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GEOLOGICAL SURVEY OF CANADA
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Report on Cruise 2023004PGC (CCCG *Vector*): B.C. coastal hydrographic and geoscientific surveys — operations off Haida Gwaii and Vancouver Island

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Permanent link: https://doi.org/10.4095/332552

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Recommended citation

Li, Z. and Kung, R., 2024. Report on Cruise 2023004PGC (CCCG *Vector*): B.C. coastal hydrographic and geoscientific surveys — operations off Haida Gwaii and Vancouver Island; Geological Survey of Canada, Open File 9155, 315 p. https://doi.org/10.4095/332552

Publications in this series have not been edited; they are released as submitted by the author.

ISSN 2816-7155
ISBN 978-0-660-69670-6
Catalogue No. M183-2/9155E-PDF

Contents

ABSTRACT

A survey cruise was collaboratively conducted by the Canadian Hydrographic Service and the Geological Survey of Canada aboard the CCGS *Vector* in the summer of 2023. The aim was to collect multibeam data, sub-bottom profile data, and grab samples for mapping bathymetry and surficial geology-one of the objectives of Marine Geoscience for Marine Spatial Planning Program. This expedition totally covered approximately 1770 km² of multibeam survey, navigated 10,576 km of sub-bottom profile lines, and collected 40 grab samples. The survey regions included Swiftsure Bank, Amphitrite Bank, Cartwright Sound, Hippa Island, Rennell Sound, Portland Canal, Portland Inlet, Bute Inlet, the Strait of Georgia, and Juan de Fuca Strait. Each area exhibited unique features, with various seafloor morphologic units such as gravel platforms, landslides, deep channels, fan deltas, moraines, and bedforms.

1. INTRODUCTION

The Geological Survey of Canada (GSC), a division of Natural Resources Canada (NRCan), has provided marine geoscience support to identify crucial habitat areas and establish a foundational dataset for studying the cumulative impacts of diverse marine land uses. As part of the Marine Geoscience for Marine Spatial Planning (MGMSP) program, mapping seafloor morphology and surficial geology is one of the key tasks for the GSC, which also involves marine fieldwork to collect data on bathymetry, sub-bottom profiles, sediment cores, grab samples, seafloor photos, and other relevant data sources. This cruise served for mapping the west coast under the MGMSP framework.

The primary objective of this cruise was to collect multibeam data, sub-bottom profile data and grab samples. The multibeam data provided crucial information about water depths and substrates (e.g., hardness and roughness) of the seafloor. Sub-bottom profiles gave insights into the stratigraphic units and sequences. The surface sediment samples were used to provide sediment components and validate the identification of surficial geology. In addition, this expedition also included a task of annual surveys in inlets (e.g., Bute Inlet and Portland Inlet) to monitor turbidity currents, river discharges, and channel changes in erosion, deposition, and migration courses, which will contribute to assessments of seafloor stability and environmental impact.

This cruise was collaboratively conducted on the Canadian Coast Guard Ship (CCGS) *Vector* by the GSC and the Canadian Hydrographic Service (CHS) from July 12th to August 28th. The survey areas included Swiftsure Bank, Amphitrite Bank, Cartwright Sound, Hippa Island, Rennell Sound, Portland Canal, Portland Inlet, Bute Inlet, the Strait of Georgia, and Juan de Fuca Strait. The cruise was executed in two legs: Leg 1 from July 12th to August 9th and Leg 2 from August 10th to August 28th. The key survey personnel included Robert Kung (Leg 1), Zhen Li (Leg 2) from the GSC, and Duncan Havens, Brian Port, Coey Lunn, Anthony Hawyrs (Leg 1), Marie-Hélène Gravel, Shyla Hocker, Brendan Hendriks (Leg 2) from the CHS. The master for Leg 1 was Captain Andrew Balakshin, and for Leg 2, Captain William Sallan.

2. TECHNICAL OPERATIONS

2.1. The vessel and support equipment

CCGS *Vector* is a mid-shore science vessel operated by the Canadian Coast Guard (CCG). It is 39.7 m long and 9.5 m wide, with the gross tonnage of 526 tons and a net tonnage of 184 tons. The maximum speed of CCGS *Vector* is 12 knots. It offers 84.4 m of laboratory space and 56 m^2 of deck space for most of the survey work during this cruise.

This ship was equipped with a heavy crane for loading and unloading scientific equipment. A thermosalinograph was used for continuous measurements of sea surface parameters including temperature and salinity. A vessel launch was provided for visiting tide gauges. A scientific hydro winch was used for deploying the Sound Velocity Profiler and grab sampler. The MVP200 Winch, Mounting Frame and controller were used for the deployment of the Moving Vessel Profiler (MVP).

2.2. Navigation

Navigation was recorded by the Ship's Global Positioning System (GPS) using Coordinated Universal Time (UTC). The sub-bottom profiler data were simultaneously recorded along the navigation tracks. The ship speed was 7 knots during the survey, and 10 knots during the transits.

Navigation data were collected using NavNet software installed in the PGC_Science computer, also known as the "GIS computer" located on the left side of the NRCan Workstation (Fig. 1a). Navigation points (Fig. 2a) and track lines (Fig. 2b) were created in several steps using Python scripts and ArcGIS tools, following the procedures outlined by internal protocol documents. These documents can be accessible upon request to the authors.

Fig. 1. NRCan Workstation. a. PGC_Science computer for collecting navigation data; b. Knudsen controller unit connecting the transducer; c. Knudsen computer for generating sub- bottom profiles; d. Spare computer. Photograph by R. Kung. NRCan photo 2023-324.

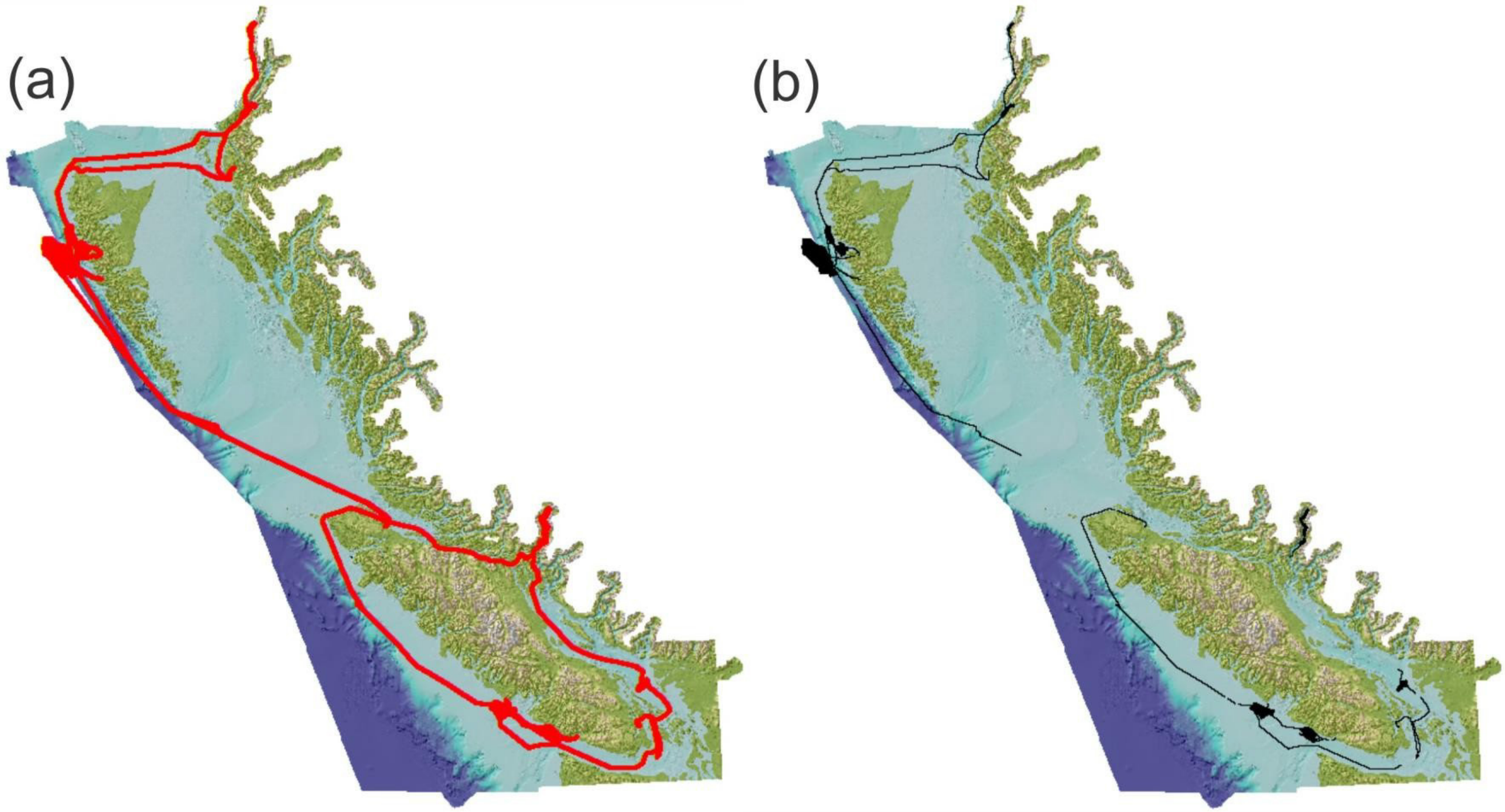

Fig. 2. Navigation points (a) and track lines (b) created during sea-going survey of Cruise 2023004PGC using Python script, ArcGIS tools and model builder (The basemap is from Kung et al., 2023).

2.3. Multibeam surveys

Multibeam surveys were conducted by hydrographers from the CHS using a Kongsberg-Simrad EM 710 Multibeam Echosounder System at sonar frequencies of 70–100 kHz. The Caris HIPS software was employed for post-processing the collected multibeam data, cleaning abnormal data, and calibrating errors induced by sound velocity, tidal state, and ship movement. A Sound Velocity Profiler (SVP) was used for sound velocity correction in Leg 1 and a MVP was utilized in Leg 2.

At the end of each UTC day (12:00 am UTC, 5:00 pm Pacific Daylight Time (PDT)), the ship stopped for the deployment of the SVP to obtain a sound velocity profile. For the MVP, it was deployed multiple times depending on changes in water properties, and the ship maintained a speed of 5 knots, except during deployment and collection when it reduced to 3-4 knots.

Multibeam data were collected, cleaned, and finalized by CHS hydrographers, then copied to NRCan marine geologists as Bathymetric Attributed Grid (BAG). The BAG format is an industry standard digital raster format directly readable and importable into ArcGIS. Hillshape tool of ArcGIS was used to create the three-dimensional shading of the bathymetric maps. Fig. 3 shows the bathymetric maps of the survey regions during the cruise.

Backscatter data were derived from the raw multibeam survey files as Kongsberg .all format. We received raw multibeam echosounder data from the CHS and processed the backscatter data into a gridded raster format using the QPS software FMGT that uses the Geocoder algorithm. The backscatter data were processed ashore.

The survey regions during this cruise include Swiftsure Bank (Fig. 3A), Amphitrite Bank (Fig.3B), offshore of Haida Gwaii (areas of Cartwright Sound, Hippa Island and Rennell Sound (Fig. 3C)), Portland Canal (Fig. 3D), Portland Inlet (Fig. 3E), Bute Inlet (Fig. 3F), Georgia Strait consisted of the areas of Pockmarks and Sandheads (Fig. 3G), and the boundary with the United States in Juan de Fuca Strait (Fig. 3H).

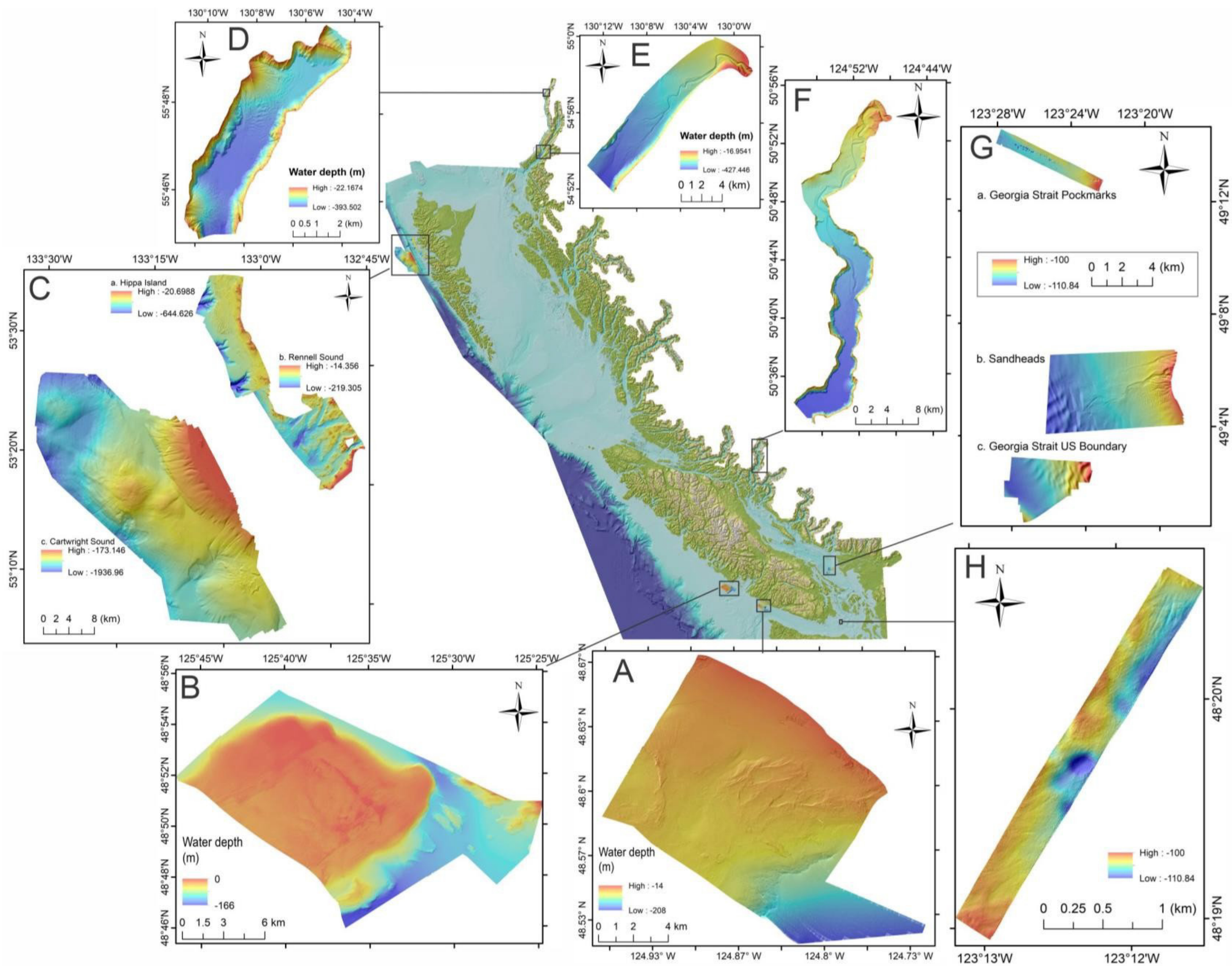

Fig. 3. Bathymetric maps of the survey regions during Cruise 2023004PGC. A. Swiftsure Bank; B. Amphitrite Bank; C. Offshore of Haida Gwaii; D. Portland Canal; E. Portland Inlet; F. Bute Inlet; G. Georgia Strait; H. United States Boundary in Juan de Fuca Strait.

2.4. Sub-bottom profile surveys

Sub-bottom profile surveys were conducted by GSC scientists using a Knudsen CHIRP 3260 3.5-kHz echo sounder. The transducer is mounted in the gondola on the bottom of the ship's hull. The main controller unit for the Knudsen CHIRP 3260, a sub-bottom profiler operating at 3.5 kHz acoustic signal, was positioned beneath the Science computer on the left side of the NRCan Workstation (Fig. 1b). The Knudsen controller unit was connected to the transducer by a cable that is a permanent part of the ship's electrical network and is always connected to the transducer.

The software applications EchoControlServer and EchoControlClient, installed on the Knudsen computer, were used to acquire the data and generate profiles. This computer is located on the right side of the NRCan workstation (Fig. 1c). Sub-bottom profile files were generated using "Configure" item in the "Recording" menu and named as "Line# Year JulianDate Time". The file formats were recorded as .kea, .keb, and .sgy files, saved in folders created for each Julian Day under the cruise folder of Cruise 2023004PGC. Parameters of Knudsen EchoControlClient Software were set up based on bathymetric conditions in the survey areas. For example, Pulse Rate and Power Level were lower, usually 0.12500 ms and 1 or 2, respectively, in shallower water areas than those in deep water areas.

Tools created by R.C. Courtney (Courtney, 2013), including software Combine_Segy, SegyJP2, and SegyJP2Viewer, were used for data analysis and profile interpretation. During the cruise, all sub-bottom profiles collected during Leg 2 were converted into JP2 format using SegyJP2 (Fig. 4), and most lines were temporarily analyzed using Segy2Viewer (Fig. 4).

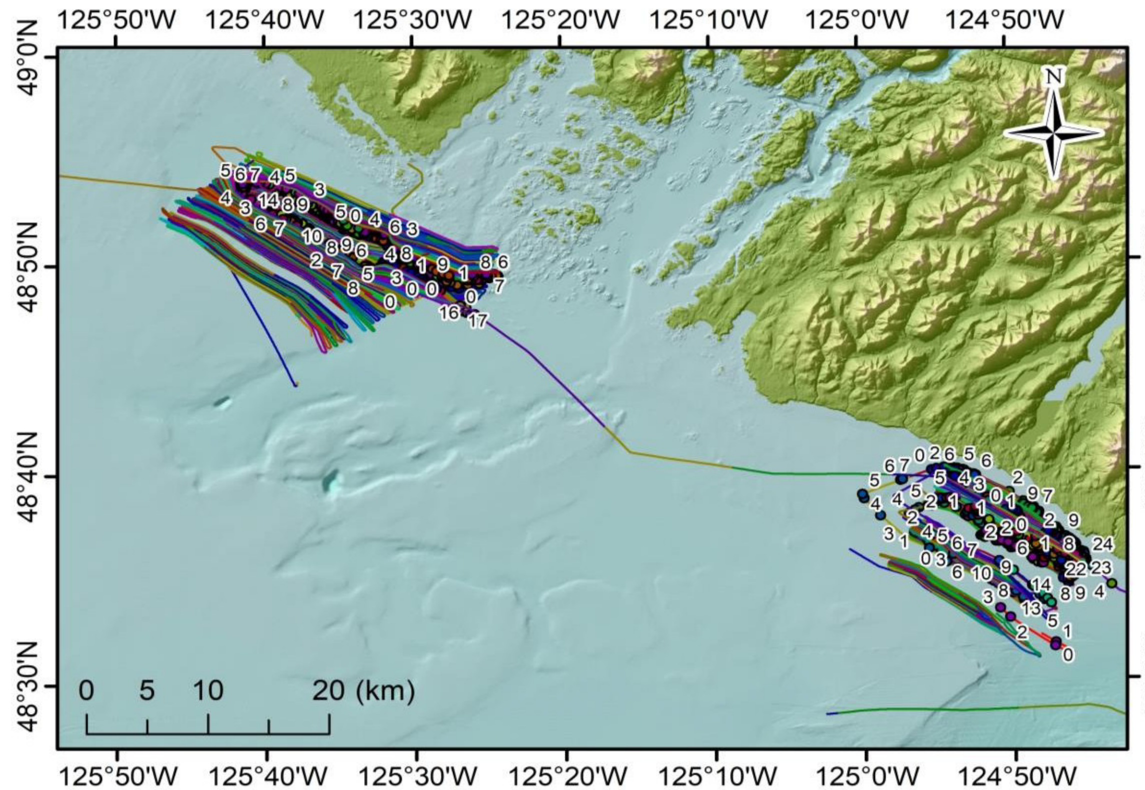

Fig. 4. Analysed sub-bottom lines in JP2 format converted from .sgy format. Various colors separated each interpreted lines and numbers along each line marked the interpretation patterns. Sub-bottom profile of the individual line was displayed in Appendix III.

2.5. Grab sampling

Grab samples were taken at random locations where the ship was at the beginning of a new UTC day (UTC_0:30-1:00 am, PDT_17:30-18:00 pm) during the first leg. In the second leg, the sample locations were planned based on previous navigation and the west coast DEM map (Kung et al., 2023). The designed locations were delivered as a .kmz file using ArcGIS or as a .gpx file using QGIS for the Bridge navigation system.

A Shipek grab sampler and a Van Veen grab sampler were prepared for grab sample collection. However, most samples were collected using the Shipek grab sampler, as the Van Veen sampler did not work well in deep-water, strong-bottom current, or hard-substrate areas in this survey. Only two out of a total of 40 samples were successfully collected using the Van Veen sampler. The speed lowering down the grab was usually 1 m s^{-1}, with a slight speed-up needed in strong current areas. Collected materials were placed in a tray for taking a picture with a scale and subsampling, or the grab was directly brought to the lab for photographing, logging and subsampling. The subsample was labeled with the cruise number and its station number, and all samples were stored in the fridge. The samples were described, and their information was recorded on the deck sheets, input into an Excel spreadsheet, and uploaded to ArcMap.

Grab samples were collected at 44 stations, with a total of 40 samples successfully obtained (Table 1). Sediment types are shown in Fig. 5. No samples were collected at Stations 3A and 17 because the samplers were not triggered. Additionally, no materials were obtained at Stations 12 and 30. At Station 24, the Van Veen sampler failed to collect samples in three attempts as it was not triggered, but the Shipek sampler was successful in obtaining a full grab of silty clay on the fourth attempt. At Station 19, the first attempt at a site at 1980 m of water depth failed due to the wire running out. Fortunately, clay sediment was successfully obtained in the second attempt at a depth of 1620 m, which set a record depth of grab recovery for the Shipek according to NRCan records.

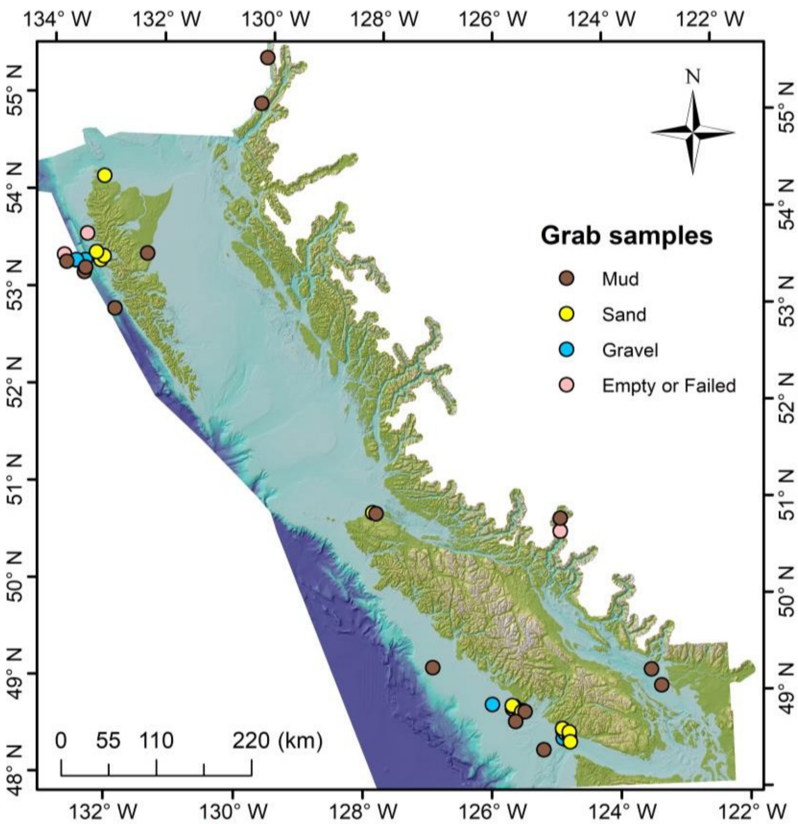

Fig. 5. Sediment types of the grab samples.

Table 1. List of grab samples.

JD	UTC_TIME	LATITUDE	LONGITUDE	STATION	SAMPLE_TYPE	DEPTH_m	COMMENTS
198	198000042	49.088373	-123.320981	STN01	Grab–van Veen	46	Fine grained greenish silt
199	199010617	49.258733	-123.474943	STN02	Grab–van Veen	286	Oozy clay
200	200005610	50.710617	-124.886288	STN03A	Grab–Van Veen	525	Failed twice. Van Veen would not trigger. Moving back to Shipek next location.
201	201010416	50.845303	-124.882311	STN03	Grab–Shipek	322	Fine smooth grey clayish silt
202	202013310	52.847967	-132.482436	STN04	Grab–Shipek	1485	Viscous clay
203	203011329	53.331365	-132.804033	STN05	Grab–Shipek	138	Coarse light coloured sand with shell fragments
204	204011919	53.374724	-132.752337	STN06	Grab–Shipek	170	Coarse darker coloured sand
205	205011347	53.409701	-132.889501	STN07	Grab–Shipek	191	Medium grained mud
206	206011913	53.442342	-132.003303	STN08	Grab–Shipek	229	Oozy silt
207	206020502	54.202227	-132.878867	STN09	Grab–Shipek	122	Medium grained sand with tiny shells
209	209010827	55.071474	-130.174229	STN10	Grab–Shipek	210	Very fine grained dense sticky clay
210	210001156	55.545931	-130.112349	STN11	Grab–Shipek	236	Clay
212	212012027	53.591848	-133.078725	STN12	Grab–Shipek	160	2 attempts, no sample taken, probably over bedrock
213	213011819	53.191867	-133.065126	STN13	Grab–Shipek	1141	Small sample in bucket of sandy compact mud
214	214011223	53.238824	-133.050848	STN14	Grab–Shipek	727	Mud slurry
215	215010525	53.315623	-133.070479	STN15	Grab–Shipek	227	Course sand with pebbles
216	216041433	53.301974	-133.225392	STN16	Grab–Shipek	679	Medium grained sand with small pebbles
217	217012527	53.350469	-133.439035	STN17	Grab–Shipek	1457	No sample taken. Scoop did not trigger. No second attempt because of time loss.
218	218013811	53.306924	-133.225174	STN18	Grab–Shipek	725	Coarse sand with some pebbles and a cobble
218	218215236	53.278909	-133.386074	STN19	Grab–Shipek	1620	1st attempt at 1980m failed. Ran out of wire. 2nd attempt successful at 1620m. A record for Shipek grab depth. Oozy thick beautiful clay.
222	222051339	50.881037	-127.905271	STN20	Grab–Shipek	179	Dark gray silt-clayey silt with strong H2S odor
222	222055553	50.890079	-127.960216	STN21	Grab–Shipek	83	Medium-coarse shelly sand with abundant foraminifera and shells
222	222222459	49.295941	-126.939142	STN22	Grab–Shipek	150	Dark gray silt-clayey silt with little H2S smell
223	223031627	48.917155	-125.994050	STN23	Grab–Shipek	62	2-5 cm gravel with little fine-medium sand remain
223	223234133	48.873441	-125.677618	STN24	Grab–Shipek	42	Empty in all three tries (2 Shipek, 1 Van Veen), the second one caught a 20 cm long sea cucumber, returned it to the sea.
224	224202131	48.899522	-125.651388	STN25	Grab–Shipek	44	One-eighth full of bucket gravel, size<4cm, one bag sample
224	224204612	48.895337	-125.667811	STN26	Grab–Shipek	39	Gravel>4 cm at the bottom of the grab, with very coarse sand scattered. 1 bag sample
224	224210352	48.907168	-125.681804	STN27	Grab–Shipek	85	One-sixth full of fine sand with brittle stars, little H2S odor
225	225153428	48.853567	-125.515795	STN28	Grab–Shipek	97	One-sixth full of muddy gravel, the largest is about 5 cm
225	225155626	48.839830	-125.511036	STN29	Grab–Shipek	97.7	Half full of muddy coarse-gravel. Gravel<1.5 cm, with sea worm, broyoin
225	225165050	48.843514	-125.483217	STN30	Grab–Shipek	101	Full of silty clay using Shipek, little H2S odor. Tried three times firstly using Van Veen, it didn't work as the grab did not close.
226	226161108	48.835780	-125.549206	STN31	Grab–Shipek	43	On-sixth full of coarse sandy gravel, the largest is 10 cm diameter
226	226162608	48.840085	-125.535345	STN32	Grab–Shipek	48	2 attempts, each one has medium sand remains at the bottom, possibly washed out with the strong current.
226	226165503	48.853923	-125.570240	STN33	Grab–Shipek	46	Half full of sandy gravel, the largest gravel is 4 cm diameter.
228	228233537	48.645116	-124.893431	STN34	Grab–Shipek	41	Half full of gravel with the size<7mm
229	229234338	48.614004	-124.856204	STN35	Grab–Shipek	59	Half full of well-sorted fine sand with abundant foraminifera
231	231233427	48.661742	-124.897107	STN36	Grab–Shipek	34	Half full of well-sorted fine sand
232	232142515	48.561812	-124.793678	STN37	Grab–Shipek	105	One-eighth full of bucket very fine sand
232	232143802	48.566927	-124.802968	STN38	Grab–Shipek	87	One-eighth full of medium-coarse sand with shells and sparse gravel, gravel<mm
233	233233151	48.626506	-124.795415	STN39	Grab–Shipek	20	One-eighth full of bucket fine sand
234	234204744	48.523978	-124.781642	STN40	Grab–Shipek	193	1/4 full fine sand, seismic profile show strong surface reflection with gas masking and weak laminated reflector.
234	234213257	48.548360	-124.841256	STN41	Grab–Shipek	122	Gravelly sand remains at the grab bottom. Gravel <2.5 cm in diameter, subangular
234	234222859	48.562268	-124.889659	STN42	Grab–Shipek	73	1/3 poorly-sorted coarse-sandy gravel, gravel<4 cm
239	239024129	48.740413	-125.630400	STN43	Grab–Shipek	161	Full, Clay-Silty clay with brittle stars and sea worms, H2S
239	239054400	48.445300	-125.192250	STN44	Grab–Shipek	157	Full, Clay-Silty clay with brittle stars and sea worms, H2S

2.6. Data acquisition

All data collected during the cruise have been archived in the relevant data repositories. Multibeam data are accessible from the CHS, CHIRP sub-bottom profiles through the GSC on the marine seismic data repository, grab samples through the GSC, with grainsize information on the Expedition Database, and water column data through the GSC or directly from the authors.

3. MINOR TECHNICAL CHALLENGES AND SOLUTIONS

Several issues arose during the cruise, and prompt resolutions were implemented. On July 16 (JD197), the Edgeport USB converter failed. Fortunately, there was a spare one in the supply boxes to replace it, and a new one was brought on board at crew change. On August 18, at 13: 41 pm (JD_UTC230204126), the Knudsen computer displayed "no sounder nodules detected”. After checking the software, computer connections with Knudsen Unit, and the transducer cable connections with Knudsen Unit step by step, the issue was found and fixed. It was induced by a disconnection between the cable and the Knudsen Unit due to a strong swell. The swell caused two wheels of the table (workstation) to unlock even the table was fastened by ratchet straps, resulting in the right side of the table moving against the wall and crashing the connection with Knudsen unit due to the sudden movement. One of wheels of the NRCan workstation didn’t work well, and we suggest repairing it before the next cruise. In addition, the length of wire on the spool of the winch was only 1900 m, although the specification shows that the wire is 2500 m long. This resulted in an unsuccessful sample collection at ~2000 m on July 29. Instead, a sample at 1620 m depth was collected.

4. SCIENTIFIC VIGNETTES

4.1. Swiftsure Bank

A total of approximately 159 km^2 of multibeam data were collected 1866 km of sub-bottom profile lines were surveyed, and 9 grab samples were collected from Swiftsure Bank. The water depth in the survey area ranges from 15 m to 208 m.

The seafloor in the survey area is characterized by high-relief sand or gravel ridges (Fig. 6), mounds, channels (Fig. 6A), bedforms in low-relief areas among the ridges, and linear features on the gravel slope (Fig. 6B). The orientations of gravel or sand ridges are diverse but are predominately either curved to the west, south, or southeast, separated by a mound and a low-relief channel. According to the grab samples, gravelly sediment is mainly distributed on the high-relief areas and slope, while sand is predominantly in the low-relief areas. Typical stratigraphic units, as shown by Chirp 3.5 kHz profiles (Fig. 7), include glaciomarine and postglacial sediment. The grab samples at the sites near Points 1 (STN 40) and 2 (STN 41) of the profile consist of fine sand and gravel sand, respectively (Table 1). The acoustic reflections of the sand unit, ground-truthed by the grab sample at STN40, exhibits a notable gas masking structure with weak lamination reflectors (Fig. 7), and its backscatter intensity is very low (Fig. 6C).

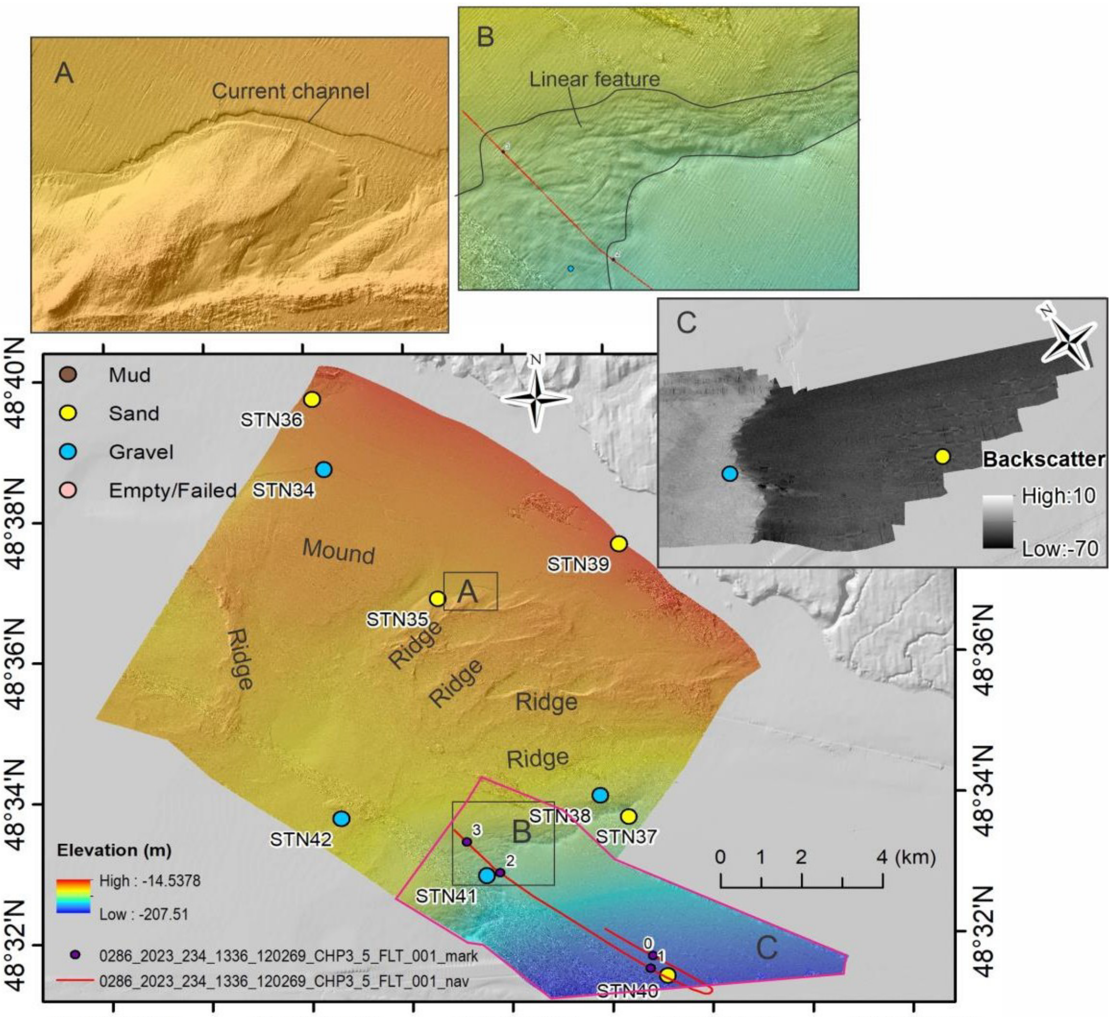

Fig. 6. Sediment types and basic seabed morphology of Swiftsure Bank area plotted on the bathymetric map. A. Current Channel; B. Lineation on the slope; C. Backscatter intensity of the southeast area. Redline and dots show the location of the sub-bottom profile in Fig. 7.

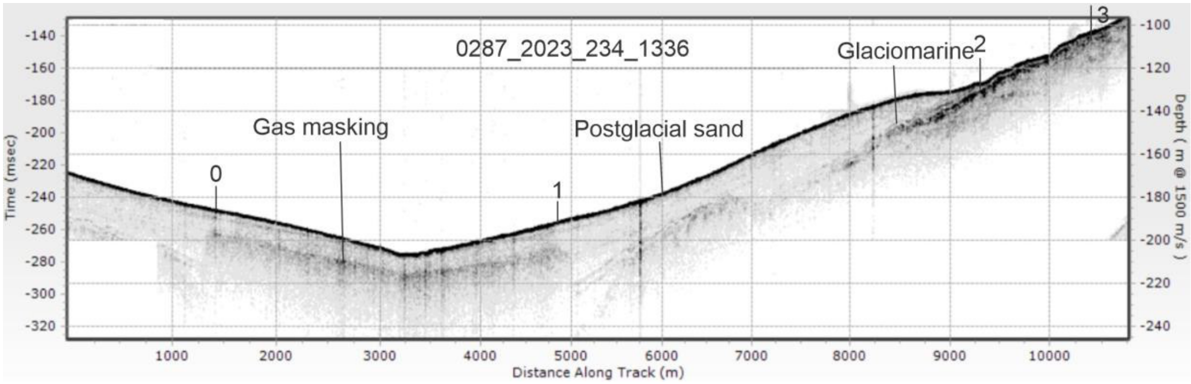

Fig. 7. Sub-bottom profile from survey line 0287_2023_234_1336 showing stratigraphic units of glaciomarine and postglacial sediments with gas masking. The grab samples at the sites near Points 1 (STN 40) and 2 (STN 41) consist of fine sand and gravel sand, respectively. Location of the lines is marked in Fig. 6.

4.2. Amphitrite Bank

A total of approximately 225 km^2 of multibeam data were collected, 2418 km of sub-bottom profile lines were surveyed, and 10 grab samples were collected from Amphitrite Bank. The water depth in the survey area ranges from 31 m to 166 m.

Amphitrite Bank is predominantly blanketed by gravelly sediment. On the slope and adjacent areas, sediments consist mainly of sand (Figs. 8 and 9). Mud was collected from the northeastern area (STN30). The sediment tends to be fining from large gravel at the central platform to muddy sediment in the adjacent lower basin or trough area. Additionally, a landslide on the southeast slope is likely indicated by sub-bottom profiles (Fig. 9) and seafloor photography would be required to observe it clearly.

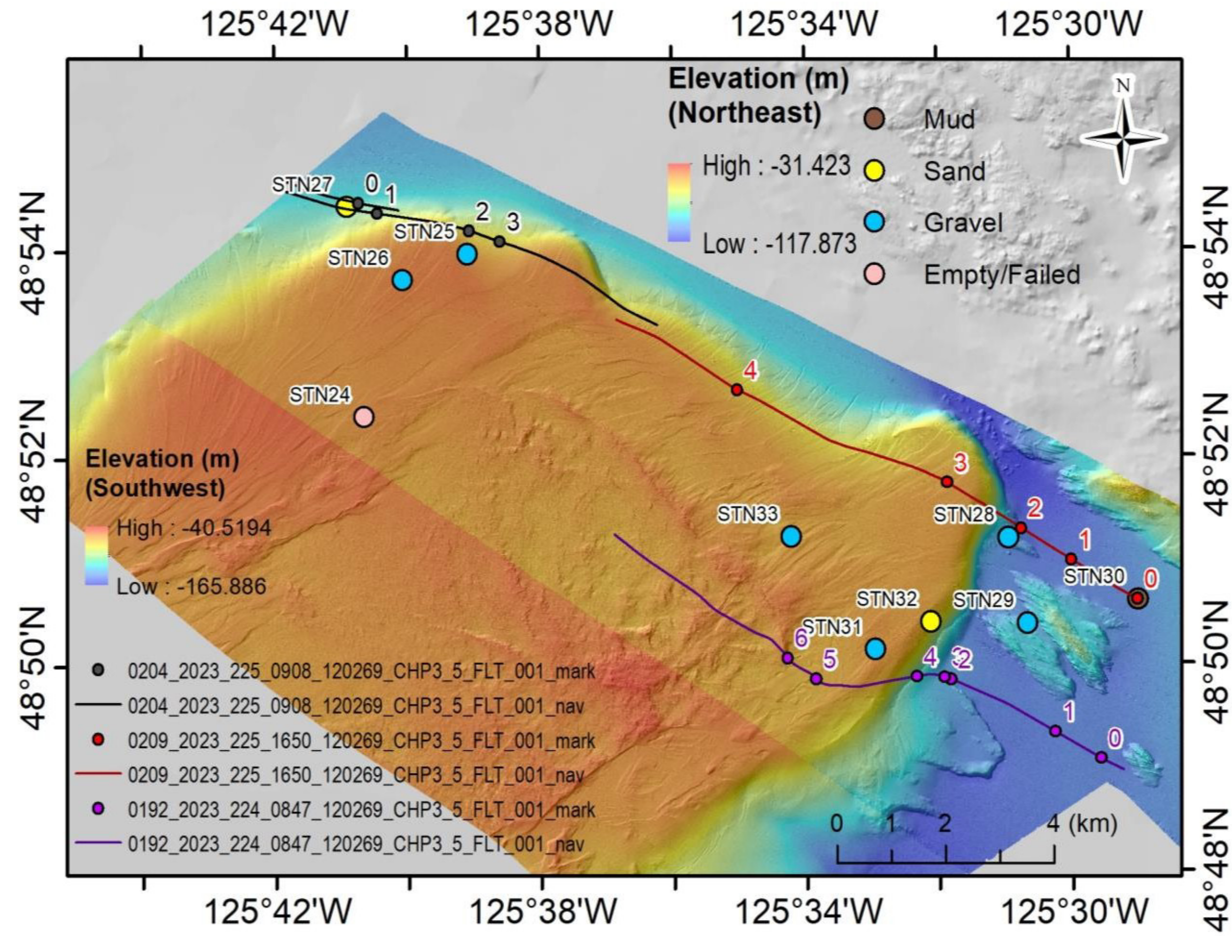

Fig. 8. Sediment types shown by grab samples plotted on the bathymetric map. Black, red, and purple lines with filled circles marked the locations of the sub-bottom profiles in Fig. 9.

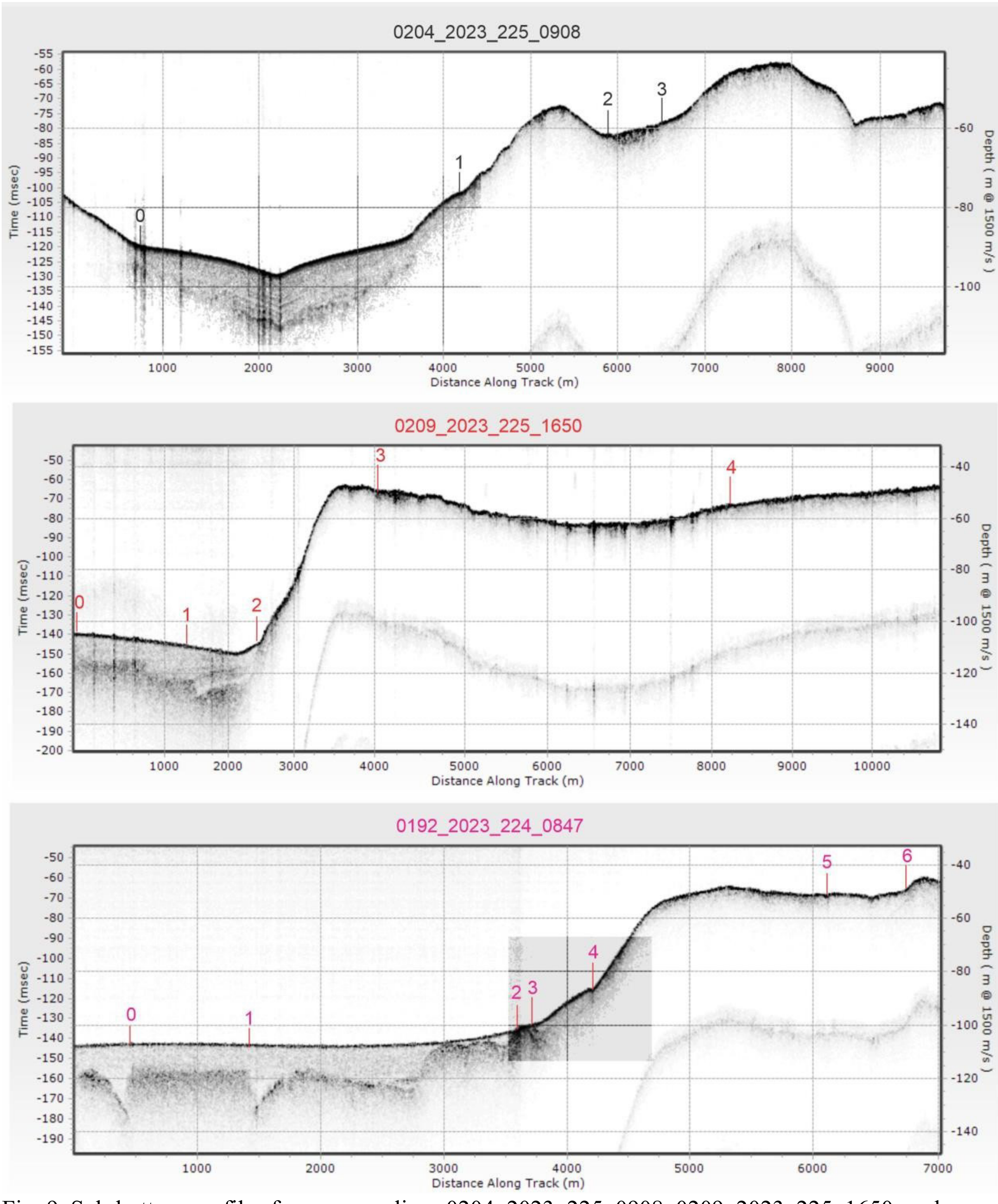

Fig. 9. Sub-bottom profiles from survey lines 0204_2023_225_0908, 0209_2023_225_1650, and 192_2023_224_0847 showing typical stratigraphic units of Amphitrite Bank. The location of the lines is marked in Fig. 8.

4.3. Fold system on the shelf

A fold system was notably reflected by sub-bottom profiles on the shelf collected during the transfer from Port Hardy to Amphitrite Bank. In comparison to the clear synclines, the anticlines appear narrow and seem to be compressed, breaching the seafloor in places. The orientations are likely near N-S or NNW-SSE (Fig. 10), not parallel or subparallel to the coastline. More survey work would be required to better understand this observation, to obtain additional detail, and to ascertain if faults also exist in this area.

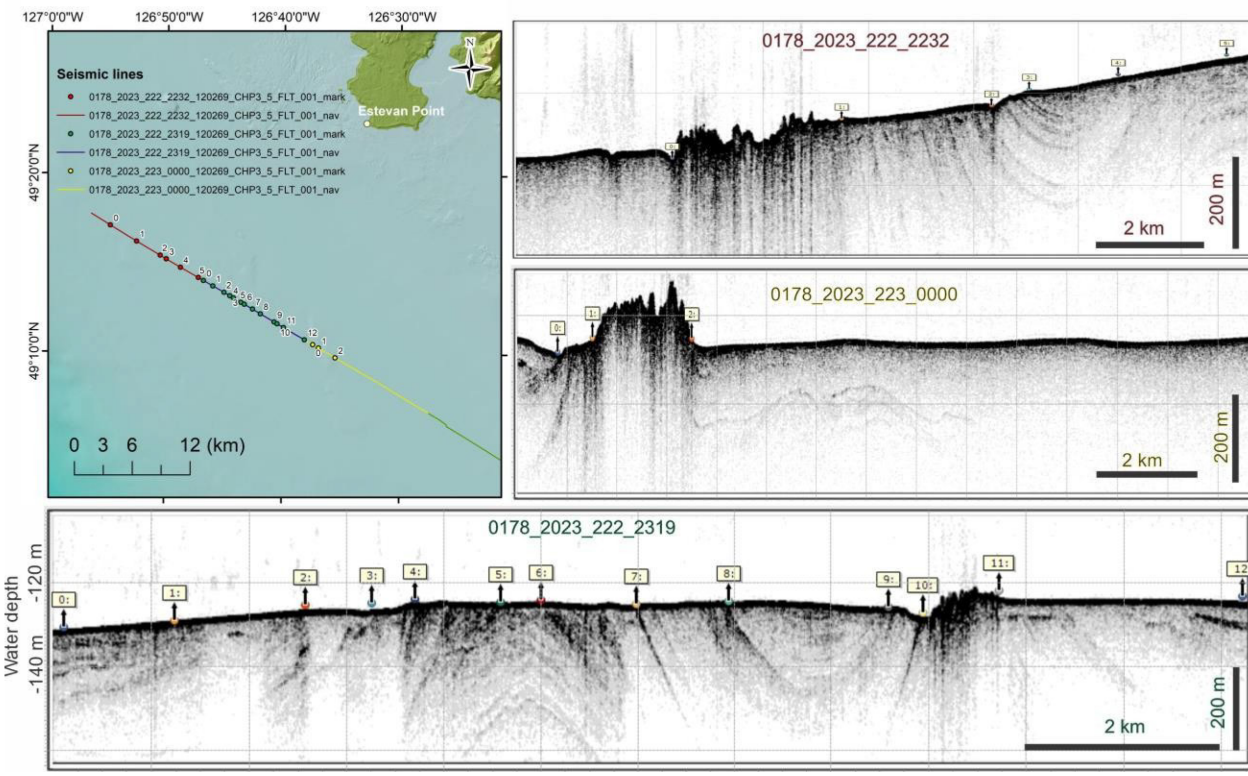

Fig. 10. Fold system on the shelf shown by transit lines on the shelf off Estevan Point.

4.4. Cartwright Sound

A total of approximately 820 km^2 of multibeam data were collected, 1712 km of sub-bottom profile lines were surveyed, and 7 grab samples were collected. The Cartwright Sound area is situated on the southwest side of the Queen Charlotte Fault. The water depth in the survey area ranges from 173 m to 1937 m, with a significant difference in water depth exceeding 1700 m between the high-relief platform and the adjacent deep area (Fig. 11).

The grab samples collected from the top of the platform consist of gravelly sediment, while the samples from the low-relief channel consist of mud (Fig. 11). Numerous failures along the slope of the sound are evident, and very common, as shown by sub-bottom profiles. The eroded surface characterizes the tops of the platforms (Fig. 12).

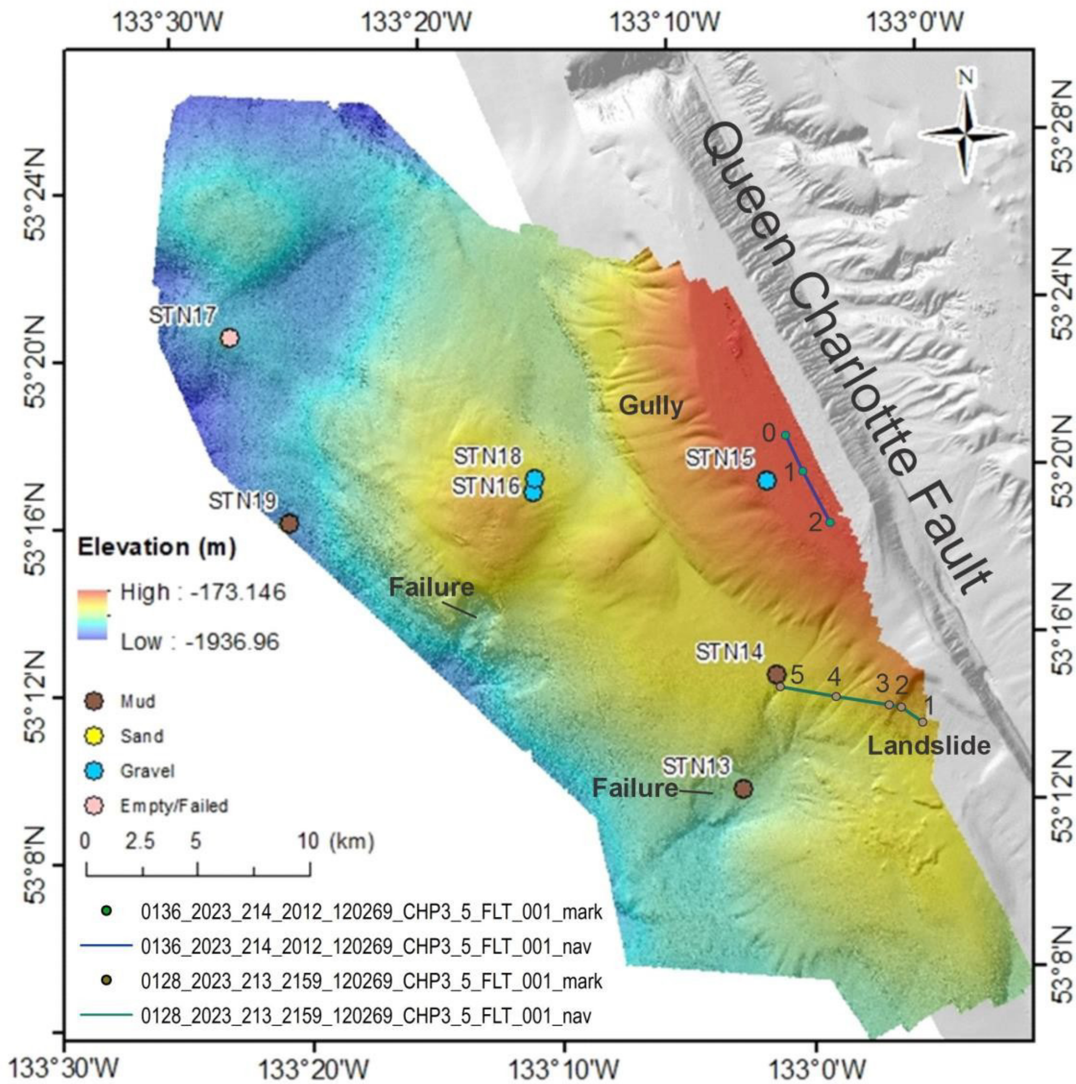

Fig. 11. Bathymetric map of Cartwright Sound and morphologies of failures, landslides, and gullies, and plotted sediment types. Lines with dots mark the locations of sub-bottom profiles in Fig. 12.

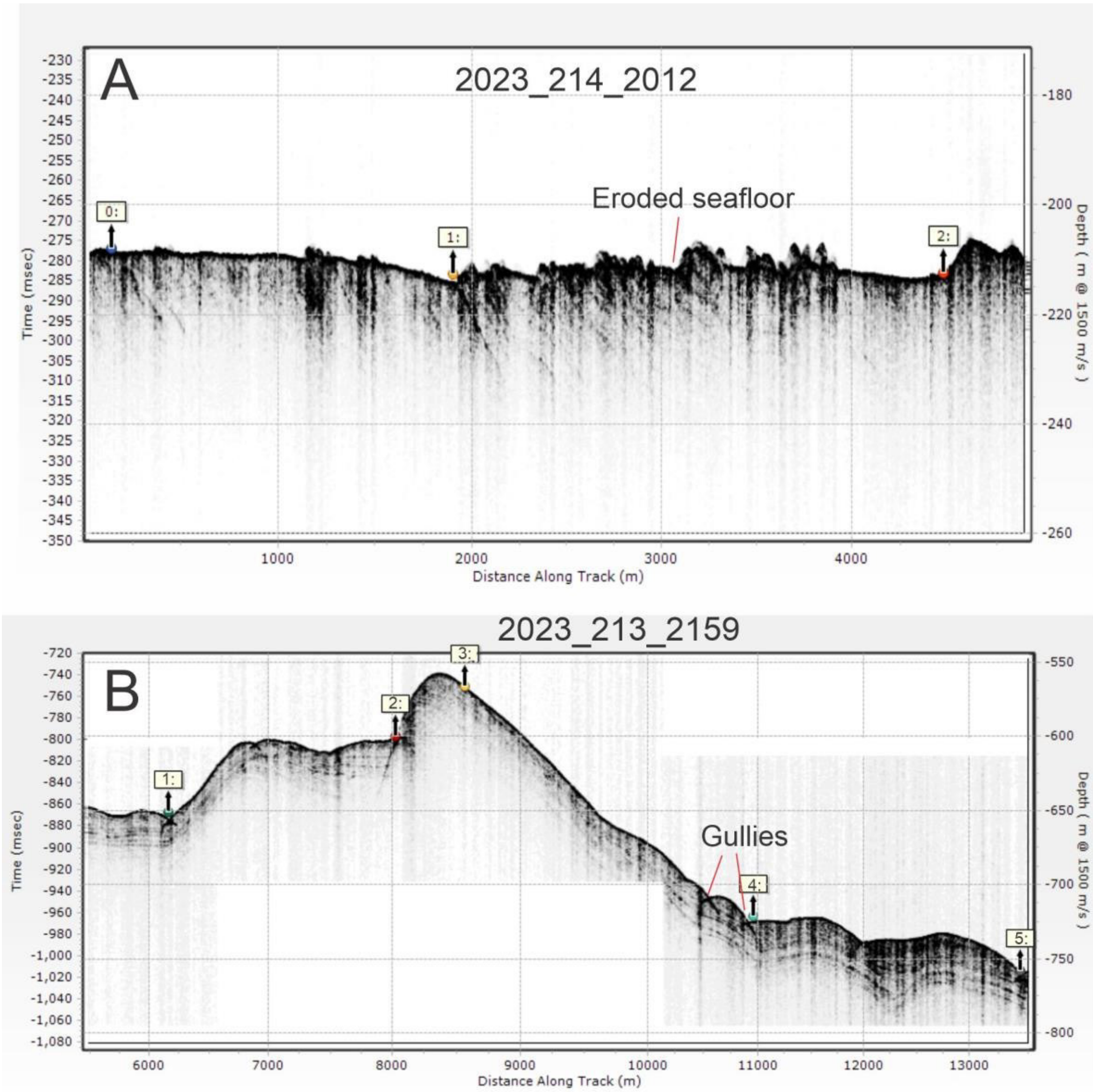

Fig. 12. Sub-bottom profiles showing the eroded surface on platform (A) and typical acoustic laminated reflectors on slopes (B). Locations of lines and marks are shown in Fig. 11.

4.5. Hippa Island

A total of approximately 114 km^2 of multibeam data were collected, 742 km of sub-bottom lines were surveyed, and 1 grab sample was collected. The water depth in the survey area around Hippa Island ranges from 20 m to 645 m. The seabed morphology is characterized by deep channels, eroded rock, linear features, and gravel ribbons (Fig. 13). A buried channel head is likely shown by the acoustic reflection between Points 5 and 6 of the sub-bottom profile (Fig. 14). We suggest collecting a gravity core here for details in a future survey to understand if a buried paleochannel exists.

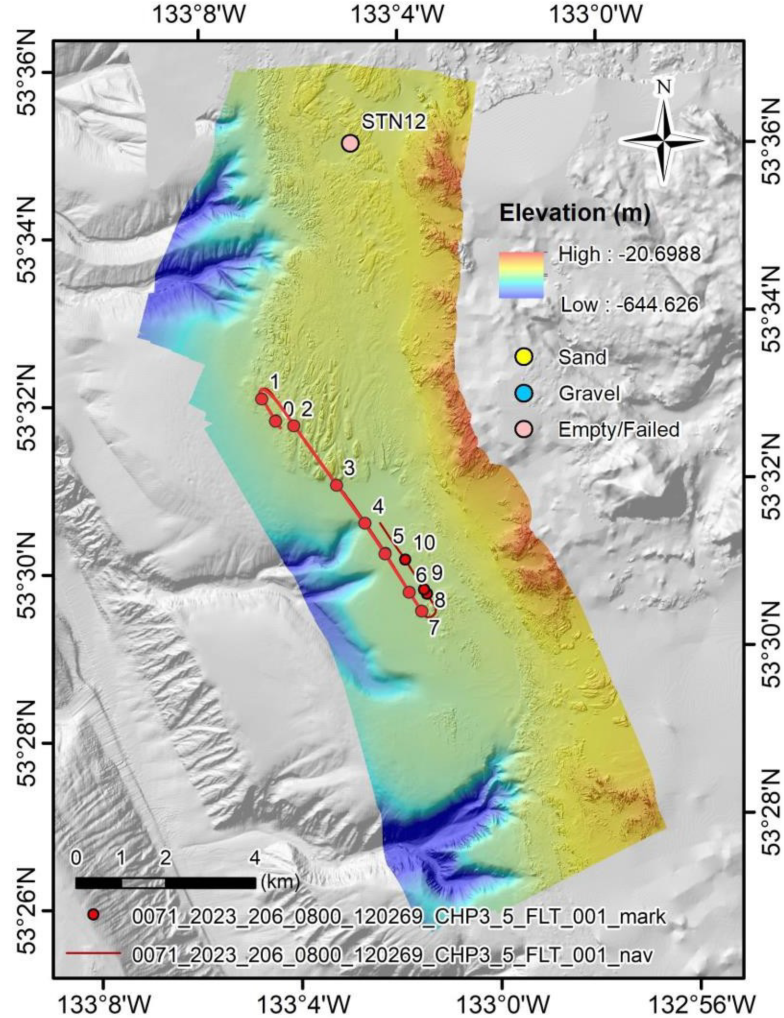

Fig. 13. Bathymetric map of survey area of Hippa Island. Red line and dots are the sub-bottom profile locations of Fig. 14.

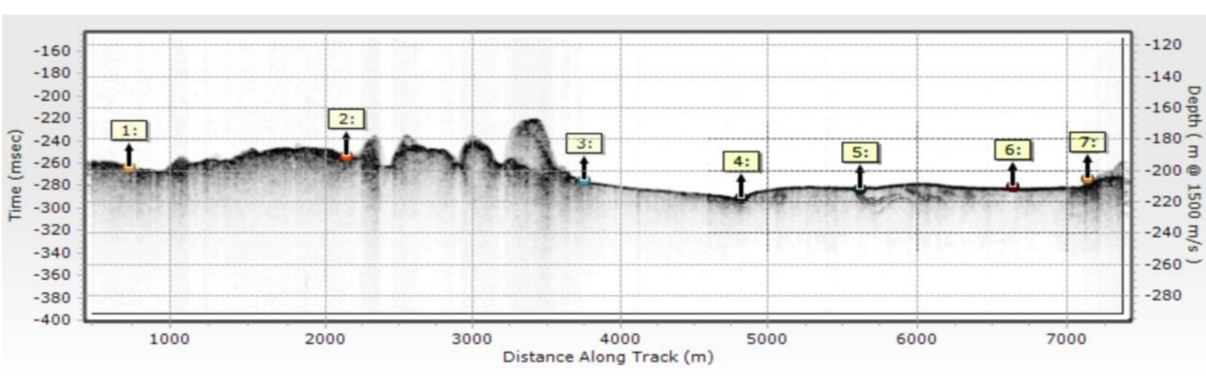

Fig. 14. Sub-bottom profile of section from Point 1 to Point 7 of line 0071_2023_206_0800 off Hippa Island. A buried channel head is likely shown between Points 5 and 6. The locations of line and markers are shown in Fig. 13.

4.6. Rennell Sound

A total of approximately 129 km^2 of multibeam data were collected, 905 km of sub-bottom profile lines were surveyed, and 3 grab samples were collected. The water depth in the survey area ranges from about 14 m to 220 m (Fig. 15). The seafloor morphology is characterized by channels and eroded banks with linear features. The sediment in the channel consists of sand and muddy sand. Bedforms are predominantly observed in the southeastern area.

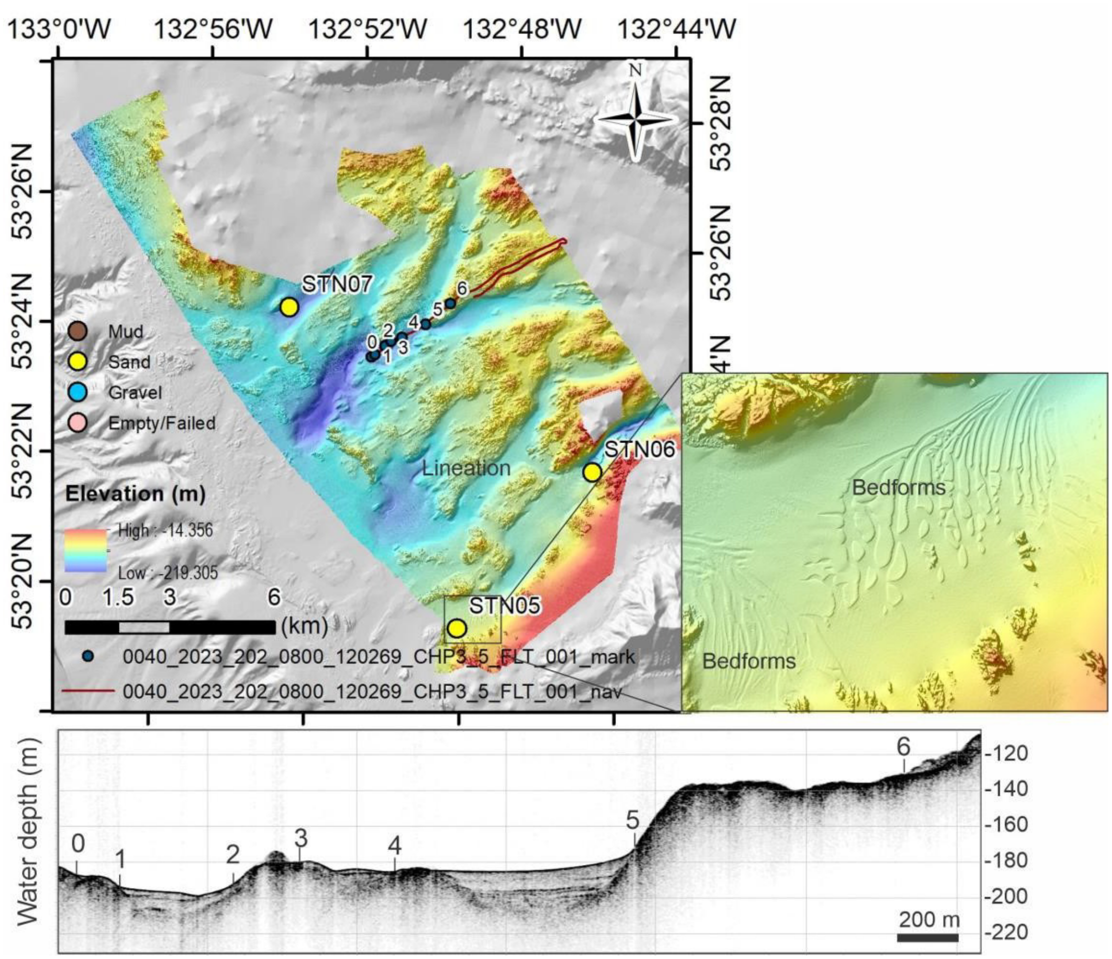

Fig. 15. Bathymetric map, sediment types, and a selected sub-bottom profile showing typical stratigraphic units of the Rennell Sound region.

4.7. Portland Inlet

A confined channel system has developed in Portland Inlet. The channel is characterized by its sinuous and winding course, featuring alternating curves and bends that define its path. Multiple surveys on Portland Inlet have been conducted as a part of the study on the Nass channel system. This study is to understand how an active submarine channel is influenced by the Nass River. This survey is the third one in a time-series since 2020. During this cruise, a total of ~68 km^2 of multibeam data were collected, 360 km of sub-bottom profile lines were surveyed, and no grab samples were collected. The water depth of survey area varies from 17 m to 427 m (Fig. 16).

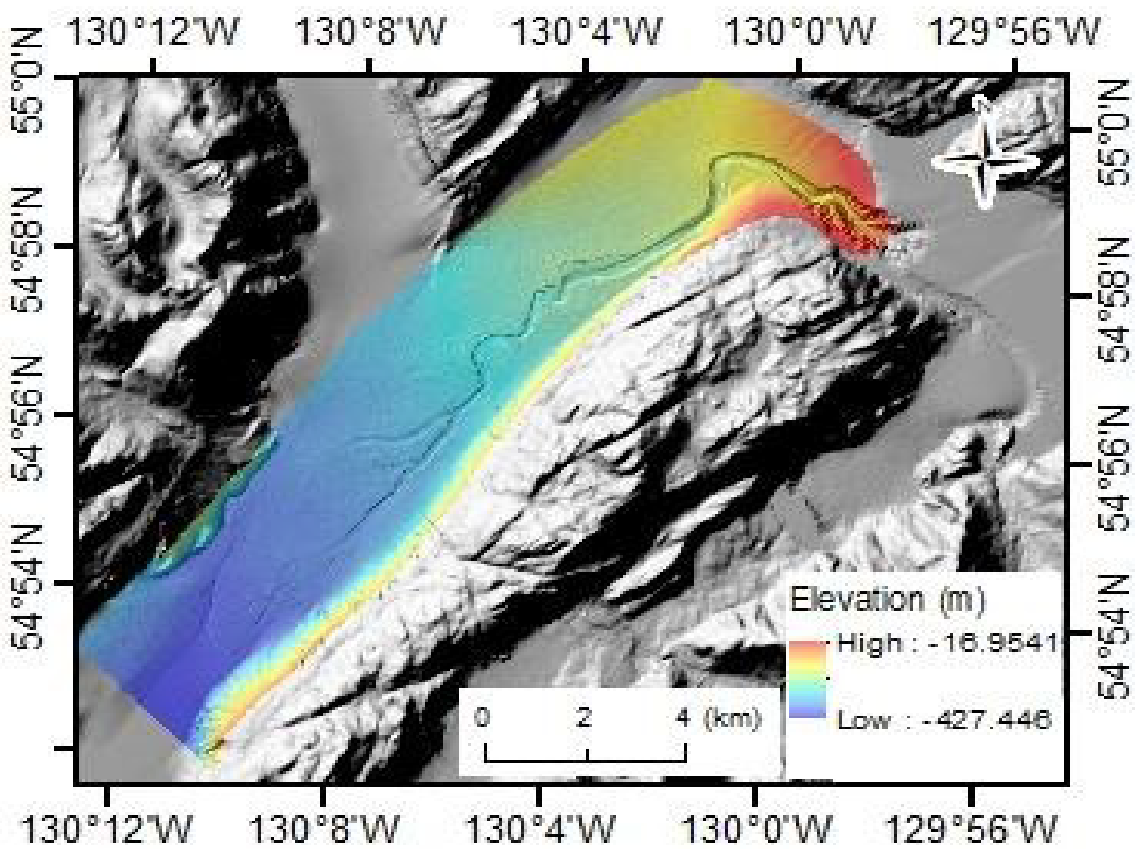

Fig. 16. Bathymetric map showing the seafloor channel system of Portland Inlet region.

4.8. Portland Canal

A total of approximately 25 km^2 of multibeam data were collected, 278 km of sub-bottom profile lines were surveyed, and no grab samples were collected. The water depth in the survey area of Portland Canal varies from approximately 22 m to 394 m (Fig. 17). Fan deltas have developed at the mouth of rivers or valleys, with the two largest located at the west side formed by rivers. The largest one, approximately 4 km^2 in area, is located near Glacier Point, and another is around 3 km^2, formed at the mouth of the Davis River. Other smaller fan deltas (<0.2 km^2) are mainly located on the east side. A ridge, likely a moraine, is observed in the canal at a water depth of 250 m, extending from Seal Rocks across the canal (Figs. 17 and 18).

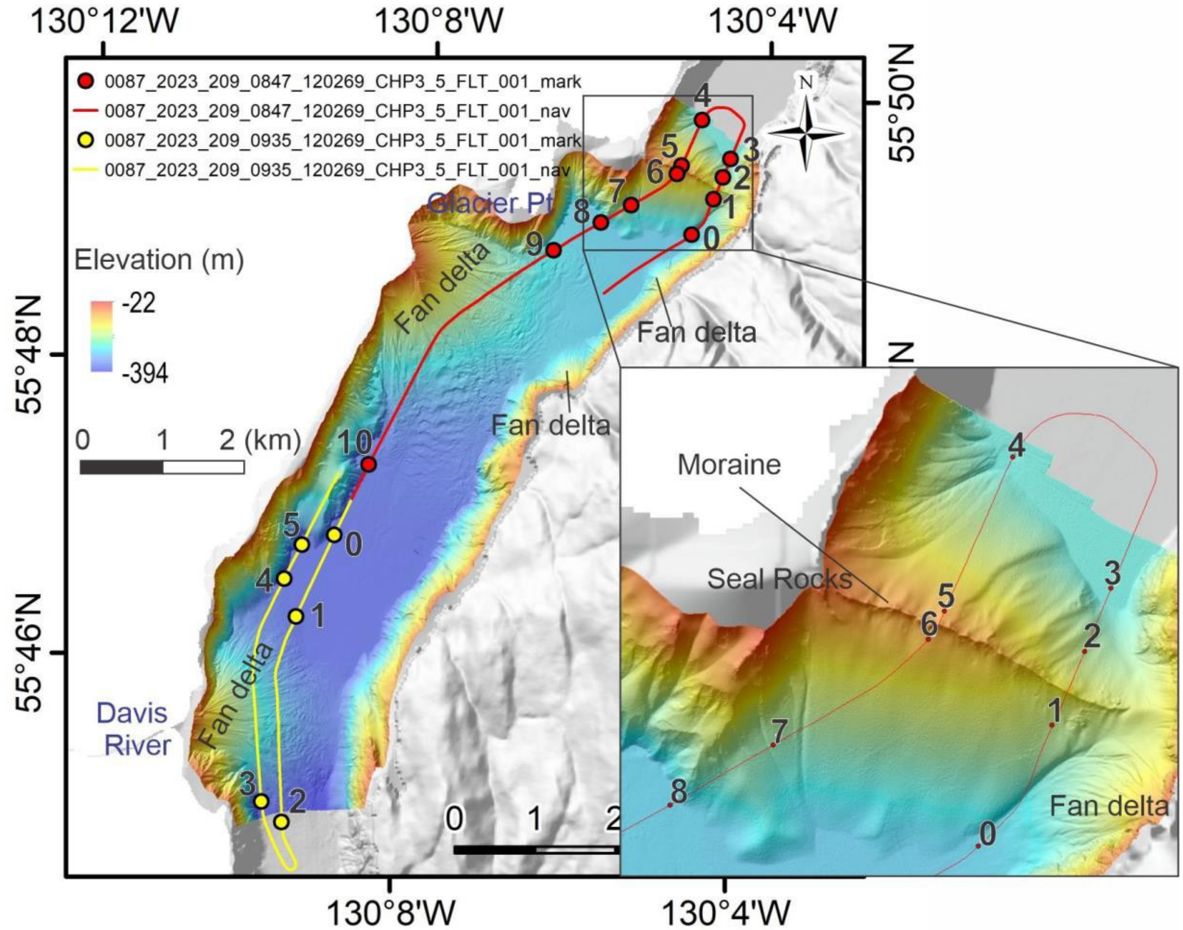

Fig. 17. Bathymetric map showing the seafloor fan deltas and moraine of Portland Canal. Lines with dots mark the locations of sub-bottom profiles.

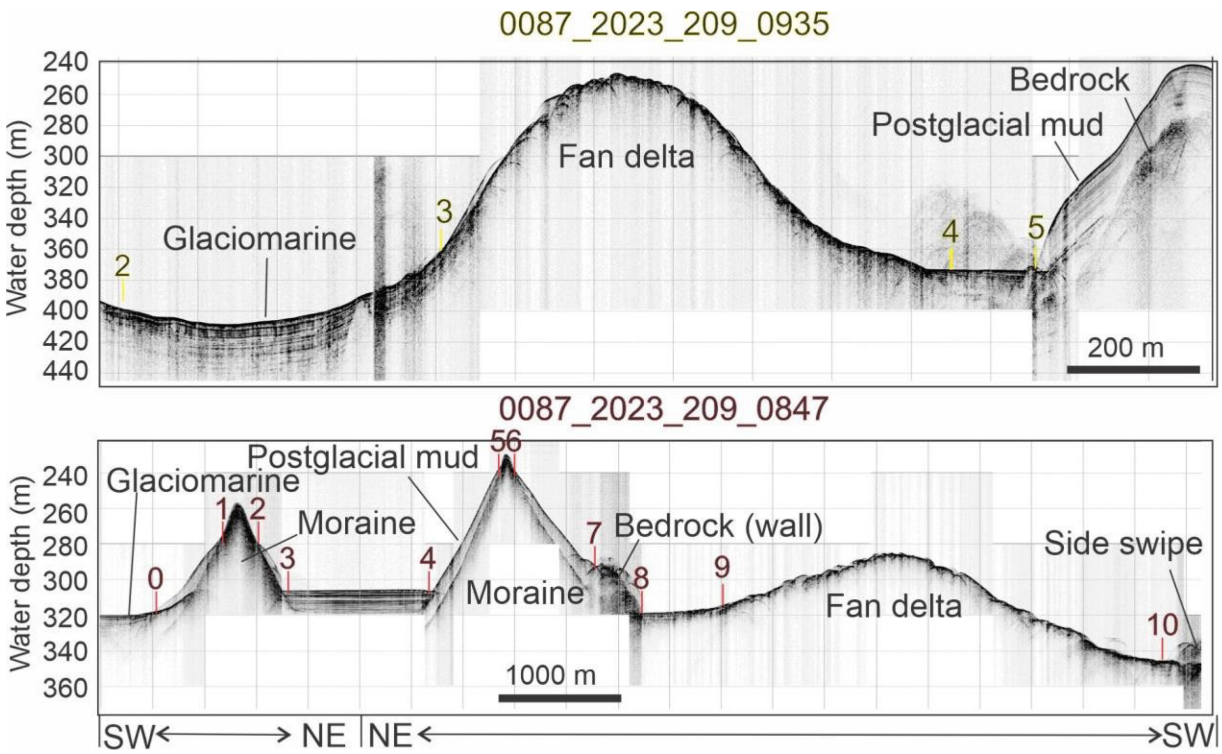

Fig. 18. Sub-bottom profiles showing typical morphologic units of fan delta, moraine, glaciomarine, postglacial mud. Lines and markers are labelled in Fig. 17. For line 008_2023_209_0935, this figure presents only the section after Point 2.

4.9. Bute Inlet

Bute Inlet exhibits a relatively complex channel, and the seafloor survey in this area is conducted annually to monitor turbidity currents, river discharge feeding, channel changes in erosion, deposition, and migration courses. During this cruise, a total of approximately 164 km^2 of multibeam data were collected, 278 km of sub-bottom profile lines were surveyed, and 2 grab samples were collected. The water depth in the survey area ranges from approximately 25 m to 645 m (Fig. 19). The upper part of the channel is characterized by multiple channel heads (Fig. 19A). The middle and the lower parts have more abandoned channels (Figs. 19B and 20).

Technically, the Chirp 3.5 kHz recording was stopped while running lines close to the walls because no data could be collected at the steep angles. The Van Veen grab sampler failed twice to collect samples at 525 m depth. We suggest using the Shipek sampler instead of the Van Veen sampler in such deep-water conditions for sample collection.

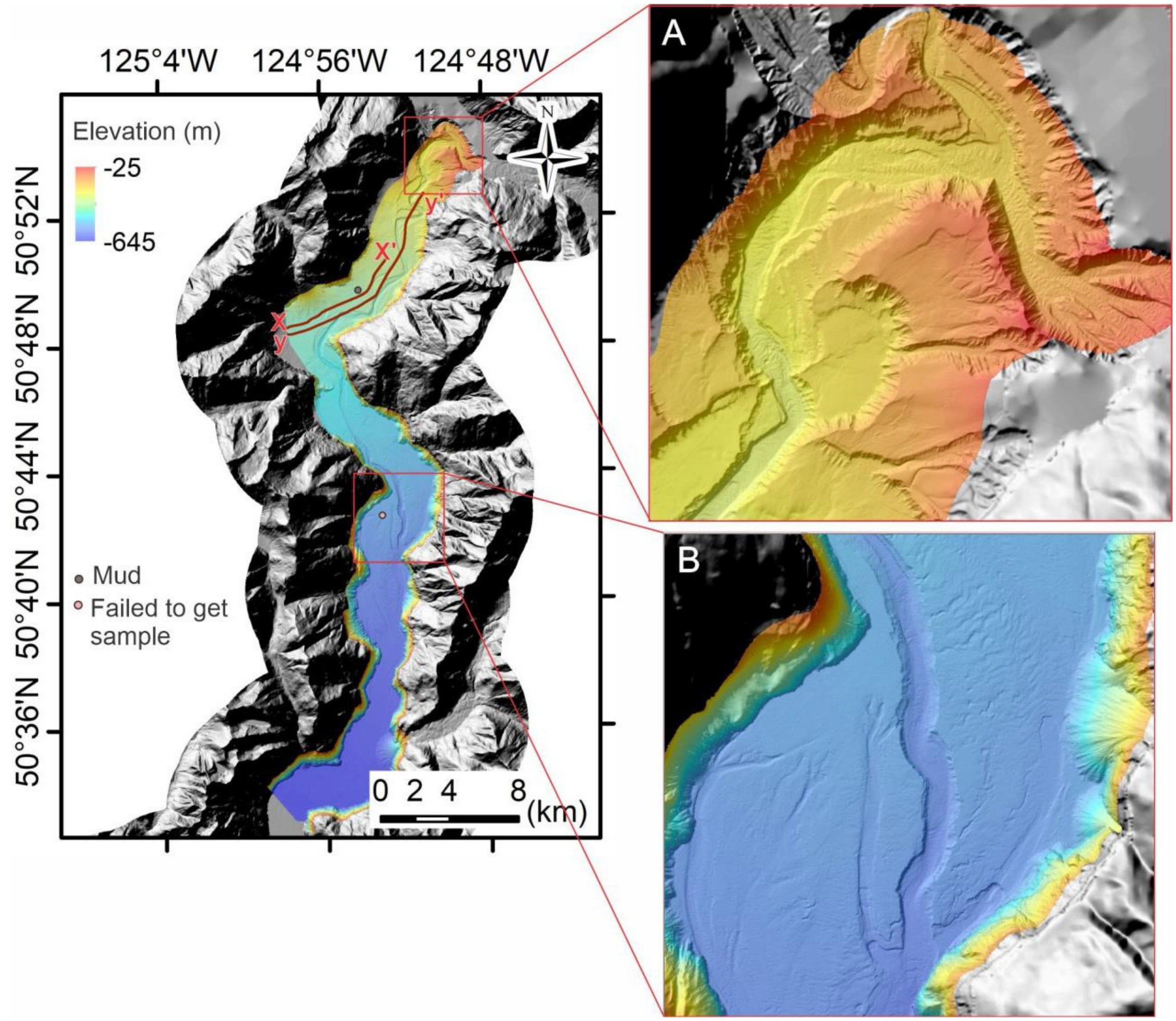

Fig. 19. Bathymetric map showing a typical channel system in Bute Inlet. A. Upper channel showing multiple channel heads. B. Lower channel showing abandoned channels.
Lines X-X’ and Y-Y’ are the location of the sub-bottom profiles in Fig. 20.

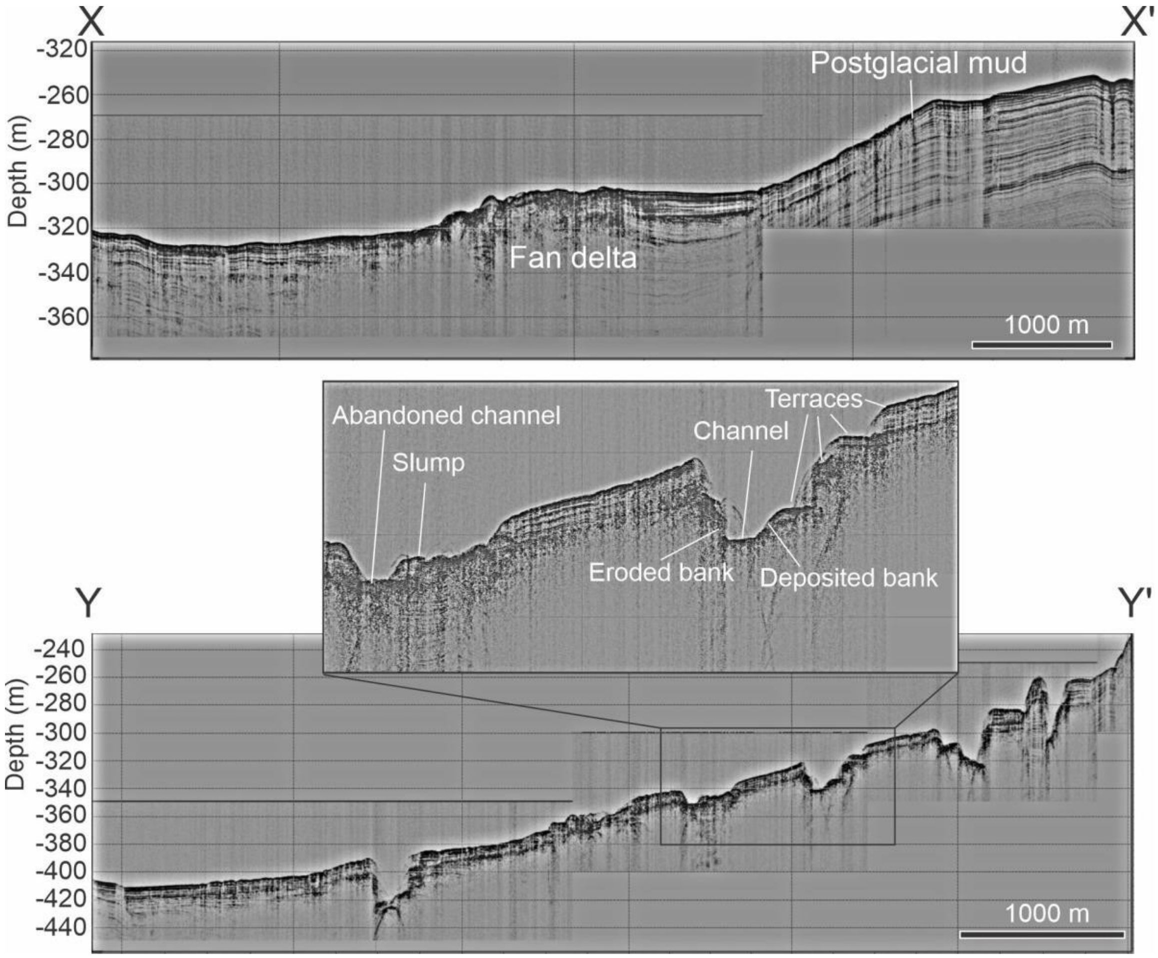

Fig. 20. Sub-bottom profiles showing morphologic patterns of fan delta, abandoned channel half-buried by slump, channel, terraces formed by migration of the channel. Locations of lines are marked in Fig. 19.

4.10. Georgia Strait Pockmarks

A total of approximately 7 km^2 of multibeam data were collected, and 34 km of sub-bottom profile lines were surveyed. One sample (STN 02) consisting of mud was collected outside of the multibeam survey area (Fig. 21). The water depth in the survey area ranges from approximately 246 m to 320 m. The survey area was centered along the linear chain of large pockmarks with the deepest reaching depths of 5-6 m (Fig. 21A). The sub-bottom profile clearly shows the gas masking.

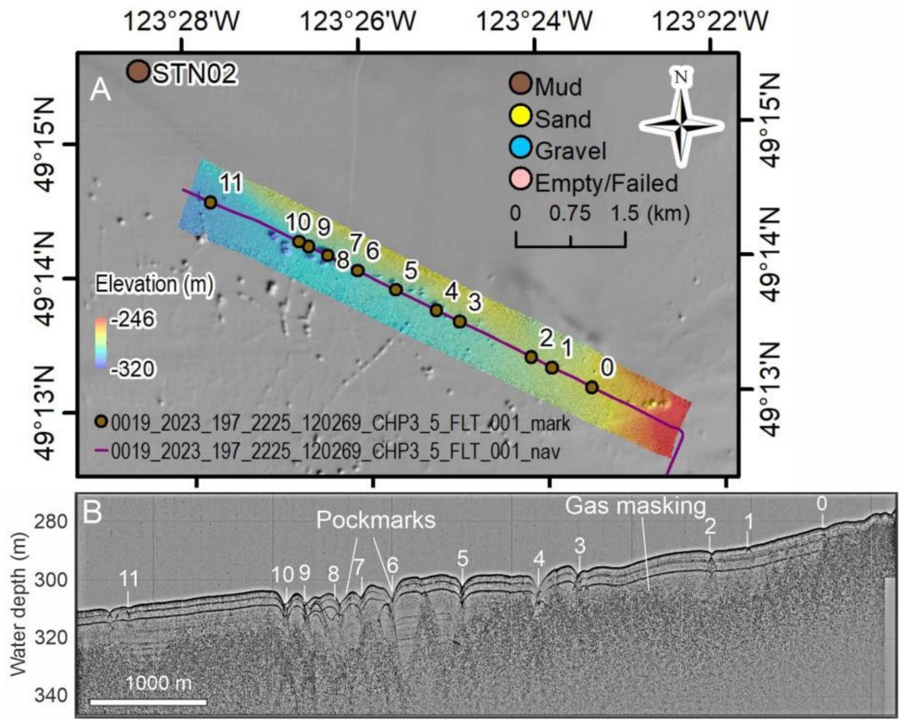

Fig. 21. Bathymetric map of the pockmark area in the Strait of Georgia (A) and a sub-bottom profile showing the stratigraphic pattern with gas masking (B).

4.11. Sandheads

Sandheads is an area of dynamic sedimentation and ocean currents, and as one of BC's most important waterways, this area has been surveyed twice per year in recent years. The survey area is characterized by the Sand Heads valley sea system, which was formed by turbidity currents and debris flows triggered by failures at the crest of the slope off the mouth of the Fraser River main channel. The sediment predominantly consists of sand and silt and gas masking which are evident in the entire sub-bottom profile (Fig. 22). Bedforms and abandoned channels are very common.

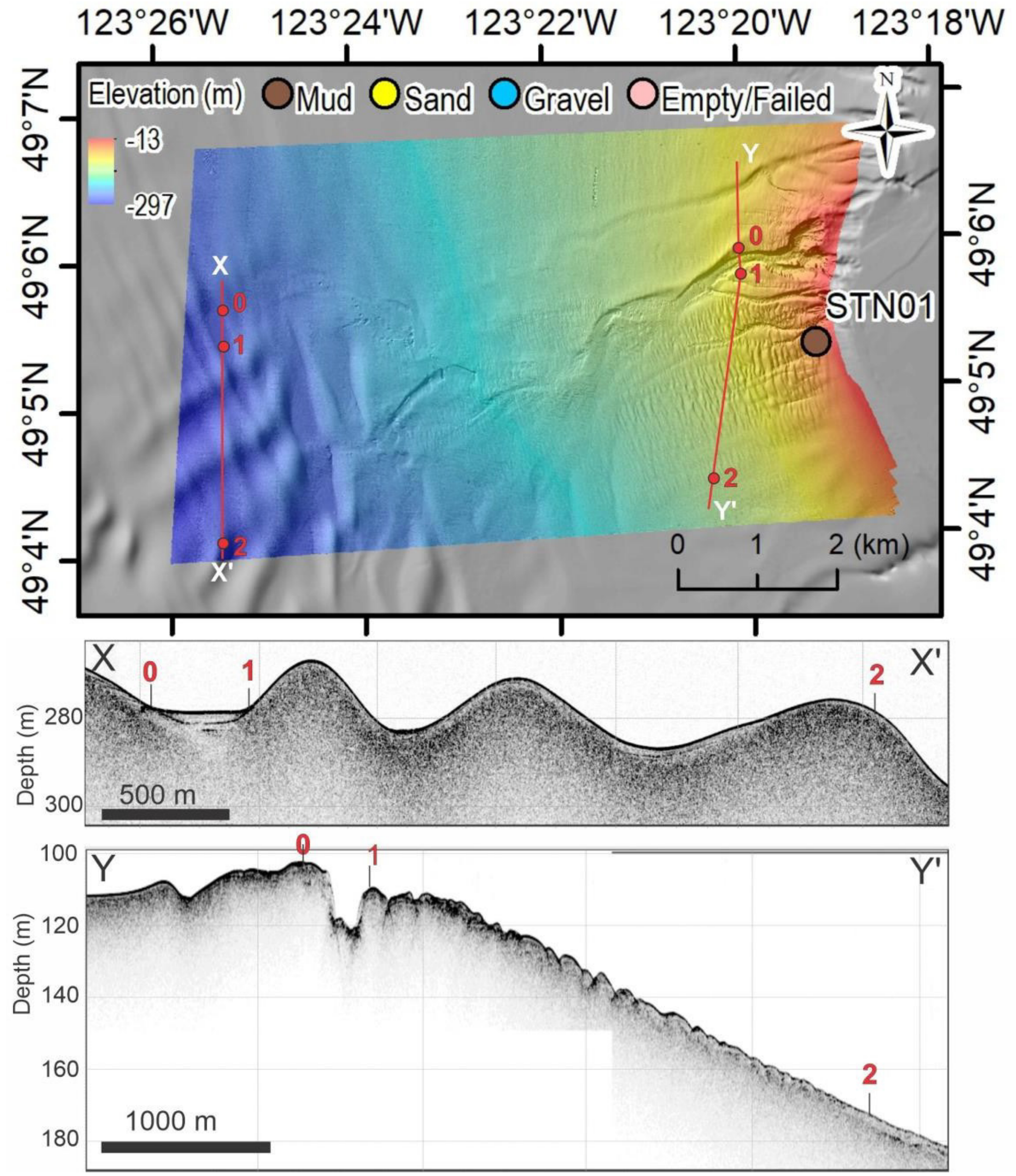

Fig. 22. Bathymetric map of Sandheads survey area and sub-bottom profiles showing the typical morphology of channels, bedforms and gas masking. X-X' and Y-Y' are from survey lines of 2023_197_1641 and 2023_197_0528, respectively.

5. SUMMARY

During this cruise, we conducted multibeam surveys covering 1770 km^2 in area, navigated 10,576 km of sub-bottom profile lines, and collected 40 grab samples. Cruise operations were documented for future expeditions to make setup and running of systems easier for other participants.

Each survey region has its unique features. Swiftsure Bank is characterized by a gravel platform and narrow channels in low reliefs. Amphitrite Bank has gravel bedforms on its platform. Landslides are very common at Cartwright Sound. Hippa Island area is characterized by deep channels and linear features, and Rennell Sound has a complex seafloor morphology with channels, linear features, and bedforms. Portland Inlet has a meandering main channel and fan deltas, and Portland Canal shows large fan deltas along the west wall and diamicton across the canal. Bute Inlet is characterized by a channel system with multiple heads, abandoned channels, and terraces. Sand channel systems with widely developed bedforms are typically observed in the survey areas of Georgia Strait. A fold system with N-S or NNW-SSE orientation is displayed by sub-bottom data collected during the transit from one region to another.

In addition, several minor technical issues encountered were effectively resolved during the cruise.

REFERENCE

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Kung, R., Douglas, K., Stacey, C.D., 2023. Geological Survey of Canada, Open File 8963, (ed. 2021) 2023, 80 pages, https://doi.org/10.4095/331539.

ACKNOWLEDGEMENT

We acknowledge the First Nations on whose traditional marine territories we conducted surveys. We are grateful to our collaboration with the CHS for multibeam data acquisition. We also thank Michelle Cote for her onshore support, and Randy Enkin and Jake Ferrier for their help with the demobilization. Finally, we would like to give our greatest acknowledgement to Captains William Sallon and Andrew Balakshin, and all crew members of the CCGS Vector for their safe operation and dedication during the cruises.

We acknowledge CHS data used in figures 3, 6, 8, 13, 15, 17, 19 and 21. The figure maps were produced by the GSC based on CHS charts and/or data, pursuant to CHS MOU no. 2022-0324-1260-N. The incorporation of data sources from CHS in this product shall not be construed as constituting an endorsement by CHS of this product. This product does not meet the requirements of the Navigation Safety Regulations, 2020 under the Canada Shipping Act, 2001. Charts and publications issued by or on the authority of CHS, corrected and up-to-date, must be used to meet the requirements of those regulations.

APPENDIX I. Cruise daily narrative

Cruise Daily Narrative for Vector 2023004PGC, 2023

July 12-14 (JD 193 – JD 195)
Coast Guard maintenance and CHS networking.

July 15 (JD 196)
Got underway around 6:30 pm (JD_UTC 196_0130). Ran test calibration lines in Saanich Inlet and Satellite Channel. Transited south down Haro Strait to where it meets Juan de Fuca Strait and ran multiple interactions of the same line at different intensities for a backscatter test requested by John Hughes Clarke. Began transit to Sandheads survey area. Successful grab using the Van Veen grab sampler in very shallow water, only 46 m depth.

July 16 (JD 197)
Spent the entire day surveying Sandheads and a CHS target area southeast of Sandheads near the U.S. Border near the BC Ferries route. Ran a transit line north of Sandheads to collect a single line of multibeam for Anna Podhorodeski. Lots of pockmark features along this transit. Van Veen grab sample only successful after two attempts, at 286m depth. Transited overnight to Bute Inlet. Edgeport USB converter failed but thankfully we had a spare in our supply boxes. Karen has asked Michelle to buy another one so there is a spare on board at all time. Zhen will bring the new one on board at crew change.

July 17 (JD 198)
Ran repeat Bute Inlet survey all day. Stopped the 3.5kHz recording while running lines close to the Fjord walls because no 3.5kHz data could be collected at such steep angles, which is true for all such fjord conditions. Resumed collecting 3.5kHz when we were further into the channel. Van Veen grab sampler failed twice after attempting in 525 m depth. I decided to go with the Shipek for the rest of the cruise, and also to move the grab time from 5pm and the end of the day to 6pm in the new Julian day. This made everyone happy, the CHS staff, the Bosun, the deckhands and me. There is no longer a rush to get it done, nobody misses dinner, and CHS can complete their survey right to the end of the Julian day. This should become a permanent change.

July 18 (JD 199)
Continued Bute Inlet survey. Loss of bottom detection during the CHS night watch at 3:50 am (JD_UTC 200_1050) and continued for two more lines. Was not fixed until I got to the lab at 6pm and fiddled with the TX Blanking value to tweak the transducer. Made a note on the white board for the CHS operator who noticed the bottom loss but did not know how to fix it. Continued Bute Inlet survey for the rest of the day.

July 19 (JD 200)
Successful Shipek grab at 6:00 pm (JD_UTC 201_0100) at 525 m depth. Finished Bute Inlet survey. Began transit from Bute Inlet to Port Hardy.

July 20 (JD 201)
Transit across Queen Charlotte Sound to west Haida Gwaii. Ran the 3.5kHz for the western part of the transit on the approach to Haida Gwaii. Experienced poor bottom detection as we

approached the shelf edge because of high ship speed and greatly increased depth.

July 21 (JD 202)
Transit up west coast of Haida Gwaii towards the Rennell Sound survey area. Took a grab at 6:00 pm (JD_UTC 203_0100) which was successful but took 1.25 hours to complete because of 1500 m water depth. According to the master stations dataset, this is the deepest Shipek taken with a successful return of sediment. Continued to collect 3.5kHz on transit. No multibeam collected on this or any other transit, which is normal. Started Rennell Sound survey around 10 pm.

July 22 (JD 203)
Continued with Rennell Sound survey all day. Very good data. Paused survey at 1:00 pm to send the rigid hull inflatable boat (RHIB) to Otter Bay with data delivery. Otter Bay begins surveying shoal areas. Resumed survey at 2:00 pm (JD_UTC 203_2100). Shipek grab as usual at 6:00 pm.

July 23 (JD 204)
Rennell Sound survey all day. As we moved towards the outer reaches of the sound, the seafloor becomes interesting, lots of mound features and linear features show up on the multibeam. Shipek grab as usual at 6 pm (JD_UTC 205_0100).

July 24 (JD 205)
Rennell Sound survey completed, and we moved to the area in the open ocean around Hippa Island. Lots of mound feature fields, linear formations and the heads of canyons which flow down to the QC fault trough.

Transited back into Rennell Sound at 6am to meet the Otter Bay to refuel her. Refuelling took a couple of hours. Had shore leave at the beach. Transit back to Hippa Island survey at 3:00 pm and resumed surveying at 5:00 pm. Shipek grab as usual at 6 pm (JD_UTC 206_0100).

July 25 (JD 206)
We are continuing the Hippa Island survey until 1pm when we will stop and start the transit to Prince Rupert for reprovisioning. We will be in Prince Rupert for all of July 26 and then on July 27 will transit up to Portland Canal. Following that we will return to west Haida Gwaii to finish the small area remaining of the Hippa Island survey and then spend the rest of the time surveying the deep water west of the QC fault zone before returning to Port Hardy for crew change.

It has been decided after consulting Karen and Cooper that in 1500-2000 m water the Shipek grabs will be done every other day to give more time for multibeam and 3.5kHz surveying. Estimate each grab will take 1.5 to 2 hours to complete and we will see how successful the Shipek is at such depth.

July 26 (JD 207)
Transit all day and night to Prince Rupert via Parry Passage and Dixon Entrance. Continuing to run 3.5kHz while multibeam is turned off. Arrived in Seal Cove, Prince Rupert at 9:00 am. Transmission of 3.5kHz turned off. In Prince Rupert for the rest of the day for reprovisioning and ship maintenance. Good weather in Prince Rupert, warm at 16 degrees with occasional sunny patches.

July 27 (JD 208)
Weighed anchor and departed the Seal Cove Coast Guard dock at 10 am (JD_UTC 208_1700). Transiting to Portland Canal, estimated arrival in 14 hours. Re-started 3.5 kHz at 12:00 pm. Interesting seafloor between Melville Island and Hodgeson reefs in Chatham Sound around JD_UTC 208_202000. Mud grab as usual at 6:00 pm (JD_UTC 209_0100). Very sticky clay at the bottom of Portland Canal.

July 28 (JD 209)
Began survey of Portland Canal. Rode the RHIB into Stewart for a couple of hours. You can't tie up right in Stewart because it is on a marshy estuary. The public docks are 2.5 km from the town so you have to walk in along the road which links Stewart and Hyder, Alaska. There is a boardwalk shortcut over the estuary into town. The setting is beautiful, however, set amongst the mountains and looking south down the canal. Got quite close to the shore at times. Saw a bear in the shore but it quickly disappeared into the woods. There are quite a few sandy beaches along this part of the canal, mostly around river mouths. The sand is whiteish in colour, possibly from granodiorite type source rocks? The surrounding mountains are granodiorite batholiths according to the Tectonic Assemblage map. At the end of the Julian day completed the survey and started transiting south back to Portland Inlet. Discovered the most efficient way to get new station and route locations to the bridge for every cruise: utilizing QGIS to convert ArcGIS feature classes to GPX format which is directly read into the bridge navigation system. Grab as usual at 6:00 pm, more sticky clay. Began survey of Portland Inlet in the evening.

July 29 (JD 210)
Surveyed in Portland Inlet all day, doing a repeat survey. Later in the day wind picked up to 30 knots, making it impossible to do the requested Parkinson cross channel 3.5kHz survey, which was already unlikely because of time constraints. It was also impossible to do the grab sample today because of the rough seas. Started transit in the evening back to Haida Gwaii to finish the Hippa Island survey and begin the NRCan block over the fault zone southwest of Hippa Island. Very rough seas transiting back through Dixon Entrance. Lots of corkscrew ship motion.

July 30 (JD 211)
Continued remaining Hippa Island survey block. Grab sample was attempted twice at 6:00 pm (JD_UTC 211_0100), both attempts coming back empty because of probable location over bedrock. Finished Hippa Island survey after midnight and transited down the south end of the NRCan block over the fault zone.

July 31 (JD 212)
Began survey of the NRCan fault zone block. Weather is calm, sea conditions are the best it could be today. No wind, no waves, minimum swell. The sea is almost lake-like.

August 1-2 (JD 213 – JD 214)
Continuous surveying in NRCan block, west of Cartwright Sound. No issues, great weather, calm seas. Sightings of humpback whales, porpoises, and sharks. Mud grabs at 6:00 pm both days.

August 3 (JD 215)
Finished the inner portion of the NRCan survey block, then at 8:30 am (JD_UTC 215_1530) stopped multibeam and changed course heading east to Kano Inlet to anchor for RHIB deployment bringing Chief Engineer ashore at Skidegate and picking up replacement. Continued to run 3.5kHz on the transit but stopped when we dropped anchor in Kano Inlet at 11:00 am. Departed Kano Inlet at 6:30 pm (JD_UTC 216_0130), restarted 3.5kHz for the transit. Returned to NRCan survey block at 9:00 pm (JD_UTC 216_0400) and did a grab sample. Continued multibeam and 3.5kHz survey after that.

August 4 (JD 216)
Continuing to survey the NRCan block west of Cartwright Sound. Variable topography, from steep plateaus to deep holes.

August 5 (JD 217)
Grab sample unsuccessful at 6 pm (JD_UTC 217_0100). Very deep, nearly 1500 m. Shipek is not the right tool for this depth in this variable seafloor topography. I looked at the master station feature class and historically, out of 5 Shipek grabs taken at > 1000 m, 3 failed. Bottom detection loss on line 0155 between 217061752 and 217064435. Stopped multibeam survey at 4:00 am (JD_UTC 217_1100) to head to Buck Channel for another refueling of Otter Bay. Arrived at Buck Channel at 8:00 am (JD_UTC 217_2000). Took the FRC at 9:00 am to Chattl Island for shore leave. Returned to Vector where the Otter Bay was tied beside for refuelling. Departed Buck Channel at 3:30 pm (JD_UTC 217_2230).

August 6 (JD 218)
Returned to NRCan survey block at 6:15 pm (JD_UTC 218_0115) and did a grab sample and an SVP cast before resuming the survey. We hope to get the rest of the block surveyed before the weather turns bad which is predicted for the next 24 hours. An interesting plateau feature is emerging in this block. Grab was successful at 725 metres. Resumed survey at 7:30 pm (JD_UTC 218_0230). This block has the most interesting seafloor of the surveys we've done on this cruise. There are large plateaus, deep depressions, large slump failures and a failure waiting to happen where you can see the line of impending failure around the feature and the build up of material at the base of the feature.

At 9:00 am (JD_UTC 210_1600) we attempted to do the deepest Shipek grab in NRCan records at almost 2000 m. Sean the bosun even rigged the line with extra weight for the tremendous depth. The specification on the winch said there was 2500 m of wire available when in fact there was only 1900 m on the spool. We will try again at about 1700-1800 m later in the day.

Finished multibeam surveying at 2:00 pm (JD_UTC 218_2100) and proceeded to the final mud grab station, with a depth of around just over 1600 metres. At 2:25 pm we deployed the Shipek. After an hour of drop and recovery we were successful in getting a whole bucketful of clay from 1620 m of water. That is a record depth mud grab recovery for our Shipek according to our sampling database. The last recorded record depth was 1530 m in 1978 by the Endeavour, but it is not clear whether they had a successful recovery or not. Earlier in the cruise we had a successful recovery at 1485 m depth, which is the 2nd deepest confirmed recovery of a Shipek grab by our records.

The multibeam survey is finished for this first leg. Multibeam and 3.5kHz have stopped recording until Zhen Li takes over from me on Wednesday, August 9.

August 7 (JD 219)
Transit to Port Hardy. No surveying.

August 8 (JD 220)
Docked in Port Hardy for refuelling, re-provisioning and crew change.

August 9 (JD 221)
Crew change day and handover between Zhen and Robert in Port Hardy.
Zhen took over the work from Robert and checked the daily process to be sure that all is working well. There is no Chirp line to record. Nav data in Aug. 8 are recorded just at the dock.

At 18:30 PDT, the ship departed and headed to survey the area through Goletas Channel. The Knudsen line started. Two grab samples (STN20 and STN21) were collected in this Channel. The one at STN20 in the mud with gas masking area shown by Chirp profiles consists of silt or clay silt. The other sample collected at STN21 in the channel system on the slope of the entrance of Goletas Channel is shelly medium-coarse sand with abundant foraminifera and shells.

The Nav output file was empty for Aug. 9 (JD221). I contacted Robert and resolved the problem. Reason: didn't copy the right JD folder to 2023004PGC under the Navloggingdata, as the Nav logging folder “JD221” was wrongly recorded as “JD220”. It has been corrected to “JD221”.

Discussed with Captain Will and Hydrographer in Charge (Marie-Helene) about sampling time and locations. Depending on the condition of moving vessel SVP (MVP200), if it works well, then, anytime is good for sample collection; if it doesn't work, then, following the regular work as Leg 1.

August 10 (JD 222)

At ~8:00 am PDT, MVP is deployed near Crowther Canyon, off Brooks Peninsula. MVP works well. At ~5:30 pm (JD_UTC 222_222459), one grab sample at STN22 was collected offshore of Nootka Sound. The sediment is silty.
A foam box from the kitchen dropped into the water at 5:30 pm, the ship stopped and Ryan using a boat hook got it out of the water quickly. A fire drill was conducted at 12:30 pm PDT. At ~8:20 pm PDT (JD_UTC 223_031627), one grab sample was taken at STN23, which is characterized by gravel.
Arrived at survey location, Amphitrite Bank East, at 9:20 pm PDT and started multibeam survey.

August 11 (JD 223)
Continued the survey of Amphitrite Bank East. The MVP was deployed at ~8:00 am PDT and recovered at 9:40 am. Discussed a regular grab sample schedule with Will and Marie-Helene, for 4:30 pm PDT daily, since 5:30 pm is close to dinner time. Multibeam data collection stopped at 4:30 pm PDT to collect grab samples. Three failed grab sample events, two using Shipek, one using Van Veen.

August 12 (JD 224)
Continued the survey of Amphitrite Bank East. Considering that the seabed of the survey area is mostly characterized by bedrock and gravel, Zhen designed 9 sites in various geomorphological areas for collecting grab samples to mitigate failure in collecting of samples. Copied the location as a .gpx file to the Bridge. Captain Will decided to collect the three nearest samples first. From ~1:20 pm to 2:30 pm PDT, we collected three samples at stations 25 (JD_UTC 224_202131), 26 (JD_UTC 224_204612), and 27 (JD_UTC 224_210352). Sediment from stations 25 and 26 consists of gravel, and the sample from station 26 is fine sand.
Added the cruise number to the grab sample labels from Leg 1.

August 13 (JD 225)
Continued the survey of Amphitrite Bank East. From 8:30-9:50 am PDT, collected three samples at stations 28 (JD_UTC 225_153428), 29 (JD_UTC 225_155626), and 30 (JD_UTC 225_165050). Samples from stations 28 and 29 consist of muddy gravel, and station 30 consists of silty clay. A full bucket of mud was collected using the Shipek sampler after three failed attempts using the Van Veen sampler at station 30, although water depth was 101 m.

August 14 (JD 226)
Continued the survey of Amphitrite Bank East. At ~9:00- 10:00 am PDT, we collected three samples at stations 31 (JD-UTC 226_161108), 32 (JD-UTC 226_162608), and 33 (JD-UTC 226_165503), two sandy gravel samples (STN31 and 33), and one sand sample (STN32). Two attempts for collection at STN32 obtained only a little sand remaining on the bottom of the grab bucket. It is possible that the sand was washed out with the strong currents and swell.

August 15 (JD 227)
Continued the survey of Amphitrite Bank East. The MVP was deployed at ~8:00 am PDT and recovered at ~10 am. Converted all lines from segy to jp2 format and uploaded on the map for interpretation. Enough grab samples have been collected for interpretation. Sent message to Pacific Geoscience Centre (PGC) group about the work this week.

August 16 (JD 228)
Continued the survey of Amphitrite Bank East. The MVP was deployed at ~8:30 am PDT. The swell in the Amphitrite Bank area was too strong to get good multibeam data, so we headed to Swiftsure Bank at JD-UTC 228_0504 and started to survey the shallow part between Carmanah Pt. and Tsuquanah Pt. (JD-UTC 228_0722). The MVP was deployed when the multibeam survey started. The acoustic patterns of Chirp 3.5kHz sub-bottom profiles were very simple and no particular structure was displayed. The Chirp3.5 kHz record from JD-UTC 229 000000 to 229_020226 was missed. At 4:30 pm, we collected a grab sample at STN34, which consists of gravel <6 cm in diameter.

August 17 (JD 229)
Continued the survey of Swiftsure Bank. Deployed the MVP at 3:00 pm. Based on the new multibeam data and Chirp 3.5kHz profiles, the survey area is characterized by bedrock and gravel. Thus, we decided to regularly collect grab samples at 4:30 pm every day. A sample at STN35 is composed of fine sand, located within a channel.

August 18 (JD 230)
Continued the survey of Swiftsure Bank. The Knudsen lost signal and showed "no sounder nodules detected" from JD_UTC 230_214126. This was caused by a strong swell that caused two wheels of the table (workstation) to unlock, resulting in the right side of the table moving against the wall. A message was sent to Robert about the issue. To resolve it, Zhen attempted to restart the software "SounderSuite EchoControlClient", but the problem persisted. After rebooting the Knudsen Computer, the issue was still there. On the third attempt, turning the Knudsen off and on, the issue had not been resolved. It appeared that the table movement induced a disconnection. With Brendan's help for safety, Zhen checked and fixed the connection, resolving the issue. With Robert's instruction and confirmation, the Knudsen was turned off and on one more time. The issue was resolved and Chirp 3.5kHz profiles recorded again after JD_UTC 230_225818!
The swell was too strong to collect grab samples and the ship headed to Port Refrew to avoid the strong winds.

August 19 (JD 231)
Departed from Port Renfrew at 6:30 am PDT and arrived at the northern area of Swiftsure Bank at ~9:00-10:00 am PDT. Deployed the MVP and continued the survey of Swiftsure Bank. Created the model for adding line number to navigation data using ModelBuilder. It is saved in the folder C:\SHIPProjectGIS\VECTOR_2023004PGC\Zhen as Tool group NavLoggingSata_Zhen. No signal for WiFi or cell phone service. Lost communications with family and PGC colleagues.

August 20 (JD 232)
Continued the survey of Swiftsure Bank. Collected two grab samples at STN36 and STN37. Sediment of STN36 consists of very fine sand, and STN37 has medium-coarse sand with gravel. Still no sign of any signal for WiFi and cell Phone. Converted all segy files into JP2 format and uploaded the map.

August 21 (JD 233)
Continued the survey of Swiftsure Bank. A grab sample was collected at STN39 at 4:30 pm PDT, consisting of very fine sand. No WIFI or cell phone signals were detected. Uploaded the new Chirp 3.5kHz profiles on the map with the most updated files and multibeam bathymetric map. The Chirp 3.5kHz profiles were truncated above 25 m, to resolve this issue, I reset the Tx Blanking from 20 m to 5 m, then, set the Tx Blanking back to 20 m, Tx Pulse to 0.25 ms, and Range=200 when the ship headed offshore of Swiftsure Bank at ~7:30 pm PDT (JD_UTC 234_0230).

August 22 (JD 234)
Continued the survey of Swiftsure Bank. The Chirp 3.5 kHz profile lost signal at 8:47 am PDT. Checked the computer and the Knudsen and found that the power was off for some unknown reason. The record was recovered after powering on the Knudsen. A similar incident occurred at 11:14 am PDT.

August 23 (JD 235)
Continued the survey of Swiftsure Bank until 6:18 am PDT, when the ship headed for Ucluelet

for fuel and supplies. Departed from Ucluelet at 4:00 pm PDT and headed back to the survey area. Chirp recording began at 5:00 pm PDT (JD_UTC 236_0000) during the transit to Amphitrite Bank.

August 24 (JD 236)
Surveyed Amphitrite Bank Southwest. I noticed that in the Chirp 3.5kHz profile record folder, two sub-bottom lines were numbered "0233" in JD228. The numbers were corrected to 0233 and 0234 for the files, and subsequent line numbers were updated accordingly.

August 25 (JD 237)
Continued the survey of Swiftsure Bank West. Contacted Michelle at the PGC and Duncan at CHS regarding demobilization. Randy will be coming for the demob. A Coast Guard crew member will crane the workstation and other items from the aft of the ship to the dock and Duncan will help to forklift the items to the hangar. Discussed with Marie-Hellen (CHS) and Will (Captain) and scheduled two stations for grab samples on the way back to IOS.

August 26 (JD 238)
Continued the survey of Swiftsure Bank West. Contacted Robert regarding navigation data, which would be recorded until domob. The multibeam survey was stopped by the CHS at 7:00 pm PDT as the ship headed back to the PGC. Adjusted the locations for grab samples based on the scheduled route. CHS switched off GPS from 7:42 pm PDT (JD_UTC239_024130) to ~11:30 pm (JD_UTC 239_062936), and the coordinates were not available for Chirp files in that interval. Collected two grab samples at STN43 and STN44. Both consist of clay-silty clay with sea worms and brittle stars.

August 27 (JD 239)
Stopped the Chirp at 6:30 am PDT. Final data management tasks were undertaken:

1) Copied sub-bottom profiles.
2) Converted all SEGY files into JP2 files and uploaded to the map for interpretations later.
3) Packed all equipment and items for grab sampling.
4) Logged files of lineParameter, Parameters, and copied to N drive.
5) Created the feature class for the last day and appended to navigation data.
6) Created leg2 track line.
7) Copied data in .all, .bag and .wcd formats from the CHS.

August 28 (JD 240)
Completed the demobilization. The cruise successfully completed.

APPENDIX II. Photos of grab samples

Photos in Figs. A-II-1–A-II17 were taken on the deck, while others were taken in the lab.

Fig. A-II-1. Grab sample from STN01. Photograph by R. Kung. NRCan 2023-325.

Fig. A-II-2. Grab sample from STN02. Photograph by R. Kung. NRCan 2023-326.

Fig. A-II-3. Grab sample from STN03. Photograph by R. Kung. NRCan 2023-327.

Fig. A-II-4. Grab sample from STN04. Photograph by R. Kung. NRCan 2023-328.

Fig. A-II-5. Grab sample from STN05.
Photograph by R. Kung. NRCan 2023-329.

Fig. A-II-6. Grab sample from STN06.
Photograph by R. Kung. NRCan 2023-330.

Fig. A-II-7. Grab sample from STN07.
Photograph by R. Kung. NRCan 2023-331.

Fig. A-II-8. Grab sample from STN08.
Photograph by R. Kung. NRCan 2023-332.

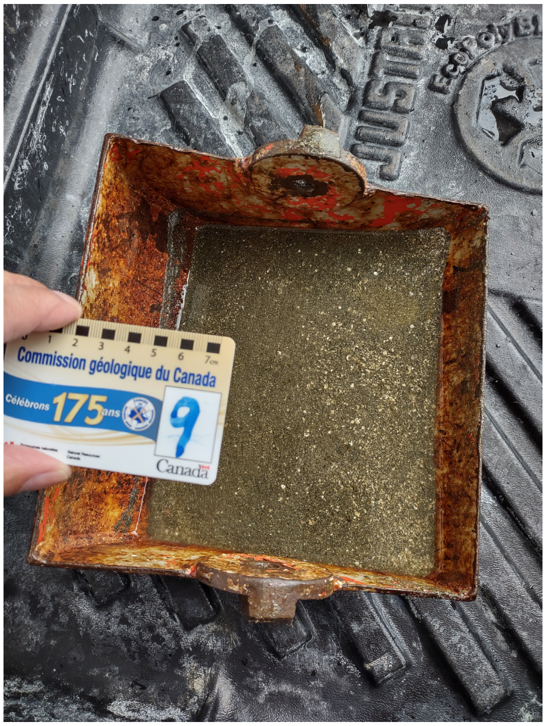


Fig. A-II-9. Grab sample from STN09.
Photograph by R. Kung. NRCan 2023-333.

Fig. A-II-10. Grab sample from STN10.
Photograph by R. Kung. NRCan 2023-334.

Fig. A-II-11. Grab sample from STN11.
Photograph by R. Kung. NRCan 2023-335.

Fig. A-II-12. Grab sample from STN13.
Photograph by R. Kung. NRCan 2023-336.

Fig. A-II-13. Grab sample from STN14.
Photograph by R. Kung. NRCan 2023-337.

Fig. A-II-14. Grab sample from STN15.
Photograph by R. Kung. NRCan 2023-338.

Fig. A-II-15. Grab sample from STN16.
Photograph by R. Kung. NRCan 2023-339.

Fig. A-II-16. Grab sample from STN18.
Photograph by R. Kung. NRCan 2023-340.

Fig. A-II-17. Grab sample from STN19.
Photograph by R. Kung. NRCan 2023-341.

Fig. A-II-18. Grab sample from STN20.
Photograph by Z. Li. NRCan 2023-342.

Fig. A-II-19. Grab sample from STN21.
Photograph by Z. Li. NRCan 2023-343.

Fig. A-II-20. Grab sample from STN22.
Photograph by Z. Li. NRCan 2023-344.

Fig. A-II-21. Grab sample from STN23.
Photograph by Z. Li. NRCan 2023-345.

Fig. A-II-22. Grab sample from STN25.
Photograph by Z. Li. NRCan 2023-346.

Fig. A-II-23. Grab sample from STN26.
Photograph by Z. Li. NRCan 2023-347.

Fig. A-II-24. Grab sample from STN27.
Photograph by Z. Li. NRCan 2023-348.

Fig. A-II-25. Grab sample from STN28.
Photograph by Z. Li. NRCan 2023-349.

Fig. A-II-26. Grab sample from STN29.
Photograph by Z. Li. NRCan 2023-350.

Fig. A-II-27. Grab sample from STN30.
Photograph by Z. Li. NRCan 2023-351.

Fig. A-II-28. Grab sample from STN31.
Photograph by Z. Li. NRCan 2023-352.

Fig. A-II-29. Grab sample from STN33. Photograph by Z. Li. NRCan 2023-353.

Fig. A-II-30. Grab sample from STN34. Photograph by Z. Li. NRCan 2023-354.

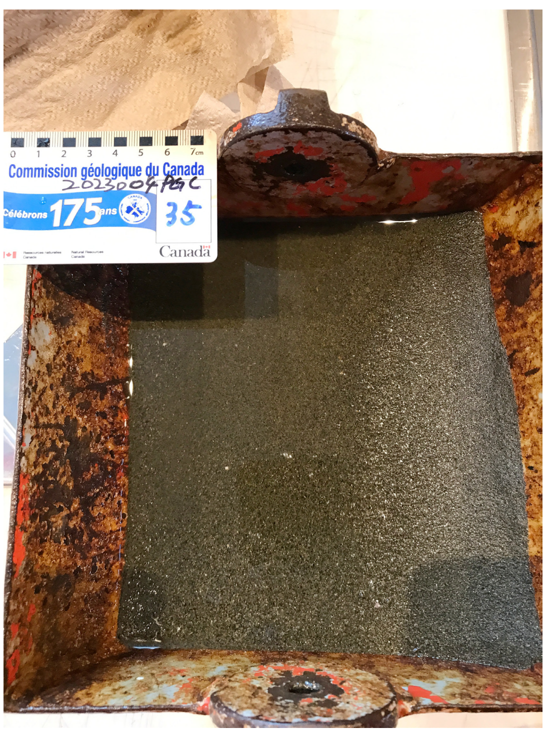


Fig. A-II-31. Grab sample from STN35. Photograph by Z. Li. NRCan 2023-355.

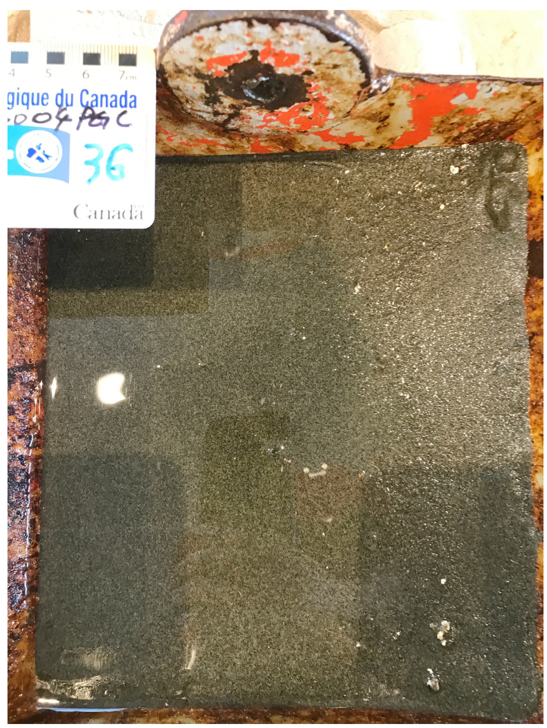
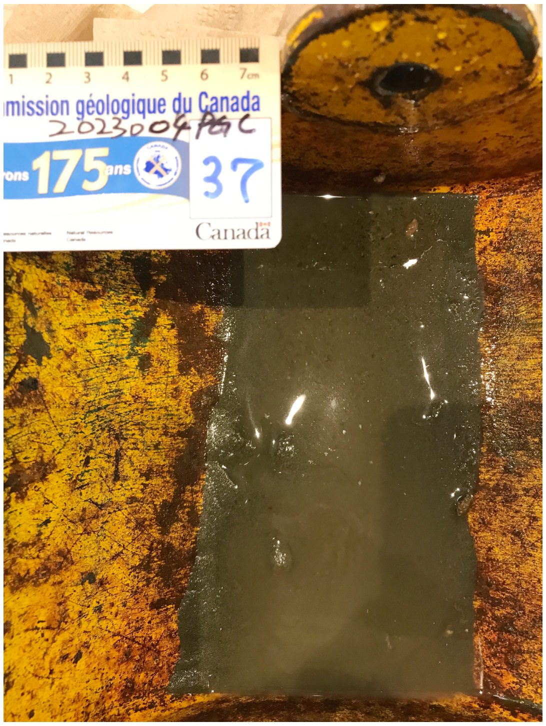


Fig. A-II-32. Grab sample from STN36. Photograph by Z. Li. NRCan 2023-356.



A-II-33. Grab sample from STN37.
Photograph by Z. Li. NRCan 2023-357.

Fig. A-II-34. Grab sample from STN38.
Photograph by Z. Li. NRCan 2023-358.

Fig. A-II-35. Grab sample from STN39.
Photograph by Z. Li. NRCan 2023-359.

Fig. A-II-36. Grab sample from STN40.
Photograph by Z. Li. NRCan 2023-360.

Fig. A-II-37. Grab sample from STN41.
Photograph by Z. Li. NRCan 2023-361.

Fig. A-II-38. Grab sample from STN42.
Photograph by Z. Li. NRCan 2023-362.

Fig. A-II-39. Grab sample from STN43.
Photograph by Z. Li. NRCan 2023-363.

Fig. A-II-40. Grab sample from STN44.
Photograph by Z. Li. NRCan 2023-364.

APPENDIX III. Sub-bottom profile lines

Fig. A-III-1. Sub-bottom line 2023_196_0039 ...UISES\2023\2023004PGC\Knudsen\JP2\JD196\0001_2023_196_0039_120269_CHP3.5_FLT_001.jp2

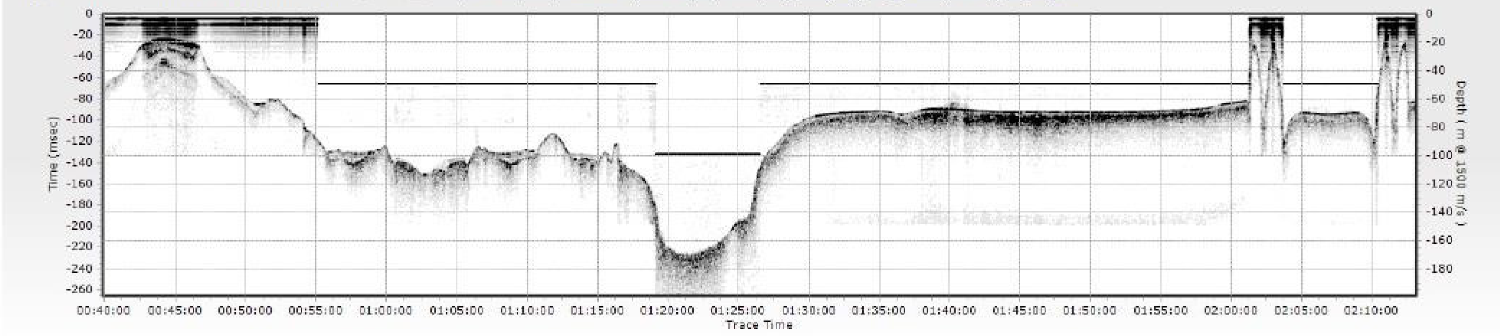


Fig. A-III-2. Sub-bottom line 2023_196_0213 ...JISES\2023\2023004PGC\Knudsen\JP2\JD196\0001_2023_196_0213_120269_CHP3.5_FLT_001.jp2

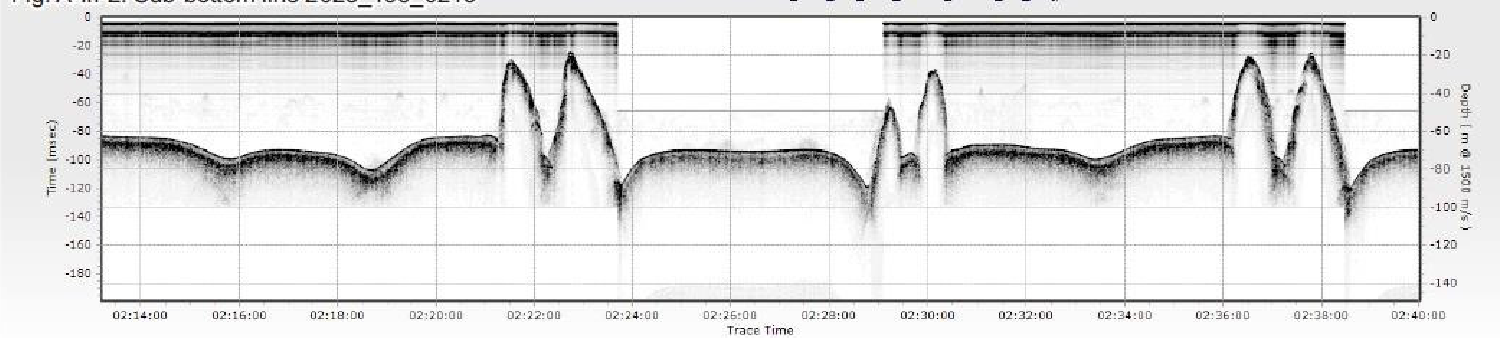


Fig. A-III-3.Sub-bottom line 2023_196_0240 ...UISES\2023\2023004PGC\Knudsen\JP2\JD196\0002_2023_196_0240_120269_CHP3.5_FLT_001.jp2

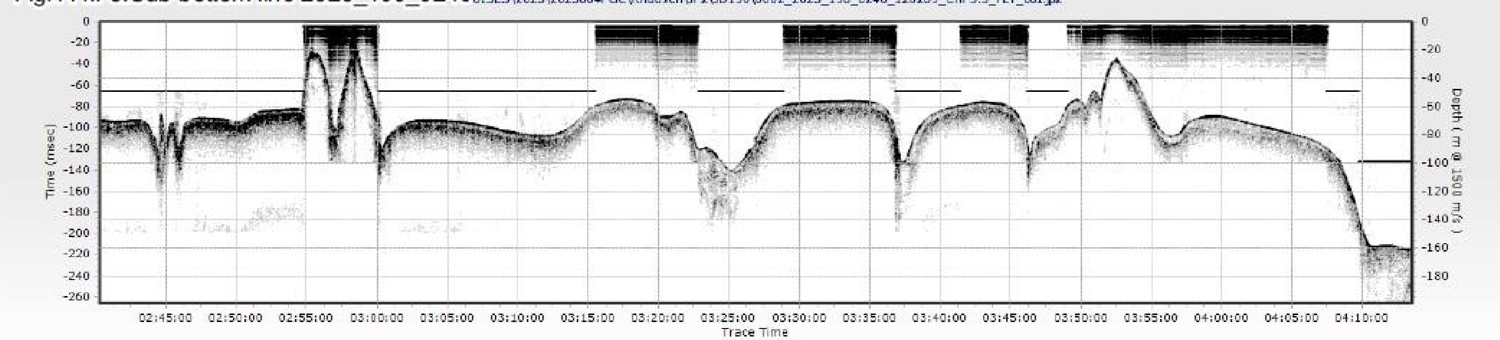


Fig. A-III-4. Sub-bottom line 2023_196_0413

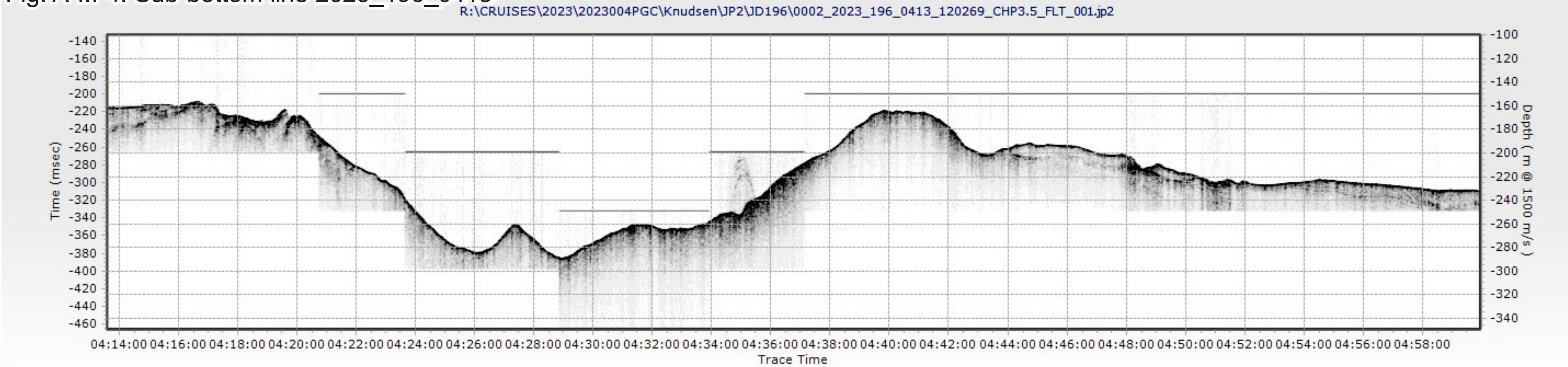


Fig. A-III-5. Sub-bottom line 2023_196_0500

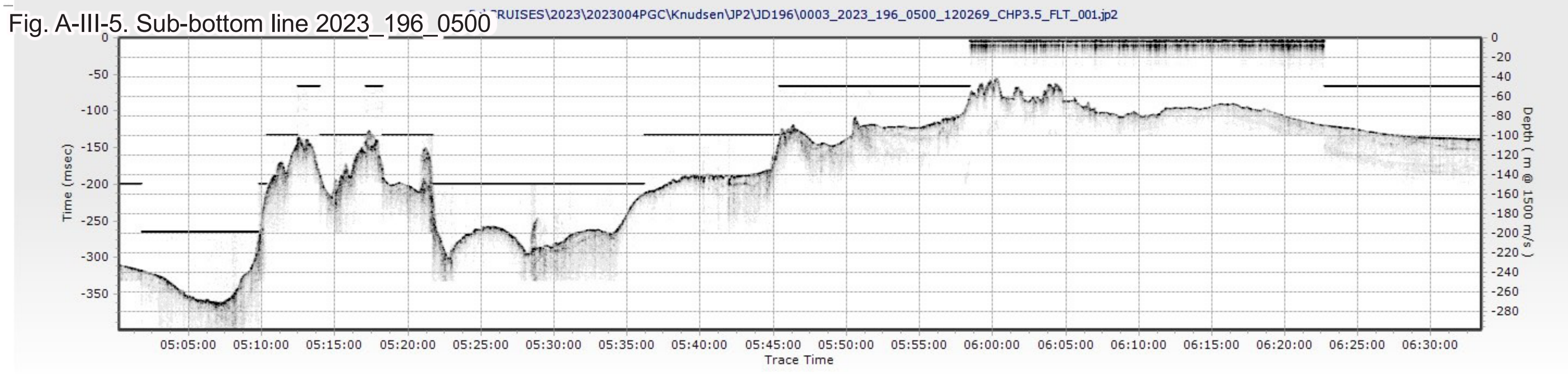


Fig. A-III-6. Sub-bottom line 2023_196_0633

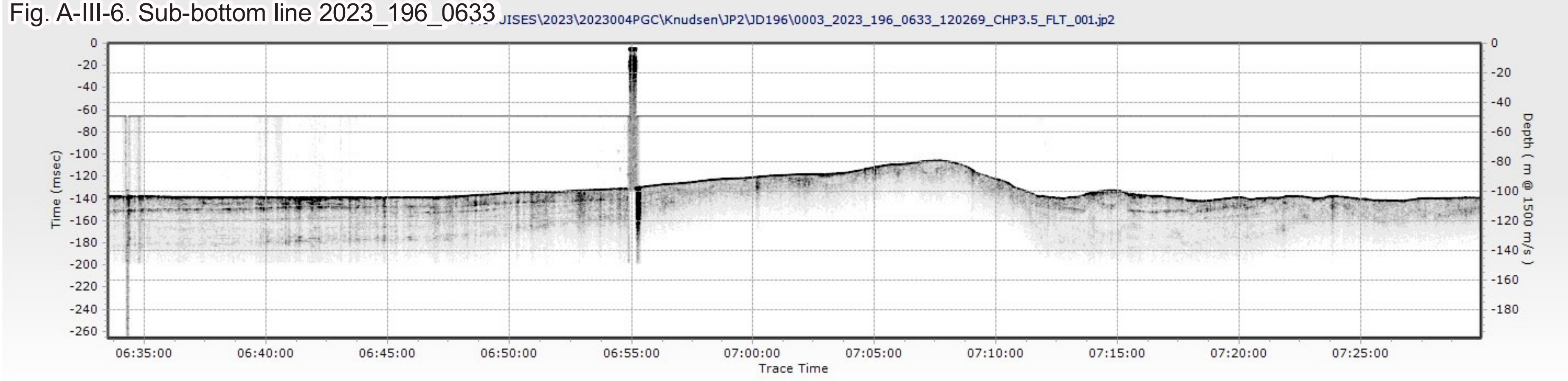


Fig. A-III-7. Sub-bottom line 2023_196_0730

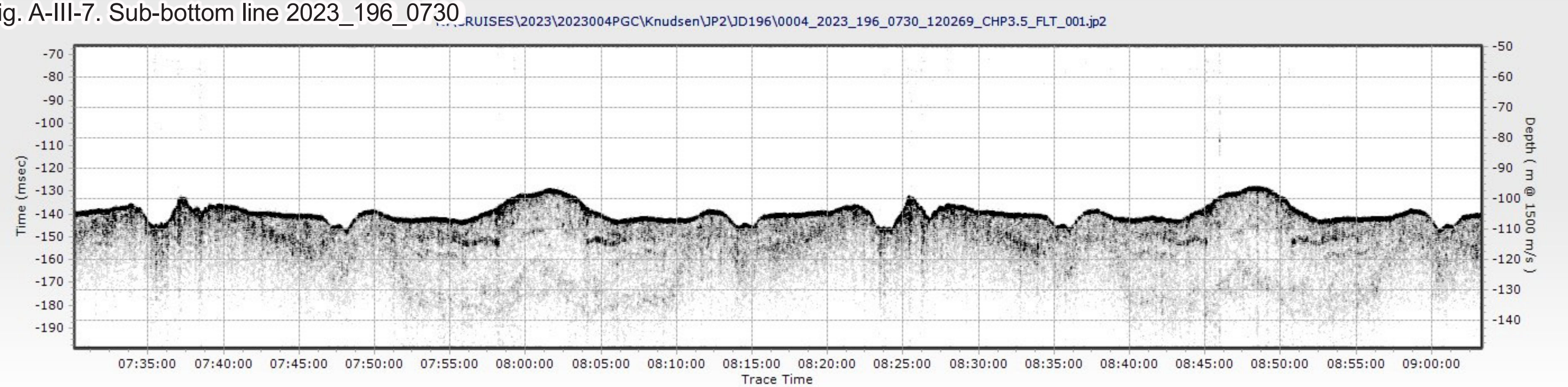


Fig. A-III-8. Sub-bottom line 2023_196__0903

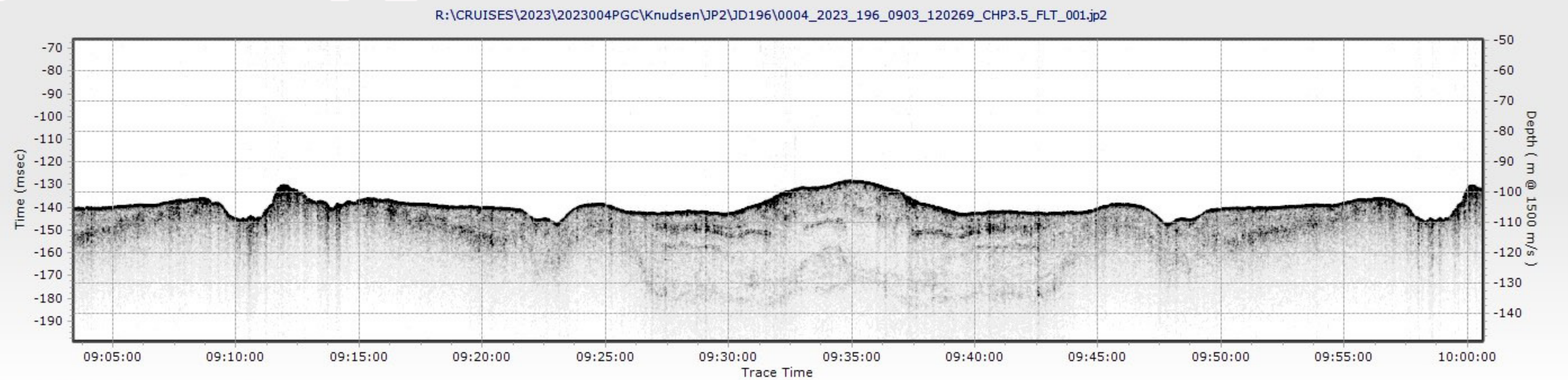


Fig. A-III-9. Sub-bottom line 2023_196_1000

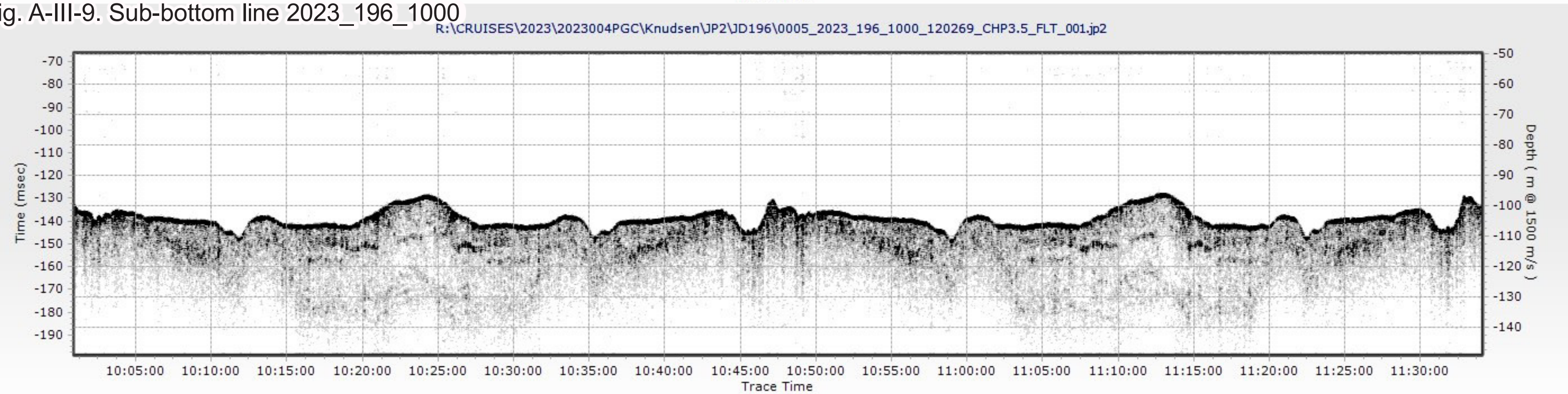


Fig. A-III-10. Sub-bottom line 2023_196_1134

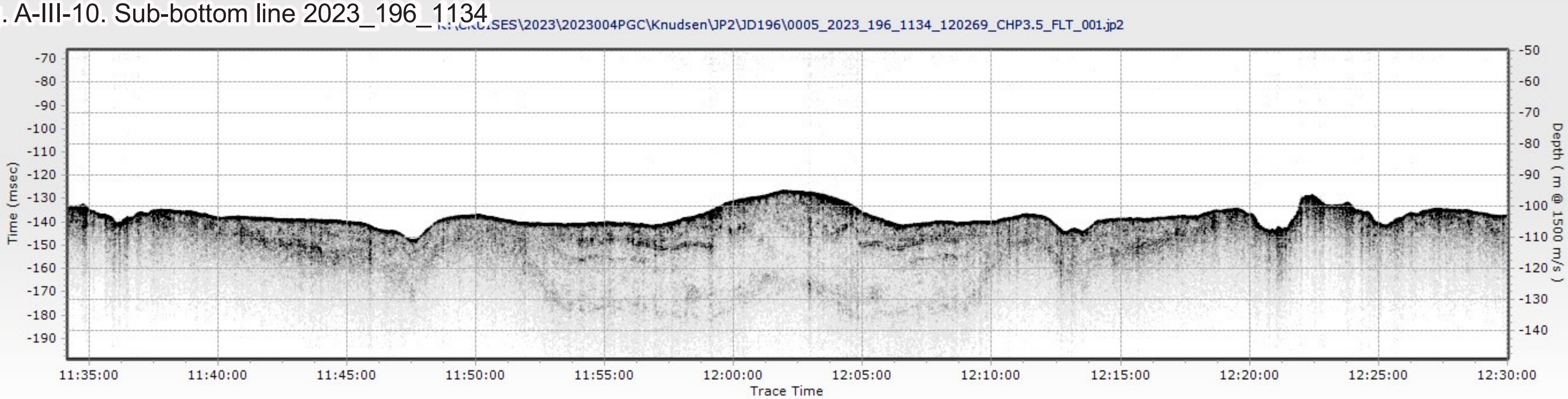


Fig. A-III-11. Sub-bottom line 2023_196_1230

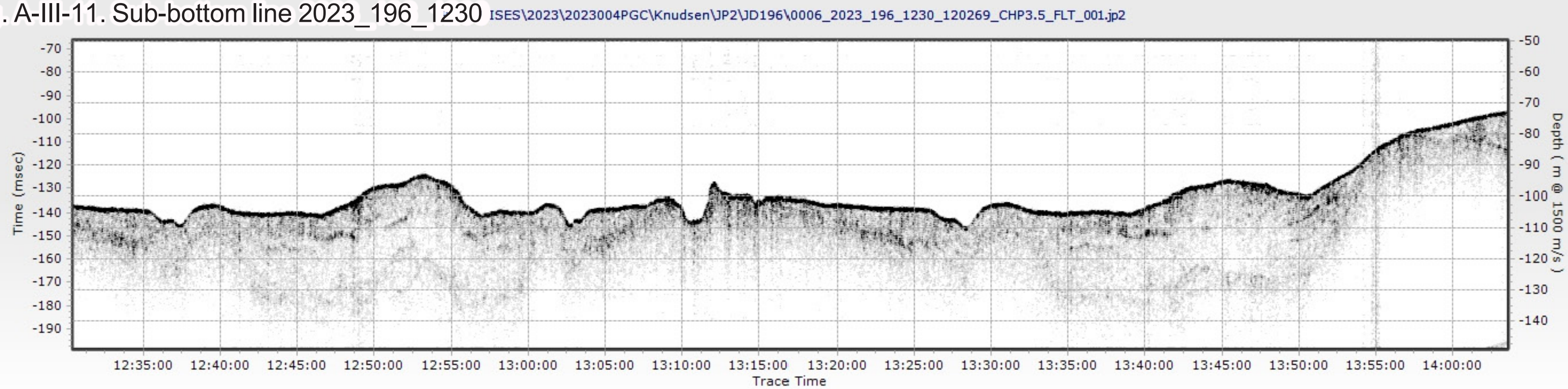


Fig. A-III-12. Sub-bottom line 2023_196_1403

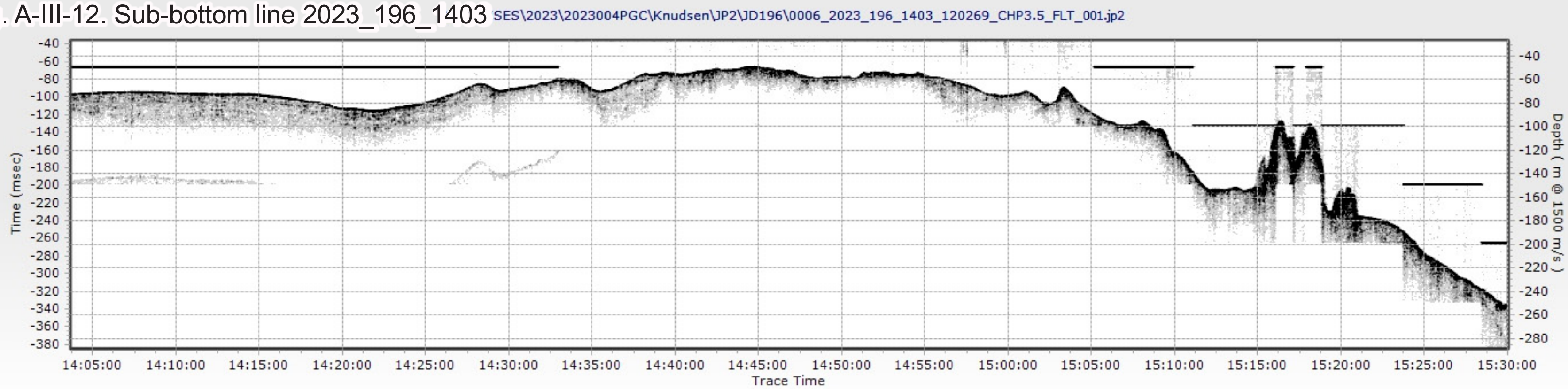


Fig. A-III-13. Sub-bottom line 2023_196_1530

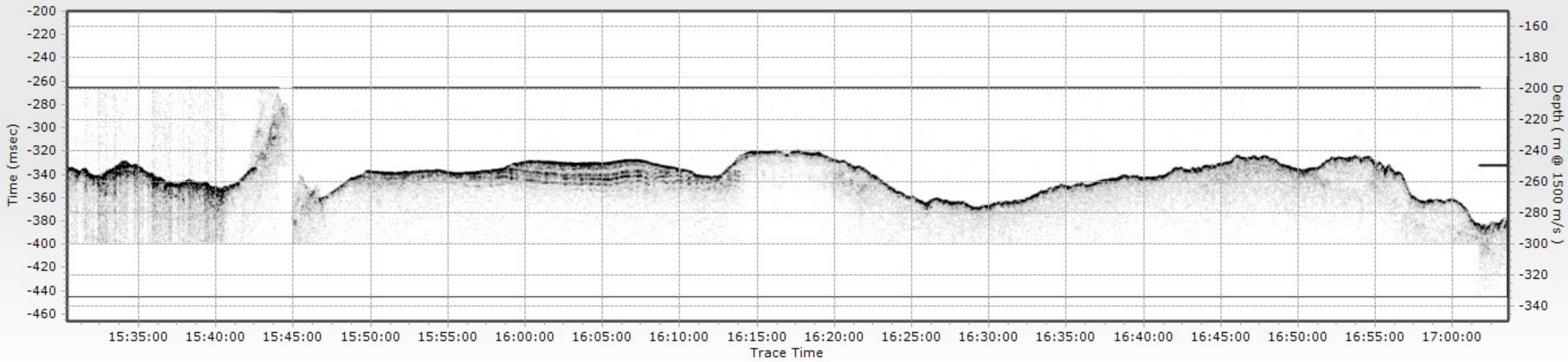


Fig. A-III-14. Sub-bottom line 2023_196_1703

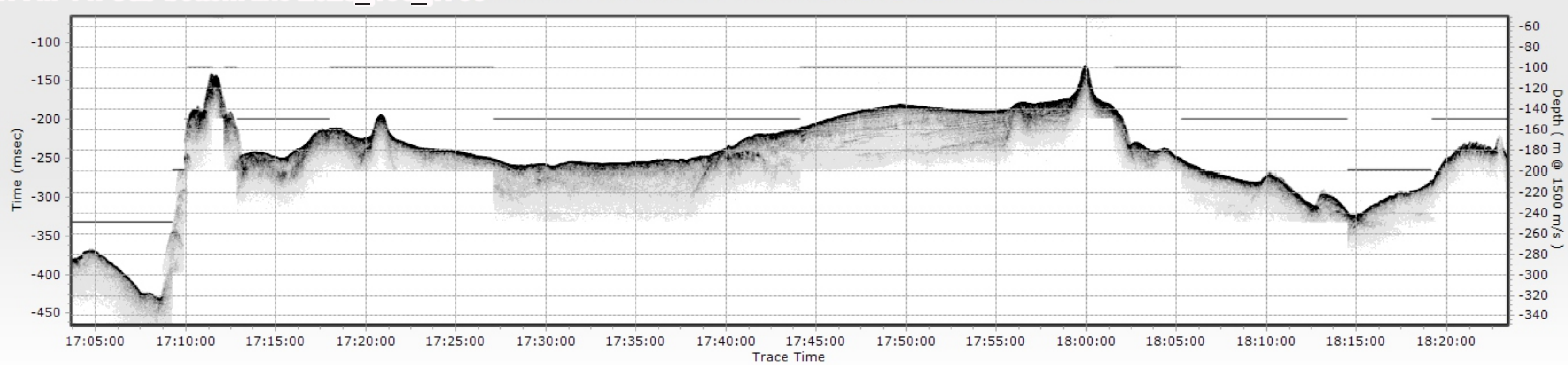


Fig. A-III-15. Sub-bottom line 2023_196_1823

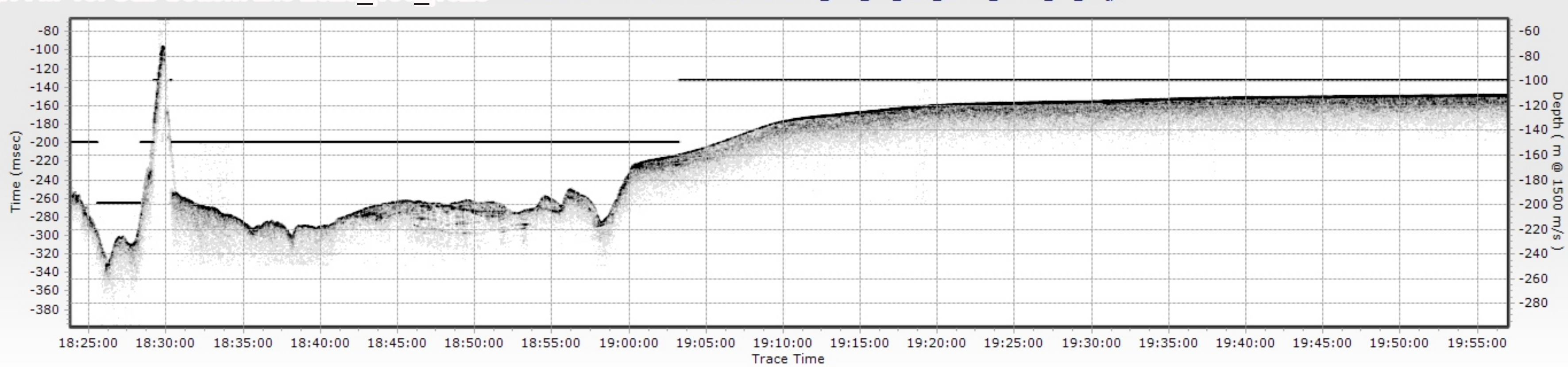


Fig. A-III-16. Sub-bottom line 2023_196_1957

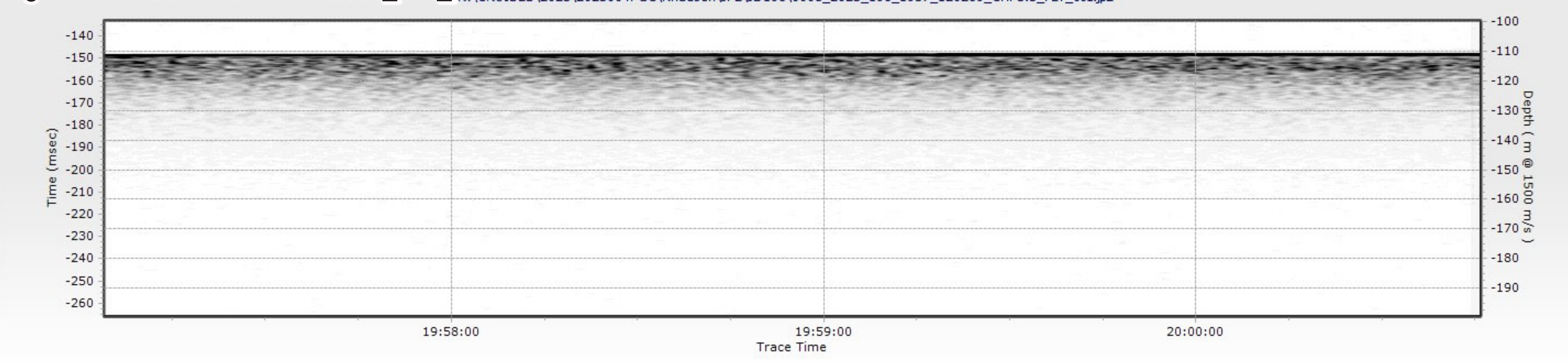


Fig. A-III-17. Sub-bottom line 2023_196_2033

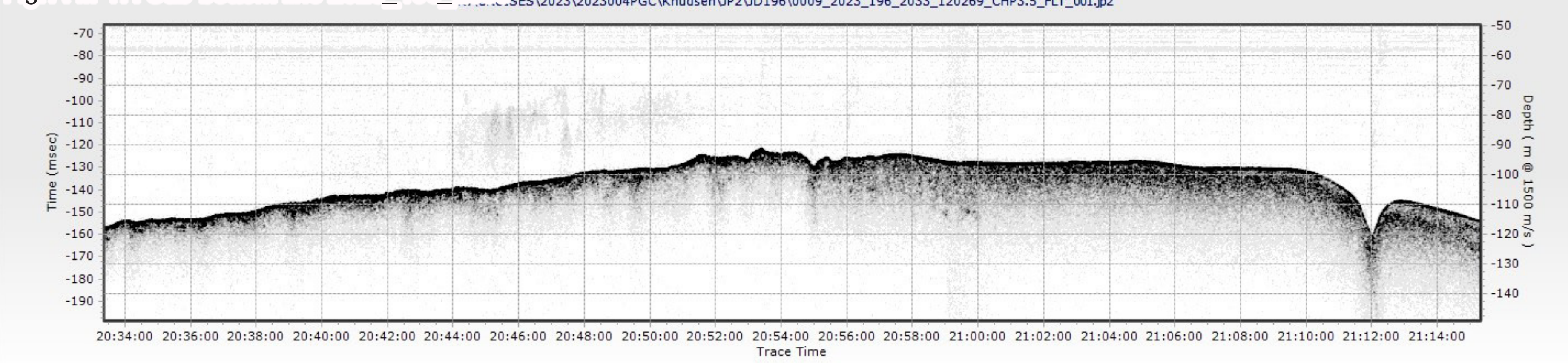


Fig. A-III-18. Sub-bottom line 2023_196_2144

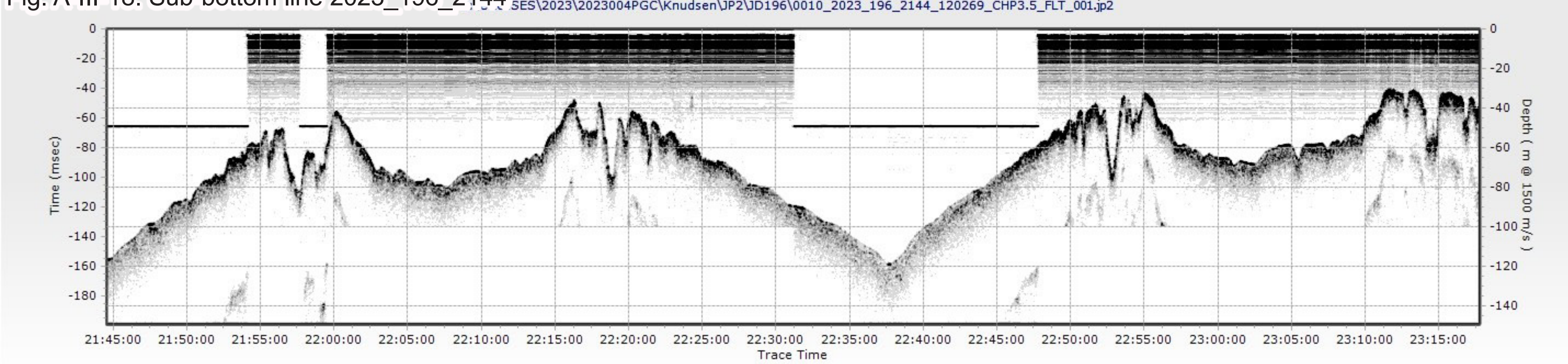


Fig. A-III-19. Sub-bottom line 2023_196_2317

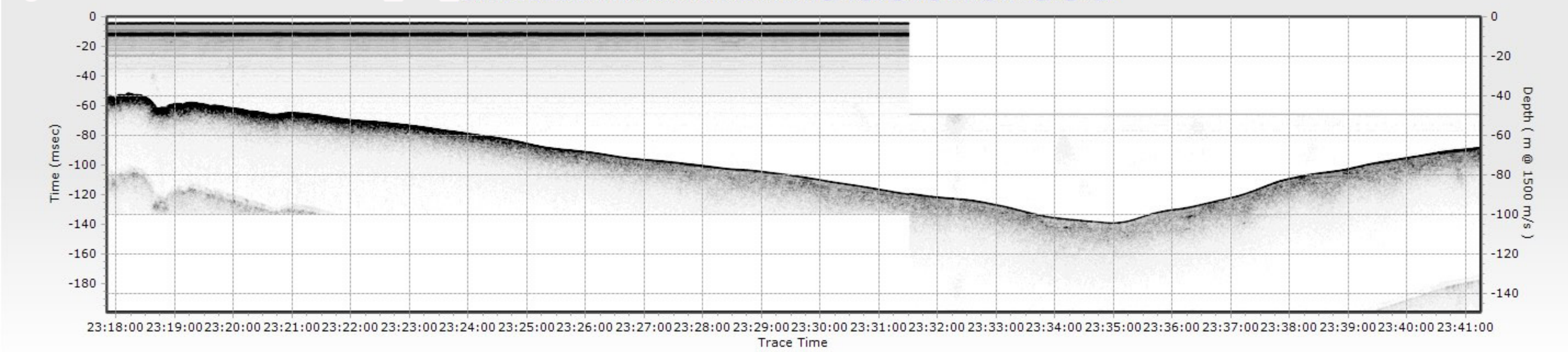


Fig. A-III-20. Sub-bottom line 2023_197_0006

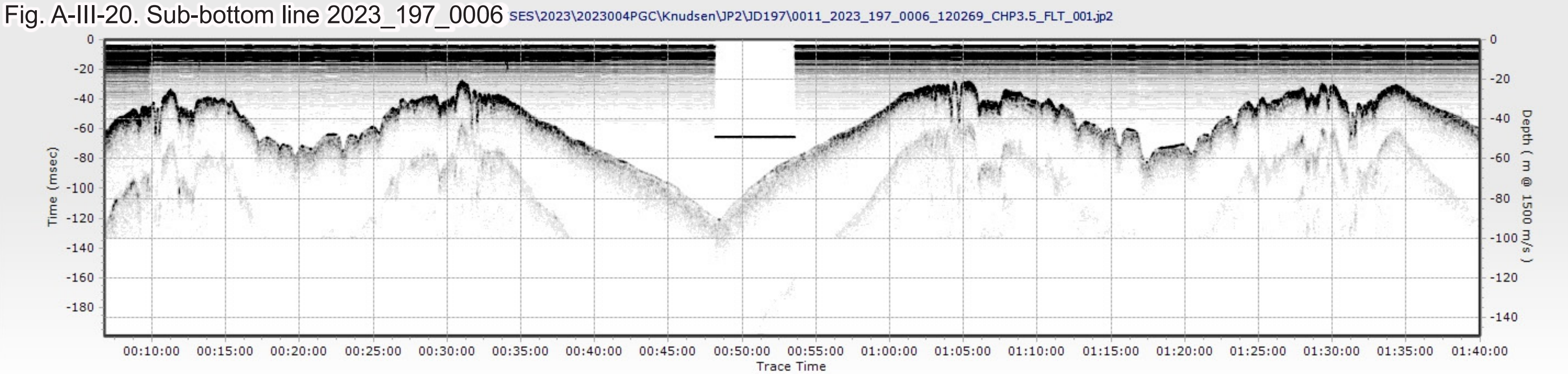


Fig. A-III-21. Sub-bottom line 2023_197_0140

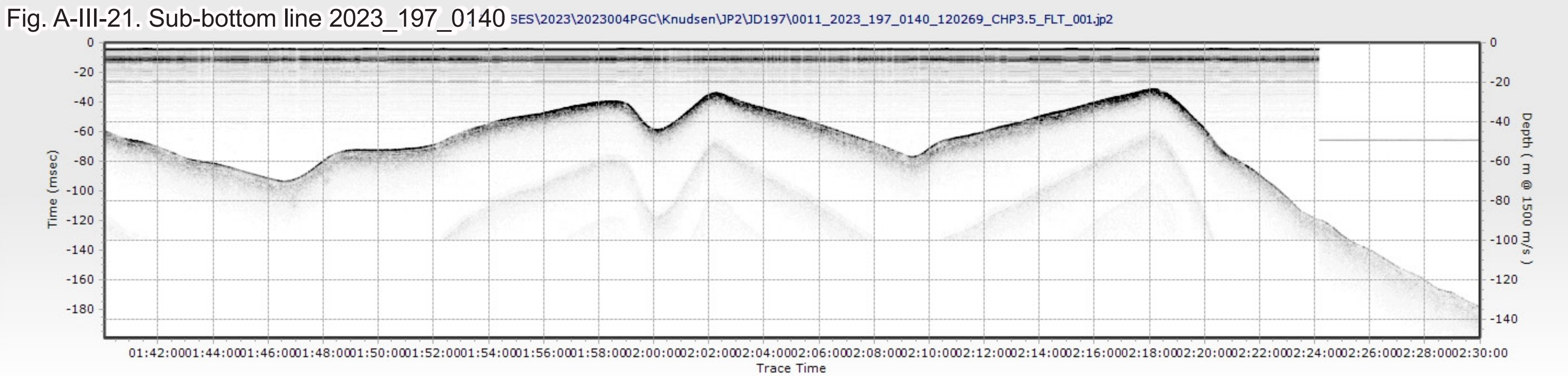


Fig. A-III-22. Sub-bottom line 2023_197_0230

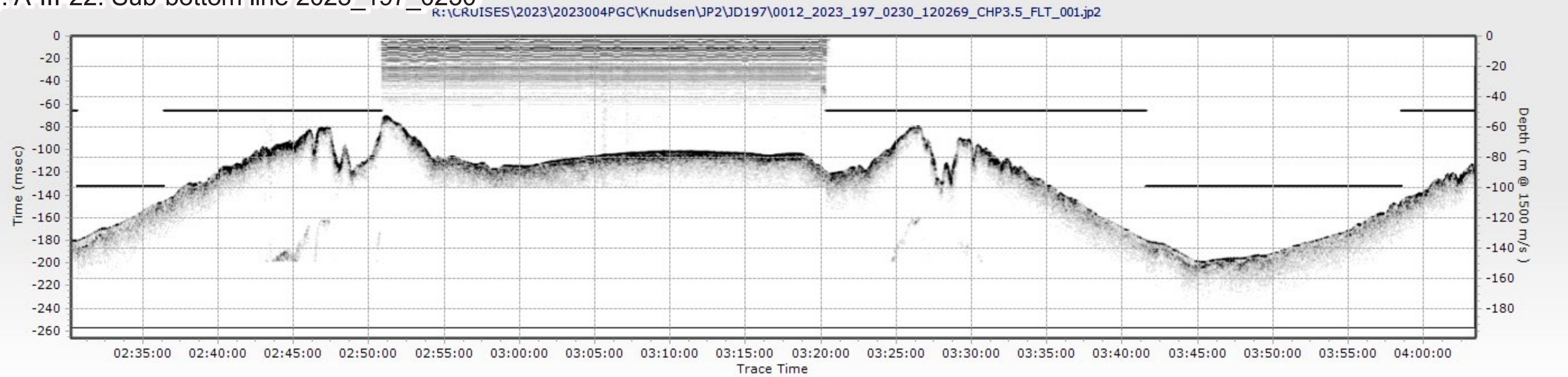


Fig. A-III-23. Sub-bottom line 2023_197_0403

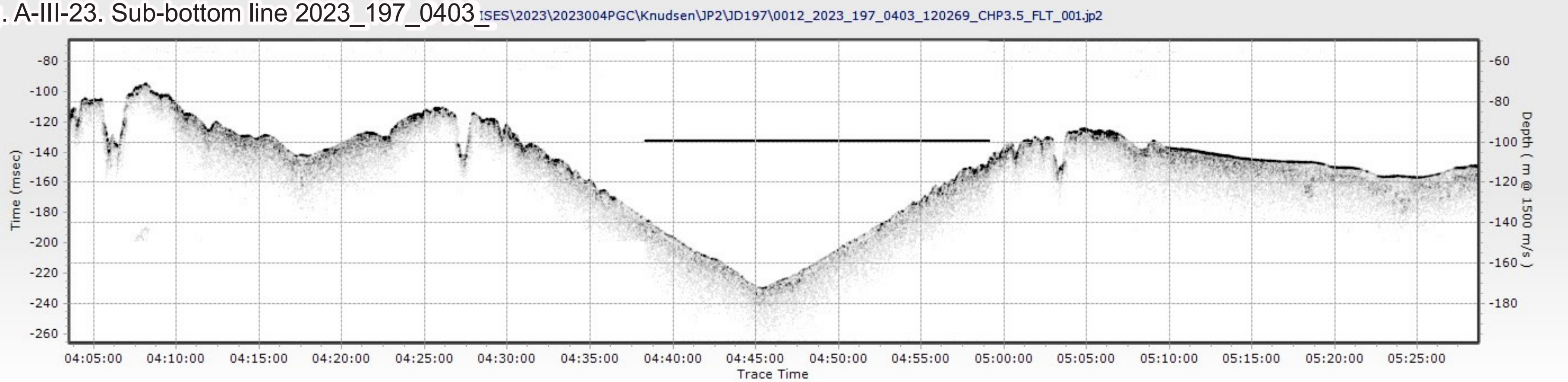


Fig. A-III-24. Sub-bottom line 2023_197_0528

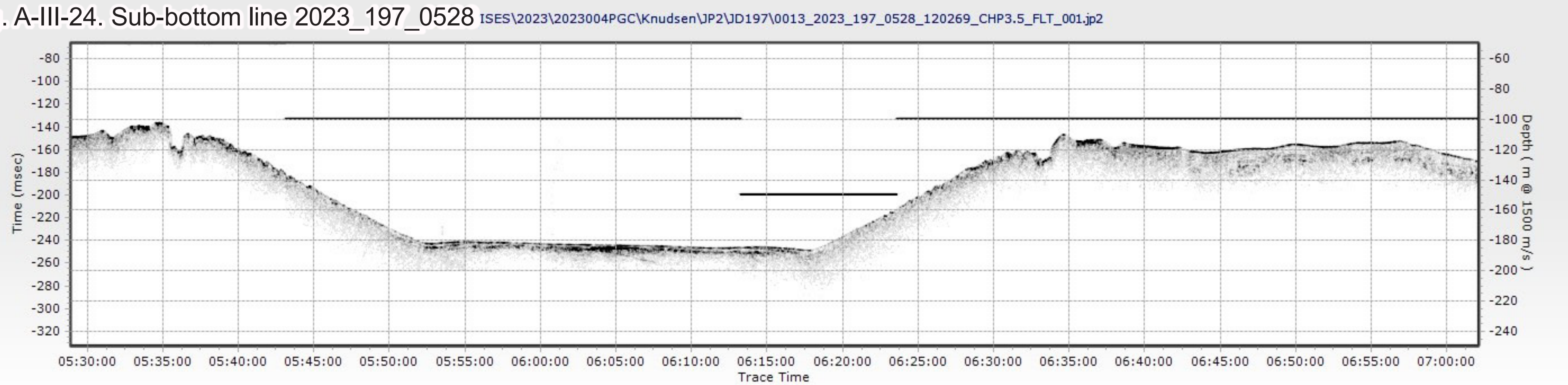


Fig. A-III-25. Sub-bottom line 2023_197_0702

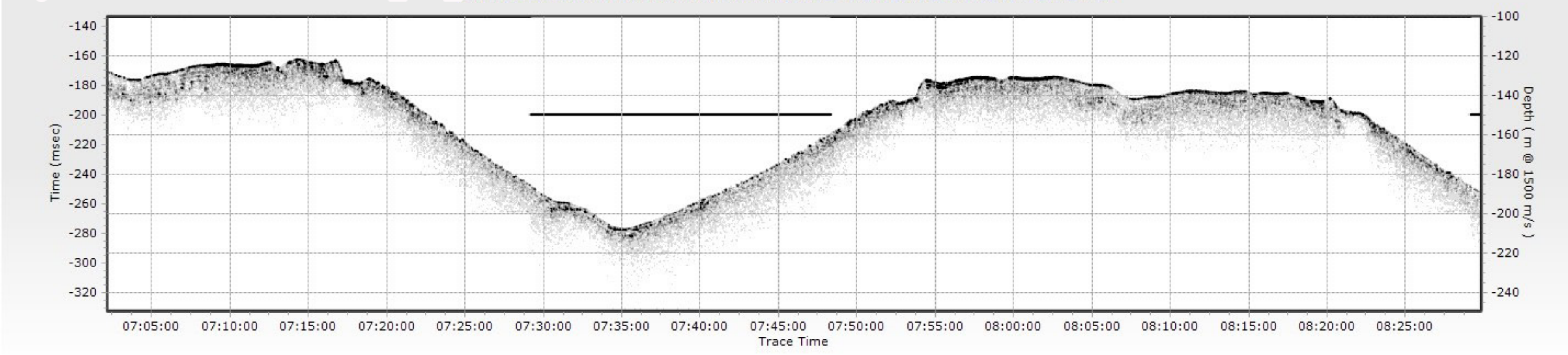


Fig. A-III-26. Sub-bottom line 2023_197_0830

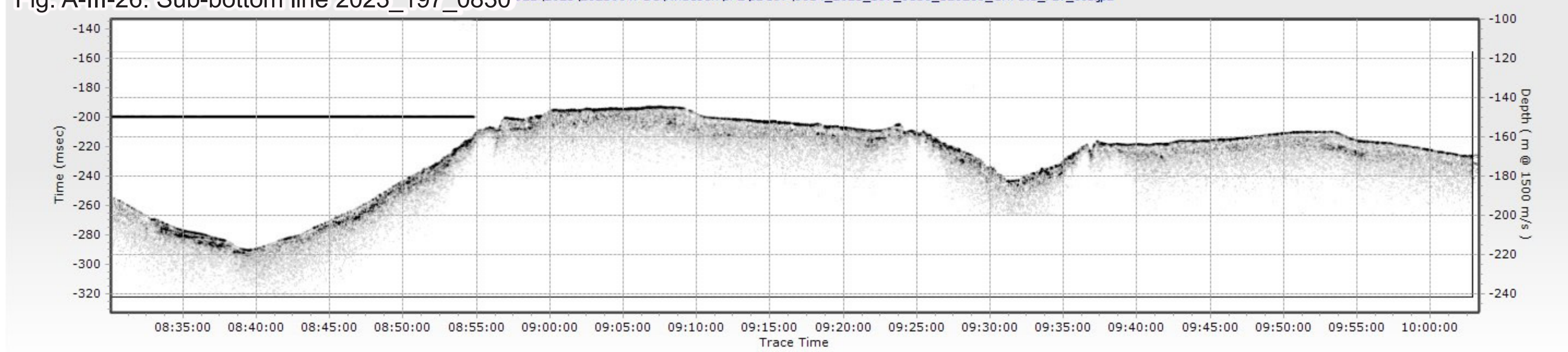


Fig. A-III-27. Sub-bottom line 2023_197_1003

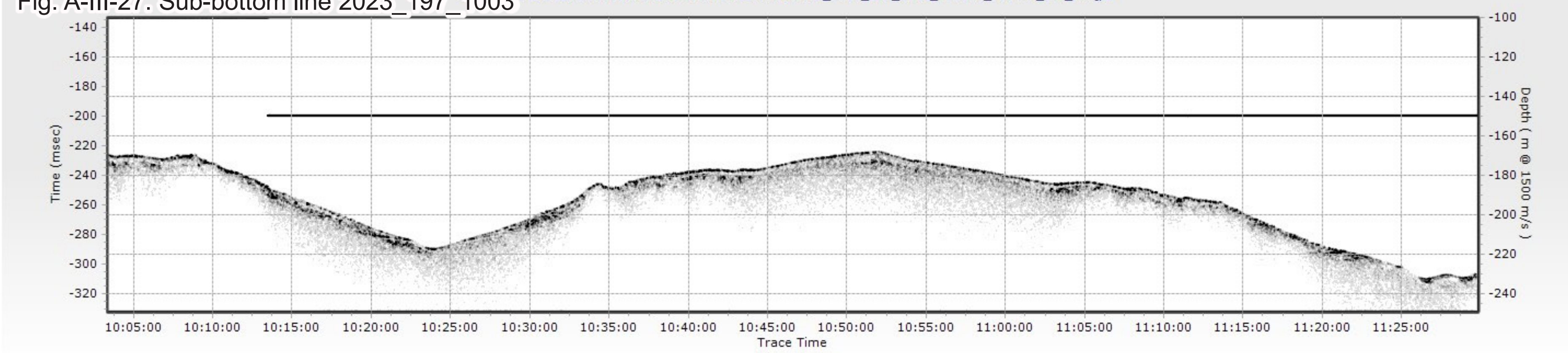


Fig. A-III-28. Sub-bottom line 2023_197_1130

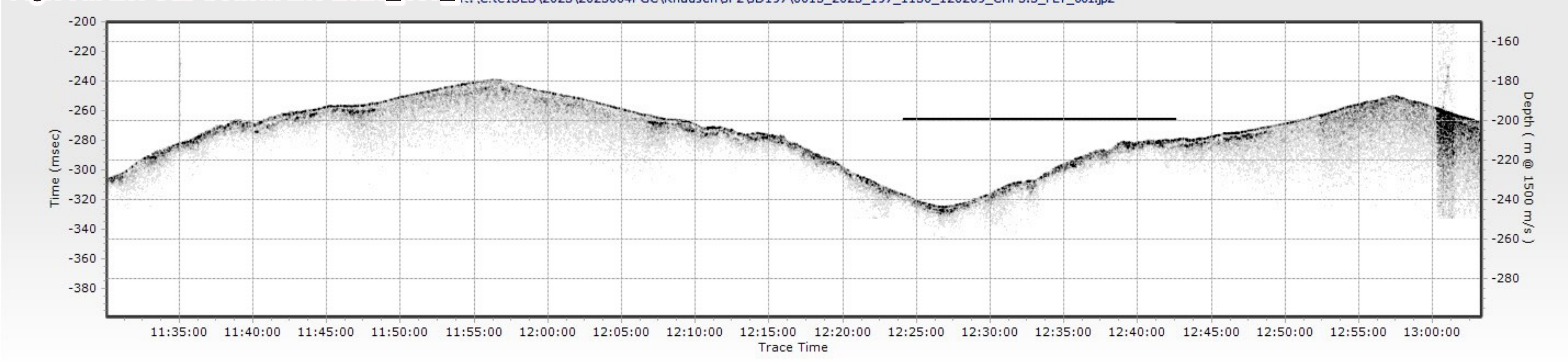


Fig. A-III-29. Sub-bottom line 2023_197_1303

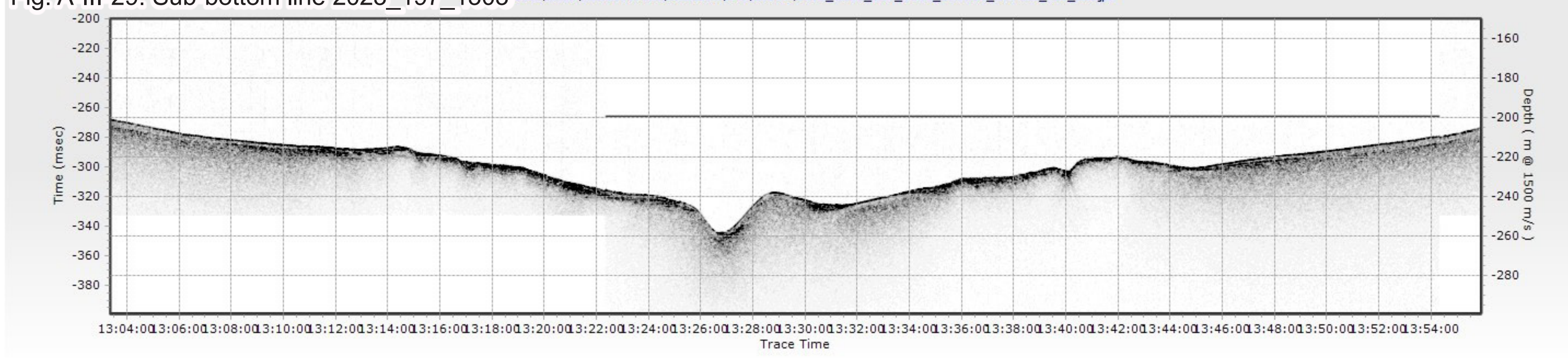


Fig. A-III-30. Sub-bottom line 2023_197_1400

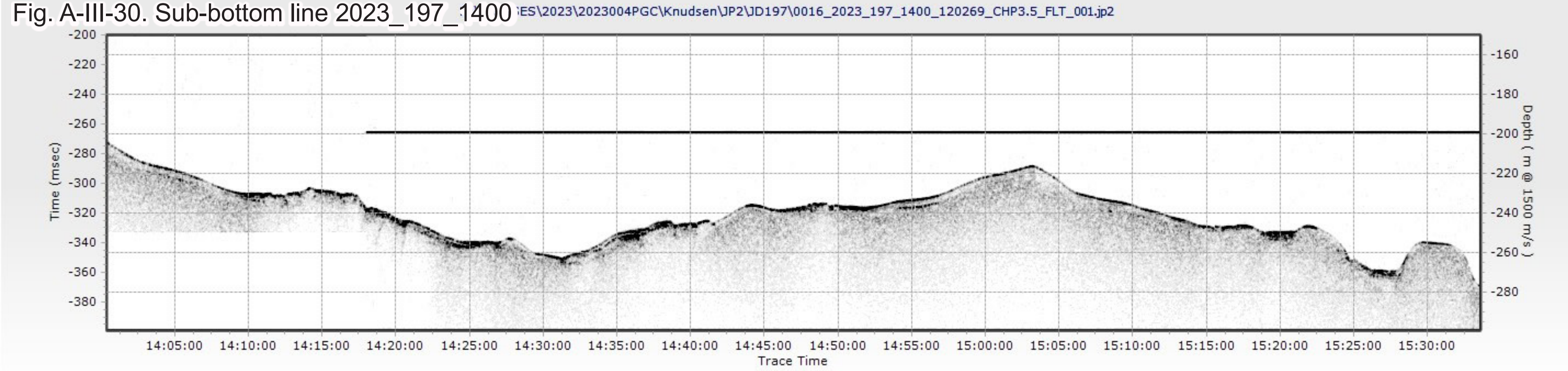


Fig. A-III-31. Sub-bottom line 2023_197_1400

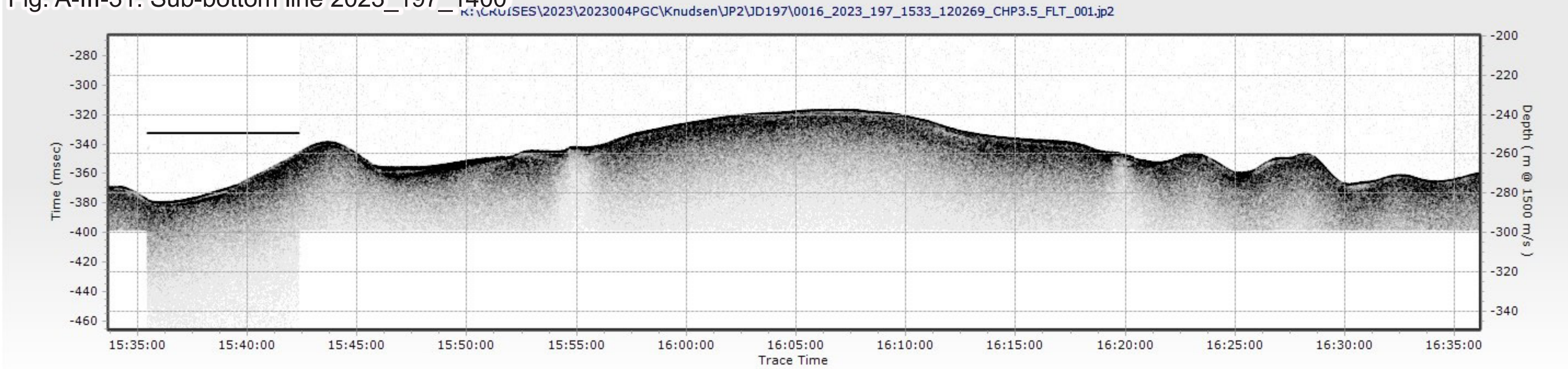


Fig. A-III-32. Sub-bottom line 2023_197_1641

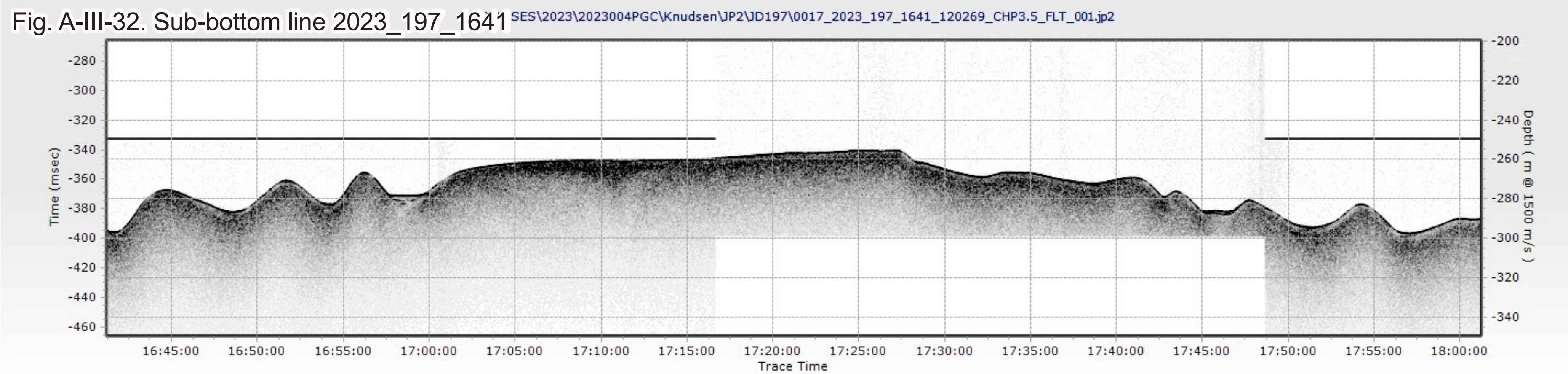


Fig. A-III-33. Sub-bottom line 2023_197_1852

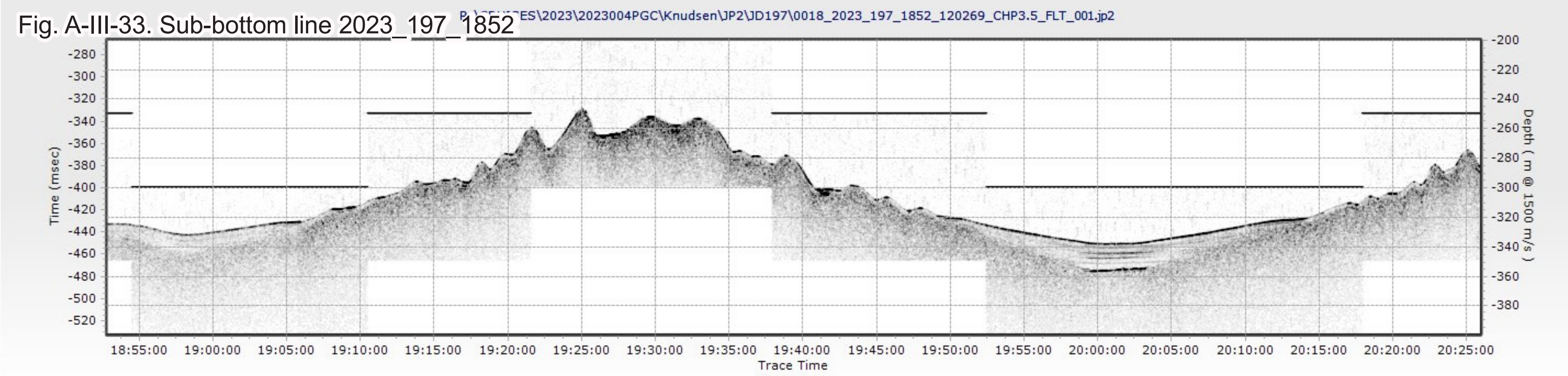


Fig. A-III-34. Sub-bottom line 2023_197_2026

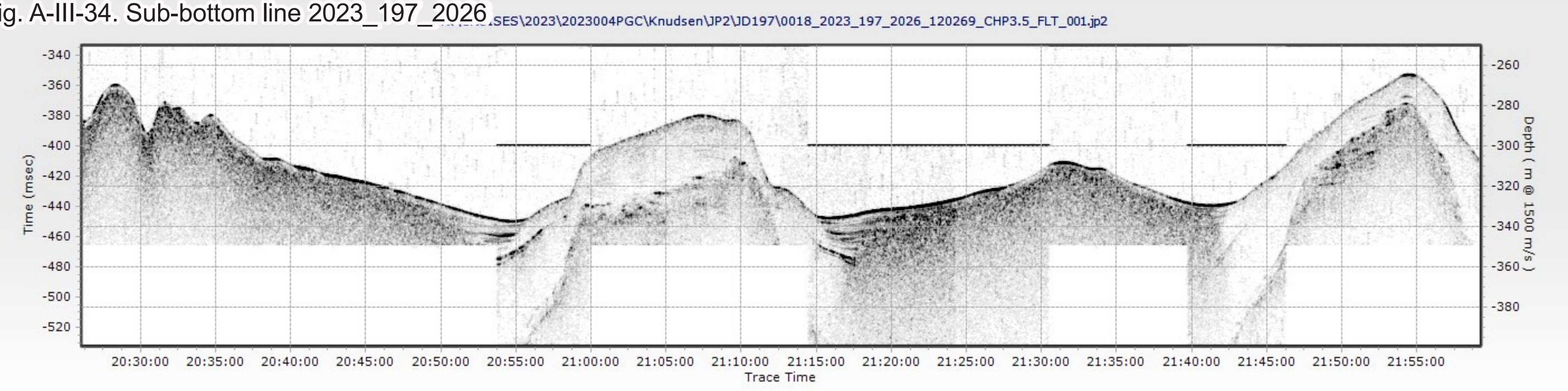


Fig. A-III-35. Sub-bottom line 2023_197_2159

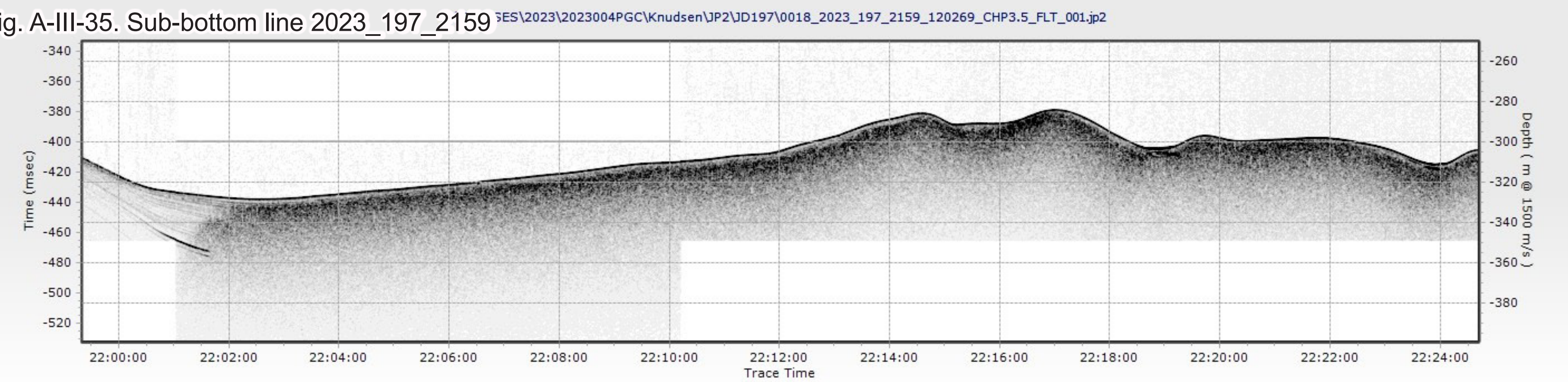


Fig. A-III-36. Sub-bottom line 2023_197_2225

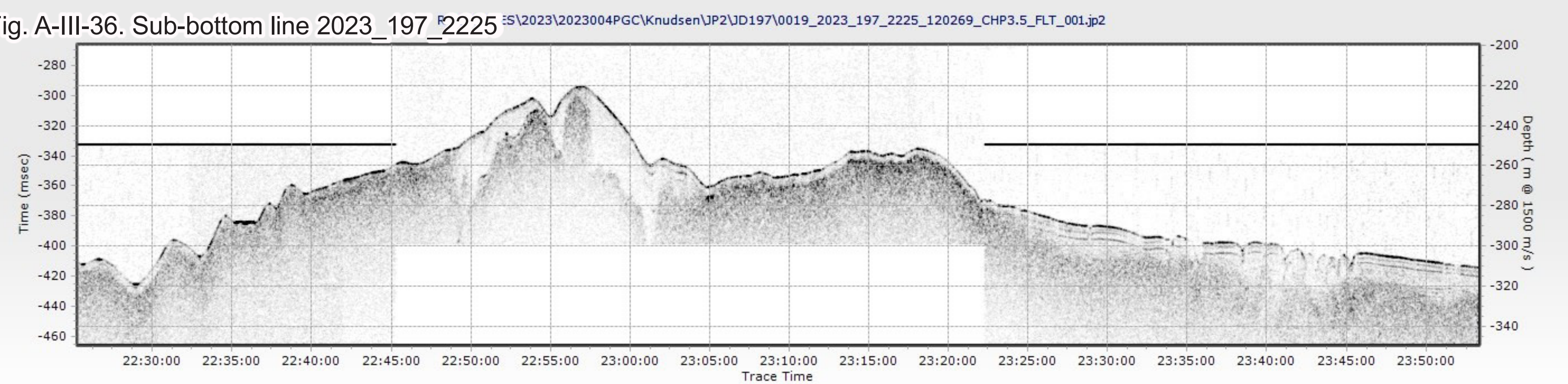


Fig. A-III-37. Sub-bottom line 2023_198_1519

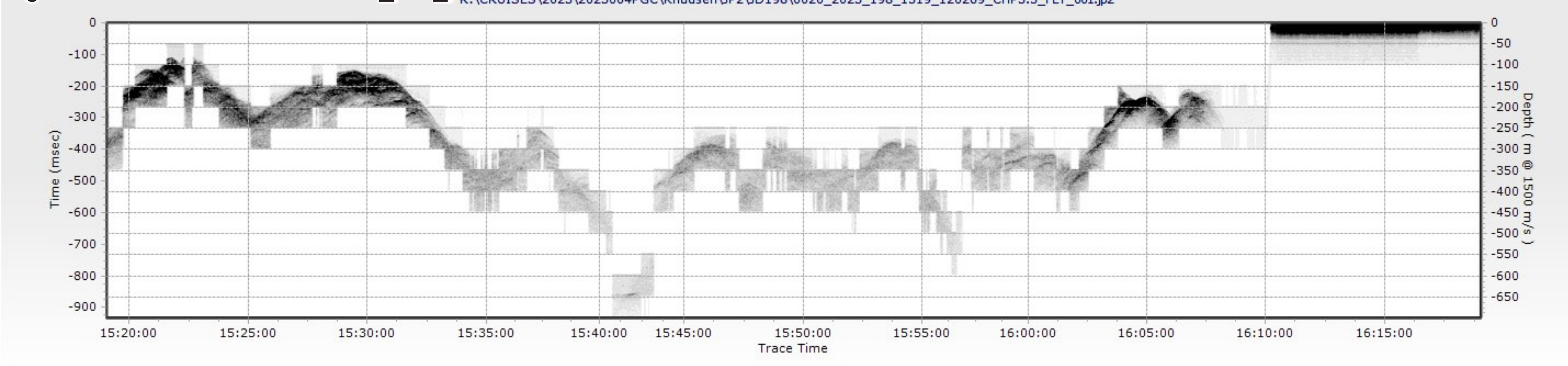


Fig. A-III-38. Sub-bottom line 2023__198_2228

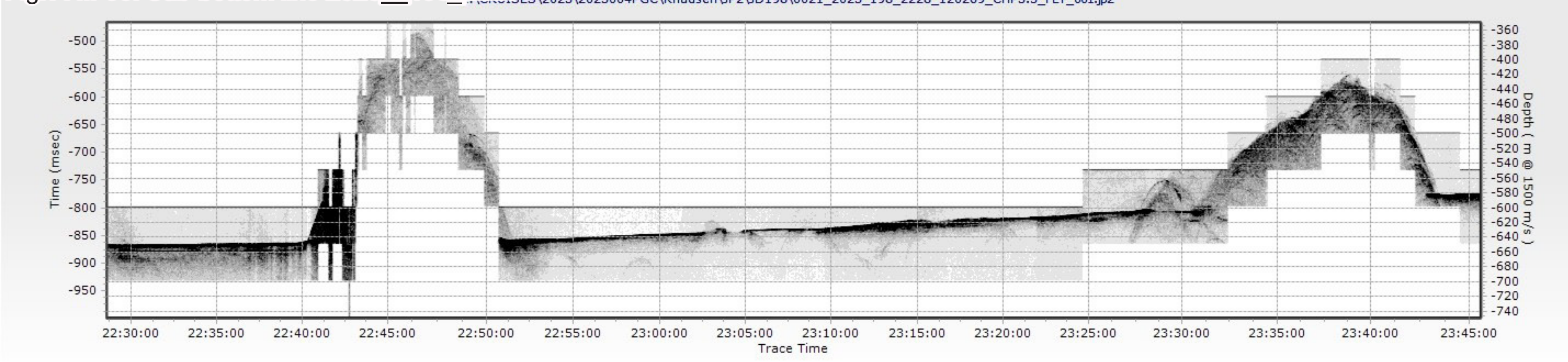


Fig. A-III-39. Sub-bottom line 2023_199_0201

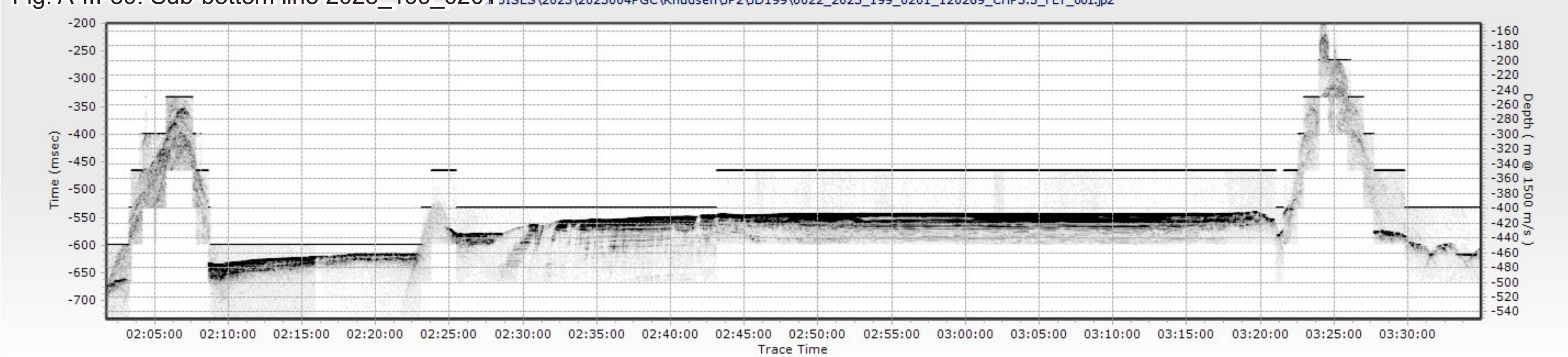


Fig. A-III-40. Sub-bottom line 2023_199_0335

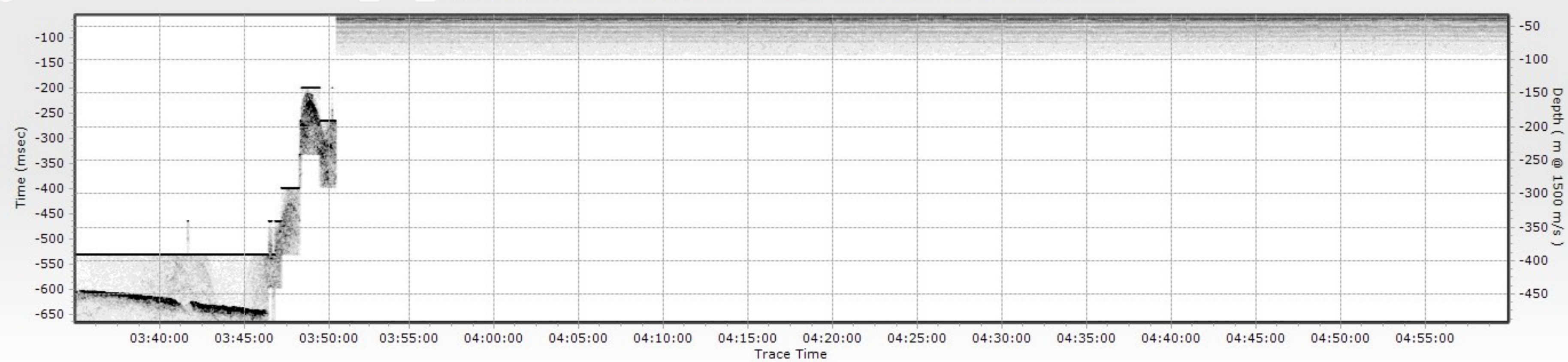


Fig. A-III-41. Sub-bottom line 2023_199_1106

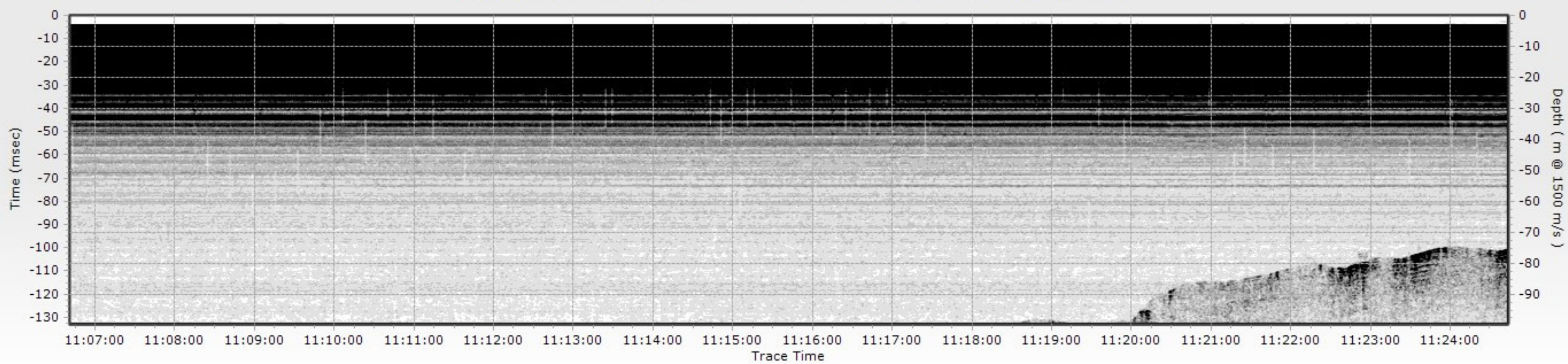
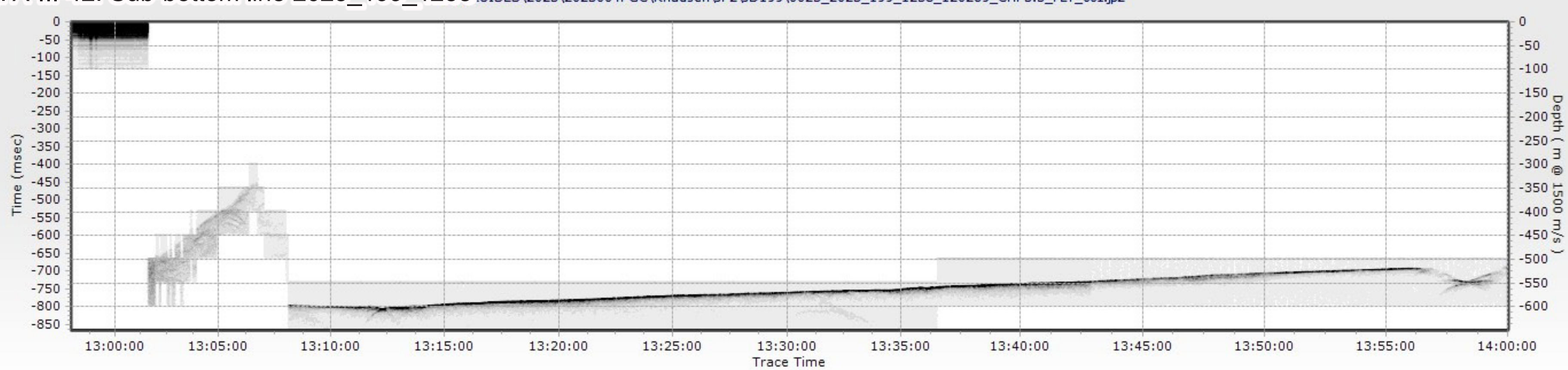


