MARSITECRUISE

R/V POURQUOI PAS?

OCTOBER 28th – November 17th, 2014

Leg 3 - Six-Month Cruise Report

Chief scientist :
Pierre Henry (CEREGE)

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With special thanks to Captain Thierry Alix and Crew of *R/V Pourquoi pas?*

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I. General context

I.1 Background

Leg 3 was dedicated to core sampling and to the recovery of geophysical instrumentation.

The general objective of core analysis will be to ground truth interpretations of high-resolution seismic data and to identify and date sedimentary events related to earthquakes. The background and specific objectives are described hereafter:

- Fault slip rates (vertical and horizontal) have been estimated from seismic data based on reflector sequence ages based on assumed 100 kyr cyclicity and correlation with low-stand deltas (Sorlien et al., 2012; Grall et al., 2012, 2013). Only very shallow horizons have been dated directly (Beck et al., 2007). One goal will be to ground truth the assumed horizon ages with long Calypso cores taken on structural highs and at fault outcrops. The originality of the approach is the use of multi-proxy data acquisition (magnetic susceptibility and artificial magnetizations, gamma-densimetry, XRF scanning, biomarkers, tephra) to correlate cores that sampled overlapping time intervals. Chronology will be established by tying local environmental changes (i.e. marine-lacustrine transitions and paleoclimate proxies) to climatic and eustatic cycles. Nannofossil assemblages during marine high stands and tephra will provide additional control points.
- Turbidites-Homogenites (TH) were sampled in cores for the Sea of Marmara basin and correlations with historic events have been attempted (Sarı and Çağatay, 2006; Çağatay et al., 2012; McHugh et al., 2014), but the TH record could not be established in Kumburgaz basin, in part because of difficulties distinguishing TH attributable to earthquake events from other turbidites (McHugh et al., 2006). A new method based on anisotropy of magnetic susceptibility (Campos et al., 2013) will be combined with more classical methods (grain size analysis, X-ray scanning) to distinguish turbidites of different origin. The knowledge of the thickness of instantaneous deposits is crucial in order to establish consistent age/depth models.
- Assessing the synchronicity of turbidite events observed at different locations and their association with historical earthquakes requires taking into account uncertainties in dating methods (e.g. radiocarbon, tephra) as well as in correlations between cores. In order to provide a reliable basis for hypothesis testing, Age models construction will include the estimation of uncertainties from multiple sources (dating and tie-point correlation) using Gaussian processes (Heaton et al., 2013). We will re-examine the Sea of Marmara dataset with this method and re-evaluate their interpretation in term of segmentation and earthquake recurrence. We will use ash layers are additional control points and sedimentary records of the last events will be dated using short lifetime radionuclides (^{137}Cs and ^{210}Pb) methods.
- Fault scarps in high-resolution bathymetric maps obtained with Automated Underwater Vehicles (AUV) display very different character on the western high and central high in the Sea of Marmara although the sedimentation rates are in the same range. We will adapt the concept of scarp degradation (Avouac and Peltzer, 1993) in the marine context, interpreting quantitatively the scarp morphologies and bringing additional constraints on past seafloor rupture history.

I.2 Objectives of Leg-3

Different seismic dataset gathered during previous scientific cruises in the Sea of Marmara were consulted to identify coring targets offering an access to interesting sediment deposit geometries. Three types of sites were selected:

- Eroded slops or fault wall offering an access to sediment horizons inferred to correspond to 100 kyr climatic cycles. Two sites were selected :
    - An eroded slope South of the Western High giving a possible access to a horizon inferred to be 530 kyr old according to indirect studies. (cores MRS-CS-23, MRS-CS-24, MRS-CS-25, MRS-CS-26)

    - The wall of the Imrali Fault in the Western Imrali basin giving an access to a horizon inferred to be 340 kyr old according to indirect studies. (MRS-CS-20, MRS-CS-21 and MRS-CS-27)

- Topographic highs on which a condensed sequence of the last glacial period can be recovered in one long core. Two cores were planned in order to retrieve the sequence North and South of the Marmara Fault:
    - In the Western High (MRS-CS-22)
    - In the eastern Imrali Basin (MRS-CS-18)
- Depocenters for a complete record of recent seismoturbidites in different basins. Two objectives were defined :
    - Kumburgaz Basin (MRS-CS-01 and MRS-CS-02 taken during Leg 1 and MRS-CS-14 taken during Leg 2)
    - Imrali Basin (MRS-CS-19)

Sub-bottom profiles were planned to precise the exact coordinates before coring and avoid possible gas-rich zone, especially close to topographic highs.

Leg 3 was also an opportunity for testing the geodetic beacon functioning. The beacons deployed during Leg 1 had to be interrogated and reprogrammed for long term recording.

Finally, the following instruments were planned for recovery during the MARsite Leg-3:

- 2 OLDOBS deployed during BOBEX Leg-1
- 1 BOB (bubble acoustic detector) deployed during BOBEX Leg-1
- 1 ANIITRA deployed during BOBEX Leg-1
- 3 broad-band OBSs of INGV
- 8 LOTOBSs of Ifremer
- 2 piezometers of Ifremer

I.3 Team

Scientific and technical staff:

Name	First name	Specialty	Position on board	Institution
Acar	Dursun	Core Tech	Coring team	ITU
Apa	Ramazan	Geophysics	Gravi - Mag	MTA
Atgin	Orhan	Geophysicits	seismic data base	DEU
Balci	Nürgul	Geochemistry		ITU
Barin	Burcu	Geophysics	coring team	
Batsi	Evangelia	Seismology	OBS data recovery (PhD)	IFREMER
Bignon	Laurent	Mechanic	BOB (acoustic bubble recorder)	IFREMER
Çifçi	Günay	Geophysicsit	Core site survey	DEU
Croguennec	Claire	Engineering	MSCL on cores	IFREMER
Danna	Giuseppe	Engineering	OBS data recovery	INGV
Dondurur	Derman	Geophysiscit	core site survey	DEU
Elbek	Sebnem	Sedimentology	Geology	ÇOMU
Eriş	Kadir	Sedimentology	Coring team	ITU
Géli	Louis	Seismology	Project Leader	IFREMER
Henry	Pierre	Geophysics	Chief scientist on Leg-3	CEREGE
Kayseri	Mine Sezgul	Sed/Pal	Coring team	DEU
Kende	Julia	Geophysics	3.5 kHz processing and coring site GIS (PhD)	CEREGE
McHugh	Cecilia	Sedimentology	Coring team	LDEO
Morvan	Laurence	Electronics	Multibeam	GENAVIR
Ogor	André	Technicien	Acoustic water column	IFREMER
Özaksoy	Volkan	Geology	Team Leader	MTA
Palas	Serak	Geology	coring team	MTA
Pehlivan	Hakan	Hydrogeologist	coring team	MTA
Pelleau	Pascal	Engineering	OBS data recovery	IFREMER
Piété	Helen	Géophysics	Geodesy	IUEM
Ponzevera	Emmanuel	Geochemistry	Fluid sampling on cores	IFREMER
Roubi	Angelique	Engineering	Core flow supervision	IFREMER
Royer	Jean-Yves	Geophysics	Geodesy	IUEM
Ruffine	Livio	Geochemistry	Fluid sampling on cores	IFREMER
Sağdıç	Nurbuke	Geology	Coring team (PhD candidate)	ITU
Scalabrin	Carla	Geophysics	Acoustic water column	IFREMER
Şengör	A. M. Celâl	Geodynamics	Co-chief on Leg-3	ITU
Speciale	Stefano	Seismology	OBS data recovery	INGV
Uçarkuş	Gülsen	Tectonics	Core siting	ITU
Yalamaz	Burak	Sedimentology	Coring team	ITU

Table 1 : Scientific and technical staff

II. Scheduled operations

Here are the planned operations as they were defined before the cruise. Part of this plan was updated before Leg 3 as some operations were done during the Leg 1 (two cores in the Kumburgaz basin).

Start	Duration (hours)	Description of operations
13/11/14 9:00	3	Exchange of personnel near Istanbul
13/11/14 12:00	5	Transit to E Imrali Basin, Sub-bottom Profiler (SBP) and Multibeam
13/11/14 17:00	6	Sediment Coring N40° 39.790' E28° 52.979' 280 m N40° 37.774' E28° 51.107' 365 m 2 long cores (24 m) and 1 interface core
13/11/14 23:00	3	Transit to W Imrali Basin, Sub-bottom Profiler (SBP) and Multibeam
14/11/14 2:00	8	Sediment Coring N40° 42.166' E28° 23.732' 289 m N40° 42.196' E28° 23.665' 277 m N40° 42.241' E28° 23.551' 269 m 3 long cores (24 m)
14/11/14 10:00	4	Transit to Western High, Sub-bottom Profiler (SBP) and Multibeam
14/11/14 14:00	17	Sediment Coring N40° 50.318' E27° 47.944' 551 m N40° 47.423' E27° 49.562' 960 m N40° 47.520' E27° 49.400' 930 m N40° 47.598' E27° 49.271' 917 m 4 long cores (30 m)
15/11/14 7:00	3	Instrument recovery: IFREMER Bubble OBservatory BOB N40° 48.780' E27° 46.037' IFREMER Long Term Ocean Bottom Seismometers MRS-LOTOBS-2 N40° 48.781' E27° 46.071' MRS-LOTOBS-1 N40° 48.777' E27° 46.080' IFREMER ADCP ANITRA3 N40° 48.775' E27° 46.103'
15/11/14 10:00	3	Instrument recovery: IFREMER Piezometers PZS N40° 48.783' E27° 46.306' PZN N40° 48.931' E27° 46.656' INGV Ocean Bottom Seismometers INGV-OBS1 N40° 48.787' E27° 46.496' INGV-OBS2 N40° 48.827' E27° 46.658'
15/11/14 13:00	10	Instrument recovery: IFREMER OBSs and 1 INGV OBS YUN_2014_02 N40° 48.917' E27° 46.614' YUN_2014_04 N40° 48.760' E27° 46.302' INGV OBS-3 N40° 47.707' E27° 50.344' YUN_2014_05 N40° 46.764' E27° 50.891' YUN_2014_03 N40° 42.775' E27° 47.224'

		YUN_2014_07 N40° 46.572' E27° 42.511' YUN_2014_09 N40° 49.186' E27° 36.304' YUN_2014_08 N40° 51.075' E27° 42.480' YUN_2014_01 N40° 55.006' E27° 45.862' YUN_2014_10 N40° 50.998' E27° 50.731' YUN_2014_06 N40° 49.886' E27° 56.820'
15/11/14 23:00	4	Sediment Coring N40° 48.366' E27° 47.984' 756 m 1 long core (30 m)
16/11/14 3:00	3	Transit to Kumburgaz Basin, Sub-bottom Profiler (SBP) and Multibeam
16/11/14 6:00	6	Interrogate acoustic ranging beacon deployed during Leg 1 and download data. F1 N40° 52.249' E28° 31.119' F2 N40° 52.093' E28° 31.414' F3 N40° 52.227' E28° 31.719' F4 N40° 52.086' E28° 30.795' G1 N40° 52.246' E28° 31.074' G2 N40° 52.096' E28° 31.354' G4 N40° 52.088' E28° 30.739' G3 N40° 52.243' E28° 31.664' G5 N40° 52.097' E28° 31.962' G6 N40° 52.289' E28° 31.315' Instruments stay on the bottom
16/11/14 12:00	4	Sediment Coring N40° 52.284' E28° 30.270' 834 m N40° 51.070' E28° 27.940' 819 m N40° 51.516' E28° 28.644' 820 m Interface cores
16/11/14 16:00	3	Transit to Istanbul
16/11/14 19:00		Arrival in Istanbul

Table 2 : Leg 3 scheduled operation

III. Chronology of the cruise

III.1 Timetable

Point references refer to Calypso Core (CS), Interface Core (II), geodetic beacon (F or G) and recovered instrument coordinates.

date	time (UTC)	Opération	point reference	Working Area
12/11	**8:00**	Leave Istanbul and transit to East Imrali basin, Sub-bottom profiler (SBP) and multibeam ON		
12/11	**9:08**	SBP Profile on CS18		**E Imrali**
12/11	**9:52**	End of profile, leave sounders ON		
12/11	**11:08**	Take 24 m calypso core (for ITU)	**CS18**	
12/11	**12:52**	SBP Profile		
12/11	**13:27**	End of profile, leave sounders ON		
12/11	**14:00**	Take ITU interface core (for ITU)	**II01**	
12/11	**15:25**	Take 24 m calypso core (for ITU)	**CS19**	
12/11	**16:50**	Transit to W Imrali basin with Sub-bottom profiler (SBP) and multibeam ON		
12/11		SBP Profile on coring site CS19		**W Imrali**
12/11	**18:18**	SBP profile E of Imrali canyon		
12/11		turn on request from coast guards		
12/11		SBP Profile on CS20 and CS 21		
12/11		End of profile, leave sounders ON		
12/11		SBP Profile (cross line on CS21)		
12/11		End of profile, leave sounders ON		
12/11	**21:02**	Take 24 m calypso core (for ITU)	**CS20**	
13/11	**0:05**	Take 24 m calypso core (for ITU)	**CS21**	
13/11	**3:48**	Sub-bottom profiler (SBP) ON		
13/11	**4:38**	SBP profile W of Imrali canyon		
13/11	**5:10**	end profile, return to coring site		
13/11	**5:52**	Transit to Western high with SBP and multibeam ON		
13/11	**9:05**	SBP profile on core sites CS23 to 26		**W High**
13/11		End of profile, leave sounders ON		
13/11		SBP profile on core CS22 site		

13/11		End of profile, leave sounders ON		
13/11	**10:08**	Take 24 m calypso core (for CEREGE)	**CS22**	
13/11	**12:21**	Recover IFREMER OBS	**YUN_2014_10**	
13/11	**12:49**	Attempt to recover IFREMER OBS	**YUN_2014_06**	
13/11	**16:02**	Recover IFREMER OBS	**YUN_2014_05**	
13/11	**17:11**	Recover INGV OBS	**INGV OBS-3**	
13/11	**18:41**	Recover INGV OBS	**INGV OBS-4**	
13/11	**19:39**	Recover IFREMER OBS	**YUN_2014_07**	
13/11	**21:00**	Take 12 m calypso core (for CEREGE)	**CS23**	
13/11	**23:08**	Take 12 m calypso core (for CEREGE)	**CS24**	
14/11	**2:11**	Take 12 m calypso core (for CEREGE)	**CS25**	
14/11	**4:55**	Take 24 m calypso core (for CEREGE)	**CS26**	
14/11	**6:52**	Mutibeam Reson 7150		
14/11	**7:13**	end of profile		
14/11	**8:10**	Recover BOB	**BOB 0**	
14/11	**8:42**	Recover IFREMER LOTOBS	**MRS-LOTOBS-1**	
14/11	**9:16**	Recover IFREMER LOTOBS	**MRS-LOTOBS-2**	
14/11	**9:46**	Recover ADCP	**ANITRA3**	
14/11	**10:20**	Recover IFREMER OBS	**YUN_2014_04**	
14/11	**11:01**	Recover IFREMER piezometer	**PZS**	
14/11	**12:05**	Recover INGV OBS	**INGV OBS-1**	
14/11	**12:50**	Recover IFREMER piezometer	**PZN**	
14/11	**13:21**	Recover IFREMER OBS	**YUN_2014_02**	
14/11	**15:15**	Recover IFREMER OBS	**YUN_2014_01**	
14/11	**16:33**	Recover IFREMER OBS	**YUN_2014_08**	
14/11	**19:06**	Attempt to recover IFREMER OBS	**YUN_2014_09**	
14/11	**20:35**	Recover IFREMER OBS	**YUN_2014_03**	
14/11		2nd Attempt to recover IFREMER OBS	**YUN_2014_06**	
15/11		Transit to W Imrali Basin		
15/11	**1:13**	Take 24 m calypso core (for ITU)	**CS27**	**W Imrali**
15/11	**2:20**	Transit to Kumburgaz Basin with multibeam and SBP ON		
15/11	**3:07**	SBP profile and RESON 7150		**Kumburgaz**

15/11	**3:38**	end profile		
15/11	**4:46**	SBP profile and RESON 7150		
15/11	**5:08**	end profile		
15/11	**5:23**	Interrogation of géodetic acoustic beacons, data download	**F1**	
15/11	**9:30**	Reprogramming of beacon G5, transit to coring site	**G5**	
15/11	**10:06**	Take interface core II02 (for ITU)	**CS01/II02**	
15/11	**11:27**	Take interface core II03 (for ITU)	**CS14/II03**	
15/11	**12:03**	Transit to W Imrali Basin with SBP and RESON 7150 ON		
15/11	**13:00**	SBP profile and RESON 7150		
15/11	**13:23**	End of profile, leave sounders ON		
15/11	**13:40**	SBP profile and RESON 7150		
15/11	**14:05**	End of profile, leave sounders ON		
15/11	**19:30**	Transit to Istanbul	**IST**	

Table 3 : Leg 3 Timetable

III.2 Overall acquisition

III.2.1 Cores

Core	Lon	Lat	Zone	Water depth (m)	Tube length (m)	Recovery (m)	Repository
MRS-CS18	28,87958	40,66206	E Imrali N slope	291	24,5	14,25	**ITÜ**
MRS-CS19	28,85178	40,62956	E Imrali depocenter	365	24,5	22,64	**ITÜ**
MRS-CS20	28,39274	40,70388	W Imrali fault scarp	289	24,5	18,9	**ITÜ**
MRS-CS21	28,39526	40,70284	W Imrali fault scarp	277	24,5	8,88	**ITÜ**
MRS-CS22	27,79906	40,83863	N Western High summit	551	23,4	20,42	**CEREGE**
MRS-CS23	27,82166	40,79283	S Western High slope	920	11,9	10,32	**CEREGE**
MRS-CS24	27,82590	40,79033	S Western High slope	953	11,9	8,9	**CEREGE**
MRS-CS25	27,82297	40,79206	S Western High slope	929	11,9	10,65	**CEREGE**
MRS-CS26	27,82401	40,79144	S Western High slope	933	23,4	17,59	**CEREGE**
MRS-CS27	28,40088	40,70049	W Imrali fault scarp base	313	23,4	20,65	**ITÜ**
MRS-II02	28,50450	40,87140	Kumburgaz (CS01)	834		1,14	**ITÜ**
MRS-II03	28,47740	40,85860	Kumburgaz (CS14)	820		0,95	**ITÜ**

Table 4 : Leg 3 Calypso cores and Interface cores

Three more Calypso cores and one interface core, initially scheduled for Leg 3, were retrieved during Leg 1 and 2 due to the ROV cable damage, during the cable repairing:

Core	Lon	Lat	Zone	Water depth (m)	Tube length (m)	Recovery (m)	Repository
MRS-CS01	28,50362	40,87140	Kumburgaz N depocenter	834	23,35	21,05	**ITÜ**
MRS-CS02	28,46567	40,85116	Kumburgaz W depocenter	819	23,35	13,55	**ITÜ**
MRS-CS14	28,47740	40,85860	Kumburgaz center	820		20.95	**ITÜ**
MRS-II01	28,85178	40,62956	E Imrali depocenter (CS19)	365	1,22	0,89	**ITÜ**

Table 5 : Leg 1 and 2 Calypso cores and Interface core retrieved for Leg 3 objectives

III.2.2 Sub-Bottom profiles (3.5 kHz seismic profiles)

The map bellow presents the complete set of Sub-Bottom profiles retrieved during the Marsite Leg 3.

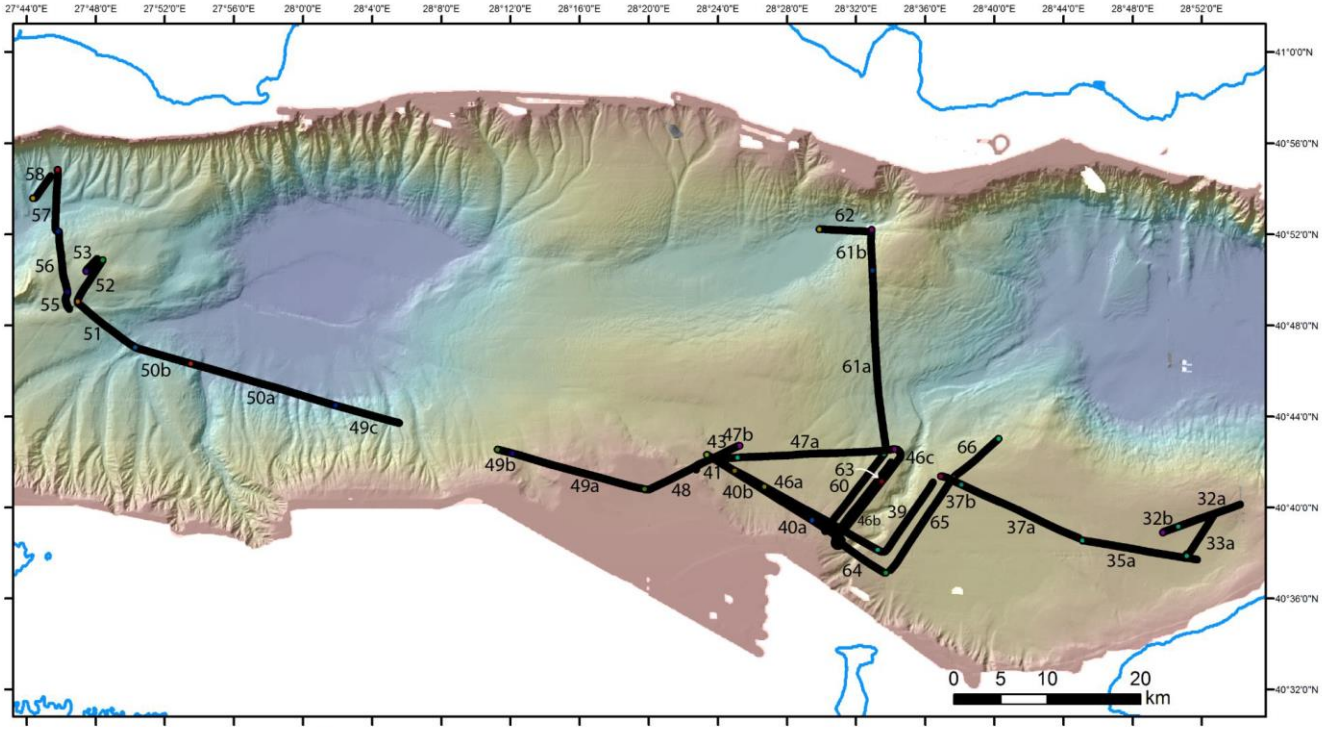


Figure 1 : Map of the overall 3.5 kHz sub bottom profile acquisitions

A table summarizing the Sub-Bottom profiles starting and ending coordinates is presented in APPENDIX 1 while profiles representations are in APPENDIX 2.

IV Calypso Cores and Interface Cores

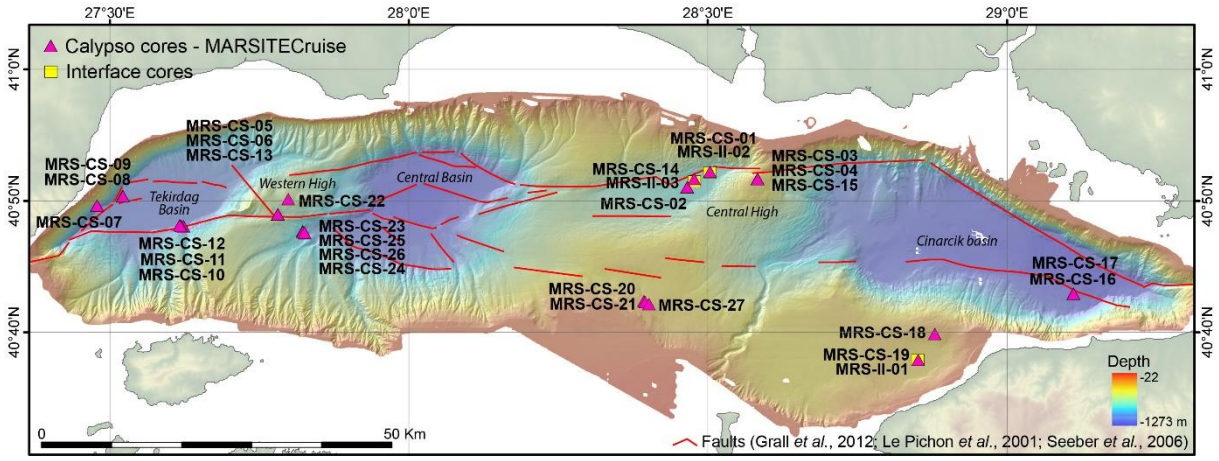
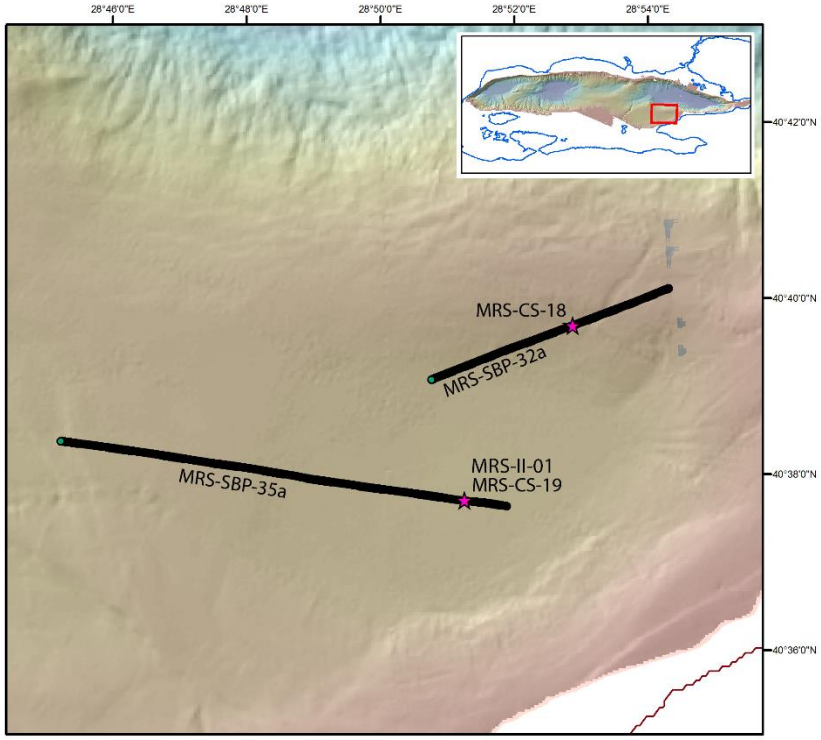


Figure 2 : Map of the overall cores retrieved during MARsite cruise (Cores MRS-CS-19 to MRS-CS-27 and MRS-II-02 and MRS-II-03 were taken during Leg 3)

