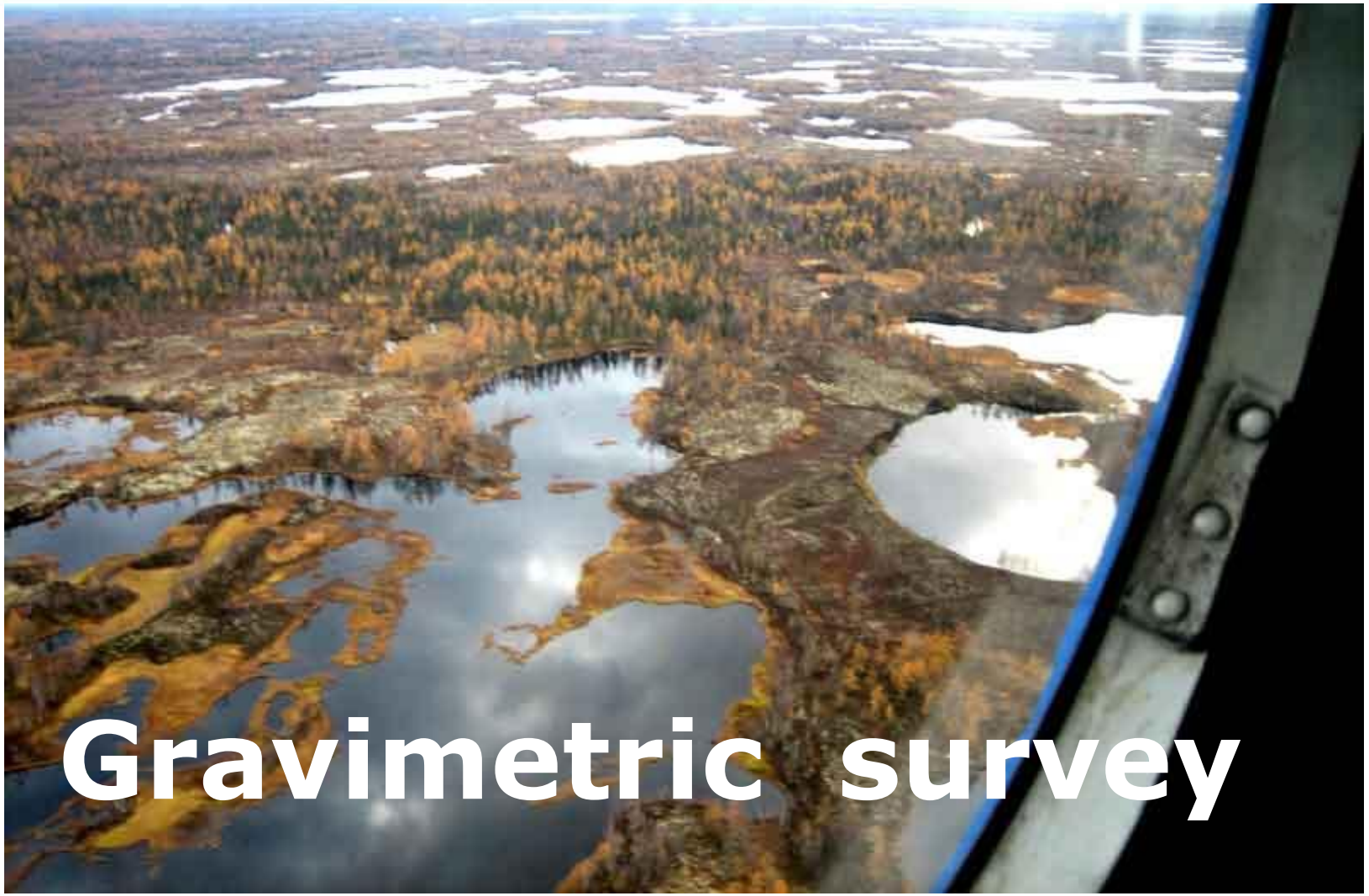
A.P. KARPINSKY RUSSIAN GEOLOGICAL RESEARCH INSTITUTE



Gravimetric survey

A.P. KARPINSKY RUSSIAN GEOLOGICAL RESEARCH INSTITUTE

Major activities of geophysic survey service of the institute:

- Creation of governmental geologic-geophysical survey baselines network, super-deep and parametric wells network;
- Regional geologic-geophysical works;
- Gravimetric surveys;
- Supervising of governmental gravimetric works;
- Preparation for the publication of state gravimetric maps.

Gravity group

Can perform the entire cycle of gravimetry operations:

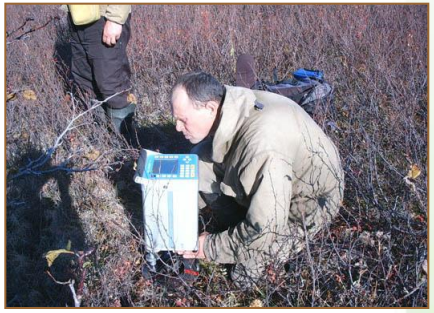
- designing of operations;
- organizational provision of field studies;
- high-precision gravity survey;
- horizontal-vertical positioning of geophysical measurements;
- interpretation of geophysical data;
- integration of geological-geophysical information into GIS projects;
- compilation of gravity maps.

Application areas of the modern high-precision gravimetry:

- ***Regional surveys*** **- structural-tectonic zoning, search for oil basins;**
- ***Exploration for hard mineral deposits*** **–**
  - gravity exploration is used at all stages including supplementary exploration for deposits (in combination with other geophysical methods);
- ***Oil geology*** **- gravity exploration is used at all stages including direct search for oil and gas fields;**
- ***Engineering geology*** **– detection of karst cavities and voids, disintegration and unconsolidation zones;**
- ***Search for placers*** **– used for detection, delineation and tracing of buried stream channels and valleys.**

Gravity group

Is equipped with the state-of-the-art gravimetry and satellite instrumentation of geodetic class, all-terrain vehicles and snowmobiles, field equip-ment as well as it has qualified specialists with a big experience of field and laboratory operations.



Gravimetrical equipment

Automated gravity meters
AUTOGRAV CG-5 «Scintrex»

These instruments are today the highest accuracy ones in the class of gravity meters measuring gravity increments between observation stations.

The main technical parameters of CG-5 gravity meters are as follows:

- **resolution: 0.001 mGal;**
- **error: 0.005 mGal;**
- **measurement range: about 8000 mGal;**
- **temperature compensation (thermostating);**
- **low residual drift of the instrument;**
- **data accumulation and averaging with a resolution of 1 measurement per second;**
- **filtering of "spikes";**
- **continuous correction of inclination;**
- **corrections for tidal gravity variations;**
- **memory up to 12 MBytes.**

Satellite geodetic equipment

Trimble R7 GNSS , Javad Legacy-E

- **Measurement accuracy – a few cm.**
  Satellite measurements are made in differential mode at a distance away from the base station up to 25 km.
- **GPS data are processed in "post-processing" mode.**
- **Thanks to the described GPS instrumentation, forest cutting-down is excluded and the traditional methods of horizontal-vertical positioning are not practically used.**

Computer engineering and software

- **Field laboratory processing is performed daily on portable computers (NB) in field camps.**
- **Differential satellite observations are processed using a specialized program Trimble Business Center.**
- **For processing and interpretation of gravity and other geophysical data the "Oasis Montaj" ("Geosoft") software package is used.**
- **The models of geological-geophysical sections are constructed using the "GM-SYS" program being part of "Oasis Montaj".**

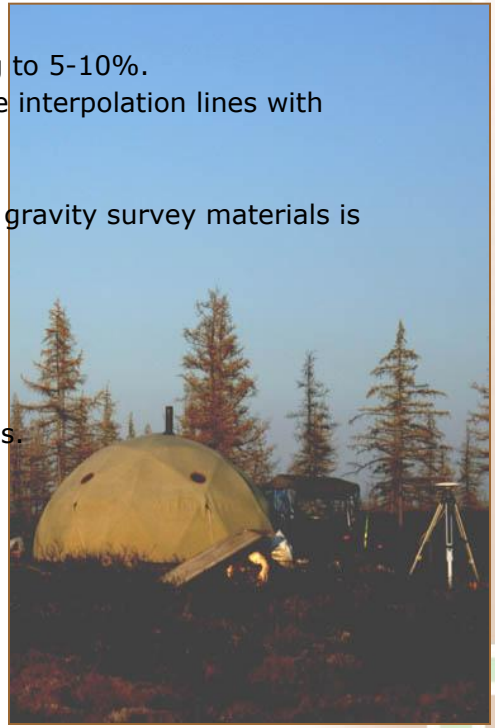
PROCEDURE AND TECHNIQUE OF FIELD OPERATIONS

Gravity survey

Gravity measurements are made in compliance with the technical and methodical instructions. The basic guiding methodical document is «Instructions for gravity exploration», M., 1980.

A gravity survey is conducted according to the following scheme:

1. The field gravity traverse grid is to be created.
2. The field traverse grid is to be tied the State traverse grid.
3. Accuracy of determining the gravity at the traverse stations is 1.5-2 times higher than at the survey ones.
4. Observations at the traverse grid stations are, mainly, made according to a central or two-stage system.
5. Observations over the survey grid are, generally, made according to a single-stage procedure, based on traverse gravity stations.
6. Instrumental drift is taken into account for each track length.
7. To assess the survey quality, independent check measurements are made amounting to 5-10%.
8. To assess the quality of the gravity map construction, measurements are made in the interpolation lines with an interval twice smaller than that for survey lines.



As the materials of field measurements become available, the current processing of the gravity survey materials is performed (every day). In includes:

- calculation of the observed gravity values;
- account for the normal field;
- introduction of corrections for height and attraction of the Bouguer plate;
- calculation of gravity anomalies (Bouguer)

In-office processing of the materials is performed after the completion of field operations.

It includes:

- calculation of topographic corrections;
- calculation of gravity anomalies with different densities of the Bouguer plate;
- compiling of the catalog of traverse and survey stations;
- construction of final maps and diagrams of gravity anomalies;
- execution of different transformations and geological interpretation;
- preparation of the report.

Topogeodetic operations

Topogeodetic operations are carried out with the view of horizontal-vertical positioning for gravity observation stations. They are performed in the State system of elevation coordinates. The technical guides for operations are:

- instruction for topographic-geodetic and navigation provision of geological exploration, 1997;
- instruction for gravity exploration, 1980.

Elevations and coordinates are determined using sets of two-frequency GPS-instrumentation Trimble R7 in differential kinematic mode with post-processing. The base stations are located at the field base of the party and within the survey area.

The current processing of field materials is made every day at the field base. It includes:

1) Check of the quality of field measurements after the transfer of data from the field equipment to the computer.
2) Input of differential corrections.
3) Transmission of non adjusted coordinates and elevations from the base stations to the field observation ones.
4) Assessment of the quality of obtained vectors and the misclosure of closed polygons.

In-office processing of the materials is performed after the completion of field operations. It includes:

1) Tie of the base stations with the stations of the State geodetic network and with each other.
2) Tie of the field gravity observation grid with the base stations and the triangulation ones.
3) Assessment of the survey quality from the results of control measurements.
4) Compiling of the catalog of coordinates and elevations of observation stations.

Metrological provision of operations

Gravimetry instrumentation

- Every year, before starting the surveys, the gravity meters should be subject to a metrological calibration at the gravimetry test site № 5 in Saint Petersburg.
- The accuracy of field measurements is ensured by compliance with the instructions and recommendations for execution of field operations.

GPS-instrumentation for horizontal-vertical positioning

- The GPS-receivers Trimble R7 to be used should be verified at CJSC NPP «Navgeokom» (Moscow) and accepted for the use as working measuring means.

Staff of Gravity group

Valery V. Koshevoy – leading specialist, chief of the gravity group.

Graduated from Saint Petersburg Mining Institute in 1988, speciality – "geophysical exploration prospecting survey method radioactive and rare elements deposits".

