Introduction: For ease of understanding of Thermovision Tomography technology (TVT), we divided all the procedures into three stages (regional, zonal and local). Below are the examples of how the results of our works on every stage look like. As an example we took search for hydrocarbons, as well as some images of the search for solid minerals. We could not provide a detailed report of any commercial contract signed because of the confidentiality obligations. However, we hope that the submitted materials will help to get a complete understanding of advantages and benefits of the Thermovision Tomography technology.
1. Regional level of study.

Zoning of the earth's crust according to the conditions for Oil & Gas formation, as well as for solid minerals formation. Search for prospective zones.

Study scale – from 1:500 000 to 1:50 000.

1.1. Example of Search for Hydrocarbons

a) Scheme of formation of tectonic structures within required area is studied (faults, geoblocks, intrusive formations)

Regional studies (“Express”) are executed using thermovision images over a large area (hundreds of kilometers in length) and depth (dozens of kilometers) to explore the concept of formation of tectonic structures of the territory, and to detect a number of signs of large hydrocarbon deposits.

For example, in selected area (-s) we map out planned location for the TVT vertical profile (Fig. 1). We build mapped out TVT vertical profile with wide scale capture in length and depth (Fig. 2). After that complex of profiles with required frequency is built.
Blocks and faults of the crust and fractured zones are clearly visible on this profile, as well as the outputs of deep geothermal decompaction zones of the Earth's crust to the surface (blue), which is one of the clear signs of large Oil&Gas deposits. Identified favorable areas are studied further with a higher resolution and scale.

b) We determine whether there are signs of favorable structures involved in hydrocarbons formation in these areas

Numerous studies of different regions of the world revealed signs of conditions for hydrocarbons formation in sedimentary cover. These include:

- structure of regional and local thermal fields;
- planned changes in the intensity of cold local zones;
- features of formation of deep structures;
- characteristics of block-and-fault tectonics (with ranking of geodynamic active zones of fluid flows and fluid accumulation within feathering faults).

As thermodynamic criteria for identifying prospective areas these are taken:

- There are outputs of deep geothermal zones of earth’s crust decompaction in the places of large Oil&Gas deposits location. (Fig.2);
- Geological objects are located near ascending linear heat flows but outside geothermal hills, where the safety of traps is unlikely. (Figure 3);
- The presence of asymmetric “peaks” in models of thermal field within a range of potential oil and gas depth; the “peaks” violate the general plan of horizontally layered section and represent the structure of rock of sedimentary cover, in which local areas of cold zones are formed;
- Situation of oncoming direction of negative and positive vectors of thermal flows.
TVT express analysis is executed for horizontal section of productive layer, 1750 m depth. Shoe string Oil deposit is found and shown by the red contour in a) block-and-fault structure volumetric model and b) model of structure homogeneity.

- Sharp lateral deviation of heat flows from the vertical direction, associated with geological objects;
- The location of geological objects is outside the geothermal holes (blue) and negative linear flow (red) (Fig. 4).
- Abnormal spatial and temporal dynamics of normalized spectral parameters of vegetation and soil condition;
- Relatively higher hypsometric position of forecasted geological object.

On the basis of volume models, we judge about the condition of the geothermal hydrocarbon traps, define the quality of impermeable traps and fluid accumulation zones, determine the presence of faults through tracing of zones of deep water unloading and how it affects the safety of deposits.
c) We execute hydrocarbon prospectivity mapping, focusing on prospective areas with their analysis and explanation of prospectivity signs and not prospective areas.

Final results of “regional level of study”: forecast maps with mapping out prospective and not prospective areas and recommendations for further works.

Below are the examples of a consecutive series of maps that complete this step of TVT-analysis (Fig. 5)

Figure 5.

a) Geographic map with “Novospasskneft” company’s licensed block contour;

b) Terrain map;

c) Horizontal section of local thermal field, 1020 m depth.

Figure 6. Relative hydrocarbon prospectivity map of the licensed block.

Legend:
- Green objects – Prospective areas;
- Blue objects – Uncertain prospects;
- Red objects – not prospective areas.
Regional studies ("Express") are executed using thermovision images over a large area (hundreds of kilometers in length) and depth (dozens of kilometers). This method allows to explore a concept of formation of tectonic structures and to make an estimate on the regional level of mineralogical informativeness of TVT (Fig. 7 and 8).

For example, on the basis of a priori information of selected area(-s), location of the TVT vertical profile with a wide scale capture in length and depth is chosen and mapped out. After that, taking into account the received informativeness of the material from the first profile, complex of profiles with more detailed scale is formed (Fig. 8). Below are the examples from 2 different countries in West Africa.

