

**DATA
ACQUISITION
PROCESSING
INTERPRETATION**

**HYDROCARBON
EXPLORATION**

**MINERALS
EXPLORATION**

**WATER
RESOURCES**

**GEO THERMAL
EXPLORATION**

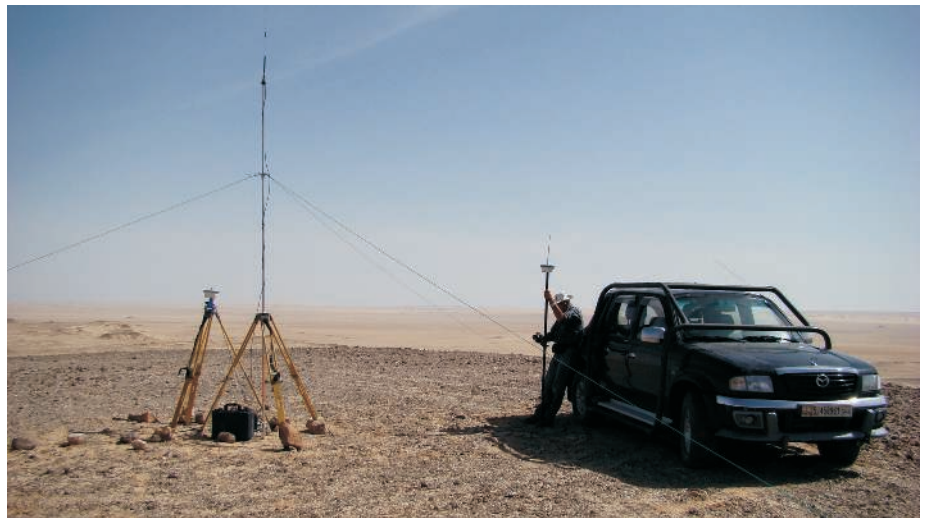


**in business
since 1950**

non-seismic geophysical service

**PBG Geophysical Exploration
Ltd.**

www.pbg.com.pl



PBG Geophysical Exploration Ltd., based in Warsaw, Poland offers a broad range of non-invasive geophysical methods for minerals, geothermal and hydrocarbon exploration as well as for shallow subsurface projects. We operate worldwide. We have a highly-specialized and qualified staff with good professional experience and international practice. Our team is equipped with a high-technology equipment. We have gained our experience in Europe, Africa and Asia, executing contracts for oil and mining corporations, government and research and private companies - always in accordance with the highest standards and with the expectations of our clients.

We have been in business for over 65 years, working to constantly improve operating procedures to deliver first class services to our clients.

GEOPHYSICAL METHODS - DATA ACQUISITION

- | | |
|---|--------------------------------------|
| ■ magnetotellurics AMT / CSAMT | ■ transient electromagnetic TEM/TDEM |
| ■ gravity & microgravity | ■ conductivity electromagnetic EM |
| ■ magnetics | ■ ground penetrating radar GPR |
| ■ electrical resistivity tomography ERT | ■ very low frequency VLF |
| ■ vertical electrical sounding VES | ■ shallow seismic methods |
| ■ induced polarization IP | |

DATA ANALYSIS

- non-seismic data processing & interpretation
- modelling and visualization; 2D/3D inversion of geophysical data
- integrated interpretation of non-seismic & seismic data
- geological interpretation
- reprocessing of legacy data

HYDROCARBON EXPLORATION

PBG Ltd. provides complex ground geophysical surveys with the use of gravity and magnetotelluric / magnetic method to identify structures perspective for hydrocarbons exploration. We offer gravity and magnetotelluric method as reconnaissance or supplementary techniques for seismic surveys for hydrocarbons, together with integrated interpretation to evaluate hydrocarbon structures and propose drilling and exploratory wells.

GEOHERMAL & WATER RESOURCES EXPLORATION

We boast many years' experience in the quest for water resources exploration. Within the last few years we have realized a number of projects aiming at identifying prospective zones thermal and mineral waters resources, as well as numbers of projects related to sources of drinking water for municipal intakes.

MINERALS EXPLORATION

For minerals prospecting both for preliminary reconnaissance and for recognition of mineral deposit settings, we offer the most efficient geophysical methods including: magnetic, magnetotelluric, electromagnetic EM, VLF and electrical IP, VES, SP, ERT techniques.

SHALE GAS PROSPECTING

We offer magnetotelluric surveys for shale gas prospecting. Magnetotelluric methods is proposed for definition of thickness of low-resistivity shale layers.

GEOLOGICAL, GEOTECHNICAL AND ENGINEERING SURVEYS

We offer a selection of geophysical methods for civil engineering, environmental protection, geohazards monitoring, forensic and archaeology.

We offer:

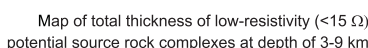
- integrated approach to solve geological problems
- professional advisory services
- commitment and effectiveness
- solid professional experience - **we are in business since 1950**

We offer:

- *field surveys, along with geodesy / GPS surveying*
 - *geophysical data processing & interpretation*
 - *modelling, visualization, 2D/3D inversion*
 - *integrated interpretation*
 - *reinterpretation of archival data*
- 



