The Undersea Malta-Gozo Tunnel Project: geophysical investigations

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GNGTS – Bologna, 19 – 21 November 2018

Summary

- Malta-Gozo Tunnel
- Targets and Geology
- Activities: MBES bathymetry, HR seismic, MCS, Airborne, VSP
- Data examples

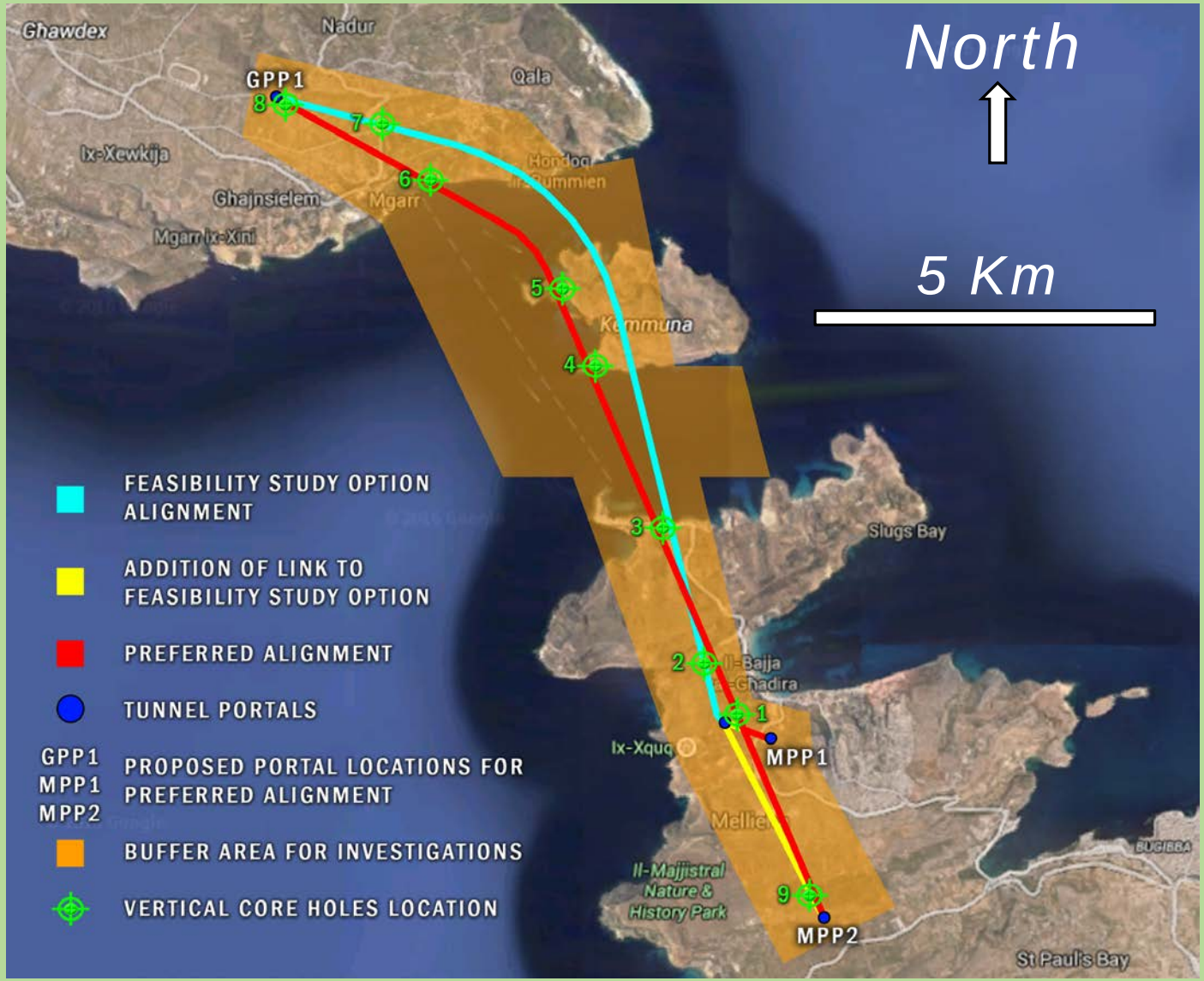
Malta-Gozo Tunnel

- **1972** first preliminary survey report on the link between Malta and Gozo.
- **2012** Economic assessment: existing traffic, traffic projection, socio-economic impact on Malta and Gozo, tolls, etc.
- **2012** The geology of the project area is potentially complex, with evidence of extensive faulting, and is not well documented. A detailed geological and geotechnical investigation is required to determine the optimunm tunnel alignment, tunnel form, cost and construction methodology.

Study area


North


Gozo
Comino
Malta


North
5 Km
Ghawdex
Nadur
Qala
Ix-Xewkija
Ghajnsielem
Mgarr
Mgarr Ix-Xini
Kemmuna
Slugs Bay
Il-Bajja
Ix-Xuqu
Mellieħa
Il-Majjistral Nature & History Park
BUGIBBA
St Paul's Bay
GPP1
MPP1
MPP2
1
2
3
4
5
6
7
8
9
FEASIBILITY STUDY OPTION ALIGNMENT
ADDITION OF LINK TO FEASIBILITY STUDY OPTION
PREFERRED ALIGNMENT
TUNNEL PORTALS
GPP1 MPP1 MPP2 PROPOSED PORTAL LOCATIONS FOR PREFERRED ALIGNMENT
BUFFER AREA FOR INVESTIGATIONS
VERTICAL CORE HOLES LOCATION

Targets

Improvement of the geological model along the projected tunnel alignment

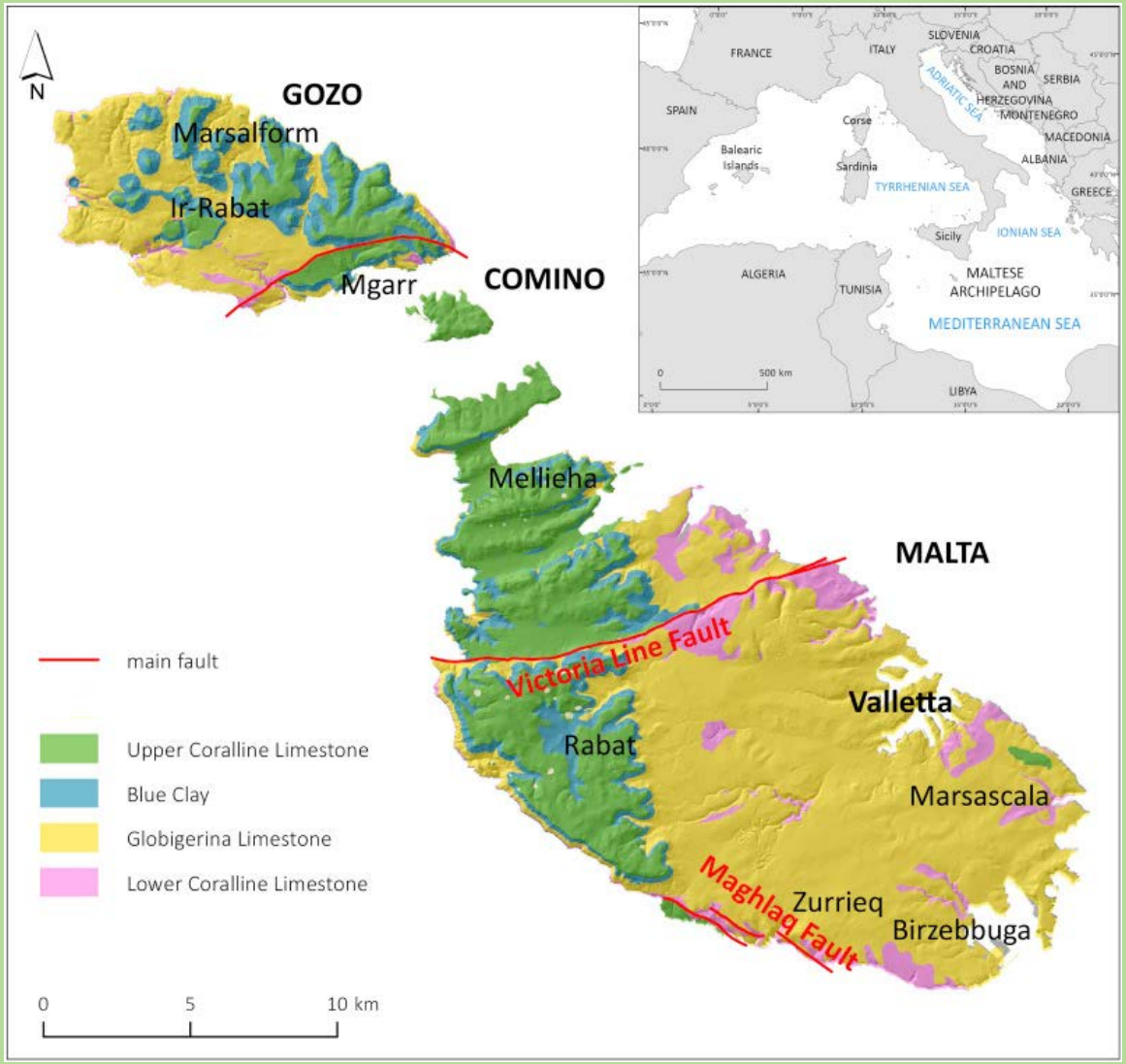
1) Faults:

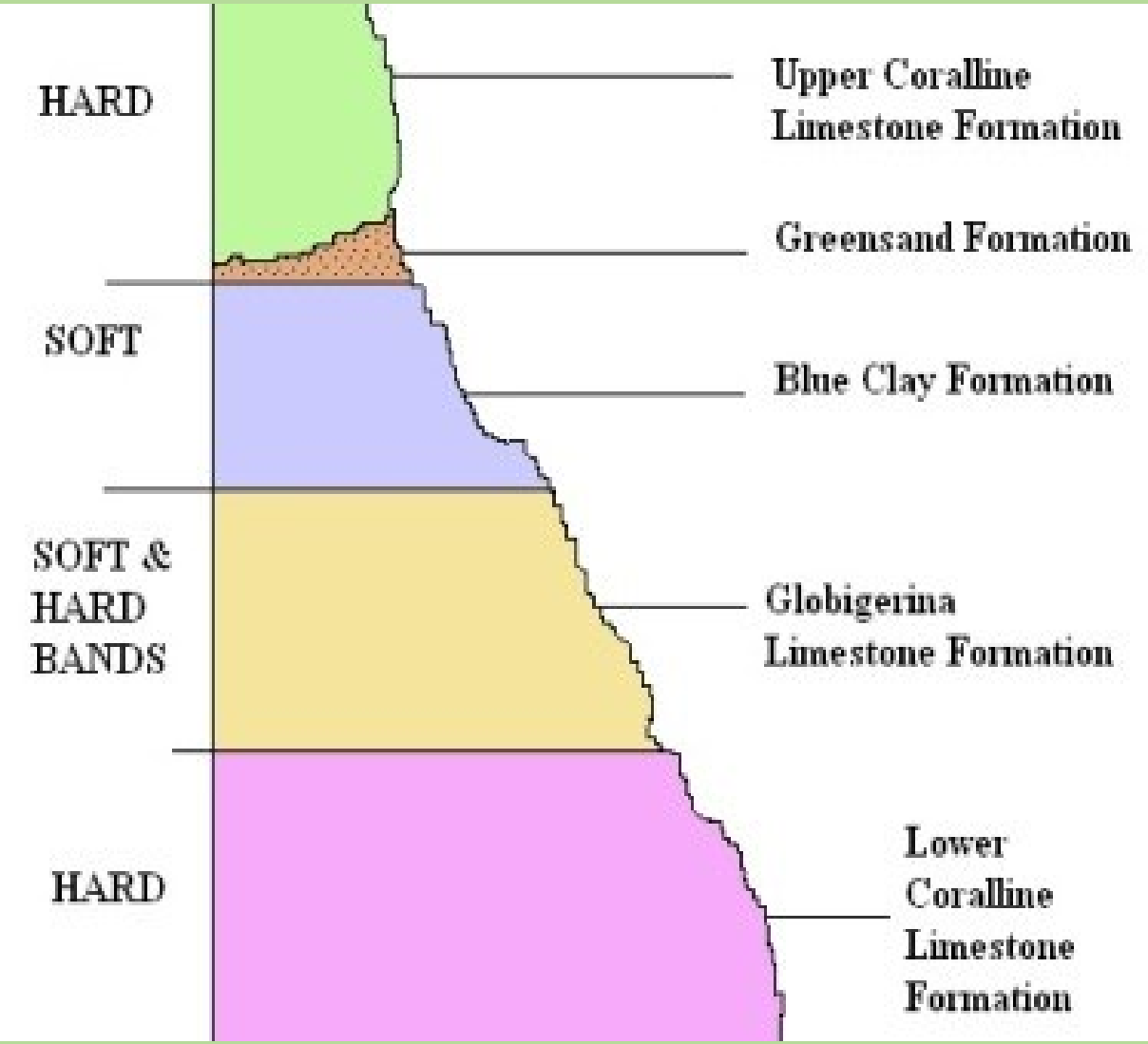
location, displacement

2) Blue Clay Formation:

location, thickness

Geology of Malta





Offshore study area area

Performed activities

1- Faults mapping:

Bathymetry (Multibeam - MBES)

Offshore Very High Resolution Reflection Seismic – (VHRS)

Offshore Multichannel Reflection Seismic (MCS)

Airborne survey

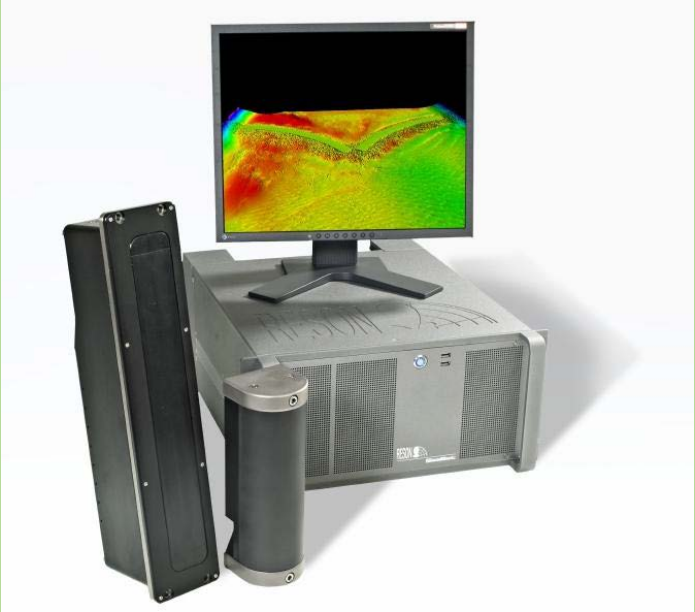
2- Blue Clay mapping:

Offshore Multichannel Reflection Seismic (MCS)

Onshore seismic (VSP and refraction)

MBES survey

Multibeam Reson Seabat 7125



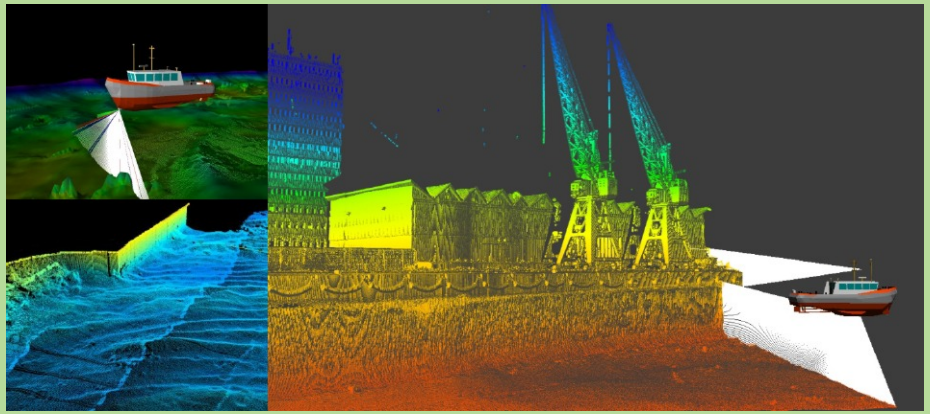
Model	Seabat 7125 SV2
Frequency	200 & 400 KHz
Swath	140°(extended 165°)
Beam	512
Maximum Range	500 m
Maximum operative depth	400 m
Maximum operative speed	12 knots
Maximum Resolution	6 mm
Acquisition Software	Reson PDS2000

