

## USE OF TRI-ELECTRODE VERTICAL ELECTRICAL SOUNDING FOR ENGINEER GEOLOGY AND HYDROGEOLOGY AS ONE EFFECTIVE AND HI-INFORMATIVE TECHNIQUE FOR SHALLOW DEPTH RESEARCHES

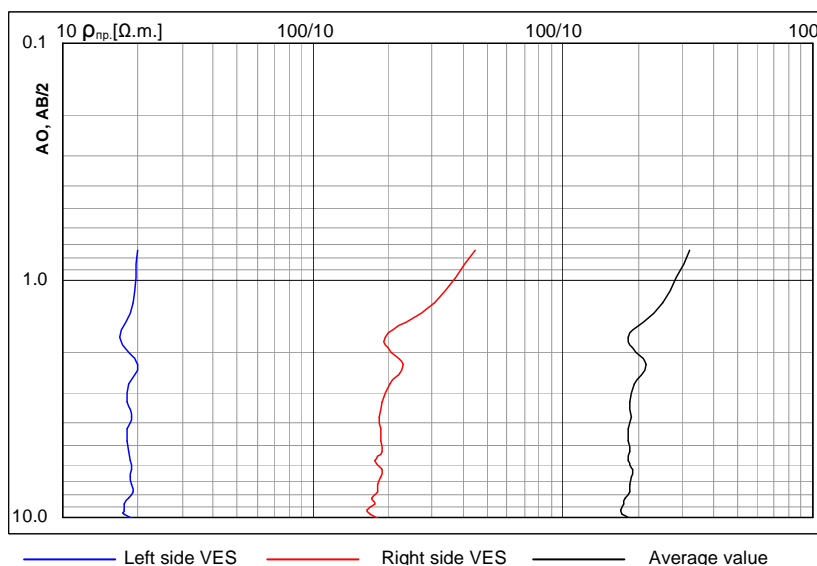
In present day geophysical practice one very actual problem is to develop methods, which could support quick expert and hi-precise and detail results mostly for depth up to 20 – 50 m. (NEAR SURFACE RESEARCHES). Such methods start to be applying for determination of a lot of engineering, hydro geological, ecological and environmental problems. Relate to that, together with development of the traditional methods used in geophysics a special interest and a special respect have been given to be adapted and developed traditional methods according the new objective needs.

According to that reason one well known and also popular as geophysics method, but with very hi potential to be used for a shallow depth researches is tri-electrodes Vertical Electrical Sounding - – AMN-B, where electrode -B is placed in endlessness. The specific characteristics of that method are it's very hi-sensitive according changes in vertical plane (in depth). A fact based on structure of the electrical field in depth, which is fully concentrated around current electrode –A usually in spherical disposition.

The interpretation of results is more easier then traditional because the depth of research usually is equal of the distance between current electrode –A and middle of the measurement dipole MN –O for a depth from 10 – 30 m.

On other hand if the method is applied on one very well prepared plan

От друга страна при едно умело прилагане на методиката с добре разчетени измервателни разноси схемата предоставя възможност за достигане на висока избирателност по отношение на детайлността при диференциране на литоложките разновидности. Търсене и отделяне на границите между отделни литоложки разновидности е възможно да бъде реализирано с максимална разрешаваща способност от порядъка на 0,30 - 0,50 м. Като резултат от такива свръх детайлни измервания кривата на привидното съпротивление в дълбочина по форма се доближава до каротажна крива, което улеснява интерпретирането и.



— Left side VES      — Right side VES      — Average value

При интерпретиране на такава крива за отделяне на границите в разреза се ползват характерни точки от потенциалната крива.

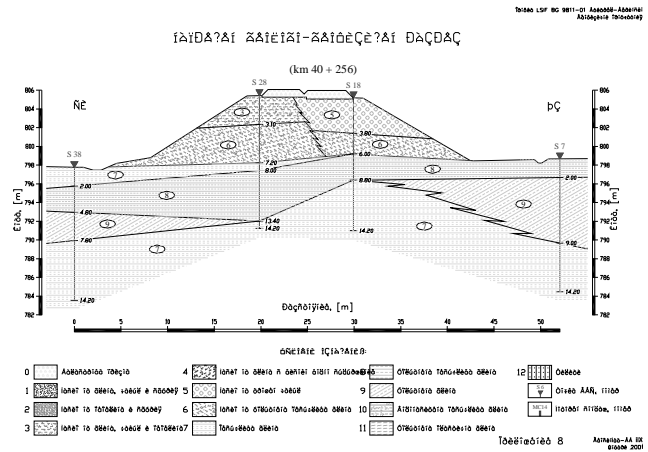
As examples at the report are given a few successfully realized projects in Bulgaria with different objectives in field of engineer-geology and hydrogeology where tri-electrode Vertical Electrical Sounding is used.

- Geophysical research along projected trace of hi-road Thrakia in segment KM 292+000 - KM 325+280 (town Stralja - town Aitos)
- Geophysical research along railway trace Vakarel - Verinsko, 40<sup>+343/755</sup> for determination of
- Researches of hydro-geological conditions for determine underground water table relate to engineer-geological expertise for gas stations of OMV and Shell in Bulgaria.
- Geophysical research for finding water support of underground objects – coal mines “Oranovo” and “Orlovec”;
- 3D reconstruction of geological layers and structures of experimental area “Chelopechene”, village Chelopechene, near to Sofia, as subcontract at INCO-COPERNICUS No. PL-971976 – “Development of tools needed for an impact analysis for groundwater quality to changing of agricultural soil use”.

By applying suitable methodology of measurements based on tri-electrode Vertical Electrical Sounding according to the needs a lot of problems in field of engineer-geology and hydrogeology were successfully determined. As example:

1. For Hi-road Trakia and railway trace were determined:

- литоложко разчленяване на геоложкия разрез на дълбочина до 15,75 м;
- 3D conditions of different layers and theirs superposition's;
- Depth of base rock and на ерозираната зона;
- Depth of underground static water table along profiles.

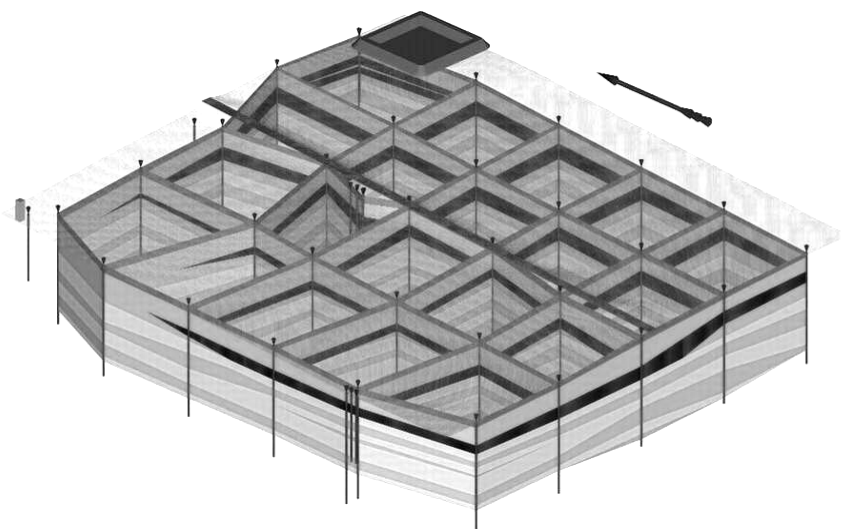


2. For coal mines Oranovo and Orlovec:

- определена е дебелината на заливни и не заливни тераси на р. Струма в близост до гр. Симитли (мини “Ораново” и “Орловец”) с разчленяване на скалите в отделни водоносни хоризонти;
- локализиране дебелината на рахлите отложения, определяне мощността на водопроницаемите пясъци и чакъли и нивото на подземните води (търсене на водоизточници с постоянно предназначение за OMV, Shell и др.)

