1 SEARCH FOR HYDROCARBONS

STAGES, TASKS, RESULTS AND INTEGRATION OF TVT IN THE SEARCH FOR HYDROCARBONS.

At the regional and detailed stage of research, the determination of geothermal features in the formation of oil and gas fields is carried out.

The genesis of the formation of hydrocarbons in the sedimentary cover is established taking into account the structure of the endogenous thermal field.

A physical-tectonic scheme of the region and a forecast map with the localization of promising hydrocarbon search structures (geographical coordinates and depth) are being formed. Models of block-fault structures are being compiled, which include zones of flow and accumulation of fluid-gas emanations with the formation of natural reservoirs of hydrocarbons.

Complexing of TVT with geophysical fields (seismic exploration, gravity and magnetometry, well logging) is being carried out to rank structures according to the conditions of perspectivity of hydrocarbon deposits (high & medium priority and unpromising areas).

We give recommendations for optimizing further exploration work, with geo-referencing deposits in geographic coordinates WGS-84 and in depth.

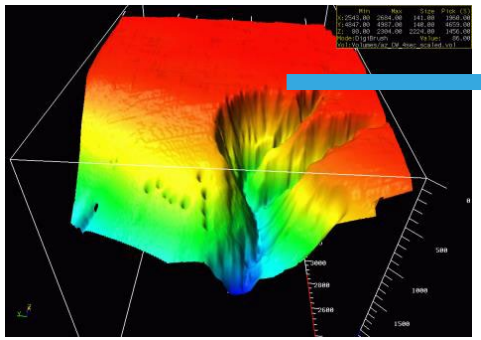
2 SEARCH FOR HYDROCARBONS

THE MAIN TVT SIGNS FOR IDENTIFYING PROMISING HYDROCARBON ACCUMULATION ZONES

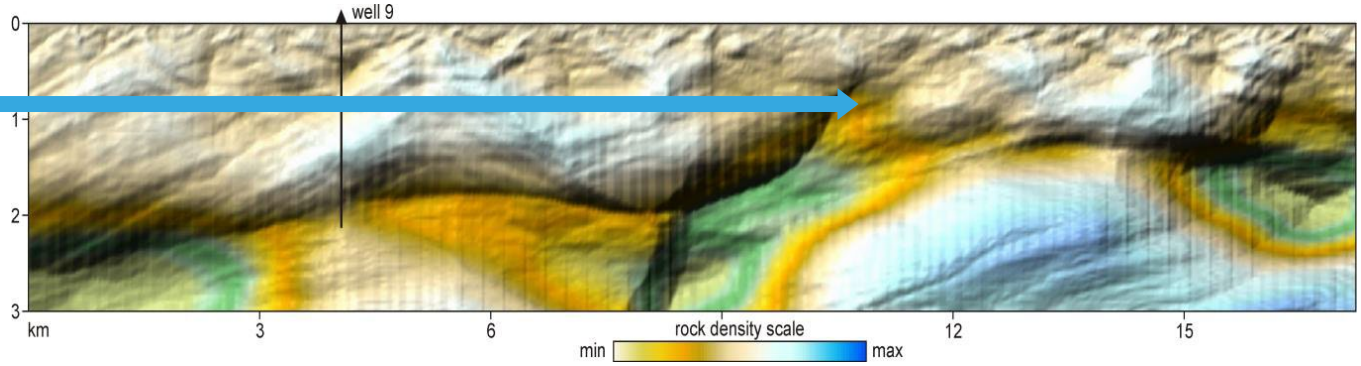
TVT model of block-fault structures along the continent and the sea shelf

- outcrops of deep geothermal zones with decompactions (horizontal or vertical) of the Earth's Crust at the locations of large oil and gas fields;
- location of geological objects near ascending linear heat flows, but outside geothermic hills, where the safety of the traps is unlikely;
- the presence of asymmetric ledges on the thermal field models for the interval of potentially oil and gas bearing depths; these ledges violate the general plan of the horizontally layered section and represent the structure of the cover rocks, in which local areas of cold zones are formed, overlain by warmer sediments;
- sharp lateral deviations of heat flows from the vertical direction associated with geological objects;
- location of geological objects outside geothermic pits and negative linear flows;
- relatively higher hypsometric position of the predicted geological object.

Seismic characters block, Equatorial Guinea



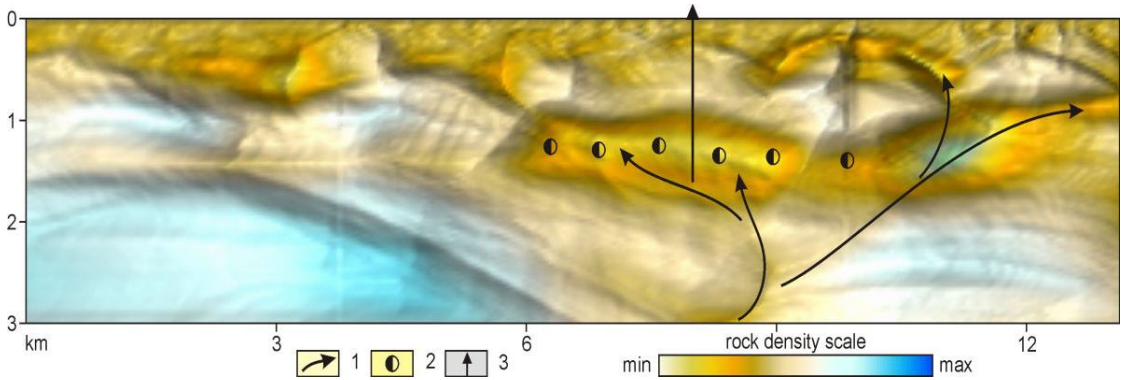
Same location. Integral characteristic of block-fault structures on TVT profile



