CRUISE REPORT SONNE 217

MAJA

VARIABILITY OF THE INDONESIAN THROUGHFLOW WITHIN THE MAKASSAR-JAVA PASSAGE

Makassar-Singapore
July 25 2011 - August 16 2011

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CONTENTS

Abstract

During RV Sonne-217 “MAJA” Cruise from Makassar (Indonesia) to Singapore from 25th July to 16th August 2011, we acquired Multibeam/Parasound-transects and deployed the shipboard CTD (with water sampler) as well as a multicorer and piston corer in three main working areas: 1) northern part of Makassar Strait, north of the Labani Channel including the Mahakam Delta and southernmost Celebes Sea; 2) central part of the Makassar Strait, south of the Labani Channel; and 3) southernmost part of the Makassar Strait including the Flores Sea and eastern Java Sea. The prime objective of the SO-217 MAJA cruise was to recover high resolution sediment archives to decipher the variability of the Indonesian Throughflow and to reconstruct regional climate history on decadal to millennial timescales over the past 150 000 years. To achieve this primary objective, 32 sediment and water stations were sampled along the Makassar Strait between the southern Celebes Sea, eastern Java Sea and eastern Flores Sea. The shipboard CTD including water sampler was deployed at 17 stations to obtain hydrographic profiles and sample the water column. The multicorer was deployed at 29 stations to obtain high quality sediment surface samples for core top calibrations. A total of 23 long piston cores with overall recovery of more than 350 m core length (26 m maximum core length, average core length over 15 m) provided high resolution sediment archives over the Holocene and the last two glacial cycles. All piston cores were measured for magnetic susceptibility in 2 cm intervals before being split into working and archive halves, the latter of which were described and measured for color reflectance in 1 cm – intervals. An initial shipboard stratigraphy was obtained by matching the magnetic susceptibility and lightness (L*) records with the stacked isotope record of Lisiecki and Raymo (2005). Prominent ash layers corresponding to the Tambora 1815 eruption and to earlier eruptions additionally provided invaluable stratigraphic marker beds for cross-correlation of piston cores recovered south of 5°S.

	Date	Start (UTC)	Latitude	Longitude	Waterdepth (m)	Penetration (cm)	Recovery
SO217-1 (18514)	28.07.2011	7:48	4°31.494'S	118°56.518'E	652	*	*
CTD	*	7:53	4°31.490'S	118°56.510'E	652	*	11
MUC	*	9:10	4°31.498'S	118°56.525'E	652	19-22	12 of 12
PC (KL)	*	10:19	4°31.500'S	118°56.520'E	652	1500	1132.5 cm
SO217-2 (18515)	28.07.2011	21:06	3°37.395' S	119°21.60' E	678	*	*
CTD	*	21:08	3°37.380' S	119°21.639' E	678	*	11
MUC	*	22:18	3°37.784' S	119°32.601' E	688	35-43	12 of 12
PC (KL)	*	23:43	3°37.791' S	119°21.601' E	688	1500	1217.5 cm
PC (KL)	*	3:10	3°37.802' S	119°21.603' E	687	2500	1530 cm
SO217-3 (18516)	29.07.2011	21:44	1°37.910' S	117°31.768' E	930	*	*
CTD	*	21:49	1°37.910' S	117°31.768' E	930	*	12
MUC	*	23:22	1°37.920' S	117°31.800' E	928	57-61	12 of 12
PC (KL)	*	0:41	1°37.916' S	117°31.809' E	917	1500	1266 cm
SO217-4 (18517)	30.07.2011	2:45	1°32.201' S	117°33.758' E	699	*	*
MUC	*	3:03	1°32.210' S	117°33.792' E	700	57-61	12 of 12
PC (KL)	*	4:27	1°32.198' S	117°33.756' E	698	1500	1427 cm
SO217-5 (18518)	30.07.2011	8:48	1°08.250' S	117°50.348' E	620	*	*
MUC	*	9:06	1°32.210' S	117°33.792' E	620	23-32	12 of 12
SO217-6 (18519)	31.07.2011	9:50	0°34.294'S	118°6.865'E	1657	*	*
MUC	*	10:24	0°34.318'S	118°6.564'E	1656	33-41	12 of 12
PC (KL)	*	12:09	0°34.329'S	118°6.859'E	1658	1500	1267 cm
SO217-7 (18520)	31.07.2011	14:22	0°30.269'S	118°10.014'E	1777	*	*
CTD	*	14:22	0°30.269'S	118°10.014'E	1777	*	13
SO217-8 (18521)	31.07.2011	22:57	0°30.194'N	118°55.643'E	991	*	*
CTD	*	22:58	0°30.194'N	118°55.642'E	991	*	12
MUC	*	0:38	0°30.200'N	118°55.530'E	1003	6-11	6 of 12
SO217-9 (18522)	01.08.2011	7:15	1°24.126'N	119°4.787'E	986	*	*
CTD	*	7:16	1°24.125'N	119°4.784'E	986	*	12
MUC	*	8:45	1°24.120'N	119°4.758'E	974	33-42	12 of 12
PC (KL)	*	10:03	1°24.106'N	119°4.781'E	975	2000	1233.5 cm
SO217-10 (18523)	01.08.2011	20:11	0°10.376'N	119°25.780'E	2175	*	*
CTD	*	20:13	0°10.361'N	119°25.812'E	2176	*	13
MUC	*	22:24	0°10.283'N	119°25.823'E	2175	32-36	12 of 12
PC (KL)	*	0:22	0°10.298'N	119°25.856'E	2176	1500	1152 cm
SO217-11 (18524)	02.08.2011	11:15	1°38.899'S	118°54.194'E	1561	*	*
MUC	*	12:10	1°38.900'S	118°54.179'E	1584	35-40	12 of 12
SO217-12 (18525)	02.08.2011	17:11	2°32.781'S	118°38.122'E	1822	*	*
CTD	*	17:12	2°32.750'S	118°38.122'E	1822	*	12
MUC	*	19:29	2°32.754'S	118°38.128'E	1822	31-37	12 of 12
SO217-13 (18526)	03.08.2011	3:20	3°36.857'S	118°10.030'E	1523	*	*
CTD	*	3:25	3°36.841'S	118°10.053'E	1538	*	13
MUC	*	5:27	3°36.860'S	118°10.058'E	1538	46.5-51.5	12 of 12
PC (KL)	*	7:11	3°36.875'S	118°10.013'E	1524	1500	1300 cm
SO217-14 (18527)	03.08.2011	14:00	3°57.841'S	117°49.161'E	1617	*	*
MUC	*	14:17	3°57.844'S	117°49.161'E	1615	34-42	12 of 12
PC (KL)	*	15:58	3°57.841'S	117°49.160'E	1614	1500	1228.5 cm
SO217-15 (18528)	04.08.2011	1:39	4°45.307'S	117°53.366'E	1785	*	*
CTD	*	1:41	4°45.314'S	117°53.365'E	1785	*	13
MUC	*	3:41	4°45.331'S	117°53.369'E	1785	38-42.5	12 of 12
PC (KL)	*	5:32	4°45.331'S	117°53.368'E	1784	2000	1746 cm
SO217-16 (18529)	04.08.2011	8:22	4°39.231'S	118°1.340'E	1915	*	*
MUC	*	9:00	4°39.226'S	118°1.434'E	1918	42.5-47	12 of 12
KL	*	11:02	4°39.250'S	118°1.433'E	1902	3000	2579 cm
SO217-17 (18530)	04.08.2011	21:17	5°14.388'S	117°20.267'E	872	*	*
MUC	*	21:39	5°14.459'S	117°20.348'E	876	27-31.5	12 of 12
SO217-18 (18531)	04.08.2011	23:04	5°10.135'S	117°27.851'E	1085	*	*
CTD	*	23:06	5°10.131'S	117°27.846'E	1084	*	12
MUC	*	0:08	5°10.129'S	117°27.918'E	1086	41-51	12 of 12
KL	*	2:03	5°10.127'S	117°27.917'E	1075	2000	1798 cm
SO217-19 (18532)	05.08.2011	8:23	5°55.620'S	116°49.315'E	628	*	*

MUC	*	8:59	5°55.849'S	116°49.300'E	629	29-40.5	12 of 12
SO217-19 (18533)	05.08.2011	9:59	5°59.929'S	116°47.761'E	636	*	*
CTD	*	9:59	5°59.929'S	116°47.761'E	636	*	11
SO217-20 (18534)	05.08.2011	20:14	7°30.618'S	116°15.804'E	563	*	*
CTD	*	20:17	7°30.602'S	116°15.798'E	563	*	11
MUC	*	21:19	7°30.679'S	116°15.789'E	565	26-36	12 of 12
PC (KL)	*	22:52	7°30.639'S	116°15.764'E	564	2000	1758 cm
SO217-21 (18535)	06.08.2011	6:00	7°7.584'S	117°13.277'E	506	*	*
CTD	*	6:00	7°7.584'S	117°13.277'E	506	*	11
MUC	*	8:58	7°7.585'S	117°13.323'E	502	29-32	12 of 12
PC (KL)	*	7:57	7°7.591'S	117°13.328'E	502	2000	1719 cm
SO217-22 (18536)	06.08.2011	19:50	7°28.131'S	118°13.935'E	835	*	*
CTD	*	19:50	7°28.131'S	118°19.935'E	835	*	11
MUC	*	21:08	7°28.130'S	118°13.948'E	836	12.5-18	12 of 12
SO217-23 (18537)	06.08.2011	22:27	7°35.581'S	118°14.534'E	930	*	*
MUC	*	22:49	7°35.595'S	118°14.644'E	929	10-15	11 of 12
SO217-24 (18538)	07.08.2011	2:11	7°35.920'S	118°16.171'E	908	*	*
PC (KL)	*	2:51	7°35.920'S	118°16.171'E	908	1000	851
PC (KL)	*	6:17	7°35.920'S	118°16.170'E	908	2000	1810 cm
SO217-25 (18539)	07.08.2011	22:14	6°56.657'S	119°22.073'E	853	*	*
MUC	*	23:18	6°56.652'S	119°22.266'E	862	25-28	12 of 12
KL	*	0:43	6°56.641'S	119°22.267'E	861	2000	1827 cm
SO217-26 (18540)	08.08.2011	4:11	6°52.399'S	119°34.977'E	1201	*	*
CTD	*	4:13	6°52.400'S	119°34.976'E	1200	*	12
MUC	*	5:52	6°52.405'S	119°34.997'E	1201	34.5-43	12 of 12
PC (KL)	*	7:22	6°52.404'S	119°34.998'E	1189	3000	2599 cm
SO217-27 (18541)	08.08.2011	11:02	6°46.302'S	119°23.929'E	739	*	*
MUC	*	11:03	6°46.302'S	119°23.928'E	739	16-34.5	12 of 12
PC (KL)	*	12:13	6°46.305'S	119°23.927'E	739	3000	2075 cm
SO217-28 (18542)	09.08.2011	1:41	5°52.046'S	119°4.719'E	925	*	*
CTD	*	1:41	5°52.046'S	119°4.719'E	925	*	9
MUC	*	3:05	5°52.060'S	119°4.728'E	924	30-34	12 of 12
PC (KL)	*	4:53	5°52.059'S	119°4.730'E	924	3000	2001 cm
SO217-29 (18543)	09.08.2011	14:38	5°19.990'S	118°45.865'E	636	*	*
MUC	*	14:56	5°19.994'S	118°45.895'E	636	19.5-23.5	4 of 12
SO217-30 (18544)	09.08.2011	22:45	4°32.075'S	118°35.418'E	2010	*	*
MUC	*	23:25	4°32.148'S	118°35.416'E	2010	49-51	8 of 12
PC (KL)	*	1:49	4°32.059'S	118°35.421'E	2010	3000	57 cm
PC (KL)	*	8:28	4°32.059'S	118°35.232'E	2009	2500	2235 cm
SO217-31 (18545)	10.08.2011	12:49	5°5.267'S	118°43.333'E	714	*	*
MUC	*	13:06	5°5.315'S	118°43.333'E	707	5-36	11 of 12

