

Presentation Overview

- Site surveys – what and why
- Equipment used
 - Type
 - Improvements
- Data limitations
- Future developments

Why are site surveys needed?

You need a survey for everything that is:

- moved from one place to another (e.g. rig move)
- laid on the seabed (e.g. pipeline, cable)
- has foundations in the seabed (e.g. platforms, buried pipelines, wellheads, manifolds, anchors, wind turbines)
- Interacts with the sub-bottom (drilling a well)
- might affect environmentally sensitive areas
- may be affected by geohazards

Geohazard Categories

- **Group A: Drilling Hazards**

- Shallow gas - high risk to facility and personnel
- Shallow water flow - high risk to facility, low risk to personnel
- Gas hydrates – unknown risks
- Reactive clays - low risk to facility, low risk to personnel, high cost implications
- Faults - low risk to facility, low risk to personnel, high cost implications

- **Group B: Facilities Placement, Foundation & Anchoring Design**

- Slope Instability - high risk to facility and personnel
- Active Faults - high risk to facility, low risk to personnel
- Mud Volcanoes and Shale Diapirs - high risk to facility, moderate to high risk to personnel
- Salt Diapirs - Low risk to facility, negligible risk to personnel
- Gas chimneys, seabed vents, seeps and pockmarks - high risk to facility, low risk to personnel
- Inadequate geotechnical characterisation - high risk to facility, low risk to personnel?

Offshore Features and Their Engineering Significance

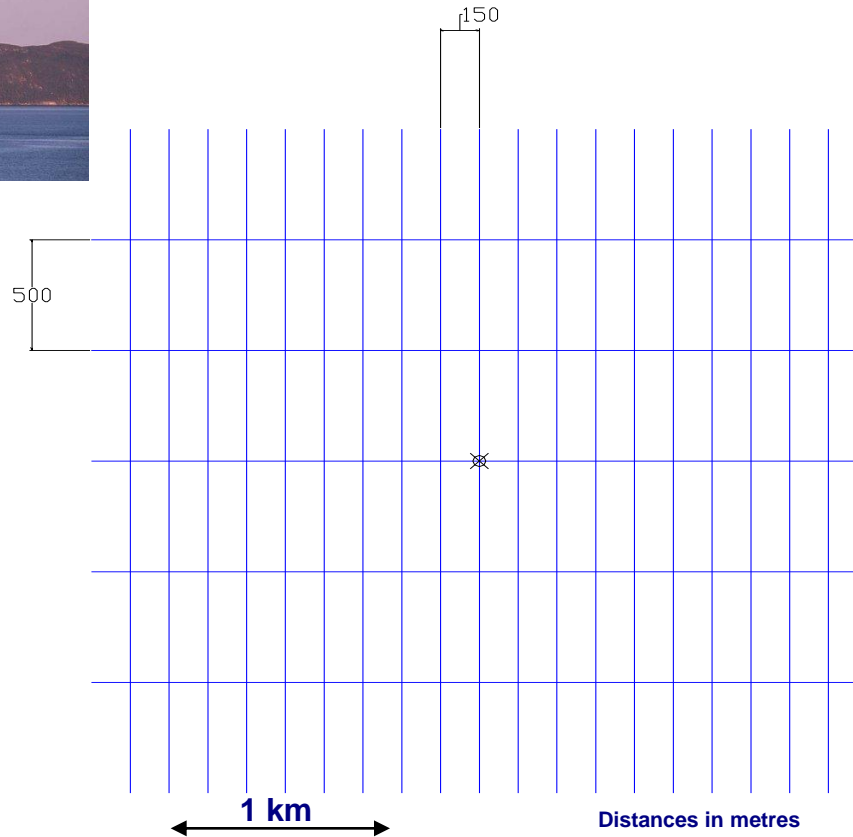
FEATURE OR CONDITION	DESCRIPTION	DISTRIBUTION / OCCURANCE	ORIGIN / CAUSE	POTENTIAL ENGINEERING SIGNIFICANCE	GEOPHYSICAL SYSTEMS MOST USEFUL FOR DETECTION
VERY SOFT SEABED	May have shear strength of as low as 0.95 kPa. Unit typically appears transparent on geophysical records	Typically occur in vicinity of modern or relict deltas and in other areas of accumulation of fine-grained sediment	Under consolidated silt and clay	Could cause difficulties	Side Scan Sonar, All sub-bottom profilers
RELATIVELY STEEP SLOPES	Slopes of as much as 25° are common in some areas	Continental slopes, submarine canyons, tectonically active areas and other localised settings	Variable	May be subject to failure. May preclude use of gravity production structures	Multibeam echo sounder, All sub-bottom profilers
LOCALLY ROUGH AND IRREGULAR SEABED	Local relief highly variable	Commonly associated with areas of hard seabed, areas where large volumes of gas escape from the seabed, or areas where mass movement is occurring or has occurred in the past	Glacial debris including boulders, coral or algal reefs, exposures of rock salt, volcanics and other rock, areas of steep mounds, fault scarps, areas of mass movement	Could cause difficulty with anchoring and installation of base plate. May preclude use of gravity production structures. Possible problems associated with mass movement	Multibeam echo sounder, Side Scan Sonar, Pinger, Boomer
LOCAL SEABED DEPRESSIONS	From a few metres to several hundred metres in diameter, and up to tens of metres deep	Variable, but most common in areas underlain by gassy sediments	Gas or fluid expulsion	Sediments with and below depression may have anomalously high or low strength. Depression may be indicative of ongoing gas flow!	Multibeam echo sounder, Side Scan Sonar, Pinger, Boomer
BURIED CHANNELS	The channels may be from a few metres to several tens of metres in depth, and can be several hundred metres in width	Common in shelf areas exposed during Pleistocene low stand of the sea	Rivers flowing across exposed shelf; may also include subaqueous channels	Sediments within channels may have significantly different strength than the surrounding sediments and may be characterised by rapid lateral and vertical strength variations	All sub-bottom profilers
MAN-MADE OBJECTS	Variable	Variable	Variable	Could interfere with installation of piles, anchors or pipelines, or emplacement of legs of jack-up rigs	Multibeam echo sounder, Side Scan Sonar, Magnetometer

Historic methods

- **20th Century surveys**
- Single beam echo sounder
- Side scan sonar - paper records
- Sub bottom profilers – paper records
- High resolution 2D

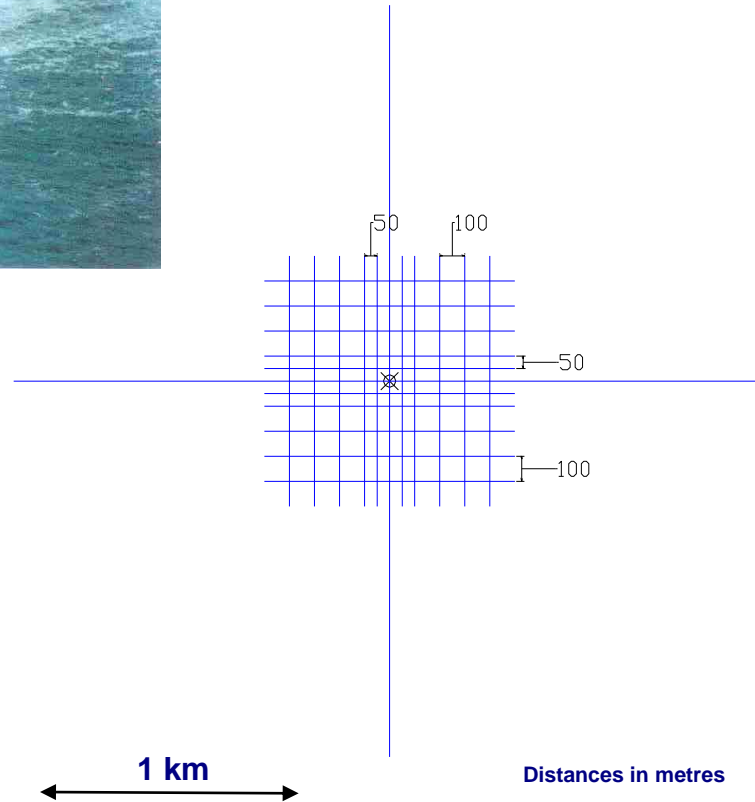
- **21st Century surveys**
- Multi-beam echo sounder and backscatter
- High frequency side scan sonar
- Underwater camera
- Sub bottom profilers – multichannel?
- AUV
- High resolution 2D / Exploration 2D
- Exploration 3D
- Desk studies