IV.1 East Imrali



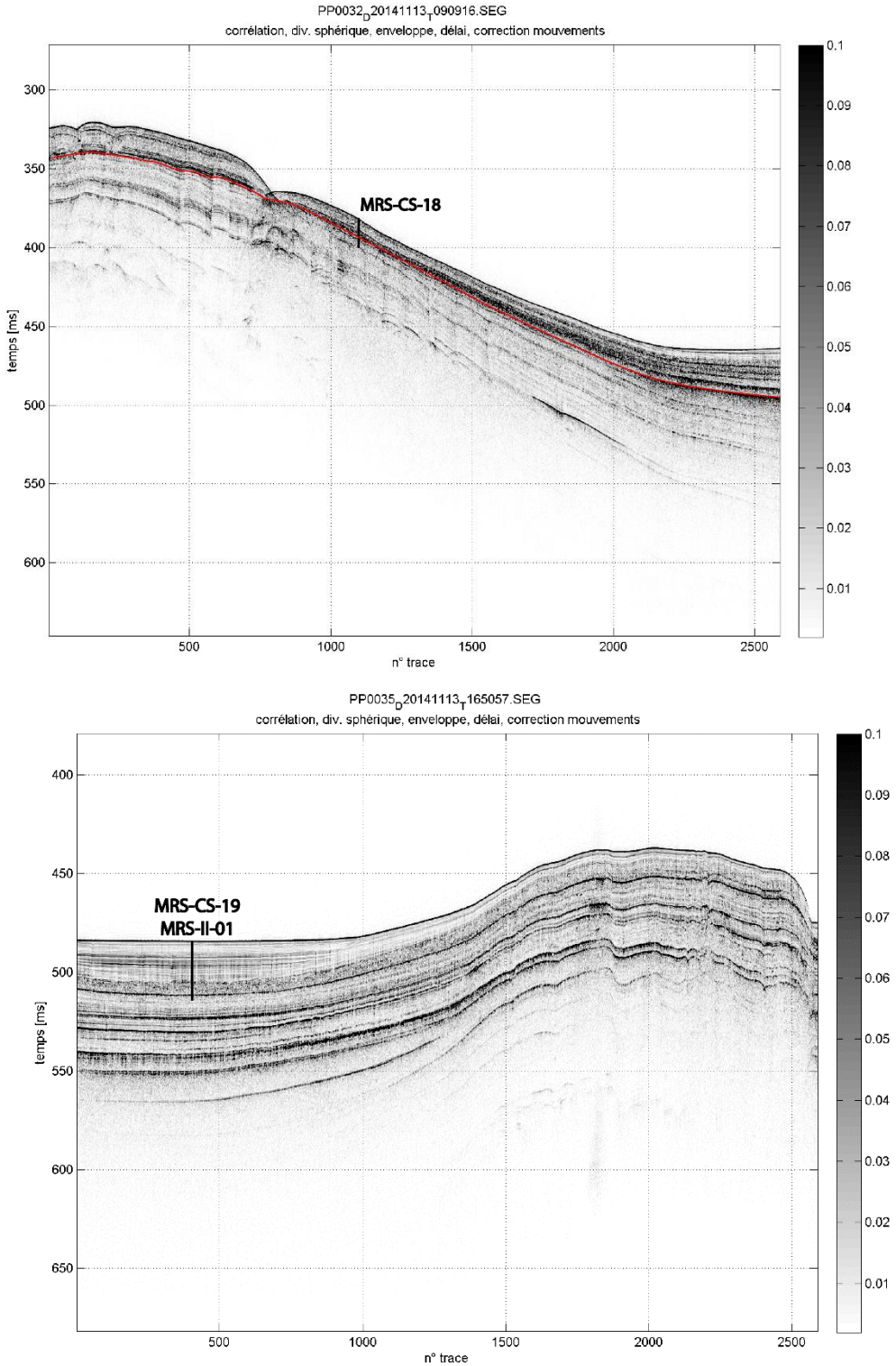


Figure 3 : Sub-bottom (Chirp) profile MRS-SBP32a & MRS-SBP35A shot In the eastern Imrali Basin along with indications on the location of Cores MRS-CS-18 & MRS-CS-19.

The eastern Imrali basin cores were taken on two sites offering very different configurations. The MRS-CS-18 is a very condensed section hopefully complete and reaching further than the Red reflector expected to correspond to 105 kyr. The MRS-CS-19 is centered on the depocenter and should contain a good recording of the last seismoturbidites in the Imrali Basin.

The MRS-II-01 Interface Core was taken at the same location as the MRS-CS-19 to complete the sediment record with intact superficial deposits.

IV.2 West Imrali

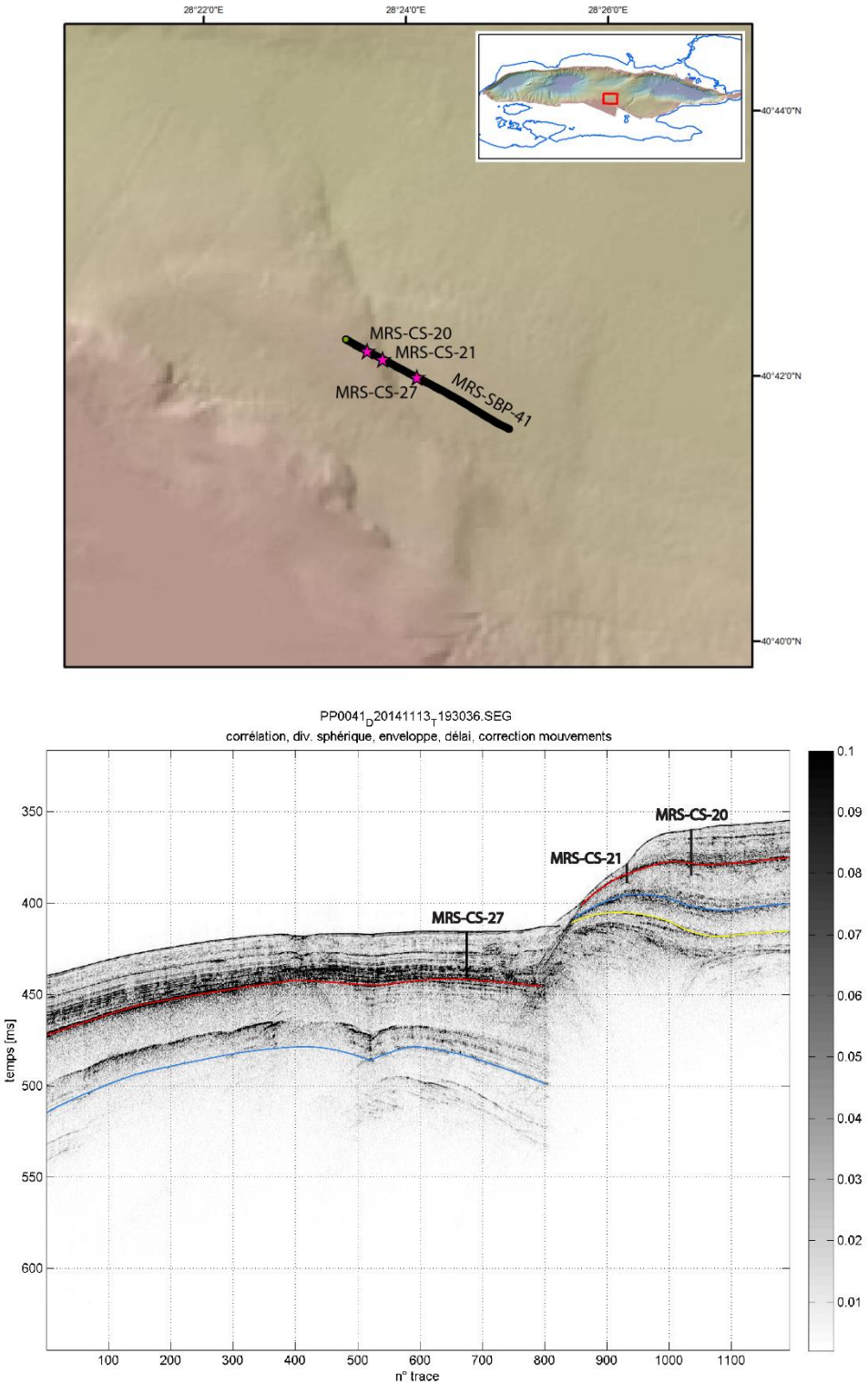
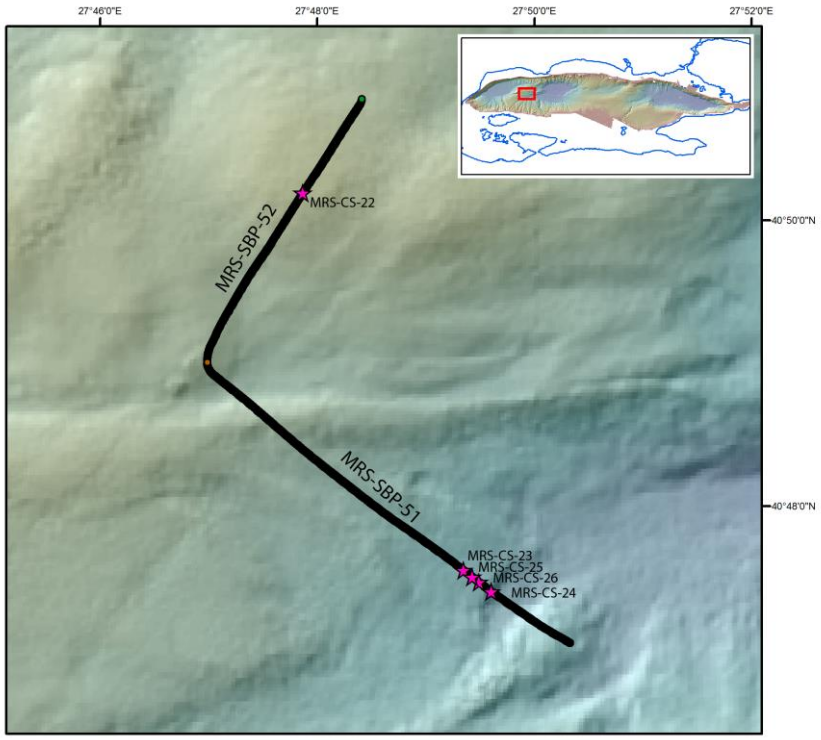
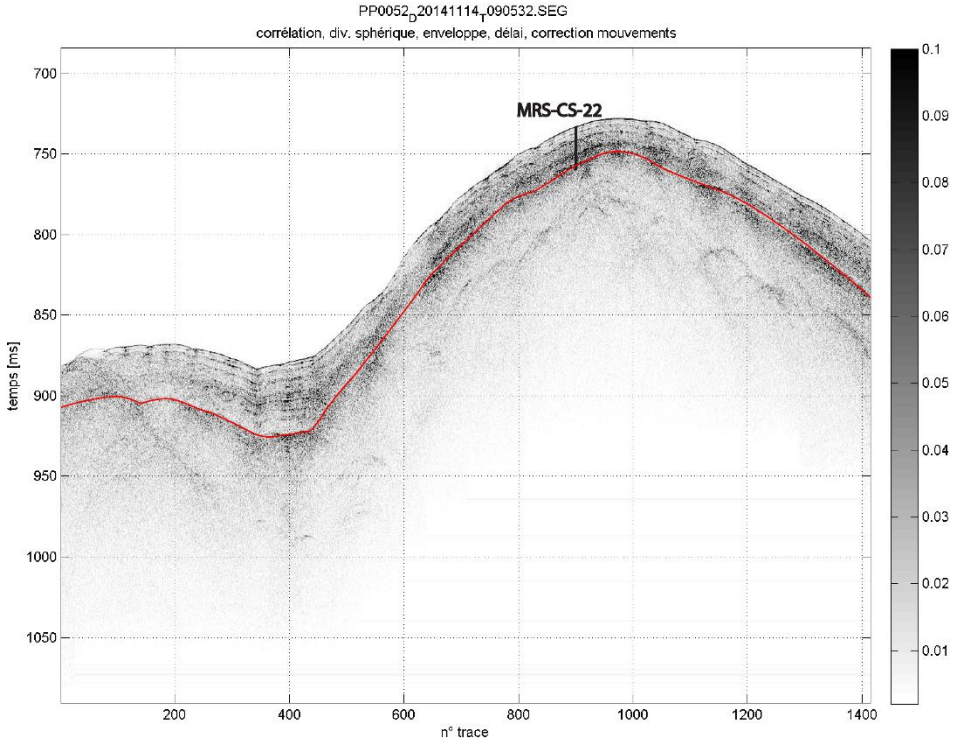


Figure 4 : Sub-bottom (Chirp) profile MRS-SBP41 shot, along with indications on the location of Cores MRS-CS-20, MRS-CS-21 & MRS-CS-27

The western Imrali targets were expected as the best ones for reaching deep reflectors. Unfortunately, when trying to go through the Blue reflector, the core bent. Nevertheless, good records of sediment deposits were obtained on both side of the Imrali fault, going further than the Red reflector expected to correspond to about 105 kyr

VI.3 Western High





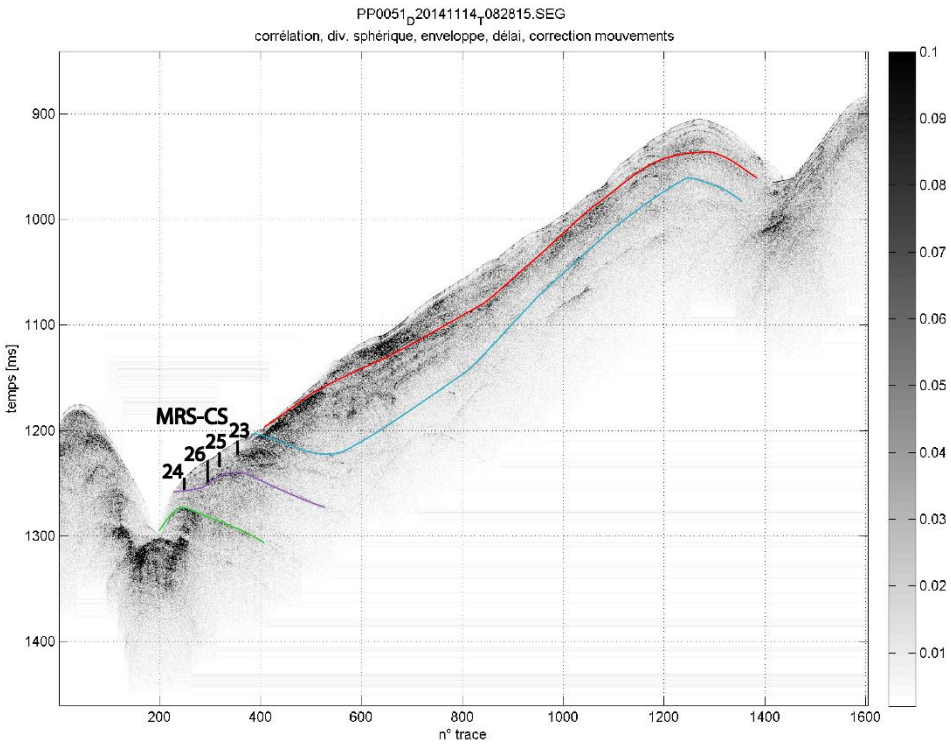


Figure 5 : Sub-bottom (Chirp) profile MRS-SBP32a & MRS-SBP35a shot In the Western High along with indications on the location of Cores MRS-CS-18 & MRS-CS-19

The Western High offered both a topographic high for a condensed record of the last glacial cycle and an eroded slope with deep reflectors close to the surface.

Four cores were retrieved on the slope expecting that, despite possible landslides, a complete sequence can be obtained with over-lapping cores, reaching as far as the violet reflector estimated to correspond to 340 kyr. First analyzes of the core catcher sediments seem to confirm that hypothesis.

IV.4 Kumburgaz Basin

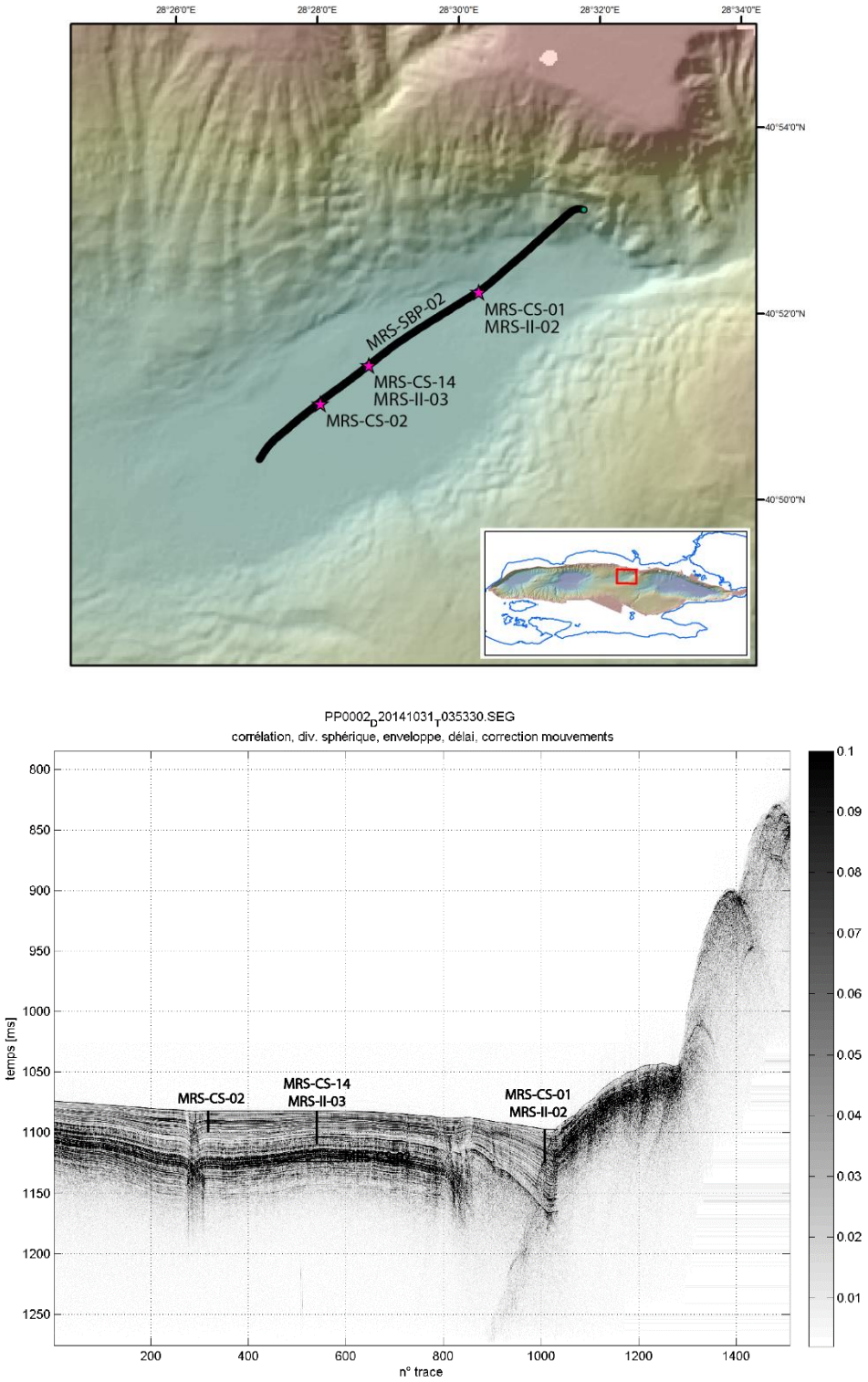


Figure 6 : Sub-bottom (Chirp) profile MRS-SBP02 shot In the Kumburgaz Basin along with indications on the location of Cores MRS-CS-01, MR-CS02, MRS-CS-14.

The cores in the Kumburgaz basin were retrieved during Leg 1 and 2 but are part of the third Leg seismoturbidite chronology objectives.

The MRS-II-02 and MRS-II-03 Interface Cores were taken at the same location as the MRS-CS-01 and MRS-CS-14 to complete the sediment records with intact superficial deposits.

V. Instrument interrogation and recovery operations

VI.1 Geodetic beacon interrogation

Using an acoustic modems, the Ifremer and Geomar geodetic beacon networks installed during the Leg 1 were interrogated to test their functioning and retrieve the first recorded data. The test was successful and the beacon were reprogrammed to widen the recording time step for long-term running.

VI.2 Instrument recovery operations

The instruments that were deployed during Leg 1 for the BOBEX experiment were recovered a the end of Leg 3:

- 2 OLDOBS
- 1 BOB (bubble acoustic detector)
- 1 ANIITRA mooring equipped with an ADCP for measuring sea-bottom currents in the water column.

In addition, the following instruments were recovered during MarsiteCruise, Leg 3 :

- 3 broad-band OBSs of INGV. 4 OBS were deployed in October 2013 with R/V Urania; 1 out of 4 popped up to the surface in june 2014 and was recovered by a fisherman. This OBS was then uploaded onboard R/V Pourquoi pas ? and shipped back to Toulon.
- 8 LOTOBSs of Ifremer. 10 LOTOBSs were deployed with R/V Yunuz in September 2014; LOTOBS3 and LOTOBS6 were not recovered by R/V Pourquoi pas?, likely due to technical failures in the release system. LOTOBS6 was eventually found floating at the surface by a fisherman.
- 2 piezometers of Ifremer. These two piezometers were deployed with R/V Urania in October 2013.

Operation	Instrument ID	N	Lat	E	Lon	date	time (UTC)	Observations
Recover IFREMER OBS	YUN_2014_10	40°	50,998'	27°	50,731'	14/11	12:21	
Attempt to recover IFREMER OBS	YUN_2014_06	40°	49,886'	27°	56,820'	14/11	12:49	No release after 3 trials
Recover IFREMER OBS	YUN_2014_05	40°	46,764'	27°	50,891'	14/11	16:02	
Recover INGV OBS	INGV OBS-3	40°	47,707'	27°	50,344'	14/11	17:11	
Recover INGV OBS	INGV OBS-4	40°	47,812'	27°	44,536'	14/11	18:41	
Recover IFREMER OBS	YUN_2014_07	40°	46,572'	27°	42,511'	14/11	19:39	
Recover BOB	BOB 0	40°	48,780'	27°	46,037'	15/11	8:10	on board
Recover IFREMER LOTOBS	MRS-LOTOBS-1	40°	48,777'	27°	46,080'	15/11	8:42	on board
Recover IFREMER LOTOBS	MRS-LOTOBS-2	40°	48,781'	27°	46,071'	15/11	9:16	no dog
Recover ADCP	ANITRA3	40°	48,775'	27°	46,103'	15/11	9:46	on board
Recover IFREMER OBS	YUN_2014_04	40°	48,760'	27°	46,302'	15/11	10:20	on board
Recover IFREMER piezometer	PZS	40°	48,783'	27°	46,306'	15/11	11:01	on board

Operation	Instrument ID	N	Lat	E	Lon	date	time (UTC)	Observations
Recover INGV OBS	INGV OBS-1	40°	48,787'	27°	46,496'	15/11	12:05	on board
Recover IFREMER piezometer	PZN	40°	48,931'	27°	46,656'	15/11	12:50	on board
Recover IFREMER OBS	YUN_2014_02	40°	48,917'	27°	46,614'	15/11	13:21	on board
Recover IFREMER OBS	YUN_2014_01	40°	55,006'	27°	45,862'	15/11	15:15	on board
Recover IFREMER OBS	YUN_2014_08	40°	51,075'	27°	42,480'	15/11	16:33	on board
Attempt to recover IFREMER OBS	YUN_2014_09	40°	49,186'	27°	36,304'	15/11	19:06	No release after 3 trials
Recover IFREMER OBS	YUN_2014_03	40°	42,775'	27°	47,224'	15/11	20:35	on board
2nd Attempt to recover IFREMER OBS	YUN_2014_06	40°	49,886'	27°	56,820'	15/11		No release after 3 trials. LOTOBS YUN_2014_06 was eventually found 15 days after the cruise by a fisherman

Table 6 : List of operations related to instrument recovery during Leg 3

VI. Gravity data

The N/O Pourquoi Pas ? is equipped with a Bodenseewerk KSS 31 installed on a stabilized platform at the ship steadiest spot. Taking advantage of this possibility, the ship gravity data were retrieved after the campaign as well as satellite data (Sandwell et al., 2013) available on the Scripps Institution of Oceanography website. As these gravity measurement are not absolute, the mean values of the ship data and of the satellite data along the ship pathway were even up. The two datasets were merged, using the ship data within 1700 m of the ship path and satellite data further than 4200 m. The resulting gaps were filled with a biharmonic spline interpolation.

