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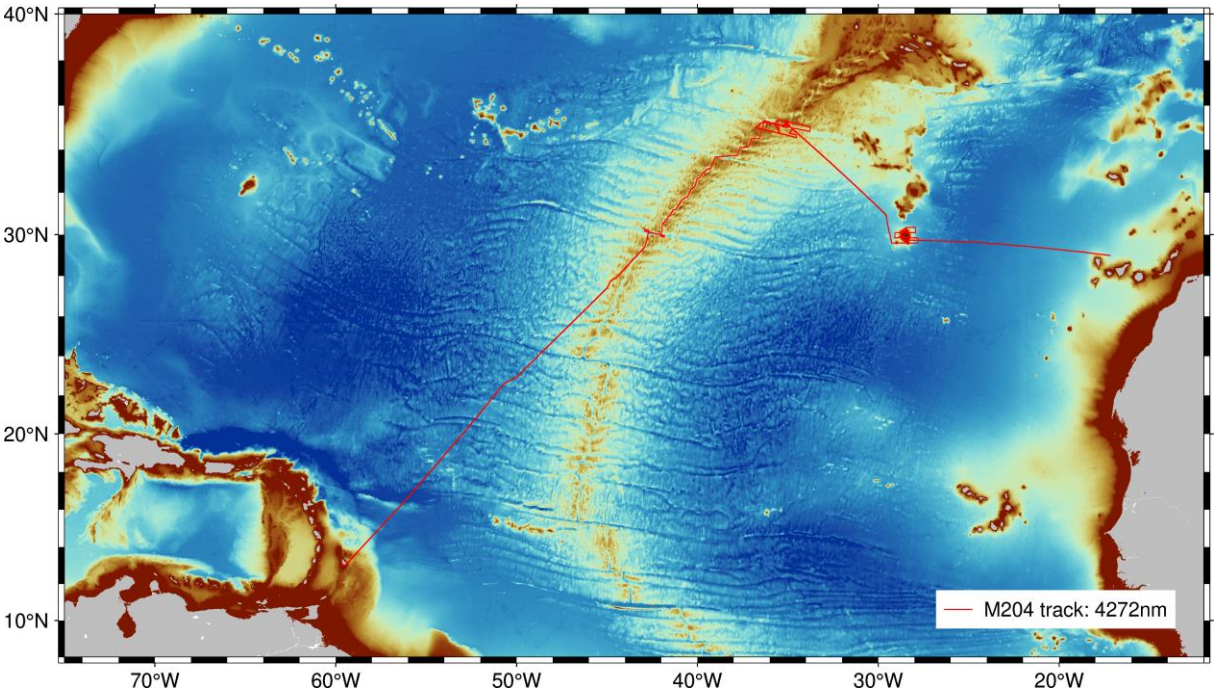
Short Cruise Report

RV METOR Cruise M204

Bridgetown, Barbados – Las Palmas, Gran Canary, Spain
27. September – 20. October 2024
Chief Scientist: Ingo Grevemeyer
Captain: Detlef Korte



Objectives

Oceanic transform faults (OTF) are one of three major types of plate boundaries of plate tectonics. Yet, plate tectonics predicted a rather simple geometry for OTFs and consequently their structure and “modus operandi” attracted reasonable little attention. However, recent evidence suggests that the traditional concept of transform faults as being conservative (non-accretionary) plate boundary faults might be wrong. Instead, numerical modelling results suggest that (i) transform faults seem to suffer from extensional tectonics below their strike-slip surface fault zone and a global compilation of legacy bathymetric data suggests that (ii) ridge-transform intersections seem to be settings of magmatic activity, modifying the lithosphere and burying the transform valley before it passes into the fracture zone region. During M204, we tested both hypotheses at the Oceanographer OTF to the south of the Azores by (i) revealing the displacement of the strike-slip fault using seafloor geodesy (direct path ranging) and (ii) studying the micro-seismicity and its relation to tectonic elements of the OTF (transform valley, strike-slip fault trace, bounding walls). Both features were studied using a network of long-term ocean-bottom-seismometers and a seafloor geodetic network deployed for one year in 2023 aboard RV MARIA S. MERIAN during the cruise MSM122. All long-term stations deployed in 2023 were recovered during M204. Furthermore, (iii) magnetic data were collected to obtain the magnetisation of the basement of both the OTF and fracture zones, testing the newly proposed model of crustal accretion at OTFs. Last, we studied heat flow over the transform fault and searched for hydrothermal activity.

Narrative of the Cruise

25.09. to 27.09.2024: Port call of RV METEOR in Bridgetown, Barbados; port logistics and mobilisation of equipment; cruise participants entering the vessel on 25th of September to setup labs and equipment in port.

