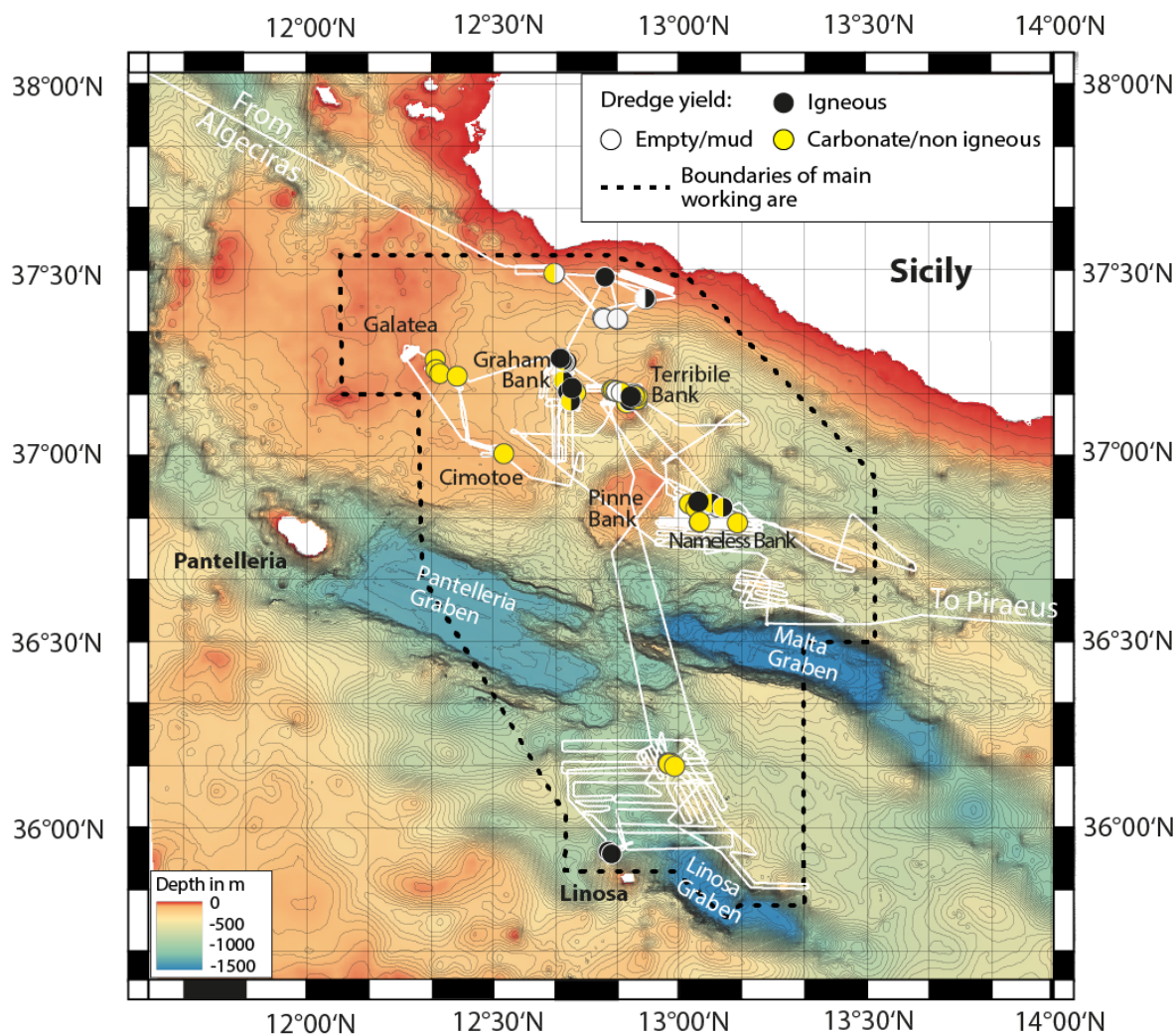


PD Dr. Jörg Geldmacher
GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel
Forschungsbereich 4 / Abt. Magmatische und Hydrothermale Systeme
Wischhofstraße 1-3
D-24148 Kiel
Tel: +49 431 600 2260
Email: jgeldmacher@geomar.de

Short Cruise Report

R/V METEOR cruise M191 (GPF 21-1_036)

Algeciras - Piraeus
16.07.2023 – 05.08.2023
Chief Scientist: Jörg Geldmacher
Captain: Derk Apetz



Objectives

The origin and role of volcanism in passive continental rifts remains poorly understood relative to other volcano-tectonic settings. The western Sicilian Channel in the central Mediterranean Sea represents an area of pronounced crustal extension with a variety of volcanic landforms closely associated with extensional faults. During Exp. M191 we have extensively mapped the seafloor (with multibeam echo sounder, sediment echo sounder, and towed magnetometer) and sampled (by chain bag dredging) unexplored volcanic structures along the Sicilian Channel Rift Zone (Pantelleria-, Malta- and Linosa-Graben) and the Capo-Granitola-Sciaccà Fault Zone (CGSFZ). The obtained data and collected samples will provide new insights into the role of magmatism in regions of continental extension, and will allow us to develop a tectonic and magmatic framework for the western Sicilian Channel. The obtained data and samples will be used to:

- i. Determine the age, mantle source, melting process and crustal evolution of magmas across the area, and interpret these alongside data from volcanic centers in the central Mediterranean (Etna, Hyblean Plateau, Ustica, Alicudi) to evaluate mantle melting processes in a regional tectonic framework,
- ii. Discriminate the volcanic signatures (melting, ascent and timing) of the magmatic manifestations at the seafloor between extensional and strike-slip kinematic fields,
- iii. Assess the relationship between the architecture and kinematics of the CGSFZ and the Sicily Channel Rift Zone, and the spatial distribution of volcanic activity,
- iv. Infer the structural framework and stress field in the southern section of the CGSFZ and its spatial and temporal evolution,
- v. Assess the type, extent and age of volcanic activity across the region to evaluate present-day hazards.

