

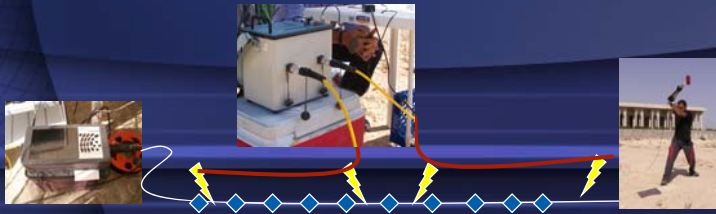
SENIOR PROJECT

Integration of Surface Seismic with Geo-electric Data

By:
Abdulrahman Al-Shuhail
Ali Al Halal
Ahmed Al Zawwad
Hasan Ramadhan
Omar Bawazir

Course Instructor and Project Coordinator
Dr. Ali Oncel (KFUPM)

Academic & Industry Consultants:
Dr. Cesar Barajas-Olalde (Schlumberger)
Dr. Abdullatif Qahwash (KFUPM)

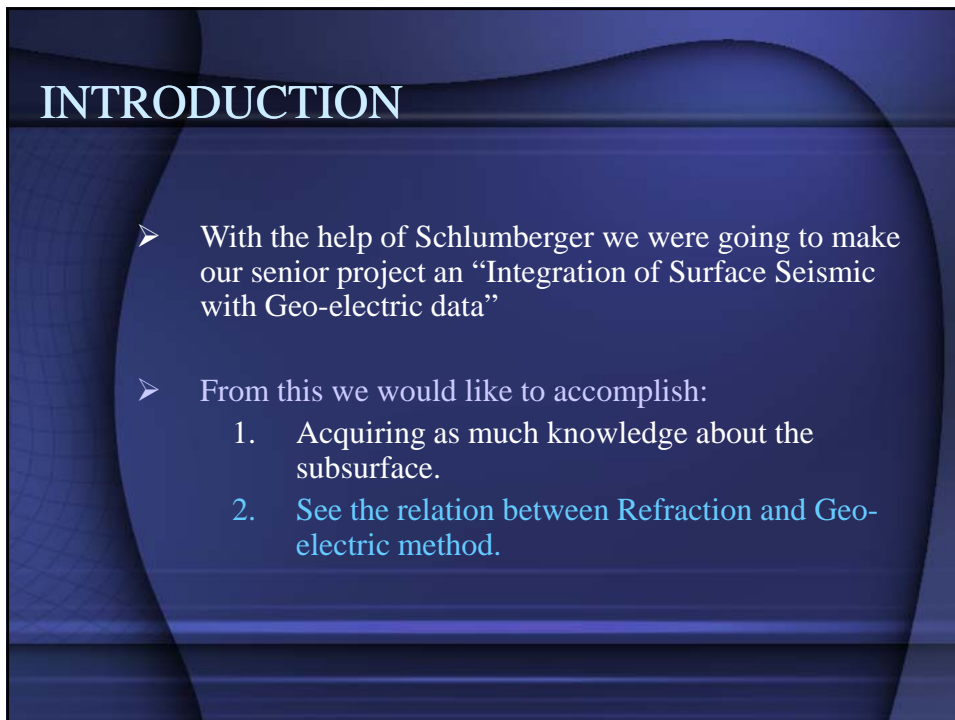
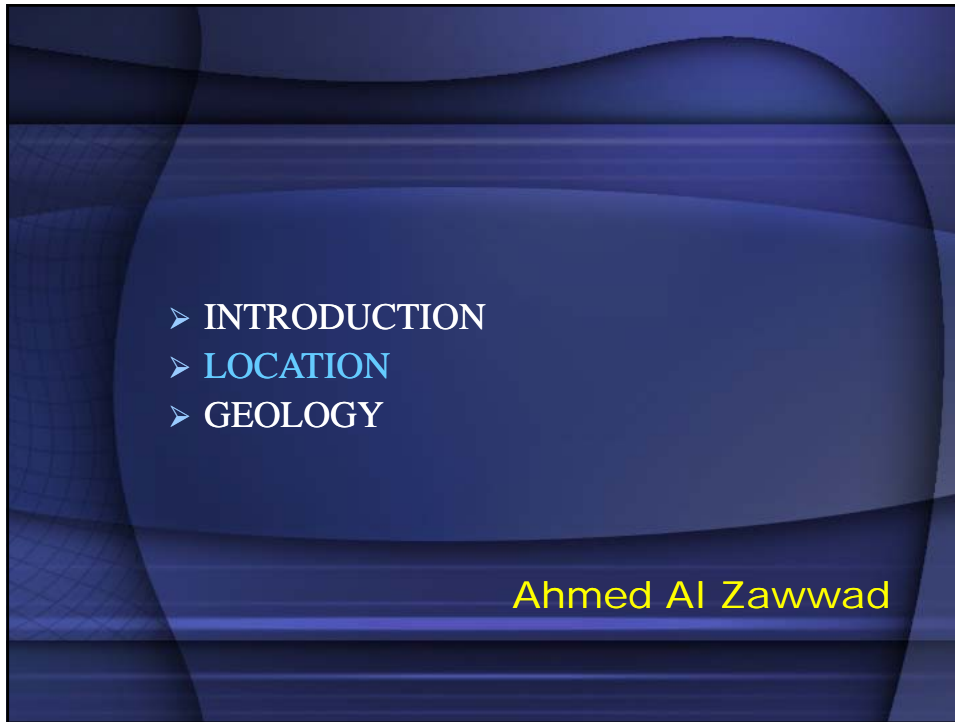


