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"ENERGY SECURITY, HOW TO FURTHER THE TECHNOLOGY"

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Two Perspective Renewable Energy Sources in Armenia

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The report reviews the main results of the work carried out in Armenia for two promising areas of alternative energy sources – geothermal water and algae growing for biodiesel production.

- **Geothermal water**
- **Algae growing for biodiesel production**

Geothermal energy

- **Geothermal energy is connected with the young volcanism in Armenia and neighboring countries, the presence of big and active faults.**

Along with the obvious advantages of geothermal energy over other renewable resources:

lowest environmental impacts
least dependent on the external conditions, time of day or season can be used for free for a long period of time.

the use of geothermal energy in Armenia is important because it can be an alternative to the use of nuclear power plant in the area of high seismic activity

In general the main phases of a geothermal resources investigation are:

I. Pre-Feasibility Study
II. Feasibility Study
III. Reservoir Engineering
IV. Legal framework

I. Pre-Feasibility Study

The key target during a preliminary survey is evidence of mineral alteration resulting from the interaction of rocks and high-temperature fluids.

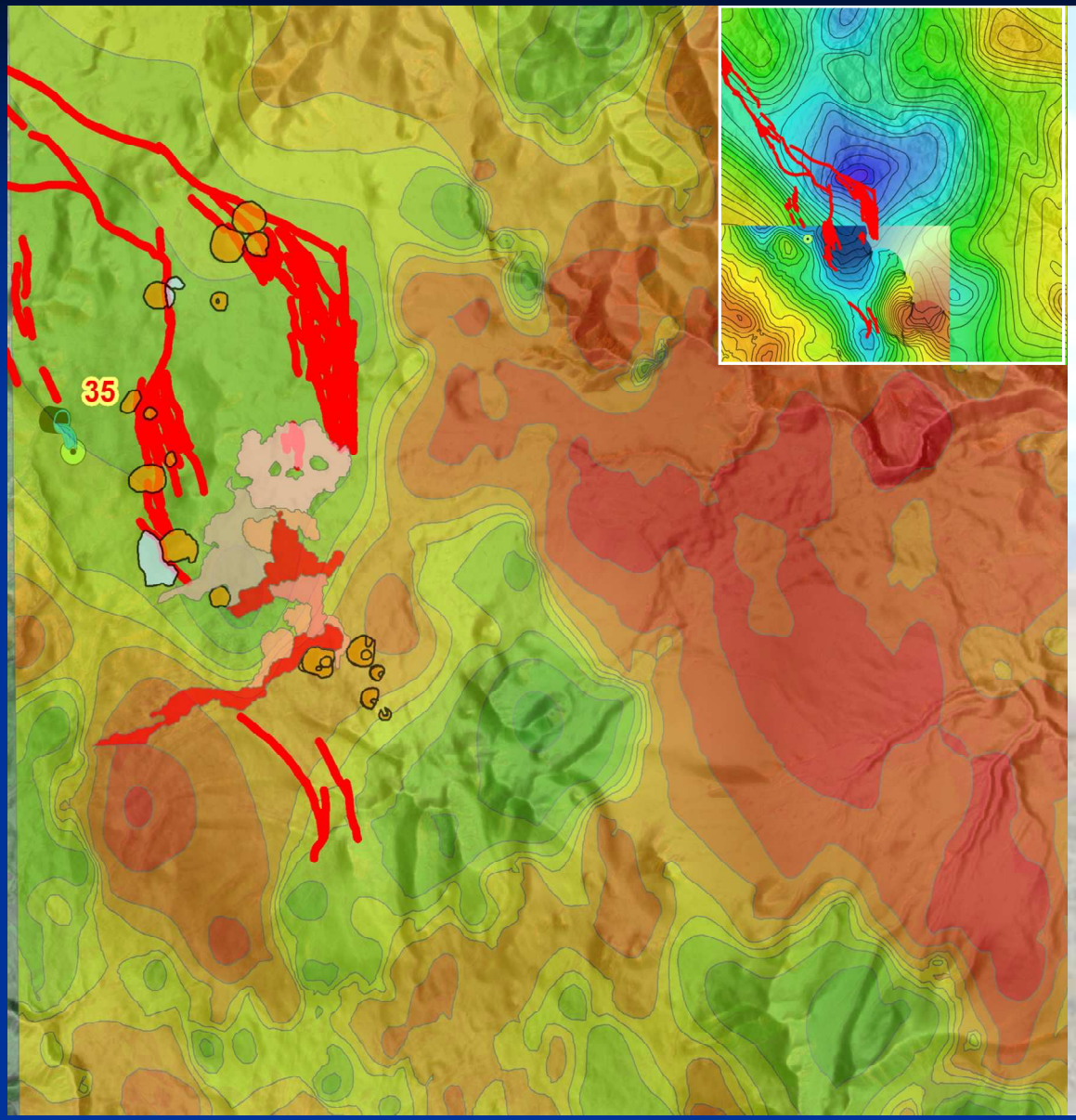
1. Survey of Geothermal Features

Approach and Methodology

A review of existing regional geologic, geochemical, and geophysical survey data .
Remote sensing is an efficient way to locate these areas of high geothermal activity. This can include both satellite imagery (e.g., SPOT, LandSat, LIDAR) and aerial photography. Alternatively, a land survey can be conducted on the ground. Ranking geothermal sites in a region prioritizes geothermal development.

Main activities:

- **Gather, organize and review all known information on the prospective sites. Review shall include information reliability and relevance as evidence for geothermal potential.**
- **Review the criteria for the selection of the 5-6 short-listed sites proposed for further investigations.**



The analysis of InSAR images indicates the presence of vertical deformation sites over considerable areas located on both sites of the "pull-apart"-basin structure. The vertical deformations could have been related to tectono-magmatic processes within the "pull-apart" basin structure. The correlation of the InSAR data with the gravimetry data indicates that vertical deformation areas are located on the flanks of the anomaly of low gravity values.

