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High resolution seismic reflection survey of lake Garda: First results

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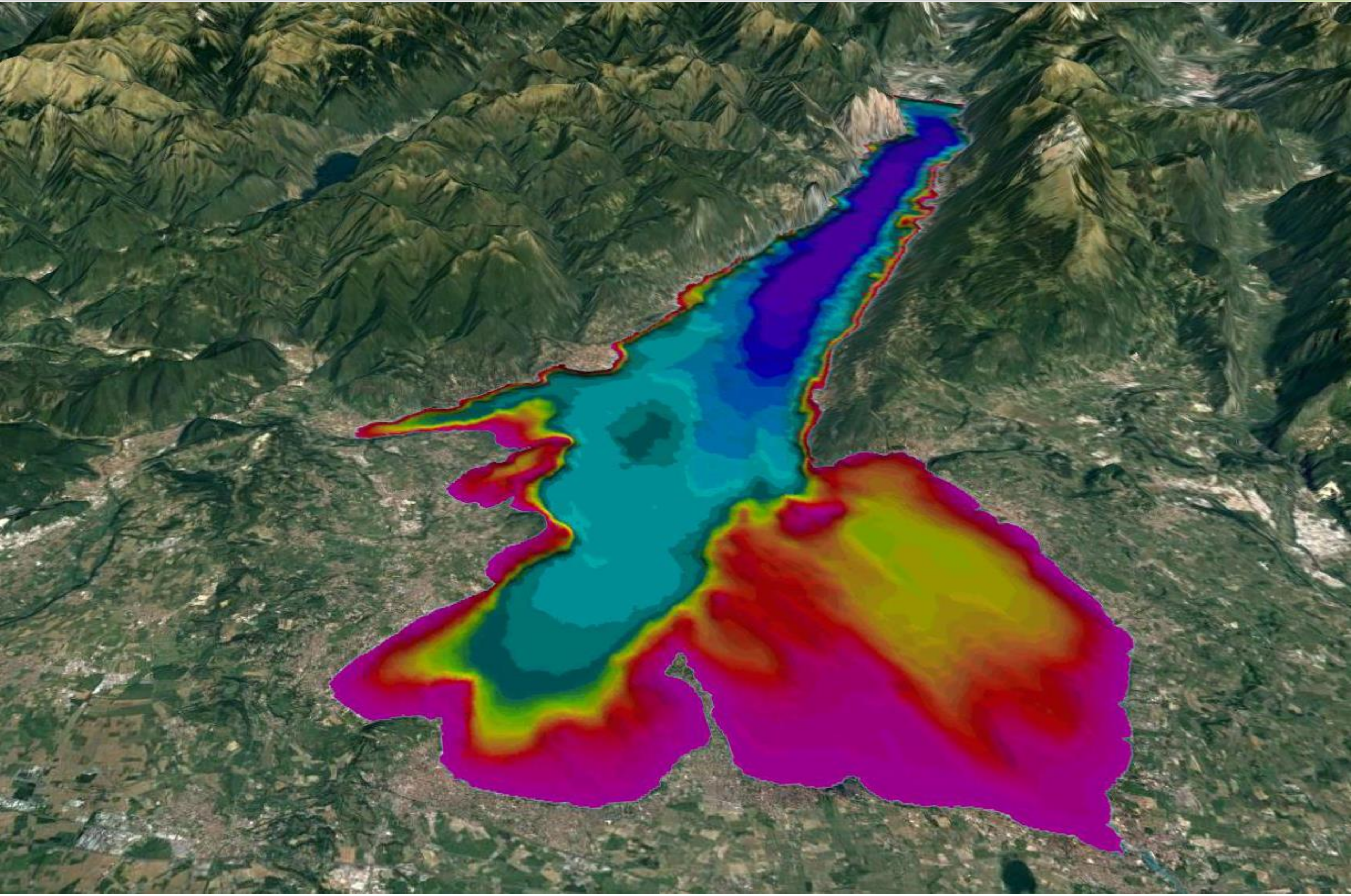
MATTEO MELI, FABRIZIO DEL BIANCO, VALENTINA FERRANTE, Consorzio, Proambiente, Bologna, Italy


Image © 2018 European Space Imaging
Google Earth



CONSIGLIO NAZIONALE DELLE RICERCHE
Istituto di Scienze Marine - Bologna

RILIEVO MORFOBATIMETRICO/STRATIGRAFICO DEL LAGO DI GARDA (*BENACO*)

Matteo Meli[a], Luca Gasperini[b] Alfredo Marzocchi [c], Giuseppe Stanghellini[b], Valentina Ferrante[a], Fabrizio Del Bianco[a], Enrico Dalpasso[b], Erica Cabrioli [c], Stefano Mazza [c], Michele Donatoni [d]

ISMAR – CNR Rapporto Tecnico n. 148

Bologna, Dicembre 2017

3. Dati tecnici del rilievo

Imbarcazione:

- motobarca Chris Craft, Coho 33, 160 cv x 2, attrezzata per gli scopi del rilievo (Fig. 1);
- veicolo autonomo di superficie (USV) SWAP (Fig. 2).

Acquisizione: rilievo eseguito dal 9 novembre al 14 dicembre 2017.

Luogo: Lago di Garda.

Obiettivi: indagine geologica/geofisica del Lago di Garda per realizzazione mappa morfo-batimetrica.

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Lavoro svolto (in dettaglio vedi **Allegato 3**):

- acquisizione di 70 profili ecografici;
- acquisizione di 1049 profili sismici a riflessione CHIRP (per un totale di circa 2300 km) ad altissima risoluzione (**Allegato 1**);
- acquisizione di 2 misure CTD per effettuare la corretta calibrazione della velocità di propagazione del suono nell'acqua del lago (**Allegato 2**);
- prove sperimentali, con esito positivo, di utilizzo del veicolo autonomo di superficie (USV) SWAP nel Golfo di Manerba per acquisizione di dati ad alta risoluzione in aree di estrema vicinanza alla costa o inaccessibili alle imbarcazioni.

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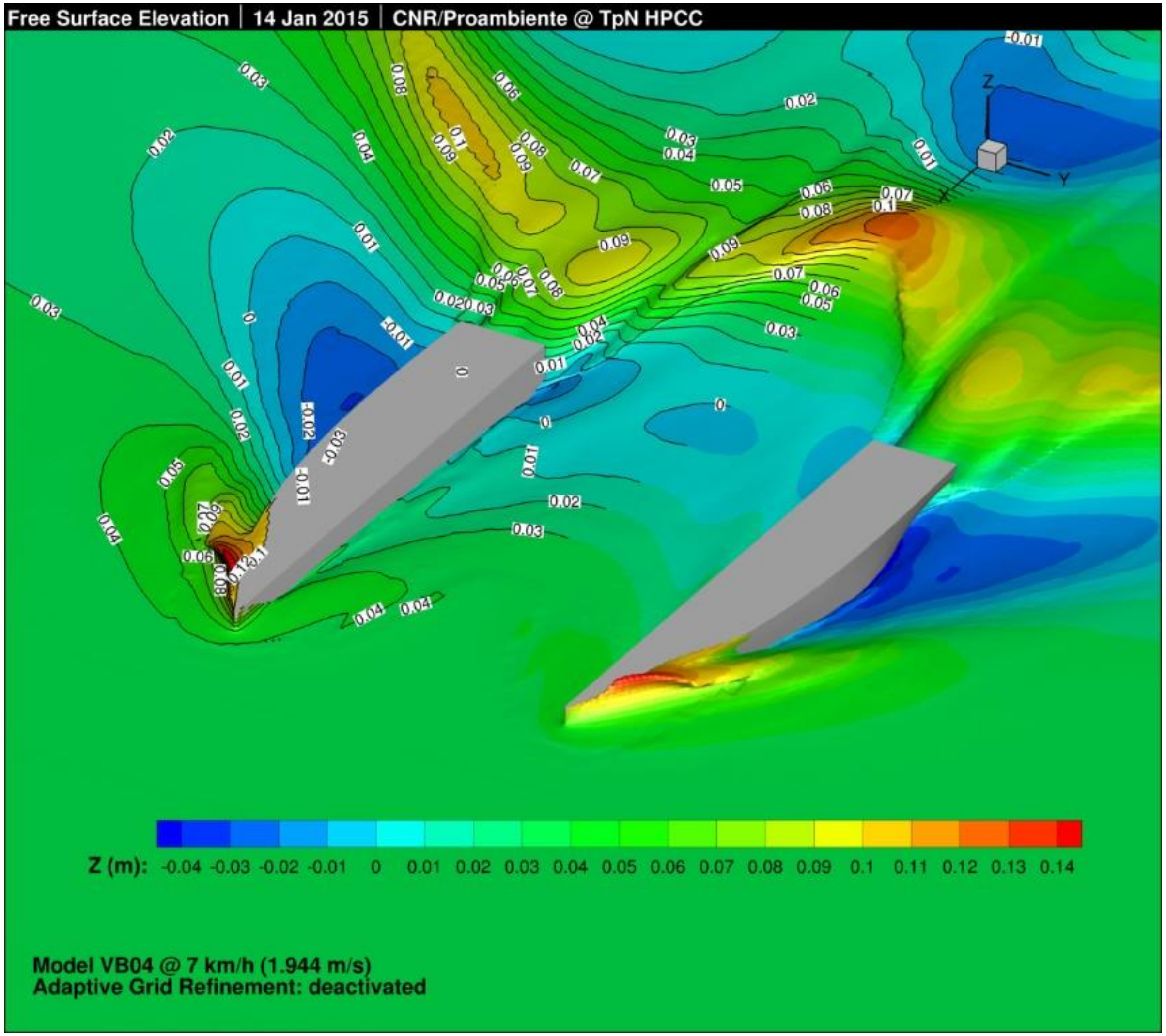
BENTHOS


