

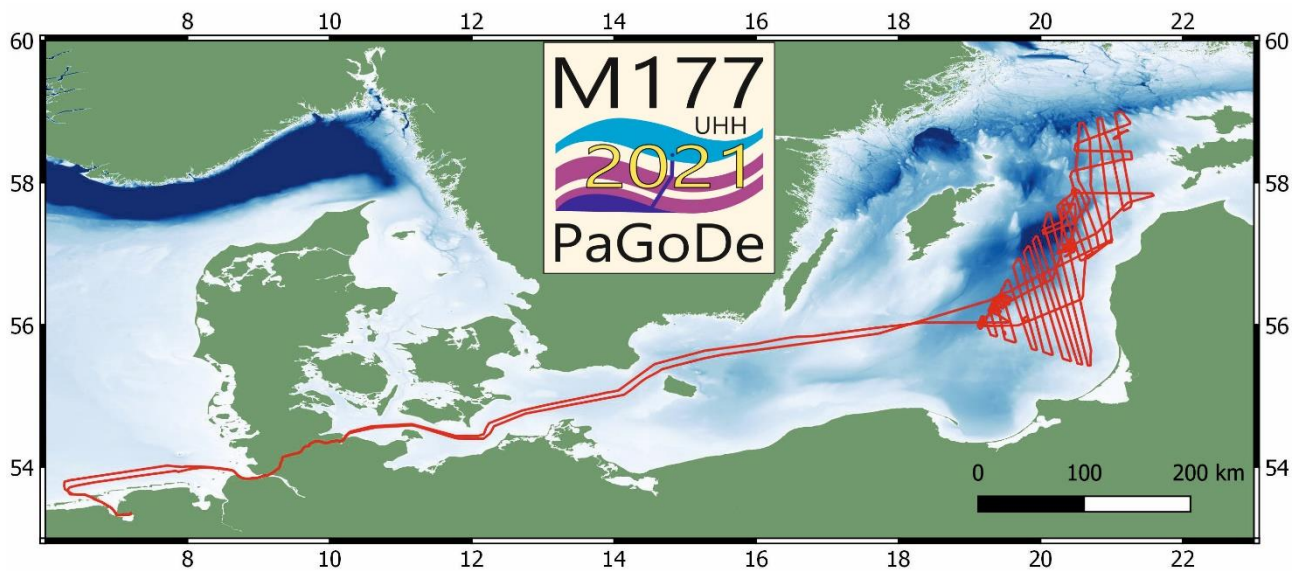
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Short Cruise Report RV METEOR M177

Emden - Emden
22.10. - 18.11.2021

Chief Scientist: Prof. Dr. Christian Hübscher
Captain: Rainer Hammacher



Objectives

Primary objectives of the PaGoDe-project are geophysical investigations (1) to study the fluid migration, sealing and bypass system for hydrocarbons and CO₂ by seismic reflection data, and (2) to refine the seismo-stratigraphic framework for the evolutions of Silurian carbonate-dominated marginal deposits and barrier reefs. A secondary objective is to investigate the bathymetry and morphogenesis of the study area regarding the discrimination between glacial erosion, glacial deposits and tectonics. Topic 1: A recent study provided compelling evidence that hydrocarbon fluids migrated north-westwards from reservoirs located beneath Latvia towards the Gotland Depression, where the fluids are partly sealed by glaciogenic deposits and partly blowout at the seabed causing marine pollution. Further, under the umbrella of the BASTOR project, Sweden and the Baltic states investigate the potential of Cambrian sandstones in the central Baltic region for Carbon Capture and Storage to ensure CO₂ storage in stratigraphic traps or structural closures. However, ground-truthing geophysical profiles that cross national boundaries are lacking yet. Necessary geochemical analyses must be carried out in follow-up projects. Topic 2: Previous studies accounted mainly relative sea-level changes as main control factor for the development of Silurian reefs. Recent studies elsewhere, however, showed how the oceanographic setting, especially currents, influences carbonate platform stratigraphy. With Topic 3 we will address various aspects of Quaternary glacial processes. Glacial erosion created scours and a cuesta type bedrock relief, glaciogenic deposits from moraines and drumlins, and both may simulate outcropping fault planes. The discrimination between erosional, depositional and tectonic features by the topography only is far from obvious. High-resolution seismic images are needed as shown by previous studies.