1. Cruise participation and acknowledgements

Cruise Sonne-217 (MAJA) - Participating Institutions and Scientists

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Participants of Cruise Sonne 217 (MAJA)

R/V Sonne Cruise 217 CREW list

No.	Name	Given Name	Rank
1	MALLON	Lutz	Master
2	ADEN	Nils-Arne	Chief Mate / 1. Officer
3	GÖBEL	Jens	2. Officer
4	HOFFSOMMER	Lars	2. Officer
5	WALTHER	Anke	Surgeon
6	LEPPIN	Jörg	Electronic Engineer
7	BORCHERT	Wolfgang	Sysman
8	EHMER	Andreas	Sysman
9	GUZMAN NAVARRETE	Werner	Chief Engineer
10	THOMSEN	Sascha	2. Engineer
11	GENSCHOW	Steffen	2. Engineer
12	ROSEMEYER	Rainer	Fitter
13	BOLIK	Torsten	Motorman
14	DEHNE	Dirk	Motorman
15	RIEPER	Uwe	Electrician
16	TIEMANN	Frank	Chief Cook
17	GANAGARAJ	Antony	2. Cook
18	POHL	Andreas	Chief Steward
19	KOSANKE	Patrick	2. Steward
20	MUCKE	Peter	Boatswain
21	STÄNGL	Günther	A.B.
22	MOHRDIEK	Finn	A.B.
23	FRICKE	Ingo	A.B.
24	KOHNKE	Frank	A.B.
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27	ALTENDORF	Denis	S.M. / Apprentice
28	GRAWE	Manuel	S.M. / Apprentice
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30	IDE	Steven	S.M. / Apprentice

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2. Cruise Objectives

Investigating Indonesian Throughflow variability and retracing regional climate history

Today, the Indonesian Throughflow (ITF) transports on yearly average ~16 Sv (1 Sv=10^6 m^3 s^{-1}) of low-salinity water from the West Pacific into the eastern Indian Ocean (You and Tomczak, 1993; Gordon and Fine, 1996; Ganachaud and Wunsch, 2000; Gordon et al., 2003). The transport and thermohaline stratification of the ITF influences the heat and freshwater budgets of both the tropical western Pacific and eastern Indian Oceans and alters patterns of heat and water vapor exchange with the atmosphere. The ITF forms a critical part of the global chain of interocean thermohaline links, and any major changes in ITF volume and physical properties would have dramatic repercussions for the tropical ocean-climate system and strongly affect Australasian and African climate. The ITF represents a key component for regional climate systems such as the El Niño Southern Oscillation and the Australasian monsoons. Over the instrumental record, the ITF has been observed to vary on seasonal and interannual time scales in response to changing patterns of regional climate. On longer, geological timescales, there is evidence that the ITF was substantially modulated by changes in the geometry of the Indonesian pathways due to sea level changes during the Pleistocene. However, our quantitative knowledge on the magnitude, dynamics, and mechanisms of ITF variability as well as its effect on regional oceanography and climate requires substantial improvement for the ITF to be realistically included in climate (prediction) scenarios.

The main objectives of Cruise SO-217 MAJA are (1) to determine the isotopic and geochemical characteristics of North Pacific thermocline water and Java Sea low salinity surface water, which have formed the main components of the ITF over most of the Holocene (Gordon et al., 2003; Xu et al., 2008; Linsley et al., 2010); (2) to evaluate present-day hydrography as well as past changes in hydrographic profiles along the ITF main inflow path during the late Pleistocene; (3) to reconstruct changes in summer and winter monsoonal systems and assess regional climate variability over the late Pleistocene to Holocene; and (4) to test model predictions of a strongly reduced glacial throughflow and significantly changed hydrographic profile within the Makassar Strait. To achieve these objectives we will carry out a regional CTD and multicorer core-top calibration within the Makassar Strait and Java Sea and undertake high resolution measurements of paleoceanographic proxies in sedimentary successions from high-resolution piston cores, which span the last two glacial cycles. The ultimate goal of Cruise SO-217 MAJA is to reconstruct ITF variability through the main bottleneck passage of the Makassar Strait over the last two glacial cycles and to elucidate the role that the ITF plays for rapid (millennial and centennial) and long-term climate change.

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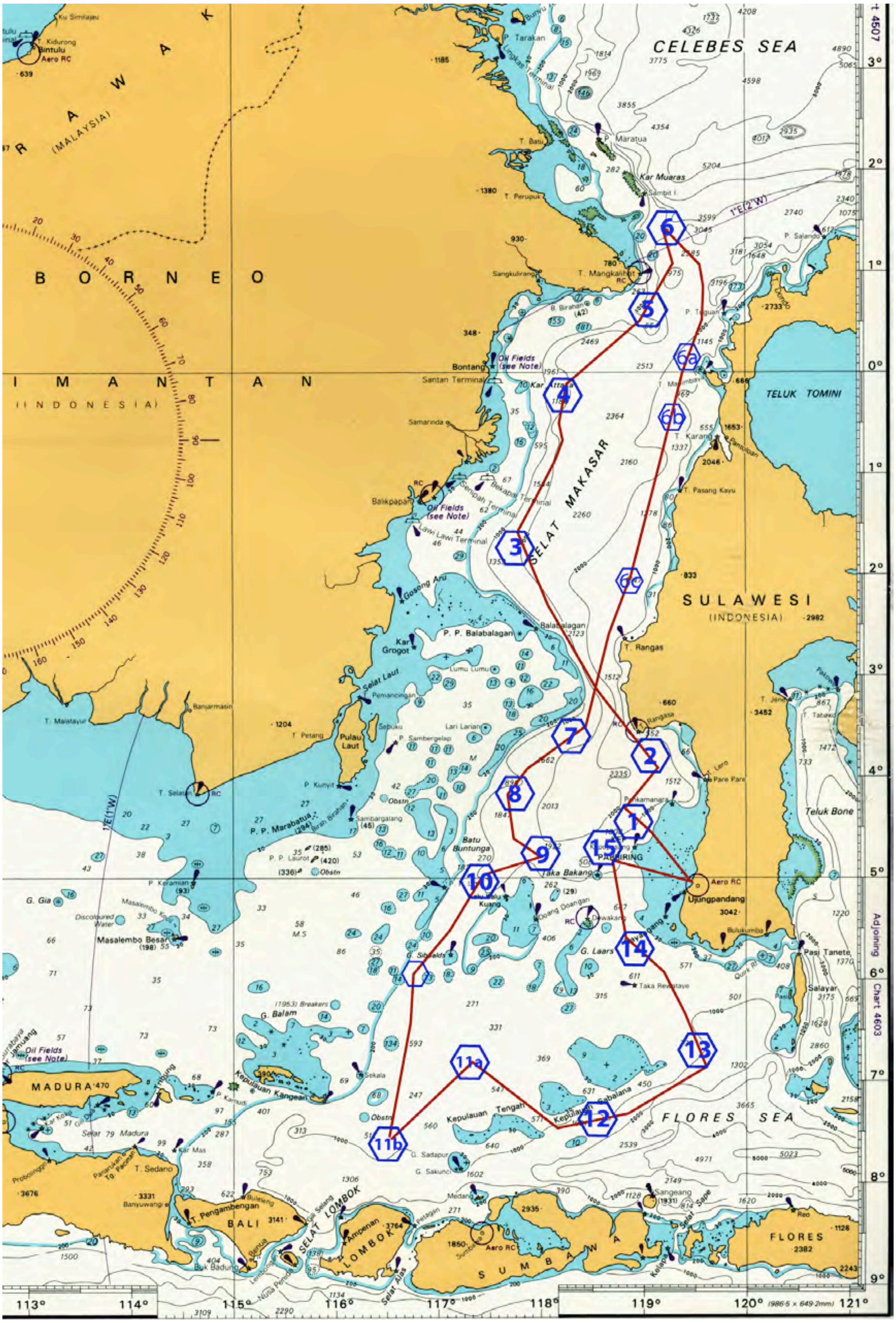


Figure 2-1: Planned cruise track and work areas for Sonne-217.

3. Methods

CTD and Rosette Water Sampling

A SBE 911 plus CTD profiler was used at 17 stations (Fig. 3-1, Table 3-11) in conjunction with a Sea Bird SBE 32 carousel water sampler to study the vertical variability of temperature, salinity, and oxygen, and to obtain water samples over the water profile. The system consists of a CTD sensor unit (temperature, conductivity, pressure), an oxygen sensor, and a Rosette with twenty-four 10 l Niskin-bottles (Fig. 3-2).

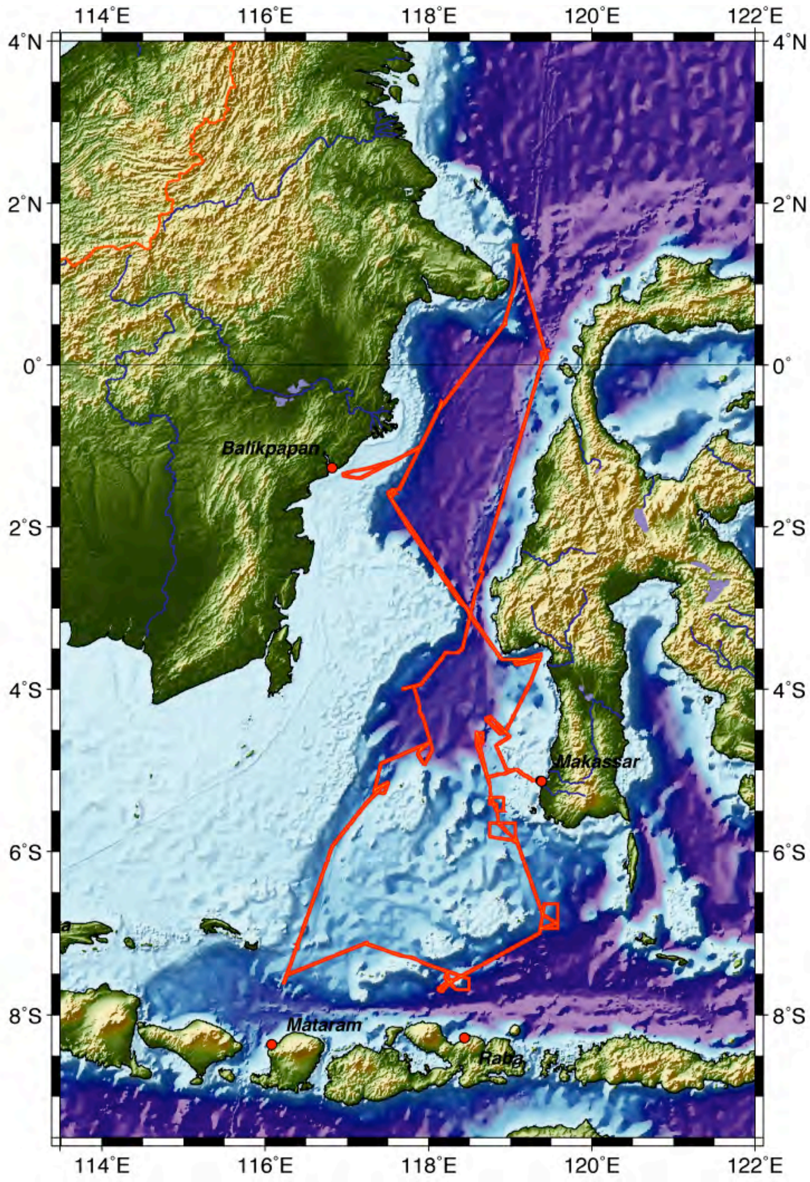


Figure 3-1. Cruise track of Sonne-217 in the Makassar Strait, Java and Flores Sea with CTD-Stations.

Figure 3-2. The Sea Bird SBE 32 carrousel water sampler with the SBE 911 plus CTD profiler.