NAIADI
NEW AUTOMATIC/AUTONOMOUS SYSTEMS
TO STUDY AND MONITOR AQUATIC ENVIRONMENTS

The SWAP Project

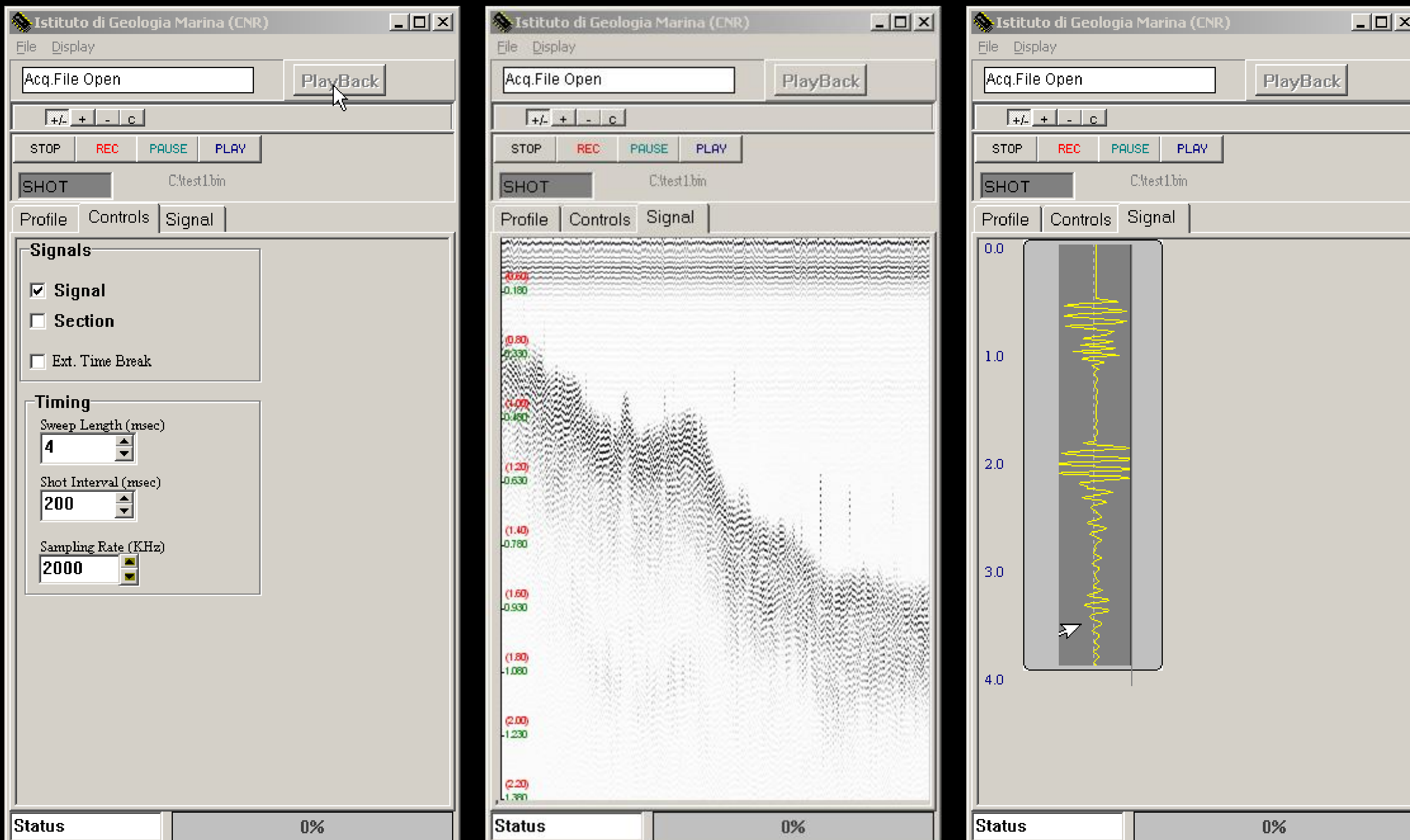
The SWAP Project



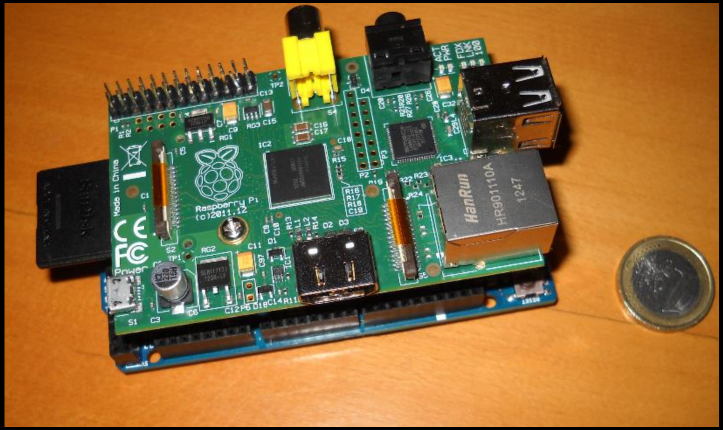
The SWAP Project

The SWAP Project

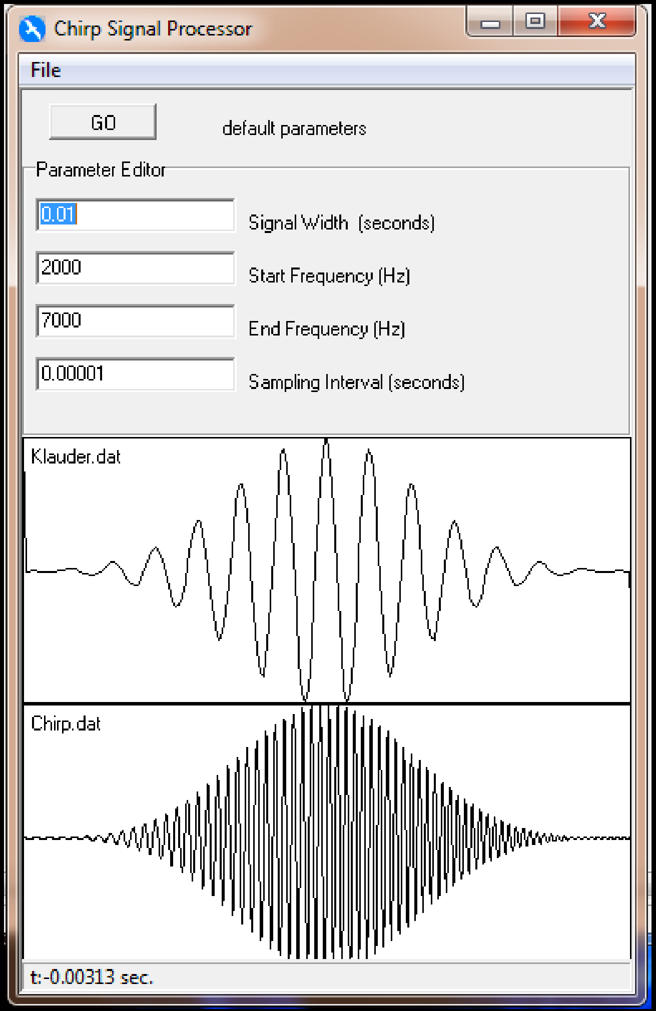
Echosounder



Chirp sonar

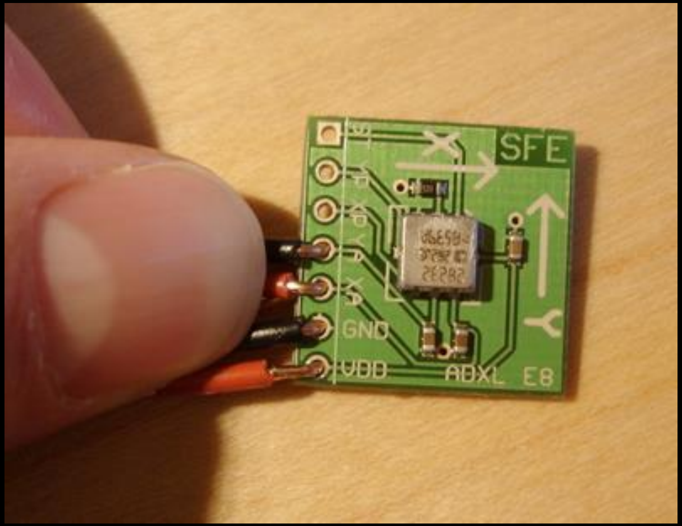

Raspberry Pi
HanRun
HR901110A

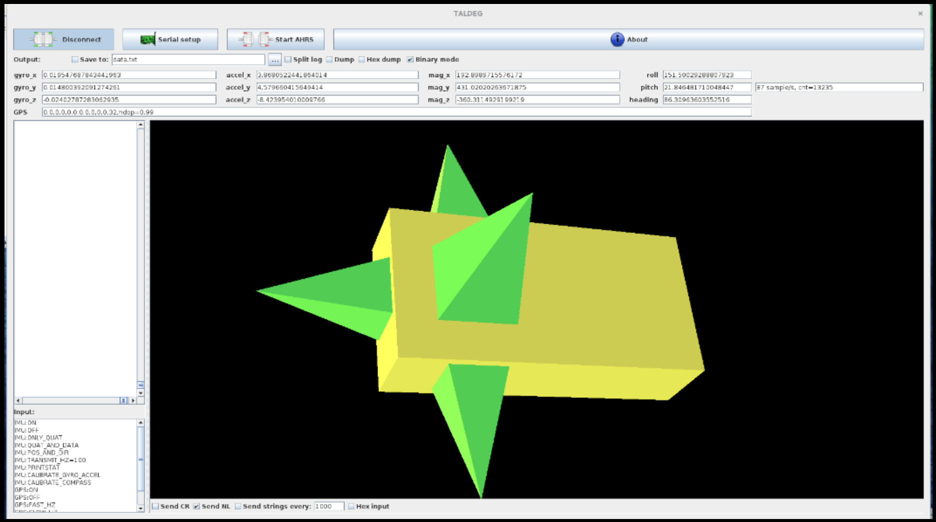

MONACOR
AR-50
50 WMAX/8 Ω

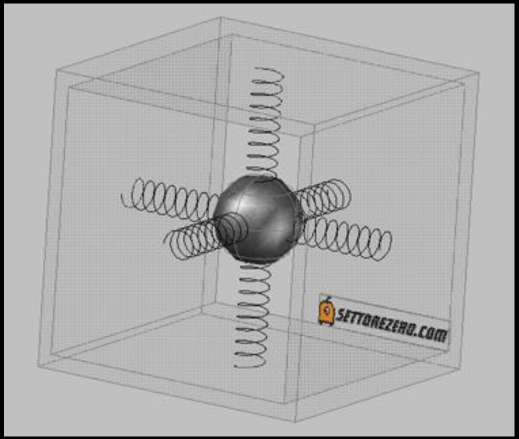

Chirp Signal Processor
File
GO
default parameters
Parameter Editor
0.01
Signal Width (seconds)
2000
Start Frequency (Hz)
7000
End Frequency (Hz)
0.00001
Sampling Interval (seconds)
Klauder.dat
Chirp.dat
t:-0.00313 sec.

MRU

(Motion Reference Unit)

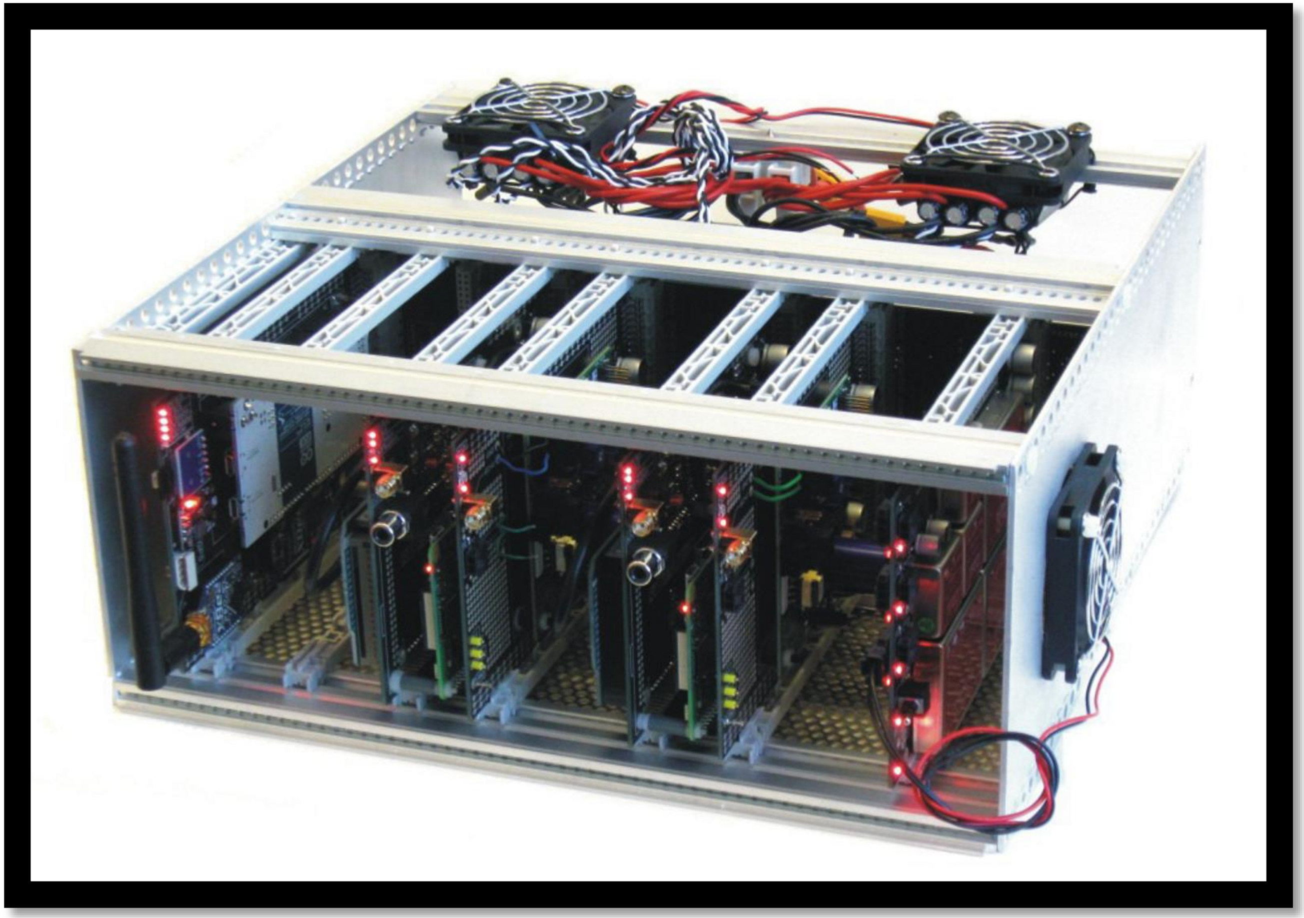






The SWAP Project

«open» Hardware



«open» Software

Computers & Geosciences 35 (2009) 1497–1507

Contents lists available at ScienceDirect

Computers & Geosciences

journal homepage: www.elsevier.com/locate/cageo

SeisPrho: An interactive computer program for processing and interpretation of high-resolution seismic reflection profiles ☆

