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Minas Basin Tidal Energy

Marine Route Engineering Report

March 2010

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Presented to:

MINAS BASIN PULP AND POWER CO. LTD.
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Hantsport, NS   B0P 1P0

Certifié
ISO 9001
Certified

REVISION LIST

Revision No.	Date	Description of Changes	Page(s) affected	Originator
00	09/05/05	FIRST ISSUE	N/A	N. Poirier
01	09/06/02	FINAL VERSION (modification to RPLs)	various	N. Poirier
02	10/02/04	Change of landing site / Updated Cable Specs	various	N. Poirier
03	10/03/10	Modify Route A to avoid Open Hydro Turbine / additional cable allowance to allow turbine positioning at far end of zones	various	N. Poirier

APPROVAL SIGNATURES

Name	Title	Signature	Date
Nancy Poirier	Director, Project Management & Cable Engineering		
Andrew Waddell	Manager, Shore End Operations		
David Mason	Director Field Operations & Maintenance		
Mike Kennah	Chief Operating Office		

Executive Summary

The cable routing of this system is quite complex. Seabed geology, strong tidal currents and size of cable make this a challenging exercise.

The stiffness of the cable and the presence of unavoidable boulder fields, gravel waves and bedrock ridges will most probably induce multiple suspensions on the cables but the heavy double armor cable should be robust enough to withstand the additional stress.

The selected routes minimize alter courses which could prove difficult to handle with a barge in that type of currents. It also keeps a 2-3 time water depth separation to allow potential repair or recovery of any of the cables. It is also routed to stay at least 3 times water depth from the Open Hydro turbine that was installed on the volcanic plateau close to zone A.

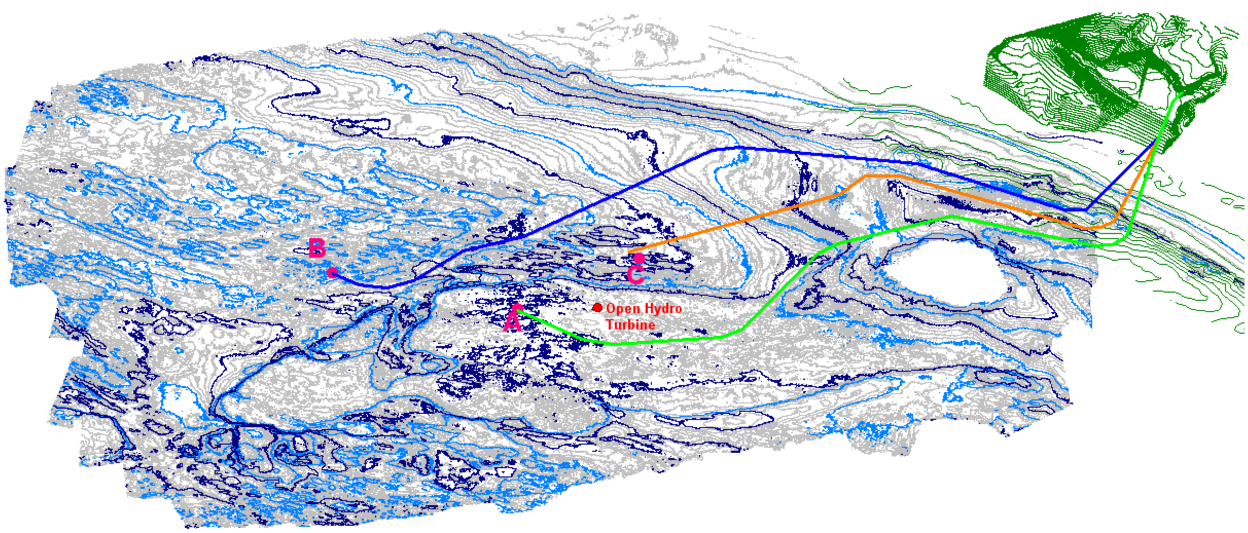
Final cable lengths are:

Cable to center of Zone A: 2,741 meters

Cable to center of Zone B: 3,157 meters

Cable to center of Zone C: 2,240 meters

These lengths include sufficient cable to allow installation of any of the turbines at the far end of their zone. Each cable is also long enough to allow temporary route deviation due to high current, for coiling and splicing in the manhole and for recovering the cable to the surface for later connection to turbines.



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MINAS BASIN TIDAL ENERGY
Marine Route Engineering Report

1. INTRODUCTION

IT International Telecom (IT) was commissioned by Minas Basin Pulp and Power Co. Ltd. (MBPP) to engineer the safest route for the 3 submarine cables to link their Minas Basin Tidal Energy Demonstration Facility to three tidal turbines to be installed on the seabed of Minas Basin Channel in the Bay of Fundy (see Figure 1). One turbine will be installed in each of the three zones shown in Figure 2.

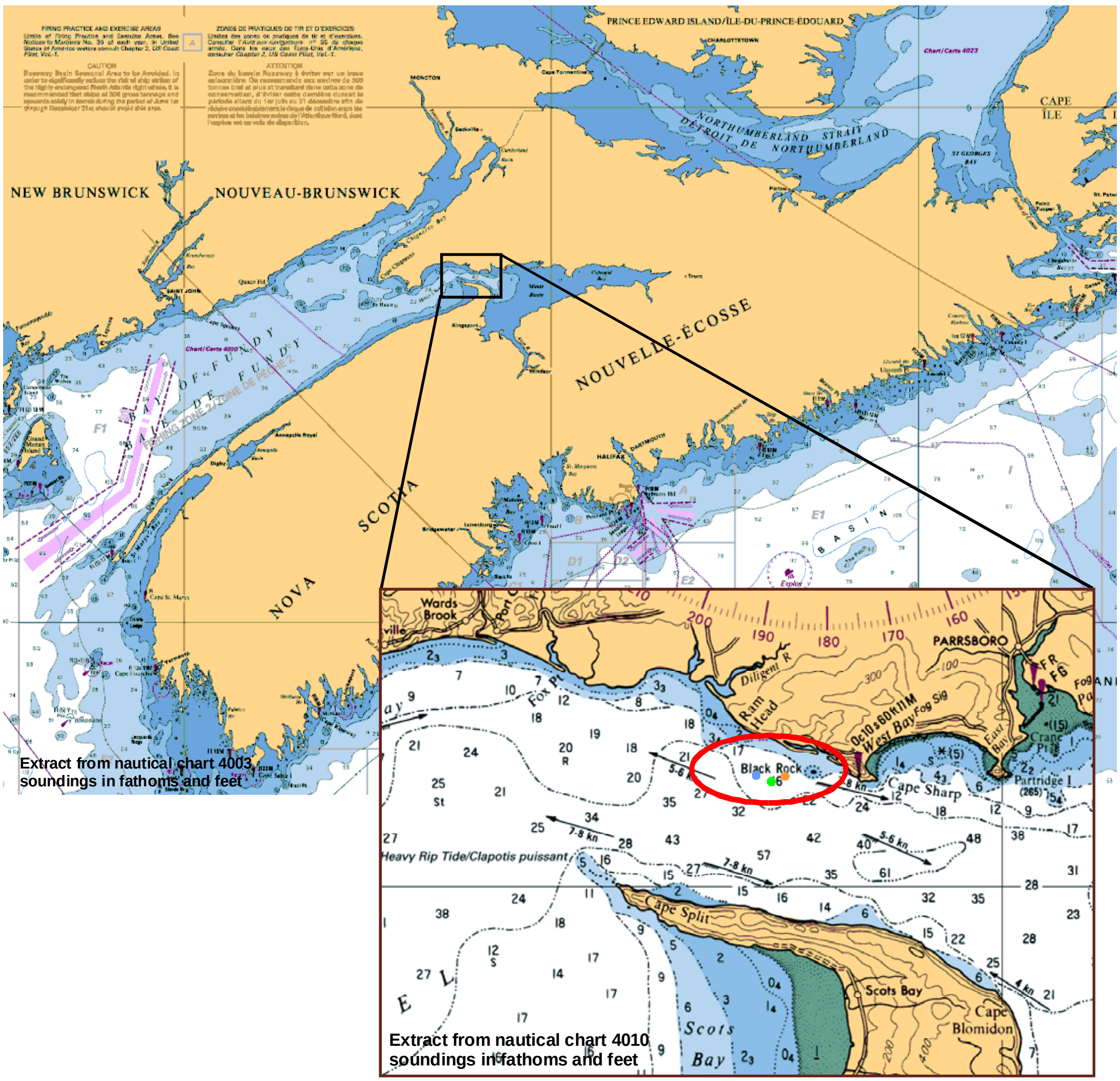
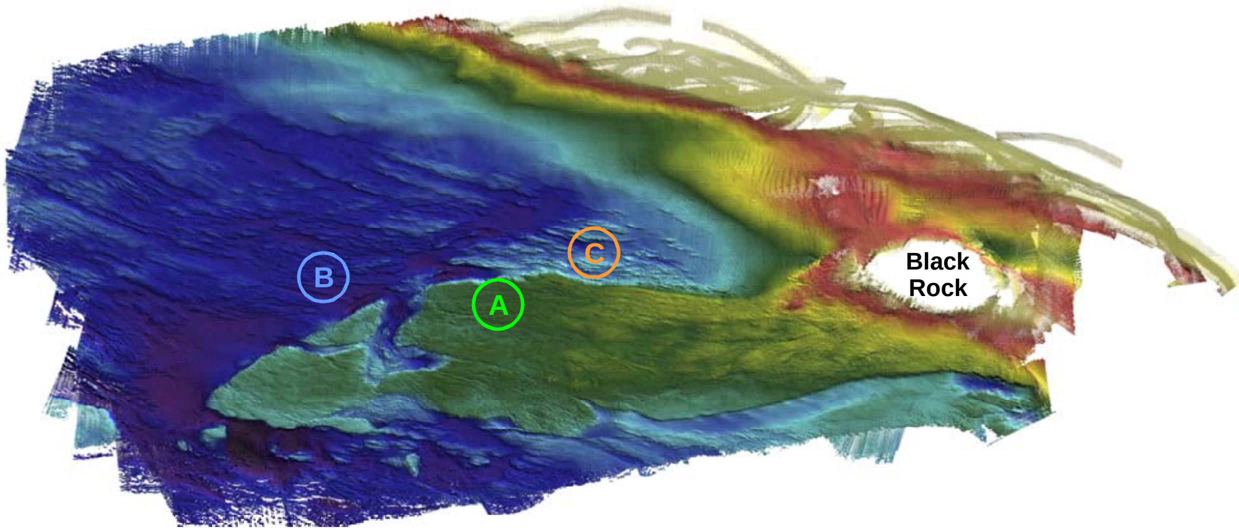


Figure 1 – Study Area



Source: Gordon Fader Presentation

Figure 2 – Turbines Installation Zones

2. DATA GATHERING

Data gathered by or on behalf of MBPP was presented to IT during a meeting at Seaforth Engineering offices in Dartmouth, March 17, 2009. Present at the meeting were:

Name	Company/Title	Title/Role
Gordon Fader	Atlantic Marine Geological Consulting Ltd. Marine Geologist	Marine geology interpretation
Joseph Kozak	AECOM Senior Environmental Consultant	Environmental assessment
Nick Strum	Strum Engineering Associates Ltd. President	Electrical engineering
Simon Melrose	Oceans Ltd. Manager, Nova Scotia Operations	Oceanography
Bruce MacDonald	Minas Basin Pulp and Power Co. Ltd. Woodland Supervisor/Surveyor	Landing site survey
David Lombardi	Seaforth Engineering Group Inc. President	Marine survey
Arthur Abbott	Seaforth Engineering Group Inc.	GIF specialist
Nancy Poirier	IT International Telecom Director, Marine Projects and Sub-Sea Engineering	Marine route engineering
Adam Kepa	IT International Telecom Project Manager and Sub-Sea Engineering	Marine route engineering

A site visit was also conducted April 14, 2009 in order to have IT marine operation specialist, David Mason, and shore end specialist, Andrew Waddell, have a look at onsite conditions.

In November 2009 IT was informed that the landing site had to be changed. A second site visit was thus organized and occurred January 12, 2010.

Seaforth Engineering Group provided bathymetric data. These 1-meter interval bathymetric lines were imported in MakaiPlan, the submarine cable planning software used by IT (see Figure 3).

Gordon Fader presented his finding and interpretation of the marine geology of the area as well as his first draft of a potential cable route (Figure 4). This route was designed to avoid slumped areas and a migrating gravel wave sector as well as maximizing natural protection using channels between rock ridges. His summarizing presentation is attached as Appendix A.

A short briefing was given about the status of the Environmental Assessment.

Tides & currents measurement have been done by Oceans Ltd. and findings were presented by Simon Melrose (see Appendix B).

There were further discussions about ice movement as well as about construction & installation methodology and manhole location. Cable specifications were later provided and are attached as Appendix C.

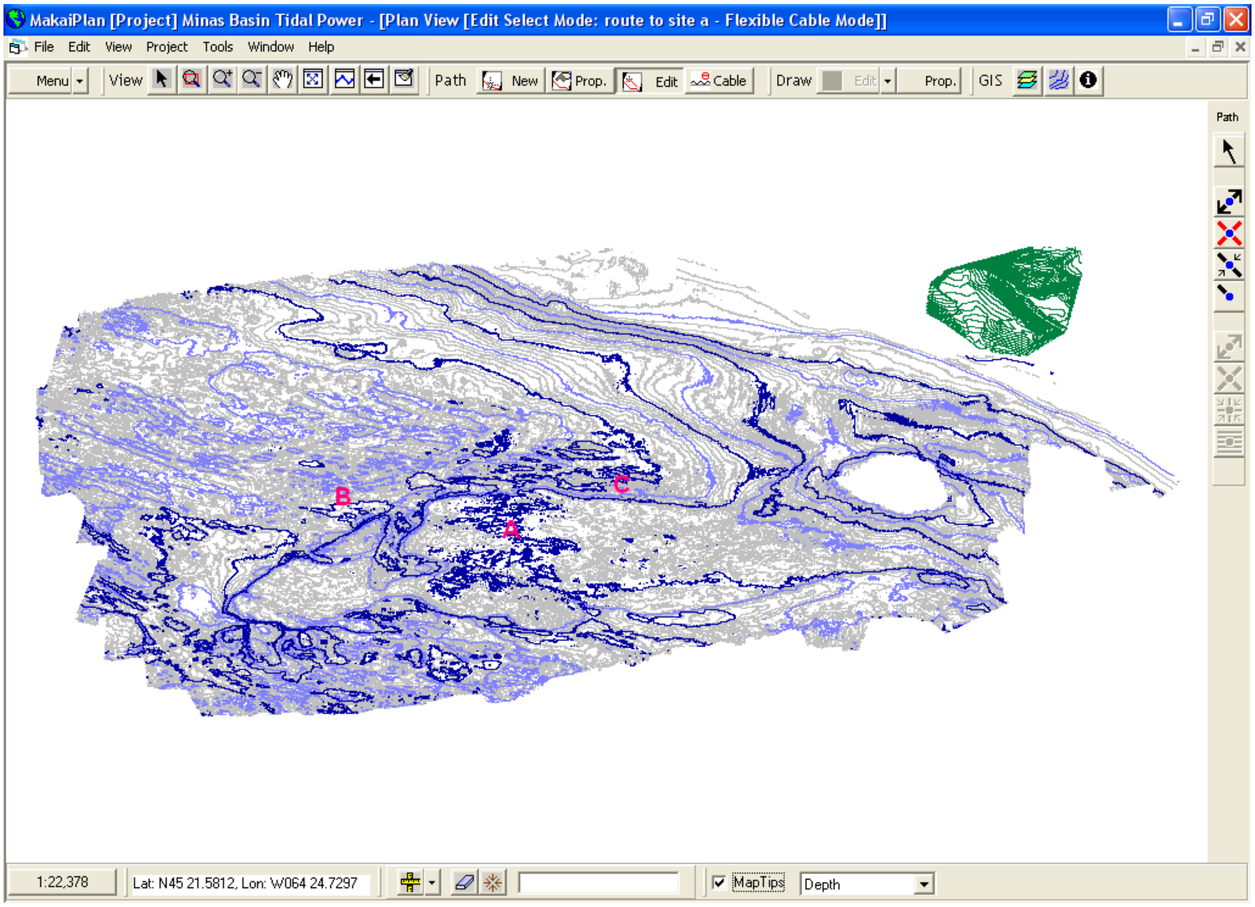
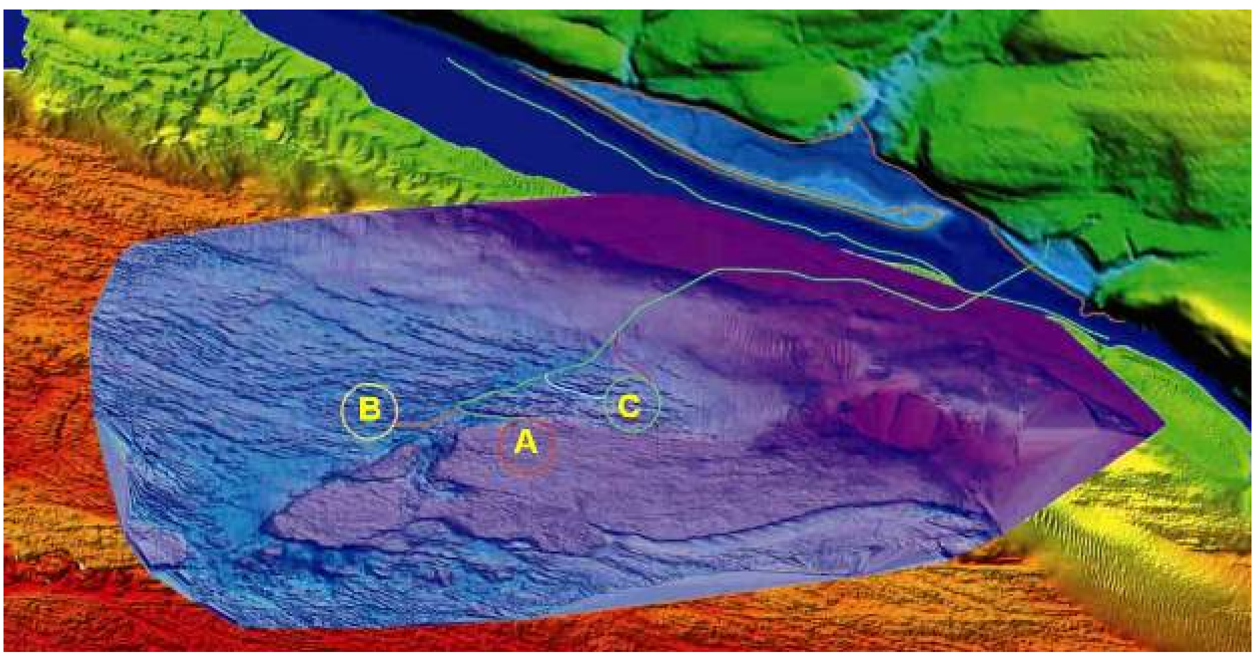


Figure 3 – Bathymetric Data from Marine and Land Survey Imported in MakaiPlan



Source: Gordon Fader Presentation

Figure 4 – Initial Potential Route

3. DATA ANALYSIS AND ROUTE ENGINEERING

Submarine cable routing has to take into account all findings presented above while still respecting industry standards for cable routing. The International Cable Protection Committee has issue several recommendations concerning several aspects of the submarine cable industry. These Recommendations are intended as a guide to aid cable owners and other seabed users in promoting the highest goals of reliability and safety in the submarine cable environment.

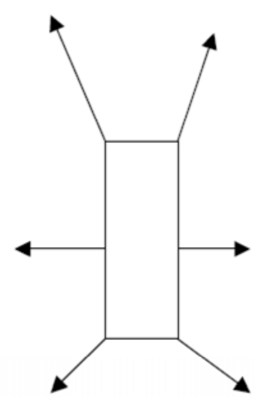
In regards to parallel cables, *ICPC Recommendation No. 2, Issue: 9A – Recommended Routing and Reporting Criteria for Cables in Proximity to Others* states that where cables parallel one another, the distance between them shall be maintained at 3 times depth of water where possible or 9 km, whichever is the lesser. However, with the use of modern navigational equipment and lay/repair practices, these distances could be reduced to 2 times depth of water and 6 km spacing, whichever is the lesser.

This separation is necessary to allow potential repair or recovery of the cables as well as providing route diversity.

In the present case, due to the high currents that will be encountered limiting the installation vessel maneuverability 3 times water depth separation was aimed at whenever possible.

3.1 Intertidal Zone

Bringing the cables ashore will require the installation of deadman anchors in the intertidal zone to hold the barge as the tide comes in and the tugs cannot be alongside. A total of 6 of these heavy concrete blocks will be buried in advance under the beach, 2 of which may be close to the high tide mark, 2 abeam of the barge mid-ship area and 2 astern of the barge (probably close to the low water mark). Final positions will be determined by the assist vessels and their draft requirements at high tide.



The barge will beach at the same place for all three cables in order to reuse the same anchors. Barge beaching point has been chosen on a relatively flat area according to survey data. The deadman anchors will be removed after completion of the cable installation.

Once the barge moves away the cable laid on the intertidal zone will need to be moved to the side to avoid the barge sitting on it when it comes back for the next cable. After all three cables are installed, they will be moved as required to be placed into the trench to the manhole.

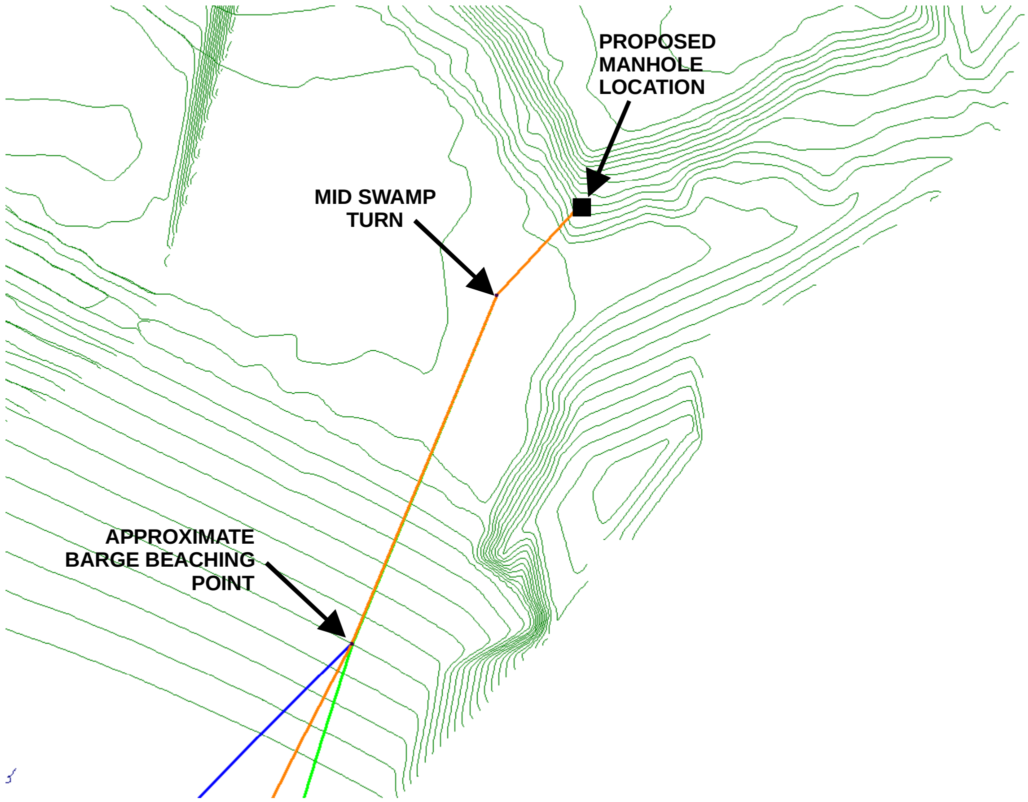


Figure 5 – Intertidal Zone Routing

3.2 Underwater Slumping/Scarp Zone

A steep scarp is found along the coast of the study area and need to be crossed to get to the bottom of the study area where the turbines will be installed. Going down steep slope should always be done at right angle mostly where there is a potential for slumping. The initially proposed routing follows the top of the scarp in approximately 5 to 6 meter water depth to avoid already slumped areas. There is limited data about ice movement but should chunks of ices the size that was mentioned during the meeting ground or raft up on the shore line, this section of cable in shallow water would be at risk. Furthermore, should the scarp slump in the future, it's the whole section of the cable parallel to the shore line that could be pulled down with it, possibly inflicting damage the cable. Going down the slope to safer, deeper water as soon as possible is usually recommended.

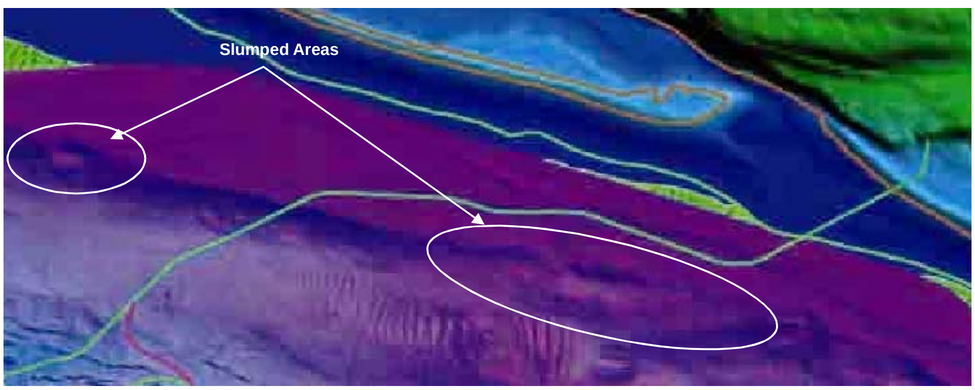
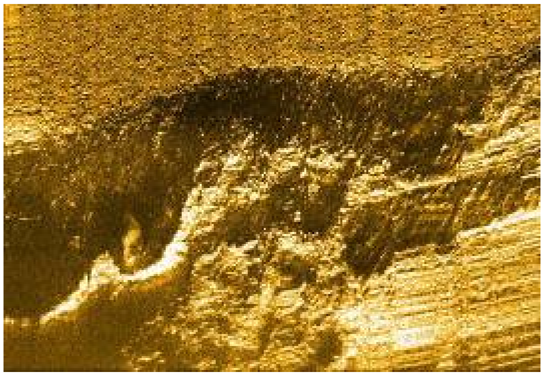


Figure 6 – Underwater Slumping/Scarp Zone

Even though the area right in front of the landing site is slumped, it is believed that it will offer a safer, shorter way down the slope. Also, the slope left not being very high, further slumping should be minimal if any and should not threaten the integrity of the double armored cable as it goes down perpendicular to the slope.

So, from the barge beaching point, the 3 routes will go down the slumped, gradually separating from one another.



Source: Gordon Fader Presentation

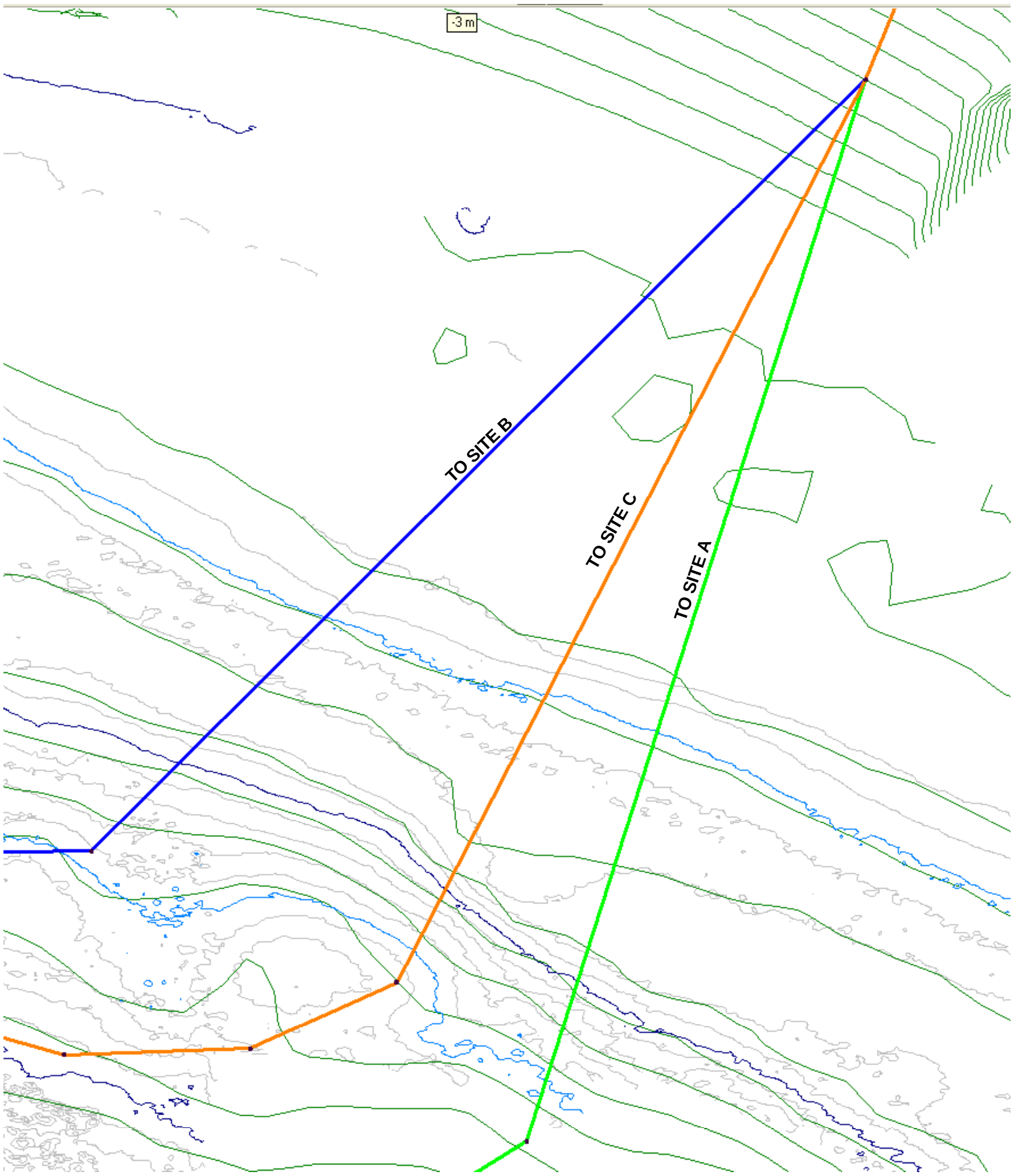
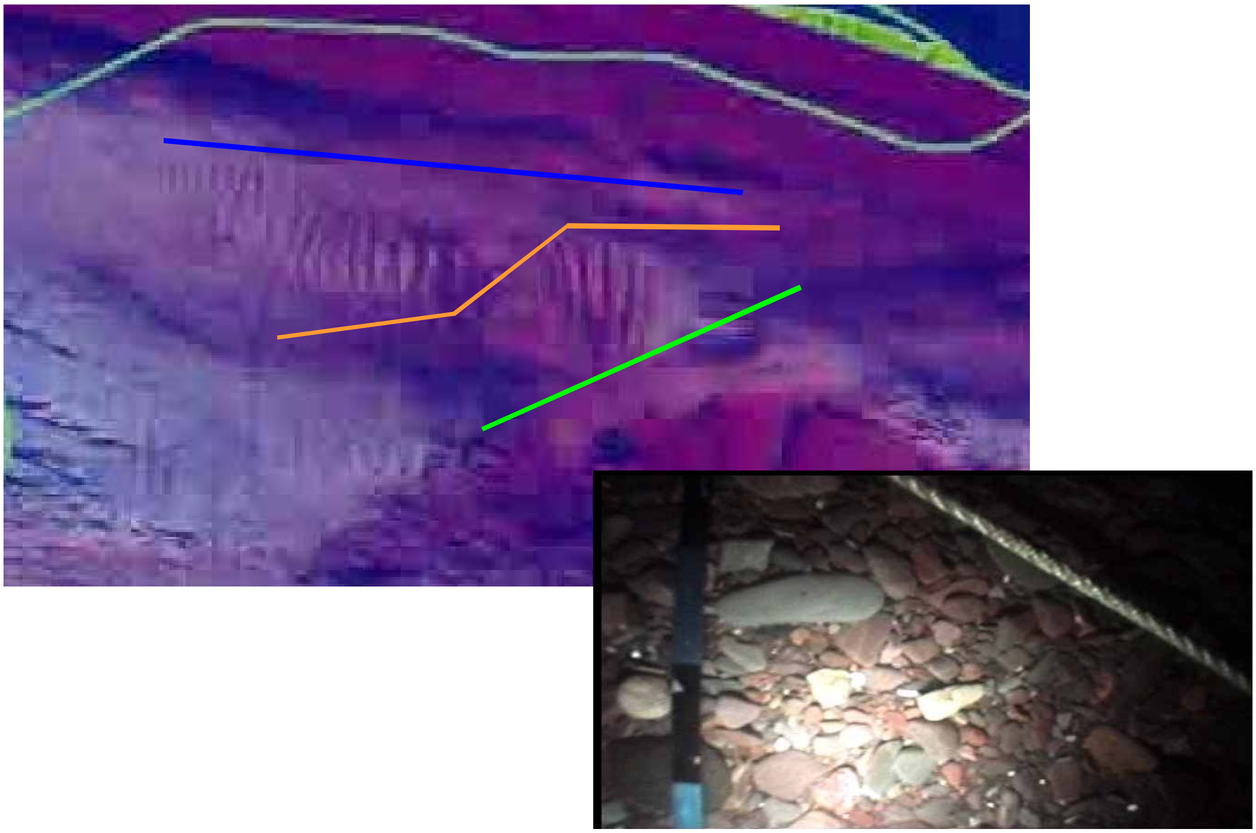


Figure 7 – Routes going down the slope

3.3 Gravel Waves Area

Right at the bottom of the slope, in front of the landing site, lies an area of shifting gravel waves. In order to keep the minimal required separation, route A and B skirt each side of the wave area. But as it is stuck between the scarp on the North and Black Rock to the South, the third route was chosen to go across the middle of the gravel waves in an area that looks smoother. Even though we realize that these waves are constantly shifting, we feel the heavy cable should have a tendency to sink as the gravel moves. Suspensions are possible but the double armor cable is robust enough to withstand these short spans.



Source: Gordon Fader Presentation

Figure 8 – Through Gravel Waves

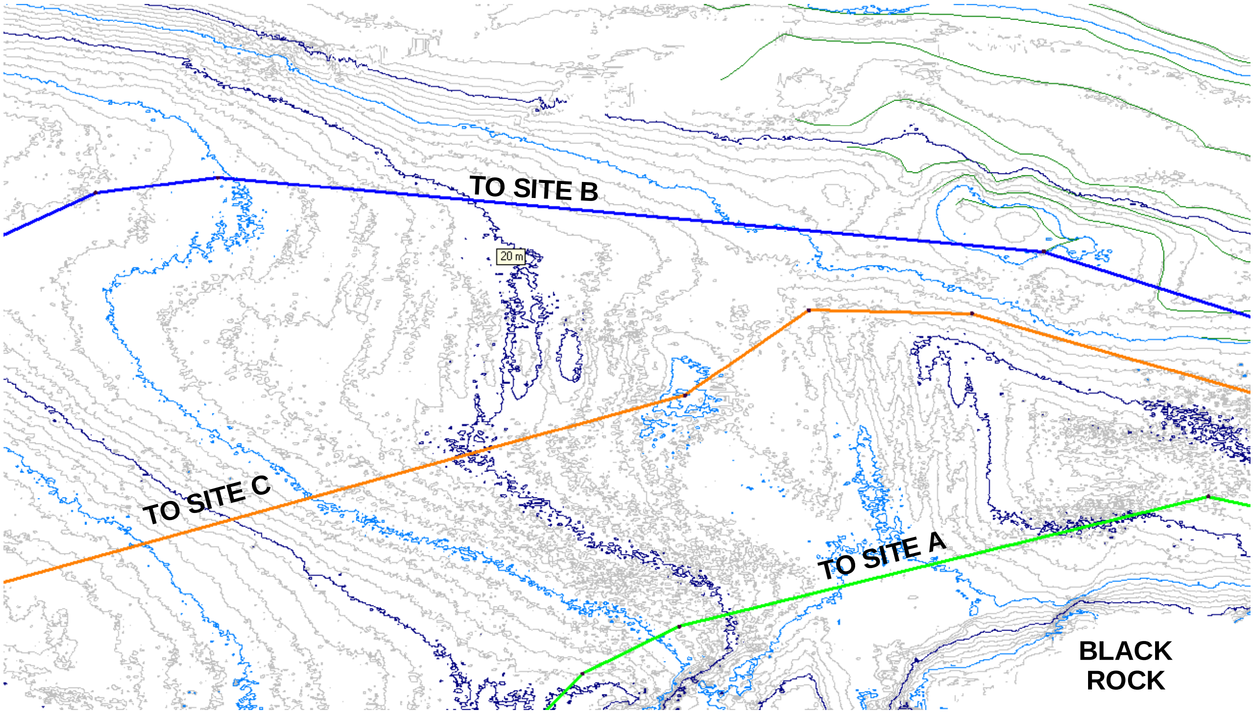


Figure 9 – Routing Through Gravel Waves

3.4 Route A Up the Volcanic Platform

Arriving from the Northeast, Route A goes up the volcanic platform in an area of lesser slope. The route then goes around Open Hydro Turbine, staying at least 3 times water depths from it and also staying away from the edge of the platform to avoid sliding down it steep sides.

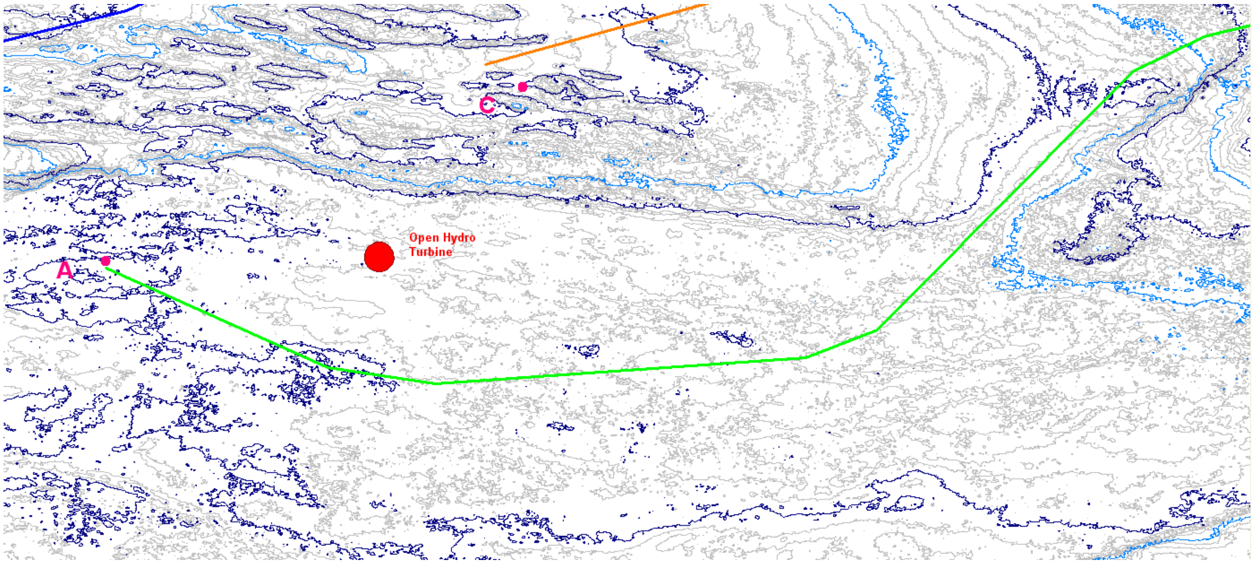
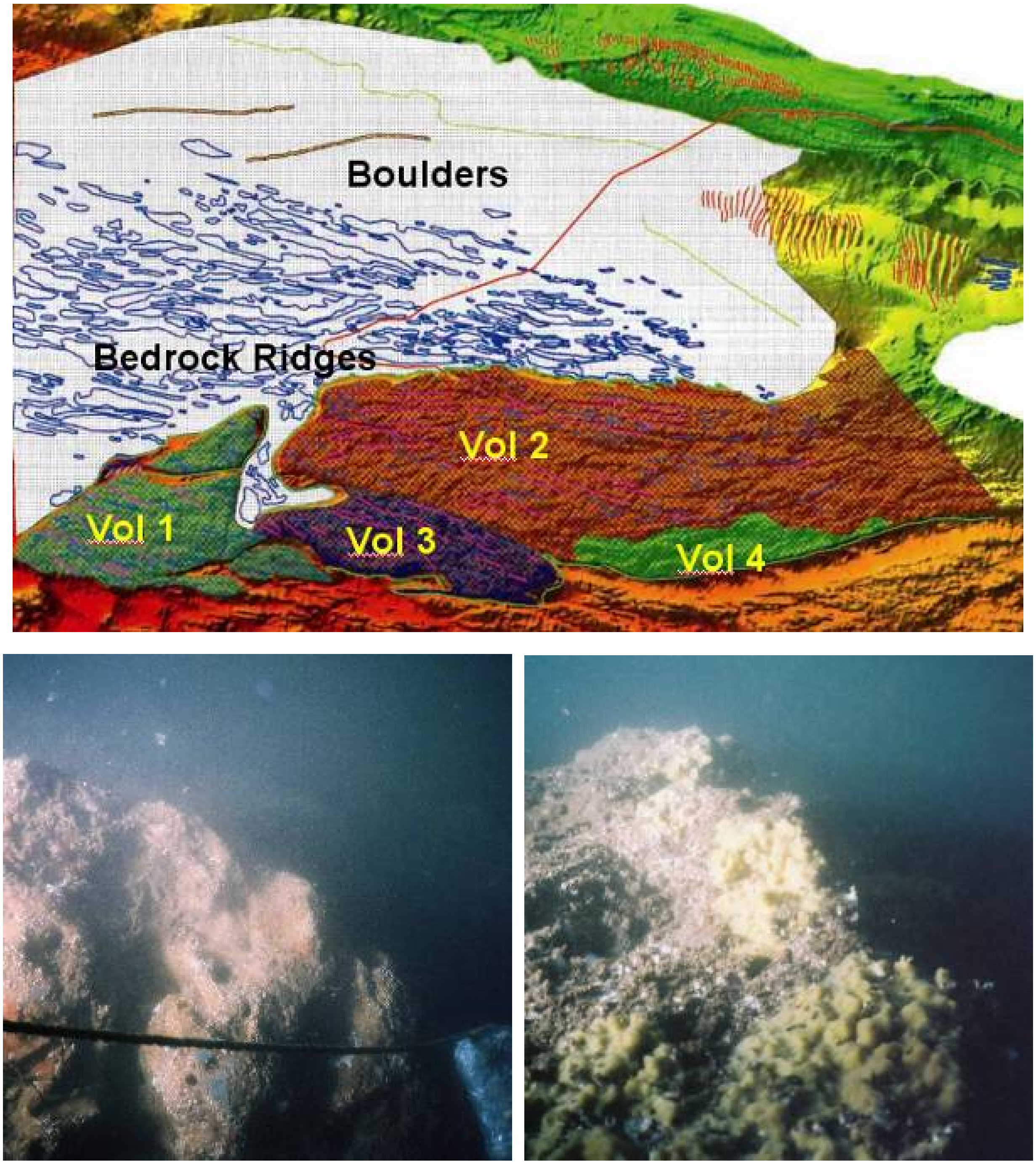


Figure 10 – Routing Up the Volcanic Platform

3.5 Route B through Channels

After going around the gravel wave zone, Route B merges back with the initially proposed route and enters an area of bedrock ridges and narrow channels. The sometime no more than 10 meter wide, 5m deep channel could be difficult to hit but as there are no larger flat area it will provide good natural protection if the cable falls all the way in it and will not induce suspension worst than any other routing through this area. Again the robustness of this heavy double armor cable should suffice to insure its integrity in this rough area.



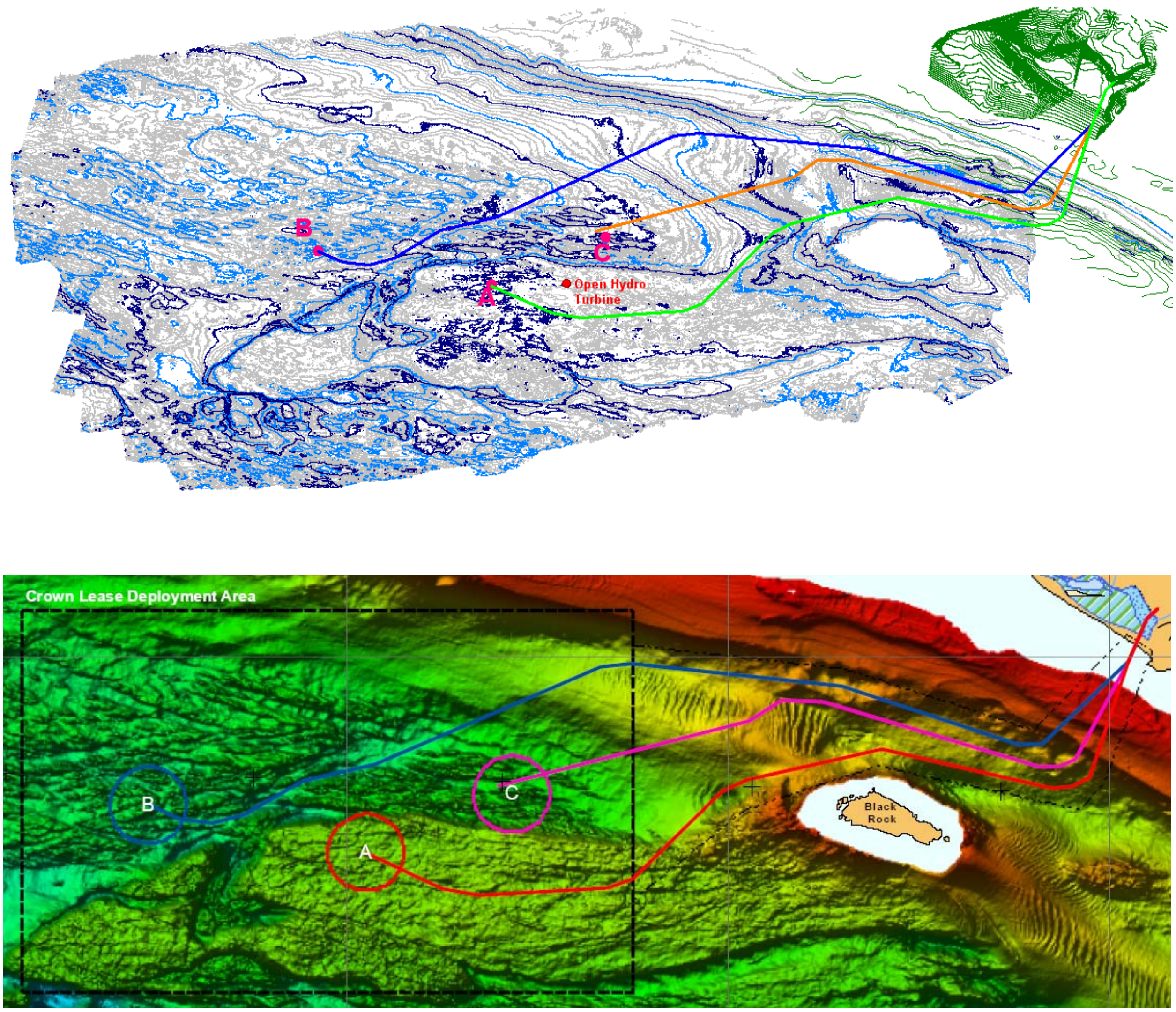
Source: Gordon Fader Presentation

Figure 11 – Bedrock Ridges Area

4. ROUTE POSITION LISTS AND PROFILES

The following are the engineered cable routes Route Position Lists (RPLs) and route profiles.

The RPLs also include required cable length equal to the bottom distance of the route following the sea floor profile. It also includes an additional 200m as installation cable allowance. These lengths should be sufficient to allow temporary route deviation due to high current, coiling and splicing in the manhole and recovering the cable to the surface for later connection to turbines as well as allow further route development to reach turbines that would be positioned at the far end of their respective zones.



