



Cruise Report of R/V Kairei

KR15-10

Precise chronology for the late Pleistocene Japan Sea sediments
and its application to paleoceanography
~Off Wakasa Bay ~

Jun. 30, 2015- Jul. 10 2015

Japan Agency for Marine-Earth Science and Technology
(JAMSTEC)



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1. Introduction

KR15-10 cruise is conducted from 30 June (JAMSTEC pier: Yokosuka) to 10 July 2015 (Oi pier: Tokyo) by R/V Kairei of JAMSTEC. The objectives of this cruise are 1) to recover piston cores from the area off Wakasa Bay for establishment of precise chronology and paleoceanographic research and 2) to collect surface and bottom water and surface sediment for understanding of modern relationship between environmental factor and paleoceanographic proxies. To achieve these objectives, the observation sites are set as a depth transect ranging from ~120 to 1750 m.

After leaving Yokosuka, the ship went into the Japan Sea through the Tsugaru Strait. The ship arrived at the first site WB8 in the morning of 3 July. Observation time of this cruise was ~3.5 days, and the oceanic condition in the research area was good. Because the typhoons No. 9, 10, and 11 were reaching south of the Japanese Islands, the ship left the research area 6 July, which is one day earlier than originally planned. In spite of reduced observation time, we achieved multiple coring, piston coring, and water sampling at priority sites (WB1, WB4, WB6, WB8) as well as multiple coring at shallower sites (WB10, 11, 12, and 13), and plankton tow sampling at WB8 site. The total length of piston cores obtained in this cruise is approximately 60 m. All surface sediments using multiple corer are well recovered.

We are grateful to the Captain Takafumi Aoki and the crew of the R/V Kairei for their professional efforts to make this scientific cruise successful. We also thank Mr. Haruhiko Higuchi and the member of Marine Technology and Engineering Center of JAMSTEC for their support.

2. Cruise Information

- Cruise ID: KR15-10
- Name of vessel: R/V Kairei
- Title of the cruise: Precise chronology for the late Pleistocene Japan Sea sediments and its application to paleoceanography
- Title of proposal: Precise chronology for the late Pleistocene sediments of Japan Sea and its application to paleoceanography
- Cruise period: June 30, 2015- July 10, 2015
- Ports of departure–arrival: Yokosuka (JAMSTEC) –Oi
- Research area: Wakasa Bay~ Oki trough
- Ship track

KR15–10_Ship_Track

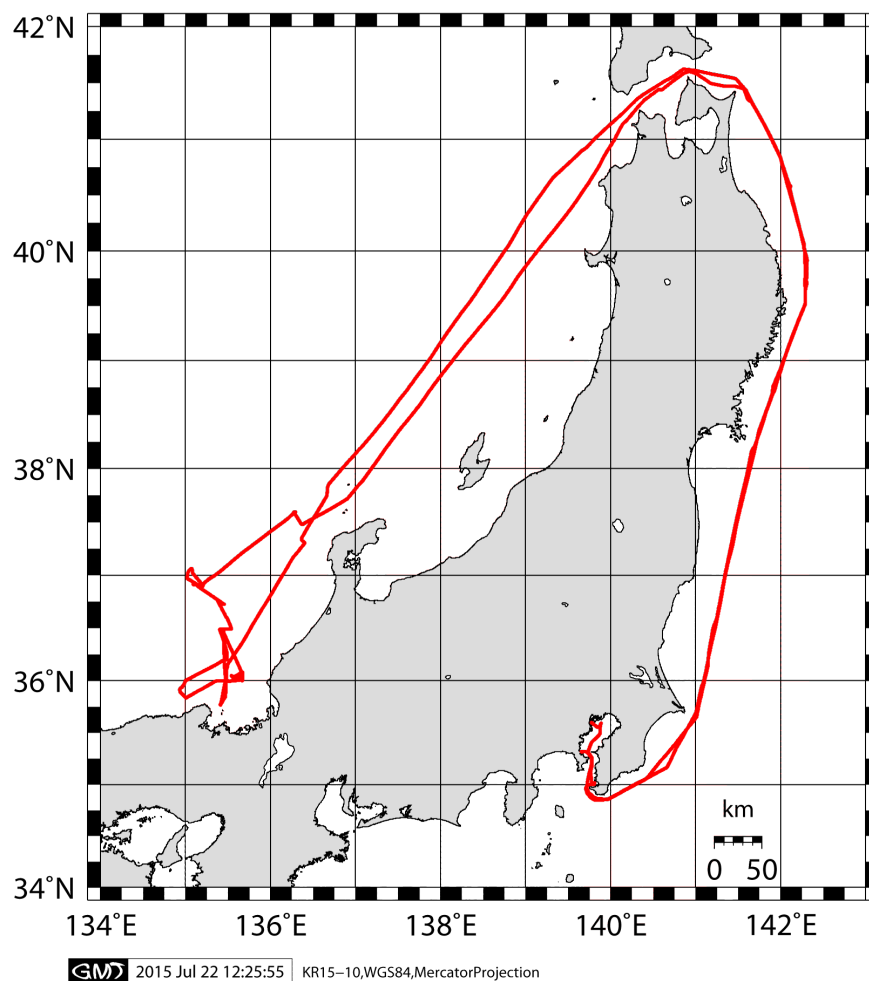


Figure 2.1 Map showing the ship track of KR15-10 cruise.

● Cruise Log

日付 Date	時間 Local Time	内容 Note	特記事項 Description	本船位置／気象／海象 Position/Weather/Wind/Sea condition
30-Jun-15		Sailed out & started KR15-10		6/30 12:00 (JST)
	10:00	Let go all shore lines & left JAMSTEC for research area.		34-56.5N 139-43.5E
	13:00	Briefing about ship's life and safety.		West of suzaki
	16:40	Konpira ceremony.		Cloudy
				NNW-2 (Light breeze)
				1 (Calm)
				1 (Low swell short or average)
				Visibly: 8'
01-Jul-15		Proceeded to the research area		7/1 12:00 (JST)
	13:30 - 15:00	Scientist seminar.		40-27.3N 142-07.7E
				East of hachinohe
				Cloudy
				SE-5 (Fresh breeze)
				3 (Slight)
				2 (Low swell long)
				Visibly: 8'
02-Jul-15		Proceeded to the research area		7/2 12:00 (JST)
	09:00 - 09:30	Scientist seminar for ship crew.		38-22.3N 137-32.5E
				West of sadogashima
				Fine but Cloudy
				South-5 (Fresh breeze)
				3 (Slight)
				2 (Low swell long)
				Visibly: 8'
03-Jul-15		Carried out MBES, SBP, Multiple core and Piston core and Plankton net		7/3 12:00 (JST)
	05:00	Arrived at research area.		36-54.4N 135-09.1E
	05:39	Released XBT.	36-54.2898N, 135-10.5428E	Off wakasa bay
	06:11 - 06:36	Carried out MBES and SBP.	Site WB 8	Fine but Cloudy
	08:27 - 10:01	Carried out the multiple core.	Site WB 8	ESE-3 (Gentle breeze)
	10:45 - 12:34	Carried out the 10 m piston core.	Site WB 8	2 (Smooth)
	15:20 - 17:06	Carried out the 20 m piston core.	Site WB 8	1 (Low swell short or average)
	18:04 - 18:29	Carried out the plankton net below 200 m from sea surface.	Site WB 8	Visibly: 8'
	18:35 - 19:08	Carried out the plankton net below 400 m from sea surface.	Site WB 8	
04-Jul-15		Carried out MBES, SBP, Multiple core and Piston core		7/4 12:00 (JST)
	06:08 - 06:52	Carried out MBES and SBP.	Site WB 6	36-10.6N 135-24.8E
	07:58 - 08:20	Carried out MBES and SBP.	Site WB 4	Off wakasa bay
	08:52 - 09:27	Carried out the multiple core.	Site WB 4	Overcast
	10:20 - 11:32	Carried out the 20 m piston core.	Site WB 4	West-2 (Light breeze)
	14:16 - 14:44	Carried out the multiple core.	Site MC line 3	2 (Smooth)
	16:01 - 16:32	Carried out the multiple core.	Site MC line 3	1 (Low swell short or average)
	19:12 - 19:47	Carried out MBES and SBP.	Site WB 1	Visibly: 6'
05-Jul-15		Carried out Multiple core and Piston core		7/5 12:00 (JST)
	06:37 - 07:08	Carried out the multiple core.	Site WB1	36-29.3N 135-25.6E
	08:44 - 09:34	Carried out the 20 m piston core.	Site WB1	Off wakasa bay
	16:08 - 17:04	Carried out the multiple core.	Site WB 6	Cloudy
	18:09 - 19:20	Carried out the 20 m piston core.	Site WB 6	North-3 (Gentle breeze)
				2 (Smooth)
				1 (Low swell short or average)
				Visibly: 8'
06-Jul-15		Carried out MBES, SBP, Multiple core and Piston core		7/6 12:00 (JST)
	07:12 - 07:32	Carried out the multiple core.	Site MC line 1	36-07.1N 135-29.0E
	08:27 - 08:50	Carried out the multiple core.	Site MC line 1	Off wakasa bay
	09:52 - 10:17	Carried out MBES and SBP.	Site WB 3	Overcast
	10:51 - 11:44	Carried out the 10 m piston core.	Site WB 3	NNE-2 (Light breeze)
	12:05 - 12:26	Carried out the 8 figure running.		1 (Calm)
	12:30	Left the research area for Tokyo.		1 (Low swell short or average)
				Visibly: 8'
07-Jul-15		Proceeded to Tokyo		7/7 12:00 (JST)
	18:00 - 18:19	Carried out the 8 figure running.		41-28.7N 140-32.5E
				Tsugaru strait
				Fine but Cloudy
				WSW-7 (Near gale)
				3 (Slight)
				2 (Low swell long)
				Visibly: 8'
08-Jul-15		Proceeded to Tokyo		7/8 12:00 (JST)
				35-44.1N 141-00.6E
				East of Inubousaki
				Fine but Cloudy
				SSE-2 (Light breeze)
				2 (Smooth)
				2 (Low swell long)
				Visibly: 2'
09-Jul-15		Proceeded to Tokyo		7/9 12:00 (JST)
				35-35.4N 139-53.0E
				Off urayasu
				Overcast
				NE-3 (Gentle breeze)
				2 (Smooth)
				1 (Low swell short or average)
				Visibly: 6'
10-Jul-15		Disembarked scientist group & completed KR15-10		
	10:00	Arrived at Oi marine products terminal. Then completed KR15-10.		

● Research Map

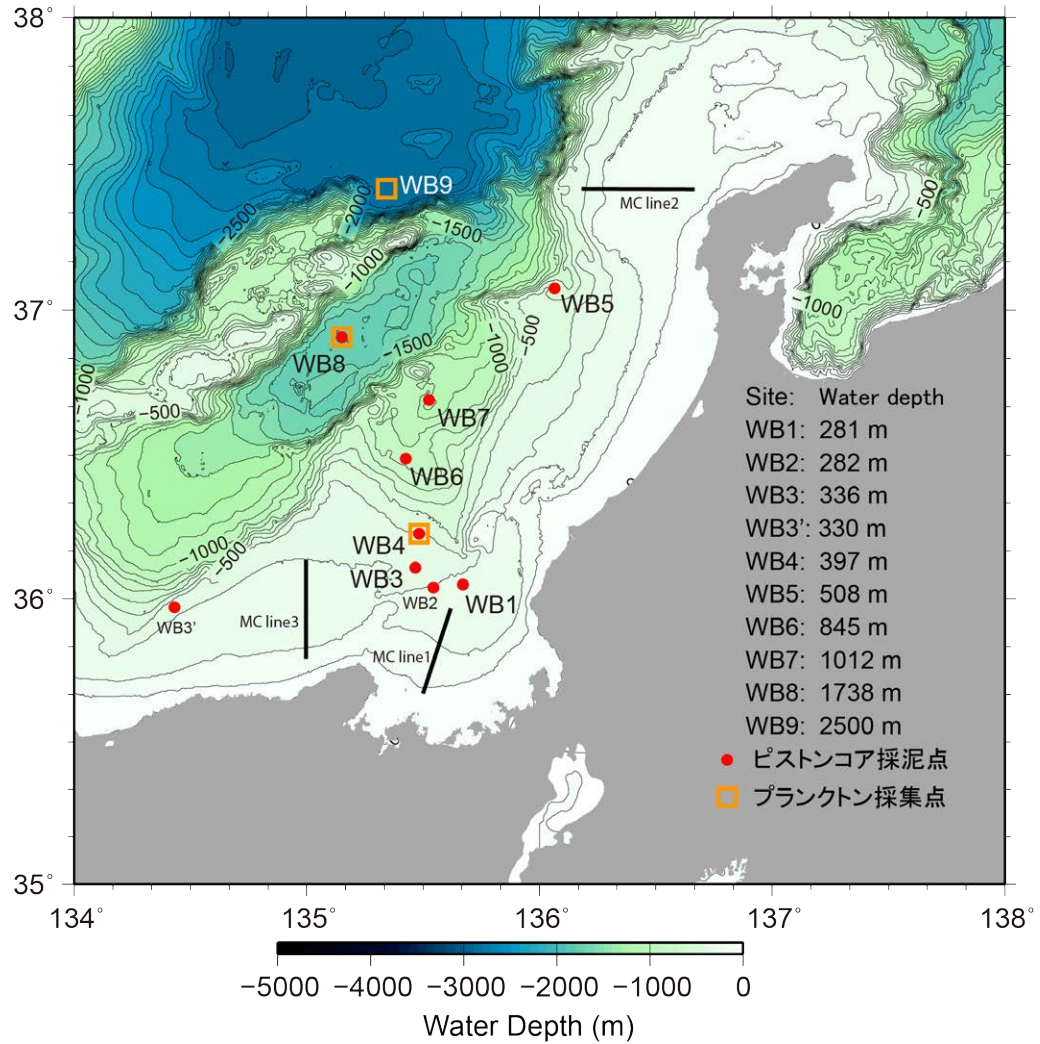


Figure 2.2 Map showing research area of KR15-10 cruise.

➤ Observation sites

KR15-10

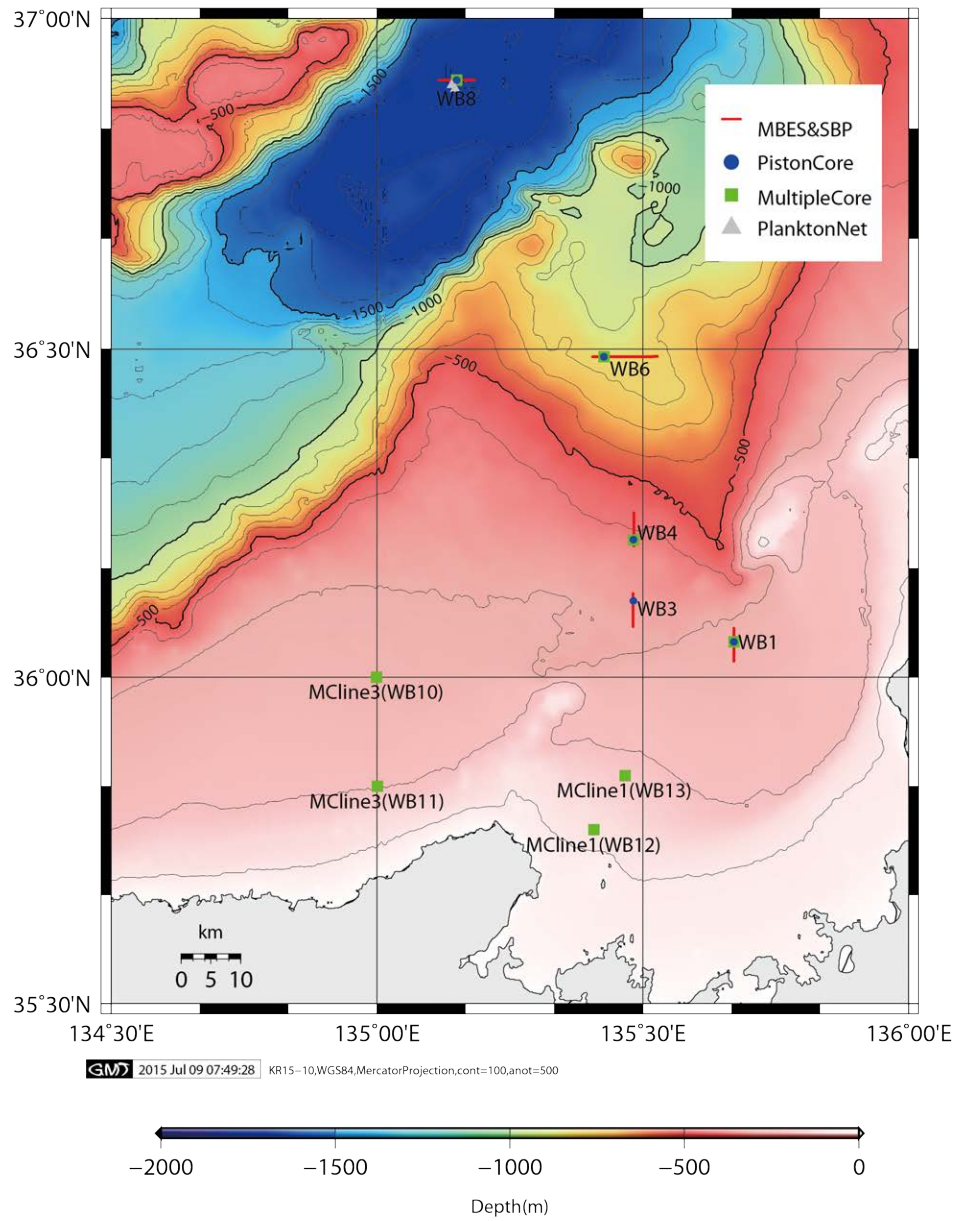


Figure 2.3 Map showing the observation sites of KR15-10.