Jermuk (Bayots Dzor region) - **this is the area where the highest temperatures were obtained (up to about 630C) and which have been most extensively developed by drilling.**

Vorotan River Valley Vorotan (Syunik region) - **the thermal springs and wells are present in a few places.**

Ankavan (Kotayk region) - **the maximum temperature detected temperature – 420C at a relatively shallow depth.**

Javakhety upland (partly in Armenia and Partly in Georgia) – **the known surficial expressions are mainly concentrated as a large group of carbonated thermal water springs. There are thermal-mineral water springs also. During the Soviet period several deep geothermal boreholes were drilled in this area. One of such boreholes (1900 m) is still functioning giving a water containing carbon dioxide (gas factor: 5) welled out from the Upper Cretaceous volcanic-sedimentary thermal aquifer.**

Karkar and Dzhermahpyur (Syunik region) **is located on the crest of the Karabakh plateau. This area is the center of the youngest volcanic activity in Armenia. In this area, carried out detailed geological mapping and a variety of geophysical surveys, including magnetotelluric, seismic, magnetic and gravity surveys. Karkar and Dzhermahpyur (Syunik region) is located on the crest of the Karabakh plateau. This area is the center of the youngest volcanic activity in Armenia. In this area, carried out detailed geological mapping and a variety of geophysical surveys, including magnetotelluric, seismic, magnetic and gravity surveys.**

II. Feasibility Study

The purpose is to identify technical, financial and environmental uncertainty in a potential geothermal project. The location of the feasibility study is dependent on the pre-survey. It is integrative, meaning several surveys are performed coincidently to gather a suite of geoscientific information. Based on competent knowledge of risk, the large costs of drilling can be significantly reduced.

2. Geological/ Geochemical Survey

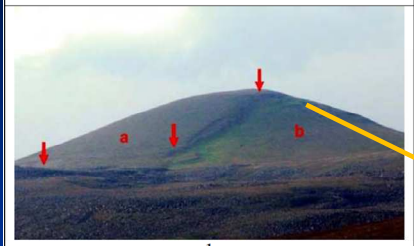
Approach and Methodology

A ground survey includes mapping lithologies and geological structures, dating of any volcanic rocks, and the measurement of permeability and porosity of rock samples. Hydrogeological information as well as knowledge of annual rainfall and regional/ local aquifers can infer the pathway of flow through the geothermal area of interest.

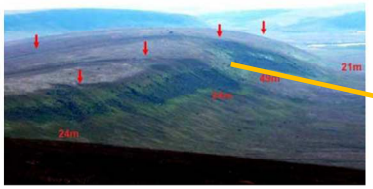
Main activities:

- **Perform geological field scouting for each listed potential geothermal site. It shall encompass the identification and mapping of fault structures, potential recharging zones, and the recording and description of surface geothermal manifestations like hot and mineral springs, fumaroles and zones with hydro thermally alternated rocks.**
- **Sample all springs and surface waters and perform the selected analysis to geochemically describe the waters. Determine age and provenience of spring-waters by specialized methods, e.g. isotope-analysis.**
- **Produce the surface geological map, containing all above mentioned indicators. Determine the location and length of the geophysical profiles, based on the geological scouting findings.**

The western side of the pull-apart basin



1



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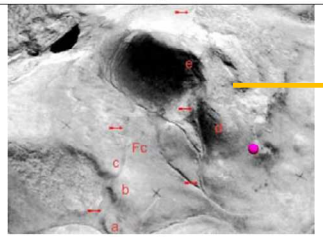

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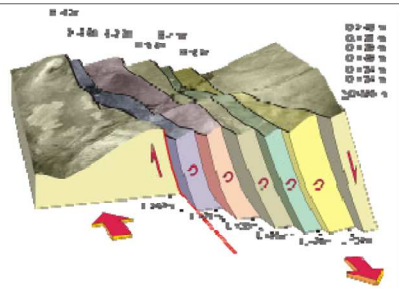

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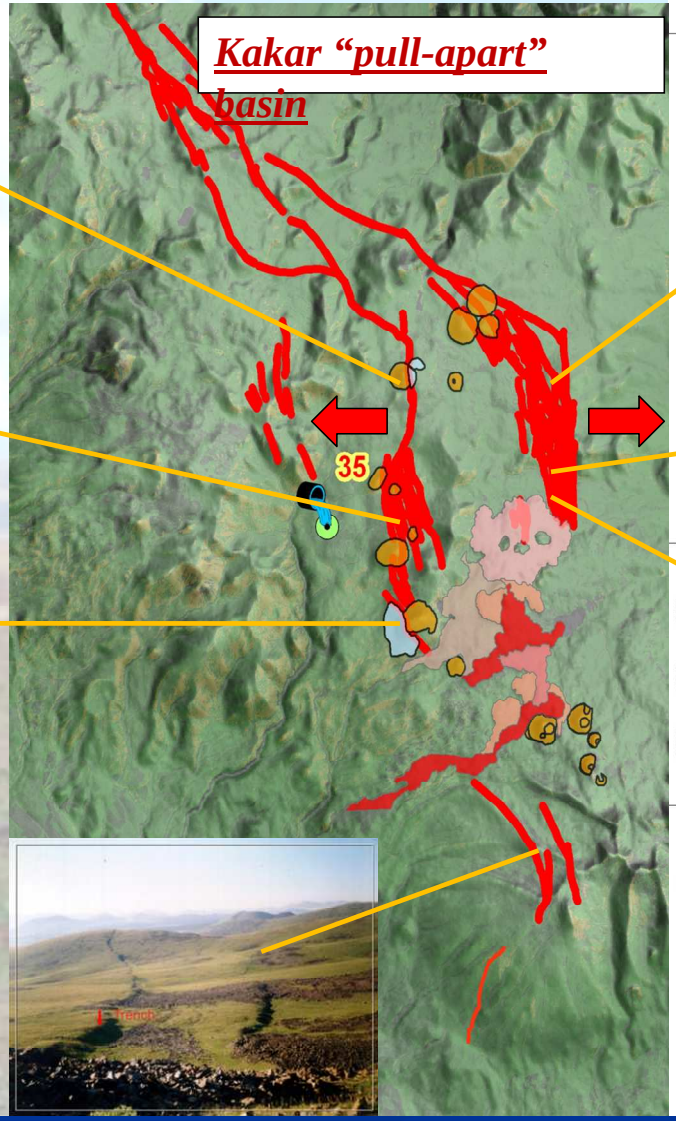
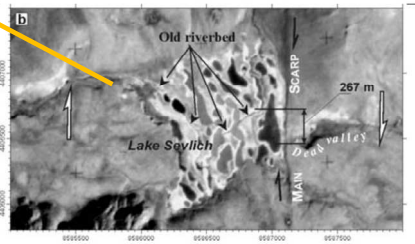
Kakar "pull-apart" basin