Outline

- INTRODUCTION
- LOCATION
- GEOLOGY

<p>(Seismic Part)</p> <ul style="list-style-type: none"> ➤ SEISMIC EQUIPMENT ➤ FIELD GEOMETRY ➤ NOISE ANALYSIS ➤ PRE-PROCESSING ➤ PROCESSING ➤ INTERPRETATION 	<p>(Geo-electric Part)</p> <ul style="list-style-type: none"> ➤ BACKGROUND ➤ INSTRUMENTAL USED ➤ GEOMETRY PARAMETERS ➤ PARAMETERS AND MEASUREMENTS ➤ PROCESSING ➤ INTERPERTATION
--	---

- INTEGRATION
- CONCLUSION



LOCATION

- The area that we agreed on doing the experiment in, is Dhahran Techno Valley.
- It lies over the proven Dammam reservoir.
- By knowing the weathering layers properties over this region it could help in reflection seismic “static correction”.



Geology

- Generally the geology expected to be encountered is either of the Dammam Formation or Rus Formation.

SERIES	STAGE	FORMATION	LITHOLOGY , MEMBER , THICKNESS	
E O C E N E Y P R E S I A N	MIDDLE	DAM	Reefal Lmsf., Calcaremites & Calcinudites	
		LUT.	DAMMAM	Khobar Member Dolomitic Lmsf. & Marl. (9.3m)
			Alveolina Lmsf. (1m)	
			Midra & Saiba Shales (7.2m)	
	RUS	Y		Chalk Member Dolomite (3.6m)
				Marl and dolomite with gypsum bands and quartz geodes (32 m)
				Dolomite (21m)
		LUMMER RADHUMA	Dolomite	

M. NAMIK CAGATAY 1990.

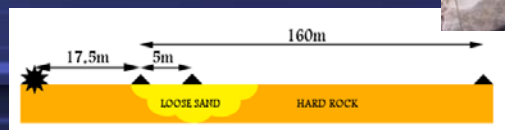
SIESMIC PART

- SIESMIC EQUIPMENT
- FIELD GEOMETRY
- NOISE ANALYSIS

Ali Al Halal

Seismic Equipment

- 3 days field work
- Day 1:
 - Decision of receiver and shot locations.
 - Flags determined the locations.
 - Digging to place the geophones.



Seismic Equipment

- 3 days field work
 - Day 2:
 - 3D Geophones were put in.
 - Cable connected.
 - 3 geodes were used.
 - Noise analysis.

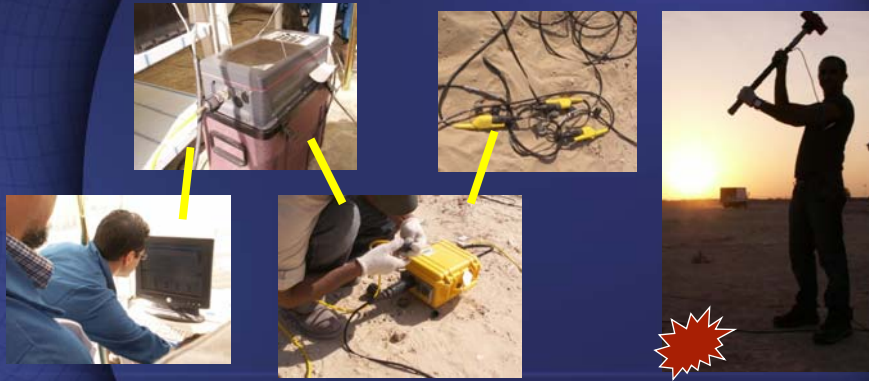


Seismic Equipment

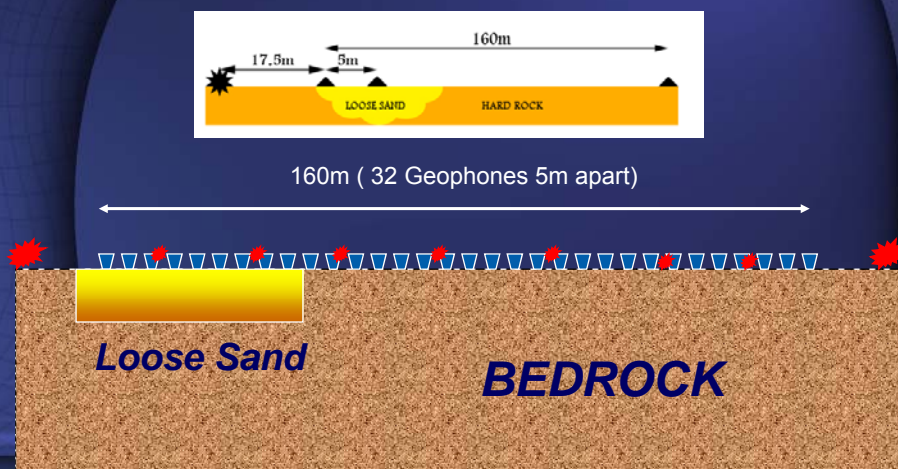
- 3 days field work
 - Day 3:
 - Hammer source.
 - 9 shots were recorded with a stack of 7.
 - Using the Seismic acquisition machine "Geometrics" the shots were recorded.