Narrative

All 15 members of the scientific party arrived in Algeciras in the afternoon/evening of July 14 and boarded the vessel the next morning on July 15. The GEOMAR equipment container and the OGS magnetometer were already loaded and placed on the working deck. The vessel left the port of Algeciras on the following day, July 16 at 09:00, to start its almost 4 days transit to the main working area in the Sicilian Channel.

While transiting through the Spanish EEZ, surface water samples (for nanoplankton research) were collected approximately every 4 h. The water sampling continued at similar sequences in Italian and Greek waters during the entire time span of the expedition.

In the early morning on July 19, we arrived in the Italian EEZ and the EM 120 and EM 710 multibeam echo sounders (MBES) and sediment echo sounder (PARASOUND) were switched on. Shortly afterwards an SVP (sound velocity profile) probe was deployed in 1900 m water depth (to calibrate the MBES data). While the ship was stationary, the magnetometer was brought into the water to test all components of the system.

Subsequently, the vessel accelerated and continued its transit to the Sicilian Channel. After a few hours, the magnetometer was recovered again.

On the morning of July 20, we arrived in our main working area south of Sicily and started our research between the Sicilian coast and Graham Bank, along the northern rim of the Sicilian Channel (see Fig. 1 map on front page). Since the water is much shallower here (generally < 300m) another SVP was conducted before a systematic mapping survey (with multibeam echosounder, PARASOUND and magnetometer) was conducted. The survey covered all known submarine cone-shaped structures (believed to be of volcanic origin). Dredge site locations were identified and it was assured that each dredge track is placed in sufficient distance from the nearest underwater cable. This evaluation followed a standardized procedure applied for all dredge sites during this expedition (criteria: >1000 m and >2.5 times water depths distance from the nearest cable). In total, eight dredge hauls (M191-5,-6,-7,-8,-10,-11,-12,-13,-14) were conducted in this area in the course of July 20 and the following day, June 21. During the night, an extensive mapping and magnetometer survey was conducted in an area, where no multibeam/magnetic data have been acquired before (M191-9). In the afternoon of July 21, the vessel transited southwards towards Graham Bank, where a short (c. 2 h) mapping survey (multibeam and magnetometer) was run over all sites (cones) of potential interest for dredging (M191-15). Two dredge hauls were conducted on one volcanic cone (M191-16,-17) near Graham Banks northern edge. The summit of Graham Bank consists of two prominent cones with flat tops, the southernmost of which rises up to 9 m below sea level. This shoal, well known to local fishermen, represents the site of the most recent volcanic eruption in the working area. In July 1831, a volcanic outburst produced a short-lived island ("Ferdinanda Island") that was washed away by wave erosion a few months thereafter. The night of July 21/22 was spent with another extensive mapping survey (M191-18) comprising the area SW of Graham Bank and the cluster of prominent cones between Cimotoe and Pinne Bank. At Site M191-20, active venting ("flares") was observed in the water column sonar data and the dredge haul recovered several tube-shaped rocks interpreted as vent chimneys. After a short mapping/magnetometer survey (M191-25), the last dredge haul of the day targeted one of the cones between Cimotoe and Pinne Bank (M191-26) before we spent the night with further mapping/magnetometer survey in the area around the Galatea shoal (M191-27).

On July 23, four sites were dredged in the newly mapped area (M191-28,-29,-30-31), none of which returned volcanic material. Dredge hauls M191-34,-35,-36 were conducted along a previously unknown chain of N-S- striking cones west of the Graham Bank summit. Near the northernmost cone of Graham Bank another vent field was observed in the water column sonar data. Afterwards, we spent the remaining time on July 24 with dredging on and near the summit of Terribile Bank (the eastern neighbor of Graham Bank), where magnetic and backscatter data implied the presence of igneous and exposed rocks (M191-37 to -45).

The night and most of the following day, July 25, was devoted to a more detailed mapping/magnetometer survey of Terribile Bank and the area NE and SW of Pinne Bank

(M191-46). During this survey, intense flare activity was observed in the water column at 37°08'N, 13°11'E indicating large-scale gas venting. Eventually, dredging resumed along the NE flank of Nameless Bank (a few miles east of Pinne Bank). Once more, the positioning of the dredge sites was guided by identified magnetic anomalies, recorded during the preceding mapping survey. Dredge hauls M191-47,-48,-49 were conducted up the steep NE slope of Terribile Bank before the vessel turned southwards and spent the night with a mapping/magnetometer survey (M191-50).

In the morning of July 26, the vessel arrived in the southernmost part of working area, north of the island of Linosa and the Linosa Graben. Immediately north of Linosa, numerous steep volcanic cones /seamounts were found. However, like in all previous working areas, the choice of potential dredge sites was greatly restricted by the presence of several underwater cables. In addition, the environmental protection zone around Linosa prevented all activities within approximately 2.5 nm from the shore line (which included several volcanic cones). Dredging of the only two cones that were accessible for us (M191-51,-52, and -54 to -57), however, retrieved excellent lava samples. The night and the following morning on July 27 were again used for mapping/magnetometer survey. No further volcanic cones were found along the northern slope of the Linosa Graben but a distinct magnetic anomaly indicated that that the large solitary seamount on the carbonate platform between the Linosa and Malta Grabens might contain igneous rock. Two dredge hauls (M191-59,-60) were carried out at the lower and upper slope of this structure.

The night and most of the following day, July 28, was devoted to multibeam/magnetometer mapping the area north of the Linosa graben (M191-61) but no structures that could have been identified as of volcanic origin were found and the vessel returned to the dredging area that was sampled the day before to obtain more igneous material from this edifice (dredge hauls M191-62 to -66). The subsequent transit back to the northern part of the Sicilian Channel was used for multibeam/magnetometer mapping (M191-67).

