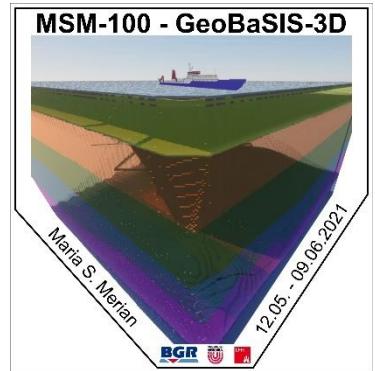


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R/V MARIA S. MERIAN
Short Cruise Report
Cruise MSM100

Emden – Emden
12.05.2021 – 09.06.2021

Chief-Scientist: Axel Ehrhardt
Captain: Björn Maaß

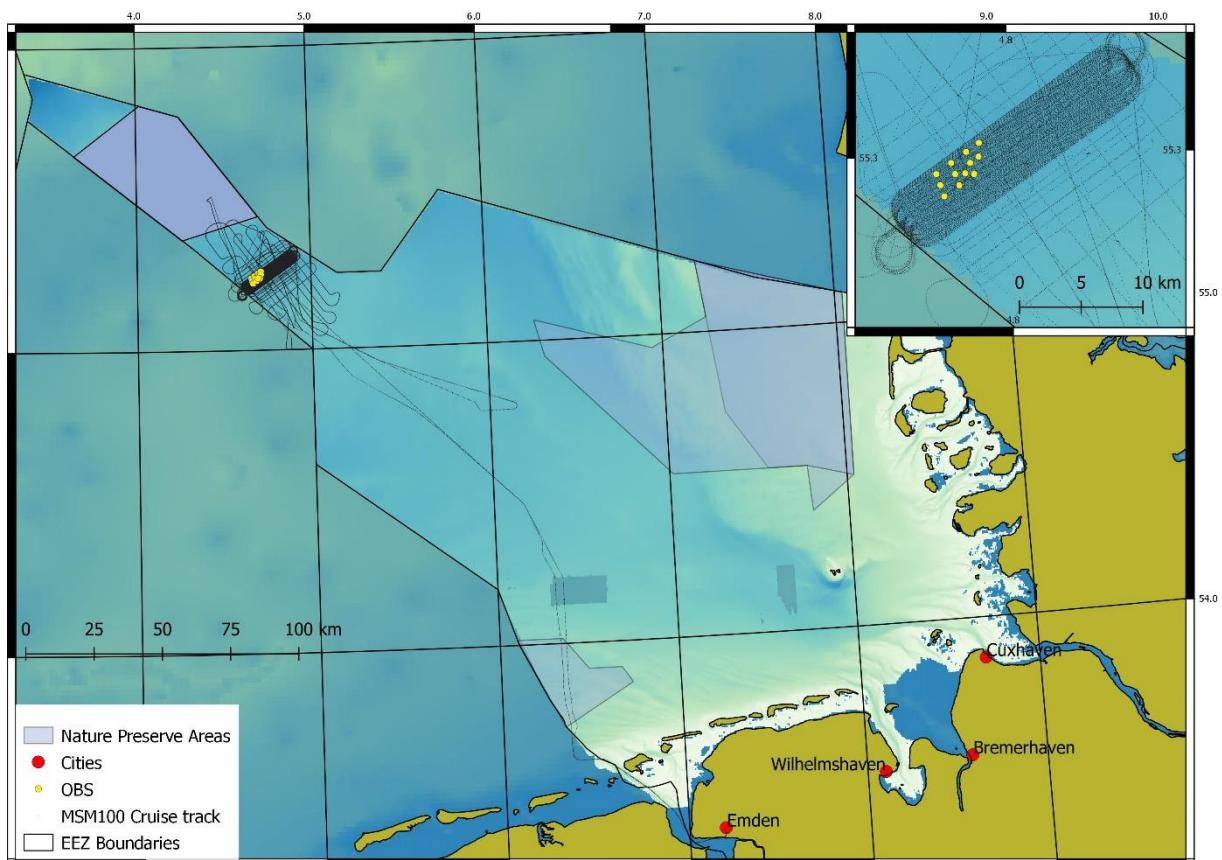


Fig. 1: Cruise plot of MSM100. The black dots mark the position of R/V MARIA S. MERIAN during the cruise. The close-up in the upper right frame depicts the 3D-survey box. The coarser line net shows the 2D lines that were acquired during a bad weather period. The Dutch EEZ and the Doggerbank Nature Preserve area were only used for turns or retrieving the equipment without data acquisition.