**1.2. Example of search for solid minerals**

a) Scheme of formation of tectonic structures within required area is studied (faults, geoblocks, intrusive formations).

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**Figure 7a.** 2 thermovision vertical profiles are built through known gold occurrences within the studied territory. (Profile 2 and 4).

**Figure 7b.** TVT-analysis is done. Vertical profiles of block-and-fault structures are shown. Both profiles clearly show features of lithosphere formation of the area. Yellow-green tree-like zones are the outcrops of magmatic geological structures, containing polymetals (including Gold). Besides, blocks and faults, fracturing zones and outcrops of decompaaction zones of the earth’s crust are clearly seen (blue color).
Figure 8. Results of Thermovision Tomography of West-African region. Terrain map (a), horizontal section of thermal flow for 20km. depth (b), vertical profile of thermal field (c) and vertical profile of block-and-fault structure (d) with various resolution.

Figure 9. Model of intrusive formations (a) and deep thermal flow (b).

Figure 8 also shows blocks and faults, fracturing zones and outcrops of decompaction zones of the earth's crust (blue color). Identified favorable areas on this stage are studied further at higher resolution and scale.

b) Determine whether there are signs of favorable structures involved in, for example, diamond and gold formations.

Numerous studies of different regions of the world revealed signs of conditions for diamond and gold formation in the earth’s crust and sedimentary cover. These include:

- Structure of regional and local thermal fields;
- Planned changes in the intensity of thermal zones;
- Features of formation of deep structures;
- Characteristics of block-and-fault tectonics (with ranking of geodynamic active zones of feathering faults).
As thermodynamic criteria for identifying prospective areas these are taken:

- location of small intrusive formations;
- outputs of deep geothermal decompression zones of the Earth’s crust;
- location of geological objects near the ascending linear heat flows.

Converted images are built using the method of «principal component». Synthesis scheme of colors R, G and B corresponds to the standard well-known spectra indexes (Fig.10) and Landsat RGB image for the channels 1, 2 and 4 (Fig.11). Processing of digital field is carried out to improve the decoding and separation of classes of natural formations (minerals) in the multidimensional space of spectral features.

On the basis of volume models, we judge about the condition of the geological environment. TVT study together with interpretation of the material allows us to determine the most likely contours and depths of the natural ore formations for exploration.

Using the significant vertical and surface features, information map of ore field is built. This map can be taken as a main basis for further geophysical researches for preparation of the exploration program of an area.

After that, we present final results of a survey area research with elements of ranking of prospective, uncertain prospects and not prospective areas (as an example – Figure 6).
2. Zonal level of study.

- Scale of research - from 1:50 000 to 1:10 000;
- Study of volumetric models of the environment (ring structures and complex oil traps);
- Ability of early estimation of prospectivity of mineral exploration FOR INVESTORS (as an example – Figure 6 and Figure 12);
- Ability of complexation of TVT results with any geophysical methods at this stage (Figure 13);
- Determination of abnormal spatial and temporal dynamics of normalized spectral parameters of condition of vegetation and soils (Figure 14).

Quick survey of oil field with low prospectivity. Recommendations for investors on how to improve business.

Figure 12. Guinea bay, offshore. Picture on the right shows vertical TVT profile (block-and-fault structure). Red arrow shows existing low-production oil well F-5. Dense rock is shown by red color; fluid-saturated rock – blue color, and green color shows zones with good collector qualities. It’s seen that there is a perspective structure under the Oil trap, but the well was drilled on the edge of the structure. Relocation of this well 1.5 km left is recommended; therefore it will significantly improve its production and will decrease water content.

Figure 13. Cadiz bay, Spain. The Well was drilled in the cover of seismic structure (monochrome image on the top, seismic profile), but it has zero oil production. TVT-analysis is done for the same coordinates (bottom image, TVT profile, block-and-fault structure). Red color shows dense rock on the profile. Integration with TVT technology clearly demonstrates the reason of the problem – absence of reservoirs.

Complexation of TVT results with seismic study results.
Correlation between the “Stress Of Vegetation” index and deep structures of the earth’s crust.

On the basis of volume models, we judge about the condition of the geothermal hydrocarbon traps, define the quality of impermeable traps and fluid accumulation zones, determine the presence of faults through tracing of zones of deep water unloading and how it affects the safety of deposits.

