

adani

Natural  
Resources

MTOS  
INTELLIGENT MINING SOLUTIONS

# High Resolution non-invasive 2D Shallow seismic survey with portable AWD source for coal exploration

Shanto Mukherjee

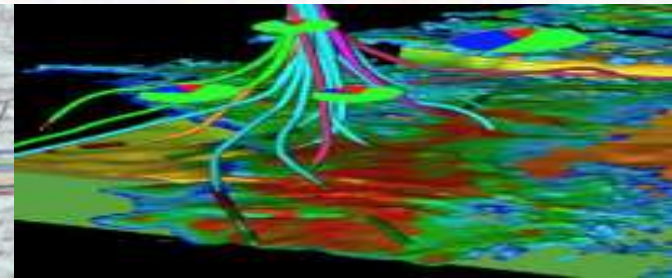
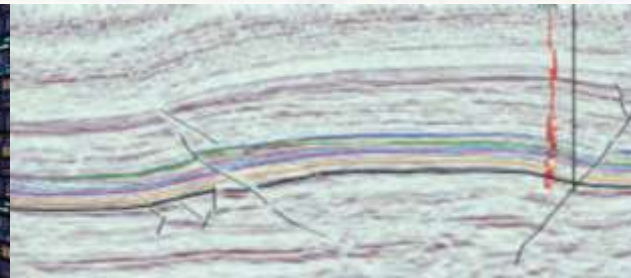
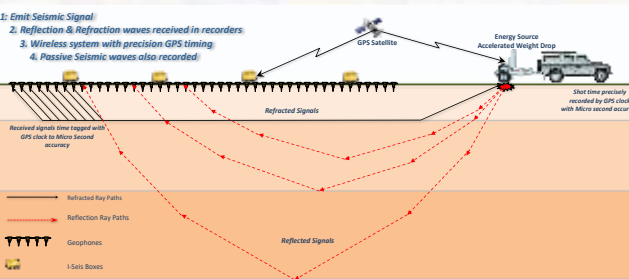
12-Oct-2023



## SPECTACULAR SEISMIC SERVICES

# ALL-IN-ONE SEAMLESS SURVEYS

*Data Acquisition*  
*Data Processing*  
*Data Interpretation*  
*Reservoir Evaluation*  
*Petrophysics Analysis*



## PARTNERS IN CRIME

### Geophysical Services Ltd

- Expertise in seismic data acquisition, processing and interpretation
- Oil & Gas, Mineral and Geotechnical survey capability
- 350 years of combined personnel experience
- Geophysical exploration for Oil & Gas and mining
- Seismic Data Processing
- Seismic Data Analysis
- Seismic Data Interpretation including Volumetrics
- Track record Marine, Land and Transition Zone seismic
- 2D, 3D, 4C, 4D, Reflection, Refraction, Time lapsed seismic
- Health Safety Environment and Quality Management consultants
- Geophysical Consultants
- Survey Design

### AKD GeoMining Ltd

- Expertise in Near Surface geophysics
- Oil & Gas, Mineral and Geotechnical survey capability
- 100 years of combined personnel experience
- Geological, hydrogeological, geophysical exploration & mining
- Mineral block assessment/development
- Geophysical well logging, CBM E & P, ground water investigation, geological mapping and resource evaluation
- 2D CDP seismic reflection survey, gravity-magnetic, magneto telluric, electrical resistivity, EM, MT, GPR, seismic refraction tomography
- In Seam Seismic Survey, exploration/drilling/mining project development & management.
- Expertise in local government, community management & liaison
- Local seismic operations, Technical & Logistical support
- Experienced survey crew and manpower supplier

## CITY SEISMIC PHILOSOPHY



*Spectacular Seismic Services for Field & City operations*

*No accidents*

*No harm to people*

*No damage to the environment*

## COMPANY PROFILE



*Respect and care for local communities,  
Invisible operation to People and Environment.*

*Super High-resolution seismic data*

*All Terrain data acquisition*

## COMPANY PROFILE

- Independent Company based in Singapore, since 2008.
- Strong Track Record
- Providing 2D, 3D, 3C, 4C, 4D Seismic Data Acquisition, Processing & Interpretation
- Oil & Gas, Energy, Tectonic, Geotechnical, Research
- Survey Design and Survey Consultancy Services
- Geophysical Equipment Manufacture
- Exclusive & Non-Exclusive surveys


## CITY SEISMIC

### LATEST CITY SEISMIC TECHNOLOGY

#### IMMEDIATE ALL TERRAIN CAPABILITY

- Asymmetric Shooting (doubling resolution)
- NEW **“DYNAMIC”** Broadband Seismic Capability
- Reflection / Refraction & MASW simultaneous data acquisition
- Integrated Systems Data Interpretation Capability
- Downhole / Cross Seismic Capability
- HRSS Land, Marine & TZ Seismic Capability
- HRSS Cavity Detection using Seismic Attributes
- New Mintox Data Processing Capability

# COMPANY HSE POLICIES

	MD-05
	Pg 1 of 1
<b>Environmental Policy</b>	1 Jan 2022
	Rev No: G

## Environmental Policy

Geophysical Service's goal is no damage to the environment; our challenge is to deliver this along with our services. To achieve this, GSL will conduct all operations based on:

- assessing the local environments in which we work;
- assessing our impact on those environments;
- planning operations to minimise or mitigate those impacts;
- monitoring our performance against those plans;
- complying with applicable laws, regulations and guidance;
- seeking means for continuous improvement.


Our environmental effort will be based on the implementation of six key strategies at work locations:

1. Minimisation of waste by design and purchase.
2. Managing waste output to follow best environmental practice.
3. Guarding against accidental and operational pollution.
4. Provision for mitigation of any accidental and operational pollution.
5. Following best practice for minimising disturbance to marine life.
6. Site remediation after operations where necessary.

All personnel have an important part in achieving our environmental goal, from managers planning and supervising operations to workers following the procedures put in place.



Andy Cunningham  
General Manager  
1 January 2022

	MD-04
	Pg 1 of 1
<b>Health and Safety Policy</b>	01 Jan 2022
	Rev No: G

## Health and Safety Policy

No activity is more important than ensuring practical and effective measures are in place to protect the health and safety of our employees, contractors and customers. In implementing this policy, GEOPHYSICAL SERVICES will not only comply with relevant legislation but also encourage other initiatives for protecting the health and safety of those affected by its activities.

GEOPHYSICAL SERVICES recognize the importance of the involvement and commitment of management and the responsibility of each employee in the application of this policy. The personal safety and health of each employee is of primary importance. The prevention of occupationally induced injuries and illnesses are of such consequence that it will be given priority over operating productivity when necessary. To the greatest degree possible, management will provide all mechanical and physical facilities required for personal safety and health in keeping with the highest standards, while taking into account national security movement.

### Our Safety and Health program will involve:

- Providing workplaces and equipment that are fit for purpose and safe to use;
- Developing safe working procedures so work may be conducted with minimum practicable risk;
- Providing necessary Personal Protective Equipment (PPE) and instruction for its use and care;
- Providing training in the use of work equipment, procedures and protective equipment;
- Conducting Safety and Health inspections to find and eliminate unsafe working conditions and practices;
- Controlling health hazards and comply fully with Safety and Health standards;
- Requiring safe working and cooperation in H&S matters as condition of employment;
- Investigating every incident to determine its cause and to correct the problem to prevent its recurrence.

Management accepts responsibility for leadership of the Safety and Health Program, for its effectiveness and improvement, and for providing the safeguards required to ensure that every worksite is a safe worksite.


### Right to Stop Work

Regardless of their position in the company, all employees are empowered to **stop any work they deem to be unsafe**.

Furthermore, they are authorized to do so with freedom from any possibility of retribution and with the full support of senior management.



Andy Cunningham  
General Manager  
1 January 2022

	MD-02
	Pg 1 of 1
<b>Quality Assurance Policy</b>	1 Jan 2022
	Rev No: G

## Quality Assurance Policy

Geophysical Services is committed to providing quality products and services to its clients in a consistent and well-defined manner. The company recognises that to achieve this it must be capable of identifying problem areas, defining solutions, implementing suitable corrective measures and subsequently reviewing the effects of such changes; also that this process needs to be a continuous and integral part of its operations. In order to achieve this, the company has chosen to adopt the internationally recognised ISO 9001 standard - "Quality Management System - Requirements" as the basic minimum requirement of its management systems.

The company acknowledges that it is through its employees that the quality of the company's products and services is realised. Therefore, the company will devote resources to the advancement of all individuals' knowledge, including quality issues through training and direct involvement.

Geophysical Services also acknowledge that their suppliers in turn can have a direct influence on the final quality of associated products and services, as such the company will require vendors and sub-contractors to provide adequate assurances of their own quality prior to engagement.

All employees are expected to make themselves aware of and perform their individual responsibilities within the quality system as defined in their personal standards of performance and relevant procedural documentation. At the same time each is to be given the freedom to suggest and implement, upon approval, modifications and improvements to the system, thus ensuring their involvement in the company's progress along the quality route.

To maintain the relevance and adequacy of all policies, guidelines and procedures, they will be subject to continuous evaluation at all levels within the company by means of internal quality audits and reviews. Such corrective actions and reviews will be documented to confirm the operation of the quality system.

The members of the top management team acknowledge the importance of having commitment to quality at the highest level and hereby endorse the contents of the company quality assurance and procedures manuals.

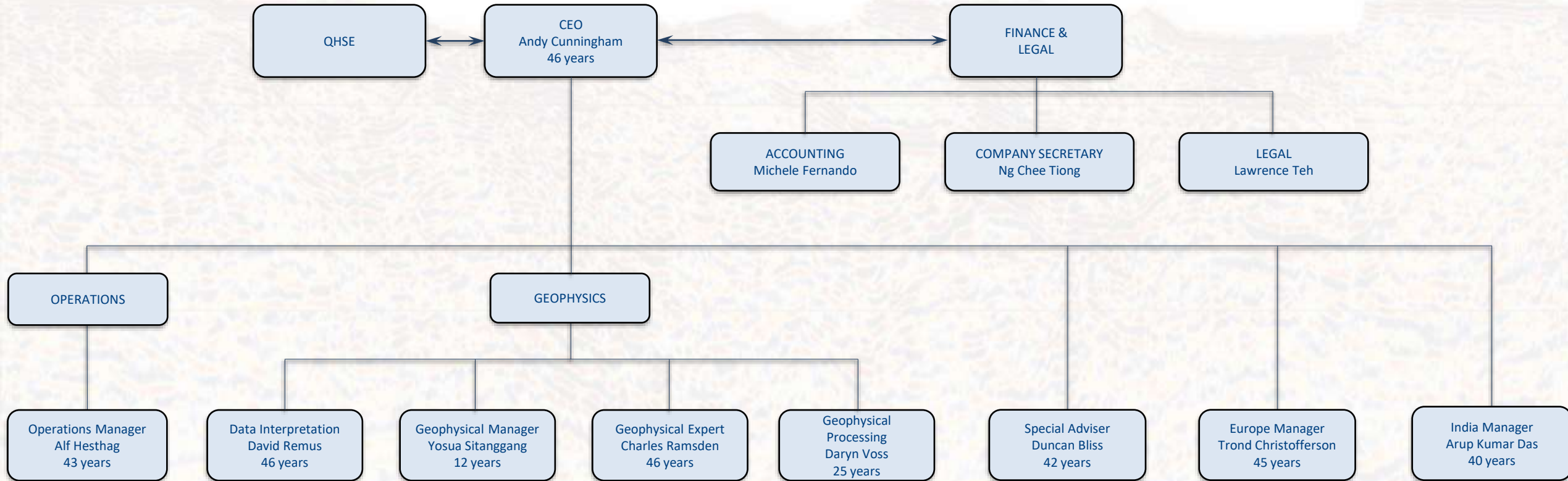


Andy Cunningham  
General Manager  
1 January 2022



# BUSINESS ORGANISATION

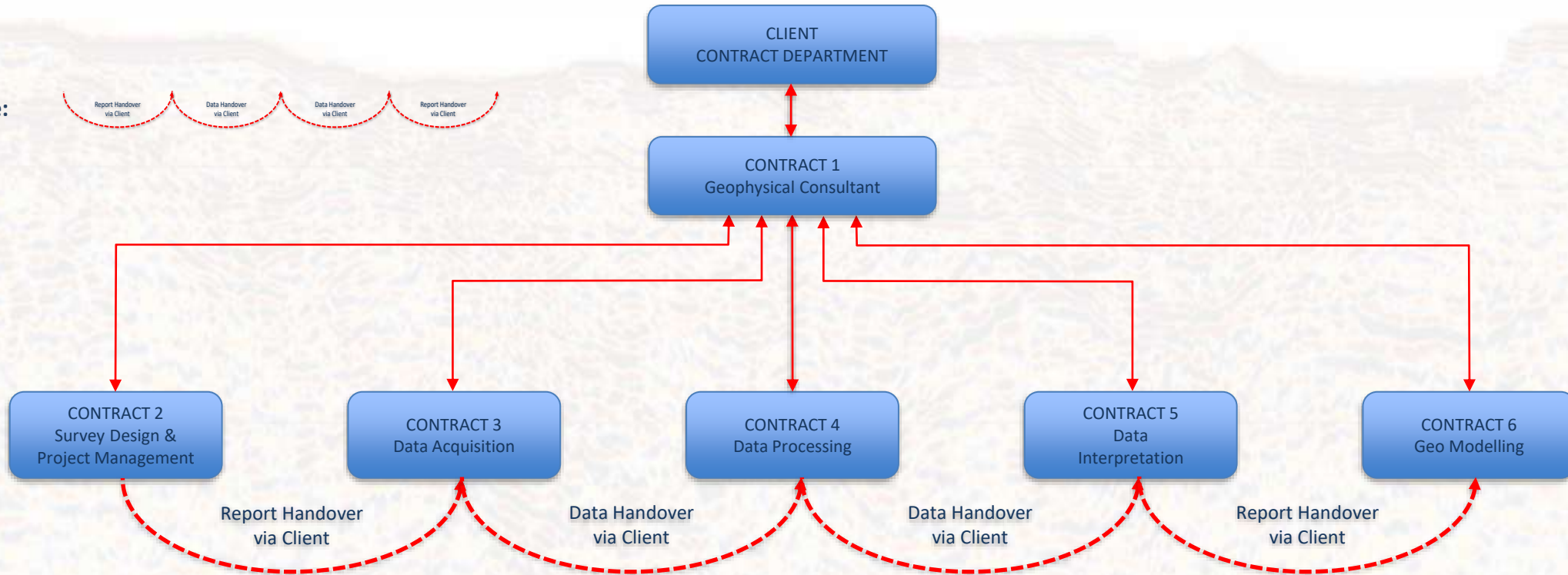
## Experience



# SEAMLESS vs TRADITIONAL

## TRADITIONAL (Obsolete) SURVEY FLOW CHART

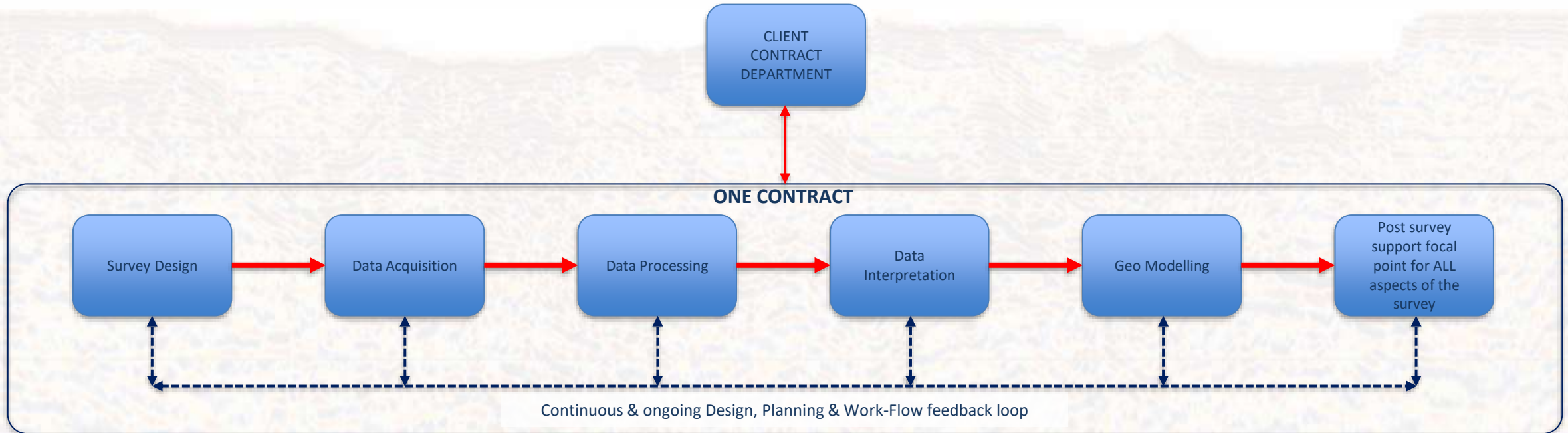
Product Line:



- Must engage SURVEY DESIGN consultant. (Typical cost \$25 - 45K)
- Almost zero through Product LINE communication.
- POTENTIAL for “Error & Blame” between the contractors
- FIVE Contracts for Client to manage.
- FIVE separate support lines (instead of one focal point)
- Client has to handover each product (BLIND) to the next contractor in line
- Need Seismic Consultant to oversee the process (Budget US\$1K / day = US\$90K)
- **SIGNIFICANT ROOM FOR ERRORS THROUGHOUT THE PROCESS TOO**

# SEAMLESS vs TRADITIONAL

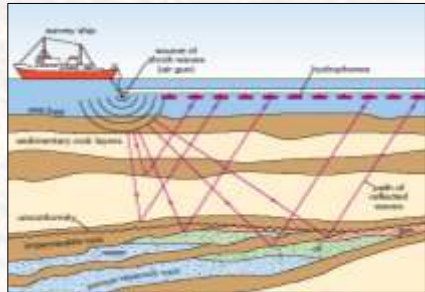
## SEAMLESS SURVEY FLOW CHART



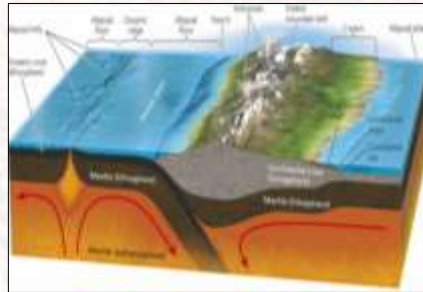
- Continuous feedback and design loop throughout entire process from Survey inception to delivery of final product.
- Process totally transparent from beginning to end.
- Problems or issues through the process can be identified and resolved before an event happens.
- Survey design is therefore Optimal for Client objectives.
- Shared experience from beginning to end.
- Only **ONE contract to manage**, means client has only one sixth of the contract effort.