3. For INCO-COPERNICUS project – experimental area Chelopechene:

- Full and detail determination of underground layers by data collected with geophysical methods (tri-electrode VES) and 6 drills for a depth of 15 m.
- Based on collected data a 3D model of structures and layers has been develop for a depth of 12 meters, which model has been successfully use for simulations of hydraulic conditions in experimental area.

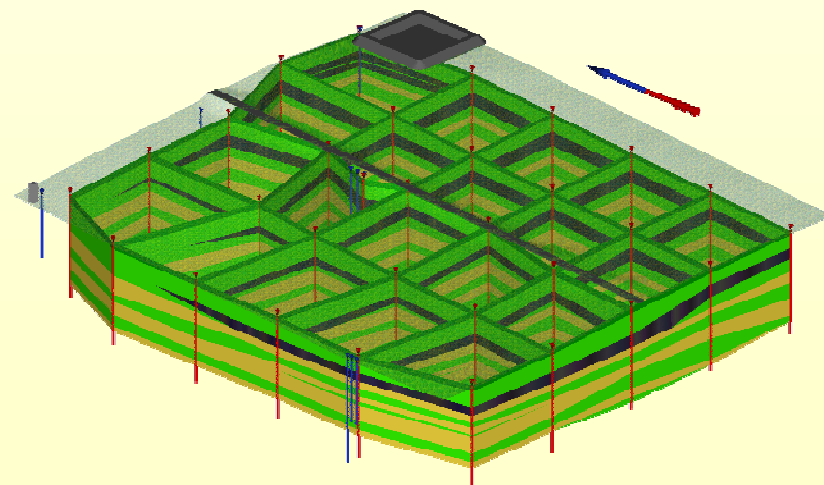
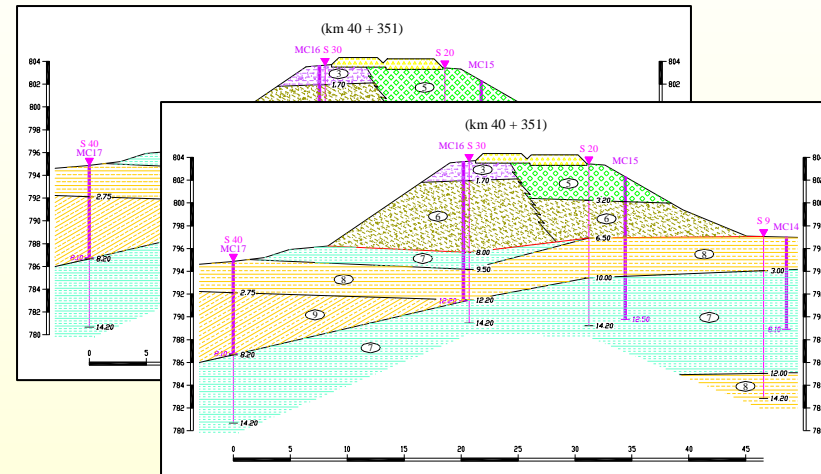
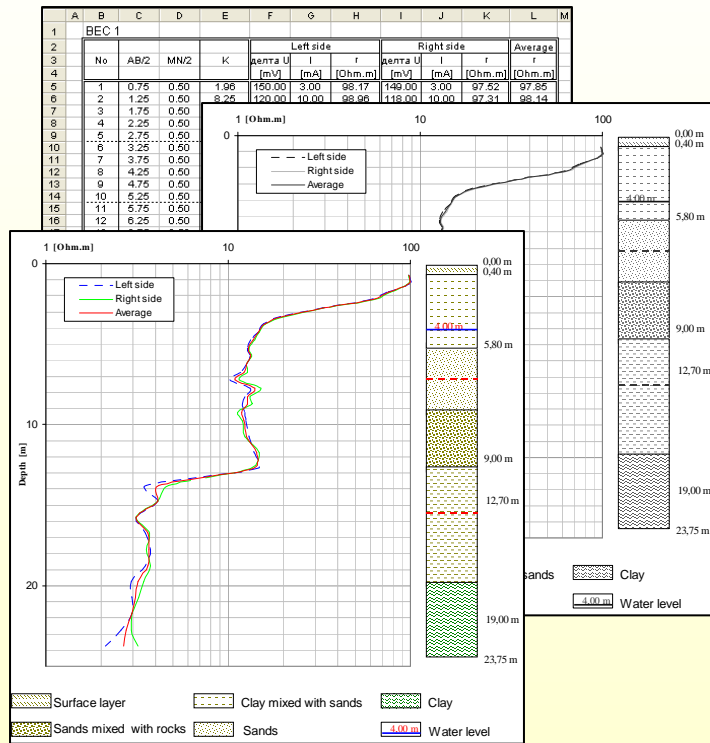


3D reconstruction of geological layers of experimental area Chelopechene, village Chelopechene, near to Sofia. INCO-COPERNICUS project.

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# USE OF THE THREE-ELECTRODE ELECTRICAL SOUNDING AS AN EFFECTIVE AND HIGHLY-INFORMATIVE METHOD FOR SHALLOW DEPTH INVESTIGATIONS