Survey line plan for a Semi-submersible Rig



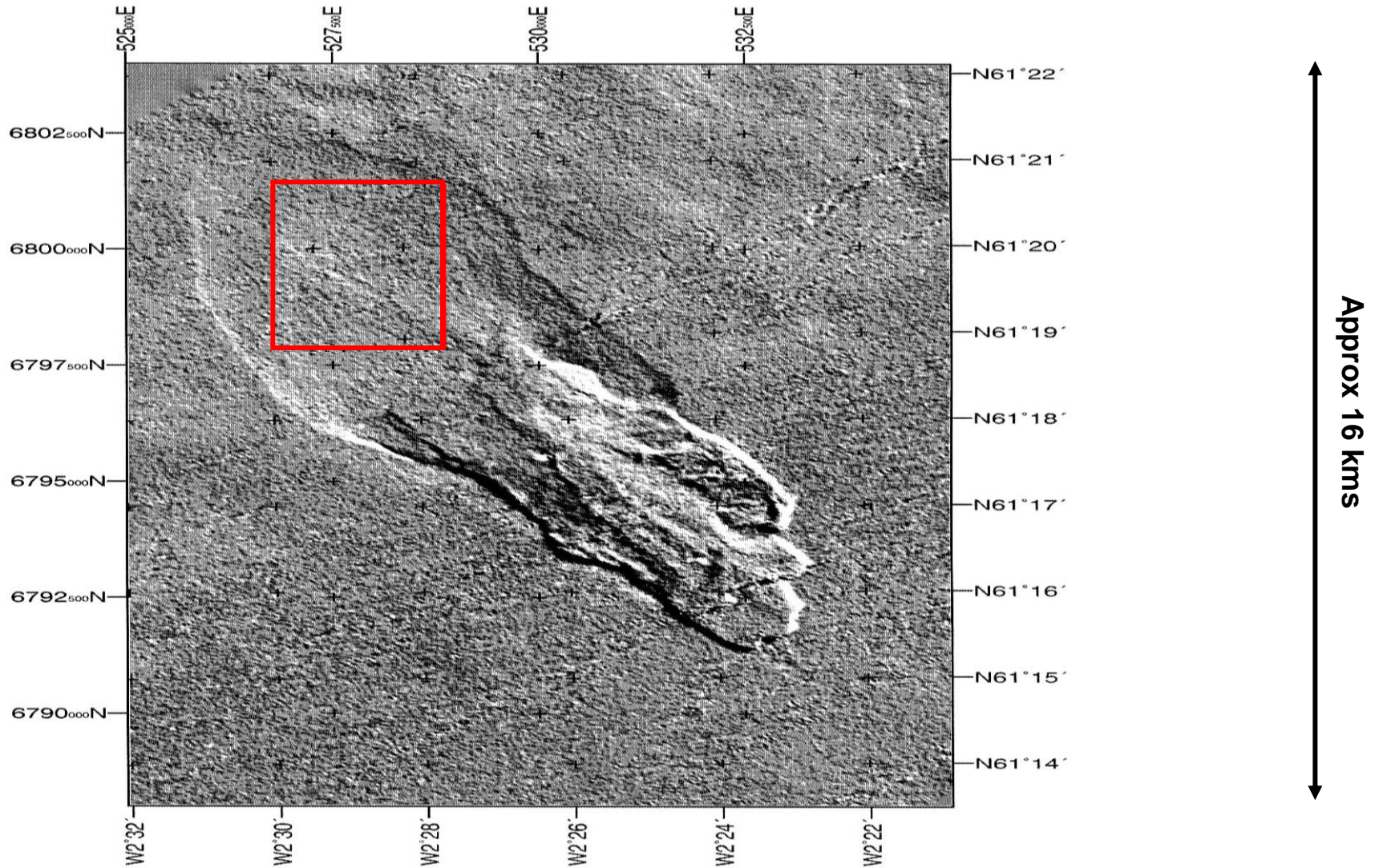
Plus tie line to adjacent core location or site survey