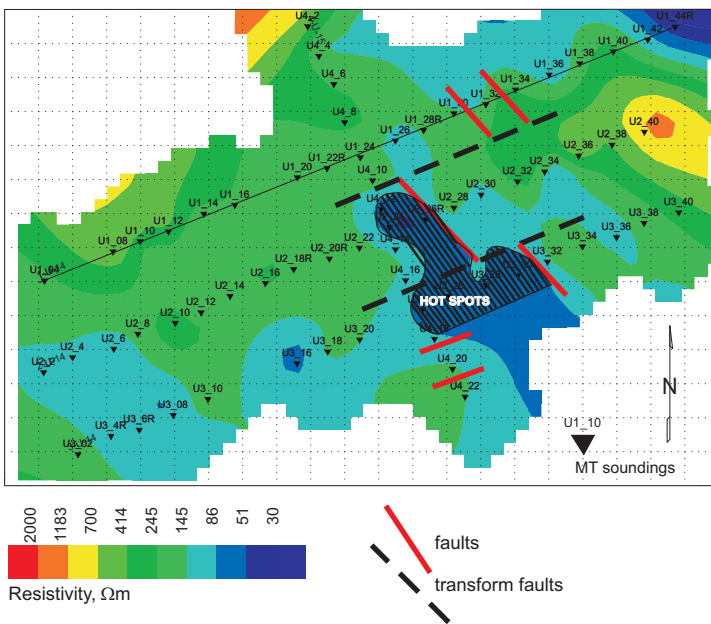
Application of **gravity method** to oil and gas prospecting consists in locating geological structures that can be hydrocarbons traps. Gravity method detects and measures variations in the Earth's gravity field. Variations are associated with the changes of rock density. Some geological structures causes anomalies (disturbances) in normal density distribution. Application of gravity method consists in calculation of gravity anomalies; that brings the idea on depth and size of the bodies causing these anomalies.



For geothermal and water resources exploration we offer set of geophysical services of the high methodological and interpretation standards, including:

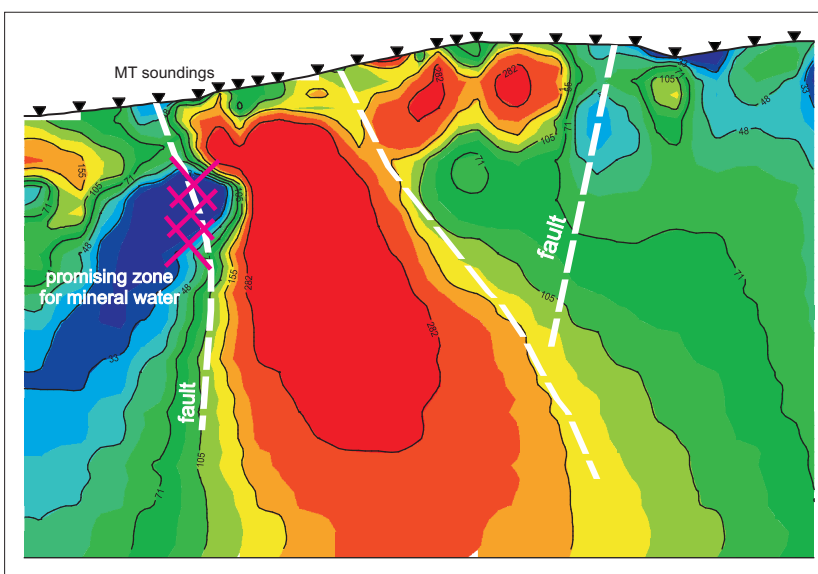
- electrical resistivity methods for surface exploration
- magnetotelluric survey for deep tectonic recognition
- gravity to detect geological formations with different resistivity
- magnetic survey for faults tracing

Magnetotelluric data interpretation



We offer:

- reconnaissance surveys
 - water-bearing structures definition
 - solving hydro-geologica problems
 - identifying perspective tectonic zones
 - drilling sites locations
-
- *data acquisition*
 - *data processing & interpretation*
 - *modeling, visualization, maps*
 - *integrated interpretation*
 - *reinterpretation of legacy data*



MT/CSAMT data interpretation

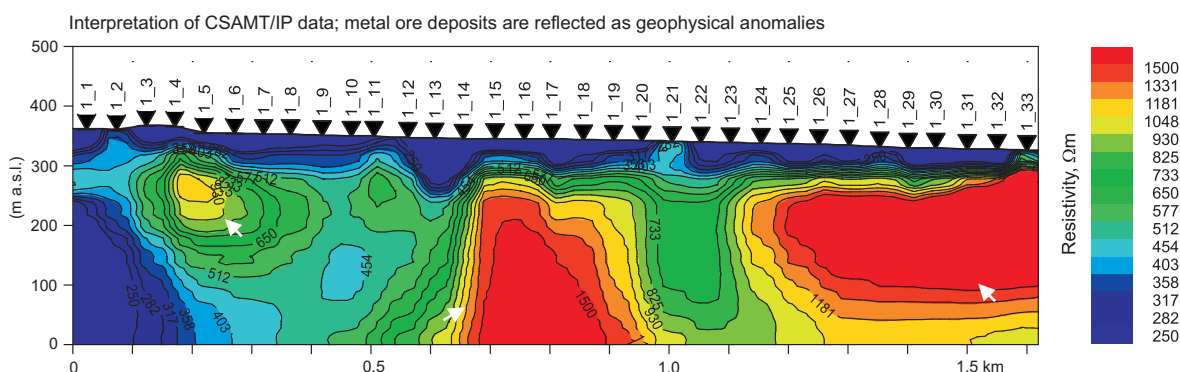
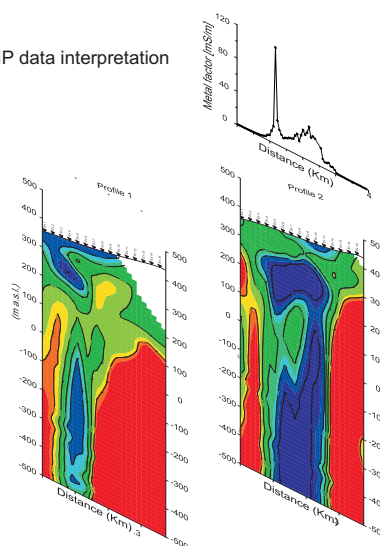


PBG Ltd. has been conducting geophysical surveys for mineral prospecting since 1950. We constantly expand the range of geophysical techniques; our present offer includes the most efficient methods for minerals exploration both for preliminary reconnaissance, ore-bearing structure definition and resource evaluation. We have gained our experience in the countries of Europe, Africa and Asia, executing contracts for mining corporations, government and research agencies and private companies.