3 SEARCH FOR HYDROCARBONS

CHARACTERIZATION OF THE THERMAL FIELD OVER VARIOUS TYPES OF HYDROCARBON TRAPS

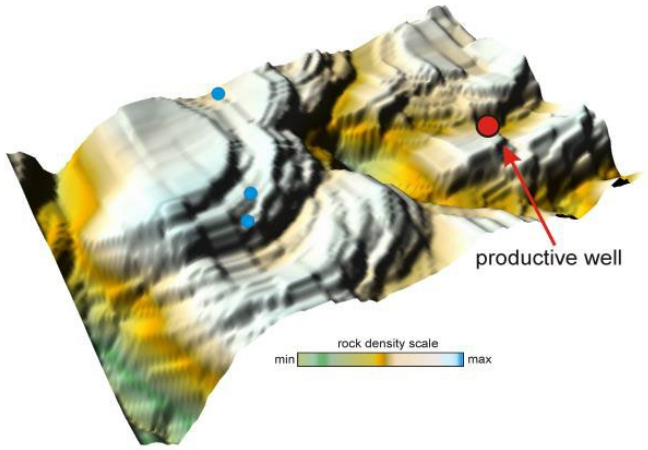
Integral model of block-fault structure, TVT profile



Legend:
1 – migration channel, 2 - hydrocarbons, 3 - recommended well

According to the characteristics of the geothermal field of block-fault structures, one can judge the quality of hydrocarbon traps, determine the area of volumetric accumulation of fluids, establish the presence of torn disorders in the discharge of deep-water zones and their effect on the safety of deposits. Taken together, this makes it possible to determine the most probable contours and depths of natural hydrocarbon reservoirs, as well as to recommend a well for drilling.

Volumetric 2.5D model of block-fault structures

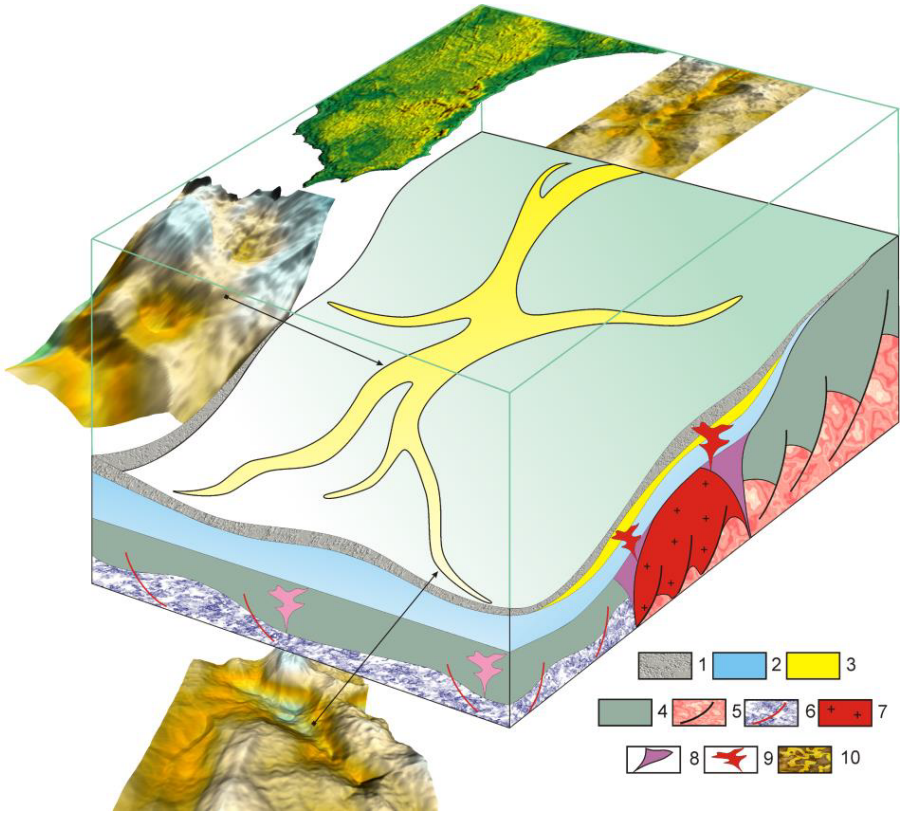


In the course of tectonic processes, horizontally located troughs or terraces are formed. They accumulate layers with high permeability.In such conditions, sandy reservoirs, in the presence of an impermeable trap, can create large hydrocarbon deposits.

Tectonic ledges in the sedimentary cover and erosional ledges of the basement — geological targets for hydrocarbon prospecting

4 SEARCH FOR HYDROCARBONS

FORMATION OF COMPLEXLY CONSTRUCTED (SLEEVE-SHAPED, STRING-SHAPED, BAR) HYDROCARBON TRAPS



Legend:
1, 2 – sedimentary cover rocks; 3 – paleoriver beds zone; 4 – metamorphized layer; 5 – block-fault structures of the continental crust; 6 – the oceanic crust; 7 – volcanogenic formations; 8 – rift structures; 9 – intrusive bodies

TVT indicators for identifying promising HC zones:

• presence in the section of a decompressed zone of an extended, tortuous shape comparable to tectonic disturbance of the environment;

• the presence of an inclined basement surface on which detrital sedimentary material was formed;

• the presence of a natural barrier in the form of local protrusions on the path of the drift of continental sediments. It creates an obstacle for the free migration of coarse debris. Thus there is a gradual accumulation of the porous layer — the reservoir;

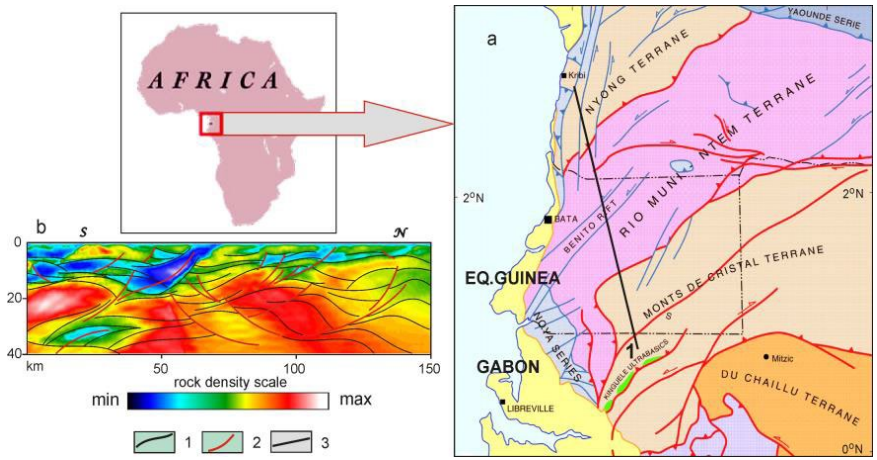
• the formation of an inclined fault at a depth along which the migration of light hydrocarbons took place;

• development of a dense trap above the collector, creating conditions for the preservation of hydrocarbon deposit.