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ARTICLE INFO

Article history:
Received 21 August 2007
Received in revised form
3 April 2008
Accepted 9 April 2008

Keywords:
SeisPrho
Seismic reflection
Marine geology
Seismic processing
Seismic interpretation
Interactive mapping

ABSTRACT

SeisPrho is an interactive computer program for processing and interpreting high-resolution seismic reflection profiles developed using the Delphi/Kylix multiplatform programming environment. For this reason, it is available under Windows™ and Linux™ operating systems. The program allows the users to handle SEG-Y data files (and other non-standard formats) carrying out a processing sequence over the data to obtain, as a final result, bitmap images of seismic sections. Some basic algorithms are implemented, including filtering and deconvolution. However, the main feature of SeisPrho is its interactive graphic interface, which provides the user with several tools for interpreting the data, such as reflector picking and map digitizing. Moreover, the program allows importing and geo-referencing maps and seismic profiles in the form of digital images. Trace-by-trace analysis of seismic signal and sea-bottom reflectivity is also implemented, as well as other special functions such as compilation of time-slice maps from close-spaced grids of seismic lines. SeisPrho is distributed as public domain software for non-commercial purposes by the Marine Geology division of the Istituto di Scienze Marine (ISMAR-CNR). This paper is an introduction to the program and a preliminary guide to the users.

1. Introduction

The rapid progress in the development of marine high-resolution seismic reflection systems provides earth scientists with powerful tools for investigating the shallow subsurface. Digital technologies applied to advanced high-resolution seismic sources and sonars (mini G.I. guns, high-resolution sparkers, boomers sub-bottom profilers, chirp and side-scan sonars) opened the use of these techniques to non-specialists by simplifying acquisition and processing procedures. On the other hand, the large amount of digital data collected, also due to the wide frequency bandwidth of these instruments, calls for the development of *ad hoc* processing and interpretation software that could provide earth scientists with a tool to manage efficiently these data sets. Geographical information systems (GIS) although useful for many types of geo-marine data, such as bathymetry, sea-bottom reflectivity and sample location, are not generally able to handle raw seismic data. Moreover, they are often rather complex, because designed to implement a number of procedures not strictly necessary to specific targets of Marine Geology. Our need for a simple and friendly tool to manage high-resolution seismic profiles, easily sharable with colleagues of different groups, stimulated us to design a new software for processing and interpretation of marine seismic data starting from field acquisition files. The result of our work is SeisPrho (Fig. 1), an interactive computer program written in Pascal and designed to be used on small portable systems operating under Windows™ or Linux™. SeisPrho includes procedures for reading SEG-Y files (Barry et al., 1975), the most widely used format for this type of data, and carry out basic processing (filtering, deconvolution and other modules). However, it is particularly useful for interpretation of final seismic sections, due to an interactive graphic interface which allows the user to perform advanced operations such as reflector picking, reflectivity analysis, editing and plotting of navigation data, and more. Additional features include the possibility of importing maps and seismic profiles in the form of bitmap images, that can subsequently be geo-referenced and some other interpretation-oriented functions such as the creation of *time-slice* maps. This paper introduces SeisPrho to the earth-science community giving an overview of philosophy and practical use of the software.

2. Backgrounds

The development of SeisPrho is a long-term project and has a complex history. Its main core is based on a batch code forgotten in old computers, originally written for processing marine single-channel seismic data during the earlier cruises where digital acquisition systems were available. Some years ago, since a Visual

☆ Code available from server: http://software.bo.ismar.cnr.it/seisprho.

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doi:10.1016/j.cageo.2008.04.014

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Computers & Geosciences 34 (2008) 103–114

COMPUTERS & GEOSCIENCES

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ChirCor: A new tool for generating synthetic chirp-sonar seismograms ☆

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Istituto di Scienze Marine, Geologia Marina, CNR, Bologna, Italy

Received 29 May 2006; received in revised form 6 September 2006; accepted 17 January 2007

Abstract

The long-term successful use of synthetic seismograms in traditional seismic reflection studies suggests that their implementation for high-resolution non-impulsive seismic sources would also be beneficial. We present here *ChirCor v1.0*, a program for managing physical-log data (P-wave velocity and density) and chirp-sonar seismograms, also equipped with a synthetic-trace generator, that could be used for correlating real seismograms to synthetics. The software, designed with a user-friendly graphic interface, is intended mainly for oceanographers and marine geologists as a tool for correlating high-resolution seismic images and sediment cores. *ChirCor v1.0* will be distributed as freeware for non-commercial purposes. We provide instructions regarding the use of the program together with a description of the algorithms implemented in the code; we also include an example of how to operate with the program based on the data collected during the MARMARA2001 marine geological expedition.

Keywords: ChirCor; Synthetic seismograms; Chirp sub-bottom profiler; Stratigraphic correlation; Sediment cores; Physical properties; Stratigraphic logs; Marmara Sea; Submarine paleoseismology

1. Introduction

Since their introduction (Peterson et al., 1955), synthetic seismograms have been employed intensively in correlating seismic reflection data and physical logs from both sediment cores and boreholes. Synthetics are obtained by converting density and velocity logs into a reflectivity time series, convolved subsequently with an appropriate wavelet to obtain a seismogram. Such synthetic traces can be useful in correlating geological boundaries, found in well-cores, to sharpen changes in acoustic impedance, the so-called "reflectors", observed in seismic profiles. Examples of the successful use of synthetics in marine geological studies are numerous and span different fields. The core log/seismic integration, for instance, helped to extrapolate paleogeographic events found in the core record of ODP leg 138 (eastern equatorial Pacific) well beyond the borehole (Bloomer and Mayer, 1997), and helped to understand the post-glacial evolution of Saanich Inlet, British Columbia (Mosher and

☆ Code available from server: http://software.bo.ismar.cnr.it/chircor, code also available from server at http://www.iamg.org/CGEditor/index.htm

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doi:10.1016/j.cageo.2007.01.004

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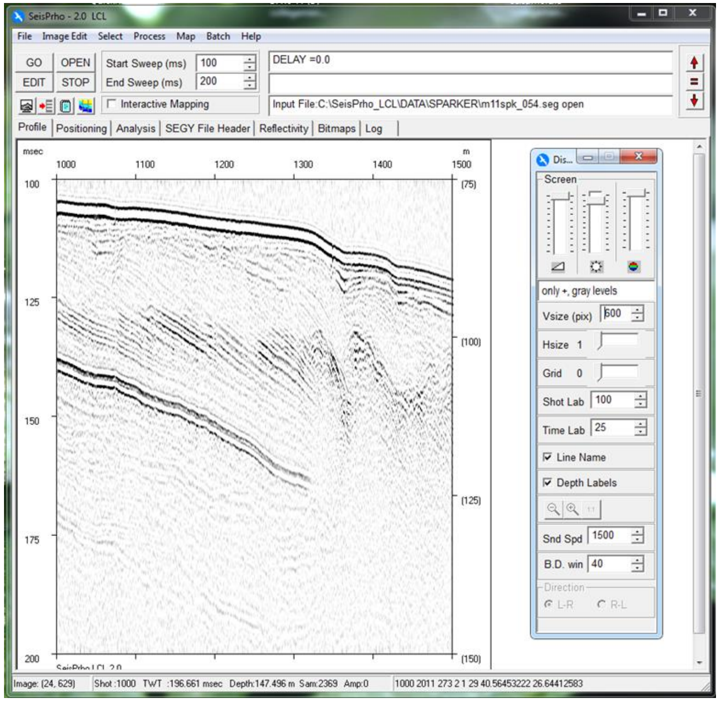
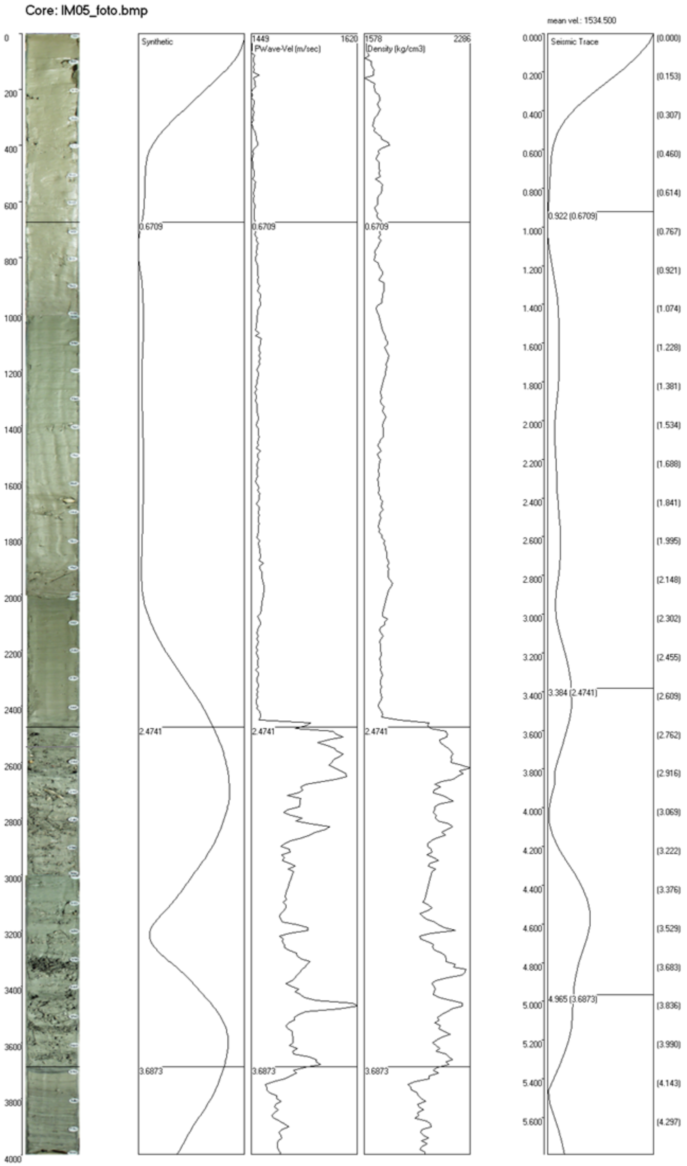
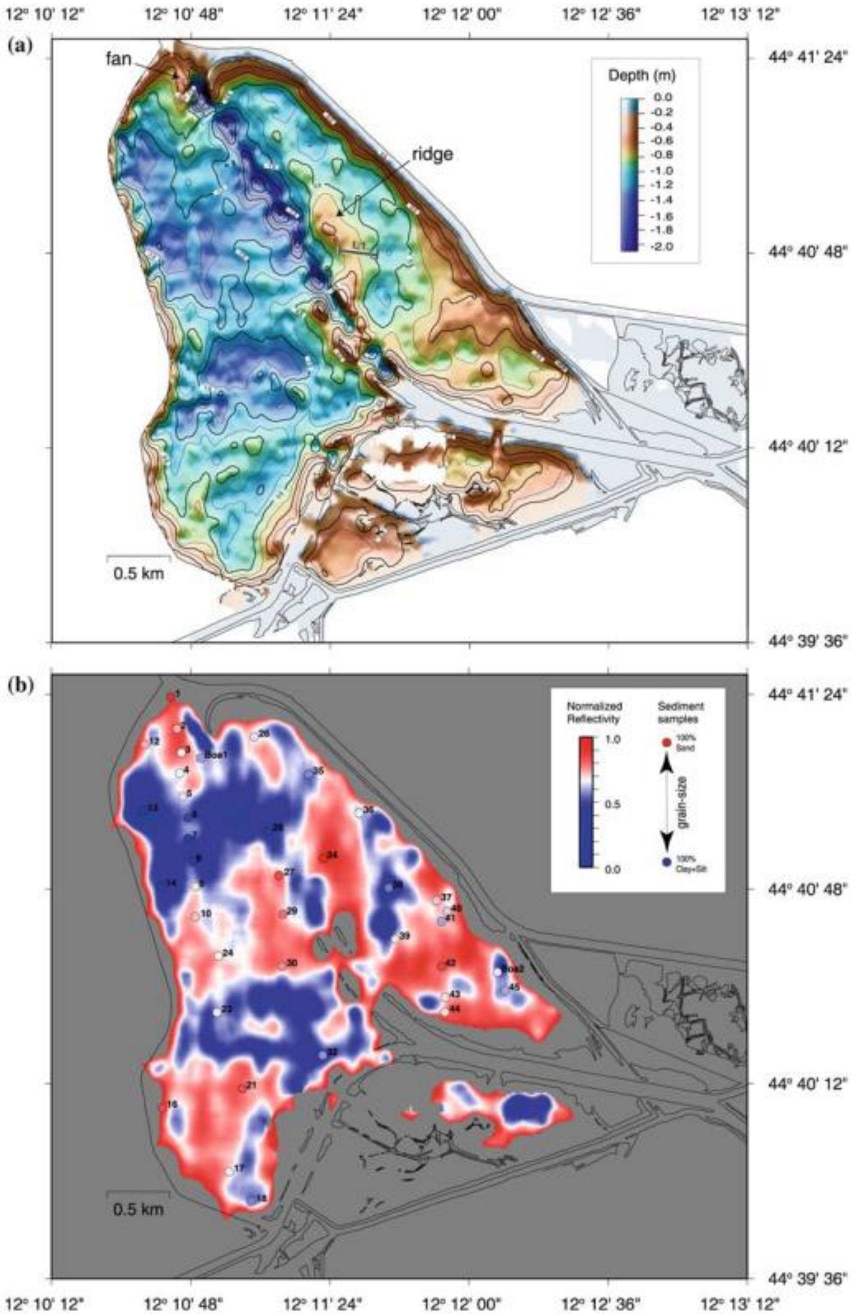