Fig. A-III-42. Sub-bottom line 2023_199_1258



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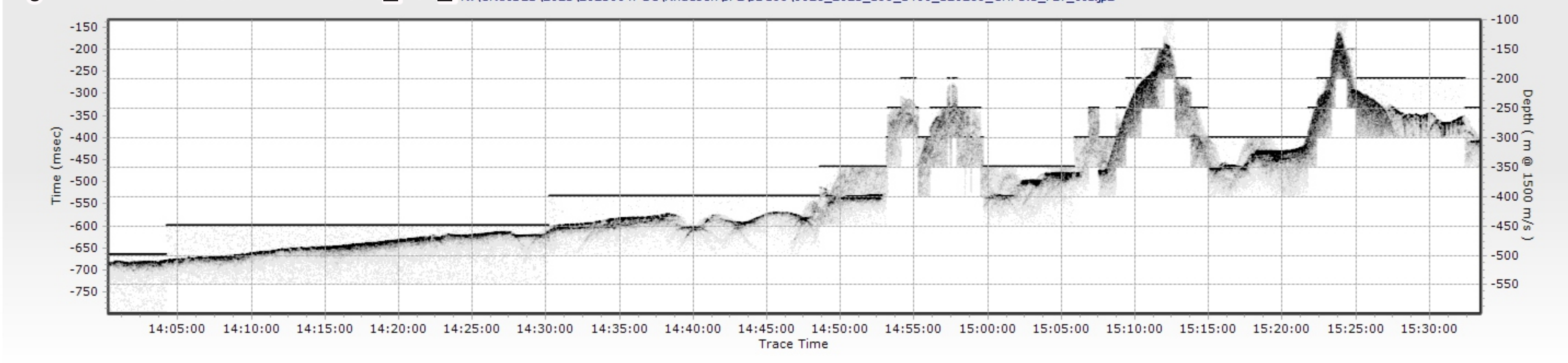

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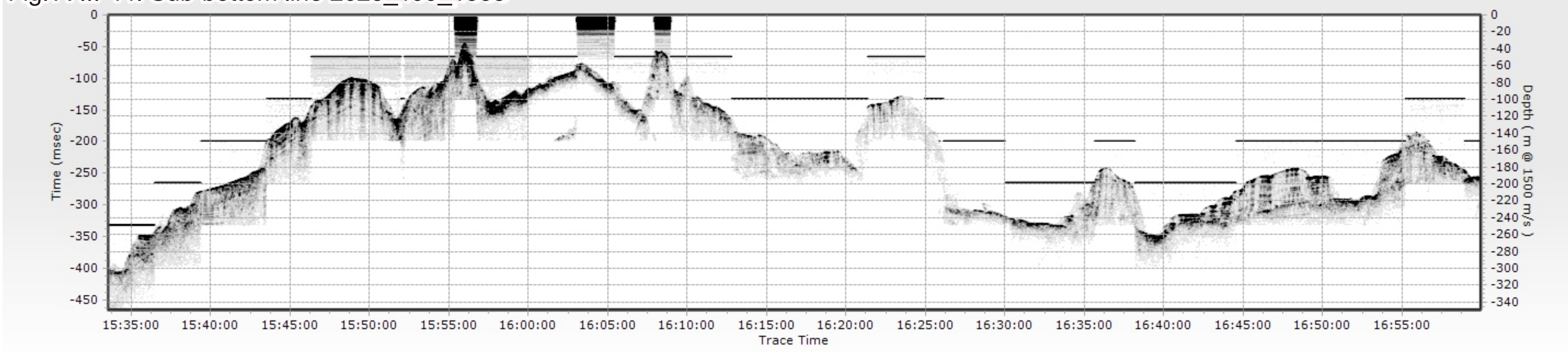

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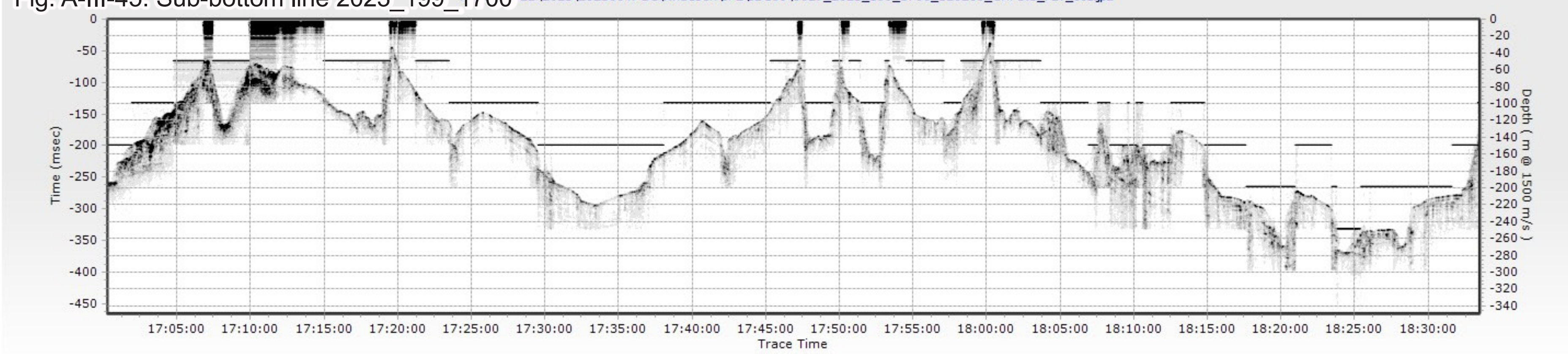

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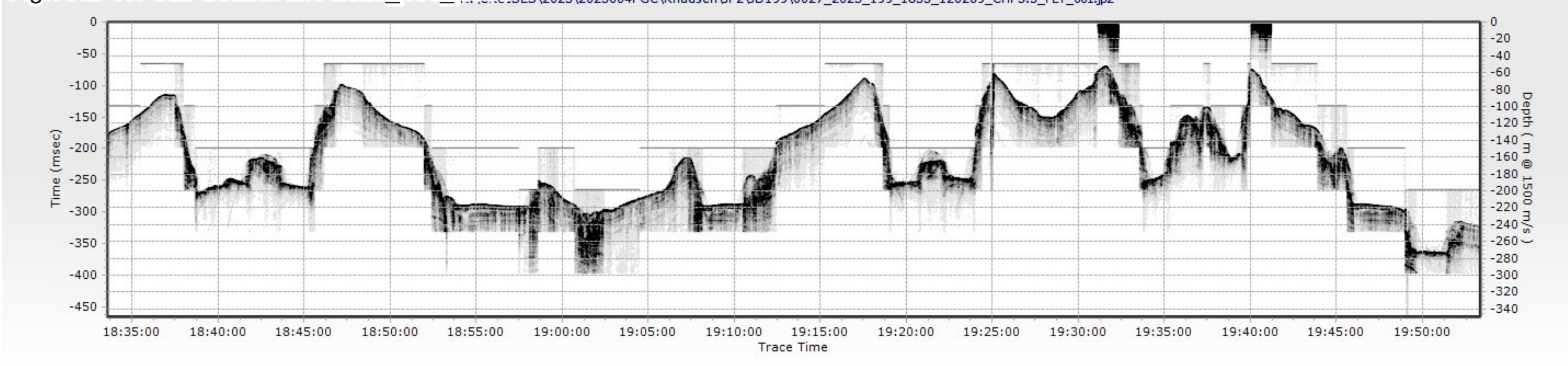

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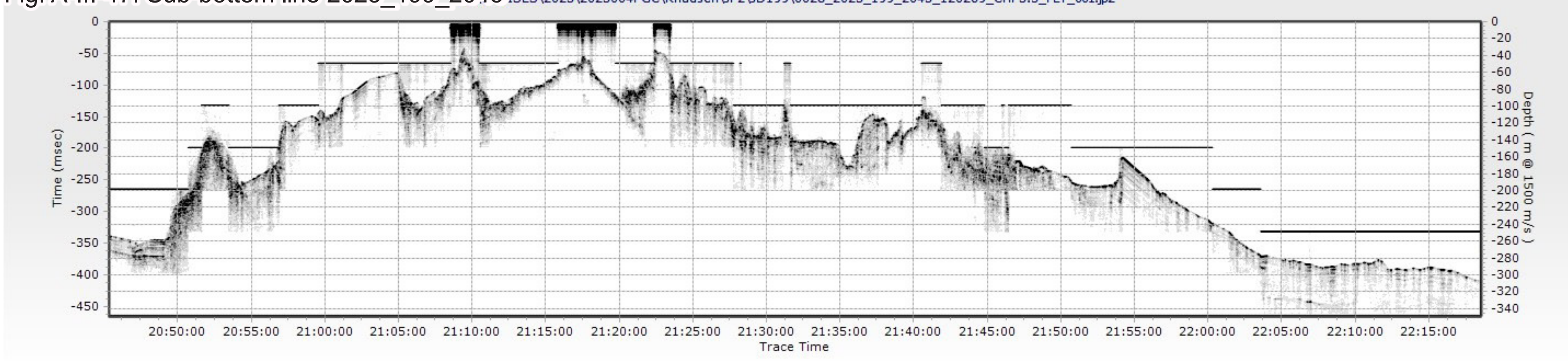

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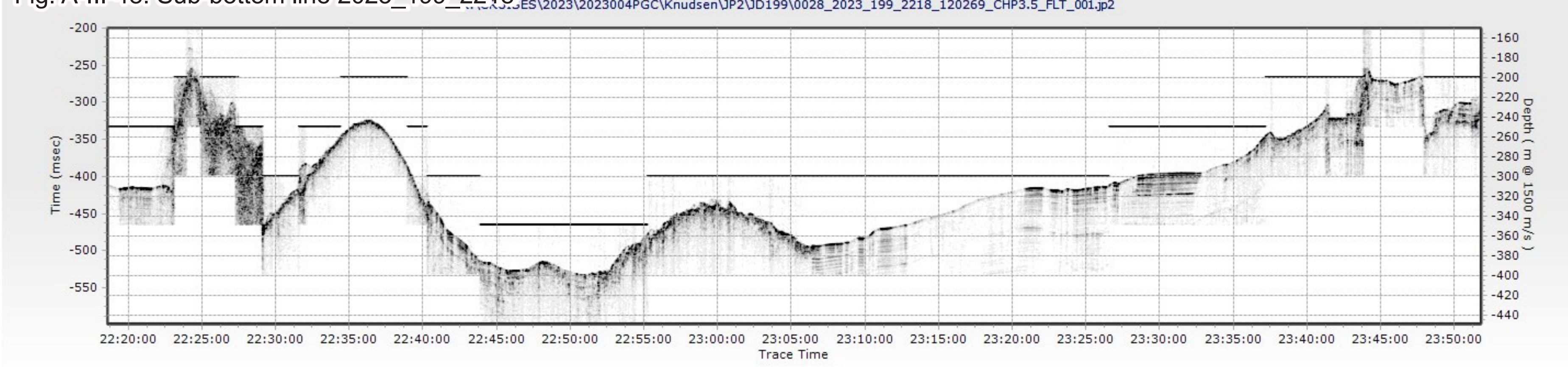

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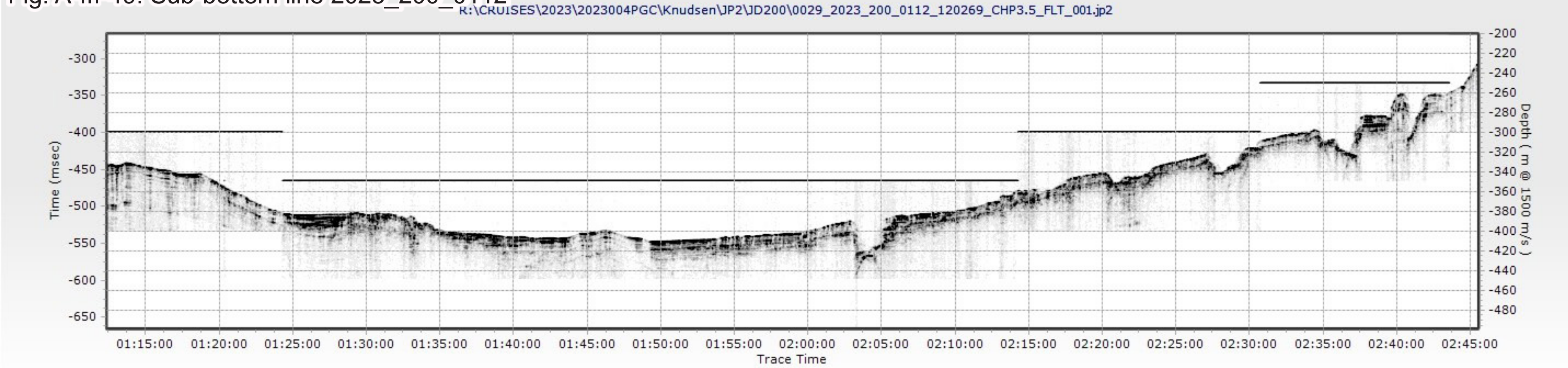

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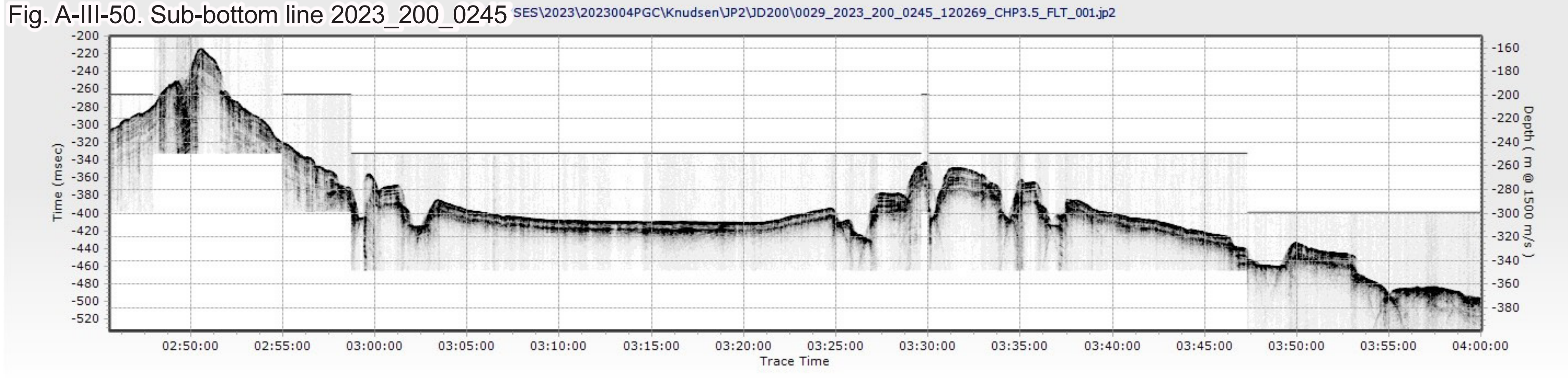


Fig. A-III-51. Sub-bottom line 2023_200_0400

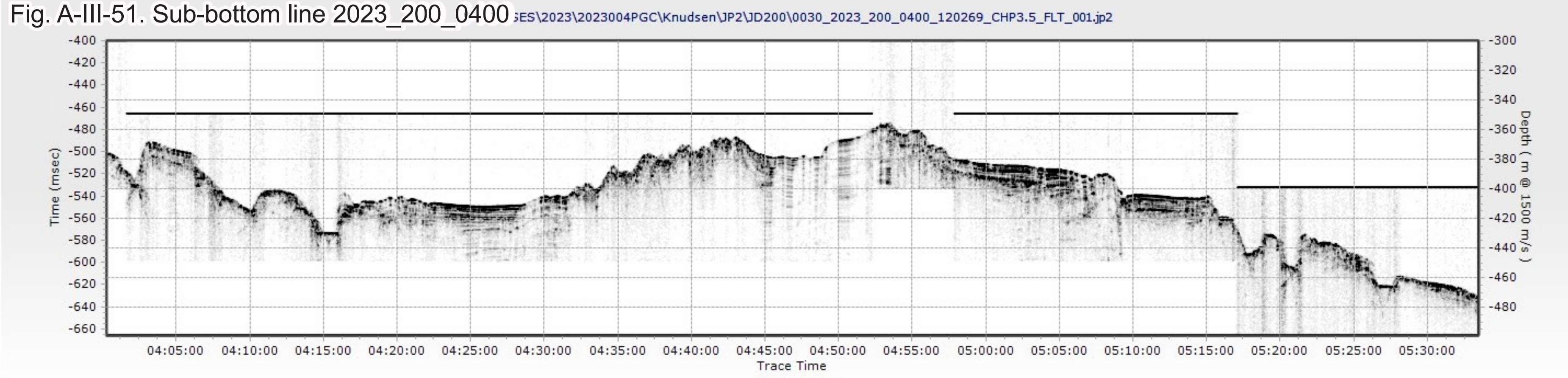


Fig. A-III-52. Sub-bottom line 2023_200_0700

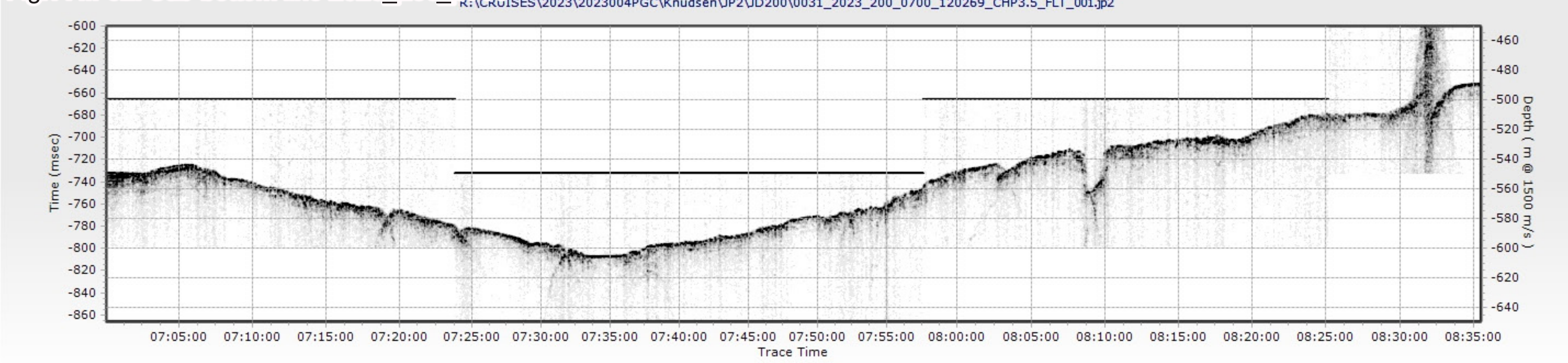
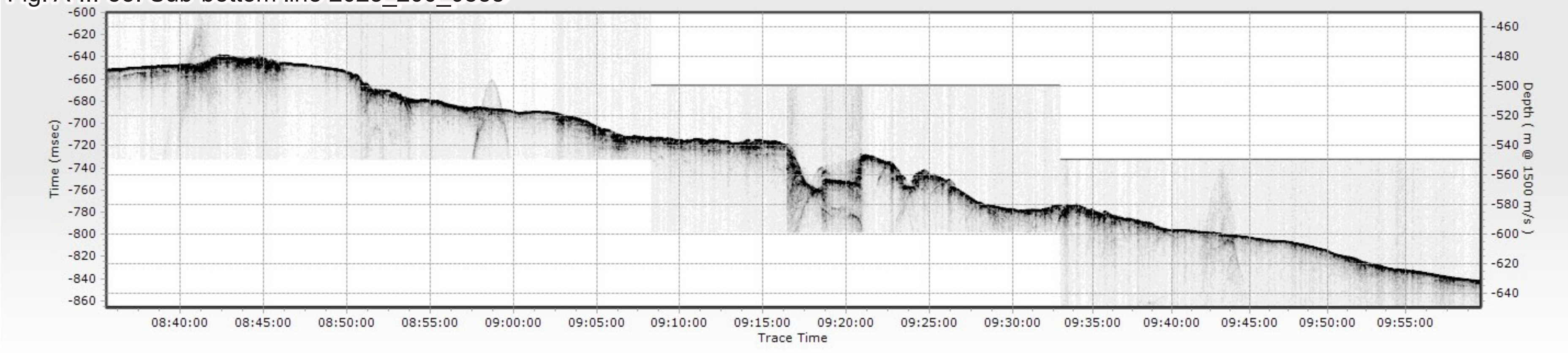


Fig. A-III-53. Sub-bottom line 2023_200_0835



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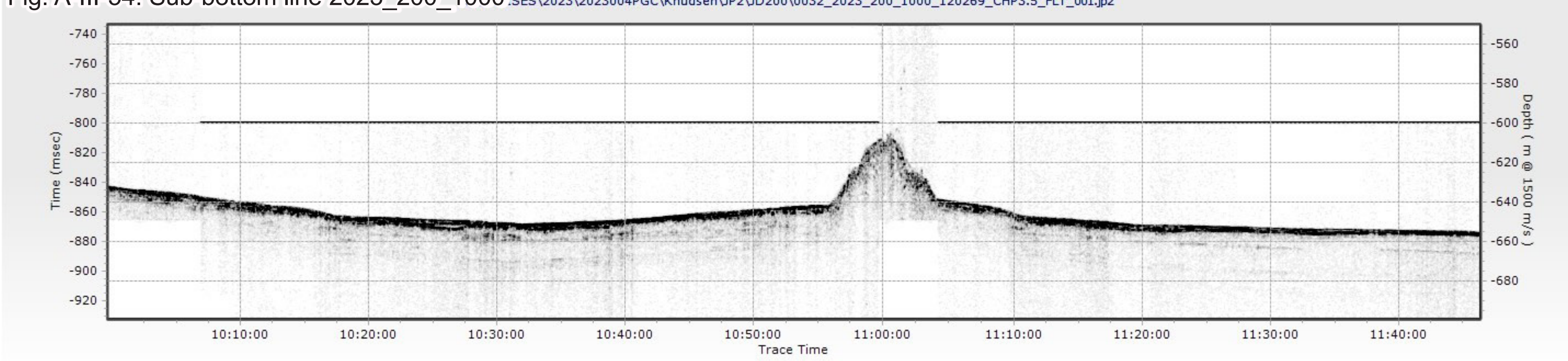

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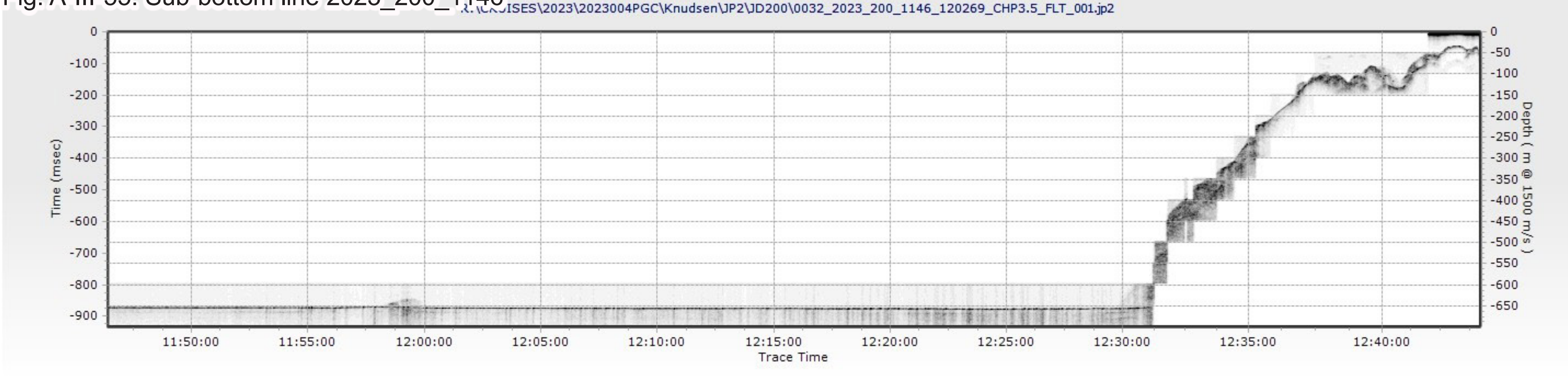

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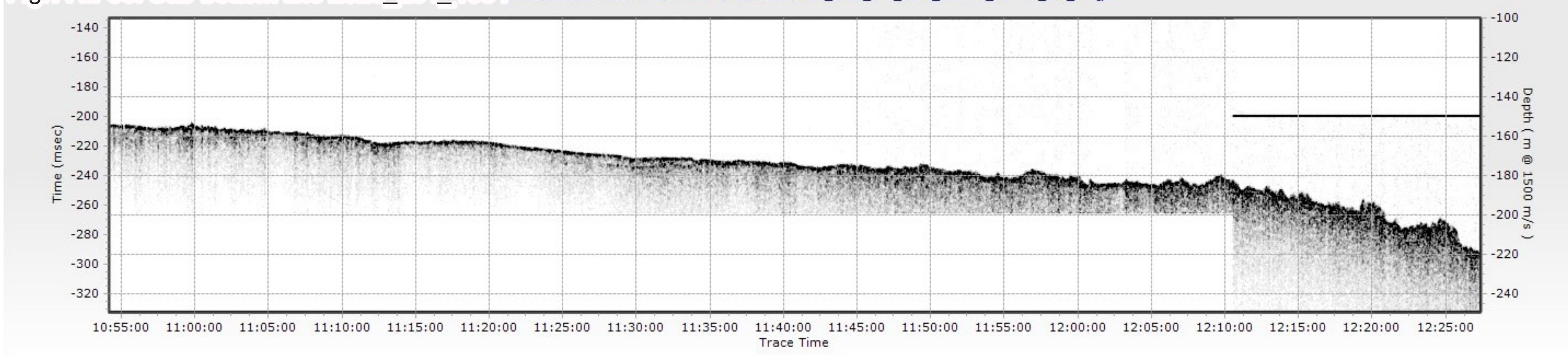

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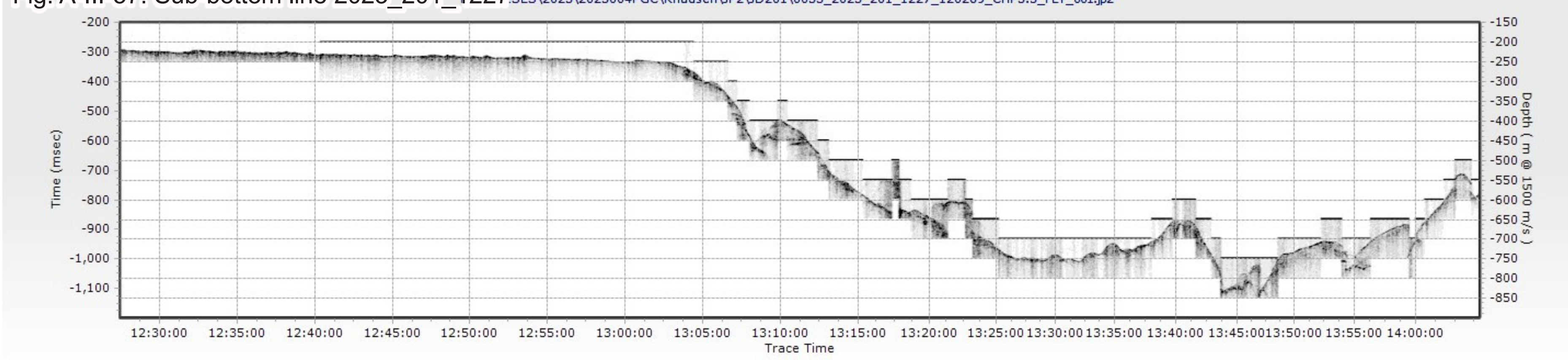
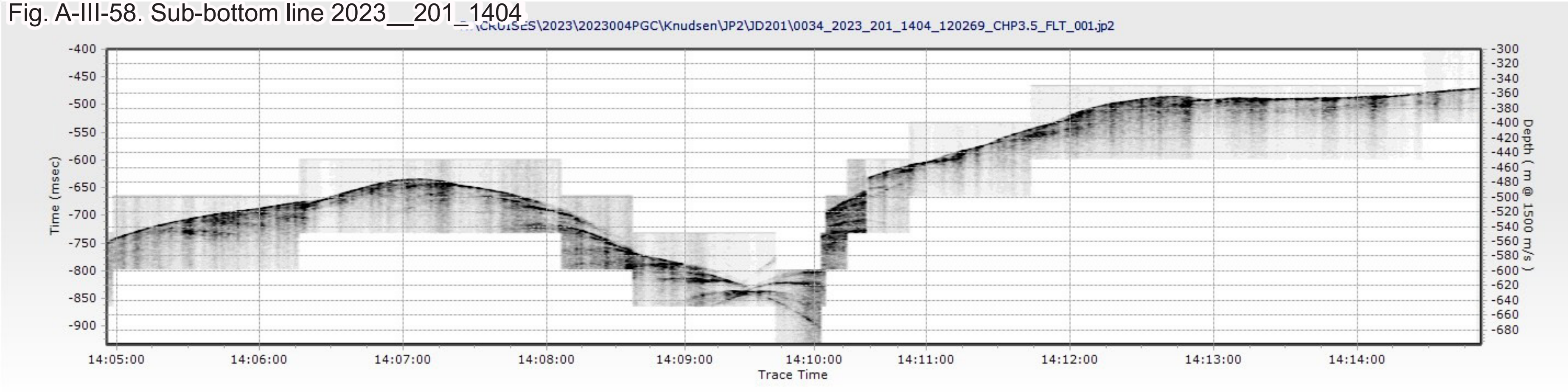


Fig. A-III-58. Sub-bottom line 2023__201_1404



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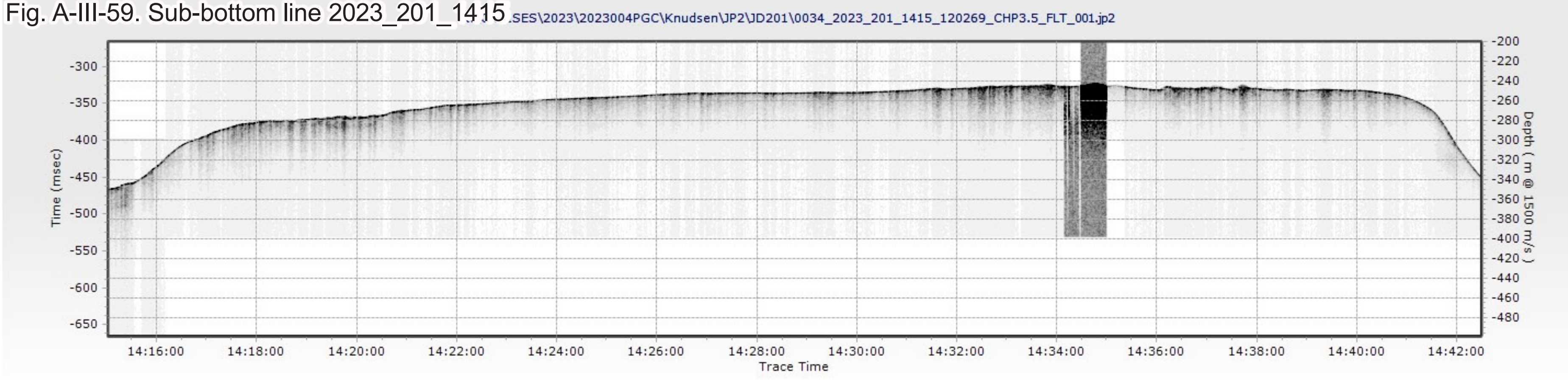


Fig. A-III-60. Sub-bottom line 2023_201_1442

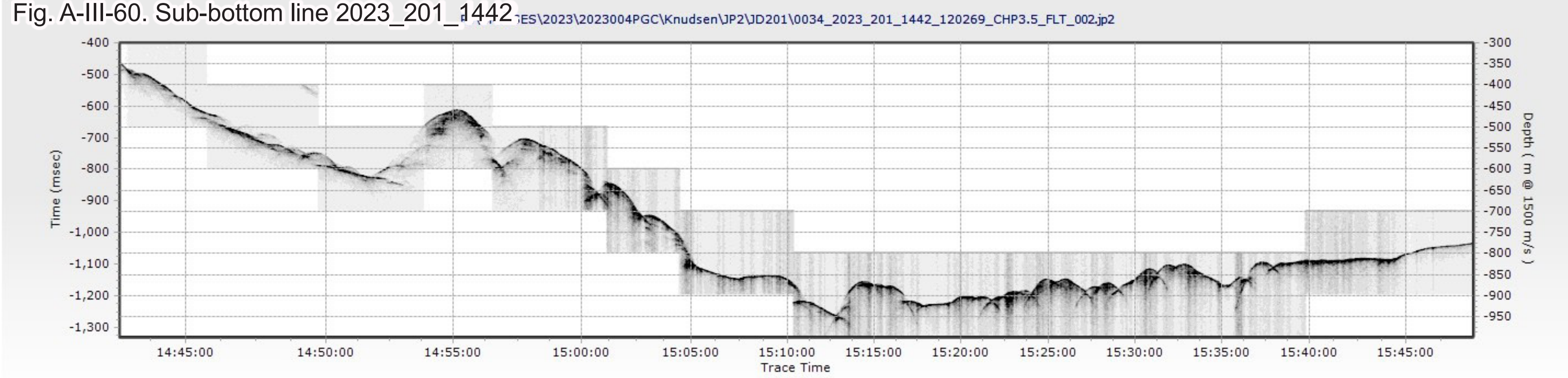


Fig. A-III-61. Sub-bottom line 2023_201_1548

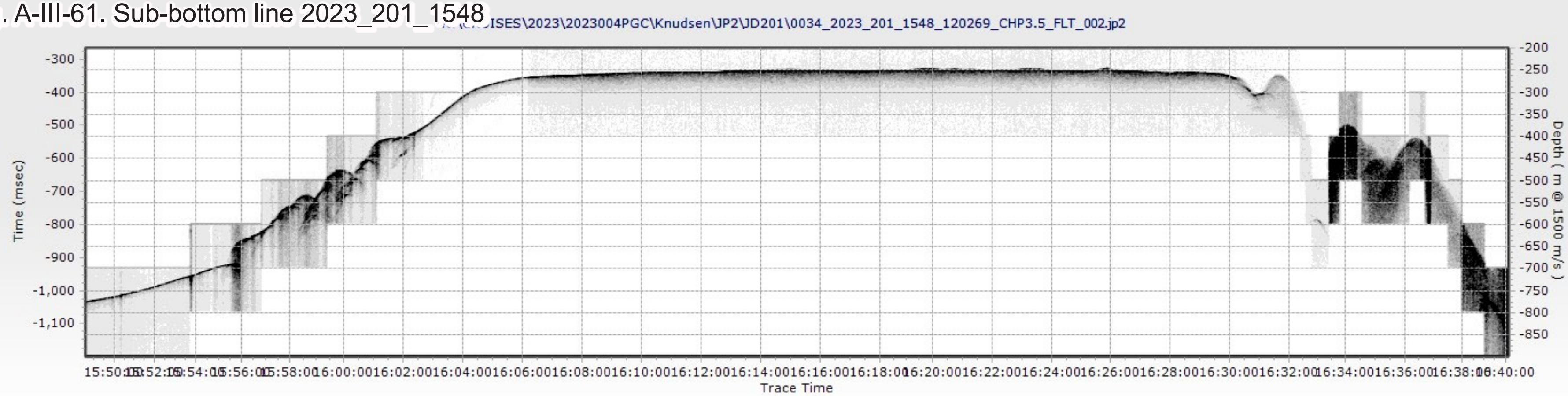
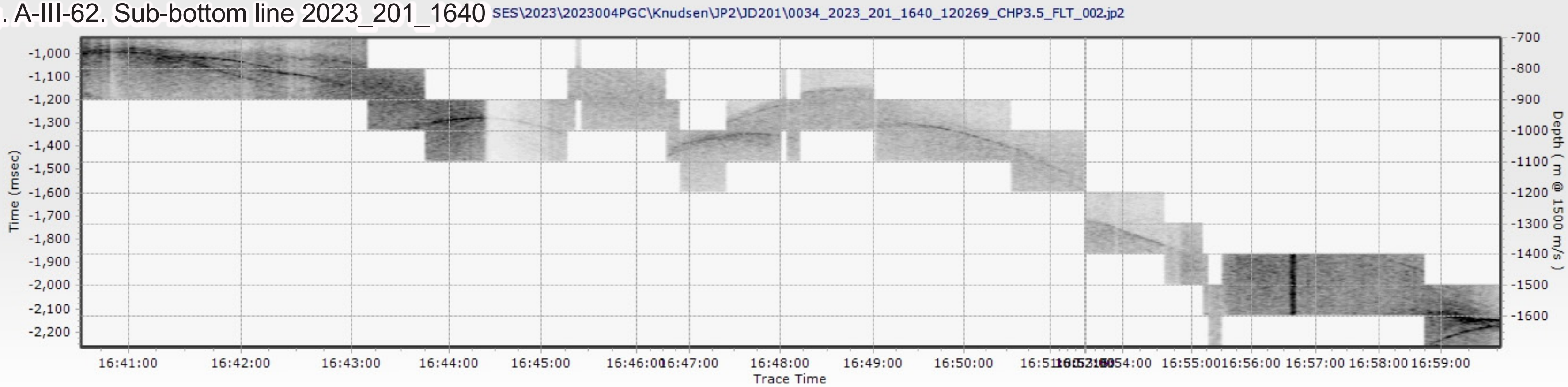


Fig. A-III-62. Sub-bottom line 2023_201_1640



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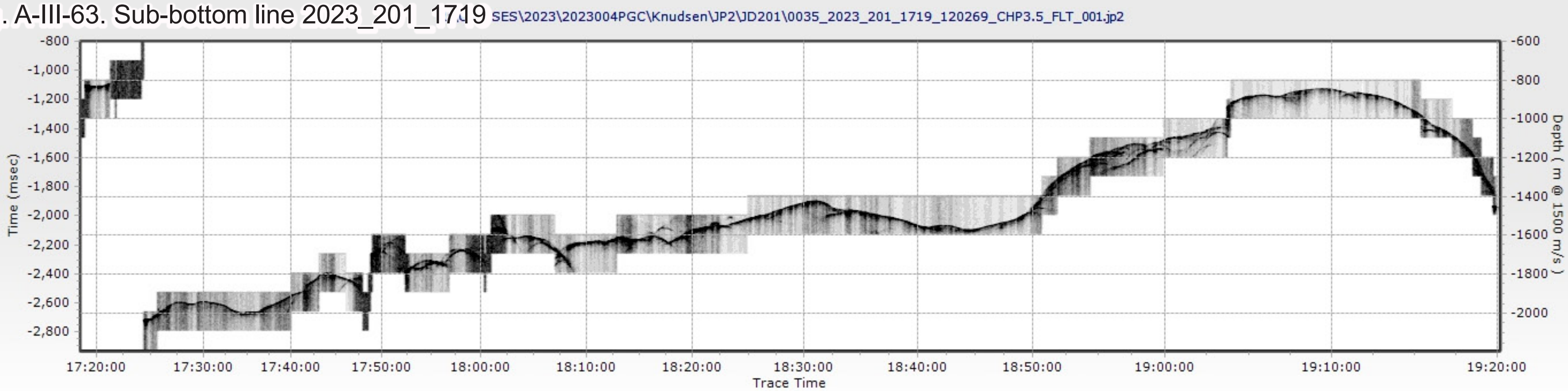

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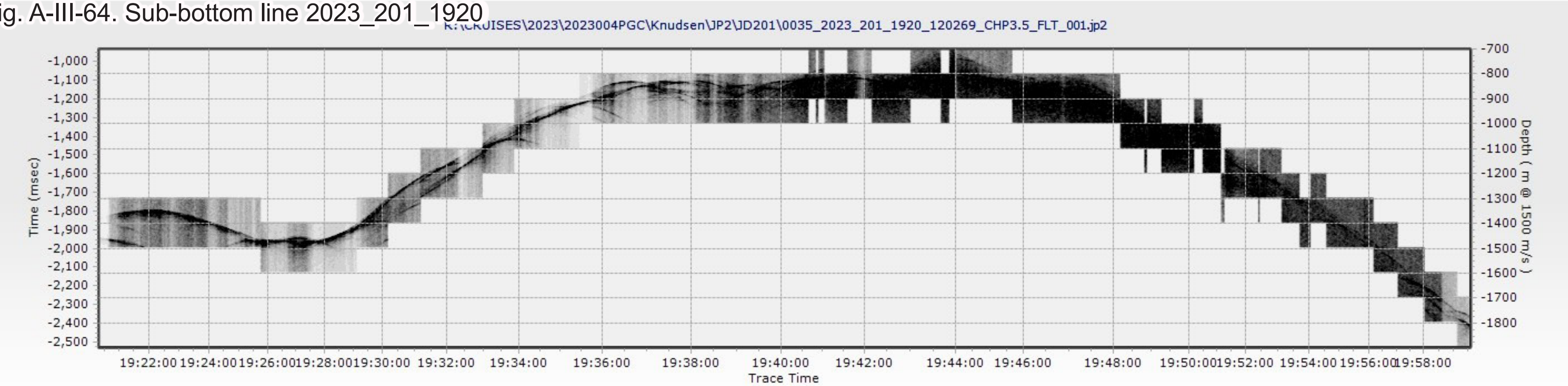

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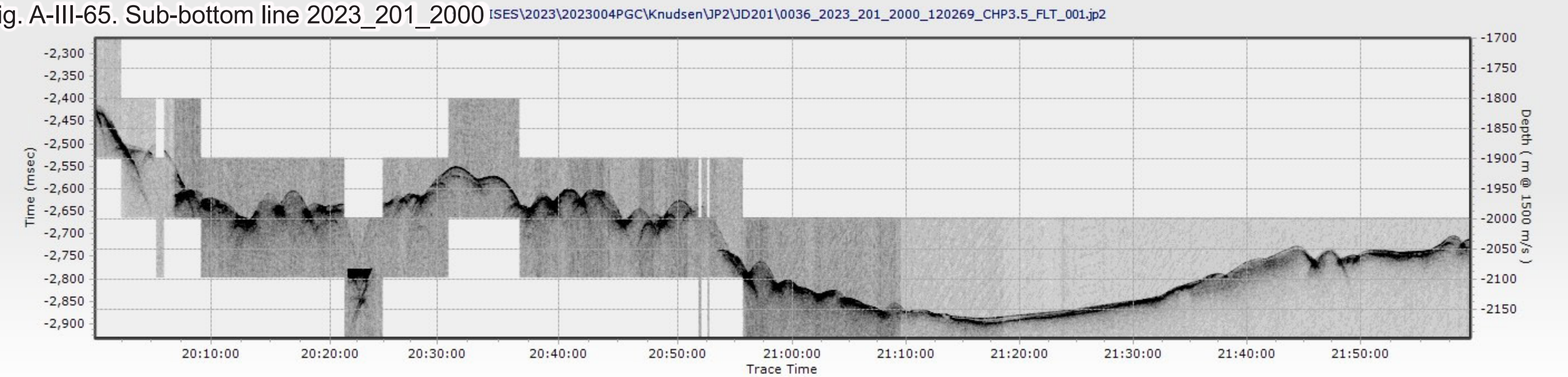

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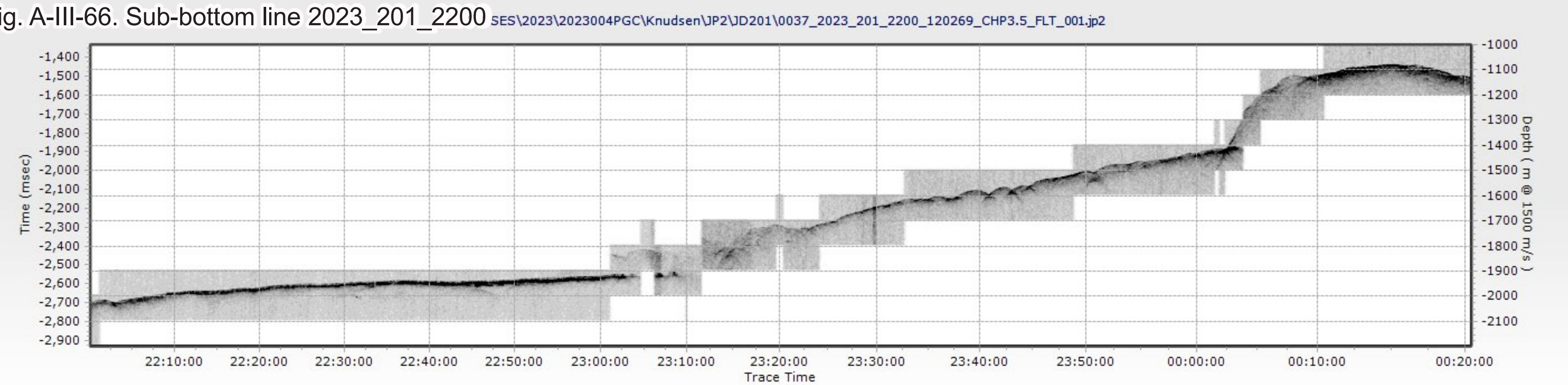
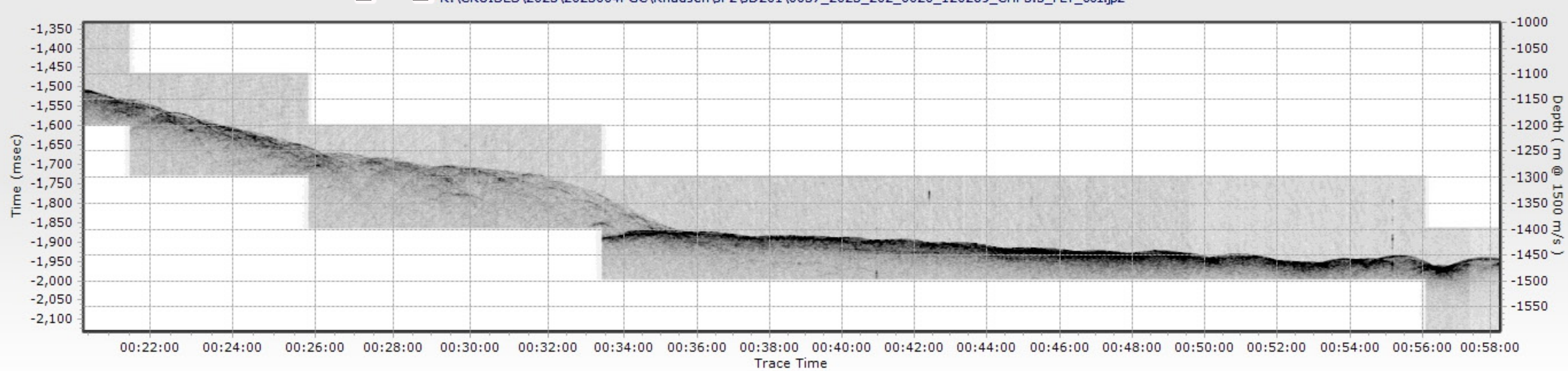


Fig. A-III-67. Sub-bottom line 2023_202_0020



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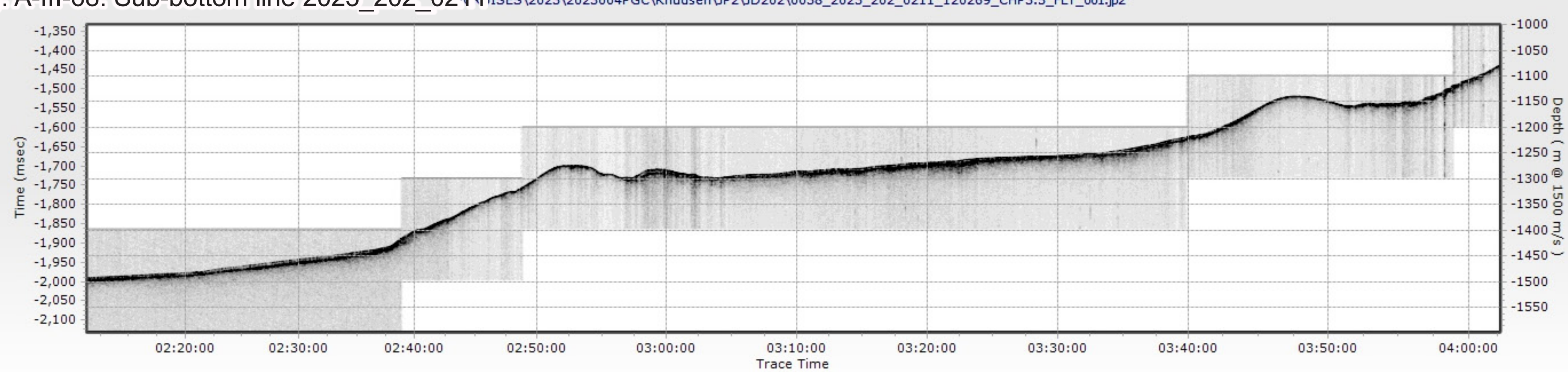
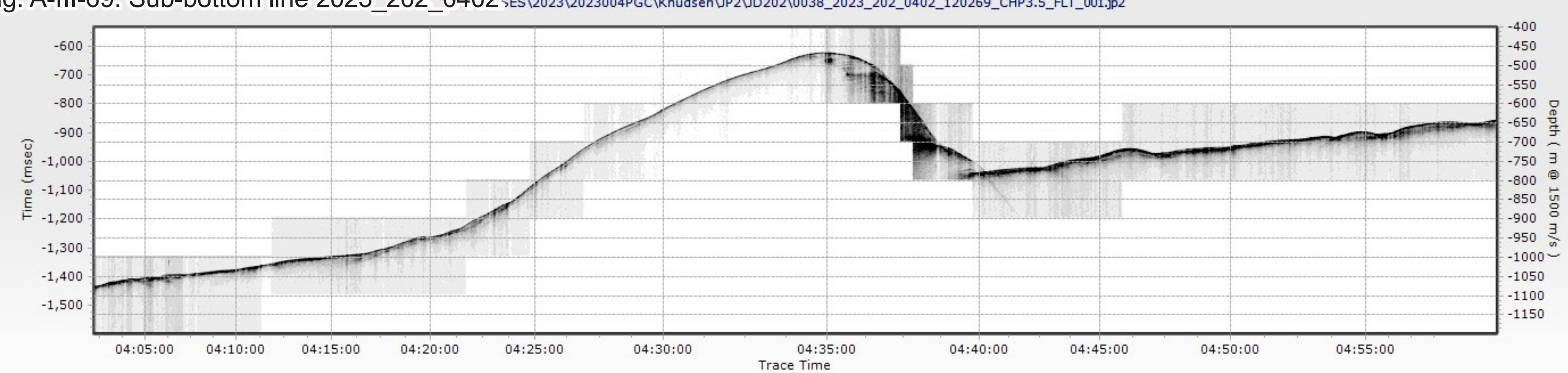


Fig. A-III-69. Sub-bottom line 2023_202_0402



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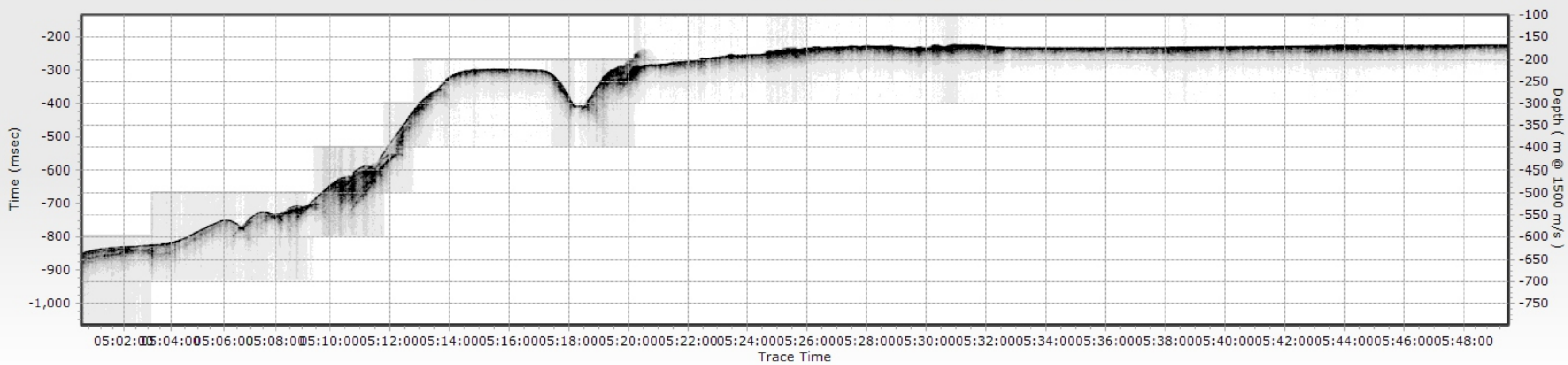

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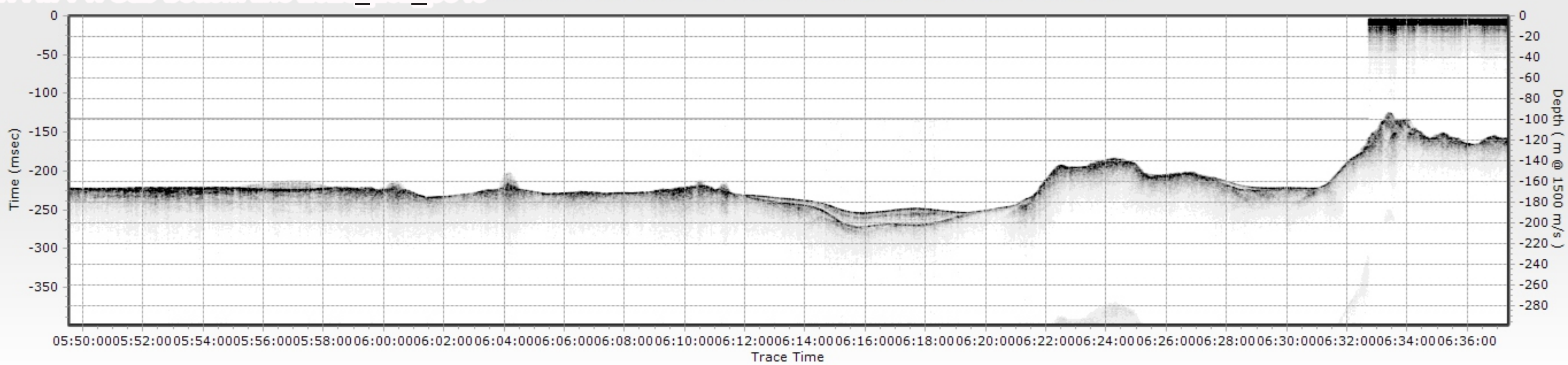

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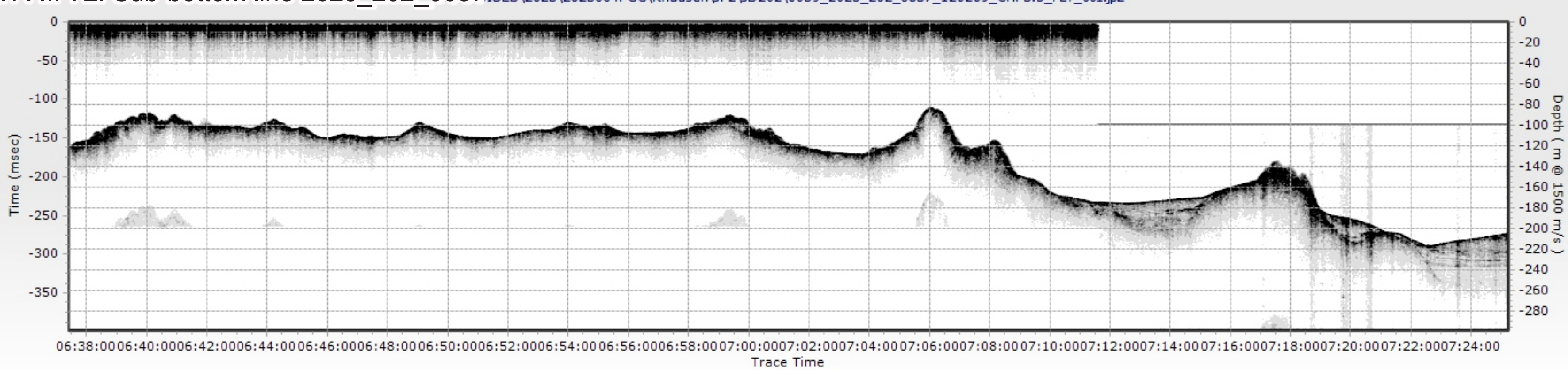


Fig. A-III-73. Sub-bottom line 2023_202_0725

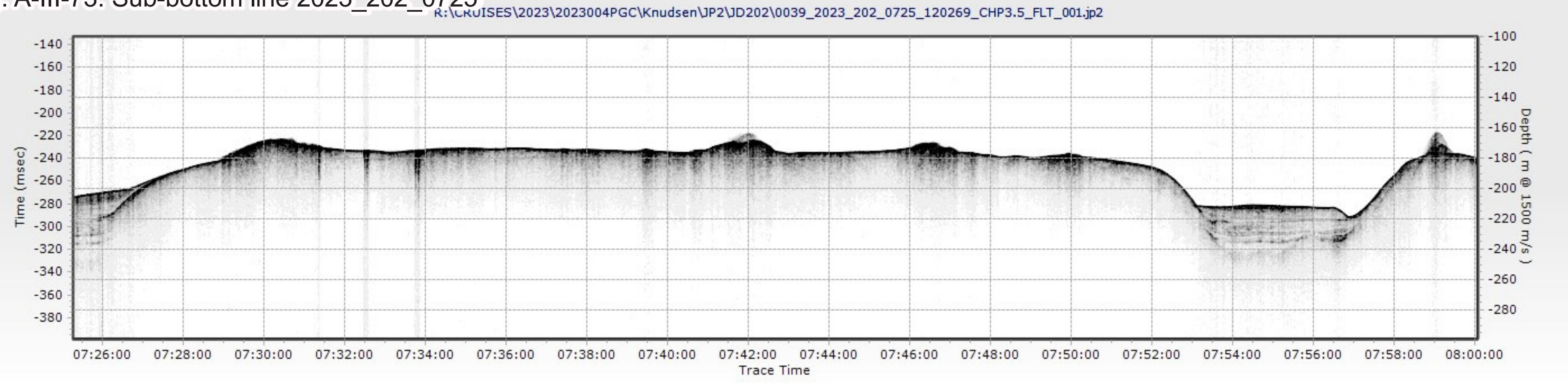


Fig. A-III-74. Sub-bottom line 2023_202_0800

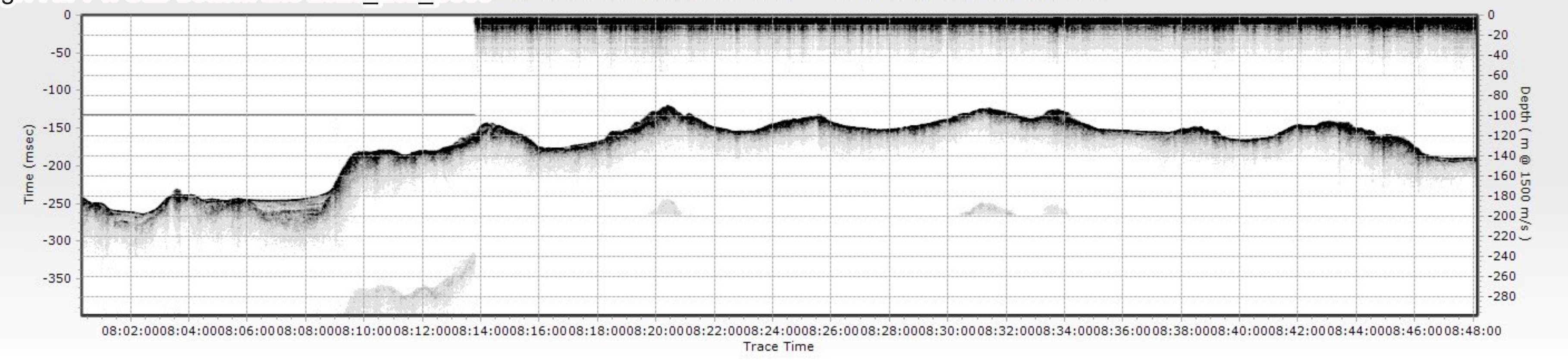
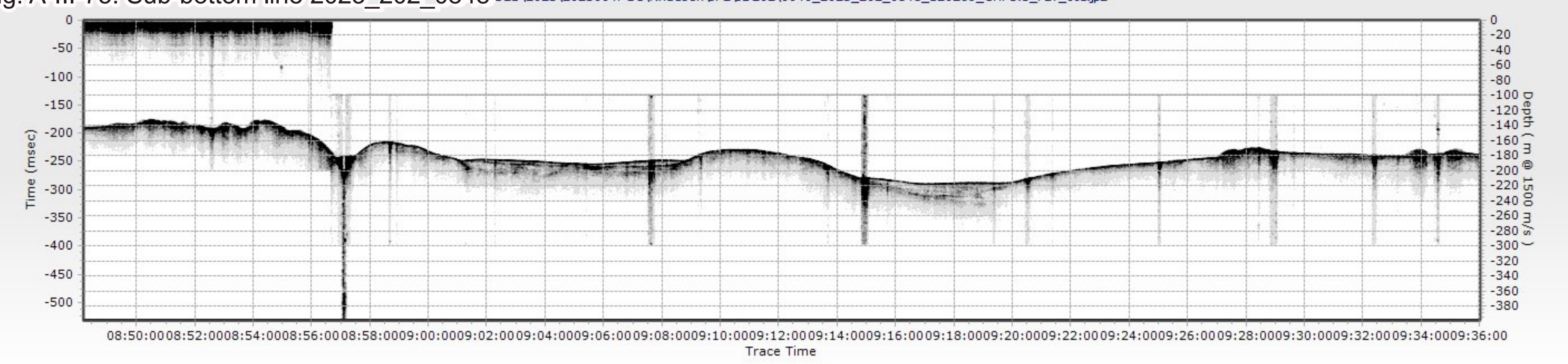


Fig. A-III-75. Sub-bottom line 2023_202_0848



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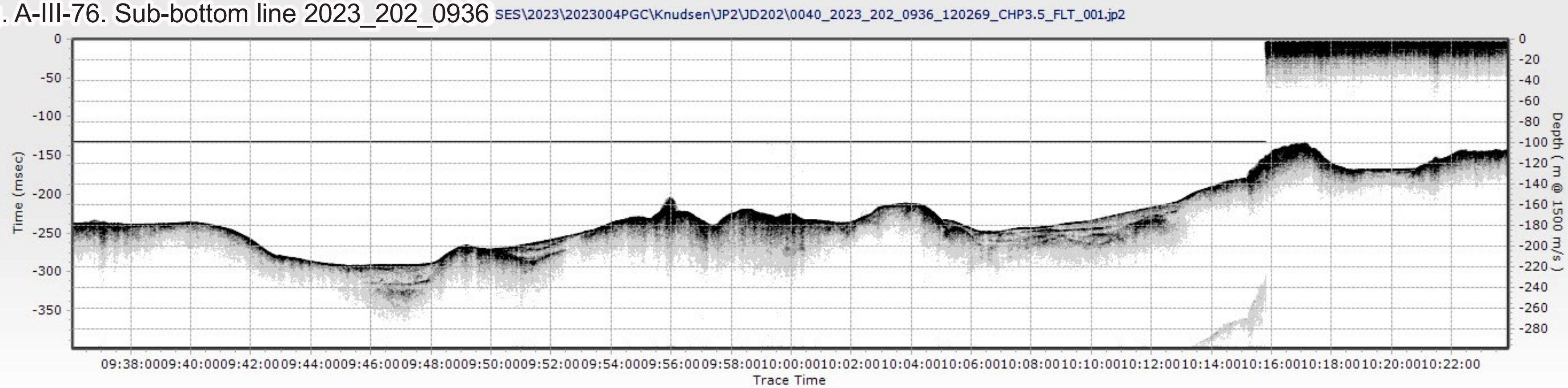


Fig. A-III-77. Sub-bottom line 2023_202_1023

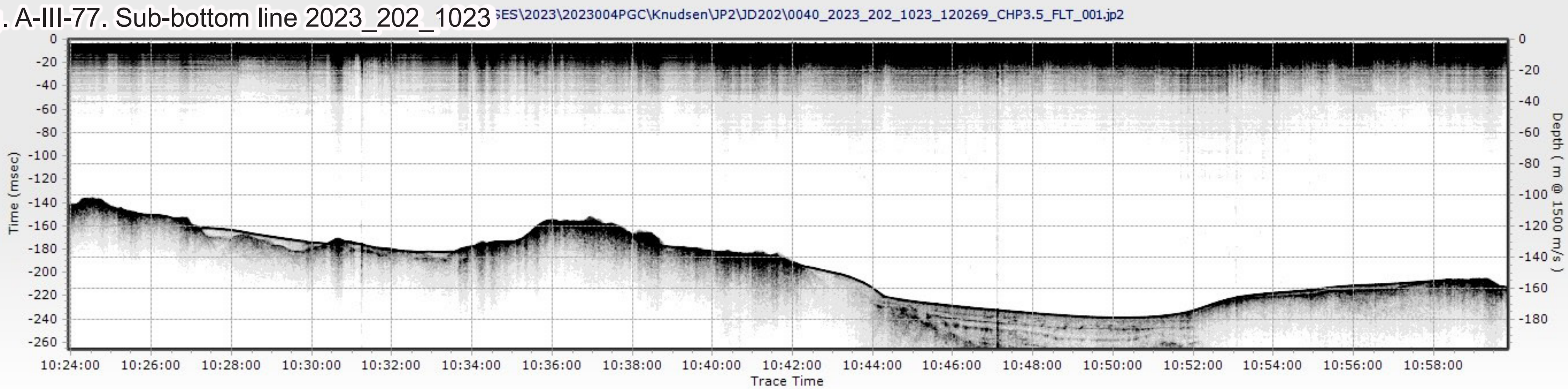


Fig. A-III-78. Sub-bottom line 2023_202_1100

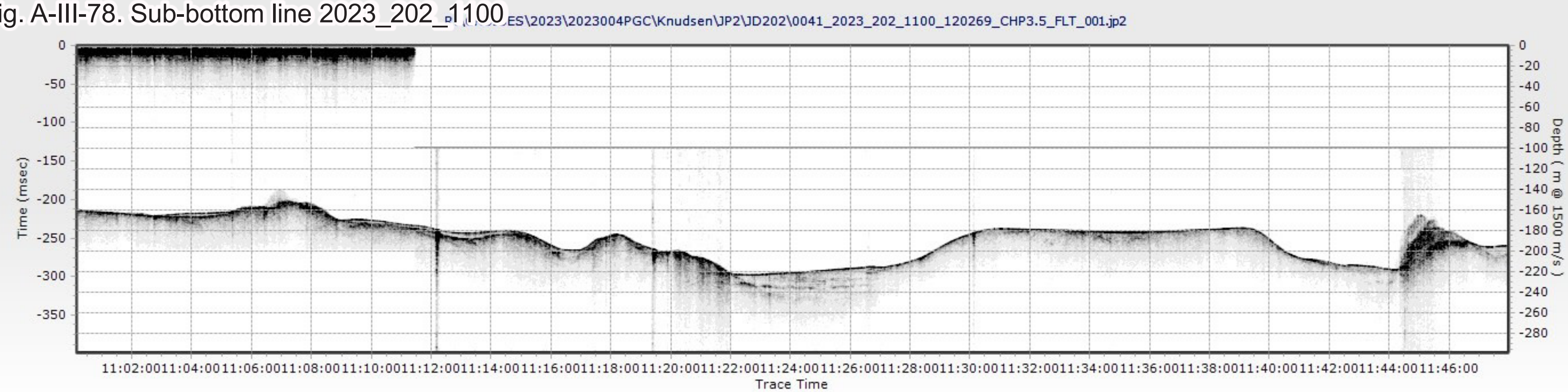


Fig. A-III-79. Sub-bottom line 2023_202_1148

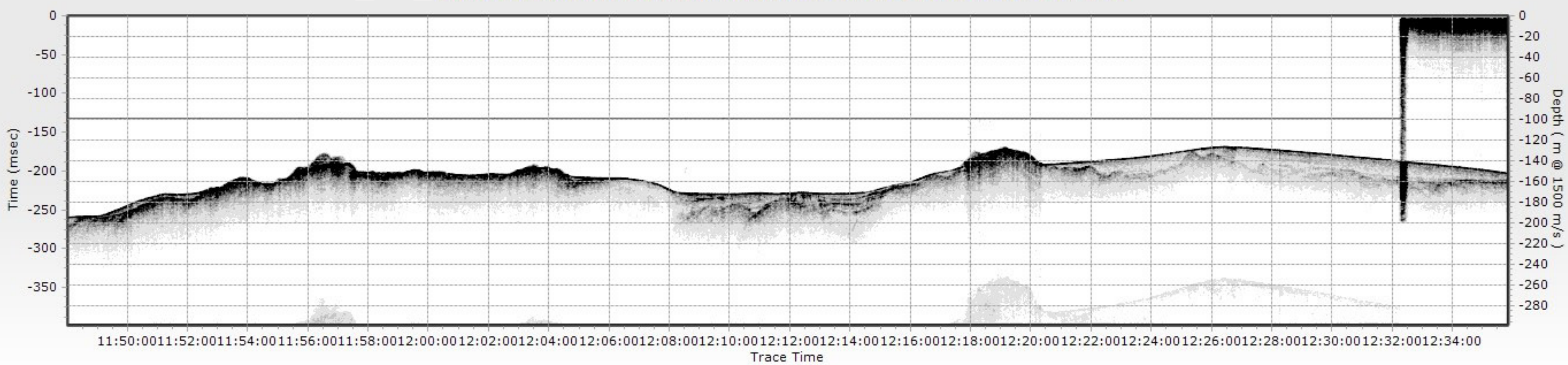


Fig. A-III-80. Sub-bottom line 2023_202_1235

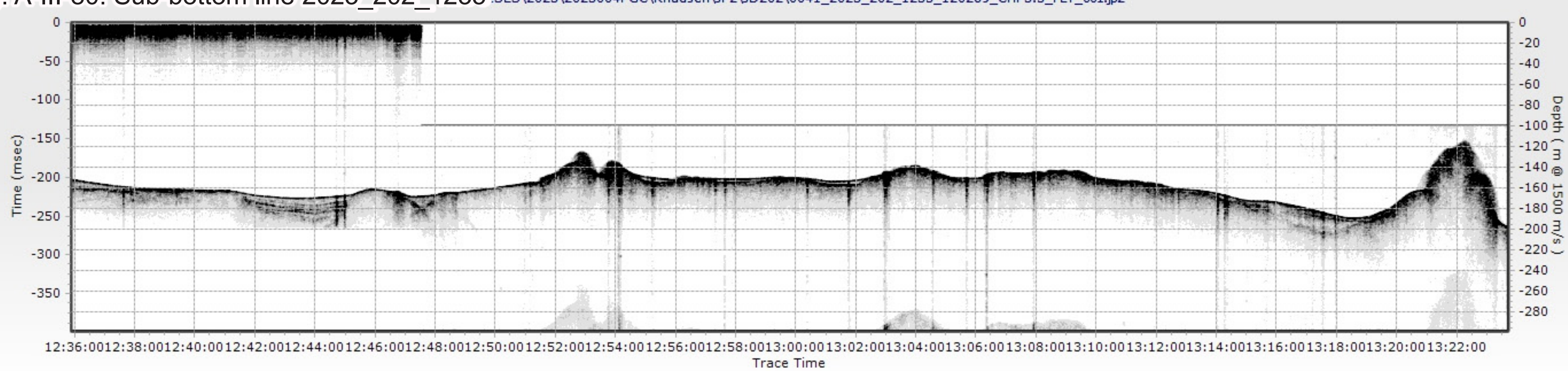


Fig. A-III-81. Sub-bottom line 2023_202_1323

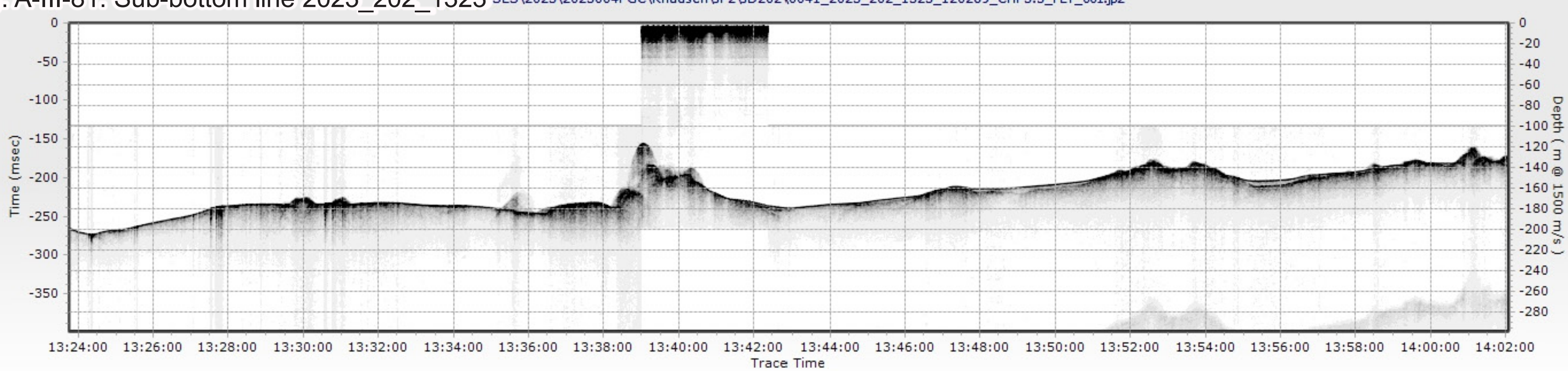
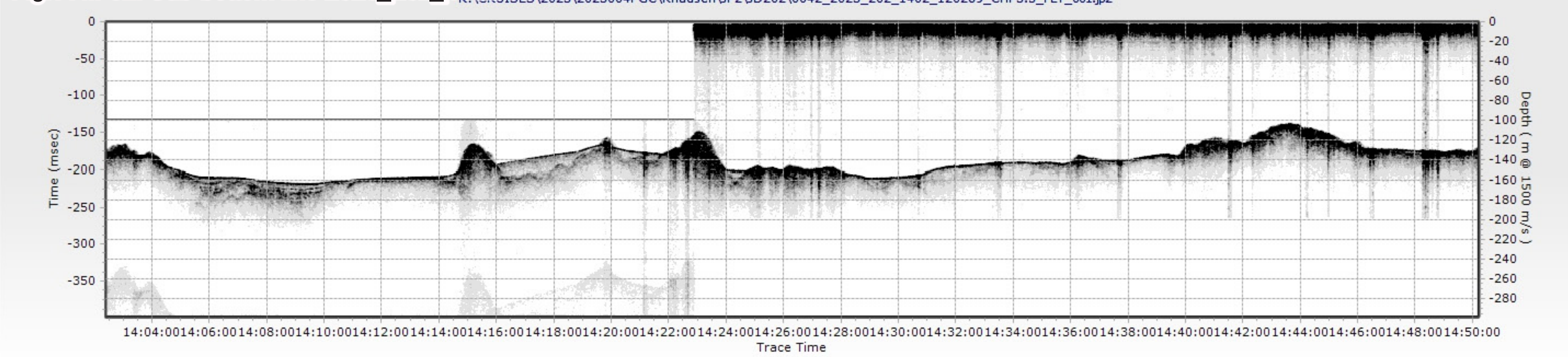


Fig. A-III-82. Sub-bottom line 2023_202_1402



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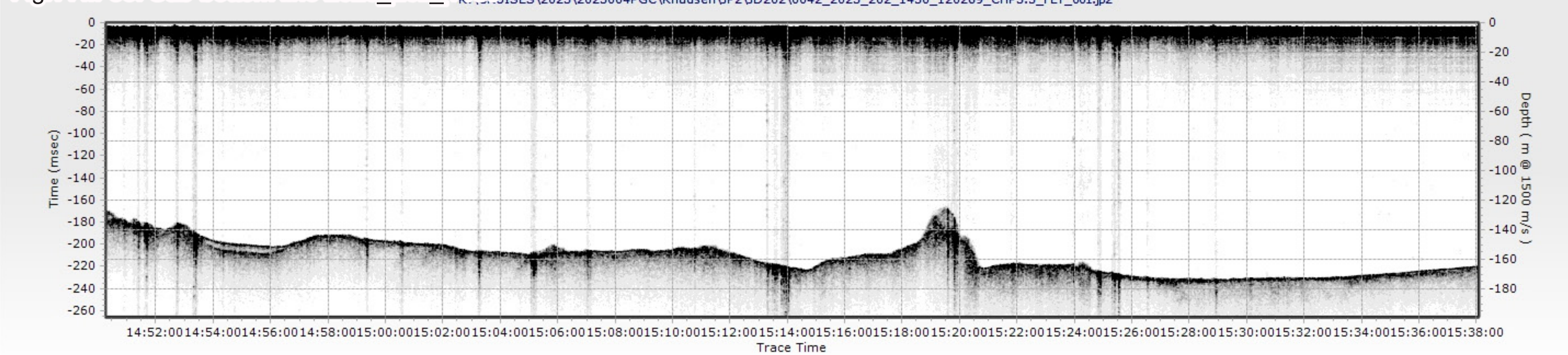


Fig. A-III-84. Sub-bottom line 2023_202_1538

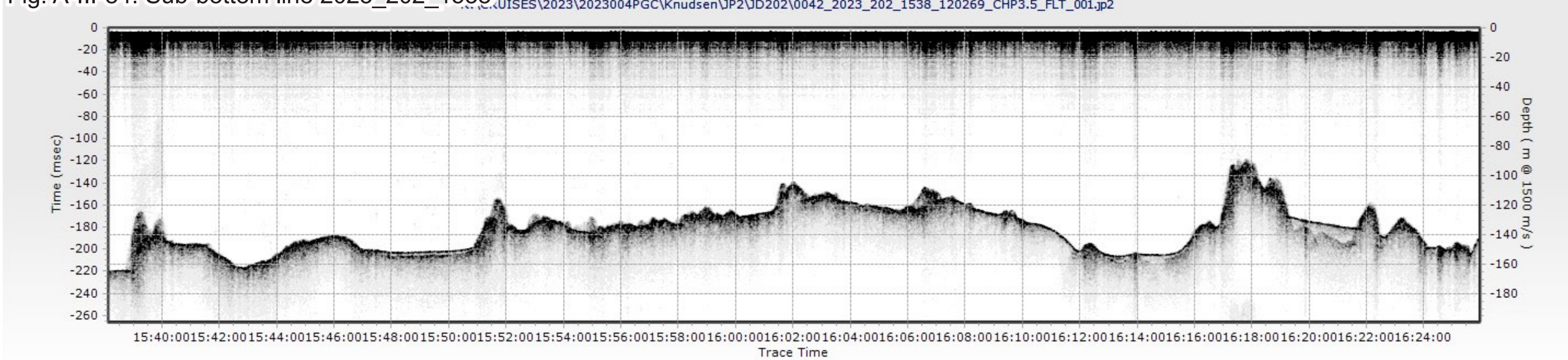


Fig. A-III-85. Sub-bottom line 2023_202_1625

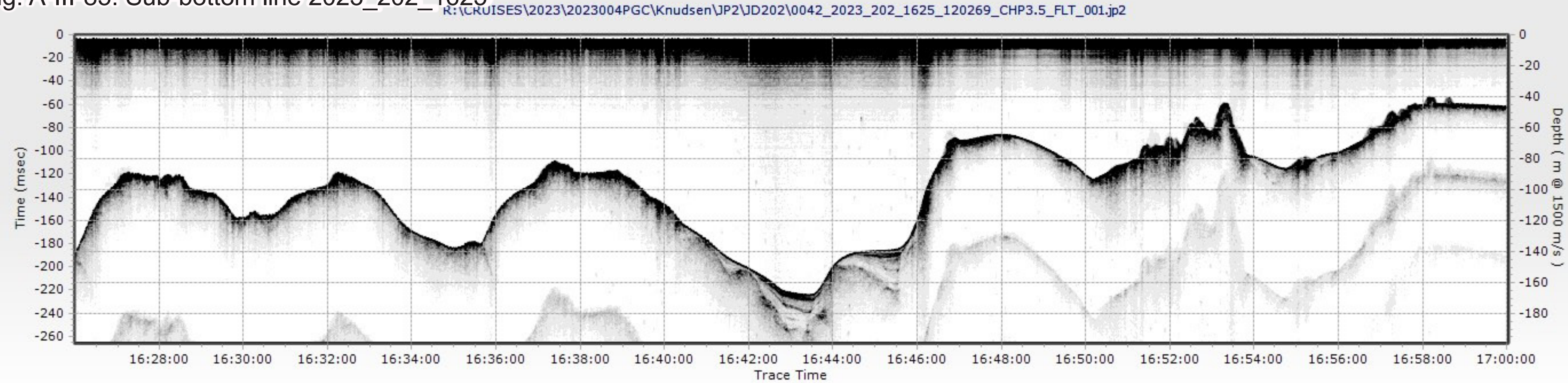


Fig. A-III-86. Sub-bottom line 2023_202_1700

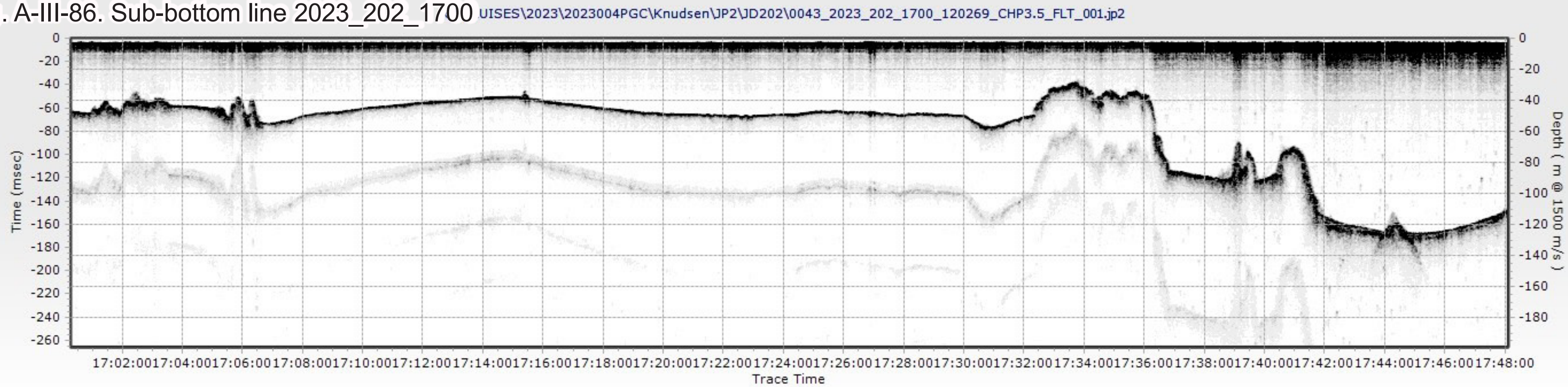


Fig. A-III-87. Sub-bottom line 2023_202_1748

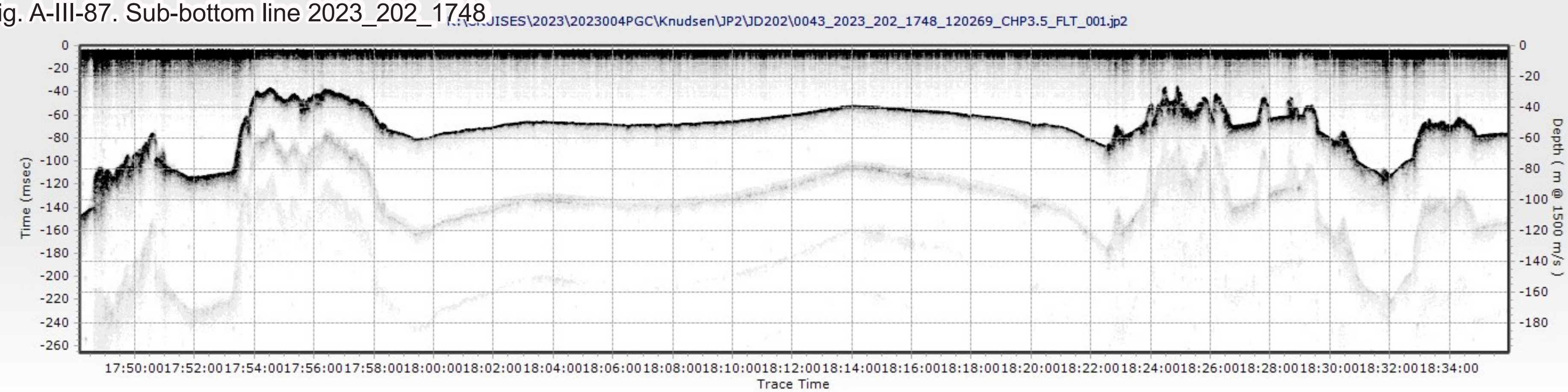
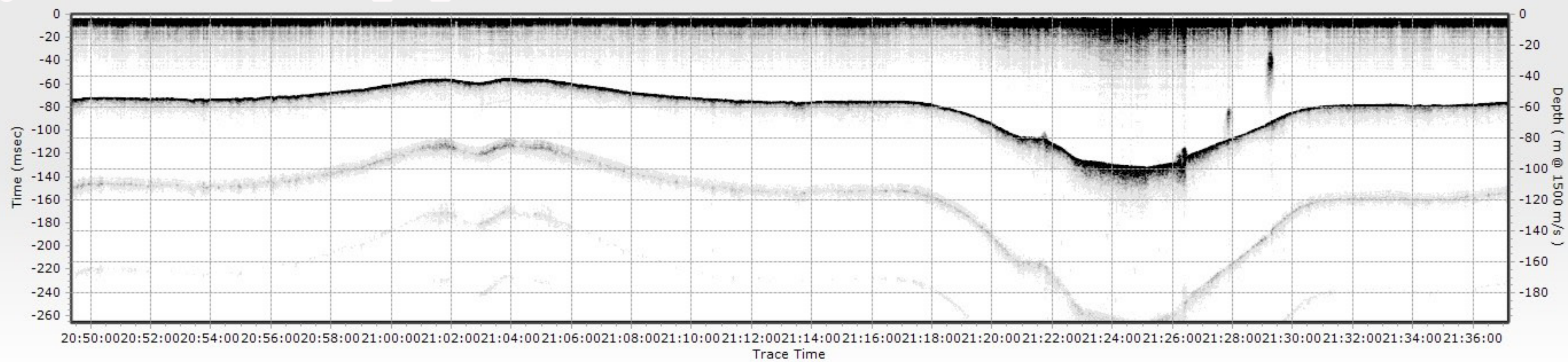


Fig. A-III-88. Sub-bottom line 2023_202_2049



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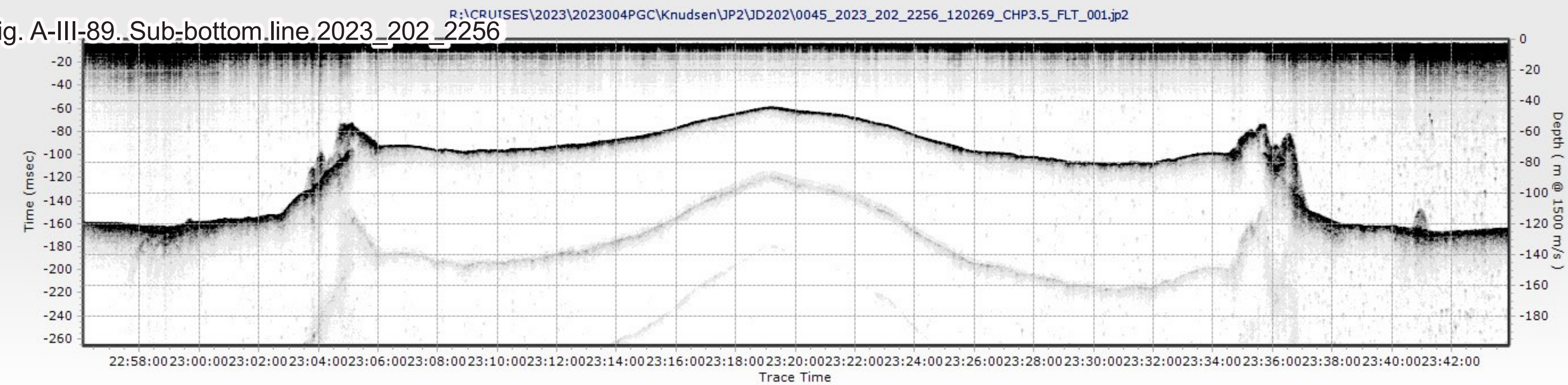

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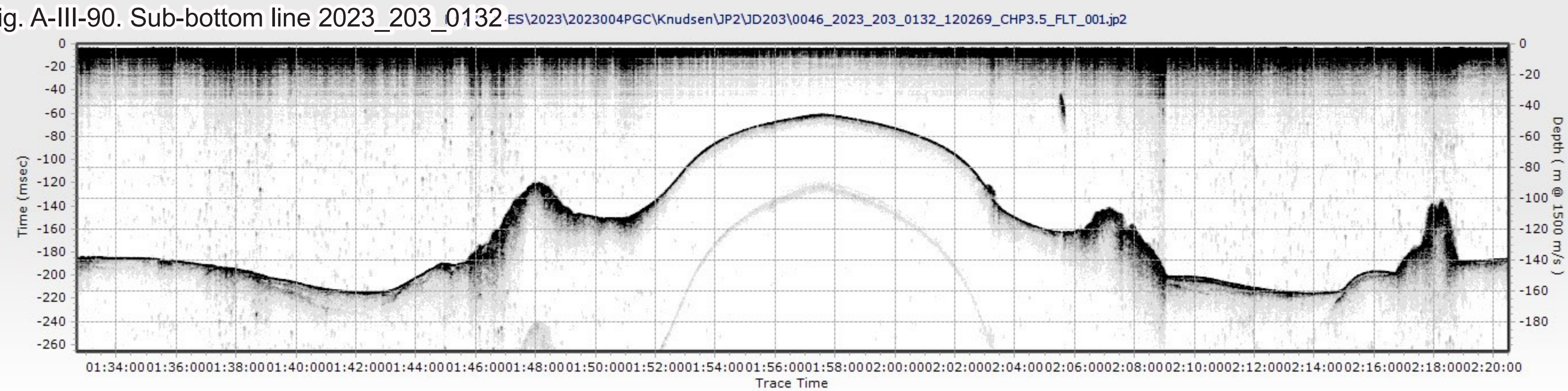

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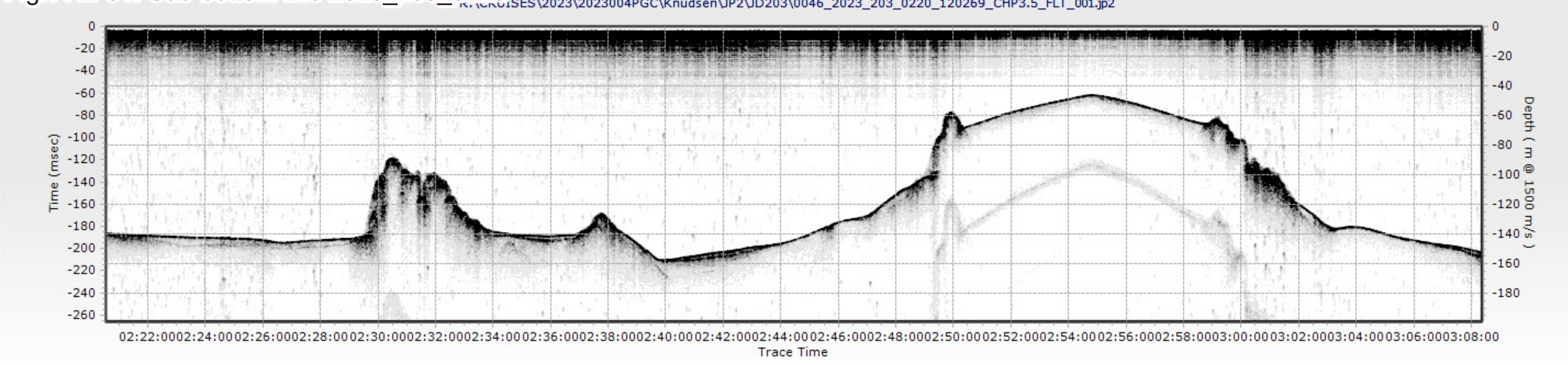
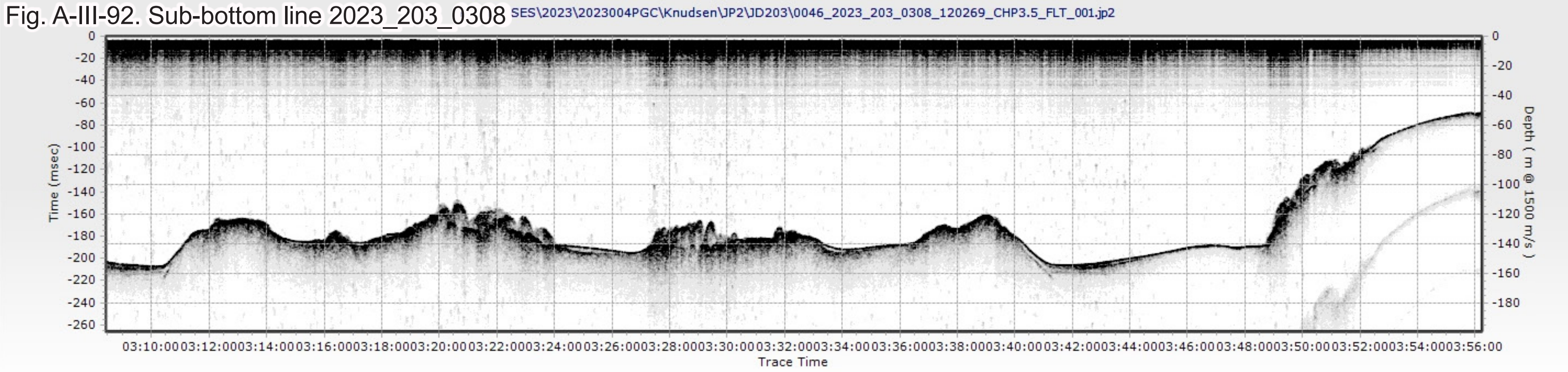


Fig. A-III-92. Sub-bottom line 2023_203_0308



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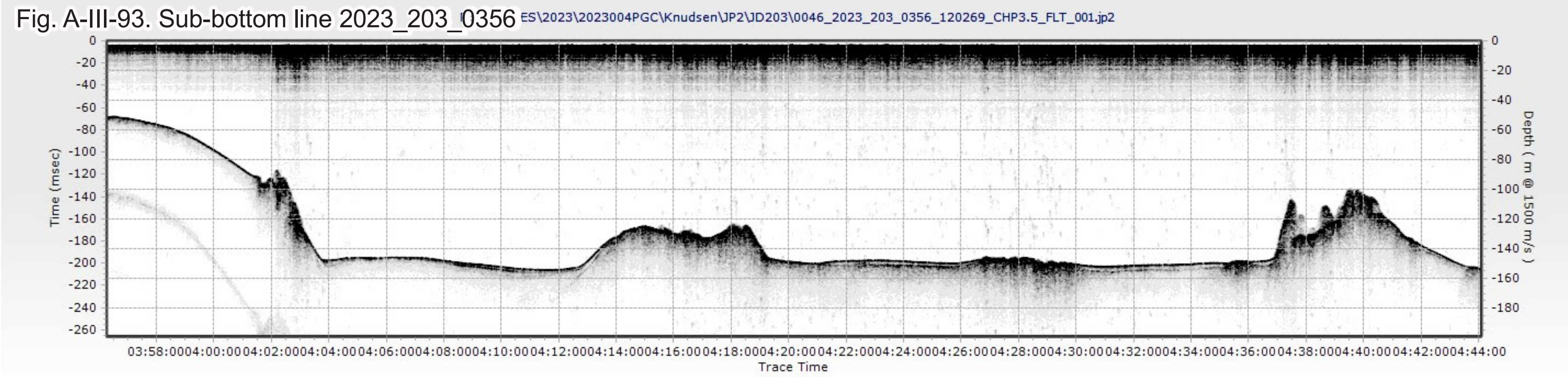


Fig. A-III-94. Sub-bottom line 2023_203_0500

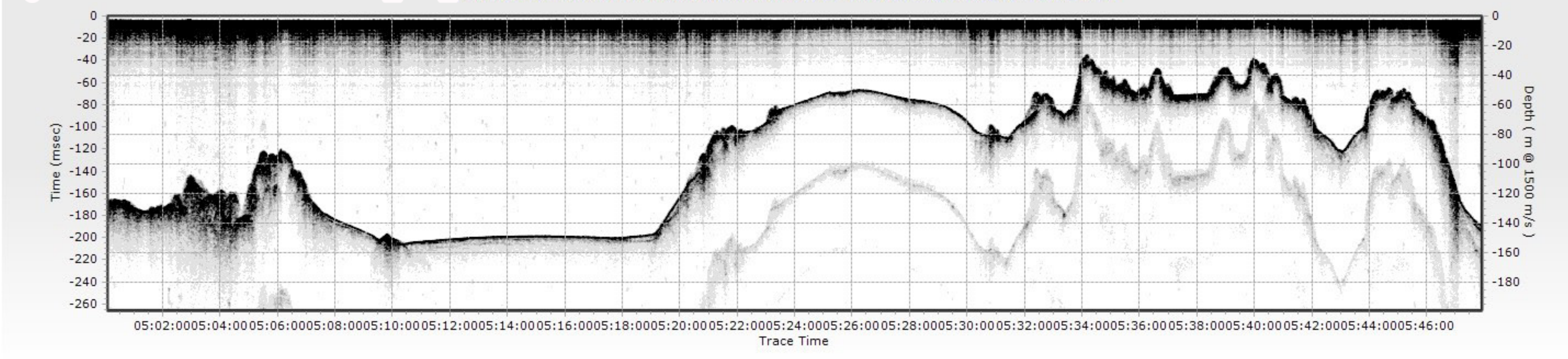


Fig. A-III-95. Sub-bottom line 2023_203_0547

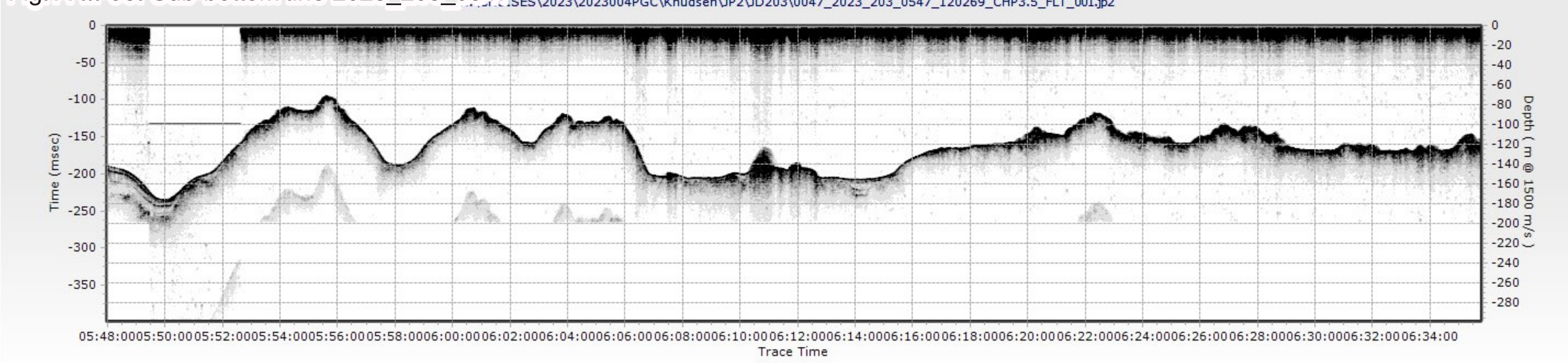


Fig. A-III-96. Sub-bottom line 2023_203_0635

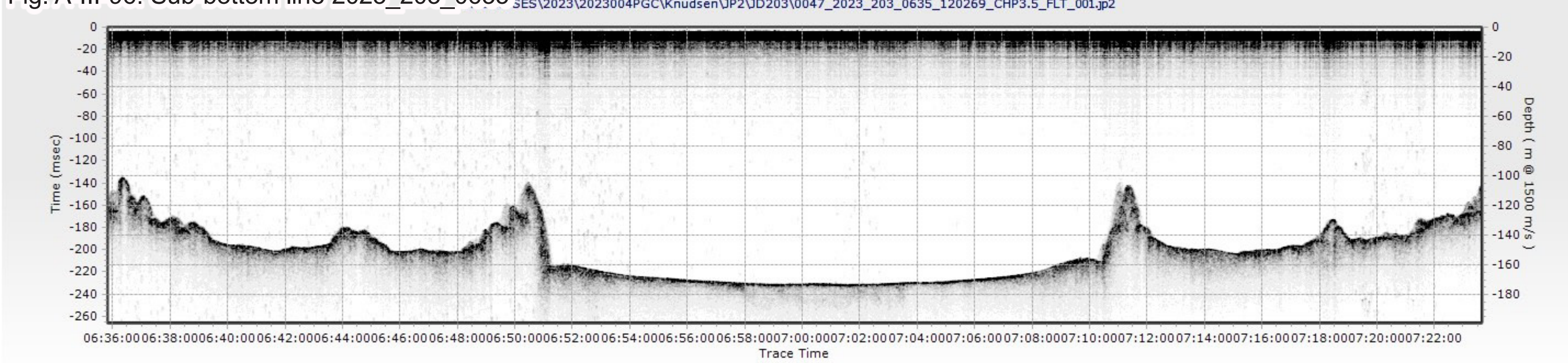


Fig. A-III-97. ub-bottom line 2023_203_0723

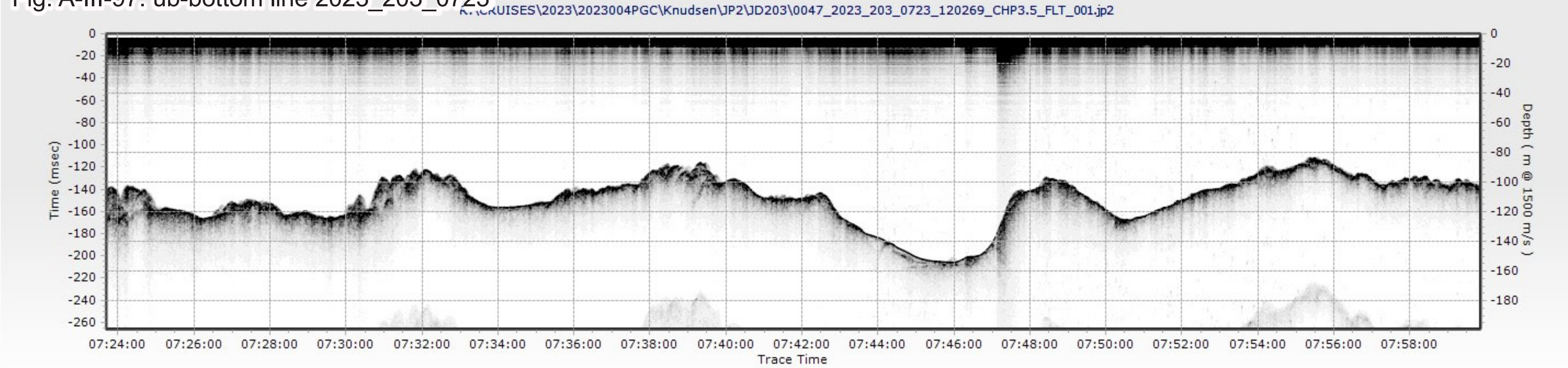


Fig. A-III-98. Sub-bottom line 2023_203_0800

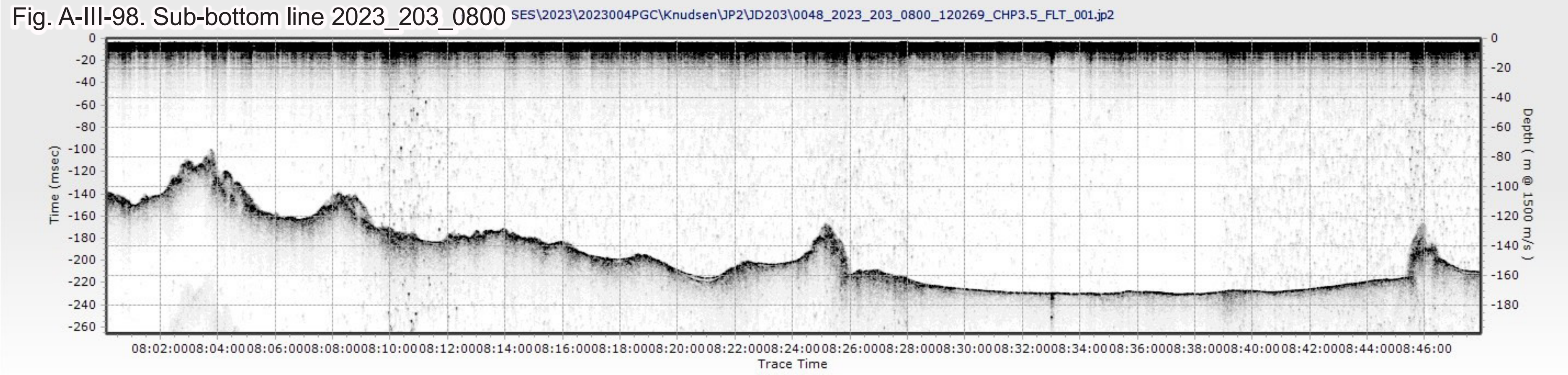
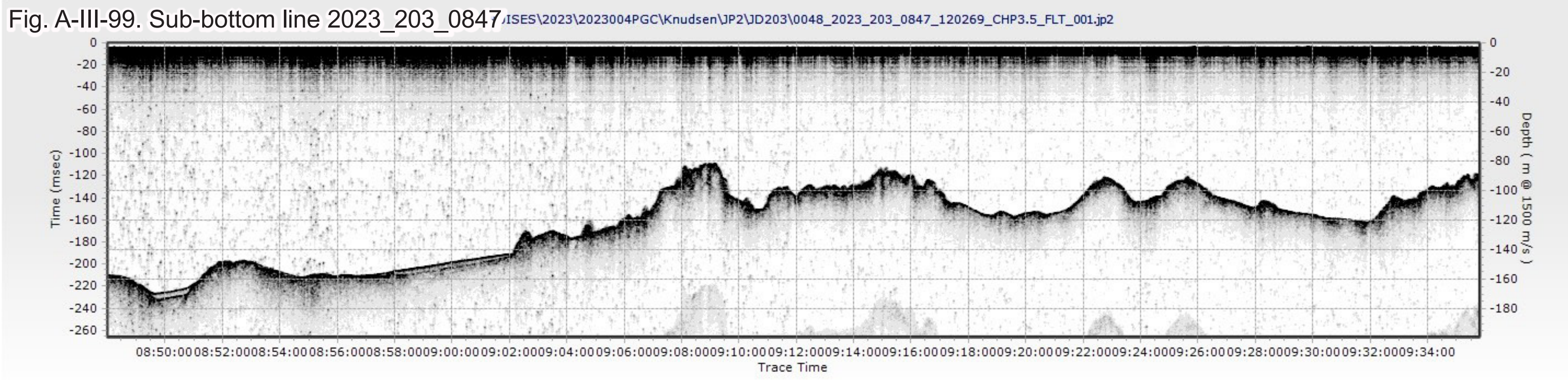


Fig. A-III-99. Sub-bottom line 2023_203_0847



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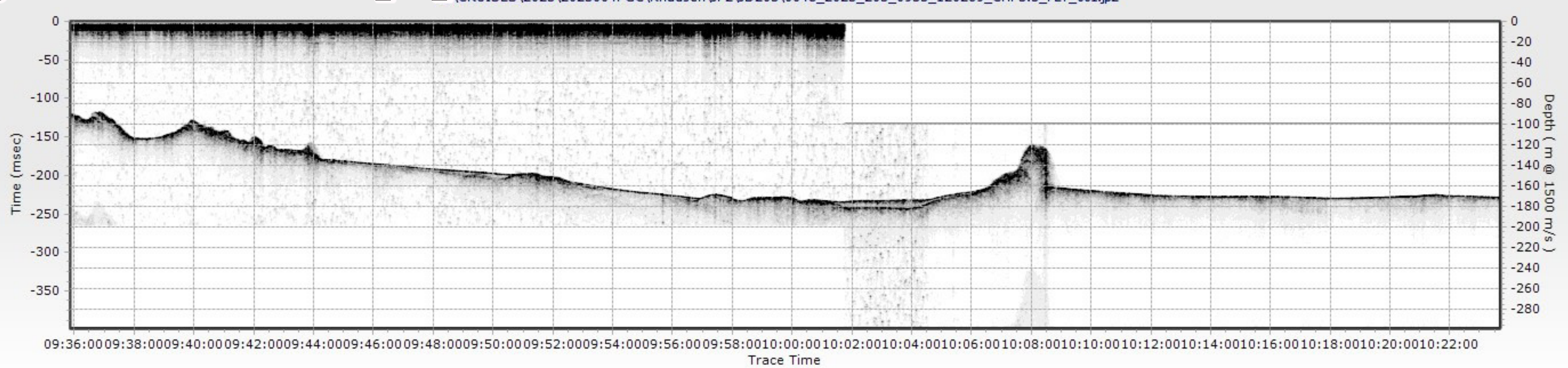

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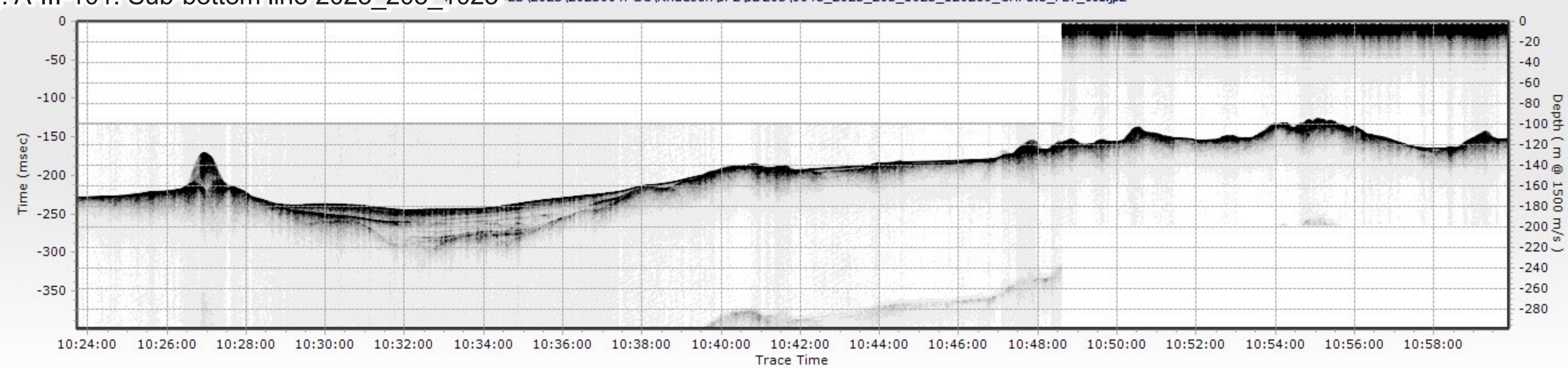


Fig. A-III-102. Sub-bottom line 2023_203_1100

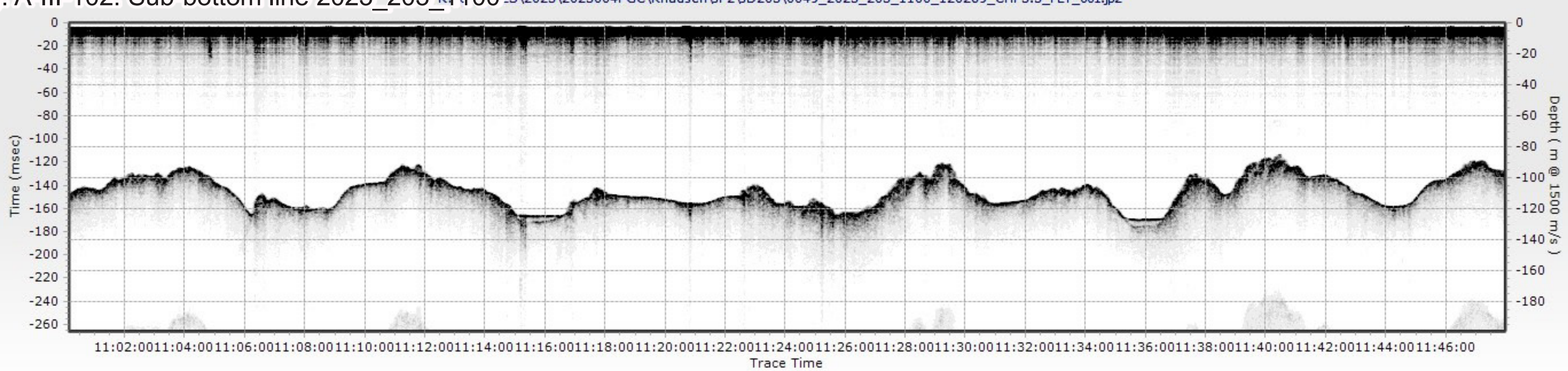
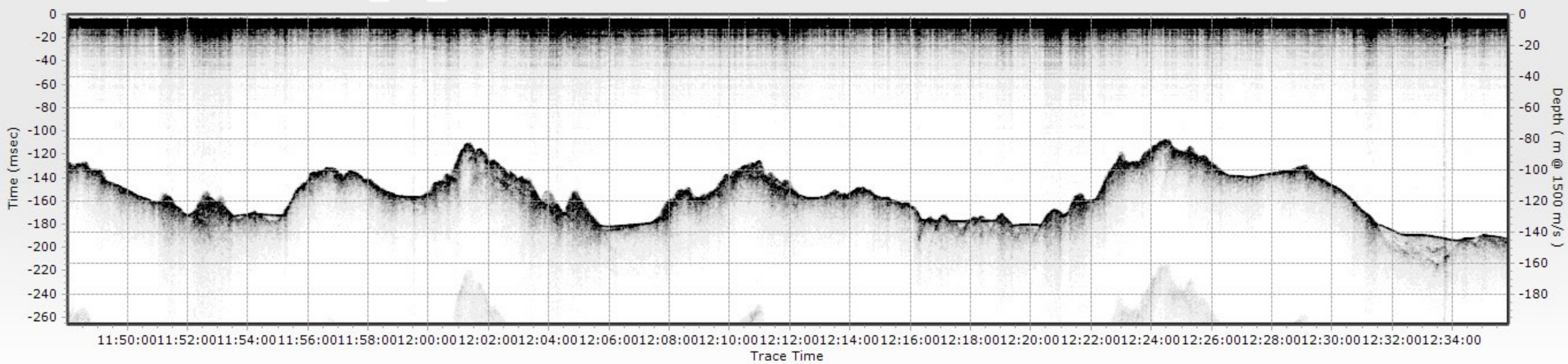


Fig. A-III-103. Sub-bottom line 2023_203_1148



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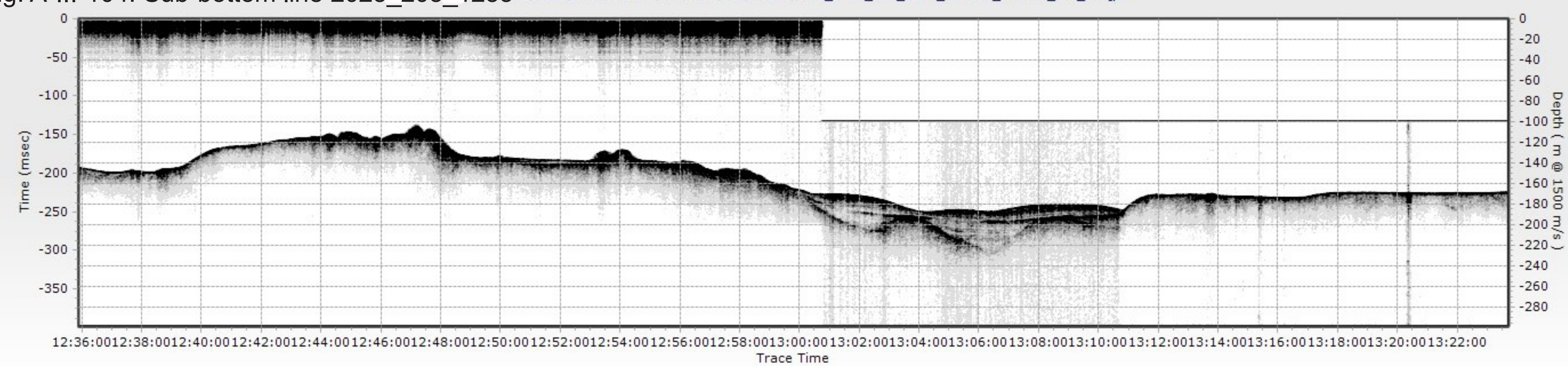

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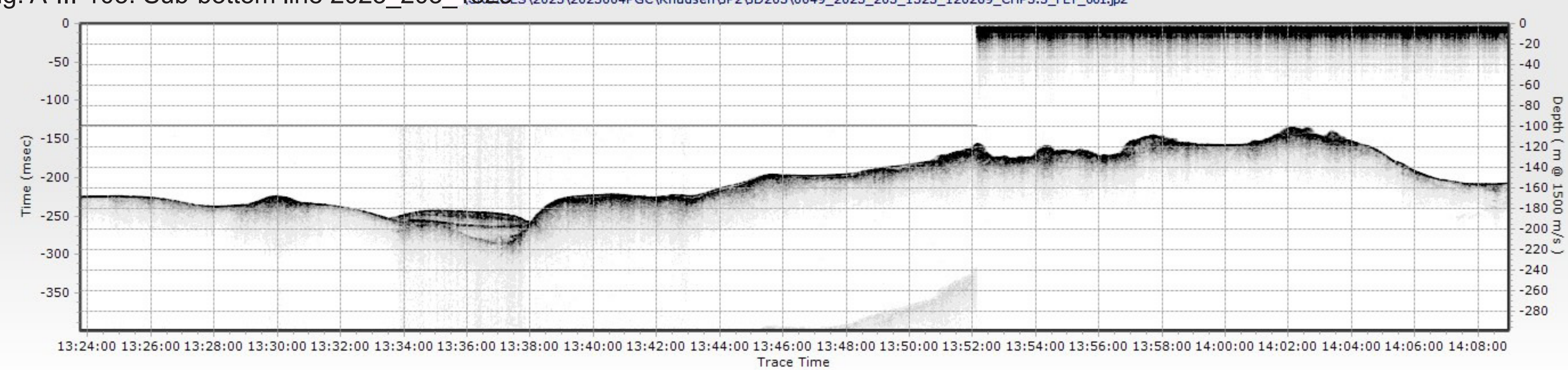


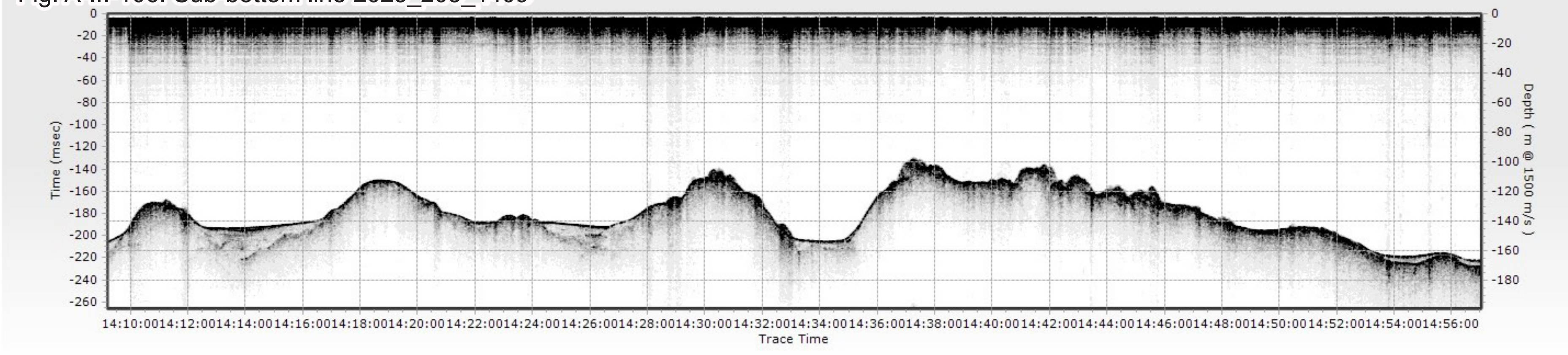
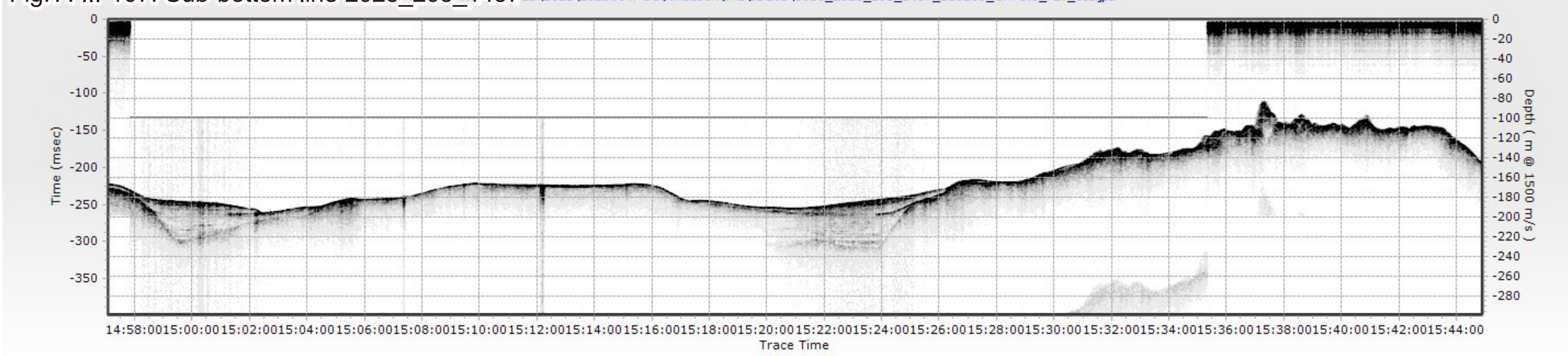


Fig. A-III-106. Sub-bottom line 2023_203_1409



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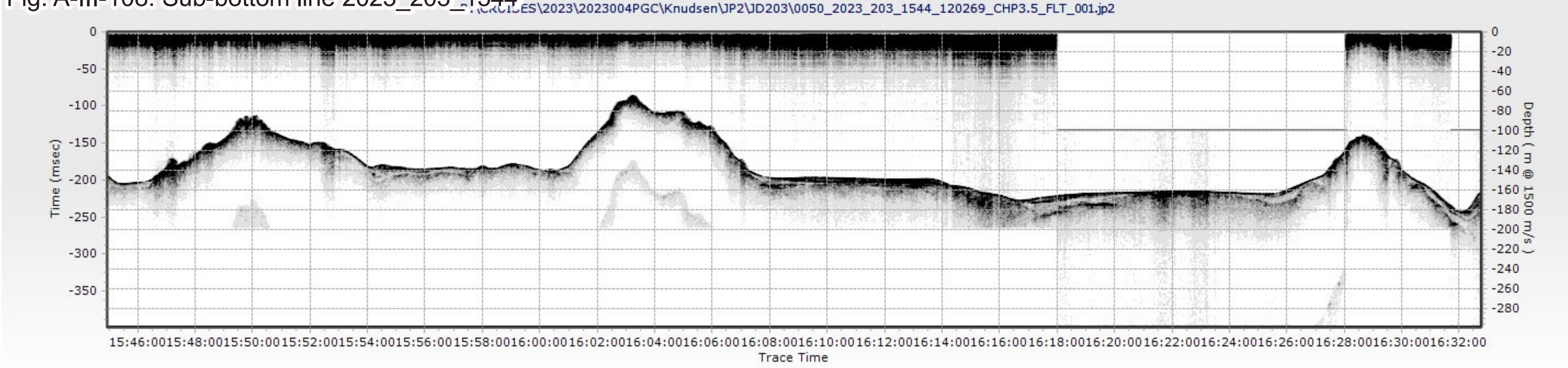
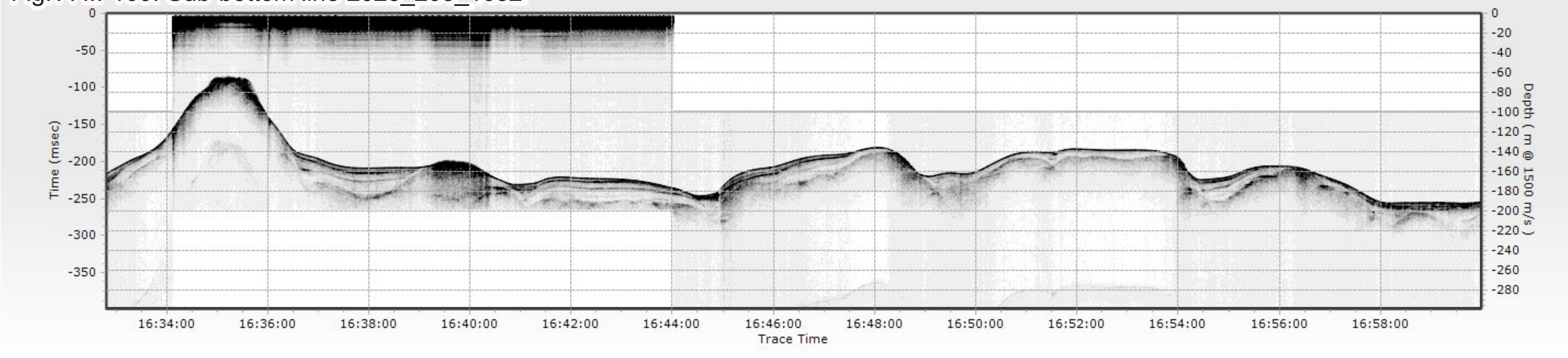


Fig. A-III-108. Sub-bottom line 2023_203_1544

Fig. A-III-109. Sub-bottom line 2023_203_1632



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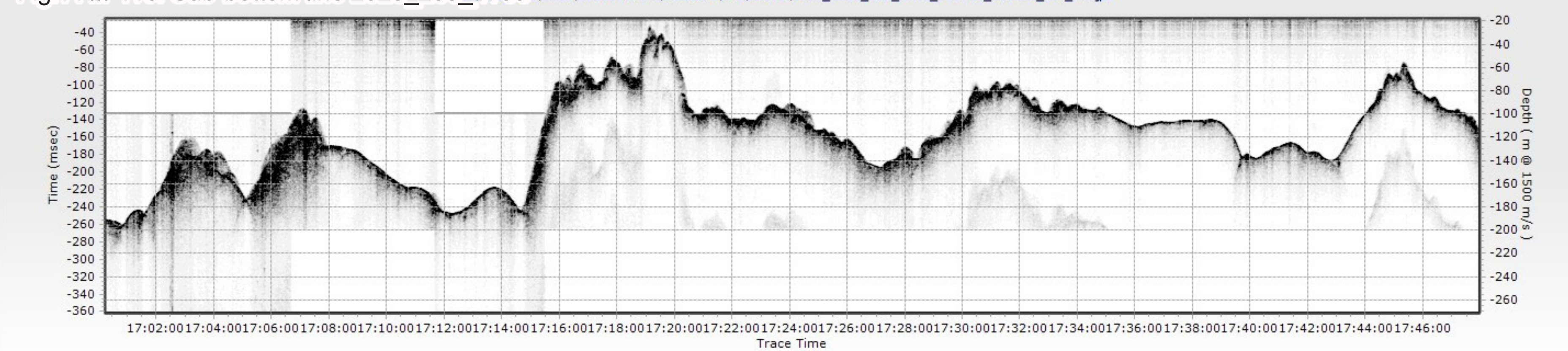
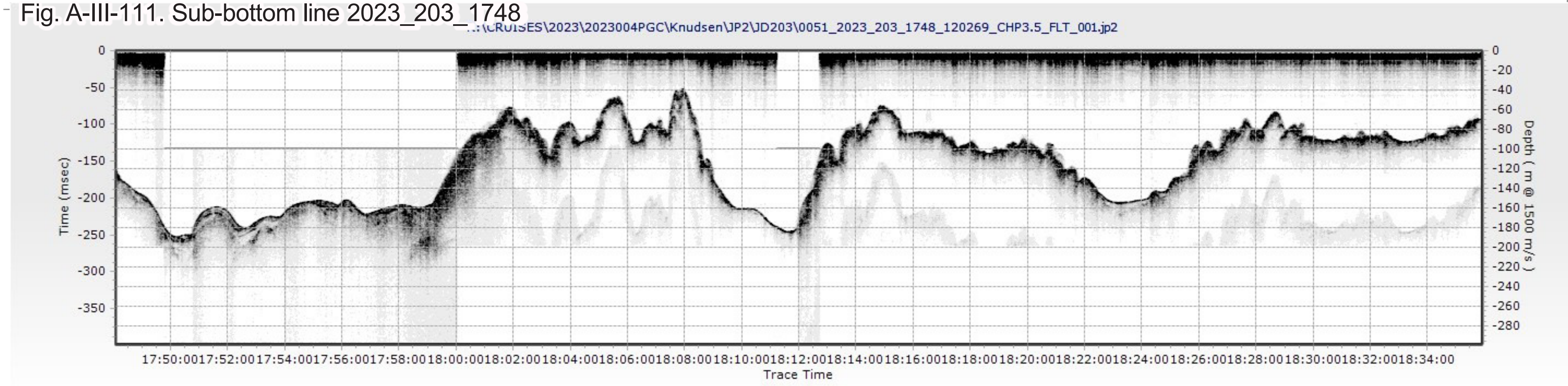


Fig. A-III-111. Sub-bottom line 2023_203_1748



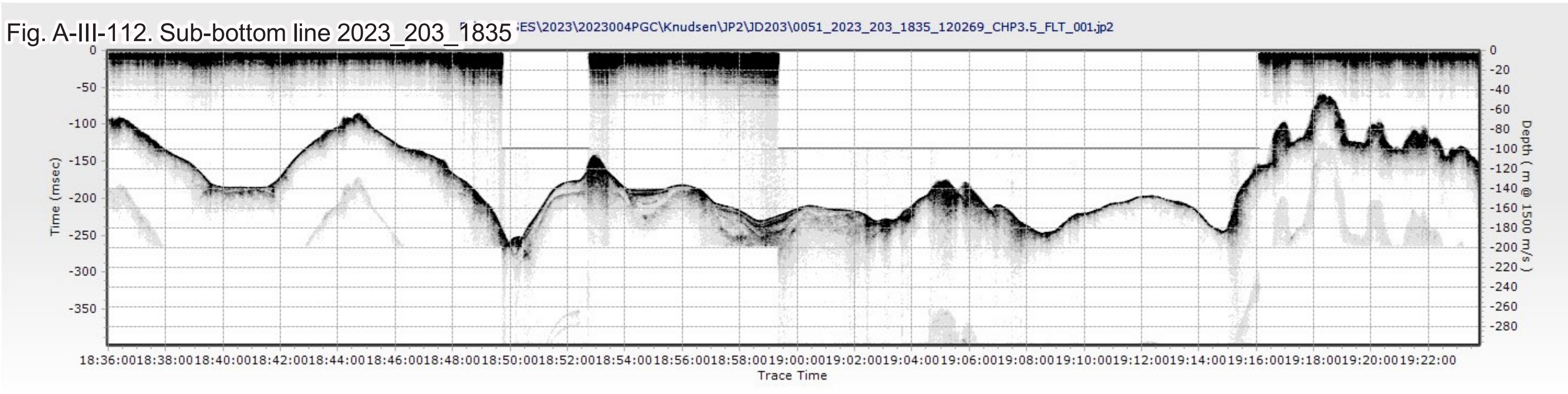


Fig. A-III-112. Sub-bottom line 2023_203_1835

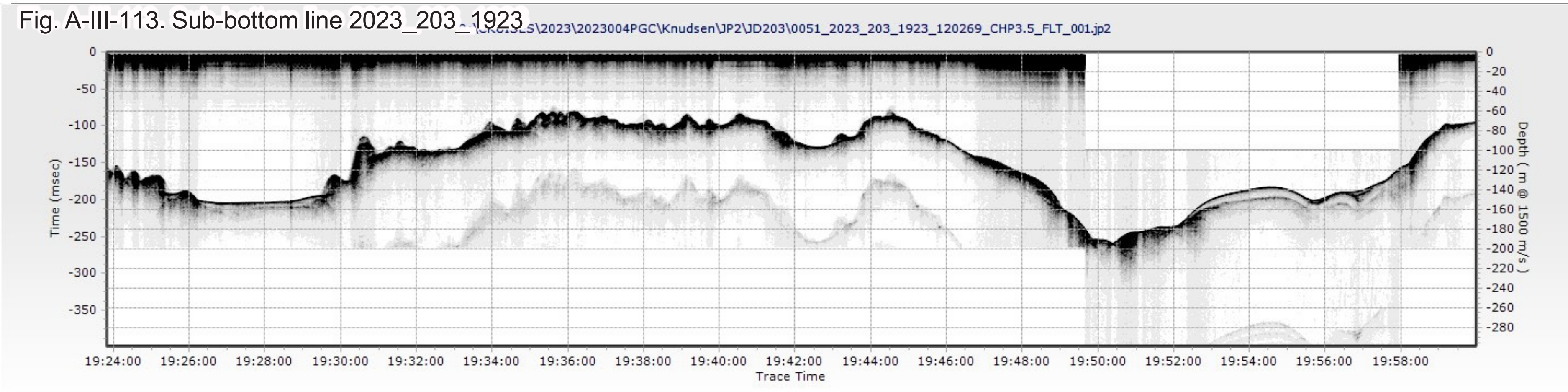


Fig. A-III-113. Sub-bottom line 2023_203_1923

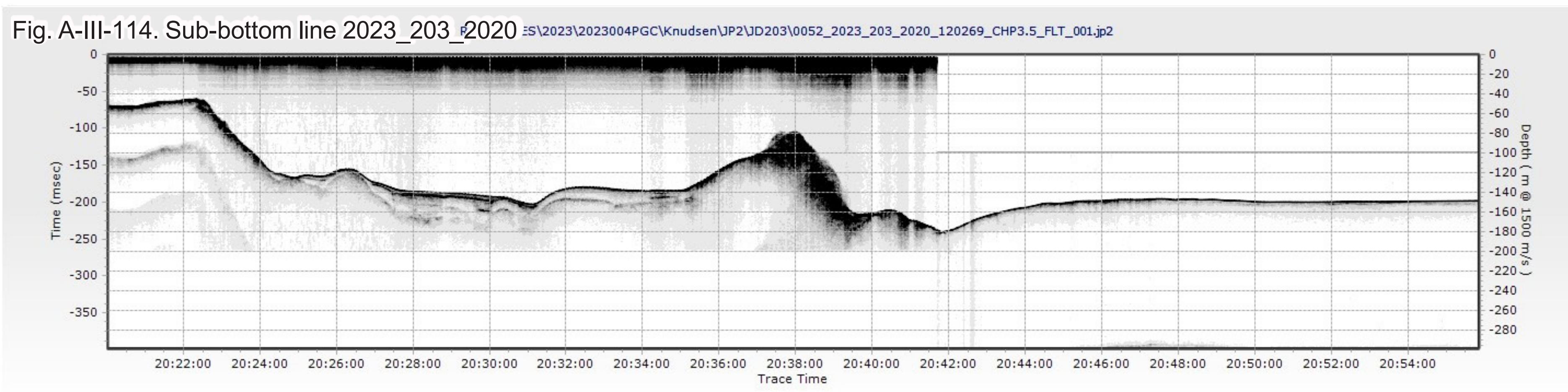


Fig. A-III-114. Sub-bottom line 2023_203_2020

Fig. A-III-115. Sub-bottom line 2023_203_2133

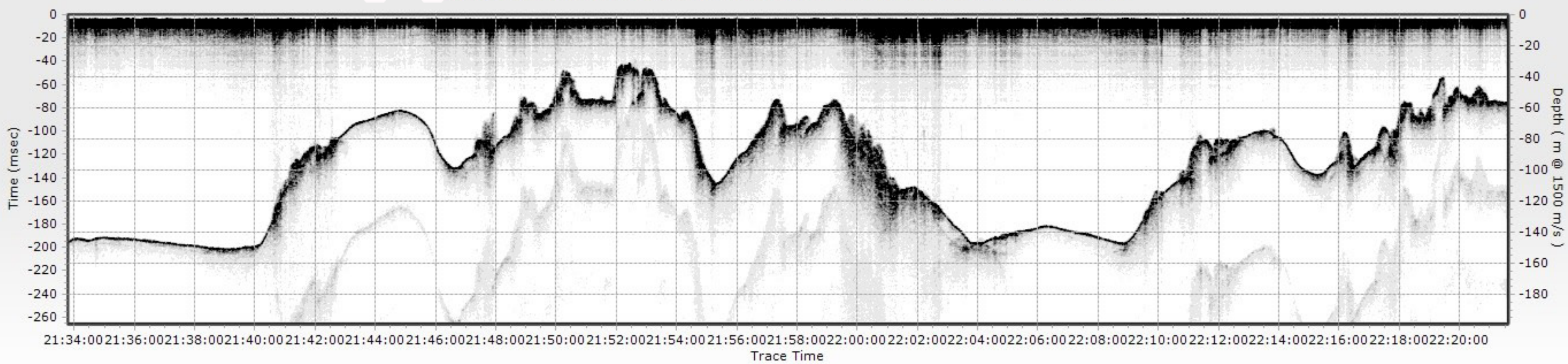


Fig. A-III-116. Sub-bottom line 2023_203_2221

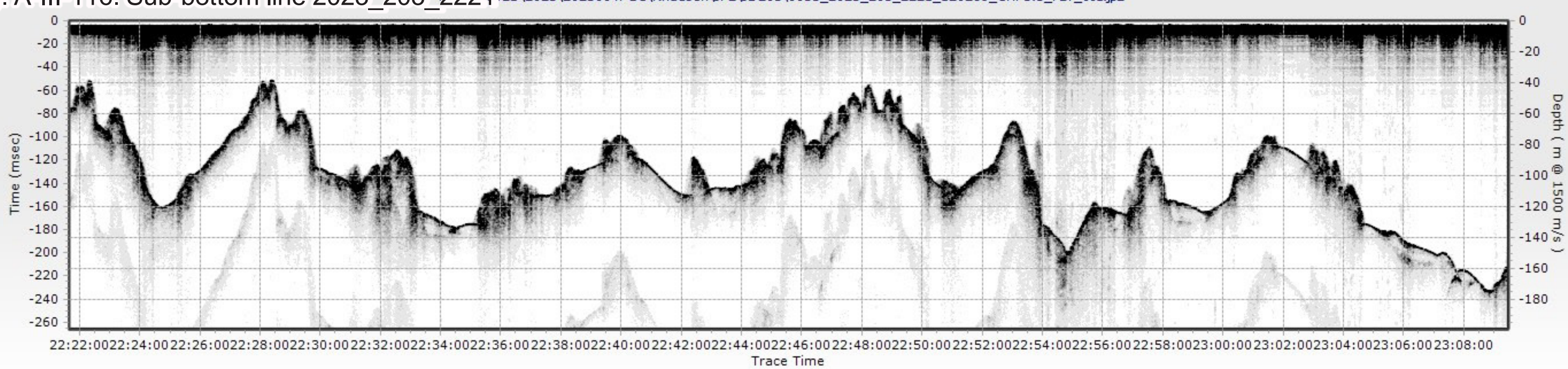


Fig. A-III-117. Sub-bottom line 2023__203_2309

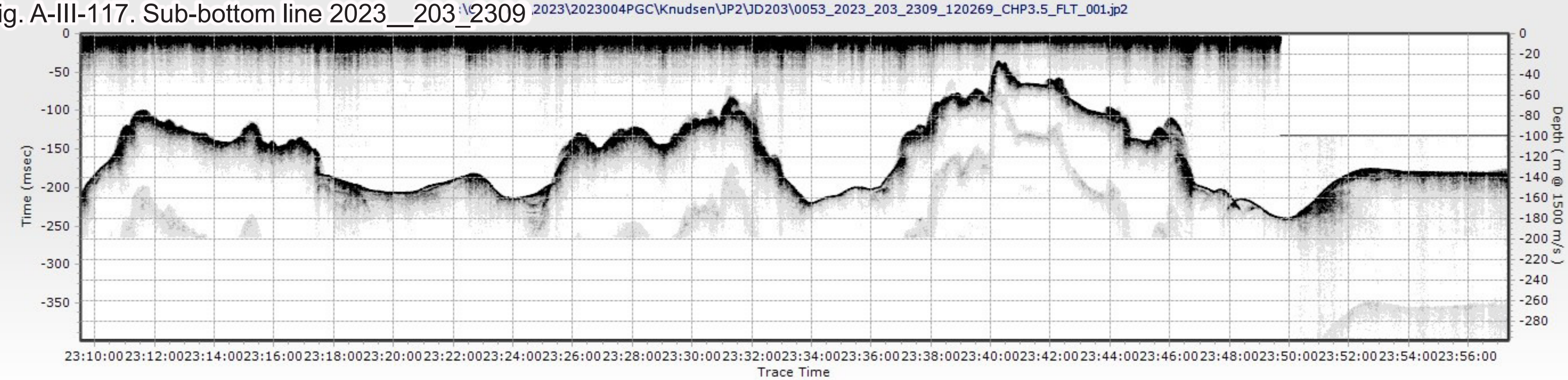


Fig. A-III-118. Sub-bottom line 2023_204_0231

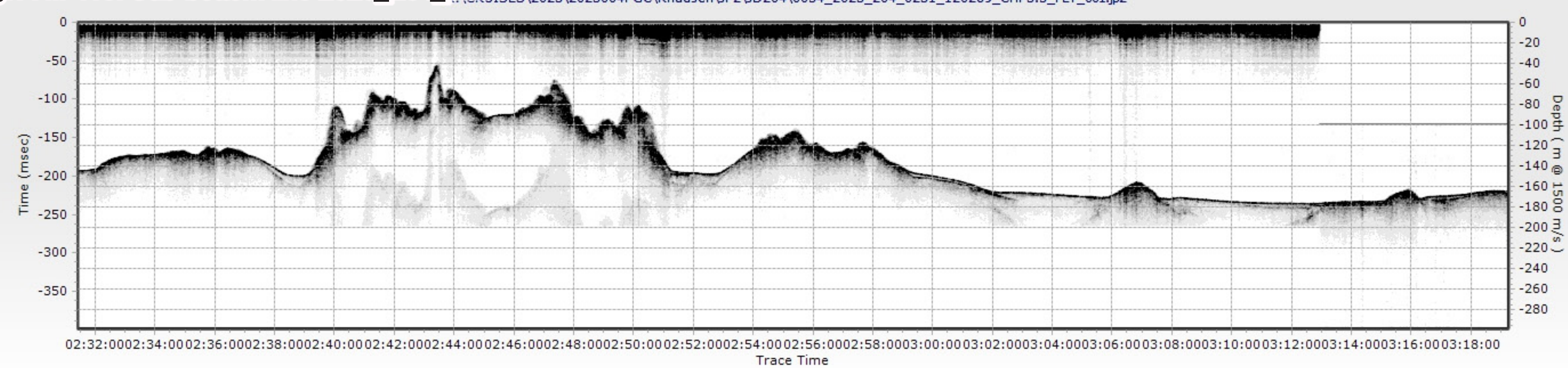
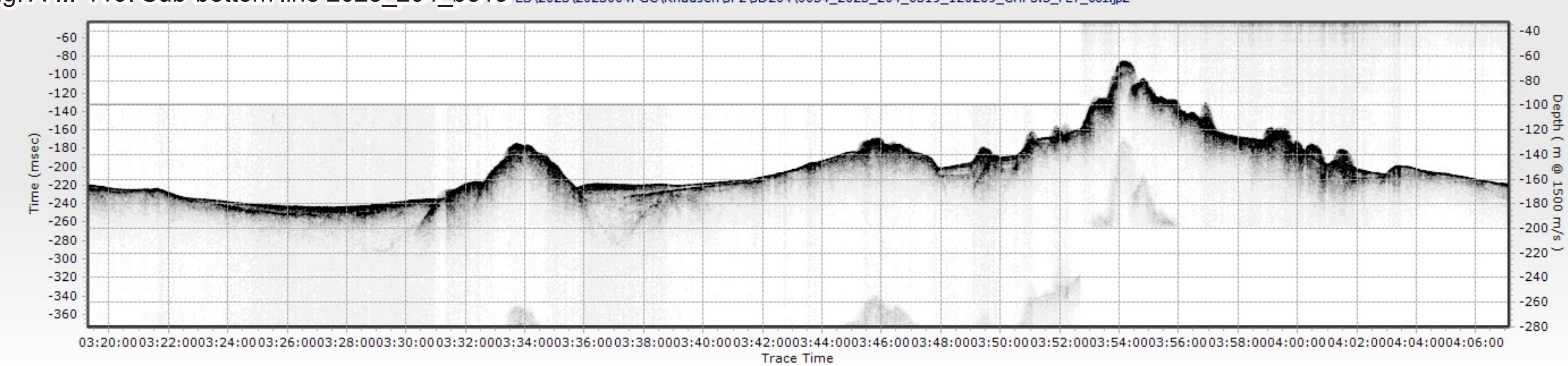


Fig. A-III-119. Sub-bottom line 2023_204_0319



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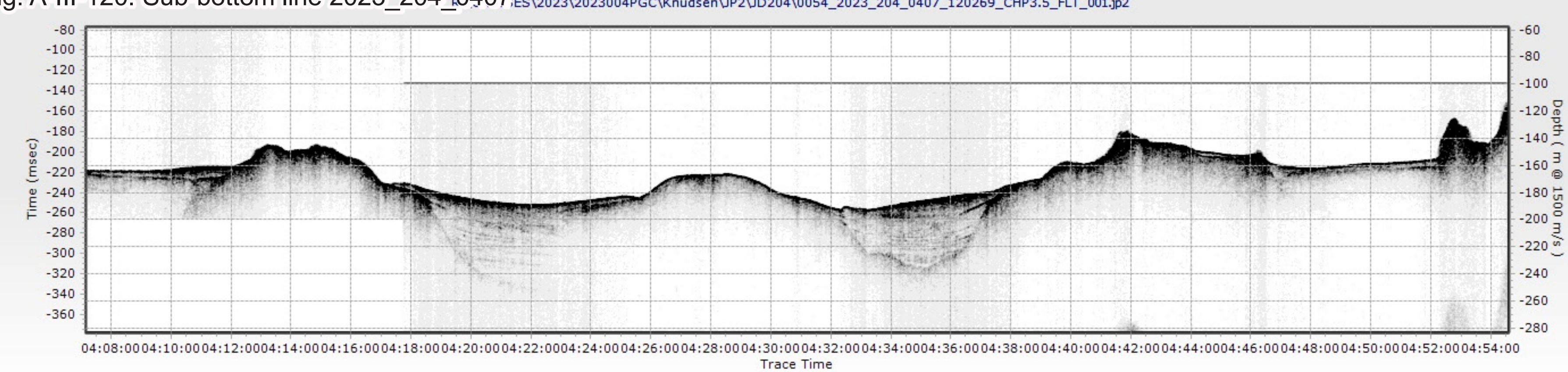


Fig. A-III-121. Sub-bottom line 2023_204_0500

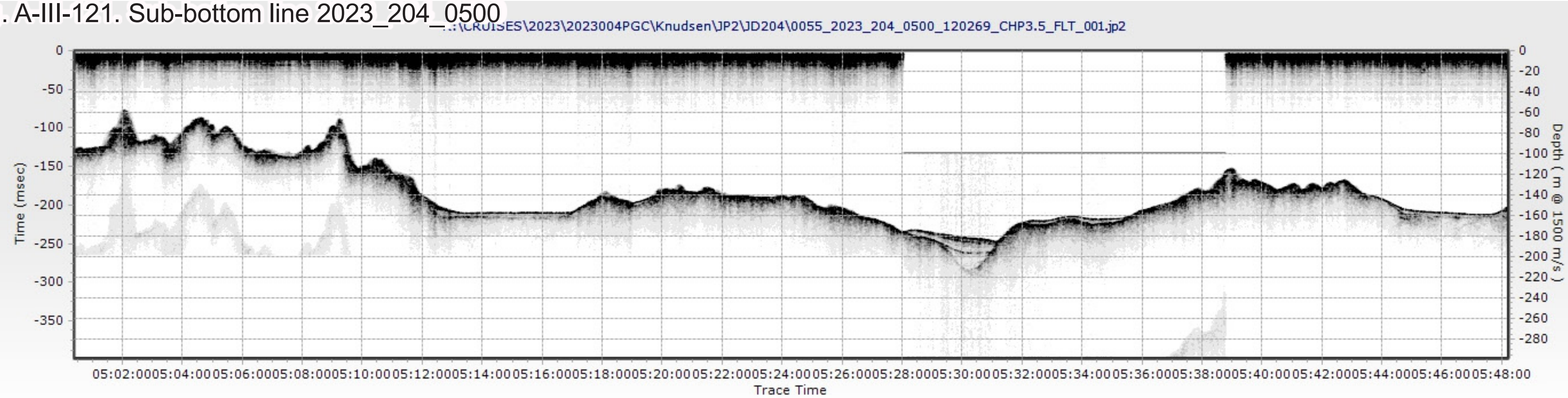


Fig. A-III-122. Sub-bottom line 2023_204_0548

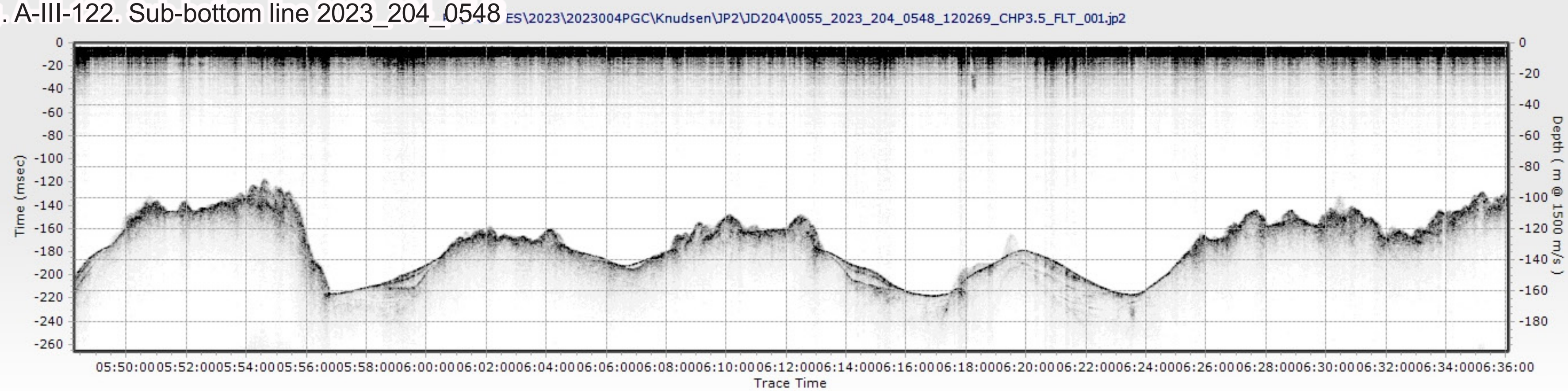


Fig. A-III-123. Sub-bottom line 2023_204_0636

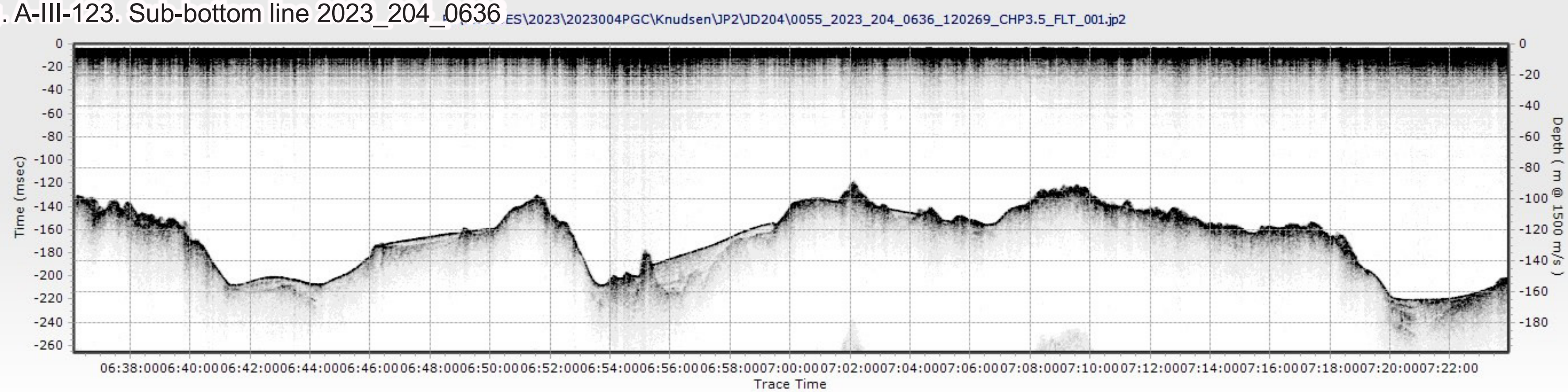


Fig. A-III-124. Sub-bottom line 2023_204_0723

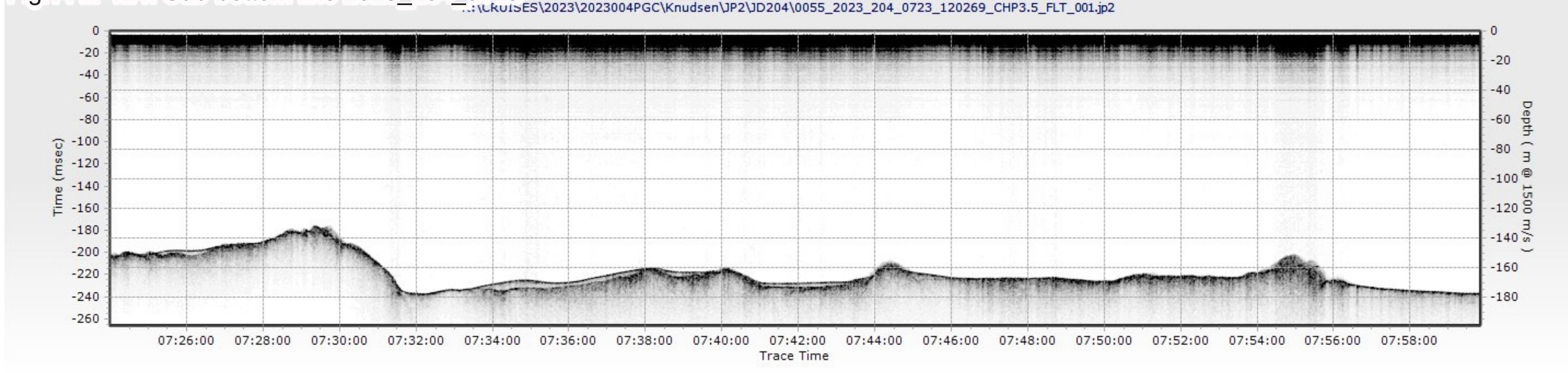


Fig. A-III-125. Sub-bottom line 2023_204_0800

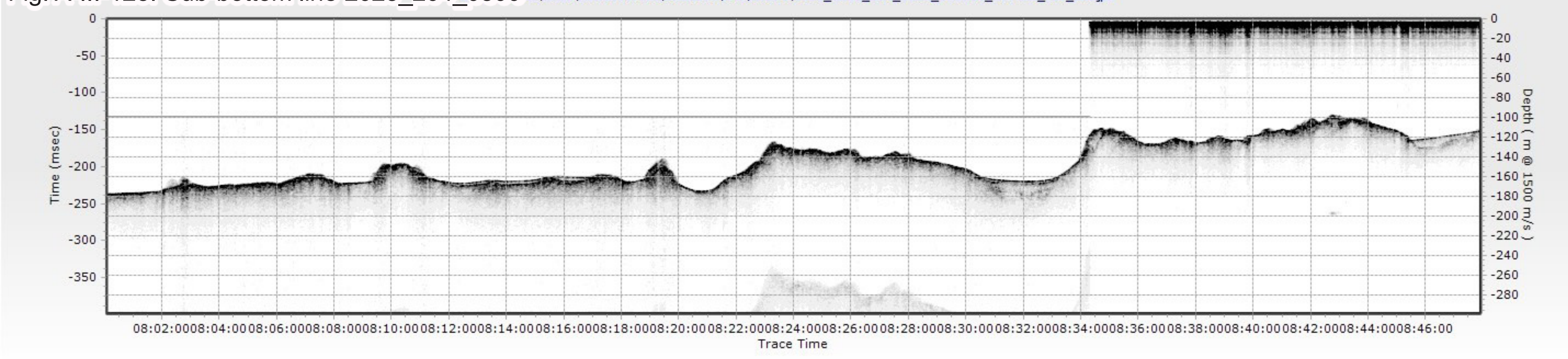


Fig. A-III-126. Sub-bottom line 2023_204_0847

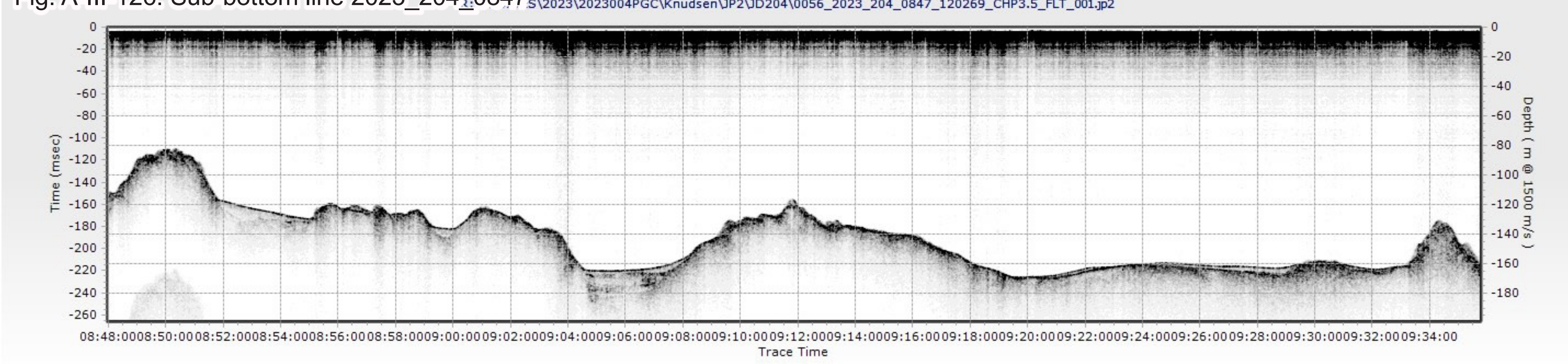


Fig. A-III-127. Sub-bottom line 2023_204_0935

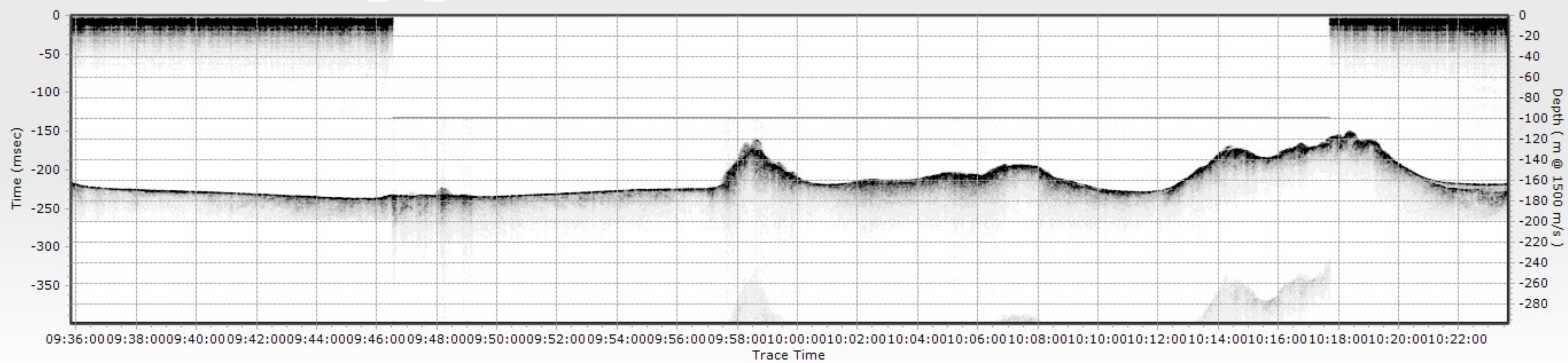


Fig. A-III-128. Sub-bottom line 2023_204_1023

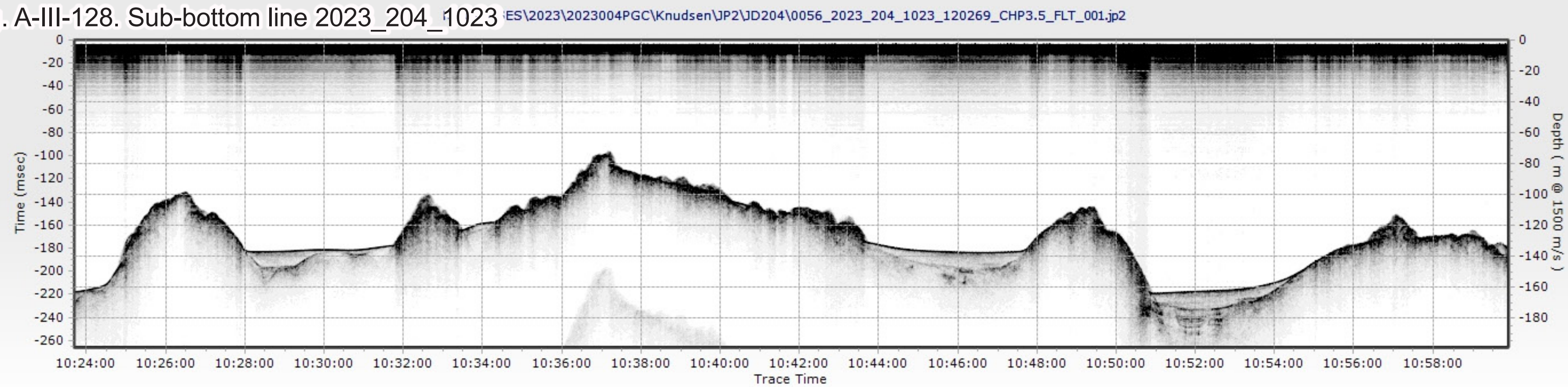


Fig. A-III-129. Sub-bottom line 2023_204_1100

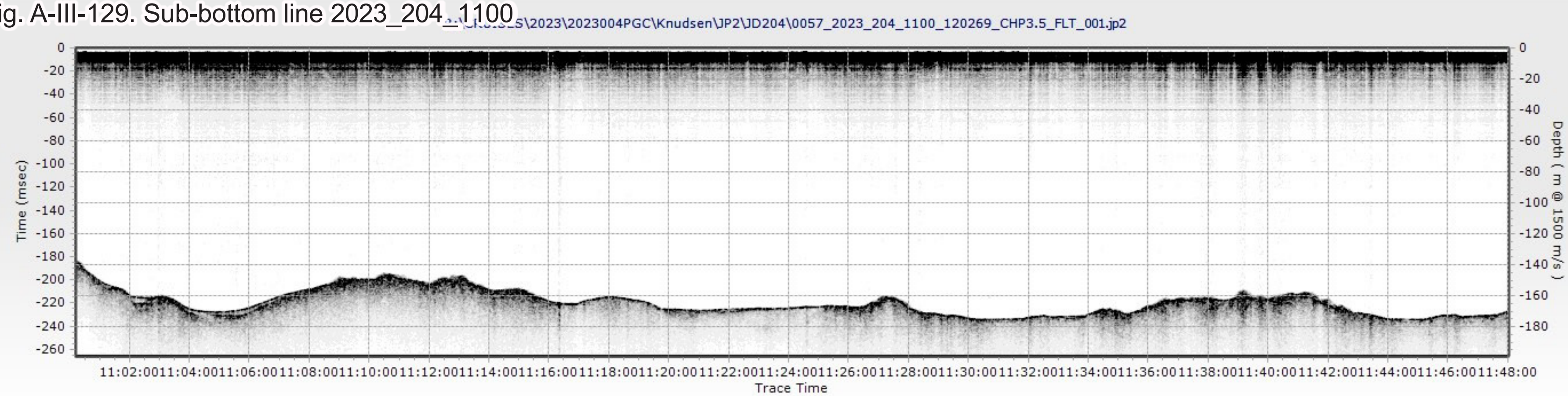


Fig. A-III-130. Sub-bottom line 2023_204_1148

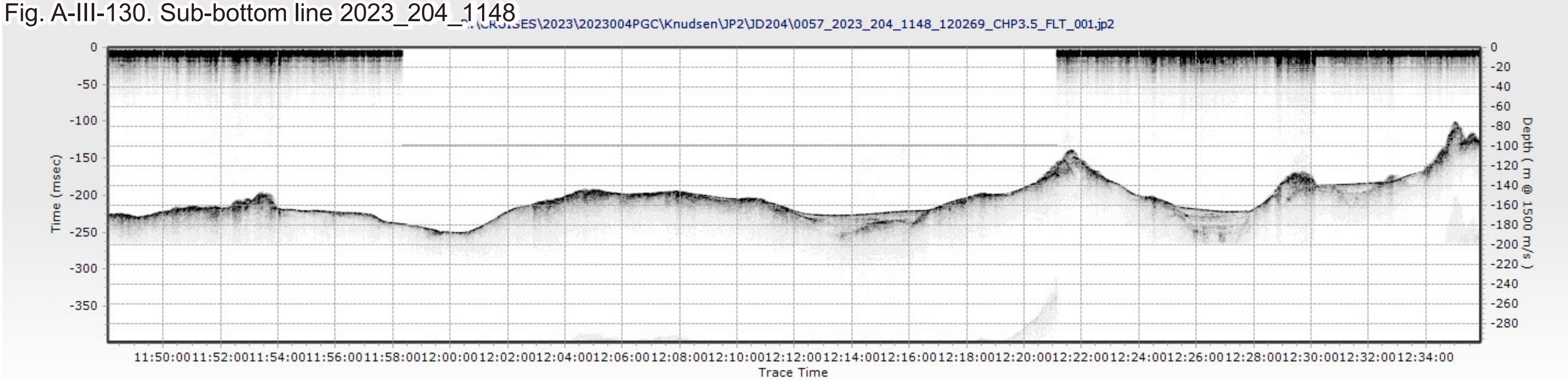
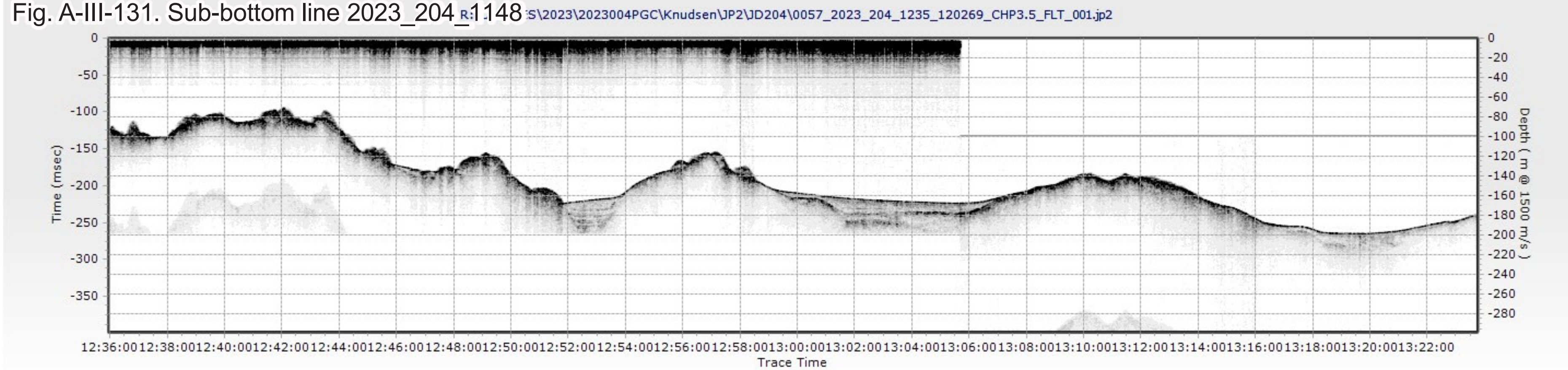


Fig. A-III-131. Sub-bottom line 2023_204_1148



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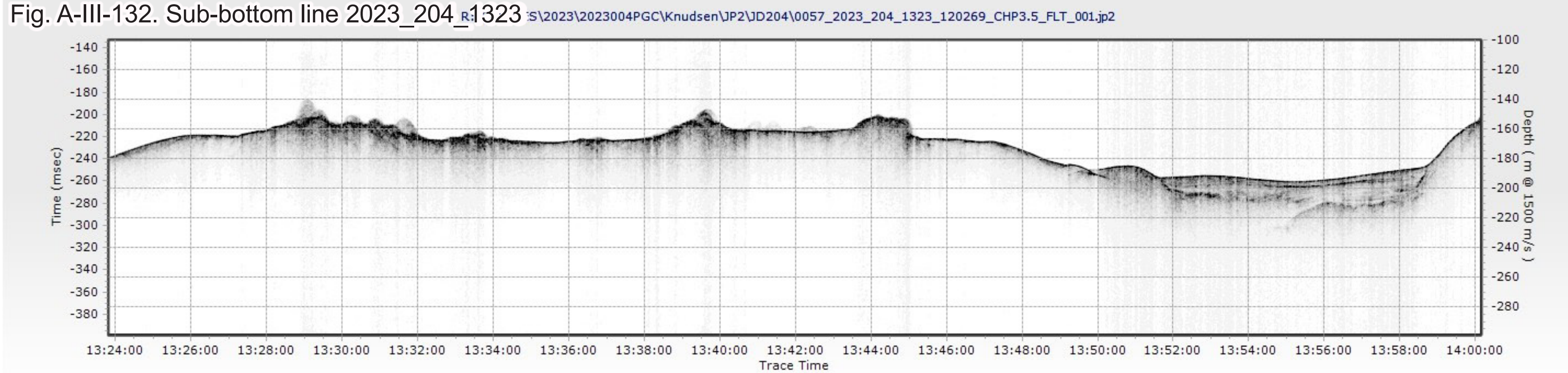


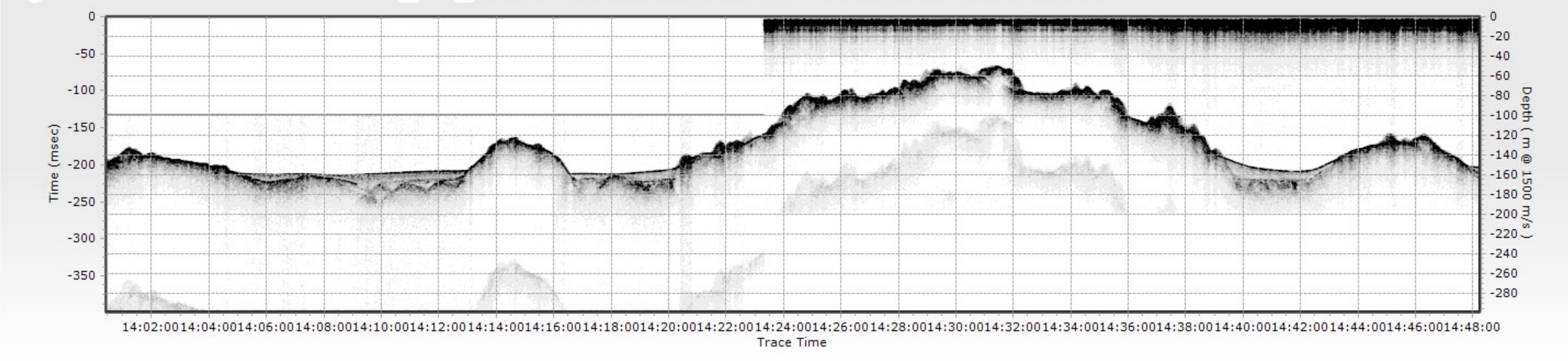
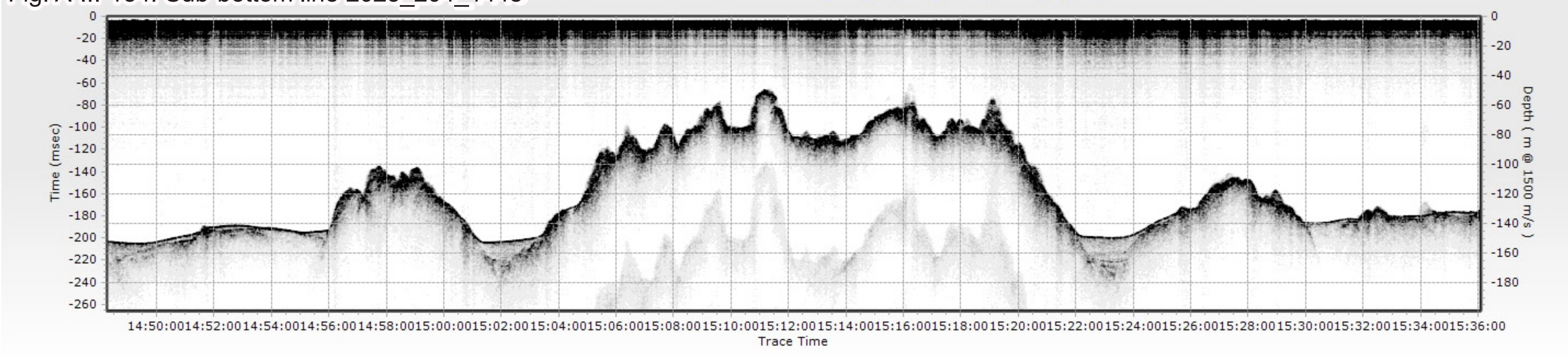


Fig. A-III-133. Sub-bottom line 2023_204_1400



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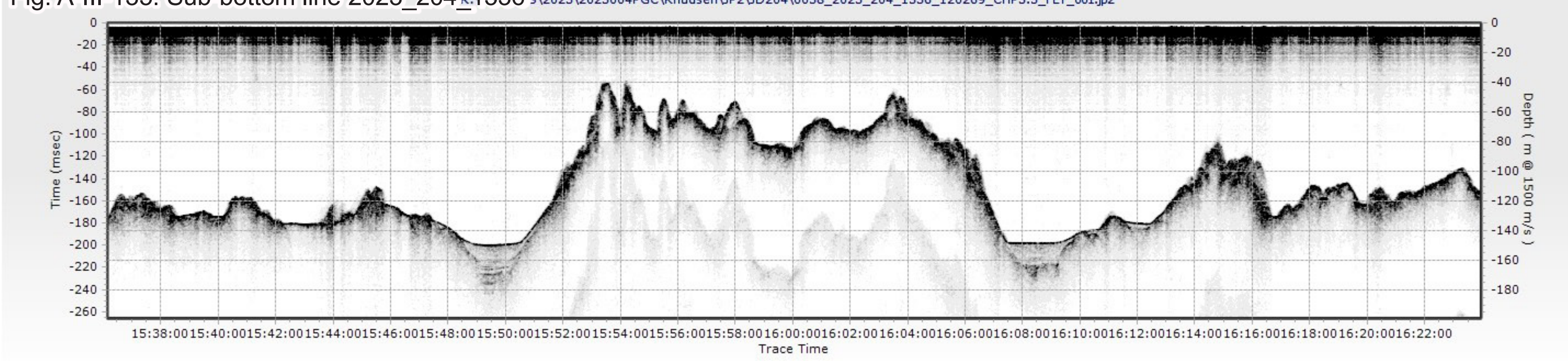


Fig. A-III-135. Sub-bottom line 2023_204_1536

Fig. A-III-136. Sub-bottom line 2023_204_1624

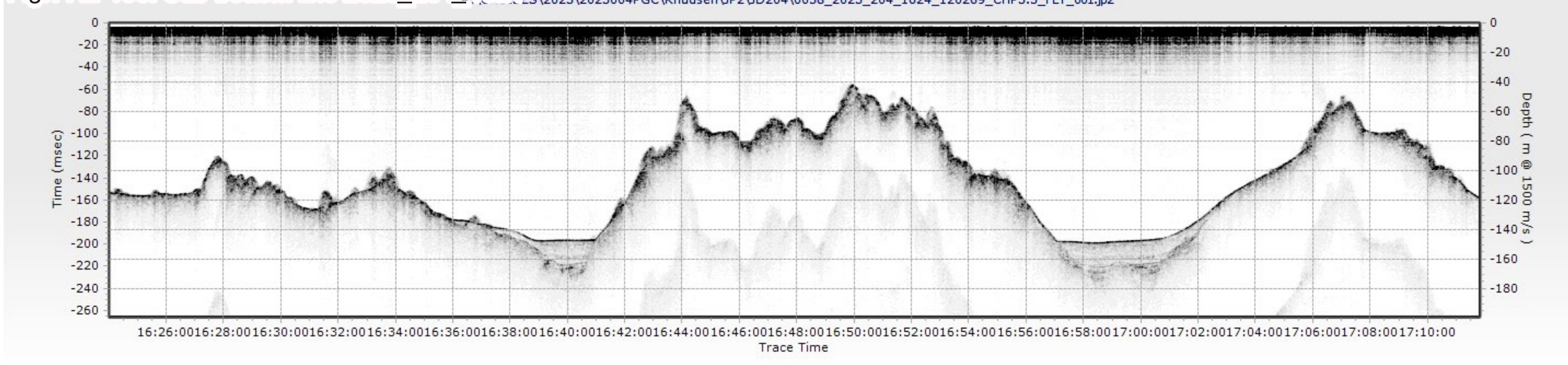


Fig. A-III-137. Sub-bottom line 2023_204_1715

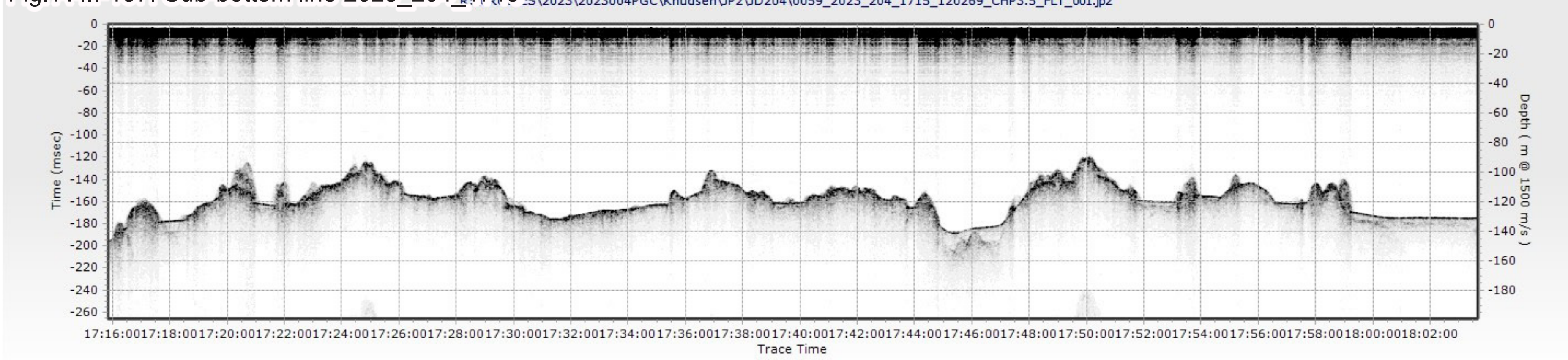


Fig. A-III-138. Sub-bottom line 2023_204_1803

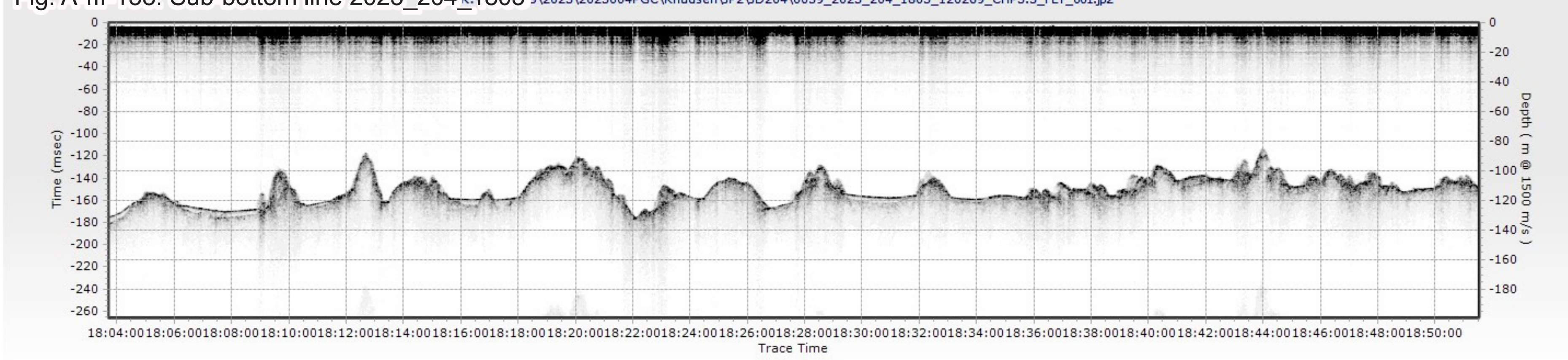


Fig. A-III-139. Sub-bottom line 2023_204_1851

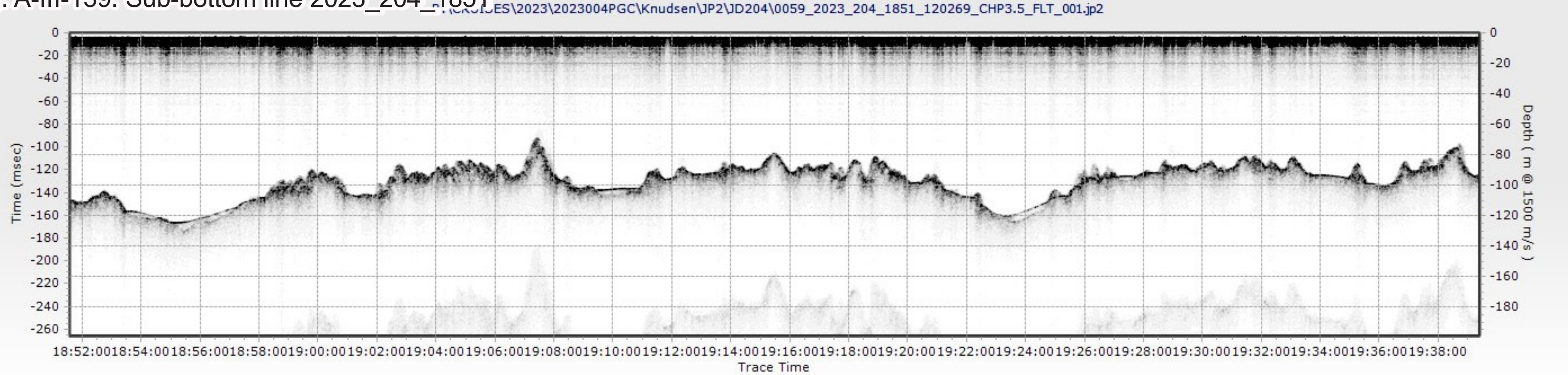


Fig. A-III-140. Sub-bottom line 2023_204_1939

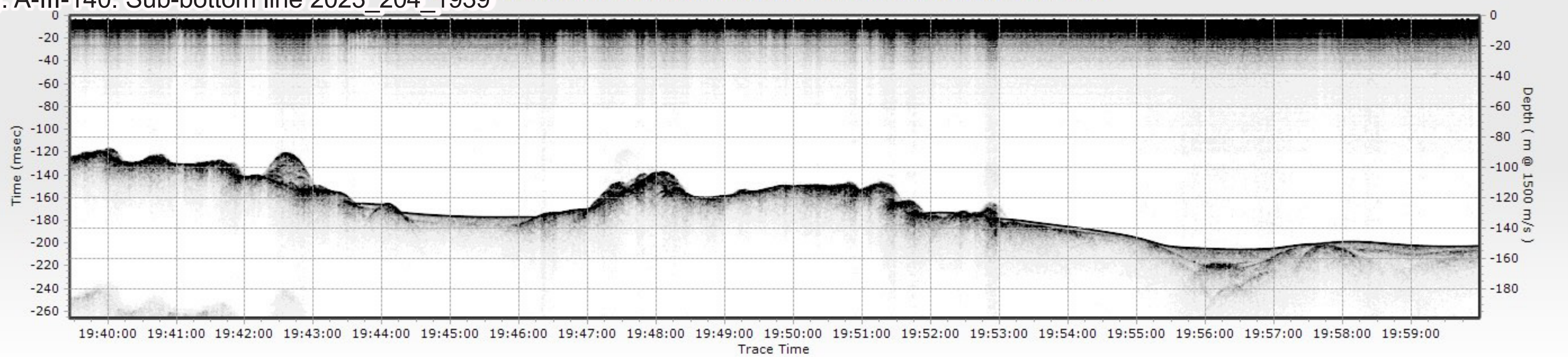


Fig. A-III-141. Sub-bottom line 2023_204_2000

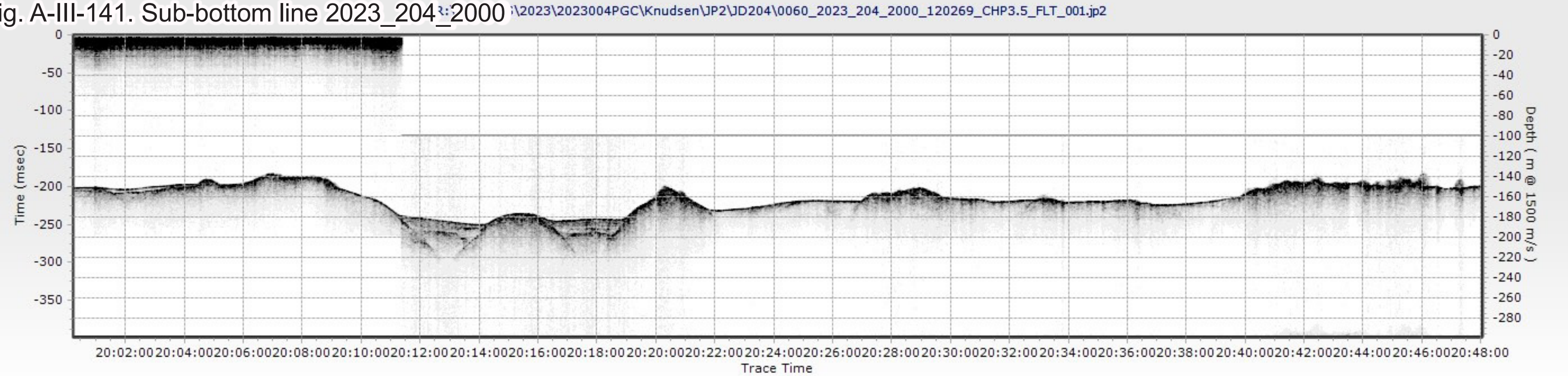
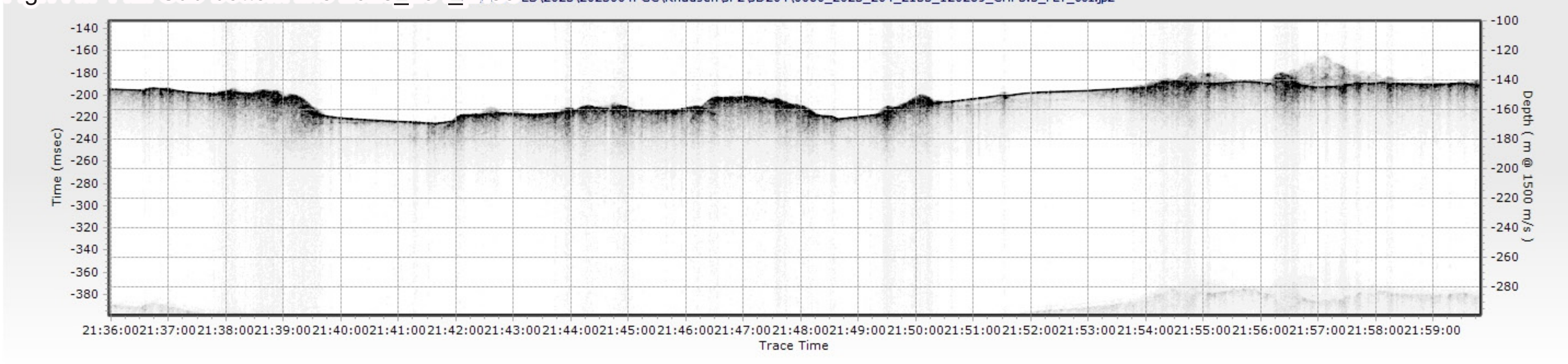


Fig. A-III-142. Sub-bottom line 2023_204_2135



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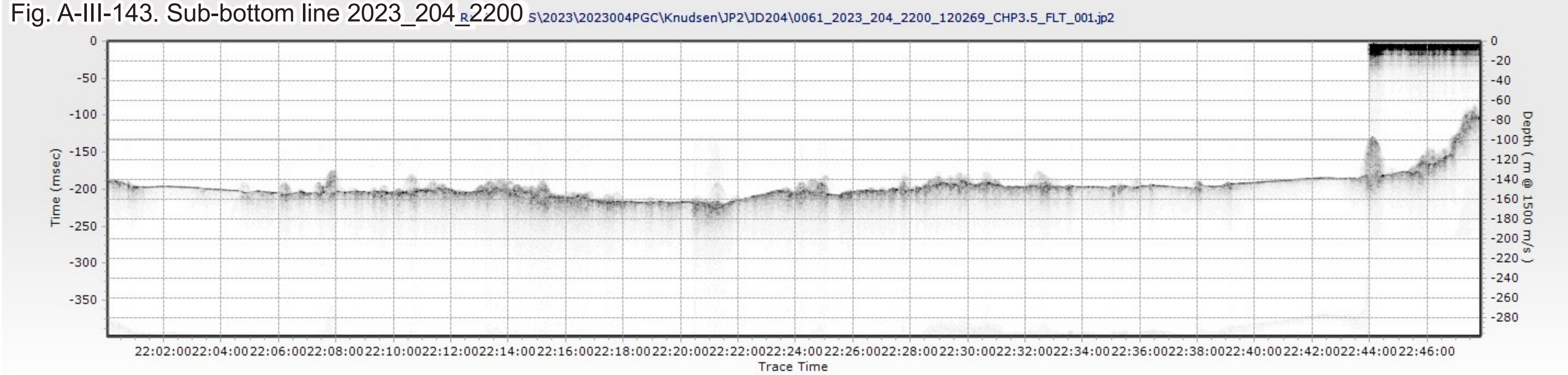
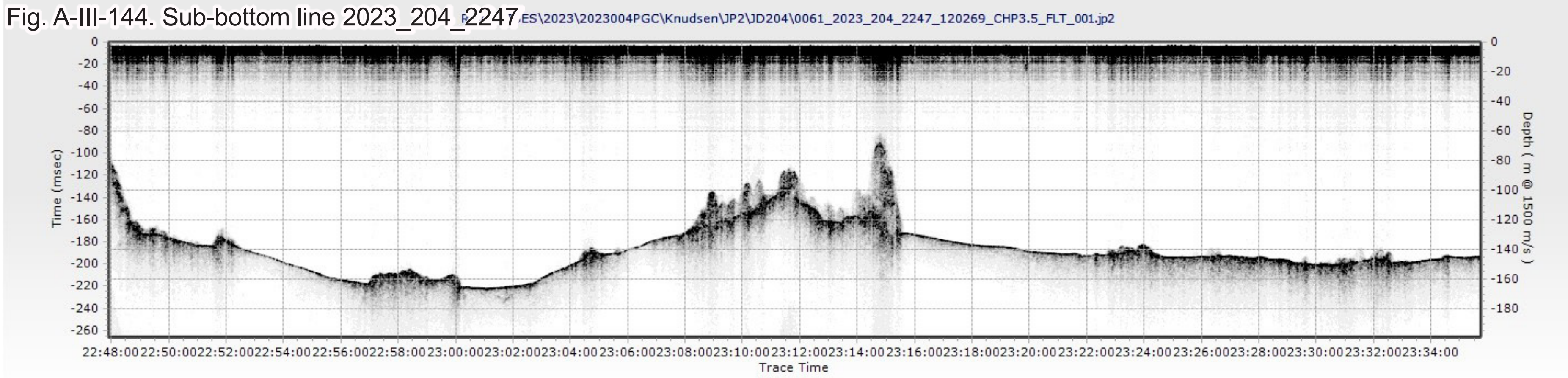


Fig. A-III-144. Sub-bottom line 2023_204_2247



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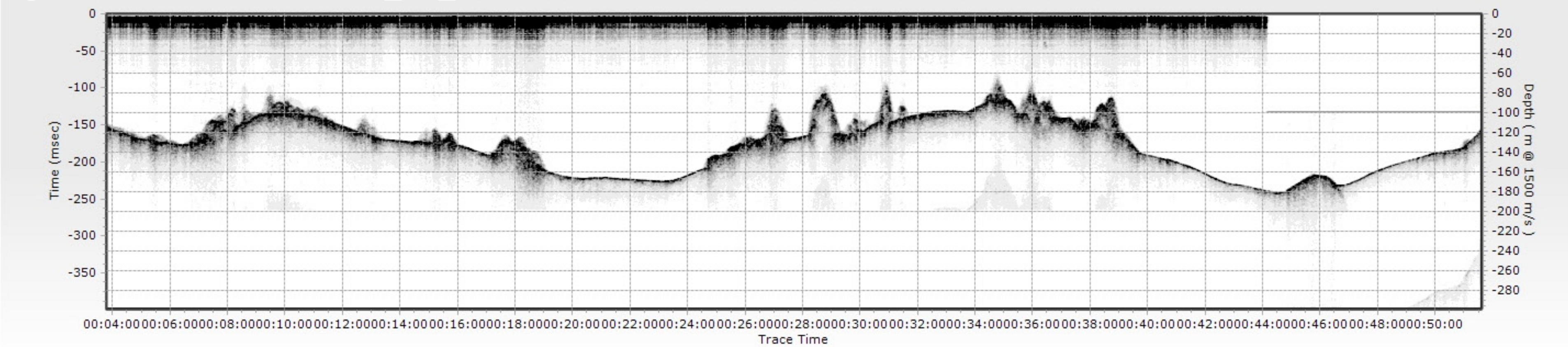

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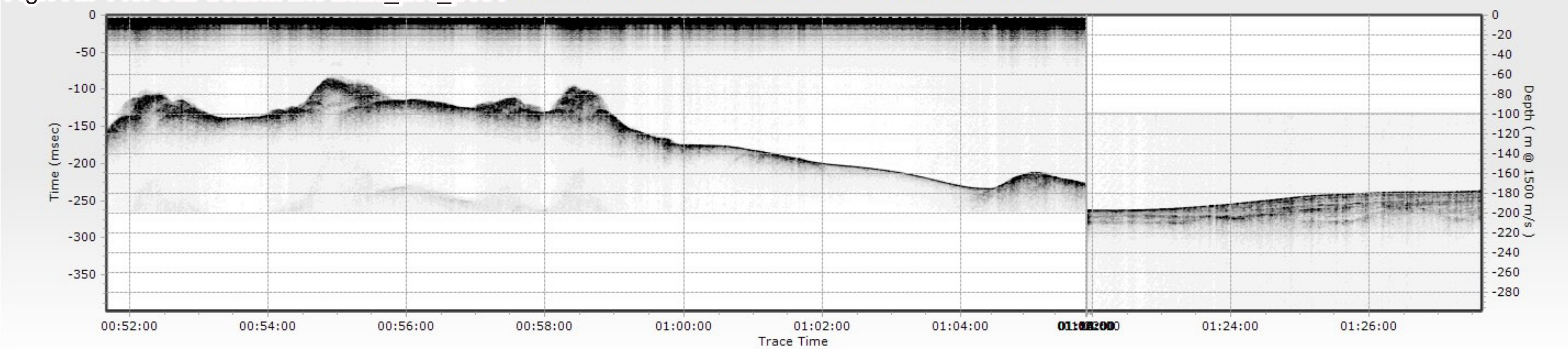


Fig. A-III-147. Sub-bottom line 2023_205_0127

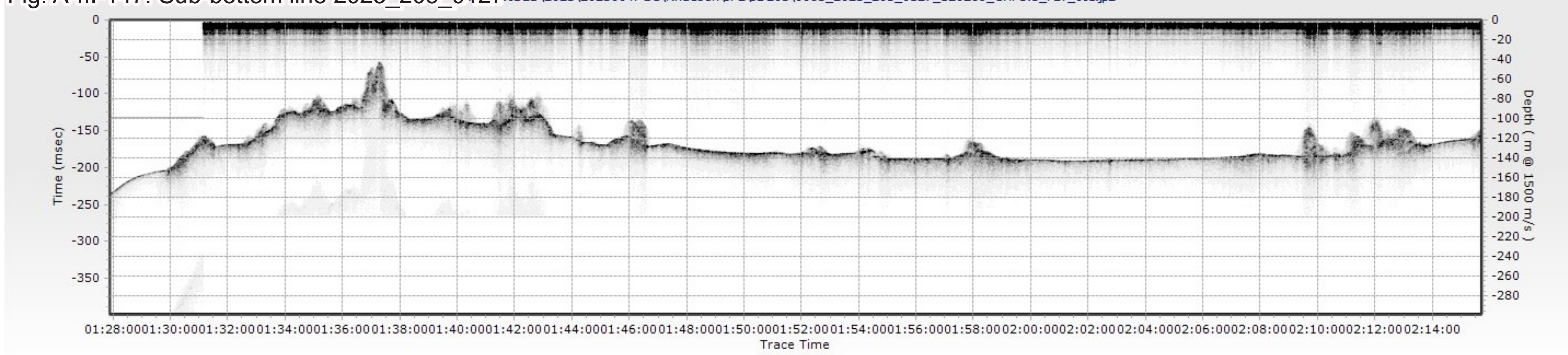
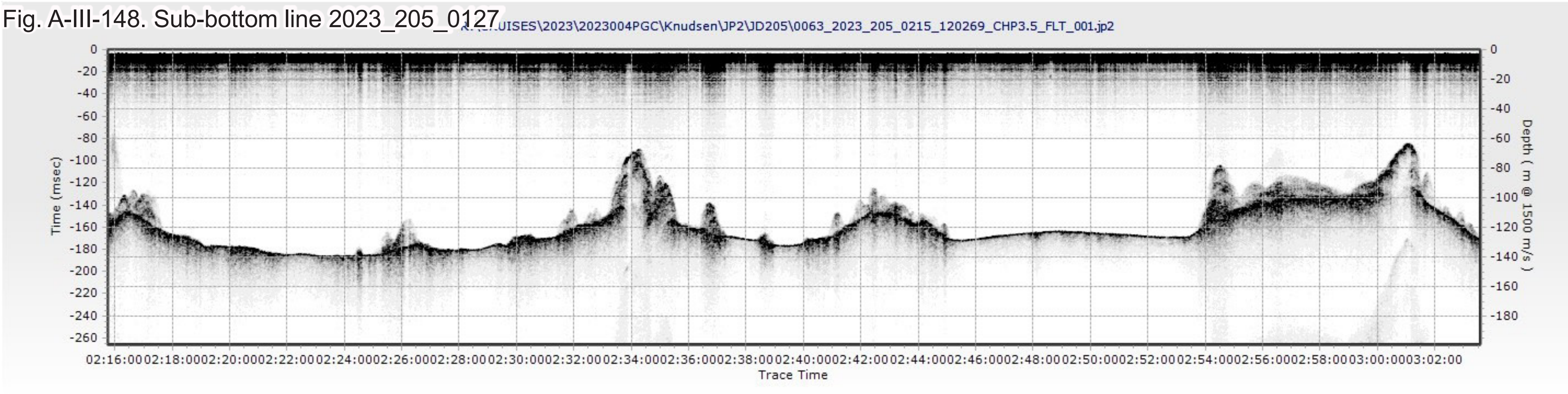


