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Possible Topic to be Covered:

- General Overview of Geophysical Survey Method.
- Application in Singapore
- SWS (Surface Wave System) and the applicaion in Slope Investigation.
- Project Visualization Pictures and Graphs

Condition & Advantage to use Geophysical survey Method

Suitable Site Condition:

1)Varing local geological Conditions.

2)Site inaccessibility for Borehole drilling.

Advantage:

1) Greater coverage of area being surveyed.

2) Investigation to be completed in Shorter Time at a lower Cost.

Application in Singapore

- Geophysical methods have been used in civil engineering for many years.
- Seismic refraction survey was first applied in Singapore in early 1980's – 11km route alignment for Bukit Timah Expressway .
- 1991, Extensive Geophysical surveys using Seismic refraction & Electrical Resistivity Methods, augmented by drilling, were used to study the feasibility of underground construction in a selected Bukit Timah Area.

METHODS OF GEOPHYSICAL SURVEYS (1 of 2)

1. **Seismic Reflection.**
2. **Seismic Refraction.**
3. **Seismic Surface Wave.**
4. **Seismic Image.**
5. **Cross-hole Seismic Tomographic Imaging (CT)**
6. **Seismic (P-S) Wave Logging**
7. **Electrical Resistivity.**

METHODS OF GEOPHYSICAL SURVEYS (2 of 2)

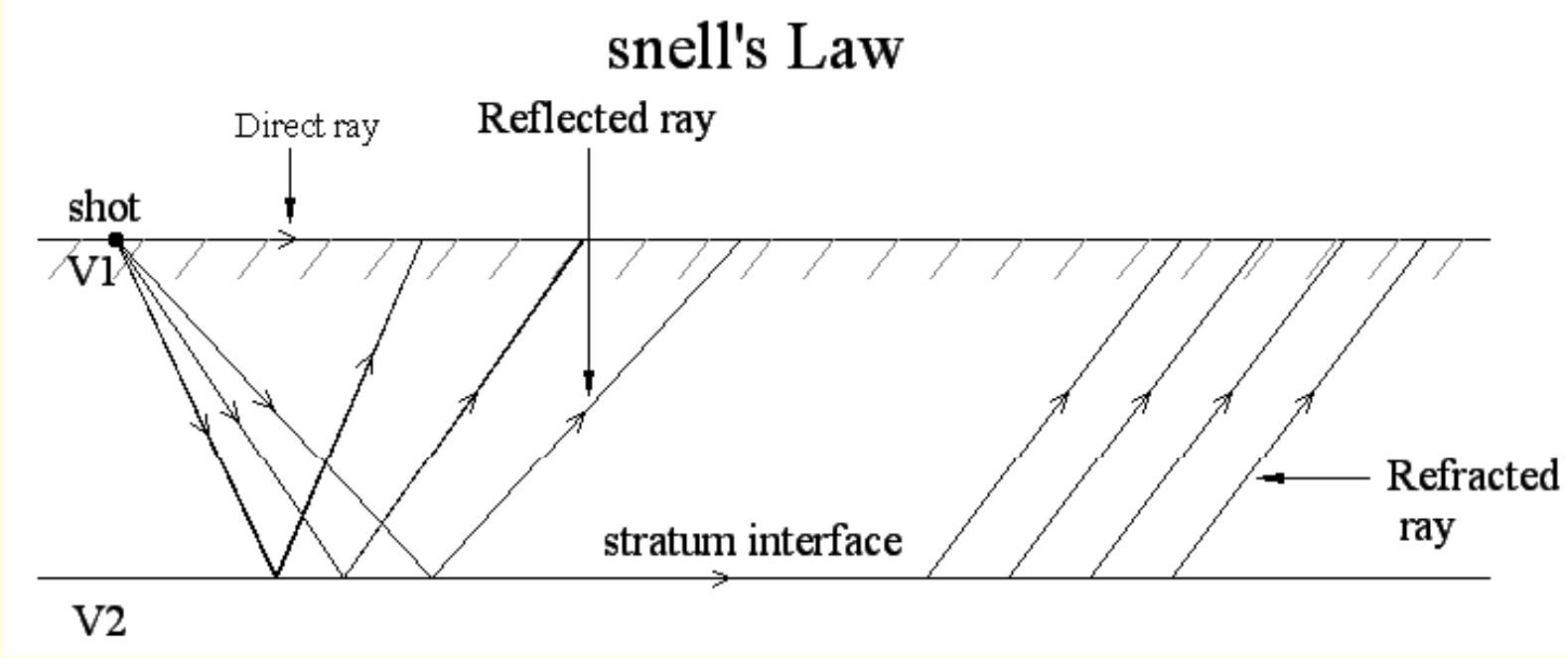
8. Electromagnetic Method

9. Gravity Method.

10. Radar Probing Profiling.

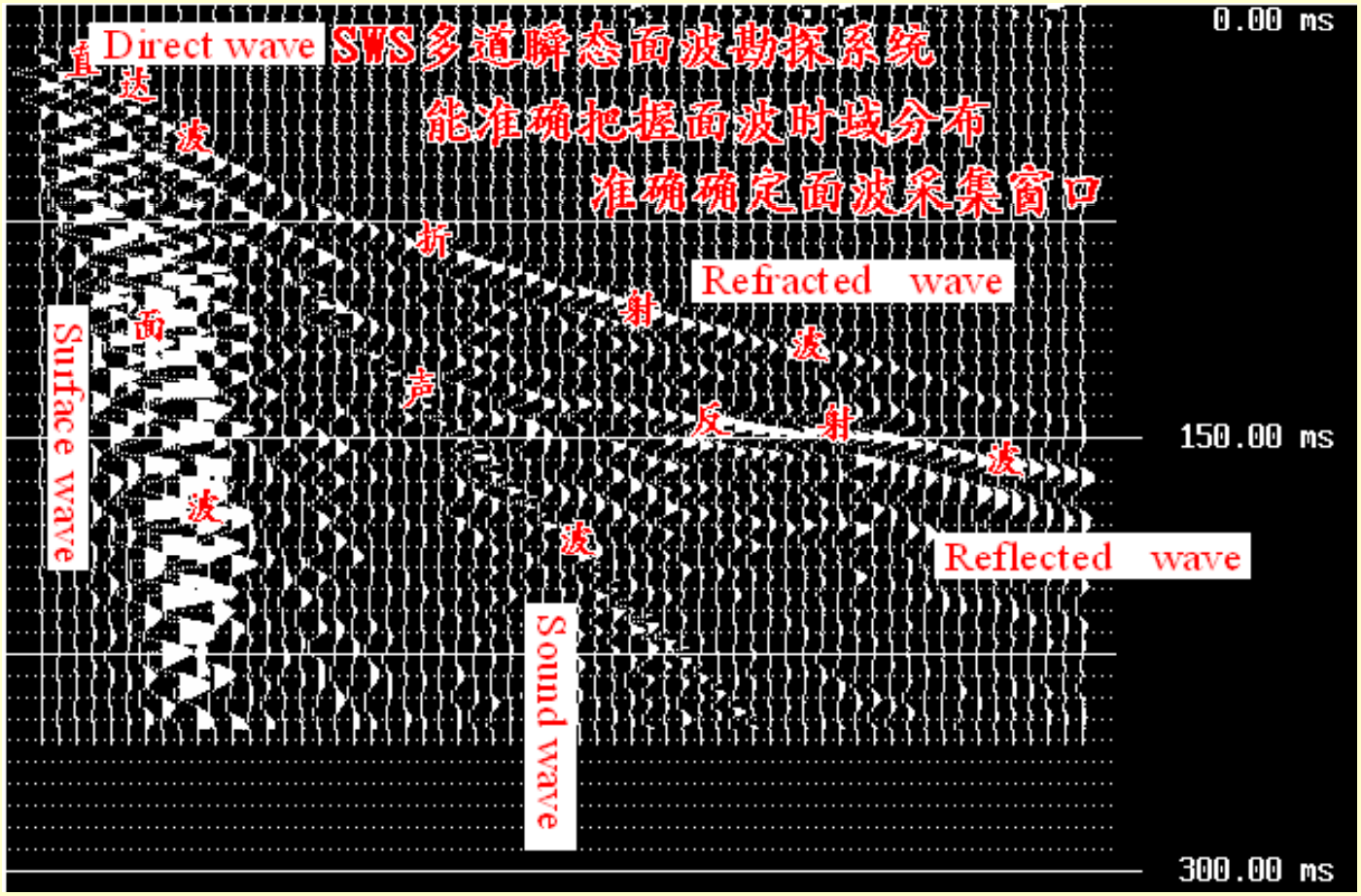
Seismic Surveys – Principle (1 of2)

Direct, refracted and reflected ray paths for two-layer case where V1<V2



Seismic Surveys-Principle (2 of 2)

Actual measurement Seismic wave in X-T domain



Reflection Method

Applications:

1)To classify geological formations;

2)To investigate depth of overburden, weathered rock & bedrock;

3)To detect width and location of fracture zone (weakness zone) in the bedrock;

4)To detect width and location of anomaly (such as cavity) underground

Geophysical Condition using Reflection Method:

1)Big difference in Wave impedance in the adjacent soil strata

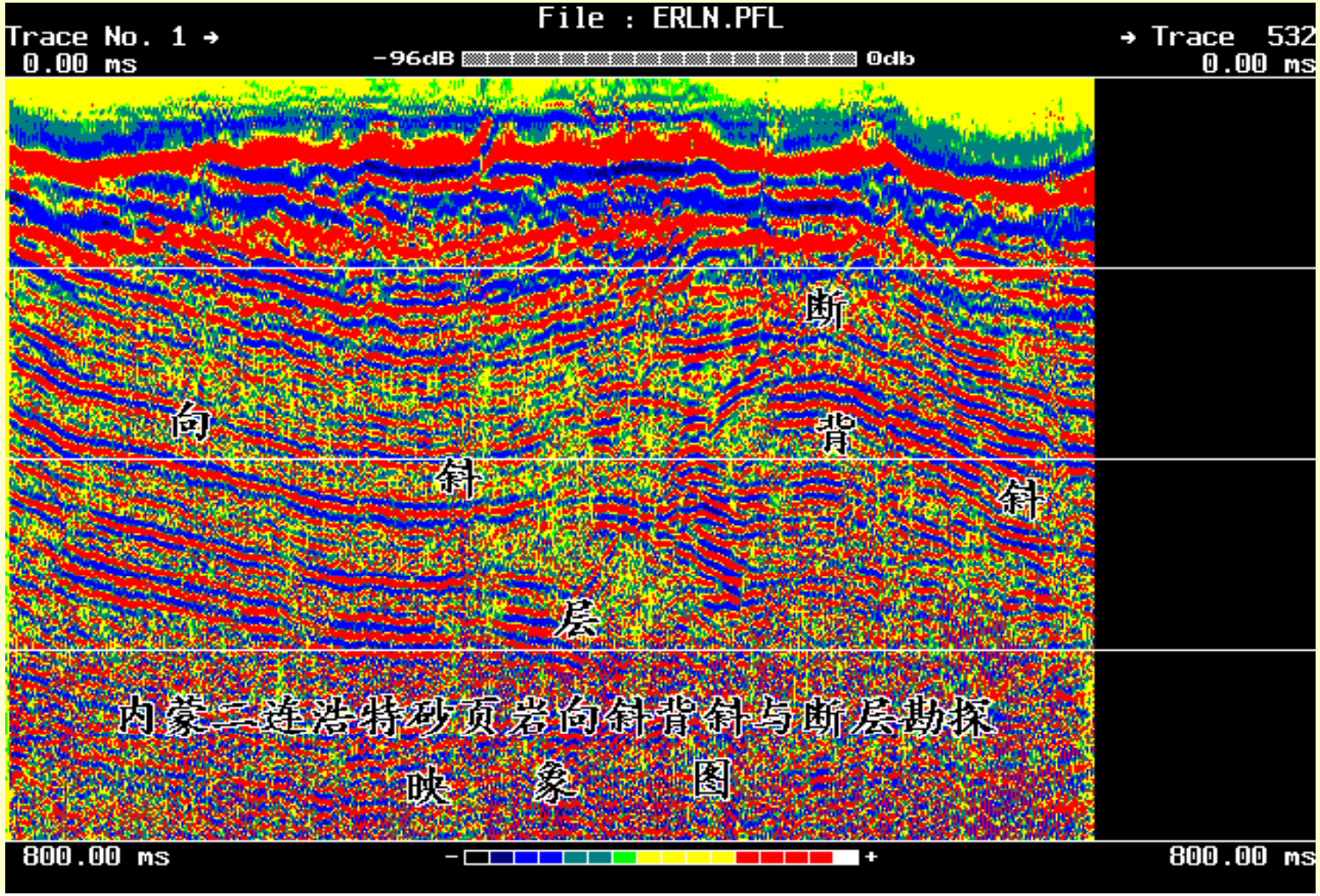
2)The relative even ground surface is required in topography survey line.

3)The objective stata is deeper than 15-25m

4) Less vibration noise

Processed Seismic Time Section

Detect coal layer. Detect depth more than 400 m.The structure of stratum, such as syncline, anticline and fault is very clear.



Refraction Method

Applications:

1)To investigate depth of overburden;

2)To determine velocity of soil & rock mass

3)To determine bedrock quality (as indicated by seismic velocity);

4)To detect width and location of low velocity zone (weakness zone) in the bedrock

Geophysical Condition using Refraction Method:

1)Vl (lower layer)>Vu (Upper layer)

2)Less vibration Noise

3)Geophone array length greater than 4-5 times the depth of objective

Seismic Method Comparision (1 of 2)

	Refraction	Reflection
Typical Targets	Depth <35 meter	Depth>15-25 meter
Required Site Conditions	Geophone array length greater than 4-5 times the depth of objective	None
Vertical Resolution	5-15% of depth	5 to 10% of depth
Lateral Resolution	one geophone space	½ geophone space
Relative Cost	$N	$3×N to $5×N

Seismic Method Comparision (2 of 2)

1) Seismic reflection generally has better resolution, but it is considerably more expensive. In the situation where both methods could be applied, the choice between seismic reflection and refraction becomes an economic decision.

2) In other cases (e.g. very deep/small targets) only reflection can be expected to work.

3) In still other cases, where boreholes or wells are accessible, neither refraction, nor reflection may be recommended in favor of seismic tomography (CT).

Surface Wave Method

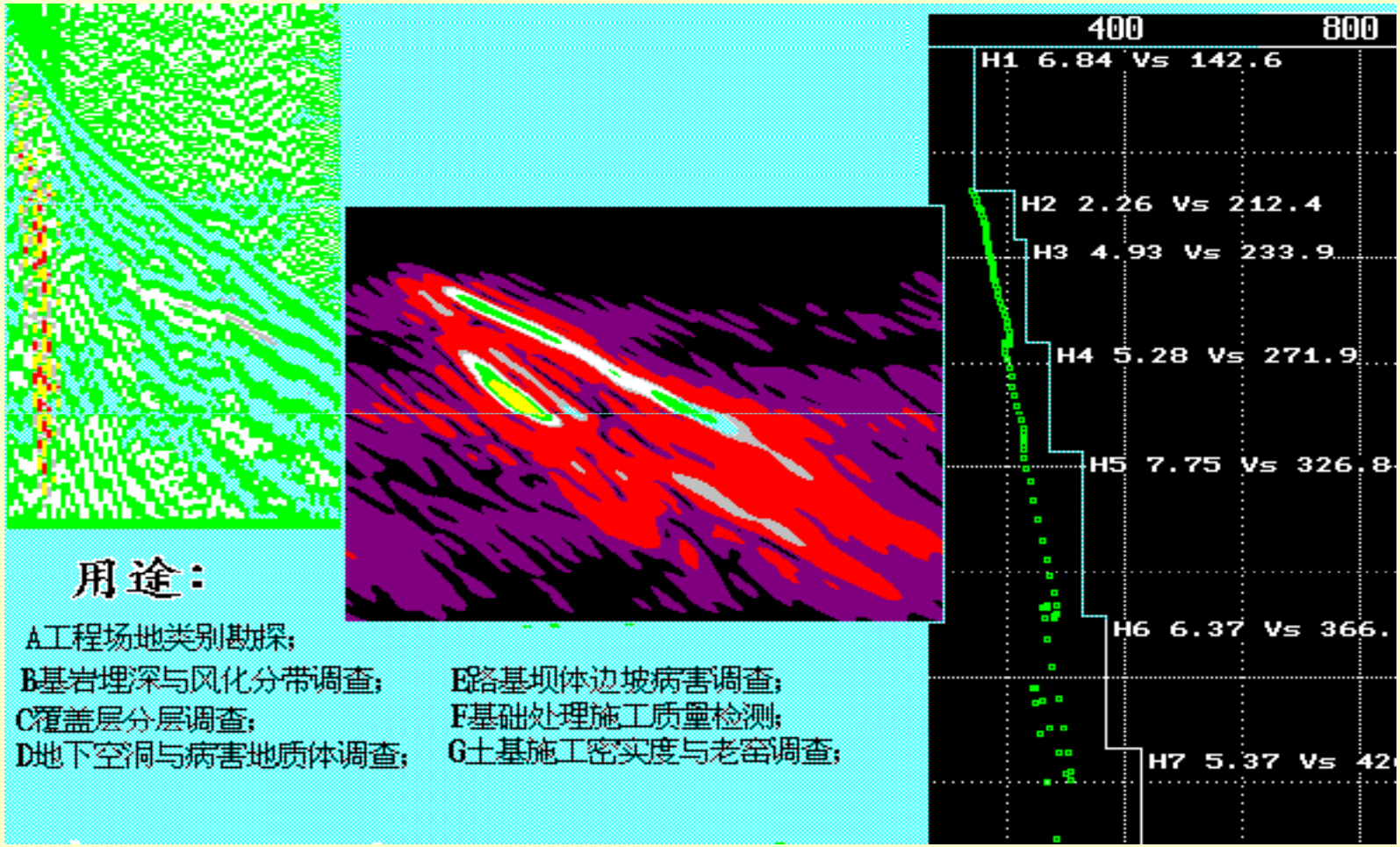
Applications:

1)To classify geological formations;
2)To determine velocity of soil & rock strata;
3)To investigate depth of overburden, weathered rock & bedrock;
4)To detect width and location of low velocity zone (weakness zone) in the bedrock;
5)To detect width and location of anomaly (such as cavity) underground
6)To verify the quality of the soil improvement

Geophysical Condition using Surface Wave Method:

1) The relative even ground surface is required in topography survey line.
2) Less Vibration

Data Processing and Result



Seismic Imaging

Applications:

1)To classify geological formations;

2)To investigate depth of overburden, weathered rock & bedrock;

3)To detect width and location of fracture zone (weakness zone) in the bedrock;