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[1] GeoPro ST, Bulgaria

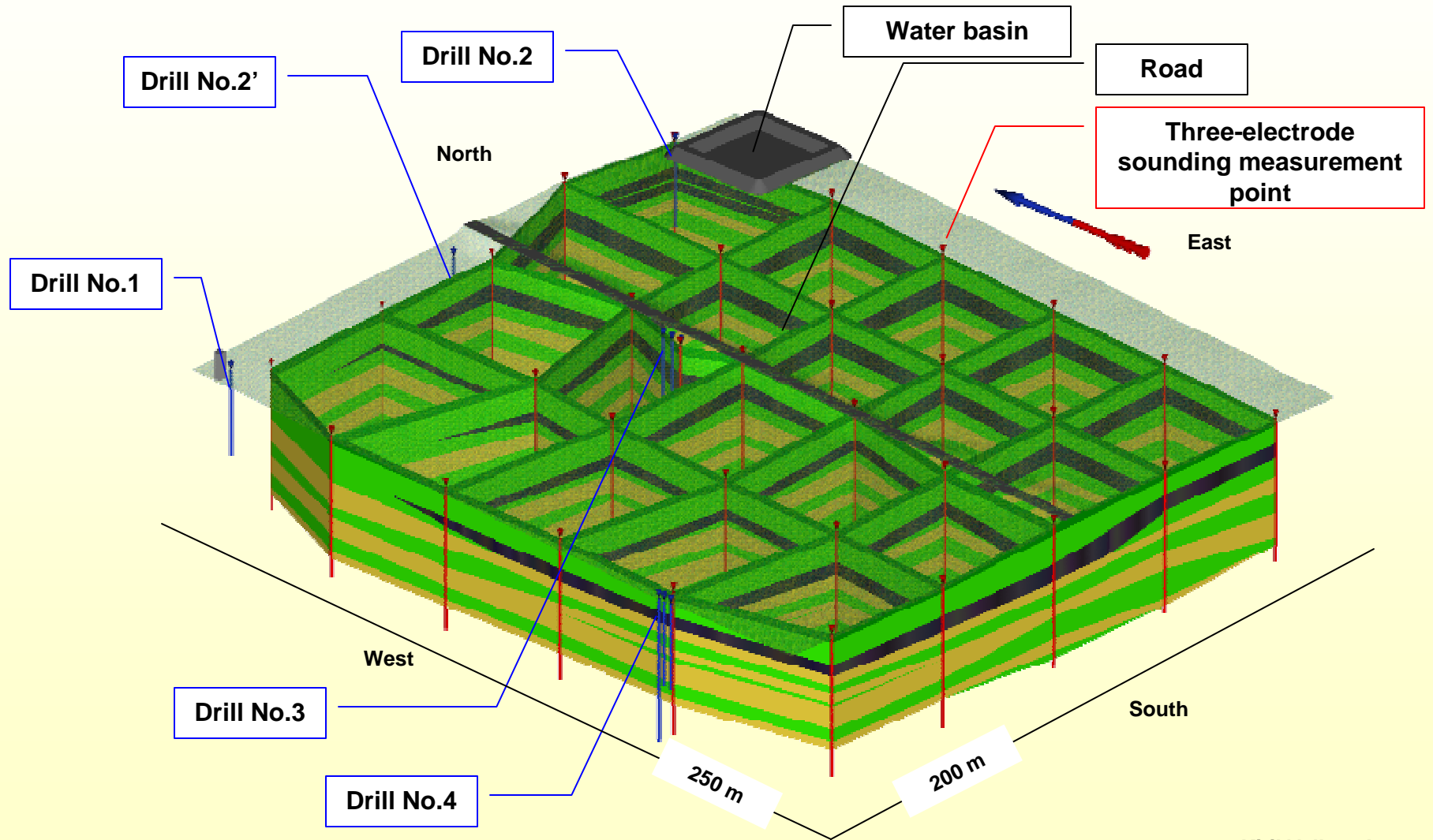
[2] Sofia Ing Ltd., A.Tchehov 78, Sofia 1113, Bulgaria. WWW Page:  
<http://cyril.webbg.com>

[3] Institute of Thrakology, Bulgarian Academy of Sciences, 13  
 Moskovska Str., 1000 Sofia, Bulgaria e-mail: [gueorge@bgnet.bg](mailto:gueorge@bgnet.bg)

Determination of geological structures by geophysical data for the experimental field near to the village of Chelopechene, Bulgaria.

Geophysical prospecting and 3D reconstruction of geological structures.

Chelopechene experimental field, grid of the measurements and drills.



# Determination of geological structures by geophysical data for the experimental field near to the village of Chelopechene, Bulgaria.

## Geophysical prospecting and 3D reconstruction of geological structures

Data processing: three-electrode electrical sounding – measured point No.16, (the point is at drill No.2).

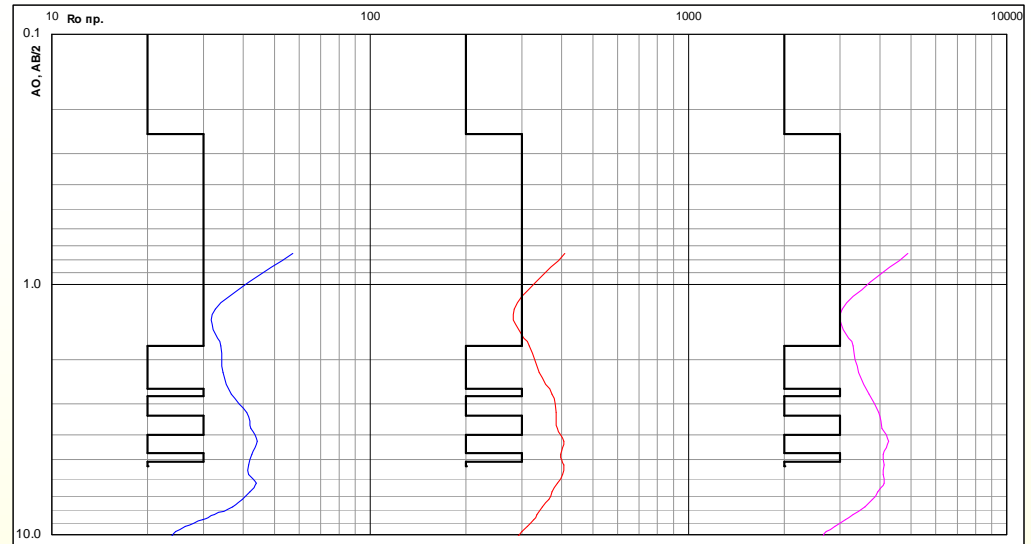
Legend:

**Black bold line** present the layers according to the drill No. 2.

**Blue** - Left side measurements.

**Red** - Right side measurements.

**Magenta** - Average values.



BEC 16

X,Y: 317,0

309.5 Тип:

A...M0.5NxВ /x=1-20/ Тип:

AxM0.5N...B /x=1-20/

No.	BO/AO	K	Delta U [mV]	I [mA]	Ro [Ohm.m.]	Delta U mV	I mA	Ro [Ohm.m.]
1	0.75	6.28	91.00	10.00	57.18	65.00	10.00	40.84
2	1.25	18.85	17.25	10.00	32.52	15.05	10.00	28.37
3	1.75	37.70	9.00	10.00	33.93	8.40	10.00	31.67
4	2.25	62.83	5.50	10.00	34.56	5.40	10.00	33.93
5	2.75	94.25	3.90	10.00	36.76	3.95	10.00	37.23
6	3.25	131.95	3.10	10.00	40.90	2.90	10.00	38.26
7	3.75	175.93	2.40	10.00	42.22	2.20	10.00	38.70
8	4.25	226.19	1.95	10.00	44.11	1.80	10.00	40.72
9	4.75	282.74	1.50	10.00	42.41	1.40	10.00	39.58
10	5.25	345.58	1.20	10.00	41.47	1.18	10.00	40.61
11	5.75	414.69	1.00	10.00	41.47	0.97	10.00	40.22
12	6.25	490.09	0.90	10.00	43.86	0.79	10.00	38.72
13	6.75	571.77	0.73	10.00	41.74	0.65	10.00	37.17
14	7.25	659.73	0.60	10.00	39.58	0.55	10.00	36.29
15	7.75	753.98	0.49	10.00	36.95	0.46	10.00	34.68
16	8.25	854.51	0.38	10.00	32.47	0.39	10.00	33.33
17	8.75	961.33	0.31	10.00	29.80	0.34	10.00	32.69
18	9.25	1074.42	0.25	10.00	26.32	0.29	10.00	31.16
19	9.75	1193.81	0.21	10.00	24.47	0.25	10.00	29.85
20	10.25	1319.47	0.18	10.00	23.75	0.22	10.00	29.03