Length of service in geophysics – 21 years (16 years in gravimetry).

Field works organisation, field measurements, office processing in program Oasis Montaj, sattelite surveys processing (Trimble Business Center, Pinnacle), methodical and technological maintenance

of field gravimetric and and topo-geodetic measurements. Processing and interpreation

of gravimetric data (Coscad-3D, Oasis Montaj programs).

Nikolay I. Berezyuk – leading geologist. Graduated from Sverdlovsk Mining Institute in 1987.

Length of service in geology – 22 years (6 years in gravimetry).

Field measurements, maintenance engineering support, GIS software: ArcGIS, MapInfo, GlobalMapper, Integration of the geologo-geophysical information in GIS projects, GIS projects management.

Evgeny A. Kovalenko. - Engineer-geophysicist.

Graduated from Saint Petersburg Mining Institute in 2006, speciality – "geophysical method of mineral deposit exploration". Length of service in geophysics – 3 years.

Field measurements, computer technical support, network administration, geophysics data office processing (MapInfo program).

Staff of Gravity group

Tatyana V. Kuznetsova – leading engineer.

Graduated from Saint Petersburg State University of Design Engineering in 1994, speciality – computer engineer. Length of service in gravimetry – 6 years.

Field measurements, satellite observations processing (Trimble Business Center, Pinnacle, Geomatic Office programs), geophysics data office processing (MapInfo program), computer design, materials computer drawing-up.

Oleg Yu. Medvedev – Leading specialist-geophysicist.

Graduated from Saint Petersburg Mining Institute in 1988, speciality - "geophysical exploration prospecting survey method radioactive and rare elements deposits" . Length of service in geophysics – 8 years (4 years in gravimetry).

Field work organisation, field measurements, methodical and technological maintenance of field gravimetric and topo-geodetic measurements. Geologic-geophysical profile modeling in program "GM-SYS" (part of Oasis Montaj).

Galina Yu. Pylaeva – Engineer-geophysicist.

Graduated from Saint Petersburg State University (Geological Faculty) in 1989, speciality – "orebody geophysics". Length of service in geophysics – 11 years. (2 years in gravimetry).

Field measurements, satellite observations processing (Trimble Business Center, Pinnacle, Geomatic Office programs), gravimetric data field preprocessing ("Oasis Montaj" program), materials computer drawing-up. Processing and interpreation of gravimetric data (Oasis Montaj programs).

Specialists (geologysts and geophysics) with vasr field work experience may be involved if case of need.

The following work was performed by the gravity party

- *over Taimyr Peninsula:*

- Cape Chelyuskin (Scale 1:200 000, S=14 000 km^2) – preparation of a geophysical basis for generation of the State geological map on a 1:200 000 scale;
- Barkovskaya area (Scale 1:200 000, S=5 500 km^2) – compilation of the State gravity map on a 1:200 000 scale, prospecting for gold, silver, copper, platinoids;
- Gulinskaya area (Scale 1:50 000, S=2 000 km^2) – prospecting for gold and platinoids;
- Nordvik Peninsula (Scale 1:50 000, S=60 km^2) – prospecting for oil;

- *in the Tyumen region*

(Scale 1:50 000, S=300 km^2) – prospecting for oil;

- *over the Volga River*

(Scale 1:50 000, 100 lineare km) – prospecting for oil;

- *in the Komi Republic*

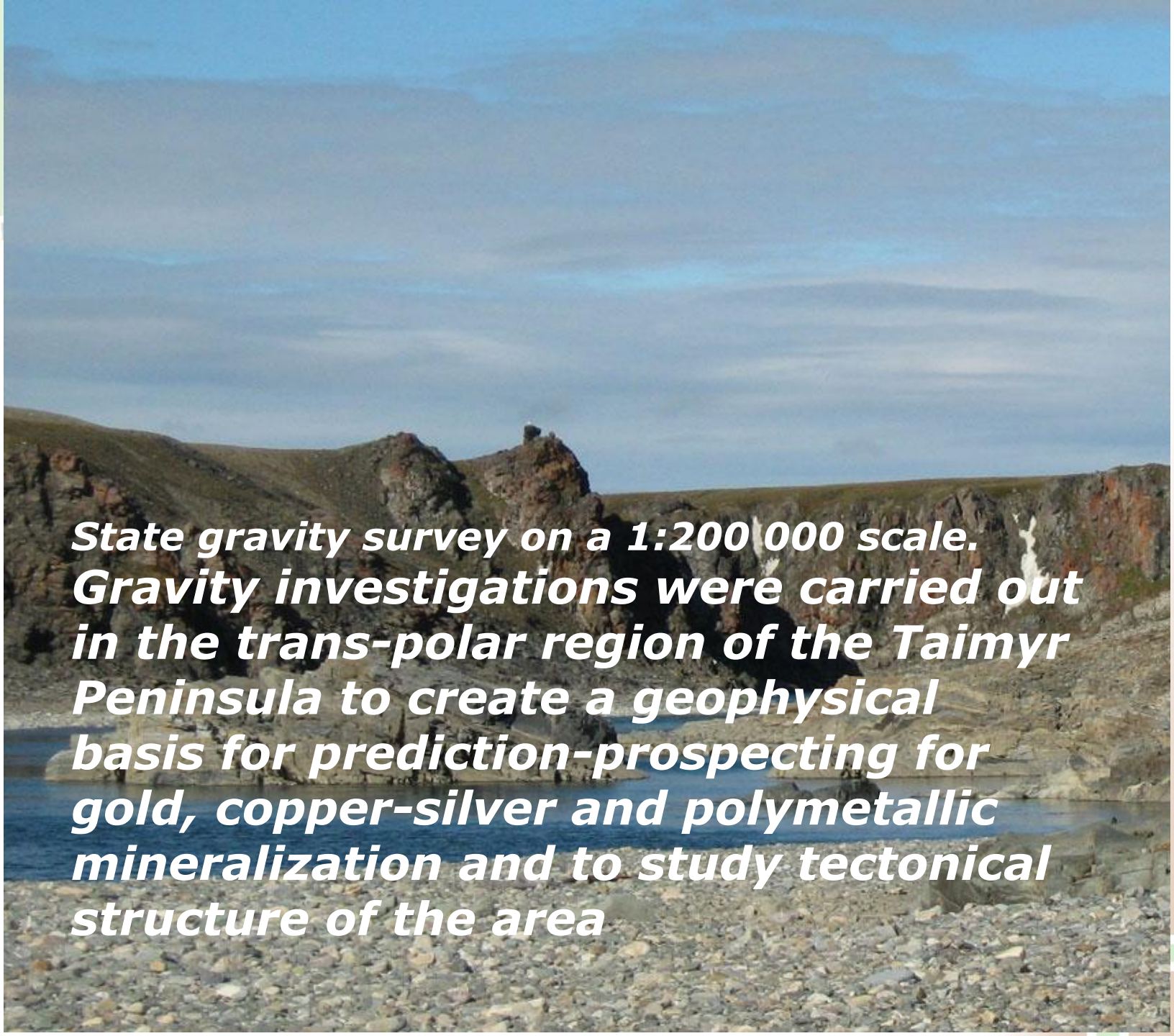
(Scale 1:50 000, 100 lineare km) – prospecting for oil;

- *the northern Turukhansky region* of the Krasnoyarsk Territory

(Scale 1:50 000, S=1 600 km^2) – structural-tectonic zoning, prospecting for copper-nickel ores.

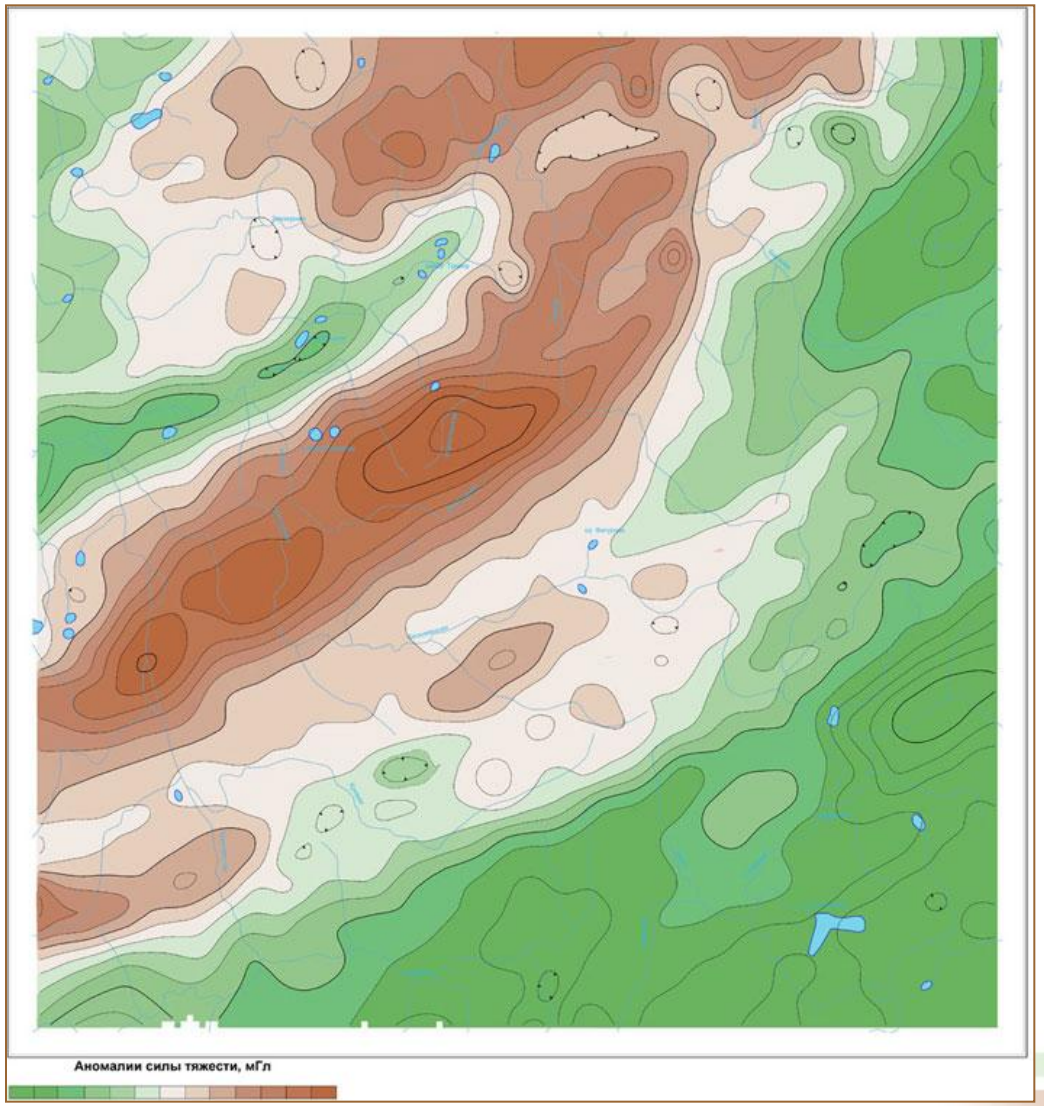
- *In the Mongolia* - (Scale 1 : 50 000, 606 lineare km) — prospecting for petroliferous basins


Examples of solving structural-mapping and geological prospecting problems from the results of interpretation of gravity survey materials



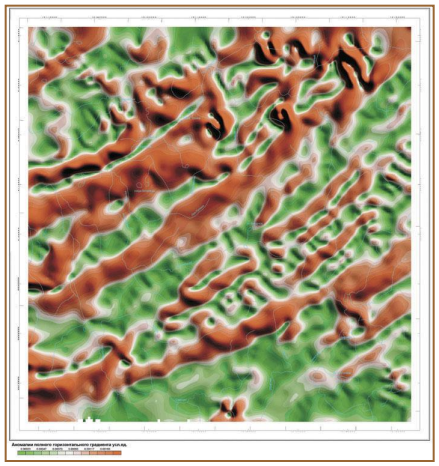
State gravity survey on a 1:200 000 scale.
Gravity investigations were carried out in the trans-polar region of the Taimyr Peninsula to create a geophysical basis for prediction-prospecting for gold, copper-silver and polymetallic mineralization and to study tectonical structure of the area