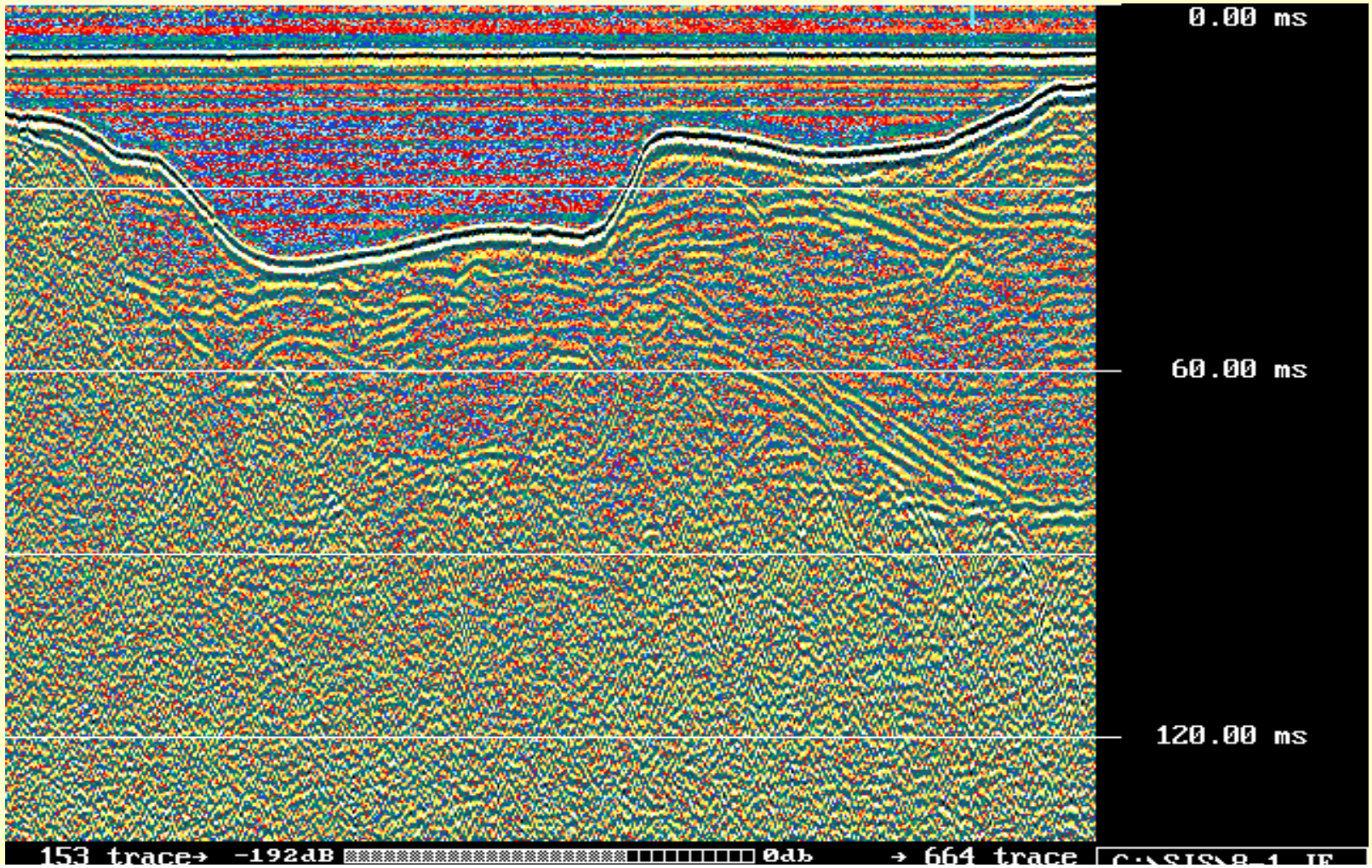
4)To detect width and location of anomaly (such as cavity) underground

Geophysical Condition using Seismic Image Method:

1) Big difference in Wave impedance in the adjacent soil strata

2) The relative even ground surface is required in topography survey line.

Typical Processed Time Section (Seismic Imaging)



Cross-hole Seismic Tomographic Imaging (CT)

Applications:

1)To classify geological formations;

2)To determine engineering properties of rock mass;

3)To detect geological anomalies such as cavity;

4)To detect width and location of weakness zone and fault;

Geophysical Condition using CT:

1) Less vibration noise

2) Depth of BH > Distance of BH.

2D Velocity Color image from CT

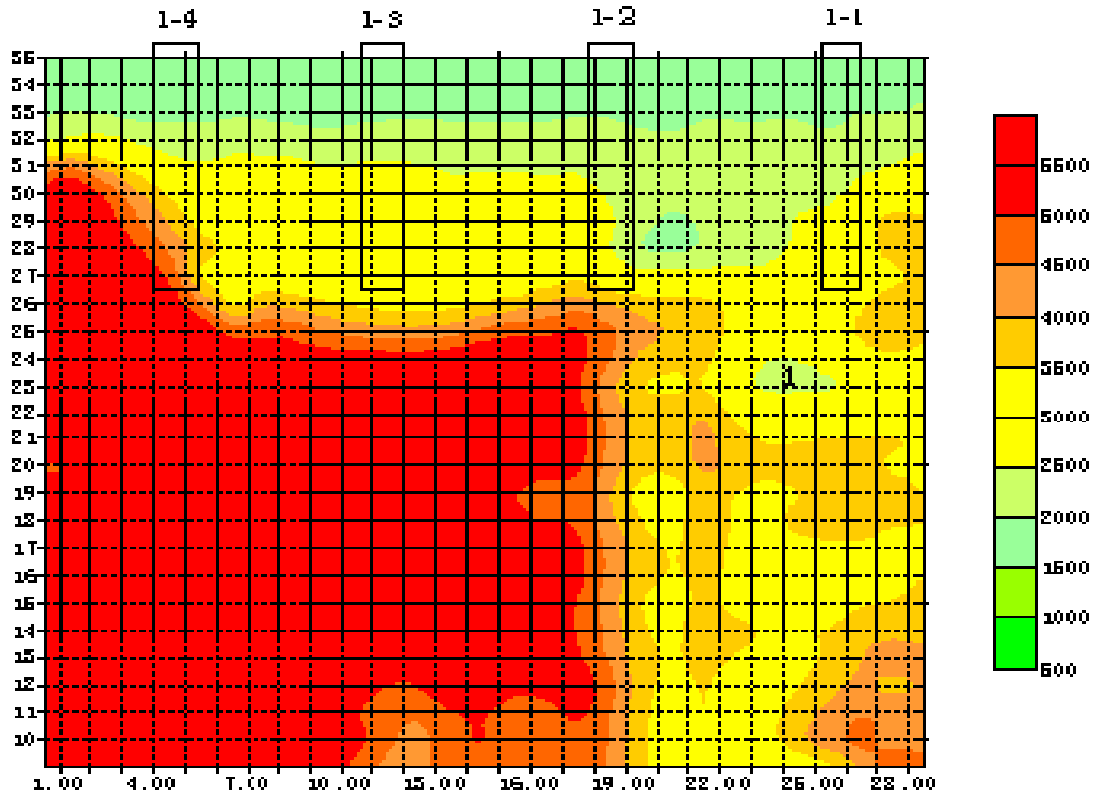


FIG5 CT Result

Seismic (P-S) Wave Logging

Applications:

1)To determine velocity (P-S) of soil & rock strata;

2)To calculate Dynamic Poisson's ratio, young's modulus and so on;

Geophysical Condition P-S BH Logging:

1) Less vibration noise

Seismic velocities of soils and rocks

Type of material	Wave velocity (m/s)	
	Compressive Wave	Shear Wave
Sand	300-800	150-280
Clay	500-2500	160-220
Shale	2000-5000	1200-3000
Limestone/dolomite	3500-6500	2000-4000
Basalt/diabase	5000-7000	2500-5000
Granite	4500-9500	1500-5000
Air	330	0
Water	1450-1500	0

Relationship between rock Quality RQD and Velocity

Rock mass Quality	RQD (%)	Velocity index (V/V_{lab})
Very poor	<25	0.25
Poor	25-50	0.25-0.5
Fair	50-75	0.5-0.75
Good	75-90	0.75-0.9
Excellent	>90	>0.9

Electrical Resistivity

Applications:

1)To classify geological formations;

2)To investigate depth of overburden, weathered rock & bedrock;

3)To detect width and location of fracture zone (weakness zone) and fault in the bedrock;

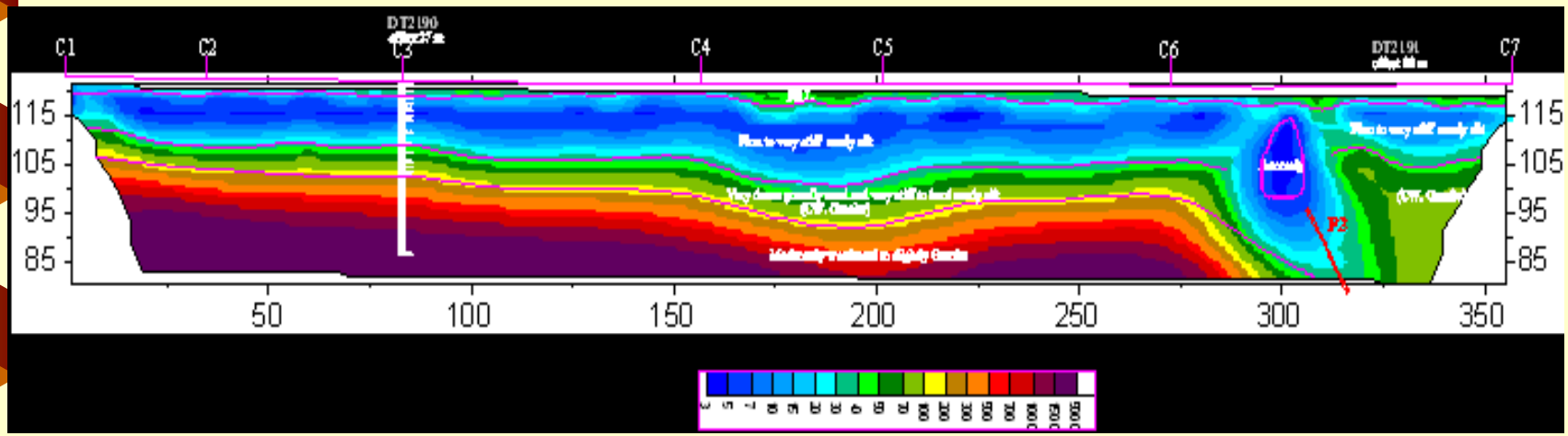
4)To detect width and location of anomaly (such as cavity, boulder) underground

Geophysical Condition using Resistivity:

1)There is no high conductive material (such as cable line, metal railing) along survey line.