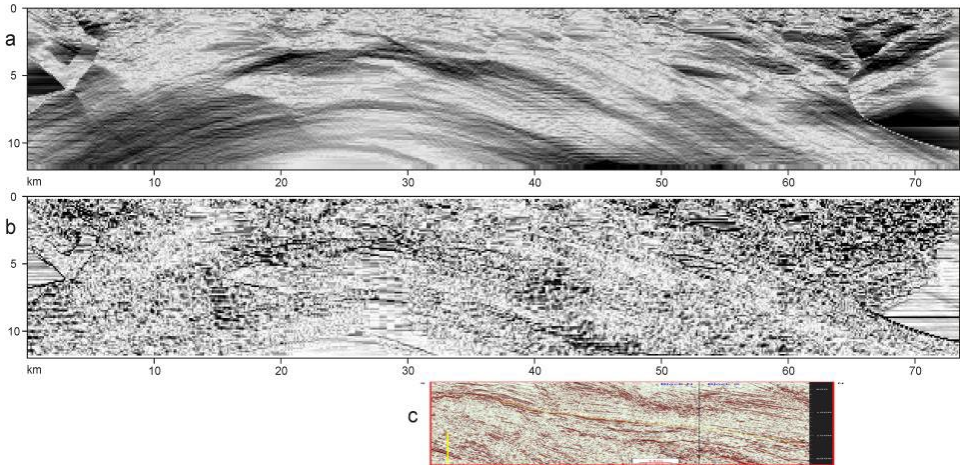
5 SEARCH FOR HYDROCARBONS

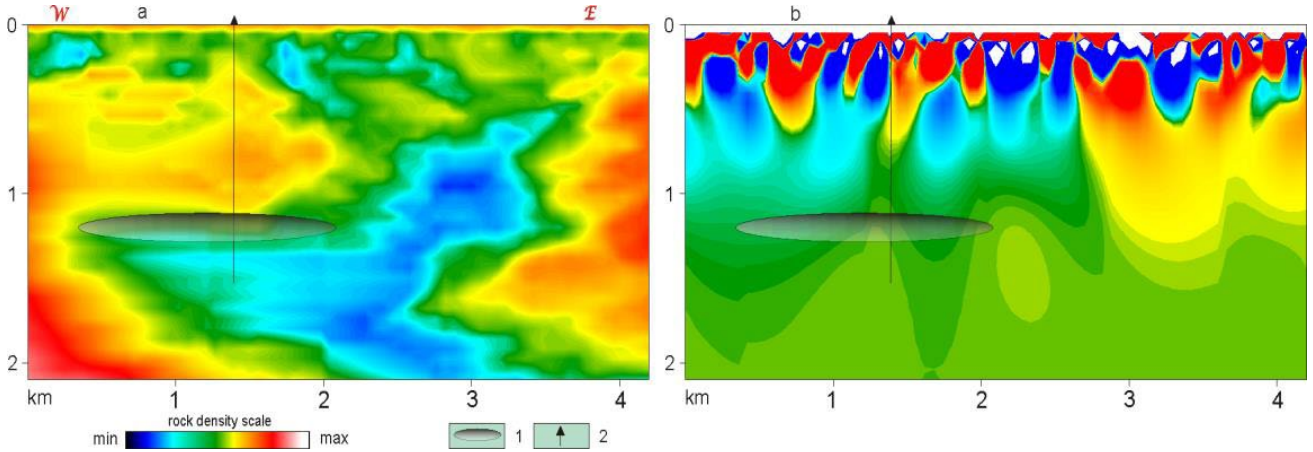
REGIONAL GEOTECTONIC AND DETAILING OF HC DEPOSIT, EQUATORIAL GUINEA.

Earth's Crust model of the RIO MUNI rift, Eq.Guinea



Earth's Crust model of the RIO MUNI rift, offshore part. Regional TVT profile (a-b) and seismic data (c)



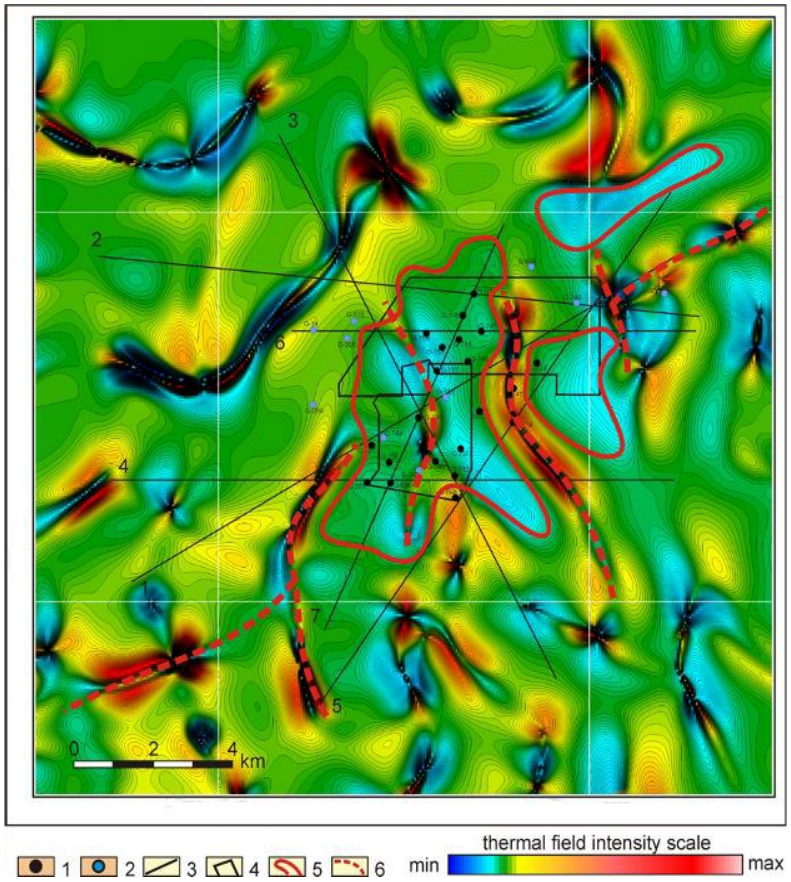


OKUME oil-field model, TVT vertical profile

Legend:
a - block-fault structures
b - heat sources
1 - hydrocarbon reservoir
2 - production well