Sound Velocity Probe Reson SVP71

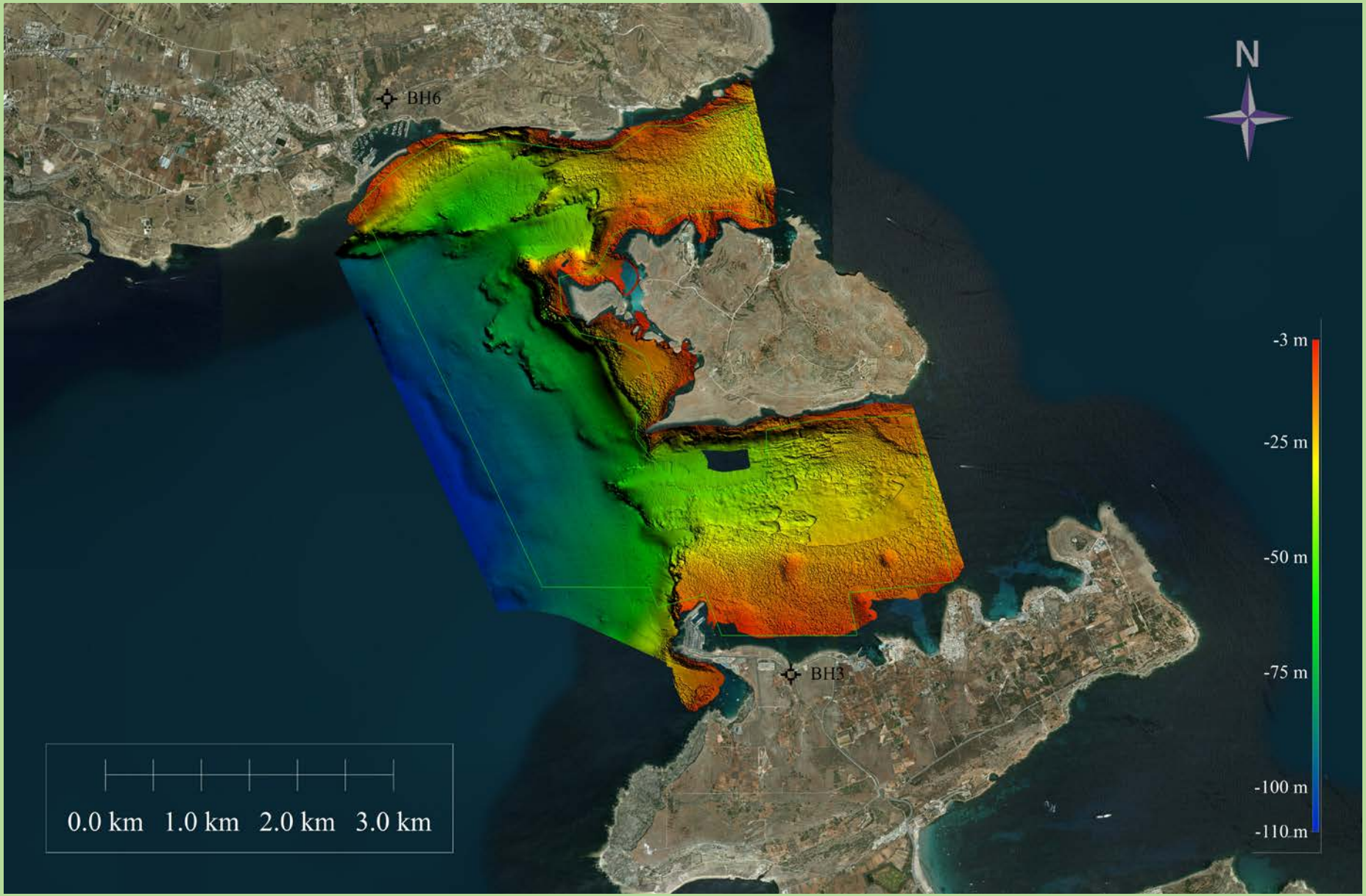
Motion Reference Unit TSS MAHRS

DGPS Trimble DSM232

Software Reson PDS 2000

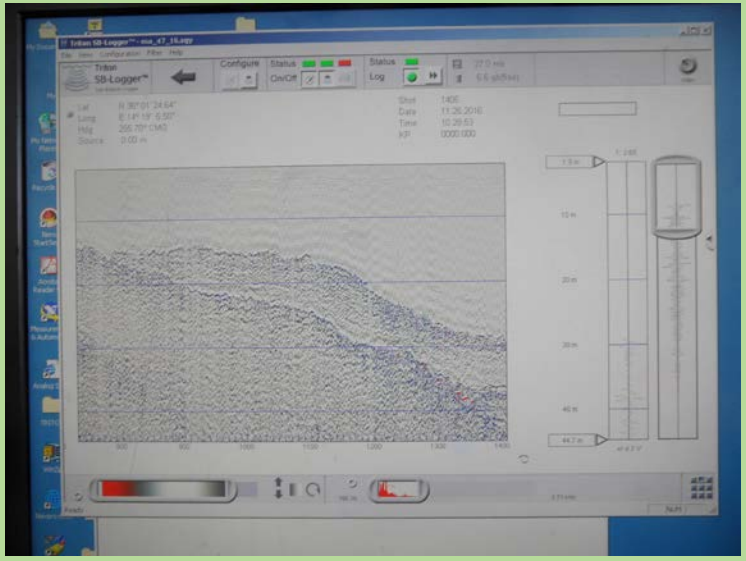


Data acquisition



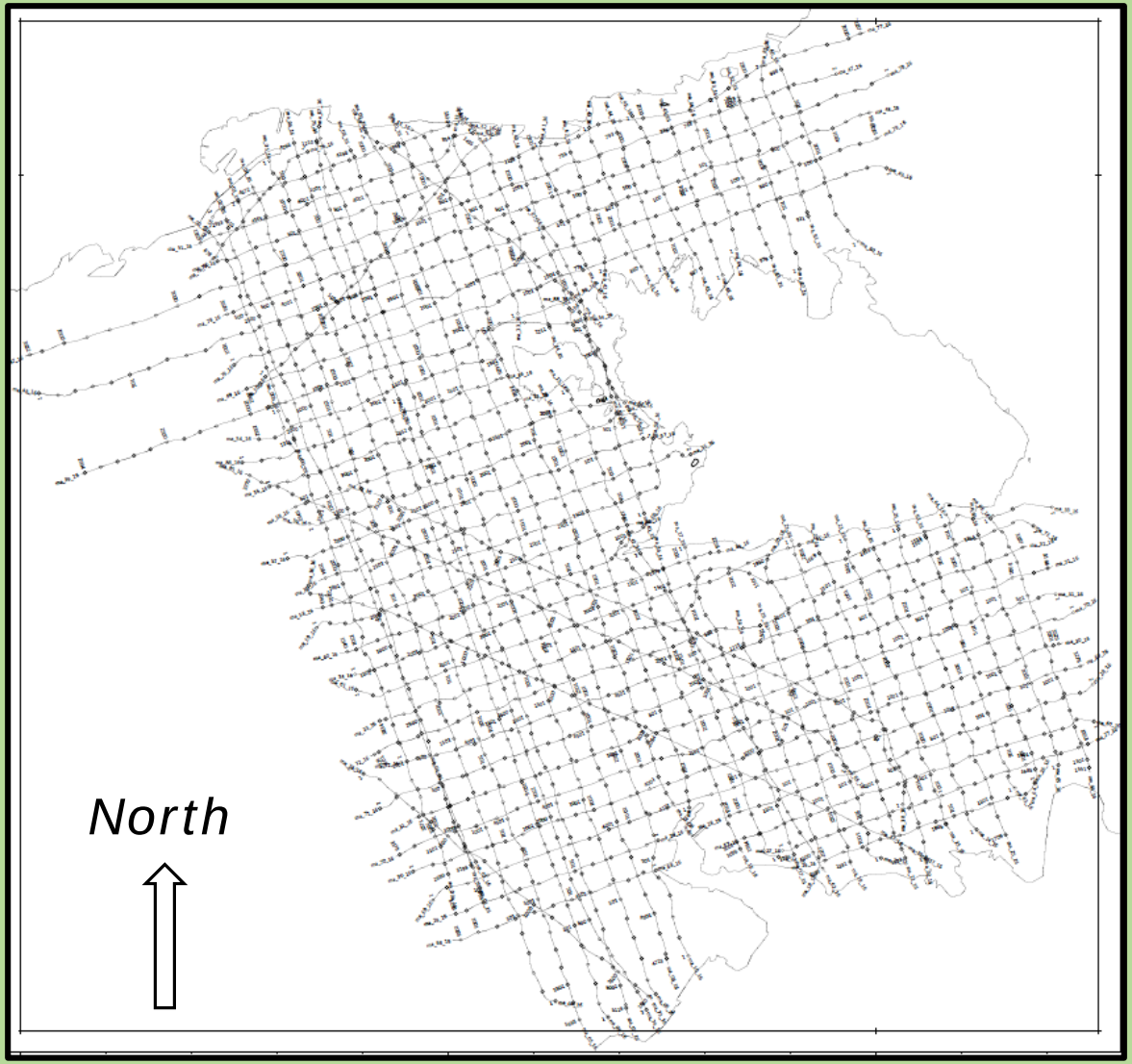
VHRS survey (Boomer)

AA301 TECHNICAL SPECIFICATIONS	
Manufacturer	Applied Acoustic Engineering
Model	AA301
Frequency Range	400-4000 Hz
Size	62x52 cm, 25 kg
Pulse length	200 microS depending on energy setting of CSP
Energization rate	3 Hz
Maximum energy	1050J/s - 350 J/shot
Operating voltage	3600 to 4000 V
Power supply unit	CSP-Nv 2400