Survey line plan for Shallow Gas survey

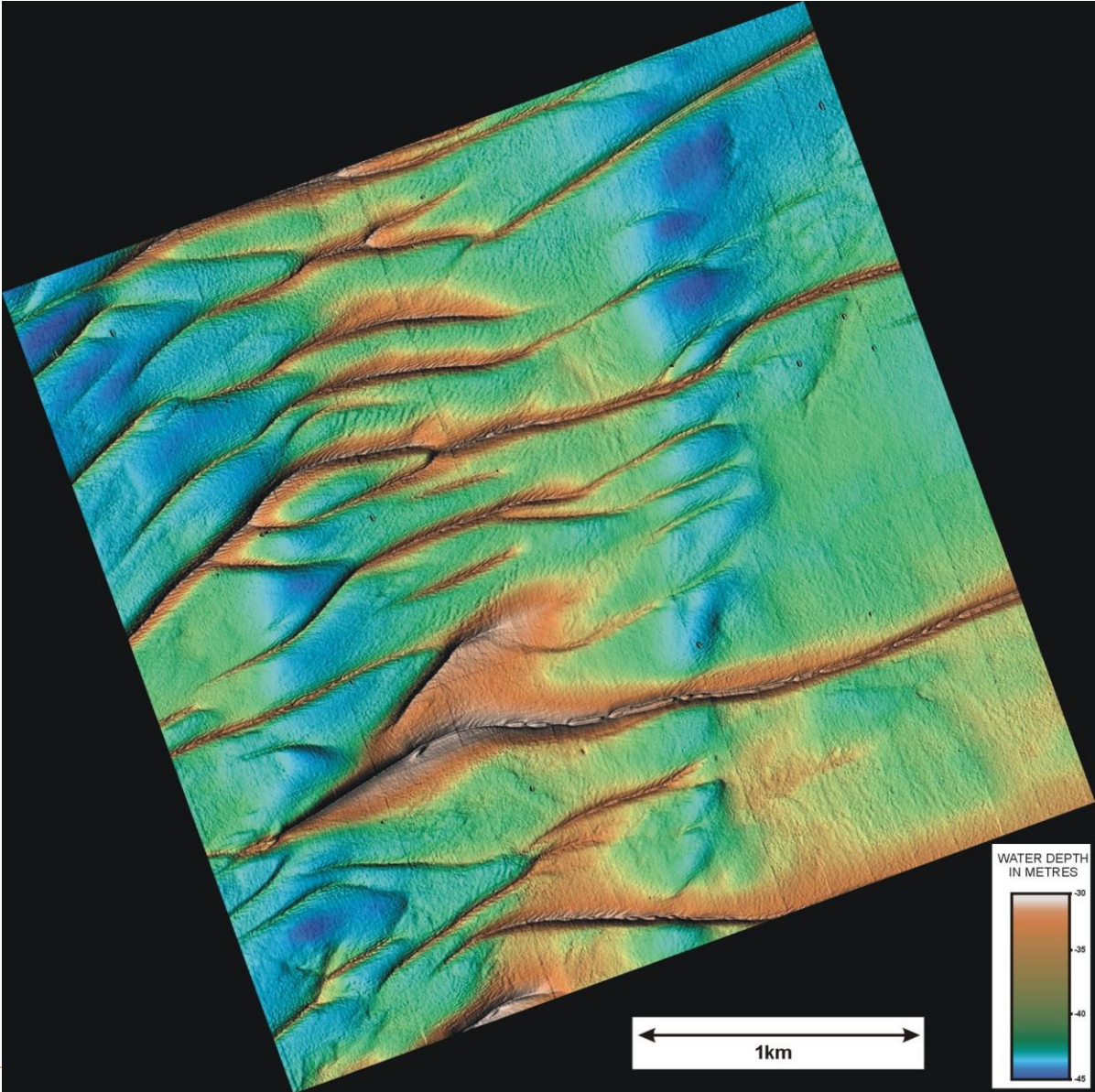


Plus tie line to adjacent borehole or survey area

The pitfall of ignoring the regional context



DTM from Multibeam Echo Sounder

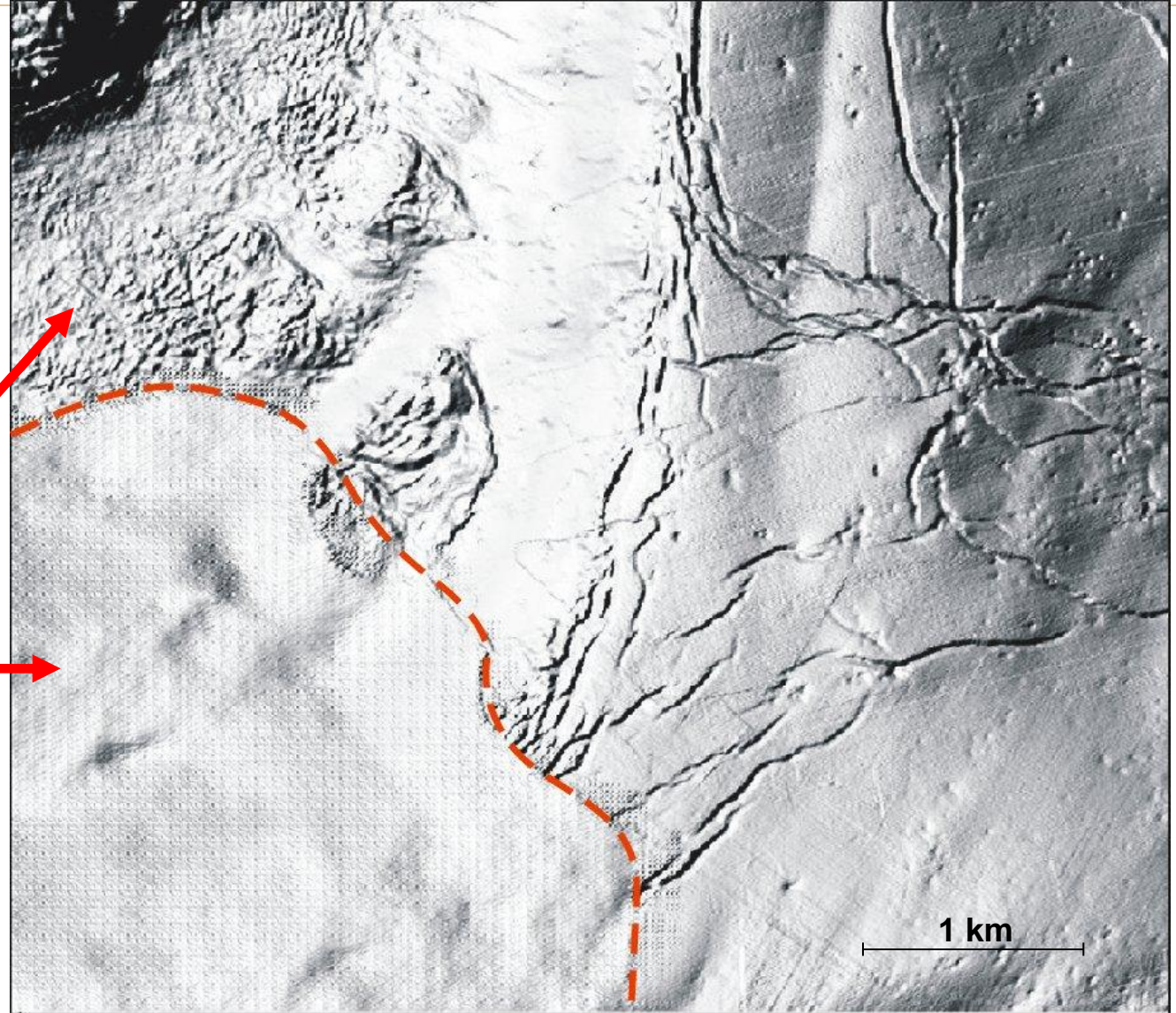


AUV Data Quality

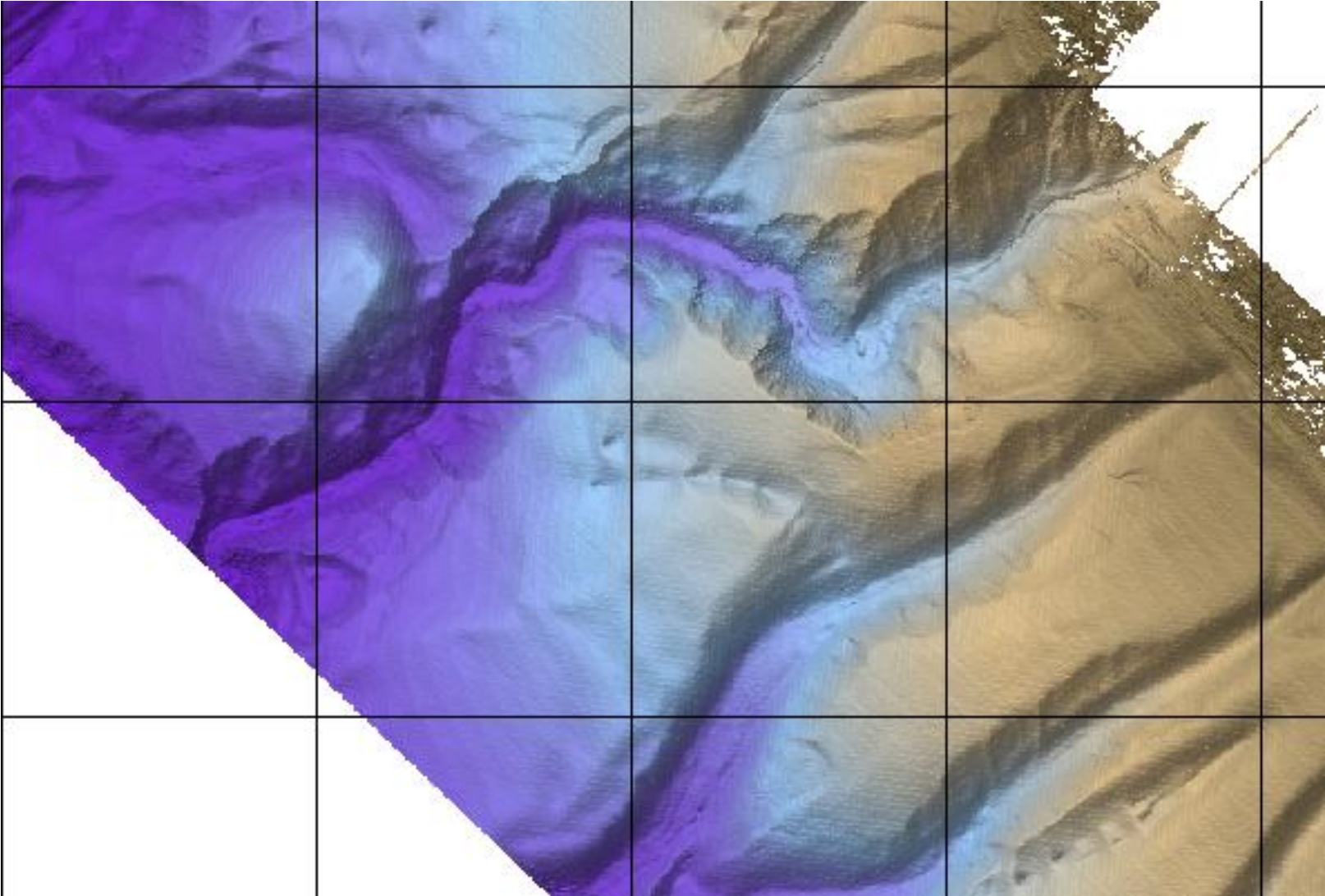
AUV compared to vessel mounted bathymetry data

- AUV mounted multibeam echo sounder data
- Vessel mounted multibeam echo sounder data

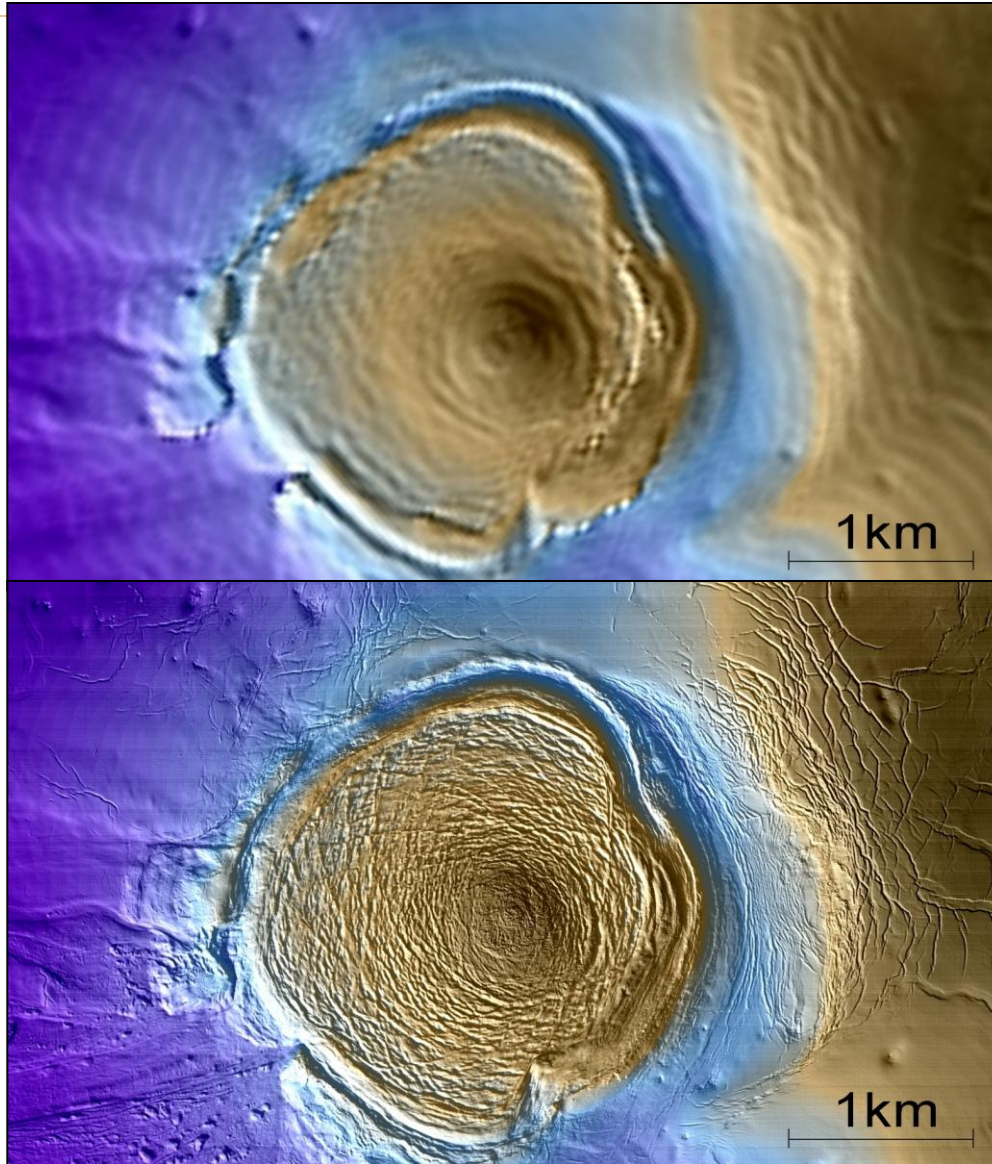
450 m water depth



Regional scale seabed assessment from 3D seabed pick



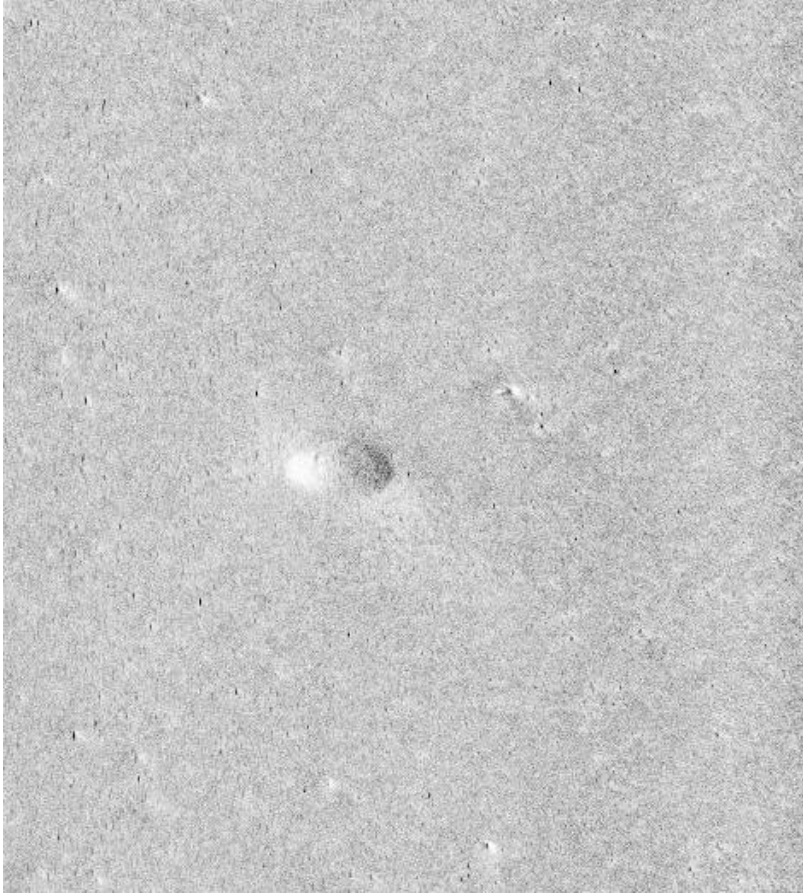
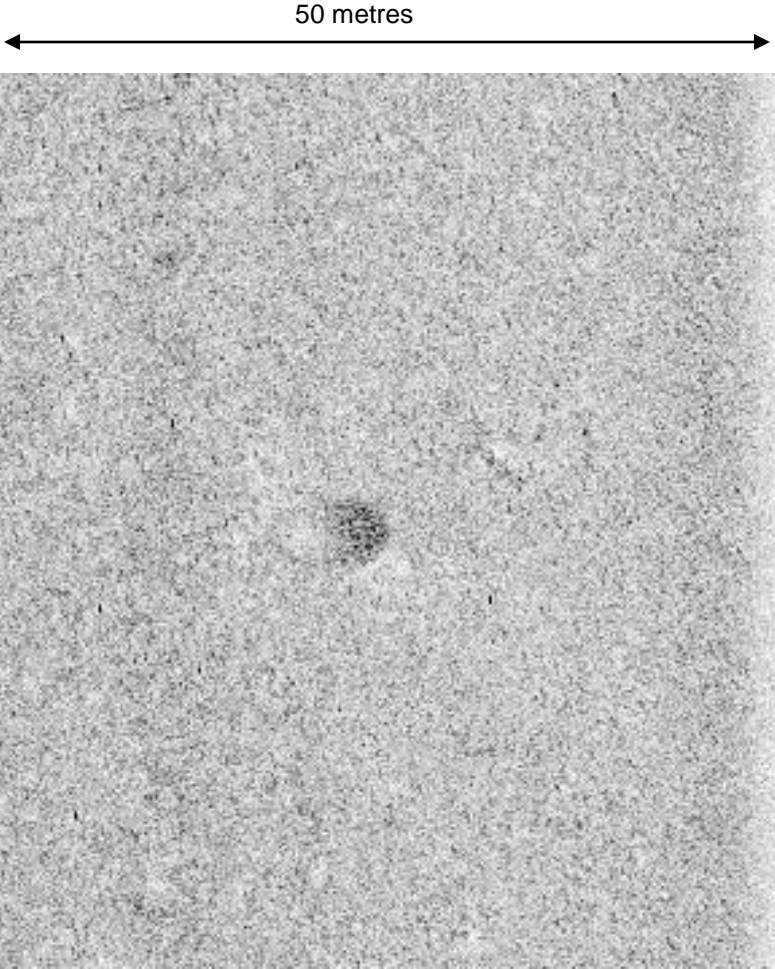
AUV Data Quality