To achieve the scientific objectives, we survey profiles parallel and perpendicular to the structural trend of the subsurface geology. The imaging method of reflection seismics allows us to create cross-sectional images through the Paleozoic strata. The parametric sediment echosounder "Parasound" forms late Pleistocene and Holocene sedimentary sequences. The multibeam is used for areal mapping of the seafloor. Continuous gravimeter records provide information on large-scale structures of the Earth's crust.

Narrative

The advance party of scientists arrived at METEOR in the port of Emden in the early evening of Oct. 21 and were warmly welcomed as usual by Captain Hammacher and his crew. The next morning, we took containers and equipment on board and started with the installation of the winches on deck, where we were actively supported by the crew. Around noon, the main group also came on board, and after a short, initial briefing, we continued with the rigging of the laboratories. The safety briefing with ship's guidance followed in the afternoon, and at 6 p.m. it was already time to "cast off", and the PaGoDe expedition with the sailing code M177 began. Beyond the Emden lock, a somewhat choppy sea awaited us in the North Sea, which provided some movement of the ship until the next morning and reaching the Elbe. In the Nord-Ostseekanal, the "NOK", we enjoyed sunshine and calm water, which facilitated further assembly work. Around 7 p.m. we passed the NOK lock at Kiel-Holtenau, and we started the transit into the working area, namely the exclusive economic zones (EEZ) of Estonia, Latvia and Lithuania. The EEZ of a coastal state marks the area beyond the territorial sea, the 12 nautical mile zone. To the west, our working area is bounded by the maritime border with Sweden. We used the time to complete the technical preparations.

On Monday morning Oct. 25 we reached the working area within the EEZ of Latvia, and started with the deployment of the reflection seismic. We inserted the digitizing modules into the starboard towed digital streamer, which took about 2 hours. On the port side, a shorter analog streamer was lowered into the water, which has its advantages in particularly shallow water. At the same time, the visual search for marine mammals began. Lastly, we launched the seismic wells. The measurements started with a ramp-up of the source and tests of its operational settings. Then, in the early evening, systematic mapping of the work area began with seismic, hydroacoustics (parasound and multibeam), and the marine gravimeter.