The eastern side of the pull-apart basin

2

4



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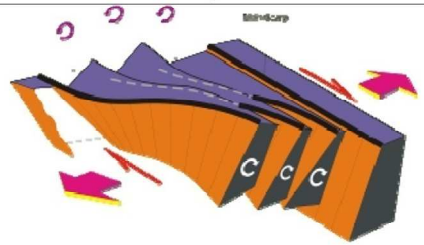

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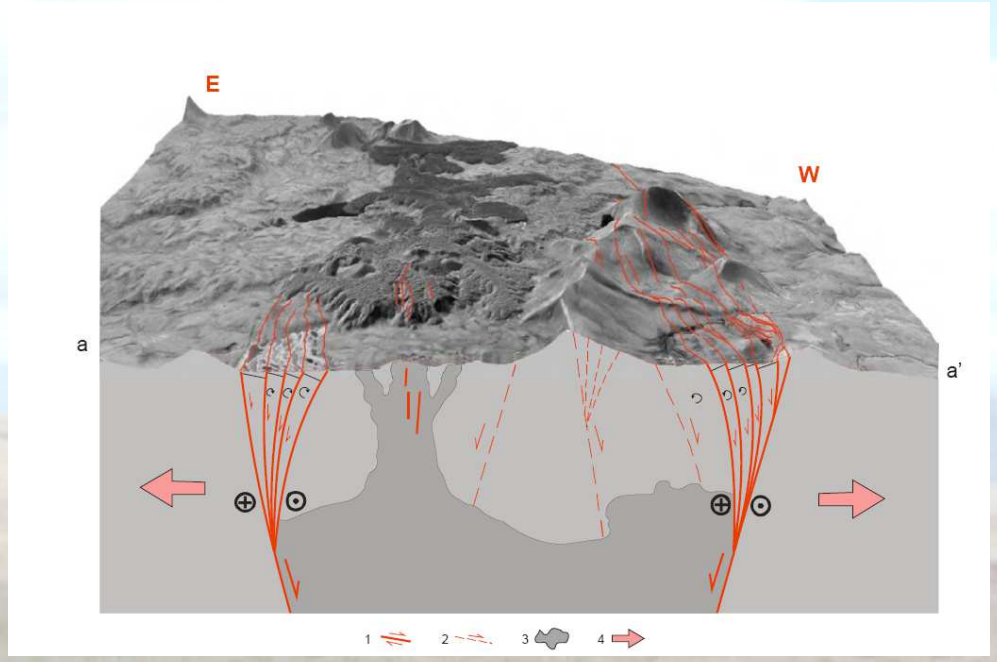
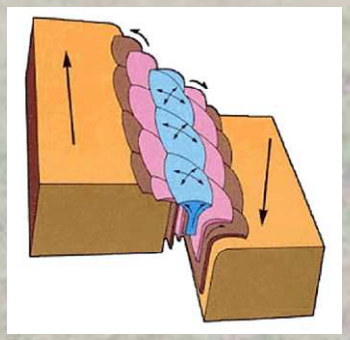
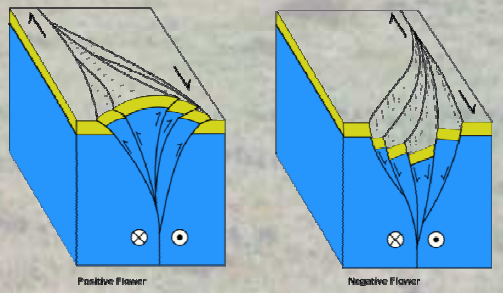
The system of faults and depressions on the flanks of the "pull-apart" basin



The western and eastern sides of the *pull-apart* b a sin are bounded by the fault systems consisting of 8 to 10 juxtaposed branches of active faults. The faults shape a negative *flower* structure at depth, in the center of which the channels of Pleistocene and Holocene volcanic eruptions and their lava fields are located.