- Bathymetry from 3D seismic data
12.5 x 12.5 m

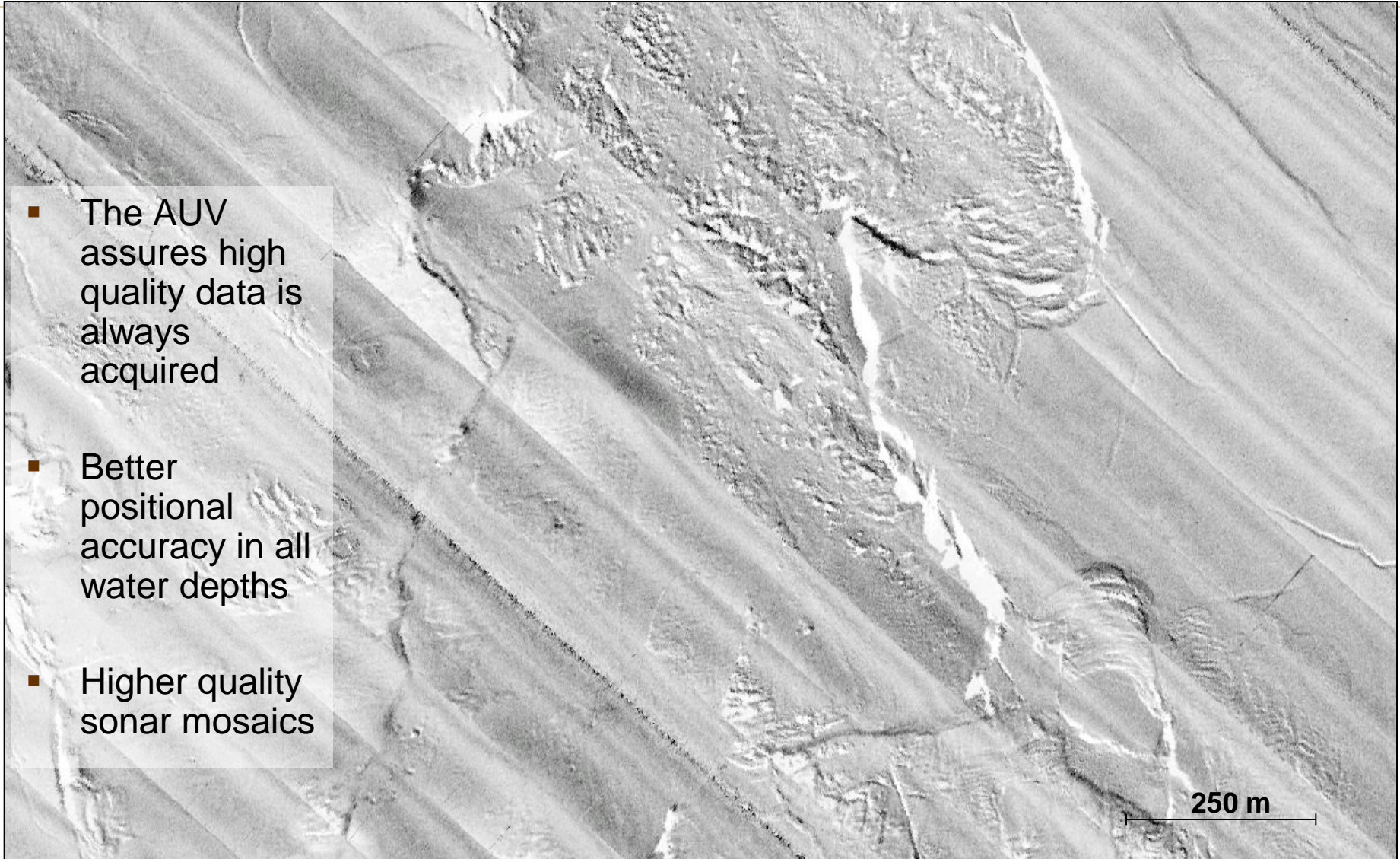
- AUV mounted multibeam echo sounder data
1 x 1 m

100 kHz and 500 kHz SSS data



AUV Data Quality

- The AUV assures high quality data is always acquired
- Better positional accuracy in all water depths
- Higher quality sonar mosaics



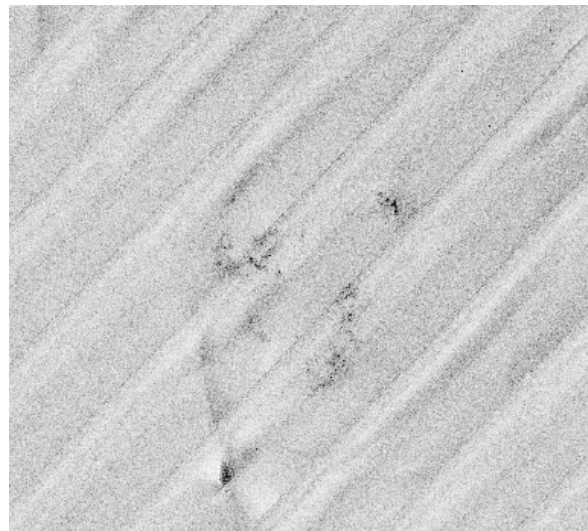
250 m

Multibeam echo sounders

- With the advent of high resolution multibeam echo sounders, side scan sonar is no longer the final word in assessing seabed textures and features
- Multibeam echo sounders can offer a more quantitative solution and be suitable for imaging subtle changes in seabed composition



Bathymetry



SSS Mosaic



Backscatter

Sub bottom profilers

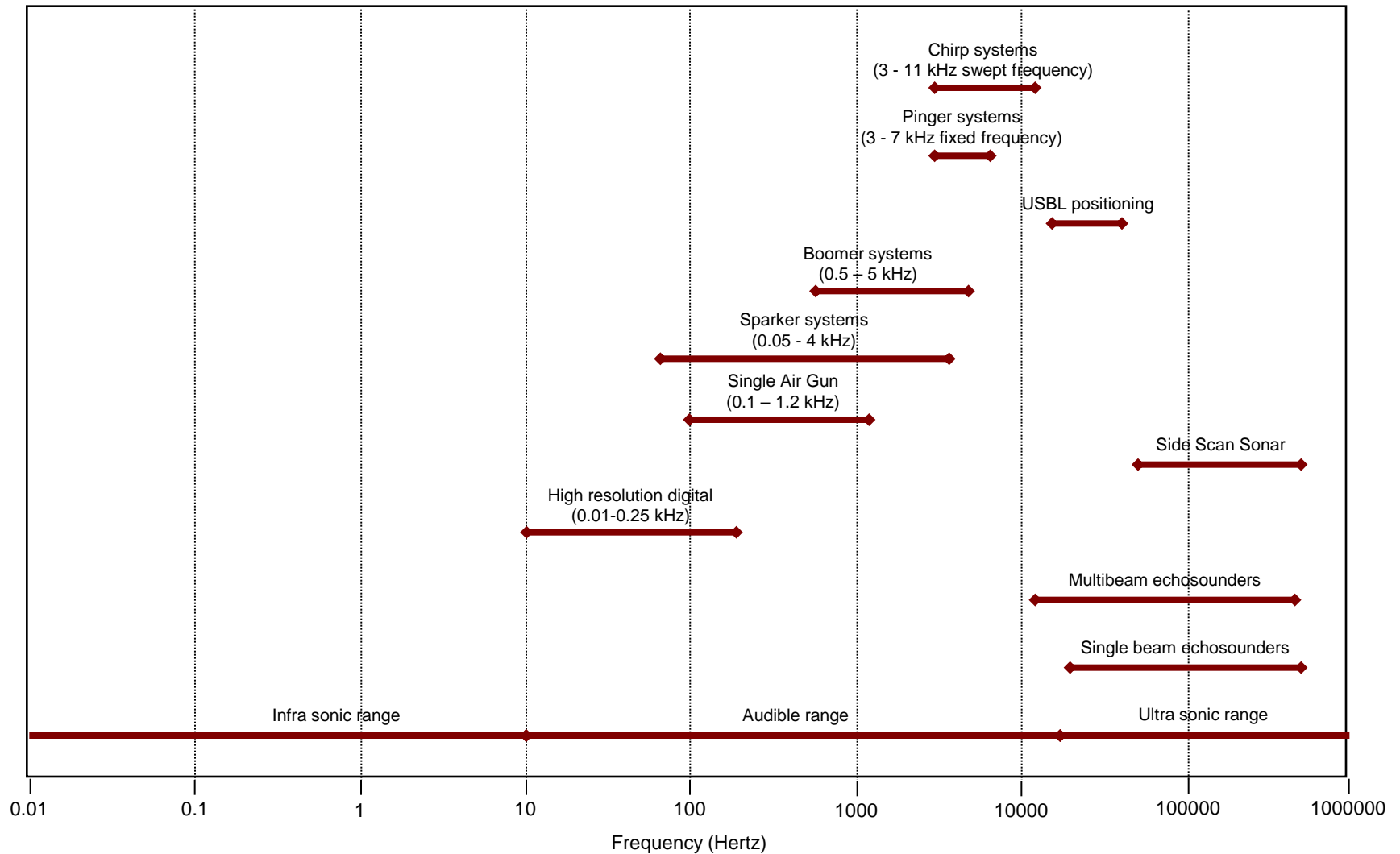
- Most of these systems are towed behind the vessel, either at the sea-surface (Surface Tow), just below the sea-surface (Sub Tow) or just above the seabed (Deep Tow)
- These towed sensors are linked to the vessel via an umbilical tow cable through which the profiler unit is triggered, and the reflected data is transported back to the vessel to be processed, displayed and recorded
- Surface Tow and Sub Tow are very susceptible to weather affects, Deep Tow to positioning issues
- Autonomous Underwater Vehicles (AUVs) are being increasingly employed as platforms for all types of analogue sensor, including profilers. There are many potential advantages of AUVs - these include short line turns and good positioning in deep water as well as low noise and superior data resolution