Registration of hydrographic parameters was performed down and up through the water column. After descent of the CTD, seawater was collected on the way up and collected immediately after recovery of the instrument. A total of 200 water samples from 17 stations (Tab. 1) was stored in 20 ml glass vials closed with crimp lids.

Table 3-1. CTD stations and water sampling during SO-217

Station	max. CTD depth	Depth (m) of water samples
18514-1	649	500, 300, 250, 200, 150, 100, 75, 50, 20, 10, 1
18515-1	677	500, 300, 250, 200, 150, 100, 75, 50, 20, 10, 1
18516-1	917	900, 500, 300, 250, 200, 150, 100, 75, 50, 20, 10, 1
18520-1	1492	1500, 900, 500, 300, 250, 200, 150, 100, 75, 50, 20, 10, 1

18521-1	984	900, 500, 300, 250, 200, 150, 100, 75, 50, 20, 10, 1
18522-1	975	900, 500, 300, 250, 200, 150, 100, 75, 50, 20, 10, 1
18523-1	1491	1500, 900, 500, 300, 250, 200, 150, 100, 75, 50, 20, 10, 1
18525-1	1492	1500, 900, 500, 300, 250, 200, 150, 100, 50, 20, 10, 1
18526-1	1492	1500, 900, 500, 300, 250, 200, 150, 100, 75, 50, 20, 10, 1
18528-1	1492	1500, 900, 500, 300, 250, 200, 150, 100, 75, 50, 20, 10, 1
18531-1	1045	900, 500, 300, 250, 200, 150, 100, 75, 50, 20, 10, 1
18533-1	632	500, 300, 250, 200, 150, 100, 75, 50, 20, 10, 1
18534-1	560	500, 300, 250, 200, 150, 100, 75, 50, 20, 10, 1
18535-1	502	480, 300, 250, 200, 150, 100, 75, 50, 20, 10, 1
18536-1	829	500, 300, 250, 200, 150, 100, 75, 50, 20, 10, 1
18540-1	1185	900, 500, 300, 250, 200, 150, 100, 75, 50, 20, 10, 1
18542-1	916	300, 250, 200, 150, 100, 75, 50, 15, 1

Multicoring

Technical specifications of Kiel multicorer

Height:	Approx. 2250 mm
Diameter:	Approx. 1900 mm
Weight of head:	Approx. 180 Kg
Weight of framework:	Approx. 465 Kg
Number of tubes:	12
Diameter of tubes:	100 mm

Video system

At three stations, the Deep Sea-Color TV-System (Marinetechnik Kawohl) was used mounted on the multicorer to check deep sea floor conditions before triggering the multicorer. The system can be deployed to a water depth of 6500 m and consists of a camera system (Seacam, US), two light beams (Seacam, US) a telemetry system and a bottom contact sensor (Marinetechnik Kawohl).

Deployment

The multicorer was lowered with an average speed of 0.8 m/second (no pinger used) until about 40 m above the seafloor, where it was stopped for approximately 2 minutes. The multicorer was then lowered with a speed of 0.3 m/second, and contact with the seafloor was monitored through the cable tension. The device was left on the seafloor for about 2 minutes, then pulled out with a speed of 0.5 m/second and finally heaved up to the surface with a speed of 1.0 m/s.

Sampling

Sediment recovery was recorded in each tube, seawater was siphoned off and a brief lithological description was made. The first 5 cm (1 cm thick slices) were preserved in Rose Bengal and methanol in 300 ml Kautex bottles. Selected cores were cut into 1 cm thick slices (below 5 cm) and put into plastic bags.

Table 3-2: Distribution of multicore samples

Working Group	Samples	Method
Kiel	Slices of top 5 cm (1cm thick)	Preserved with Rose Bengal and methanol in 300 ml Kautex bottles
Kiel	Slices below 5 cm (1 cm thick)	Preserved in plastic bags
Bandung	Slices throughout (1 cm thick)	Preserved in plastic bags
Bandung	Microbiological sample close to base of tube (1 cm thick slice)	Preserved in glass bottle
Xi’an	Half core top (1 cm thick slice)	Preserved in plastic bottles

Figure 3-3: Retrieval and sampling of multicorer with video-system

Piston Coring

Technical specifications of piston corer

The piston corer with split piston, developed by Helmut Kawohl (marinetech.-kawohl@t-online.de), can be fitted with a core barrel up to 30 m in length (in 5 m increments). On RV Sonne, the piston corer was deployed with a 18 mm steel cable attached to a geological winch for 8000 m cable (max. speed: 2 m/s for up to 70 kN or max. speed: 1 m/s for up to 140 kN).

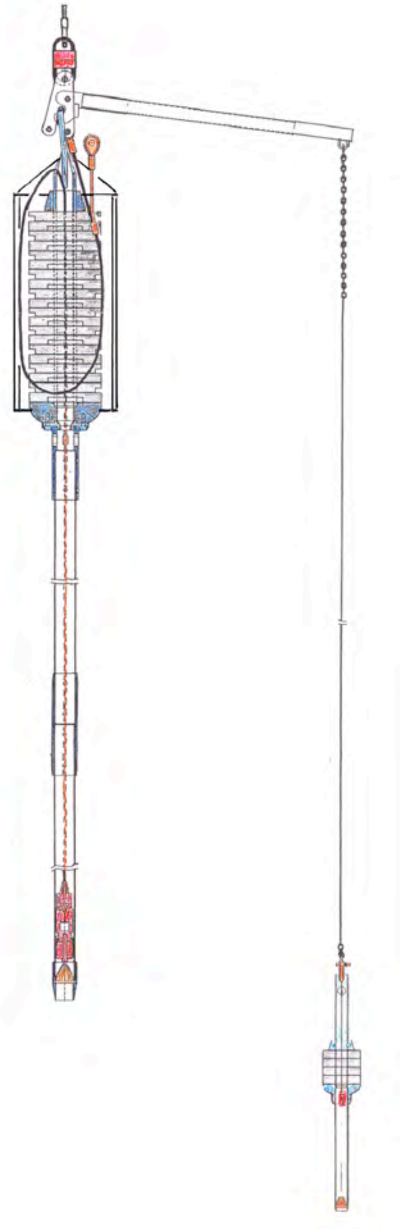


Figure 3-4: Schematic diagram of the Split-Piston Corer from Marinetechnik Kawohl, used on SO-217

Figure 3-5: Deployment and retrieval of 30 m - Piston Corer

Deployment

The piston corer was lowered with an average speed of 0.8 m/second tuntil about 50 m above the seafloor, where it was stopped for approximately 5 minutes. It was then lowered with a speed of 0.3 m/second, and contact with the seafloor was monitored through the cable tension. After the pilot core made contact with the seafloor, the piston corer was released with a free fall of 5 m. It was left at the seafloor for about 1-2 minutes after piston release, then pulled out with a speed of 0.1 m/second. Once out of the sediment, it was heaved up with a speed of 1.0 m/second.

Core handling

The core liners of the piston cores were orientated, then measured, labeled and cut into 1 m sections, starting from the top of the core. After measuring magnetic susceptibility, each section was split into working and archive halves. The sediment surface was cleaned before lithological descriptions and colour reflectance measurements were made on the archive half. The working and archive halves were packed into plastic D-tubes and stored at ~5°C, within a few hours of recovery. The sediment from core catchers was packed orientated whenever possible, and stored at ~5°C. The pilot cores were curated as whole cores with core catcher packed separately.

Labeling of core liners and D-tubes

The top and base of each section were marked with "T" and "B", respectively and the continuous depth along the core. Liners and D-Tube caps contain the following information:

- core number (185XX)
- section number (Roman numerals)
- "A" for archive half, "W" for working half (circled).
- arrow pointing to base

Visual Core Description

After shipboard visual inspection, lithological descriptions were made with the software package Applecore, using a custom pattern file following the standard Ocean Drilling Program (ODP) sediment classification scheme (modified version of the lithologic classification of Mazzullo et al., 1988). The symbols used to designate structures found in each core are shown in the core description legend.

References

Mazzullo, J.M., Meyer, A., and Kidd, R.B., 1988. New sediment classification scheme for the Ocean Drilling Program. *In* Mazzullo, J., and Graham, A.G. (Eds.), *Handbook for Shipboard Sedimentologists*:.ODP Tech. Note, 8:45-67.

Minolta Co. Ltd., 1995. Spectrophotometer CM-508d Instruction Manual, 32 pp.

Magnetic susceptibility measurements

Magnetic susceptibility was measured on board RV SONNE with the Multi-Sensor Core Logger (MSCL/016) designed and built by GEOTEK, Haslemere, UK. This system enables the amount of magnetic material in the sediment to be determined in unsplit sediment cores encased in cylindrical plastic liners. We measured magnetic susceptibility in core sections of 12 cm diameter, up to 100 cm long closed by plastic caps of 12.5 cm diameter. The section was placed on the rails of a conveyor system and aligned to the start position. A core pusher then moved the section in increments of 2 cm through the BARTINGTON MS2C sensor loop. The starting position of the section was 10 cm in front of the sensor loop. A low intensity (ca. 80 A/m RMS) non-saturating, alternating magnetic field (0.565 kHz) is produced by an oscillator circuit within the sensor. Any magnetic material in the near vicinity of the sensor causes a change in the oscillator frequency, which is electronically converted into (artificial) magnetic susceptibility values. Data were initially collected on a Macintosh SE30, using the MSQB1.BAS program from GEOTEK, then edited with EXCEL and

KALEIDAGRAPH. To eliminate artificial susceptibility minima near core section breaks, the first and last 4 measured values in every section were deleted from the plots.

Color Spectrophotometry

A Minolta CM 700d hand-held spectrophotometer was used to measure light reflectance on sediment cores immediately after splitting the core into working and archive halves. The spectral reflectance is measured at a 10 nm pitch over the wavelength from 400 to 700 nm, and a double-beam feedback system automatically compensates for variation in the illumination from the CM 700d's pulsed xenon arc lamp. Routine measurements were carried out on the damp core surface, and clear plastic film was used to cover the core. Measurements were made at 1 cm spaced intervals and automatically recorded on a laptop computer using Color Data Software Spectramagic™ NX (Vers. 1.9). The spectrophotometer was calibrated for white color reflectance and "zero calibrated" at least twice a day, at the beginning of each work shift to avoid variation in color readings due to the laboratory environment (temperature, humidity, and background light) and instrument variations. The standard color-values X,Y, and Z are automatically calculated by the software Spectramagic, which are displayed in the L*, a* and b* CIELAB color coordinates. The L* value represents brightness and can be directly correlated to gray value measurements (i.e. from video-systems).

Plankton sampling through onboard seawater pumping system

Sieved samples were collected from pumped sea water using a 63 µm sieve. Seawater was pumped from a water depth of approximately 5 m using a rotational pump ('Kreiselpumpe'). After collection, samples were preserved in methanol or dried over a filter paper.