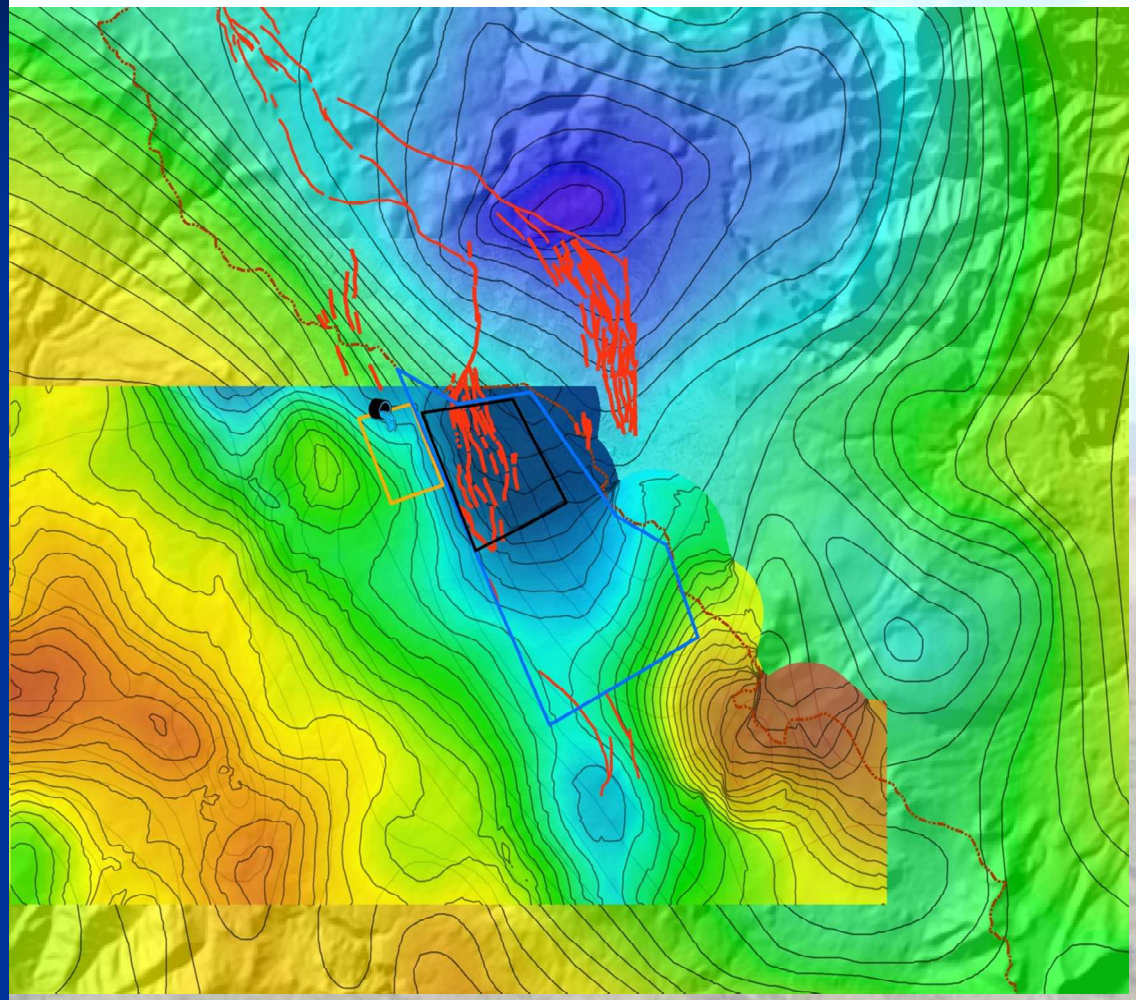
3. Geophysical Survey

Approach and Methodology

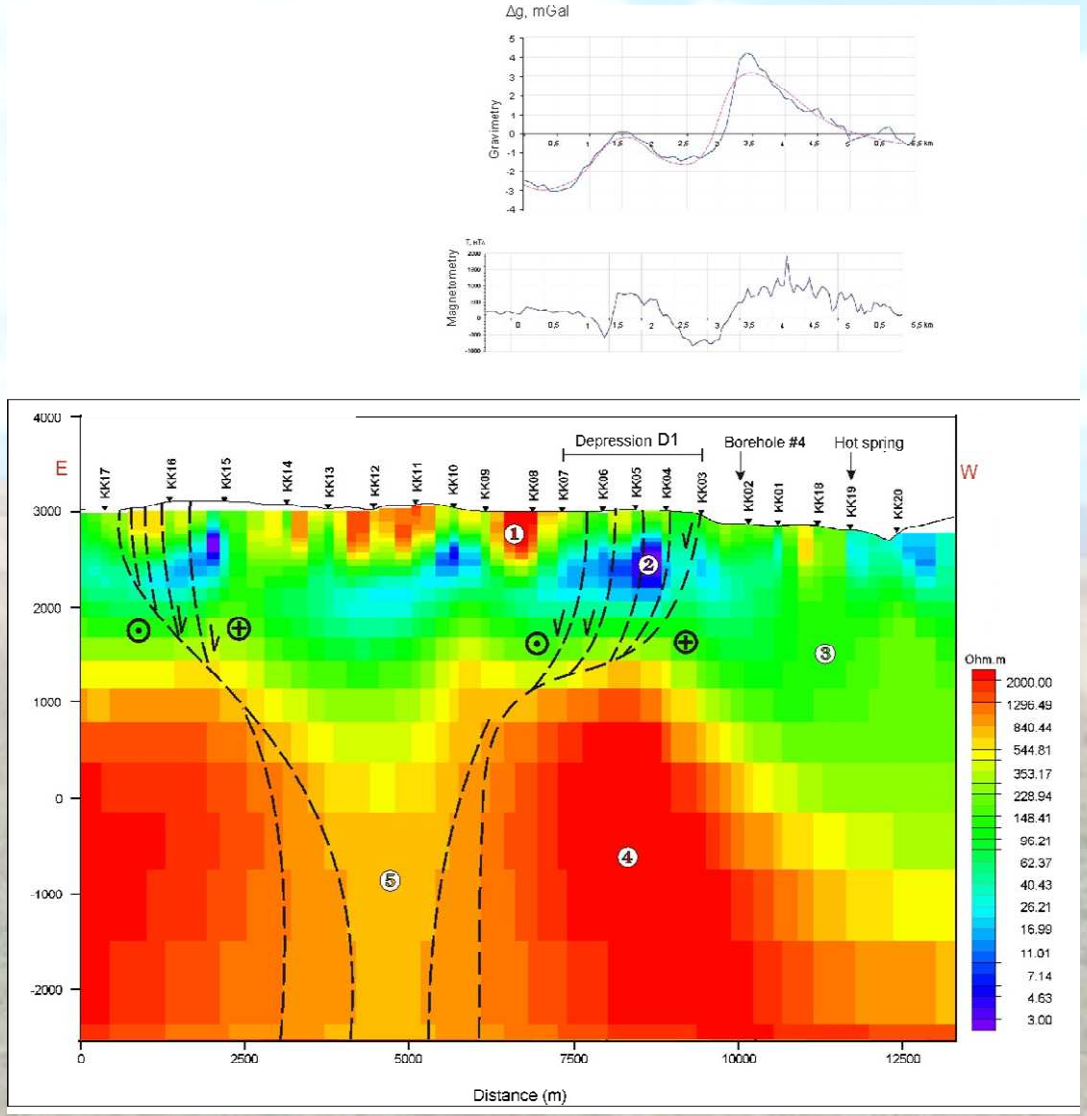
Different types of geophysical data record different images of the subsurface.
Seismic techniques (i.e., microseismicity locations, attenuation and velocity tomography, seismic reflection/ refraction surveys) provide information lithology and structure.
Electrical and electromagnetic data (e.g., magnetotellurics) are sensitive to electrical conductivity – so these methods delineate where conductive water or magma may exist in pores, or where impermeable (low resistivity) clay-cap rocks are located.
Gravimetry and magnetic measurements add additional layers of information.
Near-surface temperature measurements and temperature gradient wells identify areas with increased heat flow.
Joint interpretation of these data can constrain reservoir features.

