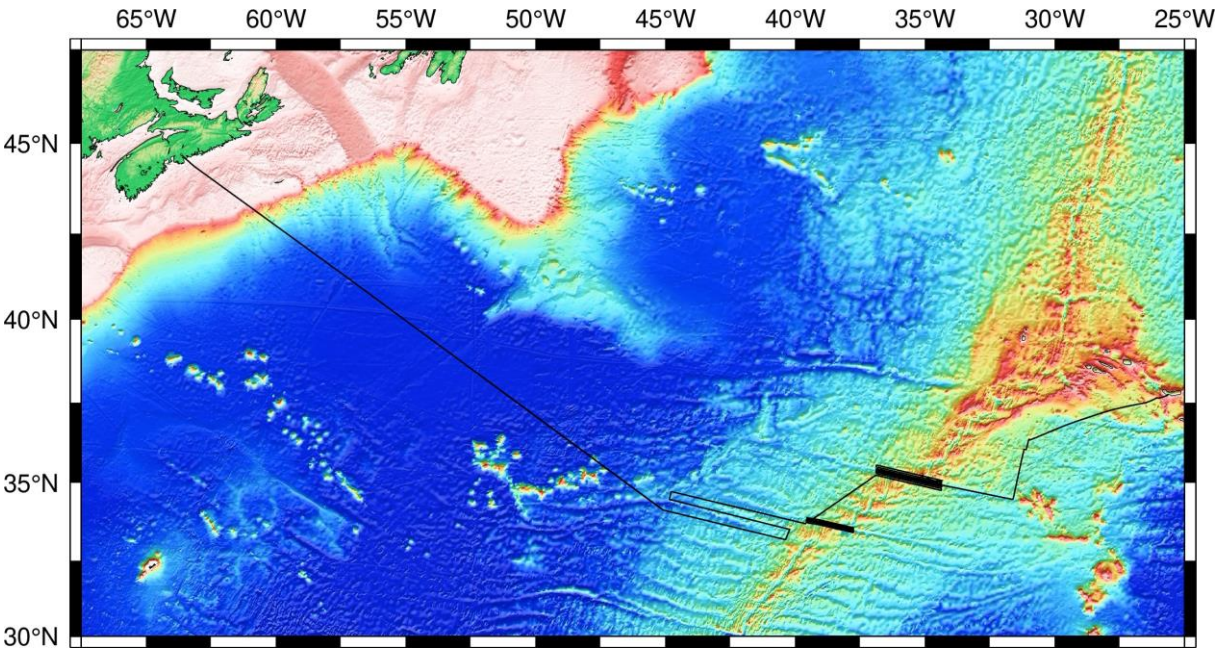
Ingo Grevemeyer
GEOMAR Helmholtz Zentrum für Meeresforschung
Forschungsbereich 4 / Abt. Marine Geodynamik
Wischhofstraße 1-3
D-24148 Kiel

Tel: +49 431 600 2336
Fax: +49 431 600 2922
Email: igrevemeyer@geomar.de

Short Cruise Report

RV MARIA S. MERIAN Cruise MSM122

Ponta Delgada, Azores, Portugal – Halifax, Canada
19. October – 9. November 2023
Chief Scientist: Ingo Grevemeyer
Captain: Ralf Schmidt



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 MSM122, we like to test 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) with a network of long-term OBS and a seafloor geodetic network deployed for one year. Further, (iii) magnetic gradiometry will be used to obtain the magnetisation of the basement of both the OTF and fracture zones, testing the newly proposed model of crustal accretion at OTFs.

Narrative of the Cruise

16.10. to 18.10.2023: Port call of RV MARIA S. MERIAN in Ponta Delgada, Azores, Portugal; port logistics and mobilisation of equipment; first cruise participants entering the vessel on 17rd of October to prepare equipment for deployment during MSM122 in port.

19.10.2023: Leaving port at 8:30 local time; begin of the transit into working area at Oceanographer transform fault near 35°N/35°W offsetting the Mid-Atlantic Ridge by 120 km. Weather and wave conditions were rather rough, preventing the scientific party to prepare equipment over the next two days on the main deck. Preparations in the hangar and in the labs are ongoing.