Multibeam echosounding

The shipboard multibeam echosounder SIMRAD EM 120 with Rx Preamp Unit (S/N 108), Tranceiver Unit (S/N 102), Tx Junction Box (S/N109), Remote Control (S/N134), MRU-5 1423, SvPlus, (S/N 3349) was used to compile bathymetric maps. The total usable width of the array of this system is: 150° with 191 beams. The individual beam width is 2° x 2° and the frequency of the sounding signal is 12 kHz (ranging between 11.25 and 12.75 kHz) (if variable frequencies are used, each frequency is recorded along with its time of use). The instrument's sampling rate (sounding/sec) was max. 5Hz, depending on depth (the ping rate, which may be variable depending on depth is included in the record)

DATA RECORDING:

Time resolution (navigation) :
hundreds of a second (0.01 s) *or*
ten-thousands of a minute (0.0001 mn)

Time resolution (sounding-two way travel times):
hundreds of milliseconds (0.01 ms)

Date:	Century and year (CCYY), month (MM) and day of the month (DD) *or* Century and year (CCYY), Julian day (DDD)
Depth resolution:	tenths of a metre (0.1 m)
Depth null value:	„Zero" is recommended, see paragraph 4.4.5.6
Horizontal resolution:	Tenths of a metre (0.1 m)
Speed:	Hundreds of a knot (0.01 kn)
Heading:	Tenths of a degree (0.1°)
Roll and pitch:	Tenths of a degree (0.1°)
Geographic position:	Degrees of million (+/- DD.DDDDDD and +/- DD.DDDDDD) *or* Degrees and minutes to hundred-thousands (+/-DD +/-MM.MMMMM and+/-MM.MMMMM).
Offset distances:	Offset for the MRU-5 applied in the MRU, offset for the EM 120 applied in the EM120 software the cross-track offset convention used, port to starboard (negative to positive) is recorded in tenth of metres
Vertical datum:	where tides are applicable, vertical datum is indicated, including information to indicate the source of tidal corrector applied, i.e., actual or predicted tides and station used)

Transducer depth correction is set in the installation parameter,used during the survey

Nominal sound velocity: 1500 m/s

Sound velocity corrections: a function sound velocity profile was used during the survey, check is used permanently during the survey; to obtain correctors in situ measurements were performed at each CTD station

Data reduction software: postprocessing software NEPTUNE, position- and depth processing

Data structures and format: see EM-datagram format

Environmental data: since multibeam data quality is particularly sensitive to environmental conditions, parameters such as the sound-velocity profile, surface water sound speed (ksv), weather and sea state are recorded

Angular coverage of the EM120 on board the Sonne is typically set at 65° to minimise noisy data at high angles, however the sea state was so calm during this voyage that it was typically set to 70°. When the ship was slowed to under 10kn during formal surveys the angle could be increased to 72° on each side. The system behaved extremely well during the course of the cruise. At the end of the cruise the data were stored as raw files and xyz-files, maps were prepared along the cruise track and for specified work areas, where piston-coring was carried out.

Sedimentacoustics: PARASOUND -System

The PARASOUND system works both as a low-frequency sediment echosounder and as high-frequency narrow-beam sounder to determine the water depth. It uses the parametric effect, which produces additional frequencies through nonlinear acoustic interaction of finite amplitude waves. If two sound waves of similar frequencies (18 kHz and e.g. 22 kHz) are emitted simultaneously, a signal of the difference frequency (e.g. 4 kHz) is generated for sufficiently high primary amplitudes. The new component is traveling within the emission cone of the original high frequency waves, which are limited to an angle of only 4 ° for the equipment used. The resulting footprint size of 7 % of the water depth is much smaller than for conventional systems and both vertical and lateral resolution is significantly improved.

The PARASOUND system is permanently installed on R/V SONNE. The hull-mounted transducer array has 128 elements on an area of 1 m^2. It requires up to 70 kW of electric power due to the low degree of efficiency of the parametric effect. The PARASOUND System sends out a burst of pulses at 400 ms intervals, until the first echo returns since the two-way travel time in the deep sea is long compared to the length of the reception window of up to 266 ms. The coverage of this discontinuous mode depends on the water depth and produces non-equidistant shot distances between bursts. On average, one seismogram is recorded about every second and provides a spatial resolution on the order of some meters on sedimentacoustic profiles. The main tasks of the operators are system and quality control and the adjustment of the start of the reception window. Only a short window close to the seafloor is recorded due to the limited penetration of the echosounder signal into the sediment (<200 m).

The PARASOUND System on R/V SONNE is equipped with a digital data acquisition system (Spieß, 1993). The system allows the buffering, transfer and storage of the digital seismograms at very high repetition rates. From the emitted series of pulses usually every second pulse is digitized and stored, resulting in recording intervals of 800 ms within a pulse sequence. The seismograms were sampled at a frequency of 40 kHz, with a typical registration length of 266 ms for a depth window of ~200 m.

Reference:

Spieß, V. (1993) Digitale Sedimentechographie - Neue Wege zu einer hochauflösenden Akustostratigraphie. (Habilitationsschrift). Berichte Fachbereich Geowissenschaften, Universität Bremen, 35, 199 pp.

4. Initial Results and Highlights

Hydrography (results of CTD measurements)

Temperature profiles (Figure 4-1) are characterized by a mixed layer in the upper 30–50 m, seasonal and permanent thermocline down to ~400 m, and uniform deep waters. Mixed-layer temperatures range from 27 to 29°C. A steep vertical temperature gradient of ~1.0°C per 10 m in the seasonal thermocline decreases between 100–140 m to ~0.4°C per 10 m in the permanent thermocline. Temperatures in deep waters are in the order of 7°C at ~400 m and 4°C below ~1100 m.

Salinity values of the mixed layer usually range from 33.6 to 34.2 psu (Figure 4-2). While stations 18520-1 and 18521-1 show low surface salinities of <33.5 psu due to their proximity to the Mahakan Delta. In contrast, salinity at station 18542-1 in the Flores Sea is >34.4 psu. At each station, salinity reaches maximum values of up to 34.9 psu between 30 and 150 m. A deeper salinity minimum centered at 350 m is characterized by values of ~34.4 psu. Deep waters show salinities of ~34.6 psu.

High oxygen concentrations of >3.5 ml/l (Figure 4-3) ventilate the mixed layer. Relatively stable oxygen concentrations between 3.0 and 3.5 ml/l were detected in the seasonal thermocline, whereas a strong decline occurs in the permanent thermocline down to oxygen concentrations of ~2.0 ml/l. Deep waters show oxygen concentrations of ~2.0 ml/l

Density profiles (Figure 4-4) illustrate strong stratification of the upper water column. The salinity-temperature diagram (Figure 4-5) supports homogeneity of the water masses in the Celebes Sea, Makassar Strait, and Flores Sea. At station 18542-1, however, stratification is weaker probably due to vertical mixing processes.

In summary, hydrographic profiles of the upper and intermediate water column in the Celebes Sea, Makassar Strait, and Flores Sea reveal relatively homogeneous and well stratified conditions. Weak stratification at station 18542-1 in the Flores Sea indicates monsoon-driven upwelling (trade winds). Lower salinity of mixed-layer water masses at stations 18520-1 and 18521-1 reflects runoff from the Mahakan Delta, off Kalimantan.

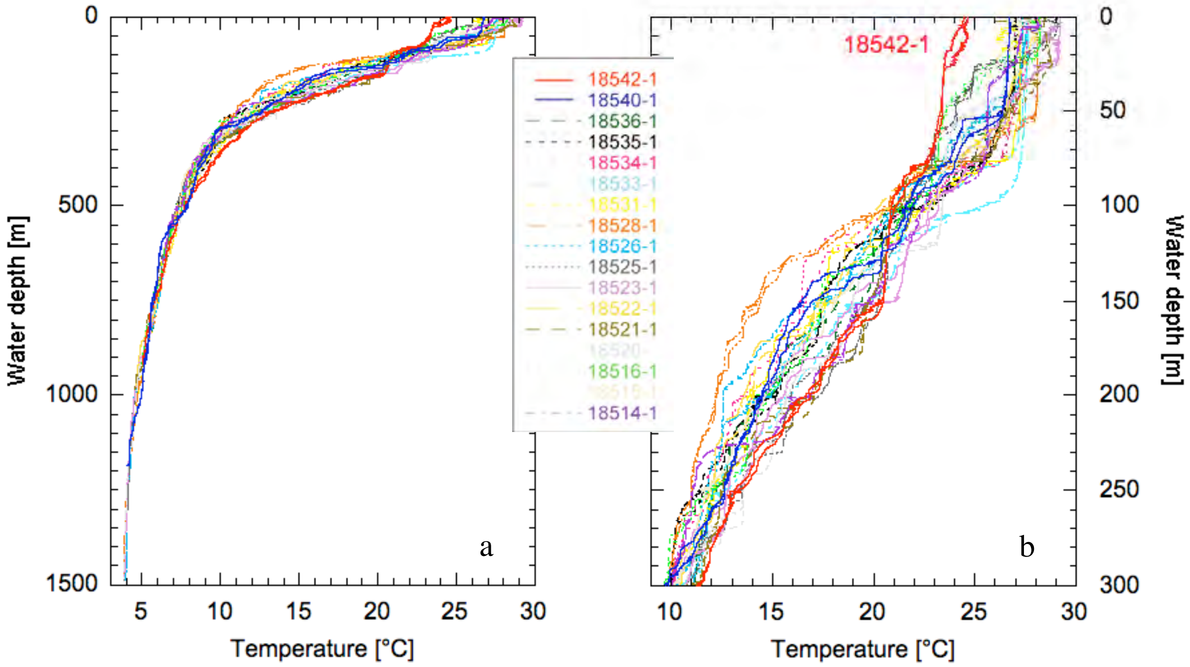


Figure 4-1. Compilation of temperature profiles from the SO-217 MAJA cruise for a) the entire depth range and b) the uppermost 300 m.

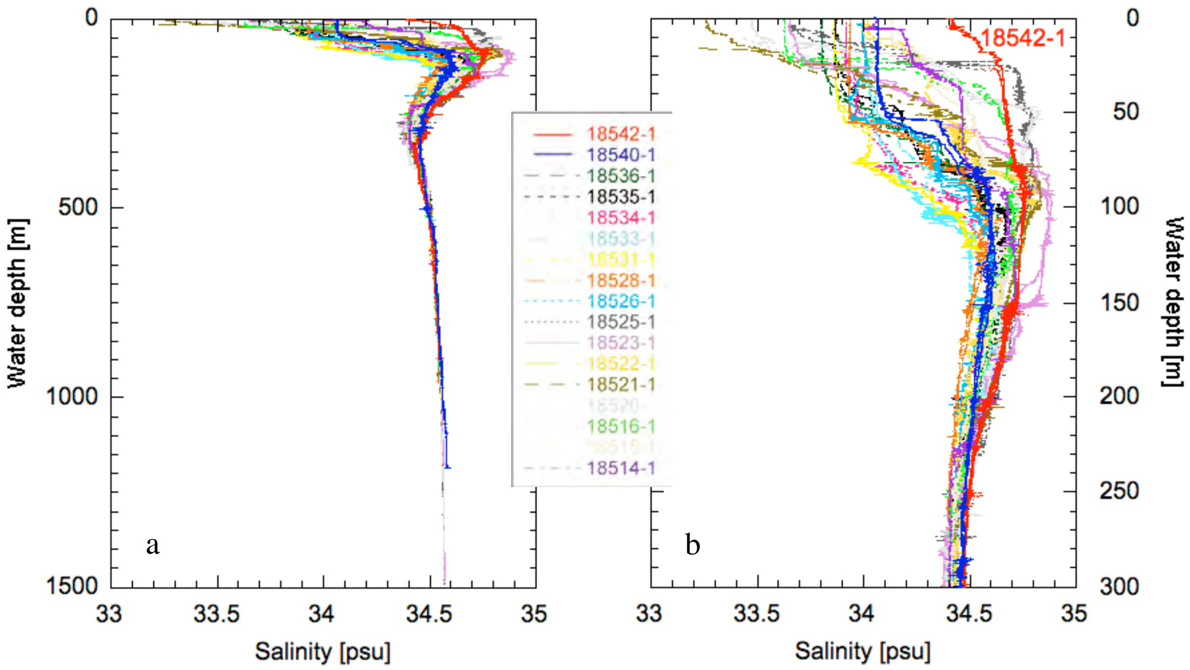


Figure 4-2. Compilation of salinity profiles from the SO-217 MAJA for a) the entire depth range and b) the uppermost 300 m.