Fig. A-III-148. Sub-bottom line 2023_205_0127



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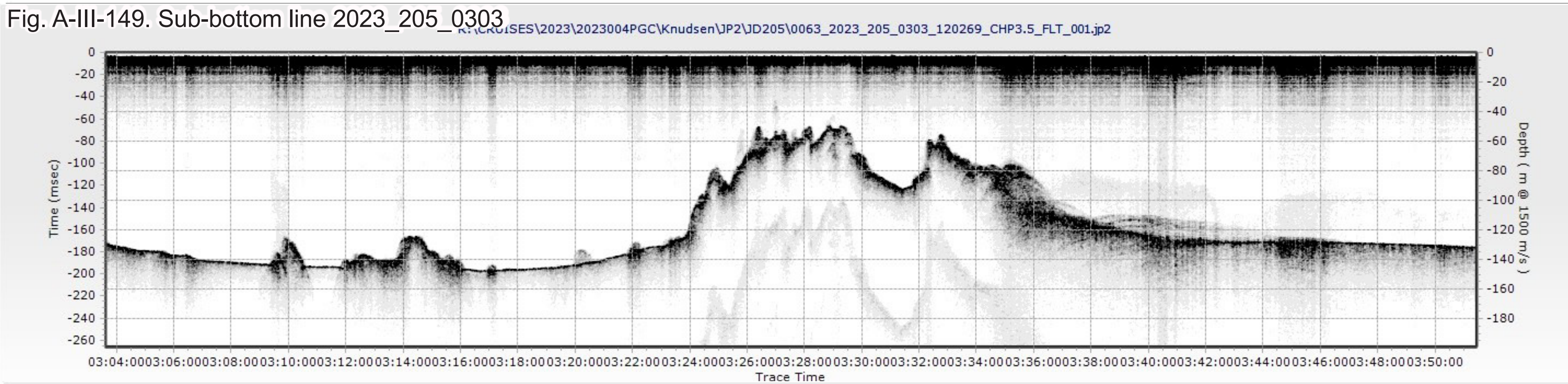
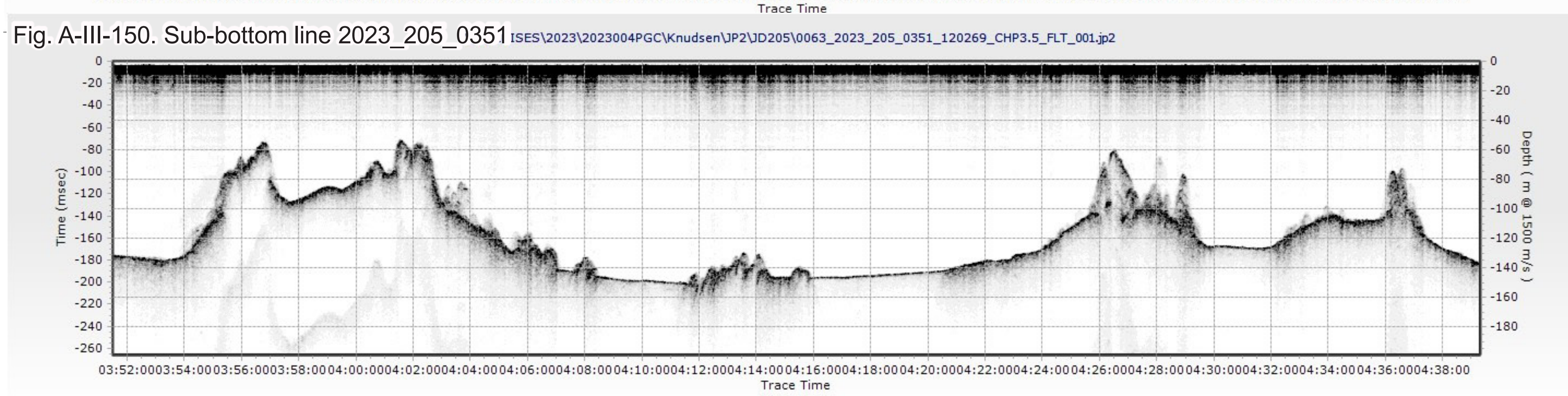


Fig. A-III-150. Sub-bottom line 2023_205_0351



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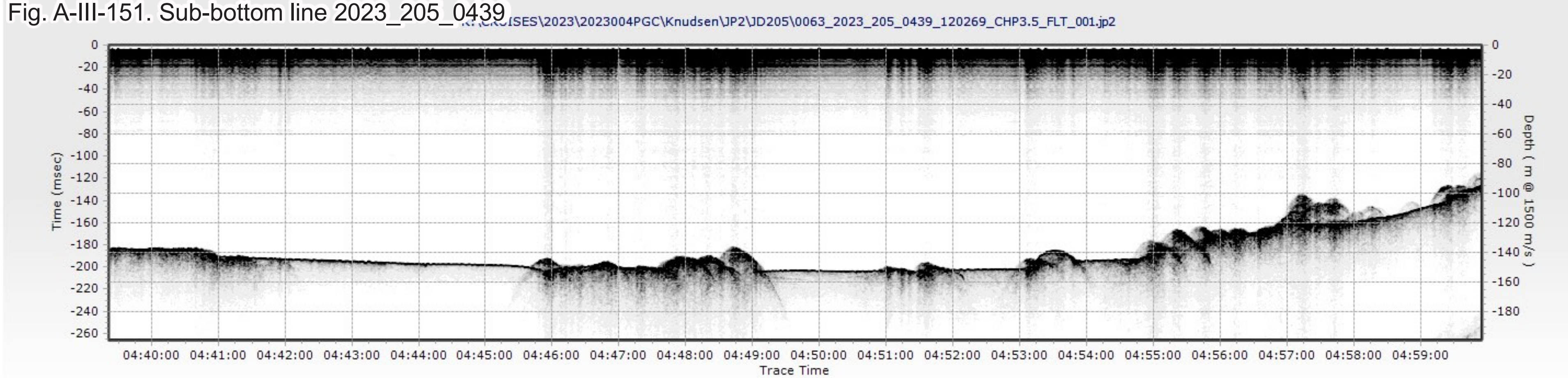


Fig. A-III-152. Sub-bottom line 2023_205_0500

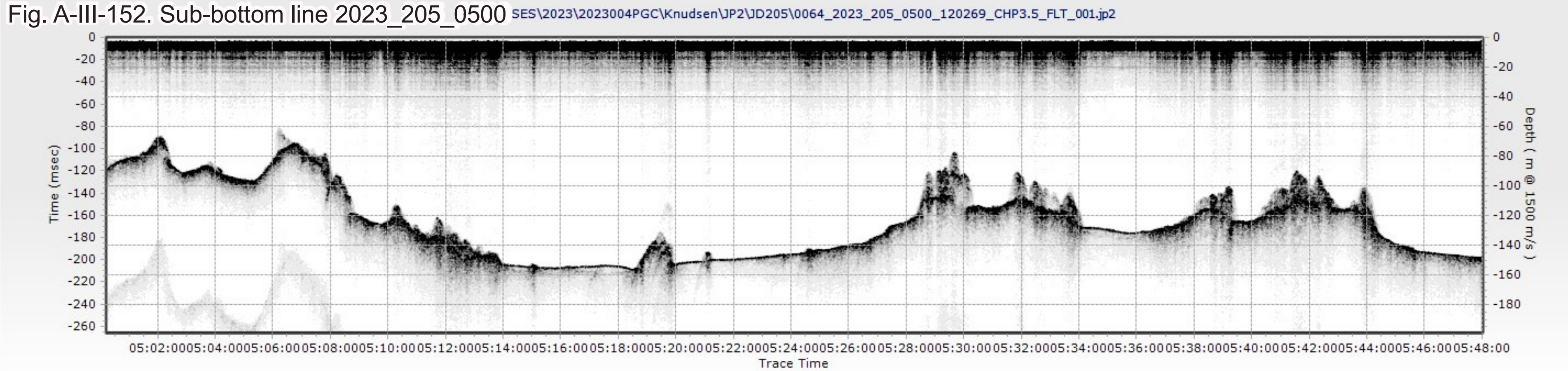


Fig. A-III-153. Sub-bottom line 2023_205_0548

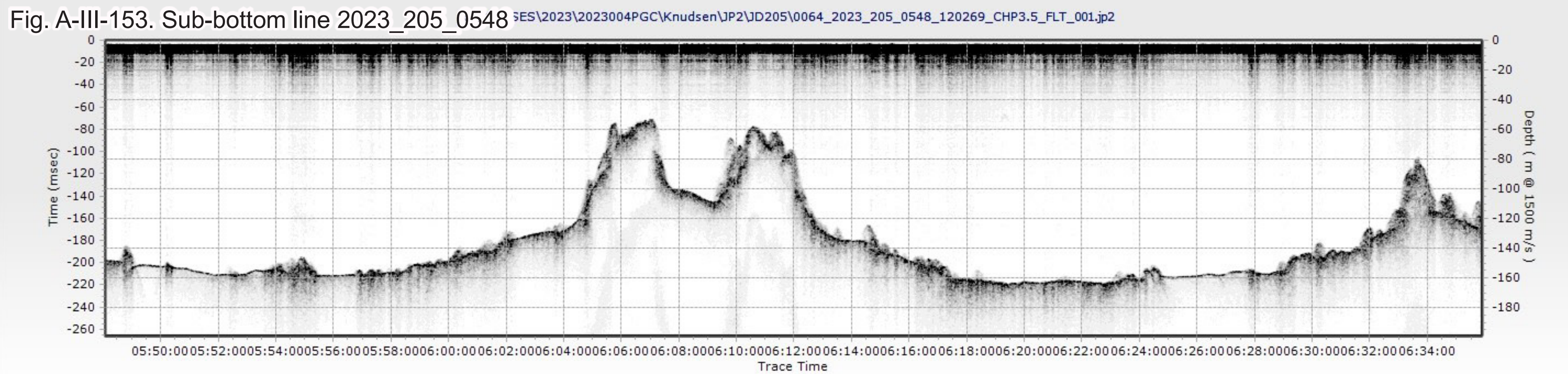


Fig. A-III-154. Sub-bottom line 2023_205_0635

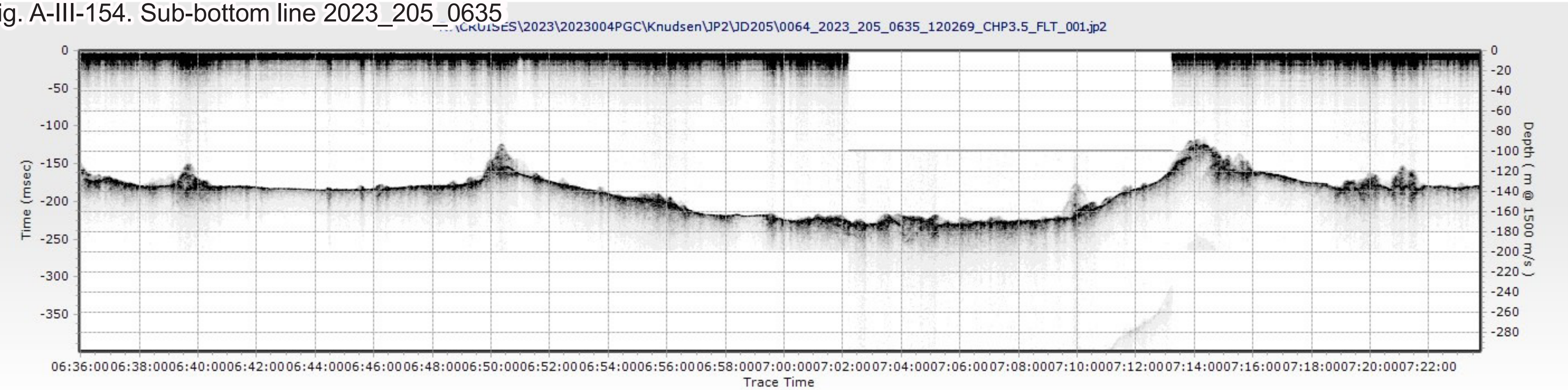


Fig. A-III-155. Sub-bottom line 2023_205_0723

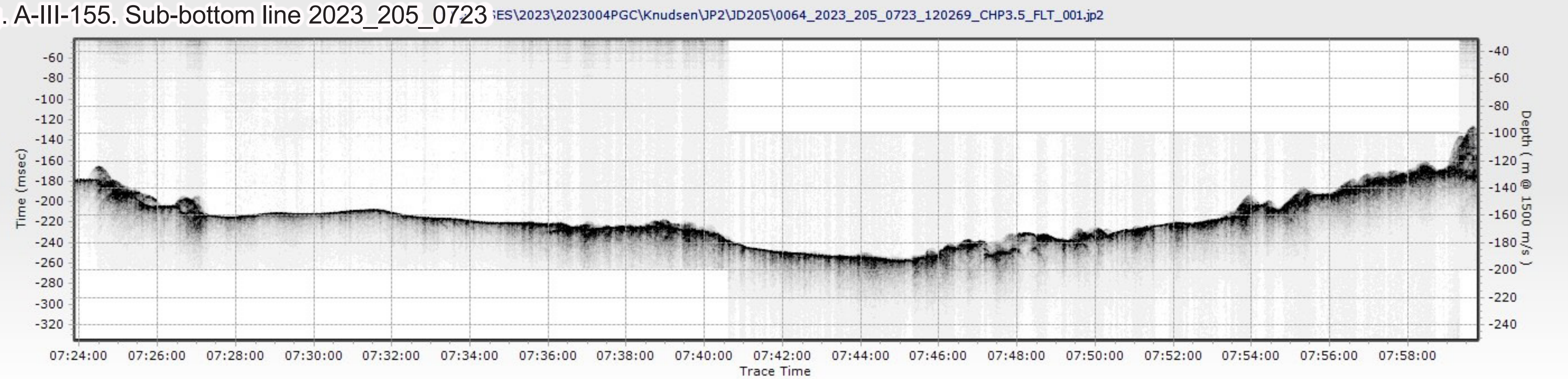


Fig. A-III-156. Sub-bottom line 2023_205_0800

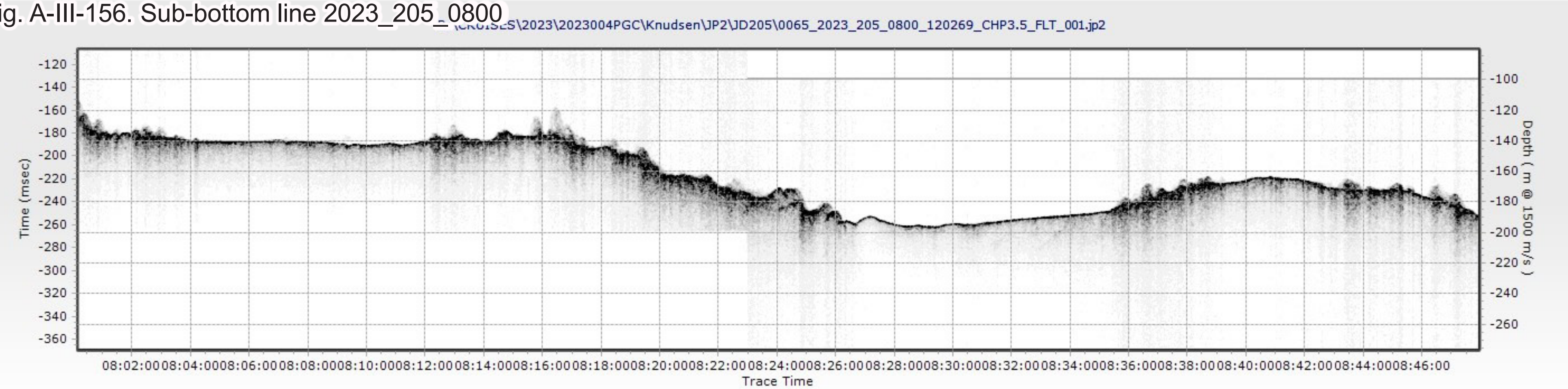
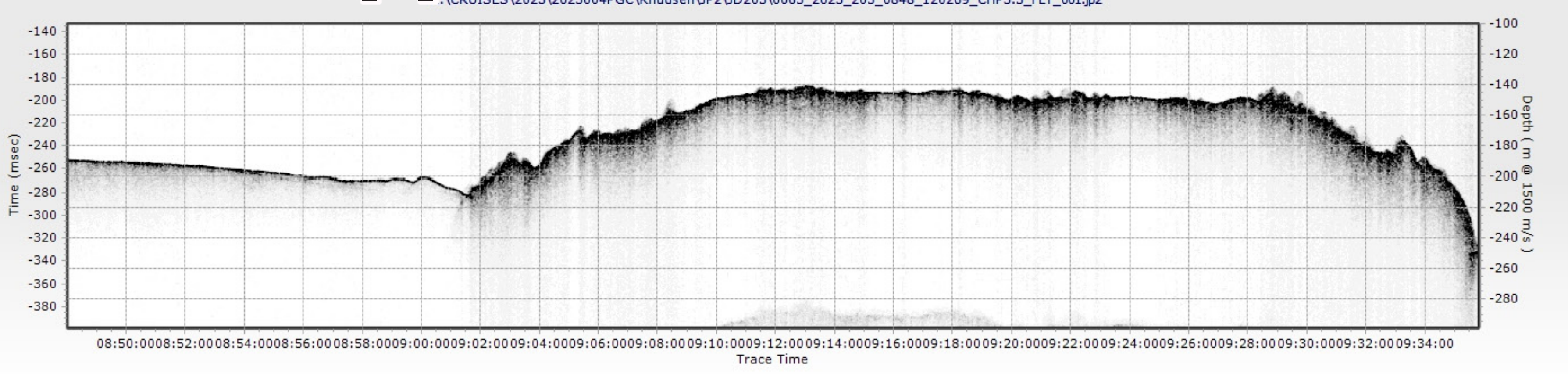


Fig. A-III-157. Sub-bottom line 2023_205_0848



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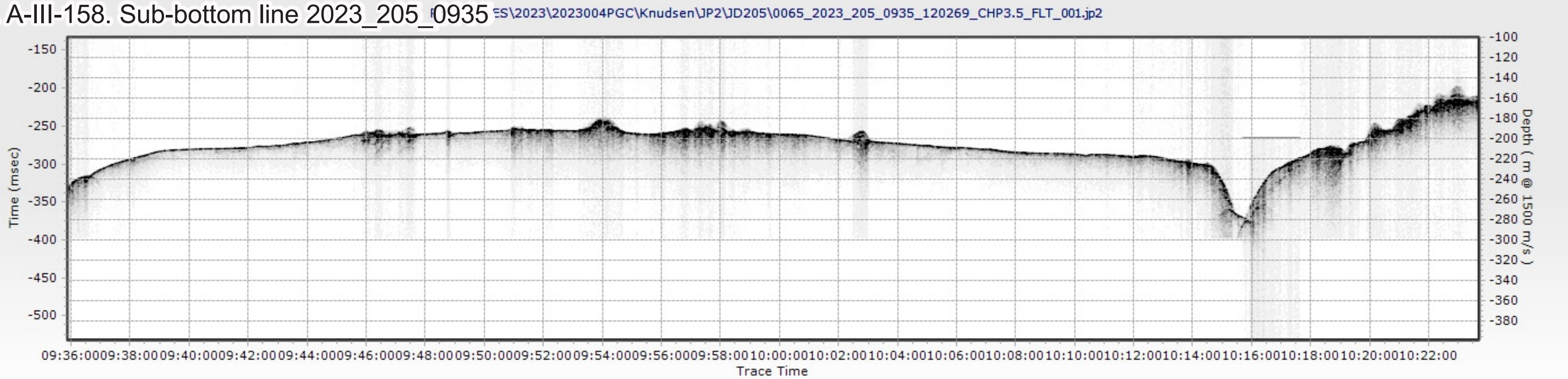


Fig. A-III-159. Sub-bottom line 2023_205_1147

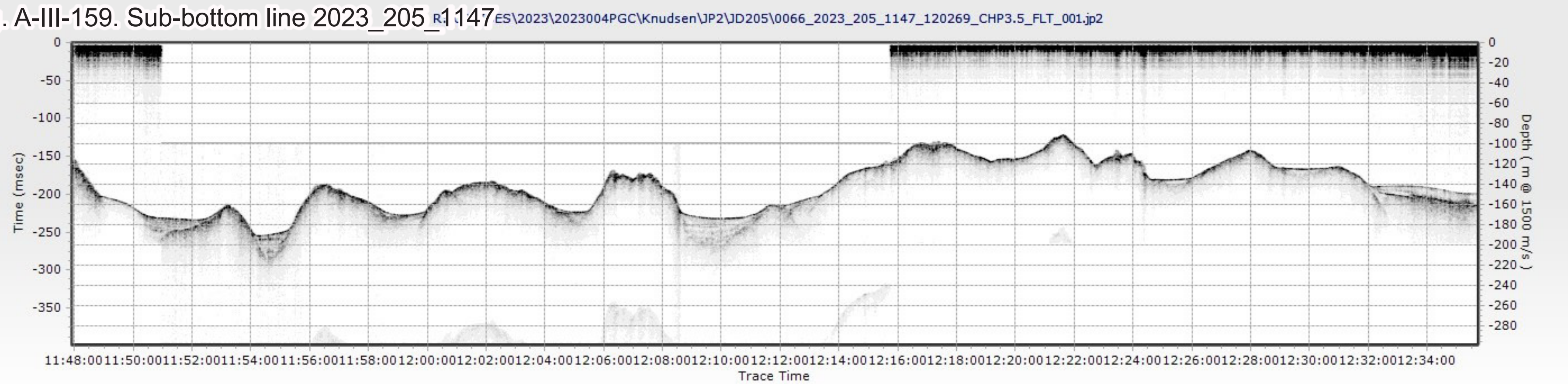


Fig. A-III-160. Sub-bottom line 2023_205_1235

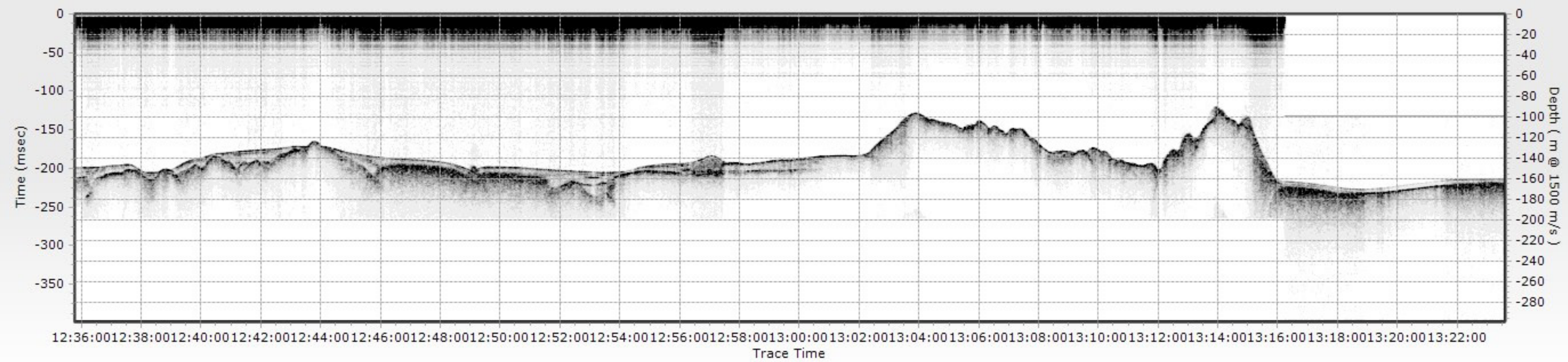


Fig. A-III-161. Sub-bottom line 2023_205_1323

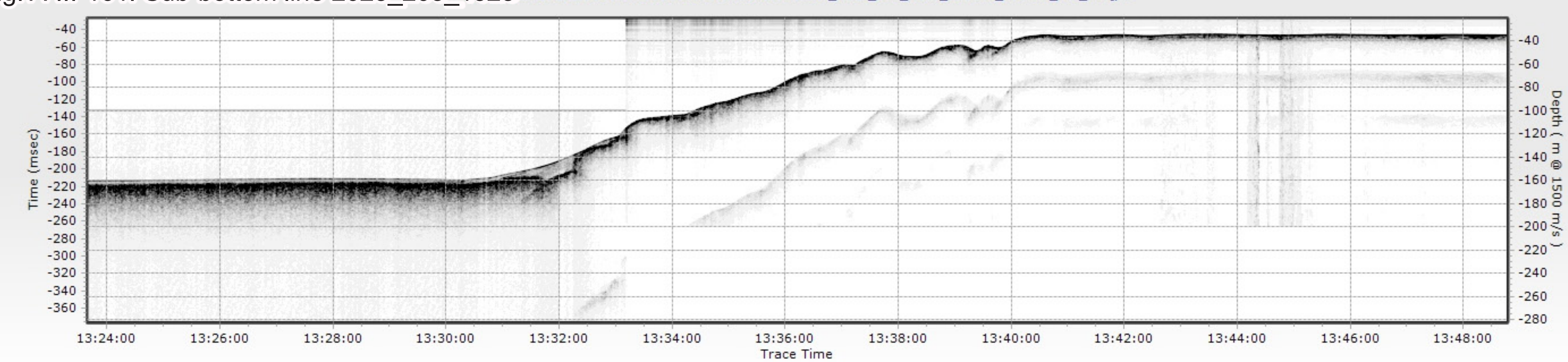


Fig. A-III-162. Sub-bottom line 2023_205_2108

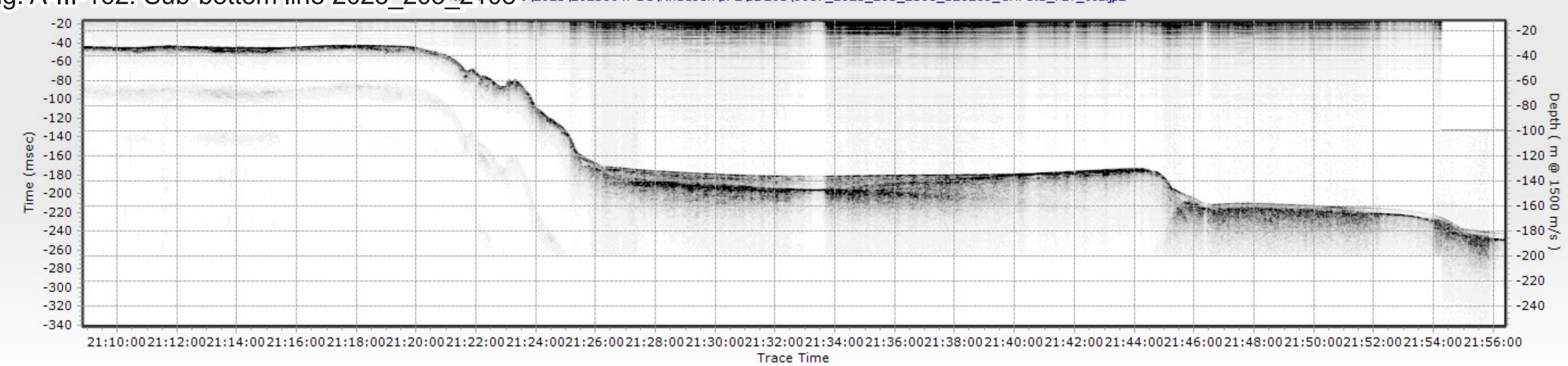


Fig. A-III-163. Sub-bottom line 2023_205_2156

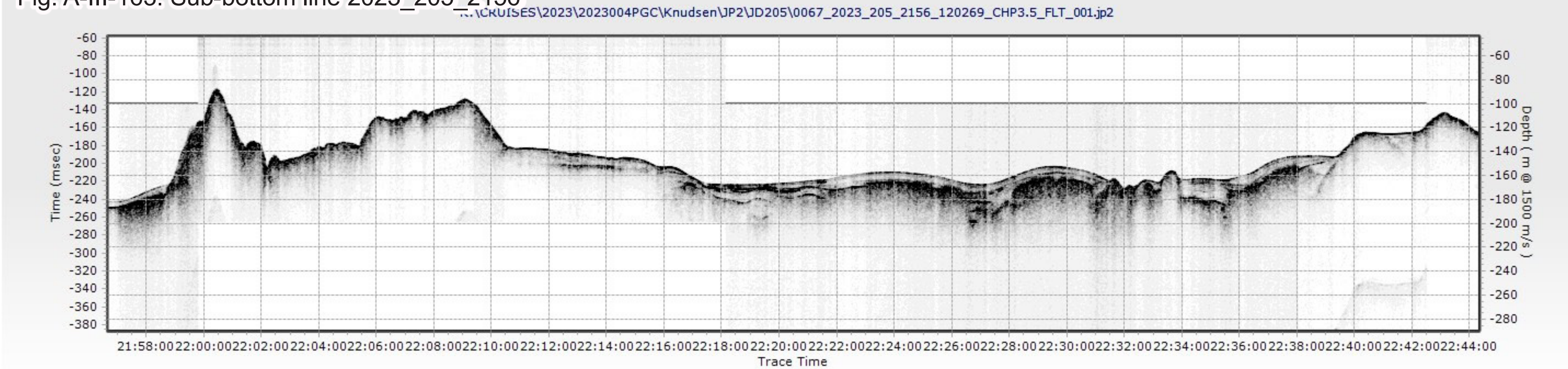


Fig. A-III-164. Sub-bottom line 2023_205_2244

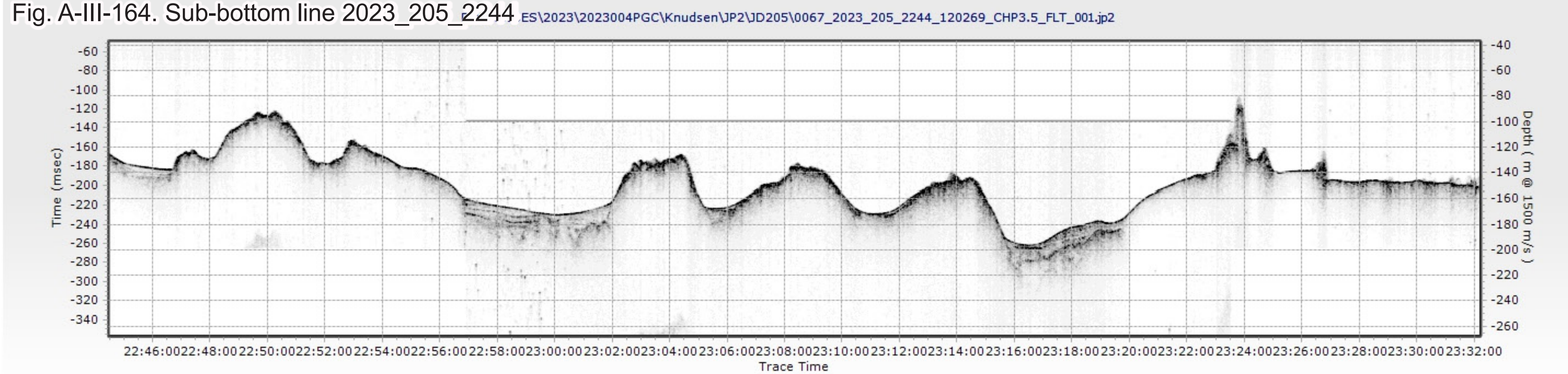
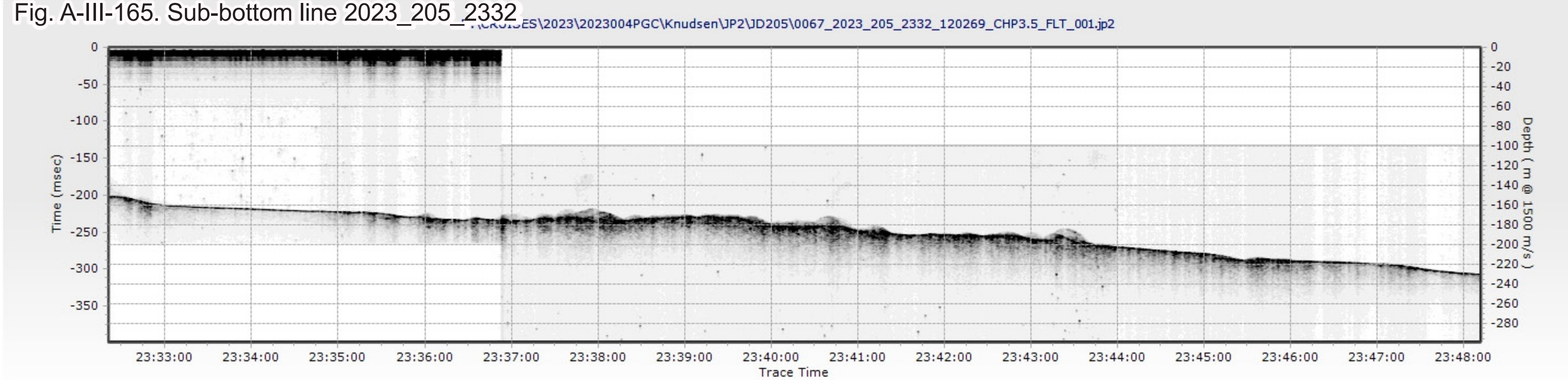


Fig. A-III-165. Sub-bottom line 2023_205_2332



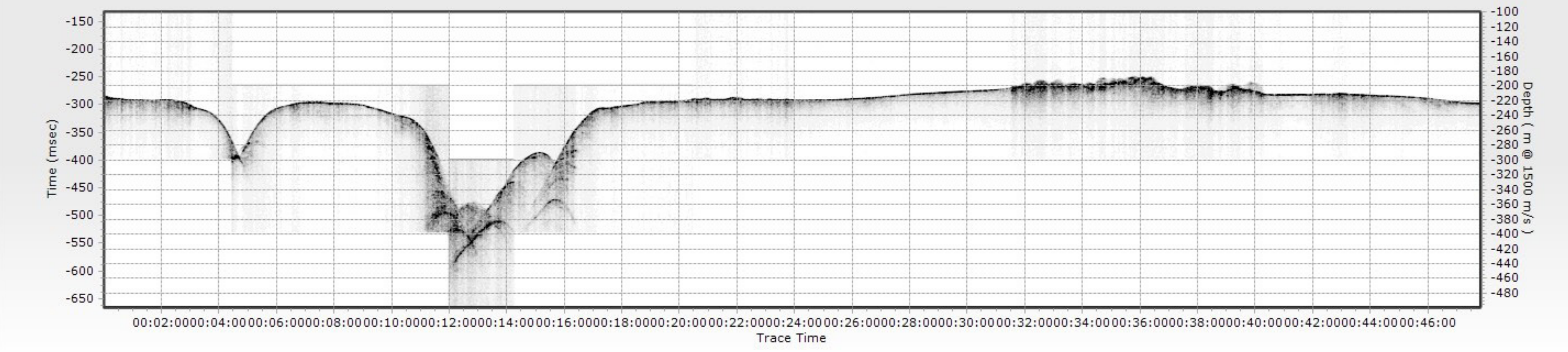


Fig. A-III-166. Sub-bottom line 2023_206_0000

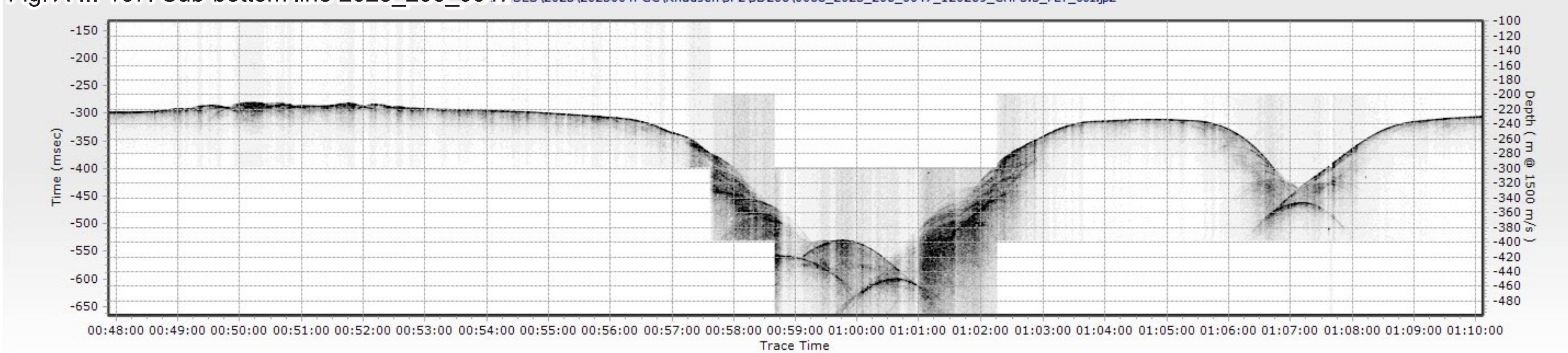


Fig. A-III-167. Sub-bottom line 2023_206_0047

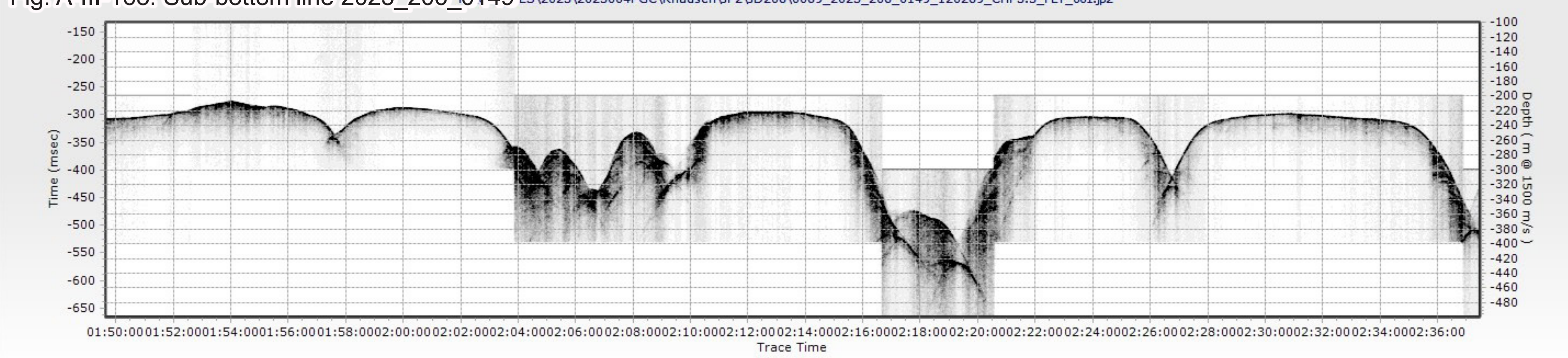


Fig. A-III-168. Sub-bottom line 2023_206_0149

Fig. A-III-169. Sub-bottom line 2023_206_0237

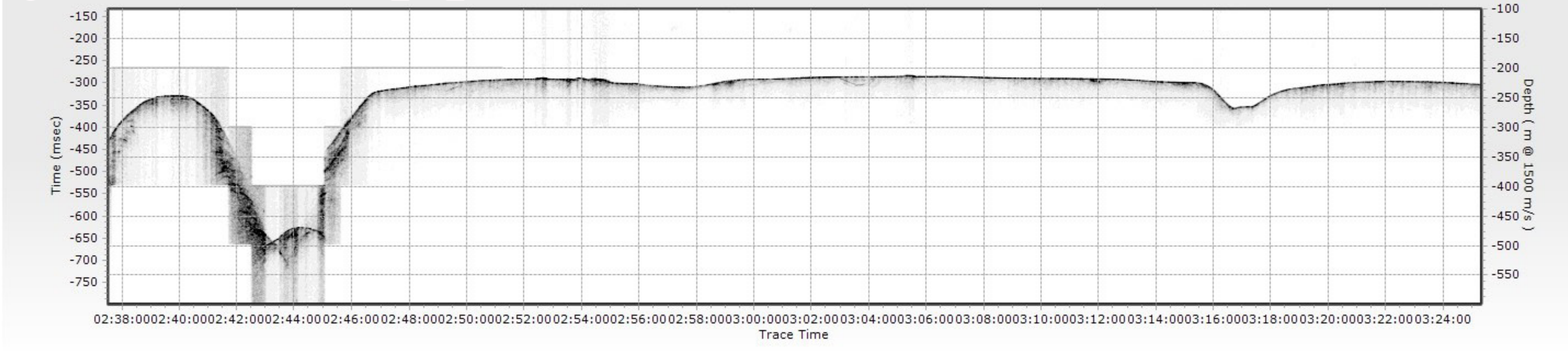


Fig. A-III-170. Sub-bottom line 2023_206_0325

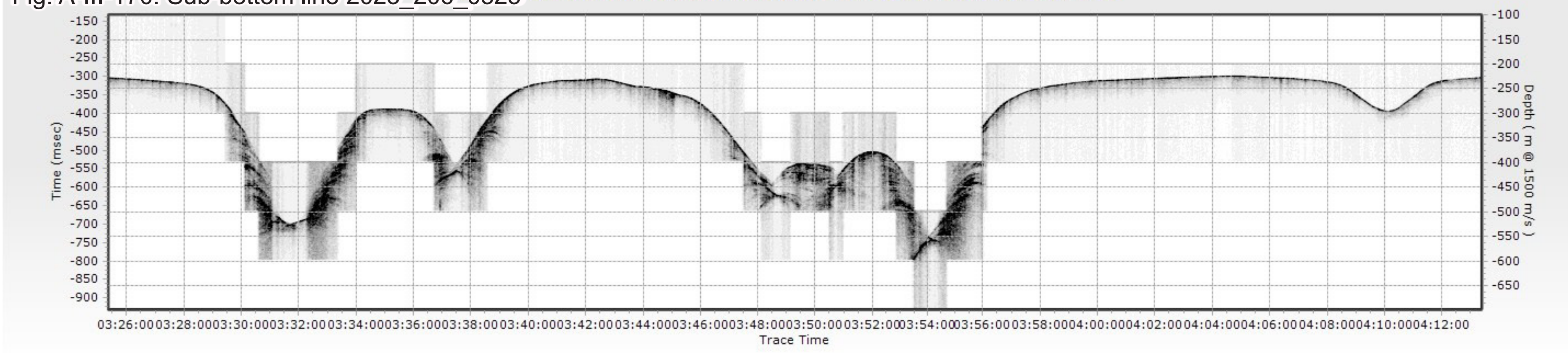


Fig. A-III-171. Sub-bottom line 2023_206_0413

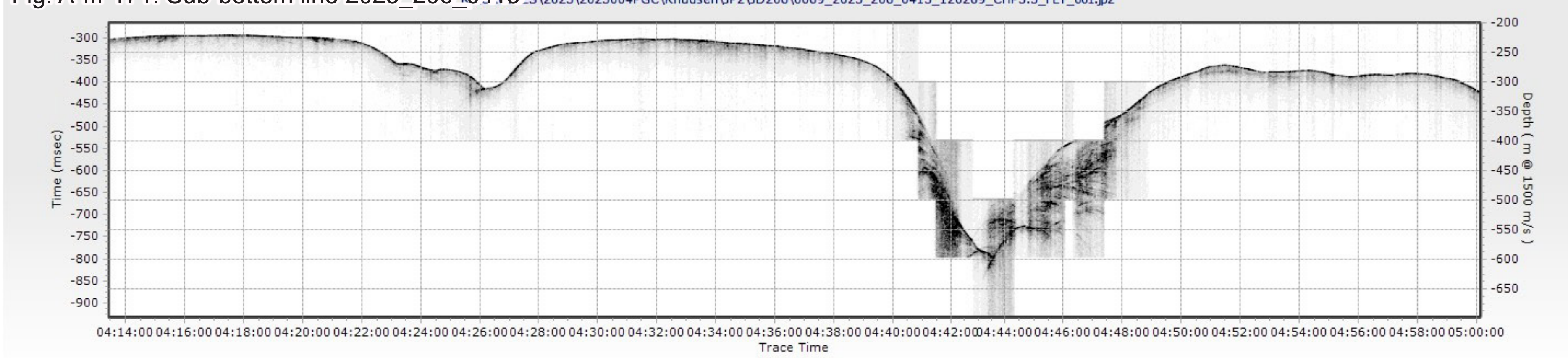


Fig. A-III-172. Sub-bottom line 2023_206_0500

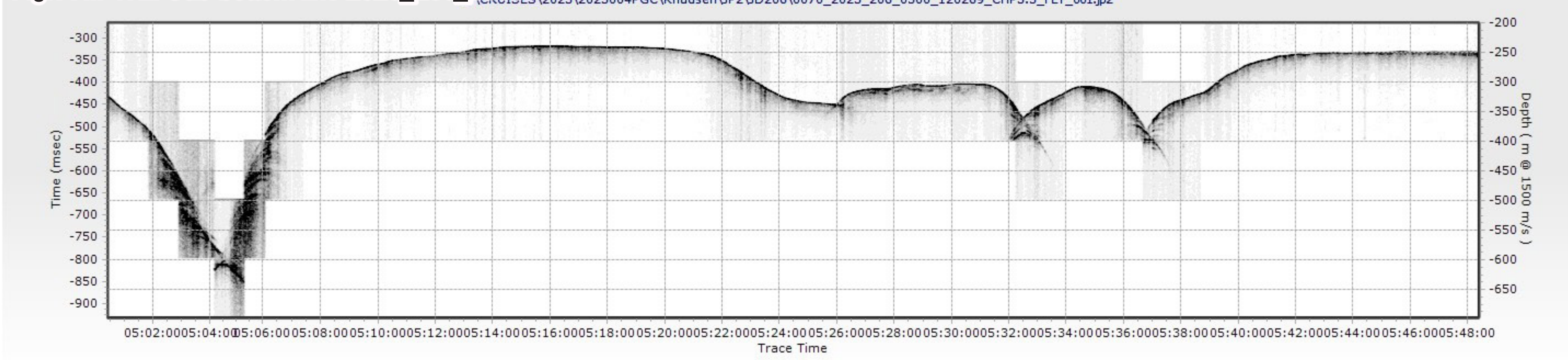
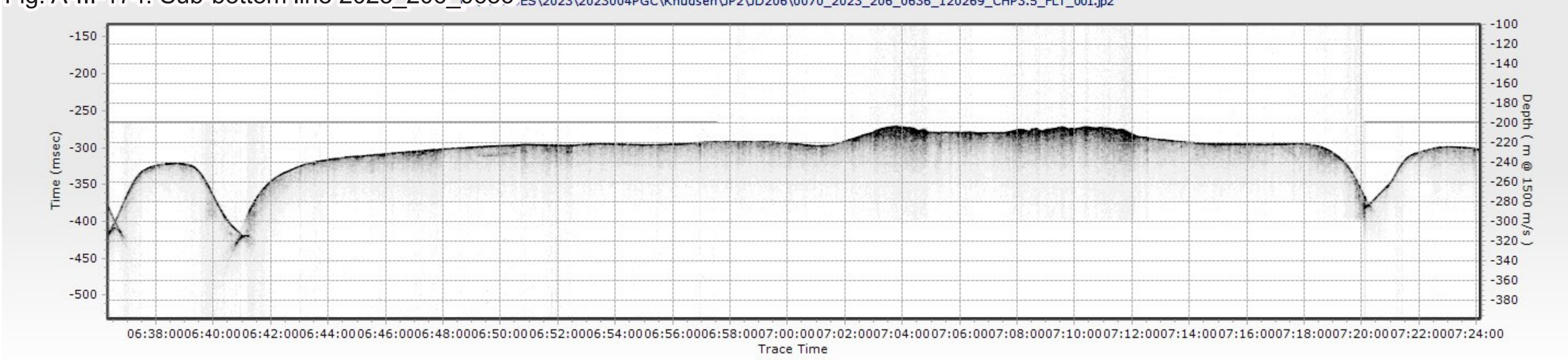
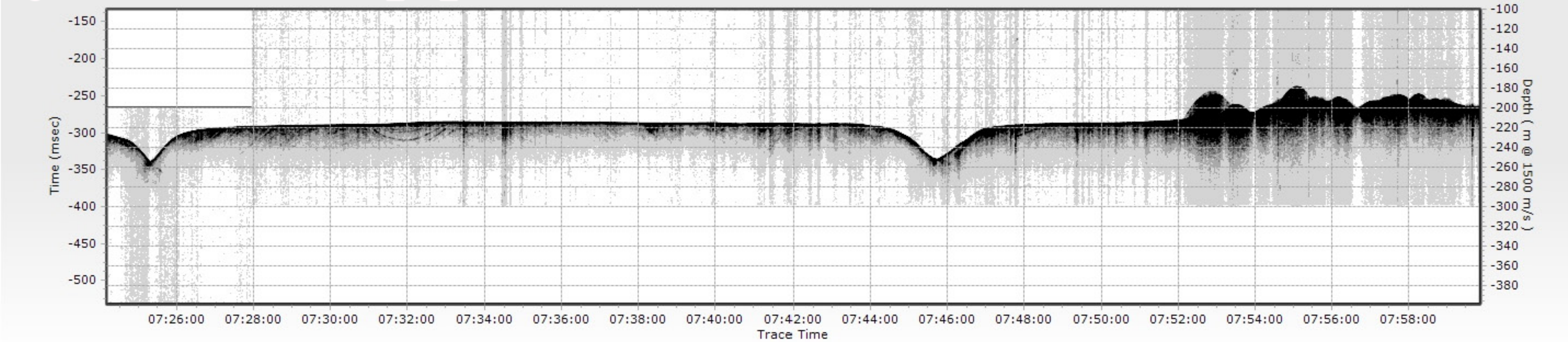


Fig. A-III-173. Sub-bottom line 2023_206_0548

Fig. A-III-174. Sub-bottom line 2023_206_0636





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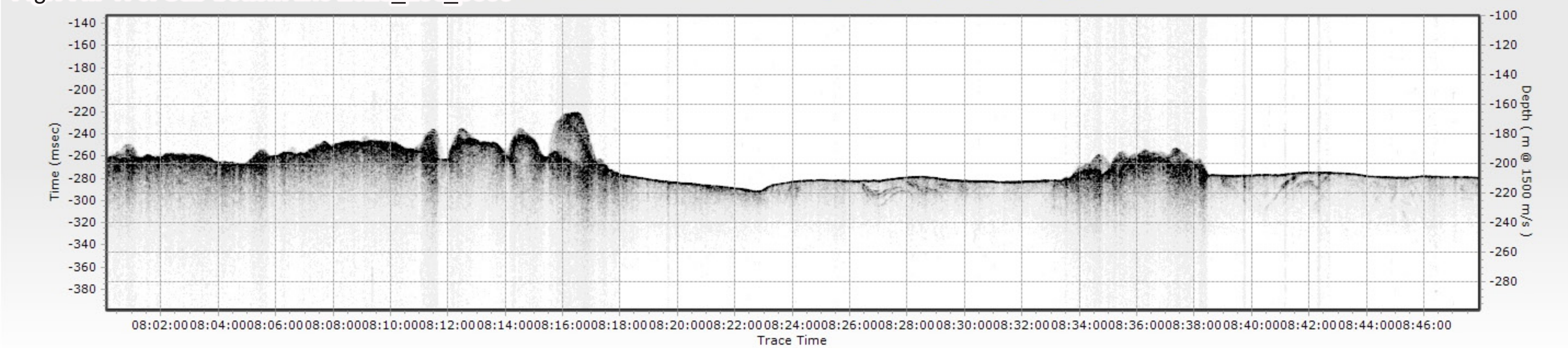


Fig. A-III-176. Sub-bottom line 2023_206_0800

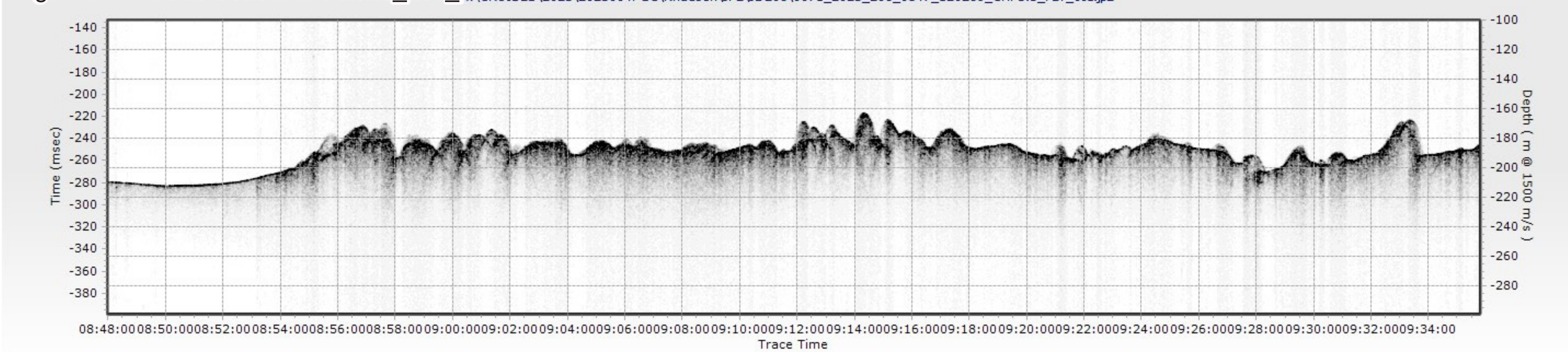
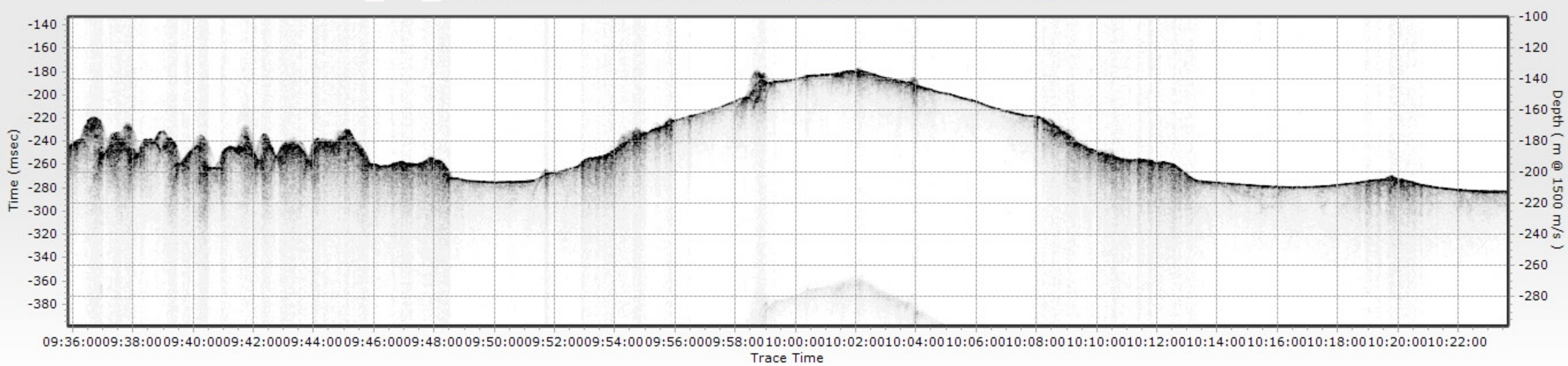


Fig. A-III-177. Sub-bottom line 2023_206_0847

Fig. A-III-178. Sub-bottom line 2023_206_0935



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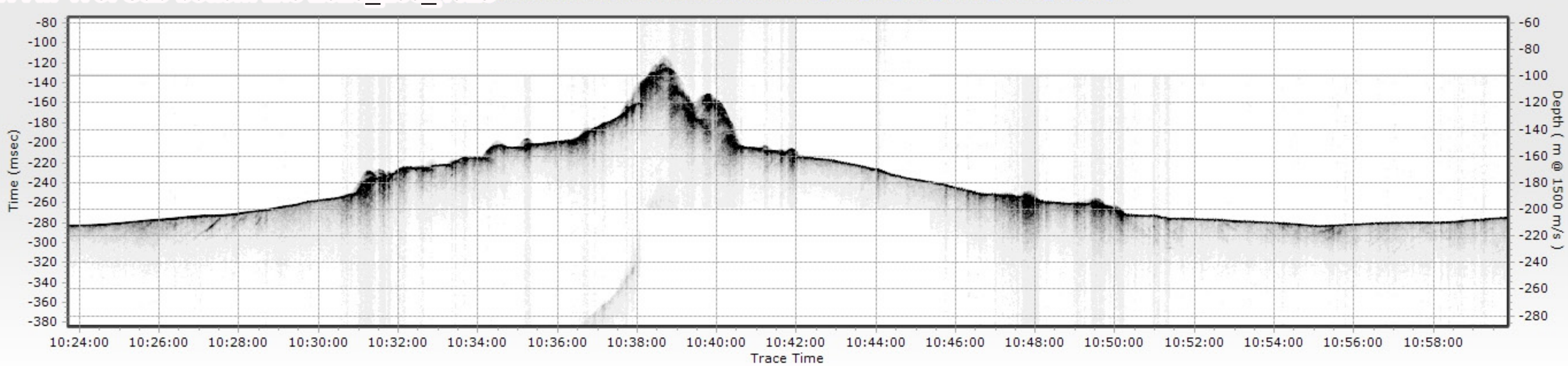


Fig. A-III-180. Sub-bottom line 2023_206_1100

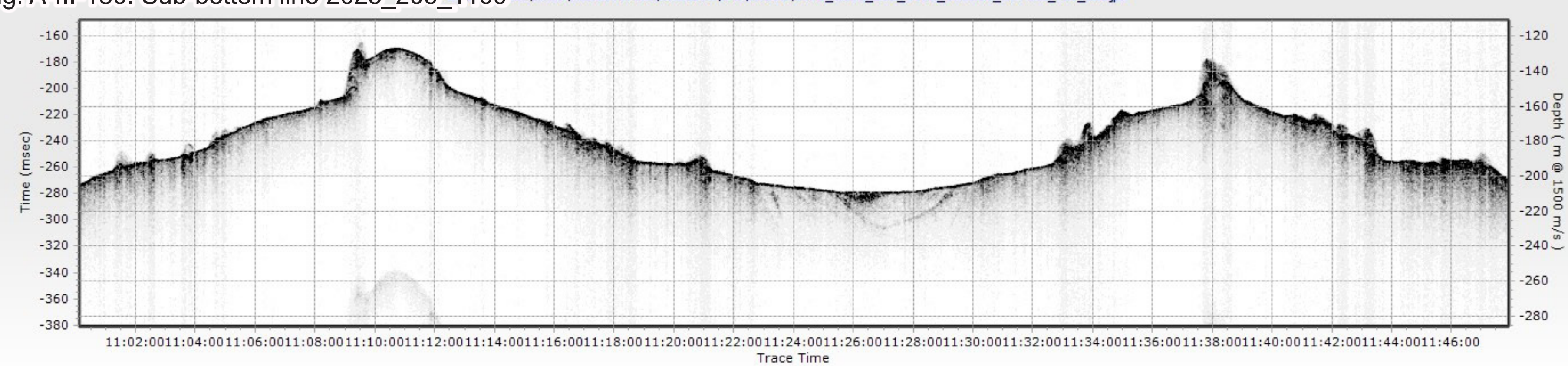


Fig. A-III-181. Sub-bottom line 2023_206_1147

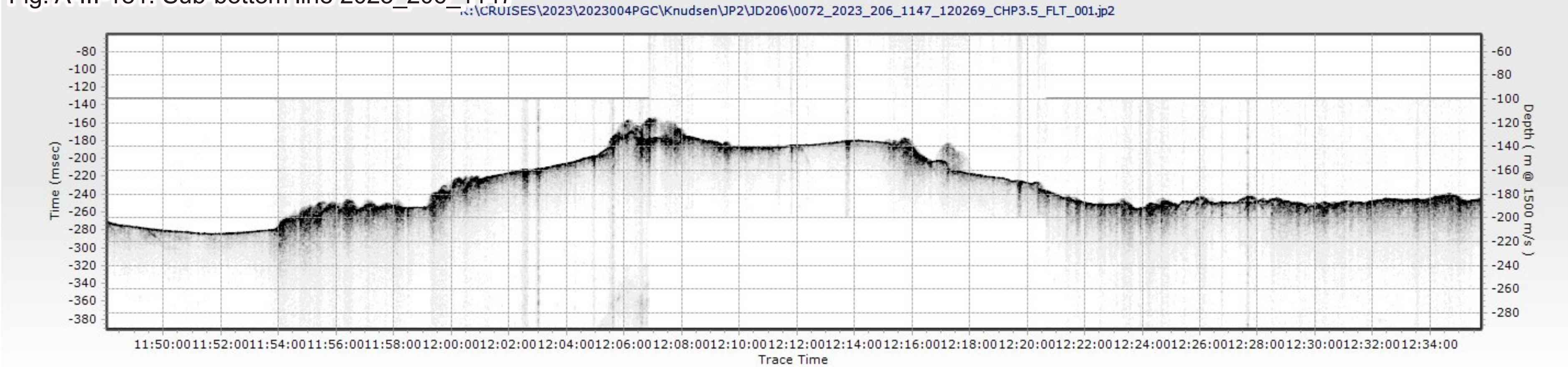


Fig. A-III-182. Sub-bottom line 2023_206_1235

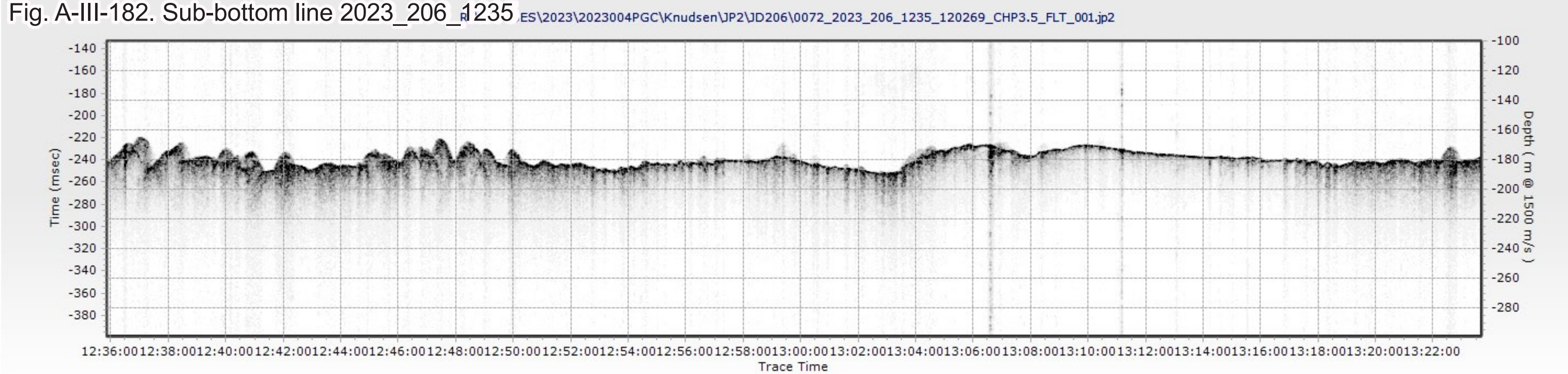


Fig. A-III-183. Sub-bottom line 2023_206_1323

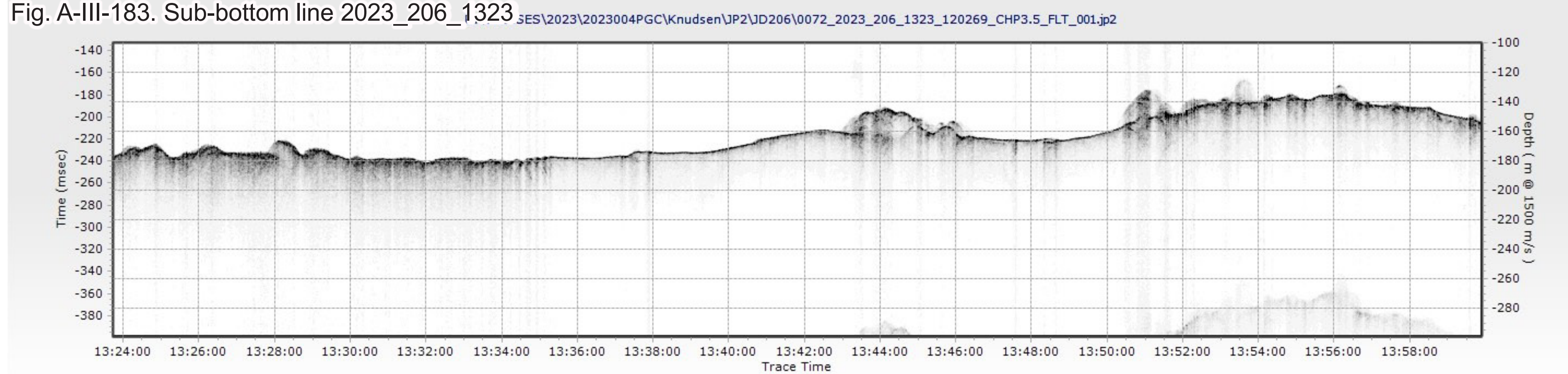
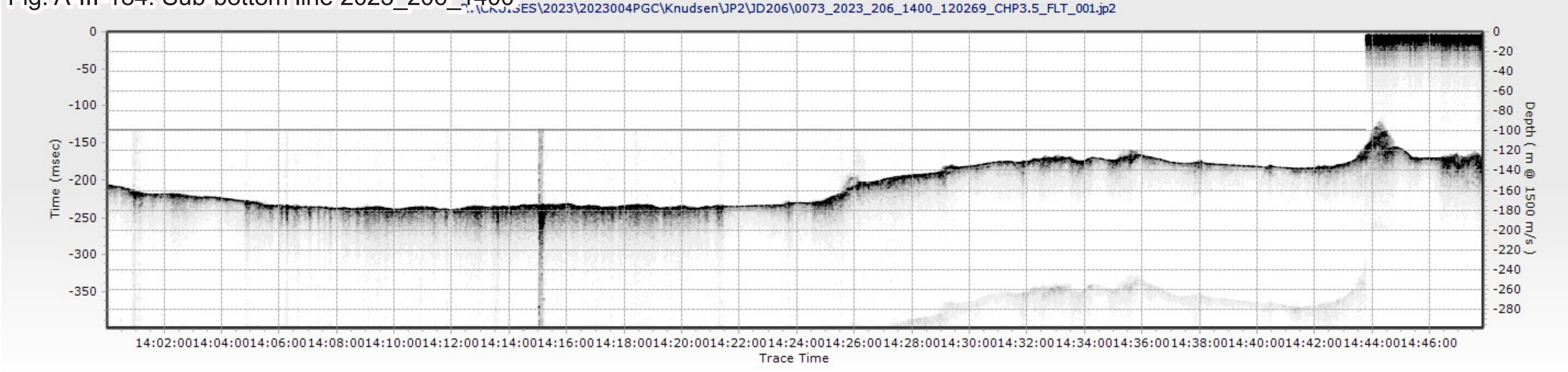


Fig. A-III-184. Sub-bottom line 2023_206_1400



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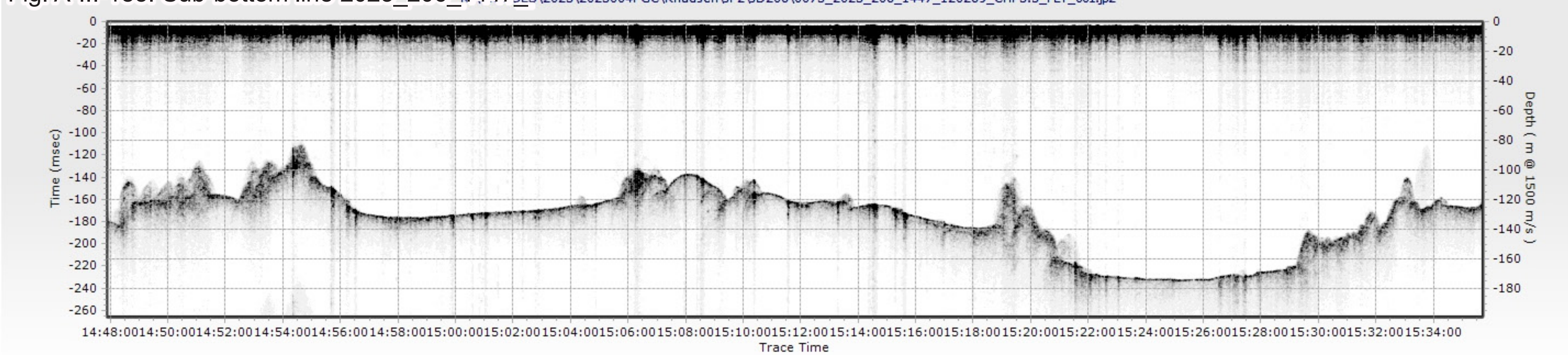
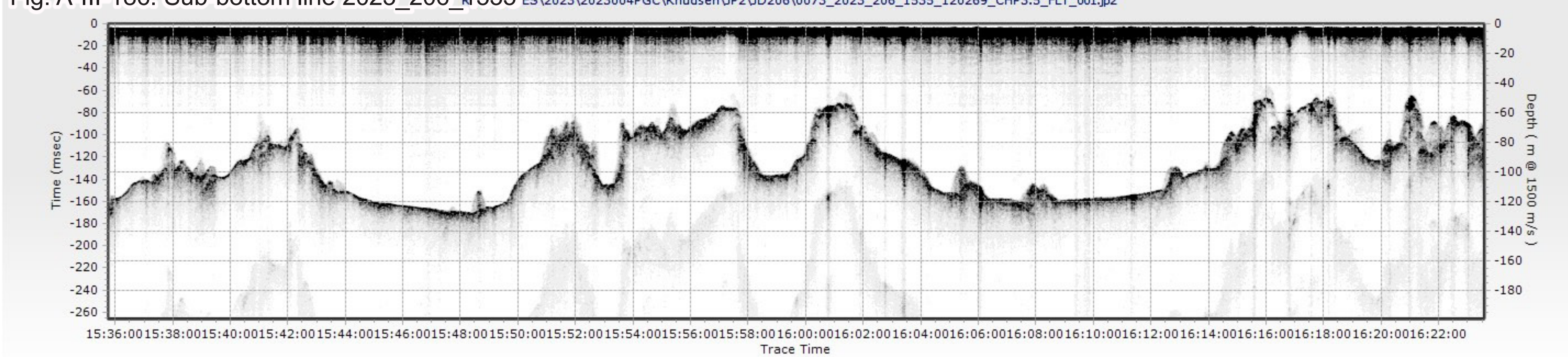


Fig. A-III-186. Sub-bottom line 2023_206_1535



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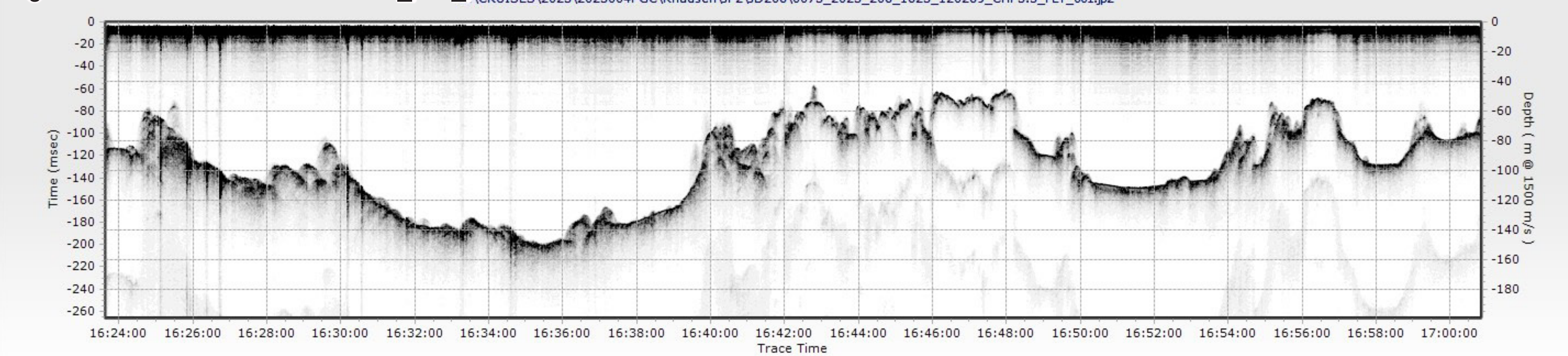


Fig. A-III-188. Sub-bottom line 2023_206_1701

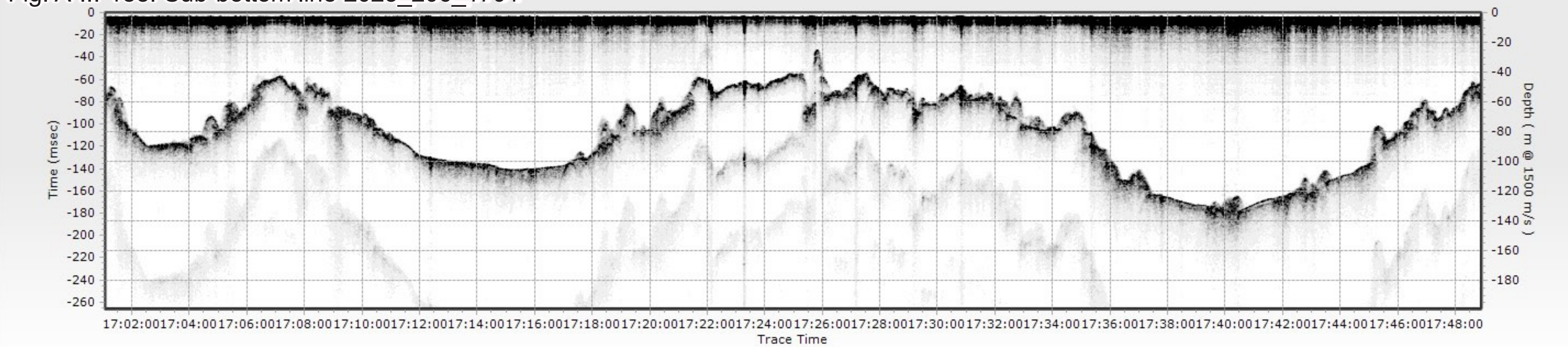


Fig. A-III-189. Sub-bottom line 2023_206_1748

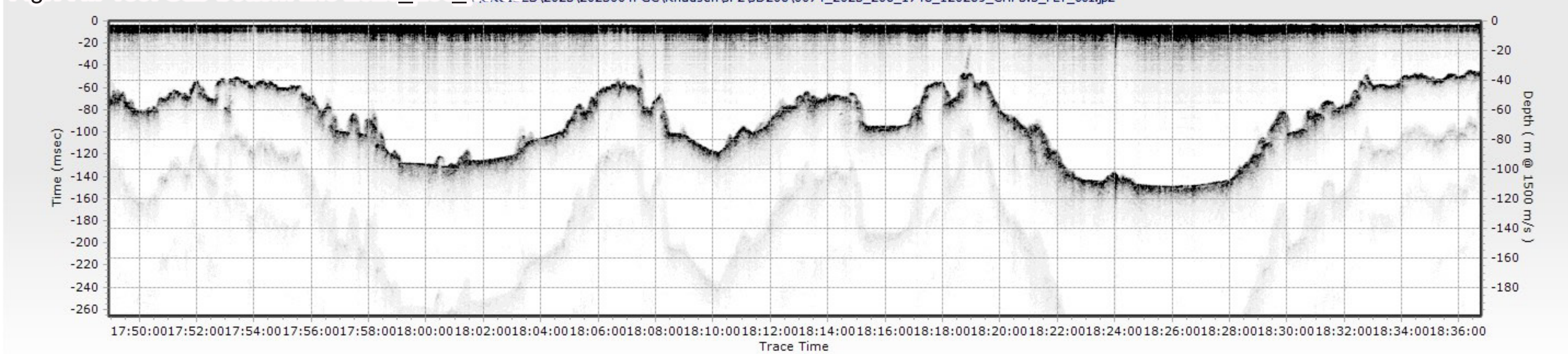
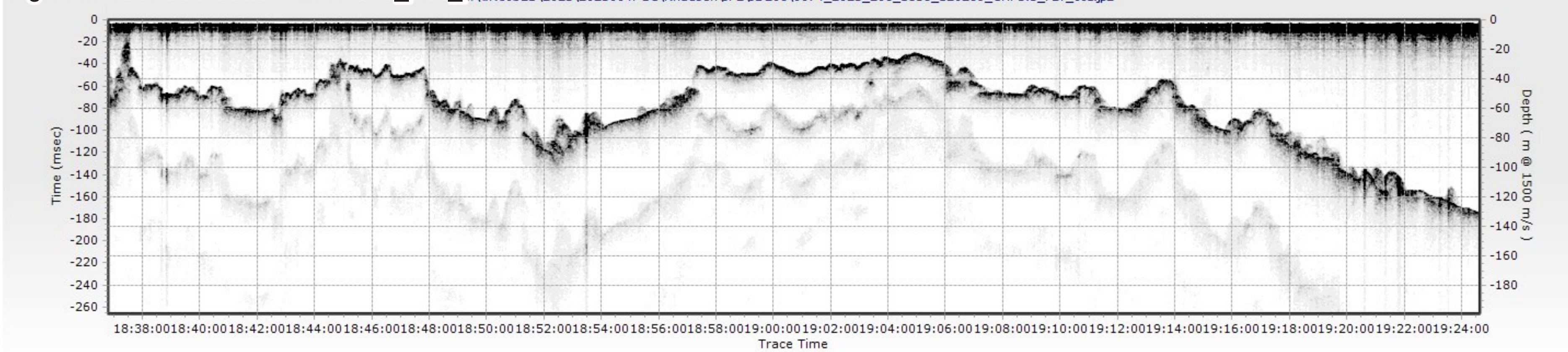


Fig. A-III-190. Sub-bottom line 2023_206_1836



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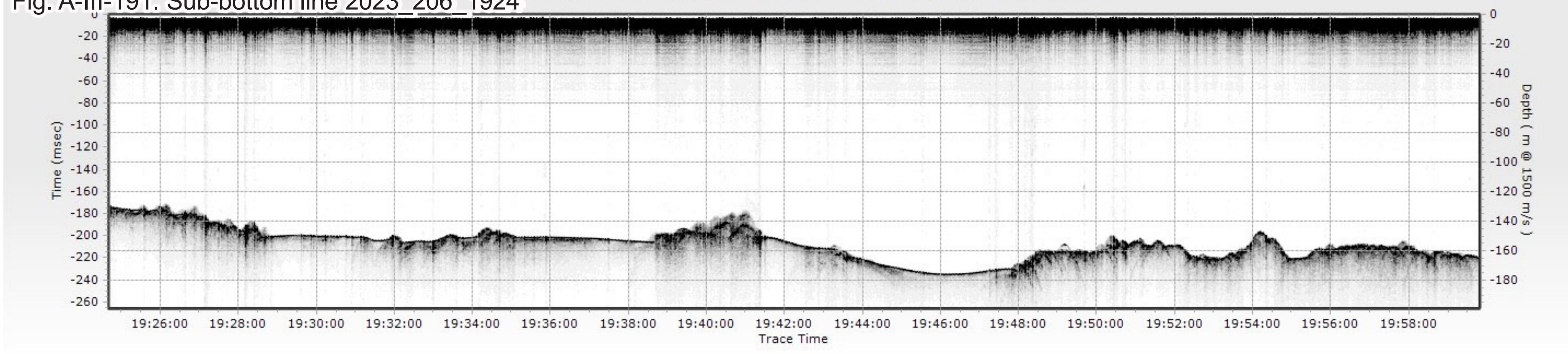


Fig. A-III-192. Sub-bottom line 2023_206_2000

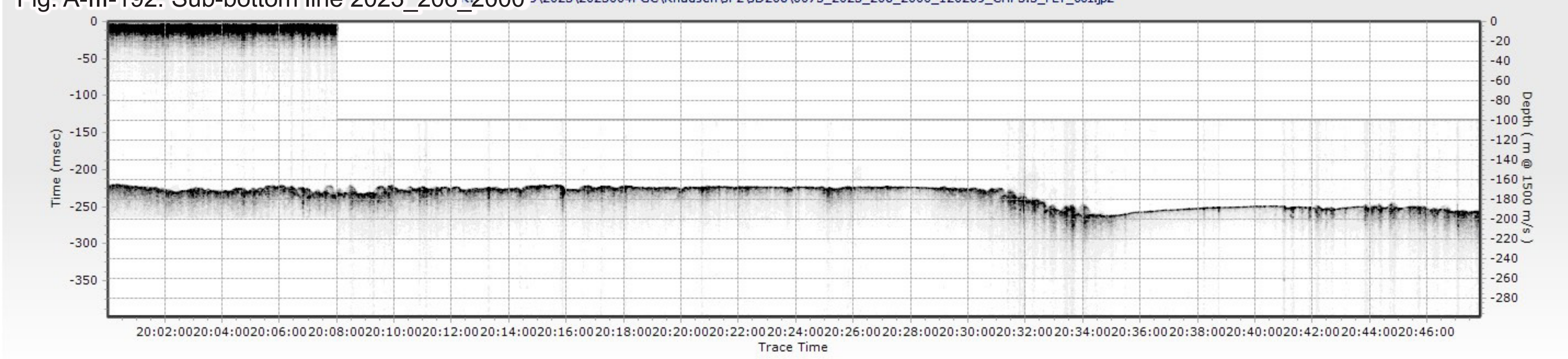
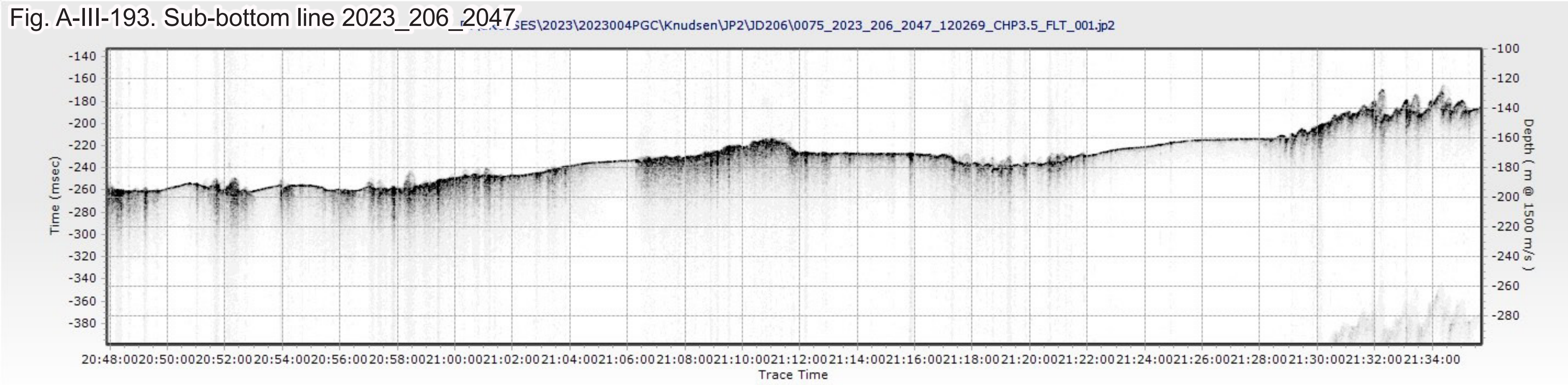


Fig. A-III-193. Sub-bottom line 2023_206_2047



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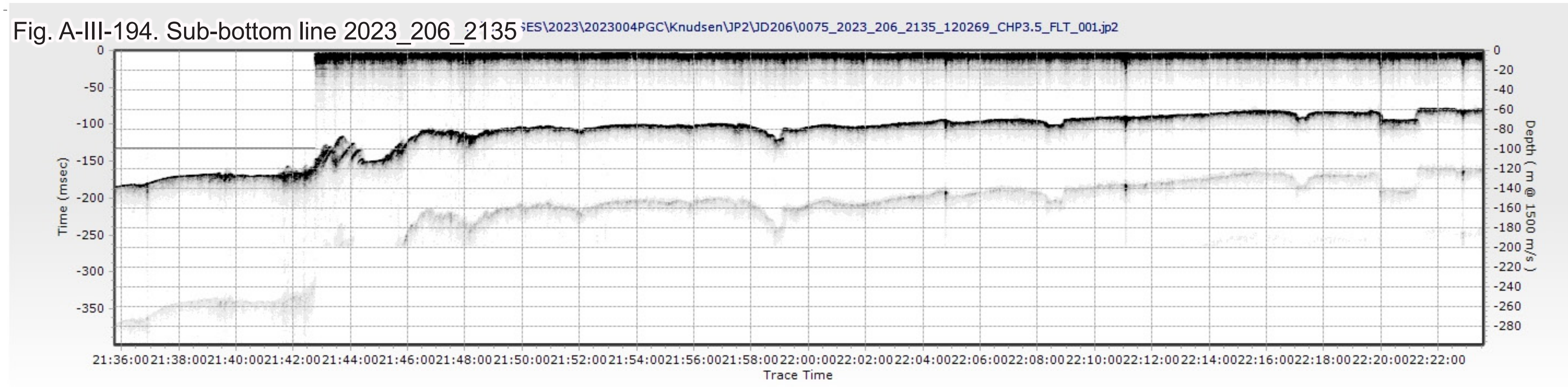

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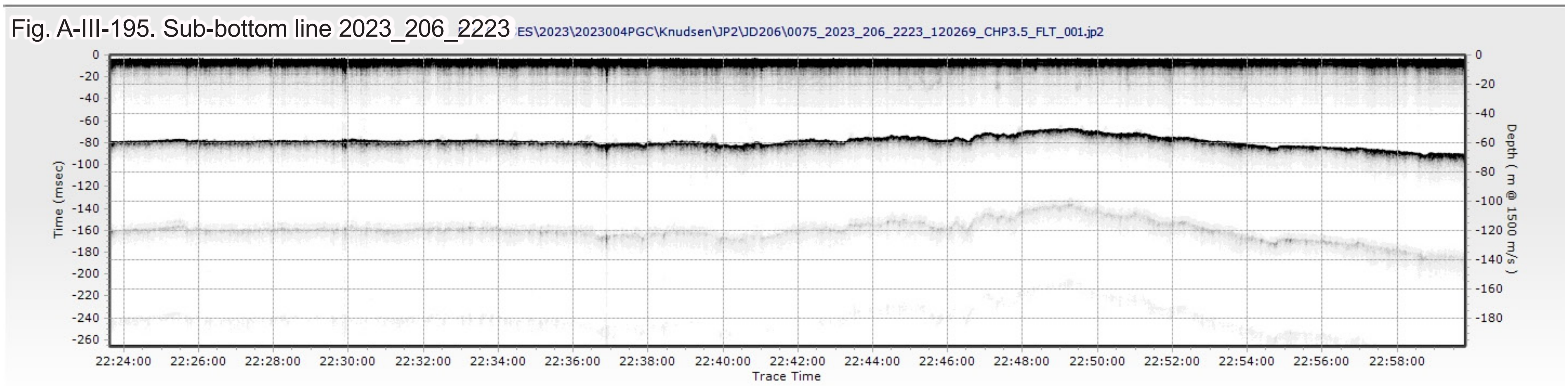

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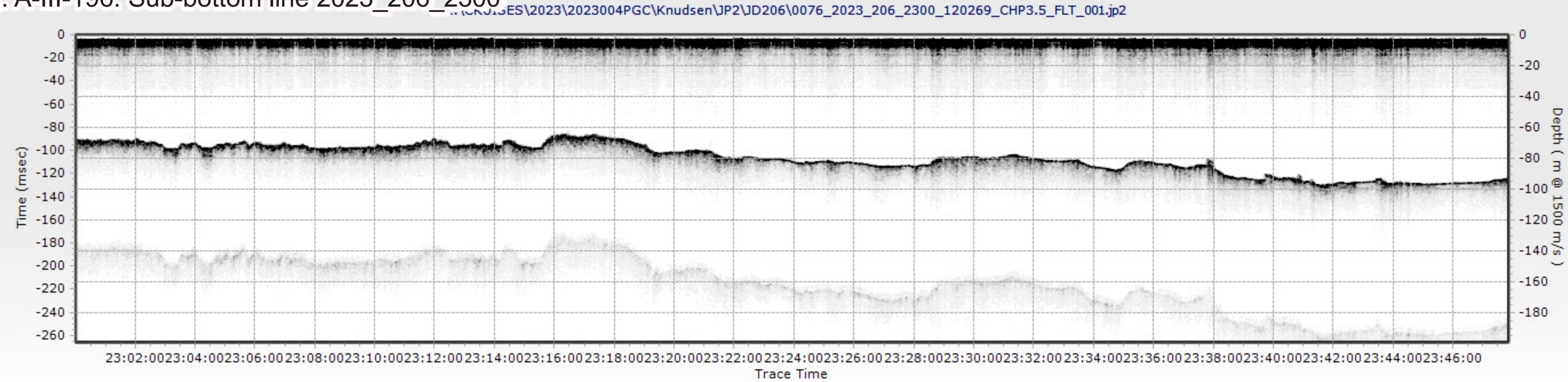
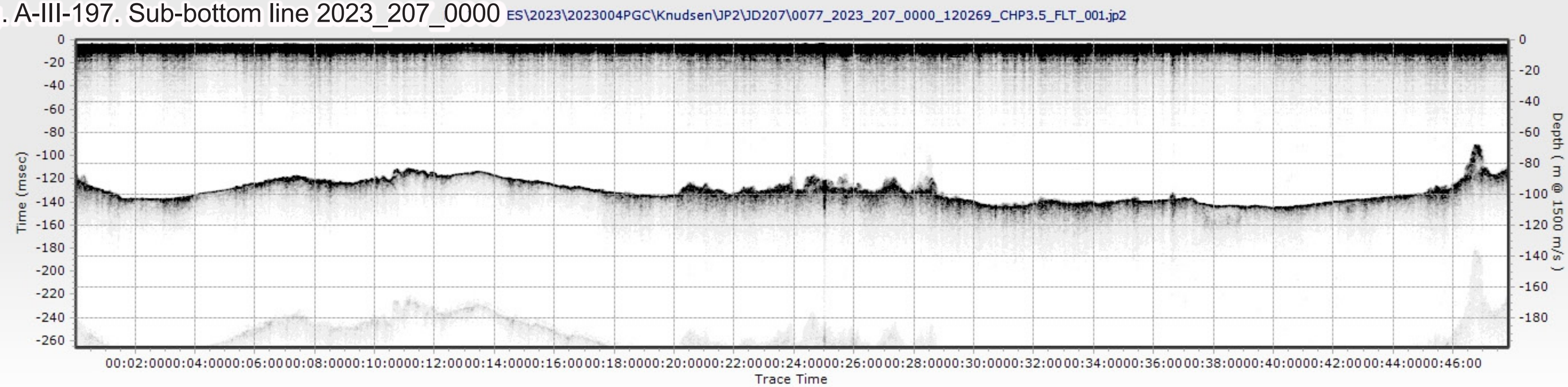


Fig. A-III-197. Sub-bottom line 2023_207_0000



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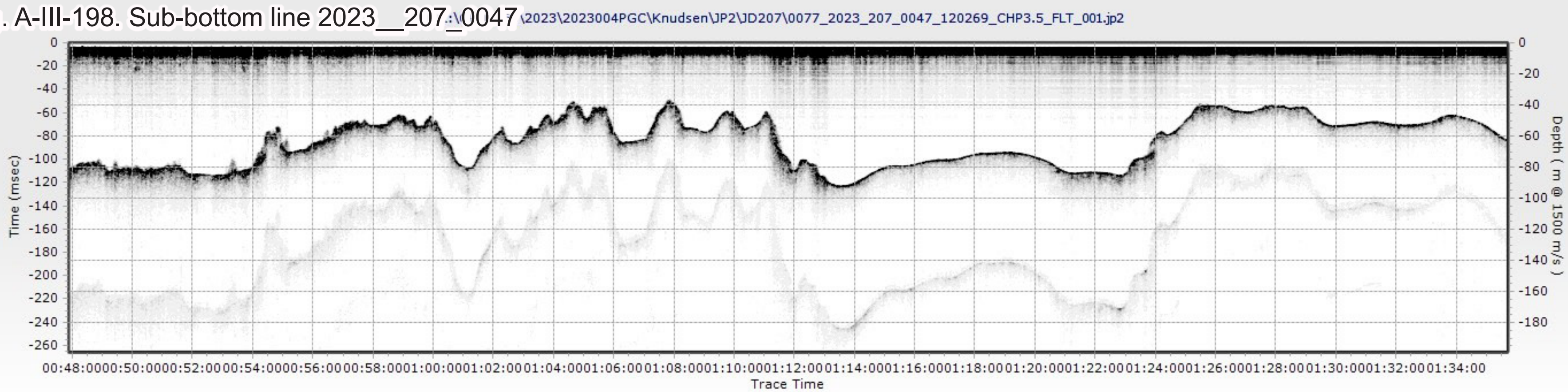


Fig. A-III-199. Sub-bottom line 2023_207_0135

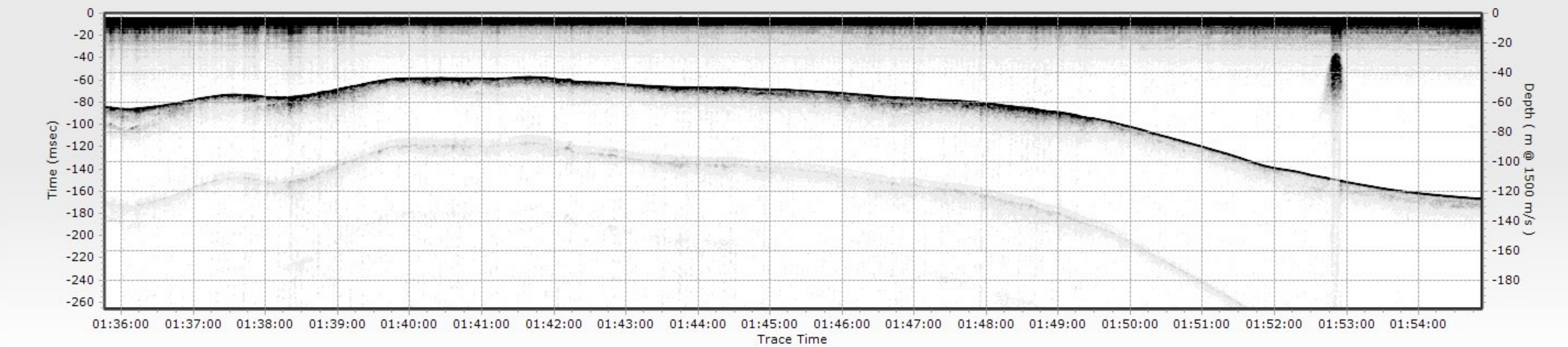
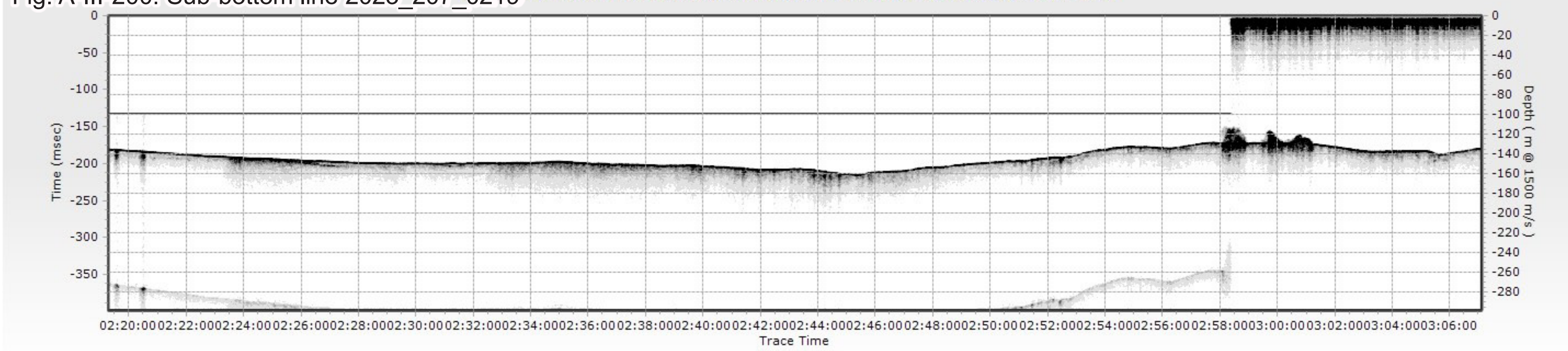


Fig. A-III-200. Sub-bottom line 2023_207_0219



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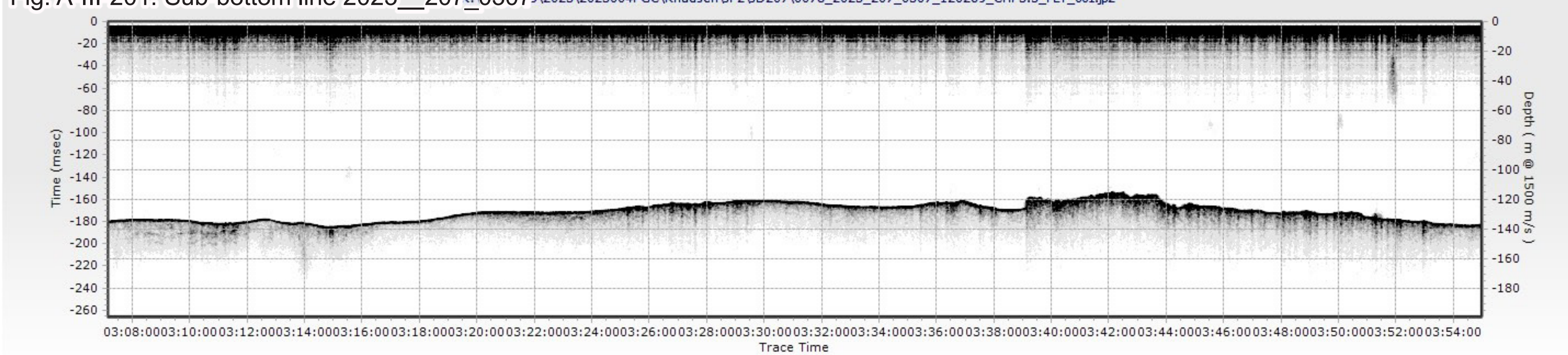
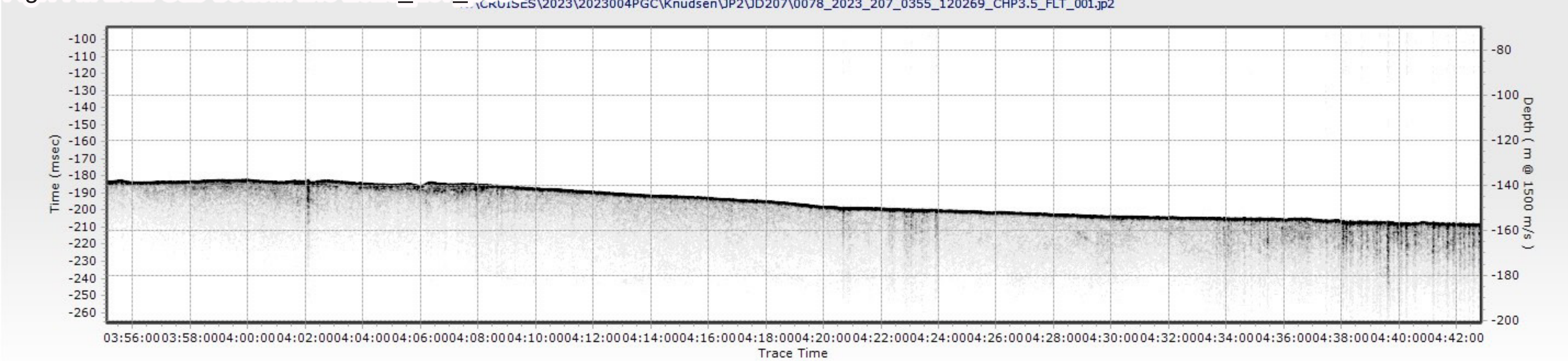


Fig. A-III-202. Sub-bottom line 2023_207_0355



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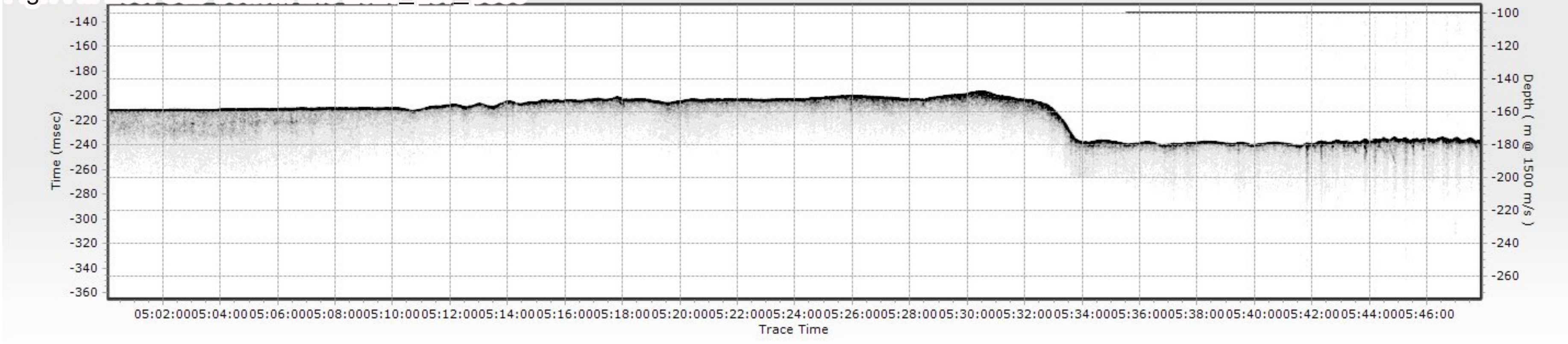


Fig. A-III-204. Sub-bottom line 2023_207_0547

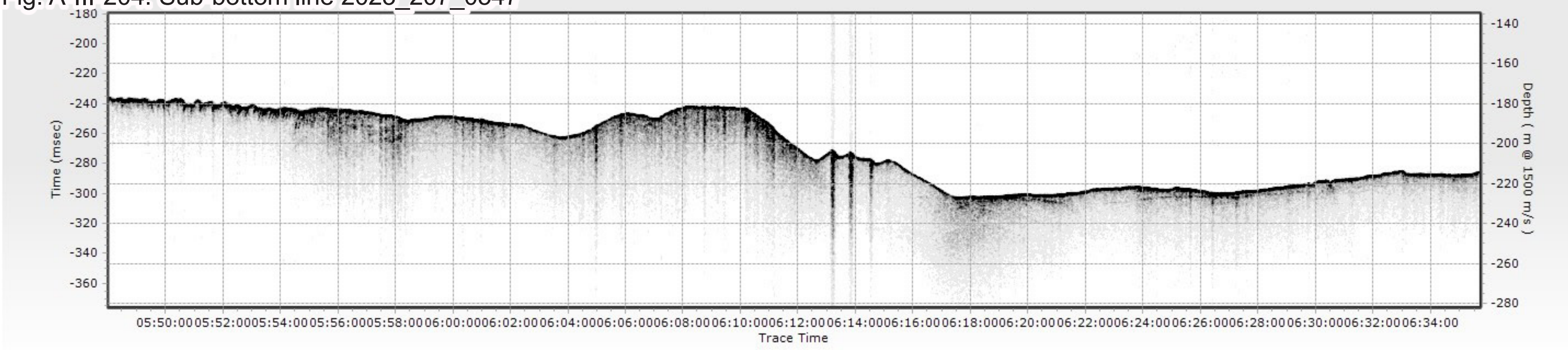


Fig. A-III-205. Sub-bottom line 2023_207_0635

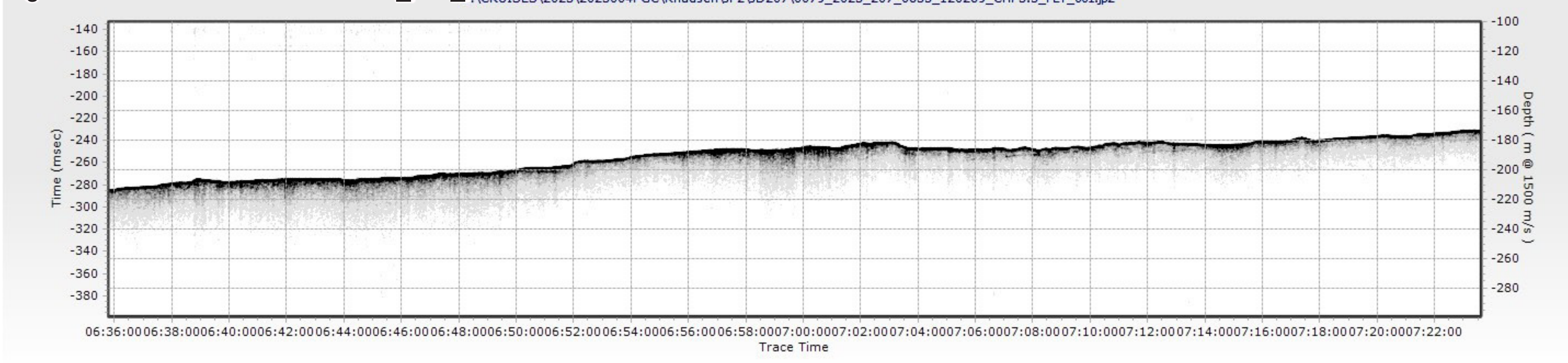


Fig. A-III-206. Sub-bottom line 2023_207_0723

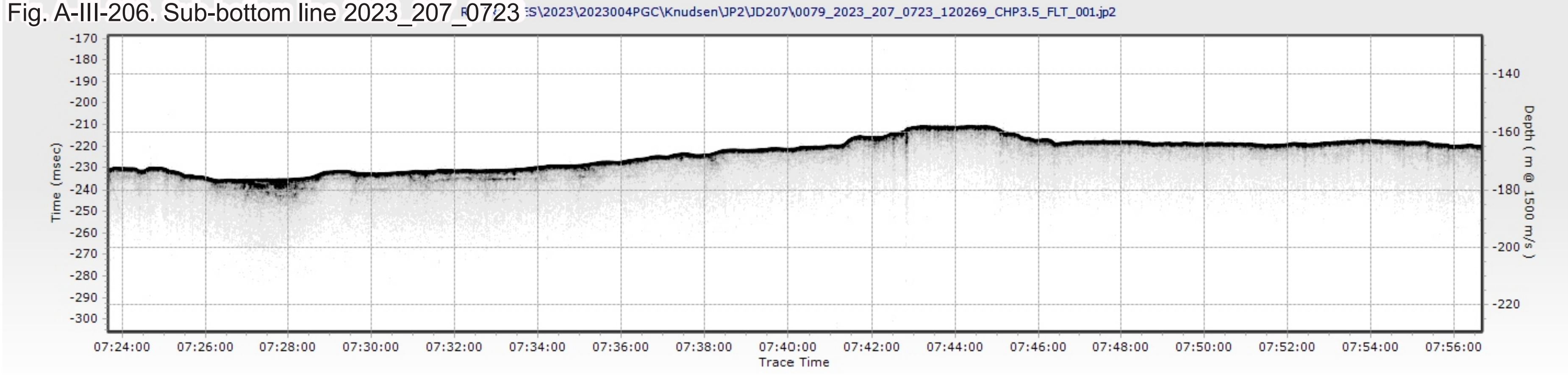


Fig. A-III-207. Sub-bottom line 2023_207_0756

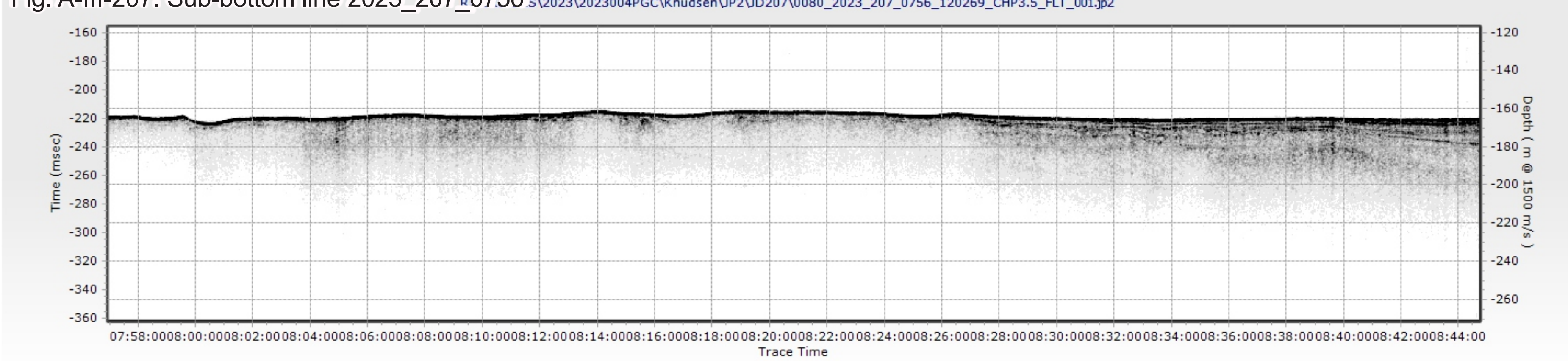


Fig. A-III-207. Sub-bottom line 2023_207_0844

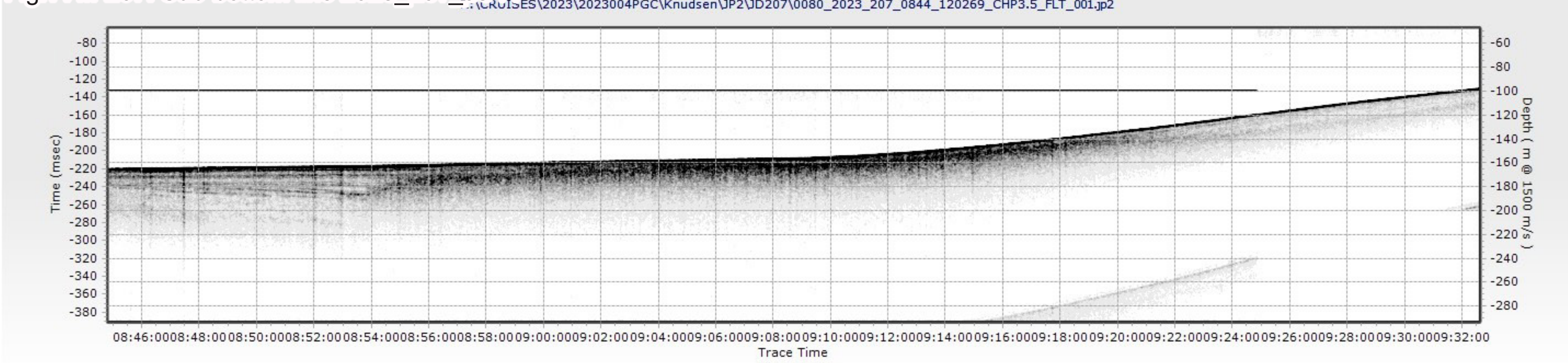


Fig. A-III-208. Sub-bottom line 2023_207_0932

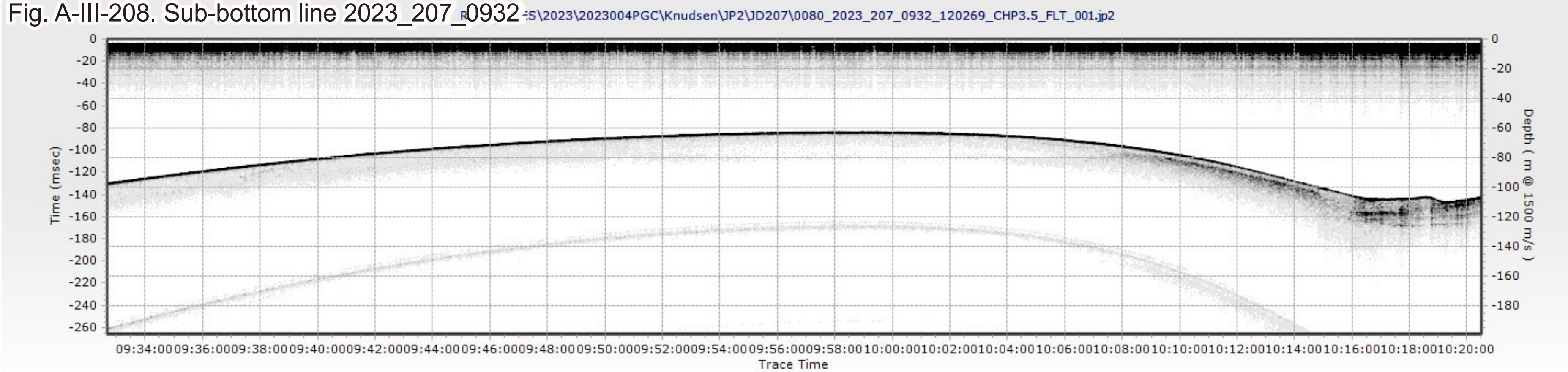


Fig. A-III-209. Sub-bottom line 2023_207_1020

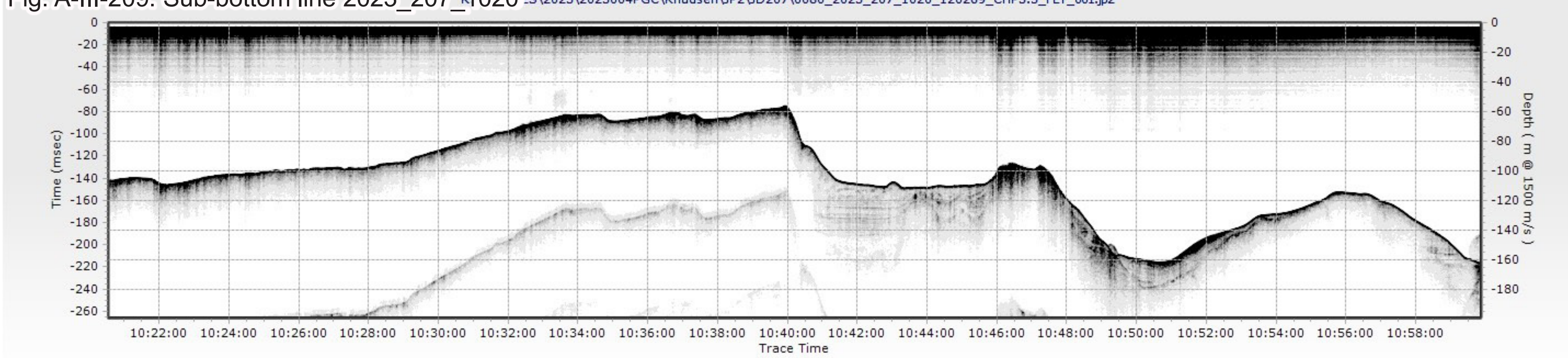


Fig. A-III-210. Sub-bottom line 2023_207_1100

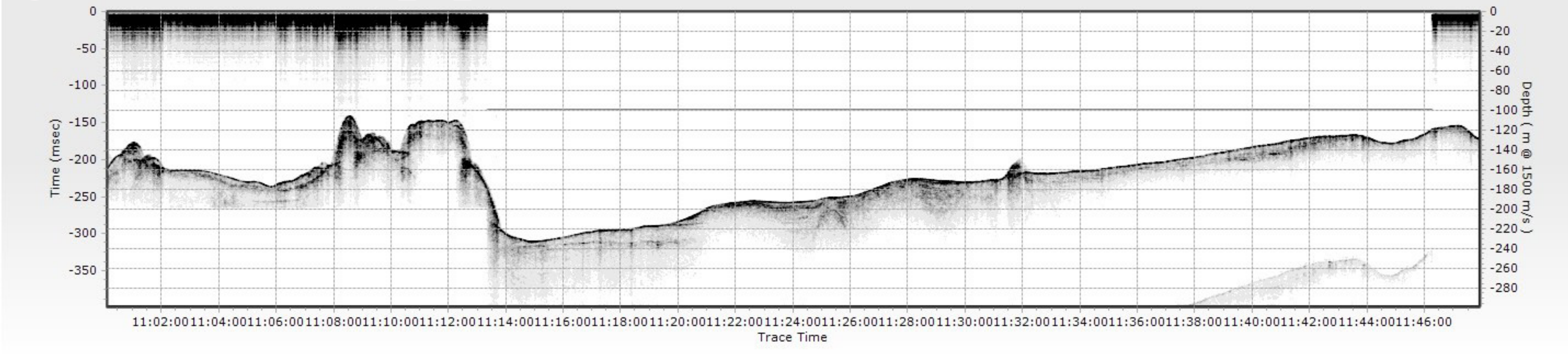


Fig. A-III-211. Sub-bottom line 2023_207_1147

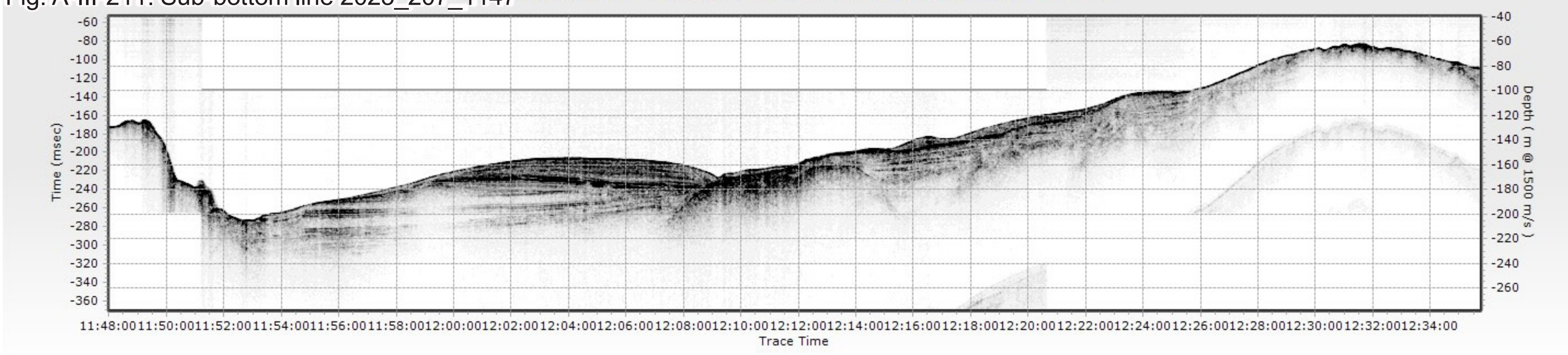
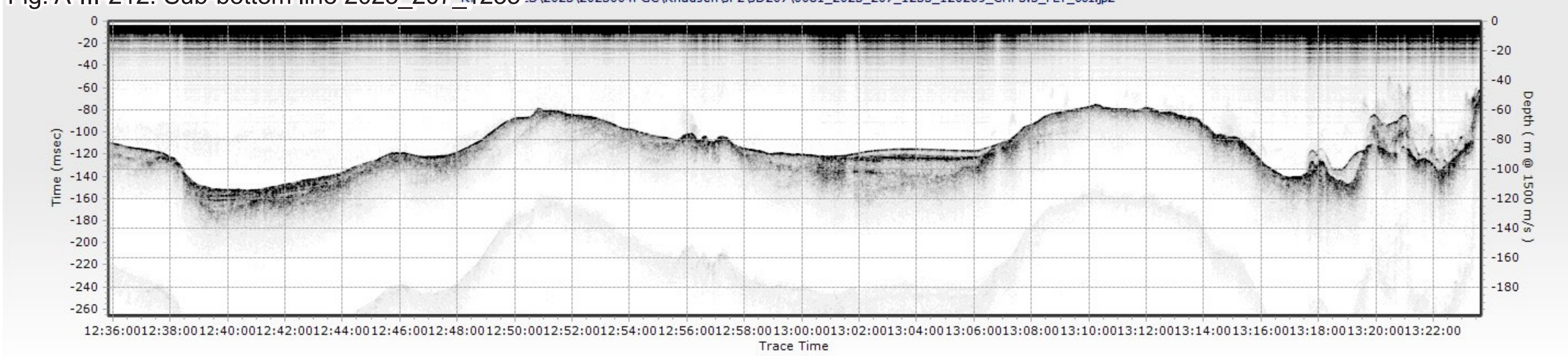
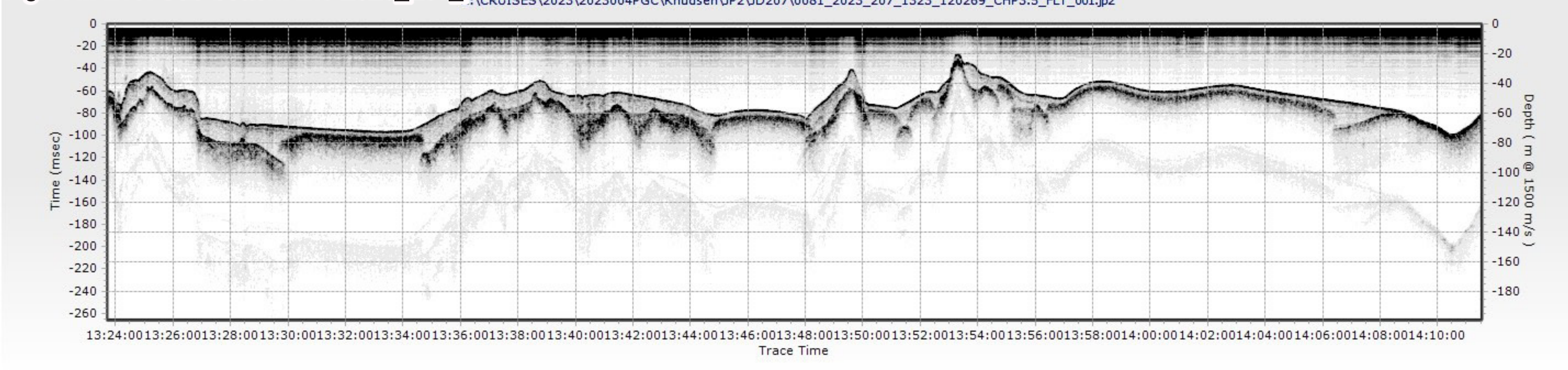


Fig. A-III-212. Sub-bottom line 2023_207_1235





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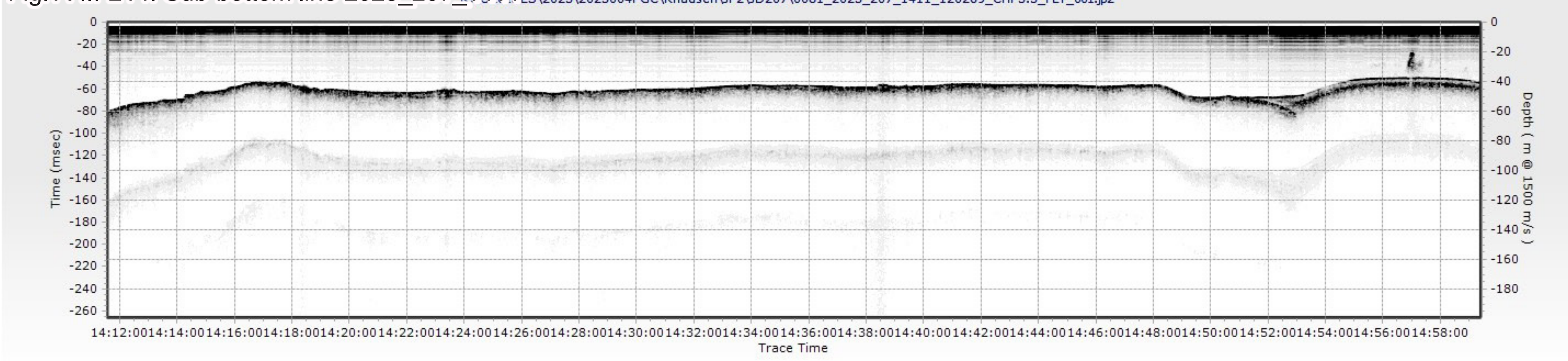


Fig. A-III-214. Sub-bottom line 2023_207_1411

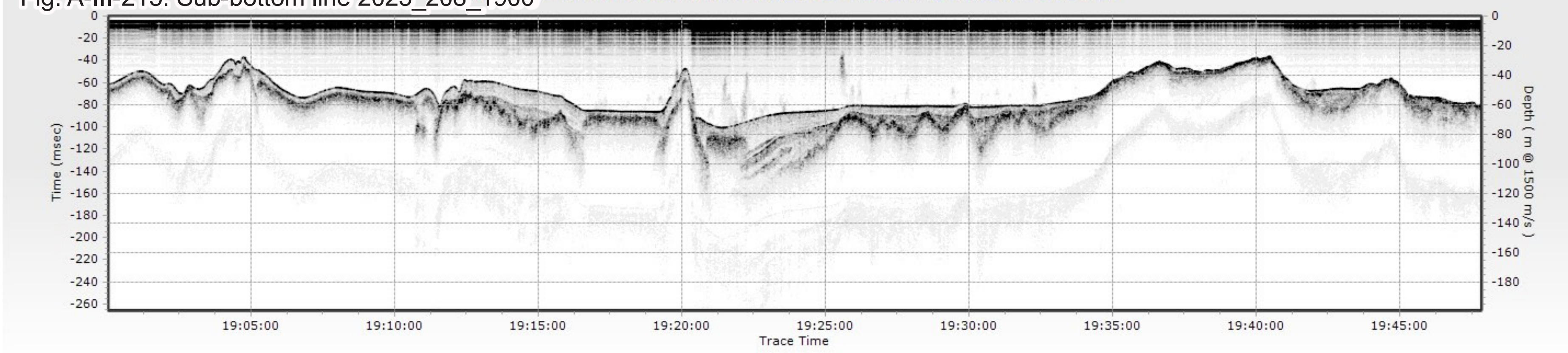


Fig. A-III-215. Sub-bottom line 2023_208_1900

Fig. A-III-216. Sub-bottom line 2023_208_1947

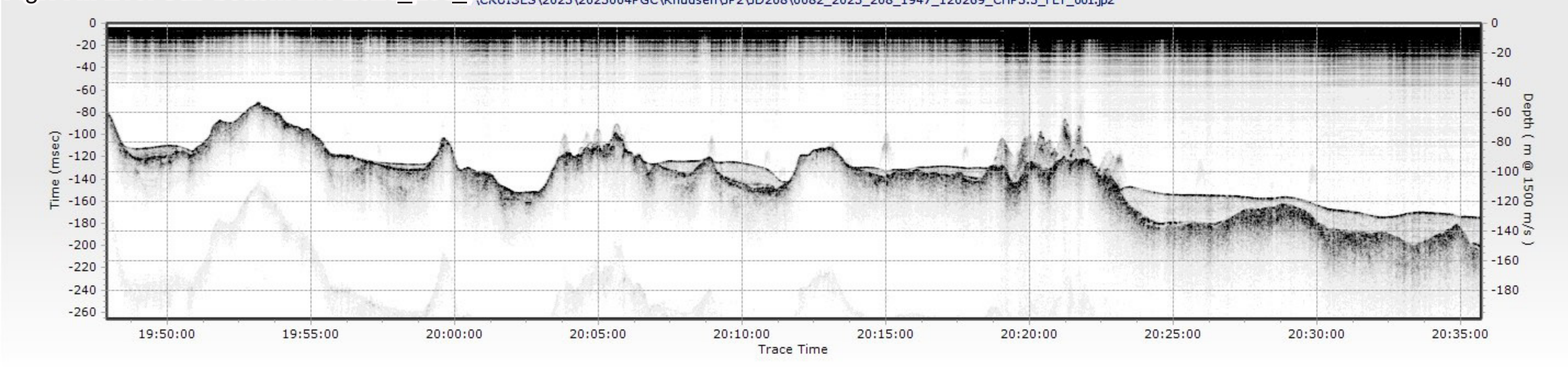


Fig. A-III-217. Sub-bottom line 2023_208_2035

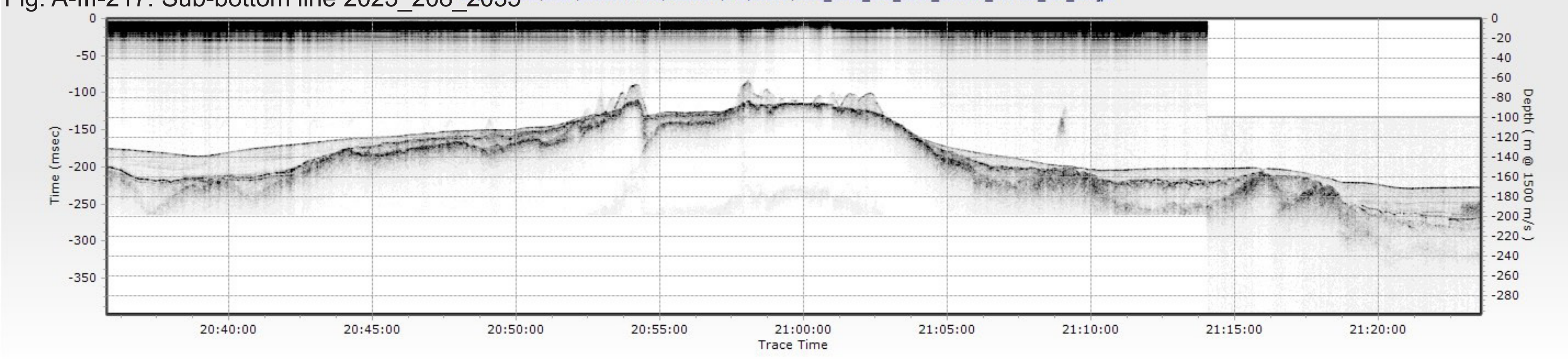


Fig. A-III-218. Sub-bottom line 2023_208_2123

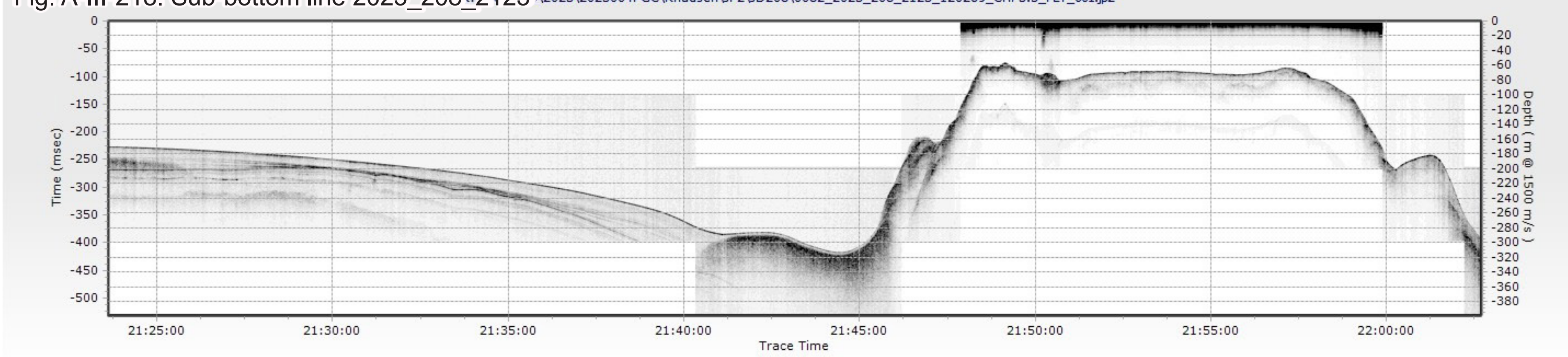


Fig. A-III-219. Sub-bottom line 2023_208_2202

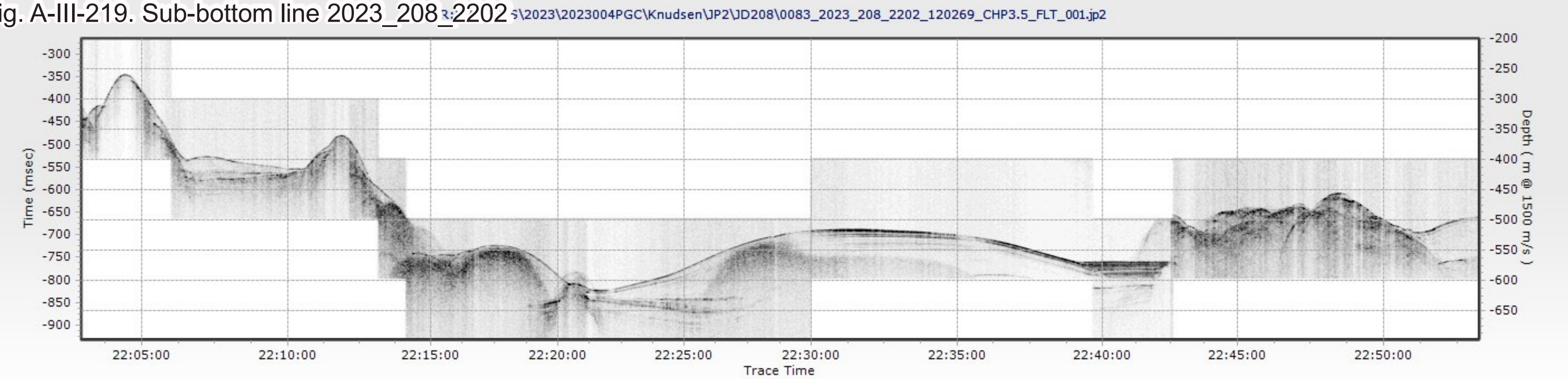


Fig. A-III-220. Sub-bottom line 2023_208_2253

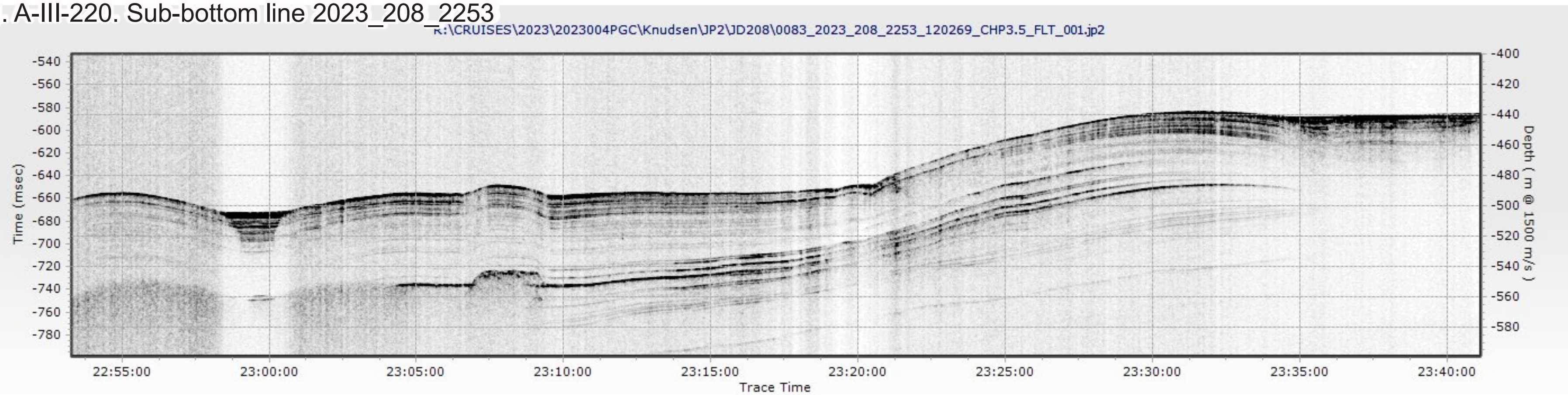


Fig. A-III-221. Sub-bottom line 2023_208_2341

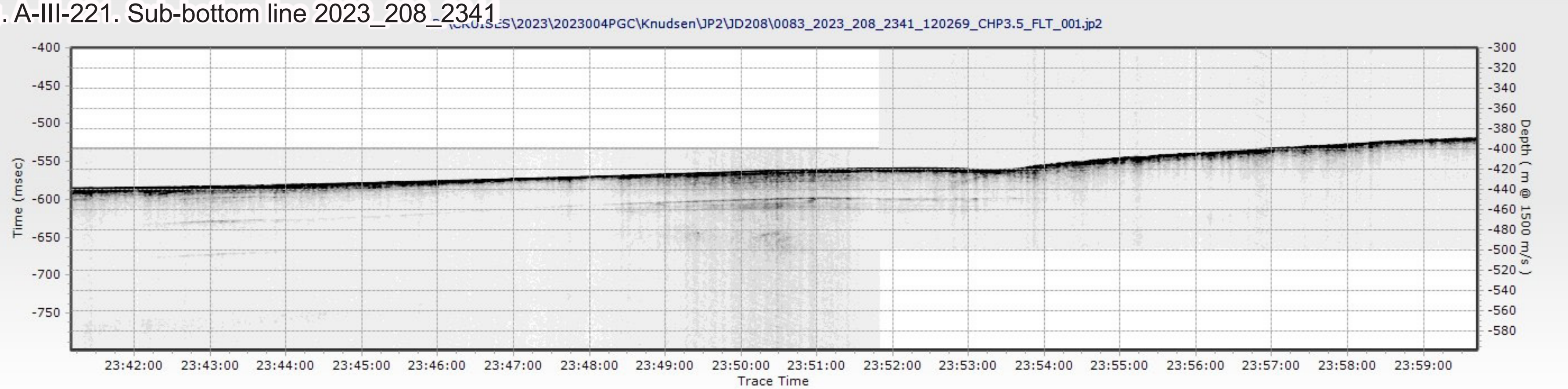


Fig. A-III-222. Sub-bottom line 2023_209_0000

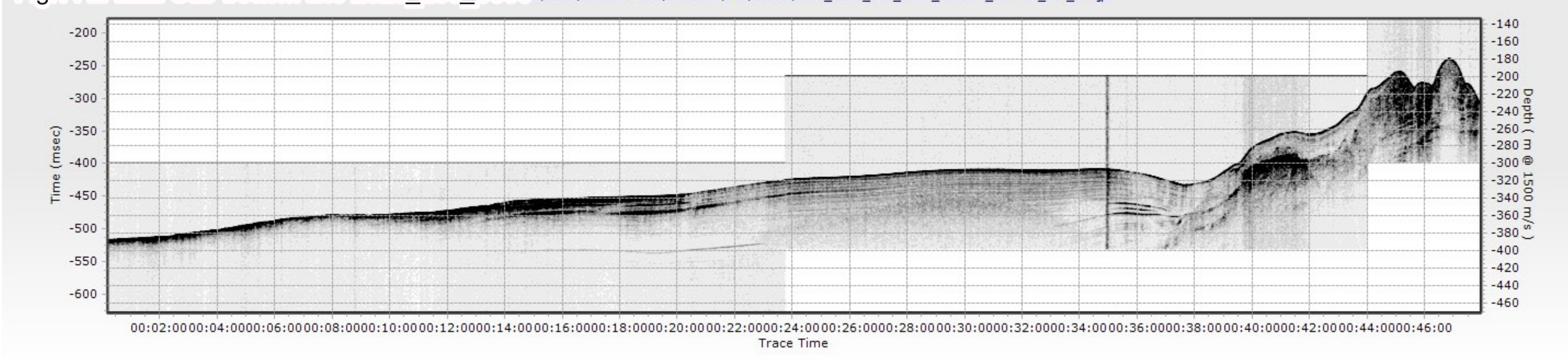


Fig. A-III-223. Sub-bottom line 2023_209_0117

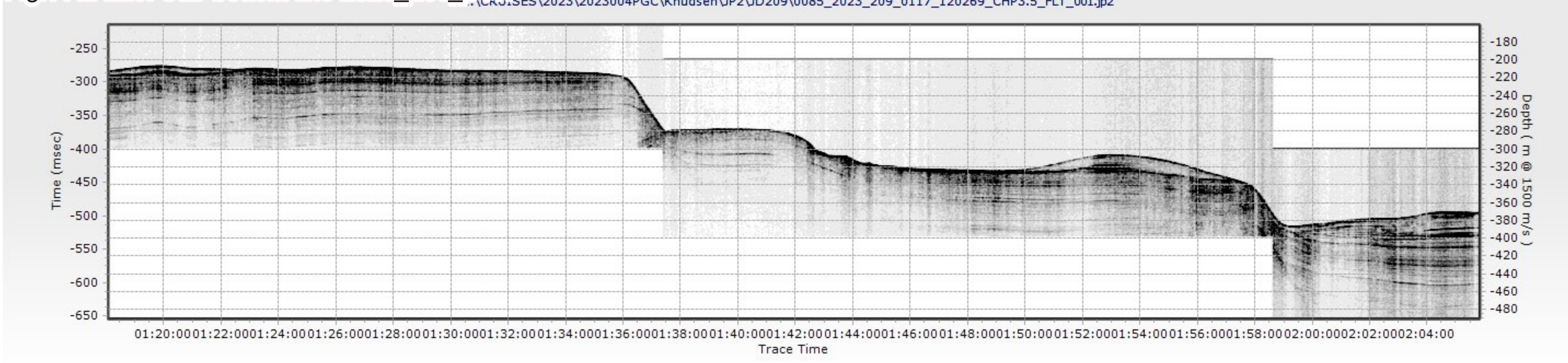


Fig. A-III-224. Sub-bottom line 2023_209_0205

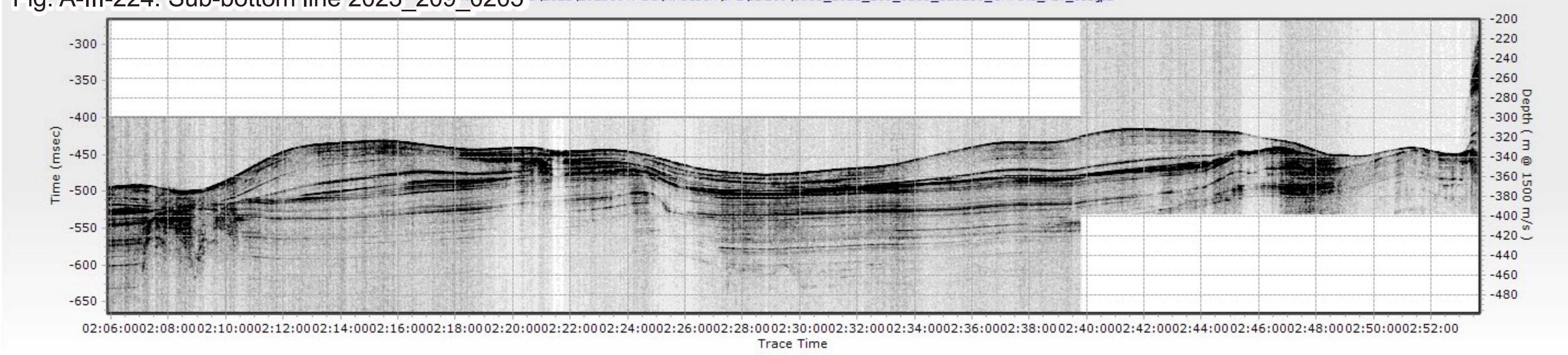


Fig. A-III-225. Sub-bottom line 2023_209_0253

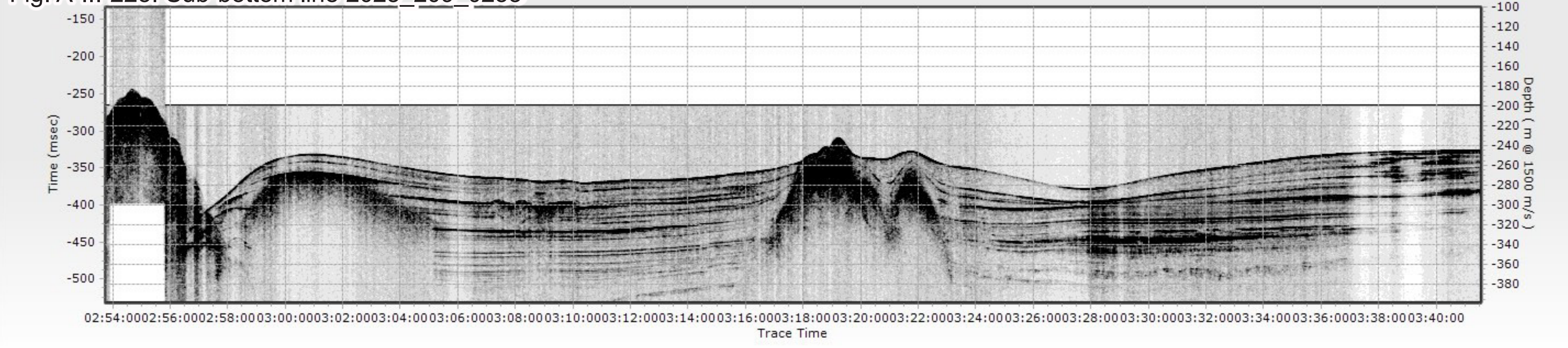


Fig. A-III-226. Sub-bottom line 2023_209_0341

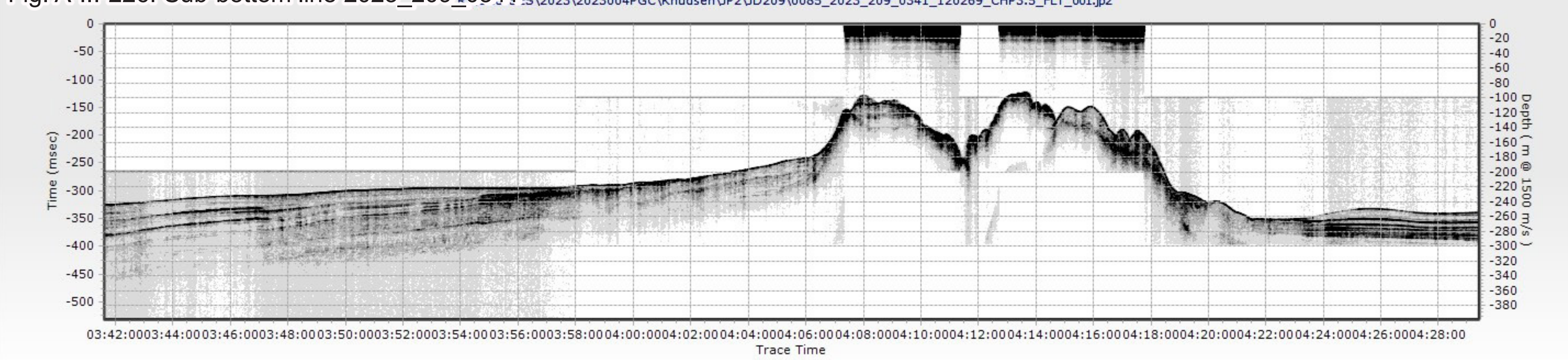


Fig. A-III-227. Sub-bottom line 2023__209_0429

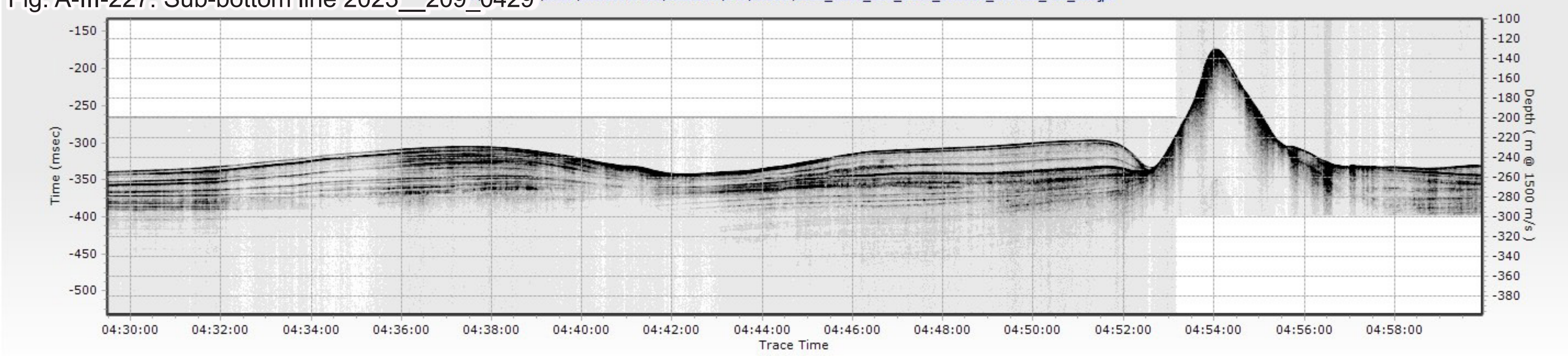


Fig. A-III-228. Sub-bottom line 2023_209_0500

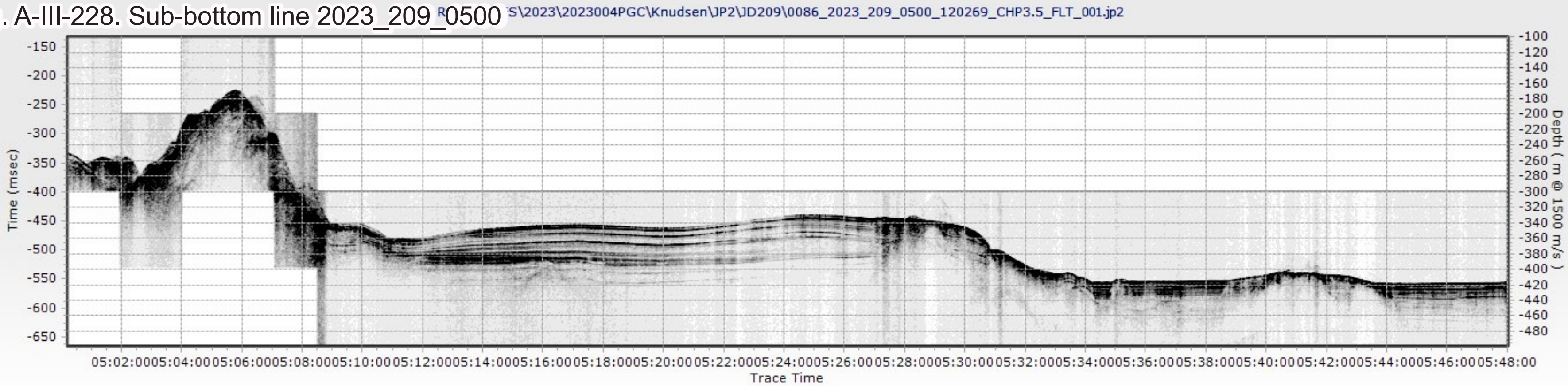


Fig. A-III-229. Sub-bottom line 2023_209_0635

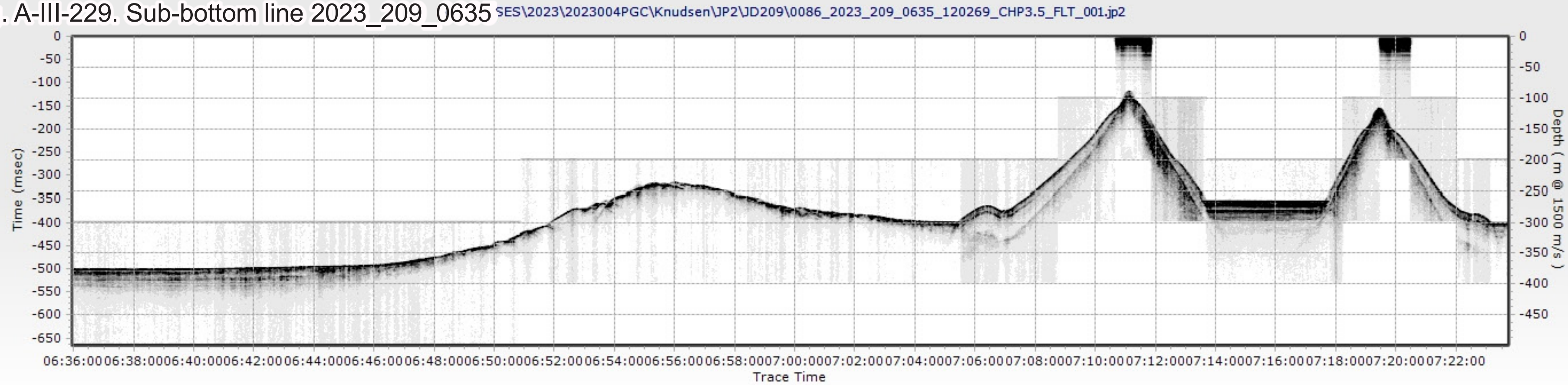
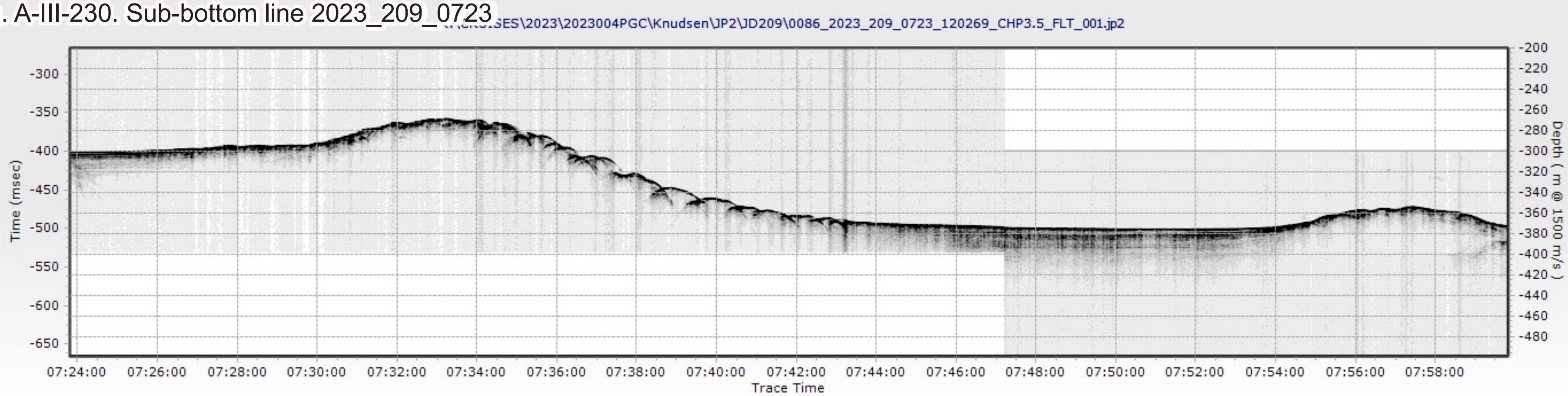


Fig. A-III-230. Sub-bottom line 2023_209_0723



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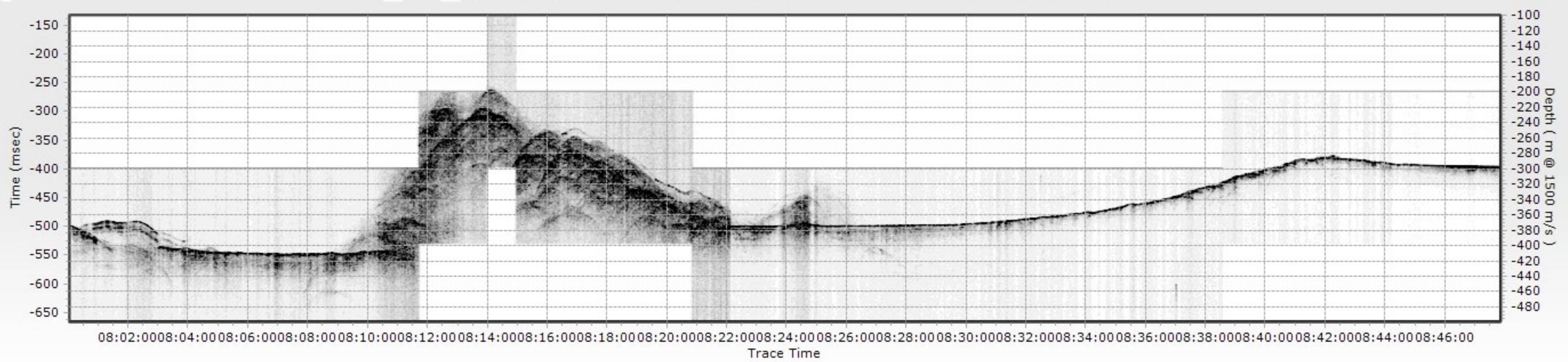


Fig. A-III-232. Sub-bottom line 2023__209_0847

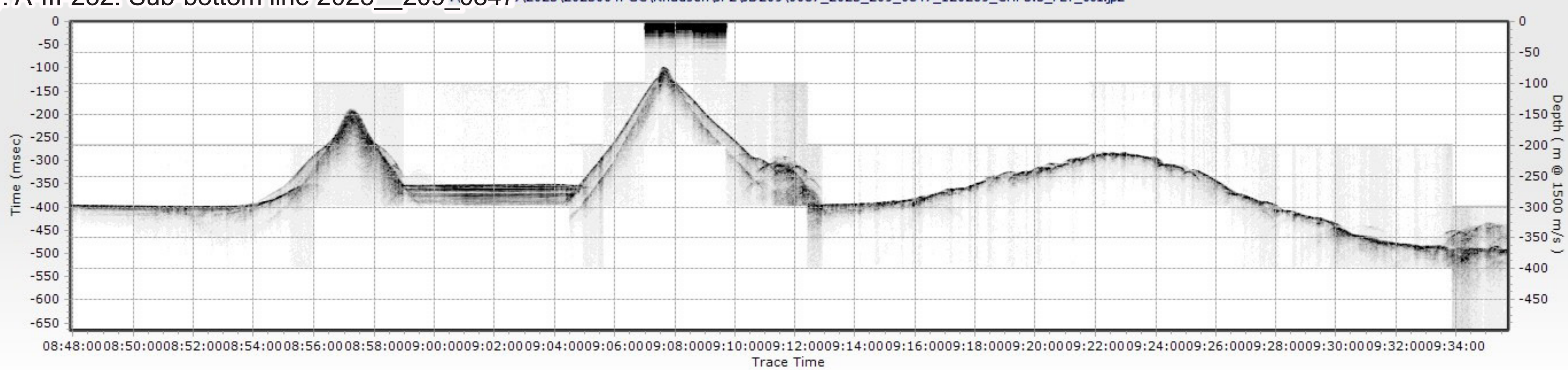


Fig. A-III-233. Sub-bottom line 2023_209_0935

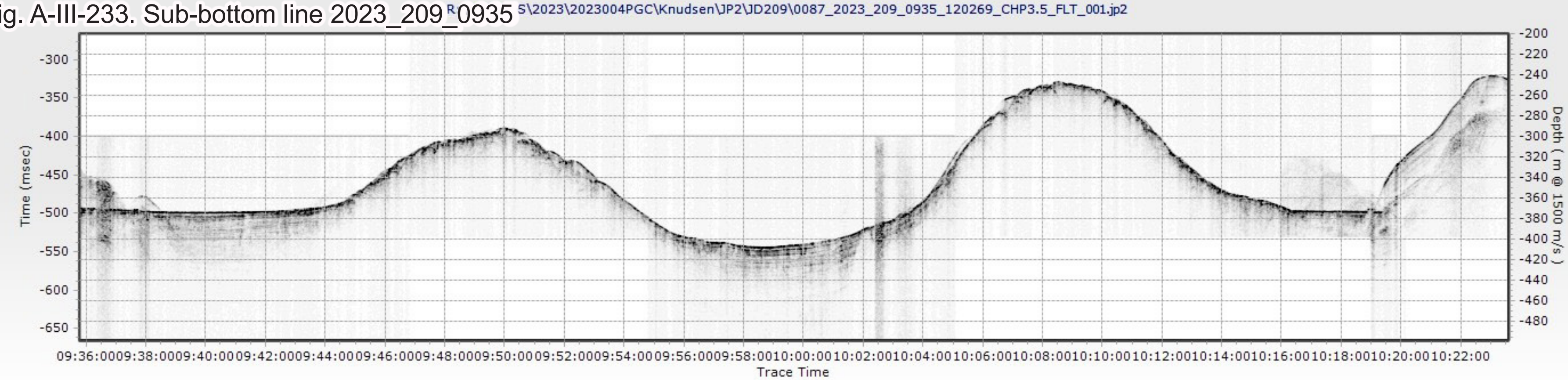


Fig. A-III-234. Sub-bottom line 2023_209_1023

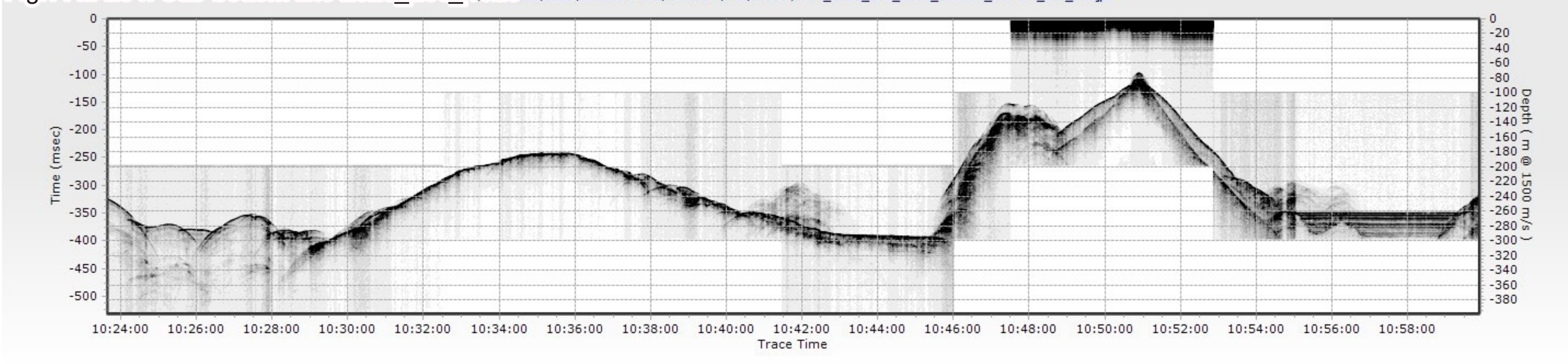


Fig. A-III-235. Sub-bottom line 2023_209_1100

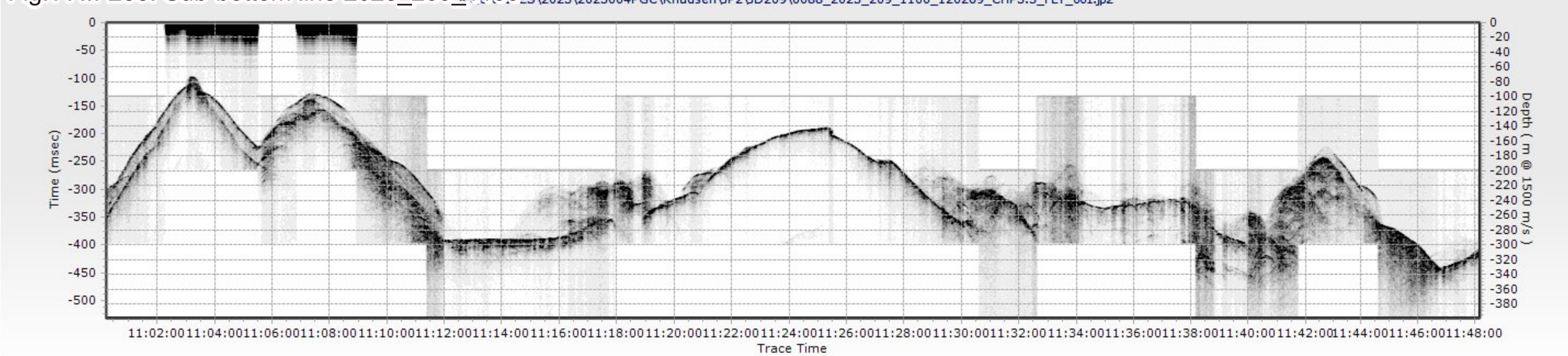


Fig. A-III-236. Sub-bottom line 2023_209_1148

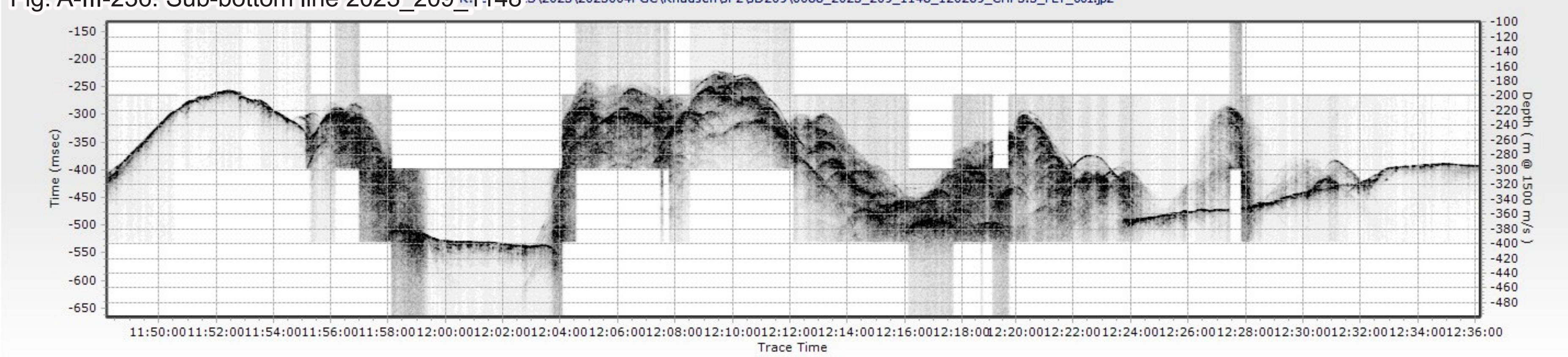


Fig. A-III-237. Sub-bottom line 2023_209_1236

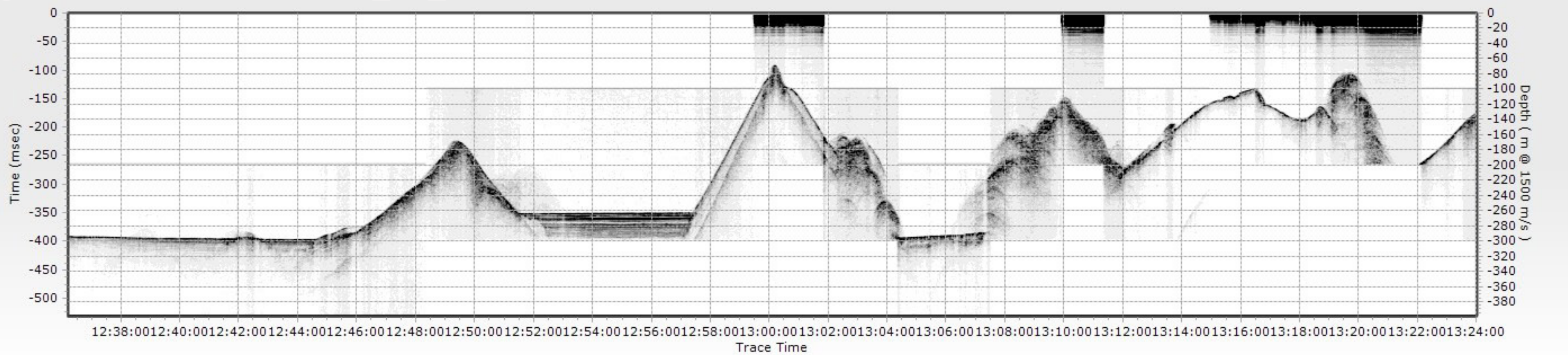


Fig. A-III-238. Sub-bottom line 2023_209_1324

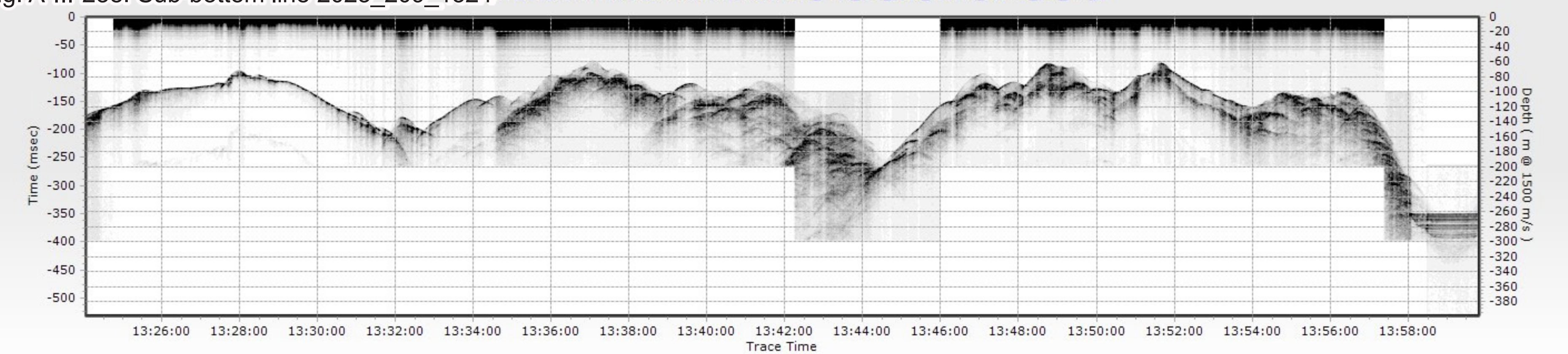


Fig. A-III-239. Sub-bottom line 2023_209_1400

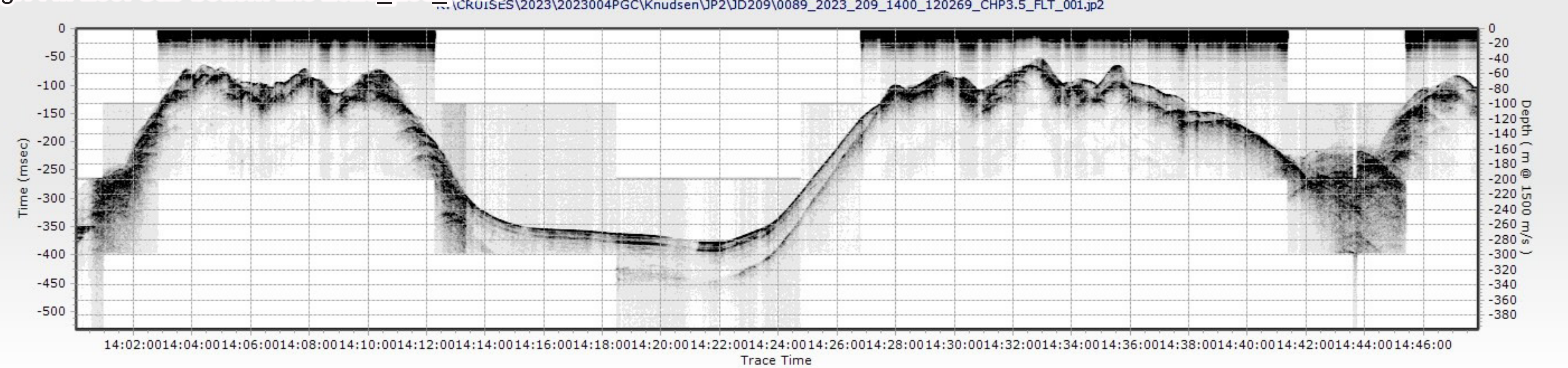


Fig. A-III-240. Sub-bottom line 2023_209_1447

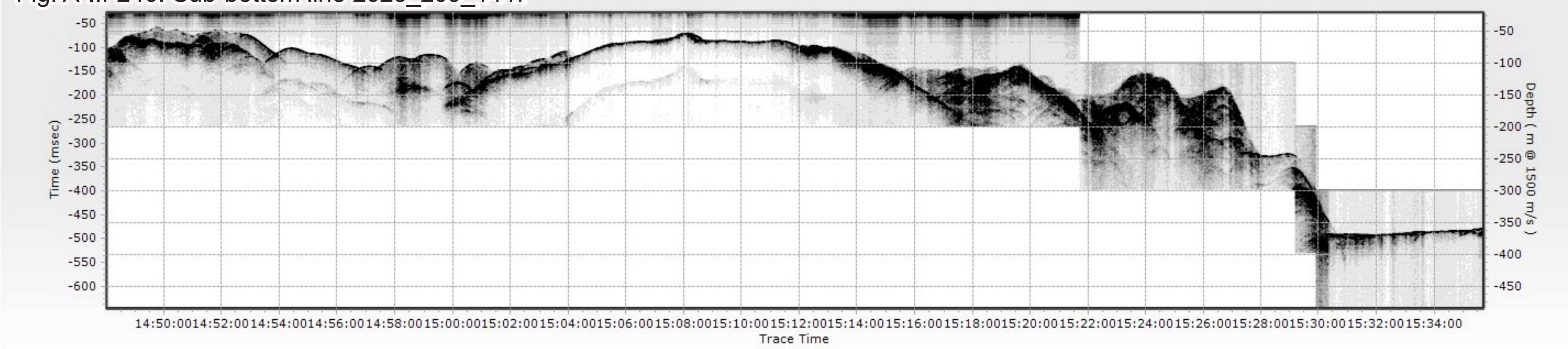


Fig. A-III-241. Sub-bottom line 2023_209_1535

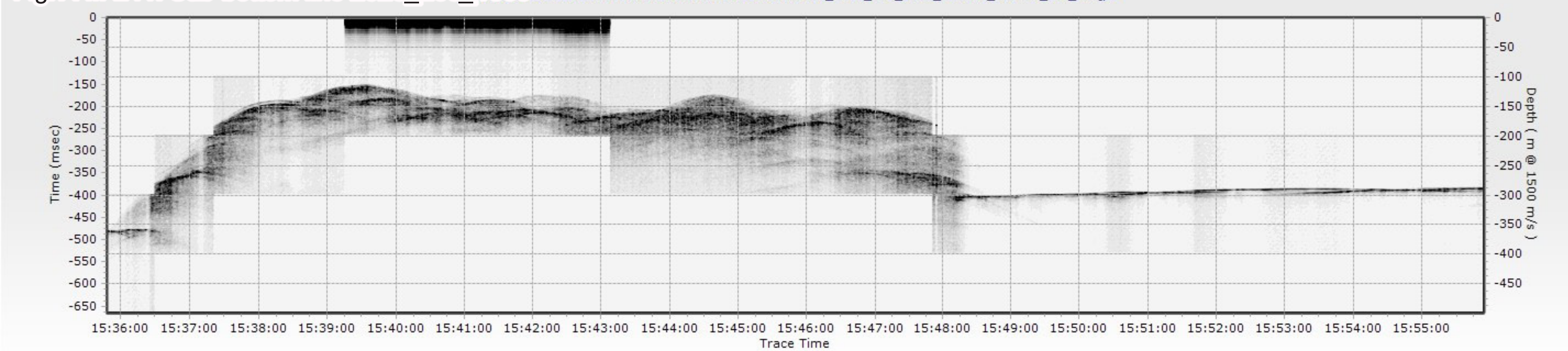


Fig. A-III-242. Sub-bottom line 2023209_1556

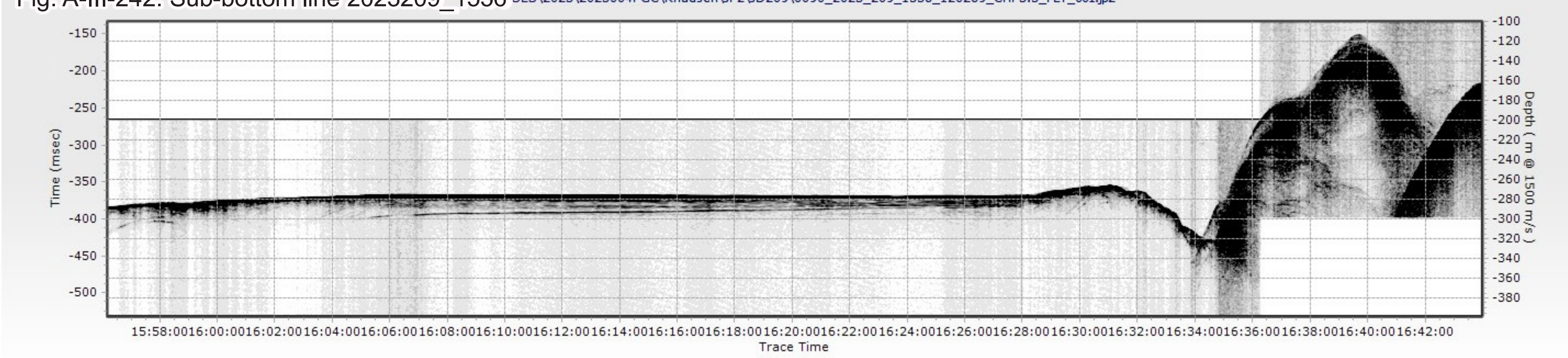


Fig. A-III-243. Sub-bottom line 2023_209_1644

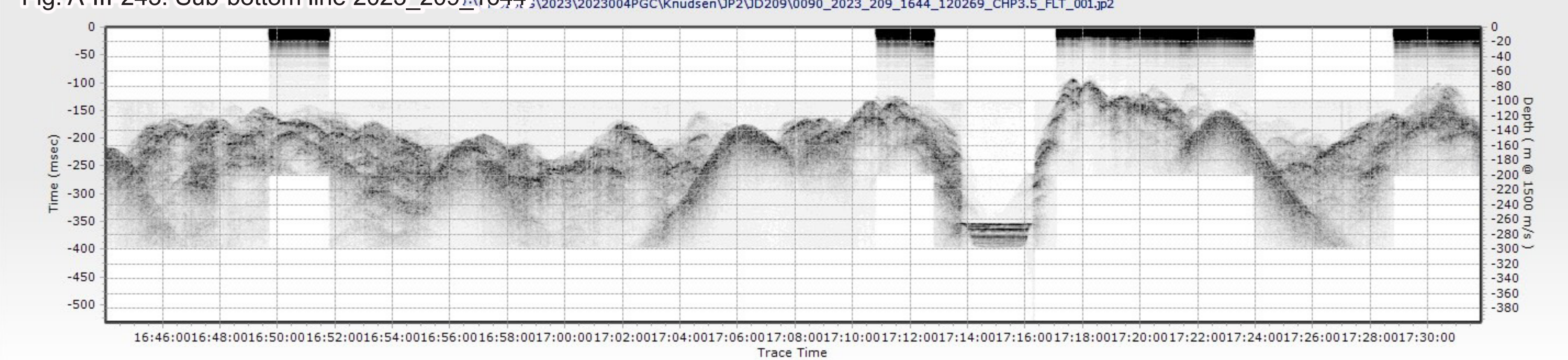


Fig. A-III-244. Sub-bottom line 2023_209_1731

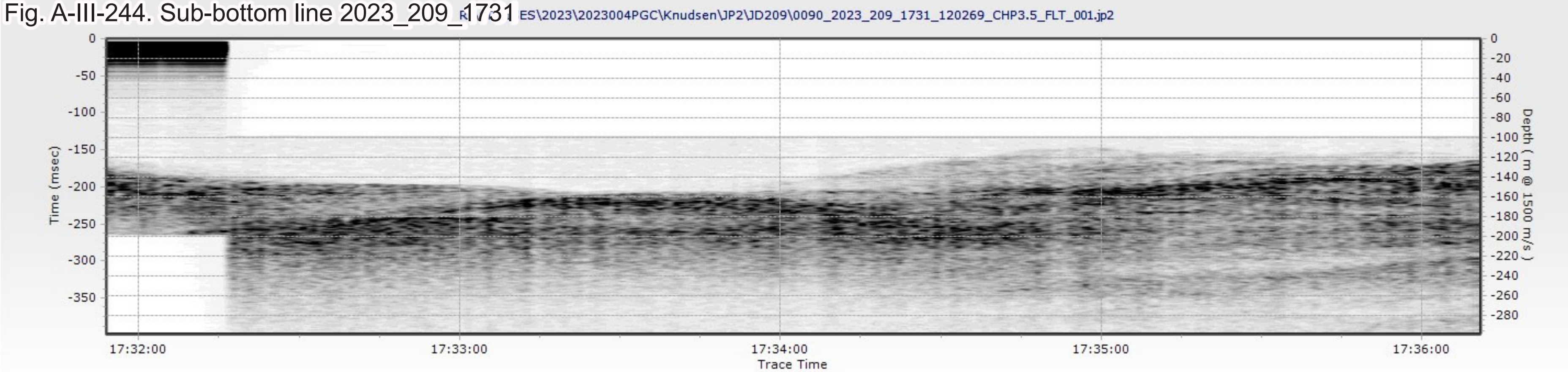


Fig. A-III-245. Sub-bottom line 2023_209_1736

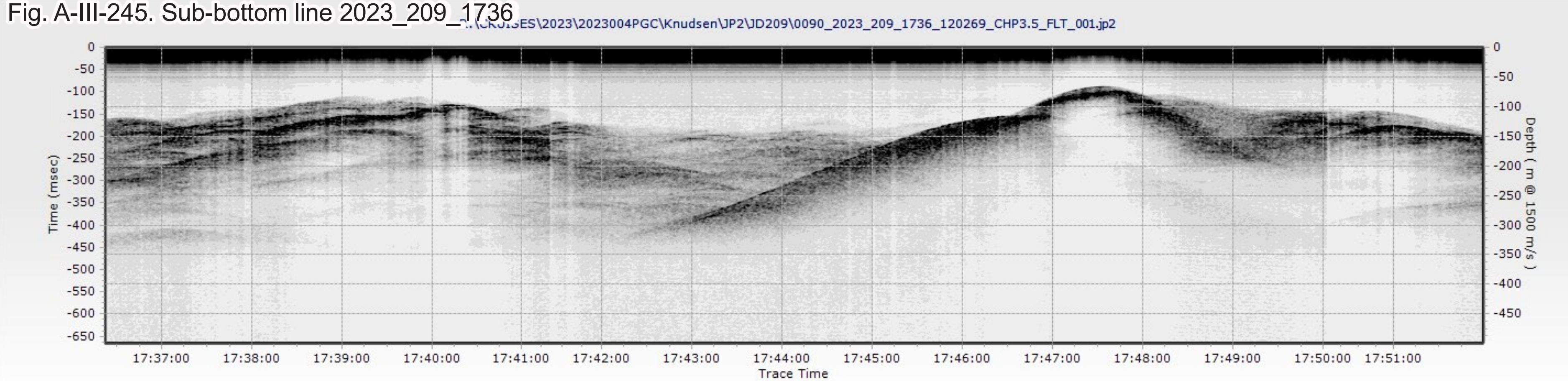
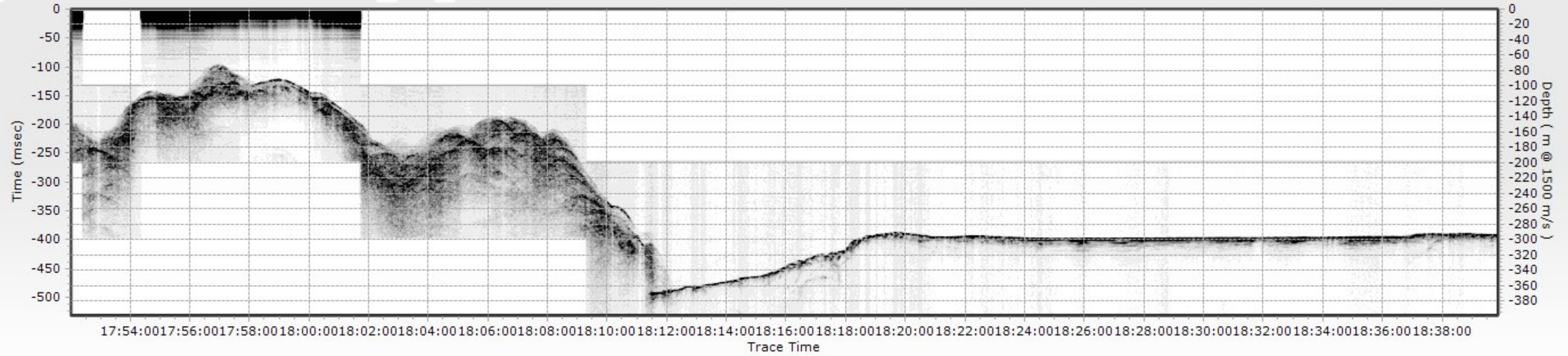


Fig. A-III-246. Sub-bottom line 2023_209_1752



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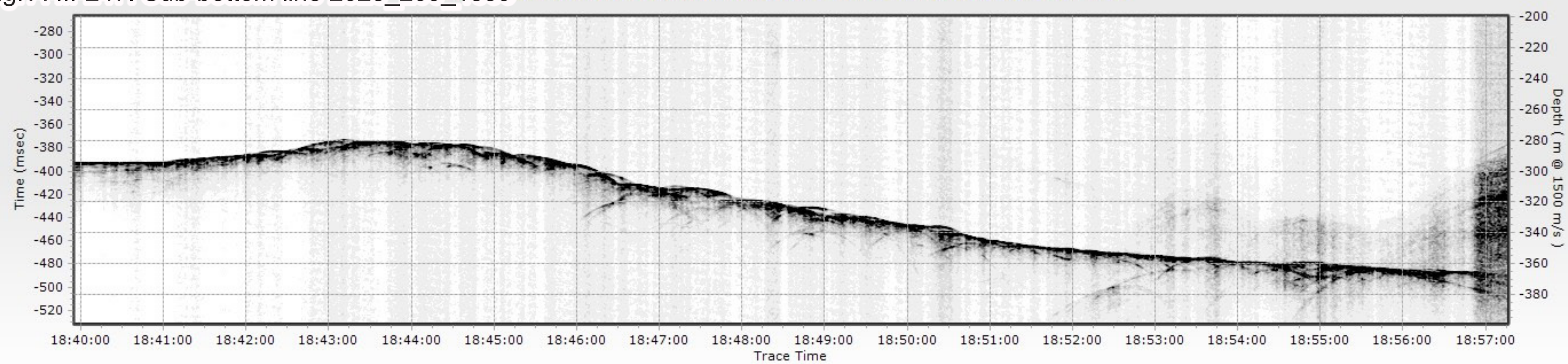


Fig. A-III-248. Sub-bottom line 2023_209_1934

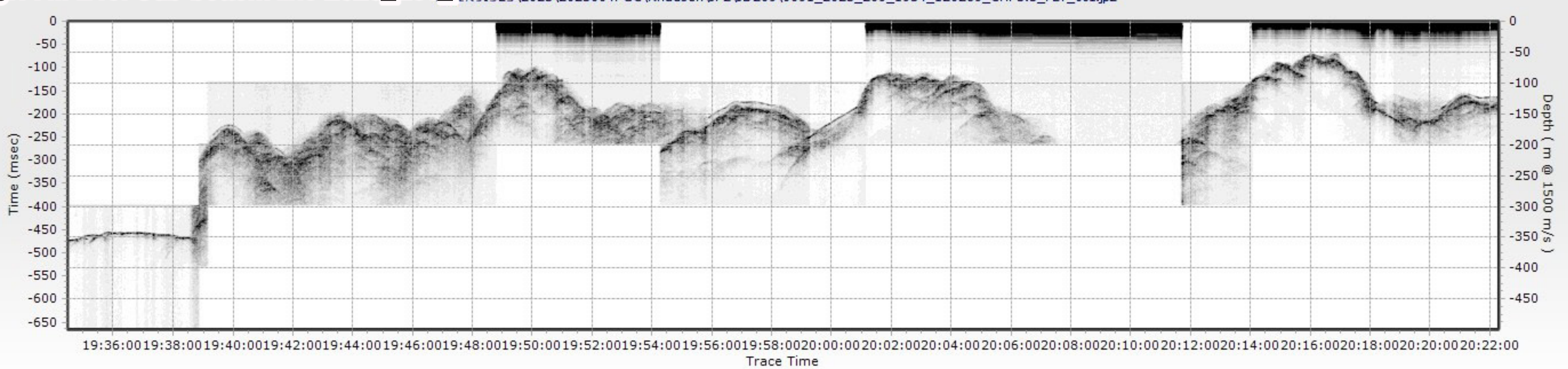
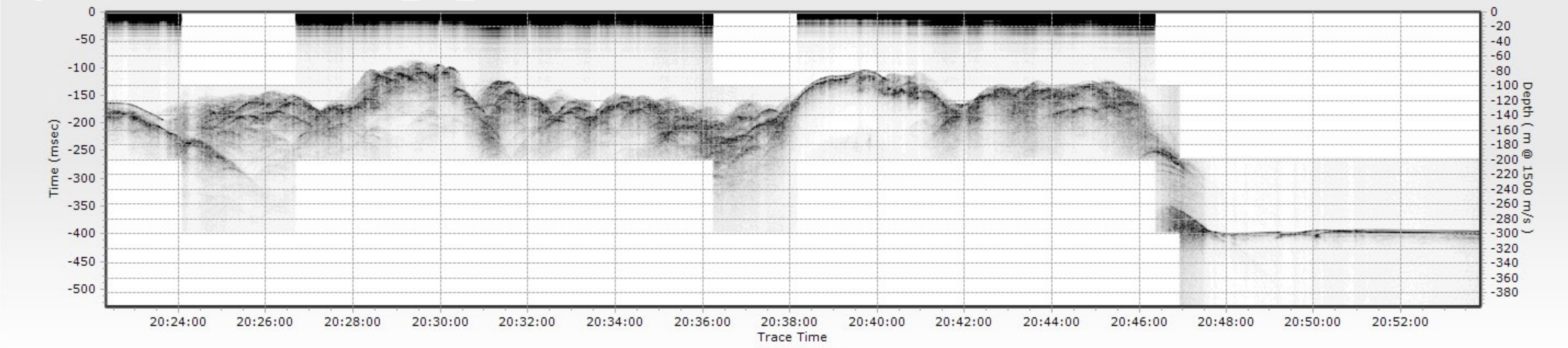


Fig. A-III-249. Sub-bottom line 2023_209_2022



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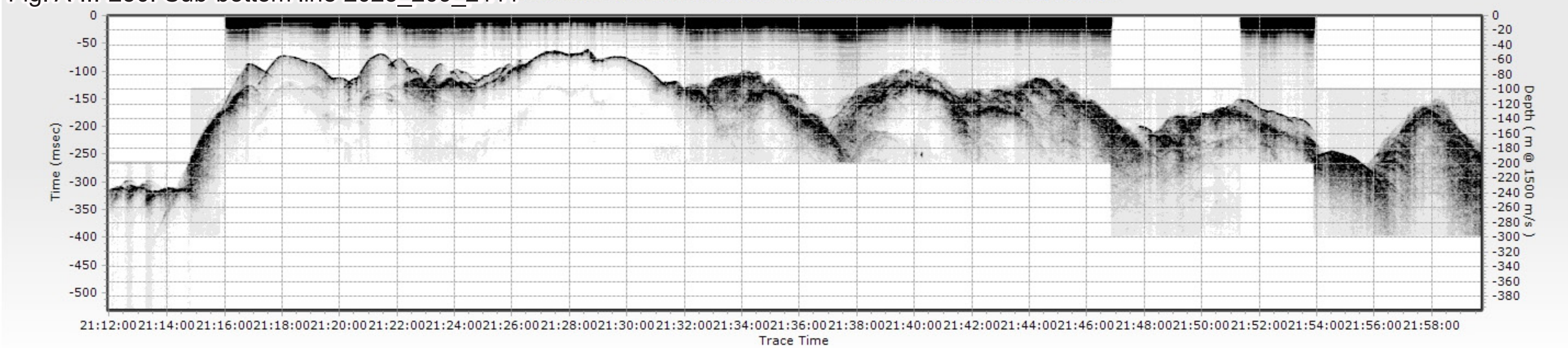


Fig. A-III-251. Sub-bottom line 2023_209_2159

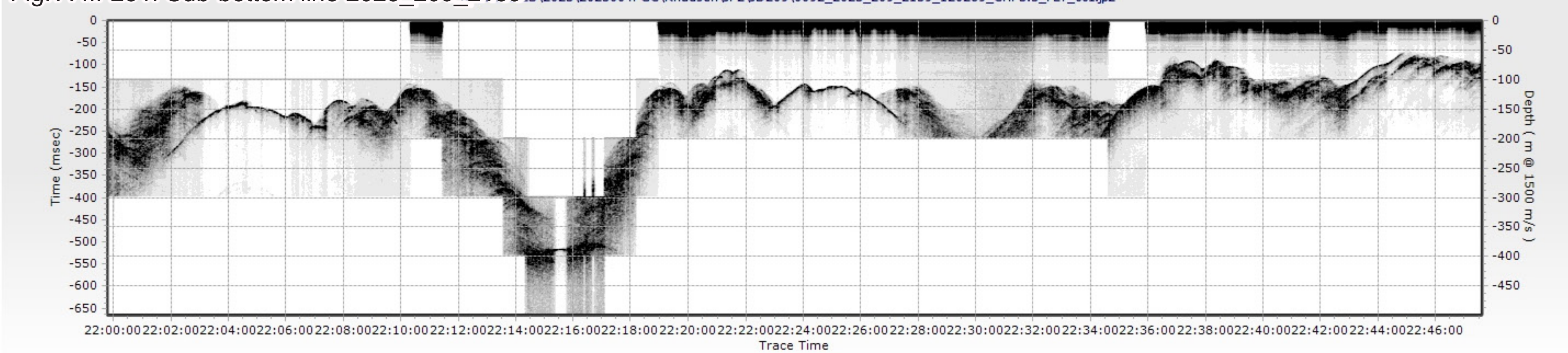


Fig. A-III-252. Sub-bottom line 2023_209_2247

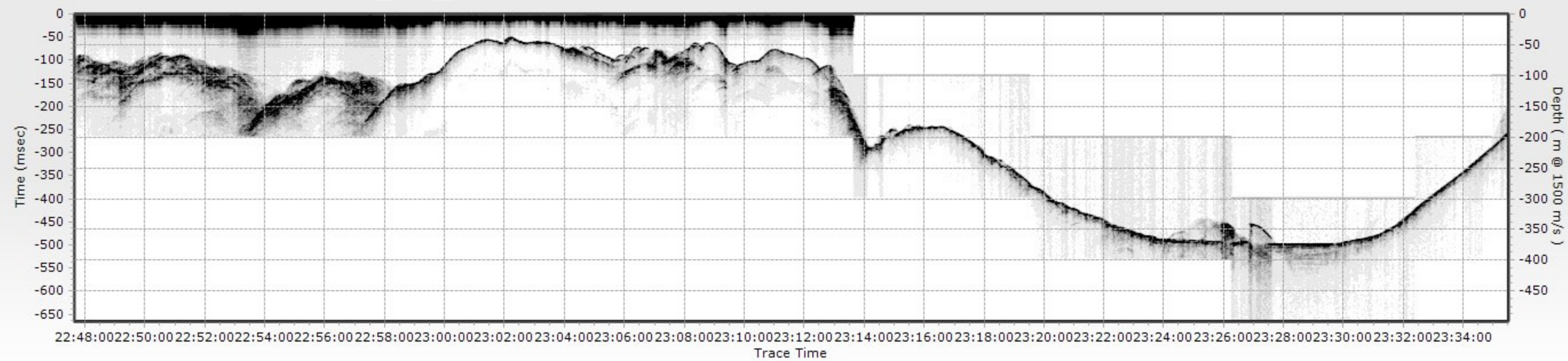
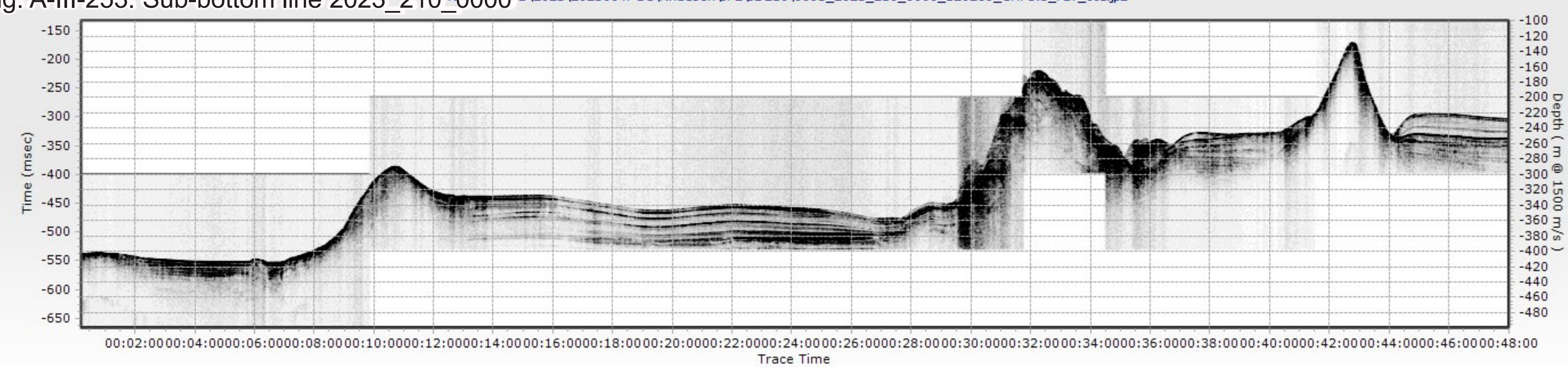


Fig. A-III-253. Sub-bottom line 2023_210_0000



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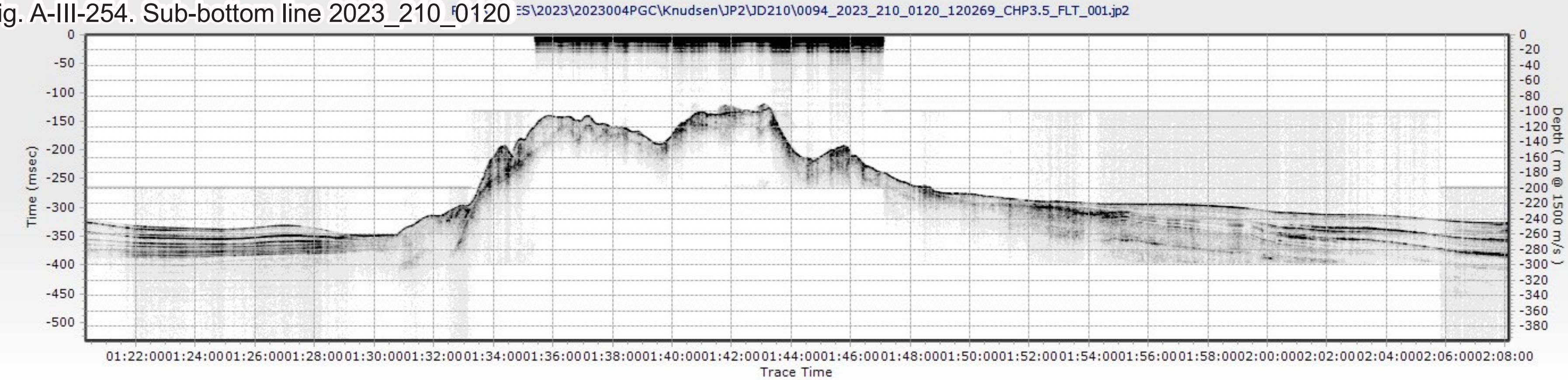

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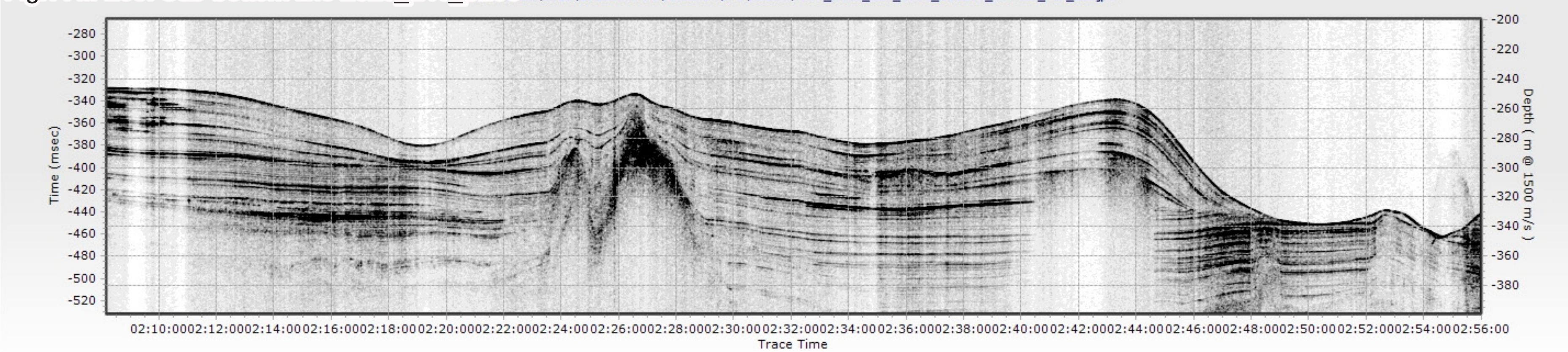
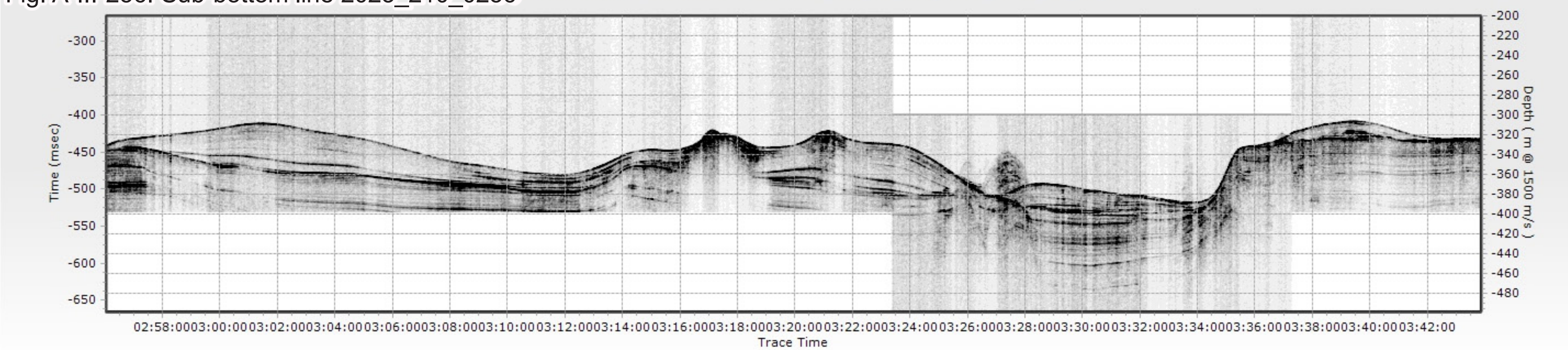


Fig. A-III-256. Sub-bottom line 2023_210_0256



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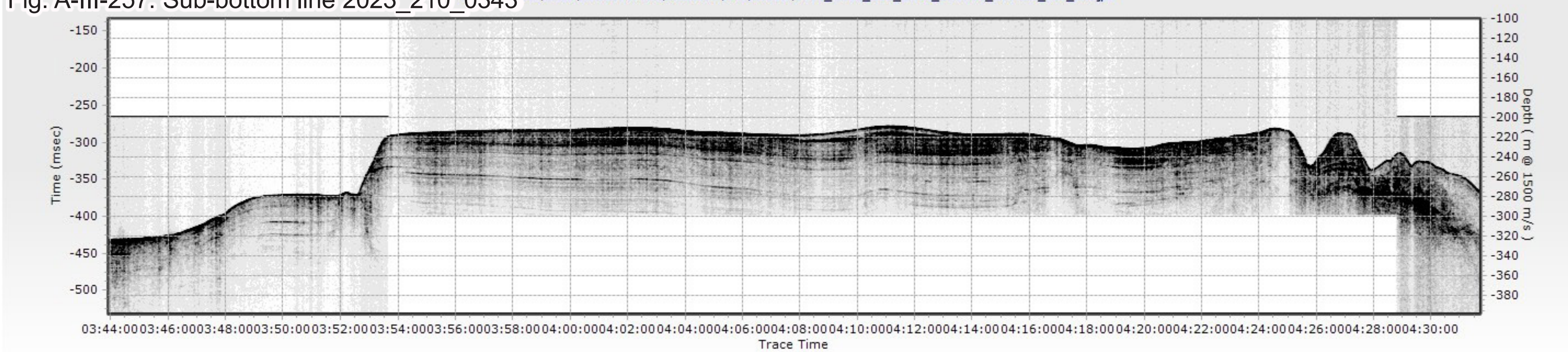
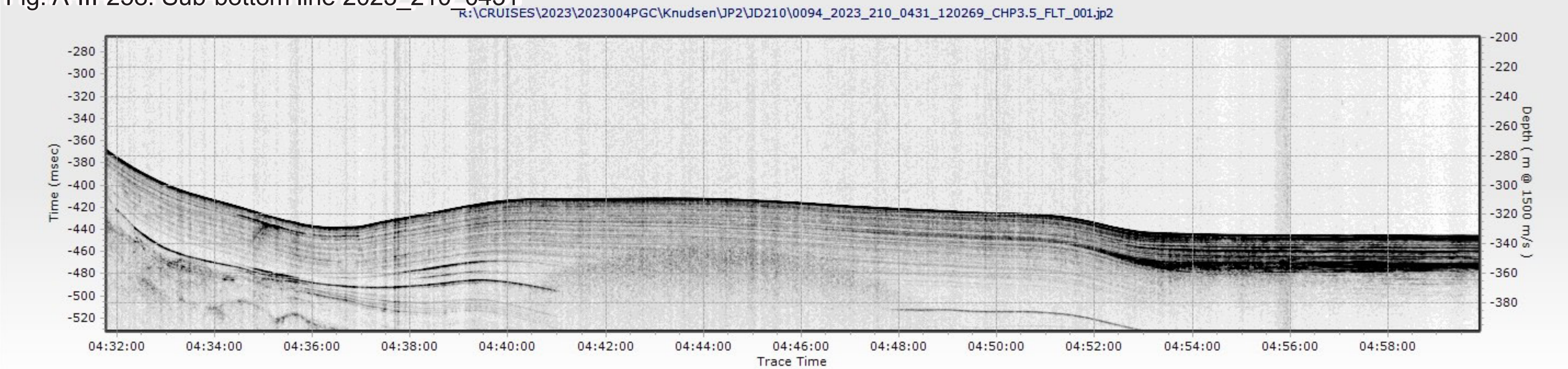