20.10.2022: releaser test: calling seabed installed equipment back to the sea surface requires an acoustic releaser system; functionality of releasers was tested by lowering them down to 1 km; two “dips”; 16:27 UTC leaving territorial waters of Azores/Portugal; underway geophysics recording the seafloor morphology along the track using Kongsberg’s EM122 swath mapping echo sounder; 21:12 UTC collection of a reference Parasound Echosounder profile while approaching the eastern branch of the fracture zone of the Oceanographer; 23:50 UTC reaching the fracture and beginning with the scientific programme of MSM122 and hence the first station MSM122-1, mapping seafloor morphology and sediment structure using the EM122 and the Parasound, respectively.

21.10.2023: Weather conditions improved and preparation of ocean-bottom-seismometers for deployment is concluded; 16:48 UTC suspending seafloor mapping; 16:52-18:40 collecting the sound velocity profile of the ocean down to 3356 m to allow precise depth calculations for the EM122 echosounder; 21:40 UTC begin deployment of 21 Ocean-Bottom-Seismometers along the Oceanographer (deployment of OBS02 to OBS05)

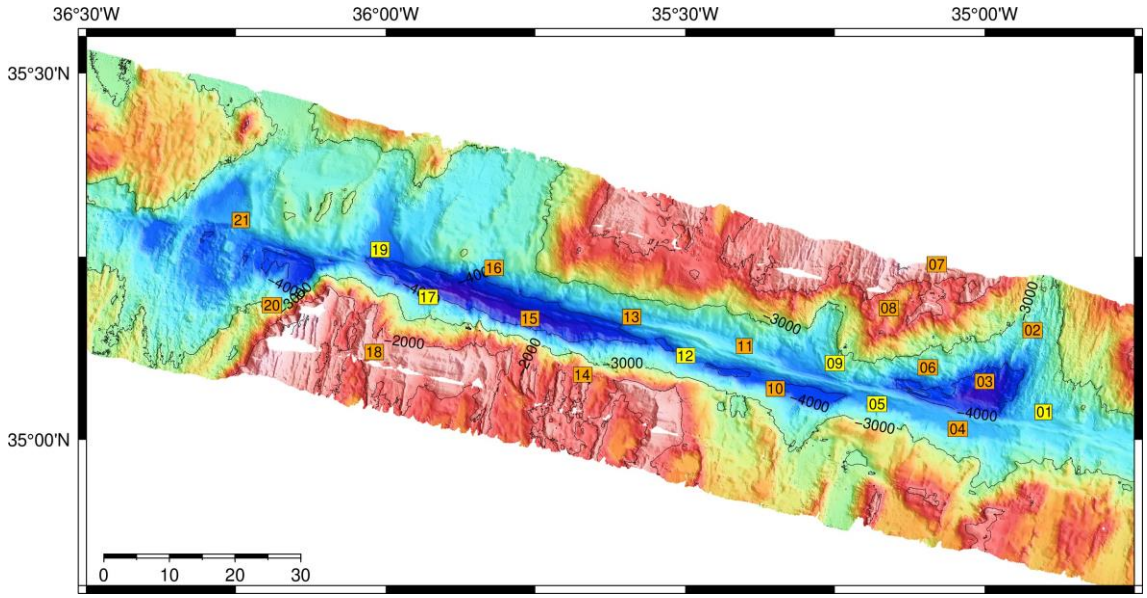


Fig 1: Location map of deployed ocean-bottom-seismometers (orange: short period OBS; yellow: broadband OBS)

22.18.2022: 00:00-09:56 UTC OBS deployment continued (deployment OBS06, OBS07, OBS08, OBS10, OBS11, OBS13, OBS14, OBS15, OBS16, OBS18, OBS19, OBS20, OBS21); 11:54-14:44 UTC video-controlled deployment of OBS17; 16:48-18:06 UTC deployment of OBS12 and OBS09; 19:55-22:30 UTC video-controlled deployment of OBS01; 22:48 UTC seployment of magnetic gradiometer.