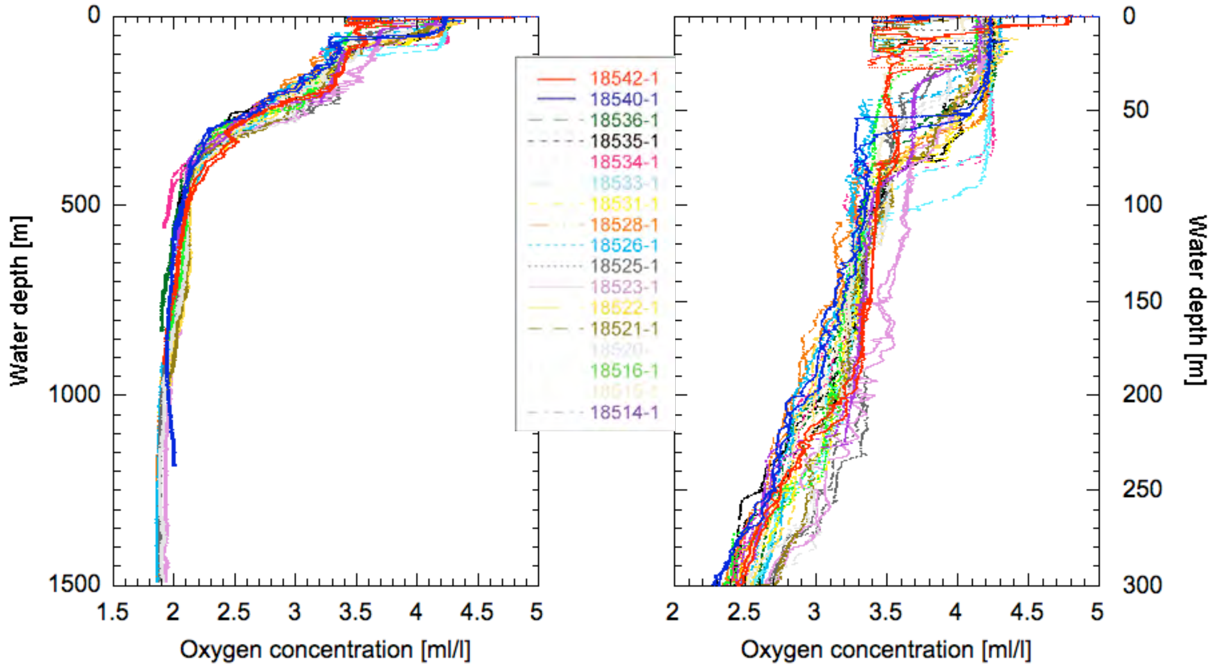


Figure 4-3. Compilation of oxygen profiles from the SO-217 MAJA cruise for a) the entire depth range and b) the uppermost 300 m.

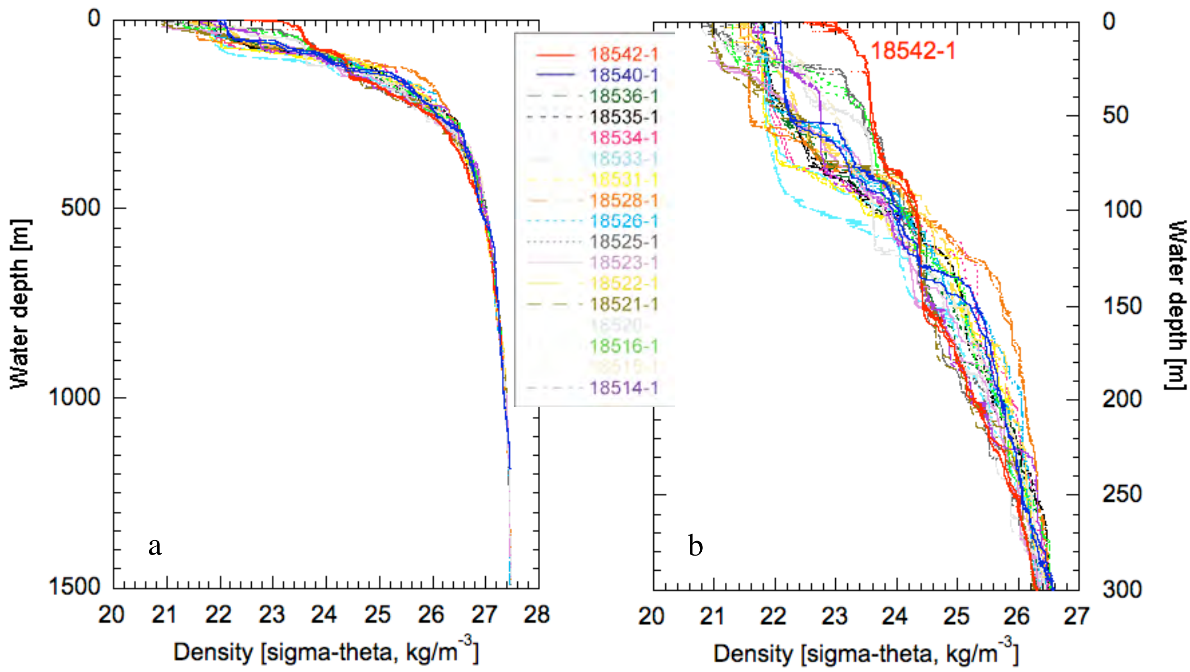


Figure 4-4. Compilation of density profiles from the SO-217 MAJA cruise for a) the entire depth range and b) the uppermost 300 m.

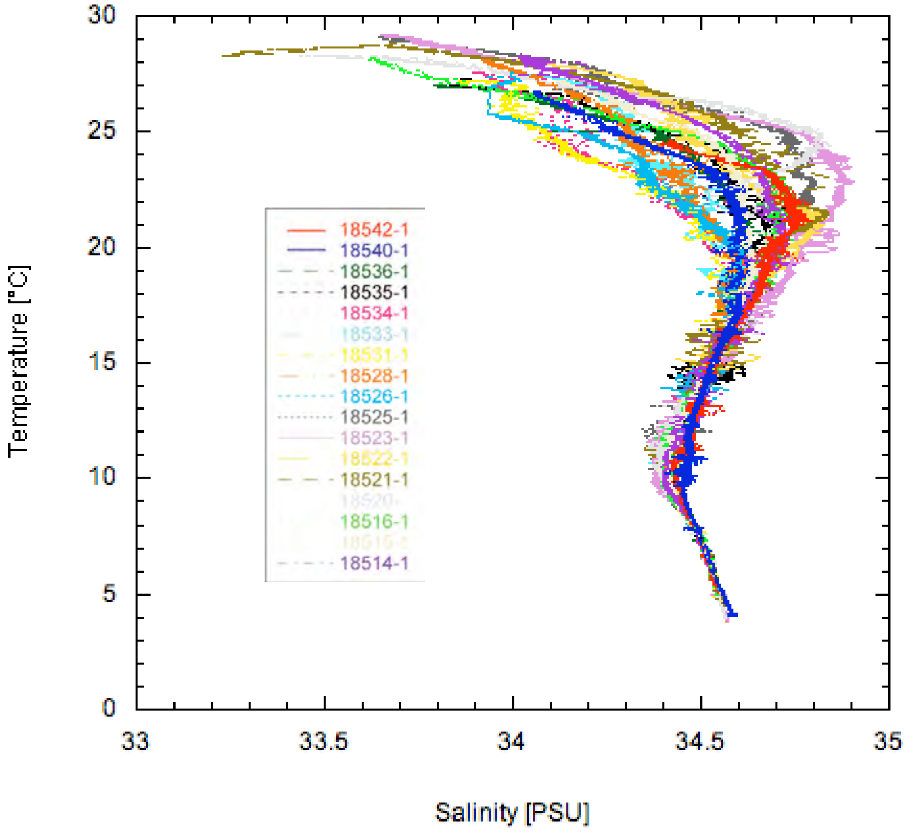
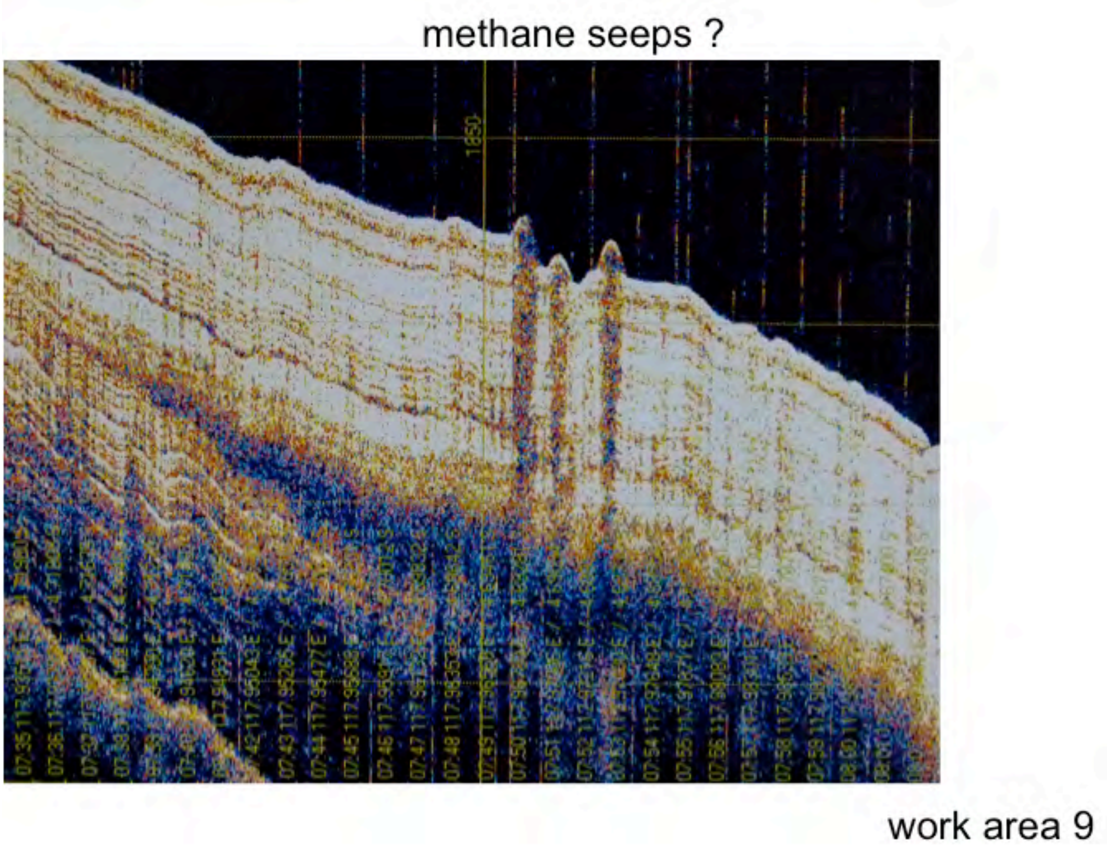
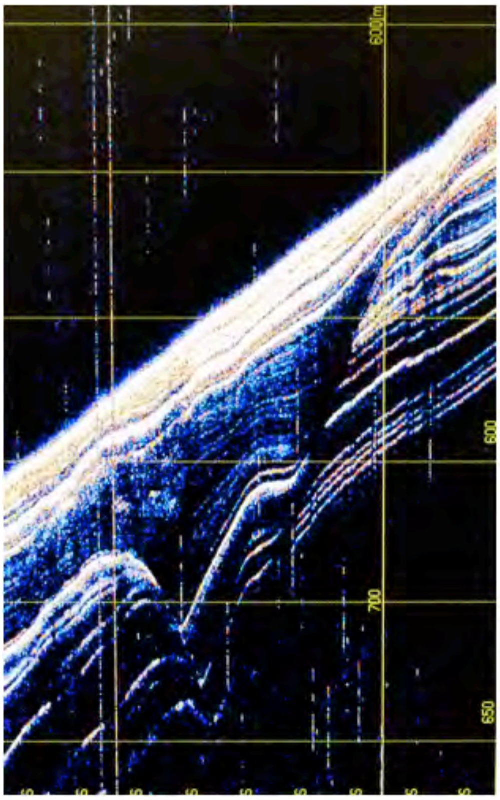


Figure 4-5. Salinity versus temperature diagram for the SO-217 MAJA cruise.