27.09.2024: Leaving port at 5:30 local time; begin of the transit into working area at Oceanographer transform fault near 35°N/35°W offsetting the Mid-Atlantic Ridge (MAR) by 120 km. Weather and wave conditions were rather fair, giving all participants and crew a “soft start”.

28.09.2024: 12:00 UTC: After leaving the territorial waters of Barbados, underway oceanographic and geophysical data acquisition begins, including mapping along track seafloor morphology using the Kongsberg’s EM122 swath mapping echo sounder. During the transit, the shortest distance track with a constant bearing was modified to nurture a programme charting proposed but unmapped seamounts, targeting six candidates between the EEZ of Barbados and the Atlantis transform fault near 30°N.

01.09.2024**:** In the night METEOR runs through the eye of the former tropical depression “Joyce”, experiencing very calm conditions. However, later after leaving the eye an unexpected strong thunderstorm and strong wind and gusts reaching 11-12 Bft hit the vessel. At 7:00 local time the worst was over.

03.10.2024 - 06:15-15:15 UTC: On 14th March 2024 the Mid-Atlantic Ridge near 29°45’N (to the south of the Atlantis transform fault) was hit by a seismic swarm. To study if this swarm was associated with magmatic activity and possibly subsequent hydrothermal activity, we search for hydrothermal activity using five “Miniature Autonomous Plume Recorders” (MAPR) deployed at 50 m intervals. The search was conducted running a “tow-yo” survey to study the water mass 100 m to 1 km above the seafloor; 16:00 UTC: MAPR survey terminated. For the remaining transit, we deviated from a great circle path and follow exactly the axis of the MAR as defined in previous studies, mapping the seafloor using the EM122 to study the segmentation of the MAR and non-transform offsets in detail. The survey was concluded three days later after reaching the Oceanographer transform. In total, this modified transit only lasted a few hours longer than a great circle path, but we gained modern high-resolution data from the neo-volcanic zone of the MAR.

05.10.2024: Local time is now GMT-1 hour; 07:15 UTC: Deployment of the magnetometer tow fish to study the magnetization of the seafloor. The sensor is towed 350 m behind the stern of the vessel. The survey line is going to provide cross-overs with magnetic field measurements conducted with RV MARIAS S. MERIAN during its cruise MSM122 along the Hayes transform. Our new profile crosses the six profiles existing lines diagonally; 16:50 UTC: Magnetometer programme concluded after recovery of tow fish.

06.10.2024- 05:45 UTC: Swath-mapping survey along the crest of the MAR; mapping

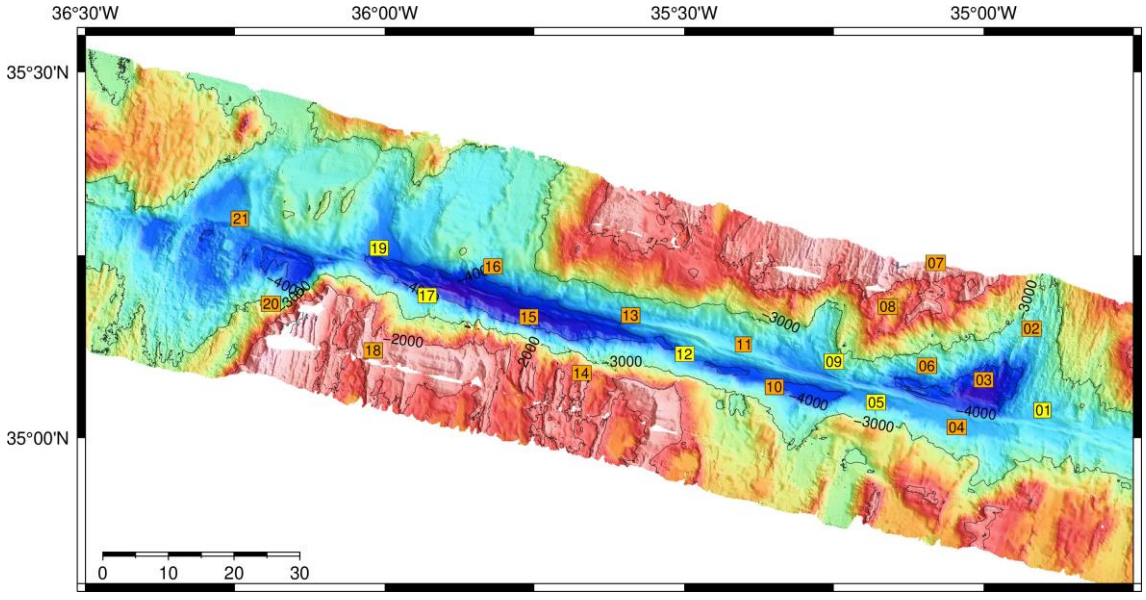


Fig 1: Location map of recovered ocean-bottom-seismometers (orange: short period OBS; yellow: broadband OBS)