Fig. A-III-258. Sub-bottom line 2023_210_0431



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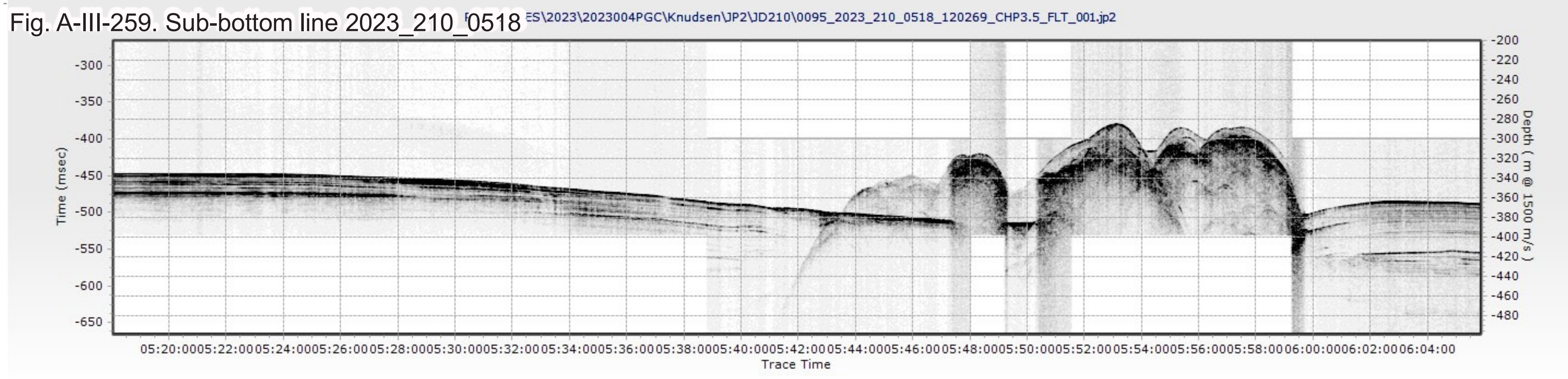
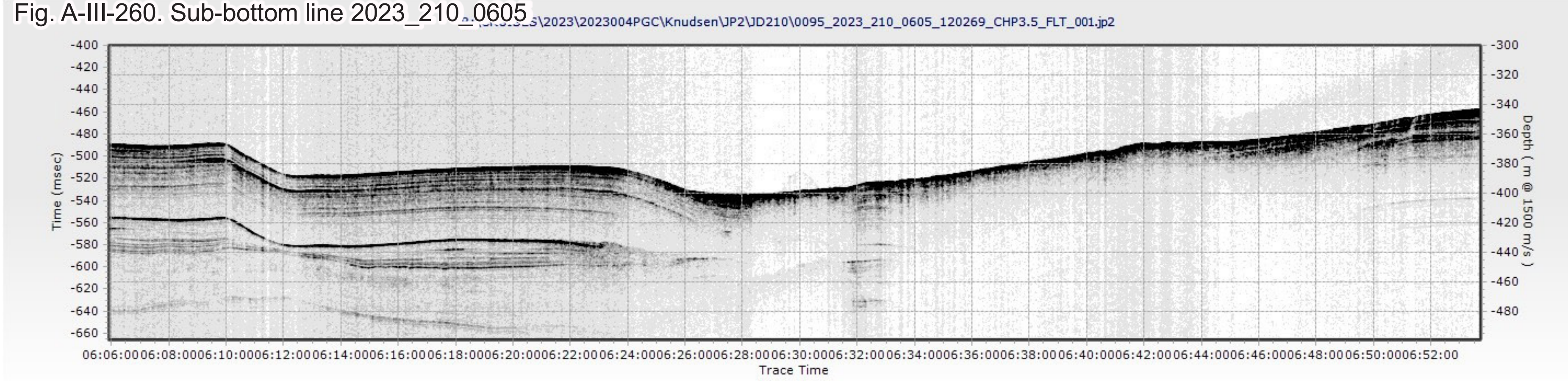


Fig. A-III-260. Sub-bottom line 2023_210_0605



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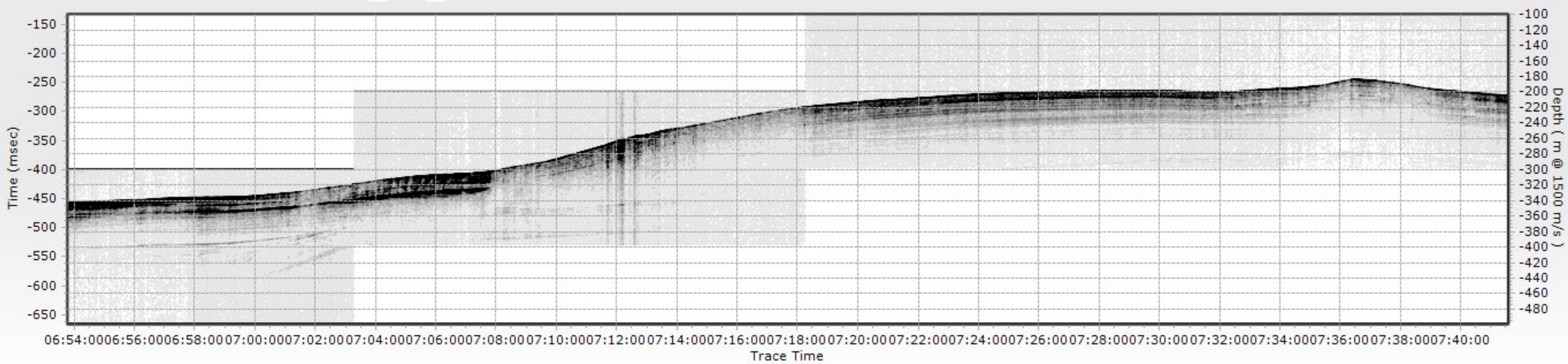


Fig. A-III-262. Sub-bottom line 2023_210_0741

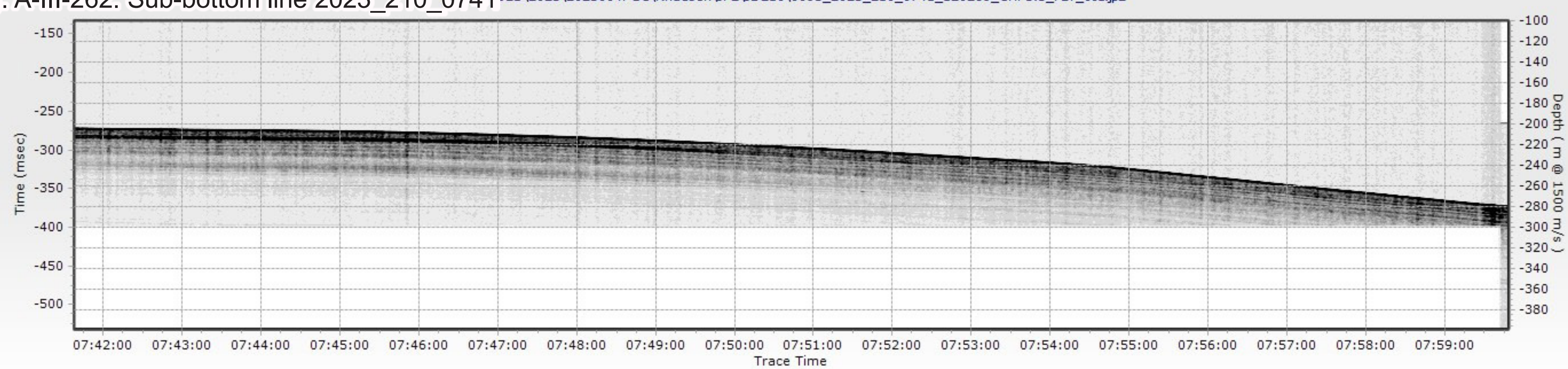
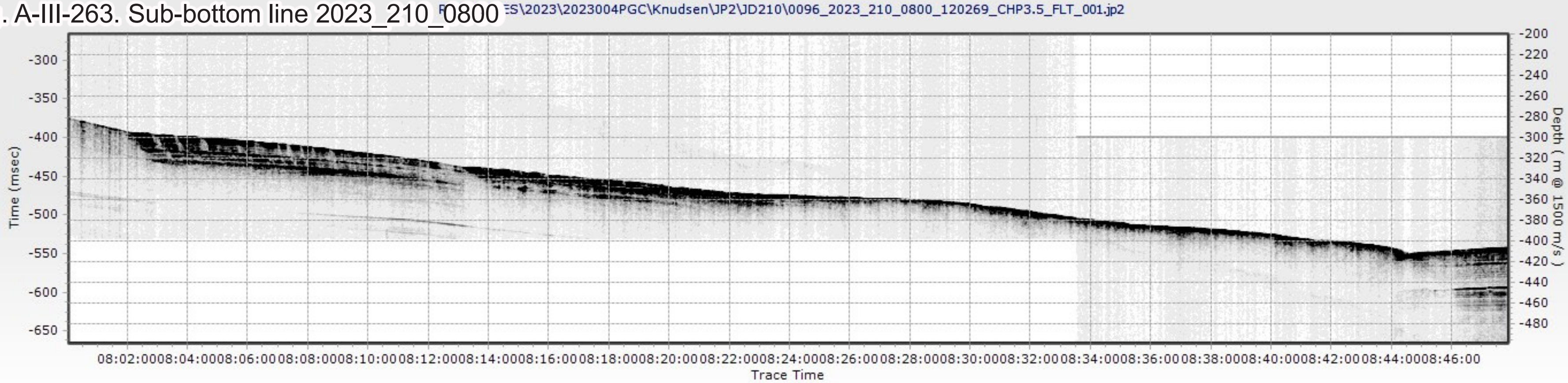


Fig. A-III-263. Sub-bottom line 2023_210_0800



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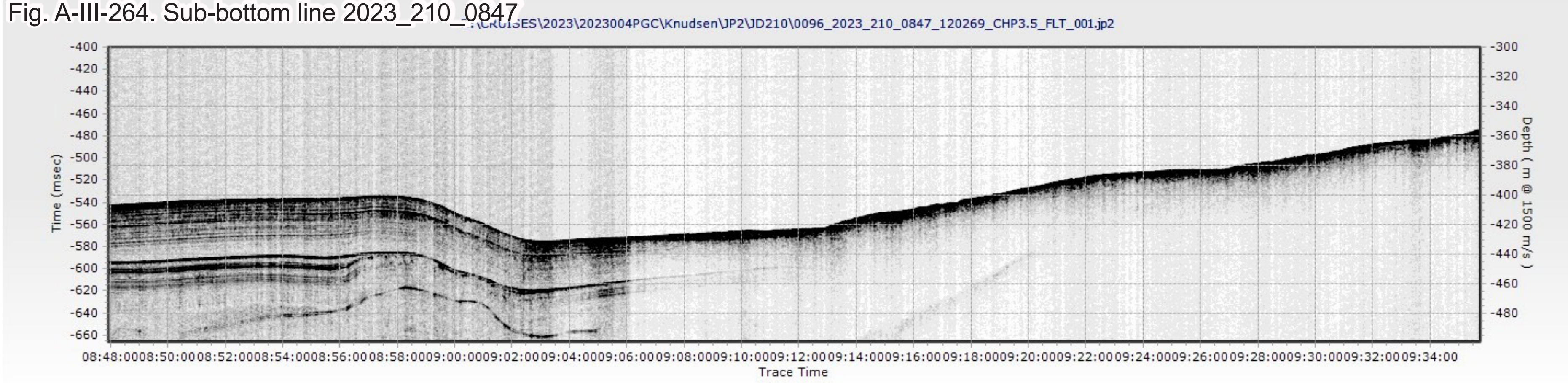


Fig. A-III-265. Sub-bottom line 2023_210_0935

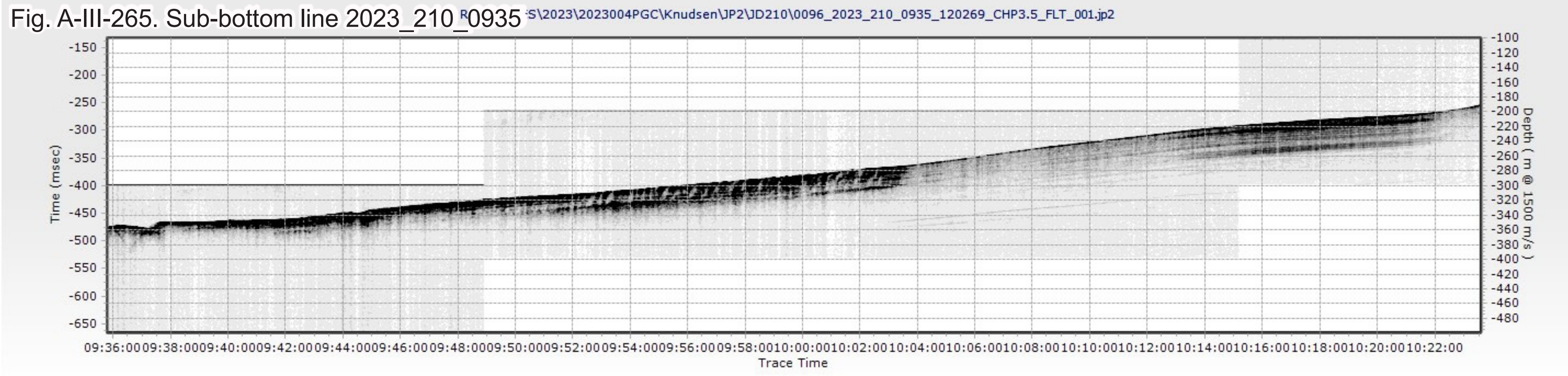


Fig. A-III-266. Sub-bottom line 2023_210_1023

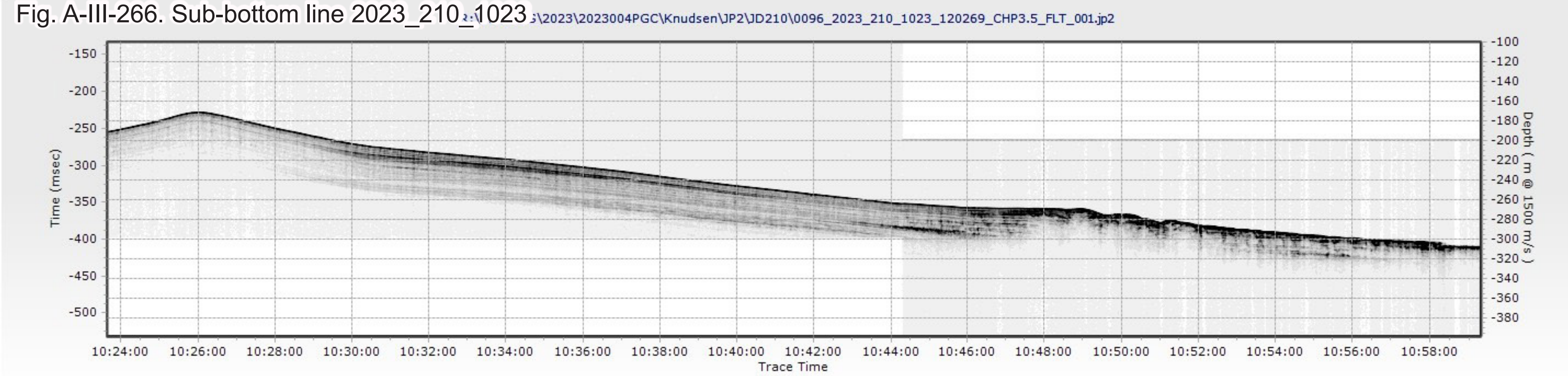


Fig. A-III-267. Sub-bottom line 2023_210_1059

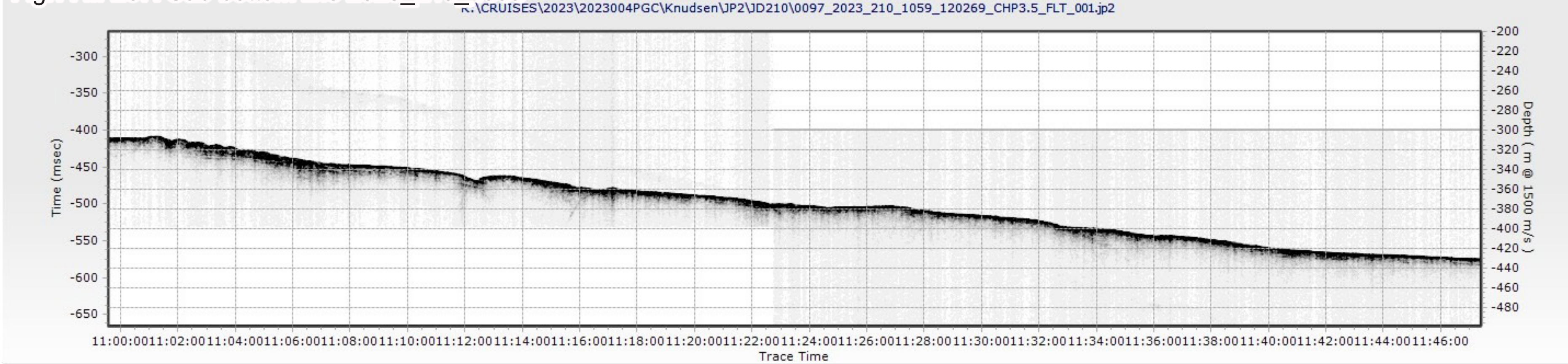


Fig. A-III-268. Sub-bottom line 2023_210_1147

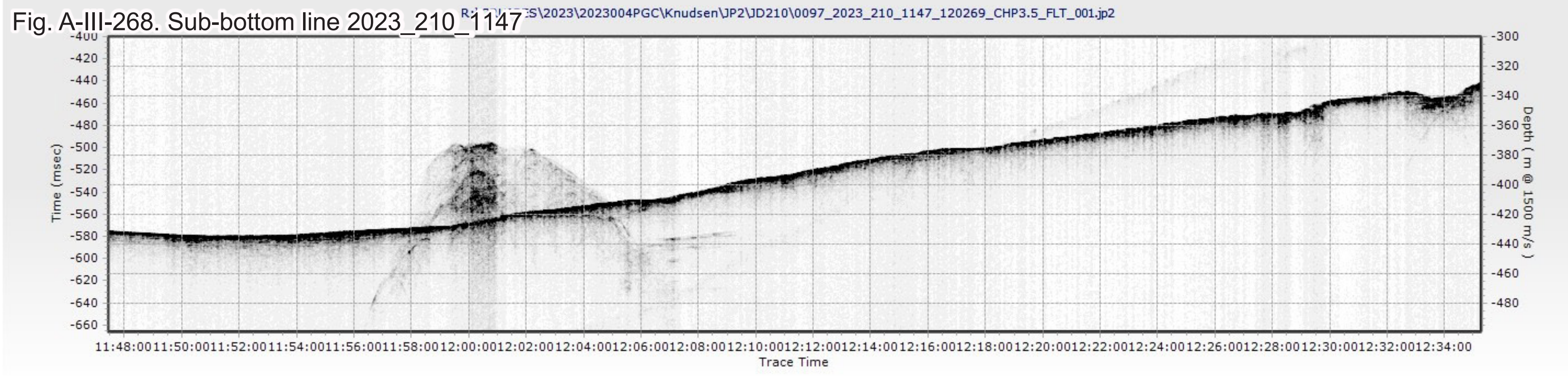


Fig. A-III-269. Sub-bottom line 2023_210_1235

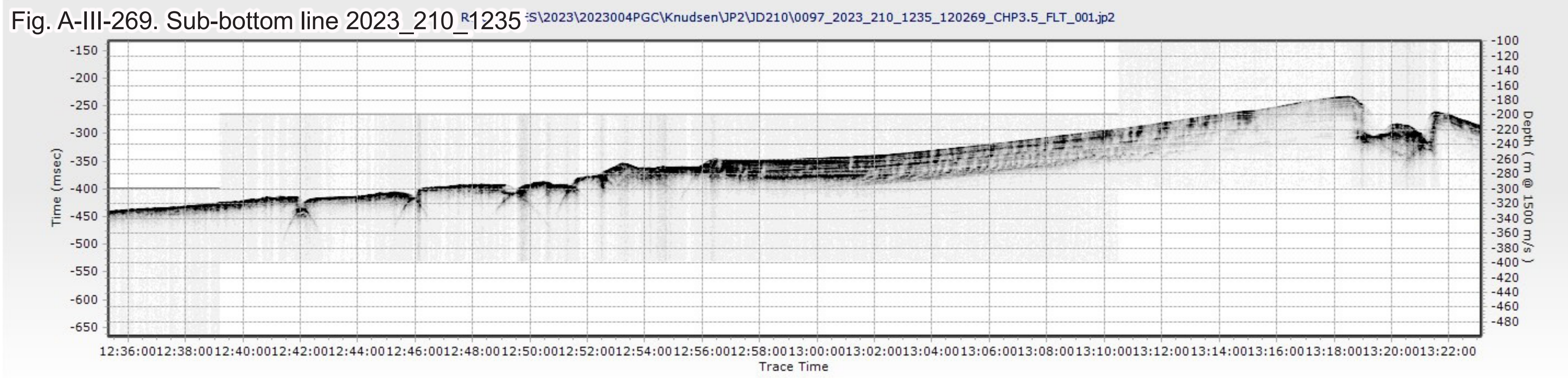


Fig. A-III-270. Sub-bottom line 2023_210_1323

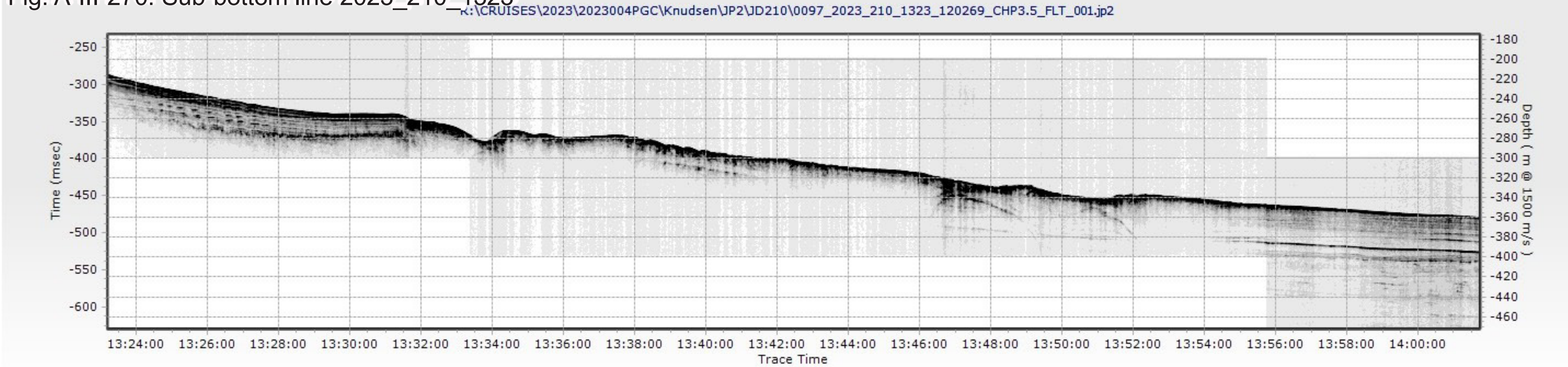


Fig. A-III-271. Sub-bottom line 2023__210_1402

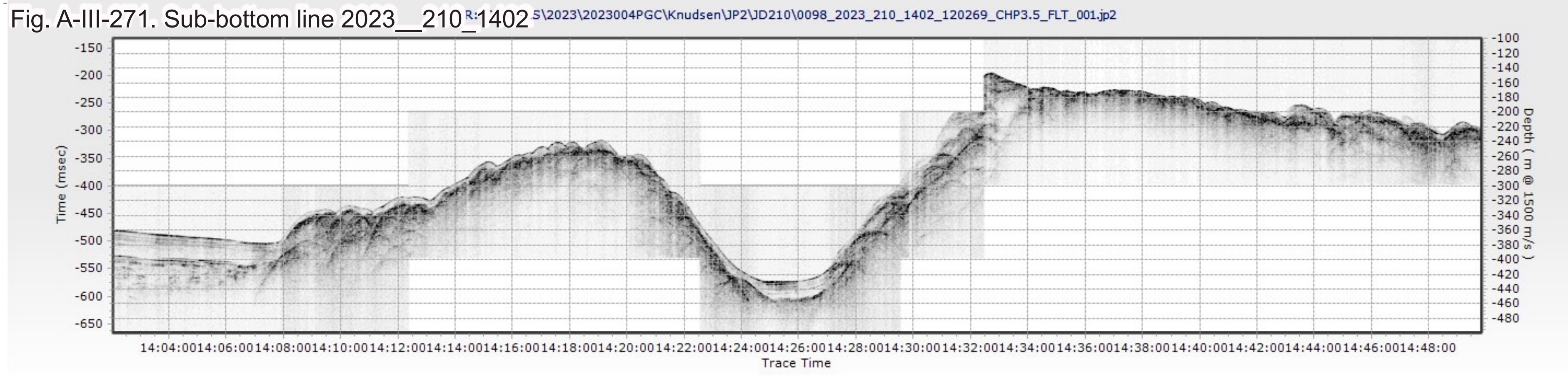


Fig. A-III-272. Sub-bottom line 2023_210_1449

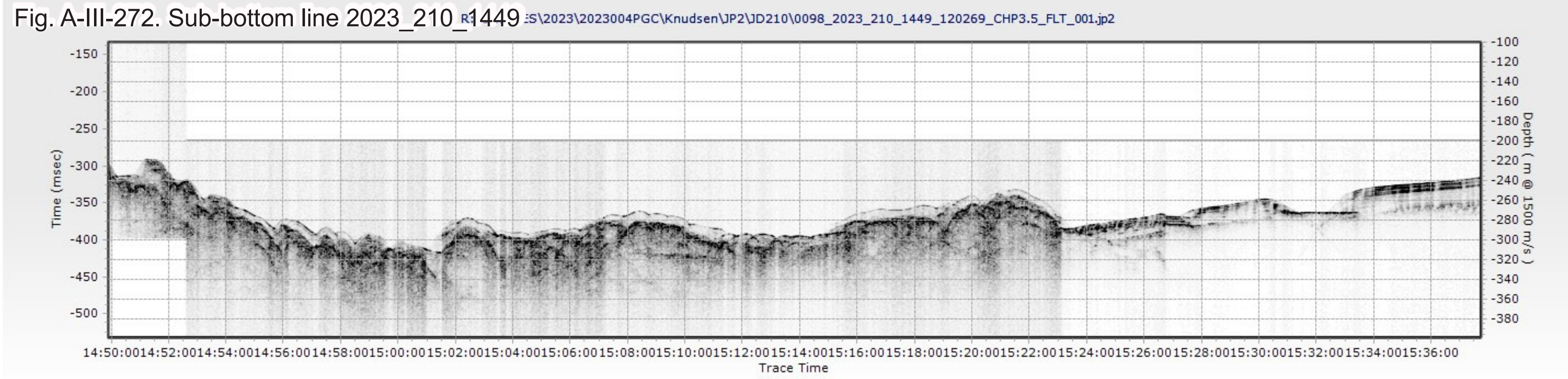


Fig. A-III-273. Sub-bottom line 2023_210_1537

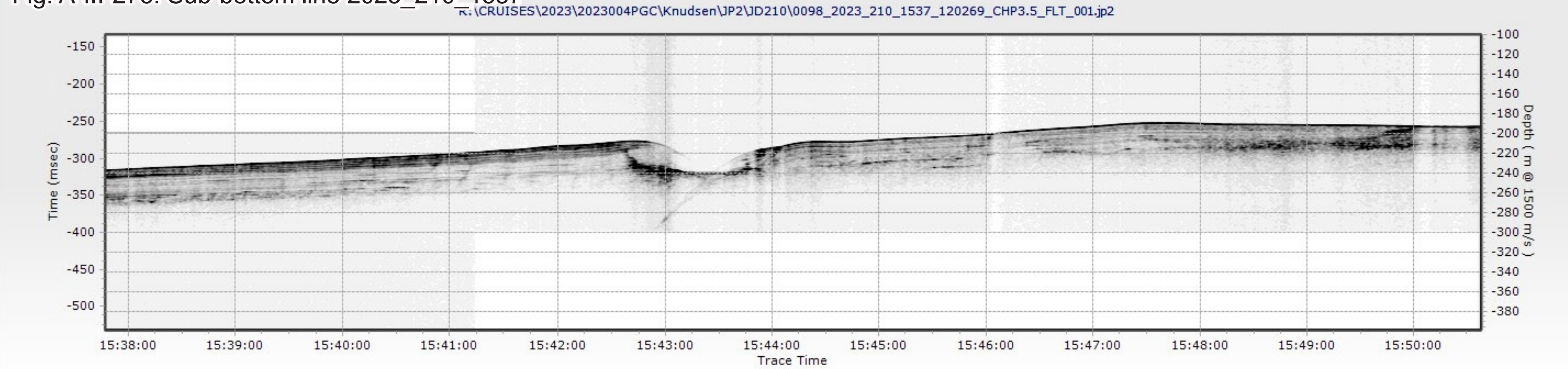


Fig. A-III-274. Sub-bottom line 2023_210_1624

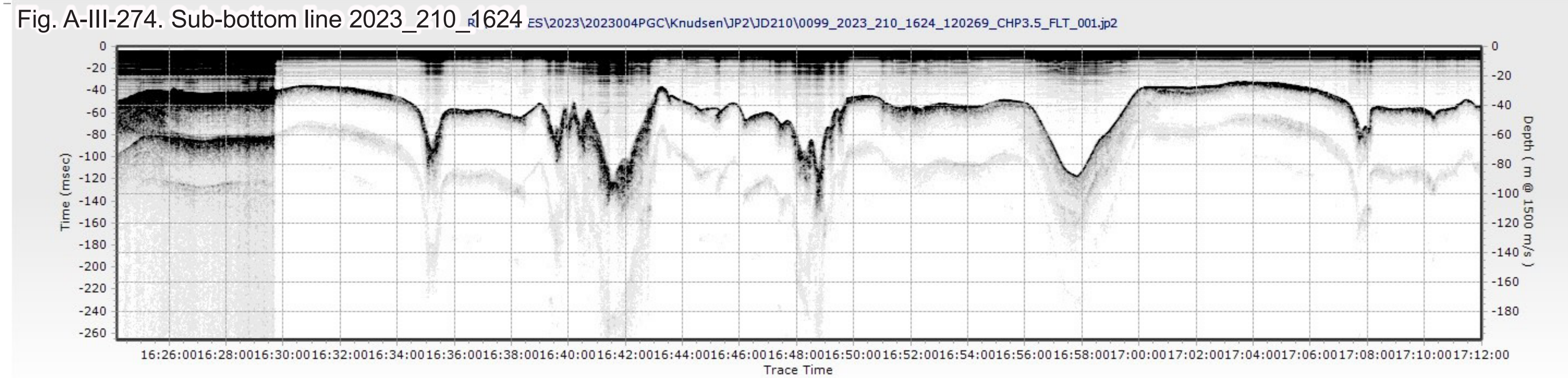


Fig. A-III-275. Sub-bottom line 2023_210_1712

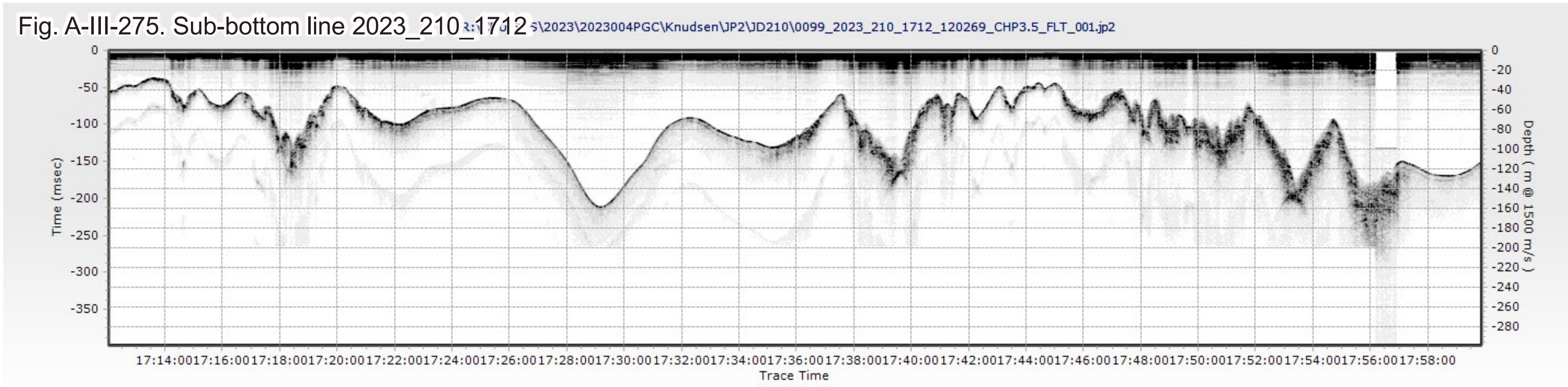


Fig. A-III-276. Sub-bottom line 2023__210_1759

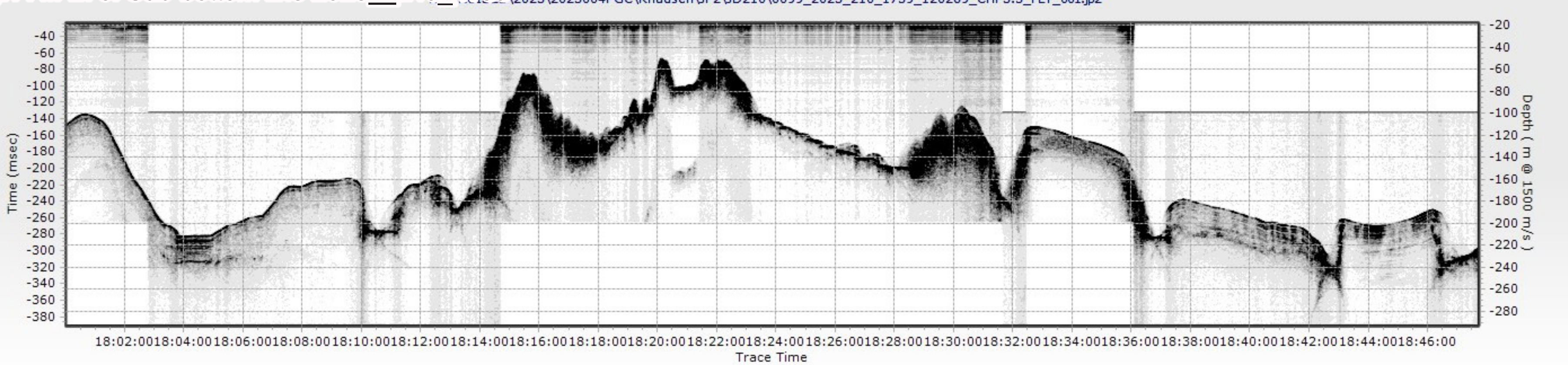


Fig. A-III-277. Sub-bottom line 2023__210_1900

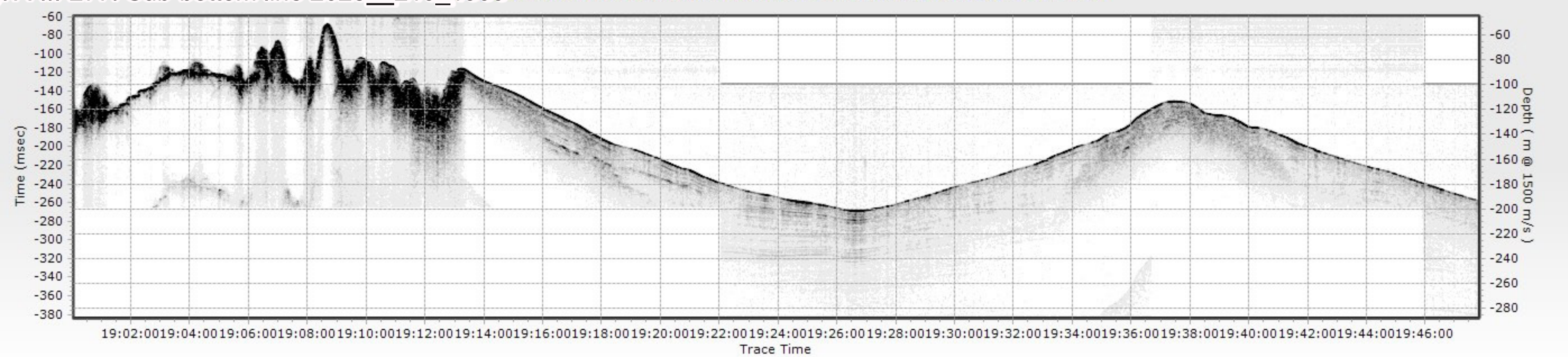


Fig. A-III-278. Sub-bottom line 2023_210_1947

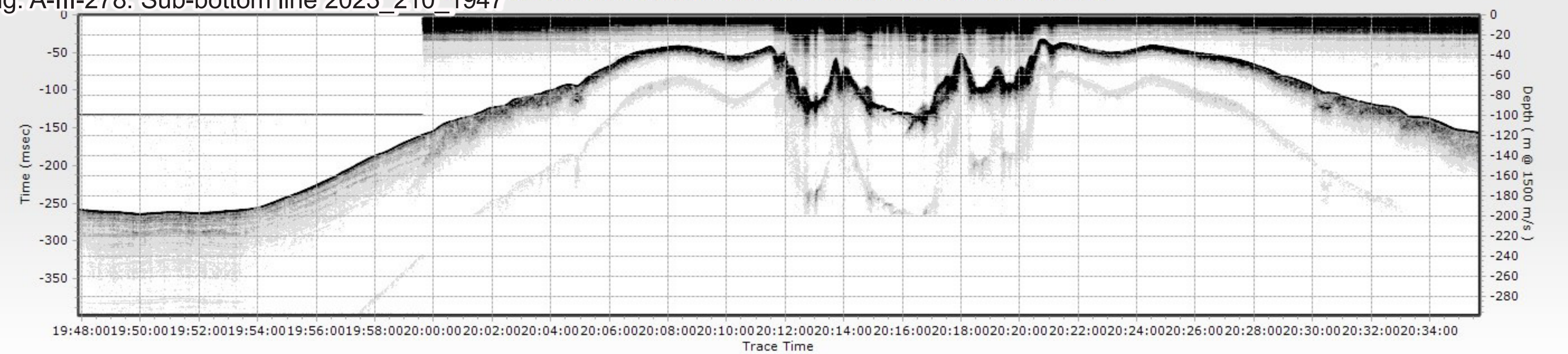


Fig. A-III-279. Sub-bottom line 2023_210_2035

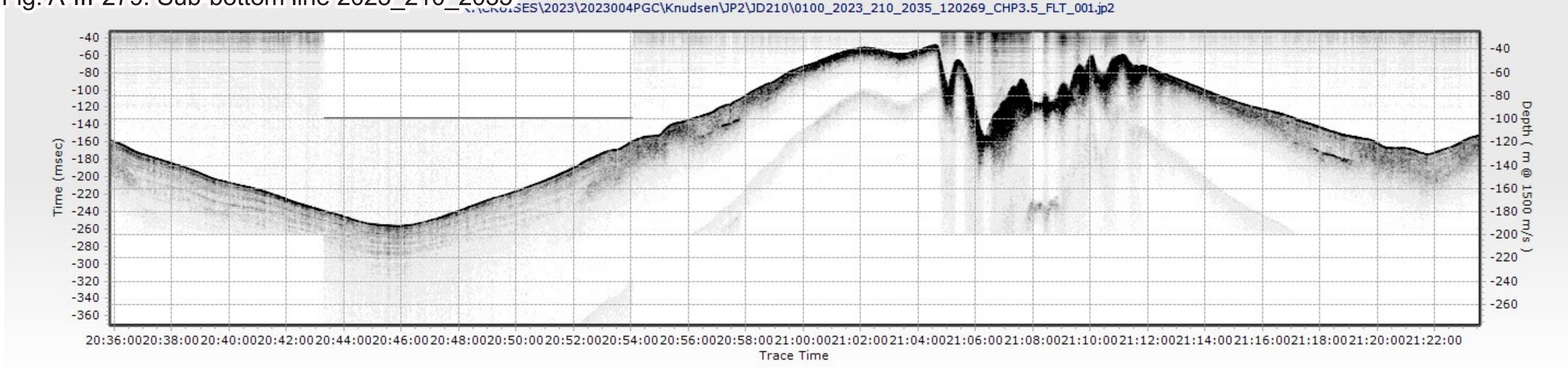


Fig. A-III-280. Sub-bottom line 2023_210_2123

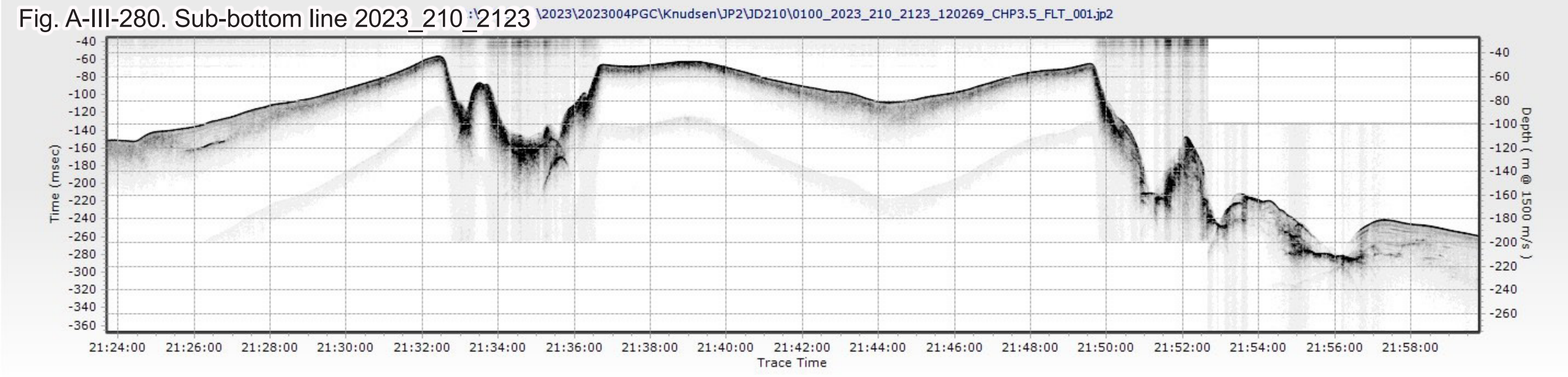


Fig. A-III-281. Sub-bottom line 2023_210_2200

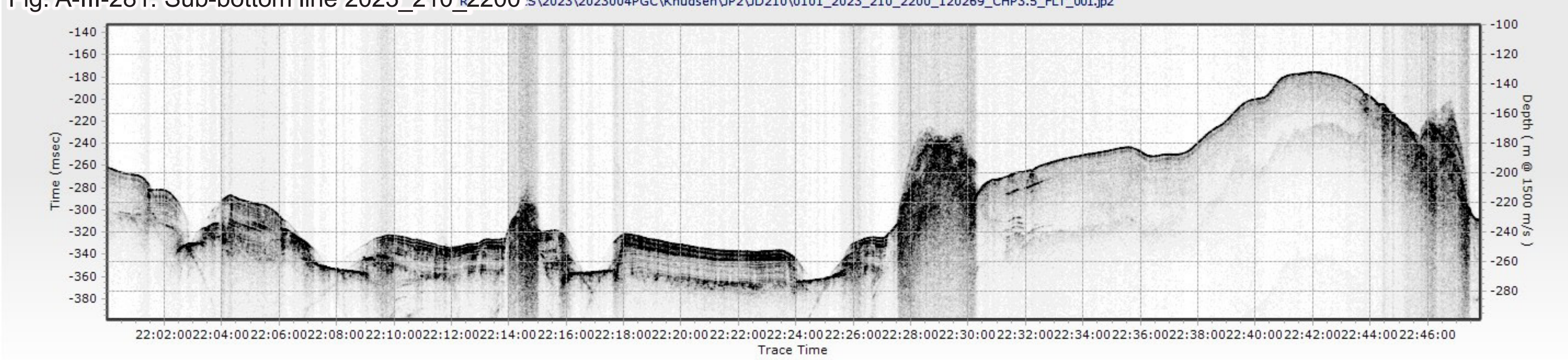


Fig. A-III-282. Sub-bottom line 2023_210_2247

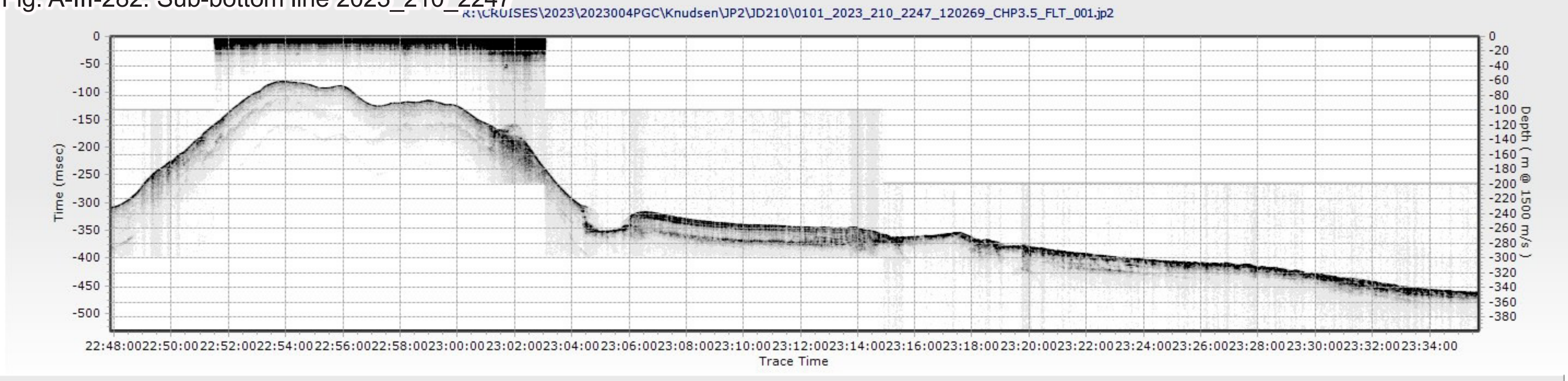


Fig. A-III-283. Sub-bottom line 2023_210_2335

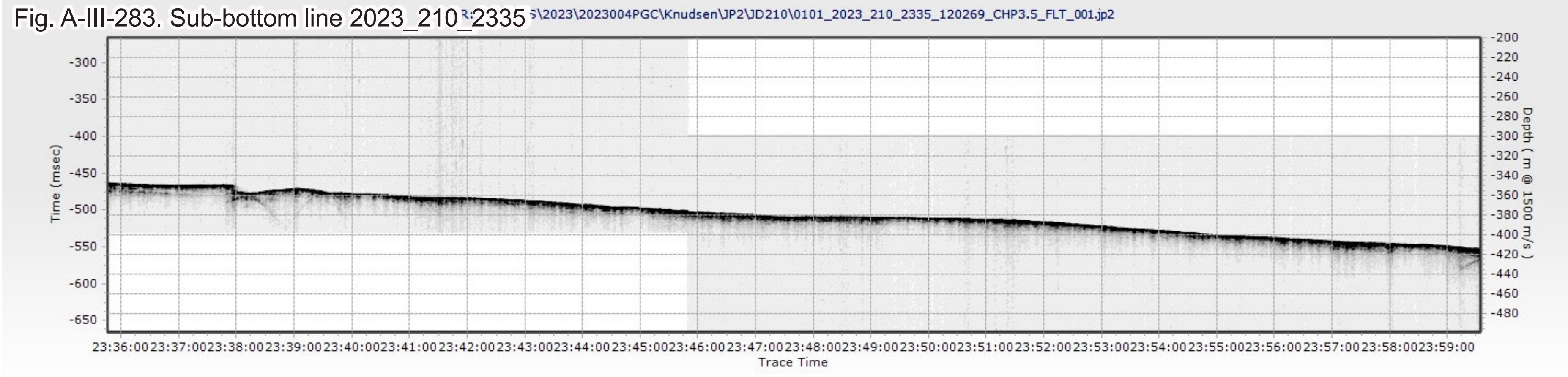


Fig. A-III-284. Sub-bottom line 2023_211_0000

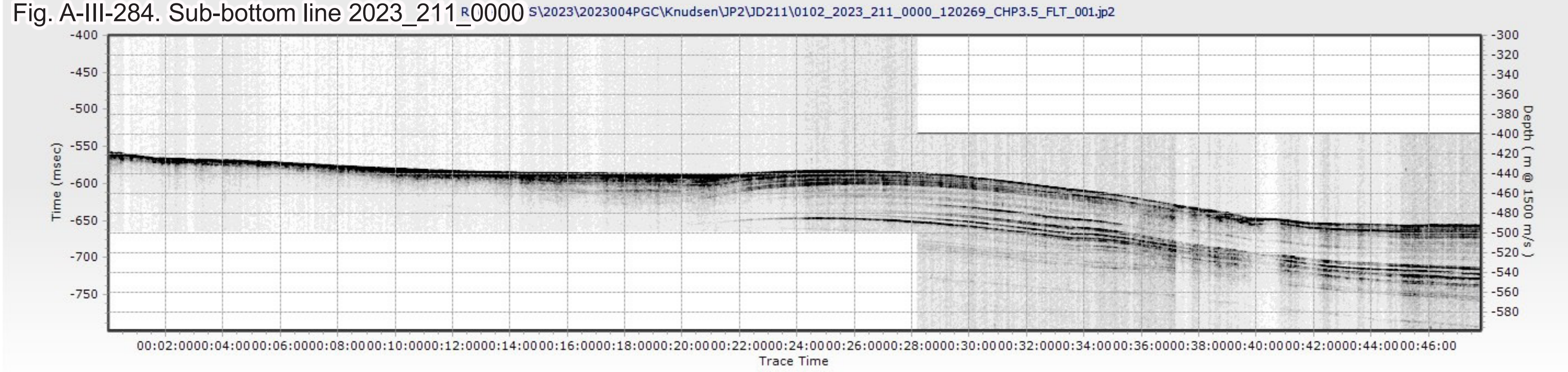


Fig. A-III-285. Sub-bottom line 2023_211_0047

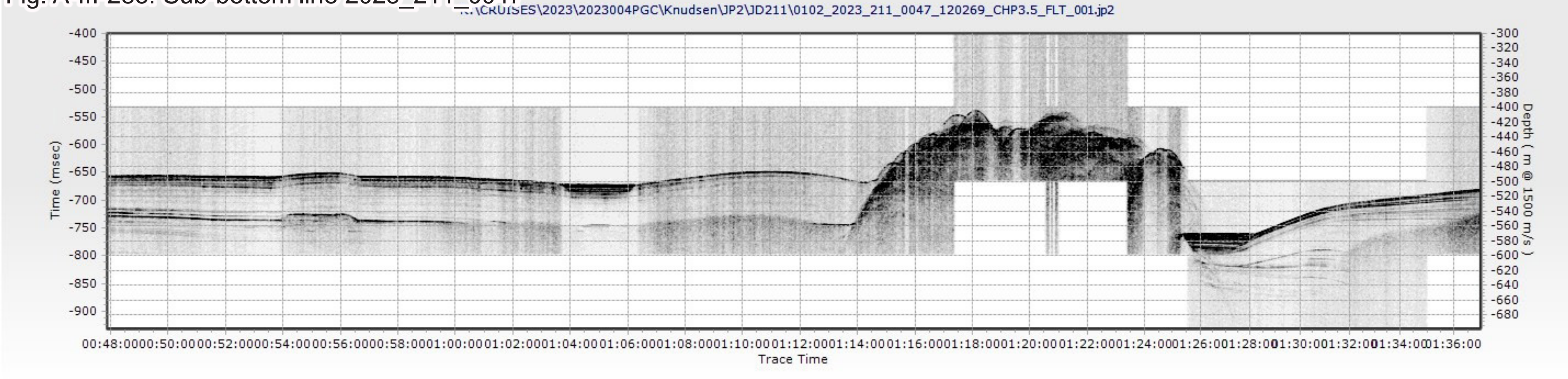


Fig. A-III-286. Sub-bottom line 2023_211_0136

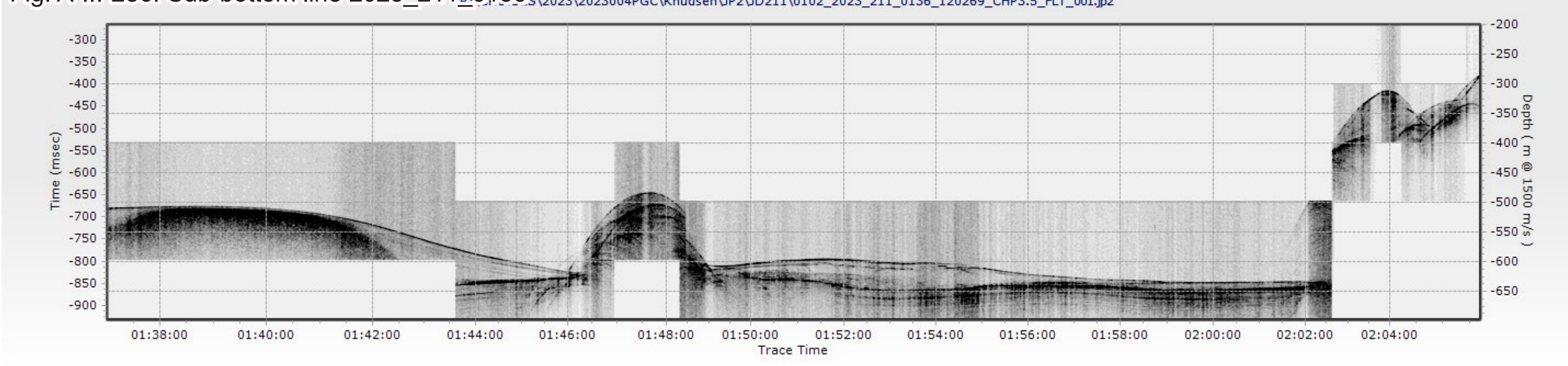


Fig. A-III-287. Sub-bottom line 2023_211_0205

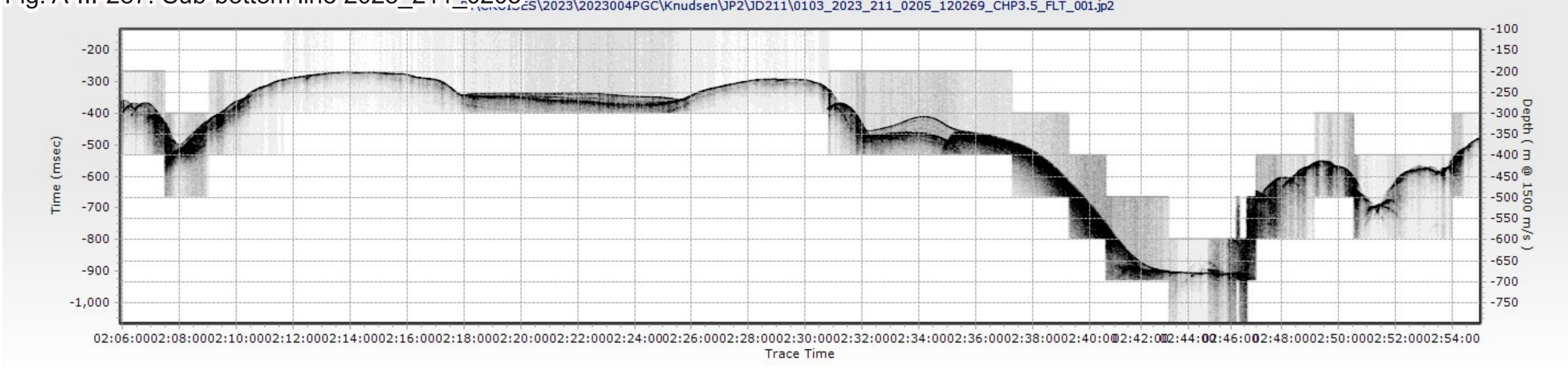


Fig. A-III-288. Sub-bottom line 2023_211_0255

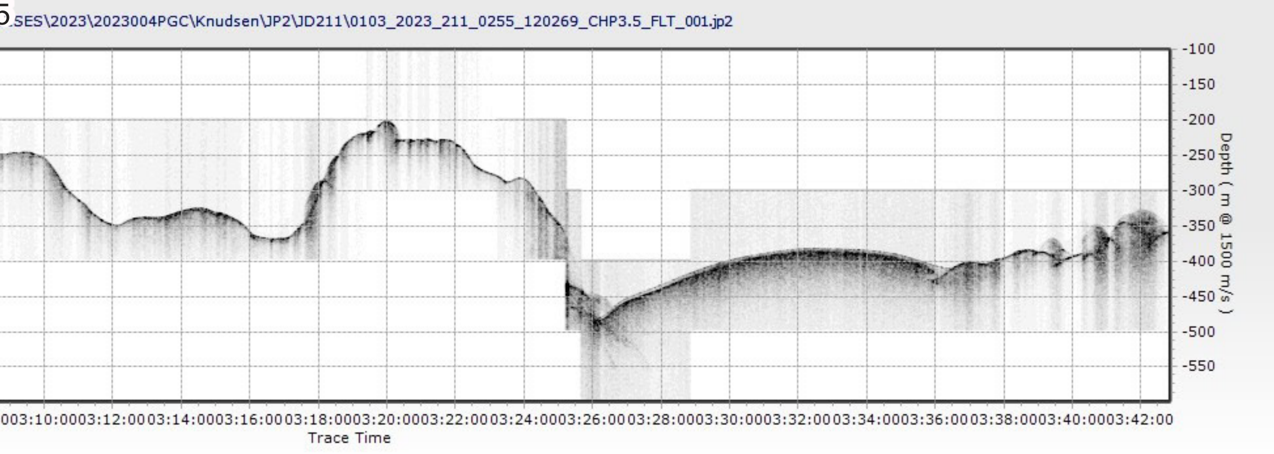


Fig. A-III-289. Sub-bottom line 2023_211_0342

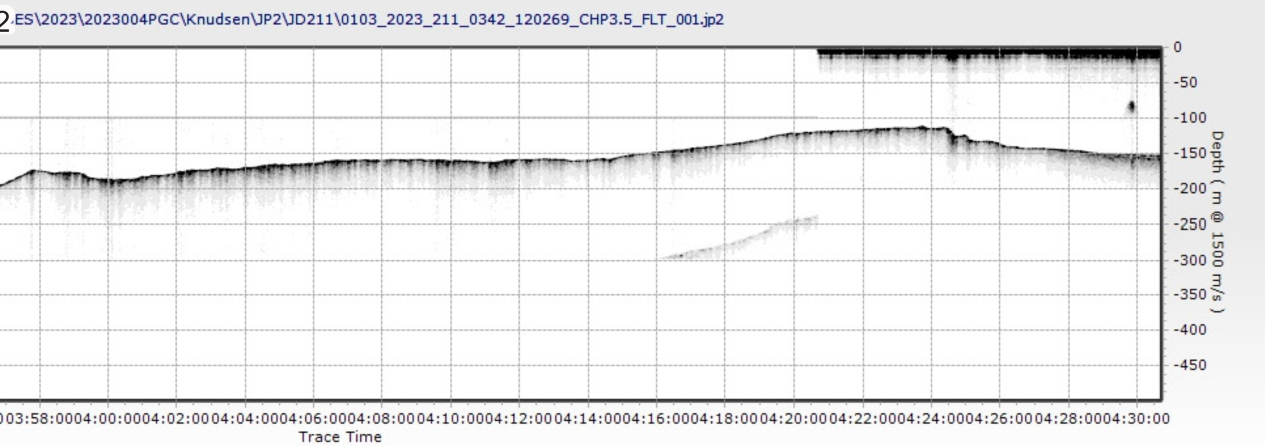


Fig. A-III-290. Sub-bottom line 2023_211_0430

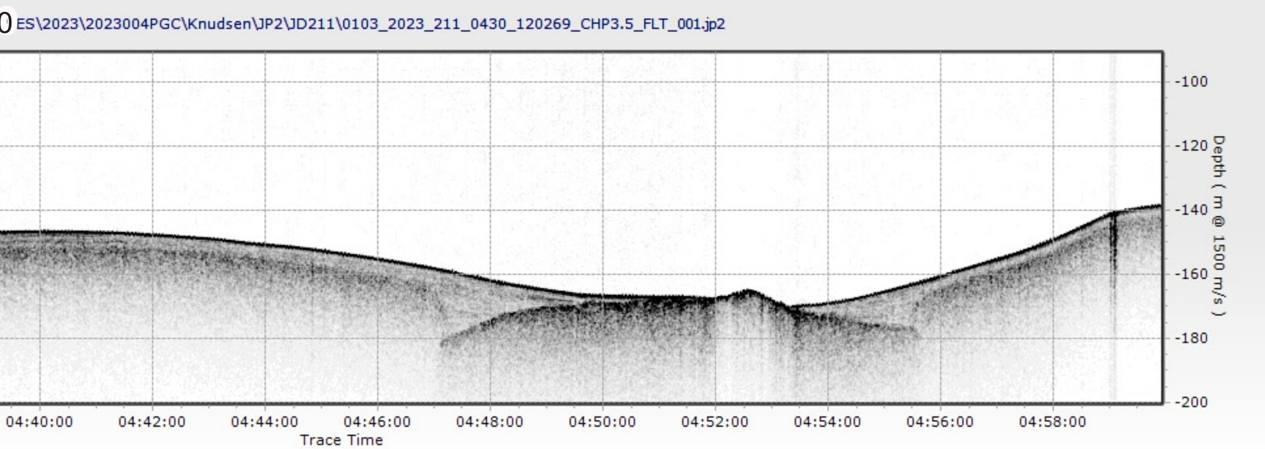


Fig. A-III-291. Sub-bottom line 2023_211_0500

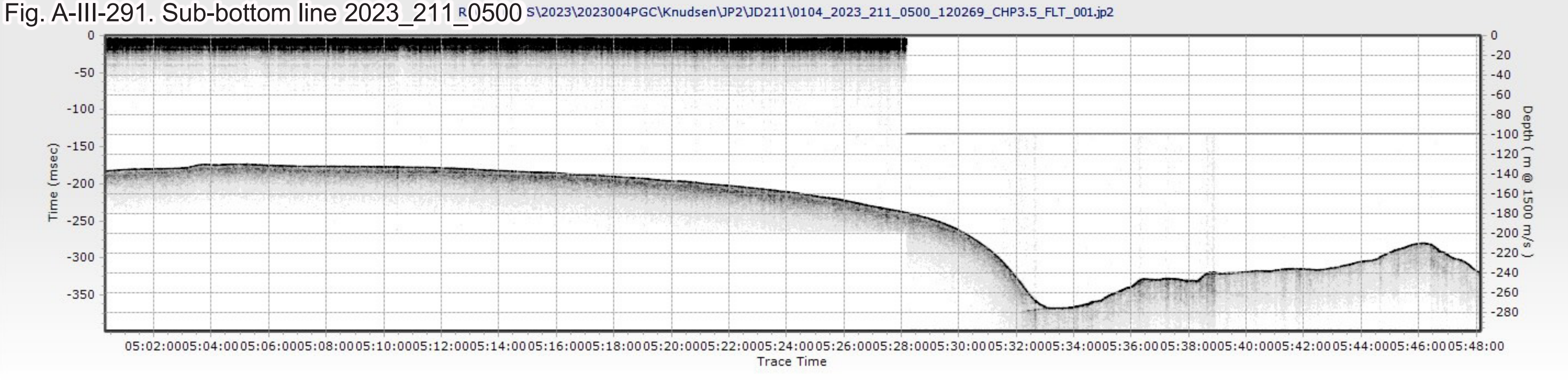


Fig. A-III-292. Sub-bottom line 2023_211_0548

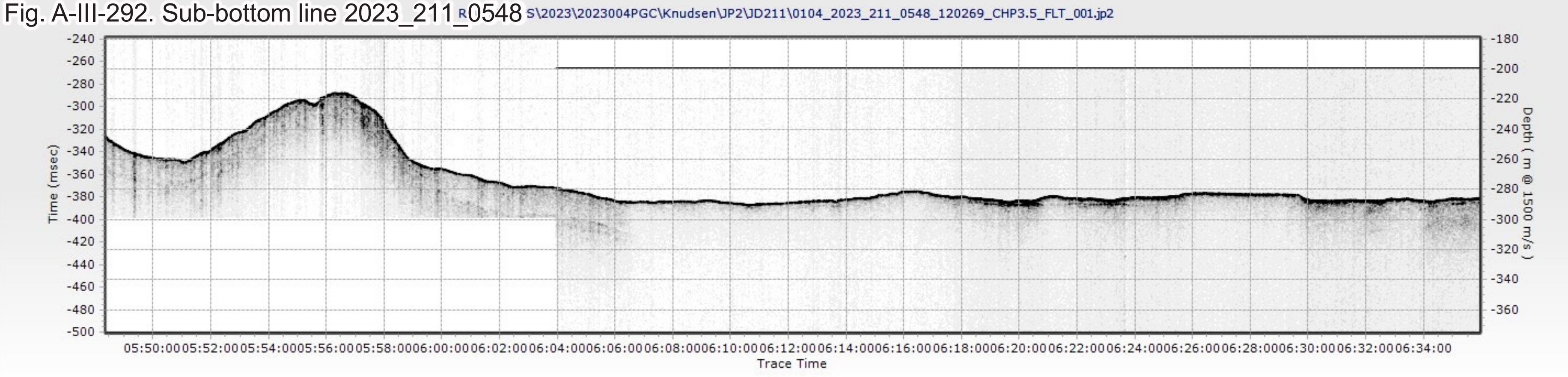


Fig. A-III-293. Sub-bottom line 2023_211_0636

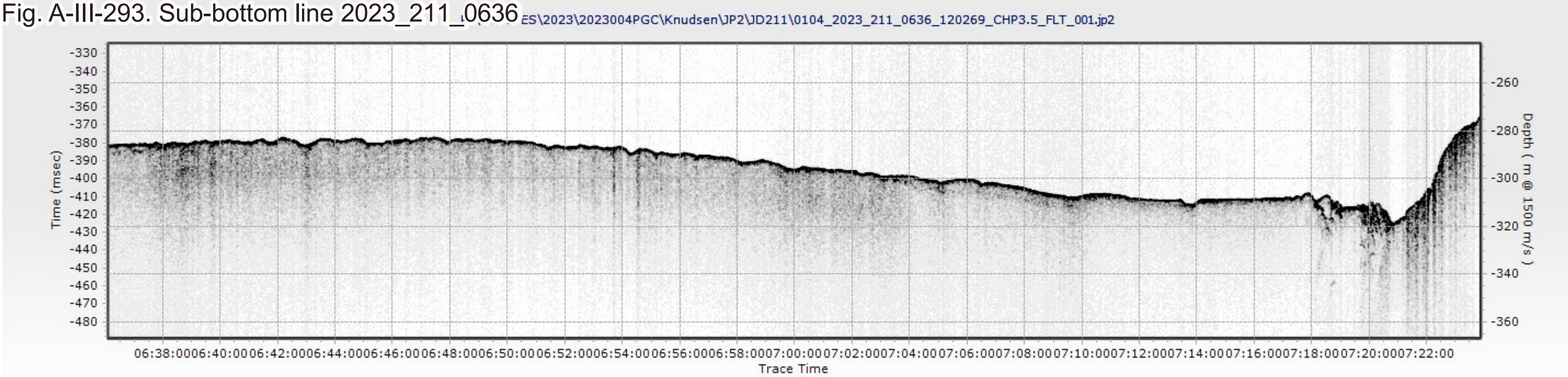


Fig. A-III-294. Sub-bottom line 2023_211_0723

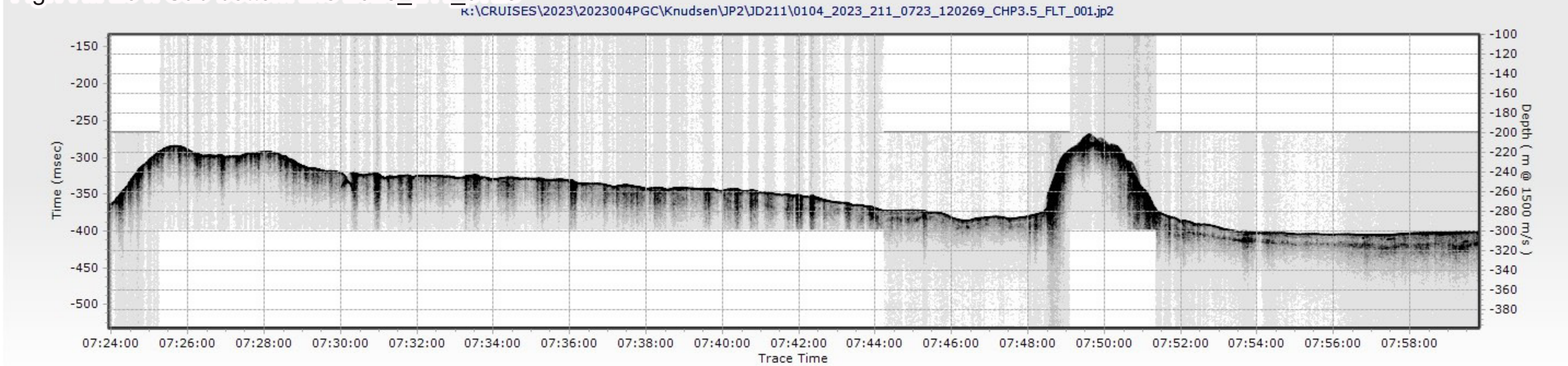


Fig. A-III-295. Sub-bottom line 2023_211_0800

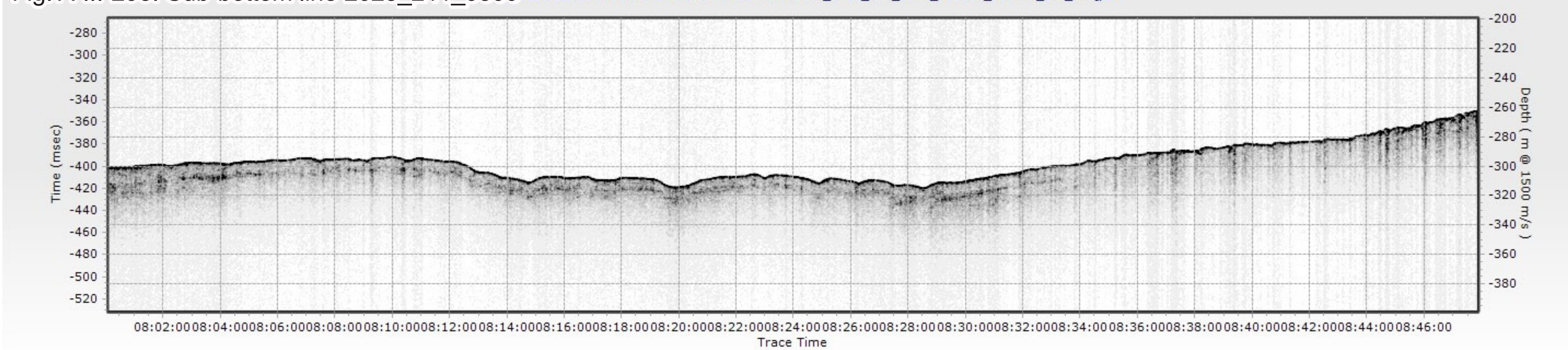


Fig. A-III-296. Sub-bottom line 2023_211_0847

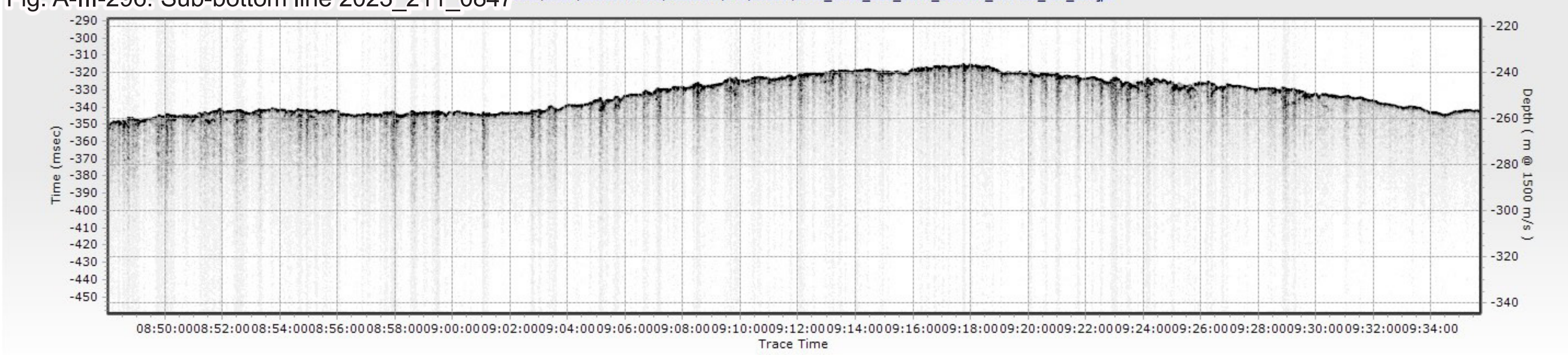


Fig. A-III-297. Sub-bottom line 2023_211_09359

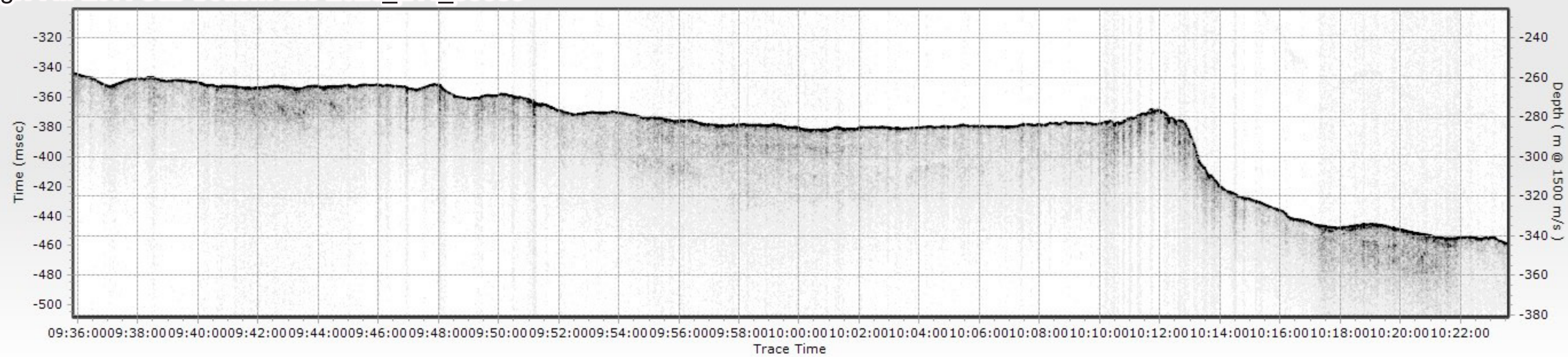


Fig. A-III-298. Sub-bottom line 2023_211_1023

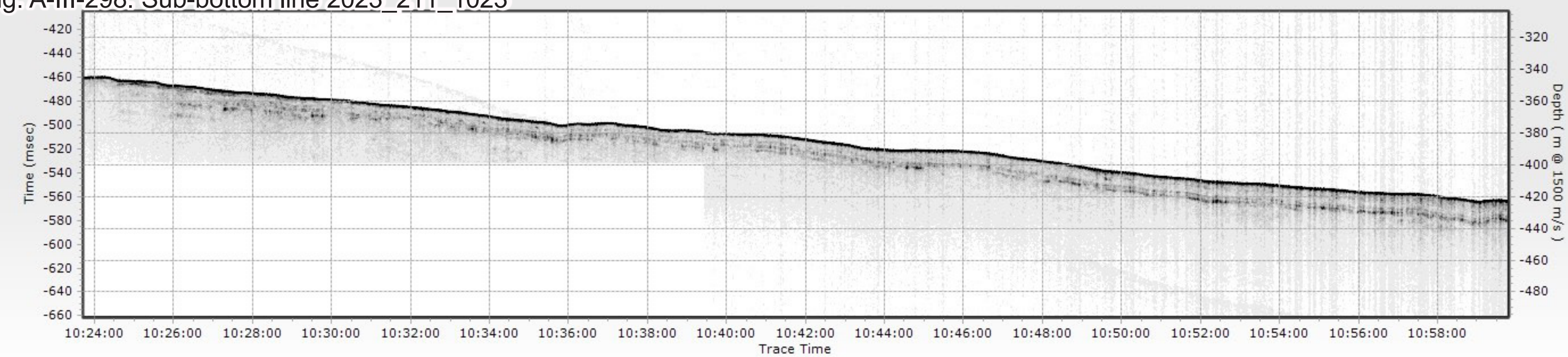


Fig. A-III-299. Sub-bottom line 2023_211_1100

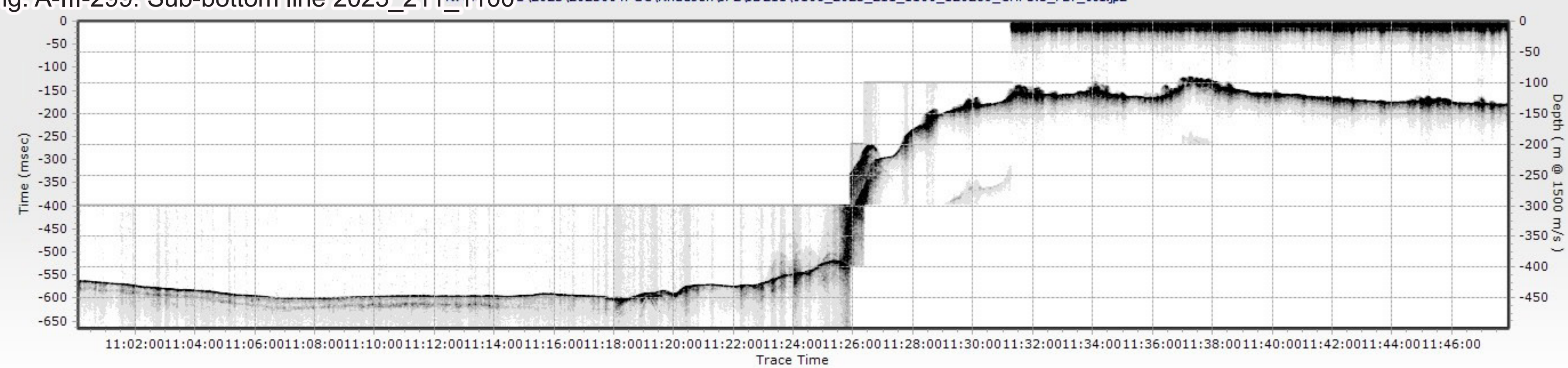
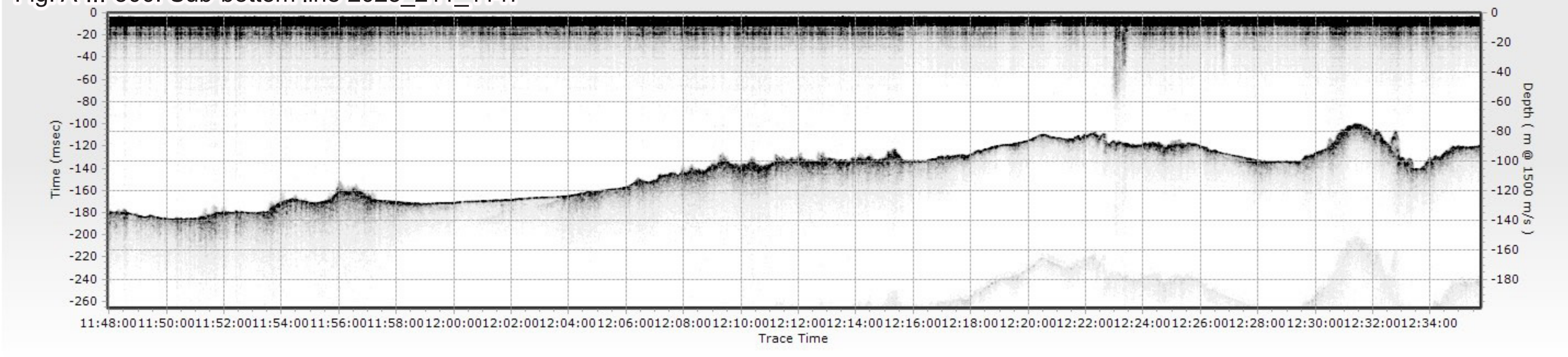


Fig. A-III-300. Sub-bottom line 2023_211_1147



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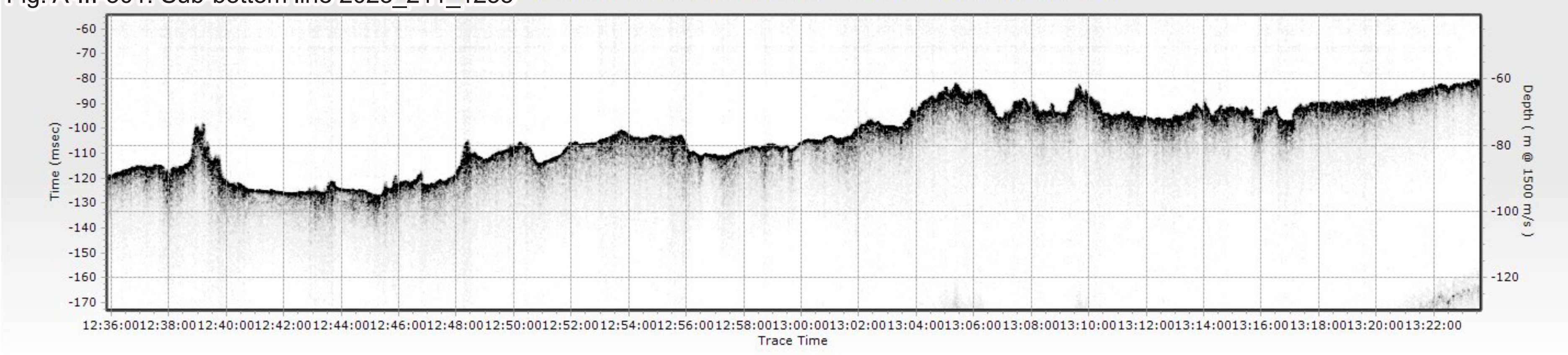

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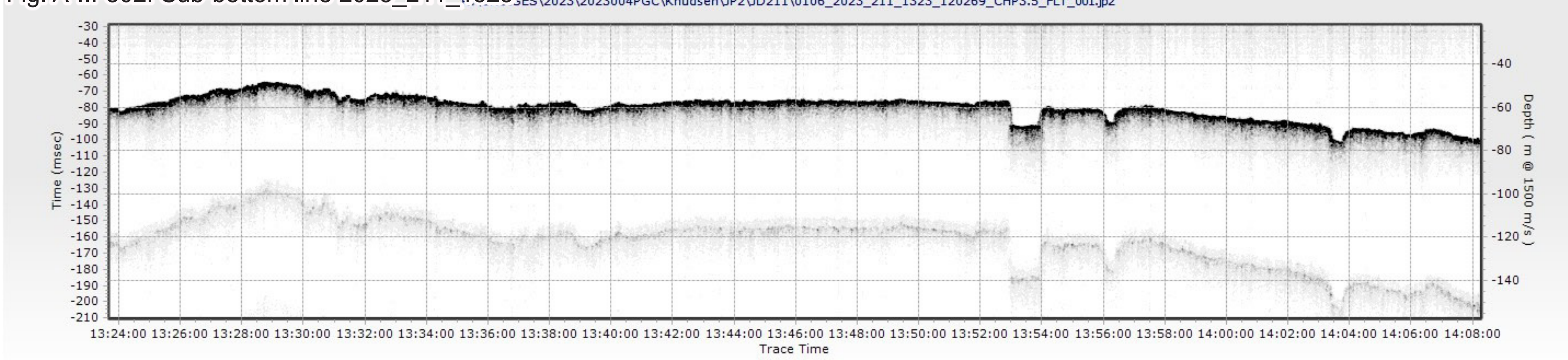
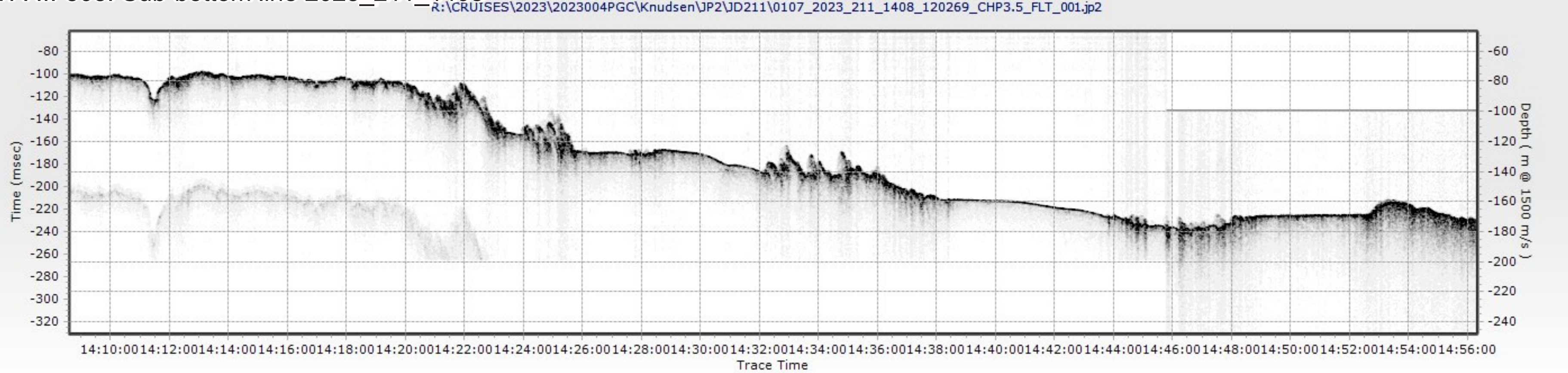


Fig. A-III-303. Sub-bottom line 2023_211_1408



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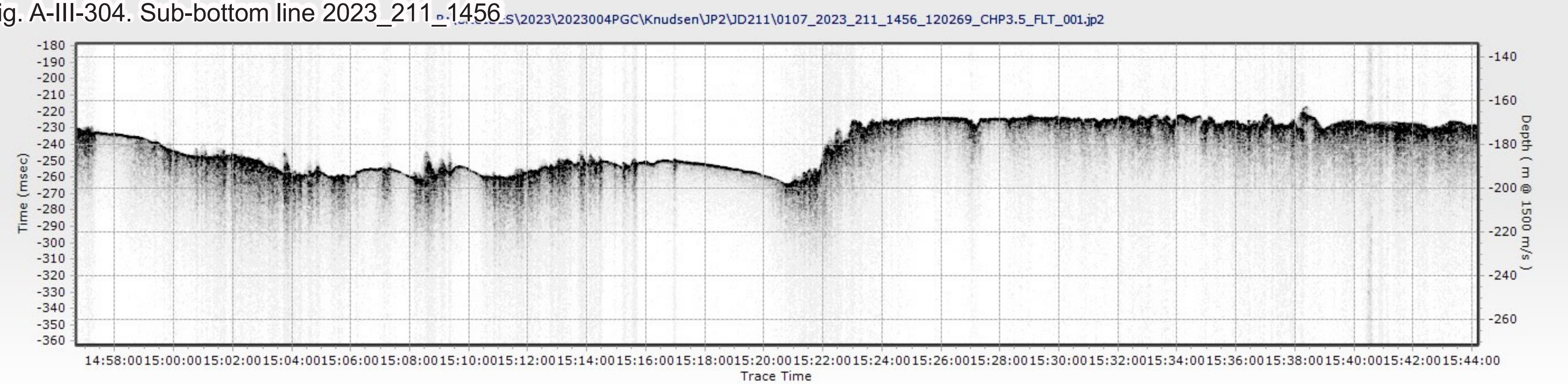

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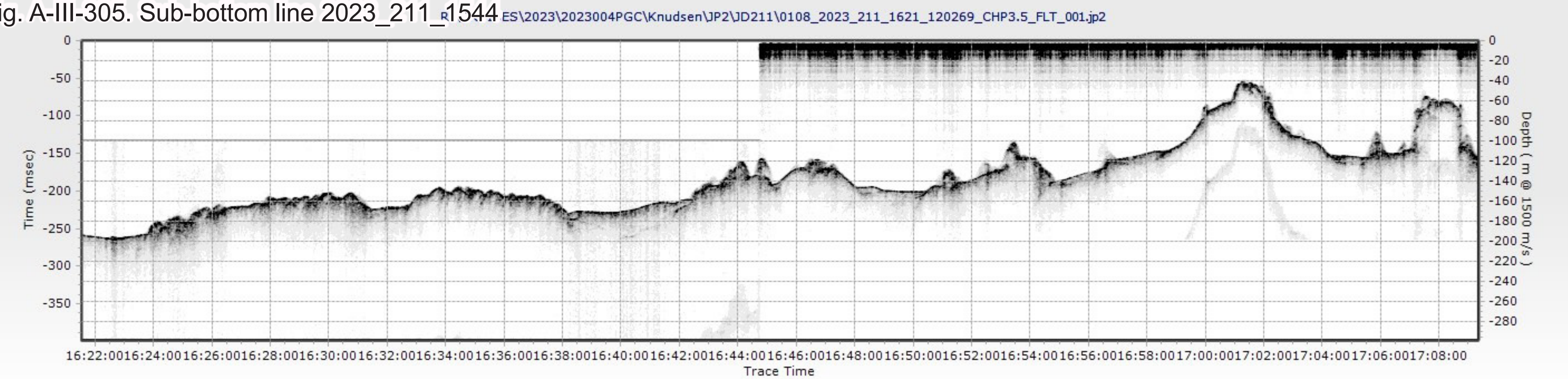


Fig. A-III-306. Sub-bottom line 2023_211_1709

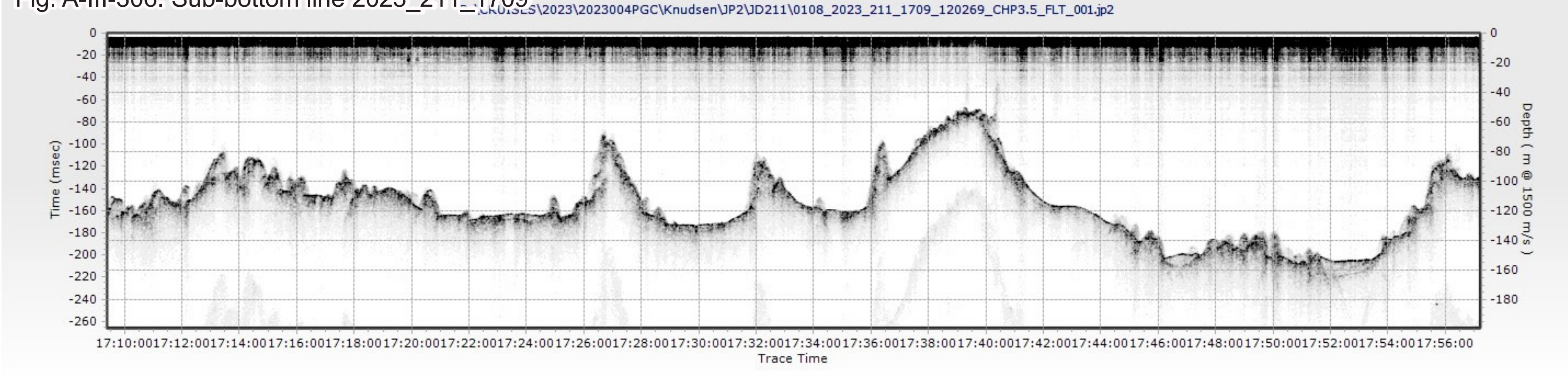


Fig. A-III-307. Sub-bottom line 2023_211_1757

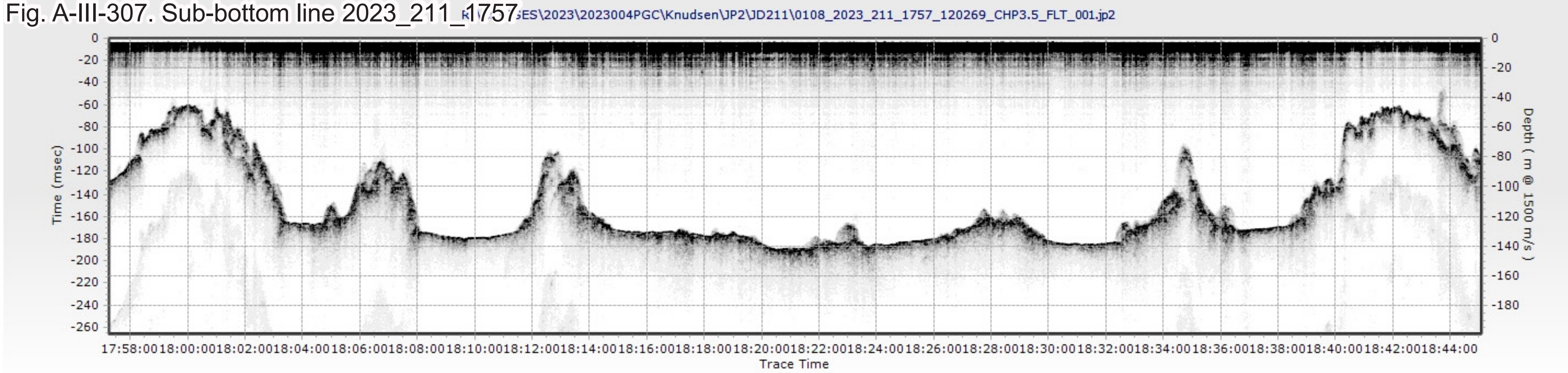
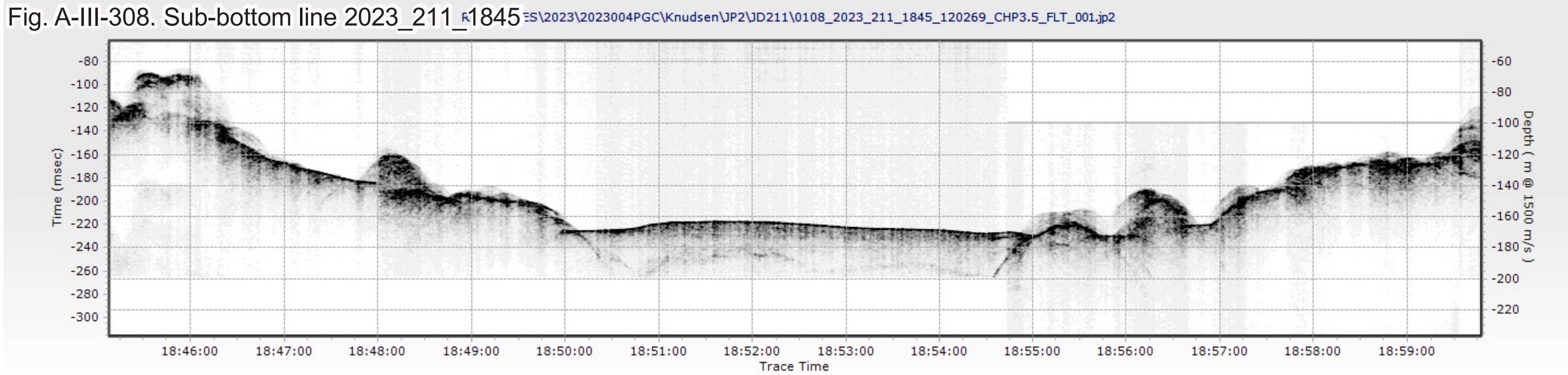


Fig. A-III-308. Sub-bottom line 2023_211_1845



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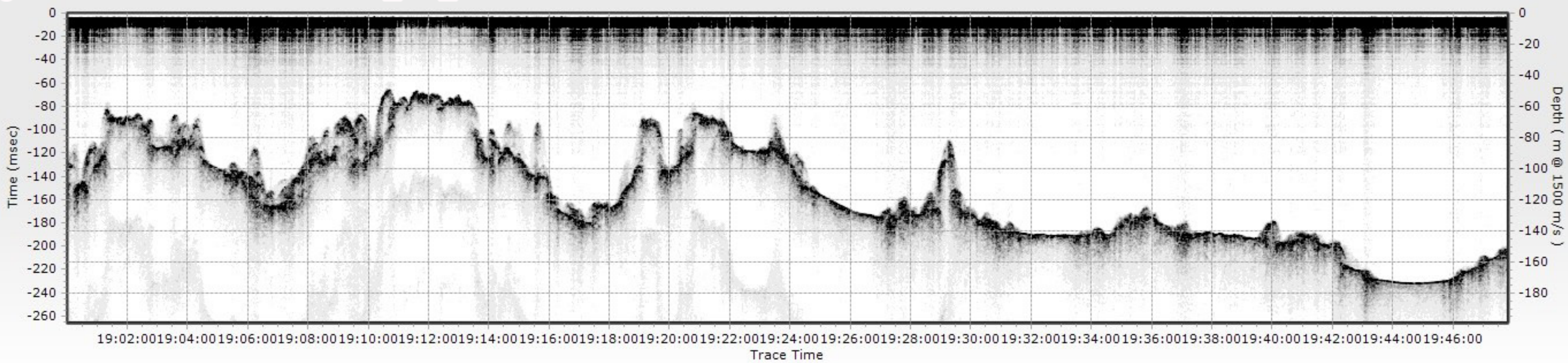
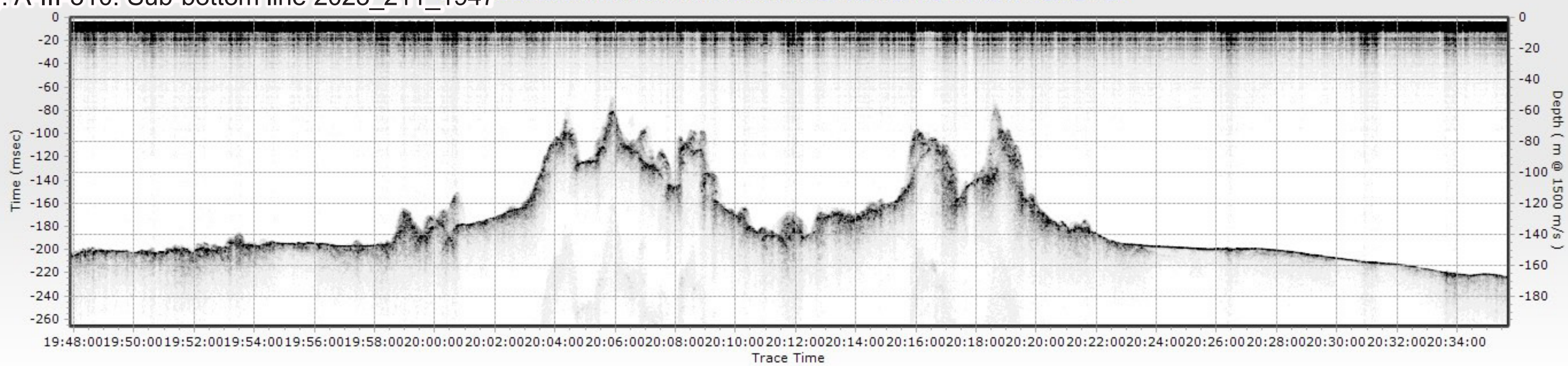


Fig. A-III-310. Sub-bottom line 2023_211_1947



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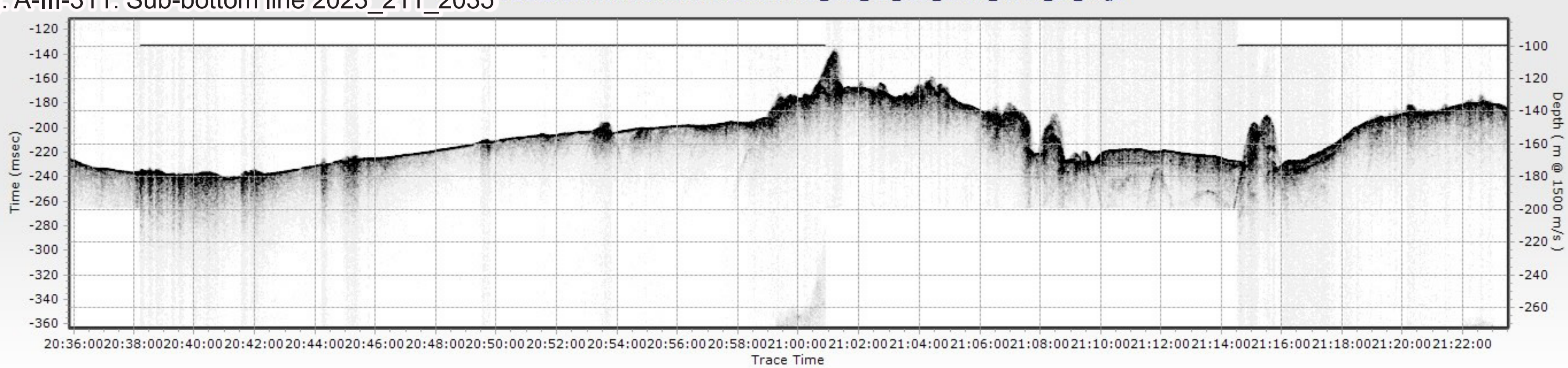

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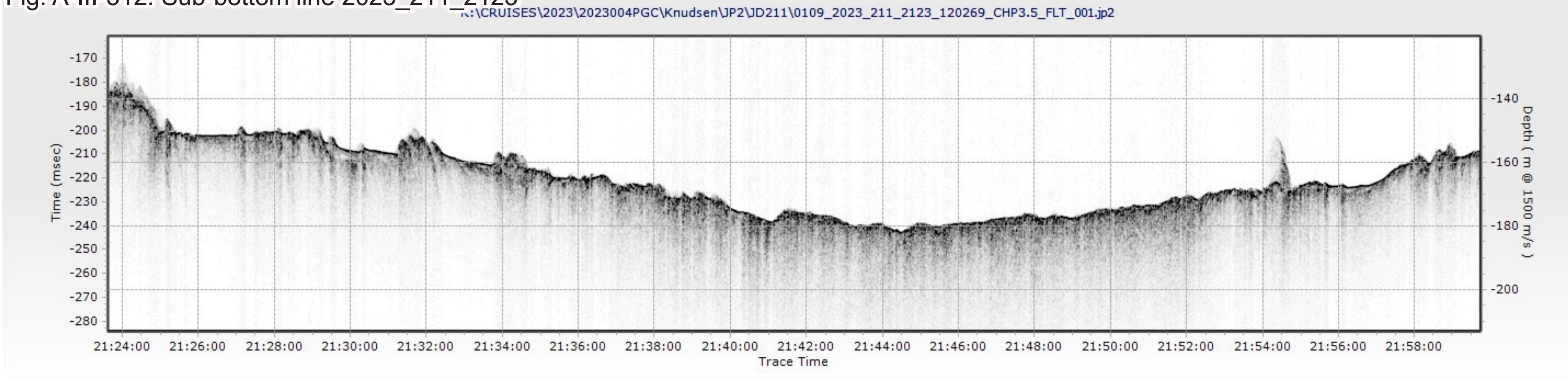

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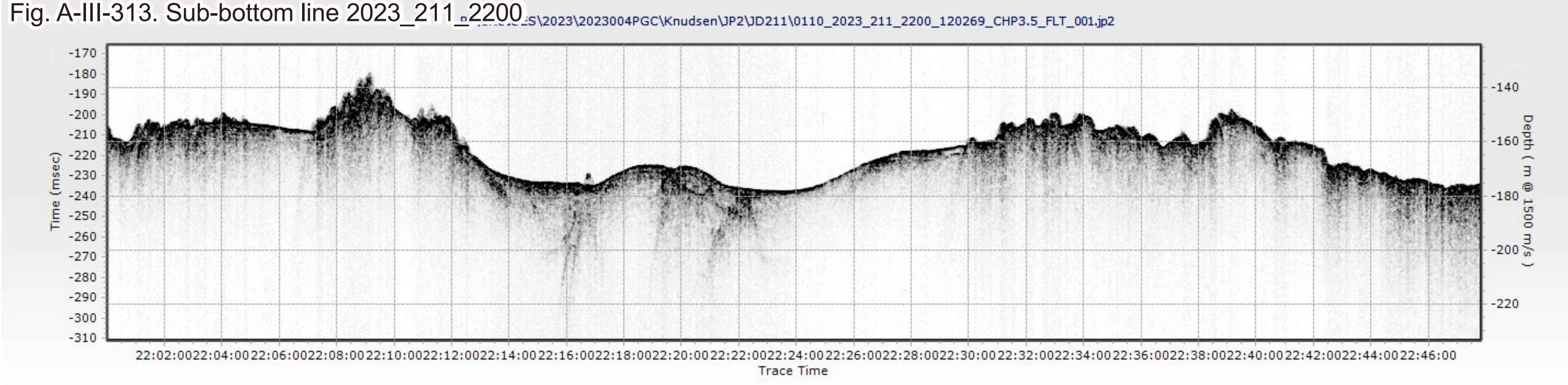

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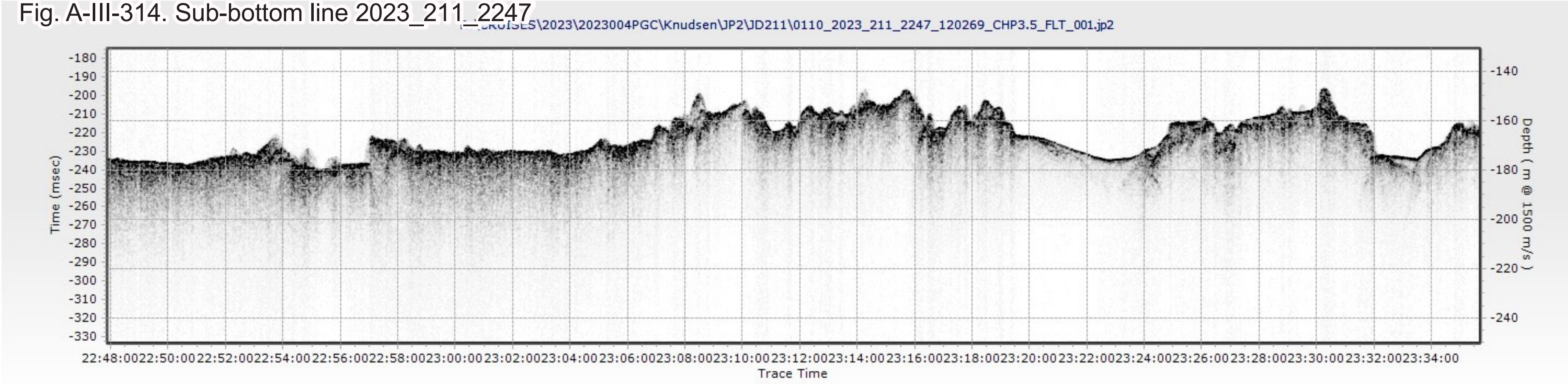

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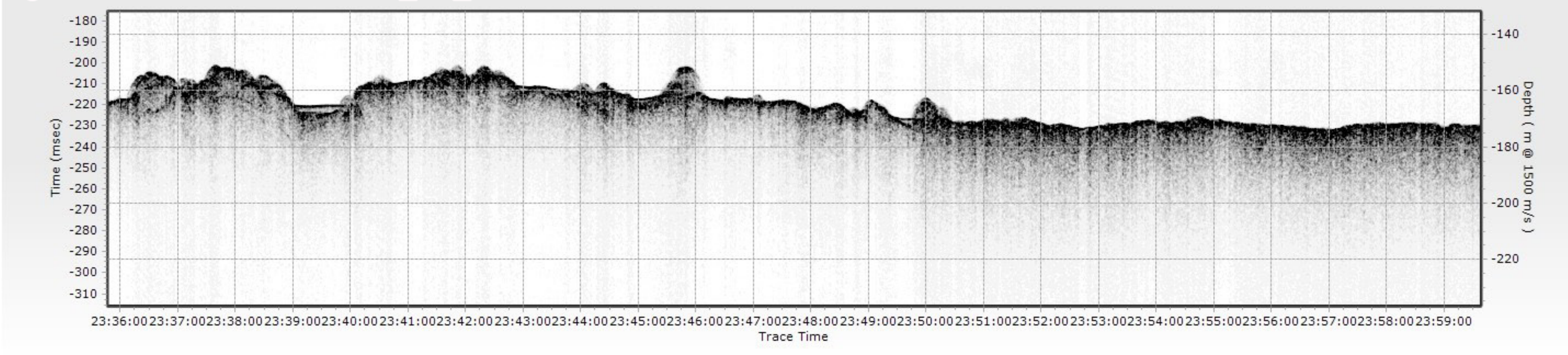

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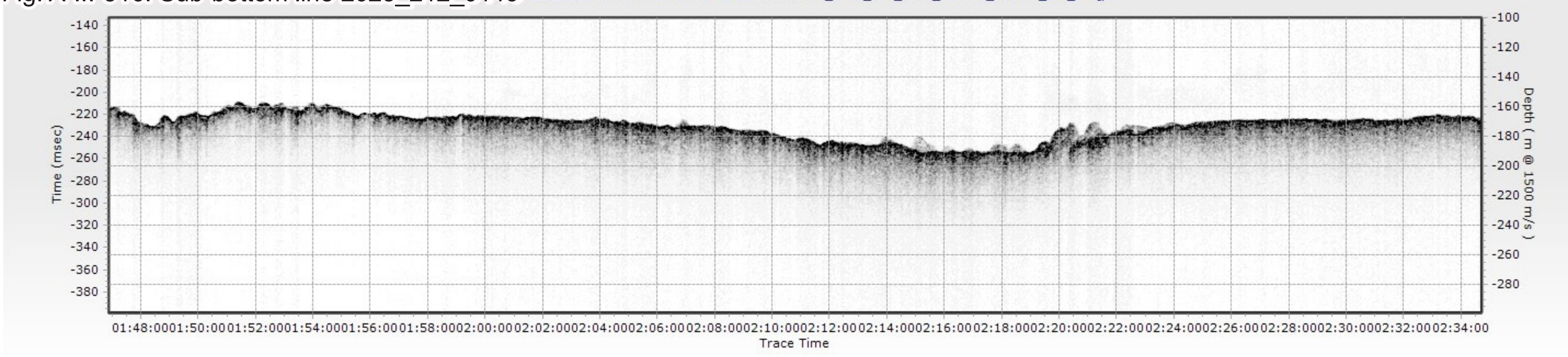
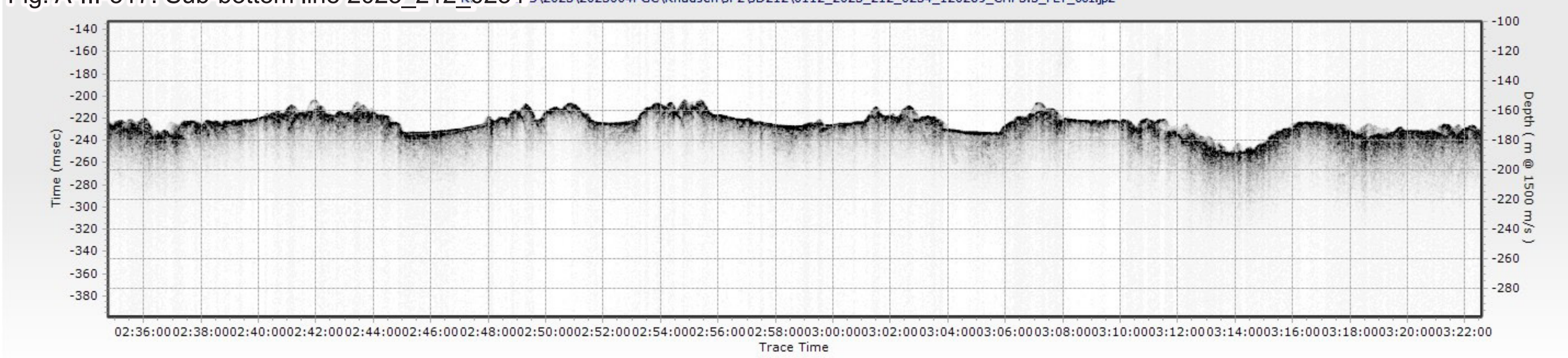


Fig. A-III-317. Sub-bottom line 2023_212_0234



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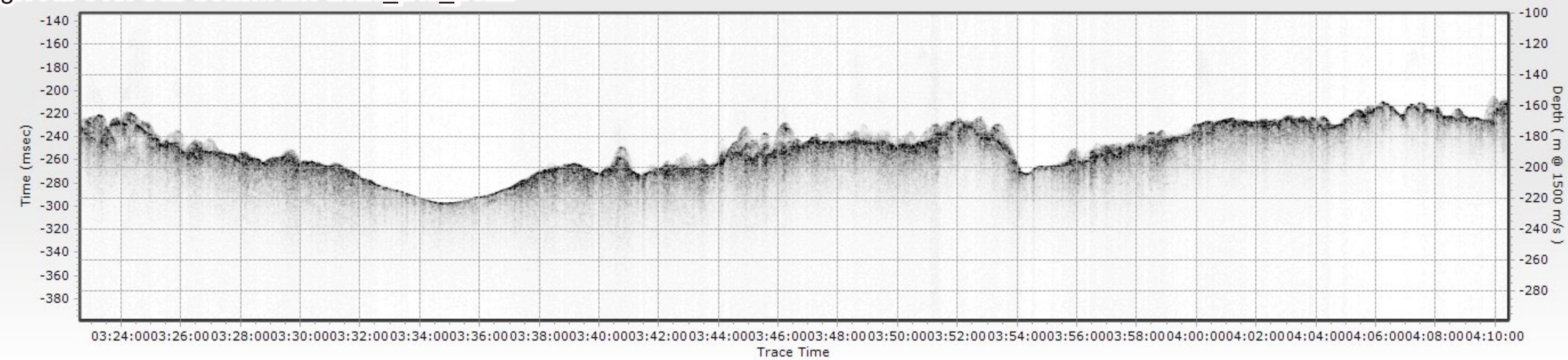

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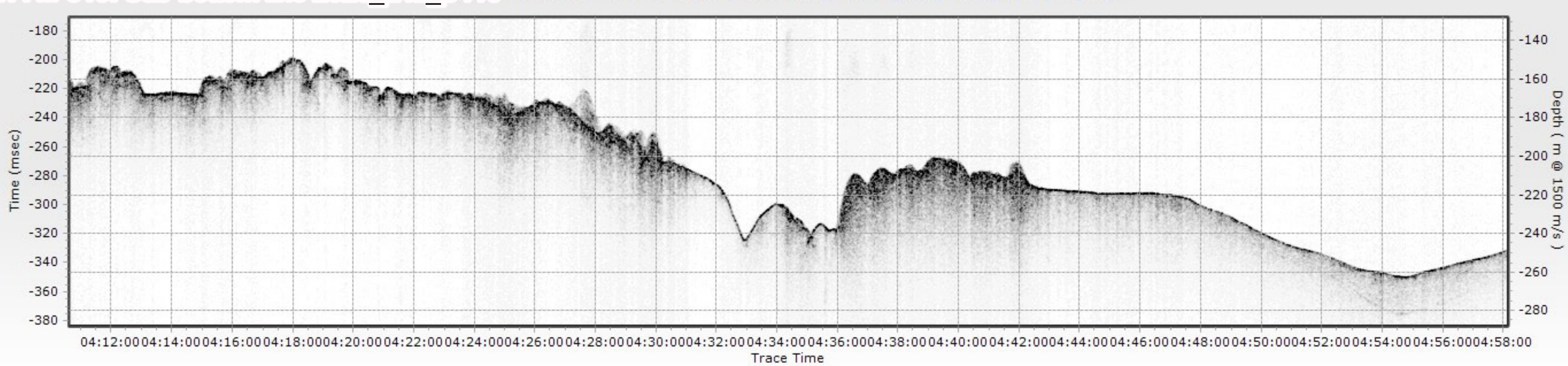

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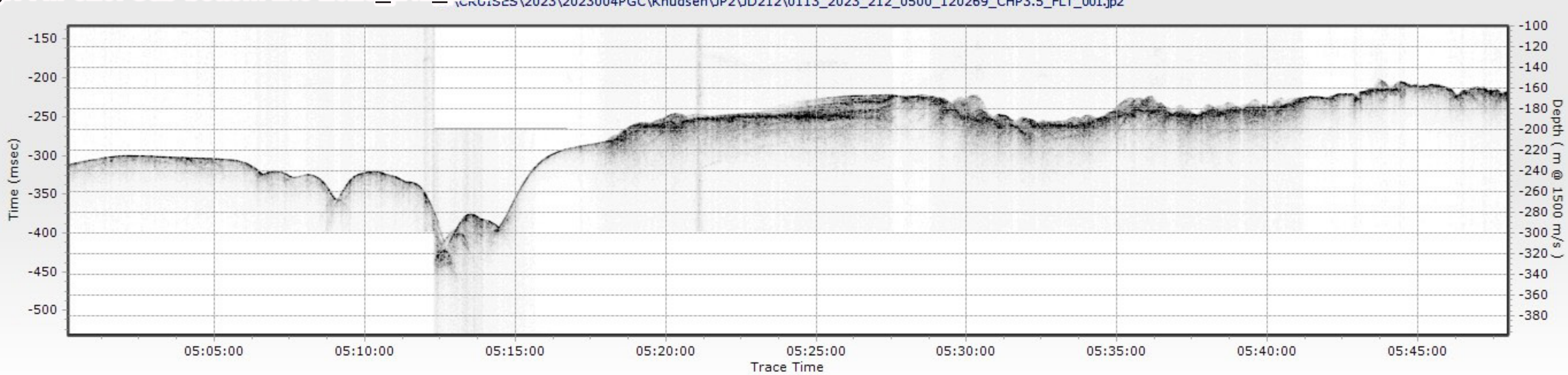

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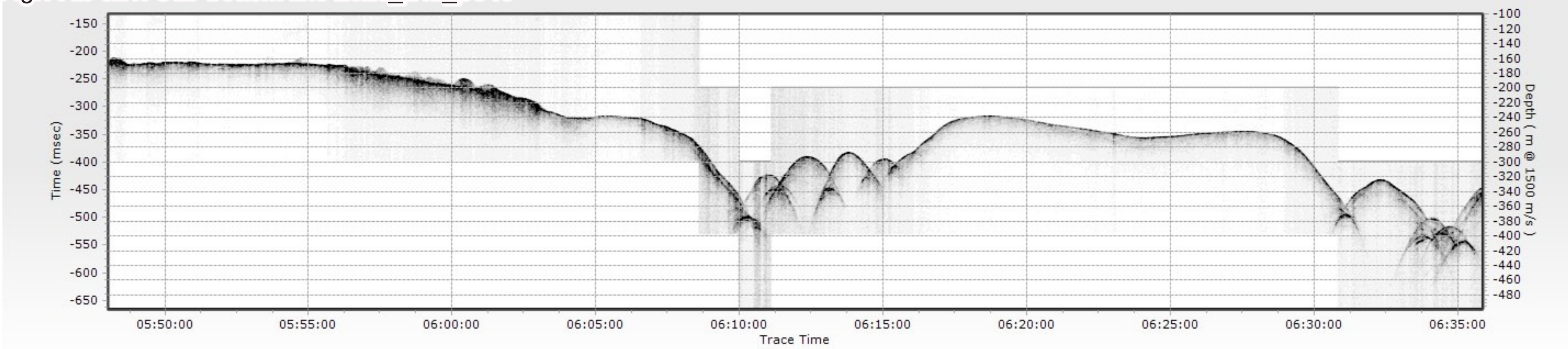

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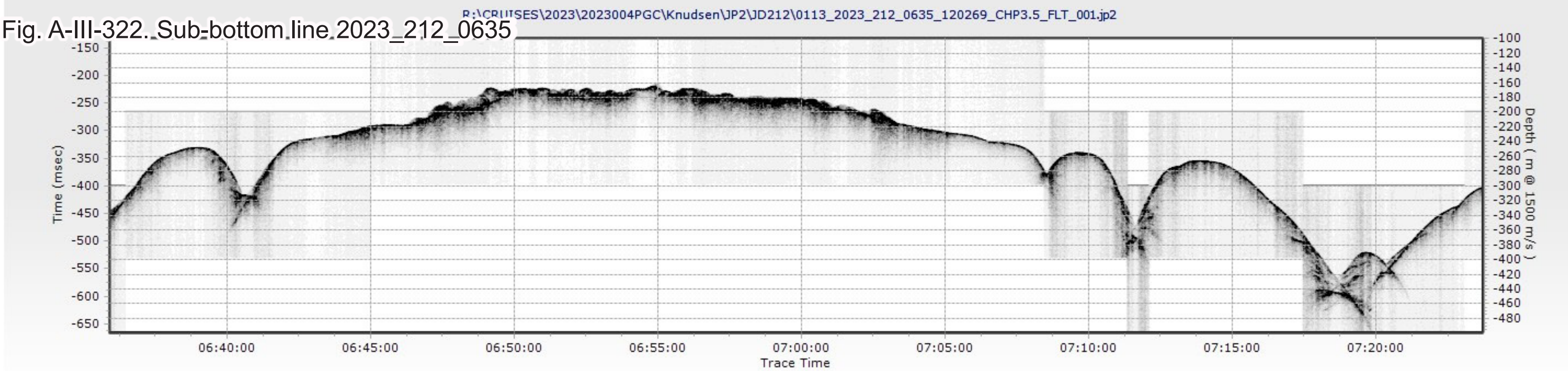

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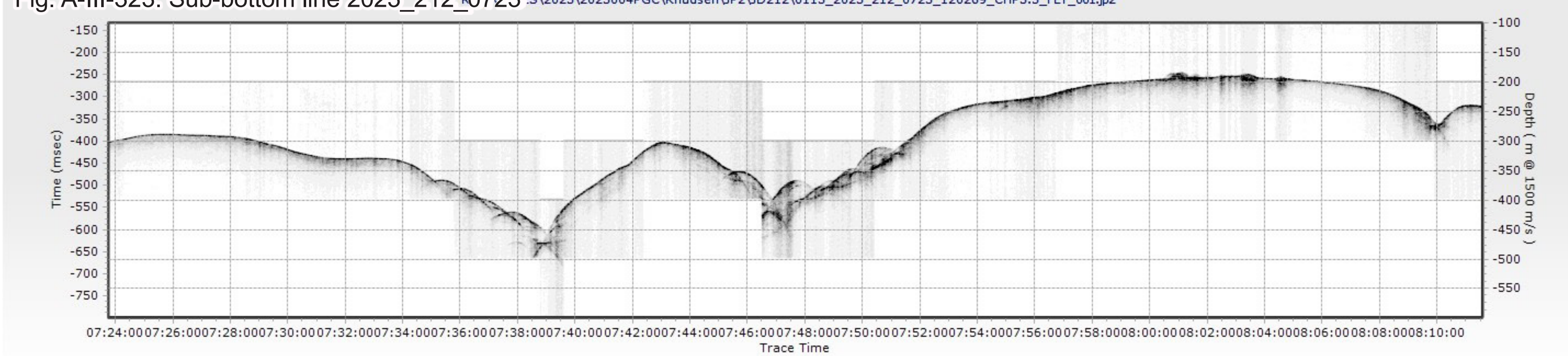


Fig. A-III-324. Sub-bottom line 2023_212_0817

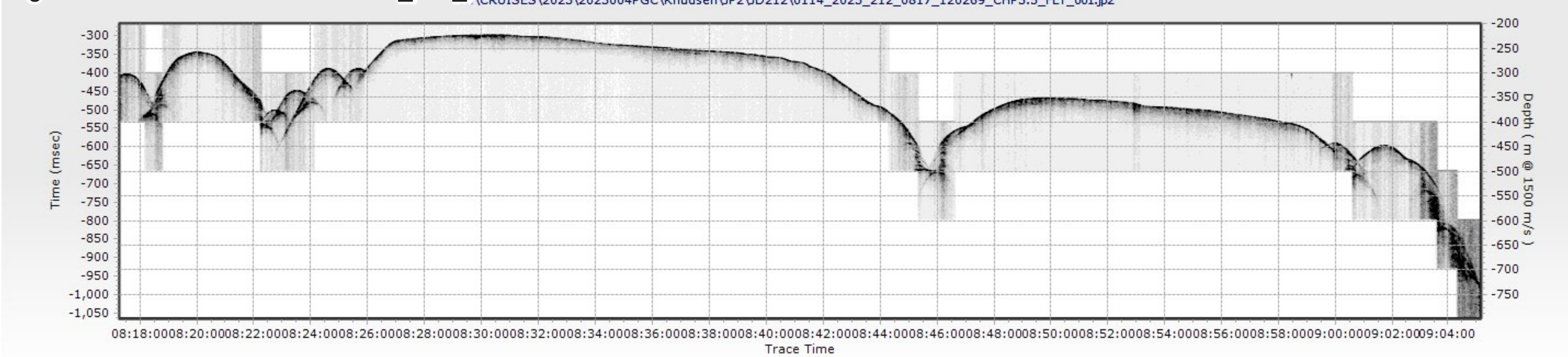
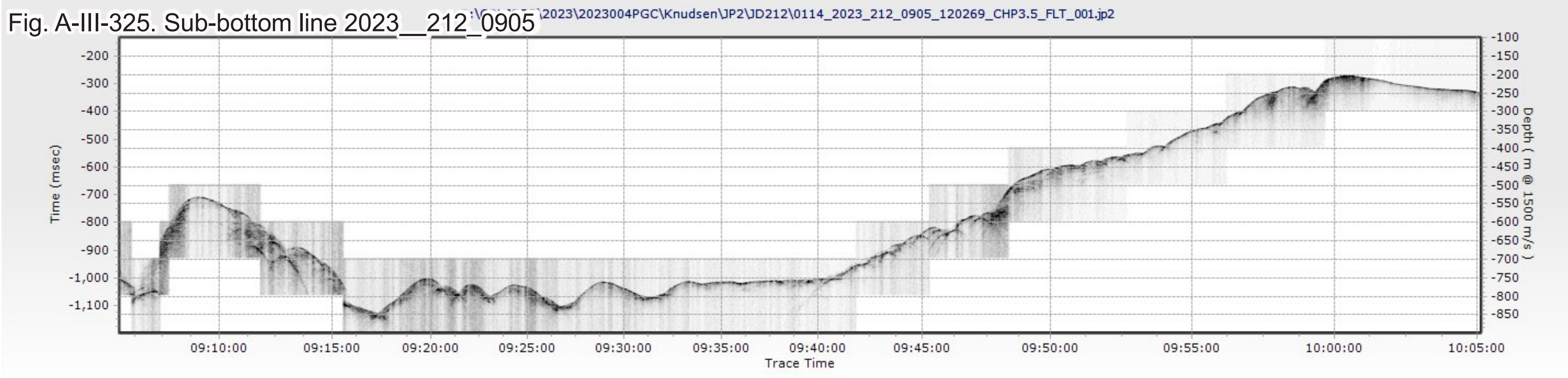


Fig. A-III-325. Sub-bottom line 2023__212_0905



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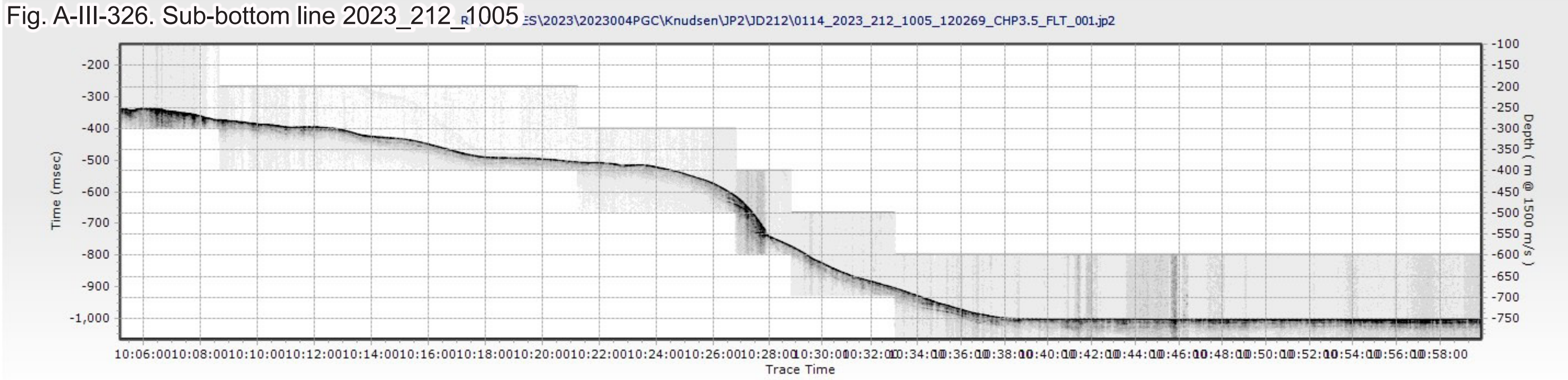

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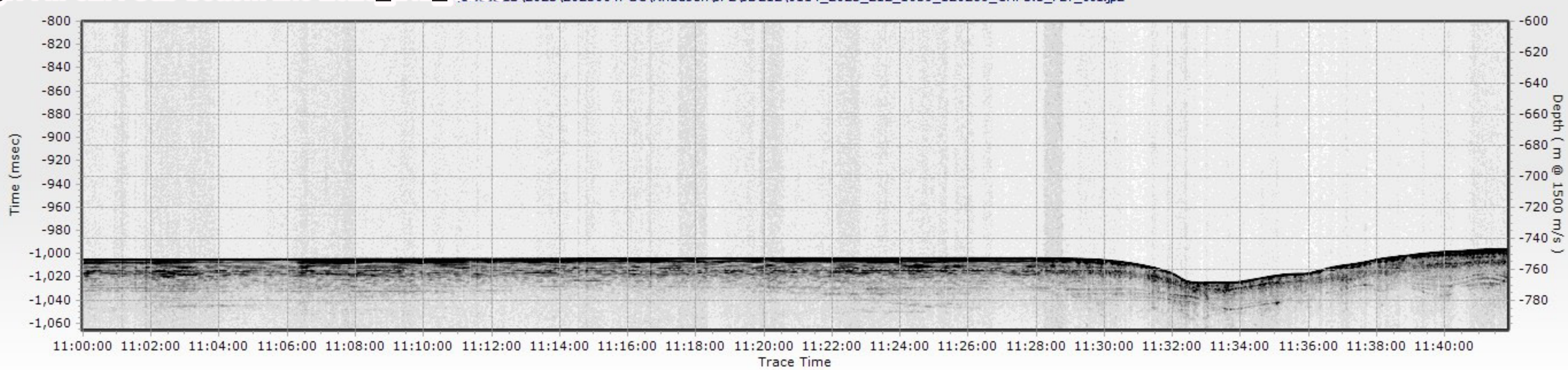
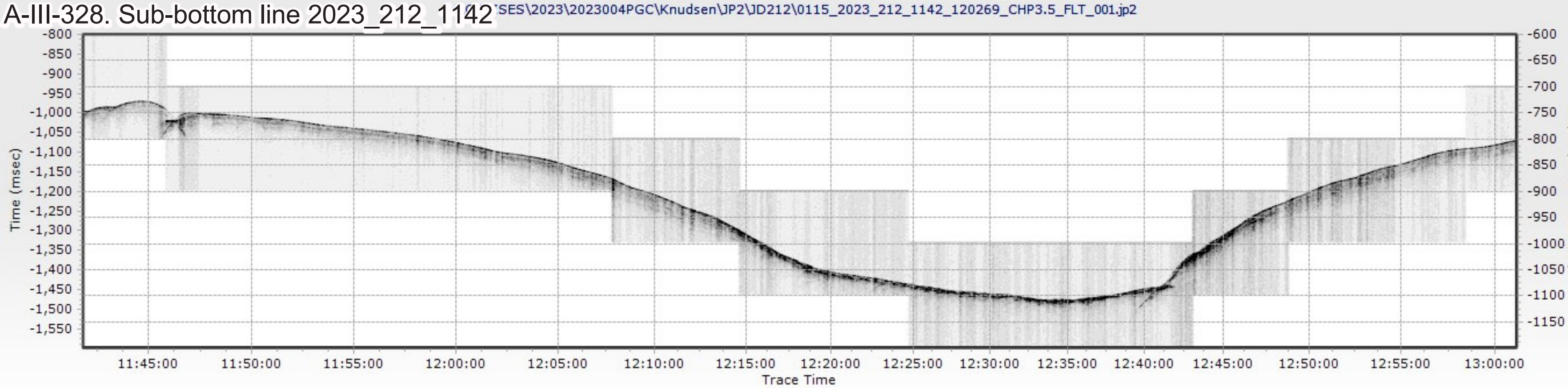


Fig. A-III-328. Sub-bottom line 2023_212_1142



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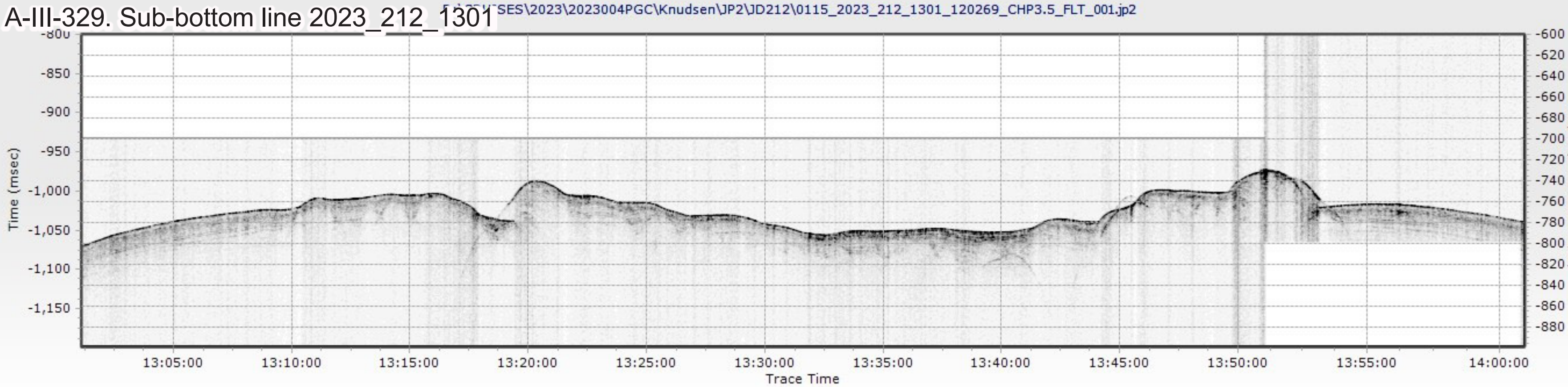


Fig. A-III-330. Sub-bottom line 2023_212_1401

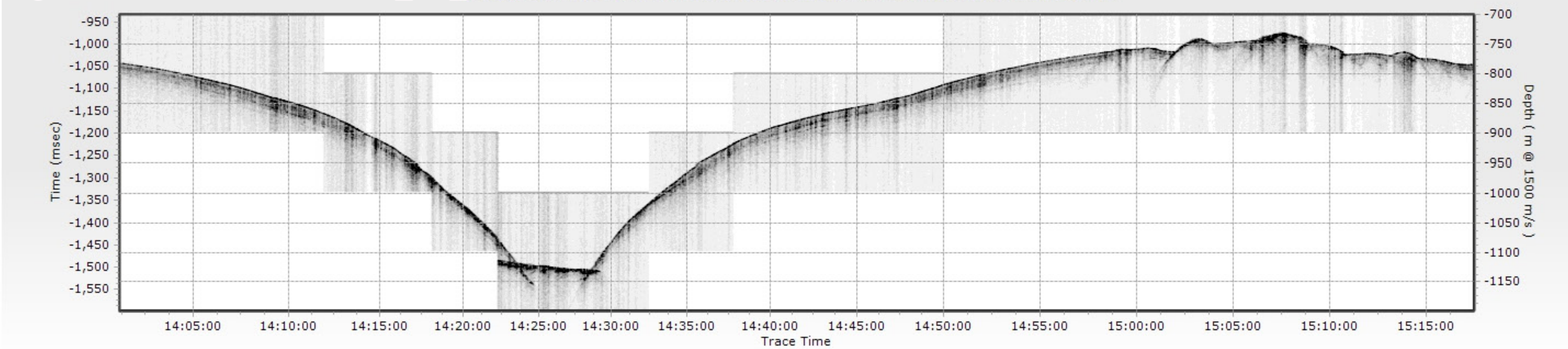
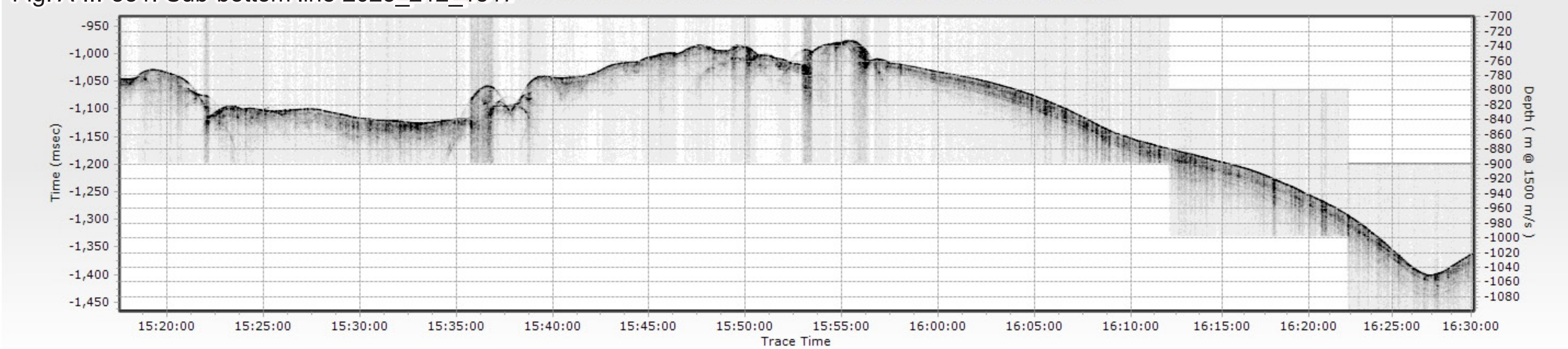


Fig. A-III-331. Sub-bottom line 2023_212_1517



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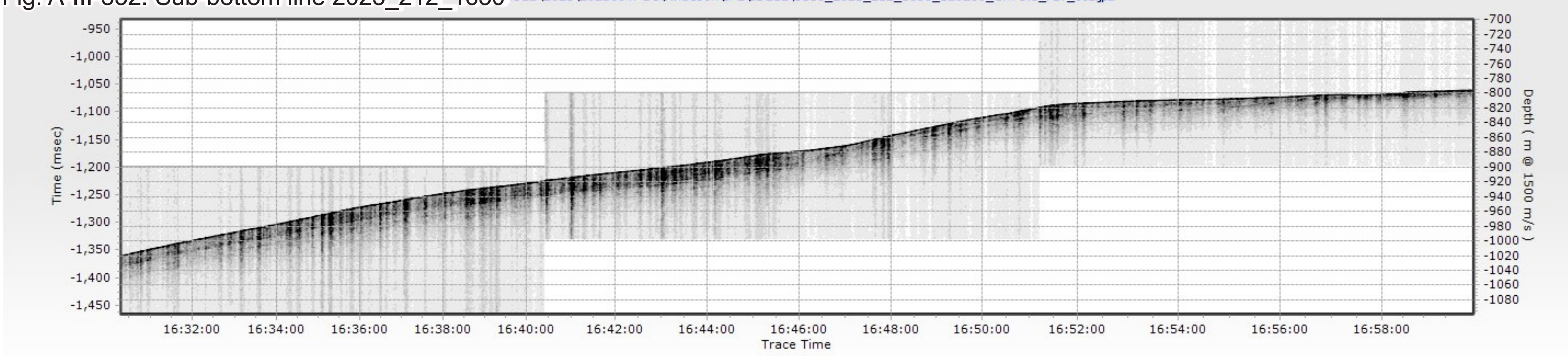
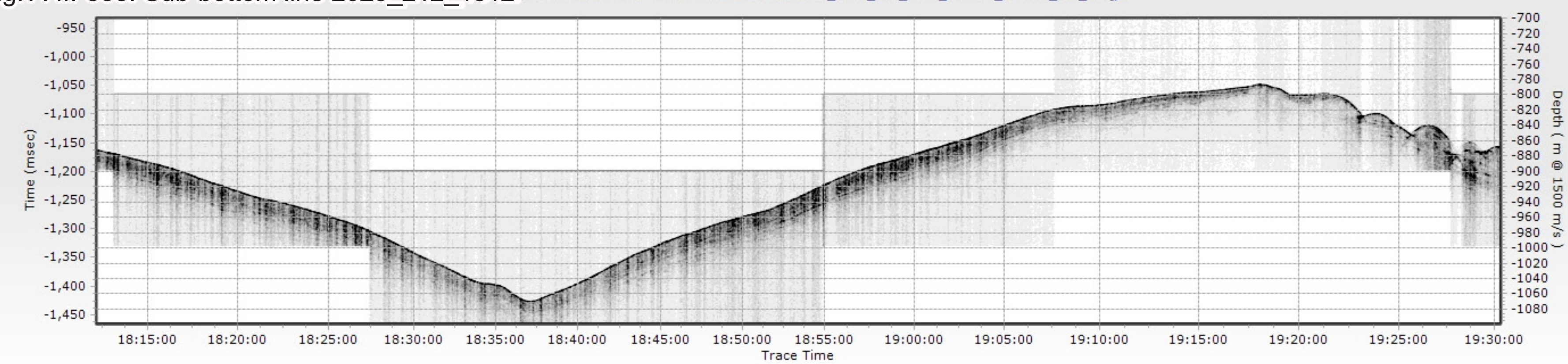


Fig. A-III-333. Sub-bottom line 2023_212_1812



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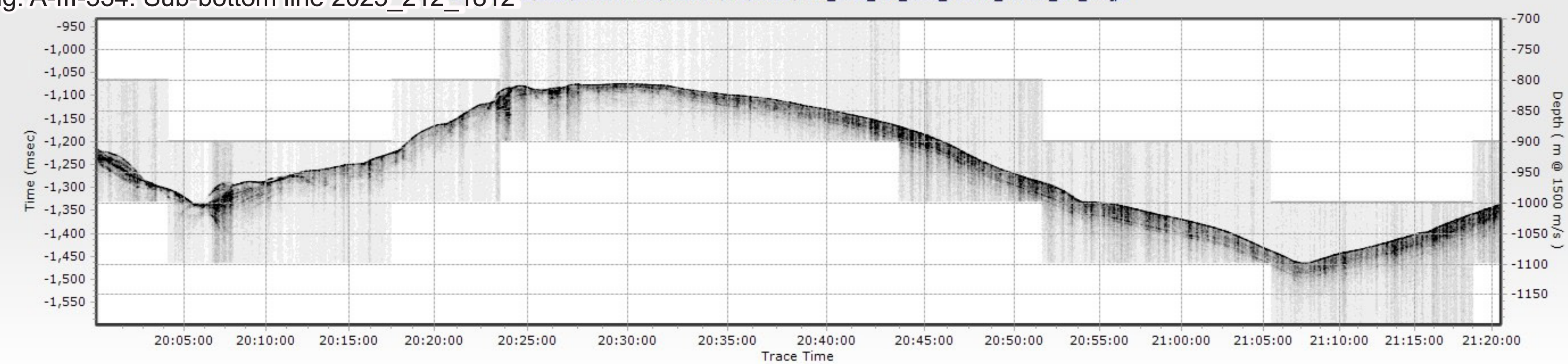


Fig. A-III-335. Sub-bottom line 2023_212_2120

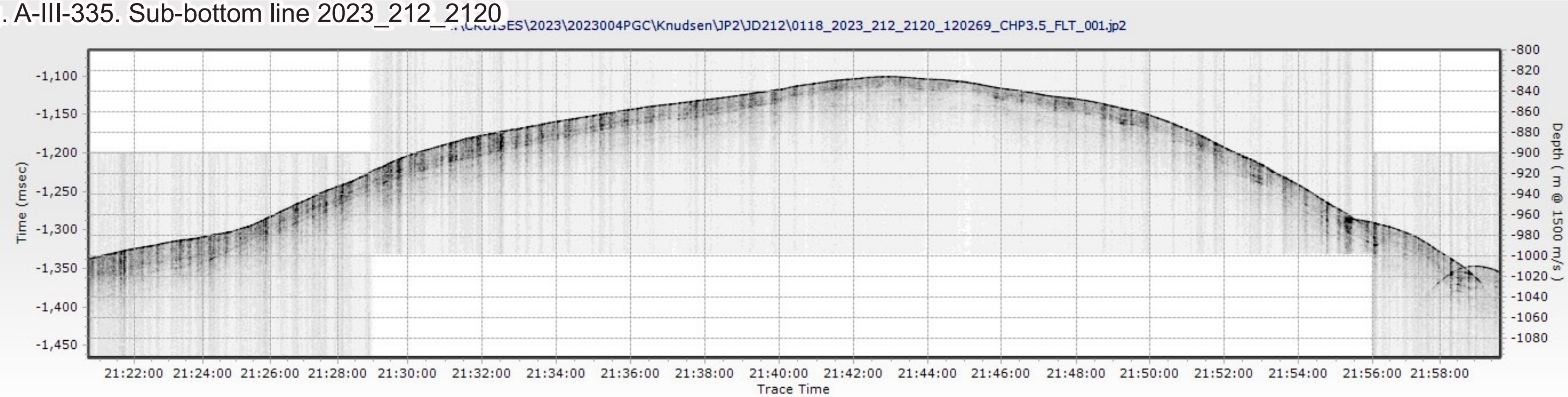


Fig. A-III-336. Sub-bottom line 2023_212_2324

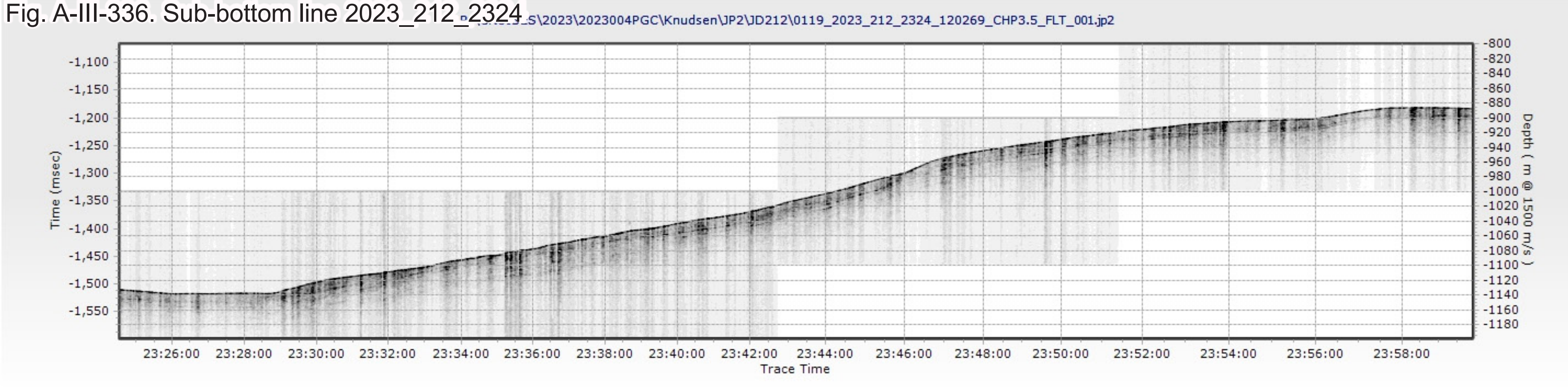


Fig. A-III-337. Sub-bottom line 2023_213_0223

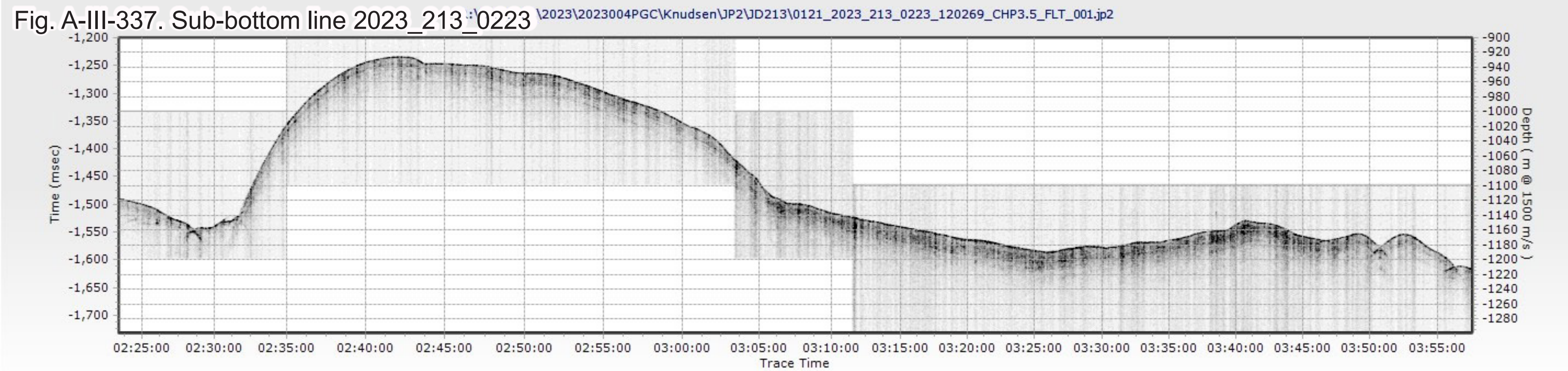


Fig. A-III-338. Sub-bottom line 2023_213_0357

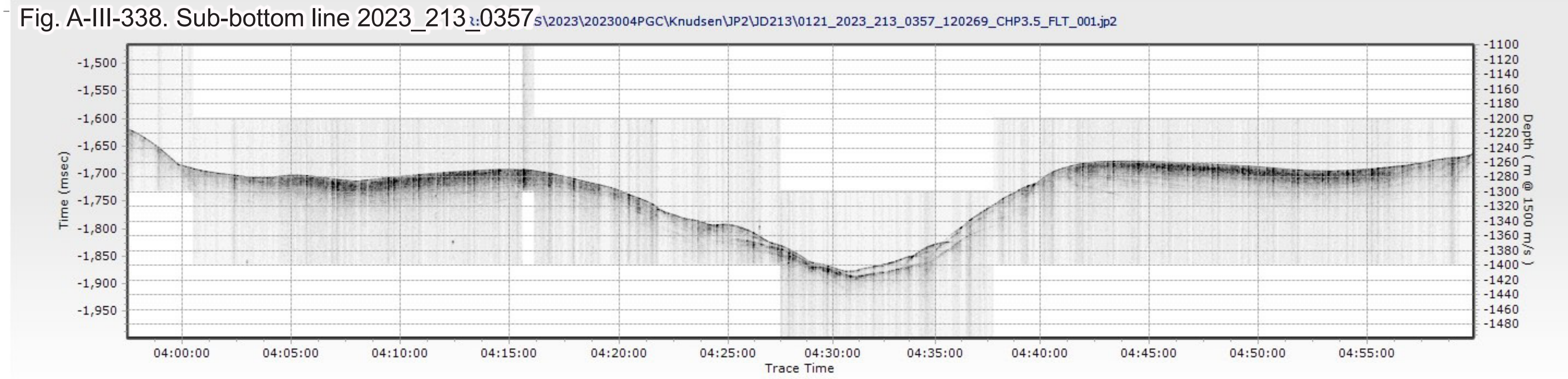


Fig. A-III-339. Sub-bottom line 2023_213_0500

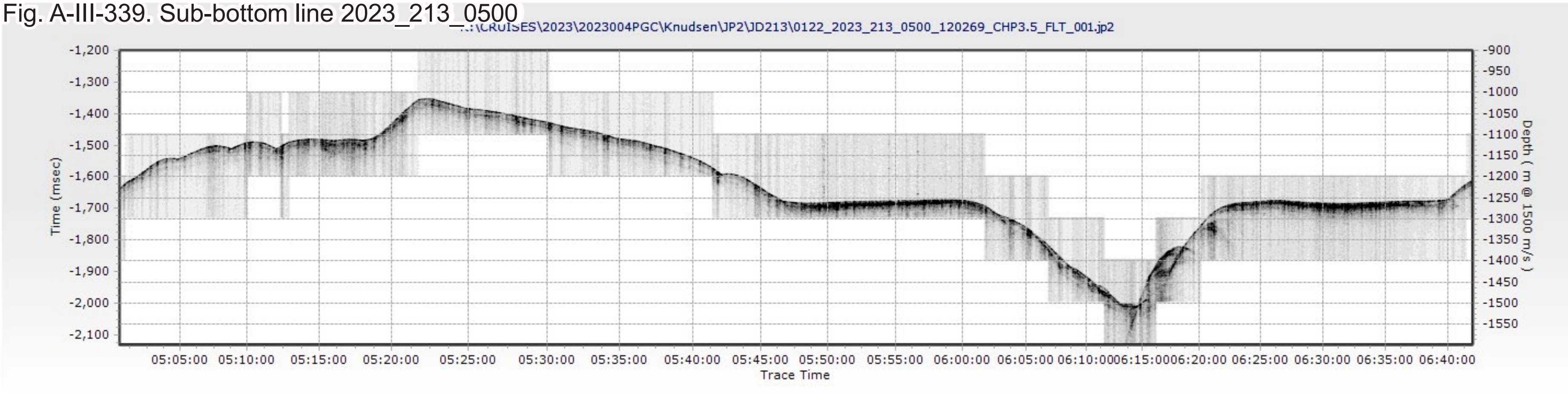


Fig. A-III-340. Sub-bottom line 2023_213_0642

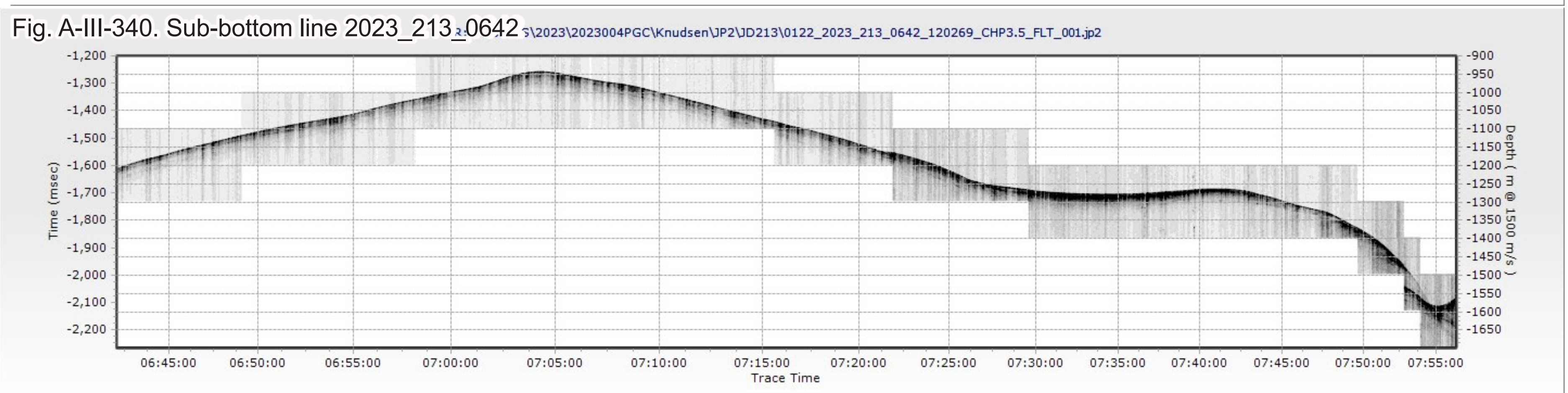


Fig. A-III-341. Sub-bottom line 2023_213_0757

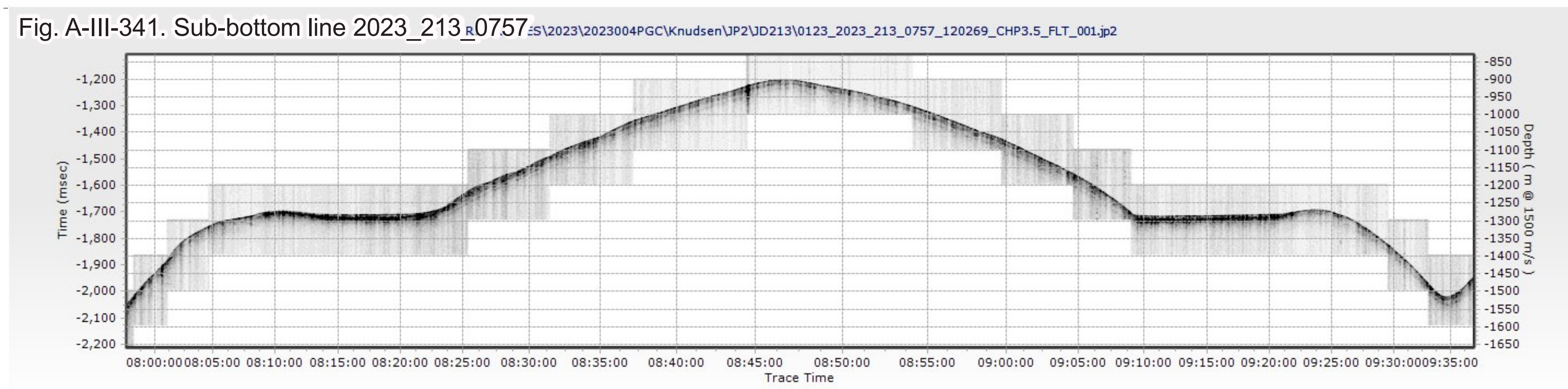


Fig. A-III-342. Sub-bottom line 2023_213_1100

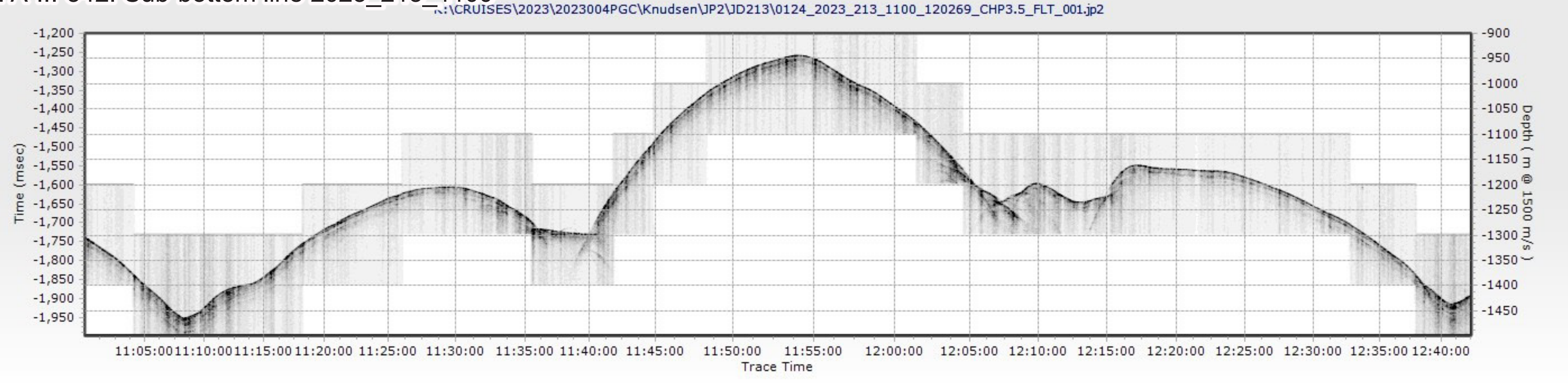


Fig. A-III-343. Sub-bottom line 2023_213_1242

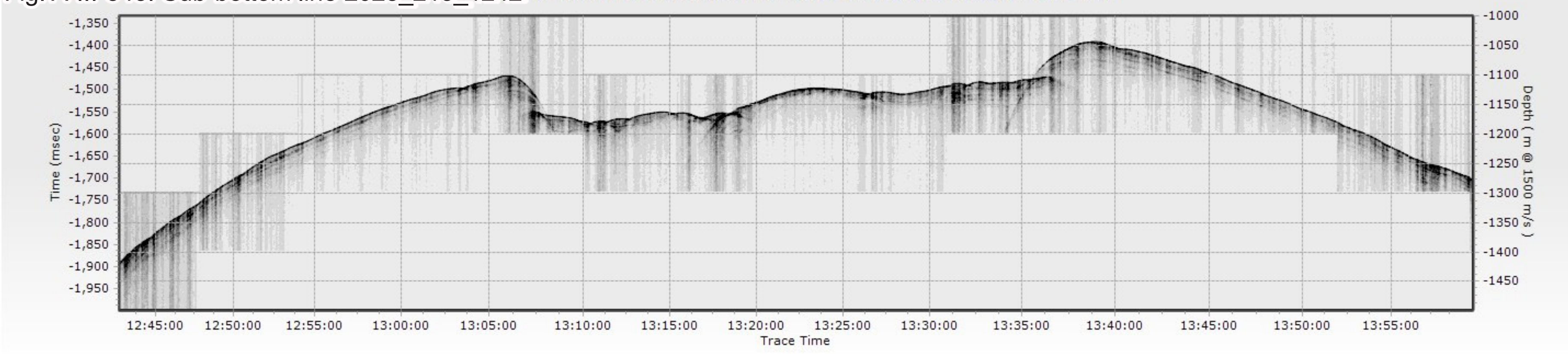


Fig. A-III-344. Sub-bottom line 2023_213_1359

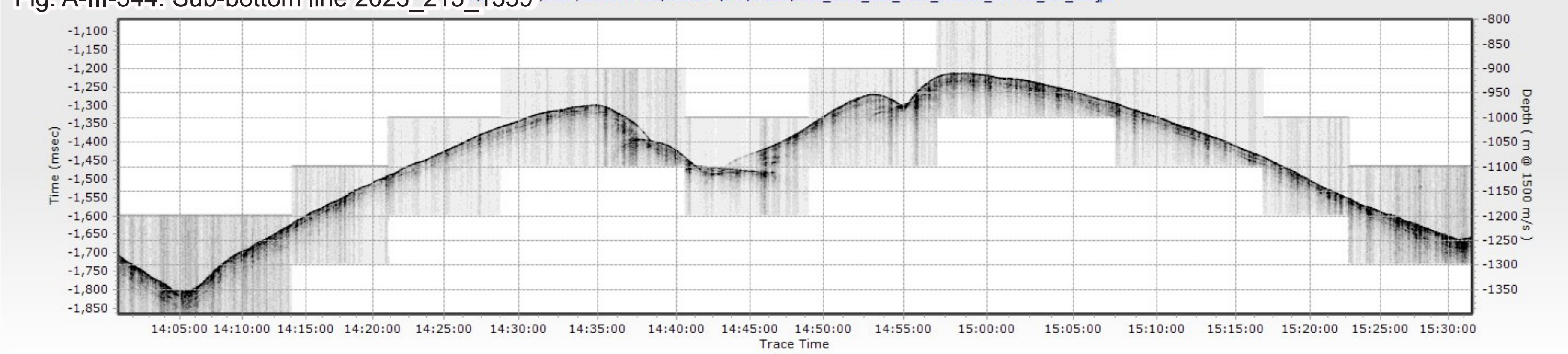
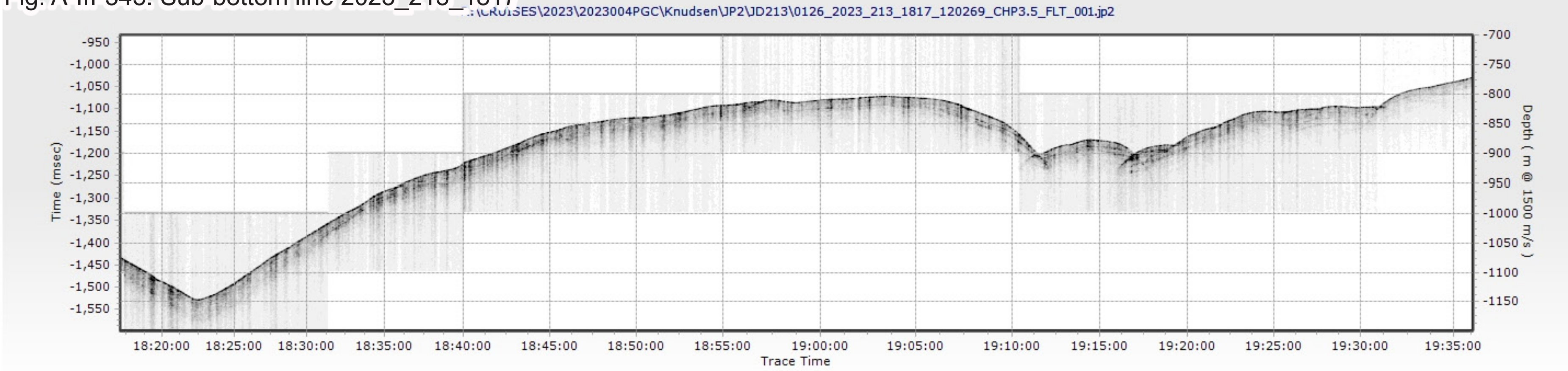


Fig. A-III-345. Sub-bottom line 2023_213_1817



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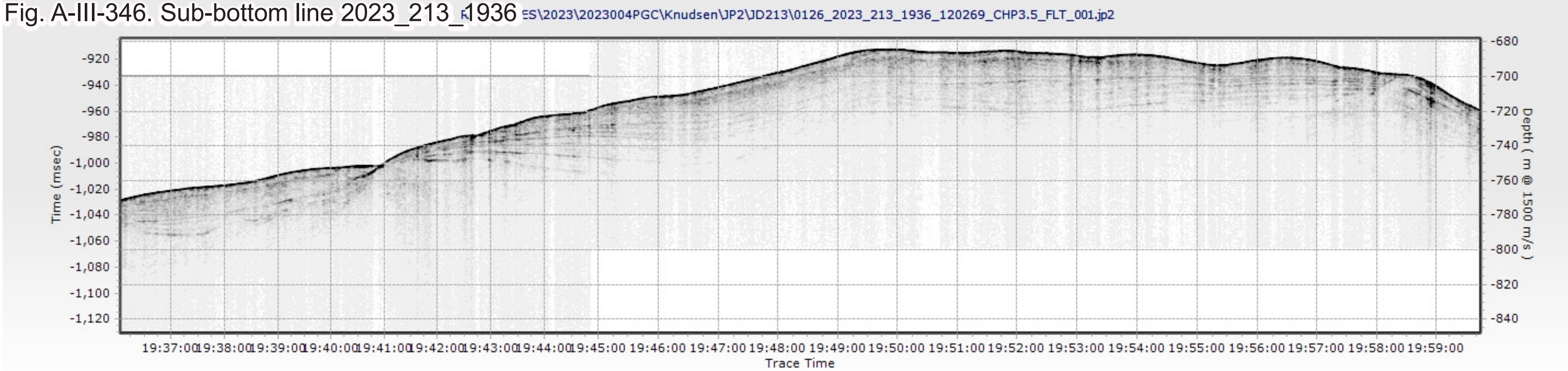


Fig. A-III-347. Sub-bottom line 2023_213_1959

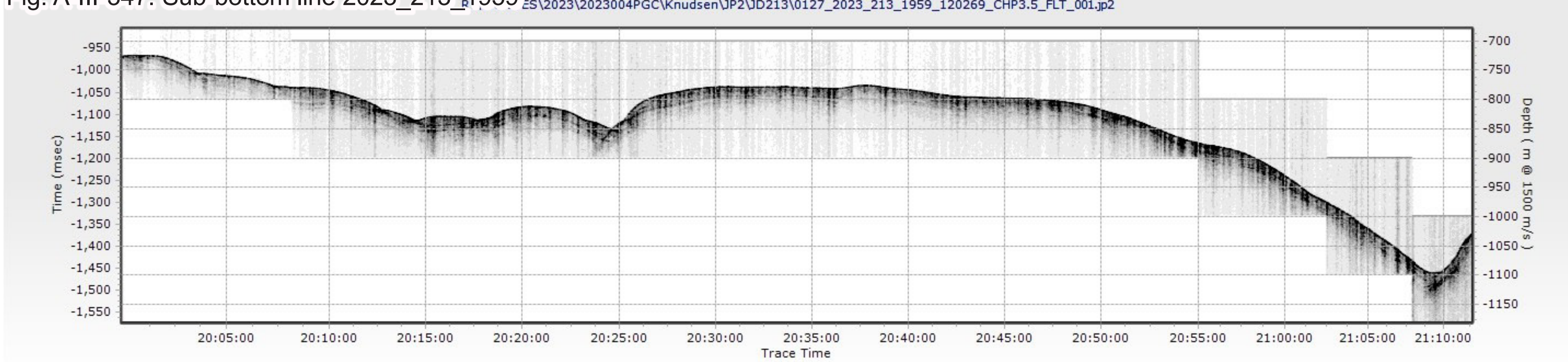


Fig. A-III-348. Sub-bottom line 2023_213_2112

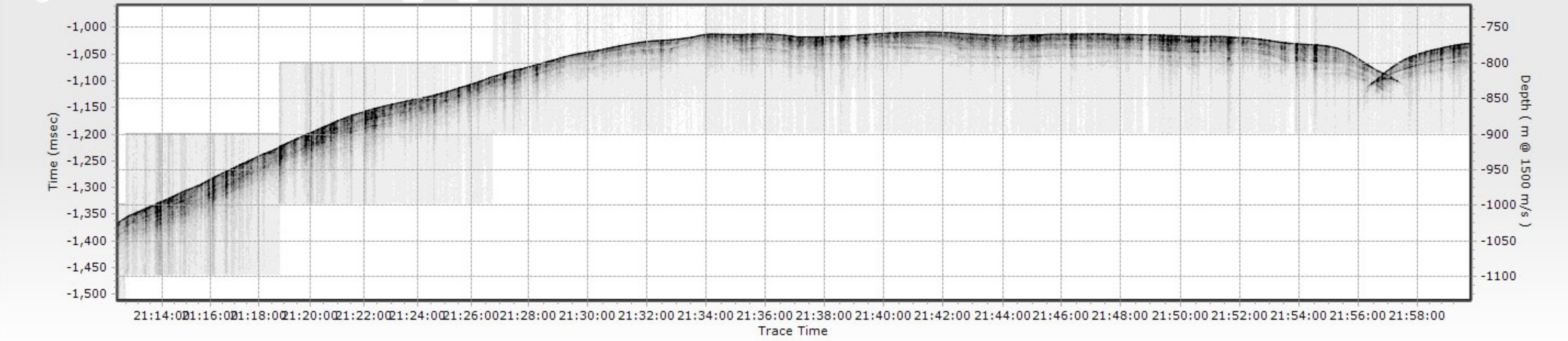


Fig. A-III-349. Sub-bottom line 2023_213_2159

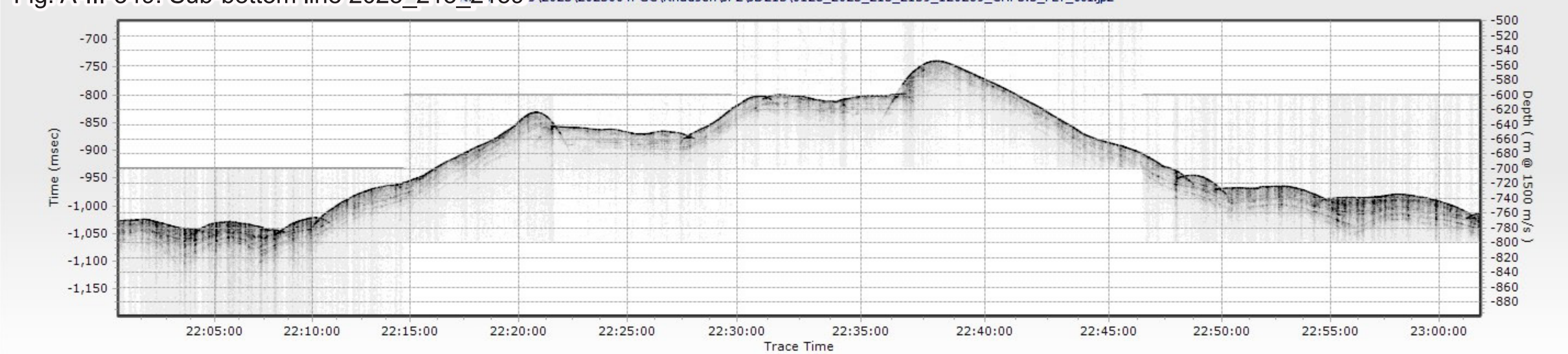


Fig. A-III-350. Sub-bottom line 2023_213_2301

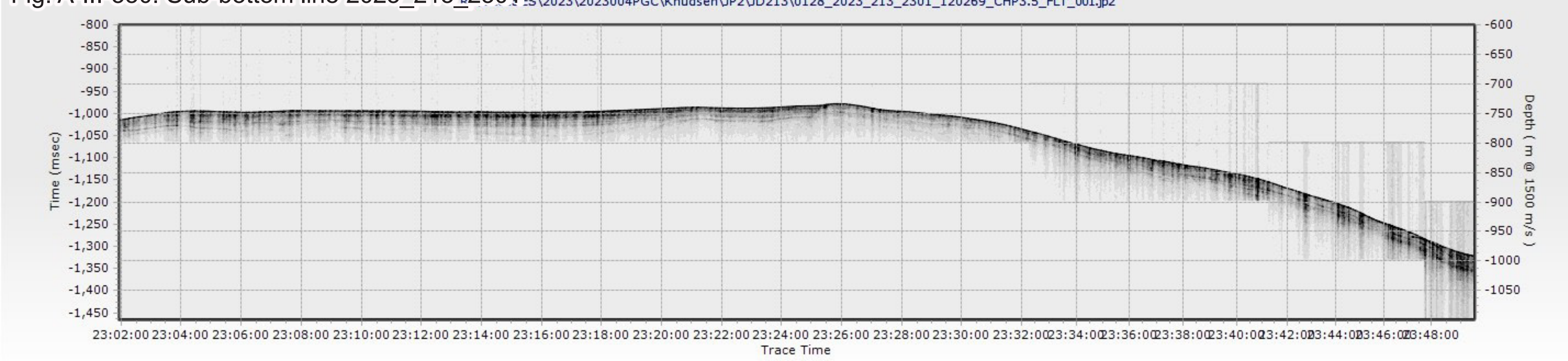
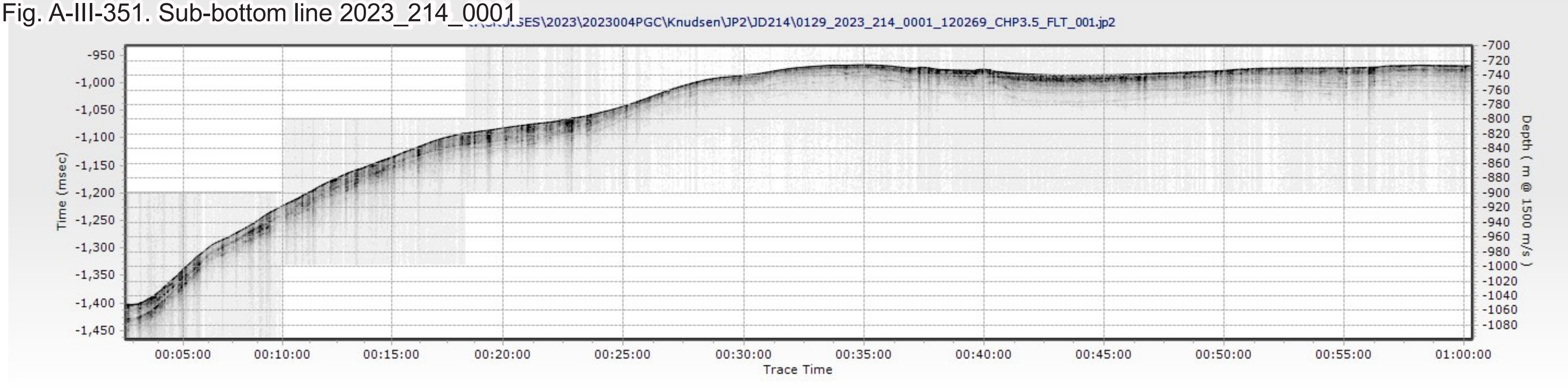


Fig. A-III-351. Sub-bottom line 2023_214_0001



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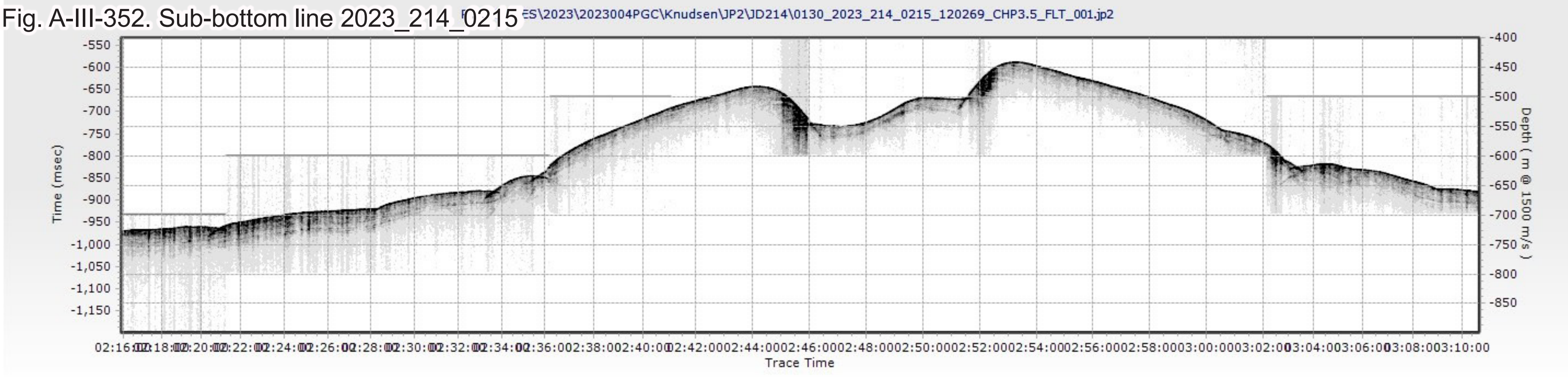

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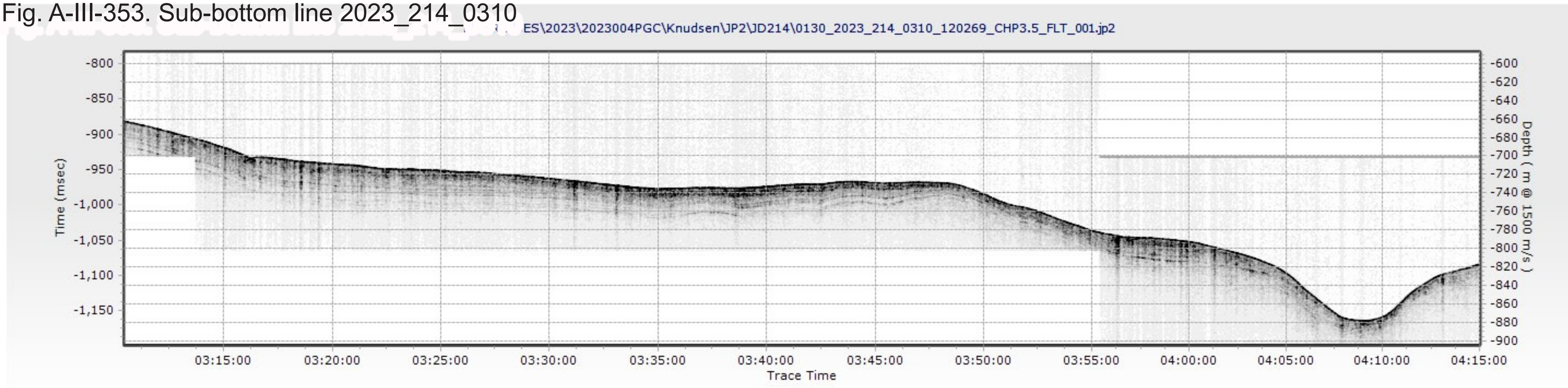


Fig. A-III-354. Sub-bottom line 2023_214_0415

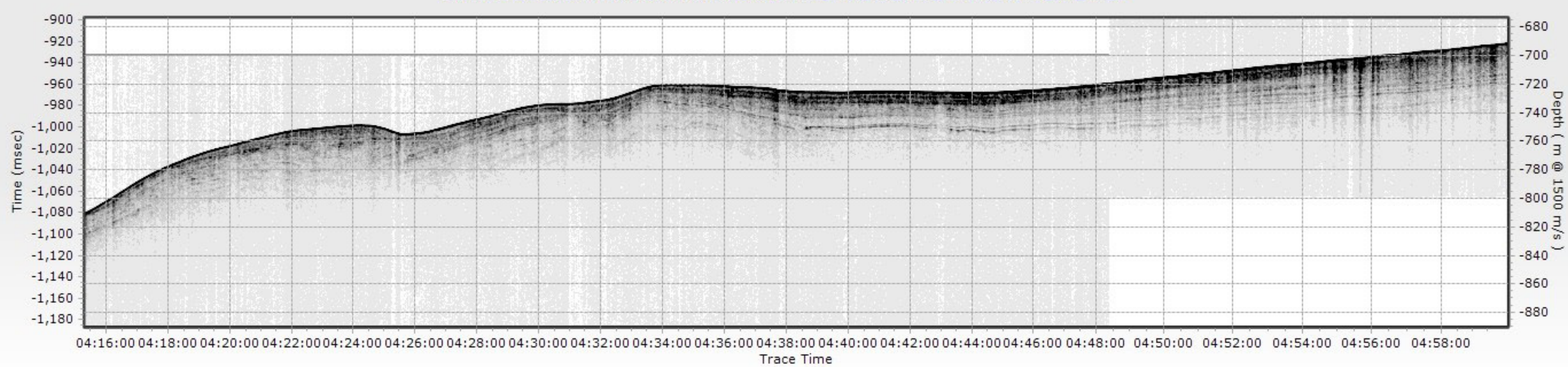


Fig. A-III-355. Sub-bottom line 2023__214_0500

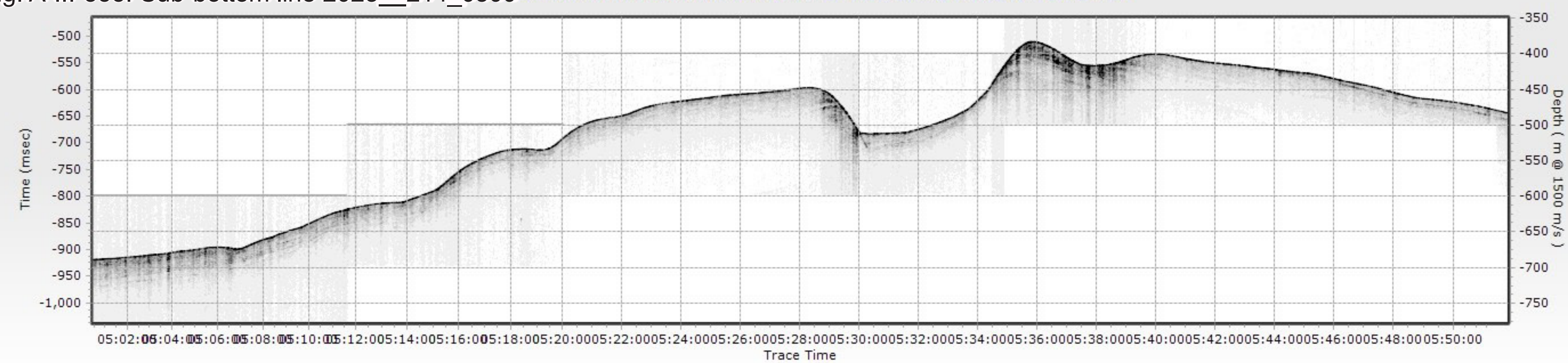


Fig. A-III-356. Sub-bottom line 2023_214_0551

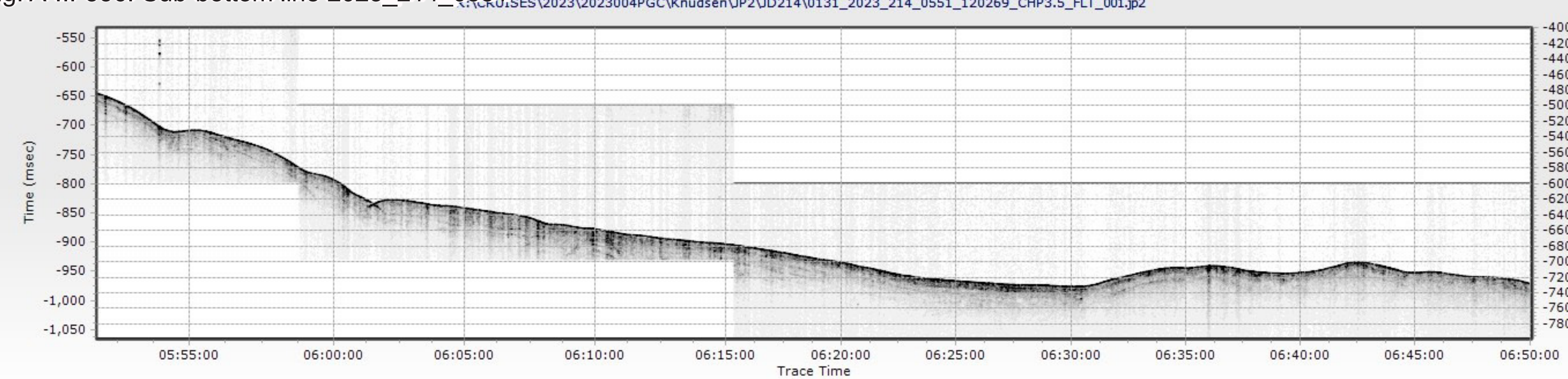


Fig. A-III-357. Sub-bottom line 2023_214_0650

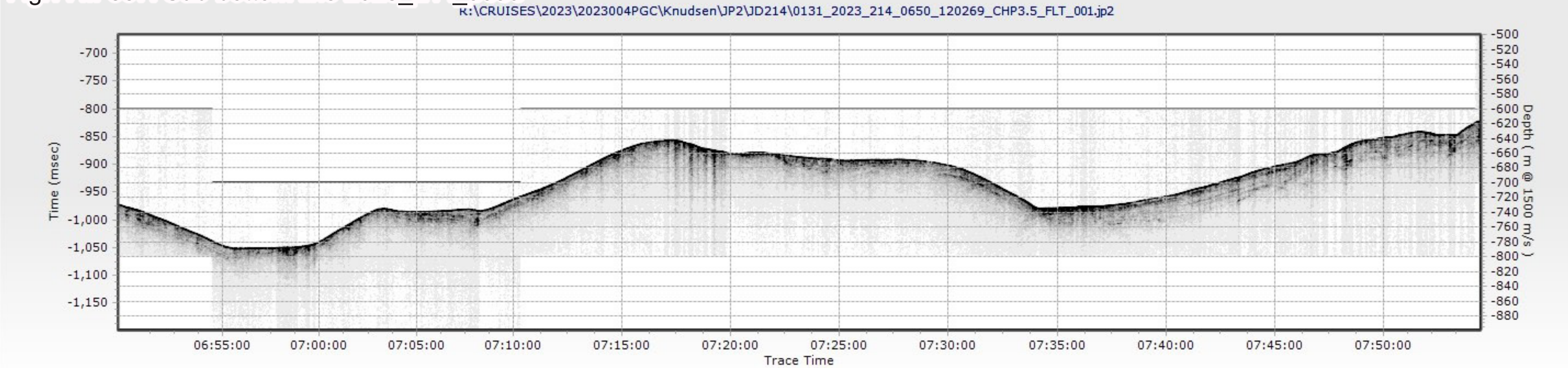


Fig. A-III-358. Sub-bottom line 2023_214_0800

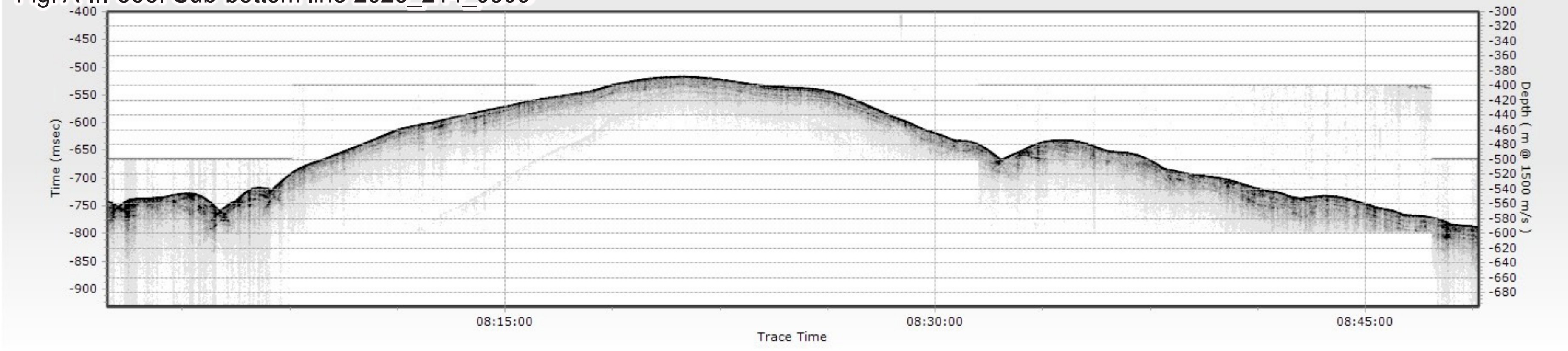


Fig. A-III-359. Sub-bottom line 2023_214_0849

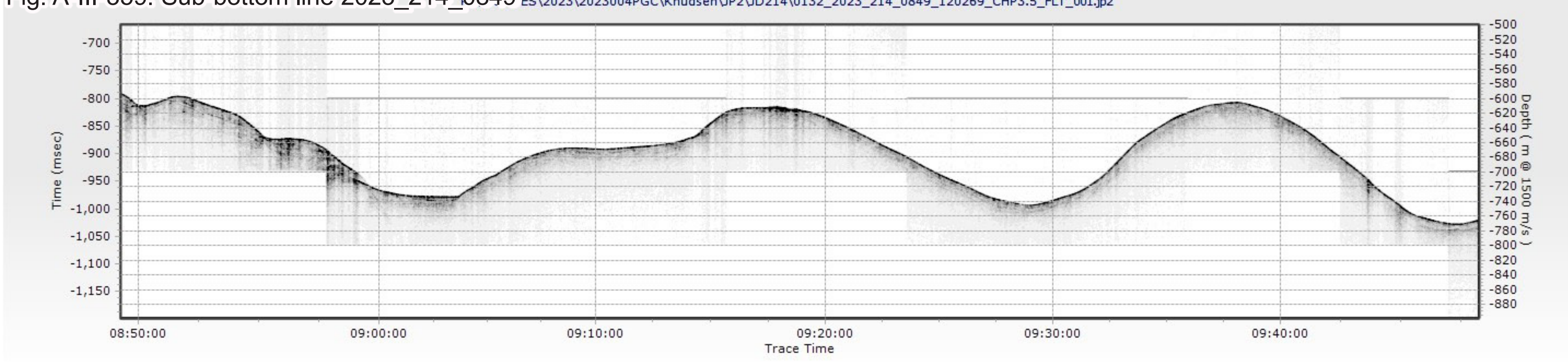


Fig. A-III-360. Sub-bottom line 2023_214_0949

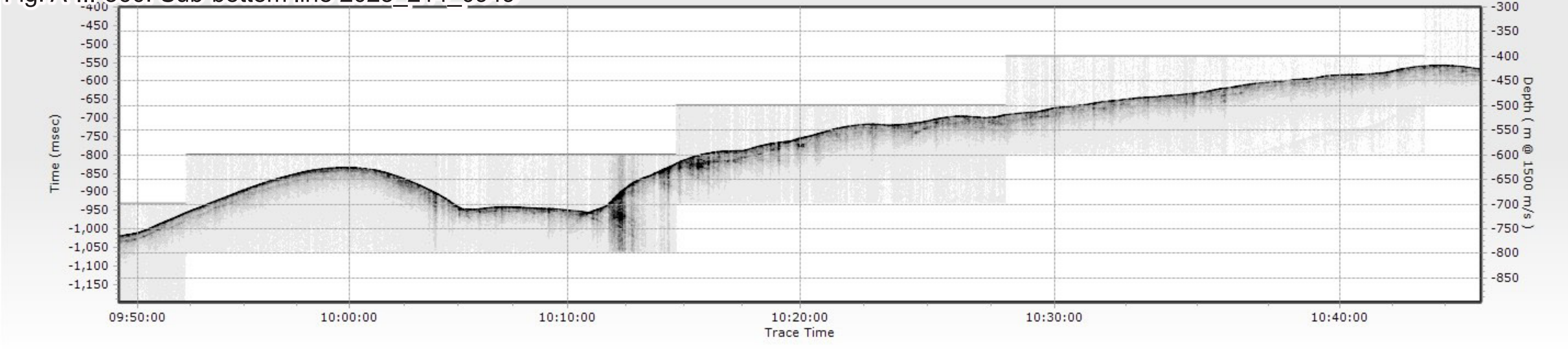


Fig. A-III-361. Sub-bottom line 2023_214_1045

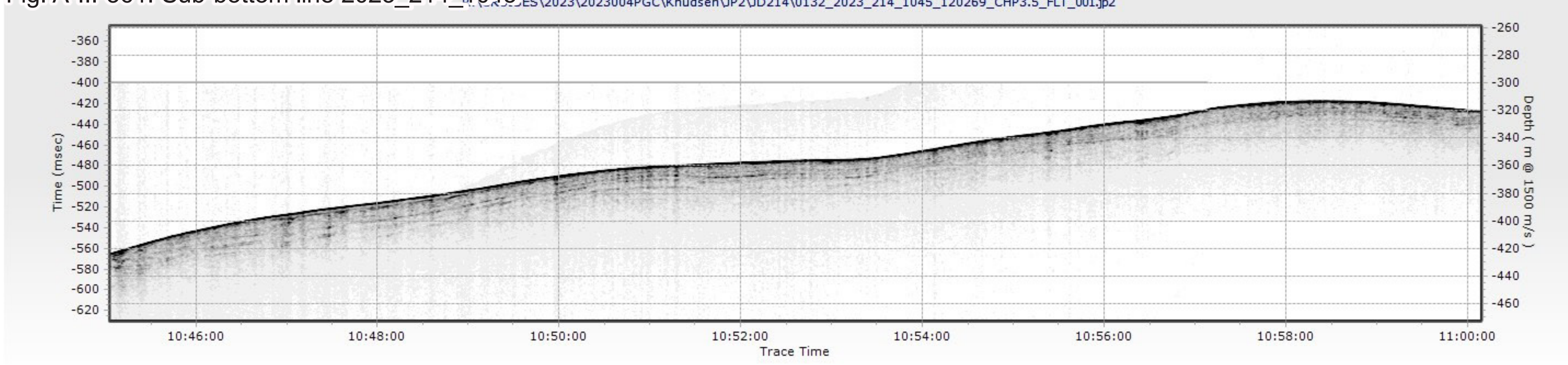


Fig. A-III-362. Sub-bottom line 2023_214_1100

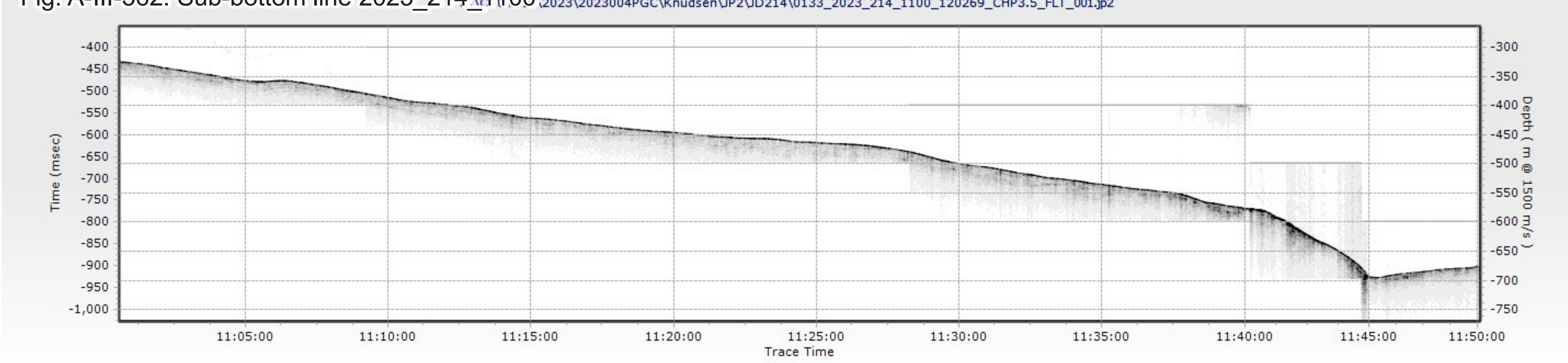
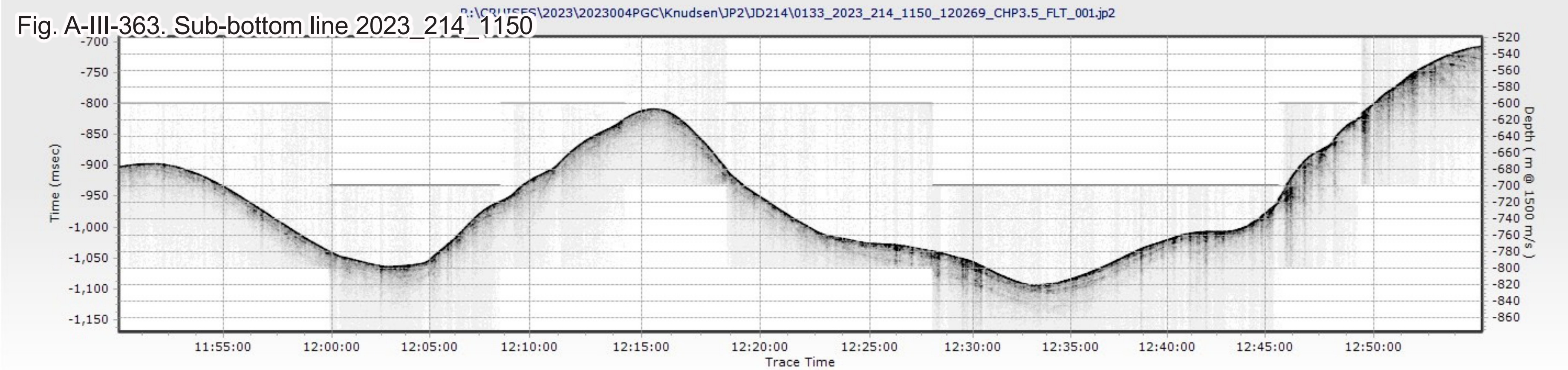


Fig. A-III-363. Sub-bottom line 2023_214_1150



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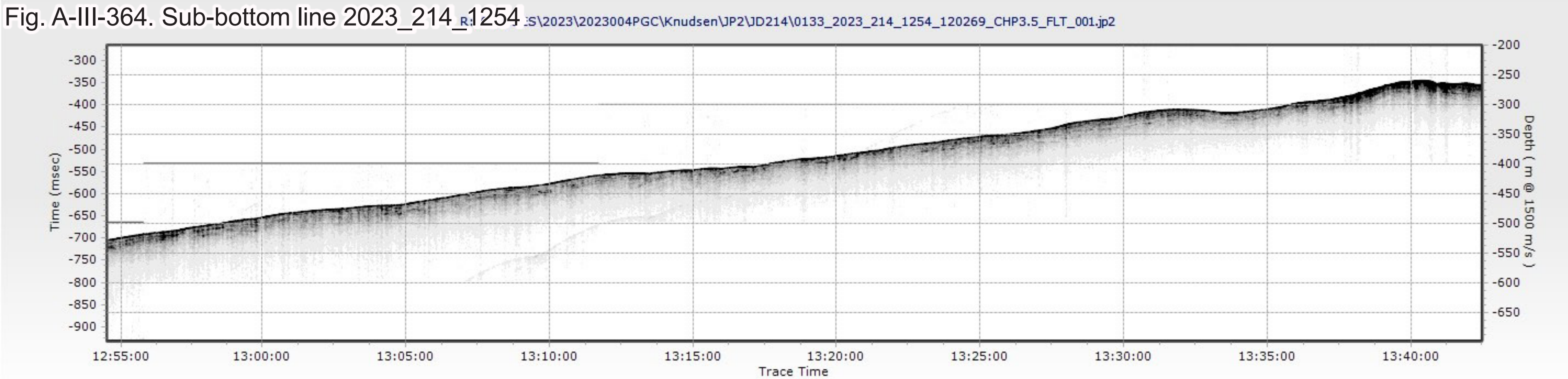

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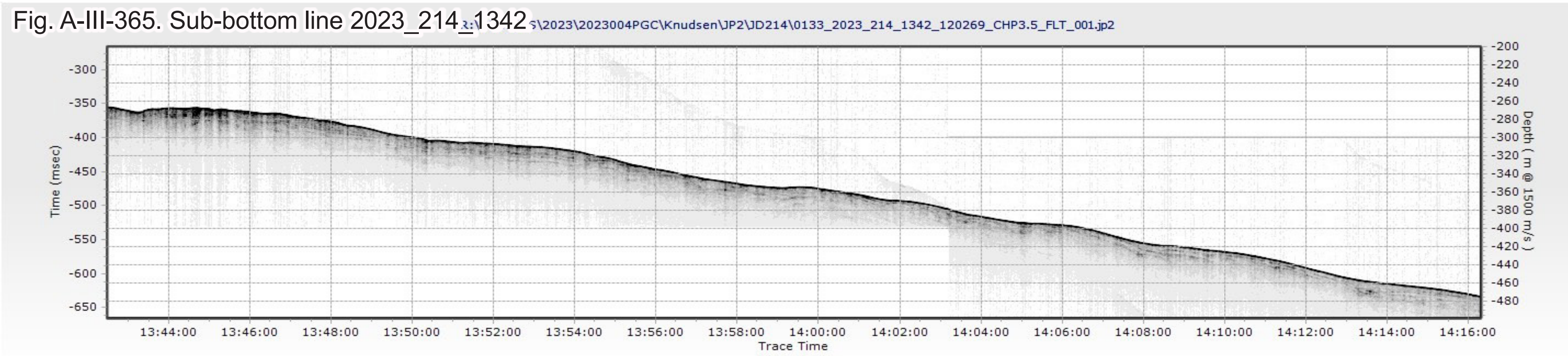