Comparison of Acoustic Tools

Source	Function	Frequency	Vertical Resolution	Penetration through seabed
Multibeam Echo Sounder	Bathymetry	200 kHz	n/a	0 m
Sub-bottom Profiler (Pinger)	Pipelines Foundation zone	1.4 – 4.5 kHz	<0.3 m	<50 m
High-resolution seismic (2D or 3D)	Shallow hazards	150 Hz	<3 m	<1500 m
Conventional 3D seismic	Reservoir exploration	50 Hz	<10 m	>3000 m



Sub Bottom Profiler systems



Equipment

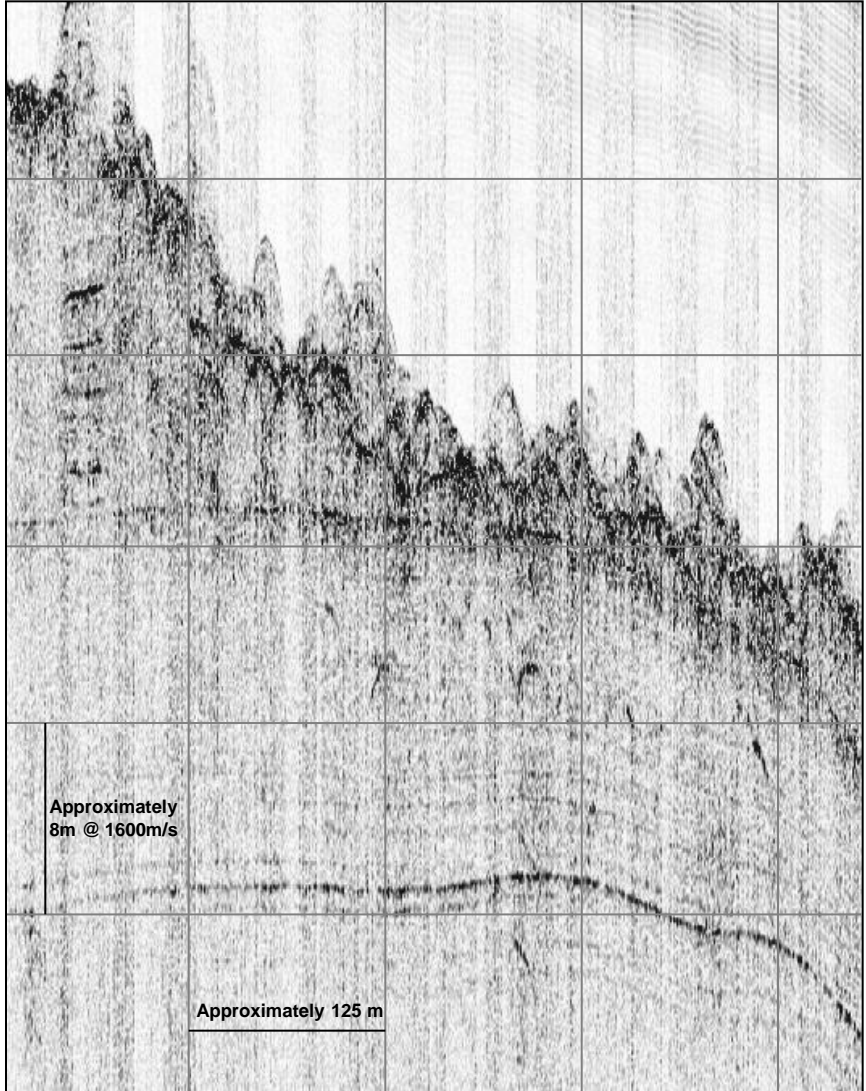
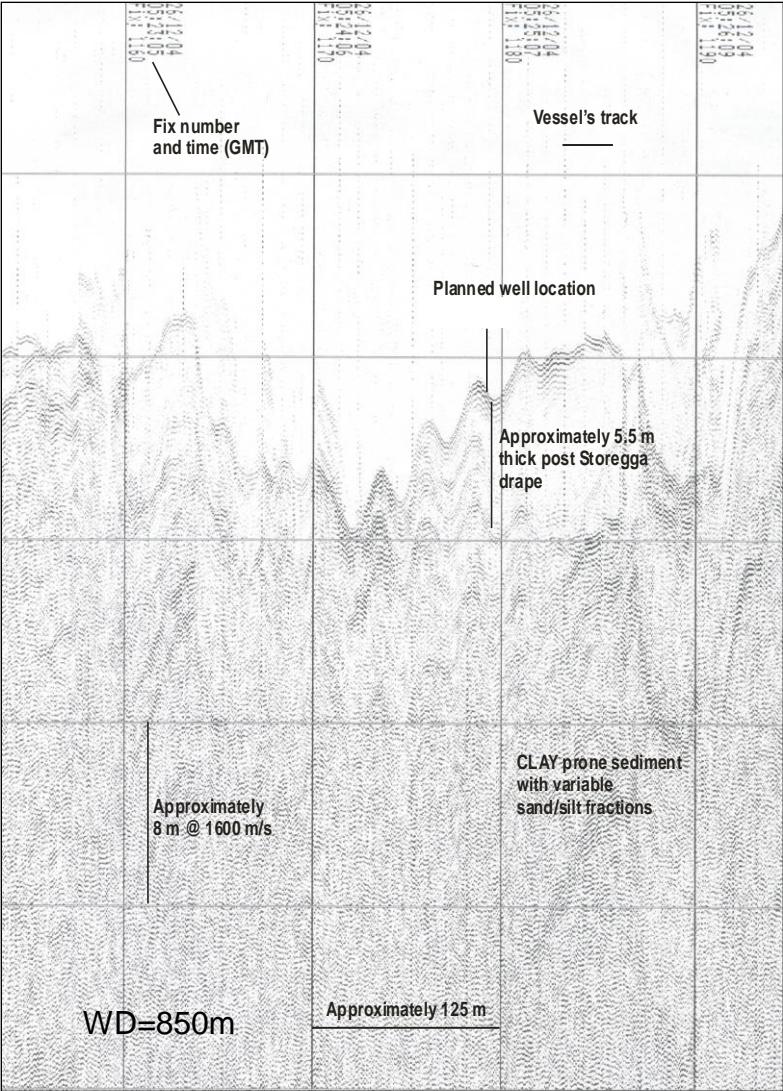
Comparison of common sub-bottom profiler systems:

	Operating Frequency	Max. Depth of Penetration	Resolution	Type of Source	Typical Energy Output
Pinger	~3.5 - 7 kHz (Fixed)	30 – 40 metres	~0.3 metres	Piezoelectric Transducer	~2 joules
Chirp	3.5 – 11 kHz (Swept)	40 – 50 metres	~0.3 metres	Piezoelectric Transducer	~2 joules
Boomer	~0.5 – 5 kHz	~100 metres	~0.5 metres	Electro-mechanical Transducer	~200 - 1500 joules
Sparker	0.05 - 4 kHz	~200 metres	1 – 10 metres	Electric Spark	~4 - 24 kilojoules
Single Air Gun	100 – 1200 Hz	~900 metres	1 – 10 metres	Compressed Air Pressure Wave	