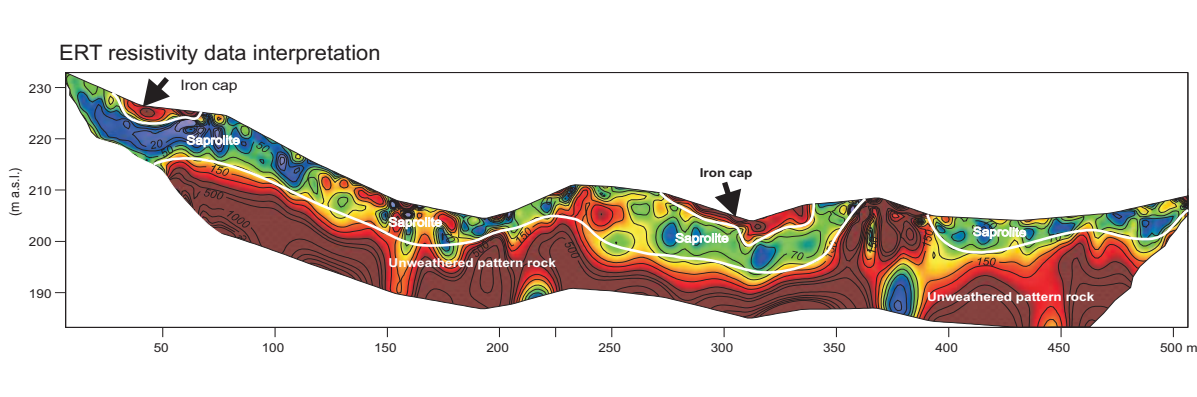
Offered methodology:

- magnetotelluric surveys
 - gravity & magnetic surveys
 - geoelectrical & resistivity methods (ERT, VES, IP)
 - VLF & CMD profiling
-
- *data acquisition, processing & interpretation*
 - *modeling and visualization, maps*
 - *integrated interpretation*
 - *reprocessing / reinterpretation of legacy data*

CSAMT / IP data interpretation



Induced polarization (IP) is a technique particularly useful in Mineral Exploration and Mine Operations. IP and resistivity surveys can be used to detect and map economic mineral deposits. IP is used to map many types of deposits including porphyry copper, gold bearing sulphides, manganese and titanium bearing placers

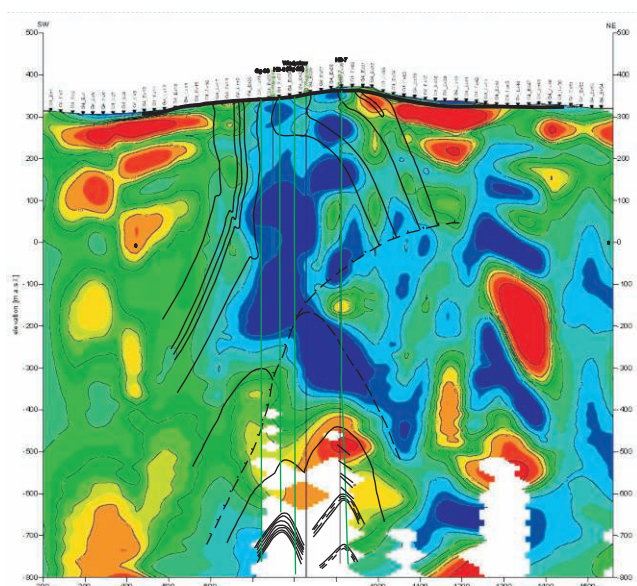


Magnetotelluric method is a surface geophysical technique especially recommended as a complementary method to regional seismic for tracing layers which might be unidentifiable on seismic records, because of strong velocity inversion (screening layers above). Type of offered MT surveys includes: **NATURAL SOURCE**: MT magnetotellurics, AMT audio-frequency magnetotellurics; **ARTIFICIAL SOURCE**: CSAMT control source audio-magnetotellurics, TDEM/TEM Transient Electromagnetic, IP Induced Polarization

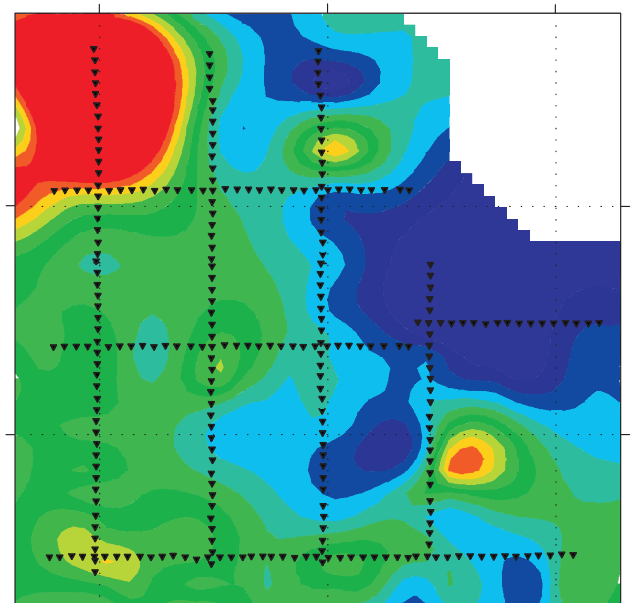
Applications:

- recognition of structure and tectonic of the studied area
- hydrocarbon (oil&gas) exploration
- shale gas exploration
- mining exploration copper, nickel, rock salt, sulfur
- thermal & mineral water prospecting
- deep crustal research
- reservoir monitoring (natural and artificial)

MT DATA PROCESSING & INTERPRETATION



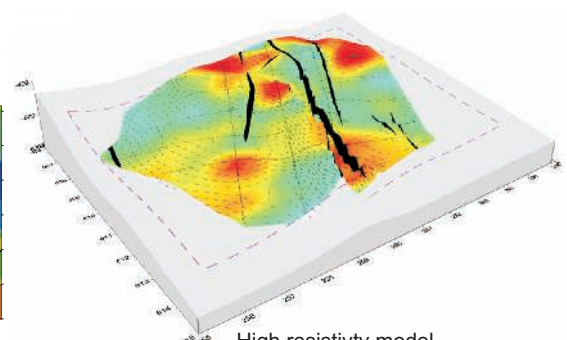
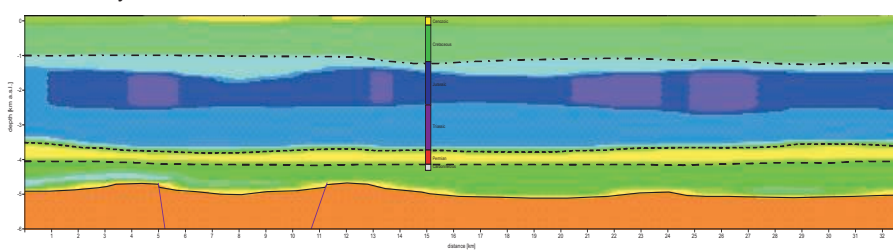
1D Occam inversion based on CSAMT data



▼ MT Sounding

Resistivity map (Occam Inversion)

Resistivity section after 2D SBI inversion



High resistivity model for further 3D seismic operations

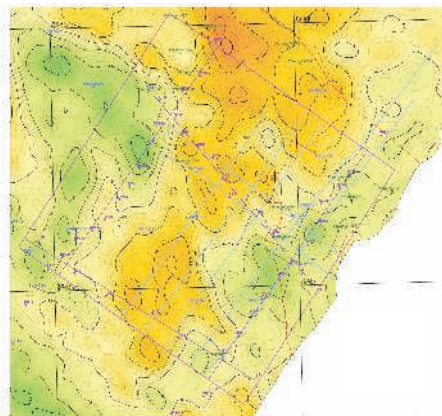
Gravity surveys are applied for minerals and petroleum prospecting bringing important information on geological settings: tectonic zones, faults locations and sedimentary thickness. Gravity method is used as a reconnaissance or supplementary technique to seismic surveys for hydrocarbons. Joint gravity and MT / magnetic surveys increase the efficiency of geophysical investigation for hydrocarbons, especially in the areas of complicated geological structure or when the seismic recognition is insufficient. Integration of the gravity, MT and magnetic data with seismic records significantly increases the results of seismic data processing and interpretation.

Application area:

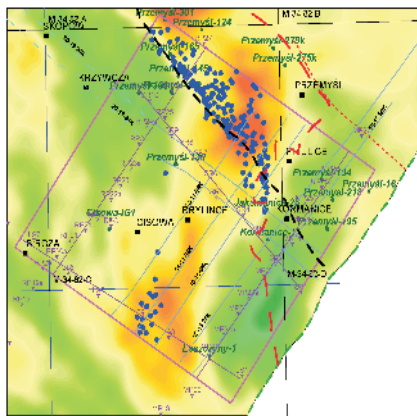
- mapping deep geological structures
- tracing elements of tectonics, density and lithological horizons
- exploring structures perspective for hydrocarbon accumulations
- mineral deposits exploration
- mapping subsurface voids and mining cavities (MICROGRAVITY)

GRAVITY DATA PROCESSING & INTERPRETATION

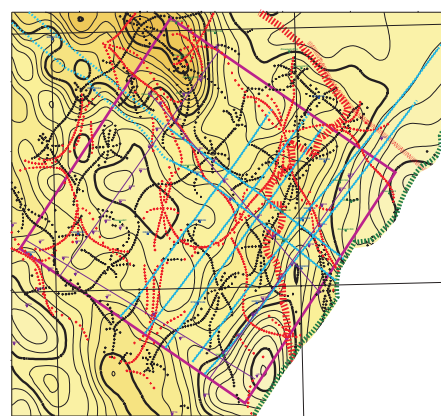
Residual anomaly map
(depth range 3-4,5 km)



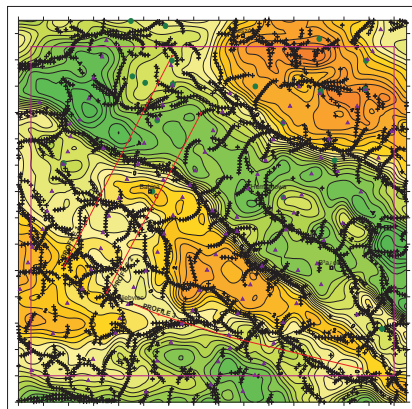
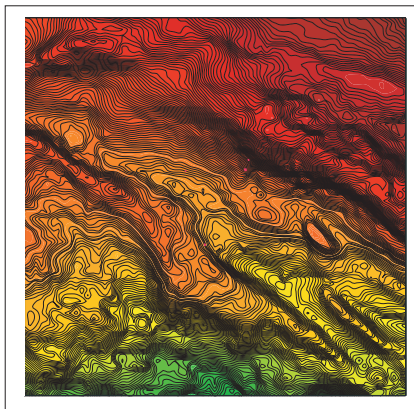
Fuler deconvolutions in residual anomaly map
(depth range 3-4,5 km)