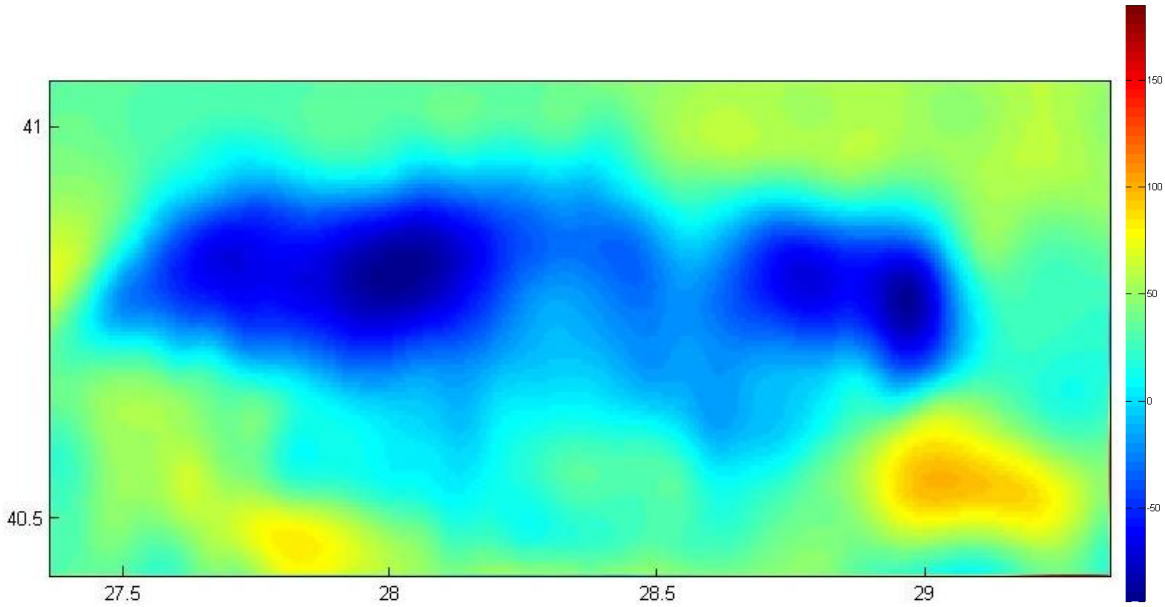


Figure 7 : Satellite gravity data in the Sea of Marmara

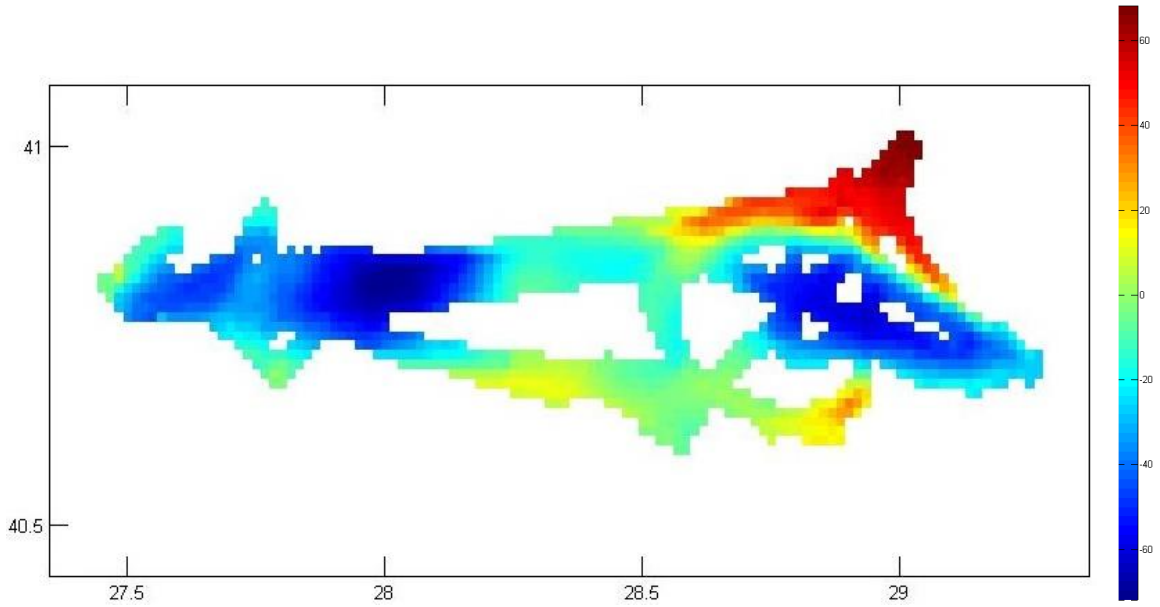


Figure 8 : Gravity data in the Sea of Marmara retrieved during the mission and extrapolated on a 1400 m wide corridor around the ship path

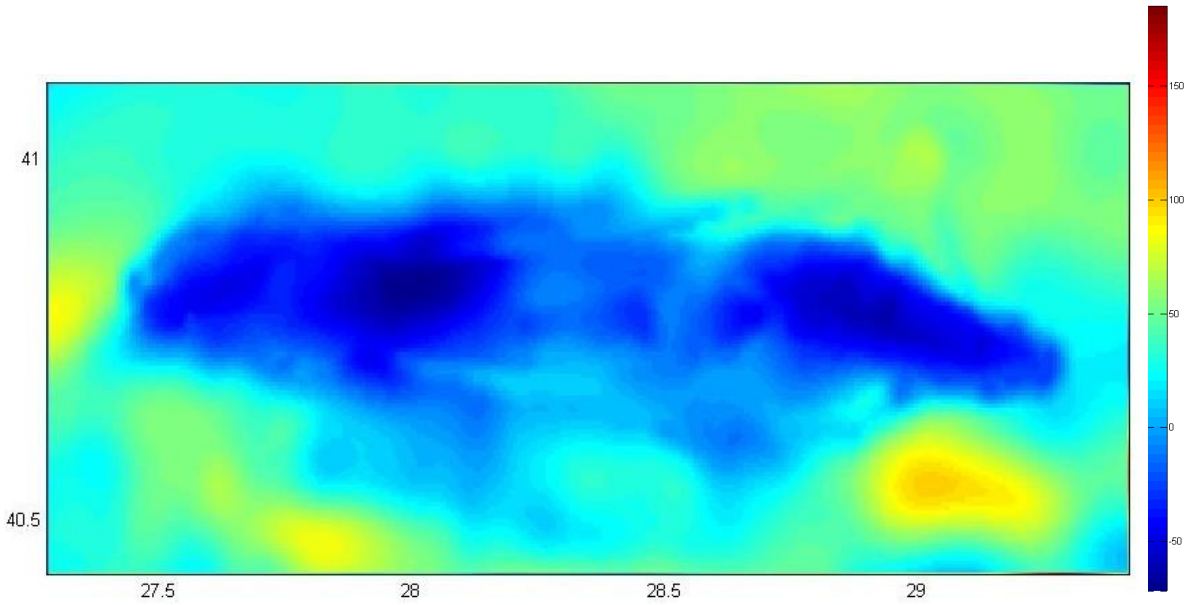


Figure 9 : Gravity data in the Sea of Marmara with merged satellite and ship data

Merging this two dataset gives a refine gravity map in part of the Marmara Sea, as satellite data present a resolution of only about 2 km^2 (Sandwell et al., 2013). It also corrects an anomaly in the eastern part of the Sea of Marmara but highlights the possible existence of such anomalies elsewhere.

VII. Structures near the Imrali Canyon

During the MARsite Leg 3, five 3,5 kHz sub-bottom parallel profiles were taken along the Imrali Canyon. The purpose was to identify folds along the canyon, responsible for its meanders. If negligible folds are indeed present around the canyon, only normal faults consistent with the Marmara Fault system were clearly identified. Two are visible in the western part of the canyon and one in the eastern part.

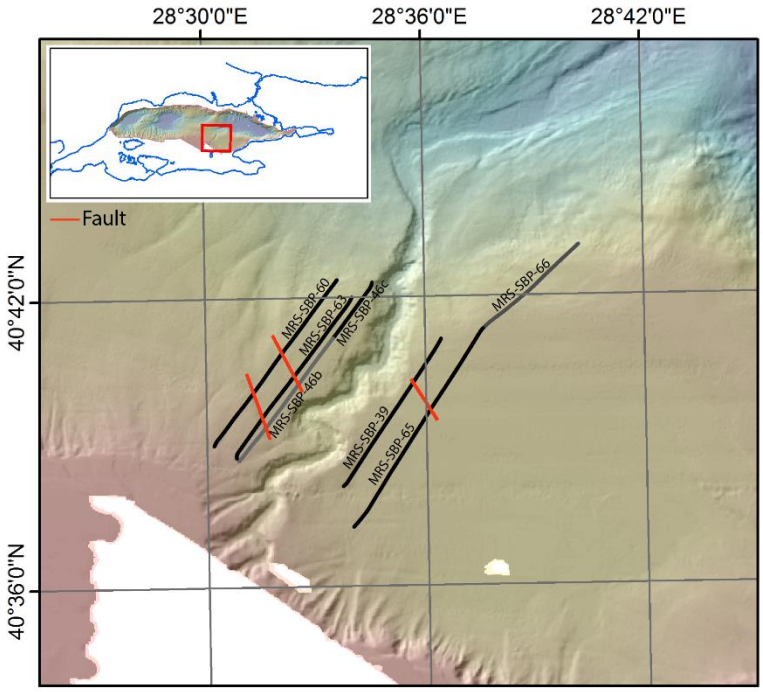


Figure 10 : map of the main Sub-Bottom profile around the Imrali Canyon and identified faults

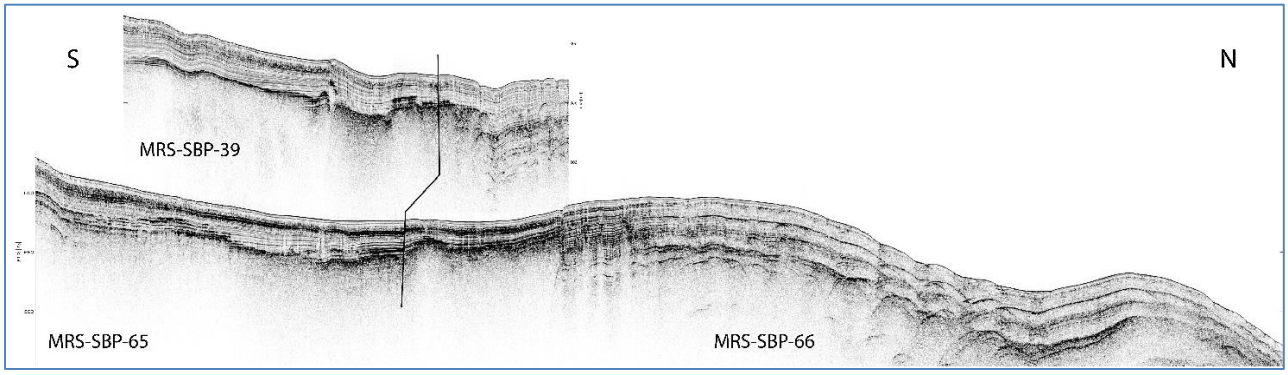


Figure 11 : Sub-bottom profiles along the eastern side of the Imrali Canyon

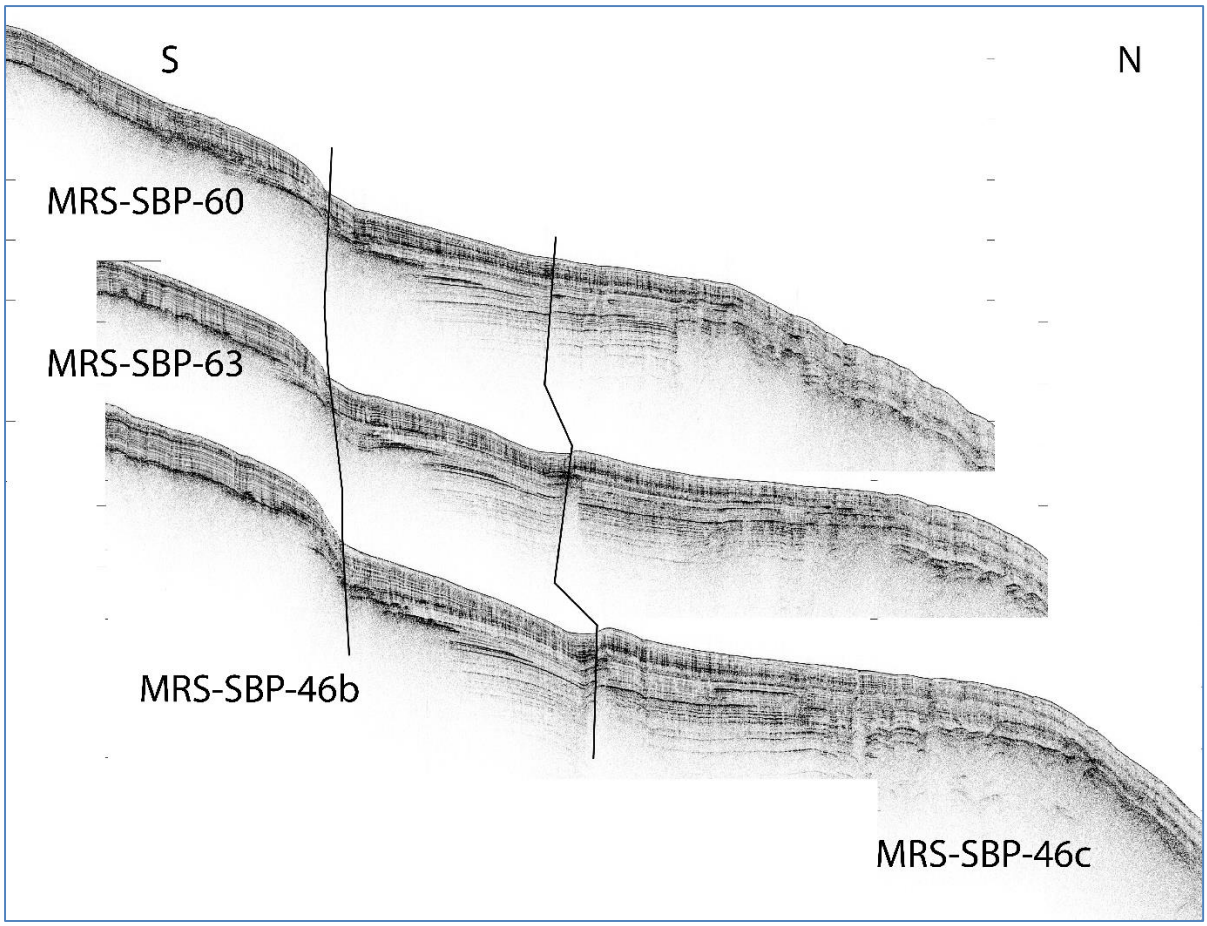


Figure 12 : Sub-bottom profiles along the Western side of the Imrali Canyon

VIII. Conclusion

The Leg 3 objectives were successfully met during the mission.
Sediment cores were acquired, both for stratigraphic and paleoseismic studies, thegeodetic beacons were interrogated and reprogrammed and most of the equipment planned for recovery was successfully fetched. The campaign was also an opportunity for recording new Sub-Bottom profiles. Profiles were systematically made at the coring target positions and a dataset of parallel profiles was acquired on either side of the Imrali Canyon to study geological structures. The only setback was the failure, due to the core bending, when trying to reach deep reflectors in the western part of the Imrali basin.
In depth study of the retrieved cores is planned, both in France and Turkey, including analyse of gamma ray, anisotropic magnetic susceptibility, P-wave, grain size, TOC-TIC, isotopic dating, micropaleontology…
As the ship instruments were constantly recording a wide set of measurement, other data from the MARsite mission may be used in a near future. We showed here how the gravity data from the ship may improve the available satellite data. Another example is the micro bathymetry recorded by the RESON 7150 that could be used to help identifying structures around the Imrali Canyon.

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APPENDIX 1 – Sub-Bottom profile starting and ending coordinates

