METHODS:
- MT/AMT/RMT/CSRMT
- TEM
- DNME
- EMS-IP
- ERT
- GRAVITY
- MAGNETICS
- CST/VSP/RVSP/VSAP

We deploy well known and newly developed techniques in order to achieve our goals. Among the other methods that UGS is capable to perform are electric, gravity, magnetic, seismic surveys for a wide range of applications.

Oil and gas exploration, mineral deposits search, detecting hydrothermal activity along with groundwater, permafrost and geohazard studies are among the most feasible tasks for our team.

As an alliance of companies with vast experience, staff competence and modern equipment, we can provide the most comprehensive range of services. We can offer our services on projects of any complexity and on any terrain.

Intellectual property of the company includes a number of patented geophysical techniques and data processing software.

In this brochure we would like to draw your attention to the most advanced technologies used by our company:
- DNME on land and water areas
- EMS-IP
- Unique TEM exploration and high-precision techniques
- High-resolution seismic observations in boreholes

Also, we are experts in RDCES (Robust Joint EM & Seismic Interpretation) – an innovative tool for reducing the uncertainties of subsurface. In addition it is also presented an information about software that was developed by us.
**DNME OFFSHORE TECHNOLOGY**

*Underwater towed observing system for deep-sea operations*

The development of deep-sea survey technology has originated over 15 years ago from measuring system towed on a sea surface. It has proved to be effective at depths from 10 to 100 m. In 2015, for the first time the operations were performed with an underwater towed system up to a depth of over 500 m (by Lukoil). In 2016, similar operations were conducted in the Romanian sector of the Black Sea. At present, the developed method allows to carry out DNME marine works in the sea with depths up to 1 km.

IP anomalies are formed at the level of geochemical barriers confined to upper regional impervious layer.

In 2006, Schlumberger conducted a DNME technology test on the North-Gulyaevskoe field. As a result of these works, geoelectric sections, IP distribution map and resistivity map were reconstructed. IP anomaly was fixed on the IP section, at the depths corresponding to upper regional impervious layer.

---

**DNME – result example (North-Gulyaevskoe field, Barents Sea)**

- The level of the Upper regional aquiclude
- The geoelectrical layer including hydrocarbon deposits
- IP anomaly on the level of the upper regional aquiclude
- The resistivity anomaly associated with the effect of the presence of hydrocarbon deposits in the section
The distribution of permafrost rocks thickness were obtained on the basis of DNME studies. This data allows us to adjust the velocities in seismic section and, thus, to correct structural maps. In addition, it could be used during pipelines installation.

APPLICATION OF DNME FOR GEOLOGICAL ENGINEERING

Along with HC deposit exploration, DNME technology allows to solve other issues. In the Far North information on areal allocation of permafrost rocks and gas-hydrates accumulations is very relevant.

DNME onshore observing system can be represented by a profile or area option. Source grounding is done with iron electrodes. For a receiver station grounding the brass electrodes are used. In winter in the Russian North, ABB power supply dipole is grounded by wells. Their drilling depth is usually 2-3 m. A leach is poured into holes in order to achieve better conductivity.

Example of the area data acquisition

In addition, we have developed a unique technology for studying the section polarization properties with usage of inductive excitation under the conditions of desert and ever frost areas.

DNME works were carried out both in the territory of Russia and outside it. For example, in Tatarstan it was being solved a problem of the prospects of local elevation within the major reef, characterized by variation in reservoir properties. As a result, zones prospective for the presence of hydrocarbon deposits, were allocated. One of the wells took up a position over the reef building trap, that was considered (based on seismic data) to be “hopeless” in relation to oil and gas. The presence of deposit was confirmed after drilling, and the complex "DNME + seismics" has been confirmed as an effective way for oil and gas exploration.

DNME onshore observing system can be represented by a profile or area option. Source grounding is done with iron electrodes. For a receiver station grounding the brass electrodes are used. In winter in the Russian North, ABB power supply dipole is grounded by wells. Their drilling depth is usually 2-3 m. A leach is poured into holes in order to achieve better conductivity.