Seismic Equipment

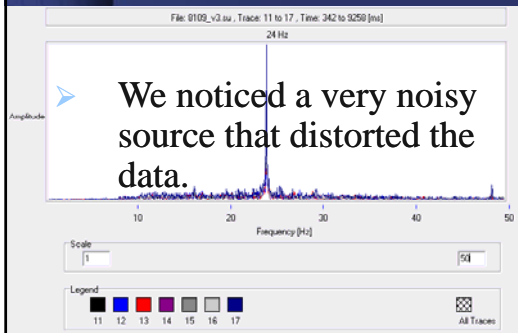


Field Geometry



Noise Analysis

- Before any shots are recorded noise analysis has to be done for QC.



Noise Analysis

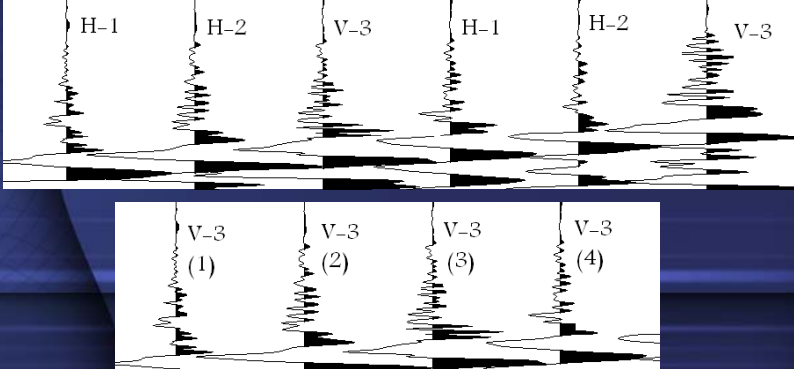


➤ PRE-PROCESSING
 ➤ PROCESSING
 ➤ INTERPRETATION

Abdulrahman Al-Shuhail

Pre-Processing

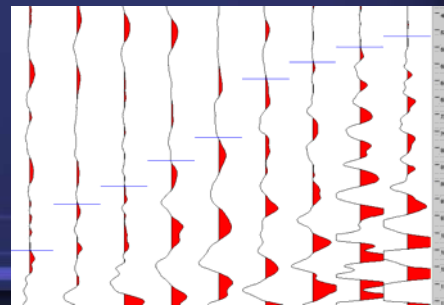
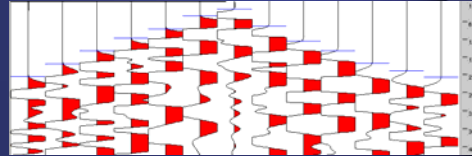
- The 3 component data was recorded using 1 profile, hence we got 96 traces in each record.
- Before any processing could take place we had to separate the H-1 and H-2 components.
- Using VISUAL SUNT we successfully separated the components and got only the V-3 component.



The figure displays seismic traces. The top row shows three traces labeled H-1, H-2, and V-3, followed by a repeat of H-1, H-2, and V-3. The bottom row shows four traces labeled V-3 (1), V-3 (2), V-3 (3), and V-3 (4), representing the isolated V-3 component after processing.

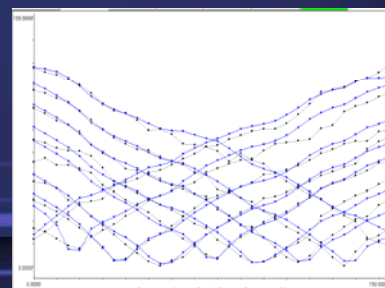
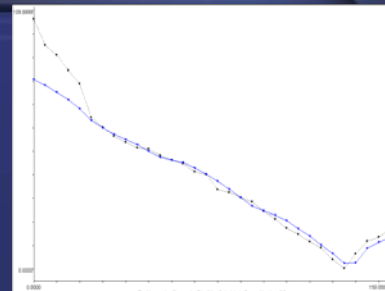
Processing

- ▶ Then next was to pick the first breaks.
- ▶ Using SeisOPT Picker we were able to get the first arrivals.
- ▶ It was difficult to find the first break when the shot was furthest from the sand.



Processing

- For modeling we used SeisOPT@2D.
- Before modeling the data we had to check the first arrivals with respect to the other shots.



Interpretation

- First model that we obtain has its parameters automatically calculated.
- Then we run it ten more times while changing one of the parameters.
- Finally we take the 3 least error models.