Bathymetry and sediment distribution

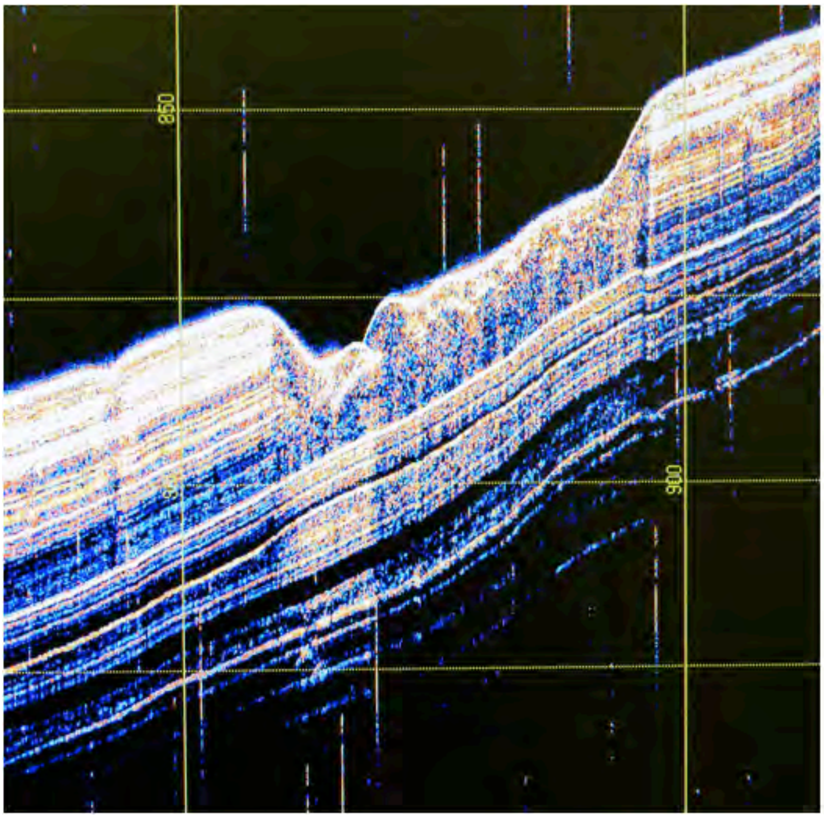
Multibeam echosounding and Parasound acoustic profiling were carried out prior to water sampling and coring operations in each selected working area. A substantial sediment cover of fine-grained clay-rich sediment was encountered in most work areas except for the Dewakang sill area at the southern end of the Makassar Strait and shallower parts of the Java Sea in the southwestern part of the Makassar Strait. In these areas, a relatively thin sandy sediment cover indicated strong bottom current activity. In the Dewakang sill area in particular, spectacular submarine sand-waves were observed in water depths ~ 600 m, close to the maximum depth of the sill at 690 m. In contrast, the sediment cover in areas influenced by high terrigenous sediment flux from nearby deltas (Core 18515 off Sulawesi and work area 3 downstream of the Makaham delta, off Kalimantan) sedimentation typically consists of fine-grained clay accumulation over short time scales. The deep water parts of the Makassar Strait are characterized by an abyssal plain with flat seafloor and quiet accumulation of pelagic sediment. Slopes exhibit sediment gravity redeposition and erosional features in channel-fan systems. Occasionally acoustic transparent zones and associated cold (hydrocarbon) seeps were observed. Selected Parasound records of characteristic sedimentation features are complied in Figure 4-6.





slope features
submarine slide

close to station
SO207-20



erosive
channel

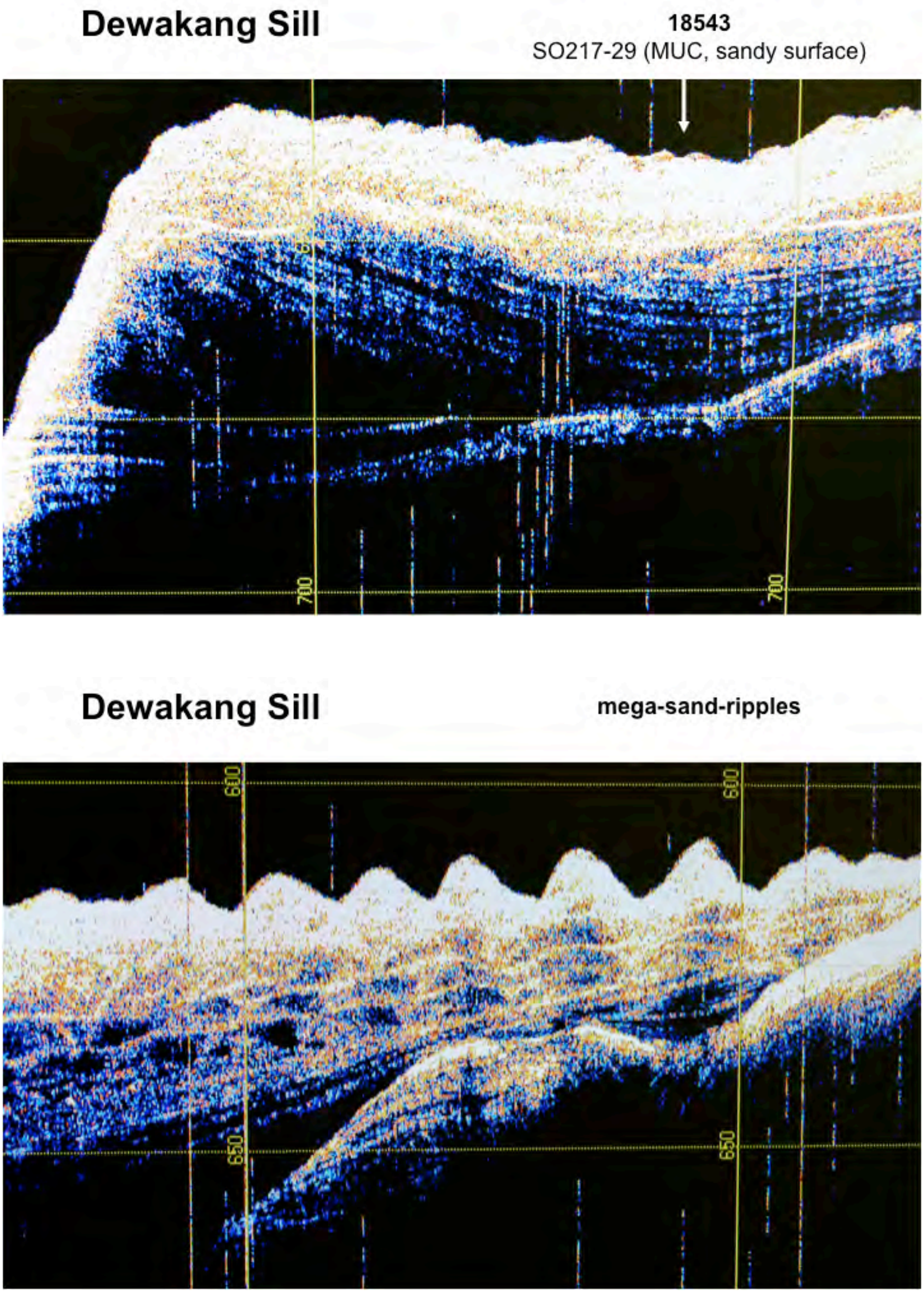


Figure 4-6. Parasound records of characteristic sedimentation features.

Preliminary stratigraphy

A preliminary shipboard stratigraphy was developed using the lightness (L*) records from spectrophotometry. The most characteristic feature is the significant increase in L* in the early part of the last glacial termination resulting in consistently lighter (carbonate rich) Holocene sediments in contrast to dark, clay-rich glacial sediments. Using this change in sediment color as diagnostic for the end of the glacial maximum and early Termination 1 (occurring between ~18.3 and ~15 ka), we were able to provide a first estimate of sedimentation rates in most of the piston cores recovered during the SO-217 MAJA cruise (Figures 4-7 to 4-10).

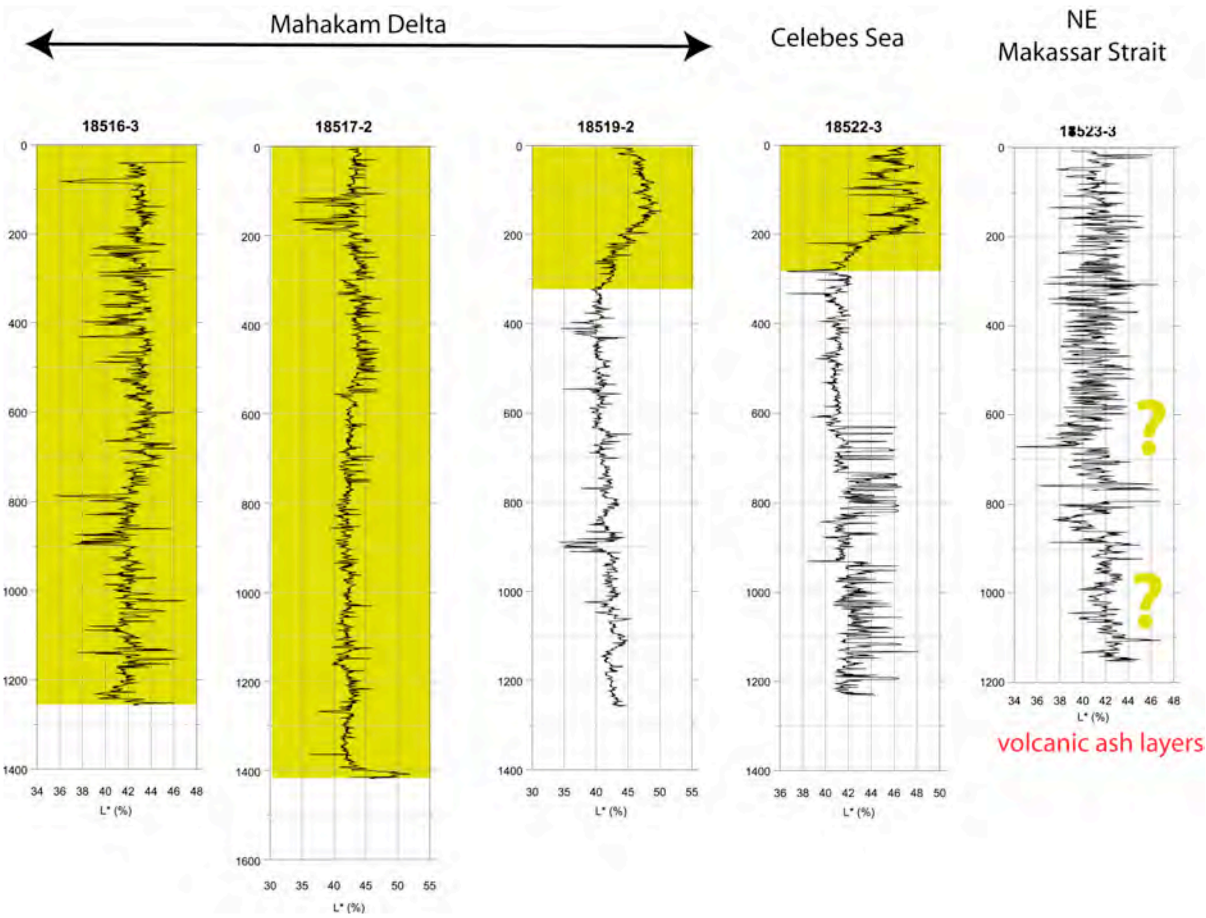


Figure 4-7. Lightness (L*) records of piston cores from the northern part of the Makassar Strait (north of the Labani-Channel) and southernmost Celebes Sea. Holocene sedimentation is indicated in yellow.