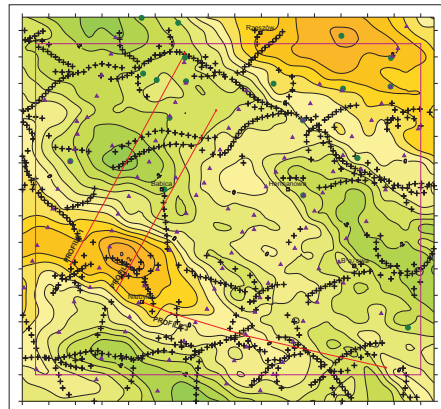
Map of horizontal gradient of gravity force
(Rosenbach method)



Bouguer anomaly map separated with the use of different filtering techniques



Maps of gravity anomalies



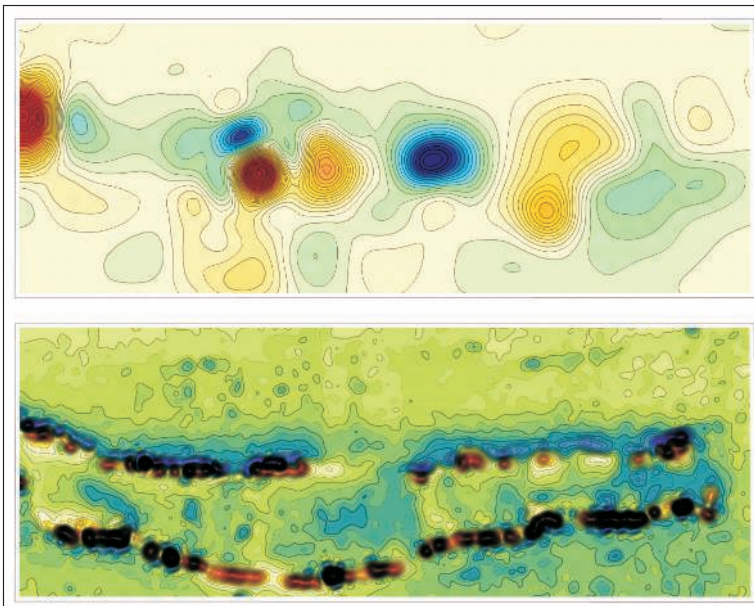
Magnetic survey is used for detailed geological mapping in exploration, engineering and archeological geophysics. Survey consists in the measurements and analysis of the Earth's natural magnetic field, determination and interpretation of magnetic anomalies generated by magnetic contrasting geological structures or metal objects in the ground. Magnetic methods is

Applications:

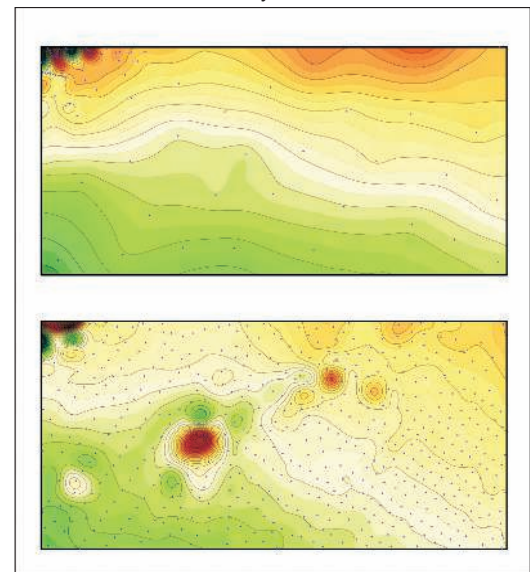
- recognition of morphology and tectonic of magnetically active basement
- recognition of deep basement for oil & gas (hydrocarbon) exploration
- minerals exploration iron, magnetite, hematite, nickel, quartz, copper, basalt, andesite,
- landslides investigations
- detecting buried objects metal drums, tanks, old water and sewage infrastructure

MAGNETIC DATA PROCESSING & INRTERPRETATION

Comparision semidetailed (3 st./sq. km) T survey
with detailed (100 st. /sq. km) T survey



Comparision regional Z survey
with semidetailed T survey



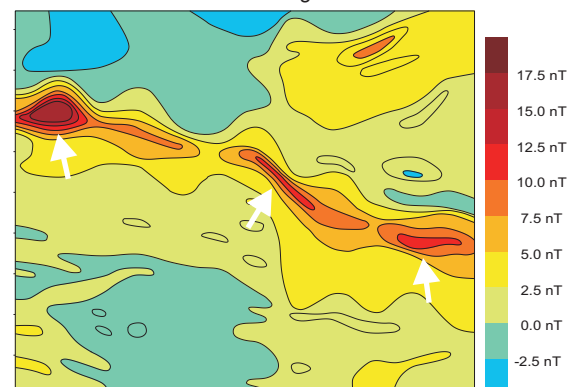
METHODOLOGY OF SURVEYS

- classic method
- difference method for noisy areas (PBG developed method)
- recording of magnetic field T daily variations at local base stations
- measurement accuracy: $\pm(1\div 2)$ nT

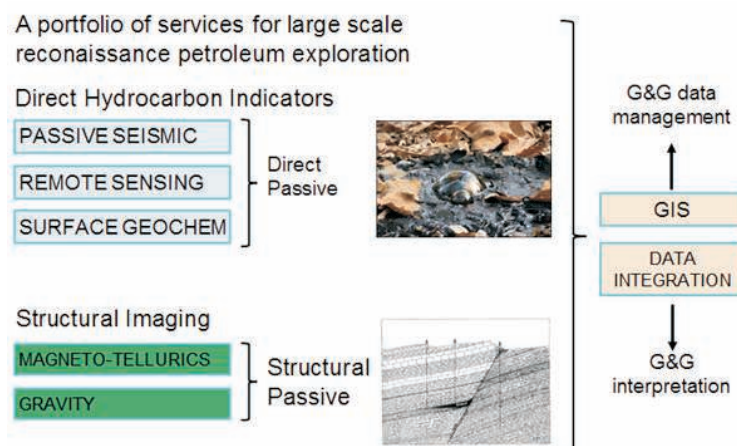
DATA PROCESSING

- magnetic data base - data handling
- calculating the magnetic anomalies ΔT

Detection of minerals by theirs magnetic properties -
ore bodies are detected as magnetic anomalies