6 SEARCH FOR HYDROCARBONS

MAPPING OF LOCAL OIL-BEARING STRUCTURES, INDIA



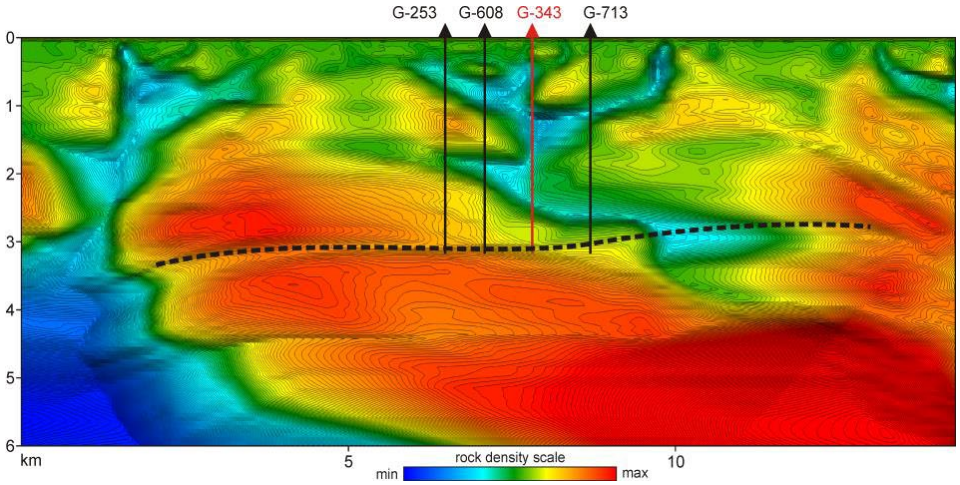
Legend:
1 – productive well, 2 - empty well, 3 - TVT profile, 4 - contour of the LFS section, 5 - HC perspective according to TVT, 6 – fault.

Map of the differential thermal field in the depth interval (2.9–3.5) km

The map of local structures was obtained by calculating the increment in the values of the thermal field at the depth level of the productive horizon of hydrocarbons.

Overview map of TVT-shooting

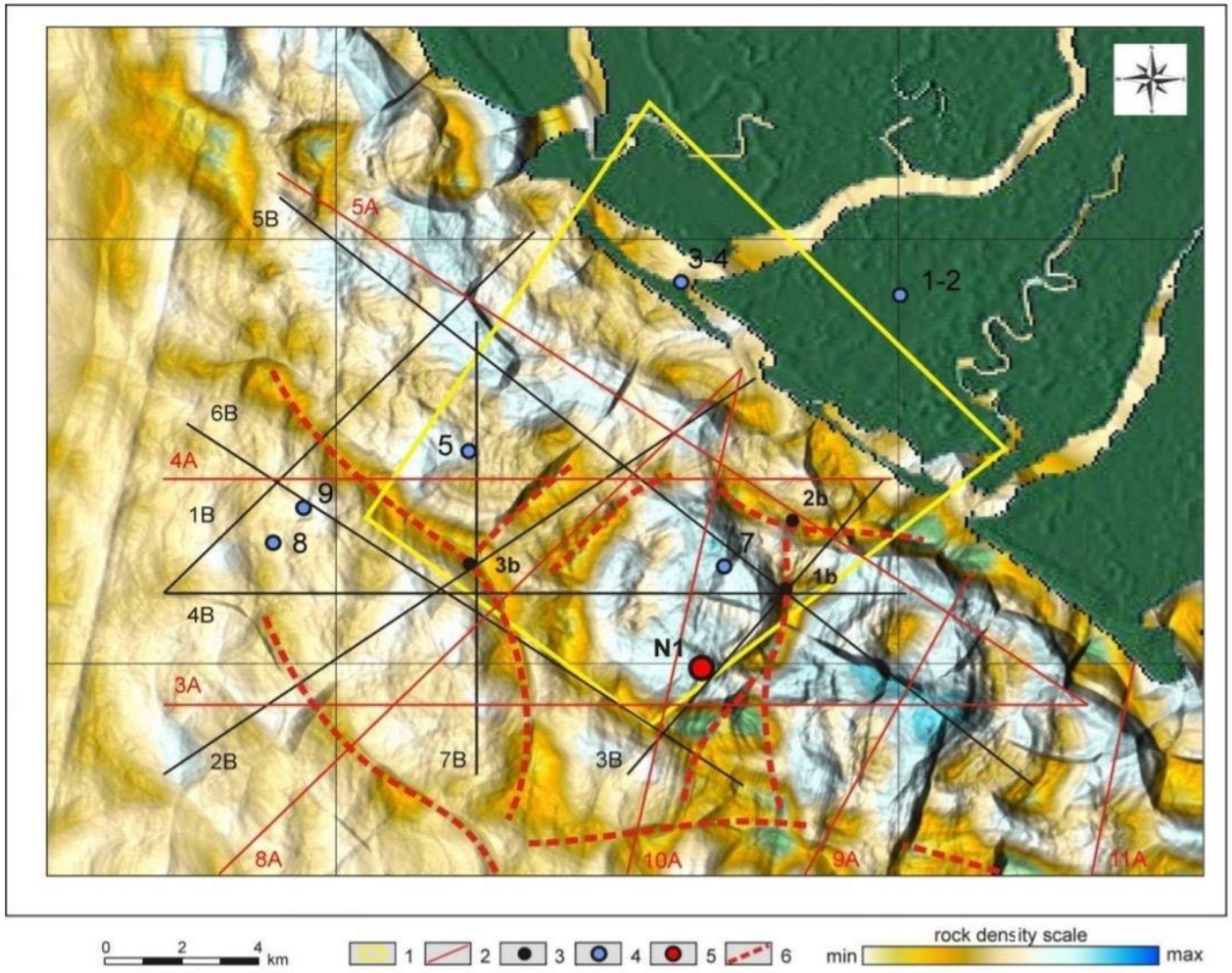
Integral characteristic of block-fault structures, Profile 4



7 SEARCH FOR HYDROCARBONS

MAPPING OF LOCAL OIL-BEARING STRUCTURES, NIGERIA

Depth interval 0.9 – 1.2 km



TVT-map of the integral field of block-fault structures, for the depth interval 0.9–1.2 km.