Multibeam map by Seaforth Geosurveys

Figure 12 – Engineered Cable Routes

4.1 Route A

Index	Label	Latitude	Longitude	Bearing deg T	AC deg	Distance (m)		Slack %		Cable (m)		Cable Type	Depth m	Comment
						Segment	Total	Surface	Bottom	Segment	Total			
0		N45 22.2617	W064 24.1888				0				0		-18	Vault #1
				225.562		39		1.78	0	40		DA		
1	AC1	N45 22.2470	W064 24.2100		-23.1		39				40		-14	Mid swamp turn
				202.461		121		0.36		121		DA		
2	AC2	N45 22.1864	W064 24.2456		-4.81		160				161		-7	Barge Beaching Point
				197.654		321		0.7		324		DA		
3	AC3	N45 22.0213	W064 24.3201		42.45		481				485		19	
				240.101		51		0.62		51		DA		
4	AC4	N45 22.0076	W064 24.3538		24.3		532				536		24	
				264.401		56		0.42		56		DA		
5	AC5	N45 22.0047	W064 24.3967		17.62		588				592		25	
				282.017		455		0.35		456		DA		
6	AC6	N45 22.0557	W064 24.7369		-25.79		1,043				1,048		21	
				256.229		363		0.69		366		DA		
7	AC7	N45 22.0090	W064 25.0076		-12.34		1,406				1,414		23	
				243.885		72		0.42		72		DA		
8	AC8	N45 21.9919	W064 25.0570		-19.18		1,478				1,486		29	
				224.709		329		0.11		329		DA		
9	AC9	N45 21.8659	W064 25.2339		23.93		1,807				1,815		28	
				248.638		69		0		70		DA		
10	AC10	N45 21.8522	W064 25.2836		17.32		1,876				1,885		29	
				265.962		337		0		337		DA		
11	AC11	N45 21.8394	W064 25.5409		12.78		2,213				2,222		29	
				278.746		99		0.05		98		DA		
12	AC12	N45 21.8475	W064 25.6155		15.29		2,312				2,320		30	
				294.038		220		0		221		DA		
13		N45 21.8959	W064 25.7695				2,532				2,541		30	Zone A
						0		N/A		200		DA		Cable Allowance
		N45 21.8959	W064 25.7695				2,532				2,741			

vertical exaggeration X10

Figure 13 – Route A Profile

4.2 Route B

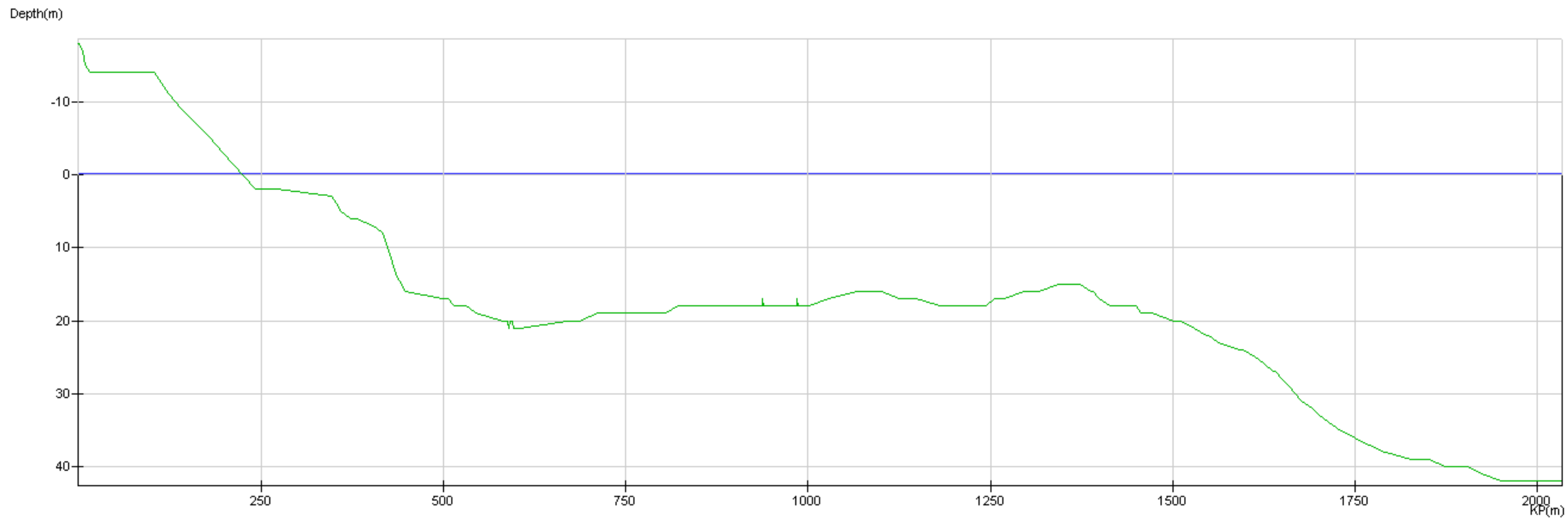
Index	Label	Latitude	Longitude	Bearing deg T	AC deg	Distance (m)		Slack %		Cable (m)		Cable Type	Depth m	Comment
						Segment	Total	Surface	Bottom	Segment	Total			
0		N45 22.2617	W064 24.1888				0				0		-18	Vault #1
				225.562		39		1.78	0	40		DA		
1	AC1	N45 22.2470	W064 24.2100		-23.07		39				40		-14	Mid swamp turn
				202.493		121		0.36		121		DA		
2	AC2	N45 22.1864	W064 24.2456		22.49		160				161		-7	Barge Beaching Position
				224.988		315		0.34		316		DA		
3	AC3	N45 22.0663	W064 24.4159		44.25		475				477		14	
				269.236		65		0.13		66		DA		
4	AC4	N45 22.0659	W064 24.4662		18.14		540				543		16	
				287.374		486		1.47		493		DA		
5	AC5	N45 22.1441	W064 24.8211		-12.26		1,026				1,036		15	
				275.114		554		0.05		554		DA		
6	AC6	N45 22.1708	W064 25.2438		-12.32		1,580				1,590		25	
				262.794		82		0.03		82		DA		
7	AC7	N45 22.1653	W064 25.3062		-17.23		1,662				1,672		27	
				245.563		643		0.12		644		DA		
8	AC8	N45 22.0216	W064 25.7547		10.75		2,305				2,316		50	
				256.316		195		0.32		195		DA		
9	AC9	N45 21.9968	W064 25.8992		-17.31		2,500				2,511		49	
				239.003		180		0.34		181		DA		
10	AC10	N45 21.9467	W064 26.0175		15.62		2,680				2,692		49	
				254.62		84		0.47		85		DA		
11	AC11	N45 21.9346	W064 26.0799		20.57		2,764				2,777		48	
				275.194		88		0.18		88		DA		
12	AC12	N45 21.9389	W064 26.1470		19.41		2,852				2,865		48	
				294.607		92		1		92		DA		
13		N45 21.9594	W064 26.2105				2,944				2,957		46	Zone B
						0		N/A		200		DA		Cable Allowance
							2,944				3,157			

vertical exaggeration X10

Figure 14 – Route B Profile

4.3 Route C

Index	Label	Latitude	Longitude	Bearing deg T	AC deg	Distance (m)		Slack %		Cable (m)		Cable Type	Depth m	Comment
						Segment	Total	Surface	Bottom	Segment	Total			
0		N45 22.2617	W064 24.1888				0				0		-18	Vault #1
				225.562		39		1.78	0	40		DA		
1	AC1	N45 22.2470	W064 24.2100		-23.07		39				40		-14	Mid swamp turn
				202.493		121		0.36		121		DA		
2	AC2	N45 22.1864	W064 24.2456		4.89		160				161		-7	Barge Beaching Position
				207.385		293		0.62		295		DA		
3	AC3	N45 22.0460	W064 24.3488		37.99		453				456		16	
				245.376		46		0.02		46		DA		
4	AC4	N45 22.0356	W064 24.3810		22.75		499				502		17	
				268.122		54		0.19		54		DA		
5	AC5	N45 22.0347	W064 24.4219		17.72		553				556		19	
				285.841		592		0.51		595		DA		
6	AC6	N45 22.1219	W064 24.8579		-14.73		1,145				1,151		17	
				271.112		109		0.05		109		DA		
7	AC7	N45 22.1230	W064 24.9413		-35.6		1,254				1,260		17	
				235.512		100		0.05		100		DA		
8	AC8	N45 22.0923	W064 25.0047		19.11		1,354				1,360		15	AC7
				254.623		679		0.15		680		DA		
9		N45 21.9951	W064 25.5061				2,033				2,040		42	Zone C
						0		N/A		200		DA		Cable Allowance
							2,033				2,240			



vertical exaggeration X10

Figure 15 – Route C Profile

APPENDIX A – GORDON FADER'S PRESENTATION OF GEOLOGICAL INTERPRETATION

In Stream Tidal Power Siting:
Choosing Cable Routes and Device Sites
Minas Passage Geoscience

Gordon Fader, Dave Lombardi
Patrick Stewart
Nov./08

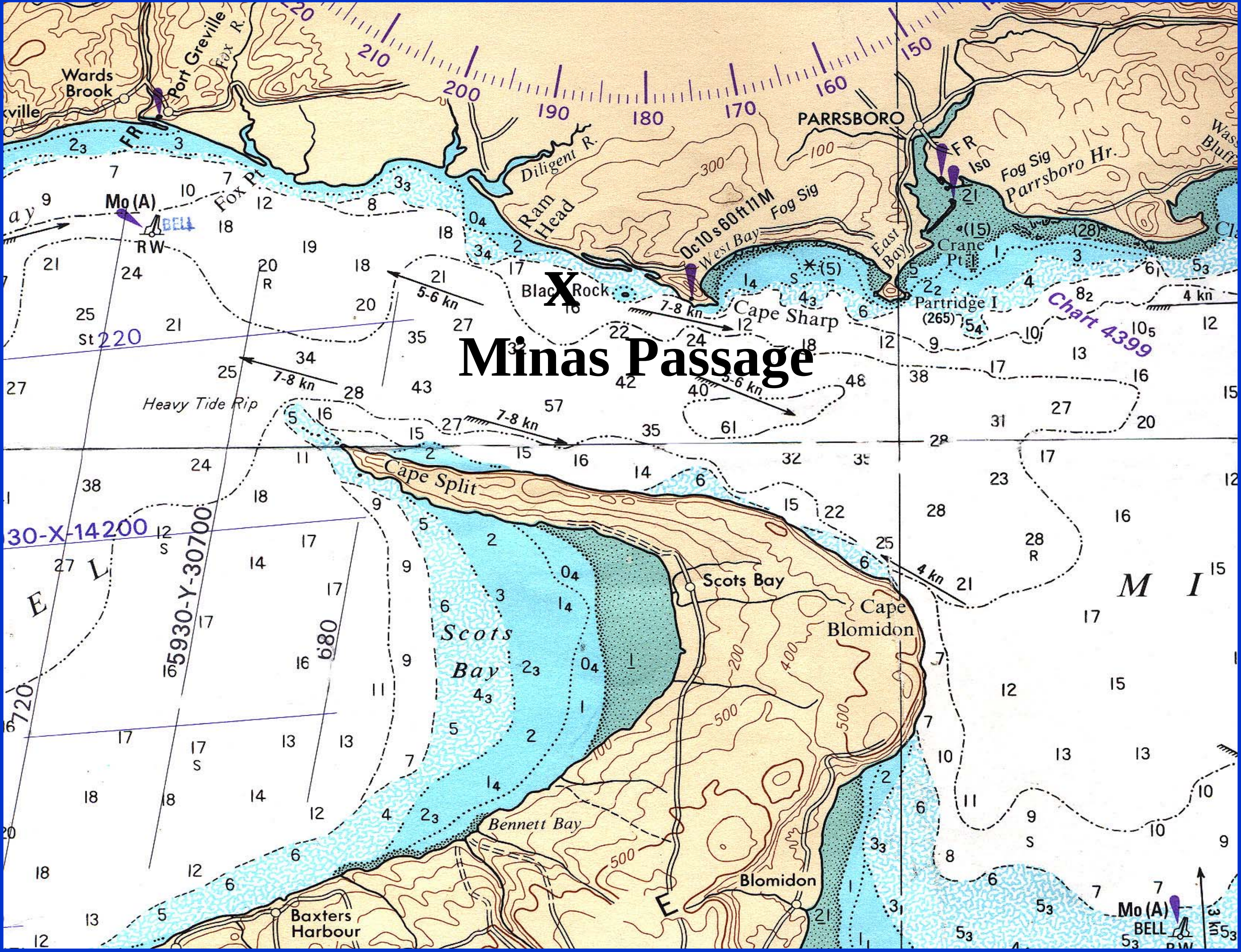
MINAS BASIN

Seabed Geoscience/Siting

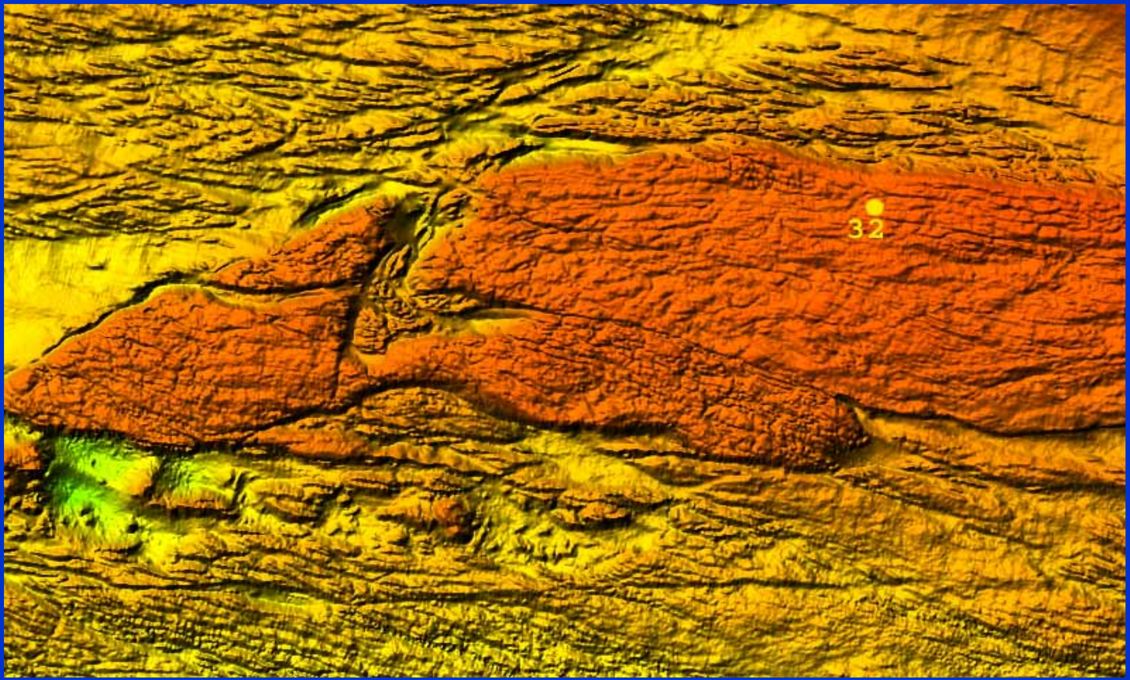
1) **Recent Marine Survey, data/examples**
2) **Geoscience Site Characteristics**
3) **Groundtruth, Photography, Sediment Transport, Concerns, Hazards, Sites and Routes**
4) **Site Selection**

Bathymetry
Sediments
Bedrock
Relief/Topography/Microtopography
Bedforms/Seabed Features
Slopes
Changes

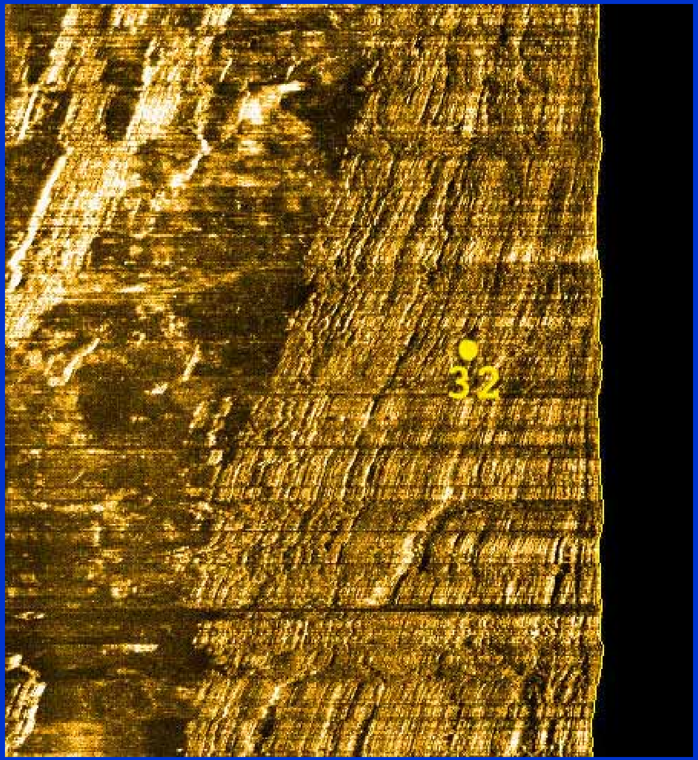
Minas Passage Assessment – Cable/Devices



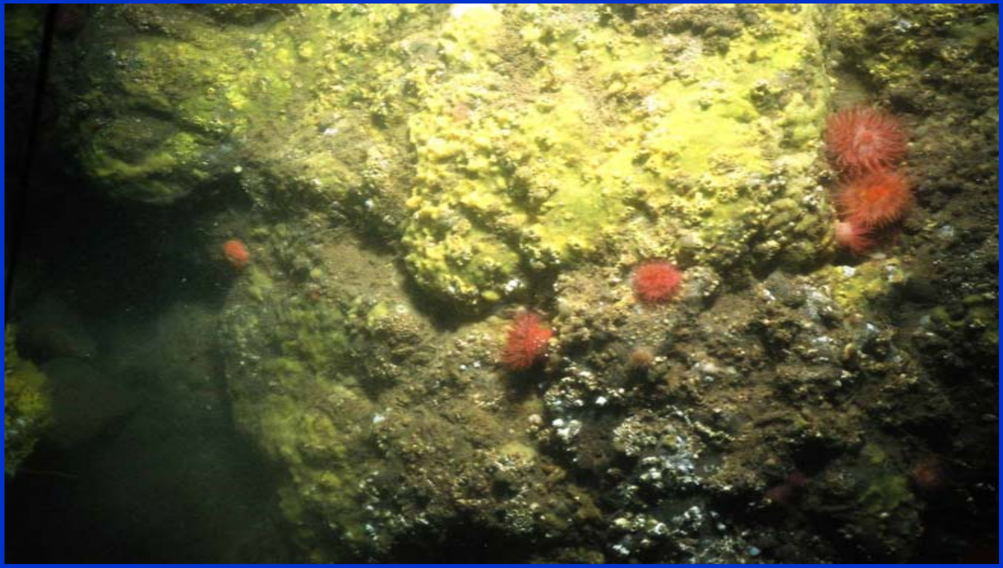
Multibeam Bathymetry – 2 m Res



Sidescan Sonar – 0.25 m Res



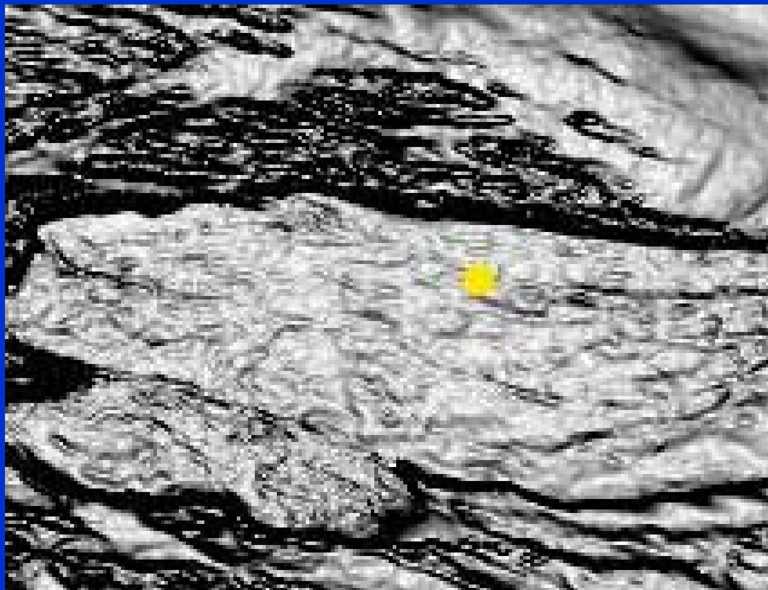
Bottom Photograph – 1 mm Res



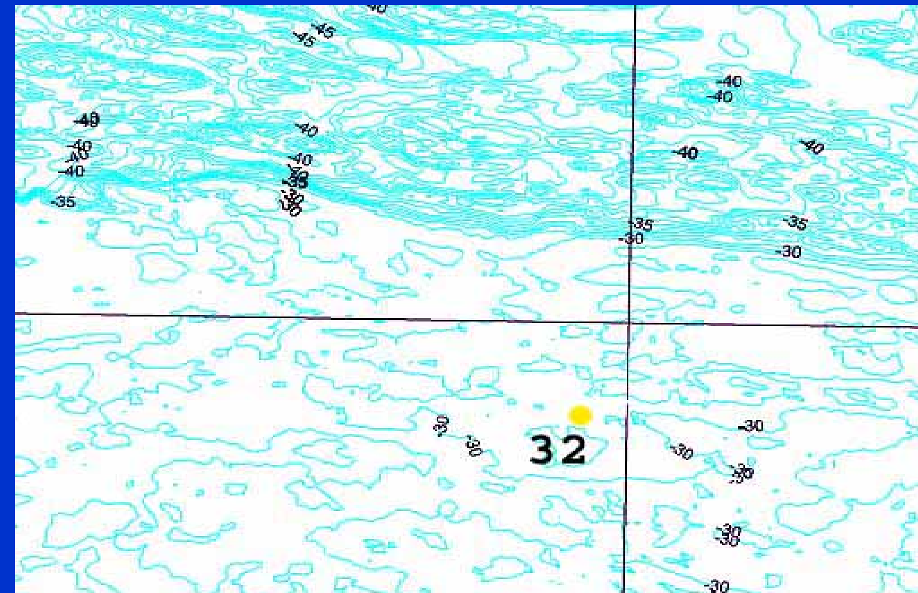
Station 32

-exposed basalt bedrock
-flat platform region
-boulders
-biological attributes
-relative resolutions

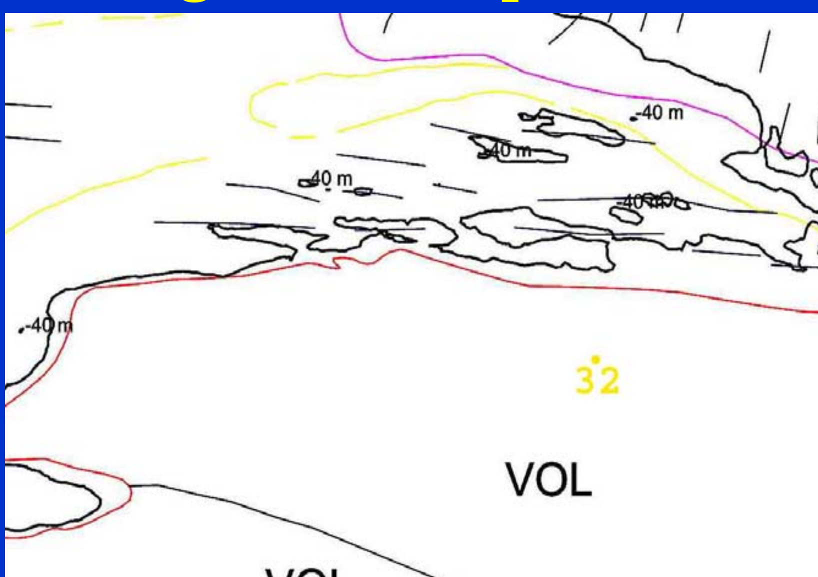
Slope



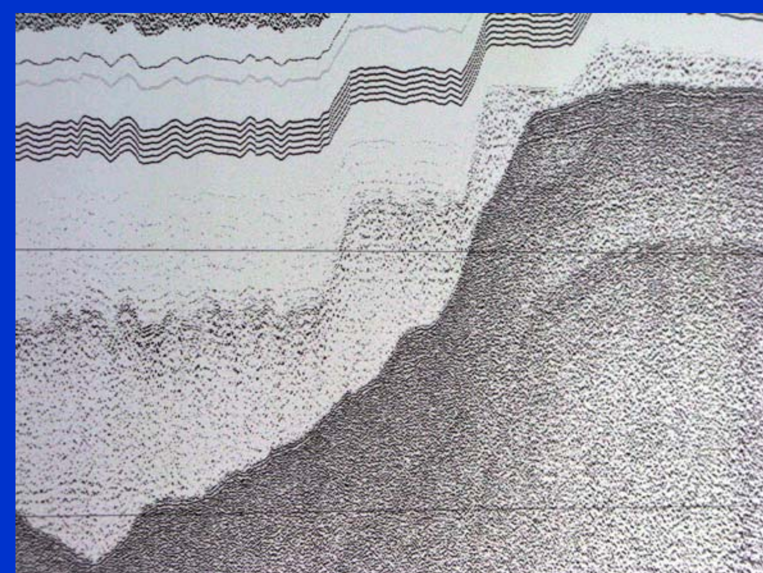
Bathymetry



Regional Interpretation

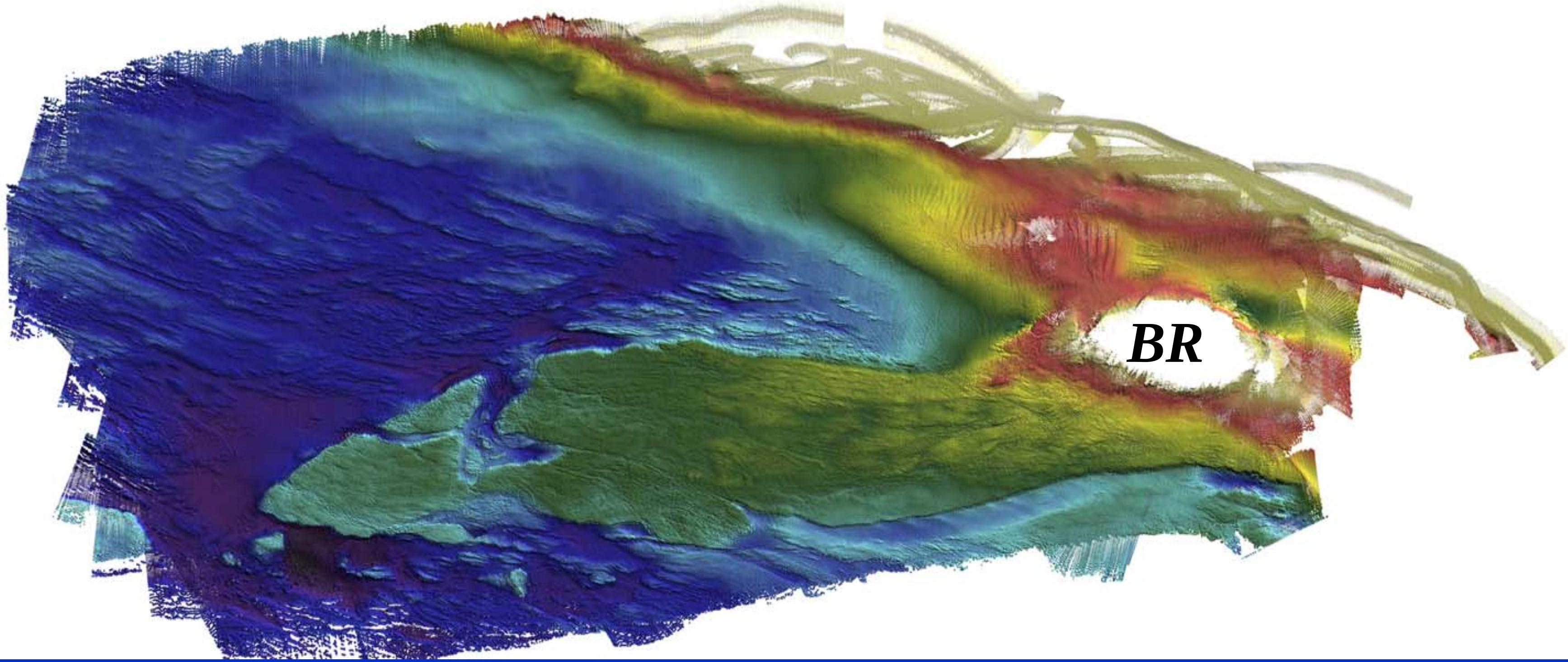


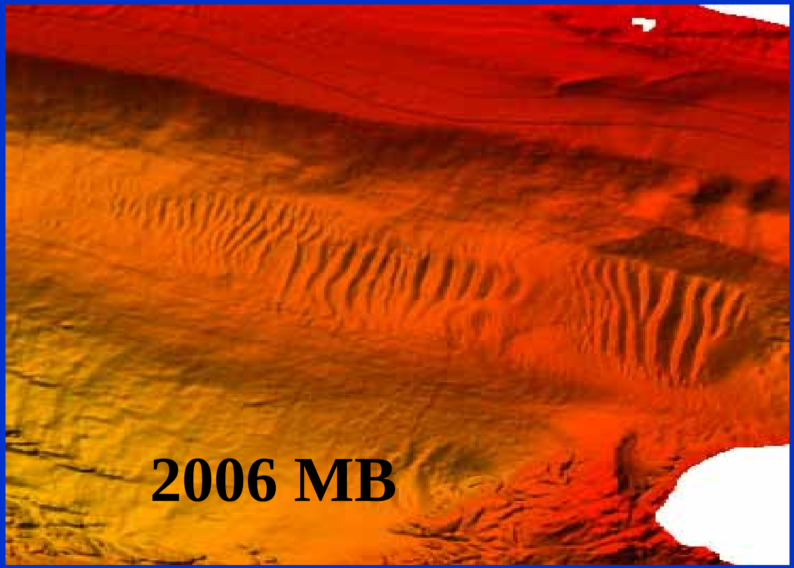
Seismic Reflection Data



Recent Survey Data

New Multibeam Bathymetry, 1 m Resolution

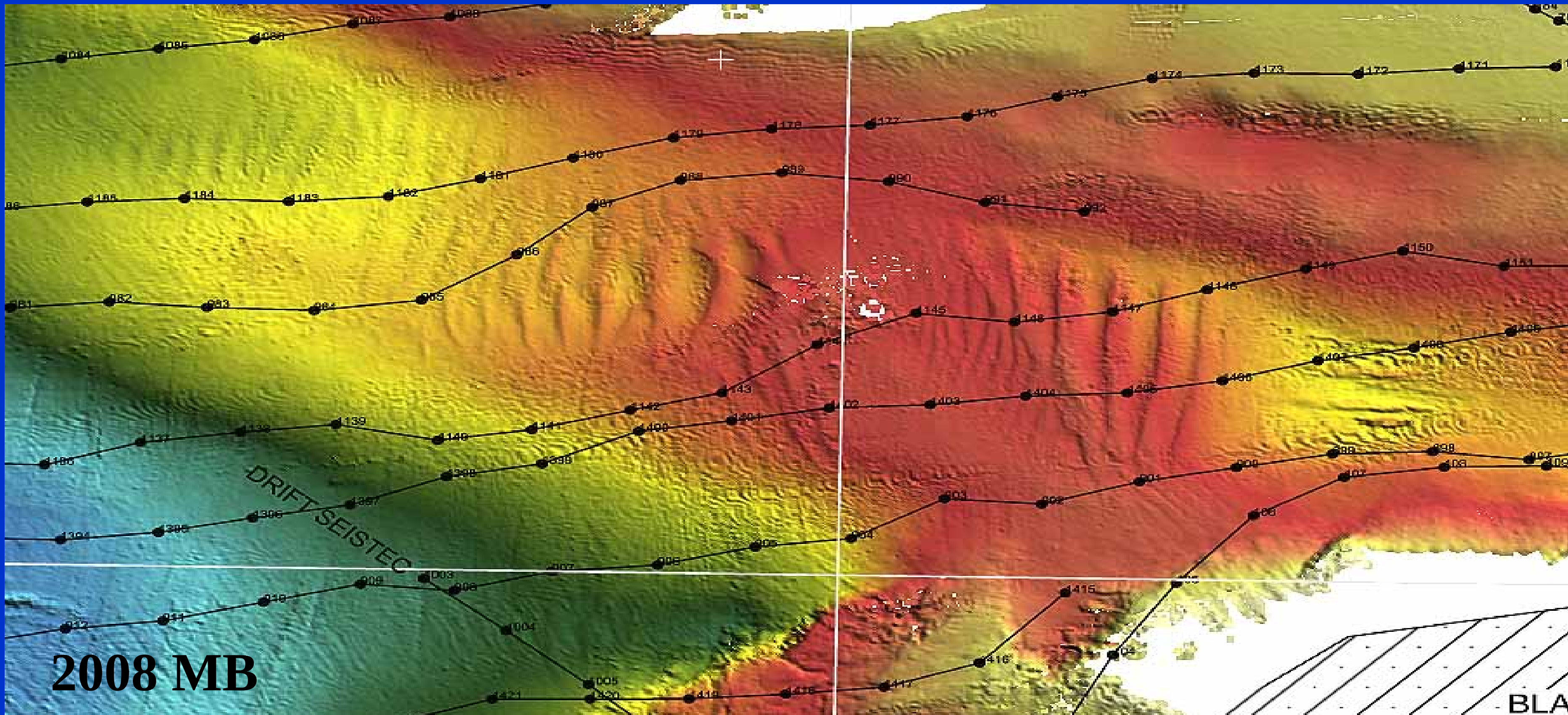




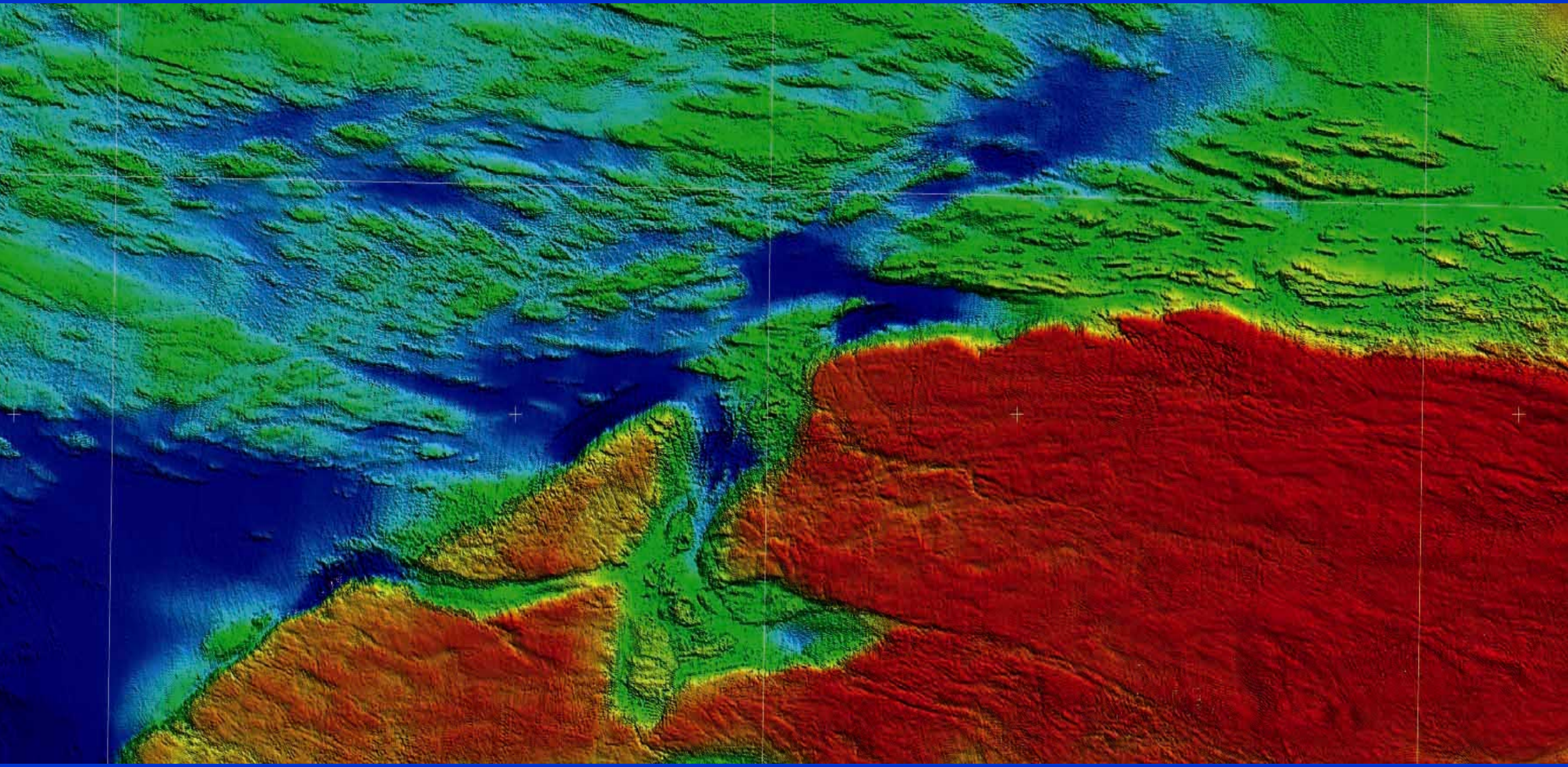
2006 MB Resolution - 2 m

2008 MB Resolution - 0.5 m

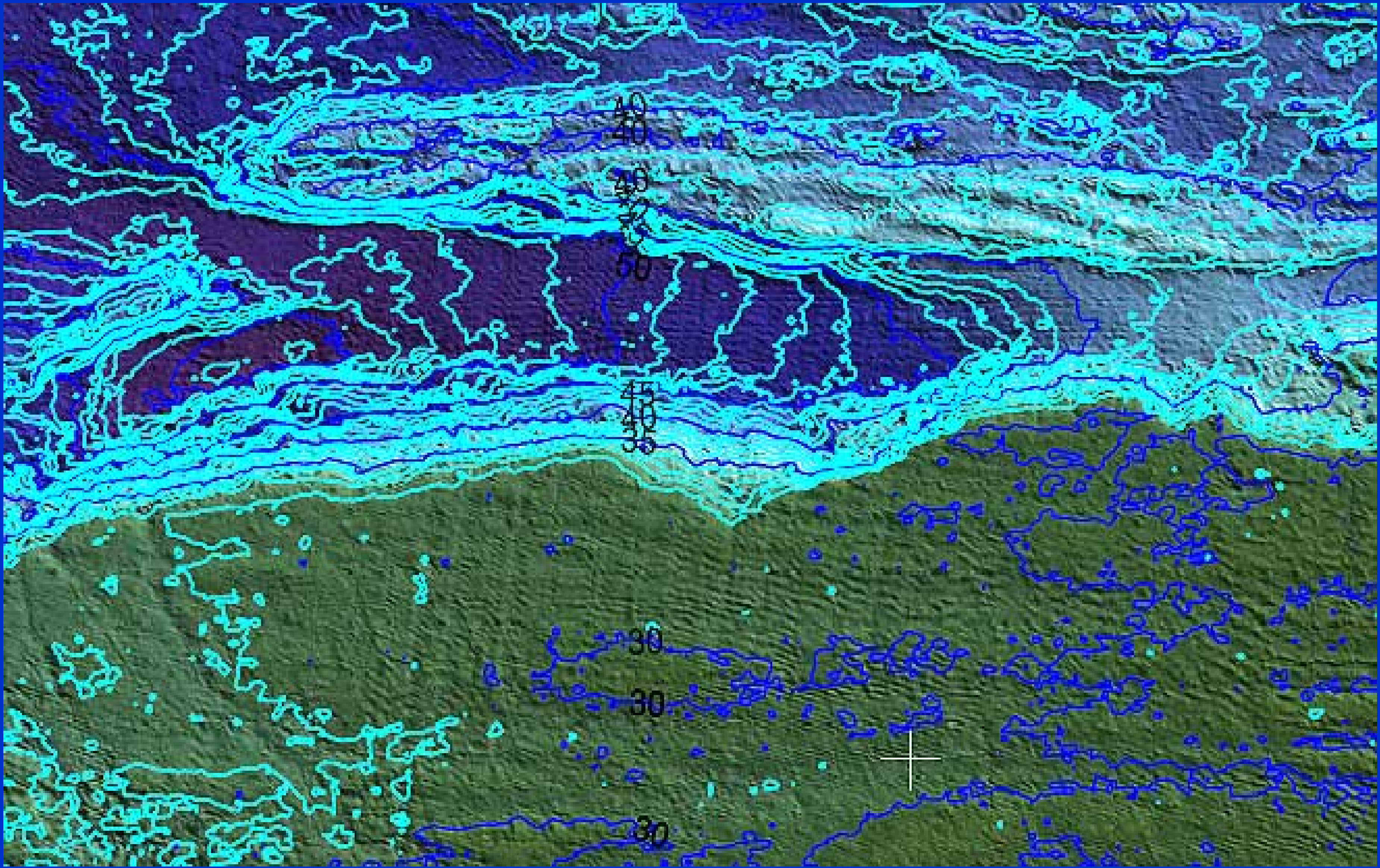
Note: Shifting Gravel Waves



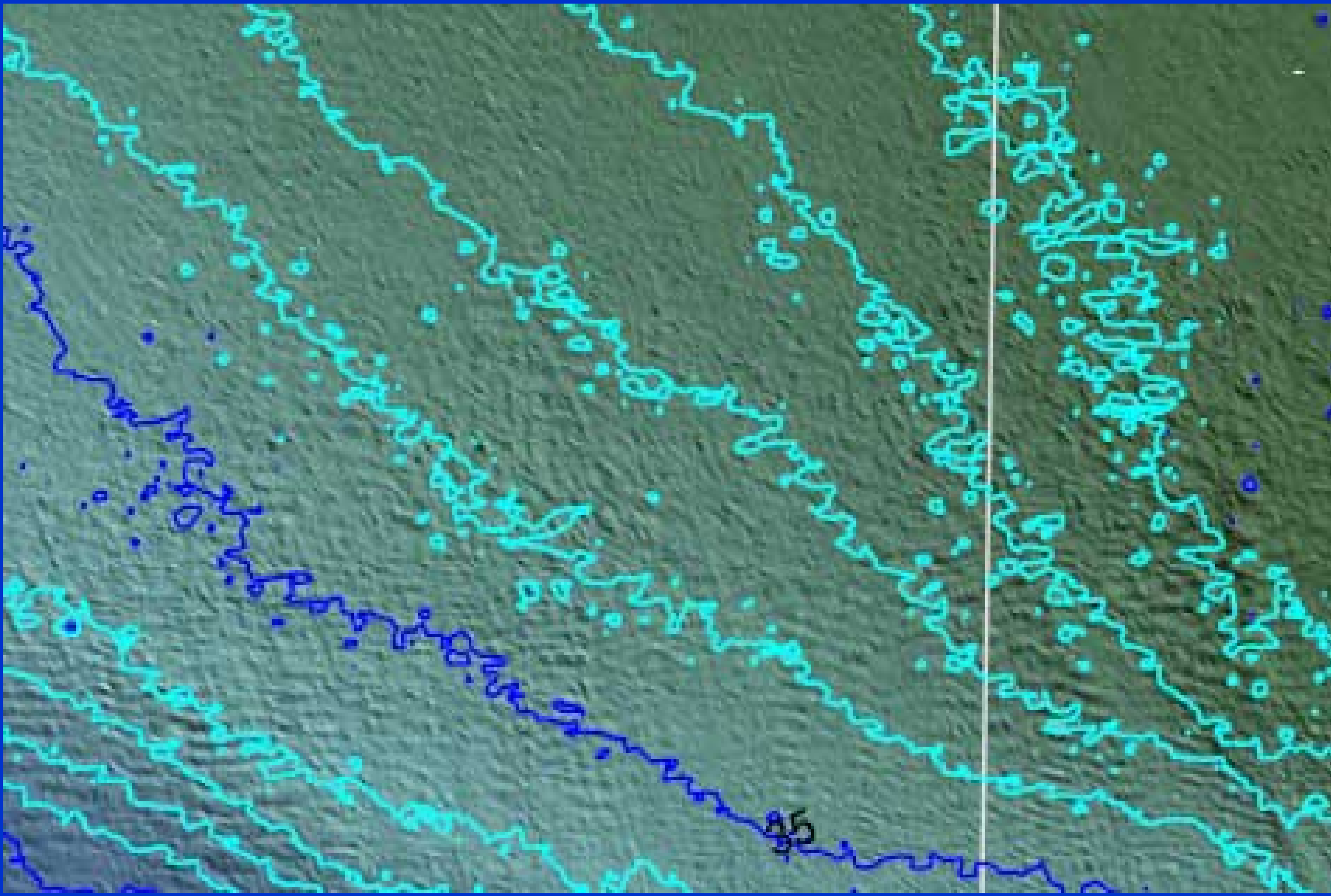
New Multibeam Bathymetry, Oct. 2008
"Focus Area"



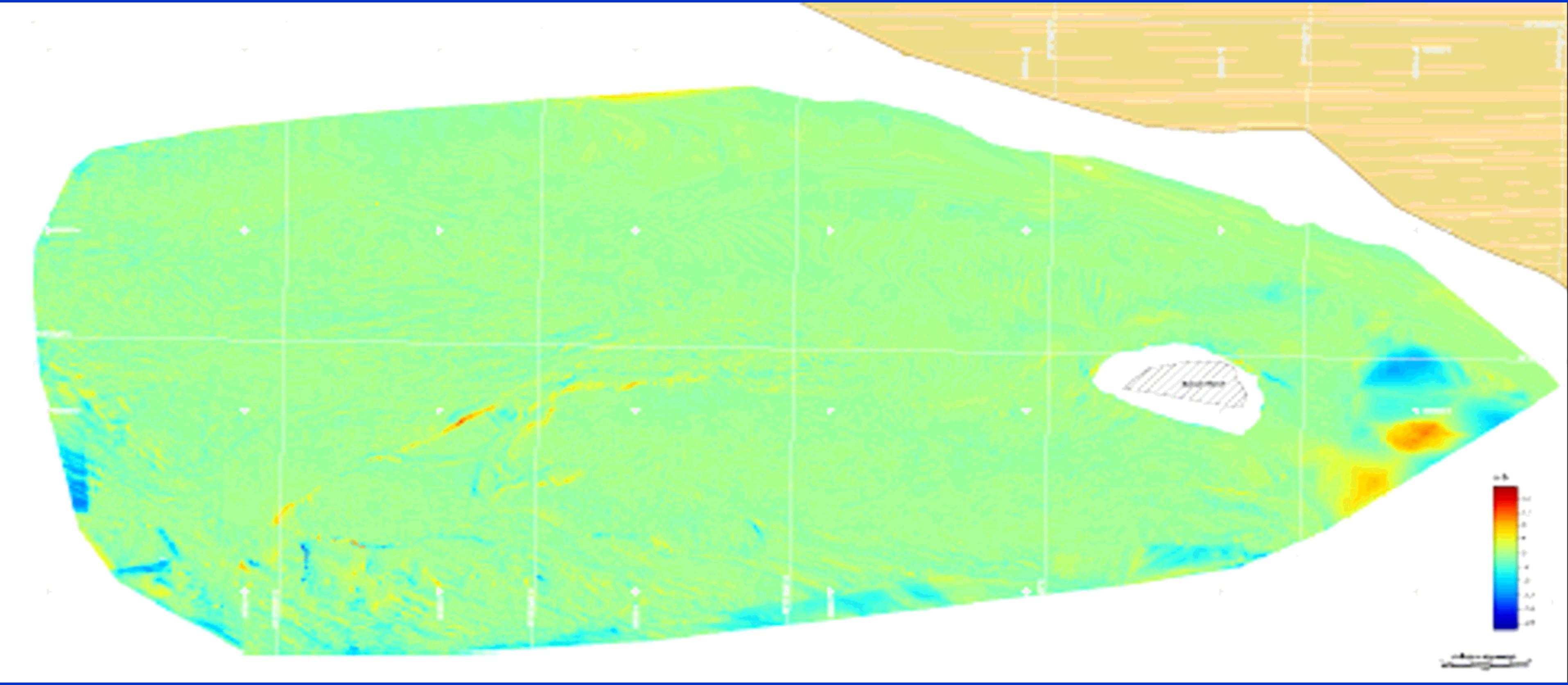
1 M Contour Intervals + MB



Contours Around Boulders

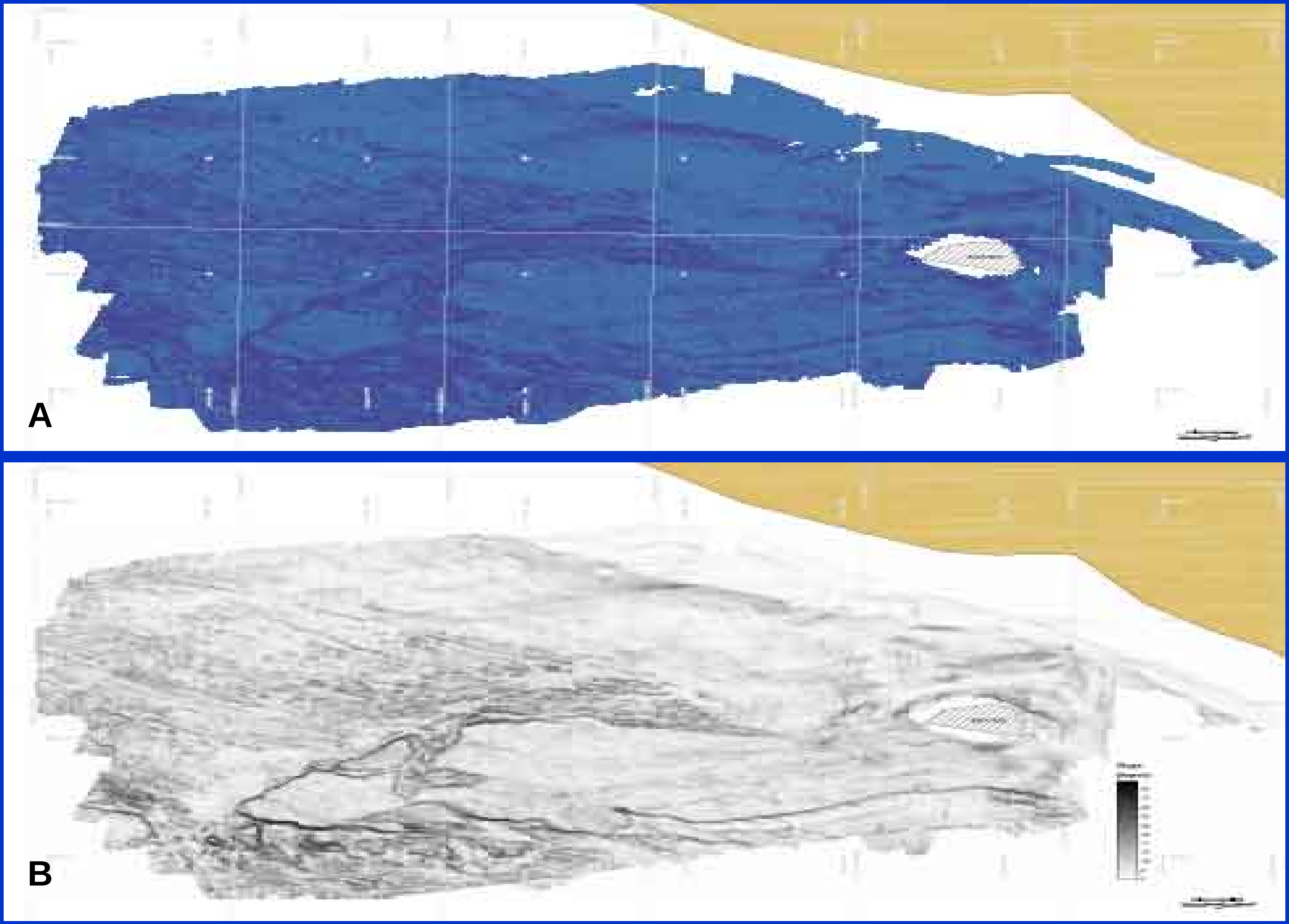


Multibeam Bathymetric Difference Map - Seabed Change

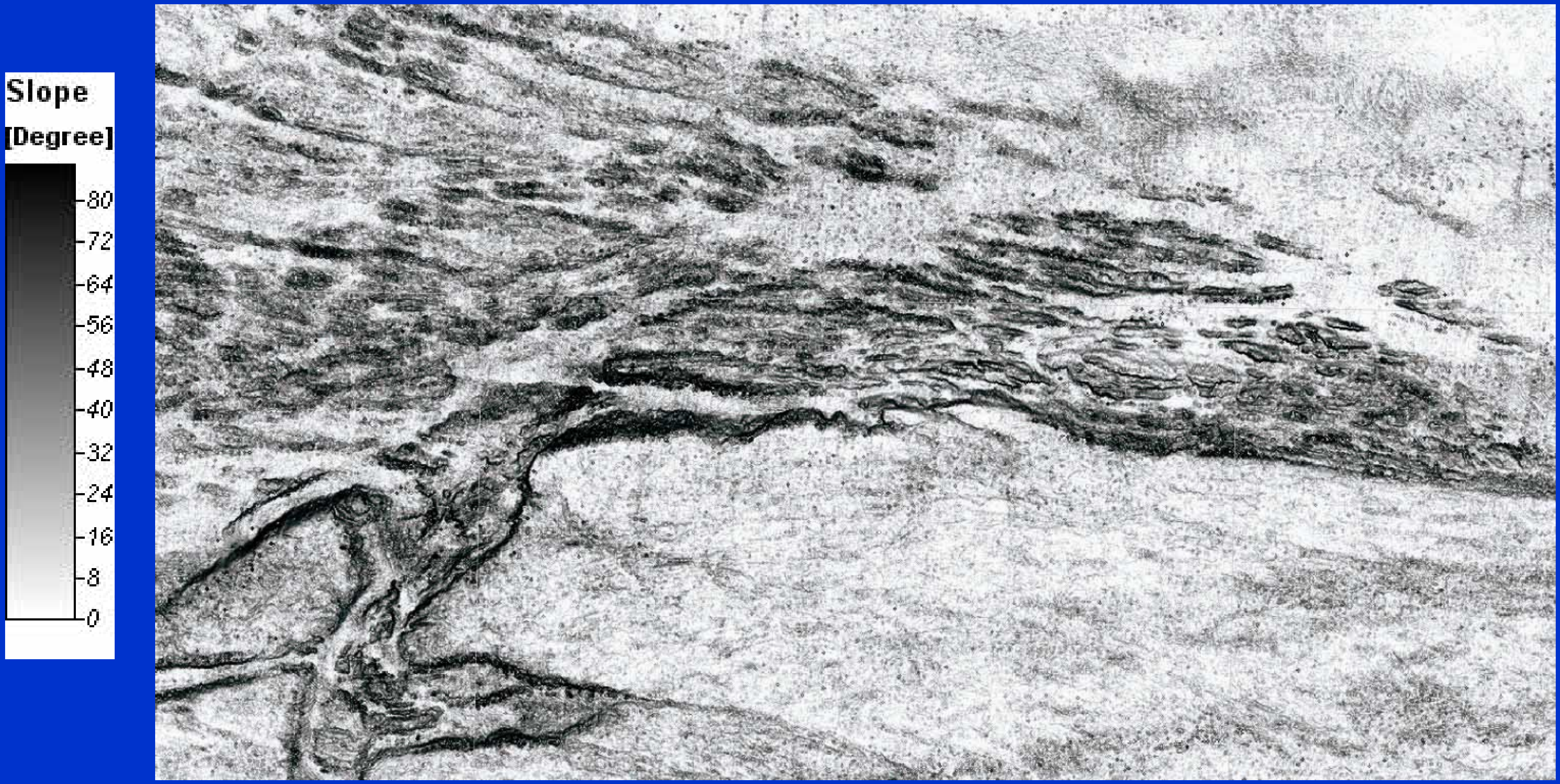


2006 - 2008

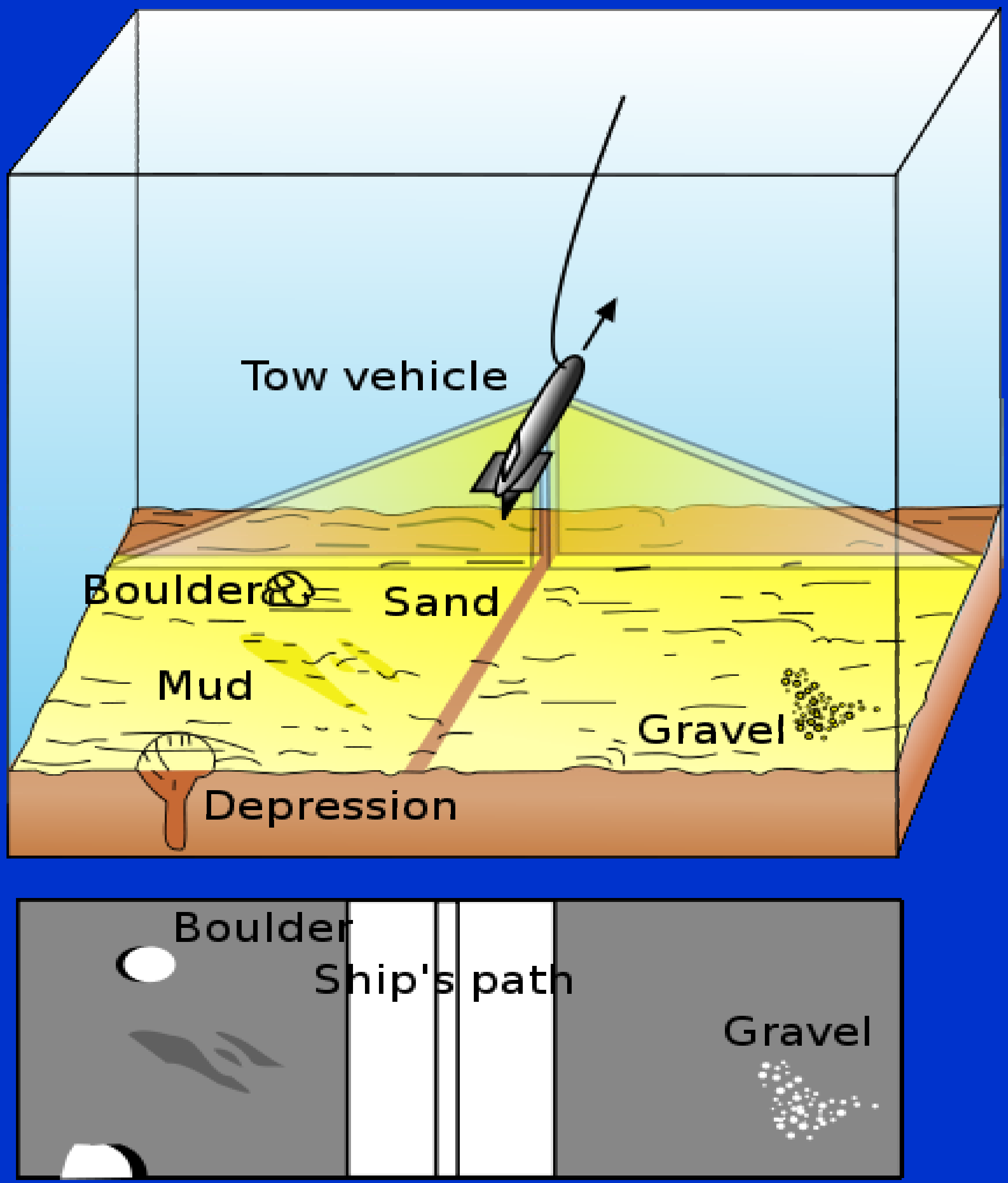
Slope Map



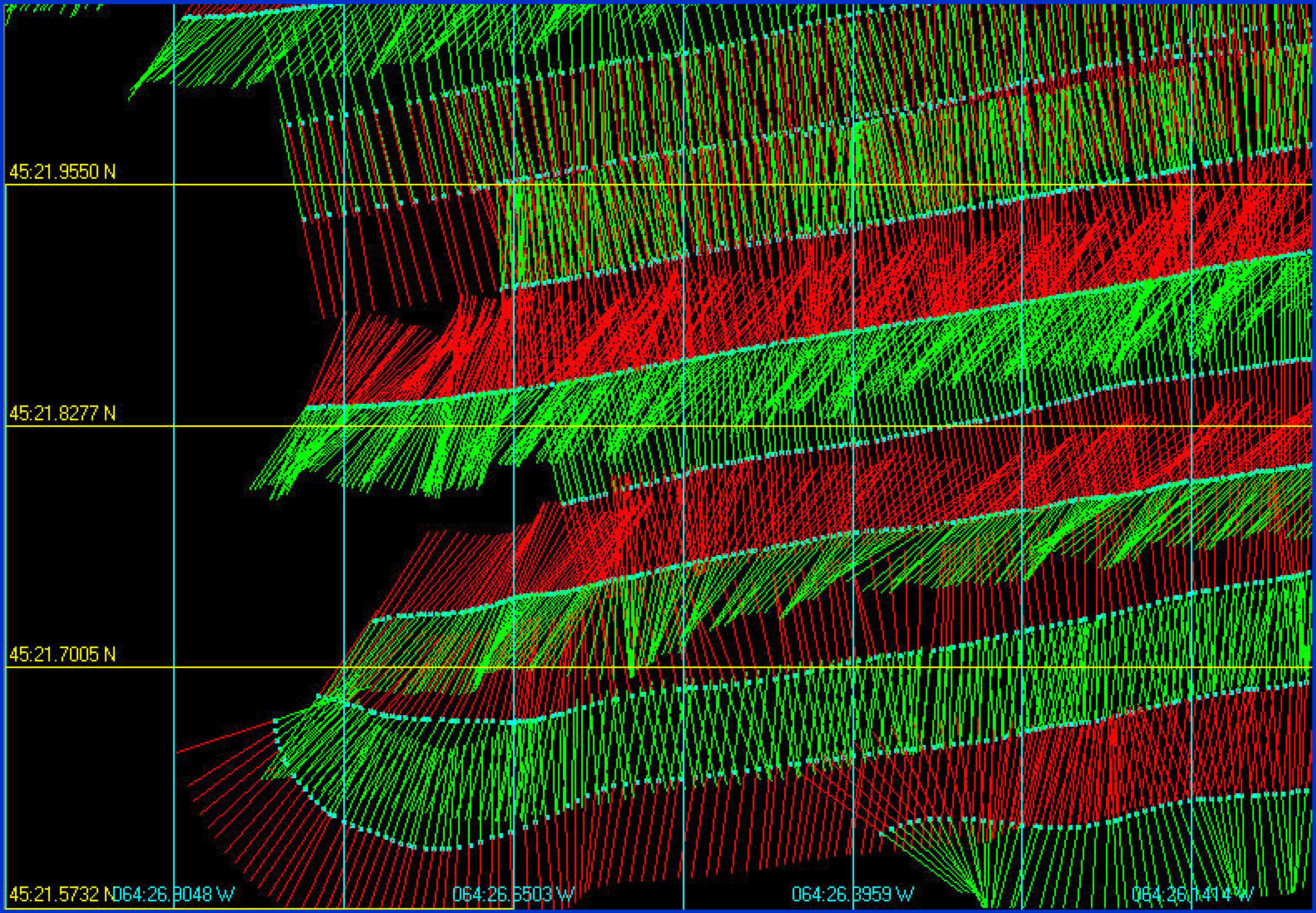
Slope Map Focus Area



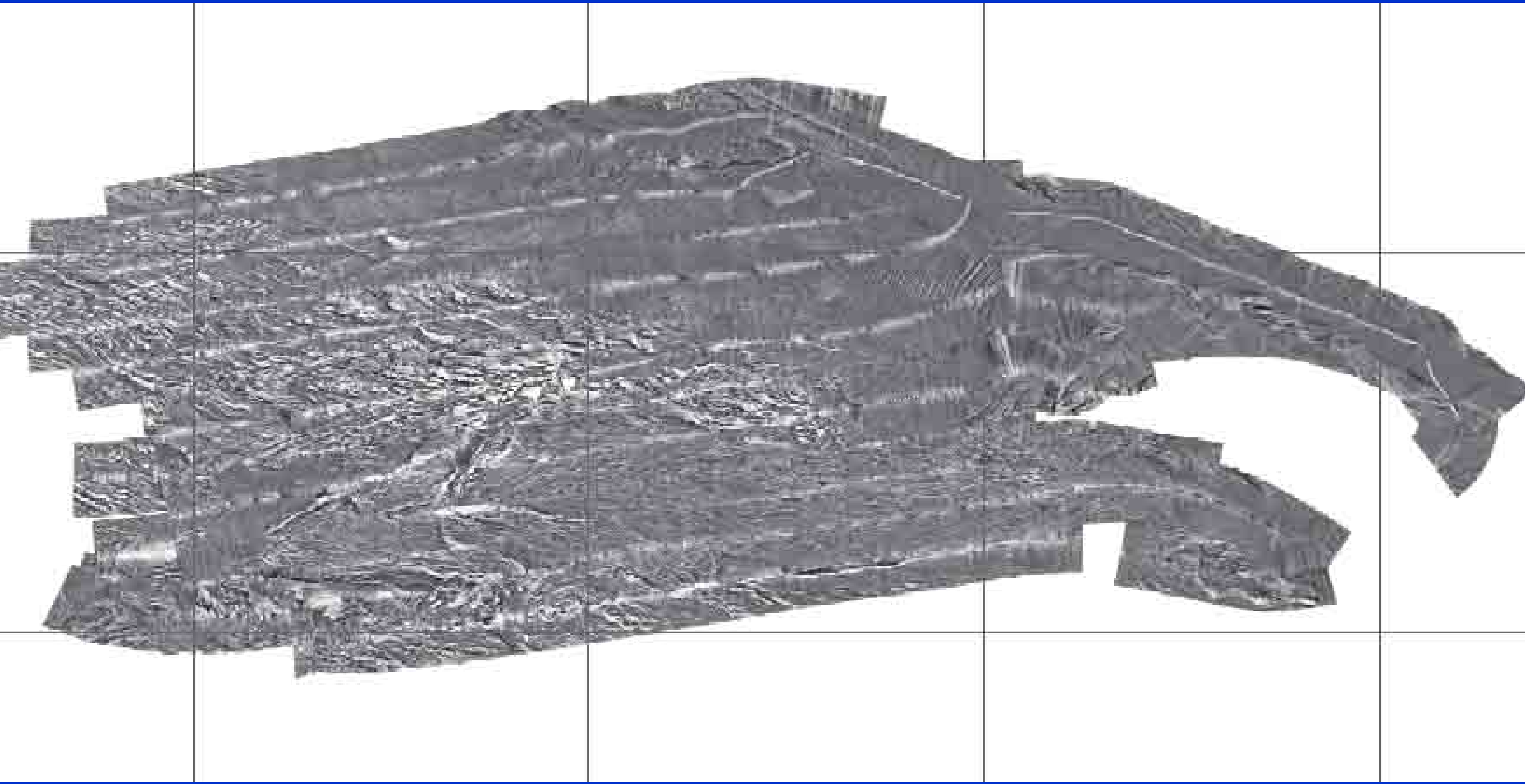
Sidescan Sonar (Acoustic Eyes)