Ro sp. [Ohm.m.]
49.01
30.44
32.80
34.24
36.99
39.58
40.46
42.41
41.00
41.04
40.85
41.29
39.45
37.93
35.81
32.90
31.24
28.74
27.16
26.39

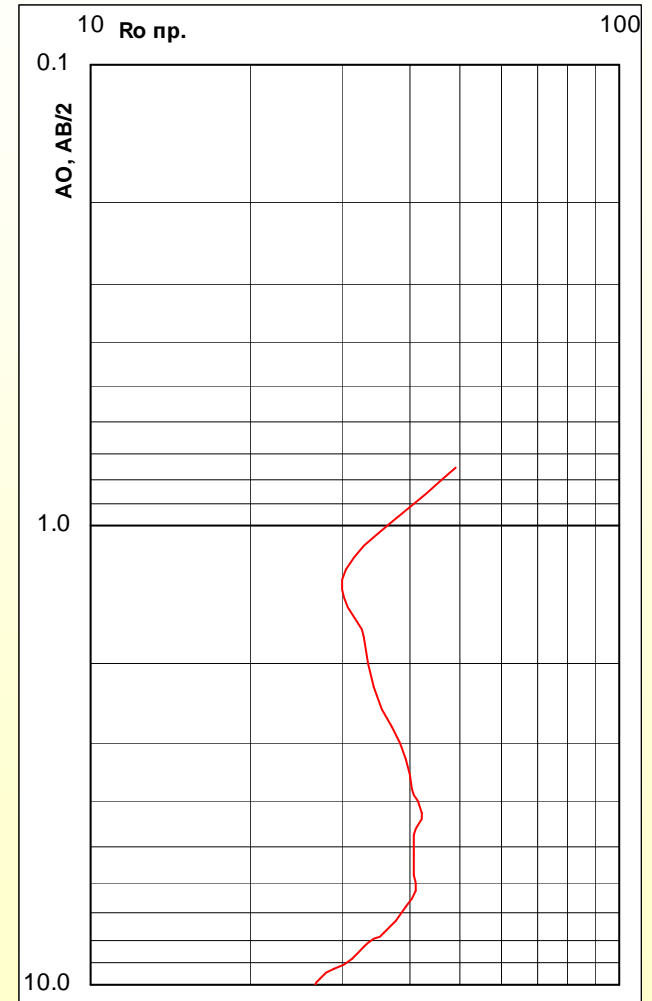
Сондаж No 2 [З]	Описание
0.10	Почвен слой
0.25	
1.75	Глини пътни с гравийни включения
2.60	Чакъли пясъчливи, заглинени
2.80	Глини пътни с гравийни включения
3.35	Пясъци, разнозърнести, слабо заглинени
4.00	Глини пясъчливи с гравийни включения
4.70	Пясъци заглинени
5.10	Глини пътни с въгищни чернилки
5.30	Глини, сиви, плътни
	Дъно

**Determination of geological structures by geophysical data for the experimental field near to the village of Chelopechene, Bulgaria.**

**Geophysical prospecting and 3D reconstruction of geological structures**

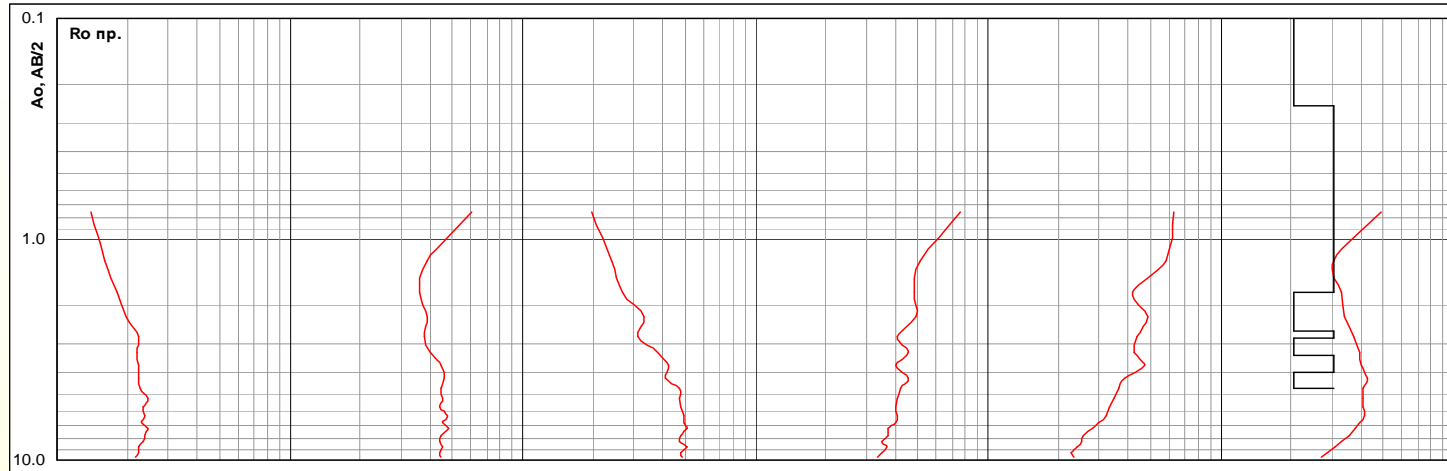
**Interpretation of the three-electrode electrical sounding – measured point No.16, (the point is at drill No.2).**

No.	AB/2	Ro ср. [Ohm.m.]	Дълбочина на пласта	Мощност на пласта	Литолошко описание
1	0.75	49.01	0	-0.30	Почвен слой
2	1.25	30.44	-0.30	-1.50	Глини пътни с гравийни включения
3	1.75	32.80	-1.80	-0.80	Чакъли пясъчливи, заглинени
4	2.25	34.24	-2.60	-0.20	Глини пясъчливи
5	2.75	36.99	-2.80	-0.60	Пясъци; Пясъци, слабо заглинени
6	3.25	39.58	-3.40	-0.60	Глини пясъчливи с гравийни включения
7	3.75	40.46	-4.00	-0.70	Пясъци; Пясъци, слабо заглинени
8	4.25	42.41	-4.70	-0.40	Глини пътни с въгищни чернилки
9	4.75	41.00	-5.10	-0.90	Глини плътни
10	5.25	41.04	-6.00	-1.30	Пясъци; Пясъци, слабо заглинени
11	5.75	40.85	-7.30		Глини пясъчливи
12	6.25	41.29			
13	6.75	39.45			
14	7.25	37.93			
15	7.75	35.81			
16	8.25	32.90			
17	8.75	31.24			
18	9.25	28.74			
19	9.75	27.16			
20	10.25	26.39			