Main activities:

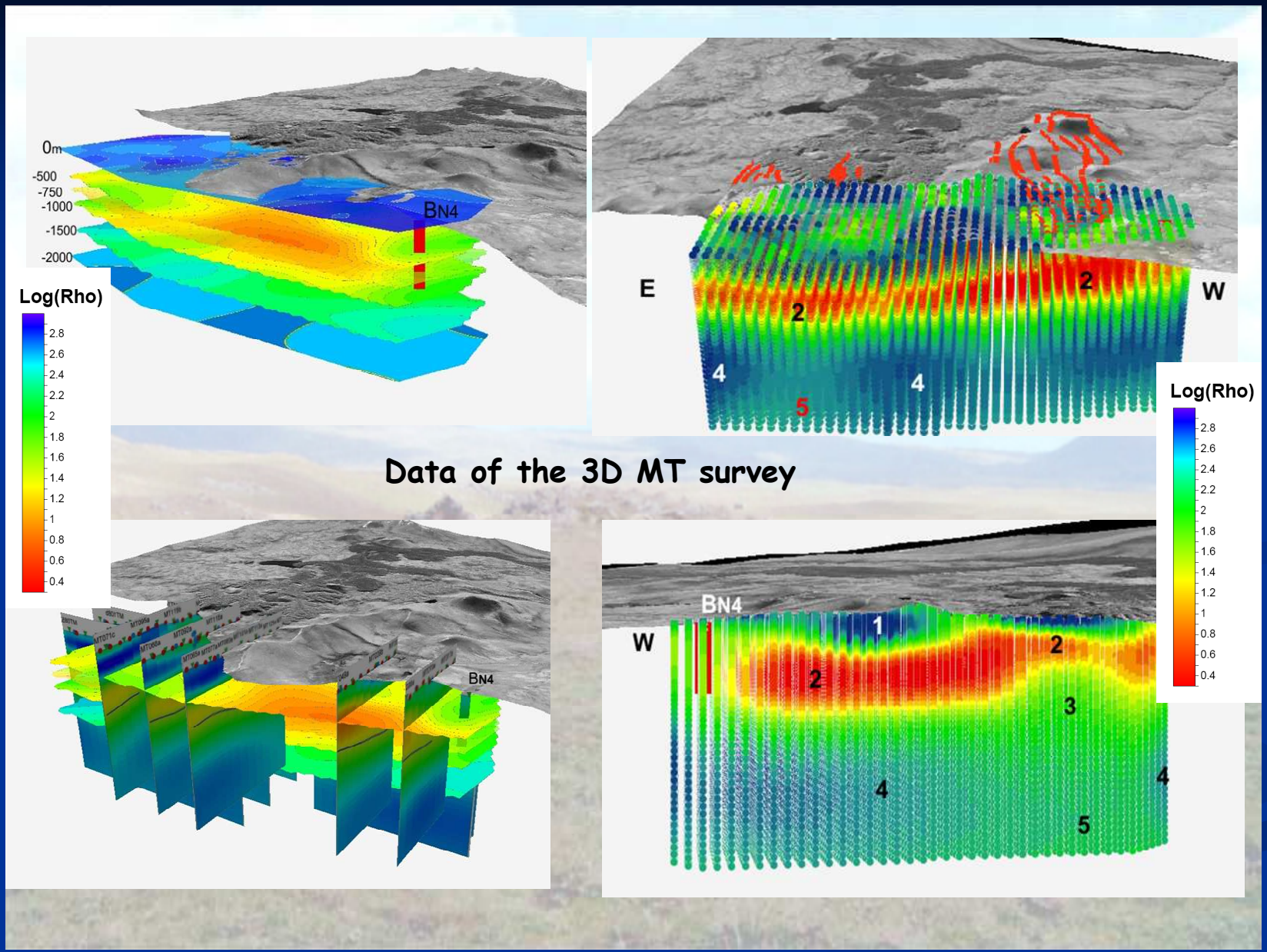
- Differential (RTK) Real Time Kinematic GPS survey
- Magneto-telluric (MT) sounding of the most prospective geothermal fields
- Detailed gravimetrical surveys over the geothermal fields and adjacent areas
- Microseismicity locations, attenuation and velocity tomography, seismic reflection/ refraction surveys



High correlation of the geometries of the western and eastern fault branches bounding the *pull-apart* basin, and of the gravity anomaly



Data of the 2D MT survey over the depth of 6 km and the gravity data


0m
-500
-750
-1000
-1500
-2000
BN4
Log(Rho)
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
E
W
2
2
4
4
5
Log(Rho)
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
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0.4
Data of the 3D MT survey
BN4
BN4
W
1
2
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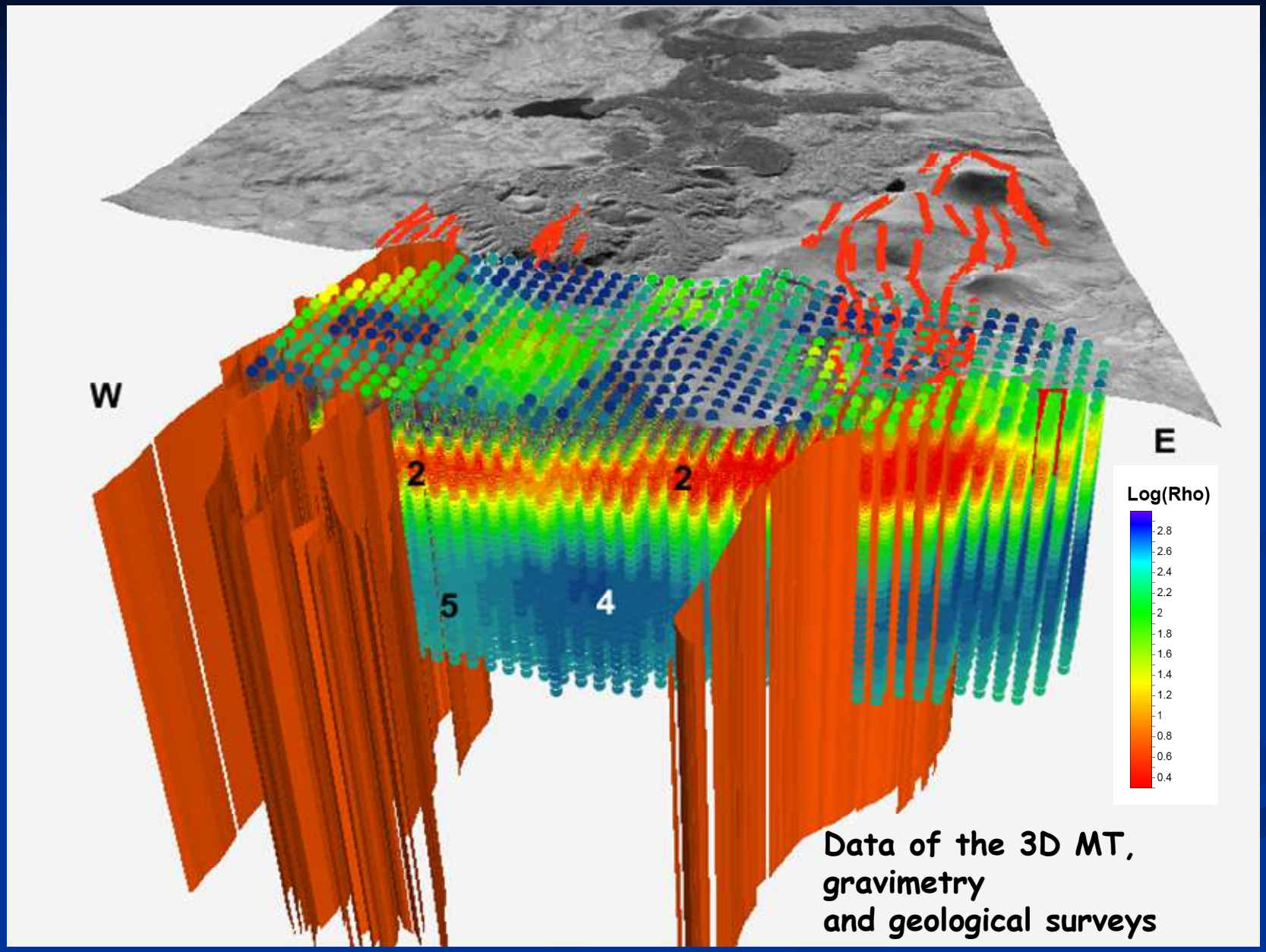
4
5