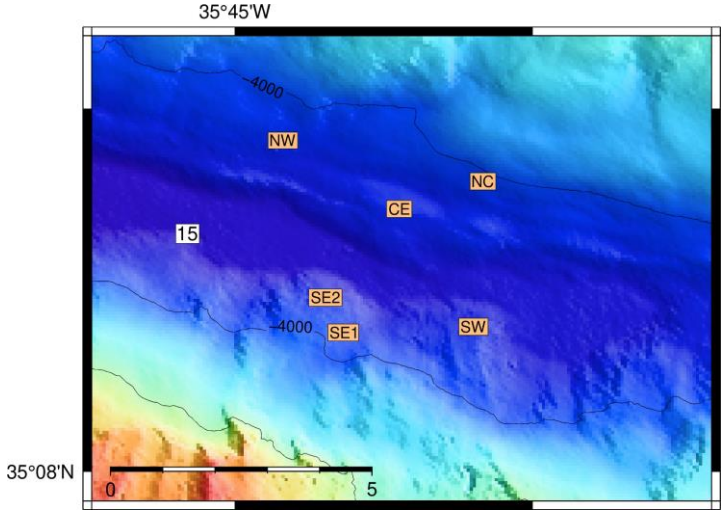


Fig 2: Location map of seafloor geodetic network

23.10.2023: 01:56 UTC magnetic and swath mapping of Oceanographer transform; Preparation seafloor geodetic stations for deployment.

24.10.2023: 11: 01 UTC magnetic and swath mapping suspended and recovery magnetometer; 11:57-21:00 cable guided deployment of seafloor geodesy stations NC & SW, including establishing communication among stations before release; 21:11 UTC deployment of magnetic gradiometer; magnetic and swath mapping of Oceanographer transform continued.

25.10.2023: 10: 15 UTC magnetic and swath mapping suspended and recovery magnetometer; 10:56-21:07 UTC cable guided deployment of seafloor geodesy stations NW, SE2 & CW, including establishing communication among stations before release; 21:12 UTC deployment of magnetic gradiometer; magnetic and swath mapping of Oceanographer transform continued.

26.10.2023: 11: 44 UTC magnetic and swath mapping suspended and recovery magnetometer; 12:22-15:43 UTC cable guided deployment of seafloor geodesy station SE1, including establishing communication among stations before release; 15:52 UTC deployment of magnetic gradiometer; magnetic and swath mapping of Oceanographer transform continued.

28.10.2023: 07: 15 UTC magnetic and swath mapping suspended and recovery magnetometer; 08:09-10:43 UTC hydrophone of the geodetic deck unit deployed, communication with all seafloor geodetic stations established and data uploaded. Network is fully operational; 10:51 UTC deployment of magnetic gradiometer; magnetic and swath mapping of Oceanographer transform continued.

29.10.2023: 07: 37 UTC magnetic and swath mapping of Oceanographer transform fault completed; 07:38 UTC transit to Hayes transform fault about 120 sm to the south west; underway geophysical data collection of EM122 and magnetics; 23:47 UTC magnetic and EM122 survey of Hayes transform fault.

01.11.2023: 08: 43 UTC magnetic and swath mapping of Hayes transform fault completed; 09:59 UTC magnetic and EM122 survey of an abandoned transform fault to the southwest of Hayes.

04.11.2023: 13: 10 UTC magnetic and swath mapping of abandoned transform fault completed; 13:11 UTC transit to Halifax with underway geophysics, including magnetics.

06.11.2023: 15:20 UTC cable between the two magnetometer sensors of the gradiomenter is damaged. The cable shows signed of a shark attack; 19:30 UTC magnetometer is back in operation in a single sensor mode.

07.11.2023: 13:28 UTC all scientific operations are concluded and the magnetometer is recovered before the vessel reaches the EEZ of Canada.

08.11.2023 after a rough start, much of the cruise was blessed with rather fair-weather conditions, though a handful of days provided short periods with up to 6 Bft and waves of up to 3 m. However, before reaching Halifax, a low-pressure system near

Newfoundland brought rough conditions. Wind speed picked to over 20 m/s (8-9 Bft) up during the day, causing the waves of up to 4 m and cool temperatures of 7°C.

09.11.2023: 08:00 LT Meeting the pilot; 08:30 LT Vessel is at the pier and the cruise terminates in Halifax.

Acknowledgments

We are thankfully to Master Ralf Schmidt, and the crew of the RV MARIA S. MERIAN cruise MSM122 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 GPF22-1/039, the GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany and co-funding for operating broadband OBS from the European Union (ERC-TRANSFORMERS-101096190).