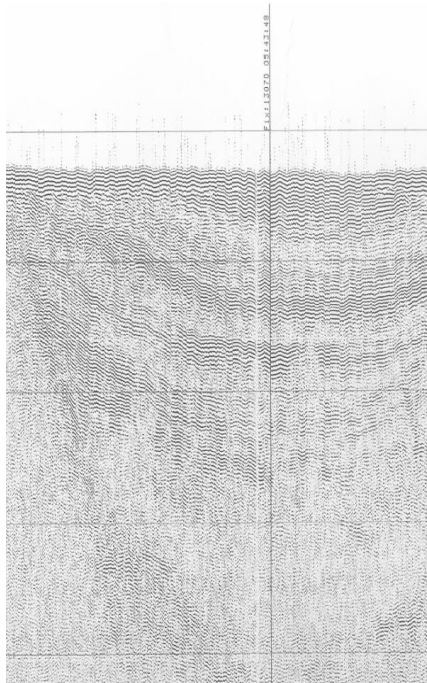
AUV Data Quality

Hull-mounted Pinger

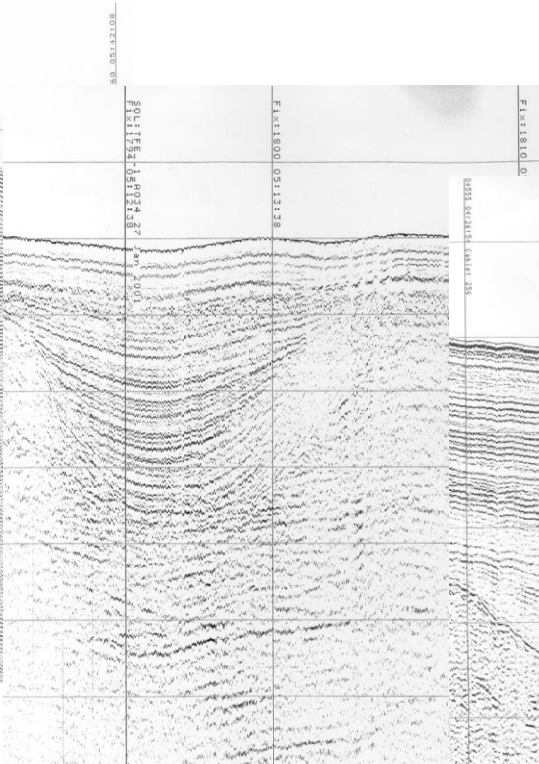
AUV Chirp



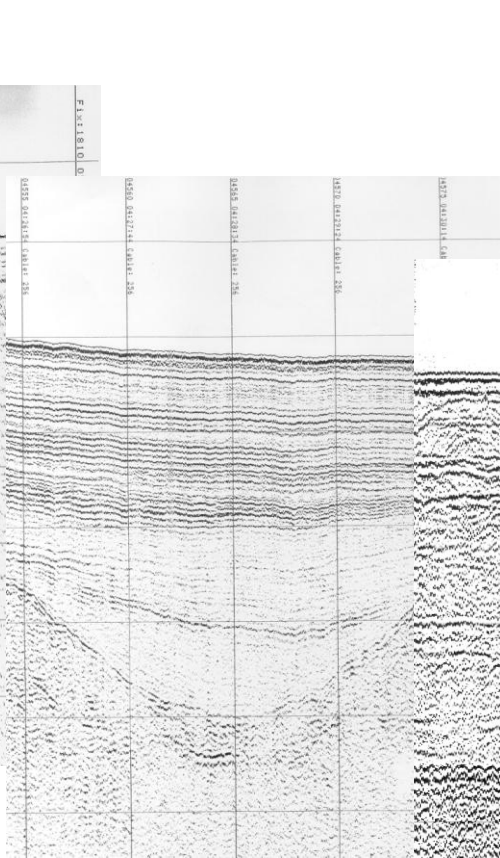
Comparison of sub-bottom profiler system data:



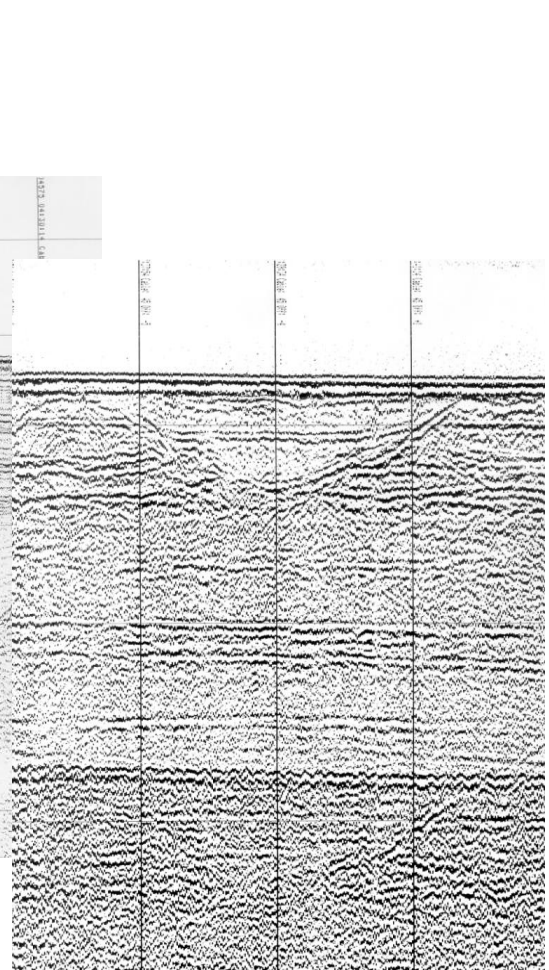
Hull-Mounted Pinger



Surface-Tow Boomer

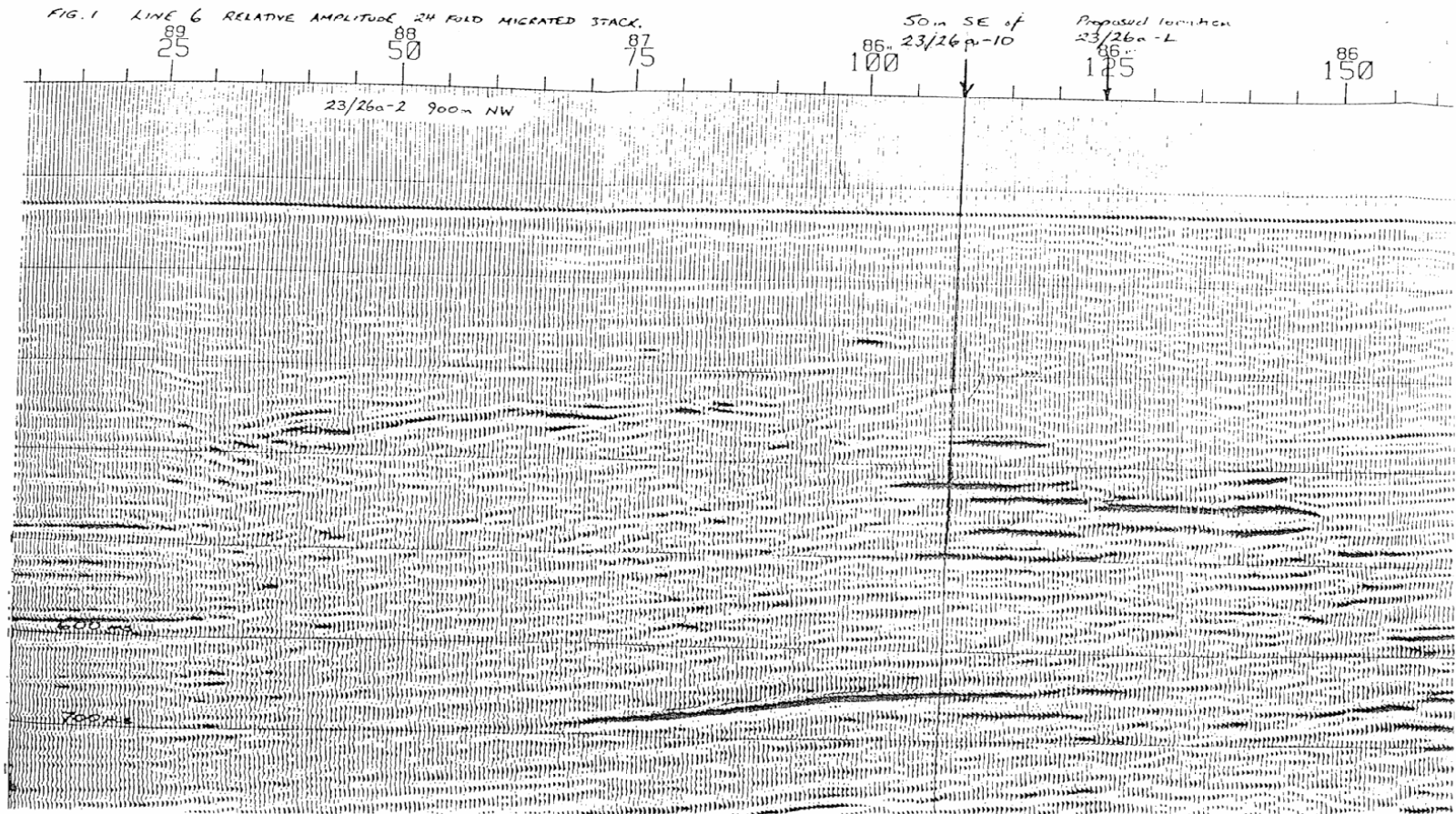


Deep-Tow Sparker



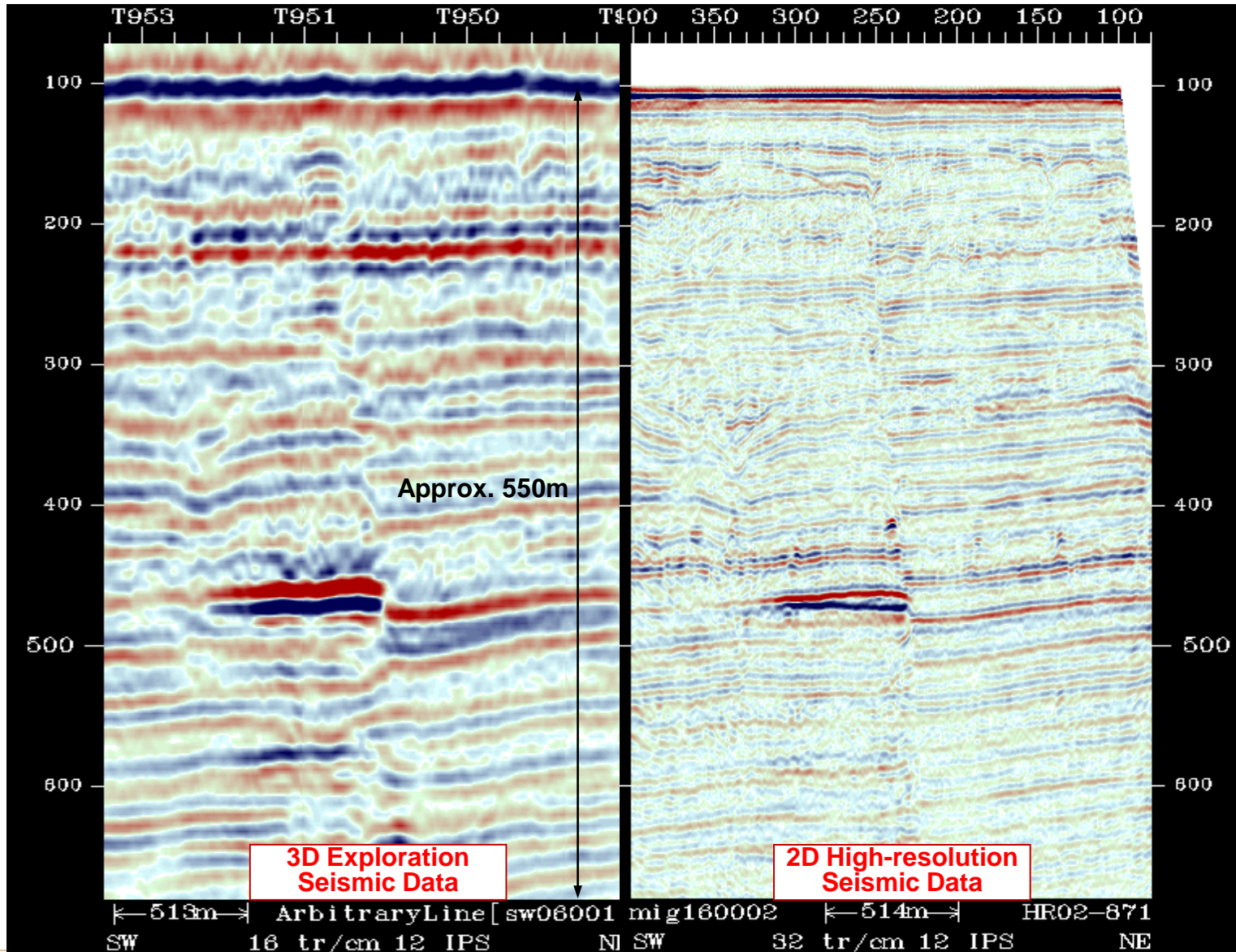
Single Air Gun

Old paper records

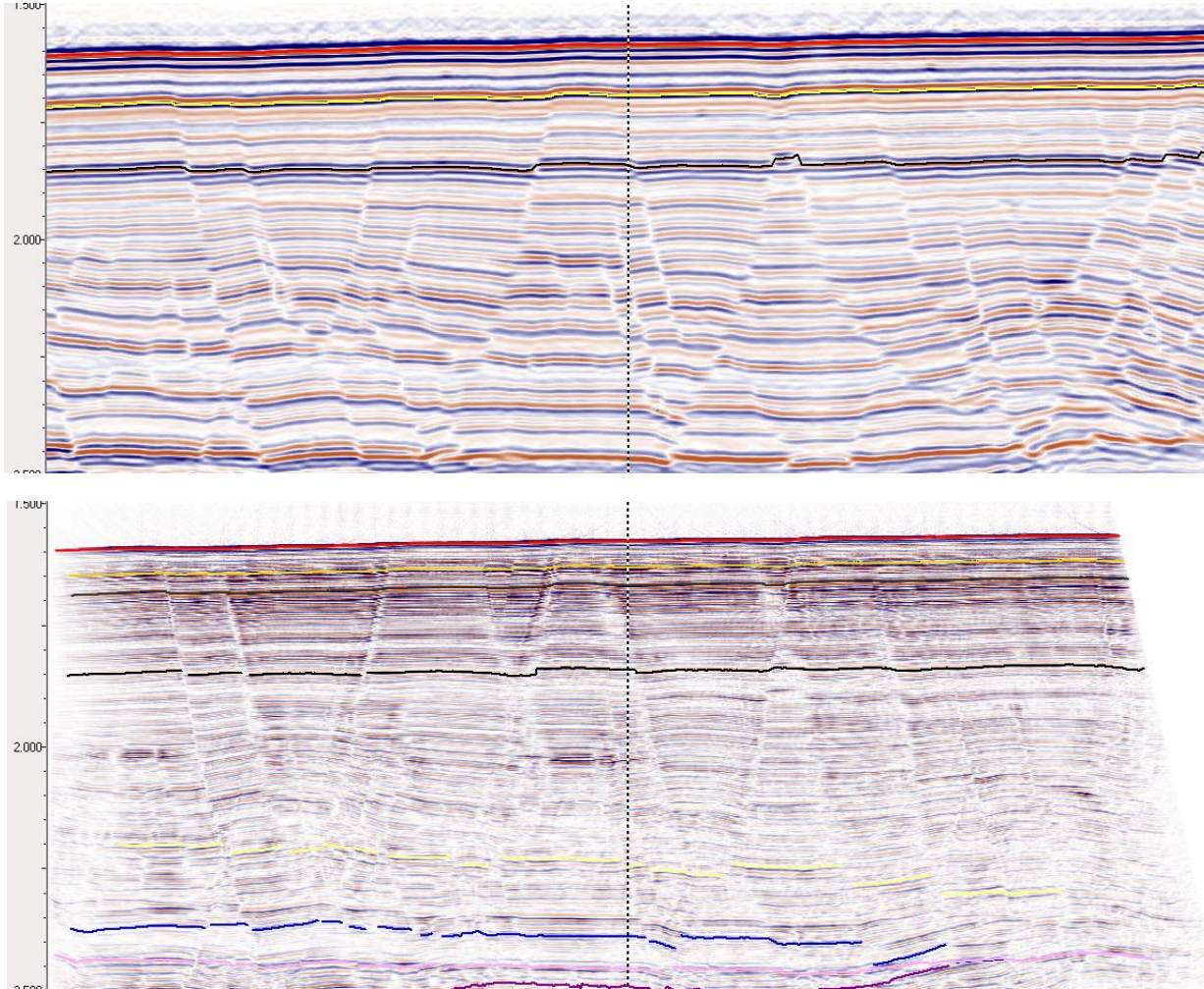


1987 HR seismic data

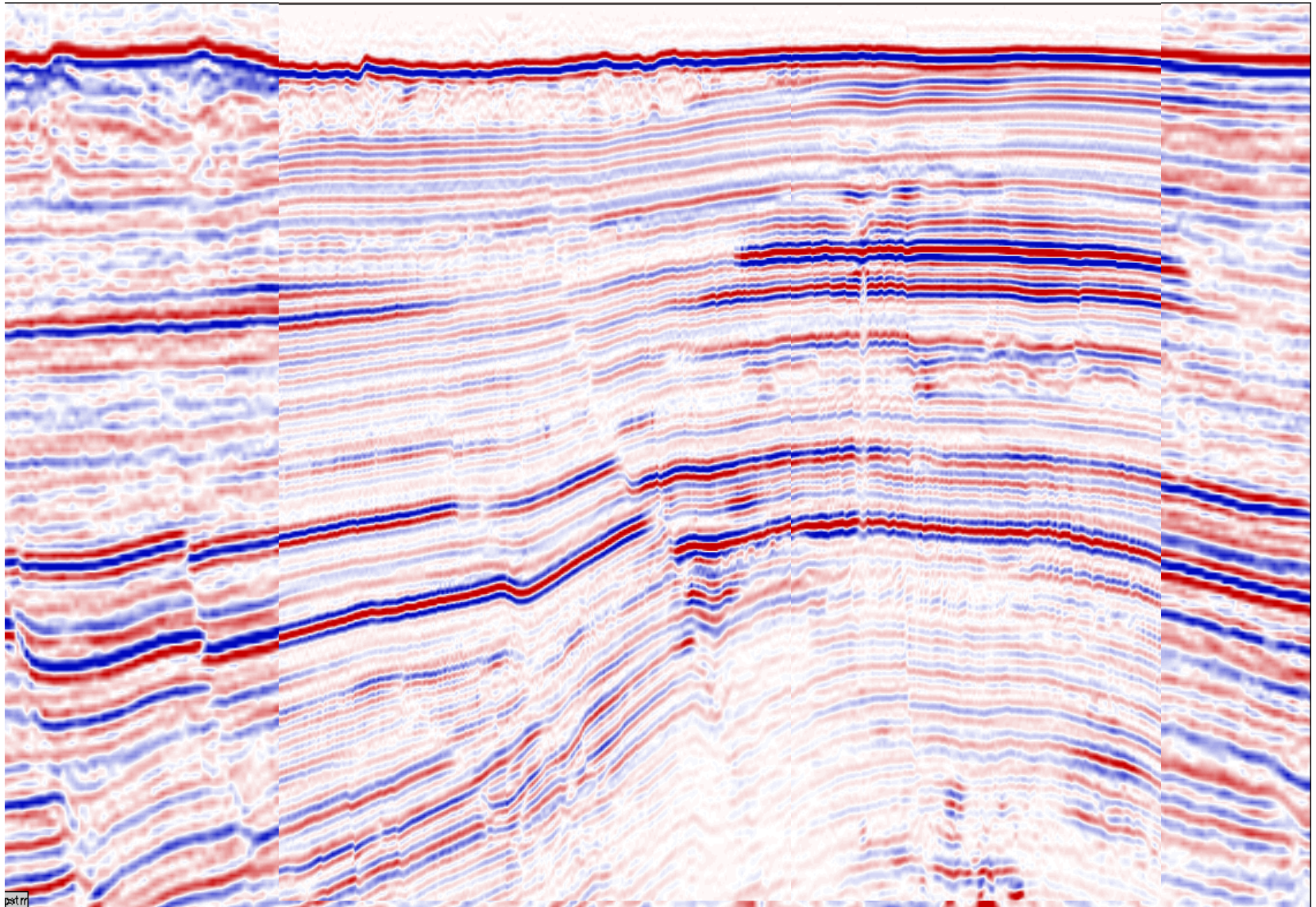
2D vs 3D Resolution



The benefit of 3D migration

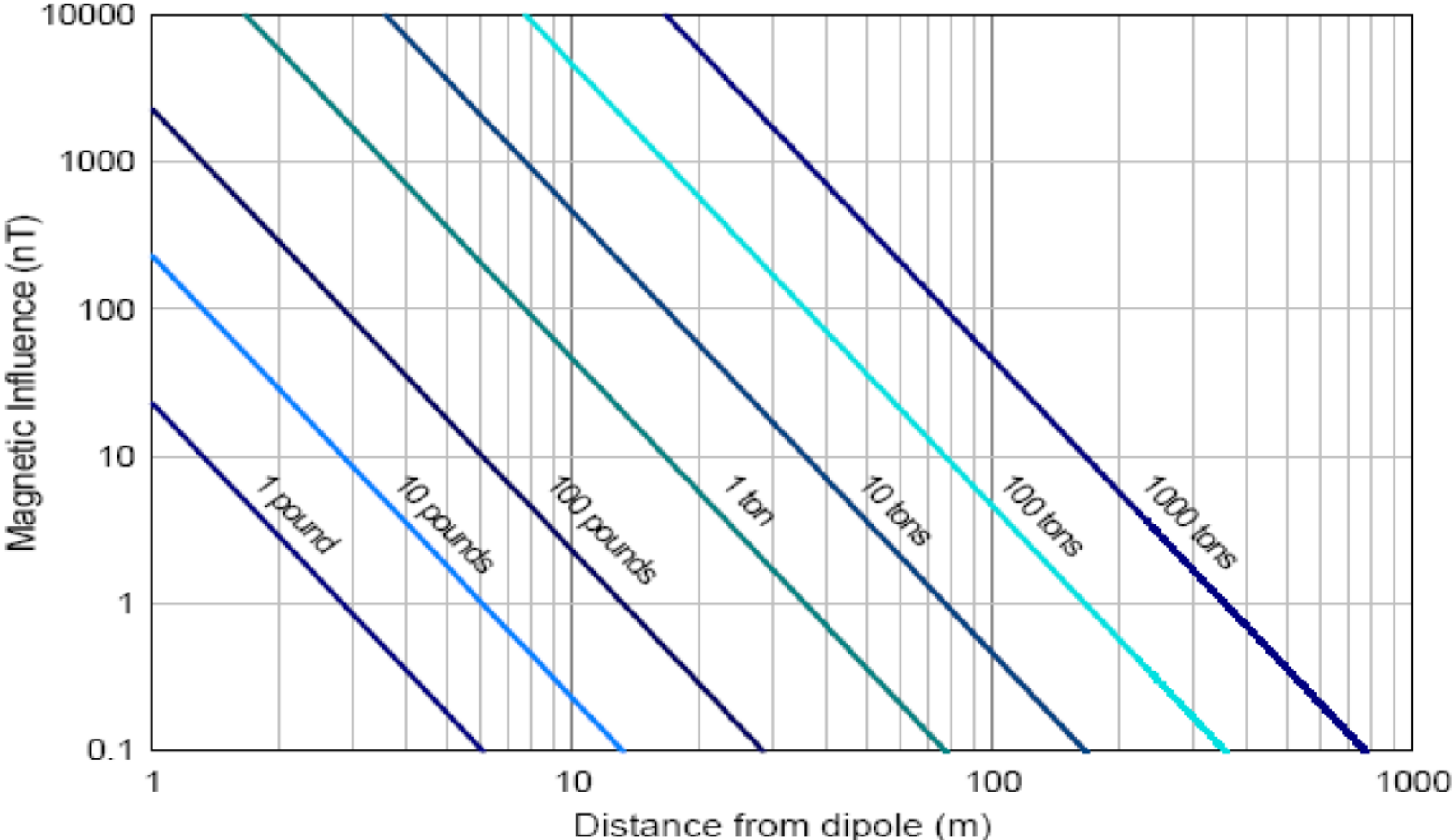


Conventional 3D vs Short-Offset Processing



ps1.r1

Magnetic Influence of Iron



This chart has been calculated assuming no permanent magnetization of the object, a susceptibility of 100, and an ambient field of 50,000nT.

Environmental Issues

- JNCC guidelines necessitate environmental surveys in sensitive areas
 - Pockmark fields – active venting encourages marine life growth and reef development
 - Sabellaria – tube worms
 - Herring spawning grounds
 - “Reefs”
- Seabed photos & sediment grab samples taken as part of geophysical survey
- EIA becoming standard part of site surveys
- Geophysicists working with marine biologists



Sabellaria spinulosa



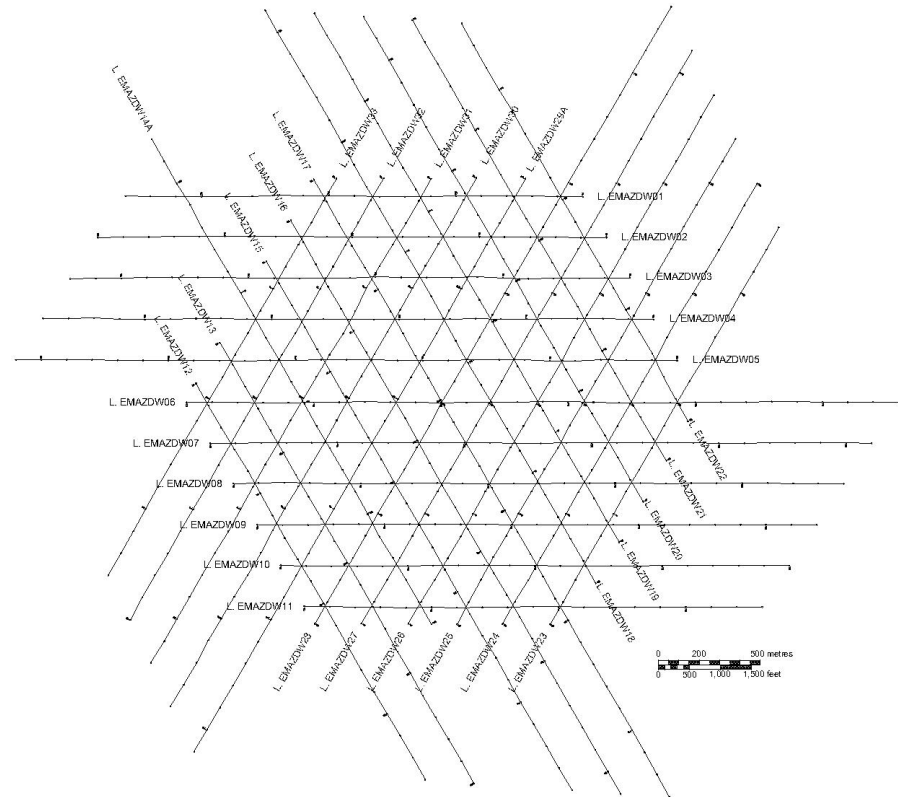
Lophelia pertusa

General Interpretation Guidelines

- From UKOOA Guidelines:
 - **Use all sources of available data** - top hole well data, borehole data, exploration seismic data, adjacent rig site survey data, regional geological data (e.g. BGS, NPD), in-house knowledge of the area, previous drilling experience in the area.
 - Interpret within regional framework.
 - **Use seismic workstations** - enhanced display options and attribute analysis.

Limitations

- Echo sounders - have improved navigation information on pitch, yaw and heave
- Side scan sonars – higher frequencies
- Backscatter – improved processing
- Camera – ground truthing – mounted
- Magnetometer – lack of range
- Sub bottom profilers – multichannel
- 2D HR – close line spacing, processed
- 3D data – Short offset reprocessed
- 3D data – Impedance/AVO/Depth cubes



Step changes and the future

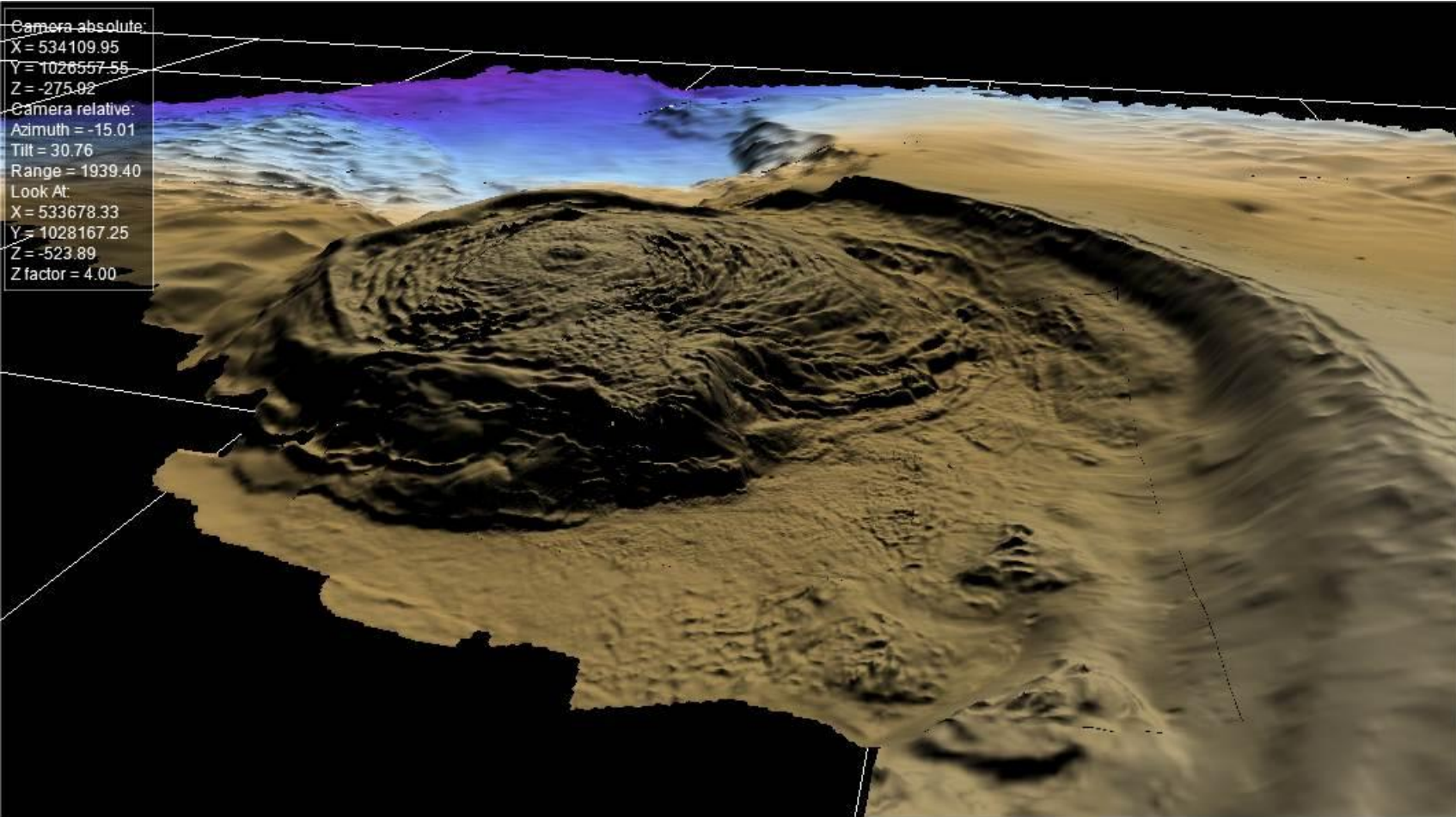
Step Changes

- Multibeam Echo sounders
- AUVs
- Interpretation software
- Visualisation software

Future Developments

- Synthetic aperture sonar systems
- Advances in sub-bottom profilers
- Magnetometer arrays
- Better pooling of information
- Better preparation before survey – desk studies

Improved visualisation



Camera absolute:
X = 534109.95
Y = 1026557.55
Z = -275.92
Camera relative:
Azimuth = -15.01
Tilt = 30.76
Range = 1939.40
Look At:
X = 533678.33
Y = 1028167.25
Z = -523.89
Z factor = 4.00

