanase 1992; Kimura et al. 1996; Bessho 1997; Ohmuri et al. 1997; and many others). Geochemical studies have, however, been relatively few, and have generally been based on limited data sets or have been part of larger studies (e.g. Kashima 1992; Kumon and Kiminami 1994). Geochemical studies of sedimentary terranes have become increasingly common in recent years, and a number of chemical discriminants and indices now permit evaluation of provenance, tectonic setting, weathering history, terrane evolution and tectonostratigraphic relationships (e.g. Nesbitt and Young 1982; Roser and Korsch 1986; McLennan et al. 1993; Kumon and Kiminami 1994; and others).

The Shimanto sequence in Kii Peninsula, southeast of Osaka, has been mapped and studied in detail, and a well-established stratigraphy exists (Suzuki et al. 1979; Tateishi et al. 1979; Tokuoka et al. 1981, 1982; Kumon et al. 1988). Detailed petrographic analysis has also been carried out in this area (Kumon 1983). This prior work provides an ideal framework for geochemical studies.

This report contains comprehensive whole-rock XRF analyses of suites of sandstones and mudstones spanning most of the Shimanto sequence in Kii Peninsula. The intention here is simply to report the data; interpretation will be published elsewhere (Roser, in prep.). The sample suites were collected with the aim of testing stratigraphic geochemical variation and evolution in the Shimanto terrane, using the extensive geological knowledge of the area as a base. The data contained here constitute a reference set for future comparison with other Shimanto sequences, and with other large accretionary terranes elsewhere.

Geological Outline

The study area lies south and east of Wakayama city (Fig. 1). The general geology of the Kii sequence has been well described by a number of authors (e.g.

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Suzuki et al. 1979; Tateishi et al. 1979; Tokuoka et al. 1981, 1982; Kumon 1983; Kumon et al. 1988). The following summary of the geology is drawn mainly from the culmination of that work (Kumon et al. 1988) and field observation.

The Shimanto terrane is separated from the Chichibu terrane to the north by the Butsuzo Tectonic line, but is itself internally divided into three sub-belts (Hidakagawa, Otonashigawa, and Muro) from north to south (Fig. 1). These belts are named from the stratigraphic groups which occur within them. A schematic stratigraphic sequence is given in Fig. 2.

Hidakagawa Group

The Cretaceous Hidakagawa Group consists of the Hanazono, Yukawa, Terasoma, Miyama, Ryujin and Nyunokawa formations, from north to south. The Hanazono Formation (Coniacian-Campanian) lies in the north of the Kii Peninsula, and consists primarily of shale, with sandstone, greenstone and chert. It is separated from the other Hidakagawa formations by the Tsujido Tectonic Line, and was not sampled in this study. Yukawa Formation (Hauterivian-Turonian) occurs in central Kii Peninsula, and consists of thick-bedded sandstone, sandstone-shale alternations, and shale; metabasalts are lacking. Terasoma Formation (middle Turonian-Santonian) crops out in the northwest of the Hidakagawa Group, against the Butsuzo Tectonic Line and adjoining Miyama Formation (Fig. 1). Sequences consist of well indurated sandstone-shale alternations. Varying sandstone-shale proportions have enabled division into three members. Miyama Formation (Coniacian-Santonian) outcrops in a continuous belt west from its inland contact with the Yukawa For-

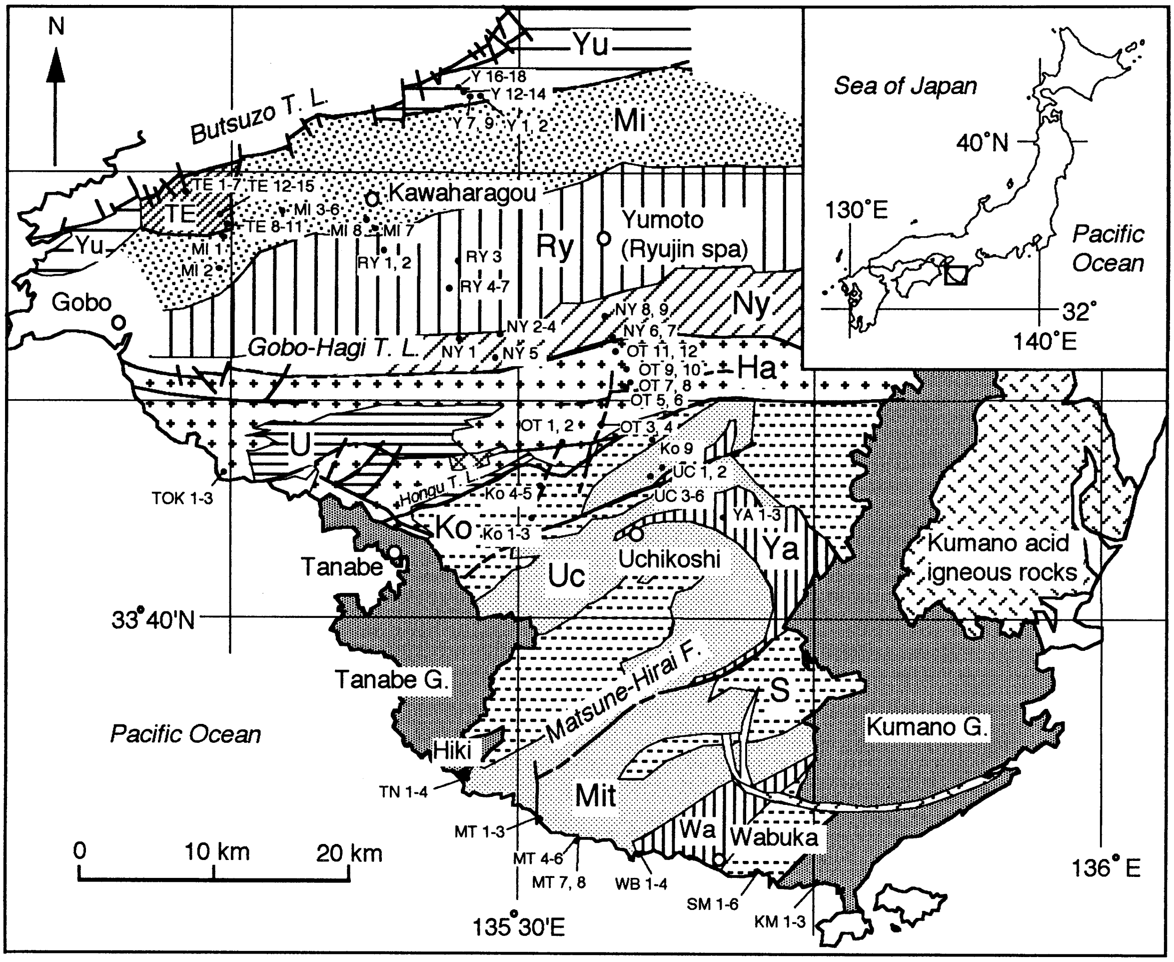

Fig. 1 Simplified geological map of the Shimanto terrane in Kii Pennsula, and sample sites. Based on Tokuoka et al. (1981), Kumon et al. (1988) and Bessho (1997). Formation abbreviations: Hidakagawa Group: Yu–Yukawa; TE– Terasoma; Mi–Miyama; Ry–Ryujin; Ny–Nyunokawa. Otonashigawa Group: U–Uridani; Ha–Haroku. Muro Group: Northern Belt Ya–Yasukawa; Uc–Uchikoshi; Ko–Kogawa; Southern Belt Wa–Wabuka; Mit–Mitogawa; S–Shimotsuyu.