Cruise participants

Name	Discipline	Institution
Grevemeyer, Ingo, chief scientist	OBS, magnetics	GEOMAR
Rüpke, Lars, scientist	Bathymetry, magnetics	GEOMAR
Dyment, Jerome, scientist	Magnetics	IPGP
Filbrandt, Christian, scientist/technician	OBS, geodesy	GEOMAR
Feldtmann, Debroah, scientist	Geography	CAU
Zhang, Yinuo, scientist	Bathymetry	GEOMAR
Bauer, Benedikt, student	OBS, geodesy	CAU / GEOMAR
Kahler, Merit, student	OBS, bathymetry	CAU / GEOMAR
Ritter, Josefa, student	OBS, bathymetry	CAU / GEOMAR
Hörnemann, Josina, student	OBS, bathymetry	CAU / GEOMAR
Schweigkofler, Felix, scientist	Bathymetry	GEOMAR

GEOMAR Helmholtz Zentrum für Meeresforschung Kiel,
Wischhofstraße 1-3,
24148 Kiel
Germany

CAU Christian-Albrechts Universität zu Kiel
Otto-Hahn-Platz
24108 Kiel
Germany

IPGP Institute de Pysique du Globe de Paris
Université de Cité
1 Rue Jussieu, 75005 Paris
France

Station Lists

Ocean-Bottom-Seismometer (OBS) & Seafloor geodetic network

Station No.		Deploy-ment	Time release	Latitude	Longitude	Water Depth
MERIAN	Sci Party	Date		[°N]	[°W]	[m]
MSM122-3	OBS02	21.10.23	n/a-	35°09,000'	34°55,220'	3344
MSM122-4	OBS03	21.10.23	01.09.2025 02:00	35°04,820'	35°04,820'	4503
MSM122-5	OBS04	21.10.23	01.09.2025 03:00	35°06,590‘	35°02,730‘	3710
MSM122-7	OBS06	22.10.23	01.09.2025 04:00	35°05,960‘	35°06,720‘	3452
MSM122-8	OBS07	22.10.23	01.09.2025 05:00	35°14,409‘	35°04,816‘	1485
MSM122-9	OBS08	22.10.23	01.09.2025 06:00	35°10,805‘	35°09,604‘	2385
MSM122-10	OBS10	22.10.23	01.09.2025 07:00	35°04,202‘	35°21,025‘	4047
MSM122-11	OBS11	22.10.23	01.09.2025 08:00	35°07,707‘	35°24,004‘	3511
MSM122-12	OBS13	22.10.23	01.09.2025 09:00	35°10,080‘	35°35,383‘	3693
MSM122-13	OBS14	22.10.23	01.09.2025 10:00	35°05,314‘	35°40,323‘	2127
MSM122-14	OBS15	22.10.23	01.09.2025 11:00	35°09,961‘	35°45,606‘	4552
MSM122-15	OBS16	22.10.23	01.09.2025 12:00	35°14,103‘	35°49,233‘	3491
MSM122-16	OBS18	22.10.23	01.09.2025 13:00	35°07,170‘	36°01,200‘	1648
MSM122-18	OBS20	22.10.23	01.09.2025 14:00	35°11,030‘	36°11,360‘	3171
MSM122-19	OBS21	22.10.23	01.09.2025 17:00	35°18,020‘	36°14,360‘	3781

Tab. 1: Deployment of short-period OBS

Station No.		Deploy-ment	Time release	Latitude	Longitude	Water Depth	Comment
MERIAN	Sci Party	Date		[°N]	[°W]	[m]	
MSM122-23	OBS01	22.10.23	01.09.25 22:00	35°02,276	34°54,000	3627	Video guided
MSM122-6	OBS05	21.10.23	02.09.25 04:00	35°02,950‘	35°10,820‘	3814	
MSM122-22	OBS09	22.10.23	01.09.25 23:00	35°06,278‘	35°14,998‘	3685	
MSM122-21	OBS12	22.10.23	02.09.25 01:00	35°06,872‘	35°30,023‘	3865	
MSM122-20	OBS17	22.10.23	02.09.25 03:00	35°11,703‘	35°55,753‘	3816	Video guided
MSM122-17	OBS19	22.10.23	02.09.25 05:00	35°15,610‘	36°00,620‘	3891	

Tab. 2: Deployment of broad-band OBS

Station No.		Deploy-ment	Time release	Latitude	Longitude	Water Depth	Comment
MERIAN	Sci Party	Date		[°N]	[°W]	[m]	
MSM122-25	2201 - NC	24.10.23	02.09.25 02:00	35°10,519‘	35°41,880‘	4071	Launch system
MSM122-26	2202 - SW	24.10.23	01.09.25 18:00	35°09,031‘	35.41,984‘	4282	Launch system
MSM122-28	2203 - NW	25.10.23	01.09.25 20:00	35°10,909‘	35°44,412‘	4209	Launch system
MSM122-29	2204 - SE2	25.10.23	01.09.25 19:00	35°09,322	35°43,821‘	4272	Launch system
MSM122-30	2205 - CW	25.10.23	01.09.25 16:00	35°10,238‘	35°42,907‘	4226	Launch system
MSM122-32	2206 - SE1	26.10.23	01.09.25 15:00	35°08,971'	35°43,603‘	4138	Launch system