Shelf of Guinea Bay and a continental part (green color). Prospecting map with location of oil- perspective structures.

Legend:
2 — TVT-profile line,
4 — existing well,
5 — recommended new Well,
6 — axis of the perspective structure,
for the depth interval 0.9–1.2 km.

8 SEARCH FOR HYDROCARBONS

MEASURING THE DENSITIES OF SEDIMENTARY COVER, NIGERIA.

Oil prospects map of the Niger Delta area, Gulf of Guinea

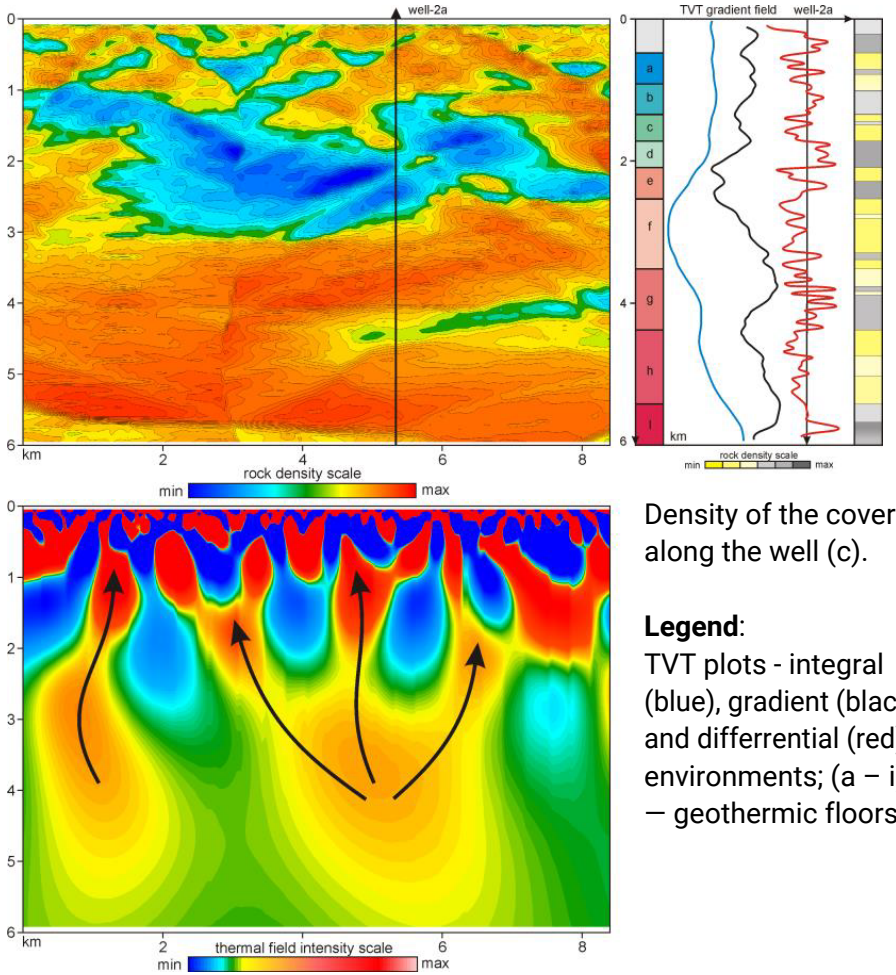
Measuring the densities along the projected well No 2a (c).

According to TVT features, two geothermic floors that are promising for hydrocarbons are distinguished:

• the first horizon is located in the depth interval of 3.8–4.5 km and is the basis for the formation of mother oil rocks. It is controlled by the hypocenter of the deep heat source.

• the second horizon is located at a depth of more than 1.2 km, in favorable conditions for the formation of reservoirs. It has a greater intensity of the thermal field and the thickness of the reservoir. It is presented in the form of multilayer deposits of hydrocarbons. The collector zone in the area of the roof and the base is contoured by dense rocks.

Integral characteristic of block-fault structures (a) and heat sources (b) by fragment of profile



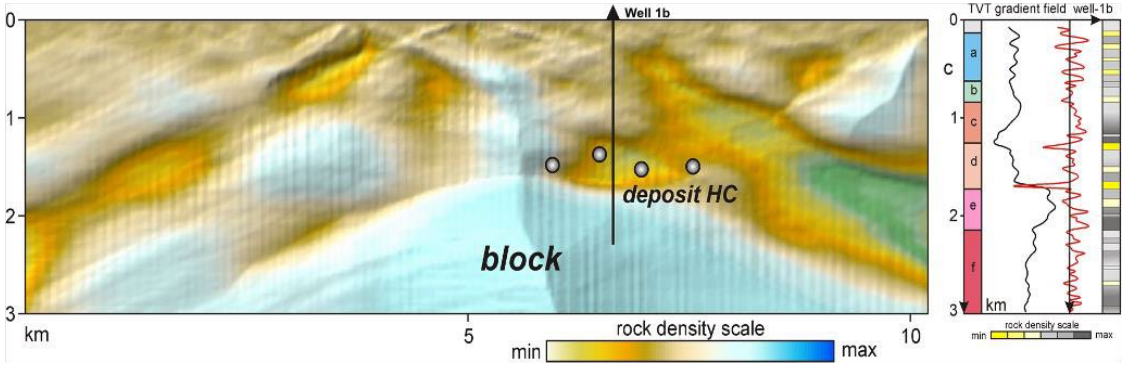
Density of the cover along the well (c).

Legend:
TVT plots - integral (blue), gradient (black) and differential (red) environments; (a – i) — geothermic floors

9 SEARCH FOR HYDROCARBONS

SEDIMENTARY COVER DENSITIES, VOLUME OF HC DEPOSITS, NIGERIA.