3. Researchers

- Chief scientist: Takuya Sagawa [Kanazawa University]
- Secondary Chief Scientist: Ken Ikehara [Geological Survey of Japan, Advanced Institute of Science and Technology (AIST)]
- Representative of the science party: Takuya Sagawa [Kanazawa University]
- Science party:

Tomohisa Irino	[Hokkaido University]
Takeshi Nakagawa	[Ritsumeikan University]
Satoshi Takahashi	[University of Tokyo]
Yoshimi Kubota	[National Museum of Nature and Science]
Kenji Matsuzaki	[Geological Survey of Japan, AIST]
Yoshiaki Suzuki	[University of Tokyo]
Yukiko Kozaka	[University of Toyama]
Song Lu	[Hokkaido University]
Toshihiro Tada	[University of Tokyo]
Ann Holbourn	[Christian-Albrechts-University, Kiel]
Andrew Henderson	[Newcastle University]
Huai-Hsuan Huang	[Hong Kong University]
- Marine Technician

Yuji Fuwa	[Nippon Marine Enterprises, LTD.]
Yuki Miyajima	[Marine Works Japan, LTD.]
Yusuke Sato	[Marine Works Japan, LTD.]
Tomohide Noguchi	[Marine Works Japan, LTD.]
Keiko Fujino	[Marine Works Japan, LTD.]
- Captain and crew of the R/V Kairei

Captain	Takafumi Aoki
Chief Officer	Akihisa Tsuji
2nd Officer	Tomoyuki Tomoyuki
3rd Officer	Yusuke Ishii
Jr.3rd Officer	Keiji Takahashi
Chief Engineer	Takashi Ohata
1st Engineer	Wataru Kurose
Jr.1st Engineer	Shinichi Ikuta
2nd Engineer	Natsuto Yamaguchi

3rd Engineer	Yoichi Yasue
Chief Radio Operator	Takehito Hattori
2nd Radio Operator	Michiyasu Katagiri
Boat Swain	Masanori Ohata
Able Seaman	Yasuo Konno
Able Seaman	Nobuyuki Ichikawa
Able Seaman	Hiroataka Shigeta
Able Seaman	Kosei Kawamura
Able Seaman	Hideaki Nakata
Sailor	Yosuke Horii
Sailor	Kohei Sato
No.1 Oiler	Toshikazu Ikeda
Oiler	Masanori Ueda
Oiler	Keiya Taniguchi
Oiler	Makoto Kozaki
Assistant Oiler	Shota Shimohata
Assistant Oiler	Shogo Iiboshi
Chief Steward	Tatsunari Onoue
Steward	Masao Hosoya
Steward	Toru Murakami
Steward	Kazuma Sonoda
Steward	Mao Kikuchi

4. Observation Methods

4.1 Site survey

4.1.1 Instruments and operation

KAI REI are equipped a multi narrow beam echo sounder (Type SeaBeam 3012, L-3 ELAC Nautik GmbH.) and a sub bottom profiler (Type BATHY-20101, SyQwest, Inc.). The specifications of these instruments are listed below.

The specifications of SeaBeam 3012

Technical data	
Operating frequency	12 kHz
Min. depth	50m below transducers
Max. depth	11,000 m (full ocean depth)
Number of beams	301 equi-distance
Accuracy	< 1 % of water depth (average across swath)
Side scan	12-Bit Resolution to maximum 2000 pixels
Average footprint resolution	2° x 1.6°
Max. vessel speed	6 knots (100 % Coverage @ 140° swath) 12 knots (100 % Coverage @ 120° swath)
Workstations	Computer with Windows 7 operating system
Measurement method	Swept beam technique
Environmental limits for compensation	
Roll	± 10°
Pitch	± 7°
Yaw	± 5°

The specifications of BATHY-2010

Depth Ranges	10, 20, 40, 80, 150, 300, 500, 750, 1000, 2000, 5000, 12000 Meters
Strata Resolution	Up to 6 cm with 200 Meter of bottom penetration bottom type dependant
Depth Resolution	0.1 Meters
Depth Accuracy	± 0.3 % to 6000 m
Frequency Output	3.5 KHz

XBT measurement (XCTD / XBT DIGITAL CONVERTER & MK - 130 SYSTEM, Tsurumi Seiki Co., LTD.) is done as a preliminary survey, from the measured temperatures the velocity of sound at each depths are found, and are used for the compensation on velocity of sound for Sea Beam and sound ranging device. The specification of the instrument is listed below.

The specification of XBT system

Digital converter	
Sampling interval	50 msec.
XBT probe	
Water temperature range	- 2.2 ~ 35.5 °C
Accuracy	± 0.2 °C
Measuring range	1830 m (T-5) Max. 6 knot 460 m (T-6) Max. 15 knot 760 m (T-7) Max. 15 knot about 300 m (T-10) Max. 10 knot
Measuring time	291 sec. (T-5) 70 sec. (T-6) 118 sec. (T-7) about 48 sec. (T-10)

4.2 Multiple coring

4.2.1 Instrument

Multiple Corer (MC) consists of frame (620 kg in weight) and eight sub-corer attachments. The sub-corer pipes made from acryl or polycarbonate are used for the sediment coring. These pipes are 60 cm in length and 74 mm in diameter. The construction of the MC system is showed in Fig. 4.1.

In this cruise, MC Water Sampling System, consists of four Niskin Bottles, SBE 39 Temperature Recorder and Magnet Switch Data Logger, was attached to the MC frame. Content of Niskin Bottle is 8 liters. SBE 39 Temperature Recorder has function of pressure meter. These instruments are detached from the MC frame when the samples are recovered.

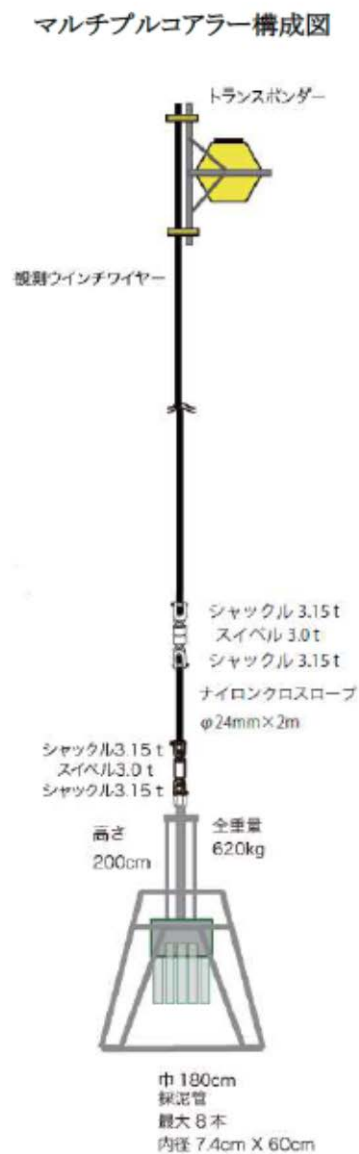


Figure 4.1 Schematic representation of multiple corer system.

4.2.2 Operation

The wire out speed is up to 50 m/min. The MC is stopped at the depth about 30 m above the sea floor and kept for 3 minutes. After that, the wire is run out at a speed of 20 m/min. Wire tension is logged during the operation and is used for judging whether MC arrive at or leave from the sea floor.

4.2.3 Treatment of Multiple core samples

The multicores were initially labelled from Hand-1 to Hand-8. These core tubes were detached from the corer, and their top and bottom ends were capped with a rubber plug (Fig. 4.2). The lengths of the collected sediments in each core were then measured. For site WB8MC, WB4MC, WB1MC, WB6MC, WB12MC and WB13MC, we attributed four cores to micropaleontological studies, one to organic geochemistry studies, one to black carbon analysis and one to visual core description (VCD). Generally, the core containing the longest sediment was used for VCD. Additionally, one core collected with opaque tube was attributed to optically stimulated luminescence (OSL) analysis for site WB8MC, WB4MC, WB1MC and WB6MC. One core for radiolarian analysis was also attributed in site WB11MC, WB12MC and WB13MC.

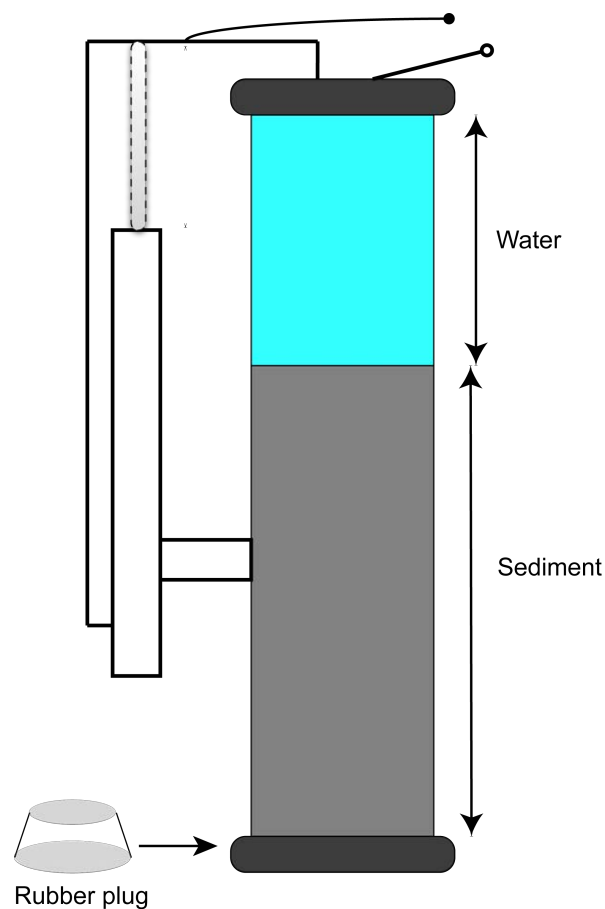


Figure 4.2 A schematic representation of sub-corer attachment and pipe.

Once capped, the cores were transported to the wet-lab. First we removed the water present between the surface sediments to the top of the core tube by a plastic tube, however, when only one or two centimeter of water is remaining, we used a pipette for remove the water in order not to disturb the structure of the surface sediments. After having removed the water, the core was transported to the multicore sampler supporter (Fig. 4.3). Here, we pushed downward the tube until one centimeter of sediments came out from the top of the tube. At this moment, the bottom of the core tube was then stabilized using a screw driver (Fig. 4.3). The sediment out from the top of the tube (1 cm) is then sampled using a spatula. During the sampling, we remove the sediments in the margin for preventing contamination.

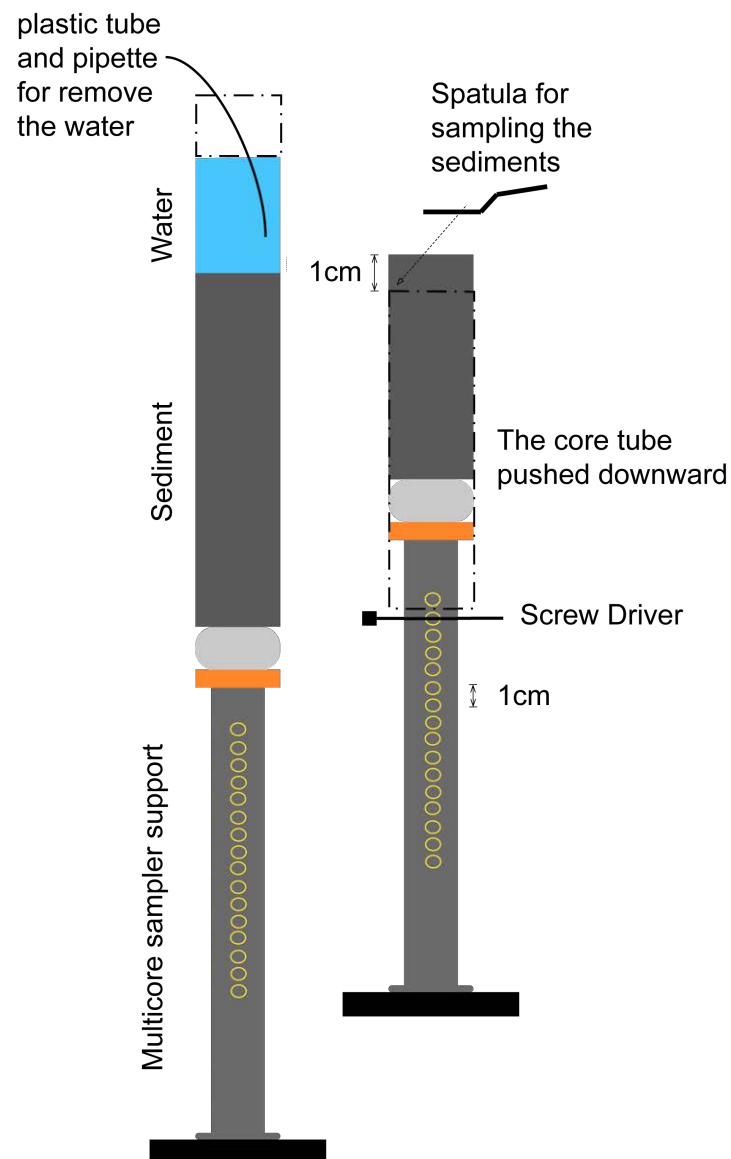


Figure 4.3 A schematic representation of sampling procedure of multiple core

All the collected cores were sampled at one centimeter interval following the method described above, excepting the core for VCD studies. Indeed for VCD studies, we prepared two half tubes joint together by tape. Once the water was removed, we put the VCD core on the multicore sampler supporter. The top of the initial tube containing the sediments was fixed by tape to the jointed two half tubes. We pushed downward both tube until the sediments contained in the core barrel was completely transferred to the jointed tube bottom. The jointed tube was then capped and divided into two by the use of a knife and thin metal plate.

For cores attributed to micropaleontological studies, the upper five centimeter was stocked in a sample bottle while the samples between 5 cm to the core bottom were stocked in plastic bags (Fig. 4.4). For samples from upper 5 cm, rose bengal solution was put in it in order to differentiate the living specimens. For radiolarians, all the sampled material was stocked in a plastic bag. Similar sampling method was done for organic geochemistry samples, however, the samples were firstly covered by aluminum foil before to be stocked in plastic bags, excepting cores from WB12MC and WB13MC. For the black carbon analysis, only the upper five centimeter was sampled. Cores for OSL studies were stocked in a dark room.

Multiple cores work flow

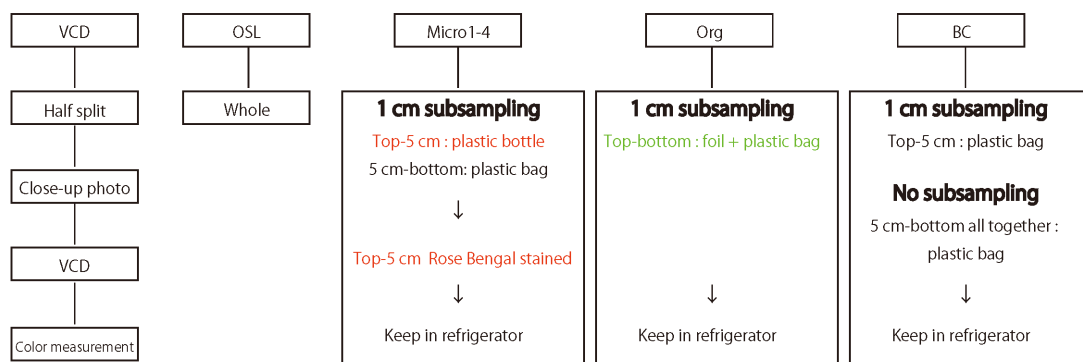


Figure 4.4 Sampling work flow of multiple cores.

4.3 Piston coring

4.3.1 Instrument

Piston core sampler system (PC) consists of the weight, metallic pipes (duralumin or stainless steel) and trigger (Fig. 4.5). The trigger works as the balance with a pilot corer. In addition, plastic liner tube (polycarbonate or vinyl chloride) is inside of the metallic pipe. The inner diameter (I. D.) of liner tube is 74-75 mm.

In this cruise, 0.9 ton or 1.2 ton weight was used. The total length of pipes and liner tubes were 10 m or 20 m. The pipe length was decided depending on scientific objectives for each site. The long and sharp bit was put at the end of the pipes to promote penetration of the PC. We chose a 74 mm (I. D.) “Long Type Pilot Corer (74 corer)” as a pilot corer. The total weight of the PC is approximately 1.1 ton or 1.4 ton in water. The construction of the PC in this cruise is showed in Fig. 4.5. Polycarbonate liner tube is characterized by less deformation when the tube is split into archive- and working-half. In order to lessen transformation during splitting process, the tube is annealed. However, the annealed polycarbonate tube as well as another type of the tubes is sometimes deformed in the metallic pipe probably because of negative pressure during coring process. Hence, we use “hybrid piston” to minimize the inner deformation of the tube. The hybrid piston is composing of stainless steel body, one O-ring (size: P62) and one rubber plate (model: CR45).

4.3.2 Operation

The wire out speed was up to 50 m/min. The PC is stopped at the depth about 50 m above the sea floor and kept for 3 minutes. After that, the wire was run out at the speed of 20 m/min. When the wire tension suddenly decreased by the loss of the weight, we judged the PC hit the bottom. Then the winch was immediately stopped and winched up at the speed of 10 m/min until the tension gauge indicated PC was completely lift off the sea floor. After the PC left the sea floor, the winch speed was increased at the maximum speed (60 m/min).