W
E
2
2
5
4
Log(Rho)
2.8
2.6
2.4
2.2
2
1.8
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1
0.8
0.6
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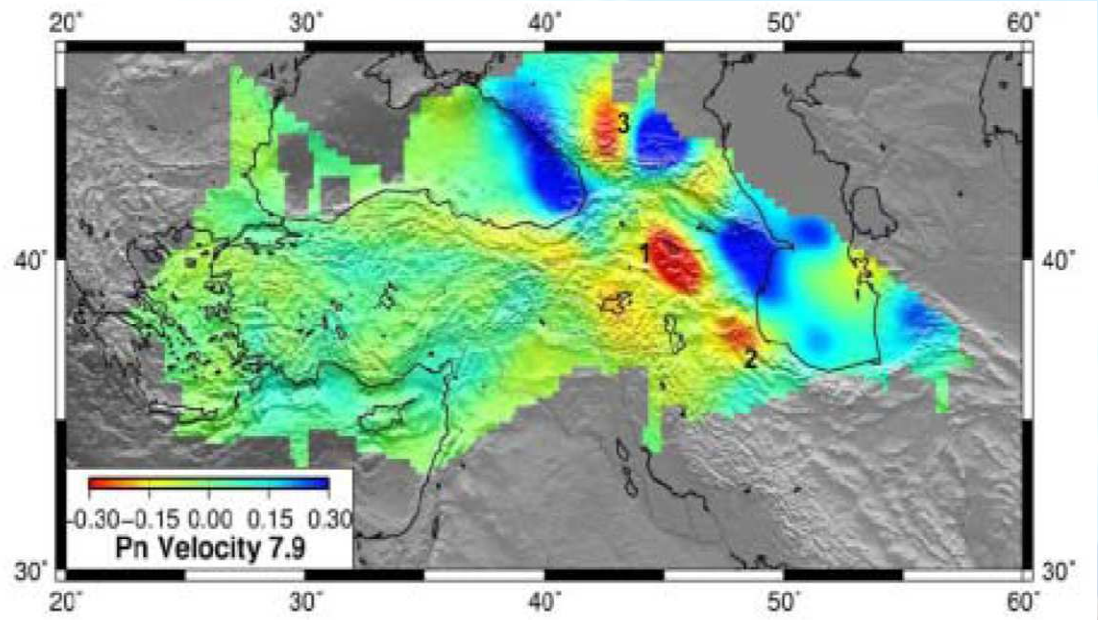
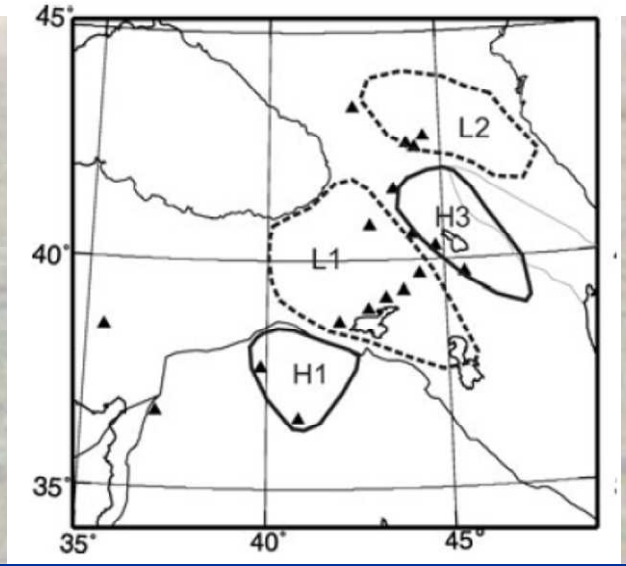
Data of the 3D MT,
gravimetry
and geological surveys