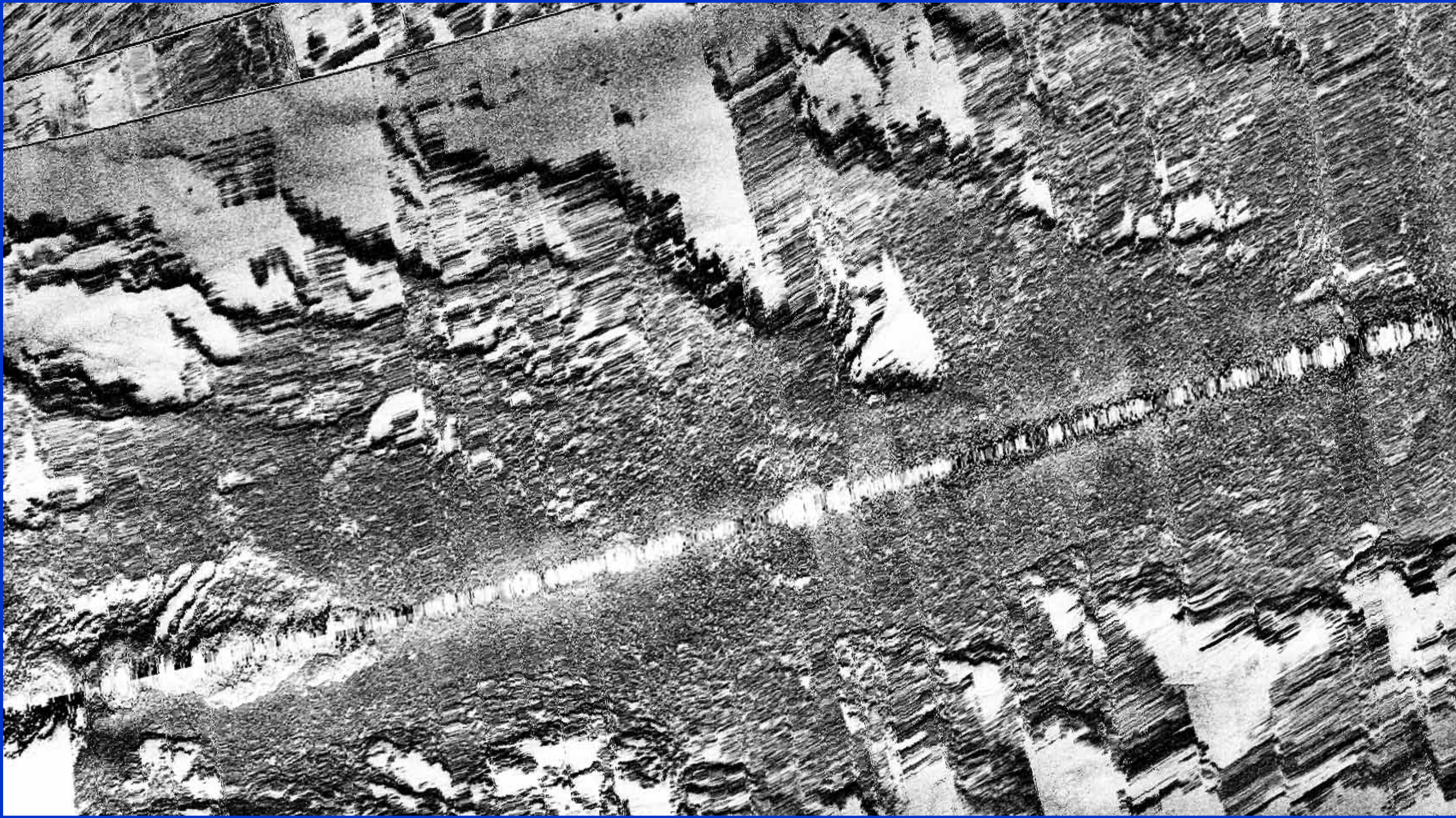
Sidescan Control – Overlapping Lines



Sidescan Sonar Mosaics

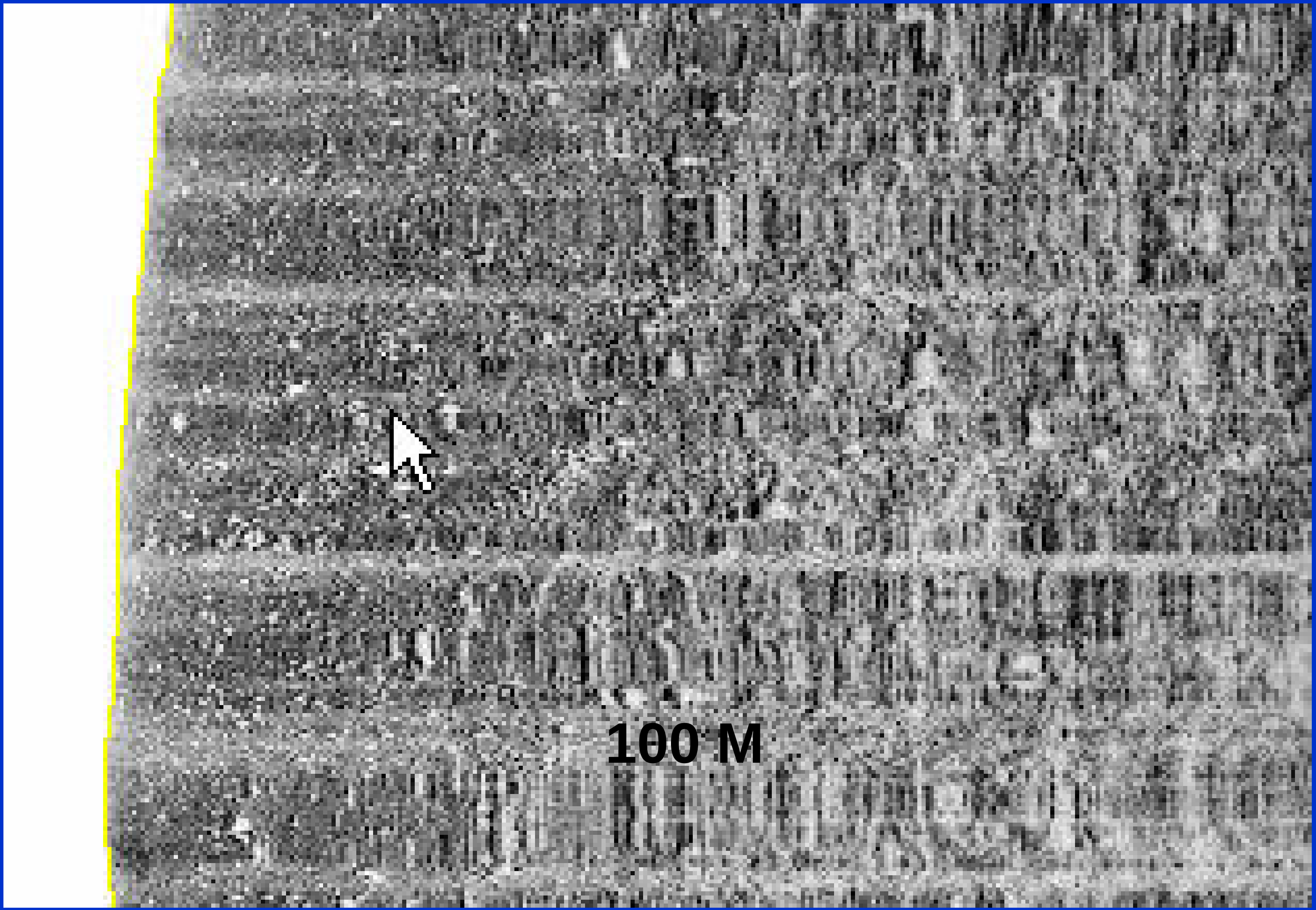


Sidescan Sonogram Bedrock and Boulders

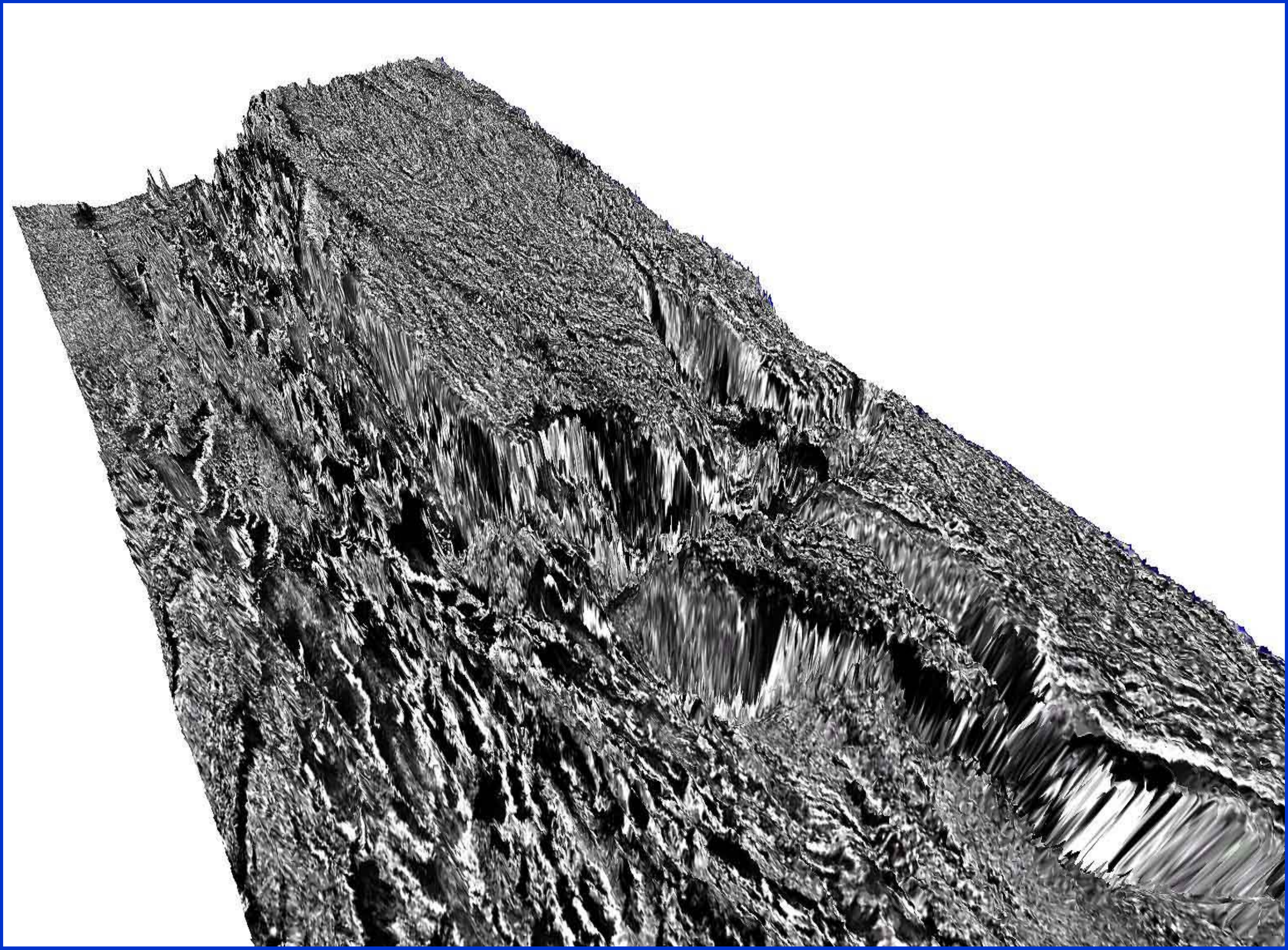


Resolution – Dead Body

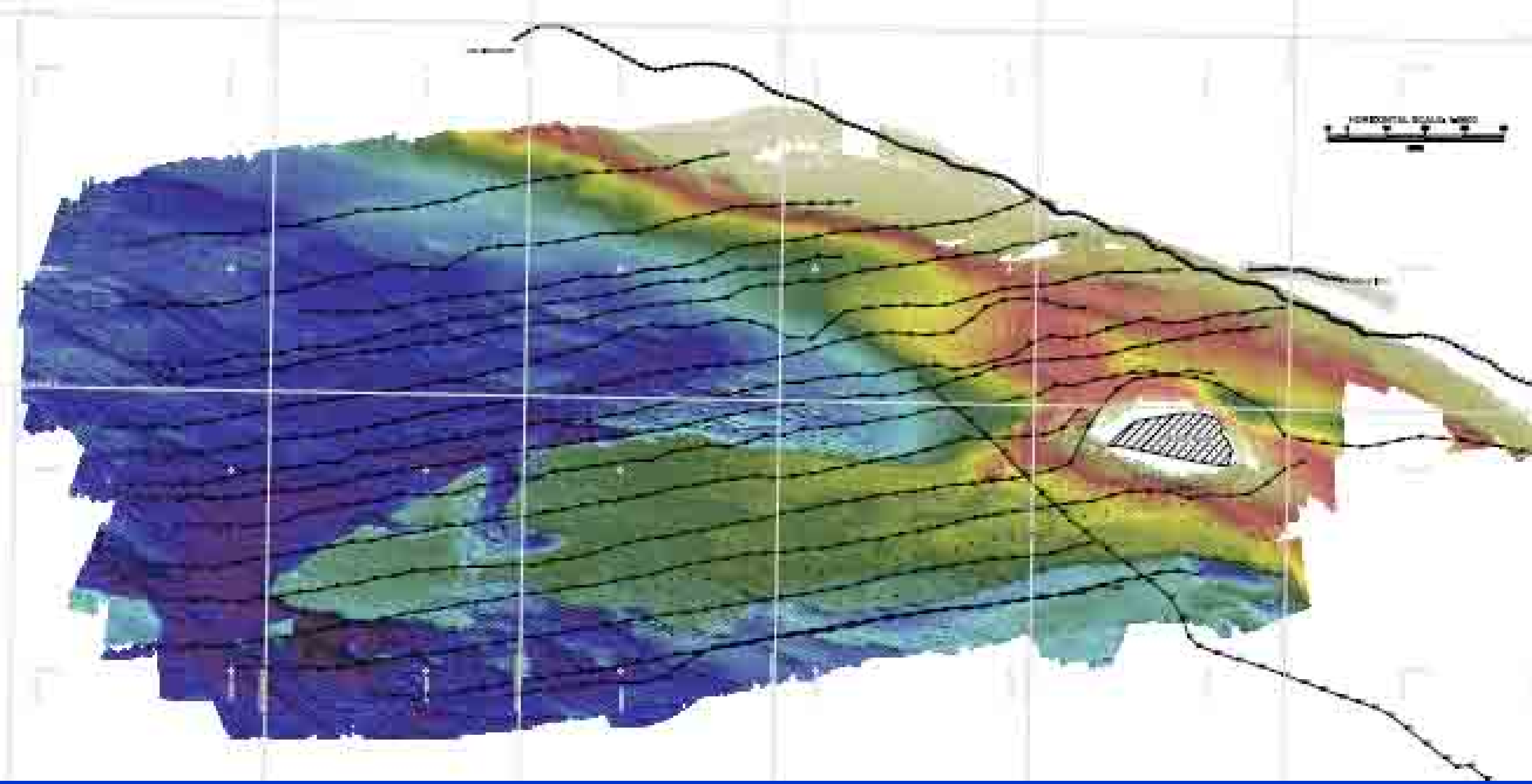
Sidescan Sonogram Boulders



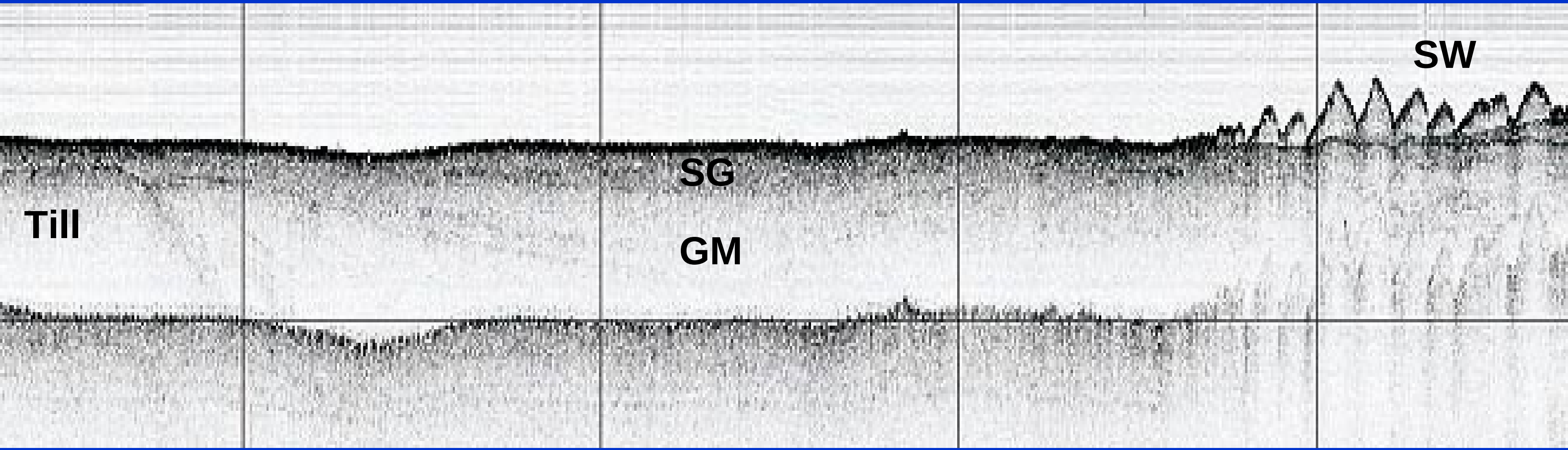
Sidescan Data Draped Over Multibeam



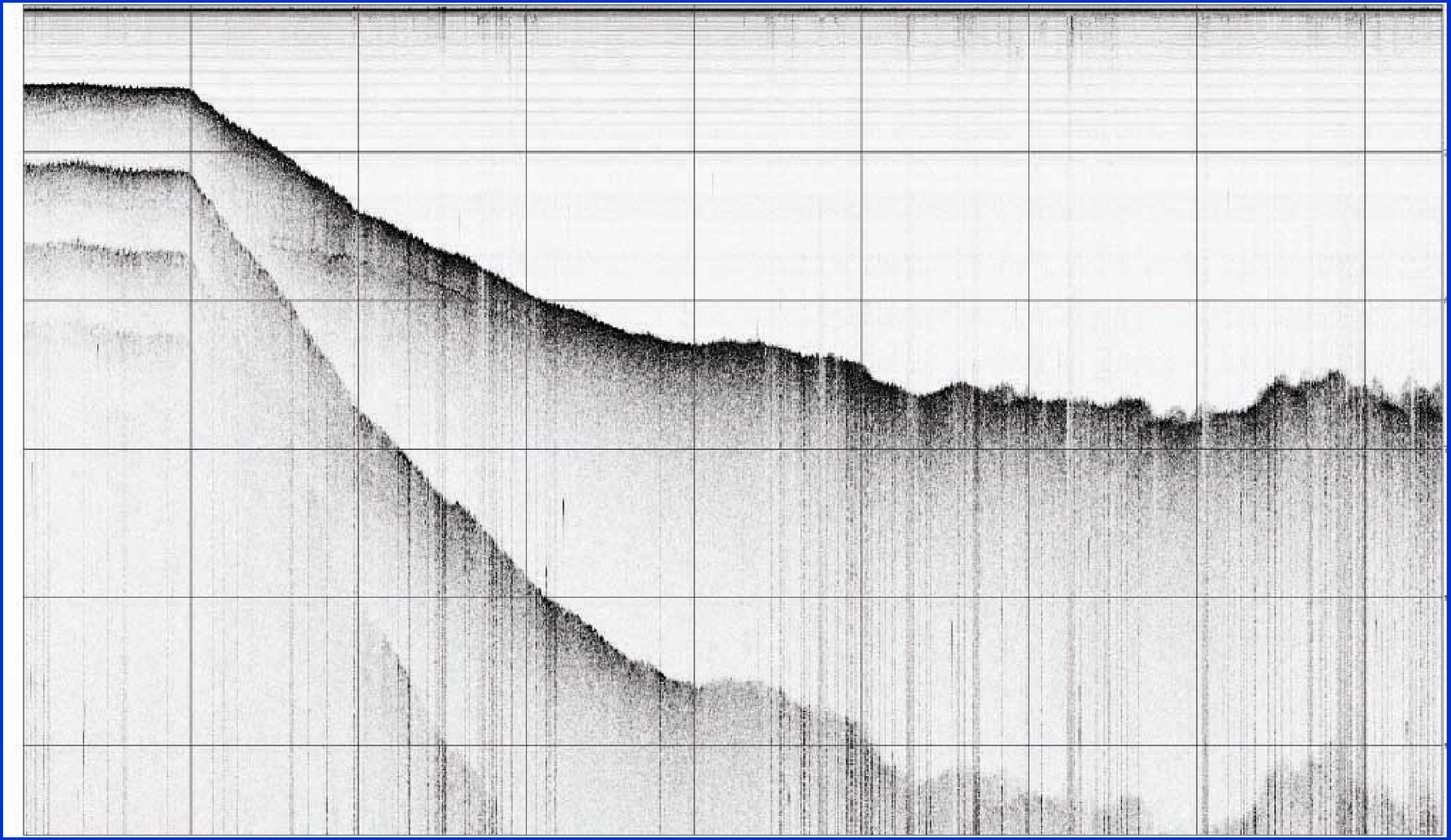
Seistec Line in Cone Seismic Reflection System Survey Tracks