# WHAT ARE SEISMIC SURVEYS USED FOR?

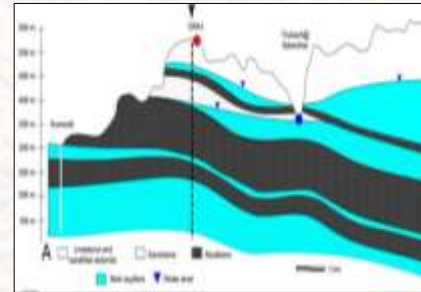
**Oil & Gas Exploration**  
2D 3D 4D Wireless seismic



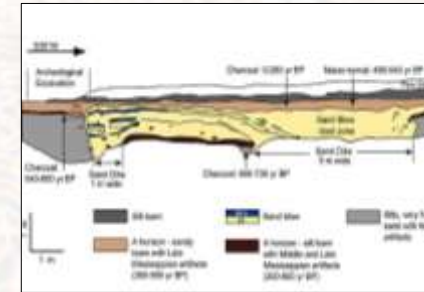
**Plate Tectonics Studies**  
(Regional hazards, i.e. tsunami earthquake)



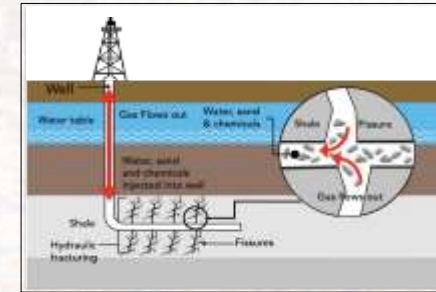
**Hydrology**  
Water storage / exploration



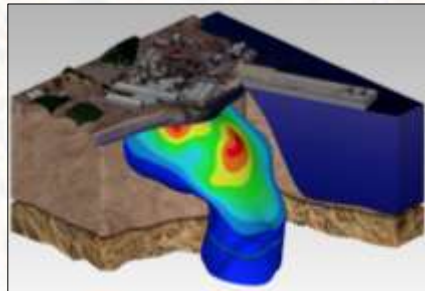
**Archaeology**  
Seismic before construction



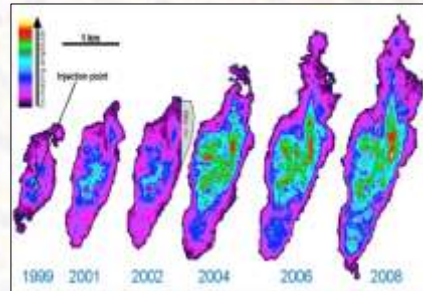
**Shale Gas**  
Exploration and site hazard assessment



**Earth Volumetrics**  
For quantity surveying



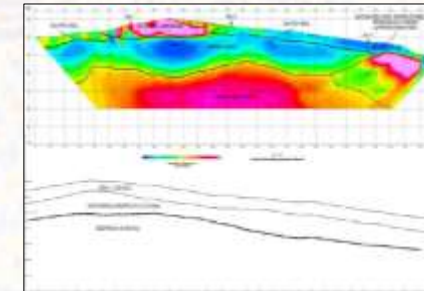
**4D for MRT Ground improvement assessment**



**Mining**



**Geotechnical**  
i.e. MRT subway and construction hazards



**Wind Farm**  
site hazard assessment



## ADDED VALUE OF USING CITY SEISMIC TECHNOLOGY

### IMMEDIATE ALL TERRAIN CAPABILITY

#### Economy

- More data same budget.
- Operations and Business risk reduced

#### Operations & Data Quality

- Greater fold coverage = higher quality data
- Signal to Noise ratio dramatically improved
- Refraction - Reflection - MASW simultaneous data collection
- Greater operational flexibility, i.e. can reposition lines to adapt to a dynamic condition.

#### Data recording 24/7

- Meaning reflected and or refracted shot can be extracted with ease
- Bad shots can be rejected
- Additional shots can be added
- Can detect earth movements (i.e. tremors)

## ADDED VALUE OF USING CITY SEISMIC TECHNOLOGY

### Environment, Health, Safety, Security and Quality

#### No Explosive - Hazard removed!

- Zero shot holes
- Water table damage eliminated
- No Security requirement
- No explosive license requirement

#### No large Vibroseis or Weight Drop

#### Low Impact

- Less noise
- Less visible
- Can work in almost any environment  
(City, Forest, Reserves, schools etc etc)

#### No need for mass labor

- Less man hours means less exposure to hazards
- Less time required to complete the work.

## ADDED VALUE OF USING CITY SEISMIC TECHNOLOGY

### Social Impact Actual & Perceived is Minimized

- Less visible operation
- Lower profile to 3<sup>rd</sup> parties i.e. NGOs
- Less disruption to local environment
- Reduced social turbulence / disruption

### Borehole Campaign Design

- Data can be used to design a Strategic Borehole campaign
- Minimize borehole drilling
- Acquire data where boreholes cannot go

### Infill Tool

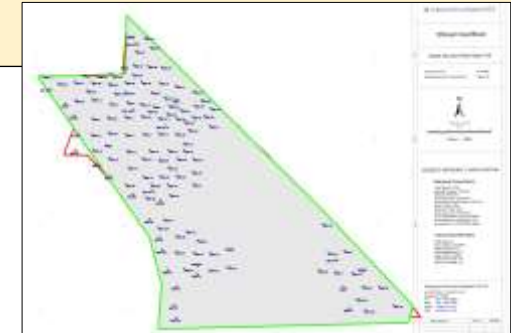
Can infill areas where normal access is not available

- Infill in villages and kampongs
- Infill in the city
- Infill in protected areas

# ADDED VALUE OF USING CITY SEISMIC TECHNOLOGY

## BOREHOLE COST VERSUS SEISMIC COST

COST SAVINGS USING SEISMIC (LOSELY BASED ON DHIRALI EXPERIENCE & DHIRALI BOREHOLE DENSITY)																				
Borehole cost / Meter	₹ 3,500 = \$50.00																			
Borehole depth in meters	450																			
Borehole Density / Sq Kms (Optimal)	11																			
Borehole density with Seismic / Sq kms	2																			
Seismic costs / Sq Kms Approx	\$25,000																			
Square KMs	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Borehole requirement No Seismic BH / Sq Kms	11	22	33	44	55	66	77	88	99	110	121	132	143	154	165	176	187	198	209	220
Borehole requirement with Seismic	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
Seismic ONLY Costs / Sq Kms (Approx). US\$ 1000s	\$25	\$50	\$75	\$100	\$125	\$150	\$175	\$200	\$225	\$250	\$275	\$300	\$325	\$350	\$375	\$400	\$425	\$450	\$475	\$500
Borehole Cost without Seismic US\$ 1000s	\$248	\$495	\$743	\$990	\$1,238	\$1,485	\$1,733	\$1,980	\$2,228	\$2,475	\$2,723	\$2,970	\$3,218	\$3,465	\$3,713	\$3,960	\$4,208	\$4,455	\$4,703	\$4,950
Borehole & Seismic combined cost w/reduced no. of Boreholes US\$ 1000s	\$45	\$90	\$135	\$180	\$225	\$270	\$315	\$360	\$405	\$450	\$495	\$540	\$585	\$630	\$675	\$720	\$765	\$810	\$855	\$901
<b>TOTAL COST SAVINGS. US\$ 1000s</b>	<b>\$202</b>	<b>\$405</b>	<b>\$607</b>	<b>\$810</b>	<b>\$1,012</b>	<b>\$1,215</b>	<b>\$1,417</b>	<b>\$1,620</b>	<b>\$1,822</b>	<b>\$2,025</b>	<b>\$2,227</b>	<b>\$2,430</b>	<b>\$2,632</b>	<b>\$2,835</b>	<b>\$3,037</b>	<b>\$3,240</b>	<b>\$3,442</b>	<b>\$3,645</b>	<b>\$3,847</b>	<b>\$4,050</b>





# COMPANY TRACK RECORD ACQUISITION & PROCESSING



Area	Project description	Client	Type	Objective	Depth Meters	Group Length	Cable Length Meters	Number channels
Indonesia	Nuclear Power Plant Geological study	PT Surveyor	2D Land	Granite foundation assessment	0 to 3000	12.5 meters	4500	200
Indonesia	Oil gas survey	Sumatra Lampung	2D Land	Oil & Gas	0 - 2000	12.5 meters	4500	200
Singapore	Pipeline detection	Singapore PUB	2D Land	Pipeline detection	0 - 50	0.3 meters	30	90
Singapore	Geological study to identify bedrock	Singapore BCA	2D Land	Rockhead identification	0 - 600	6.25 meters	1125	180
Singapore	Seismic 3D survey for MRT tunnel path	Singapore LTA	3D Land	Rockhead identification	0 - 200	2.5 meters	450	180
Indonesia	2D seismic survey	Conoco-Phillips	2D Land	Oil & Gas	0 - 2000	12.5 meters	4125	330
Singapore	2D seismic survey	GSL Multi Client	2D Land	Geology Study of Singapore	0 - 3000	12.5 meters	4125	300
Singapore	5 * 3D seismic survey	Singapore LTA	3D Land	Rockhead identification	0 - 200	2.5 meters	450	180
Singapore	Marine Seismic Survey	Singapore Multi	2D Marine	Geology Study of Singapore	0 - 1000	3.125 meters	200	64
Singapore	Land Seismic Survey	TriTech	2D Land	Rockhead identification	0 - 50	1.0 meters	135	135
Singapore	Land Seismic Survey	NUS / PUB	2D Land	Geology Study of Singapore	0 - 500	5.0 meters	2000	250
Singapore	Land Seismic Survey	Shimizu	2D Land	Hazard Identification and geology mapping	0 - 200	1.0 meters	180	180
Singapore	Land Seismic Survey	Shanghai Tunnel	2D Land	Hazard Identification and geology mapping	0 - 200	0.5 meters	180	180
Singapore	Seismic 3D survey for MRT tunnel path	Singapore LTA	3D Land	Rockhead identification	0 - 200	2.5 meters	450	180
Singapore	Seismic 2D survey for MRT tunnel path	Daewoo	2D Land	Hazard Identification and geology mapping	0 - 200	2.5 meters	300	180
Singapore	Seismic 2D survey for MRT tunnel path	China Railway	2D Land	Ground Improvement assessment	0 - 200	2.5 meters	450	180
Singapore	Seismic 2D survey for MRT tunnel path	Samsung	2D Land	Hazard Identification and geology mapping	0 - 200	2.0 meters	450	180
Singapore	Penta Hyundai Boskalis	Penta Hyundai	3D Marine	Cavity Detection & Geological mapping	0 - 100	1.0 meters	30	60
Singapore	Pulau Bukom Pipeline Survey	Shell / Geometra	2D Marine & TZ	Hazard Identification and geology mapping	0 - 100	1.0 meters	30	60
Singapore	Granite Rock Survey / Woodlands	LS Cable Korea	2D Marine	Hazard Identification and geology mapping	0 - 100	1.0 meters	30	60
Singapore	4D seismic / Ground Improvement	Daewoo	3D/4D Land	Ground Improvement assessment	0 - 100	1.0 meters	3 x 80 meters	240
Hong Kong	Ultra High Res Wide Azimuth 3D	Shanghai Tunnel	UHR 3D Land	Hazard Identification and geology mapping	0 - 200	0.5 meters	180	180
India	2D & 3D Reflection Seismic with FWI	ADANI COMPANY	2D/3D Land	Coal Reserve evaluation and Mine Development	0 - 100	1.0 meters	3 x 80 meters	240

ACQUISITION

Area	Designation	Project description	Client	Depth Meters	Length or Area	Group Interval
Mongolia	Gobi Coal exploration	2D Land Survey for coal	Geocon	0-500	90 km	5
Australia	Otway	2D Land Survey for oil/gas	VicPet	0-4000	600 km	10
Australia	Macintyre 2D	2D Land Survey for various targets	Multi-client	0-3000	333 km	20
Turkey	Anatalya gas exploration	2D Land Survey for various targets	Geocon	0-1000	340 km	5
Australia	Gunnedah Basin 2D	2D Land Survey, gas	Multiclient	0-3000	399 km	20
Australia	Various 2D projects	2D Land Survey for oil/gas	MBA Petroleum	0-3000	200 km	15
Australia	Hunter 2D	2D Land Survey for CSG	Multiclient	0-3000	92 km	10
Australia	Moree North	2D Land Survey for oil/gas	Eastern Star	0-3000	102 km	10
Vietnam	Orchard Energy 3D	3D Marine Survey for oil/gas	Temasek	0-6000	62 square km	12.5
Thailand	Bangkok 3D	3D Land Survey, various targets	Mitra	0-3000	52 square km	12.5
Brunei	Blok M	2D Land Survey for oil/gas	Tap Oil	0-3000	70 km	12.5
Pakistan	Khangarh 2D	2D Land Survey for oil/gas	Dewan Petroleum	0-3000	720 km	10
Thailand	Block L15/50	3D Land Survey for oil/gas	Salamander Energy	0-6000	232 square km	25
Indonesia	West Bangka	2D Land/Marine/Trans Nuclear power plant study	GSS	0-2000	35 km	12.5
Australia	Bass Strait 2D	2D Marine Survey for oil/gas	Tap Oil	0-6000	52 km	12.5
Uzbekistan	Ustyurt/Tashkent	2D Land Survey for oil/gas	Geocon	0-5000	3100 km	12.5
New Zealand	Taranaki Well tie	2D Marine Survey for oil/gas	NZOG/Multiclient	0-6000	2800 km	12.5
Pakistan	Rukanpur	2D Land Survey for oil/gas	Dewan Petroleum	0-3000	365 km	10
Pakistan	Noorsouth	2D Land Survey for oil/gas	Dewan Petroleum	0-3000	620 km	10
Pakistan	Johi	2D Land Survey for oil/gas	OGIL	0-3000	84 km	10
Australia	Reg Sprigg 3D	3D Land Survey for oil/gas	Multiclient	0-3000	90 square km	20
India	Well-tie survey	2D Land Survey for oil/gas	Oil India	0-4000	1200 km	12.5
Malawi	Malawi 2D	2D Lacustrine survey, various targets	Beach Energy	0-2000	100 km	6.25
Indonesia	Sumatra Lampung	2D Land Survey for oil/gas	GSS	0-1000	60 km	12.5
Indonesia	Kualakurun	2D Land Survey for oil/gas	ConocoPhillips/GSS	0-1000	100 km	12.5
Singapore	Railway 2D	2D Land Survey, various targets	GSS	0-500	28 km	12.5
Pakistan	Safaidkoh	2D Land Survey for oil/gas	Dewan Petroleum	0-3000	200 km	10
Pakistan	Yazman	2D Land Survey for oil/gas	Dewan Petroleum	0-3000	180 km	10
UAE	Umm Al Quwain 2D	2D Land Survey for oil/gas	Quest	0-8000	420 km	12.5

PROCESSING

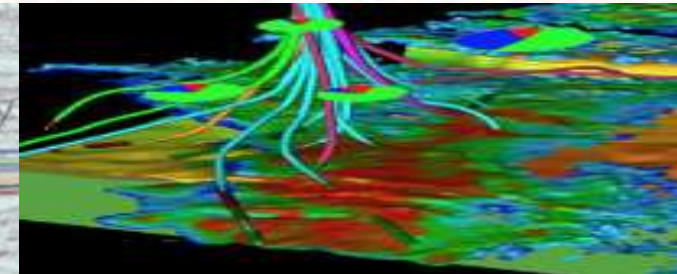
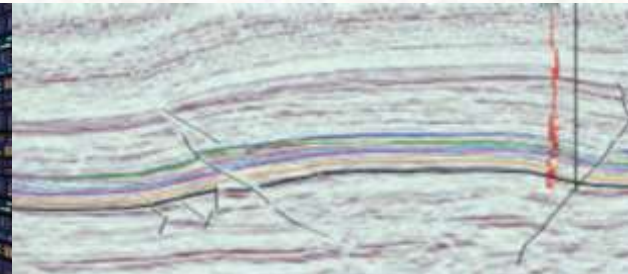
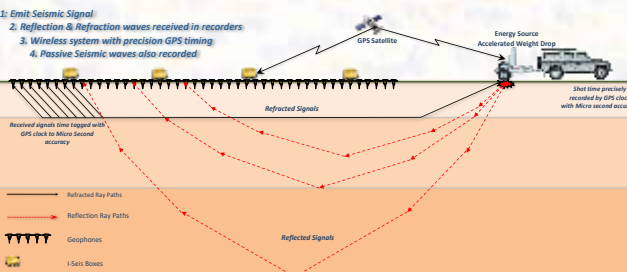
Area	Project description	Client	Target Depth (Meters)	Group Length / Interval	Cable Length Meters	Number of channels
Indonesia	Nuclear Power Plant Geological study	PT Surveyor Indonesia	0 to 3000	12.5 meters	4500	200
Indonesia	Oil gas survey	Sumatra Lampung	0 - 2000	12.5 meters	4500	200
Singapore	Pipeline detection (to within 5 centimetres accuracy)	Singapore PUB	0 - 50	33.3 centimetres	30	90
Singapore	Geological study to identify bedrock	Singapore BCA	0 - 600	6.25 meters	1125	180
Singapore	Seismic 3D survey for MRT tunnel path	Singapore LTA	0 - 200	2.5 meters	450	180
Indonesia	2D seismic survey	Conoco-Phillips	0 - 2000	12.5 meters	4125	330
Singapore	2D seismic survey	GSL Multi Client Survey	0 - 3000	12.5 meters	4125	300
Singapore	5 * 3D seismic survey	Singapore LTA	0 - 200	2.5 meters	450	180
Singapore	Marine Seismic Survey	Singapore Multi Client	0 - 1000	3.125 meters	200	64
Singapore	Land Seismic Survey	TriTech	0 - 50	1.0 meters	135	135
Singapore	Land Seismic Survey	NUS / PUB	0 - 500	5.0 meters	2000	250
Singapore	Land Seismic Survey	Shimizu	0 - 200	1.0 meters	180	180
Singapore	Land Seismic Survey	Shanghai Tunnel company	0 - 200	0.5 meters	180	180
Singapore	Seismic 3D survey for MRT tunnel path	Singapore LTA	0 - 200	2.5 meters	450	180
Singapore	Seismic 2D survey for MRT tunnel path	Daewoo	0 - 200	2.5 meters	300	180
Singapore	Seismic 2D survey for MRT tunnel path	China Railway	0 - 200	2.5 meters	450	180
Singapore	Seismic 2D survey for MRT tunnel path	Samsung	0 - 200	2.0 meters	450	180
Singapore	Seismic 2D survey for MRT tunnel path	China Railway	0 - 200	2.5 meters	450	180
Singapore	Seismic 2D survey for MRT tunnel path	Samsung	0 - 200	2.0 meters	450	180

INTERPRETATION

Area	Project description	Client	Project Size
North West Shelf	Vulcan Graben 3D/2D-Offshore	Confidential	>10000 km 2D/3D
Poseidon /Kronos	3D Mapping For Reserves Estimation-Offshore	Confidential	>2000 sq. km.
Sarawak	Regional Exploration Mapping-Offshore	Confidential	>10000 km 2D/3D
Nam Con Son	Regional Exploration Mapping-Offshore	Confidential	>10000 km 2D/3D
Gulf Of Thailand	Regional Exploration Mapping-Offshore	Confidential	>10000 km 2D/3D
Straits Of Singapore	Singapore Marine Multi Client 2D	GSL	~30 km
Singapore	Land Seismic Survey	Shanghai Tunnel company	~2.5 km
Singapore	Seismic 3D survey for MRT tunnel path	Singapore LTA	~500 sq m
Singapore	Seismic 2D survey for MRT tunnel path	Daewoo	~500 m
Singapore	Seismic 2D survey for MRT tunnel path	China Railway	~500 m
Singapore	Seismic 2D survey for MRT tunnel path	Samsung	~500m
Singapore	Cavity Detection & Geological mapping	Penta Hyundai Boskalis	10,000m
Singapore	Hazard Identification and geology mapping ahead of Pipeline	Shell / Geometra	15,000m
Singapore	Hazard Identification and geology mapping ahead of Pipeline	LS Cable Korea	6500m
Singapore	Ground Improvement assessment	Daewoo	~500m
Singapore	Hazard Identification and geology mapping ahead of tunneling	Shanghai Tunnel company	2500m
Singapore	Coal Reserve evaluation and Mine Development planning	ADANI COAL COMPANY	120 line kms