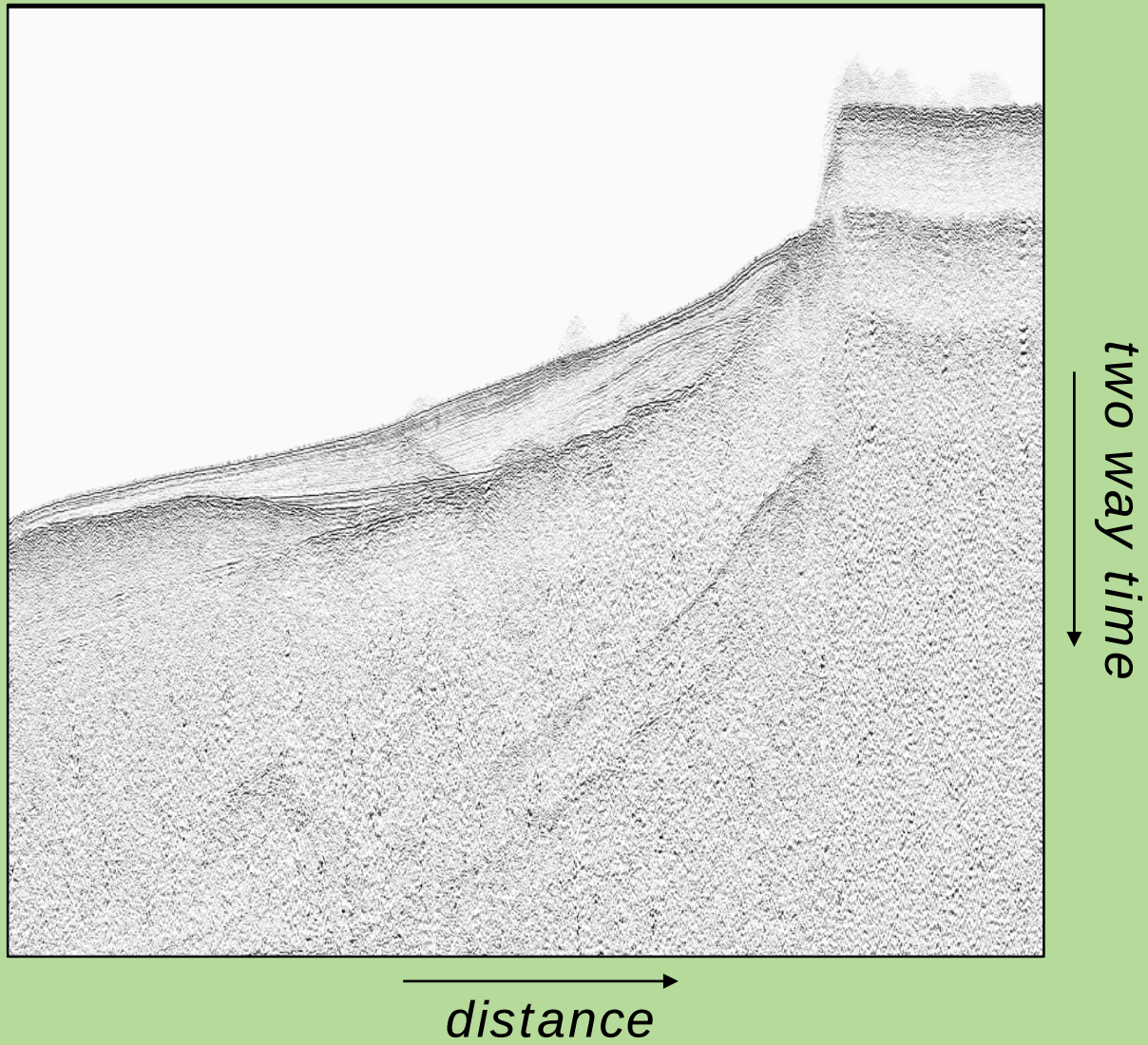


VHRS data

Acquisition map



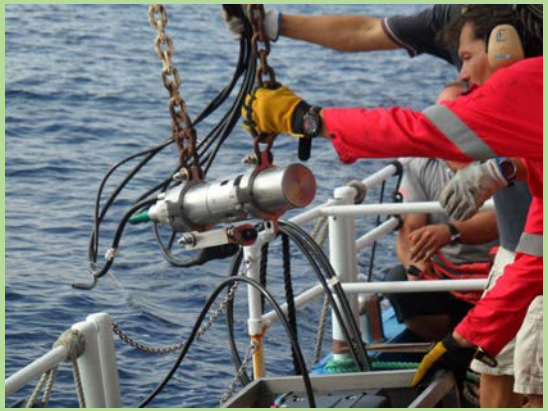
Seismic section (time)



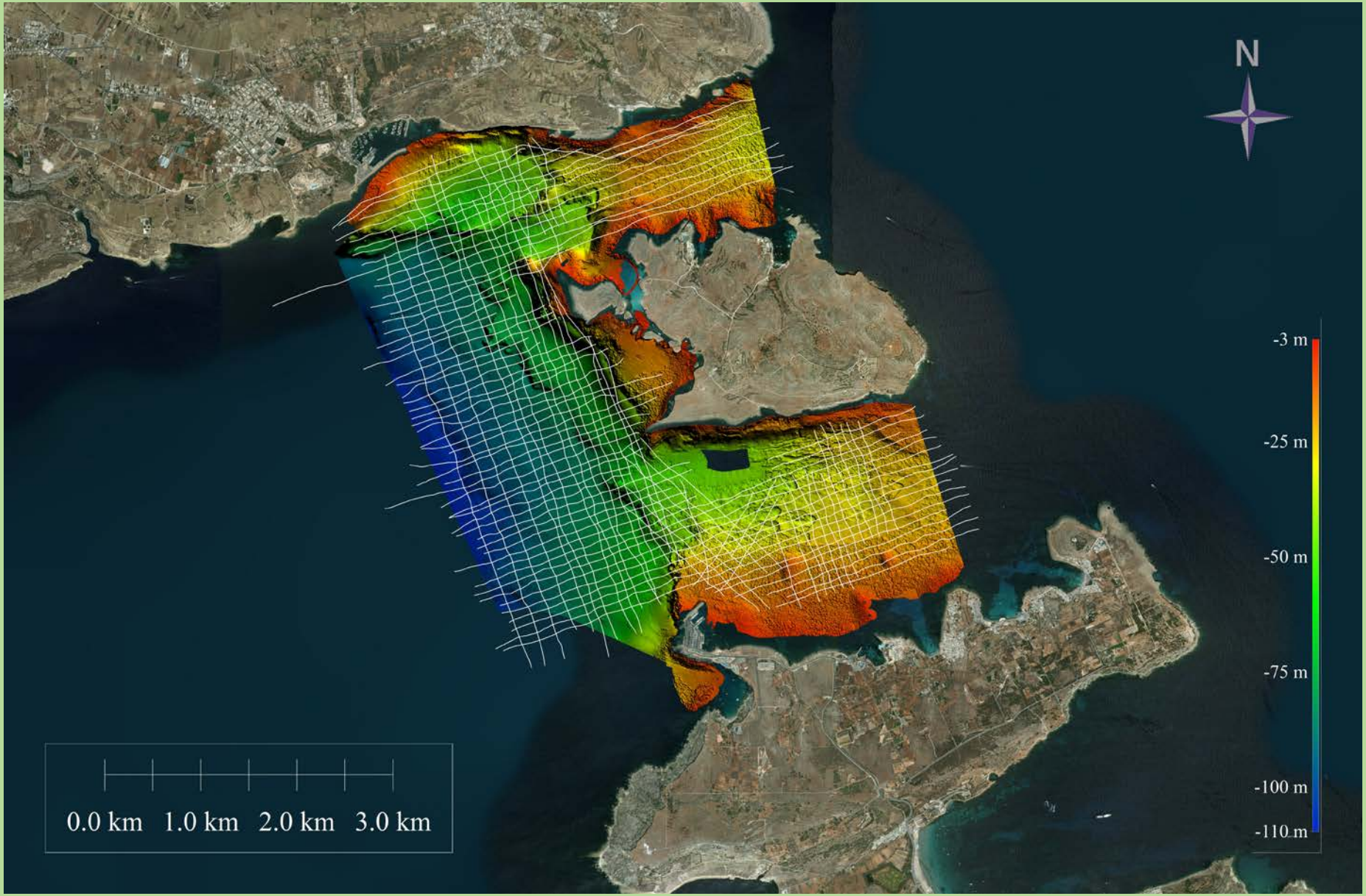
MCS data acquisition

ACQUISTION PARAMETERS					
SOURCE		STREAMER		RECORDING	
Model	Mini GI-GUN Sercel	Model	Geometrics Geoeel	Model	Geometrics CNT-1
Array	1 x 60 cu.in (1l)	Length	300 m	Sampling rate	0.5 ms
Gun Mode	30G+30I Harmonic	Ch. No.	96	Record length	2 sec
Shot Interval	15.625 m and 18.75 m	Ch. Dist.	3.125 m	LC filters	3 Hz (LC);
Depth	1.5 m ± 0.5 m	Depth	2 m ± 0.5 m	HC filters	Antialias
Pressure	140 atm.	Min off.	12.5 m	Aux channels	Ch.2
SYNCHRONIZATION		Max off.	312.5 m		
Controller	RTS Sure Shot	Max fold	9.6		
Aim Point	50 ms delay	min fold	8		

Image from TM video



MCS data acquisition



Lines 106
Spacing 75m
Total kms 236

MCS data processing

1) Data Reformatting.

2) Quality control and trace editing.

3) Geometry assignment and water bottom picking.

4) Preliminary velocity analysis -> CDP Sorting -> NMO Correction -> AGC -> Brute stack.

6) Surface Related Multiple Elimination (SRME, water bottom deconvolution).

7) True amplitude recovery.

8) Predictive deconvolution.

9) Final Velocity Analysis.

10) Normal moveout correction.

11) Manual Stretch mute.