is suspended after reaching the Oceanographer transform fault; 05:59-07:50: measurement of sound velocity profile (SVP probe of RV METEOR); 07:22 UTC onwards: begin of recovery of 21 OBS deployed during MSM122 in October 2023; release of OBS21; 19:01 UTC: OBS12 recovered; in total, 9 OBS recovered (OBS21 to OBS13); 21:16-21:57 UTC: Test of an acoustic modem to establish communication with seafloor moored geodetic transponders deployed during MSM122. Test failed and station terminated; 22:17 UTC: deployment of magnetometer tow fish for second magnetometer programme to densify and add lines to a magnetic survey conducted in 2023 during MSM122 along the Oceanographer.

07.10.2024: Hurricane Kirk was passing the working area, storm approached rapidly with 17 kn from the southwest, later turning northeastward to run northward of the Azores towards the Bay of Biscay, bringing rough sea with up to 4 m tall wave, wind of 6-7 Bft. and gusts of up to 10 Bft., hindering station work in the study area; hence, magnetic survey was continued.

08.10.2024- 07: 40 UTC: Magnetic and swath mapping suspended; magnetometer recovered; 08:07 UTC onwards: OBS12 released and 1 h 10 min. later on deck; 18:25 UTC: OBS05 on deck; during the day OBS12 to OBS05 were recovered; 20:22 UTC: first heat flow station; heat probe with five autonomous data loggers attached to 3 m long strength member deployed; deployment is facilitated using deep-sea winch W12.

09.10.2024: 06: 39 UTC: Heat probe after 4 measurements recovered, including one inspection of the probe on deck at 03:01.; station M204-23 concluded; 08:16 UTC onwards: OBS04 released and recovered 1 h 3 min. later; 13:53 UTC: last OBS01 successfully recovered. All OBS deployed one year earlier during MSM122 were back on deck; 17:37-23:43: second heat flow station; heat probe with five autonomous data logger attached to 3 m long strength member deployed; deployment with W12; three successful sites and probe inspection at 23:14 UTC: station M204-28 concluded.

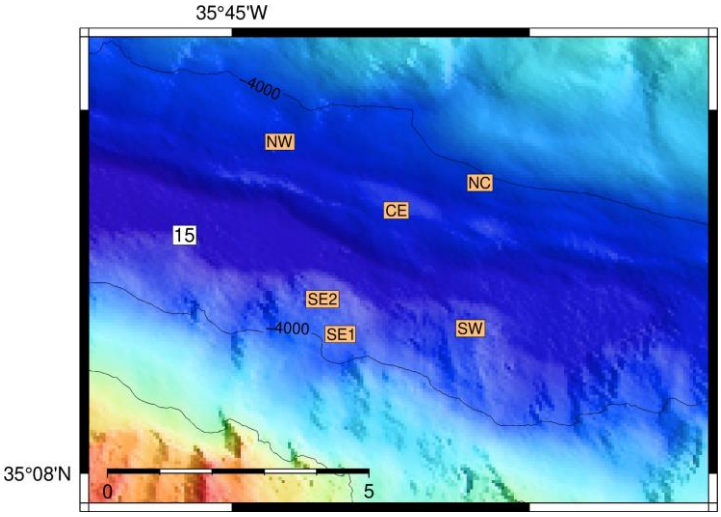


Fig 2: Location map of seafloor geodetic network

10.10.2024 - 04: 01 UTC: Strong wind and swell made it impossible to keep the vessel at the station and the ship was sometimes rolling heavily. Station was abandoned after two additional successful heat flow measurements; station M204-35 concluded; 08:18 UTC onwards: release of the first seabed moored geodetic transponder; 1 h 30

min later, instrument recovered; 17:32 UTC: The last of six geodesy transponders recovered. Again, all six instruments deployed during MSM122 were safely back on the vessel; 18:00 UTC: 3rd heat flow station; heat probe with five autonomous data logger attached to 3 m long strength member deployed; 100 m and 150 m above the heat probe two MAPR are attached to the cable of the W12 connecting the heat probe with the ship; two measurements, station M204-35 concluded; 23:00 UTC: Deployment of magnetometer tow fish for third magnetometer programme to provide cross-overs and add lines to a magnetic survey conducted in 2023 during MSM122 along Oceanographer.