INTERPRETATION

## GSL/AKD SEISMIC SURVEY CAPABILITIES



## WIRELESS RECORDING SYSTEM DEPLOYMENT CAPABILITIES



Coastal Areas



Transition Zone



Construction Sites



Jungles



Oil & Gas



Condominiums



Traffic Junctions



Between Road Lanes



Side of Road Lanes



Mining

# NUSEIS - WIRELESS RECORDING SYSTEM CAPABILITIES



## NuSeis™ NRU 1C™ Specs

<p><b>Seismic Data Channel</b> 1C (available 3C in Q3 2019)</p> <p><b>ADC Resolution</b> 24 bit Delta Sigma</p> <p><b>Sample Interval</b> 0.5ms, 1ms, 2ms, 4ms 0.25ms 0.125ms</p> <p><b>Preamplifier Gain</b> Programmable 0dB to 43dB in 6dB steps</p> <p><b>Anti-alias Filter</b> • 206.5Hz @2ms, 413 Hz @1ms • Linear Phase or Minimum Phase</p> <p><b>Low Cut Filter</b> None</p> <p><b>Operating Temperature Range</b> -40° C to +75° C</p> <p><b>Operational Autonomy</b> • 560 Hours • 12 Hours per day: 46 days • 24 Hours per day: 23 days</p> <p><b>Weight</b> 690 kg, 1.5 lbs</p> <p><b>Dimensions</b> • Max 53.5 mm tube, 209 mm long • Max 2.1" tube, 8.23" long</p> <p><b>Battery</b> • 13.4Ah Li-Ion • Charge Temperature Range: 0° C – +45° C • Cycle Life: &gt;500 cycles to 80%</p>	<p><b>Acquisition Channel</b> @2ms sample interval, 25°C, 31.25 Hz</p> <ul style="list-style-type: none"> <li>• Maximum input signal: 1768 mVrms @0dB</li> <li>• Total Harmonic Distortion: 0.0001% @31.25Hz</li> <li>• Instantaneous Dynamic Range: 127dB @2ms</li> <li>• System Dynamic Range: 140dB</li> <li>• Equivalent Input Noise:             <ul style="list-style-type: none"> <li>• 1500 nV @0dB</li> <li>• 400 nV @12dB</li> <li>• 160 nV @24dB</li> </ul> </li> <li>• Gain Accuracy: 0.25% unit to unit</li> <li>• Input Impedance: 20k Ohm</li> <li>• Timing Accuracy: +/- 12.5µsec customizable at client request</li> </ul> <p><b>Instrument Test</b> Internal Noise, Total Harmonic Distortion, Impulse Response</p> <p><b>Sensor Test</b> Resistance, Impedance, Noise</p> <p><b>Sensor</b> • Internal, Single Geophone • 5Hz or 10 Hz +/- 3.5% • 85.8 V/m/s +/- 3.5% • Other geophones available upon request</p> <p><b>Memory</b> 8 GB standard (expandable to 16, 32 or 64 GB)</p>
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Learn More at [geophysicaltechnology.com](http://geophysicaltechnology.com)  
W/specifications subject to change without notice

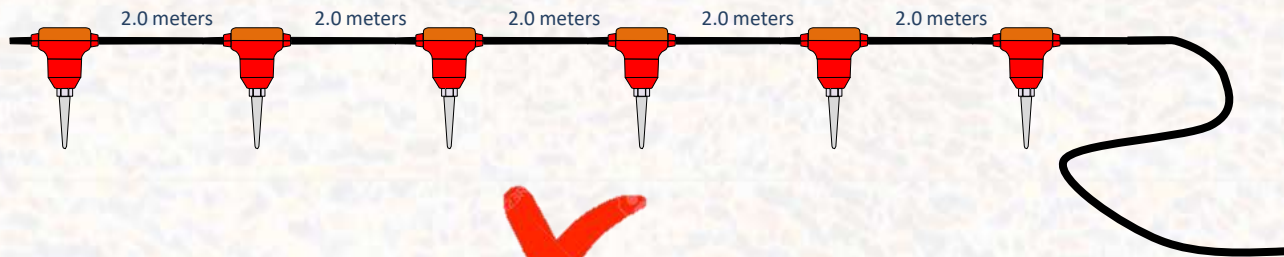


## NU-SEIS IN THE FIELD



# GEPHONE RECEIVER - SM24 VERSUS GEOSPACE-ONE COMPARISON

6 x SM24 geophones in  
Linear Series 10 meters long  
Geophone array

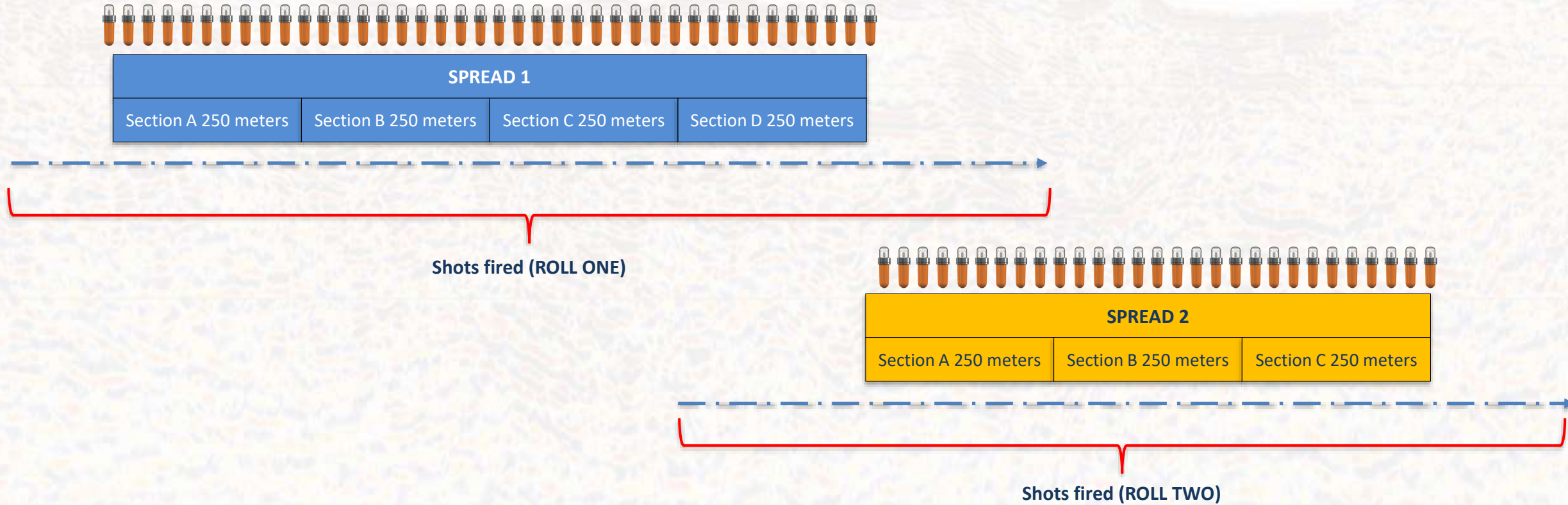


1 x GS-ONE Geophone Single Point



1 x GS-ONE  $\approx$  1 x 6 Elements SM24 String

# DATA ACQUISITION DEPLOYMENT - SPREAD ROLLING OVERVIEW



**LEGEND**



NUSEIS Recording Node Receivers

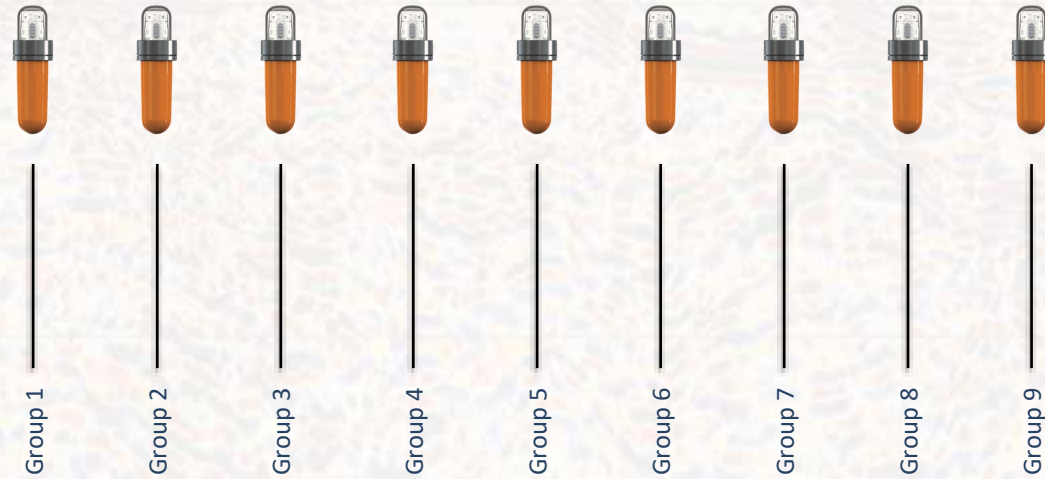
## GSL BROADBAND SEISMIC

- 2D, 3C, 3D, 4C, 4D Capability
- Short group interval for shallow High Resolution
- Able to sum adjacent channels independently in processing for the deeper targets
- Undershoot capability
- Real-time QC using NuSeis system



## GSL BROADBAND SEISMIC

**Shallow Targets <150 meters**  
25 cm to 2 m groups with zero summing  
CDP Interval 12 cm to 1.0 m



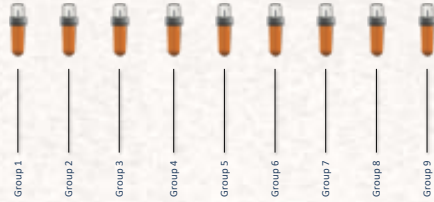
# GSL BROADBAND SEISMIC



Geophysical Services

## DATA ACQUISITION DEPLOYMENT - INDIVIDUAL GROUP SUMMATION (BROADBAND SEISMIC)

Shallow Targets <150 meters  
25 cm to 2 m groups with zero summing  
CDP Interval 12 cm to 1.0 m



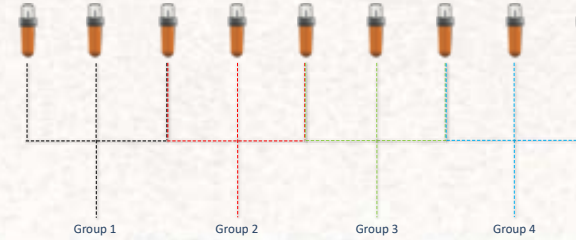
GSL City Seismic



Geophysical Services

## DATA ACQUISITION DEPLOYMENT - INDIVIDUAL GROUP SUMMATION (BROADBAND SEISMIC)

Medium Deep Targets 500 meters  
10 m group - 10 m Interval  
Independent summing in processing  
CDP Interval 2.5 to 5 m



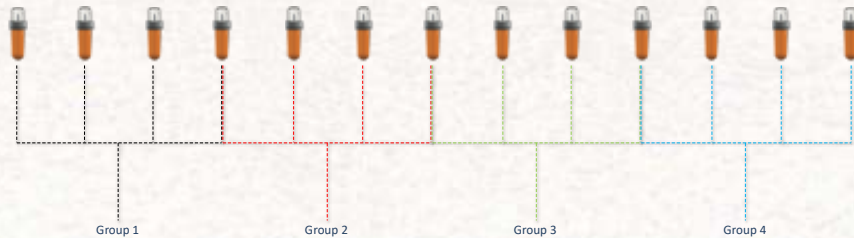
GSL City Seismic



Geophysical Services

## DATA ACQUISITION DEPLOYMENT - INDIVIDUAL GROUP SUMMATION (BROADBAND SEISMIC)

Deeper Targets 1000 meters  
15 m group - 15 m interval  
Independent summing in processing  
CDP Interval 2.5 to 5 m



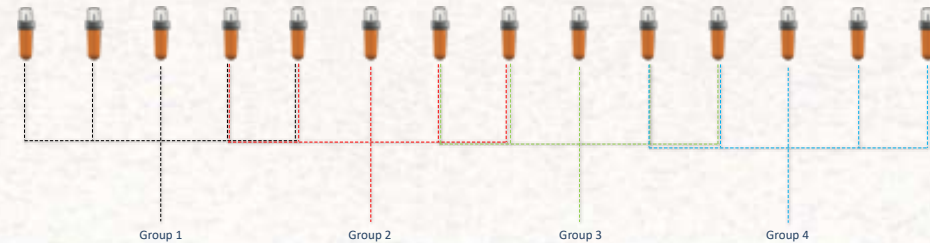
GSL City Seismic



Geophysical Services

## DATA ACQUISITION DEPLOYMENT - INDIVIDUAL GROUP SUMMATION (BROADBAND SEISMIC)

Deeper Targets 1000 meters  
20 m groups - 15 m Interval  
Independent summing in processing  
CDP Interval 2.5 to 5 m



GSL City Seismic



# DATA ACQUISITION METHODOLOGY - DATA RECORDING AND ENERGY SOURCE SYSTEMS

## Energy Source Systems

## Wireless Recording

GSL PSS-100  
Down to 450 m



ESS 100  
Down to 700 m



ESS 500  
Down to 1000 m



ESS 900  
Down to 2000 m



ESS 2000  
Down to 3000 m



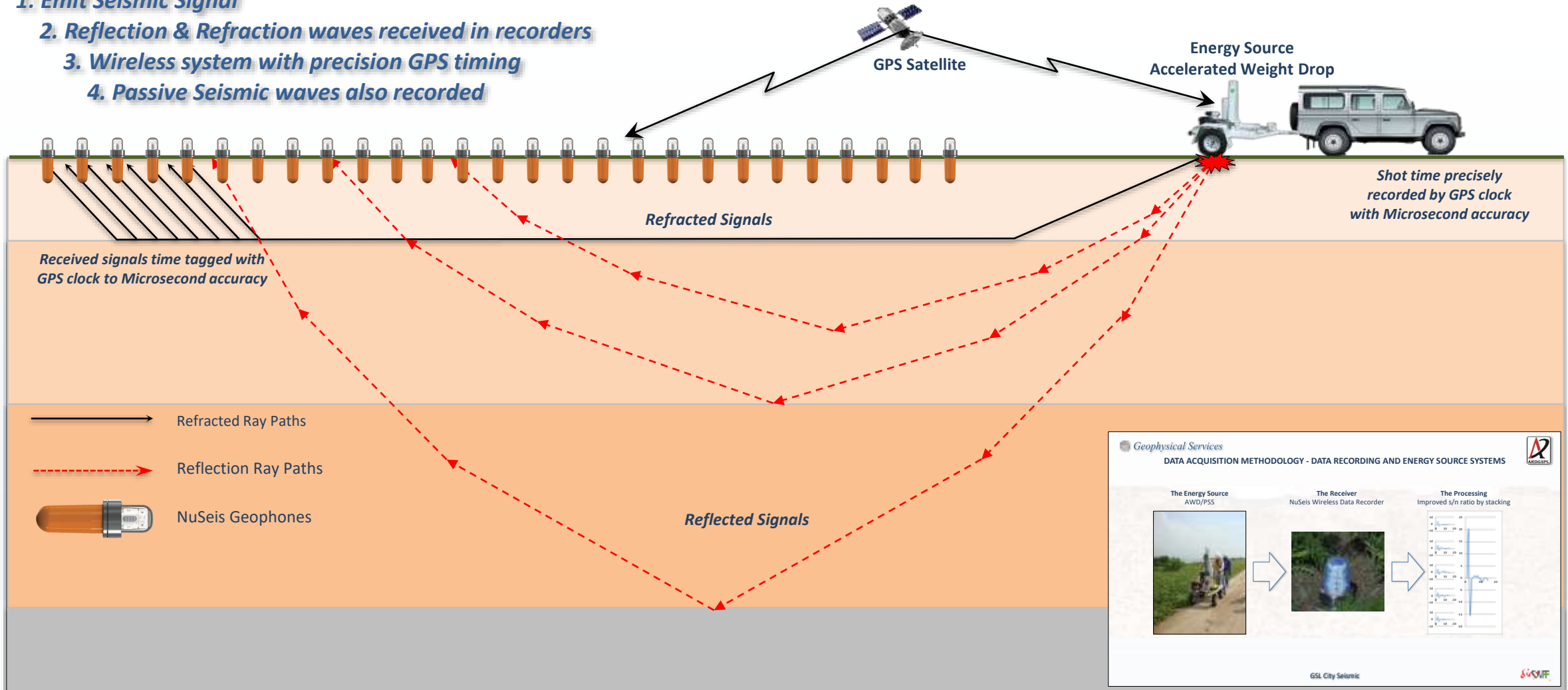
NuSeis NRU



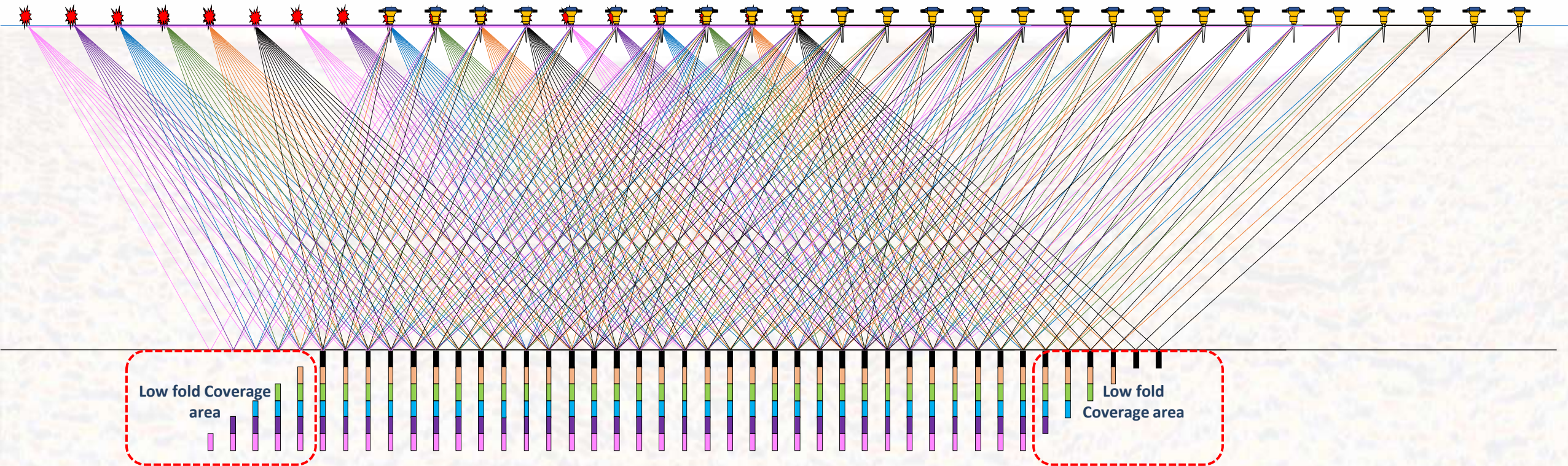
# DATA ACQUISITION METHODOLOGY

## Reflection and Refraction Land Seismic

- 1: Emit Seismic Signal
- 2: Reflection & Refraction waves received in recorders
- 3: Wireless system with precision GPS timing
- 4: Passive Seismic waves also recorded