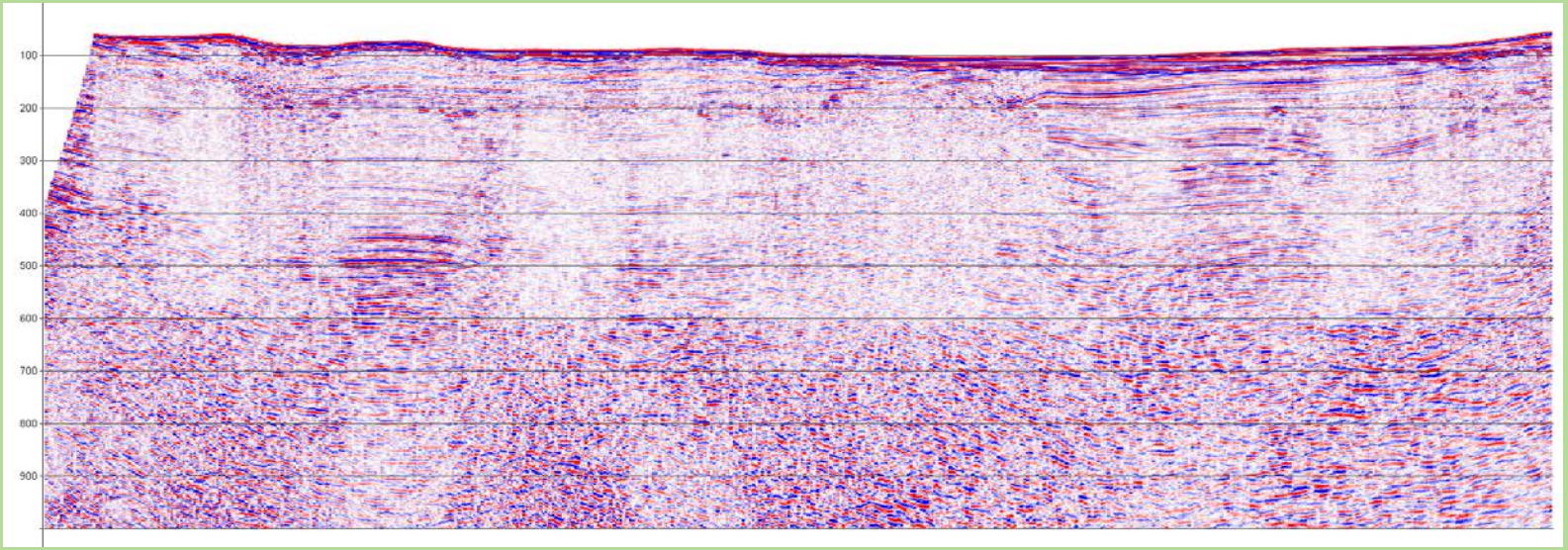
12) Stack -> FX deconvolution -> Time variant filter -> Amplitude balance -> Final stack output.

13) Post stack time migration -> Time variant filter -> Amplitude balance -> Final migrated stack output.

MCS data example (migrated sections)

Line 106

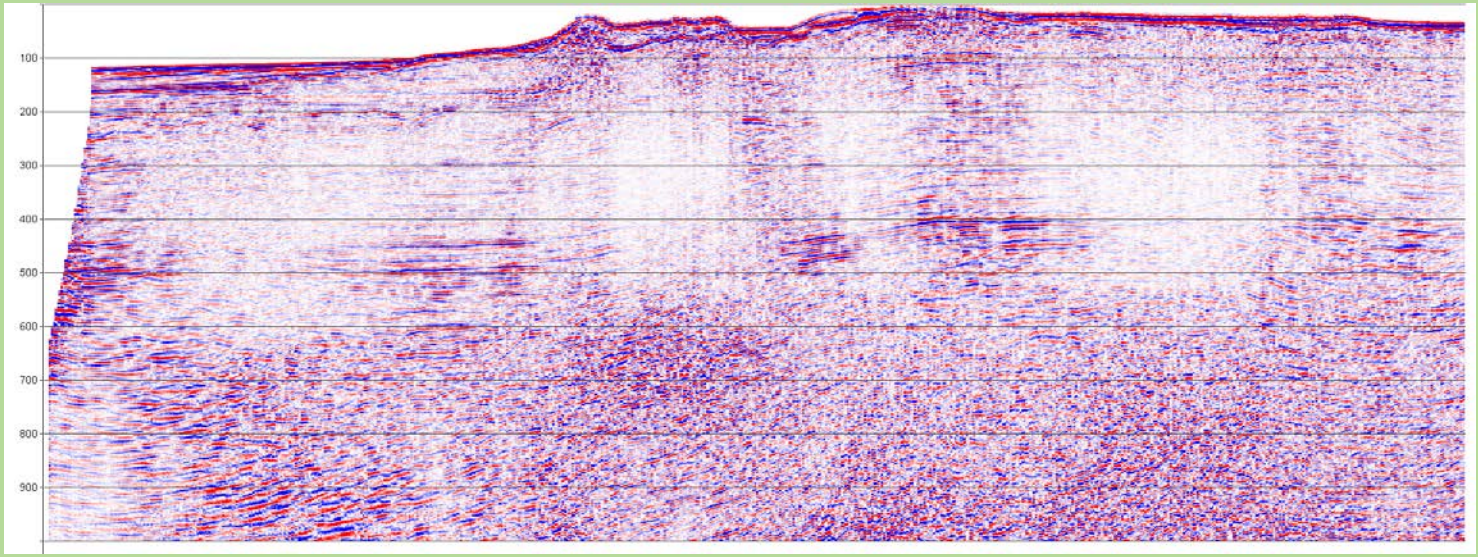
N



S

Line 097

W



E

Gas Mapping acquisition

LGR Los Gatos - Ultraportable Greenhouse Gas Analyzer (CH4, CO2, H2O)

Laptop

LGR system

GAS inlet

CESSNA 172M Skyhawk

Performance Specifications

Repeatability / Precision (1-sigma):
CH_4: <2 ppb (1 sec), <0.6 ppb (10 sec), <0.25 ppb (100 sec)

CO_2: <300 ppb (1 sec), <100 ppb (10 sec), <40 ppb (100 sec)

H_2O: <100 ppm (1 sec), <35 ppm (10 sec), <15 ppm (100 sec)

Response Time (flow time through meas. cell):
10 s

Measurement Range:
CH_4: 0.01 – 100 ppm
CO_2: 1 – 20000 ppm
H_2O: 500 – 70000 ppm

Operational Range:
CH_4: 0 – 500 ppm
CH_4: 0 – 10% (with Extended Range option)
CO_2: 0 – 20000 ppm
H_2O: 0 – 70000 ppm

Outputs:
Digital (RS232), Analog, Ethernet, USB

Data Storage:
Internal Solid State Hard Disk Drive

Ambient Humidity:
<98% RH non-condensing

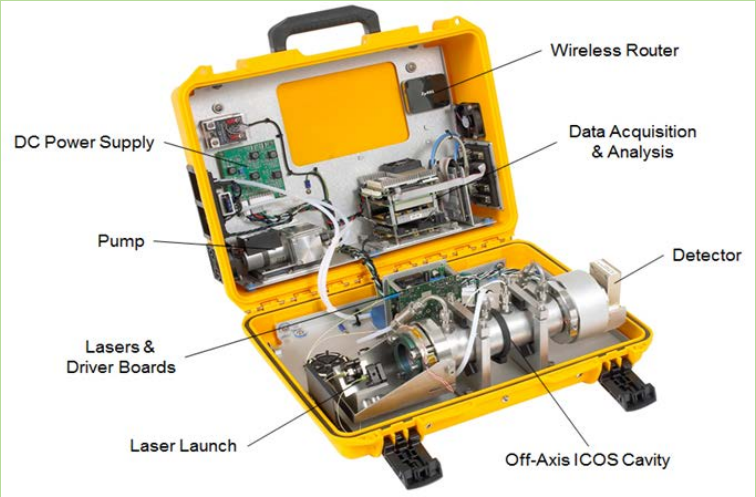
Operating Temperature:
5 – 45 °C

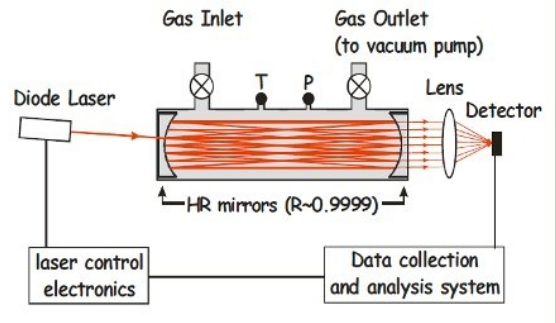
Inlet / Outlet Fittings:
¼" Push-Connect

Power Requirements:
60 watts (10-30 VDC)
66 watts (115/230 VAC, 50/60 Hz)