4.3.3 Treatment of Piston core samples

Working and archive halves of the collected core sections were measured and described their basic features onboard. Cut surface of core sections were groomed to make sediment textures and structures clear using a kitchen knife. In order to keep stratigraphic consistency between working and archive halves, marker pins were put at the identical stratigraphic horizons for both halves by every 10 cm. Exact position of pins were described as the offset distance from the top of the section. The working halves were subjects for photograph, measurement of reflectance spectrum, and visual core descriptions (VCD) (Fig. 4.6).

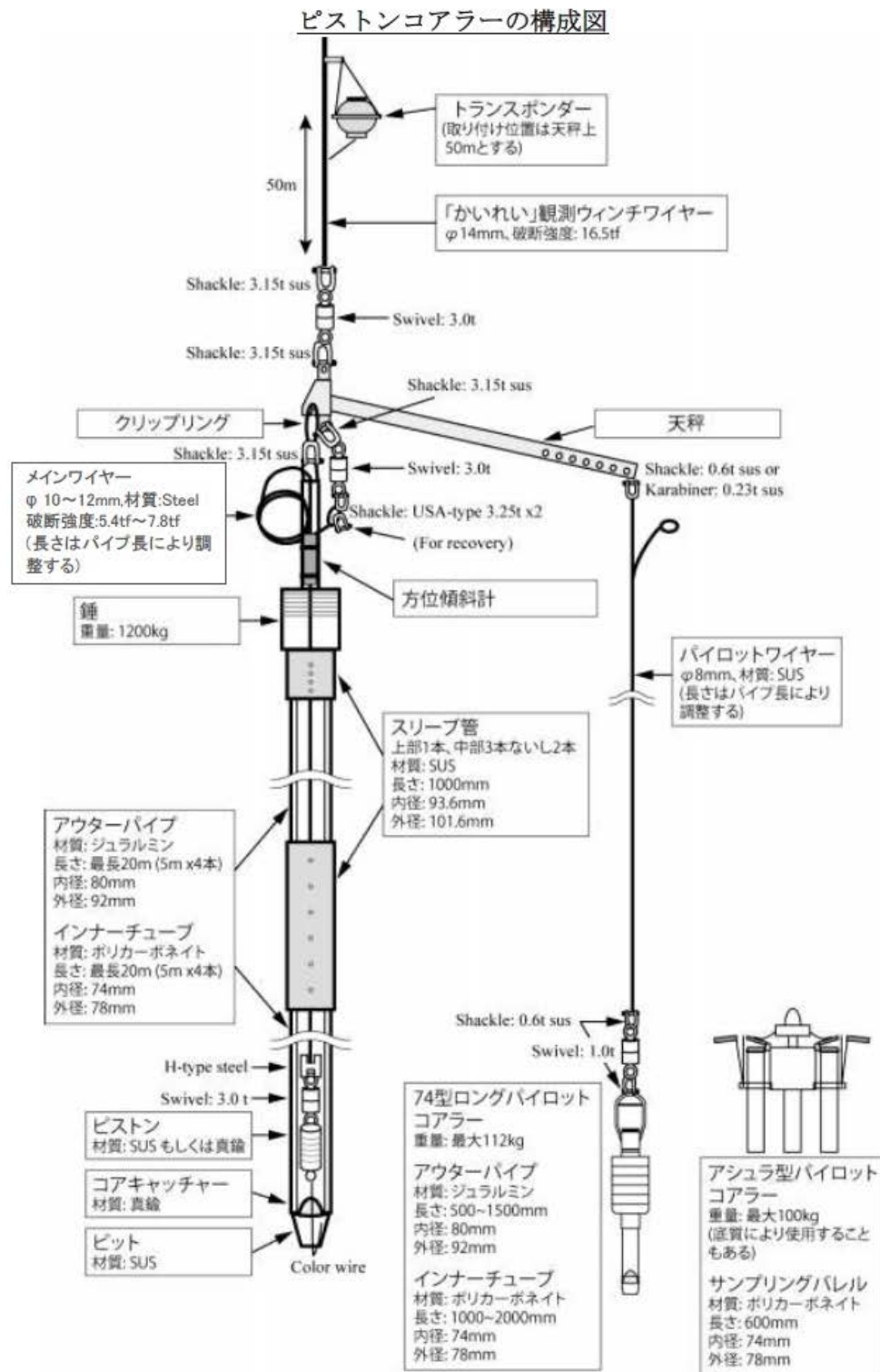


Figure 4.5 Schematic representation of piston corer system.

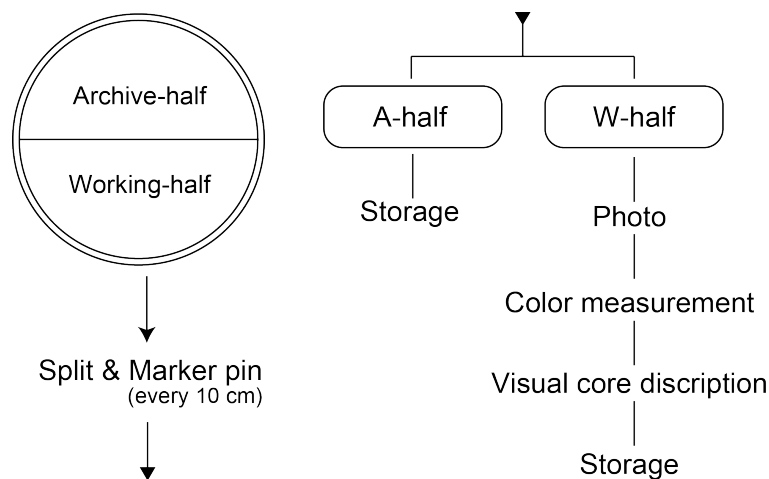


Figure 4.6 Work flow of piston core samples.

Close up picture of core was taken by Nikon D800 single lens reflex camera with AF-S VR Micro-Nikkor 105mm f/2.8G IF-ED lens. A set of four flat LED light bars were used as the controlled light source. White balance was adjusted using Ginichi silk grey card version 2. Also taken in every single picture was Kodak color separation guide and grey scale CAT 152 7654. The pictures were saved in both RAW and jpeg formats in the maximum resolution of the camera (7360 x 4912 pixels). The working distance was 840 mm which means the fill with of the image (7360 pixels) corresponds to 30 cm. All pictures were taken in the same camera setting (ISO=1600, F=3.6, 1/500s). RAW pictures were calibrated for the lens specific spherical and chromatic aberrations by Adobe Photoshop software and precisely connected after slight color correction to compose the single section images. Section length and positions of marker pins were precisely determined when the photograph was taken.

Reflectance spectrum of the cut surface of section was measured using Minolta CM-700d spectrophotometer. The cut surface of section was covered with transparent film (Saran Wrap ® Asahi Kasei Home Products Corporation) where air bubbles between film and sediment surface were carefully eliminated, and the reflectance spectrum was measured through the film. Two points calibration with zero (no reflection) and white (known standard) was conducted for every measured section. Reflectance of diffused light was taken from 300 to 700 nm wave length by 10 nm interval, and tristimulus (XYZ) and color indices ($L^*a^*b^*$) were calculated under condition of specular component excluded (SCE), D65 illuminant, and 10° viewing angle. The measurements were conducted by 1 cm interval, and the stratigraphic position of the measurement was calibrated based on the relative distance from the closest marker pin.

Visual features of core sections were recorded on common barrel sheets. Munsell color, structure, texture, grain size, and dominant composition as well as mode of disturbance were described based on the visual impression of core sections.

4.4 Plankton tow experiment

4.4.1 Instruments

The NORPAC plankton tow (64 μm mesh size) was used in this cruise. A schematic representation of plankton tow system is shown in Fig. 4.7. The diameter of aperture was 0.5 m and the length of the net was 2.1 m. The metal ring frame was hanged at four spots with strings that connect to the main wire of the ship. The weight of 25 kg was used.

The net (63 μm mesh size) was used to collect the plankton from the pumped seawater in the wet laboratory. The net was connecting to the tap of the pumped seawater (Fig. 4.8). The seawater collected by pumping system of this vessel is supplied from ~ 5 m water depth.

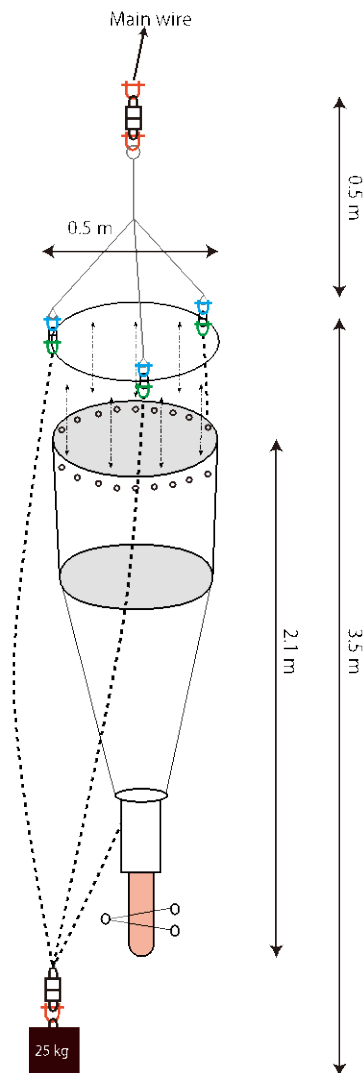


Figure 4.7 A schematic diagram of NORPAC plankton net used in this cruise.



Figure 4.8 Plankton sampling system using pumped seawater.

4.4.2 Operation and sample treatment

The NORPAC plankton tow experiment was carried out at site WB8. Two casts were conducted: one was from 200 m to 0 m and the other was from 400 m to 0 m. The wire length was regarded as water depth the net reached, and tilt of the wire was not measured. The speed of wire letting out and in was 0.5 and 1.0 m/min, respectively. The collected plankton was temporally stored in plastic sample container on afterdeck, and its volume was approximately 100 ml including seawater. The obtained samples were sieved through 45 μm sieve in order to remove seawater and finally fixed with ethanol. Amount of the samples we obtained eventually is approximately 30 ml. The sample containers were preserved in the refrigerator. The samples will be used for planktic foraminifer assemblage, radiolarian assemblage and geochemical analyses using foraminiferal tests.

Thirteen samples were obtained from pumped seawater in the wet lab. The samples were fixed with ethanol in the plastic containers. The each sampling interval was approximately 6 hours. The sample containers were preserved in the refrigerator.

4.5 Water sampling

4.5.1 Sampling methods

Surface water samples were collected at 9 sites. Sample from one site (sample #02) was collected by the pumping system in the wet lab (~5 m in water depth). Samples from other sites were collected with a polypropylene (PP) bucket from the port side of the ship during piston coring. Time, longitude, latitude and water temperature were recorded at the time of sample collection.

Bottom water samples were collected using four Niskin sampling bottles (General Oceanics, Inc., 8.0 L) attached to a multiple corer. The cap of the Niskin bottle was closed before the corer reached the seafloor to avoid the contamination of the sediment. Therefore, we defined the depth of the bottom water collected as 1 m above the reported coring depth. We used two Niskin bottles out of four attached to the corer. In all site, we found #2 Bottle leaked. Basically, we obtained the water samples from #3 and #4. Samples for analyses of total alkalinity, dissolved inorganic carbon, salinity, oxygen isotope ratios and Ba concentration were transferred using silicon tubes cleaned with 1 N HCl. Samples for analyses of neodymium isotope ratios, rare earth elements and silicon isotope ratios were transferred with tygon tubes cleaned with aqua regia.

4.5.2 Handling of samples

We collected the water samples using different equipment/procedure depending on the purpose of analyses as follows.

- For total alkalinity (TA) and dissolved inorganic carbon (DIC)
 - We basically followed a standard operating procedure (SOP 1) in Dickson et al. (2007).
 - 1. Fill 100 ml (DIC) and 125 ml (TA) glass bottles with seawater carefully so that any bobbles do not remain inside.
 - 2. Take 1 ml seawater using a micro pipette.
 - 3. Add 500 μ l of saturated mercury chloride solution for sterilization.
 - 4. Cap bottles with rubber caps.
 - 5. Swage aluminum caps.
 - 6. Store the samples at low temperature (~5 °C).
- For salinity
 - 1. Fill a 100 ml PP bottle with seawater with minimum head space to avoid contact with air.
 - 2. Store the samples at room temperature.
- For oxygen isotope ratios ($\delta^{18}\text{O}$)
 - 1. Fill a 10 ml glass bottle with seawater with minimum head space to avoid contact with air.

2. Store the samples at low temperature ($\sim 5^{\circ}\text{C}$).
- For barium concentration in seawater
 1. Fill a 50 ml PP bottle with seawater.
 2. Rinse a syringe three times with the seawater.
 3. Rinse a disk filter (PALL, GHP Acrodisc® 25mm syringe Filter with 0.2 μm GHP Membrane) with the seawater.
 4. Fill a 20 ml Nalgene bottle with the filtered seawater.
 5. Store the samples at low temperature ($\sim 5^{\circ}\text{C}$).
 - For neodymium isotope ratios and rare earth elements (REEs)

We use Cutter et al. (2010) as a reference. PP bags, Teflon® bottles, pipette tips and filters were cleaned with HCl (Wako, super special grade).

Surface water

1. Fill two PP bag (AS ONE, Tough-Tainer, Strengthened Type, 10 L) with seawater.
2. Rinse tygon tubes and Steradisc 50 with the seawater.
3. Filter the sample with Steradisc 50 (KURABO, 0.2 μm γ -ray sterile) using a pump.
4. Split filtered seawater into a 500 ml PP bottle for REE analysis. The remaining water is used for Nd isotope analysis.
5. Add 1 mL 30% HCl (TAMA, TAMAPURE AA-100) to 1L of the seawater sample.
6. Store the samples at room temperature.

Bottom water

1. Attach tygon tubes and the filter AcroPak® 200 (PALL, Capsule with Supor Membrane, 0.8/0.2 μm , 200 cm^2 EFA, sterile) to Niskin sampling bottles.
 2. Rinse the tubes and the AcroPak® 200 with seawater.
 3. Filter with the AcroPak® 200.
 4. Rinse a polyethylene bag and a Teflon® bottle with the filtered seawater.
 5. Cover the bottle mouth and the tubes with plastic wrap.
 6. Fill the polyethylene bag and the Teflon® bottle with the filtered seawater.
 7. Add 1 mL 30% HCl (TAMA, TAMAPURE AA-100) to 1L of the seawater sample.
 8. Store the samples at room temperature.
- For silicon isotope ratios
 1. Take a fraction of filtered sample collected for Nd isotope analysis into a 300 ml bottle.
 2. Add 3 drops of 30% HCl (TAMA, TAMAPURE AA-100).
 3. Store the samples at low temperature ($\sim 5^{\circ}\text{C}$).

- For suspended materials
 1. Fill a polyethylene bag (Sekisui Seikei, Lontainer) with seawater.
 2. Collect suspended materials from 2 L seawater by filter (ADVANTEC, Mixed Cellulose Ester Membranes, 47 mm dia, 0.45 μm) using an aspirator.
 3. Store the filter at room temperature.

5. Observation Results

5.1 Site Survey

5.1.1 Site WB8

Geological and sedimentological settings: Site WB8 is located at the flat sea floor in the Oki Trough, which is a ENE-WSW oriented bathymetric depression in the southern Japan Sea, with its water depth of around 1750 m. The Oki Trough has been filled by hemipelagic mud with numerous submarine gravity flow deposits (e.g., Ikehara et al., 1990) from its southern slope. Acoustic facies in

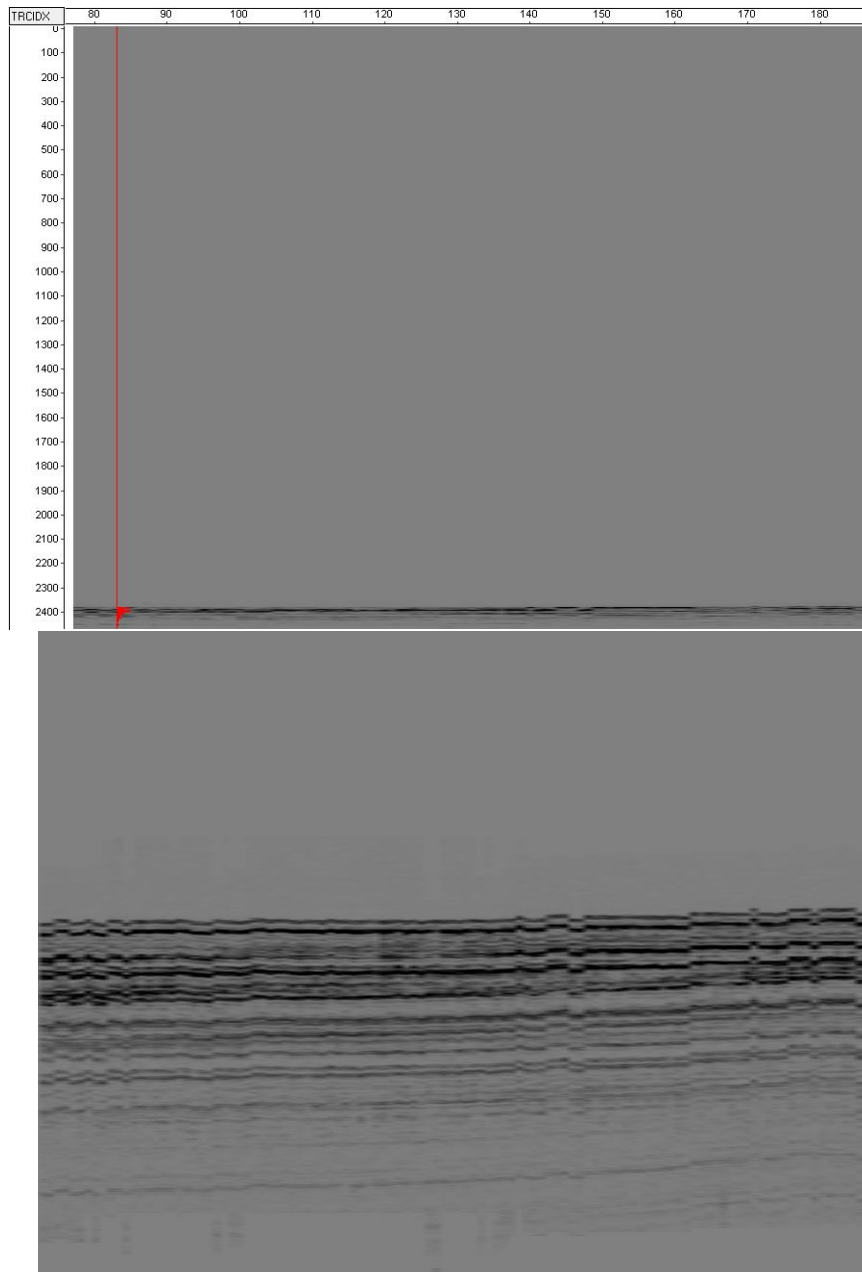


Figure 5.1 SBP profile crossing site WB8 (west (left) to east (right)). Red line in the upper panel indicates the coring location.

the Oki Trough floor is finely stratified facies. Chaotic and acoustically transparent facies occurred at the southern half of the Trough. The SBP profile obtained during this cruise for the site survey of site WB8 (Fig. 5.1) was also showed the finely and well-stratified acoustic facies with high acoustic penetration. There were several strong reflectors with numerous weak but well-continuous reflectors. The acoustic facies suggests that hemipelagic and fine-grained turbidite deposition has been dominant at and around the coring site.