Between July 29 and July 31, mapping and sampling activities alternated between Terribile Bank (dredge hauls M191-68 to -73 and M191-78 to -79) and the neighboring Nameless Bank (M191-75,-76, and M191-81 to -85).

While mapping Nameless Bank, an elongated, c. 100x16 long feature was found lying on the seafloor in about 100 m water depth, which appears to be a ship wreck (especially in the backscatter data).

The following day, Aug. 1 was spent with further systematic multibeam/magnetometer mapping of the southern portion of Nameless Bank (M191-86) and four dredge hauls were subsequently carried out on the eastern part of this bank (M191-87 to -90). The last night of this expedition in the main working area was devoted to a multibeam/magnetometer survey of the northern flank of the Malta Graben (M191-91) where several seamount-like structures were mapped. Since no magnetic anomaly was found, the search on the following morning, Aug. 2, focused on a vast bathymetric high located halfway between the Malta Graben und Nameless Bank. However, no further magnetic anomaly was found.

After the final recovery of the magnetometer, a last SVP concluded our research in the main working area of the Sicilian Channel. Underway multibeam mapping, however, continued until the vessel left the Italian EEZ on Aug. 3. While most scientists spent the 2.5 days transit time cleaning the labs, packing the equipment and report writing, surface water sampling for nanoplankton research continued until we reached the port of Piraeus. At 08:35, Aug. 5 the first line was fixed to the pier and Exp. M191 officially ended. In the afternoon all scientists disembarked the vessel.

In total, 18 dedicated multibeam/sediment echo sounder/magnetometer surveys, covering 2886 km (Fig. 2), were conducted to record high-resolution bathymetric data, backscatter, water column and sub-bottom profile data and the total magnetic field intensity. We have carried out 68 dredge stations, only 11 of which returned empty or contained just unconsolidated mud. All others delivered carbonate crusts, consolidated limestone (most likely continental bedrock) and, at 24 dredge stations, igneous rocks. In addition, 82 surface water samples for nanoplankton research were taken along our track between Algieras and Piraeus. No deployed device was lost or seriously damaged.

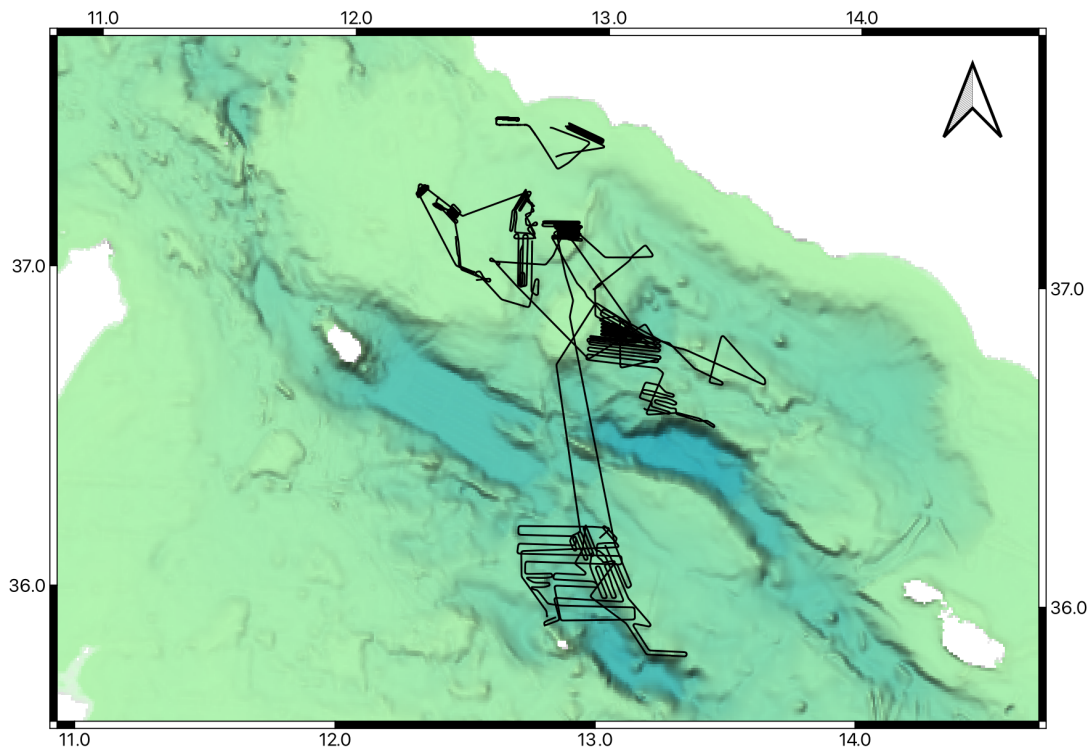


Figure 2: Geographical overview of the magnetic/multibeam surveys conducted during Exp. M191 in the Sicilian Channel.

Acknowledgements

First of all, we would like to thank Master Derk Apetz and his skillful crew for their excellent support, professionalism and for providing a very pleasant working atmosphere on board, which contributed enormously to the success of this expedition. We also thank Andreas Raeke and Tobias Altmann from the German National Meteorological Service (DWD) for the daily weather briefings. We are grateful to Danilo Cavallaro for providing existing multi-

beam bathymetric data of Terribile Bank and Dario Civile and Emanuele Lodolo (both OGS) for being part of the SUAVE project team and their ongoing shore-based support. Filippo Muccini (INGV, La Spezia) is especially thanked for providing the magnetometer which was of vital importance for localizing and identifying the possible presence of volcanic outcrops. Maik Lange, Mia Schumacher, Bettina Domeyer, Anke Bleyer and Karin Junge (all GEOMAR) are thanked for help with cruise preparations at GEOMAR. Special thanks are due to Jens O. Herrle (Goethe University Frankfurt) for kindly providing the equipment and supplies for filtration of seawater, and his encouragement. We are also grateful to the Geschäftsstelle des Gutachterpanels Forschungsschiffe (GPF), the Leitstelle Deutsche Forschungsschiffe (LDF) and Briese Research for their support. We are very grateful to Briese Research and the LDF for obtaining detailed data on the distribution of submarine cables in the working area without which dredging at most positions could not have been carried out. Last but not least we would like to thank the countries of Spain, Italy and Greece for permitting our research in their exclusive economic zones. This cruise was funded by the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG) and the GEOMAR Helmholtz Centre for Ocean Research Kiel.