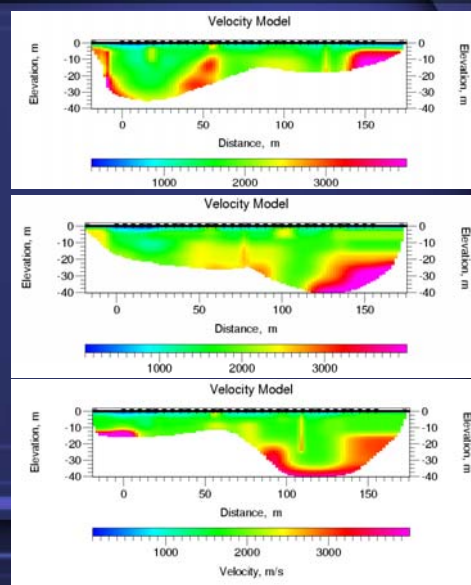
Interpretation

Best Models

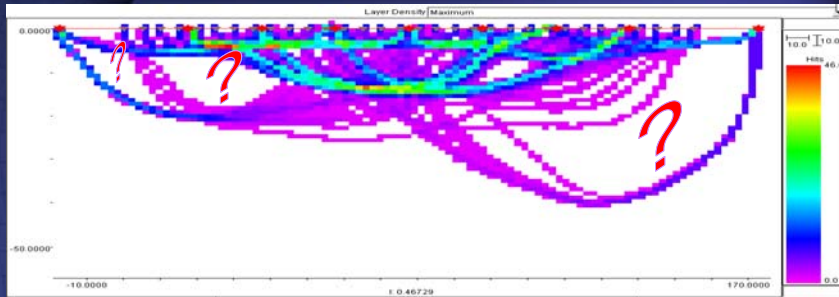
(a) Error: $4.872072e-006$

(b) Error: $5.523698e-006$

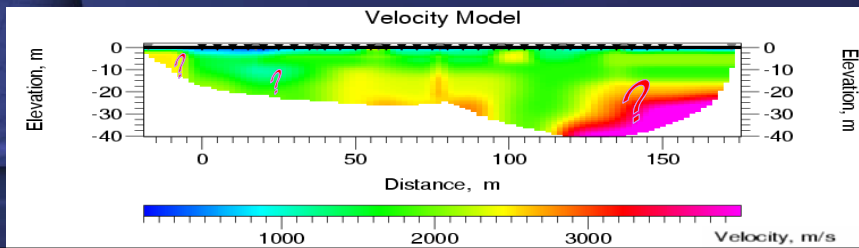
(c) Error: $4.934083e-006$



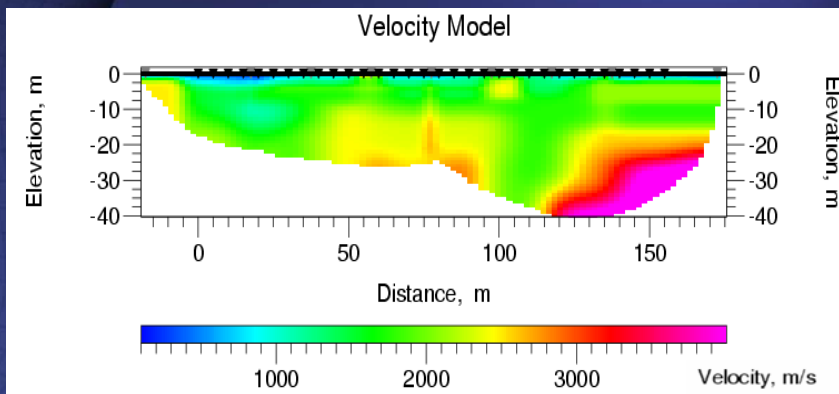
Interpretation



- ✓ Each model defines a certain area bounded by the ray paths.



Interpretation



GEO-ELECTRIC PART

- BACKGROUND
- INSTRUMENTS USED
- GEOMETRY PARAMETERS
- PARAMETERS AND MEASUREMENTS

Hassan Al Ramadhan

BACKGROUND

- Principle: transmitting a DC current “I” through two electrodes and measuring a voltage “V” with two other electrodes
- Apparent resistivity: $\rho_a = kV / I$, K depending on the electrode separation
- Detects many kinds of features
 - layering
 - folds, faults
 - bedrock
 - voids and cavities

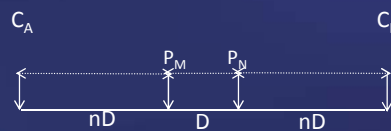
SURVEY STRATEGY

- Resistivity mapping, constant separation traversing (**CST**) used to determine lateral variations of resistivity. The current and potential electrodes are maintained at a fixed separation and moved along profiles
- Vertical electrical sounding (**VES**): used in the study of near-horizontal interfaces. The electrode spread is progressively expanded about a central point
- Resistivity tomography (**ERT**): is a mix between CST and VES. Also named electrical imaging