5.1.2 Site WB4

Geological and sedimentological settings: Site WB4 is located near the edge of marginal terrace off San'in which is a typical submarine terrace with its water depth of 200-400 m, and of gentle slope toward the Wakasa Basin between the Wakasa knoll chain at west and the slope from marginal terrace off Hokuriku at east. The acoustic facies obtained by the SBP survey (Fig. 5.2) indicated the stratified facies with smaller penetration depth than that in the Oki Trough (site WB8). Sediment thickness of the uppermost layer was thicker at the northern end of the survey line than that at the southern part, although it is not clear in Fig 5.2.

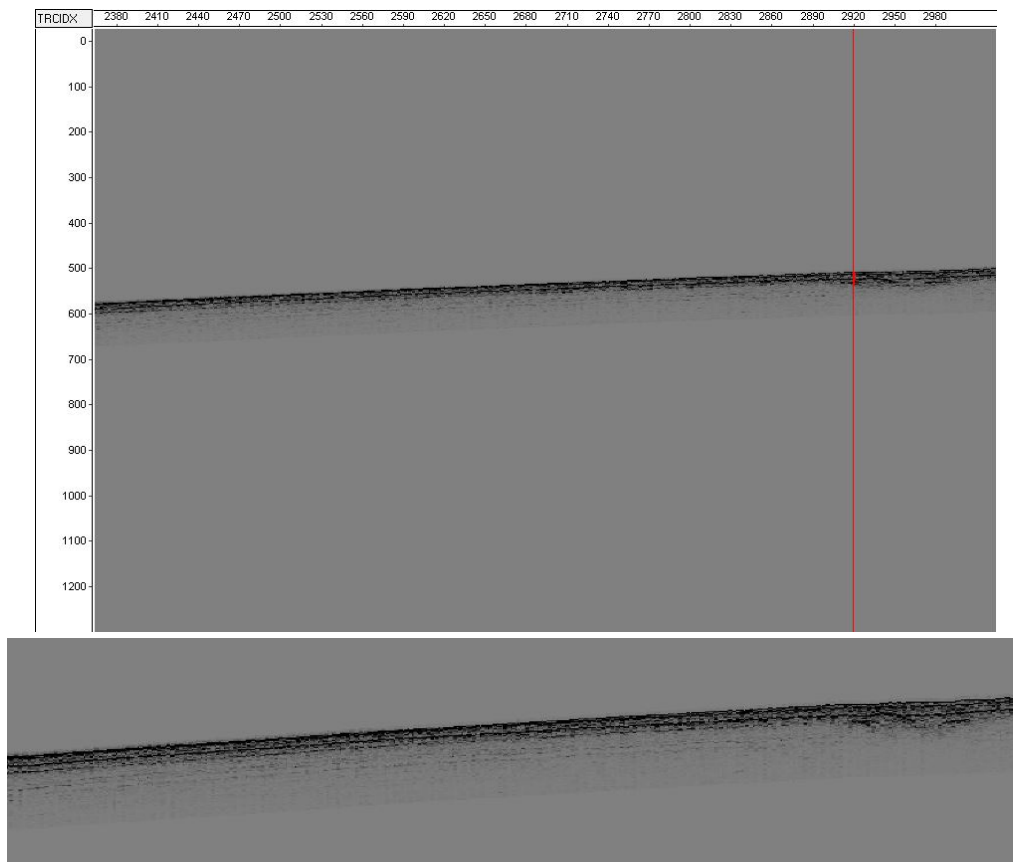


Figure 5.2 SBP profile crossing site WB4 (north (left) to south (right)). Red line in the upper panel indicates the coring location.

5.1.3 Site WB1

Geological and sedimentological settings: Site WB1 is located at the mouth of Wakasa Bay. ENE-SWS oriented bathymetric highs from Echizen knoll chain to Cape Kyo-ga-misaki makes a tectonically formed bathymetric and basement highs, and separates the Wakasa Bay from offshore Japan Sea. The acoustic facies in the Wakasa Bay is thickly stratified facies with some strong and continuous reflectors (e.g., Ikehara et al., 1990). The obtained SBP profile crossing site WB1 (Fig. 5.3) is basically well stratified acoustic facies. The intervals of each reflector, however, become larger northward, suggesting larger sedimentation rate toward north. Although of no significant bathymetric feature of erosion, the sedimentation rate seems to be very low at the southern part of the survey line because the first (uppermost) reflector occurs close to the sea floor. The sediment core WB1PC was taken from the position where the first (uppermost) sediment layer had a few meter in thickness.

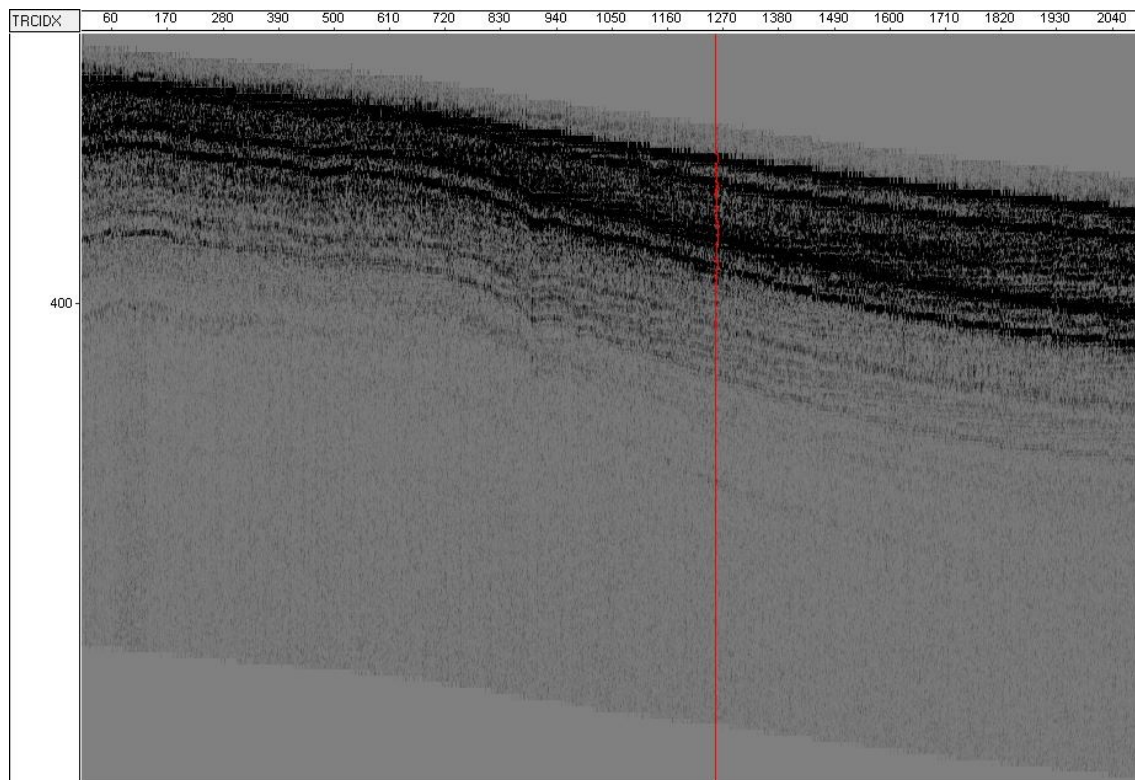


Figure 5.3 SBP profile crossing site WB1 (south (left) to north (right)). Red line indicates the coring location.

5.1.4 Site WB6

Geological and sedimentological settings: Site WB6 is located in the Wakasa Basin at east of Wakasa sea knoll chain. Bathymetric map shows a gentle bathymetric high from east to south of the coring site. Yamamoto (1991) reported a submarine mass movement deposit from the western slope of Hokuriku marginal terrace, there is no evidence on its influence at the flat basin floor from the obtained SBP profile (Fig. 5.4). Finely stratified acoustic facies was occupied along the entire profile crossing the proposed coring site (Fig. 5.4). Although of the existence of a narrow but clear channel in the profile, no clear levee was recognized in the profile. Based on the sub-bottom depths of each reflector, sedimentation rate of the upper sedimentary unit might be higher at west of the channel than at east of the channel.

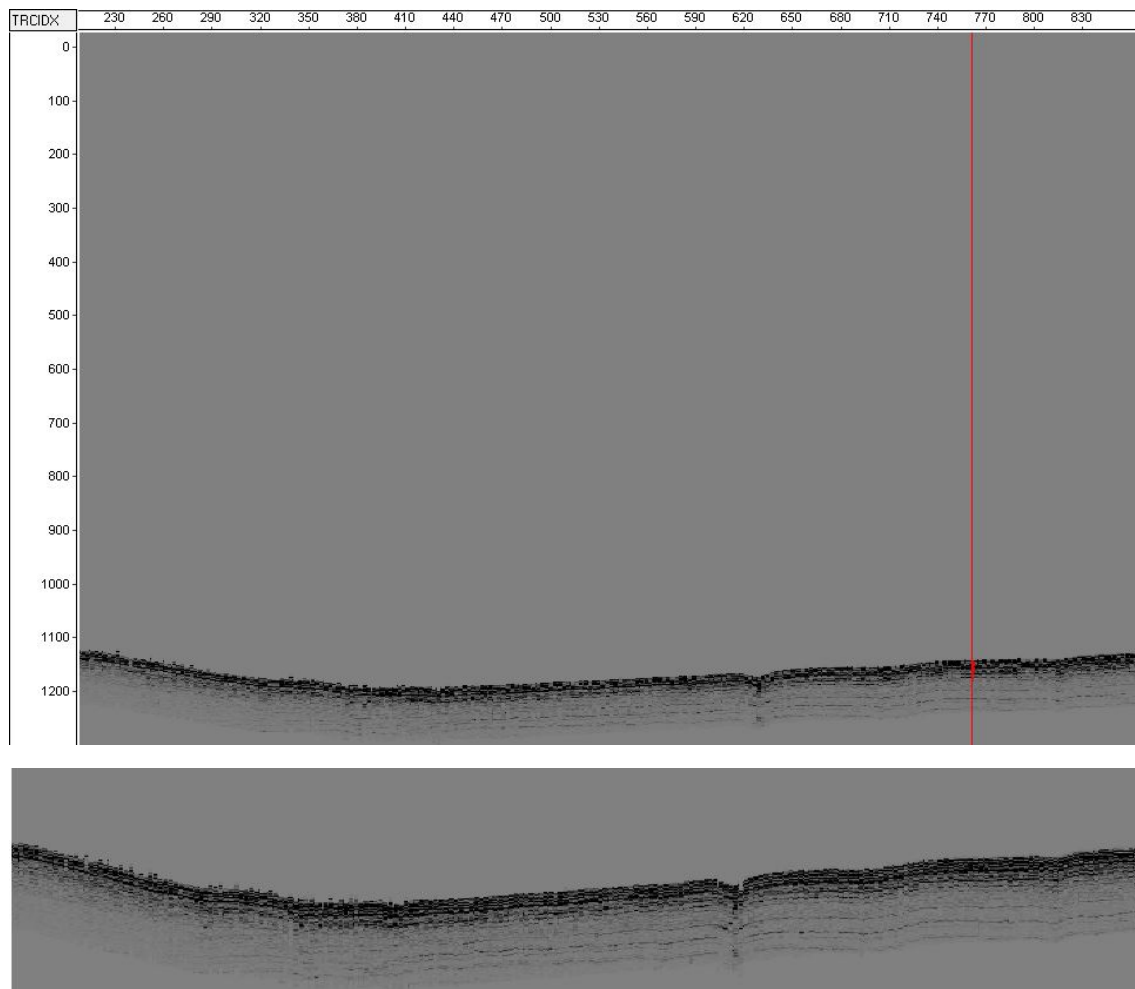


Figure 5.4 SBP profile crossing site WB 6 (east (left) to west (right)). Red line in the upper panel indicates the coring location.

5.2 Sediment cores

We collected undisturbed surface sediments using a multiple corer at 8 sites, WB1, 4, 6, 8, 10, 11, 12, and 13 (Fig. 5.5, Table 5.1). Five piston core operations also successfully recovered longer sediments at WB1, 3, 4, 6, and 8 (Table 5.2). Piston core sediments from WB1, 4, 6, and 8 were split into two halves and described onboard, and sediment core from WB3 was capped by opaque caps to avoid light reaching to cut surface of the sediment after cutting into 1 m-long section and stored in the reefer. The WB3 core will be opened in a dark laboratory on land.

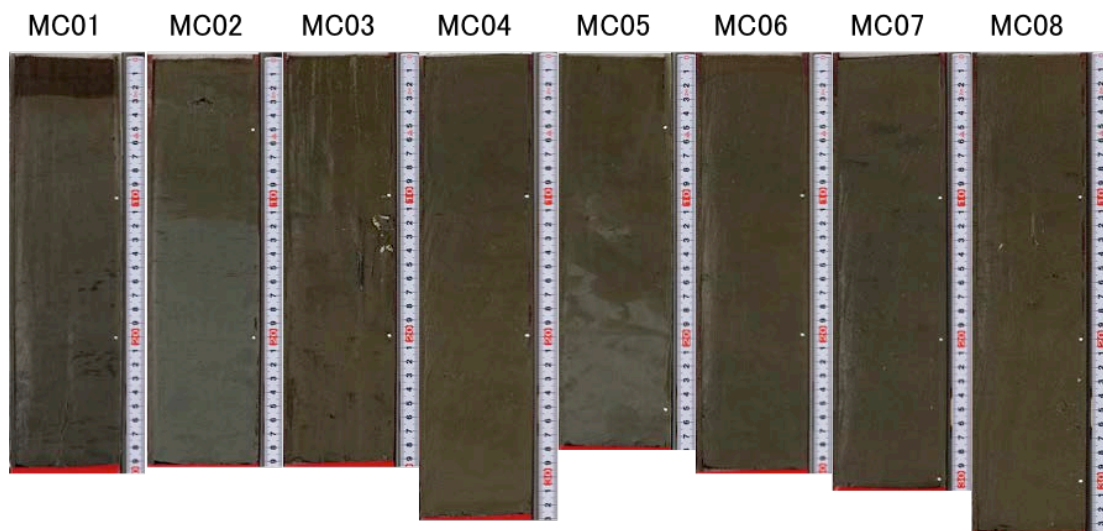


Figure 5.5 Surface sediments collected using multiple corer during KR15-10 cruise

5.2.1 Site WB1

Surface sediment, WB1MC (MC05), and piston core, WB1PC (PC04), were collected at Site WB1. Sediments mainly consist of gray to olive gray homogeneous or bioturbated silty clay.

WB1MC (MC05) is 27.7 cm long which consists of gray (7.5Y 4/1) bioturbated silty clay. Brownish black (2.5Y 3/1) oxidized layer of 20 cm thick at the sediment surface was well recovered (Fig. 5.5).

WB1PC (PC04) covers from Sec 16 to Sec 20, and is 457.7 cm in total length including the core catcher. Vertical fracture disturbs the sediment at Sec 16, 6-42 cm. Only Sec 16, 0-6 cm shows surface oxidized layer, which suggests the top ~15 cm is lost. This core consists of gray (10Y 4/2) to olive gray (10Y 5/2) homogenous or bioturbated silty clay (Figs. 5.6 and 5.7). Gray vitric ash is intercalated from Sec 16, 45 cm to Sec 17, 7 cm, which shows normal grading and diffuses out upward to normal mud. The bottom part of this ash layer is rotated by 90° due to coring shear. Dispersed shell fragments are frequently observed below Sec 17, 36 cm.