2) The relative even ground surface is required along topography survey line.

Resistivity Profile



Radar Method

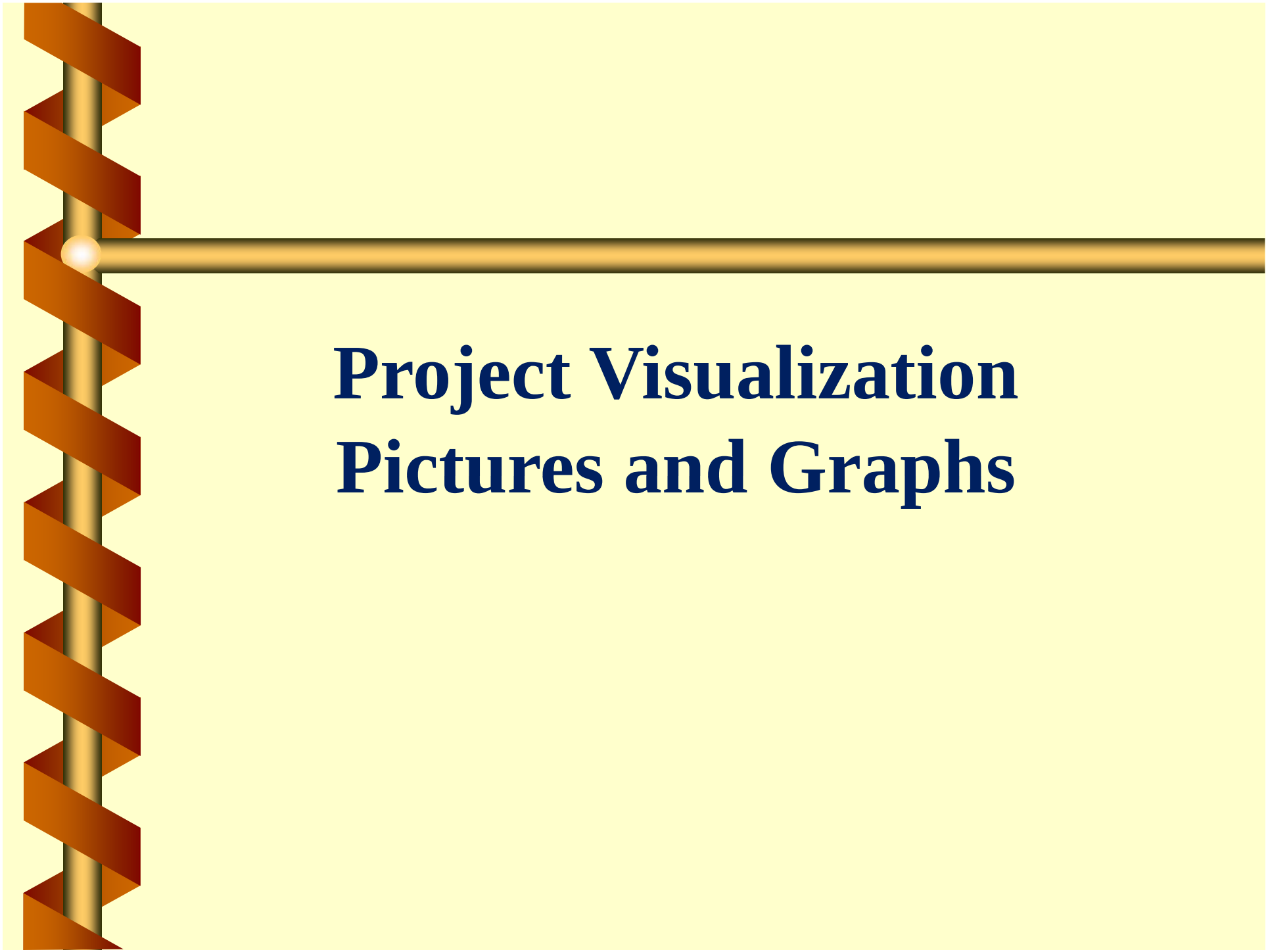
Applications:

1)To detect width and location wipe, cavity & boulder;

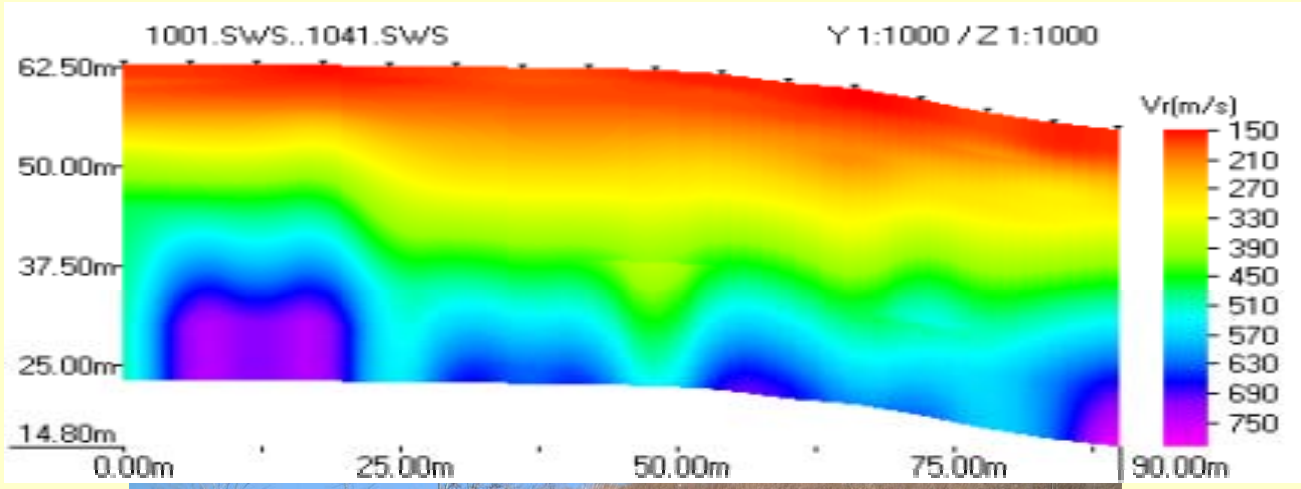
2)To detect construction quality of tunnel, roadbed and so on;

3)To investigate depth of shallow bedrock & water table;

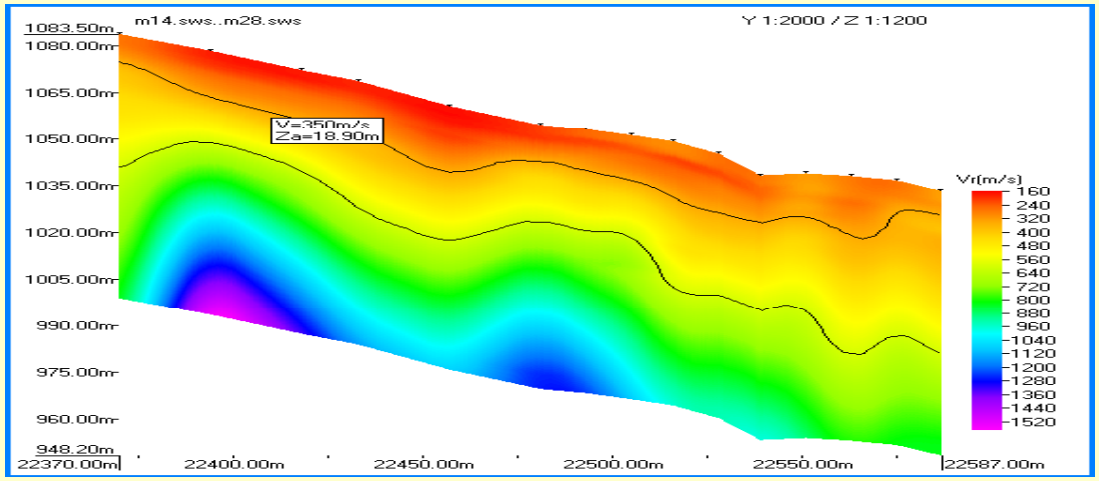
4) For archeology study purpose.