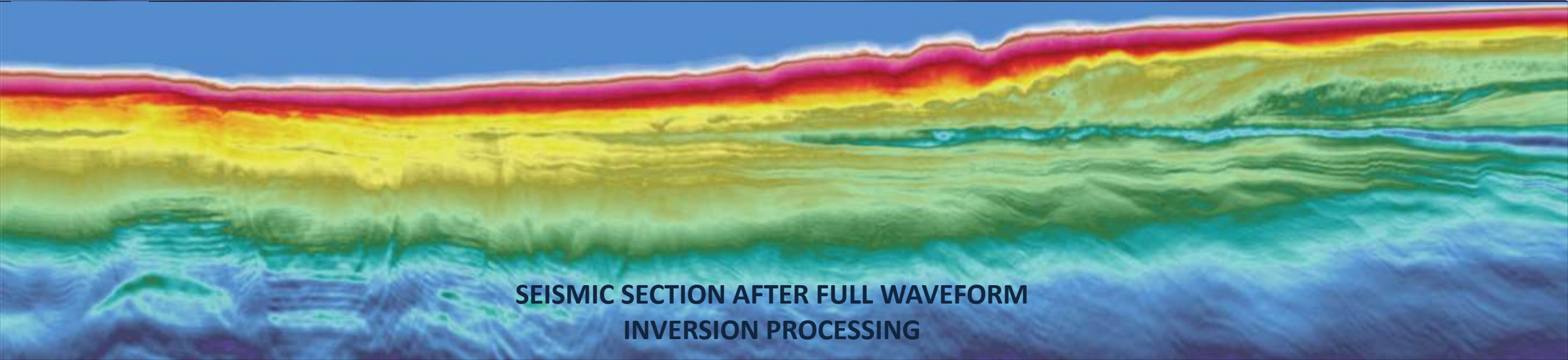
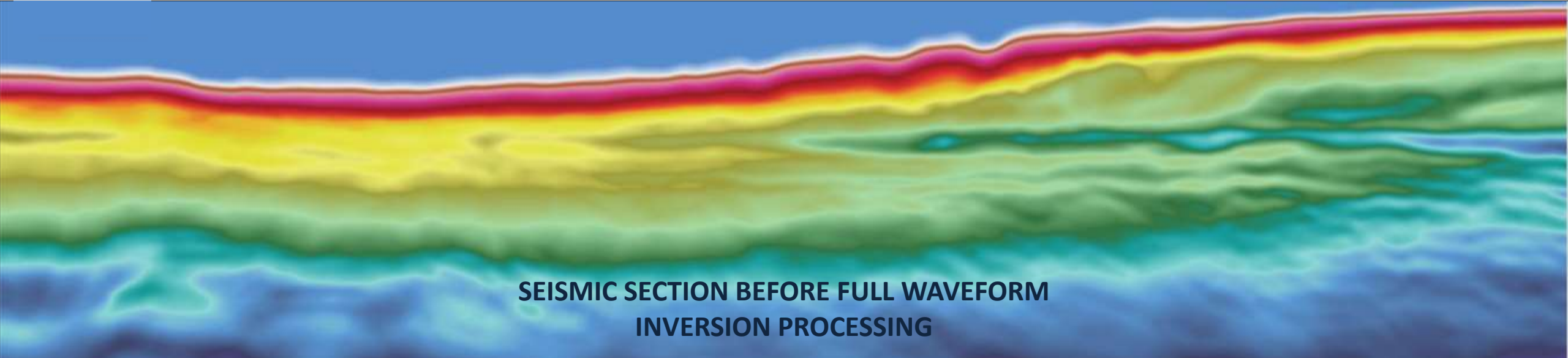
# REFLECTION SEISMIC COVERAGE



Multiple Fold coverage build up – and so on

# **FWI – FULL WAVEFORM INVERSION (ITERATIVE PROCESSING TECHNIQUE)**

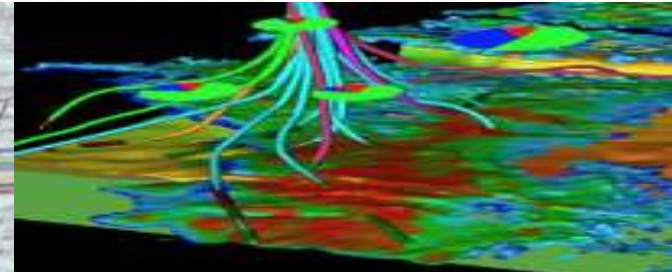
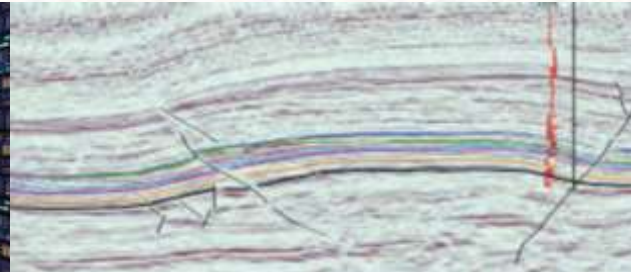
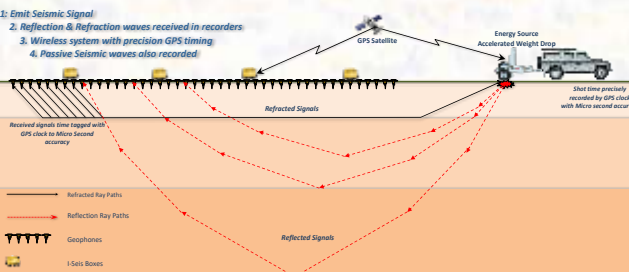
Full Waveform Inversion inverts the data giving a high-resolution earth model (typically velocity), using the entire seismic wavefield



## MAIN ACTIVITY CHALLENGES OVERCOME

- High vehicular traffic density creating seismic interference
- Environmental Issues: Public residential properties, Golf Courses, Nature Reserves
- Security Issues
- Permit issues overcome

## SEISMIC SURVEYS






## HIGH-RESOLUTION CITY SEISMIC SURVEYS



# HIGH-RESOLUTION CITY SEISMIC SURVEYS



Fort Road Singapore

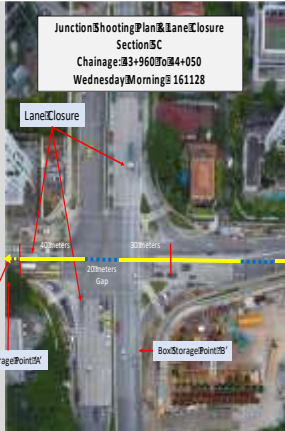
*Geophysical Services*

**TRAFFIC MANAGEMENT PLAN  
FORT ROAD**

- Boreholes impossible in road junction
- Traffic Diversion not permitted as no other ingress/exit routes
- Lane closure time permitted = 20 minutes only

Seismic Equipment ————

Seismic Undershoot - - - - -



Junction Shooting Plan & Lane Closure  
Section 3C  
Chainage: 3+960 To 4+050  
Wednesday Morning @ 161128

Lane Closure

40 meters


20 meters Gap


30 meters


Box Storage Point 1

Box Storage Point 2

Overlap Shots (10m)



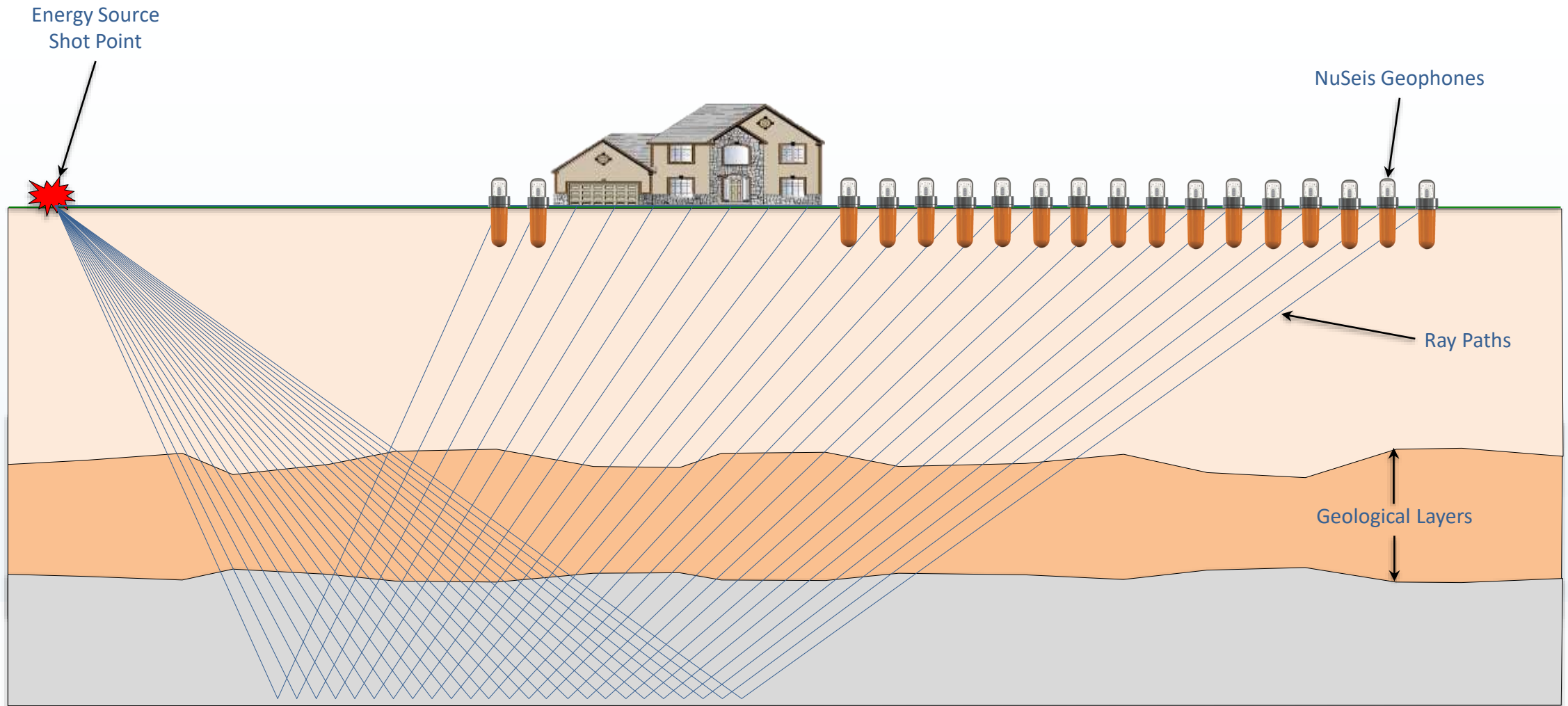




Single MRT tunnel passing below a condominium

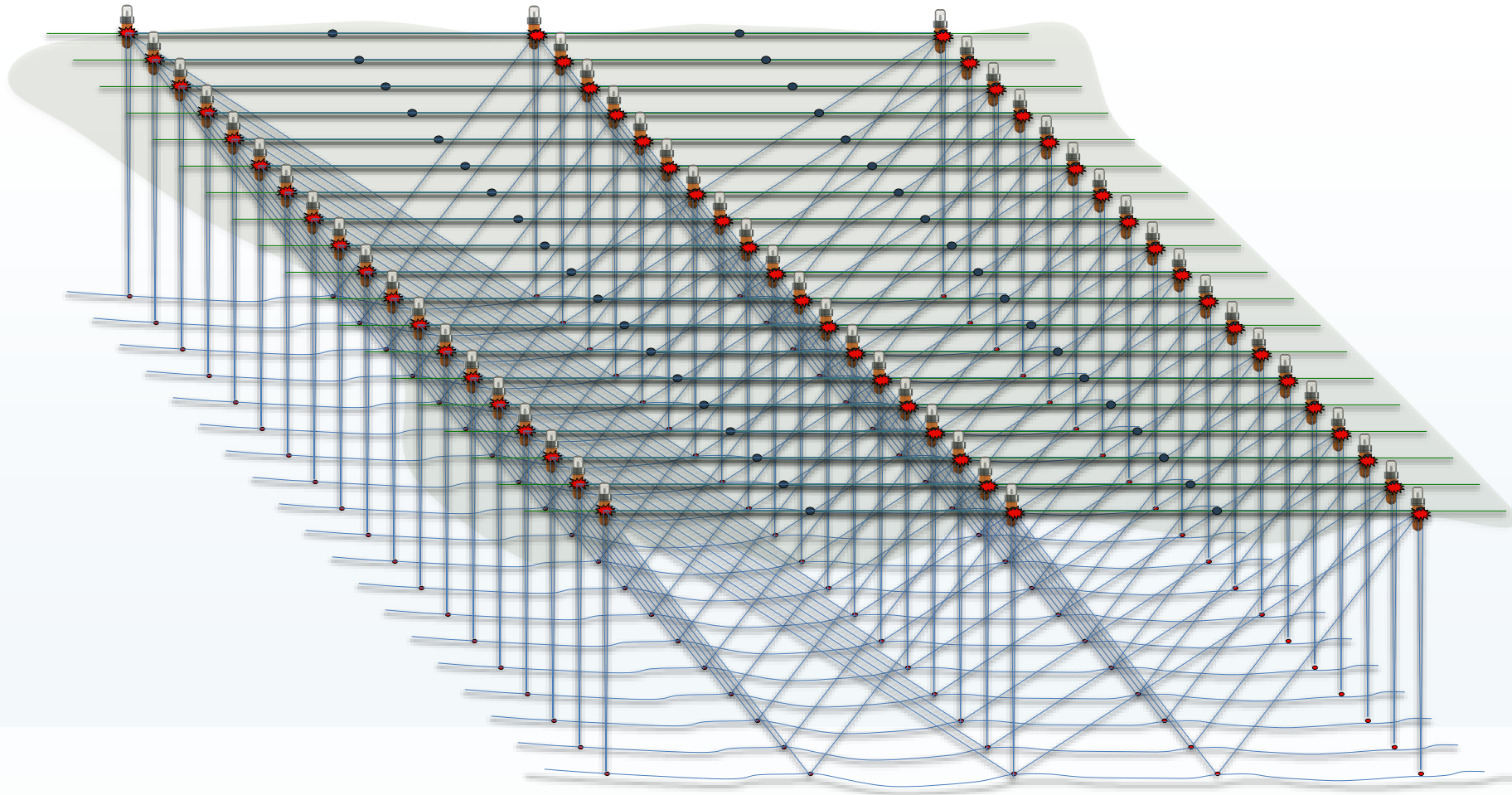
## ADVANTAGES OF GSL CITY SEISMIC TECHNOLOGY

### Undershooting Obstacles with Seismic Surveys

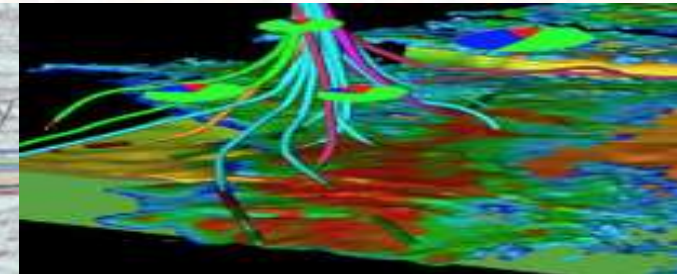
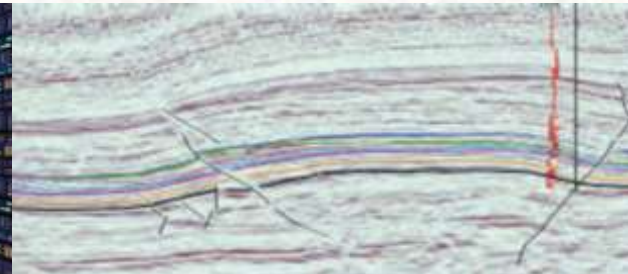
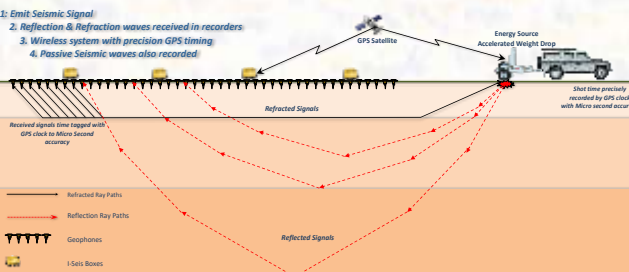


## CAPABILITIES OF GSL CITY SEISMIC TECHNOLOGY

### Triple Cable 3D Shooting Configuration



## DATA SAMPLES AND SURVEY SCENARIOS



# **DHIRALI PROJECT & DATA SUMMARY**

## SUMMARY OF OPERATIONS

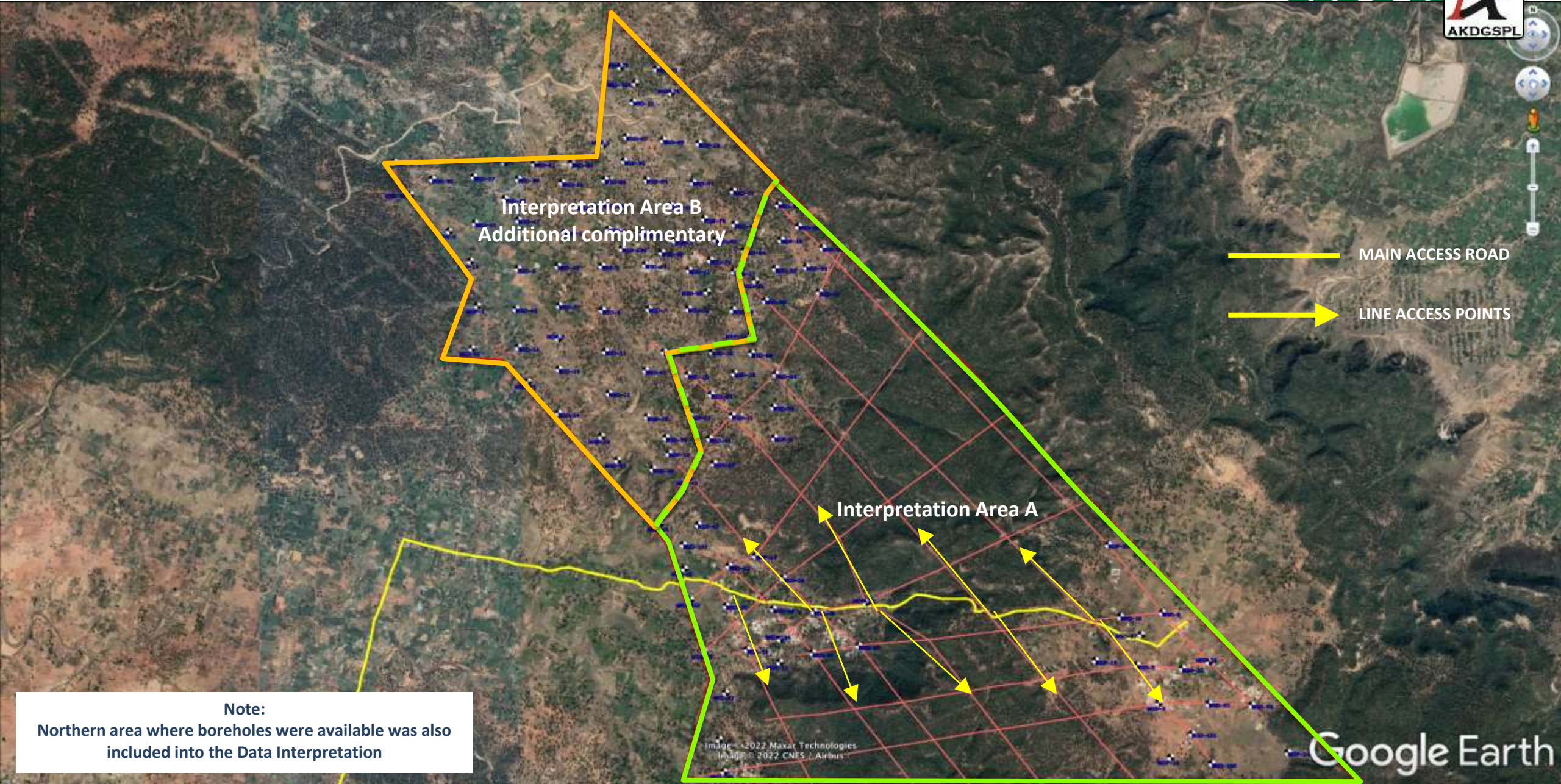
Total Data Acquired: = 61.2 kms  
 Production Days: = 52  
 Average Daily: = 1.2 kms / Day  
 Parameters: = Shot 5 meters Receiver 10 meters

