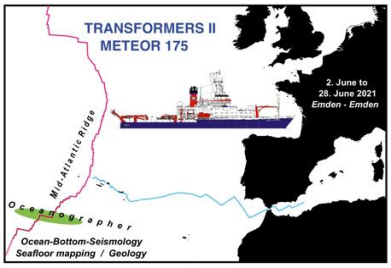
PD Dr. Thor H. Hansteen
GEOMAR Helmholtz - Zentrum für Ozeanforschung Kiel
Wischhofstr. 1 - 3, D - 24148 Kiel, Germany
Phone: +49 431 600 2130
Email: thansteen@geomar.de



R/V METEOR
Short Cruise Report
Cruise M175 (GPF 20-3_090)

Emden, Germany – Emden, Germany
02 June – 28 June 2021

Chief Scientist: Thor H. Hansteen
Captain: Rainer Hammacher

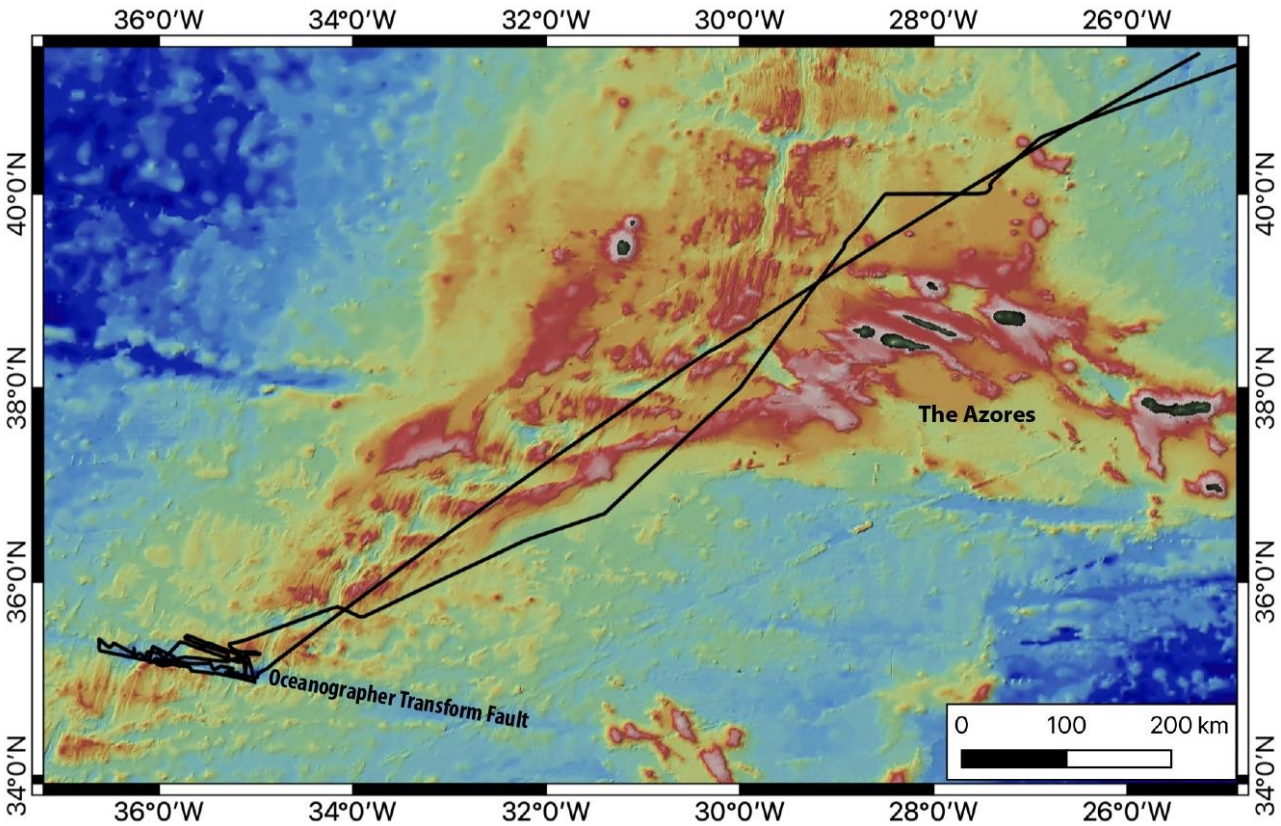


Fig. 1: Cruise track of M175 between the Azores and the main work area.