Dr. Laurent Marescot, 2007

WENNER-SCHLUMBERGER ARRAY

- Sensitive to both horizontal & vertical changes




C_A & C_B = current electrodes

P_M & P_N = potential electrodes

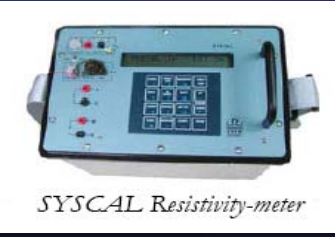
n = the ratio of the distances between the C_A - P_M and P_M - P_N

The IRIS instrument (Syscal R1 Plus):

Specifications:	Applications:
<ul style="list-style-type: none"> • Measures both resistivity and chargeability (IP) • Two strings of cable with 24 electrode • DC current of 2.5mA, 200 watts 	<ul style="list-style-type: none"> ▪ environmental studies, ▪ groundwater investigation, ▪ civil engineering, ▪ Archaeology. ▪ geotechnical investigations



A current electrode



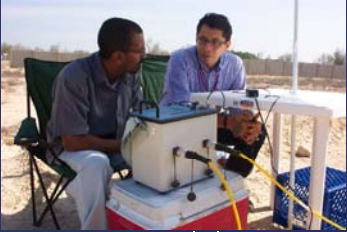
Syscal R1 PLUS


GEOMETRY PARAMETERS

- Number of electrodes= **34**
- A constant electrode spacing “a” = **5 meters**
- Spread length “L”= **170 meters**
- Depth of investigation= **34 meters**

Wenner-Schlumberger Array

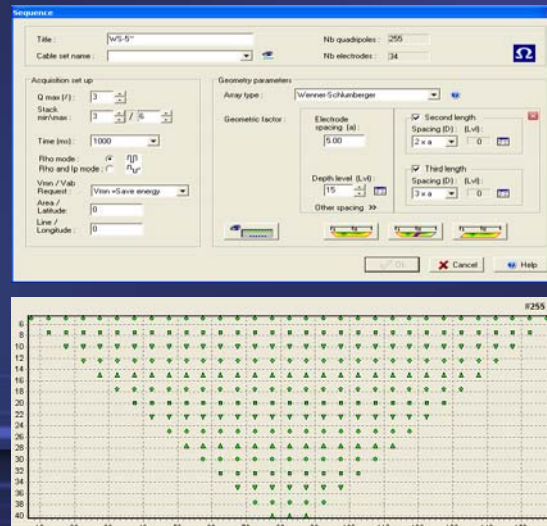
Depth: about 0.2 x L





PARAMETERS AND MEASUREMENTS

1) CREATE A SEQUENCE OF READING WITH ELECTRE II SOFTWARE.



PARAMETERS AND MEASUREMENTS

2) TAKING READINGS IN THE FIELD WITH Syscal R1 Plus



PARAMETERS AND MEASUREMENTS

Regular check steps during the survey

- Checking the internal transmitter battery of the SYSCAL.
- Checking the connection of these electrodes with the “RS CHECK” key, by spraying slight salty water around a disconnected electrode.



- PARAMETERS AND MEASUREMENTS
- PROCESSING
- INTERPERTATION (RES2Dinv)
- INTERPRETATION (RES1D)

Omar Ba-wazir

PARAMETERS AND MEASUREMENTS

3) Transfer And Process The Data With PROSYSII Software.

The main functions of the PROSYSII software are the following:

- Data download:

The screenshot shows the PROSYSII Software interface. A menu is open for 'Communication port', showing options like 'SYSVAL V21 / Linux 1', 'SYSVAL K1 switch', 'SYSVAL K1', 'SYSVAL I/O / EPC2 I/O', and 'P10 via modem'. Below the menu is a table with columns for '#', 'E-array', 'Spa.1', 'Spa.2', 'Spa.3', 'Spa.4', 'Rho', 'Dev.', 'M', 'Sp', 'Vp', and 'In'. The table contains 25 rows of data for 'Wenner-Schlumberger' measurements.