The gravity field on the map reflects the main structural elements of the Taimyr fold-thrust system of the NE strike

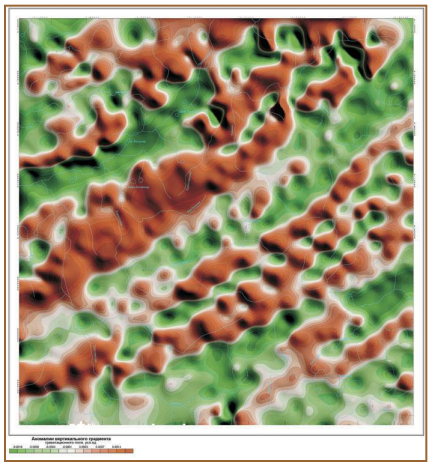


Map showing Bouguer gravity anomalies

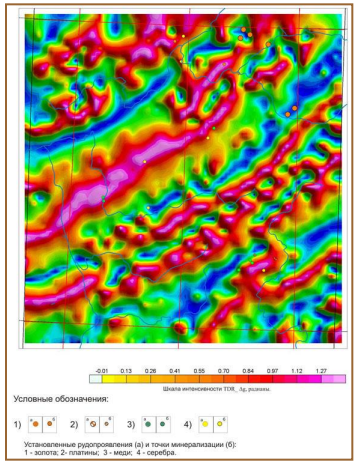
For solving structural-tectonic and prediction-prospecting problems the following different transforms of potential fields were used:



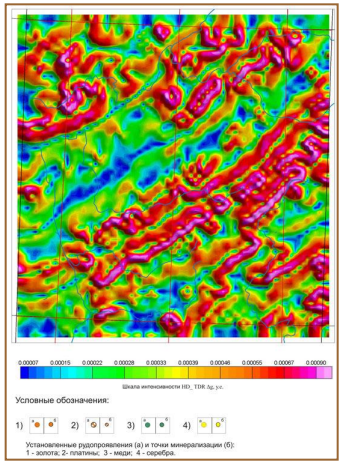
Map showing the full horizontal gradient of the gravity field



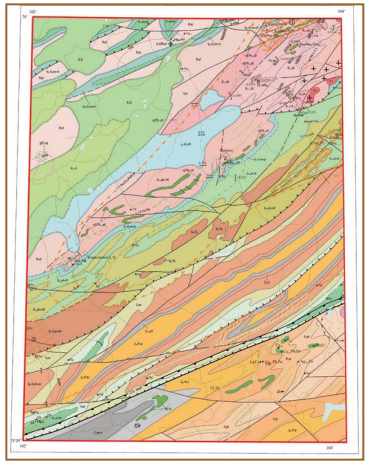
Map showing the vertical gradient of the gravity field



Map showing the transform of the gravity field TDR_ Dg= arctg(VDR/THDR)

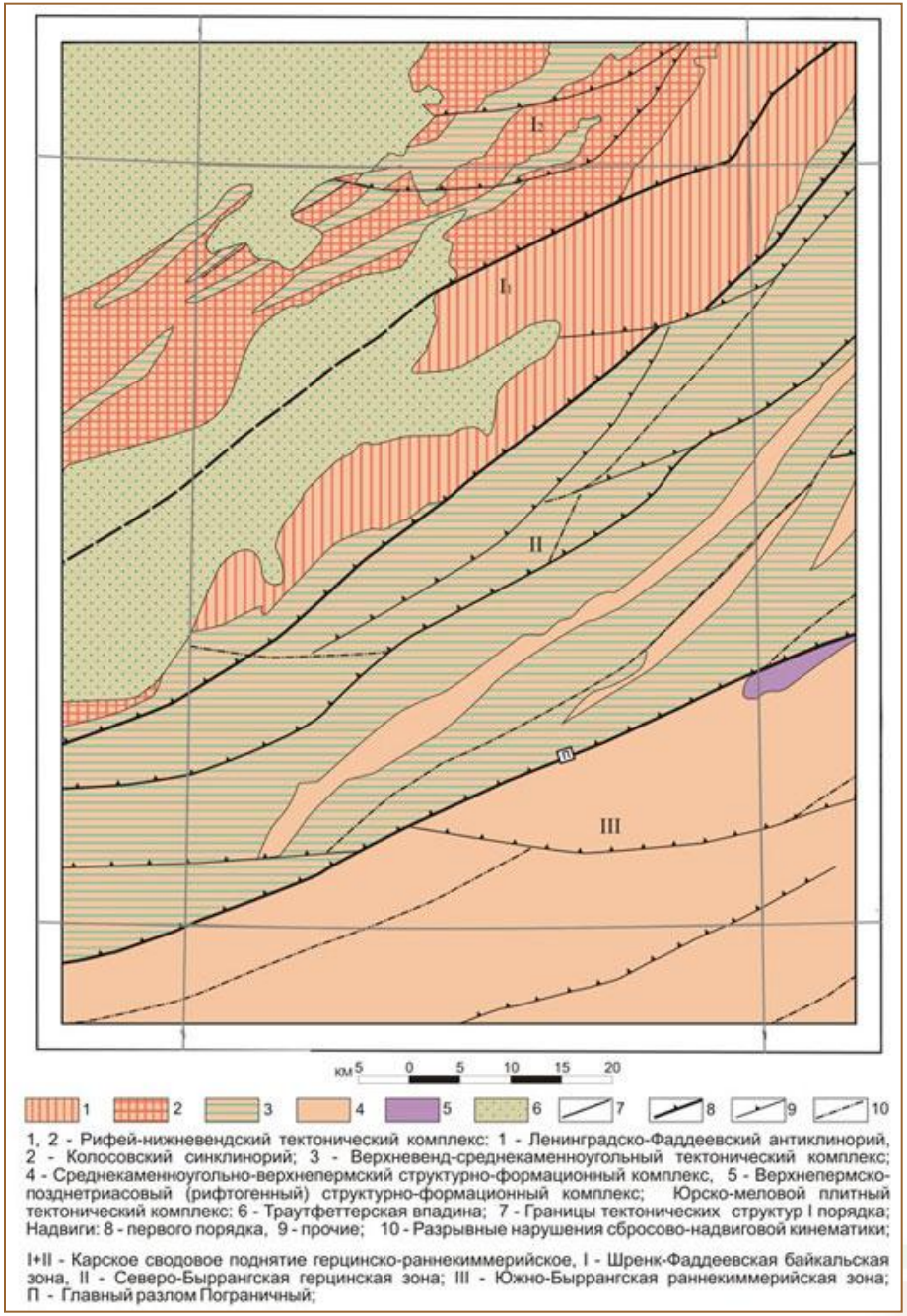


Map showing the transform of the gravity field HD_TDR□ Dg=√ ((dTDR/dx)²+(dTDR/dy)²)



Geological scheme

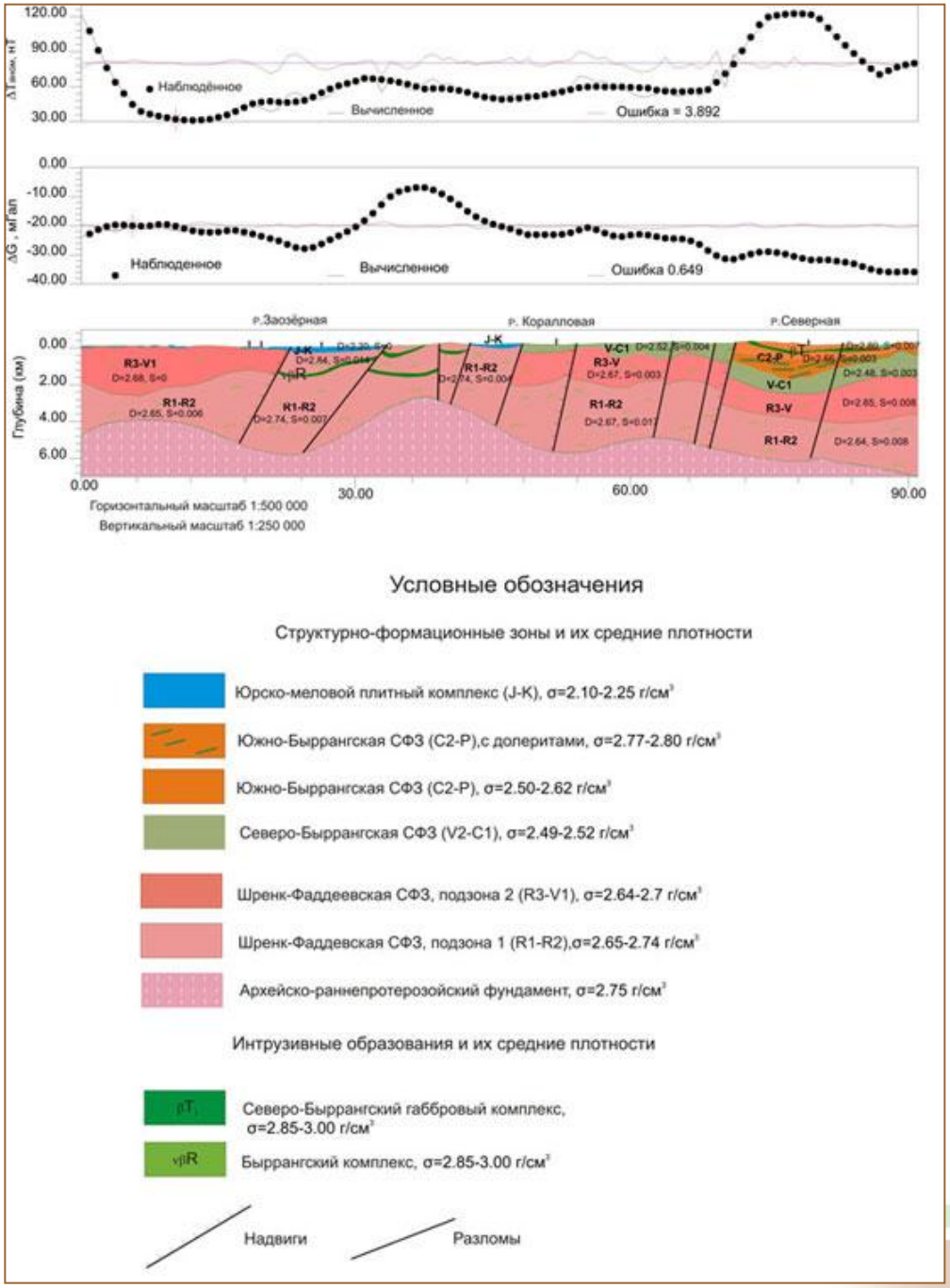
The scheme shows the main tectonic dislocations and geoblocks, contrastingly reflected in the gravity field