Profile name	START		END	
	Lat	Lon	Lat	Lon
MRS-SBP-32a	40.6688972	28.9036111	40.6525972	28.8441167
MRS-SBP-32b	40.6525917	28.8440917	40.6480472	28.8288167
MRS-SBP-33	40.6600722	28.8774833	40.6310444	28.8520611
MRS-SBP-35	40.6283000	28.8621833	40.6423833	28.7514083
MRS-SBP-37a	40.6439306	28.7481639	40.6835639	28.6349389
MRS-SBP-37b	40.6835806	28.6348944	40.6896889	28.6149806
MRS-SBP-39	40.6851694	28.6073861	40.6354694	28.5541667
MRS-SBP-40a	40.6355722	28.5539056	40.6819083	28.4447639
MRS-SBP-40b	40.6819583	28.4446417	40.6937694	28.4160639
MRS-SBP-41	40.6938361	28.4158917	40.7054333	28.3892139
MRS-SBP-43	40.6945639	28.3791444	40.7120056	28.4207972
MRS-SBP-46a	40.7030444	28.3957389	40.6572806	28.4906583
MRS-SBP-46b	40.6572583	28.4907028	40.6859167	28.5581611
MRS-SBP-46c	40.6859472	28.5581889	40.7095167	28.5705583
MRS-SBP-47a	40.7095167	28.5702389	40.7033056	28.4189194
MRS-SBP-47b	40.7033028	28.4188639	40.7020639	28.3933056
MRS-SBP-48	40.7020306	28.3930556	40.6802667	28.3292306
MRS-SBP-49a	40.6803222	28.3289556	40.7065444	28.2019278
MRS-SBP-49b	40.7065556	28.2018806	40.7093167	28.1875722
MRS-SBP-49c	40.7286639	28.0927472	40.7413972	28.0314389
MRS-SBP-50a	40.7415472	28.0307417	40.7721861	27.8918944
MRS-SBP-50b	40.7722056	27.8918000	40.7840722	27.8383028
MRS-SBP-51	40.7842417	27.8379083	40.8173694	27.7826139
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MRS-SBP-53	40.8487778	27.8013944	40.8394750	27.7908056
MRS-SBP-55	40.8119556	27.7746833	40.8245361	27.7727972
MRS-SBP-56	40.8253444	27.7726500	40.8687611	27.7640833
MRS-SBP-57	40.8689083	27.7624889	40.9138194	27.7635389