- At the final stage of zonal level of study we provide a detailed description of prospective zones (*), including:
  - A list of objective signs of prospectivity for a specific block
  - Depth of prospective Oil&Gas horizons or Solid Minerals (Figure 4)
  - TVT horizontal sections and vertical profiles of prospective areas
  - Coordinates of corner points of prospective objects on a geographical map
  - Interpretation of received results
  - Recommendations for drilling of pilot wells, their GPS coordinates and optimal drilling depth (Figure 15).

(*) Note: this part of the materials can be provided to a Client with a separate detailed description in the form of final report, if “express analysis” of the territory is ordered and the works include only regional and zonal levels of study. In case of a “Full-scale” analysis of a licensed block - the above mentioned detailed description is included in the total scope of work.

Thus, the final results of "regional and zonal levels of study": prospectivity maps, characteristics of prospective areas, recommendations for pilot well drilling and further works.
Examples of volumetric modeling of prospective Oil areas.

3. Local level of study.

- (Search for Oil&Gas/Solid Minerals deposits and their characteristics)
- Mapping scale - up to 1: 2500;
- Building volumetric models, including 3D-models of prospective structures (Figure 16);
- A detailed description of fluid systems during the formation of deposits;
- Effective interpretation of biothermal structures, salt domes, faults, shoe string deposits, etc.;
- Localization of fracturing zones of environment, compression, stretching and decompression zones of rocks, which include areas of fluid flow and fluid accumulation (Figure 17);
- Local forecast of oil-bearing capacity / deposits of solid minerals and a location of the well / mine (Figure 18);
- Estimation of reserves of a prospective structure (Figure 19);
- GPS-coordinates and depth for a well / mine drilling (Figure 20).
Local forecast of Oil-bearing capacity.

Using special tools of TVT technology, we provide a consistent development and analysis of complex of various maps and corresponding vertical profiles, characterizing formation and genesis of underground structures, condition of fluid saturation and fluid flow, thermal properties of rocks and others. Such an integrated approach allows us to define and evaluate reserves of oil and other minerals with a high degree of certainty.

Figure 18. The example of local forecast of offshore prospect. Guinea Bay. A, B, C images show the example of such maps. Red color shows the contour of oil-bearing zone.

A. Fragment of local thermal field map, TVT.

B. Map of block-and-fault structure, TVT, 1750 depth

C. Map of homogeneity, TVT, 1750 depth
Estimation of reserves of high prospective structure. Guinea bay.

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Coordinates and depth for well/mine drilling.

Final report provides a geographical map with exact GPS-coordinates for drilling. Drilling depth is defined and shown on TVT vertical profiles of prospective zone (figure 20).

90 mmbbl of Oil
Estimation of geological reserves of the identified structure using Thermovision Tomography technology.

\[ V_{НГК} = S \cdot h_{\text{эфф}} \cdot K_{ПО} \cdot K_{Н} \cdot K_{гр} \cdot K_{в} \cdot \alpha \]

Area of prospective structure – 17.5 sq.km
Area of deposit – 9.65 sq.km
Effective deposit thickness – 20-30 m
Water depth - 10-40 m
Target depth of deposit – up to 1750 m
Effective porosity of collector – 20%
Average Oil saturation – 40%
Water saturation – 25%

Figure 20. Vertical profile of block-and-fault structure. Arrows show 2 oil prospects with the ~1,2 km depth. Dense rocks are shown by red color, decompaction rocks, containing collectors are shown by green color.
A final report is submitted in paper and electronic versions. The report includes all received initial pictures, all types of maps, horizontal sections, vertical profiles, tables, volume models of a studied area, detailed analytical materials and interpretation of received results, and also recommendations about prospectivity and further works.

Presentation of the report and discussion of results of a research is carried out jointly together with experts of a Client and the Service Provider. After final report presentation the Service Provider additionally holds 4-8 hour educational seminar for Clients’ experts called “Reading and Analysis of TVT-research results”.

Intermediate reports are presented both during meetings, and with the use of video conference technology. During the execution of works regular “on-line” consultations between the responsible specialists of the Parties are held.

Besides, after completion of all works and presentation of the final report, the Service Provider can additionally carry out current consultations and give explanations during a preparation of drilling operations.

Presentation of materials
TVT technology advantages

Short execution period: 1 000 sq.km. — 3-6 months; 5 000 sq.km. and above — 7 months
More economical vs. traditional methods
Physical presence is not required
Regardless to relief, terrain and seabed conditions (Inc. complex fault structures)
TVT has no problem identifying oil reserves even due to interference from gas clouds
Enables possibility to build vertical and horizontal profiles of block-and-fault structures at any given depth and in any direction
Maximal Depth: up to 100 km
Zero environmental impact
8 - hour seminar for clients specialists:

“Reading and interpretation of TVT materials”
Thank you