Dimensions:
7" H x 18.5" W x 14" D

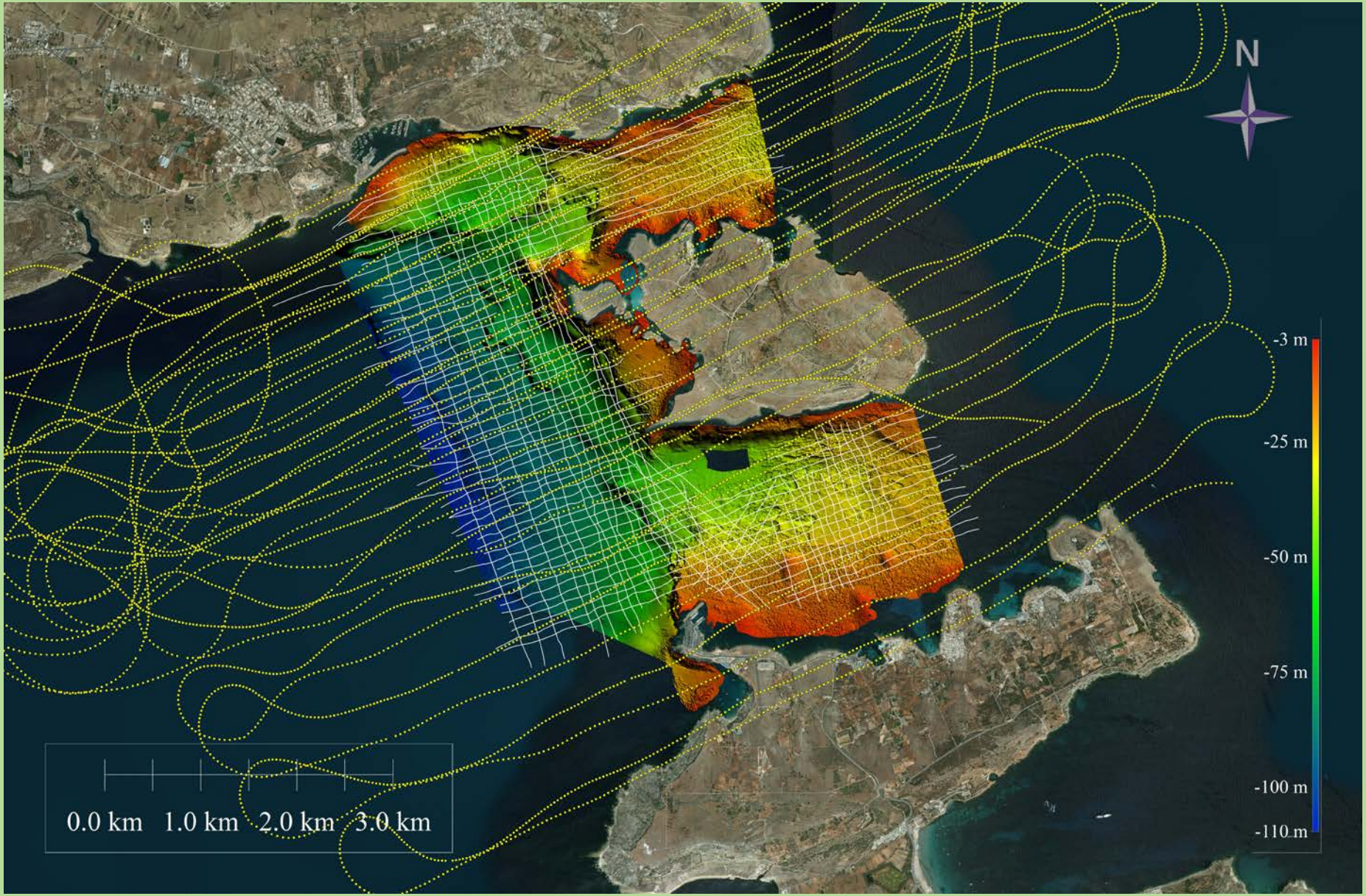
Weight:
15 kg





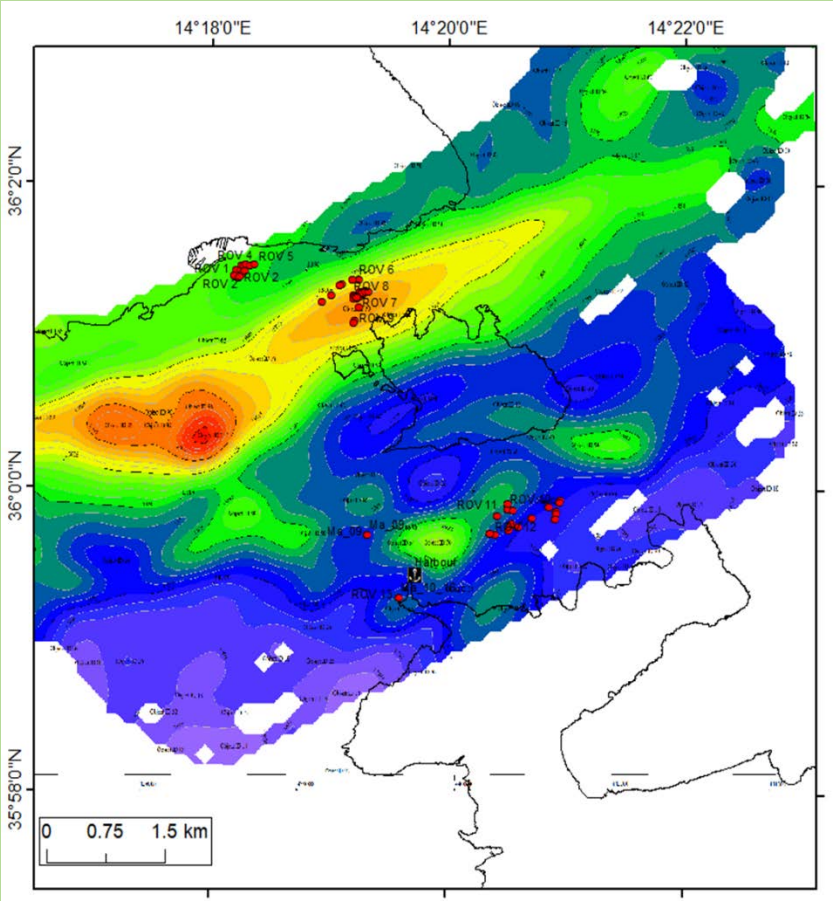
Off-Axis ICOS (Intergrated Cavity Output Spectroscopy)

Gas mapping acquisition



Gas mapping

Survey Area: Flight trajectory



CH4 concentration (ppm)

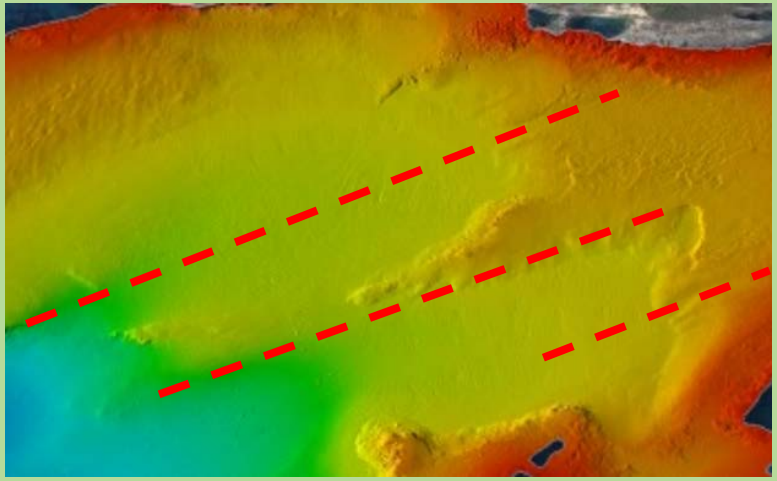
pockmarks

Target 1: Faults

- Are we able to detect/map faults? → Yes

MBES

Bathymetry – sea bottom

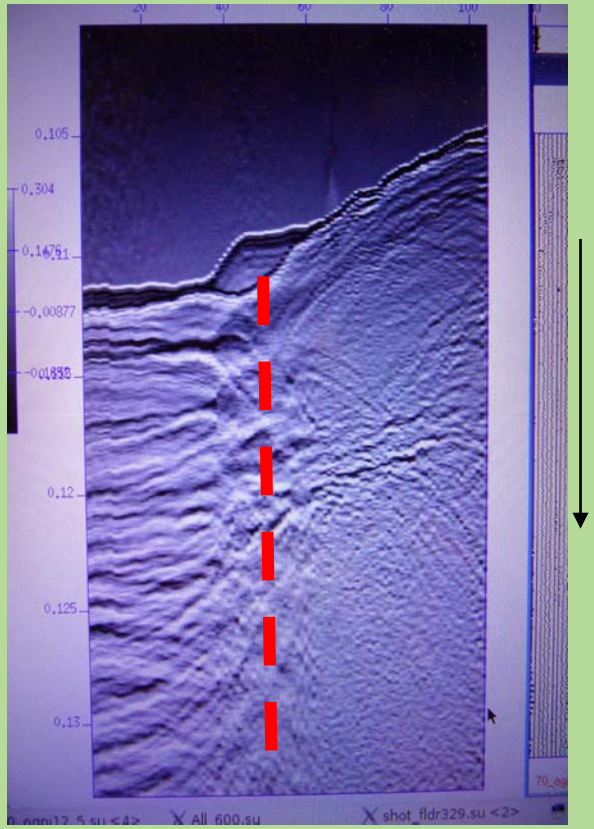


Distance (y)

Distance (x)

HR/boomer

s.b. – 20/50 m below s.b.

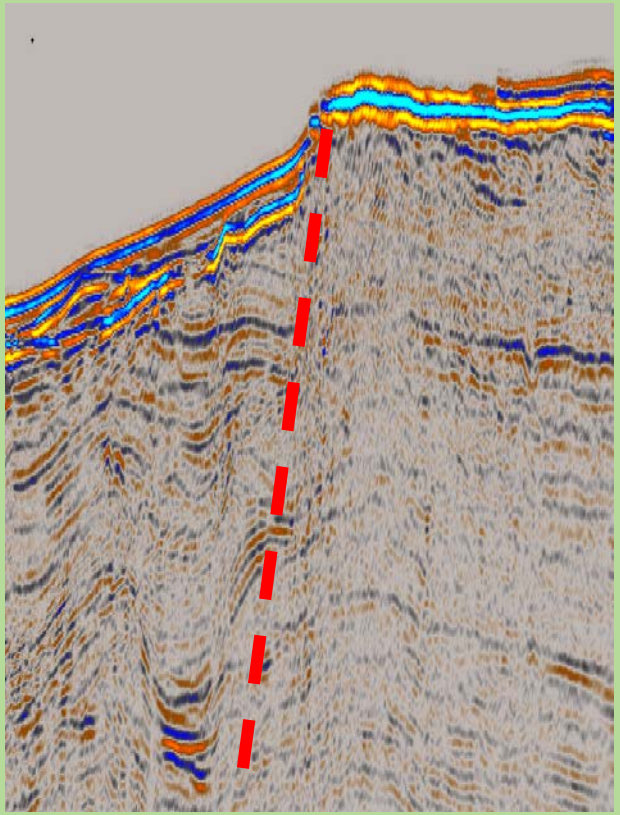


two way time

distance

Reflection Seismic

s.b. – 500 m below s.b.



