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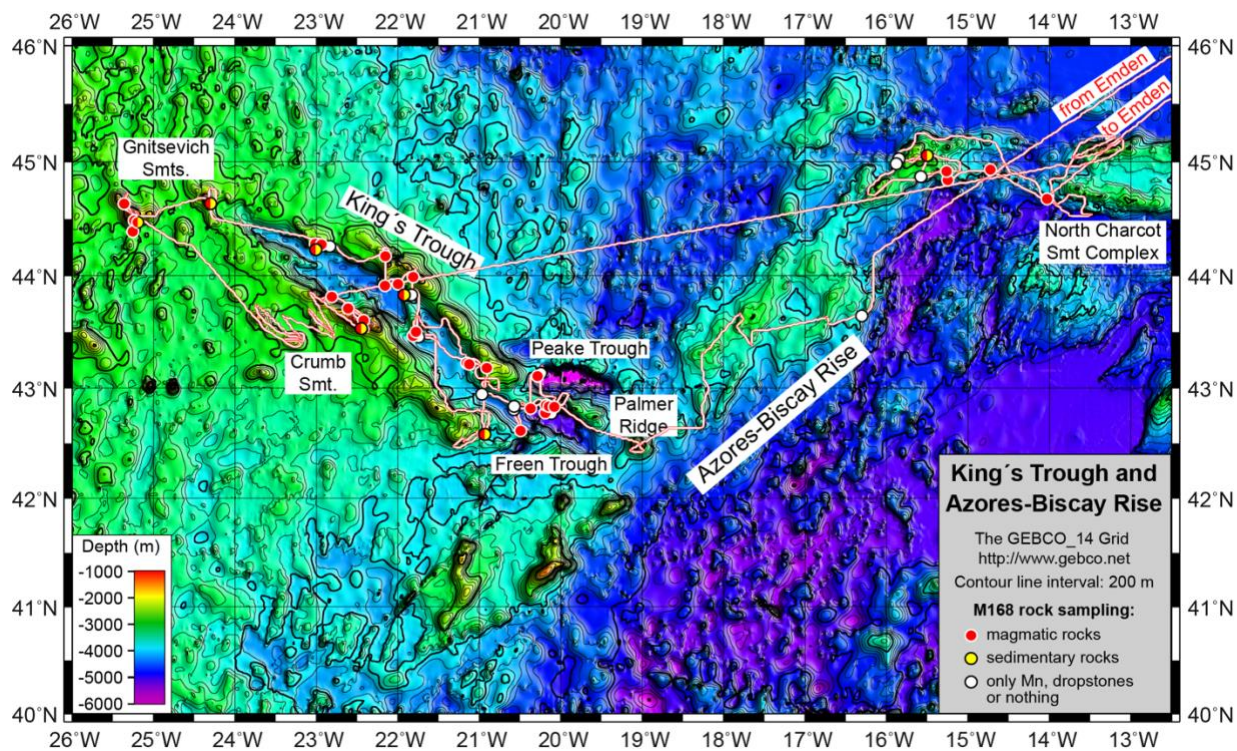
## Short Cruise Report R/V METEOR cruise M168 (GPF 20-3\_080)

**Emden (Germany) – Emden (Germany)**

**08.11.2020 – 08.12.2020**

**Chief Scientist: Dr. Antje Dürkefälden**

**Captain: Rainer Hammacher**



## **Objectives**

The goal of the R/V METEOR expedition M168 was to investigate the geodynamic evolution of the central eastern Atlantic (Iberian Plate) that led to the origin of the enigmatic King's Trough Complex, the seamounts surrounding King's Trough and the Azores-Biscay Rise. This goal shall be achieved by the analysis of the obtained multi-beam bathymetric data in combination with the geochemical characterization and age dating of the recovered igneous rock samples. Before M168, these structures were still largely unexplored and their origin has been debated for decades. Previous dredging of the King's Trough Complex mainly focused on two restricted areas and the entire Azores-Biscay Rise as well as the seamounts west of the King's Trough Complex have never been sampled before.