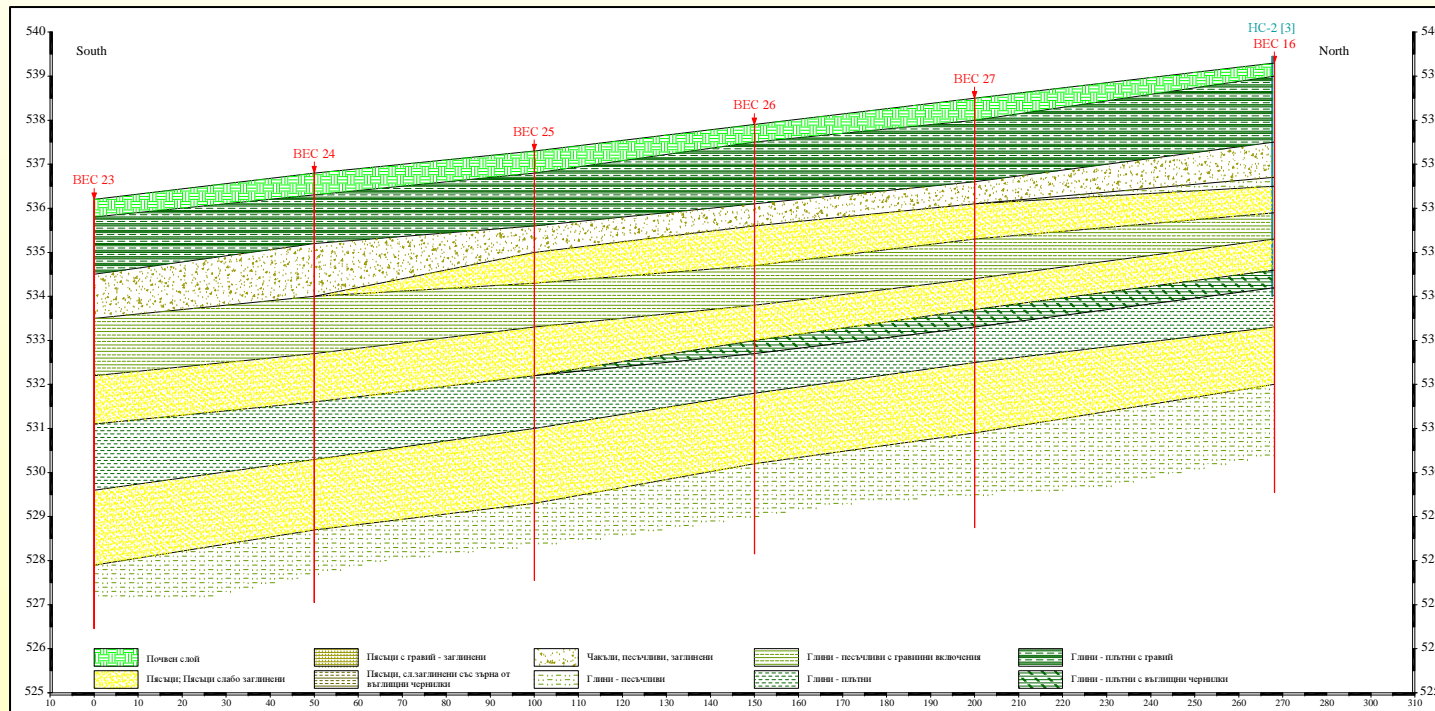


# Determination of geological structures by geophysical data for the experimental field near to the village of Chelopechene, Bulgaria.

## Geophysical prospecting and 3D reconstruction of geological structures



Data processing of three-electrode electrical soundings along line V South-North - VES charts.

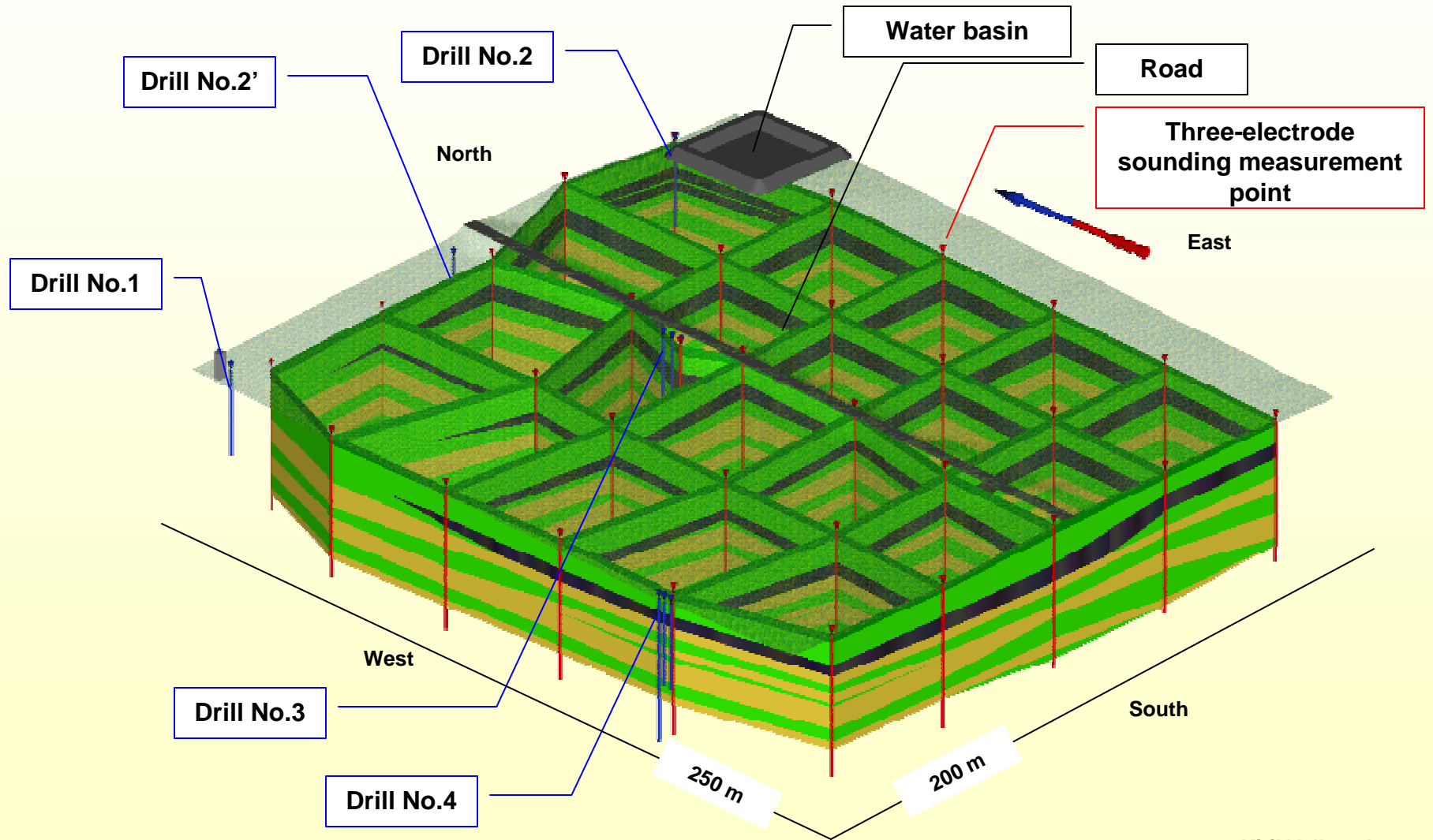


Geo-Electrical section along profile V – South-North.