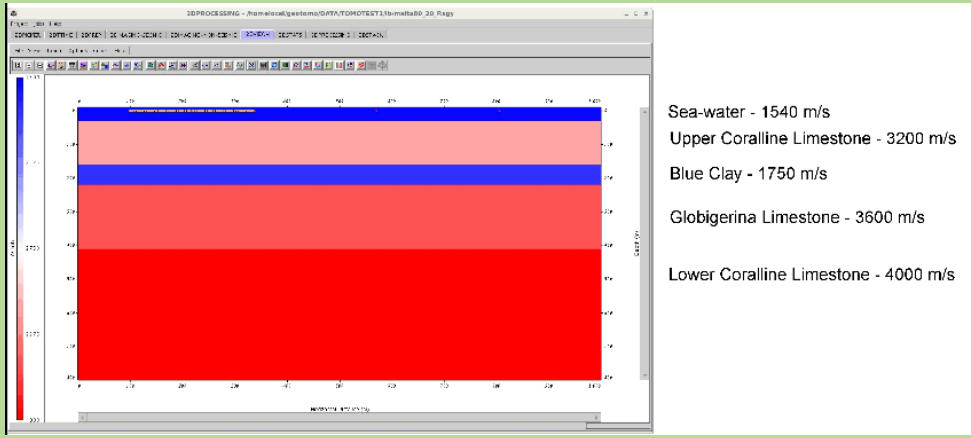
two way time

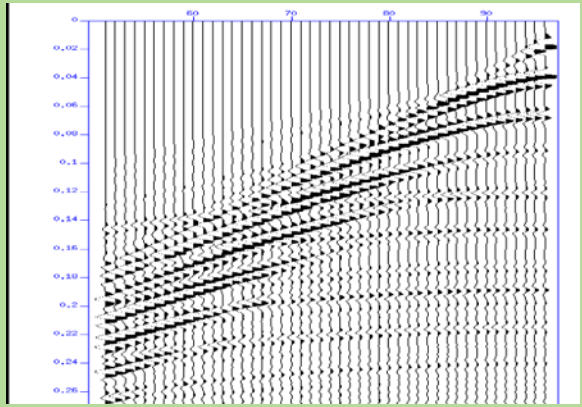
distance

Target 2: Blue Clay Formation

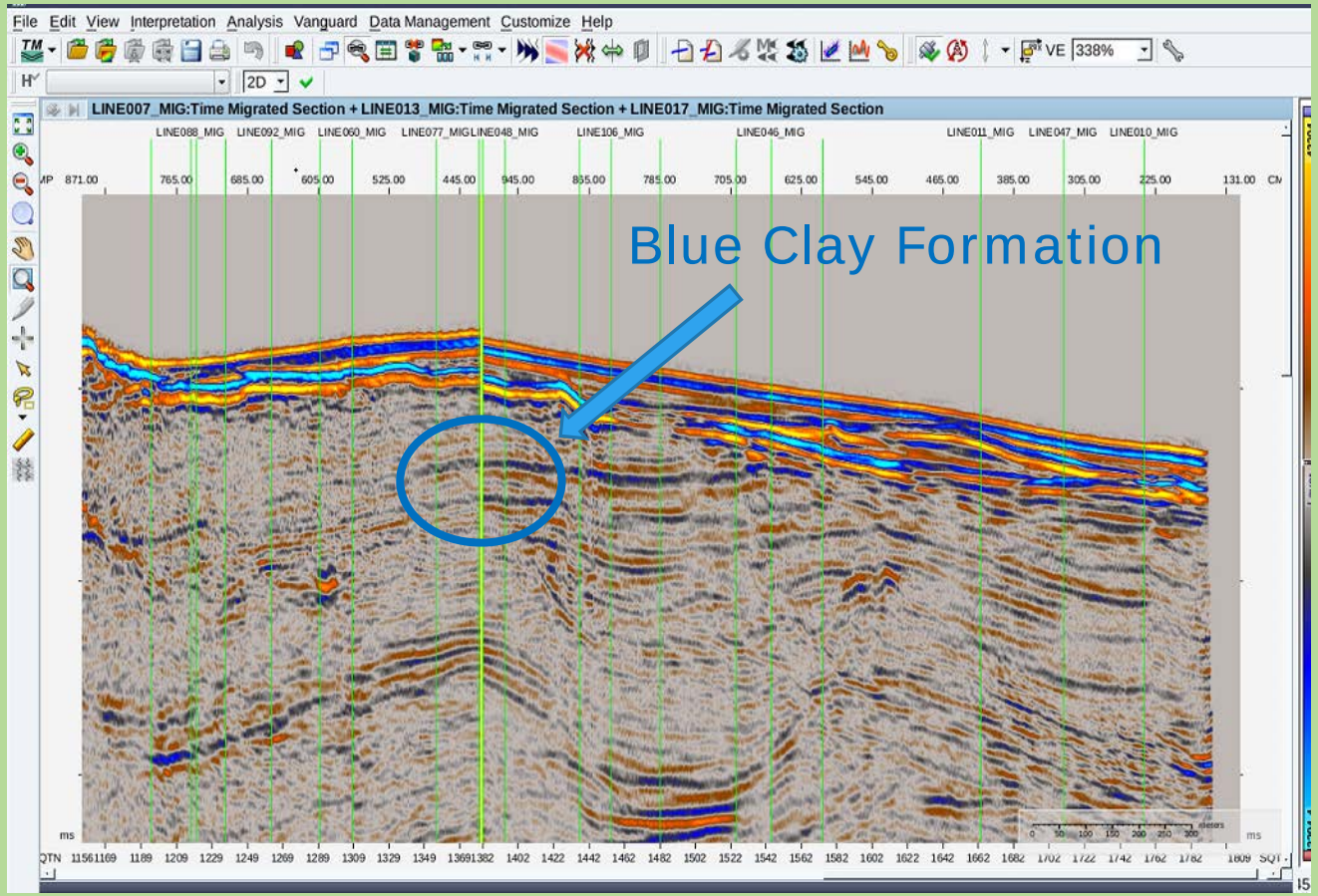
- Are we able to detect and estimate the Blue Clay thickness? → Yes