Participant list

1. Jörg Geldmacher	Chief Scientist	GEOMAR
2. Aaron Micallef	Co-Chief Scientist, Bathymetry	MBARI / UM
3. Christian Timm	Expedition Manager, Petrology	GEOMAR
4. Maxim Portnyagin	Shift leader dredging I	GEOMAR
5. Folkmar Hauff	Shift leader dredging II	GEOMAR
6. G. Matilde Ferrante	Shift leader magnetometer	OGS
7. Jonathan Ford	Magnetometer	OGS
8. Sebastian Watt	Petrology	Univ. Birmingham
9. Odysseas A. Archontikis	Nannoplankton	Univ. Oxford / NHM
10. Alastair Hodgetts	Petrology	Univ. Edinburgh
11. Jacqueline Grech Licari	Petrology/Outreach	Univ. Wellington
12. Kerys Meredew	Petrology	Univ. Birmingham
13. Silke Hauff	Petrology	GEOMAR
14. Jakob Lang	Petrology	GEOMAR
15. Meret Felgendreher	Petrology	GEOMAR
16. Andreas Raeke	Meteorology	DWD
17. Holger Jens	Meteorology	DWD

Abbreviation of participating institutions:

GEOMAR	Helmholtz-Zentrum für Ozeanforschung Kiel (Germany)
MBARI	Monterey Bay Aquarium Research Institute (USA)
UM	University of Malta (Malta)
OGS	Instituto Nazionale di Oceanografia e di Geofisica Sperimentale (Italy)
Univ. Birmingham	University of Birmingham (UK)
Univ. Oxford	University of Oxford (UK)
Univ. Edinburgh	University of Edinburgh (UK)
Univ. Wellington	University of Wellington (NZ)
NHM	The Natural History Museum London (UK)
DWD	Deutscher Wetterdienst, Geschäftsfeld Seeschifffahrt (Germany)

Station list

Station	Date / Time UTC	Device	Action	Latitude	Longitude	Depth (m)
M191_1-1	19.07.23 08:43	Sound Velocity Profiler	max depth/on ground	38° 20,979' N	008° 41,937' E	1954
M191_2-1	19.07.23 09:40	Magnetometer	in the water	38° 20,854' N	008° 41,882' E	1973
M191_2-1	19.07.23 12:50	Magnetometer	on deck	38° 21,839' N	008° 55,563' E	1852
M191_3-1	20.07.23 08:17	Sound Velocity Profiler	max depth/on ground	37° 30,670' N	012° 32,302' E	90
M191_4-1	20.07.23 08:44	Magnetometer	in the water	37° 30,660' N	012° 32,310' E	88
M191_4-1	20.07.23 16:10	Magnetometer	on deck	37° 29,126' N	012° 45,749' E	80
M191_5-1	20.07.23 16:57	Dredge	max depth/on ground	37° 29,435' N	012° 39,964' E	44
M191_6-1	20.07.23 17:40	Dredge	max depth/on ground	37° 29,447' N	012° 39,980' E	35
M191_7-1	20.07.23 19:32	Dredge	max depth/on ground	37° 22,315' N	012° 47,758' E	166
M191_8-1	20.07.23 20:52	Dredge	max depth/on ground	37° 22,141' N	012° 47,922' E	179
M191_9-1	20.07.23 22:10	Magnetometer	in the water	37° 23,268' N	012° 47,653' E	156
M191_9-1	21.07.23 04:59	Magnetometer	on deck	37° 29,778' N	012° 48,912' E	71
M191_10-1	21.07.23 06:18	Dredge	max depth/on ground	37° 22,023' N	012° 50,205' E	177
M191_11-1	21.07.23 07:38	Dredge	max depth/on ground	37° 22,157' N	012° 50,131' E	174
M191_12-1	21.07.23 09:04	Dredge	max depth/on ground	37° 25,320' N	012° 54,717' E	78
M191_13-1	21.07.23 10:33	Dredge	max depth/on ground	37° 25,465' N	012° 54,611' E	81
M191_14-1	21.07.23 13:09	Dredge	max depth/on ground	37° 28,877' N	012° 48,135' E	76
M191_15-1	21.07.23 15:25	Magnetometer	in the water	37° 16,801' N	012° 41,717' E	191
M191_15-1	21.07.23 18:28	Magnetometer	on deck	37° 07,585' N	012° 44,083' E	210
M191_16-1	21.07.23 19:23	Dredge	max depth/on ground	37° 11,911' N	012° 41,466' E	228
M191_17-1	21.07.23 20:46	Dredge	max depth/on ground	37° 12,208' N	012° 41,424' E	226
M191_18-1	21.07.23 22:05	Magnetometer	in the water	37° 11,328' N	012° 41,886' E	229
M191_18-1	22.07.23 05:23	Magnetometer	on deck	37° 07,298' N	012° 40,926' E	284
M191_19-1	22.07.23 05:47	Sound Velocity Profiler	max depth/on ground	37° 08,128' N	012° 41,322' E	320
M191_20-1	22.07.23 06:54	Dredge	max depth/on ground	37° 10,960' N	012° 42,798' E	154
M191_21-1	22.07.23 09:50	Dredge	max depth/on ground	37° 10,363' N	012° 42,219' E	143
M191_22-1	22.07.23 12:02	Dredge	max depth/on ground	37° 10,374' N	012° 42,097' E	167
M191_23-1	22.07.23 13:04	Dredge	max depth/on ground	37° 10,168' N	012° 43,416' E	114
M191_24-1	22.07.23 14:20	Dredge	max depth/on ground	37° 08,833' N	012° 42,596' E	182
M191_25-1	22.07.23 15:23	Magnetometer	in the water	37° 08,203' N	012° 42,872' E	218
M191_25-1	22.07.23 20:05	Magnetometer	on deck	36° 59,935' N	012° 29,358' E	117
M191_26-1	22.07.23 20:46	Dredge	max depth/on ground	37° 00,356' N	012° 31,820' E	114
M191_27-1	22.07.23 21:42	Magnetometer	in the water	37° 00,569' N	012° 30,898' E	110
M191_27-1	23.07.23 05:59	Magnetometer	on deck	37° 15,568' N	012° 20,595' E	57
M191_28-1	23.07.23 06:26	Dredge	max depth/on ground	37° 15,524' N	012° 20,768' E	80
M191_29-1	23.07.23 08:11	Dredge	max depth/on ground	37° 13,920' N	012° 20,913' E	74
M191_30-1	23.07.23 09:40	Dredge	max depth/on ground	37° 13,301' N	012° 21,490' E	78
M191_31-1	23.07.23 11:00	Dredge	max depth/on ground	37° 12,865' N	012° 24,300' E	104
M191_32-1	23.07.23 12:26	Sound Velocity Profiler	max depth/on ground	37° 08,984' N	012° 25,027' E	139
M191_33-1	23.07.23 12:48	Magnetometer	in the water	37° 08,515' N	012° 24,925' E	138
M191_33-1	24.07.23 05:49	Magnetometer	on deck	37° 16,363' N	012° 40,837' E	183
M191_34-1	24.07.23 06:19	Dredge	max depth/on ground	37° 15,183' N	012° 41,538' E	141
M191_35-1	24.07.23 07:20	Dredge	max depth/on ground	37° 15,364' N	012° 41,271' E	158
M191_36-1	24.07.23 08:24	Dredge	max depth/on ground	37° 15,379' N	012° 41,316' E	158
M191_37-1	24.07.23 11:10	Dredge	max depth/on ground	37° 09,629' N	012° 53,325' E	54
M191_38-1	24.07.23 12:44	Dredge	max depth/on ground	37° 09,984' N	012° 52,827' E	98
M191_39-1	24.07.23 13:36	Dredge	max depth/on ground	37° 09,686' N	012° 52,892' E	68
M191_40-1	24.07.23 14:24	Dredge	max depth/on ground	37° 09,416' N	012° 52,410' E	55
M191_41-1	24.07.23 15:09	Dredge	max depth/on ground	37° 09,583' N	012° 53,295' E	53
M191_42-1	24.07.23 17:01	Dredge	max depth/on ground	37° 10,435' N	012° 49,881' E	126