The DNME method is applicable in different geological and geophysical conditions, including a search of deposits under the halogen-carbonate show weak conducting complex, widespread trap magmatism, in regions of ancient and recent platforms, continental depressions, fore deeps and shelves. The results of method do not depend on types of traps (structural, structural-tectonic, lithological, etc.) and reservoirs (terrigenous, carbonate).
By using the EMS-IP technology it becomes possible to identify values of electrical parameters of the medium that have a close correlation with the matter composition. These electrical parameters are related to petrophysical properties of rock and allow to determine reliably the position of sulphides in high- and low-resistance mediums at depths of 1 km and more. EMS-IP technology is based on the calculation of normalized transient processes from 10 to 125 ms. Its implementation starts with transmitting a time-domain, square-wave bipolar pulses into a long grounded generator line. Pulses are separated by pauses what allows to extract information about transients from recorded signal on a receiving line.

Results of EMS-IP technology usage obtained during the search for deposits of ore minerals in the area of the Altai Mountains (Russia).

Map of polarizability based on the results of 3D inversion on a depth interval 50-90 m

Notation:
- Drilled well
- Planned well according to EMS-IP data
- Mineralization points
- Anomalous zones according to 3D inversion
  - depth from 50 to 90 meters
  - polarizability above 20%
  - polarizability from 14% to 19%
  - depth from 90 to 290 meters
  - polarizability above 20%
  - polarizability from 14% to 19%
**UNIQUE TEM EXPLORATION AND HIGH-PRECISION TECHNIQUES**

**TEM features**

- High resolution
- The ability to use small offsets, no uncertainties about recording point
- Wide range of survey depths (from a few tens of meters up to 4-7 km)
- High field work performance
- Electromagnetic field propagates inductively allowing to explore the subsurface in the presence of high-resistive layers (not possible at DC method)
- Better subsurface description due to of lower heterogeneities interference (compared to electrical lines)
- Lower sensitivity to IP effects, better ability to resolve resistivity of formations
- TEM method may be carried out in any climate zone and geographic conditions, in eluding populated areas

**Exploration stage**

**Clastic reservoirs map obtained from 3D TEM data**

- TEM-based prediction confirmed by subsequent drilling
- Deep boreholes:
  - Oil+water
  - Gas+water
  - Dry holes

**3D TEM outcome:**

- Maps of reservoir and nonreservoir rocks and their saturation types
- Predicted reservoir rocks and saturation confirmed by data from three boreholes
- Reduced drilling risks by joint use of 3D seismics and 3D TEM

**Formation of a secondary oil accumulation**

- Oil accumulations confirmed by drilling
- Seeps of oil-in-water emulsion
- Active deep faults
- Abnormal formation pressure
- Joint interpretation of seismic and TEM data allowed to divide the revealed shallow high-resistivity zones into subzones of dense rocks and permeable zones of potential oil contamination
- Three highly resistive zones associated with potential oil contamination were revealed in Quaternary alluvium

**Clastic reservoirs map obtained from 3D TEM data**

- TEM-based prediction confirmed by subsequent drilling
- Deep boreholes:
  - Oil+water
  - Gas+water
  - Dry holes

**3D TEM outcome:**

- Maps of reservoir and nonreservoir rocks and their saturation types
- Predicted reservoir rocks and saturation confirmed by data from three boreholes
- Reduced drilling risks by joint use of 3D seismics and 3D TEM

**Formation of a secondary oil accumulation**

- Oil accumulations confirmed by drilling
- Seeps of oil-in-water emulsion
- Active deep faults
- Abnormal formation pressure
- Joint interpretation of seismic and TEM data allowed to divide the revealed shallow high-resistivity zones into subzones of dense rocks and permeable zones of potential oil contamination
- Three highly resistive zones associated with potential oil contamination were revealed in Quaternary alluvium
BOREHOLE SEISMIC METHODS

Seismic survey is the most common geophysical method for studying the structure of rocks that provides convincing and fairly reliable results when carrying out geological exploration.