#	E-array	Spa.1	Spa.2	Spa.3	Spa.4	Rho	Dev.	M	Sp	Vp	In
1	Wenner-Schlumberger	0.00	195.00	75.00	80.00	169.78	0.0	0.00	0.0	0.963	21.39
2	Wenner-Schlumberger	0.00	145.00	70.00	75.00	417.30	2.0	0.00	0.0	0.134	1.06
3	Wenner-Schlumberger	0.00	125.00	65.00	70.00	112.54	0.0	0.00	0.0	11.954	301.13
4	Wenner-Schlumberger	0.00	125.00	60.00	65.00	109.10	0.0	0.00	0.0	12.201	274.03
5	Wenner-Schlumberger	0.00	115.00	65.00	60.00	111.49	0.0	0.00	0.0	14.859	270.21
6	Wenner-Schlumberger	0.00	105.00	50.00	55.00	112.54	0.0	0.00	0.0	10.465	180.67
7	Wenner-Schlumberger	0.00	95.00	45.00	50.00	110.85	0.0	0.00	0.0	16.775	213.94
8	Wenner-Schlumberger	0.00	85.00	40.00	45.00	173.01	0.0	0.00	0.0	21.629	141.39
9	Wenner-Schlumberger	0.00	75.00	35.00	40.00	113.81	0.0	0.00	0.0	23.851	163.91
10	Wenner-Schlumberger	0.00	65.00	30.00	35.00	116.82	0.0	0.00	0.0	20.812	117.54
11	Wenner-Schlumberger	0.00	55.00	25.00	30.00	113.19	0.0	0.00	0.0	23.111	96.21
12	Wenner-Schlumberger	0.00	45.00	20.00	25.00	92.27	0.0	0.00	0.0	21.798	74.19
13	Wenner-Schlumberger	0.00	35.00	15.00	20.00	66.98	0.0	0.00	0.0	20.794	58.84
14	Wenner-Schlumberger	0.00	25.00	10.00	15.00	66.59	0.0	0.00	0.0	19.808	28.04
15	Wenner-Schlumberger	0.00	15.00	5.00	10.00	49.91	0.0	0.00	0.0	20.336	12.80
16	Wenner-Schlumberger	5.00	150.00	80.00	85.00	246.46	0.0	0.00	0.0	4.743	72.95
17	Wenner-Schlumberger	5.00	150.00	75.00	80.00	153.77	1.0	0.00	0.0	0.893	19.16
18	Wenner-Schlumberger	5.00	140.00	70.00	75.00	95.00	0.0	0.00	0.0	5.869	176.31
19	Wenner-Schlumberger	5.00	130.00	65.00	70.00	102.52	0.0	0.00	0.0	9.934	237.44
20	Wenner-Schlumberger	5.00	120.00	60.00	65.00	102.18	0.0	0.00	0.0	7.871	159.72
21	Wenner-Schlumberger	5.00	110.00	55.00	60.00	101.67	0.0	0.00	0.0	14.172	240.84
22	Wenner-Schlumberger	5.00	100.00	50.00	55.00	106.43	0.0	0.00	0.0	16.670	221.42
23	Wenner-Schlumberger	5.00	90.00	45.00	50.00	106.97	0.0	0.00	0.0	20.463	216.95
24	Wenner-Schlumberger	5.00	80.00	40.00	45.00	161.61	0.0	0.00	0.0	21.626	117.71
25	Wenner-Schlumberger	5.00	70.00	35.00	40.00	128.46	0.0	0.00	0.0	22.697	116.57

PARAMETERS AND MEASUREMENTS

- Numeric & graphic presentation:

The screenshot shows the PROSYSII Software interface with two plots. On the left is a 2D resistivity map showing a cross-section of the ground with a color scale from 0 to 1000. On the right is a 1D resistivity profile plot showing resistivity versus depth (0 to 150 meters). The software interface includes a menu bar and a toolbar with icons for file operations, communication, processing, and viewing. The main window title is 'SYSVAL multi electrodes'.

PROCESSING

- Processing → Filtering:

The screenshot shows the Prosys II Software interface. A 'Filtering data' dialog box is open, with the 'Dev.' field set to '999.000'. Below the dialog, a table of data is displayed with columns for electrode ID, name, and various resistivity values. A blue arrow points from the 'Dev.' field in the dialog to the 'Data: 239 / 255' status bar at the bottom of the table.

#	Electrode	Spa.1	Spa.2	Spa.3	Spa.4	Rho	Dev.	M	Sp	Vp	In
<input checked="" type="checkbox"/>	236	Wenner-Schlumberger	115.00	160.00	135.00	140.00	66.33				
<input checked="" type="checkbox"/>	237	Wenner-Schlumberger	115.00	150.00	130.00	135.00	64.25				
<input checked="" type="checkbox"/>	238	Wenner-Schlumberger	115.00	140.00	125.00	130.00	51.79				
<input checked="" type="checkbox"/>	239	Wenner-Schlumberger	115.00	130.00	120.00	125.00	46.50				
<input checked="" type="checkbox"/>	240	Wenner-Schlumberger	120.00	165.00	140.00	145.00	131.27				
<input checked="" type="checkbox"/>	241	Wenner-Schlumberger	120.00	155.00	135.00	140.00	53.57				
<input type="checkbox"/>	242	Wenner-Schlumberger	120.00	145.00	130.00	135.00	38.74				
<input checked="" type="checkbox"/>	243	Wenner-Schlumberger	120.00	135.00	125.00	130.00	37.31				

PROCESSING

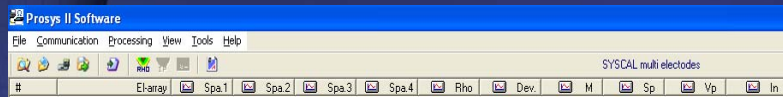
- Make a file readable by the interpretation software:

The screenshot shows the Prosys Software interface. The 'Export and save' menu is open, with 'Res2dinv / Res3dinv...' selected. A dialog box is open for saving a file, with the file name 'test_1.dat' and type 'Res2dinv / Res3dinv'. Red arrows point from the menu option to the 'Enter title for data set' field (containing 'test-1 bin') and from the dialog box to the 'Nom du fichier' field (containing 'test_1.dat').