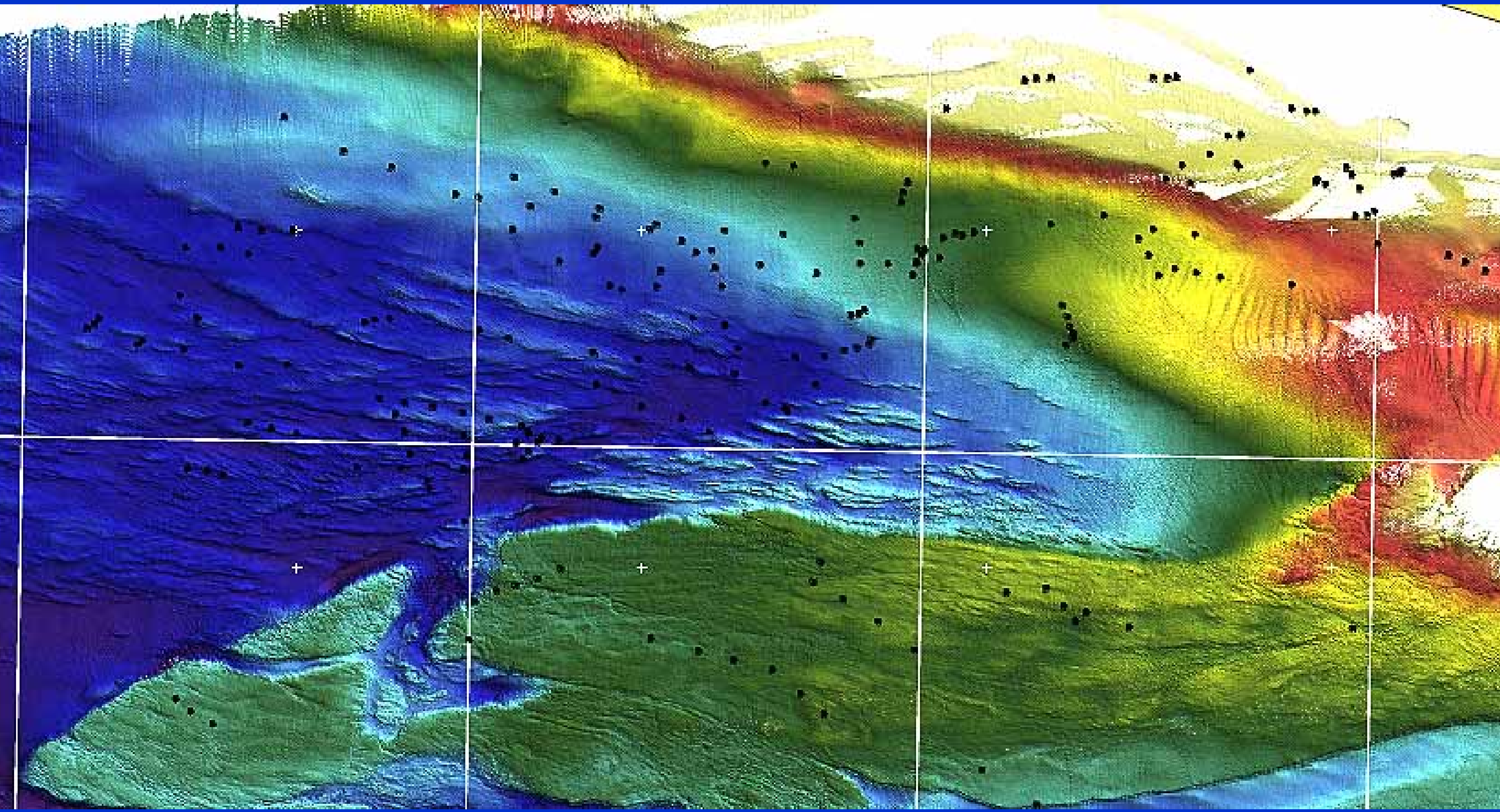
Seistec Reflection Profile

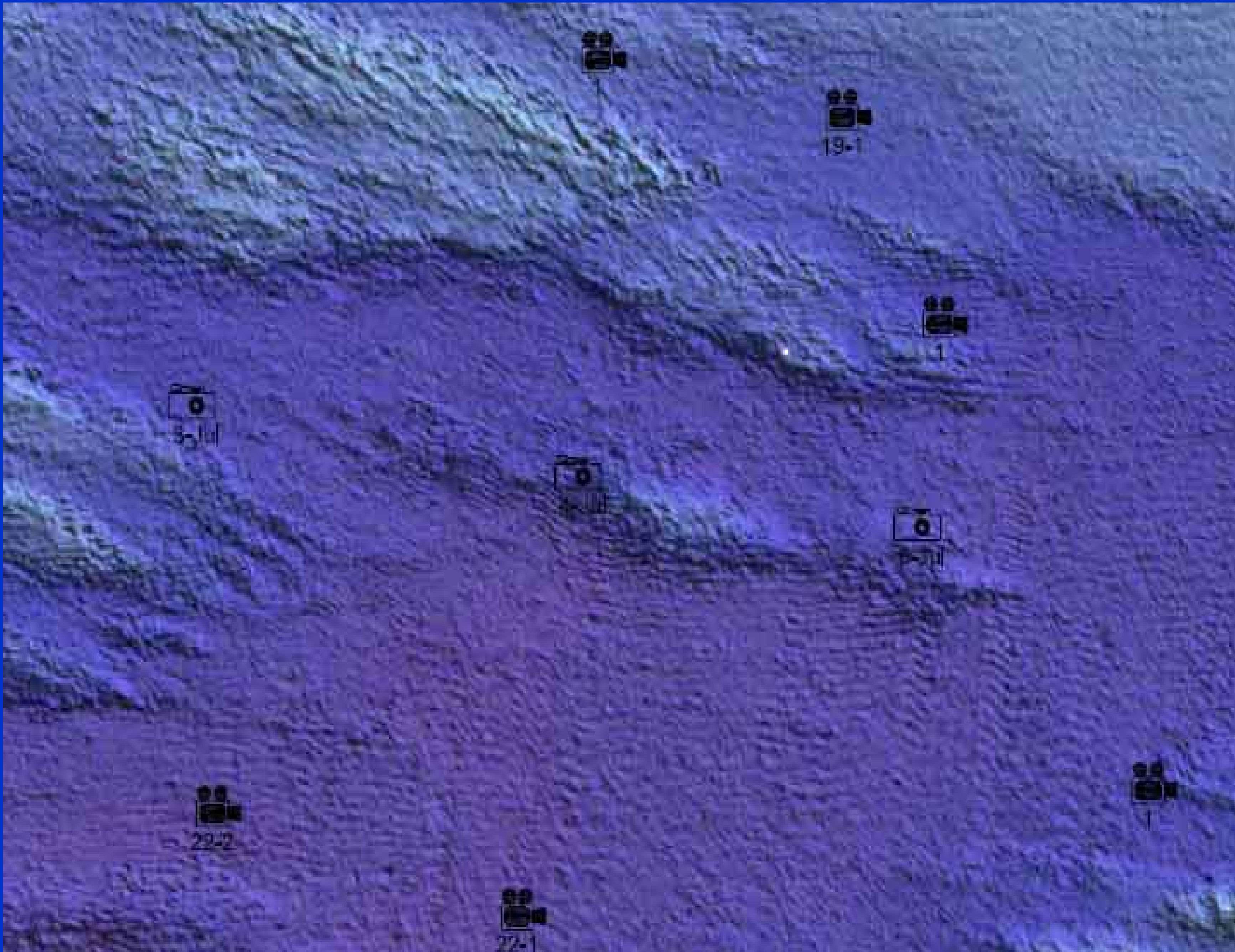


Seistec Reflection Profile



Bottom Photographic and Video Stations

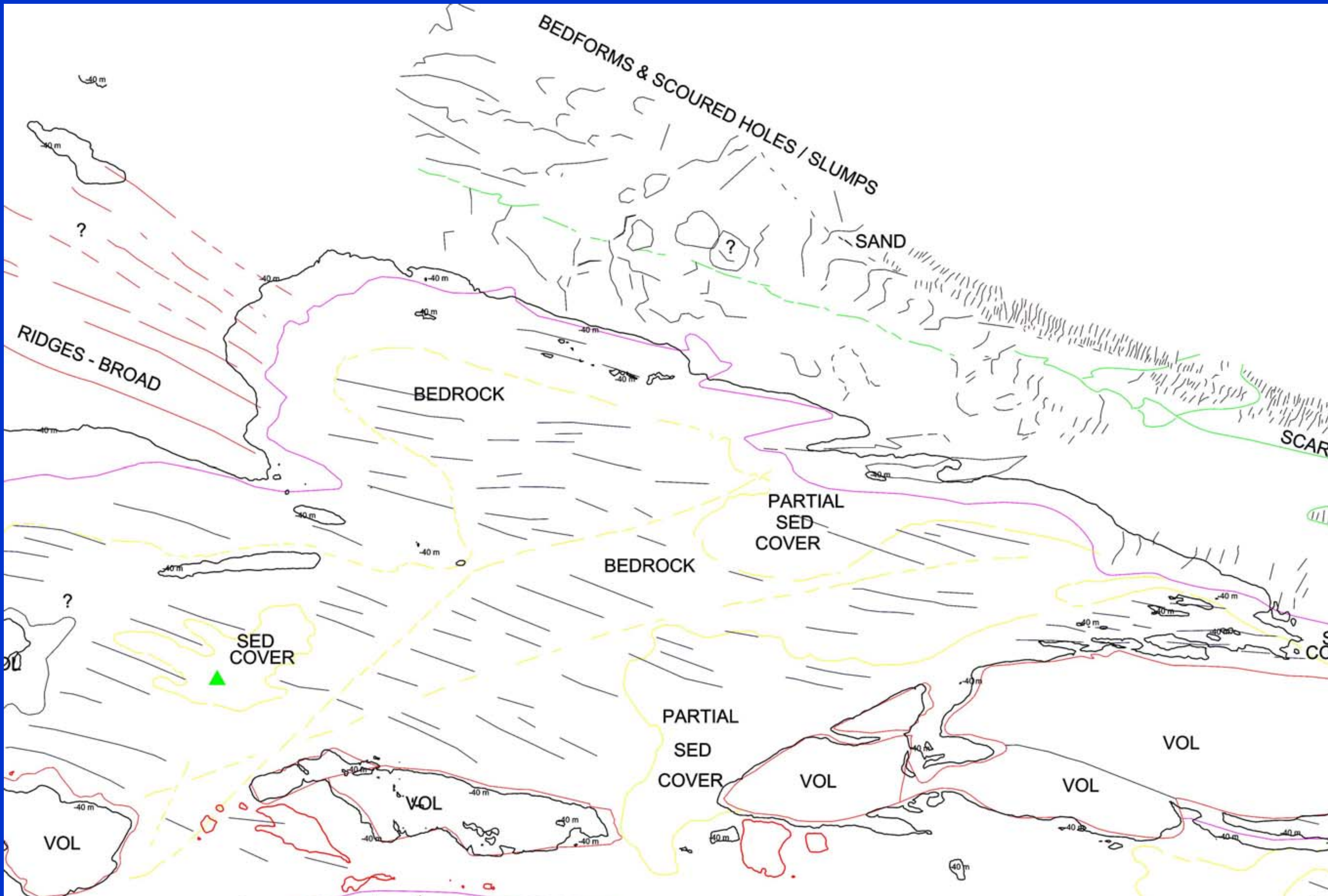



19-1
1
22-2
1
22-1

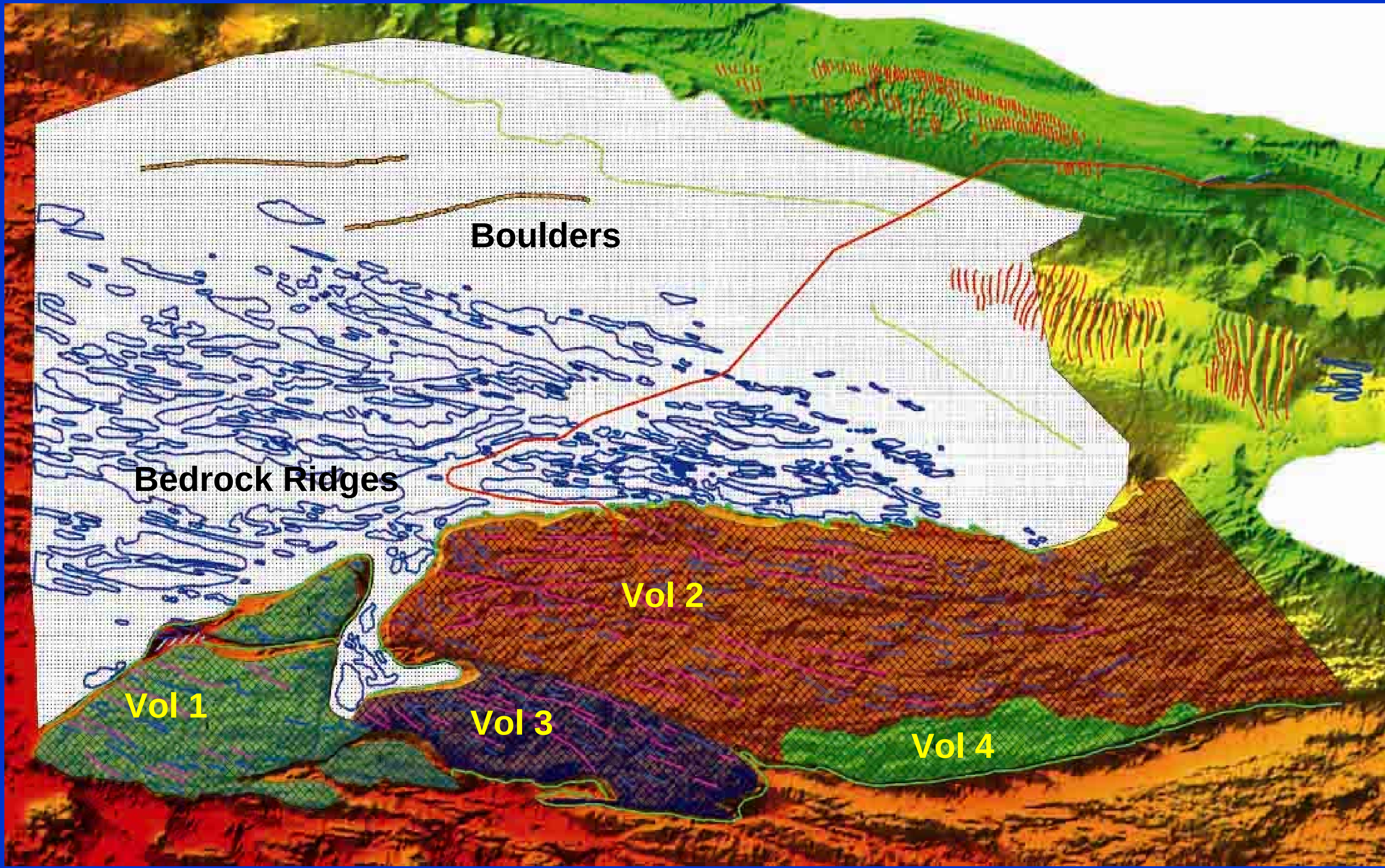
Seabed Geoscience Characteristics

MINAS
BASIN

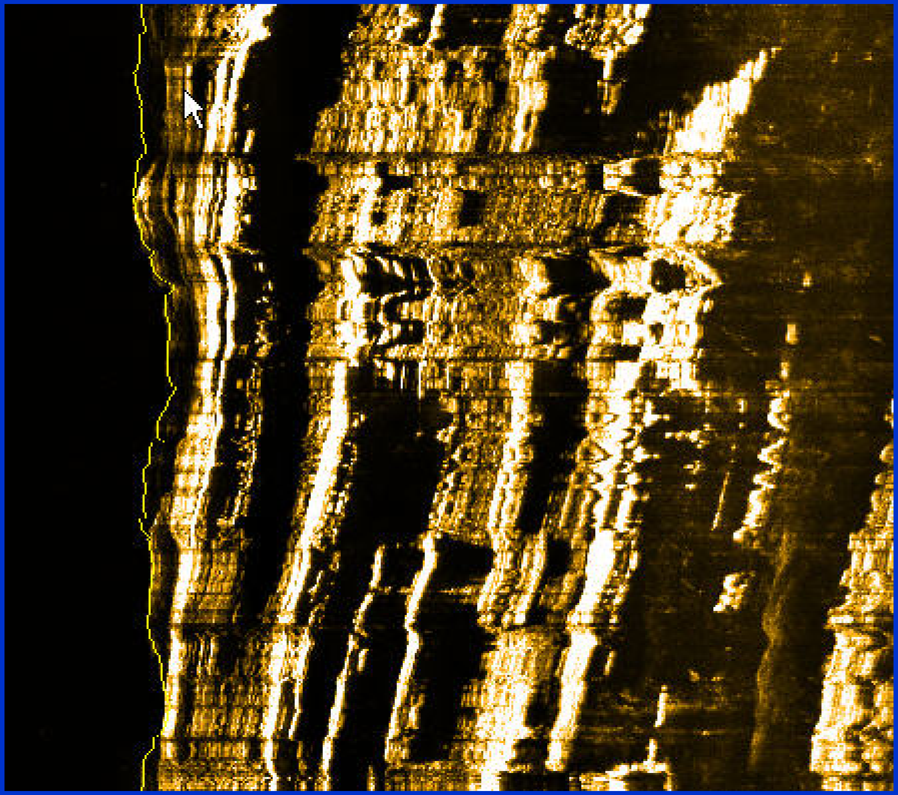
Regional Geological Interpretation

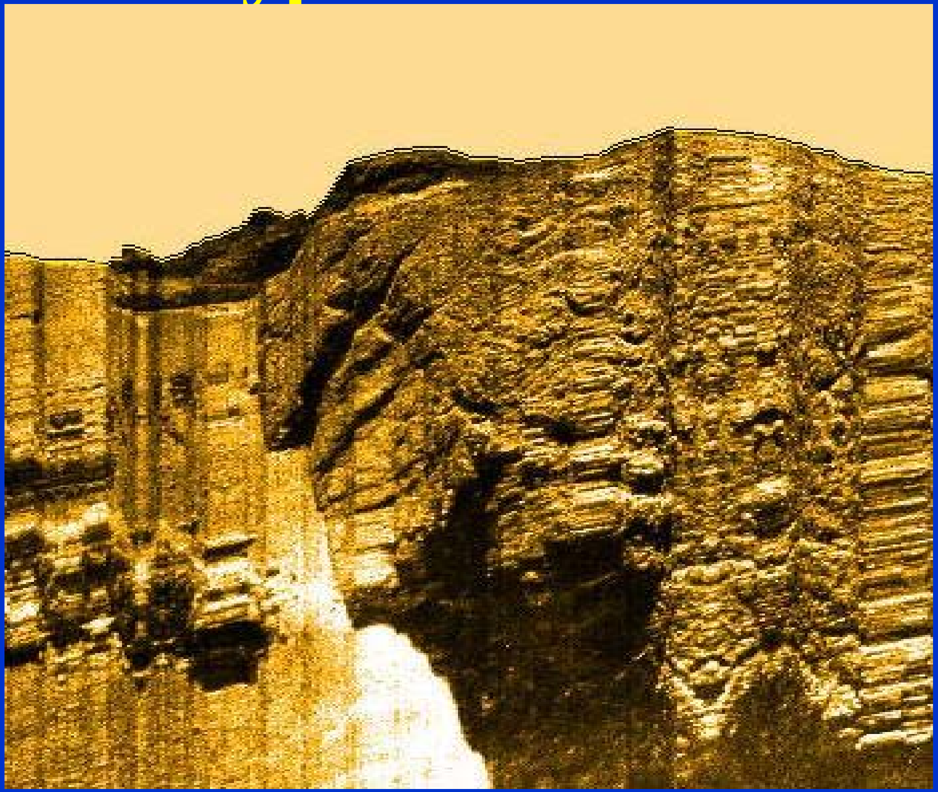


High-Resolution Geological Interpretation



Bedrock – Two Types

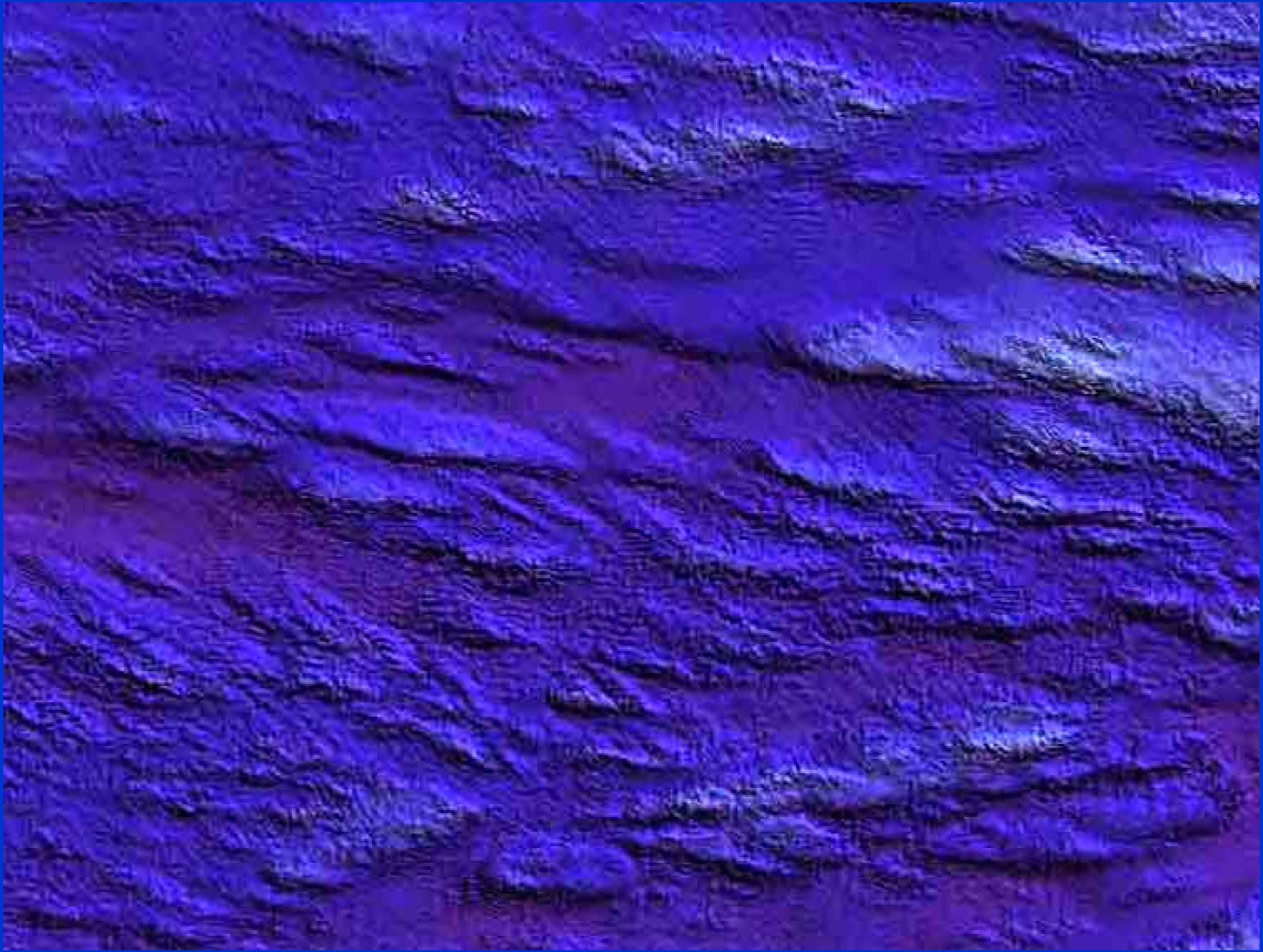


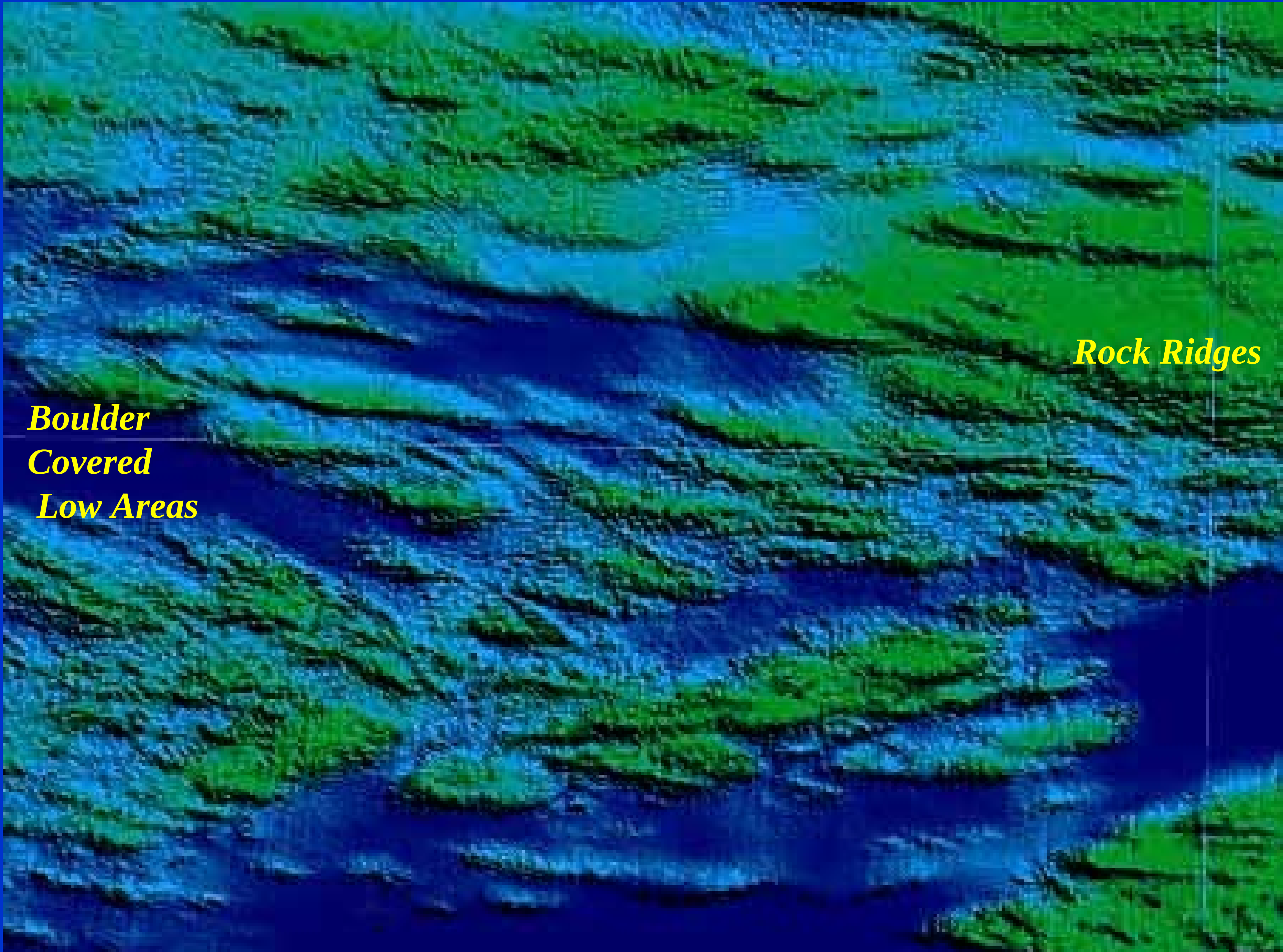


Sandstone ridges, angular

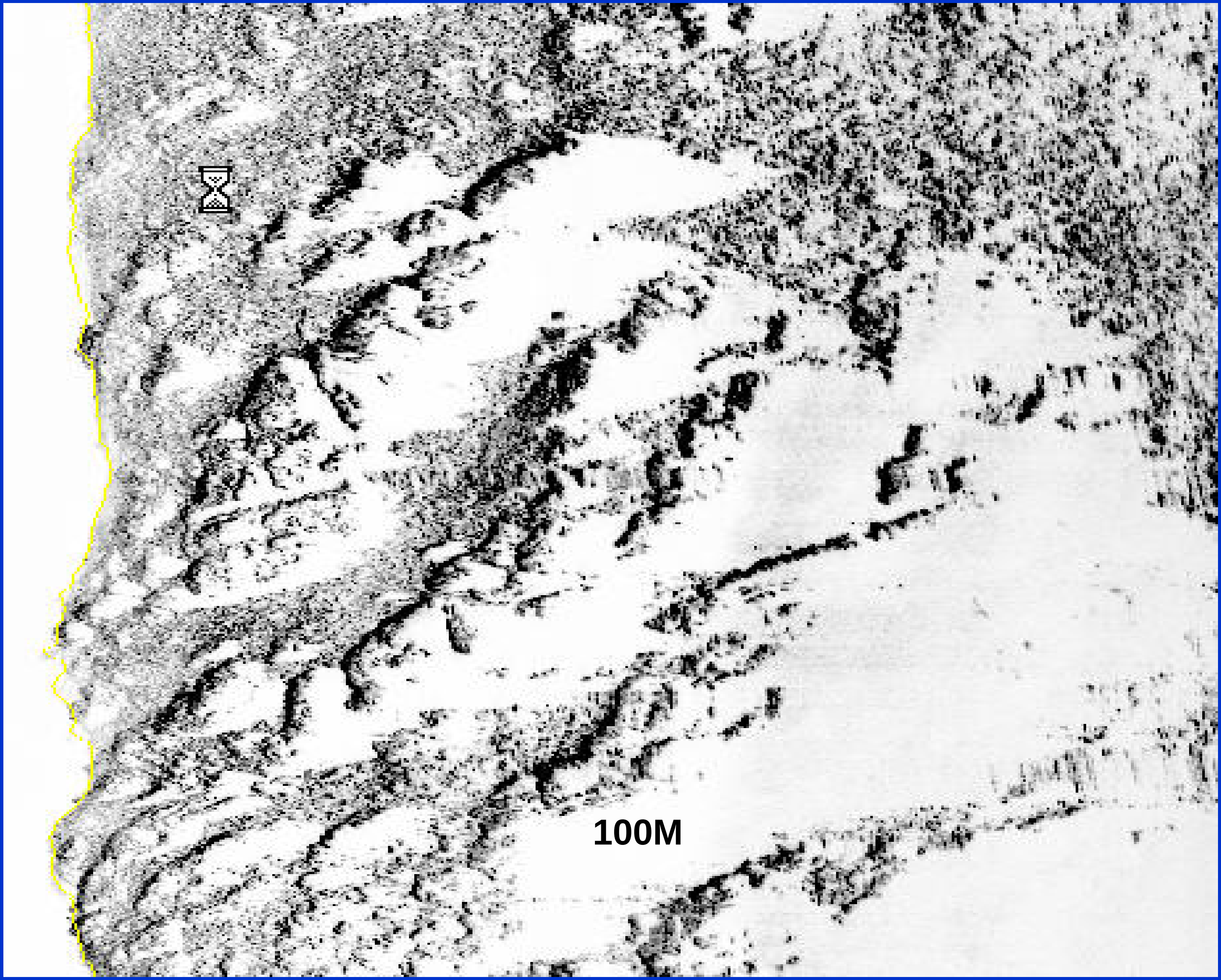
Volcanic, hummocky, flat

Parrsboro Formation, Grey and Red Mudrock, Sandstone

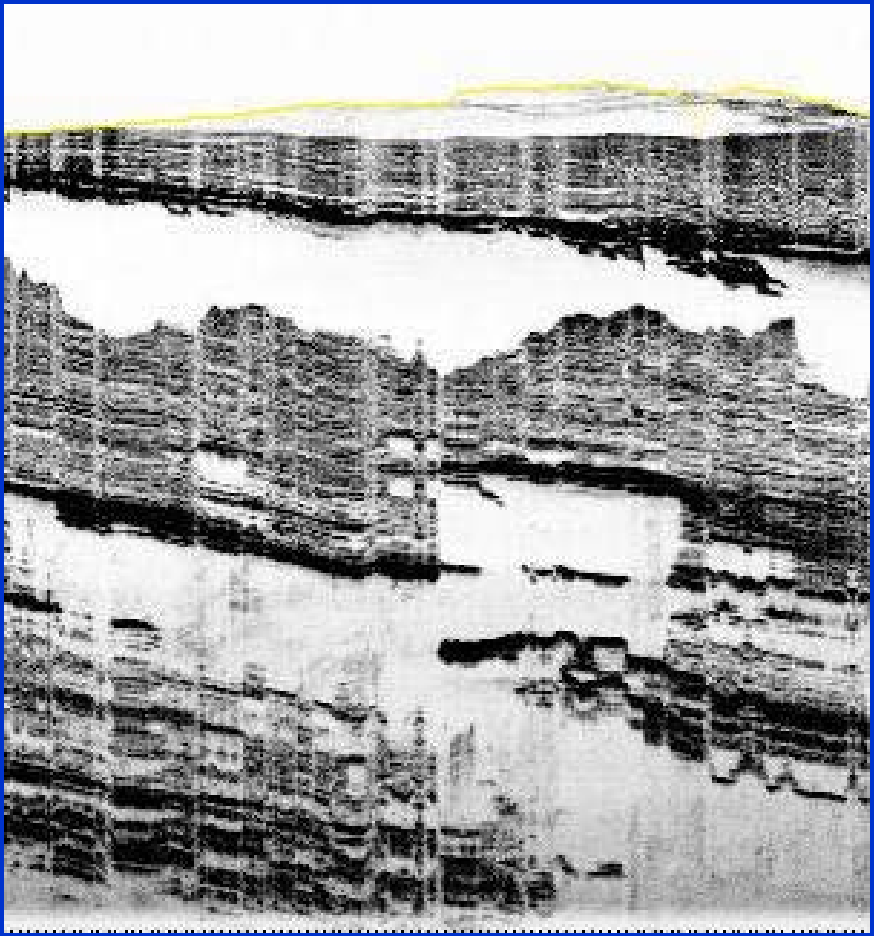


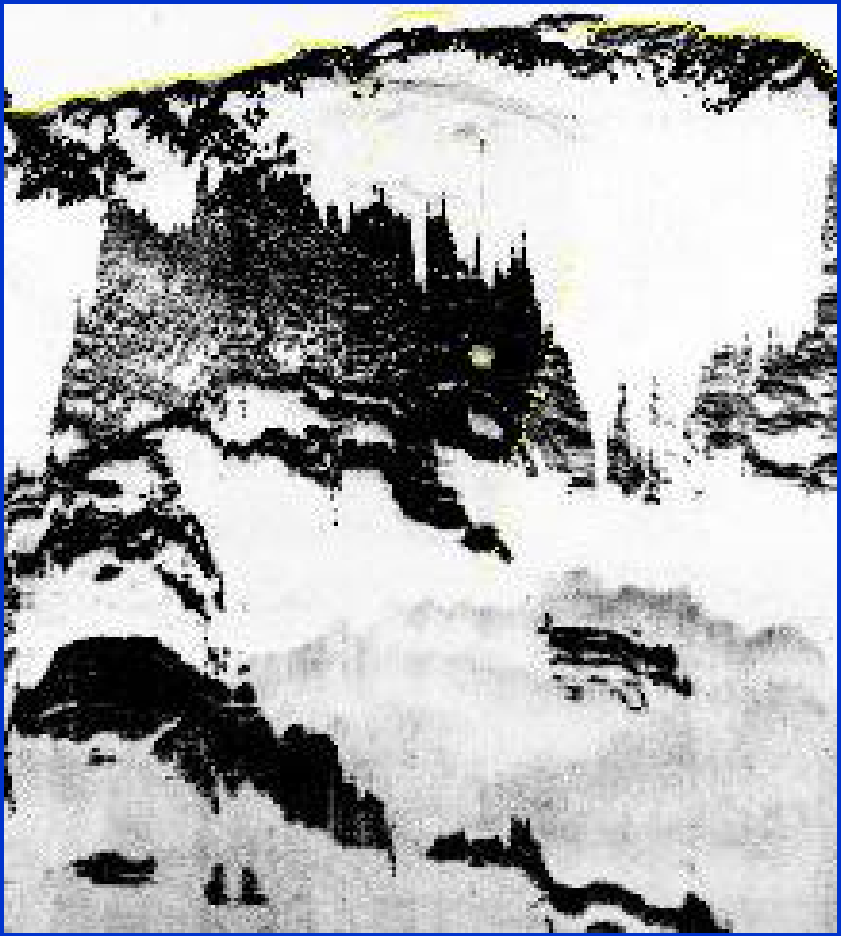

Rock Ridges
Boulder
Covered
Low Areas

Sidescan Sonogram Bedrock Ridges and Boulders

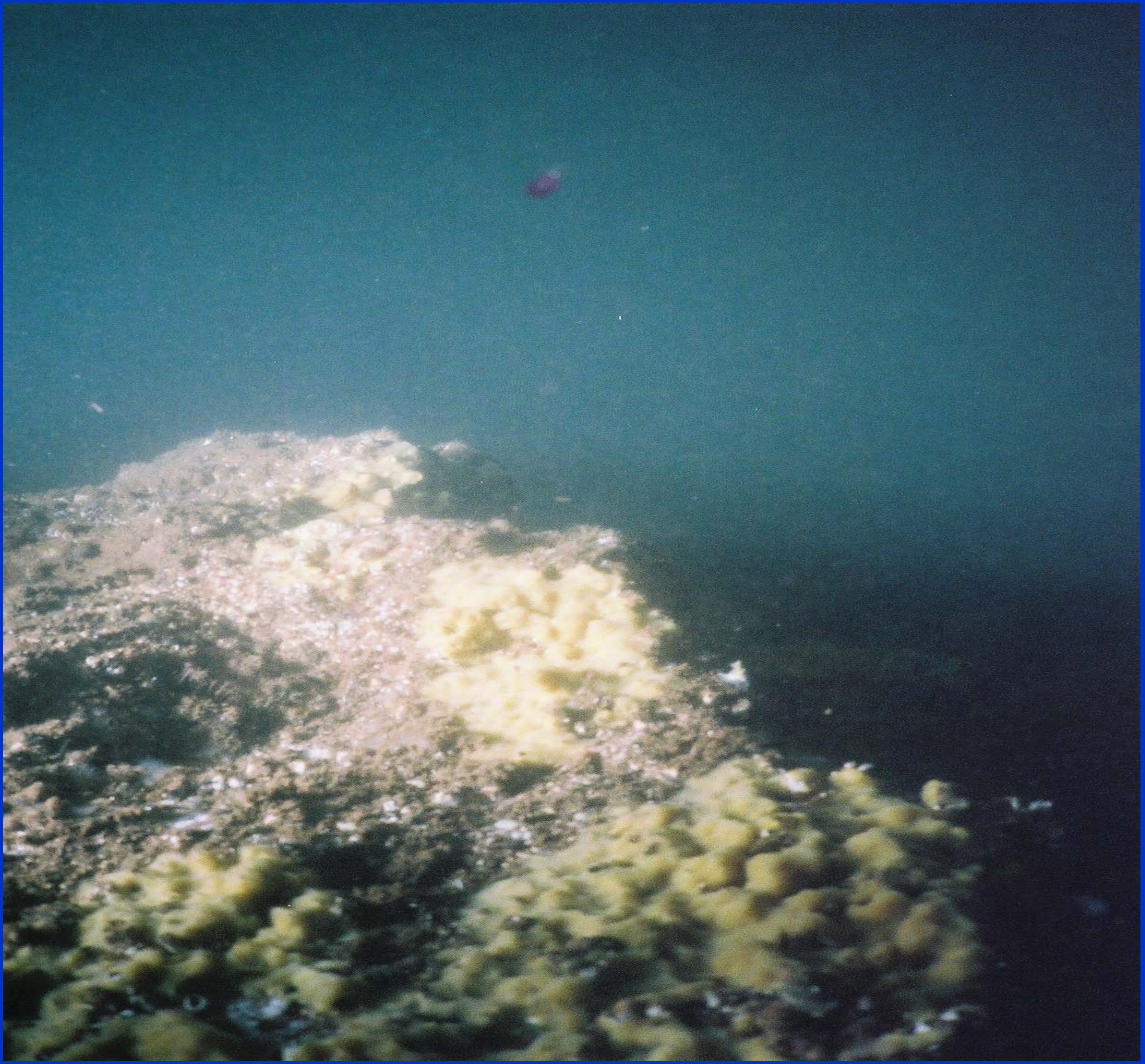


Sidescan Shadows Define Bedrock Ridge Shape





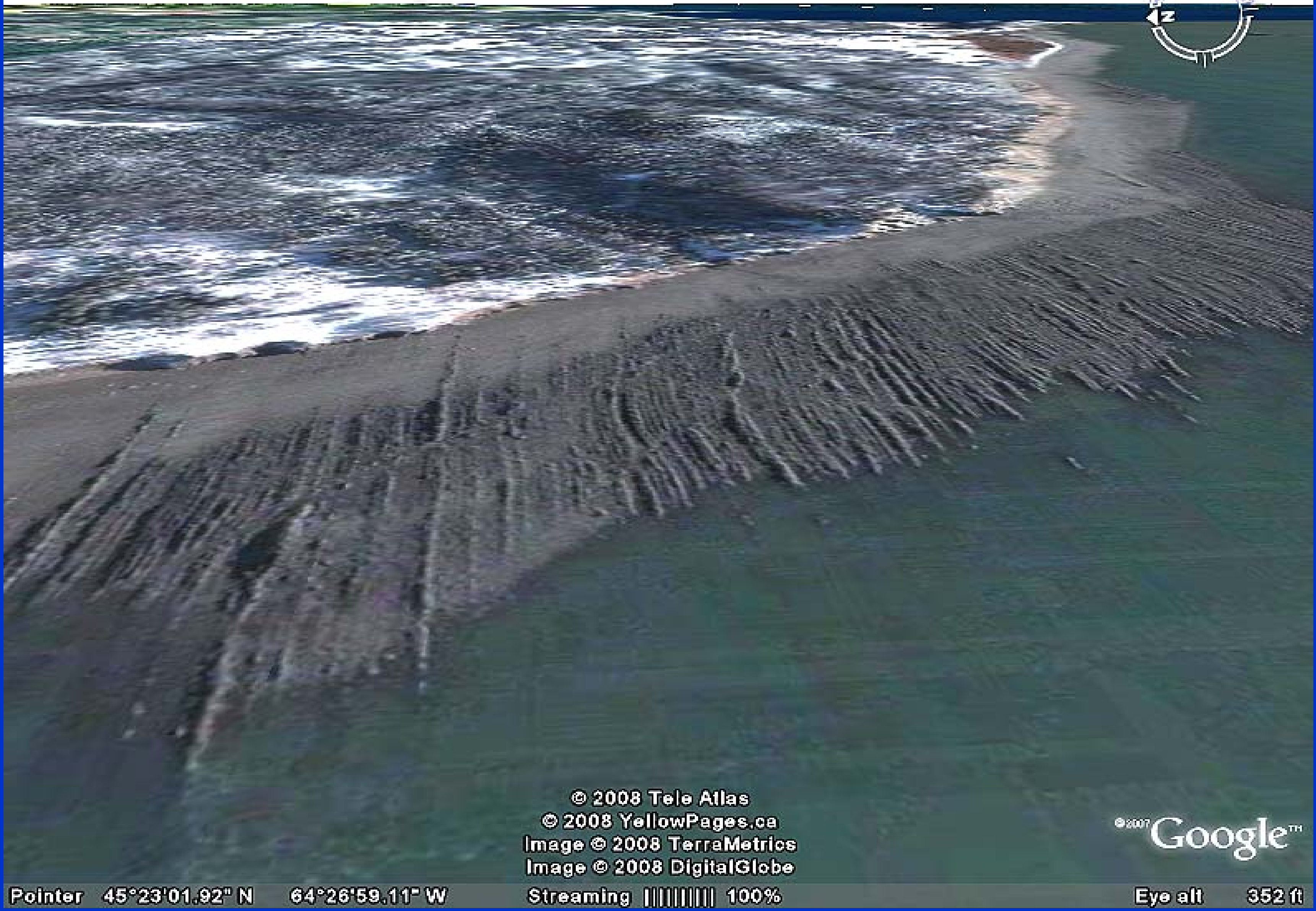
Bedrock Ridge



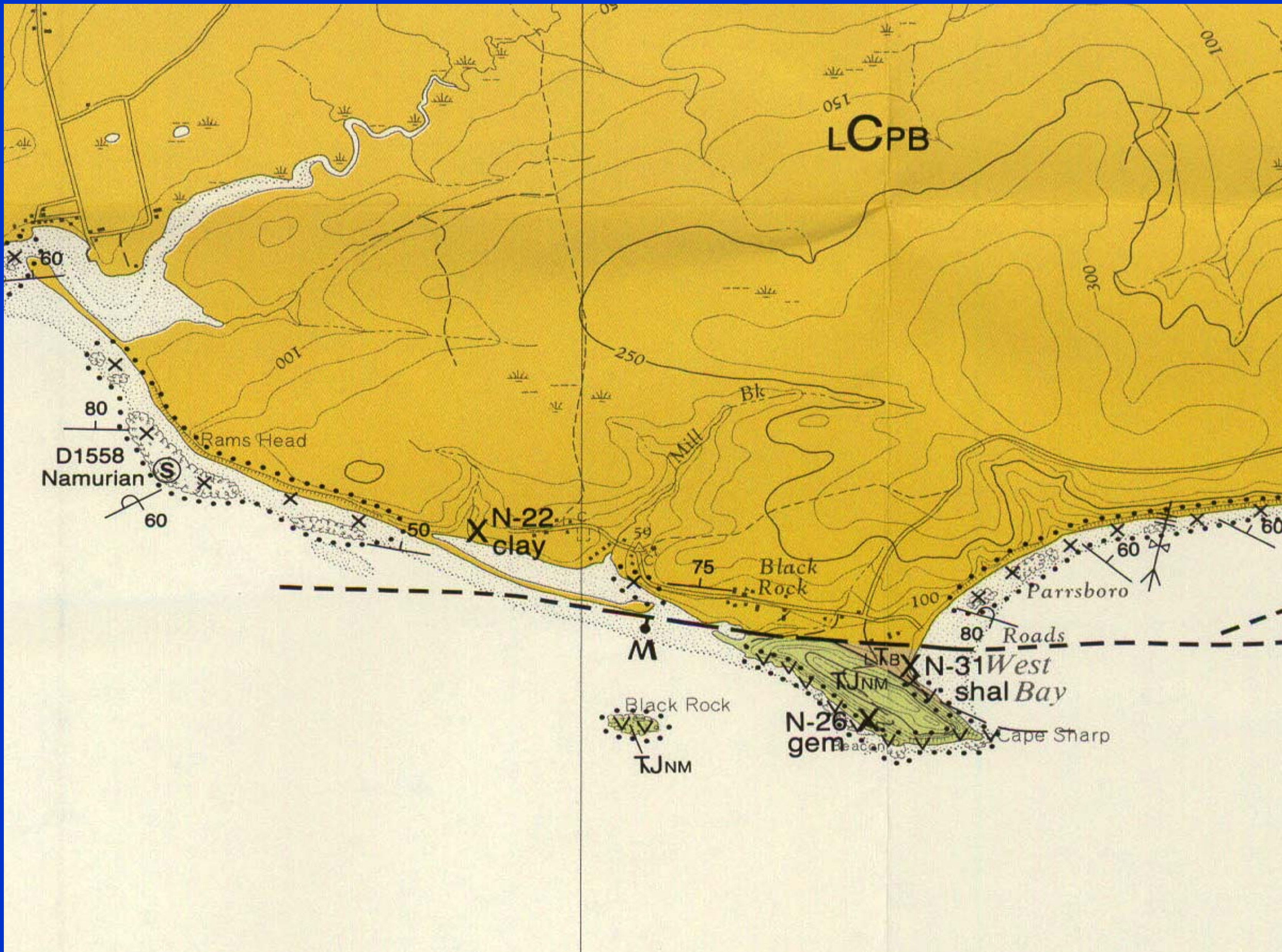
Sculpin over Bedrock

Bedrock Ridge

Exposed Bedrock Low Tide Ram Head

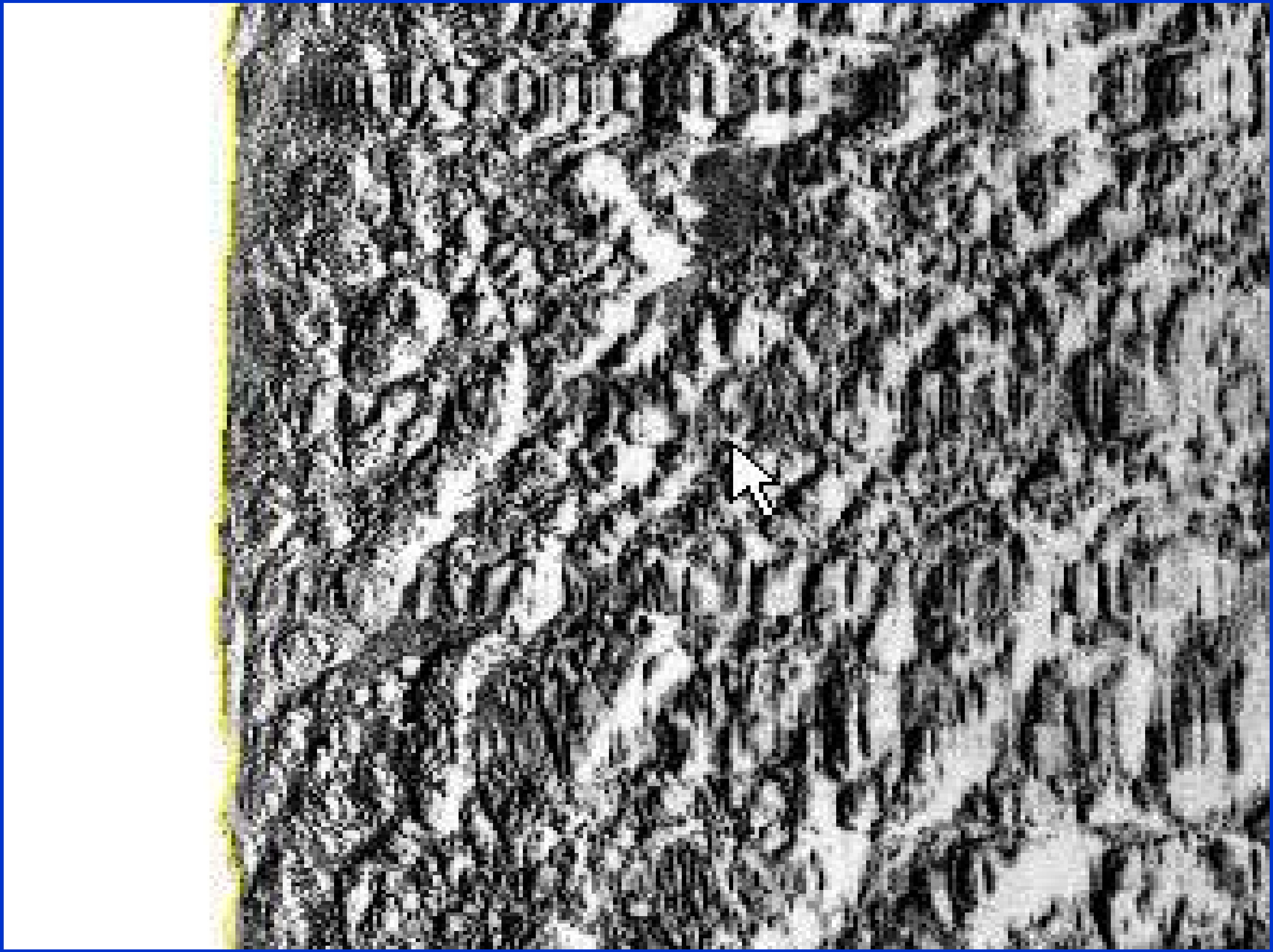


Bedrock Geology Land

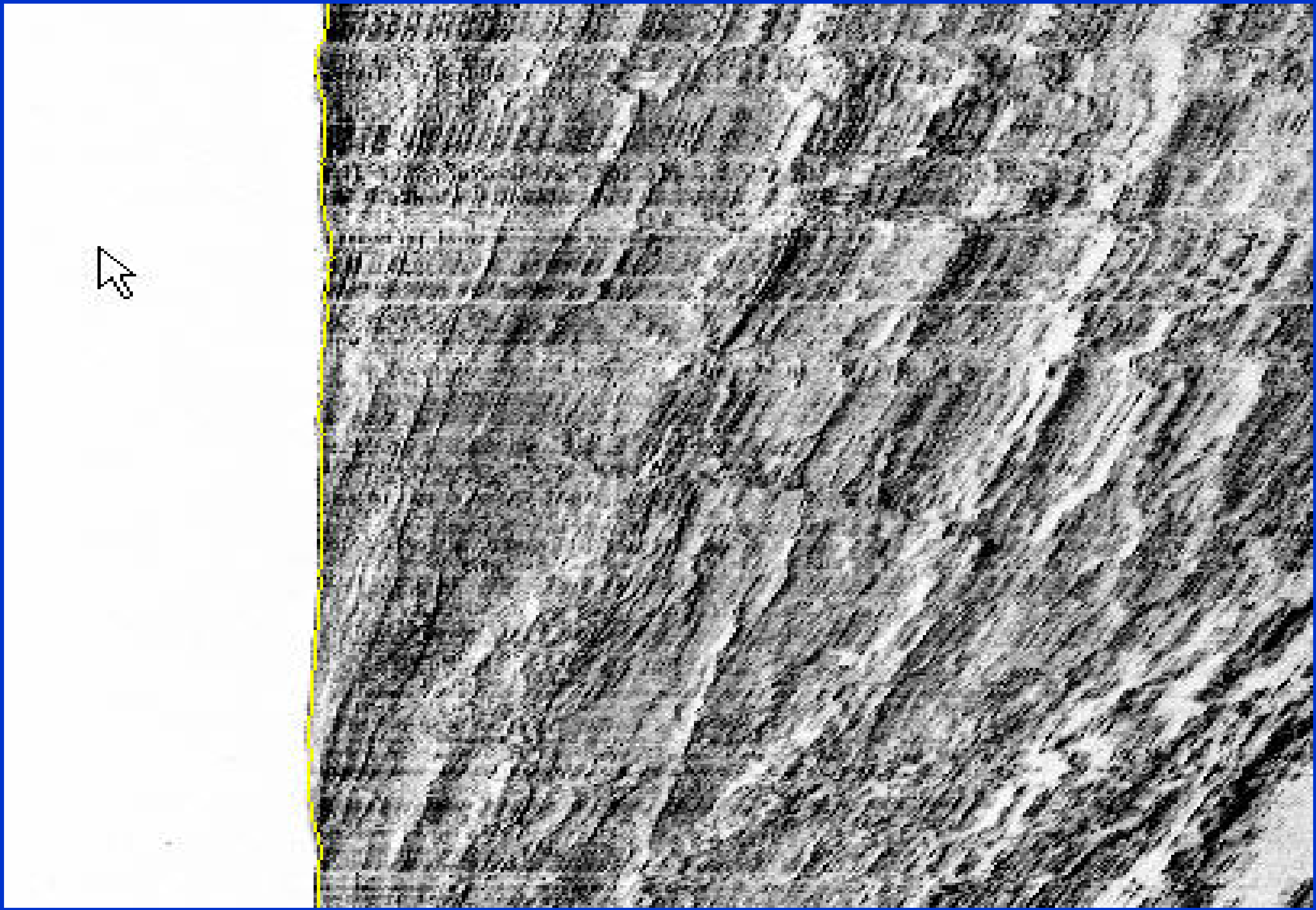


Volcanic Platform

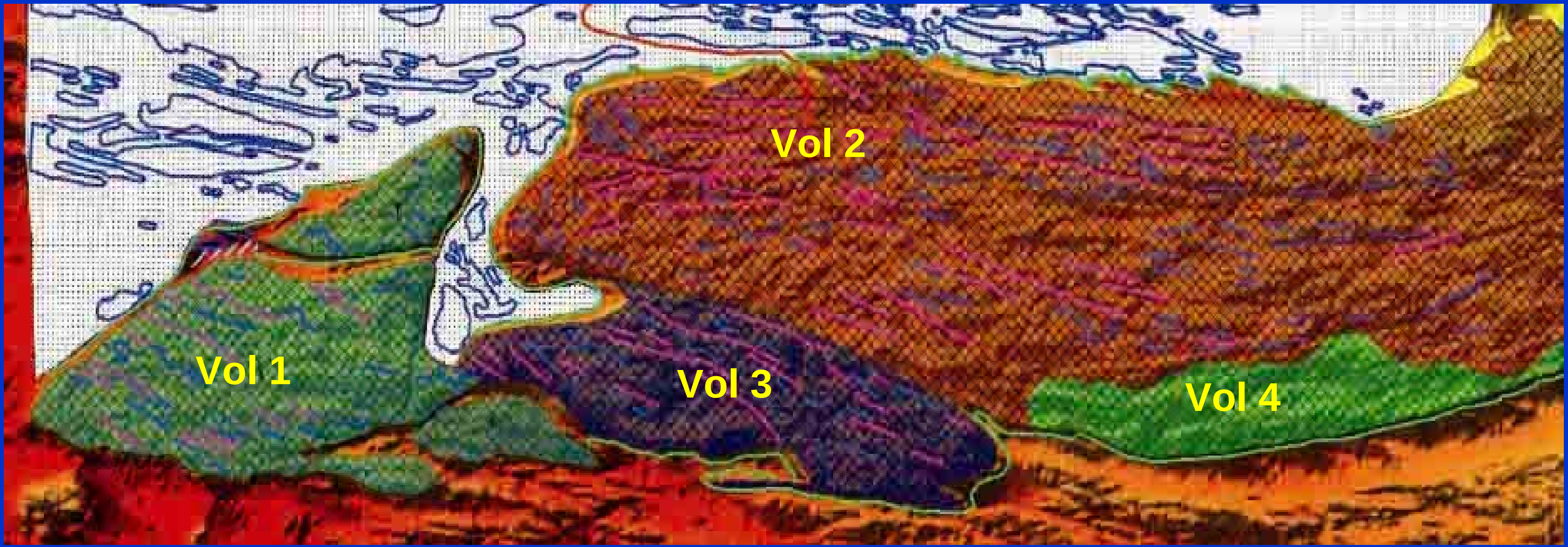
Sidescan Sonogram Volcanic Platform



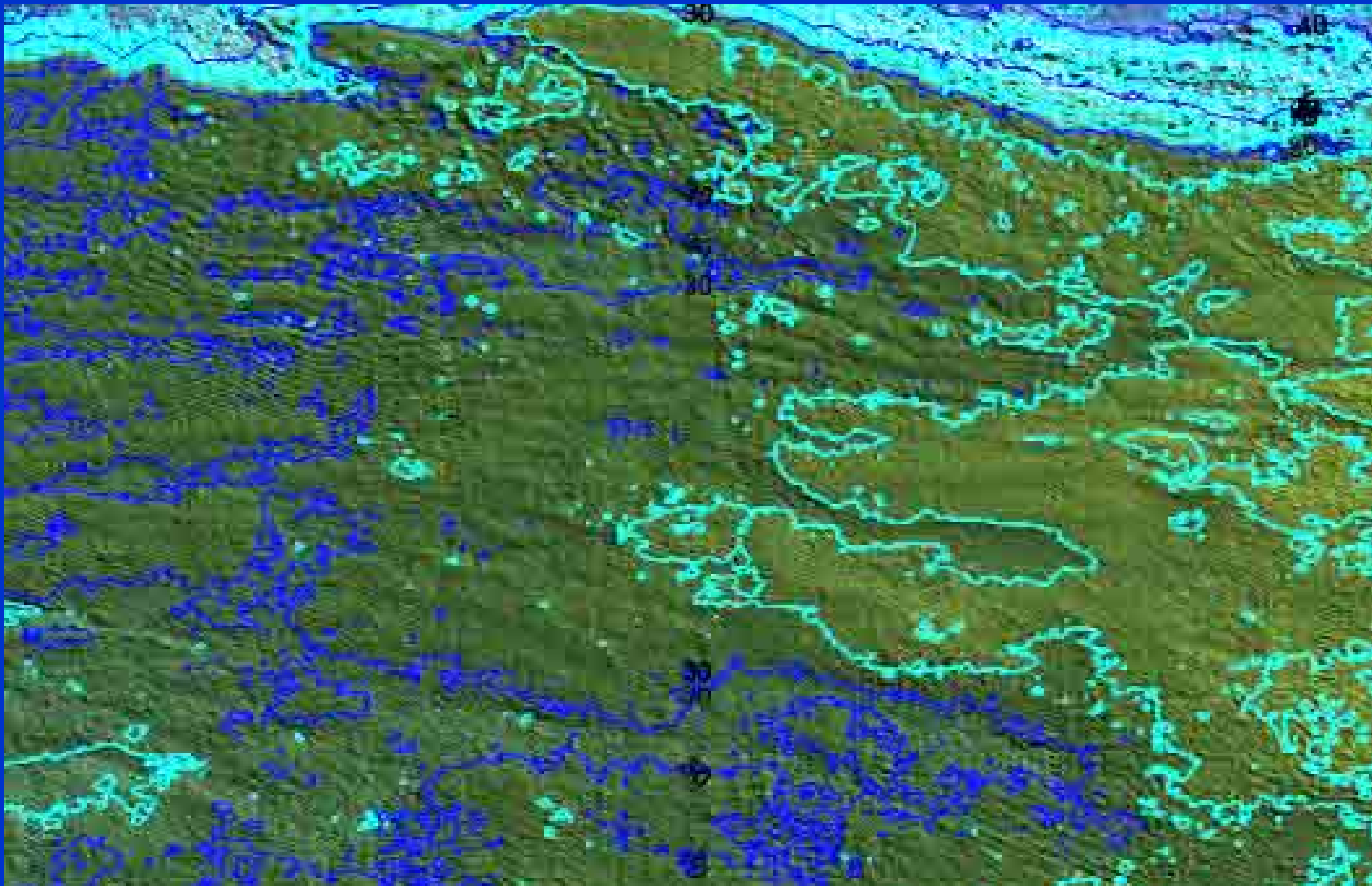
Sidescan Sonogram Volcanic Platform

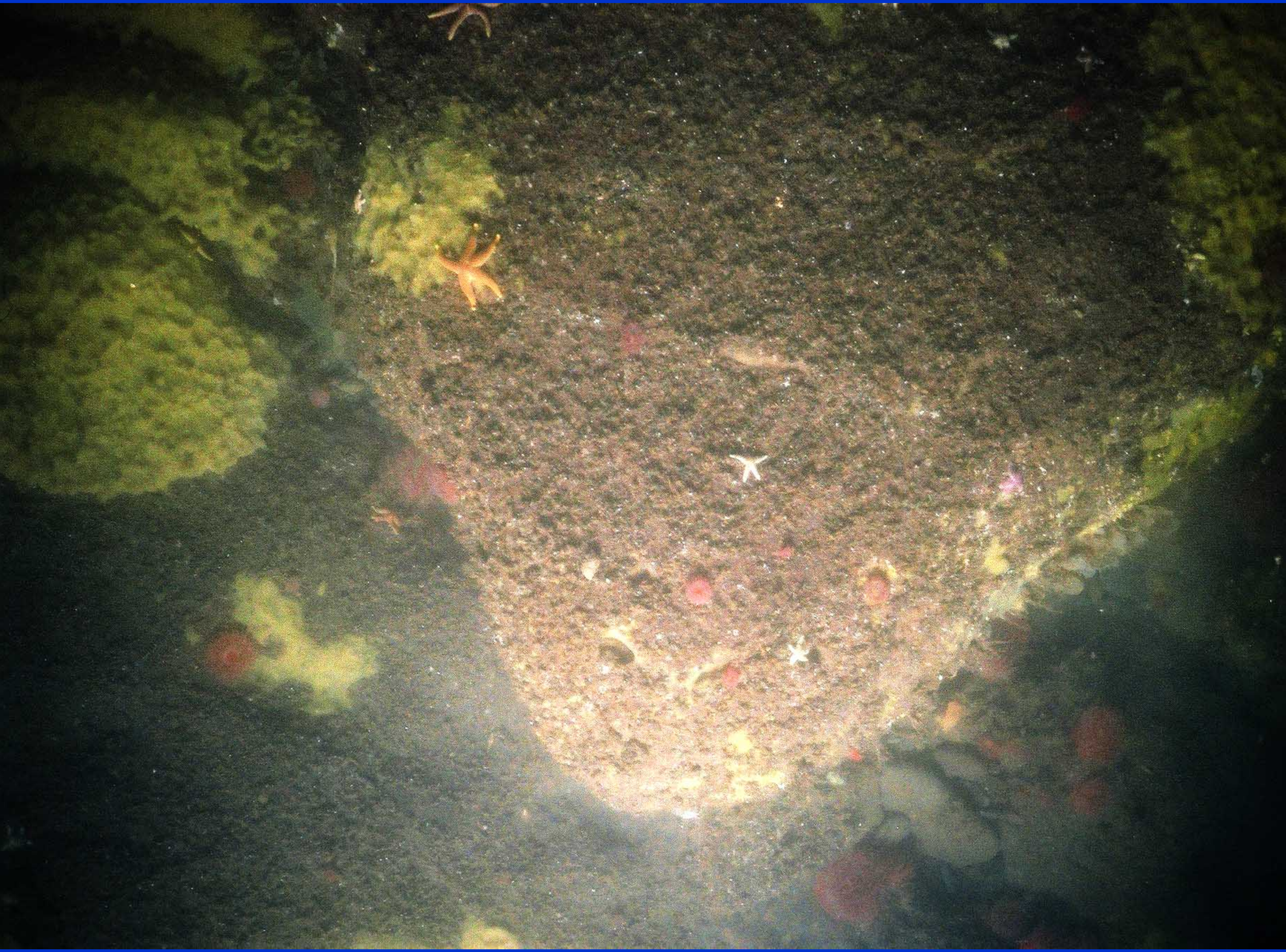


Interpretation of Volcanic Platform Structure

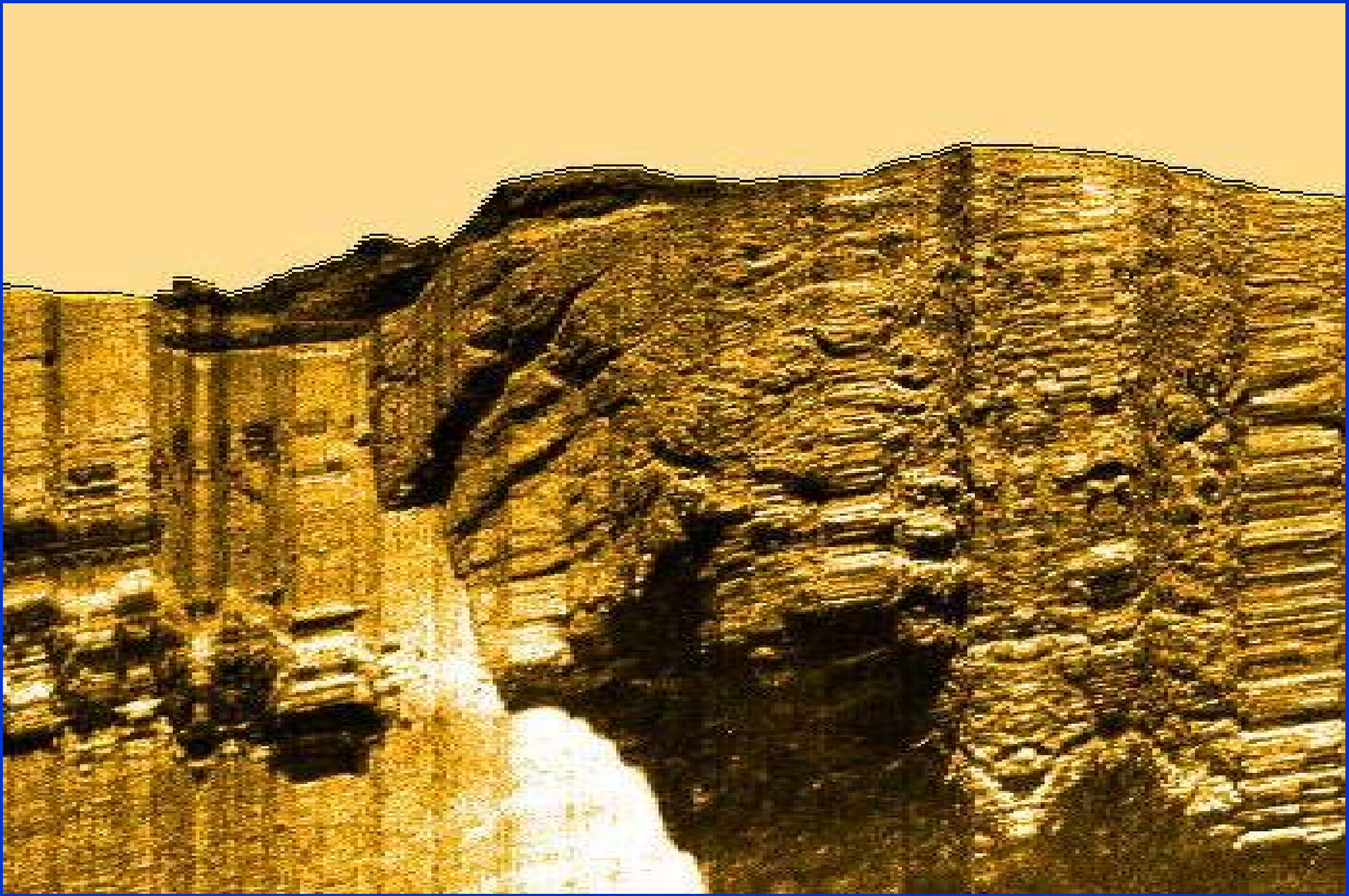


Volcanic Platform 1 M Contours

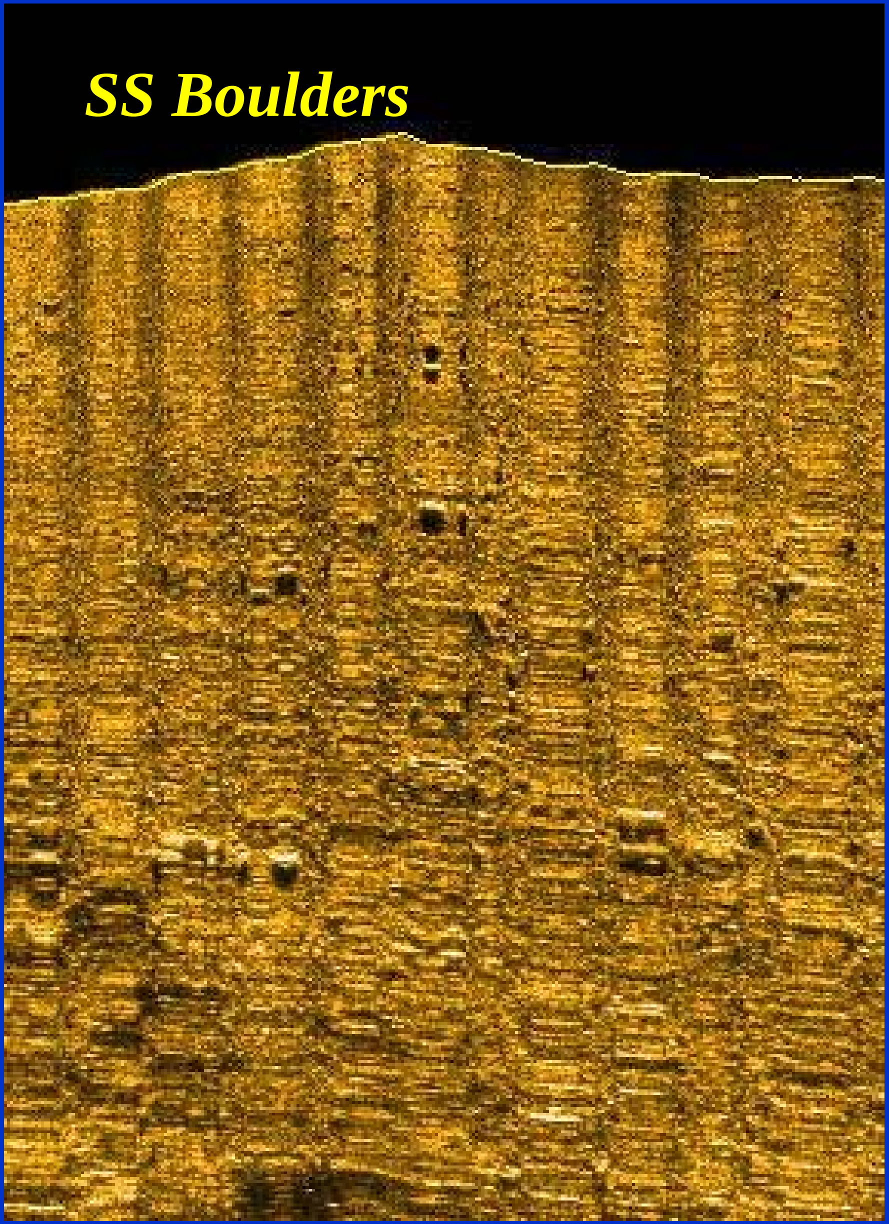




Sidescan Sonogram Volcanic Plateau Flank



Sediments



- ***Bottom photographs are the true sediment groundtruth, as it is difficult to sample bedrock and bouldery seabeds***

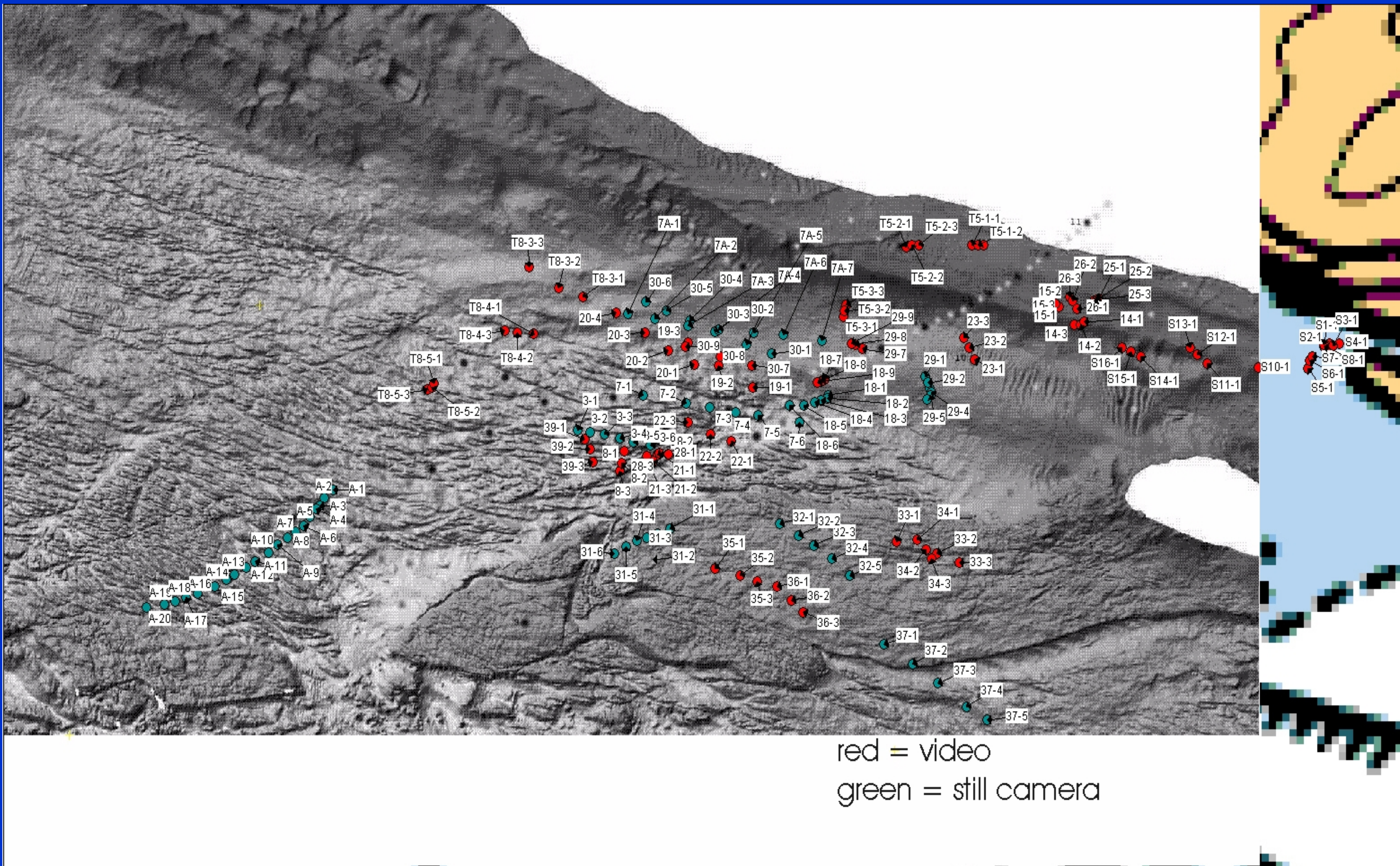
- ***Photographs and video tell us a lot about sediment transport, particle shape and size, relationship to benthic communities, geological history***

Seabed Photography, Sediment Grain Size, Transport, Concerns, Hazards Probable Sites and Cable Routes

Phi Units*	Size	Wentworth Size Class	Sediment/Rock Name
		Boulders	Sediment: GRAVEL Rock RUDITES: (conglomerates, breccias)
-8	256 mm	Cobbles	
-6	64 mm	Pebbles	
-2	4 mm	Granules	
-1	2 mm	Very Coarse Sand	Sediment: SAND Rocks: SANDSTONES (arenites, wackes)
0	1 mm	Coarse Sand	
1	1/2 mm	Medium Sand	
2	1/4 mm	Fine Sand	
3	1/8 mm	Very Fine Sand	
4	1/16 mm	Silt	Sediment: MUD Rocks: LUTITES (mudrocks)
8	1/256 mm	Clay	

* Udden-Wentworth Scale

Bottom Photographic and Video Stations



Granules, Pebbles, Cobbles

Granules, Pebbles, Cobbles, Boulders

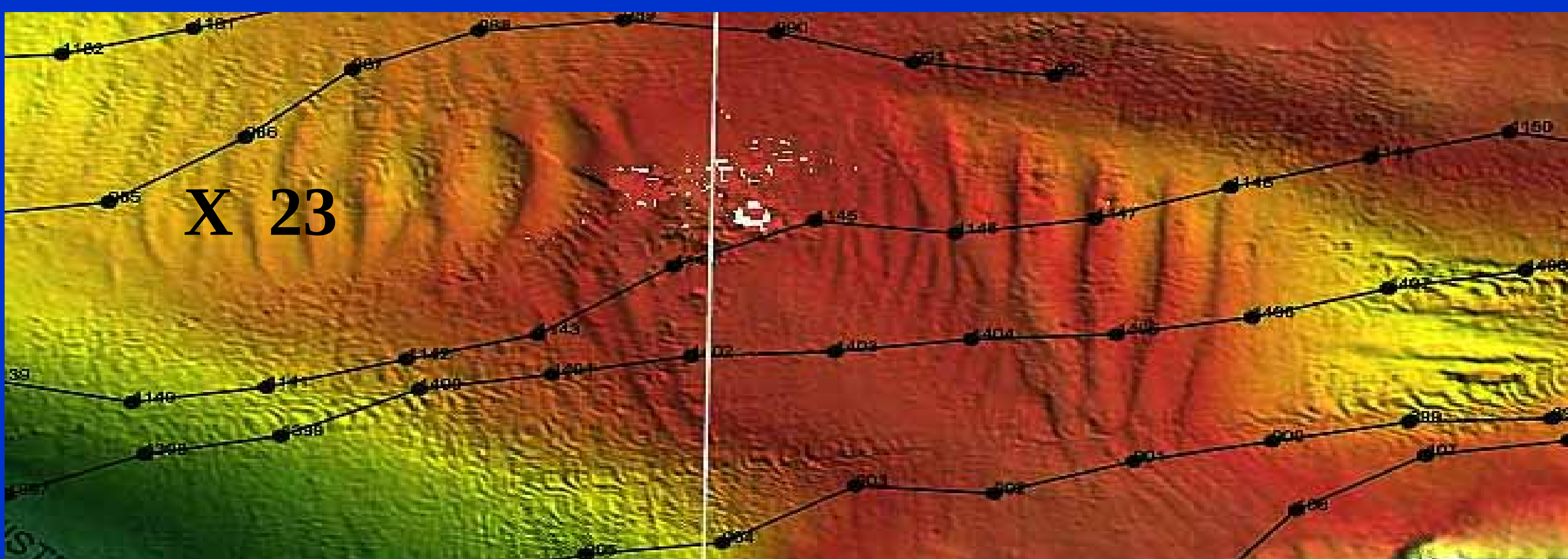
Imagery tells us:

Pebbles and cobbles have little attached growth - they likely move

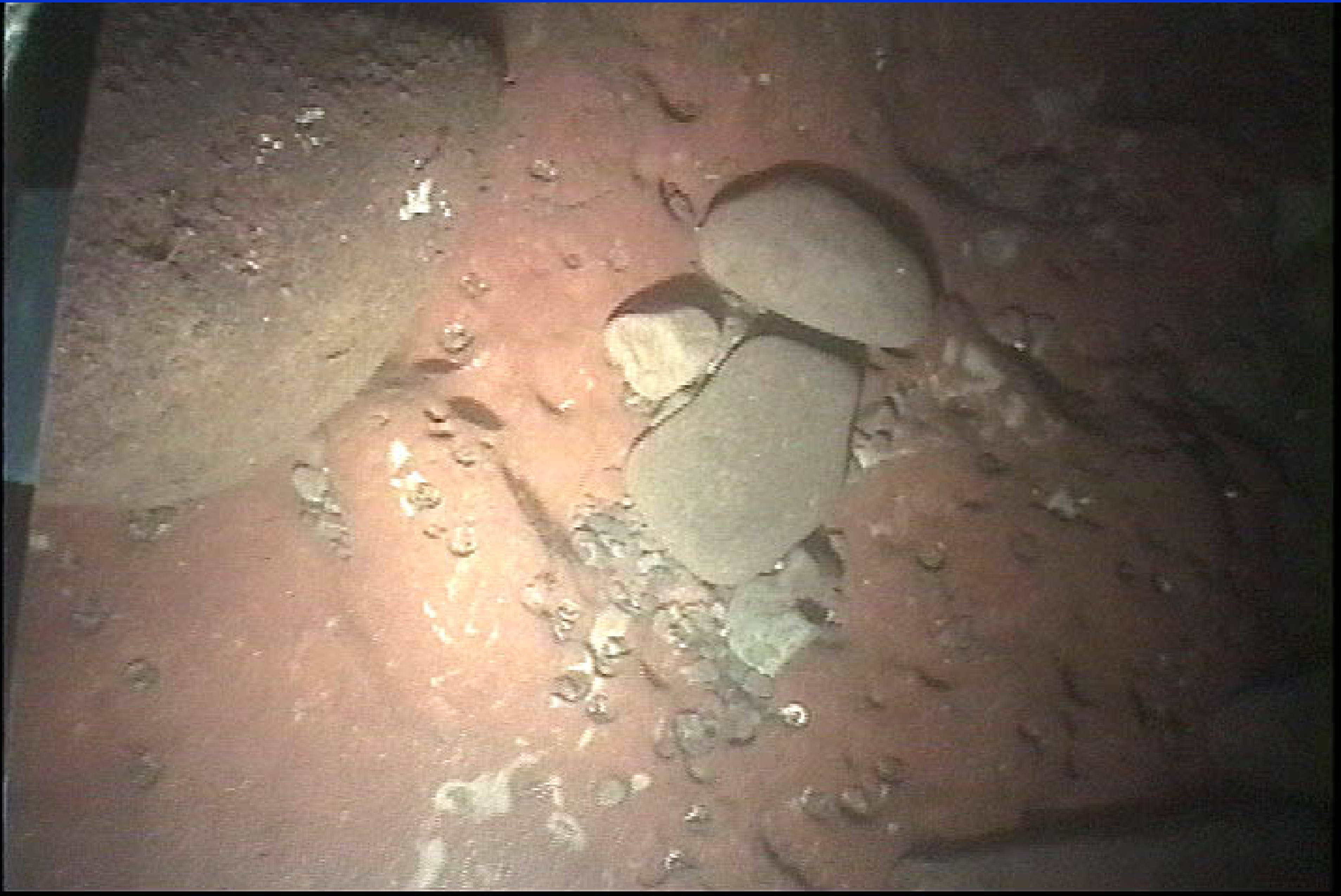
Boulders have attached growth above a 20 cm clean zone
-bedload is confined to the immediate Seabed*

Boulders on Volcanic Platform


Gravel Waves


X 23

Pebbles, Cobbles and Boulder on Red Mudstone Bedrock



Nearshore Sand, Granules, Pebbles and Cobbles with Growth

Conclusions/Observations

-Only granules, pebbles and perhaps cobbles move as bedload,

-No dusting of fine-grained sediments at slack water on gravel, suggesting no sand in transport,

-No debris such as logs, wharfs, wood, rope, pieces of ships, etc. seen on seabed imagery

-Basal zone of "no growth" on most boulders 20 cm high – the "bedload zone of influence"

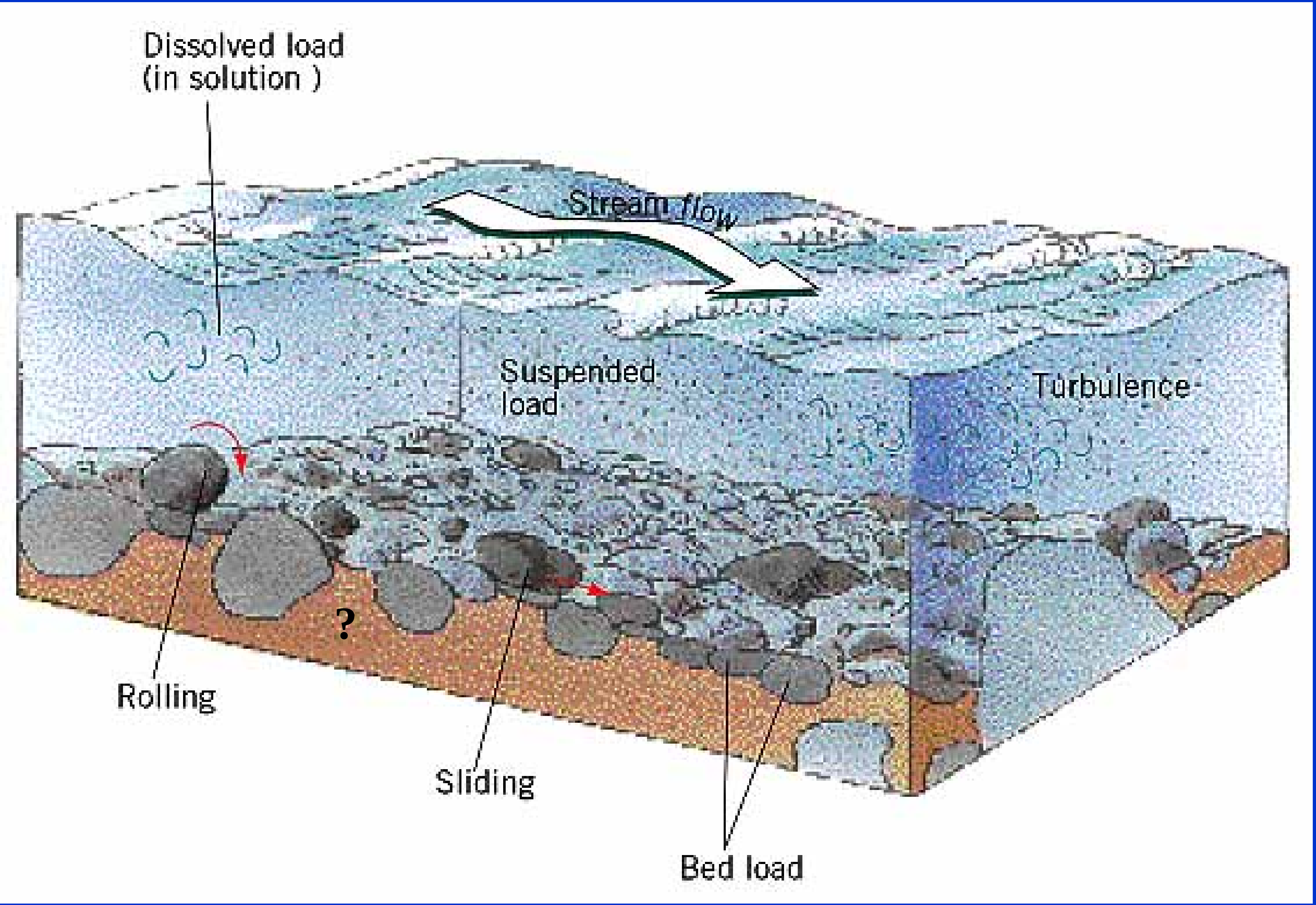
Continued,

- *Boulders were rounded as a result of lowered sea levels 10 – 15,000 years ago and not modern movement*

-No indication of impact marks from moving cobbles on boulder surfaces

-Minor indication on sidescan of linear scours made by moving boulders/debris, few in shallow water

Sediment Transport Models



Cautions/Hazards

- Slumping, slope failure features - avoid

- Stratigraphy - Mud beneath gravel – scour, settling, foundation stability, locate on bedrock if possible?