SeisPrho - 2.0 LCL
File Image Edit Select Process Map Batch Help
GO OPEN
EDIT STOP
Start Sweep (ms) 100
End Sweep (ms) 200
DELAY =0.0
Interactive Mapping
Input File:C:\SeisPrho_LCL\DATA\SPARKER\m11spk_054.seg open
Profile Positioning Analysis SEGY File Header Reflectivity Bitmaps Log
msec
m
1000 1100 1200 1300 1400 1500
100 125 150 175 200
(75) (100) (125) (150)
Screen
only +, gray levels
Vsize (pix) 600
Hsize 1
Grid 0
Shot Lab 100
Time Lab 25
Line Name
Depth Labels
Snd Spd 1500
B.D. win 40
Direction
L-R R-L
Image: (24, 629) Shot :1000 TWT :196.661 msec Depth:147.496 m Sam:2369 Amp:0 1000 2011 273 2 1 29 40.56453222 26.64412583



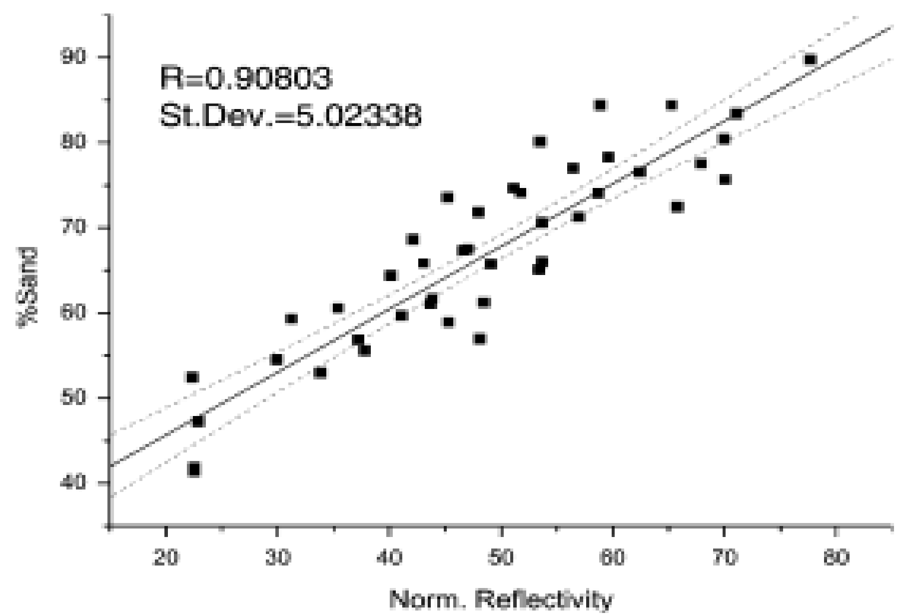
Core: IM05_foto.bmp
Synthetic
PWave-Vel (m/sec)
Density (kg/cm3)
mean vel.: 1534.500
Seismic Trace
0.6709
2.4741
3.6873
0.922 (0.6709)
3.384 (2.4741)
4.965 (3.6873)