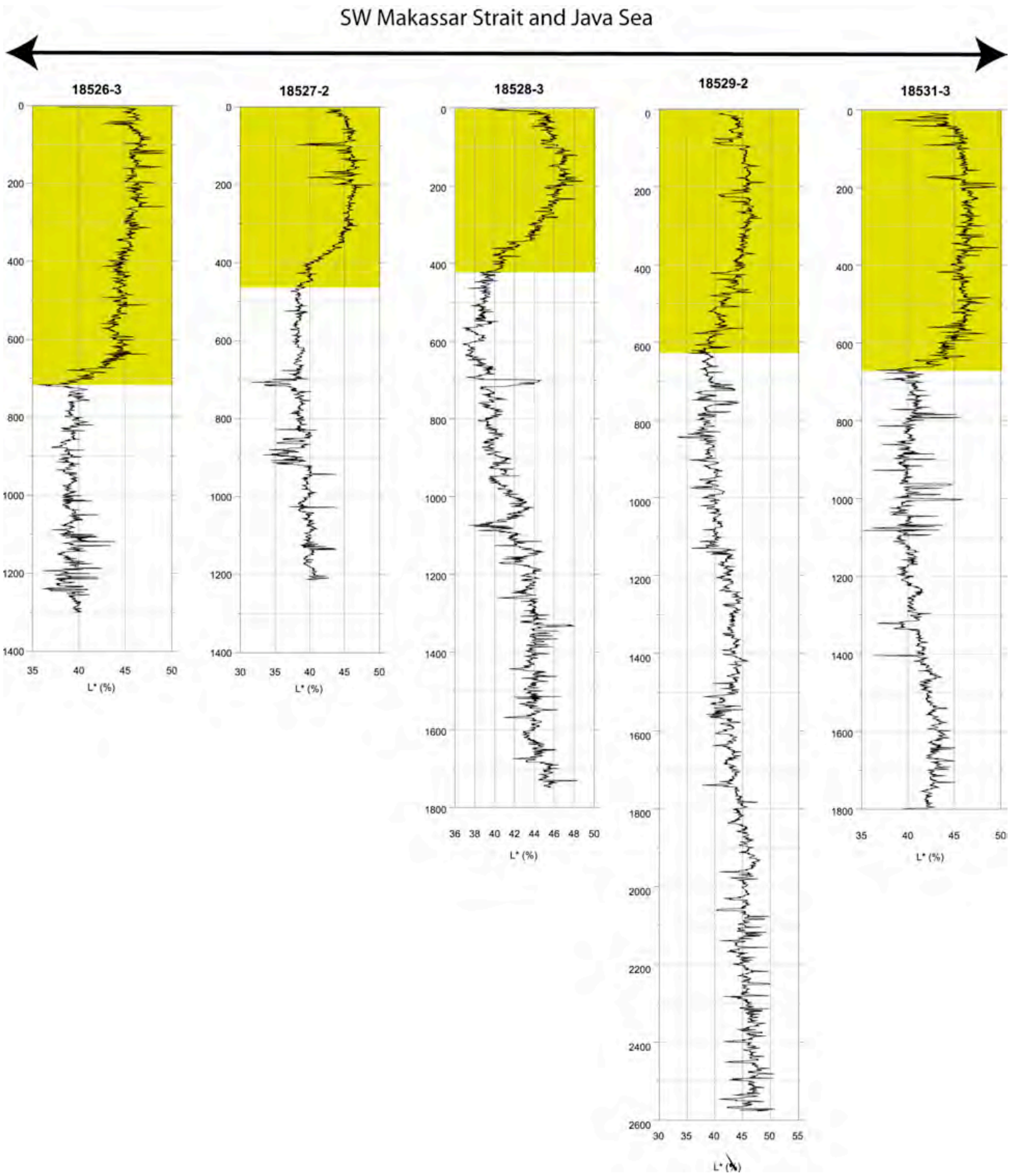


Figure 4-8. Lightness (L*) records of piston cores from the southwestern part of the Makassar Strait and Java Sea. Holocene sedimentation is indicated in yellow.

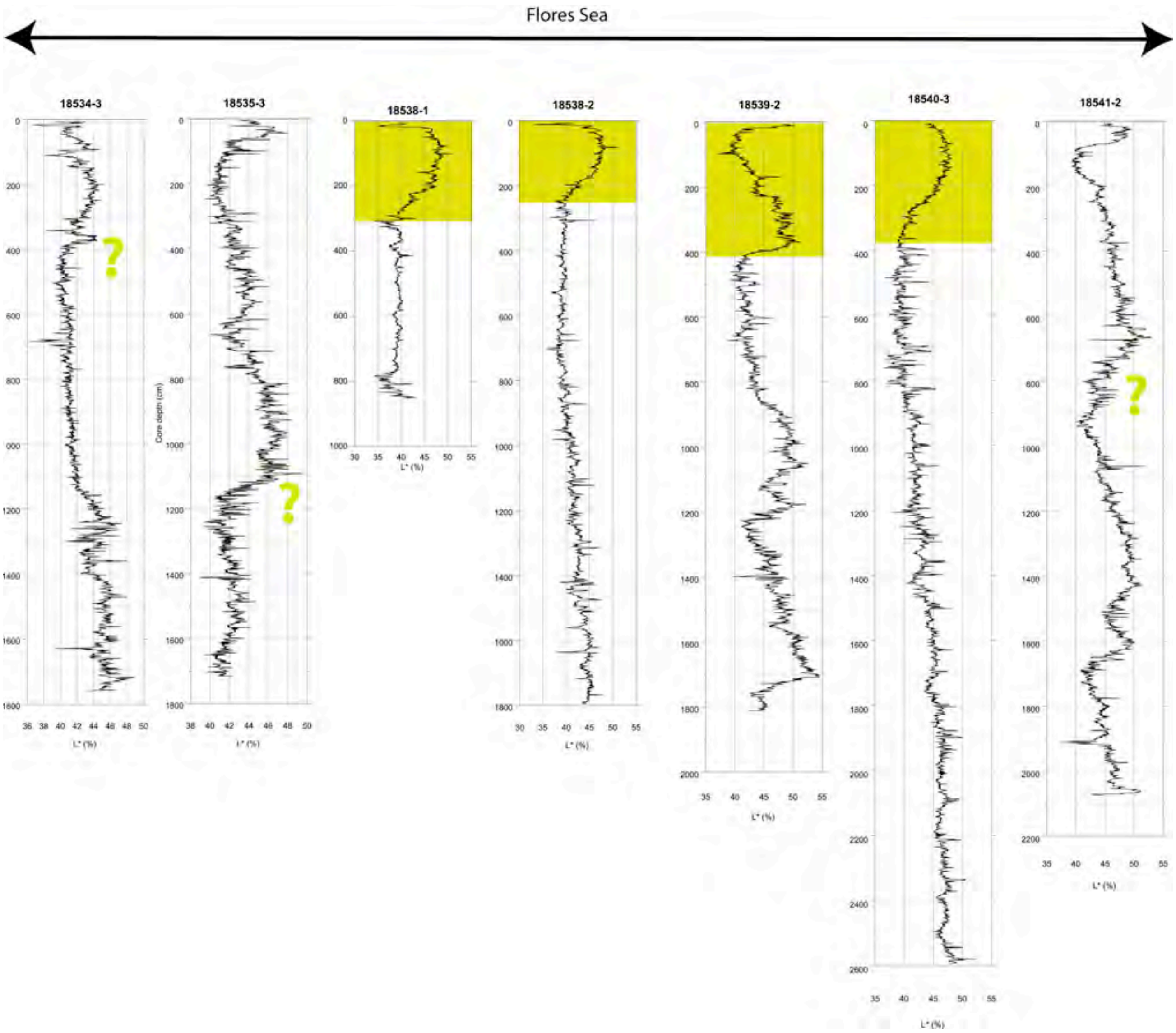


Figure 4-9. Lightness (L*) records of piston cores from the northern part of the Flores Sea. Holocene sedimentation is indicated in yellow.

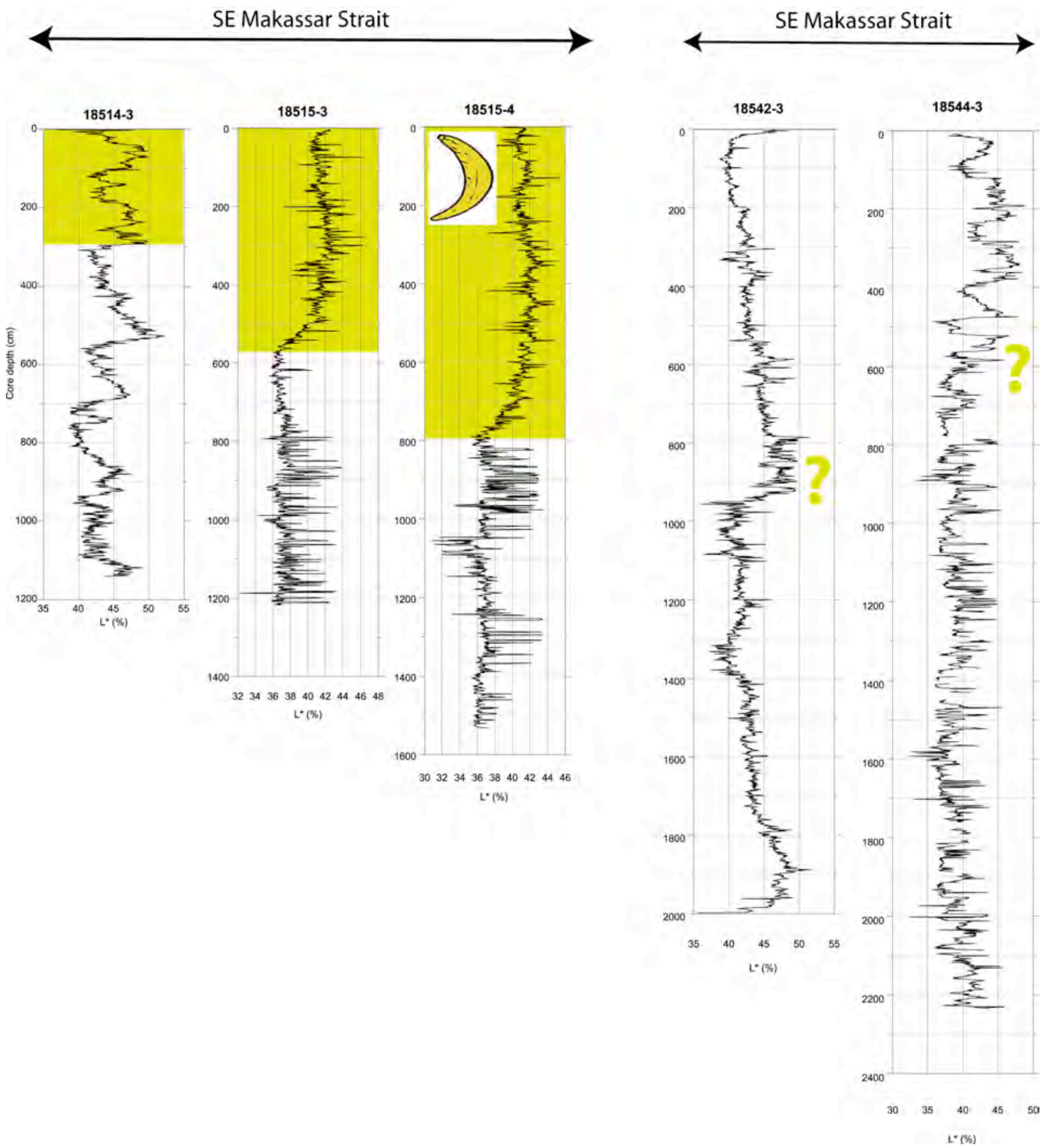


Figure 4-10. Lightness (L*) records of piston cores from the southeastern part of the Makassar Strait (south of the Labani Channel). Holocene sedimentation is indicated in yellow.