Objectives

Oceanic transform faults are ubiquitous features of the seafloor, and occur in all major oceans worldwide. They represent offsets between the spreading segments of mid-ocean ridges, and are typically viewed as conservative plate boundaries connecting active segments. Contrary to this idealised view of plate tectonics, recent scientific efforts indicate that oceanic transform faults are not conservative plate boundaries, but that they are shaped by two stages of magmatic accretion, separated by a tectonic phase stretching the transform valley while crust and lithosphere are moved along the transform fault. Global observations show that transform valleys are always much deeper than the associated fracture zones, suggesting that transform valleys are buried before being converted to fracture zones. The burial of transform valleys is supposed to be related to a second phase of magmatic activity as the plate moves along the ridge-transform-intersection (RTI), which can readily be identified in seafloor imagery and seafloor geology. The main aim of the M175 cruise is to test this hypothesis by combining seismic investigations, seafloor morphology, geological sampling and video recordings of the seafloor at the major Oceanographer Transform Fault, located to the southwest of the Azores. The cruise is a continuation of the aborted M170 cruise in January 2021, during which ocean-bottom seismometers were deployed but only partly recovered, bathymetric data were recorded, and geological sampling had begun. Accordingly, the M175 cruise focussed on the recovery of OBS, and on geological sampling and video observations.

Narrative of the cruise

The scientific team embarked the R/V METEOR in Emden in the afternoon of June 1, 2021. The ship left the port of Emden in the morning of June 2, entering and following the river Ems towards the North Sea under good weather conditions. Calm weather accompanied us along the coasts of The Netherlands and Belgium. The scientists used the first two days of transit to prepare the ship´s labs, and for initial set-up of equipment needed. Entering the English Channel on June 3 brought foggy but still calm weather. We used the next couple of days for specific instructions to all cruise participants about the functioning and usage of the diverse equipment, and for explanations of the planned work flows. At noon on June 6, R/V METEOR left the British EEZ off the Bay of Biscay, and the underway data acquisition started. They included continuous EM 122 swath bathymetry, 38 and 75 kHz ADCP, and daily seawater bottle sampling for later TSG analyses. The calm weather continued during transit, and helped us reach the Azores archipelago already during daytime on June 8 (Fig. 1). In the afternoon of June 9, we had crossed the submarine Azores Platform from the NE to the SW, and reached water depths of about 2500m, enough to deploy an expandable bathythermograph (XBT). The data was used to derive a local seawater sound velocity profile, important for correcting the multibeam echosounder bathymetry data to be obtained from the work area.

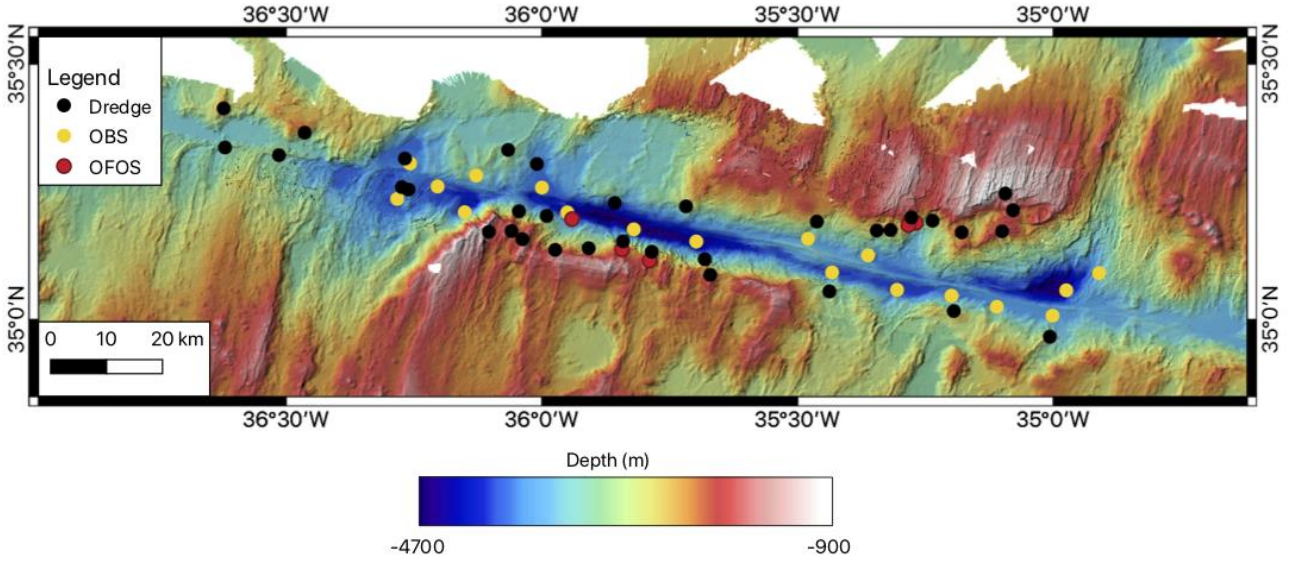


Fig. 2: Station work at the Oceanographer Transform Fault during M175.