- Bedrock ridges have varying relief, width, slope and complex shape

- Debris /Ice? Little evidence for submerged components

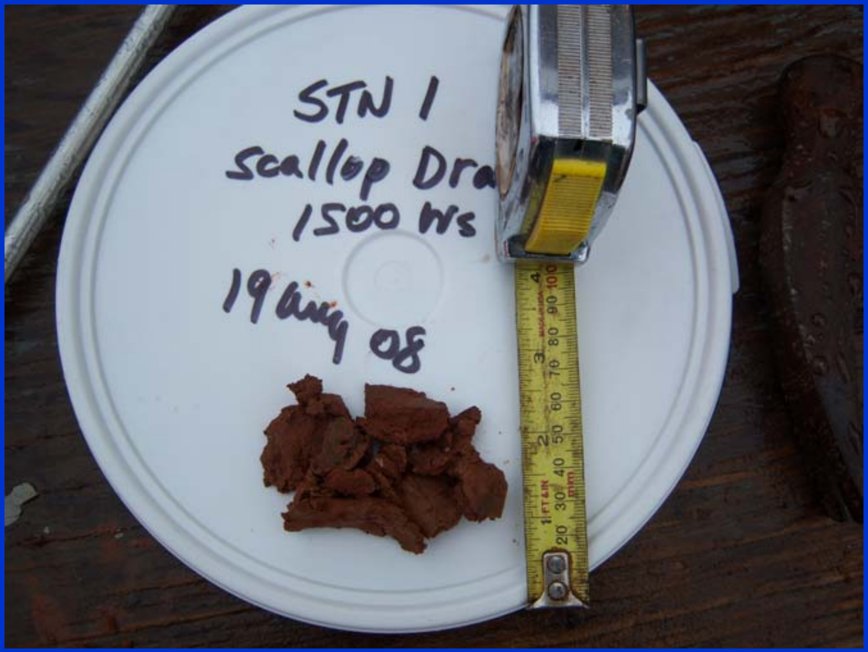
Stratigraphy

Seismic can't penetrate bedrock as it has too high a velocity,

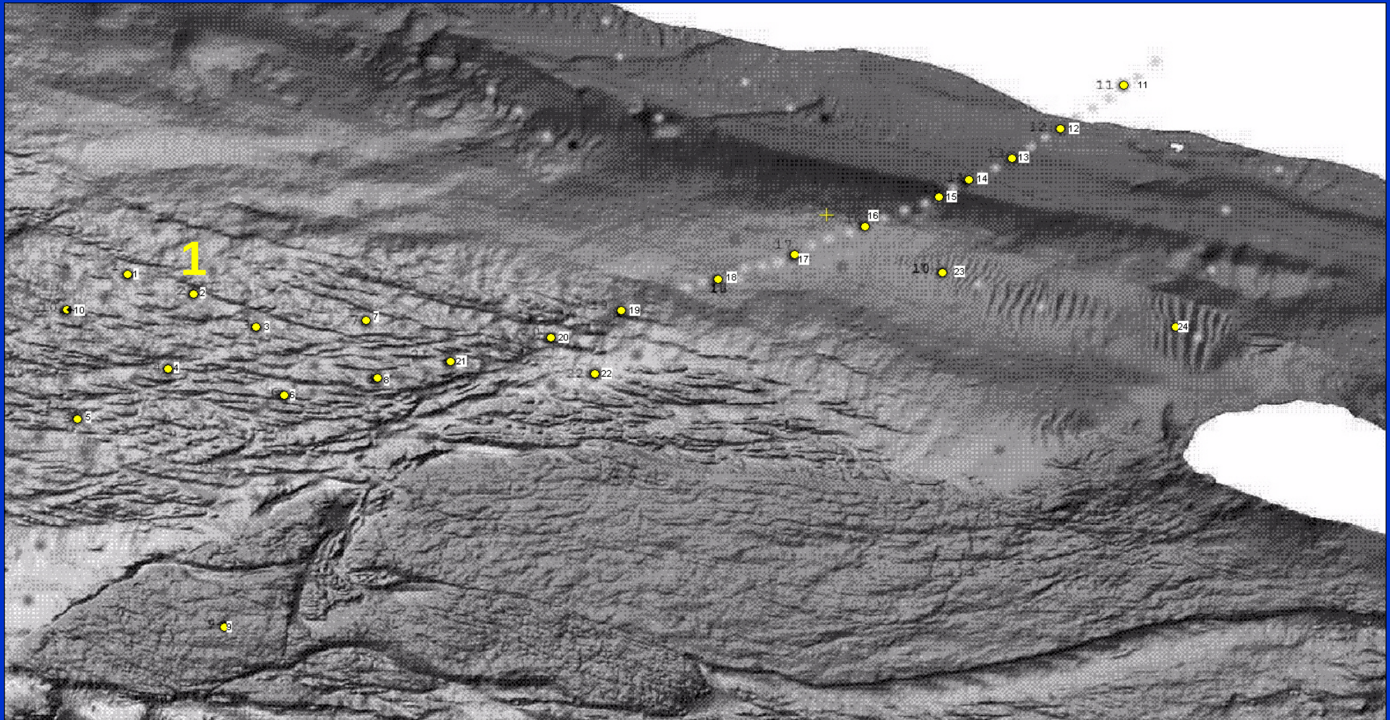
Does not show good penetration in boulder covered regions between bedrock ridges

Scallop rake samples show some mud in the subsurface – likely glaciomarine

Two types of sediment above bedrock in region – till and glaciomarine mud; glaciomarine mud more extensive

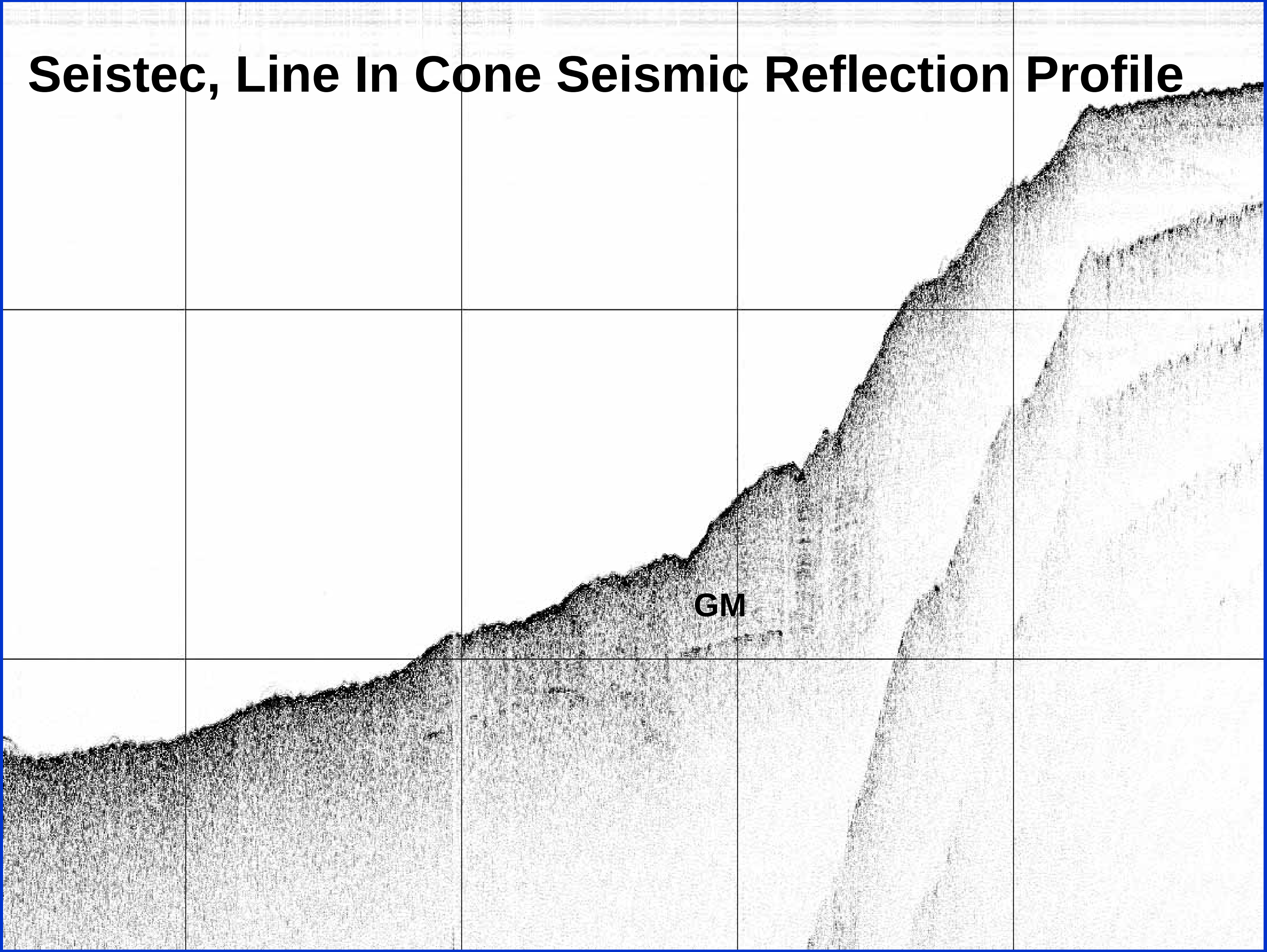

STN 1
Scallop Dra
1500 hrs
19 Aug 08


Mud At Station #1

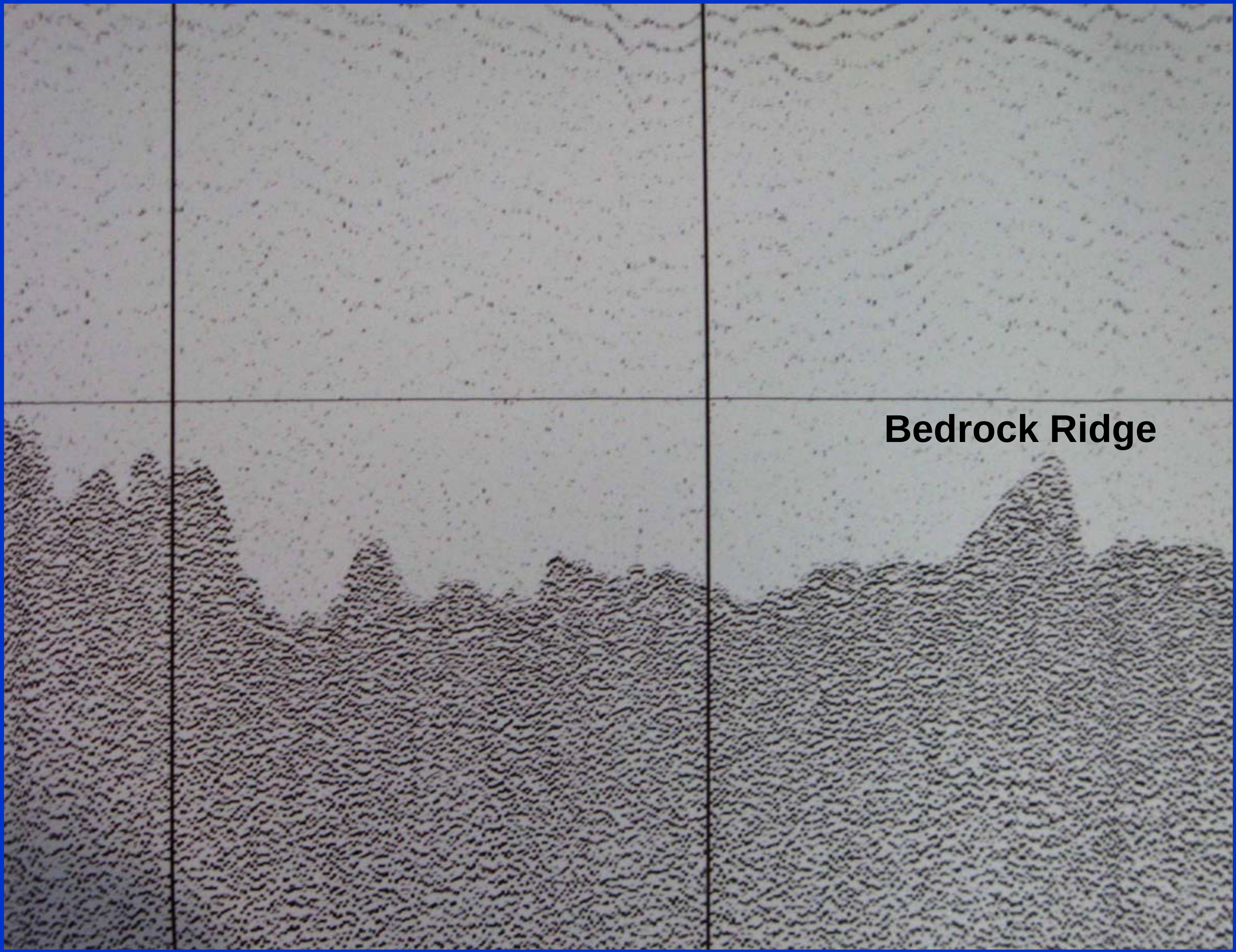

1

Cobble, Boulder Station #3

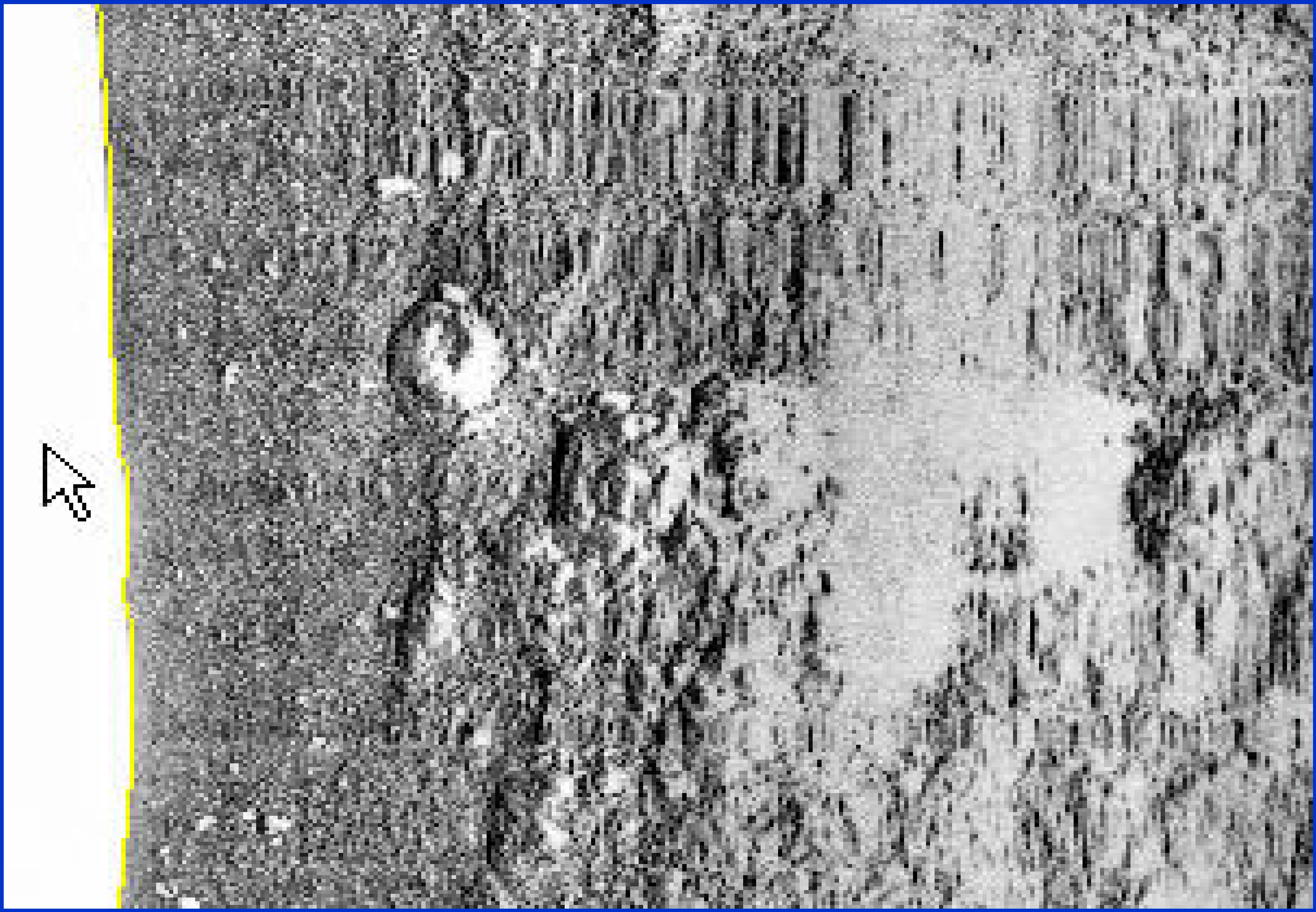
Seistec, Line In Cone Seismic Reflection Profile



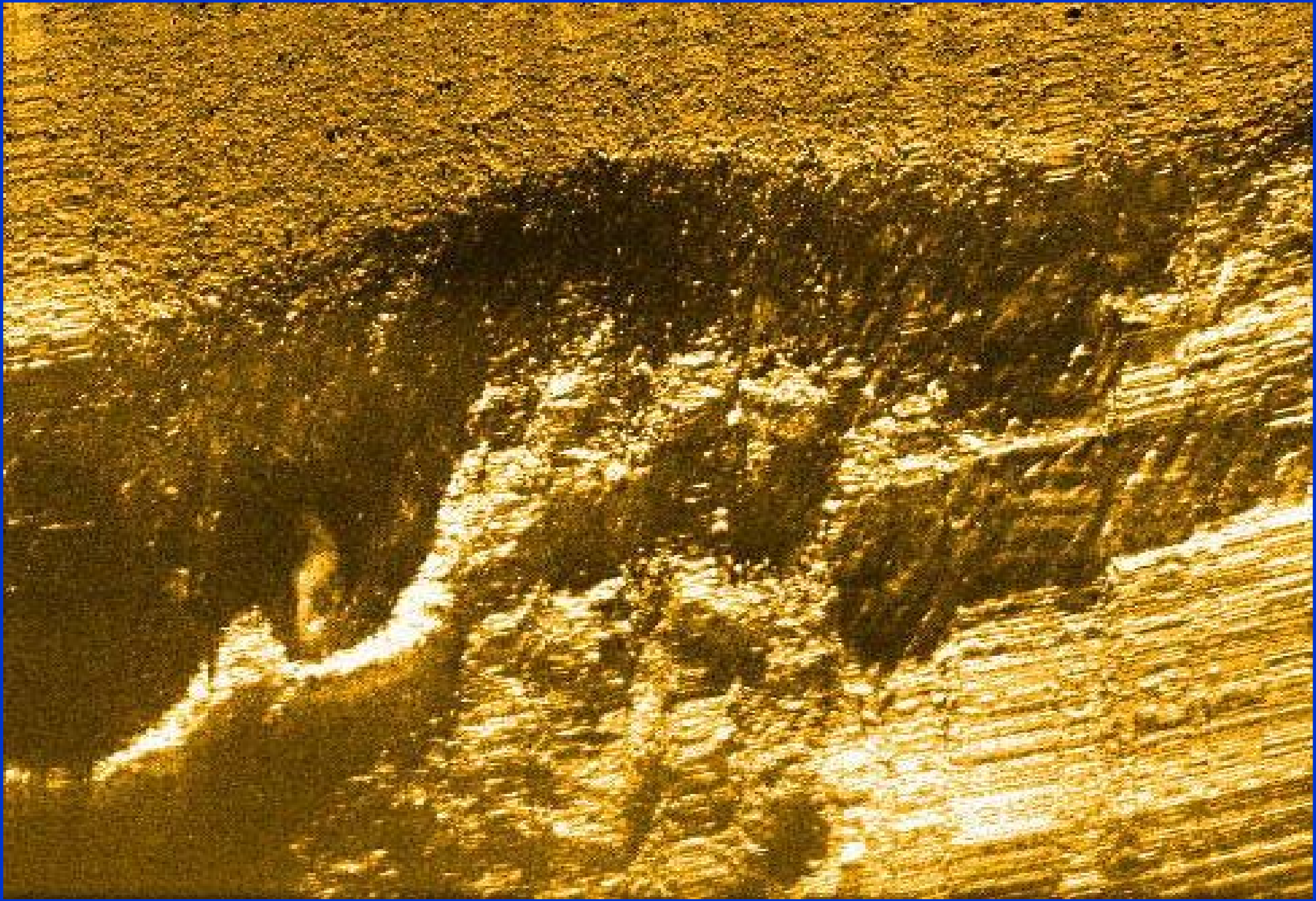
Huntec DTS Profile – penetration/side echo?



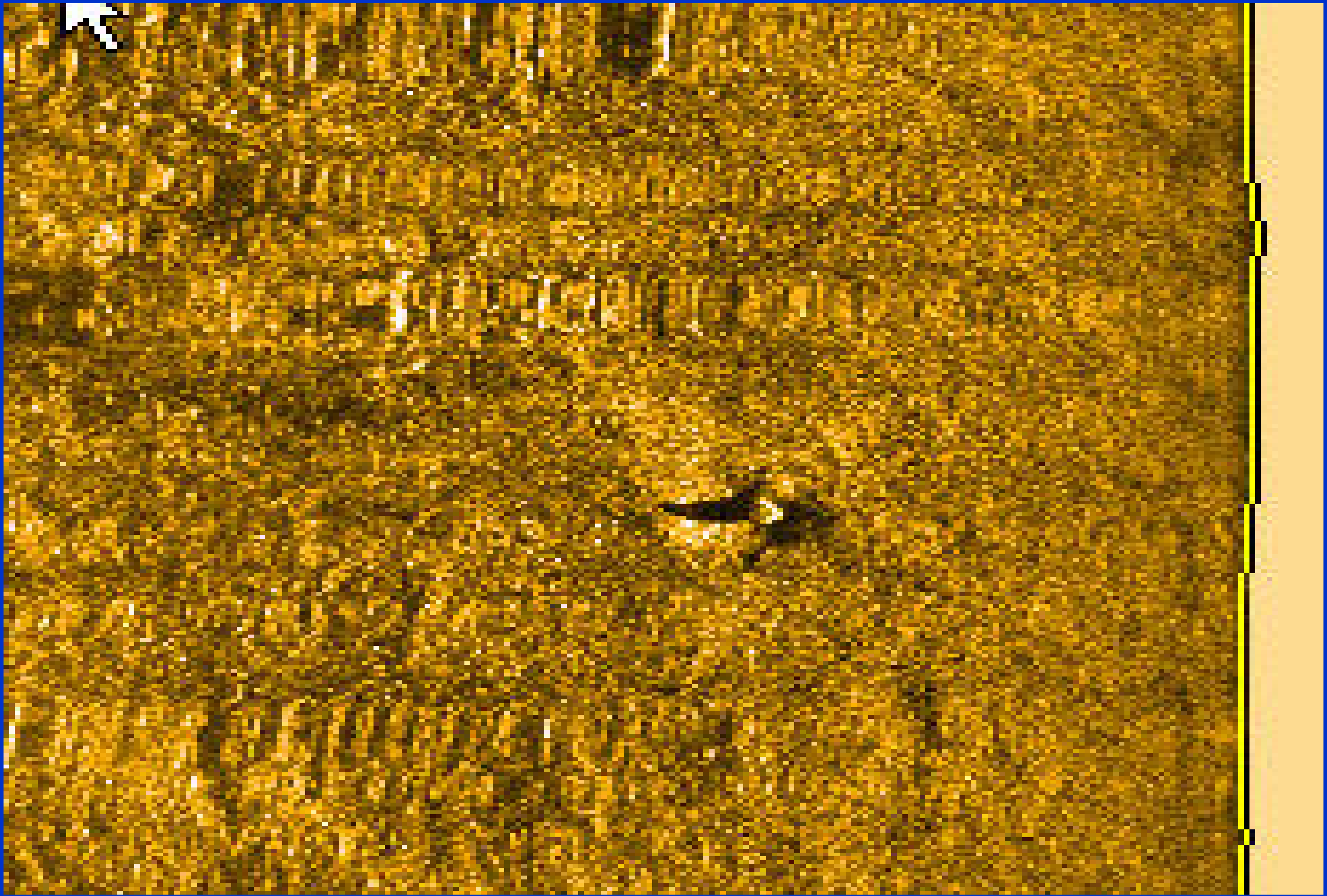
Circular Features – Anthropogenic dredging, spoils, other?



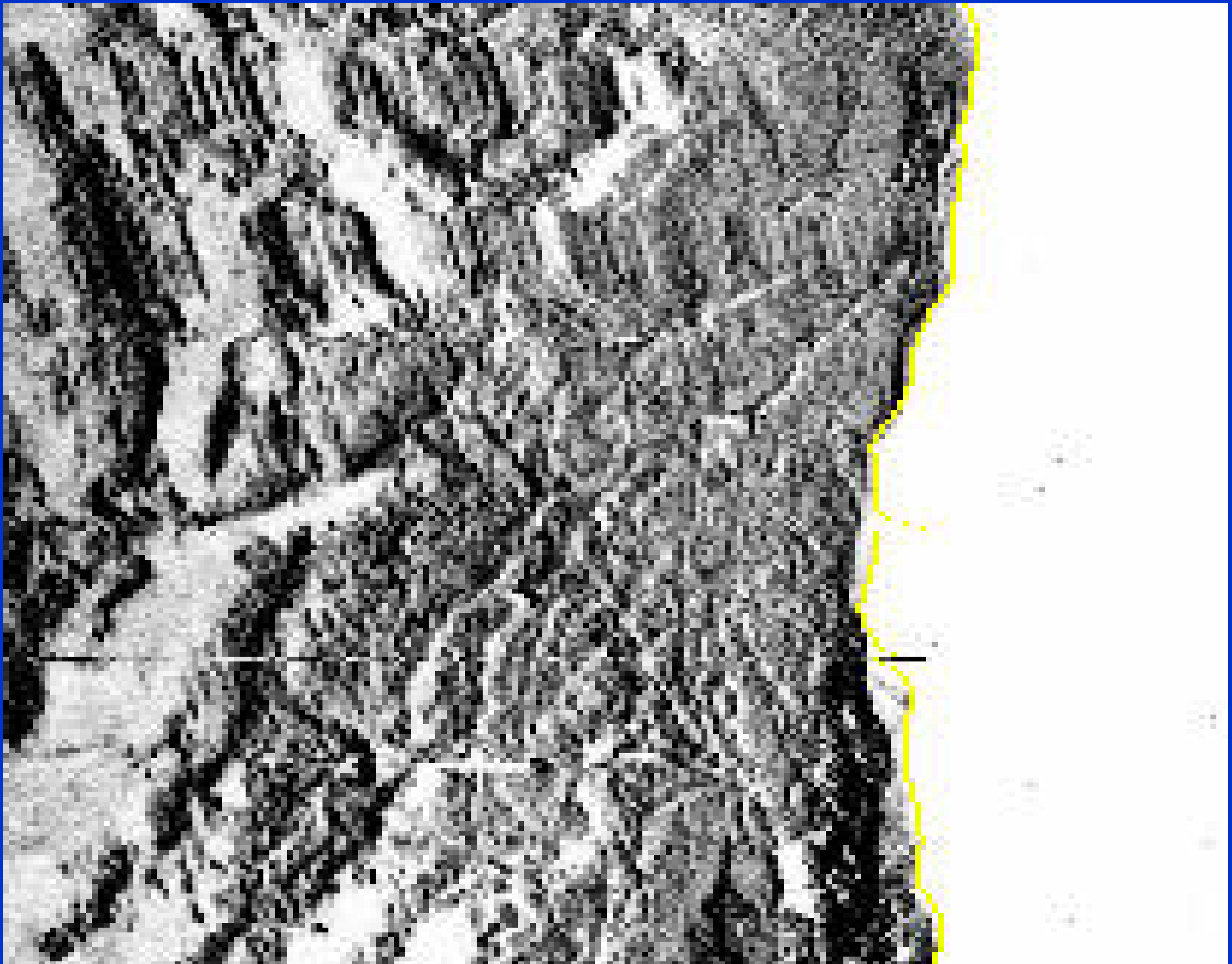
Sonogram – Headwall Scarp and Slump



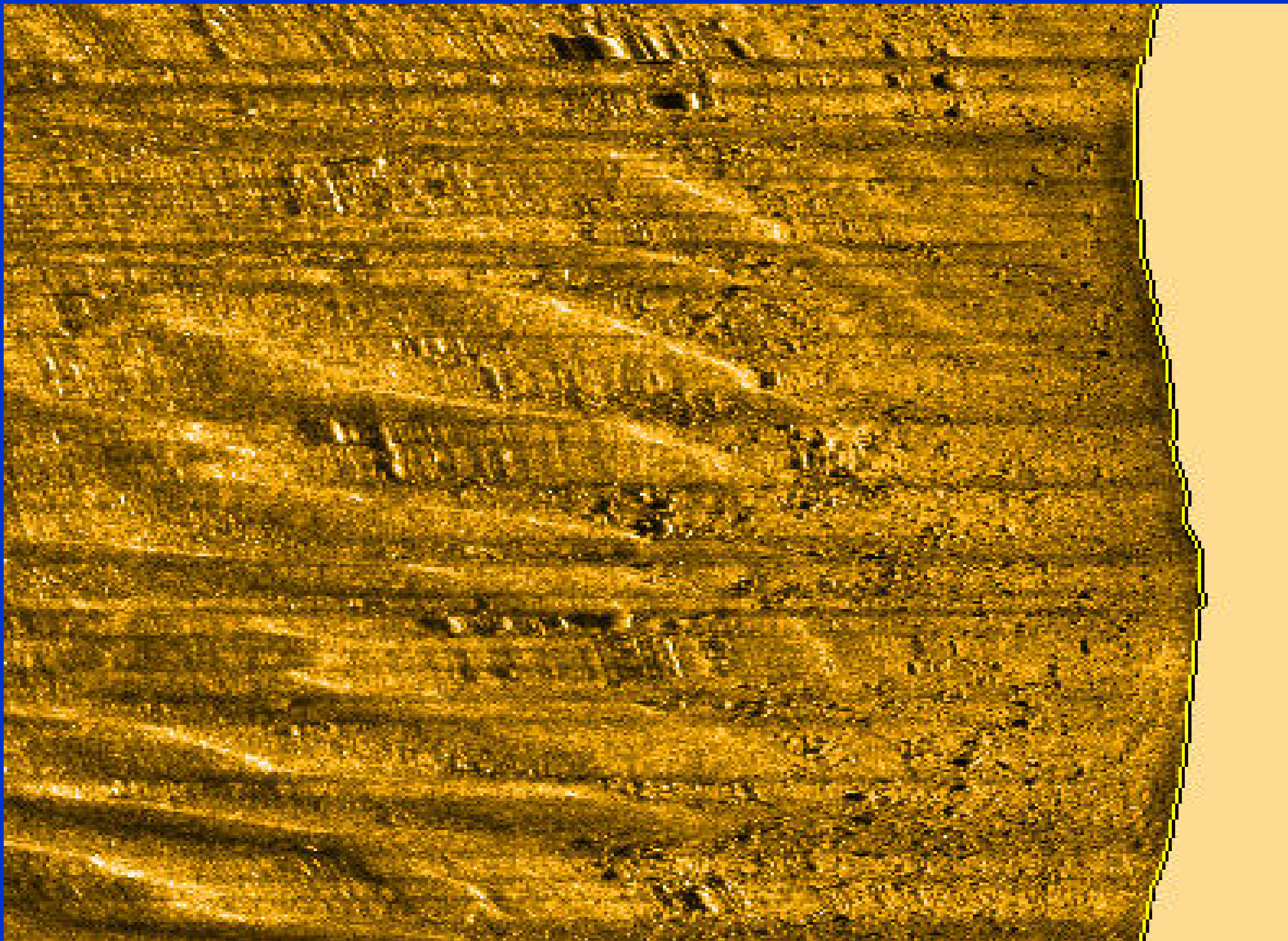
Sonogram – boulder in a scour pit



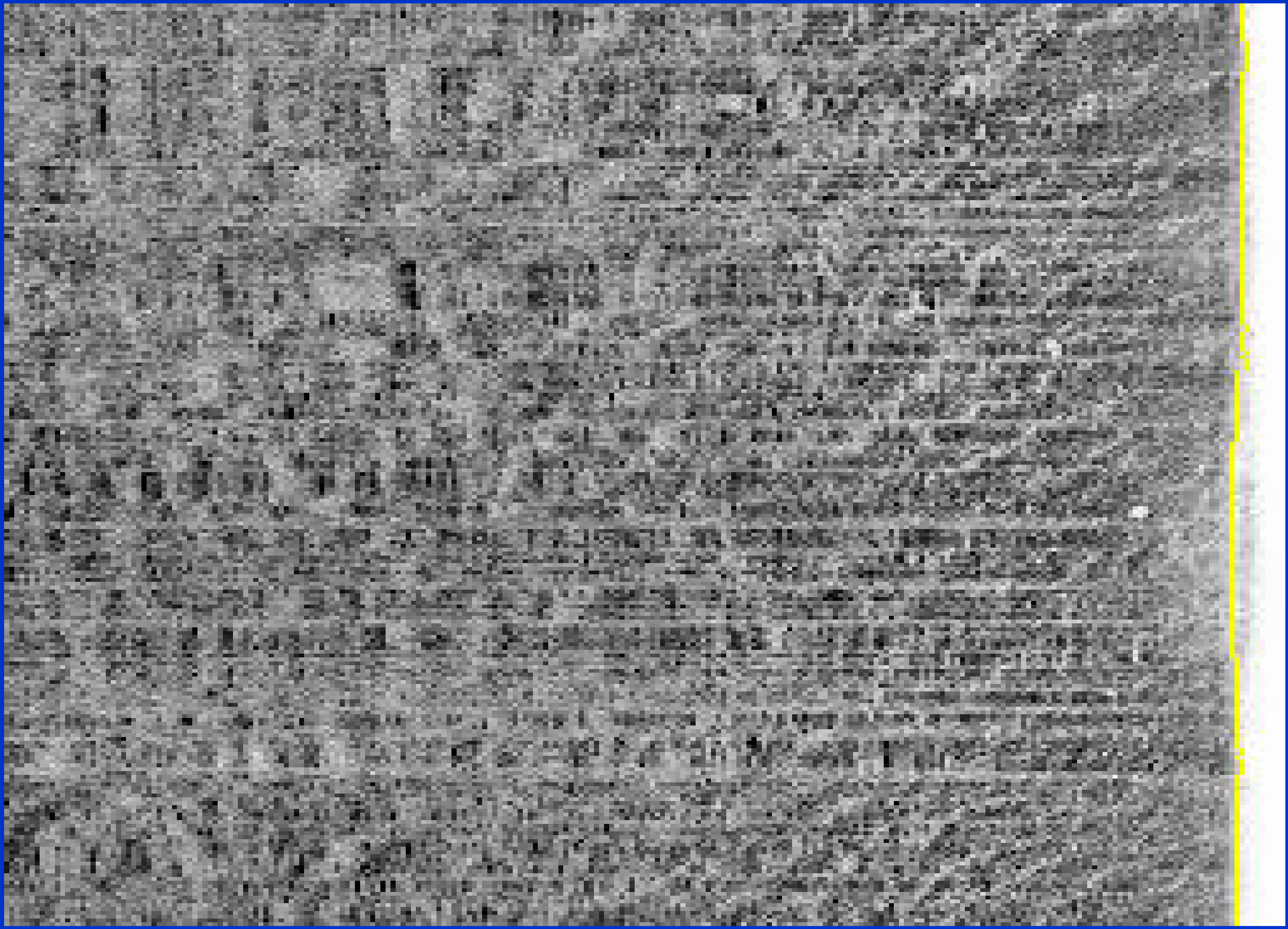
Sonogram – Crossing Linear Features Vol. Platform



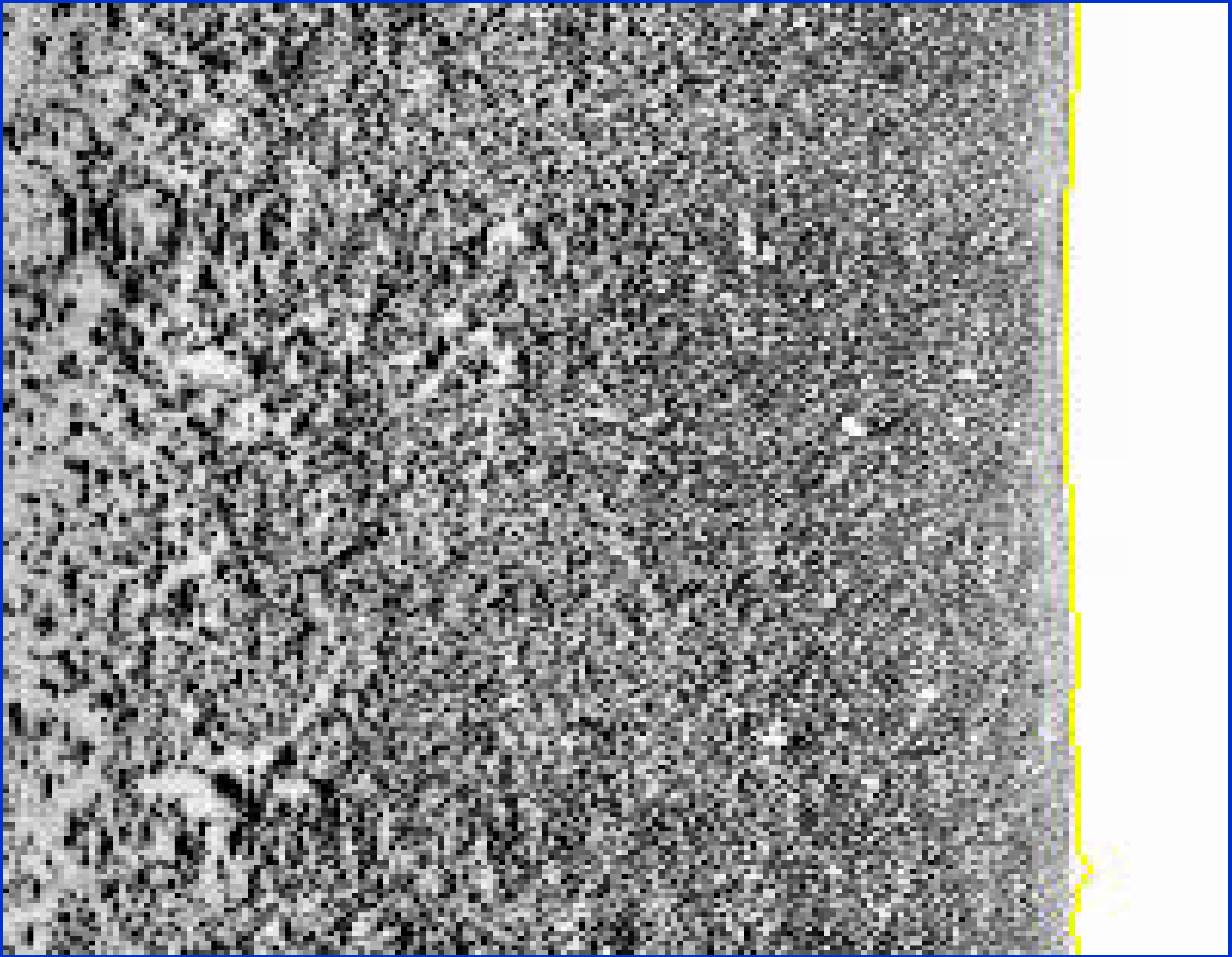
Sonogram – Gravel Waves with Boulders in Troughs



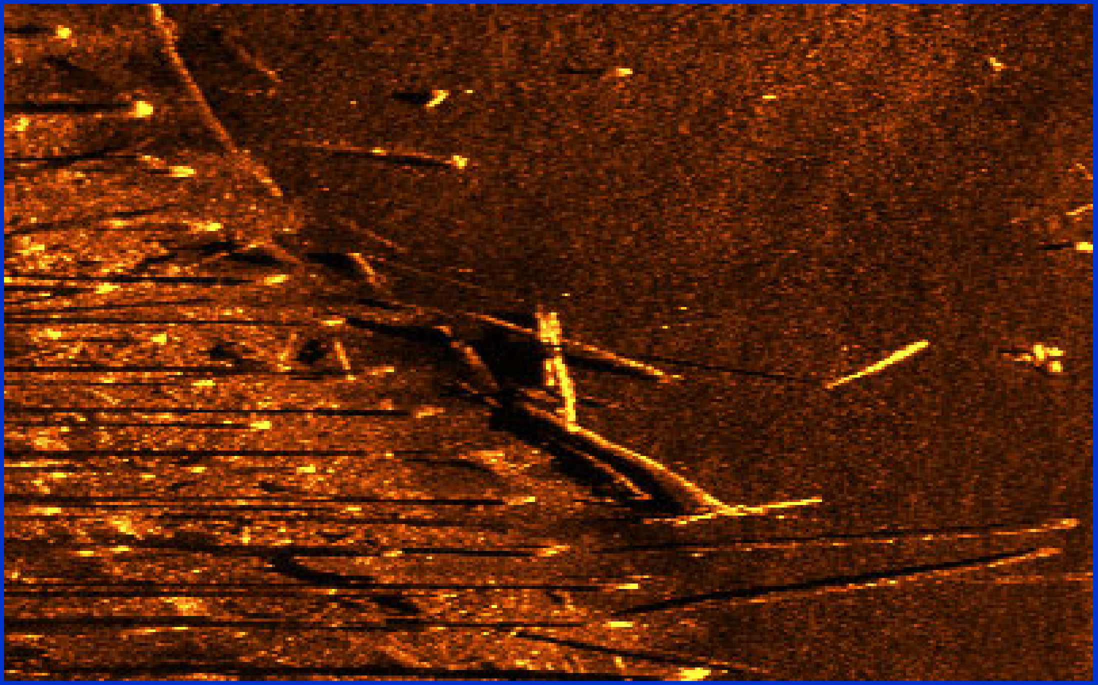
Sonogram – with low relief sand and gravel bedforms



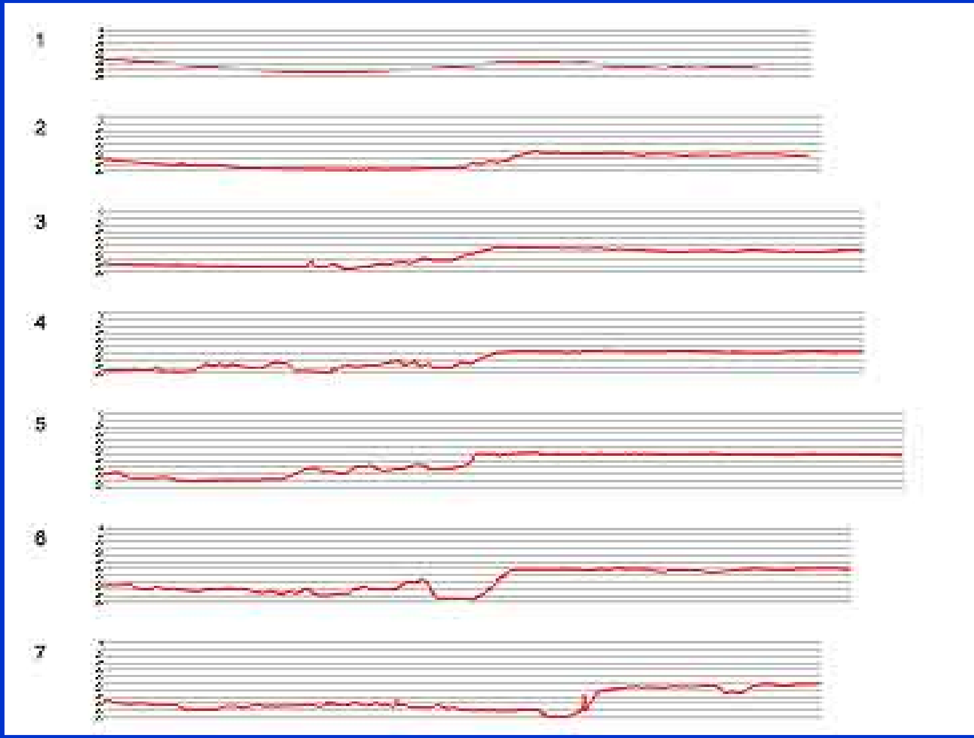
Sonogram – with subtle linear drag marks nearshore



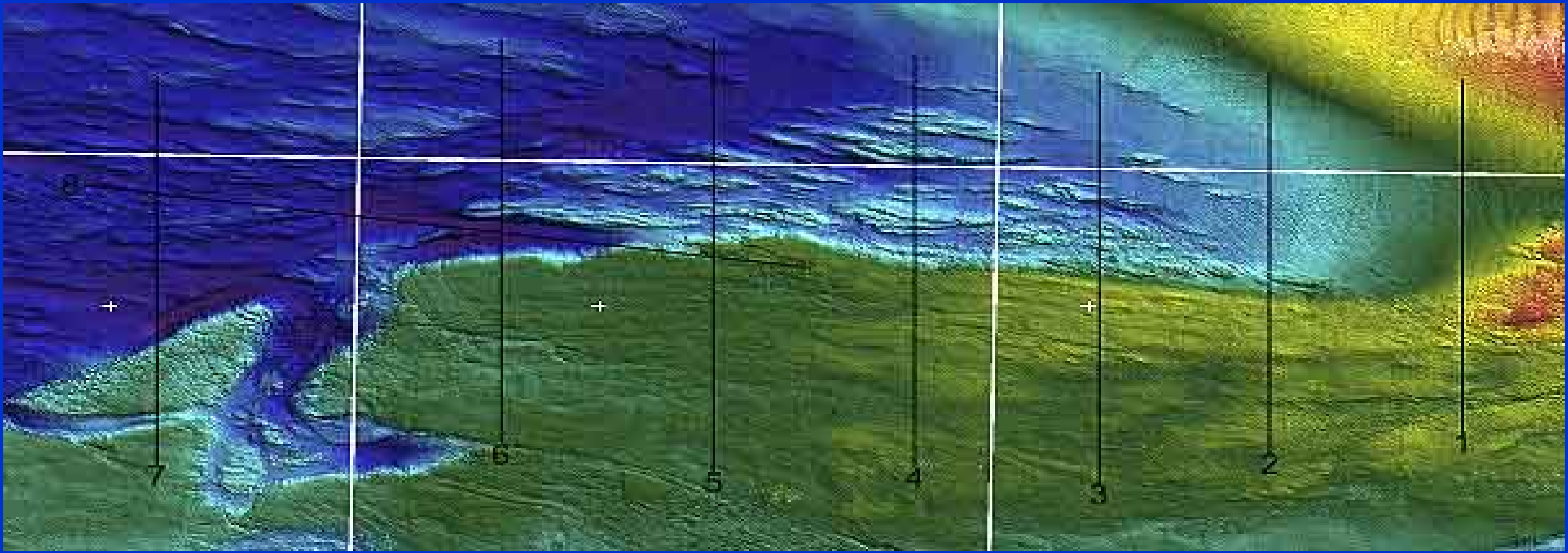
Example of wood, trees on river bottom



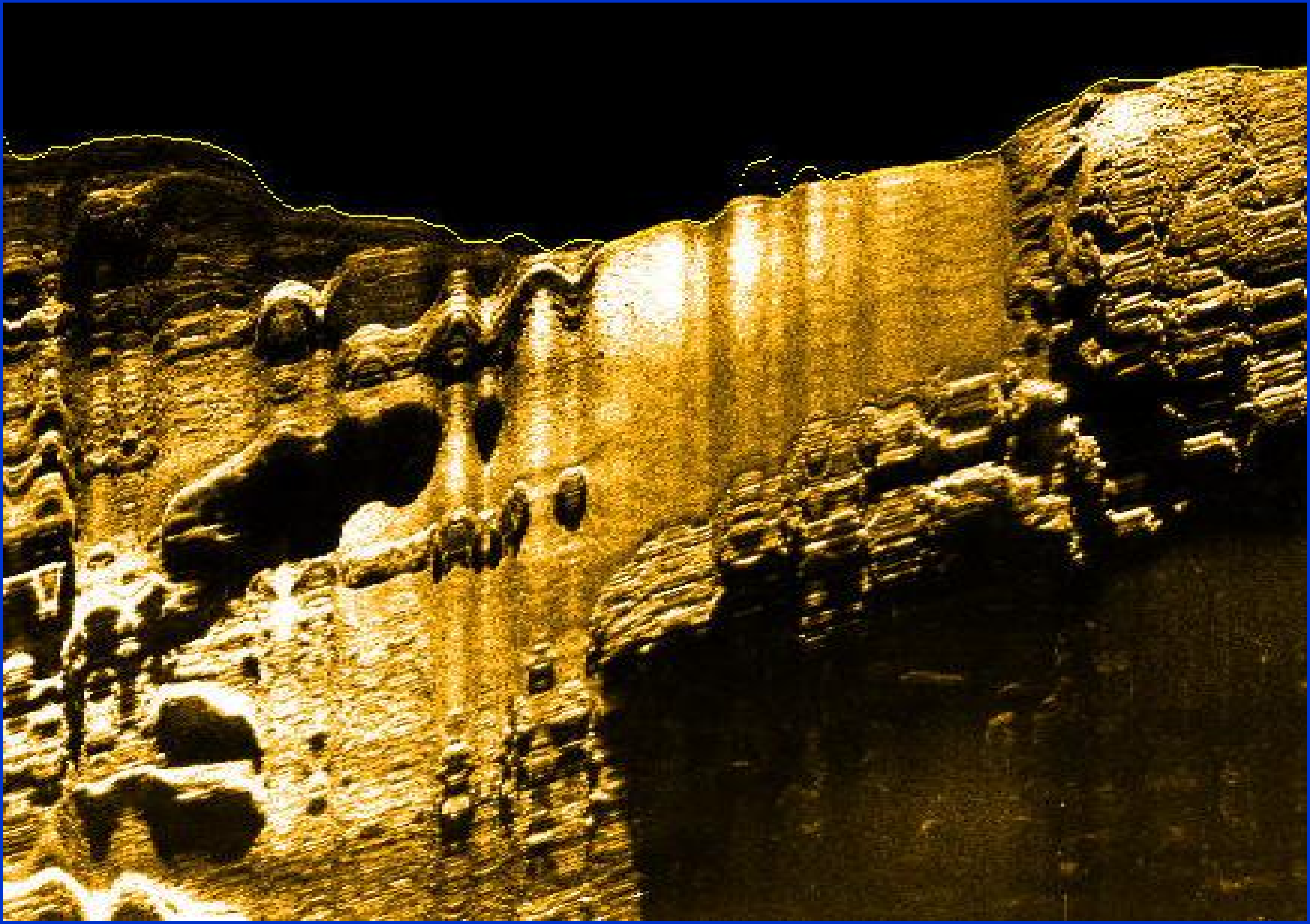
Sidescan Sonogram of logs on seabed (not Fundy)