Objectives

Within the transition to renewable energy, the integrity of barriers and seals in the deep underground becomes increasingly important for storage purposes, e.g. for CO₂ in the framework of Carbon Capture and Storage (CCS) or for synthetic energy gases in the course of the change to renewable energy (Power2Gas). The tasks of this project are exemplary studies on the integrity of barrier formations of Cenozoic shale layers in the German North Sea. If the barrier formation is not closed, either because of abandoned drill holes or along natural pathways it enables discharge of fluids into the North Sea. Thus, the second topic is the understanding of migration of fluids along pathways through seal formations. For the first time we acquired high-resolution 3D multi-channel seismic and ocean bottom seismometers (OBS) data to image the Cenozoic sediments in detail, in order to identify and interpret the fault systems that may enable fluid migration to the surface and to transfer the interpretation into a 3D geological model. By means of the high-resolution data, we will image fault systems that were previously postulated in the “sub-seismic” domain. The data will cover different fault systems, seeps, and undisturbed strata in close proximity. The outcome of this study will be a profound understanding of fault systems and structures in the Cenozoic sediments like polygonal-, crestal- or step faults as well as tunnel valleys and especially how they communicate. Such a study on potential seal bypass systems is missing so far in the German North Sea.

Narrative

On May 11th 2021 the scientific/technical party of MSM100 embarked on the Research Vessel MARIA S. MERIAN, after a 10-day Covid-19 quarantine within a hotel in Varel. All scientists and technicians were tested negative. We used May 11th and 12th to mobilize all the heavy equipment, while being in the port of Emden. On Wednesday, May 12th evening we left the port of Emden and sailed towards the research area in the “Entenschnabel” area of the German Exclusive Economic Zone (EEZ) (Fig. 1).

After the arrival in the research area in the morning of May 13th we started deploying “click-detectors” in the framework of a common project with the Stiftung Deutsches Meeresmuseum (Stralsund). These “click-detectors” should monitor the presence of harbor porpoises in the survey area during and after our seismic survey. After the deployment of the “click-detectors” we started the deployment of 12 Ocean Bottom Seismometers (OBS). Because of the obligation to remove everything after finishing the survey, the anchors of the OBS were connected with a rope to the floating body of the OBS. After releasing the OBS from the anchor the OBS should pop up and the anchor would be retrieved by means of the rope. Because of the significant tide related bottom currents we used two anchors, welded together. After all OBS were deployed, we started handling tests of the paravans. During the night, we acquired Parasound sediment echosounder profiles.

On May 14th we started to deploy the 3D seismic equipment. Both streamer cables had to be equipped with collars for the compass birds and acoustic transponder (digirange) units and with Aux modules for the Quiet Sea Passive Acoustic Monitoring (PAM) system. Because of a defect bird on the port side streamer cable and issues with the power line to the tail buoy, we had to retrieve the port side equipment again in the evening. During the night, the starboard equipment stayed deployed and Parasound data was collected.

On May 15th the bird and the power line were fixed and the port side equipment was deployed. At noon we started with the first sail line of the 3D seismic survey.

From May 16th to May 20th we acquired 3D seismic data. We observed a bad weather period on the weather forecast with high wind speeds (8 – 9 Bft) and high swell and wind sea (up to 2.8 m), so we decided to retrieve the entire equipment on May 20th at 13:00 LT. During the bad weather window from May 20th to May 24th we switched to 2D seismic data acquisition and acquired 18 2D seismic lines. In order to test the new OBS anchor system we released and picked up two OBS successfully.

On May 25th we switched back to 3D seismic data acquisition. From May 25th to June 5th we acquired 3D seismic data. A 5.2 x 18 km box was completely covered by 118 sail-lines including 12 additional fill-in lines, which closed prominent gaps in the survey box. On June 5th we retrieved the 3D seismic equipment. During June 6th we released the 10 remaining OBS. One OBS did not surface, although we received a positive response to the release command. During the night, we localized the OBS by means of the EM712 shallow water multibeam system with an accuracy of about 1 m. The crew of R/V MARIA S. MERIAN assembled a provisory dredge system and on June 7th the crew successfully dredged the missing OBS. Back on board we recognized that the rope was entangled on the reel so that the rise of the OBS stopped after a few meters.