Station	Date / Time UTC	Device	Action	Latitude	Longitude	Depth (m)
M191_43-1	24.07.23 17:42	Dredge	max depth/on ground	37° 10,426' N	012° 49,973' E	112
M191_44-1	24.07.23 18:35	Dredge	max depth/on ground	37° 10,231' N	012° 50,765' E	97
M191_45-1	24.07.23 19:47	Dredge	max depth/on ground	37° 09,771' N	012° 53,036' E	52
M191_46-1	24.07.23 20:54	Magnetometer	in the water	37° 09,704' N	012° 52,903' E	71
M191_46-1	25.07.23 14:15	Magnetometer	on deck	36° 52,102' N	013° 04,625' E	173
M191_47-1	25.07.23 14:52	Dredge	max depth/on ground	36° 52,377' N	013° 05,787' E	604
M191_48-1	25.07.23 16:31	Dredge	max depth/on ground	36° 52,383' N	013° 05,373' E	460
M191_49-1	25.07.23 18:25	Dredge	max depth/on ground	36° 51,709' N	013° 07,146' E	554
M191_50-1	25.07.23 20:44	Magnetometer	in the water	36° 51,855' N	013° 07,077' E	656
M191_50-1	26.07.23 11:38	Magnetometer	on deck	35° 57,436' N	012° 51,746' E	1127
M191_51-1	26.07.23 12:40	Dredge	max depth/on ground	35° 56,172' N	012° 48,670' E	689
M191_52-1	26.07.23 14:13	Dredge	max depth/on ground	35° 55,999' N	012° 48,743' E	694
M191_53-1	26.07.23 16:15	Sound Velocity Profiler	max depth/on ground	35° 55,675' N	012° 49,181' E	663
M191_54-1	26.07.23 17:06	Dredge	max depth/on ground	35° 56,113' N	012° 48,848' E	749
M191_55-1	26.07.23 18:13	Dredge	max depth/on ground	35° 56,168' N	012° 48,667' E	688
M191_56-1	26.07.23 20:08	Dredge	max depth/on ground	35° 55,739' N	012° 49,195' E	733
M191_57-1	26.07.23 21:57	Dredge	max depth/on ground	35° 56,069' N	012° 48,841' E	757
M191_58-1	26.07.23 23:08	Magnetometer	in the water	35° 56,178' N	012° 48,730' E	713
M191_58-1	27.07.23 12:41	Magnetometer	on deck	36° 11,210' N	013° 01,248' E	750
M191_59-1	27.07.23 13:32	Dredge	max depth/on ground	36° 09,899' N	012° 59,362' E	533
M191_60-1	27.07.23 14:59	Dredge	max depth/on ground	36° 10,460' N	012° 58,274' E	419
M191_61-1	27.07.23 15:56	Magnetometer	in the water	36° 11,424' N	012° 59,472' E	814
M191_61-1	28.07.23 13:26	Magnetometer	on deck	36° 15,058' N	012° 57,042' E	1051
M191_62-1	28.07.23 14:29	Dredge	max depth/on ground	36° 10,287' N	012° 58,418' E	429
M191_63-1	28.07.23 15:25	Dredge	max depth/on ground	36° 10,325' N	012° 58,774' E	407
M191_64-1	28.07.23 16:59	Dredge	max depth/on ground	36° 10,377' N	012° 58,784' E	390
M191_65-1	28.07.23 17:58	Dredge	max depth/on ground	36° 10,414' N	012° 58,306' E	423
M191_66-1	28.07.23 18:51	Dredge	max depth/on ground	36° 10,292' N	012° 58,412' E	431
M191_67-1	28.07.23 19:32	Magnetometer	in the water	36° 10,101' N	012° 58,414' E	428
M191_67-1	29.07.23 09:05	Magnetometer	on deck	37° 09,442' N	012° 54,589' E	93
M191_68-1	29.07.23 09:55	Dredge	max depth/on ground	37° 09,056' N	012° 53,294' E	48
M191_69-1	29.07.23 12:00	Dredge	max depth/on ground	37° 09,052' N	012° 53,342' E	45
M191_70-1	29.07.23 14:52	Dredge	max depth/on ground	37° 10,603' N	012° 49,413' E	115
M191_71-1	29.07.23 16:04	Dredge	max depth/on ground	37° 10,611' N	012° 49,251' E	85
M191_72-1	29.07.23 17:01	Dredge	max depth/on ground	37° 10,533' N	012° 49,956' E	138
M191_73-1	29.07.23 18:24	Dredge	max depth/on ground	37° 10,623' N	012° 49,516' E	112
M191_74-1	29.07.23 19:10	Magnetometer	in the water	37° 10,556' N	012° 49,763' E	110
M191_74-1	30.07.23 11:32	Magnetometer	on deck	36° 51,320' N	013° 03,956' E	110
M191_75-1	30.07.23 12:16	Dredge	max depth/on ground	36° 51,889' N	013° 06,543' E	495
M191_76-1	30.07.23 14:16	Dredge	max depth/on ground	36° 51,731' N	013° 07,339' E	656
M191_77-1	30.07.23 15:13	Magnetometer	in the water	36° 52,455' N	013° 06,583' E	725
M191_77-1	30.07.23 17:39	Magnetometer	on deck	37° 08,870' N	012° 51,151' E	62
M191_78-1	30.07.23 18:04	Dredge	max depth/on ground	37° 08,527' N	012° 51,607' E	50
M191_79-1	30.07.23 19:27	Dredge	max depth/on ground	37° 08,868' N	012° 52,062' E	49
M191_80-1	30.07.23 20:18	Magnetometer	in the water	37° 08,841' N	012° 51,754' E	56
M191_80-1	31.07.23 11:36	Magnetometer	on deck	36° 49,074' N	013° 02,487' E	138
M191_81-1	31.07.23 12:23	Dredge	max depth/on ground	36° 49,295' N	013° 03,351' E	105
M191_82-1	31.07.23 13:42	Dredge	max depth/on ground	36° 49,369' N	013° 03,382' E	108
M191_83-1	31.07.23 15:06	Dredge	max depth/on ground	36° 52,144' N	013° 05,176' E	280
M191_84-1	31.07.23 16:48	Dredge	max depth/on ground	36° 52,148' N	013° 05,173' E	283
M191_85-1	31.07.23 18:16	Dredge	max depth/on ground	36° 52,105' N	013° 05,145' E	225