We arrived in the work area, the Oceanographer Transform Fault (OTF), in the morning of June 10, and turned off the 38 kHz ADCP due to possible interference with other hydroacoustic equipment like the "Parasound" (sediment echosounder) and the Posidonia positioning system. We started the recovery of 18 ocean bottom seismometers (OBS) which were deployed but not recovered in January 2021 during the cruise M170. In the course of June 10, 9 OBS were recovered, and one re-deployed within the area of interest. The OBS were all located at the floor of the so far poorly investigated transform valley (Fig. 2), at distances between each station of only a few nm. In order to use the allotted ship time efficiently, the transits between the OBS locations were used to record several Parasound profiles across and along the transform valley floor, giving evidence for broken-up and irregular strata. On June 10, the essential on-board EM122 multibeam echosounder had a very unusual total failure, which could only be repaired by the ship's crew the next day by substituting electronic boards from the computer system operating the on-board EM710 multibeam echosounder. During June 11, another 8 OBS were successfully recovered, however, one OBS confirmed its release but did not surface. We ranged and re-released this OBS again on the same day and also two days later, but it was not possible to recover it, possibly due to rough ground conditions.

In the late afternoon of June 11, the first three dredges were hauled at the western ridge-transform intersection (RTI) of the OTF (Fig. 2). A prominent volcanic cone and a rugged lava field was obviously blanketed by clay-like mud, as we recovered mud only. Dredging continued on June 12 at the western outside corner (OC) of the OTF. Among the four dredge hauls here, one contained a basalt and a gabbro, two contained basalts, and one was empty. Following a few hours transit used to complete mapping of the western part of the working area in the night between June 12 and 13, dredging continued at the western inside corner (IC) of the OTF. One dredge contained serpentinised gabbro and basalt, and subordinate serpentinite, three further dredges contained pillow basalts, some with glassy rinds. One further dredge was hauled at the western inside corner, at a steep N-S-oriented ridge close to the RTI, and was practically empty, but contained minor rubble of biogenic carbonate. Early in the morning of June 14, dredging continued on the west part of the northern OTF shoulder, and yielded serpentinite and serpentinised gabbros, or

empty dredges. Still in the morning of June 14, the main winch was equipped with a coax cable for use with the OFOS (Ocean Floor Observations system) video camera.

The first two OFOS video tracks aimed at locating lithological boundaries in the western steep parts of the OTF south shoulders. During all dives, the OFOS was equipped with a Posidonia system for precise positioning, and a MAPR system (Miniature Autonomous Plume Recorder), to detect possible hydrothermal fluid emanations in hindsight. Moving downhill, the first OFOS track revealed thick pillow lava sequences, slowly transitioning into gabbros and dykes, and finally gabbro/ serpentinite intercalations. The second, semi-parallel track revealed lavas only. The third OFOS track was aimed at detecting hydrothermal fluids in the deep western sections of the OTF; data analyses will reveal the results in the coming weeks. The late night to June 15 was used to enhance the multibeam map of the eastern IC. The final two OFOS tracks were located in a scarp in the eastern IC. Moving downhill revealed a more than 400m thick lava pile, intercalated with gabbros at greater depths. In addition, the night to June 15 was used to enhance the multibeam map of the eastern IC. The only OBS re-deployed so far was recovered in the morning of June 16, as news emerged from the maker that the system may not have enough battery power to cover the planned period of deployment.

Dredging continued on June 16 with hauls at the eastern IC, producing basalts, gabbros and dykes. At deeper levels in the central northern OTF wall, gabbros and pyroxenites were recovered in the morning of June 17. Four dredges distributed along the upper shoulders of the western IC produced basaltic rocks. One further dredge at greater depths delivered basalts and gabbros. Further dredge hauls on June 18 from the eastern end of the OTF valley recovered basalts and gabbros. The last few dredges of the cruise were hauled in the night between June 18 and 19, and recovered basalt and volcaniclastic breccias. The very last dredge from the shallowest area of the eastern IC delivered fresh basalt, probably testifying to young volcanism in this area. After a short final mapping track, R/V METEOR left the main work area in the forenoon of June 19, and headed for the Azores. From here on, the 38 kHz ADCP and the EM 122 multibeam were used again for underway data collection.