Tephrochronology

The prominent ash layer of the 1815 Tambora eruption is recognizable in virtually all magnetic susceptibility records from the Flores Sea, southwestern part of the Makassar Strait and in most records from the SE part of the Makassar Strait (Figures

4-11 to 4-12). The characteristic "Tambora-spike" in the magnetic susceptibility records is not observed in any of the cores north of the Labani Channel and is also very weak or absent in the northernmost sites of the SE part of the Makassar Strait, which were furthest away from the eruption center of Tambora. Older ash layers, detected in cores SO-217-18529-18539, 18541 and 19542 may serve as an additional tool for stratigraphic correlation once their age relationship has been confirmed using AMS ^{14}C dating.

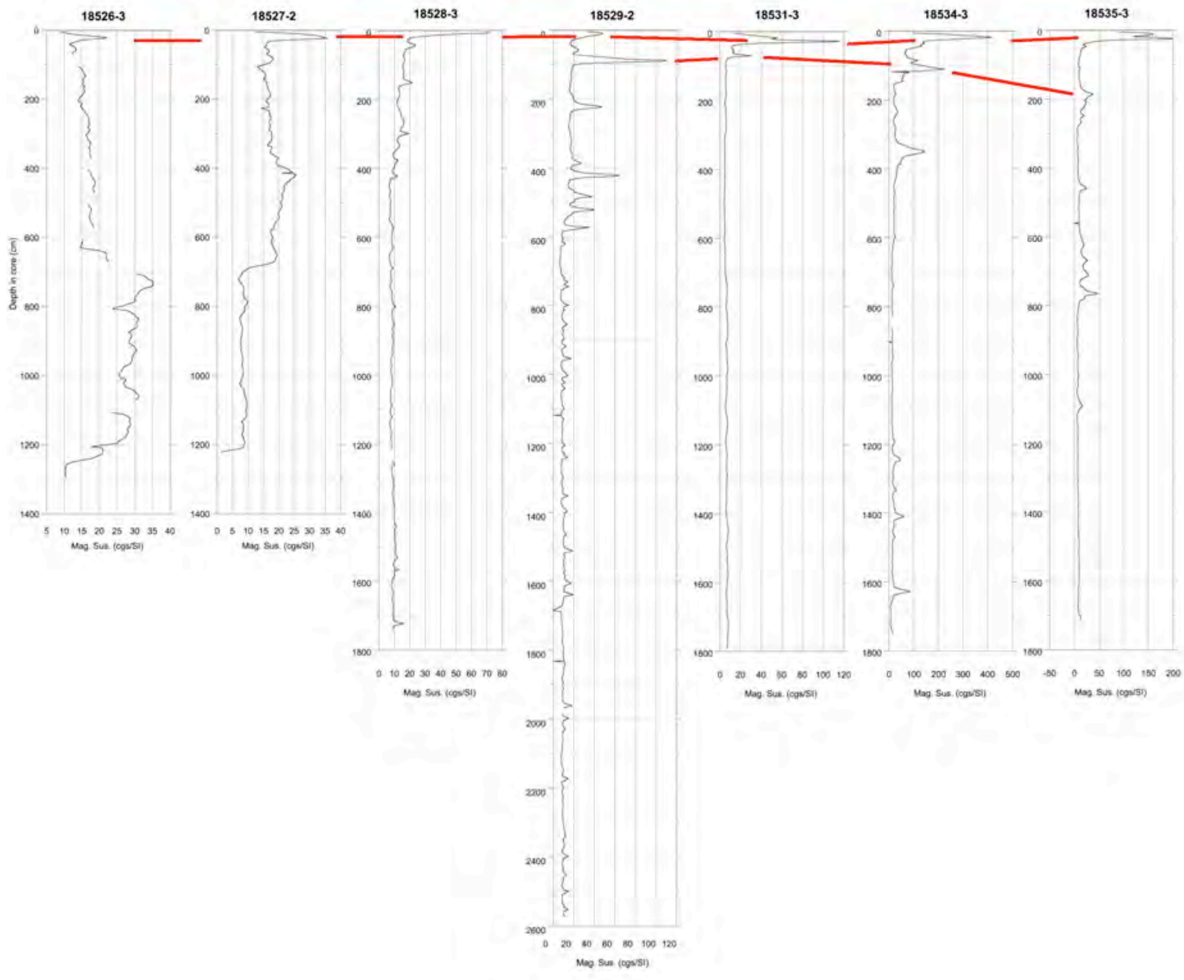


Figure 4-11. Magnetic susceptibility records of piston cores from the southwestern part of the Makassar Strait (south of the Labani Channel). Tentative correlation of volcanic ash layers with red lines.

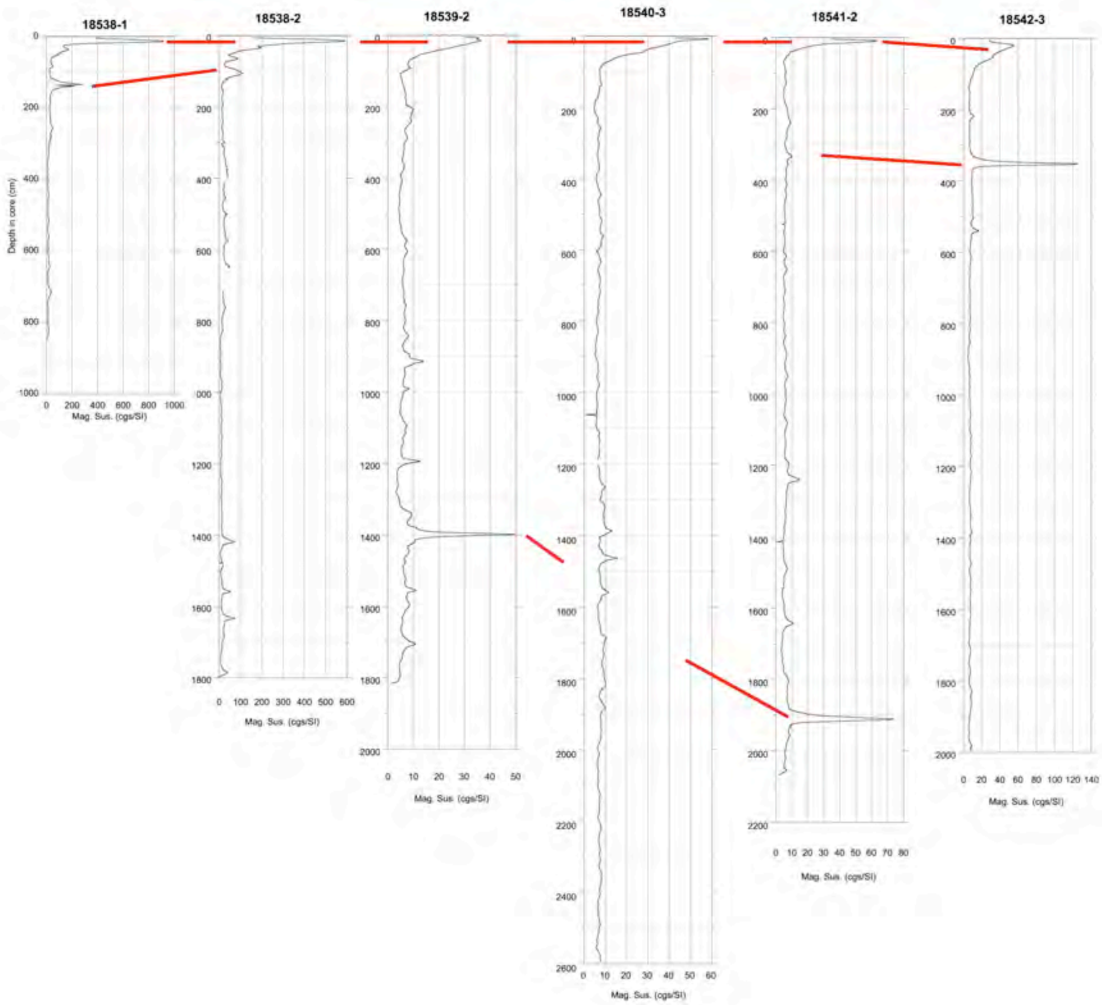


Figure 4-12. Magnetic susceptibility records of piston cores from the Flores Sea and southeastern part of the Makassar Strait (south of the Labani Channel). Tentative correlation of volcanic ash layers with red lines.

Highlights and future work

The CTD data, water samples, sedimentary archives from multicores and piston cores acquired during the SO-217 MAJA cruise surpassed expectations, despite the highly frustrating delay of 3 days at the beginning of the cruise, which was due to bureaucratic inertia in processing the permission for RV "Sonne" to operate in Indonesian waters. Preliminary shipboard results show high potential for tracking ITF variability and reconstructing regional climate history over the last two glacial cycles within specialized topics that will be integrated into broader thematic syntheses:

- *Modern hydrography of Makassar Strait:*

Investigation will be based on core tops from 29 MUC stations and water samples from 17 CTD stations. We will use stable isotopes (measured on water and foraminiferal shells), Mg/Ca based temperature and salinity reconstruction (measured in planktic and benthic foraminifers), planktic and benthic foraminiferal census counts to reconstruct modern hydrographic properties and test the reliability of proxy data in the Makassar Strait.

- *ITF current variability:*

Study will focus on Cores SO-217-18514, 18526, MUC 18543-44, which are placed in strategic locations within the ITF main pathway. We will use sortable silt, XRF scanning, stable isotopes, benthic foraminiferal census counts (monitoring in particular the abundance of suspension feeders) to decipher change in ITF current intensity over the last glacial cycle.

- *Freshwater outflow from Java Sea:*

We will analyze surface $\delta^{18}O$ and Mg/Ca in foraminiferal shells from Cores SO-217-18526-29, 18531 at the entrance of the Java Sea, Cores 18534-35 close to Lombok in the southernmost part of the Makassar Strait and Core 18515 in the eastern part of the Makassar Strait to monitor the regional and temporal variability of the freshwater plume from the Java Sea over the Holocene (and possibly Termination 2). This freshwater inflow inhibits the ITF surface flow through the Makassar Strait during austral winter monsoon, thus having major repercussions for regional climate and for trans-oceanic salt and heat transfer. These cores will additionally allow us to explore ITF circulation modes during sea level lowstands, when the freshwater supply from the Java Sea remained cut off (LGM, parts of MIS 3)

- *History of deep water ventilation:*

Analysis of benthic $\delta^{13}C$ in the deeper Cores SO-217-18522-23, 1826, 18545, 18538, which are strategically located downstream of the main sills and narrow entrance/exit passages of the ITF will allow to monitor changes in deep water ventilation and relations to global thermohaline circulation and climate over the last two glacial cycles.

- *Flores Sea upwelling, indicator of austral summer monsoon variability:*

Analysis of stable isotopes and productivity proxies (foraminiferal assemblages, XRF scanning, TOC) in Core SO-217-18539-41 will provide unprecedented insights into the evolution of the Flores Sea upwelling and variability of the SE trade winds over the last glacial cycle.

- *Monsoonal run off from Borneo and Sulawesi:*

Core SO-217-18515 (off Sulawesi) and Cores SO-217-18516-20 (off Kalimantan) will allow monitoring of monsoonal runoff from two main deltaic systems. We will use XRF scanning, surface stable isotopes and foraminiferal Mg/Ca based temperature and salinity reconstructions to unravel local hydrographic changes and to reconstruct the variability of the austral winter monsoon over the Holocene and Termination 1.

- *Volcanic history of Sulawesi and Java (Tambora):*

Cores SO-217-18523 from the northern part of the Makassar Strait off Sulawesi, and all cores from the southern part of the Makassar Strait (south of 5°S) recovered numerous ash layers. We will use AMS^{14}C dating, grain size analysis as well as study the impact on benthic foraminiferal communities to cross-correlate cores, reconstruct volcanic depositional patterns and retrace the volcanic history of north Sulawesi and Java (Tambora).