MRS-SBP-58	40.9091000	27.7566861	40.8928167	27.7394667
MRS-SBP-59	40.8904056	27.7330889	40.8495528	27.7058222
MRS-SBP-60	40.6490806	28.5033278	40.7060583	28.5603806
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MRS-SBP-61b	40.8401500	28.5492139	40.8700500	28.5483194
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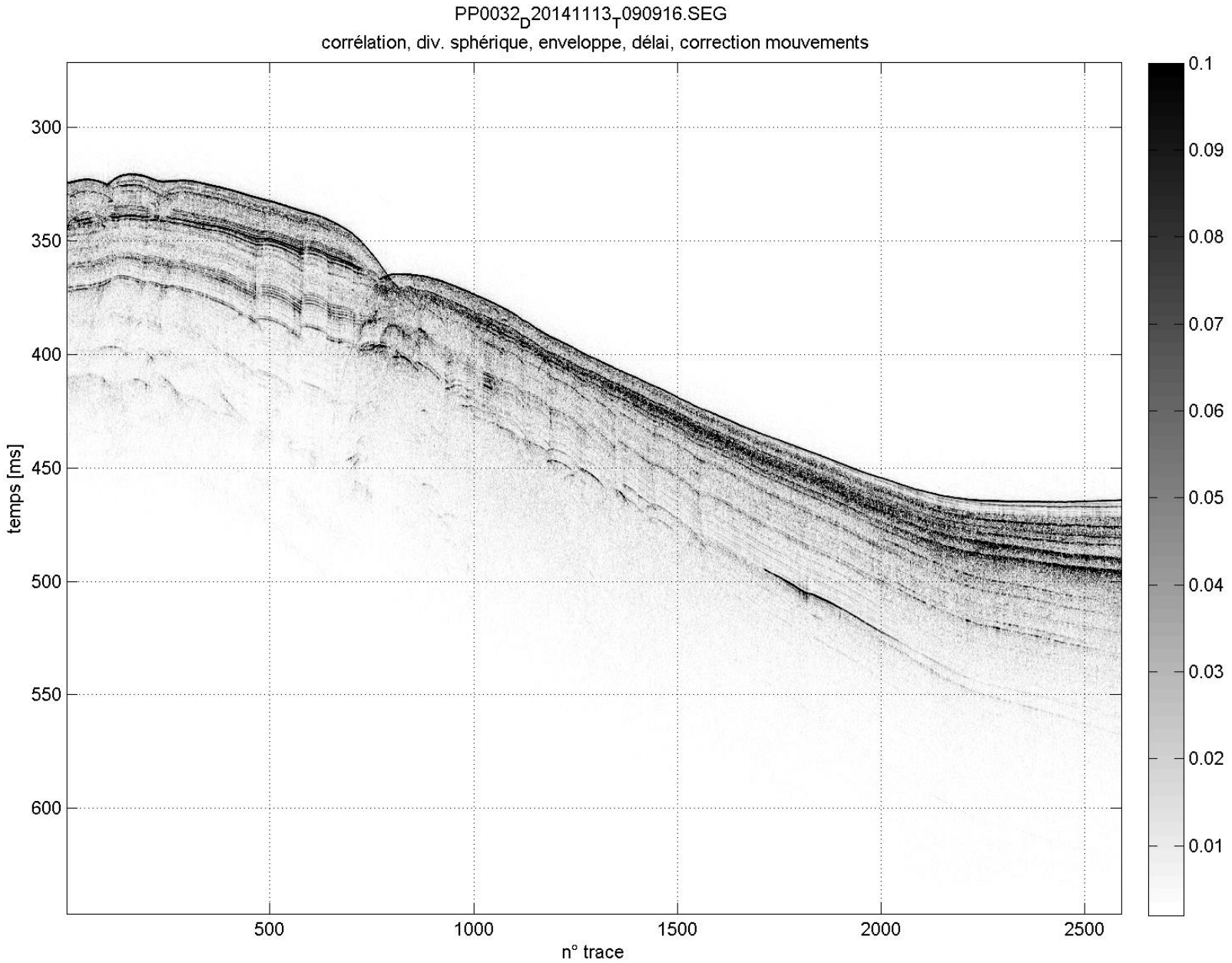
APPENDIX 2 - Sub-bottom profile images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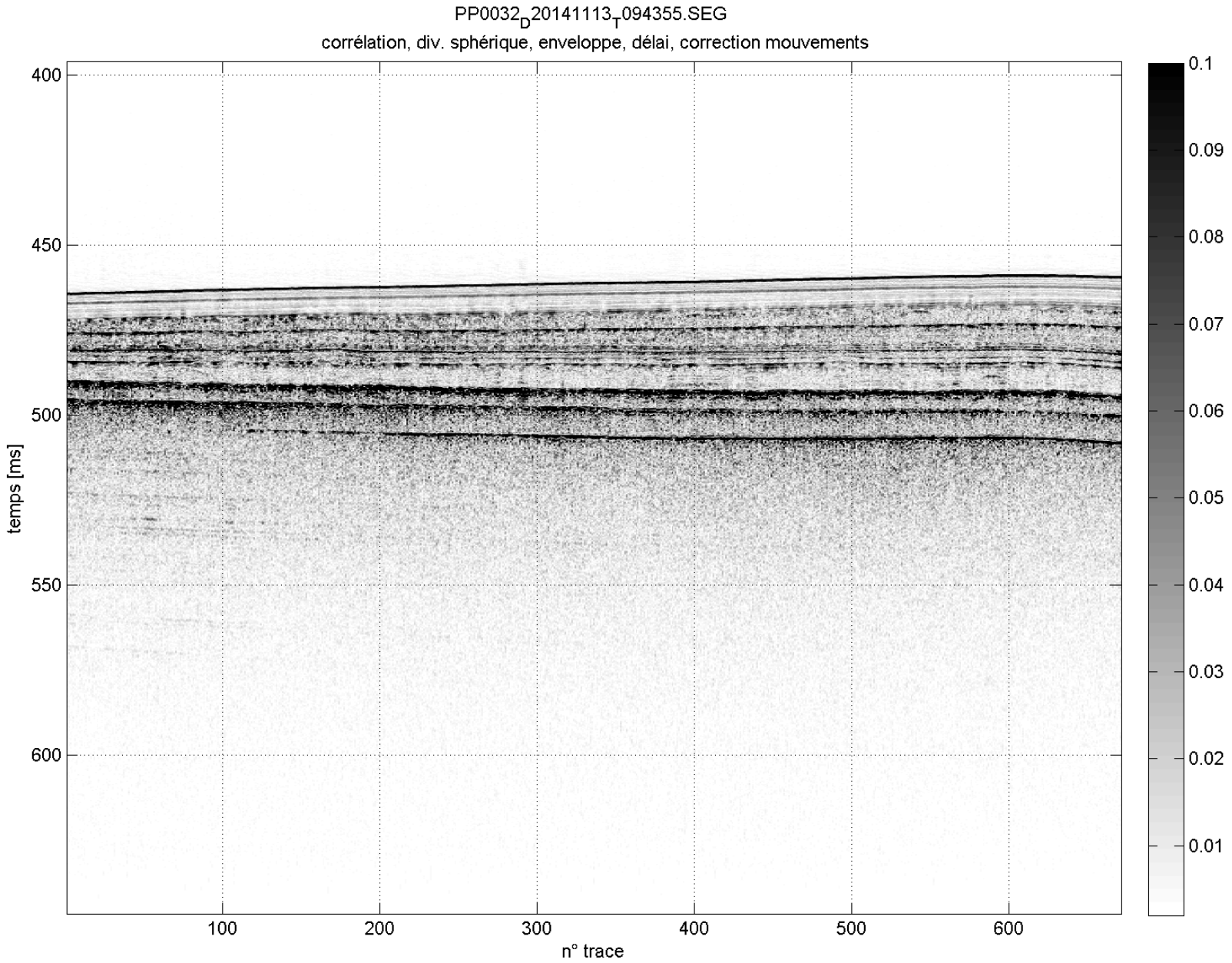
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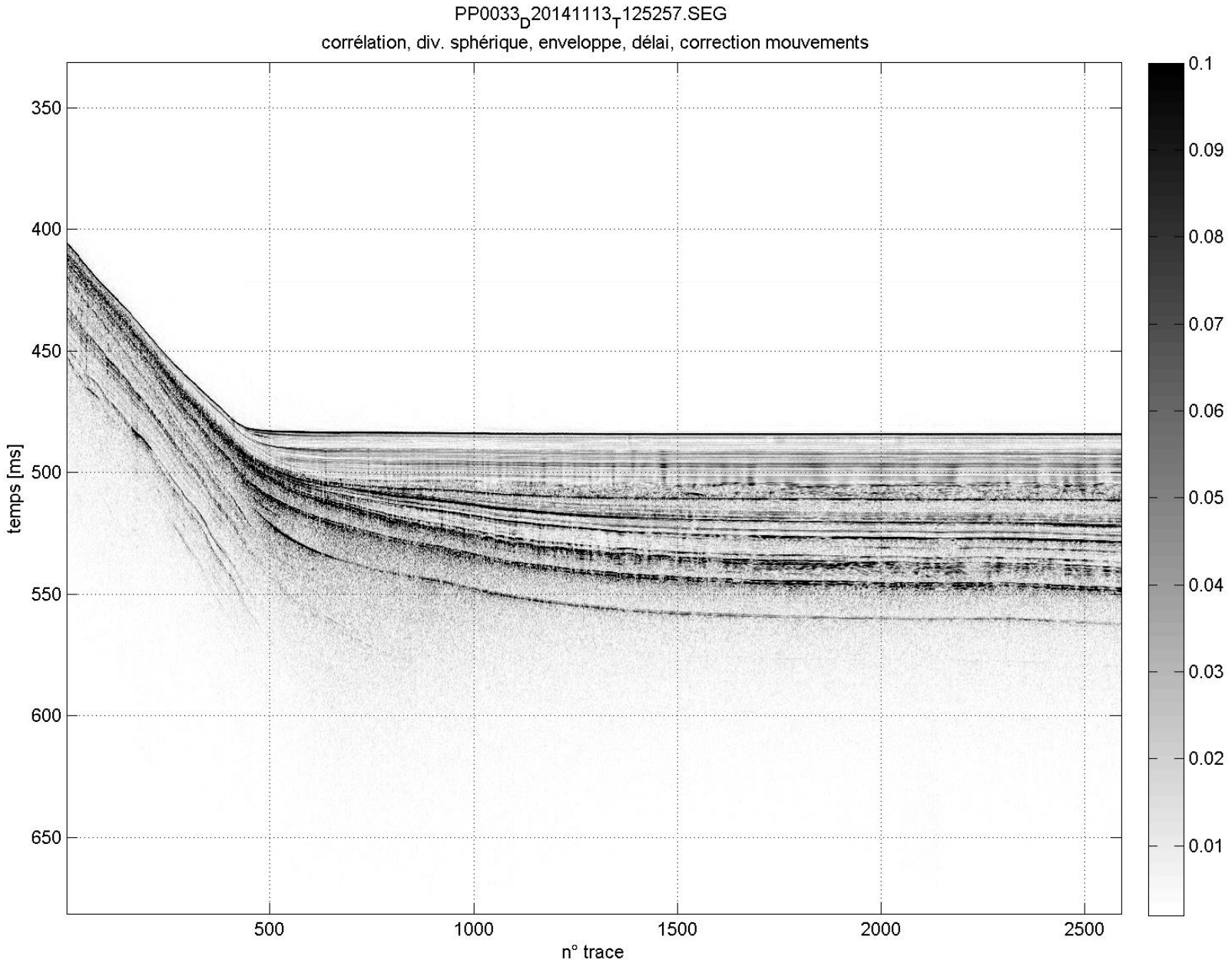
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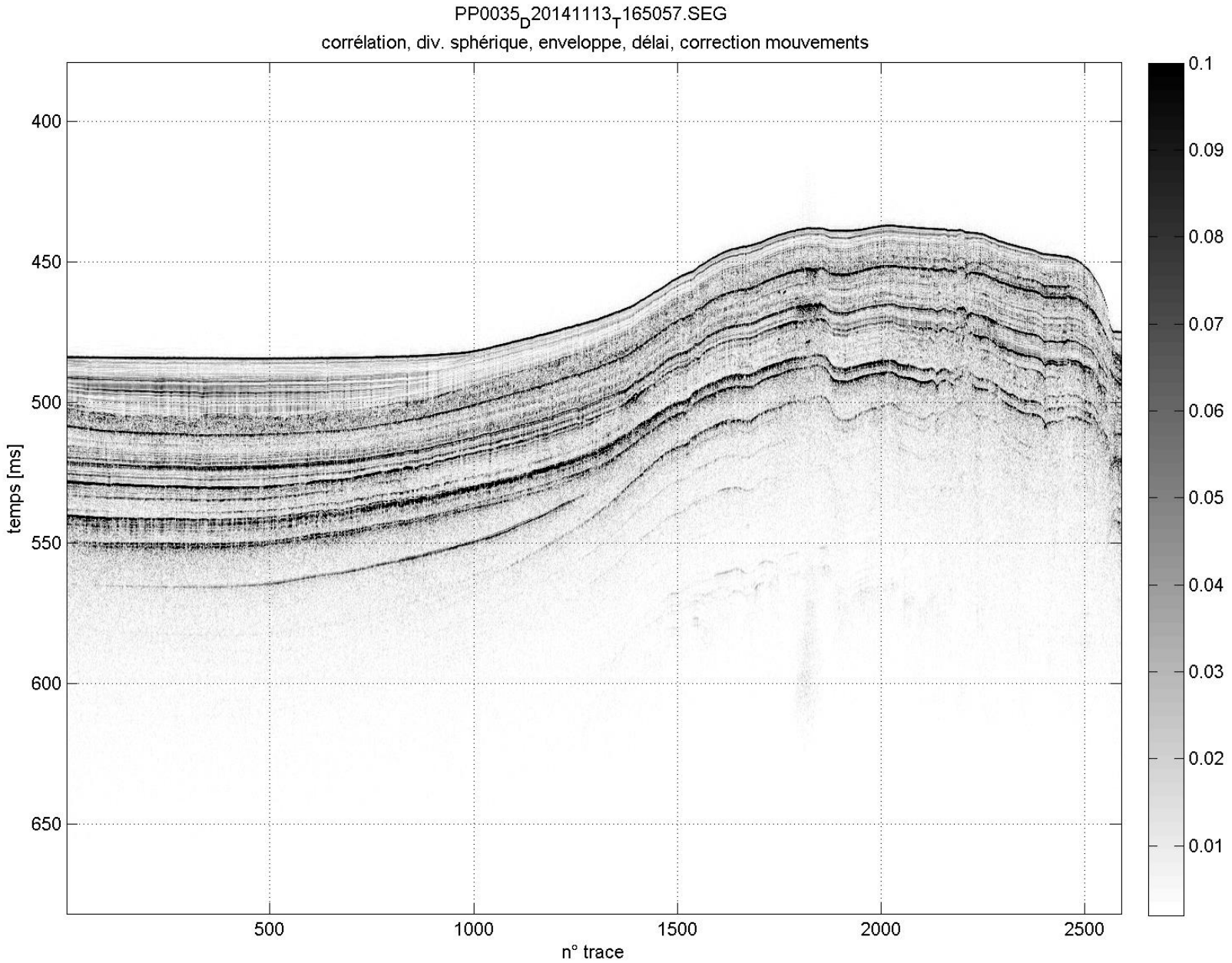
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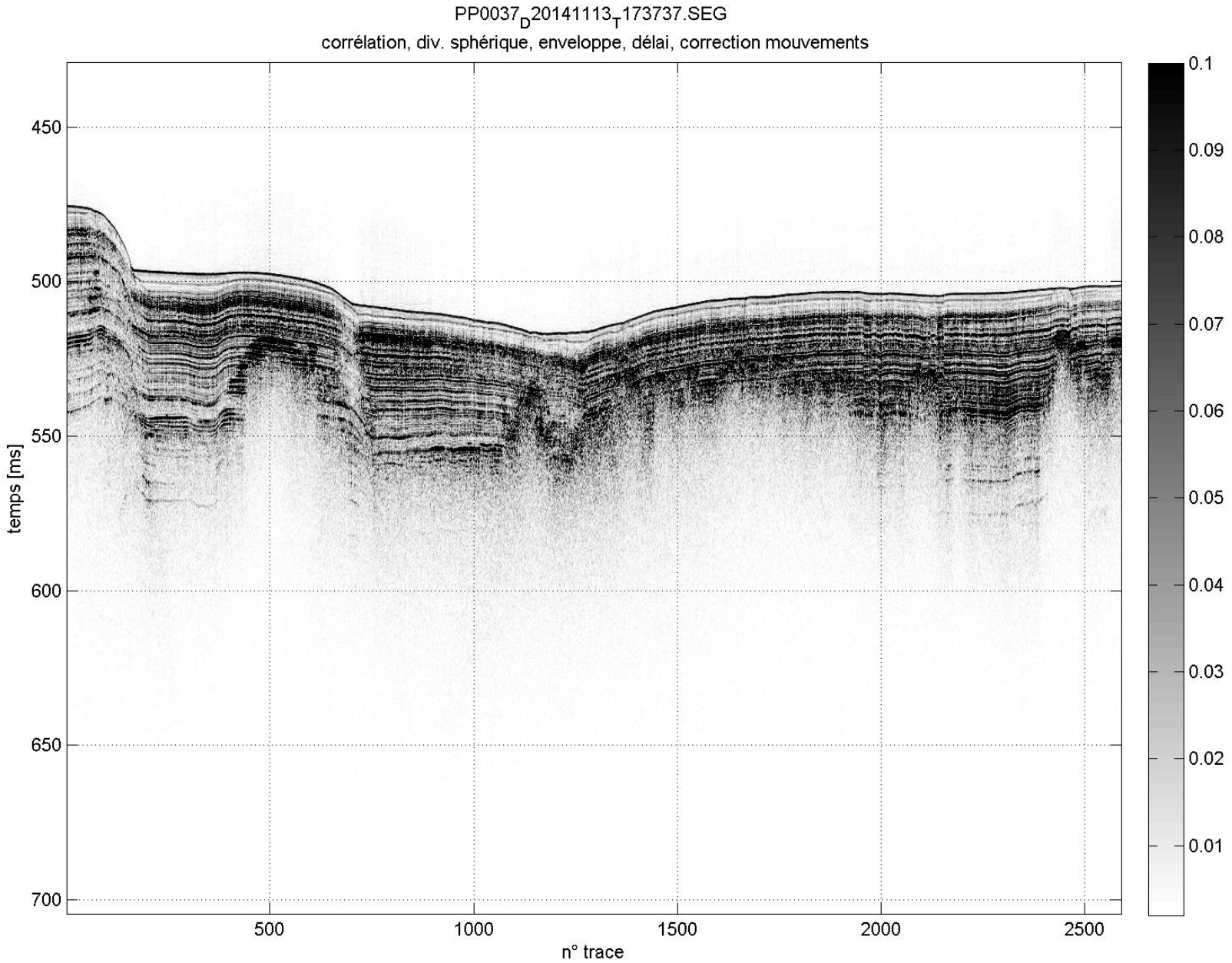
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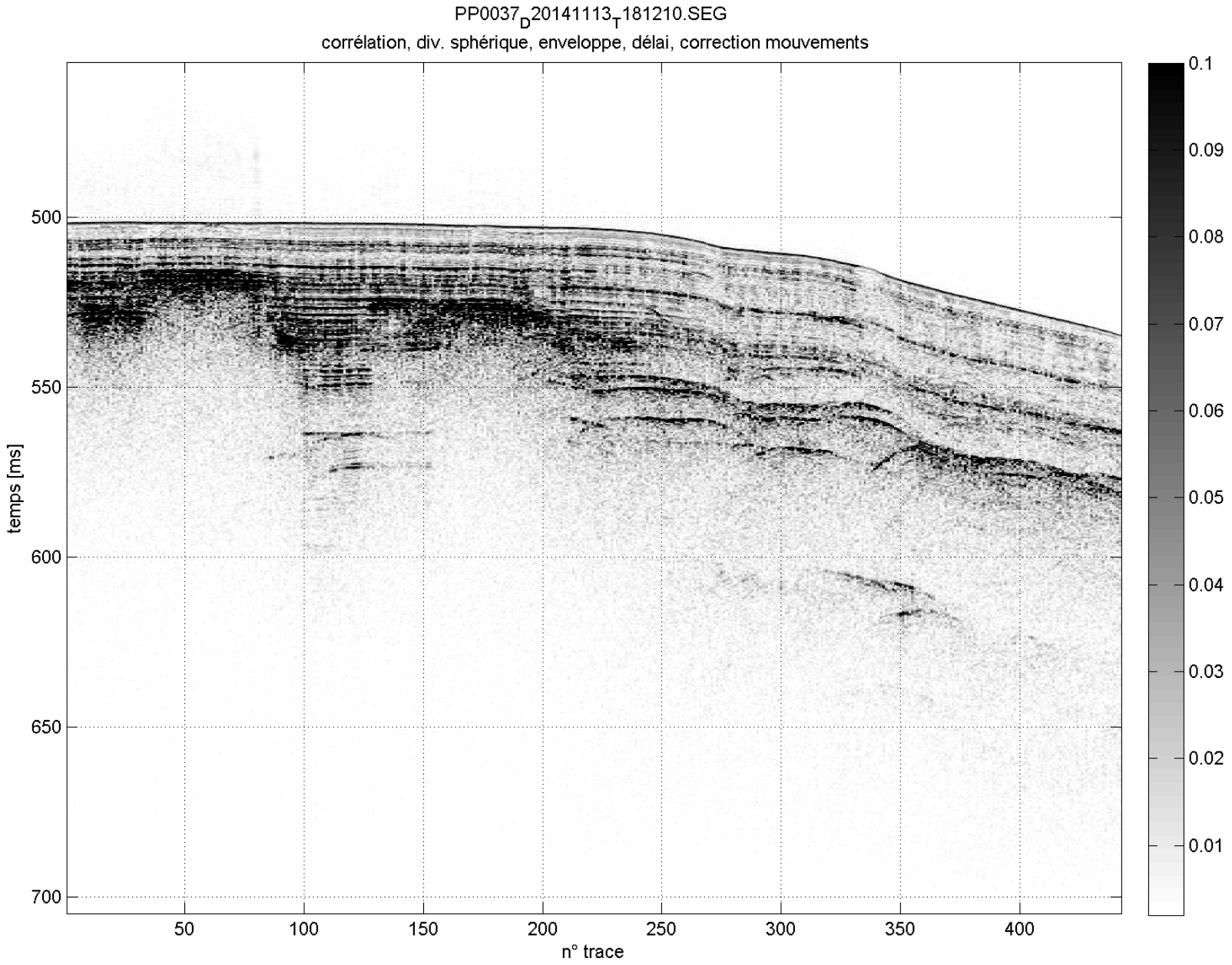
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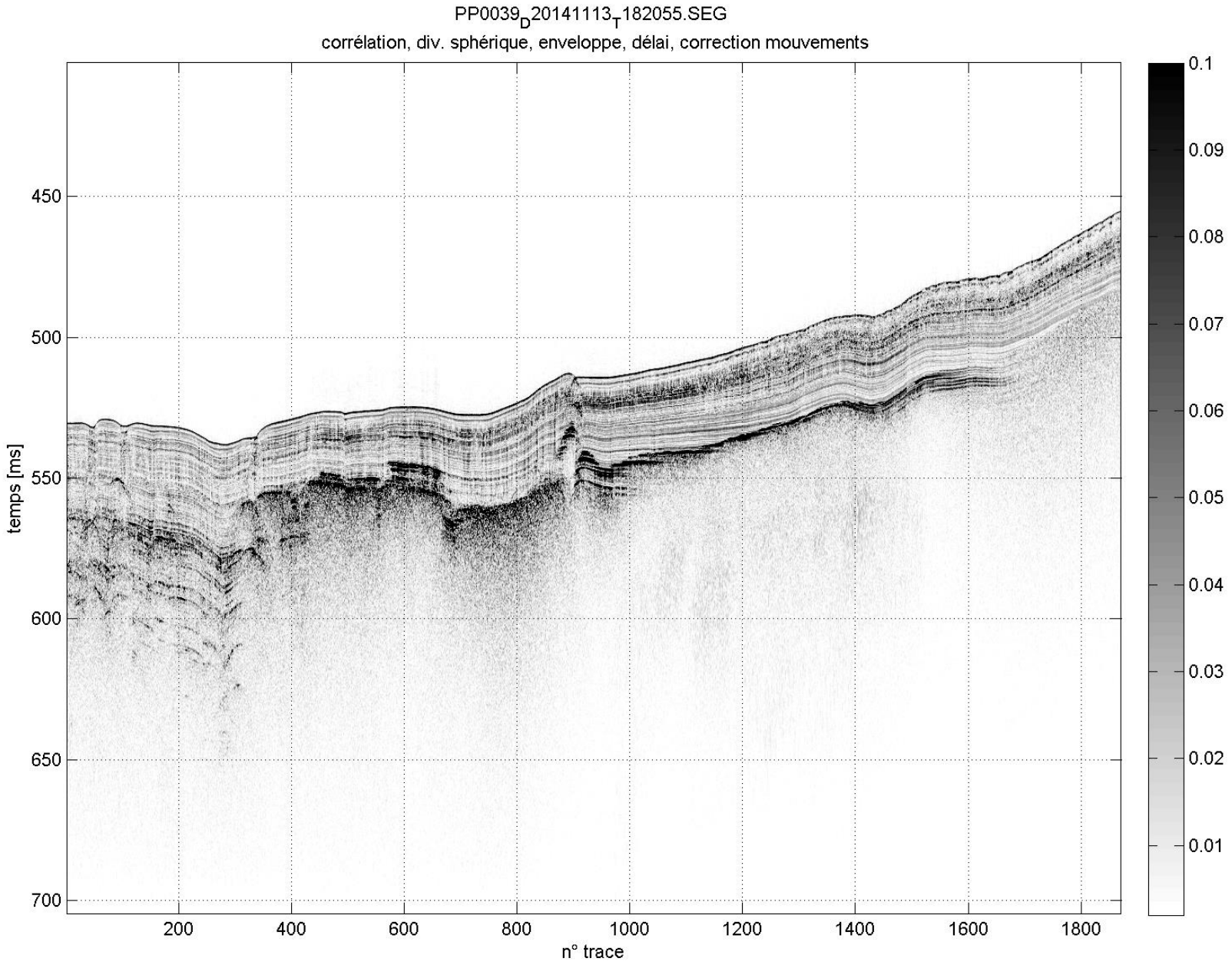
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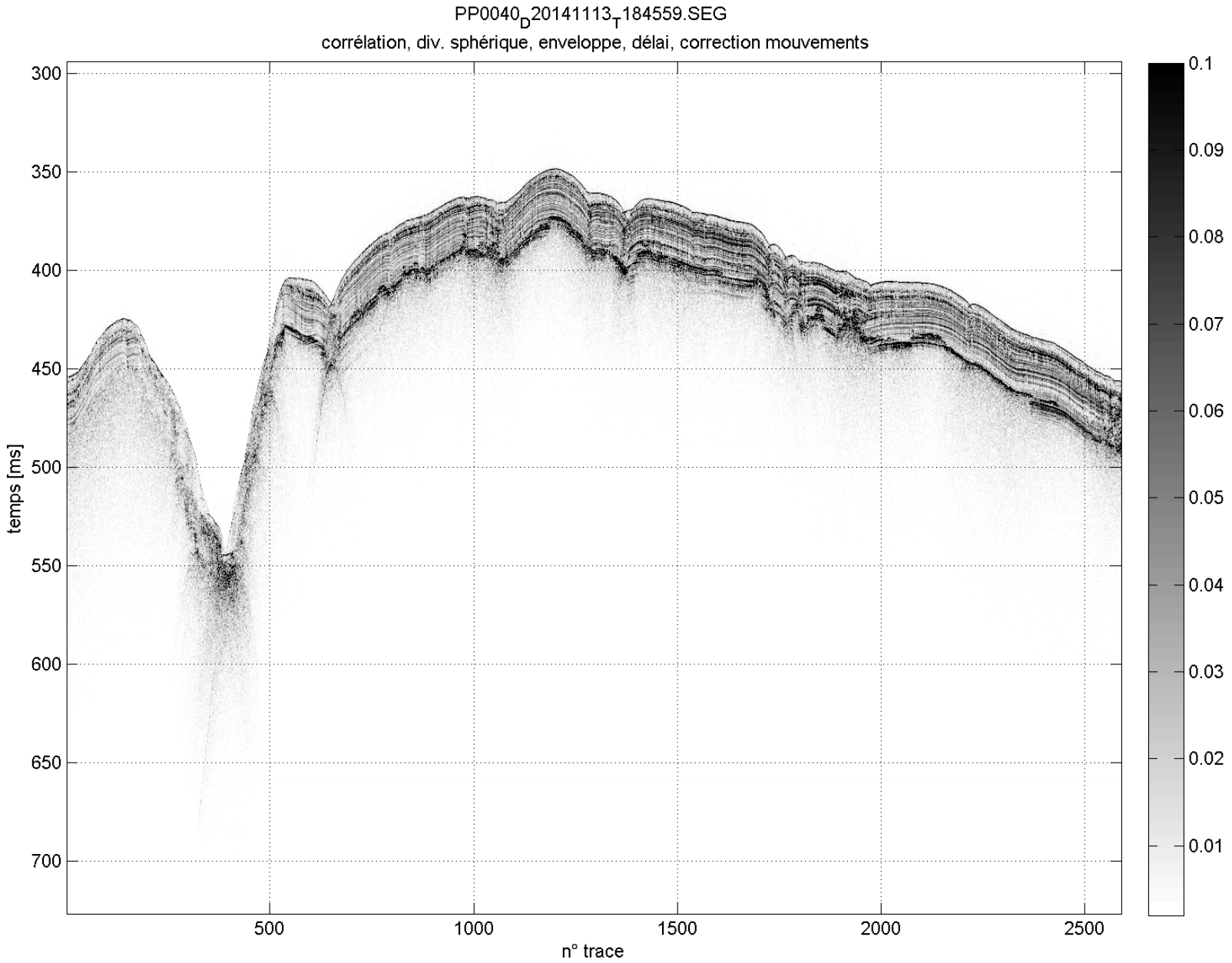
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corrélation, div. sphérique, enveloppe, délai, correction mouvements
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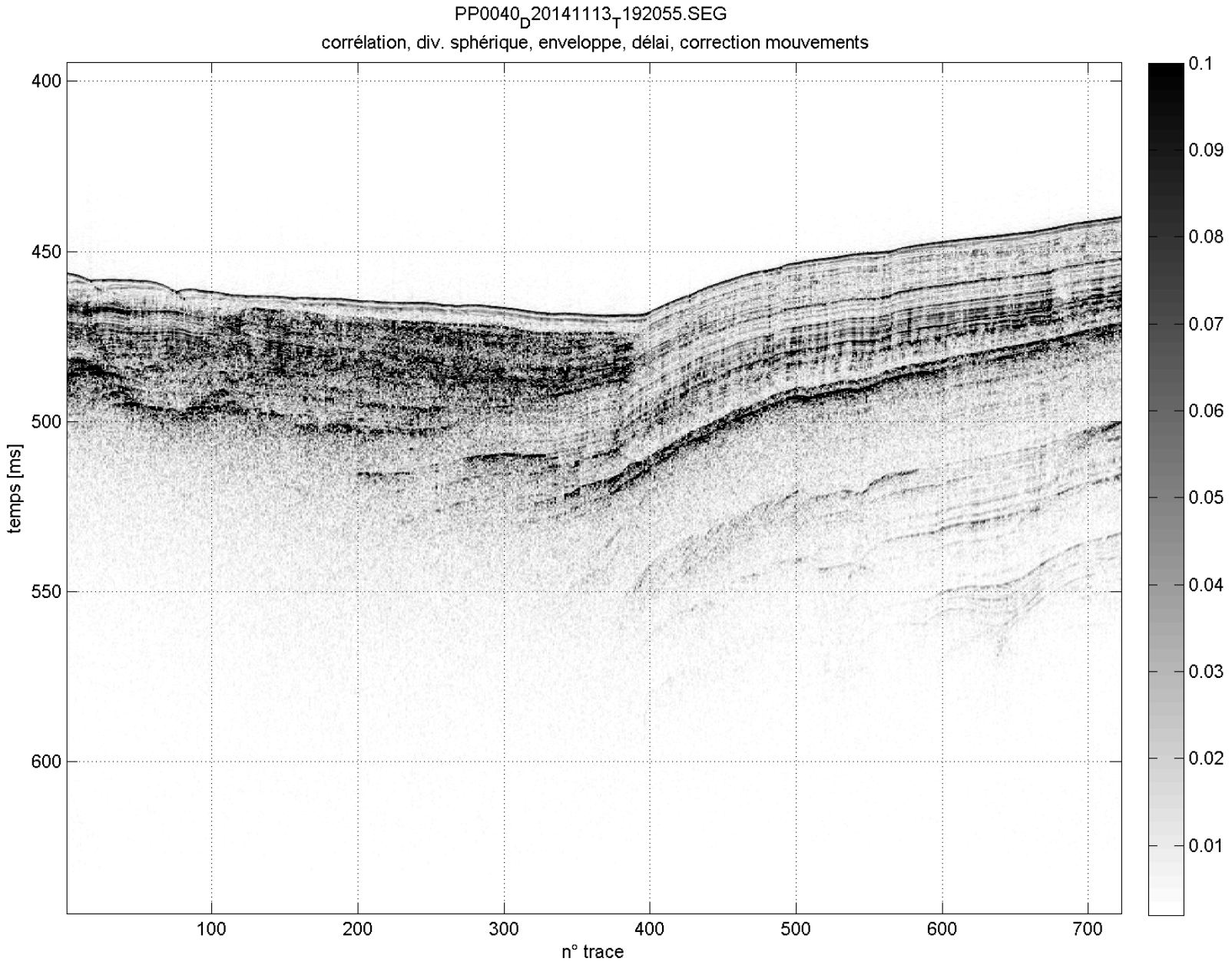
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n° trace
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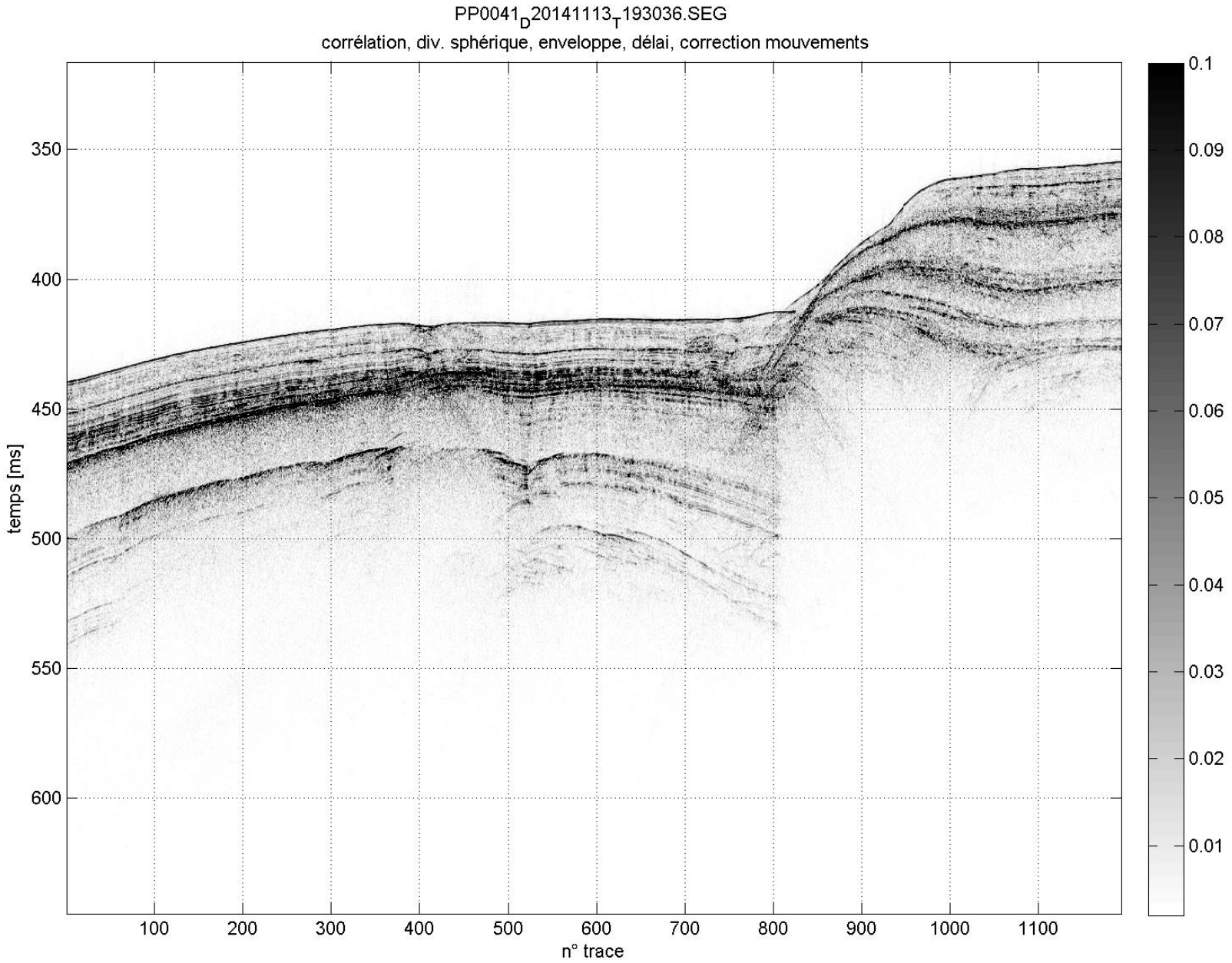
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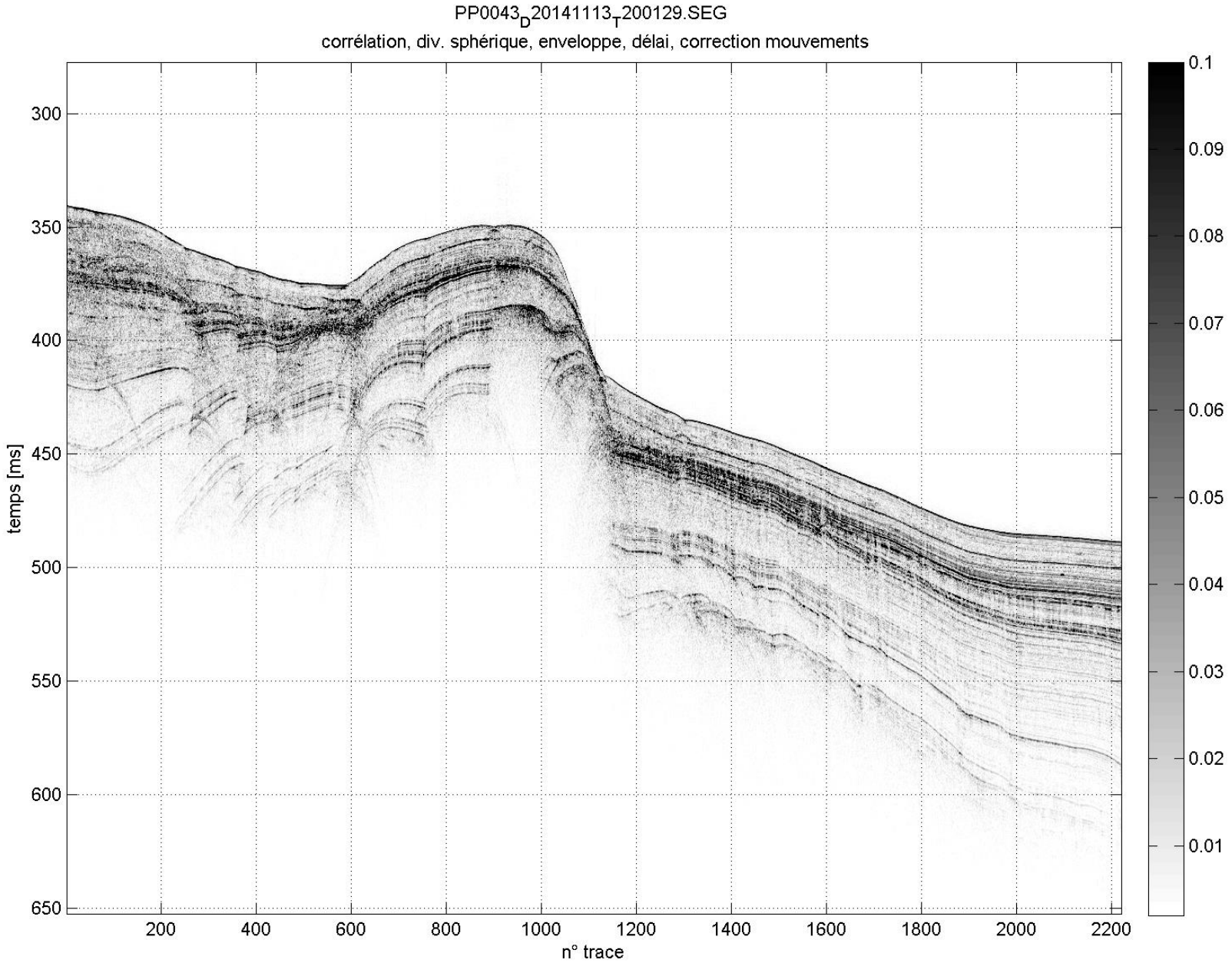
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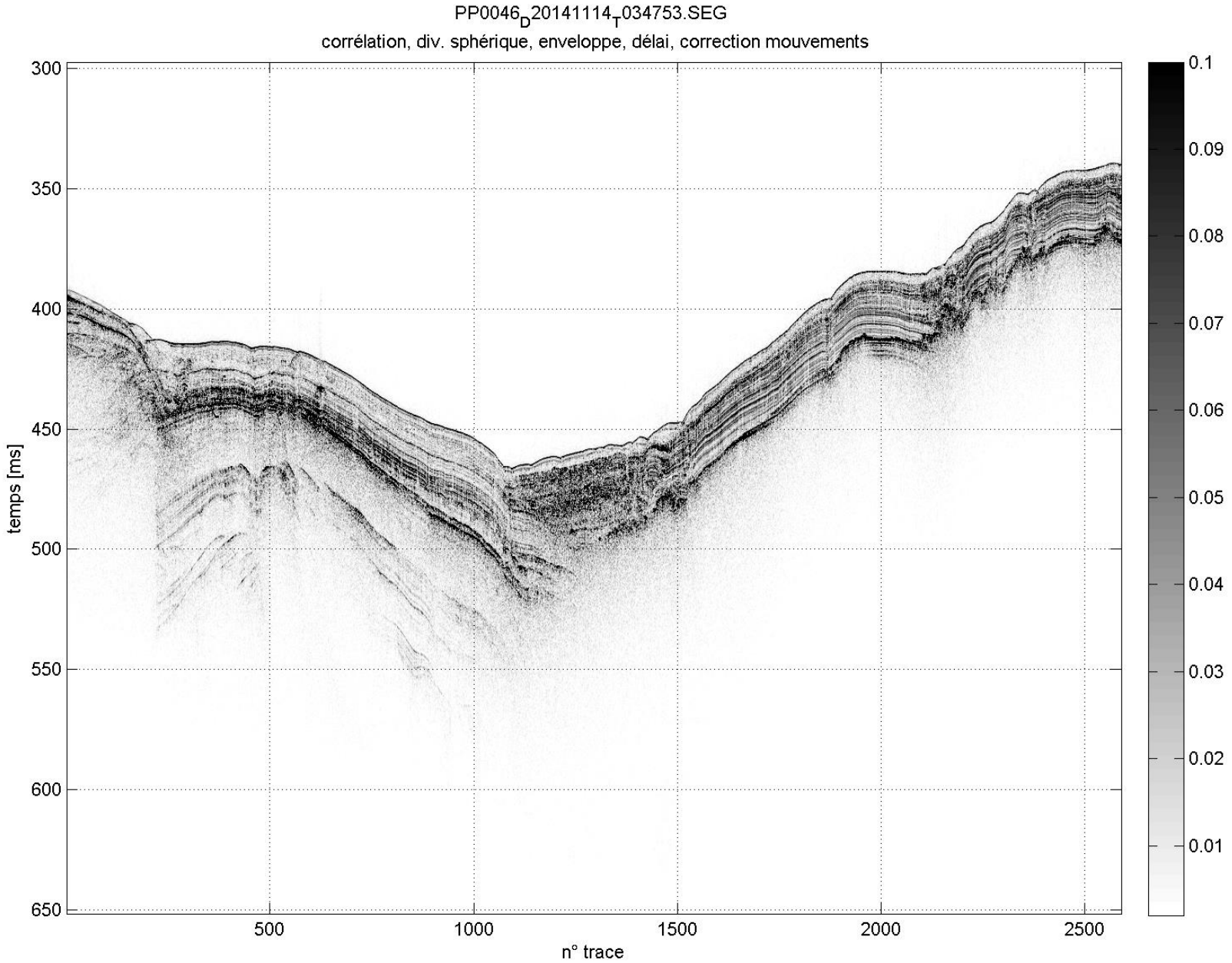