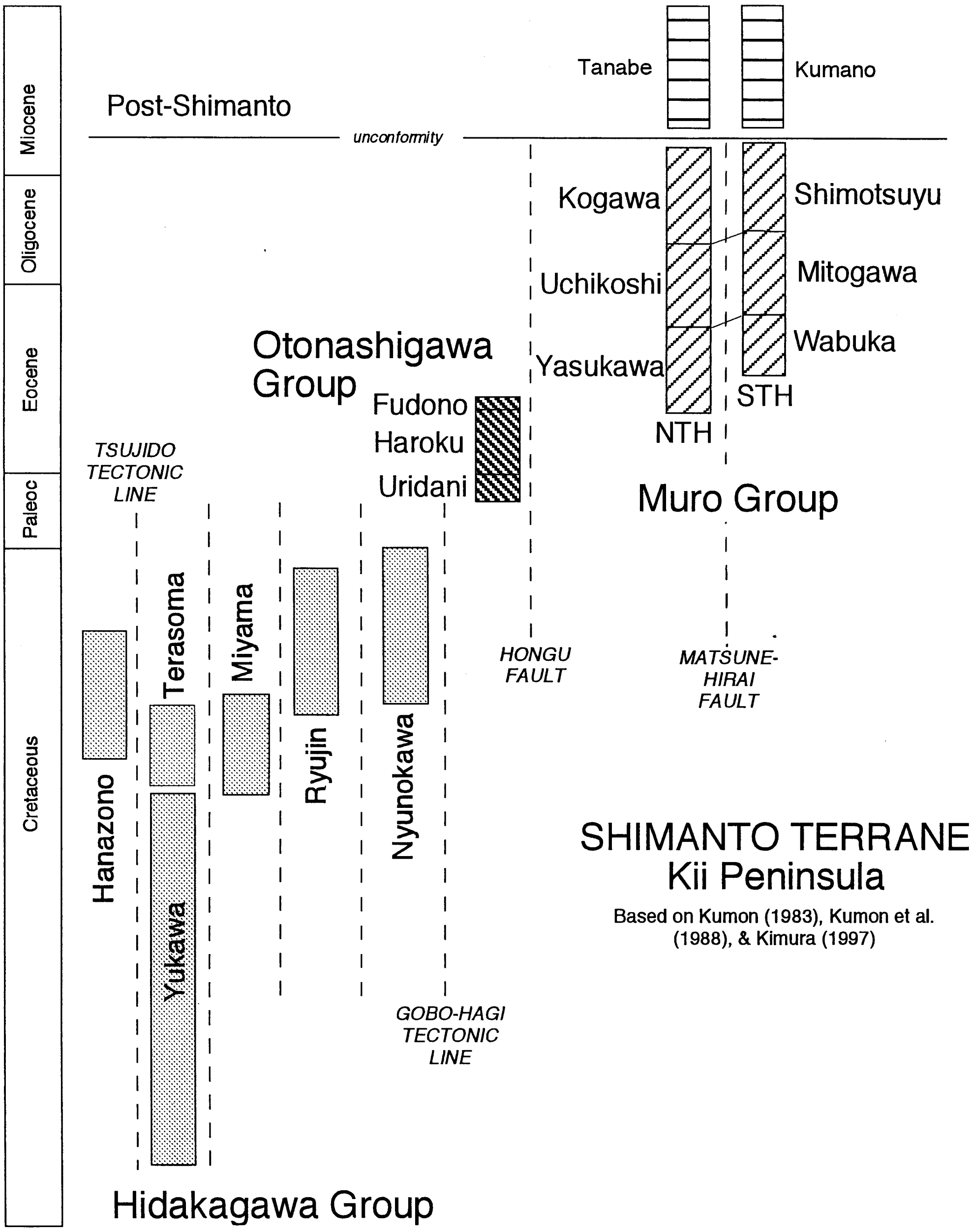

Fig. 2 Schematic stratigraphy of the Shimanto terrane in Kii Peninsula.

mation (Fig. 1). Both "flysch" (sandstone-shale alternations) and chert-greenstone facies occur. The latter are interpreted as olistostromes (Kumon et al. 1988). Sampling for this study was confined to coherent sequences. The Ryujin Formation (Campanian-Maastrichtian) also outcrops in a continuous belt, and near the coast is terminated by the Gobo-Hagi Tectonic Line (Fig. 1). Facies association differs from the above units, being dominated by black shale, with lesser and thin shale-sandstone alternations, along with greenstones and stratified acidic tuffs. Nyunokawa Formation (Campanian-Maastrichtian) outcrops inland, south of the Ryujin Formation, and is also terminated to the south by the Gobo-Hagi Tectonic Line. Nyunokawa sequences are primarily medium to very coarse grained sandstone-shale "flysch" alternations, but conglomerates and sporadic greenstones also occur. Clasts in the conglomerates include sedimentary rocks, felsic volcanics and granitoids.

Otonashigawa Group

The Otonashigawa Group forms a relatively narrow east-west trending belt, bounded by the Gobo-Hagi Tectonic Line to the north and the Hongu Fault to the south. Age control is less certain due to paucity of reliable fossils, but is presumed to be Paleocene to early

Eocene based on the relationships with the Hidakagawa and Muro Groups (Kumon et al. 1988). The Otonashigawa Group is cut into a number of imbricate slices by north-dipping reverse faults, and also displays several orders of folds. The sediments consist of mudstone, and sandstone-shale and sandstone-conglomerate alternations.

The sequence is divided into the Uridani, Haroku and Fudono formations in ascending order. The Uridani Formation occupies the central portion of the belt, and consists of monotonous black bedded mudstone, commonly containing calcareous nodules. Red and green mudstone also occur toward the top of the sequence, but greenstones and chert are absent. Haroku Formation forms the majority of the belt, comprising sandstone-shale alternations which become thicker and coarser upwards. Lower sandstones are frequently graded and laminated. Trace fossil suggest relatively deep water deposition. In the upper part sandy units are typical, and very coarse sand and polymict conglomerate horizons occur in some areas. Fudono Formation consists of muddy alternations of sandstone and mudstone, and crops out in a very restricted area. It was not sampled in this study.

Muro Group

Muro Group sediments occupy an extensive area southeast of the Hongu Fault (Fig. 1), and range in age from Eocene to Early Miocene. The Muro Group is composed of sandstone, mudstone, sandstone-mudstone alternations, and conglomerate. Compared with the Hidakagawa and Muro Groups, sandstones are more quartzose and feldspathic (arkose and feldspathic arenite) and are thus less lithic. Induration is also less marked. Conglomerate clasts (pebble-cobble) are mainly sandstone, chert and felsic volcanics, with lesser granitoid, shale and limestone clasts.

The Muro sub-belt is divided into two by the Matsune-Hirai fault (Fig. 1), delimiting northern and southern blocks. Deformation is less than in the other groups, with folding forming anticlines and synclinoriums (see Fig. 8 of Kumon et al. 1998), particularly in the northern belt. In the southern belt block faulting is more typical. Both blocks are divided into three conformable and correlative formations: the Yasukawa, Uchikoshi, and Kogawa (north) and the Wabuka, Mitogawa and Shimotsuyu (south). Yasukawa Formation consists mainly of sandstone and bedded mudstone, and coarsens upwards in its upper part. Correlative Wabuka Formation in the southern block consists of mudstone and muddy sandstone alternations. The Uchikoshi and Mitogawa formations are characterised by sand-dominated sequences, although both muddy and polymict conglomerate horizons also occur. The Kogawa and Shimotsuyu Formations exhibit a wide variety of lithofacies, ranging from sand-dominated, sand-mud alternations, mud-dominated, and conglomeratic beds. Both formations have been divided into a number of units based on variations in their facies associations.

Post-Shimanto Sediments

The Muro Group is unconformably overlain by fore-arc sediments of the Miocene Tanabe and Kumano Groups. Both exhibit relatively simple structure, and varied lithofacies ranging from conglomerates to coal and shale deposits, with depositional environments ranging from bathyal to shoreline facies (Chijiwa 1988; Hisatomi 1988).

Sample Suites

The Shimanto suite comprises 100 samples. Most are fine to medium grained sandstones, since the focus of the collection was comparison with published modal data. Some coarse sands, very fine sands and mudstones were also collected to test grain size variations. Samples were usually collected at bed midpoints to avoid rip-up clasts where present, and basal heavy mineral concentrations if present.