Fig. A-III-366. Sub-bottom line 2023_214_1416

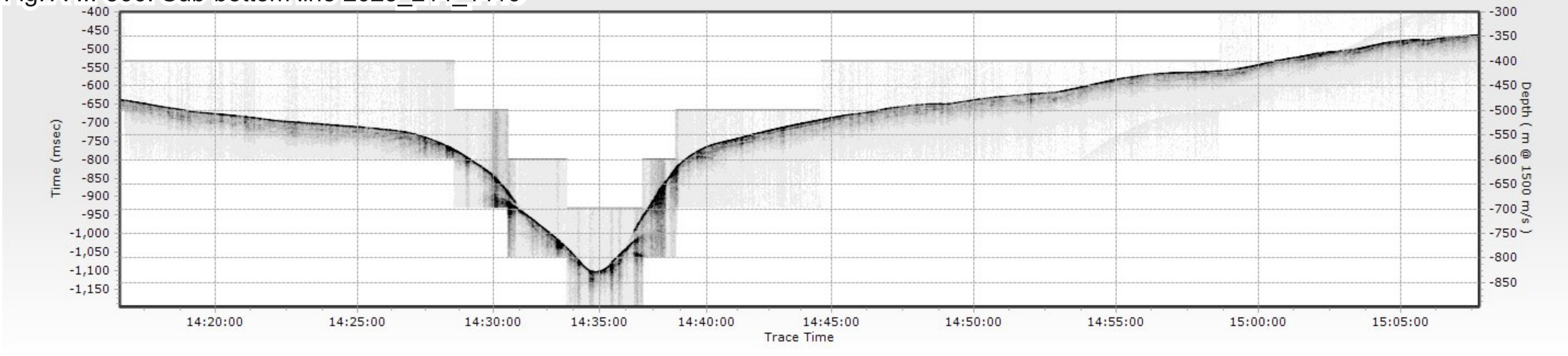


Fig. A-III-367. Sub-bottom line 2023_214_1507

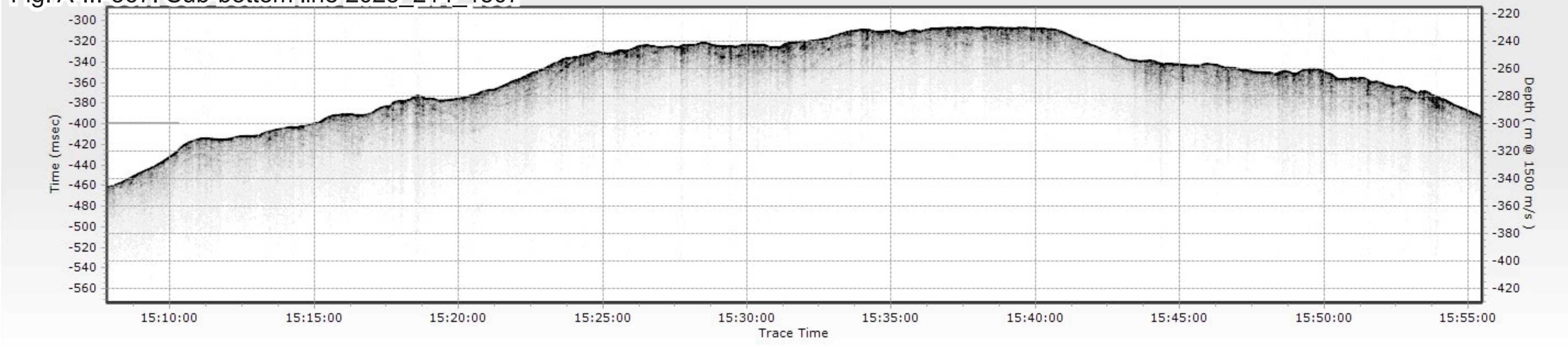


Fig. A-III-368. Sub-bottom line 2023__214_1555

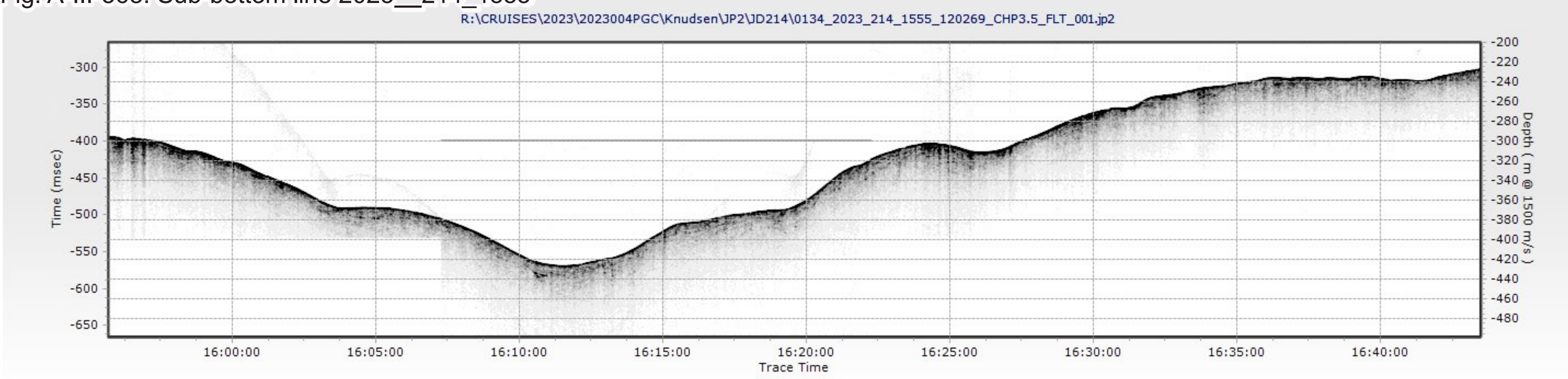


Fig. A-III-369. Sub-bottom line 2023_214_1643

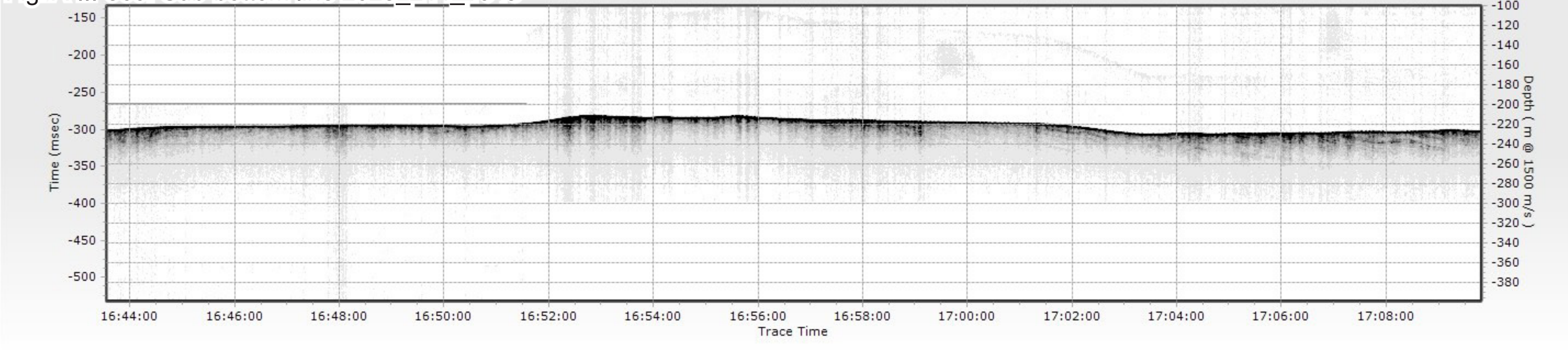


Fig. A-III-370. Sub-bottom line 2023_214_1710

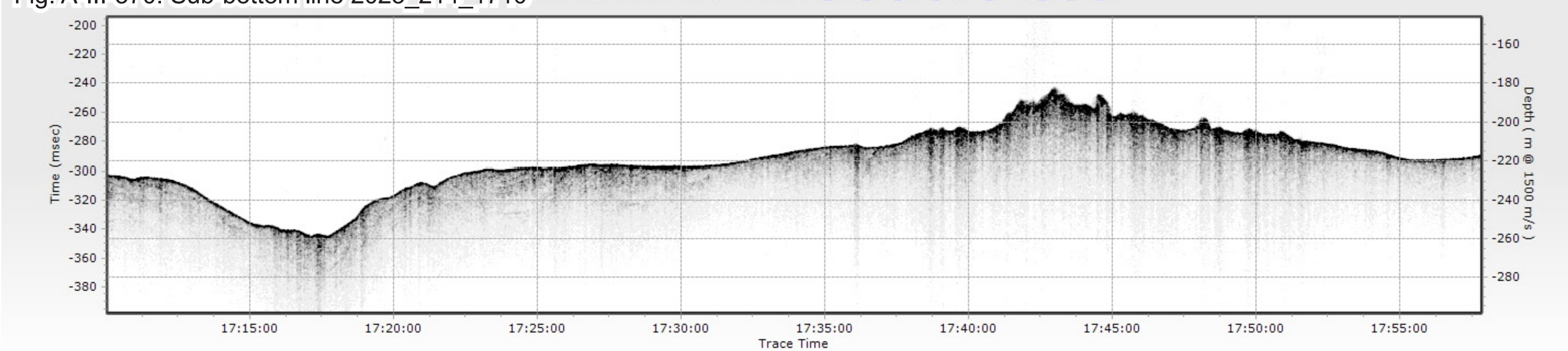


Fig. A-III-371. Sub-bottom line 2023_214_1757

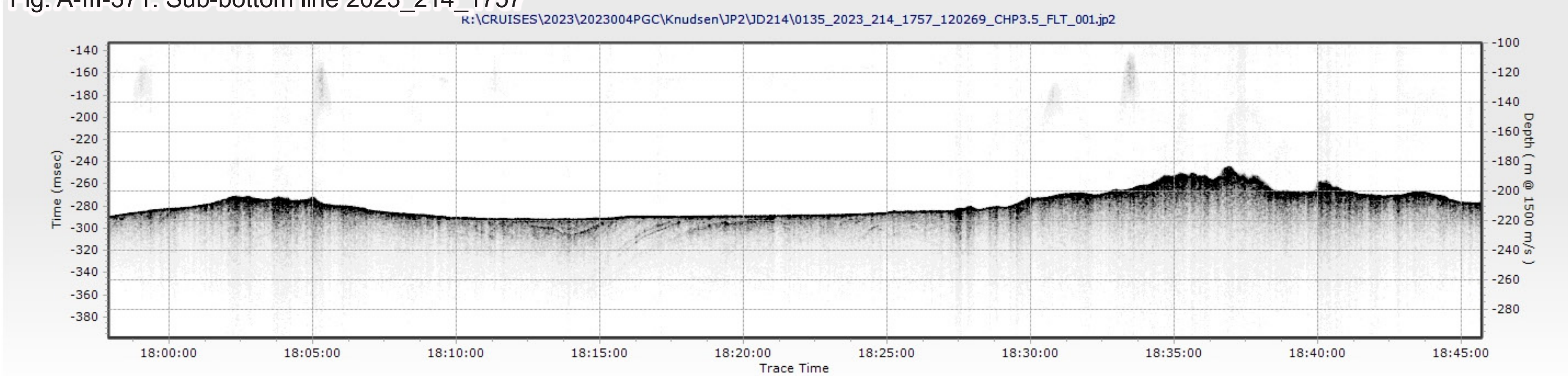
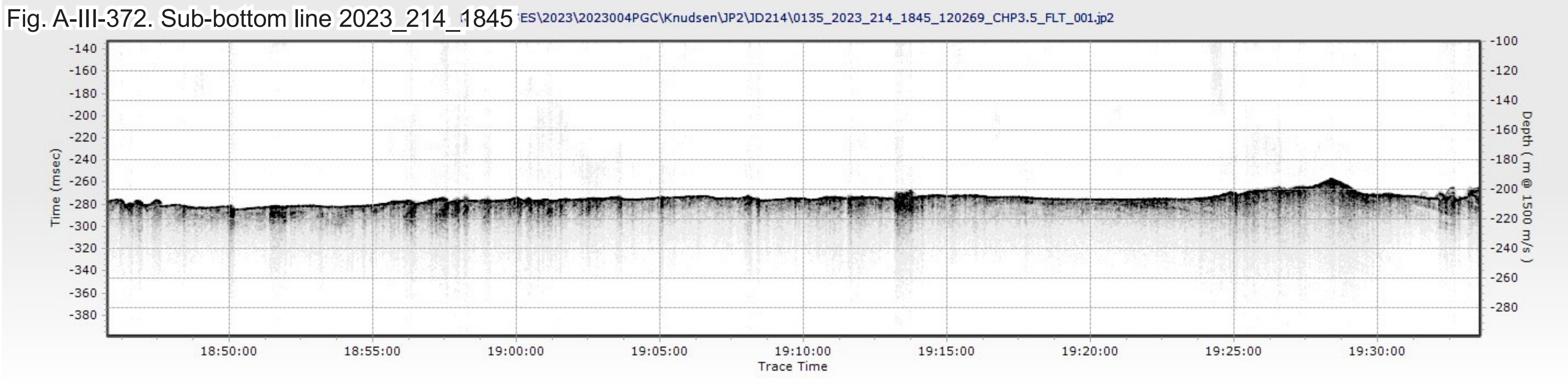


Fig. A-III-372. Sub-bottom line 2023_214_1845



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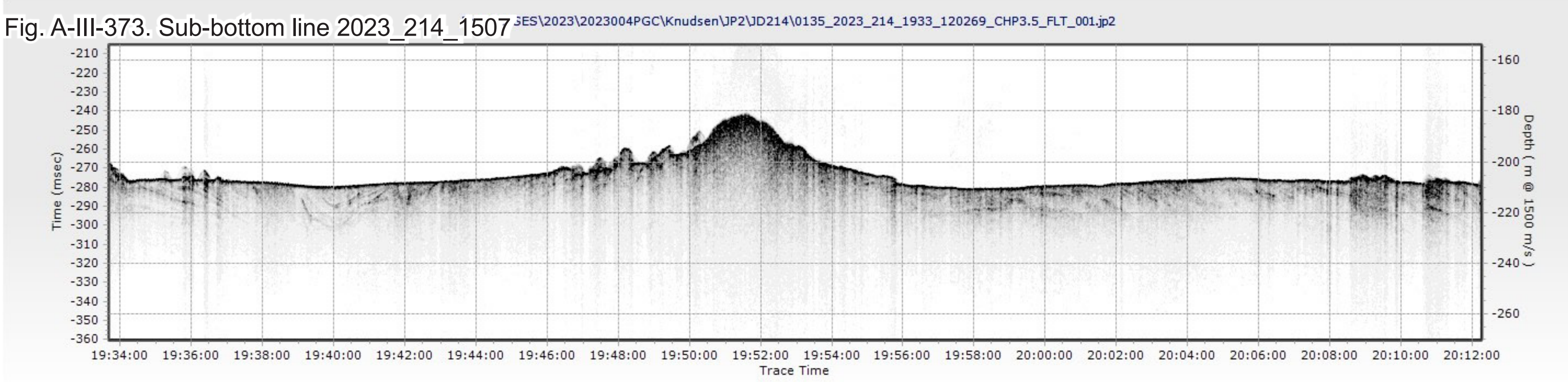


Fig. A-III-374. Sub-bottom line 2023_214_2012

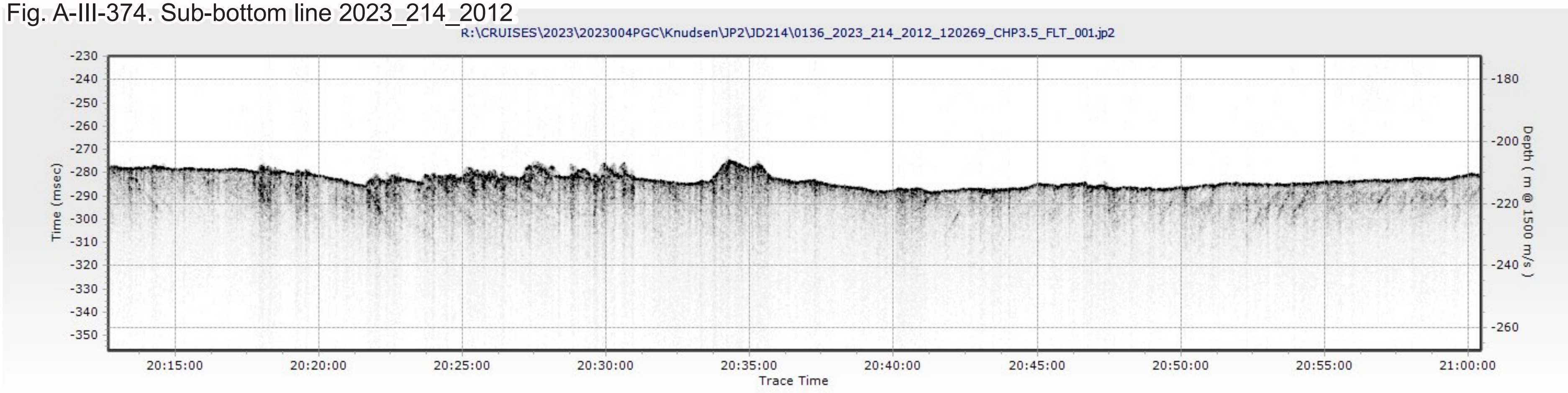
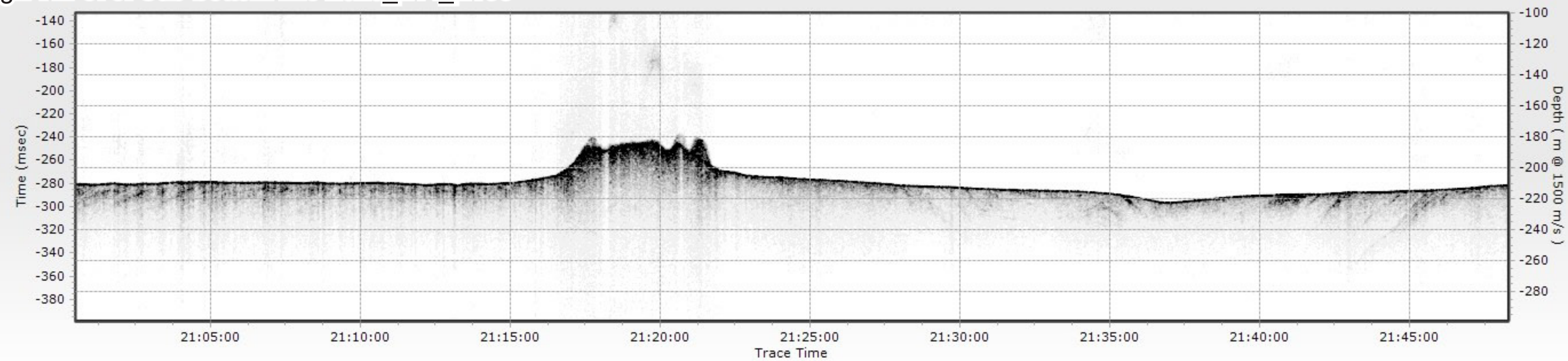


Fig. A-III-375. Sub-bottom line 2023_214_2100



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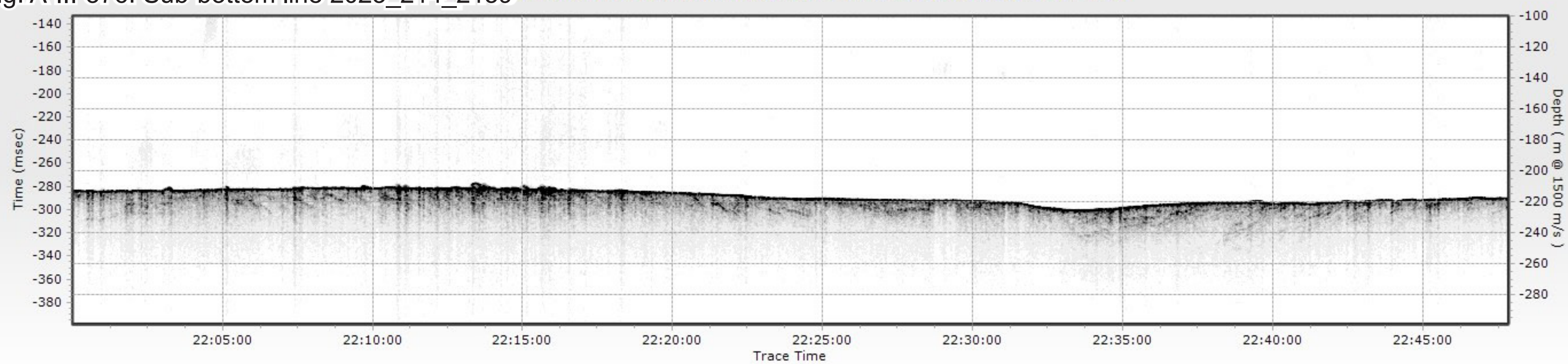

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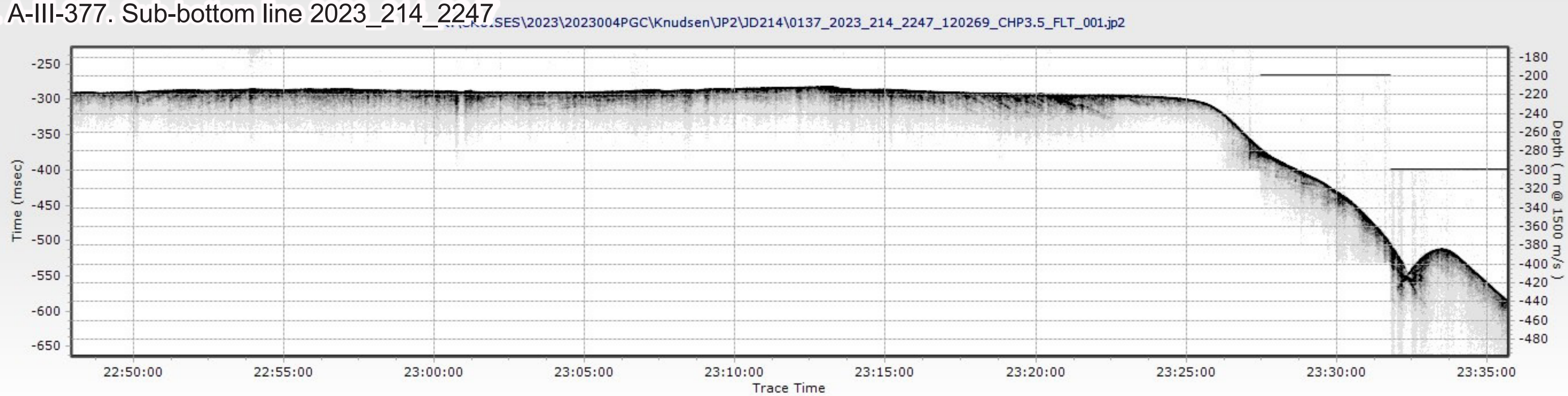


Fig. A-III-378. Sub-bottom line 2023_214_2335

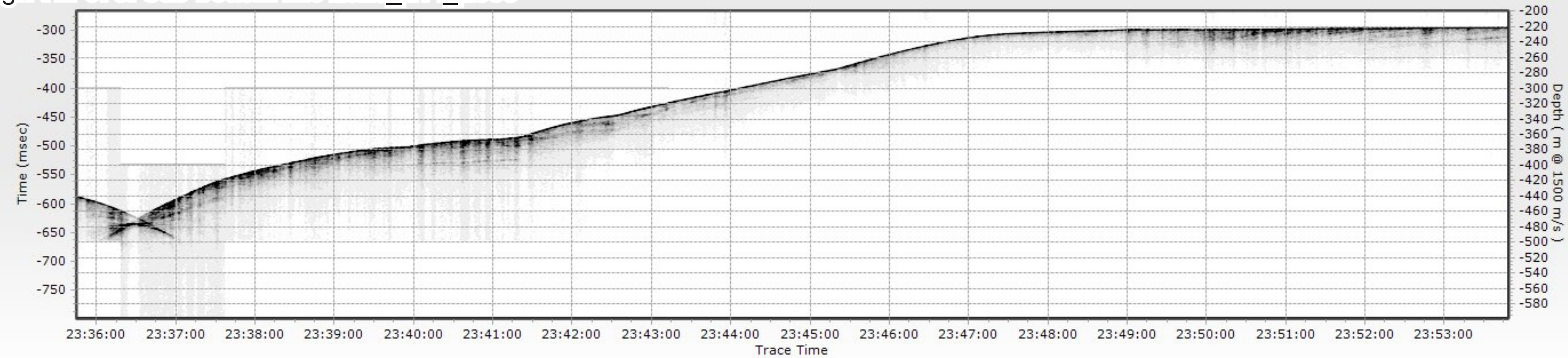


Fig. A-III-379. Sub-bottom line 2023_215_0005

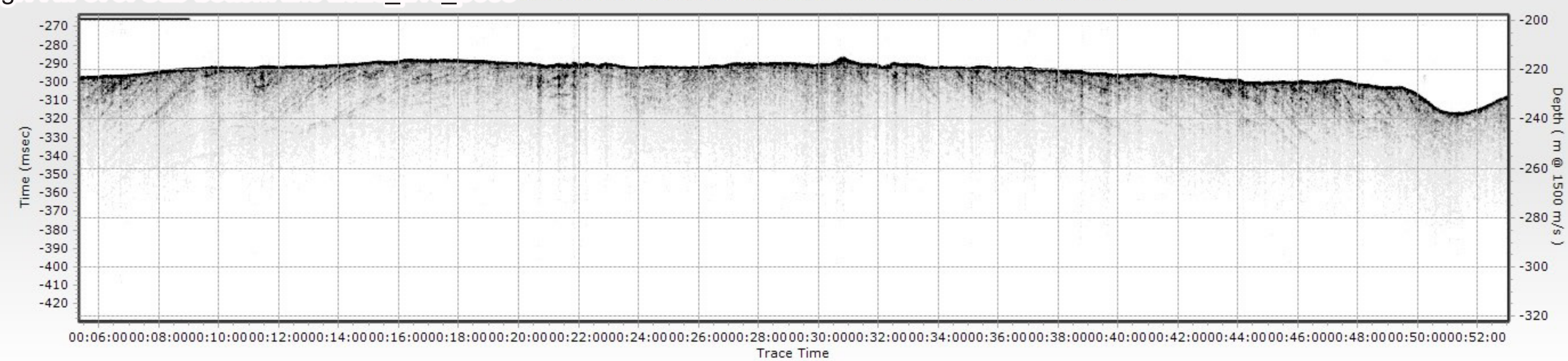


Fig. A-III-380. Sub-bottom line 2023_215_0133

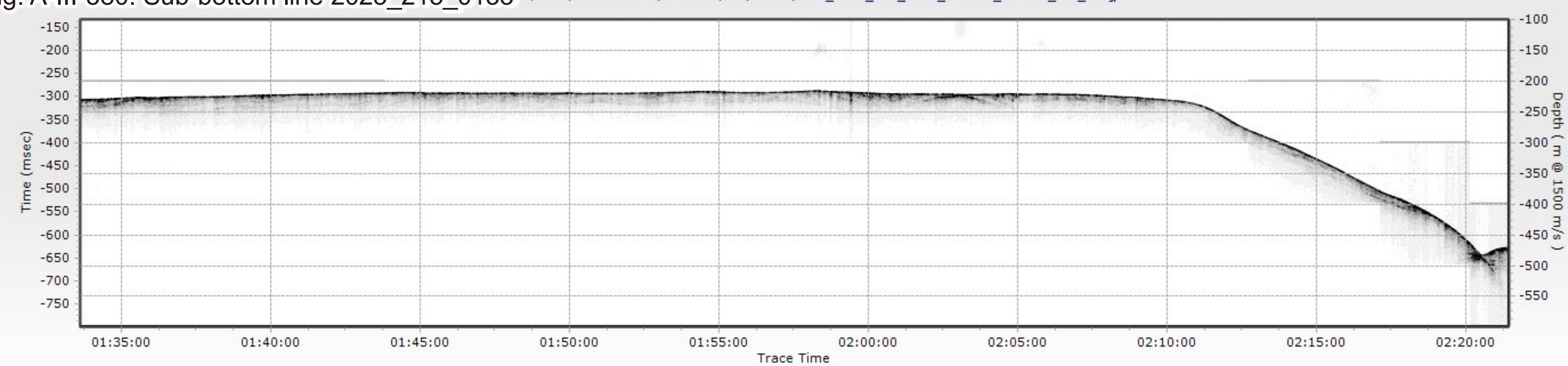


Fig. A-III-381. Sub-bottom line 2023_215_0221

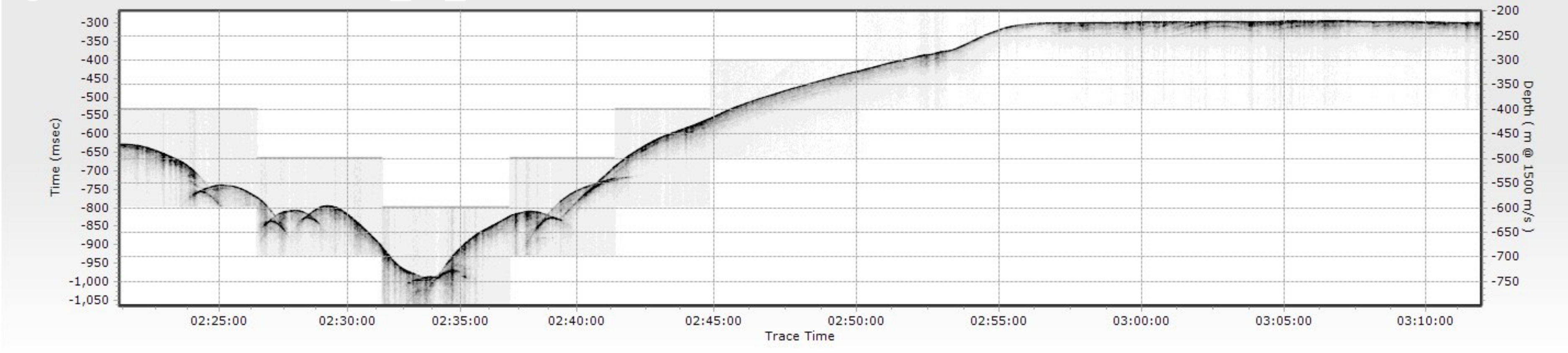


Fig. A-III-382. Sub-bottom line 2023_215_0311

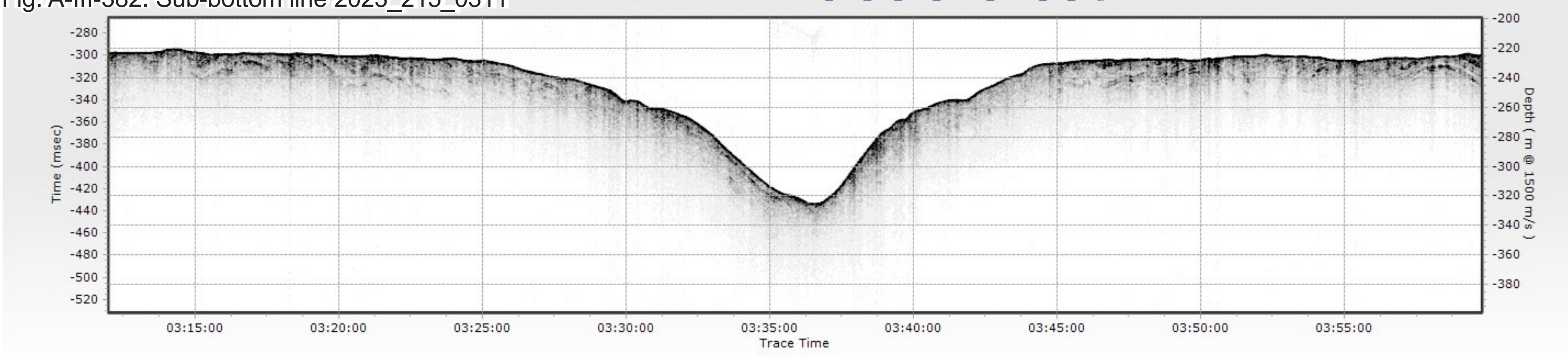
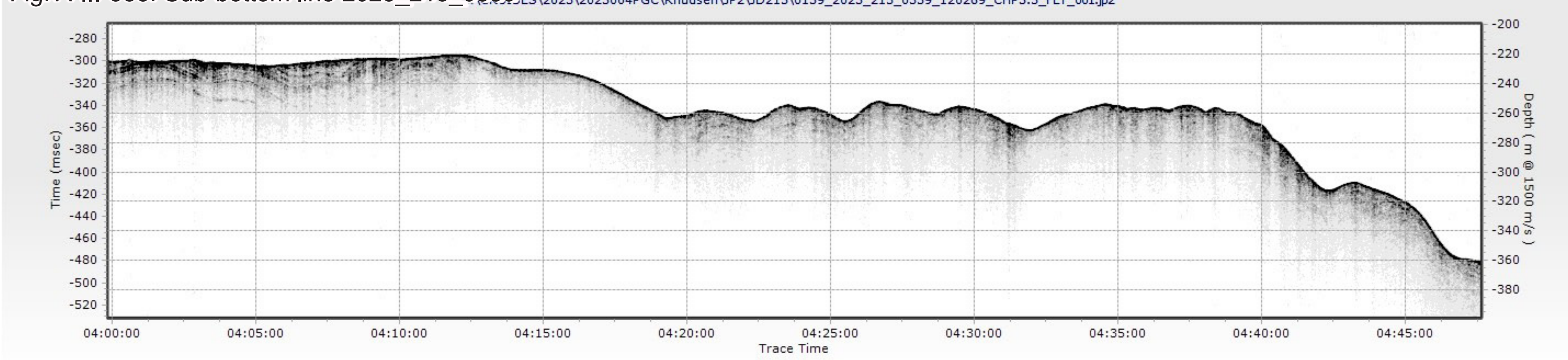


Fig. A-III-383. Sub-bottom line 2023_215_0359



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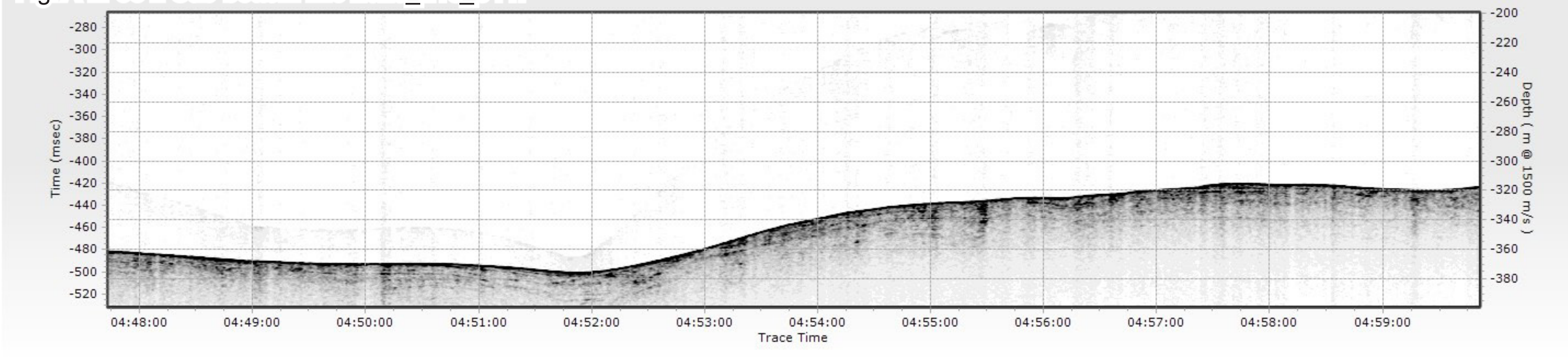
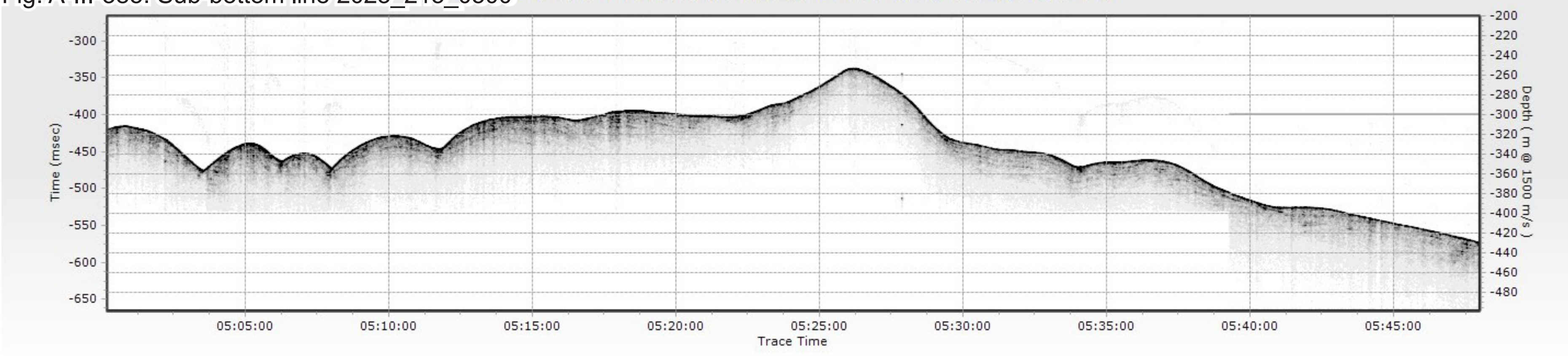


Fig. A-III-385. Sub-bottom line 2023_215_0500



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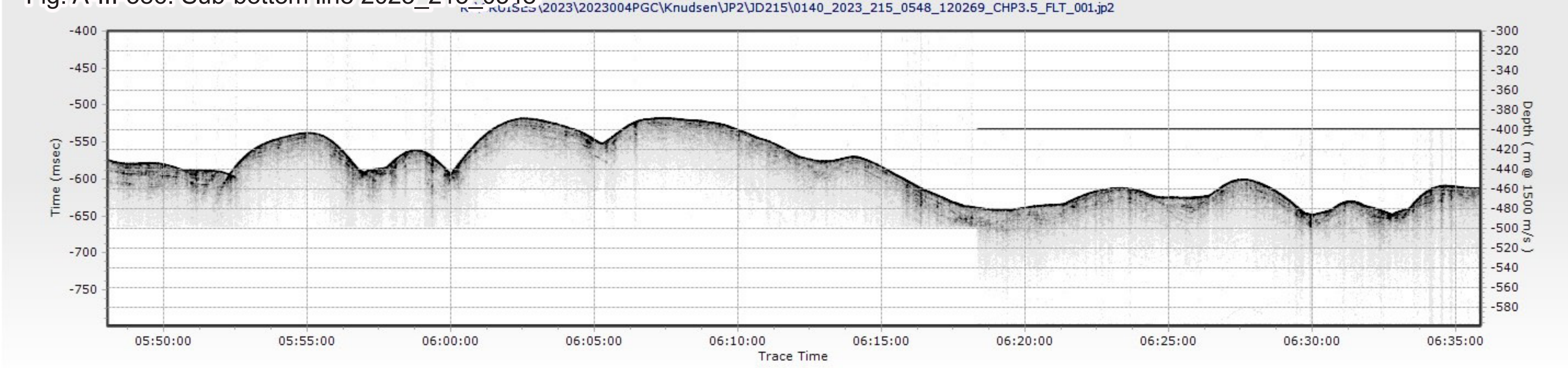

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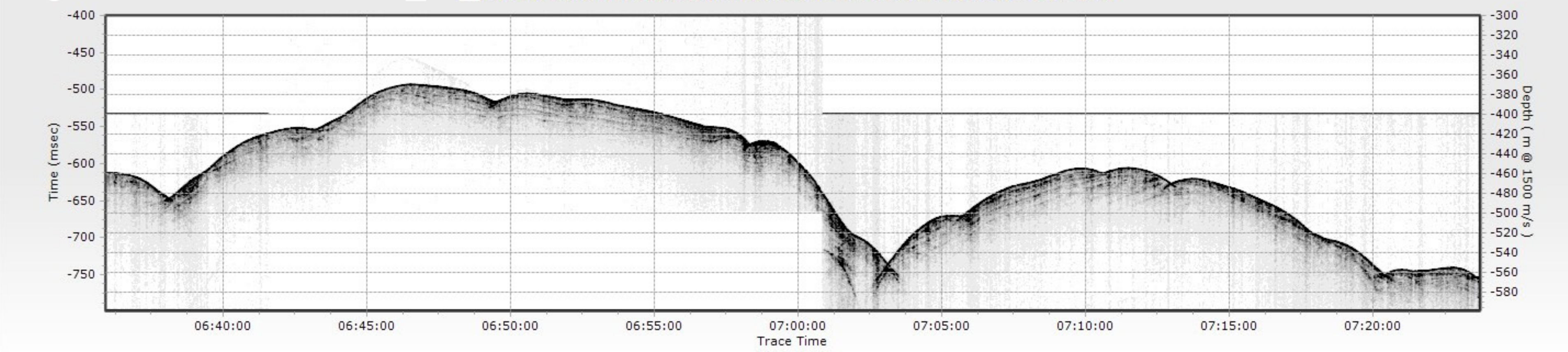


Fig. A-III-388. Sub-bottom line 2023_215_0723

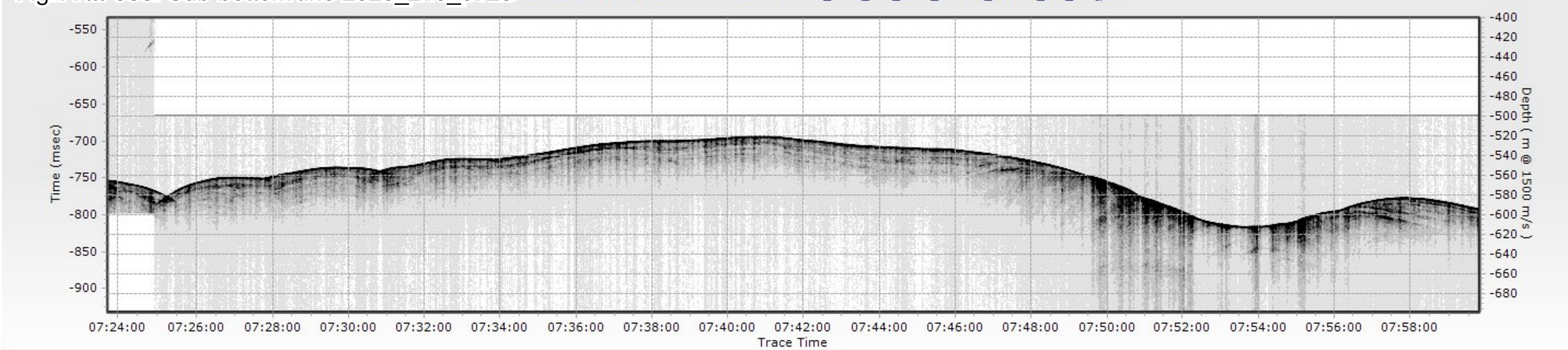
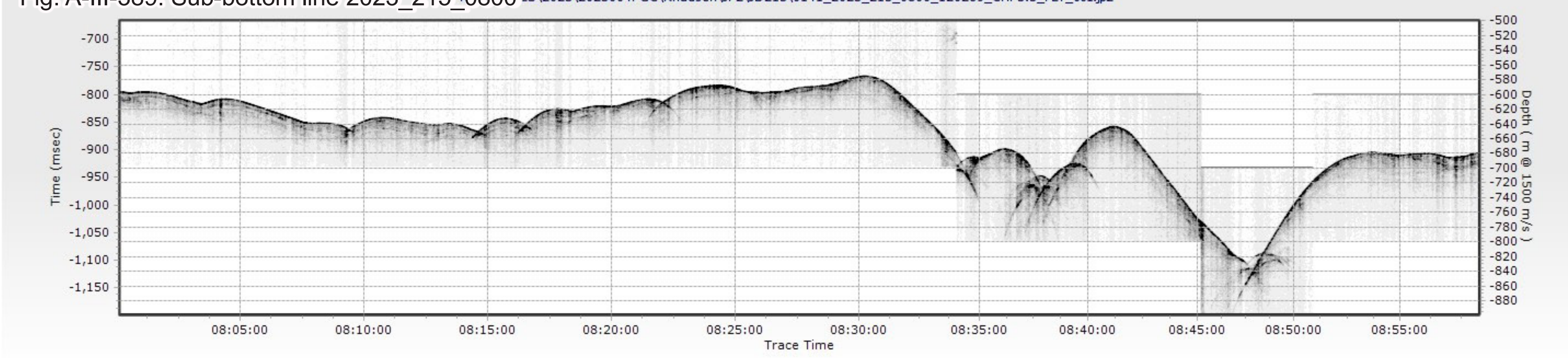


Fig. A-III-389. Sub-bottom line 2023_215_0800



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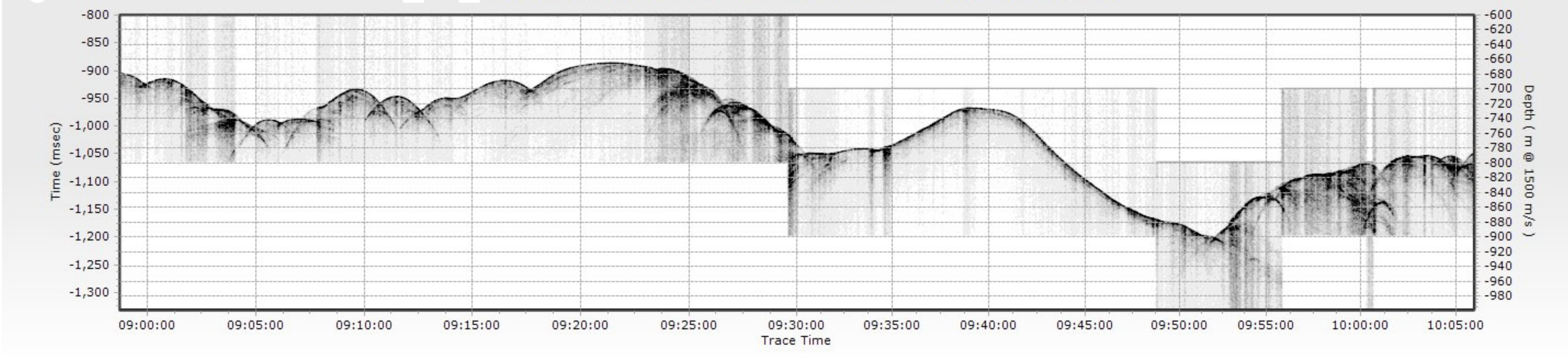

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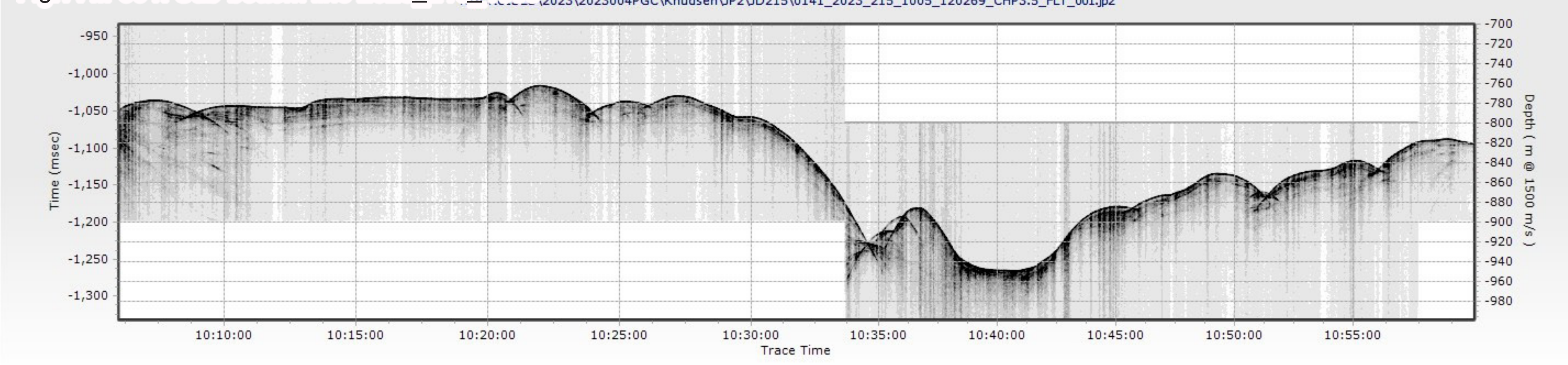

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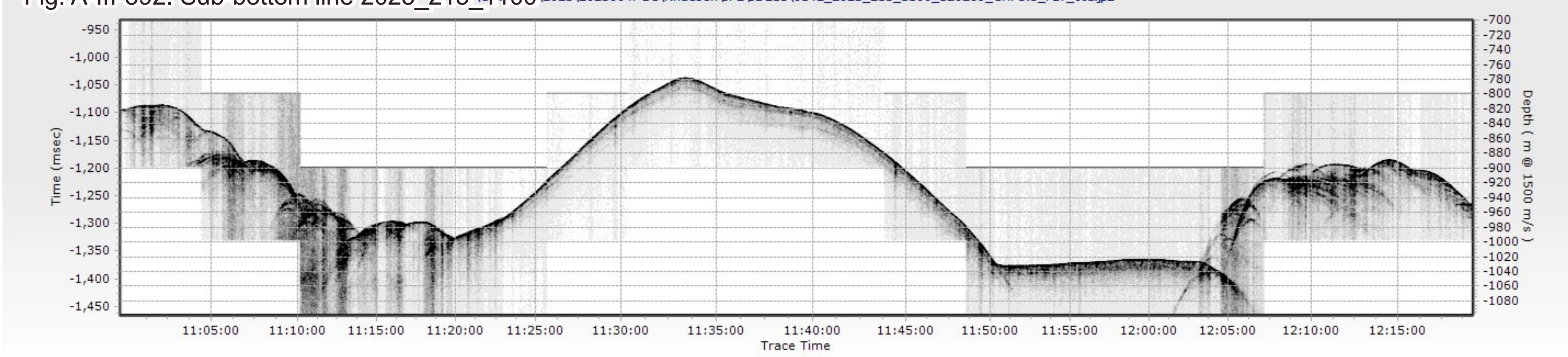


Fig. A-III-393. Sub-bottom line 2023_215_1219

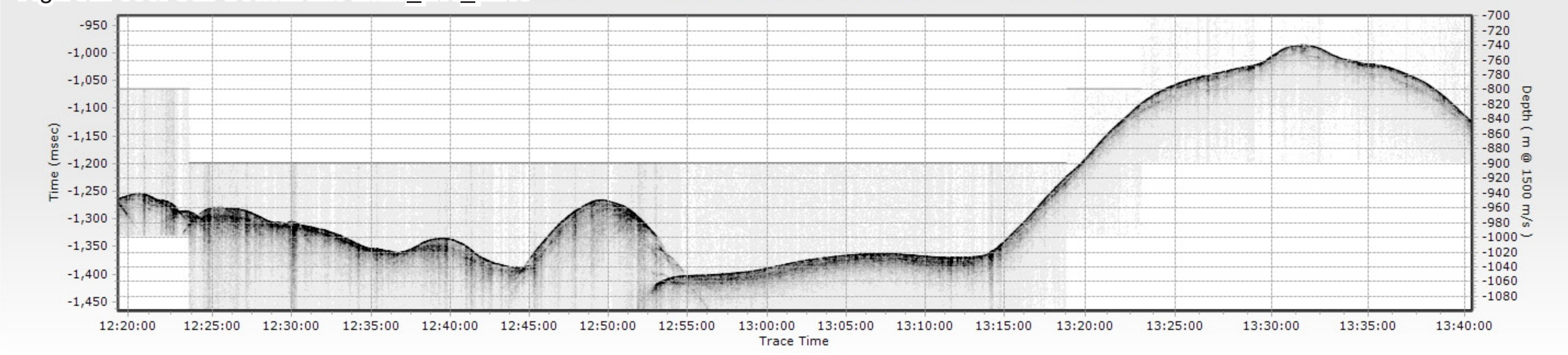


Fig. A-III-394. Sub-bottom line 2023_215_1340

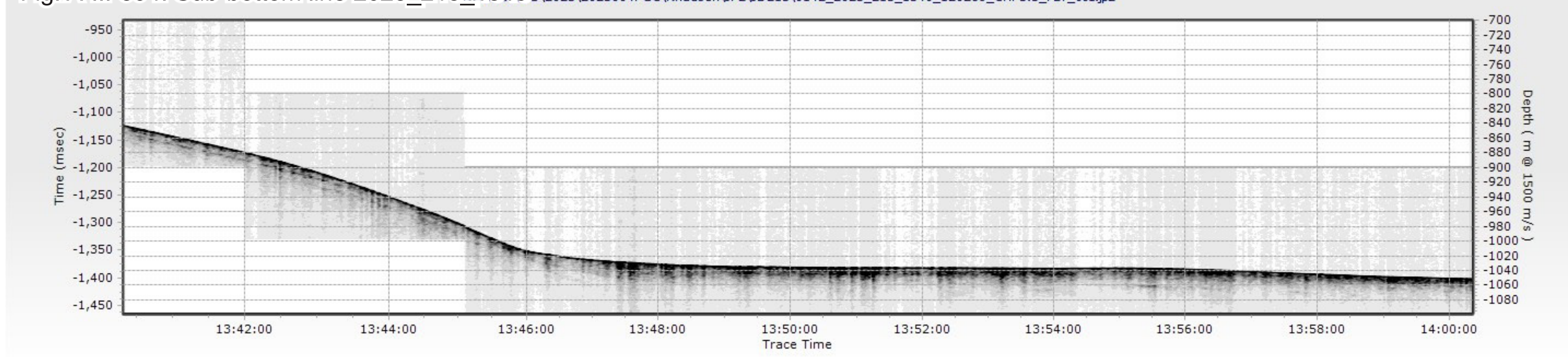
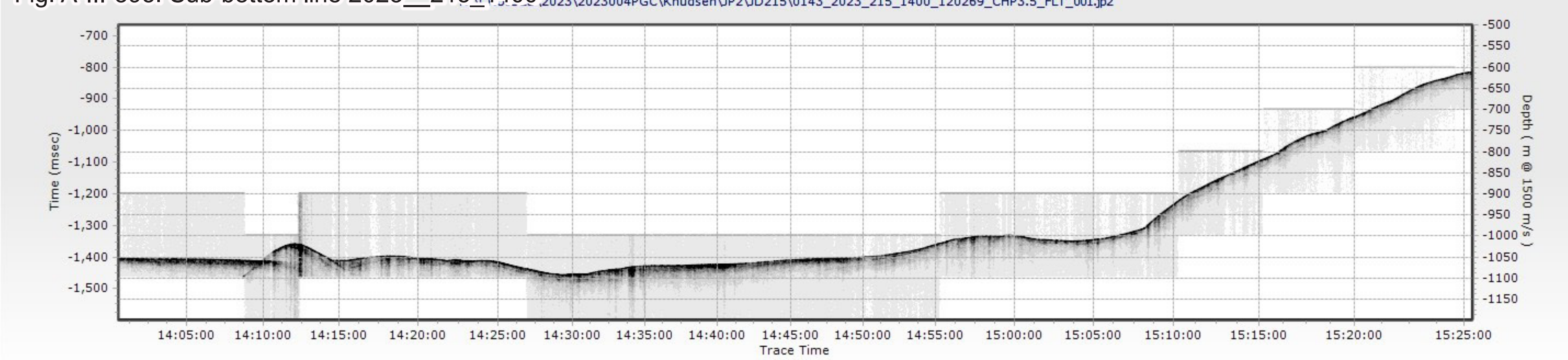


Fig. A-III-395. Sub-bottom line 2023__215_1400



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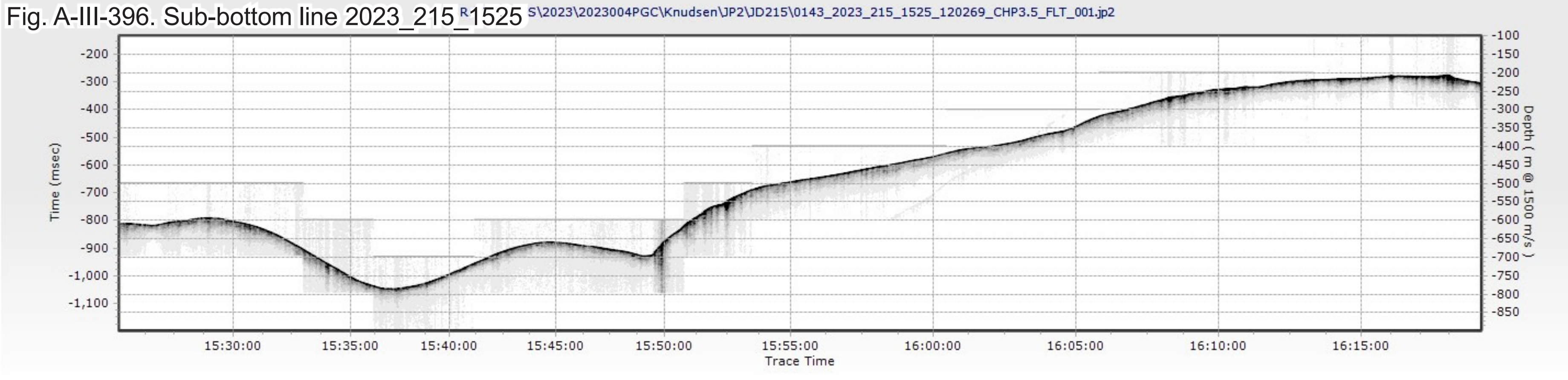

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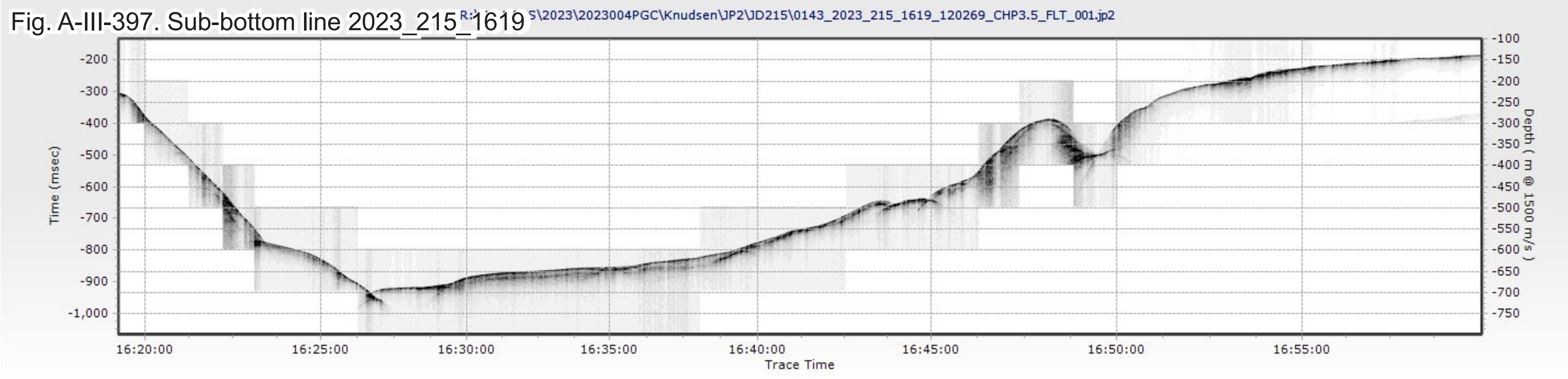

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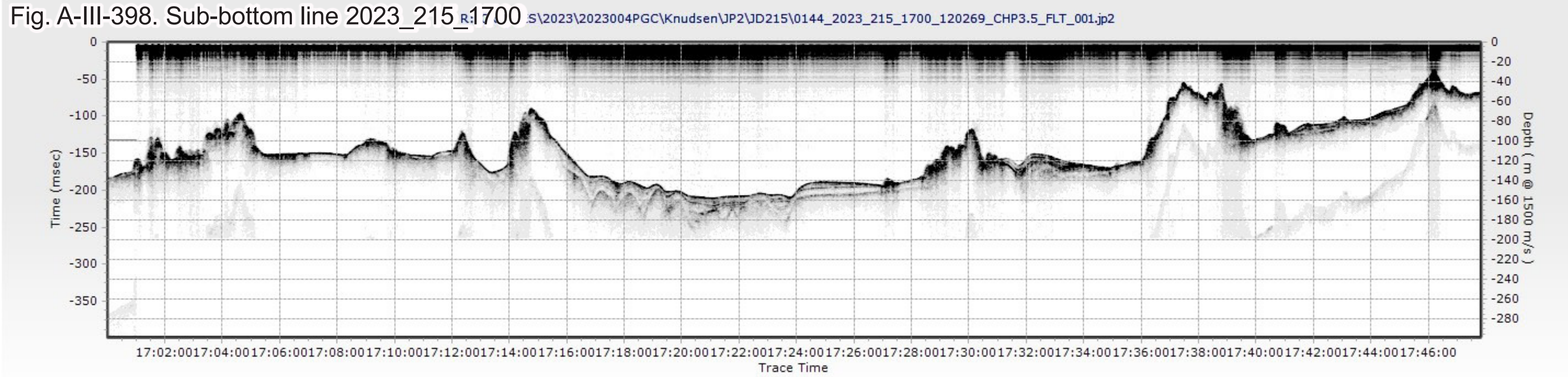

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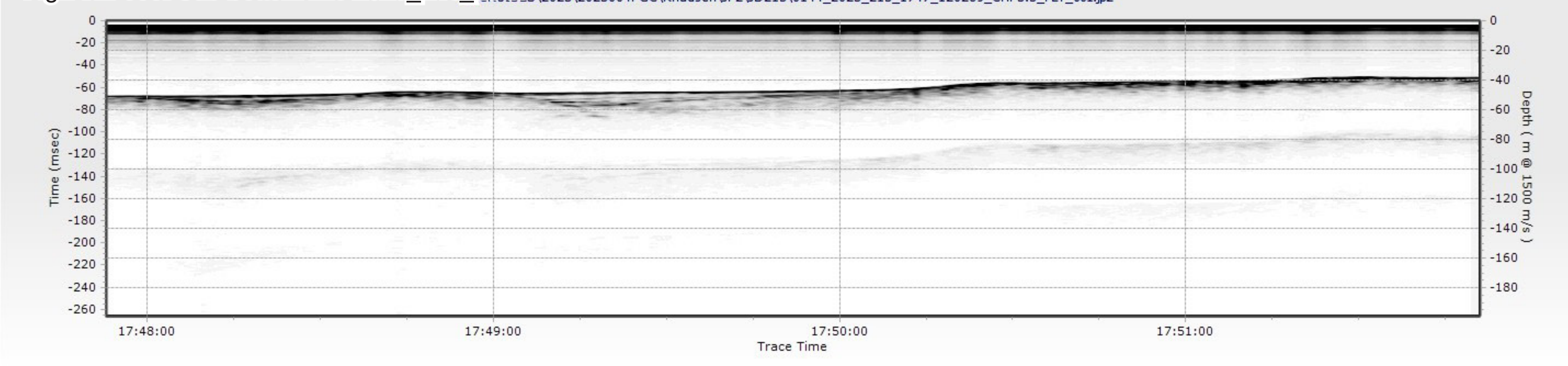


Fig. A-III-400a. Sub-bottom line 2023_216_0142

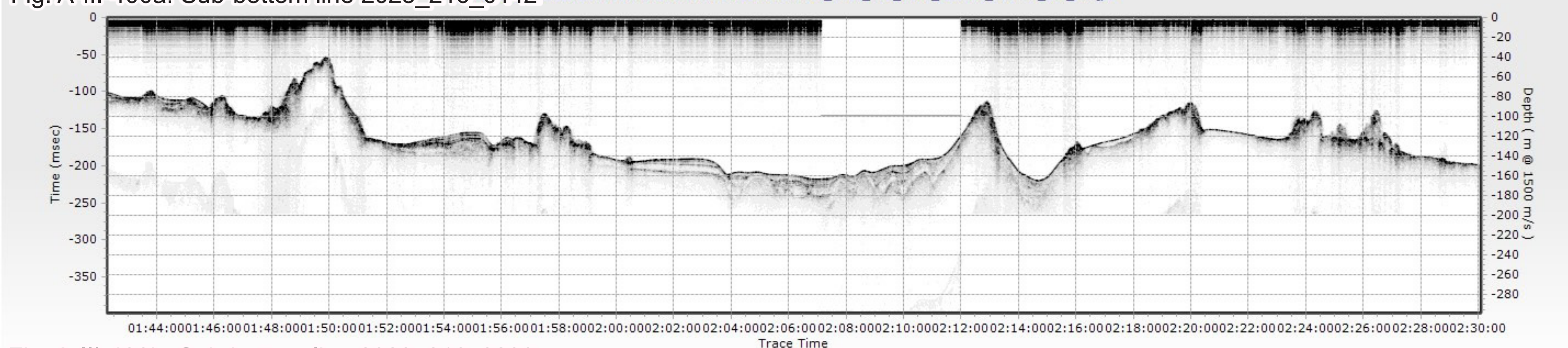


Fig. A-III-400b. Sub-bottom line 2023_216_0230

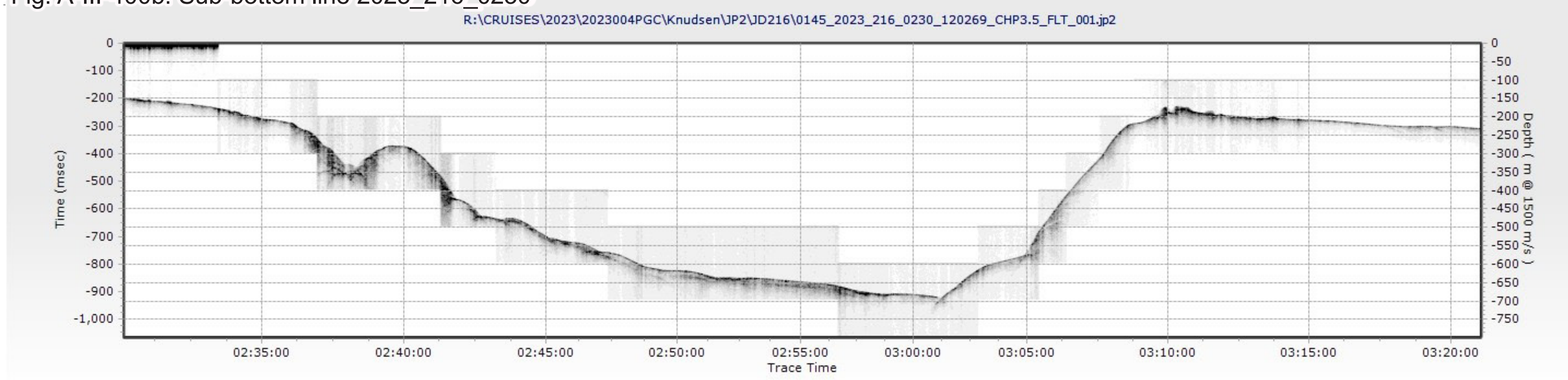


Fig. A-III-401. Sub-bottom line 2023_216_0321

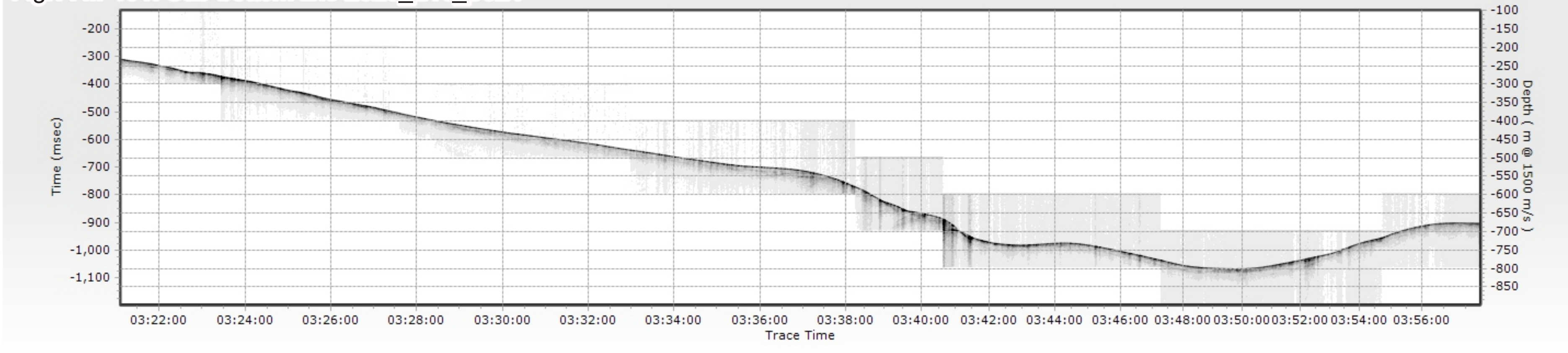


Fig. A-III-402. Sub-bottom line 2023_216_0507

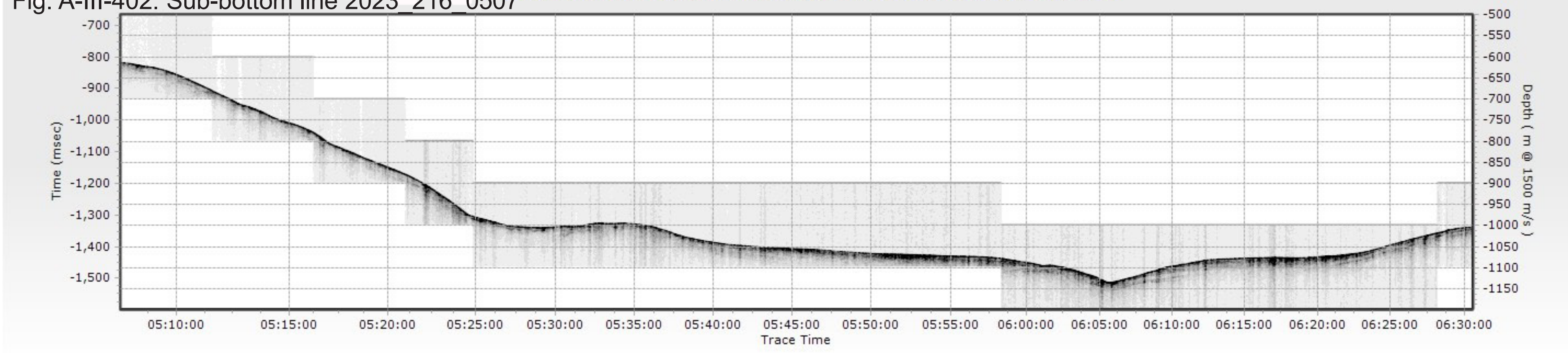


Fig. A-III-403. Sub-bottom line 2023_216_0630

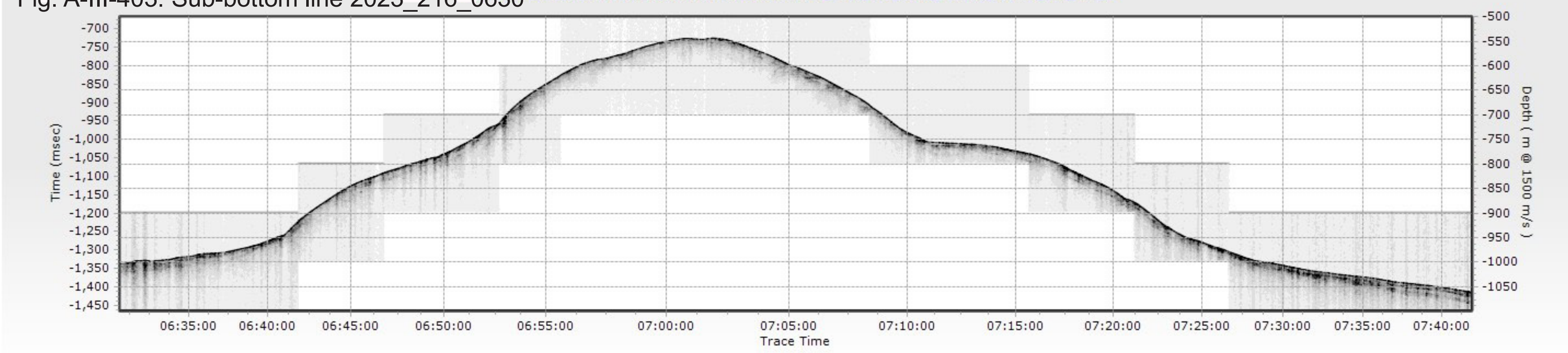


Fig. A-III-404. Sub-bottom line 2023_216_0741

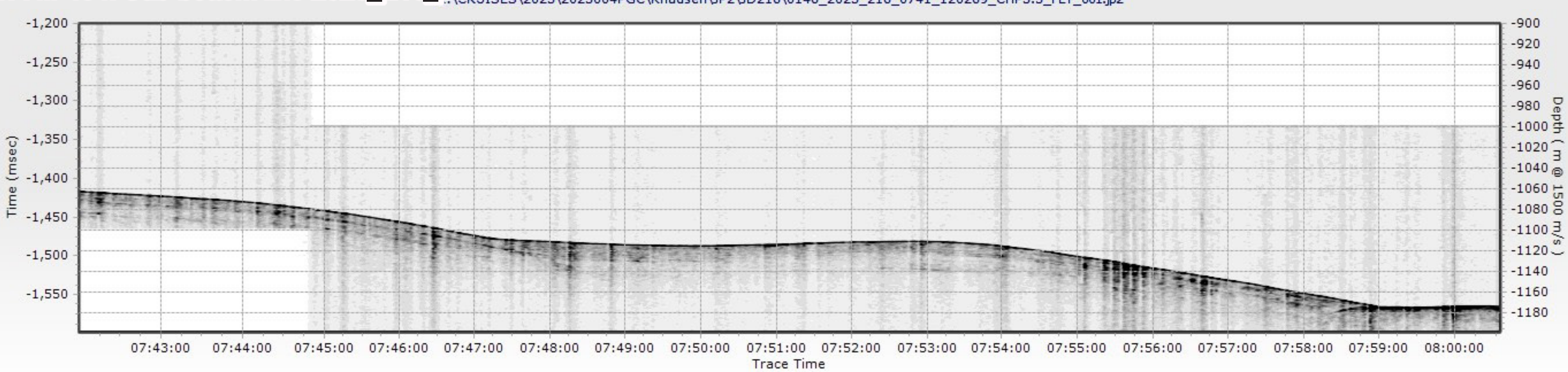


Fig. A-III-405. Sub-bottom line 2023_216_0800

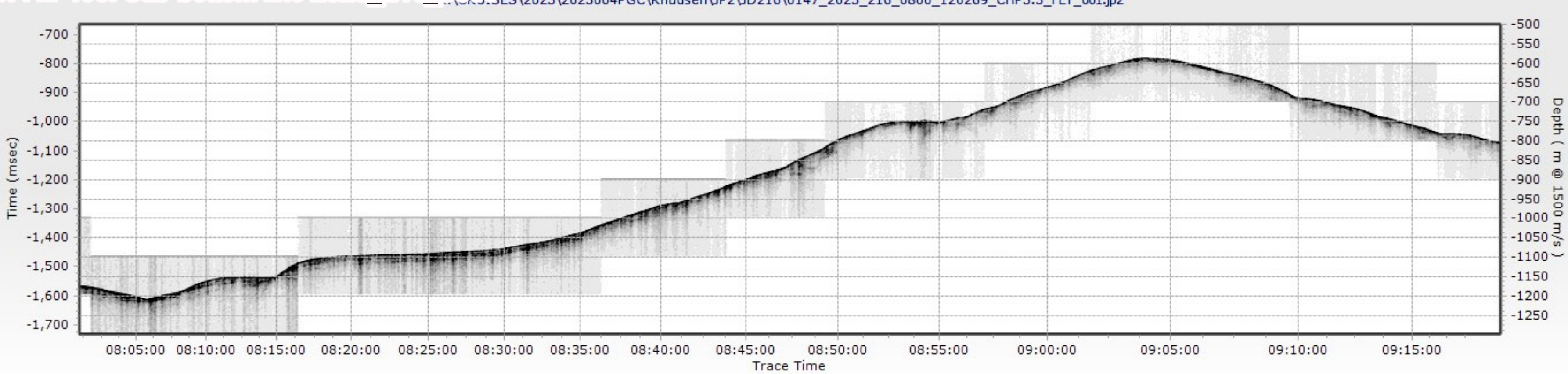


Fig. A-III-406. Sub-bottom line 2023_216_0919

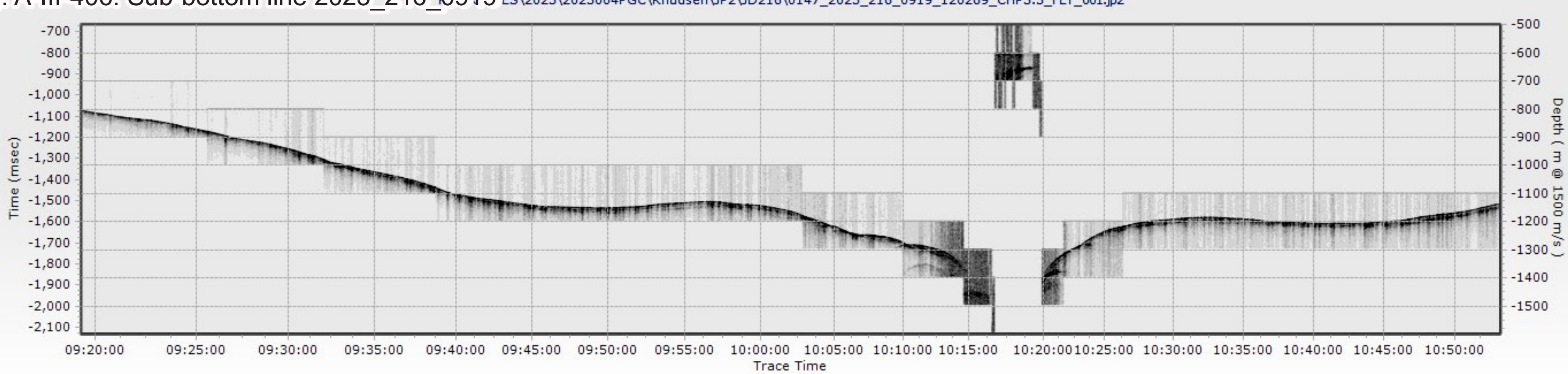


Fig. A-III-407. Sub-bottom line 2023__216_1100

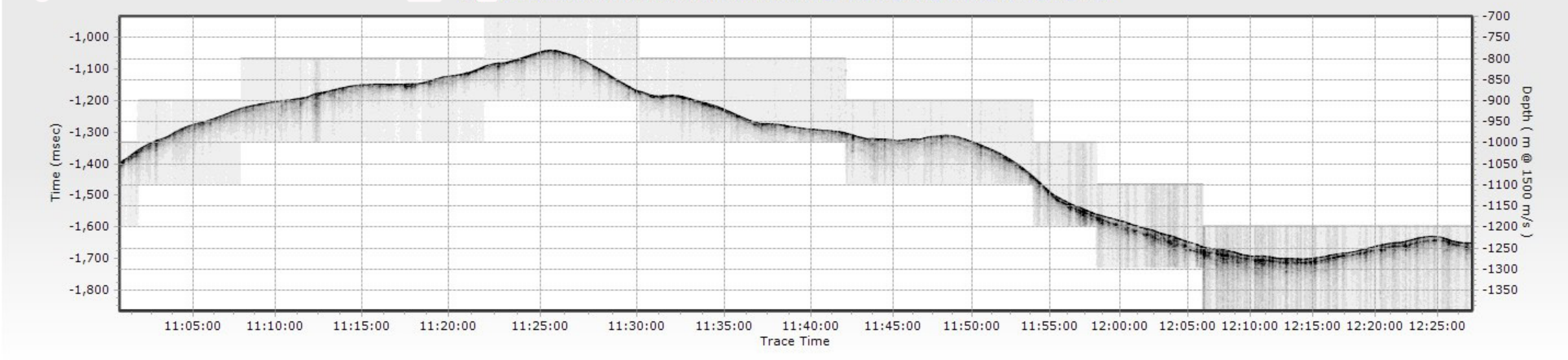


Fig. A-III-408. Sub-bottom line 2023_216_1227

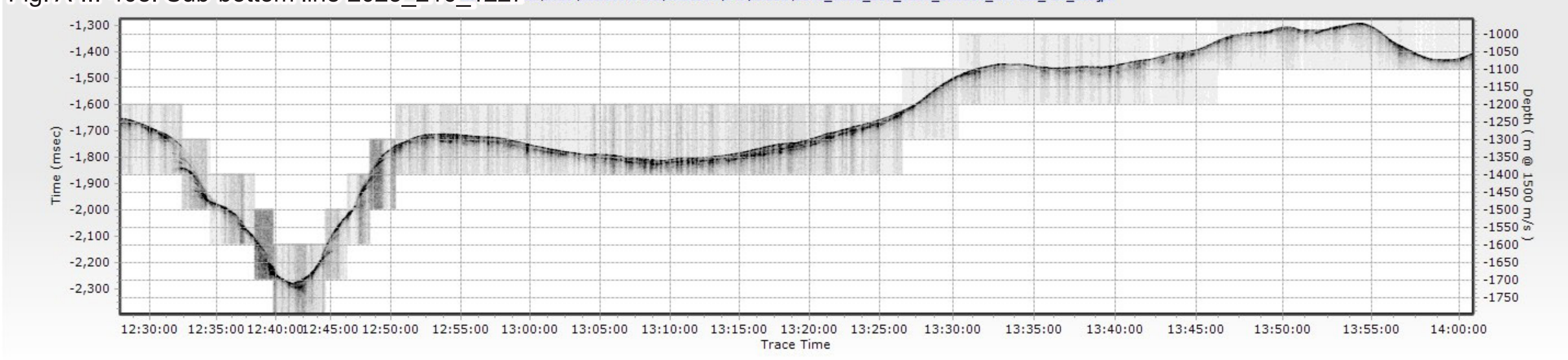


Fig. A-III-409. Sub-bottom line 2023_216_1557

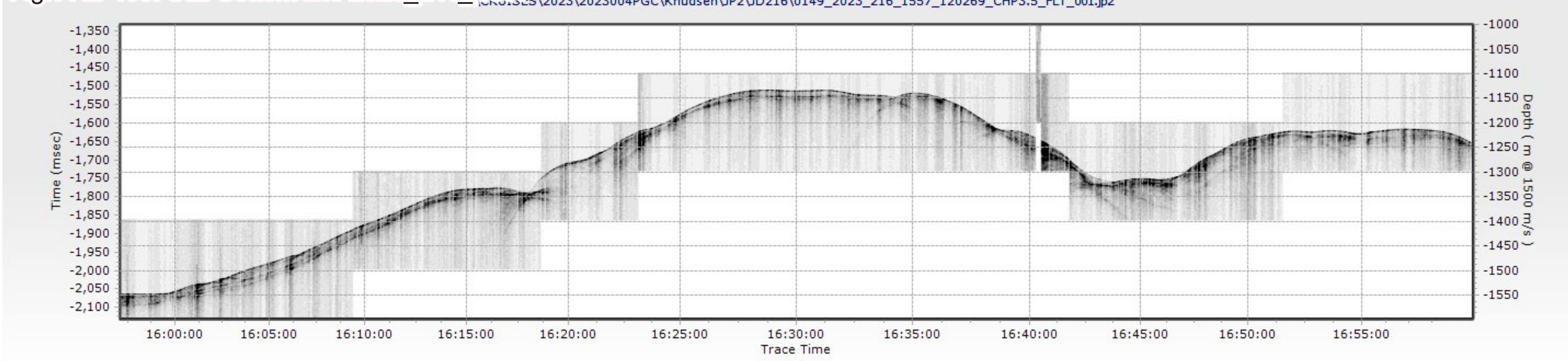


Fig. A-III-410. Sub-bottom line 2023_216_1659

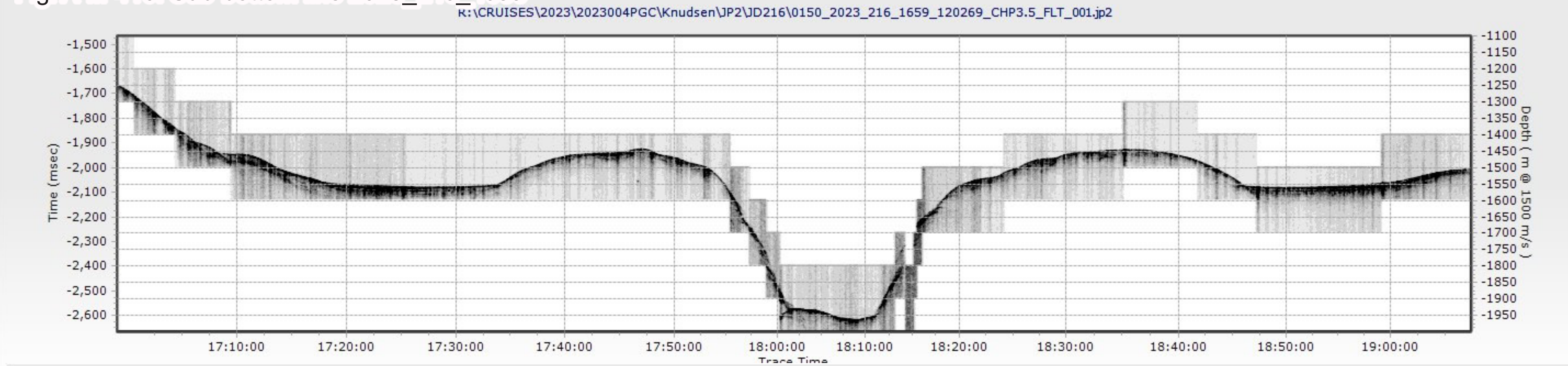


Fig. A-III-411. Sub-bottom line 2023_216_1907

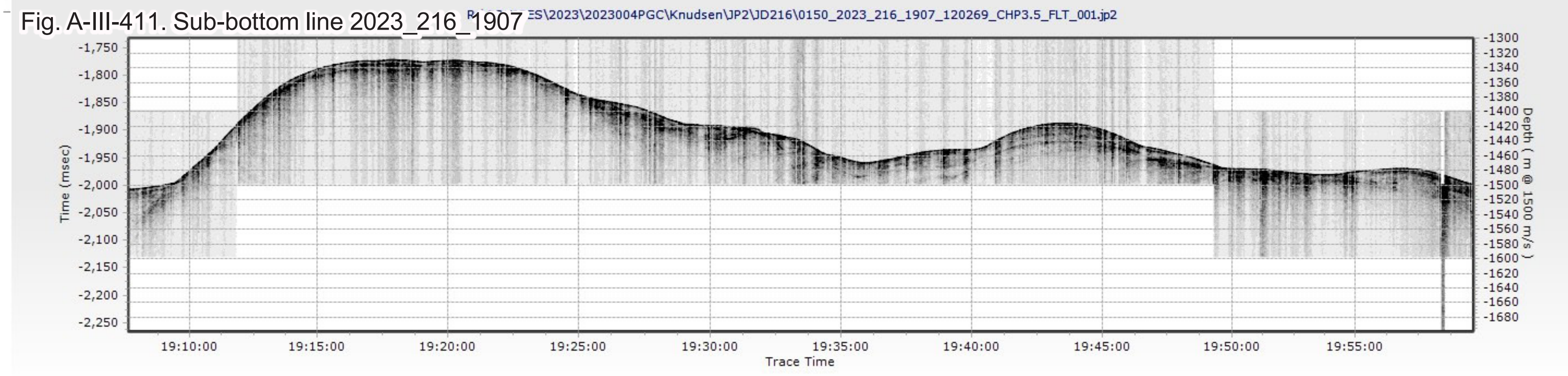


Fig. A-III-412. Sub-bottom line 2023_216_2000

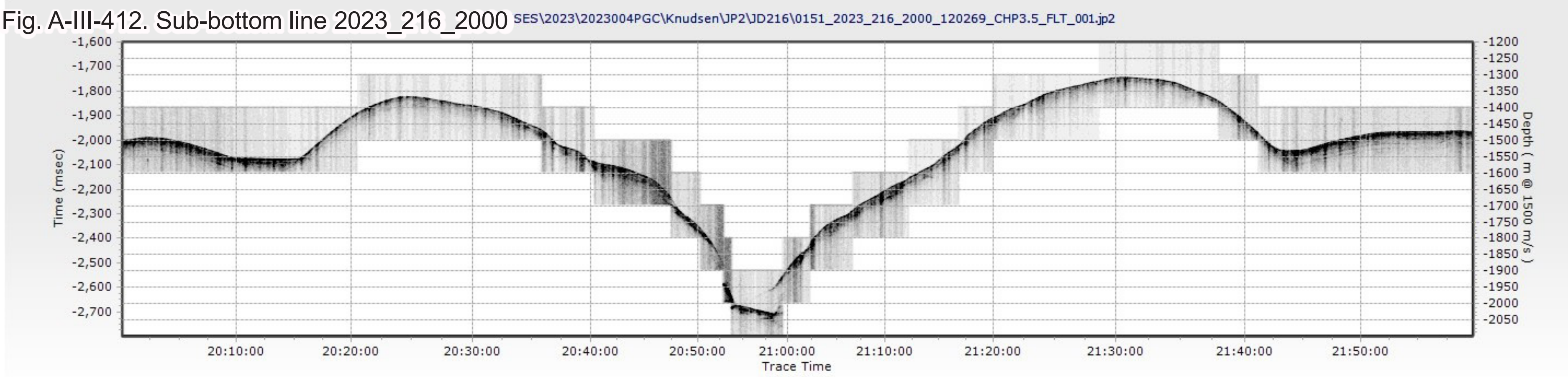


Fig. A-III-413. Sub-bottom line 2023_217_0001

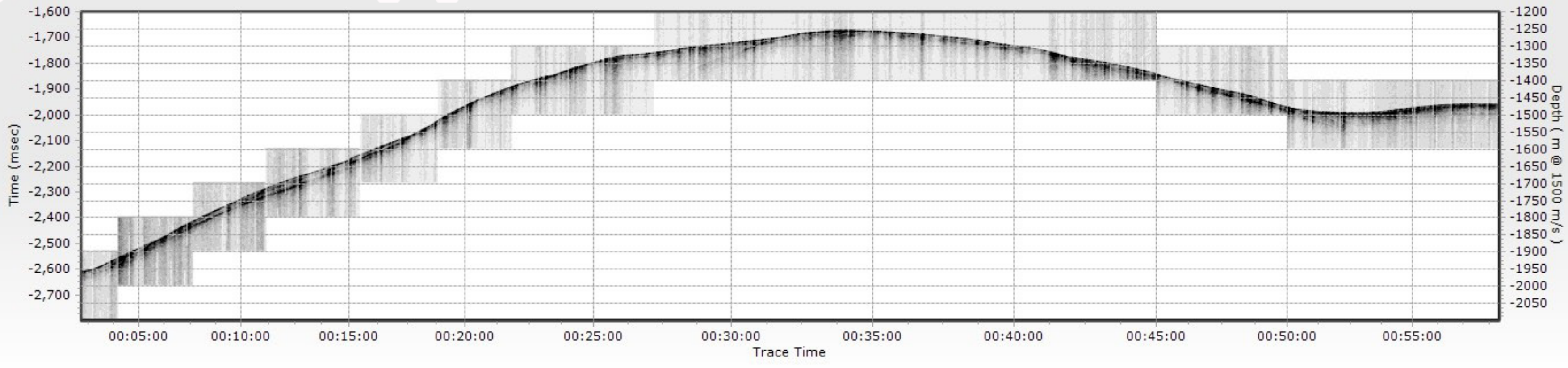


Fig. A-III-414. Sub-bottom line 2023_217_0237

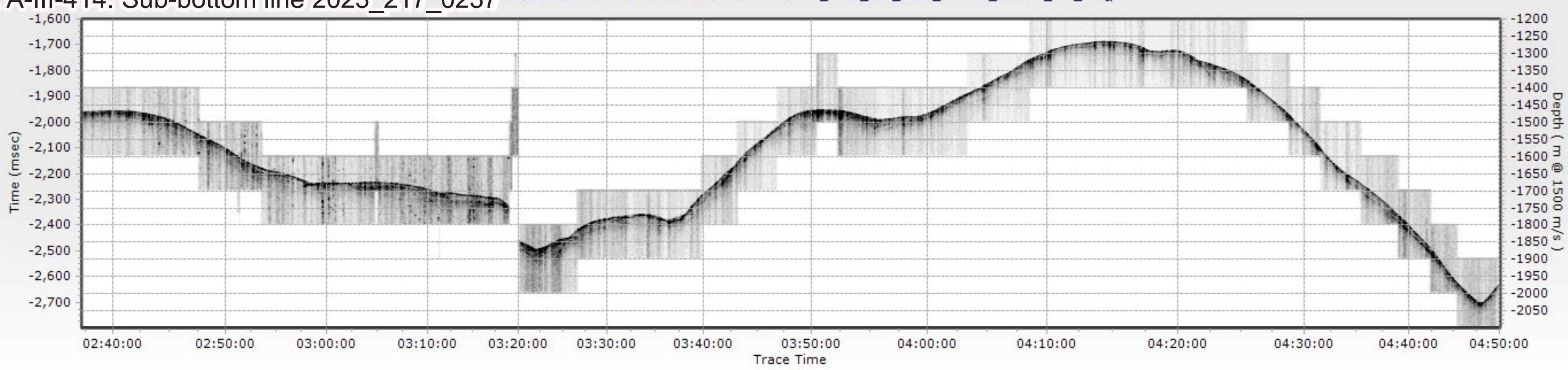


Fig. A-III-415. Sub-bottom line 2023_217_0800

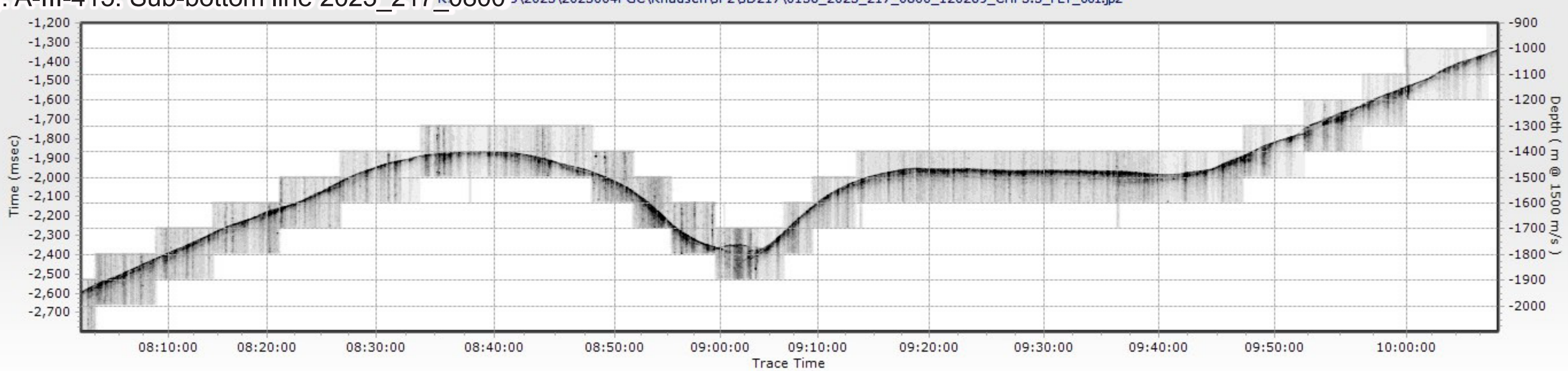


Fig. A-III-416. Sub-bottom line 2023_217_0450

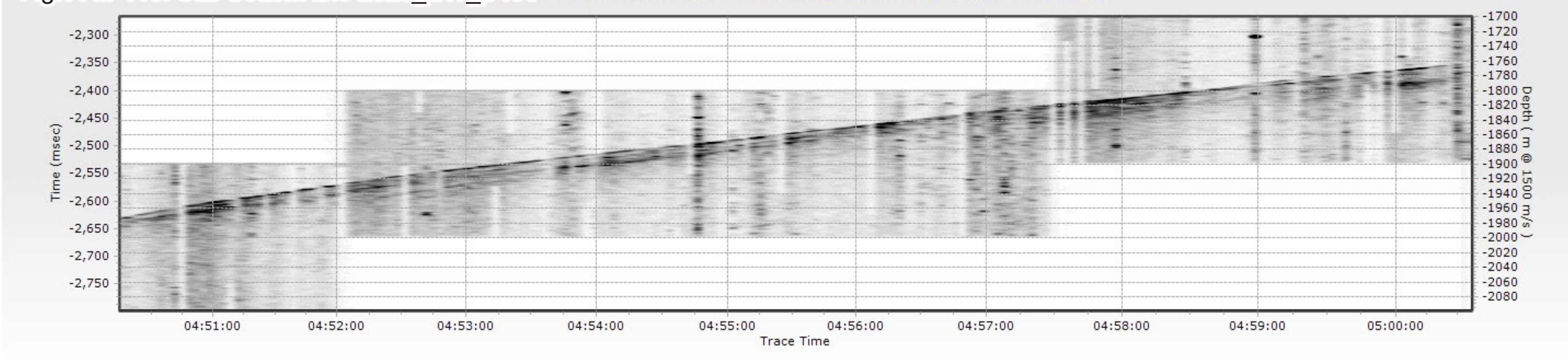


Fig. A-III-417. Sub-bottom line 2023_217_0501

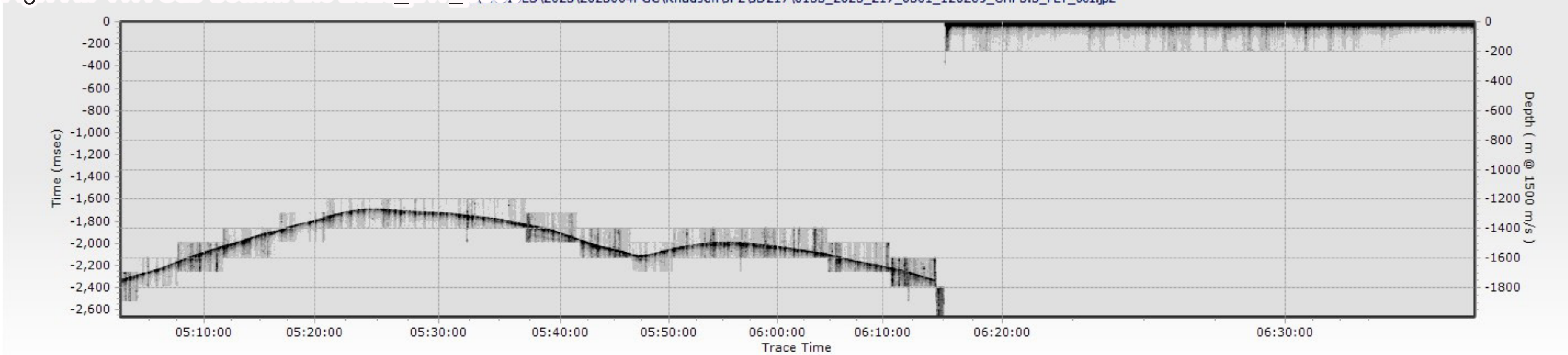


Fig. A-III-418. Sub-bottom line 2023_217_0800

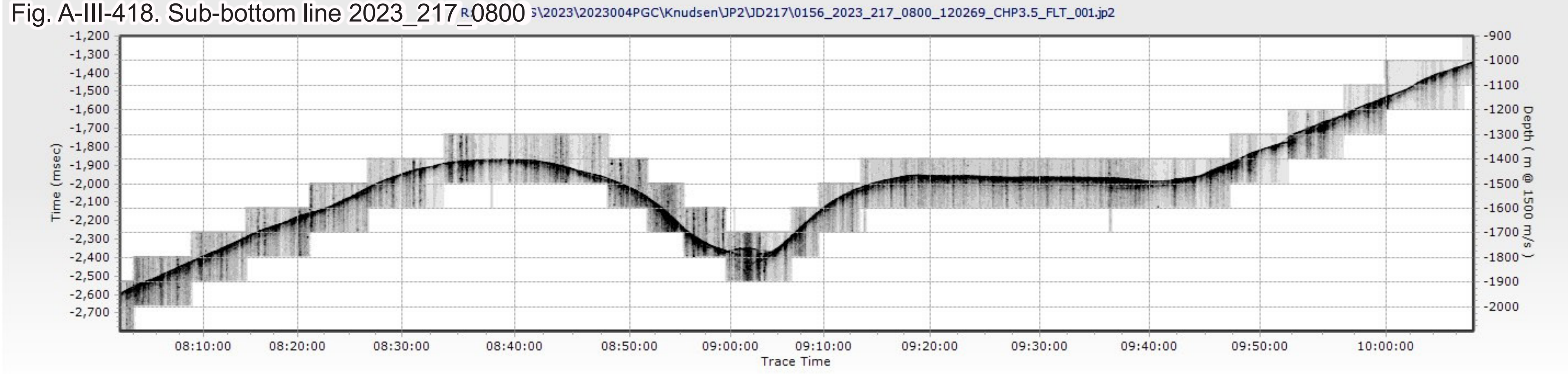


Fig. A-III-419. Sub-bottom line 2023_217_1006

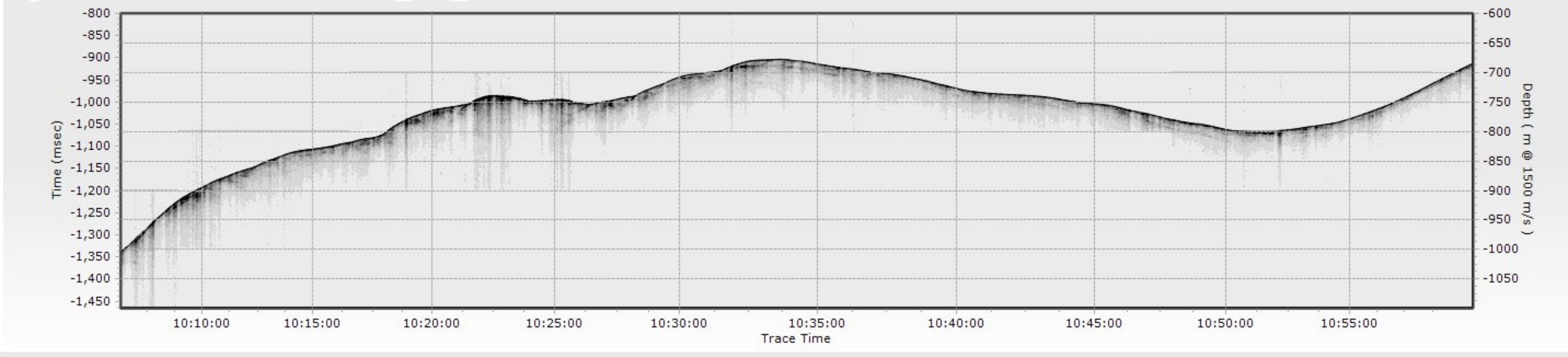


Fig. A-III-420. Sub-bottom line 2023_217_1100

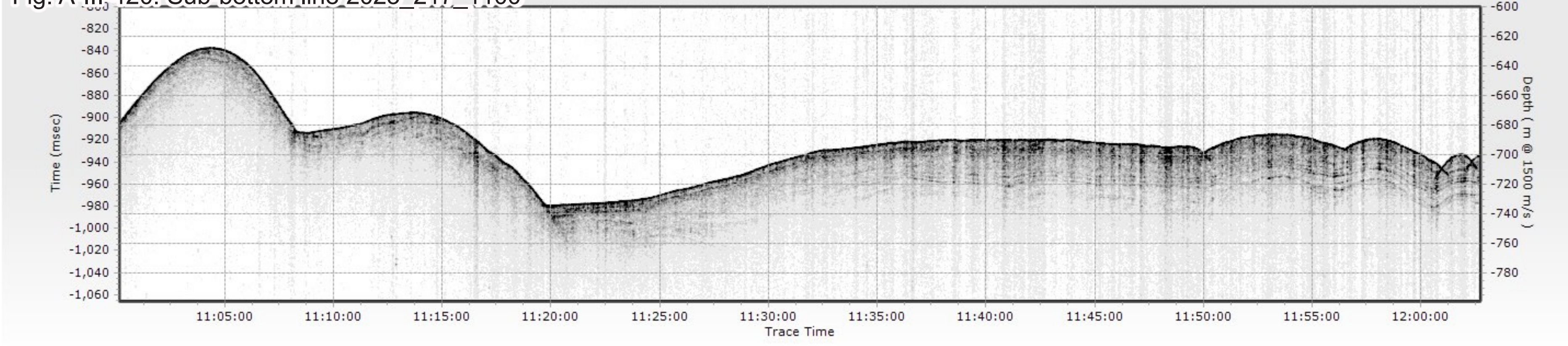


Fig. A-III-421. Sub-bottom line 2023_217_1202

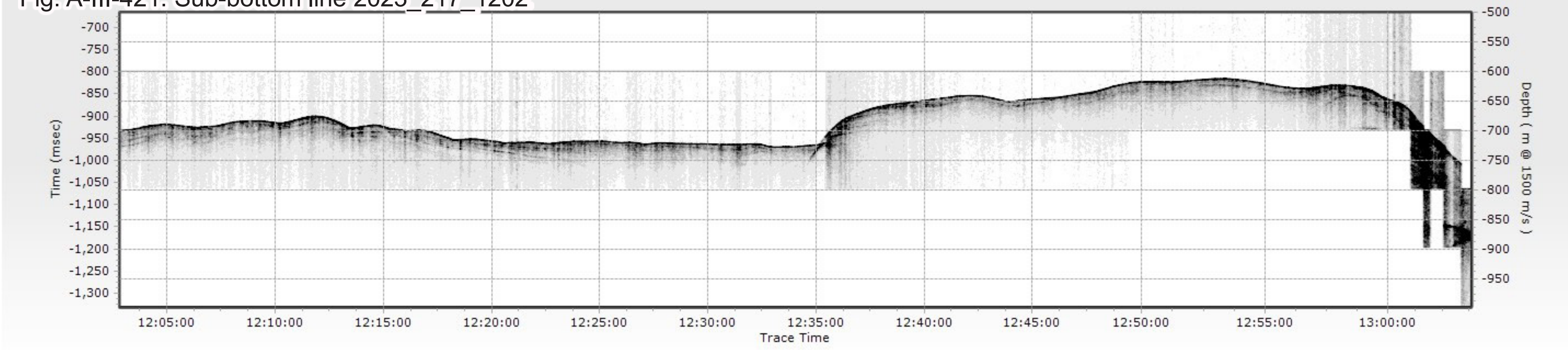


Fig. A-III-422. Sub-bottom line 2023_217_1304

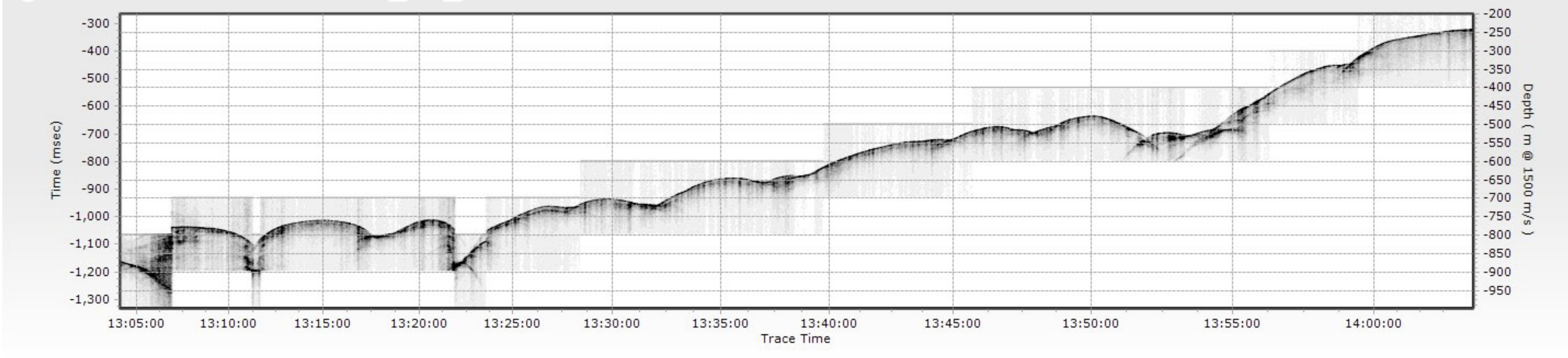


Fig. A-III-423. Sub-bottom line 2023_217_1403

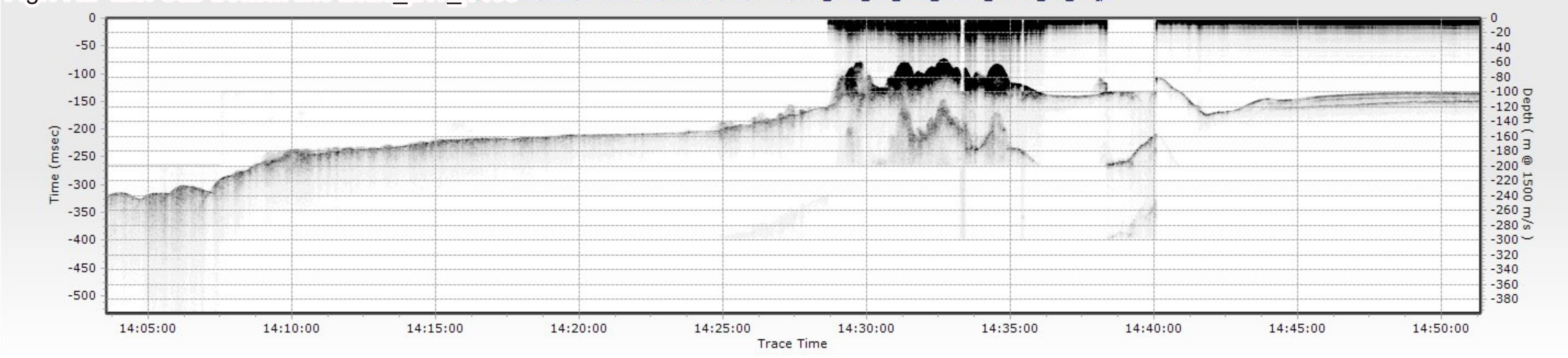


Fig. A-III-424. Sub-bottom line 2023_217_2219

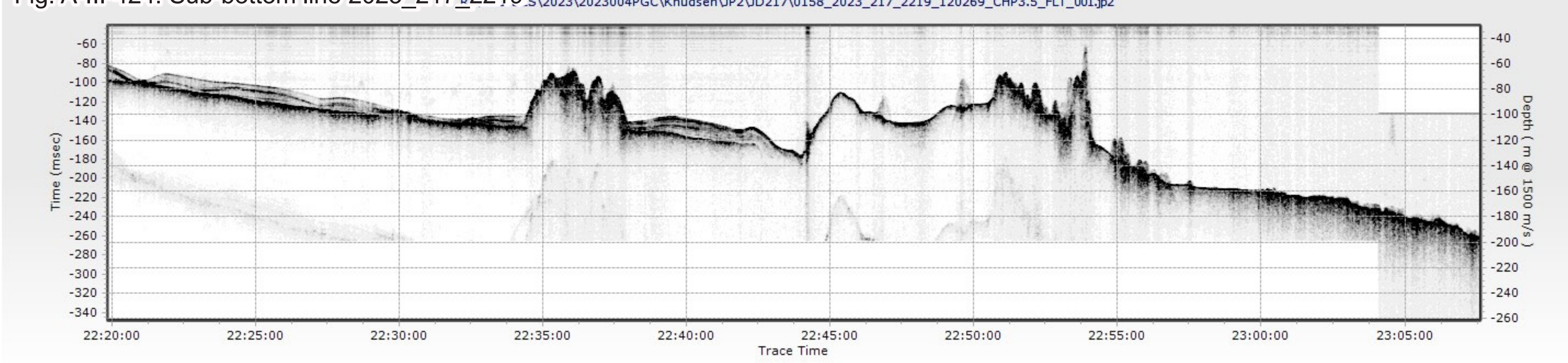


Fig. A-III-425. Sub-bottom line 2023_217_2307

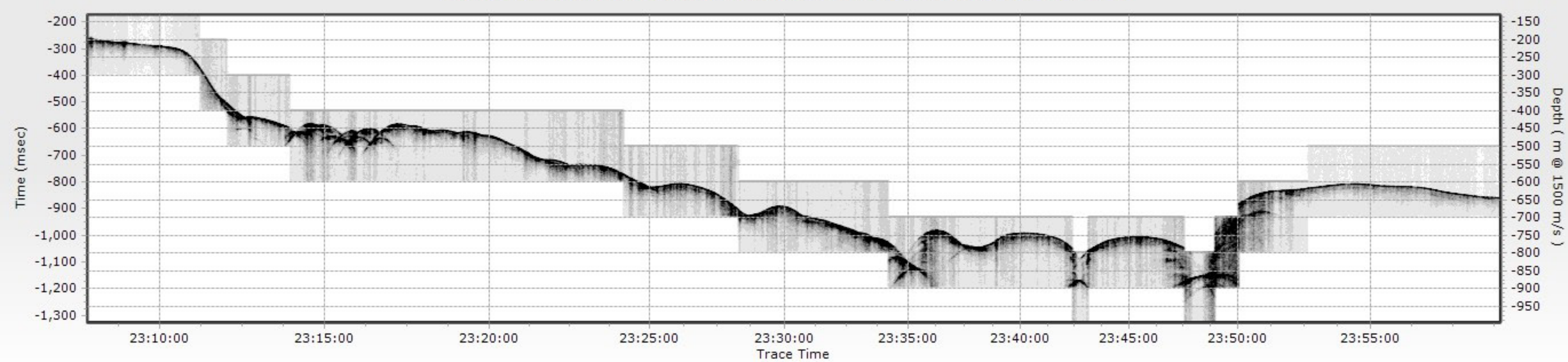


Fig. A-III-426. Sub-bottom line 2023_218_0000

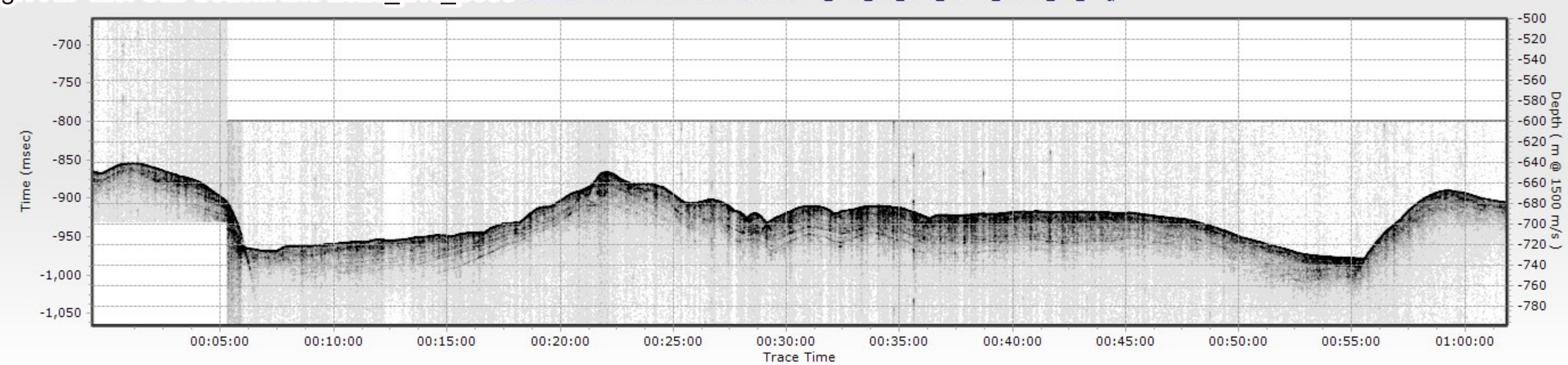
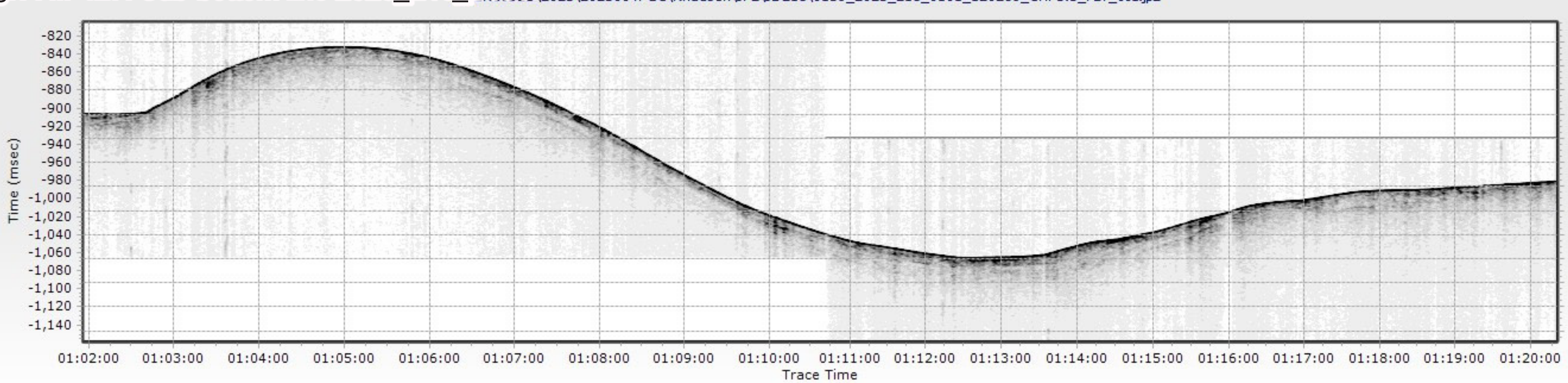


Fig. A-III-427. Sub-bottom line 2023_218_0101



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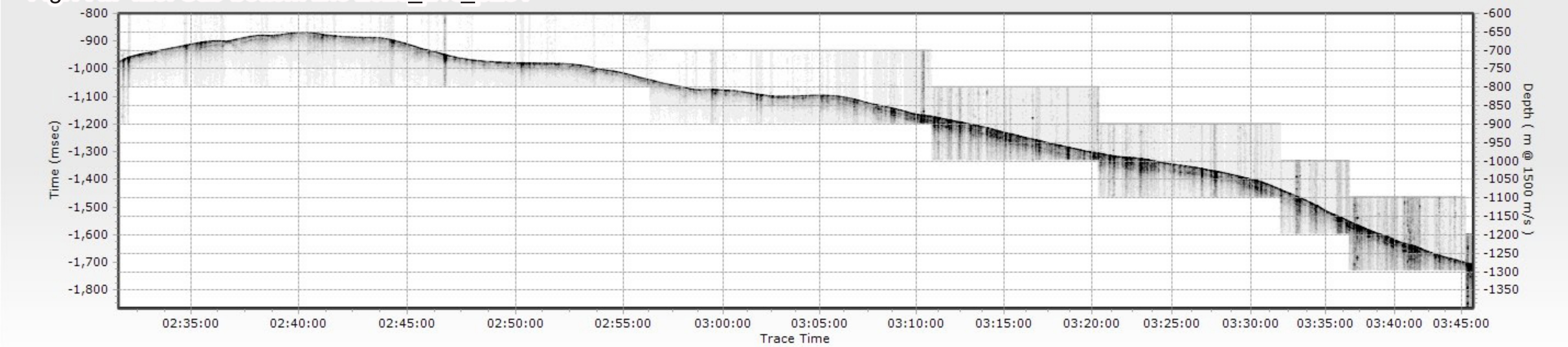

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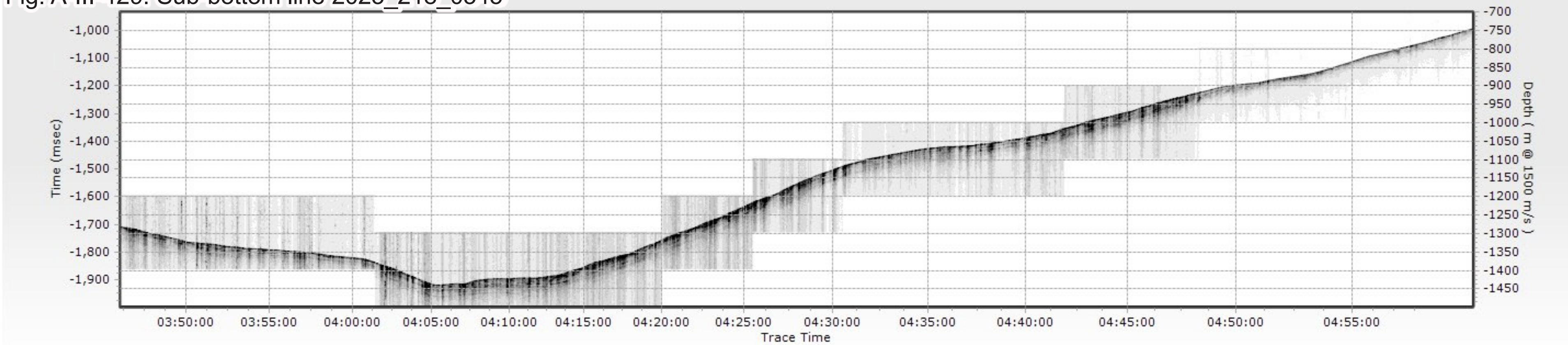

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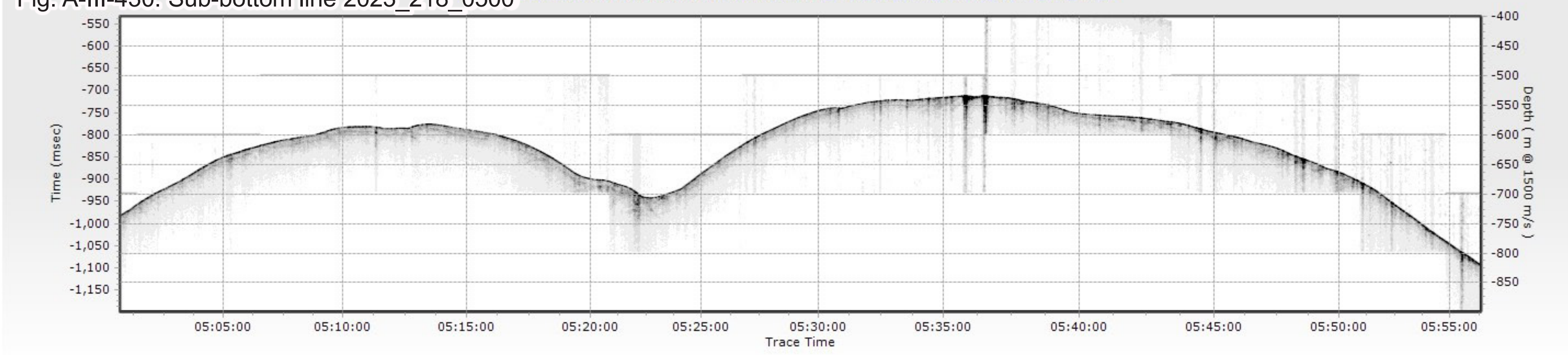

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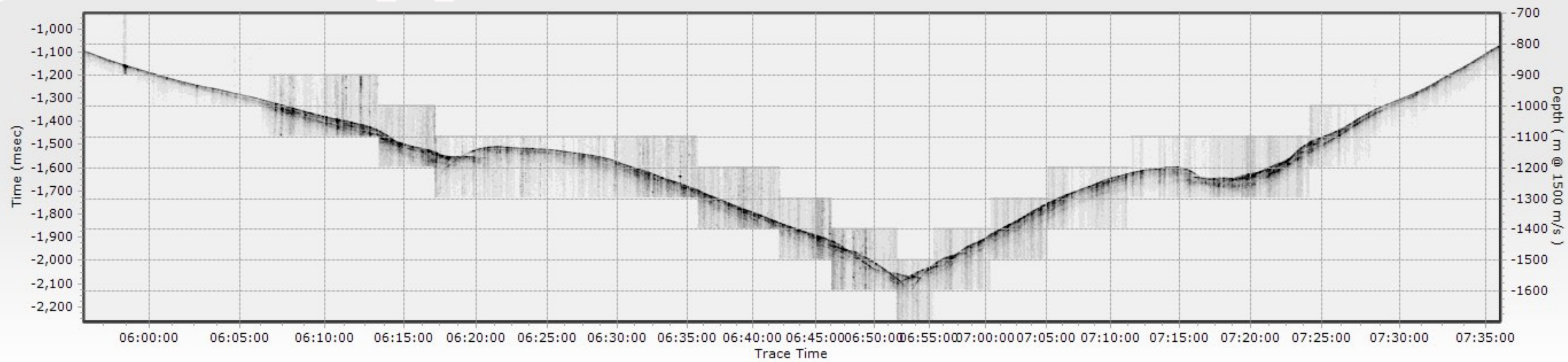

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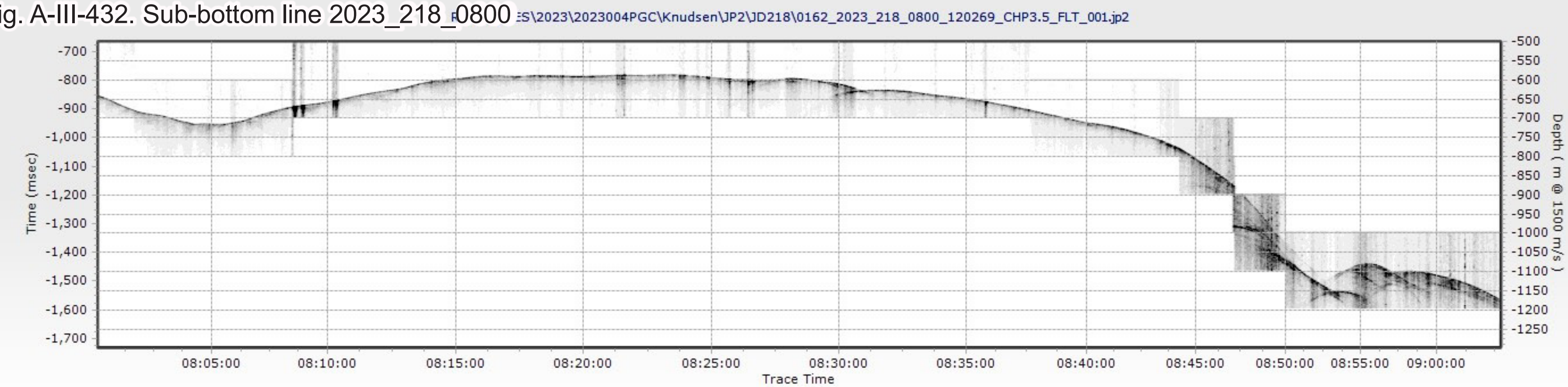

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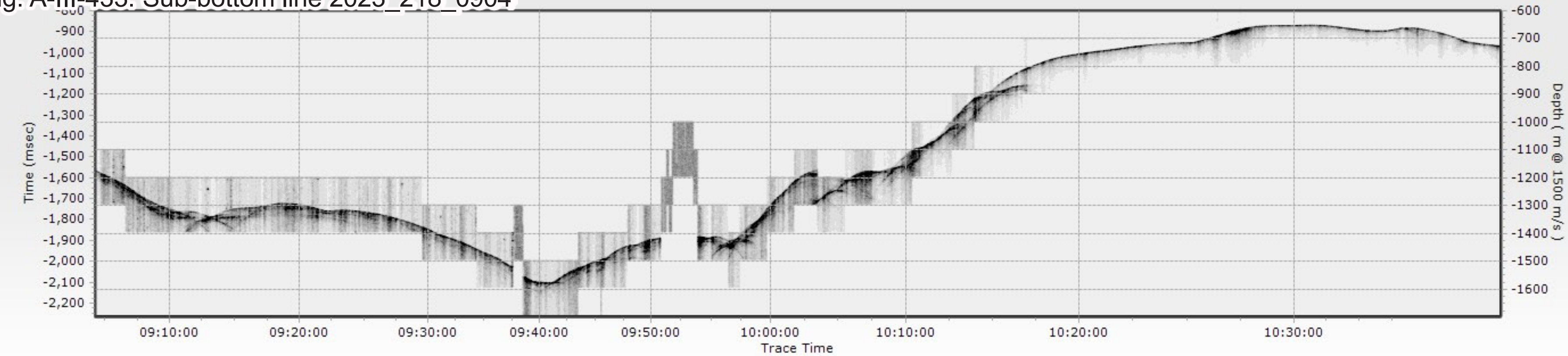
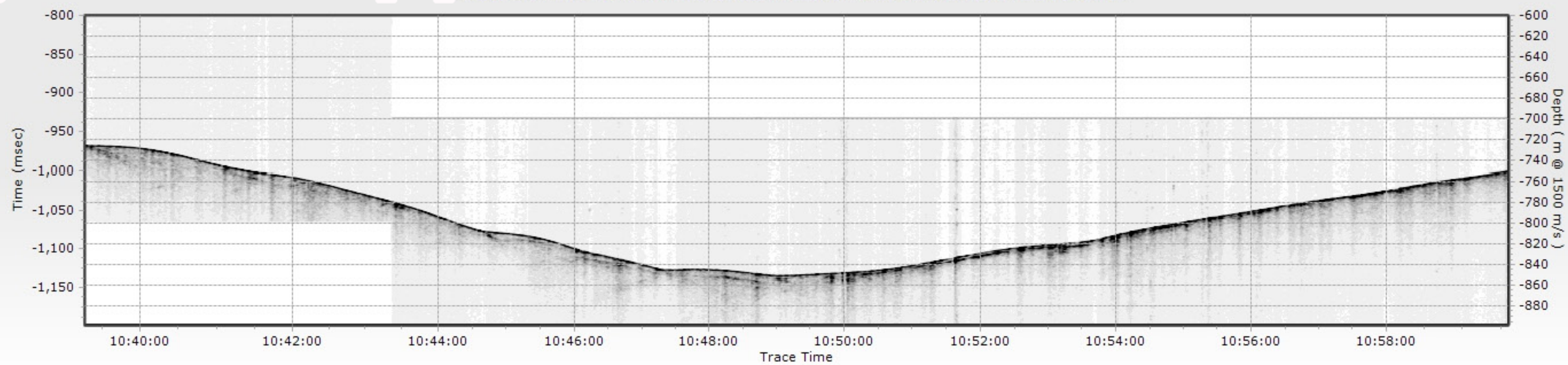


Fig. A-III-434. Sub-bottom line 2023_218_1039



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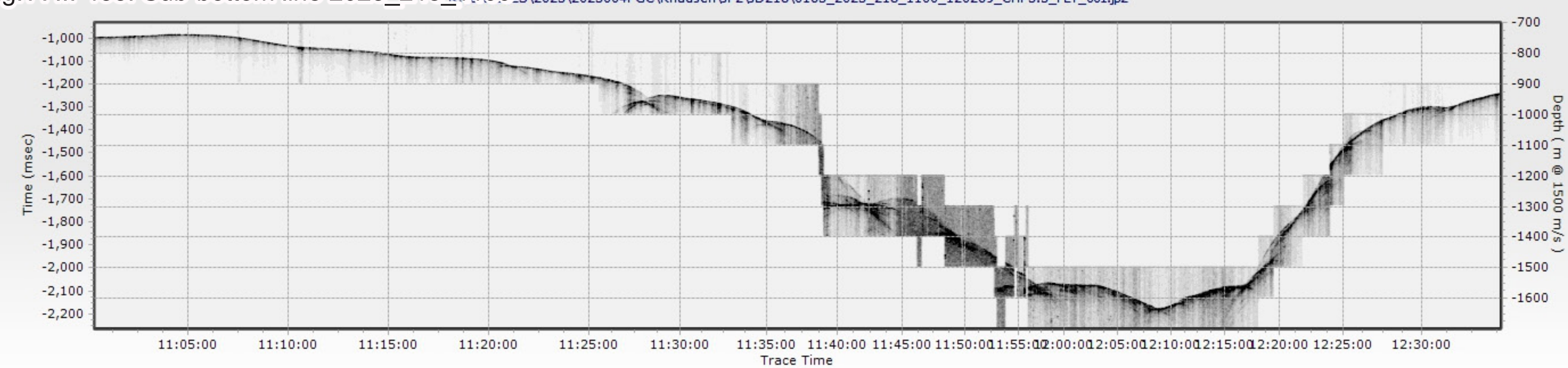

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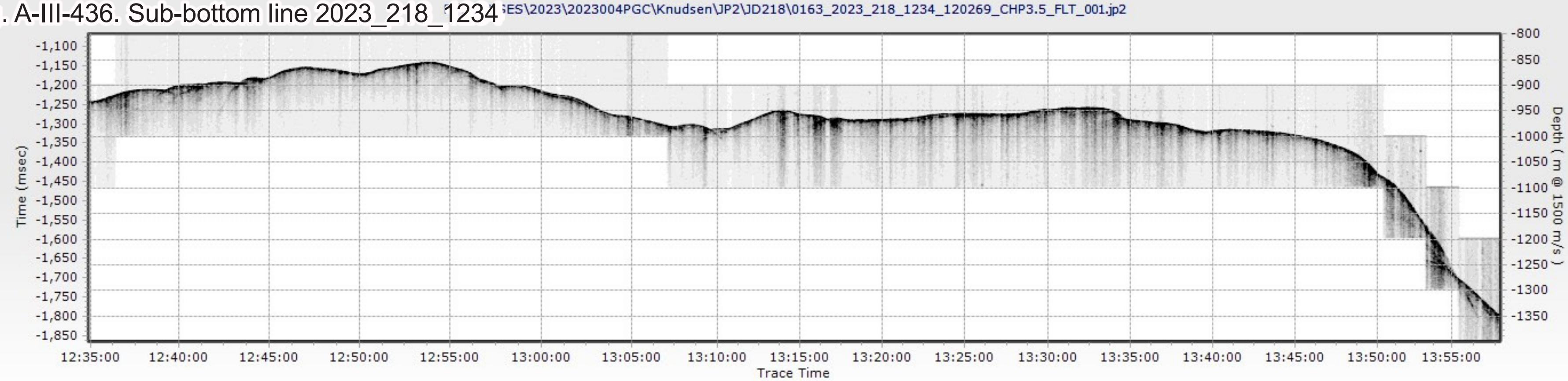

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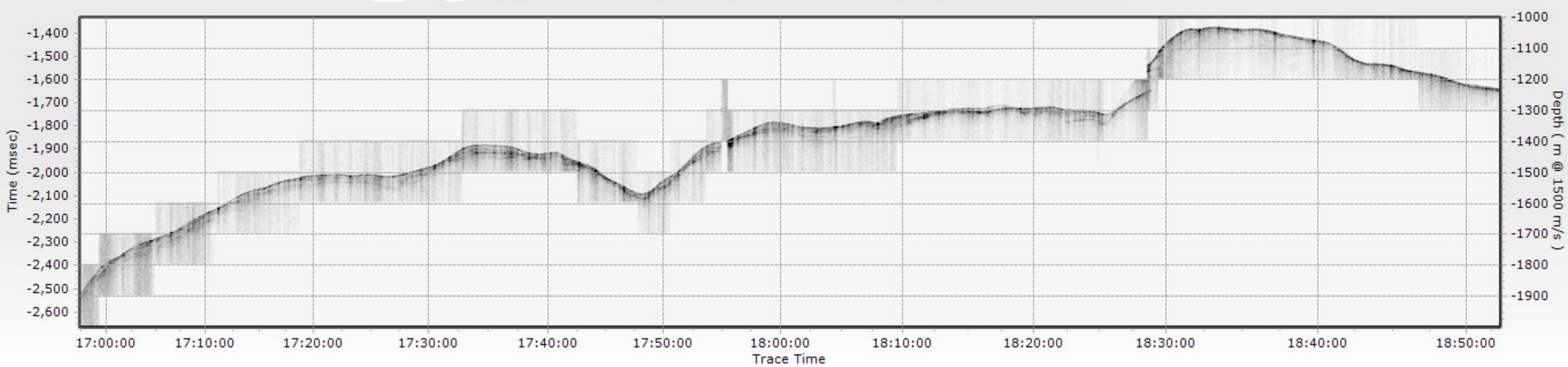

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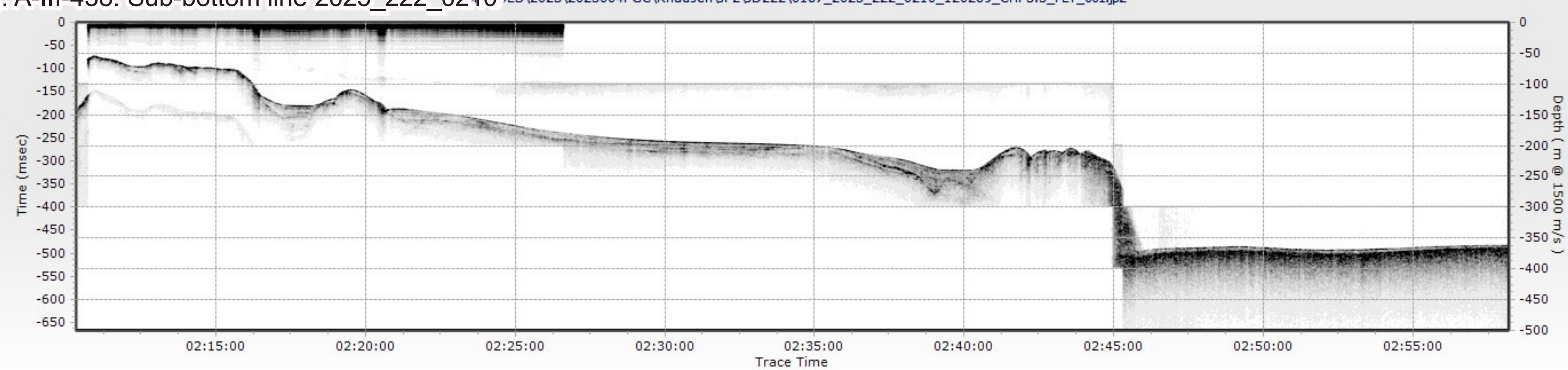

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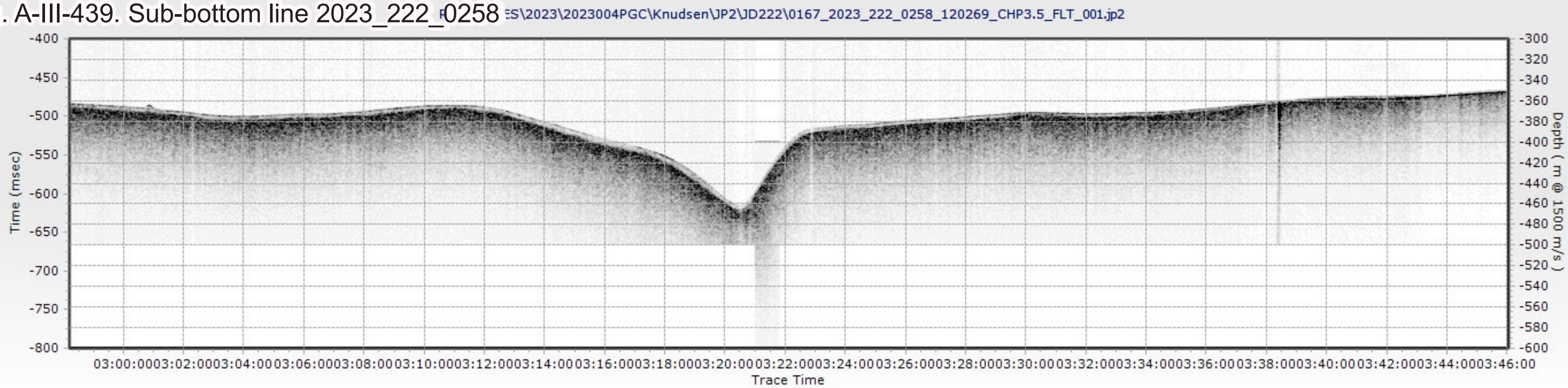

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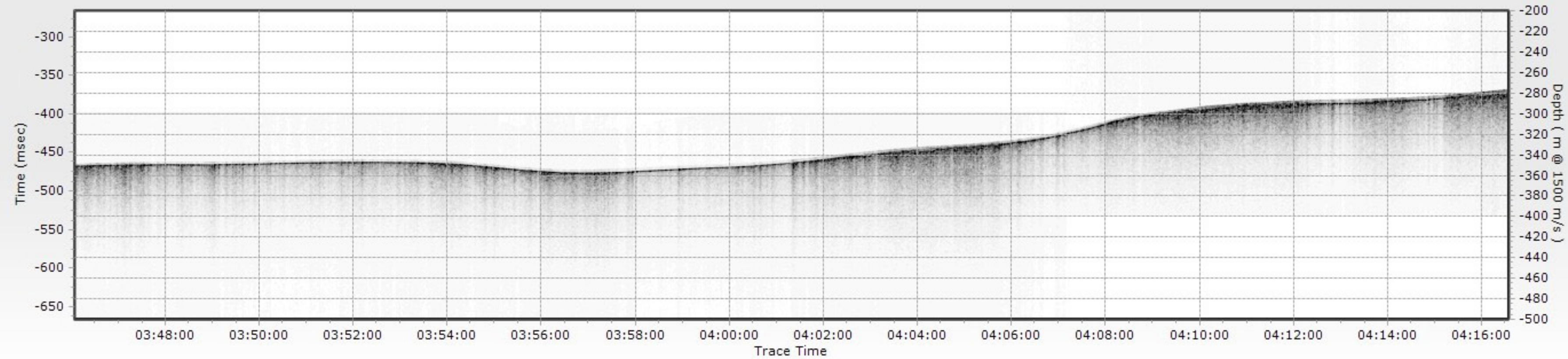

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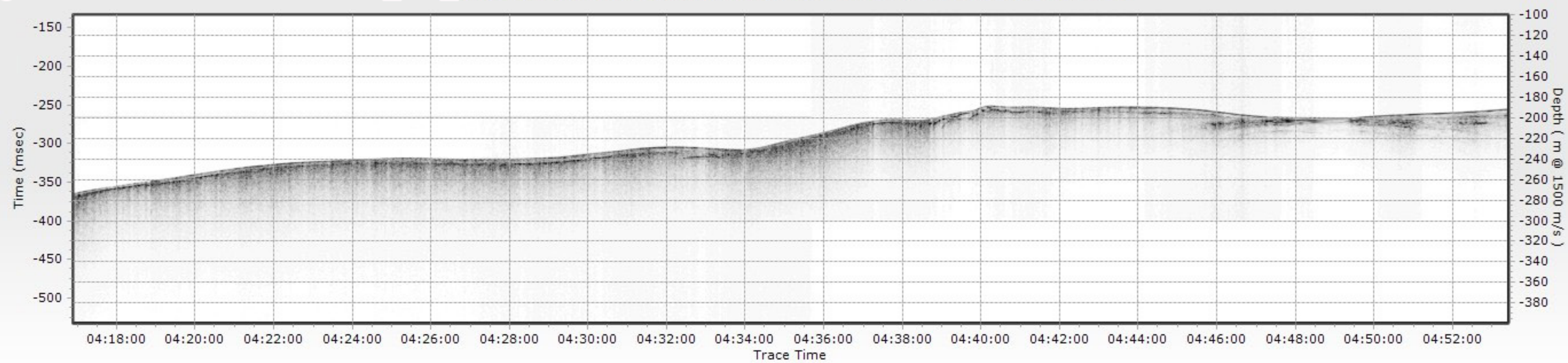

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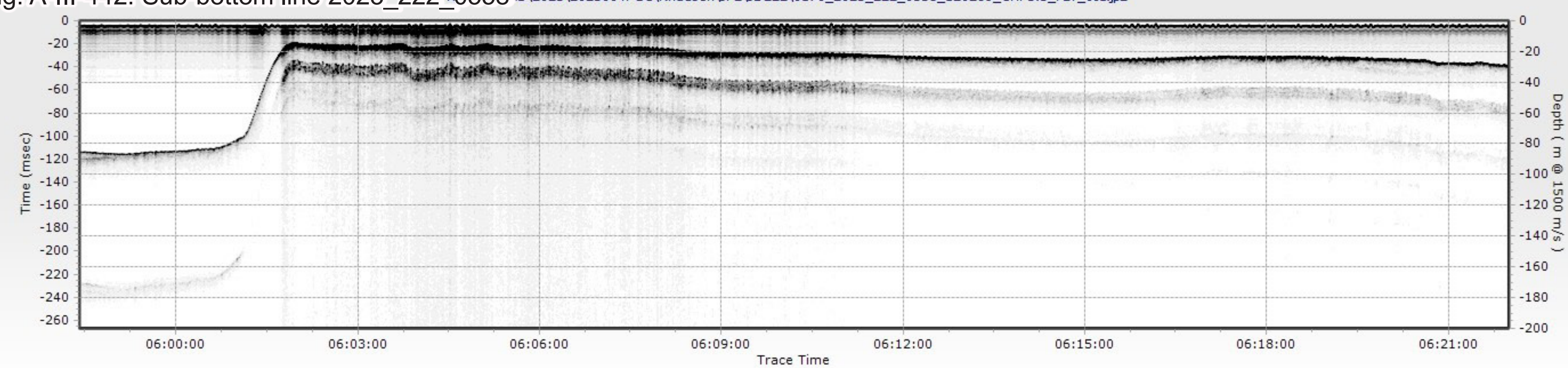

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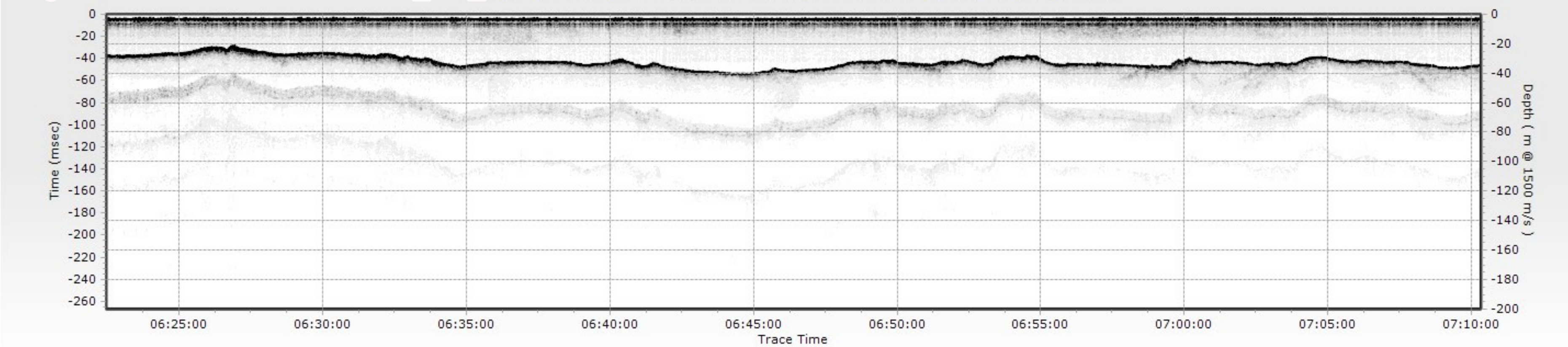

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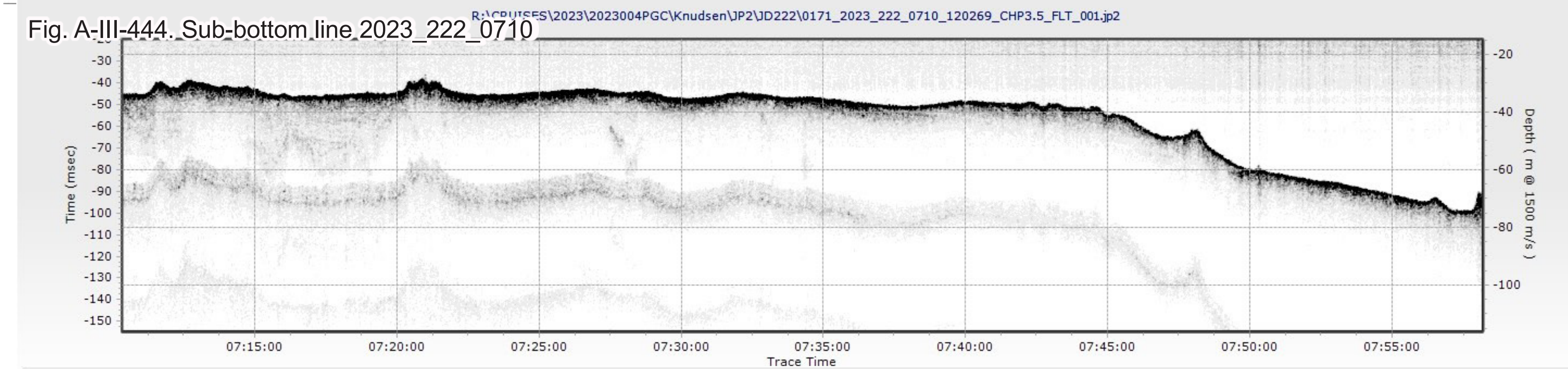

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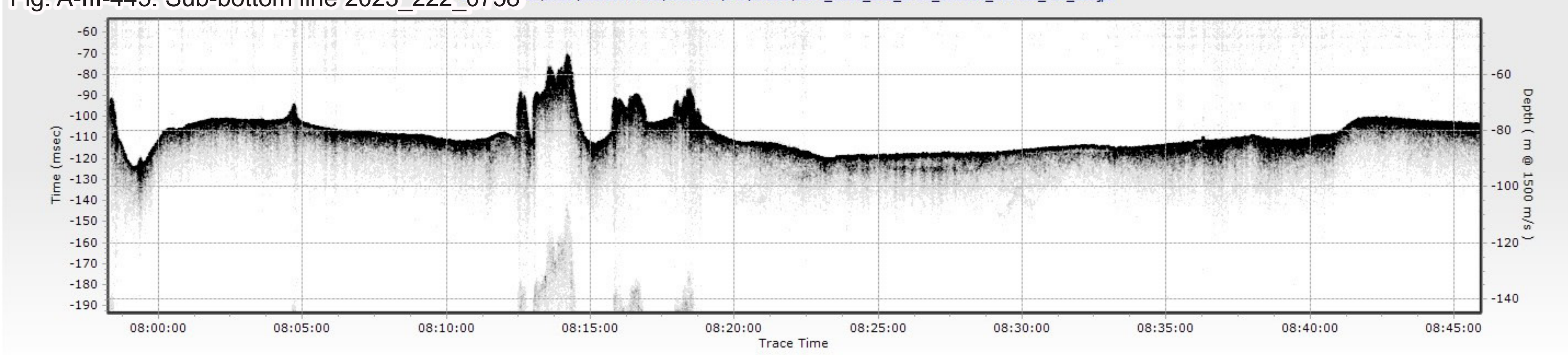

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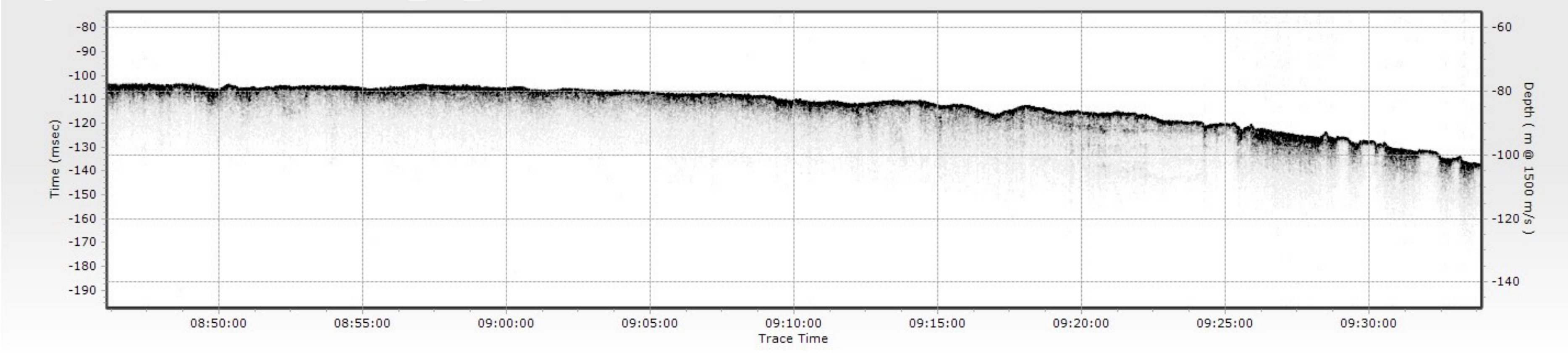

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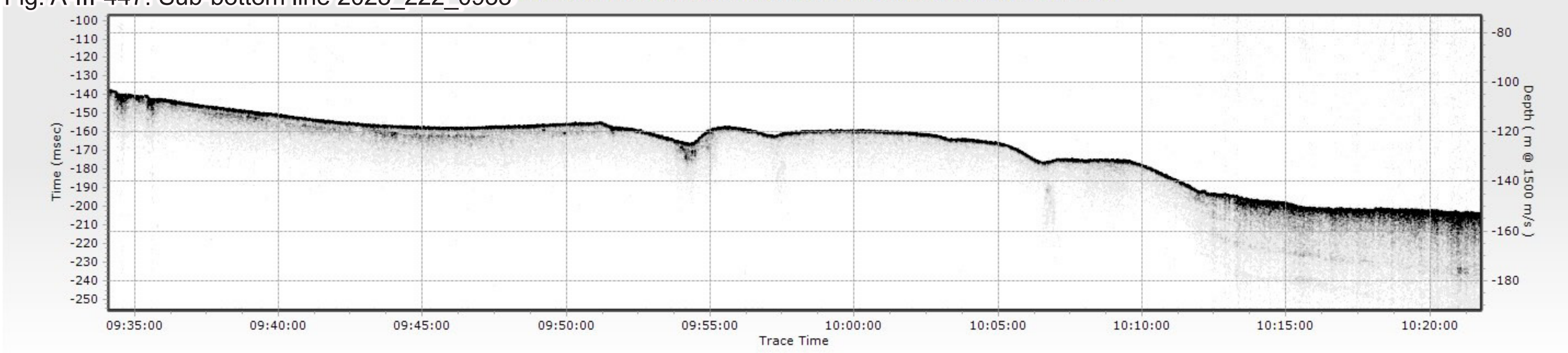

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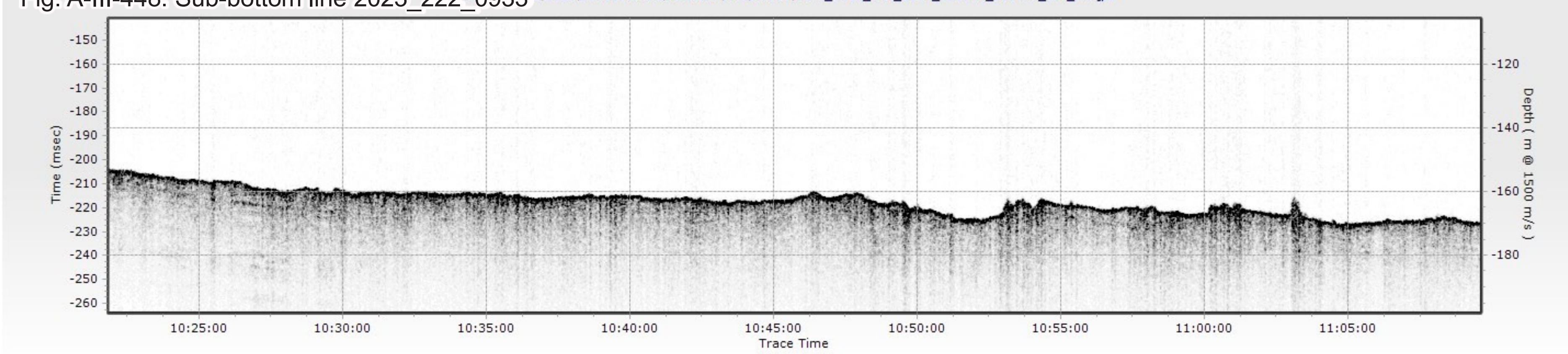

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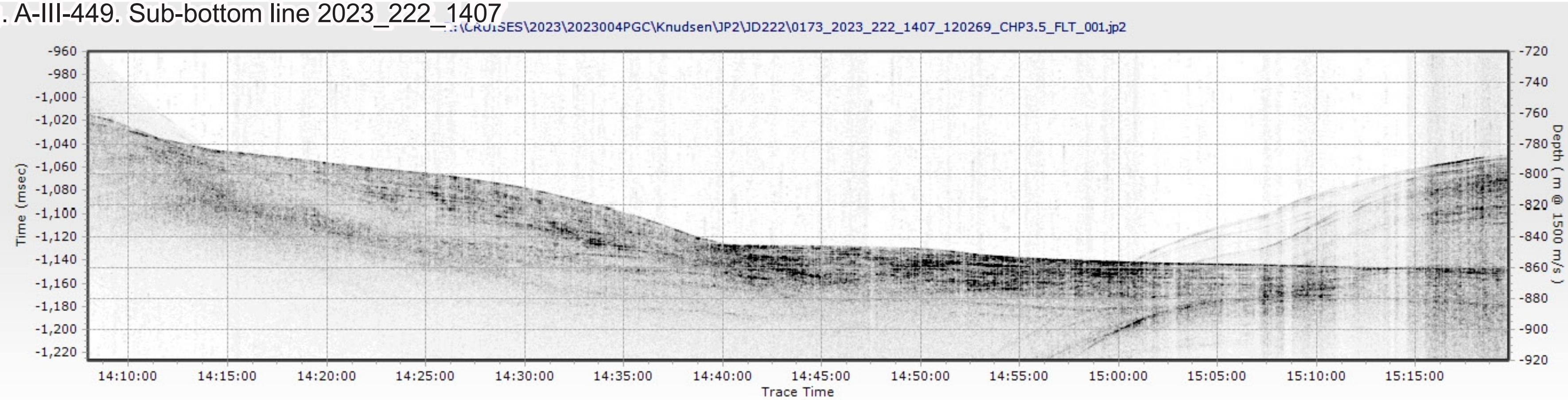

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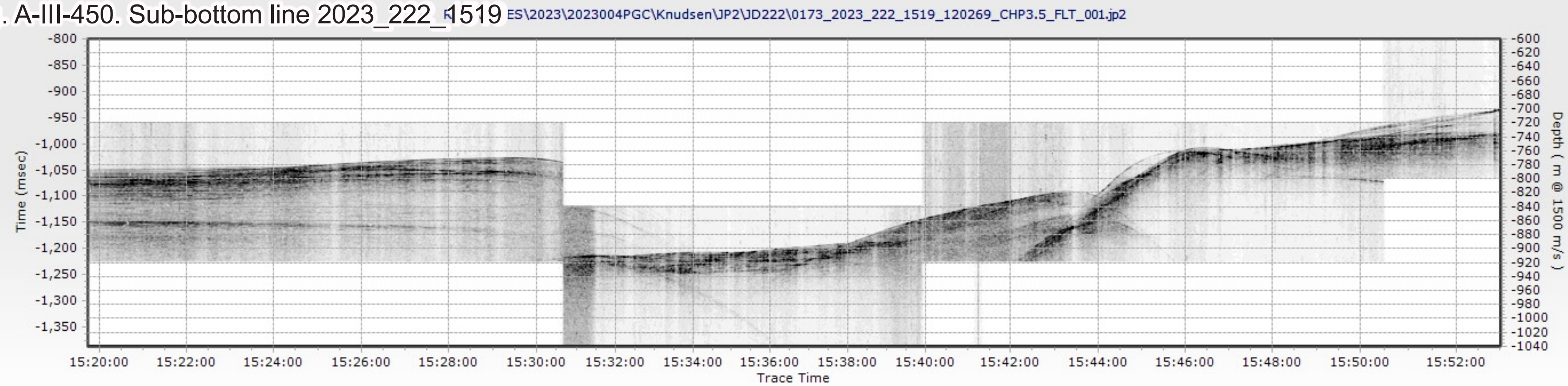

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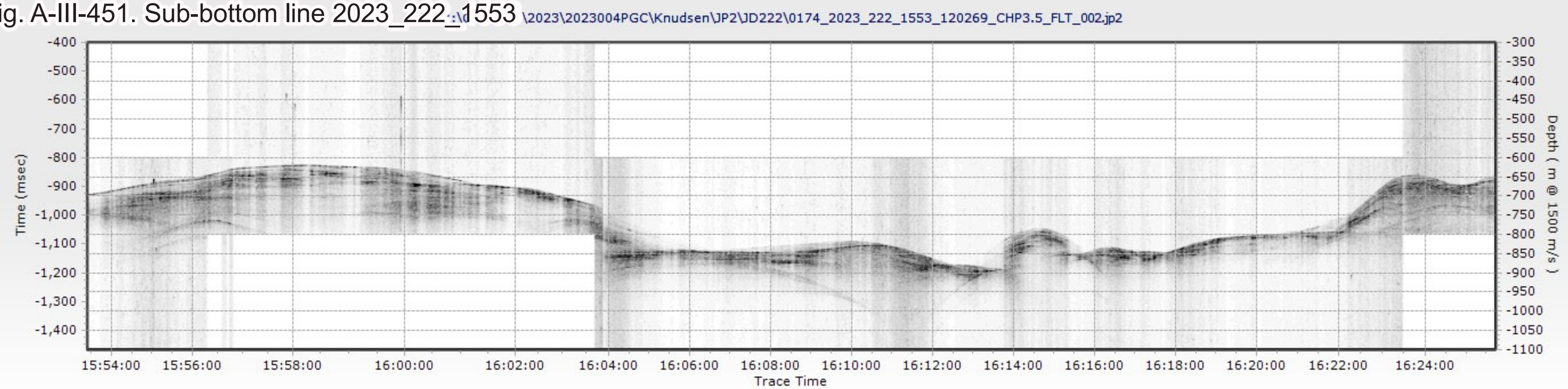

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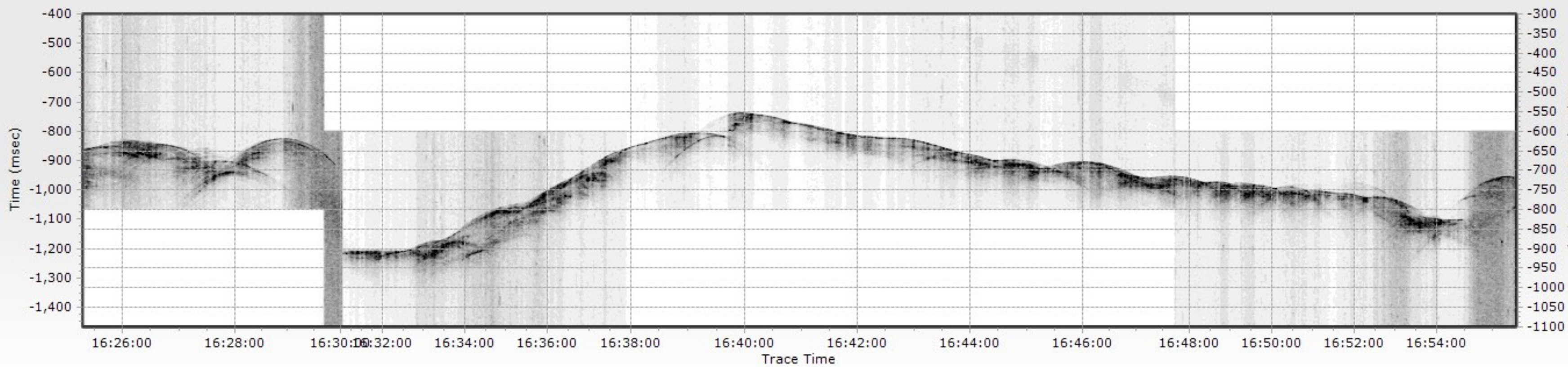

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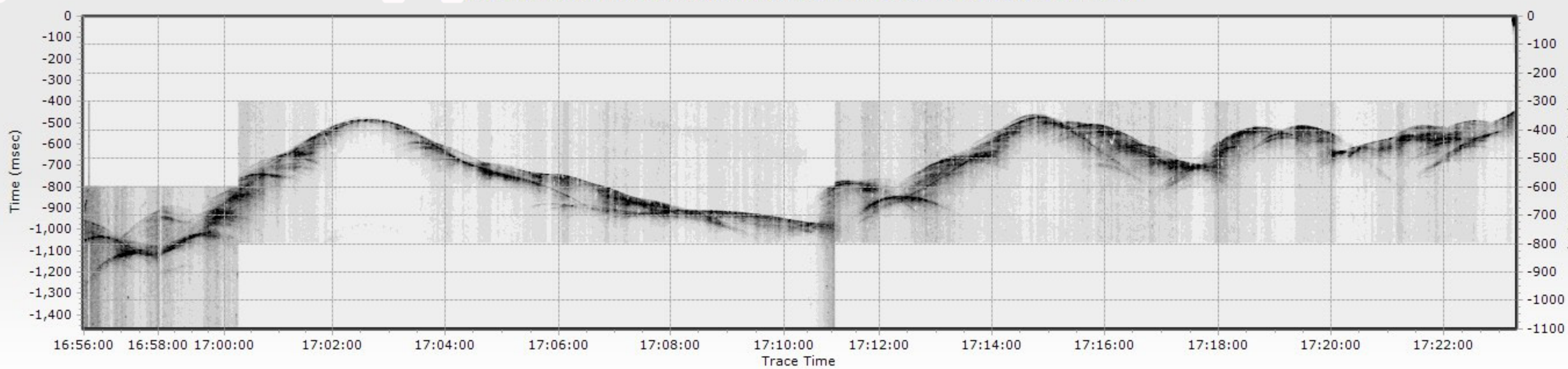

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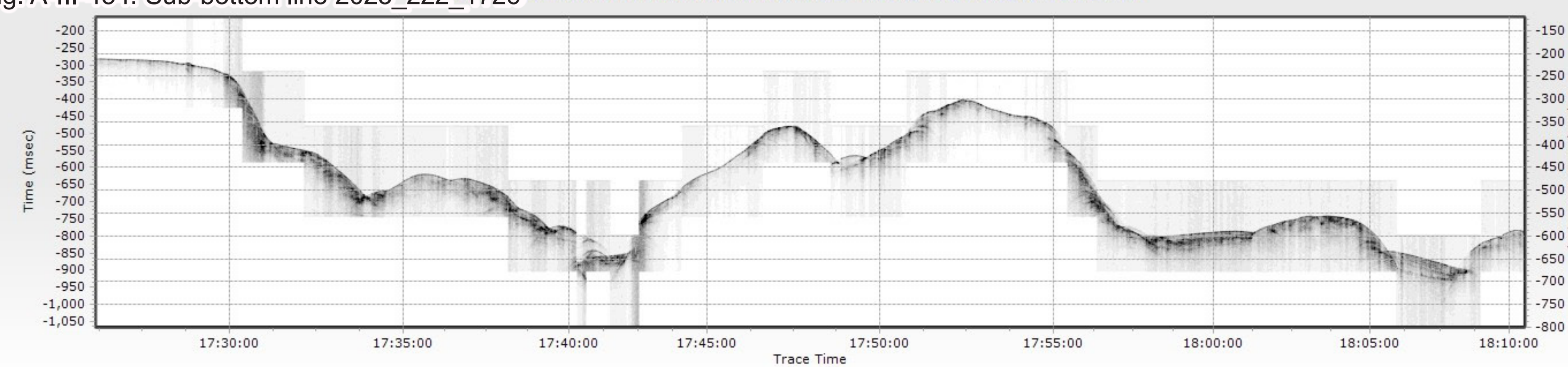

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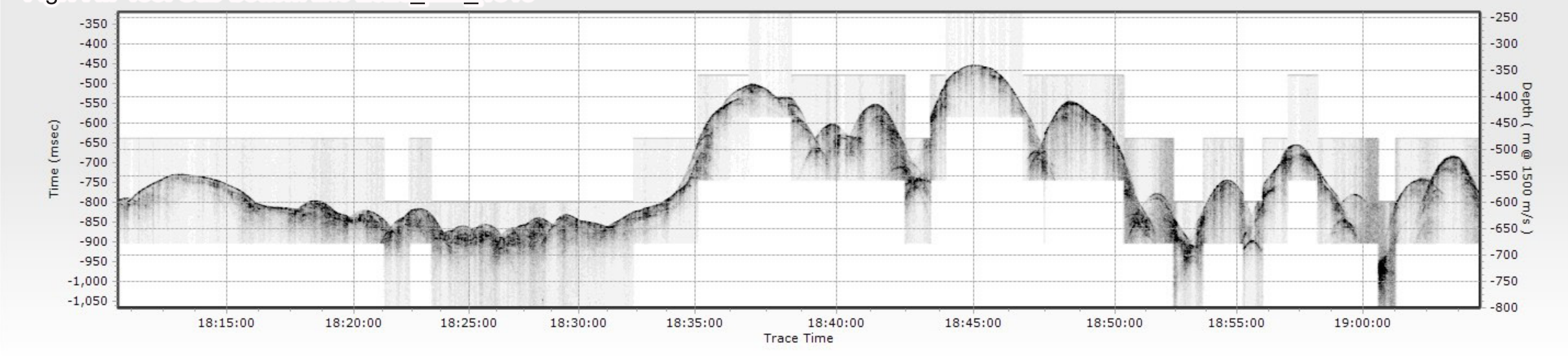

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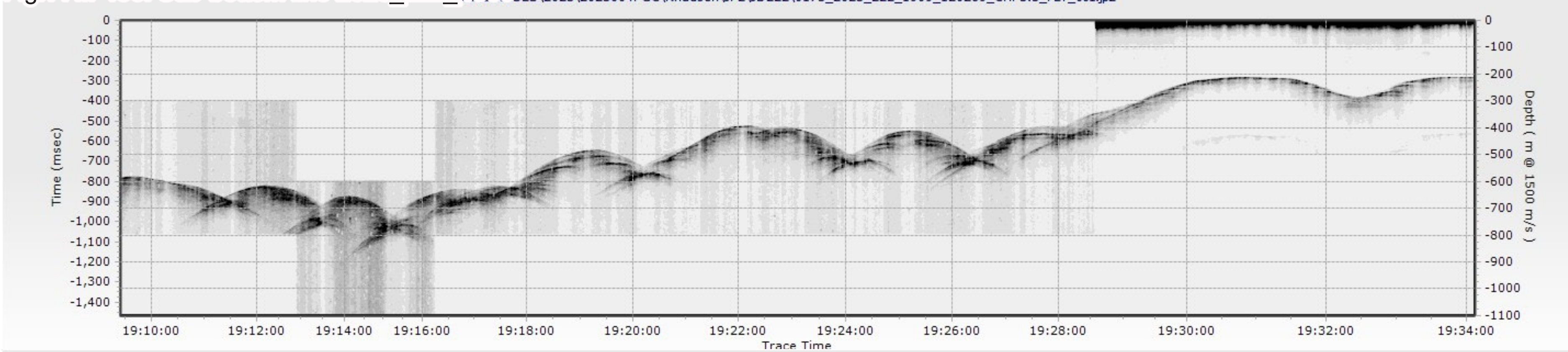

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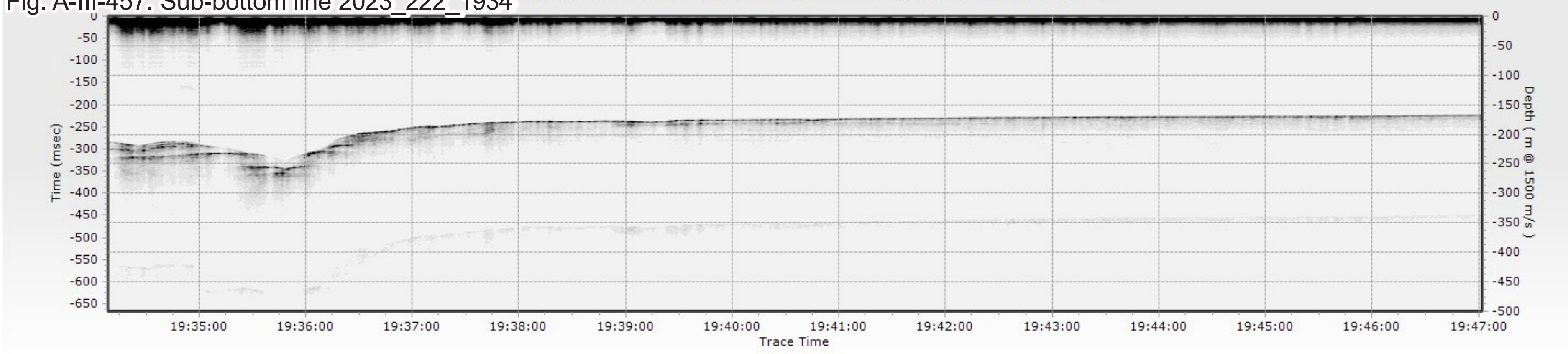

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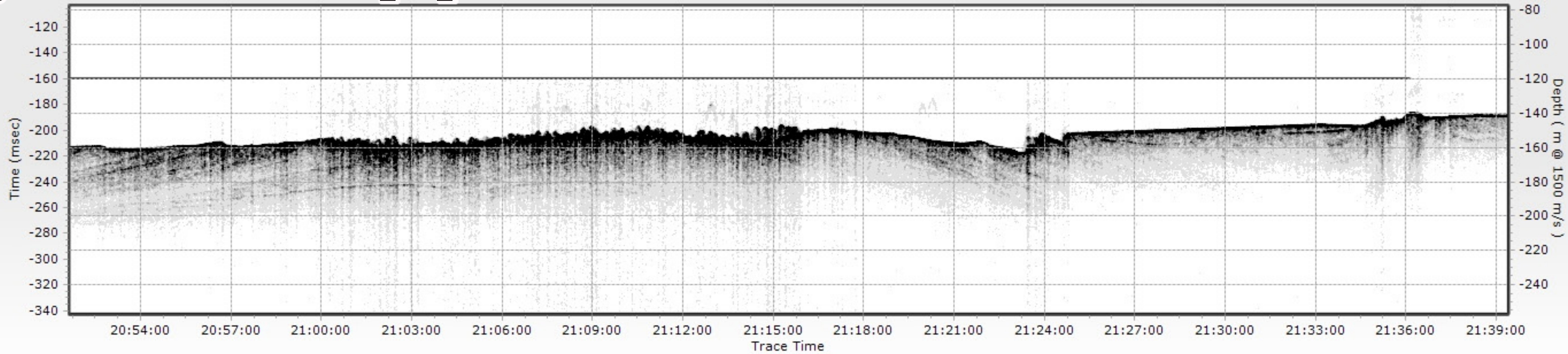


Fig. A-III-459. Sub-bottom line 2023_222_2139

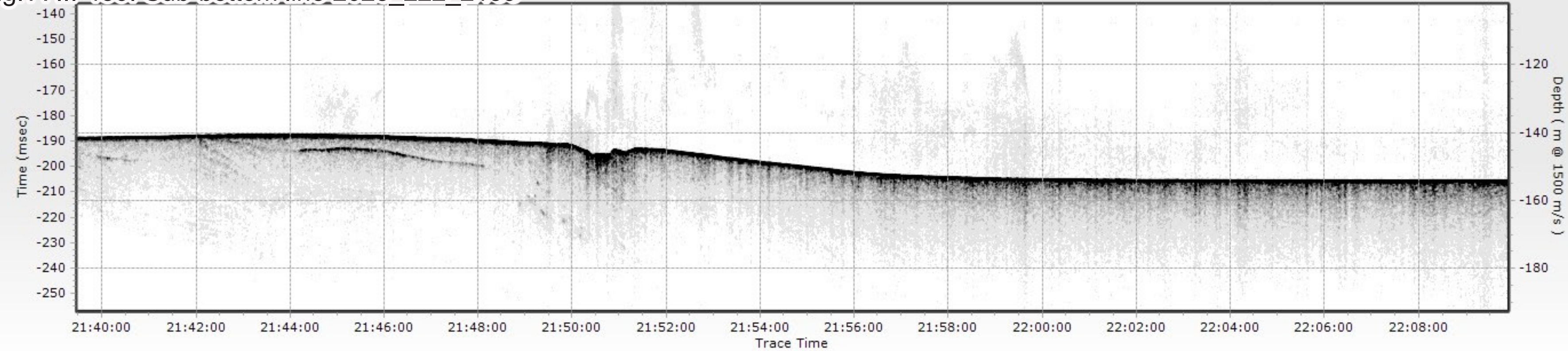
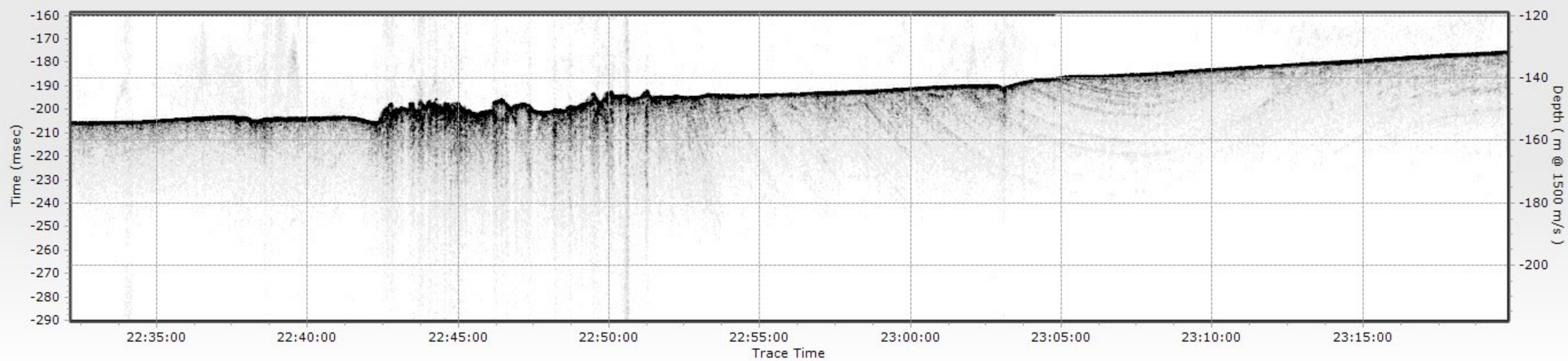


Fig. A-III-460. Sub-bottom line 2023_222_2232



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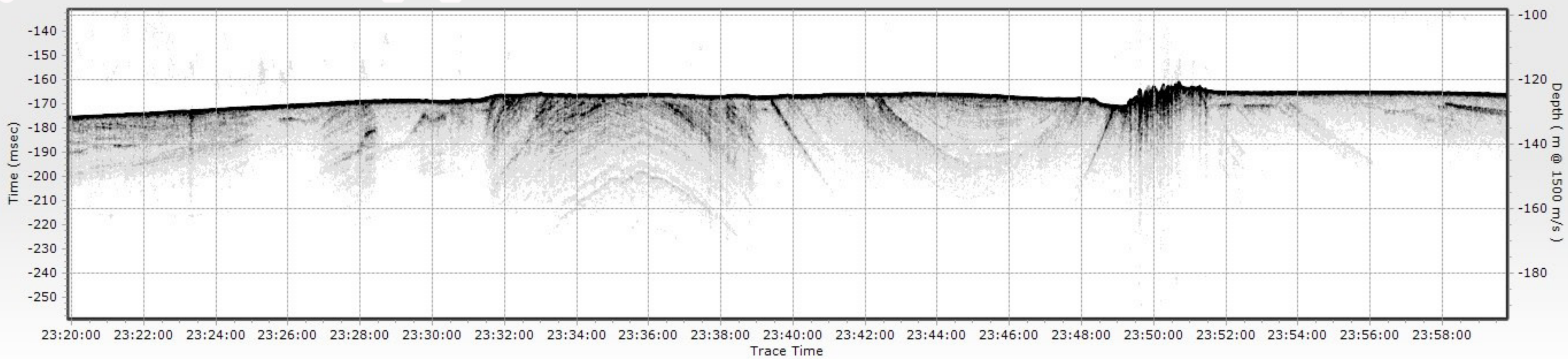

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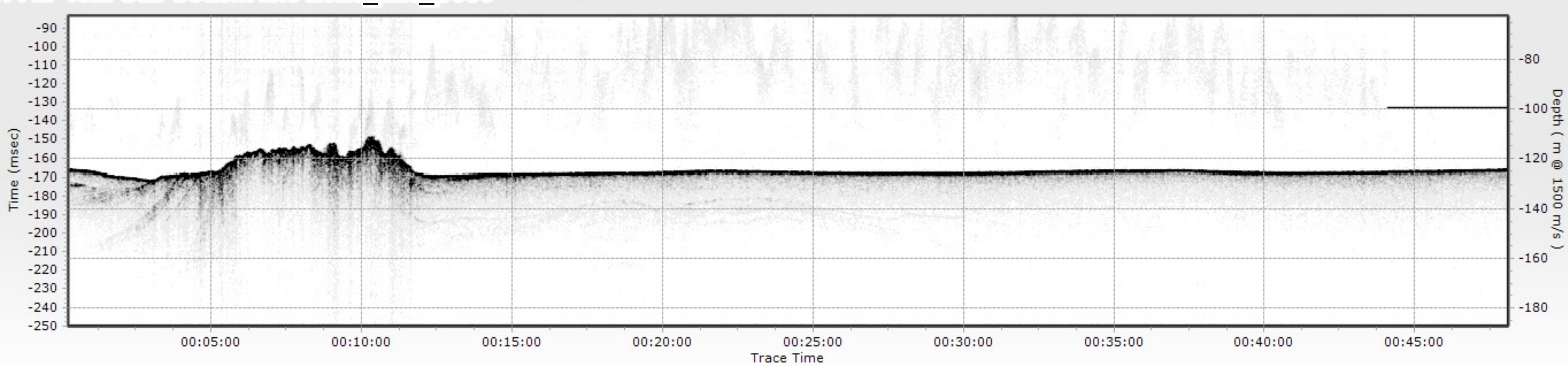

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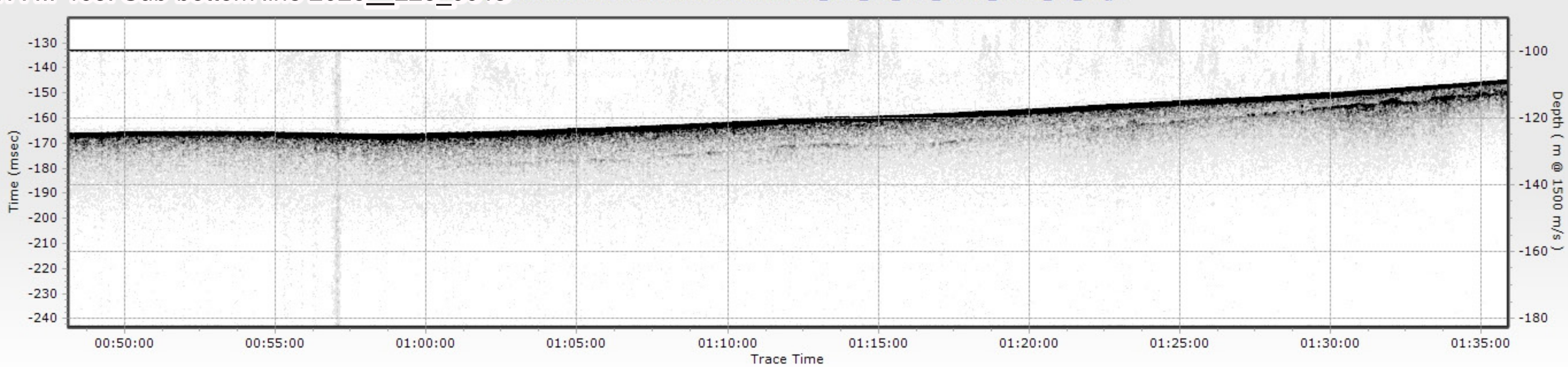

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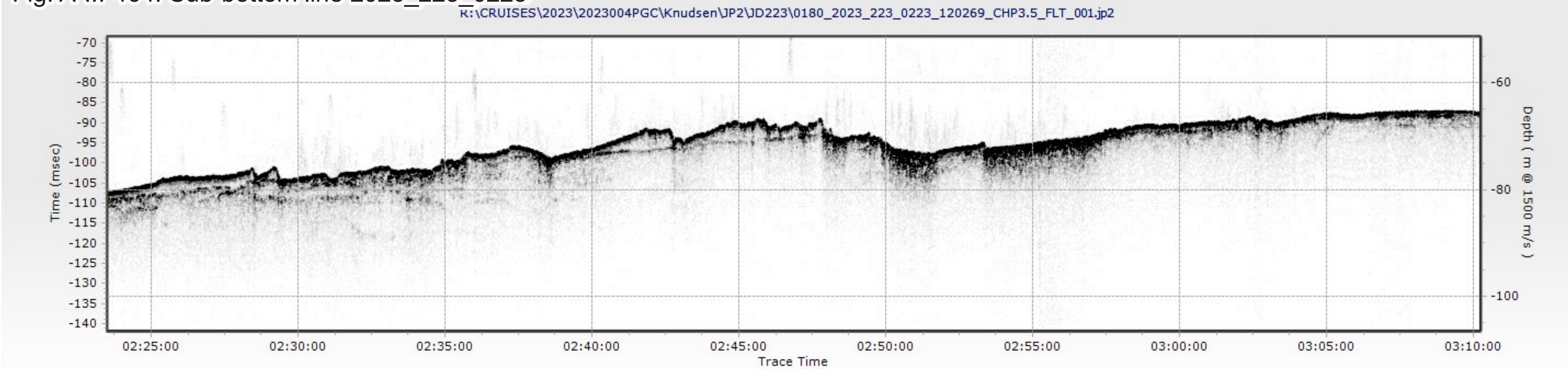

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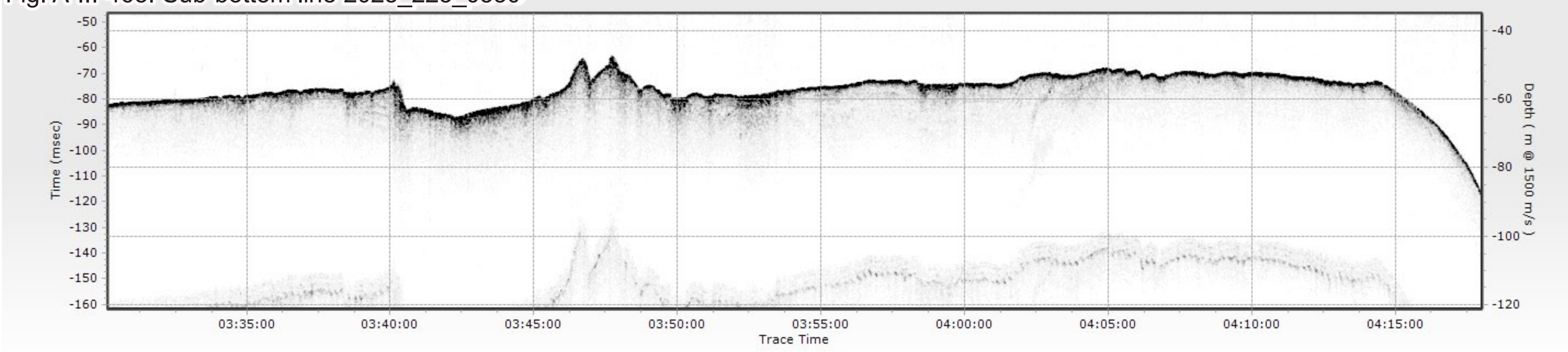


Fig. A-III-466. Sub-bottom line 2023_223_0418

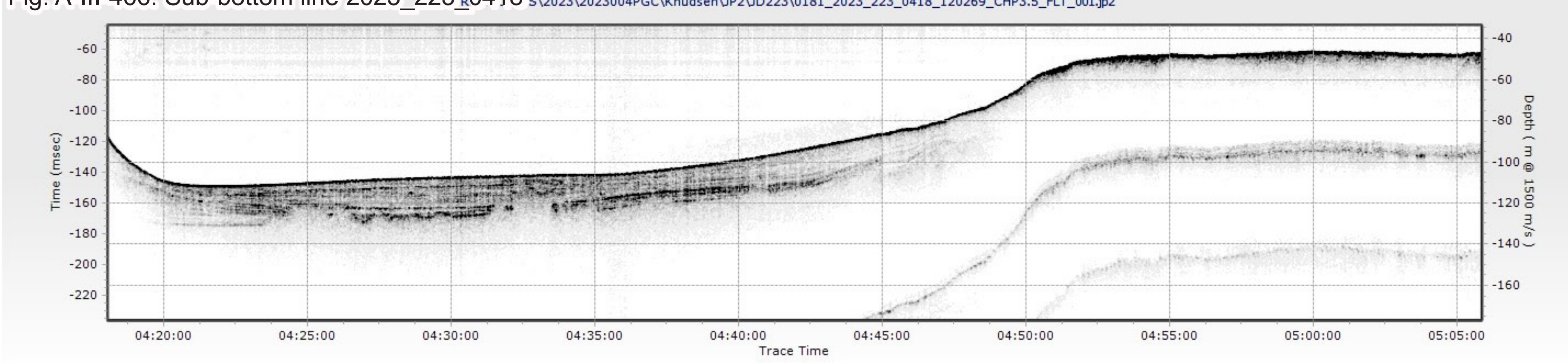
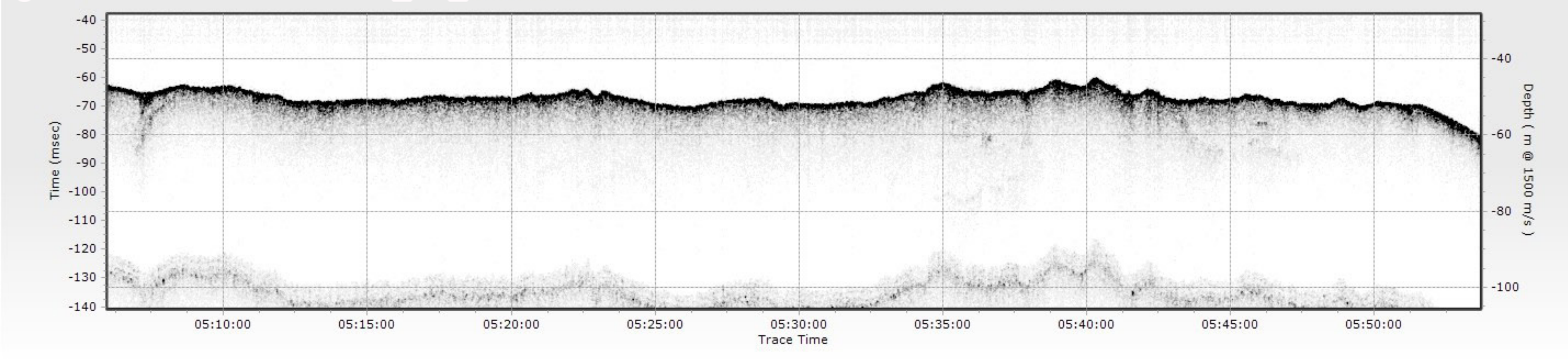


Fig. A-III-467. Sub-bottom line 2023_223_0505



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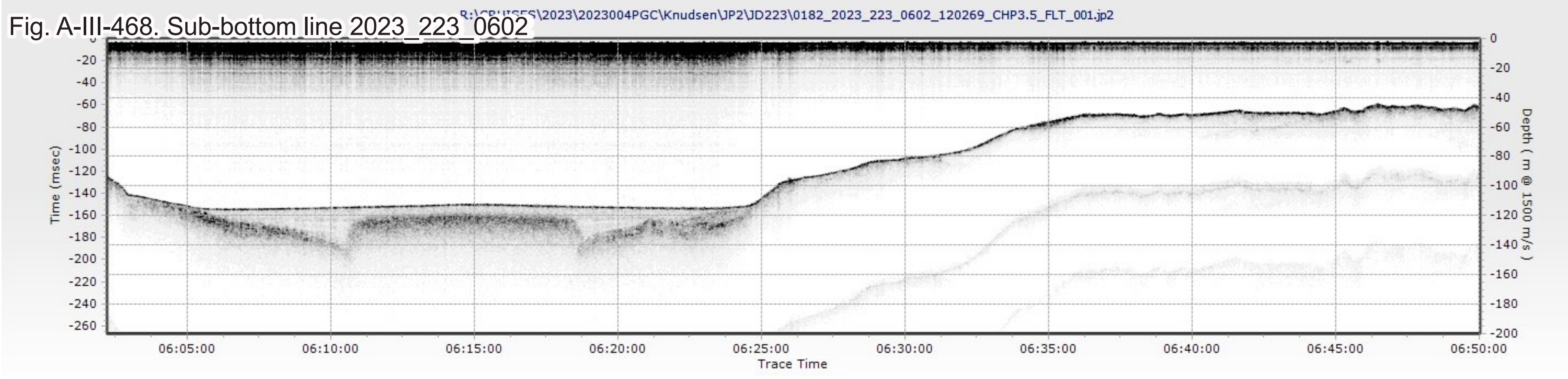

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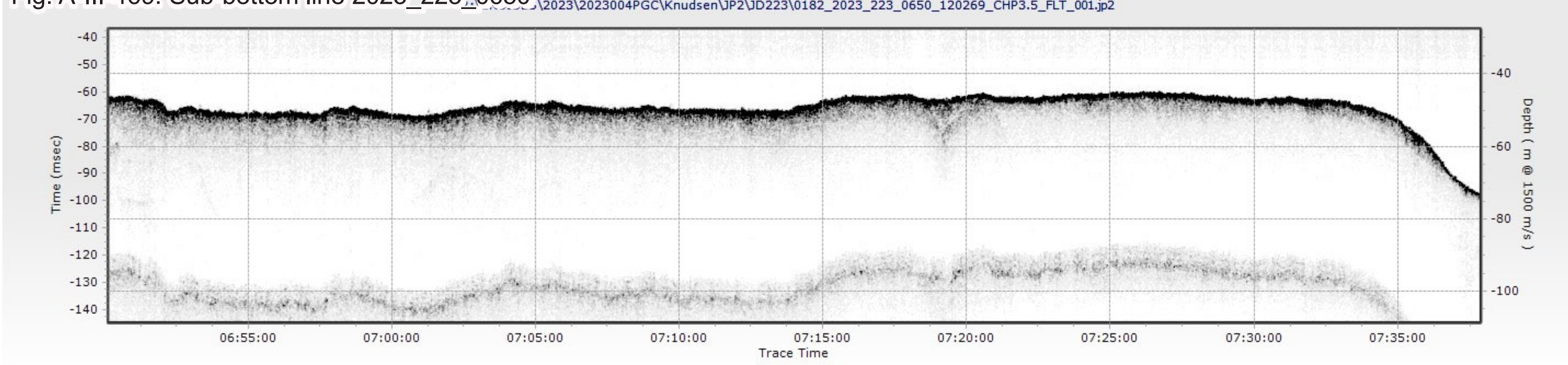


Fig. A-III-470. Sub-bottom line 2023_223_0737

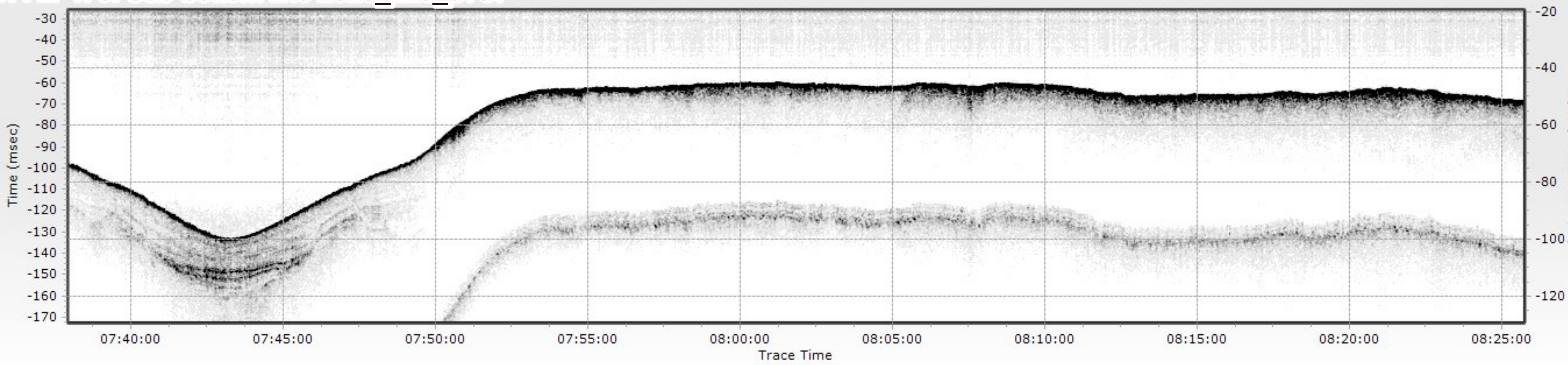


Fig. A-III-471. Sub-bottom line 2023_223_0825

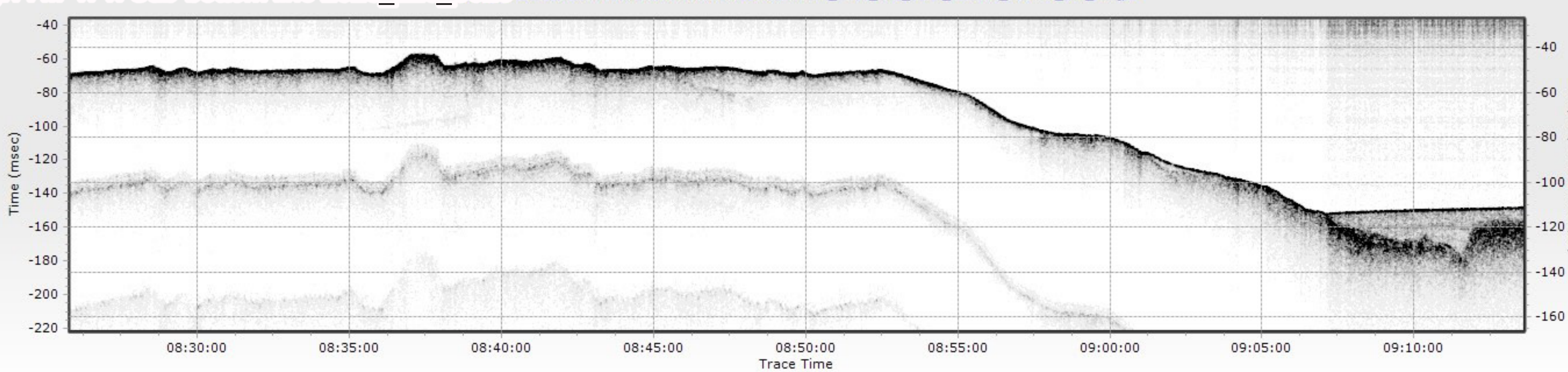


Fig. A-III-472. Sub-bottom line 2023_223_0921

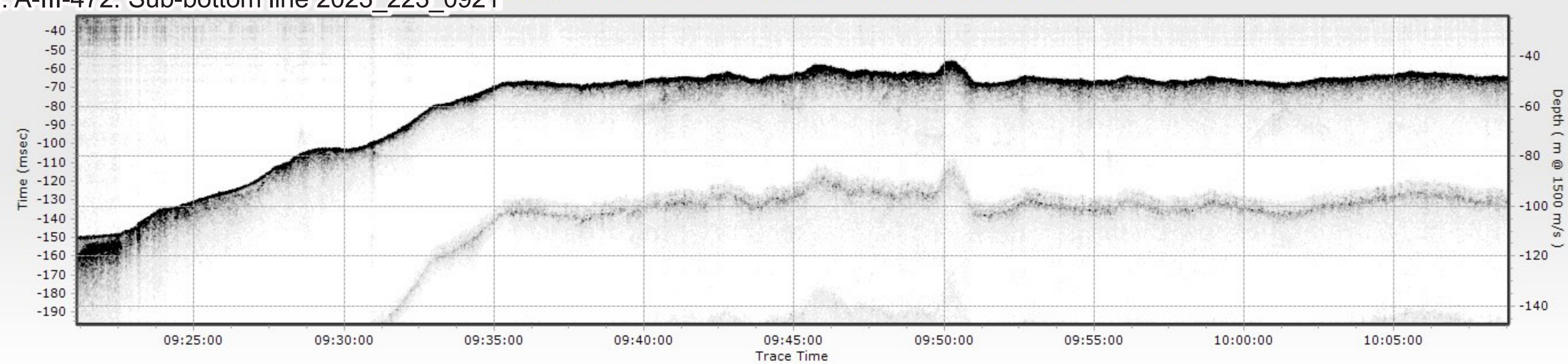


Fig. A-III-473. Sub-bottom line 2023_223_1008

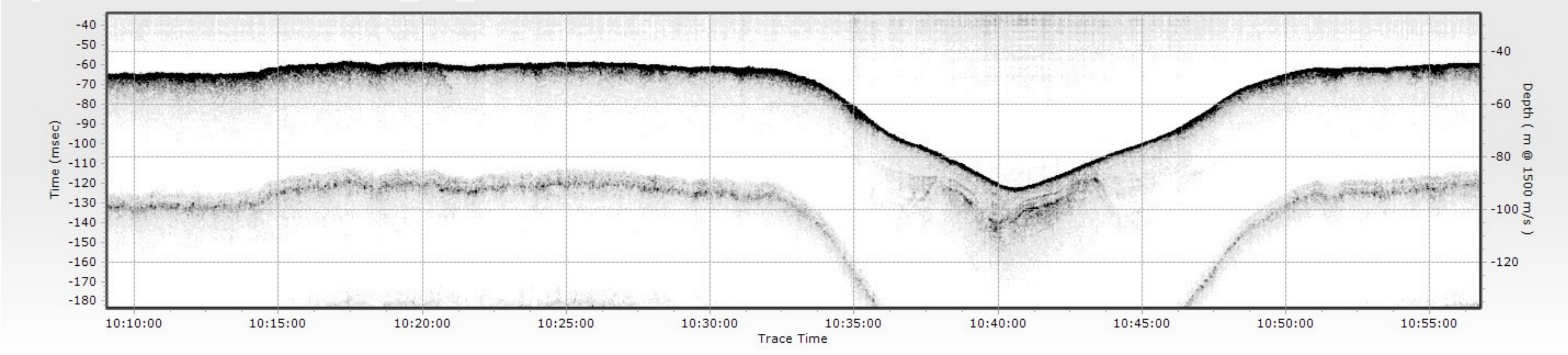


Fig. A-III-474. Sub-bottom line 2023_223_1056

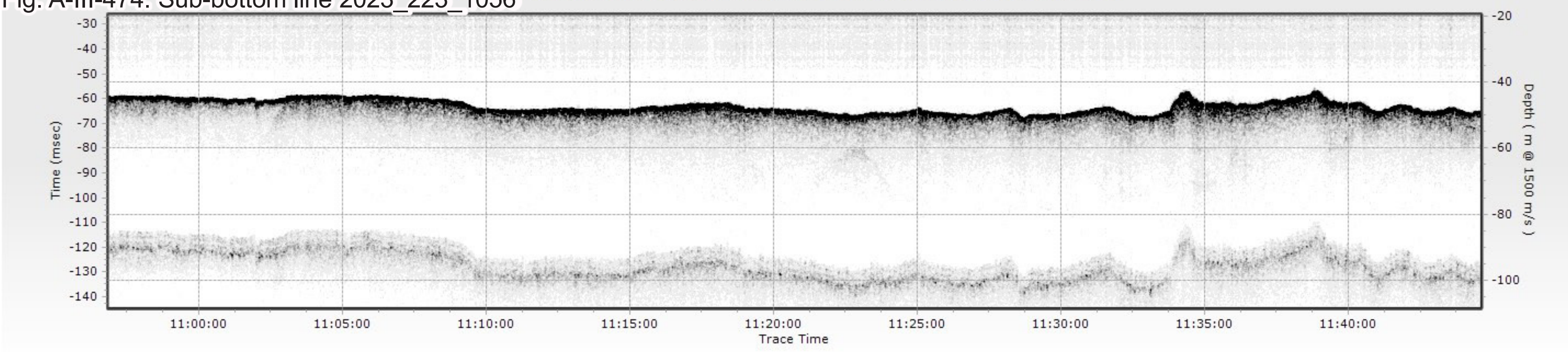
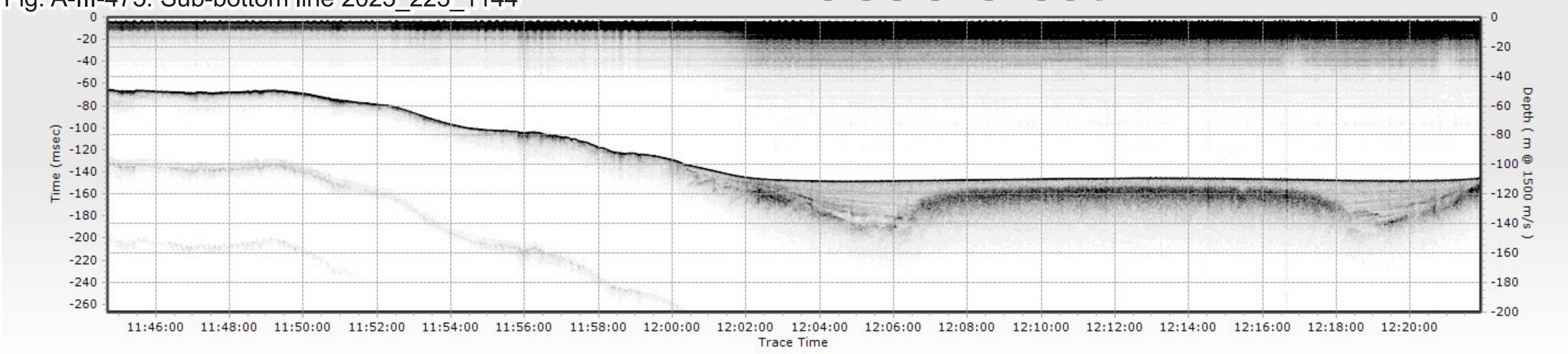