In particular, the geochemical composition of the oceanic crust in which King's Trough is embedded is to be determined in order to figure out if it is regular (depleted) mid-ocean ridge basalt or if the local crust could be formed by plume-ridge interaction. The aim is also to investigate possible temporal and spatial geochemical variations along the King's Trough Complex, to detect possible signs of multi-stage volcanism and to decipher tectonic processes during formation and evolution of the trough. Furthermore, it should be tested whether oceanic lithosphere is exposed at the flanks of the Peake and Freen Troughs being part of the complex and, if so, a cross-section through the lithosphere that is as complete as possible should be recovered in order to constrain the composition and possible heterogeneities of the oceanic lithosphere in the King's Trough Complex area. Another aim is to constrain the origin of the seamounts located on the elevated seafloor to the west of King's Trough, for example if they were formed at the Mid-Atlantic Ridge or by intraplate processes, and to investigate if a mantle plume was involved in the formation and if the seamounts are possibly related to the King's Trough Complex. Concerning the Azores-Biscay Rise, its origin is to be constrained and it shall be investigated if the geochemistry of the recovered rock samples is consistent with an intraplate formation and if the seamounts making up the rise formed by different magmatic phases (e.g., a shield phase and a younger magmatic event).

## **Narrative**

After a four-day quarantine in a hotel in Leer and after all 14 members of the scientific party of M168 had tested negative for COVID-19, the participants embarked R/V METEOR on November 7. In the morning of November 8, the vessel left the port of Emden under nice weather conditions. The five-day transit to the working area was used to unpack the containers, to set up the laboratories and to conduct other preparations for the cruise. After passage through the English Channel with fine weather and calm seas, the sea became rougher and winds increased significantly when reaching the North Atlantic Ocean.

On Thursday afternoon, November 12, R/V METEOR finally reached the central Azores-Biscay Rise, the first section of the working area. First of all, a sound velocity profile was conducted using a sound probe to calibrate the EM 122 multi-beam echo-sounder system. In the evening, the first dredge haul (station -2) was conducted at the eastern flank of a small seamount but returned empty. Unfortunately, bad weather conditions with stormy winds and a swell of 3 - 4 m did not allow further dredging until Saturday afternoon. Since bathymetric mapping was still possible, the time was used for further mapping of the central Azores-Biscay Rise in order to find appropriate sample stations. However, it turned out that this part of the rise would be difficult to sample due to only few steep enough slopes.

In the evening of November 13, the vessel therefore headed for the Freen and Peake Troughs directly west of the rise. Despite continued high swell, we were able to carry out three dredge hauls (-3 to -5) on the western flanks of both troughs on November 14 and 15, which returned numerous lava fragments including abundant fresh glassy margins. Since the wind and wave conditions allowed dredging only in northern directions, sampling focused on the southern flank of Palmer Ridge November 15 and 16, and six dredge hauls (-6 to -11) were carried out at different depth intervals. One dredge returned empty, but the other dredges contained lava fragments with some fresh glass, a microgabbro/dolerite and volcanoclastic rocks. The next station (-12) was conducted at the southern flank of Freen Trough at the transition to King's Trough and some lava fragments and a volcanic breccia were recovered. On Tuesday morning, two attempts were made to sample the transition from Freen to King's Trough at the northern flank (-13 and -14), but the first dredge returned empty, whereas the second dredge haul had to be aborted because the weather conditions rapidly deteriorated.