11.10.2024 - 14: 22 UTC: Magnetometer recovered; 15:12 UTC: 4th heat flow station with 2x MAPR at 100 and 150 m above heat probe; 19:50 UTC Heat probe after three measurements on deck; MAPRs recovered; heat flow station M204-37 concluded; 23:50 UTC: 5th Heat flow station; two measurements.

12.10.2024- 02:43 UTC: Heat probe on deck and station M204-38 concluded; 06:21 UTC: 6th and last heat flow station (continuation of station #2); five measurements; 12:28 UTC: Heat probe on deck and station M204-39 concluded; 14:45 UTC onwards: MAPR tow-yo survey at eastern inside corner of Oceanographer with 5 MAPRs and Posidonia USBL positioning system; 21:57 UTC: MARPRs and Posidonia recovered; station M204-40 concluded; 22:00 UTC Transit to Great Meteor Tablemount.

14.10.2024 - 18:11 UTC: Sound-velocity profile taken roughly 80 km to the west of the Meteor Seamount; 20:25 UTC onwards: begin swath mapping of the Great Meteor Seamount with the EM122 swathmapping echosounder; at water depth <2000 m the EM710 was used to complement measurements.

16.10-2024 – 20:18 UTC: end of bathymetric survey of Great Meteor Seamount; transit to Las Plamas.

18:10.2024: at 1 a.m. we reached the territorial waters of Spain and all scientific measurements were concluded.

19.10.2024: at 7 a.m. METEOR sailed past the island of La Palma.

20.10.2024: at 8:25 a.m. pilot enters vessel off the port of Las Palmas; on 9:25 METEOR cruise M204 terminates, unloading of equipment during the day.

Acknowledgments

We are thanking Master Detlef Korte and the crew of the RV METEOR cruise M204 for excellent sea-going support and a great working environment. The work conducted during this cruise was funded by the Deutsche Forschungsgemeinschaft (DFG) through the grant GPF23-2/038, the GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany and the European Union (ERC-TRANSFORMERS-101096190).

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Station Lists

Station No.		Deployment	Recovery	Latitude	Longitude	Water Depth
METEOR	Sci Party	Date	Date	[°N]	[°W]	[m]
M204-27	OBS01	22.10.23	09.10.24	35°02,276	34°54,000	3627
M204-26	OBS02	21.10.23	09.10.24	35°09,000'	34°55,220'	3344
M204-25	OBS03	21.10.23	09.10.24	35°04,820'	35°04,820'	4503
M204-24	OBS04	21.10.23	09.10.24	35°06,590‘	35°02,730‘	3710
M204-22	OBS05	21.10.23	08.10.24	35°02,950‘	35°10,820‘	3814
M204-21	OBS06	22.10.23	08.10.24	35°05,960‘	35°06,720‘	3452
M204-20	OBS07	22.10.23	08.10.24	35°14,409‘	35°04,816‘	1485
M204-19	OBS08	22.10.23	08.10.24	35°10,805‘	35°09,604‘	2385
M204-18	OBS09	22.10.23	08.10.24	35°06,278‘	35°14,998‘	3685
M204-17	OBS10	22.10.23	08.10.24	35°04,202‘	35°21,025‘	4047
M204-16	OBS11	22.10.23	08.09.24	35°07,707‘	35°24,004‘	3511
M204-15	OBS12	22.10.23	08.10.24	35°06,872‘	35°30,023‘	3865
M204-12	OBS13	22.10.23	06.10.24	35°10,080‘	35°35,383‘	3693
M204-11	OBS14	22.10.23	06.10.24	35°05,314‘	35°40,323‘	2127
M204-10	OBS15	22.10.23	06.10.24	35°09,961‘	35°45,606‘	4552
M204-9	OBS16	22.10.23	06.10.24	35°14,103‘	35°49,233‘	3491
M204-8	OBS17	22.10.23	06.10.24	35°11,703‘	35°55,753‘	3816
M204-7	OBS18	22.10.23	06.10.24	35°07,170‘	36°01,200‘	1648
M204-6	OBS19	22.10.23	06.10.24	35°15,610‘	36°00,620‘	3891
M204-5	OBS20	22.10.23	06.10.24	35°11,030‘	36°11,360‘	3171
M204-4	OBS21	22.10.23	06.10.24	35°18,020‘	36°14,360‘	3781