After all OBS were back on board we used the June 7th and 8th to start the demob of our equipment. In the time being, we acquired the remaining multibeam data of our survey area. On Wednesday, June 9th we met the pilot at the rendezvous position and headed towards the port of Emden (Südkai). Here we finished the demobilization of our equipment and the gravity land tie measurement was done. At 15:00 LT the scientific/ntechnical party disembarked from R/V MARIA S. MERIAN.

Acknowledgements

We would like to thank Captain Björn Maaß and the entire crew of R/V MARIA S. MERIAN for their excellent support during our cruise, for the hospitality and friendliness on board. The research cruise (GPF 19-2_070) was funded by the German Research Foundation (DFG) within the METEOR/MERIAN program.

MSM100 scientific/ technical party

Table 1: Technical and scientific party of the cruise MSM100. BGR: Bundesanstalt für Geowissenschaften und Rohstoffe (Hannover). University of Bremen, Fachbereich Geowissenschaften, Klagenfurter Straße 2-4 28359 Bremen. University of Hamburg, Institute of Geophysics, Bundesstr. 55, 20146 Hamburg. Gravionic: GRAVIONIC GmbH, - German Geoservices - Jasperallee 15 38102 Braunschweig. ION Concept Systems, 1 Logie Mill, Edinburgh EH7 4HG, UK.

| Name | Discipline | Institution |
|------------------|------------------------------------|-----------------------|
| Aike Albers | Hydroacoustics, Protocol, MMO | University of Bremen |
| Thomas Behrens | Streamer / Airguns | BGR |
| Ümit Demir | Seismic Acquisition System | BGR |
| Timo Ebert | Streamer / Airguns | BGR |
| Axel Ehrhardt | Chief-Scientist | BGR |
| Martin Engels | Navigation | BGR |
| Boris Hahn | Seismic Acquisition System | BGR |
| Benno Hankers | Marine Mammal Observer (MMO) | Gravionic |
| Ingo Heyde | Gravimetry, Protocol | BGR |
| Paul Leslie | Field Service Engineer Navigation | ION |
| Maximilian Meyer | Hydroacoustics, Protocol, MMO | University of Bremen |
| Michael Schauer | OBS, Streamer / Airguns | BGR |
| Michael Schnabel | Co-Chief Scientist / Navigation | BGR |
| Peter Steinborn | Seismic Acquisition System, OBS | BGR |
| Wiebke Schäfer | Hydroacoustics, Processing, MMO | University of Hamburg |
| Stephan Steuer | Interpretation, Protocol, Hydroac. | BGR |
| Arne Warwel | Hydroacoustics, Processing, MMO | University of Hamburg |

Station List

Table 2: Table of acquired 3D reflection seismic lines during MSM100. 3D survey locations is plotted in Fig. 1. The survey area consists out of 105 sail lines with a sail line distance of 50 m, resulting in an area of approximately 94 km². Additional 12 sail lines were used as ‘fill-in lines’. SOL: Start of Line; EOL: End of Line; UTC: Coordinated Universal Time (UTC=MEST-2h); SP: Shot-Point