Feasibility study: syntethic data



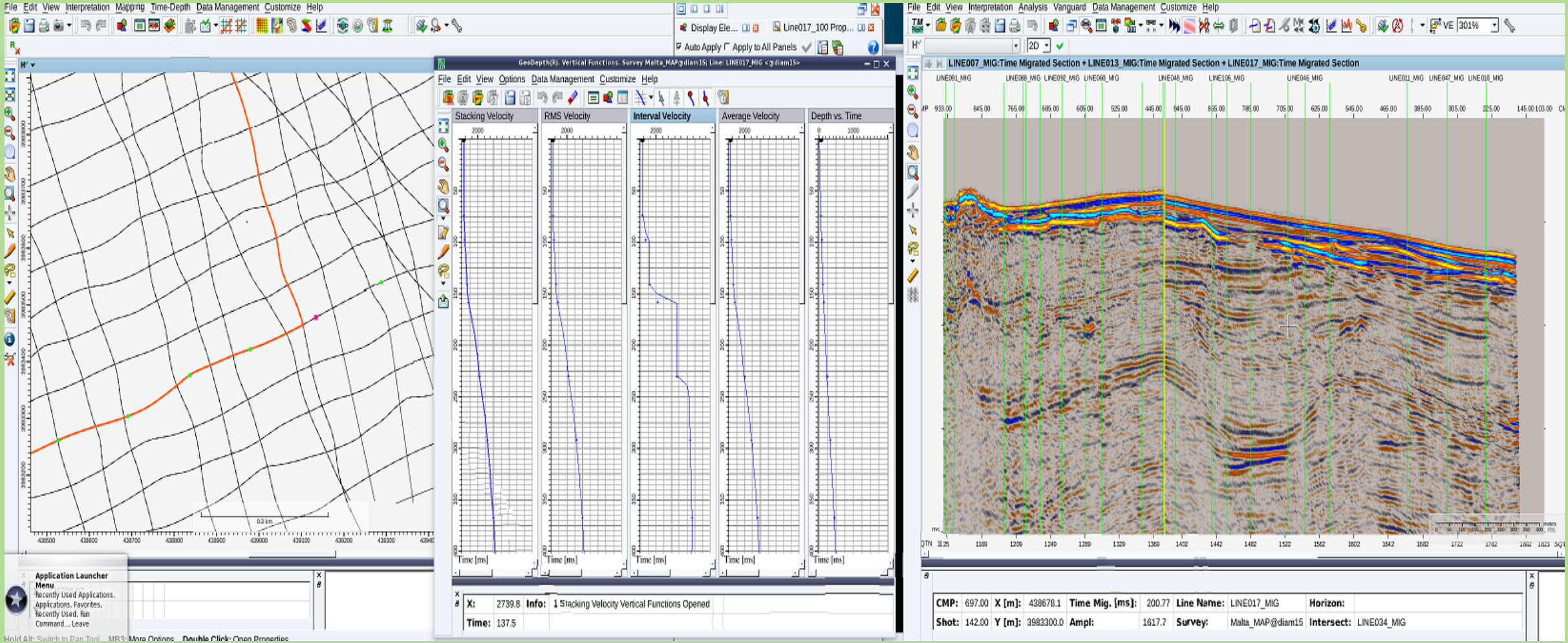


Real data



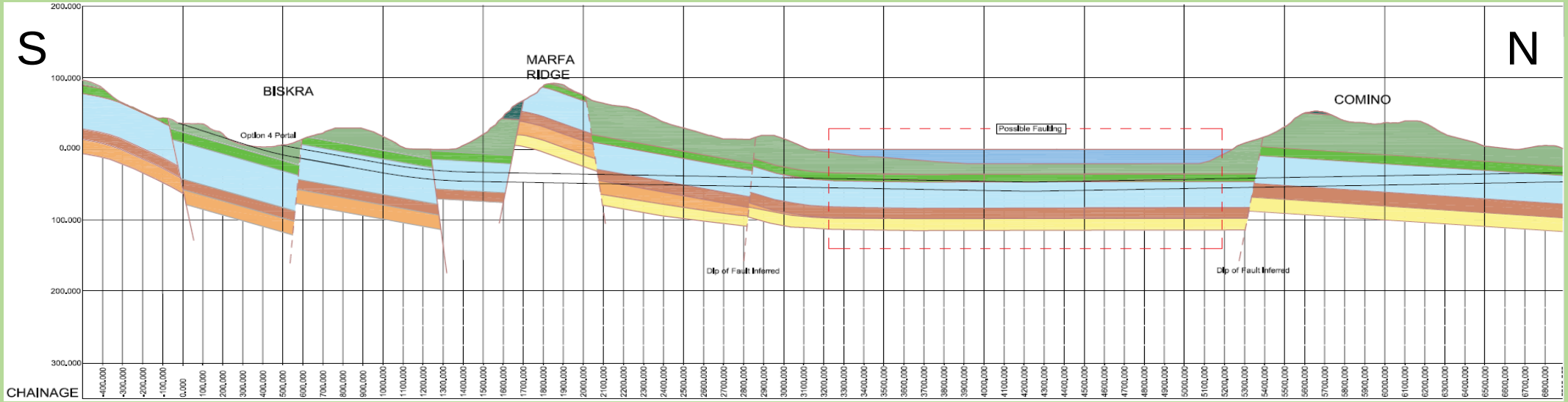
Target 2: Blue Clay Formation

- Seismic data need borehole data for validation, calibration and time to depth conversion

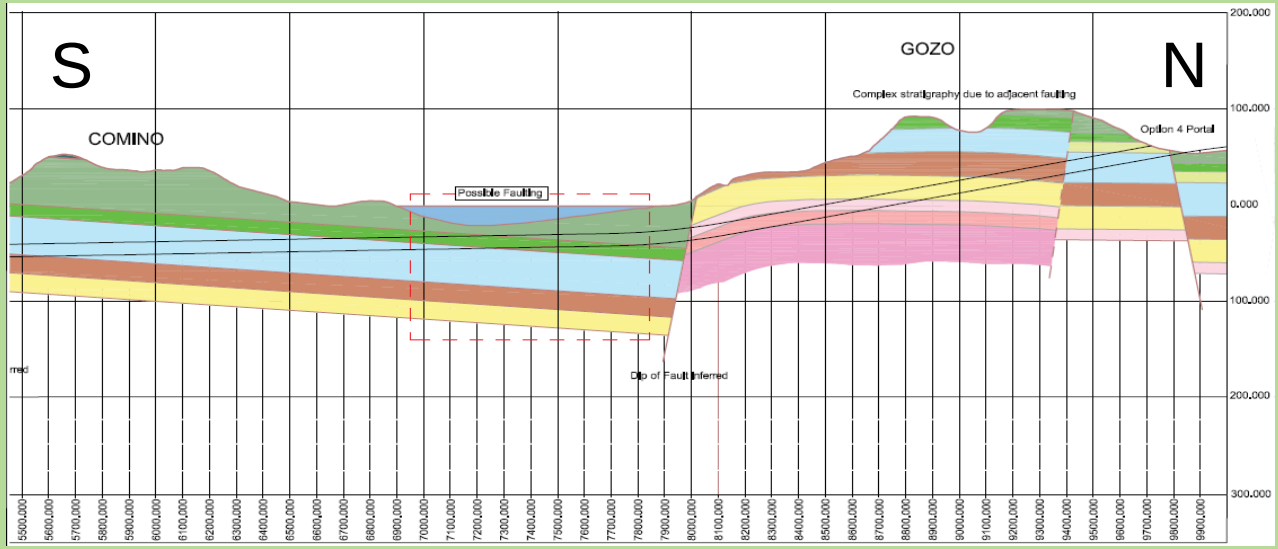


Faults mapping – Initial model

Southern sector



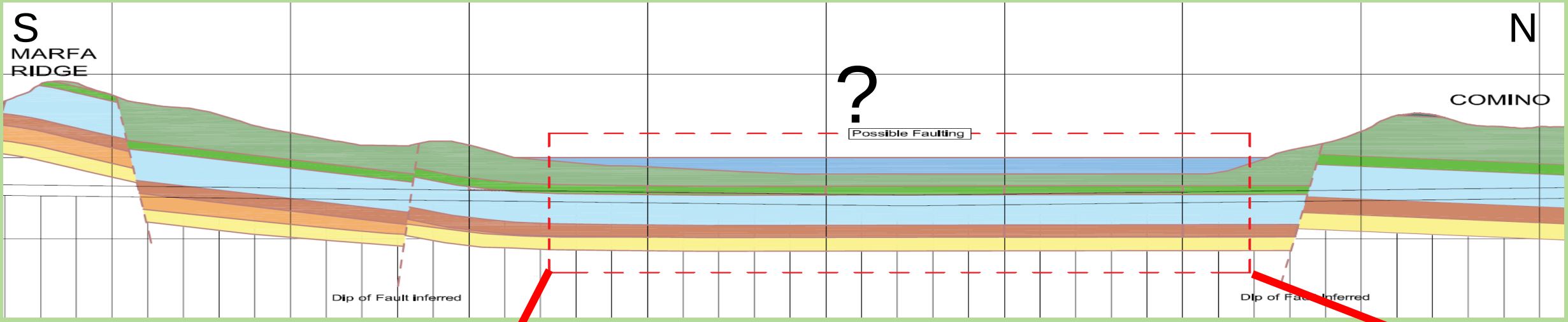
Northern sector



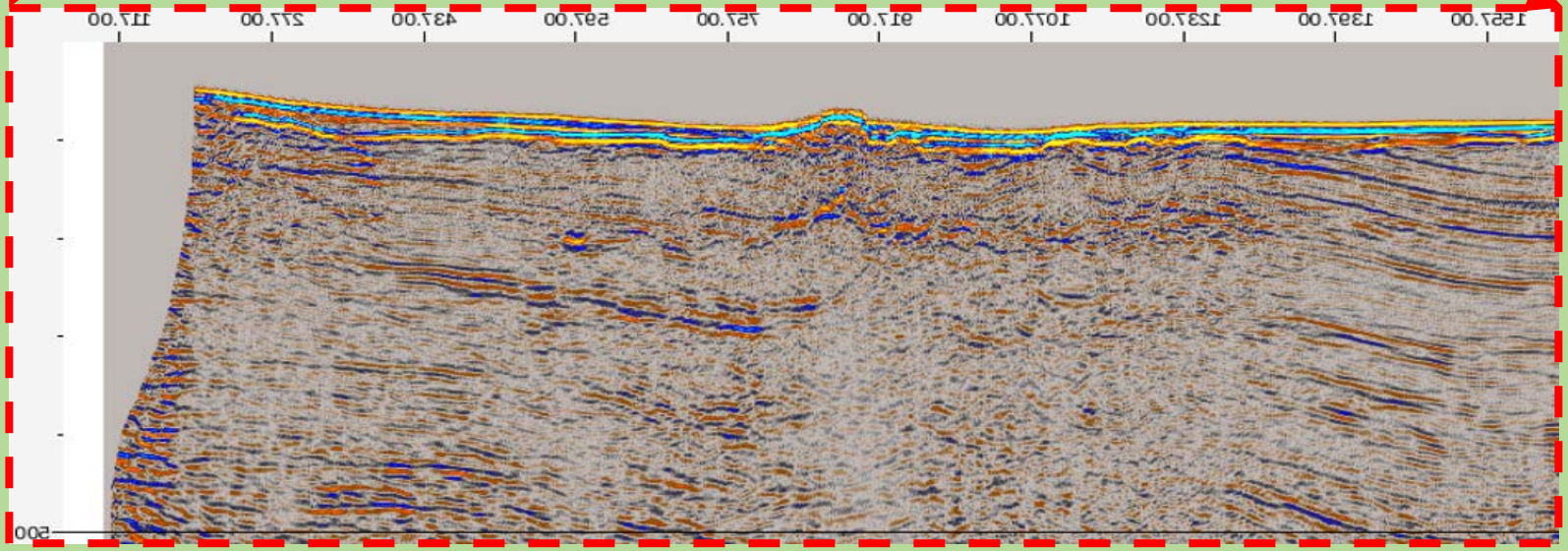
From:
Preliminary results –
Assessment of road tunnel option
between Malta and Gozo
Mott MacDonald, 2012

Faults mapping – real data

Initial model



Real data



Real data appear more complex than prognosis!