During the transit back to Germany, on June 20 and 21, respectively, a total of four OBS were deployed on the Azores Platform inside the Portuguese EEZ, as part of a multinational effort to observe the regional-scale seismicity in the region. Helped by the excellent weather conditions, we entered the EEZ of England again in the evening of June 24, and ended the underway data acquisition of EM 122 mapping, 38 and 75 kHz ADCP and daily water sampling. On 25 June we entered the English Channel, and passed St. Anne islet and the Cherbourg peninsula at noon June 26 with a clear view. R/V METEOR called at the port of Emden in the morning of June 28, having successfully completed cruise M175.

Acknowledgements

We thank Captain Rainer Hammacher, the officers and the entire crew of R/V METEOR for their excellent support. They created a very professional working environment and contributed a lot to the success of this cruise. We furthermore acknowledge the professional patronage of the German Federal Foreign Office and the German Research Fleet Coordination Centre. We appreciate the support of the Ministry of Foreign Affairs of the Republic of Portugal for providing permission to work in their territorial waters. The expedition was funded by the German Research Foundation (DFG) and GEOMAR.

Participants

	Name	Function	Institution
1	Hansteen, Thor H.	Chief Scientist, geology	GEOMAR
2	Beniest, Anouk	Co-Chief Sci., OBS, geology	GEOMAR
3	Filbrandt, Christian	Student, OBS	CAU / GEOMAR
4	Gautreau, Louis-Maxime	Scientist, geology	GEOMAR
5	Hunkemöller, Annette	Student, OBS	CAU / GEOMAR
6	Klein, Johanna	Student, Parasound, OBS	CAU / GEOMAR
7	Rohde, Lea	Technician, OBS, logistics	GEOMAR
8	Schenk, Johanna	Student, geology	CAU / GEOMAR
9	Unger Moreno, Katharina	Scientist, geology, bathymetry	GEOMAR
10	Raeke, Andreas	Technician, meteorology	DWD
11	Elsässer, Antje	Meteorologist, meteorology	DWD

Institutions

GEOMAR GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel
Wischhofstr. 1-3, D-24148 Kiel / Germany

CAU Institut für Geowissenschaften, Christian-Albrechts Universität zu Kiel
Ludewig-Meyn Straße 10, D-24118 Kiel / Germany

DWD Deutscher Wetterdienst, Seeschifffahrtsberatung
Bernhard-Nocht-Straße 76, D-20359 Hamburg / Germany