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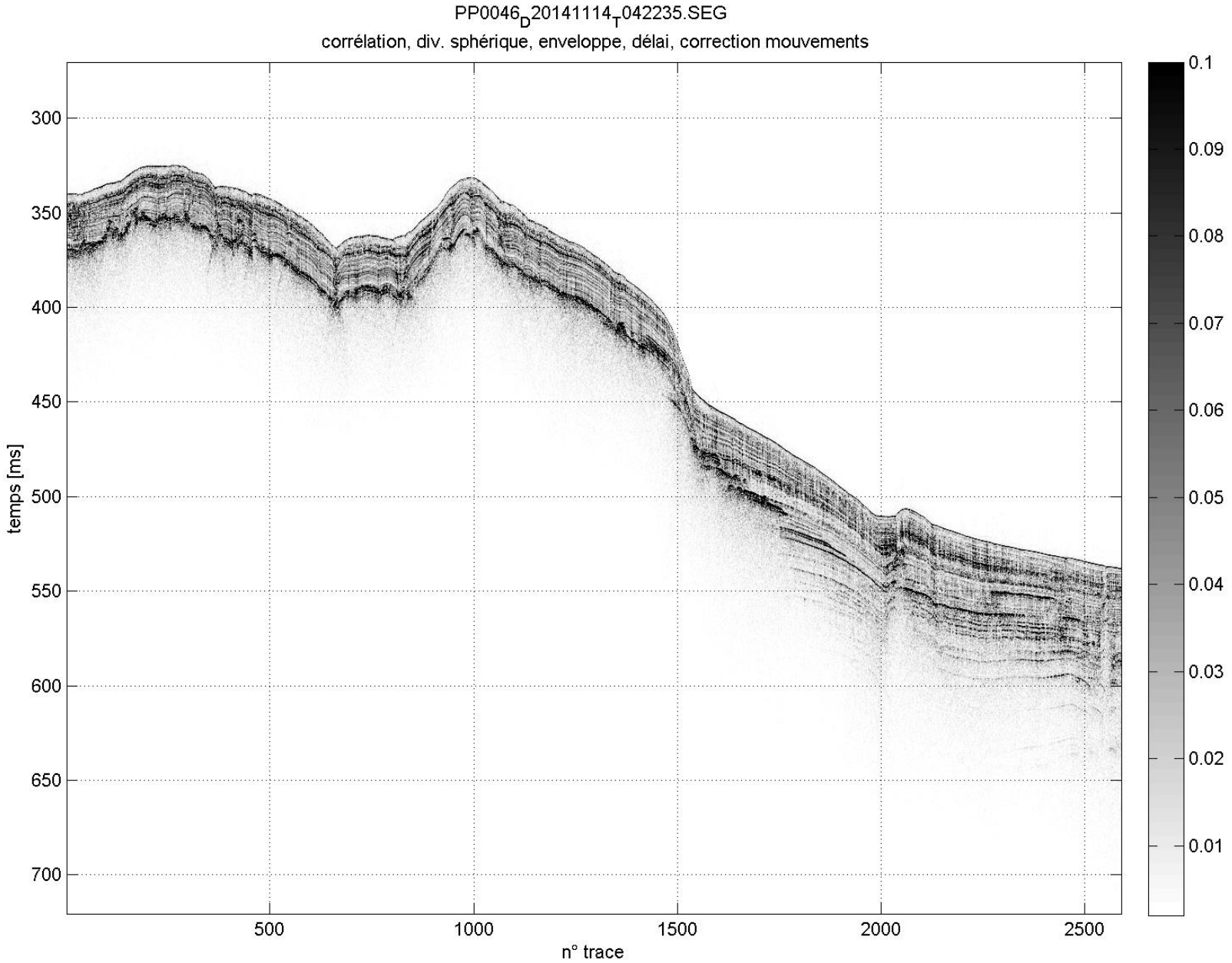
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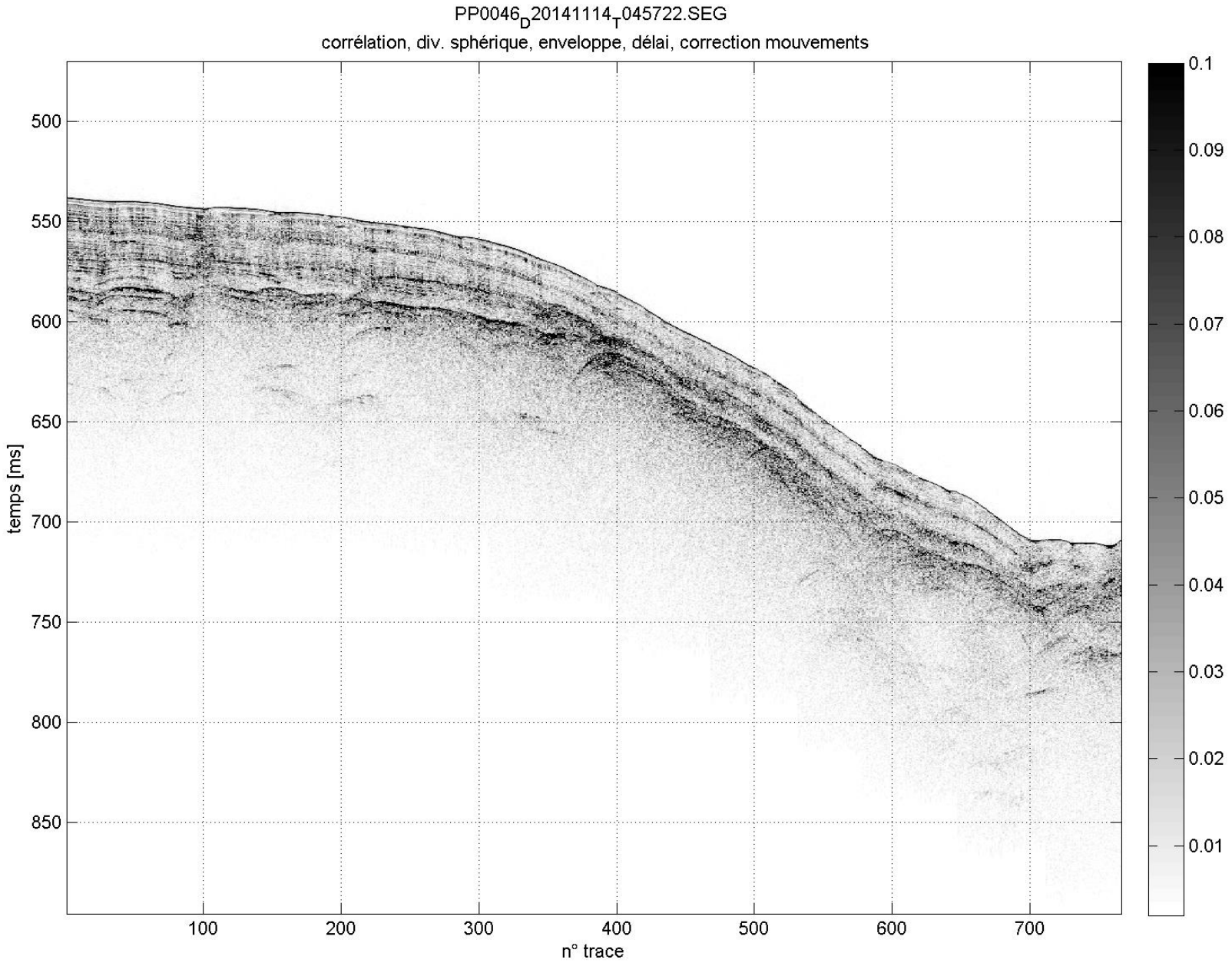
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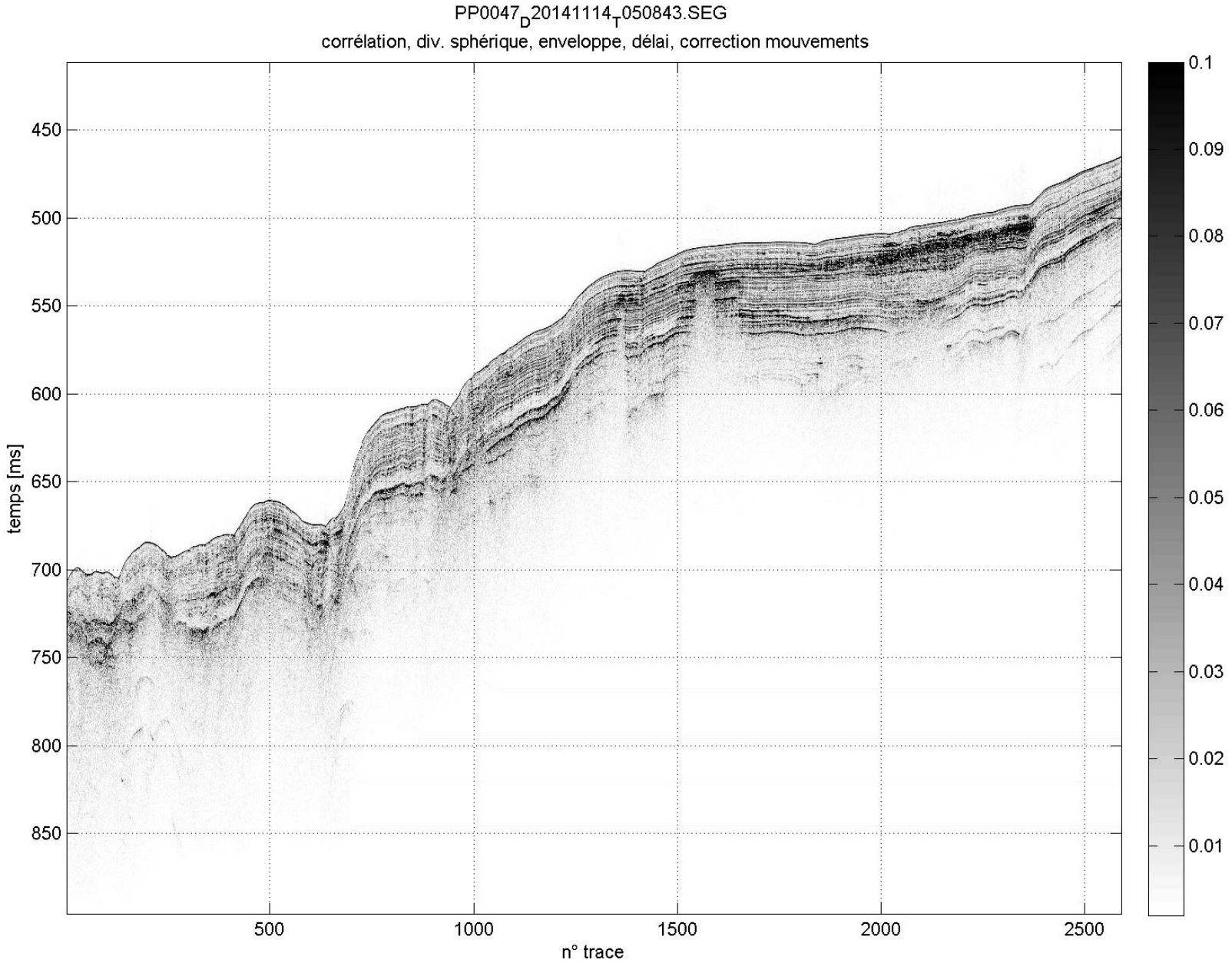
PP0047_D20141114_T050843.SEG
corrélation, div. sphérique, enveloppe, délai, correction mouvements
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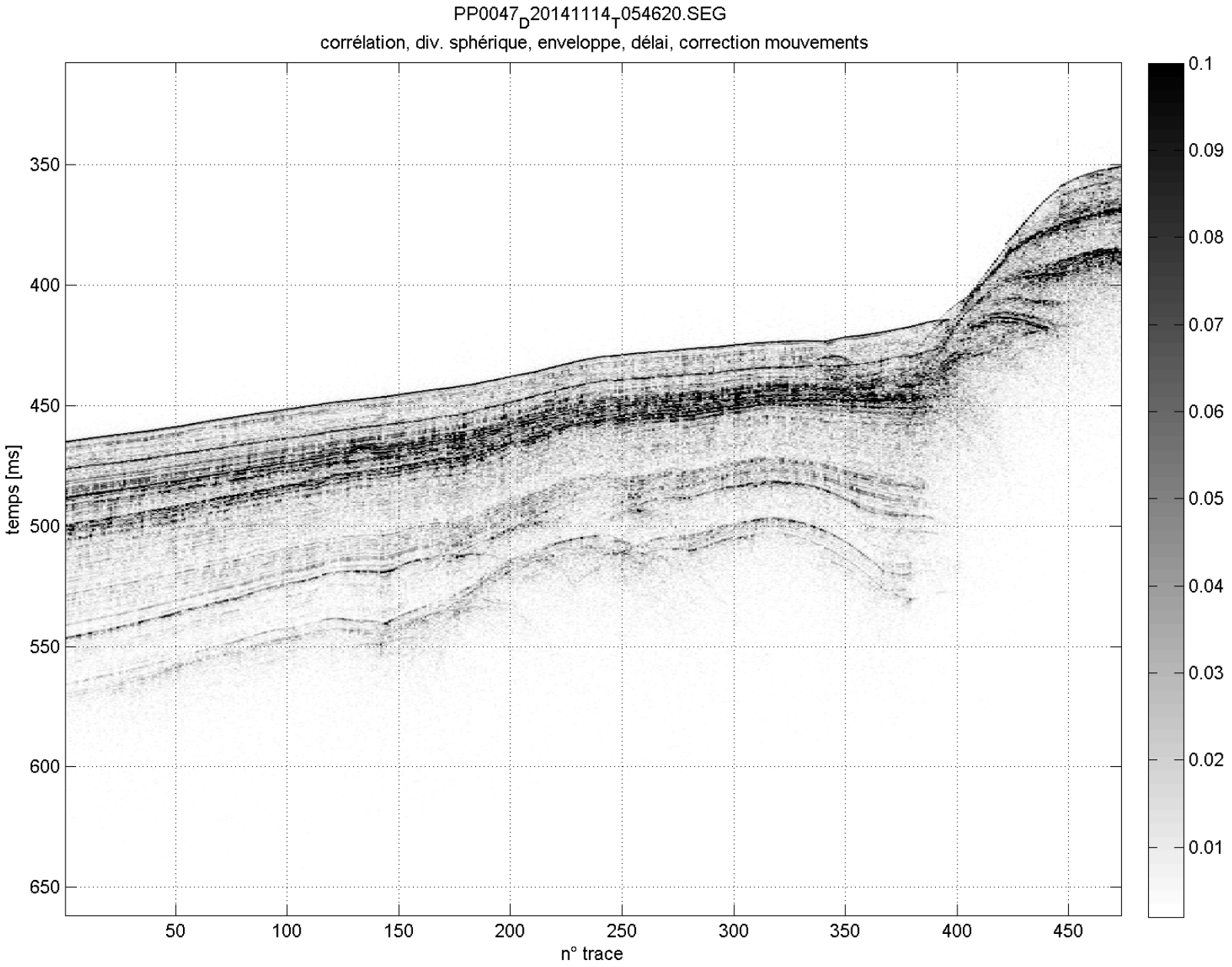
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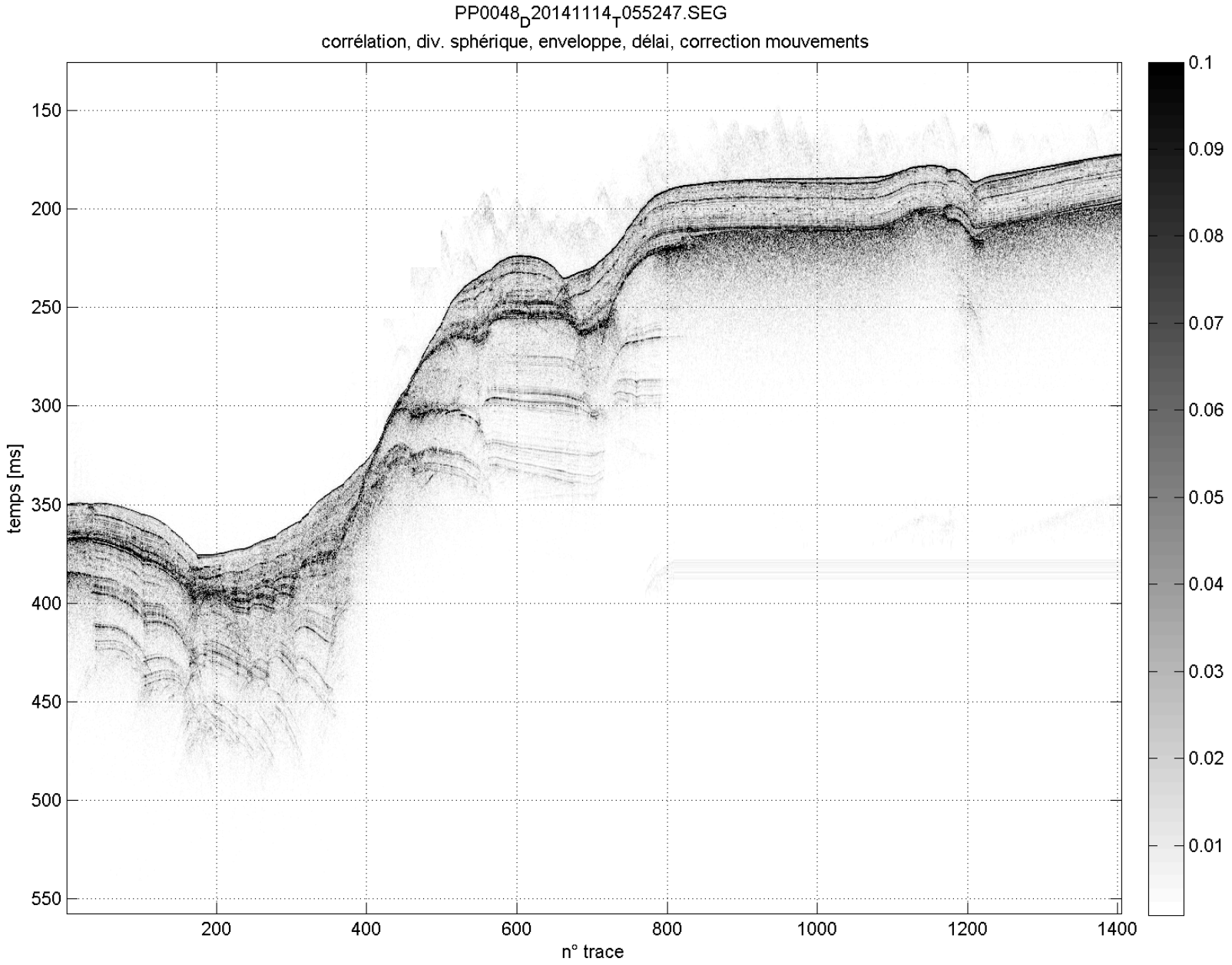
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corrélation, div. sphérique, enveloppe, délai, correction mouvements
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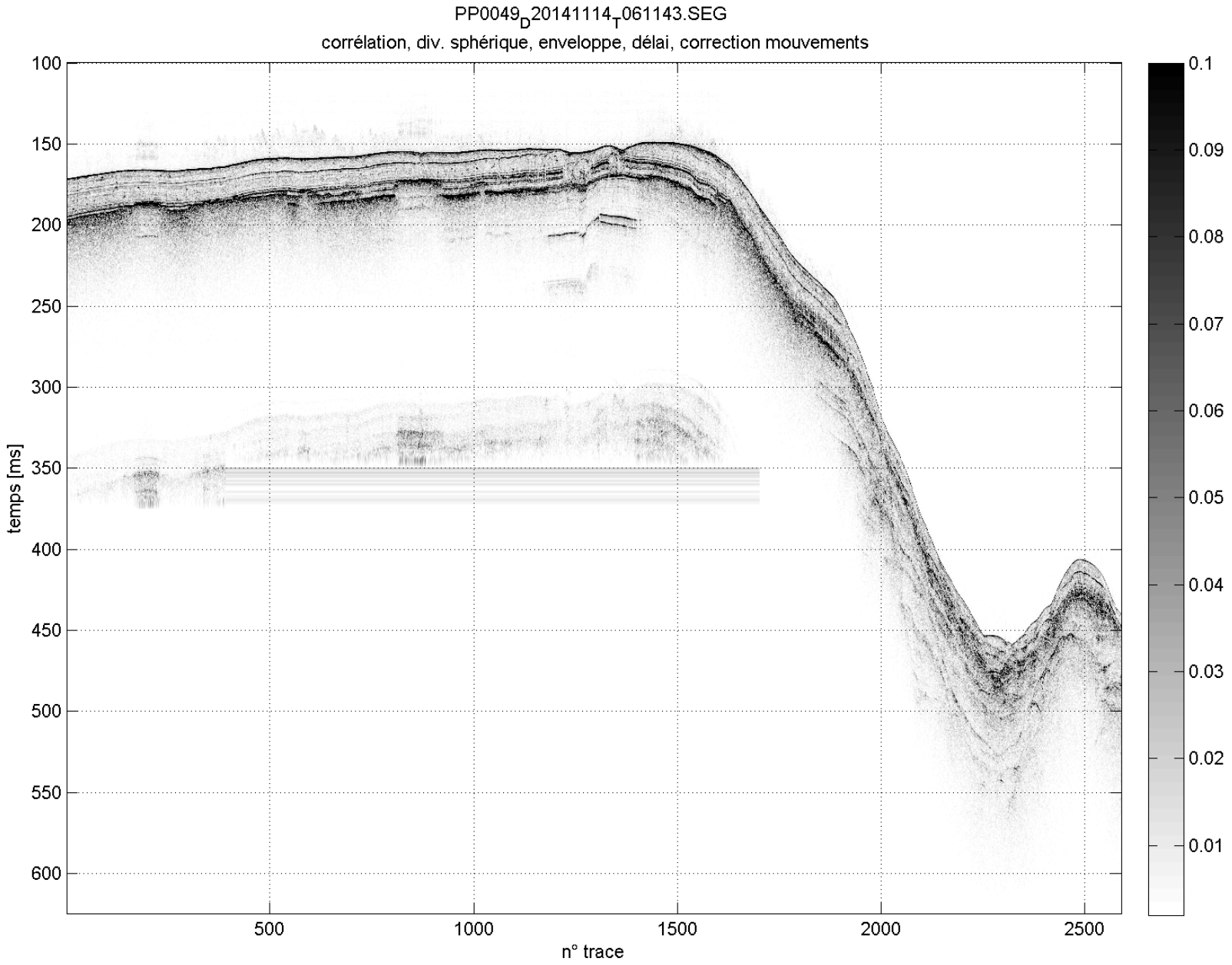
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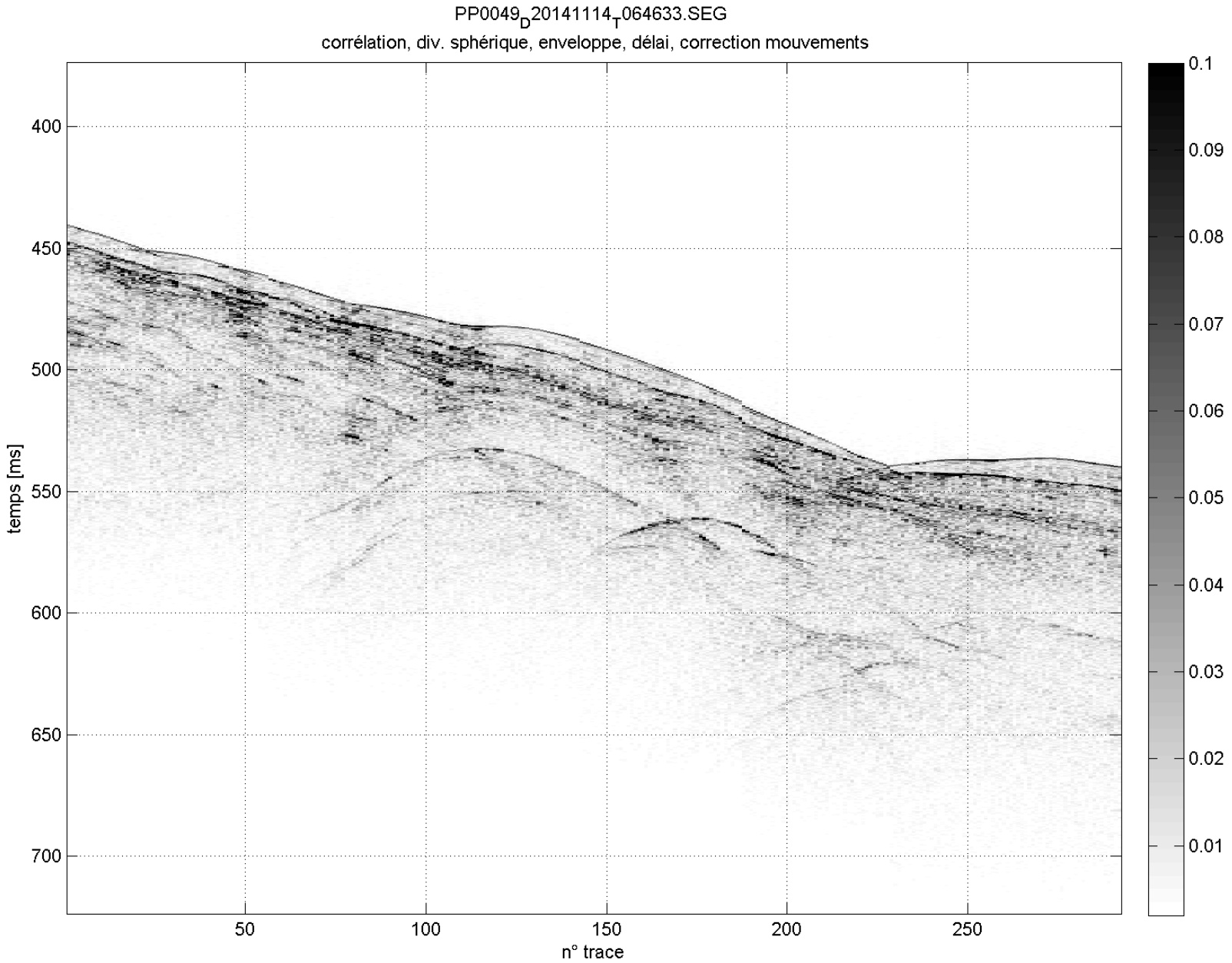
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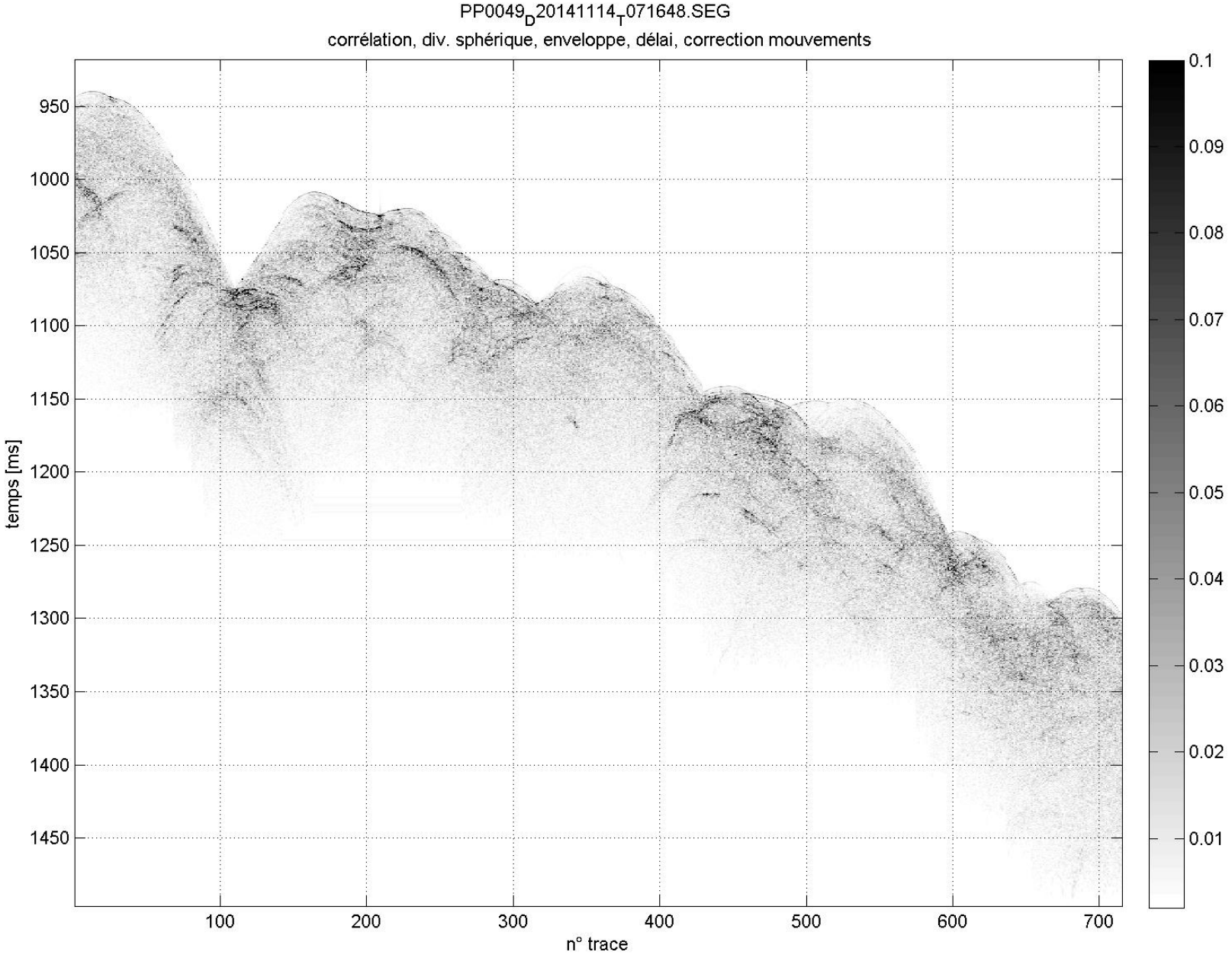
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corrélation, div. sphérique, enveloppe, délai, correction mouvements
temps [ms]
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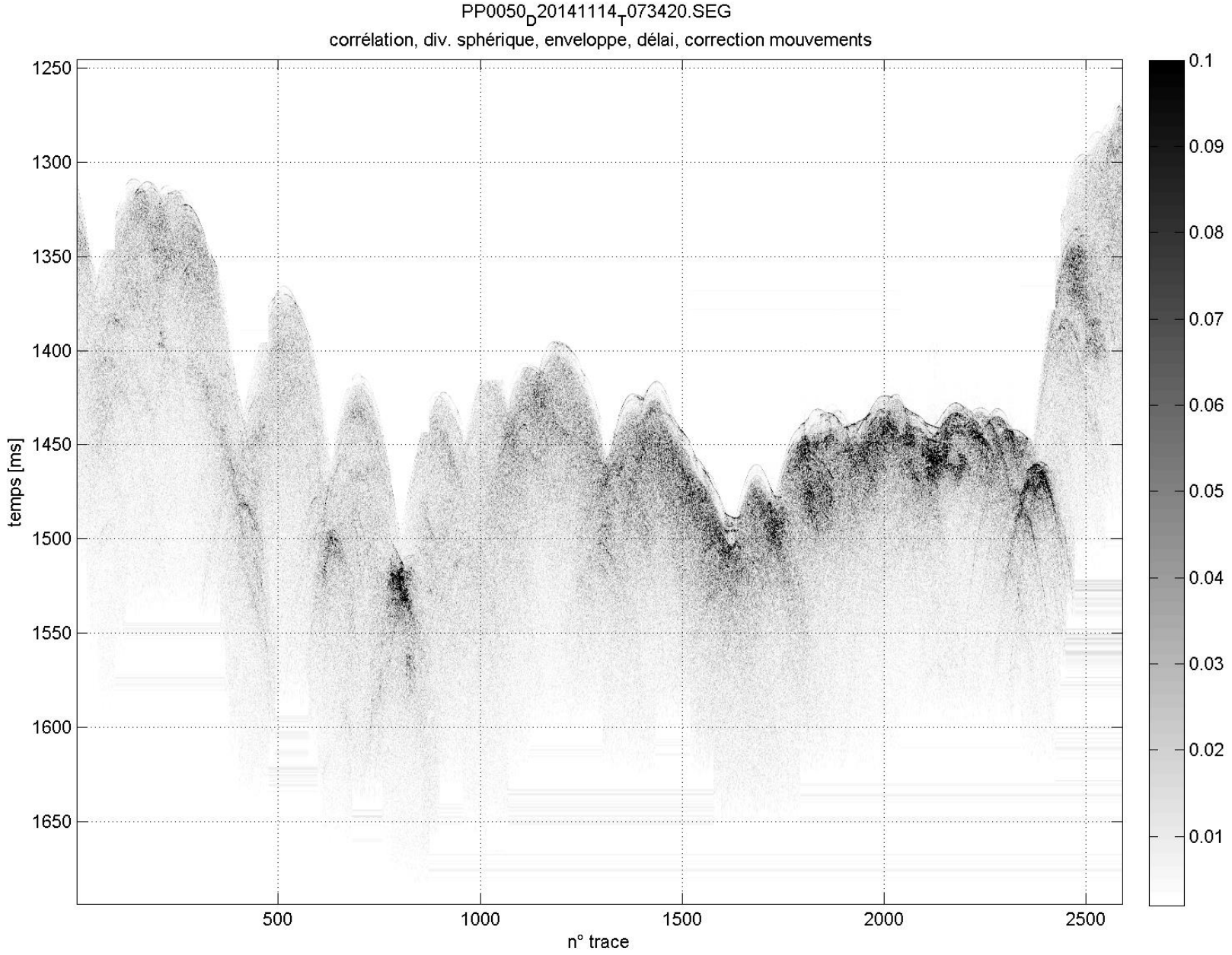
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corrélation, div. sphérique, enveloppe, délai, correction mouvements
temps [ms]
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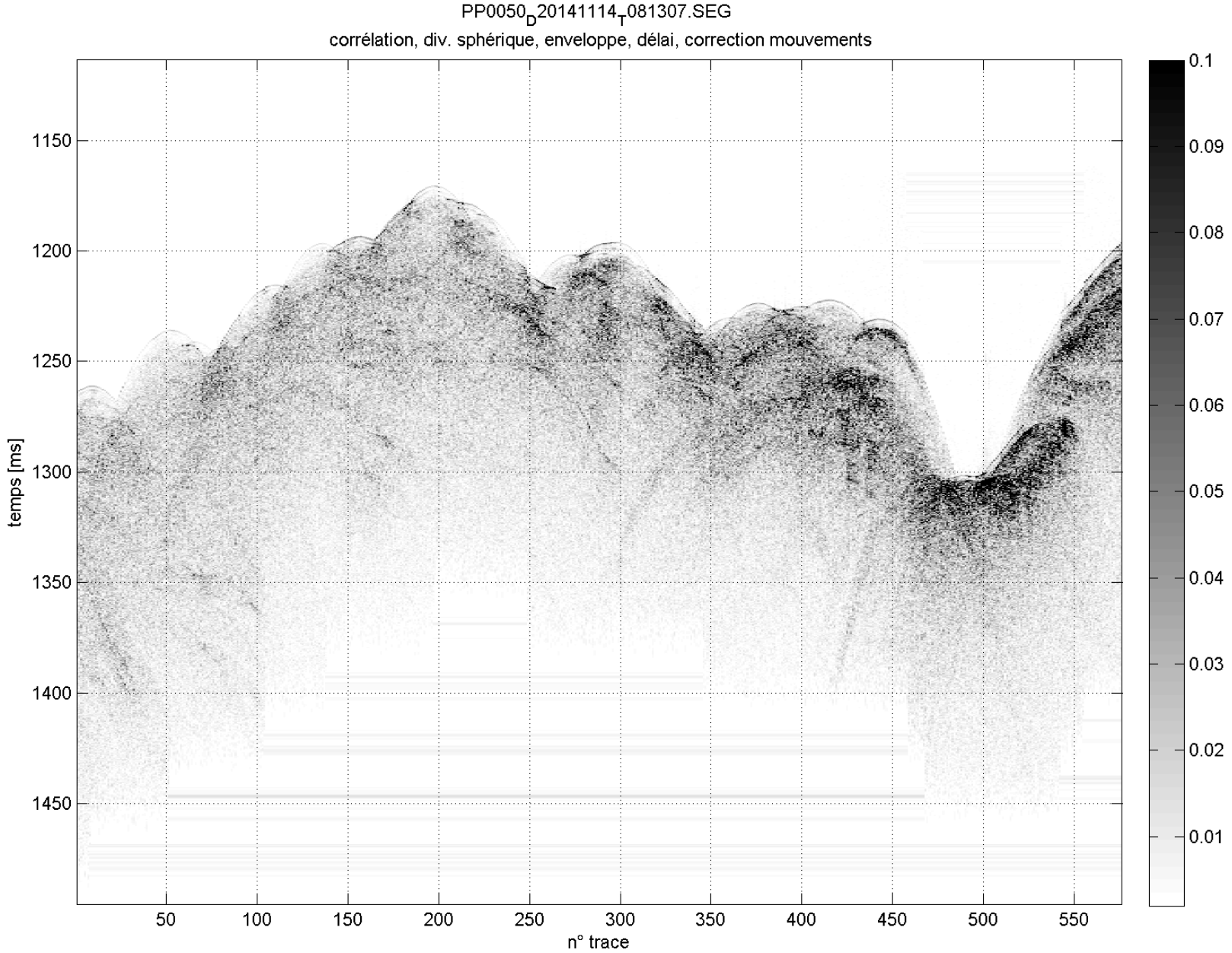
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corrélation, div. sphérique, enveloppe, délai, correction mouvements