The Hidakagawa Group is represented by 49 samples. Miyama samples (MI 1-7) are very fine to medium sands, generally from massive beds. One mudstone (MI 5) was collected. A larger suite of samples ranging from medium sand to mudstone was collected from the Terasoma Fm. (TE 1-15). These were split between the lower (TE 12-15), middle (TE 1-7) and upper units (TE 8-11). Beds sampled ranged from 10 cm alternations of sand and mud (TE 13,14) through 10-50 cm bedded Tb-Te turbidites with sand:mud ratio of >15:1 (TE 1, 2), to massive amalgamated sands 4-5 m thick (TE 15). Finer grain size of the Ryujin Fm. restricted sampling to four mudstones and three sandstones (RY 1-7). The sands were collected from isolated, thin (<30 cm), very fine sandstones in mud-dominated sequences. Nyunokawa Fm. (NY 1-9) samples range from mud to fine sand,collected from poorly-graded 10-50 cm bedded sandstone-shale alternations, which were generally sand-dominated.

The majority of fifteen Otonashigawa Group samples were collected from the Haroku Fm., spanning the grain size range from coarse sand to mud. Both upper (OT 5-7, 11-12) and lower (OT 3, 4, 8-10) Haroku members as mapped by Suzuki et al. (1979) and Tokuoka et al. (1981) are represented, collected along an inland road traverse north of Kurisagawa. Beds varied widely in thickness (10-200 cm). Most were not strongly graded, and mud was subordinate. Three samples (TOK 1-3) from coastal exposure at Kirimi-zaki were collected from thick (1-3 m) sandstones, which were strongly graded from granule to fine sand. Uridani Fm. (OT 1,2) mudstones were taken from a bedded mudstone exposure near Kurisugawa. This contained scattered carbonate concretions. The Fudono Formation was not sampled.

Thirty six samples represent the Muro Group, with 18 from both the northern and southern belts. Samples were collected from equivalent formations in both blocks. Northern block formations (Yasukawa, Uchikoshi, and Kogawa) were sampled inland (Kurisagawa district) as coastal exposures of northern belt Muro sediments are limited by overlying Tanabe Group sediments. Only three samples were collected from the Yasukawa Fm. (YA 1-3). These comprise massive fine to medium sands from bedded sandstone units, lacking mudstone. Six samples from the Uchikoshi Fm. (UC 1-6) range from coarse sand to mud, taken from thickly bedded and often graded sandstone units with subordinate mud. Mud rip-ups were common in several samples (UC 1,2). Kogawa sandstones (KO 1-9) were collected from four localities. Beds sampled ranged from thin-bedded units (10-20 cm) showing marked plane lamination and weak convolution (KO 1, 2) to thicker (30-60 cm), more massive units (KO8, 9).

Southern block equivalents (Wabuka, Mitogawa, Shimotsuyu) were collected from coastal exposures. Wabuka Fm. (WB 1-6) samples are massive (WB 1) or plane laminated (WB 2) fine-medium sandstones from thickly bedded (20-100 cm) coherent sandstone facies. Mitogawa Fm. (MT 1-8) was collected at three sites between Susami and Esu-zaki. Most are very fine to medium sandstones from thick sand-dominated intervals; only one mudstone was collected. Sandstones show distinct plane lamination (MT 3), and grading from coarse sand, with mud rip-up clasts at bed bases (MT 4, 6). Shimotsuyu Fm. samples (SM 1-6) consist of plane- or convolute-laminated very fine sandstones from a single locality between Yokoshima and Soshima.

Seven samples were also collected from single exposures of the post-Shimanto Tanabe and Kumano Groups. Time did not permit more extensive sampling, and the suite cannot be regarded as fully representative of Tanabe/Kumano compositions. Additional sampling is required. The existing Tanabe samples (TN 1-4) are very fine-grained laminated sandstones, from 5-10 cm sandstone-shale alternations in the Hiki Formation (Lower Tanabe Grp) at the west end of Hiki Beach. Kumano Group samples (KM 1-3) are buff-weathering coarse silts from dcm-bedded coastal outcrop of Shimosato Formation (lowermost Kumano Grp) east of Tanosaki.

Analytical Methods

Samples were coarsely chipped ($<$1 cm diameter) in a manual hydraulic rock splitter, removing any surficial weathering or oxide staining. Any chips containing visible mud rip-ups clasts or significant veining were also discarded. The fresh chip was rinsed repeatedly in tap water, followed by distilled water, and steeped overnight in deionised distilled water. Oven-dried sample chip was then crushed for 30-60 seconds in a tungsten-carbide ring mill, with sample weights ranging from 70 g in the shales to a maximum of 200 g in the sandstones. Sample weights exceeding 70 g were crushed in several loads, which were then combined. Previous work has shown that contamination from this crushing equipment is not detectable for all the elements reported here (Roser et al., 1998). Mill times are adequate for rocks of the degree of induration shown by the Shimanto samples, producing powders with a median grain size of $<$5 microns (Roser et al., 1998).

Major element analyses were made by XRF, using the Rigaku RIX-2000 instrument at Shimane University, which is equipped with an Rh-anode X-ray tube. Analyses were carried out on an anhydrous basis, using the ignited material from loss on ignition (LOI) determinations. LOI was measured by weight loss in 5-6 g of oven dried (110℃) sample after ignition at

1000℃ in a muffle furnace for two hours. Major element determinations were made on fused glass beads prepared with commercial lithium tetraborate flux (Merck Spectromelt® A 10) in an NT-2000 automatic bead sampler, with preheat, fusion and agitation times of 120, 120 and 180 seconds, respectively. Sample weight used was 0.7000 g, with 3.5000 g of flux, giving a 1:5 sample: flux ratio. The method is essentially that of Norrish and Hutton (1969). Calibration was made using standard reference samples produced by the Geological Survey of Japan, and analyses monitored by repeat analyses of GSJ standards JB-1 a and JG-1 a. Additional detail of the analytical methods will be provided elsewhere (Sawada et al., in prep).

Trace elements were analysed by the Analytical Facility, Victoria University of Wellington, New Zealand, using a Philips PW 1404 automated sequential XRF spectrometer. Techniques were similar to those described in more detail by Palmer (1990) and Roser et al. (1995), from which the following outline is summarised. All elements were determined on boric acid-backed pressed powder pellets (Norrish and Hutton 1969) 40 mm in diameter, containing 4 g of undiluted hydrous sample. No binder was used. The trace elements were determined in two blocks (Sc, V, Cr, Ni, Cu, Zn, Zr, Nb, Ba, La, Ce and Ga, As, Rb, Sr, Y, Pb, Th, U) using Au and dual anode Sc/Mo x-ray tubes, respectively. Summary instrument conditions, sensitivities, and lower limits of detection (LLD) are given in Table 1. The sensitivities and lower limits of detection are calculated for an average andesitic matrix (USGS standard AGV-1). The instrument was calibrated using a wide range of international rocks standards (GSJ, USGS, ANRT, and SARM). A number of synthetic trace element and matrix pellets were also included to allow accurate determination of line overlaps and absorption edge corrections. Regression lines were calculated using the Philips regression model, and the internal ratio method using MoKα and AuLα Compton peaks was used for matrix correction. For elements with wavelengths longer than the Fe absorption edge, empirically determined alpha factors were calculated to correct for Fe, Mn, Cr and Ti absorption edge effects where necessary.

Table 1 XRF trace element analysis instrument conditions, sensitivity and lower limits of detection.