From November 17 until the end of the week, the NE flank and the southeastern part of the SW flank of King's Trough including several of the flanking ridges were extensively mapped and sampled. Due to the difficult weather conditions with strong winds, work concentrated on mapping of both flanks on Tuesday and Wednesday. On Wednesday evening, decreasing wind and waves again allowed dredging and thus, the southeasternmost end of the SW flank was sampled (-15) and yielded volcanoclastics but no lava. Station -16 was conducted at the base of the southeasternmost part of the NE King's Trough flank directly south of a ridge-like structure but returned empty. On the following day, November 19, three dredge hauls were carried out near the summit (-17) and at the base (-18 and -19) of this structure and recovered lava fragments, plutonic rocks and volcanoclastics. The next target was a triangular-shaped seamount located in the central portion of King's Trough between the two flanks. Whereas dredging at station -20 was unsuccessful, -21 and -22 yielded lava fragments and plutonic rocks. In the morning of November 20, R/V METEOR headed for the NE King's Trough flank north of the triangular-shaped seamount and six dredge hauls were conducted at the large seamount opposite to the prominent Antialtair Seamount on the central SW flank, during this and the following day. One dredge haul (-23) at the base of the southern flank of the seamount only returned dropstones, but station -24 near the summit obtained several lava fragments. The next three stations (-25 to -27) were carried out at the lower section of the seamount and recovered lava fragments, subvolcanic/plutonic and pegmatitic rocks and volcanoclastics. Station -28 was again located at the summit but further northwest of station -24 and the dredge contained lava fragments from two large blocks. The vessel subsequently sailed further to the west-northwest to a seamount on the NE King's Trough flank. Of four dredge hauls (-29 to -32), conducted on Sunday, November 22, three yielded lava fragments, subvolcanic rocks, ultramafic rocks possibly of harzburgitic composition and volcanoclastics. The last dredge haul (-32) returned empty.

In the evening of November 22, R/V METEOR left King's Trough for a short time and reached the Gnitsevich Seamounts, a group of seamounts in the northwest of King's Trough. During the night and the following day, the easternmost seamount (-33), a large seamount west of it (-34 to -36) and the northwesternmost seamount were sampled (-37) and yielded lava fragments and volcanoclastic rocks.

Early in the morning of November 24, the vessel headed for the Crumb Seamount Group in the southeast located in the vicinity of Antialtair Smt on the SW King's Trough flank. However, the weather conditions deteriorated by that time and stormy wind and rough seas with high swell made dredging impossible for the next two days. So we instead mapped the Crumb Seamount Group as well as the Antialtair Smt. On Thursday, November 26, the wind and wave heights finally decreased and we successfully

conducted four dredge hauls (-38 to -41), two at the summit and one at the northwestern base of Antialtair Smt, which returned several lava fragments and volcanoclastic rocks, and another dredge haul at the base of the SW King's Trough flank in the northwest of Antialtair Smt, which recovered an ultramafic rock, possibly a harzburgite. Since a strong storm front was developing in our working area, our dredge program had to be canceled in the late evening of the same day, and R/V METEOR had to sail nearly 400 nm towards the east-northeast to get out of the influence of the storm front as much as possible. Unfortunately, this meant that due to time constraints, it was not possible to return to the working area in order to continue sampling of the SW King's Trough flank and to sample the southwestern and central Azores-Biscay Rise as originally planned. However, the avoidance of the storm led to the northwesternmost part of the Azores-Biscay Rise, which R/V METEOR reached on Saturday, November 28, and provided the unexpected opportunity to collect samples from the rise after all. Since winds and waves were still too strong for dredging, a large E-W oriented ridge/seamount complex representing the end of the Azores-Biscay Rise and the North Charcot Seamount Complex adjoining directly in the east were partly mapped on November 28 and 29. During the next two days, on November 30 and December 1, the weather conditions again allowed dredging at both structures. Two attempts (-42 and -43) at the western flank of the seamount complex belonging to the Azores-Biscay Rise were unsuccessful. One dredge haul was carried out at the summit cone (-44) and four at the southern flanks (-45 to -48) and returned lava fragments and volcanoclastics. Another dredge haul (-49) was conducted at the southern base of the North Charcot Seamount Complex and yielded lava fragments as well. This was also the last station of cruise M168. Since another strong storm front approached the region between the British Isles and the working area, the vessel had to leave the area and start the return transit very early in the morning of Wednesday, December 2, two days earlier than originally planned, in order to reach the British Channel safely. After a four-day transit, which was used to pack the containers and to clean the laboratories, R/V METEOR arrived at the port of Emden in dull and cold weather in the morning of Sunday, December 6.