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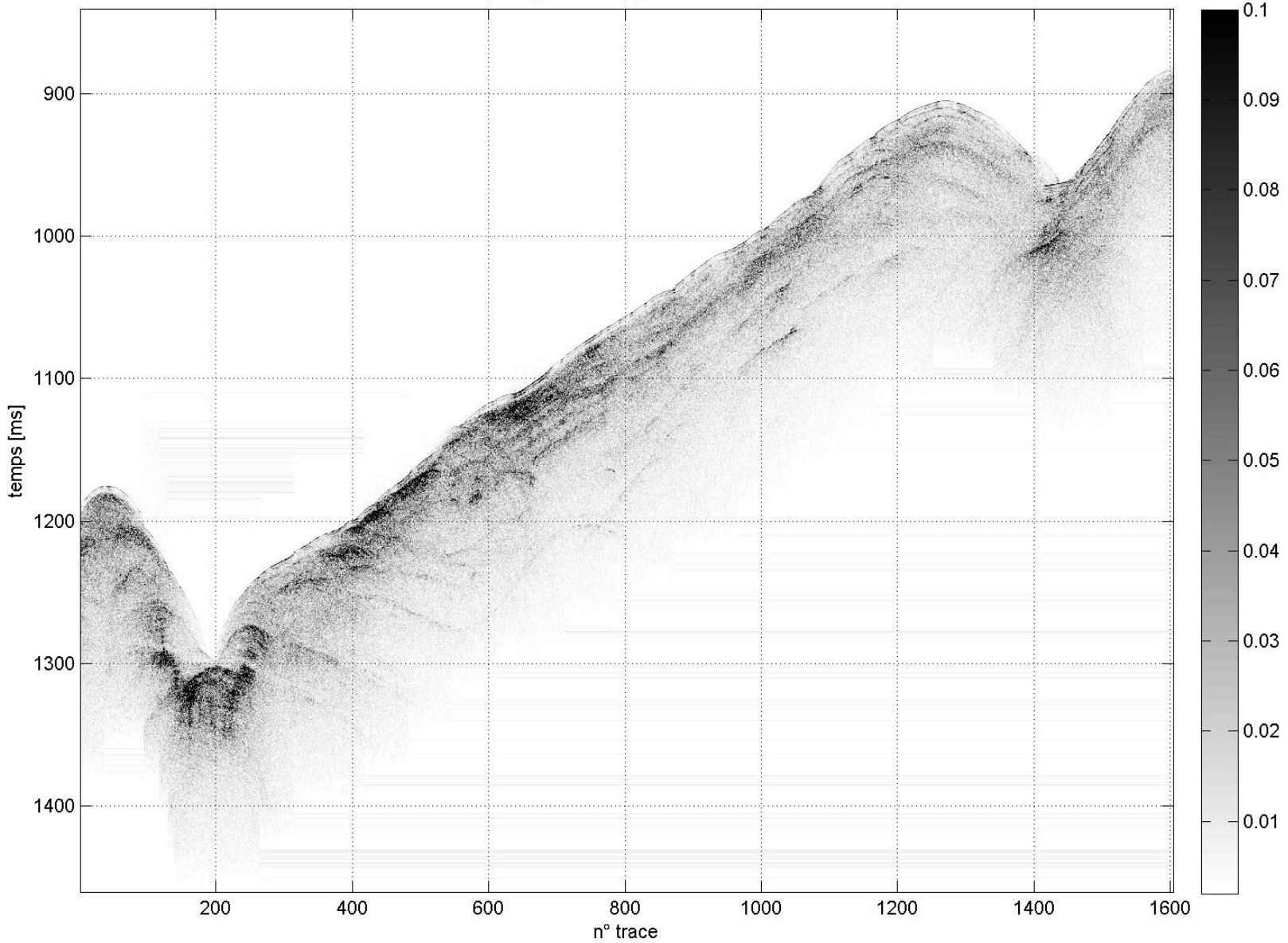
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corrélation, div. sphérique, enveloppe, délai, correction mouvements
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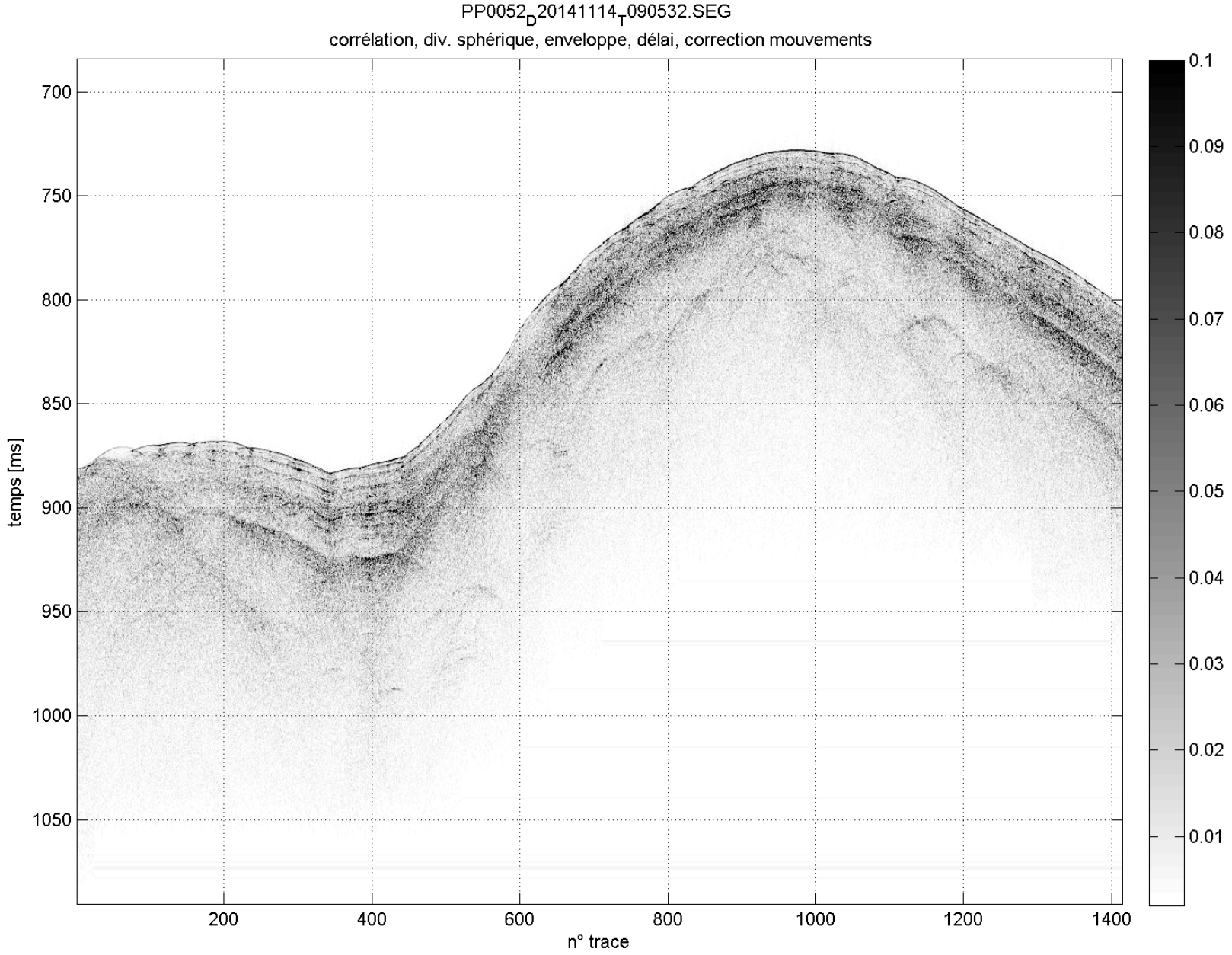
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corrélation, div. sphérique, enveloppe, délai, correction mouvements
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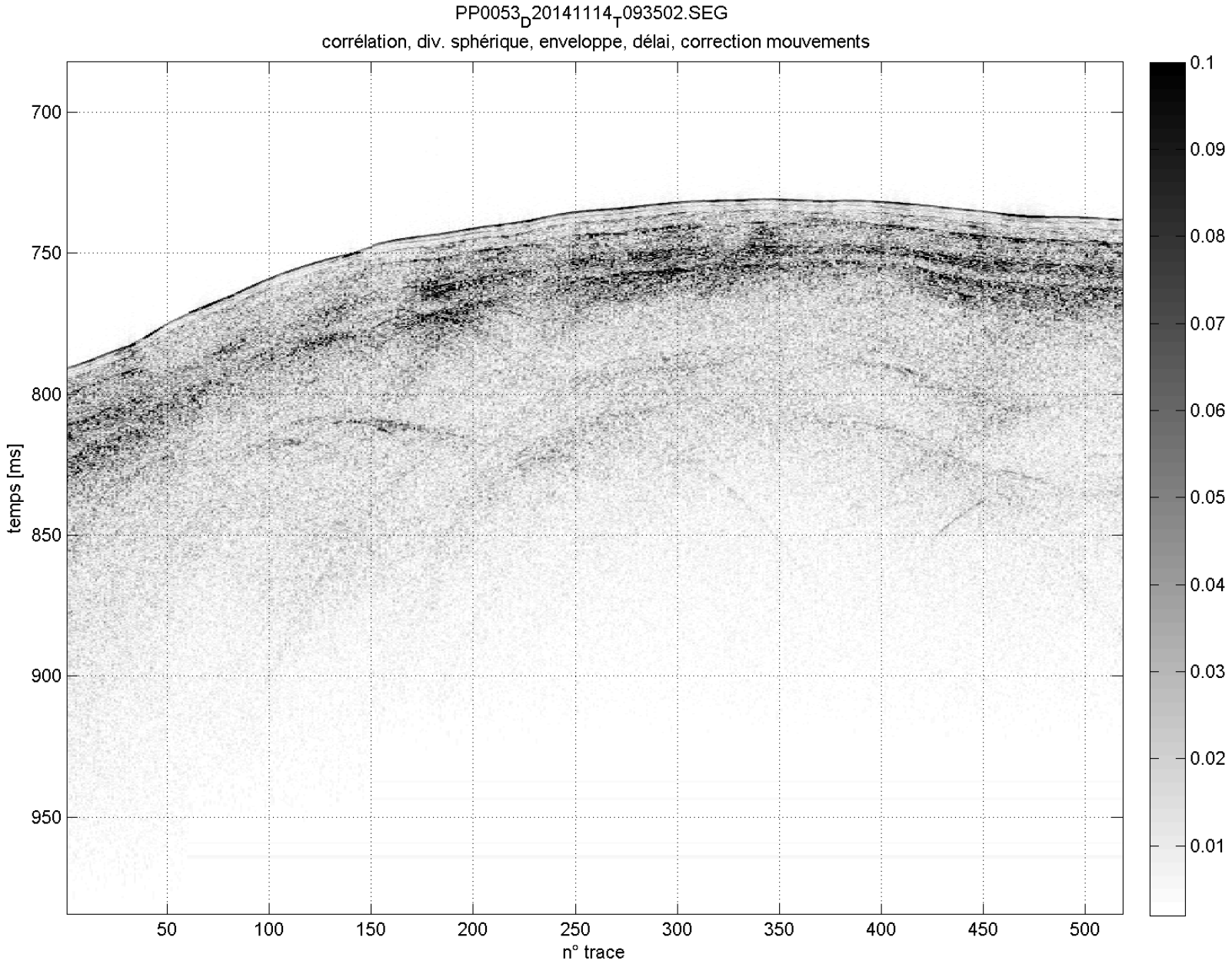
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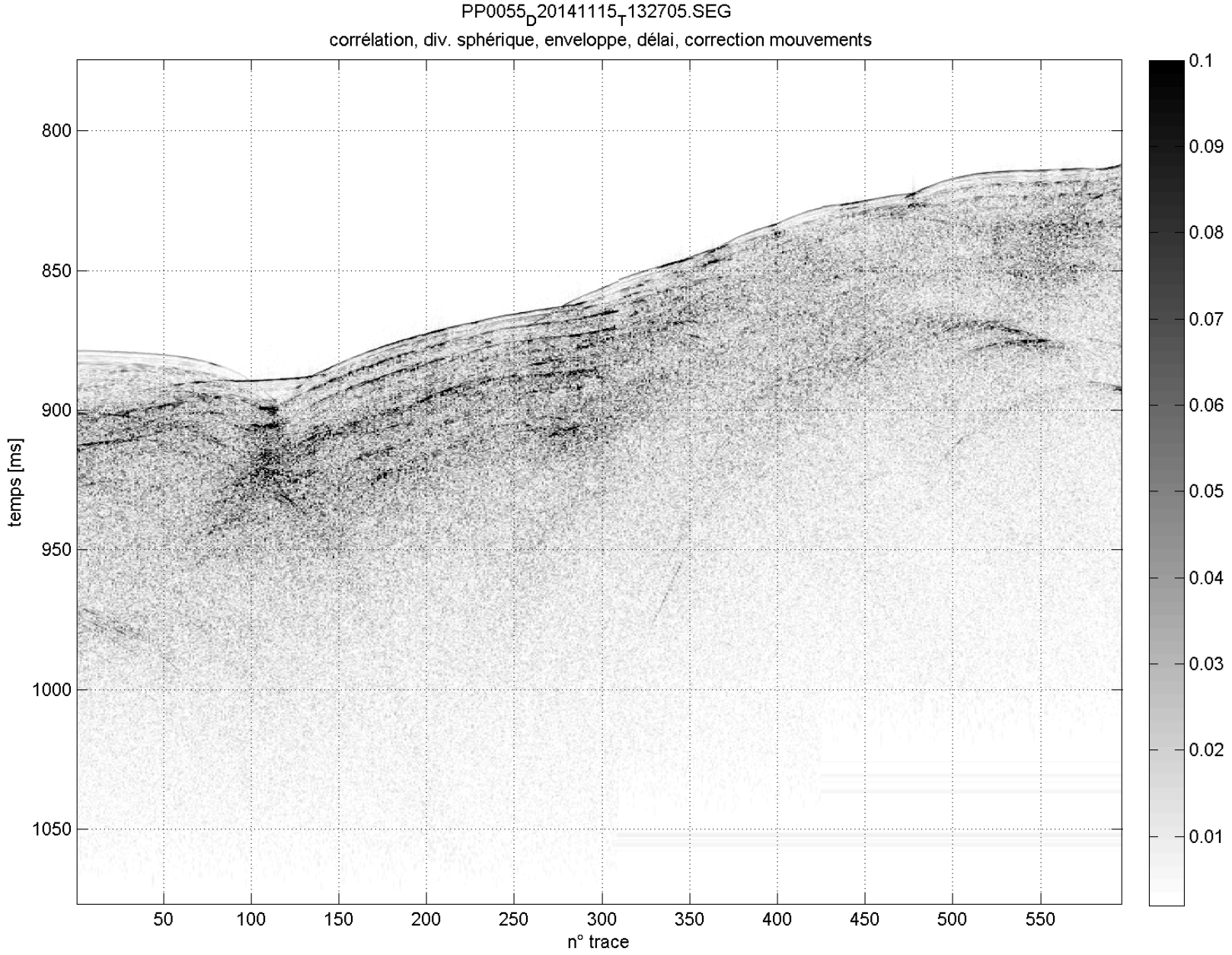
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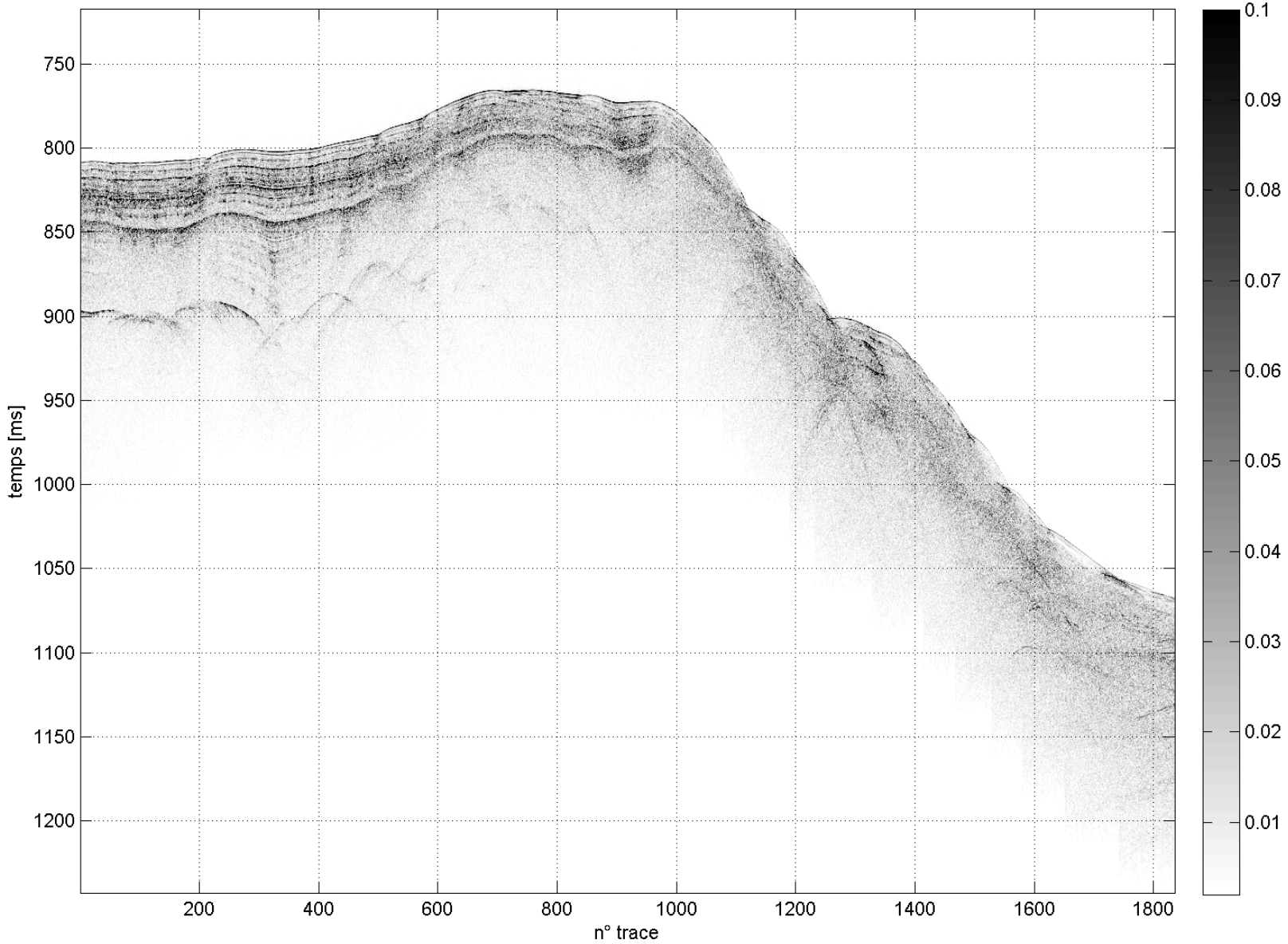
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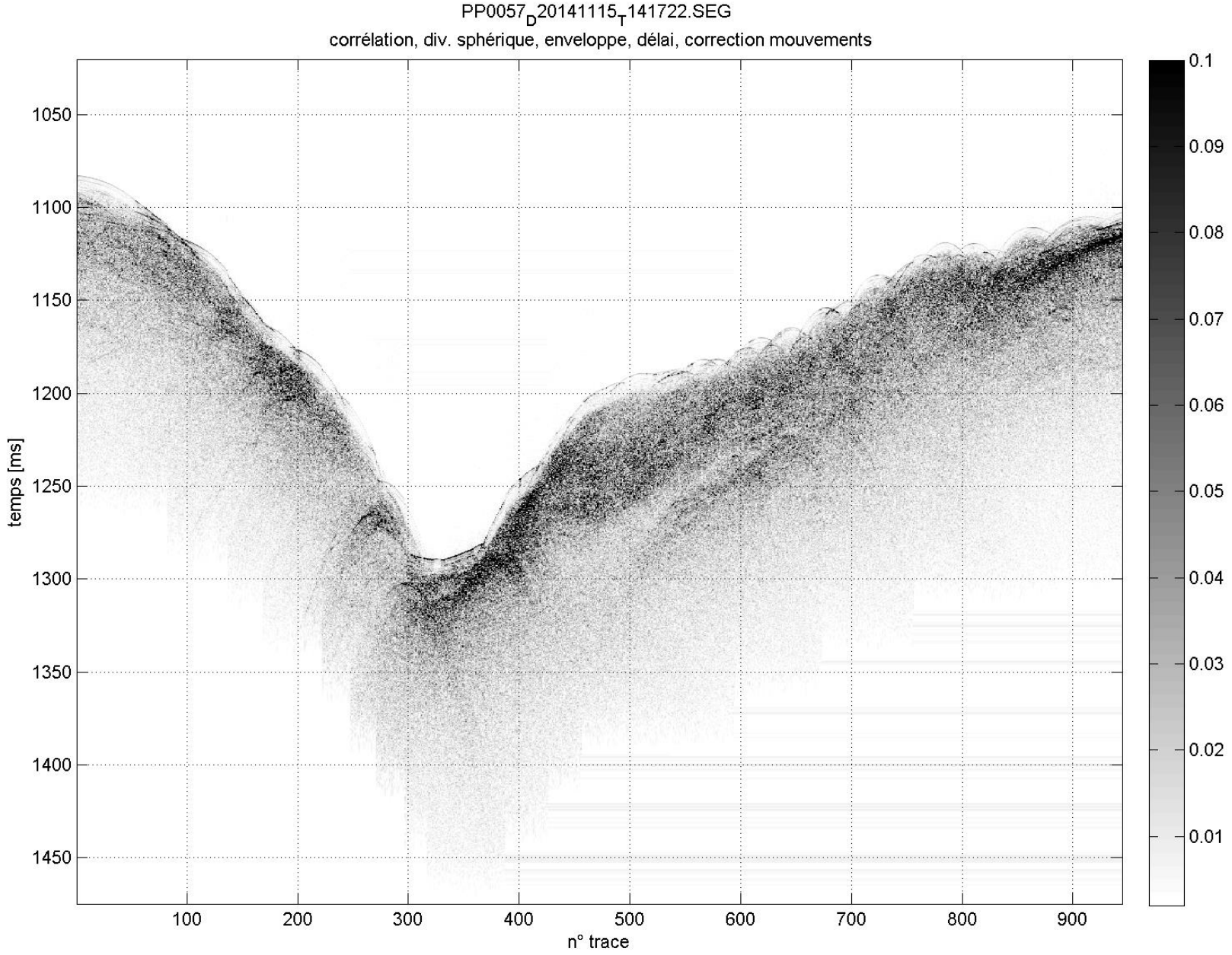
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corrélation, div. sphérique, enveloppe, délai, correction mouvements
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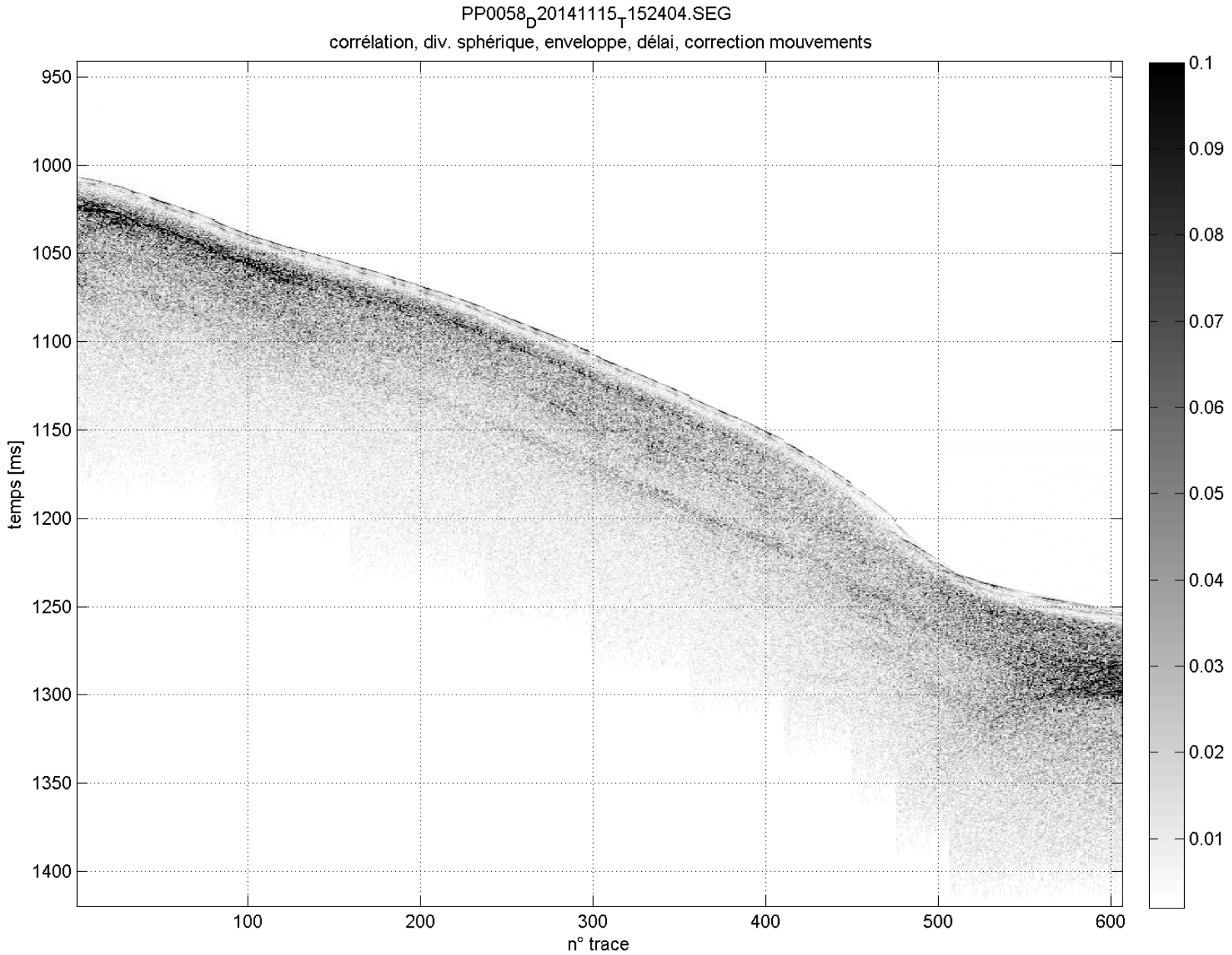
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corrélation, div. sphérique, enveloppe, délai, correction mouvements
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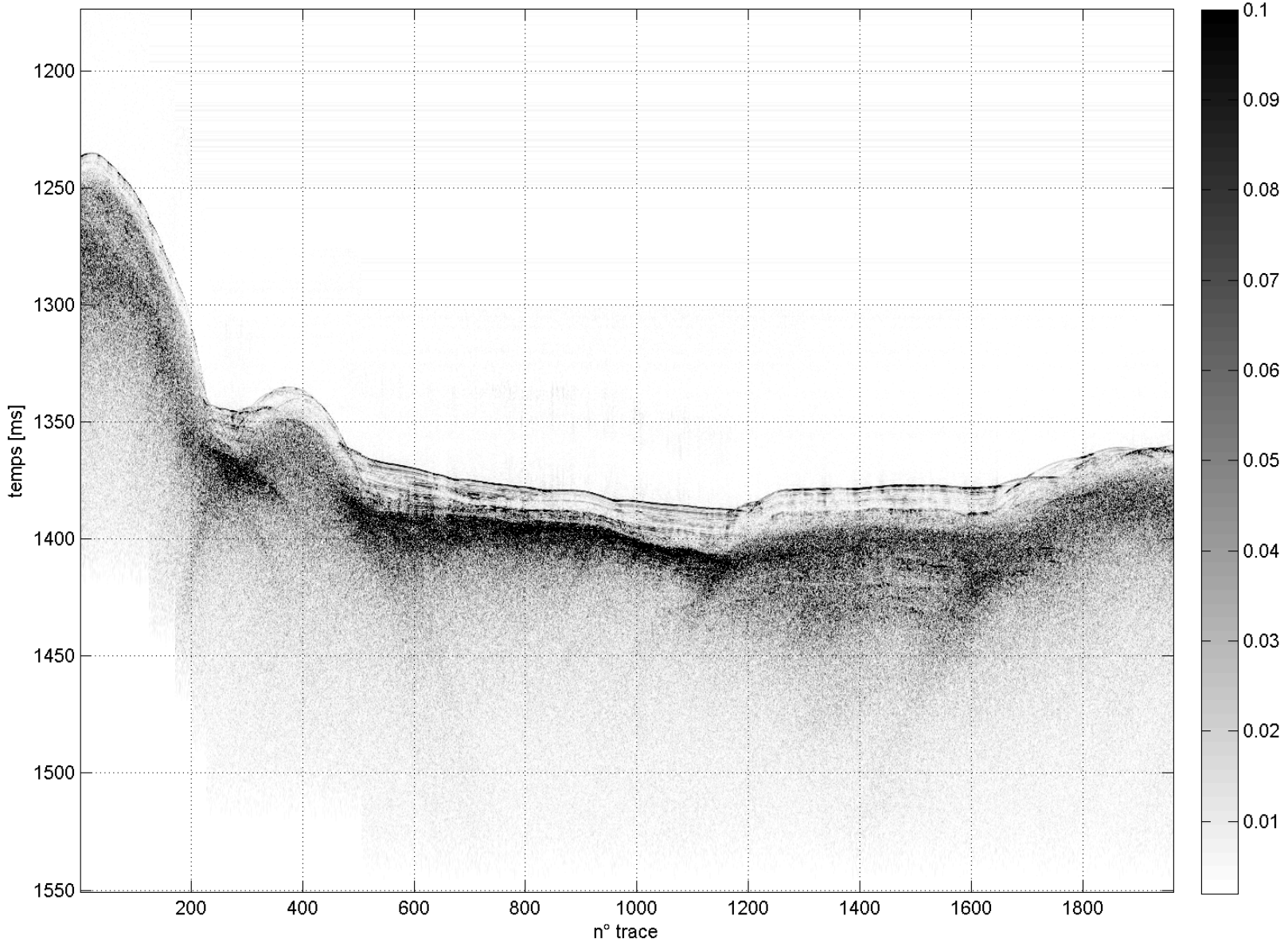
PP0059_D20141115_T154736.SEG
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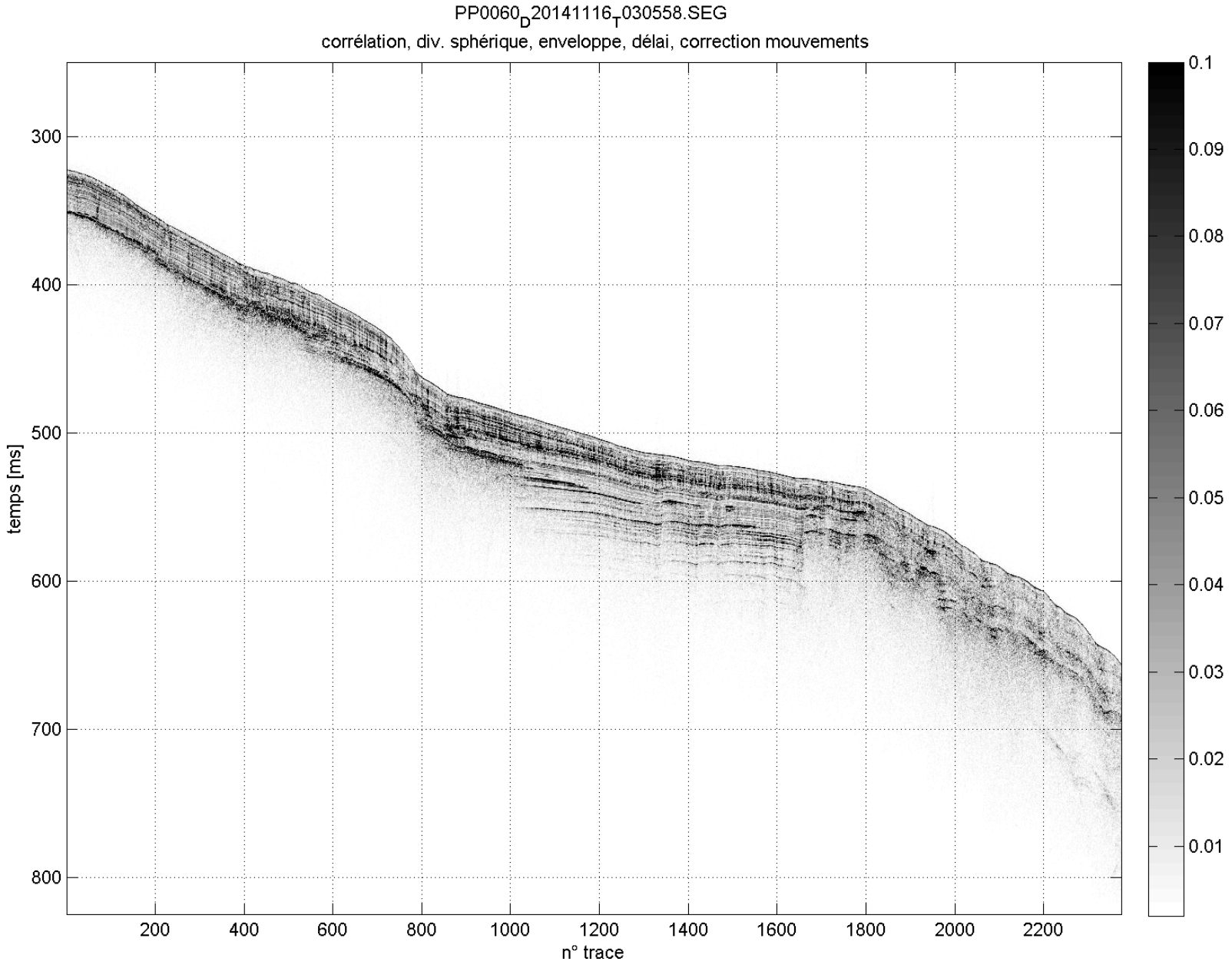
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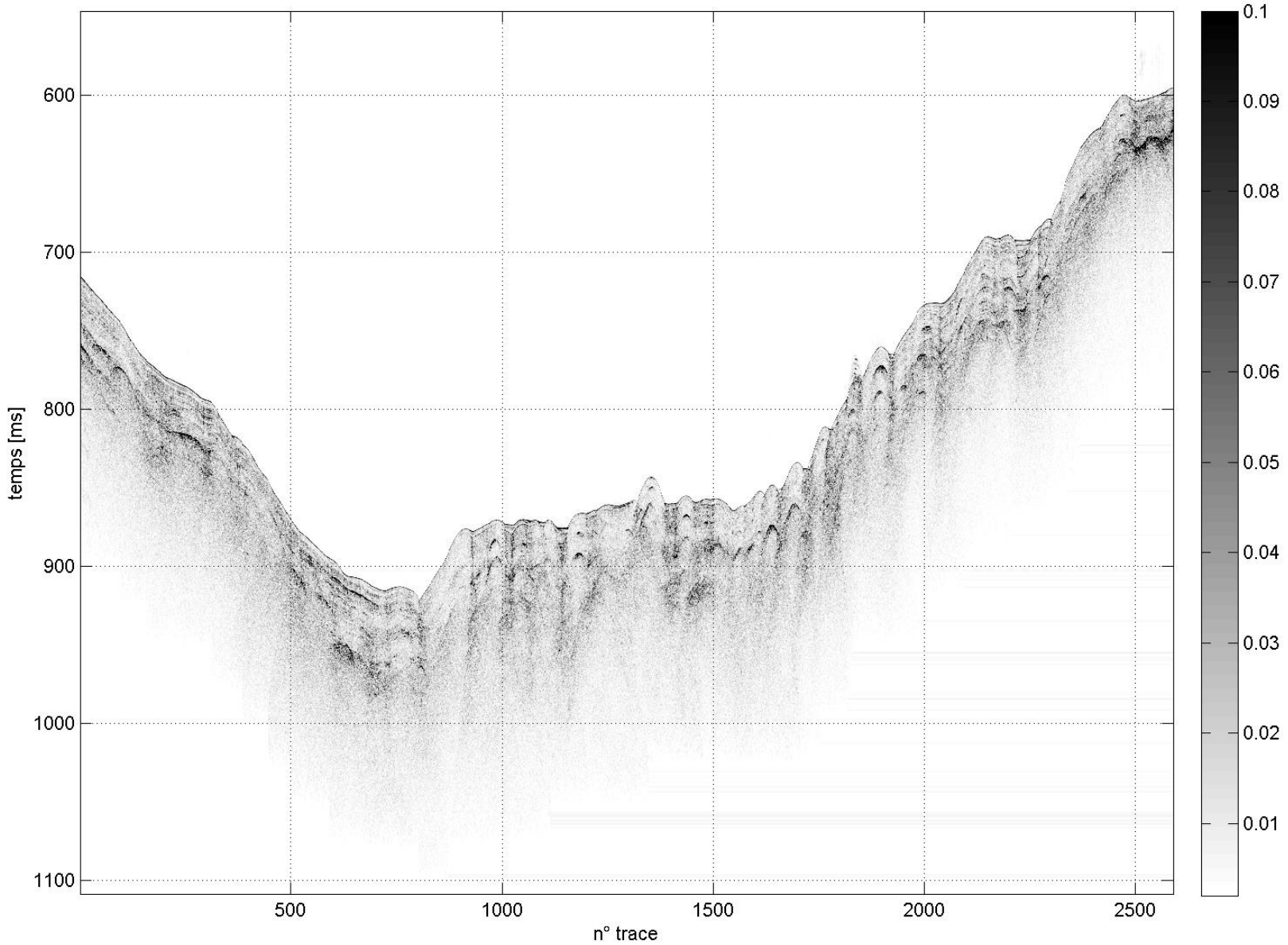
PP0061_D20141116_T034020.SEG
corrélation, div. sphérique, enveloppe, délai, correction mouvements
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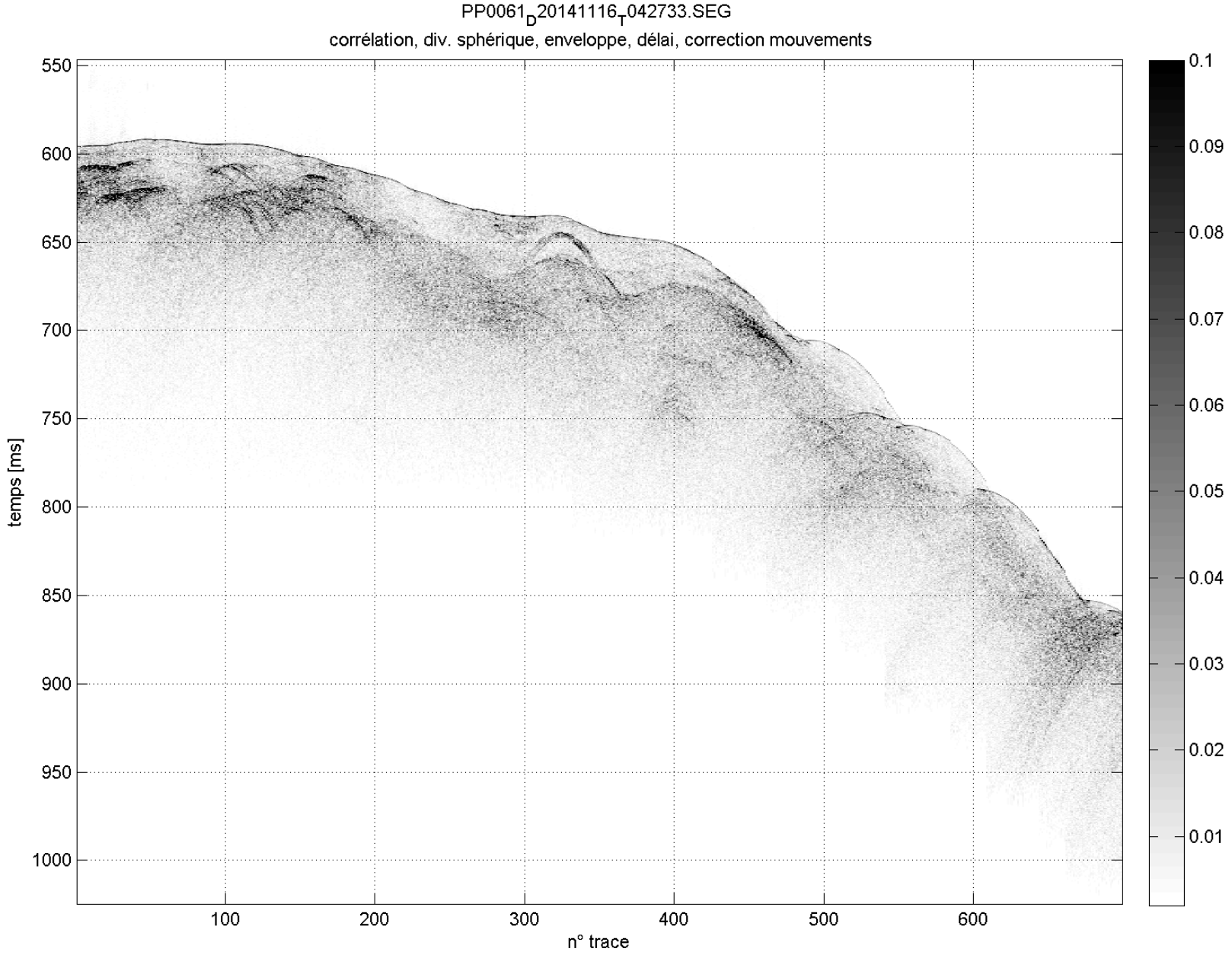