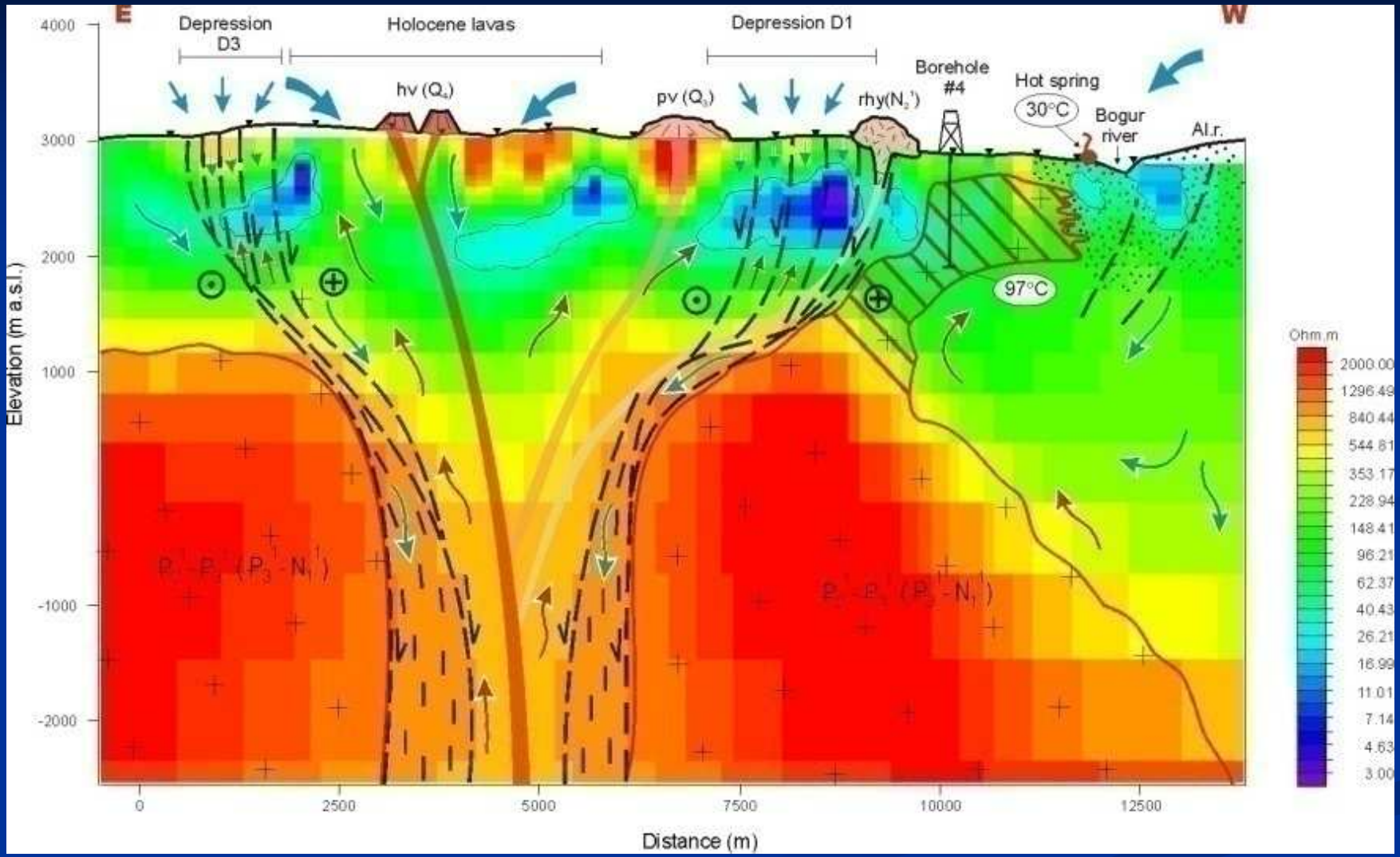


Anomalies of P-wave velocities. Areas of lower velocities, interpreted as provinces of partly melted, higher mantle, are indicated with red color:
1 – area of volcanic highlands of Gegham, Vardenis and Syunik; 2 – Sahand Volcano (Iran); 3 – Elbrus Volcano (Toksoz et al., 2007)



Anomalies of P-wave velocities

H1, H3, L1 and L2 are the velocity anomalies in the shallow part of the upper mantle. (Zor, 2008)


E
W
Depression D3
Holocene lavas
Depression D1
hv (Q4)
pv (Q3)
rhy(N2')
Borehole #4
Hot spring
30°C
Bogur river
Al.r.
97°C
Elevation (m a.s.l.)
4000
3000
2000
1000
-1000
-2000
0
2500
5000
7500
10000
12500
Distance (m)
Ohm.m
2000.00
1296.49
840.44
544.61
353.17
228.94
148.41
96.21
62.37
40.43
26.21
16.99
11.01
7.14
4.63
3.00

4. Exploratory Drilling

Approach and Methodology

Preliminary drilling during the feasibility study is the only way to directly confirm temperature, reservoir fluid composition and flow rate. Therefore, early stages of drilling significantly reduces risk.
Well logs of the geological units contained in the upper 2 km around the well can inform geological, geochemical and geophysical models.
After a resource has been discovered, additional wells are needed to confirm the size of the geothermal resource through well flow tests. The cost of drilling is non-trivial, and represents the largest upfront cost of a geothermal development.

Main activities:

- Large-diameter conventional wells (>10cm) or 'slim hole' wells (<10cm diameter) are drilled to depths of around 1200 – 1800m.

5. Resource Evaluation & Confirmation

Approach and Methodology

Development of conceptual modeling is the last step of a feasibility study. Information from each survey is integrated to develop a consistent model of the geothermal resource at depth. This model may need to be further constrained by the interconnection and environmental factors. The conclusions drawn from a feasibility study should include estimates of energy potential, lifetime, and economic worth.

Main activities:

- **Estimation of energy potential, lifetime, and economic worth.**

6. Legal framework

Approach and Methodology

A legal permit or license is often required to extract energy from a geothermal resource. Permitting may also be required at early stages of geothermal development, for example, prior to a feasibility study. Around the world, the permitting structure varies dynamically. Examples of the permits required for a geothermal project: zoning; land use; building; water rights; mineral rights; well construction; underground injection; surface disposal. One should consult local and national laws, and communicate with local and national authorities to ensure this process is successfully completed on-time.

Study of opportunities and development of biodiesel production technologies from algae in Armenia

- It is well known that algae consume CO2 as a carbon source for growing.
- Algae can be grown not only for using as biomass for feeding and other purposes, but also for biodiesel production.
- This will be an important contribution into mitigation of increase CO2 in the ambient atmosphere.
- Solar radiation conditions in Armenia are excellent for algae growing (2500 hrs of sunshine per year at 1720 kWh/m2, whereas the average in Europe is 1000 kWh/m2).
- Algae require more or less stable temperature for growing, preferably in the range of 17oC-30oC.