Fig. A-III-475. Sub-bottom line 2023_223_1144



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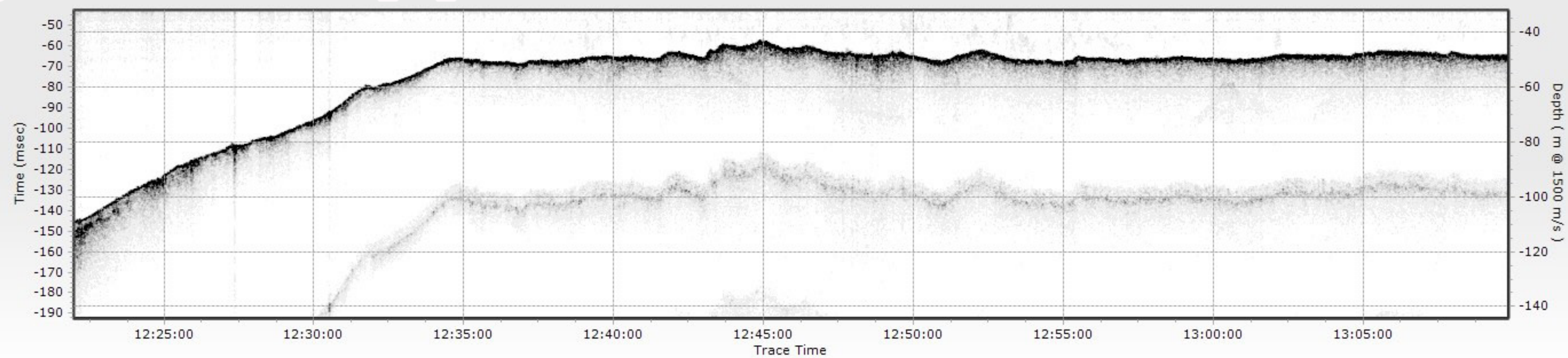

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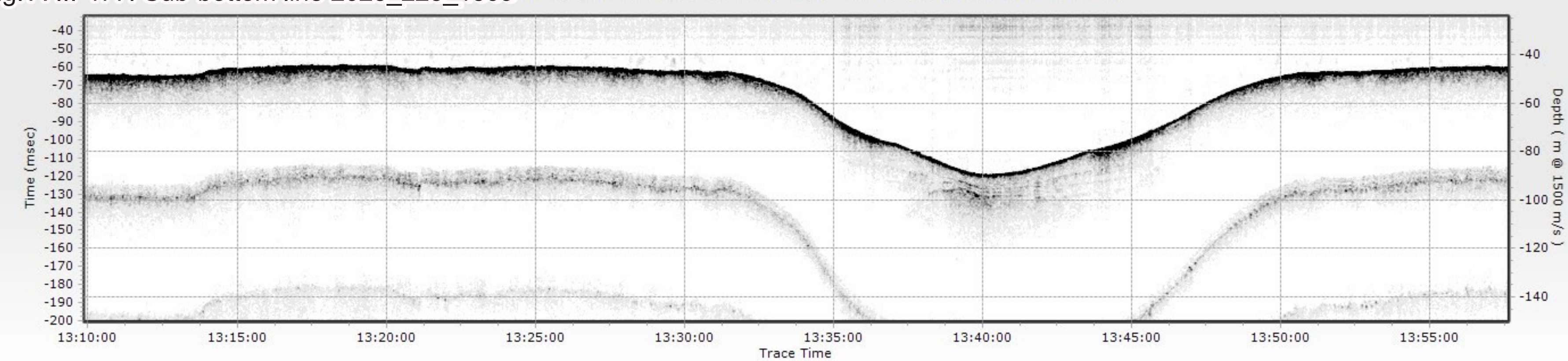

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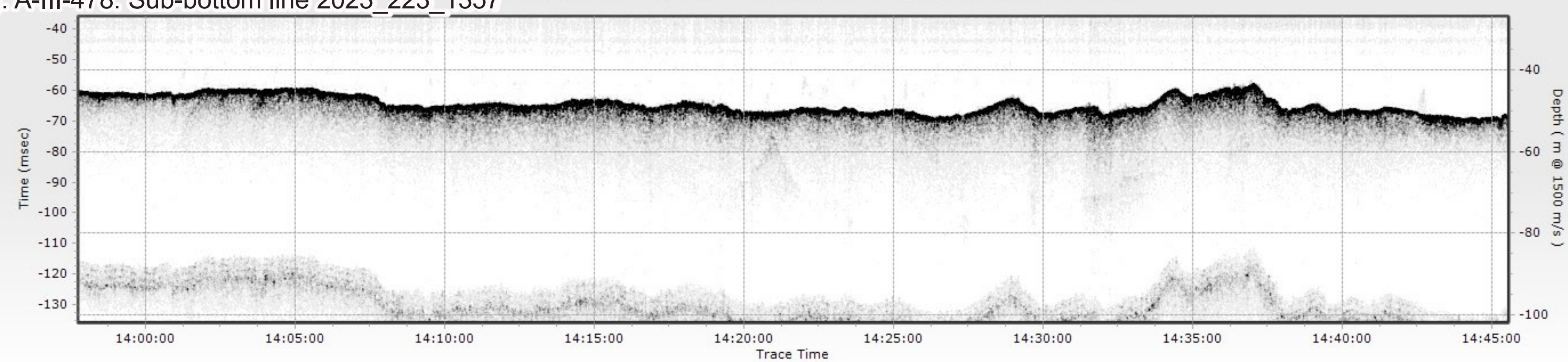

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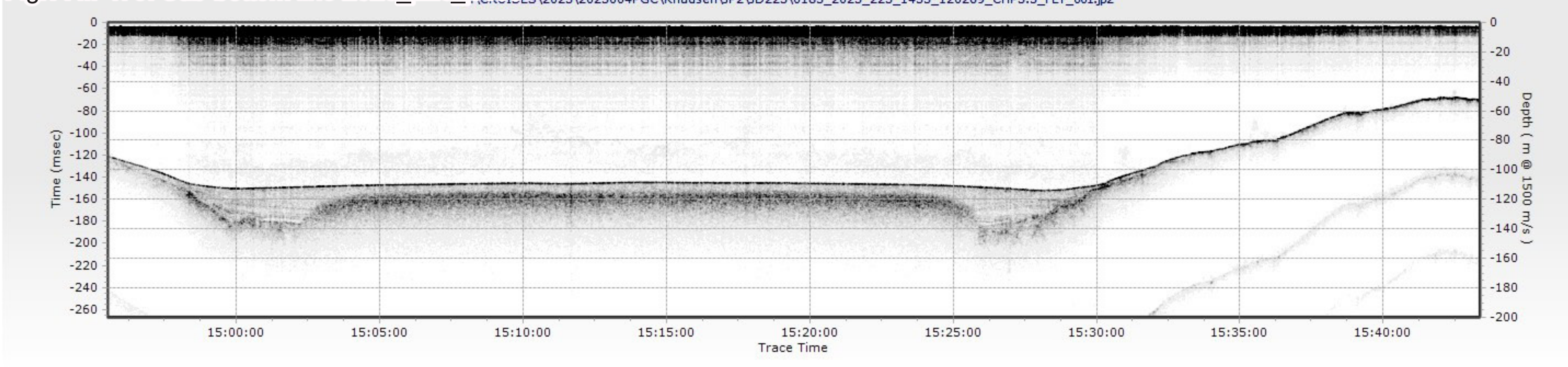


Fig. A-III-480. Sub-bottom line 2023_223_1543

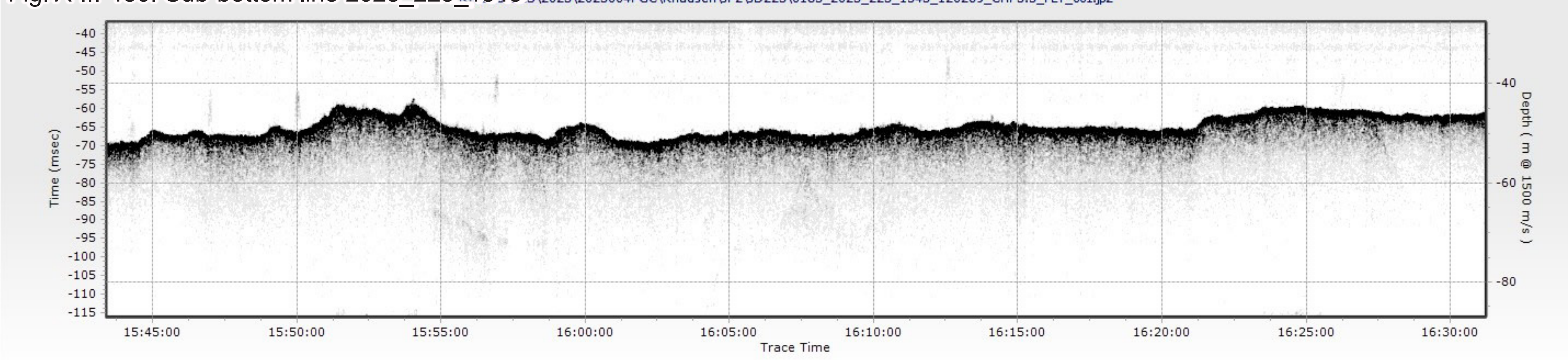


Fig. A-III-481. Sub-bottom line 2023_223_1631

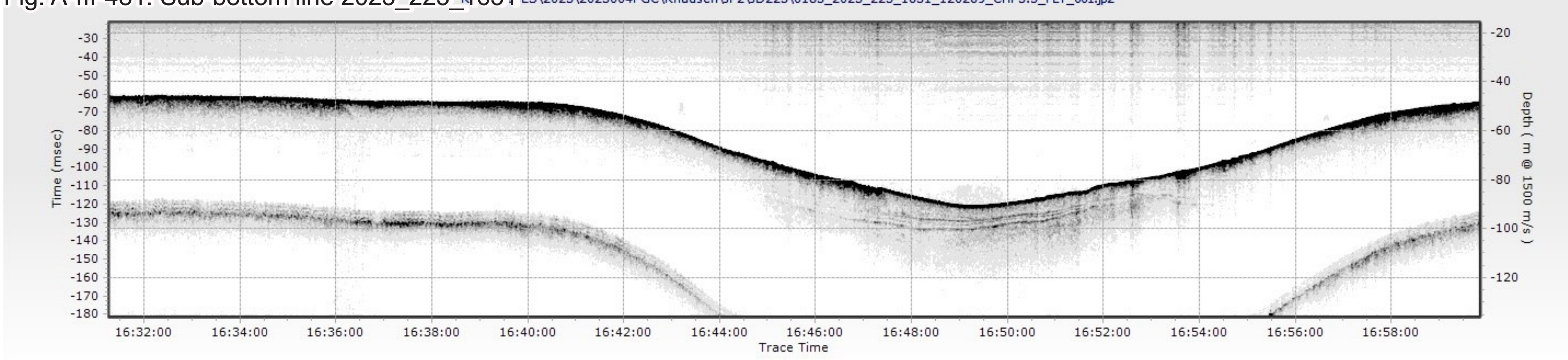


Fig. A-III-482. Sub-bottom line 2023_223_1631

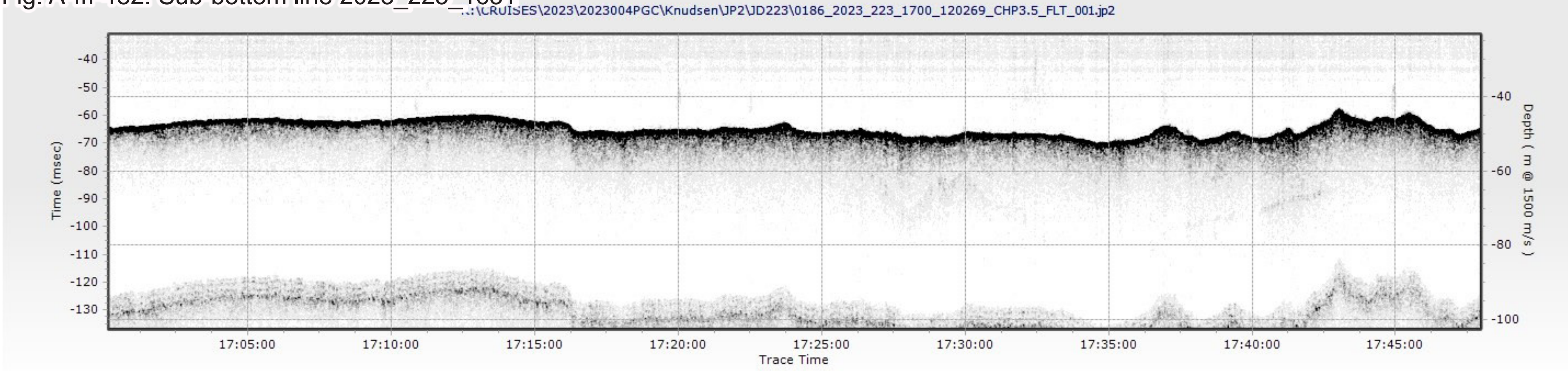


Fig. A-III-483. Sub-bottom line 2023_223_1748

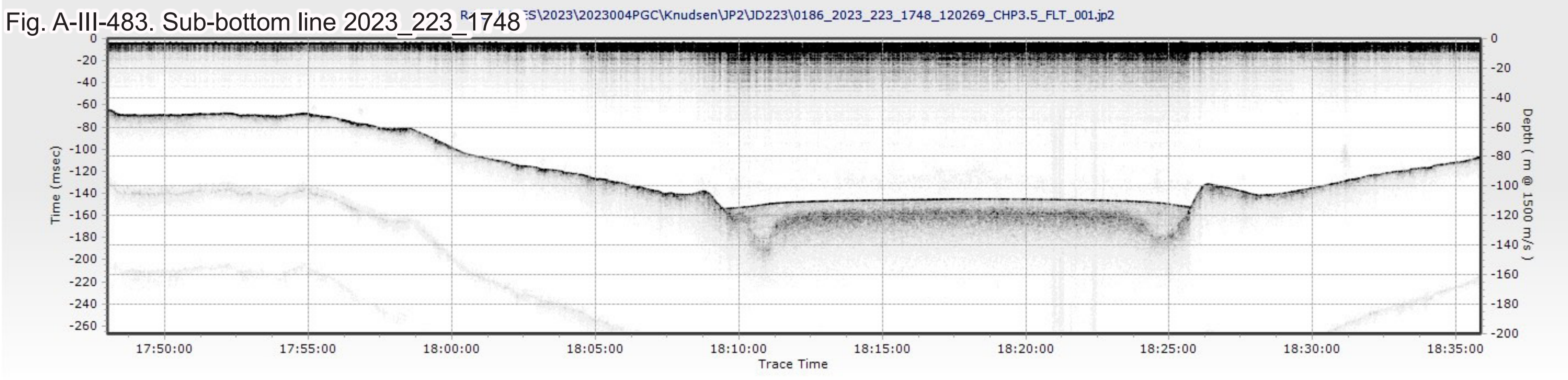
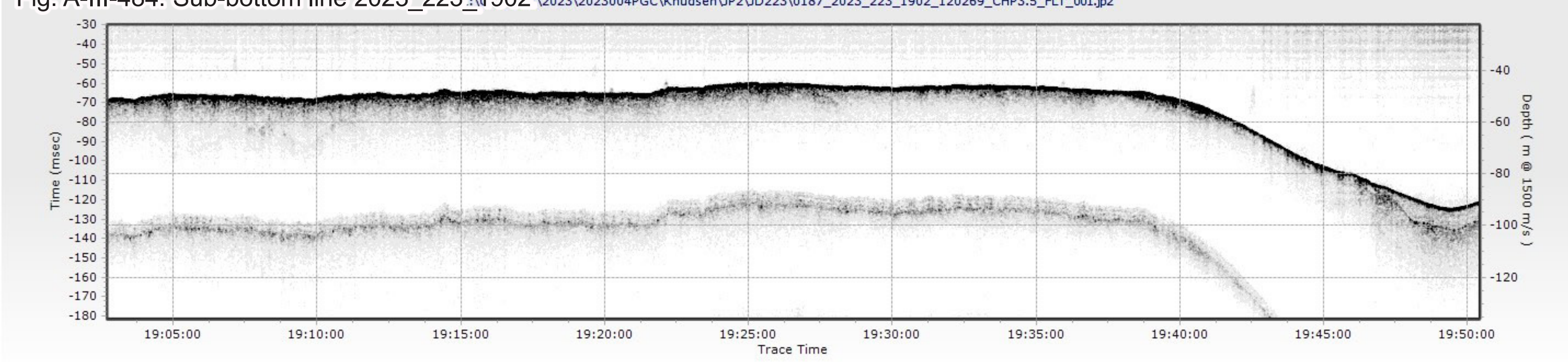


Fig. A-III-484. Sub-bottom line 2023_223_1902



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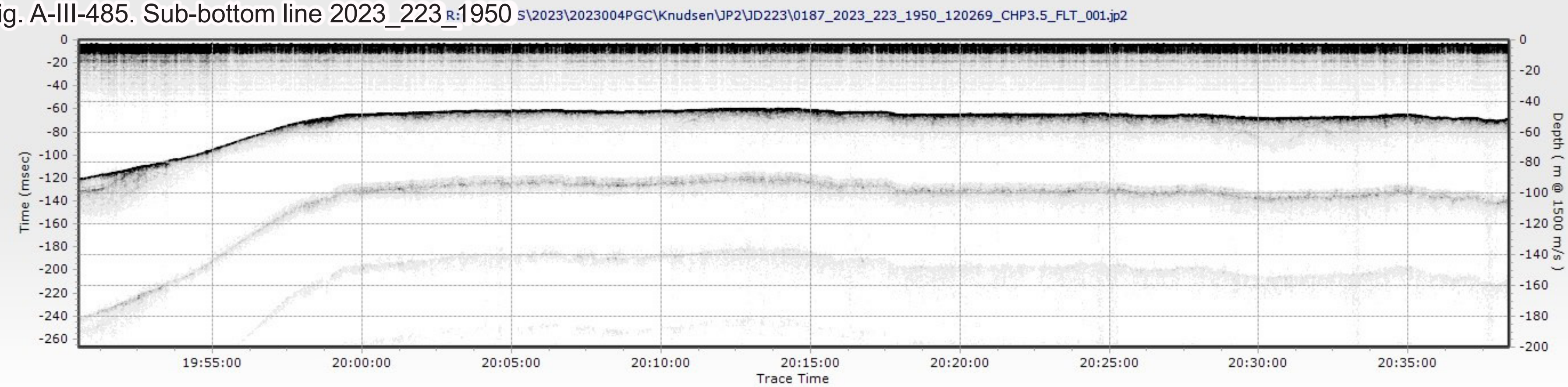


Fig. A-III-486. Sub-bottom line 2023_223_2038

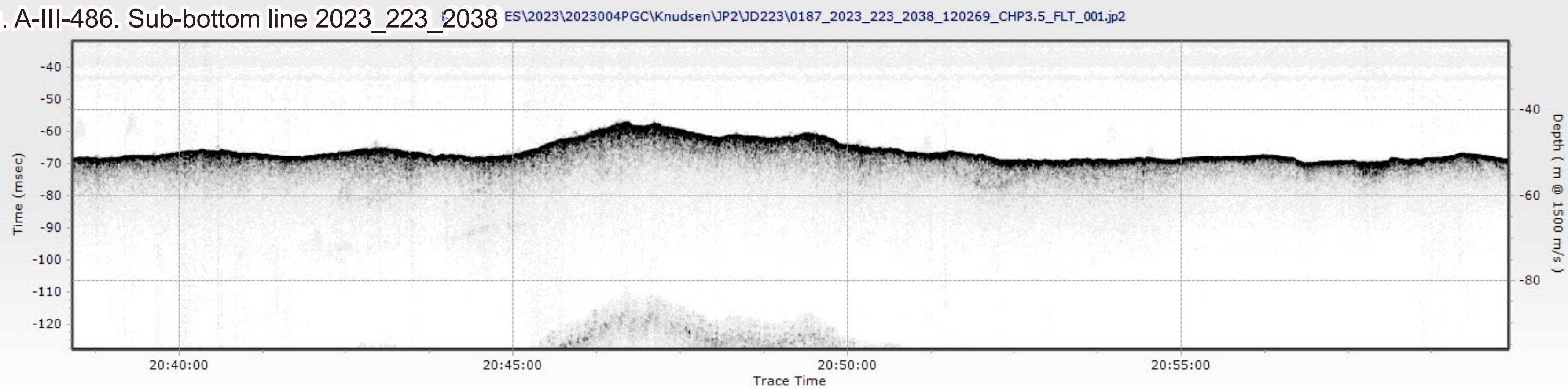


Fig. A-III-487. Sub-bottom line 2023_223_2100

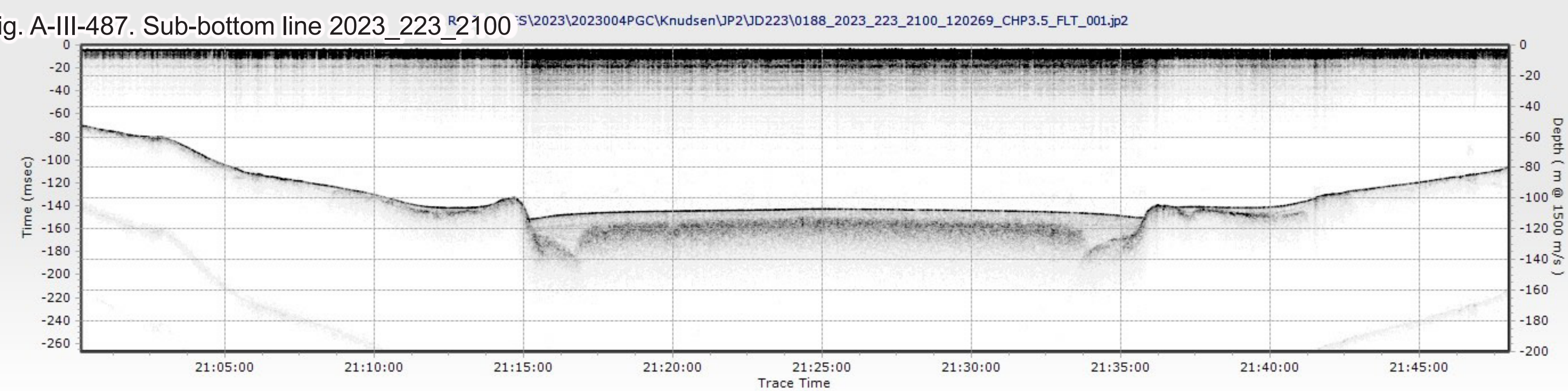


Fig. A-III-488. Sub-bottom line 2023_223_2148

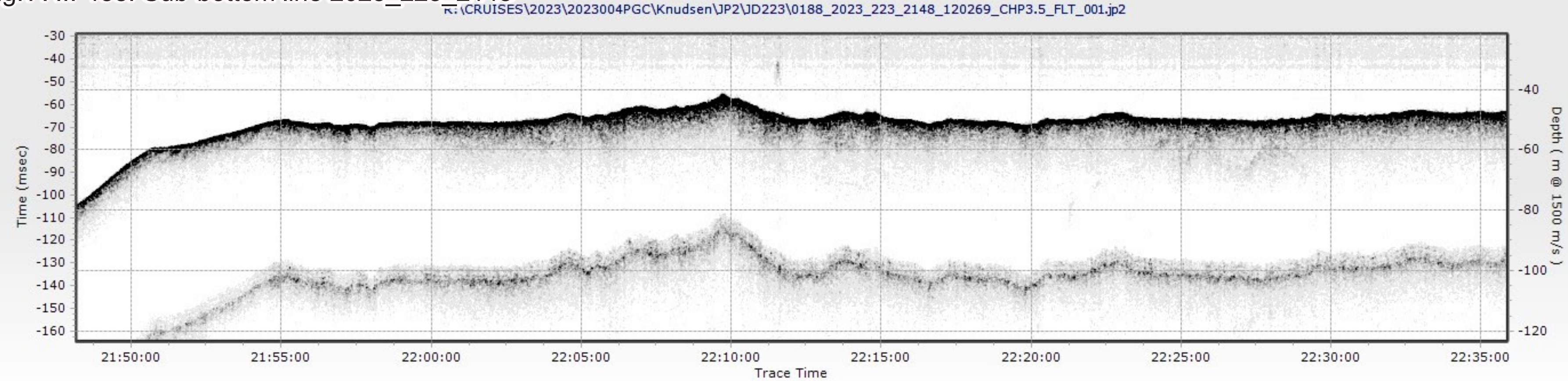
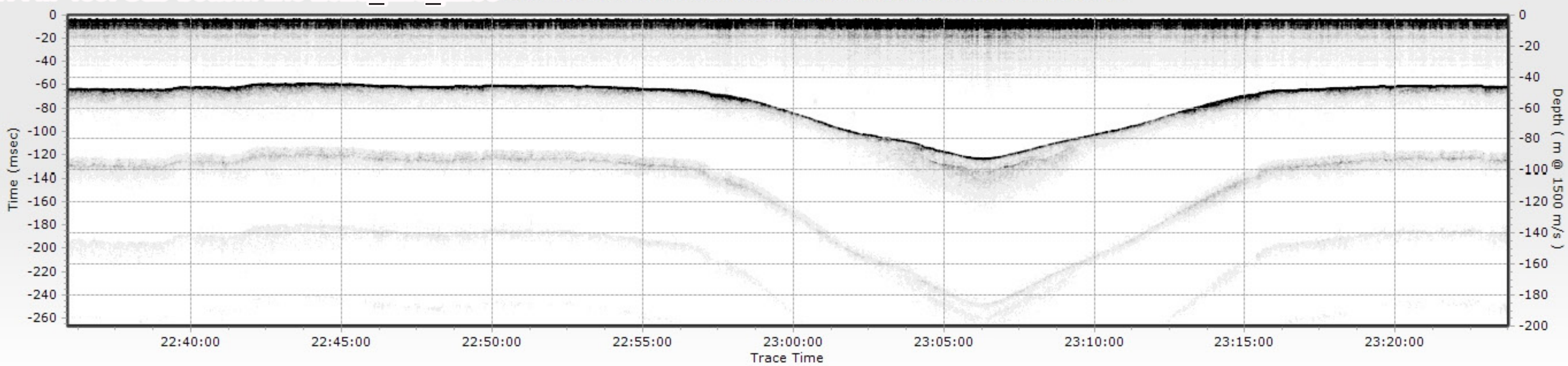


Fig. A-III-489. Sub-bottom line 2023_223_2235



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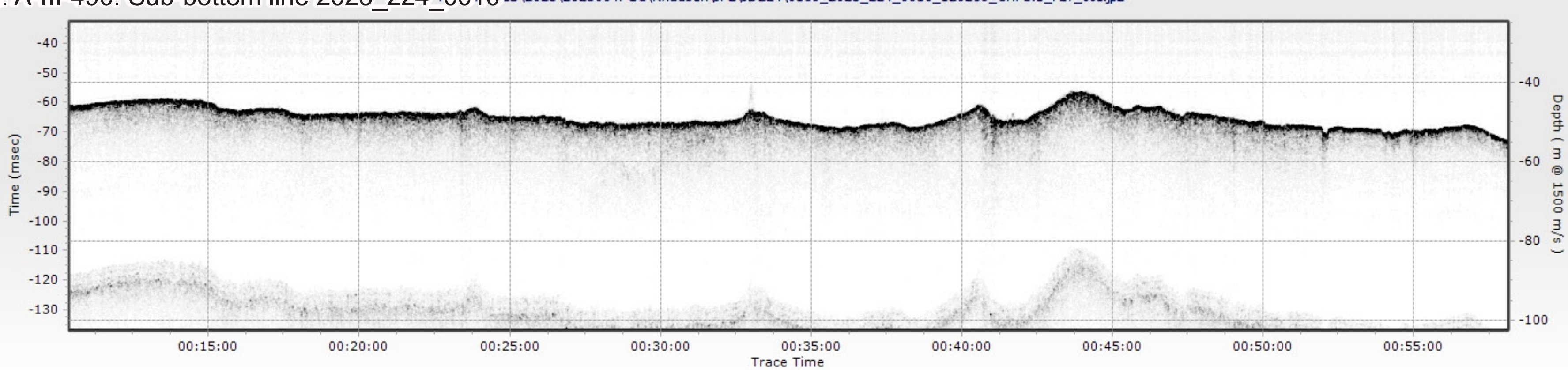
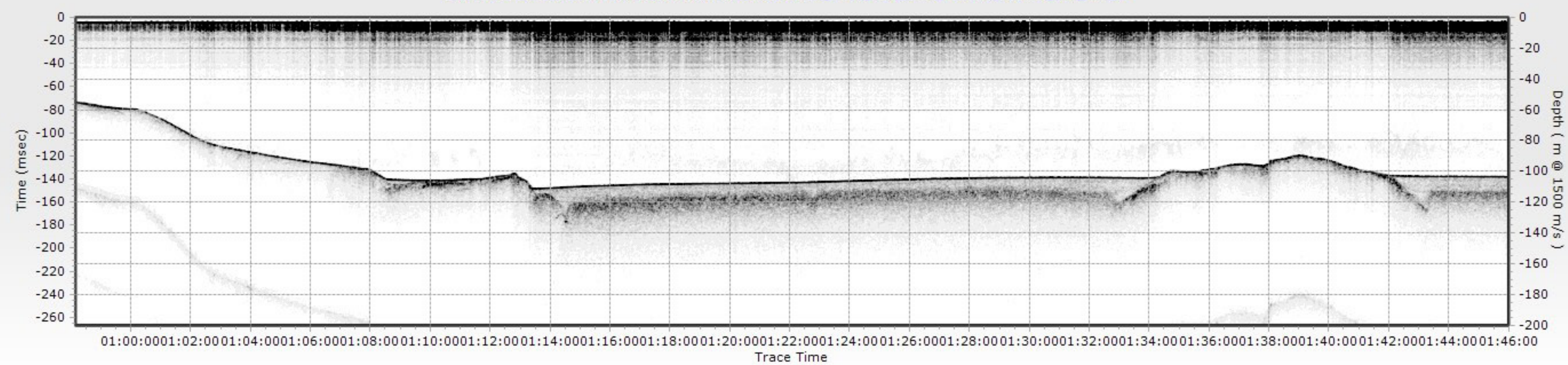


Fig. A-III-491. Sub-bottom line 2023_224_0058



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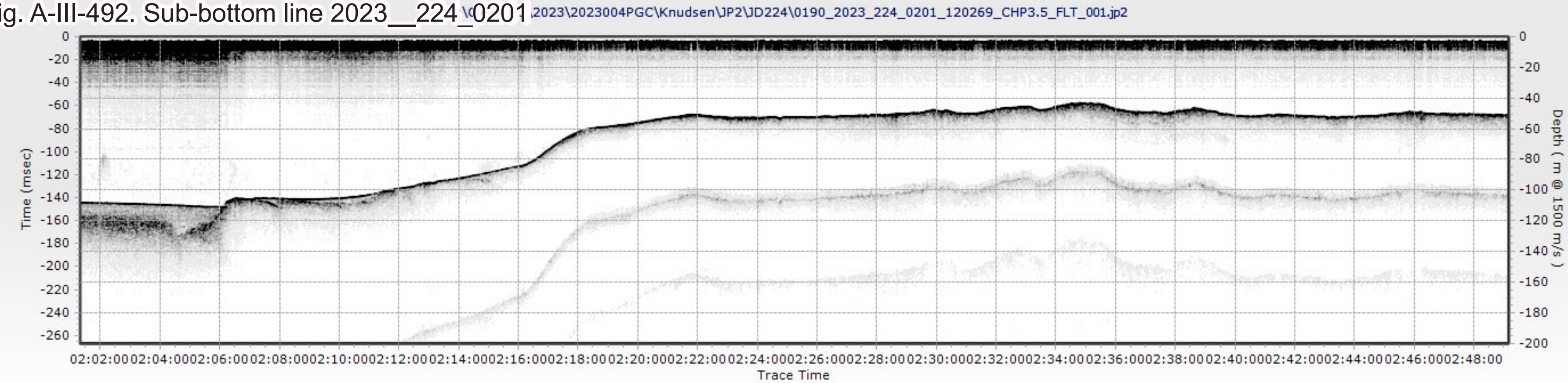

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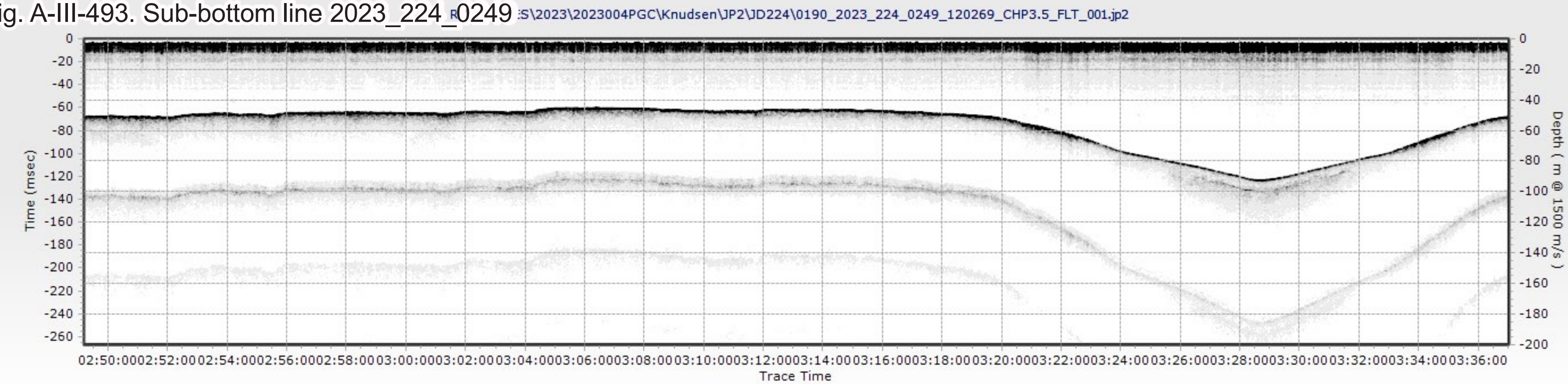

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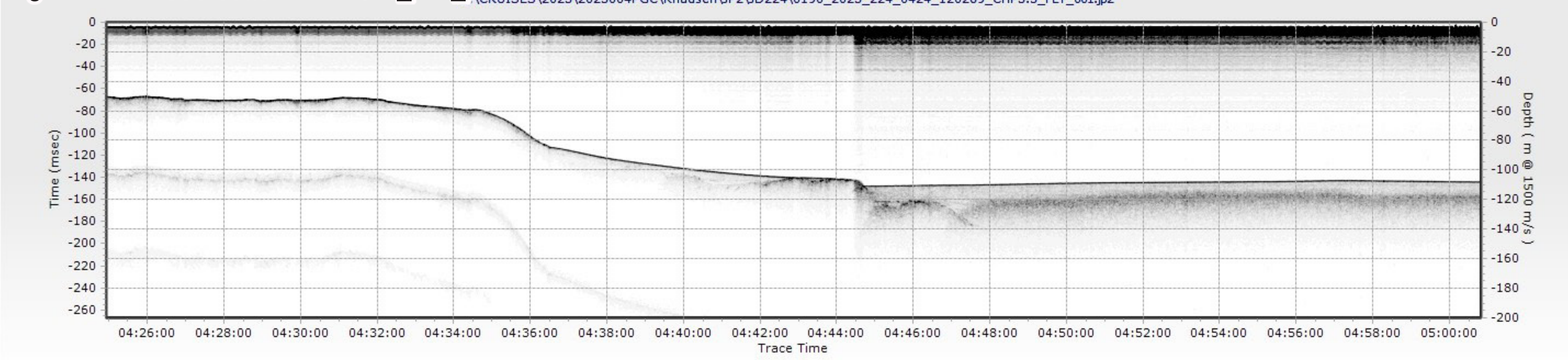

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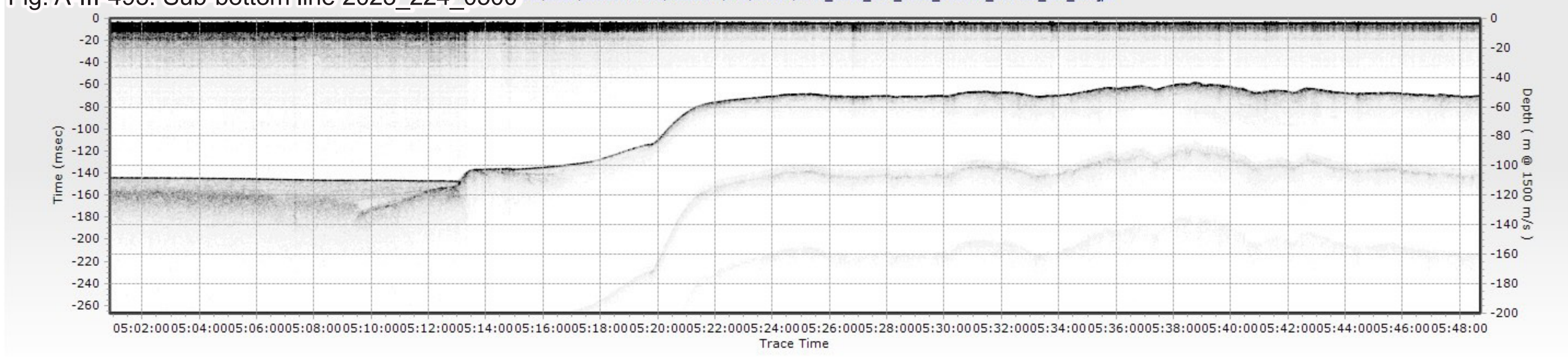

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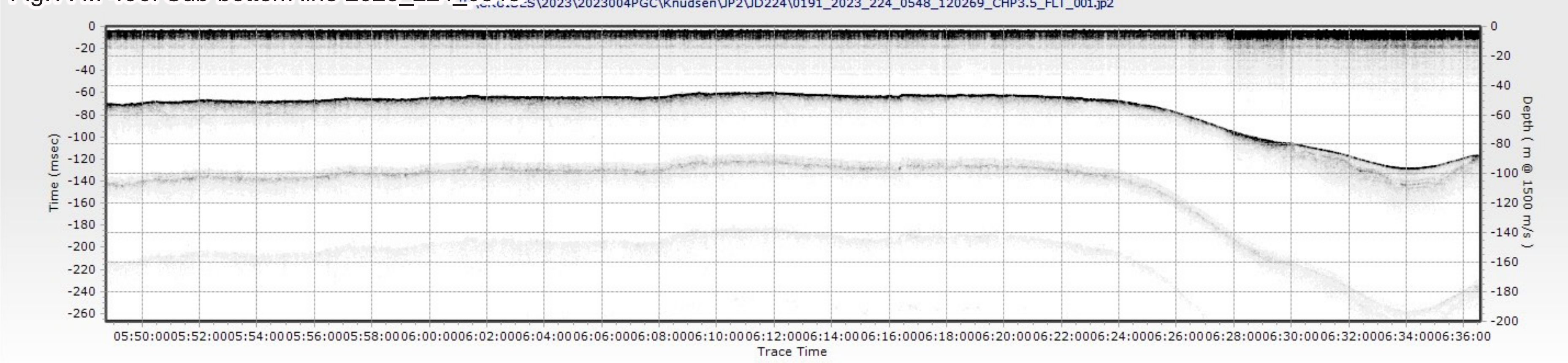

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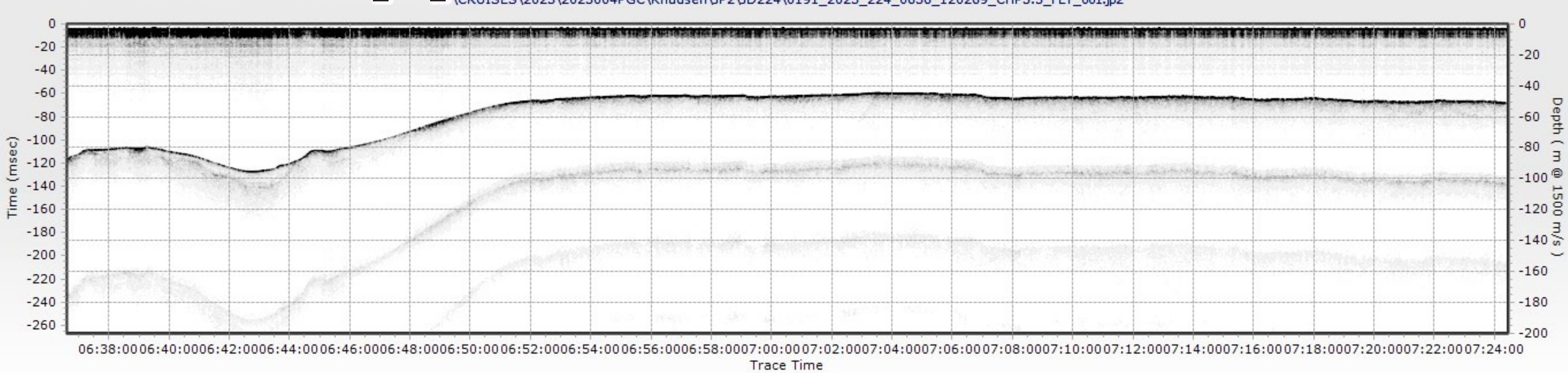

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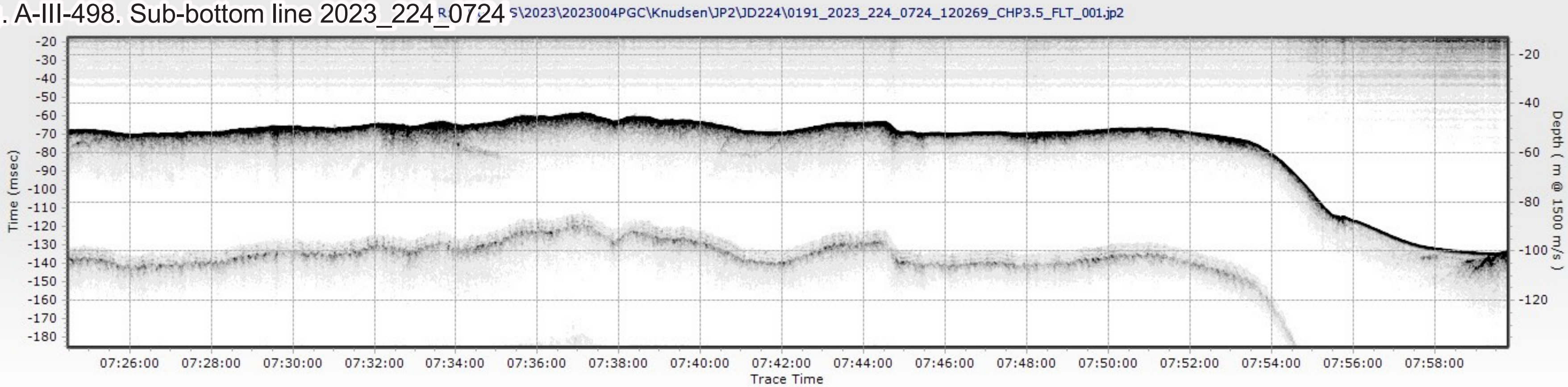

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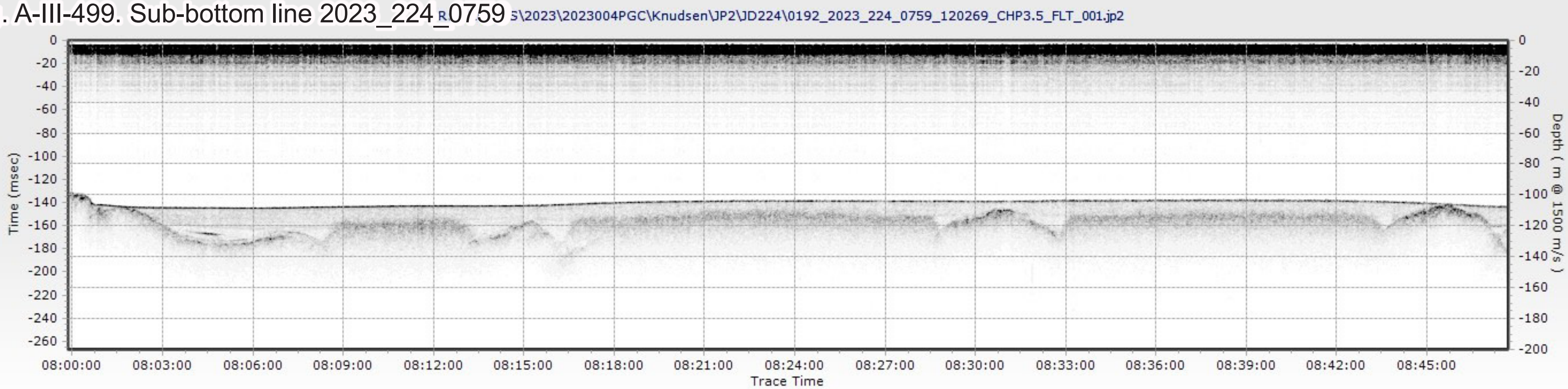

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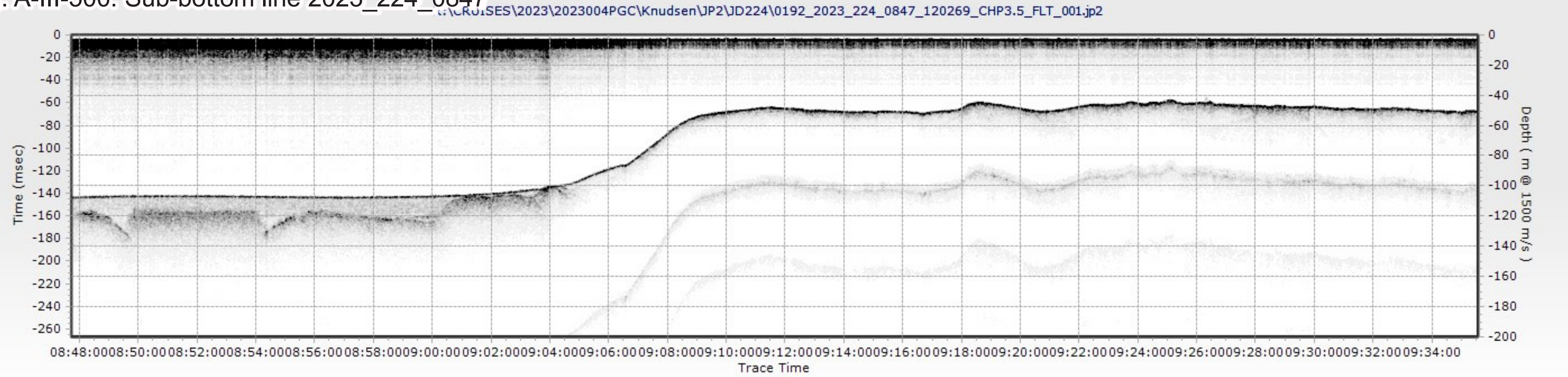

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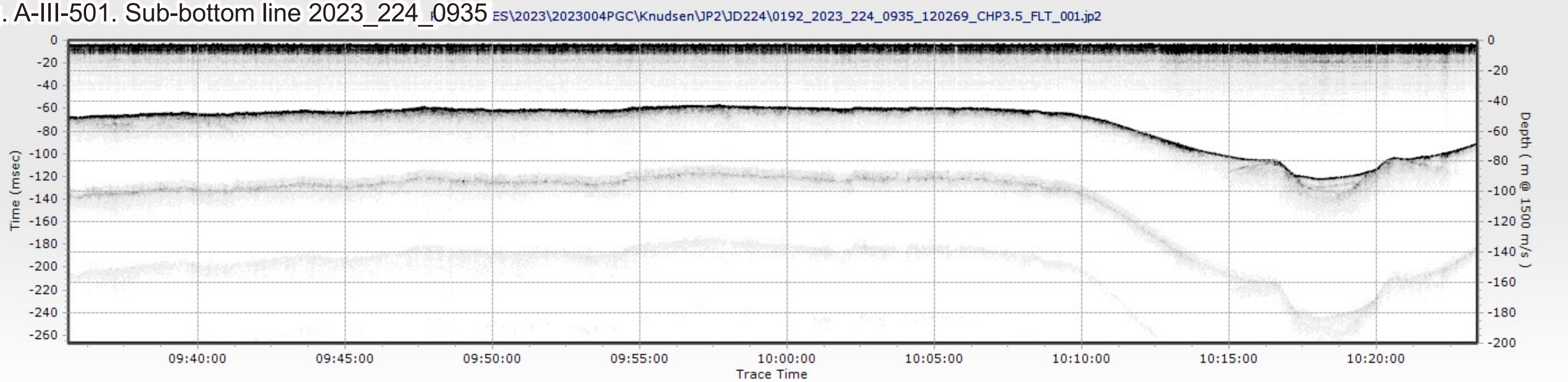

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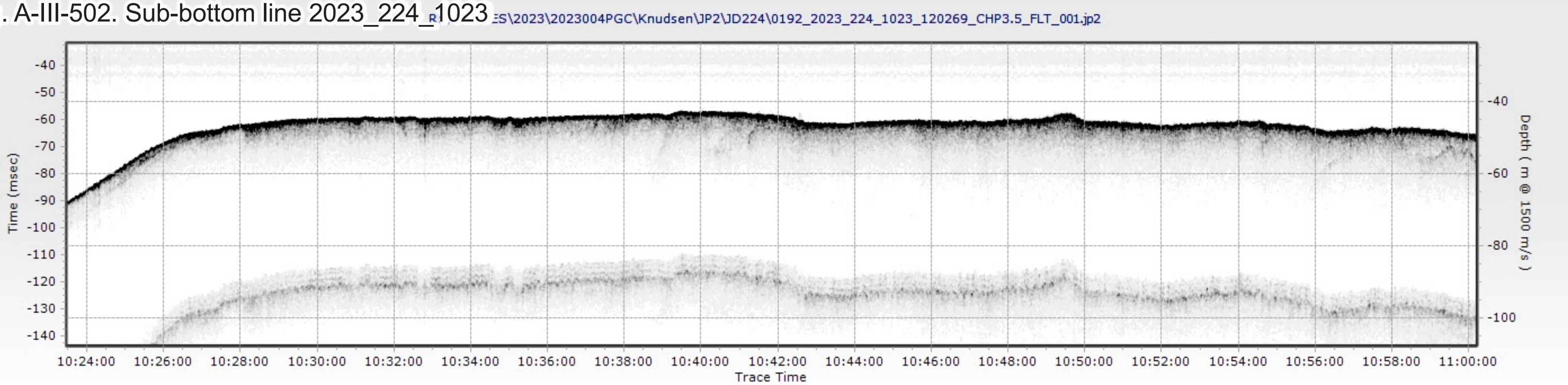

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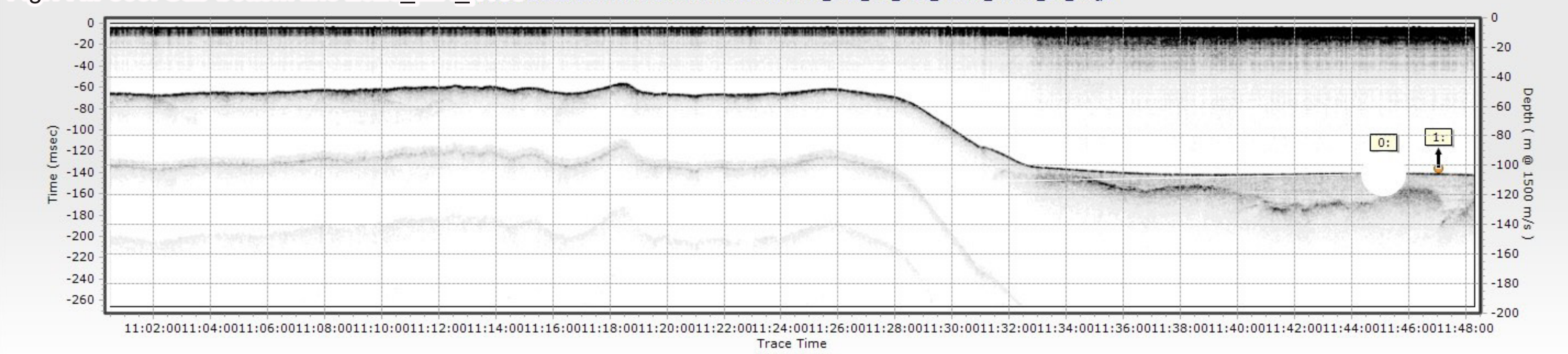

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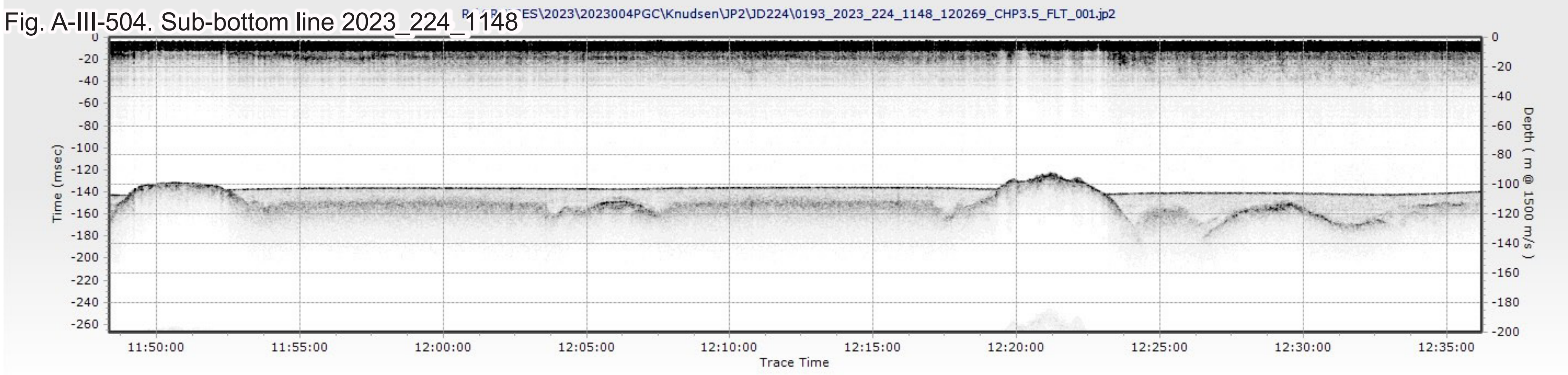

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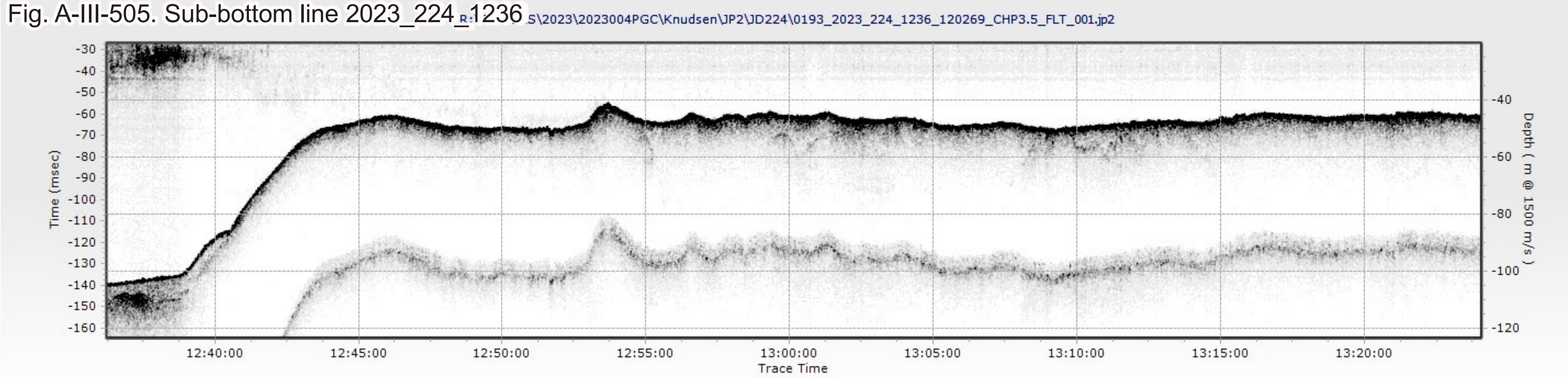

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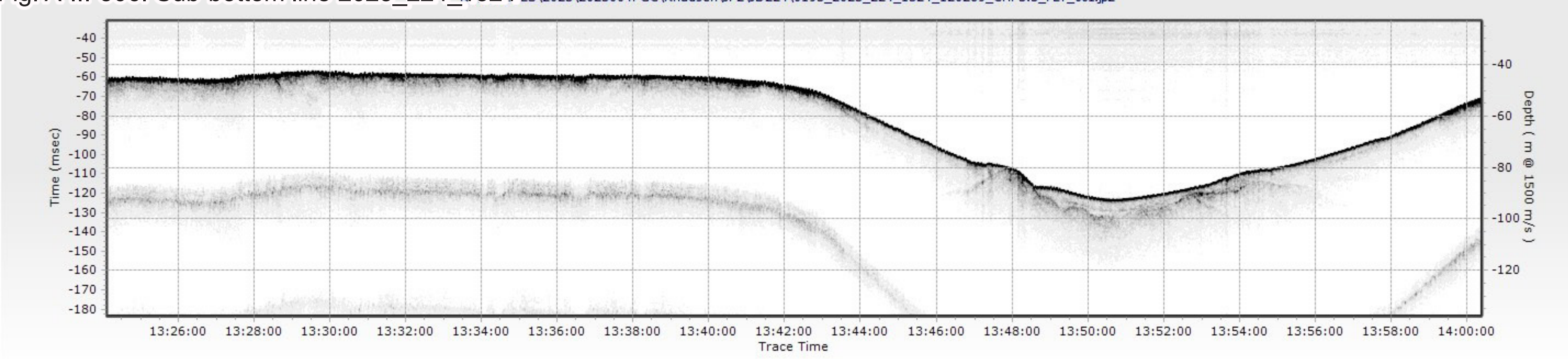

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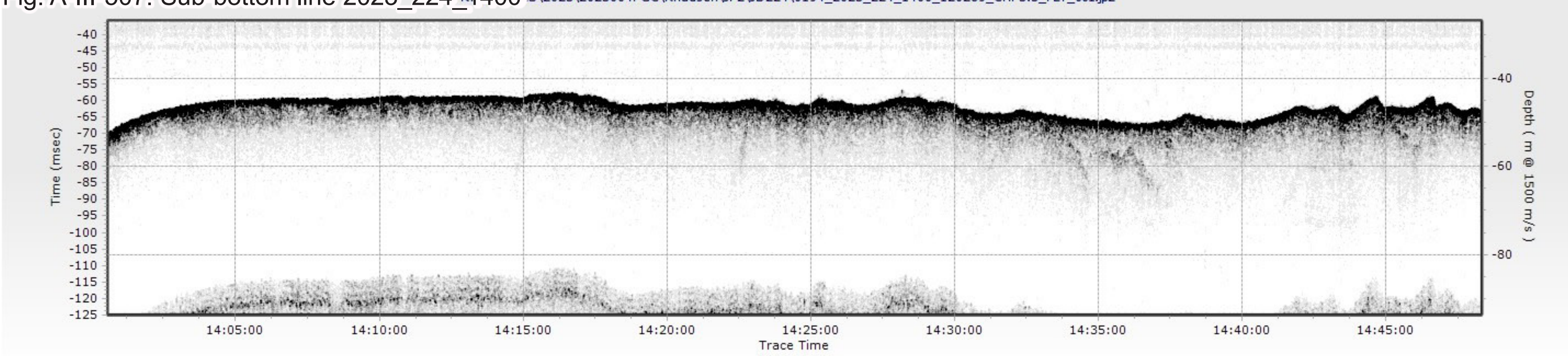
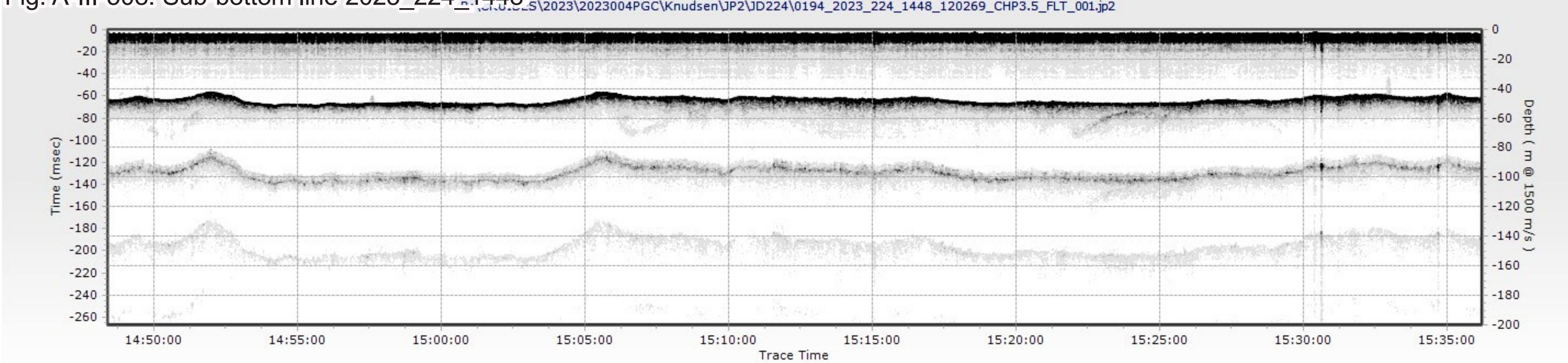


Fig. A-III-508. Sub-bottom line 2023_224_1448



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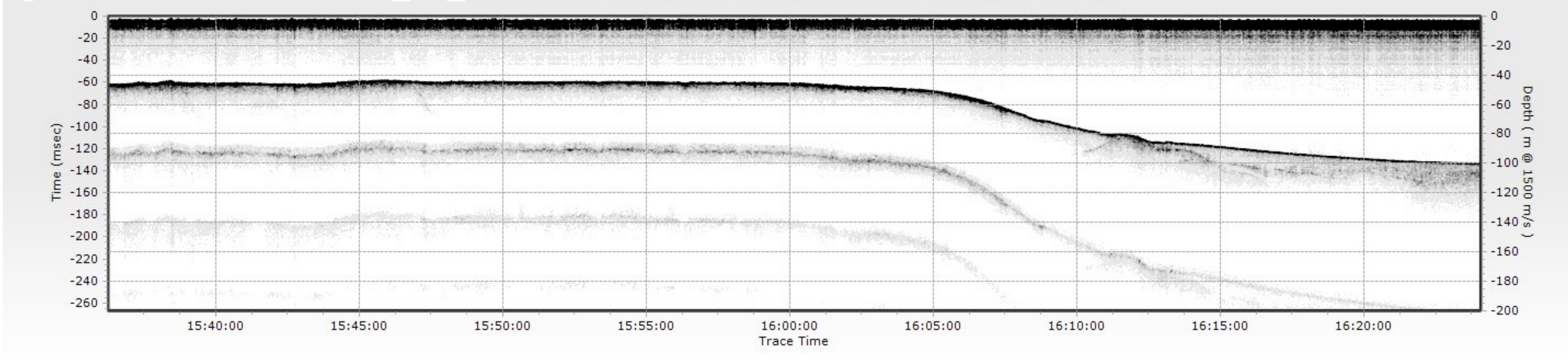

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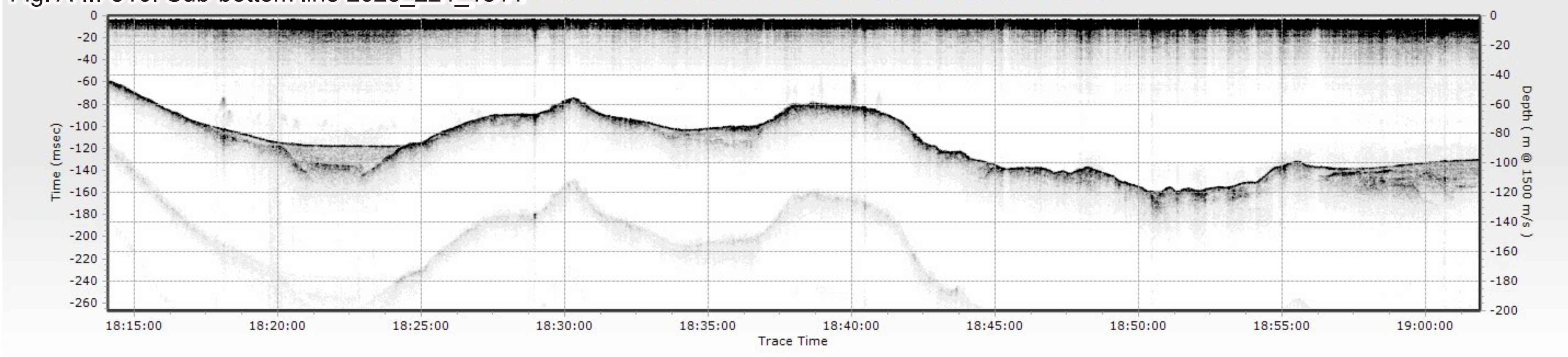

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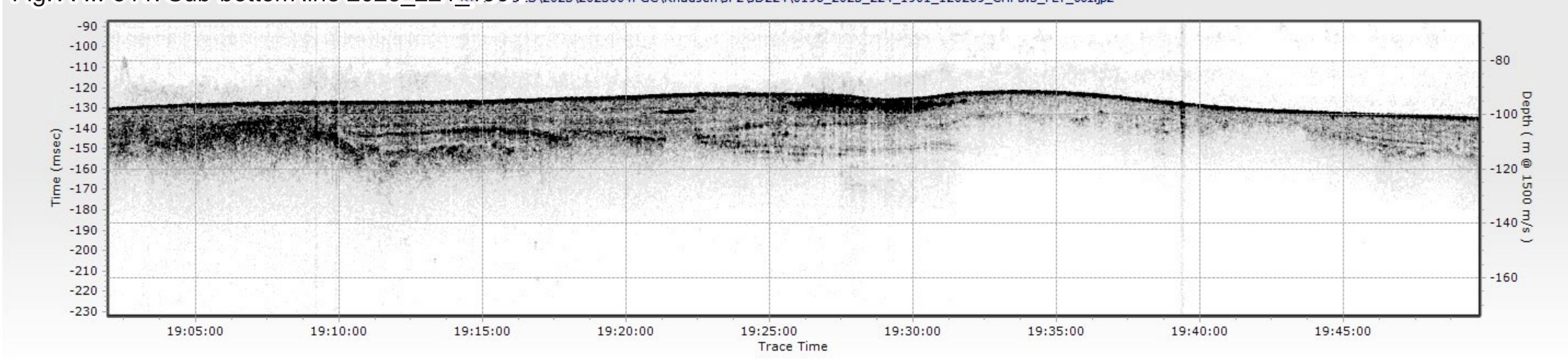

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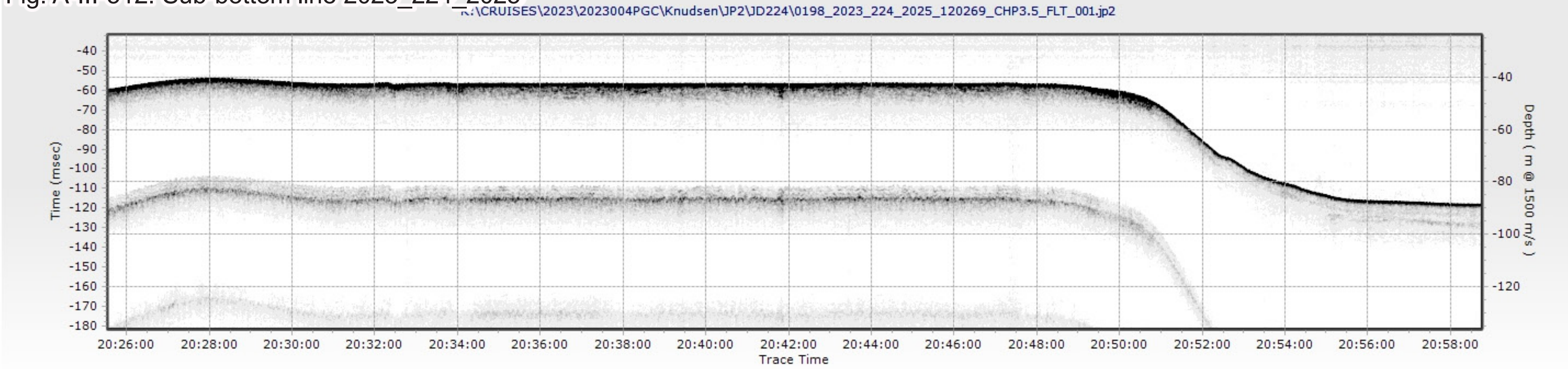

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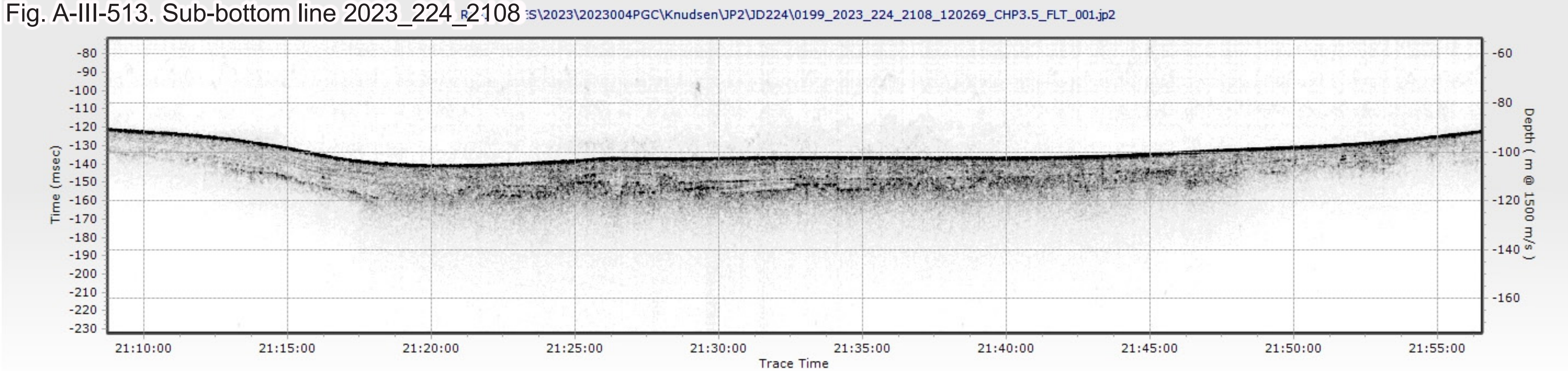

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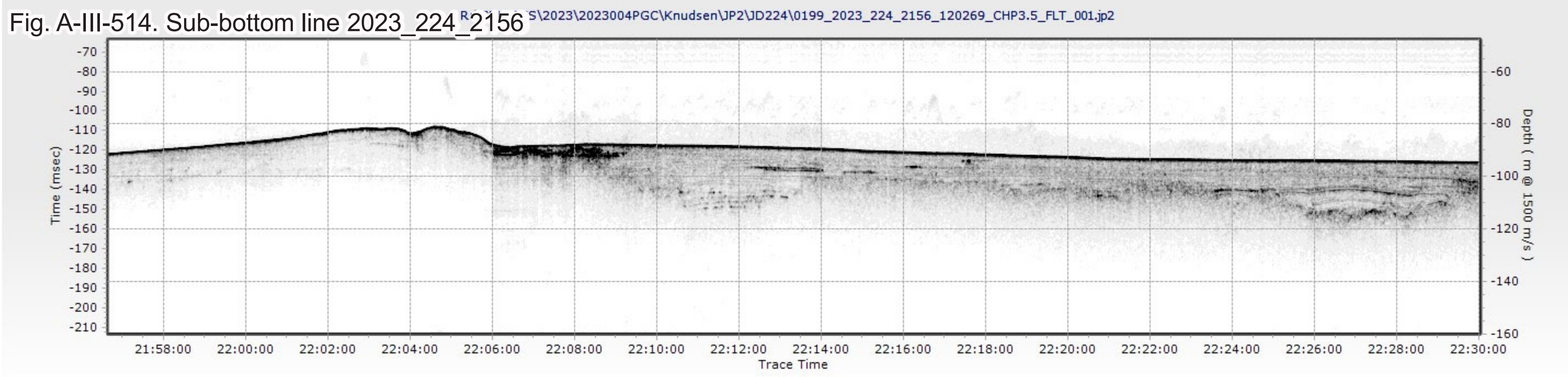

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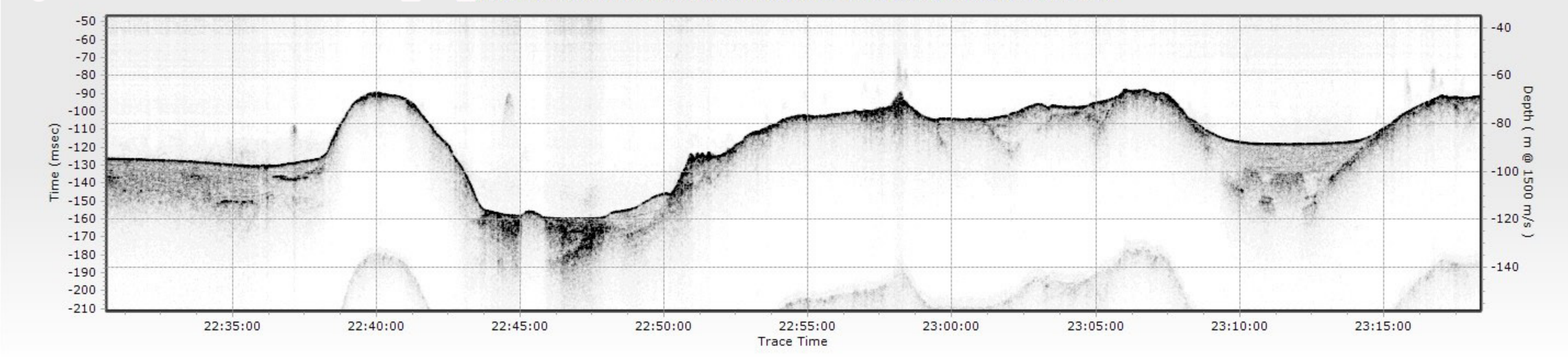

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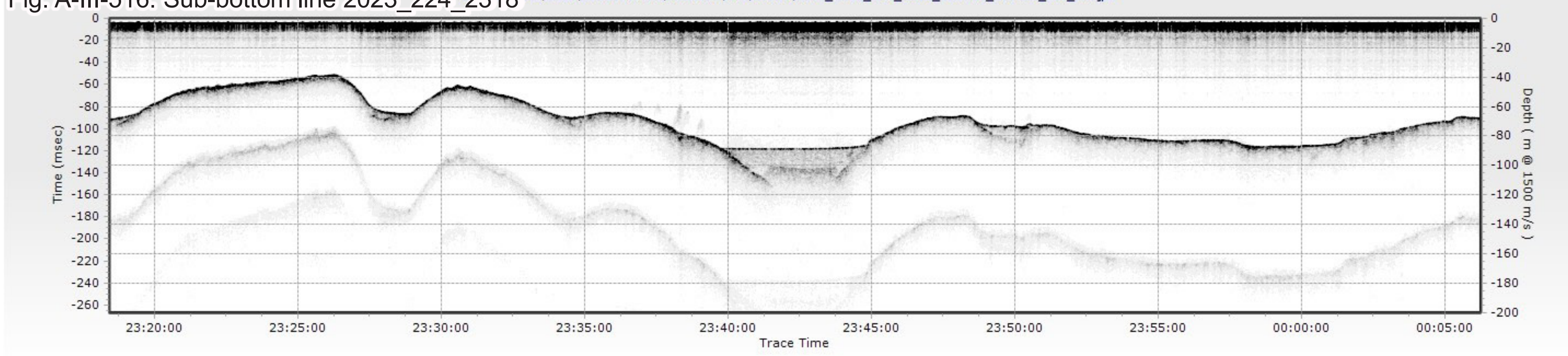

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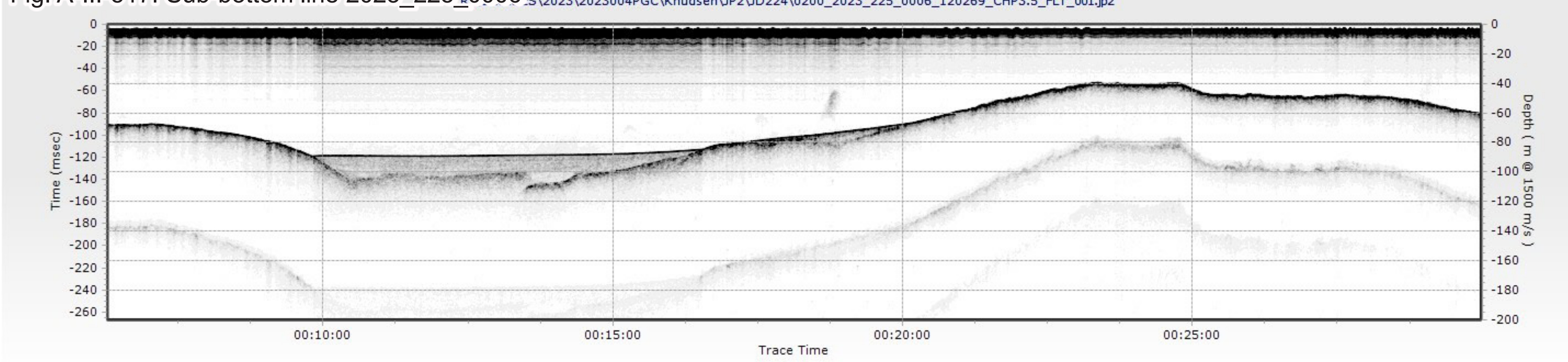

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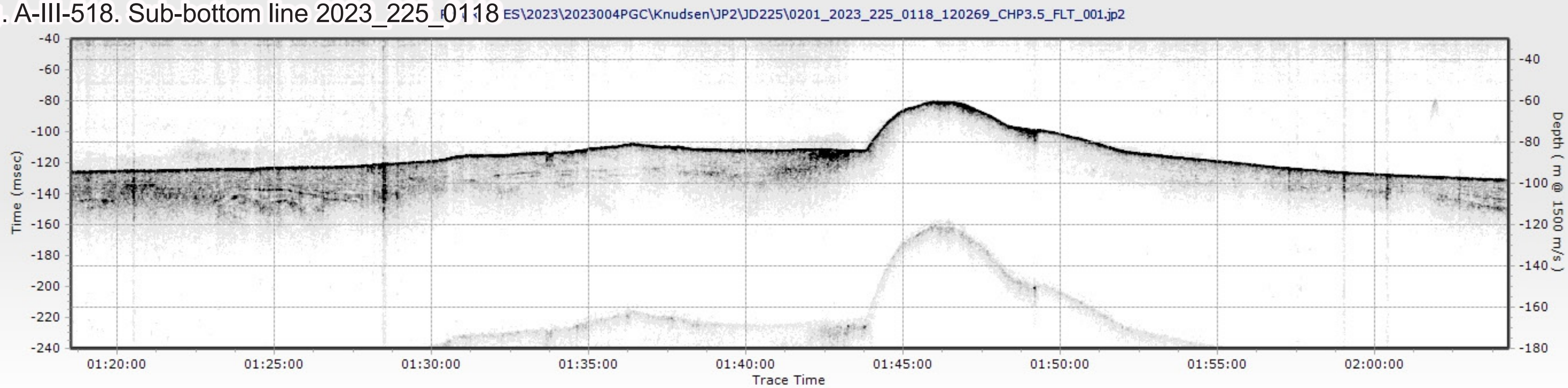

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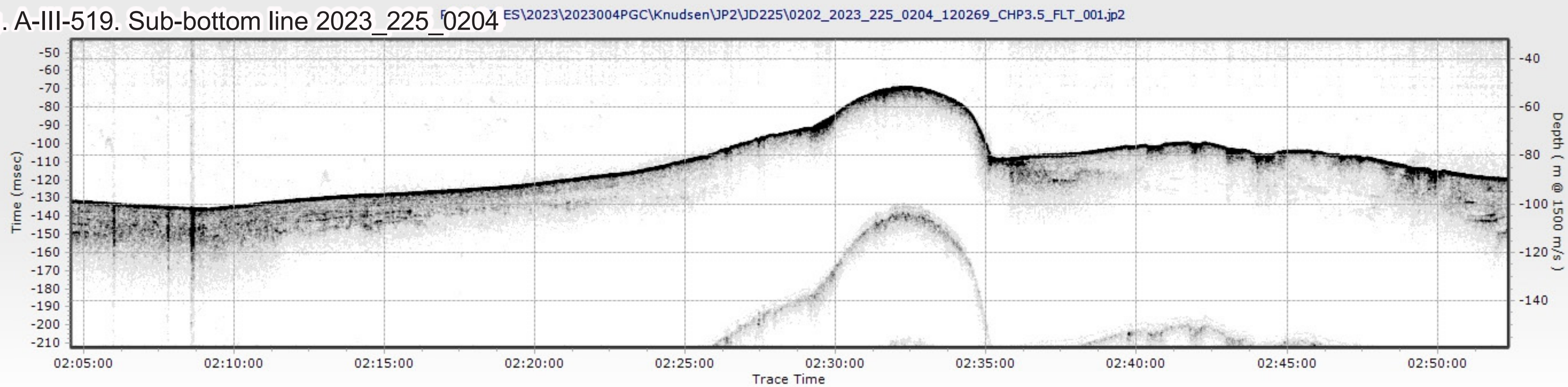

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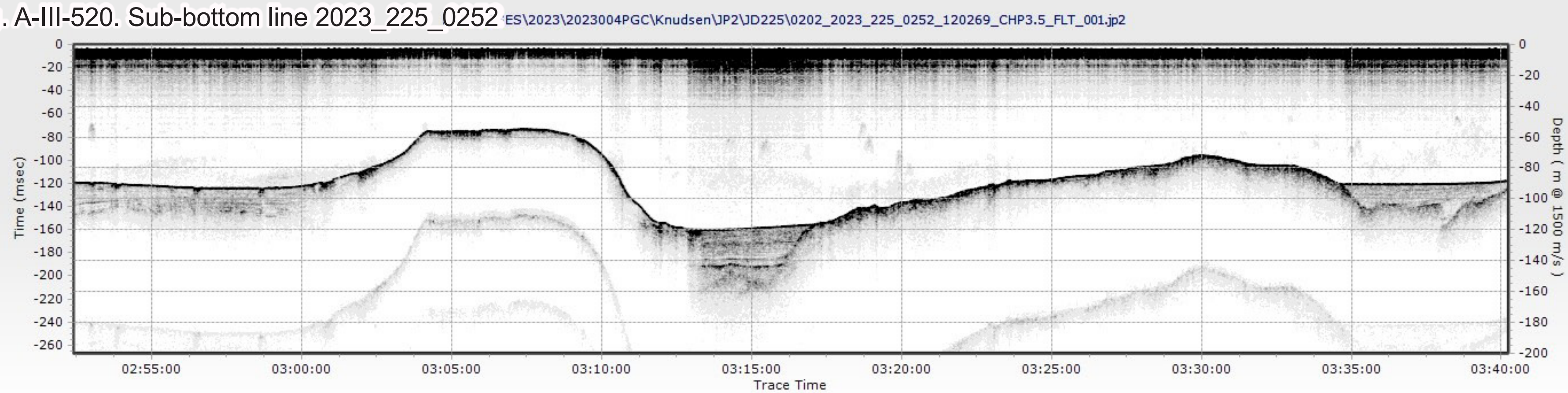

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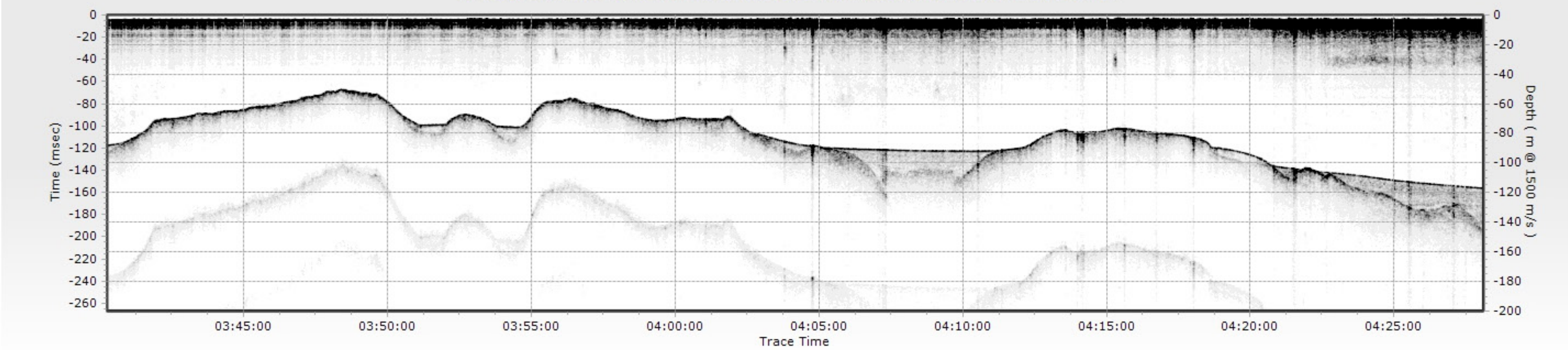

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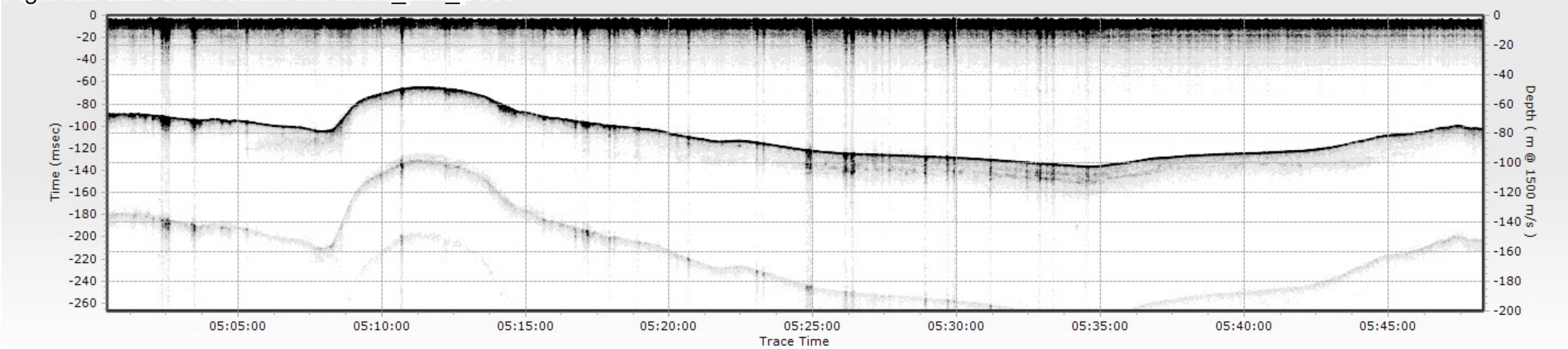

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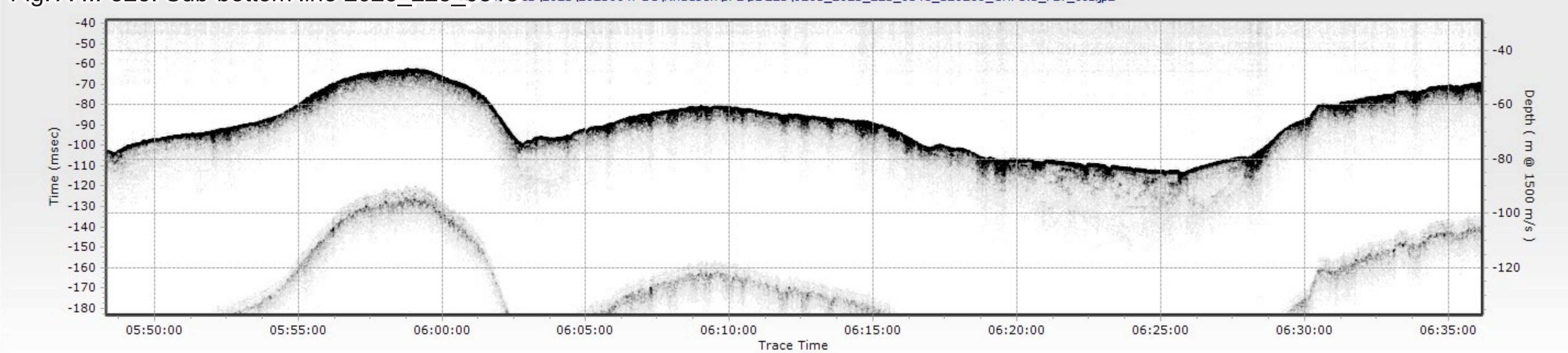

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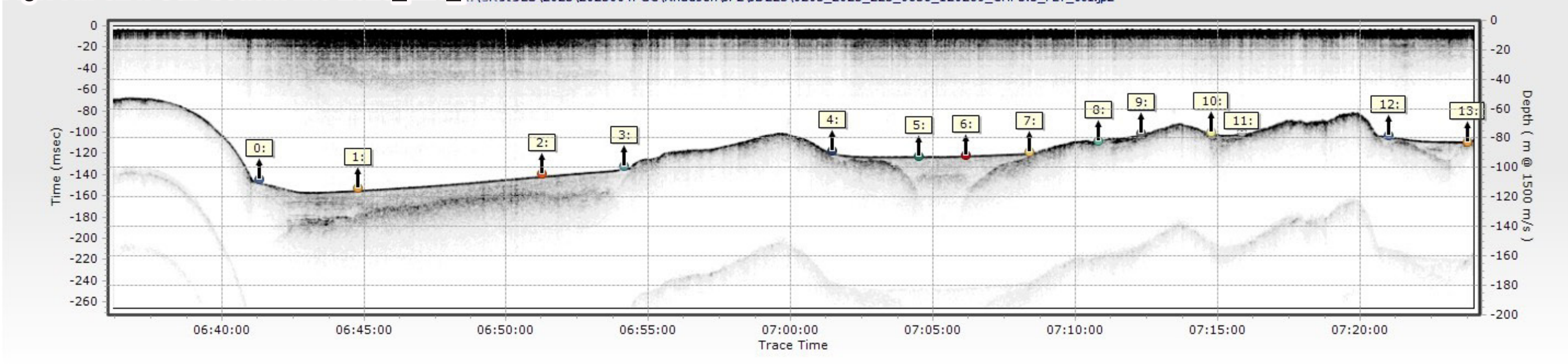

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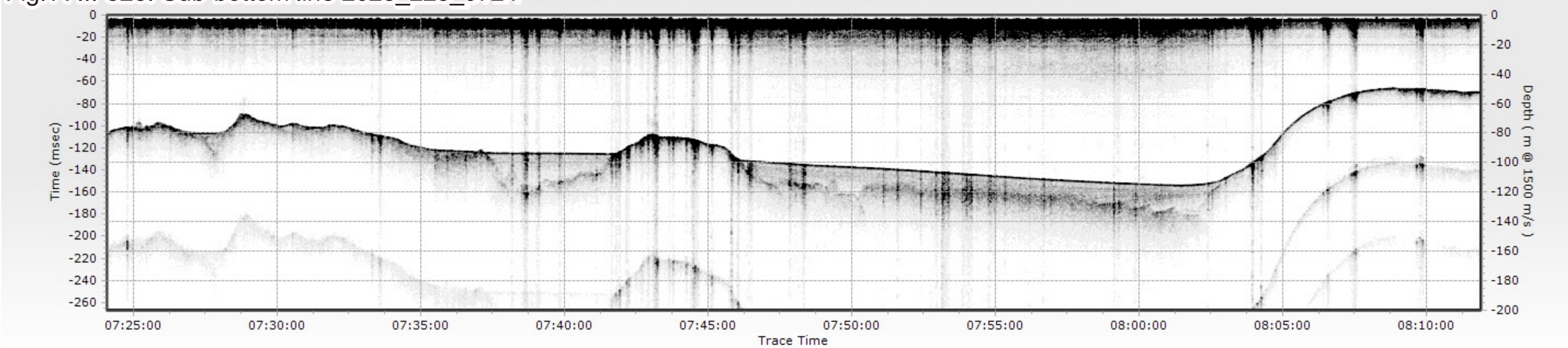

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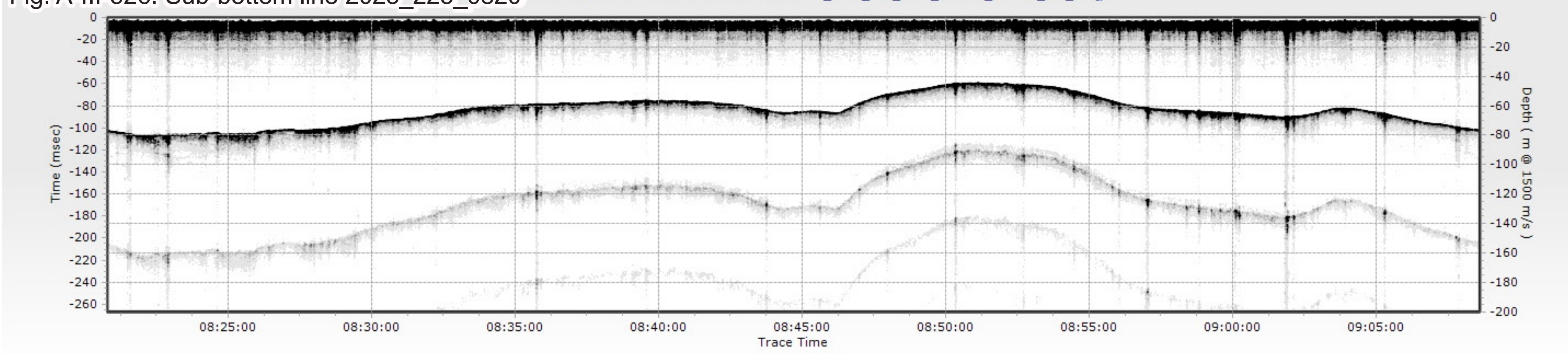

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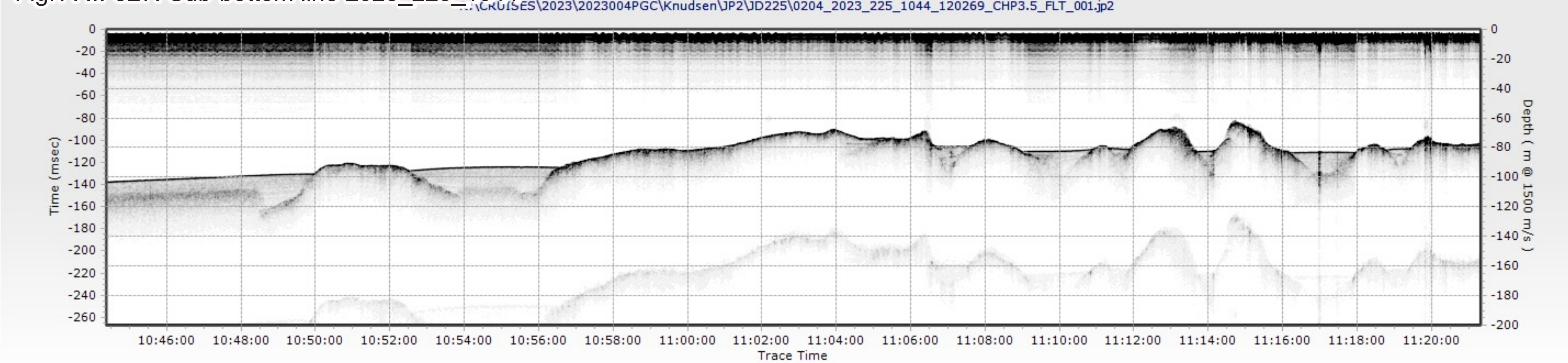

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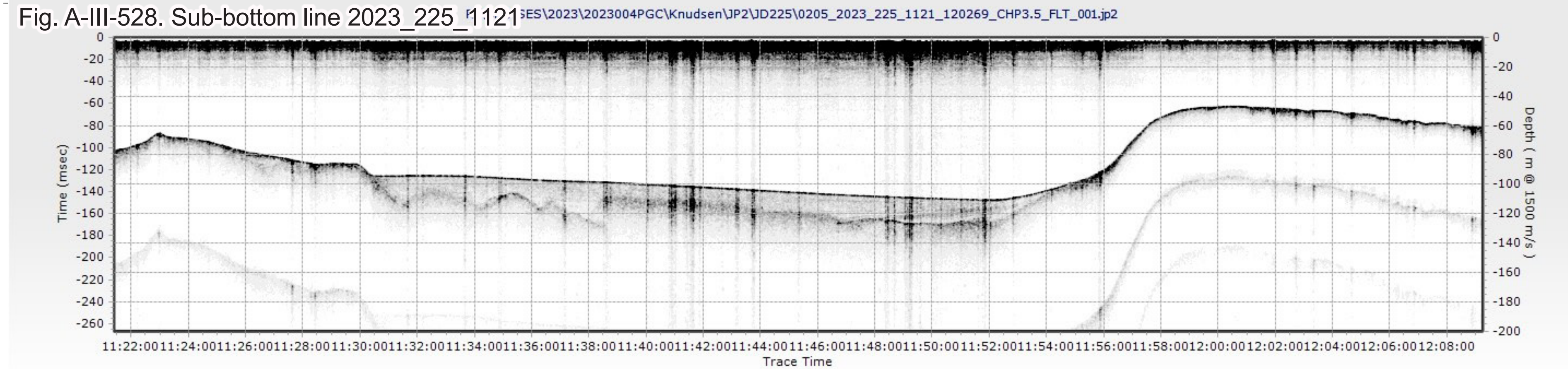

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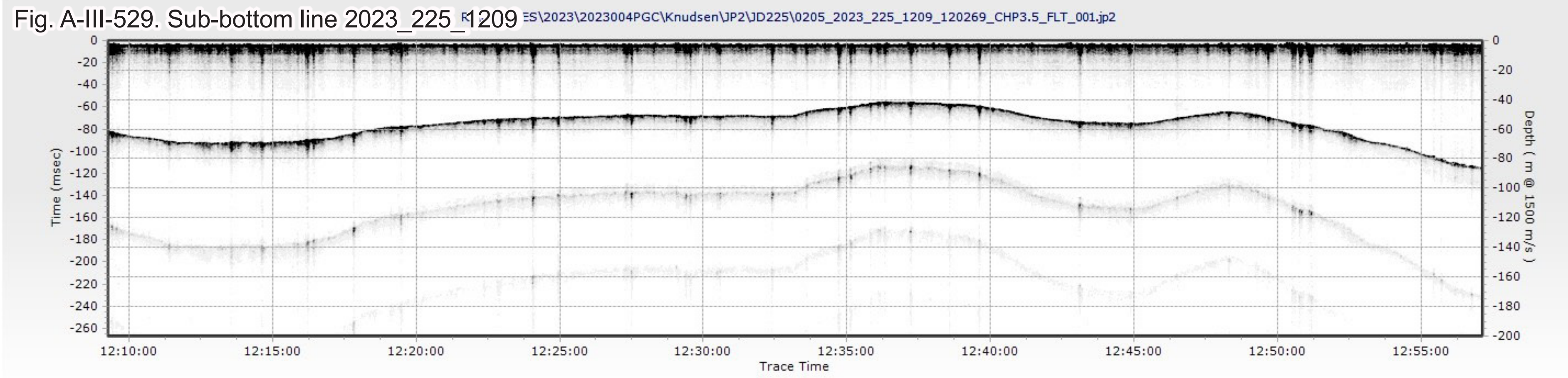

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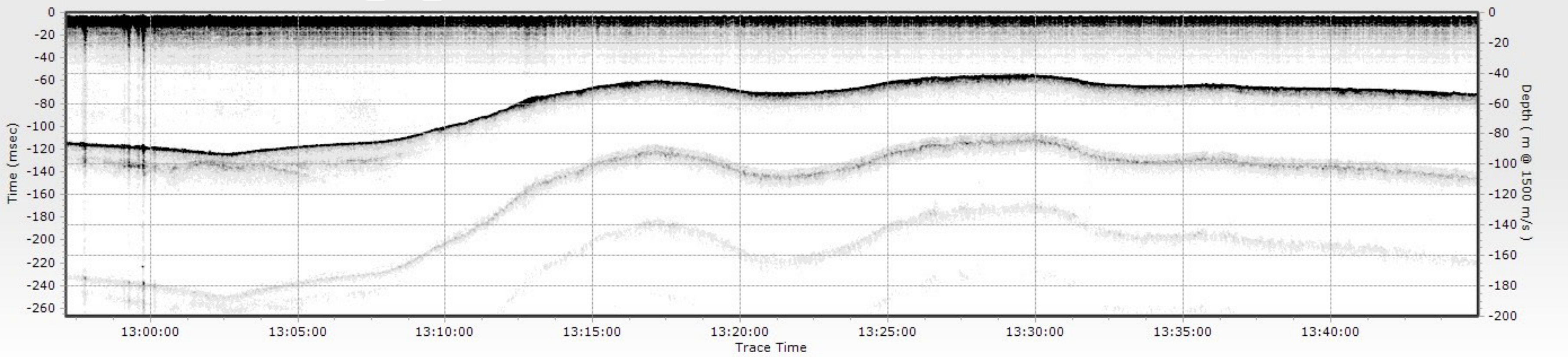

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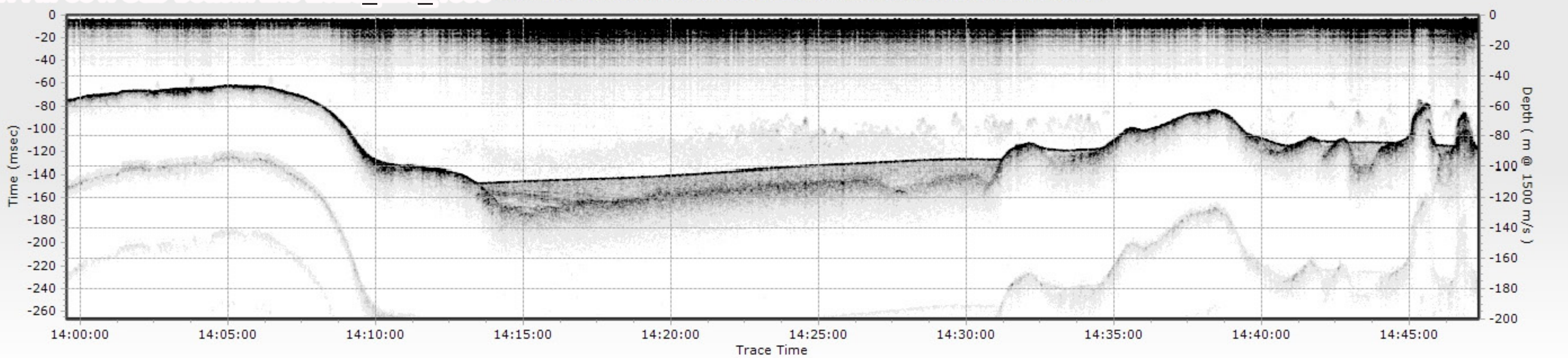

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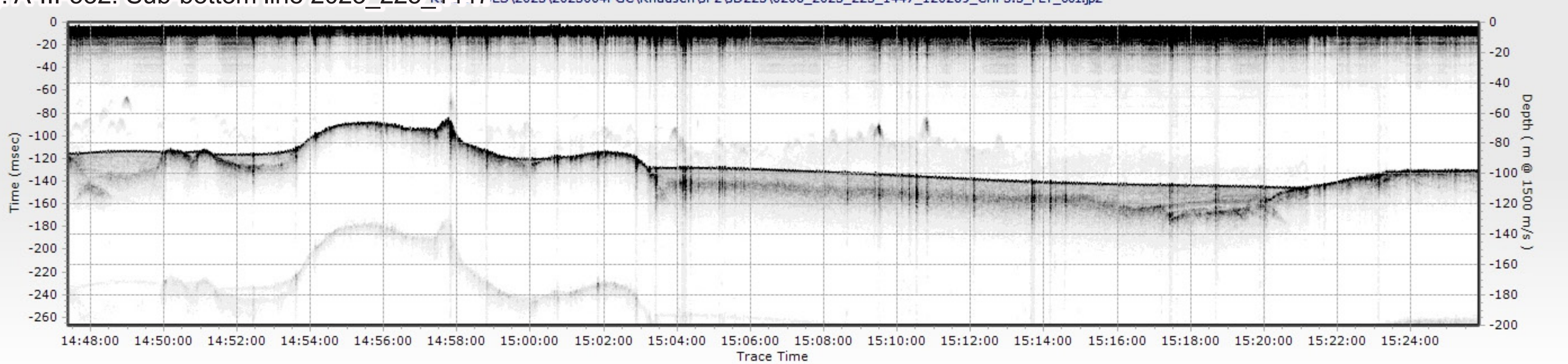

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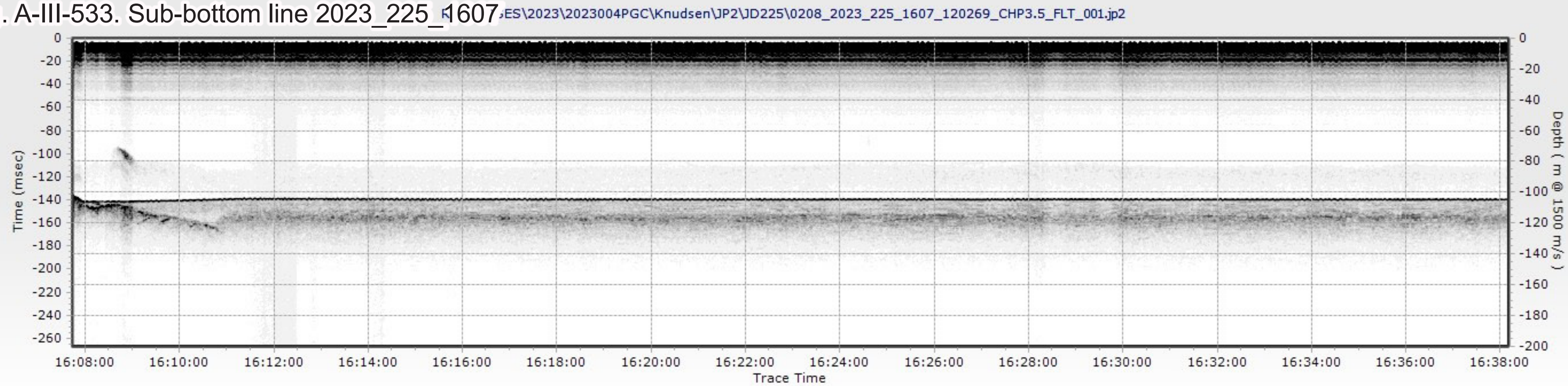

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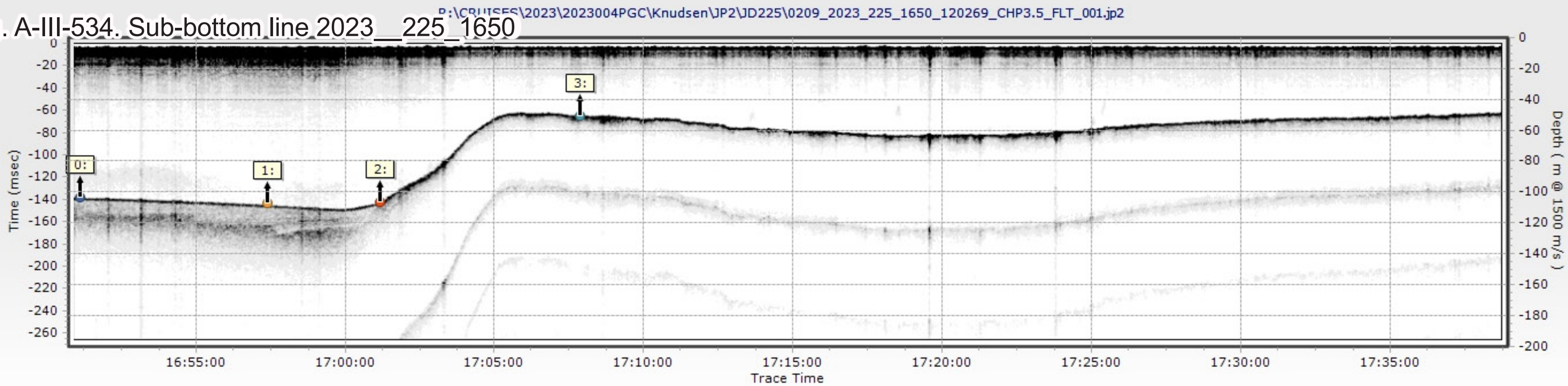

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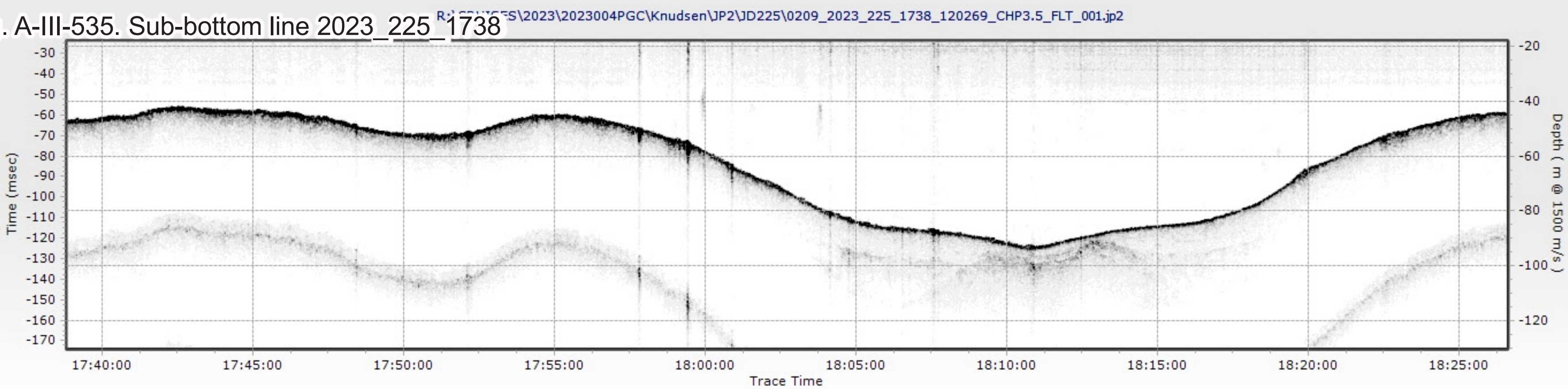

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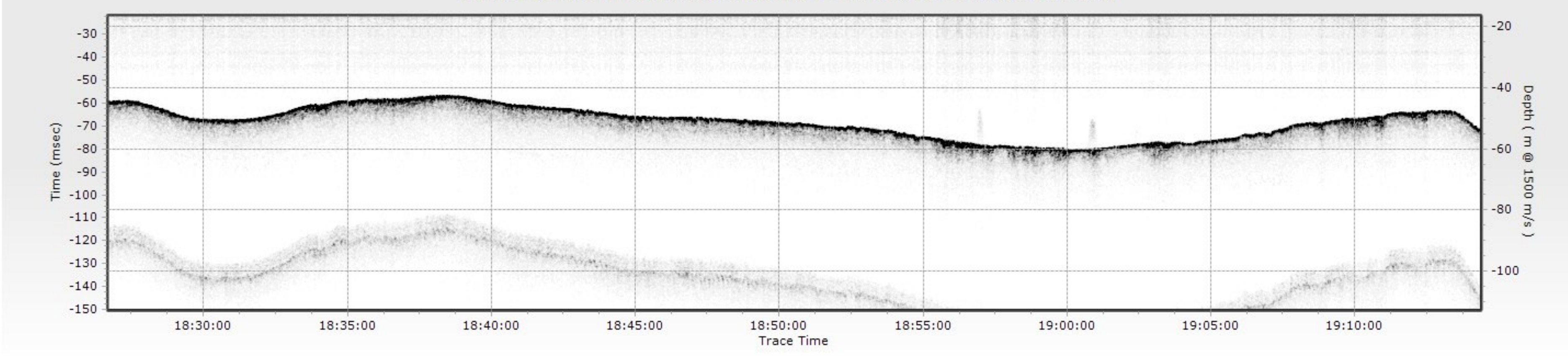

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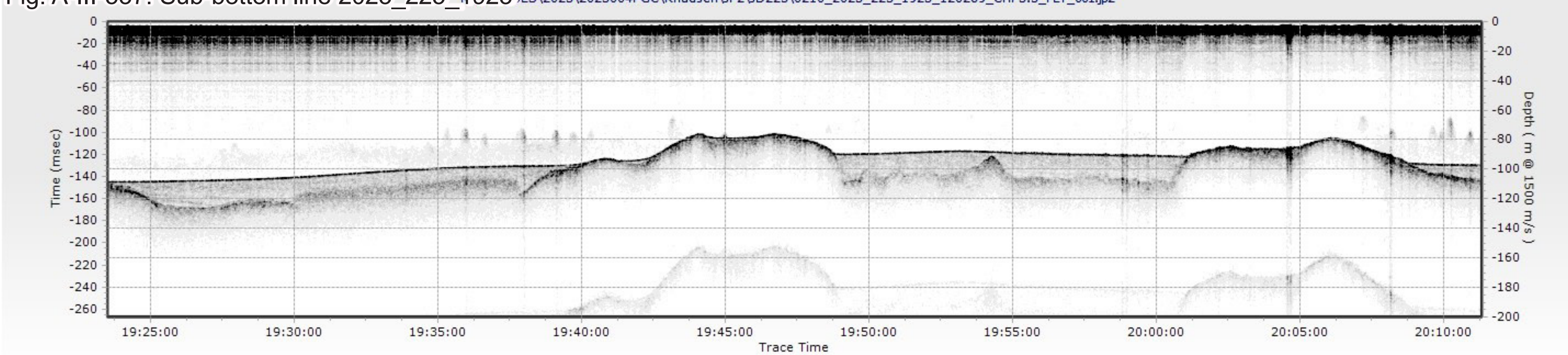

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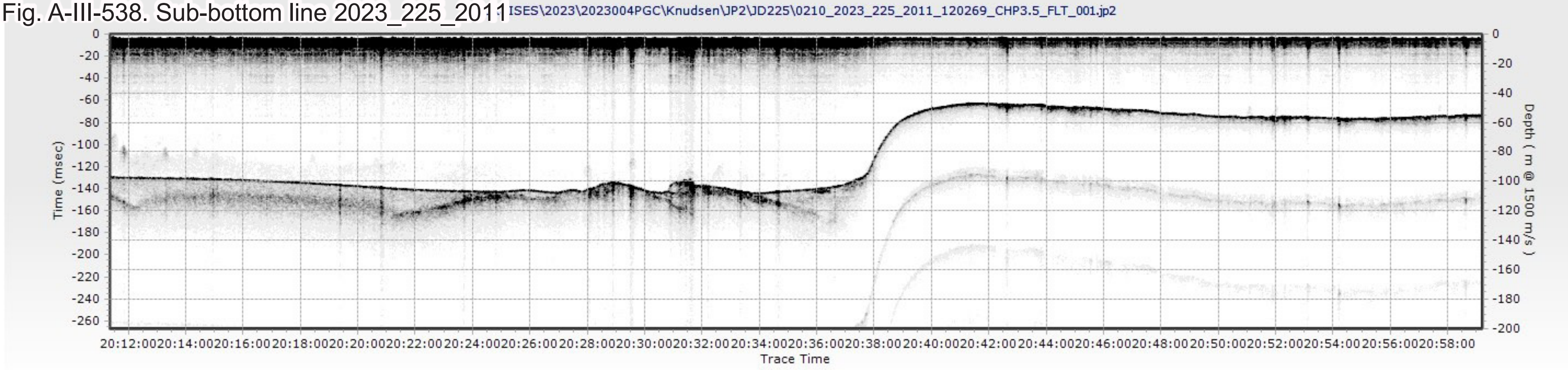

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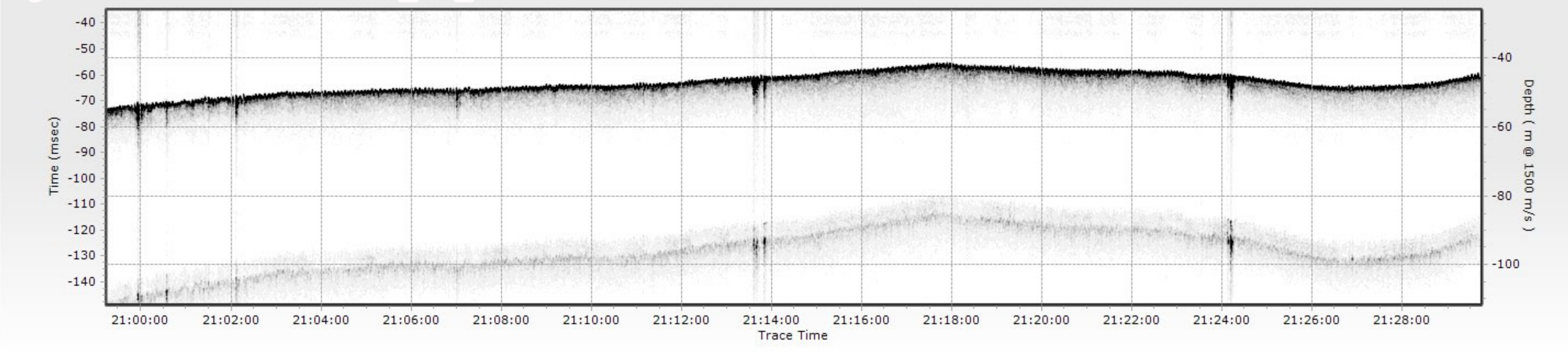

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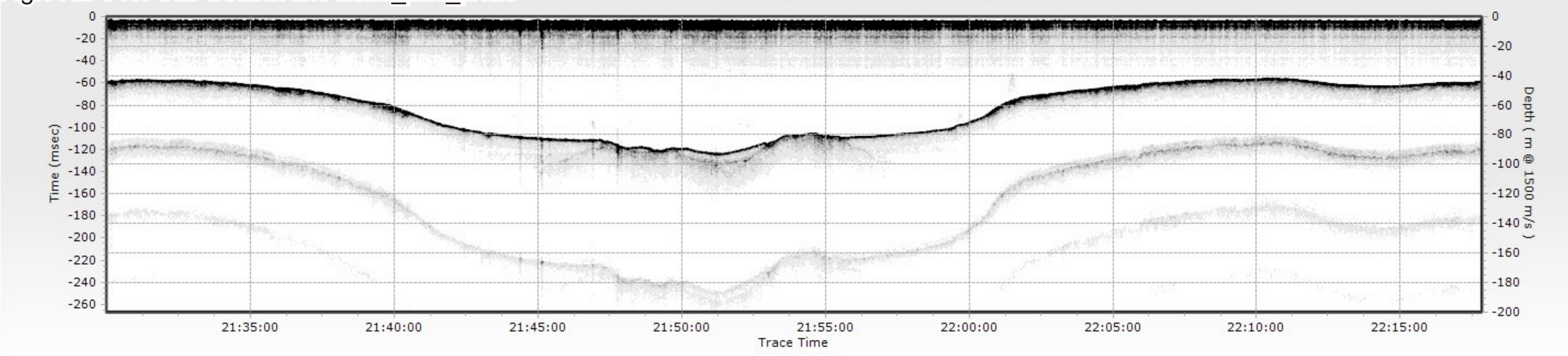

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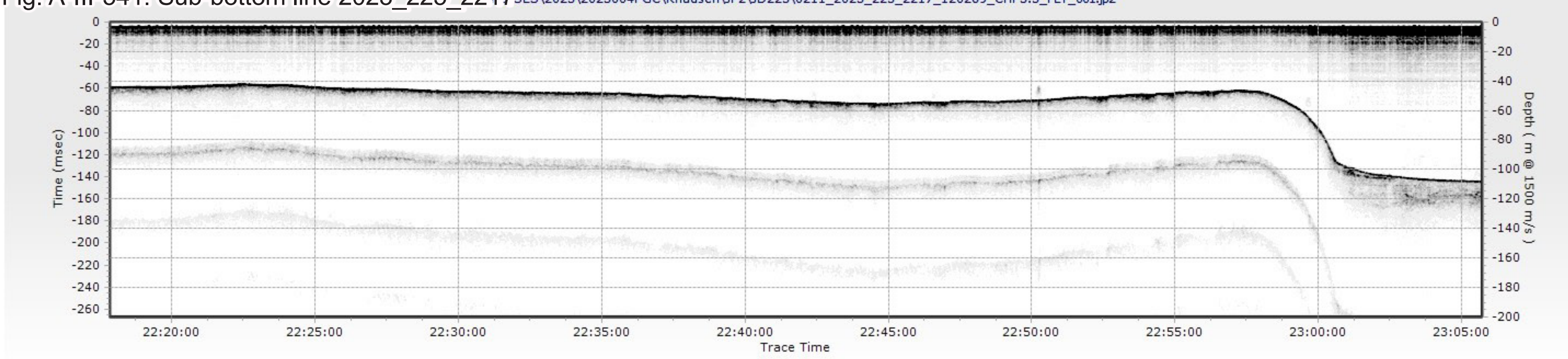

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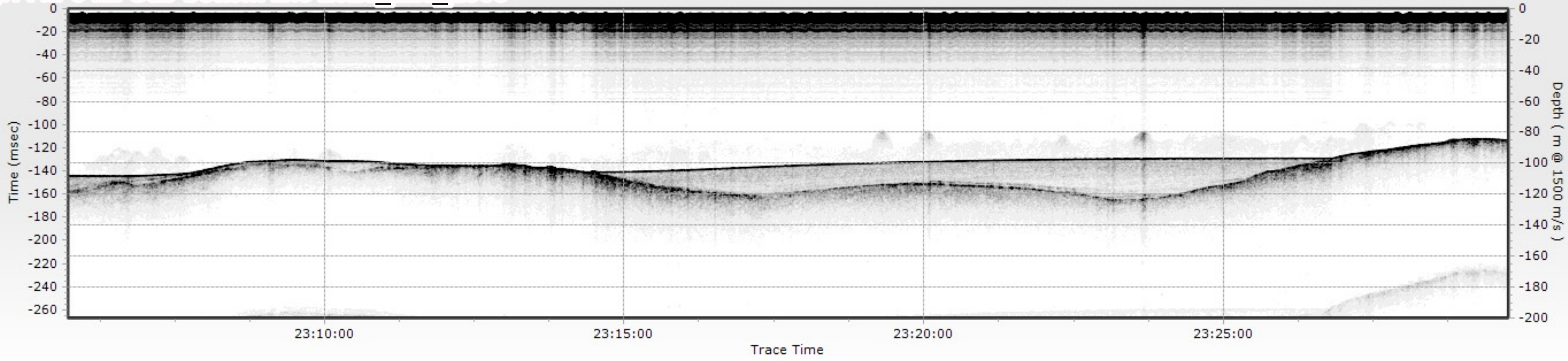

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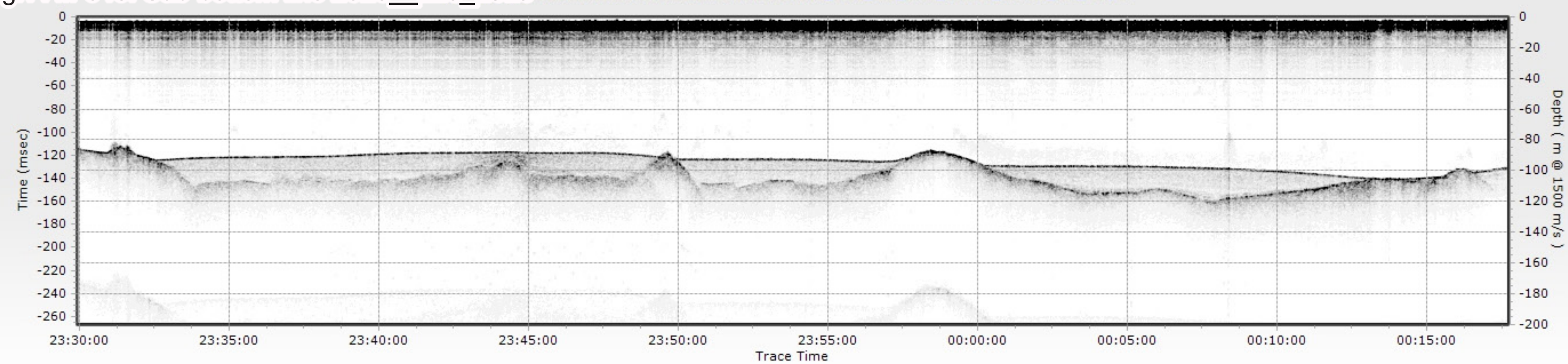

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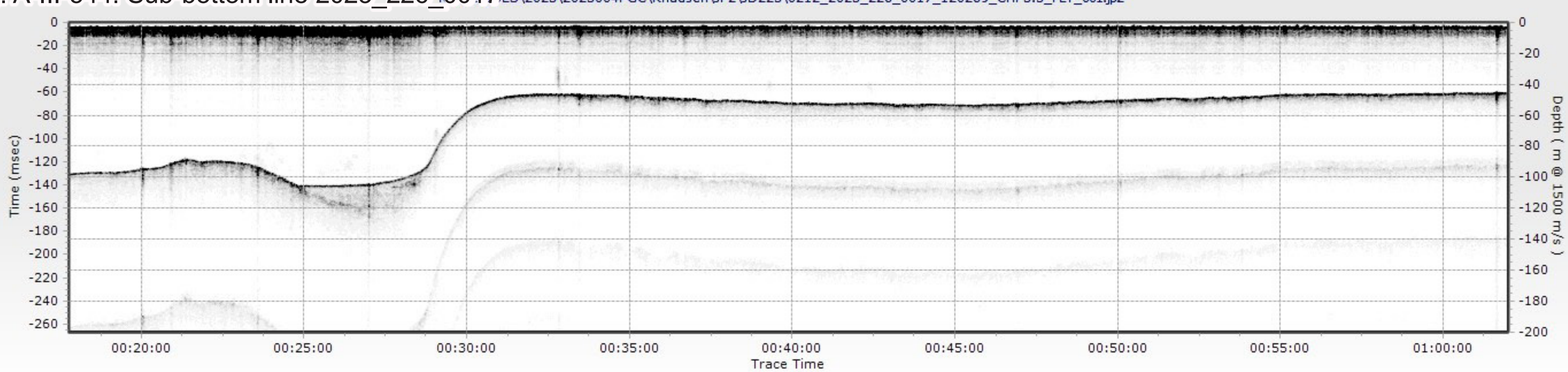

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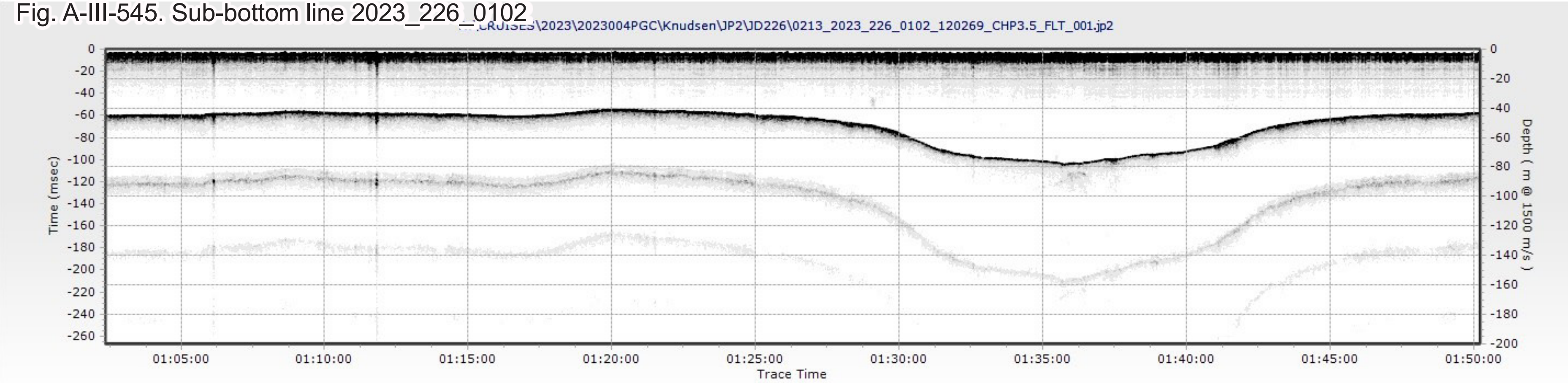
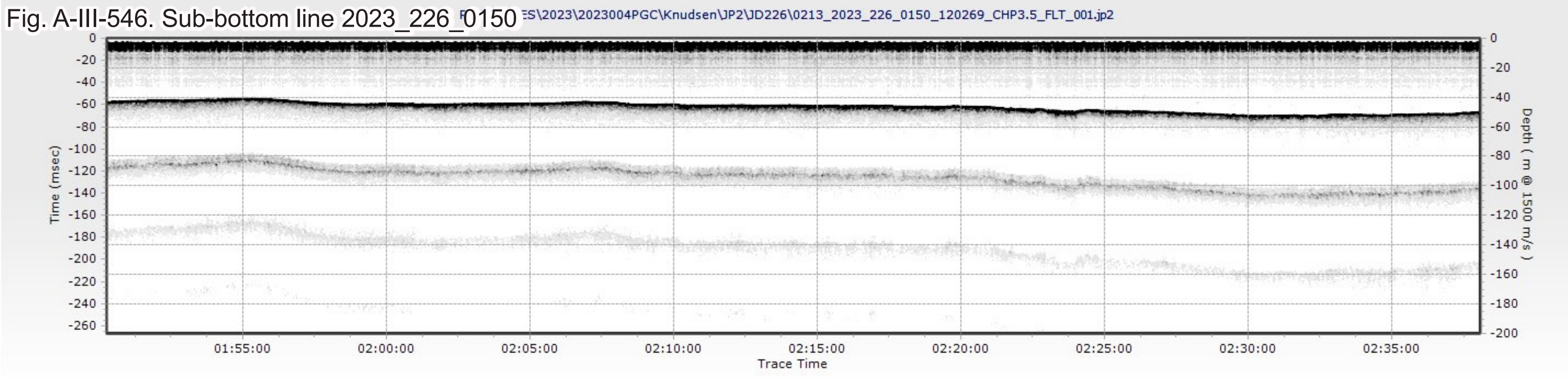


Fig. A-III-546. Sub-bottom line 2023_226_0150



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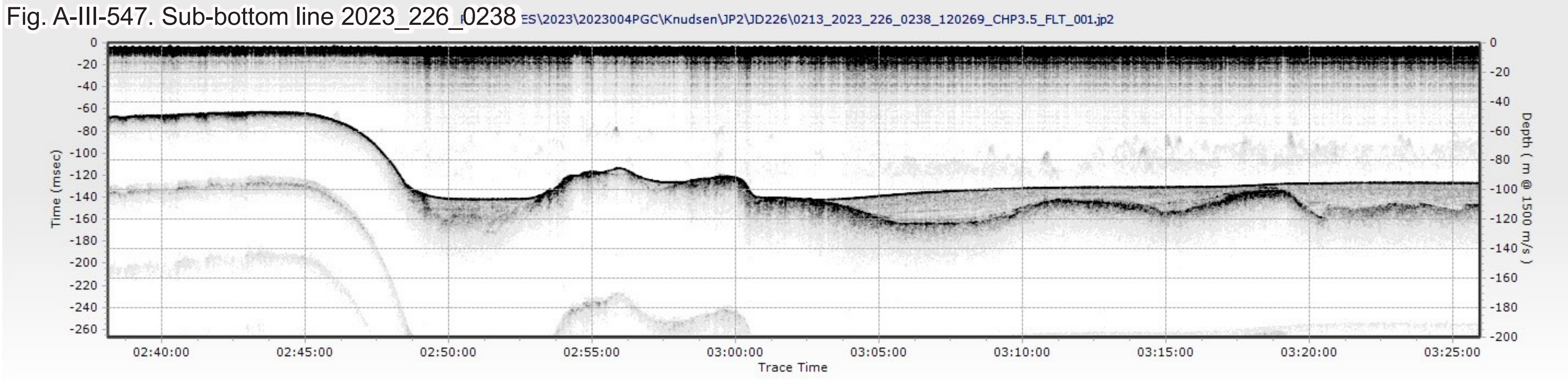

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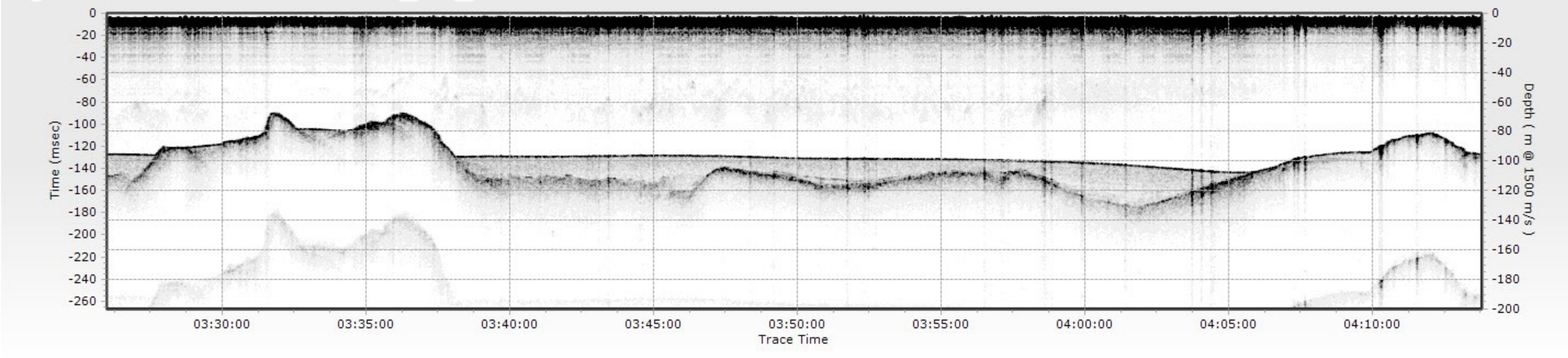

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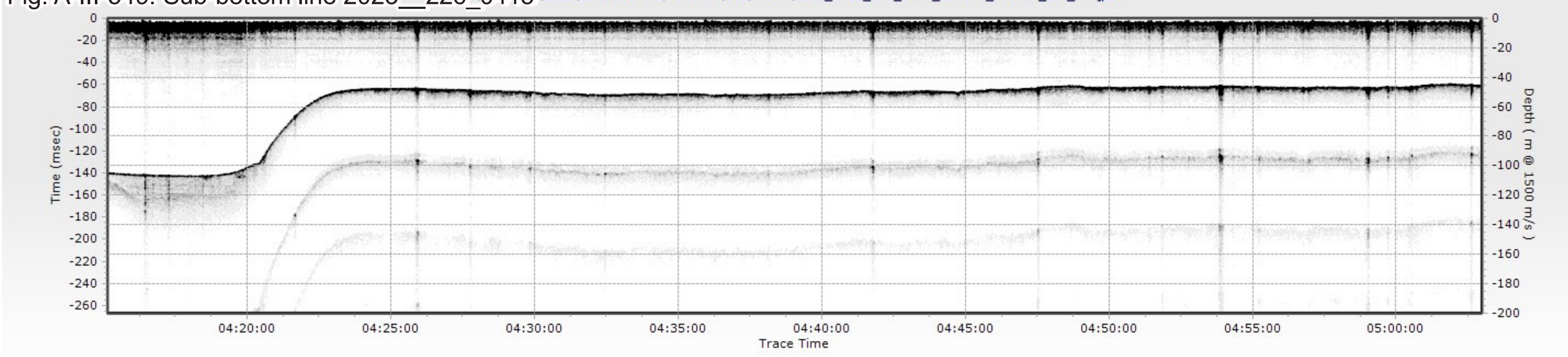

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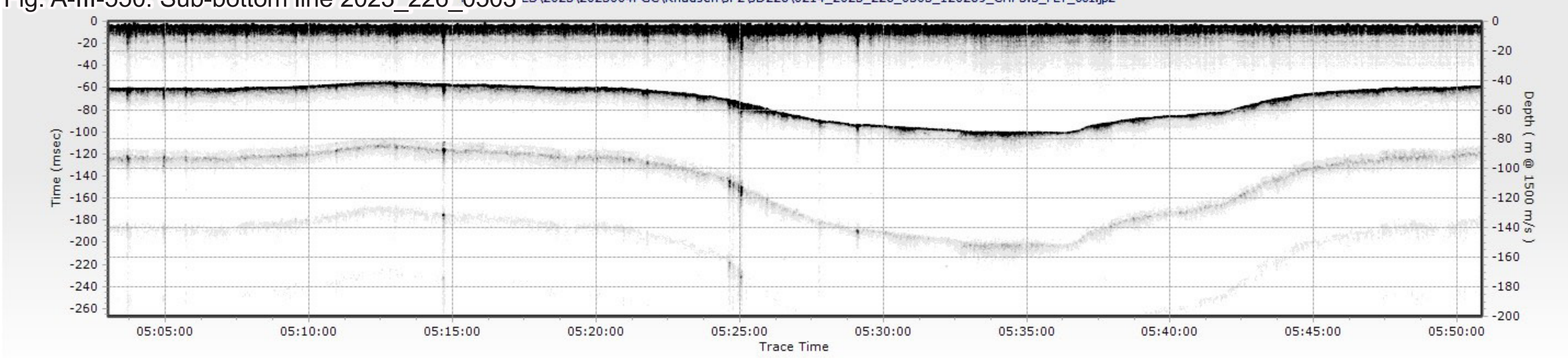

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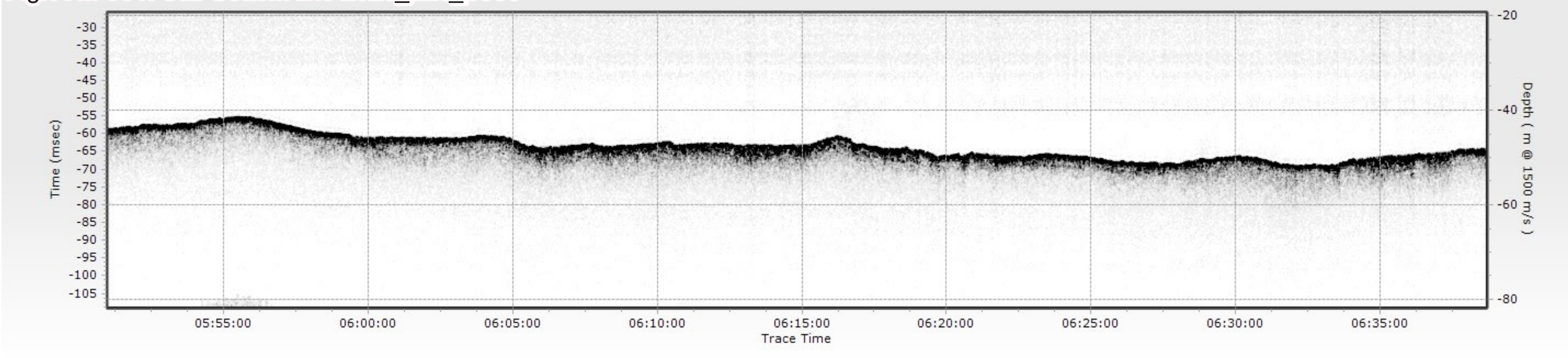

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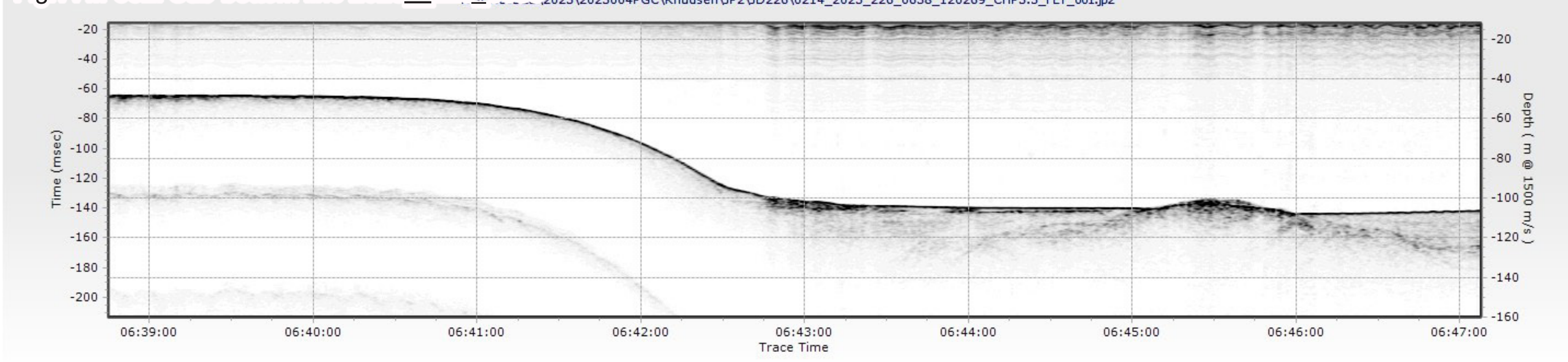

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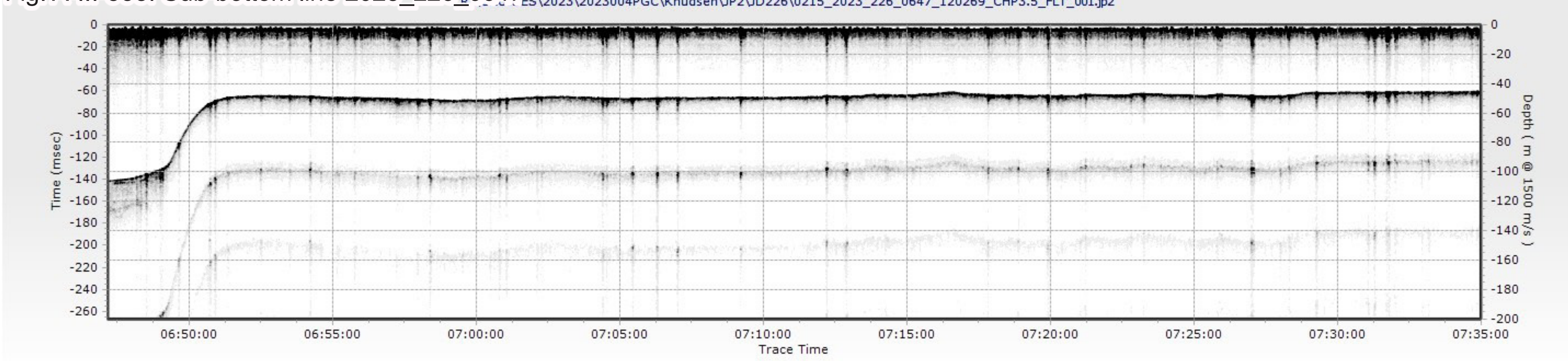

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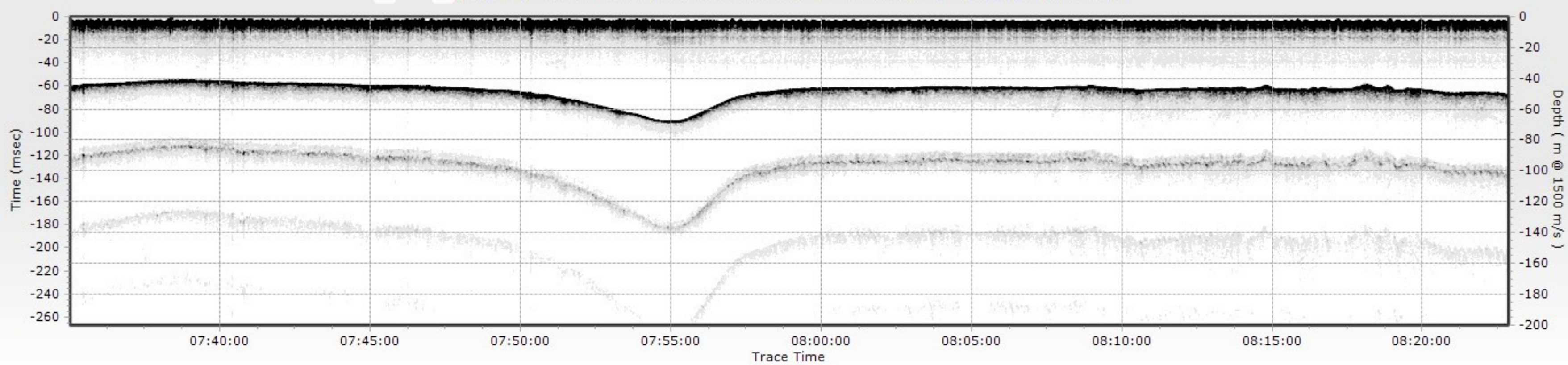
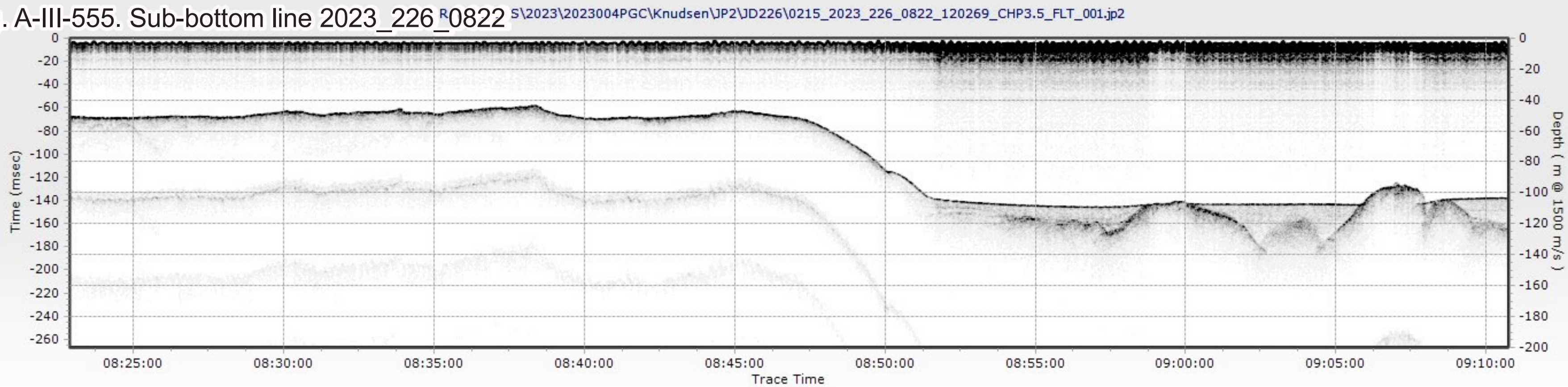


Fig. A-III-555. Sub-bottom line 2023_226_0822



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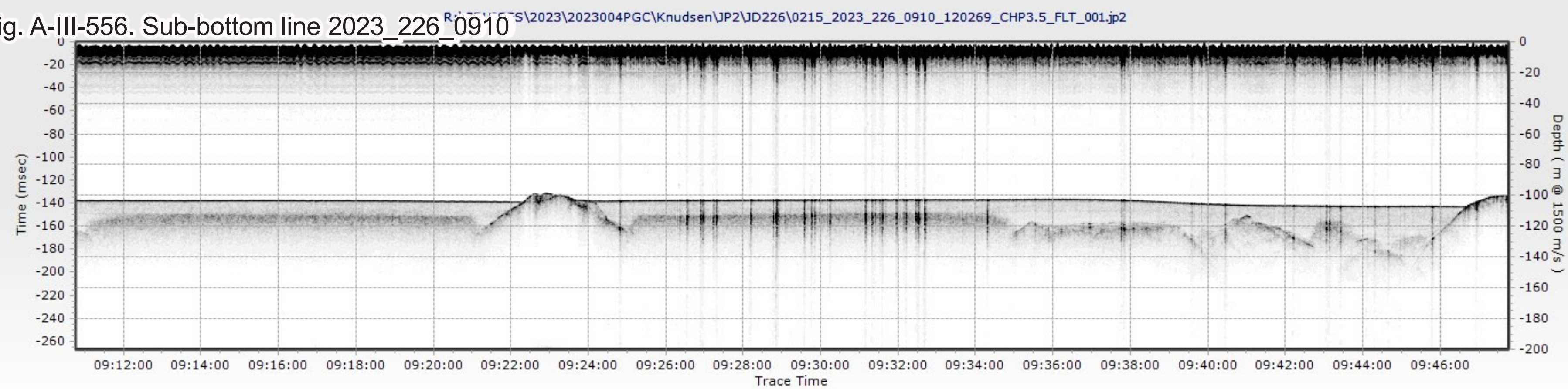

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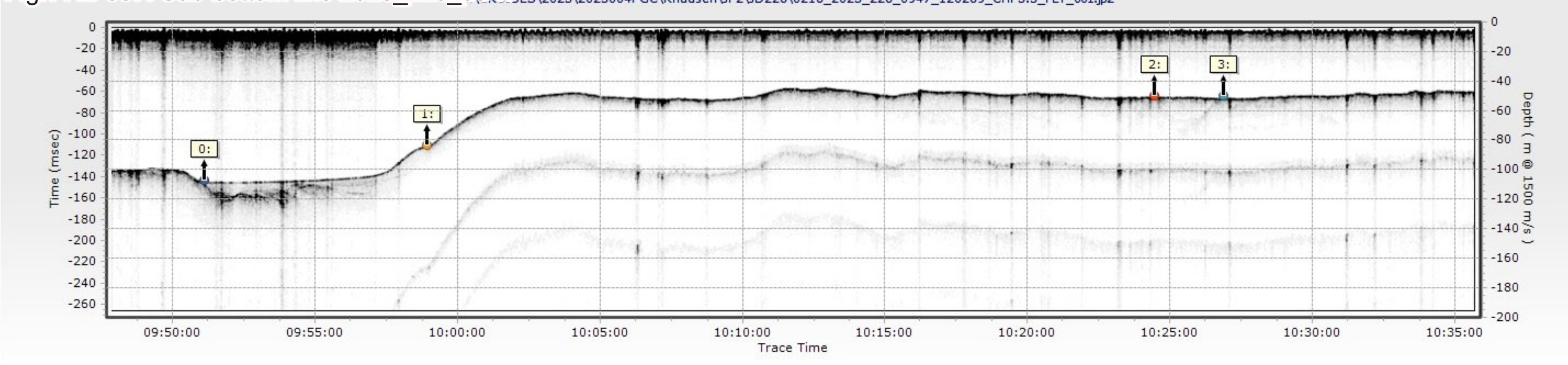

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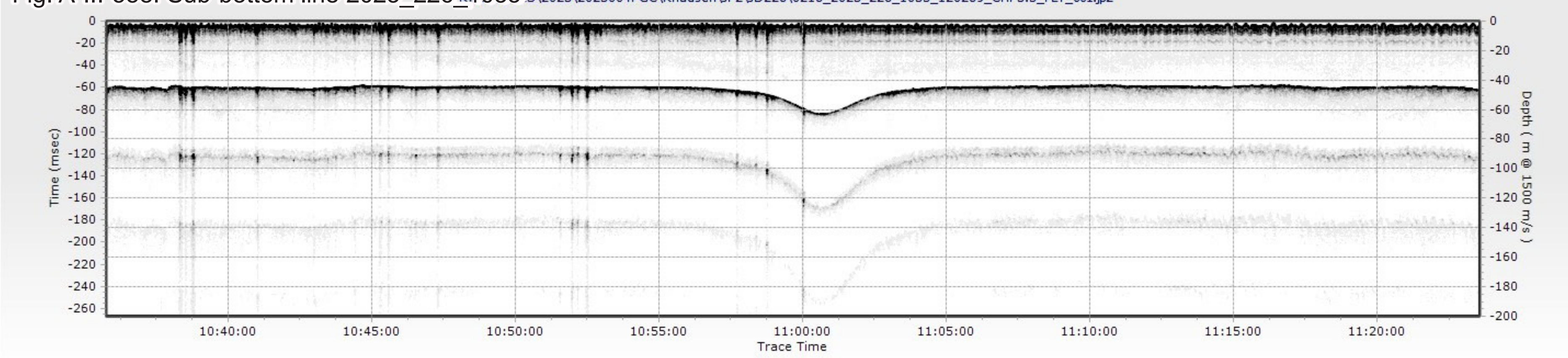

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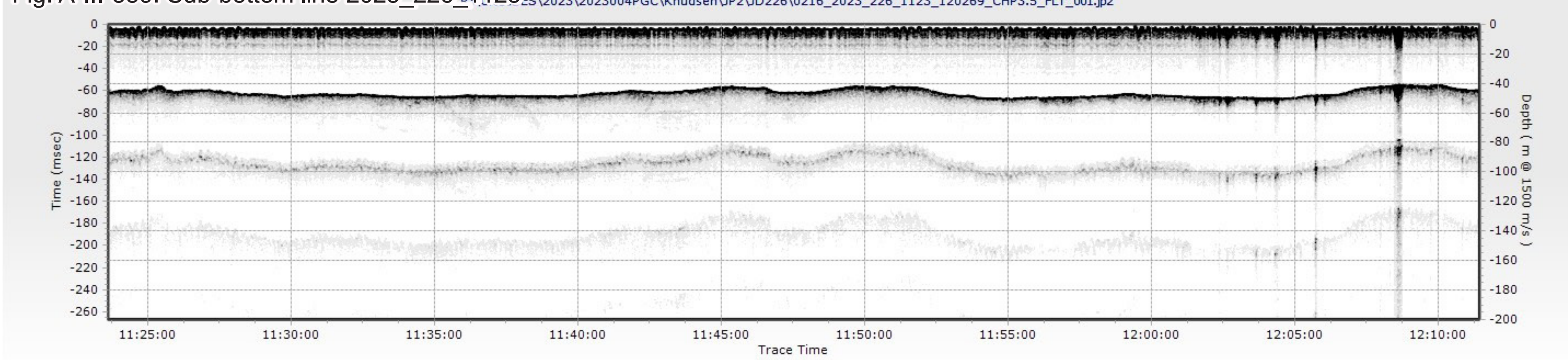

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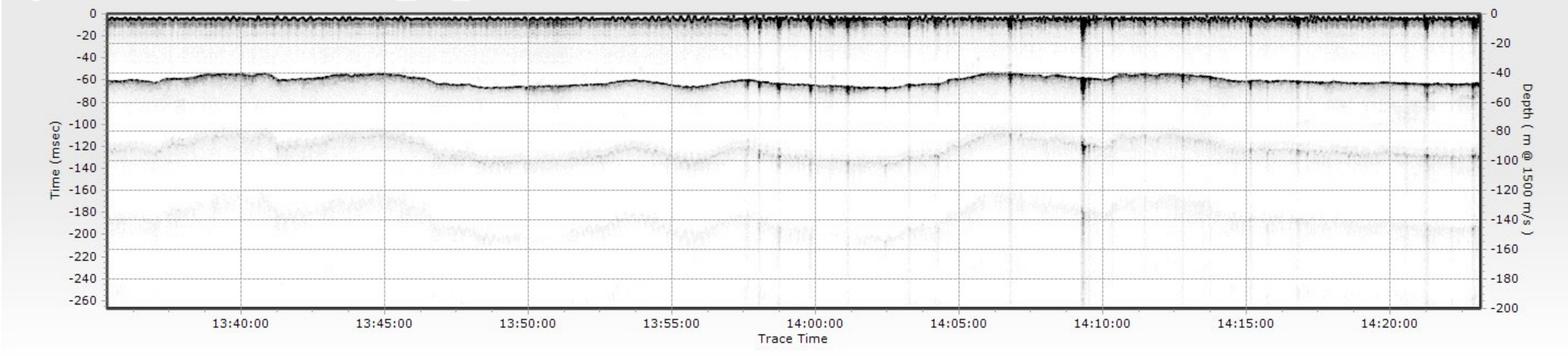

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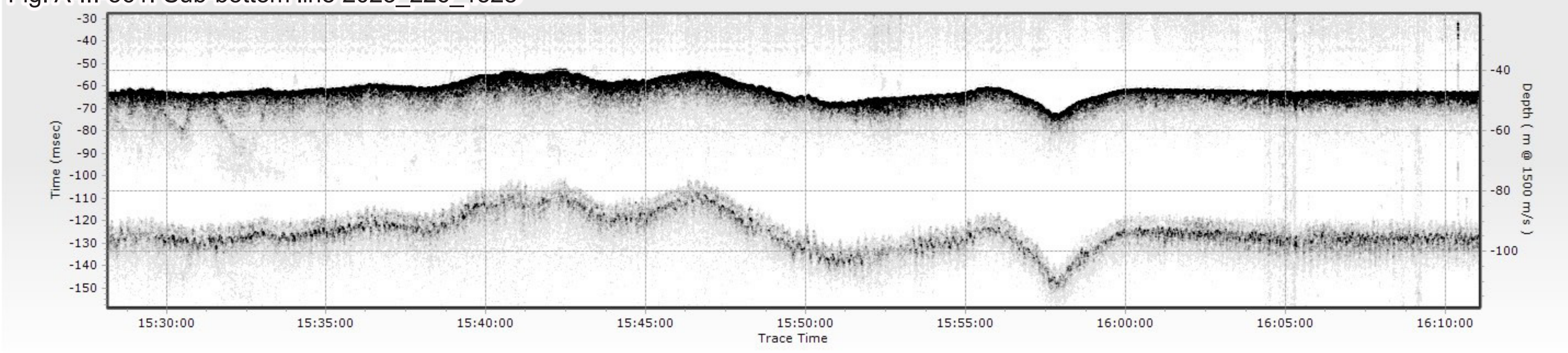
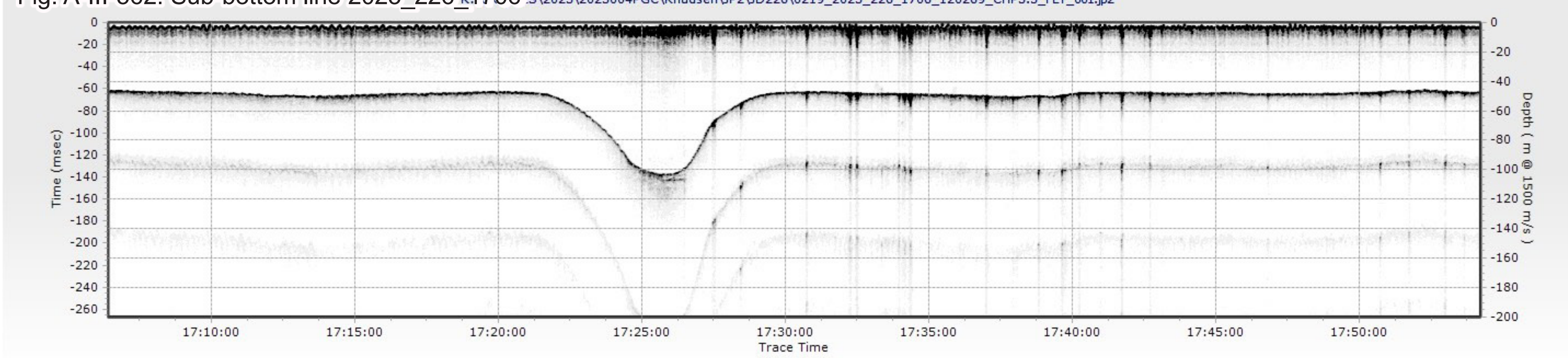


Fig. A-III-562. Sub-bottom line 2023_226_1706



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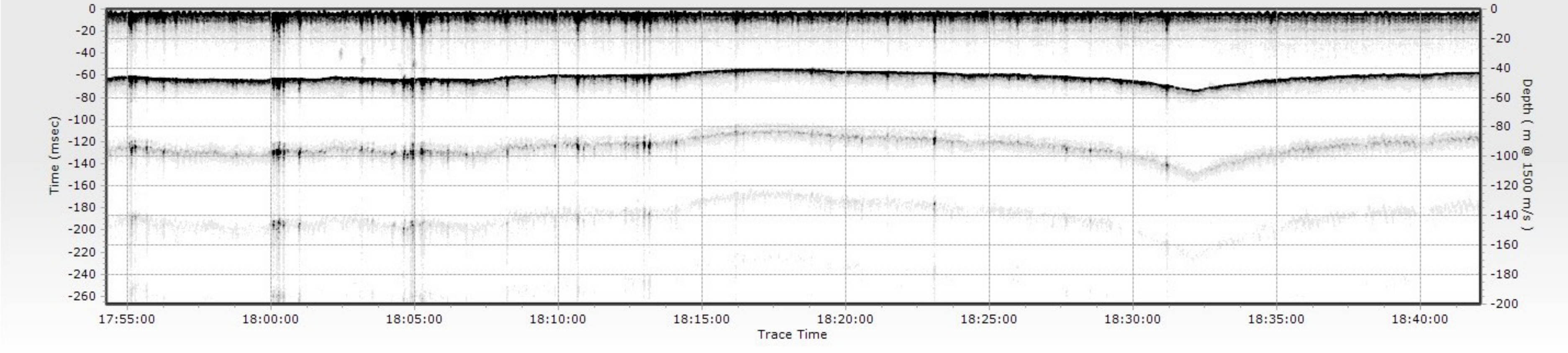


Fig. A-III-564. Sub-bottom line 2023_226_0039

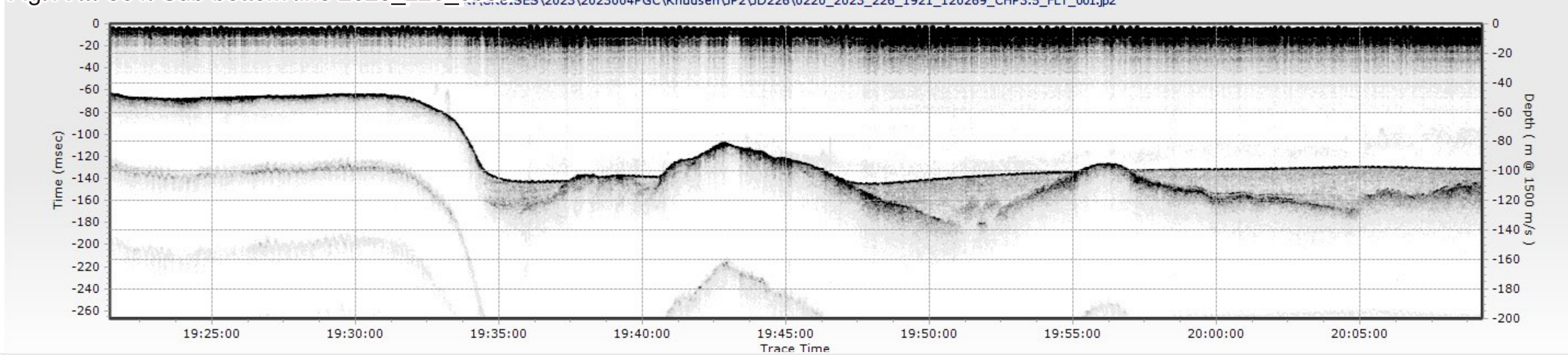


Fig. A-III-565. Sub-bottom line 2023_196_0039

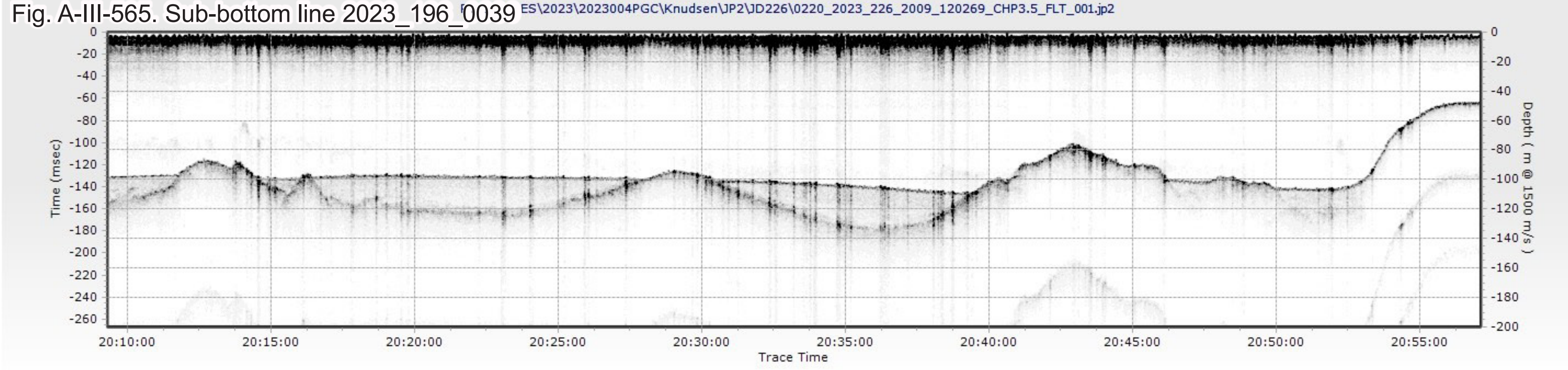


Fig. A-III-566. Sub-bottom line 2023_226_2202

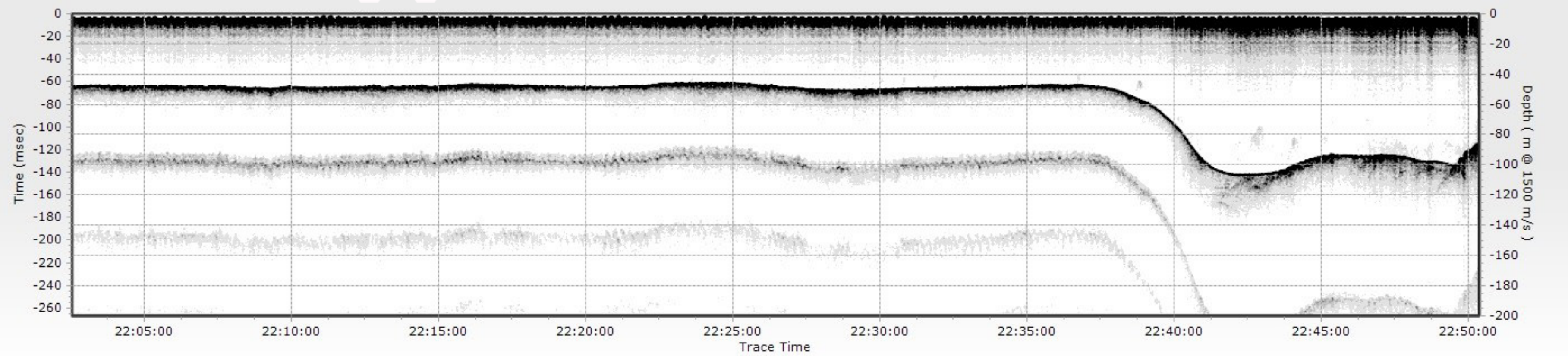
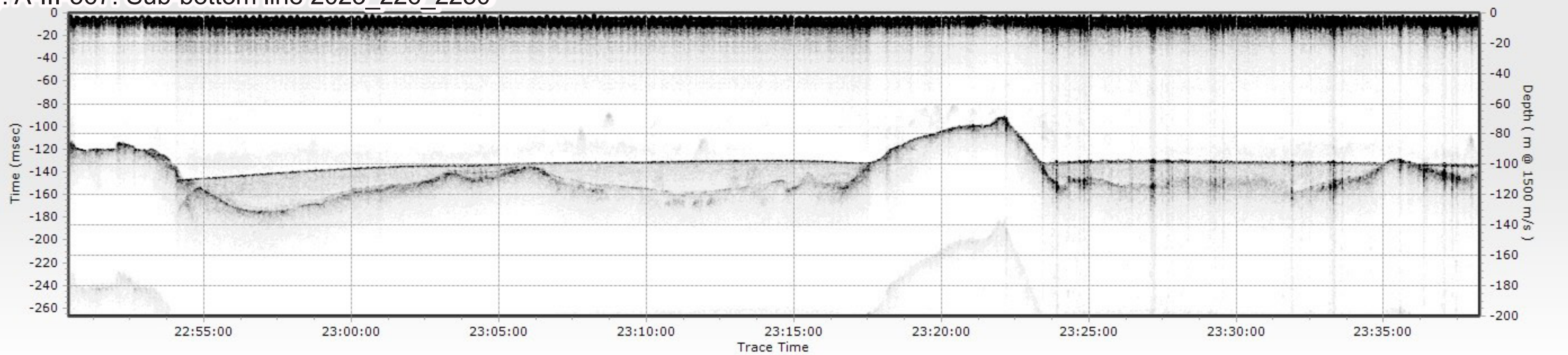


Fig. A-III-567. Sub-bottom line 2023_226_2250



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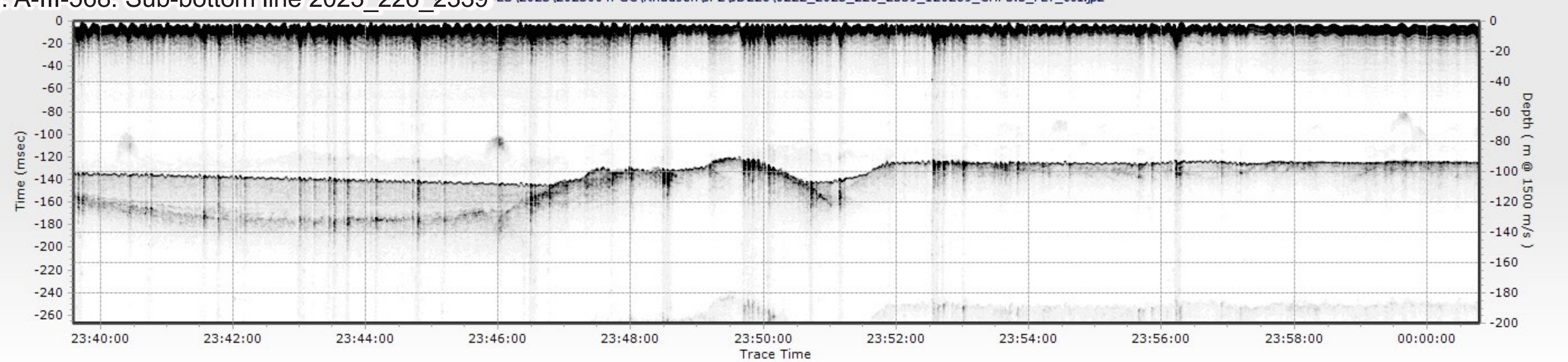

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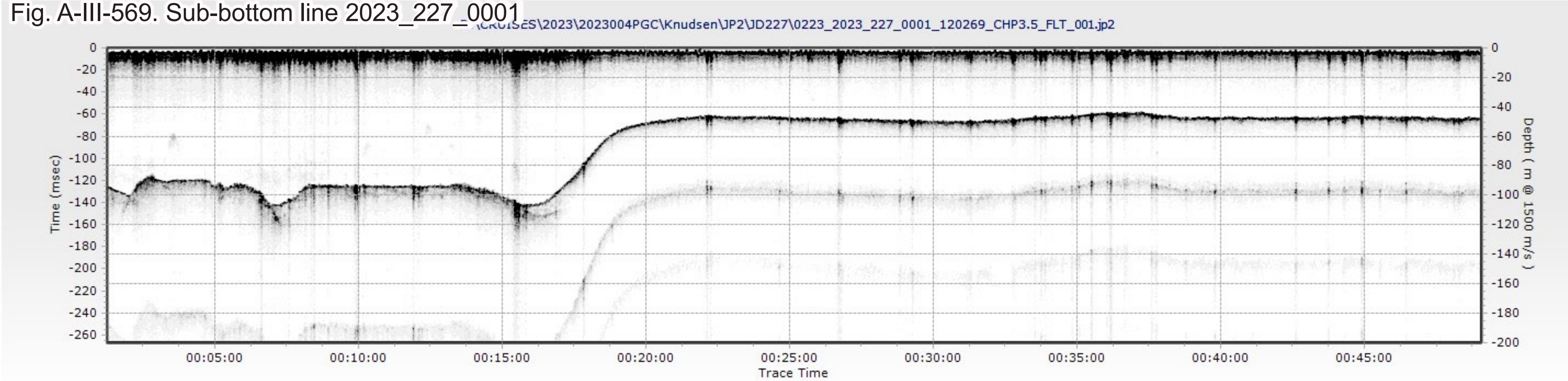

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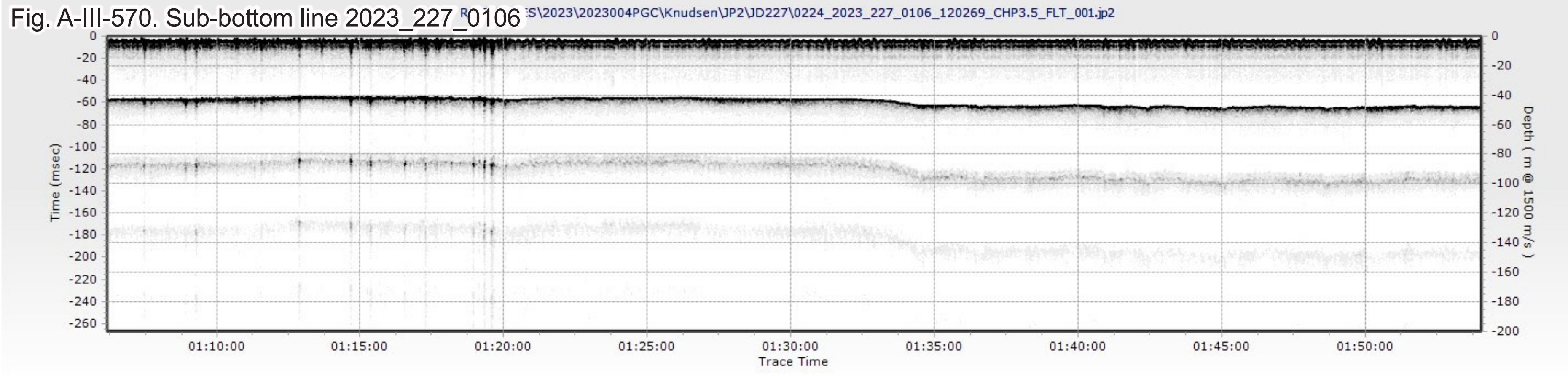

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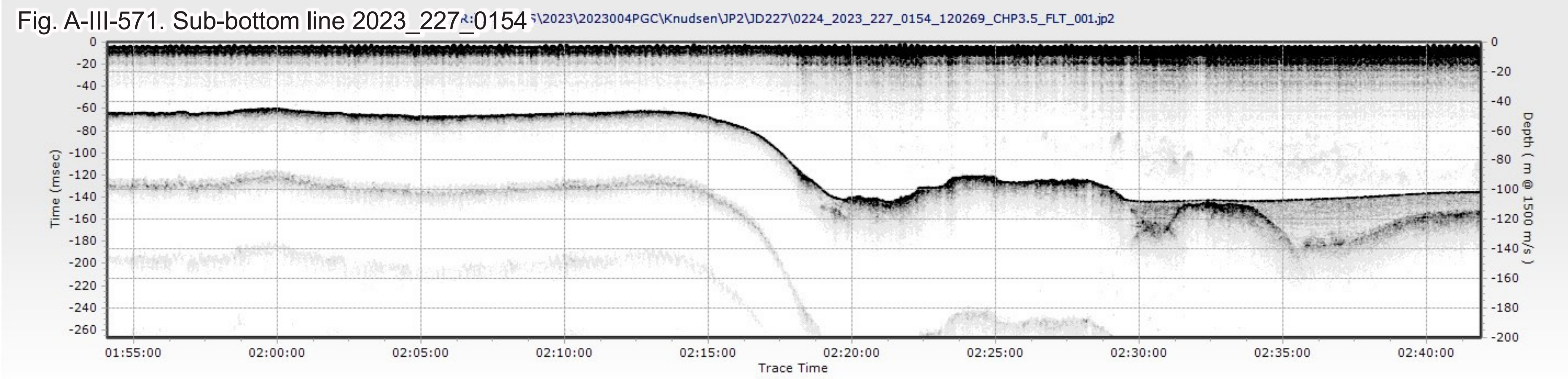

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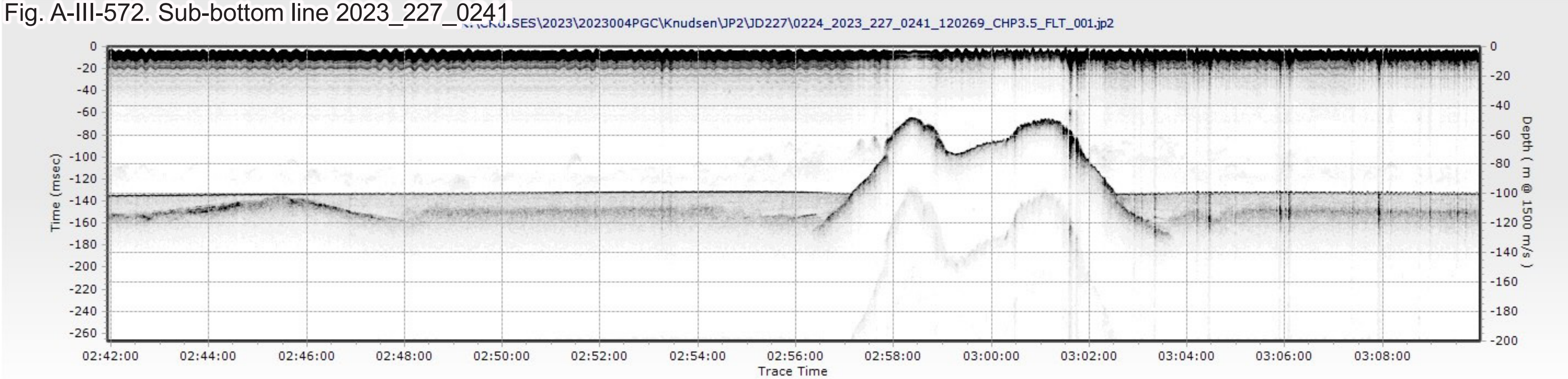

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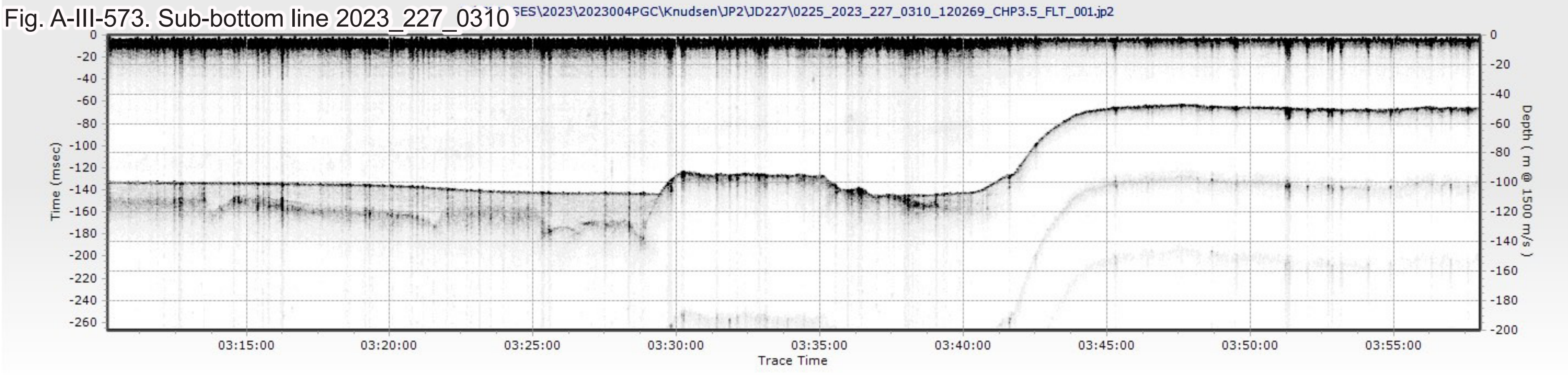

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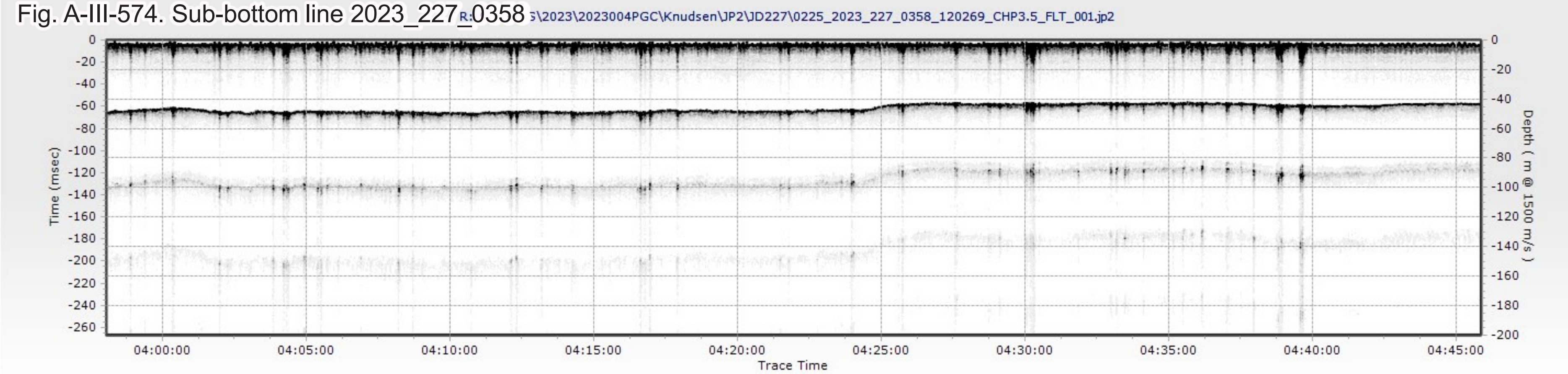

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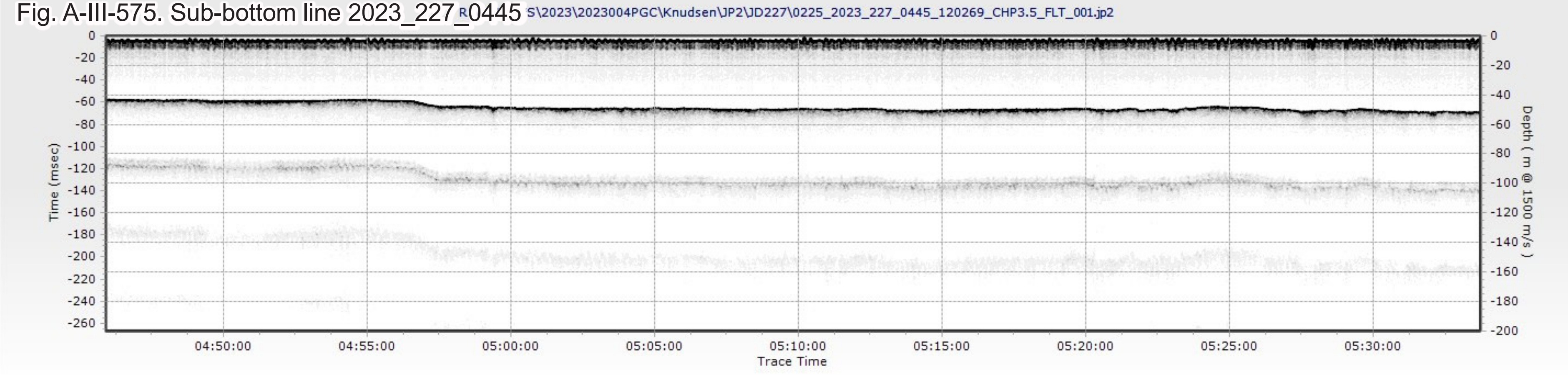

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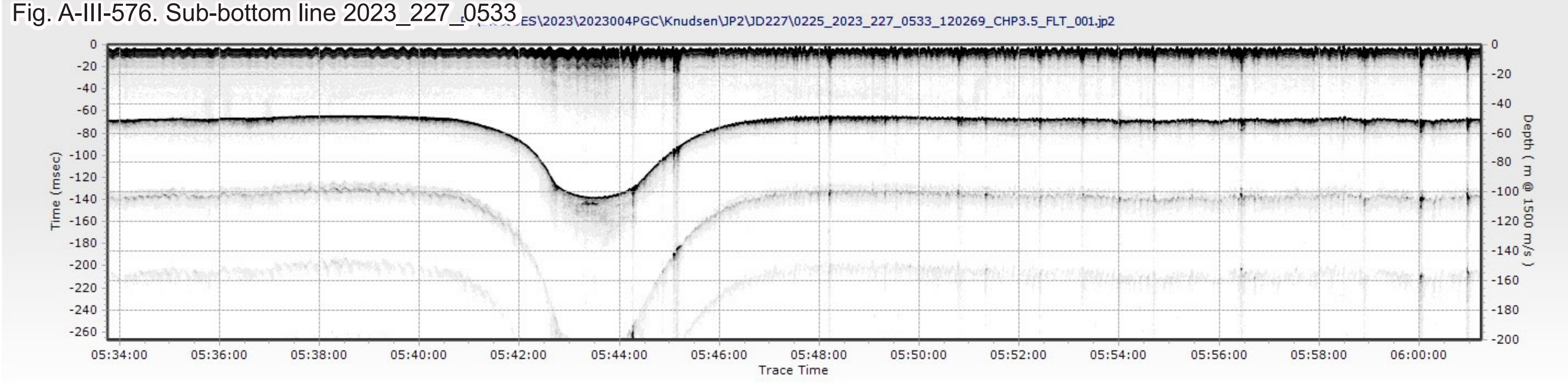

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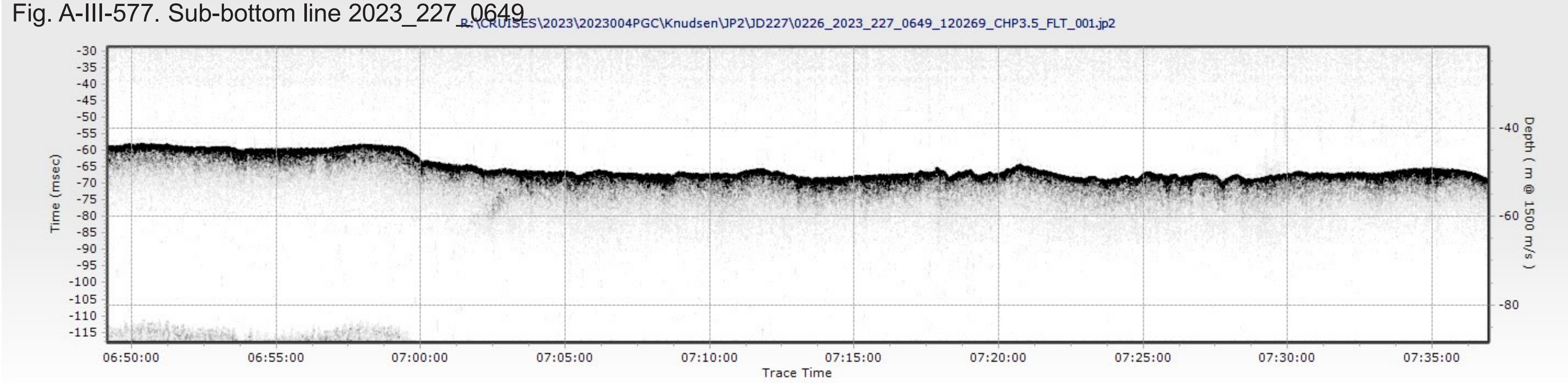

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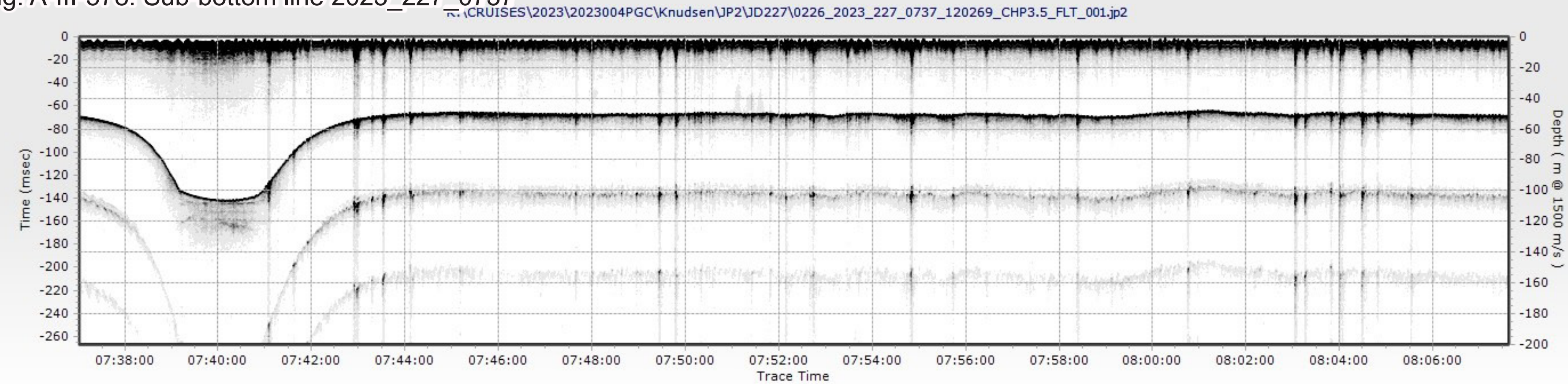

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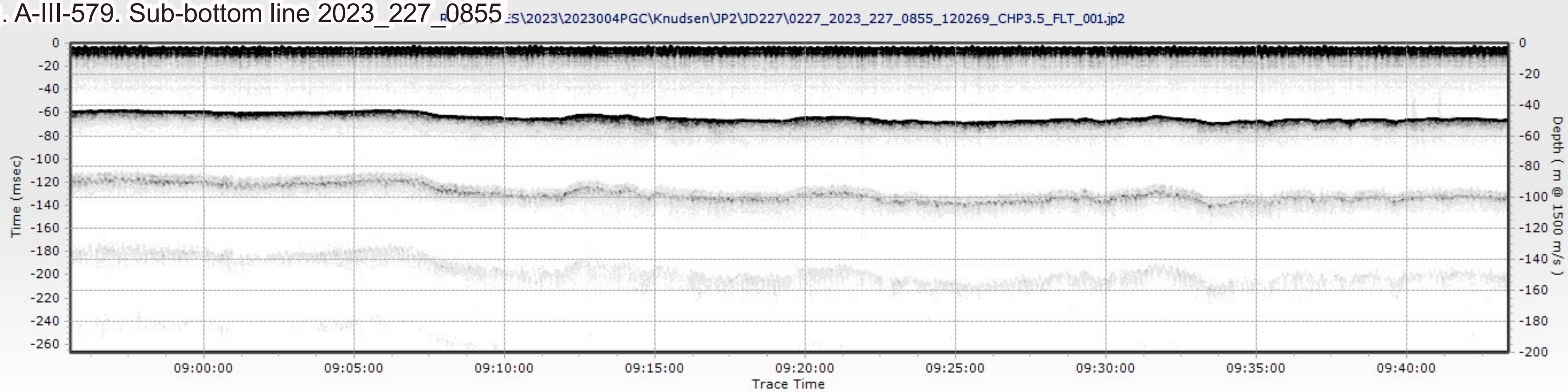

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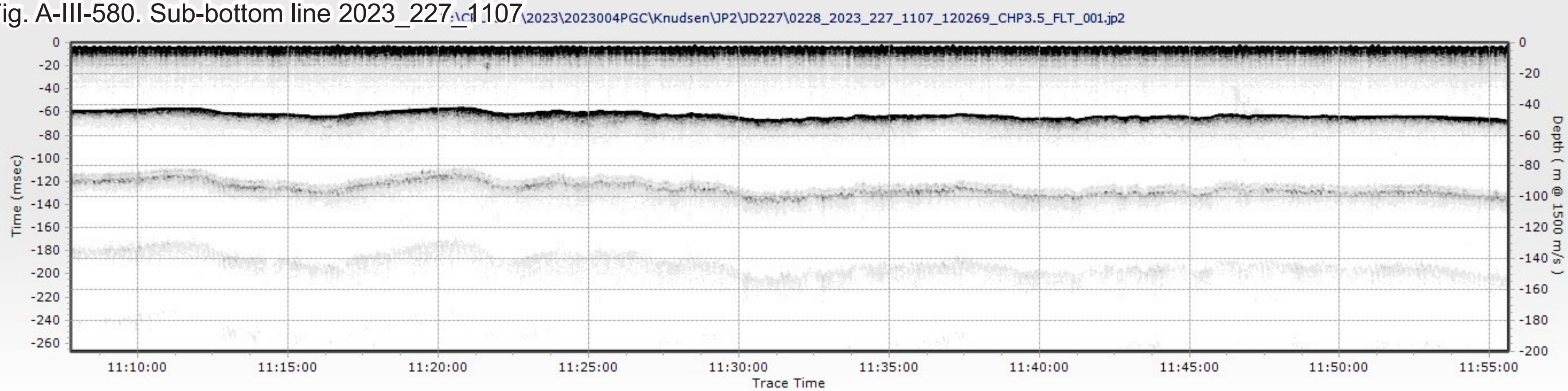

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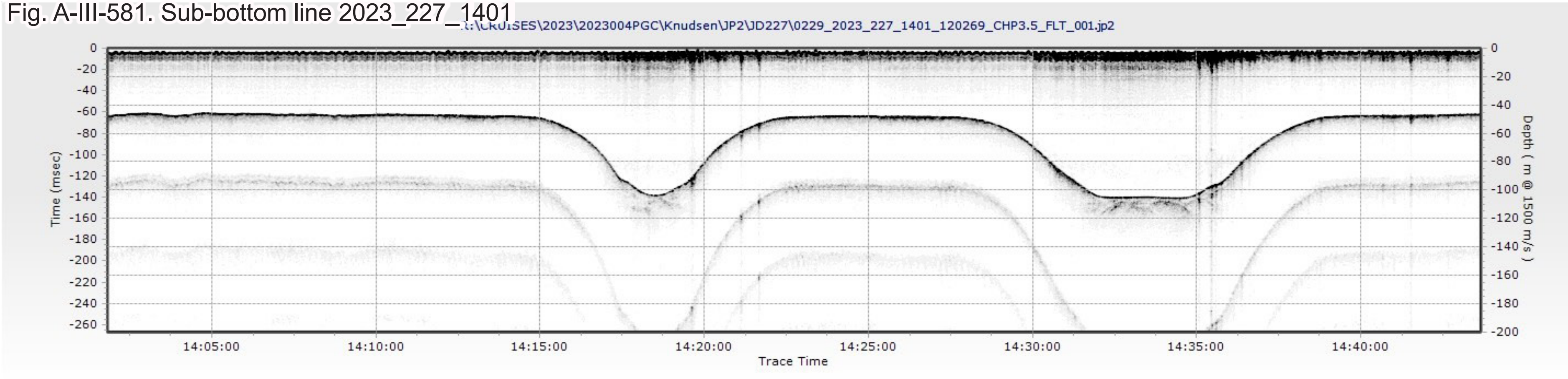

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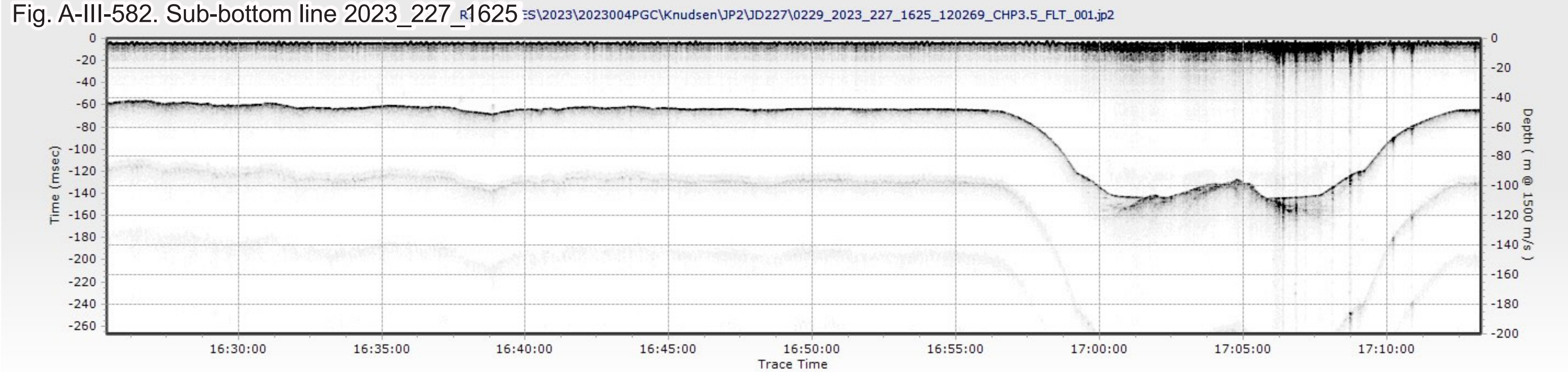

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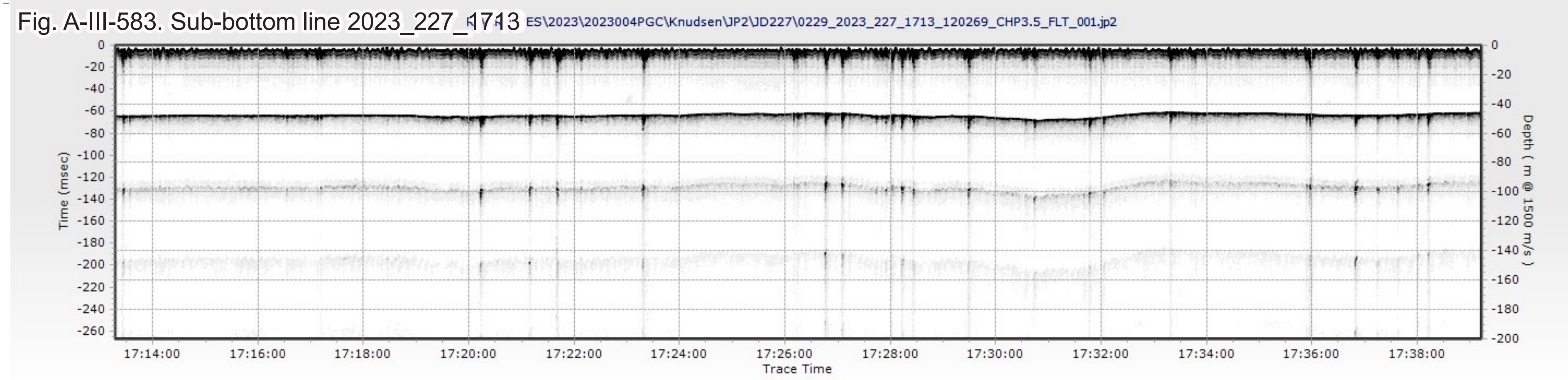

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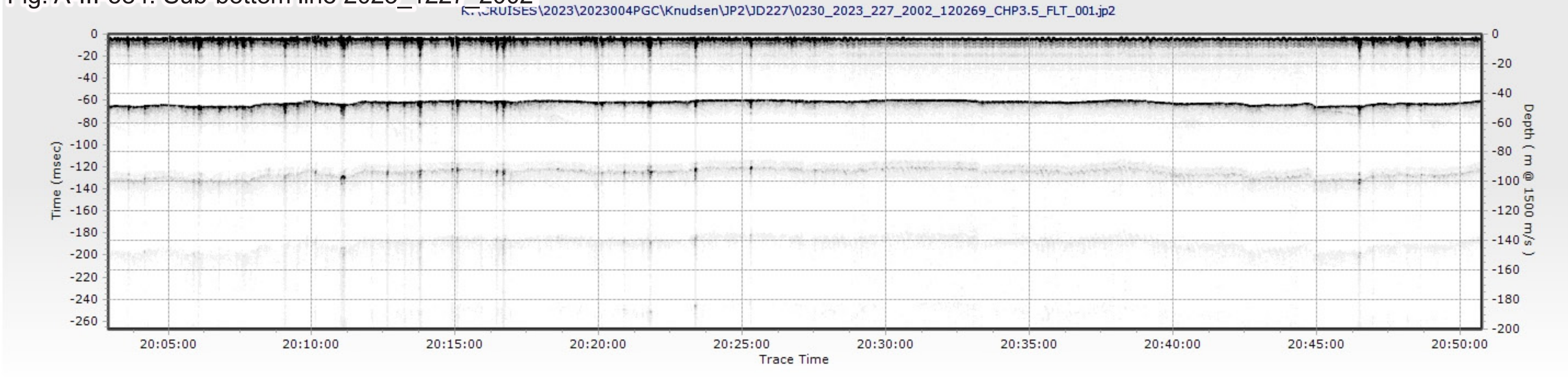