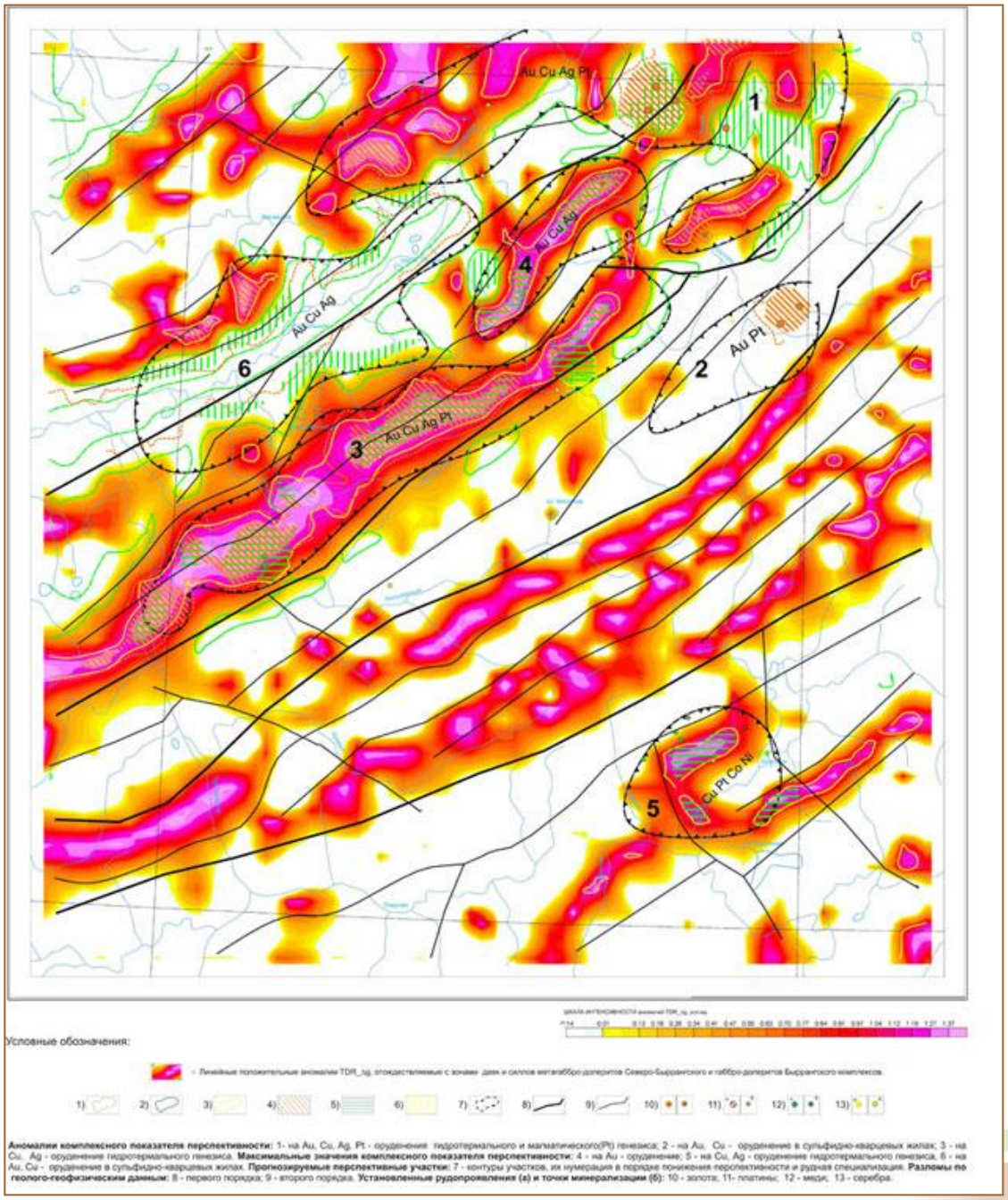


Structural-tectonic scheme

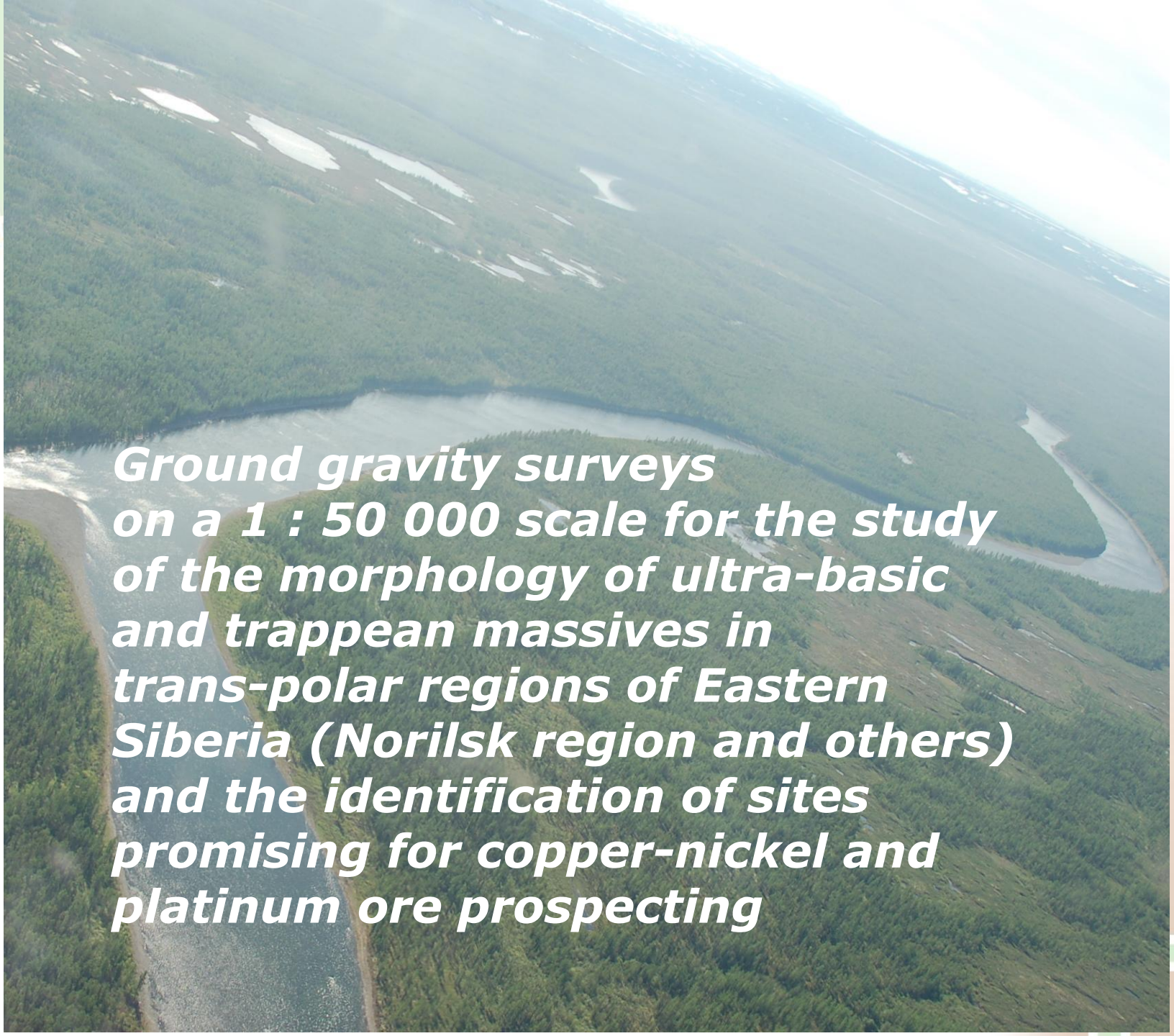
The section shows a modelled relief of the roof of Pre-Riphean crystalline basement and the boundaries of the main structural-formation complexes

Geological-geophysical section



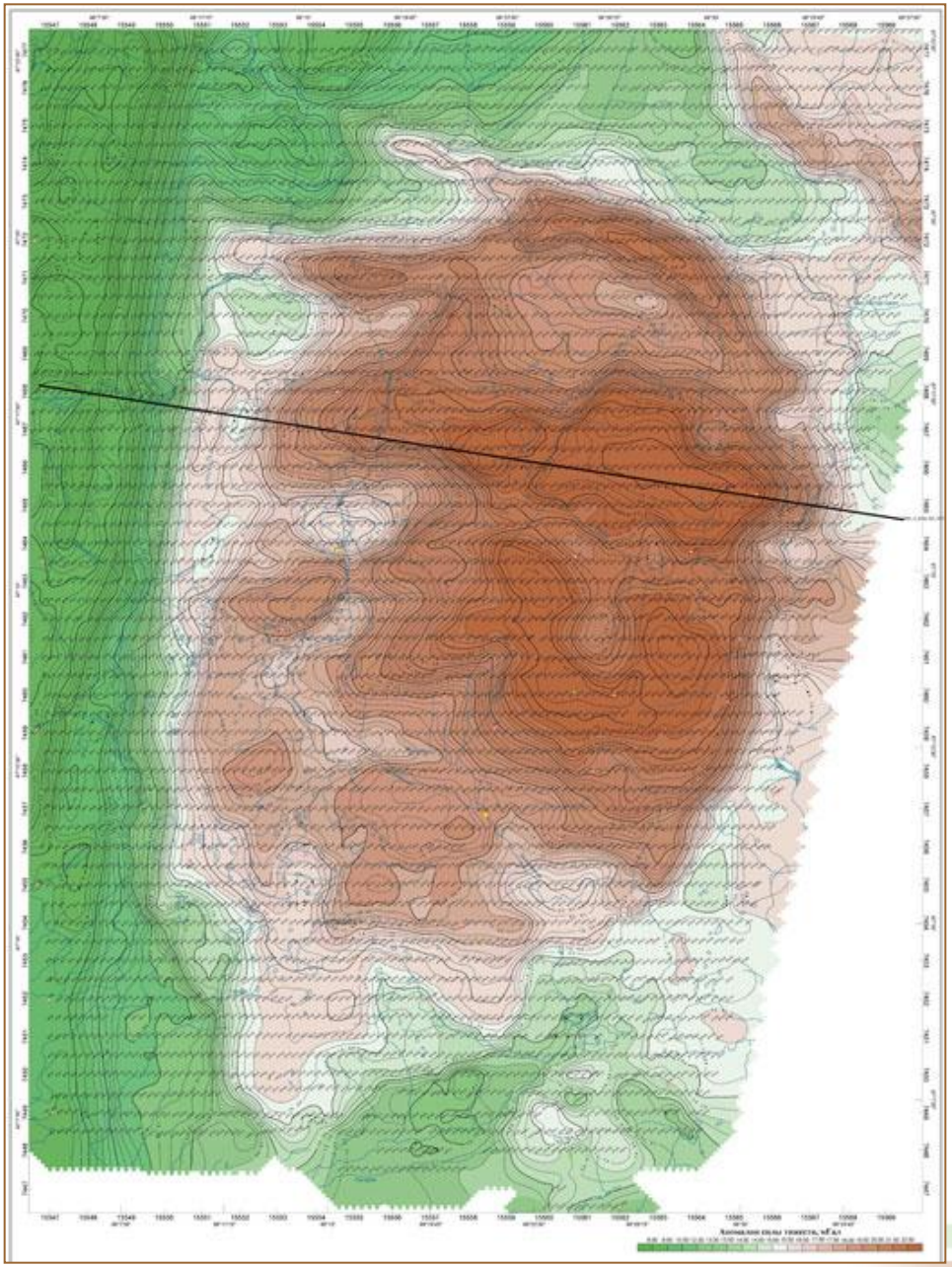


Sketch showing the sites promising for the detection of gold, copper-silver and polymetallic mineralization



Ground gravity surveys on a 1 : 50 000 scale for the study of the morphology of ultra-basic and trappean massives in trans-polar regions of Eastern Siberia (Norilsk region and others) and the identification of sites promising for copper-nickel and platinum ore prospecting

The gravity anomaly map reflects the total gravity effect from the block uplift of the crystalline basement and the massif of differentiated intrusions of trappean formation

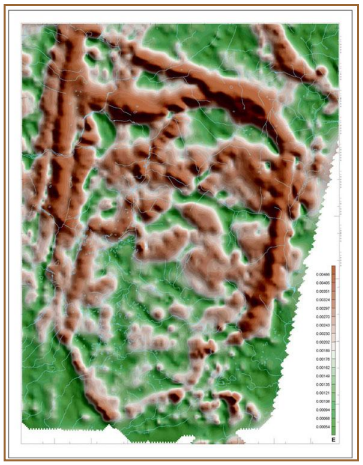


Map showing Bouguer gravity anomalies

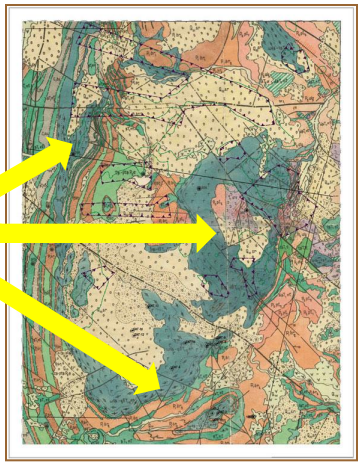
For solving structural-tectonic and prediction-prospecting problems practically the entire set of transforms of potential fields was used:

Map showing the full horizontal gradient of the gravity field

Map showing the vertical gradient of the gravity field

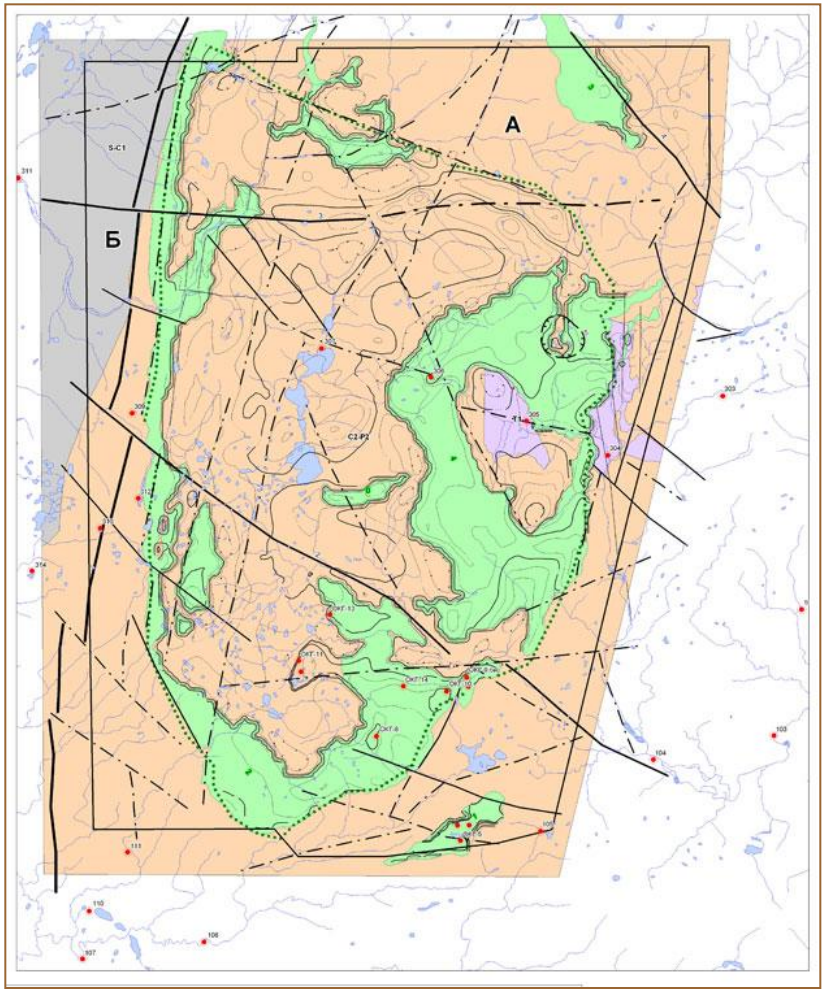


Map showing the full gradient of the gravity field



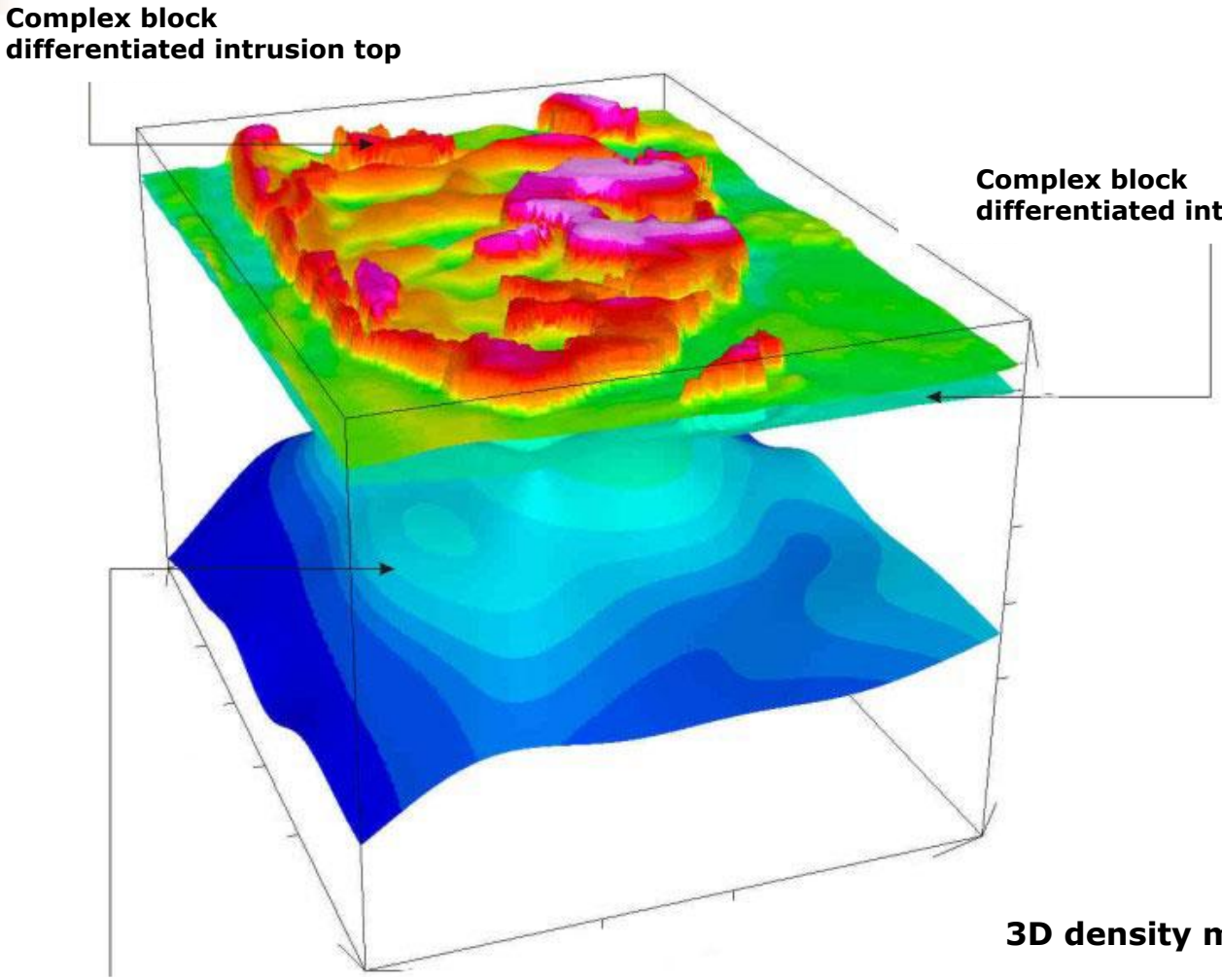
Geological map

The scheme shows the main elements of the geological structure of the study area, reflected in the gravity field: tectonic dislocations of different kinds and the thickest bodies of differentiated intrusions of basic composition



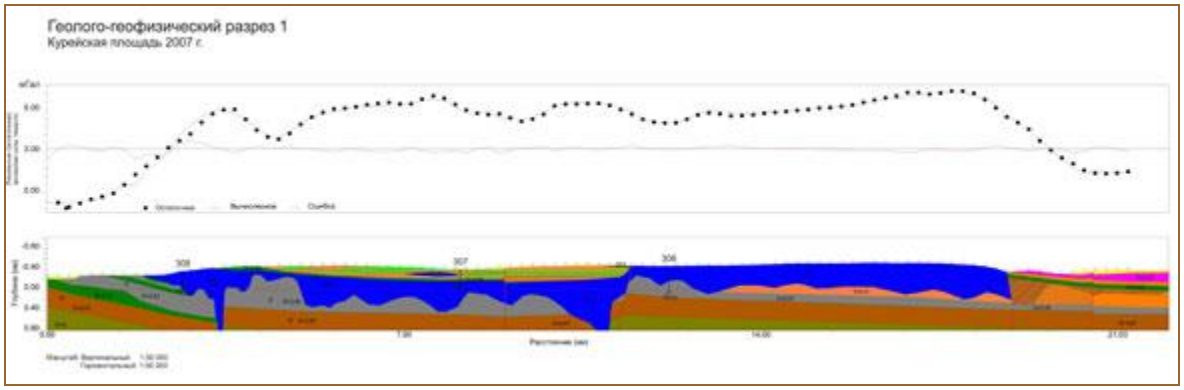
Structural-tectonic scheme

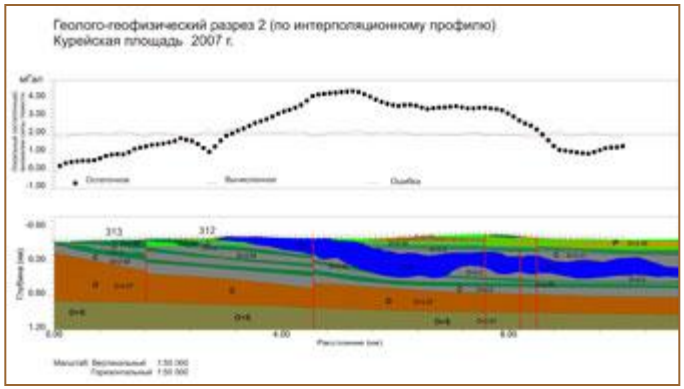
The 3D model reflects the main gravitating geological targets: an uplifted block of the crystalline basement with the supposed hyperbasite intrusion in the roof and outcropping bodies of differentiated intrusions of trappean formation

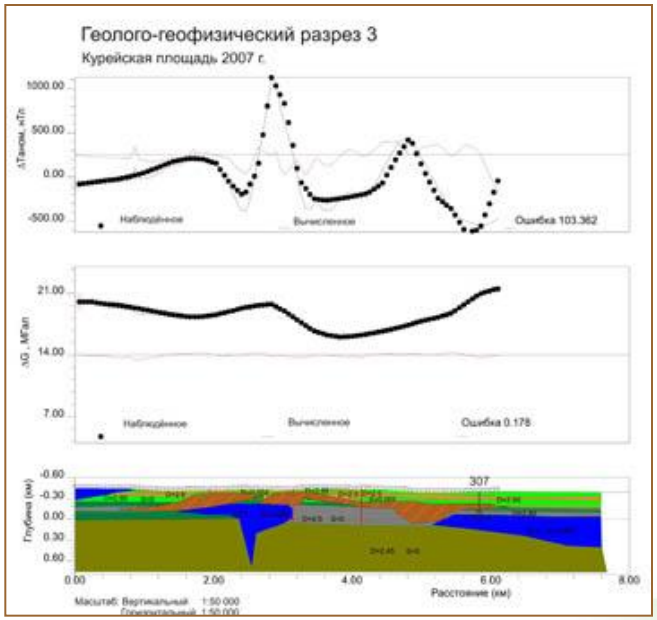


3D density model

The sections show the shape and occurrence of potential ore-bearing intrusive bodies, modelled from the gravity field