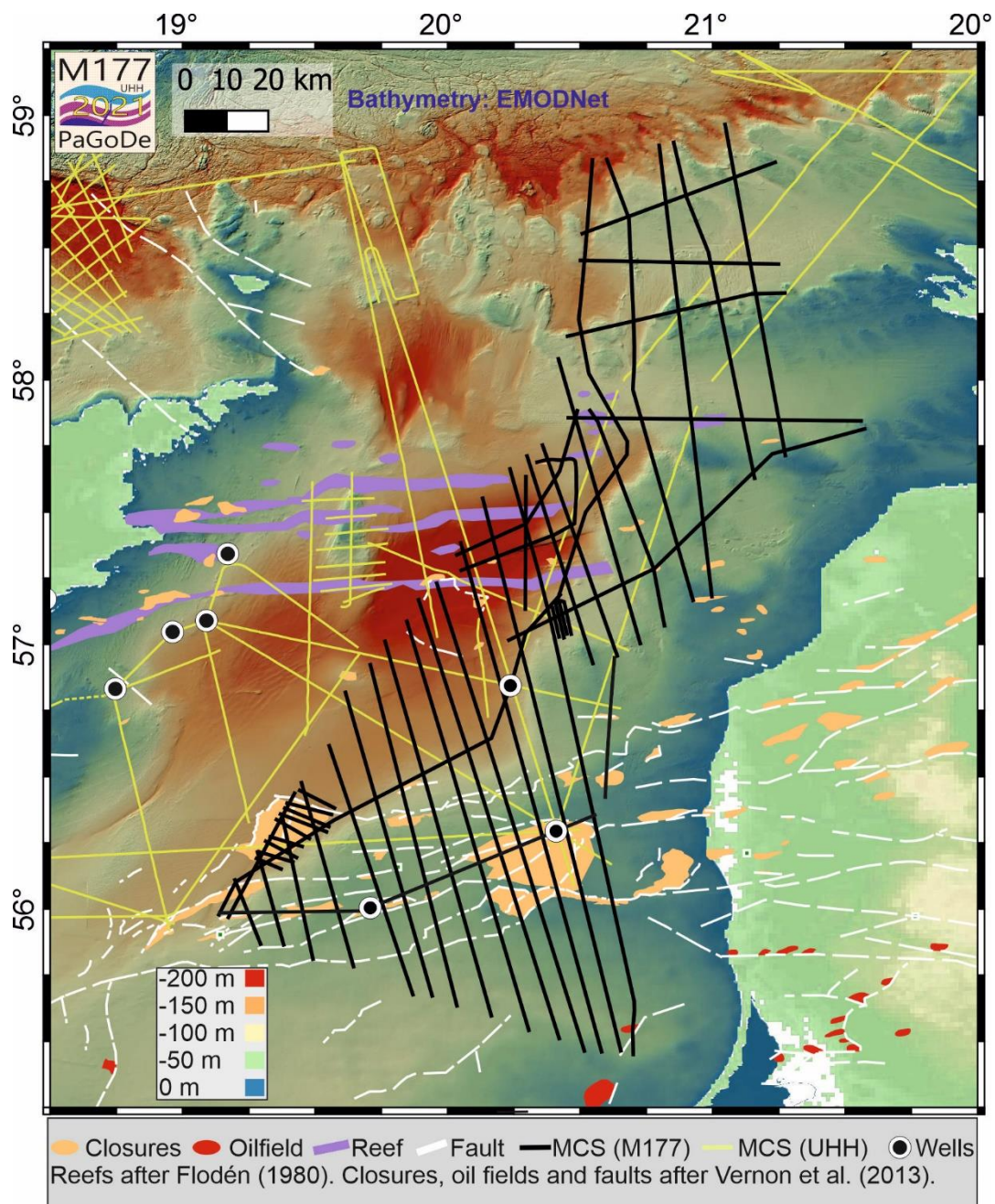
Since the digital streamer had too much downwelling, we interrupted the measurements on Tuesday and removed ballast in the forward sections, and since then the streamer has been stable at 2 m depth. In the first days we had quite heavy seas and strong winds, which were not optimal for our measurements, but did not lead to any delay. As the week progressed, the weather improved and we even enjoyed some sunny days. After a few days, a routine had settled in, as we were measuring "24/7", that is, around the clock. On Nov. 3 the processing of the seismic data had progressed so far that deeper insights could be gained. It turned out that fluids from the Paleozoic basement rise to the seafloor and escape there, as suspected.

The profiles measured up to Nov. 4 extend from the Gotland Basin to the 12 nautical mile zone of the Baltic States. The most important goal of the profiles measured up to this point was to investigate fluid transport in the subsurface and to map Silurian reefs. The profiles of the next two days were transverse to the previous profiles and will facilitate stratigraphic correlation between the profiles.

On Saturday, Nov. 6, seismic measurements were interrupted for maintenance. By early afternoon the following day, METEOR was cruising along numerous parallel profiles across fluid seeps. In the afternoon of that Nov. 7, seismic profiling began again. Two profiles over Silurian reefs lasted until the next day. The five approximately west-east trending profiles in the Estonian EEZ measured until Nov. 11 were planned to distinguish glacial erosional features from glacial sediments and to stratigraphically connect the north-south profiles measured until Nov. 13.

A subsequent traverse of about 300 km between the northernmost and southernmost boundaries of our work area was interrupted only by three short profiles on Nov. 13 for a detailed study of fluid seepages. The traverse was completely surveyed by 8 p.m. on Nov. 14. The profiles surveyed by early afternoon on Nov. 15 were used to investigate suspected karst structures, covered by Devonian sand stones.