| Line name BGR- | Date (SOL) | UTC Time (SOL) | SP (SOL) | Lat (SOL) | Lon (SOL) | Date (EOL) | UTC Time (EOL) | SP (EOL) | Lat (EOL) | Lon (EOL) |
|----------------|------------|----------------|----------|-----------|-----------|------------|----------------|----------|-----------|-----------|
| 102A001 | 15.05.2021 | 14:18:08 | 1000 | 55.23018 | 4.62134 | 15.05.2021 | 16:42:09 | 2491 | 55.32478 | 4.86339 |
| 342A002 | 15.05.2021 | 17:28:05 | 2441 | 55.29791 | 4.87834 | 15.05.2021 | 19:52:35 | 0950 | 55.20321 | 4.63658 |
| 106A003 | 15.05.2021 | 20:39:27 | 1000 | 55.22981 | 4.62179 | 15.05.2021 | 23:03:13 | 2491 | 55.32438 | 4.86386 |
| 346A004 | 15.05.2021 | 23:52:56 | 2441 | 55.29744 | 4.87889 | 16.05.2021 | 02:16:04 | 0950 | 55.20300 | 4.63682 |
| 110A005 | 16.05.2021 | 03:01:44 | 1000 | 55.22947 | 4.62220 | 16.05.2021 | 05:25:53 | 2491 | 55.32383 | 4.86451 |
| 350A006 | 16.05.2021 | 06:10:49 | 2441 | 55.29714 | 4.87925 | 16.05.2021 | 08:35:29 | 0950 | 55.20266 | 4.63724 |
| 114A007 | 16.05.2021 | 09:20:01 | 1000 | 55.22905 | 4.62270 | 16.05.2021 | 11:44:02 | 2491 | 55.32364 | 4.86475 |
| 354A008 | 16.05.2021 | 12:31:58 | 2441 | 55.29673 | 4.87974 | 16.05.2021 | 15:01:53 | 0950 | 55.20228 | 4.63771 |
| 118A009 | 16.05.2021 | 15:47:26 | 1000 | 55.22873 | 4.62308 | 16.05.2021 | 18:11:20 | 2491 | 55.32317 | 4.86531 |
| 358A010 | 16.05.2021 | 18:57:51 | 2441 | 55.29635 | 4.88019 | 16.05.2021 | 21:22:35 | 0950 | 55.20198 | 4.63805 |
| 122A011 | 16.05.2021 | 22:07:35 | 1000 | 55.22827 | 4.62363 | 17.05.2021 | 00:31:38 | 2491 | 55.32286 | 4.86567 |
| 362A012 | 17.05.2021 | 01:18:22 | 2441 | 55.29601 | 4.88060 | 17.05.2021 | 03:41:36 | 0950 | 55.20153 | 4.63858 |
| 126A013 | 17.05.2021 | 04:26:07 | 1000 | 55.22794 | 4.62403 | 17.05.2021 | 06:49:48 | 2491 | 55.32244 | 4.86618 |
| 366A014 | 17.05.2021 | 07:36:20 | 2441 | 55.29567 | 4.88101 | 17.05.2021 | 10:01:00 | 0950 | 55.20116 | 4.63903 |
| 130A015 | 17.05.2021 | 10:45:10 | 1000 | 55.22758 | 4.62447 | 17.05.2021 | 13:09:26 | 2491 | 55.32216 | 4.86651 |
| 370A016 | 17.05.2021 | 13:56:39 | 2441 | 55.29529 | 4.88146 | 17.05.2021 | 16:20:00 | 0950 | 55.20077 | 4.63948 |
| 134A017 | 17.05.2021 | 17:07:18 | 1000 | 55.22721 | 4.62491 | 17.05.2021 | 19:30:49 | 2491 | 55.32169 | 4.86708 |
| 374A018 | 17.05.2021 | 20:16:47 | 2441 | 55.29491 | 4.88191 | 17.05.2021 | 22:41:17 | 0950 | 55.20052 | 4.63980 |
| 138A019 | 17.05.2021 | 23:25:53 | 1000 | 55.22684 | 4.62534 | 18.05.2021 | 01:50:08 | 2491 | 55.32126 | 4.86759 |
| 378A020 | 18.05.2021 | 02:36:14 | 2441 | 55.29451 | 4.88239 | 18.05.2021 | 04:59:47 | 0950 | 55.20006 | 4.64036 |
| 142A021 | 18.05.2021 | 05:45:30 | 1000 | 55.22647 | 4.62579 | 18.05.2021 | 08:08:52 | 2491 | 55.32096 | 4.86795 |
| 382A022 | 18.05.2021 | 08:56:09 | 2441 | 55.29416 | 4.88281 | 18.05.2021 | 11:20:29 | 0950 | 55.19970 | 4.64078 |
| 146A023 | 18.05.2021 | 12:04:30 | 1000 | 55.22612 | 4.62622 | 18.05.2021 | 14:28:47 | 2491 | 55.32070 | 4.86826 |