Table 5.1 Summary of multiple cores

Date (UTC)	Core ID	Location	Water Depth (m)	Positon			HAND No.	Core length (cm)	Tension max. (kN)	Remarks	
yyyymmdd				Latitude	Longitude	Type					
21050703	MC01	Off Wakasa bay (WB8)	1,745	36_54.4050N	135_09.0001E	Transponder*	HAND1	28.0	ND**		The closed time of niskin bottles : No.1-No.4: 00:17:40 (1794.908 db , 0.2280°C) MC hit the bottom : 00:17:47 (1795.005 db , 0.2282°C)
							HAND2	31.5			
							HAND3	31.0			
							HAND4	32.0			
							HAND5	32.0			
							HAND6	31.0			
							HAND7	31.0			
							HAND8	32.5			
21050704	MC02	Off Wakasa bay (WB4)	382	36_12.5696N	135_28.9617E	Ship	HAND1	31.0	ND**		The closed time of niskin bottles : No.1-No.2: ND No.3-No.4: 00:12:09 (388.636 db , 0.7415°C) MC hit the bottom : 00:12:31 (388.636 db , 0.7483°C)
							HAND2	31.0			
							HAND3	29.0			
							HAND4	29.0			
							HAND5	30.0			
							HAND6	29.5			
							HAND7	29.5			
							HAND8	30.5			

* Transponder type : XT-6001-10

**Tension meter is not available.

Table 5.1 *Continued*

Date (UTC)	Core ID	Location	Water Depth (m)	Positon			HAND No.	Core length (cm)	Tension max. (kN)	Remarks	
yyyymmdd				Latitude	Longitude	Type					
21050704	MC03	Off Wakasa bay (WB10)	269	36_00.0245N	134_59.9489E	Ship	HAND1	30.5	12		Water sampling did not carry out. MC hit the bottom : 05:31:37 (273.443 db , 1.7532 °C)
							HAND2	-		vacant	
							HAND3	-		vacant	
							HAND4	31.5			
							HAND5	32.0			
							HAND6	-		vacant	
							HAND7	-		vacant	
							HAND8	32.5			
21050704	MC04	Off Wakasa bay (WB11)	203	35_49.9961N	135_00.0533E	Ship	HAND1	35.5	11		The closed time of niskin bottles : No.1-No.4 : 07:15:40 (205.568 db , 2.3430°C) MC hit the bottom : 07:15:43 (205.568 db , 2.4422°C)
							HAND2	34.0			
							HAND3	35.0			
							HAND4	34.0			
							HAND5	32.0			
							HAND6	35.0			
							HAND7	35.5			
							HAND8	35.0			

Table 5.1 *Continued*

Date (UTC)	Core ID	Location	Water Depth (m)	Positon			HAND No.	Core length (cm)	Tension max. (kN)	Remarks	
yyyymmdd				Latitude	Longitude	Type					
21050704	MC05	Off Wakasa bay (WB1)	284	36_03.2517N	135_40.3040E	Ship	HAND1	30.0	15	Sediment sample is leaked between the under lid and the sampling pipe.	The closed time of niskin bottles : No.1-No.4 : 21:54:51 (289.054 db , 0.8986°C) MC hit the bottom : 21:54:54 (289.151 db , 0.8990°C)
							HAND2	30.0			
							HAND3	29.5			
							HAND4	29.5			
							HAND5	30.0			
							HAND6	28.5			
							HAND7	29.0			
							HAND8	29.0			
20150705	MC06	Off Wakasa bay (WB6)	847	36_29.2786N	135_25.6374E	Transponder*	HAND1	25.0	16	The face of sediment is incline.	The closed time of niskin bottles : No.1-No.2: 07:38:48 (864.052 db , 0.3033°C) No.3-No.4: 07:38:52 (864.246 db , 0.3036°C) MC hit the bottom : 7:38:54(864.343 db , 0.3037°C)
							HAND2	31.5			
							HAND3	30.5			
							HAND4	27.5			
							HAND5	31.0			
							HAND6	29.5			
							HAND7	29.0			
							HAND8	30.0			

* Transponder type : XT-6001-10

Table 5.1 *Continued*

Date (UTC)	Core ID	Location	Water Depth (m)	Positon			HAND No.	Core length (cm)	Tension max. (kN)	Remarks	
yyyymmdd				Latitude	Longitude	Type					
20150705	MC07	Off Wakasa bay (WB12)	118	35_46.0022N	135_24.5050E	Ship	HAND1	29.0	12		The closed time of niskin bottles : No.1-No.2: 22:22:00 (117.331 db , 12.4098°C) No.3-No.4: 22:21:59 (117.234 db , 12.4236°C) MC hit the bottom : 22:22:00 (117.331 db , 12.4098°C)
							HAND2	29.0			
							HAND3	32.5			
							HAND4	32.5			
							HAND5	32.0			
							HAND6	31.5			
							HAND7	31.0			
							HAND8	30.5			
20150705	MC08	Off Wakasa bay (WB13)	176	35_50.9990N	135_27.9888E	Ship	HAND1	35.5	12	The face of sediment is rough.	Water sampling did not carry out. MC hit the bottom : 23:39:29 (176.964 db , 6.6403°C)
							HAND2	36.5			
							HAND3	36.5			
							HAND4	37.0			
							HAND5	35.5			
							HAND6	36.0			
							HAND7	36.5			
							HAND8	33.5			

Table 5.2 Summary of piston cores

Date (UTC) yyyymmdd	Core ID	Location	Water Depth (m)	Position			Corer Wegiht	Core length (m)		Tension MAX (kN)	Piston type
				Latitude	Longitude	Type*		PC	PL		
20150703	PC01	Off Wakasa bay (WB8)	1,746	36_54.3967N	135_09.0003E	Transponder	900 kg	8.39 / 10	0.94	ND**	Standard
20150703	PC02	Off Wakasa bay (WB8)	1,745	36_54.3940N	135_09.0069E	Transponder	1200 kg	17.88 / 20	1.01	ND**	Standard
20150704	PC03	Off Wakasa bay (WB4)	381	36_12.6045N	135_28.9657E	Ship	1200 kg	7.72 / 20	0.08	37	Standard
20150705	PC04	Off Wakasa bay (WB1)	284	36_03.2740N	135_40.2773E	Ship	1200 kg	4.53 / 20	0	36	Hybrid Piston
20150705	PC05	Off Wakasa bay (WB6)	847	36_29.3015N	135_25.6223E	Transponder	1200 kg	13.60 / 20	1.08	34	Hybrid Piston
20150706	PC06	Off Wakasa bay (WB3)	337	36_07.0087N	135.28.9670E	Ship	900 kg	7.11 / 10	0.02	20	Standard

* Transponder type : XT-6001-10

**Tension meter is not available.

WB1 (PC04)



Figure 5.6 Photograph of piston core KR15-10, WB1PC (PC04).

KR15-10 WB1_PC (PC04)

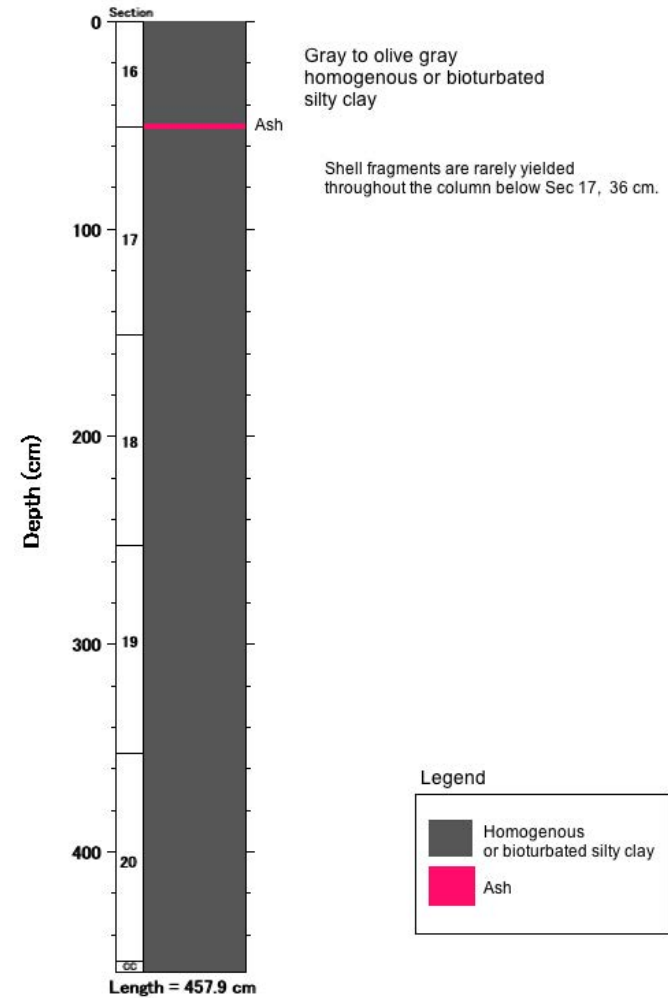


Figure 5.7 Generic column of KR15-10, WB1PC (PC04).

Fig.5.8 shows the depth profiles of L^* , a^* , and b^* color indices for cores collected at WB1. All color indices show small variations throughout the column except for ash layer interval that is characterized by brighter (higher L^*) and dull (near zero a^* and b^*) color. Surface oxidized layer shows lower L^* and higher a^* and b^* .

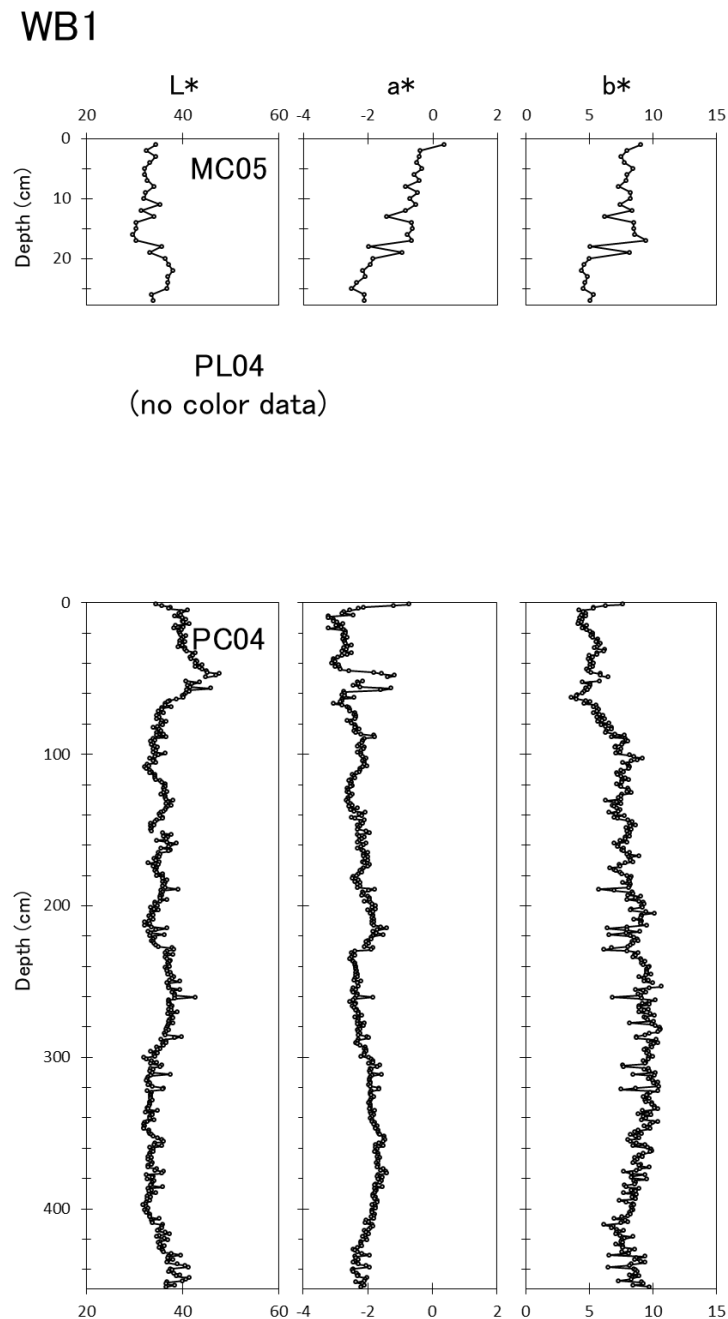


Figure 5.8 Depth variations of L^* , a^* and b^* color indices for KR15-10, WB1MC (MC05) and WB1PC (PC04).

5.2.2 Site WB4

Surface sediment, WB4MC (MC02), and piston core, WB4PC (PC03), as well as a short recovery in the pilot corer, WB4PL (PL03), were collected at Site WB1. Sediments mainly consist of gray, greenish gray to olive gray homogeneous or bioturbated clayey silt to silty clay.

WB4MC (MC02) is 29.2 cm long which consists of greenish gray (2.5GY 4/1) bioturbated clayey silt. Brownish (5Y 4/2 to 7.5Y 4/2) oxidized layer of 11.7 cm thick at the sediment surface was well recovered (Fig. 5.5).

WB4 (PL03 & PC03)

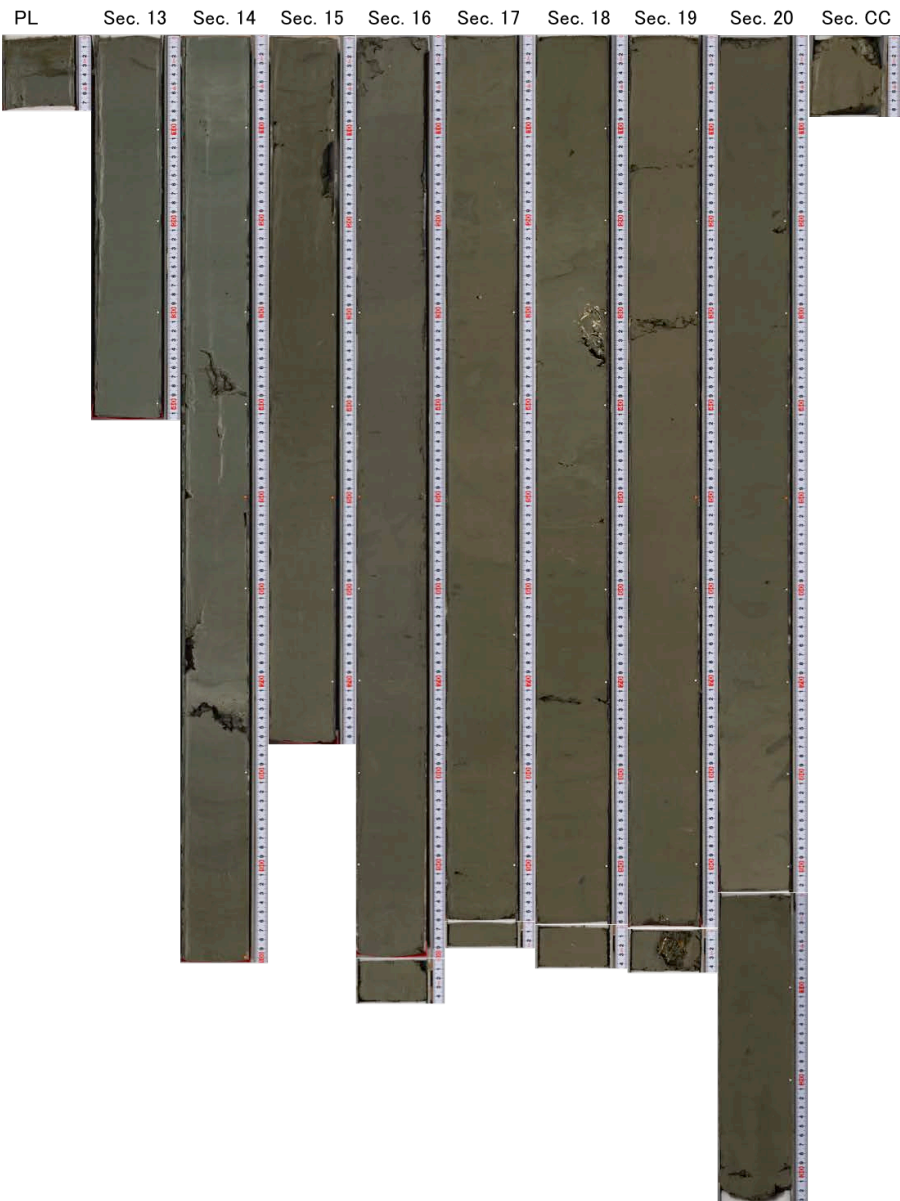


Figure 5.9 Photograph of piston core KR15-10, WB4PC (PC03) with WB4PL (PL03).

WB4PL (PL03) covers only 7.8 cm thick which shows brownish (2.5Y 4/2) surface oxidized layer on the top 4 cm underlain by greenish gray (7.5GY 5/1) clayey silt (Fig. 5.9). Comparison with WB4MC (MC02) suggests that the top ~7 cm sediment could not be recovered by this core.

WB4PC (PC03) covers from Sec 13 to Sec 20, and is 757.8 cm in total length including the core catcher. Secs 16, 17, 18, 19, and 20 are separated into the subsections A and B due to significant core expansion during onboard treatment. The archive half was used for photograph, color measurement, and visual description for Sec 16A because the working half was highly disturbed. Although the top of this core does not yield oxidized layer, the burrow infillings at Sec 13, 0-4 cm shows brownish (2.5Y 4/2) color presumably taken from the overlain surface oxidized layer, which suggests the top ~12 cm at least was not recovered by this piston core. This core mainly consists of gray (10Y 4/2), greenish gray (7.5GY 5/1) to olive gray (2.5GY 4/1) homogenous or bioturbated clayey silt to silty clay (Figs. 5.9 and 5.10). Gray vitric ash is intercalated from Sec 14, 70-73 cm. Dispersed shell fragments, plant debris, and sponge spicules aggregation are frequently yielded below Sec 15, 3 cm, where larger individual shells were found at Sec 18A, 29-36 cm, and Sec 19B, 0-4 cm.