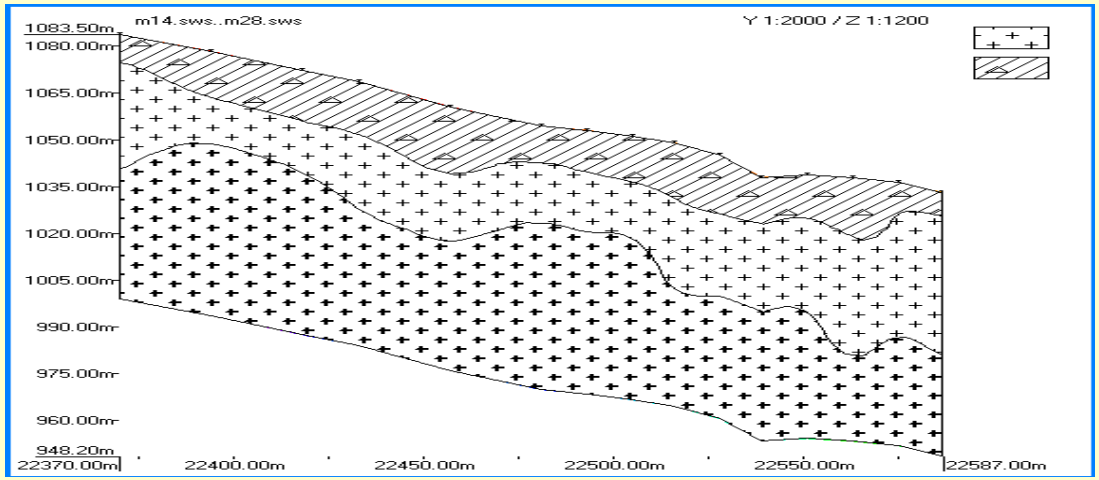

Project Visualization
Pictures and Graphs

Site investigation of power plant

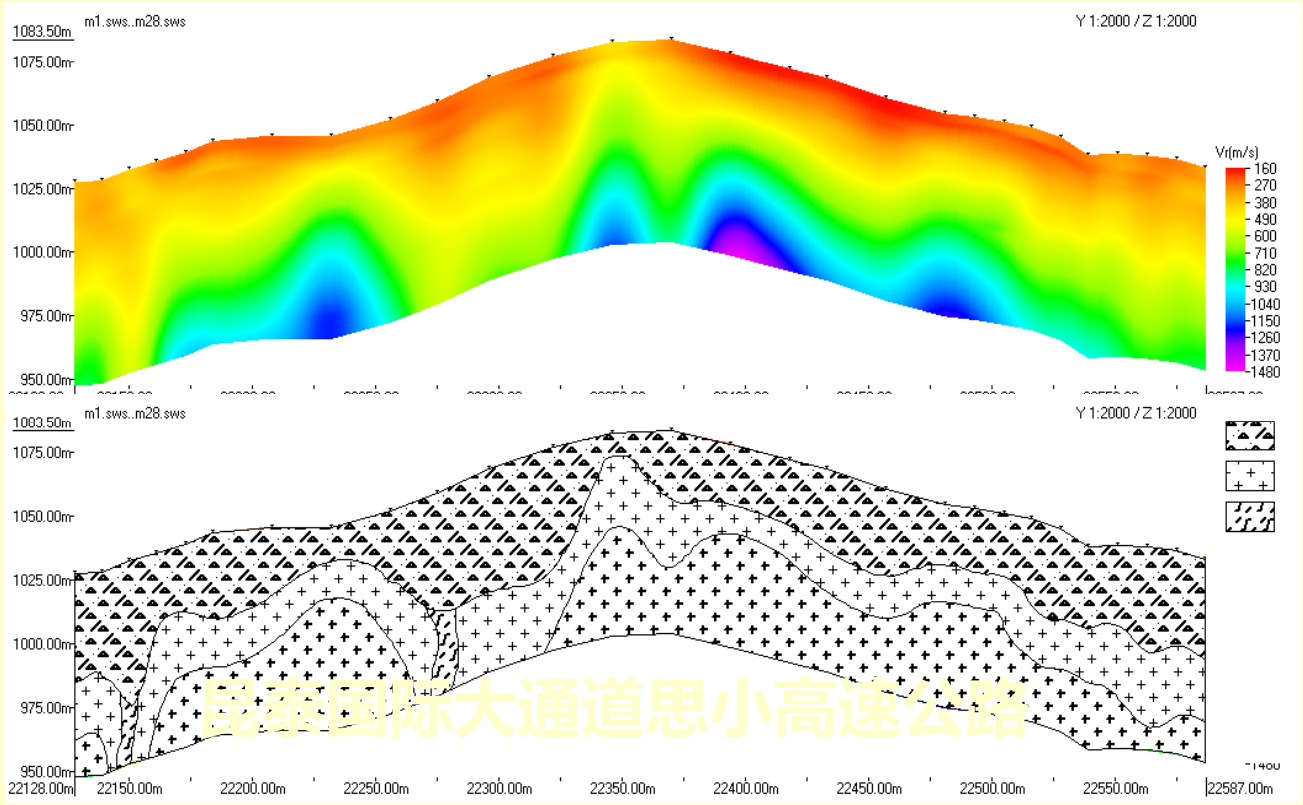


Weathering zone investigation



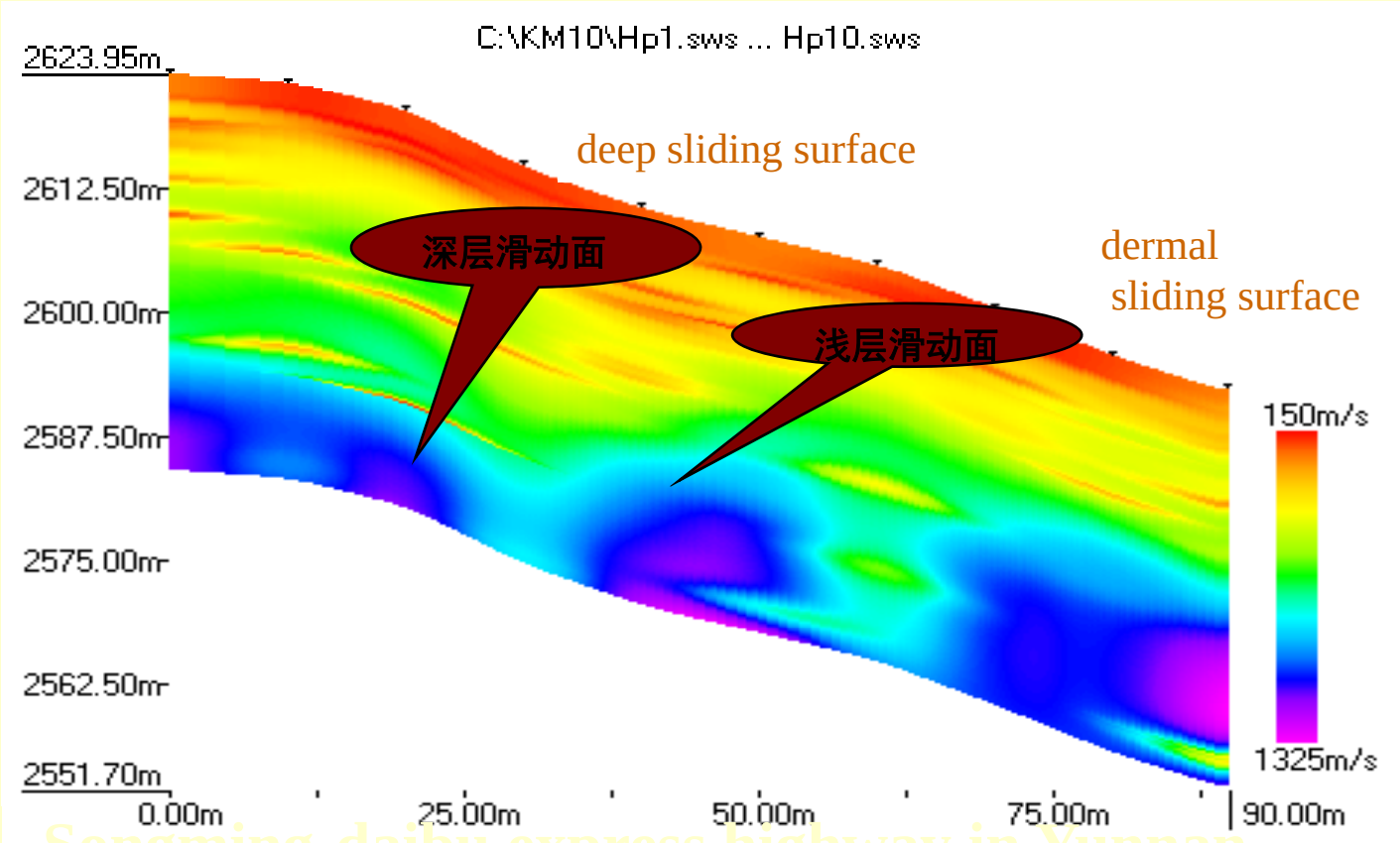


Weathered Zone investigation



Sixiao express highway connecting Kunming to Thai highway

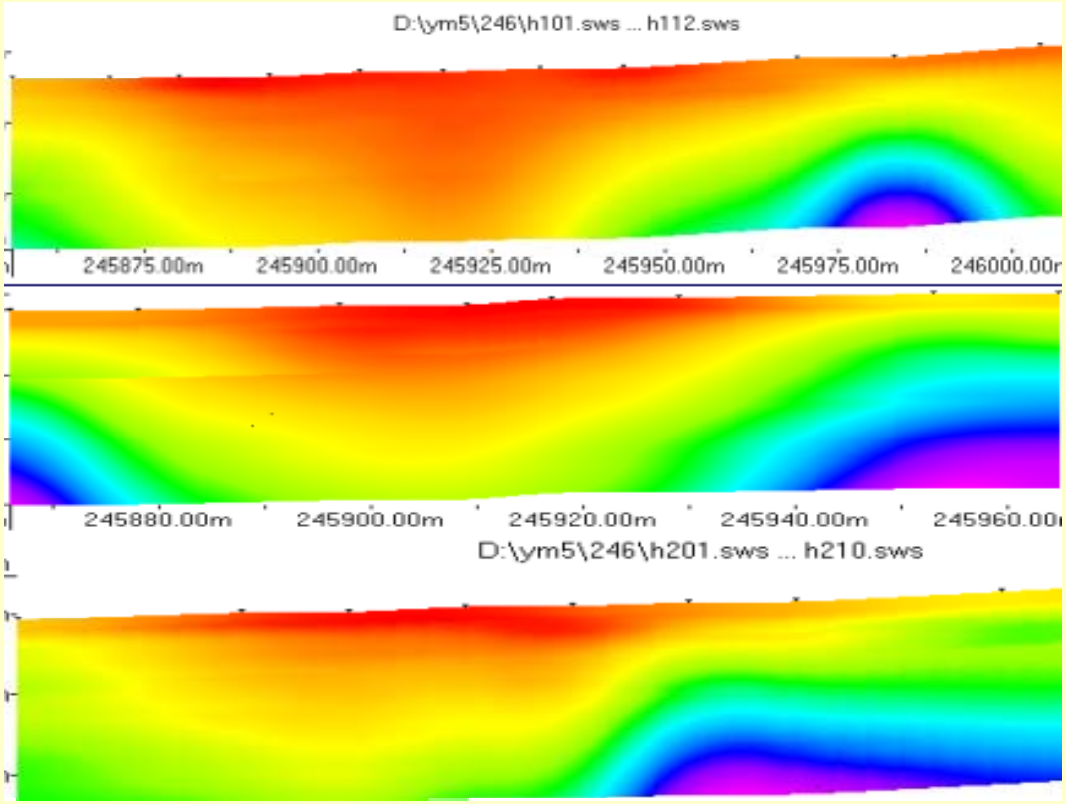
Landslide investigation



Landslide Investigation (revived antique landslide profile)

“V” type（landslide in gray-yellow；rock mass in black）Line array：3 red line