Tab. 1: Recovery of Ocean-Bottom-Seismometers

Station No.		Deployment	Recovery	Latitude	Longitude	Water Depth
METEOR	Sci Party	Date		[°N]	[°W]	[m]
M204-30	2201 - NC	24.10.23	10.10.24	35°10,519‘	35°41,880‘	4071
M204-29	2202 - SW	24.10.23	10.10.24	35°09,031‘	35.41,984‘	4282
M204-34	2203 - NW	25.10.23	10.10.24	35°10,909‘	35°44,412‘	4209
M204-33	2204 - SE2	25.10.23	10.10.24	35°09,322	35°43,821‘	4272
M204-31	2205 - CW	25.10.23	10.10.24	35°10,238‘	35°42,907‘	4226
M204-32	2206 - SE1	26.10.23	10.10.24	35°08,971'	35°43,603‘	4138

Tab. 2: Recovery of seafloor geodesy stations

Station name	Profile No.	Long. begin	Lat. begin	Day/time	Long. end	Lat. end	Day/time	Comment
METEOR	Sci. Party	[°W]	[°N]	[jday / time]	[°W]	[°N]	[jday / time]	
M204-2	P01	39.01596	33.64306	279 / 09:22	37.80867	33.73163	279 / 15:23	Hayes
M204-14	P02	35.33036	35.33705	280/ 01:16	33.75179	35.02851	280 / 10:21	N of Oceano.
M204-14	P03	33.81009	34.83830	280 / 11:48	34.70491	34.98260	280 / 17:27	E of Oceano.
M204-14	P04	34.90586	34.74619	280 / 19:31	34.52083	34.66862	280 / 21:38	S of Oceano.
M204-14	P05	34.53220	34.55271	280 / 22:25	35.45853	34.74564	281 / 04:11	S of Oceano.
M204-36	P06	35.43290	34.74233	285 / 03:01	36.78045	34.93801	285 / 10:46	S of Oceano.

Tab. 3: Magnetic field measurements – profile coordinates of begin and end points

Station name	Long. begin	Lat. begin	Day/time	Long. end	Lat. end	Day/time	Comment
METEOR	[°W]	[°N]	[jday / time]	[°W]	[°N]	[jday / time]	
M204-1	42° 48,008'	29° 45,149'	277 / 06:23	42° 45,883'	29° 53,522'	277 / 15:11	5 MAPRS Tow-yo
M204-35	35° 45,529'	35° 10,235'	284/ 18:22	35° 45,718'	35° 10,433'	284 / 22:27	2 MAPRS
M204-37	36° 16,700'	35° 18,242'	285 / 15:20	36° 17,969'	35° 18,242'	285 / 19:44	2 MAPRS
M204-40	34° 58,812'	35° 13,477'	286 / 14:47	35° 02,275'	35° 09,384'	286 / 21:55	5 MAPRS Tow-yo.

Tab. 4: Plume hunting – deployment of miniature autonomous plume recorders (MAPRS)

Station name	Heaf flow station	Day/time	Long. begin	Lat. begin	Depth	Number sensors	Comment
METEOR		[jday / time]	[°W]	[°N]	[m]		
M204-23	HF01P01	282 / 21:44	35.24482	35.05822	4015	3	
M204-23	HF01P02	282/ 23:33	35.25425	35.05988	4018	2	
M204-23	HF01P03	283 / 02:11	35.26402	35.06192	4026	0	failed
M204-37	HF02P01	283 / 05:15	35.29352	35.06768	4025	3	
M204-28	HF03P01	283 / 18:37	35.26657	35.1548	3460	3	
M204-28	HF03P02	283 / 20:08	35.27073	35.14557	3473	3	
M204-28	HF03P03	283 / 21:55	35.27492	35.13615	3483	3	
M204-35	HF04P01	284 / 00:40	35.27898	35.12682	3576	6	
M204-35	HF04P02	284 / 01:57	35.28302	35.1182	3714	4	
M204-37	HF05P01	284 / 19:42	35.75965	35.16988	4545	2	
M204-37	HF05P02	284 / 20:45	35.76995	35.17147	4562	0	failed
M204-37	HF06P01	285 / 16:25	36.27982	35.3042	3798	5	
M204-37	HF06P02	285 / 17:38	36.29073	35.30612	3819	5	
M204-38	HF06P03	285 / 18:38	36.2995	35.30825	3835	5	
M204-38	HF07P01	285 / 23:49	35.87988	35.21322	4663	2	
M204-38	HF07P02	286 / 01:08	35.86997	35.19683	4655	3	
M204-39	HF08P01	286 / 07:26	35.28683	35.10875	3702	5	
M204-39	HF08P02	286 / 08:36	35.2906	35.09987	3767	3	
M204-39	HF08P03	286 / 10:01	35.29465	35.09057	3862	3	
M204-39	HF08P04	286 / 11:12	35.29875	35.08117	3708	3	

Tab. 5: Heat flow sites