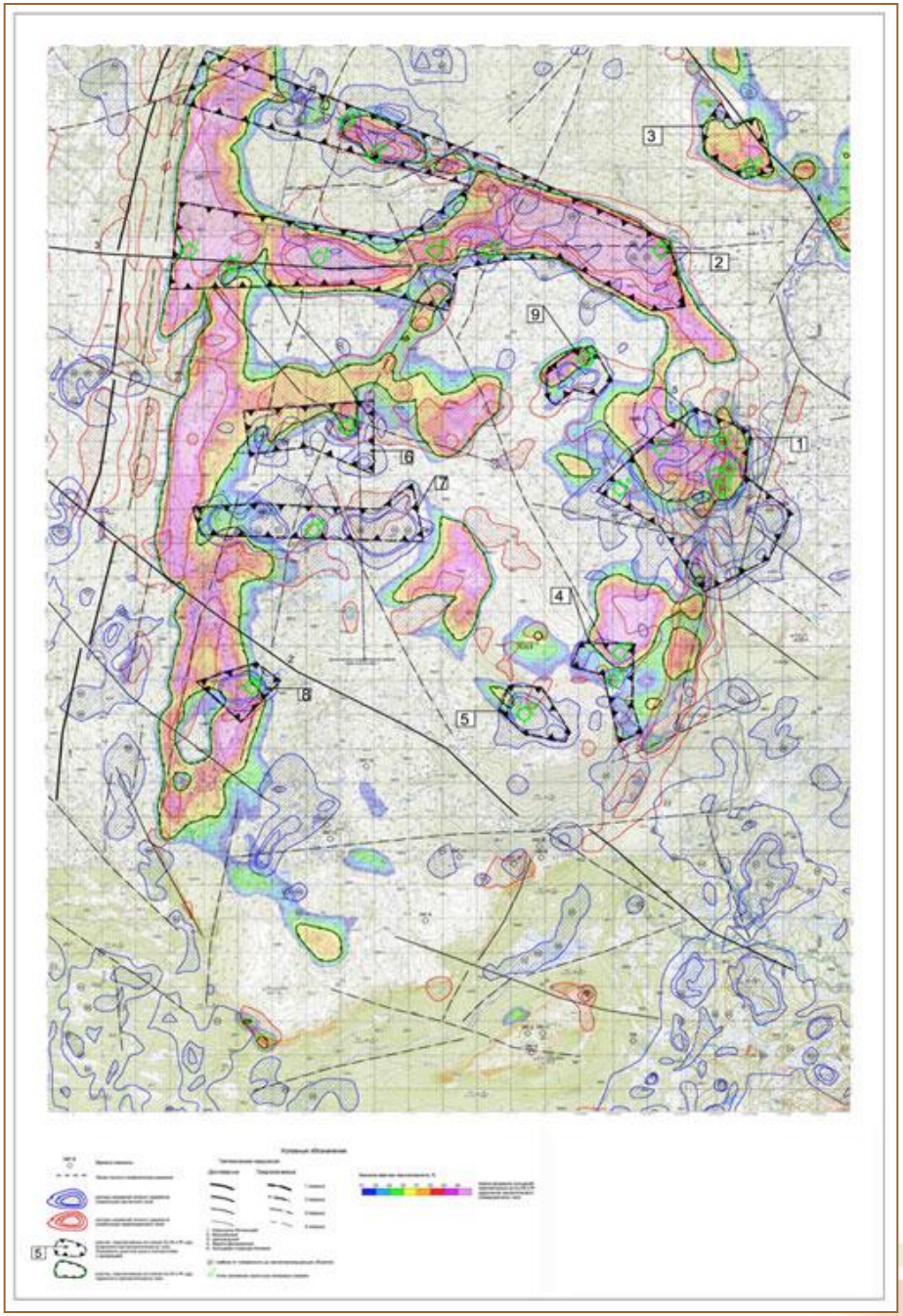




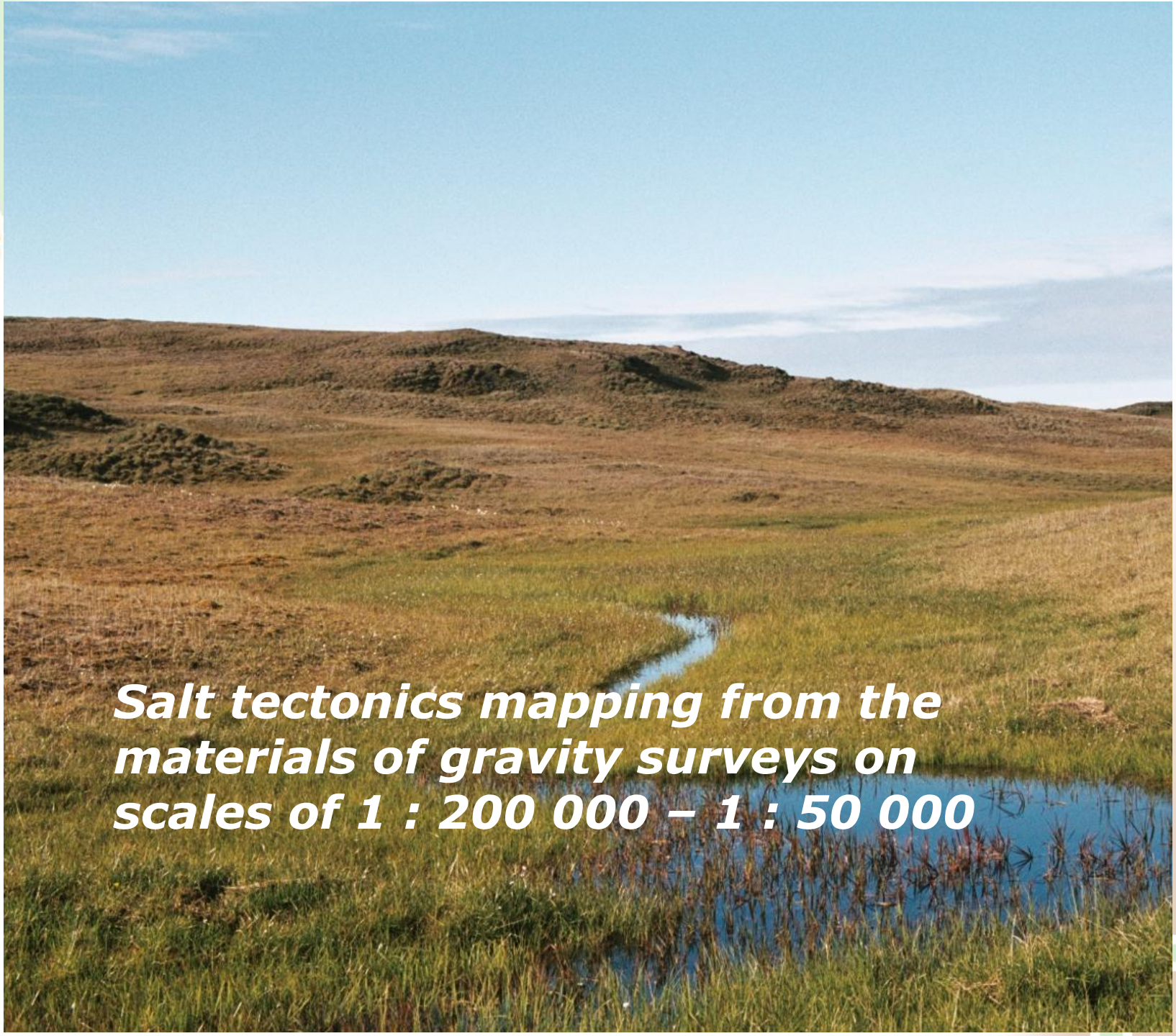


Geological-geophysical sections

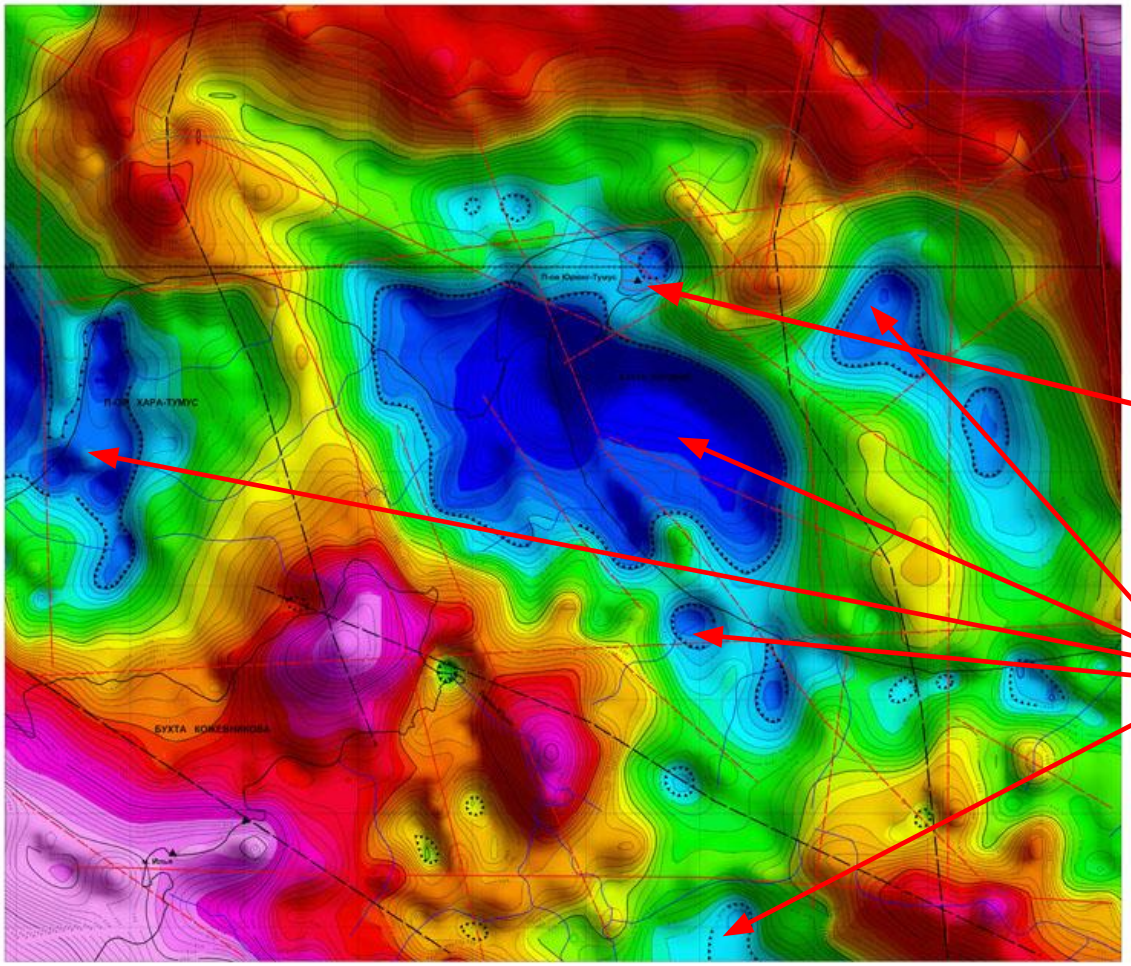
The sketch shows the sites delineated for exploration drilling from the results of integrated geological-geophysical interpretation. For Cu-Ni-Pt ores



Sketch showing the promising sites


Salt tectonics mapping from the materials of gravity surveys on scales of 1 : 200 000 – 1 : 50 000

Local isometric negative anomalies of excess density reflect salt dome structures (salt diapirs)