Landslide shape Surface wave profile

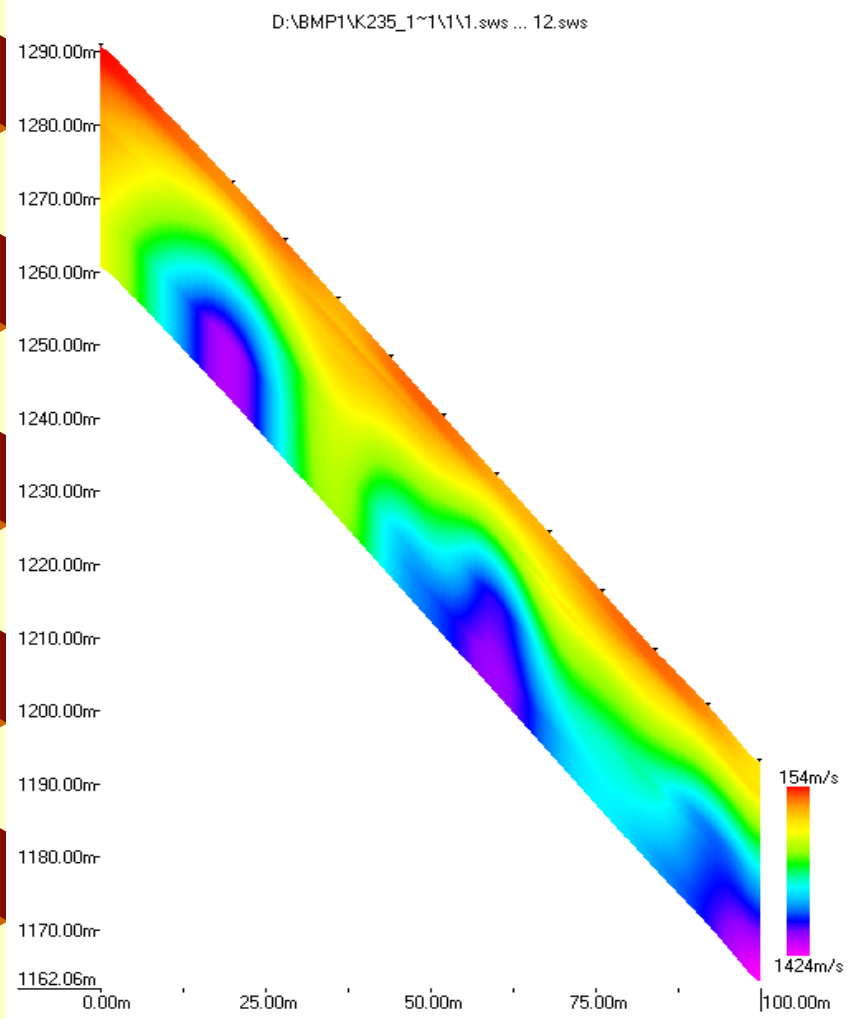


Red: “V” shape in 3 profiles,indicates antique landslide shape。

Shear velocity range from 180m/s～850m/s in red to purple of the chart。

Yuanmo Highway Project

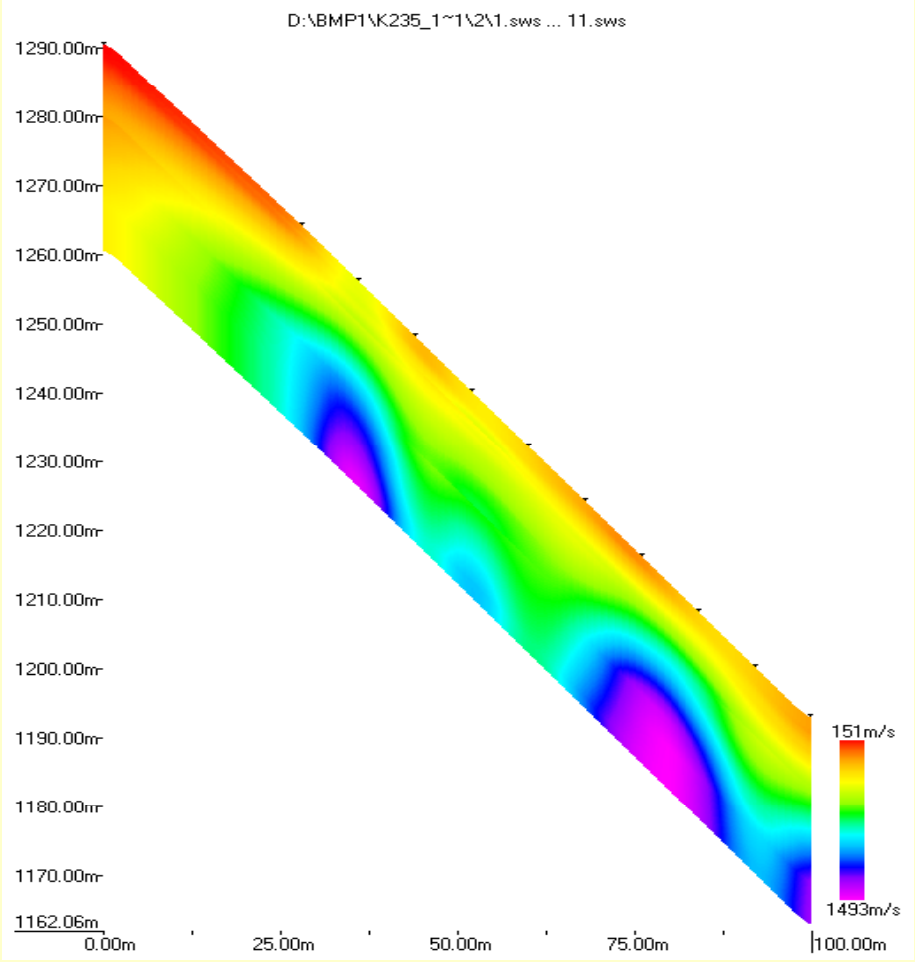
Slope Investigation By SWS Method



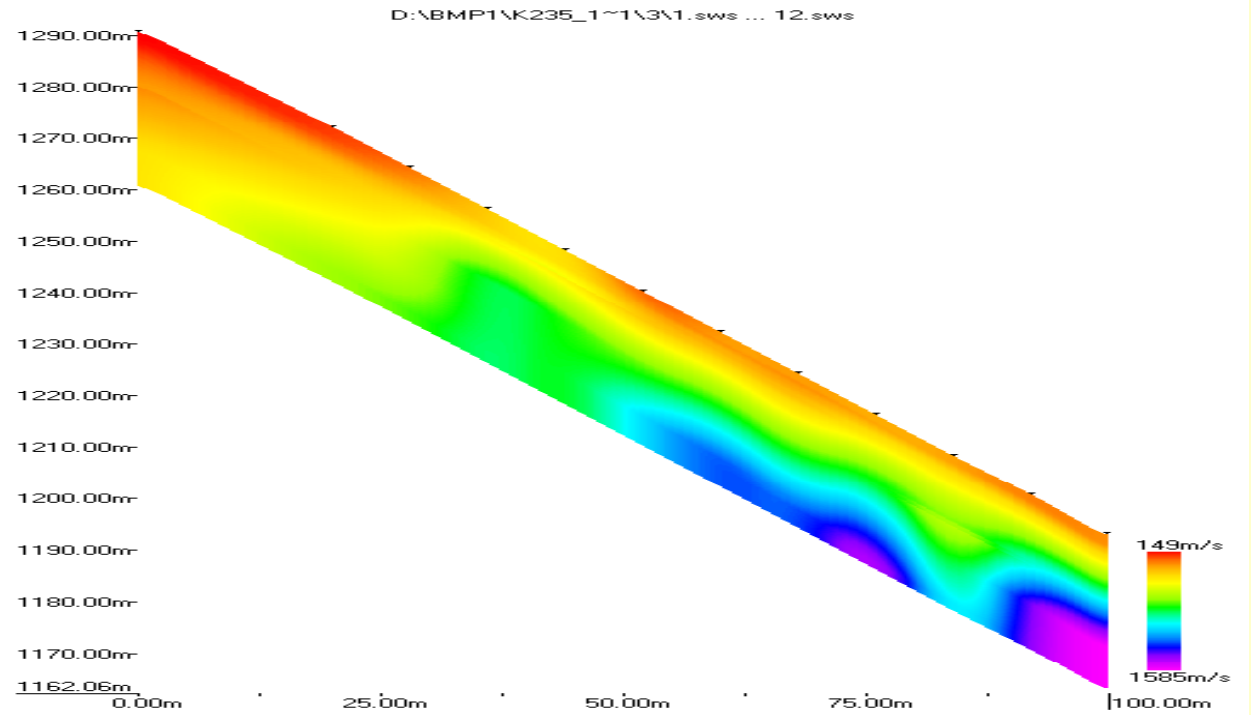
- Red for fully weathered rock；
- Yellow for strongly weathered rock；
- Green for moderately weathered rock
- Blue-pink for slightly weathered rock;