Data Quality: Data quality was good but SIGNIFICANT noise from high voltage power lines  
 (This was removed in processing)

HSE UNPLANNED EVENTS: Some socialisation issues and some stolen equipment

Manhours: 43,560 man hours (reduced exposure)





Interpretation Area B  
Additional complimentary

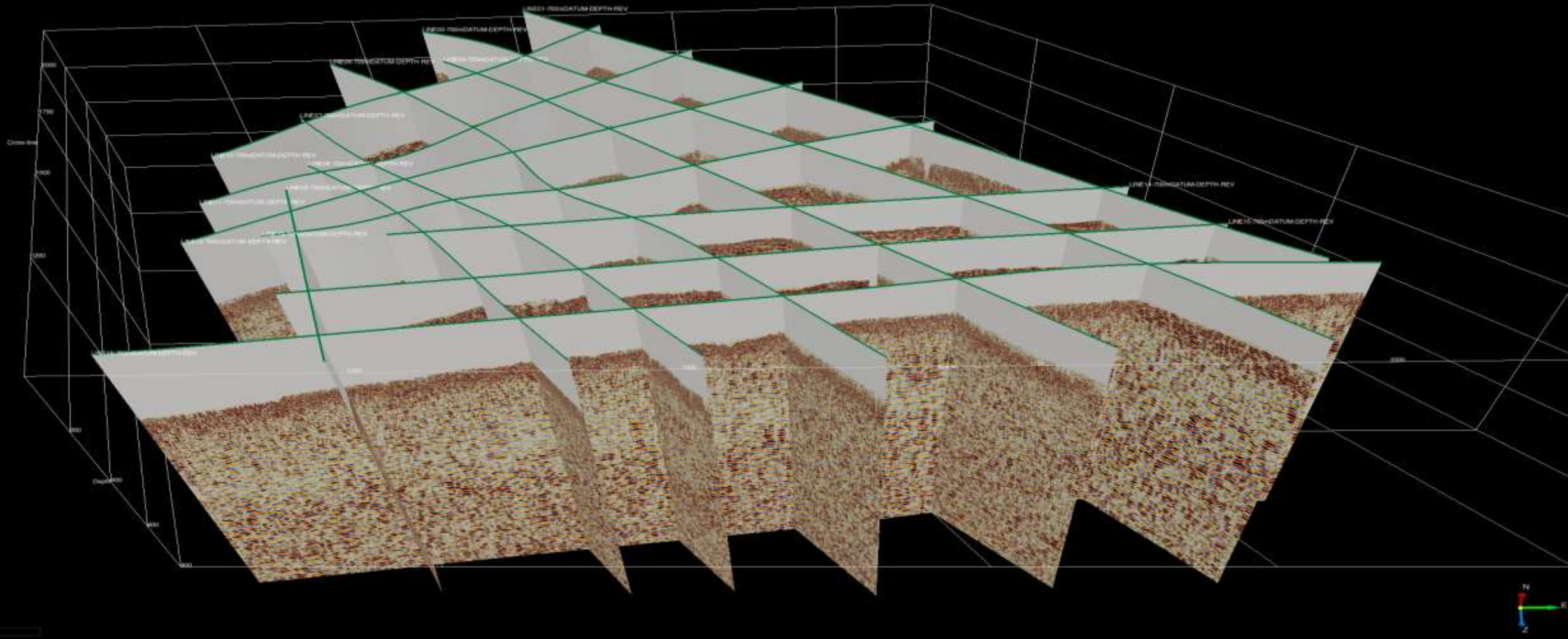
Interpretation Area A

MAIN ACCESS ROAD  
LINE ACCESS POINTS

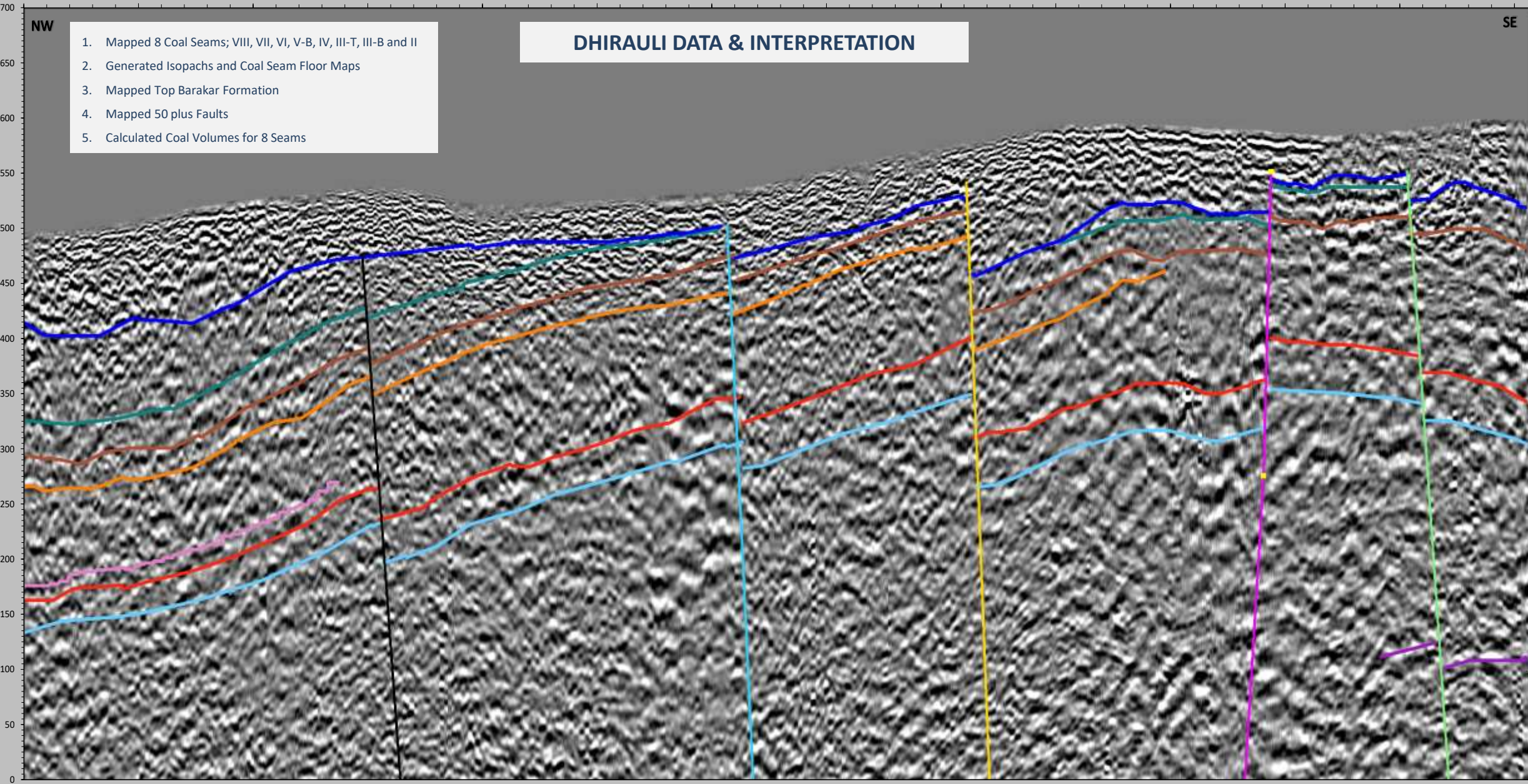
Note:  
Northern area where boreholes were available was also included into the Data Interpretation



## DHIRAULI SURVEY IN OPENDTECT



0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000 5500 6000 6500

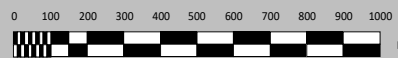


- NW**
1. Mapped 8 Coal Seams; VIII, VII, VI, V-B, IV, III-T, III-B and II
  2. Generated Isopachs and Coal Seam Floor Maps
  3. Mapped Top Barakar Formation
  4. Mapped 50 plus Faults
  5. Calculated Coal Volumes for 8 Seams

### DHIRAULI DATA & INTERPRETATION

**SE**

Reduced Level (Meters)



Horizontal distance in meters

LINE 1 - DEPTH - FINAL FILTERING

Top Barakar	<span style="color:blue">█</span>	Seam VI	<span style="color:orange">█</span>	Deep Event 2	<span style="color:purple">█</span>
Seam VIII	<span style="color:green">█</span>	Seam III	<span style="color:red">█</span>	Deep Event 1	<span style="color:blue">█</span>
Seam VII	<span style="color:brown">█</span>	Seam II	<span style="color:lightblue">█</span>	Base Weathering	<span style="color:limegreen">█</span>

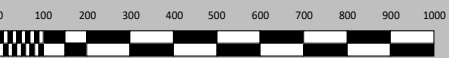
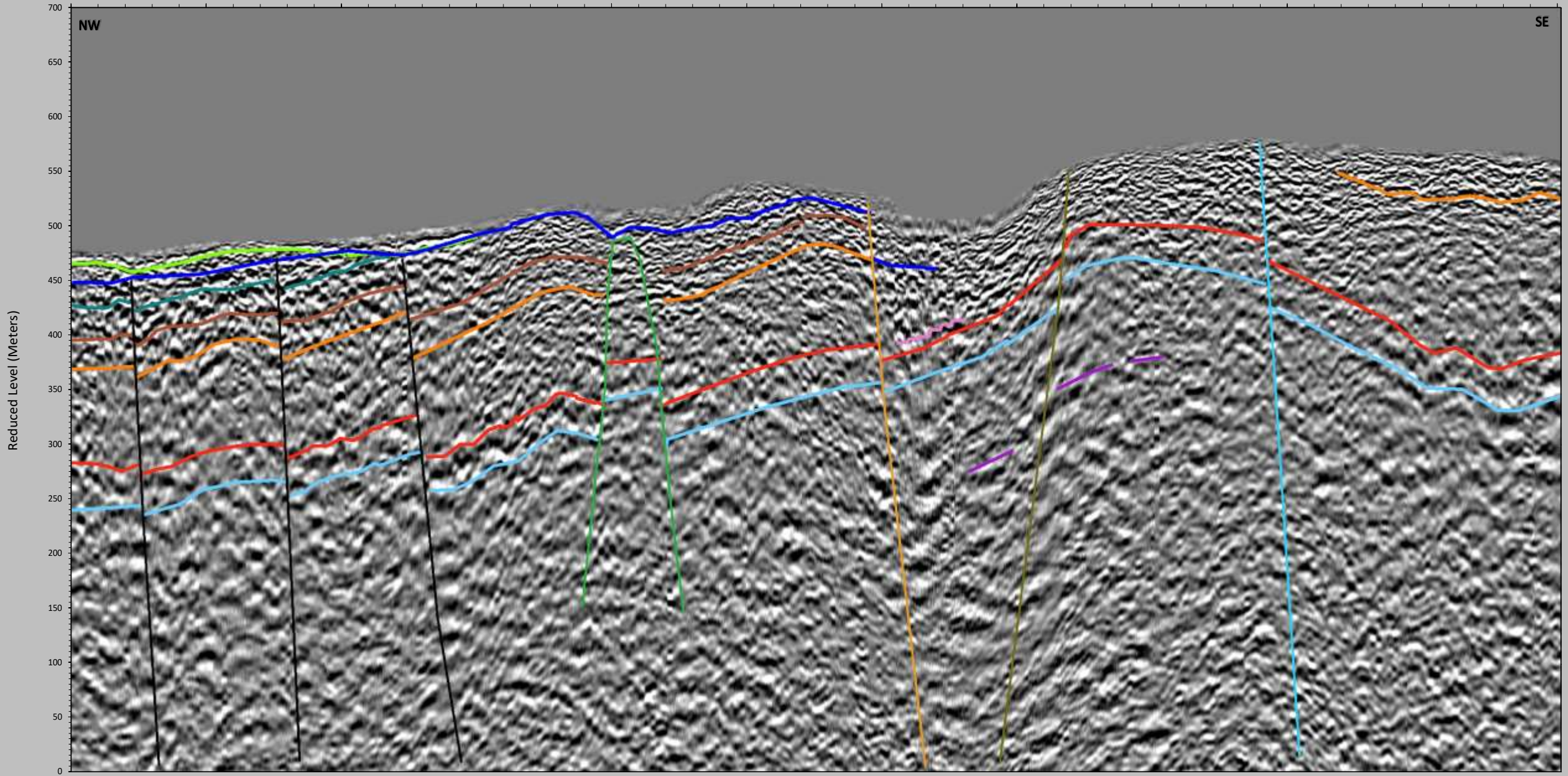
Geodetic Coordinates Top Left & Right of this Seismic Section			
UTM	WGS 84	UTM Zone:	44
False Easting:	500000.0	False Northing:	0.0
Central Meridian:	81.0	Scale Factor:	0.9996
		Latitude of Origin:	0.0
		Linear unit Meter:	1.0

E636556  
N2651867

DHIRAULI SEISMIC LINE  
DISTANCE ALONG THE LINE IN METERS

E640172  
N2647746

0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000 5500



Horizontal distance in meters

LINE 6 - DEPTH - FINAL FILTERING

Top Barakar		Seam VI		Deep Event 2	
Seam VIII		Seam III		Deep Event 1	
Seam VII		Seam II		Base Weathering	

Geodetic Coordinates Top Left & Right of this Seismic Section					
UTM	WGS 84	UTM Zone:	44	Latitude of Origin:	0.0
False Easting:	500000.0	False Northing:	0.0	Linear unit Meter:	1.0
Central Meridian:	81.0	Scale Factor:	0.9996		

E636556  
N2651867

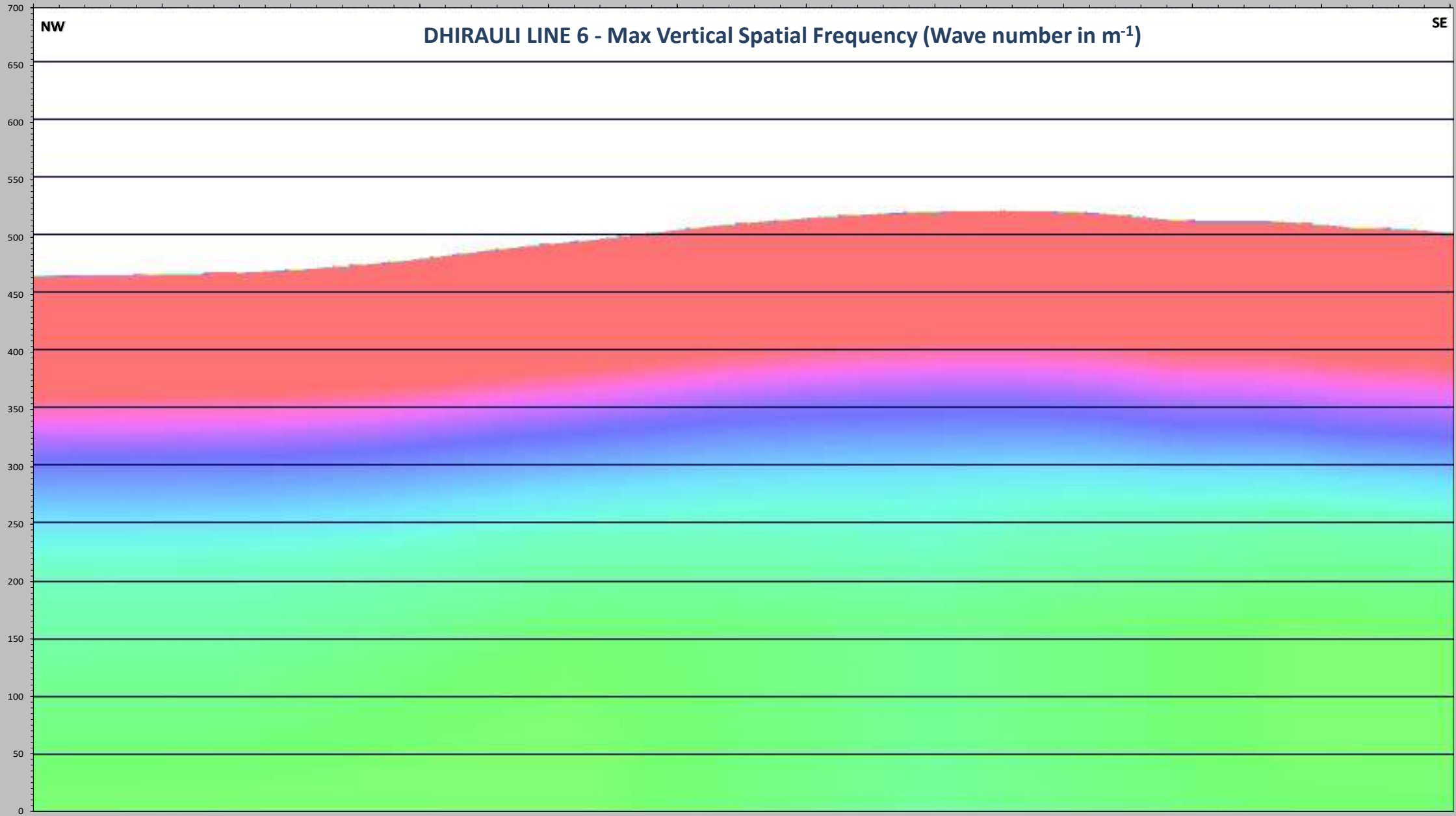
DHIRALI SEISMIC LINE  
DISTANCE ALONG THE LINE IN METERS

E640172  
N2647746

0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000 5500

NW DHIRALI LINE 6 - Max Vertical Spatial Frequency (Wave number in m<sup>-1</sup>) SE

Reduced Level (Meters)



Max Vertical Spatial Frequency (Wave number in m<sup>-1</sup>)

.210 1.1  
.200 1.2  
.190 1.3  
.180 1.4  
.170 1.5  
.160 1.6  
.150 1.7  
.140 1.8  
.130 1.9  
.120 2.1  
.110 2.3  
.100 2.5  
.090 2.8  
.080 3.1  
.070 3.6  
.060 4.2  
.050 5

Estimated resolution in meters (=  $\lambda/4$  Ref: Society of Exploration Geophysicists)

DHIRALI LINE 6 - Max Vertical Spatial Frequency (Wave number in m<sup>-1</sup>)

Geodetic Coordinates Top Left & Right of this Seismic Section					
UTM	WGS 84	UTM Zone:	44	Latitude of Origin:	0.0
False Easting:	500000.0	False Northing:	0.0	Linear unit Meter:	1.0
Central Meridian:	81.0	Scale Factor:	0.9996		

# GONDKHAIRI PROJECT & DATA SUMMARY

## GONDKHAIRI DATA ACQUISITION PROCESS FLOW CHART “THE GEOLOGICAL CHALLENGE”

Conduct Experimental Line to determine best Data acquisition, processing and Interpretation parameters. Line length 2025 meters



Completed remainder of survey lines using the best parameters as determined by the experimental line.  
Total length 38,228 meters



Conduct Pseudo 3D seismic and Undershoot seismic beneath areas where surface access was prohibited (i.e. under explosive storages).