Tab. 3: Deployment of seafloor geodesy stations using a cable guided launch system

Magnetic survey profiles

Station name	Profile No.	Long. begin	Lat. begin	Day/time	Long. end	Lat. end	Day/time	Comment
		[°W]	[°N]	[jday / time]	[°W]	[°N]	[jday / time]	
MSM122-24	P01	34.347834	35.071443	296 / 01:53	36.866642	35.555943	296 / 15:53	Gradiometer
MSM122-24	P02	36.801638	35.483065	296/ 15:35	34.380162	35.017101	297 / 03:46	Gradiometer
MSM122-24	P03-1	34.385602	34.968100	297 / 04:10	35.666090	35.215065	297 / 10:42	Gradiometer
MSM122-27	P03-2	35.652019	35.212533	297 / 21:50	36.881594	35.430022	298 / 04:05	Gradiometer
MSM122-27	P04-1	36.860841	35.414070	298 / 04:15	35.739883	35.199374	298 / 09:51	Gradiometer
MSM122-31	P04-2	35.690371	35.189341	298 / 21:41	34.385351	34.938012	299 / 04:16	Gradiometer
MSM122-31	P05-1	34.377038	34.896576	299 / 04:37	35.720809	35.155679	299 / 11:24	Gradiometer
MSM122-33	P05-2	35.714886	35.154707	299 / 16:27	36.868550	35.375871	299 / 22:21	Gradiometer
MSM122-33	P06	36.801638	35.483065	299 / 22:50	34.380162	35.017101	300 / 11:20	Gradiometer
MSM122-33	P07	34.365015	34.913284	300 / 11:31	36.862500	35.394690	301 / 00:15	Gradiometer
MSM122-33	P08-1	36.877807	35.297944	301 / 00:55	35.786457	35.087690	301 / 06:31	Gradiometer
MSM122-35	P08-2	35.756780	35.082353	301 / 11:34	34.381764	34.817322	301 / 18:33	Gradiometer
MSM122-35	P09	34.376335	34.756621	301 / 18:58	36.967813	35.195707	302 / 08:10	Gradiometer
MSM122-36	T10	36.977402	35.190231	302 / 08:13	39.527298	33.740485	302 / 23:48	Gradiometer
MSM122-37	H11	39.506258	33.719601	302 / 23:55	37.758382	33.411671	303 / 09:10	Gradiometer
MSM122-37	H12	37.763895	33.451362	303 / 09:17	39.517565	33.766270	303 / 18:16	Gradiometer
MSM122-37	H13	39.515763	33.790931	303 / 18:29	37.779534	33.479133	304 / 03:25	Gradiometer
MSM122-37	H14	37.766478	33.476283	304 / 03:28	39.518566	33.811457	304 / 12:37	Gradiometer
MSM122-37	H15	39.467821	33.829768	304 / 13:04	37.772236	33.522769	304 / 21:47	Gradiometer
MSM122-37	H16-1	37.759103	33.564999	304 / 22:05	37.860481	33.585082	304 / 22:37	Gradiometer
MSM122-37	H16-2	37.970295	33.605968	305 / 00:37	39.525033	33.882000	305 / 08:43	Gradiometer
MSM122-37	SH17	39.597045	33.694020	305 / 09:59	44.766066	34.718828	306 / 12:25	Gradiometer
MSM122-37	SH18	44.839259	34.469746	306 / 14:05	40.224218	33.511769	307 / 13:46	Gradiometer
MSM122-37	SH19	40.378200	33.180696	307 / 15:56	45.087006	34.131006	308 / 16:10	Gradiometer
MSM122 to Halifax	T20	45.107383	34.141882	308 / 16:17	52.902983	38.773995	310 / 15:19	Gradiometer
MSM122 to Halifax	T21	53.321470	39.040295	310 / 18:27	57.134164	41.169289	311 / 17:28	Single sensor

Tab. 4: Magnetic field measurements – coordinates of begin and end points