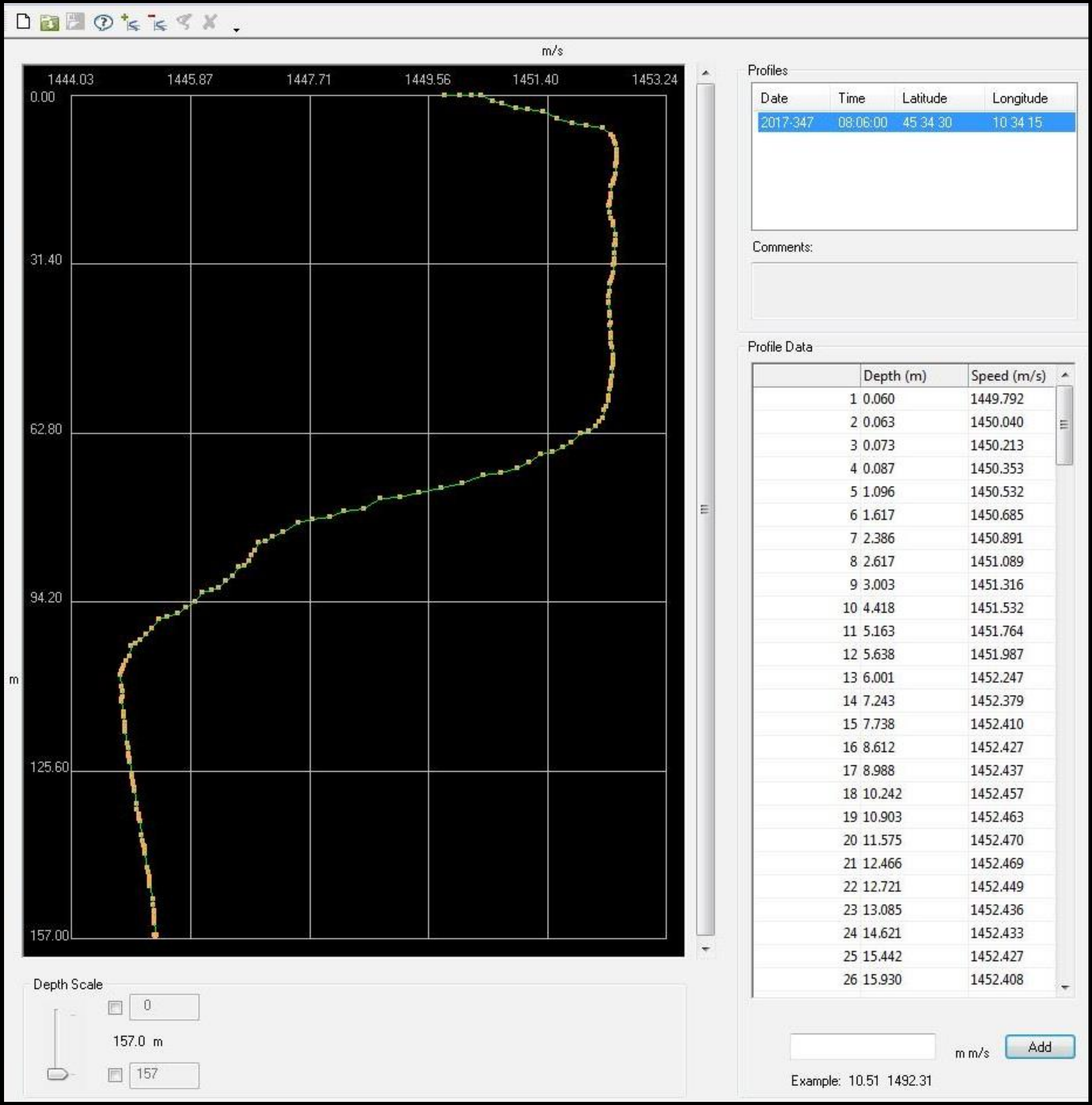


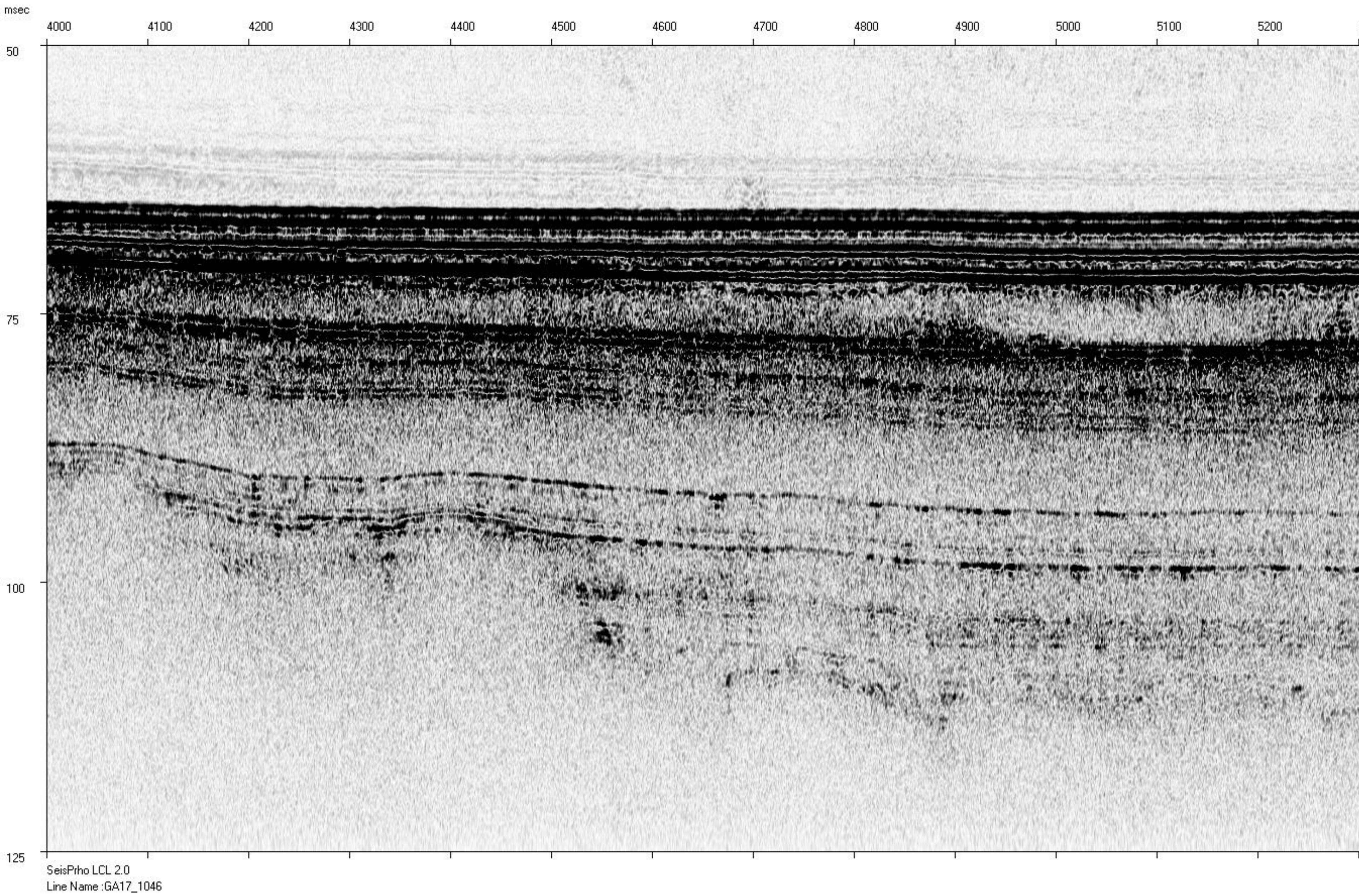
$$R = (A_r/A_s)\, z$$

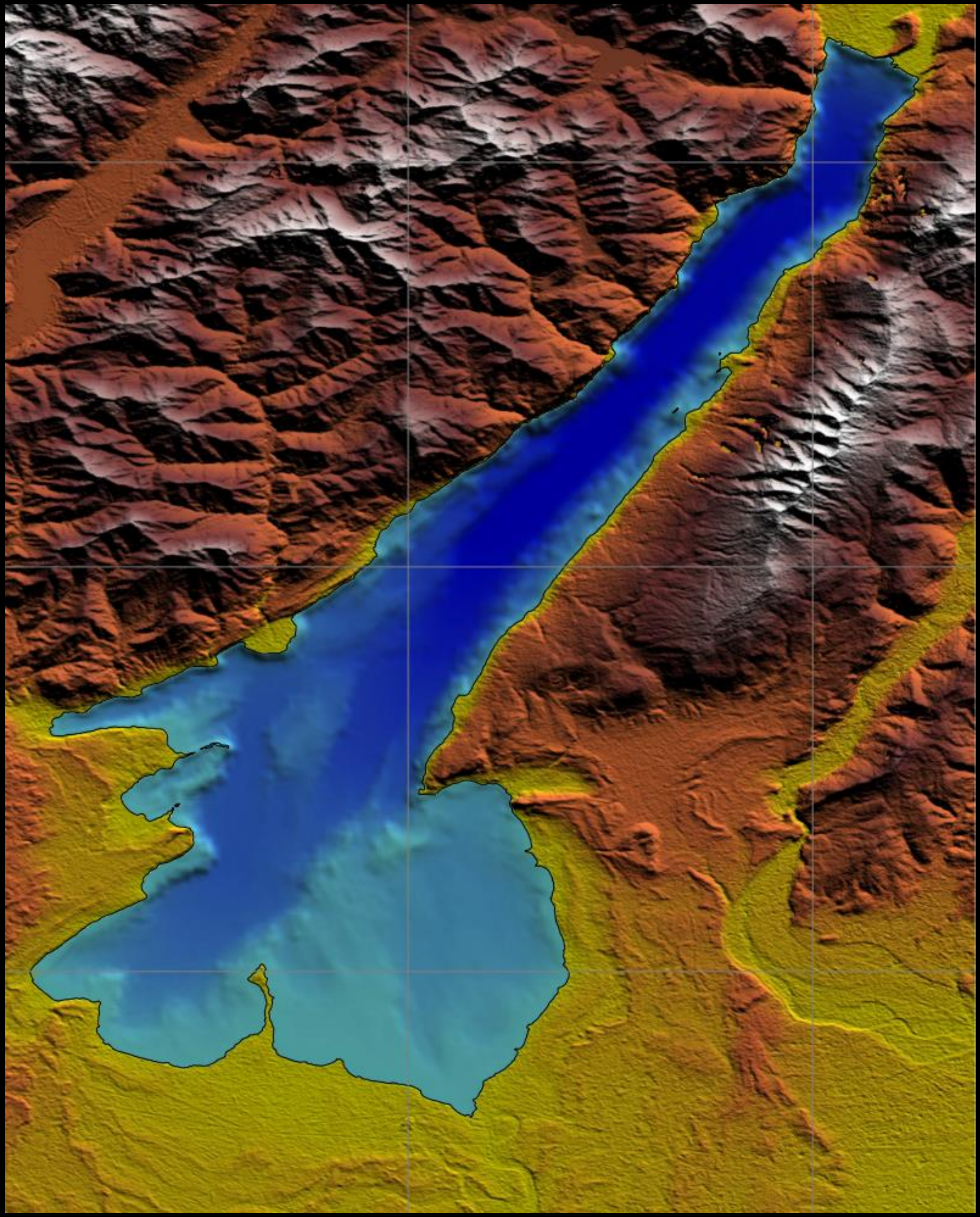
$$A_s = \sum_{i=0}^{W} |x_i|$$

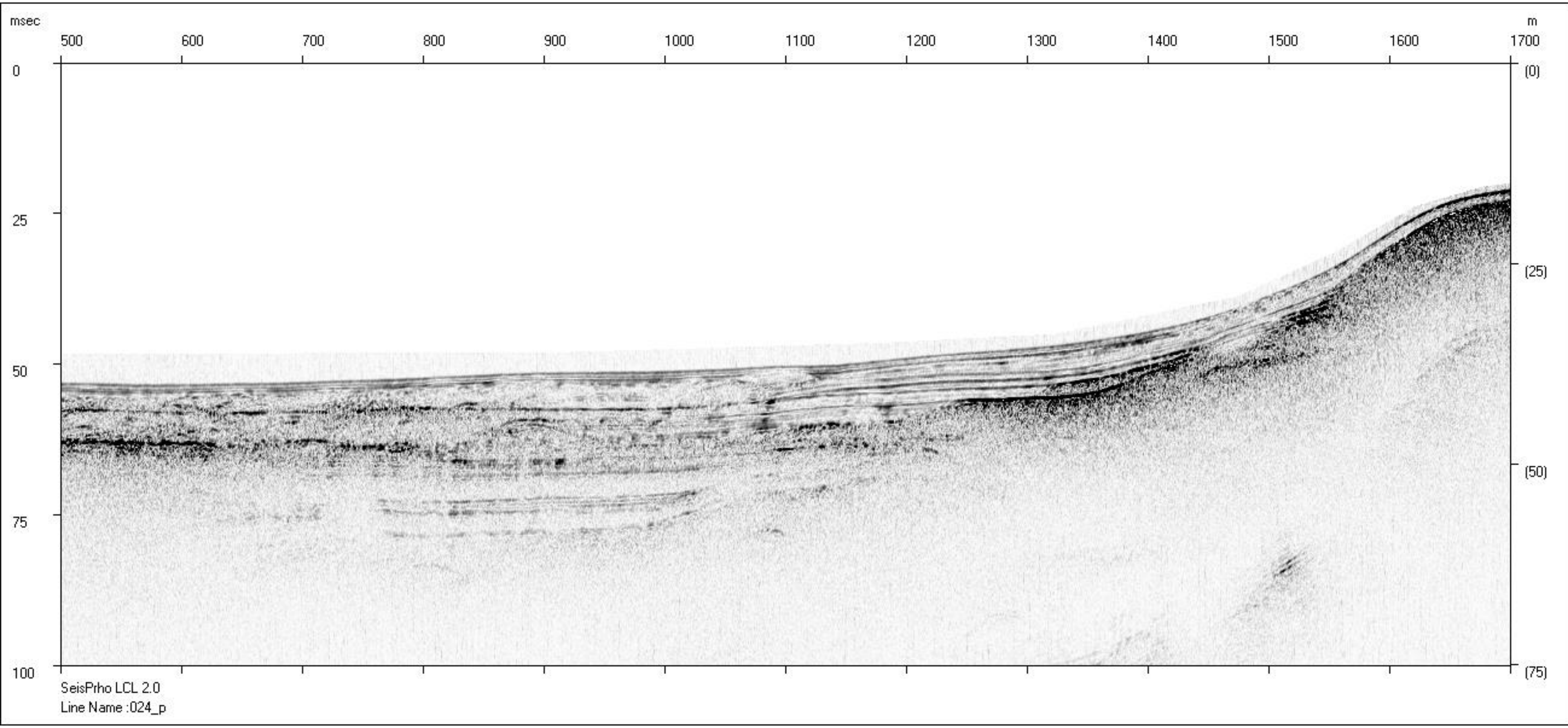
$$A_r = \sum_{i=B}^{B+W} |x_i|$$

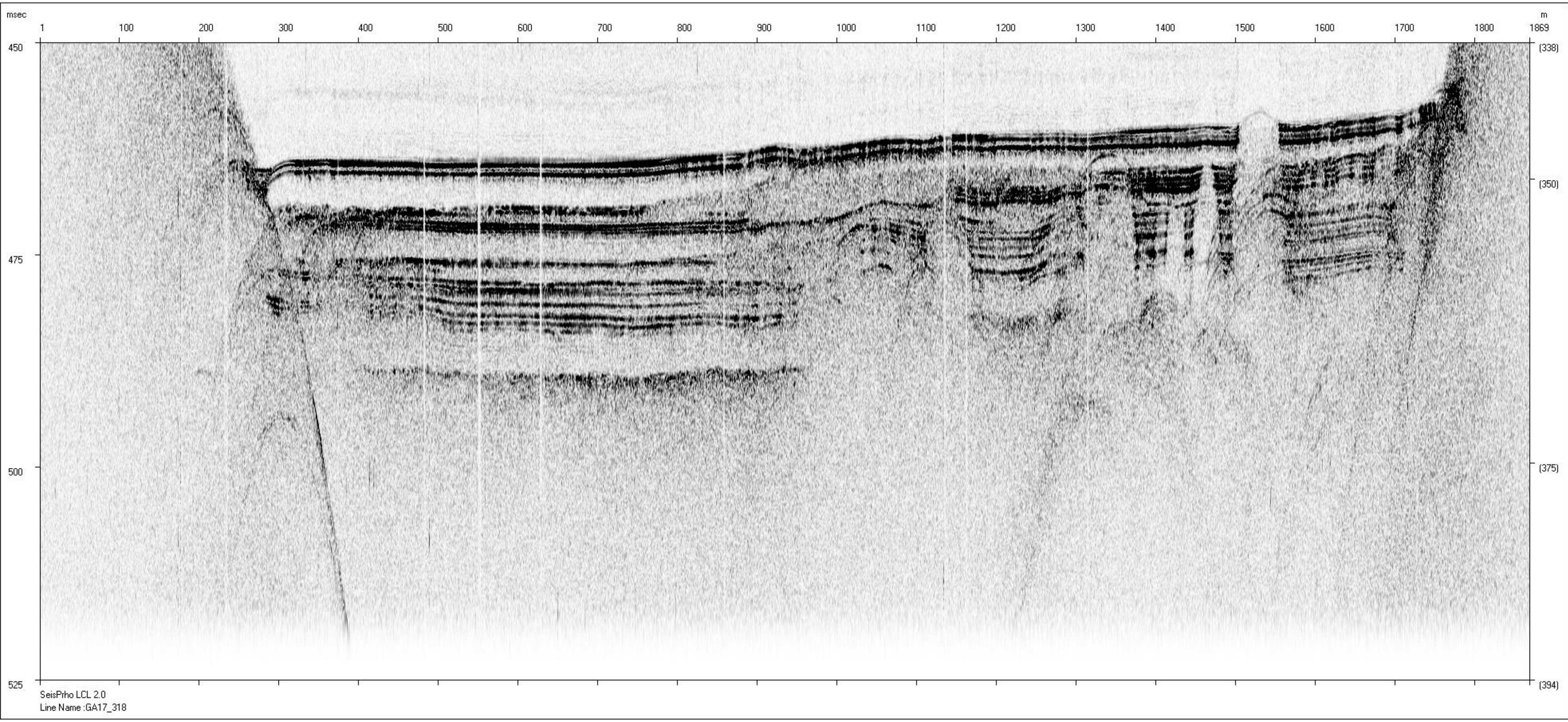



m/s
1444.03
1445.87
1447.71
1449.56
1451.40
1453.24
0.00
31.40
62.80
94.20
125.60
157.00
m
Profiles
Date Time Latitude Longitude
2017-347 08:06:00 45 34 30 10 34 15
Comments:
Profile Data
Depth (m) Speed (m/s)
1 0.060 1449.792
2 0.063 1450.040
3 0.073 1450.213
4 0.087 1450.353
5 1.096 1450.532
6 1.617 1450.685
7 2.386 1450.891
8 2.617 1451.089
9 3.003 1451.316
10 4.418 1451.532
11 5.163 1451.764
12 5.638 1451.987
13 6.001 1452.247
14 7.243 1452.379
15 7.738 1452.410
16 8.612 1452.427
17 8.988 1452.437
18 10.242 1452.457
19 10.903 1452.463
20 11.575 1452.470
21 12.466 1452.469
22 12.721 1452.449
23 13.085 1452.436
24 14.621 1452.433
25 15.442 1452.427
26 15.930 1452.408
Depth Scale
0
157.0 m
157
m m/s
Add
Example: 10.51 1492.31


msec
4000
4100
4200
4300
4400
4500
4600
4700
4800
4900
5000
5100
5200
50
75
100
125
SeisPrho LCL 2.0
Line Name :GA17_1046




msec
m
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
0
25
50
75
100
(0)
(25)
(50)
(75)
SeisPrho LCL 2.0
Line Name :024_p


msec
m
1
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1869
450
475
500
525
(338)
(350)
(375)
(394)
SeisPrho LCL 2.0
Line Name :GA17_318


msec
m
1
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
0
25
50
75
100
(0)
(25)
(50)
(75)
SeisPrho LCL 2.0
Line Name :GA17_1046