SWS Investigation Profile

B



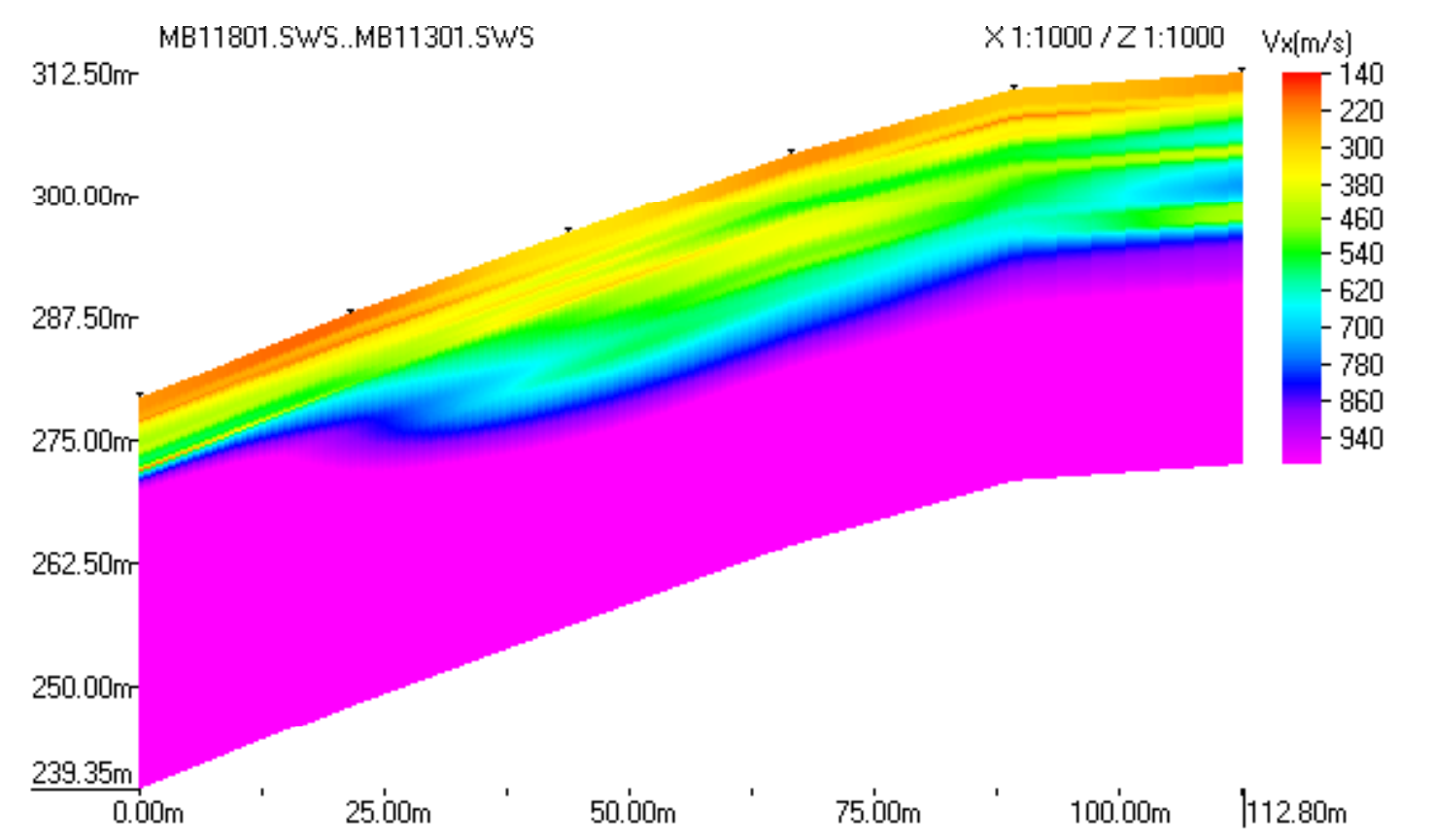
SWS Investigation Profile



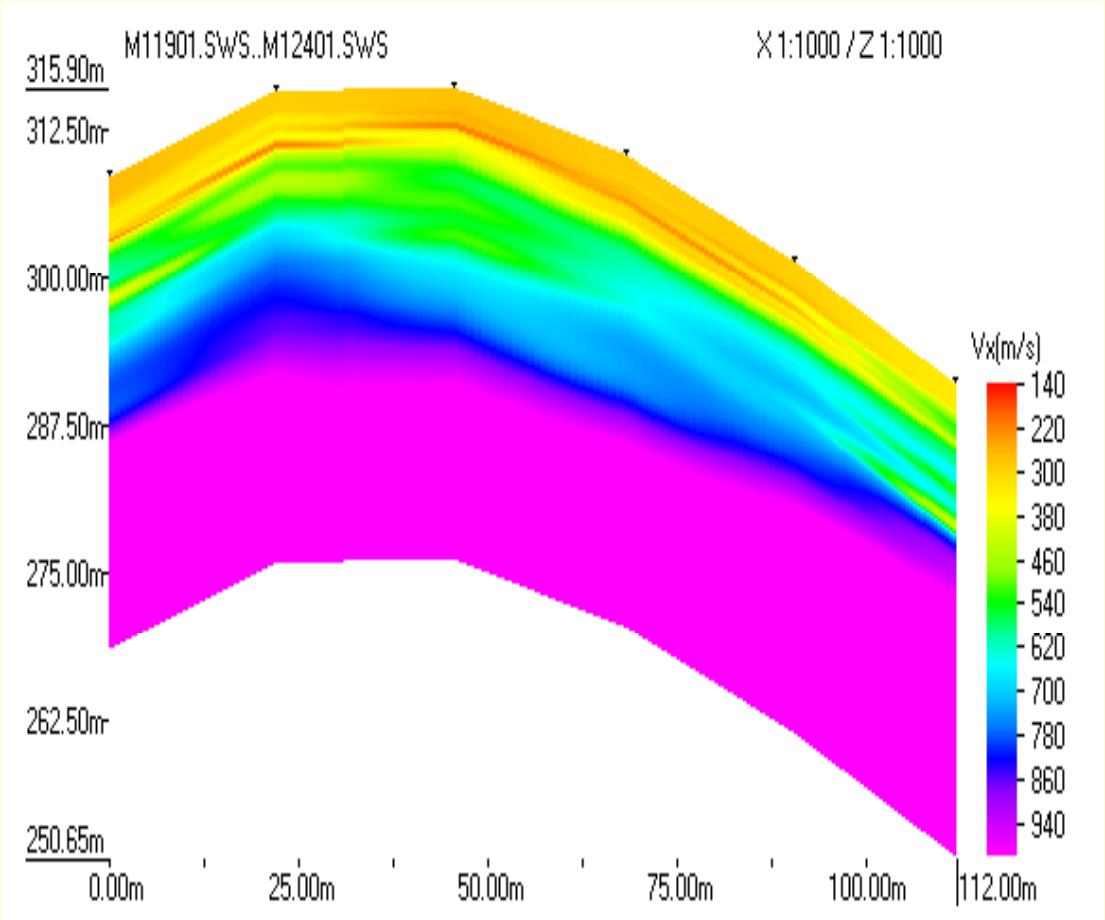
边坡治理效果

the treated slope

Other Slope Investigation Profile by SWS



Other Slope Investigation Profile by SWS