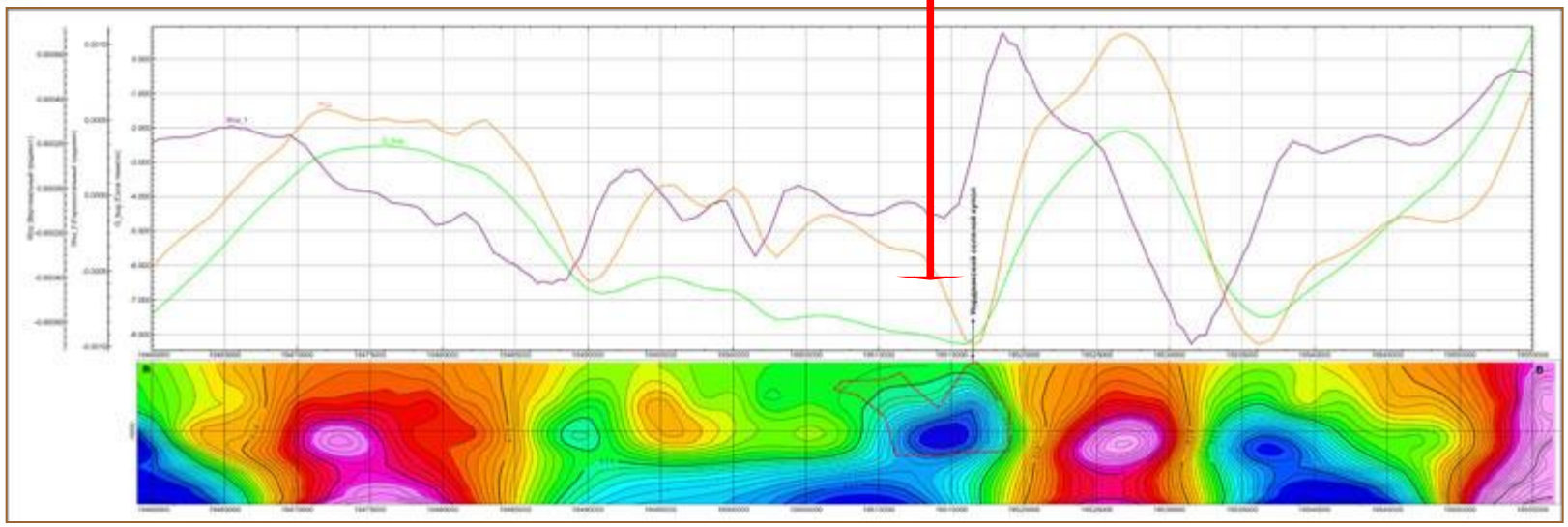


The salt dome on the flanks of which the oil pools were intersected

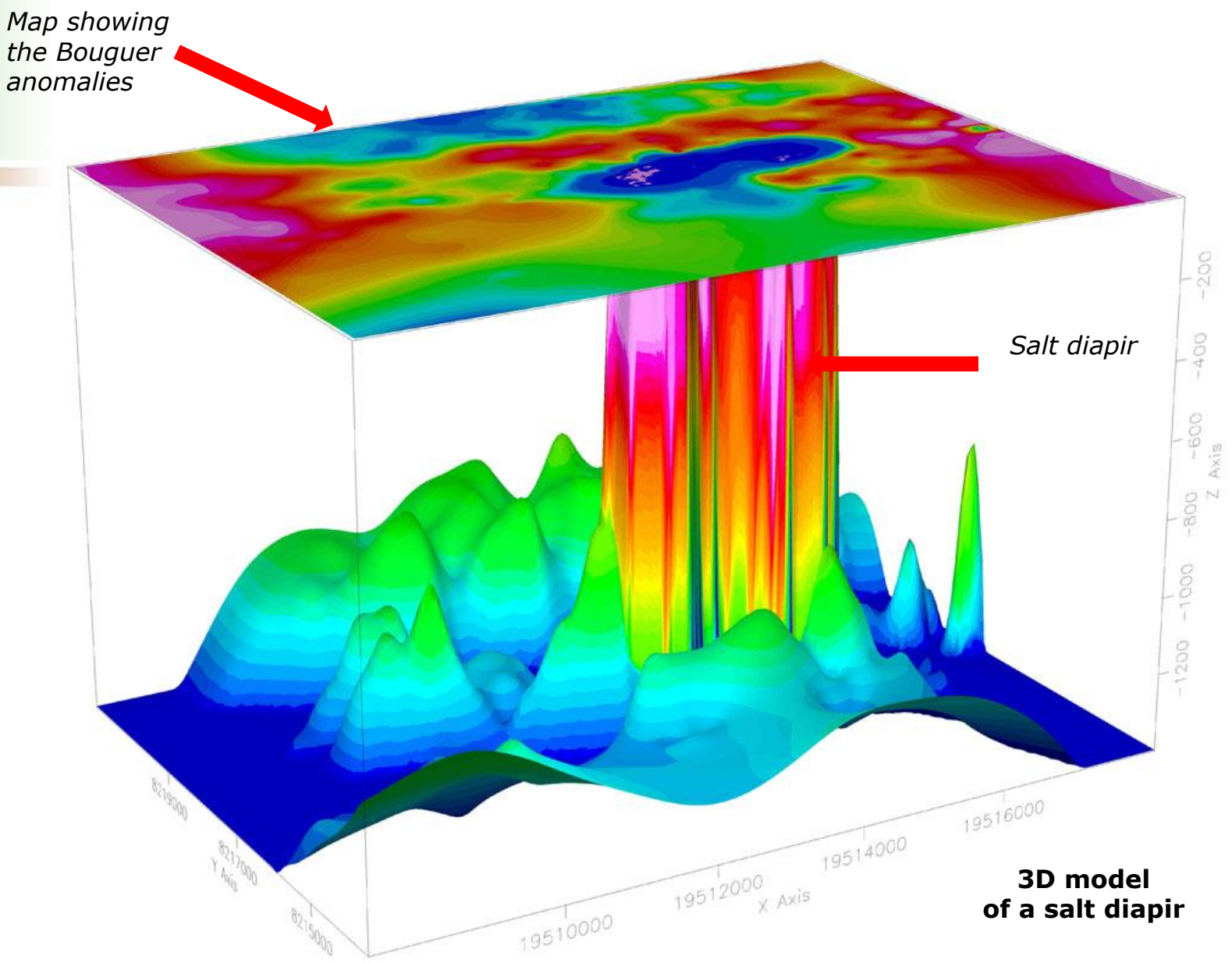
The hypothetical salt dome

Map showing the effective excess density

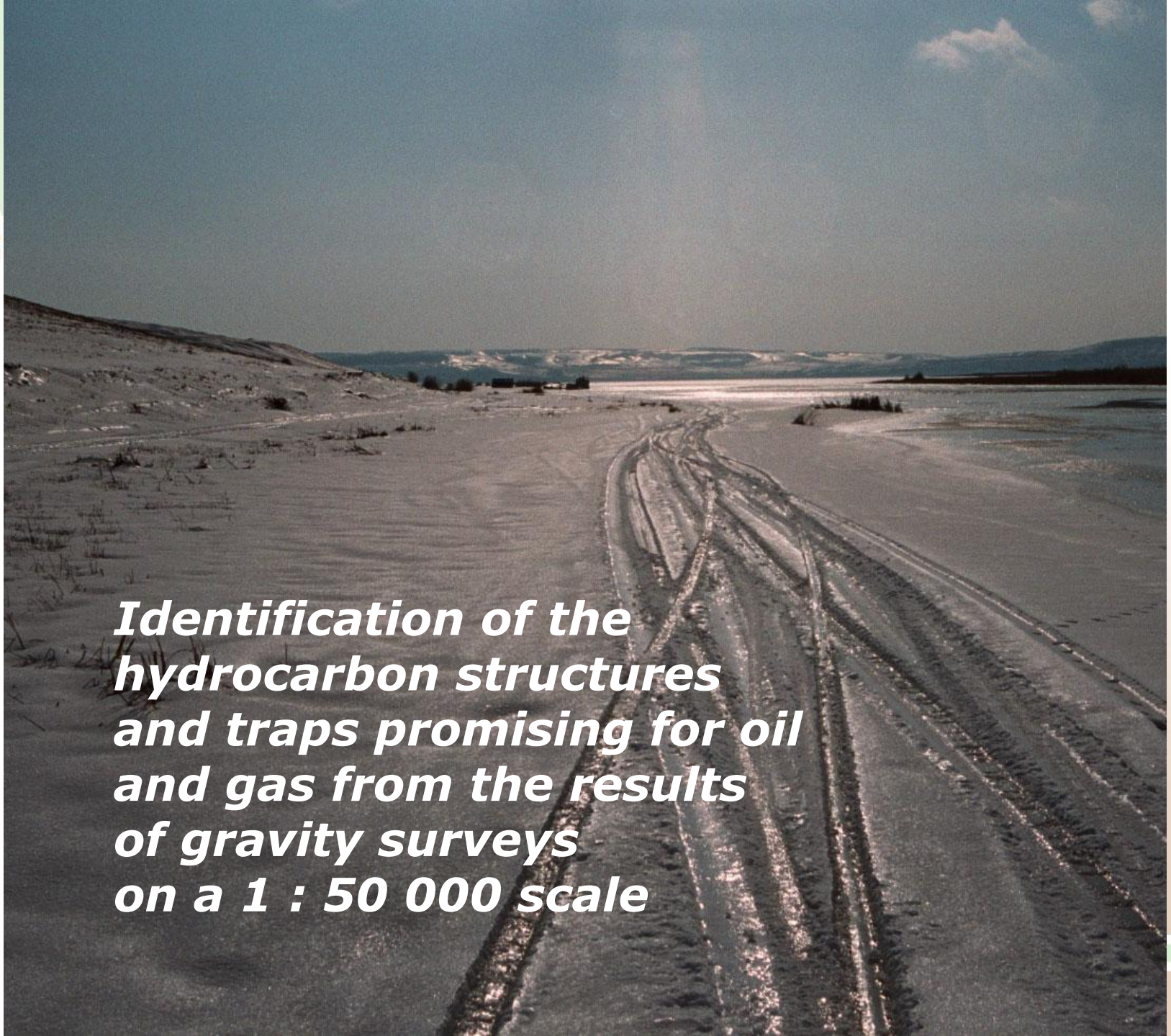
The salt dome on the flanks of which the oil pools were intersected



Section of the effective excess density



3D model of a salt diapir


Identification of the
hydrocarbon structures
and traps promising for oil
and gas from the results
of gravity surveys
on a 1 : 50 000 scale

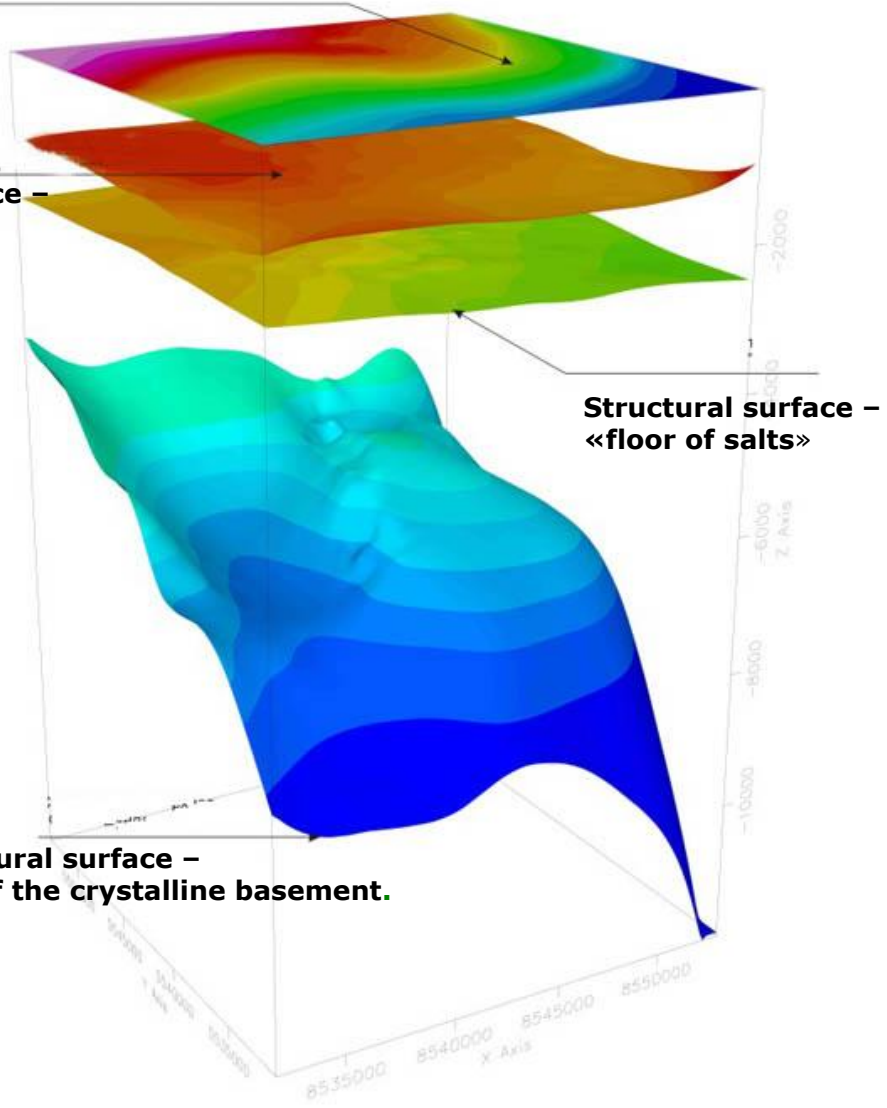
Gravity field anomalies at the sea level