Station list

Station	Action	Latitude	Longitude	Depth (m)	OBS Type	Comment
M175_1-1	OBS03 on deck	35° 05,532' N	034° 54,416' W	2989	Design-02	
M175_1-2	OBS02 on deck	35° 03,640' N	034° 58,318' W	4344	Design-02	
M175_1-3	OBS01 on deck	35° 00,844' N	034° 59,983' W	3678	LOBSTER	
M175_1-4	OBS06 on deck	35° 01,210' N	035° 06,469' W	3667	Design-02	
M175_2-1	OBS101 deployed	35° 01,571' N	035° 06,224' W	3667	Design-02	
M175_1-5	OBS08 on deck	35° 02,994' N	035° 11,884' W	3520	LOBSTER	
M175_1-6	OBS10 on deck	35° 03,425' N	035° 19,258' W	3727	Design-02	
M175_1-7	OBS11 on deck	35° 07,561' N	035° 21,673' W	3613	Design-02	
M175_1-8	OBS12 on deck	35° 05,531' N	035° 25,957' W	3927	LOBSTER	
M175_1-9	OBS13 on deck	35° 09,431' N	035° 28,587' W	3508	Design-02	
M175_1-10	OBS16 on deck	35° 09,013' N	035° 41,401' W	4419	LOBSTER	
M175_1-11	OBS18 not recovered	35° 10,555' N	035° 49,040' W	4564	Design-02	
M175_1-12	OBS20 on deck	35° 11,965' N	035° 56,663' W	4247	LOBSTER	
M175_1-13	OBS21 on deck	35° 15,522' N	035° 59,584' W	3902	Design-02	
M175_1-14	OBS23 on deck	35° 16,598' N	036° 07,249' W	3316	Design-02	
M175_1-15	OBS24 on deck	35° 13,054' N	036° 08,875' W	4162	Design-02	
M175_1-16	OBS25 on deck	35° 15,643' N	036° 11,687' W	3980	Design-02	
M175_1-17	OBS26 on deck	35° 14,055' N	036° 16,447' W	3787	Design-02	
M175_1-18	OBS27 on deck	35° 18,064' N	036° 15,611' W	4012	LOBSTER	
M175_3-1	Dredge	35° 18,822' N	036° 16,102' W	3789		empty
M175_4-1	Dredge	35° 15,214' N	036° 15,654' W	3813		empty
M175_5-1	Dredge	35° 15,498' N	036° 16,455' W	3761		empty
M175_6-1	Dredge	35° 21,881' N	036° 27,880' W	2526		successful
M175_7-1	Dredge	35° 19,247' N	036° 30,851' W	3066		successful
M175_8-1	Dredge	35° 24,741' N	036° 37,354' W	2256		empty
M175_9-1	Dredge	35° 20,185' N	036° 37,175' W	3156		successful
M175_10-1	Dredge	35° 08,453' N	035° 54,549' W	2551		successful
M175_11-1	Dredge	35° 12,154' N	035° 59,462' W	3320		successful
M175_12-1	Dredge	35° 12,681' N	036° 02,705' W	2748		successful
M175_13-1	Dredge	35° 10,380' N	036° 03,557' W	2042		successful
M175_14-1	Dredge	35° 10,297' N	036° 06,212' W	1542		
M175_14-2	Dredge	35° 10,292' N	036° 06,223' W	1526		
M175_15-1	Dredge	35° 19,906' N	036° 03,978' W	3021		empty
M175_16-1	Dredge	35° 18,257' N	036° 00,588' W	3787		empty
M175_17-1	Dredge	35° 13,746' N	035° 51,461' W	3754		successful
M175_18-1	OFOS Profile 1	35° 09,116' N	035° 50,603' W	2489		
M175_19-1	OFOS Profile 2	35° 07,771' N	035° 47,381' W	2097		
M175_20-1	OFOS Profile 3	35° 11,787' N	035° 56,469' W	3787		
M175_21-1	OFOS Profile 4	35° 12,426' N	035° 16,977' W	2028		
M175_22-1	OFOS Profile 5	35° 12,028' N	035° 16,918' W	2230		
M175_1-19	OBS101 on deck	35° 01,521' N	035° 06,457' W	3977	Design-02	

Station	Action	Latitude	Longitude	Depth (m)	OBS Type	Comment
M175_23-1	Dredge	35° 10,339' N	035° 05,940' W	2027		empty
M175_24-1	Dredge	35° 10,245' N	035° 10,722' W	2278		successful
M175_25-1	Dredge	35° 11,963' N	035° 16,606' W	2296		successful
M175_26-1	Dredge	35° 10,447' N	035° 20,678' W	2717		successful
M175_27-1	Dredge	35° 11,484' N	035° 27,727' W	2836		empty
M175_28-1	Dredge	35° 13,296' N	035° 43,031' W	3000		successful
M175_29-1	Dredge	35° 09,426' N	036° 02,258' W	1848		successful
M175_30-1	Dredge	35° 08,135' N	035° 58,417' W	2117		empty
M175_31-1	Dredge	35° 09,144' N	035° 50,465' W	2824		successful
M175_32-1	Dredge	35° 07,889' N	035° 47,190' W	2424		successful
M175_33-1	Dredge	35° 07,081' N	035° 40,913' W	3057		successful
M175_34-1	Dredge	35° 05,232' N	035° 40,283' W	1999		successful
M175_35-1	Dredge	35° 03,275' N	035° 26,339' W	2964		successful
M175_36-1	Dredge	35° 00,954' N	035° 11,678' W	2716		successful
M175_37-1	Dredge	34° 57,940' N	035° 00,420' W	3041		successful
M175_38-1	Dredge	35° 12,805' N	035° 04,716' W	2040		successful
M175_39-1	Dredge	35° 11,621' N	035° 14,168' W	2607		empty
M175_40-1	Dredge	35° 10,520' N	035° 19,072' W	2322		empty
M175_41-1	Dredge	35° 14,727' N	035° 05,662' W	1366		successful
M175_42-1	Site 17 OBS deployed	36° 41,995' N	031° 24,027' W	2637	LOBSTER	
M175_43-1	Site 19 OBS deployed	37° 59,998' N	030° 00,011' W	1925	LOBSTER	
M175_44-1	Site 12 OBS deployed	40° 00,000' N	028° 29,980' W	2249	LOBSTER	
M175_45-1	Site X25 OBS deployed	40° 35,426' N	026° 52,712' W	2633	LOBSTER	