| 386A024 | 18.05.2021 | 15:14:28 | 2441 | 55.29381 | 4.88322 | 18.05.2021 | 17:38:18 | 0950 | 55.19926 | 4.64132 |
| 150A025 | 18.05.2021 | 18:24:26 | 1000 | 55.22573 | 4.62668 | 18.05.2021 | 20:47:56 | 2491 | 55.32024 | 4.86881 |
| 390A026 | 18.05.2021 | 21:34:54 | 2441 | 55.29342 | 4.88369 | 18.05.2021 | 23:59:07 | 0950 | 55.19902 | 4.64159 |
| 154A027 | 19.05.2021 | 00:42:44 | 1000 | 55.22534 | 4.62714 | 19.05.2021 | 03:07:00 | 2491 | 55.31994 | 4.86917 |
| 394A028 | 19.05.2021 | 03:52:47 | 2441 | 55.29303 | 4.88416 | 19.05.2021 | 06:16:14 | 0950 | 55.19855 | 4.64217 |
| 158A029 | 19.05.2021 | 07:03:21 | 1000 | 55.22498 | 4.62759 | 19.05.2021 | 09:27:03 | 2491 | 55.31952 | 4.86967 |
| 398A030 | 19.05.2021 | 10:14:04 | 2441 | 55.29267 | 4.88458 | 19.05.2021 | 12:38:21 | 0950 | 55.19826 | 4.64251 |
| 162A031 | 19.05.2021 | 13:22:52 | 1000 | 55.22463 | 4.62799 | 19.05.2021 | 15:20:16 | 2213 | 55.30163 | 4.82480 |
| 402A032 | 19.05.2021 | 16:33:10 | 2441 | 55.29227 | 4.88506 | 19.05.2021 | 18:56:45 | 0950 | 55.19779 | 4.64308 |
| 166A033 | 19.05.2021 | 19:43:59 | 1000 | 55.22428 | 4.62843 | 19.05.2021 | 22:07:31 | 2491 | 55.31876 | 4.87058 |
| 406A034 | 19.05.2021 | 22:52:30 | 2441 | 55.29195 | 4.88544 | 20.05.2021 | 01:16:48 | 0950 | 55.19753 | 4.64338 |
| 170A035 | 20.05.2021 | 02:01:26 | 1000 | 55.22387 | 4.62892 | 20.05.2021 | 04:25:43 | 2491 | 55.31845 | 4.87094 |
| 410A036 | 20.05.2021 | 05:12:42 | 2441 | 55.29154 | 4.88593 | 20.05.2021 | 07:36:21 | 0950 | 55.19708 | 4.64393 |
| 174A037 | 20.05.2021 | 08:23:40 | 1000 | 55.22353 | 4.62933 | 20.05.2021 | 10:47:53 | 2491 | 55.31801 | 4.87148 |
| 414A038 | 20.05.2021 | 12:09:18 | 2441 | 55.29129 | 4.88662 | 20.05.2021 | 14:33:20 | 0950 | 55.19683 | 4.64461 |
| 178A039 | 20.05.2021 | 15:18:38 | 1000 | 55.22301 | 4.62956 | 20.05.2021 | 17:41:36 | 2491 | 55.31759 | 4.87158 |
| 418A040 | 20.05.2021 | 18:29:02 | 2441 | 55.29089 | 4.88710 | 20.05.2021 | 20:52:40 | 0950 | 55.19656 | 4.64494 |
| 182A041 | 20.05.2021 | 21:37:55 | 1000 | 55.22264 | 4.62999 | 20.05.2021 | 00:02:03 | 2491 | 55.31715 | 4.87211 |
| 422A042 | 26.05.2021 | 00:45:06 | 2441 | 55.29058 | 4.88747 | 26.05.2021 | 03:09:14 | 0950 | 55.19611 | 4.64549 |
| 186A043 | 26.05.2021 | 03:52:23 | 1000 | 55.22227 | 4.63044 | 26.05.2021 | 06:13:03 | 2491 | 55.31689 | 4.87241 |
| 426A044 | 26.05.2021 | 07:05:13 | 2441 | 55.29016 | 4.88798 | 26.05.2021 | 09:28:10 | 0950 | 55.19584 | 4.64580 |
| 190A045 | 26.05.2021 | 10:13:10 | 1000 | 55.22189 | 4.63089 | 26.05.2021 | 12:37:37 | 2491 | 55.31641 | 4.87299 |
| 430A046 | 26.05.2021 | 13:20:56 | 2441 | 55.28981 | 4.88839 | 26.05.2021 | 15:44:55 | 0950 | 55.19536 | 4.64638 |
| 194A047 | 26.05.2021 | 16:31:28 | 1000 | 55.22155 | 4.63129 | 26.05.2021 | 18:50:52 | 2491 | 55.31609 | 4.87336 |
| 434A048 | 26.05.2021 | 19:38:54 | 2441 | 55.28939 | 4.88890 | 26.05.2021 | 22:08:59 | 0950 | 55.19508 | 4.64672 |
| 198A049 | 26.05.2021 | 22:51:44 | 1000 | 55.22128 | 4.63163 | 27.05.2021 | 01:15:28 | 2491 | 55.31572 | 4.87381 |