Station	Date / Time UTC	Device	Action	Latitude	Longitude	Depth (m)
M191_86-1	31.07.23 19:34	Magnetometer	in the water	36° 52,281' N	013° 04,889' E	297
M191_86-1	01.08.23 12:57	Magnetometer	on deck	36° 52,057' N	013° 04,507' E	159
M191_87-1	01.08.23 13:36	Dredge	max depth/on ground	36° 52,608' N	013° 03,899' E	261
M191_88-1	01.08.23 14:51	Dredge	max depth/on ground	36° 52,269' N	013° 01,743' E	255
M191_89-1	01.08.23 16:04	Dredge	max depth/on ground	36° 51,601' N	013° 02,800' E	151
M191_90-1	01.08.23 17:58	Dredge	max depth/on ground	36° 49,188' N	013° 09,488' E	250
M191_91-1	01.08.23 18:47	Magnetometer	in the water	36° 49,287' N	013° 09,141' E	225
M191_91-1	02.08.23 12:06	Magnetometer	on deck	36° 38,742' N	013° 14,657' E	403
M191_92-1	02.08.23 13:11	Sound Velocity Profiler	information	36° 32,732' N	013° 14,216' E	1485

APPENDIX

Underway water sampling list (nannoplankton research)

Introduction and Method

The M191 Expedition provided a unique opportunity to perform nannoplankton sampling across the Mediterranean Sea (from Algeciras, Spain to Piraeus, Greece) and therefore, investigate plankton assemblages and determine patterns of coccolithophore/nannoplankton biogeography, calcification, and life-cycle dynamics. Accordingly, surface seawater samples were collected in the main Exp. M191 working area in the Sicilian Channel and during transits throughout the Spanish and Greek exclusive economic zones, to assess extant coccolithophore (nannoplankton) species assemblages. Samples (~12 L) were collected day and night at approximately every 2–4 hours whilst in transit and approximately every 12 hours while dredging operations were carried out. Sampling was conducted either via a plastic bucket with a nylon rope over the side of the starboard main deck or via a tap near the suction valve of the automated thermosalinograph (“Reinseewasser”, supplied by the sinus pump system) located at the bow of the vessel. The sampling depth approximately represents a mixed upper 10 m of surface water. Upon retrieval, the plastic 12L bucket was transferred into the lab; latitude and longitude coordinates, the time and date of each collection (in UTC) and the water temperature, salinity, conductivity, and density were recorded (see Tables below).