For the moment, a large number of borehole measurements have been developed: operations in single boreholes, shooting between boreholes as well as between borehole and land surface. Unfortunately, in near-surface seismic surveys such approaches are used undeservingly rarely or in simplified modifications, although they allow to increase resolution and detail of investigations.

How it works:

There are 4 types of shallow seismic surveys on land exist where we can deploy a borehole sparker source in the most effective way:

- **Low Frequency Acoustic Logging**: sparker travels with receiver at fixed distance in the same borehole.
- **Vertical SeismoAcoustic Profiling (VSAP)**: sparker is fixed in the same borehole with receiver(s) that is (are) being moved along it.
- **Reverse Vertical Seismic Profiling (RVSP)**: sparker travels in borehole; receivers are fixed on the surface.

- **Crosshole Seismic Testing (CST)**: sparker travels in one borehole; receivers travel in another (other) borehole(s).

Nevertheless, crosshole seismic testing can be carried out not only on pressure waves! At the moment, there are 4 main designs of CST exist: a) single-ray parallel sounding on pressure waves, b) multiwave parallel sounding (i.e. on pressure and shear waves), c) tomographic sounding on pressure waves, d) multiwave tomographic sounding. In more sophisticated realizations of the method, the day surface is taken into account during observations or studies are conducted in shafts and galleries in an arbitrary plane.

Application:

- high-risk and hazardous facilities: nuclear power plants, hydro-electric power plants, high-rise buildings, chemical plants, etc.
- improving the seismic properties of soils by creating a pile field at sites composed of dispersed and water-saturated soils
- non-destructive testing of construction stages (e.g. the creation of a wall in the ground), monitoring the formation of ice wall, carrying out the injection operations
- locating karst areas
**JOINT SEISMIC/EM INTERPRETATION**

Prediction of reservoir properties from joint use of geophysical methods based on acoustic and electric properties of rocks.

- Data obtained with of any single method is ambiguous because of complex geology
- Joint use of different methods improves prediction quality for oil-water contact in tectonically isolated blocks and reveals changes in reservoir rock properties (net pay thickness and porosity)

**INPUT**

- **SEISMICS**
  - reservoir thickness
  - reservoir porosity
- **WELL/LOG**
  - well-based reservoir thickness
  - well-based reservoir porosity
  - well-based reservoir water saturation
- **TEM**
  - resistivity of target interval
- **PETROPHYSICS**
  - resistivity vs. Kp and Sw

**OUTPUT**

- Prediction of water saturation coefficient and updated OWC
- Corrected porosity and net pay thickness
- Updated geological reservoir model

**Approach novelty** is in bringing together resistivity and seismic data via a petrophysical model link for geological modeling of target reservoir.

**Combined seismic and EM sections**

Combination of 3D seismic and 3D TEM soundings provides a breakthrough in processing for:

- Joint analysis of seismic and geoelectric parameters
- Estimation of porosity, net pay thickness and saturation of reservoirs
- Creation of comprehensive 3D reservoir models that image faithfully the real geology
- Delineation of pay zones to subtlest details
The software is designed for 1D modeling and 1D inversion with data of various modifications of setups – line to line loop to loop – with a variety of sources and receivers.

The inversion process robust residual functional based on Hampel function is used, what allows to obtain a stable solution during the processing of a real survey data.

**MARS 1D – MODELING & INVERSION**

The software is designed for 3D modeling and 3D inversion of data obtained during land-based, airborne, and marine electrical explorations.

The computational software component is based on solving the 3D inverse problem and using special regularization and the Gauss-Newton method with computing the fields of 3D objects’ impacts by finite element 3D modeling.

**GEMIR – GEOELECTROMAGNETIC INVERSION & RESEARCH**