PP0061_D20141116_T042733.SEG
corrélation, div. sphérique, enveloppe, délai, correction mouvements
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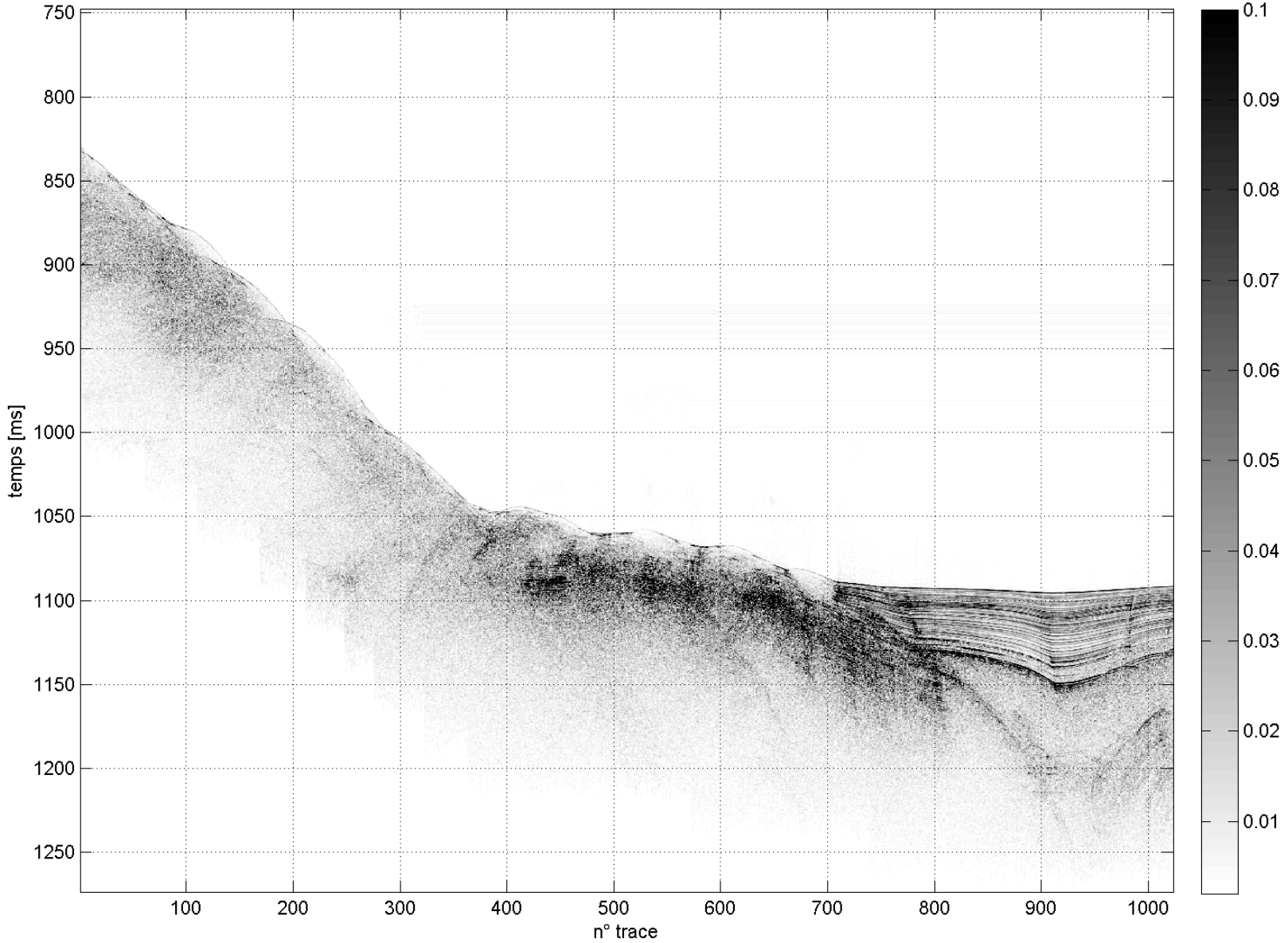
PP0062_D20141116_T044531.SEG
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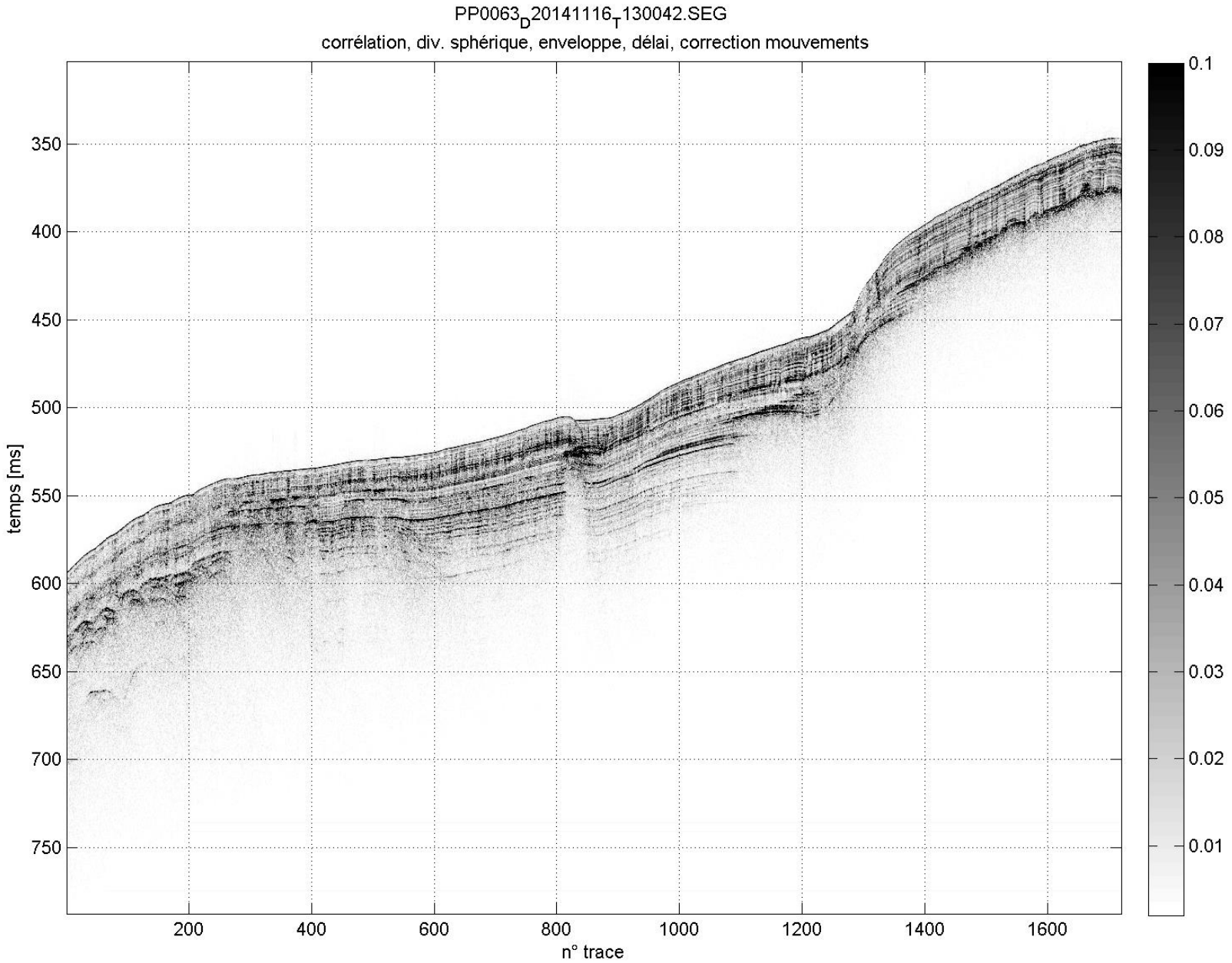
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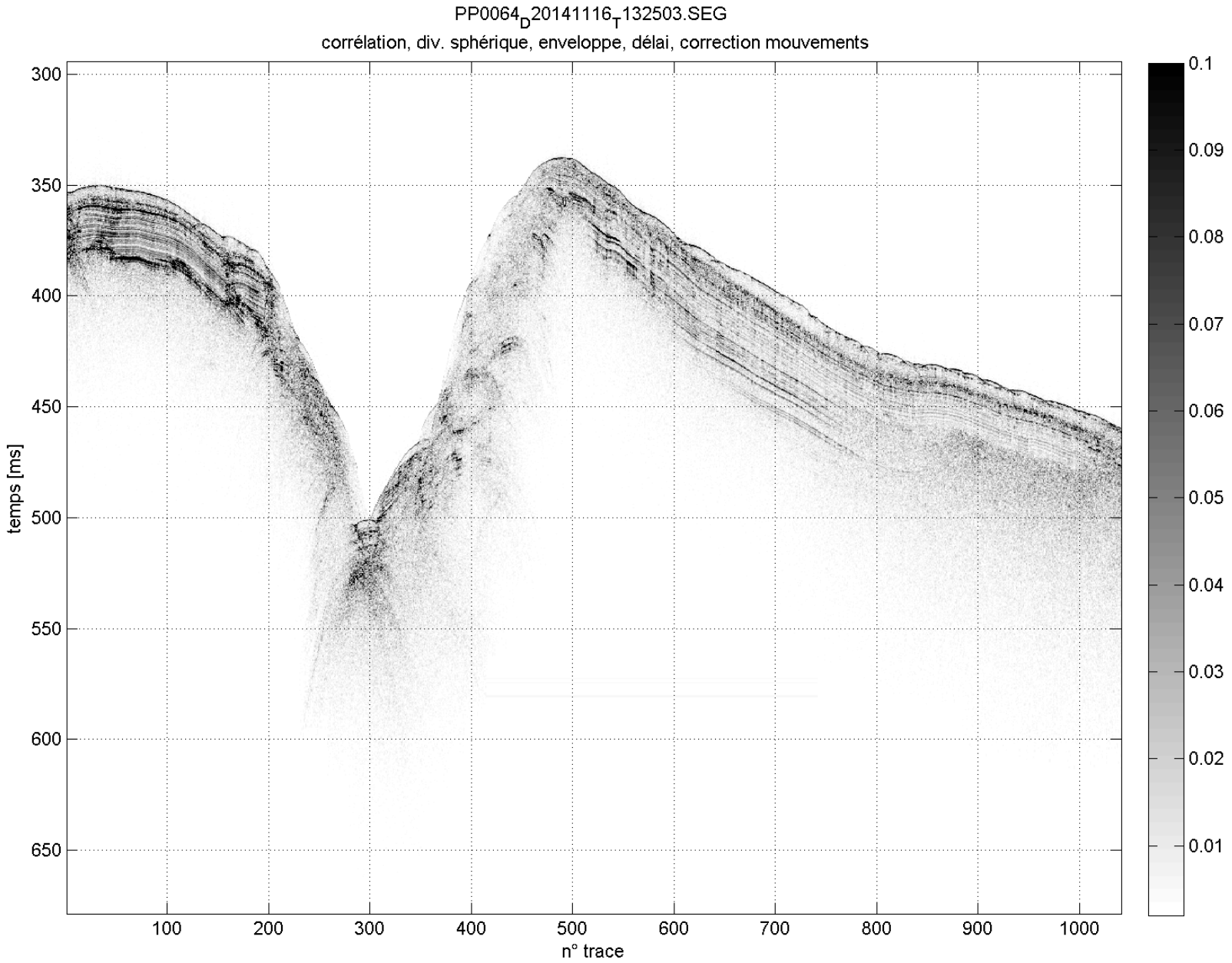
1000
1200
1400
1600
n° trace
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01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corrélation, div. sphérique, enveloppe, délai, correction mouvements
temps [ms]
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350
400
450
500
550
600
650
100
200
300
400
500
600
700
800
900
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n° trace
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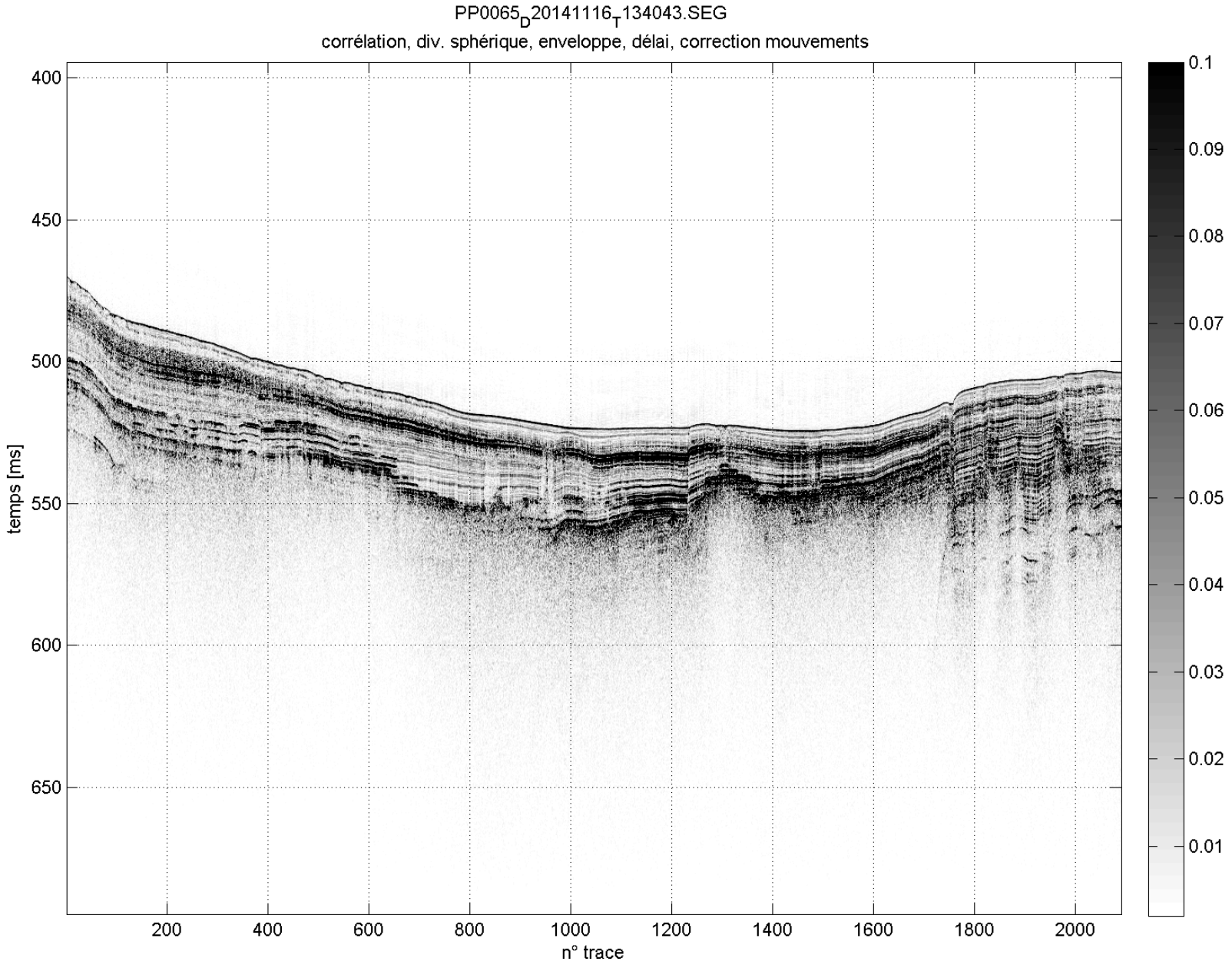
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temps [ms]
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600
650
200
400
600
800
1000
1200
1400
1600
1800
2000
n° trace
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0.09
0.08
0.07
0.06
0.05
0.04
0.03
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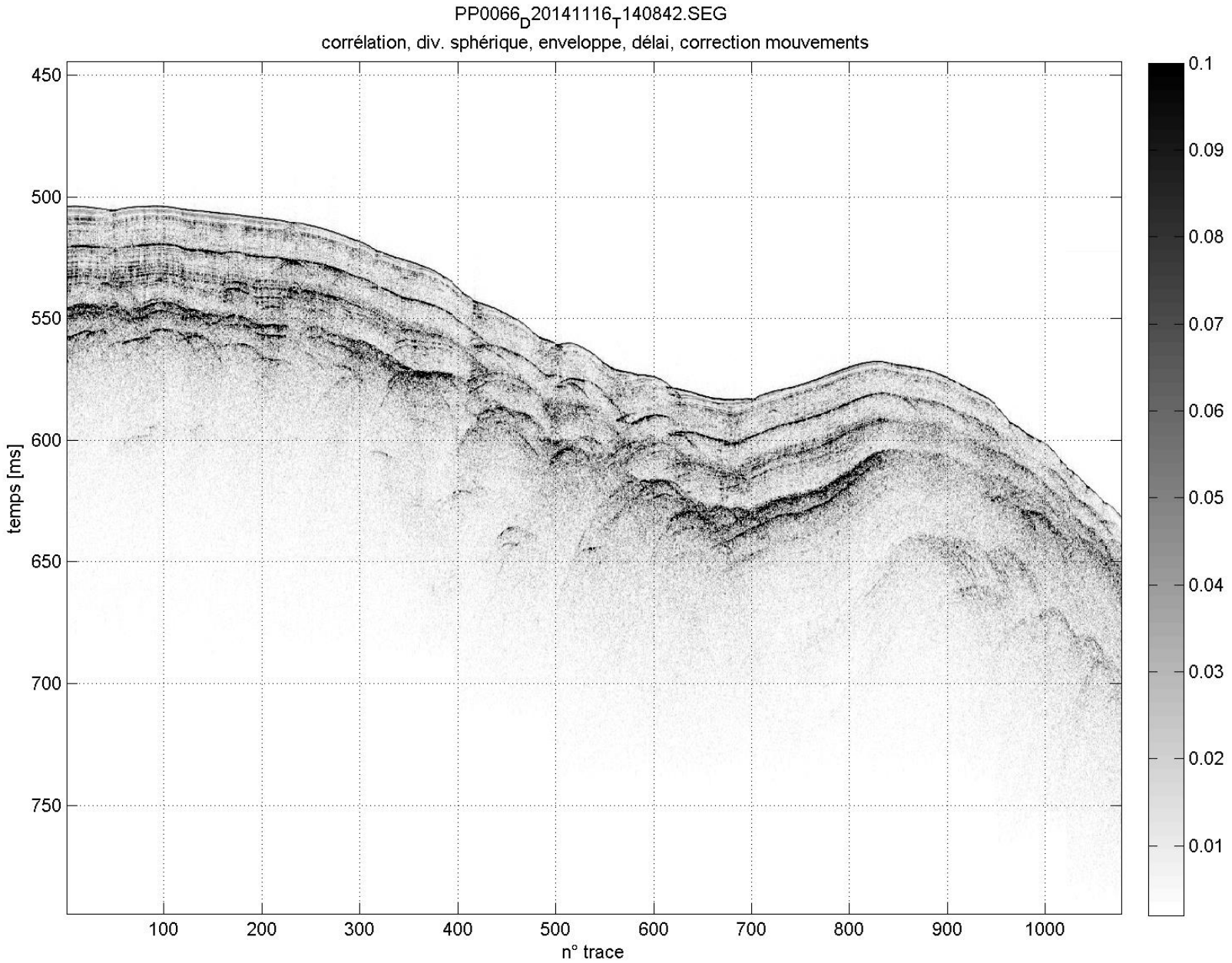
0.01


PP0066_D20141116_T140842.SEG
corrélation, div. sphérique, enveloppe, délai, correction mouvements
temps [ms]
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500
550
600
650
700
750
n° trace
100
200
300
400
500
600
700
800
900
1000
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01