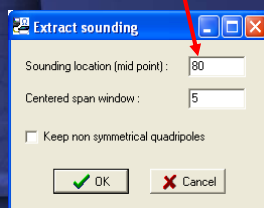
PROCESSING

Vertical Electrical Sounding (VES):

- Click on "File| Extract and Save", then "Spreadsheet Sounding".

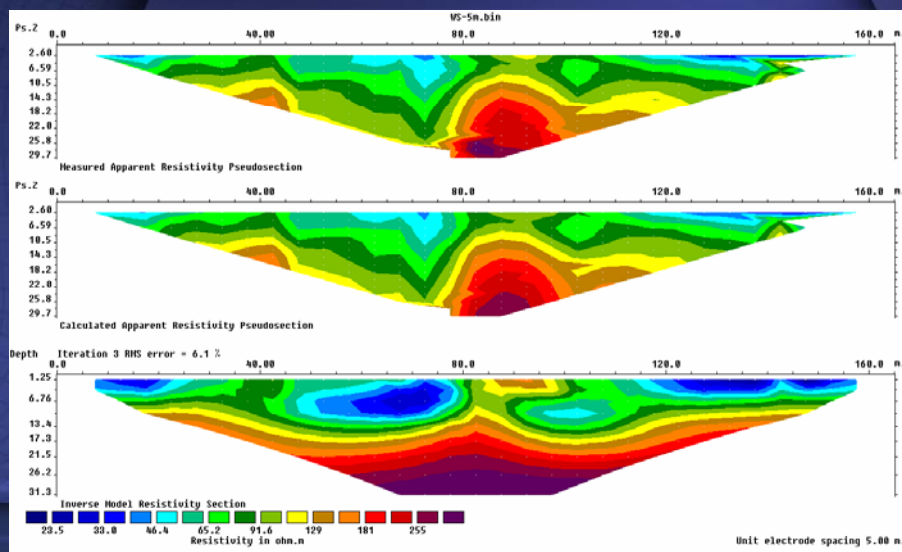


- Enter the X location (mid-point of the quadripoles, in meters).

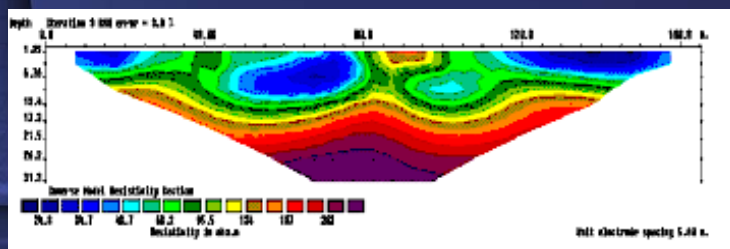
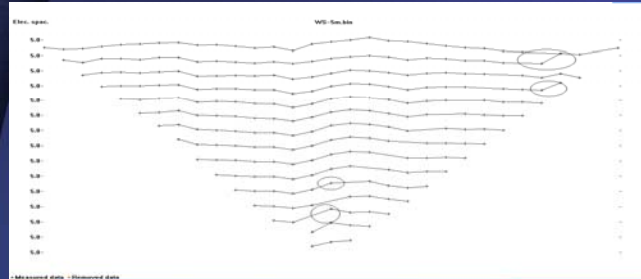


AB/2	ohm-m
7.5	74.95
12.5	67.12
17.5	67.15
22.5	78.58
27.5	93.17
32.5	107.46
37.5	120.62
42.5	130.44
47.5	140.37

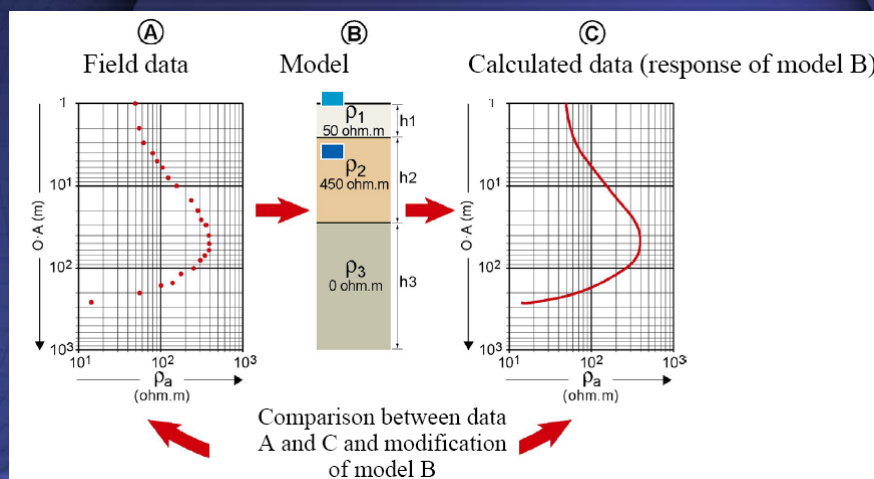
INTERPRETATION (RES2Dinv SOFTWARE)