Total length 2,584 meters  
101,860 sq meters meters

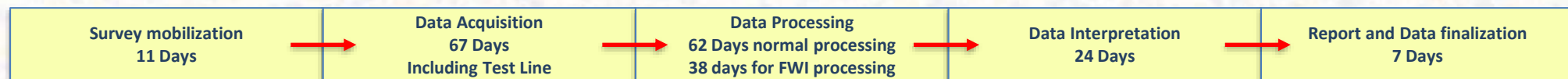
## SUMMARY OF OPERATIONS

Total Data Acquired: = 40.2 kms - Plus PSEUDO 3D  
 Production Days: = 52  
 Average Daily: = 0.9 kms / Day  
 Parameters: = Shot 5 meters Receiver 5 meters

Data Quality: Data quality was exceptionally good and imaging beneath the Basalt Layer achieved

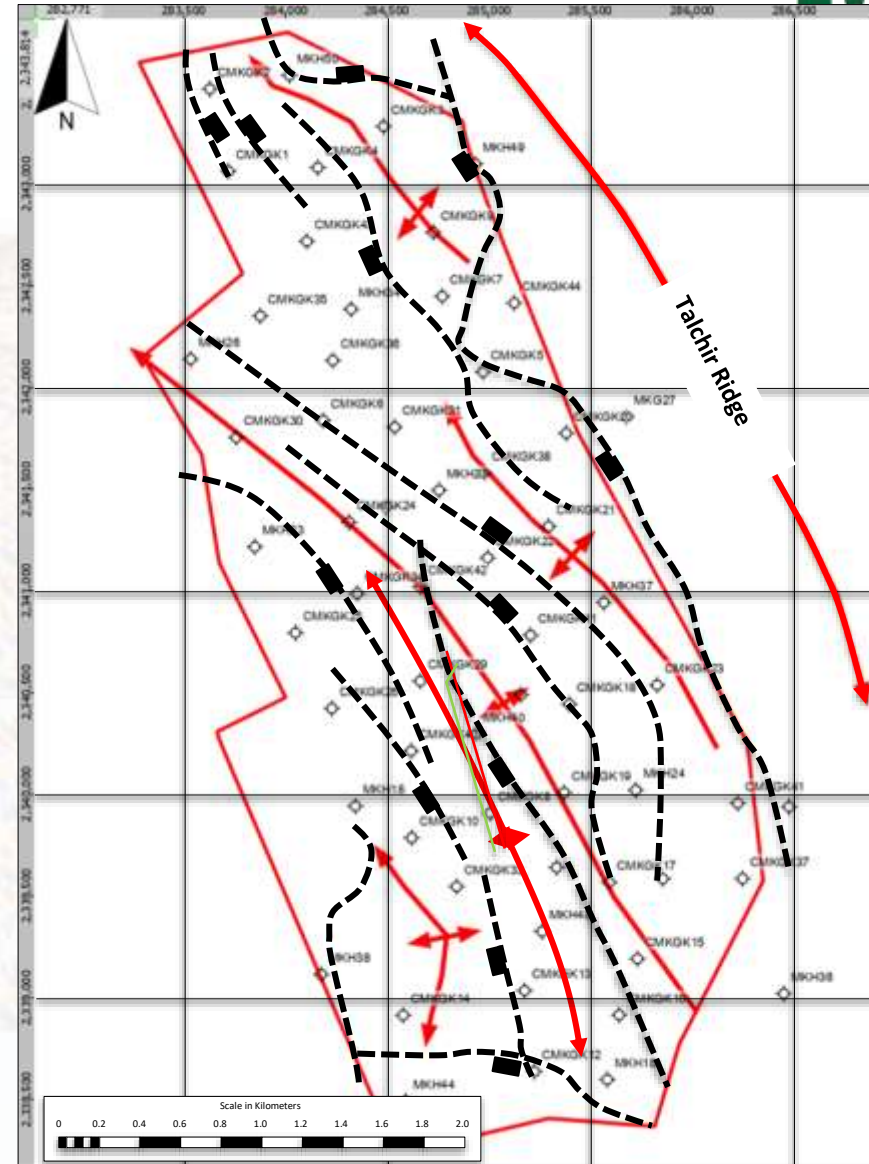
HSE UNPLANNED EVENTS: Forest fire, minor permit problems, no access to hazards areas (fixed by undershooting)

Manhours: 40,848 man hours (reduced exposure)





Survey area & Lines

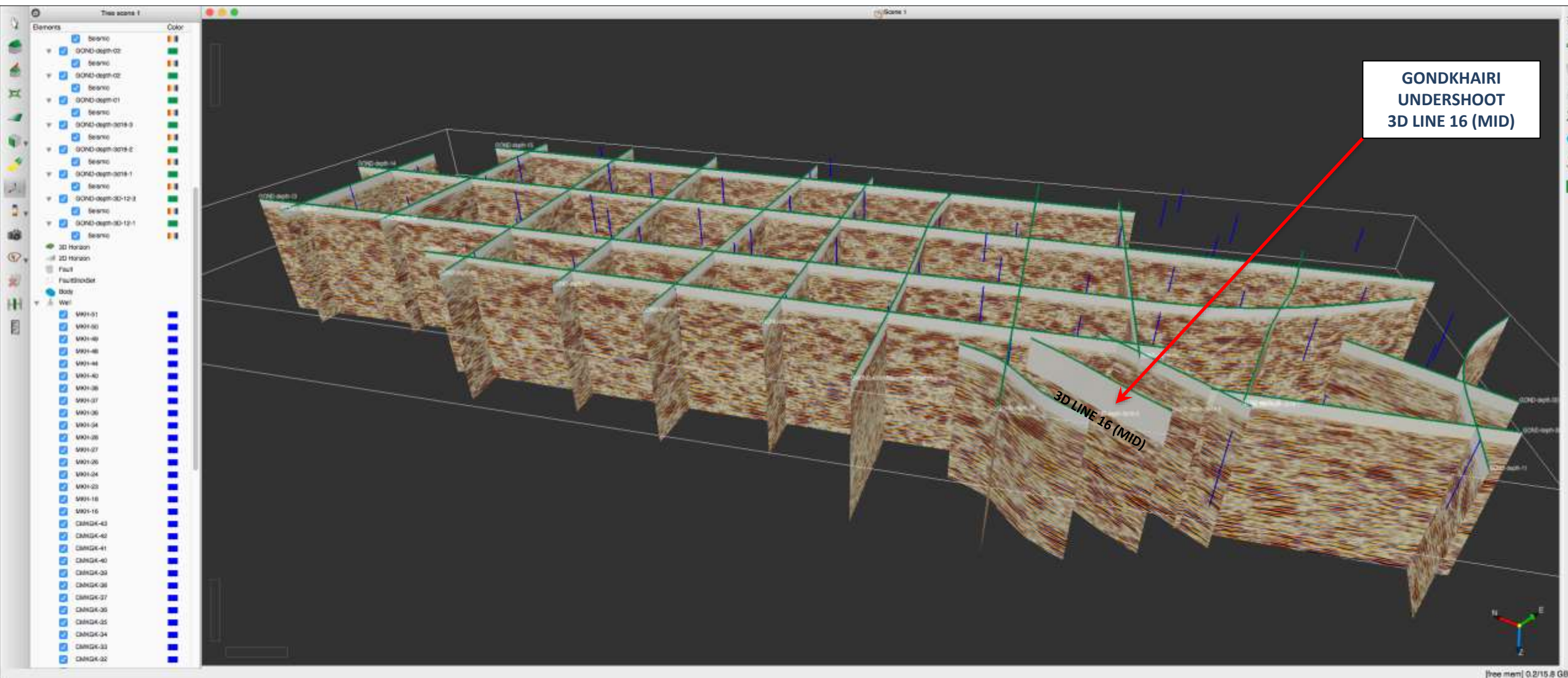


Simplified Tectonic Elements



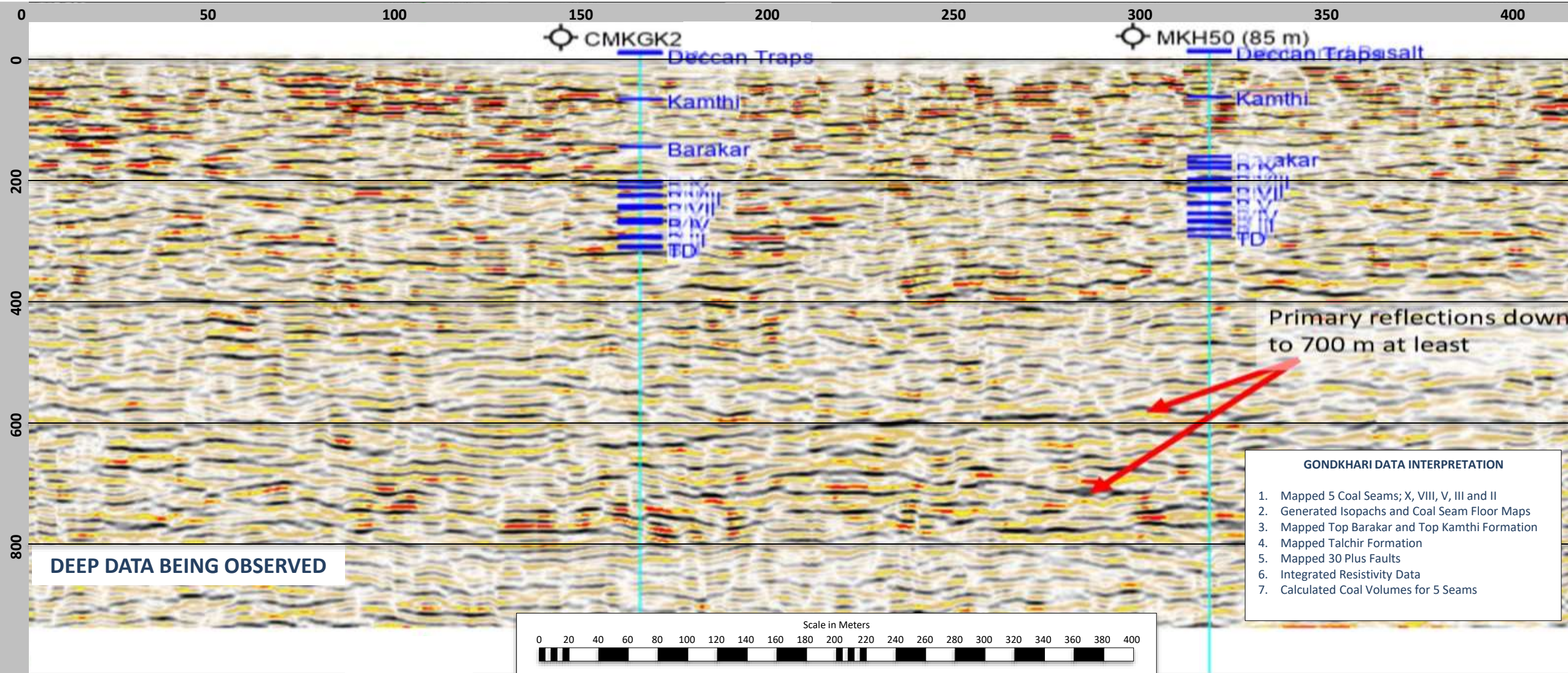
# GONDKHAIRI DATA OVERVIEW

# GONDKHAIRI SURVEY IN OPENDTECT



# GONDKHARI DEEP DATA

COMMON MID POINT

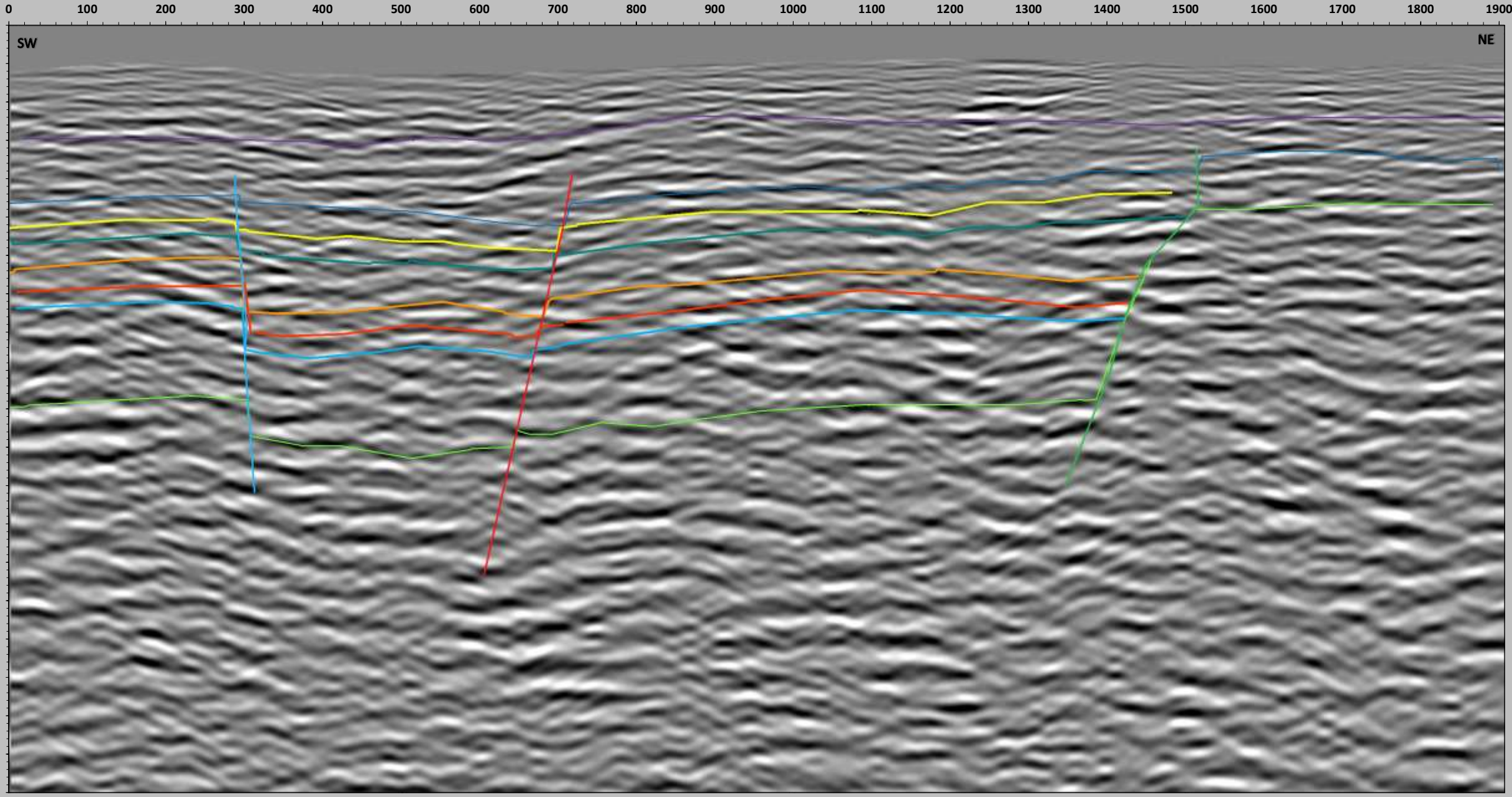


E283535  
N2341579

### GONDKHARI SEISMIC LINE

DISTANCE ALONG THE LINE IN METERS

E285251  
N2342406



Top Karathi	Seam VIII	Fault 1
Top Barakar	Seam V	Fault 3
Talchir	Seam III	Fault 4
Seam X	Seam II	

### LINE 4 - DEPTH - FULL WAVEFORM INVERSION

**Geodetic Coordinates Top Left & Right of this Seismic Section**

UTM:	WGS 84	UTM Zone:	44N	Latitude of Origin:	0.0
False Easting:	500000.0	False Northing:	0.0	Linear unit Meter:	1.0
Central Meridian:	81.0	Scale Factor:	0.9996		

E283535  
N2341579

GONDKHARI SEISMIC LINE  
DISTANCE ALONG THE LINE IN METERS

E285251  
N2342406

0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900

SW

NE

GONDKHAIRI LINE 4 - Max Vertical Spatial Frequency (Wave number in m<sup>-1</sup>)

Reduced Level (Meters)

400  
350  
300  
250  
200  
150  
100  
50  
0  
-50  
-100  
-150  
-200  
-250  
-300  
-350  
-400

Max Vertical Spatial Frequency (Wave number in m<sup>-1</sup>)

.200 1.2  
.190 1.3  
.180 1.4  
.170 1.5  
.160 1.6  
.150 1.7  
.140 1.8  
.130 1.9  
.120 2.1  
.110 2.3  
.100 2.5  
.090 2.8  
.080 3.1  
.070 3.6  
.060 4.2  
.050 5

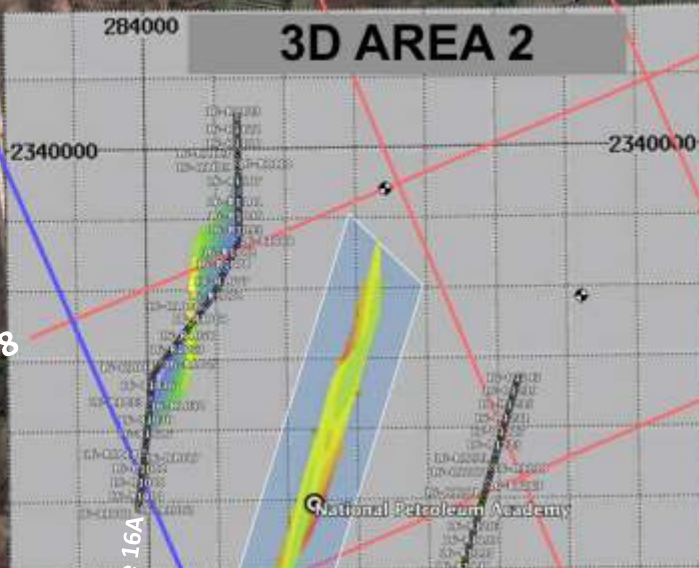
Estimated resolution in meters (=  $\lambda/4$ , Ref: Society of Exploration Geophysicists)