Element/	Line	Tube	kV/mA	Xstl	DET	COL	Peak time	c/sec ppm	LLD (ppm)
As	Kα	Sc/Mo	80/30	200	SC	F	80	18.5	0.26
Ba	Lβ	Au	60/40	220	FL	C	160	1.4	3.33
Ce	Lβ	Au	60/40	200	FL	F	160	0.7	3.72
Cr	Kα	Au	60/40	200	FL	F	80	4.5	0.37
Cu	Kα	Au	60/40	200	SC	C	80	17.9	0.44
Ga	Kα	Sc/Mo	80/30	200	SC	F	60	3.0	1.45
La	Lα	Au	60/40	220	FL	C	100	2.3	2.25
Nb	Kα	Au	80/30	220	SC	F	80	7.0	1.17
Ni	Kα	Au	60/40	200	SC	C	80	22.9	0.28
Pb	Lβ	Sc/Mo	80/30	200	SC	F	100	4.2	1.49
Rb	Kα	Sc/Mo	80/30	220	SC	F	100	6.9	0.51
Sc	Kα	Au	60/40	200	FL	F	80	1.2	1.66
Sr	Kα	Sc/Mo	80/30	200	SC	F	80	15.0	0.57
Th	Lα	Sc/Mo	80/30	200	SC	F	150	5.9	1.12
U	Lα	Sc/Mo	80/30	220	SC	F	200	3.2	1.13
V	Kα	Au	60/40	220	FL	F	80	2.0	1.39
Y	Kα	Sc/Mo	80/30	200	SC	F	40	22.6	0.60
Zn	Kα	Au	60/40	200	SC	C	40	19.7	0.57
Zr	Kα	Au	80/30	220	SC	F	80	6.4	1.18

DET (Detector): SC=scintillation, FL=flow counter
COL (collimator): F=fine; C=coarse
Peak Time (sec); total background time is equal
C/sec/ppm - sensitivity; LLD- lower limit of detection

Results

Results for major and trace elements are listed in Table 2, by formation. The data are listed on a hydrous basis. Lithology was estimated from hand specimens using a hand lens and grain size comparator. Where trace elements were below the lower limit of detection, they are listed as < (n), where n is the rounded LLD from Table 1. The data provide a useful reference set, intended as a benchmark in future studies of other Shimanto sequences.

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Table 2 Major element and trace element analyses of Shimanto terrane sedimentary rocks, Kii Peninsula. Major elements wt. %, trace elements p.p.m. LOI=loss on ignition. LITH=lithology (CS=coarse sandstone; M=medium sst; FS=fine sst; VFS=very fine sst; SLT=siltstone; MUD=mudstone/shale).

SA#	LITH	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	SUM	As	Ba	Ce	Cr	Cu	Ga	La	Nb	Ni	Pb	Rb	Sc	Sr	Th	U	V	Y	Zn	Zr
HIDAKAGAWA GROUP																																
Yukawa																																
Y1	MS	66.39	0.48	14.76	4.14	0.05	1.91	1.97	4.39	2.33	0.10	2.49	99.01	4	563	32	51	16	17	16	5	13	16	70	10	418	8.4	1.0	71	18	46	145
Y2	MS	67.27	0.47	14.24	4.22	0.09	1.62	2.18	4.12	2.11	0.10	2.76	99.18	4	444	36	51	16	14	14	4	9	17	63	11	275	9.2	1.1	68	17	48	147
Y7	CS	70.25	0.36	13.50	3.06	0.06	1.32	2.11	3.09	2.76	0.08	2.86	99.45	4	496	33	47	19	13	14	5	12	19	88	7	264	8.7	1.3	52	15	41	127
Y9	FS	70.87	0.35	11.93	2.10	0.06	0.86	4.01	3.86	2.01	0.07	3.51	99.63	4	482	33	44	13	11	15	4	8	16	53	9	364	7.4	1.0	46	15	29	149
Y12	CS	72.30	0.33	12.72	2.77	0.04	1.10	1.87	3.13	2.87	0.07	2.43	99.63	2	560	31	29	13	12	13	4	9	20	82	7	240	9.4	1.5	46	14	36	125
Y13	MS	72.08	0.32	12.62	2.49	0.04	1.02	2.45	3.16	2.77	0.06	2.70	99.71	2	542	30	28	11	11	13	5	6	16	79	7	252	7.7	0.7	41	12	30	120
Y14	FS	70.80	0.41	12.55	3.35	0.05	1.20	0.67	3.21	2.05	0.06	4.91	99.26	4	529	46	67	15	14	22	9	20	16	71	7	210	11.8	2.5	55	20	48	181
Y16	MS	69.62	0.37	13.00	2.23	0.05	1.03	3.37	3.80	2.56	0.08	3.36	99.47	3	562	31	26	15	13	15	6	6	17	72	8	365	7.7	1.4	48	15	37	139
Y17	MS	71.76	0.29	12.48	2.44	0.07	0.52	2.68	4.78	1.46	0.03	2.76	99.27	4	540	55	18	11	15	25	7	3	18	48	8	175	11.5	1.0	26	22	44	135
Y18	CS	68.97	0.41	10.96	2.97	0.16	1.26	5.69	2.94	1.81	0.07	4.76	100.00	4	480	41	137	14	11	20	4	26	14	51	13	195	11.4	1.1	62	18	36	89
Miyama																																
MI1	MS	75.72	0.32	11.95	2.52	0.05	0.74	0.44	3.71	2.52	0.04	1.66	99.67	5	562	51	26	13	14	21	9	8	16	77	6	141	11.2	1.6	33	19	43	145
MI2	FS	76.49	0.31	11.94	1.90	0.03	0.51	0.74	3.99	2.55	0.05	1.42	99.93	3	616	36	10	10	11	16	6	2	17	76	4	154	9.2	1.5	28	15	33	142
MI3	FS	76.30	0.32	12.14	2.17	0.03	0.65	0.72	3.34	2.98	0.06	1.21	99.92	3	598	35	17	11	11	16	6	4	19	94	4	193	9.4	1.1	31	18	41	152