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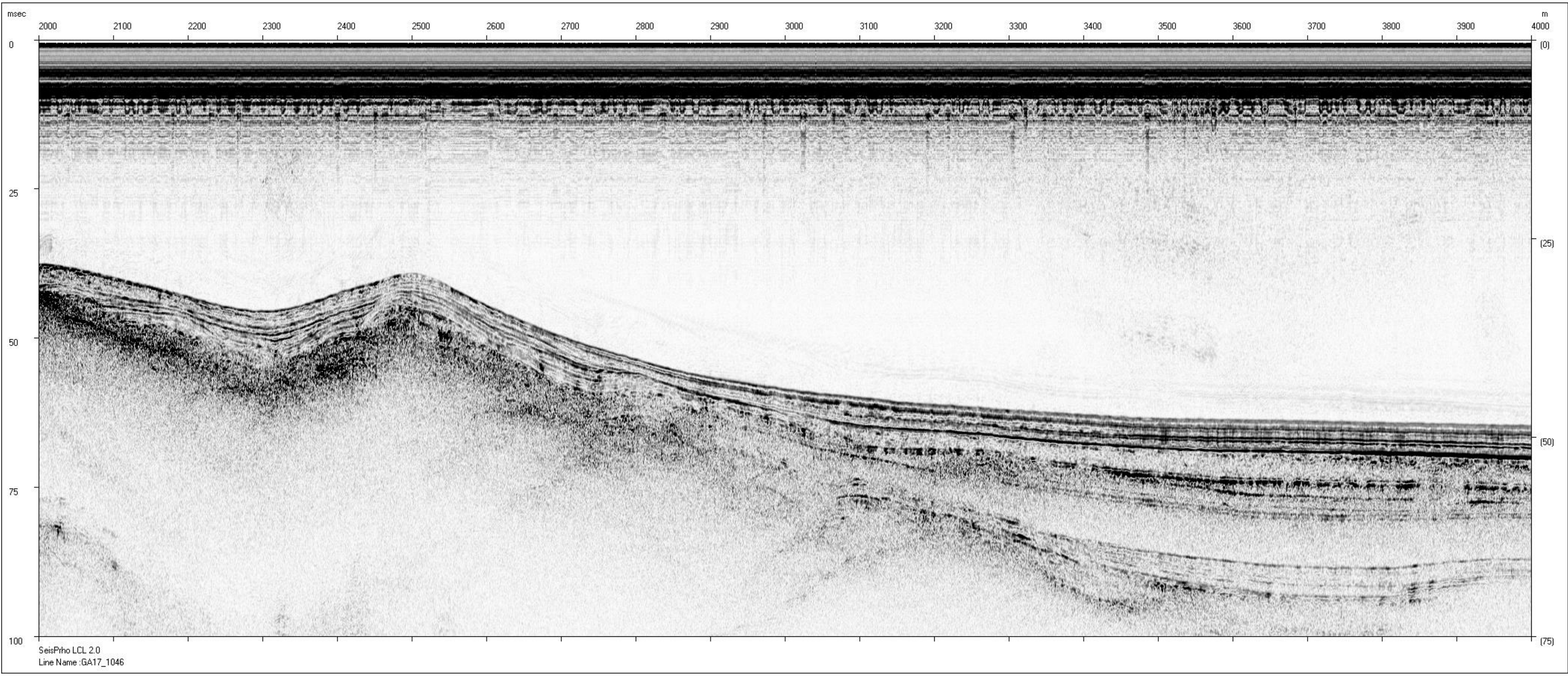
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m
2000
2100
2200
2300
2400
2500
2600
2700
2800
2900
3000
3100
3200
3300
3400
3500
3600
3700
3800
3900
4000
0
25
50
75
100
(0)
(25)
(50)
(75)
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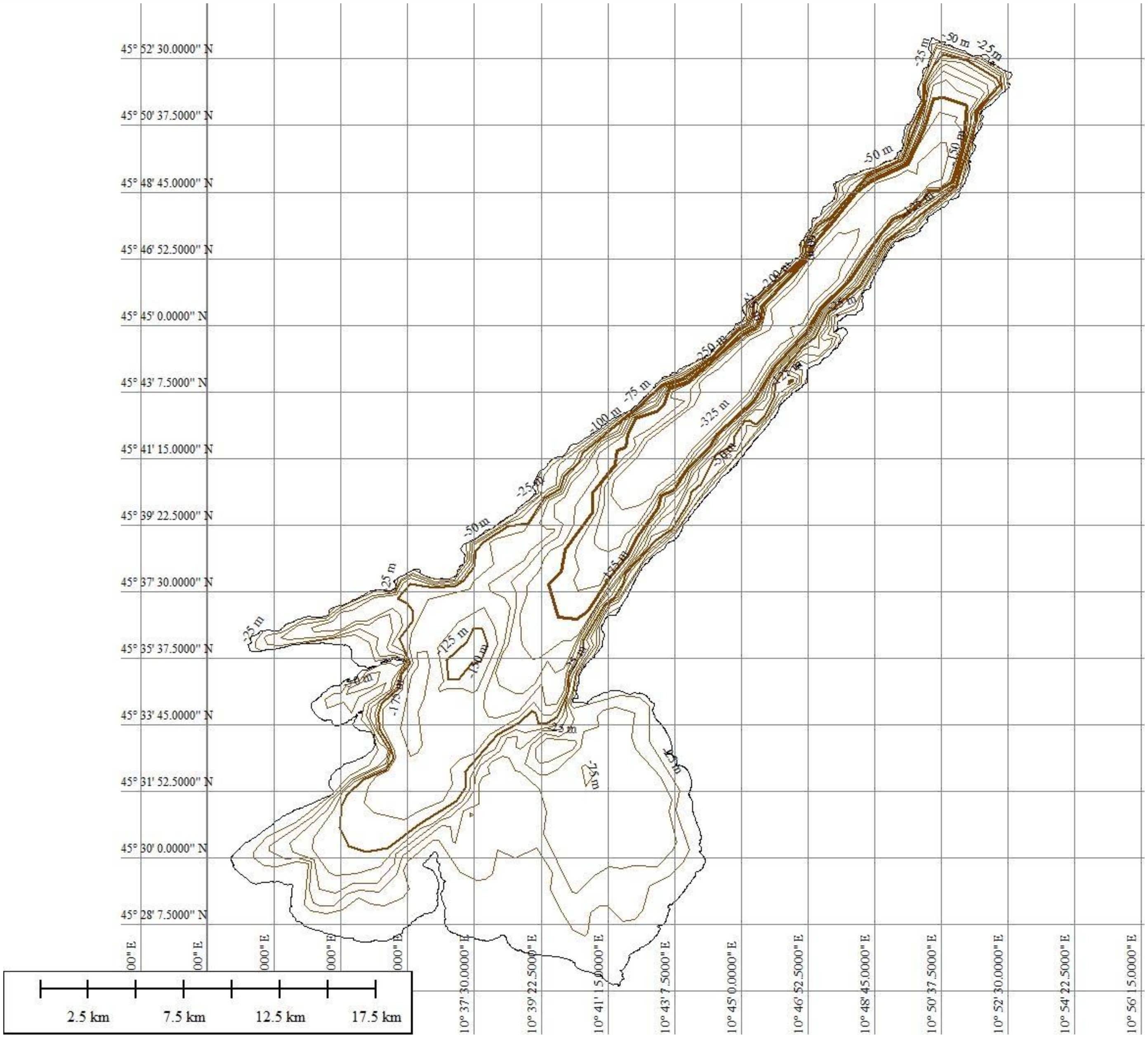

45° 52' 30.0000" N
45° 50' 37.5000" N
45° 48' 45.0000" N
45° 46' 52.5000" N
45° 45' 0.0000" N
45° 43' 7.5000" N
45° 41' 15.0000" N
45° 39' 22.5000" N
45° 37' 30.0000" N
45° 35' 37.5000" N
45° 33' 45.0000" N
45° 31' 52.5000" N
45° 30' 0.0000" N
45° 28' 7.5000" N
10° 37' 30.0000" E
10° 39' 22.5000" E
10° 41' 15.0000" E
10° 43' 7.5000" E
10° 45' 0.0000" E
10° 46' 52.5000" E
10° 48' 45.0000" E
10° 50' 37.5000" E
10° 52' 30.0000" E
10° 54' 22.5000" E
10° 56' 15.0000" E
-25 m
-50 m
-75 m
-100 m
-125 m
-150 m
-250 m
-325 m
2.5 km
7.5 km
12.5 km
17.5 km