GONDKHAIRI LINE 4 - Max Vertical Spatial Frequency (Wave number in m<sup>-1</sup>)

Geodetic Coordinates Top Left & Right of this Seismic Section			
UTM:	WGS 84	UTM Zone:	44N
False Easting:	500000.0	False Northing:	0.0
Central Meridian:	81.0	Scale Factor:	0.9996
		Latitude of Origin:	0.0
		Linear unit Meter:	1.0

# GONDKHAIRI DATA PSEUDO 3D & UNDERSHOOT

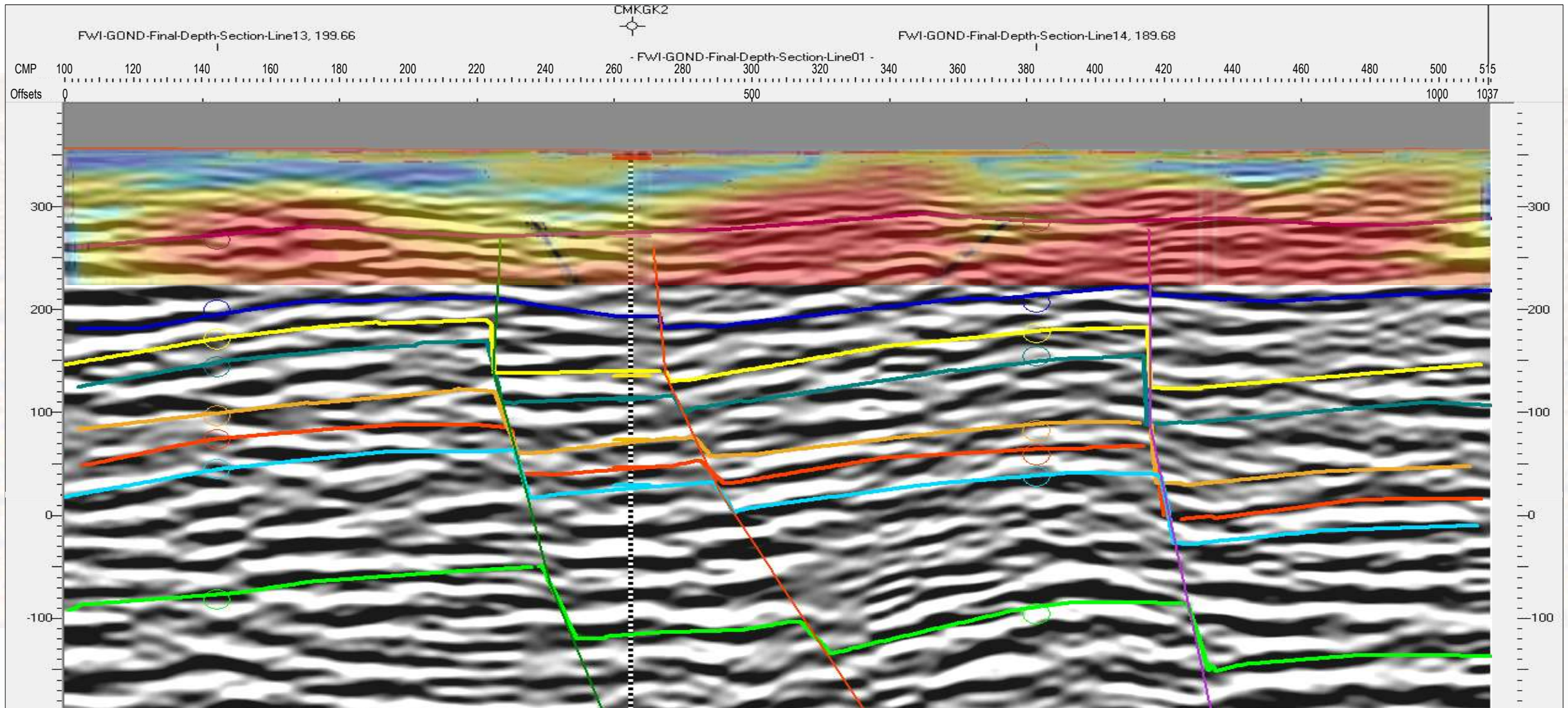
Coverage %



#### Index Key

Seismic shot line

3D coverage areas



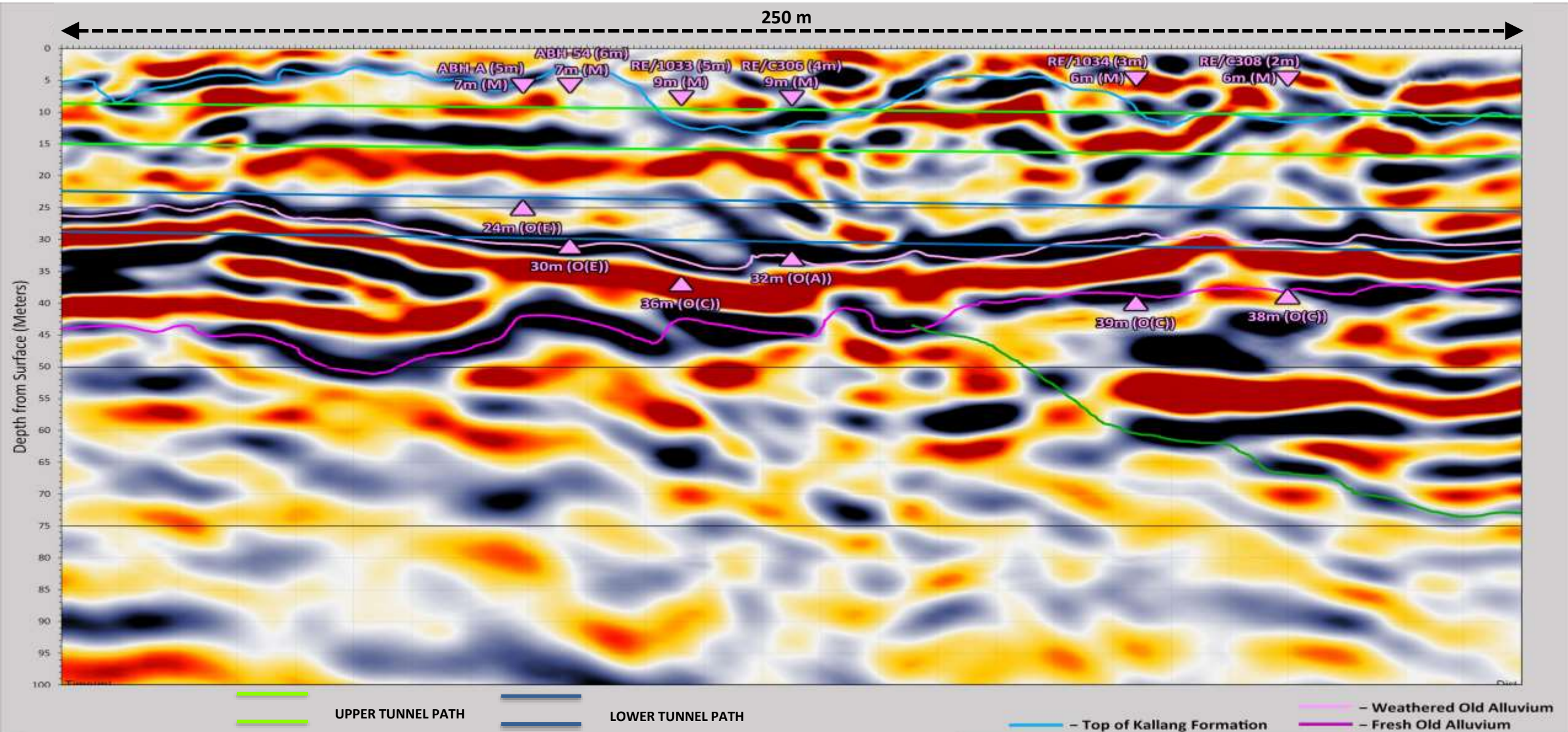
Line 1 With Resistivity Overlay



## OTHER DATA OVERVIEW

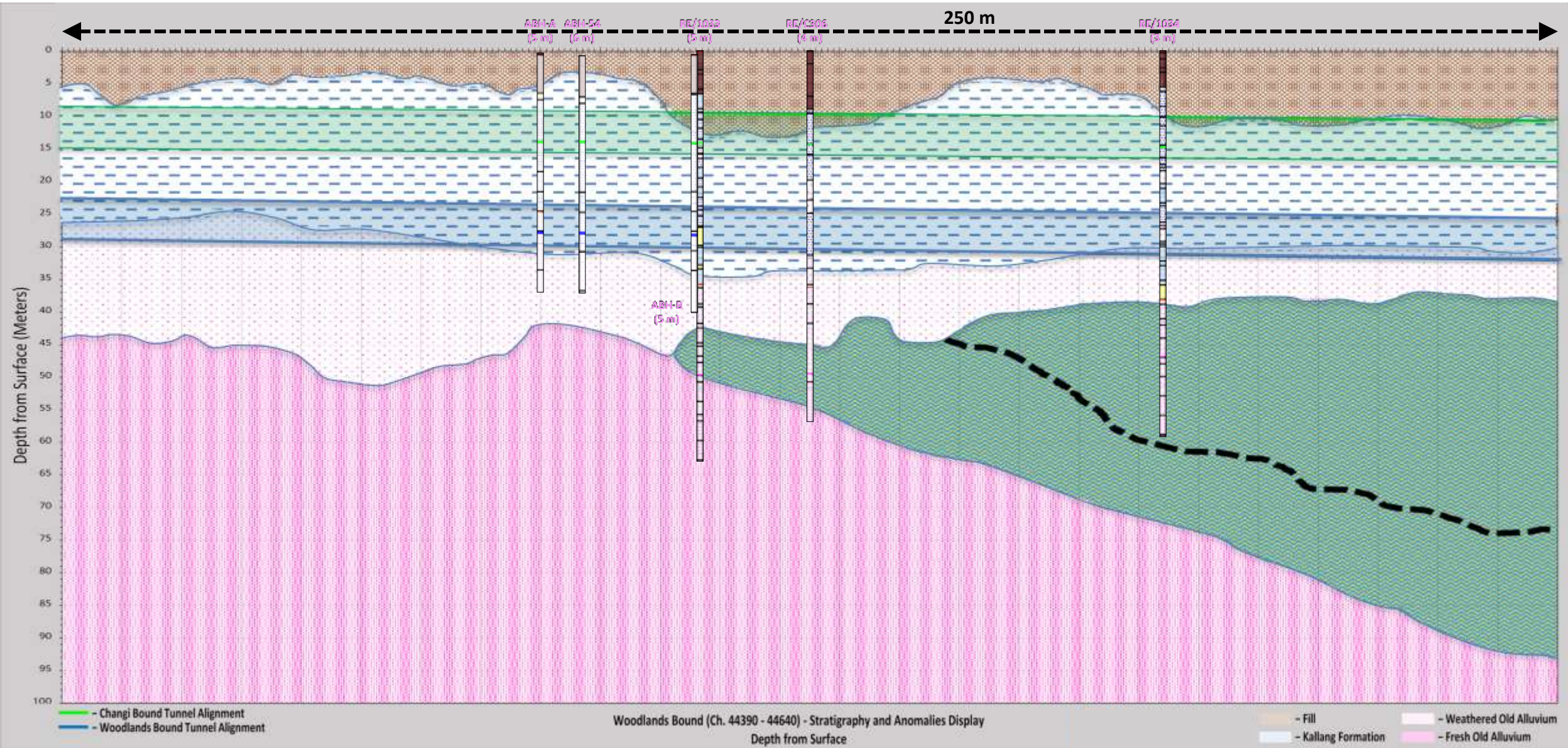
# THOMSON EAST COAST LINE MRT DATA

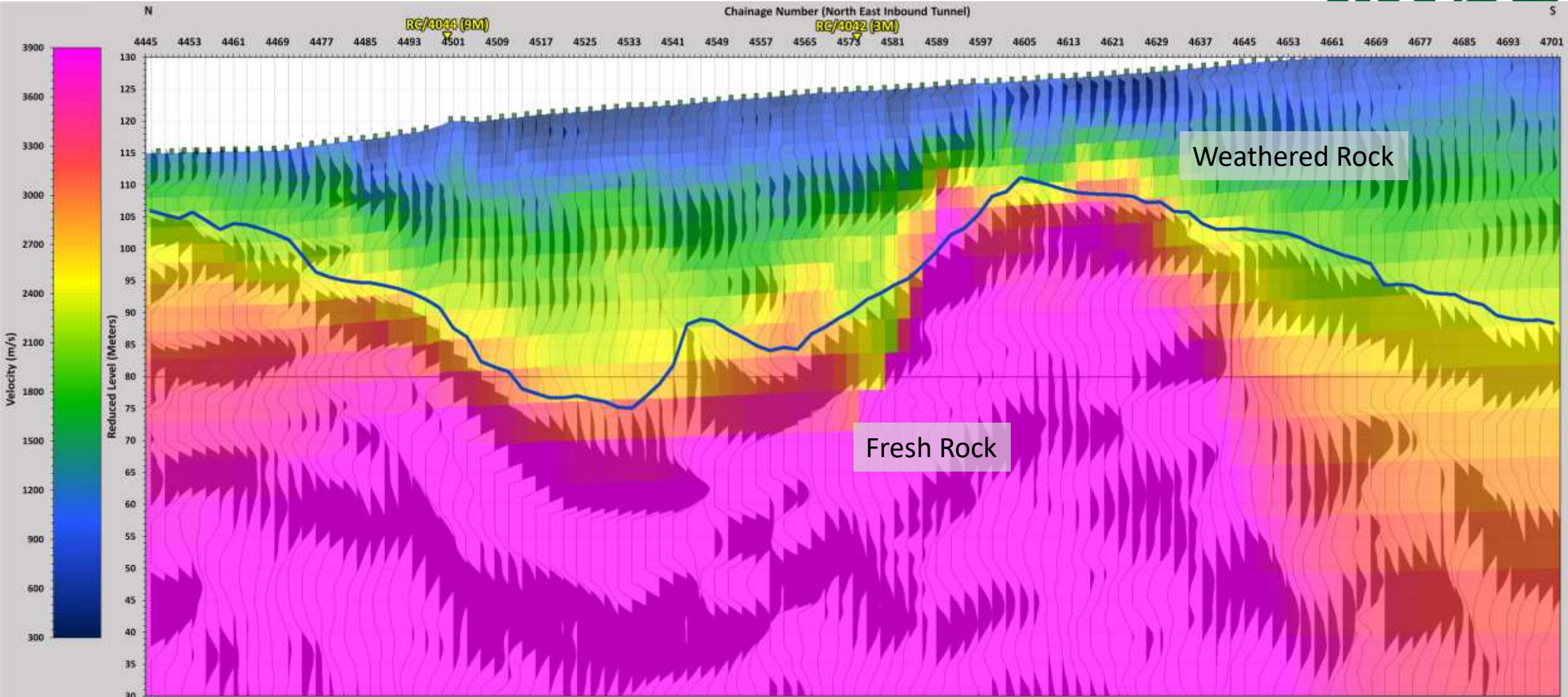
Seismic Section showing Fill, Kallang and Old Alluvium