Determination of geological structures by geophysical data for the experimental field near to the village of Chelopechene, Bulgaria.

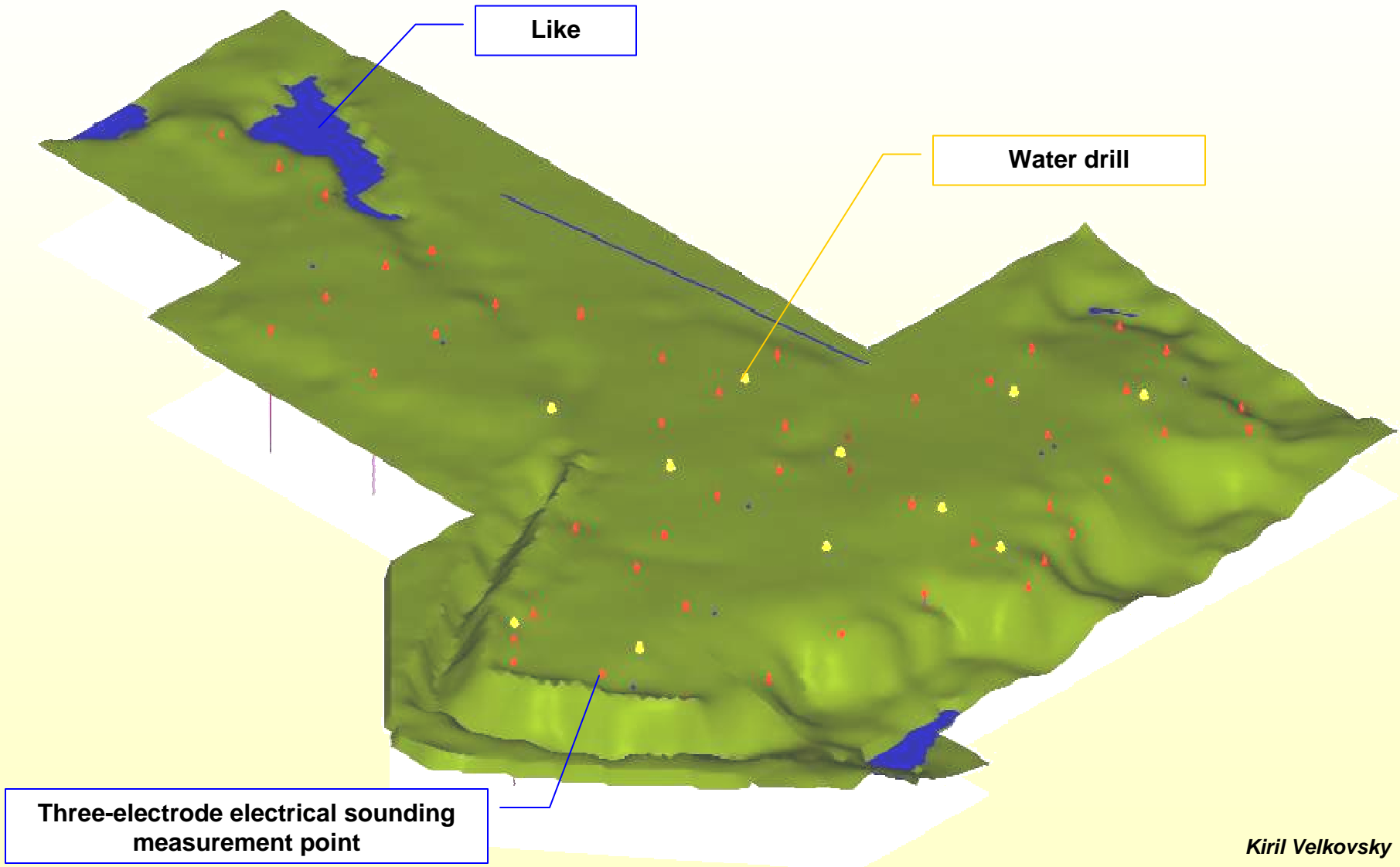
Geophysical prospecting and 3D reconstruction of geological structures.

Chelopechene experimental field, grid of the measurements and drills.



Determination of geological structures by geophysical data using three-electrode electrical sounding for area near to the village of Bogorov, Bulgaria.

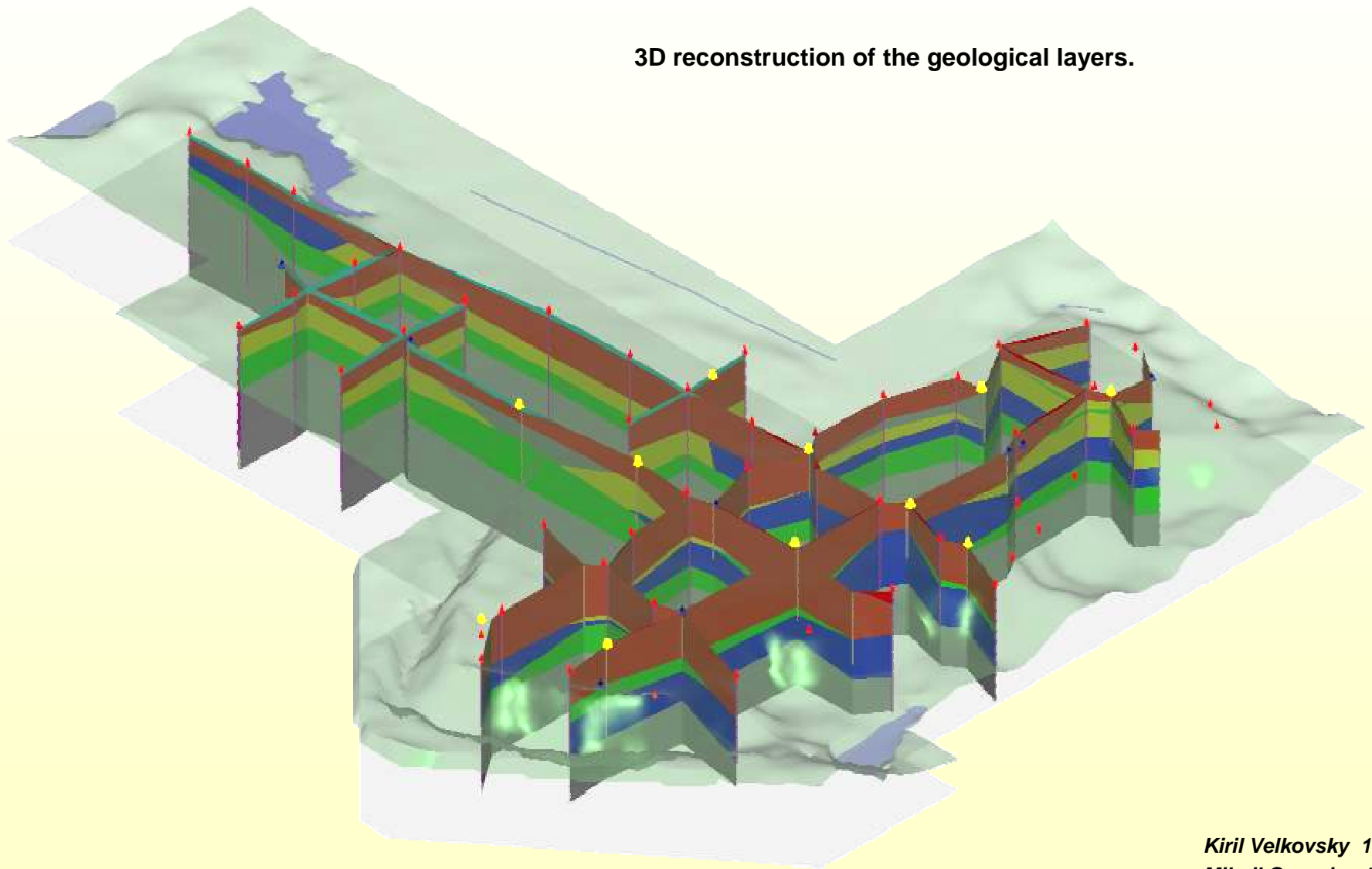
3D surface reconstruction and grid of the measurements.