## **Acknowledgements**

First of all, we would like to thank Captain Rainer Hammacher and the entire crew of R/V METEOR for their excellent support, professionalism and high flexibility as well as the pleasant working atmosphere on board, which contributed directly to the success of this cruise. We also thank Carola Heitmann-Bacza from the German National Meteorological Service (DWD) for her daily remote weather briefings from Hamburg and the weather technician on board, Martin Stelzner, who worked closely together. We are grateful to Dr. Timm Schoening (GEOMAR) for providing multi-beam data and to Maik Lange (GEOMAR) for his help with cruise preparations. We are also grateful to the Geschäftsstelle des Gutachterpanels Forschungsschiffe (GPF), the Leitstelle Deutsche Forschungsschiffe (LDF) and Briese Research for their support. This cruise was funded by the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG) and the German Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung, BMBF).

## Cruise Participants

|                      |                                   |           |
|----------------------|-----------------------------------|-----------|
| 1. Antje Dürkefälden | Chief Scientist                   | GEOMAR    |
| 2. Reinhard Werner   | Co-Chief Scientist / Shift Leader | GEOMAR    |
| 3. Jörg Geldmacher   | Shift Leader / Rock Sampling      | GEOMAR    |
| 4. Folkmar Hauff     | Shift Leader / Rock Sampling      | GEOMAR    |
| 5. Marc Fassbender   | Rock Sampling                     | GEOMAR/VO |
| 6. Luisa Franzen     | Rock Sampling                     | GEOMAR    |
| 7. Fabian Hampel     | Rock Sampling                     | GEOMAR    |
| 8. Silke Hauff       | Rock Sampling                     | GEOMAR    |
| 9. Kevin Krohne      | Rock Sampling                     | GEOMAR    |
| 10. Jakob Lang       | Rock Sampling                     | GEOMAR    |
| 11. Avriinder Sandhu | Rock Sampling                     | GEOMAR    |
| 12. Janne Scheffler  | Rock Sampling                     | GEOMAR    |
| 13. Johanna Schenk   | Rock Sampling                     | GEOMAR    |
| 14. Anna Völkert     | Rock Sampling                     | GEOMAR    |
| 15. Martin Stelzner  | Meteorological Technician         | DWD       |

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VO University of Ottawa, 75 Laurier Ave. East, Ottawa ON K1N 6N5, Canada, [www.uottawa.ca](http://www.uottawa.ca)

DWD Deutscher Wetterdienst, Geschäftsfeld Seeschifffahrt, Bernhard-Nocht-Str. 76, 20359 Hamburg, Germany, [www.dwd.de](http://www.dwd.de)

## Station List

Abbreviations:

DR - Chain bag dredge

SVP - Sound velocity profile

XSV - Lockheed Martin expendable sound velocimeter

| Station   | Institute Identification | De-vice | Date [UTC] | Time [UTC] | Latitude [°N] | Longitude [°W] | Max. Depth [m] | Comment / Recovery                    |
|-----------|--------------------------|---------|------------|------------|---------------|----------------|----------------|---------------------------------------|
| M168_1-1  | n.a.                     | XSV     | 12.11.20   | 15:30      | 44°34.46'     | 15°19.54'      | n.a.           | SVP                                   |
| M168_2-1  | n.a.                     | DR      | 13.11.20   | 00:49      | 43°38.85'     | 16°15.68'      | 3997           | empty                                 |
| M168_3-1  | n.a.                     | DR      | 14.11.20   | 15:38      | 42°49.32'     | 20°21.80'      | 5271           | hard rocks                            |
| M168_4-1  | n.a.                     | DR      | 15.11.20   | 00:00      | 43°07.90'     | 20°14.37'      | 4874           | crusts                                |
| M168_5-1  | n.a.                     | DR      | 15.11.20   | 05:02      | 43°07.43'     | 20°14.51'      | 5281           | hard rocks                            |
| M168_6-1  | n.a.                     | DR      | 15.11.20   | 13:43      | 42°50.41'     | 20°09.40'      | 4411           | hard rocks                            |
| M168_7-1  | n.a.                     | DR      | 15.11.20   | 18:14      | 42°47.08'     | 20°09.66'      | 5336           | empty                                 |
| M168_8-1  | n.a.                     | DR      | 15.11.20   | 23:10      | 42°47.27'     | 20°10.10'      | 5329           | hard rocks                            |
| M168_9-1  | n.a.                     | DR      | 16.11.20   | 04:06      | 42°49.67'     | 20°06.91'      | 4789           | hard rocks                            |
| M168_10-1 | n.a.                     | DR      | 16.11.20   | 10:37      | 42°49.94'     | 20°03.79'      | 3766           | hard rocks                            |
| M168_11-1 | n.a.                     | DR      | 16.11.20   | 15:02      | 42°51.18'     | 20°07.95'      | 3537           | hard rocks                            |
| M168_12-1 | n.a.                     | DR      | 16.11.20   | 22:10      | 42°36.64'     | 20°28.68'      | 4386           | hard rocks                            |
| M168_13-1 | n.a.                     | DR      | 17.11.20   | 03:38      | 42°48.81'     | 20°32.10'      | 4086           | empty                                 |
| M168_14-1 | n.a.                     | DR      | 17.11.20   | 07:37      | 42°49.99'     | 20°32.28'      | 3249           | aborted due to bad weather conditions |
| M168_15-1 | n.a.                     | DR      | 18.11.20   | 19:21      | 42°35.70'     | 20°55.44'      | 3413           | clastic rocks                         |
| M168_16-1 | n.a.                     | DR      | 19.11.20   | 01:01      | 42°56.73'     | 20°56.88'      | 4410           | empty                                 |
| M168_17-1 | n.a.                     | DR      | 19.11.20   | 06:08      | 43°20.60'     | 20°53.32'      | 2420           | hard rocks                            |
| M168_18-1 | n.a.                     | DR      | 19.11.20   | 11:36      | 43°13.27'     | 21°06.97'      | 4242           | hard rocks                            |
| M168_19-1 | n.a.                     | DR      | 19.11.20   | 15:46      | 43°13.58'     | 21°07.67'      | 4297           | hard rocks                            |
| M168_20-1 | n.a.                     | DR      | 19.11.20   | 22:33      | 43°27.59'     | 21°45.03'      | 3994           | empty                                 |
| M168_21-1 | n.a.                     | DR      | 20.11.20   | 02:44      | 43°29.93'     | 21°46.60'      | 3069           | hard rocks                            |
| M168_22-1 | n.a.                     | DR      | 20.11.20   | 06:44      | 43°28.21'     | 21°45.63'      | 3637           | hard rocks                            |
| M168_23-1 | n.a.                     | DR      | 20.11.20   | 13:39      | 43°49.62'     | 21°49.12'      | 4026           | dropstones                            |