MI4	VFS	73.80	0.38	13.01	2.76	0.04	0.79	1.06	3.19	2.82	0.07	2.14	100.06	5	473	29	25	13	14	10	8	7	18	90	6	186	10.1	1.7	45	19	42	162
MI5	MUD	70.68	0.51	14.56	3.87	0.05	1.06	0.65	1.93	4.18	0.08	2.86	100.43	10	585	59	34	42	16	23	12	14	25	157	10	116	14.1	2.2	67	29	79	159
MI6	FS	73.38	0.45	12.52	3.29	0.05	1.00	0.97	4.42	2.13	0.08	1.65	99.94	5	594	33	26	12	11	15	7	6	16	59	6	221	9.4	1.5	57	19	45	169
MI7	MS	75.04	0.29	11.84	2.41	0.04	0.61	1.03	4.04	2.76	0.05	1.58	99.69	3	595	35	8	10	11	18	4	1	19	82	4	130	8.6	1.6	26	16	39	123
MI8	VFS	74.40	0.38	13.67	2.45	0.02	0.71	0.30	4.22	2.58	0.06	1.44	100.23	4	543	60	15	12	15	27	9	6	19	88	6	174	12.9	1.4	38	24	66	206
Terasoma																																
TE1	VFS	73.04	0.30	13.75	2.35	0.05	0.79	1.31	4.17	2.84	0.05	1.47	100.12	4	587	49	40	14	13	22	12	17	21	93	7	256	14.8	2.6	31	27	63	169
TE2	FS	72.98	0.41	13.27	3.11	0.06	0.91	0.96	4.86	2.26	0.07	1.38	100.27	4	655	42	57	14	11	19	7	20	15	57	8	196	10.1	1.1	48	20	52	138
TE3	MS	72.46	0.33	13.80	3.56	0.06	0.68	0.78	3.70	3.67	0.06	1.32	100.42	5	1066	86	33	10	18	39	9	6	18	94	12	263	13.9	0.8	31	23	53	177
TE4	MS	75.05	0.30	12.80	2.43	0.05	0.59	0.49	4.00	3.19	0.05	1.02	99.97	3	1162	92	27	11	12	48	9	8	17	70	7	233	13.2	0.9	25	22	54	182
TE5	VFS	72.29	0.45	13.20	3.98	0.06	1.58	1.30	2.56	2.72	0.08	2.11	100.33	4	459	44	55	18	14	18	7	26	17	96	10	161	9.6	2.0	54	22	58	148
TE6	FS	76.36	0.36	11.60	2.38	0.06	0.90	0.90	3.41	2.54	0.07	1.38	99.96	4	581	44	89	19	11	21	6	29	14	69	8	155	9.1	0.8	51	16	46	116
TE7	MS	68.63	0.56	13.33	5.45	0.07	2.09	0.90	1.77	2.99	0.09	4.18	100.06	9	423	49	69	40	16	20	9	42	22	137	11	120	12.1	2.2	83	28	86	101
TE8	FS	75.44	0.34	12.87	2.42	0.02	0.73	0.47	3.03	2.90	0.05	1.89	100.16	4	543	48	22	13	13	23	9	8	16	103	7	99	13.1	2.6	35	24	70	153
TE9	MUD	64.49	0.62	16.43	4.63	0.02	1.27	0.51	2.30	3.73	0.08	6.42	100.50	13	545	69	49	31	18	28	14	29	32	157	11	113	15.8	3.4	77	33	90	179
TE10	FS	76.02	0.29	10.82	2.41	0.04	0.63	1.91	3.38	2.28	0.05	2.35	100.18	4	478	41	20	11	9	19	8	6	14	79	7	151	10.3	1.9	30	21	37	130
TE11	FS	74.56	0.32	11.29	2.62	0.05	0.64	2.21	3.03	2.42	0.05	2.57	99.76	5	501	43	20	11	13	19	7	10	19	86	6	166	12.1	0.8	28	24	40	149
TE12	FS	73.76	0.38	13.23	3.03	0.05	1.07	0.71	4.23	2.12	0.07	1.48	100.13	4	522	41	63	14	14	18	6	20	16	66	8	229	9.3	2.2	50	19	50	151
TE13	FS	73.64	0.62	12.27	3.15	0.05	1.11	1.37	3.37	2.41	0.09	1.98	100.06	3	431	54	102	11	12	22	11	19	18	84	8	160	12.5	3.0	60	22	47	437
TE14	MUD	66.41	0.57	15.45	5.57	0.09	1.85	0.68	2.04	3.43	0.10	3.88	100.07	11	450	56	53	38	18	21	11	43	28	164	11	132	14.5	2.5	78	31	101	117
TE15	VFS	72.40	0.45	13.85	3.14	0.07	1.26	0.99	3.29	2.77	0.08	1.78	100.08	5	565	44	58	18	15	21	9	24	18	97	10	207	12.0	2.6	53	21	58	183
Ryujin																																
RY1	MUD	65.08	0.65	16.32	5.74	0.07	1.73	0.47	2.03	3.82	0.10	4.04	100.05	8	508	74	49	66	20	29	11	27	28	170	13	107	16.3	2.0	105	35	117	145
RY2	VFS	72.45	0.46	13.68	3.74	0.04	1.07	0.65	3.59	2.15	0.10	2.14	100.07	5	430	64	18	22	16	26	11	11	23	84	10	127	12.2	1.9	42	33	79	232
RY3	MUD	70.60	0.57	13.86	4.80	0.09	1.40	0.43	1.92	3.13	0.08	2.90	99.78	6	434	61	39	80	16	23	10	24	23	139	9	129	12.5	2.3	87	26	83	136
RY4	MUD	68.11	0.61	15.64	4.71	0.05	1.41	0.48	3.15	2.77	0.10	3.30	100.33	13	529	72	48	43	19	29	10	35	30	115	11	127	15.7	2.8	95	34	156	166
RY5	MUD	64.45	0.71	17.47	5.50	0.06	1.64	0.46	2.73	3.60	0.11	3.64	100.37	9	531	74	56	100	20	31	14	29	22	157	13	120	15.3	3.2	115	33	122	153
RY6	VFS	74.31	0.26	12.25	1.97	0.06	0.29	1.16	5.08	2.21	0.05	2.35	99.99	2	496	64	4	9	11	28	12	0	20	50	5	123	14.0	2.1	15	29	46	193
RY7	VFS	69.79	0.54	14.54	3.82	0.05	1.03	0.53	2.17	4.75	0.09	2.58	99.89	20	593	65	40	37	16	26	10	28	29	158	9	113	14.8	2.7	76	29	89	155