Structural surface –
«roof of salts»

Structural surface –
«floor of salts»

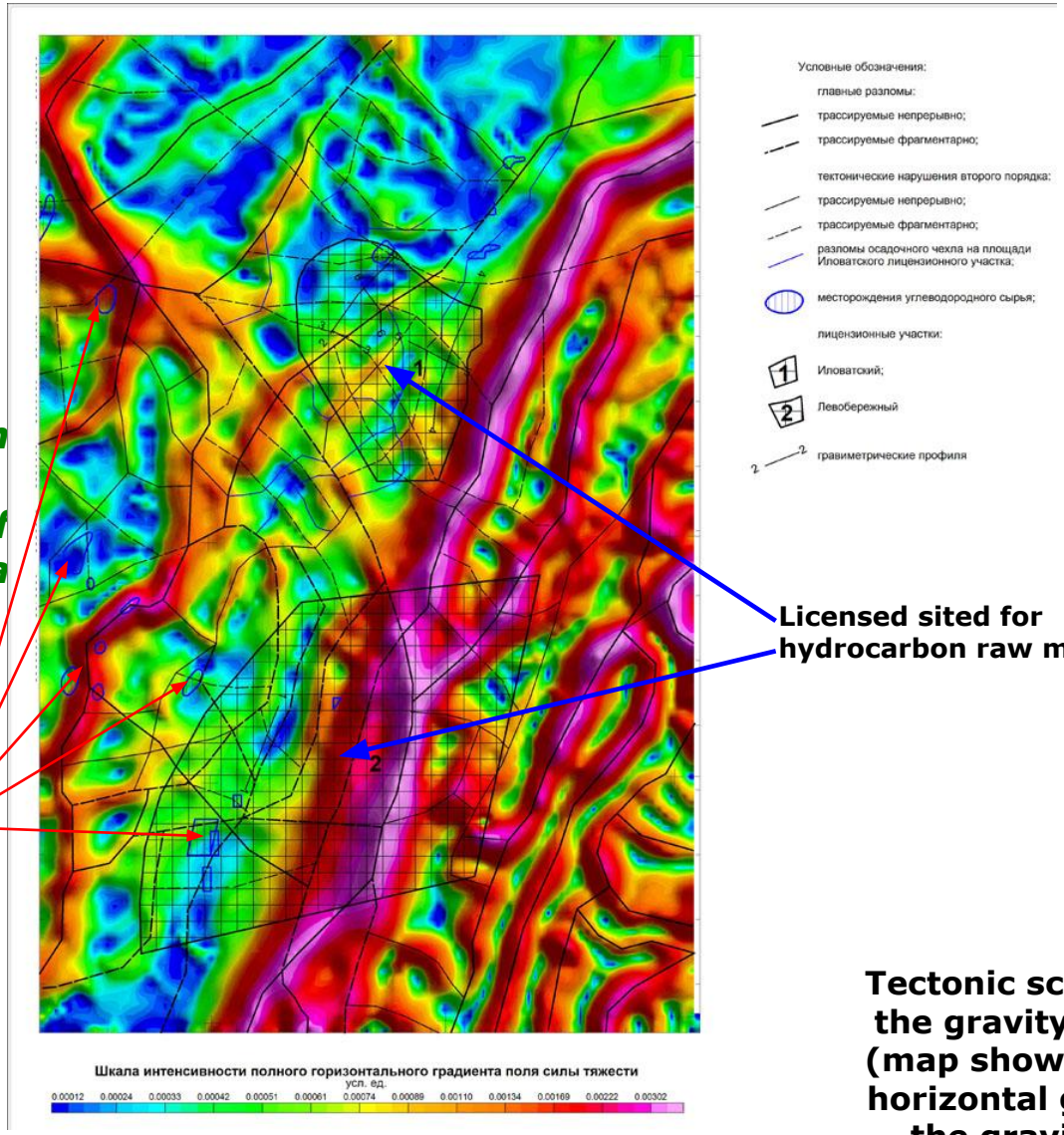
The 3D model shows the main gravitating structural surfaces, the total effect of which is exhibited in the gravity field anomalies

Structural surface –
roof of the crystalline basement.



Structural-density 3D model from gravity and seismic data

Structural-tectonic zones traced from the highs of the full horizontal gradient of the gravity field

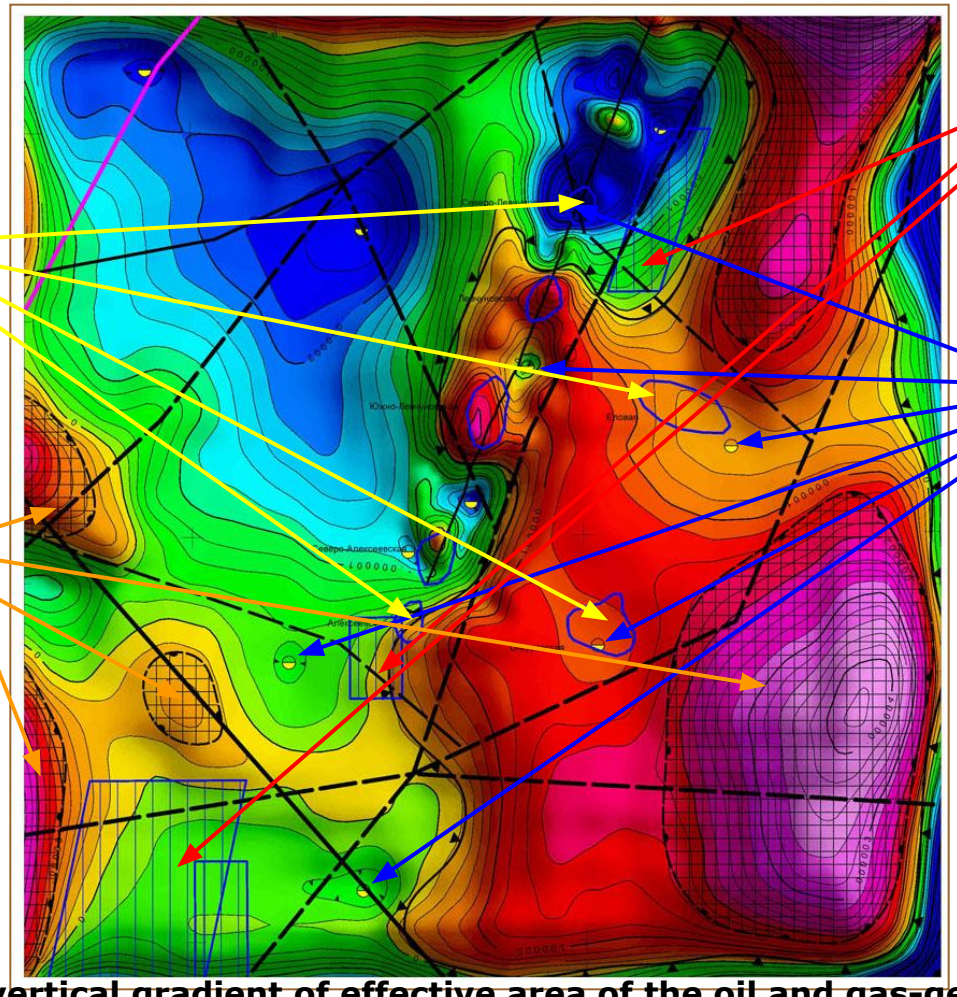


Known deposits of hydrocarbons

Licensed sited for hydrocarbon raw materials

Tectonic scheme from the gravity materials (map showing the full horizontal gradient of the gravity field)

Integrated interpretation of materials of seismic and gravity exploration investigations – detection of density heterogeneities in an oil and gas-generating block of rocks.



Deposits of hydrocarbons

Local structures (from seismic exploration)

Local lows of density, being of hydrocarbon prospecting interest

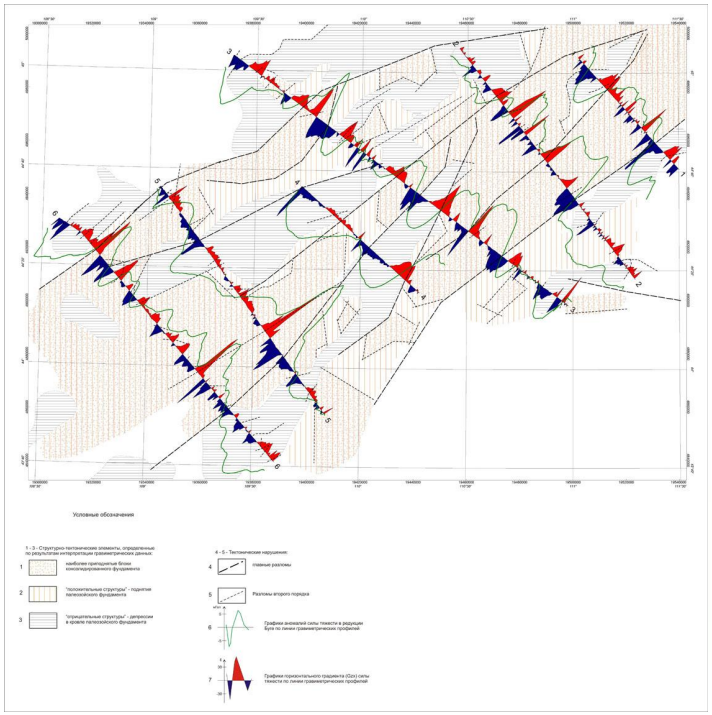
Potential oil and gas-bearing targets – carbonate cores of reef-genetic massives, identified from the gravity field.

Map showing the vertical gradient of effective area of the oil and gas-generating block of rocks enclosed between the reflecting horizons C_{1t} и $D_{3к}$

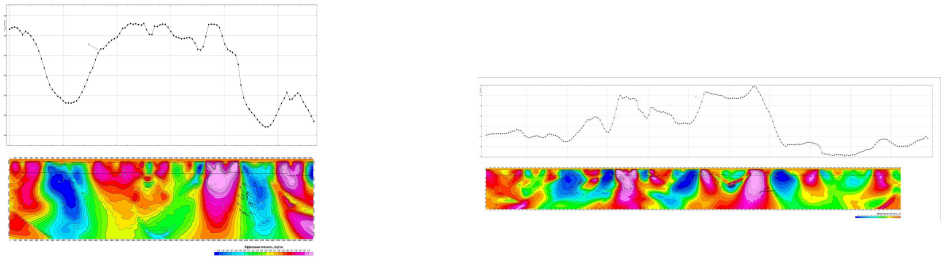

The efficiency estimation of gravimetric data use for identifying rift structure in Mongolia

The significance of completed work comprise identifying of Jurassic–Early Cretaceous rift structures boundaries, overlaid by later paraplatform complexes, identifying of sedimentary potentially petroliferous basins, delimitation of rift complex bottom – Paleozoic rocks top depth, rift boundaries faults, and main faults, making its structure complicated.

Schematic map, showing structural tectonic zoning



Density sections along gravimetric profile



Geological–geophysical sections along gravimetric profile