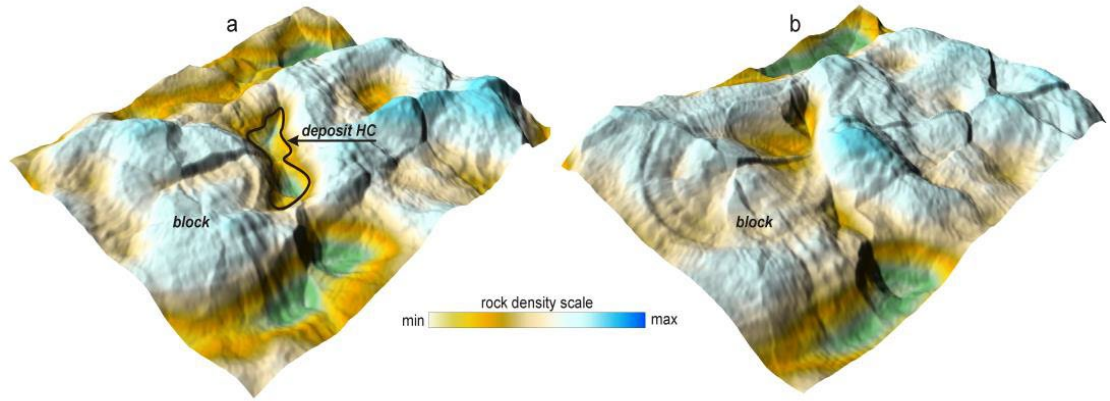
Integral characteristic of block-fault structures, Profile 3B



Sedimentary cover densities along the recommended Well 1b

Legend:
TVT graphics - gradient (black line) and differential (red line) environments; (a – f) — geothermic floors; black arrow - recommended well.

On the profile: dense rocks are painted in white and blue colors, decompacted rocks — in light brown and greenish colors.



Volumetric 2.5D model of local characteristic of block fault structures of the Contour No 1B at depths of 1200 m (a) and 1500 m (b)

Volumetric calculations of HC deposits:

The intensive anomalous zone is distinguished along the integral thermal field. Its area is about 1.3 sq km

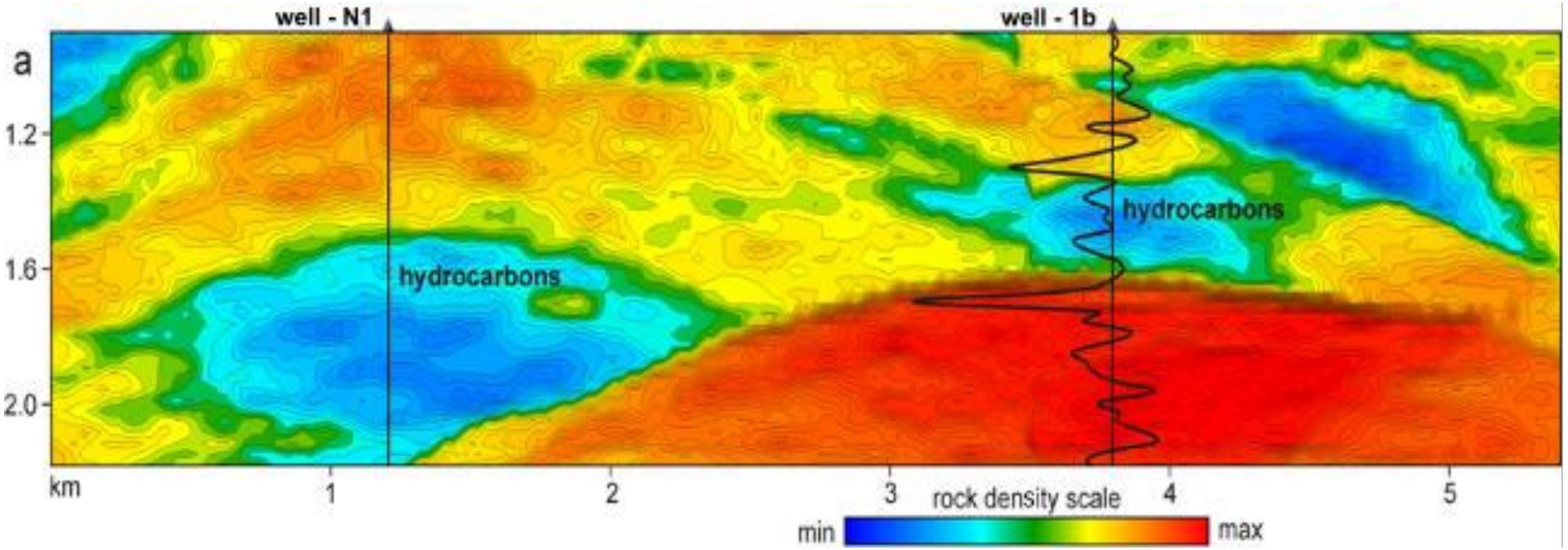
Effective collector capacity is estimated at 68 meters.

We accepted the porosity value of the reservoir about 10%, taking into account the high permeability of the productive horizon.

Geological reserves are estimated at 8,568,000 barrels of oil.

10 SEARCH FOR HYDROCARBONS

DELINEATION (VISUALIZATION) OF HYDROCARBON DEPOSITS, NIGERIA.



TVT model of the integral field of block-fault structures along the vertical profile “C”. Dense rocks are shown in red and yellow, and decompacted rocks — in green and blue. Black arrow indicates location of the projected well No1. Of interest is a promising hydrocarbon deposit in the left part of the image. In the upper part, a Trap consisting of dense rocks is clearly visible, as well as a decompacted area (below) containing collector rocks (green and blue color). **The boundaries of the deposit are clearly visible.**

Drilling of wells No 1 and No 2 (see next page) to a depth of 2500 meters is recommended. The zone has large reserves of hydrocarbons from a depth of 1.4 km. The composition of the field is oil and gas.