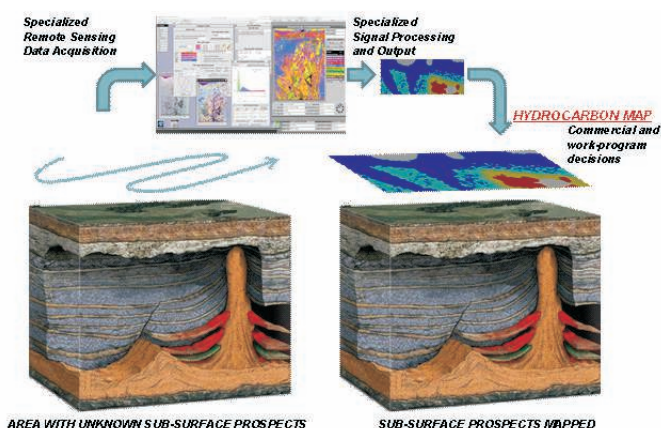
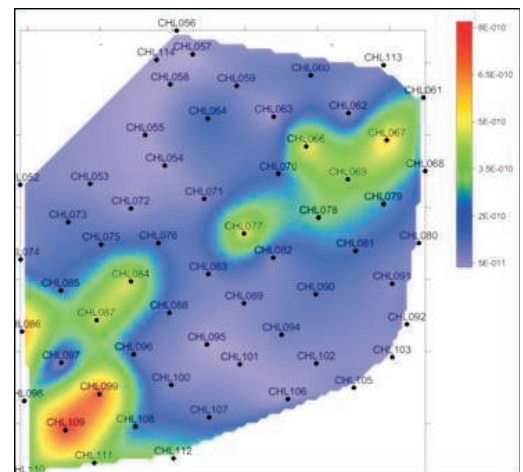


PBG Ltd. has established a project-based partnership with Geodynamics Worldwide (GWW), a company based in Rovereto, Italy which offers non-invasive geophysical services designed to reduce the risk of onshore oil&gas exploration. These technologies have less limitations than conventional seismic when it comes to explore frontier areas such as sub- salt, sub- basalt, complex geology and significantly minimize the capital expenditure by concentrating the efforts of conventional seismic only on prospective areas. The simultaneous application of the technologies offered by PBG Ltd. and GWW lead to synergies in the acquisition phase, thus allowing the client to take advantage of economies of scale.



Passive Seismic Spectroscopy

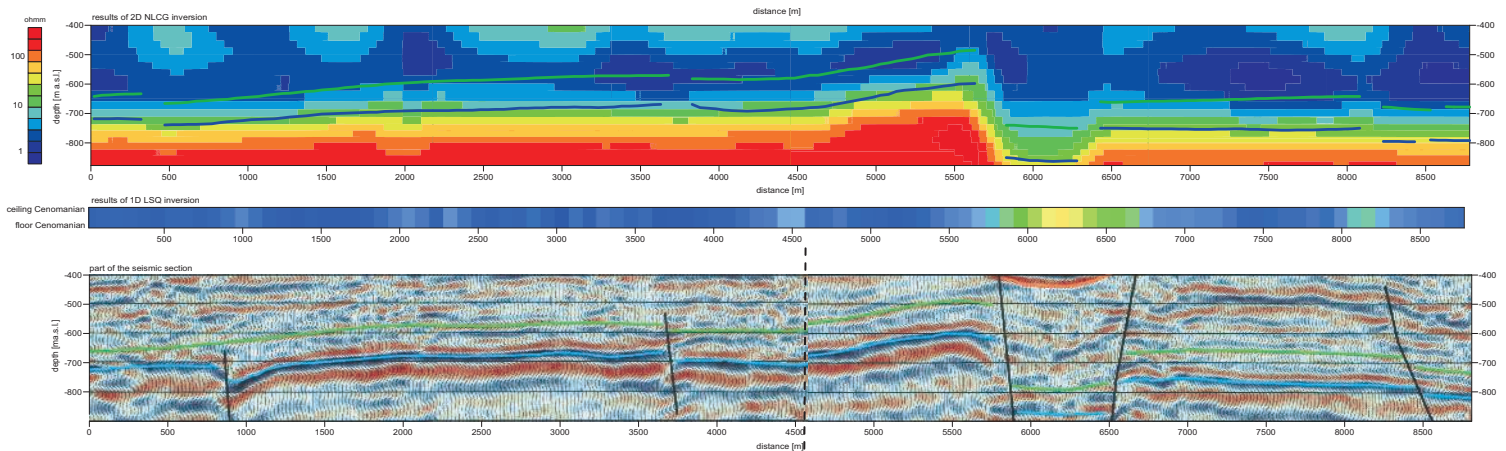
This recent technology is applied as a Direct Hydrocarbon Indicator (DHI). The analysis in the frequency domain will highlight the areas where the probability of hydrocarbon presence is higher. In fact, numerous surveys [Dangel et al:2003] [Holzner et al:2003] over different oil and gas fields worldwide have established the presence of spectral anomalies in a low-frequency window (1.5 – 10 Hz). The passive seismic acquisition, carried out on a grid basis, does not require any explosions, vibrations or similar.