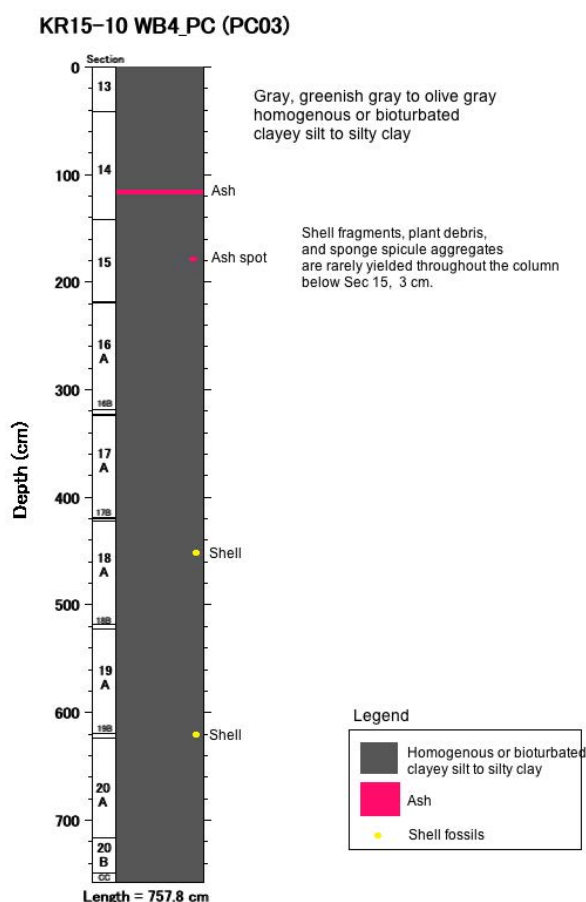


Figure 5.10 Generic column of KR15-10, WB4PC (PC03).

Fig. 5.11 shows the depth profiles of L^* , a^* , and b^* color indices for cores collected at WB4. L^* from Sec 13 to 15 is lower (darker) than those from Sec 16A to bottom. The b^* is characteristically higher from Sec 14 to 15 where ash layer and spot were observed. Although the sediment appearance is generally monotonous (Fig. 5.9), color variability between brighter (higher L^*) and dull (near zero a^* and b^*) color and darker (lower L^*) and vivid (larger absolute values of a^* and b^*) is recognized below Sec 16. Surface oxidized layer shows lower L^* and higher a^* and b^* .

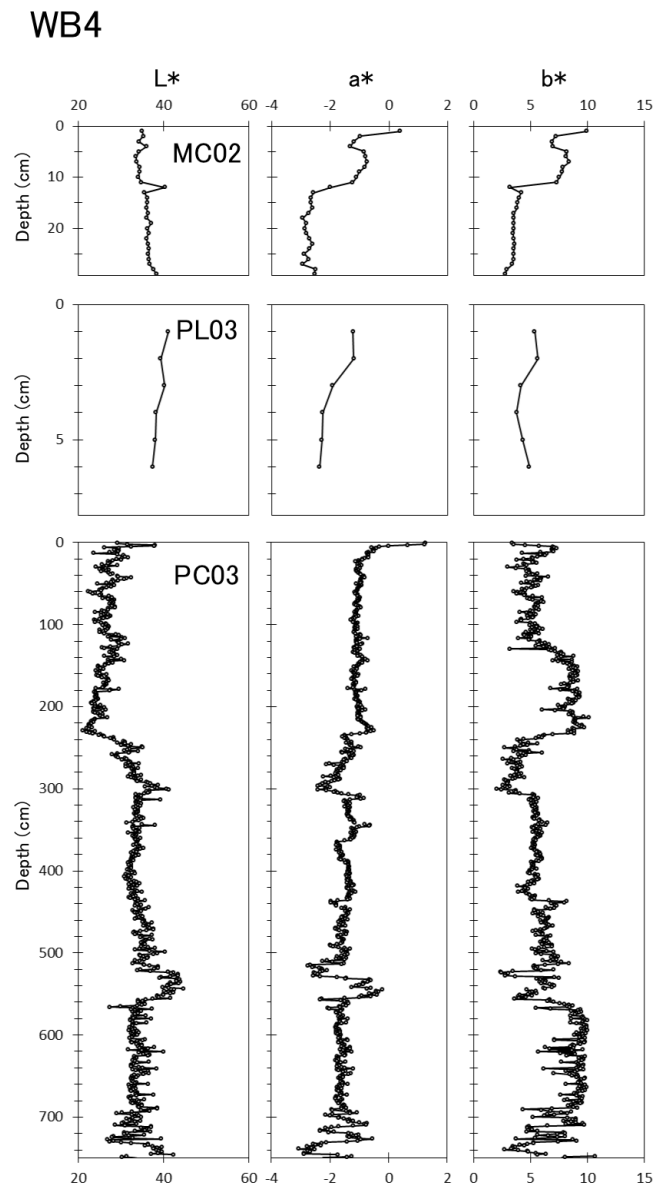


Figure 5.11 Depth variations of L^* , a^* and b^* color indices for KR15-10, WB4MC (MC02), WB4PL (PL03), and WB4PC (PC03).

5.2.3 Site WB6

Surface sediment, WB6MC (MC06), and piston core, WB6PC (PC05), as well as a good recovery in the pilot corer, WB6PL (PL05), were collected at Site WB6. Sediments mainly consist of alternation of gray to grayish olive lighter color homogeneous or bioturbated silty clay and darker color bioturbated or laminated silty clay.

WB6MC (MC06) is 29.8 cm long which consists of grayish olive (5Y 4/2 to 7.5Y 4/2) bioturbated silty clay (Fig. 5.5).

WB6 (PC05 & PL05)

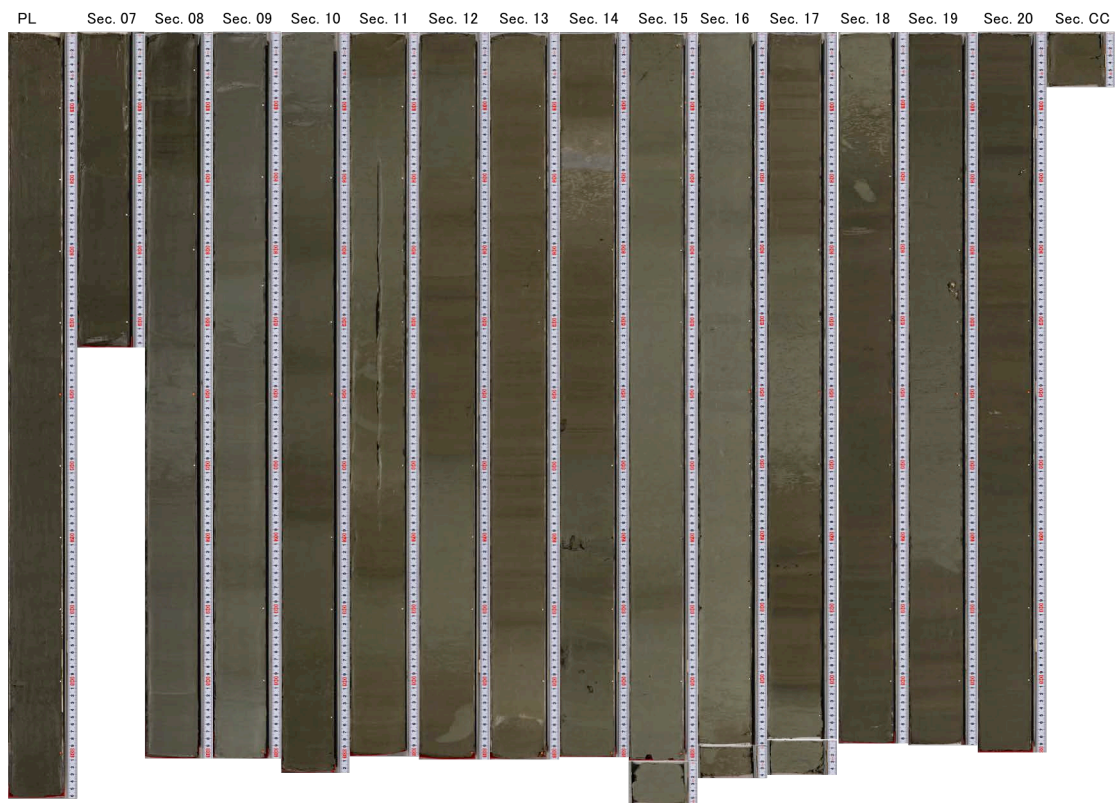


Figure 5.12 Photograph of piston core KR15-10, WB6PC (PC05) with WB6PL (PL05).

WB6PL (PL05) covers 110.8 cm thick including core catcher which shows gray (5Y 4/1 to 2.5Y 4/1) homogeneous or bioturbated silty clay (Fig. 5.12). Coarse silt size gray vitric ash lens was found at 91.2-91.6 cm from the top.

WB6PC (PC05) covers from Sec 7 to Sec 20, and is 1367.5 cm in total length including the core catcher. Secs 15, 16, and 17 are separated into the subsections A and B due to significant core expansion during onboard treatment. Because the color of Sec 7 (5Y 4/1) is similar to that of WB6PL (PL05) although the PL05 did not yield the similar ash layer found in Sec 8, 7-8.5 cm of

PC05, the bottom of PL05 would be correlated to the interval above Sec 8, 7 cm of PC05 (Figs. 5.12 and 5.13). Therefore, this piston core did not recover the surface sediment of more than 60 cm thick. Center of core is slightly disturbed with vertical discordance or fracture at the interval between Sec 10, 23 cm and Sec 11, 67 cm. This core mainly consists of alternation of gray or grayish olive lighter color (5-7.5Y or 2.5-7.5GY 5/1) homogeneous or bioturbated silty clay and darker color (5-7.5Y 4/2 to 3/1) bioturbated or laminated silty clay. (Figs. 5.12 and 5.13). Dark laminated silty clay tends to show sharp contact with the underlain lighter color layer, yielding foraminifer tests in most cases. Dark color layers tend to end upward with bioturbated layer gradually changing to the overlain lighter color layer. Parallel lamination is occasionally disturbed by the overlapped burrows. Light color layers show homogeneous or mottled appearance, and get darker upward just below the overlain dark layers. Coarse silt size ash layers of several mm to cm were rarely intercalated in the sequence (Fig. 5.13). Shell fragments are rarely found below Sec 16A, 41 cm.

KR15-10 WB6_PC (PC05)

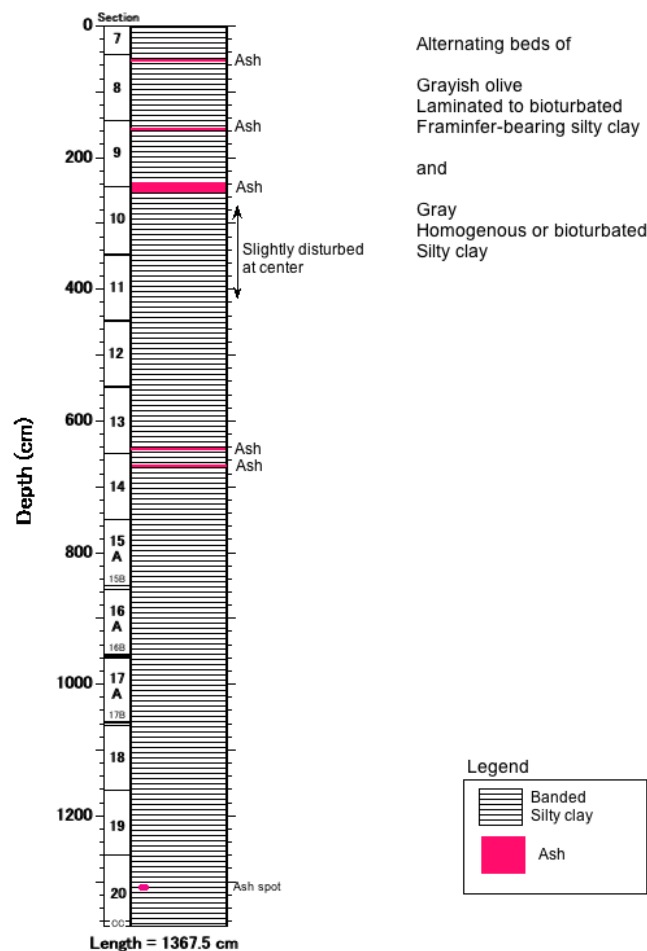


Figure 5.13 Generic column of KR15-10, WB6PC (PC05).

Fig. 5.14 shows the depth profiles of L^* , a^* , and b^* color indices for cores collected at WB6. The top ~100 cm represented by WB6PL (PL05) is characterized by lower L^* and higher a^* and b^* that is generally invariable. The topmost oxidized layer observed in WB6MC (MC06) shows slightly lower L^* and higher a^* and b^* . WB6PC (PC05) characteristically shows a decimeter-scale alternation of color between brighter (higher L^*) and more greenish (lower a^* and b^*), and darker (lower L^*) and more yellowish (larger a^* and b^*) throughout the column.

WB6

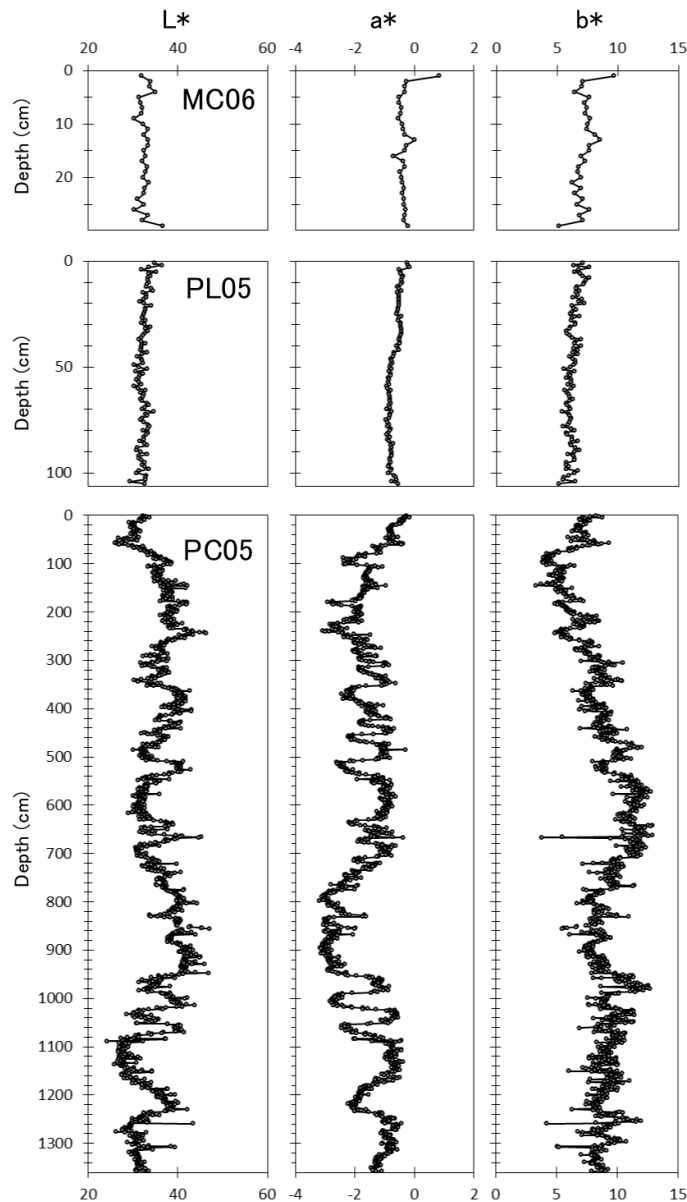


Figure 5.14 Depth variations of L^* , a^* and b^* color indices for KR15-10, WB6MC (MC06), WB6PL (PL05), and WB6PC (PC05).

5.2.4 Site WB8

Surface sediment, WB8MC (MC01), a 10 m piston core, WB8PC_A (PC01), with a good recovery in the pilot corer, WB8PL (PL01), a 20 m piston core, WB8PC_B (PC02), with a good recovery in the pilot corer, WB8PL (PL02) were collected at Site WB8. Sediments mainly consist of alternation of gray to grayish olive lighter color homogeneous or bioturbated silty clay and darker color bioturbated or laminated silty clay. The sediment sequence is also frequently interrupted by homogeneous cm to m scale event layers.

WB8MC (MC01) is 29.4 cm long which consists of olive black (7.5Y 3/2) bioturbated silty clay (Fig. 5.5). The topmost 2.5 cm sediment is brownish black (10YR 2/3) oxidized layer with sharp color boundary at its bottom.

WB8_A (PC01 & PL01)

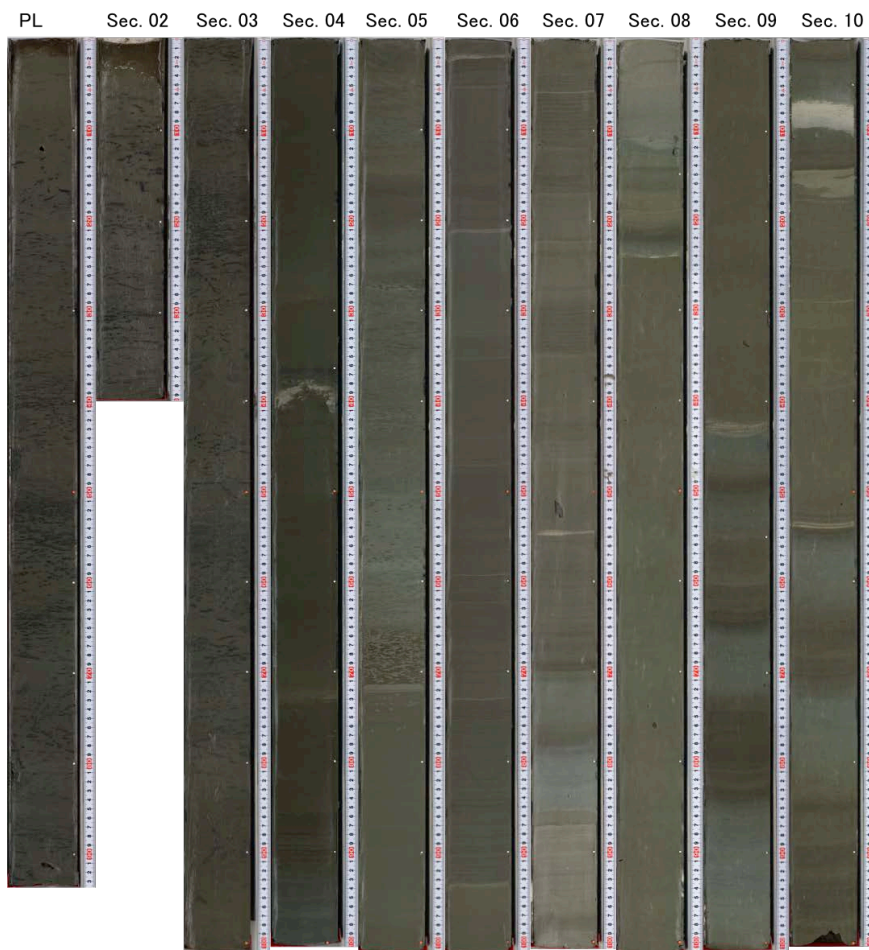


Figure 5.15 Photograph of piston core KR15-10, WB8PC_A (PC01) with WB8PL_A (PL01).