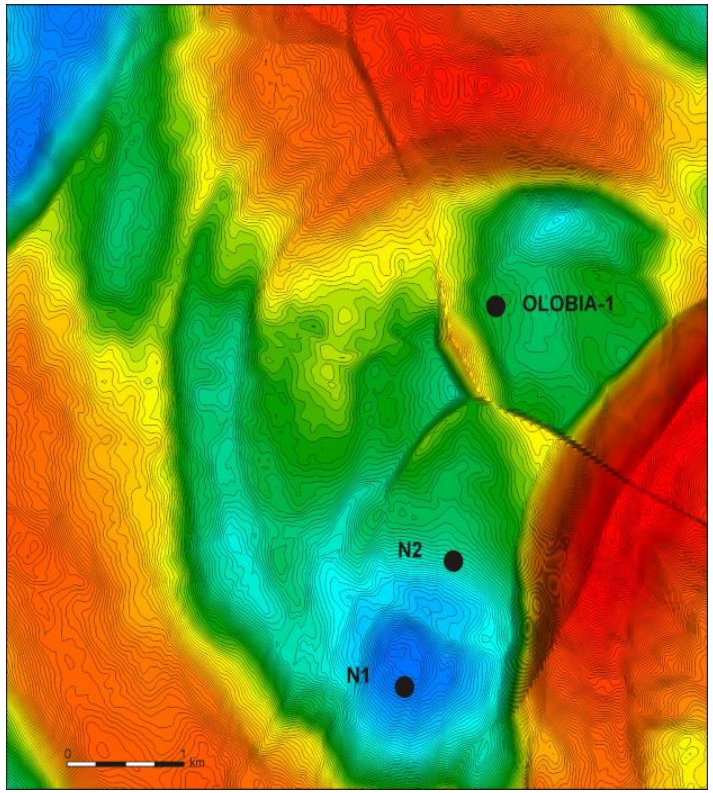
Replenishment of light hydrocarbons can occur from deep layers (more than 3.5 km) along a permeable zone formed along the top of a dense block.

11 SEARCH FOR HYDROCARBONS

DETAILING OF PERSPECTIVE HC DEPOSIT, RECOMMENDATION ON THE WELLS, NIGERIA

Map in the depth interval (1.5 – 1.8) km.

Localization of the same perspective structure, see vertical profile on previous page.

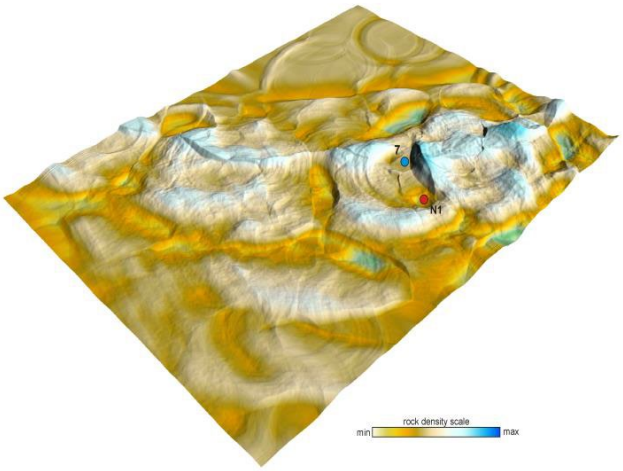


Drilling of wells N1 (see previous page) and N2 to a depth of 2500 meters is recommended. The zone has large reserves of hydrocarbons. The composition of the field is oil and gas.

Results of drilling.
The well Ol-1 is a productive well on Hydrocarbons, with depths of layers:

1. Oil D1: 4500 ft (1372 meters);
2. Oil D2:4770 ft (1454 meters);
3. Oil D3: 4900 ft (1494 meters);
4. E1 Gas: 6600 ft (2012 meters);
5. E5 Gas: 7200 ft (2195 meters).

Map of the integral field of block-fault structures, Volumetric 2.5D model.

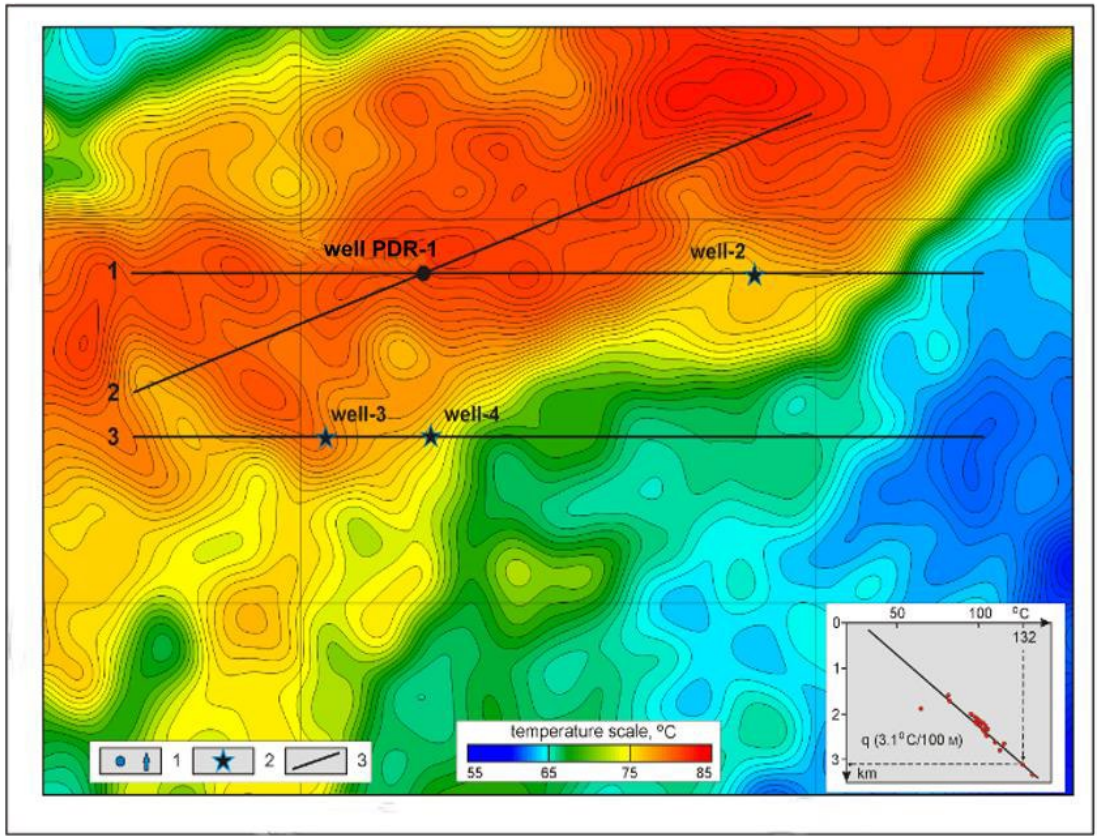


The search depth for hydrocarbon deposits increases from 0.9-1.2 km near the coastline to 1.5-1.8 km in the deep-water part of the Gulf of Guinea.