Remote Sensing

Remote Sensing allows the identification of a working petroleum system by using satellite data. This technology does not require operation on the ground and, thus, can cover large areas rapidly and cost effectively, with no environmental impact, enabling focus where potential concentrations of hydrocarbons actually exist underground, validating the structures on seismic.

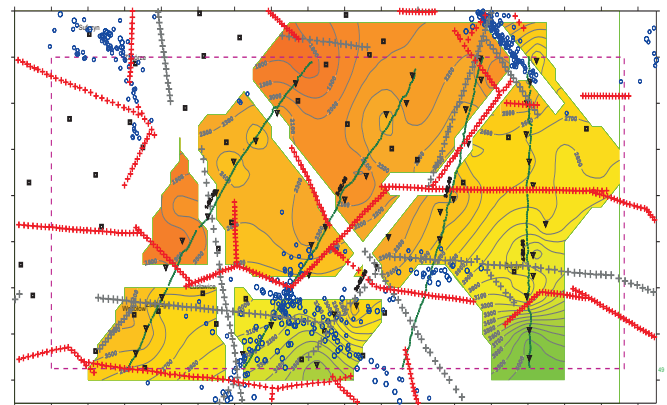
Integrated data interpretation utilizes data from many geophysical methods (well-logging, gravity, MT, seismic) to elaborate final section or map presenting geological structure of the area.



Resistivity distribution from three different inverse methods (MT data) vs seismic section for analysis of Cenomanian-Jurassic boundary

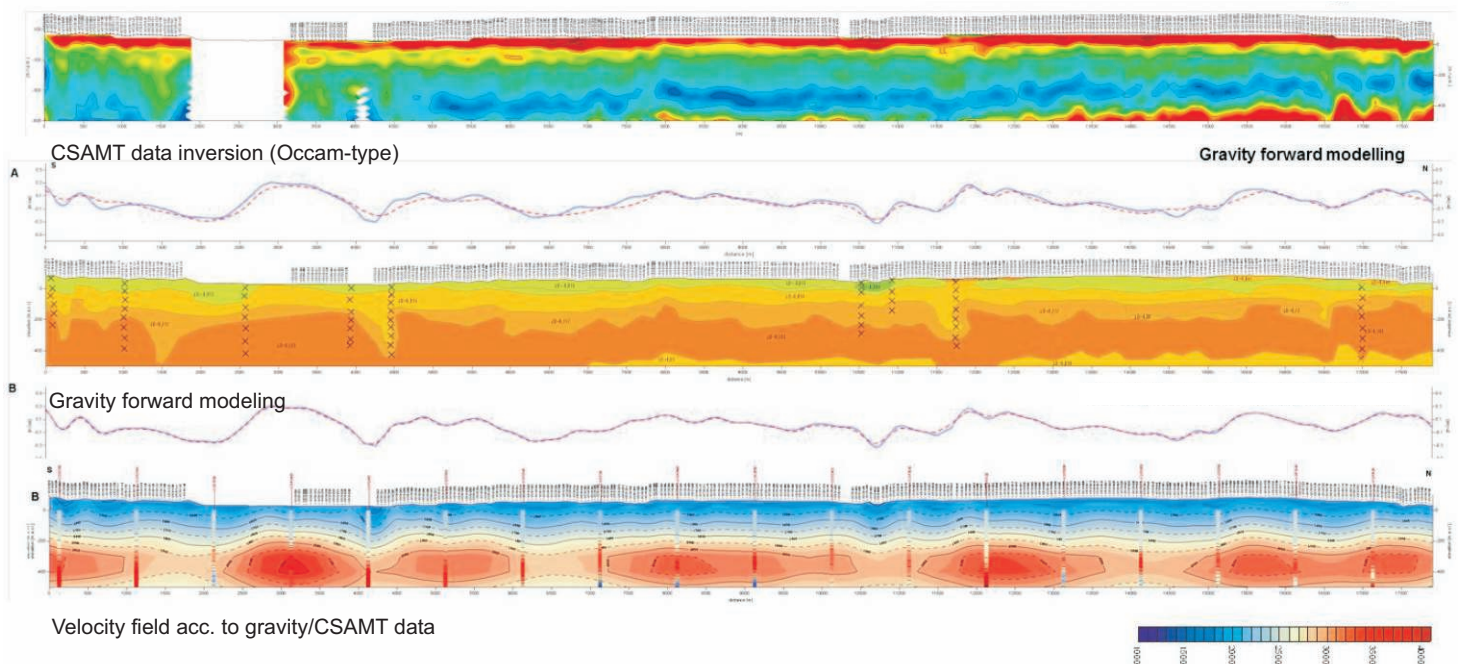
PBG Ltd. recommends integrated and joint analysis of geophysical - geological data especially to be completed for the areas of complicated geological structure and where the result of seismic investigations is insufficient.

Integrated interpretation is especially recommended for hydrocarbon prospecting at the areas of complicated geological structure and for recognition of complexes below layers screening or attenuating seismic waves.



Result of integrated MT/gravity interpretation: structural sketch of sub-flysch/sub-Miocene basement

Mapping depth and thickness of subsurface layers; velocity model calculated from CSAMT and gravity data



PBG Ltd. owns and operates precise instruments to realize acquisition of geophysical data the most cost effective. We offer a selection of geophysical techniques of the highest methodological and interpretation standards.