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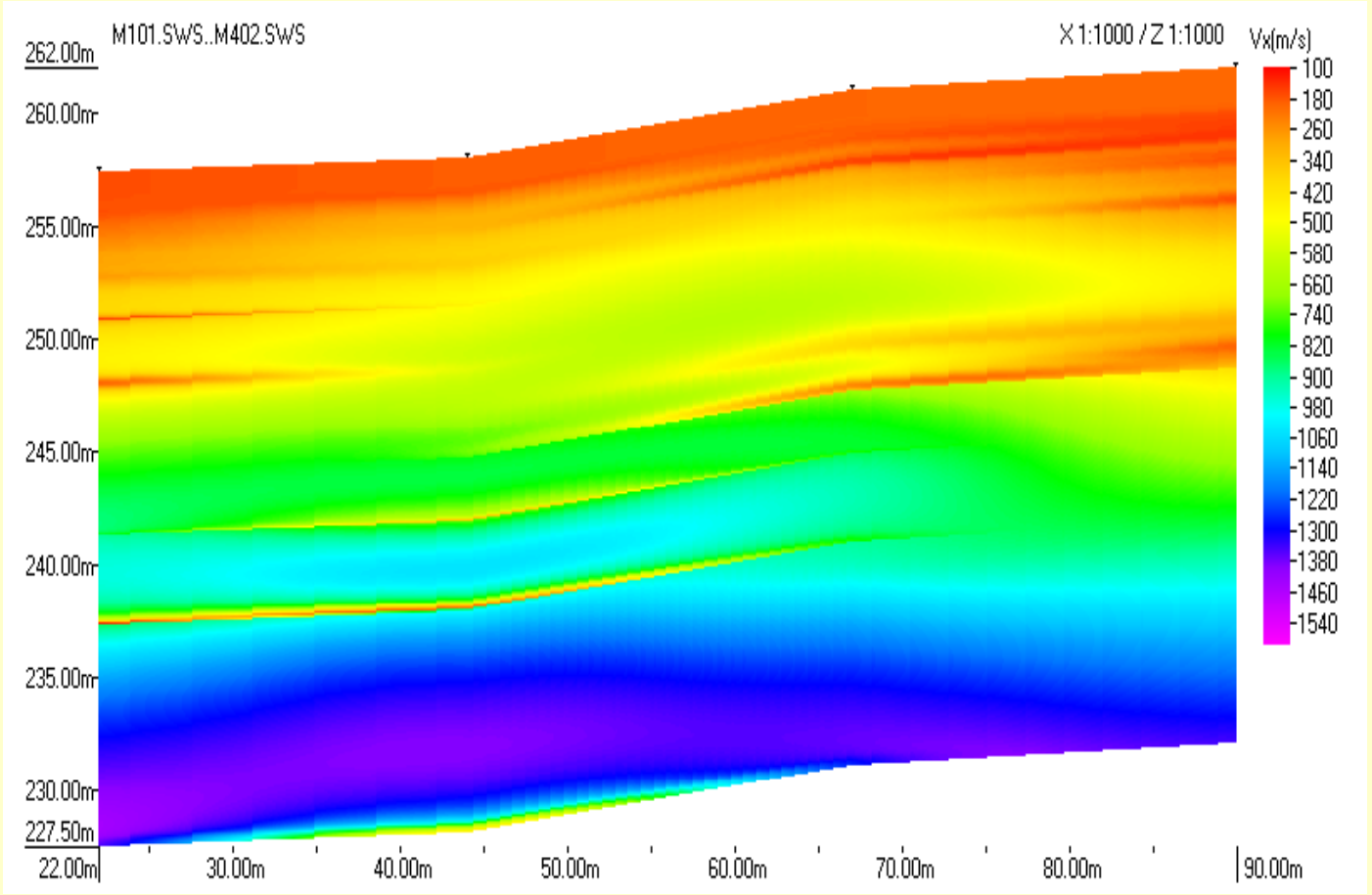
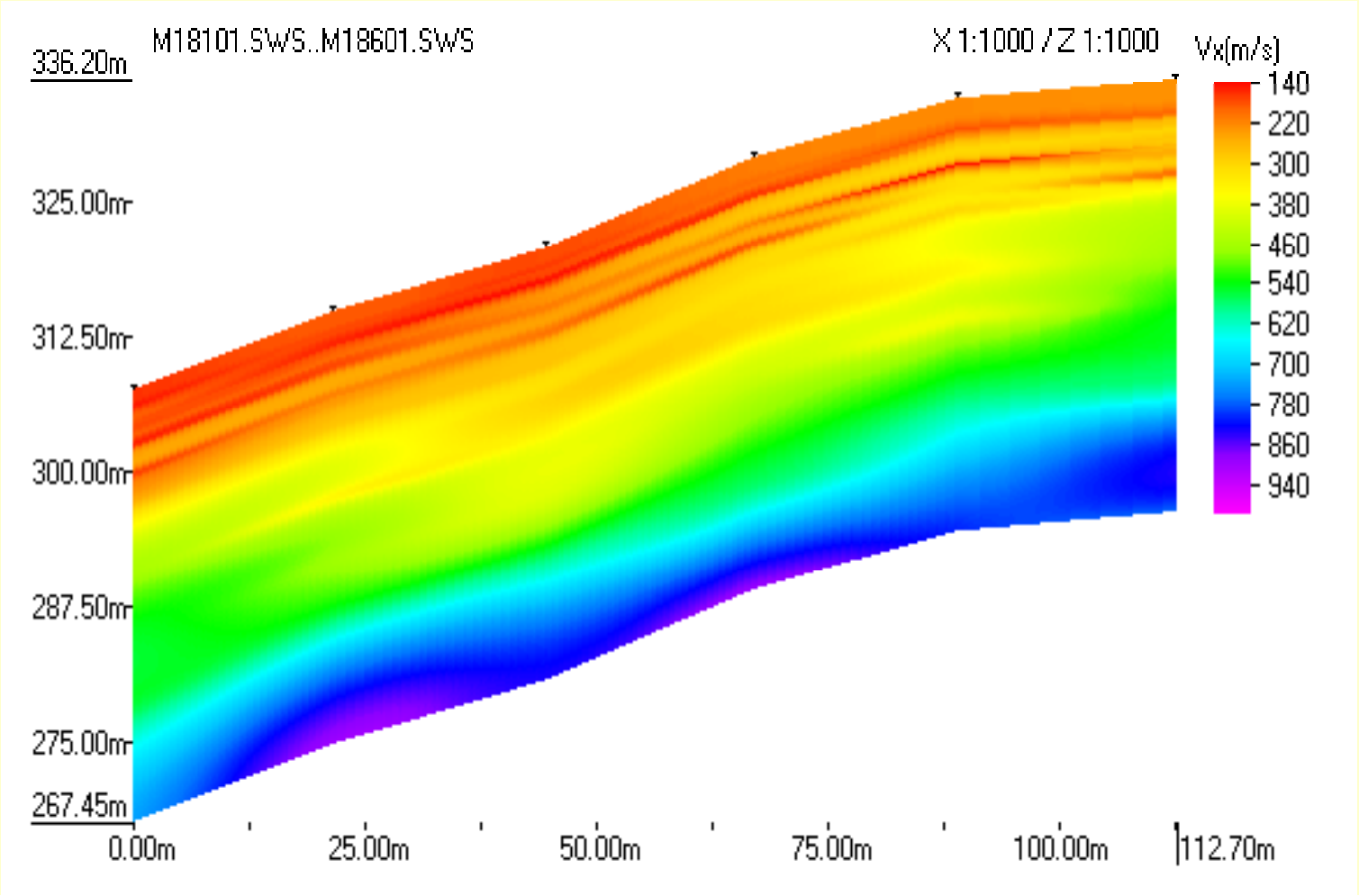


Other Slope Investigation Profile by SWS



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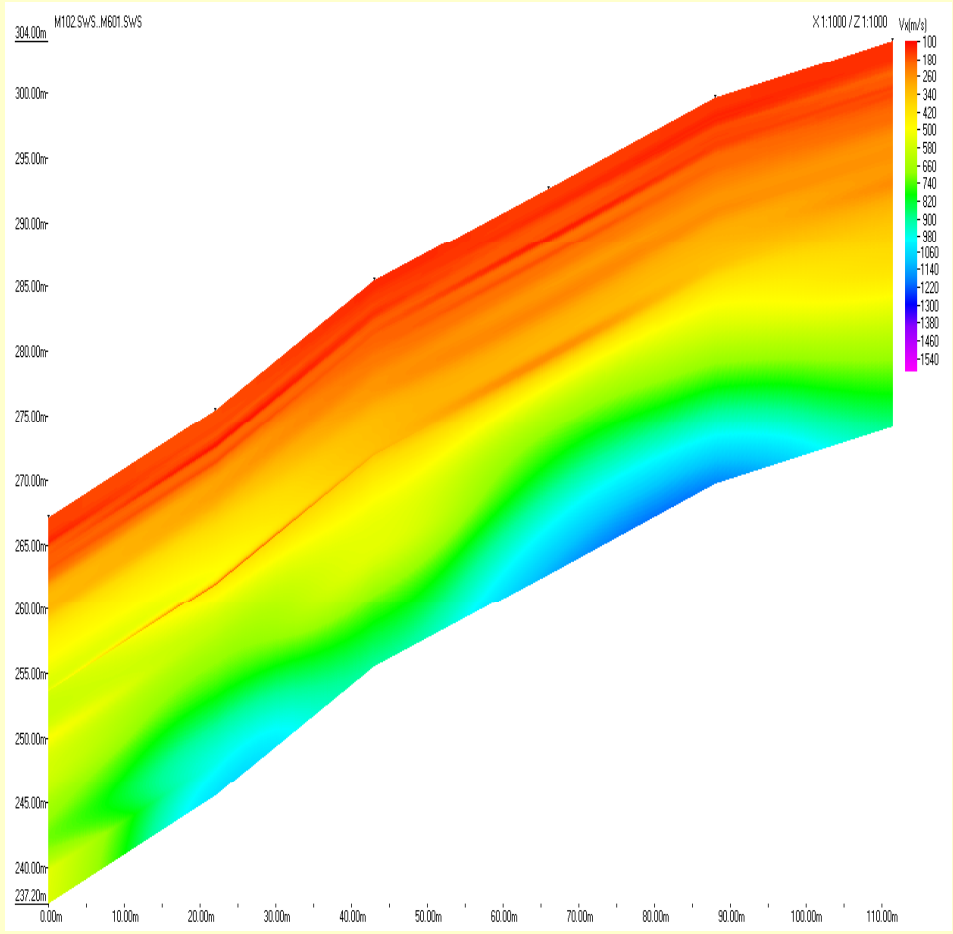

Thank You!