Table 2 Major element and trace element analyses of Shimanto terrane sedimentary rocks.

SA#	LITH	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	SUM	As	Ba	Ce	Cr	Cu	Ga	La	Nb	Ni	Pb	Rb	Sc	Sr	Th	U	V	Y	Zn	Zr
HIDAKAGAWA GROUP (ctd)																																
Nyunokawa																																
NY1	VFS	79.76	0.25	8.92	2.67	0.07	0.81	1.25	2.47	1.56	0.06	1.96	99.78	2	356	32	17	18	9	13	6	9	15	57	4	124	8.6	1.4	26	17	43	154
NY2	VFS	78.30	0.22	9.27	1.88	0.16	0.82	1.62	2.96	1.66	0.05	2.49	99.43	3	357	33	14	11	9	14	5	5	13	58	4	135	8.2	1.3	24	16	31	135
NY3	VFS	82.88	0.20	9.04	1.29	0.01	0.37	0.29	3.40	1.56	0.05	1.02	100.11	3	372	37	12	12	8	15	4	5	16	51	3	88	9.9	1.2	19	13	31	138
NY4	MUD	65.69	0.72	18.45	3.39	0.01	1.40	0.16	1.85	4.15	0.10	4.24	100.16	8	504	73	67	66	20	30	16	21	29	172	13	95	16.2	3.0	139	29	121	167
NY5	FS	81.24	0.19	9.55	1.36	0.01	0.33	0.26	3.64	1.95	0.04	1.00	99.57	2	500	45	10	11	8	20	5	7	16	62	3	147	10.7	1.6	16	12	41	169
NY6	FS	78.85	0.22	10.05	1.85	0.03	0.52	1.26	3.42	1.96	0.05	1.51	99.72	3	410	42	13	11	11	18	4	6	18	64	5	137	10.4	<1.0	22	16	38	138
NY7	FS	79.32	0.24	9.91	2.02	0.03	0.56	0.76	3.01	2.03	0.04	1.63	99.55	2	537	43	15	12	11	19	7	8	18	67	4	130	10.2	1.4	28	14	37	140
NY8	FS	82.44	0.20	8.78	1.44	0.03	0.38	0.68	3.52	1.34	0.05	1.08	99.94	1	370	38	12	11	6	16	5	5	16	39	2	119	8.9	<1.0	20	13	26	145
NY9	FS	76.97	0.25	9.60	2.25	0.10	0.81	1.89	3.14	1.84	0.05	2.70	99.60	4	368	43	15	11	9	19	5	5	15	64	4	159	11.1	1.4	27	21	39	171
OTONASHIGAWA GROUP																																
Uridani																																
OT1	MUD	67.60	0.62	14.30	6.40	0.19	2.39	0.32	2.32	2.27	0.10	3.24	99.76	4	313	52	55	66	17	16	7	36	19	91	12	91	10.2	1.8	128	23	95	107
OT2	MUD	67.76	0.63	14.50	5.89	0.18	2.31	0.40	2.41	2.38	0.10	3.34	99.90	5	293	48	57	64	17	17	9	34	24	92	12	92	10.0	1.1	130	22	93	113
Haroku																																
OT3	MS	77.33	0.20	11.12	1.76	0.03	0.61	0.83	3.40	2.76	0.04	1.47	99.55	3	575	42	13	12	12	20	3	3	17	82	5	146	9.1	<1.0	23	12	23	146
OT4	FS	77.86	0.21	10.13	2.00	0.02	0.67	0.44	2.38	2.62	0.05	3.23	99.61	1	549	36	15	16	11	15	6	6	18	85	4	117	10.0	<1.0	31	13	26	99
OT5	FS	80.00	0.14	9.70	1.69	0.03	0.60	0.91	3.64	1.82	0.04	1.33	99.90	<1	549	43	6	9	9	19	1	1	15	48	4	150	9.0	<1.0	14	9	17	85
OT6	FS	78.79	0.18	10.12	1.83	0.05	0.68	1.09	3.74	1.54	0.04	1.57	99.63	1	460	47	8	9	9	22	2	4	16	45	4	173	10.3	1.4	18	12	24	116
OT7	CS	80.01	0.15	10.45	1.38	0.03	0.40	0.51	3.07	2.46	0.04	0.95	99.45	2	650	47	8	12	9	25	2	4	16	69	3	162	9.4	<1.0	16	11	25	93
OT8	MUD	80.36	0.18	9.88	1.46	0.02	0.42	0.86	3.61	1.91	0.04	1.19	99.93	1	528	29	8	9	8	13	2	3	15	52	3	149	7.3	<1.0	15	11	26	103
OT9	MUD	67.13	0.64	16.70	4.51	0.04	1.50	0.25	1.20	4.13	0.08	3.96	100.14	4	469	59	63	82	21	24	11	24	16	192	12	63	13.0	2.3	122	24	98	123
OT10	FS	83.07	0.19	8.84	1.19	0.03	0.44	0.66	3.20	1.44	0.03	0.90	99.99	<1	493	44	10	10	8	21	3	6	15	42	3	152	8.4	<1.0	14	13	26	165
OT11	FS	79.26	0.17	10.60	1.25	0.02	0.42	0.59	2.56	3.26	0.04	1.26	99.43	1	625	34	8	11	9	16	5	3	18	102	2	112	8.6	1.1	13	12	21	94
OT12	MS	79.75	0.16	10.01	1.11	0.02	0.35	0.87	2.85	2.90	0.03	1.82	99.87	2	520	39	7	10	9	21	3	2	16	90	3	103	8.5	<1.0	13	10	16	97
TOK1	MS	79.23	0.19	11.00	1.35	0.01	0.55	0.13	3.32	2.73	0.04	1.33	99.88	1	593	24	10	10	10	13	3	<1	18	71	4	115	8.6	<1.0	19	7	9	114
TOK2	CS	80.36	0.17	10.32	1.17	0.01	0.60	0.28	3.16	2.65	0.04	1.23	99.99	<1	631	35	9	11	9	18	4	<1	17	70	3	117	9.0	<1.0	16	9	15	91
TOK3	CS	81.65	0.16	10.00	1.06	0.01	0.40	0.11	2.99	2.70	0.04	0.93	100.05	1	599	34	8	11	8	20	2	<1	17	72	3	103	7.6	<1.0	14	7	11	83
MURO GROUP																																
NORTHERN BELT																																
Yasukawa																																
YA1	MS	79.18	0.31	10.90	1.72	0.02	0.59	0.16	3.20	2.59	0.05	1.08	99.80	3	506	36	22	12	11	16	6	10	17	83	2	107	8.0	<1.0	29	12	32	178
YA2	MS	79.26	0.28	10.74	1.84	0.02	0.63	0.21	2.51	2.85	0.05	1.15	99.54	2	585	30	18	12	10	15	5	5	14	88	3	132	7.4	<1.0	23	12	14	153
YA3	VFS	81.31	0.32	8.90	1.63	0.02	0.62	1.02	2.78	1.24	0.05	1.52	99.41	<1	298	52	27	11	8	22	8	4	10	47	5	137	10.1	1.9	30	17	13	362
Uchikoshi																																
UC1	MS	80.77	0.21	9.57	1.22	0.02	0.37	0.68	1.88	3.18	0.04	1.68	99.62	2	558	26	13	10	9	11	4	4	18	94	2	98	7.1	<1.0	16	9	23	117
UC2	MS	81.78	0.23	9.39	1.66	0.02	0.60	0.54	2.19	2.19	0.05	1.39	100.04	2	517	33	19	11	10	16	2	5	16	87	3	97	7.8	<1.0	26	11	28	111
UC3	FS	81.76	0.22	9.07	1.61	0.02	0.50	0.72	1.83	2.69	0.04	1.40	99.86	1	448	49	16	13	10	24	4	5	16	73	4	88	9.4	<1.0	25	14	34	133
UC4	FS	81.39	0.22	9.22	1.66	0.03	0.51	0.75	1.97	2.53	0.04	1.40	99.72	3	529	41	18	11	10	20	4	5	15	85	5	94	7.6	<1.0	29	11	31	111
UC5	MUD	65.04	0.76	16.56	4.83	0.03	1.27	0.17	0.88	4.43	0.09	5.57	99.63	15	550	49	94	50	19	20	12	42	23	192	12	137	11.4	2.2	121	26	129	149
UC6	CS	84.46	0.19	7.95	0.88	0.02	0.32	0.56	1.80	2.66	0.04	1.29	100.17	6	541	22	9	11	7	10	3	4	15	78	<2	129	6.9	<1.0	11	8	14	144