■ gravity / microgravity surveys

- CG-5 / CG-5 HT Gravity Meters (SCINTREX)

■ magnetotelluric surveys

- System2000.net for A-MT, CSAMT, IP, TDEM data acquisition (PHOENIX-GEOPHYSICS)

■ magnetic surveys

- ENVI PRO Proton Magnetometers (SCINTREX)
- ENVI-MAG/TOTAL FILED Magnetometers (SCINTREX)
- ENVI-GRAD-VLF System (SCINTREX)

■ electrical resistivity surveys

- Terrameter LS for ERT, IP, SP data acquisition (ABEM)
- TIPIX - ELREC PRO for VES & IP surveys (Iris Instruments)
- ARES II for ERT, IP surveys (GF Instruments)
- ARS - ERT System (GF Instruments)
- ELMES ADG-4 for VES surveys

■ electromagnetic GPR, VLF, conductivity surveys

- Georadar SIR-20 (GSSI Incorp.)
- CDM Conductivity Meter (GF Instruments)
- T-VLF System (Iris Instruments)
- GEM-2 (CDM)(Terraplus)

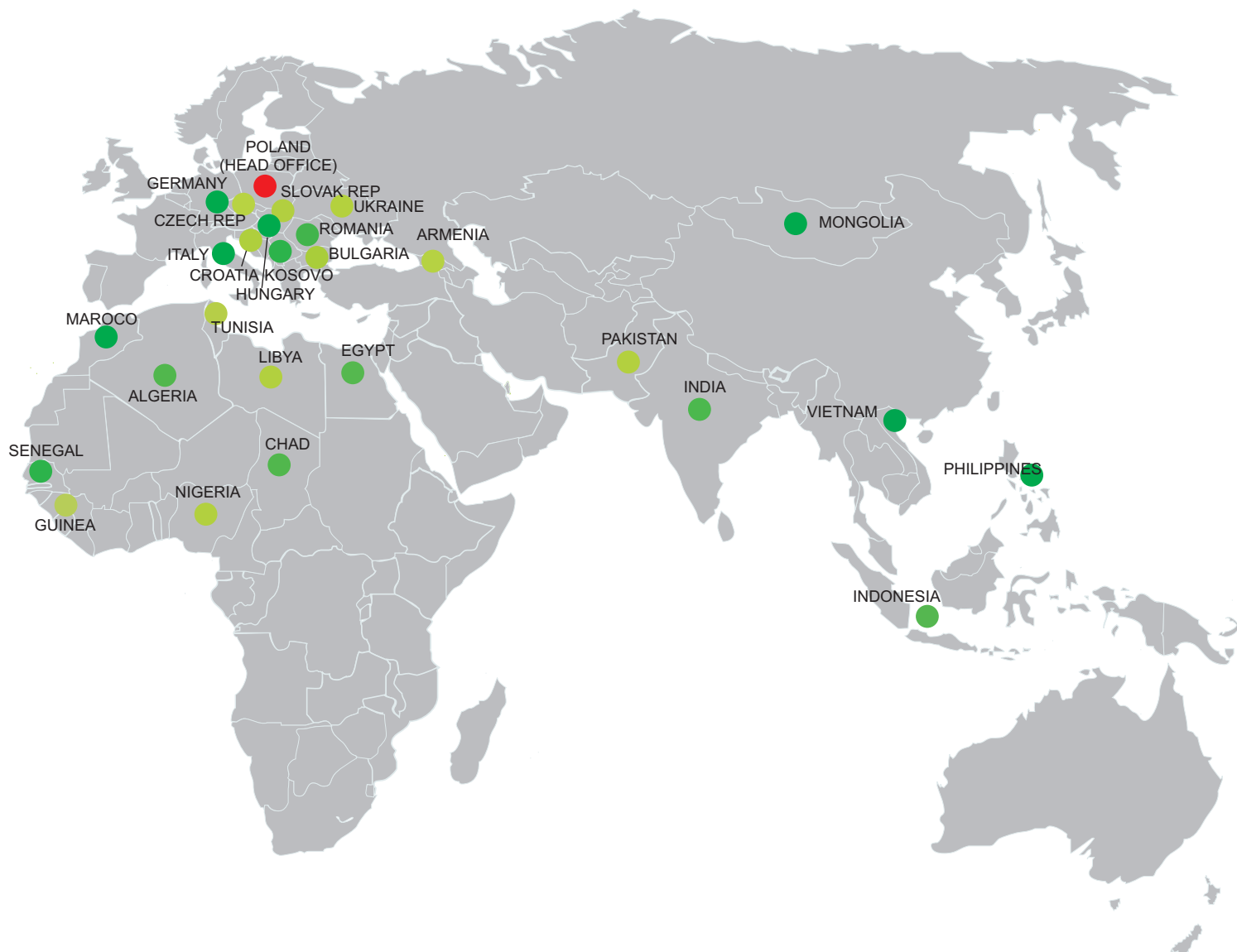
■ shallow engineering seismics

- TERRALOC MK-6 Seismographs (ABEM)

■ XRF Spectrometer

- handheld heavy and precious metal analyzer





INTEGRATED MANAGEMENT SYSTEM

The Company functioning is based on the procedures allowing to operate in accordance with the law and the best practice and international standards. Specified procedures define the responsibilities of staff and proper communication system and ensure effectiveness in both primary production - geophysical surveys as well as in supporting activities. Integrated Management System provides quality, innovative and procedural approach towards the management of the organization, based on ISO 9001:2008, ISO 14001:2004, AQAP 2110:2009 and PN-N 18001:2004 standards, to ensure satisfaction of clients, protection of environment and improvement of the offered services.

QUALITY MANAGEMENT SYSTEM

PBG Ltd. developed a set of processes and procedures required to design and complete services in the Company's core business area. The system is continuously monitored to reduce and eliminate non-conformance to procedures, as well as to meet clients expectations in the most cost effective and efficient manner.

HSE

It is the policy of PBG Ltd. to manage its activity in a responsible manner that promotes safety and health of its employees and protection of the environment. All PBG's activities are designed and managed to prevent safety and minimize adverse impact on the environment. PBG's staff is aware of the HSE responsibilities and complies with all applicable HSE regulations and standards.

HEAD OFFICE

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