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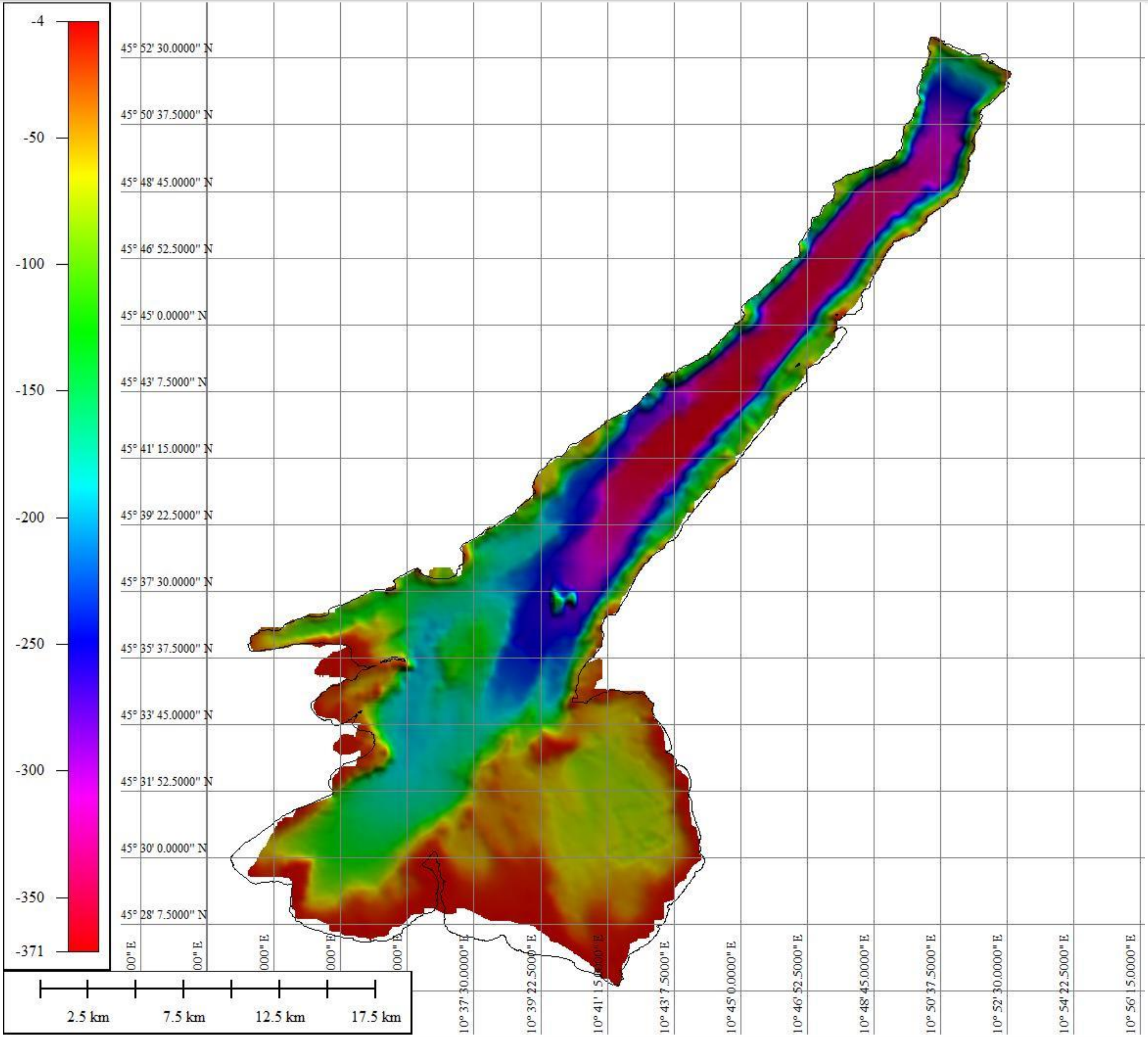
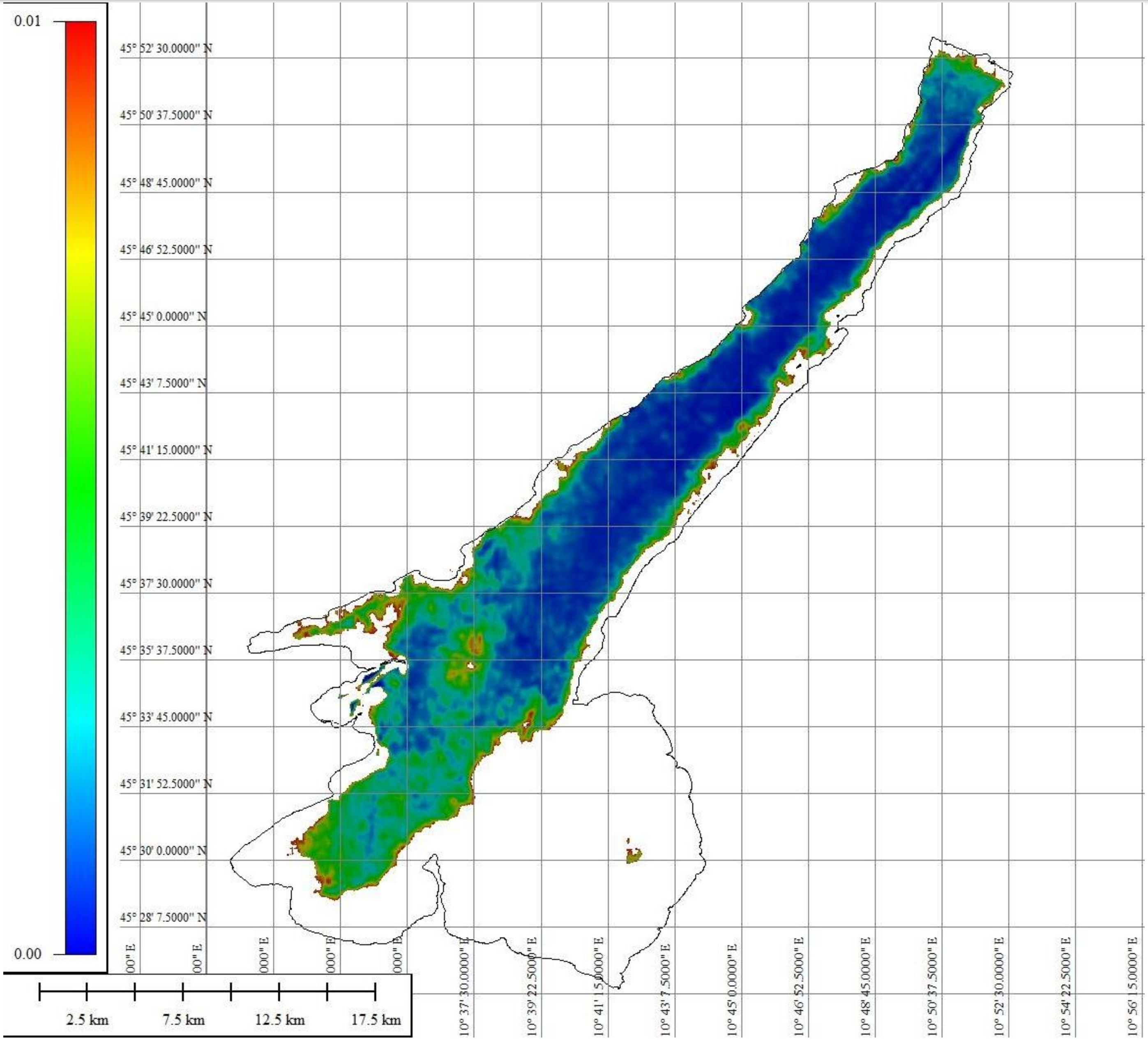


-4
-50
-100
-150
-200
-250
-300
-350
-371
45° 52' 30.0000" N
45° 50' 37.5000" N
45° 48' 45.0000" N
45° 46' 52.5000" N
45° 45' 0.0000" N
45° 43' 7.5000" N
45° 41' 15.0000" N
45° 39' 22.5000" N
45° 37' 30.0000" N
45° 35' 37.5000" N
45° 33' 45.0000" N
45° 31' 52.5000" N
45° 30' 0.0000" N
45° 28' 7.5000" N
2.5 km
7.5 km
12.5 km
17.5 km
10° 37' 30.0000" E
10° 39' 22.5000" E
10° 43' 7.5000" E
10° 45' 0.0000" E
10° 46' 52.5000" E
10° 48' 45.0000" E
10° 50' 37.5000" E
10° 52' 30.0000" E
10° 54' 22.5000" E
10° 56' 15.0000" E


0.01
0.00
45° 52' 30.0000" N
45° 50' 37.5000" N
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45° 45' 0.0000" N
45° 43' 7.5000" N
45° 41' 15.0000" N
45° 39' 22.5000" N
45° 37' 30.0000" N
45° 35' 37.5000" N
45° 33' 45.0000" N
45° 31' 52.5000" N
45° 30' 0.0000" N
45° 28' 7.5000" N
10° 37' 30.0000" E
10° 39' 22.5000" E
10° 41' 15.0000" E
10° 43' 7.5000" E
10° 45' 0.0000" E
10° 46' 52.5000" E
10° 48' 45.0000" E
10° 50' 37.5000" E
10° 52' 30.0000" E
10° 54' 22.5000" E
10° 56' 15.0000" E
2.5 km
7.5 km
12.5 km
17.5 km

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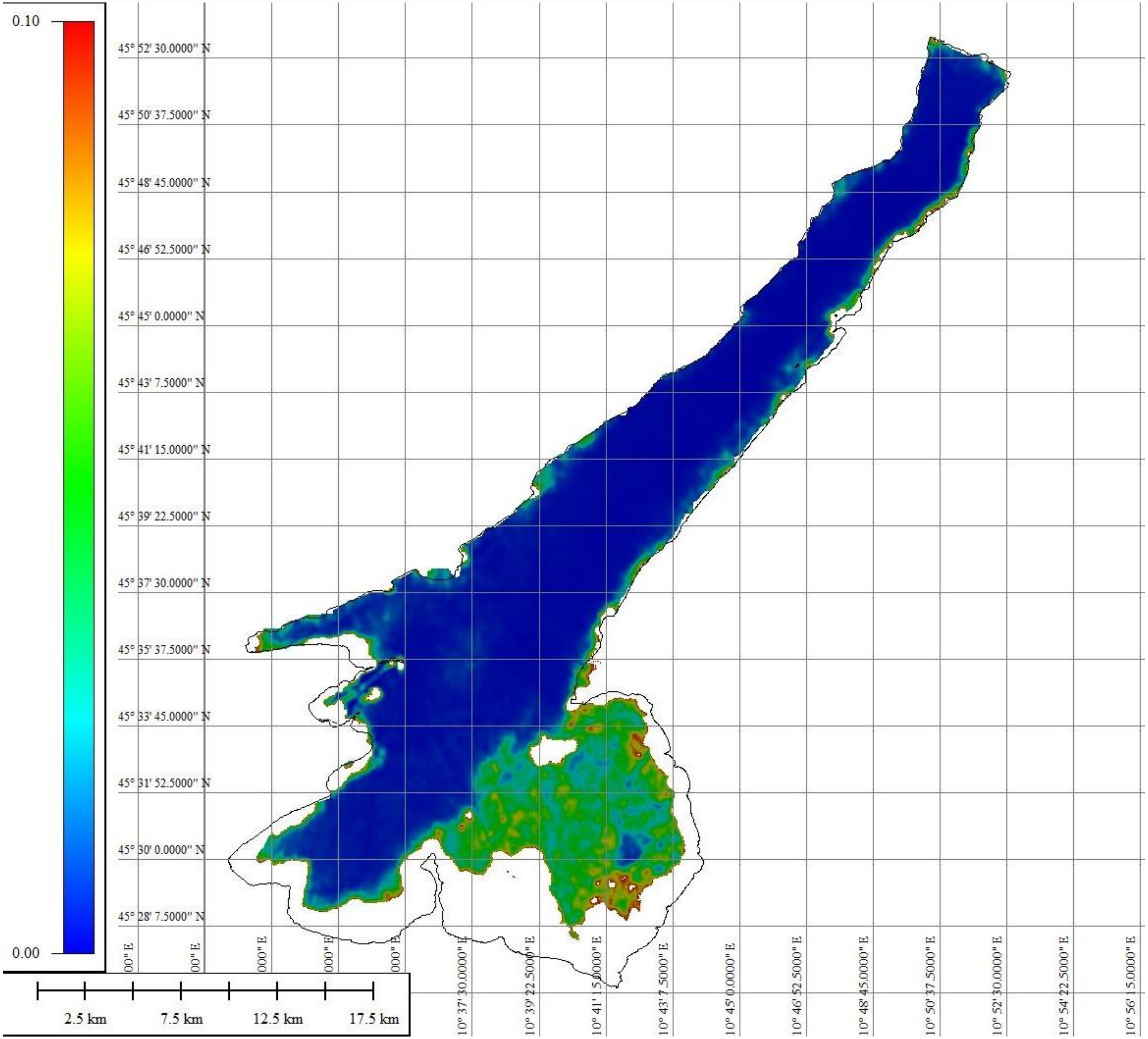
0.10
0.00
45° 52' 30.0000" N
45° 50' 37.5000" N
45° 48' 45.0000" N
45° 46' 52.5000" N
45° 45' 0.0000" N
45° 43' 7.5000" N
45° 41' 15.0000" N
45° 39' 22.5000" N
45° 37' 30.0000" N
45° 35' 37.5000" N
45° 33' 45.0000" N
45° 31' 52.5000" N
45° 30' 0.0000" N
45° 28' 7.5000" N
2.5 km
7.5 km
12.5 km
17.5 km
10° 37' 30.0000" E
10° 39' 22.5000" E
10° 41' 15.0000" E
10° 43' 7.5000" E
10° 45' 0.0000" E
10° 46' 52.5000" E
10° 48' 45.0000" E
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10° 52' 30.0000" E
10° 54' 22.5000" E
10° 56' 15.0000" E