The scientific work program ended shortly before 2 p.m. on Nov. 15. Seismic and all soundings were exhibited. By 5 p.m., all towed equipment was safely on deck and METEOR began transit to the Kiel Canal, which was transited on Nov. 17. In the North Sea, the ship expected somewhat choppy seas, but they calmed down as soon as the Ems was reached. On Nov. 18 at 9 am RV METEOR moored at the Südkai in Emden - the PaGoDe expedition M177 was over.



Map with M177 seismic profiles and geological structures. Closures are either anticlines or structural traps. Green lines mark seismic profiles collected with RV MARIA S. MERIAN (MSM52, 2016) and RV ALKOR (AL502, 2017; AL515, 2018; AL526, 2019), all by IFG-HH. The stratigraphic information from the shown wells is available. Profile extend was limited by 12 nm zone of Estonia, Latvia and Lithuania as well as national borders to Sweden and Russia.

Acknowledgements

We like to thank Captain Rainer Hammacher and the professional crew of the RV METEOR for their enthusiastic support during the entire cruise that enabled us to successfully complete our working program in a good atmosphere on board.

Teilnehmerliste

1.	Prof. Dr. Christian Hübscher	Chief scientist	IfG-HH
2.	Jonas Preine	Deputy chief scientist	IfG-HH
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4.	Malte Aster	Seismics	IfG-HH
5.	Ingra Barbosa	Seismics	IfG-HH
6.	Laura Bogner	Seismics	IfG-HH
7.	Tobias Häcker	Shift leader	IfG-HH
8.	Benedict Haimerl	Seismics	IfG-HH
9.	Matthias Hartge	Shift leader	IfG-HH
10.	Zainab Iftikhar	Seismics	IfG-HH/IfG-UW
11.	Niklas Kornrumpf	Hydroacoustics	IfGeol-HH
12.	Xenia Lotze	Interior design (invited)	IAD-RO
13.	Christian Rohleder	Technician (Met.)	DWD
14.	Wiebke Schäfer	Shift leader	IfG-HH
15.	Victoria Strehse	Hydroacoustics	IfGeol-HH
16.	Patrick Suter	Meteorology	DWD
17.	Karolina Uhl	Seismics	IfG-HH
18.	Arne Warwel	Shift leader	IfG-HH
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Stationsliste