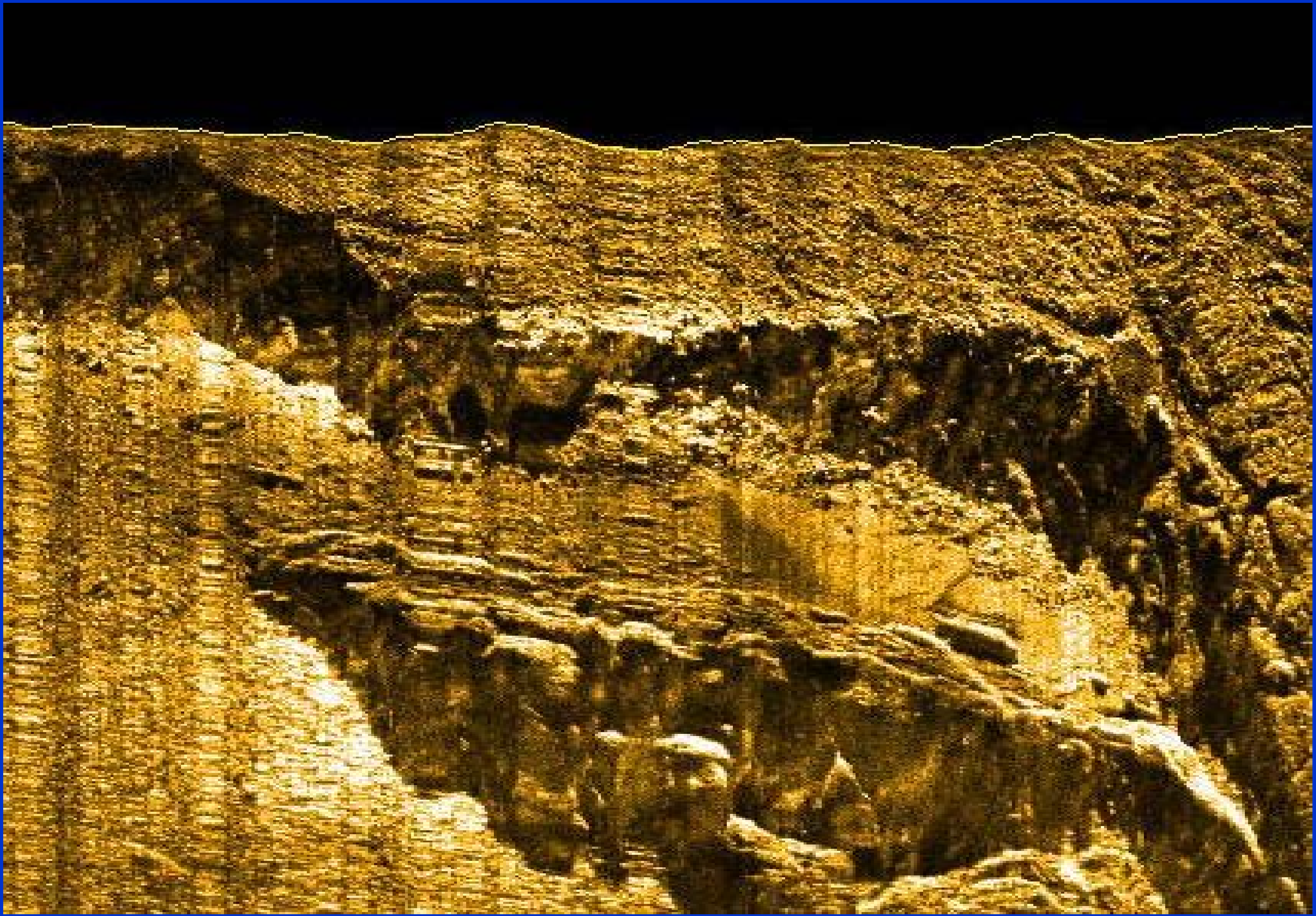
Multibeam Bathymetry with bathymetric profiles



Sonogram –moat around Vol. Platform, granules no boulders



Sonogram - flank of Vol. platform, boulders at base of slope



Site and Route Selection

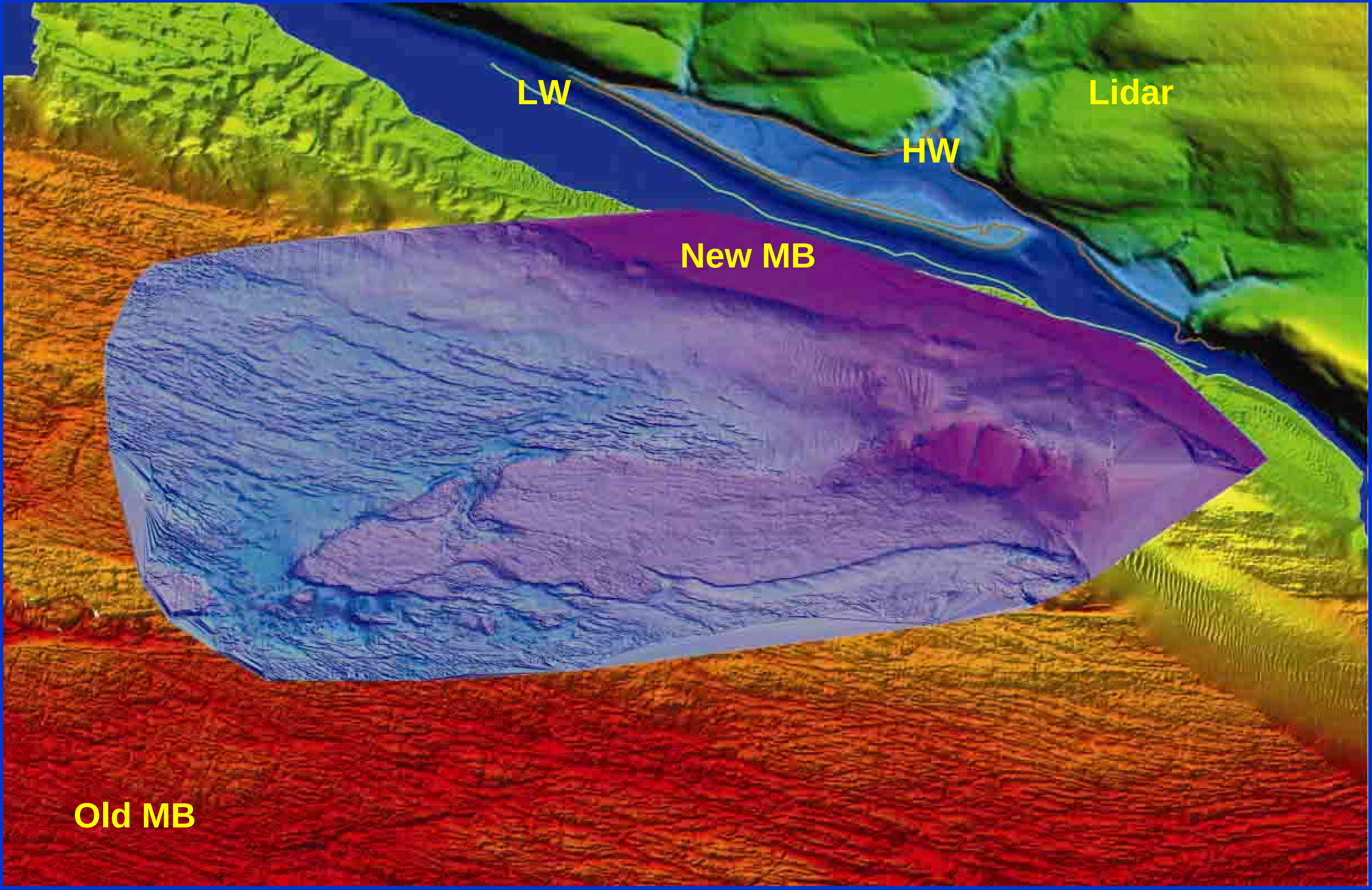
Some Criteria for Site Selection

1) Appropriate water depth
2) Correct oceanographic currents
3) Stable and flat seabed
4) Lack of moving bedforms
5) Avoidance of hazards – steep slopes, scours, important habitats, slumps, debris, anthropogenic material, sharp abrasive edges,
6) Compatibility with gravity base, ease of installation
7) Cable route controls (minimize length, natural protection)

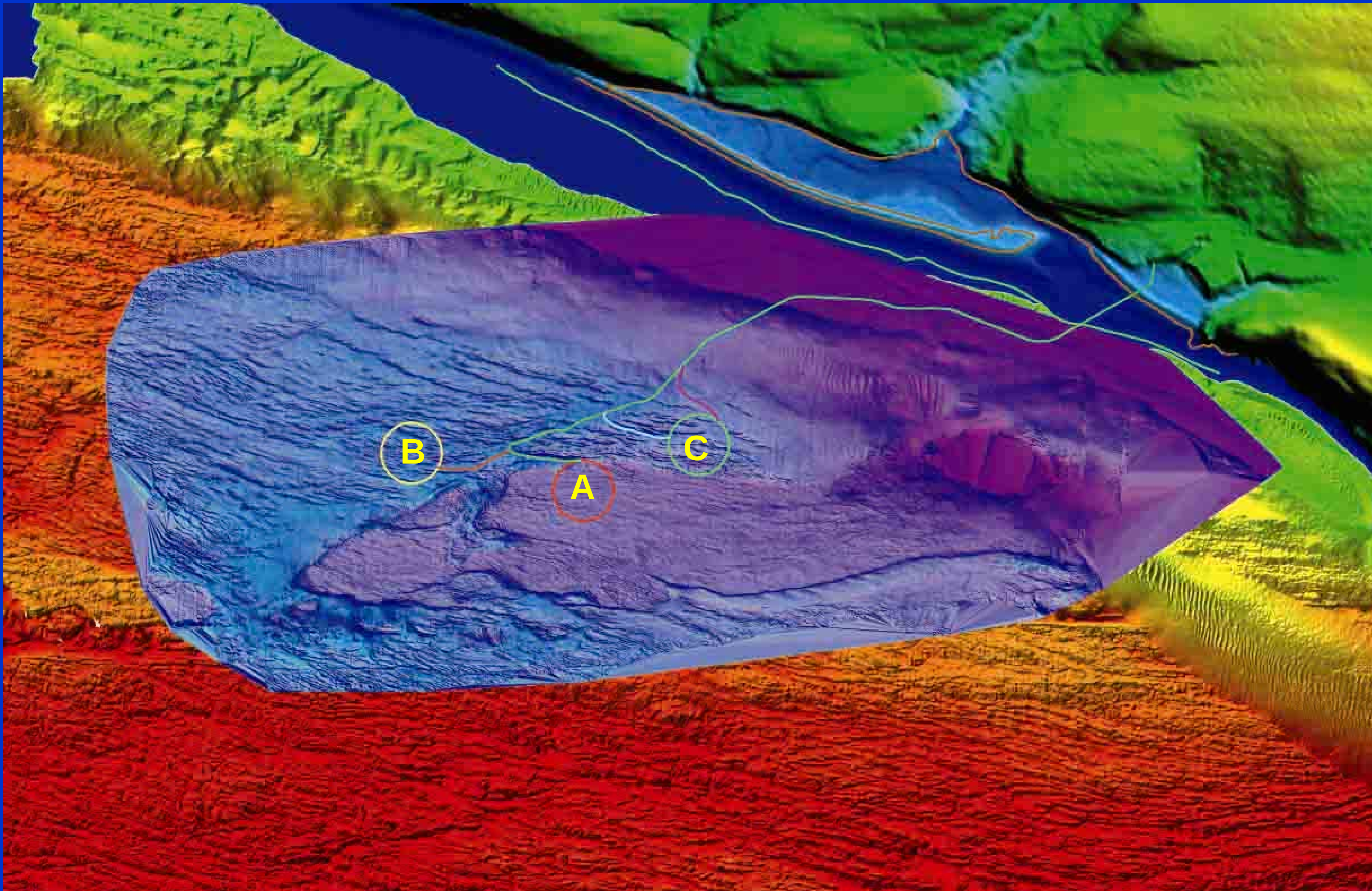

IBEROSTAR
W Bay Rd
Spruce Rd
N
© 2008 Tele Atlas
© 2008 YellowPages.ca
Image © 2008 DigitalGlobe
Image © 2008 GeoEye
Google
Pointer 45°22'13.31" N 64°24'23.83" W
Streaming 100%
Eye alt 6871 ft

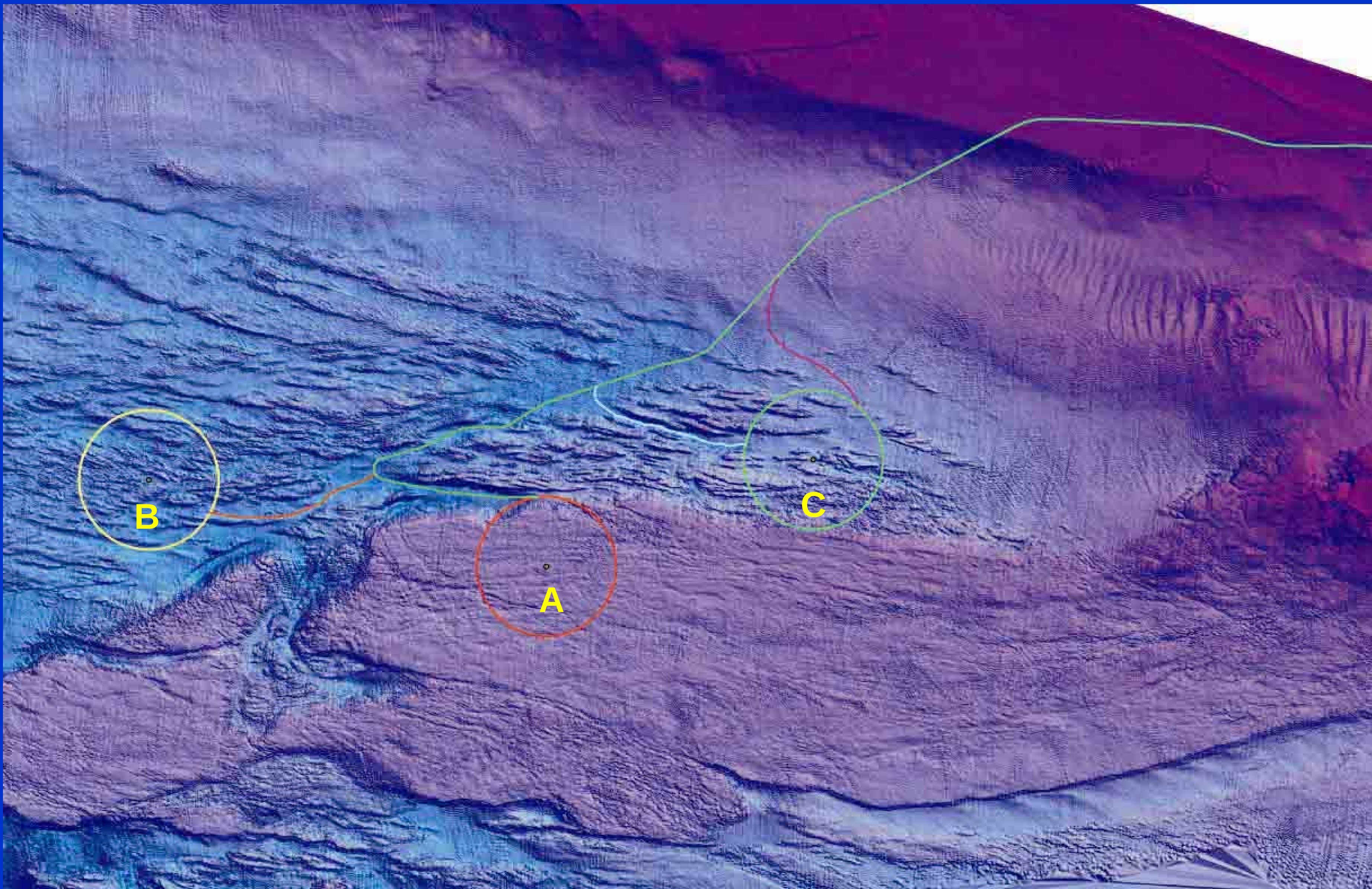

IBEROSTAR
W Bay Rd
Spruce Rd
© 2008 Tele Atlas
© 2008 YellowPages.ca
Image © 2008 DigitalGlobe
Image © 2008 GeoEye
Google
Pointer 45°22'13.31" N 64°24'23.83" W
Streaming 100%
Eye alt 6871 ft

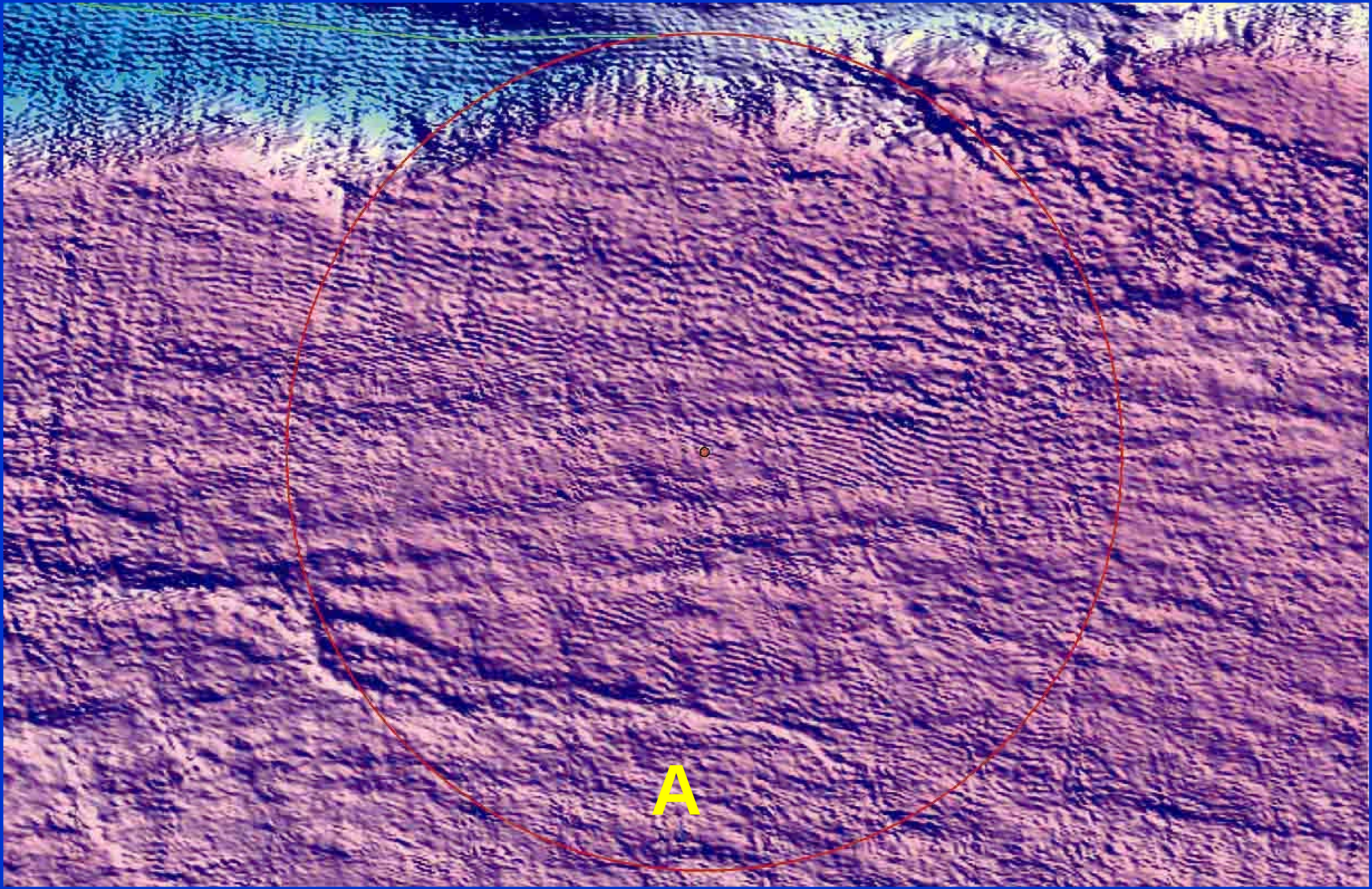
Lidar, Multibeam Bathymetry, Shorelines

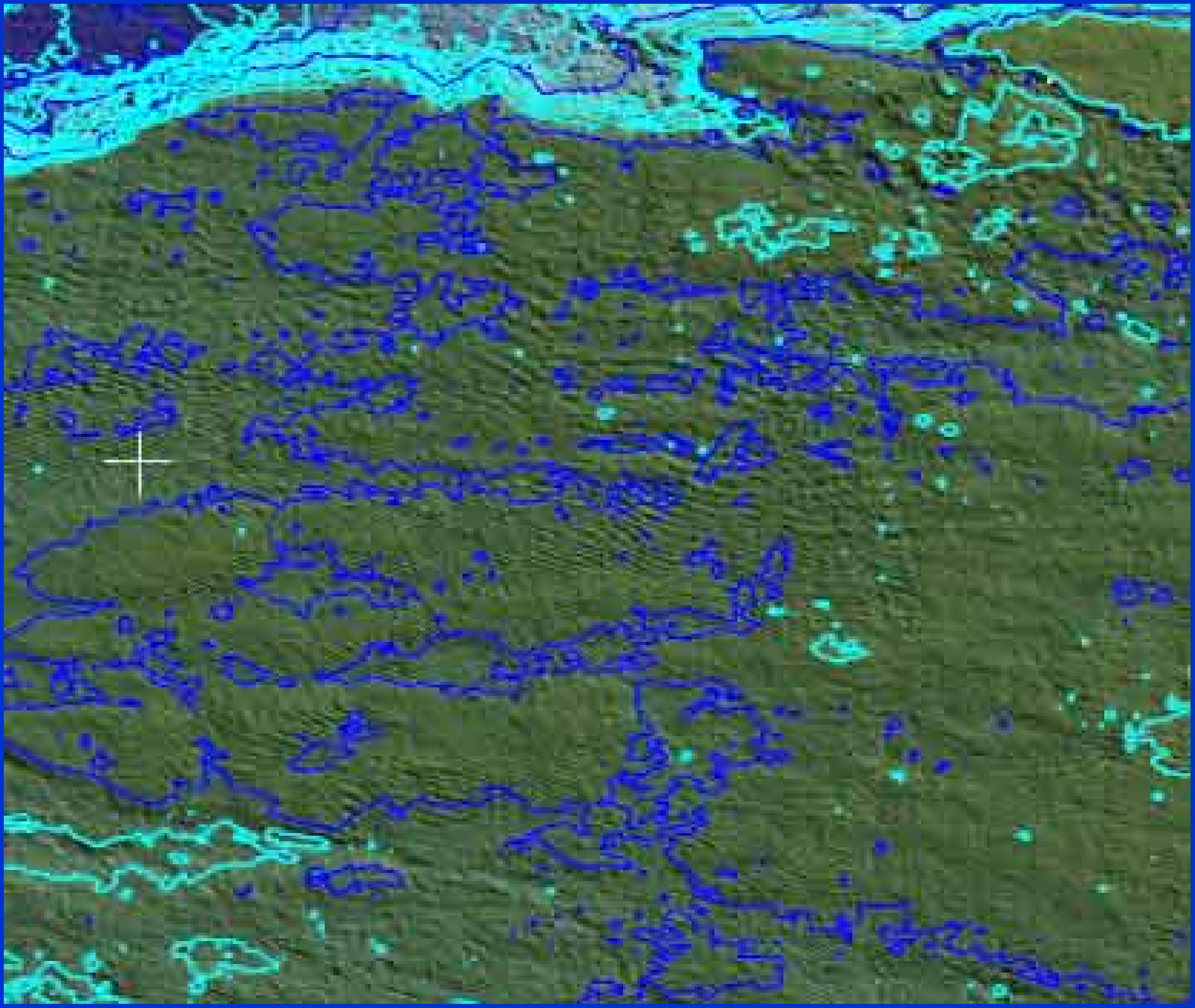


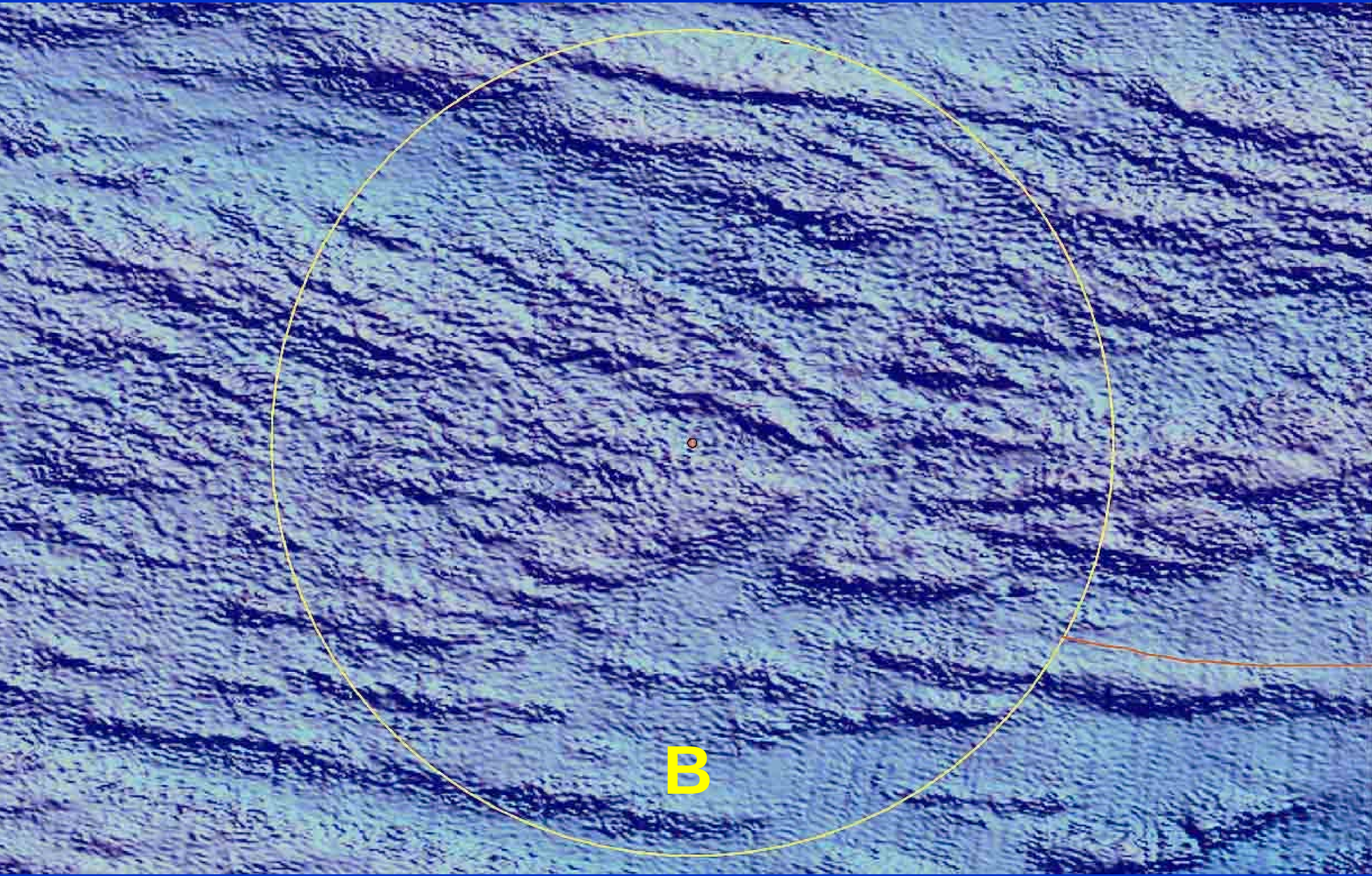
Composite with Potential Sites




B
A
C


A

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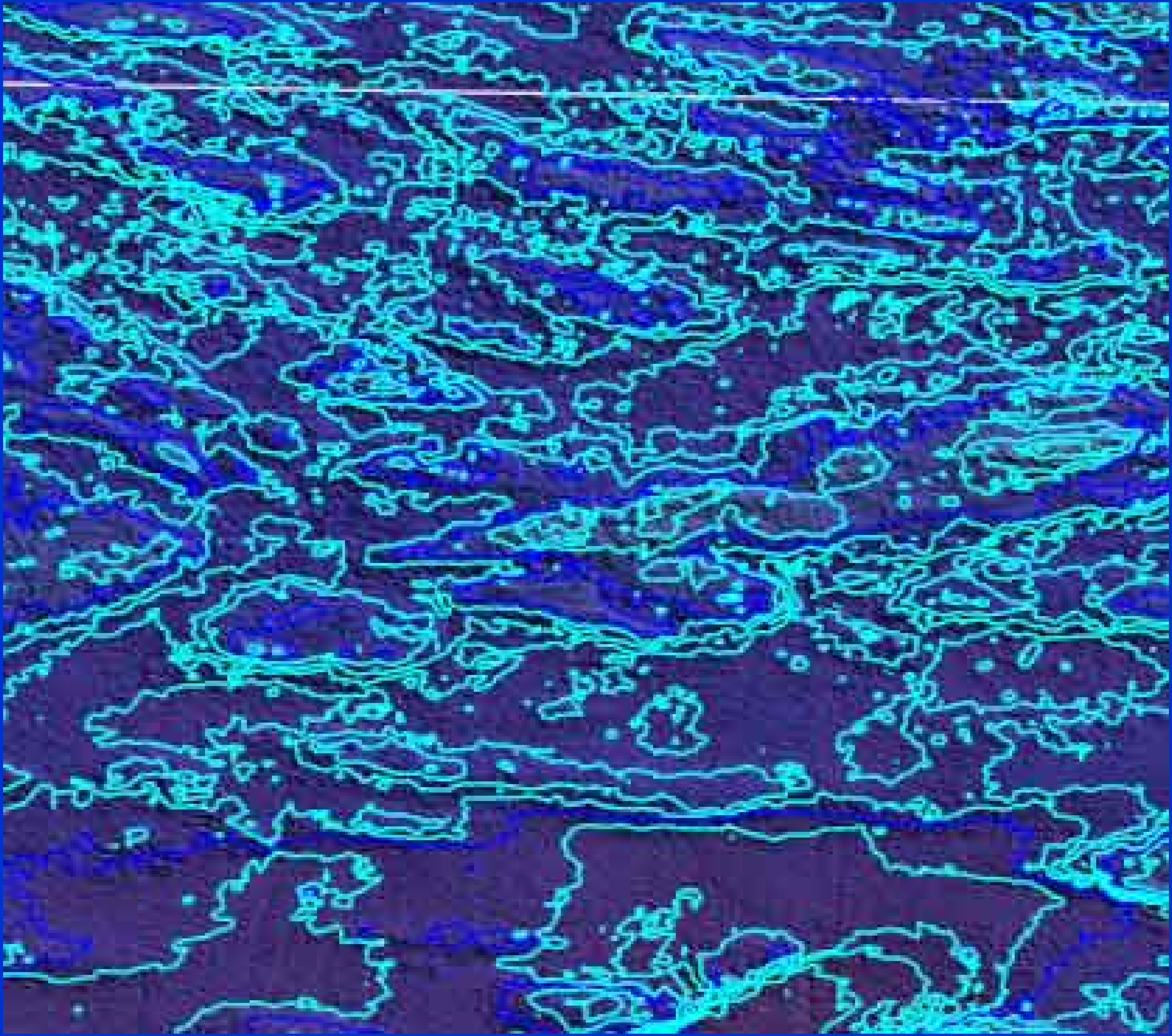

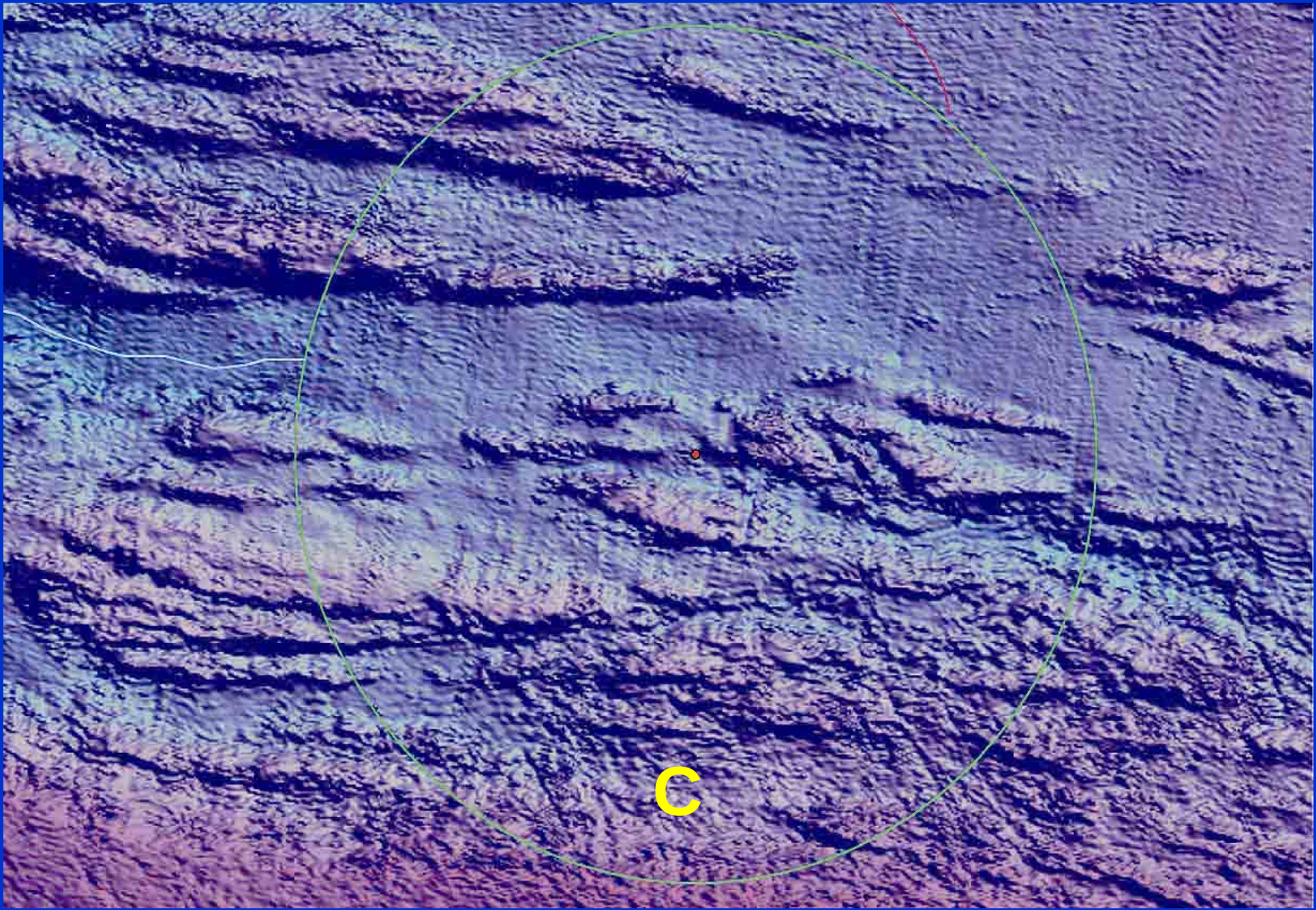
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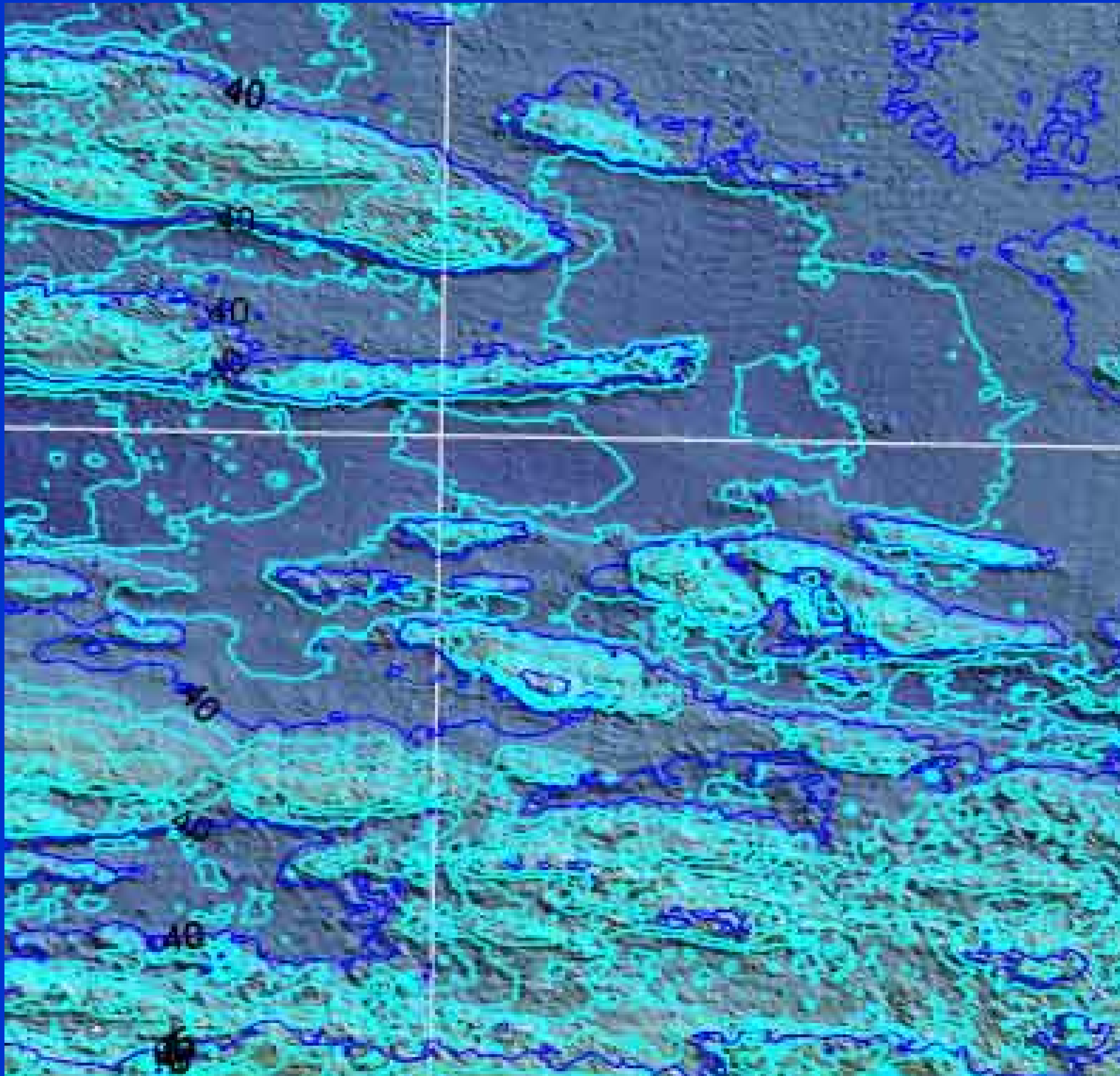
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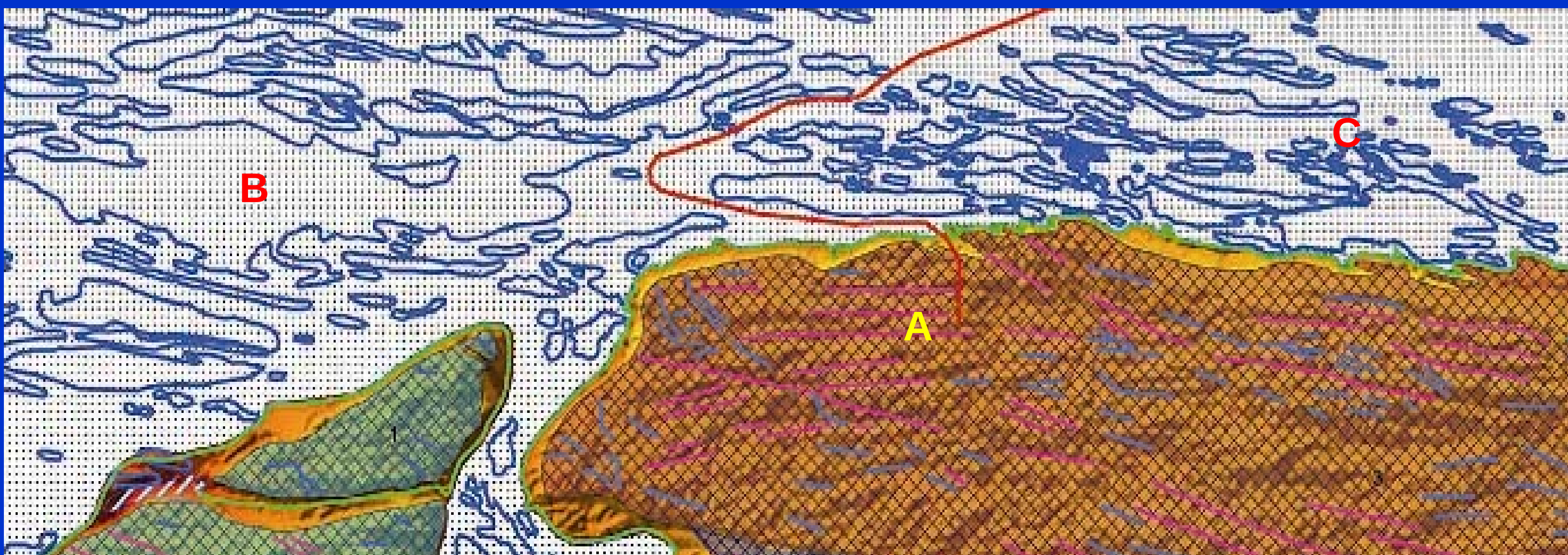
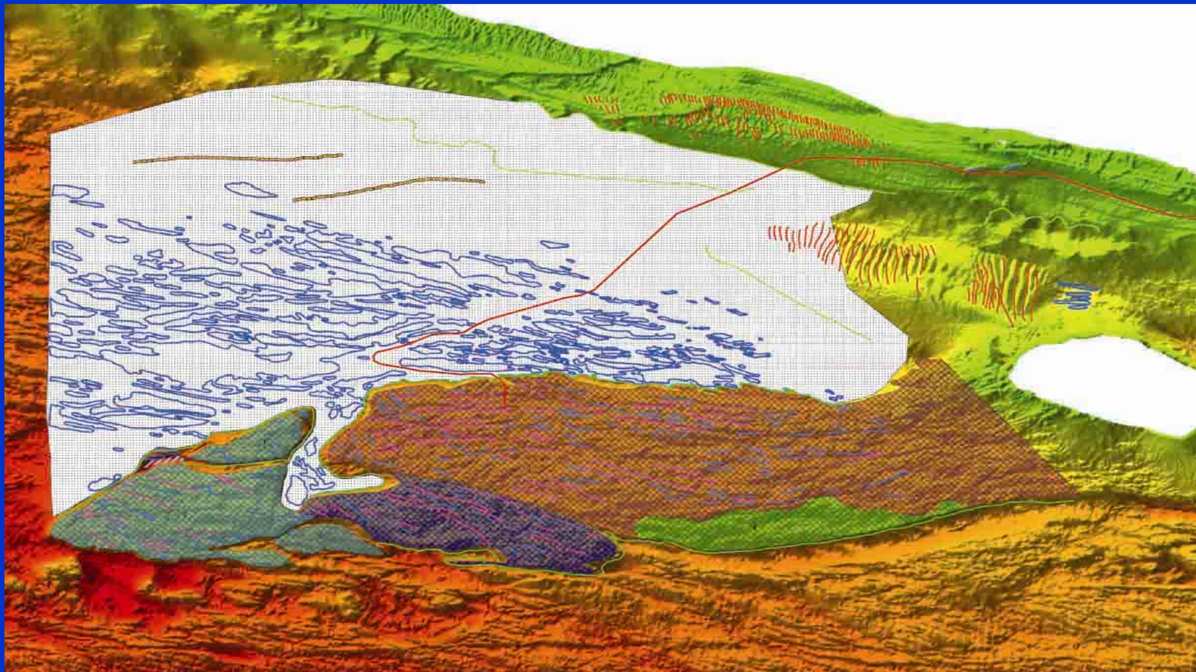
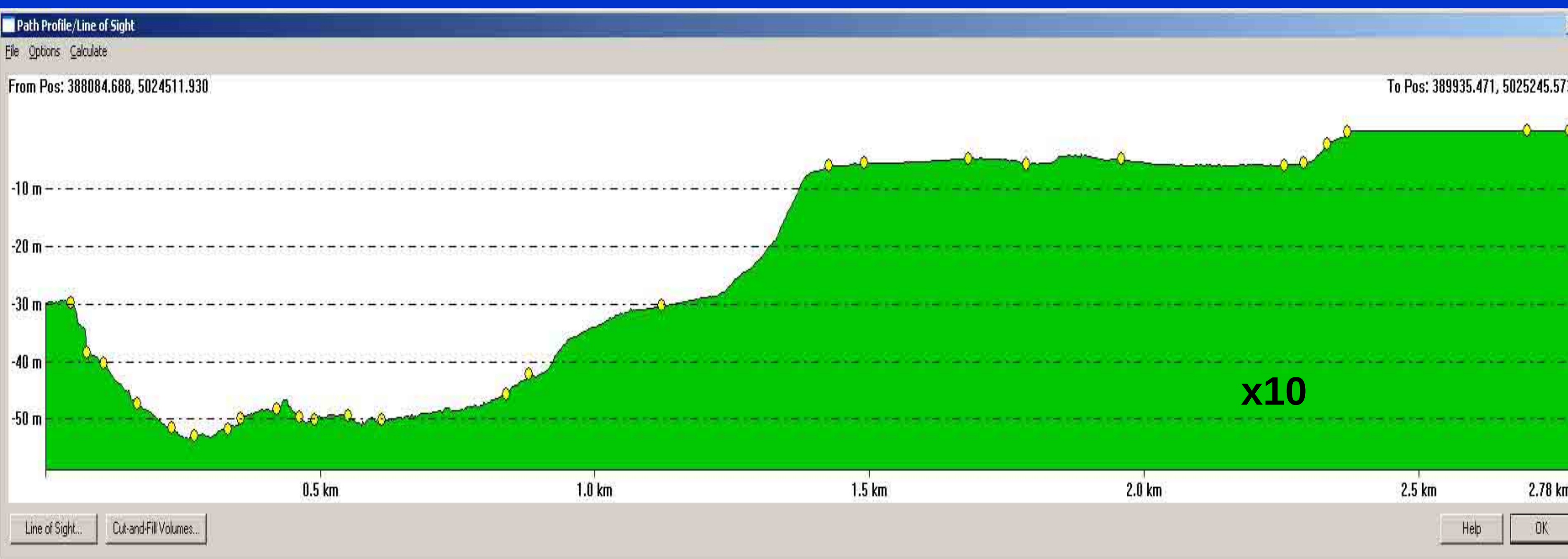
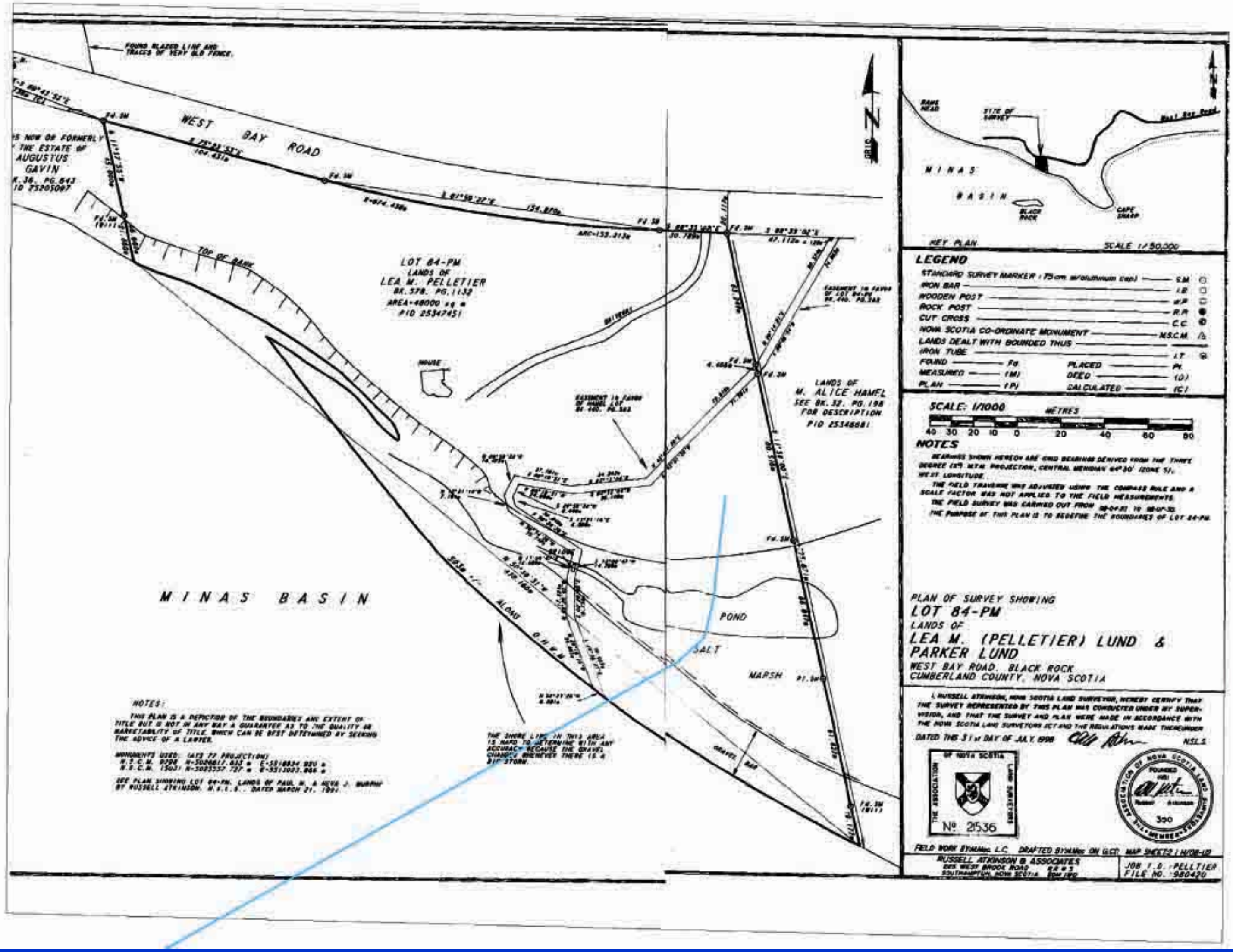

B
C
A



Cable Route and Bathymetric Profile



Lot Plan



WEST BAY ROAD
LOT 84-PM
LANDS OF
LEA M. PELLETIER
MINAS BASIN
POND
SALT
MARSH
LANDS OF
M. ALICE HAMEL
HOUSE
TOP OF BANK
LEGEND
NOTES
SCALE: 1/1000
KEY PLAN
SCALE 1/50,000
MINAS
BASIN
BLACK
ROCK
PLAN OF SURVEY SHOWING
LOT 84-PM
LANDS OF
LEA M. (PELLETIER) LUND &
PARKER LUND
WEST BAY ROAD, BLACK ROCK
CUMBERLAND COUNTY, NOVA SCOTIA
RUSSELL ATKINSON & ASSOCIATES
Nº 2536

Lidar - Potential Building Location

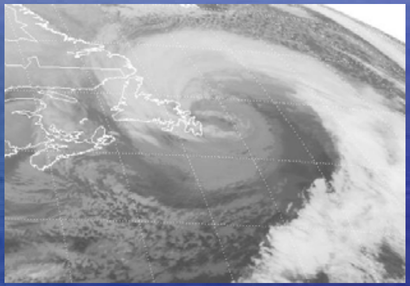
Discussion and Questions

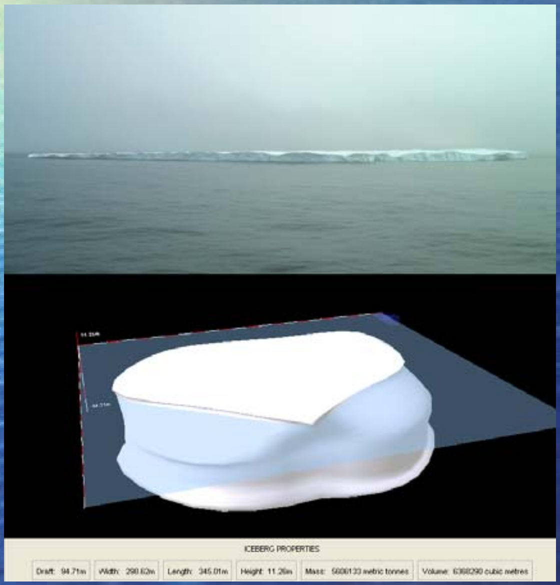
MINAS BASIN

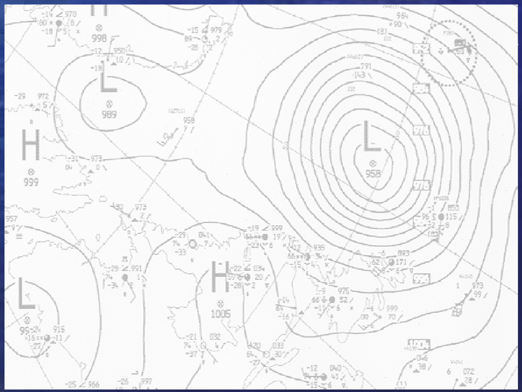
APPENDIX B – SIMON MELROSE'S OCEANOGRAPHY PRESENTATION

Oceans LTD.