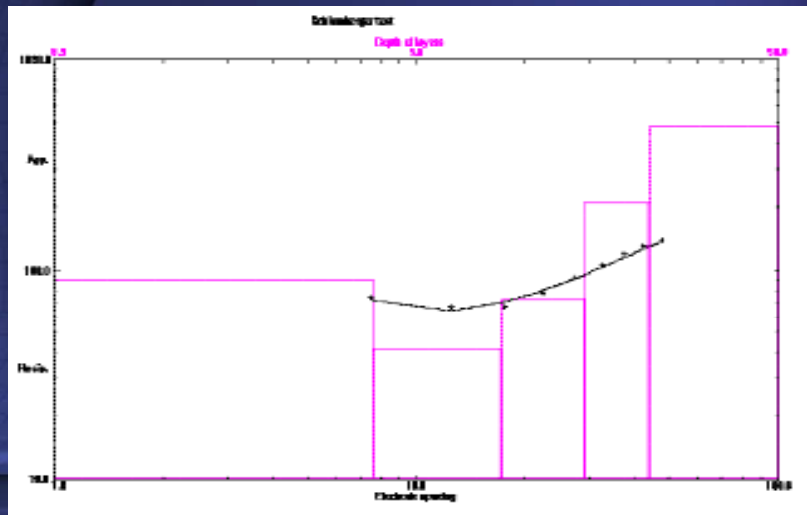
INTERPRETATION (RES2Dinv SOFTWARE)



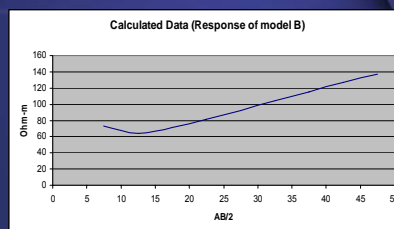
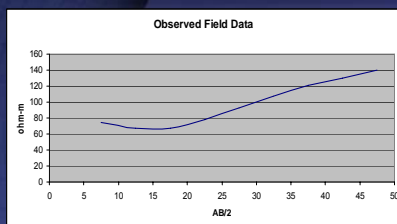
INTERPRETATION (RES1D)



INTERPRETATION (RES1D)

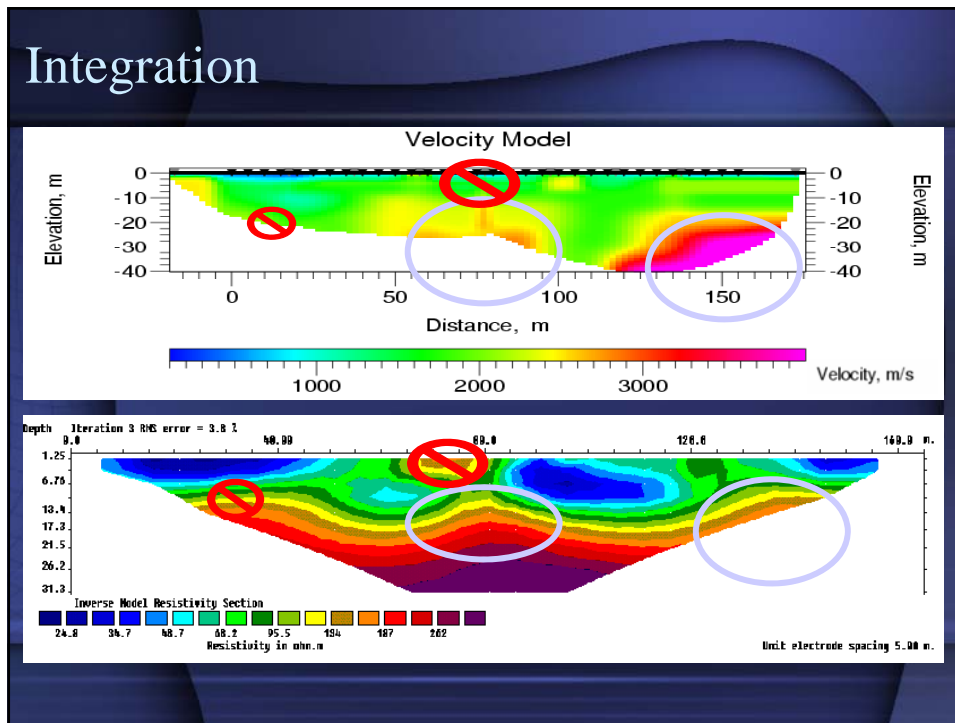


INTERPRETATION (RES1D)



Layer	Resistivity (Ohm-m)	Thickness (m)
1	91.095	3.825
2	41.663	4.781
3	73.141	5.977
4	208.799	7.471
5	484.053	

Integration



Conclusion

- Using two geophysical methods proves to be very useful in interpreting the subsurface.
- There were many models but we chose the one that agreed with real structures and the surface geology seen during the acquisition phase.
- The Seismic and resistivity models agreed in some aspects (bulging structure), but in other aspects they greatly disagreed (middle outcrop).

Acknowledgments

- We would like to thank Earth Sciences Department for giving us this opportunity.
- We would also like to thank Schlumberger Carbonate Research Center for all their help and support.
- Everyone that helped us accomplish this project.



Thank
You