Project “CO2 capture and storage technologies for zero emission power generation in the Black Sea Region: Natural analogue investigation for CCS in the Southern Caucasus” (BLACK SEA ERA.NET, Caucas-ccs)

- **The Institute of Geological Sciences of Armenia**
- **SPC "Armbiotehnologiya" NAS**

1. The listing of prospective implementation sites taking in consideration environment characteristics and nutritional issues, and creation of data base.

2. Creation of data base for Algae strains that can be used in these technologies. The microbiological part of our group is engaged in selection of algae strains with high lipid producing activity.

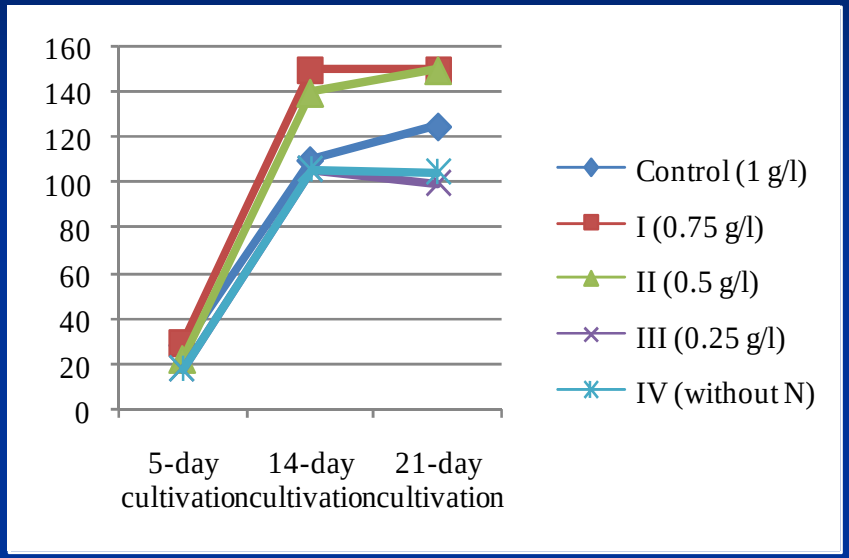
3. Analysis of environmental protection issues in case of implementation of method. This part of the work will take into account on the one hand of waste production, and on the other - the impact on water resources in Armenia.

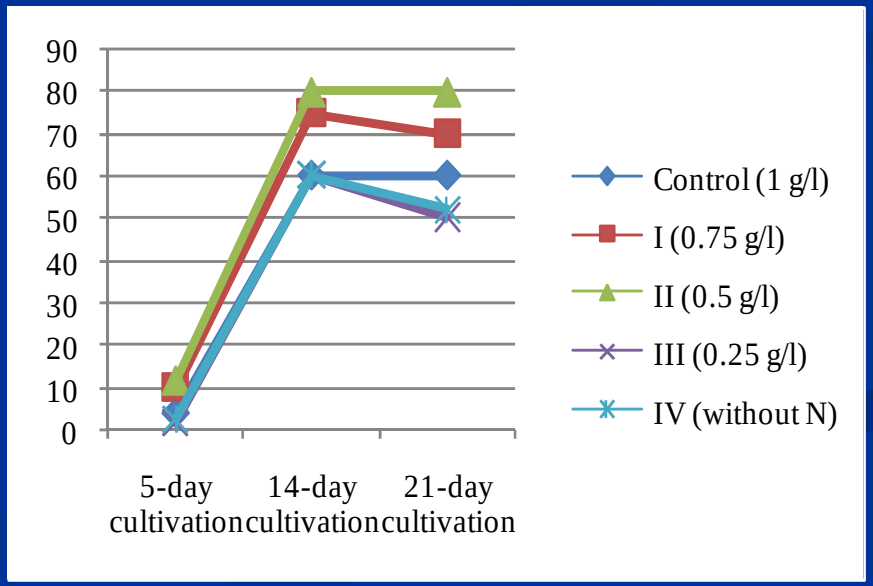
4. Preliminary assessment of economy issues.

Briefly about some of the preliminary results

- **There are springs in Armenia with warm water in outlet which attractive for this purpose.**
- **The water temperatures in outlet is more or less stable (18-28oC) during the year.**
- **Waters saturated by carbon dioxide.**
- **Salinity of waters is moderate (TDS=1200-1500 mg/l).**
- **These characteristics are good prerequisites for assessment the technology capabilities for use these springs waters to grow algae and produce biodiesel.**
- **Isolation, characterization of morphological, physiological, biochemical properties, genetics, systematics and maintenance of cultures of photosintesizing bacteria and algae due to their distribution in various geochemical environment and extreme conditions**
- **Understanding of photosynthetic mechanisms of conversion and storage of light energy by anoxygenic phototrophic purple (APP) sulfur and non-sulfur bacteria and algae**
- **Identification of the limit steps, definition and validation of the strategies for optimization efficient ways for production of biodiesel, biohydrogen, lipids, fatty acids, carotenoids, bacteriocins and other biologically active substances**
- **Investigation on biosynthesis of lipids by microalgae *Dunaliellasalina*during growth dynamics under conditions of salinity with concentrations of 2.0M and 3.5M NaCI as well as nitrogen limitation from 1.0 g/l to 0.25 g/l NaNO3 in nutrient media including versions without nitrogen source.**

The production of biomass, lipids and chlorophyll content in media with concentrations of 2.0M NaCI as well as nitrogen limitation (Control and I-IV versions) during 21-day growth dynamics of D. salina is presented in Figures





The approaches currently used in the laboratory relate

- **(i) to exploration of natural extreme diversity of APP bacteria species (Rhodobacter capsulatus, R.sphaeroides, Rhodopseudomanas palustris, R.acidophila, Rhodospirillum rubrum, Chromatium vinosum, Lamprocystis roseopersicina, Thiocapsa sp., Thiospirillum sp., Ectothiorodospira sp., etc.) for strains' selection with high carotenoid pigments, organic acids, bacteriocins and various enzymes synthesizing capacities**

- **(ii) to revealing the metabolic pathways for lipids / omega fatty acids synthesis and accumulation, as well as their regulations in cells of algae species belonging to genera Chlorella, Dunaliella, Scenedesmus, etc.**

- **(iii) to evaluation of abilities for producing of hydrogen by selected strains of genera Rhodobacter**

Thank you