"SAFETY AT SEA"







Presented by Simon Melrose

Manager, Nova Scotia Operations

Integrated Approach

- We started with the seabed
- Reviewed the geoscience and bathymetry
- Selected areas of interest, picked potential sites
- Measured the tidal currents and tidal range
- Surveyed the Benthos, water quality and related issues
- Reviewed the local weather climate
- Provided input into the Environmental Impact Assessment

Oceanographic Site Selection

- The large scale models provided a starting point, local understanding is then required
- Baseline data was virtually non existent
- Searched for sites which met all the criteria for suitability
- Undertook a series of instrument deployments and recoveries in the target area

Area of Interest

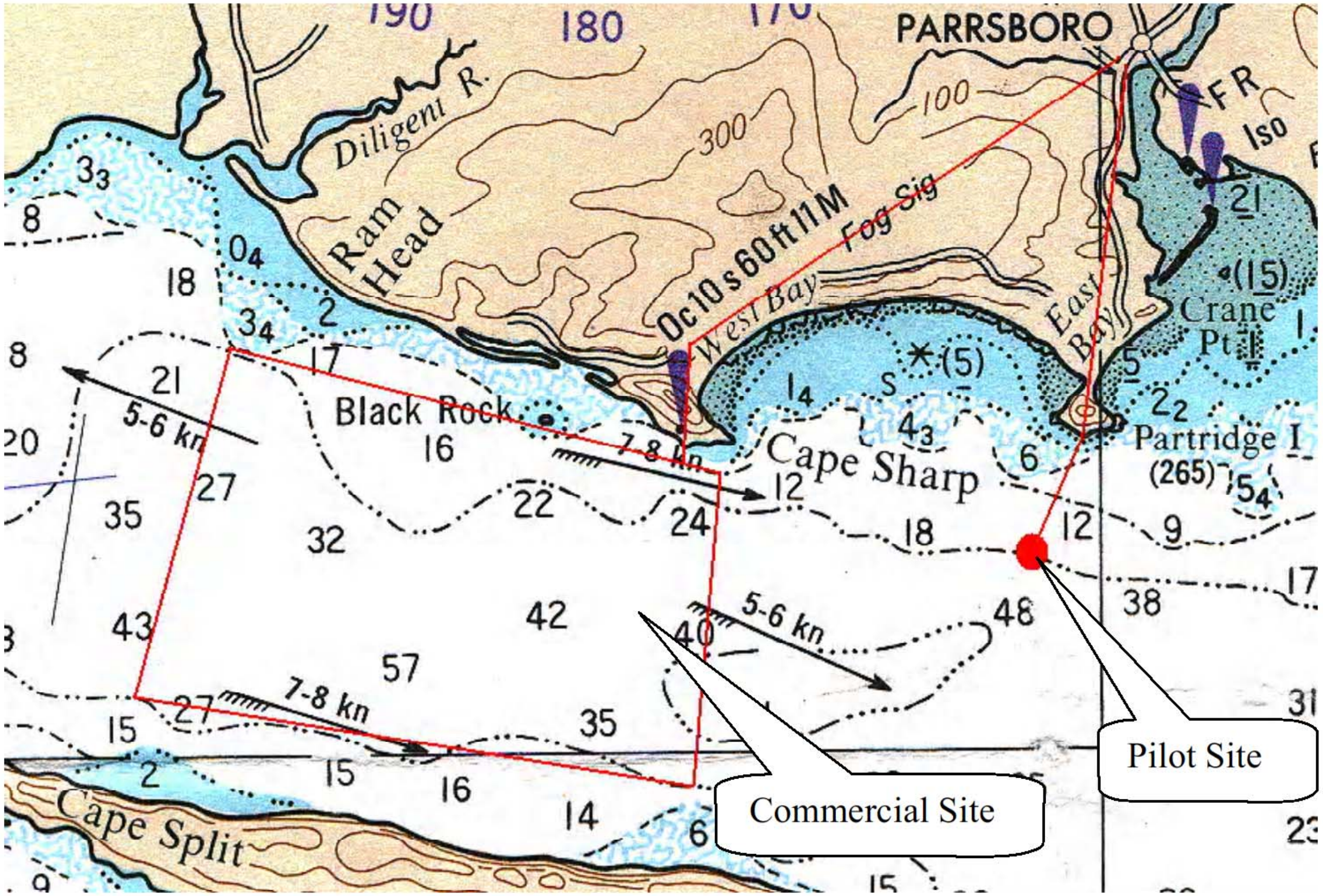


Figure 19 - Local Site overview showing pilot and commercial deployment sites

Proposed Site

Oceanographic Measurement

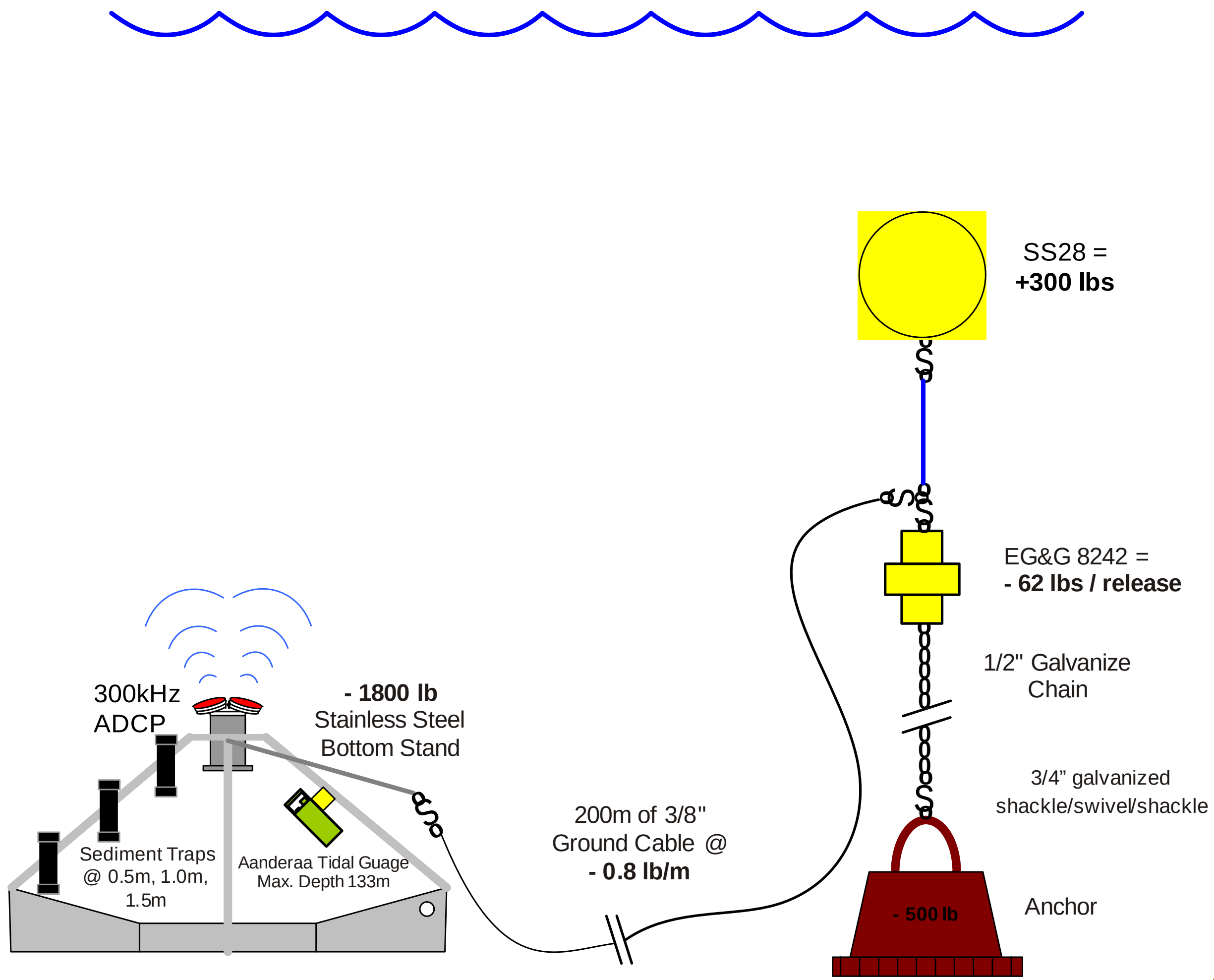
Overview

- Three complete sets of current profile data achieved plus sample from 4th site.
- Three sets of tidal range
- Two sets of vessel mounted profiles
- Extensive CTD traces
- 3 acoustic baseline profiles
- Very limited sea floor current velocity data achieved

Tideforce 1 in Hall's Harbour

Data Measurement

Bottom Mounted ADCP Mooring- Approximately 60-70 Metres Depth

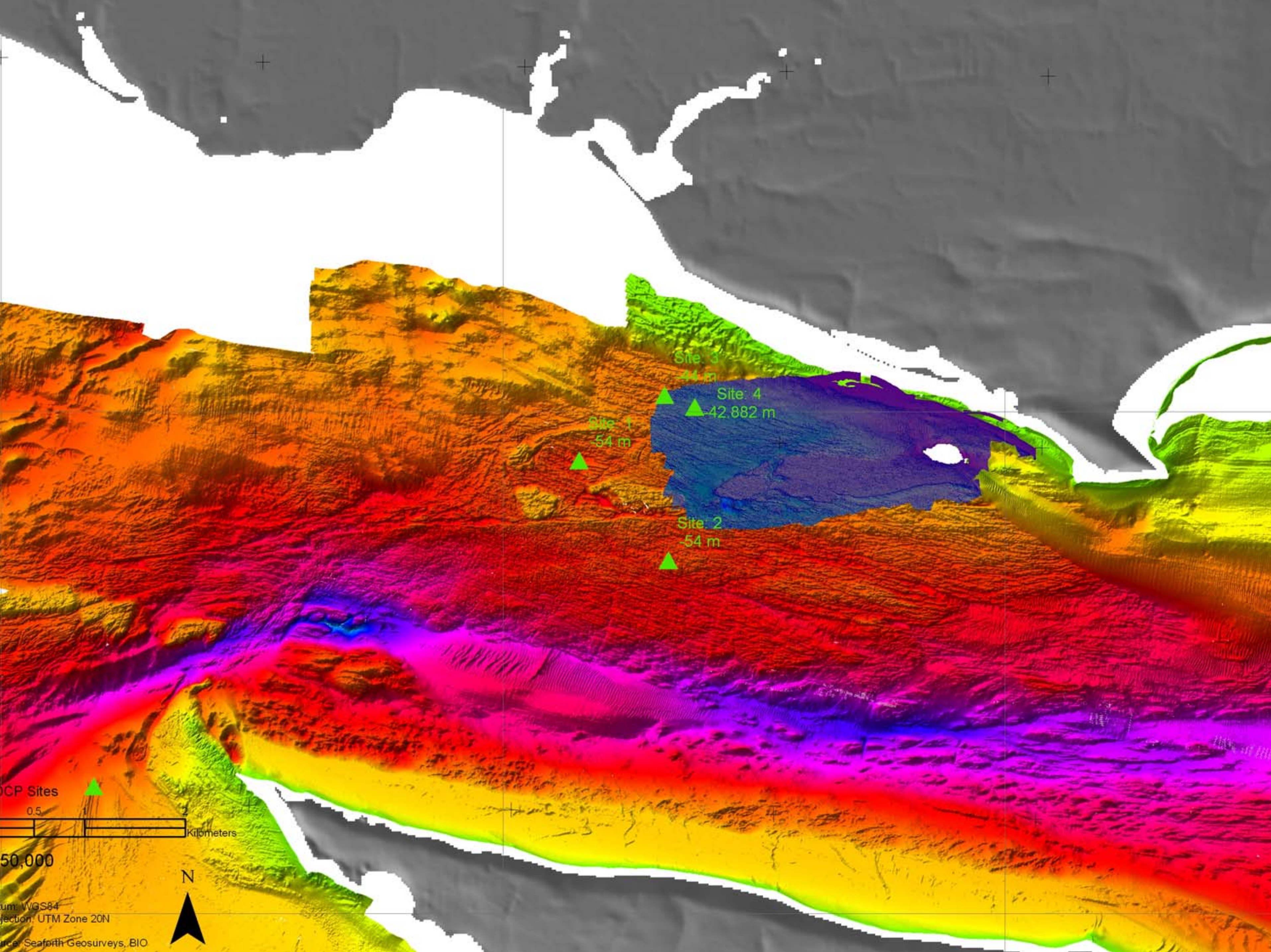


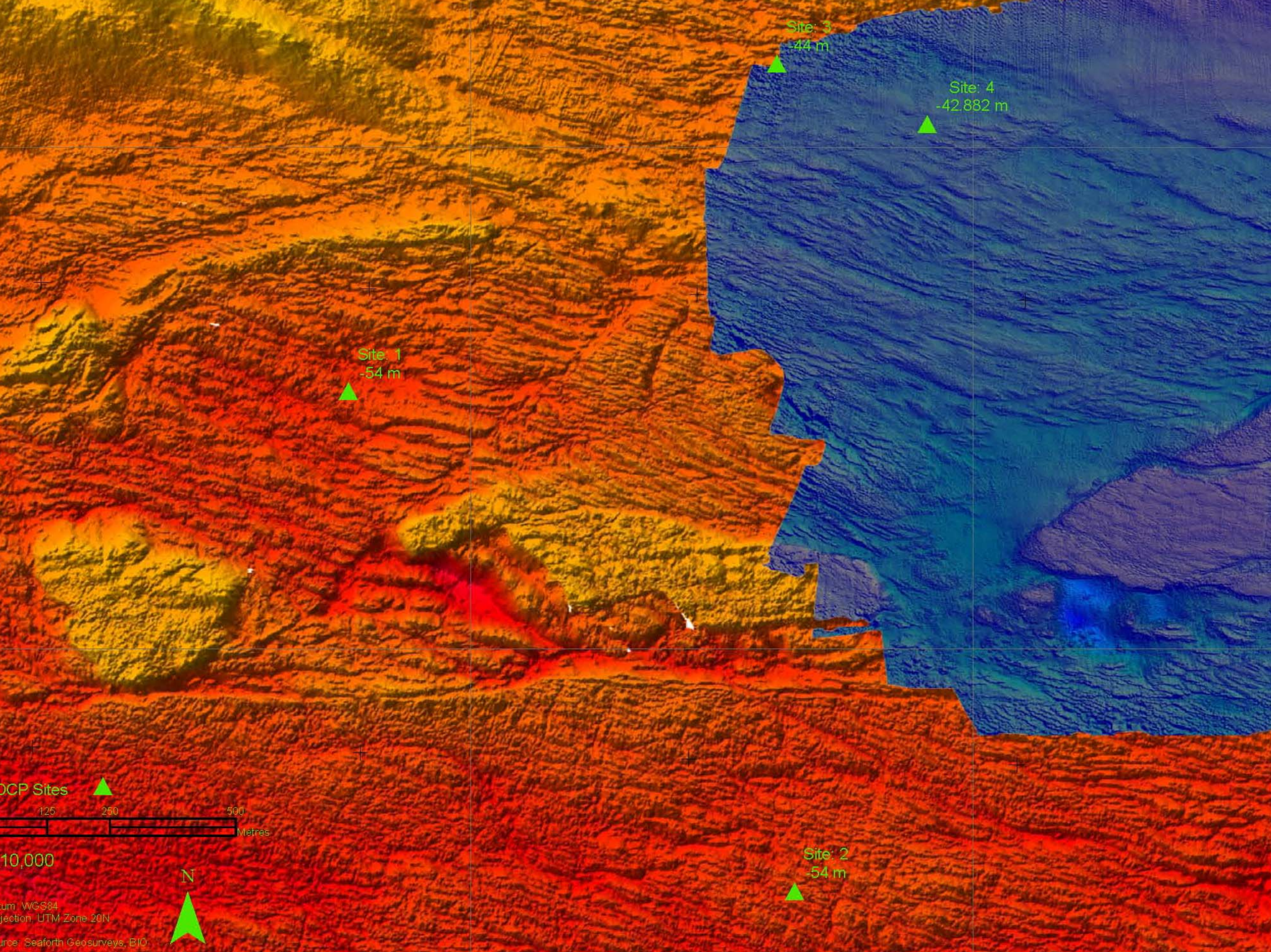
* Diagram Not Drawn to Scale

Second generation mooring

Moored Instrument Deployments. ADCP and other instruments deployed

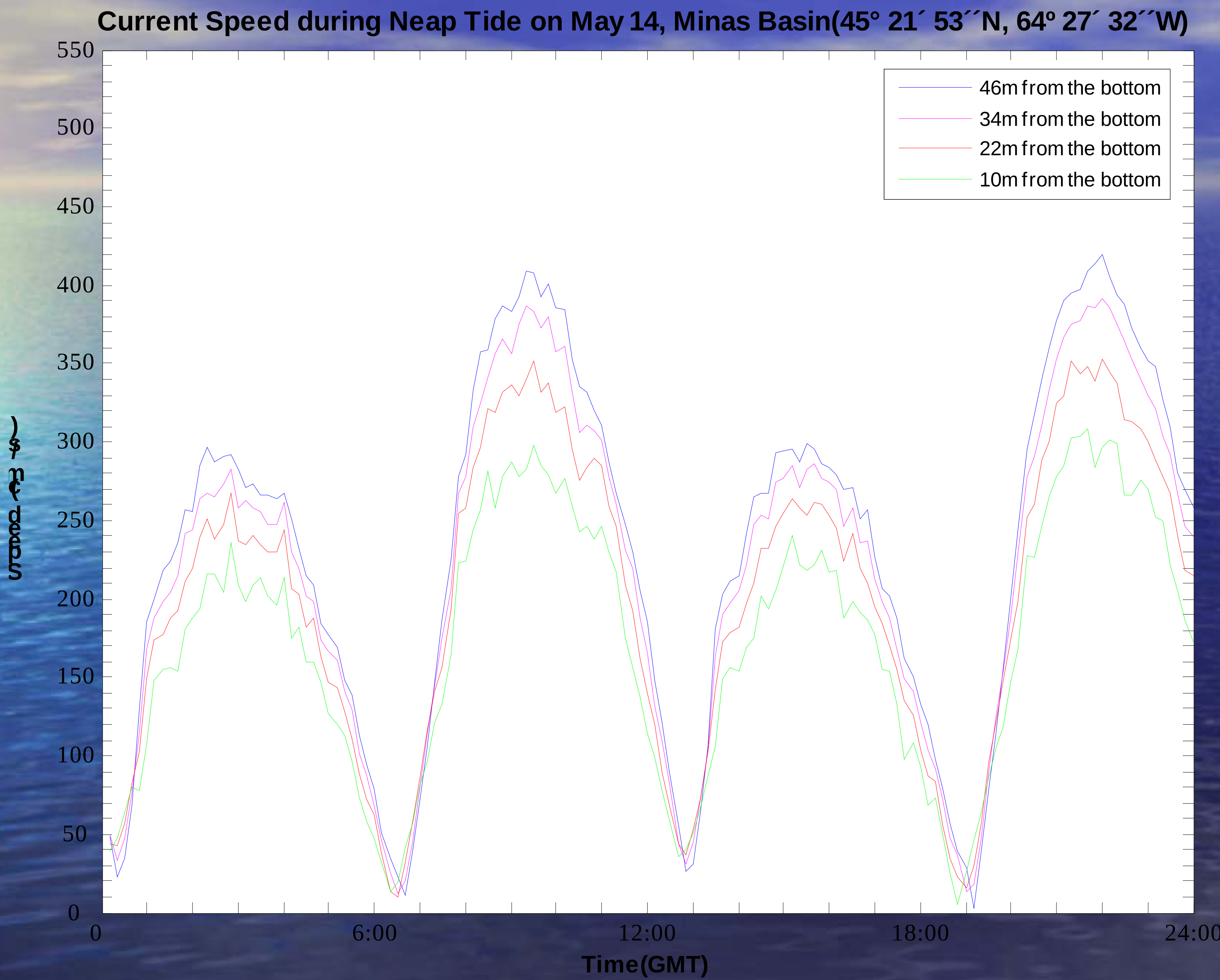
- Site 1. Depth 54 m, 29 days of ADCP data, full tidal record
- Site 2. Depth 54 m, Instrument damaged, 24 hours of data recovered, full tidal data record
- Site 3. Depth 44 m, ADCP provided 29+ days of data. Full tidal record. Near bottom S4 current meter broken through impact, no data
- Site 4. Depth 42 m, ADCP provided full data return. Near bottom Falmouth Scientific current meter failed, no data


Site: 3
-44 m
Site: 4
-42.882 m
Site: 1
-54 m
Site: 2
-54 m
CP Sites
0.5
1
2
Kilometers
50,000
N
um: WGS84
jection: UTM Zone 20N
rce: Seaforth Geosurveys, BIO

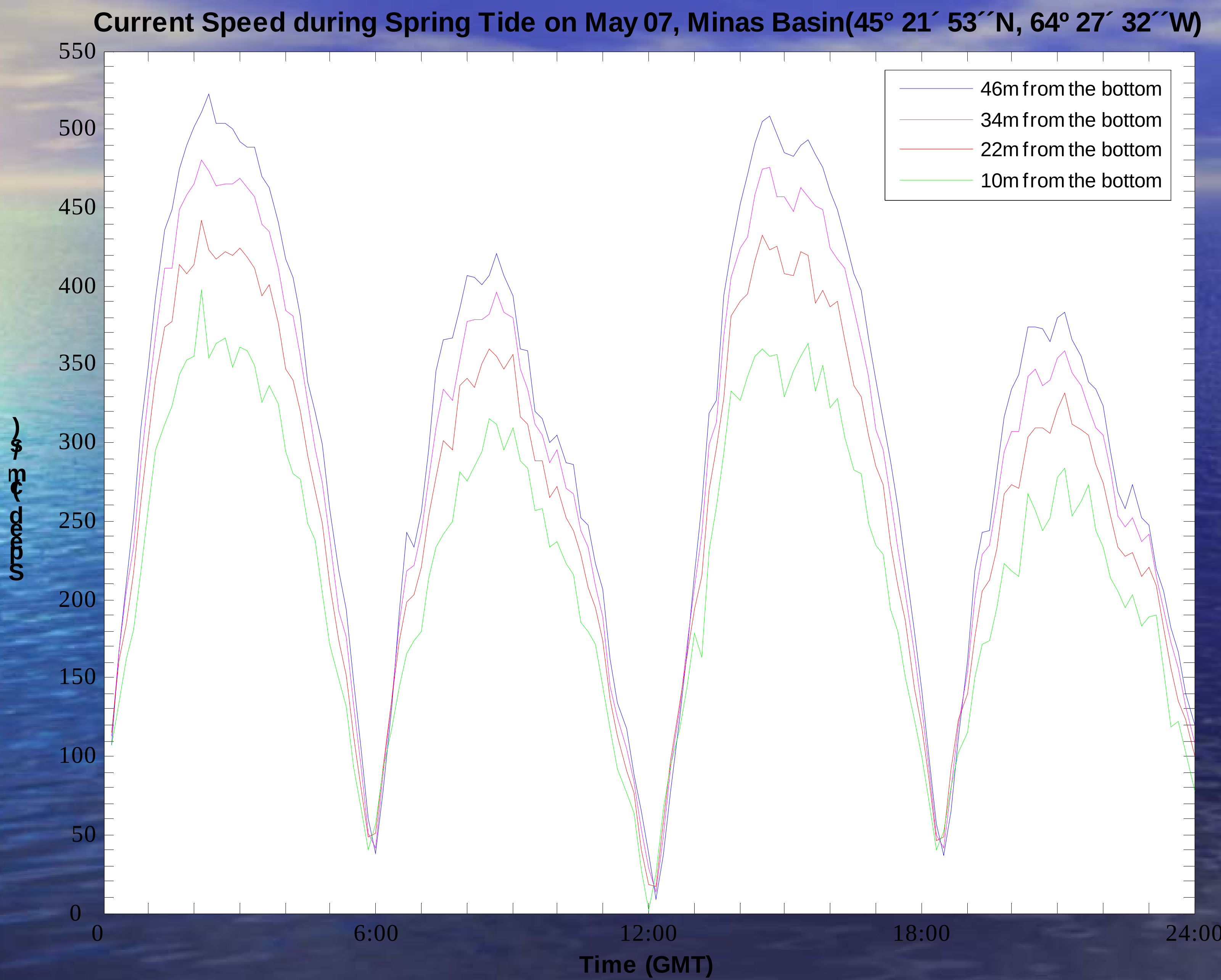


Site: 3
-44 m
Site: 4
-42.882 m
Site: 1
-54 m
Site: 2
-54 m
OCP Sites
125
250
500
Metres
10,000
N
um: WGS84
jection: UTM Zone 20N
rce: Seaforth Geosurveys, BIO

Site 1

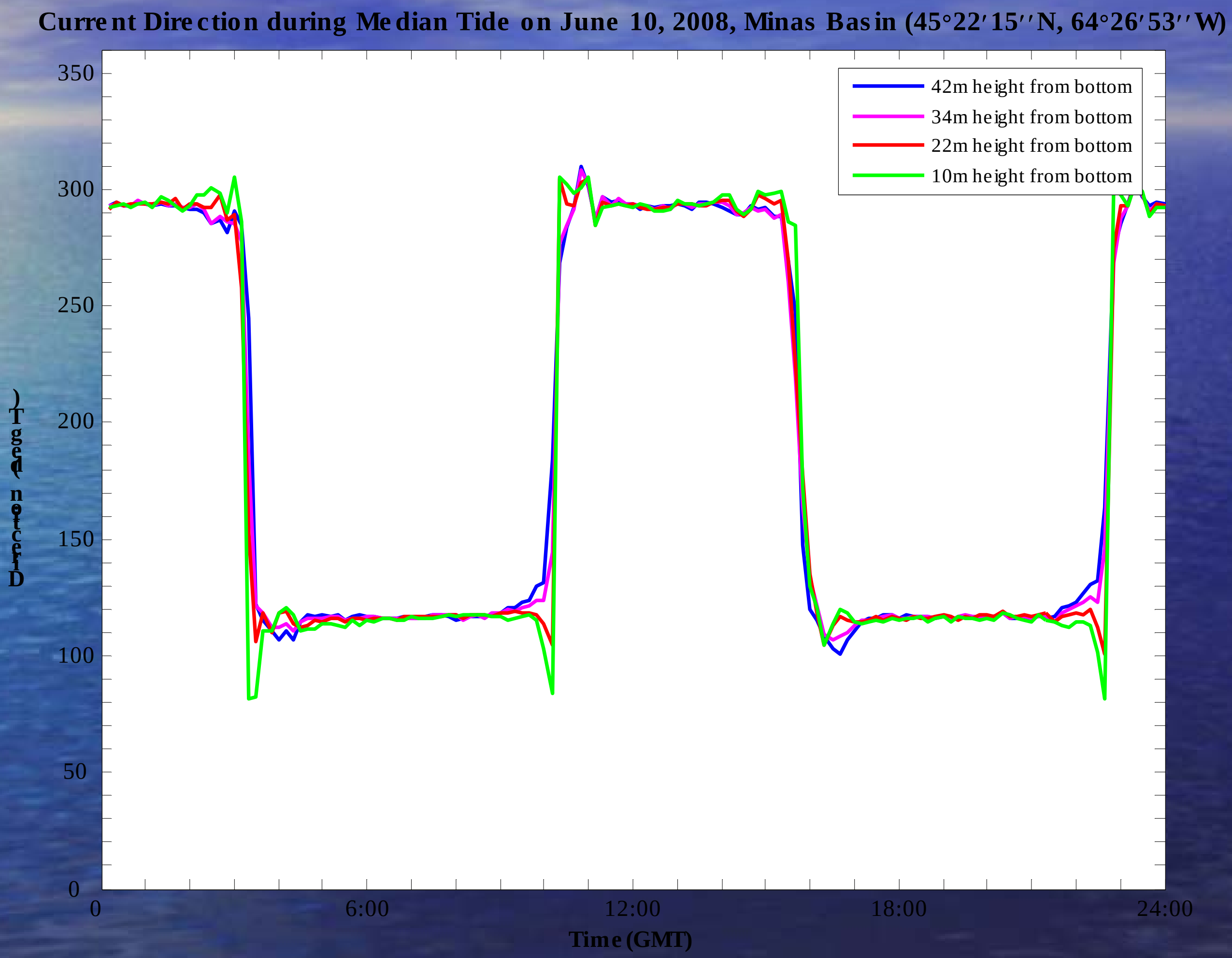

Current Speed during Neap Tide on May 14, Minas Basin(45° 21´ 53´´N, 64º 27´ 32´´W)
46m from the bottom
34m from the bottom
22m from the bottom
10m from the bottom
550
500
450
400
350
300
250
200
150
100
50
0
0
6:00
12:00
18:00
24:00
Time(GMT)

Site 1

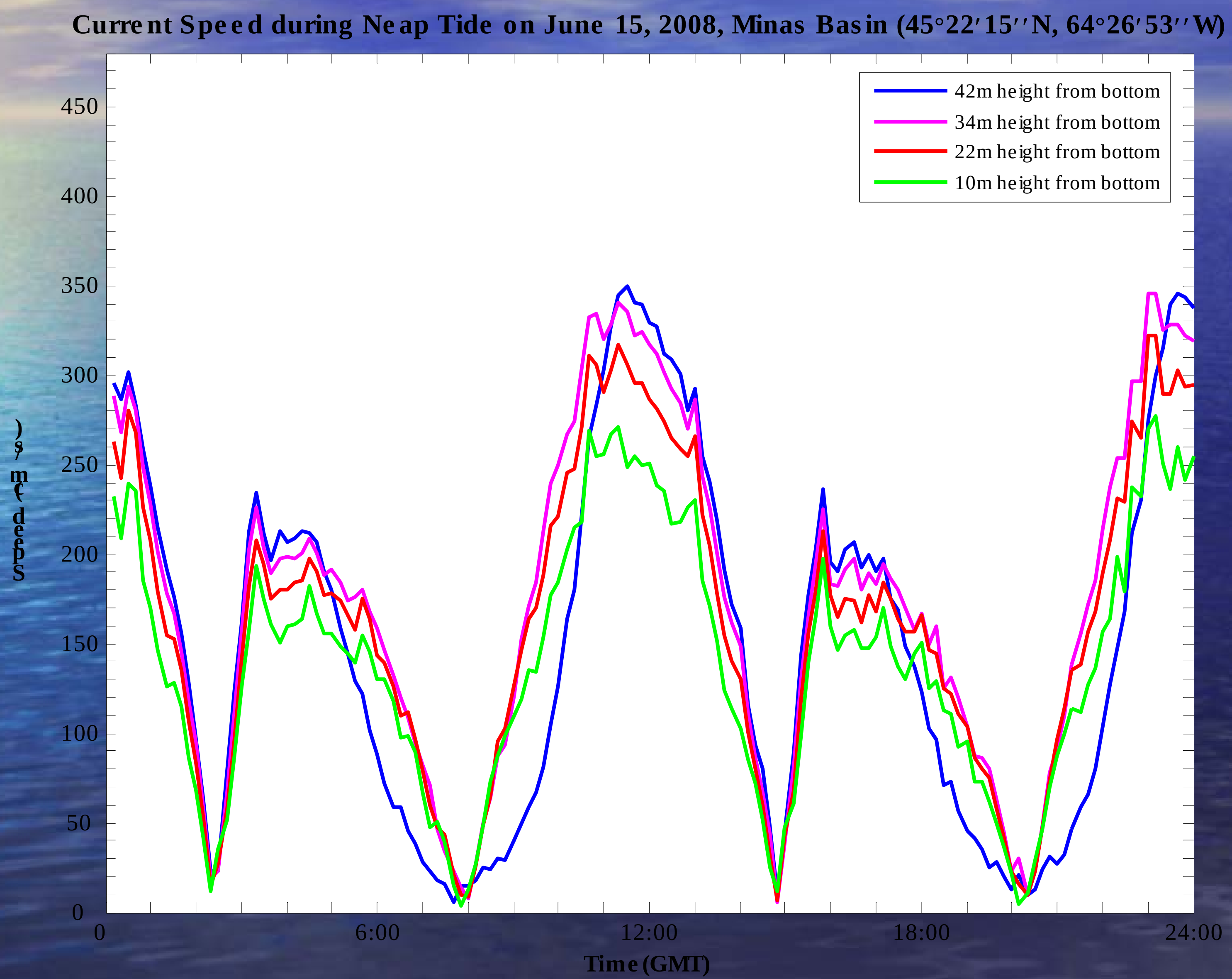


Current Speed during Spring Tide on May 07, Minas Basin(45° 21´ 53´´N, 64º 27´ 32´´W)
550
500
450
400
350
300
250
200
150
100
50
0
6:00
12:00
18:00
24:00
Time (GMT)
46m from the bottom
34m from the bottom
22m from the bottom
10m from the bottom

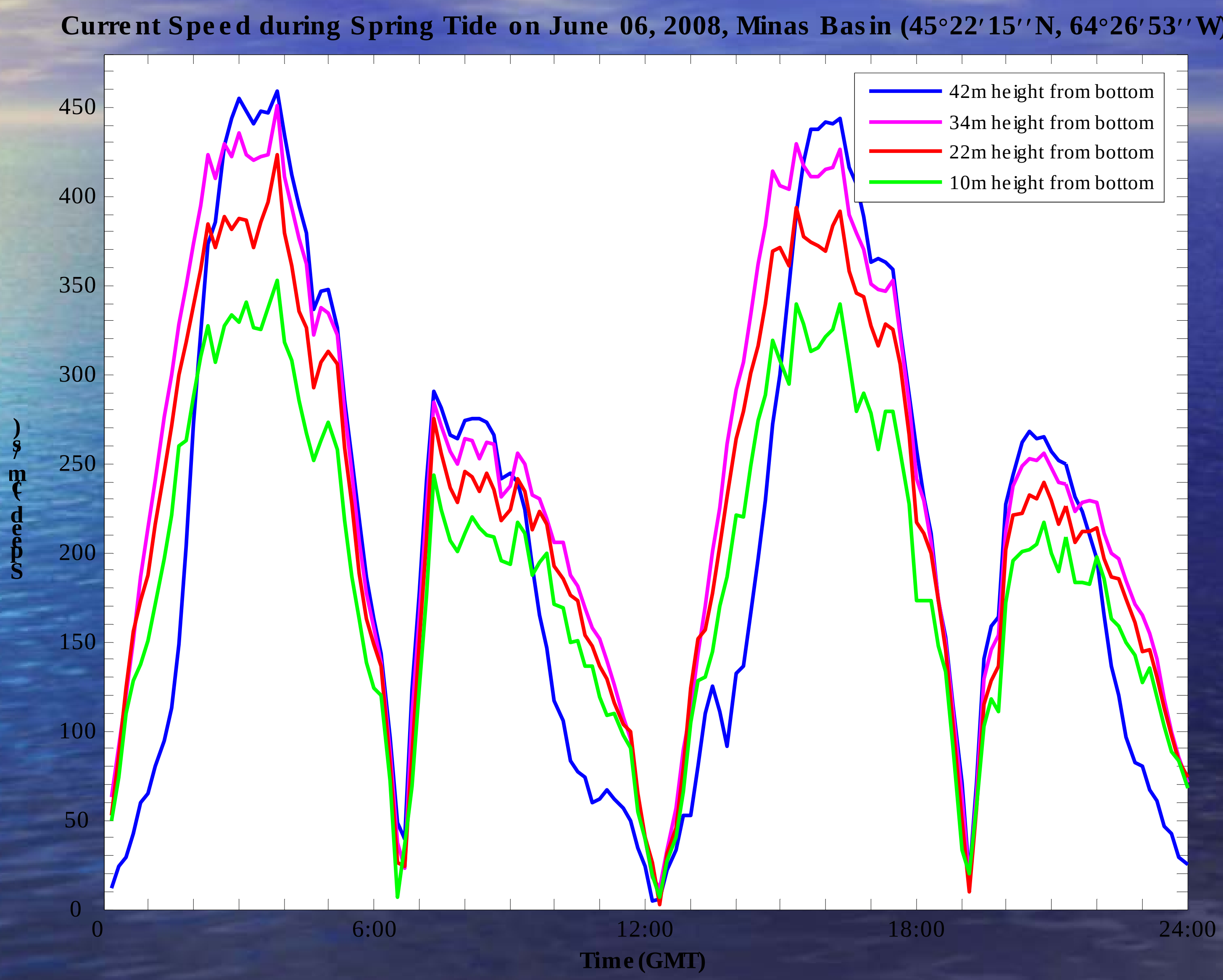
Site 1, Current Direction



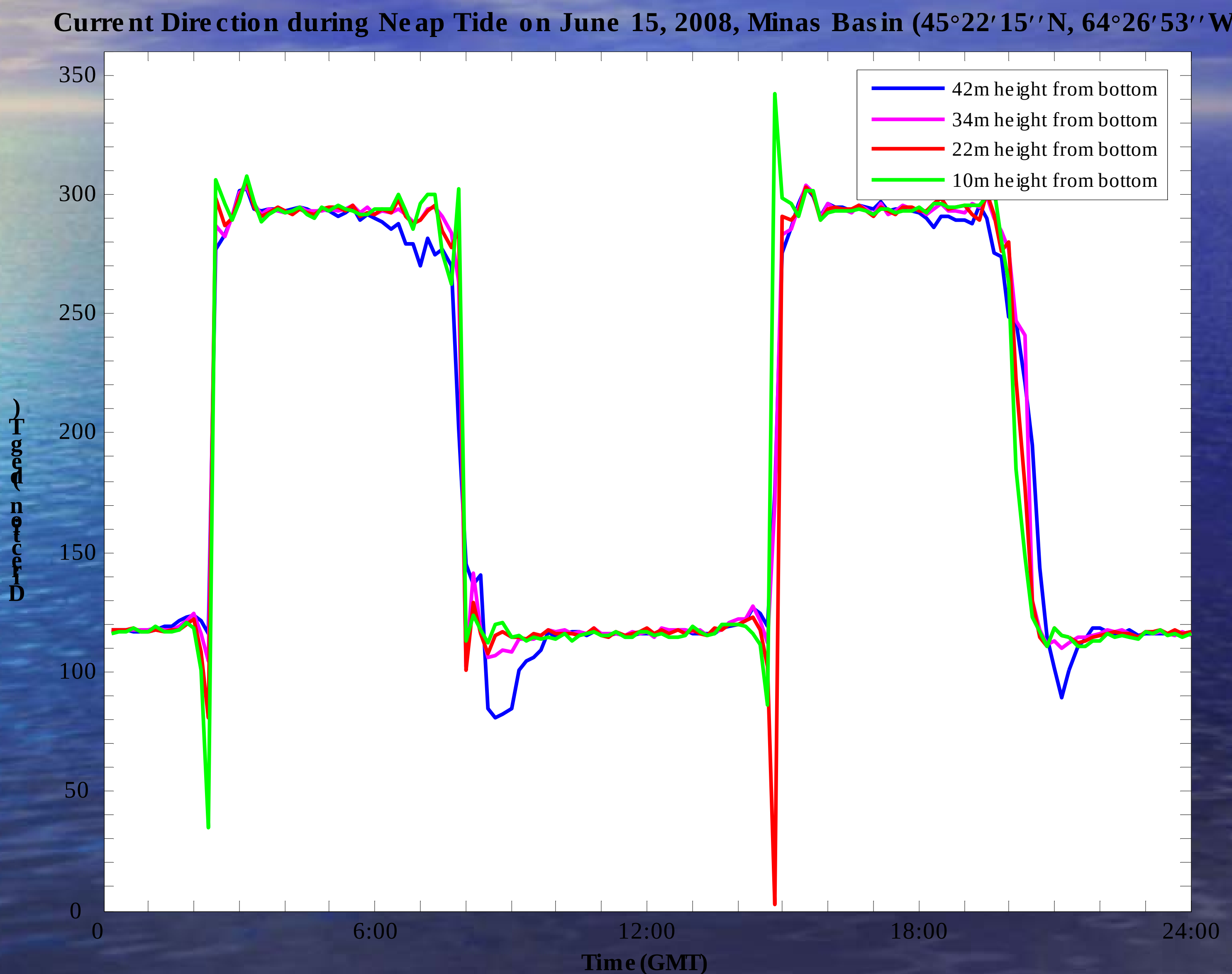
Site 3, Neap tide, June 15, 2008



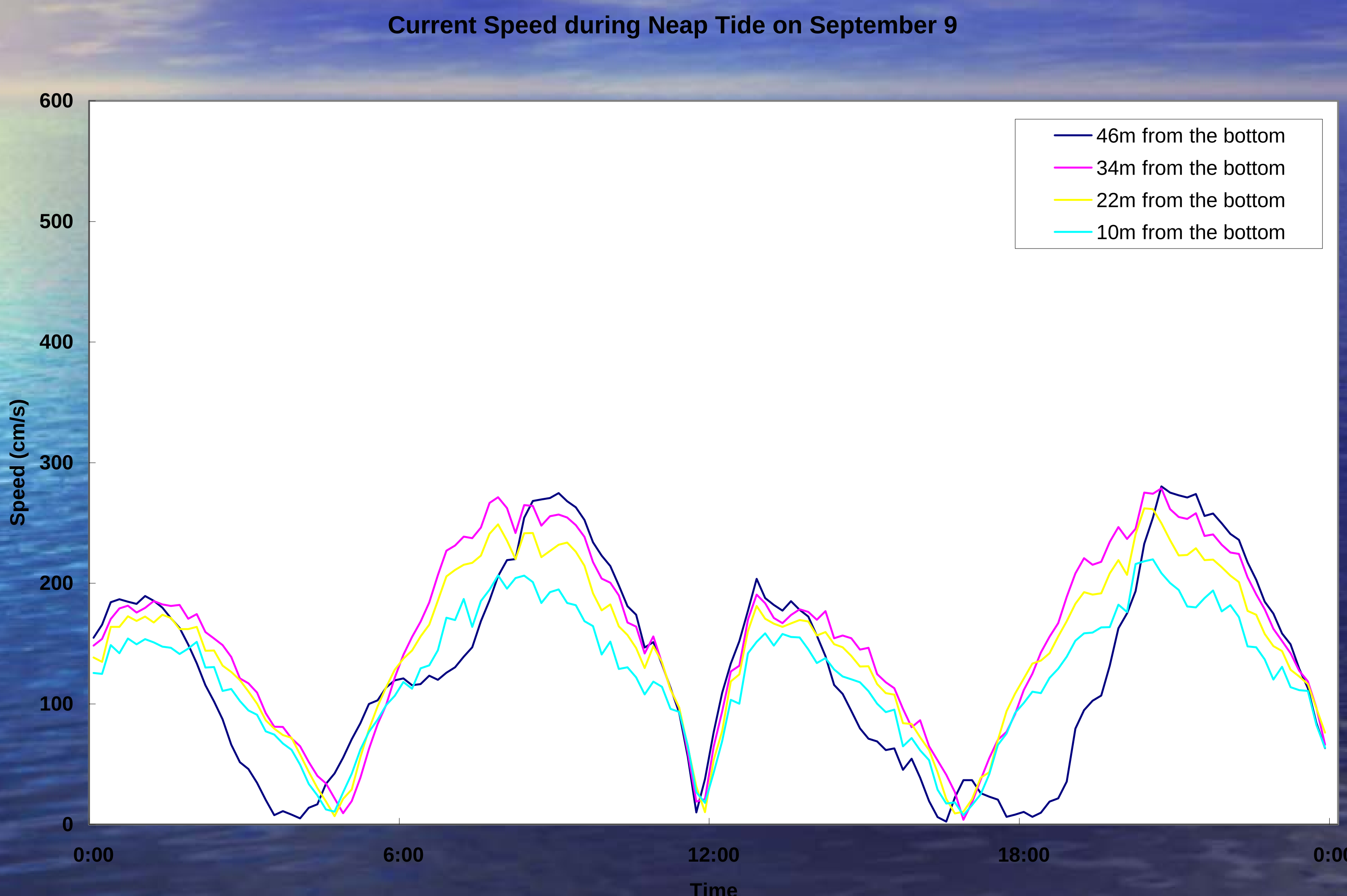
Site 3, Spring tide, June 6, 2008



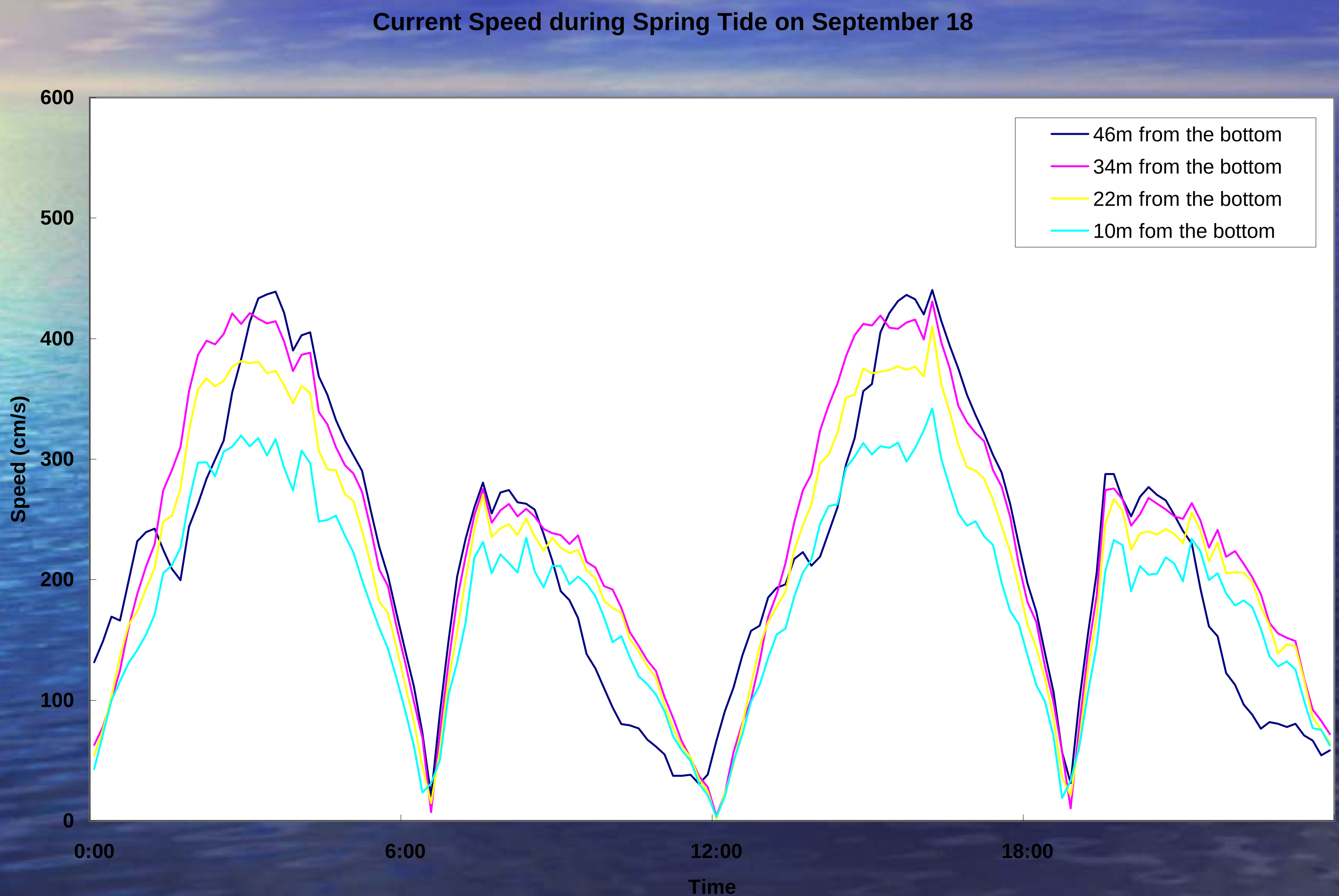
Site3, Current Direction June 15, 2008



Site 4, Neaps, September 2008



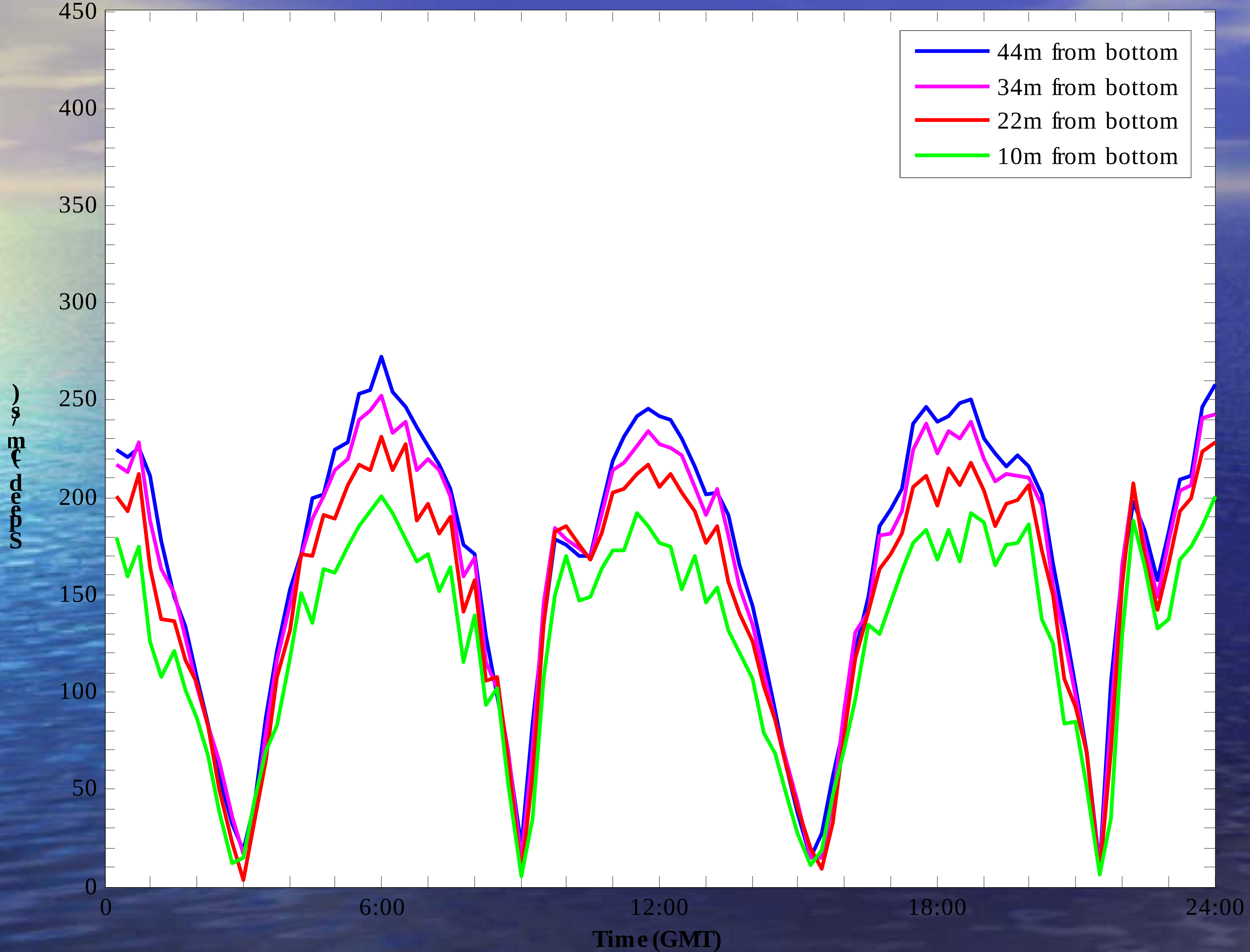
Site 4, Springs, September 18,2008



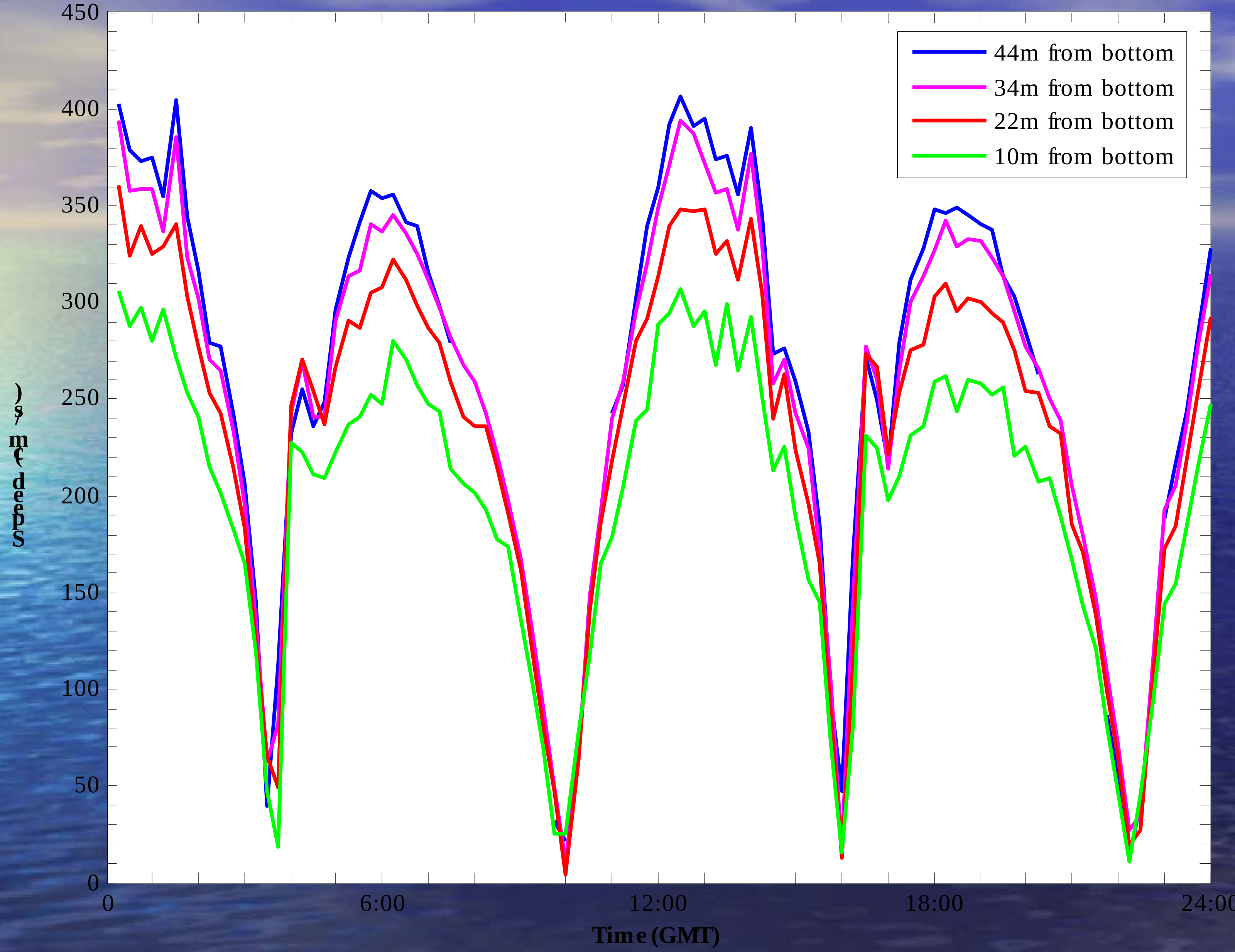
BIO Dataset

ADCP 300Mhz

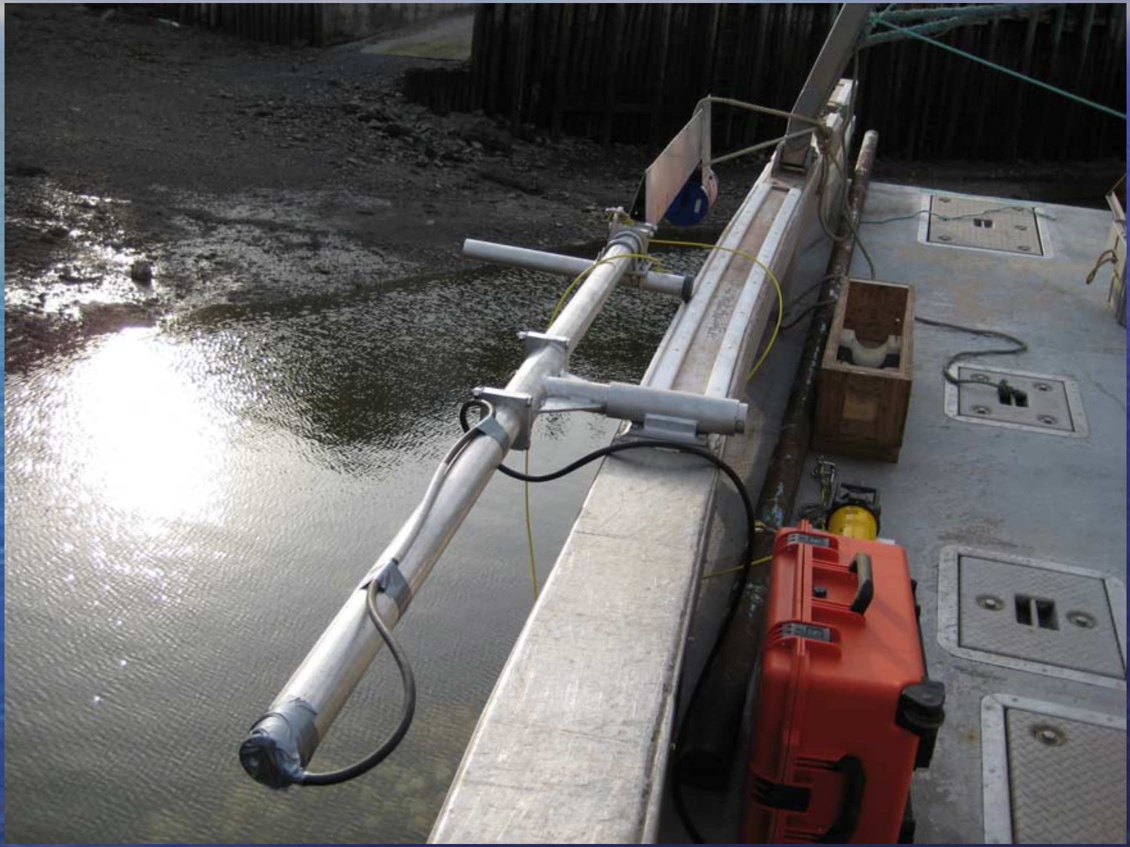
Current Speed during Neap Tide on August 23, 2007, Minas Basin (45°21′23′′N, 64°24′13′′W)