*Kiril Velkovsky 1998  
Mihail Georgiev 1998*

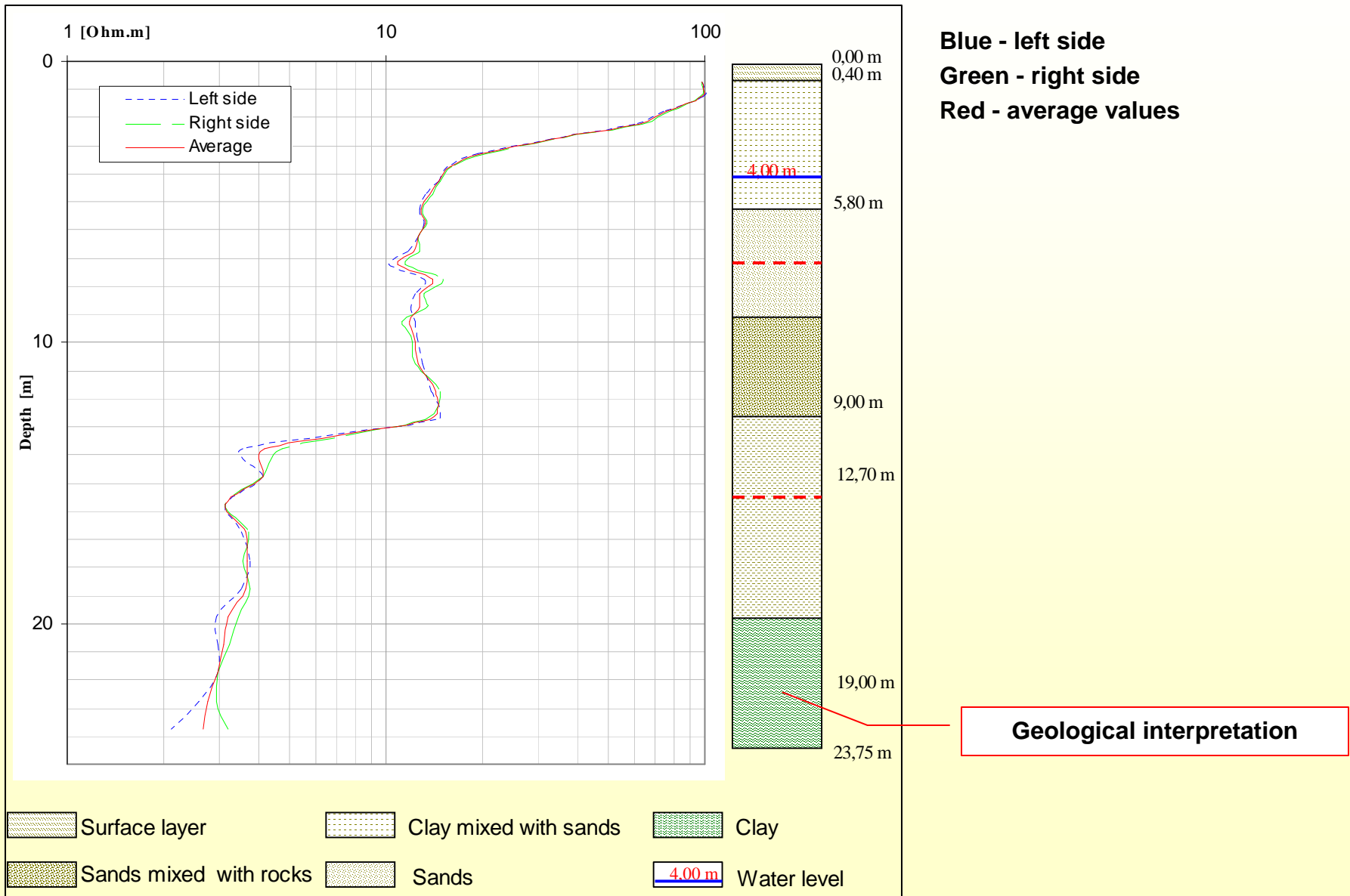
Determination of geological structures by geophysical data using three-electrode electrical sounding for area near to the village of Bogorov, Bulgaria.

3D reconstruction of the geological layers.