Table 3: Table of acquired 2D reflection seismic lines during MSM100. The locations of the seismic lines are in the vicinity of the 3D survey area (Fig. 1). SOL: Start of Line; EOL: End of Line

| Line name | Date (SOL) | UTC Time (SOL) | SP (SOL) | Lat (SOL) | Lon (SOL) | Date (EOL) | UTC Time (EOL) | SP (EOL) | Lat (EOL) | Lon (EOL) |
|---------------|------------|----------------|----------|-----------|-----------|------------|----------------|----------|-----------|-----------|
| BGR21-812A001 | 21.05.2021 | 10:14:09 | 1975 | 55.18707 | 4.67094 | 21.05.2021 | 10:41:28 | 2265 | 55.16031 | 4.70335 |
| BGR21-802A002 | 21.05.2021 | 12:29:47 | 1000 | 55.16766 | 4.69500 | 21.05.2021 | 14:50:42 | 2722 | 55.27939 | 4.97115 |
| BGR21-801A003 | 21.05.2021 | 15:39:45 | 2626 | 55.24800 | 5.01347 | 21.05.2021 | 18:15:44 | 1022 | 55.13898 | 4.76289 |
| BGR21-813A004 | 21.05.2021 | 19:59:23 | 2694 | 55.14271 | 4.81059 | 21.05.2021 | 22:31:41 | 950 | 55.30082 | 4.60830 |
| BGR21-811A005 | 22.05.2021 | 00:28:36 | 1000 | 55.26412 | 4.57156 | 22.05.2021 | 02:44:11 | 2514 | 55.35728 | 4.82098 |
| BGR21-807A006 | 22.05.2021 | 03:31:05 | 2540 | 55.32294 | 4.87319 | 22.05.2021 | 05:53:10 | 958 | 55.22203 | 4.61702 |
| BGR21-810A007 | 22.05.2021 | 06:42:01 | 1025 | 55.25628 | 4.58843 | 22.05.2021 | 08:55:34 | 2508 | 55.34913 | 4.83078 |
| BGR21-806A008 | 22.05.2021 | 10:05:50 | 2357 | 55.30360 | 4.85265 | 22.05.2021 | 12:12:23 | 950 | 55.21447 | 4.62414 |
| BGR21-809A009 | 22.05.2021 | 13:41:16 | 1000 | 55.24369 | 4.59898 | 22.05.2021 | 15:57:10 | 2510 | 55.34066 | 4.84278 |
| BGR21-819A010 | 22.05.2021 | 17:19:43 | 2124 | 55.28186 | 4.82218 | 22.05.2021 | 19:09:37 | 950 | 55.20744 | 4.63167 |
| BGR21-808A011 | 22.05.2021 | 21:25:00 | 1000 | 55.23493 | 4.61210 | 22.05.2021 | 23:35:12 | 2507 | 55.33161 | 4.85548 |
| BGR21-828A012 | 23.05.2021 | 00:43:51 | 1541 | 55.28522 | 4.96662 | 23.05.2021 | 02:19:13 | 2644 | 55.18571 | 5.09581 |
| BGR21-827A013 | 23.05.2021 | 03:59:53 | 3255 | 55.15722 | 5.07302 | 23.05.2021 | 07:25:23 | 1043 | 55.36077 | 4.82359 |
| BGR21-826A014 | 23.05.2021 | 09:19:54 | 1478 | 55.33382 | 4.80780 | 23.05.2021 | 12:39:14 | 3696 | 55.13041 | 5.05933 |
| BGR21-825A015 | 23.05.2021 | 14:03:20 | 4050 | 55.09744 | 5.06540 | 23.05.2021 | 18:34:48 | 1033 | 55.36857 | 4.70983 |
| BGR21-824A016 | 23.05.2021 | 19:58:15 | 860 | 55.37347 | 4.64742 | 24.05.2021 | 00:32:01 | 3902 | 55.09670 | 4.99785 |
| BGR21-823A017 | 24.05.2021 | 02:03:26 | 4300 | 55.05976 | 5.00364 | 24.05.2021 | 06:30:56 | 1074 | 55.34589 | 4.61497 |
| BGR21-822A018 | 24.05.2021 | 07:44:24 | 1000 | 55.34603 | 4.58074 | 24.05.2021 | 11:00:07 | 3249 | 55.14384 | 4.84572 |