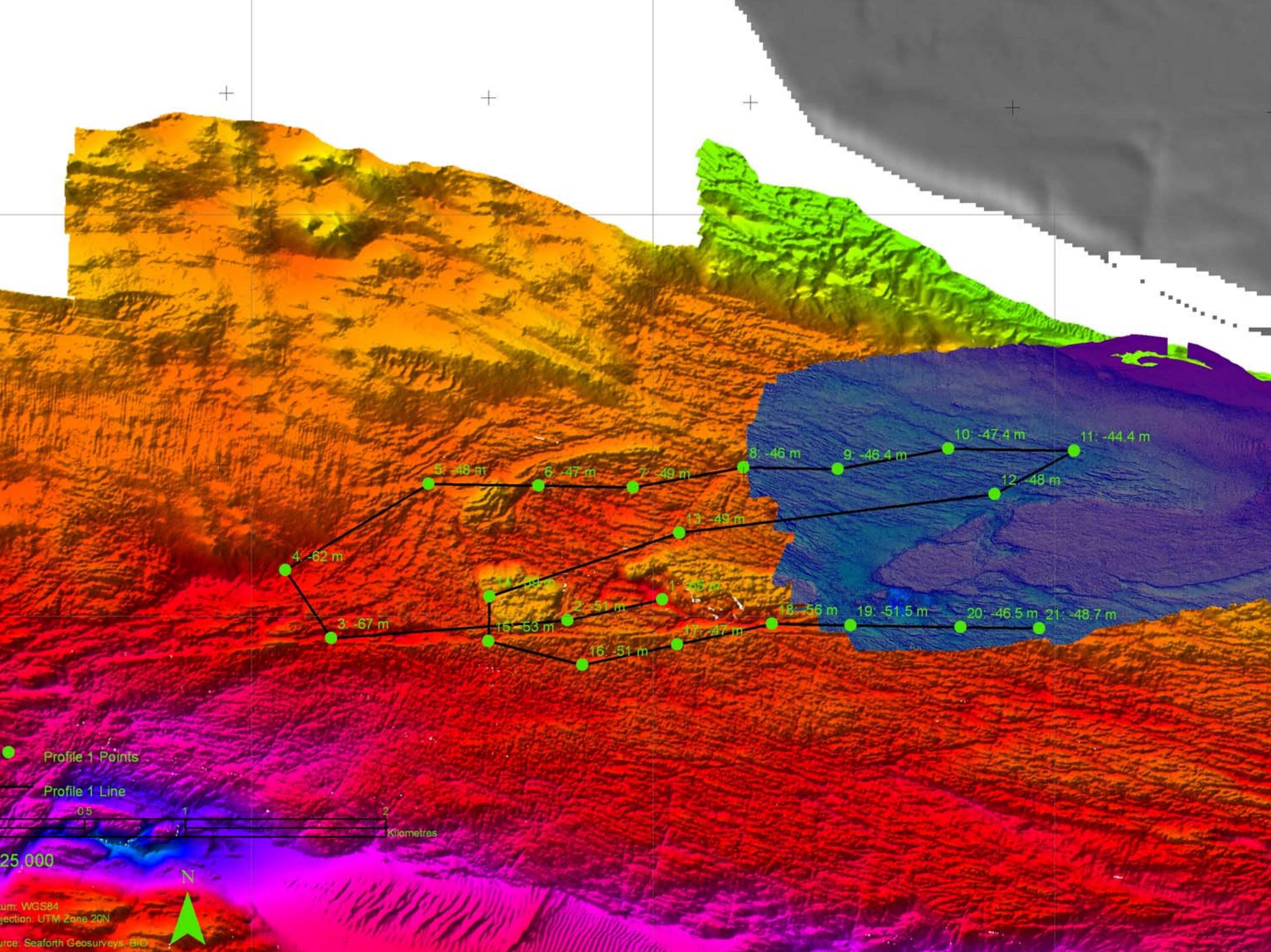
Current Speed during Spring Tide on August 31, 2007, Minas Basin (45°21′23′′N, 64°24′13′′W)



Vessel Profiling.
ADCP boat mount

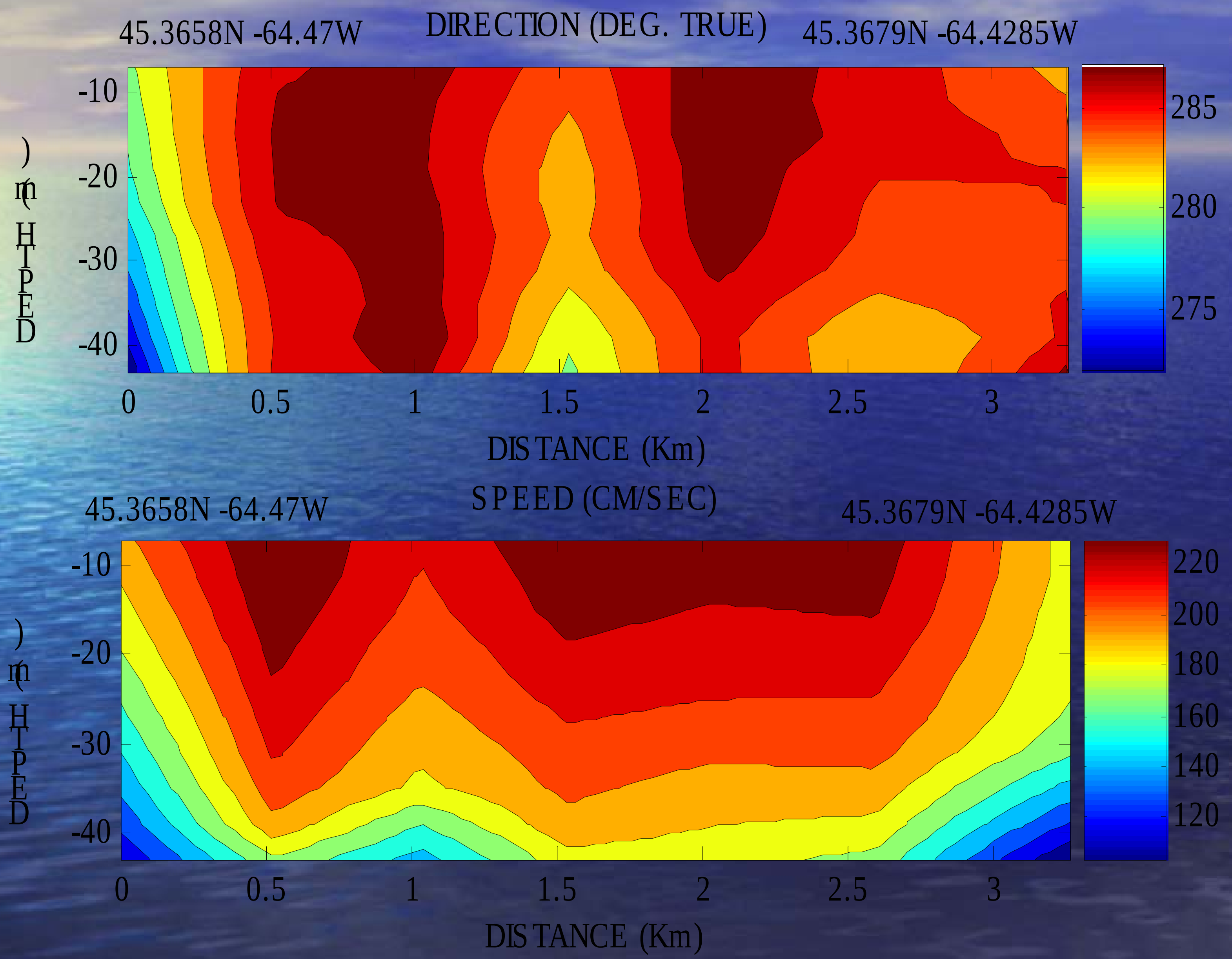


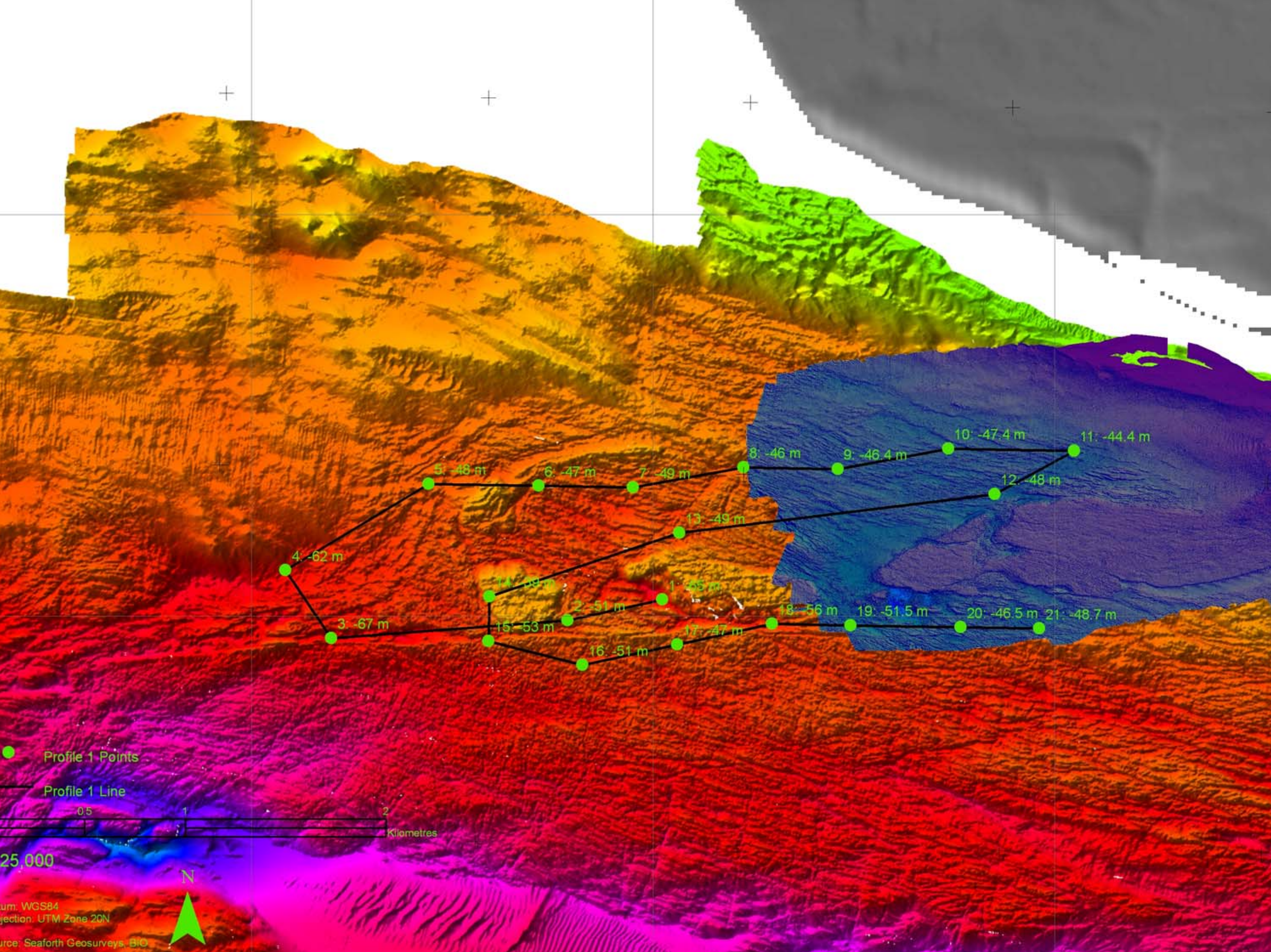
Acoustic Doppler Current Profiler



5: -48 m
6: -47 m
7: -49 m
8: -46 m
9: -46.4 m
10: -47.4 m
11: -44.4 m
12: -48 m
13: -49 m
4: -62 m
1: -65 m
2: -51 m
3: -67 m
15: -53 m
16: -51 m
17: -47 m
18: -56 m
19: -51.5 m
20: -46.5 m
21: -48.7 m
Profile 1 Points
Profile 1 Line
0.5
1
2
Kilometres
25,000
N
um: WGS84
jection: UTM Zone 20N
urce: Seaforth Geosurveys, BIO

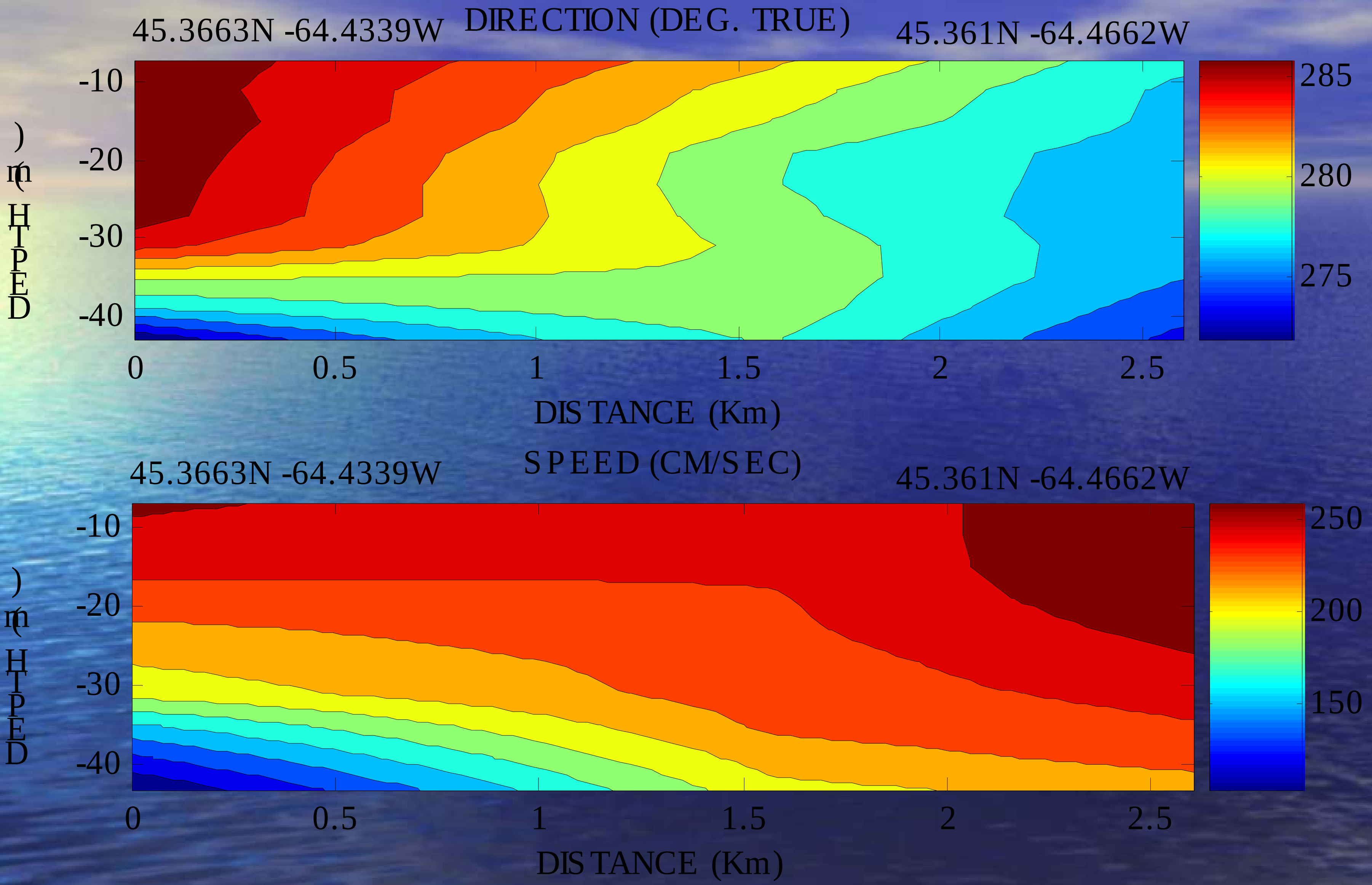
Current Speed and Direction from Station 5 to Station 11

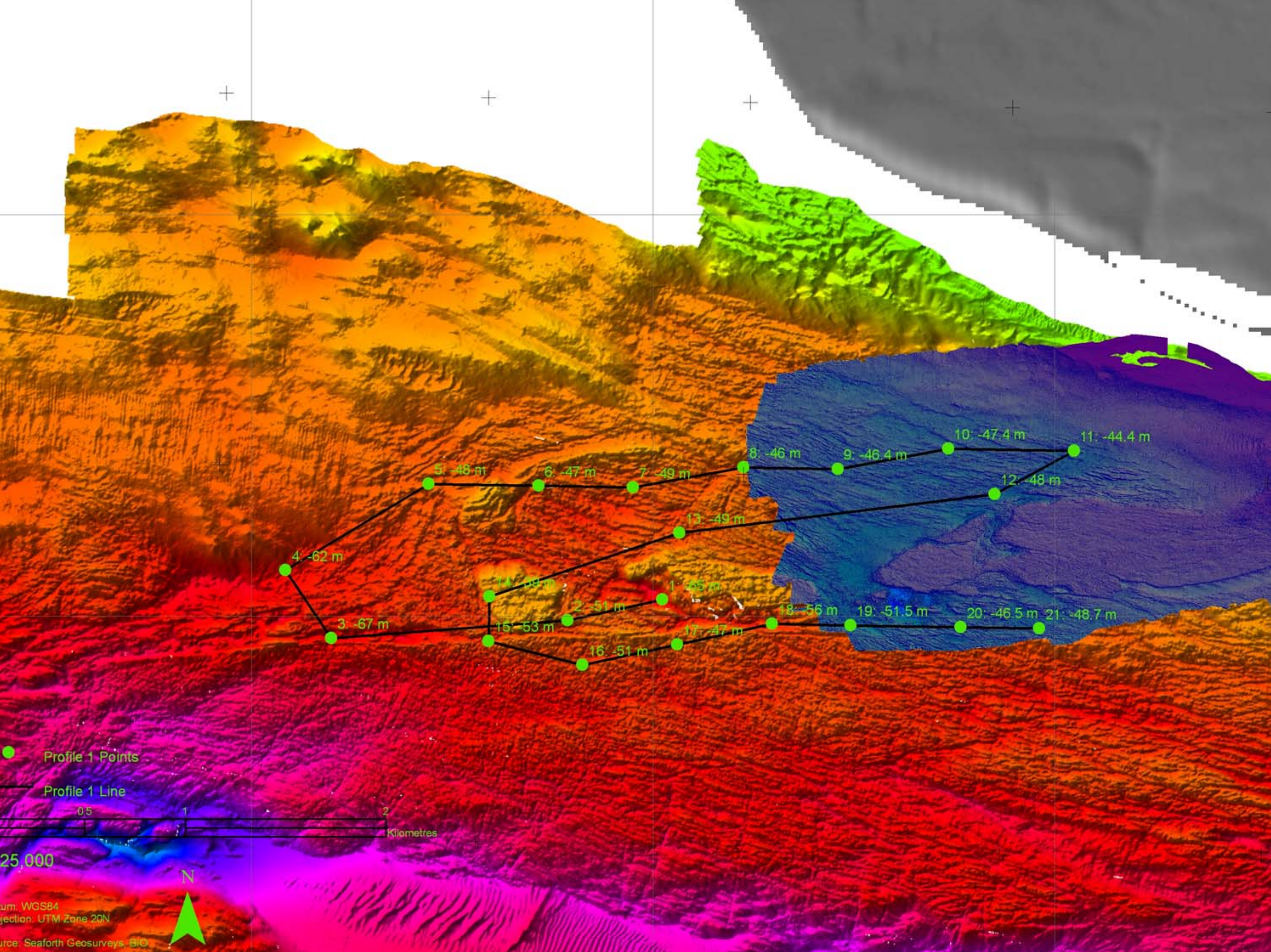




2: -51 m
3: -67 m
4: -62 m
5: -48 m
6: -47 m
7: -49 m
8: -46 m
9: -46.4 m
10: -47.4 m
11: -44.4 m
12: -48 m
13: -49 m
15: -53 m
16: -51 m
17: -47 m
18: -56 m
19: -51.5 m
20: -46.5 m
21: -48.7 m
Profile 1 Points
Profile 1 Line
0.5
1
2
Kilometres
25,000
N
um: WGS84
jection: UTM Zone 20N
urce: Seaforth Geosurveys, BIO

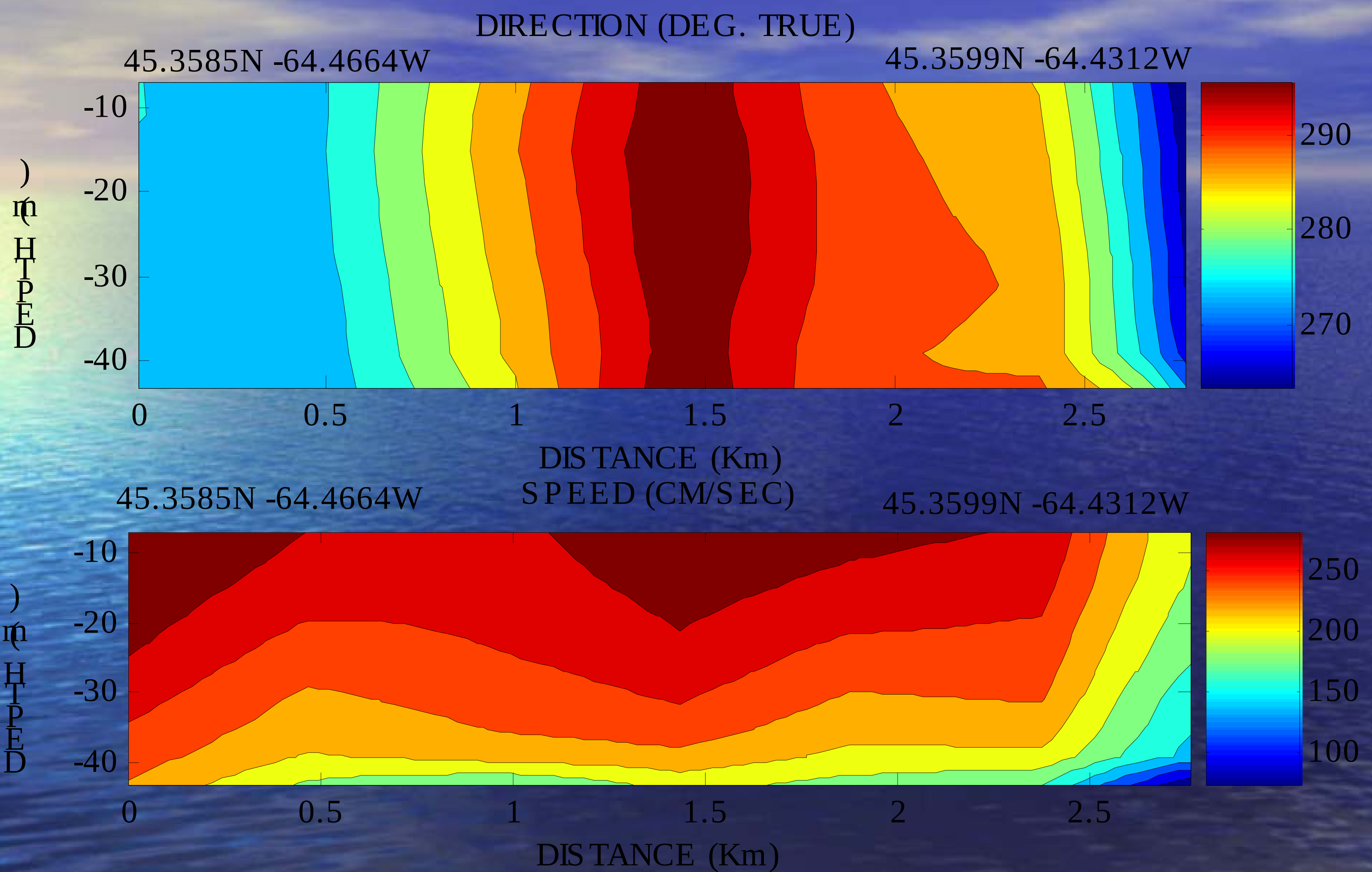
Current Speed and Direction from Station 12 to Station 14

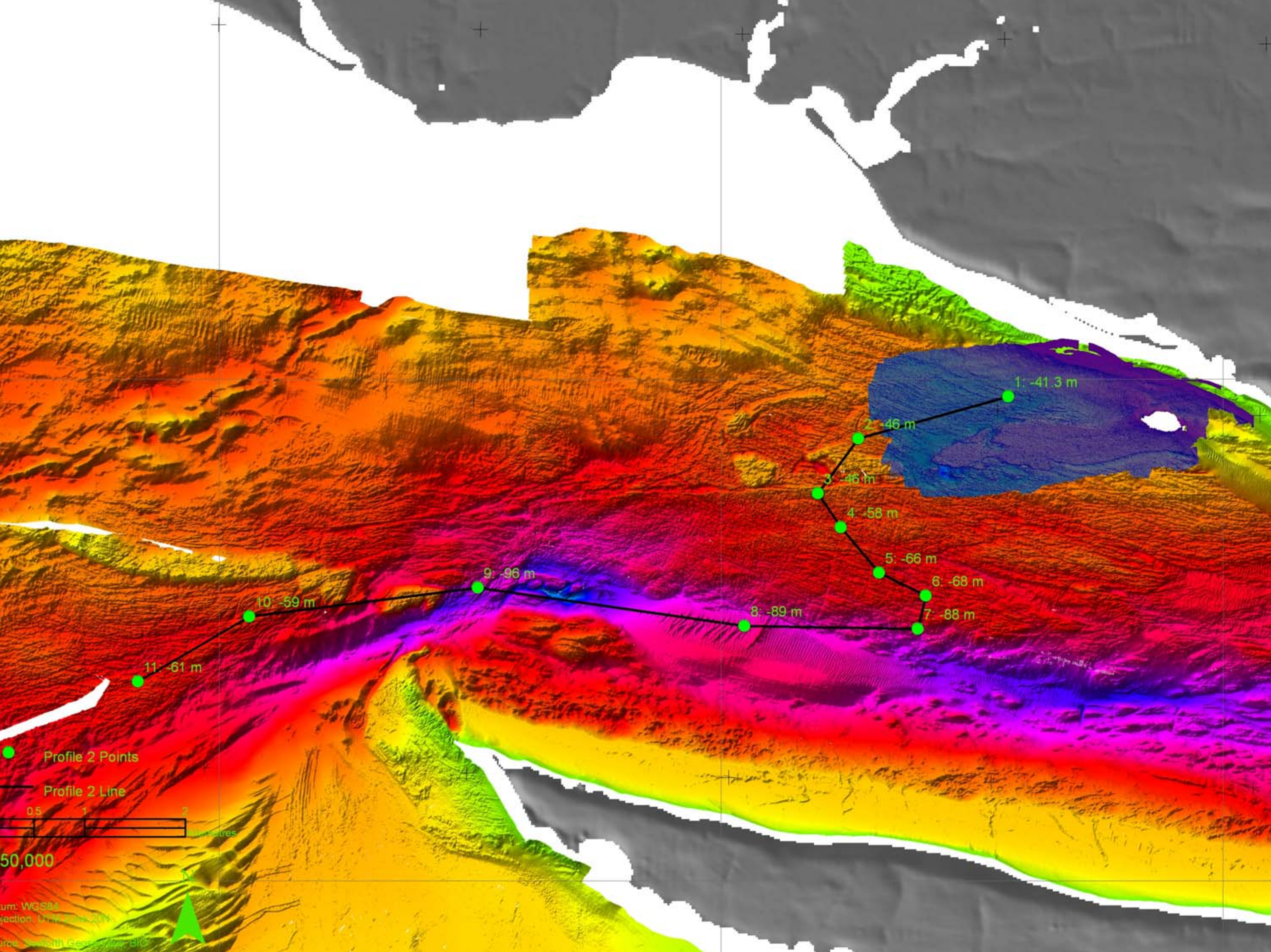




1
2: -51 m
3: -67 m
4: -62 m
5: -48 m
6: -47 m
7: -49 m
8: -46 m
9: -46.4 m
10: -47.4 m
11: -44.4 m
12: -48 m
13: -49 m
15: -53 m
16: -51 m
17: -47 m
18: -56 m
19: -51.5 m
20: -46.5 m
21: -48.7 m
Profile 1 Points
Profile 1 Line
0.5
1
2
Kilometres
25,000
N
um: WGS84
jection: UTM Zone 20N
urce: Seaforth Geosurveys, BIO

Current Speed and Direction from Station 15 to Station 21




1: -41.3 m
2: -46 m
3: -46 m
4: -58 m
5: -66 m
6: -68 m
7: -88 m
8: -89 m
9: -96 m
10: -59 m
11: -61 m
Profile 2 Points
Profile 2 Line
0.5
1
2
50,000
N

Further Studies

Oceans Ltd and Envirosphere combined survey program

- Seafloor sampling:
- A) Photography and video
- B) Geophysical sampling
- C) Benthic sampling
- Acoustics Baseline dta
- CTD measurements

Scallop Dredge for geophysical samples

Dredging for Benthic Samples

Preparing the camera

The Sea Floor

Conclusion

- The area is notable for its strong and linear currents, ideal for power production
- The profiles show little sign of turbulence
- The currents near bottom (5 metres) have a peak of 2.4 m/s. We have no good data below that.
- Further work is required once actual sites are selected.
- Seasonal effects such as during winter have yet to be fully considered or measured.

APPENDIX C – CABLE SPECIFICATIONS

In-Stream Tidal Power Generation Demonstration Facilities

SUBMARINE COMPOSITE CABLE DESIGN

- **3x120 mm^2 34.5 kV**
- **3x120 mm^2 13.8 kV**

0	Firs issue	GDA	MM	24/08/2009
Revision	**Description**	**Prepared**	**Approved**	**Date**

Table of contents

1. General description

This specification outlines and details the construction of three (3) conductor, EPR insulated (133%) and double wire armoured submarine composite cable at two different voltage level: 34.5 kV and 13.8 kV as alternative.
The cable design is generally in accordance with ICEA, IEC standards (where applicable) Prysmian in house design rules and Customer Specification unless otherwise stated in schedule N°3 (ref. 023-478-2-08).
Three cable lengths (2770m, 2350m and 1830 m) are offered to transmit power and data signal between tidal turbine generators and the shore end.

2. Cable construction and manufacturing features

2.1 Conductor

The conductors offered are of a compacted circular design, constructed from plain copper wires and filled with a water blocking compound to limit water propagation in case of cable severance. They have a nominal cross sectional area of 120 mm^2 and the design meets the requirements laid down by class 2 stranding per IEC 60228.

2.2 Conductor screen, Insulation and Insulation screen

The insulation system consists of an inner semi-conducting screen layer, the insulation compound and an outer semi-conducting extruded insulation screen.
The insulation is composed of EPR compound at 133% insulation level.
The insulation shield is securely bonded to the insulation and requires the application of heat for removal, thus assuring the consistent bond required at this important stress interface.

2.3 Metallic shield

The insulated core has one (1) layer of two (2) tinned copper tapes, applied over the insulation screen with a suitable overlap.
Tinned copper shall be used to reduce corrosion potentials with other metallic components.

2.4 Phase identification

Phase identification is provided under the metallic shield. This is composed of coloured longitudinal strips (Red – Yellow – Blue).

2.5 Assembly

The three power cores, the interstitial F.O. unit (12 fibers) and the pilot cable (2x4 mm2) are laid-up together using a laying up machine, which avoids the imposition of torsion stresses to the cores.
Polypropylene fillers are included in the interstices to give a substantially round shape.
The assembled cores are bound with a synthetic tape and a manufacturer's identification tape is included underneath.

1.6 Double Armoring and Bedding

The “armouring” includes the bedding, the armour and the serving application in one common process.
One layer of polypropylene string is applied over the assembly as bedding for the armour wires.
Two counter-helical layers of galvanised steel armour wires are applied over this bedding with a PP yarn separation layer between them.
The application of bitumen is provided over each armour layer and over the separation layer as further anti-corrosion protection and to aid the adhesion of the overall serving.
One layer of polypropylene string is applied over the armour as cable serving, to provide a degree of abrasion protection and to reduce cable/skid friction during lay.
The polypropylene serving is applied with a black and yellow pattern in order to give high visibility to the cable and enable monitoring of cable horizontal movement by ROV cameras.

1.8 Manufacturing lengths and factory splices

Where necessary, the shielded cores are joined by means of the factory joint technique. These joints represent a virtual reinstatement of the original cable structure, minimising local changes in core dimensions. They do not impose any restrictions on further cable making operations, the cable being armoured in one continuous process.
A flush ferrule connects the two conductor ends.
The insulation is reconstructed by means of tapes followed by moulding operation.
The copper tape shield is reconstructed by soldering.

The splice is carried out prior to the armouring operation, so that the section of cable containing the splice is continuously armoured without any discontinuity or appreciable distortion of the armour wires in the vicinity of the splice.
Factory joints (on power, pilot and optical units) may be provided in case of accidental cable damage and/or production needs.

3. Testing

The submarine composite cables shall be tested in accordance with following standards (where applicable):

- IEC 60840
- ICEA S-93-639
- Prysmian's recommendations

The test particulars and guarantees discussed in this part are stated in the following tables:

Test	Reference table
Factory acceptance tests (Routine Tests)	
Electrical tests on each manufacturing length before jointing and armouring	Table 1
Sample tests	Table 2
Factory splice test	Table 3
Tests on complete cable lengths including factory installed joints (if any)	Table 4

The nominal testing frequency is 50 Hz.
However, resonant systems (i.e. in the range 15÷100 Hz) may be used where necessary.
Unless otherwise stated, the test voltage shall be applied between the conductor and the metallic screen.
Where necessary, some tests may be carried out on samples.

3.1 Table 1 - Tests on each manufacturing length before jointing and armouring

Test Description	Particulars and Guarantees	Test Circuit Description
Partial Discharge Test - test level for 34.5 kV cable - test level for 13.8 kV cable - discharge magnitude	ICEA S-93-639 84 kV 44 kV ≤10 pC	On cable samples taken from the beginning and the end of each extrusion campaign.
AC Voltage test for 5 minutes - test voltage for 34.5 kV cable - test voltage for 13.8 kV cable	ICEA S-93-639 84 kV 44 kV	On each extrusion campaign length, before jointing and armouring.

3.2 Table 2 - Sample tests

Test Description	Particulars and Guarantees	Test Circuit Description
Conductor examination	IEC 60228	On sample of conductor material
Conductor D.C. electrical resistance test	IEC 60228	On sample of conductor material
Measurement of thickness of insulation	ICEA S-93-639	On sample of insulation material
Measurement of thickness of metallic tapes	ICEA S-93-639	On sample metallic tapes
Hot set test for EPR insulation	ICEA S-93-639	On sample of insulation material

For technical particulars and guarantees, please refer to the relevant technical data sheets.

3.3 Table 3 – Factory splice tests

Should a factory splice be necessary, we would perform only the following test:

Test Description	Particulars and Guarantees	Test Circuit Description
AC Voltage test for 5 minutes - test voltage for 34.5 kV cable - test voltage for 13.8 kV cable	Prysmian proposal 84 kV 44 kV	On each factory splice, before lay-up and armouring

3.4 Table 4 – Tests on complete cable lengths including factory joints (if any)

Test Description	Particulars and Guarantees	Test Circuit Description
AC Voltage test for 5 minutes - test voltage for 34.5 kV cable - test voltage for 13.8 kV cable	ICEA S-93-639 84 kV 44 kV	On the individual complete production lengths (coils)
Insulation resistance measurement - minimum D.C. ins. Res. @15.6°C for 34.5 kV cable - minimum D.C. ins. Res. @15.6°C for 3413.8 kV cable	ICEA S-93-639 >2500 MΩ×km >1560 MΩ×km	
Conductor resistance measurement - D.C. resistance at 20°C (indicative only)	0.0153Ω/km	
Metallic screen continuity measurement	Record	
OTDR - 1310 nm - 1550 nm	< 0.40 dB/km < 0.25 dB/km	On each fibres measured from both ends

4. Technical data sheet – 34.5 kV cable

Type of cable (Prysmian's designation)		RG7H1OJFJFJ
Phase to phase design voltage (U)	kV	34.5
Number of power cores	n°	3
Cross sectional area	mm^2	120
Reference standard (as far as applicable)		IEC60228, ICEA S-93-639, IEC 60840

4.1 Constructional data

CONDUCTOR

- Type		Longitudinally water sealed compact strand
- Diameter	mm	13.10

CONDUCTOR SCREEN

- Material		Extruded semi-conducting compound
- Minimum thickness	mm	0.6

INSULATION

- Material		EPR compound
- Maximum thickness	mm	11.4
- Min. absolute thickness	mm	10.2

INSULATION SCREEN

- Material		Extruded semi-conducting compound
- Minimum thickness	mm	0.6

METALLIC SHIELD

- Material		Tinned copper tapes
- Number of tapes	n°	2
- Nominal thickness of each tape	mm	0.13

THREE CORES as above are cabled together with one (1) interstitial fibre optic unit and one (1) pilot cable placed in the power core interstices with polypropylene fillers and bound with a synthetic tape

BEDDING

- Material		Polypropylene strings
- Indicative thickness	mm	2.8

ARMOUR

- Material:		Galvanised steel wires
- Nominal diameter of each bare wire (including galvanisation)	mm	6.05

SEPARATION LAYER

- Material		Polypropylene strings
- Indicative thickness	mm	2.0

SECOND ARMOUR

- Material		Galvanised steel wires
- Nominal diameter of each bare wire (including galvanisation)	mm	6.05

SERVING

- Material		Single layer of polypropylene strings
- Indicative thickness	mm	3.5

OVERALL CABLE DIMENSIONS (approx.):

- Diameter	mm	130
- Weight in air	kg/m	34.5
- Weight in water	kg/m	24.5

4.2 Mechanical data

4.2.1 Bending

- Minimum drum diameter	m	2.8
- Minimum bending radius static	m	1.6
- Minimum bending radius under tension (MBR)	m	2.0

4.2.2 Mechanical Forces

- Maximum straight pull tension	kN	86
- Maximum tension on MBR	kN	80

4.3 Power core thermal data

- Maximum continuous conductor temperatures (normal service)	°C	90
- Maximum continuous conductor temperatures (short circuit)	°C	250
- Conductor short circuit current for 1 s (90-250 °C)	kA	17.5
- Metallic sheath short circuit current for 1 s (70-250 °C)[1]	kA	2

4.4 Power Core electrical data

- Maximum DC resistance of each conductor at 20°C	Ω/Km	0.153
- Maximum AC resistance of each conductor at 90 °C	Ω/Km	0.196
- Star reactance	Ω/Km	0.156
- Capacitance	µF/Km	0.163

[1] One screen.

5. Technical data sheet – 13.8 kV cable

Type of cable (Prysmian's designation)		RG7H1OJFJFJ
Phase to phase design voltage (U)	kV	13.8
Number of power cores	n°	3
Cross sectional area	mm^2	120
Reference standard (as far as applicable)		IEC60228, ICEA S-93-639

5.1 Constructional data

CONDUCTOR

- Type		Longitudinally water sealed compact strand
- Diameter	mm	13.10

CONDUCTOR SCREEN

- Material		Extruded semi-conducting compound
- Minimum thickness	mm	0.6

INSULATION

- Material		EPR compound
- Maximum thickness	mm	5.33
- Min. absolute thickness	mm	6.35

INSULATION SCREEN

- Material		Extruded semi-conducting compound
- Minimum thickness	mm	0.6

METALLIC SHIELD

- Material		Tinned copper tapes
- Number of tapes	n°	2
- Nominal thickness of each tape	mm	0.13

THREE CORES as above are cabled together with one (1) interstitial fibre optic unit and one (1) pilot cable placed in the power core interstices with polypropylene fillers and bound with a synthetic tape

BEDDING

- Material		Polypropylene strings
- Indicative thickness	mm	2.8

ARMOUR

- Material:		Galvanised steel wires
- Nominal diameter of each bare wire (including galvanisation)	mm	5.16

SEPARATION LAYER		
- Material		Polypropylene strings
- Indicative thickness	mm	2.0
SECOND ARMOUR		
- Material		Galvanised steel wires
- Nominal diameter of each bare wire (including galvanisation)	mm	5.16
SERVING		
- Material		Single layer of polypropylene strings
- Indicative thickness	mm	3.5
OVERALL CABLE DIMENSIONS (approx.):		
- Diameter	mm	100
- Weight in air	kg/m	23
- Weight in water	kg/m	17

5.2 Mechanical data

5.2.1 Bending

- Minimum drum diameter	m	2.2
- Minimum bending radius static	m	1.25
- Minimum bending radius under tension (MBR)	m	1.5

5.2.2 Mechanical Forces

- Maximum straight pull tension	kN	86
- Maximum tension on MBR	kN	60

5.3 Power core thermal data

- Maximum continuous conductor temperatures (normal service)	°C	90
- Maximum continuous conductor temperatures (short circuit)	°C	250
- Conductor short circuit current for 1 s (90-250 °C)	kA	17.5
- Metallic sheath short circuit current for 1 s (70-250 °C)[2]	kA	2

5.4 Power Core electrical data

- Maximum DC resistance of each conductor at 20°C	Ω/Km	0.153
- Maximum AC resistance of each conductor at 90 °C	Ω/Km	0.196
- Star reactance	Ω/Km	0.132
- Capacitance	μF/Km	0.255

[2] One screen.

6. Ampacity Calculation

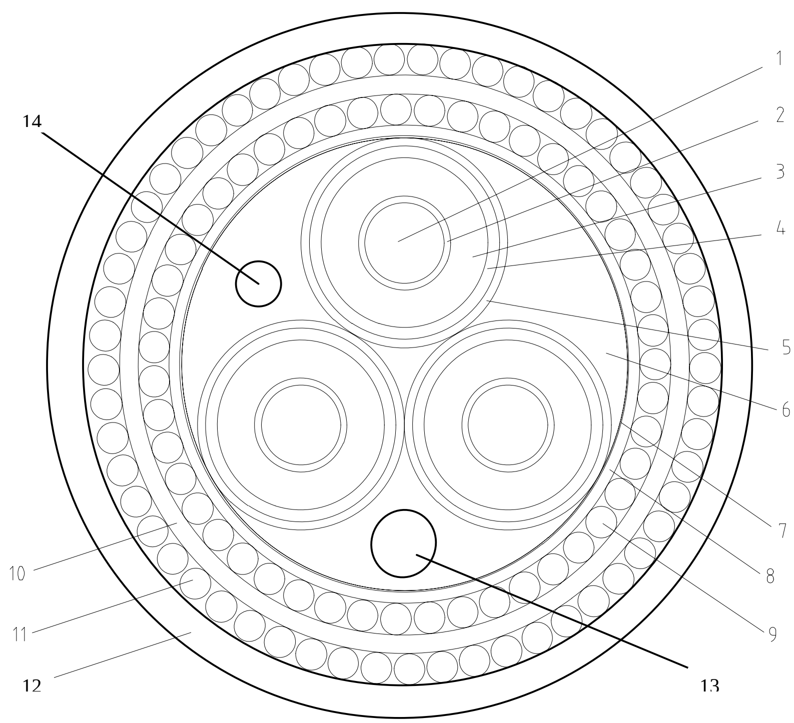
Cable ampacity has been calculated according the following assumed environmental and installation conditions:

	Max ambient Temperature (°C)	Soil Th. Resistivity (mK/W)	Burial depth (m)	AC 34.5 kV cable ampacity (A)	AC 13.8 kV cable ampacity (A)
Sea	20	0.6	1	358	361
Shore end	35	0.6	1	317	320
	35	0.7	1	307	309
	30	0.7	1.5	314	315
	25	0.7	1.1	332	334

According to Customer specification it should be considered a maximum ambient temperature = 40°C that seems to be very high; according to EPRI Green Book 2006, the maximum expected soil temperature at typical cable burial depth (1.1m) at the Boston-Chicago latitude is 22°C.
Even if 40°C air temperature is reached, it probably occurs only for very short periods and not regularly (i.e. few hours during few days per year), so that it should not influence the soil temperature at the cable burial depth significantly.
As far as short time overload is concerned, the maximum amps that can be reached are strictly dependent on the initial cable temperature and the duration; to not oversize dramatically the conductor dimension it is suggested to highlight the possible overload duration and the maximum daily average temperature expected during the overload period.

To calculate the DC cables maximum current capacities it is necessary to know how the cables could operate, if only one power core will transmit power with current return flowing into the sea water, if two cores will operate, etc.

7. Cable cross sectional drawing



(Diagrammatic only – not to scale)

Description

1. Plain copper wires	8. PP string bedding
2. Conductor screen	9. Galvanised steel wire armour
3. EPR Insulation (133% ins. level)	10. PP string bedding
4. Insulation screen	11. Galvanised steel wire armour
5. Metallic shield	12. PP string serving
6. Fillers	13. Optical unit (12 single mode fibers)
7. Binder tape	14. Pilot cable (2x4 mm2)

8. Shipping

The cable lengths shall be delivered on drums with sealed ends in order to prevent entry of moisture and other materials.
Expected drums dimension for the 34.5 kV cables are the following:

- Cable lengths = 2770 m and 2350 m
  Drums = 4.2x8 m

- Cable length = 1830 m
  Drum = 4.2x5.5 m

Expected drums dimension for the 13.8 kV cables are the following:

- Cable lengths = 2770 m and 2350 m
  Drums = 4.2x4.5 m

- Cable length = 1830 m
  Drum = 4.2x3.5 m

TECHNICAL SPECIFICATION FOR

SUBMARINE OPTICAL FIBER CABLE

0	For approval	GDA	MM	24/08/2009
Revision	**Description**	**Prepared**	**Approved**	**Date**

Table of contents

1.1 Fibre Optic Cable Element

The optical unit is our standardised design for submarine applications in composite cables or to be bundled with a single core power cable. These two typical constructions are shown in the attached technical data sheets.
The optical units used in these cables have been designed to meet the arduous sub sea physical conditions.
All the materials used for cables construction have low hydrogen emission. In order to prevent strain being imposed on the fibres during mechanical loading of the cable, the fibres are installed in the unit with an appropriate extra length. In addition, a cable sample taken from the production length is subjected to a tensile test in order to check the fibre attenuation versus elongation.

1.2 Unit structure

The optical unit is based on a slotted plastic extrusion with a steel central strength member. The fibres are set into helical slots.
The slots are filled with a gel to give a degree of mechanical support to the fibres and to block the longitudinal propagation of water in case of cable severance.
The core is bound with synthetic tapes.

1.3 Copper sheath

The unit is enclosed in a longitudinally welded, hermetic copper sheath to prevent the ingress of water or hydrogen gas.

1.4 Outer sheath

An extrusion of polyethylene is applied to the sheath to give a degree of corrosion protection and increase robustness to the unit.

1.5 Fibre identification (color scheme up to 48 fibers)

The fibres will be identified by colour and slot as shown below.

SLOT	COLOUR							
1	Red	Natural	Violet	Orange	Turquois	Pink	Brown	Blue
2	Green	Natural	Violet	Orange	Turquois	Pink	Brown	Blue
3	Yellow	Natural	Violet	Orange	Turquois	Pink	Brown	Blue
4	Yellow	Natural	Violet	Orange	Turquois	Pink	Brown	Blue
5	Yellow	Natural	Violet	Orange	Turquois	Pink	Brown	Blue
6	Yellow	Natural	Violet	Orange	Turquois	Pink	Brown	Blue

1.6 Optical Unit Data Sheet

Cable Characteristics

General
Optical cable with slotted rod structure, fully filled optical core, welded copper sheath and extruded polyethylene sheath
Number of Fibres
Cable equipped with up to 48 optical fibres

Cable Structure		
STEEL CENTRAL STRENGTH MEMBER		
Nominal diameter	mm	0.95
OPTICAL STRUCTURE		
Type: helicoidal slotted rod structure (S-Z)		
Number of slots	n°	6
Nominal diameter	mm	6.9
GEL FILLER DESCRIPTION		
Silicon filling compound (into each slot)		
PROTECTIVE SYNTHETIC TAPES		
WATER PROTECTION BARRIER		
Material: longitudinally welded copper sheath		
Nominal thickness	mm	0.65
OUTER SHEATH		
Material: polyethylene sheath		
Nominal thickness	mm	2.3
Approximate Overall Cable Dimensions:		
Diameter	mm	14
Weight in air	kg/m	0.29

1.7 Optical Fiber Characteristics

Fibres are of single mode type, in line with ITU-T, Rec. G652. Typical attenuation figures are stated in the attached Table.

General Characteristics	
Material	Silica/Doped Silica
Refractive Index Profile	Step Index
Geometrical Characteristics	
Mode Field Diameter	9.2 µm (±) 0.4 µm
Cladding Diameter	125.0 µm (±) 1 µm
MFD/Cladding Concentricity Error	≤ 0.7 µm
Cladding Non Circularity Error	≤ 1.0 %
Coating Characteristics	
Primary Coating Material	Double layer UV curable acrylates
External Diameter Coating/Cladding concentricity	245 µm ± 10 µm ≤ 12 µm
Attenuation Coefficients for Cabled Fibre	
At 1310 nm	≤ 0.40 dB/km
At 1550 nm	≤ 0.25 dB/km
Point Discontinuity	≤ 0.05 dB at 1550 nm
Dispersion Coefficients	
Between 1285 ÷ 1330 nm	≤ 3.5 ps/(nm×km)
Between 1525 ÷ 1575 nm	≤ 19 ps/(nm×km)
Zero-Dispersion Wavelength	1302 ÷ 1324 nm
Nominal Dispersion Slope	0.092 ps/nm^2×km
Cut-Off Wavelength	≤1260 nm
Mechanical Characteristics	
Proof Test	≥1.0%

1.8 Optical Unit Cross Sectional Area

(Diagrammatic only - do not scale)