Station Number	MCS Profile	Start Date	Start Time (UTC)	Start Latitude (°N)	Start Longitude (°E)	End Date	End Time (UTC)	End Latitude (°N)	End Longitude (°E)
M177_2_1 SEISTR	01	25.10.21	13:45	56°58.11'	020°38.213'	25.10.21	22:02	57°47.09'	020°20.85'
	02	25.10.21	23:23	57°39.94'	020°13.99'	26.10.21	06:10	56°59.56'	020°24.57'
	03	26.10.21	11:45	57°00.40'	020°25.45'	27.10.21	03:00	55°38.03'	020°42.49'
	04	27.10.21	05:31	55°26.23'	020°39.61'	28.10.21	05:04	57°33.83'	020°07.80'
	05	28.10.21	07:35	57°22.10'	020°03.25'	29.10.21	04:34	55°27.13'	020°35.03'
	06	29.10.21	05:13	55°27.60'	020°31.02'	29.10.21	23:38	57°14.57'	019°57.33'
	07	30.10.21	00:39	57°10.43'	019°53.37'	30.10.21	23:06	55°29.92'	020°25.52'
	08	31.10.21	00:00	55°31.92'	020°18.58'	31.10.21	17:13	57°05.08'	019°50.85'
	09	31.10.21	18:39	57°00.74'	019°45.85'	01.11.21	10:34	55°35.44'	020°10.03'
	10	01.11.21	11:37	55°27.39'	020°02.28'	02.11.21	04:06	56°54.90'	019°42.70'
	11	02.11.21	05:43	56°49.48'	019°36.77'	02.11.21	21:21	55°39.59'	019°56.73'
	12	02.11.21	22:05	55°40.71'	019°52.10'	03.11.21	08:35	56°37.23'	019°33.18'
	13	03.11.21	11:27	56°30.08'	019°27.50'	03.11.21	19:36	55°46.22'	019°38.92'
	14	03.11.21	20:50	55°48.29'	019°29.58'	04.11.21	03:45	56°20.77'	019°22.34'
	15	04.11.21	05:25	56°13.62'	019°16.78'	04.11.21	10:00	55°51.10'	019°23.10'
	16	04.11.21	10:15	55°51.65'	019°17.83'	04.11.21	13:06	56°06.84'	019°11.77'
	17	04.11.21	14:43	55°59.12'	019°07.56'	05.11.21	01:25	56°21.61'	020°34.12'
	18	05.11.21	02:00	56°24.67'	020°35.72'	05.11.21	07:00	56°57.50'	020°37.87'
	19	05.11.21	07:00	56°57.50'	020°37.87'	05.11.21	18:49	57°53.28'	020°32.11'
	20	05.11.21	19:12	57°53.18'	020°29.40'	06.11.21	02:05	57°20.12'	020°01.65'
	21	06.11.21	02:45	57°16.71'	020°02.94'	06.11.21	08:24	57°41.38'	020°28.97'
M177_5_1 SEISTR	22	07.11.21	12:55	57°00.27'	020°14.26'	08.11.21	01:30	57°41.38'	020°28.97'
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	24	08.11.21	09:43	57°54.32'	020°26.74'	08.11.21	21:16	56°54.80'	020°33.28'
	25	08.11.21	22:41	57°00.03'	020°43.74'	09.11.21	09:37	58°05.17'	020°25.01'
	26	09.11.21	10:25	58°09.84'	020°26.88'	09.11.21	15:08	58°19.73'	021°16.16'
	27	09.11.21	16:23	58°26.28'	021°15.08'	09.11.21	21:04	58°27.10'	020°29.94'
	28	09.11.21	22:09	58°32.62'	020°29.60'	10.11.21	03:26	58°49.61'	021°14.86'
	29	10.11.21	03:45	58°51.31'	021°15.27'	10.11.21	05:27	58°59.73'	021°08.44'
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	31	11.10.21	02:04	57°36.95'	021°09.70'	11.11.21	15:24	58°53.84'	020°51.58'
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	33	12.11.21	09:53	57°09.70'	020°55.55'	13.11.21	02:42	58°50.42'	020°35.93'
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	35	13.11.21	21:48	57°02.43'	020°28.01'	13.11.21	22:59	57°09.65'	020°26.41'
	36	13.11.21	23:23	57°08.86'	020°23.65'	14.11.21	00:36	57°01.48'	020°25.29'
	37	14.11.21	00:54	57°01.87'	020°27.15'	14.11.21	02:07	57°09.29'	020°25.50'
	38	14.11.21	02:58	57°10.88'	020°25.16'	14.11.21	18:02	55°57.87'	019°07.78'
	39	14.11.21	18:20	55°57.22'	019°09.90'	14.11.21	23:36	56°25.85'	019°25.15'
	40	14.11.21	23:50	56°26.08'	019°27.40'	15.11.21	00:47	56°22.66'	019°34.92'
	41	15.11.21	01:04	56°21.42'	019°33.80'	15.11.21	02:11	56°24.16'	019°23.57'
	42	15.11.21	02:29	56°22.95'	019°22.84'	15.11.21	03:46	56°18.52'	019°33.55'
	43	15.11.21	04:04	56°17.51'	019°32.27'	15.11.21	05:17	56°21.58'	019°21.91'
	44	15.11.21	05:34	56°20.43'	019°21.04'	15.11.21	06:44	56°15.76'	019°29.13'
	45	15.11.21	07:08	56°14.15'	019°27.24'	15.11.21	08:02	56°16.48'	019°19.58'
	46	15.11.21	08:23	56°15.00'	019°18.53'	15.11.21	09:24	56°11.57'	019°26.11'
	47	15.11.21	09:40	56°10.61'	019°25.10'	15.11.21	10:37	56°13.14'	019°17.03'
	48	15.11.21	10:58	56°11.62'	019°16.40'	15.11.21	11:48	56°08,842'	019° 22,875'