For each sampling station, c. 5–8 L of seawater were filtered using a stainless-steel filtration ramp onto 47 mm diameter, 0.8 µm pore-size Millipore polycarbonate track-etched filters. Prefiltration through a brass 63 µm test sieve was carried out to remove larger zooplankton and contaminants. A low-pressure vacuum pump was also used during the

filtration to avoid mechanical breakage of specimens. Salt was removed by washing the filters with ~3 mL of Milli-Q deionised water buffered to a pH of about 8.5 with ammonia (NH₃). After filtration, the filters were placed individually in 47 mm plastic Millipore Petri-slides and dried in an oven at 50°C. Once dry, a portion of each filter was cut out and mounted onto a glass microscope slide using Norland Optical Adhesive (NOA) 61 (refractive index= 1.56). The filter membranes were then sealed in Petri-slides, covered with Parafilm, and frozen for post-cruise analyses.

Preliminary Results

In total, 82 water samples were collected during the passage across the Mediterranean Sea from Algeciras, Spain to Piraeus, Greece and in the main working area in the Sicilian Channel where dredging operations were conducted. Water temperature, salinity, conductivity, and density were measured/recorded by the ship's built-in automated thermosalinograph at all sampling locations, and these fluctuated, respectively, from 19–31°C, 36–38 PSU, 50–61 mS/cm and 1023–1025 kg/m³. The bulk of the nanoplankton analyses will be undertaken post-cruise, together with synthesis of data from previous coccolithophore studies. Some preliminary observations are, however, made by using a Leica/Wild M3Z Stereo Microscope. These revealed the presence of 1) organic matter ranging in content across sampling stations; 2) larger planktonic organisms (e.g., juvenile planktonic foraminifera) that were found sporadically on the filter membranes; and 3) diverse assemblages of smaller (< 45 µm) plankton. Detailed nanoplankton analyses including taxonomic identification, counts and geochemical studies will be implemented post-cruise with appropriate access to geochemical labs and high-resolution microscopy.

In total, the 82 water samples collected during M191 expedition, represented over 510 L, while preliminary analyses were carried out on ship on 28 samples. Seawater sampling was productive in terms of recovery of plankton assemblages and will correspondingly formulate promising post-cruise research on coccolithophore diversity, ecology and calcification as means to understand and monitor effects of climate change on marine ecosystems.

Water samples taken within the Spanish EEZ:

Sample	Date	Time (UTC)	Depth (m)	Latitude (°N)	Longitude (°E)	Temperature (°C)	Salinity (PSU)
M191-PL-1	16.07.23	08:45:20	0-5	36°03,086'	-05°22,111'	19.2	-
M191-PL2	16.07.23	12:35:48	0-5	36°05,054'	-04°38,177'	24.6	36.35
M191-PL2b	16.07.23	12:52:00	0-5	36°05,345'	-04°35.683'	24.8	36.35
M191-PL3	16.07.23	18:20:11	0-2	36°12,678'	-03°31,374'	20.8	36.33
M191-PL4	16.07.23	22:16:20	0-2	36°18,041'	-02°46,118'	26.4	36.74
M191-PL5	16.07.23	02:05:15	0-2	36°24,450'	-02°01,598'	27.5	36.83
M191-PL6	16.07.23	06:21:55	0-2	36°39,327'	-01°12,518'	27.1	36.96
M191-PL7	16.07.23	10:23:55	0-2	36°59,058'	00°02,977'	27.3	37.12
M191-PL8	16.07.23	14:16:30	0-2	37°21,397'	00°08,706'	27.8	36.97
M191-PL9	16.07.23	17:54:17	0-2	37°41,589'	00°45,490'	28	36.74
M191-PL10	16.07.23	21:42:33	0-2	37°46'	01°24'	28.3	37.32

Water samples taken within the Italian EEZ:

Sample	Date	Time (UTC)	Depth (m)	Latitude (°N)	Longitude (°)	Temperature (°C)	Salinity (PSU)
M191-PL11	19.07.23	01:44:19	0-2	38°15,363'	07°17,526'	28.9	37.33
M191-PL12	19.07.23	04:52:28	0-2	38°17,372'	08°00,563'	28.8	37.38
M191-PL13	19.07.23	08:31:36	0-2	38°21,045'	08°41,979'	27.3	37.69
M191-PL14	19.07.23	00:05:18	0-5	38°21,523'	008°50,448'	30.5	37.7
M191-PL15	19.07.23	17:14:51	0-5	38°25,301'	009°51,648'	30.9	38
M191-PL16	19.07.23	21:22:54	0-2	38°27,884'	010°43,451'	29.1	37.76
M191-PL17	20.07.23	01:36:45	0-2	38°05,901'	011°27,052'	29.7	36.8
M191-PL18	20.07.23	05:26:24	0-2	37°44,707'	012°06,141'	28	37
M191-PL19	20.07.23	08:32:28	0-2	37°30,656'	012°32,320'	25.1	37.69
M191-PL19b	20.07.23	08:23:27	0-5	37°30,666'	012°32,307'	26.3	37.74
M191-PL20	20.07.23	13:09:39	0-5	37°25,857'	012°44,642'	27.7	37.74
M191-PL21	20.07.23	17:30:55	0-5	37°29,434'	012°39,973'	25.4	37.75
M191-PL22	20.07.23	21:19:52	0-5	37°22,176'	012°47,719'	26.7	37.69
M191-PL23	21.07.23	01:12:44	0-5	37°28,129'	012°54,625'	26.7	37.78
M191-PL24	21.07.23	05:59:16	0-5	37°21,978'	012°50,270'	26.8	37.75