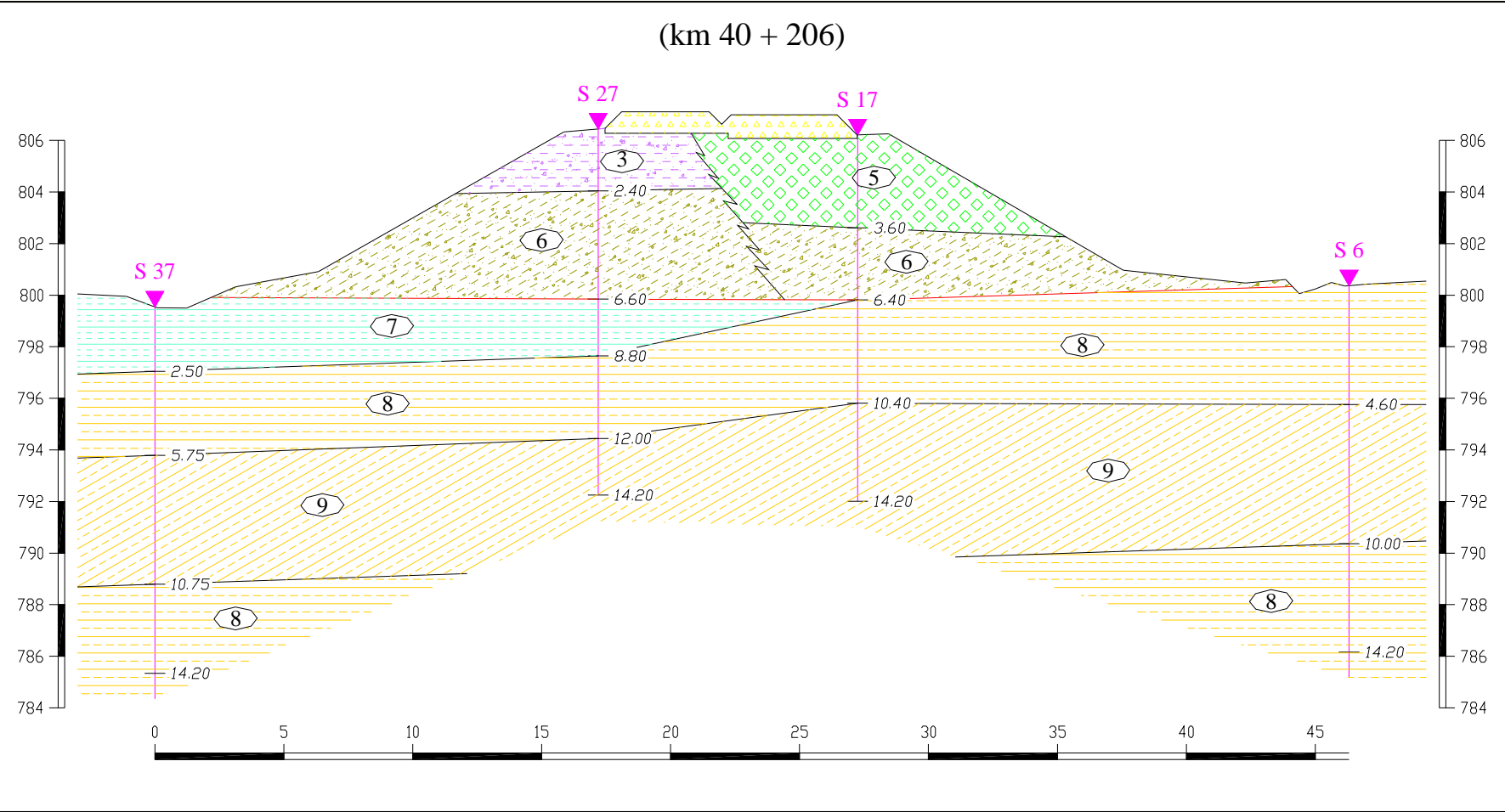


*Kiril Velkovsky 1998*  
*Mihail Georgiev 1998*

# Graphic of a three-electrode electrical sounding and geological interpretation of the results.



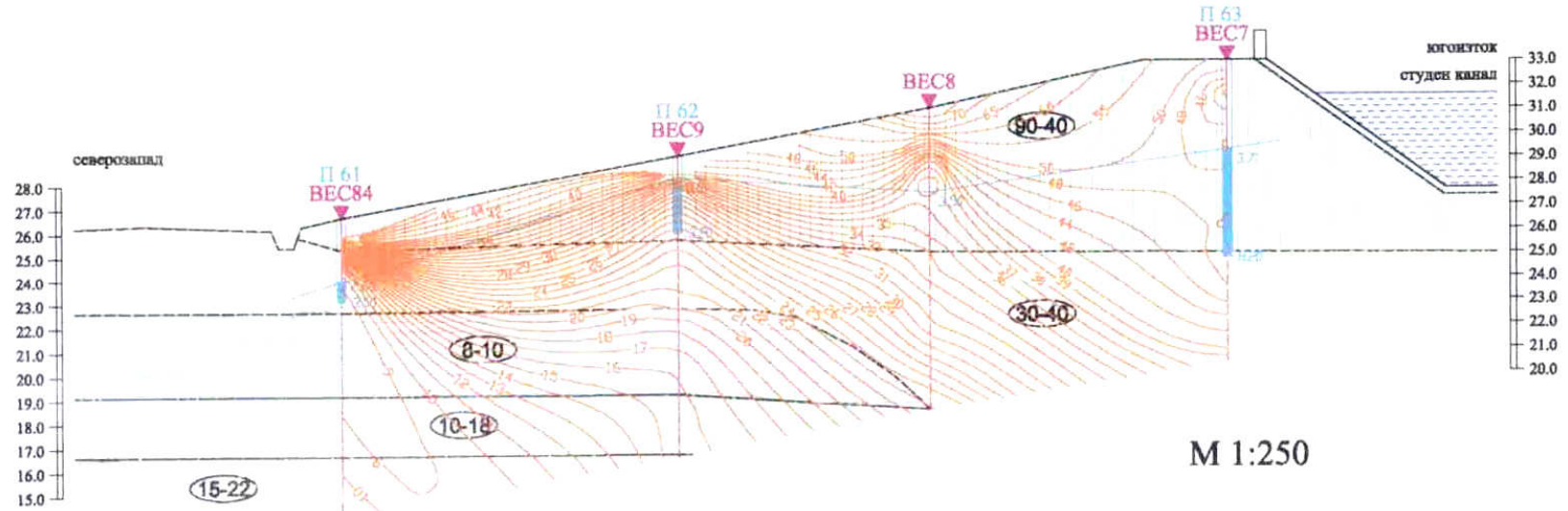
**Geo-electrical section constructed on a base of results from the interpretation of the three-electrode electrical soundings in series of points.**



## НАПРЕЧЕН ГЕОЛОГО-ГЕОФИЗИЧЕН РАЗРЕЗ ПРОФИЛ 9

Тема: Определяне на депресионната повърхност на студена дига от км. +0.655 до км. +1.140

Обект: АЕЦ Козлодуй  
Изпълнител: Енергопроект ЕАД



ВЕС, номер	ВЕС 84	ВЕС 9	ВЕС 8	ВЕС 7
Пиезометър, номер	П 61	П 62		П 63
Кота терен, [m]	26,64	29,17	31,10	33,03
Кота водно ниво към 12. 04. 2000 г.	23,98	28,26	27,60	29,32
Хоризонтално разстояние, [m]		14,16	10,57	12,50

Насип от лъс  
 Лъс (глинесто пясъчлив)  
 Едрозърнест пясък

Пясък с чакли  
 Водообилен лъс  
 Привидно съпротивление, [Ohm.m]

Водно ниво, дълбочина, [m]  
 ВЕС, номер  
 Пиезометър, номер

10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 50 60 70 80  
 Сечение на изомите, [Ohm.m]

Фигура 7

## **Effective usage of a three-electrode electrical sounding**

**Engineer-geology**

**Detail prospecting**

**Hydro-geological  
conditions**

**Bad rock prospecting**

**Environmental**

**Prospecting of a  
pollutions with  
hydrocarbons**

**Hydro-geological  
conditions**

**Archaeology**

**Prospecting of a**