WB8PL_A (PL01) covers 93.5 cm thick which shows olive black (7.5Y 3/1) to gray (7.5Y 4/1) bioturbated silty clay (Fig. 5.15). Burrows with black infillings are very frequent. Top 1.2 cm is brownish black (2.5Y 3/2) oxidized layer.

WB8PC_A (PC01) covers from Sec 2 to Sec 10, and is 859.1 cm in total length including the core catcher. The topmost oxidized layer recognized in WB8MC (MC01) and WB8PL_A (PL01) was not clear in this piston core, which suggests that the surface sediment was lost. This core shows gray (7.5Y 4/1-3/1) mottled silty clay in Secs 2 and 3, and mainly consists of alternation of lighter gray (7.5Y 5-4/1) bioturbated silty clay and darker olive black (3-10Y 4/1 to 3/2) bioturbated or laminated silty clay from Secs 4 to 10 (Figs. 5.15 and 5.16). Dark laminated silty clay tend to show sharp contact with the underlain lighter color layer, yielding foraminifer tests in most cases. Light color layers show mottled appearance, and get darker upward just below the overlain dark layers.

KR15-10 WB8_PCA (PC01)

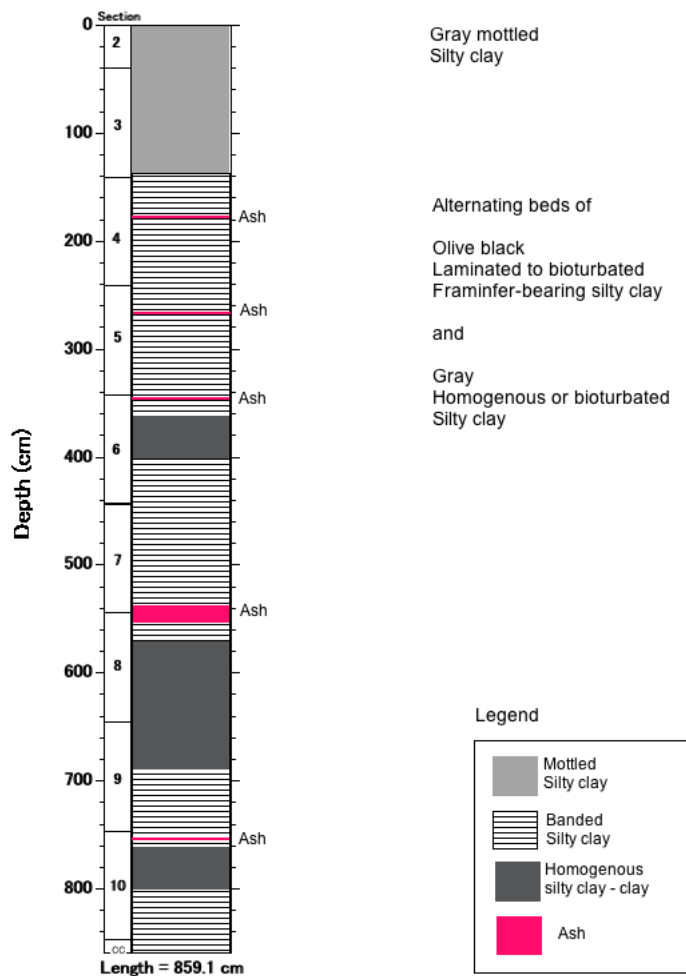


Figure 5.16 Generic column of KR15-10, WB8PC_A (PC01).

Below Sec 5, 72 cm, the dark-light alternation sequence of this core is frequently interrupted by cm to m scale olive black (10Y 3/2) very homogeneous layers associated with thin lighter color clay layer on its top (Fig. 5.17). These homogenous layers show characteristic sharp bottom contacts or thin, sometimes laminated, foraminifer sand layer at their bottom (Fig. 5.17). In Secs 6, 8 to 9 and 10, such homogenous facies are dominant (Fig. 5.16). Coarse silt size ash layers of several mm to cm were rarely intercalated in the sequence (Figs. 5.15 and 5.16).

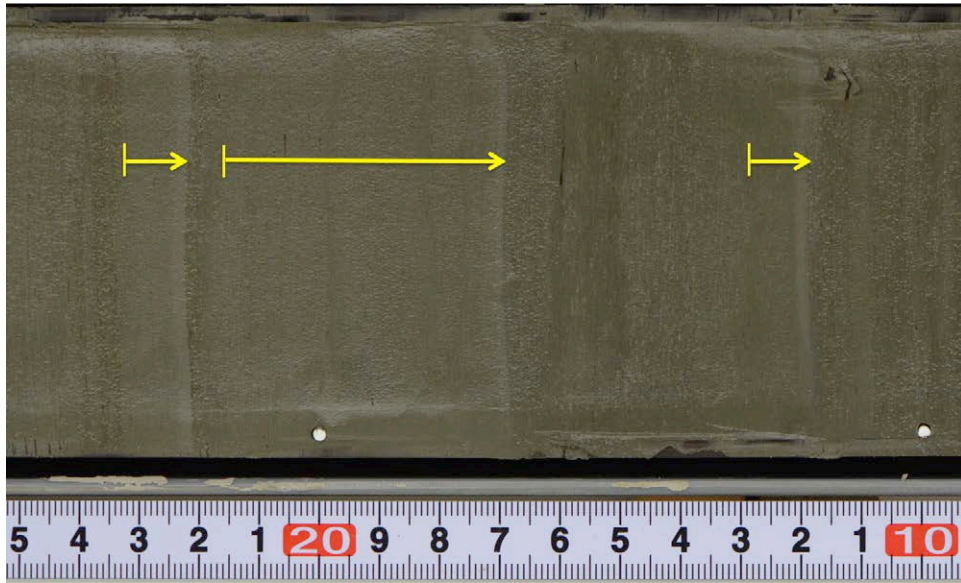


Figure 5.17 Homogenous event layers observed in WB8PC_A (PC01) Sec 7, 10-25 cm. There are 3 sets of event layers, where each yellow arrow indicates a single set of homogenous event layer beginning with sharp bottom contact and ending with thin light color clay layer.

WB8PL_B (PL02) covers 99.2 cm thick which shows olive black (7.5Y 3/1) to gray (7.5Y 4/1) bioturbated silty clay (Fig. 5.18). Burrows with black infillings are very frequent. Top 2 cm is brownish black (2.5Y 3/1) oxidized layer.

WB8PC_B (PC02) covers from Sec 3 to Sec 20, and is 1800.9 cm in total length including the core catcher. At the top of Sec 3, dark brown oxidized layer sediment was observed which suggests this piston core recovered the surface sediment although it was fluidized and slightly disturbed. Inner barrel crash during the coring process destroyed sediment structures from Sec 7, 46 cm to the bottom of Sec 9. Sec 10 was separated into 3 subsections A, B, and C to avoid difficulty in core handling due to the inner barrel crash. This barrel crash affected the intervals from Sec 4, 80 cm to Sec 7, 46 cm, and from Sec 10, 10 cm to 33 cm, where center of sediments were distorted. Secs 11, 12, 13, 14,

15, and 18 are separated into the subsections A and B due to significant core expansion during onboard treatment. In spite of the disturbance in Secs 7 to 9, light color clay overlain by burrow-rich mud at WB8PC_A (PC01), Sec 5, 72 cm can be correlated to the same feature at WB8PC_B (PC02), Sec 6, 45 cm (Figs. 5.15 and 5.18). Below the disturbed interval, foraminifer sand layer at WB8PC_A (PC01), Sec 7, 55 cm can be correlated to that at WB8PC_B (PC02), Sec 10A, 24 cm (Figs. 5.15 and 5.18). Therefore, the 185.3 cm thick interval from Sec 5, 72 cm to Sec 7, 55 cm in WB8PC_A (PC01) corresponds to the 359.4 cm thick interval from Sec 6, 45 cm to Sec 10A, 24 cm in WB8PC_B (PC02). Judging from these correlations between two piston cores, the disturbed interval was expanded by 1.9 times due to inner barrel crash.

WB8PC_B (PC02) shows gray (7.5Y 4/1-3/1) mottled silty clay in Secs 3 and 4, and mainly consists of alternation of lighter gray (7.5Y 5-4/1) bioturbated silty clay and darker olive black (3-10Y 4/1 to 3/2) bioturbated or laminated silty clay from Secs 5 to 20 (Figs. 5.15 and 5.16). In Secs 16 through 18, relatively thick lighter color mottled silty clay interval continues for ~150 cm (Figs. 5.18 and 5.19). Dark laminated silty clay tends to show sharp contact with the underlain lighter color layer, yielding foraminifer tests in most cases. Light color layers show mottled appearance, and get darker upward just below the overlain dark layers. Below Sec 4, 80 cm, the dark-light alternation sequence of this core is frequently interrupted by cm to m scale olive black (10Y 3/2) very homogeneous layers associated with thin lighter color clay layer on its top. These homogenous layers show characteristic sharp bottom contacts or thin, sometimes laminated, foraminifer sand layer at their bottom. In Secs 11A to 11B and 14A, such homogenous facies are dominant (Fig. 5.19). Coarse silt size ash layers of several mm to cm were rarely intercalated in the sequence (Figs. 5.18 and 5.19).

Fig. 5.20 show the depth profiles of L*, a*, and b* color indices for cores collected at WB8. The top ~100 cm represented by WB8PL_A (PL01) and WB8PL_B (PL02) is characterized by lower L* and b*, and higher a* that is generally invariable. The topmost oxidized layer observed in WB8MC (MC01) as well as other pilot and piston cores shows lower L* and higher a* and b*. WB8PC_A (PC01) and WB8PC_B (PC02) characteristically show a decimeter-scale alternation of color between brighter (higher L*) and more greenish (lower a* and b*), and darker (lower L*) and more yellowish (larger a* and b*) throughout the column. Homogenous event layers dominantly found in Secs 6, 8-9, and 10 of WB8PC_A (PC01) and Secs 11 and 14 of WB8PC_B (PC02) exhibit characteristically lower L*, neutral a*, and higher b* (Figs. 5.16, 5.19, and 5.20).

WB8_B (PC02 & PL02)



Figure 5.18 Photograph of piston core KR15-10, WB8PC_B (PC02) with WB8PL_B (PL02).

KR15-10 WB8_PCB (PC02)

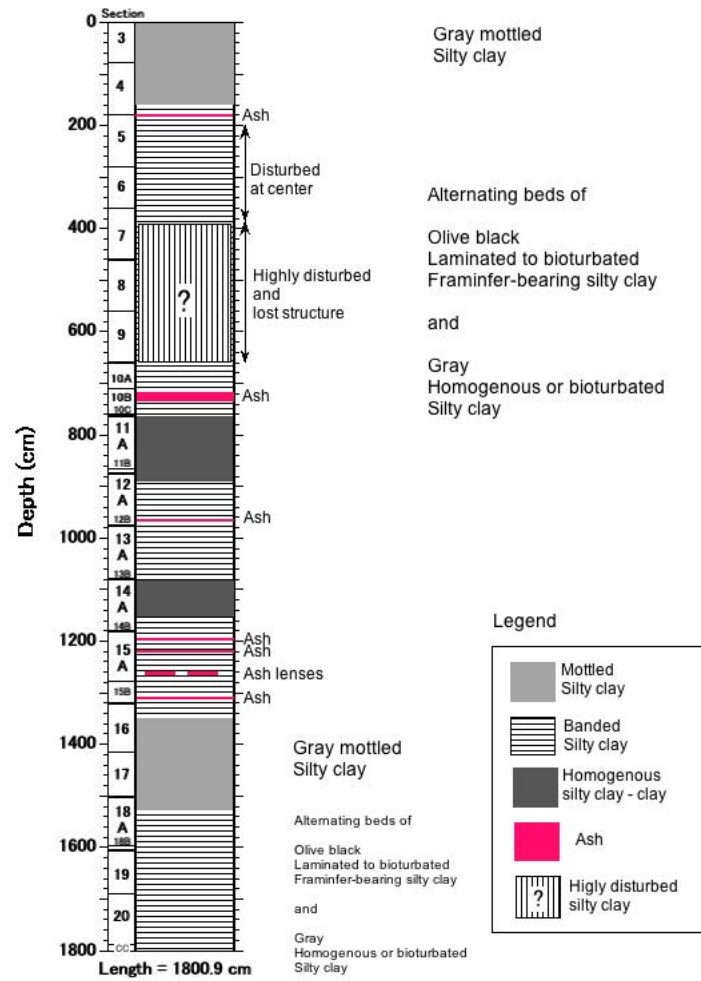
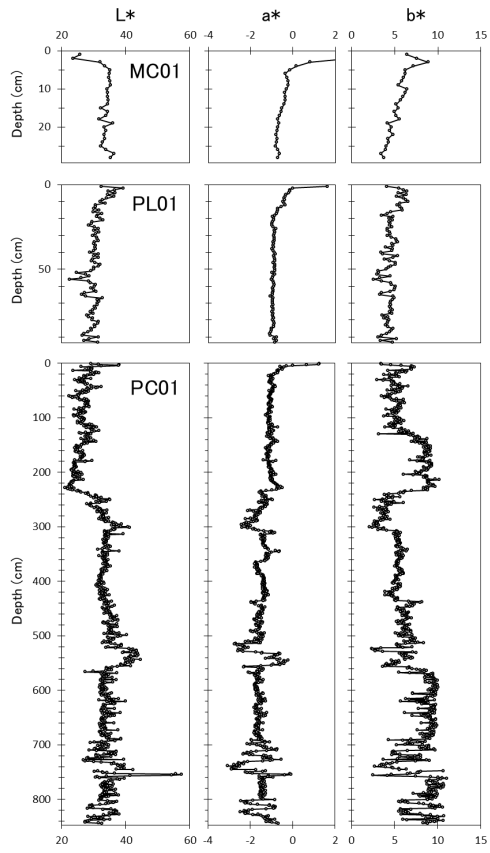


Figure 5.19 Generic column of KR15-10, WB8PC_B (PC02).

WB8_A



WB8_B

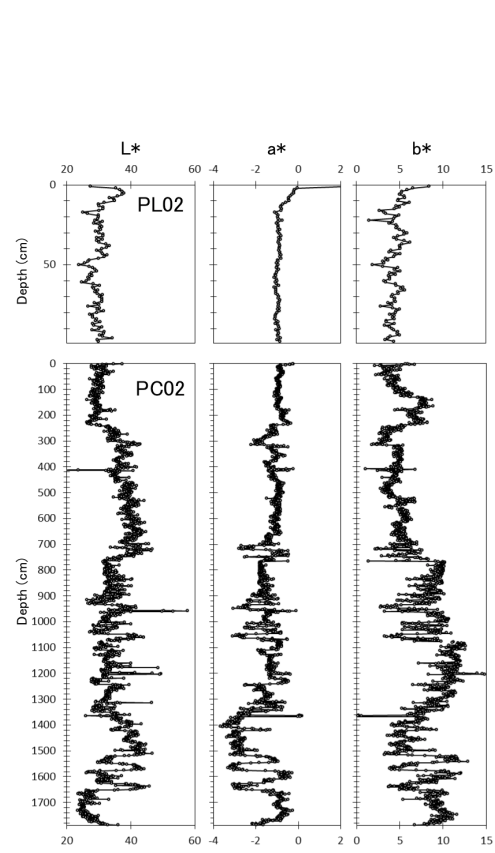


Figure 5.20 Depth variations of L*, a* and b* color indices for (A; left) KR15-10, WB8MC (MC01), WB8PL_A (PL01), and WB8PC_A (PC05), and (B; right) KR15-10, WB8PL_B (PL02) and WB8PC_B (PC02).

5.2.5 Site WB10

WB10MC (MC03) was recovered using multiple corer. The collected thickness of sediment was 29.3 cm (Fig. 5.5). The sediment consists of olive black (5Y 3/2-3/1) bioturbated clayey silt. A 7 cm long worm tube was yielded from 9.5 to 16.5 cm.

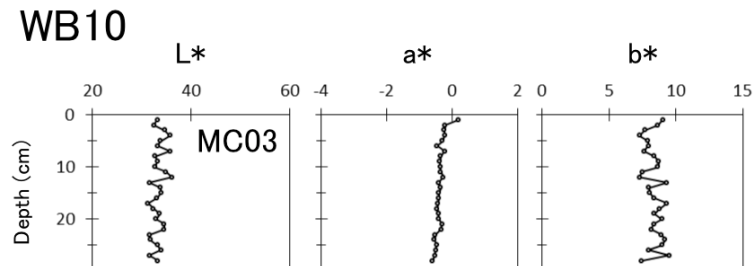


Figure 5.21 Depth variations of L*, a* and b* color indices for KR15-10, WB10MC (MC03).