Fig. A-III-585. Sub-bottom line 2023_227_2153

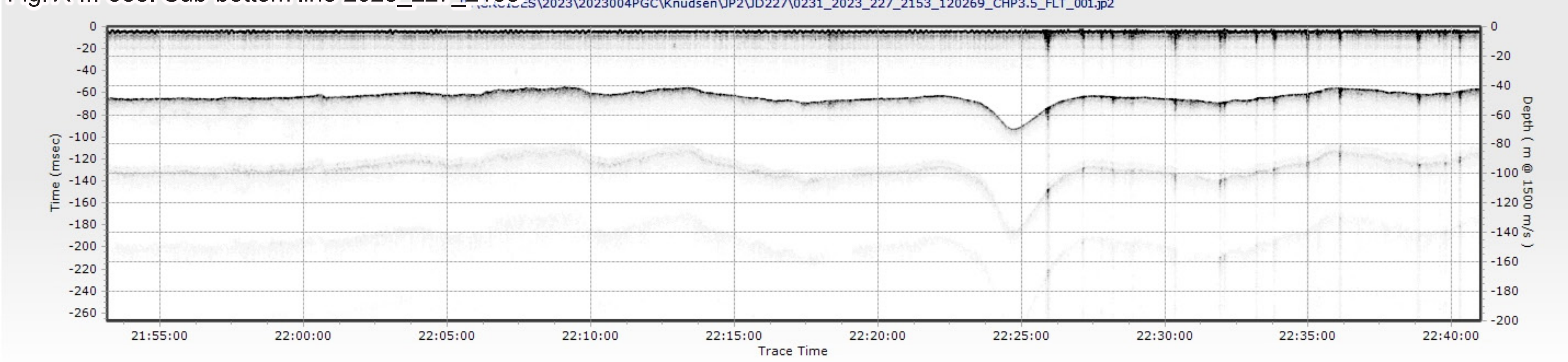
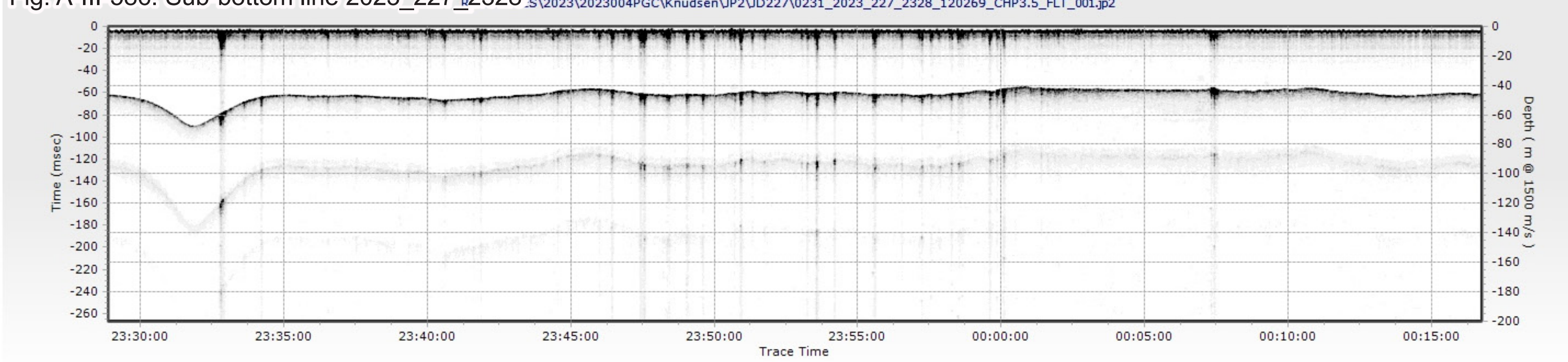


Fig. A-III-586. Sub-bottom line 2023_227_2328



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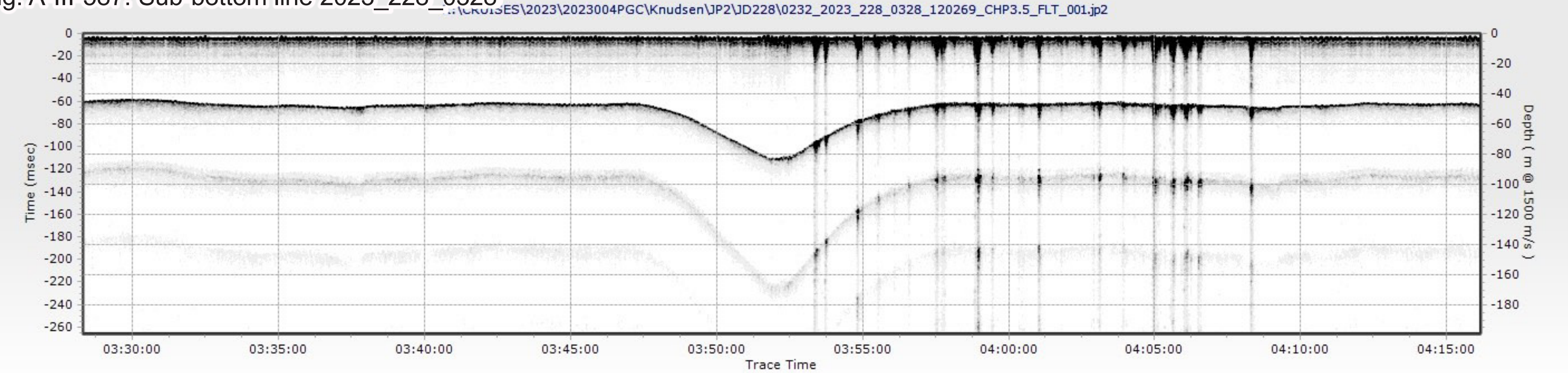

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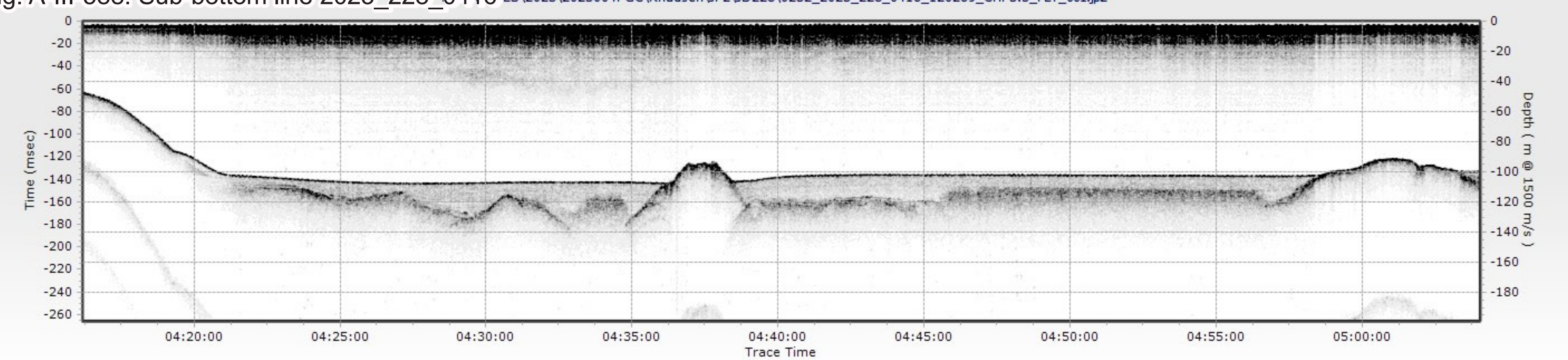

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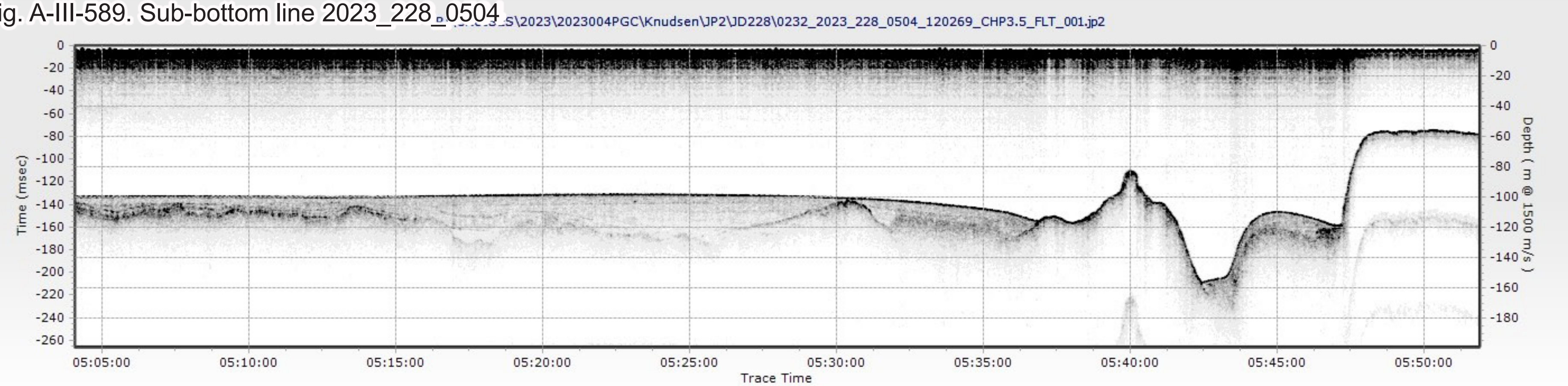

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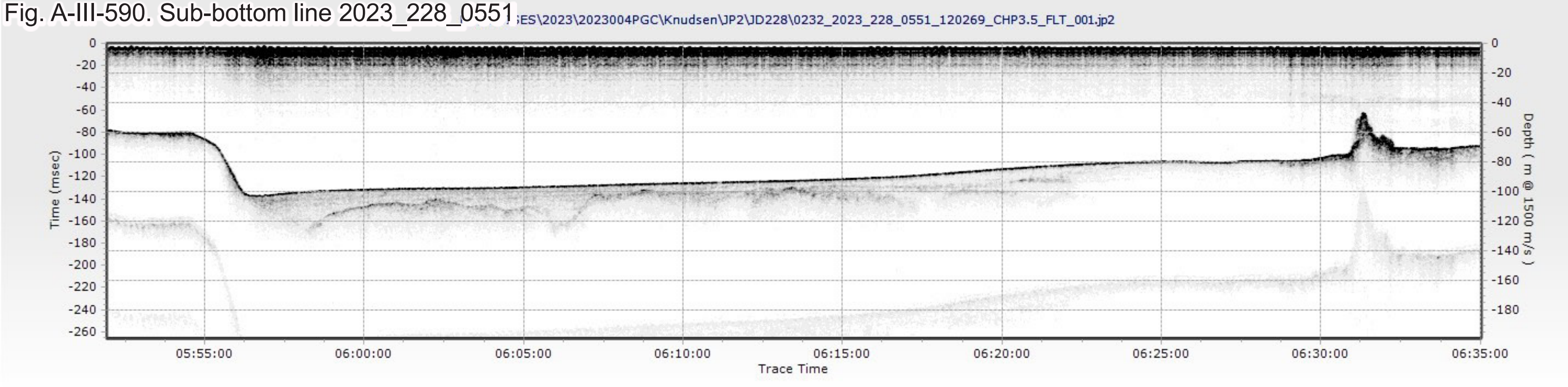

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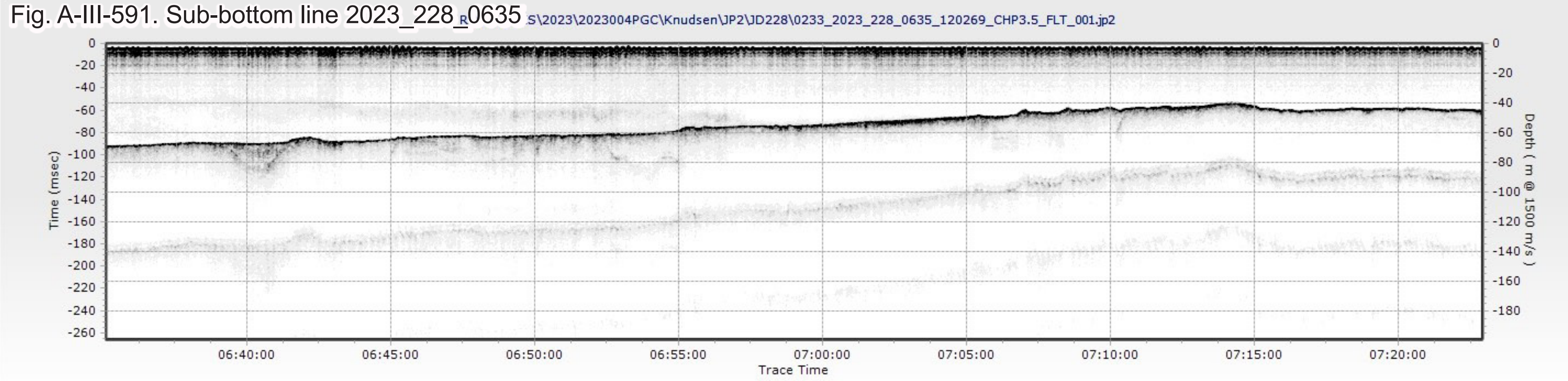

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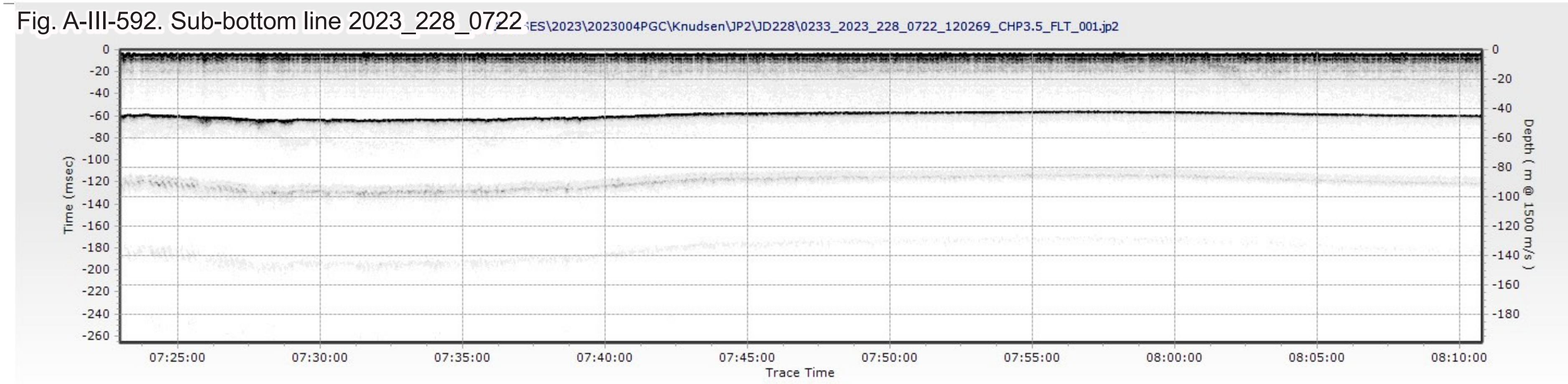

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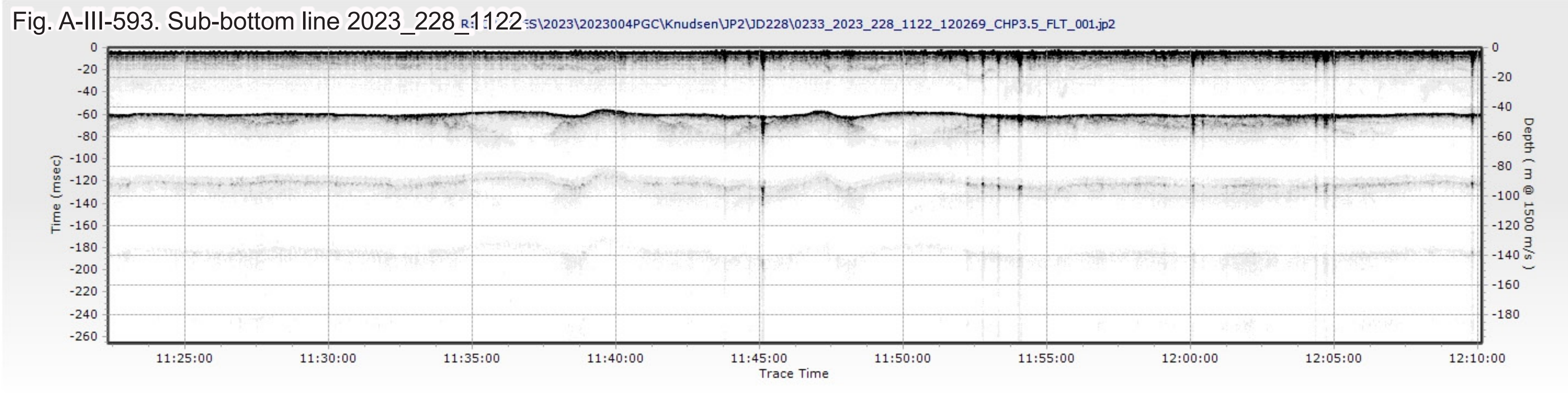

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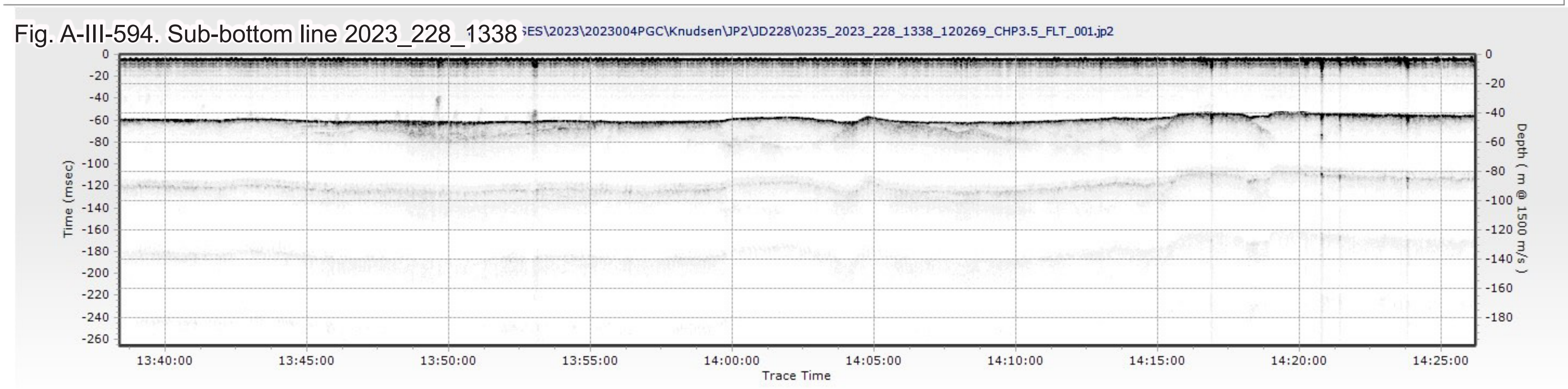

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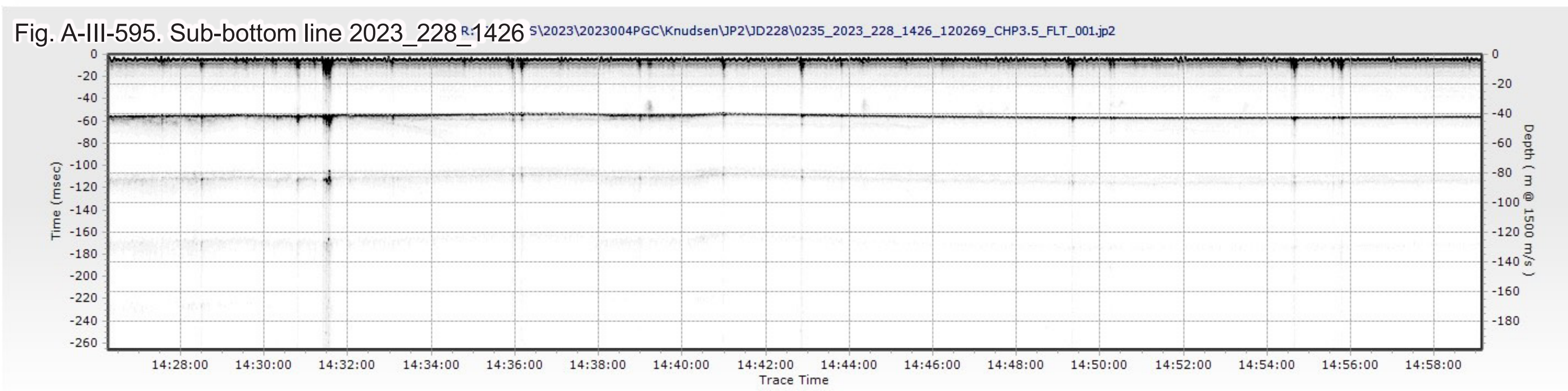

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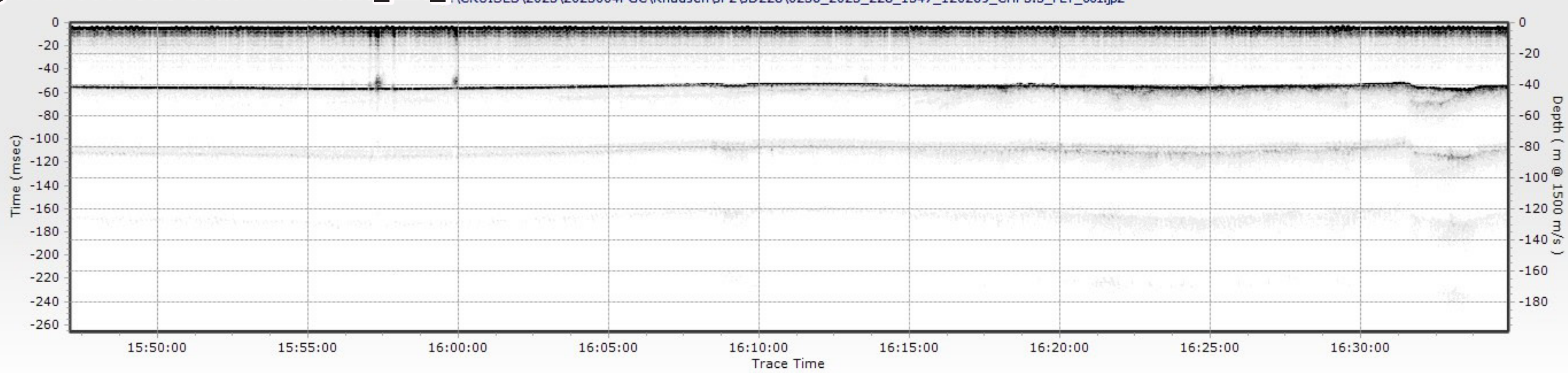

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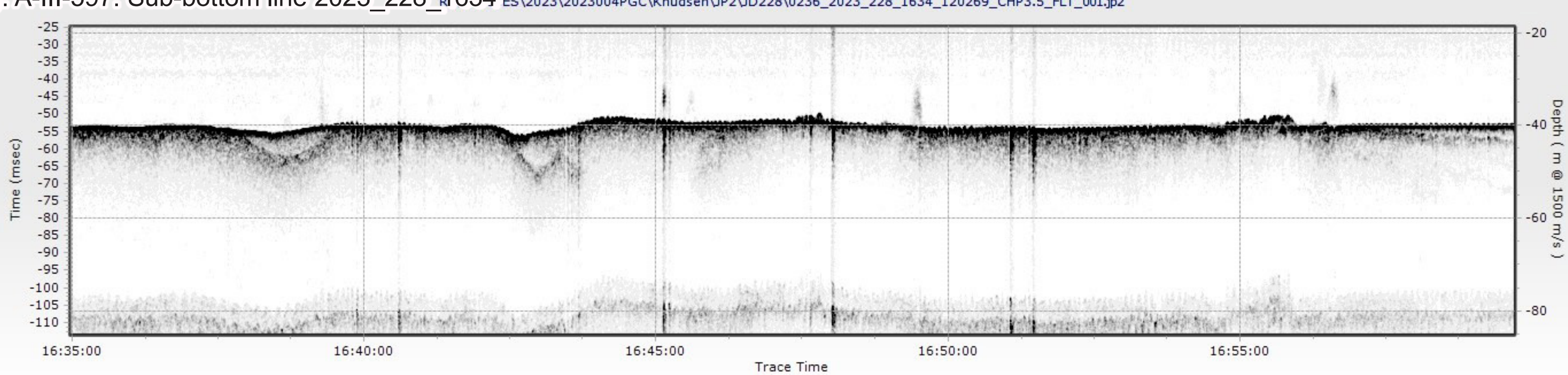
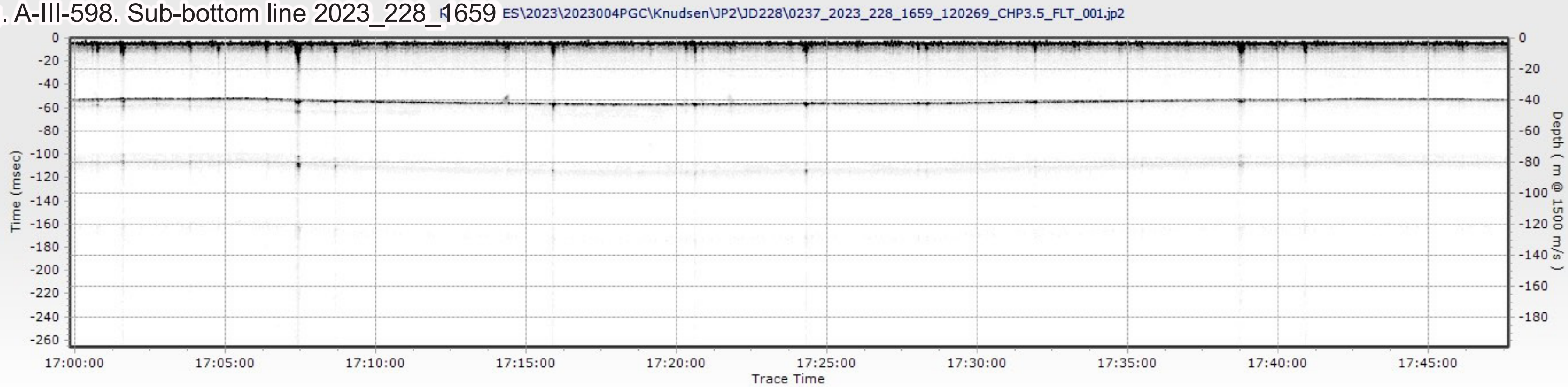


Fig. A-III-598. Sub-bottom line 2023_228_1659



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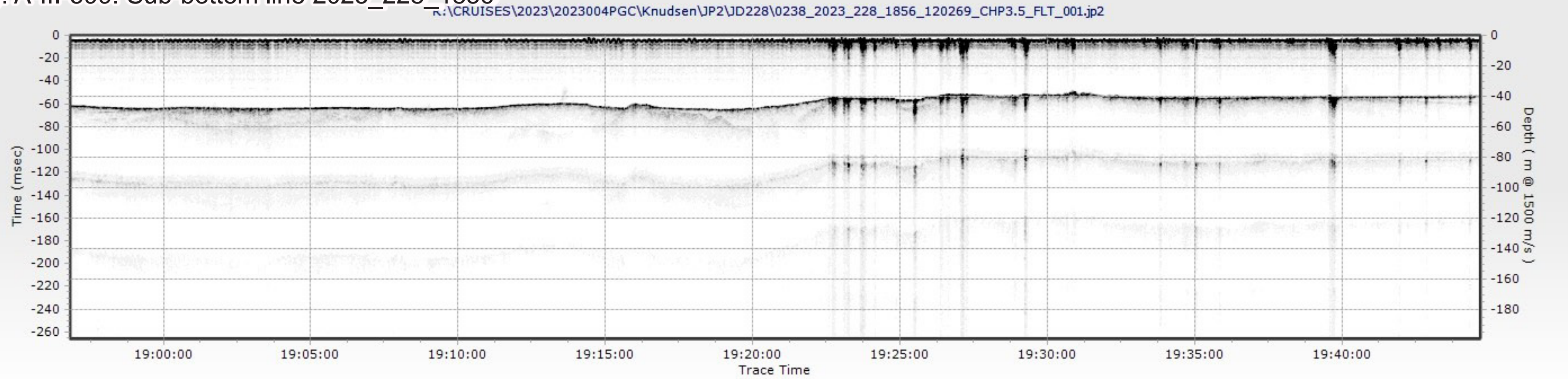


Fig. A-III-600. Sub-bottom line 2023_228_2059

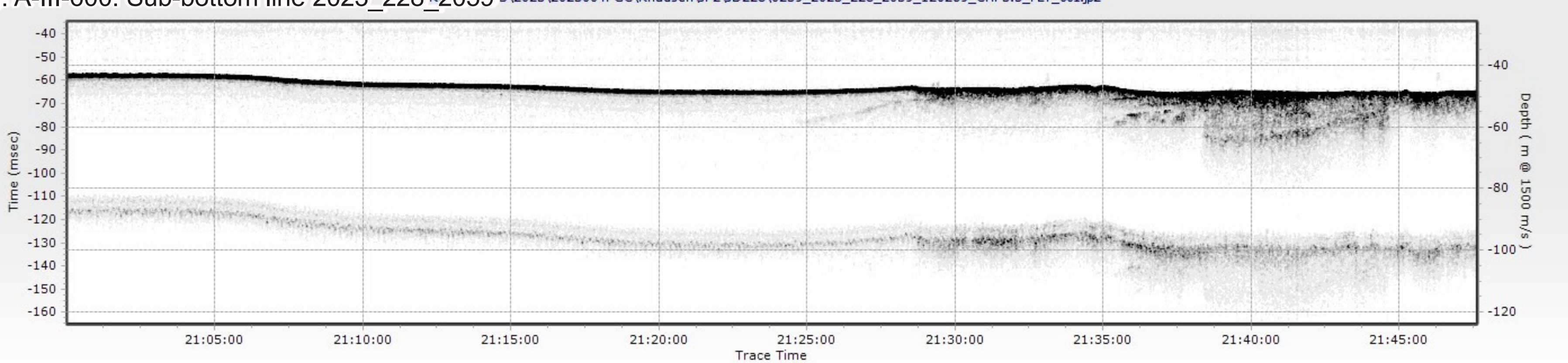
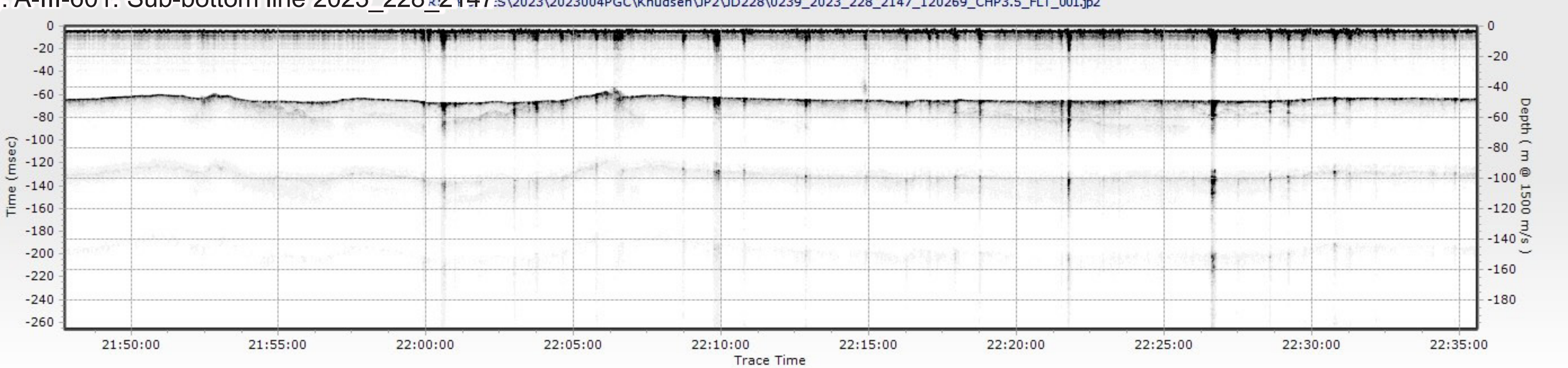


Fig. A-III-601. Sub-bottom line 2023_228_2147



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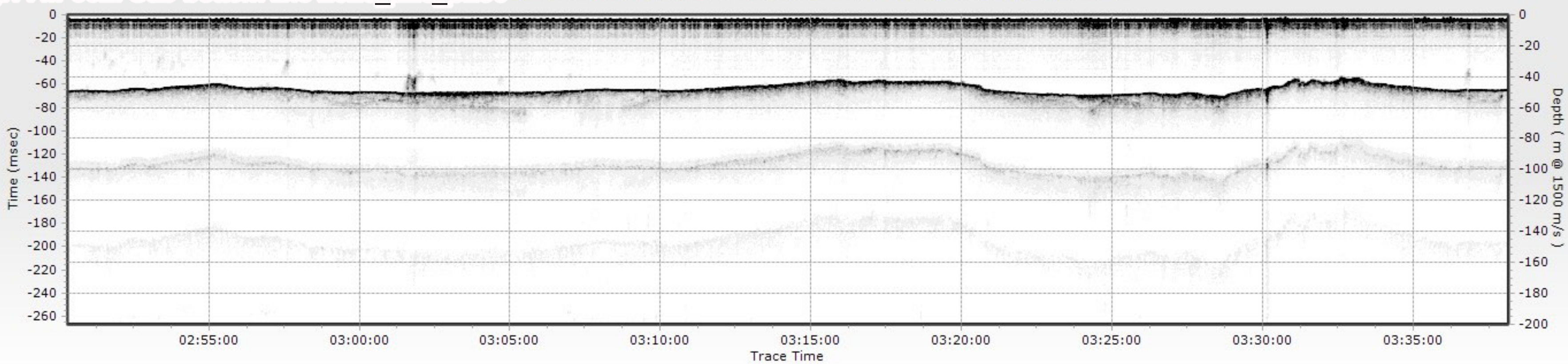

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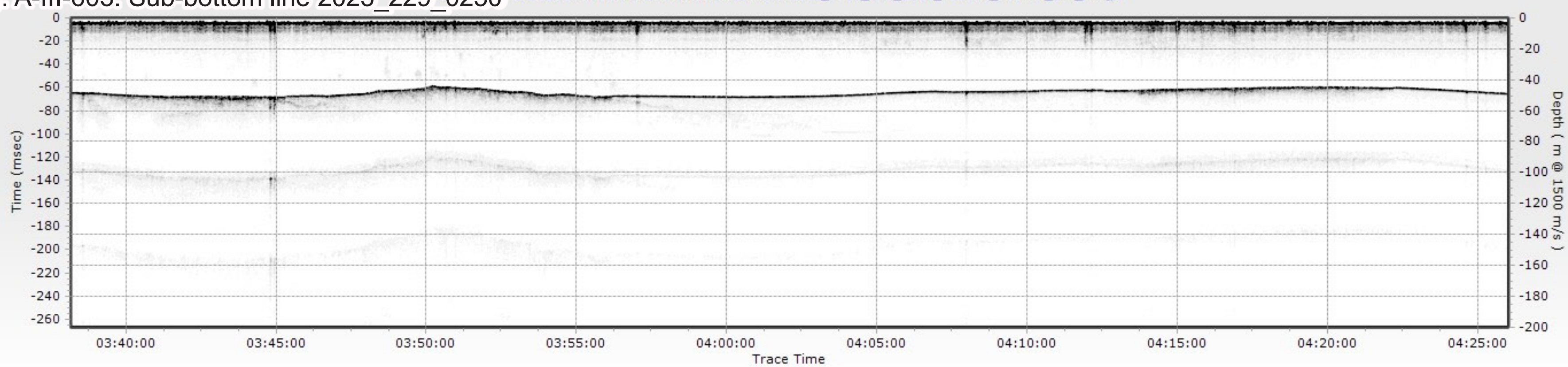

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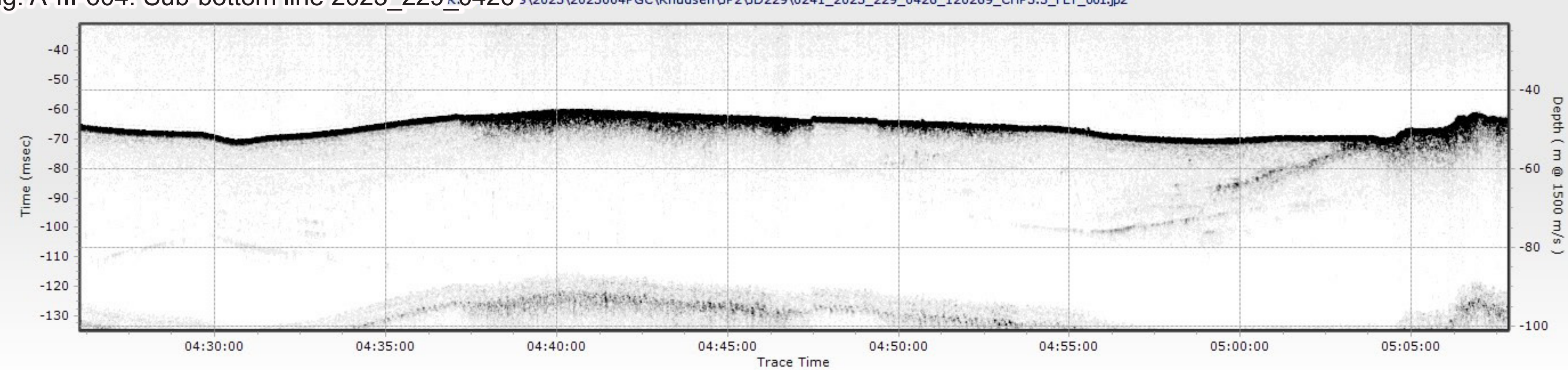

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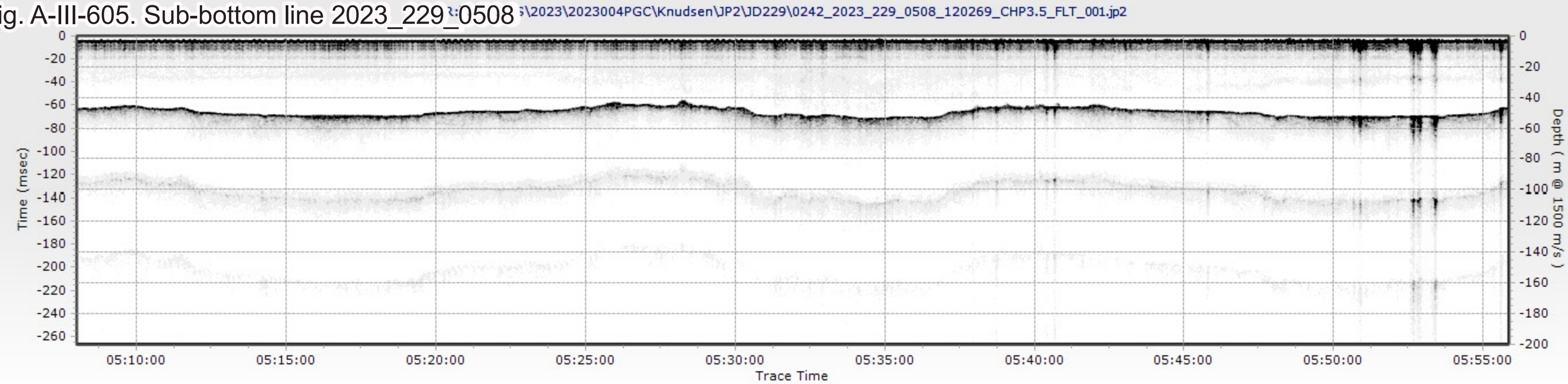

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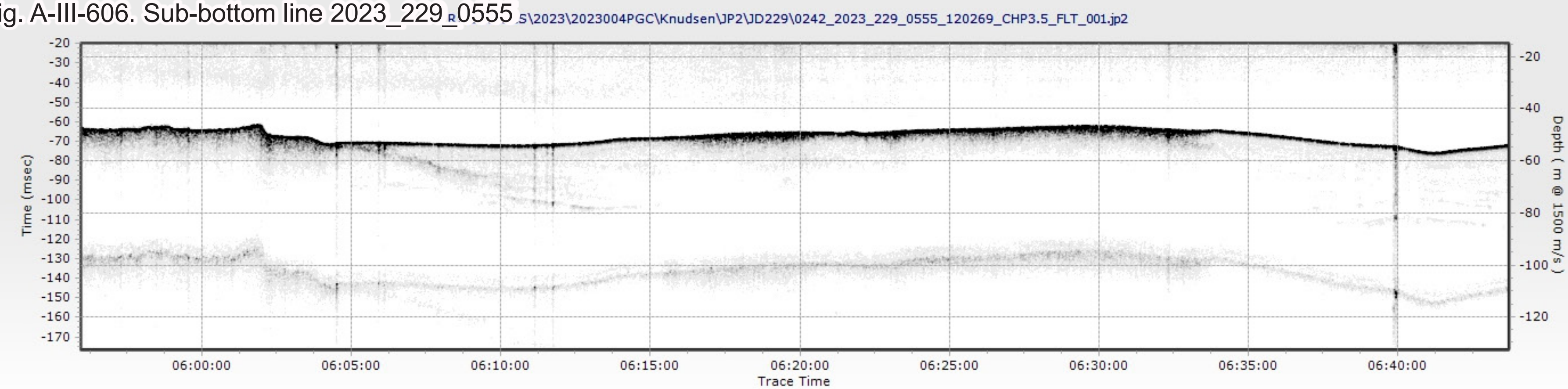

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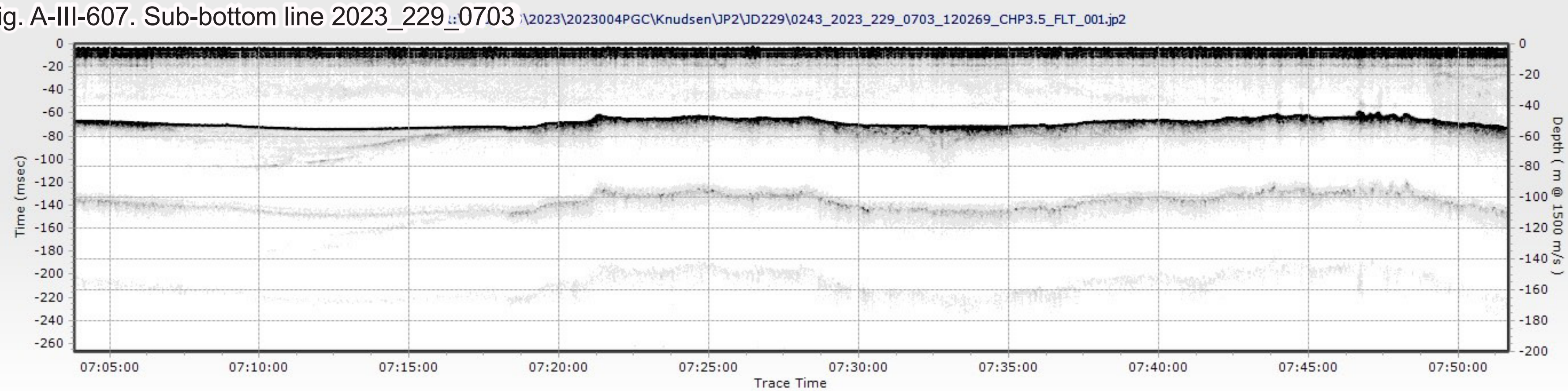

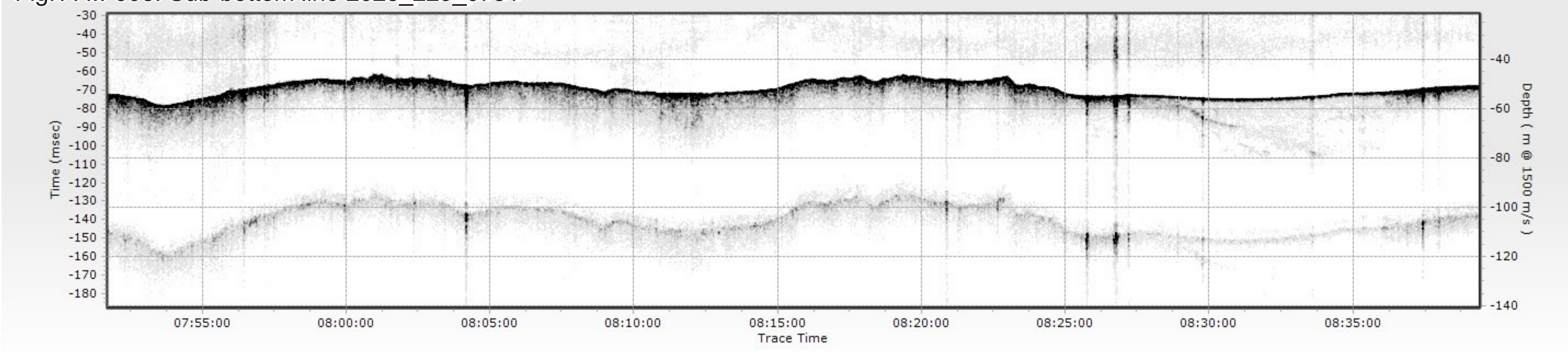

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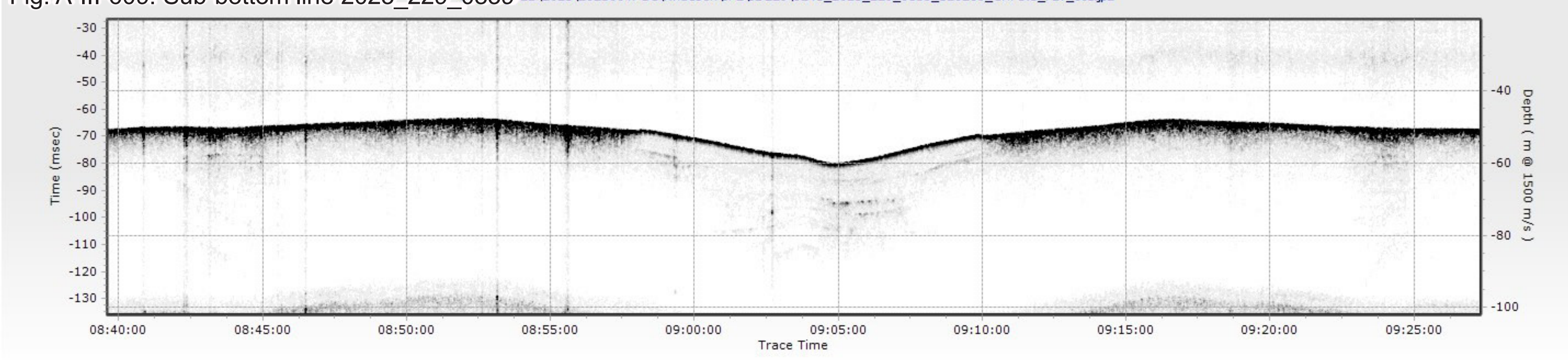


Fig. A-III-609. Sub-bottom line 2023_229_0839

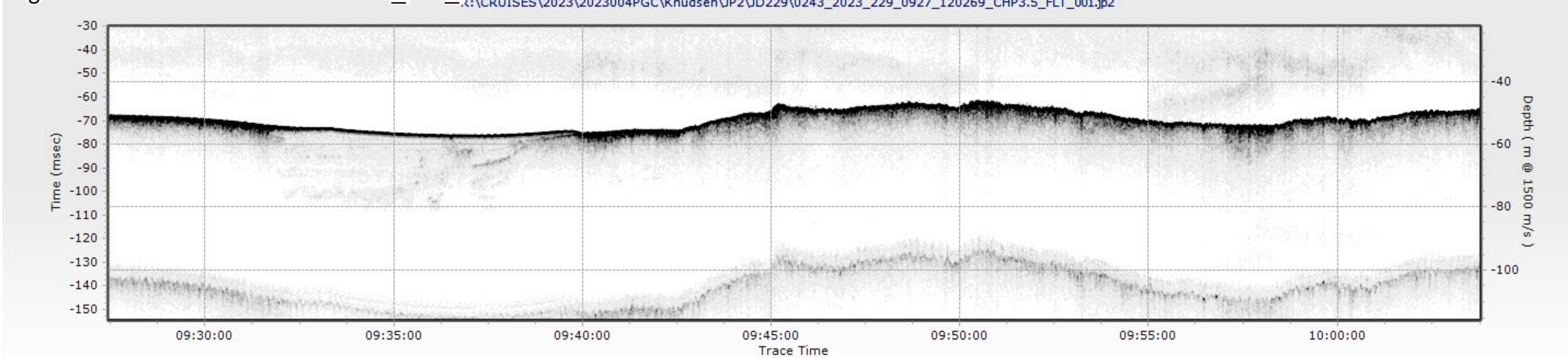
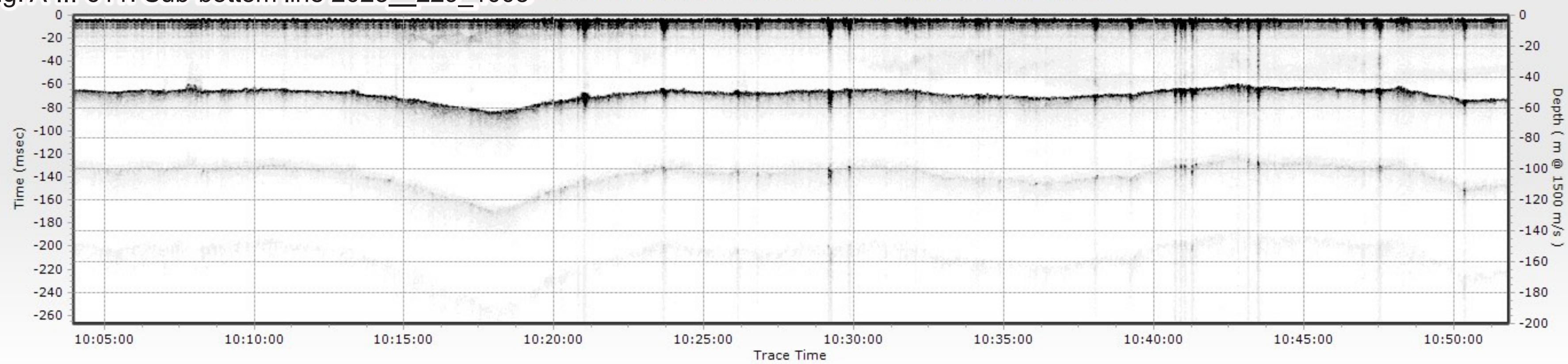


Fig. A-III-610. Sub-bottom line 2023_229_0927

Fig. A-III-611. Sub-bottom line 2023__229_1003



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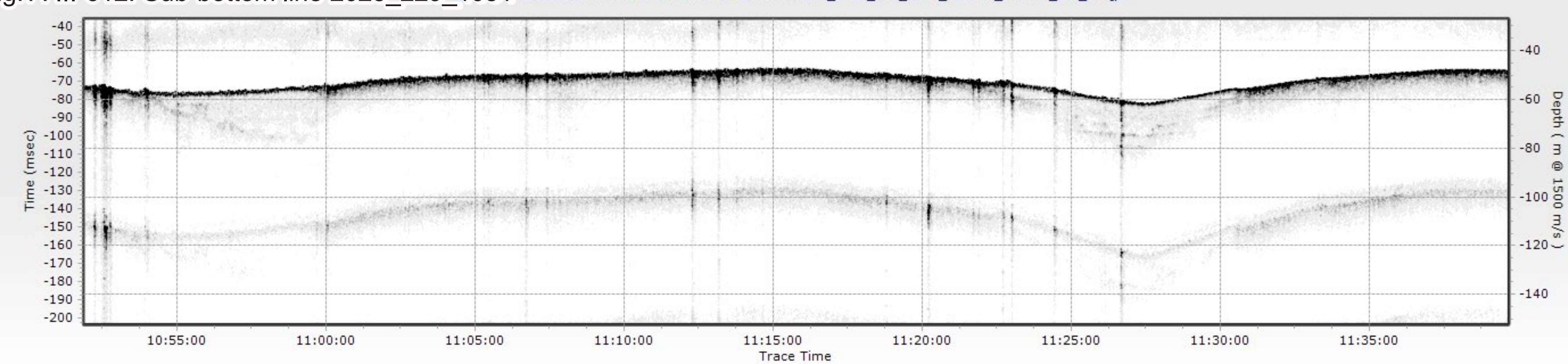

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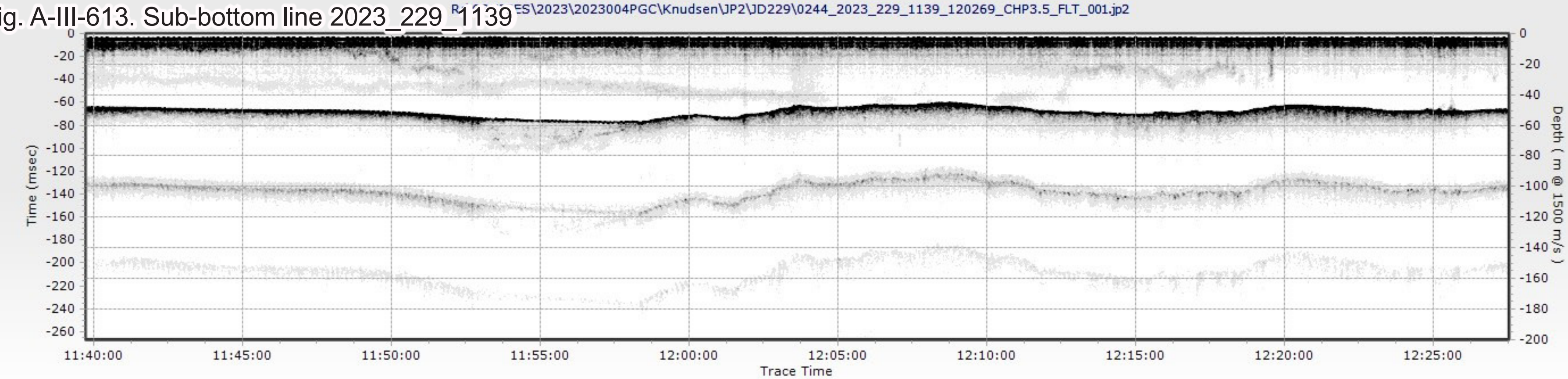

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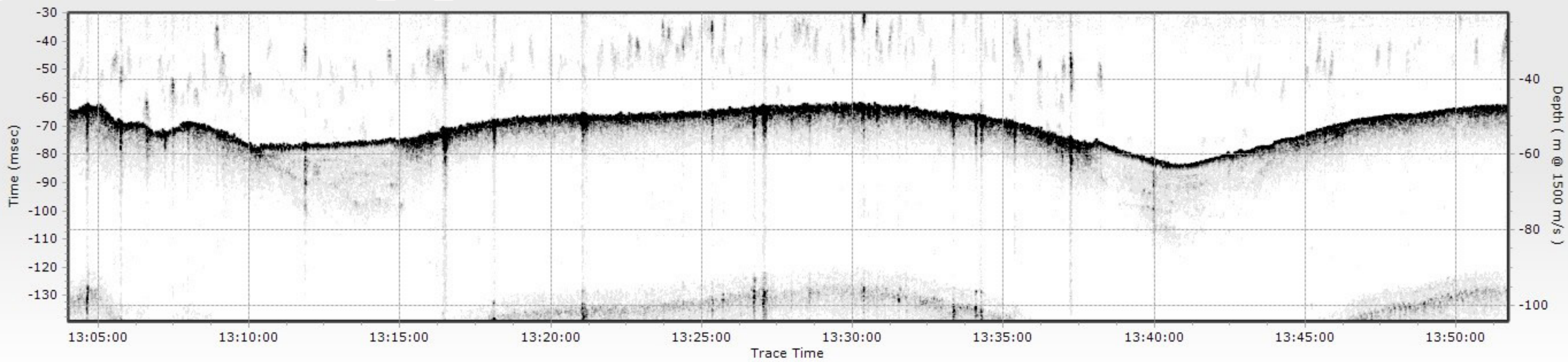

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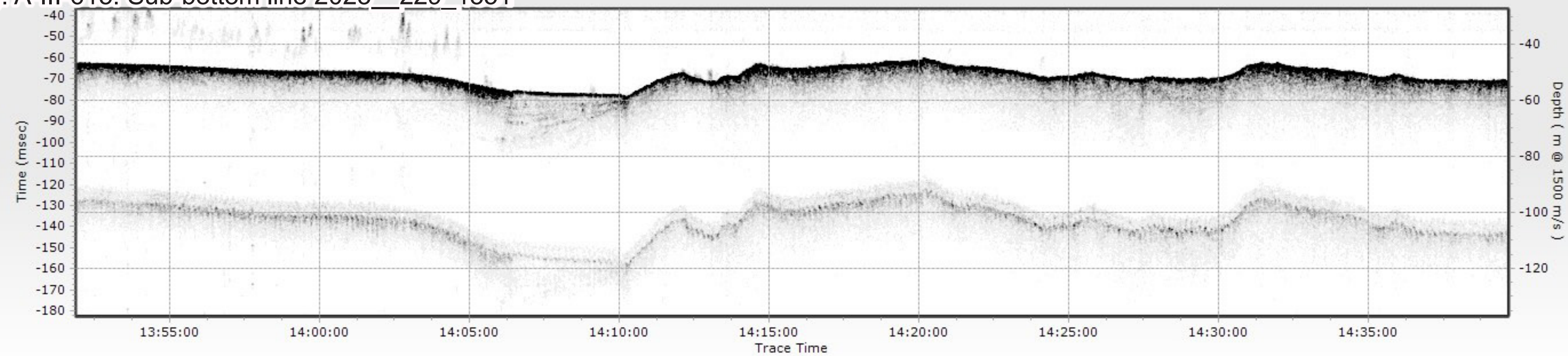

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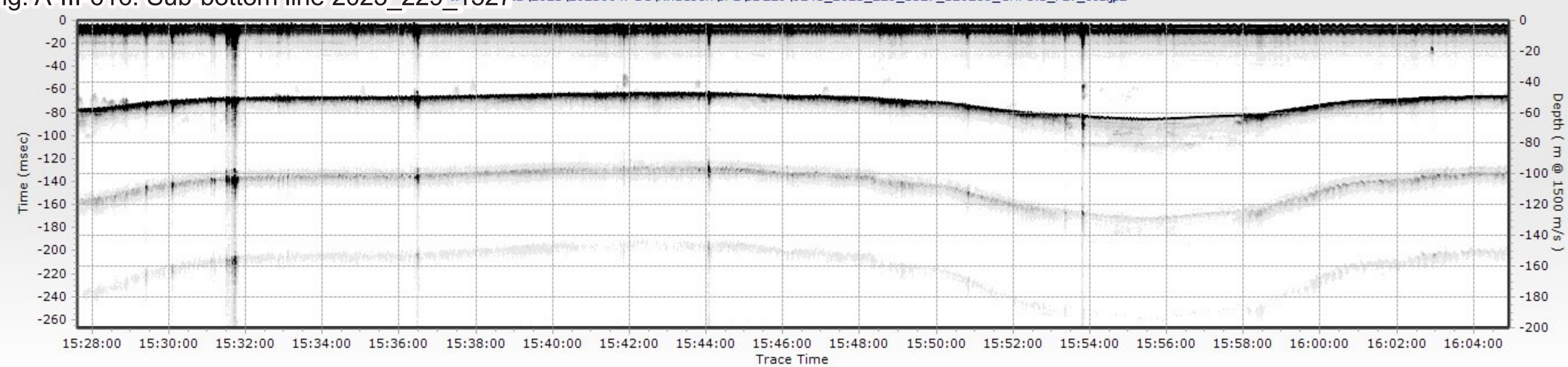

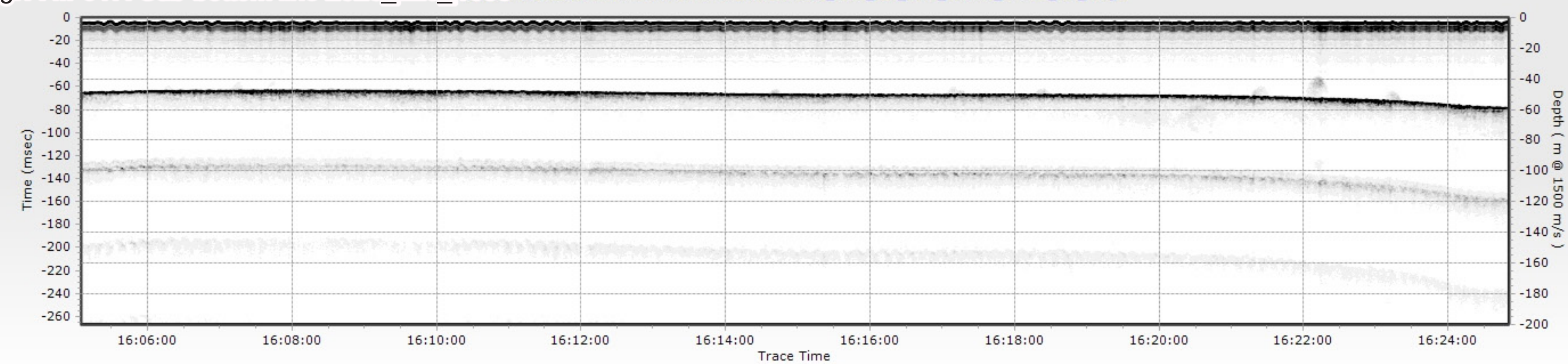

Fig. A-III-617. Sub-bottom line 2023_229_1605

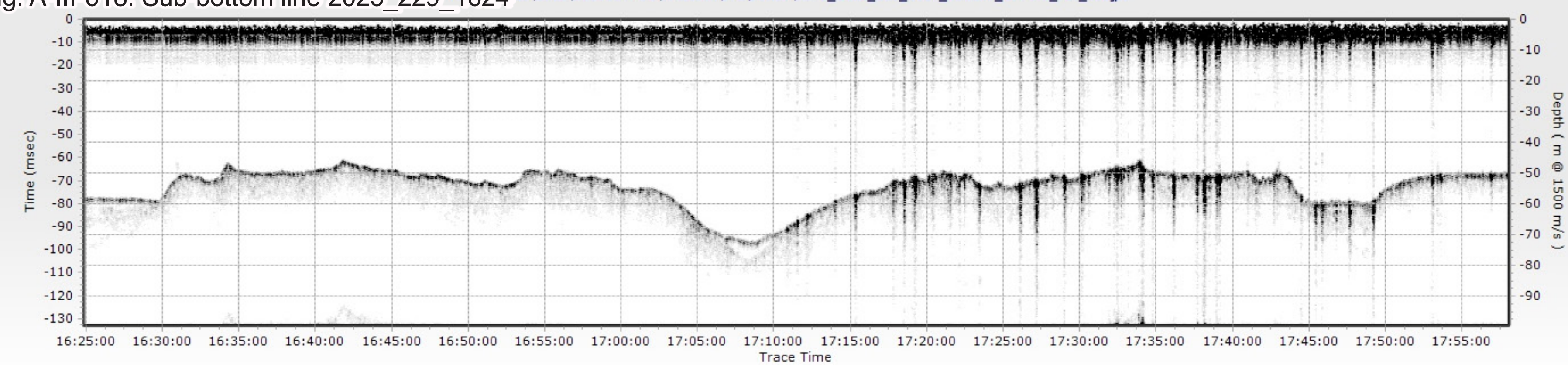

Fig. A-III-618. Sub-bottom line 2023_229_1624

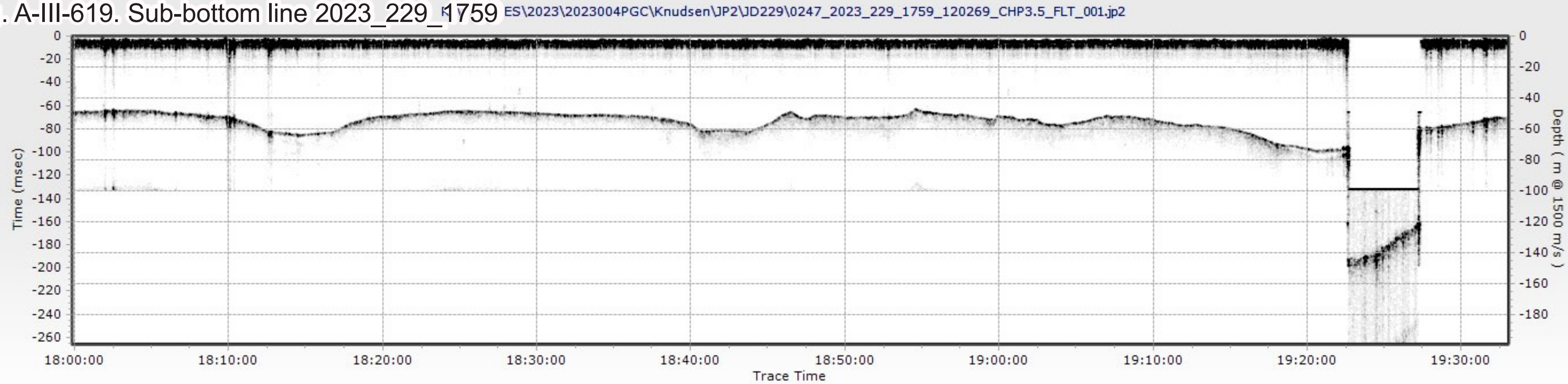

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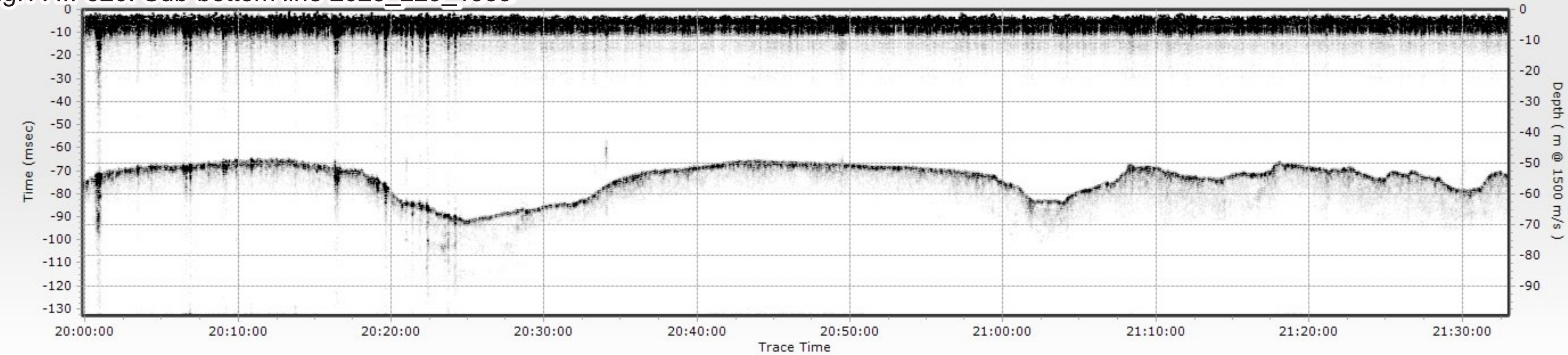
Fig. A-III-620. Sub-bottom line 2023_229_1959



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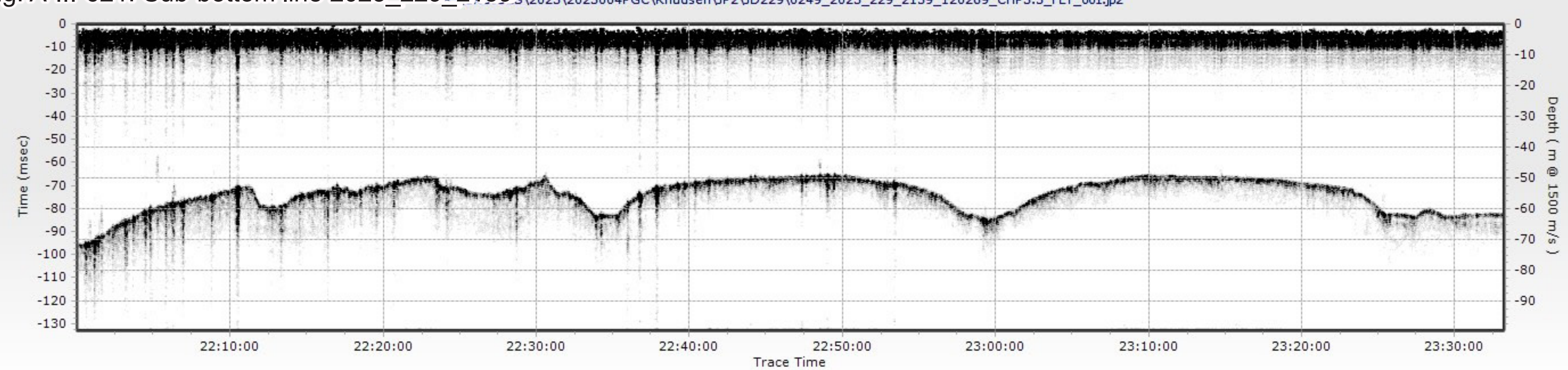
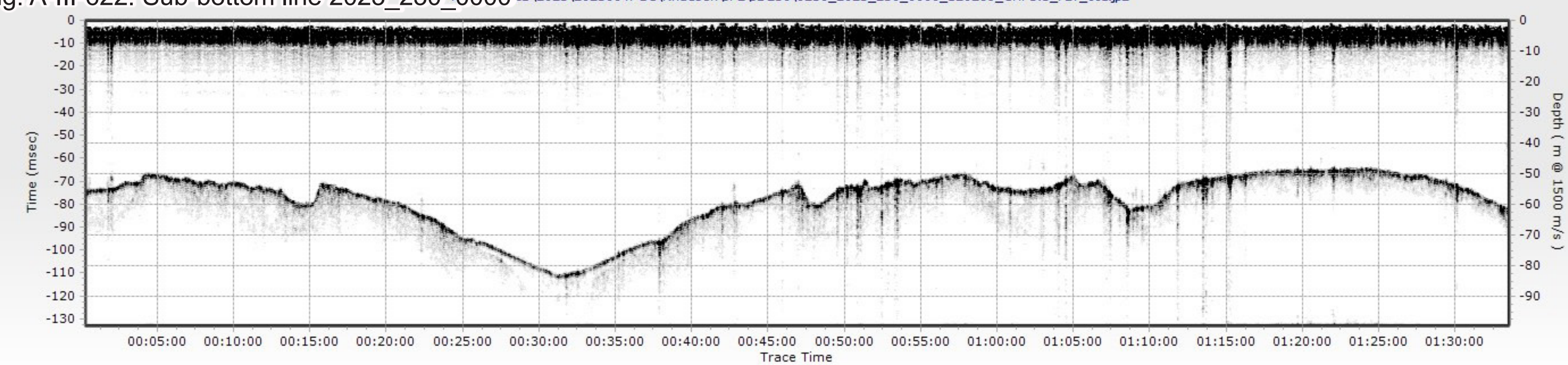


Fig. A-III-622. Sub-bottom line 2023_230_0000



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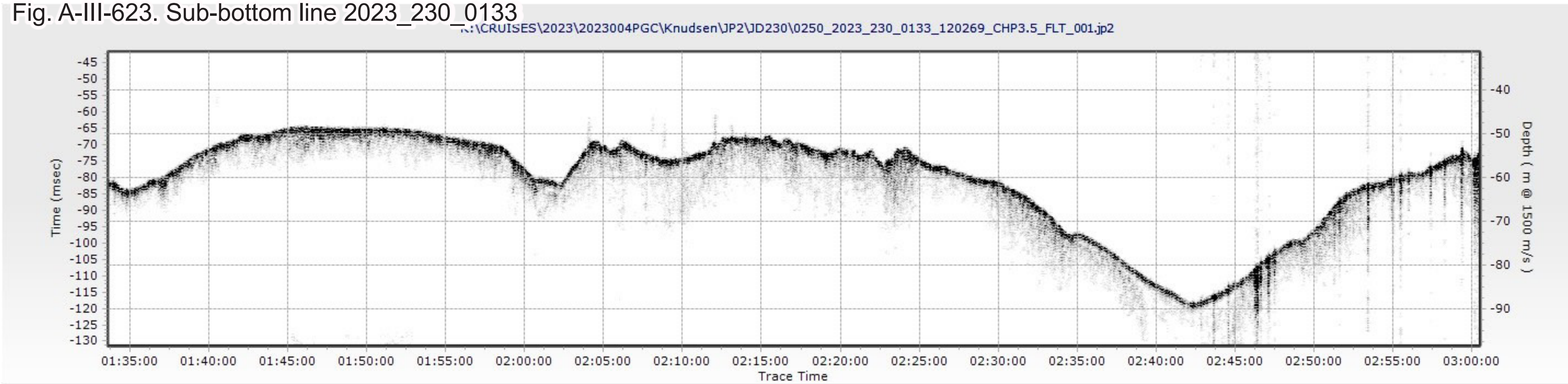

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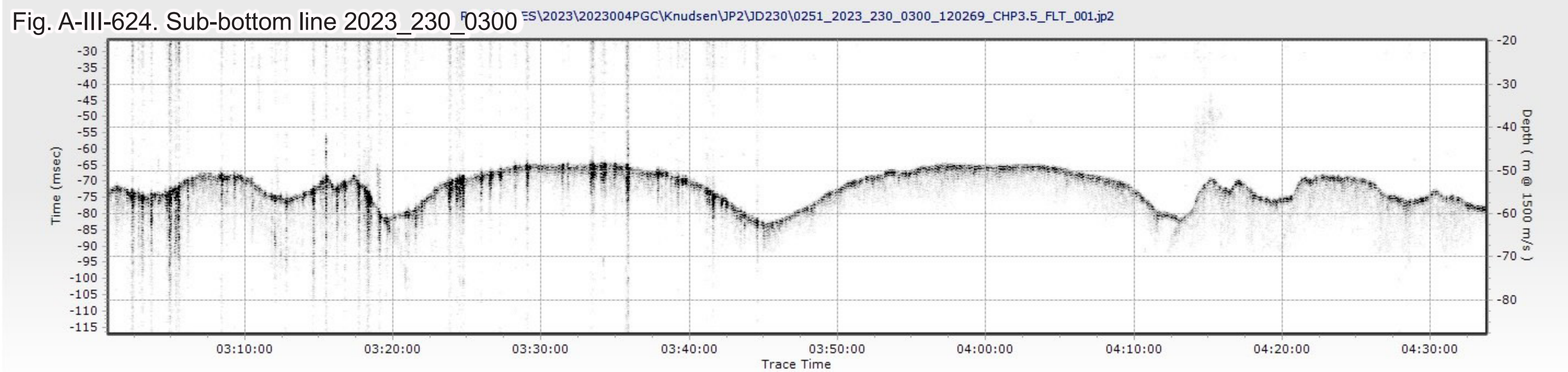
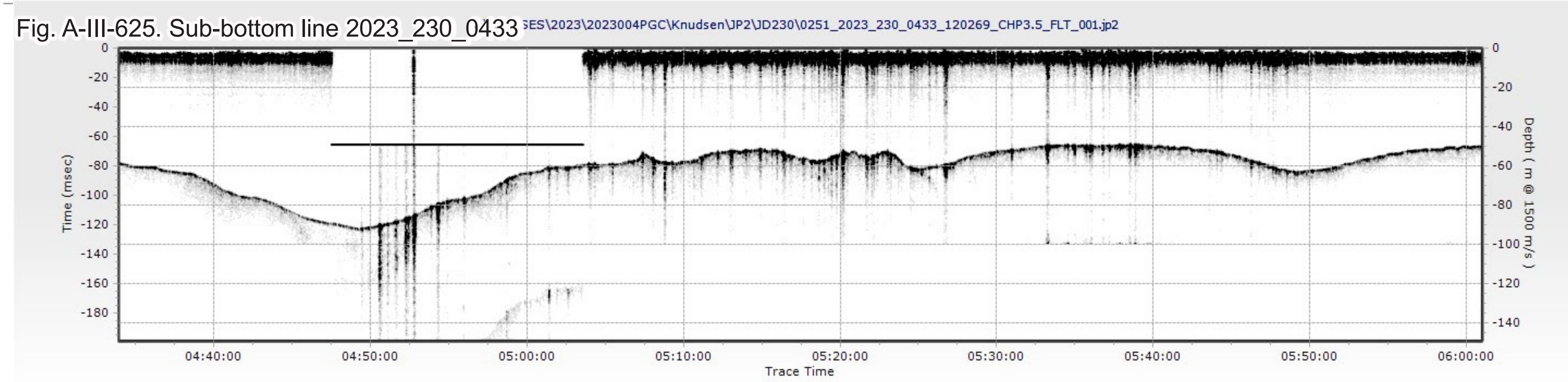


Fig. A-III-625. Sub-bottom line 2023_230_0433



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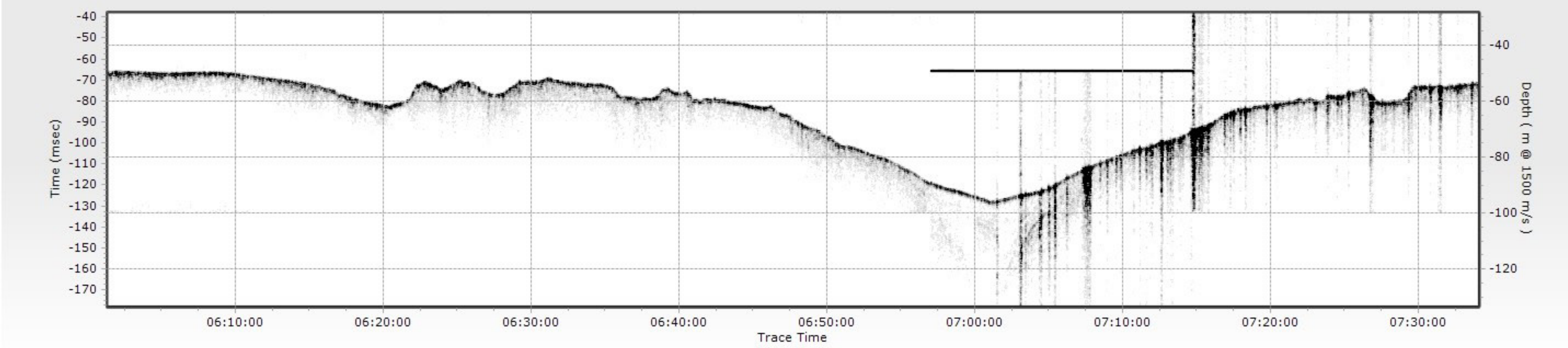
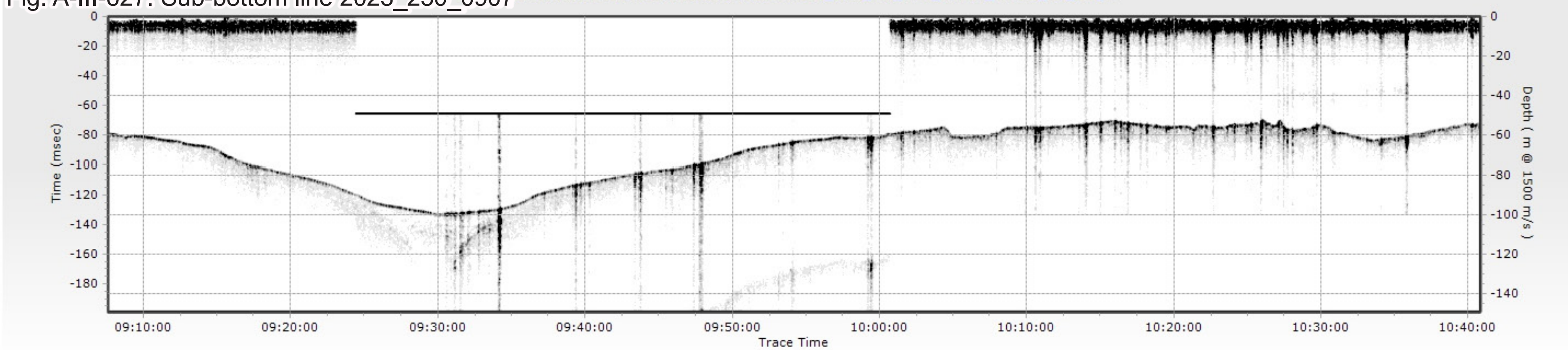


Fig. A-III-627. Sub-bottom line 2023_230_0907



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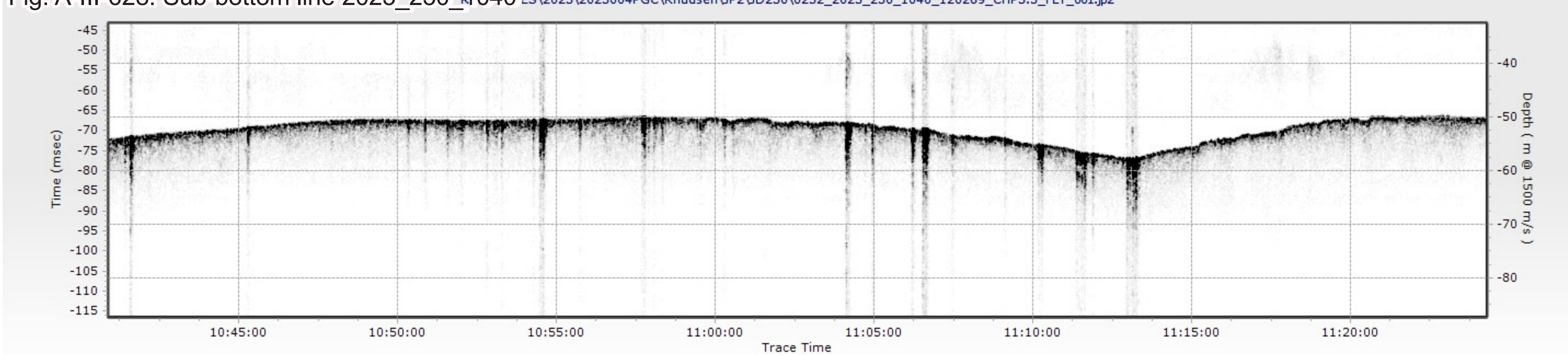

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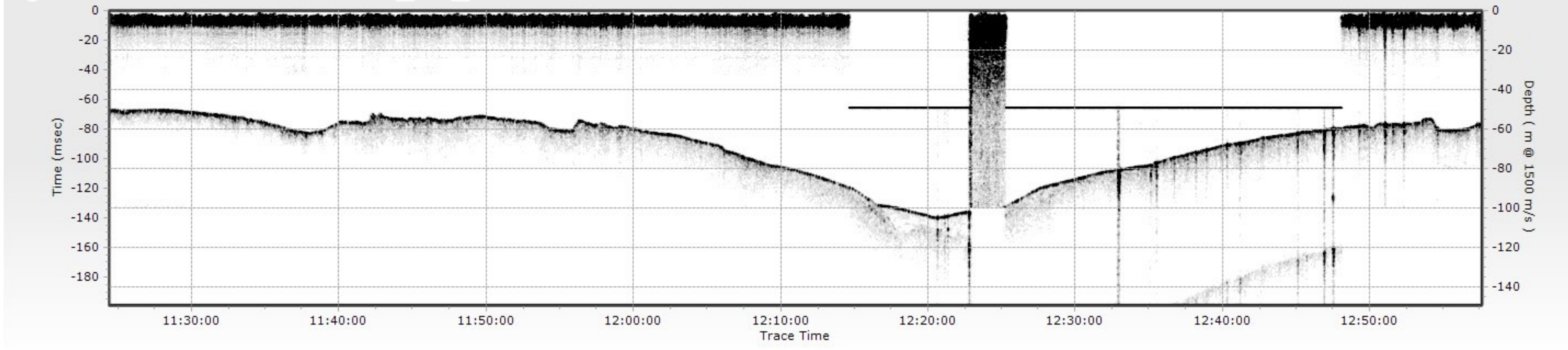
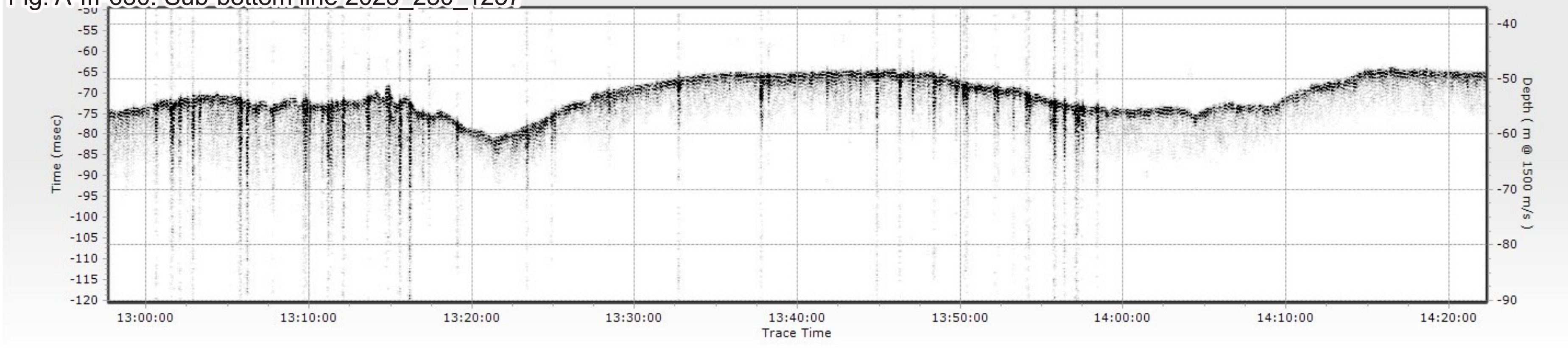


Fig. A-III-630. Sub-bottom line 2023_230_1257



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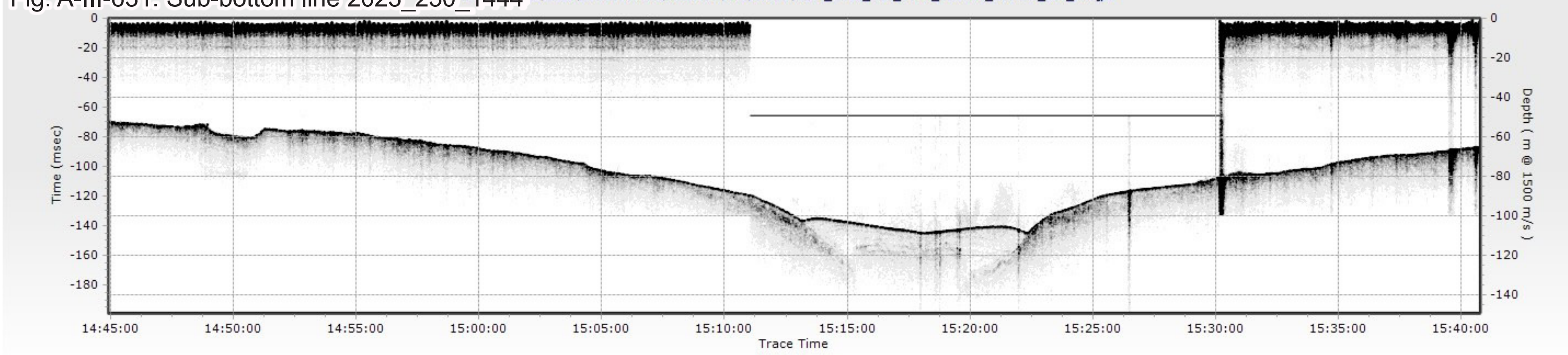

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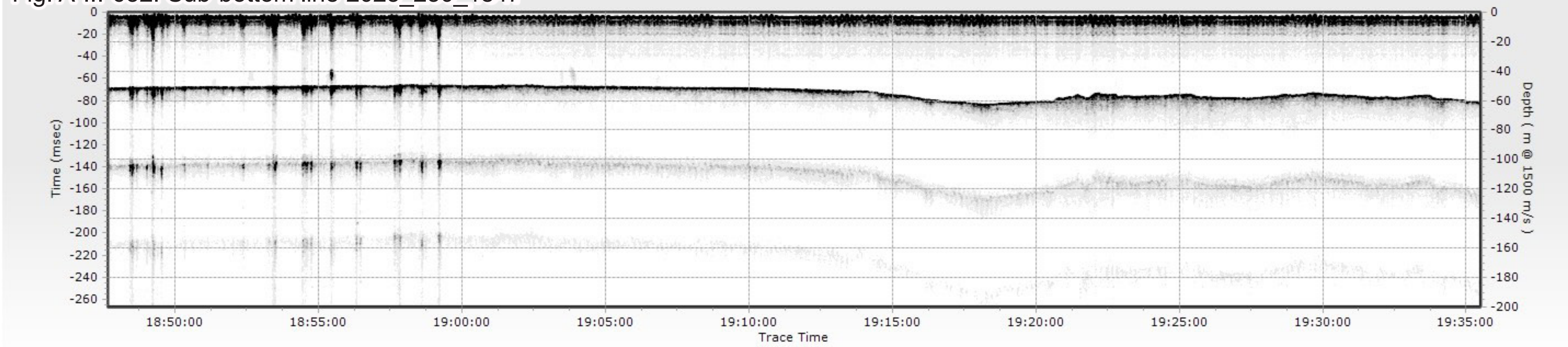

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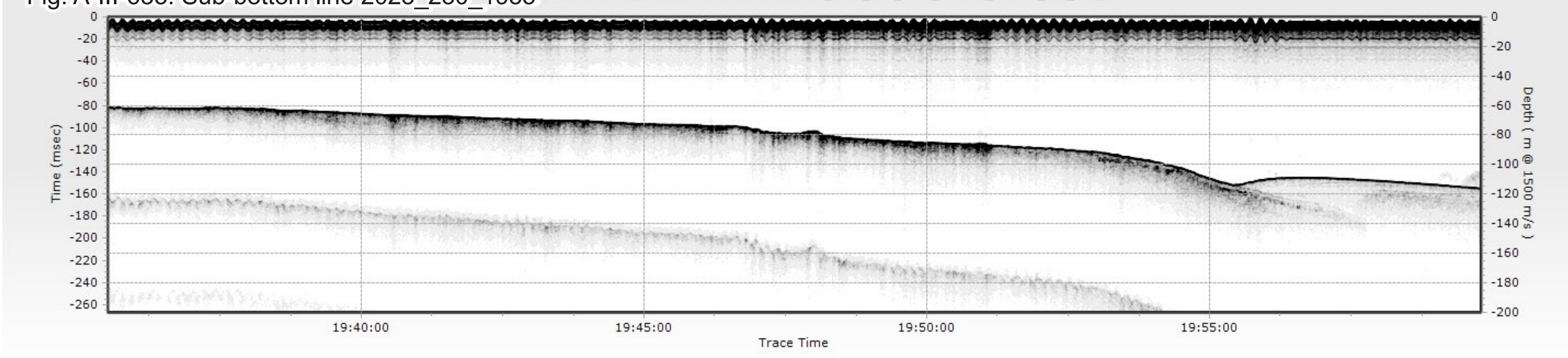

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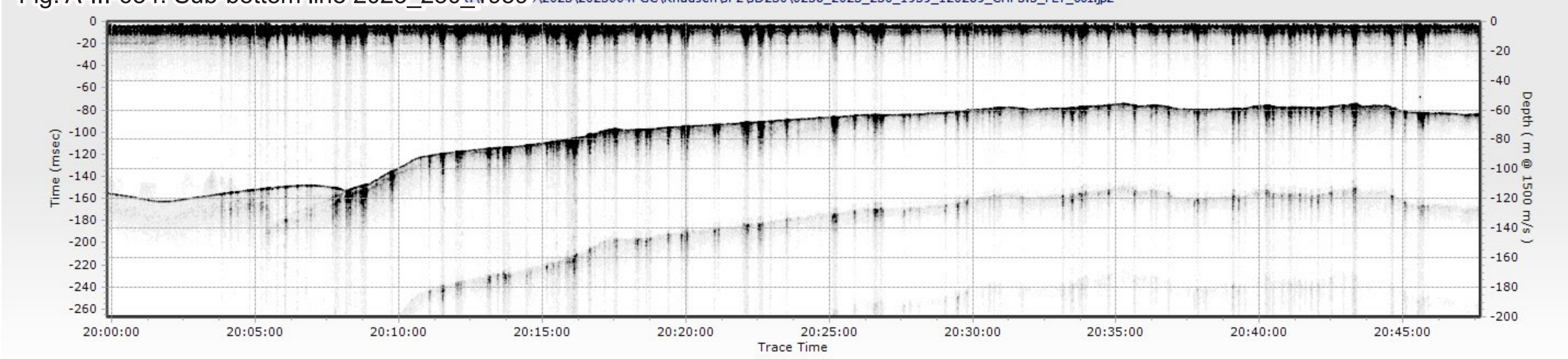

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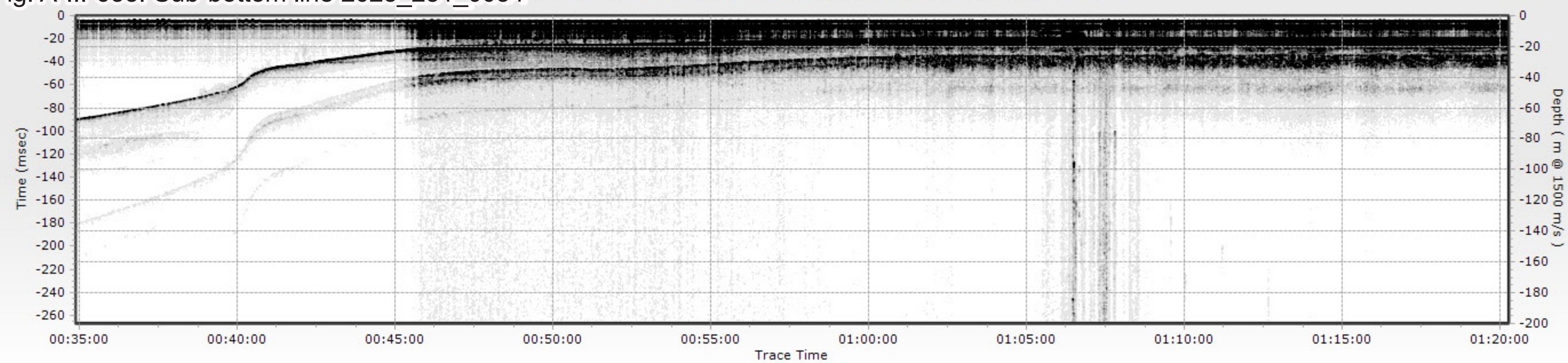

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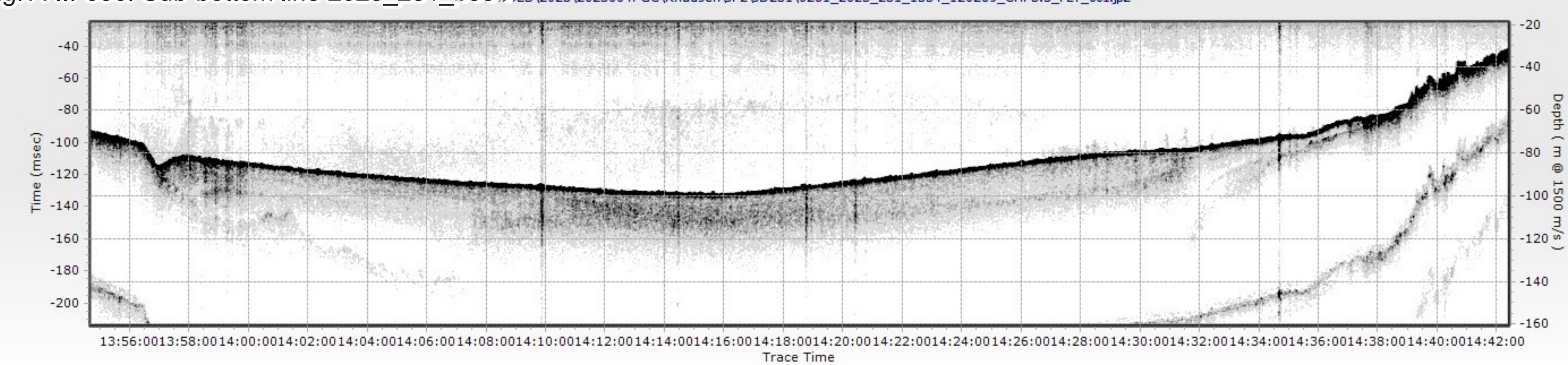
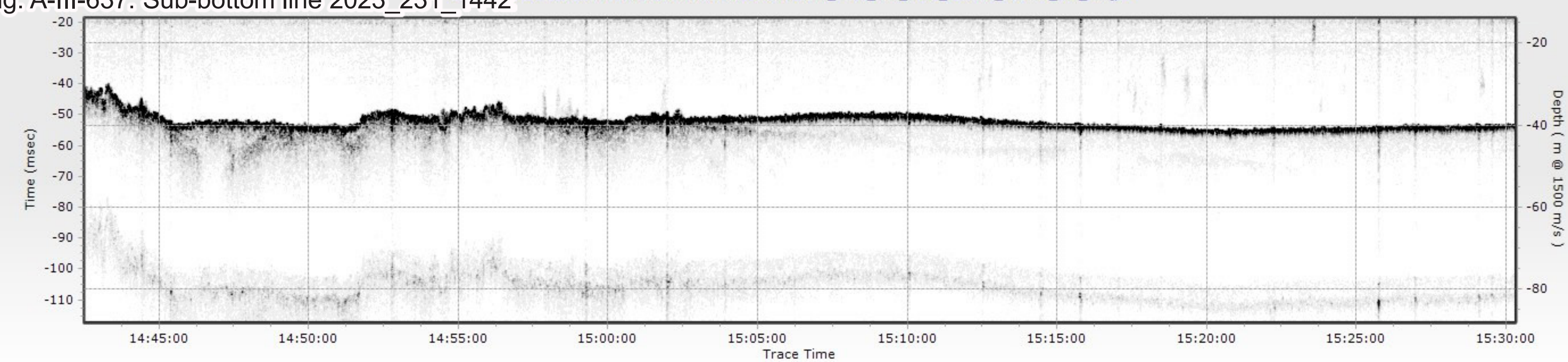


Fig. A-III-637. Sub-bottom line 2023_231_1442



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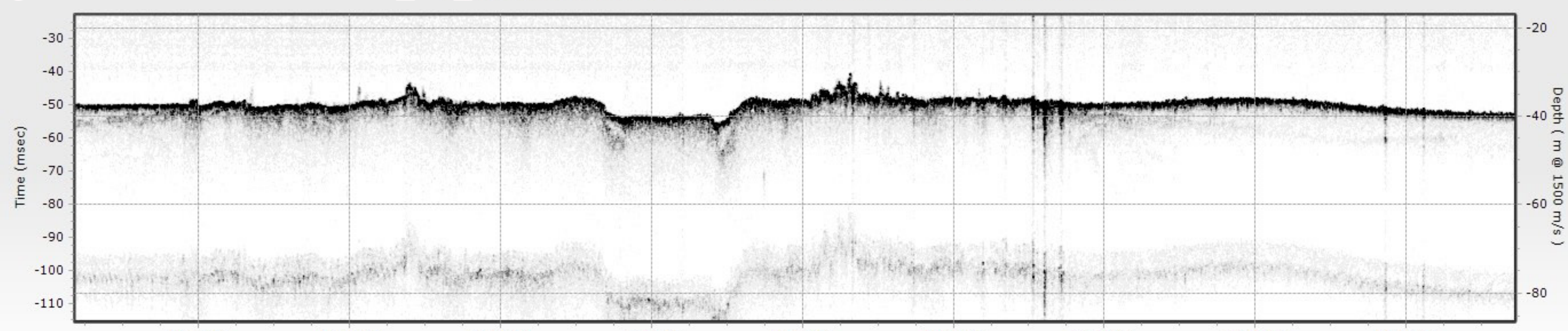

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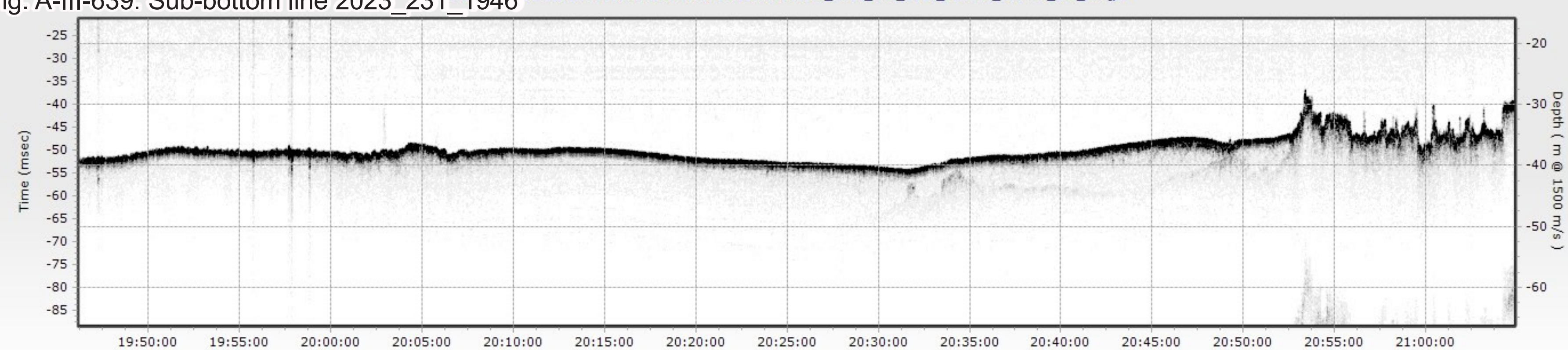

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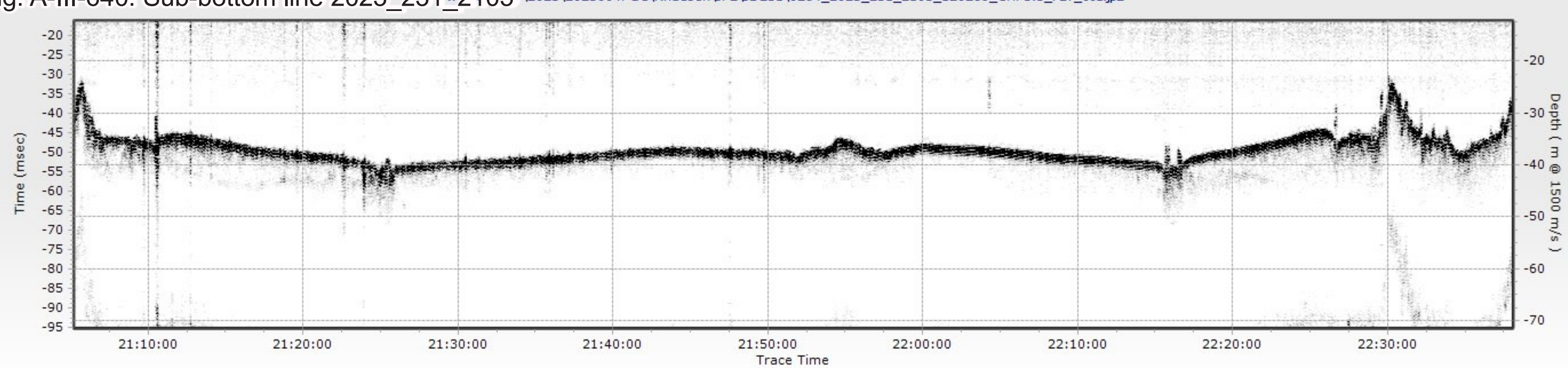

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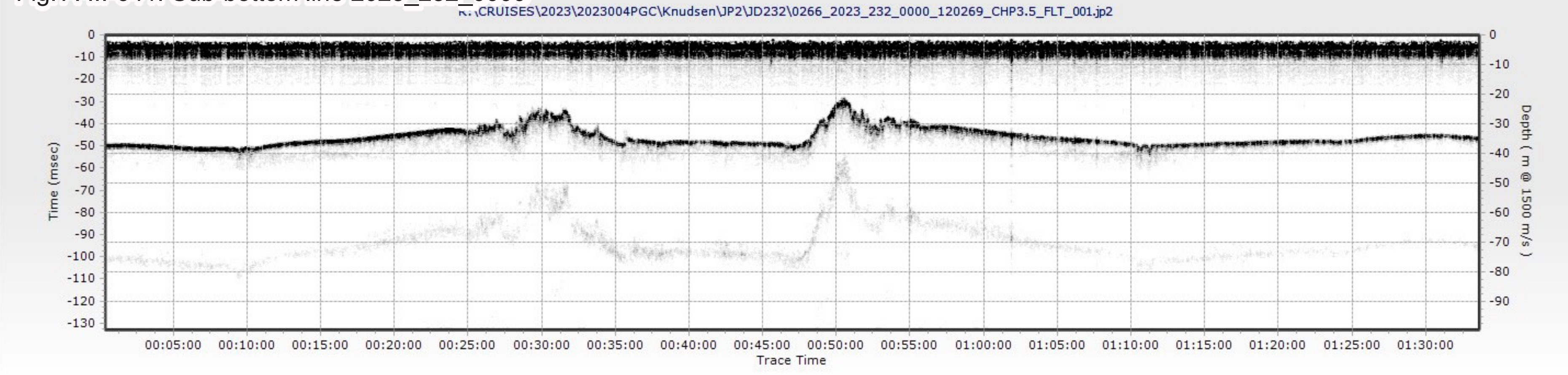

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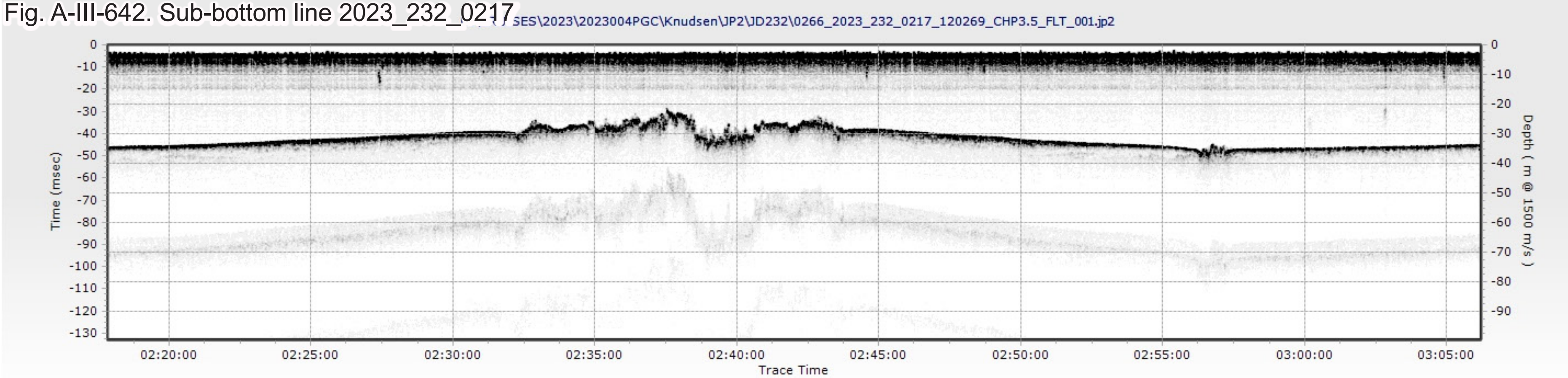

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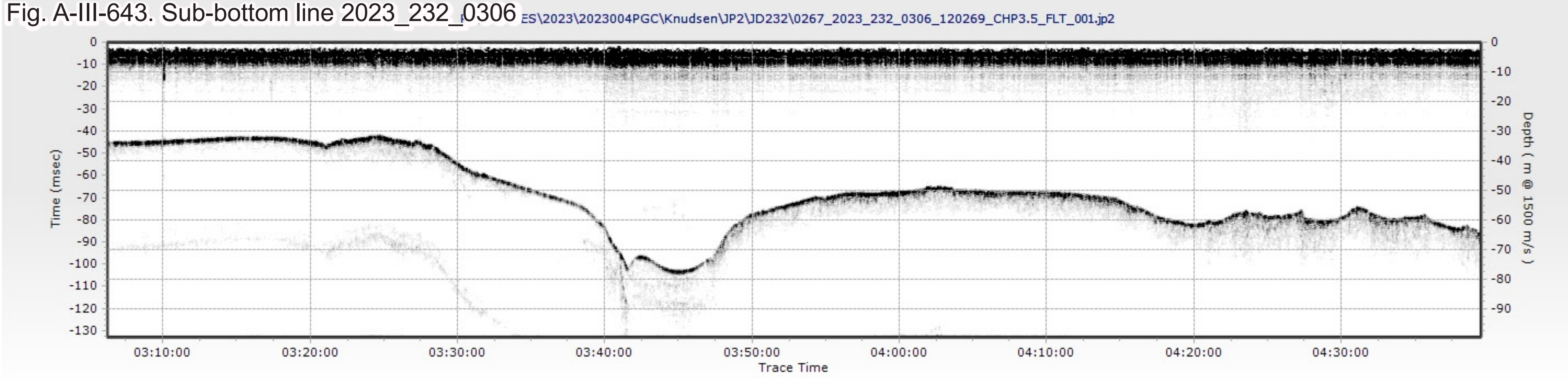

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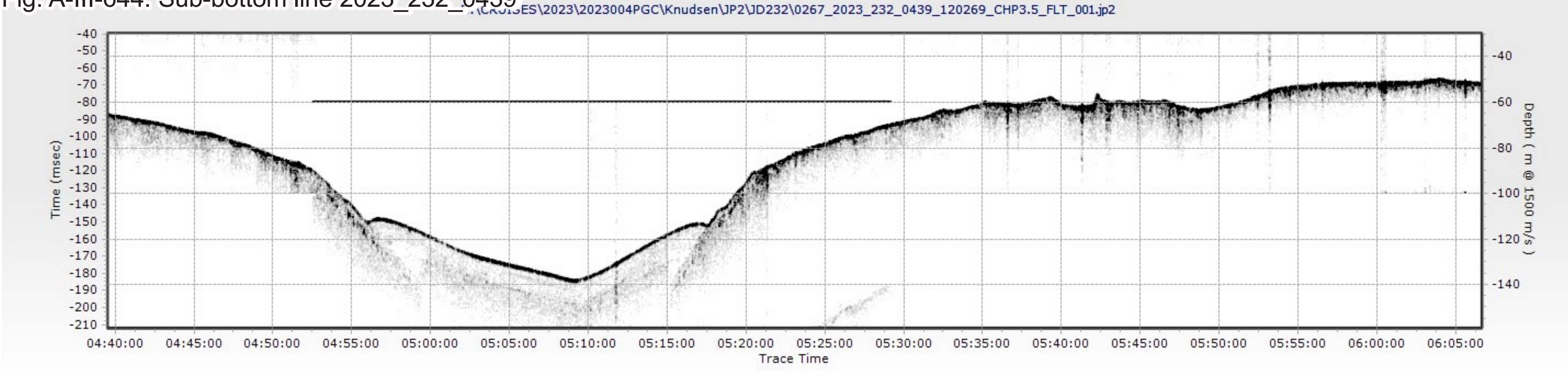

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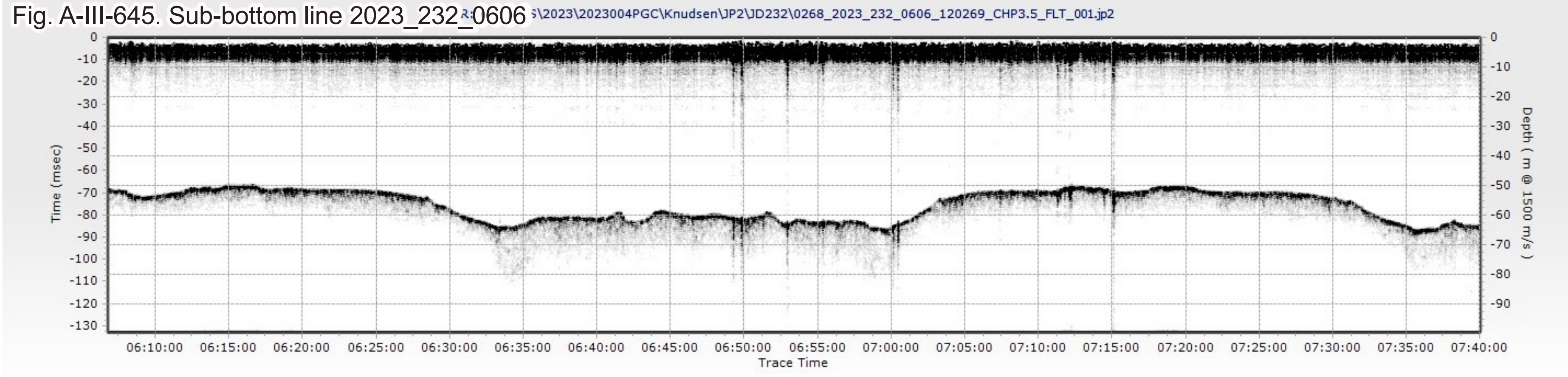

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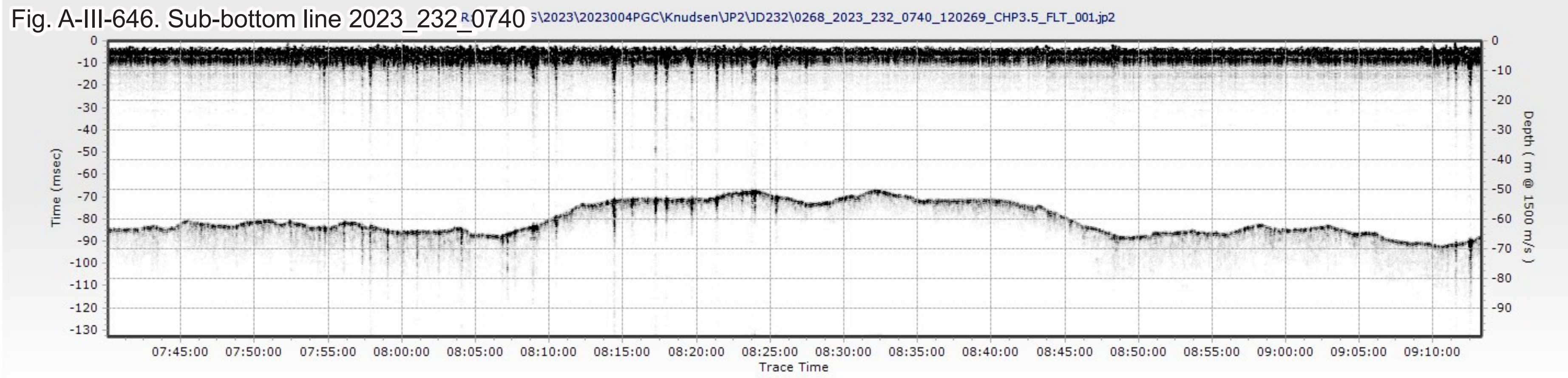

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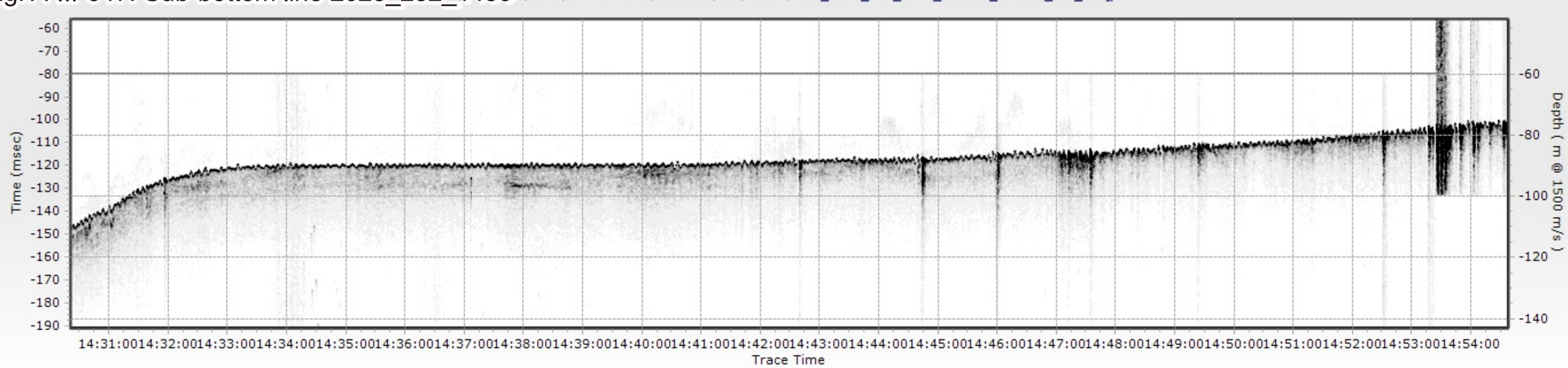

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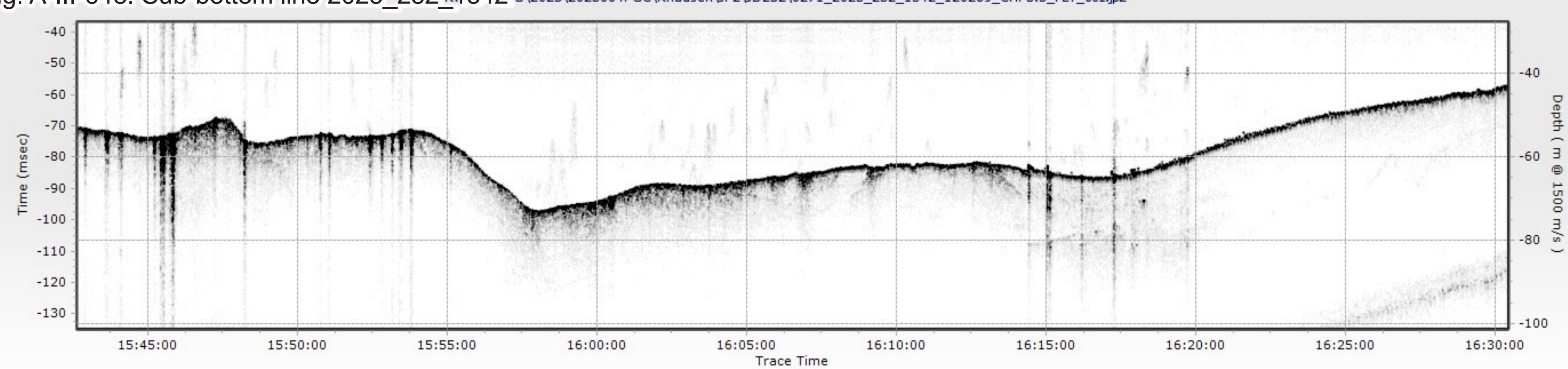

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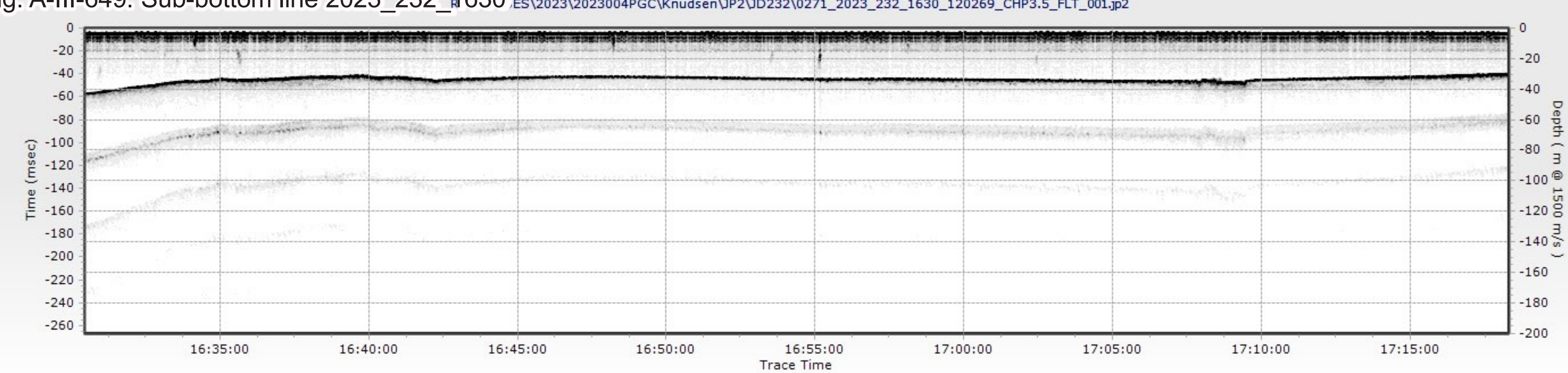

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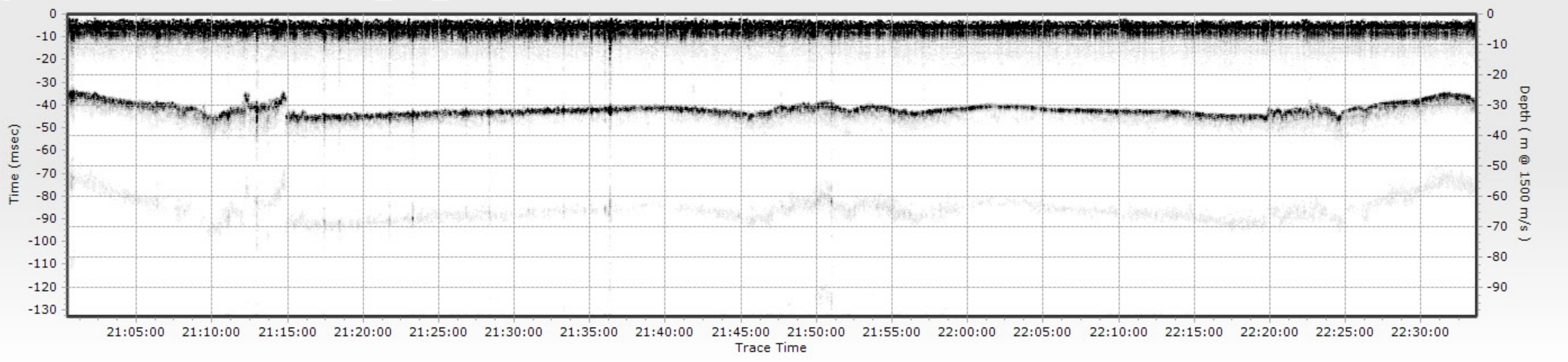

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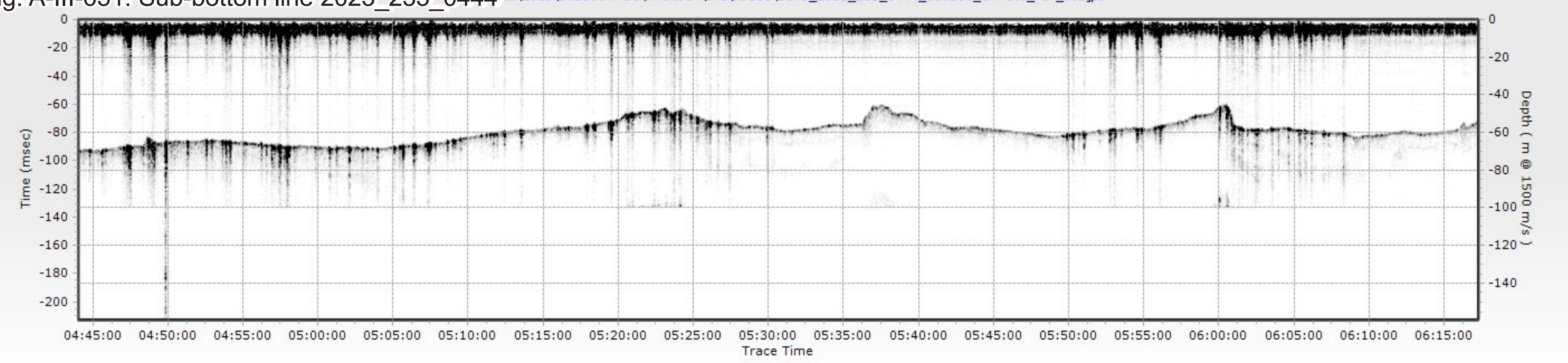

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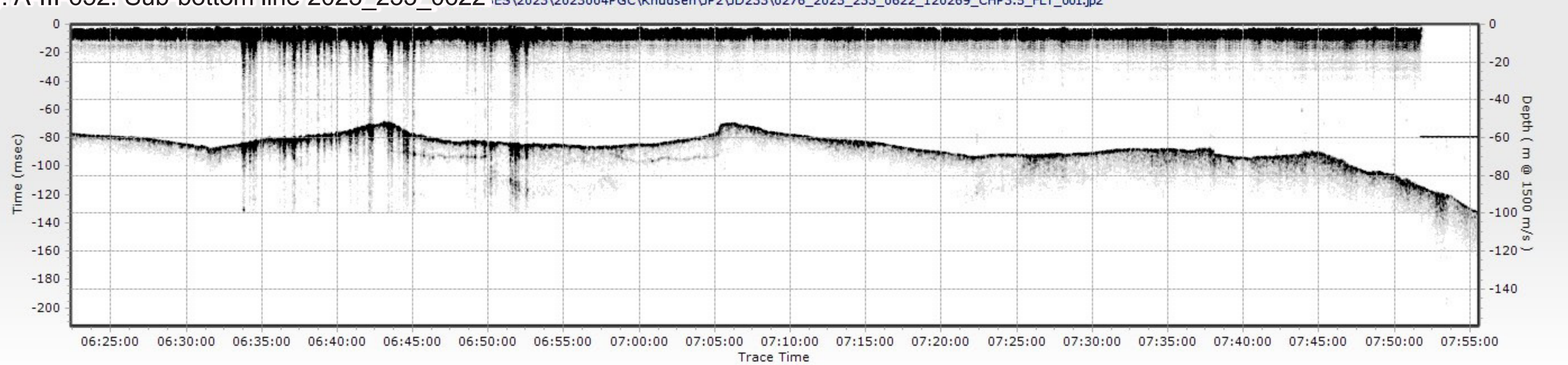

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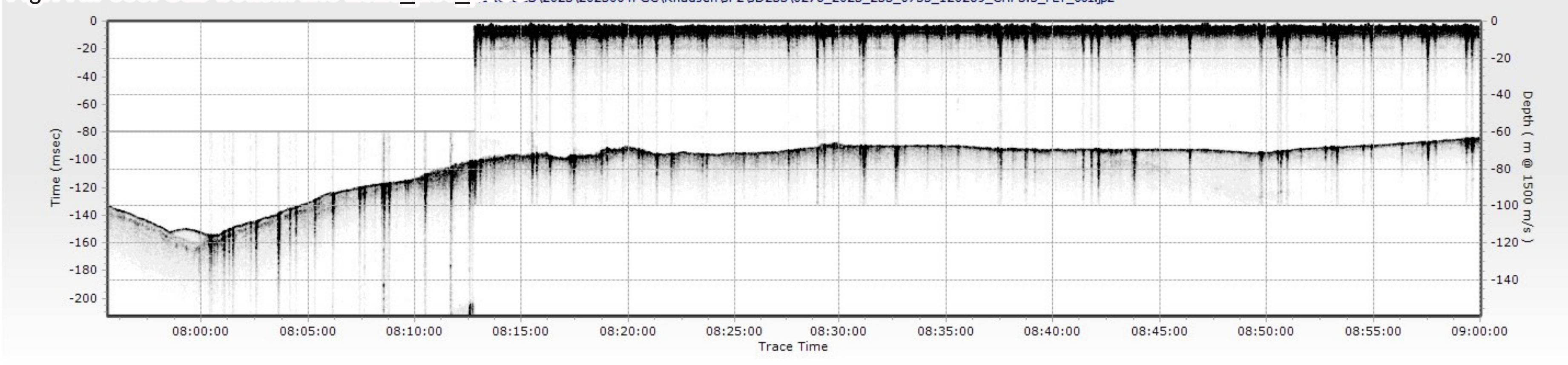
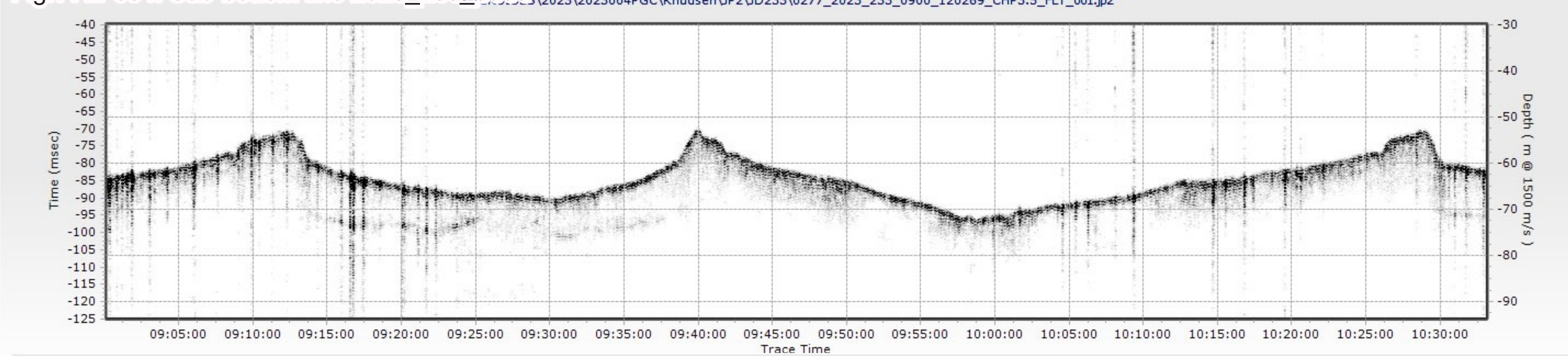


Fig. A-III-654. Sub-bottom line 2023_233_0900



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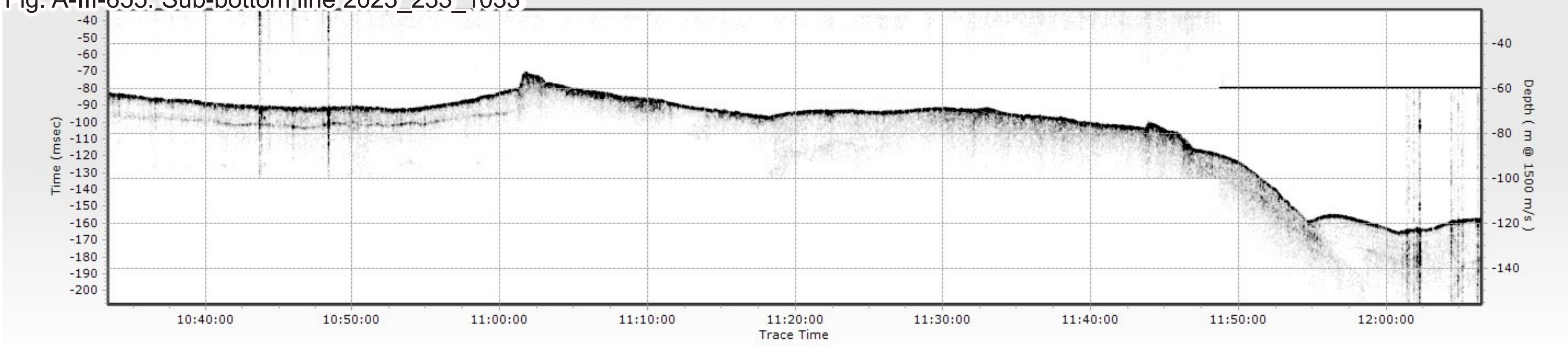

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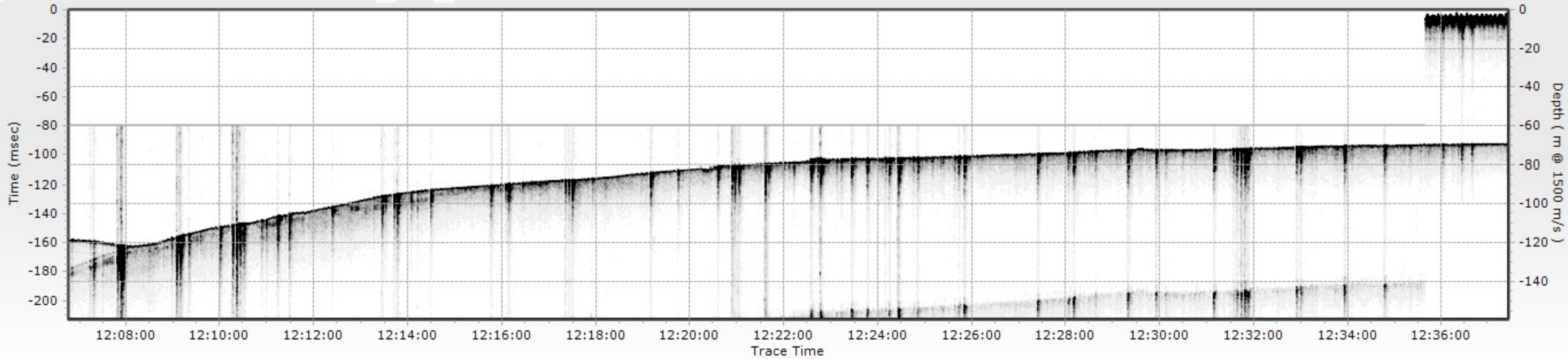

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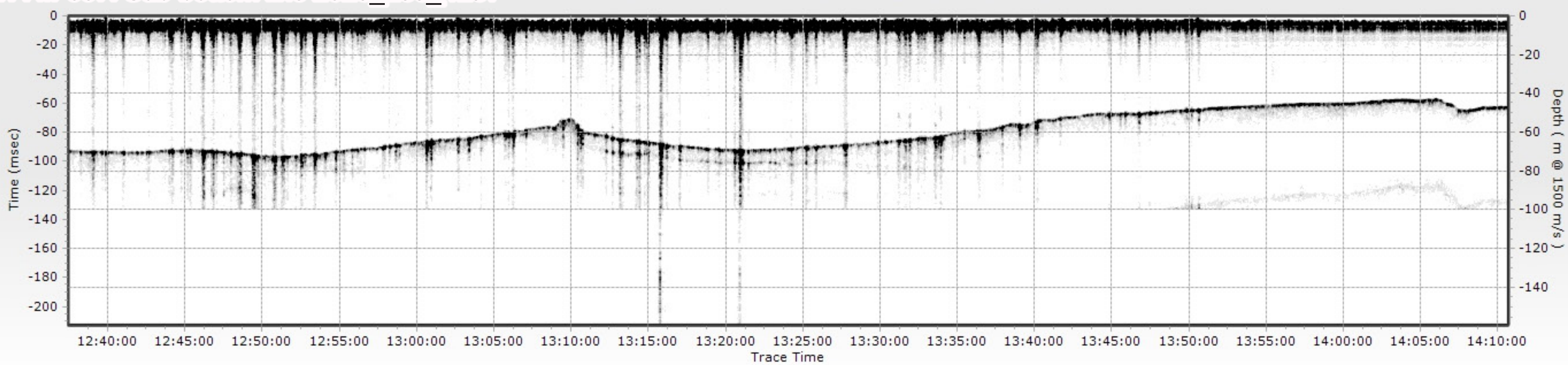

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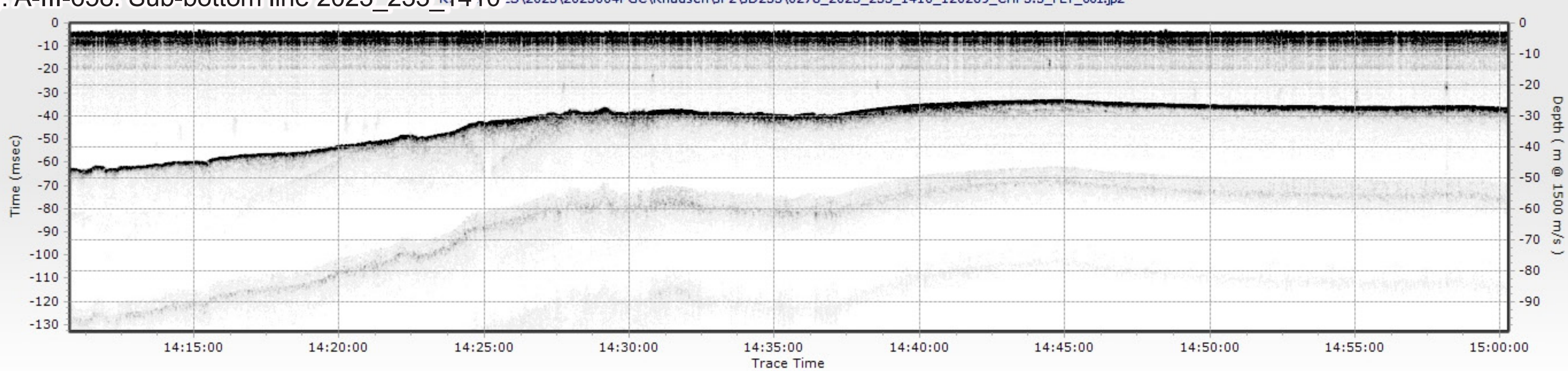

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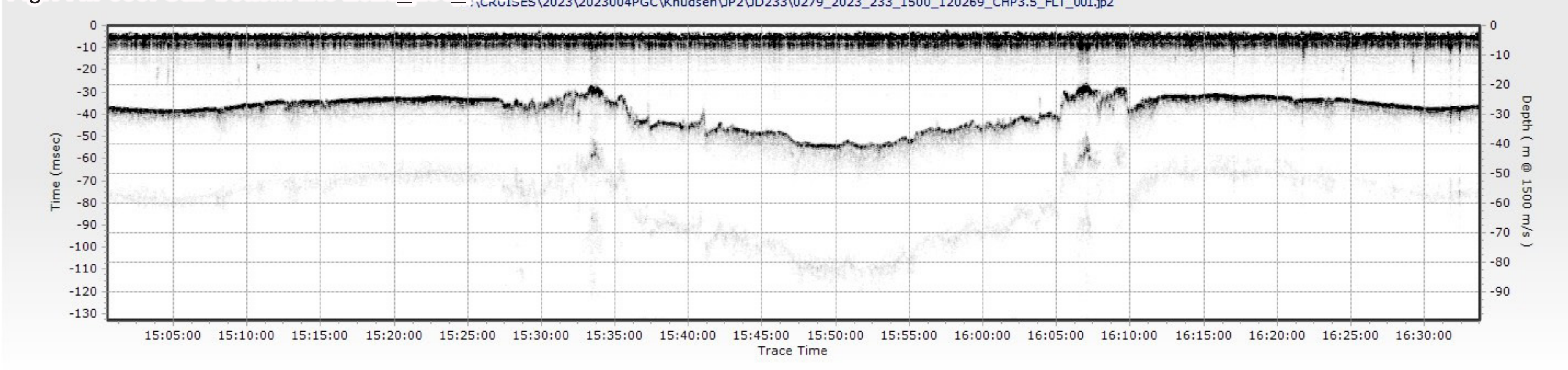

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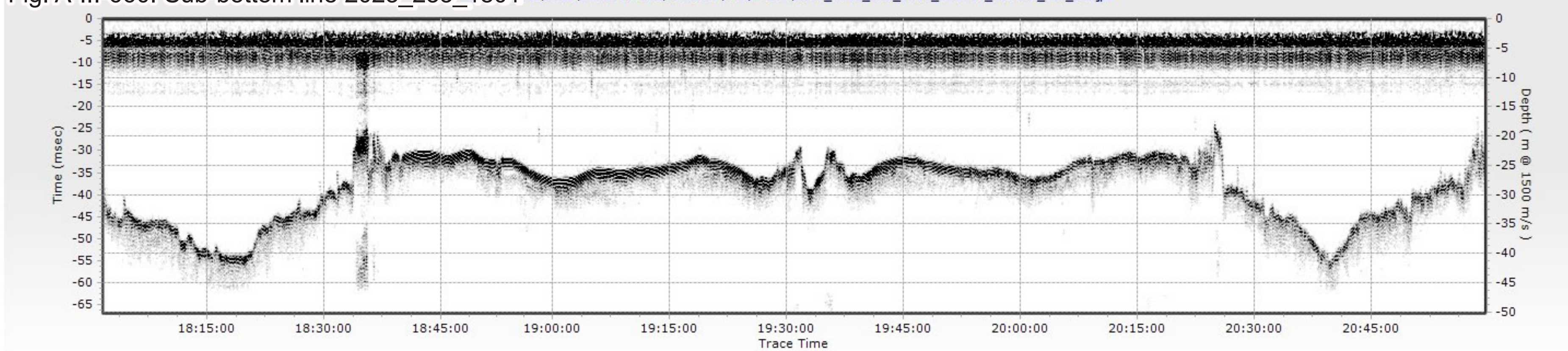

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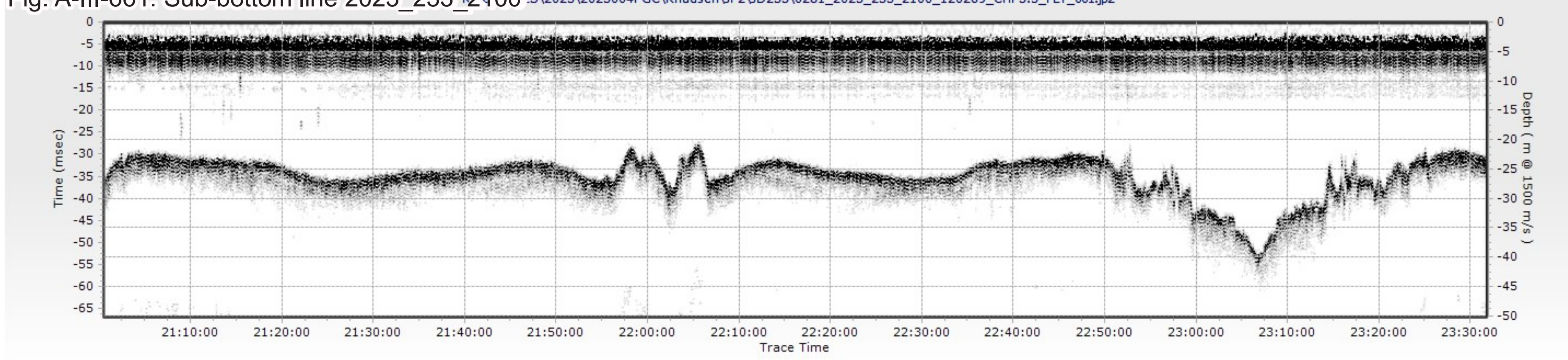

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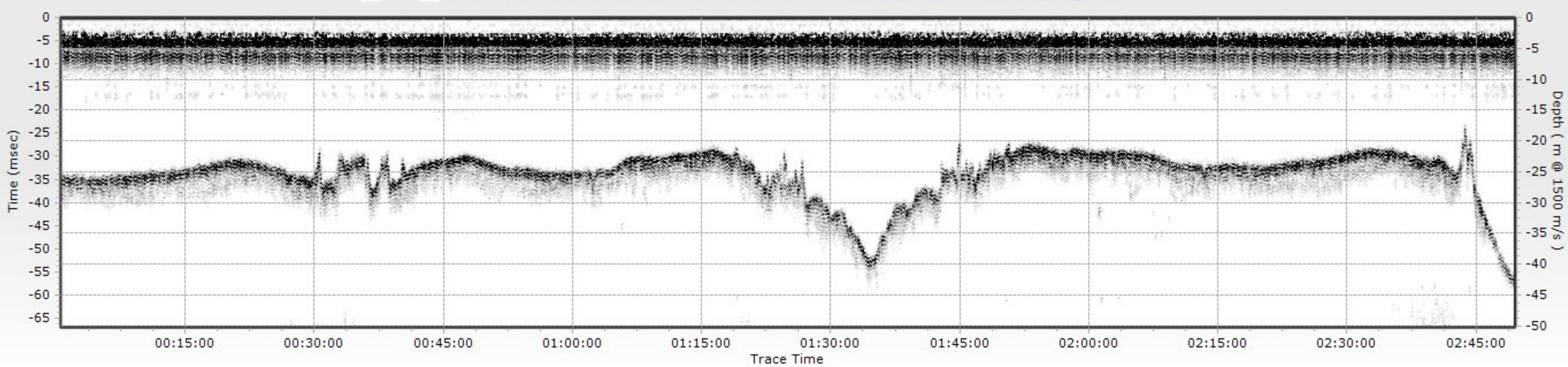

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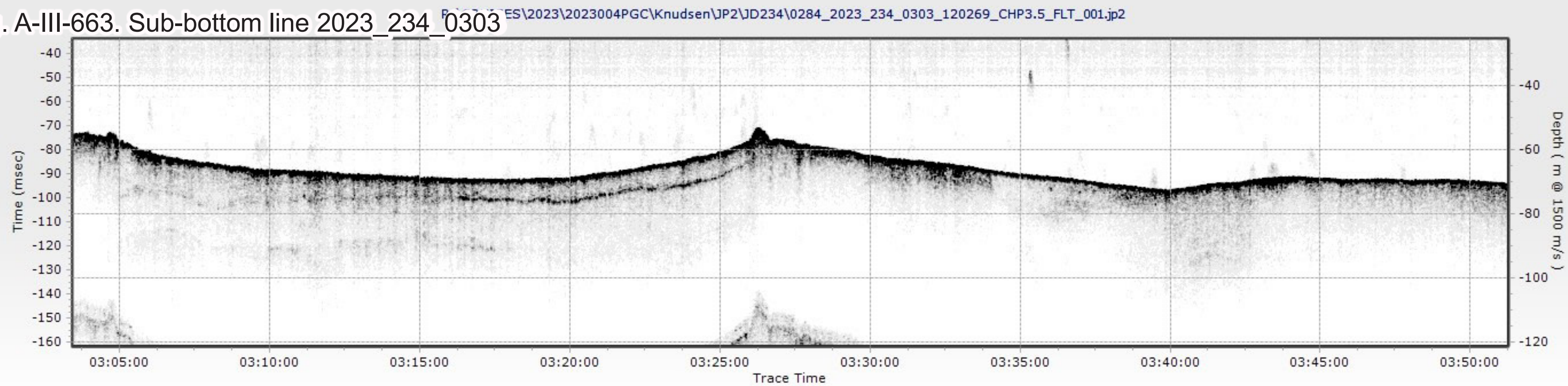

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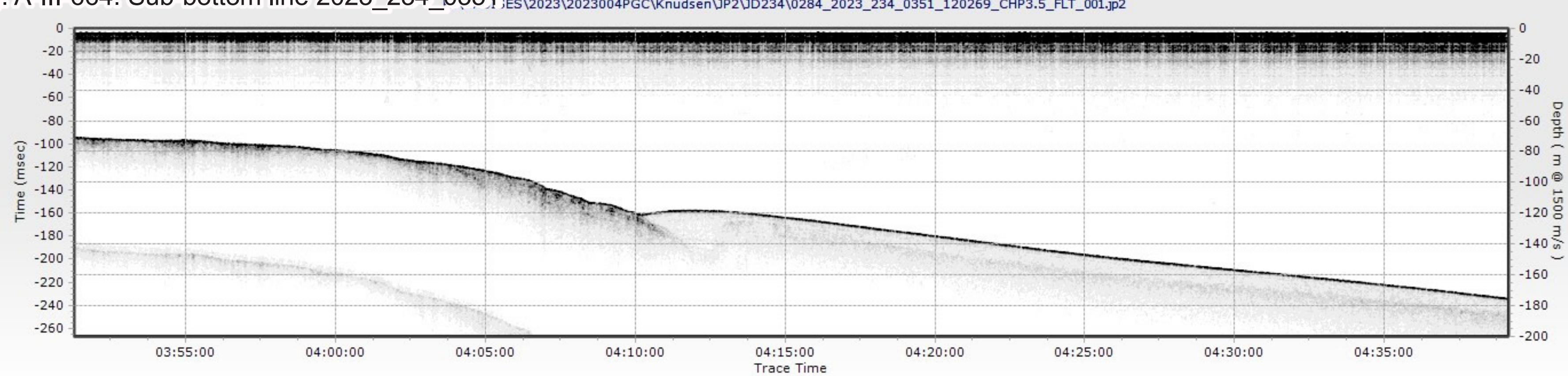

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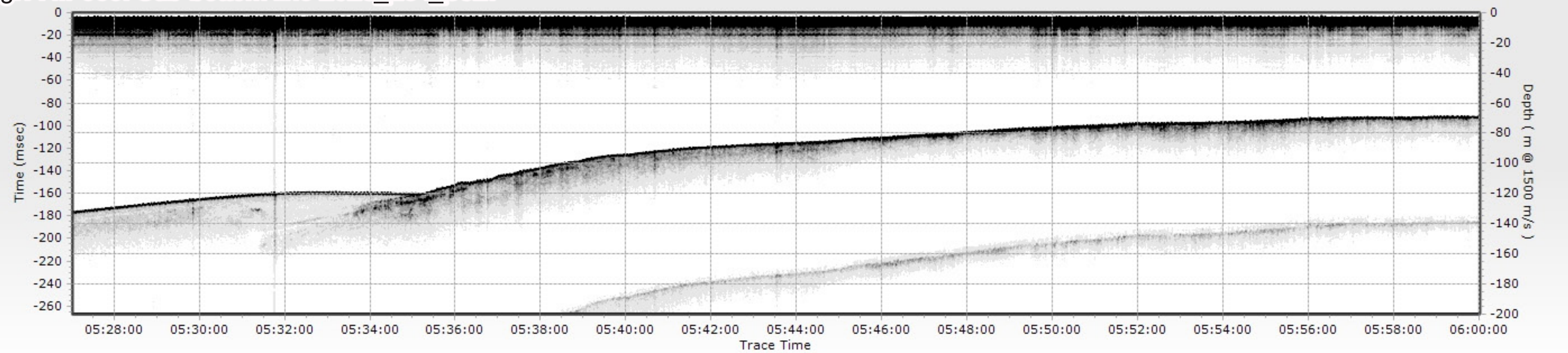

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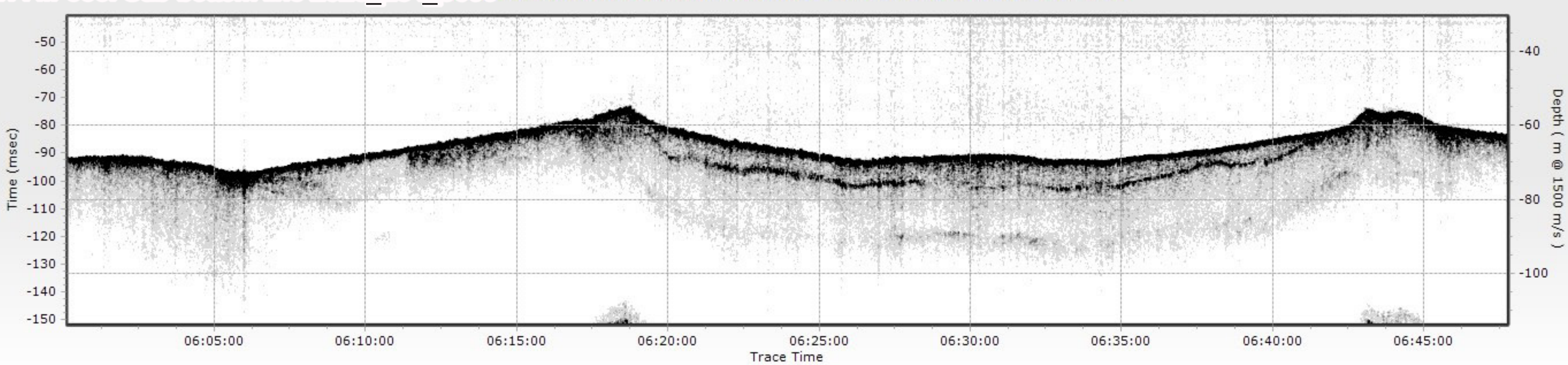

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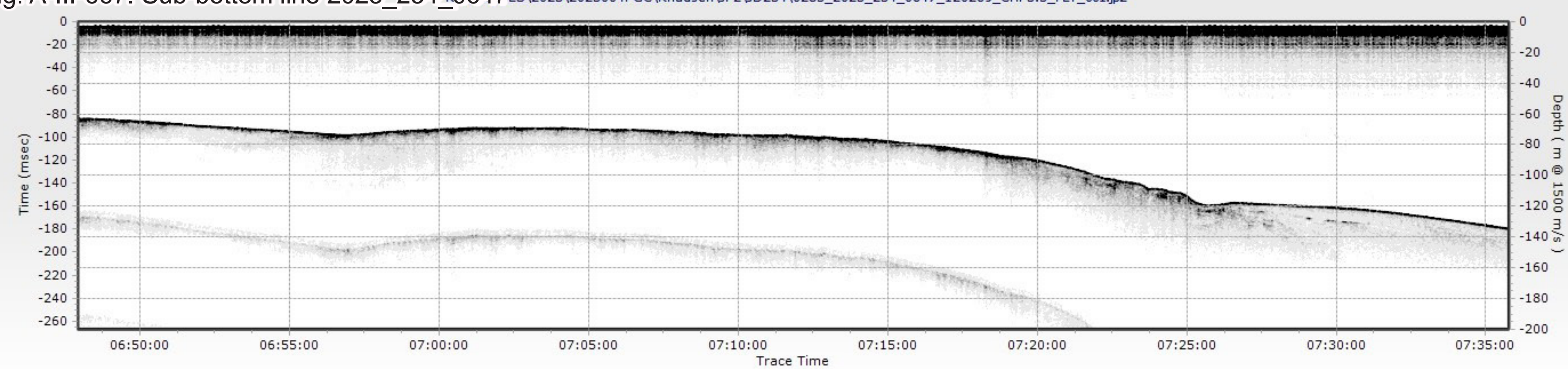

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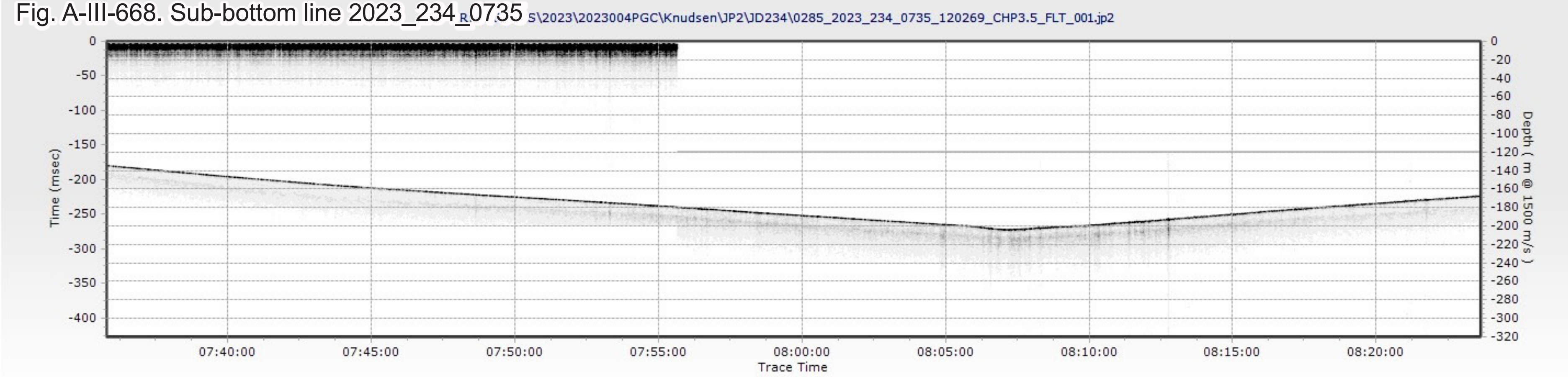

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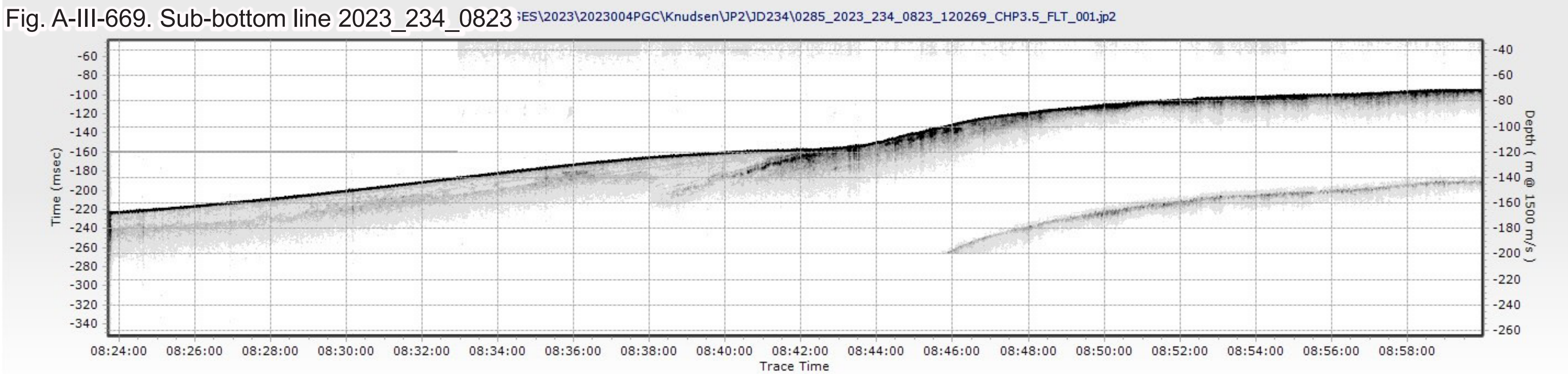

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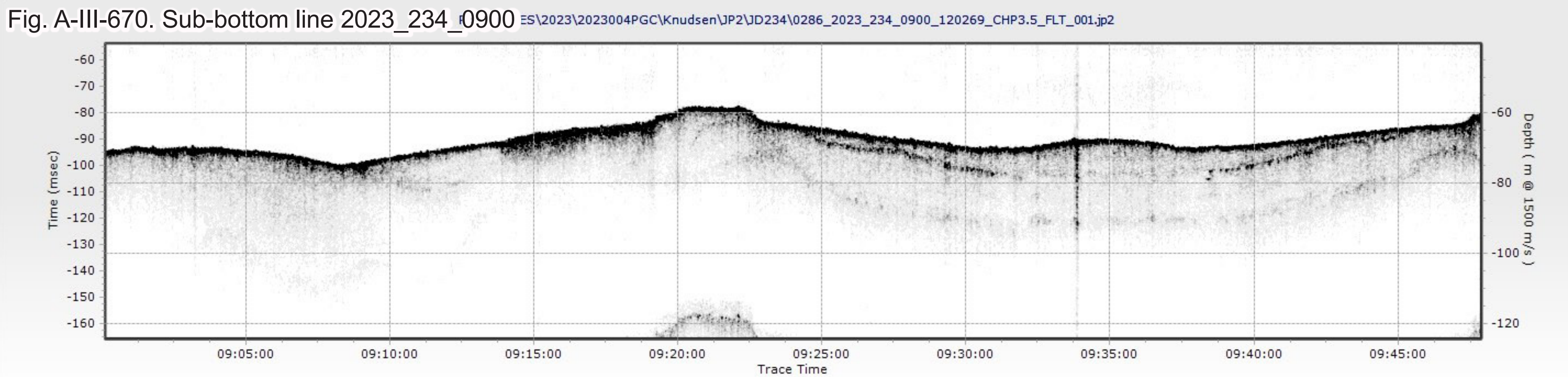

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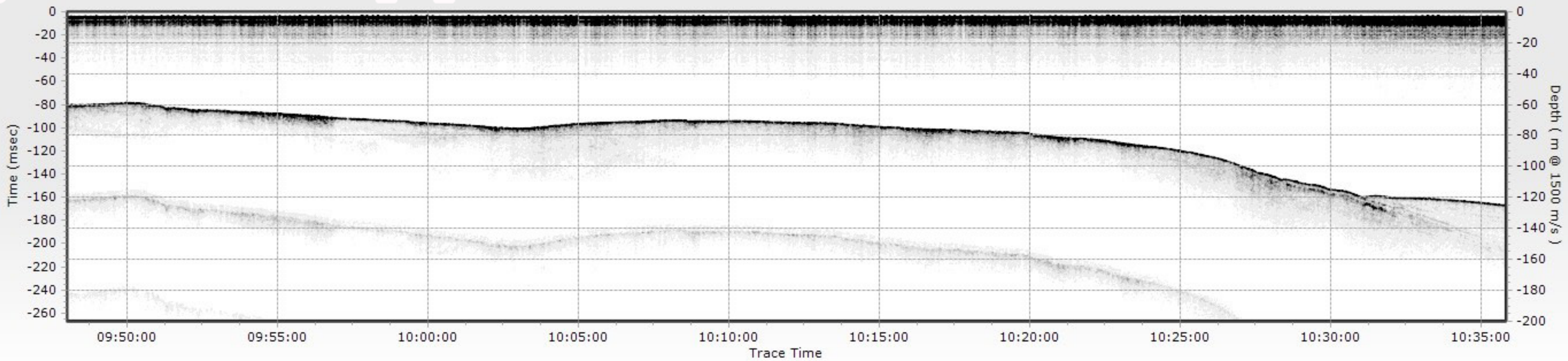

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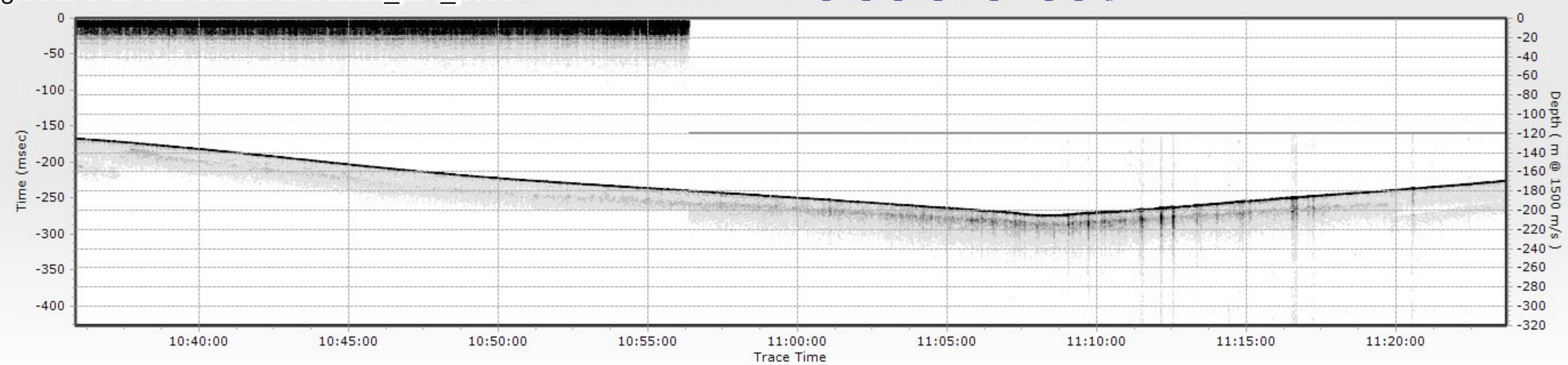

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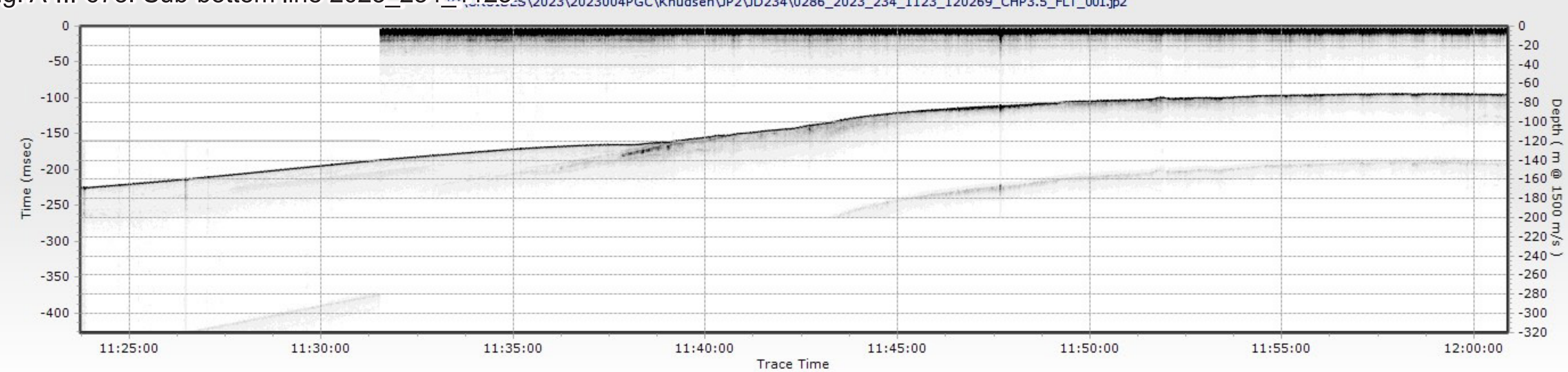

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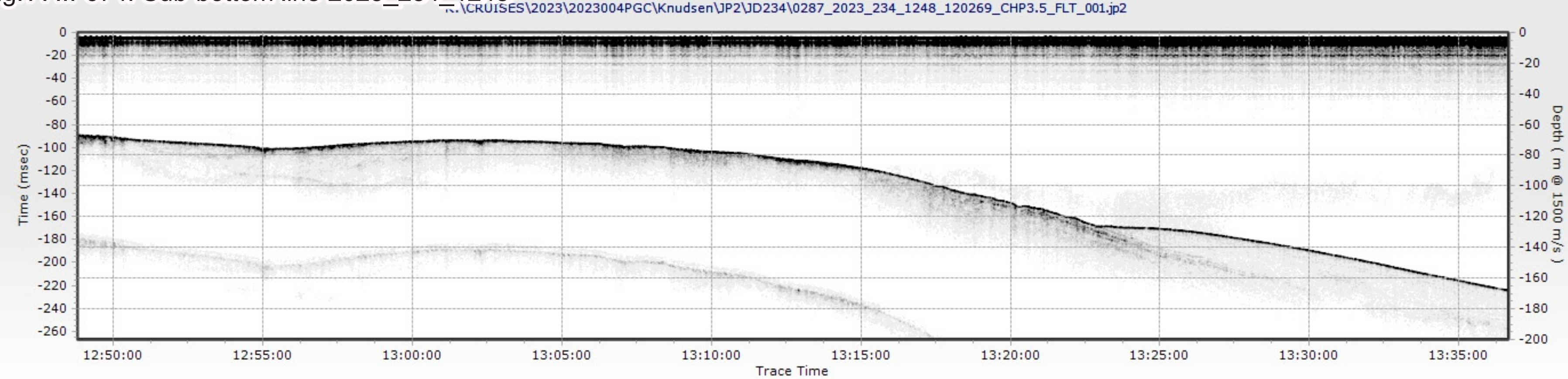
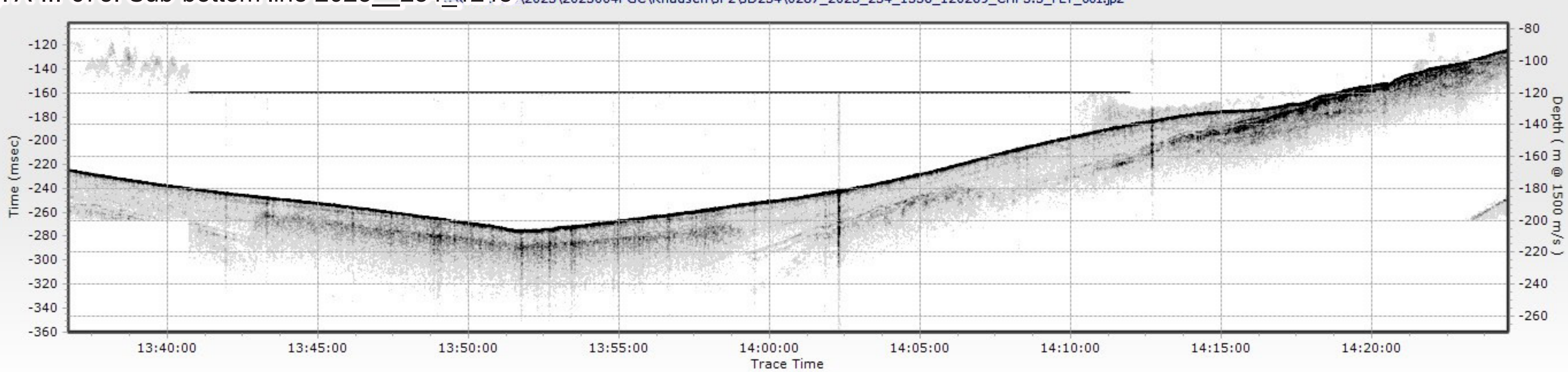


Fig. A-III-675. Sub-bottom line 2023__234_1248



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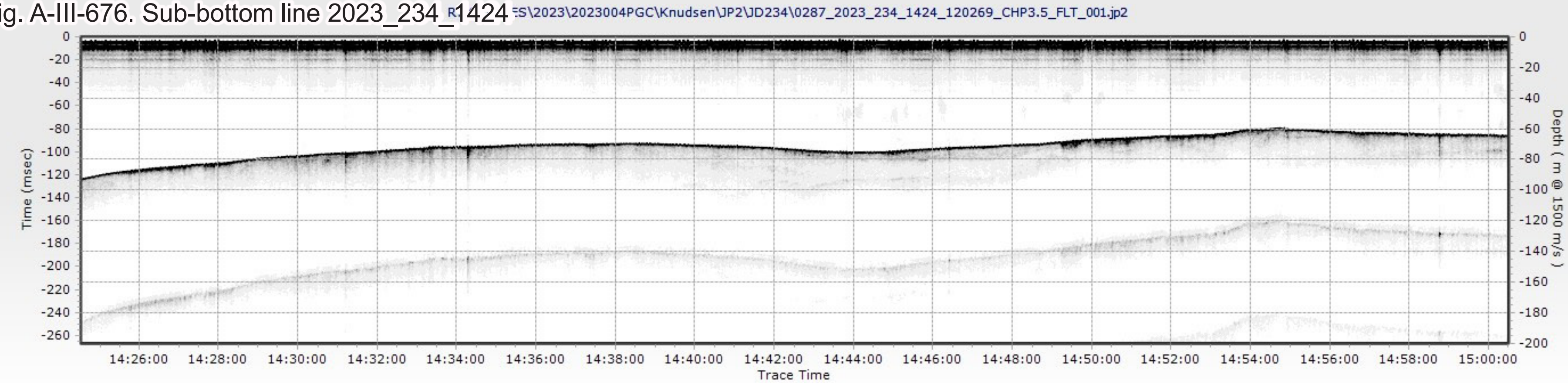

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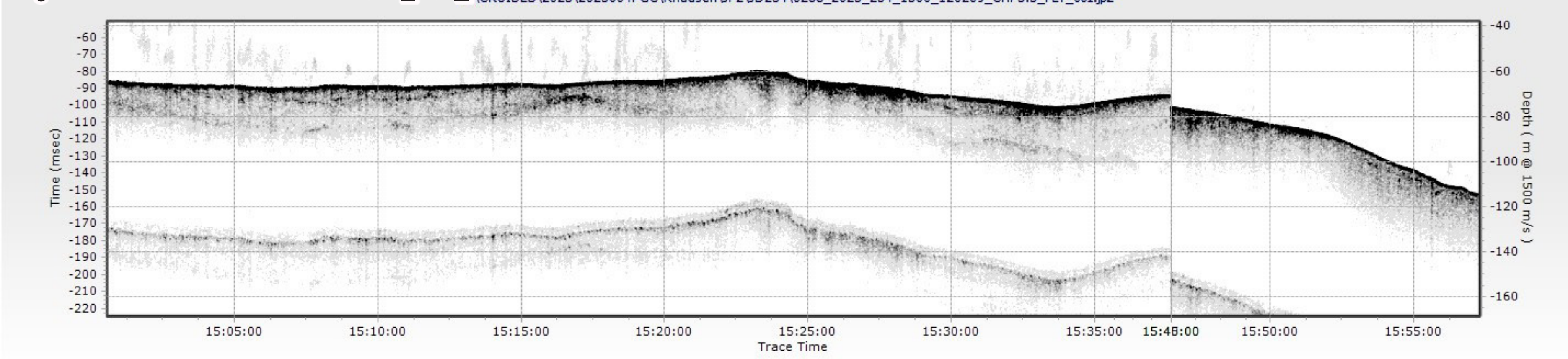

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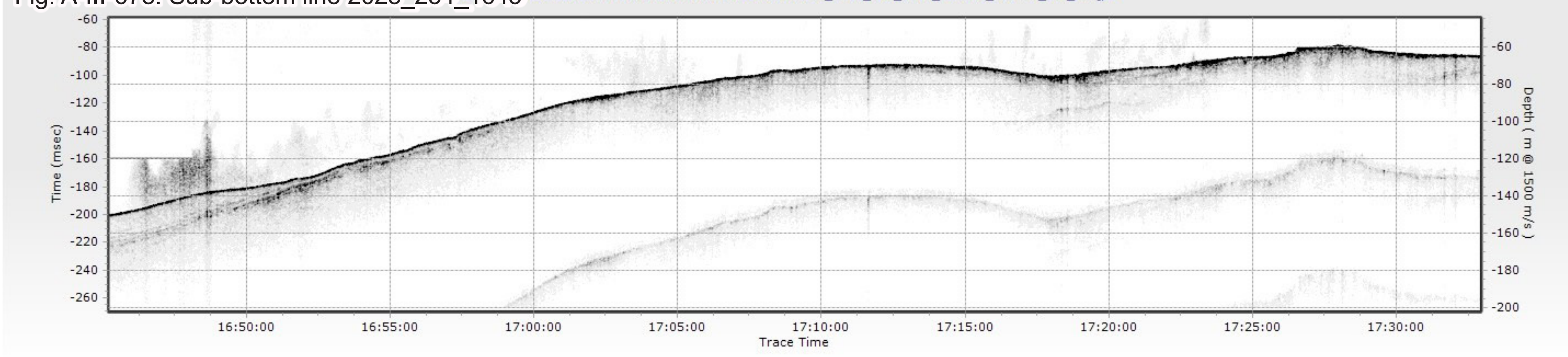

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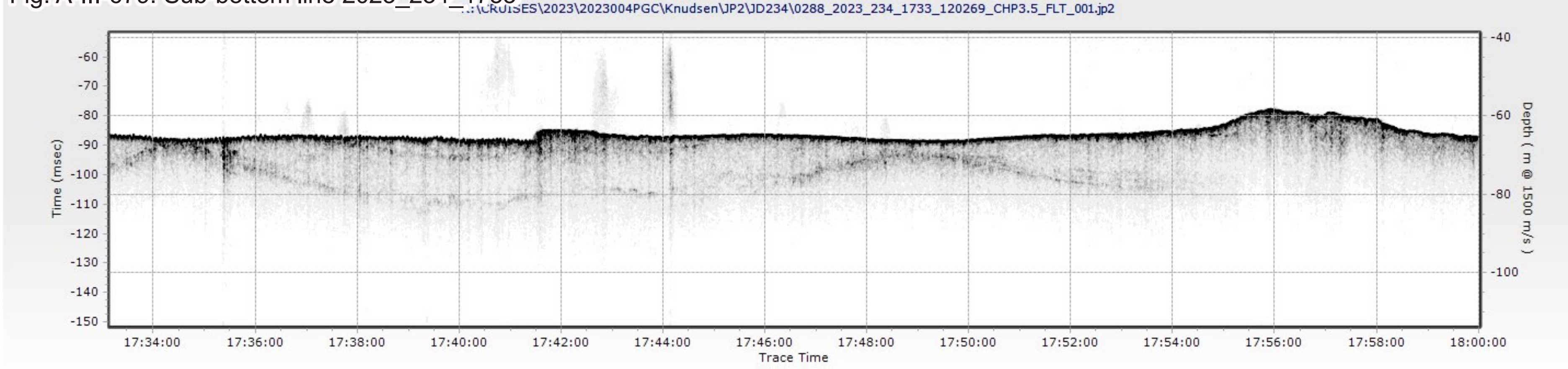

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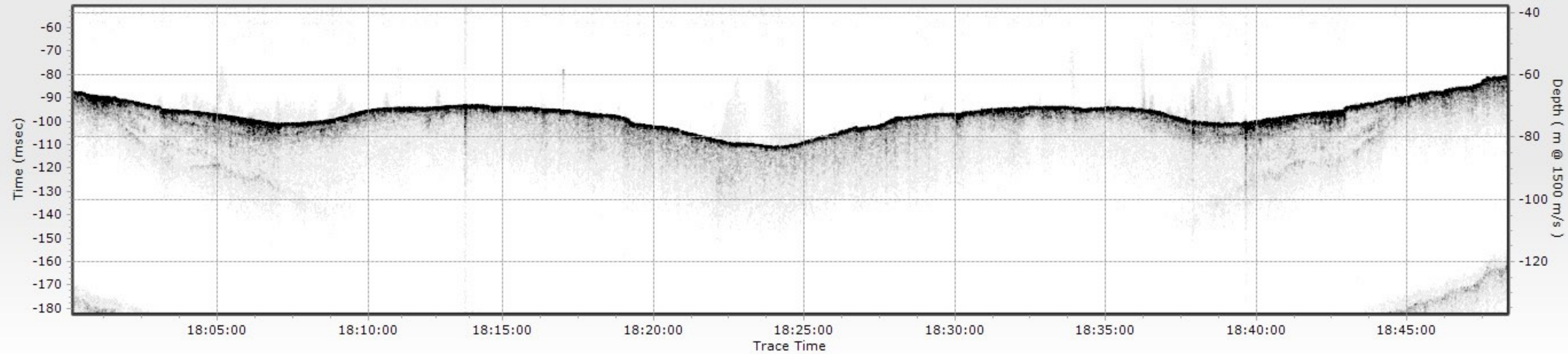

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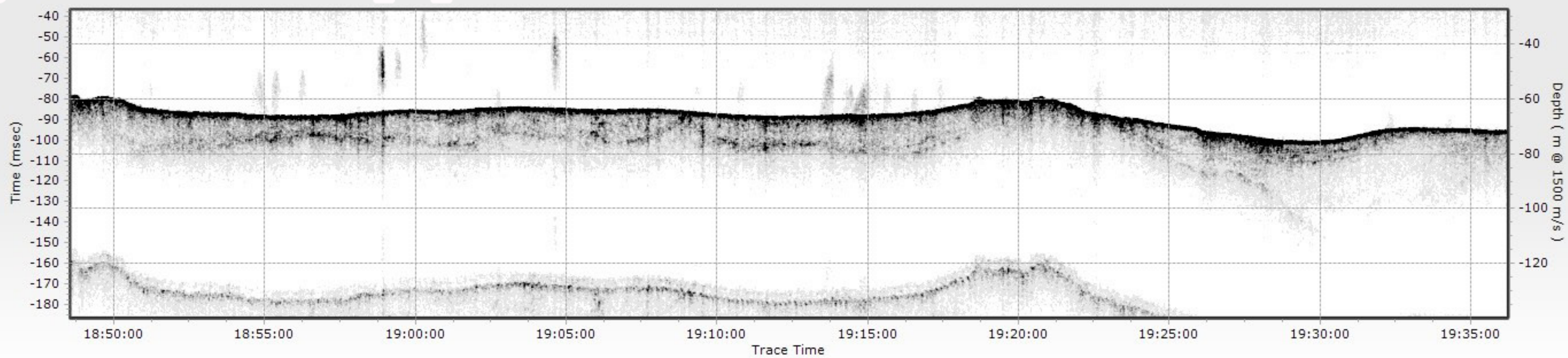

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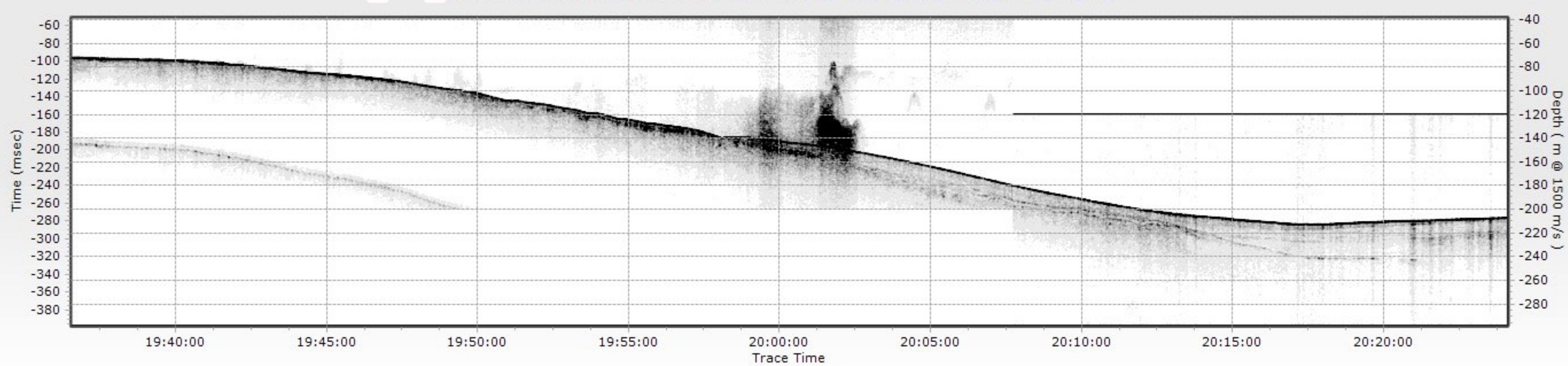
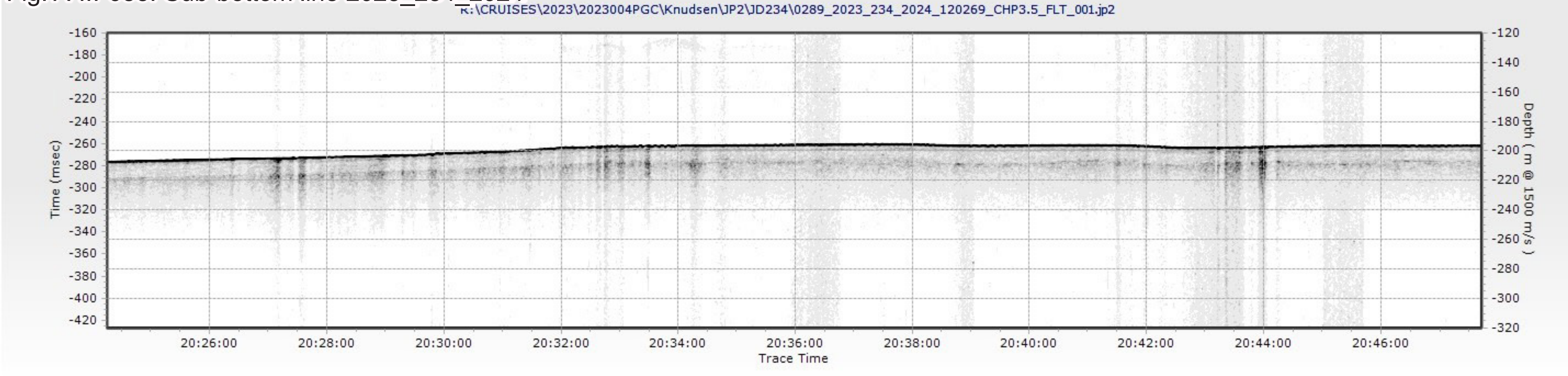


Fig. A-III-683. Sub-bottom line 2023_234_2024



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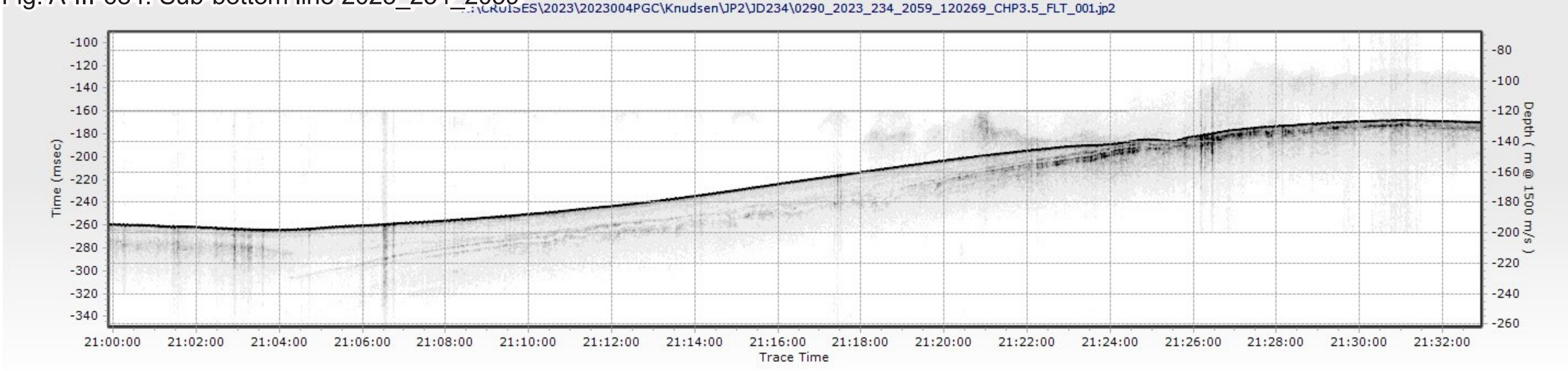

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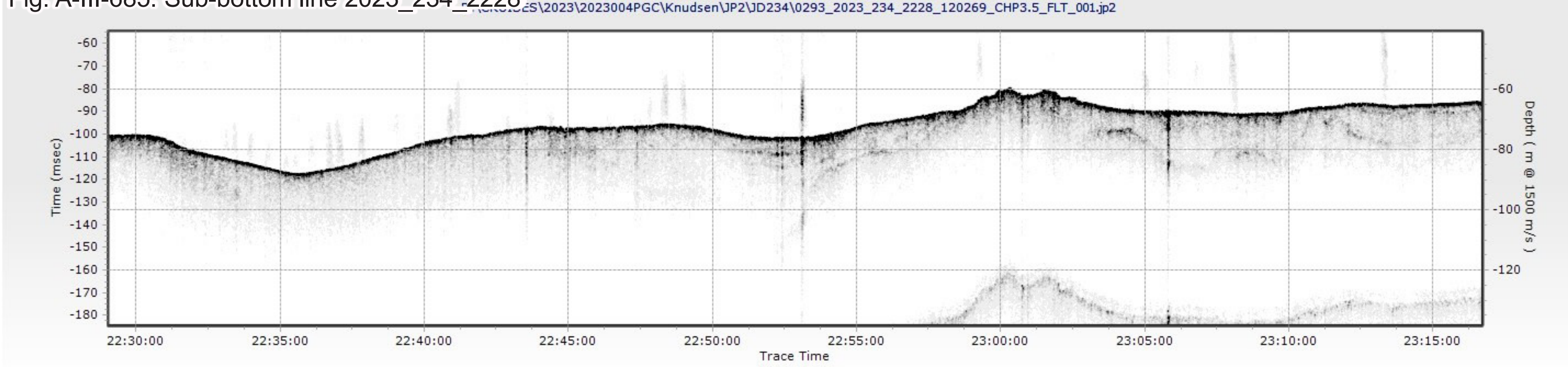

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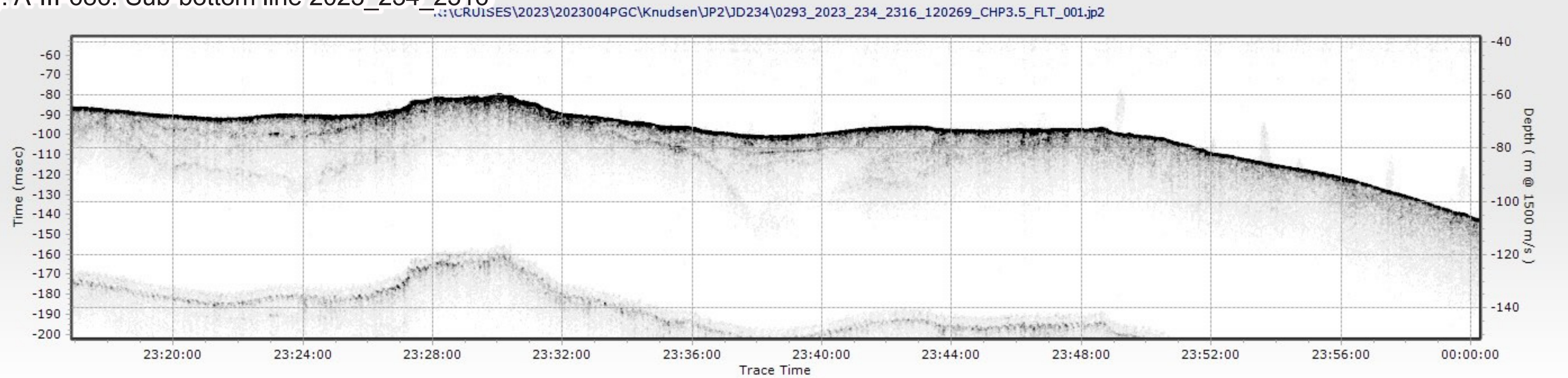

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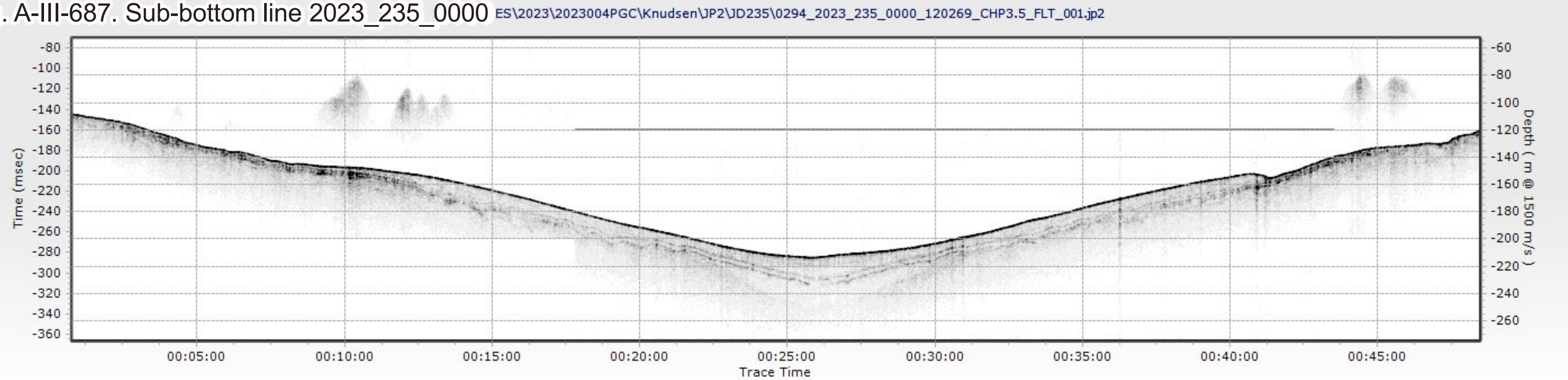

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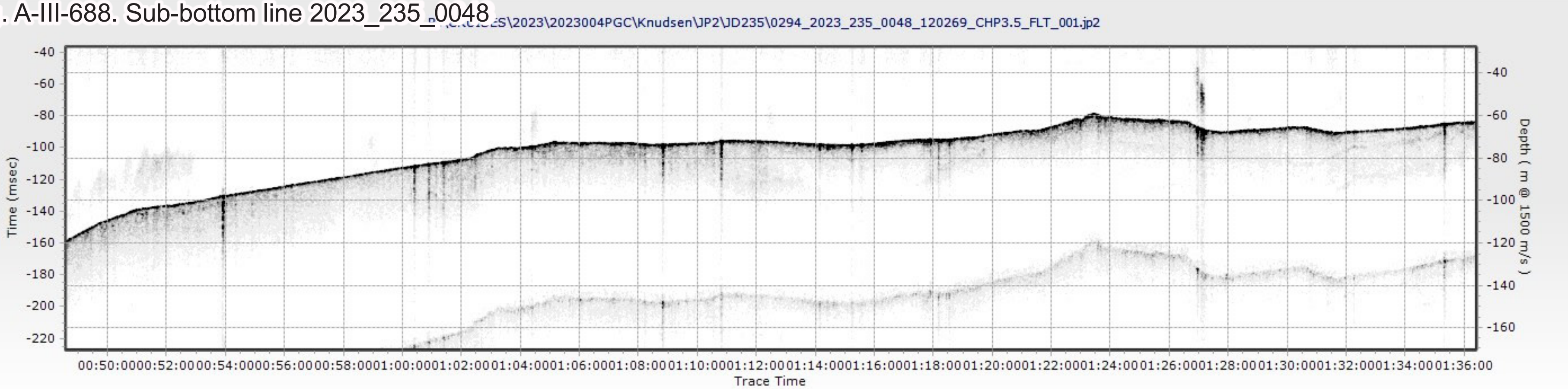
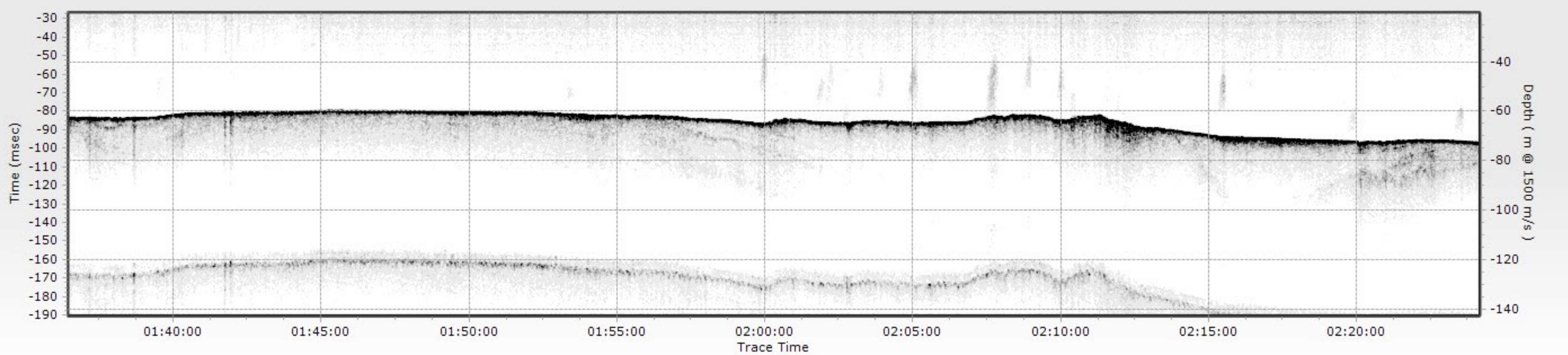


Fig. A-III-689. Sub-bottom line 2023_235_0136



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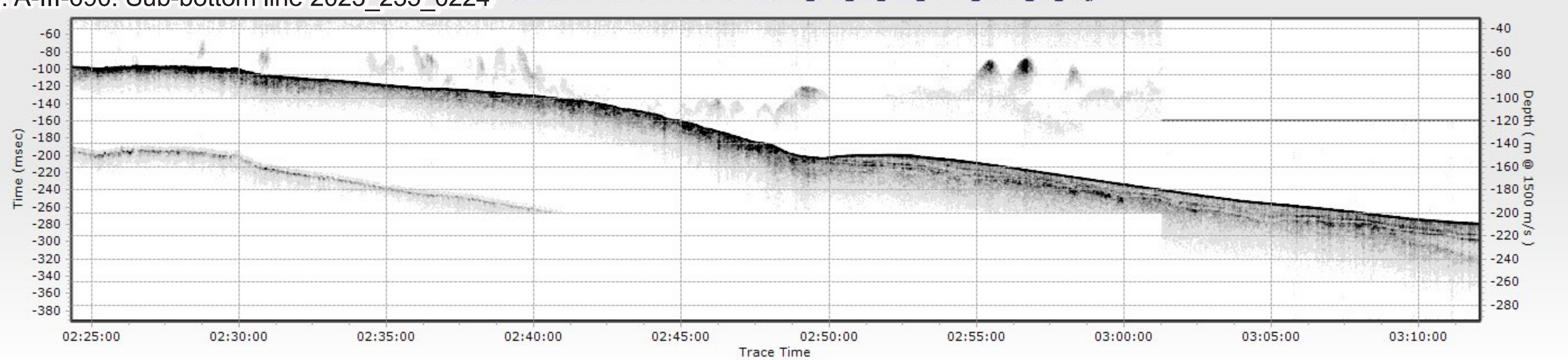

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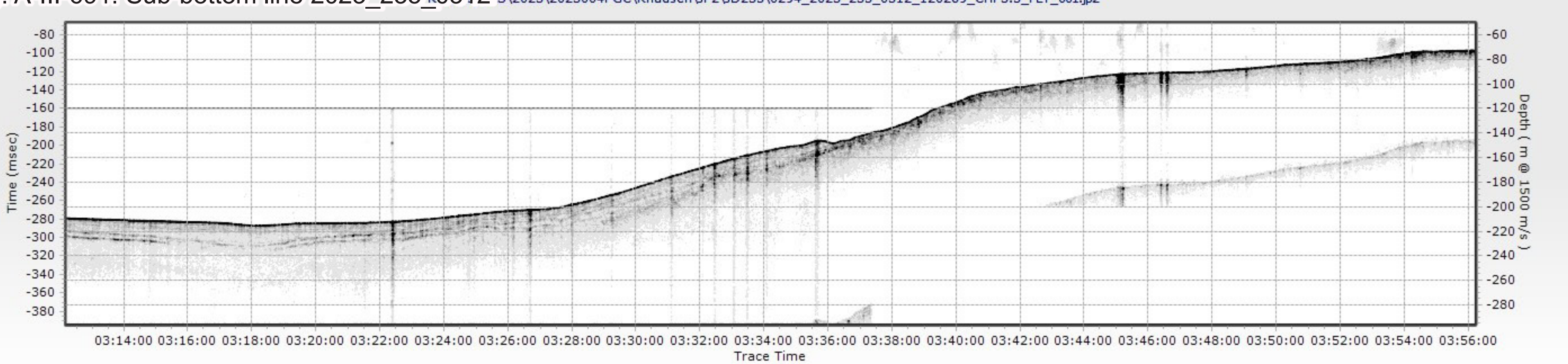

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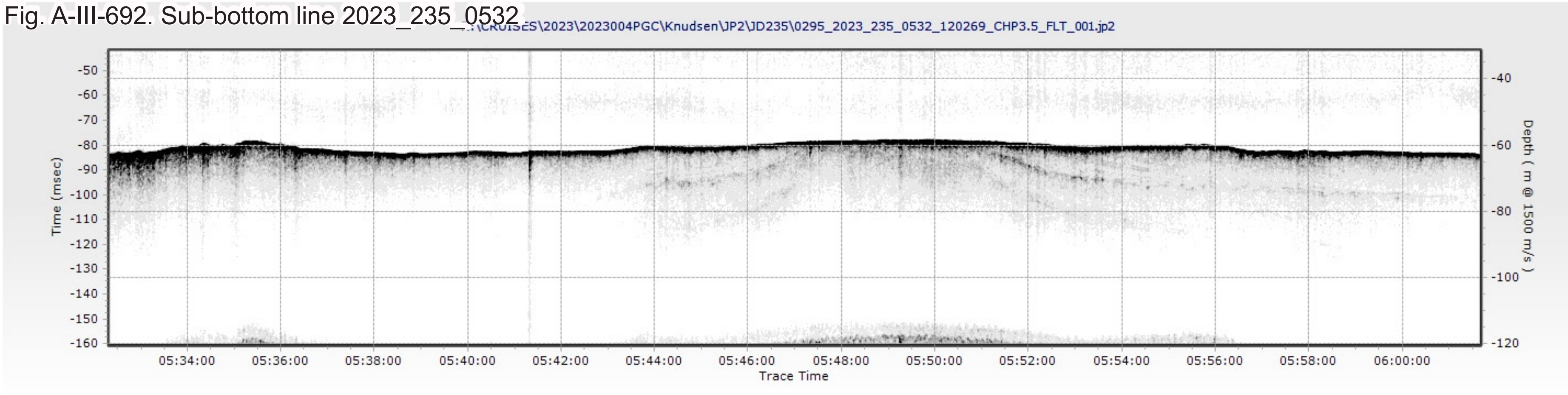

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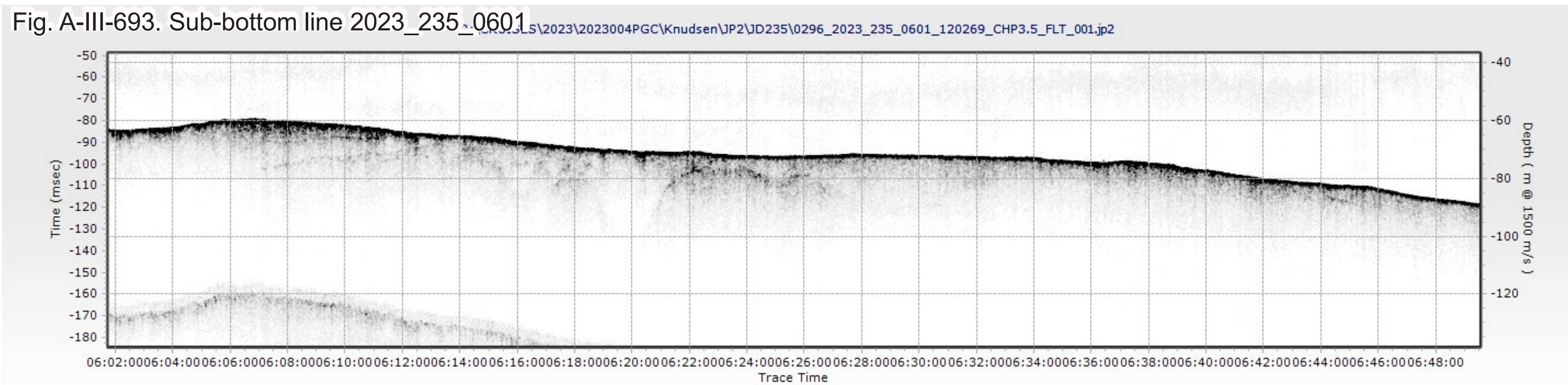

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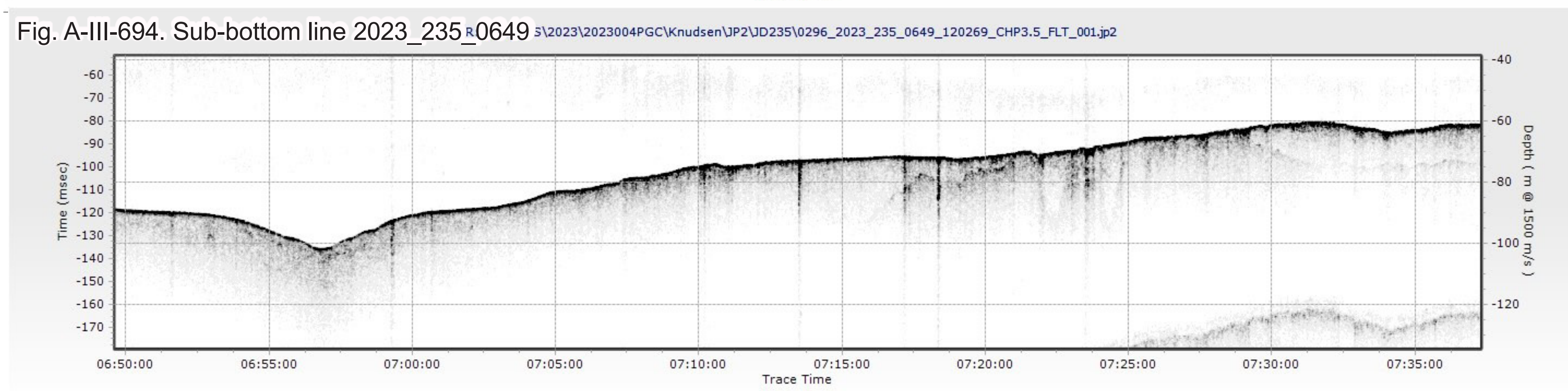