Table 2 Major element and trace element analyses of Shimanto terrane sedimentary rocks.

SANR	LITH	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	SUM	As	Ba	Ce	Cr	Cu	Ga	La	Nb	Ni	Pb	Rb	Sc	Sr	Th	U	V	Y	Zn	Zr
MURO GROUP (ctd)																																
NORTHERN BELT																																
Kogawa																																
KO1	FS	78.93	0.28	10.94	1.95	0.03	0.78	0.12	2.77	2.45	0.04	1.29	99.58	1	556	47	17	12	11	23	4	6	14	83	4	110	9.6	1.3	34	12	27	150
KO2	FS	80.47	0.28	10.30	1.53	0.03	0.61	0.14	2.65	2.28	0.04	1.14	99.47	1	575	55	17	11	11	28	4	6	16	78	5	103	11.5	1.6	32	13	27	197
KO3	FS	78.71	0.28	11.09	2.08	0.03	0.88	0.12	2.81	2.21	0.04	1.43	99.68	1	478	32	17	13	11	13	5	8	15	79	5	104	8.9	<1.0	33	11	43	118
KO4	FS	82.66	0.25	9.44	1.24	0.03	0.49	0.20	2.73	2.09	0.04	0.80	99.97	1	582	93	15	12	9	32	4	19	11	70	4	118	14.4	1.0	24	15	60	249
KO5	VFS	78.60	0.28	10.80	2.34	0.02	0.92	0.21	2.87	2.33	0.05	1.47	99.89	1	601	46	20	13	11	30	5	5	14	82	5	120	9.2	1.4	35	12	28	150
KO6	FS	77.27	0.33	11.45	2.52	0.03	0.80	0.32	2.57	2.62	0.05	1.56	99.52	<1	540	32	19	12	12	16	7	6	18	91	5	123	8.7	1.6	39	13	48	117
KO7	FS	79.26	0.29	10.53	1.79	0.02	0.63	0.30	2.99	2.75	0.05	1.18	99.79	1	526	34	16	11	11	15	6	3	16	92	5	98	9.5	<1.0	33	11	13	123
KO8	FS	77.95	0.28	10.47	1.95	0.04	0.65	1.14	2.91	2.41	0.05	1.77	99.62	1	501	58	18	11	13	28	5	5	16	83	6	127	10.6	1.0	34	14	39	140
KO9	MS	80.37	0.19	9.34	1.13	0.03	0.33	0.81	2.11	3.31	0.04	2.20	99.86	3	717	27	11	10	8	11	4	5	17	94	3	146	6.8	1.1	14	10	16	113
SOUTHERN BELT																																
Wabuka																																
WB1	FS	81.49	0.24	9.34	2.03	0.02	0.57	0.25	2.11	2.78	0.05	0.84	99.72	1	608	34	14	16	9	15	5	7	10	83	2	116	6.7	1.7	17	11	4	170
WB2	FS	82.17	0.27	8.88	2.24	0.02	0.56	0.26	2.18	2.48	0.05	0.87	99.98	<1	543	35	16	17	8	18	6	6	12	77	2	72	8.3	1.0	16	13	3	211
WB4	FS	80.82	0.30	9.20	2.63	0.02	0.67	0.25	2.16	2.60	0.05	0.87	99.57	3	631	40	19	18	8	22	7	8	10	78	2	93	7.7	1.4	21	12	3	214
WB6	FS	79.60	0.26	9.28	3.43	0.02	0.76	0.25	2.01	2.89	0.05	0.91	99.46	2	769	38	18	15	8	17	3	4	12	83	<2	107	6.8	1.0	19	13	4	162
Mitogawa																																
MT1	MS	84.47	0.19	8.32	0.92	0.00	0.31	0.11	2.67	2.14	0.02	0.59	99.74	<1	540	53	14	8	8	24	3	12	10	55	<2	123	6.8	<1.0	15	9	4	111
MT2	MS	85.30	0.17	7.87	1.02	0.01	0.46	0.10	2.38	2.25	0.02	0.61	100.19	2	560	27	12	9	7	14	3	14	10	58	<2	127	5.5	1.4	10	8	4	104
MT3	MS	81.57	0.24	9.83	0.86	0.01	0.44	0.26	2.90	3.07	0.05	0.66	99.89	<1	782	39	15	8	10	16	5	7	12	84	2	161	7.1	<1.0	22	11	7	151
MT4	MUD	78.84	0.28	10.25	3.03	0.03	0.65	0.04	1.83	3.33	0.03	1.20	99.51	<1	691	39	19	13	10	14	5	5	12	108	3	86	7.2	<1.0	23	14	4	153
MT5	MS	81.72	0.23	9.22	1.95	0.02	0.45	0.10	1.84	3.24	0.06	0.96	99.79	1	735	32	12	13	8	17	3	4	13	95	<2	96	6.7	<1.0	13	11	11	130
MT6	FS	78.78	0.29	10.32	2.68	0.02	0.51	0.08	2.10	3.60	0.05	0.97	99.40	<1	810	14	19	10	9	5	7	4	13	105	2	109	8.6	<1.0	22	11	2	171
MT7	VFS	78.62	0.31	11.02	1.28	0.02	0.58	0.49	3.67	2.93	0.05	0.63	99.60	2	635	38	20	11	10	20	8	3	13	83	3	220	7.2	1.0	26	10	16	185
MT8	VFS	75.94	0.45	11.11	4.16	0.03	1.00	0.26	1.93	2.89	0.07	1.58	99.42	<1	672	30	34	14	9	8	9	13	10	95	4	101	9.4	1.2	37	16	13	303
Shimotsuyu																																
SM1	VFS	80.34	0.35	9.77	1.99	0.04	0.56	0.44	2.97	2.26	0.06	0.80	99.58	6	741	52	21	17	8	29	8	9	13	70	<2	153	7.2	1.1	21	16	14	281
SM2	VFS	76.83	0.47	11.35	2.87	0.04	0.88	0.56	3.42	1.87	0.08	1.15	99.52	6	536	81	32	15	11	39	10	16	12	67	4	172	10.1	1.2	35	25	18	363
SM3	VFS	82.25	0.22	7.70	1.70	0.04	0.48	1.61	2.73	1.47	0.05	1.63	99.88	8	519	43	9	13	6	20	5	7	94	47	2	198	6.1	<1.0	11	14	118	157
SM4	VFS	70.04	0.67	14.16	4.95	0.06	1.42	0.70	2.76	2.44	0.10	2.35	99.65	6	539	51	53	16	15	22	14	18	11	99	9	132	12.1	2.4	68	25	36	270
SM5	VFS	74.61	0.48	11.87	2.84	0.04	0.90	1.52	3.43	1.65	0.08	2.21	99.63	4	415	47	36	12	11	21	12	13	22	64	5	197	9.9	1.8	43	16	42	306
SM6	VFS	79.08	0.33	10.23	2.37	0.05	0.66	0.38	2.93	2.57	0.06	0.91	99.57	4	730	37	20	11	9	20	7	7	12	80	3	106	7.0	1.0	24	13	50	207
POST-SHIMANTO																																
Tanabe Group																																
TN1	VFS	80.72	0.36	10.29	1.21	0.01	0.57	0.11	3.13	2.35	0.05	0.98	99.78	2	492	29	34	15	7	14	9	8	17	75	3	106	6.7	2.3	35	12	27	295
TN2	VFS	81.02	0.30	9.28	1.13	0.03	0.60	0.77	2.63	2.18	0.04	1.46	99.44	1	467	28	32	20	7	13	6	8	20	68	2	113	8.3	<1.0	27	11	56	238
TN3	VFS	81.14	0.32	9.85	1.32	0.01	0.59	0.10	2.97	2.26	0.05	0.95	99.56	2	483	25	32	11	8	12	8	9	17	71	3	100	5.8	1.6	34	8	33	201
TN4	VFS	82.61	0.28	9.38	1.07	0.01	0.48	0.10	2.80	2.27	0.05	0.85	99.90	1	509	22	28	24	7	11	6	8	18	70	2	101	8.0	1.5	26	8	25	149
Kumano Group																																
KM1	SLT	71.26	0.55	11.52	5.74	0.13	2.26	0.49	1.96	3.15	0.09	2.41	99.56	3	682	46	52	40	15	16	7	18	13	98	10	84	9.8	2.4	87	25	147	121
KM2	SLT	69.27	0.63	13.56	4.80	0.10	1.87	0.56	2.61	3.82	0.09	2.42	99.73	3	769	47	56	46	15	19	9	19	12	121	10	102	10.9	3.3	92	23	25	144
KM3	SLT	72.89	0.56	13.03	3.07	0.07	1.02	0.57	4.91	2.31	0.06	1.13	99.62	6	785	43	39	20	11	23	8	6	22	59	9	108	10.1	1.4	58	29	44	191

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（要　旨）

Barry　Roser・石賀裕明・別所孝範・道前香緒里，1998，西南日本紀伊半島の白亜系〜中新統の堆積岩の主元素・微量元素の分析，島根大学地球資源環境学研究報告，17, 57–68

白亜紀から中新世の地層群からなる西南日本の四万十帯は地質学的にはよく研究されてきた．しかし，地球化学的検討はわずかに行われているにすぎず，全岩化学組成はの報告は少ない．そこで本報告では，紀伊半島，和歌山県において採集した砂岩と泥岩の100試料について蛍光X線分析を行った．分析は主元素と19の微量元素（As, Ba, Ce, Cr, Cu, Ga, La, Nb, Ni, Pb, Rb, Sc, Sr, Th, U, V, Y, ZnおよびZr）について行った．さらに，田辺層群と熊野層群から採集した7試料についても同様に分析を行った．本論ではこれらの分析結果を報告する．

APPENDIX: Sample localities

Appendix: Sample localities.