Fig. 5.21 shows the depth profiles of L*, a*, and b* color indices for WB10MC (MC03). The color is generally monotonous. Although oxidized layer was not clearly recognized, the topmost sediment shows slightly higher a* and b*.

5.2.6 Site WB11

WB11MC (MC04) was recovered using multiple corer. The collected thickness of sediment was 32.8 cm. The sediment consists of grayish olive black (7.5Y 4/2) bioturbated silt (Fig. 5.5). Coarse silt patch as burrow fill is observed at 30 cm.

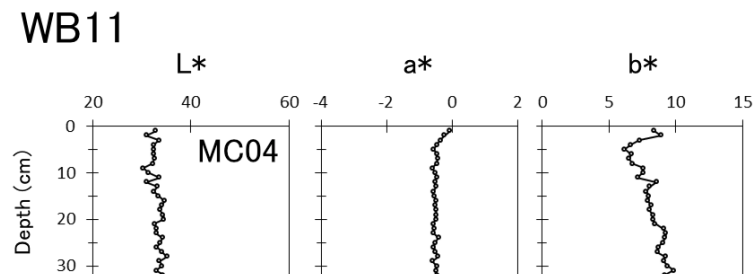


Figure 5.22 Depth variations of L*, a* and b* color indices for KR15-10, WB11MC (MC04).

Fig. 5.22 shows the depth profiles of L^* , a^* , and b^* color indices for WB11MC (MC04). The L^* and a^* are generally monotonous throughout the column whereas b^* shows decreasing trend upward. Although oxidized layer was not clearly recognized, the topmost sediment shows slightly higher a^* and b^* .

5.2.7 Site WB12

WB12MC (MC07) was recovered using multiple corer. The collected thickness of sediment was 30.5 cm. The sediment consists of grayish olive black (7.5Y 4/1) bioturbated coarse silt to muddy very fine sand (Fig. 5.5).

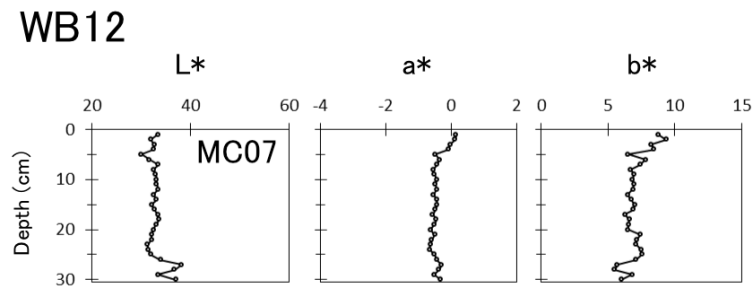


Figure 5.23 Depth variations of L^* , a^* and b^* color indices for KR15-10, WB12MC (MC07).

Fig. 5.23 shows the depth profiles of L^* , a^* , and b^* color indices for WB12MC (MC07). The color is generally monotonous except for the bottom 5 cm interval with higher L^* and lower b^* . Although oxidized layer was not clearly recognized, the topmost sediment shows slightly higher a^* and b^* .

5.2.8 Site WB13

WB13MC (MC08) was recovered using multiple corer. The collected thickness of sediment was 33.6 cm. The sediment consists of grayish olive black (7.5Y 4/2) bioturbated silt (Fig. 5.5). Echinoid spines were observed at 12 to 13 cm, 22 cm, and 33 cm.

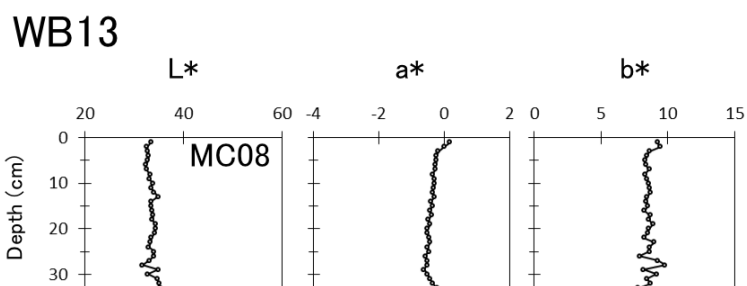


Figure 5.24 Depth variations of L*, a* and b* color indices for KR15-10, WB13MC (MC08).

Fig.5.24 shows the depth profiles of L*, a*, and b* color indices for WB13MC (MC08). The L* and b* are generally monotonous throughout the column whereas a* shows increasing trend upward. Although oxidized layer was not clearly recognized, the topmost sediment shows slightly higher a* and b*.

5.3 Plankton tow experiment

Two casts using NORPAC plankton net at WB8 site and 13 samples from pumped seawater in the wet lab were obtained (Table 5.3). The samples will be used for planktic foraminiferal assemblage and geochemical analyses.

5.4 Water sampling

All samples were numbered serially. List of the samples is shown in Table 5.4. We collected 15 samples for TA, DIC, salinity and oxygen isotope analyses, 8 samples for Nd isotope ratios and REE analyses, 3 samples for Si isotope ratios analysis and 9 samples for suspended materials analysis.

Table 5.3 List of plankton net samples.

No.	On board ID	Station No.	Sampling Method		Latitude			Longitude			Depth [m]	Date Collected				
					Deg.	Min.	N/S	Deg.	Min.	E/W		YYYY	MM	DD	hh:mm	UTC/JST
1	KR15-10 #2	-	Pumped seawater	Start	37	39.1473	N	136	45.9030	E	5	2015	7	2	16:36	JST
				End	37	33.3735	N	136	14.4692	E	5	2015	7	2	22:28	JST
2	KR15-10 #3	WB8	Pumped seawater	Start	36	54.4188	N	135	09.0458	E	5	2015	7	3	9:10	JST
				End	36	54.3733	N	135	09.0623	E	5	2015	7	3	15:34	JST
3	KR15-10 #4	WB8	Plankton net		36	53.6181	N	135	08.8010	E	200-0	2015	7	3	18:27	JST
4	KR15-10 #5	WB8	Plankton net		36	53.9579	N	135	08.4470	E	400-0	2015	7	3	19:05	JST
5	KR15-10 #6	WB4	Pumped seawater	Start	36	14.8840	N	135	28.9979	E	5	2015	7	4	8:46	JST
				End	36	12.6053	N	135	28.9518	E	5	2015	7	4	11:03	JST
6	KR15-10 #7	WB10	Pumped seawater	Start	36	9.9678	N	135	23.2971	E	5	2015	7	4	12:05	JST
				End	35	57.3230	N	134	58.3818	E	5	2015	7	4	14:38	JST
7	KR15-10 #8	WB11	Pumped seawater	Start	35	54.7815	N	135	55.7564	E	5	2015	7	4	15:18	JST
				End	35	51.9065	N	135	4.2637	E	5	2015	7	4	17:00	JST
8	KR15-10 #9	-	Pumped seawater	Start	36	3.4510	N	135	37.1864	E	5	2015	7	4	20:04	JST
				End	36	1.5354	N	135	34.3414	E	5	2015	7	4	21:48	JST

Table 5.3 *Continued*

No.	On board ID	Station No.	Sampling Method		Latitude			Longitude			Depth [m]	Date Collected				
					Deg.	Min.	N/S	Deg.	Min.	E/W		YYYY	MM	DD	hh:mm	UTC/JST
9	KR15-10 #10	WB1	Pumped seawater	Start	36	3.2433	N	135	40.3324	E	5	2015	7	5	6:25	JST
				End	36	11.0057	N	135	36.0340	E	5	2015	7	5	10:25	JST
10	KR15-10 #11	WB6	Pumped seawater	Start	36	29.3151	N	135	25.5365	E	5	2015	7	5	12:51	JST
				End	36	29.1980	N	135	26.0641	E	5	2015	7	5	20:18	JST
11	KR15-10 #12	WB12 & WB13	Pumped seawater	Start	35	46.0046	N	135	24.5062	E	5	2015	7	6	7:27	JST
				End	35	52.7327	N	135	28.1832	E	5	2015	7	6	9:00	JST
12	KR15-10 #13	WB3	Pumped seawater	Start	36	05.7498	N	135	28.9328	E	5	2015	7	6	10:00	JST
				End	36	07.0623	N	135	28.8994	E	5	2015	7	6	11:53	JST
13	KR15-10 #14	-	Pumped seawater	Start	36	11.1216	N	135	31.0898	E	5	2015	7	6	12:40	JST
				End	37	12.1410	N	136	17.8823	E	5	2015	7	6	17:02	JST

Table 5.4 List of Seawater sample

Sample No.	Date	Time (JST)	Site	Longitude	Latitude	Water depth (m)	Temperature (°C)		Sampling method			Sub sampling method									
							Ship info. (5m)	Temp. logger (bottom)	Surface		Btm	NMNS		Hokkaido Univ.		University of Toyama			Newcastle Univ.	Univ. of Bremen	
									Bucket (0m)	Pumped (5m)		TA (100ml)	DIC (125ml)	Sal. (100ml)	δ18O (10ml)	Ba (20ml)	Nd (10-20L)	REE (500ml)	Si (300ml)	Suspended material (2L)	
02	2015/7/2	19:46	-	136-16.3798	37-35.4884	5	19.9			✓		✓	✓	✓	✓	✓				✓	
03	2015/7/3	9:20	WB8	135-09.0515	36-54.4182	0	21.3		✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	
04	2015/7/3	9:17	WB8	135-09.0001	36-54.4050	1744		0.2280			✓	✓	✓	✓	✓	✓	✓	✓	✓		
05	2015/7/4	9:12	WB4	135-28.9617	36-12.5696	381		0.7415			✓	✓	✓	✓	✓	✓	✓	✓			
06	2015/7/4	10:37	WB4	135-28.9601	36-12.6043	0	21.6		✓			✓	✓	✓	✓	✓	✓	✓		✓	
07	2015/7/4	14:34	WB10	134-59.9396	36-00.0213	0	21.8		✓			✓	✓	✓	✓	✓				✓	
08	2015/7/4	16:13	WB11	135-00.0563	35-49.9988	0	22.7		✓			✓	✓	✓	✓	✓				✓	
09	2015/7/4	16:15	WB11	135-00.0533	35-49.9961	202		2.3430			✓	✓	✓	✓	✓	✓	✓	✓			
10	2015/7/5	6:54	WB1	135-40.3040	36-03.2517	283		0.8986			✓	✓	✓	✓	✓	✓	✓	✓			
11	2015/7/5	8:41	WB1	135-40.2894	36-03.2653	0	21.6		✓			✓	✓	✓	✓	✓			✓	✓	
12	2015/7/5	16:38	WB6	135-25.6374	36-29.2786	846		0.3036			✓	✓	✓	✓	✓	✓	✓	✓			
13	2015/7/5	18:33	WB6	135-25.5791	36-29.3202	0	22.3		✓			✓	✓	✓	✓	✓				✓	
14	2015/7/6	7:05	WB12	135-24.5072	35-45.9920	0	22.2		✓			✓	✓	✓	✓	✓				✓	
15	2015/7/6	7:22	WB12	135-24.5050	35-46.0022	117		12.4236			✓	✓	✓	✓	✓	✓	✓	✓			
16	2015/7/6	10:57	WB13	135-28.9337	36-07.0043		22.1		✓			✓	✓	✓	✓	✓				✓	

6. Future Plan

6.1 Temperature variability in the southern Japan Sea (Takuya Sagawa)

Paleotemperature reconstruction using Mg/Ca-thermometry will be conducted for several piston cores. Mg/Ca ratios of planktonic and benthic foraminifer are supposed to record surface and bottom temperatures, respectively. The vertical structure of temperature will be reconstructed by using planktonic and benthic foraminiferal Mg/Ca from different water depth sediments. Carbonate preservation/dissolution and elemental composition of sediments will be also investigated.

6.2 Tephrostratigraphy (K. Ikehara and Y. Nagahashi)

To establish the late Quaternary tephrostratigraphy of this area, we, Prof. Nagahashi of Fukushima Univ. and myself, will conduct the geochemical analysis of volcanic glass shards and petrographic analysis of the visible tephra beds found in the obtained cores during this cruise. Correlation of the results to the tephrostratigraphy and tephrochronology of Lake Suigetsu will be useful to polish up the lithostratigraphy of the Japan Sea sediments.

6.3 Depositional processes of the Oki Trough (K. Ikehara)

There are many fine-grained event deposits in core WB8 PC_A and _B. To determine the event deposits and to understand the depositional processes of the Oki Trough, we will conduct the detailed analysis of sedimentary structures of two cores. Furthermore, sediment grain size and mineral composition of the event beds and nearby normal beds will be analyzed to characterize the event deposits.

6.4 Distribution of elemental carbon in surface sediments (Song Lu and Tomohisa Irino)

Reconstruction of biomass burning history deduced from elemental carbon (EC) content in the Japan Sea sediments could potentially give us insights about the relative impacts from human activity and climate change on the fire history of the northeastern Eurasia. In order to establish a better interpretation scheme of EC variability in the marine sediments, we need to collect a systematic data for its distribution in the surface sediments in the Japan Sea. For this purpose, we will use all the multiple core samples collected during KR15-10 cruise. Measurement will be conducted using thermal optical transmission (TOT) method because this method has good sensitivity for quantification of EC.

6.5 Radiolarian assemblages (Kenji Matsuzaki)

I am planning to analyze the radiolarian assemblages of the shallow water depth using multi core collected at WB6-MC06, WB12-MC07 and WB13-MC08. The objective is to determine the expansion of the coastal water and to monitor the possible influences of water masses related to the

Tsushima Current through time in the Wakasa Bay.

6.6 Benthic foraminiferal geochemistry and planktic assemblage (Yoshimi Kubota)

1. to establish Mg/Ca-temperature calibration and (oxygen isotope analyses) using *Uvigerina* spp.
2. assemblage analyses of planktic foraminifers using plankton net samples
3. trace element analyses (Ba/Ca, B/Ca, etc.) for benthic foraminifers
4. analyses of total alkalinity and dissolved inorganic carbon content in the water samples

6.7 Core-top calibration of Mg/Ca thermometry and Nd isotope (Keiji Horikawa, Yukiko Kozaka)

K. Horikawa will analyze Mg/Ca for paleothermometry of planktonic foraminifera (*Neogloboquadrina incompta*) in surface sediments.

Y. Kozaka will analyze Nd isotopes of fossil fish teeth and seawater in order to clarify the relationship between them. Water mass structure will be clarified through the analysis of Nd isotope ratios of seawater samples collected various depths.

6.8 Investigating interspecies correction factors and extending the applicability of benthic foraminiferal oxygen isotopes studies (Ann Holbourn)

The main objectives of this project are: (1) to evaluate interspecies oxygen isotopic offsets in ten benthic foraminifers that commonly occur in intermediate- to deep-water masses, (2) to test the hypothesis of a significant influence of pH/carbonate ion concentration on the isotopic composition of infaunal foraminiferal tests and (3) to provide constraints for interspecific oxygen isotope calibrations in order to extend the applicability of composite benthic records over the Holocene to Neogene periods.

6.9 Sea surface temperature variability over the last 100 ka (Andrew Henderson)

The aim of my research is to reconstruct sea surface temperature (SST) variations over the last 100 ka using the organic geochemical proxies Uk37' and TEX86. Surface sediment samples collected using the multi-core will be used to calibrate the Uk37' and TEX86 SST proxies, as well as using global and regional calibration data sets.

6.10 Evolution of the Asian monsoon over the last 100 ka (Andrew Henderson)

Using the precise chronology developed for WB4 and WB8 I plan to couple SST records with leaf wax (δD , $\delta^{13}C$) records of monsoonal and vegetation change. In addition, I will investigate the oxygen and silicon isotope composition ($\delta^{18}O$, $\delta^{30}Si$) of diatoms at WB8 to track changes in the Tsushima Warm Current and nutrient availability over 100 ka.

6.11 Ostracoda assemblage in southern part of Japan Sea (Huai-Hsuan Huang)

A part of the 8 multiple cores from 8 different depths and locations will be used for ostracoda assemblage investigation. These are supplementary to my current research on the influence of Tsushima Warm Current on ostracoda assemblage. In addition, comparison between these 8 locations may reveal recent distribution patterns of ostracoda and their relationship to oceanographic conditions. Depends on the ostracoda abundance in these samples, I may need more surface samples, especially deep-sea samples, from this region or its adjacent waters in the future. I plan to do statistical analyses, such as biodiversity and geographical distribution, and possibly geochemical analyses, such as stable isotope and Mg/Ca ratios, to achieve the above objectives.

6.12 Optically Stimulated Luminescence dating (Saiko Sugisaki)

PC06 and 4 multiple cores were taken with opaque tube for OSL dating, which determine the burial age of quartz and feldspar grains since its last exposure to the sunlight.

Our attempts are 1) test quartz and feldspar OSL dating for surface sediments of PC06 and other multiple cores whether those grains were well bleached before its deposition; thus suitable for OSL dating, 2) test fine-grained quartz/feldspar of the PC06 for OSL dating and, where possible, test its reliability against radiocarbon ages and tephrochronology, 3) for further possibility of OSL dating, test dating for non-aeolian dust origin quartz/feldspar using luminescence signals as a provenance proxy.

6.13 J-DESC core school

Sediment core samples, WB8PL_B and some sections of WB8PC_B (from Sec 2 to 12B), will be used for outreach activities such as J-DESC core school held at Kochi University.

7. Notice on Using

This cruise report is a preliminary documentation as of the end of the cruise.

This report may not be corrected even if changes on contents (i.e. taxonomic classifications) may be found after its publication. This report may also be changed without notice. Data on this cruise report may be raw or unprocessed. If you are going to use or refer to the data written on this report, please ask the Chief Scientist for latest information.

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