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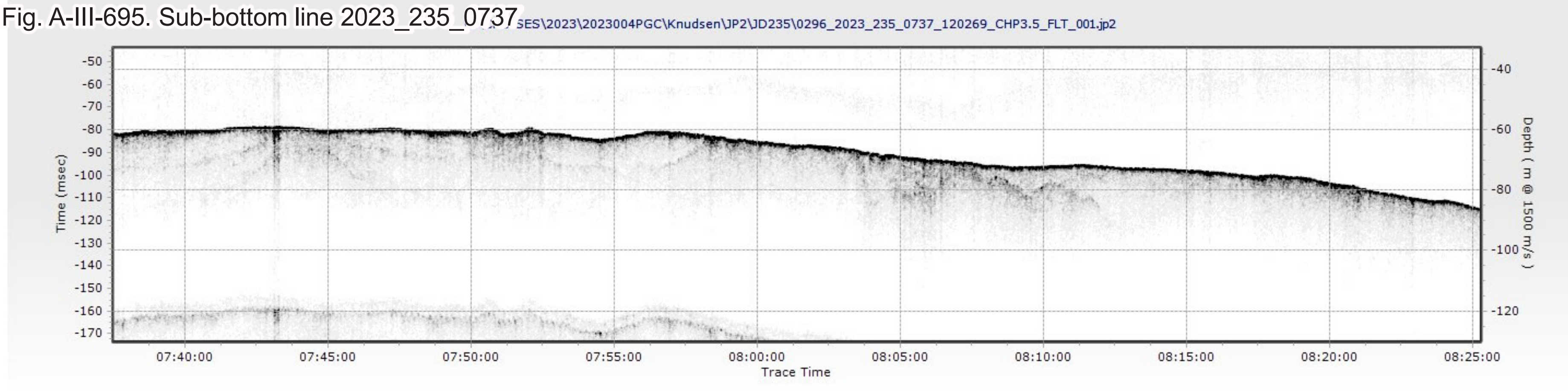

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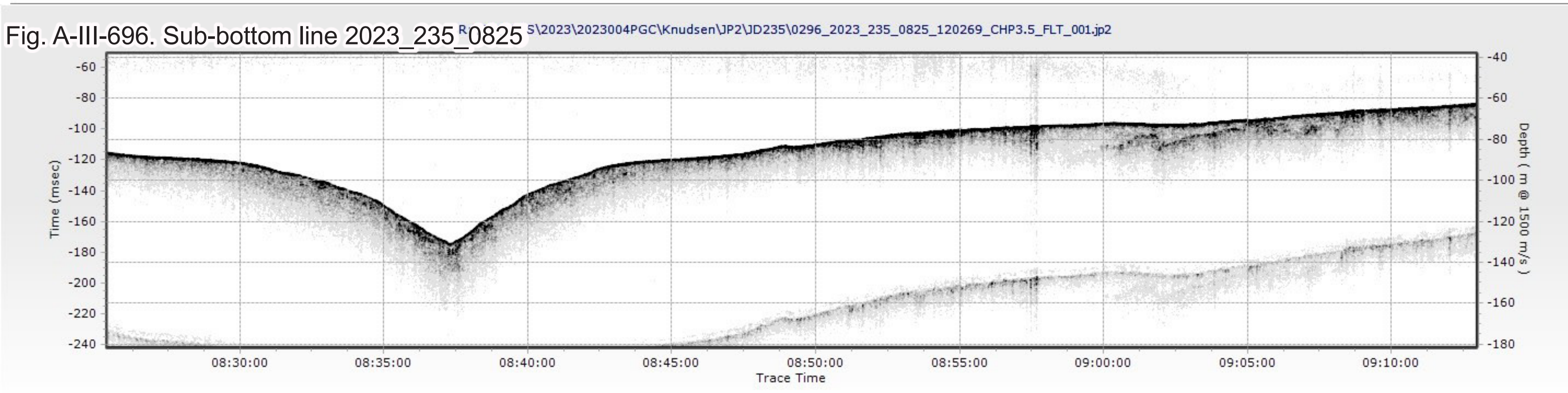

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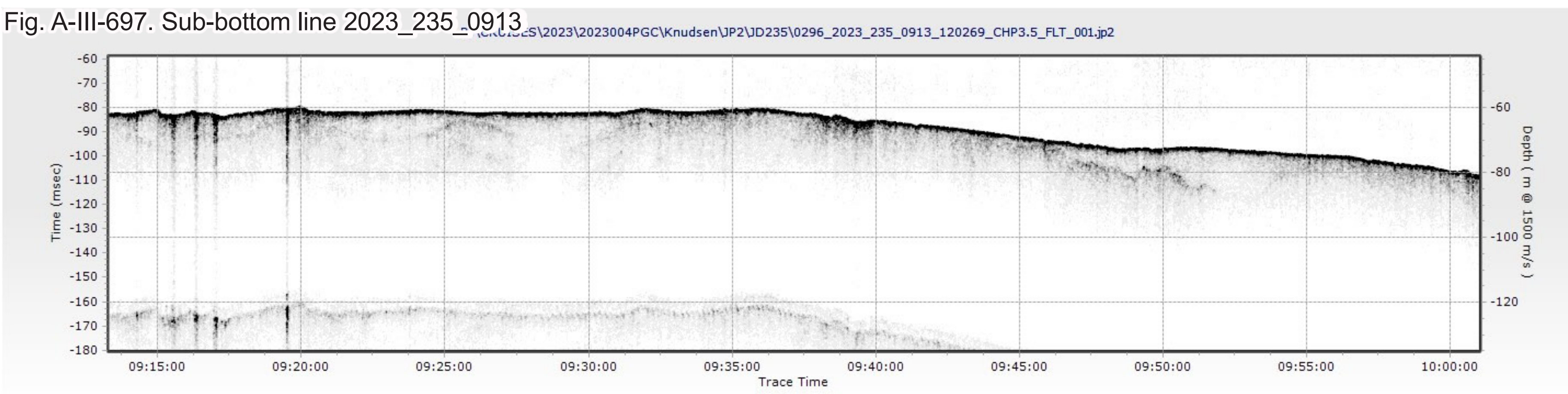

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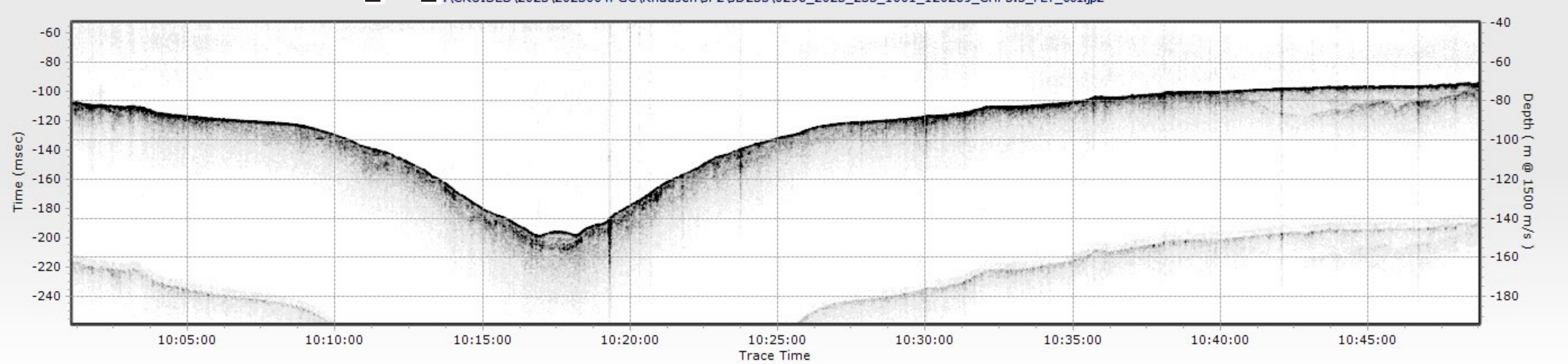

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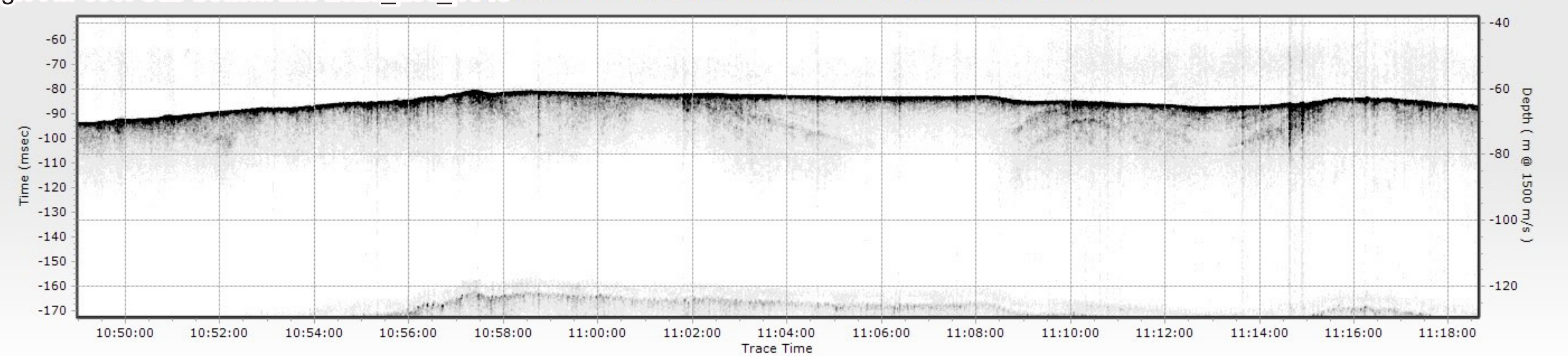

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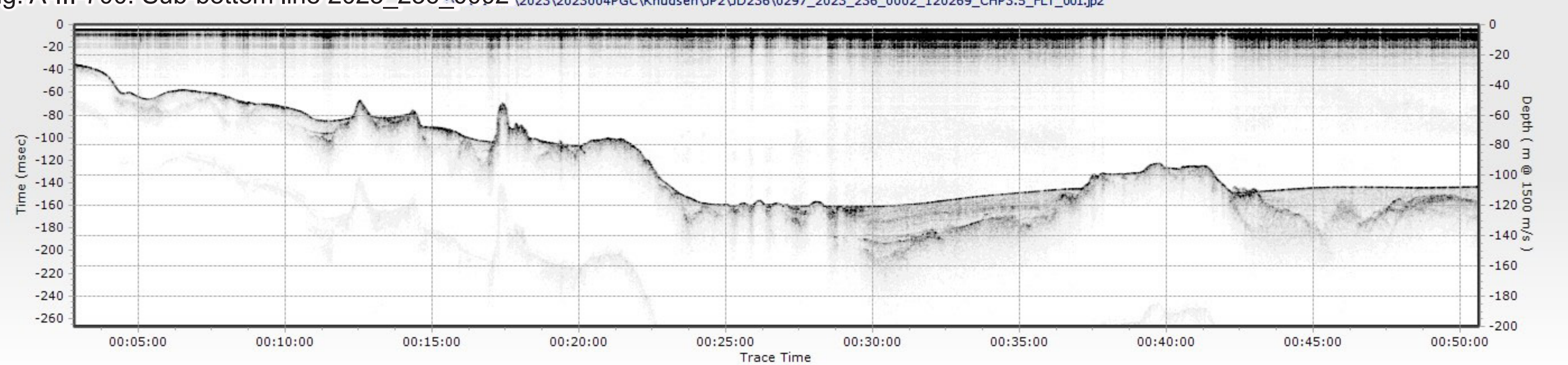

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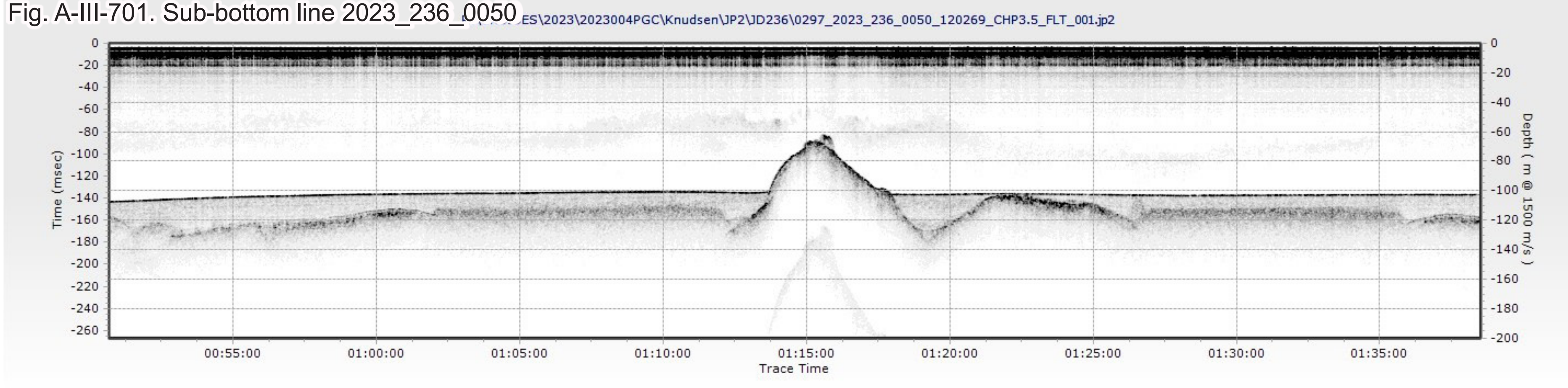

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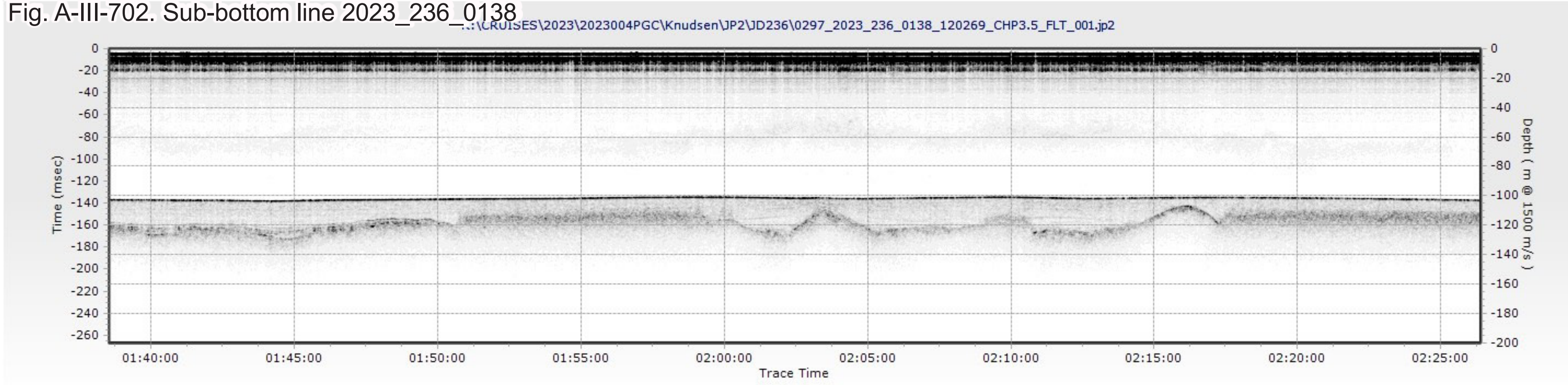

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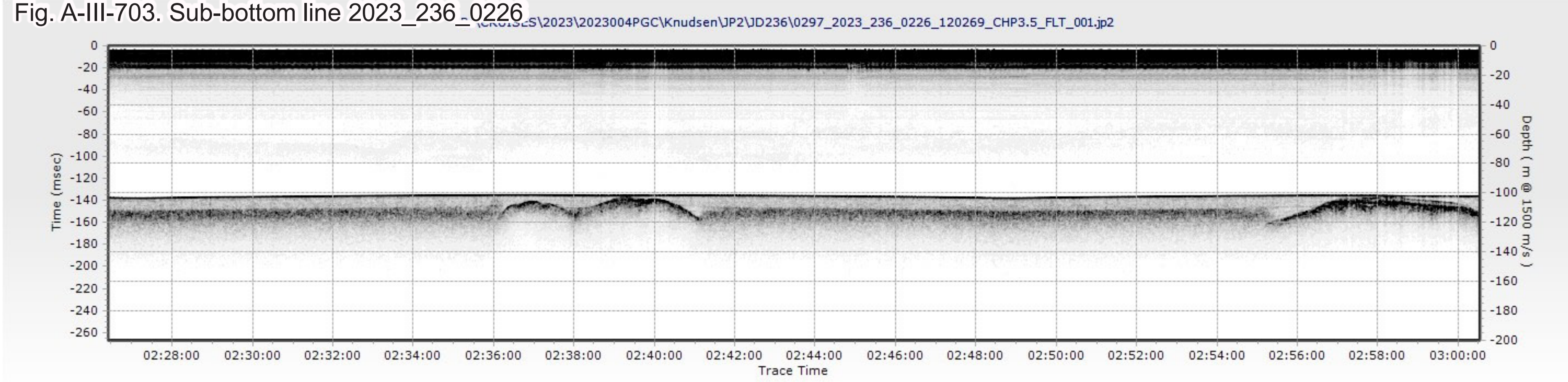

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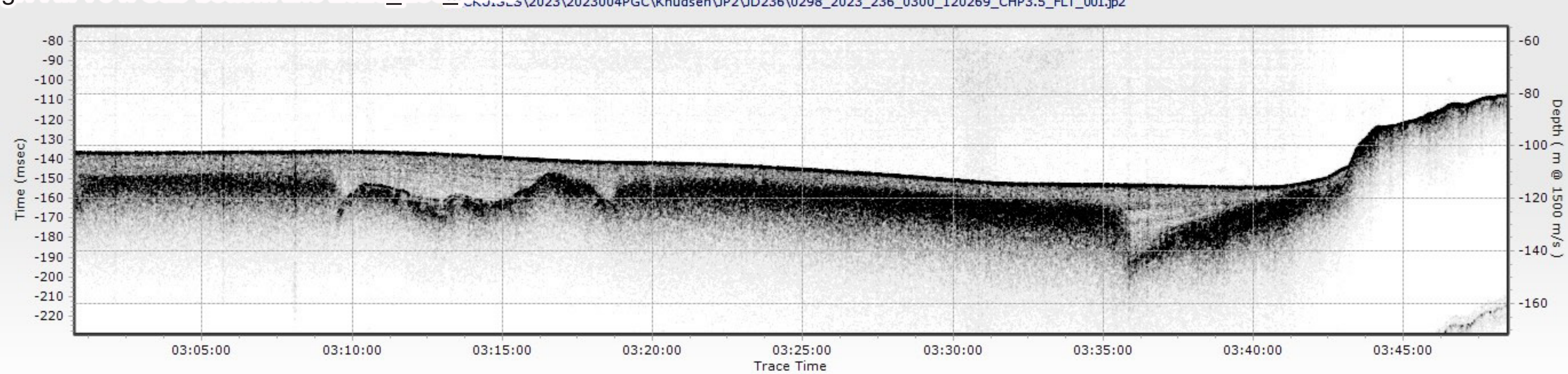

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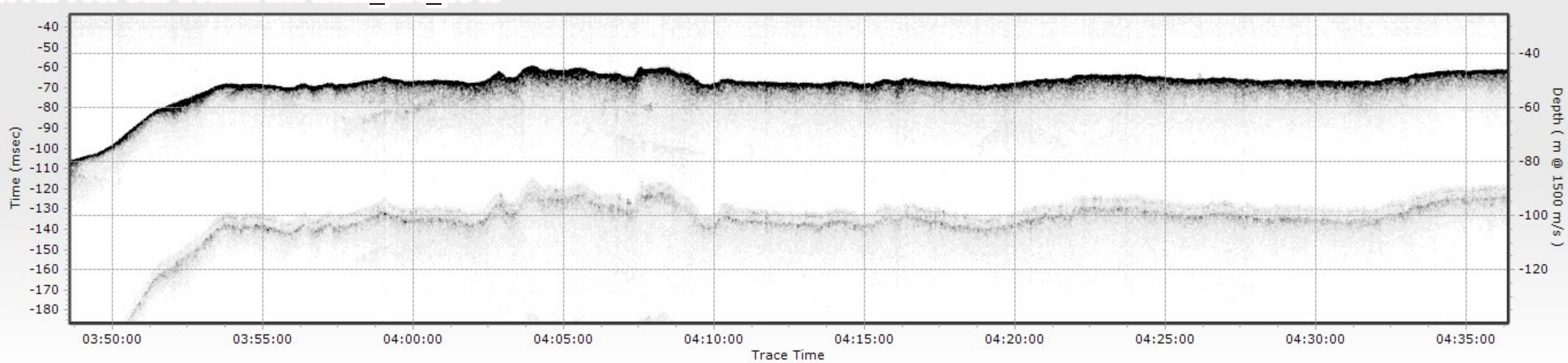

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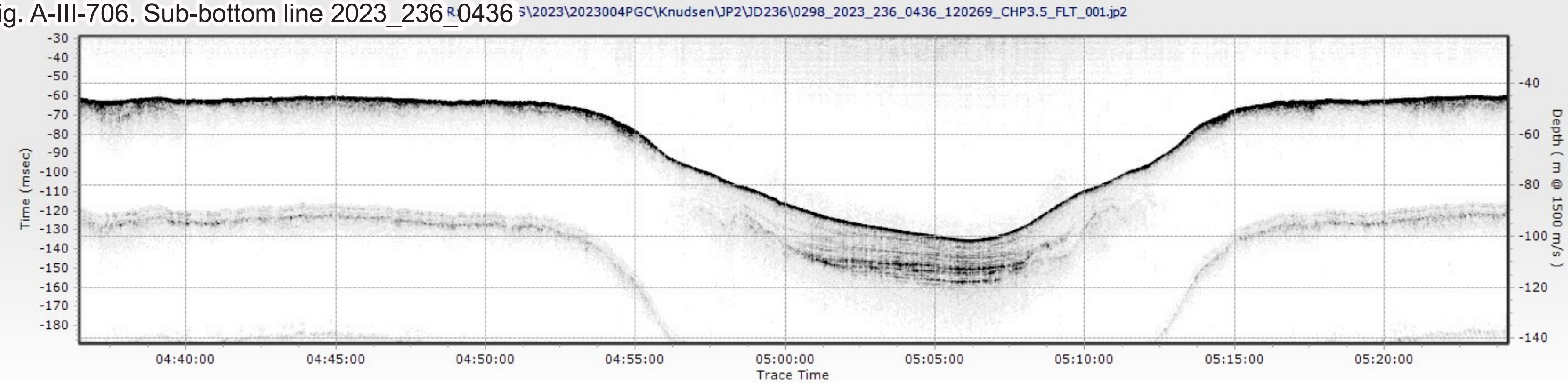

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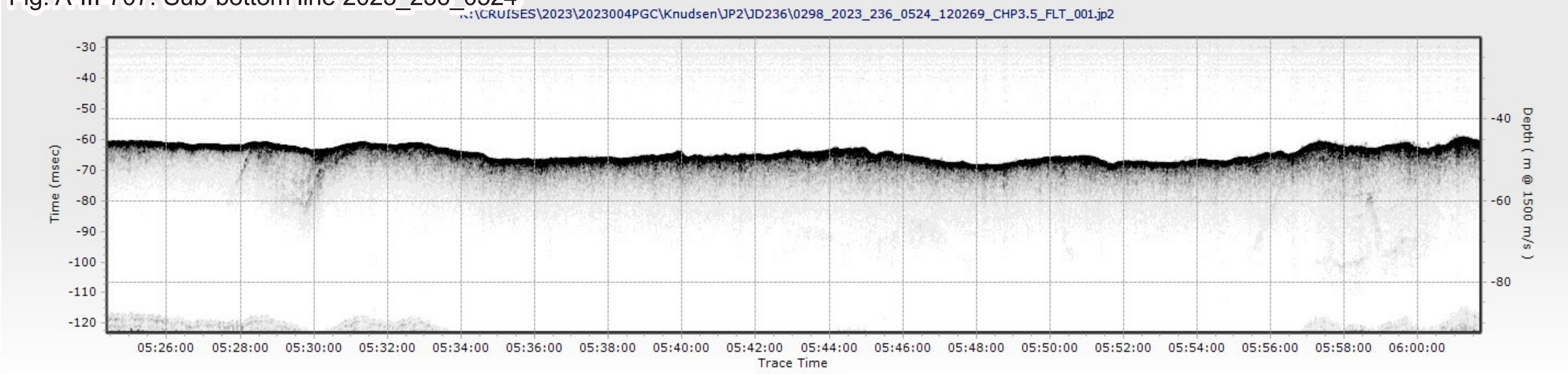

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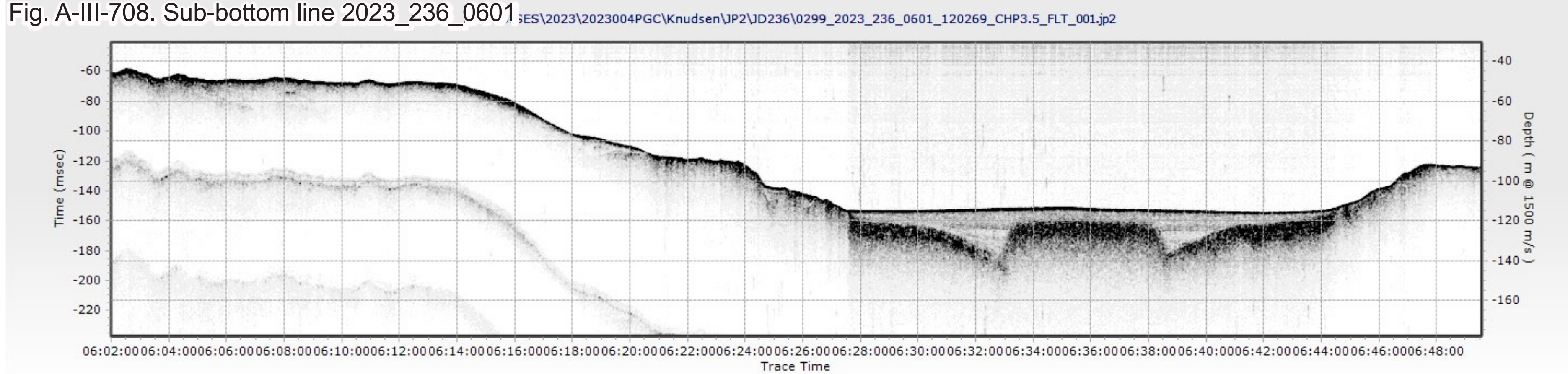

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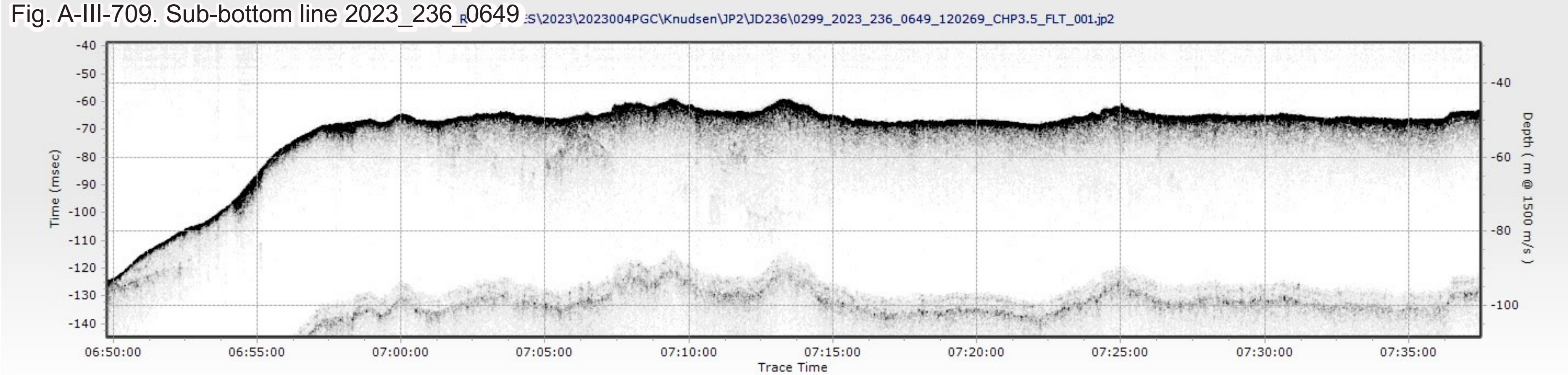

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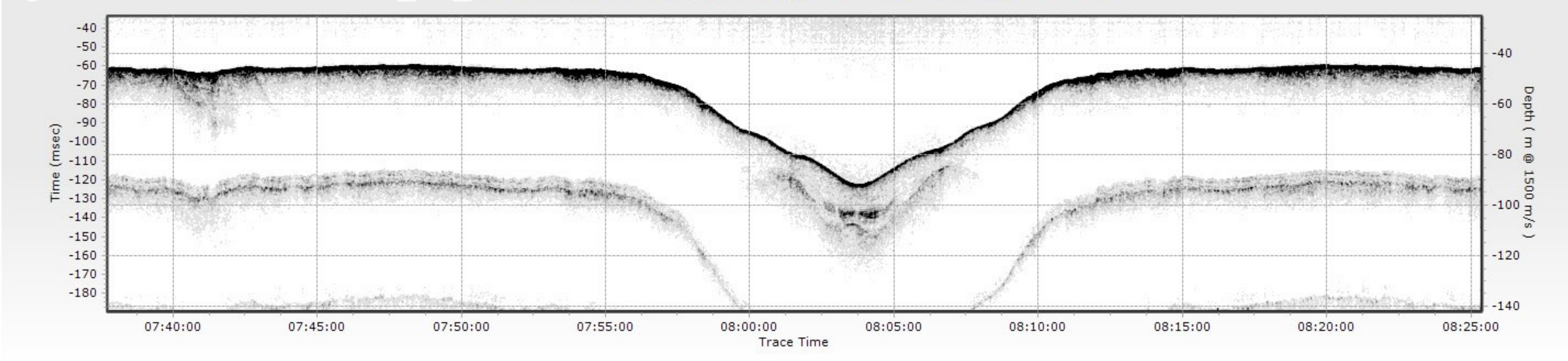

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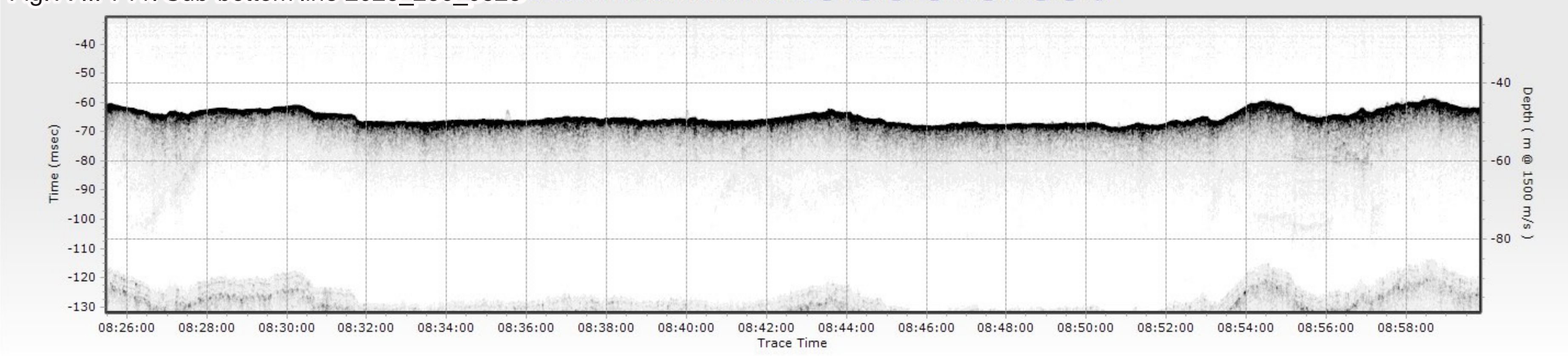

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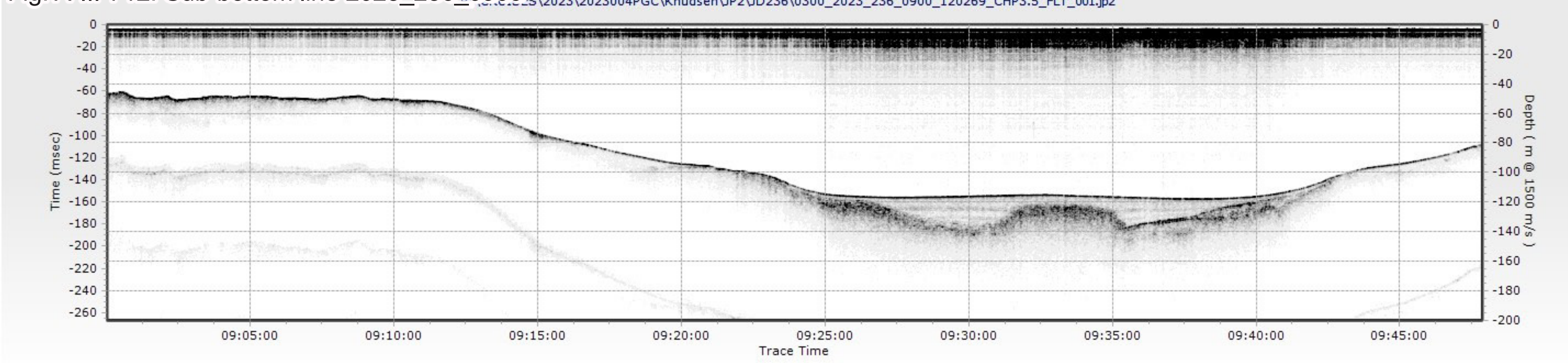

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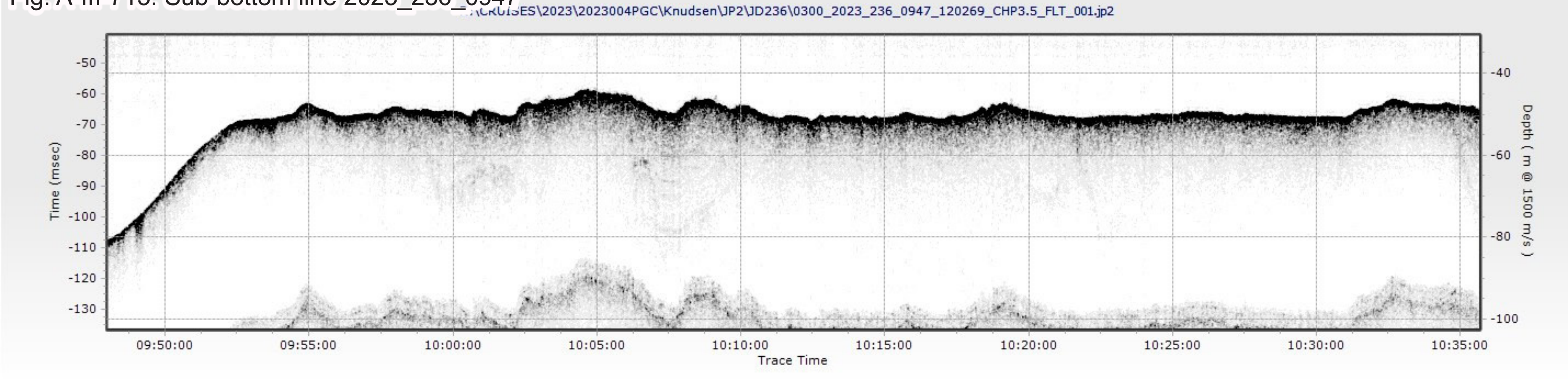

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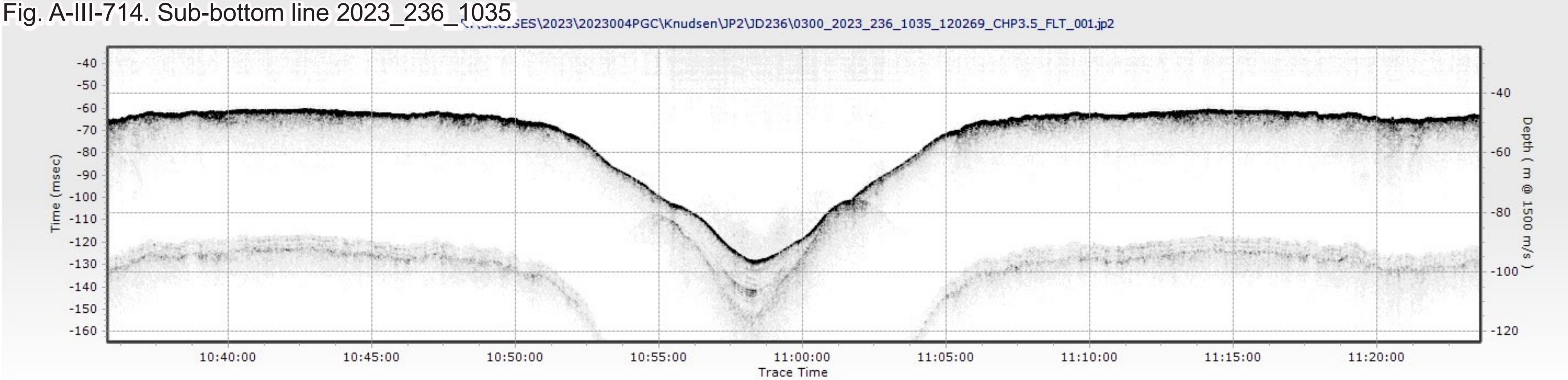

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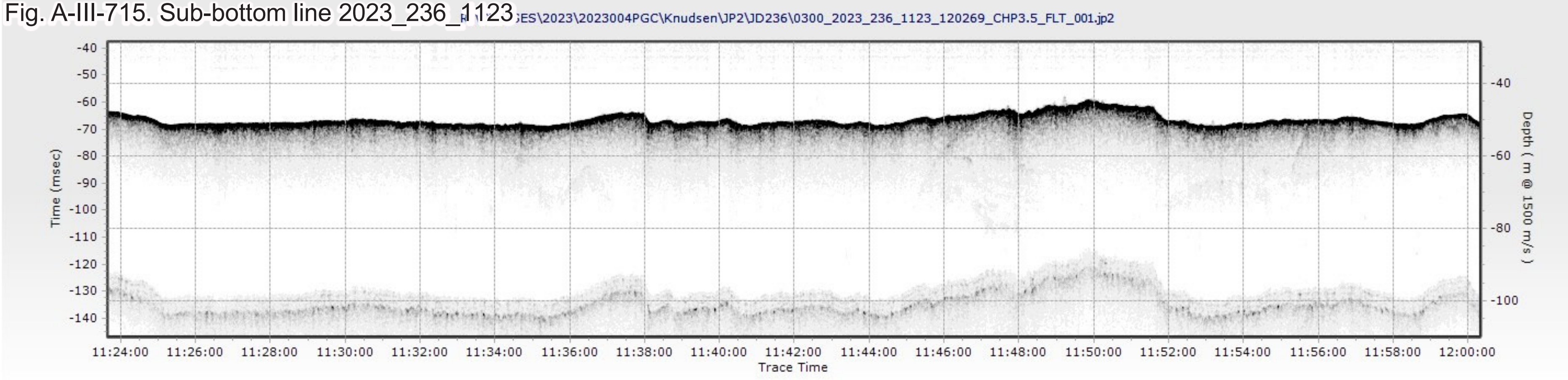

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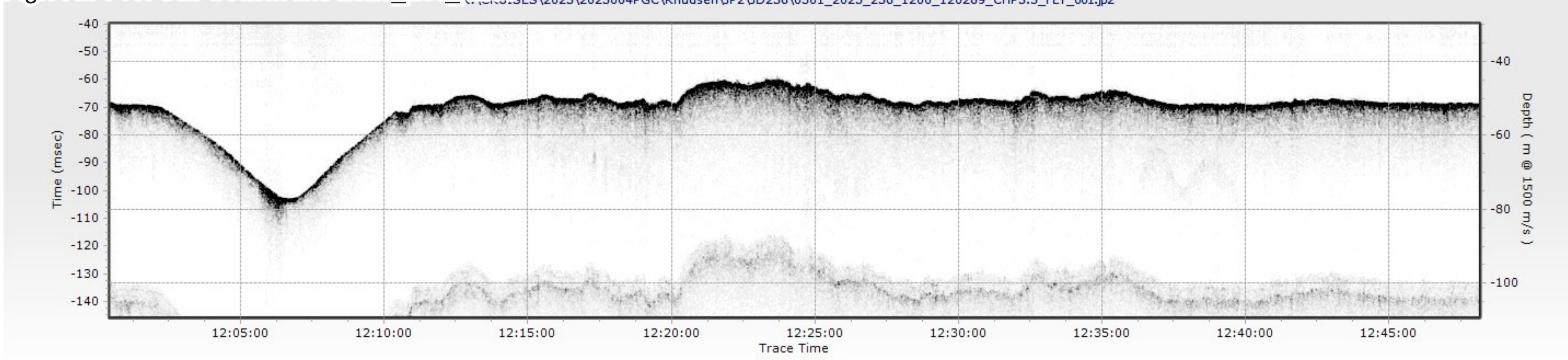

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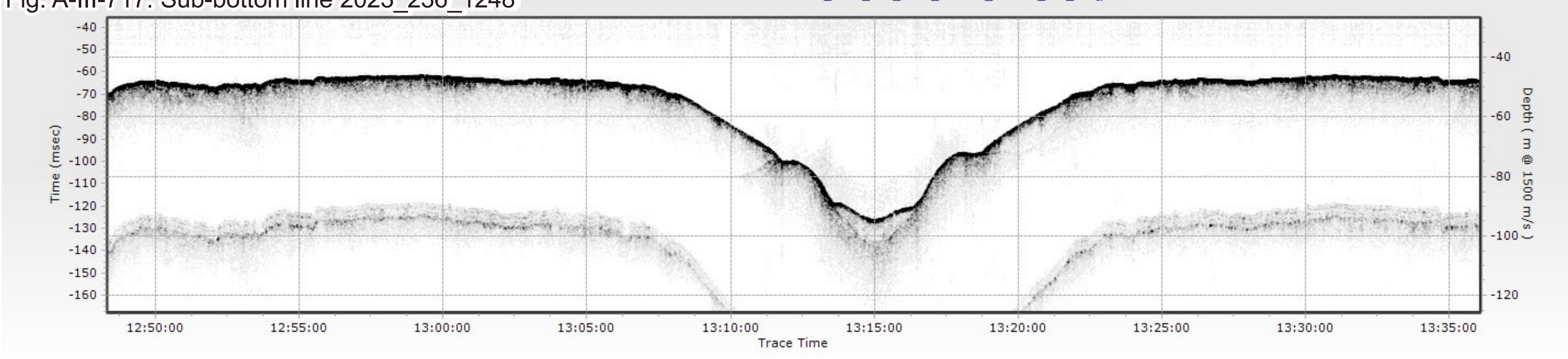

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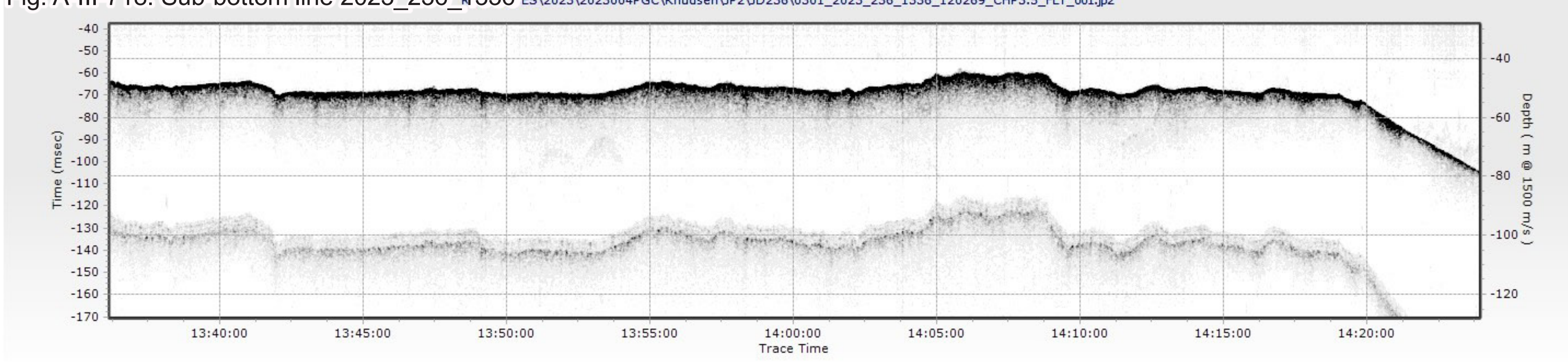

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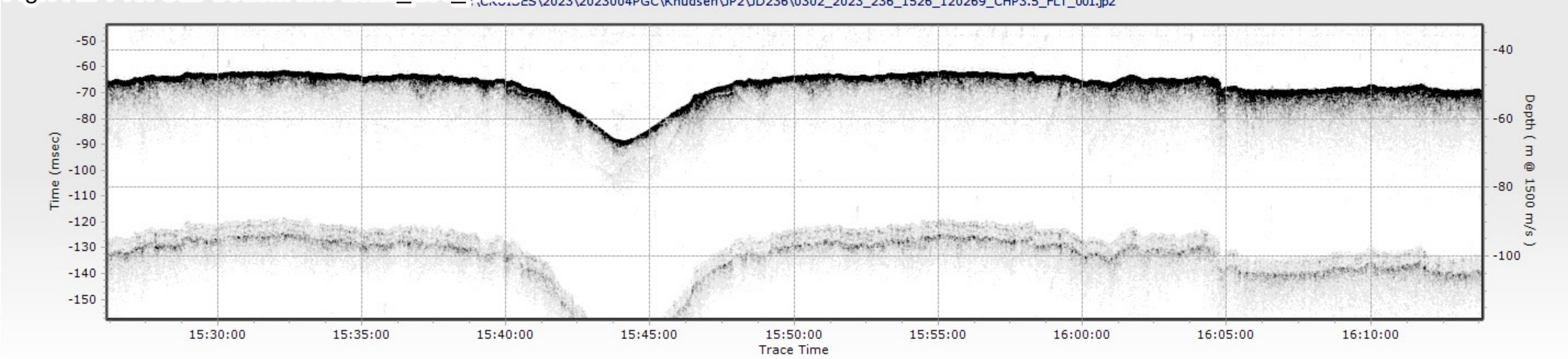

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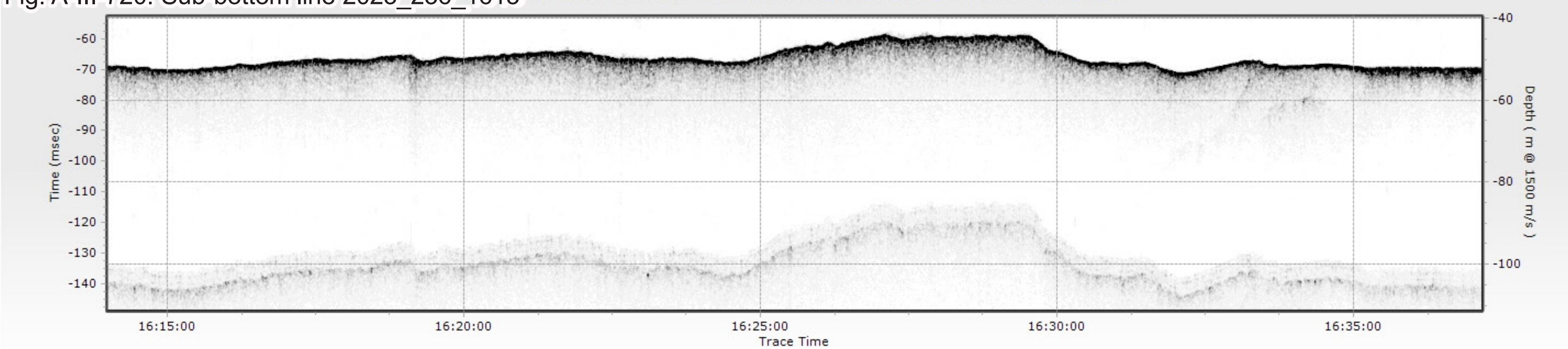

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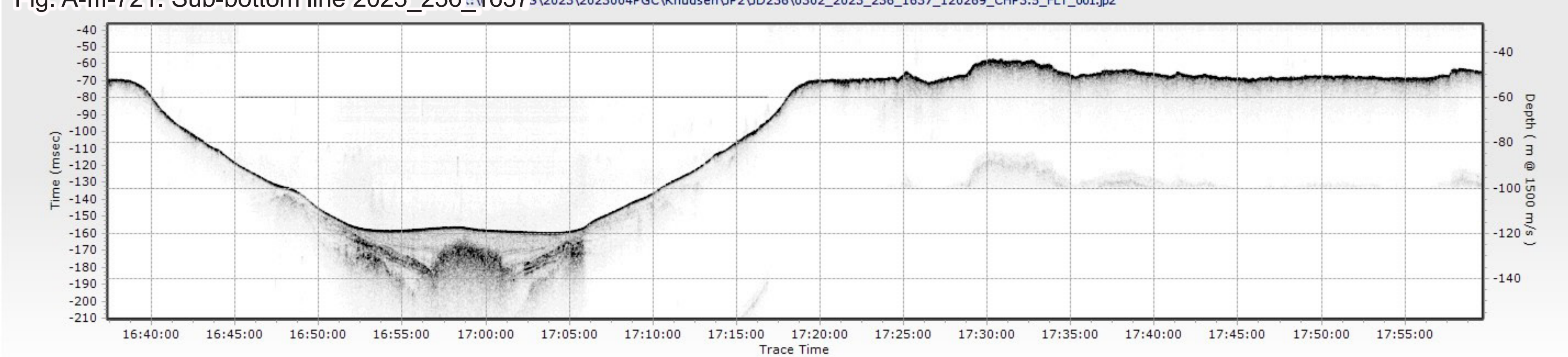

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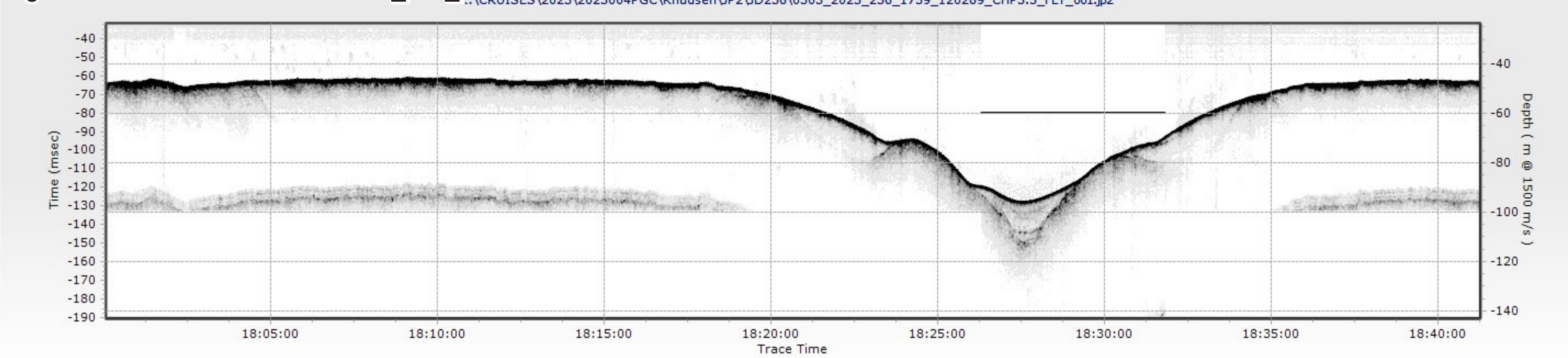

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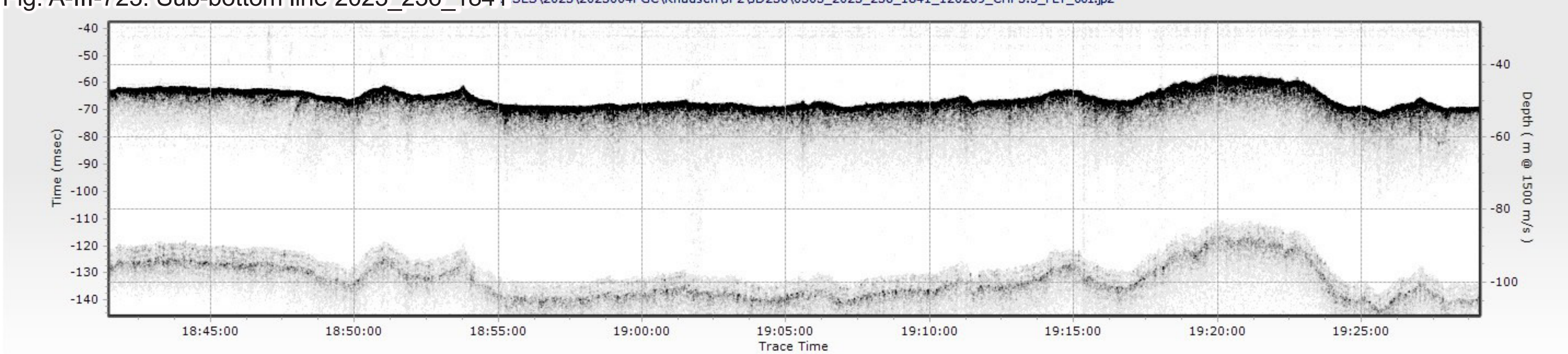

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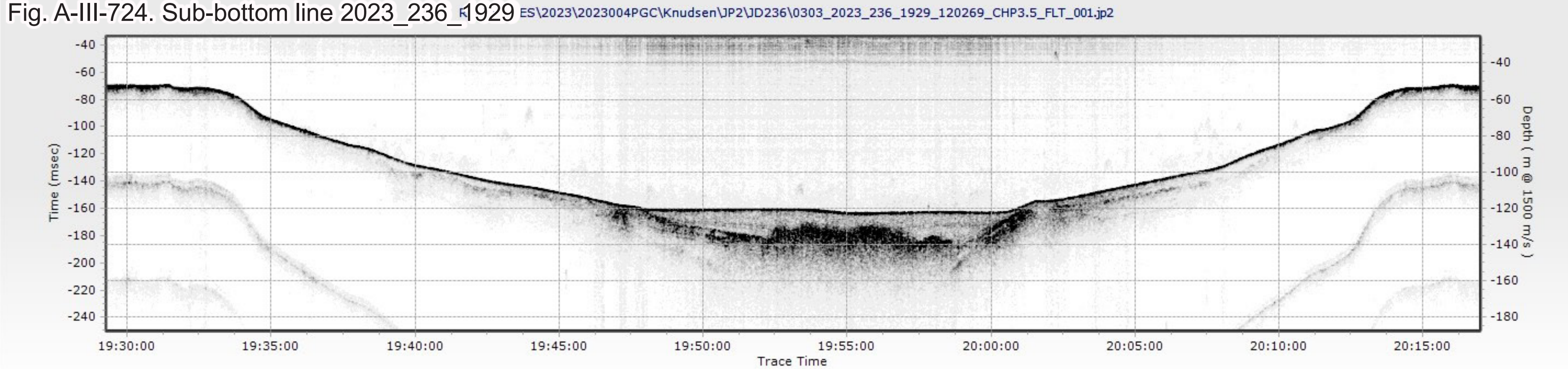

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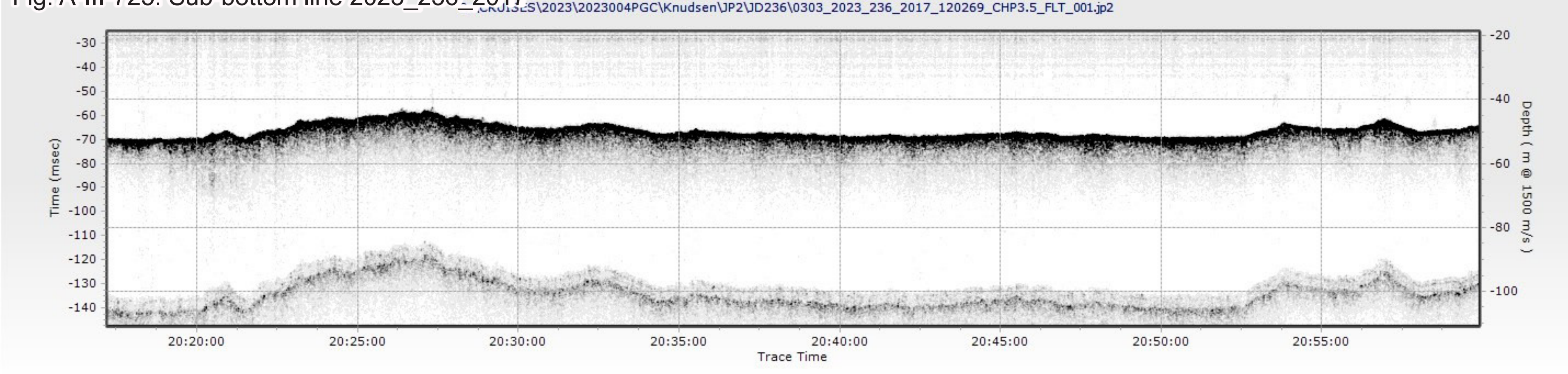

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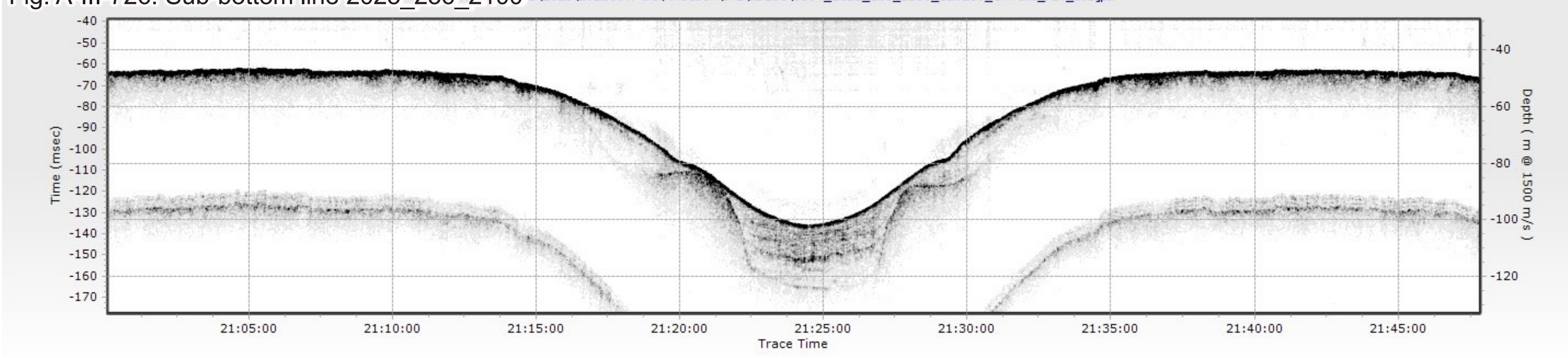

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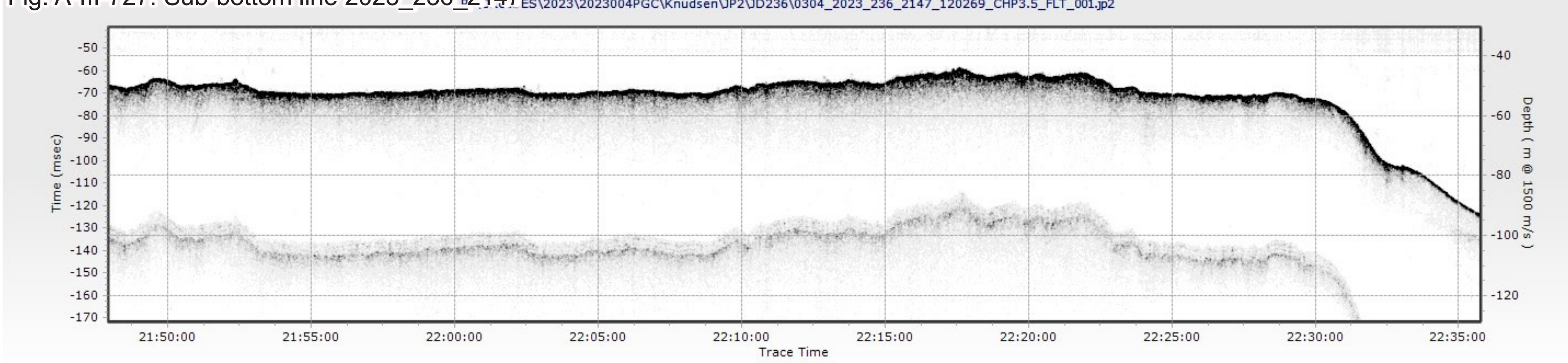
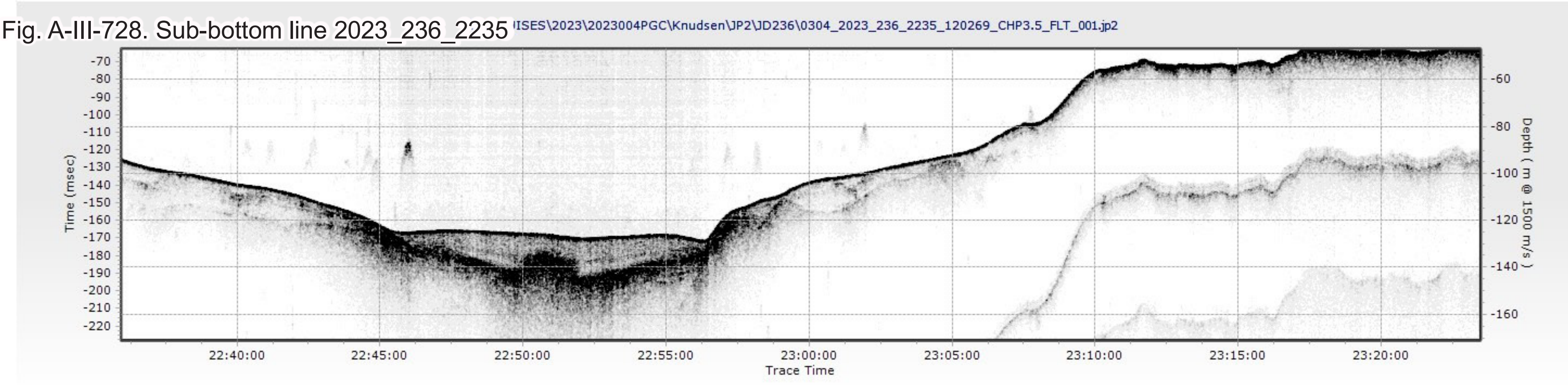


Fig. A-III-728. Sub-bottom line 2023_236_2235



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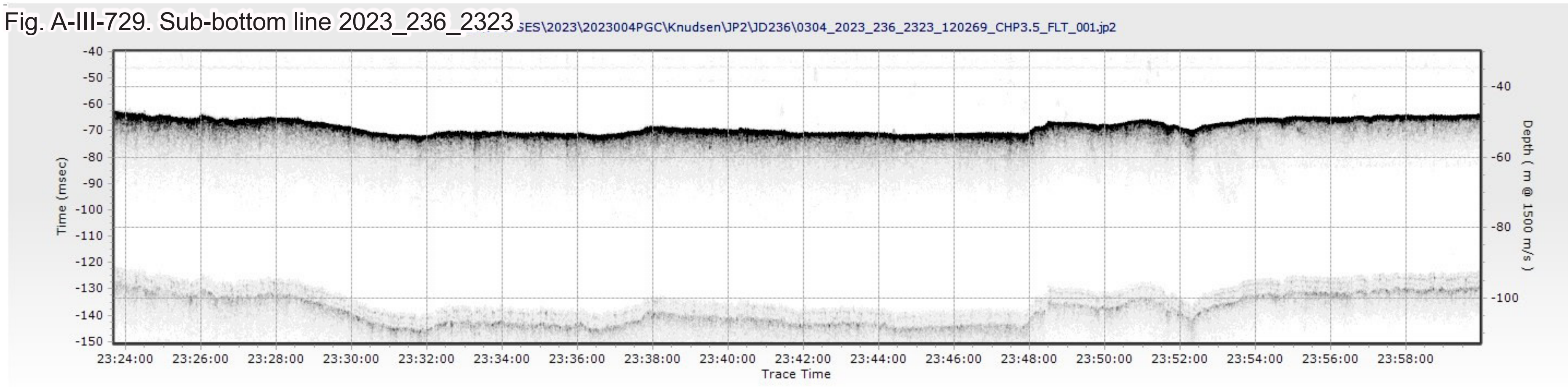

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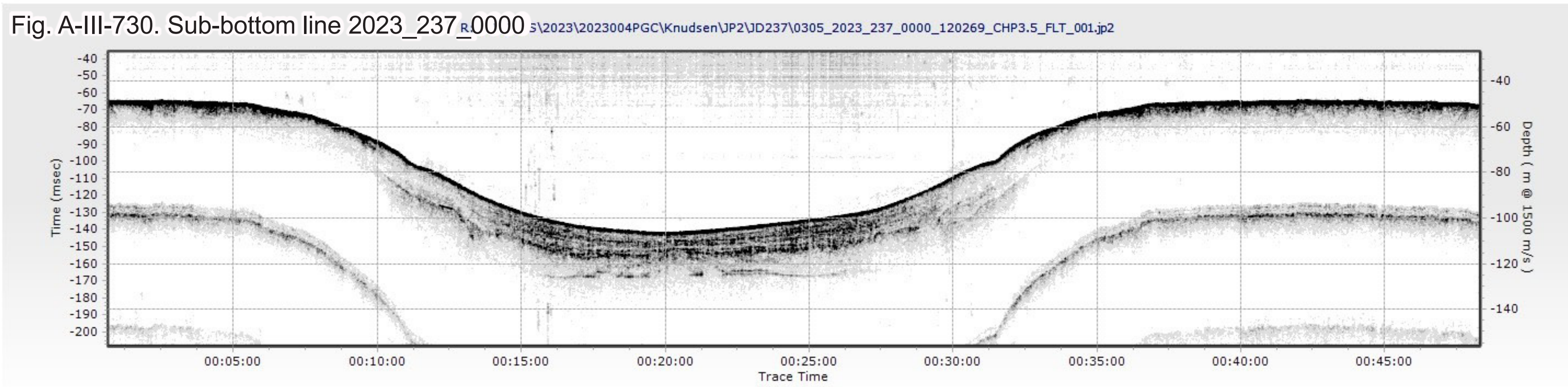

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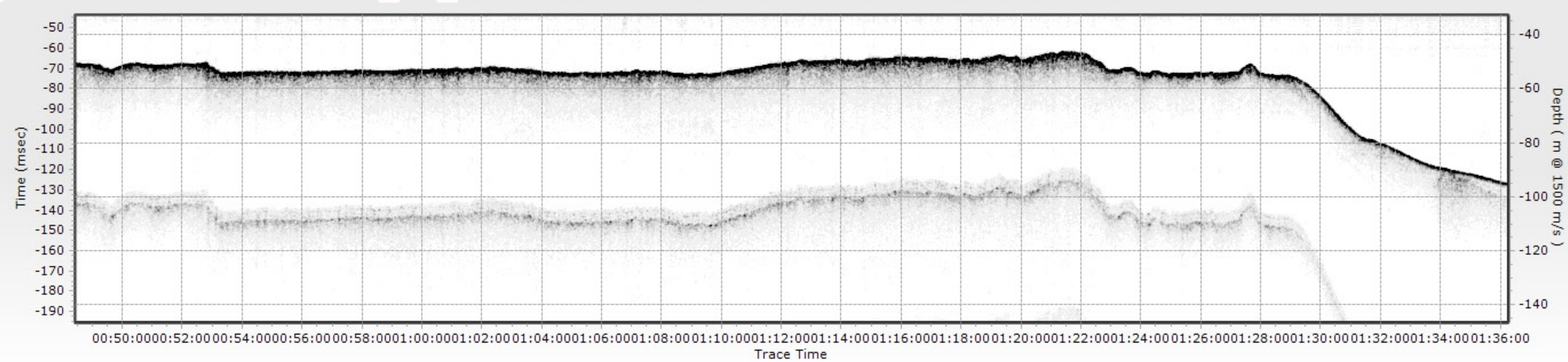
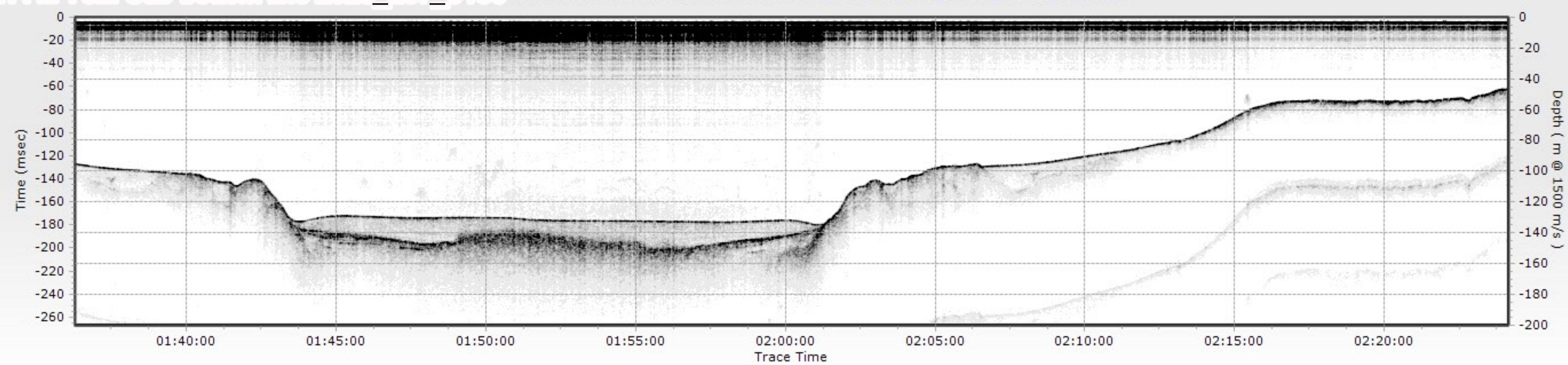


Fig. A-III-732. Sub-bottom line 2023_237_0136



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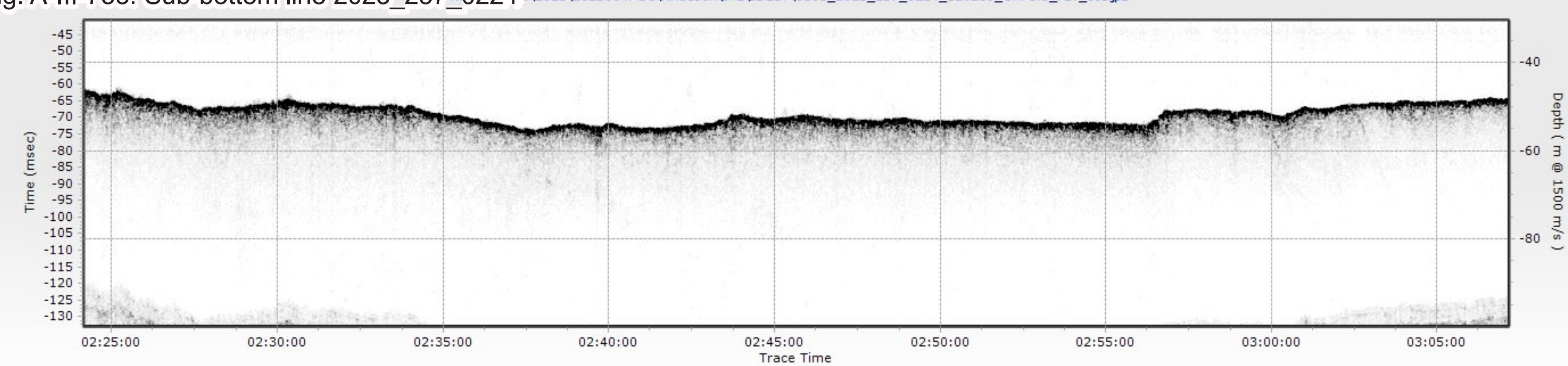

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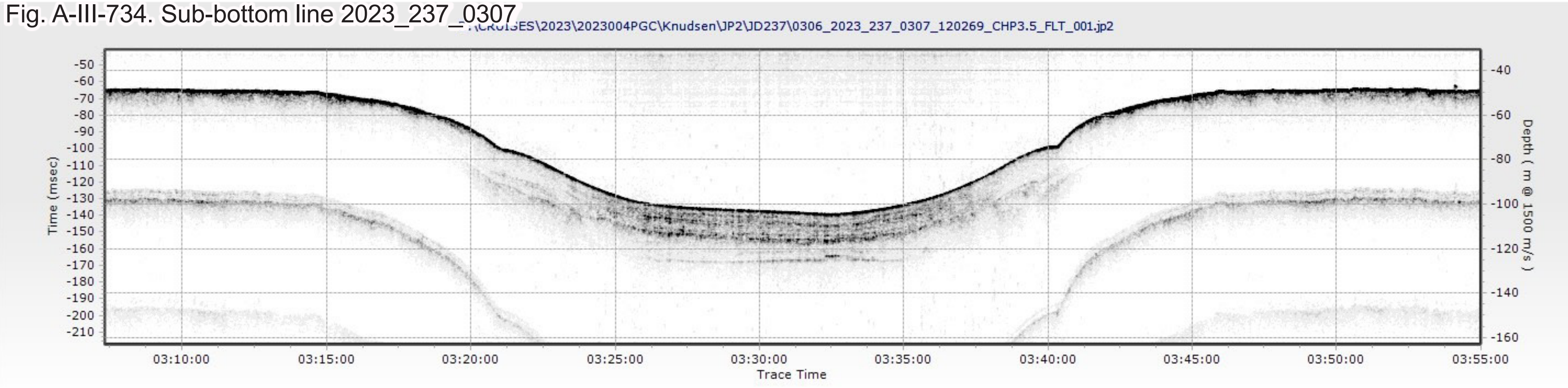

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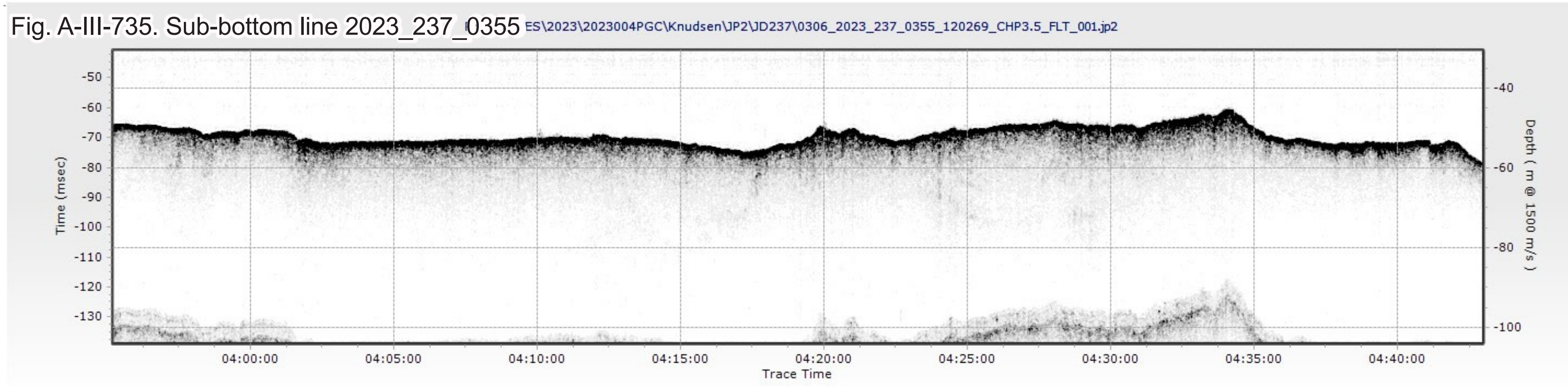

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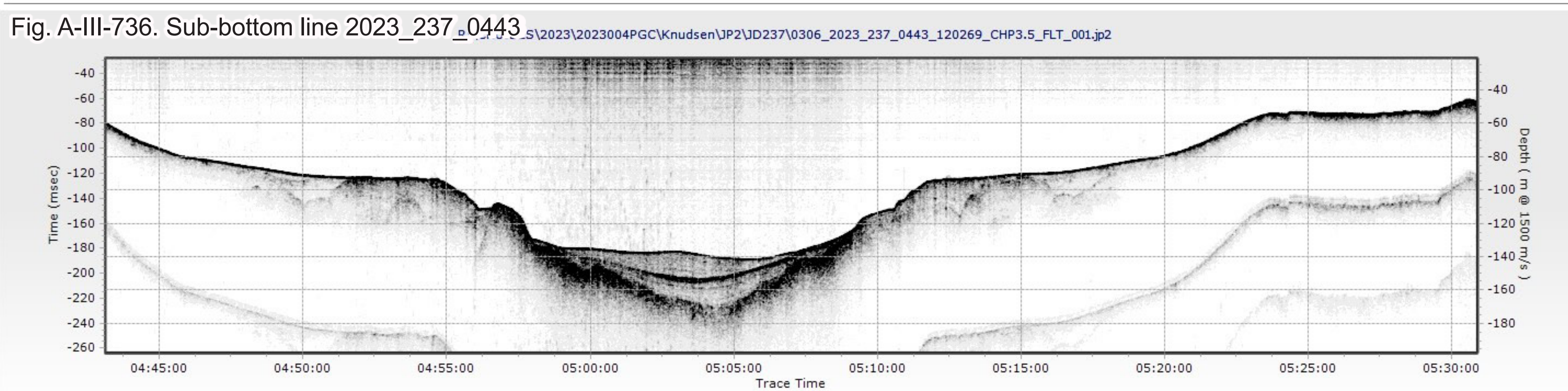

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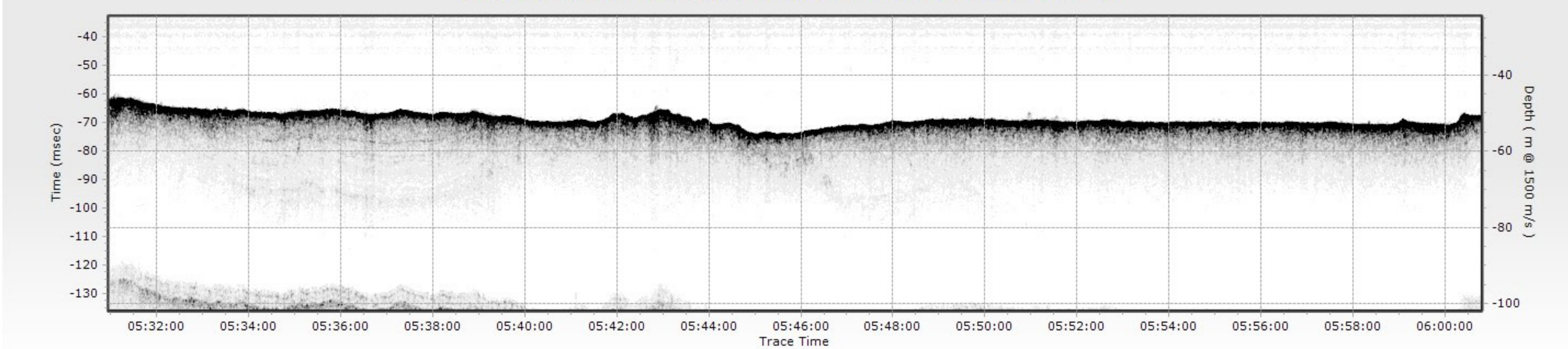

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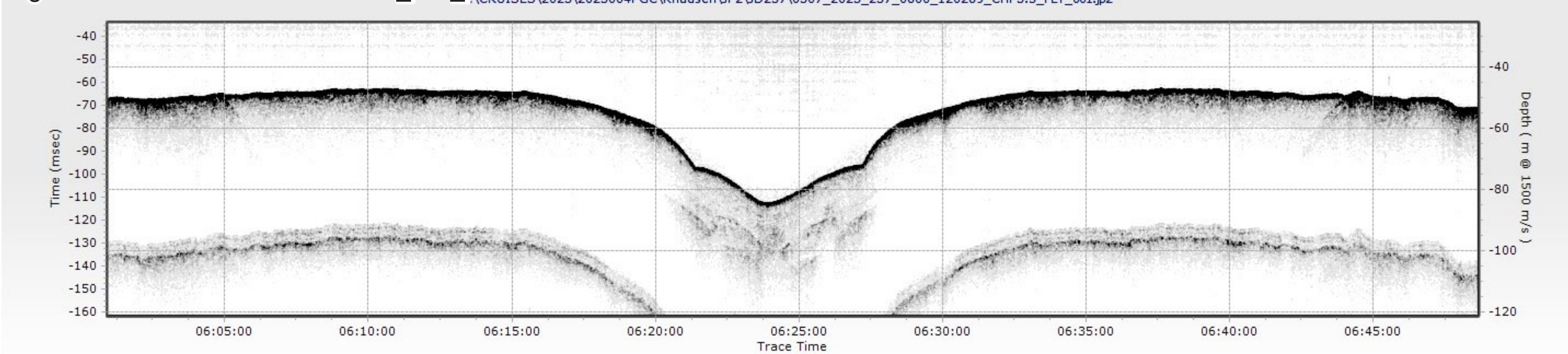

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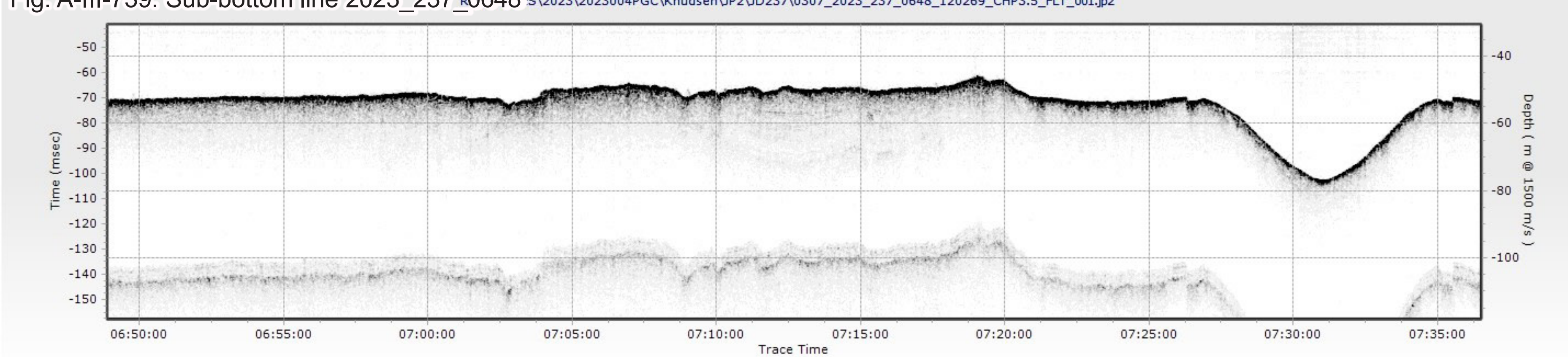

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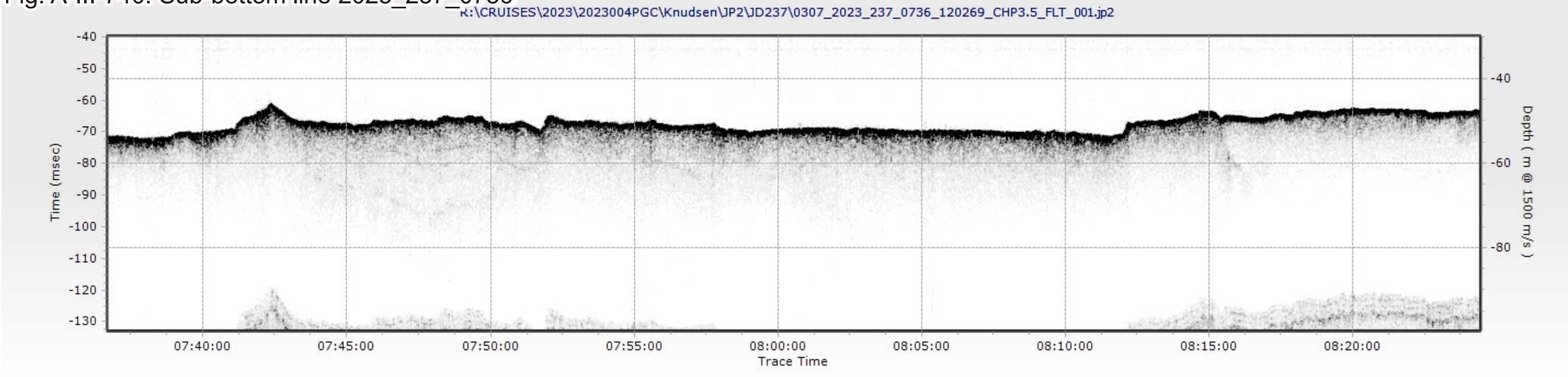

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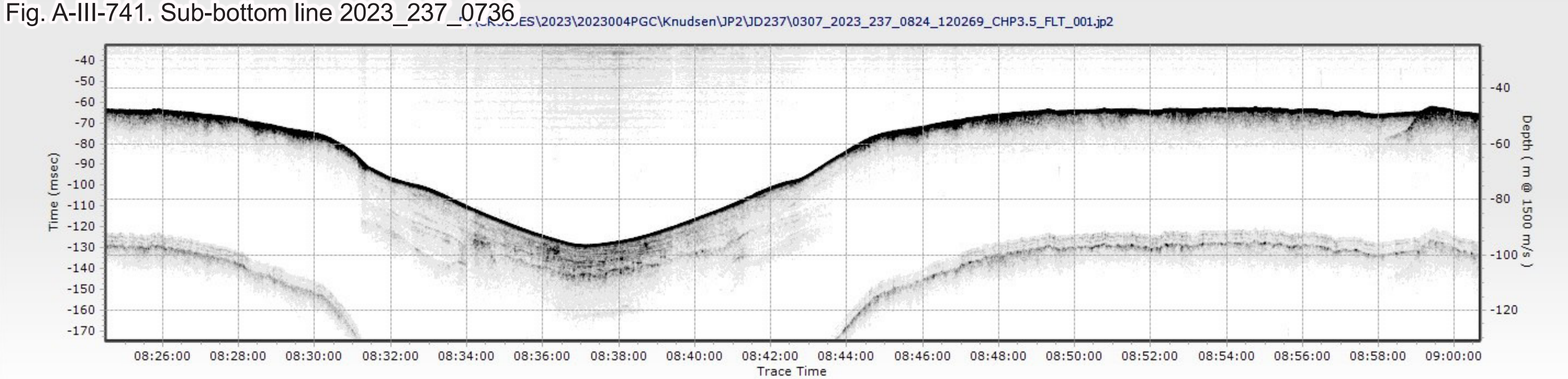

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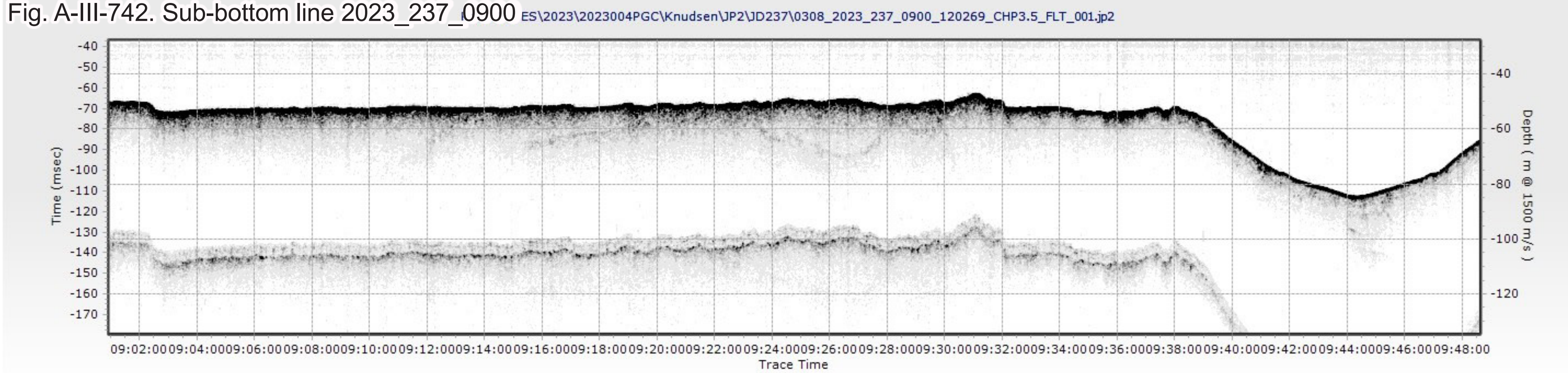

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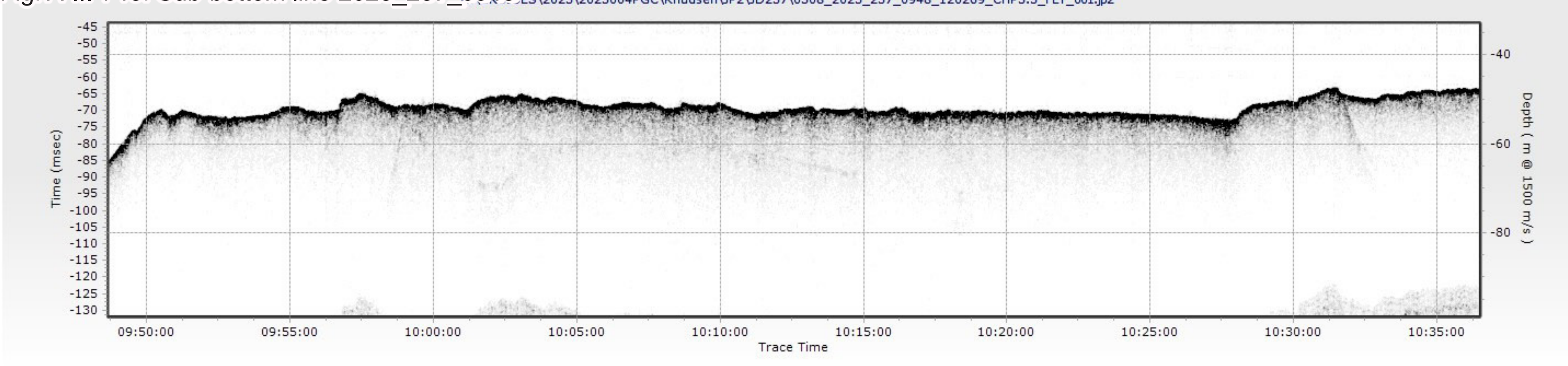
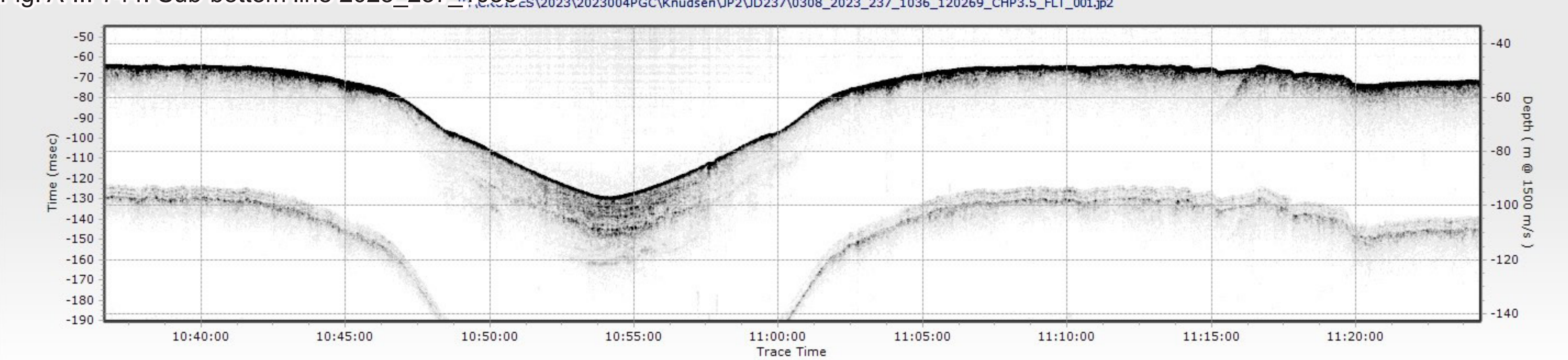


Fig. A-III-744. Sub-bottom line 2023_237_1036



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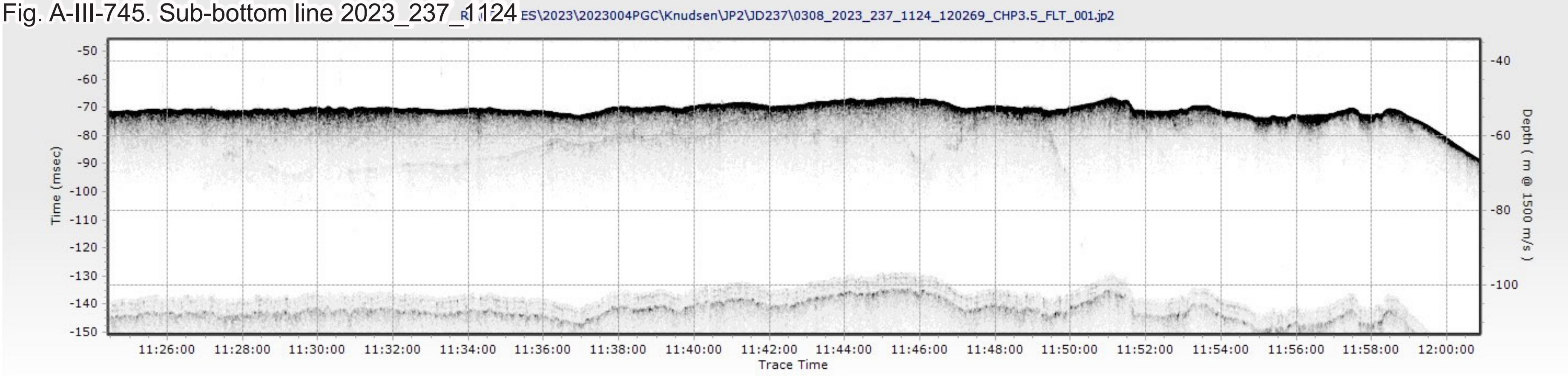


Fig. A-III-746. Sub-bottom line 2023_237_1201

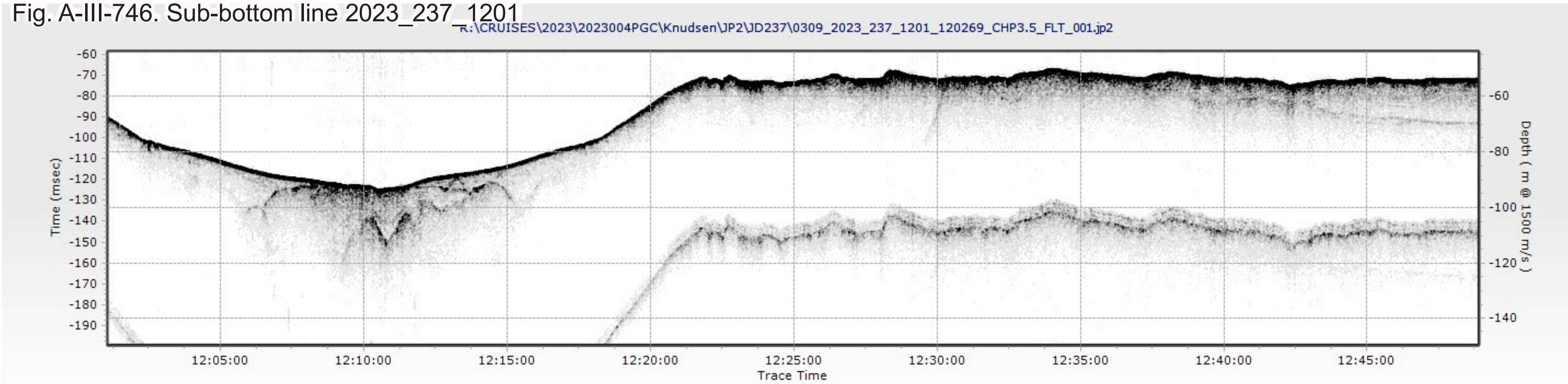
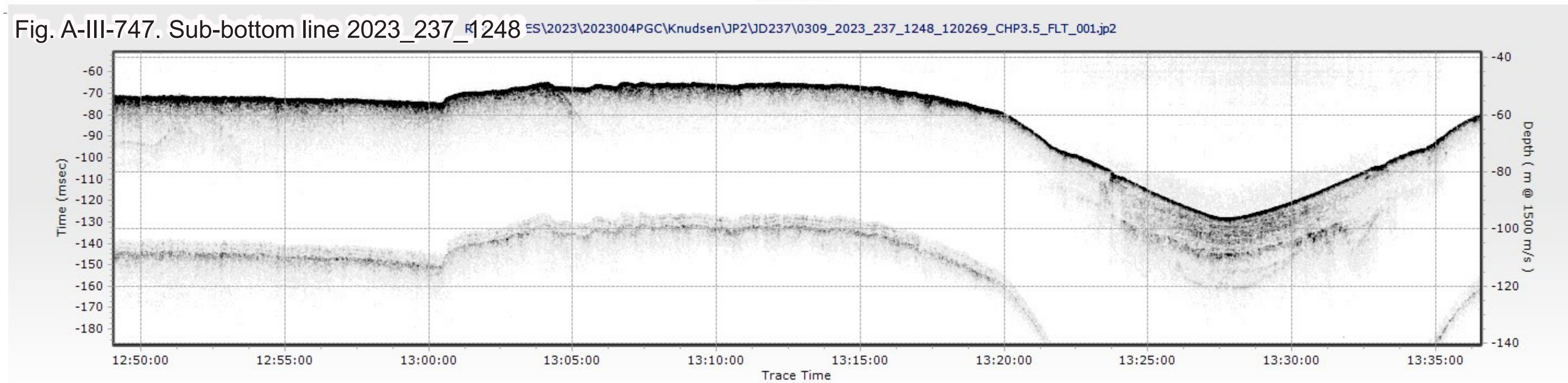


Fig. A-III-747. Sub-bottom line 2023_237_1248



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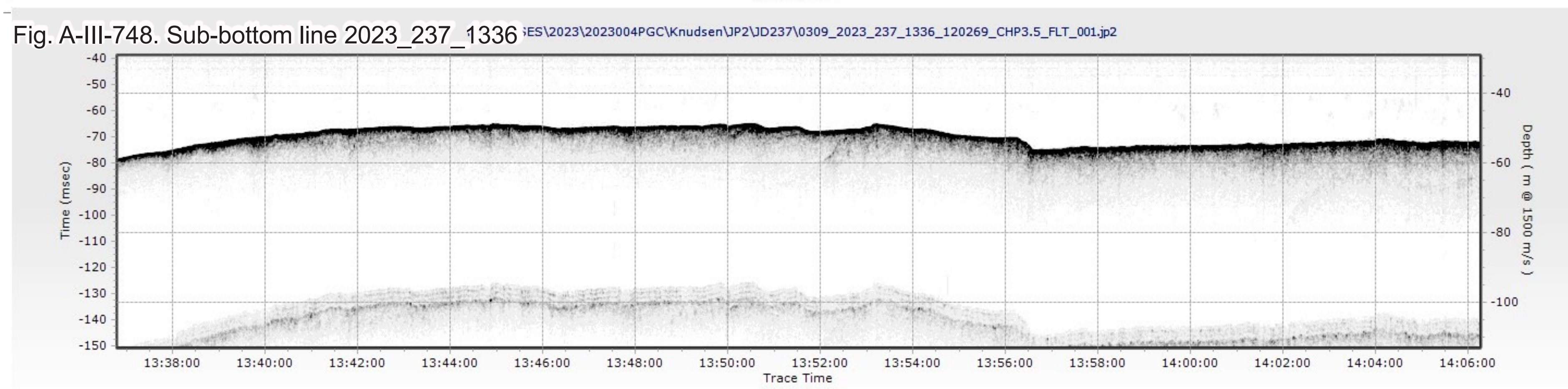

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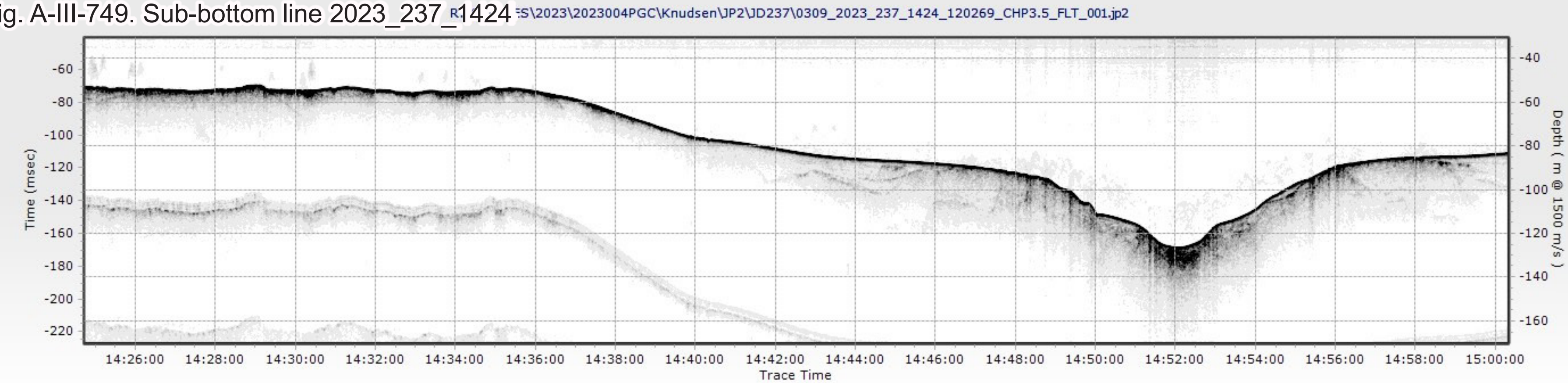

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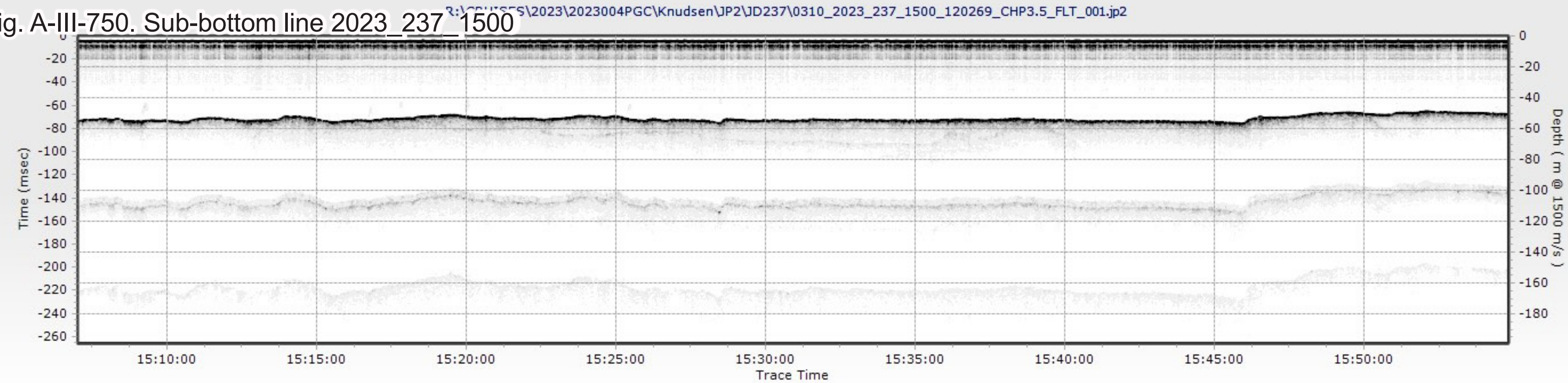

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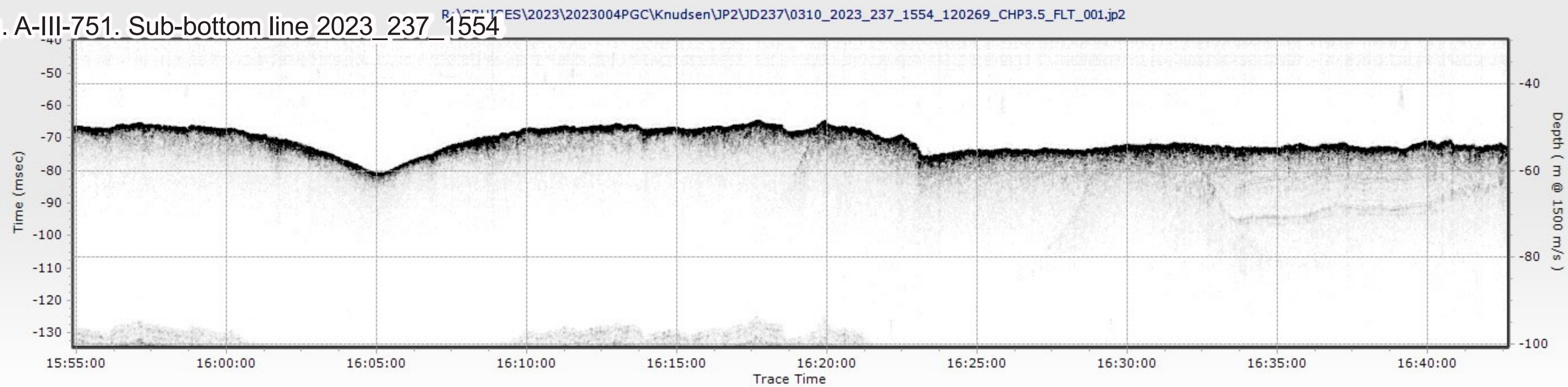

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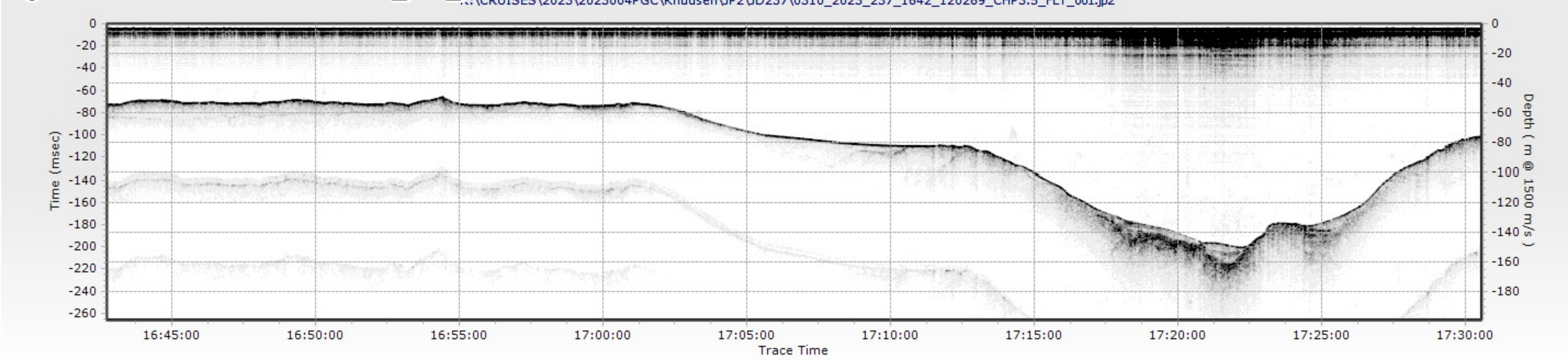

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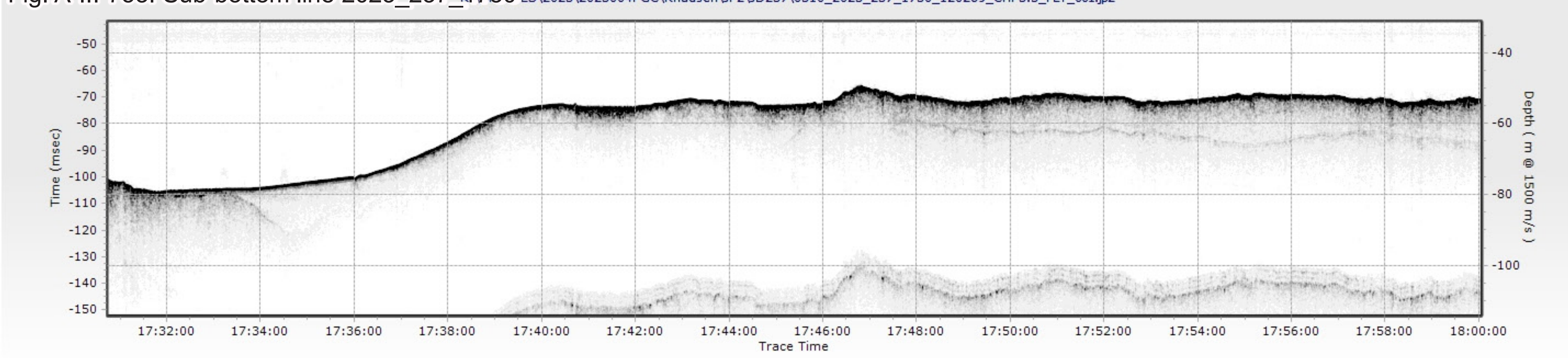

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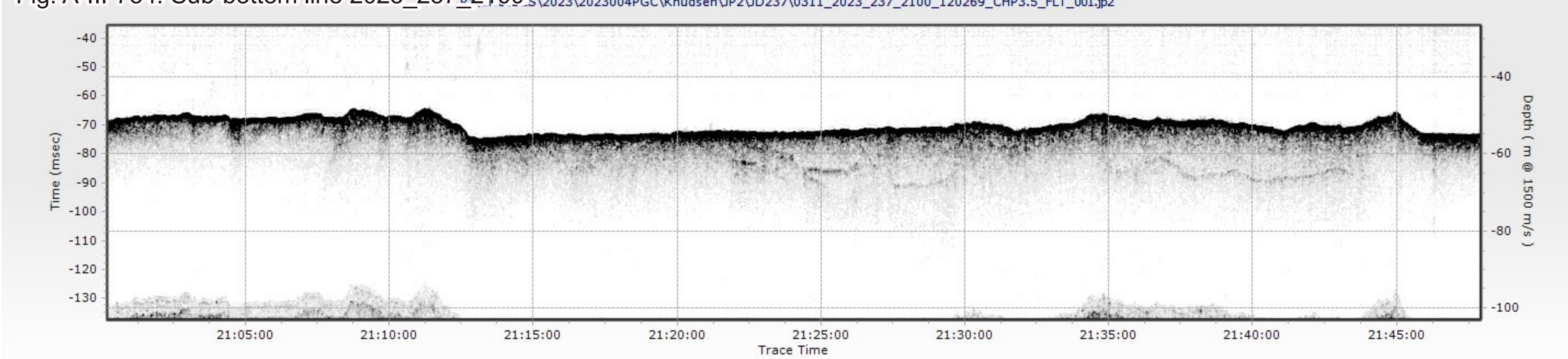

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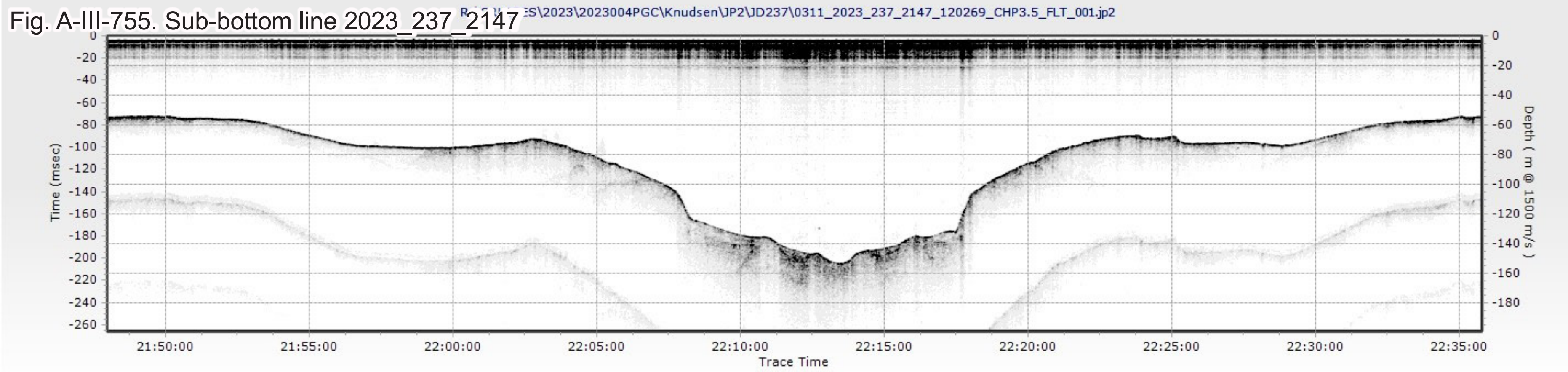

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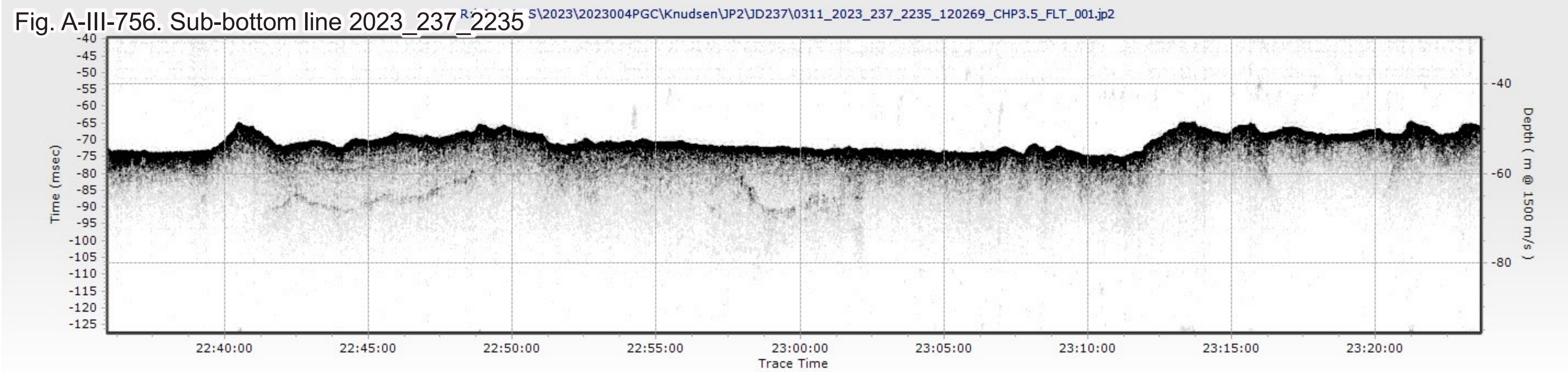

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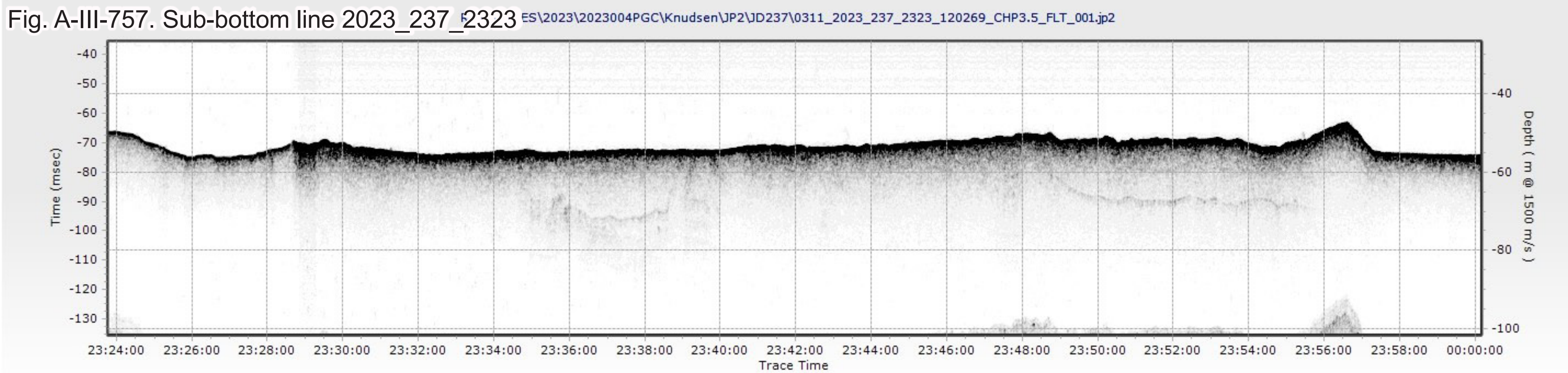
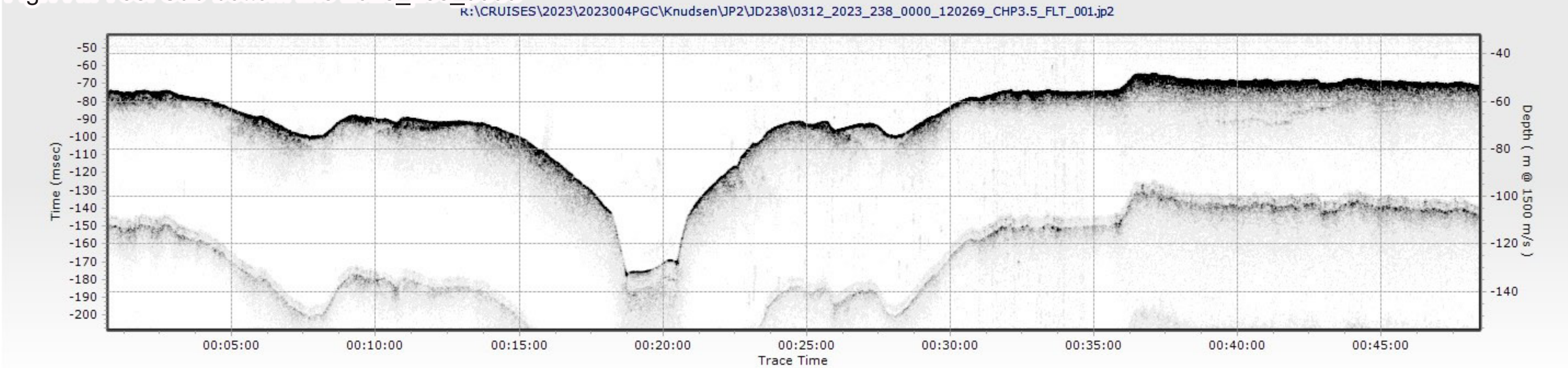


Fig. A-III-758. Sub-bottom line 2023_238_0000



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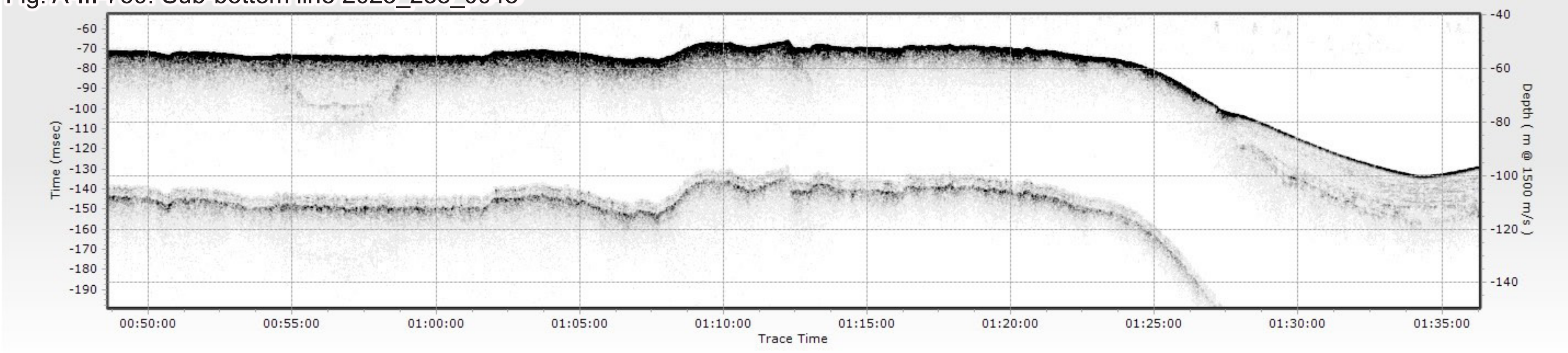

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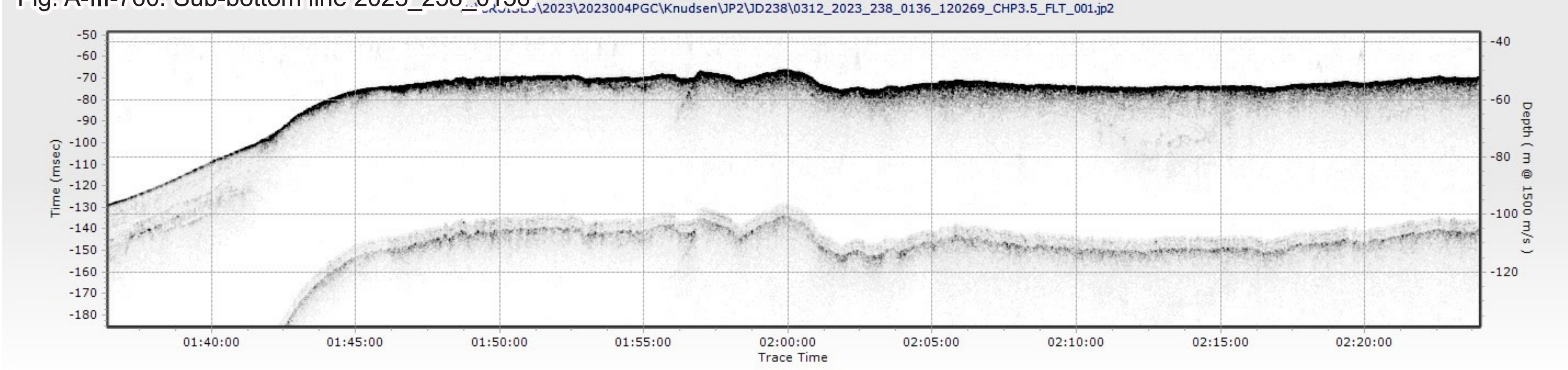

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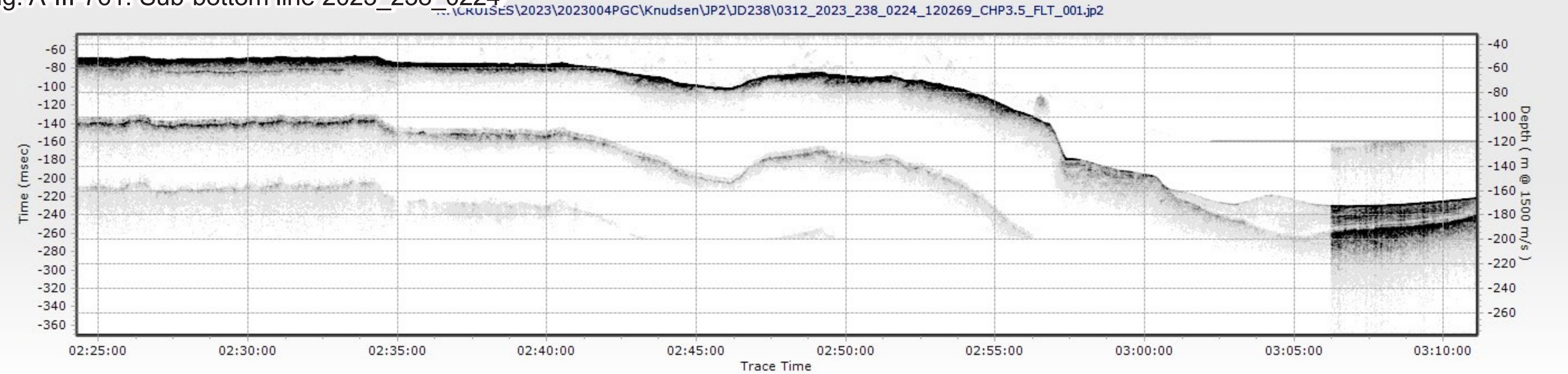

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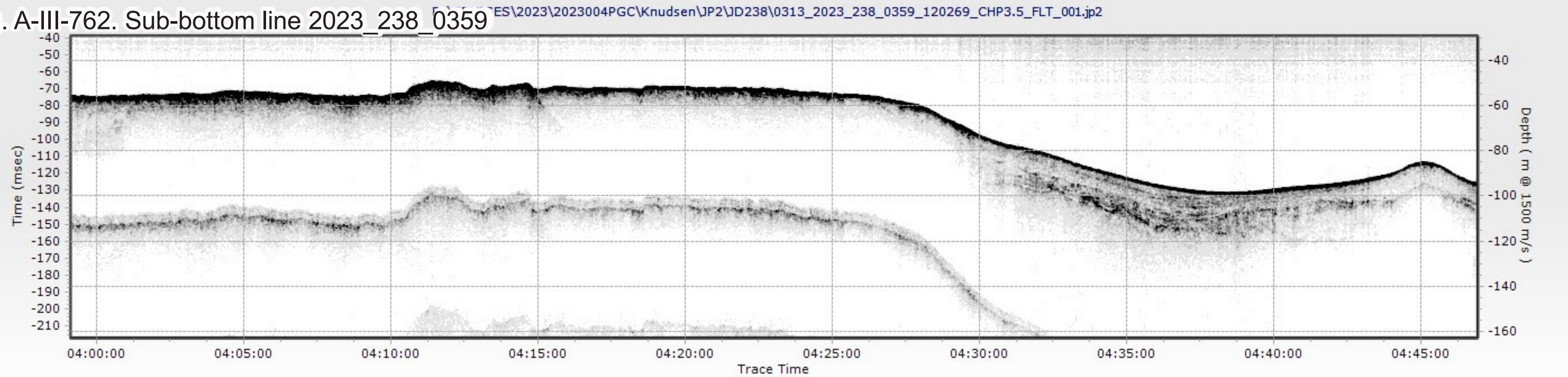

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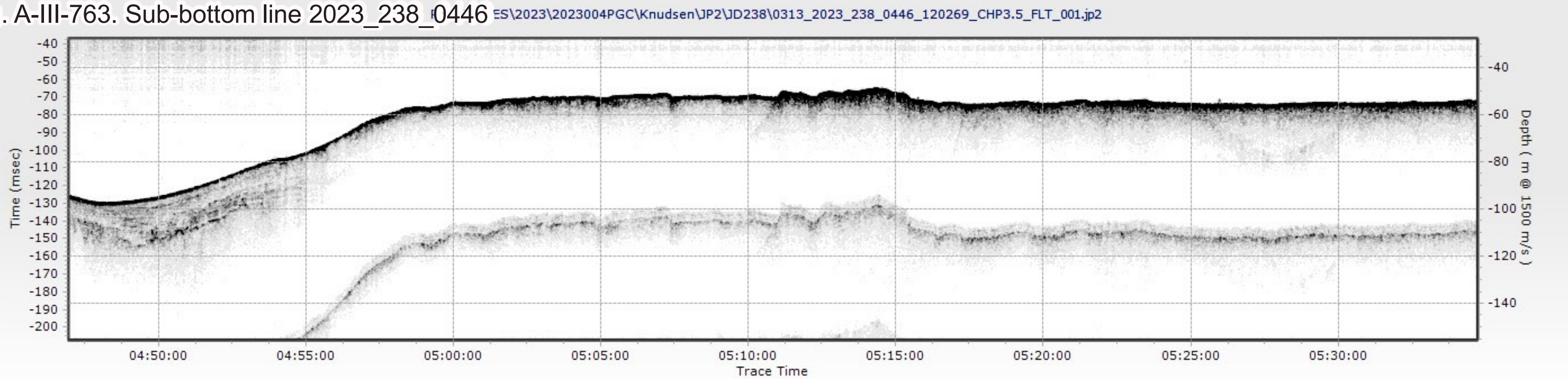

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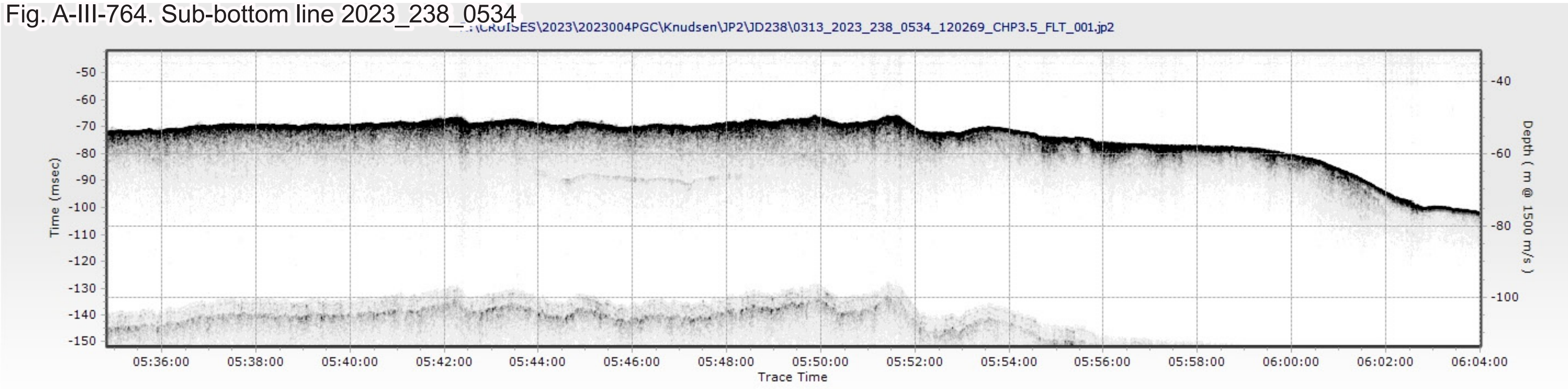

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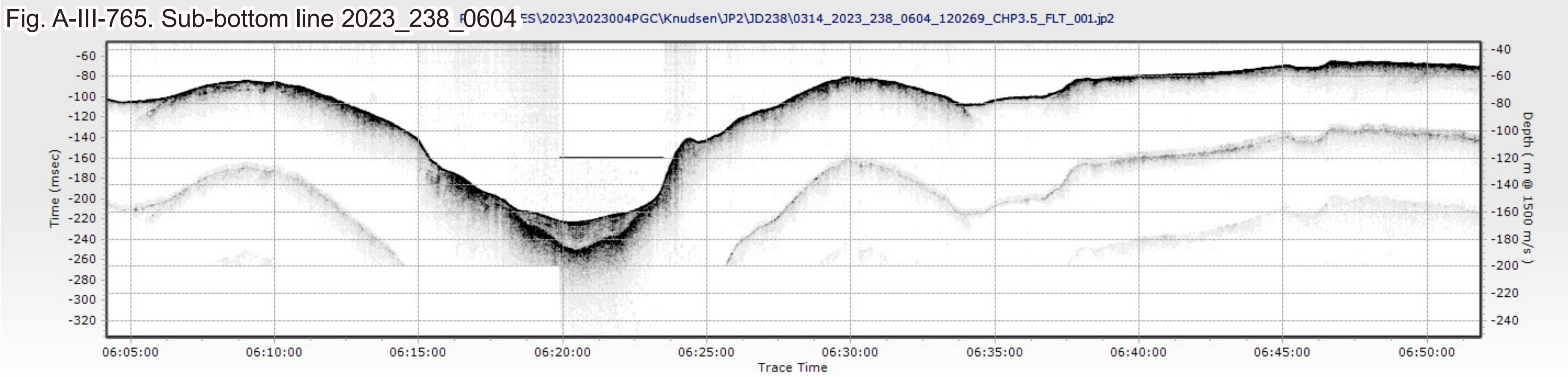

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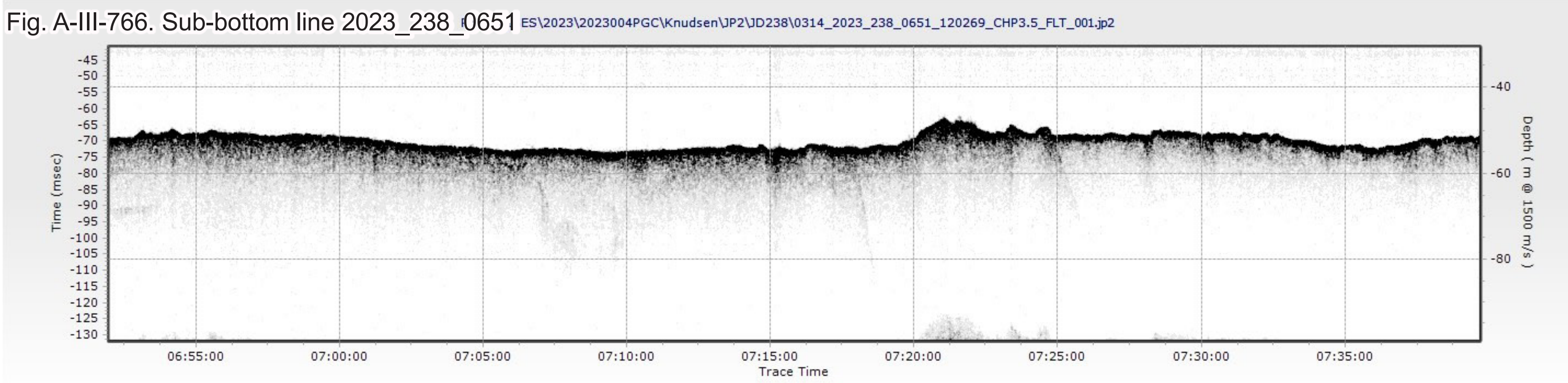

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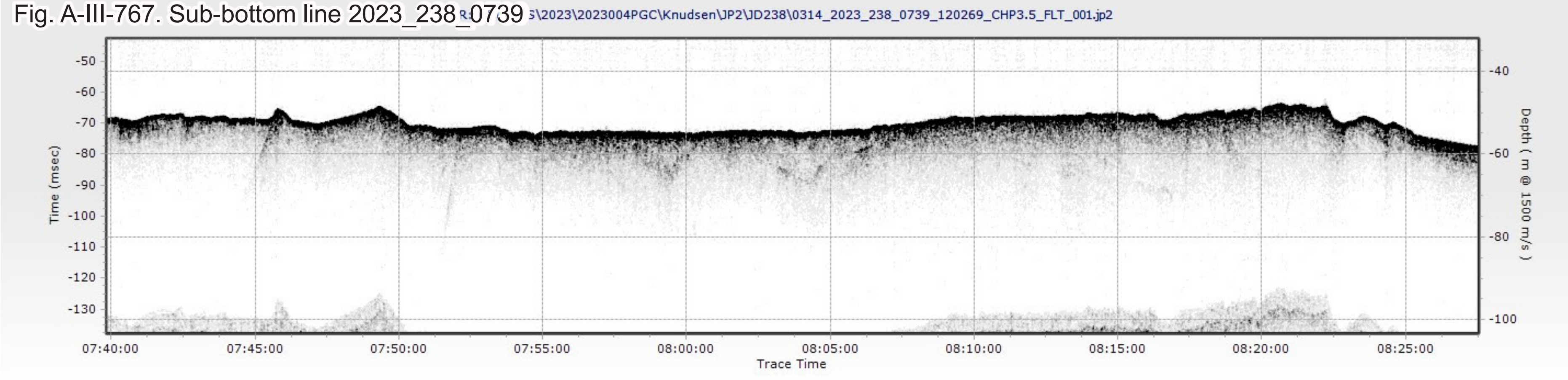

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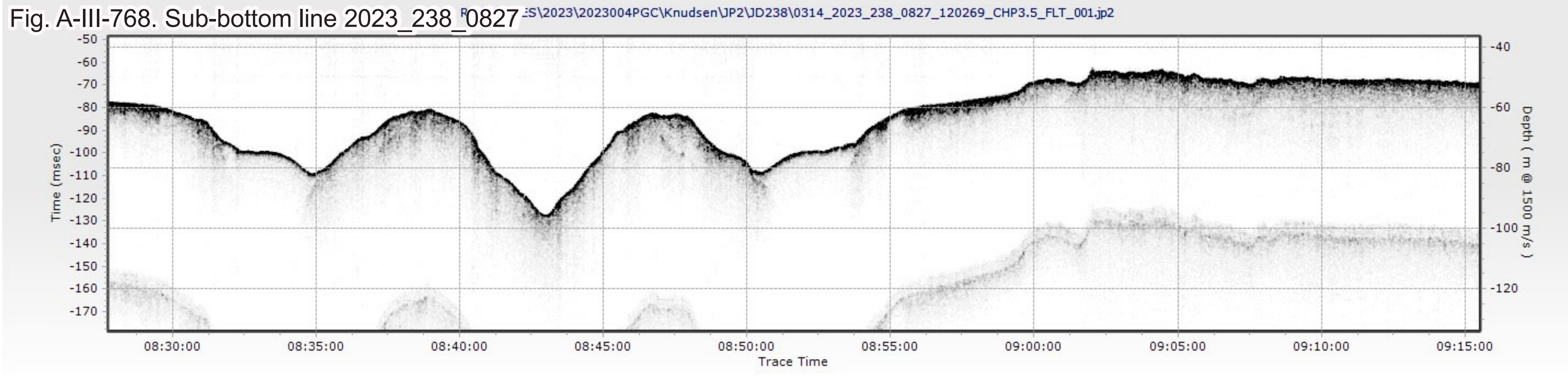

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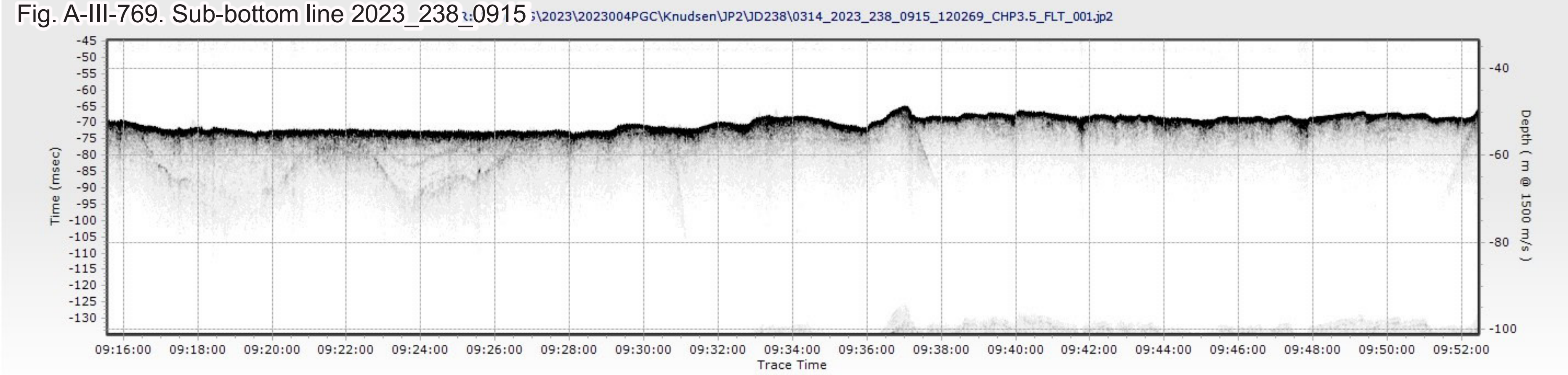

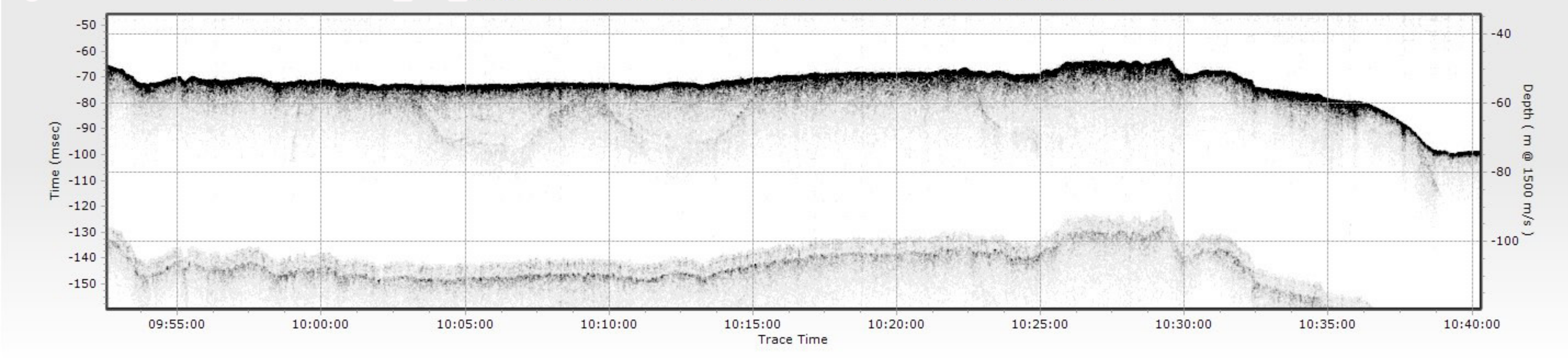

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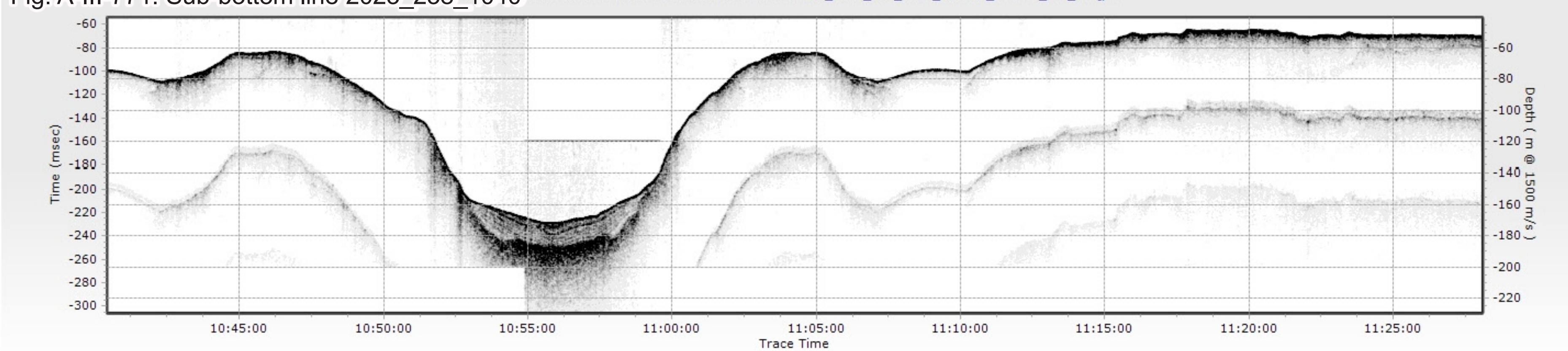

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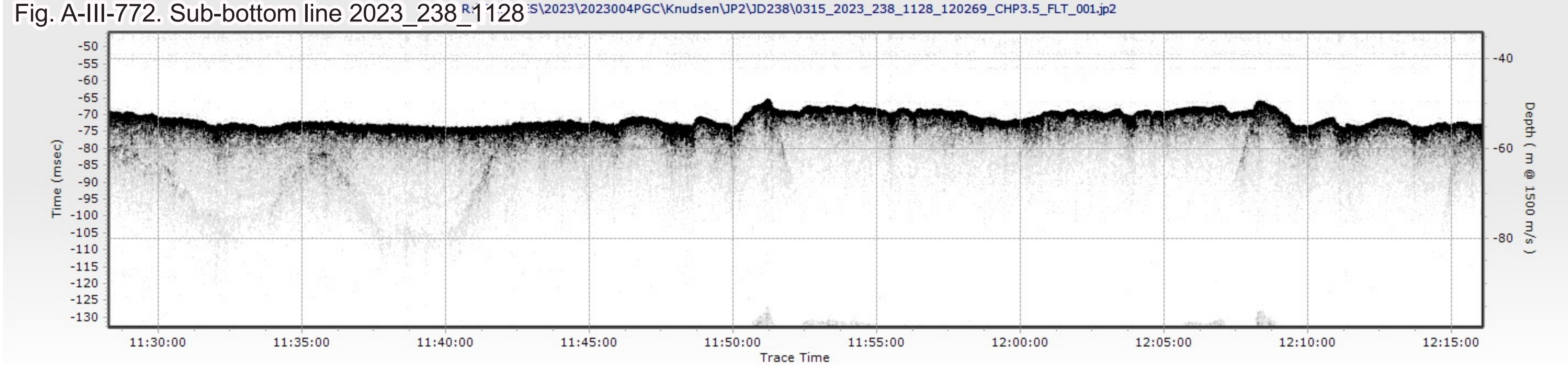

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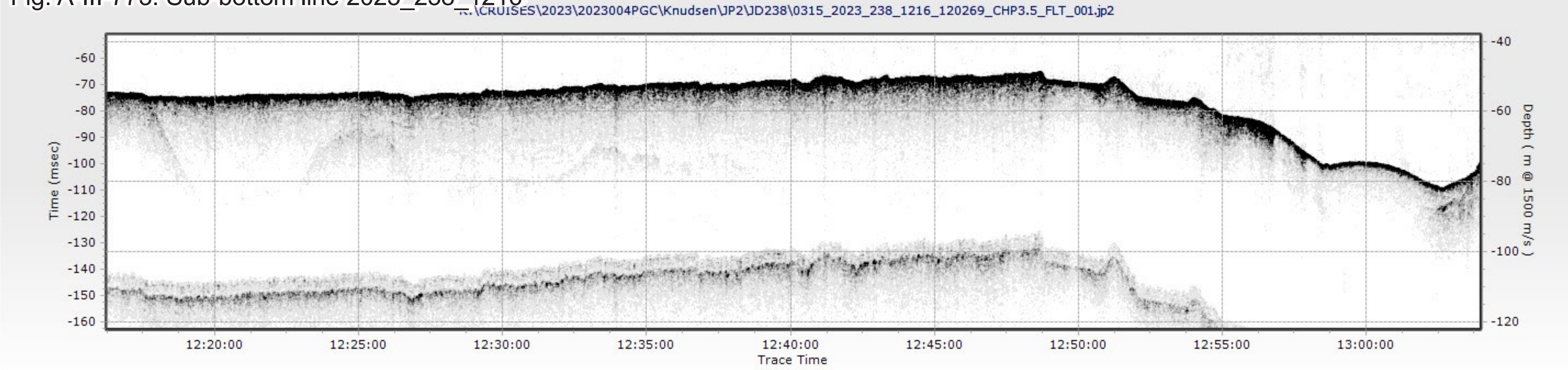
Fig. A-III-773. Sub-bottom line 2023_238_1216



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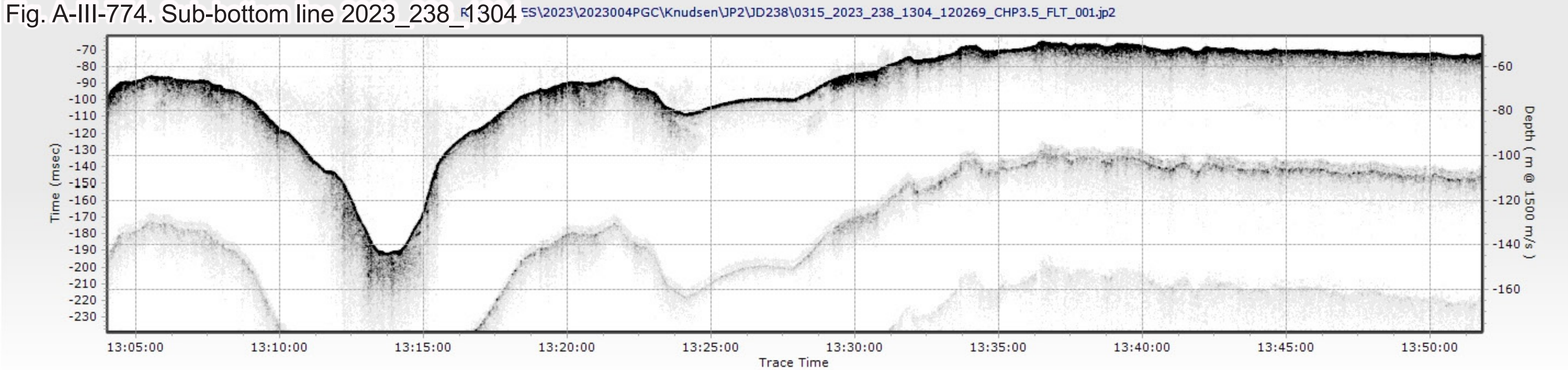

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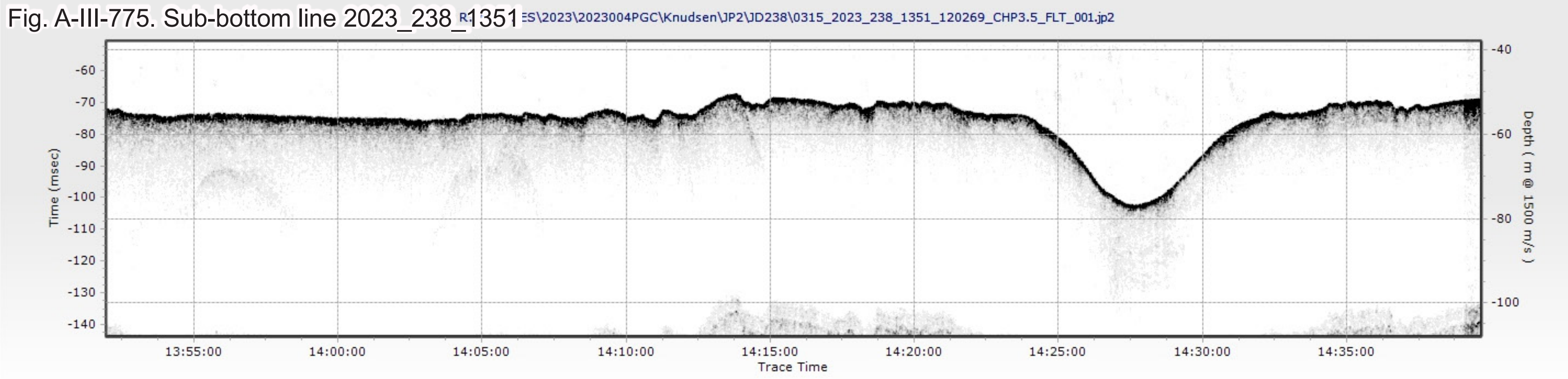

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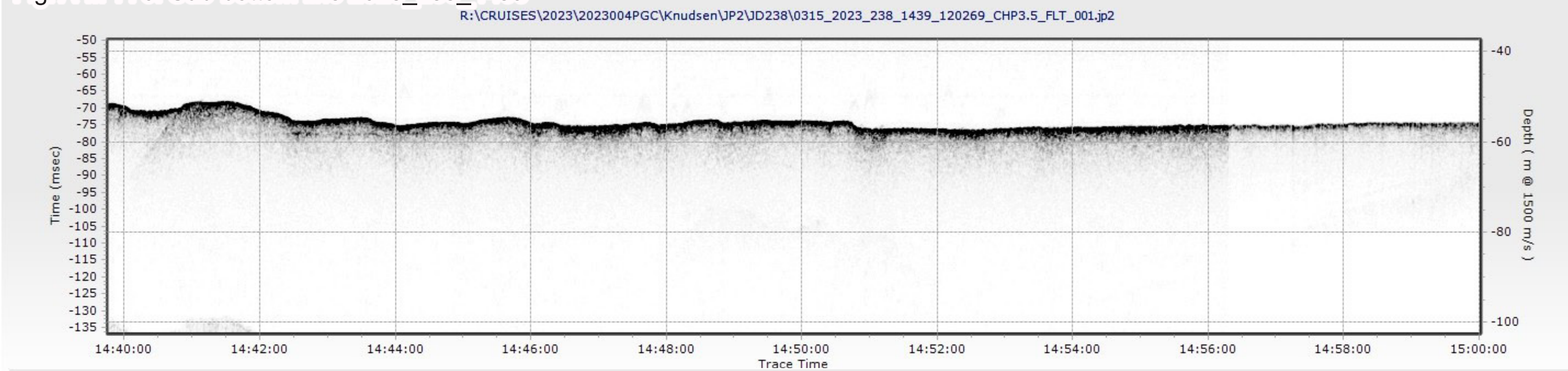

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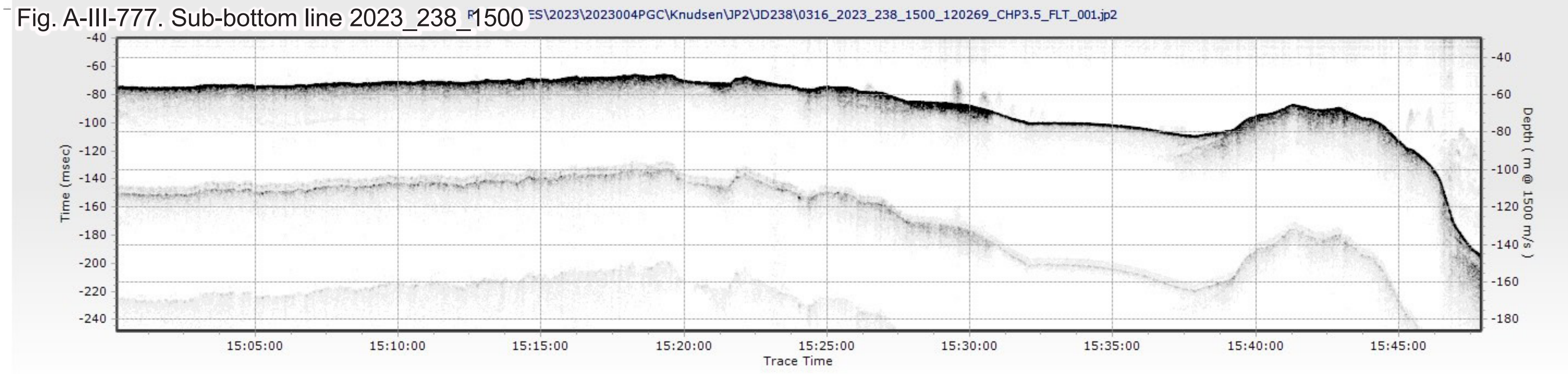

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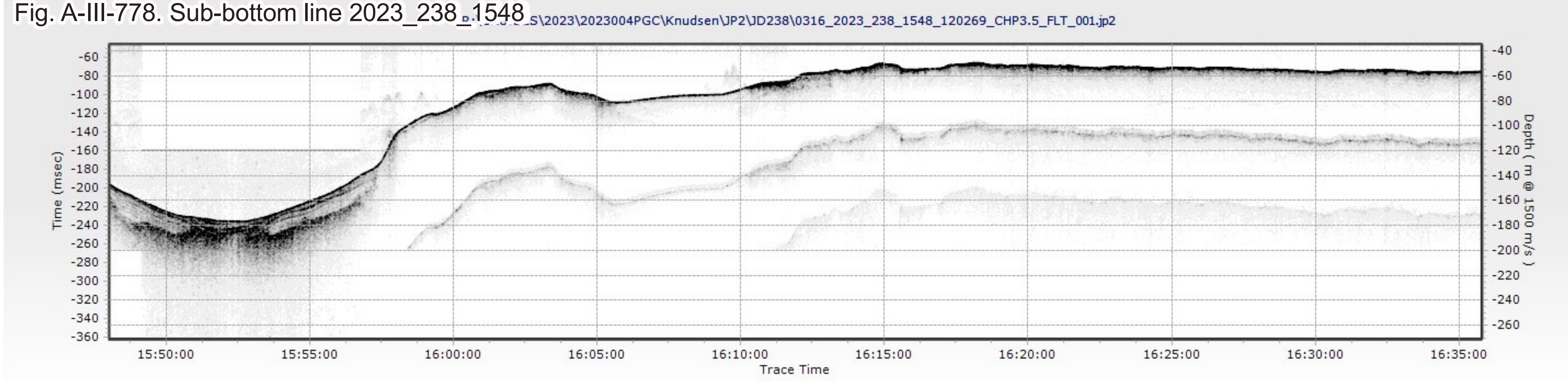

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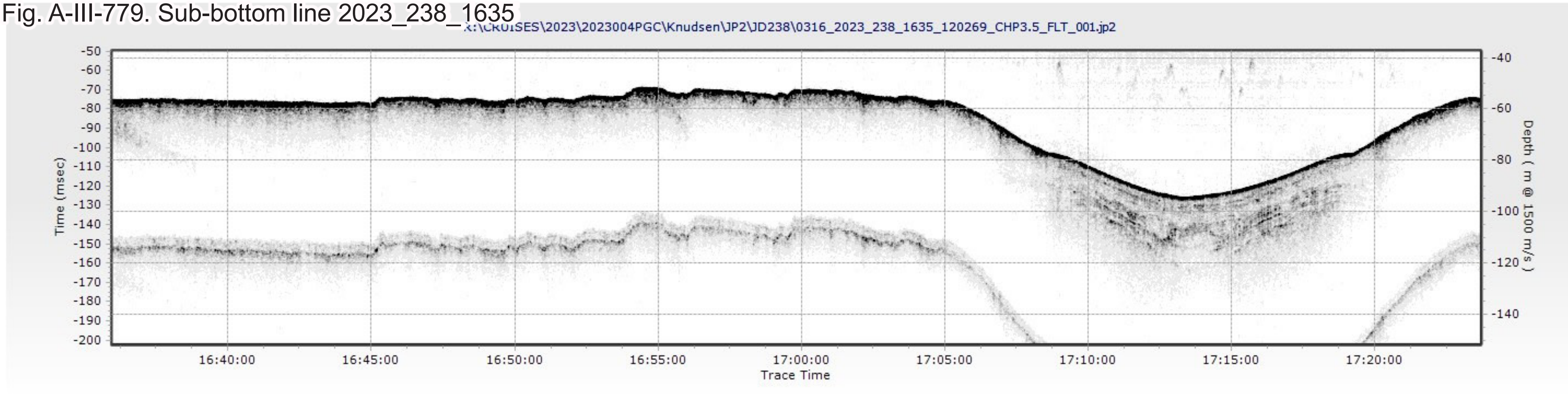

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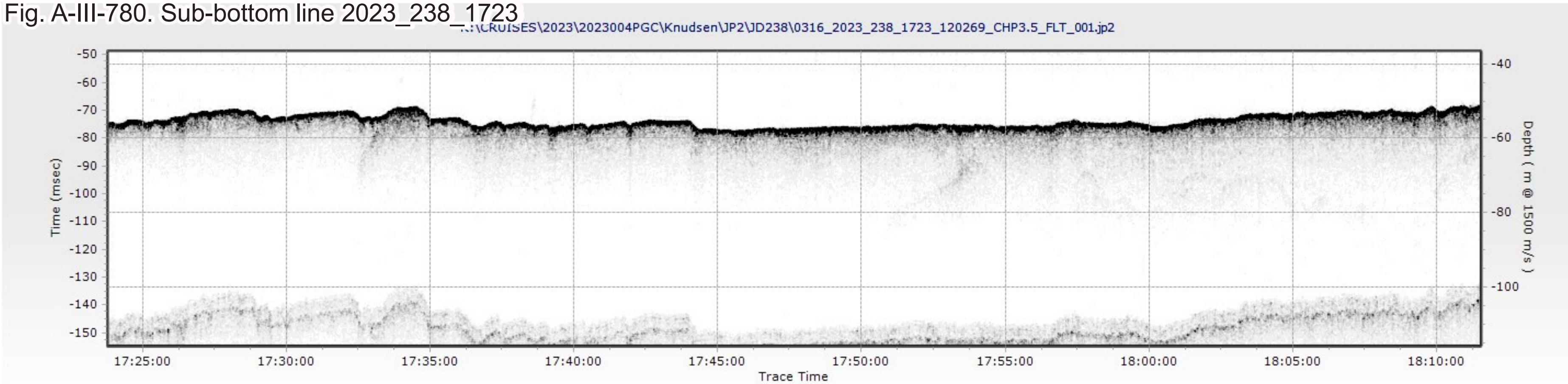

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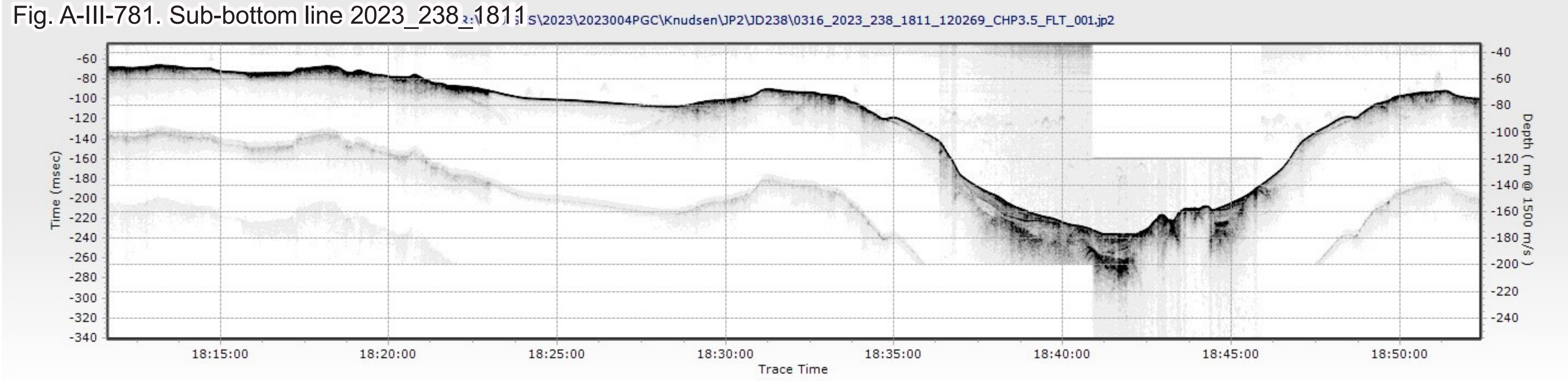

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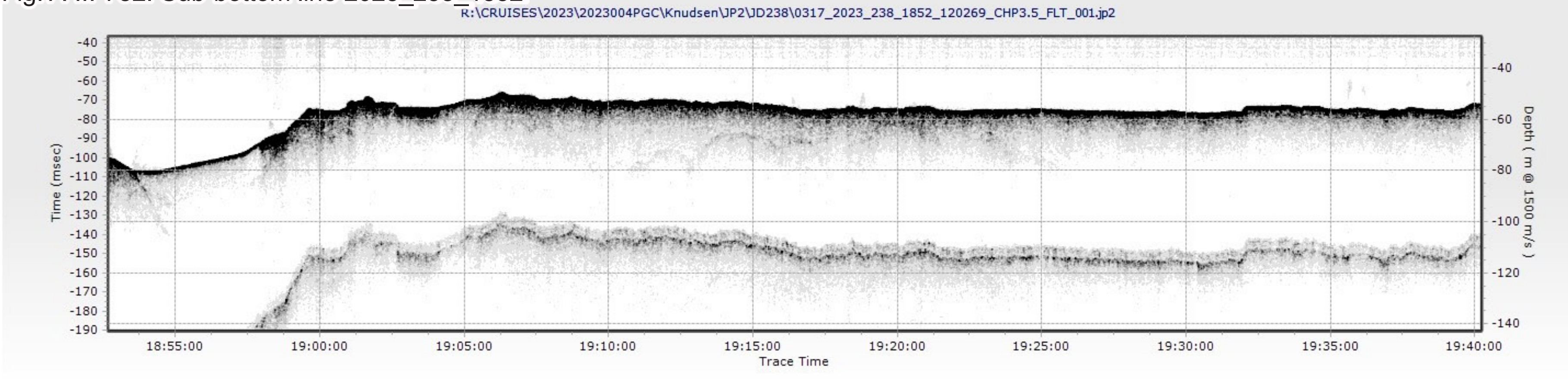

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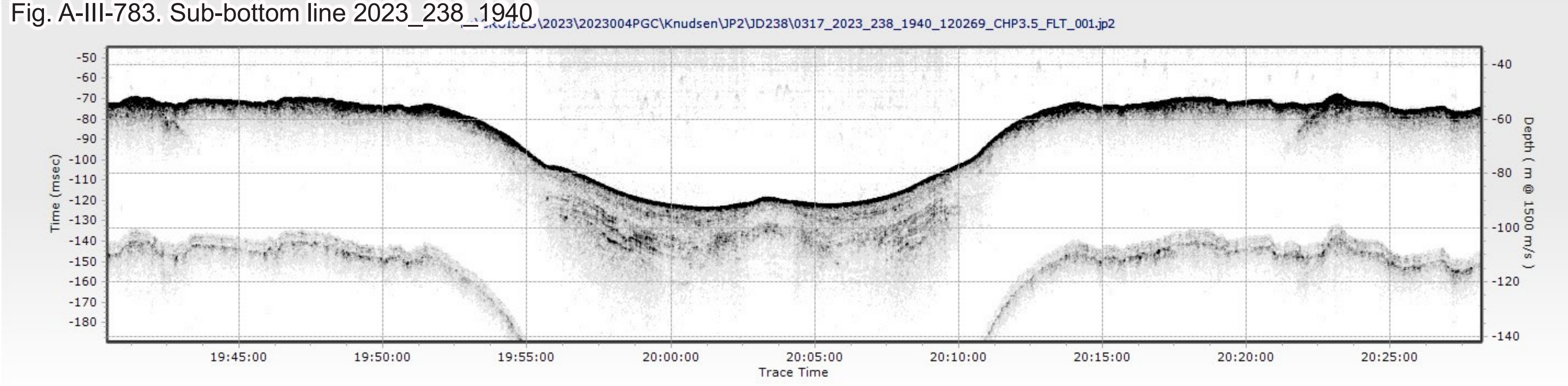

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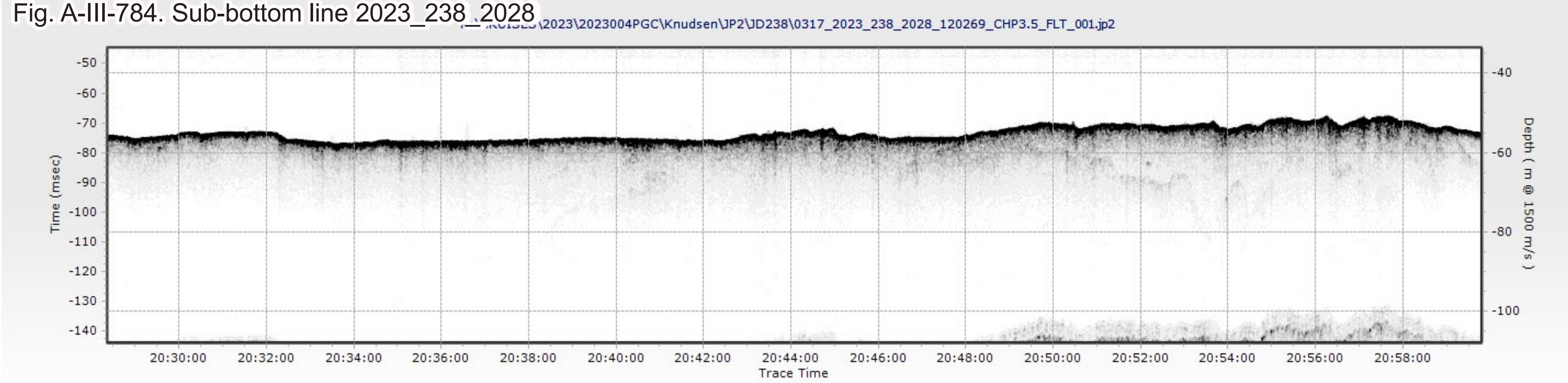

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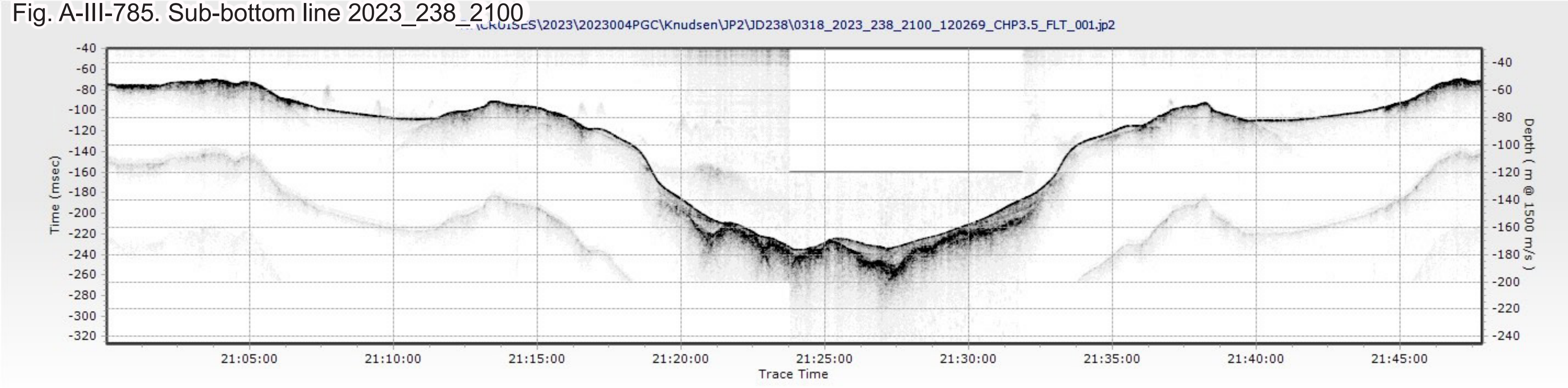

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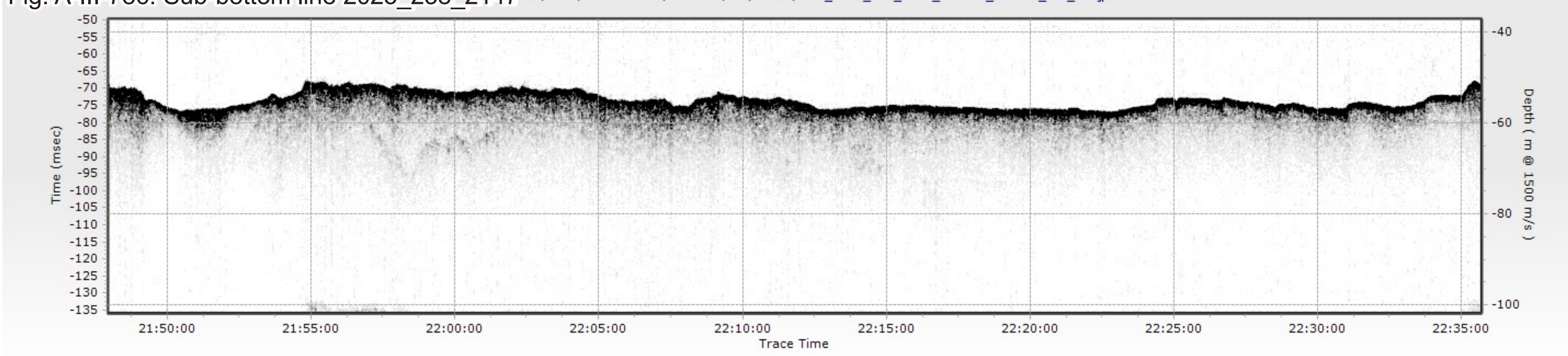

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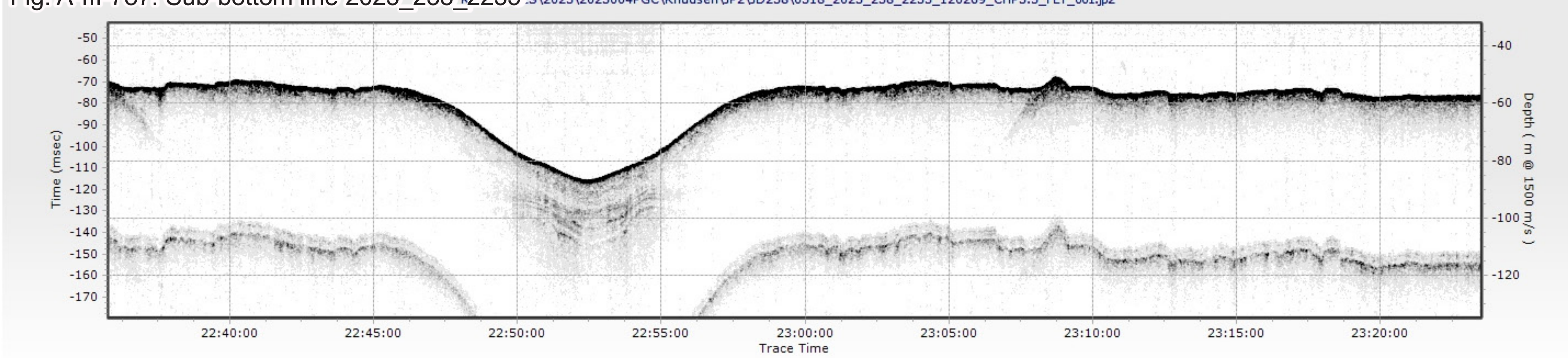

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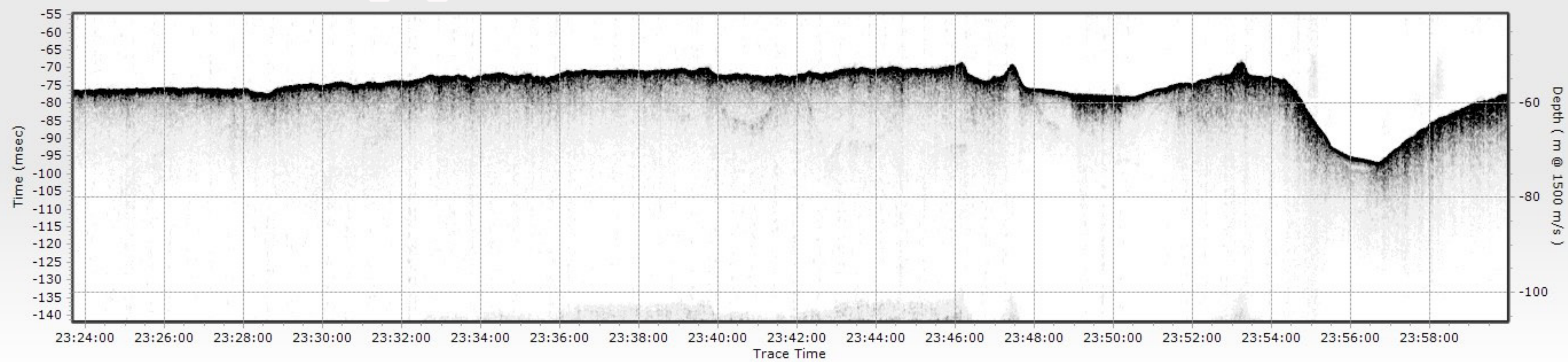

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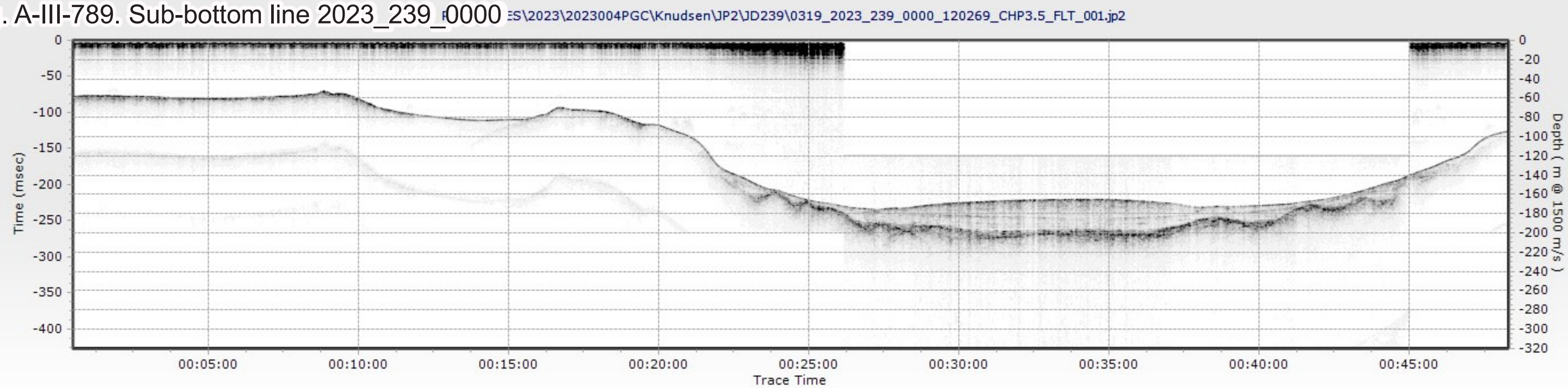

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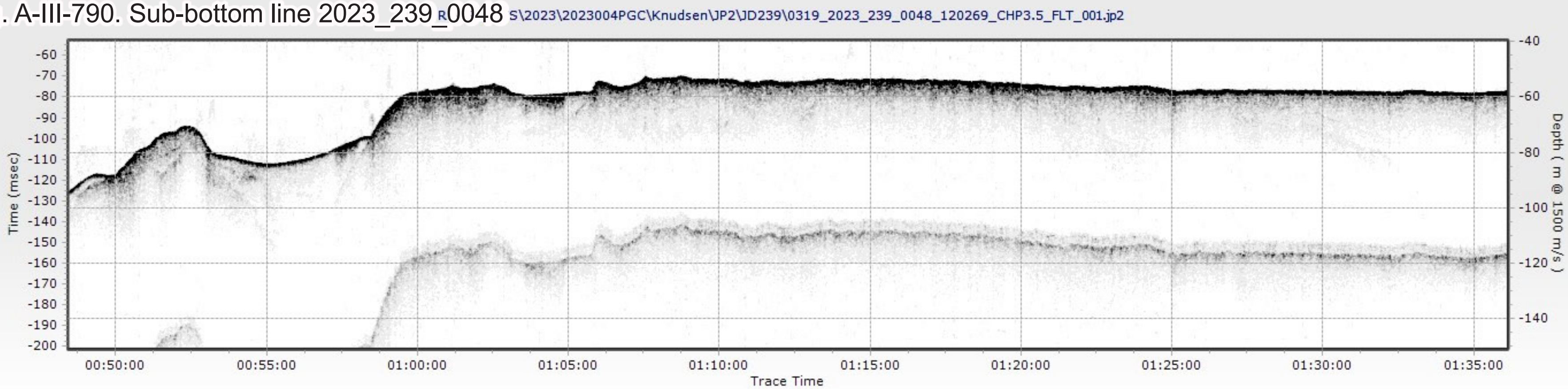

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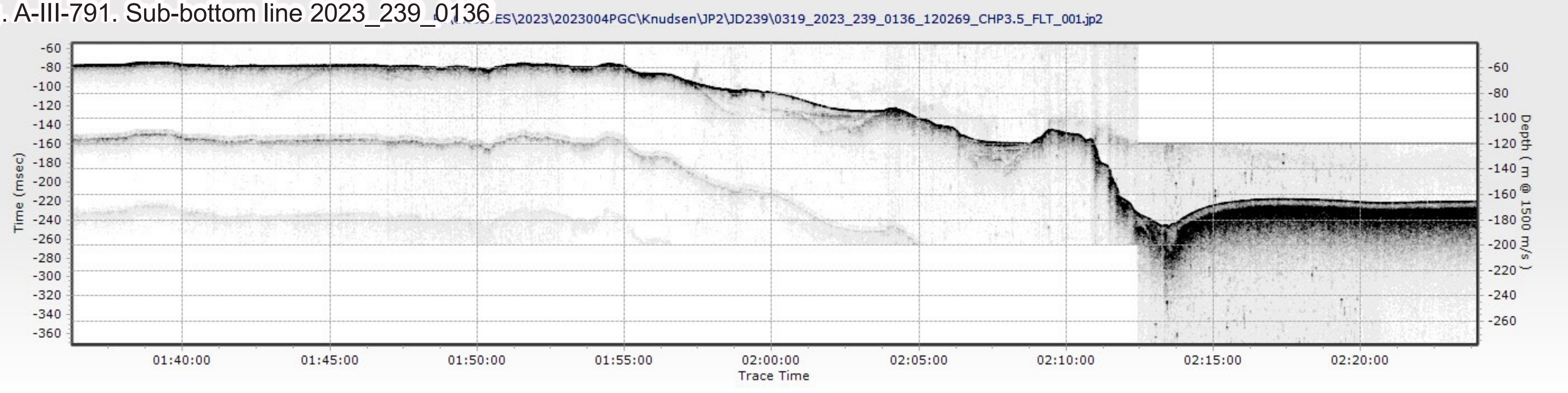

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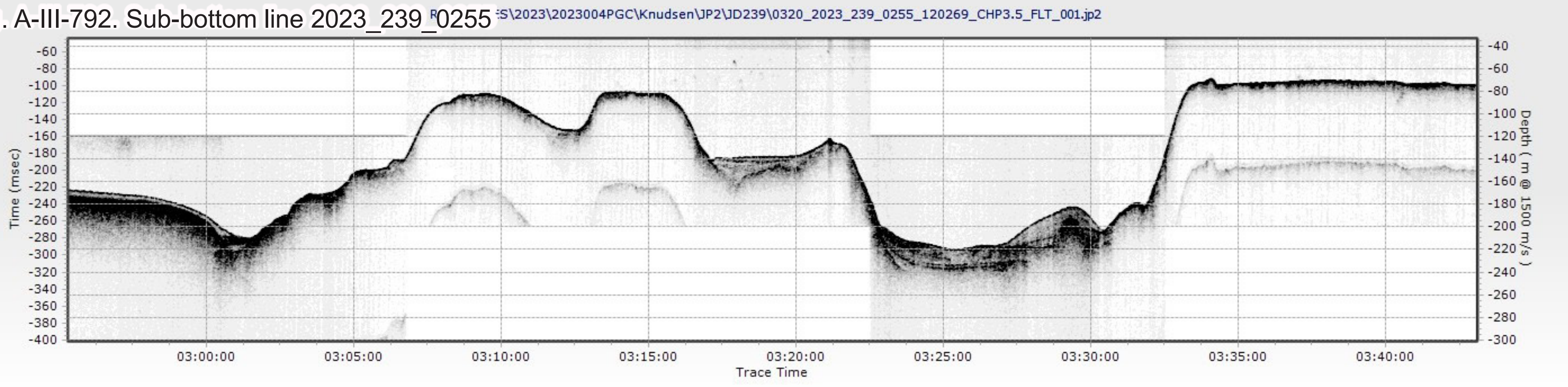

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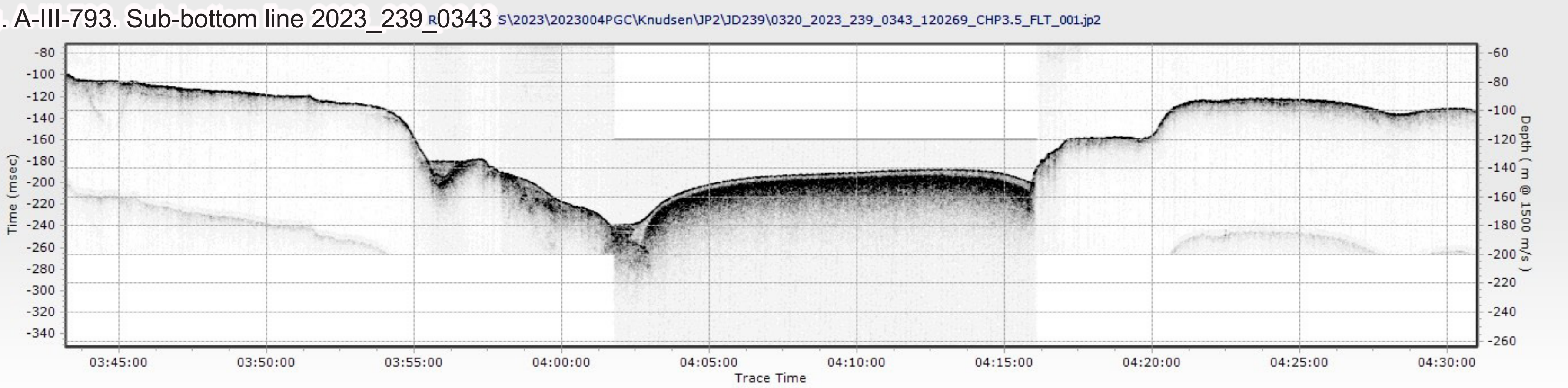

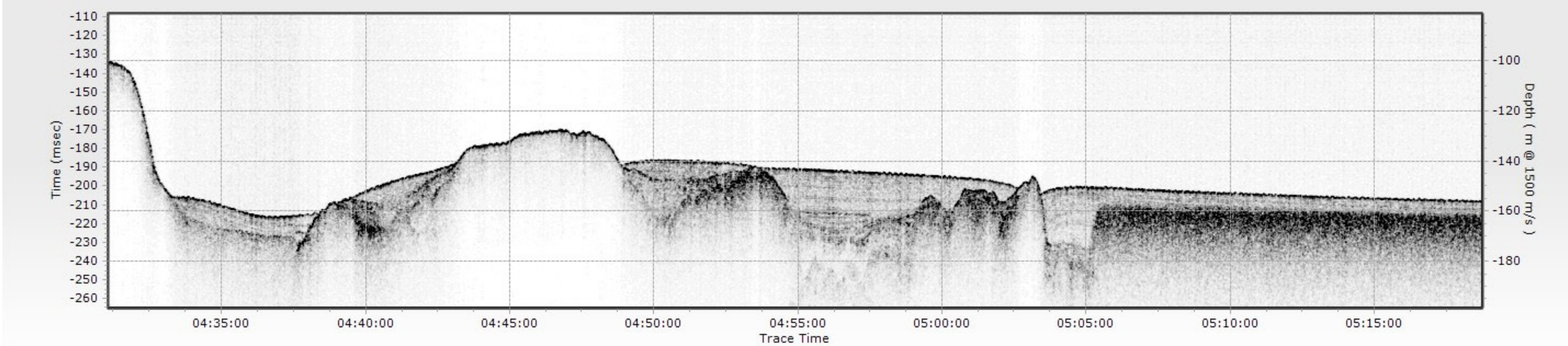

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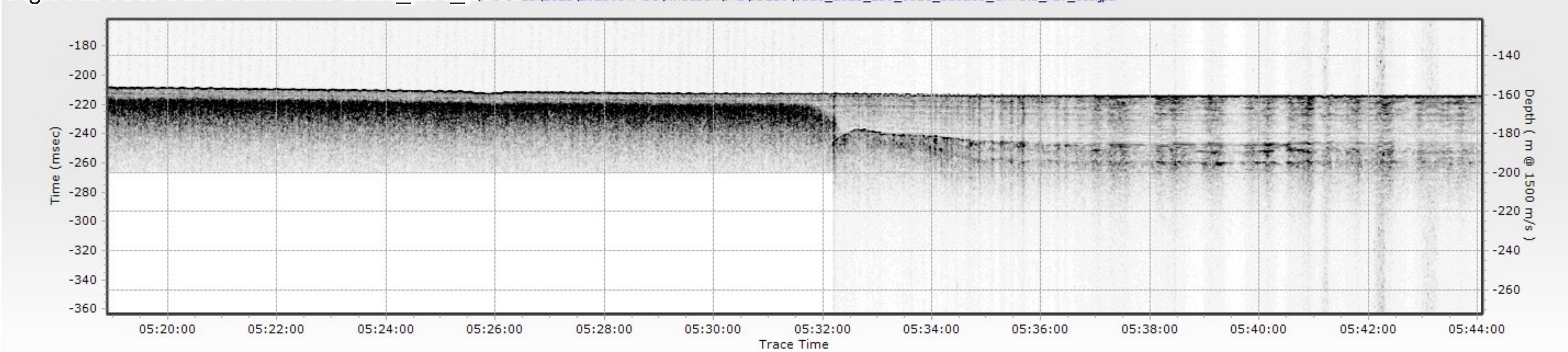

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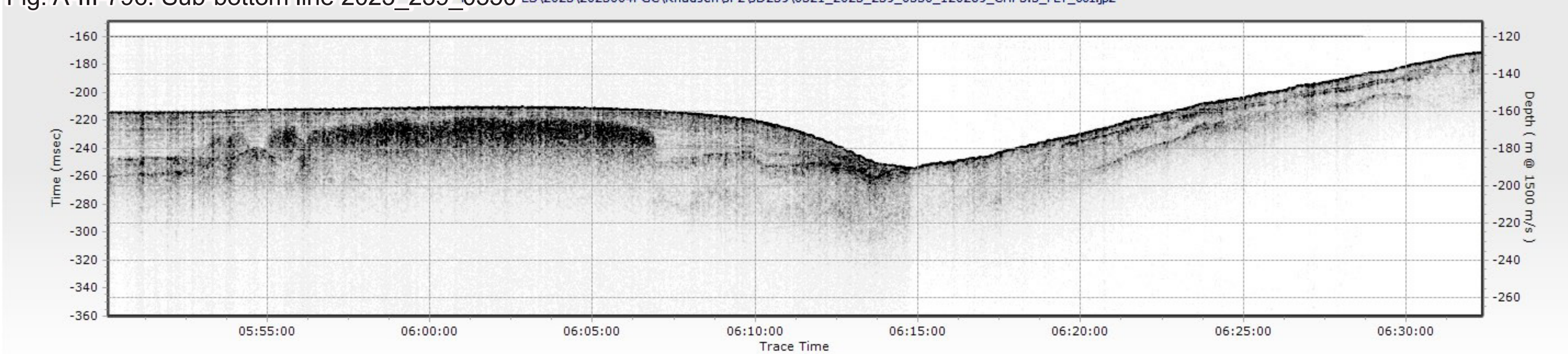

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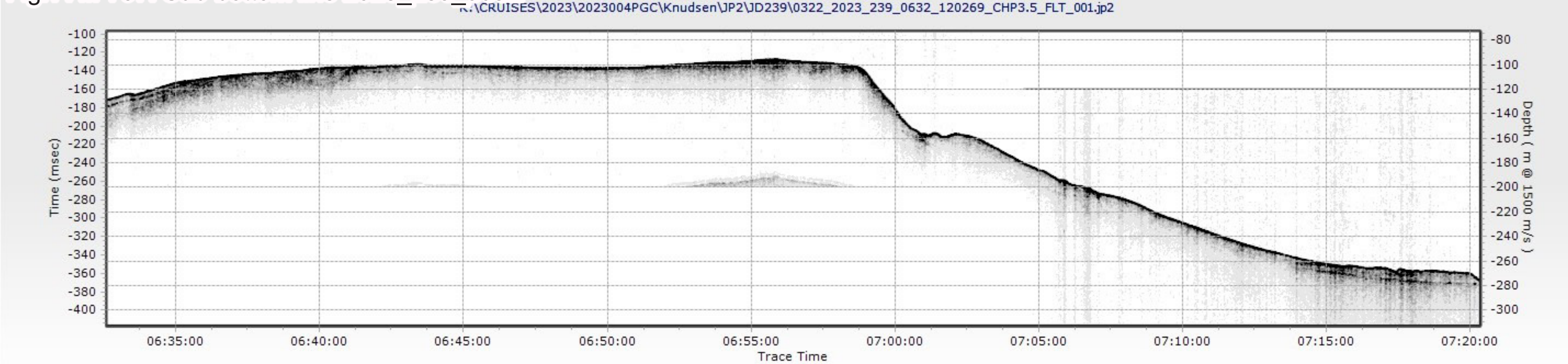

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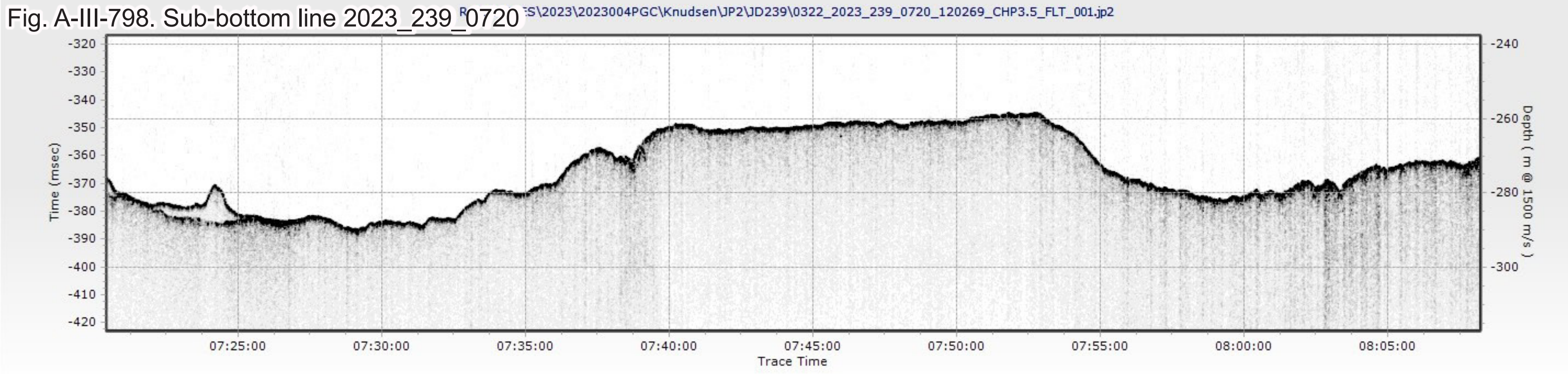

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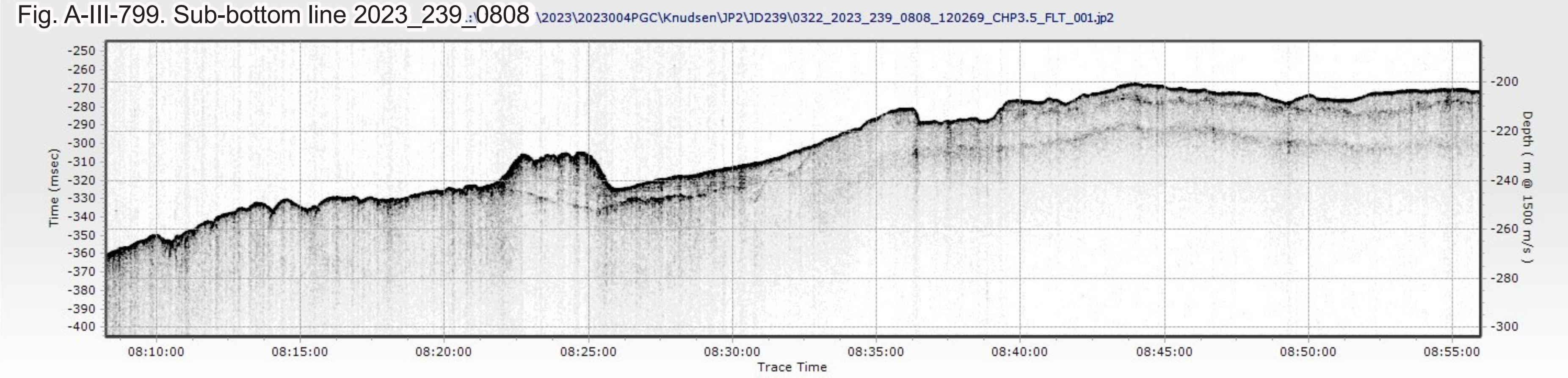

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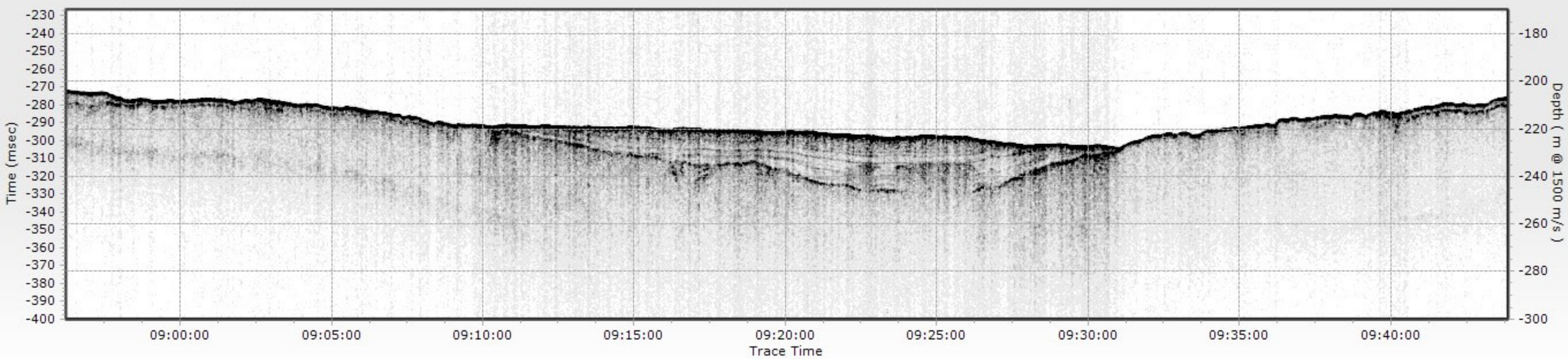

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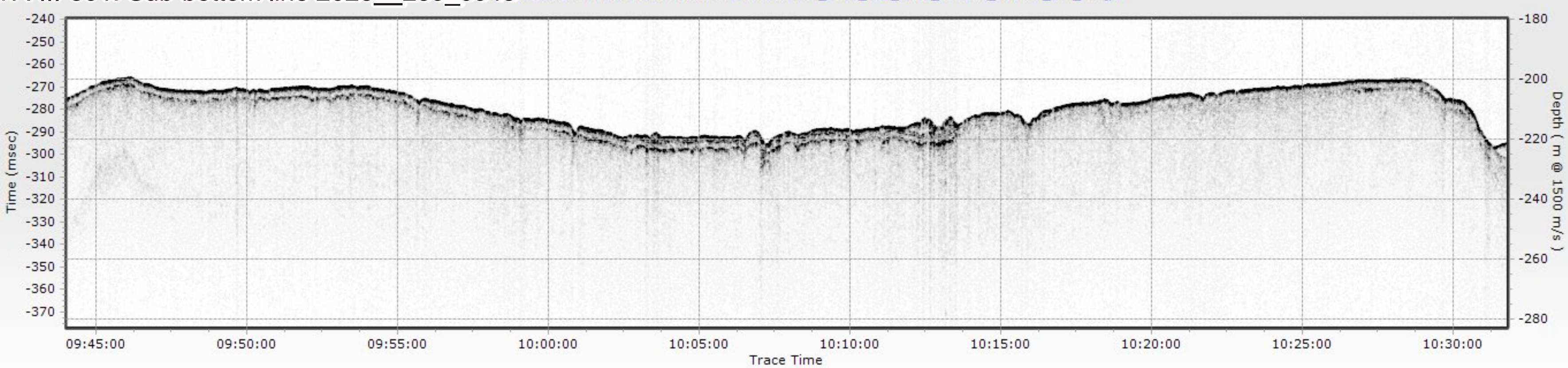

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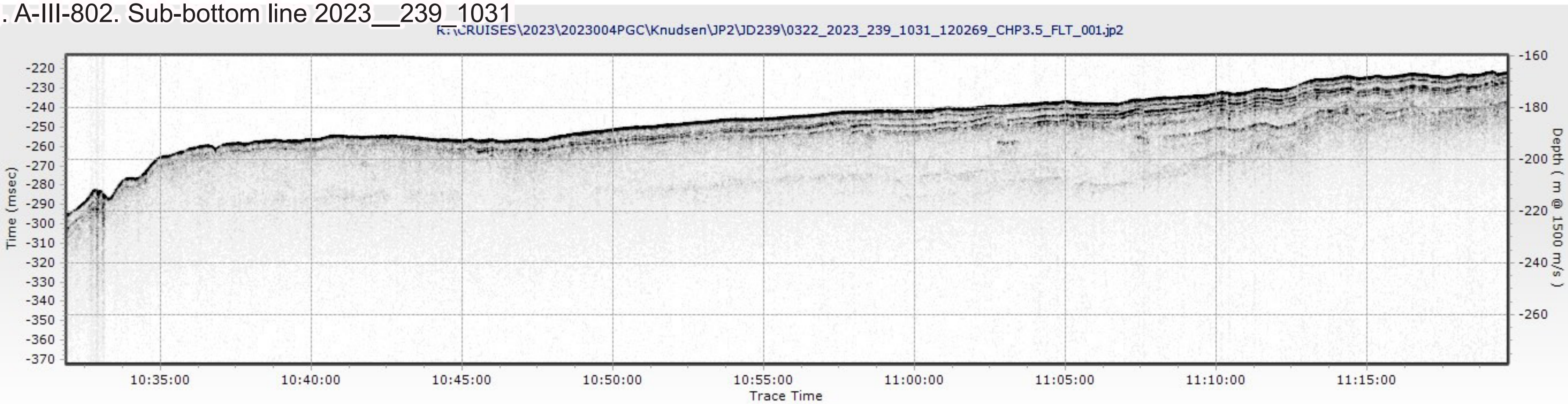

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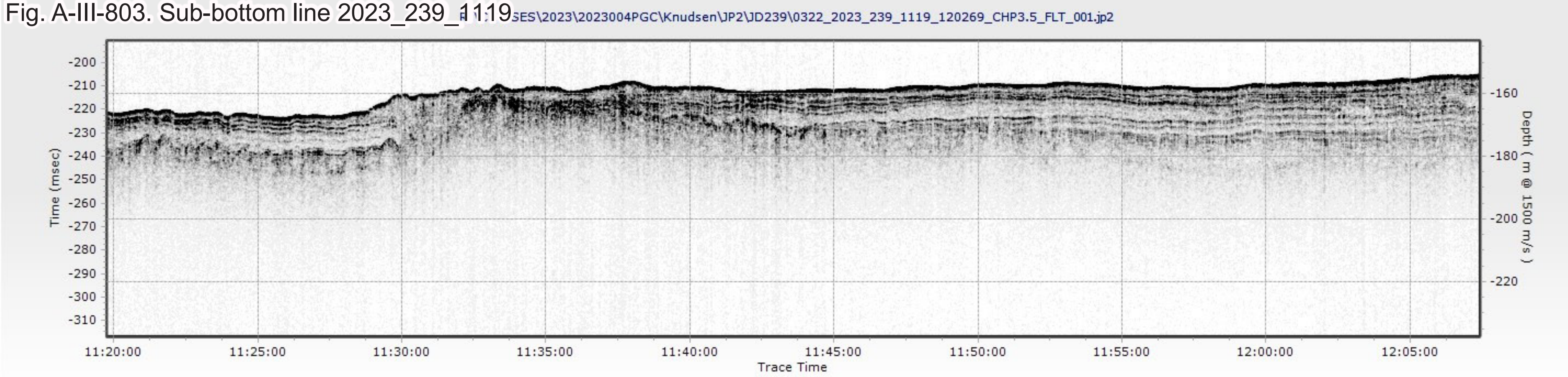

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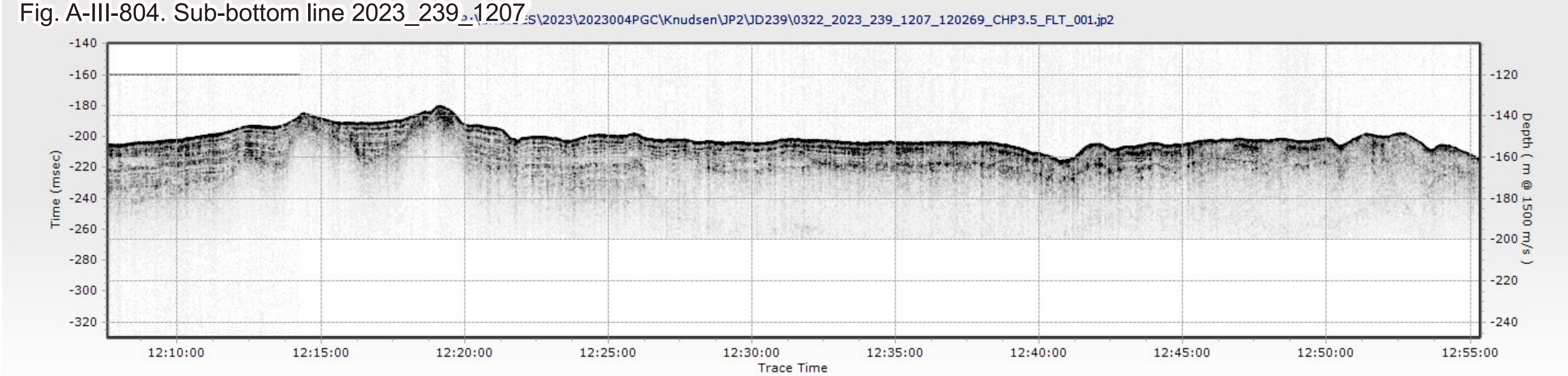

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