# THOMSON EAST COAST LINE MRT DATA

Stratigraphy Section showing Fill, Kallang and Old Alluvium



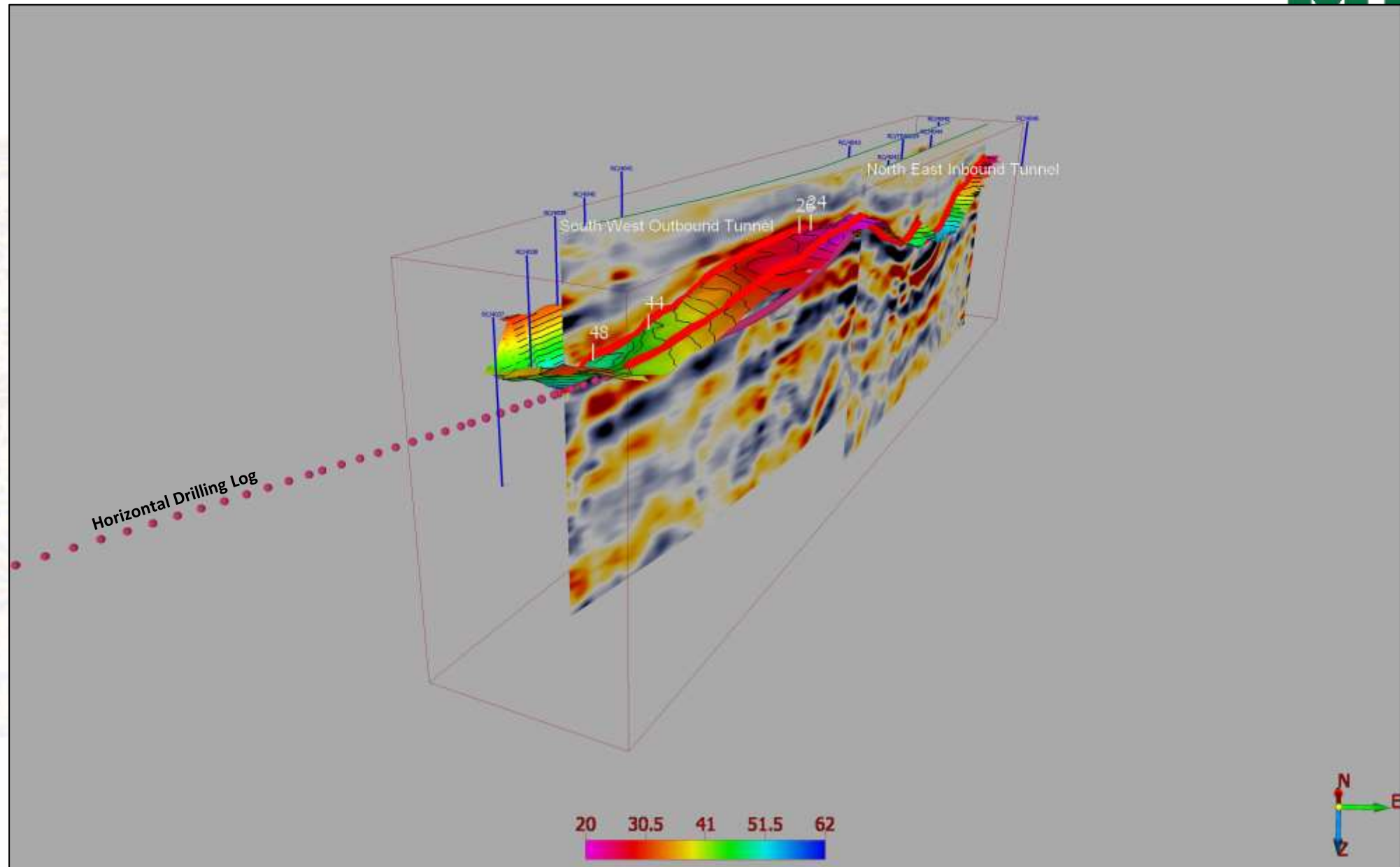


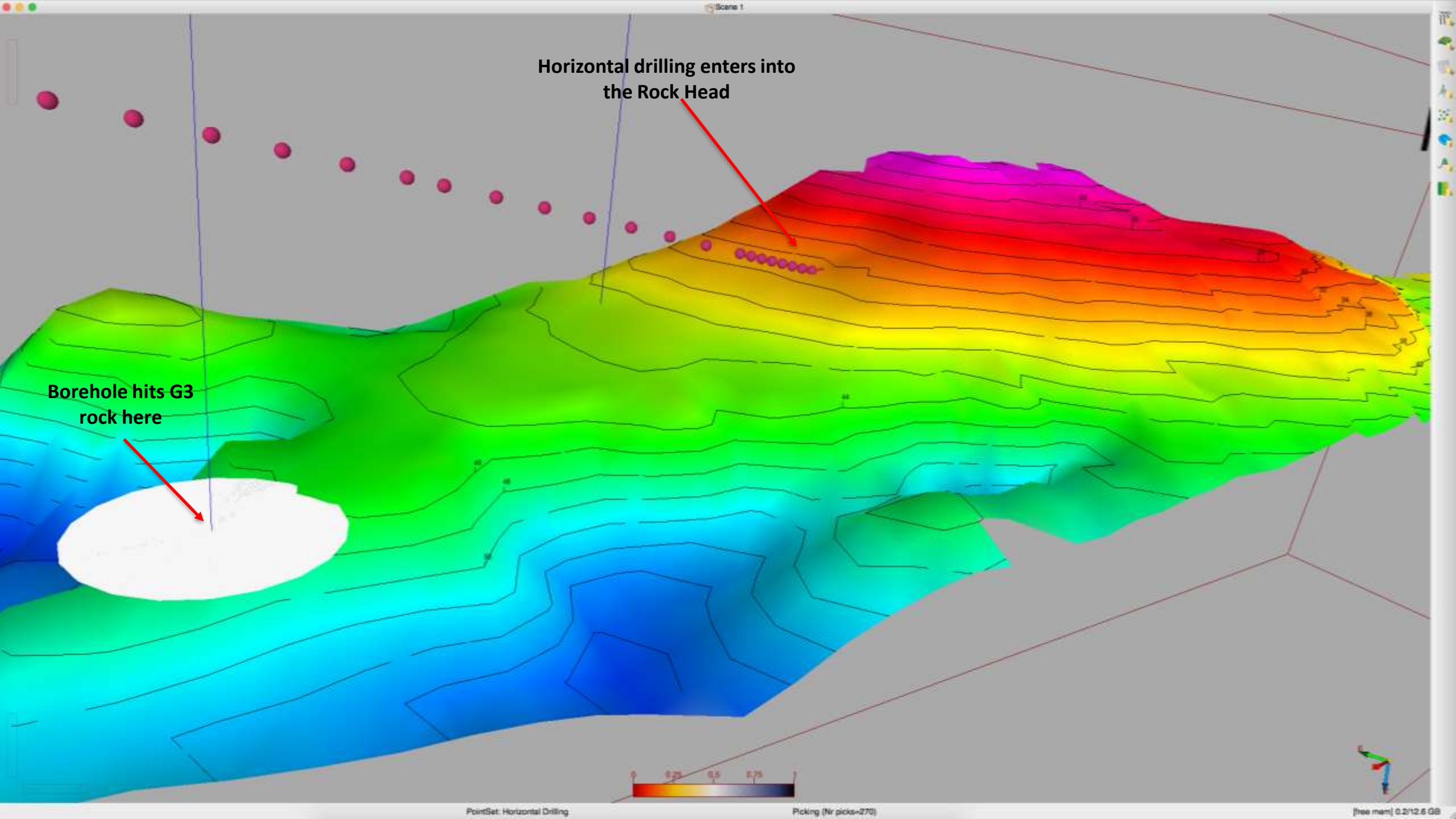
Weathered Rock

Fresh Rock

Note:

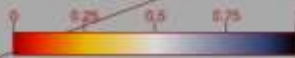
— Rockhead (GIV or better)      RC/0000 (BM) - Borehole Number (Offset from tunnel alignment in meters)





Horizontal drilling enters into the Rock Head

Borehole hits G3 rock here



## HIGH-RESOLUTION SEISMIC SURVEY 2D DEEP CITY SEISMIC TECHNOLOGY



HIGH-RESOLUTION SEISMIC SURVEY  
2D DEEP CITY SEISMIC TECHNOLOGY  
OIL & GAS EXPLORATION

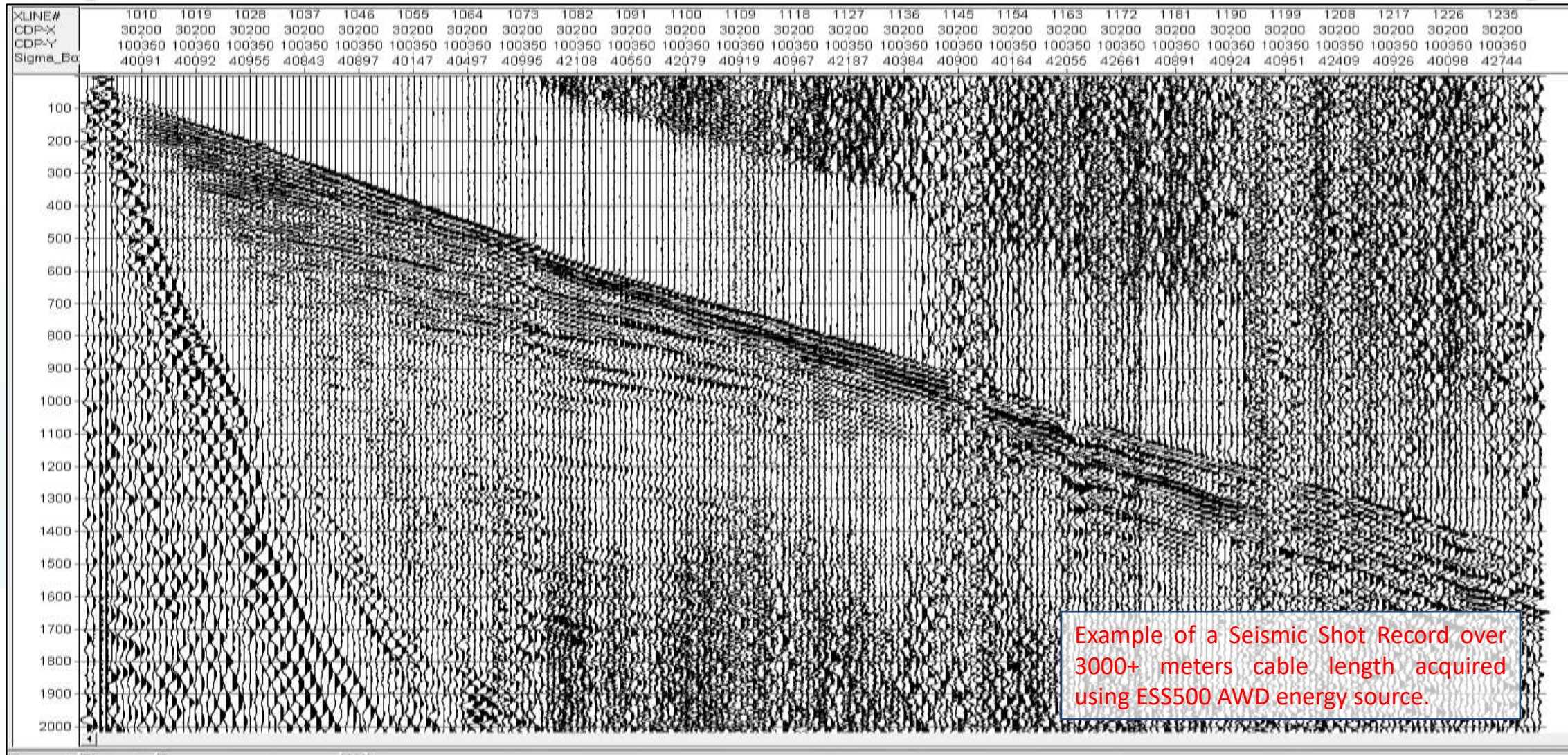
Seismic Survey Specifications

Group Interval:	12.5 meters
Shot Interval:	25.0 meters
CDP Interval:	6.13 meters

# HIGH-RESOLUTION SEISMIC SURVEY - 2D DEEP CITY SEISMIC TECHNOLOGY

## RAW SHOT RECORD

*Shot travels along 3025 meters of active cable (i.e. 241 channels \* 12.5 meters)*

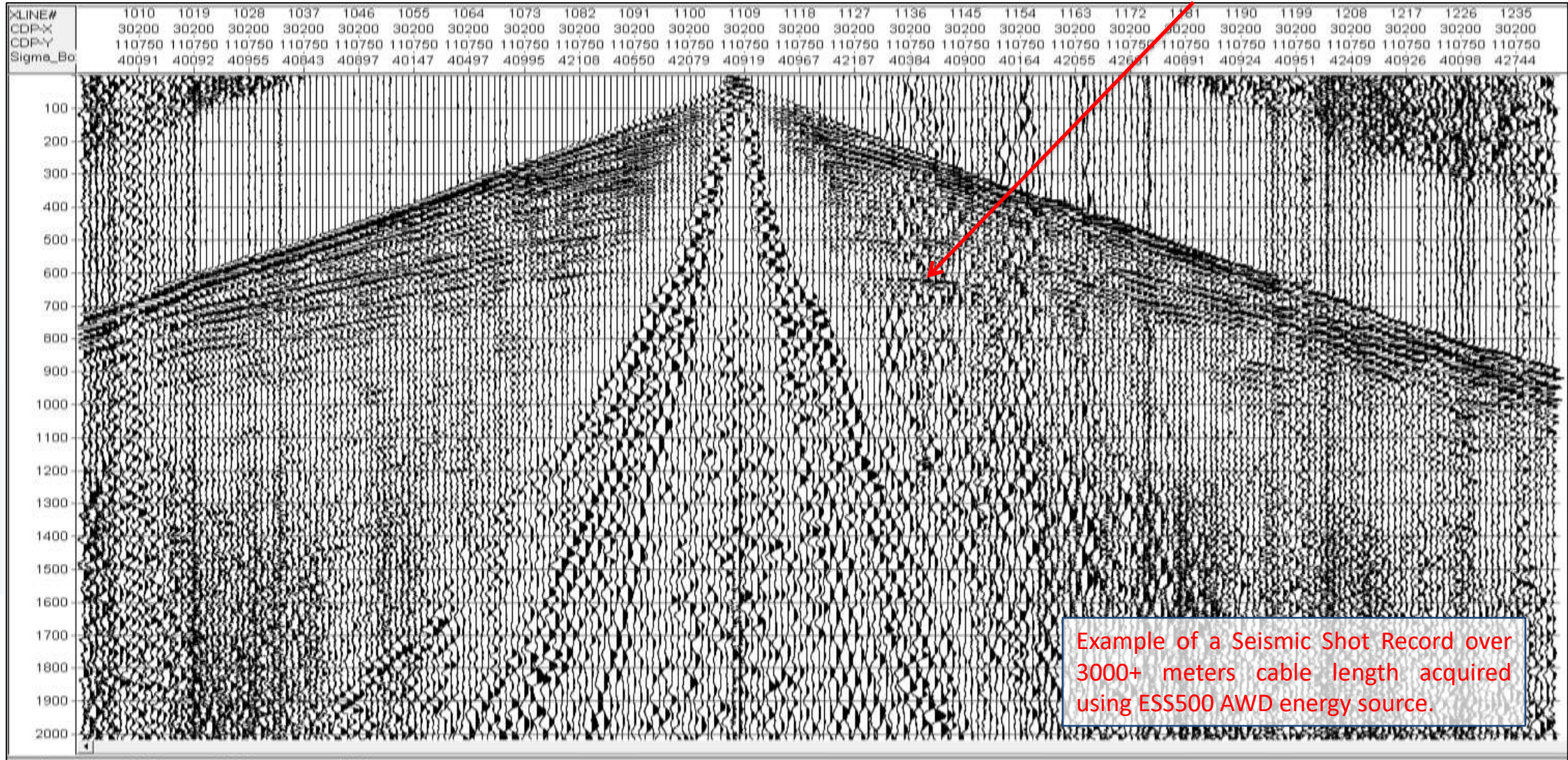




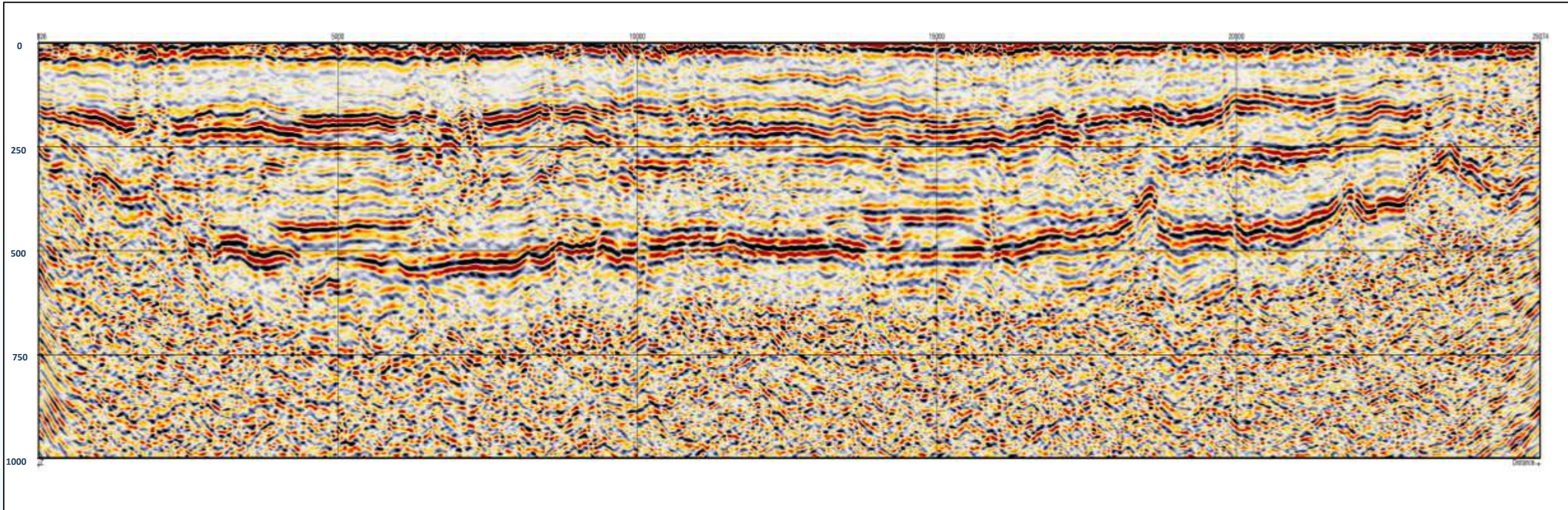
# HIGH-RESOLUTION SEISMIC SURVEY - 2D DEEP CITY SEISMIC TECHNOLOGY

## RAW SHOT RECORD

*Basement at 600+ meters*



**HIGH-RESOLUTION SEISMIC SURVEY - 2D DEEP CITY SEISMIC TECHNOLOGY**  
RESULTING FINAL SEISMIC SECTION DOWN TO BASEMENT USING ESS500 ACCELERATED WEIGHT DROP ENERGY SOURCE









# SUPER HIGH-RESOLUTION 3D SEISMIC SURVEY – UNDERSHOOT AUSTRALIAN EMBASSY

## 3D BIN GRID LINE LAYOUT AND SHOOTING MATRIX

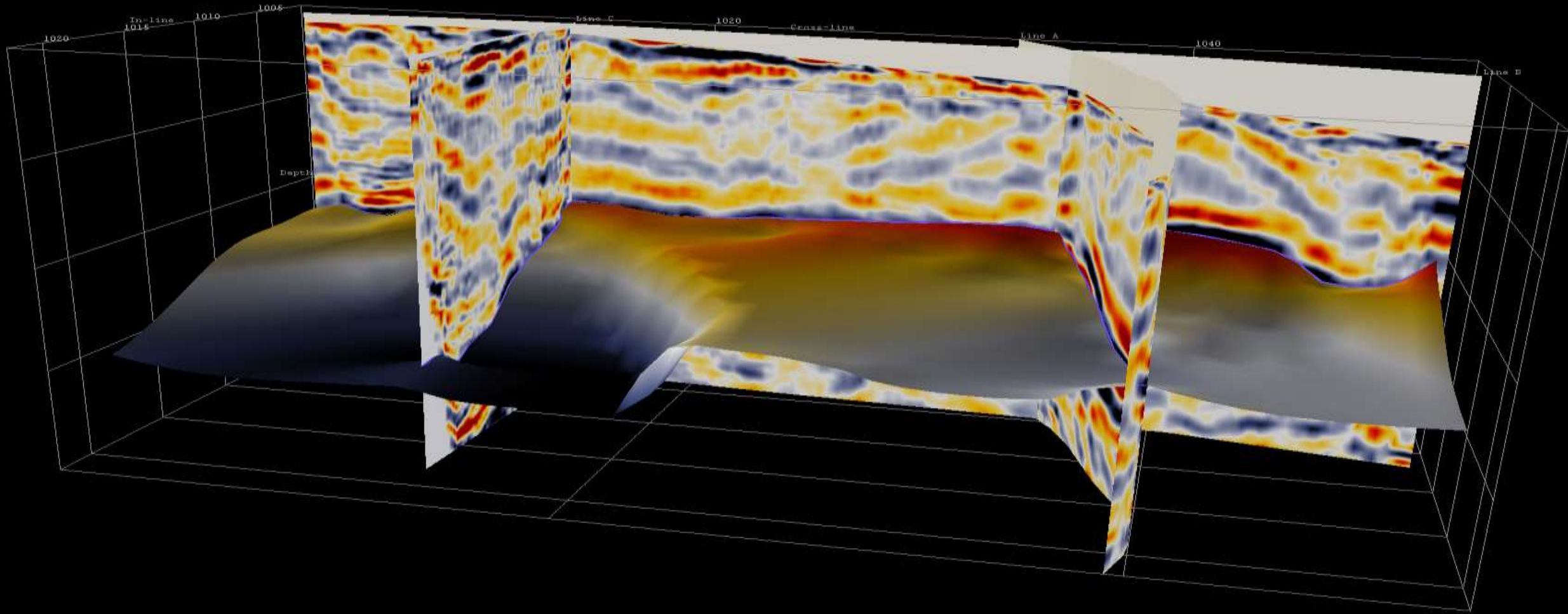


**Key:**

-  Deployed Seismic Line
-  Seismic Survey Line Name
-  Energy Source Shot Point
-  Energy Source Signals
-  3D Bin Grid
-  Area of Interest

# SUPER HIGH-RESOLUTION SEISMIC SURVEY - 3D SHALLOW CITY SEISMIC TECHNOLOGY

## PROCESSED DATA SAMPLES - 3D ROCKHEAD CONTOUR AND 2D SEISMIC SECTION DATA



# SUPER HIGH-RESOLUTION SEISMIC SURVEY - 3D SHALLOW CITY SEISMIC TECHNOLOGY

## PROCESSED DATA SAMPLES - 3D ROCKHEAD CONTOUR SEISMIC MODEL