| M168_24-1 | n.a.                     | DR      | 20.11.20   | 19:32      | 43°59.52'     | 21°48.01'      | 2298           | hard rocks                            |
| M168_25-1 | n.a.                     | DR      | 21.11.20   | 00:48      | 43°50.19'     | 21°54.53'      | 4340           | hard rocks                            |
| M168_26-1 | n.a.                     | DR      | 21.11.20   | 05:35      | 43°55.78'     | 21°59.80'      | 4508           | hard rocks                            |
| M168_27-1 | n.a.                     | DR      | 21.11.20   | 10:54      | 43°55.53'     | 22°08.04'      | 3444           | hard rocks                            |
| M168_28-1 | n.a.                     | DR      | 21.11.20   | 19:25      | 44°11.03'     | 22°08.50'      | 2490           | hard rocks                            |
| M168_29-1 | n.a.                     | DR      | 22.11.20   | 02:19      | 44°15.75'     | 22°49.57'      | 3830           | hard rocks                            |
| M168_30-1 | n.a.                     | DR      | 22.11.20   | 07:32      | 44°14.81'     | 22°59.79'      | 4108           | hard rocks                            |
| M168_31-1 | n.a.                     | DR      | 22.11.20   | 12:04      | 44°17.08'     | 22°56.78'      | 2390           | hard rocks                            |
| M168_32-1 | n.a.                     | DR      | 22.11.20   | 15:20      | 44°16.58'     | 22°54.01'      | 3308           | empty                                 |
| M168_33-1 | n.a.                     | DR      | 23.11.20   | 02:39      | 44°38.48'     | 24°17.84'      | 2251           | clastic rocks                         |
| M168_34-1 | n.a.                     | DR      | 23.11.20   | 10:49      | 44°29.39'     | 25°11.63'      | 2390           | hard rocks                            |
| M168_35-1 | n.a.                     | DR      | 23.11.20   | 14:45      | 44°29.61'     | 25°12.78'      | 1701           | hard rocks                            |
| M168_36-1 | n.a.                     | DR      | 23.11.20   | 18:24      | 44°28.60'     | 25°14.66'      | 2028           | hard rocks                            |
| M168_37-1 | n.a.                     | DR      | 23.11.20   | 23:55      | 44°38.88'     | 25°20.83'      | 2404           | hard rocks                            |
| M168_38-1 | n.a.                     | DR      | 26.11.20   | 06:29      | 43°32.37'     | 22°25.65'      | 1643           | hard rocks                            |
| M168_39-1 | n.a.                     | DR      | 26.11.20   | 09:22      | 43°36.25'     | 22°24.76'      | 1865           | clastic rocks                         |
| M168_40-1 | n.a.                     | DR      | 26.11.20   | 13:17      | 43°42.95'     | 22°35.57'      | 3410           | hard rocks                            |
| M168_41-1 | n.a.                     | DR      | 26.11.20   | 18:40      | 43°49.11'     | 22°48.90'      | 4196           | hard rocks                            |
| M168_42-1 | n.a.                     | DR      | 30.11.20   | 09:20      | 44°58.14'     | 15°51.83'      | 4039           | crusts                                |
| M168_43-1 | n.a.                     | DR      | 30.11.20   | 13:01      | 45°00.11'     | 15°50.97'      | 3358           | empty                                 |
| M168_44-1 | n.a.                     | DR      | 30.11.20   | 18:06      | 45°01.37'     | 15°31.05'      | 2614           | hard rocks                            |
| M168_45-1 | n.a.                     | DR      | 30.11.20   | 22:18      | 44°51.07'     | 15°35.13'      | 4210           | clastic rocks                         |
| M168_46-1 | n.a.                     | DR      | 01.12.20   | 03:19      | 44°54.05'     | 15°16.57'      | 3326           | hard rocks                            |
| M168_47-1 | n.a.                     | DR      | 01.12.20   | 07:16      | 44°48.34'     | 15°14.30'      | 4322           | hard rocks                            |
| M168_48-1 | n.a.                     | DR      | 01.12.20   | 13:37      | 44°54.41'     | 14°43.25'      | 4108           | hard rocks                            |
| M168_49-1 | n.a.                     | DR      | 01.12.20   | 20:28      | 44°39.20'     | 14°02.89'      | 4791           | hard rocks                            |