M191-PL25	21.07.23	15:54:26	0-5	37°25,953'	012°54,153'	26.6	37.78
M191-PL26	21.07.23	15:59:48	0-2	37°14,578'	012°42,588'	28.1	37.63
M191-PL27	21.07.23	09:49:05	0-5	37°14,168'	012°43,140'	28.4	37.75
M191-PL28	21.07.23	20:01:25	0-5	37°12,064'	012°41,471'	28.7	37.77
M191-PL29	22.07.23	00:05:16	0-5	37°04,202'	012°39,717'	27.9	37.77
M191-PL30	22.07.23	03:56:11	0-5	37°01,677'	012°41,035'	27.8	37.75
M191-PL31	22.07.23	08:21:56	0-5	37°10,305'	012°42,200'	27.2	37.78
M191-PL32	22.07.23	14:14:03	0-5	37°08,834'	012°42,597'	26.6	37.82
M191-PL33	22.07.23	18:31:11	0-5	36°58,452'	012°33,705'	27.8	37.77
M191-PL34	22.07.23	21:58:28	0-5	37°00,953'	012°29,650'	28.2	37.75
M191-PL35	23.07.23	01:02:38	0-5	37°13,457'	012°23,952'	26.8	37.7
M191-PL36	23.07.23	05:55:03	0-5	37°15,437'	012°20,533'	27.1	37.69
M191-PL37	23.07.23	13:48:43	0-5	37°02,011'	012°27,888'	28.8	37.77
M191-PL38	23.07.23	21:50:05	0-5	37°12,794'	012°24,377'	28.6	37.74
M191-PL39	24.07.23	11:01:45	0-5	37°09,625'	012°53,321'	28.4	37.66
M191-PL40	24.07.23	20:02:18	0-5	37°09,718'	012°53,066'	28.9	37.68
M191-PL41	25.07.23	11:50:57	0-5	36°49,943'	013°07,809'	28.9	37.69
M191-PL42	25.07.23	23:31:50	0-5	36°45,793'	012°50,191'	28.1	37.51
M191-PL43	26.07.23	10:45:41	0-5	35°55,770'	012°49,110'	28.8	37.56
M191-PL44	26.07.23	21:45:47	0-5	35°56,070'	012°48,838'	27.9	37.38
M191-PL45	27.07.23	11:11:54	0-5	35°59,398'	013°08,717'	27.5	37.43
M191-PL46	27.07.23	21:55:04	0-5	36°08,777'	012°46,023'	27.3	37.22
M191-PL47	28.07.23	10:12:22	0-5	36°03,511'	012°59,616'	26.4	37.22
M191-PL48	28.07.23	22:12:30	0-5	36°01,095'	013°03,266'	27.4	37.25
M191-PL49	29.07.23	12:01:11	0-5	37°09,051'	012°53,340'	26.2	37.71
M191-PL50	29.07.23	21:43:01	0-5	37°11,014'	012°46,491'	26.3	37.75
M191-PL51	30.07.23	10:14:53	0-5	36°49,261'	013°10,539'	26.7	37.71
M191-PL52	30.07.23	21:34:41	0-5	37°06,890'	012°48,881'	26.3	37.69
M191-PL53	31.07.23	10:36:23	0-5	36°47,944'	013°12,174'	27	37.73
M191-PL54	31.07.23	21:37:00	0-5	36°51,133'	013°04,572'	25.5	37.55
M191-PL55	01.08.23	10:01:33	0-5	36°43,369'	013°24,115'	26.5	37.71
M191-PL56	01.08.23	20:22:28	0-5	36°46,554'	013°04,134'	25.6	37.55
M191-PL57	02.08.23	10:27:23	0-5	36°35,762'	013°15,156'	26.4	37.69
M191-PL58	02.08.23	22:14:19	0-5	36°26,010'	015°00,728'	27.3	37.71
M191-PL59	03.08.23	01:11:57	0-2	36°22,047'	015°36,569'	27.6	38.41
M191-PL60	03.08.23	04:07:49	0-2	36°20,068'	016°12,335'	28.1	38.39
M191-PL61	03.08.23	09:11:01	0-2	36°16,664'	017°14,807'	28.6	37.39
M191-PL62	03.08.23	12:14:49	0-2	36°14,772'	017°52,052'	27.8	37.84

Water samples taken within the Greek EEZ:

Sample	Date	Time (UTC)	Depth (m)	Latitude (°N)	Longitude (°E)	Temperature (°C)	Salinity (PSU)
M191-PL63	3.8.23	15:11	0-2	36°12,883'	018°28,390'	29.8	37.68
M191-PL64	3.8.23	6:21	0-2	36°11,511'	019°06,533'	28.9	38.47
M191-PL65	3.8.23	20:59	0-2	36°10,403'	019°37,530'	28.7	38.81
M191-PL66	3.8.23	23:09	0-2	36°09,498'	020°02,901'	28.6	39.05
M191-PL67	4.8.23	0:53	0-2	36°08,769'	020°23,200'	28.4	38.99
M191-PL68	4.8.23	3:03	0-2	36°07,918'	020°46,928'	28.2	38.42
M191-PL69	4.8.23	5:00	0-2	36°07,112'	021°09,405'	27.8	38.64
M191-PL70	4.8.23	7:07	0-2	36°06,209'	021°35,098'	28.2	39.03
M191-PL71	4.8.23	9:07	0-2	36°05,318'	021°59,349'	27.7	38.63
M191-PL72	4.8.23	11:08	0-2	36°04,352'	022°23,161'	27.4	38.94
M191-PL73	4.8.23	13:12	0-2	36°03,579'	022°47,888'	28.2	39.35
M191-PL74	4.8.23	14:48	0-2	36°03,755'	023°06,881'	27.6	38.96
M191-PL75	4.8.23	17:14	0-2	36°22,521'	023°20,736'	27.9	39.02
M191-PL76	4.8.23	19:01	0-2	36°38,638'	023°26,700'	28.4	38.94
M191-PL77	4.8.23	21:10	0-2	36°57,852'	023°33,223'	28	39.33
M191-PL78	4.8.23	23:03	0-2	37°14,587'	023°38,176'	28.3	38.7
M191-PL79	5.8.23	1:02	0-2	37°31,848'	023°43,174'	28.2	38.88
M191-PL80	5.8.23	3:02	0-2	37°45,333'	023°42,544'	28.4	38.97