SA#	Longitude	Latitude	Local name
HIDAKAGAWA GROUP			
Yukawa			
Y1	135°27' 09"	34°03' 27"	Shimizu-cho, Shimoyukawa, Nakamura
Y2	135°27' 16"	34°03' 30"	Shimizu-cho, Shimoyukawa, Nakamura
Y7	135°26' 15"	34°03' 45"	Shimizu-cho, Shimoyukawa, Kuratani
Y9	135°26' 19"	34°03' 54"	Shimizu-cho, Shimoyukawa, Kuratani
Y12	135°26' 17"	34°04' 02"	Shimizu-cho, Shimoyukawa, N of Kuratani
Y13	135°26' 15"	34°04' 04"	Shimizu-cho, Shimoyukawa, N of Kuratani
Y14	135°26' 18"	34°04' 11"	Shimizu-cho, Shimoyukawa, N of Kuratani
Y16	135°26' 14"	34°04' 20"	Shimizu-cho, Shimizu, Okuno
Y17	135°25' 56"	34°04' 28"	Shimizu-cho, Shimizu, east of Okuno
Y18	135°25' 30"	34°04' 19"	Shimizu-cho, Shimizu, west of Okuno
Miyama			
MI1	135°14' 29"	33°55' 46"	Kawabe-cho, Hiragawa
MI2	135°14' 16"	33°58' 43"	Kawabe-cho, Hiragawa
MI3	135°17' 40"	33°58' 05"	Nakatsu-mura, north of Takatsuo
MI4	135°17' 56"	33°58' 22"	Nakatsu-mura, north of Takatsuo
MI5	135°17' 56"	33°58' 23"	Nakatsu-mura, north of Takatsuo
MI6	135°17' 56"	33°58' 28"	Nakatsu-mura, north of Takatsuo
MI7	135°21' 50"	33°58' 00"	Miyama-mura, south of Kawaragou
MI8	135°22' 08"	33°57' 34"	Miyama-mura, south of Kawaragou
Terasoma			
TE1	135°12' 35"	33°59' 08"	Hirokawa-cho, Sarugawa
TE2	135°12' 39"	33°59' 13"	Hirokawa-cho, Sarugawa
TE3	135°12' 36"	33°59' 13"	Hirokawa-cho, Sarugawa
TE4	135°12' 40"	33°59' 14"	Hirokawa-cho, Sarugawa
TE5	135°12' 40"	33°59' 14"	Hirokawa-cho, Sarugawa
TE6	135°12' 40"	33°59' 14"	Hirokawa-cho, Sarugawa
TE7	135°12' 40"	33°59' 14"	Hirokawa-cho, Sarugawa
TE8	135°12' 59"	33°58' 14"	Hirokawa-cho, south of Terasoma
TE9	135°13' 00"	33°58' 14"	Hirokawa-cho, south of Terasoma
TE10	135°13' 00"	33°58' 14"	Hirokawa-cho, south of Terasoma
TE11	135°13' 00"	33°58' 14"	Hirokawa-cho, south of Terasoma
TE12	135°14' 23"	33°57' 44"	Hirokawa-cho, Kotsurudani
TE13	135°14' 23"	33°57' 44"	Hirokawa-cho, Kotsurudani
TE14	135°14' 16"	33°53' 44"	Hirokawa-cho, Kotsurudani
TE15	135°14' 13"	33°53' 43"	Hirokawa-cho, Kotsurudani
Ryujin			
RY1	135°22' 37"	33°56' 58"	Miyama-mura, Takigashira
RY2	135°22' 37"	33°56' 58"	Miyama-mura, Takigashira
RY3	135°26' 10"	33°56' 03"	Ryujin-mura, east of Oie
RY4	135°25' 00"	33°55' 16"	Ryujin-mura, Kainokawa, Oose
RY5	135°25' 00"	33°55' 16"	Ryujin-mura, Kainokawa, Oose
RY6	135°25' 33"	33°55' 12"	Ryujin-mura, Kainokawa, Oose
RY7	135°25' 33"	33°55' 12"	Ryujin-mura, Kainokawa, Oose
Nyunokawa			
NY1	135°26' 40"	33°53' 00"	Ryujin-mura, Fukui
NY2	135°28' 15"	33°53' 00"	Ryujin-mura, Yanase
NY3	135°28' 33"	33°52' 43"	Ryujin-mura, east of Yanase
NY4	135°28' 33"	33°52' 43"	Ryujin-mura, east of Yanase
NY5	135°28' 15"	33°51' 47"	Ryujin-mura, north of Toragamine
NY6	135°35' 08"	33°53' 07"	Nakahechi-cho, S of Sakayasu tunnel
NY7	135°35' 08"	33°53' 07"	Nakahechi-cho, S of Sakayasu tunnel
NY8	135°34' 42"	33°53' 33"	Nakahechi-cho, Nyunokawa
NY9	135°34' 08"	33°53' 41"	Nakahechi-cho, Nyunokawa
OTONASHIGAWA GROUP			
Uridani			
OT1	135°31' 19"	33°47' 43"	Nakahechi-cho, Kurisugawa
OT2	135°31' 19"	33°47' 38"	Nakahechi-cho, Kurisugawa
Haroku			
OT3	135°33' 25"	33°48' 51"	Nakahechi-cho, Hebikoshi
OT4	135°33' 25"	33°48' 51"	Nakahechi-cho, Hebikoshi
OT5	135°34' 06"	33°49' 46"	Nakahechi-cho, north of Fukusada
OT6	135°34' 06"	33°49' 46"	Nakahechi-cho, north of Fukusada
OT7	135°34' 48"	33°50' 10"	Nakahechi-cho, Tomita R., S of Hyouzei
OT8	135°34' 48"	33°50' 13"	Nakahechi-cho, Tomita R., S of Hyouzei
OT9	135°35' 00"	33°51' 21"	Nakahechi-cho, Tomita R., Hyouzei
OTONASHIGAWA GROUP (ctd)			
Haroku (ctd)			
OT10	135°35' 00"	33°51' 21"	Nakahechi-cho, Tomita R., Hyouzei
OT11	135°35' 19"	33°52' 16"	Nakahechi-cho, Tomita R., N of Hypuzei
OT12	135°35' 15"	33°52' 41"	Nakahechi-cho, Tomita R., N of Hypuzei
TOK1	135°14' 10"	33°46' 53"	Kirimi-zaki
TOK2	135°14' 10"	33°46' 53"	Kirimi-zaki
TOK3	135°14' 10"	33°46' 53"	Kirimi-zaki
MURO GROUP			
NORTHERN BELT			
Yasukawa			
YA1	135°38' 25"	33°44' 50"	Ohtou-mura, east of Shimogawakami
YA2	135°38' 48"	33°45' 00"	Ohtou-mura, east of Shimogawakami
YA3	135°38' 50"	33°44' 58"	Ohtou-mura, east of Shimogawakami
Uchikoshi			
UC1	135°36' 54"	33°47' 28"	Nakahechi-cho, NE of Takanosu-yama
UC2	135°36' 46"	33°47' 16"	Nakahechi-cho, NE of Takanosu-yama
UC3	135°36' 36"	33°46' 40"	Nakahechi-cho, S of Takanosu-yama
UC4	135°35' 56"	33°46' 30"	Nakahechi-cho, S of Takanosu-yama
UC5	135°35' 31"	33°46' 35"	Nakahechi-cho, SW of Takanosu-yama
UC6	135°35' 31"	33°46' 35"	Nakahechi-cho, SW of Takanosu-yama
Kogawa			
KO1	135°30' 04"	33°45' 13"	Nakahechi-chou, Hokusogi
KO2	135°30' 04"	33°45' 13"	Nakahechi-chou, Hokusogi
KO3	135°30' 04"	33°45' 13"	Nakahechi-chou, Hokusogi
KO4	135°31' 08"	33°45' 56"	Nakahechi-chou, west of Ishiburi
KO5	135°31' 08"	33°45' 56"	Nakahechi-chou, west of Ishiburi
KO6	135°31' 00"	33°46' 00"	Nakahechi-chou, west of Ishiburi
KO7	135°31' 00"	33°46' 05"	Nakahechi-chou, west of Ishiburi
KO8	135°30' 54"	33°46' 10"	Nakahechi-chou, west of Ishiburi
KO9	135°36' 35"	33°47' 52"	Nakahechi-cho, south of Chikatsuyu
SOUTHERN BELT			
Wabuka			
WB1	135°37' 52"	33°30' 16"	Susami-cho, south of Satono
WB2	135°37' 52"	33°36' 13"	Susami-cho, south of Satono
WB4	135°37' 52"	33°36' 13"	Susami-cho, south of Satono
WB6	135°37' 52"	33°36' 13"	Susami-cho, south of Satono
Mitogawa			
MT1	135°30' 46"	33°31' 51"	Susami-cho, Kuchiwabuka
MT2	135°30' 46"	33°31' 51"	Susami-cho, Kuchiwabuka
MT3	135°30' 46"	33°31' 51"	Susami-cho, Kuchiwabuka
MT4	135°32' 10"	33°31' 21"	Susami-cho, Kurosaki
MT5	135°32' 10"	33°31' 21"	Susami-cho, Kurosaki
MT6	135°32' 07"	33°31' 6"	Susami-cho, Kurosaki
MT7	135°35' 33"	33°30' 00"	Susami-cho, Esumisaki
MT8	135°35' 31"	33°30' 00"	Susami-cho, Esumisaki
Shimotsuyu			
SM1	135°41' 35"	33°29' 05"	Kushimoto-cho, Tako
SM2	135°41' 35"	33°29' 05"	Kushimoto-cho, Tako
SM3	135°41' 35"	33°29' 05"	Kushimoto-cho, Tako
SM4	135°41' 35"	33°29' 05"	Kushimoto-cho, Tako
SM5	135°41' 35"	33°29' 05"	Kushimoto-cho, Tako
SM6	135°41' 35"	33°29' 05"	Kushimoto-cho, Tako
POST-SHIMANTO			
Tanabe Group			
TN1	135°25' 50"	33°34' 05"	Hikigawa-cho, Hiki
TN2	135°25' 50"	33°34' 05"	Hikigawa-cho, Hiki
TN3	135°25' 50"	33°34' 05"	Hikigawa-cho, Hiki
TN4	135°25' 50"	33°34' 05"	Hikigawa-cho, Hiki
Kumano Group			
KM1	135°44' 15"	33°28' 56"	Kushimoto-cho, Arita
KM2	135°44' 15"	33°28' 56"	Kushimoto-cho, Arita
KM3	135°44' 15"	33°28' 56"	Kushimoto-cho, Arita