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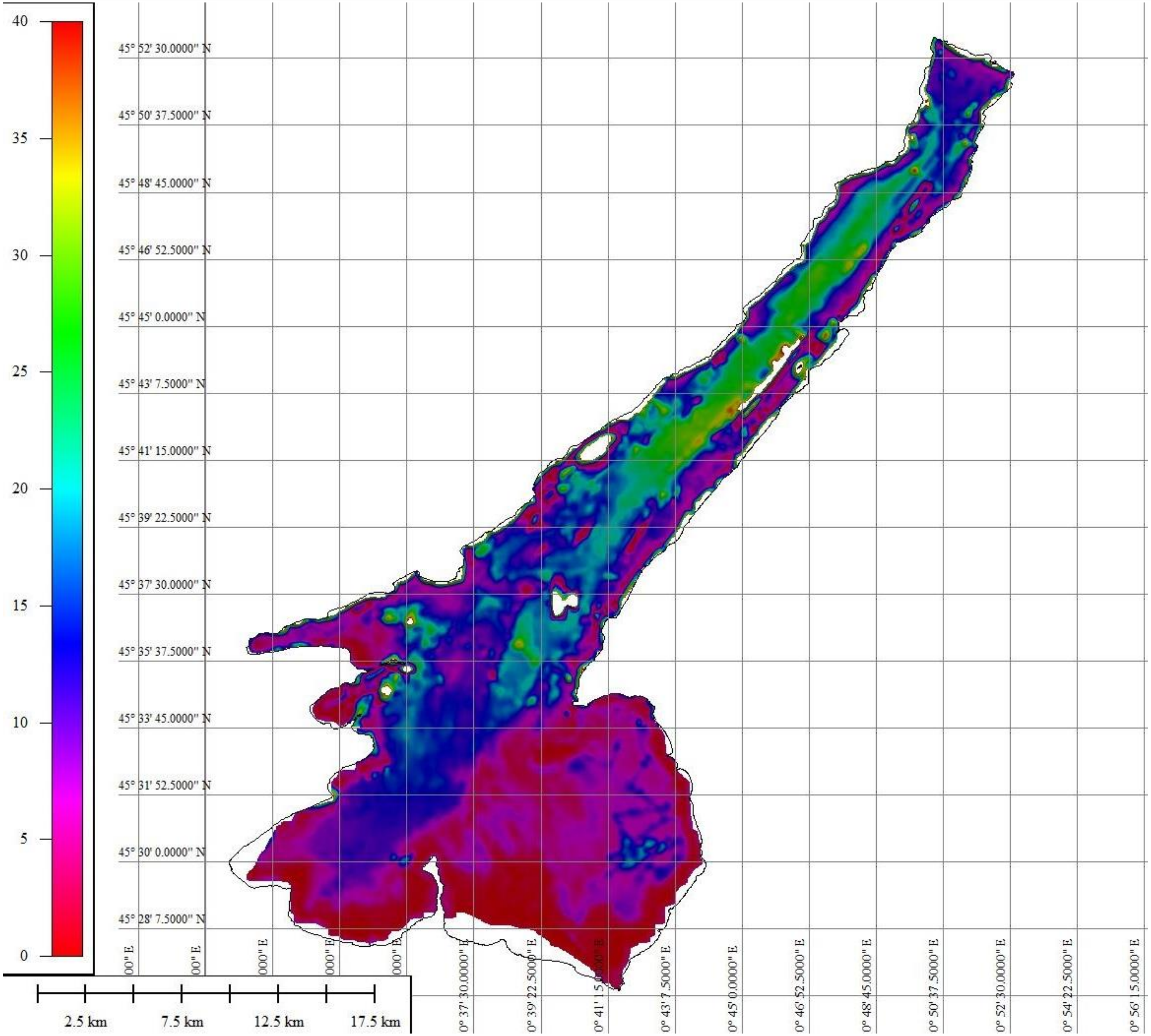
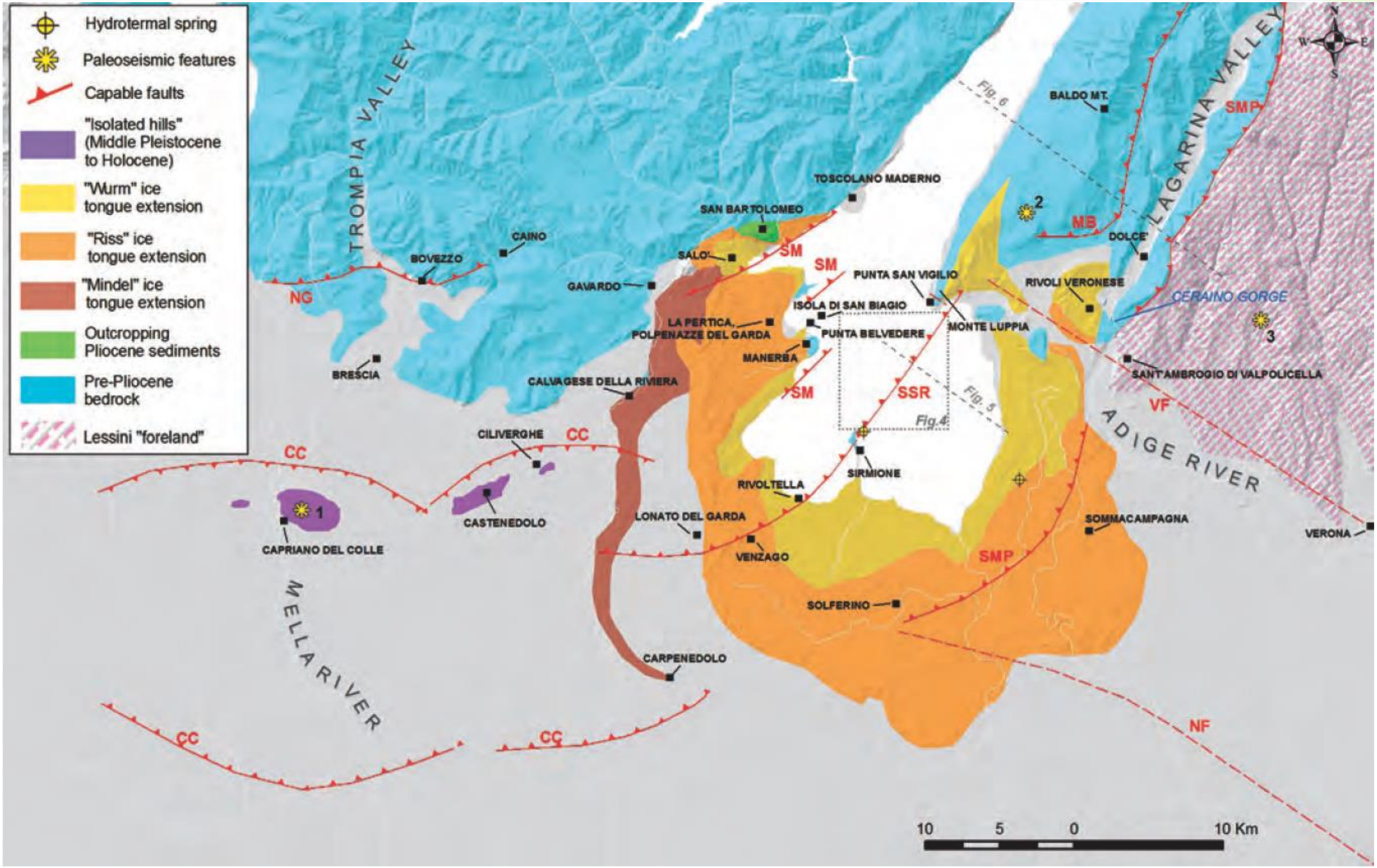
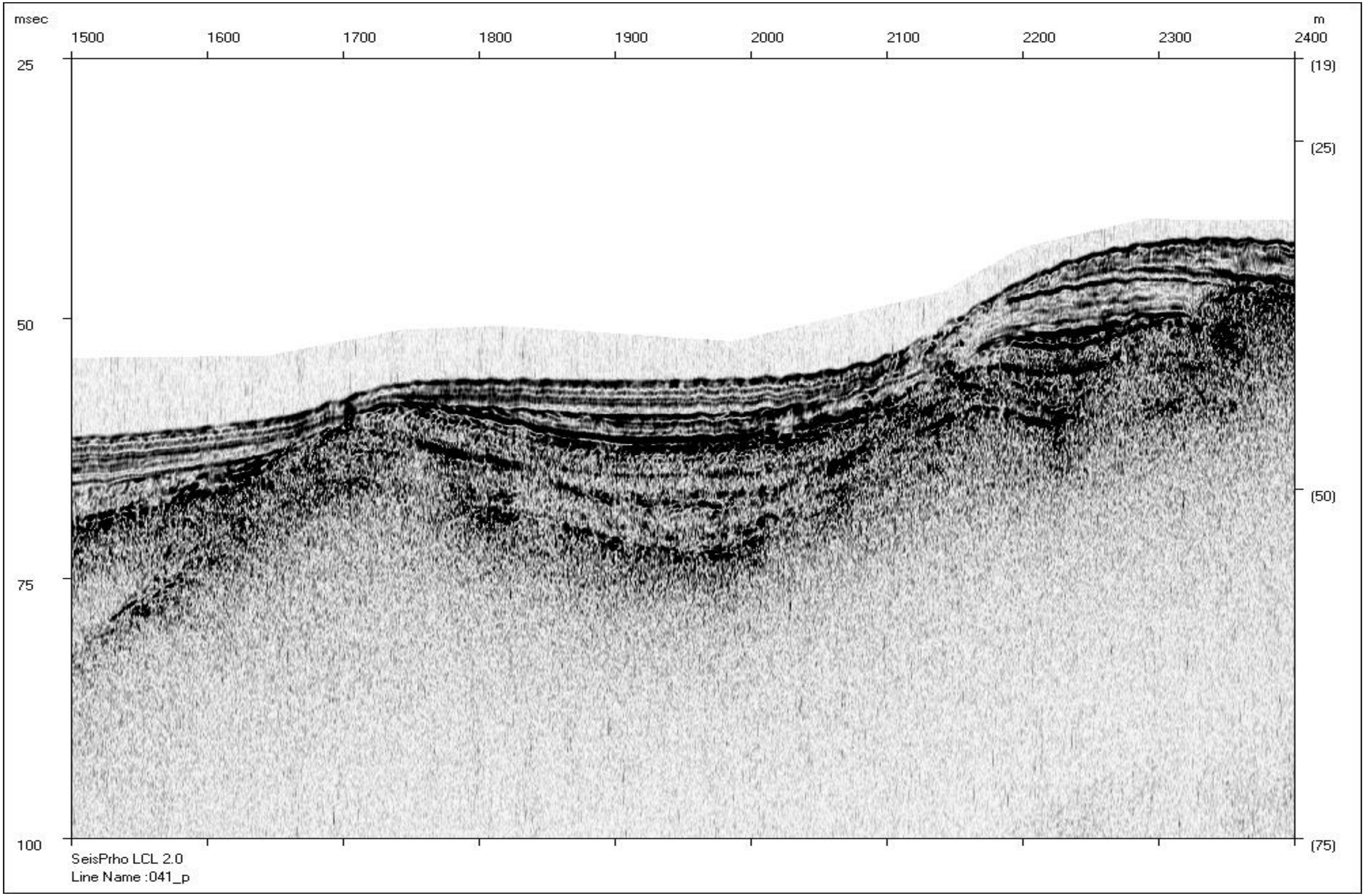


40
35
30
25
20
15
10
5
0
45° 52' 30.0000" N
45° 50' 37.5000" N
45° 48' 45.0000" N
45° 46' 52.5000" N
45° 45' 0.0000" N
45° 43' 7.5000" N
45° 41' 15.0000" N
45° 39' 22.5000" N
45° 37' 30.0000" N
45° 35' 37.5000" N
45° 33' 45.0000" N
45° 31' 52.5000" N
45° 30' 0.0000" N
45° 28' 7.5000" N
00" E
00" E
000" E
000" E
000" E
0° 37' 30.0000" E
0° 39' 22.5000" E
0° 43' 7.5000" E
0° 45' 0.0000" E
0° 46' 52.5000" E
0° 48' 45.0000" E
0° 50' 37.5000" E
0° 52' 30.0000" E
0° 54' 22.5000" E
0° 56' 15.0000" E
2.5 km
7.5 km
12.5 km
17.5 km



From Berlusconi et al.2013


msec
m
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
25
50
75
100
(19)
(25)
(50)
(75)
SeisPrho LCL 2.0
Line Name :041_p

Main processes causing disturbances/deformations in the Lake Garda sedimentary sequence

1. Earthquake induced slumps
2. River floods
3. Slope instability
4. Bottom currents
5. Gas and fluid mobilization
6. Tectonics