12 SEARCH FOR HYDROCARBONS

PERSPECTIVE ASSESSMENT FOR PLANNED PDR-1 WELL, OFFSHORE, MALAYSIA

Thermal field map at a depth of 1.8 km



Legend:
1 – location of the PDR-1 well, 2 – NEW promising point for drilling, 3 - TVT profile

Based on seismic surveys in shallow water, the Client planned to drill PDR-1 well.

The local TVT-forecast of the oil-bearing prospects of the offshore zone (Malaysia) was estimated using the map of the endogenous thermal field (Landsat-8), TVT profiles and models of block-fault structures.

The main conclusion of the TVT modeling is that the design well PDR-1 is located in an unfavorable tectonic zone, above a geothermal stock, which is characterized by dense rocks. There are no TVT-signs, indicating the prospects for the manifestation of hydrocarbons in the sedimentary cover, so our suggestion was — NOT TO DRILL.

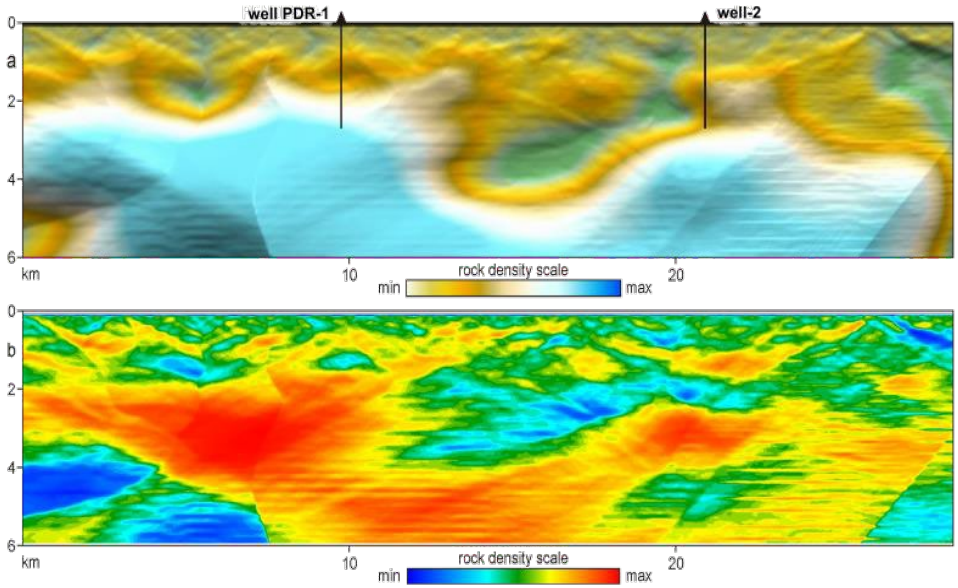
Drilling of the PDR-1 well in 2015 confirmed the conclusion of TVT for the absence of oil deposits

13 SEARCH FOR HYDROCARBONS

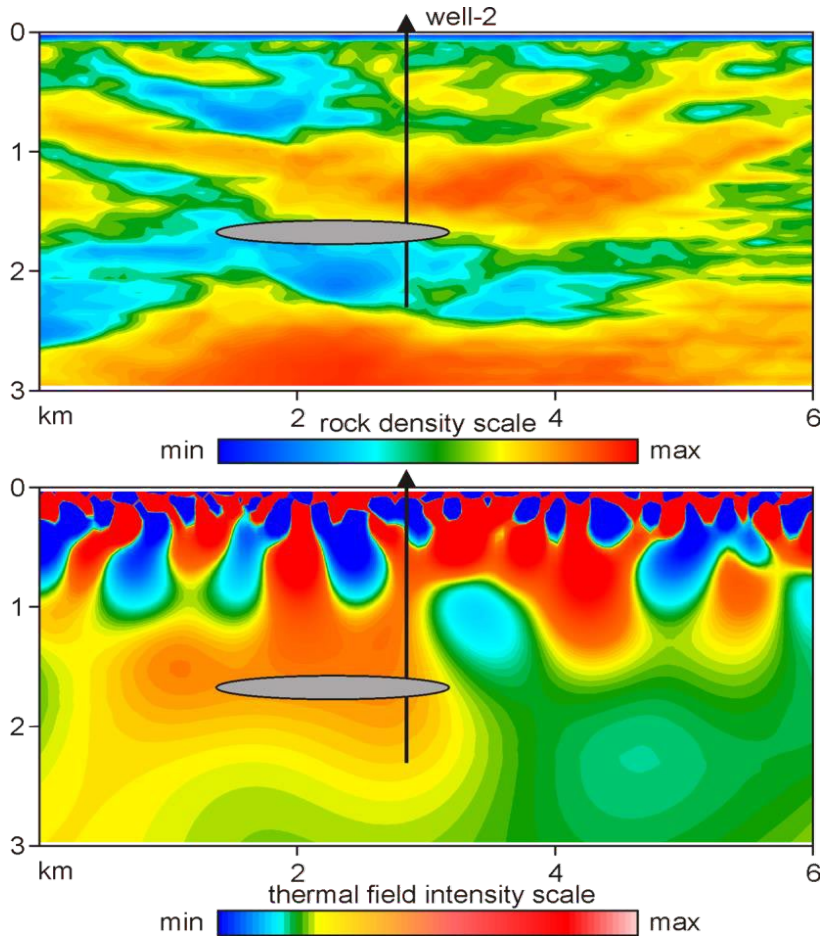
THEN WHERE TO DRILL IN THIS AREA (?), OFFSHORE, MALASIA.

Models of integral (a) and differential (b) fields of block-fault structures along profile 1

Profile 1



Profile 2



Subsequent prospecting work in the nearby area of the site (see previous page) along profile 1 found a new promising zone A, at PC 21 km, in the depth interval (1.7–2.2) km. The nature of its formation is associated with the rift structure. It screens the coarse-grained sandy layers of the cover in a shallow saddle. There is a pronounced system of natural channels for migration and accumulation of fluids.

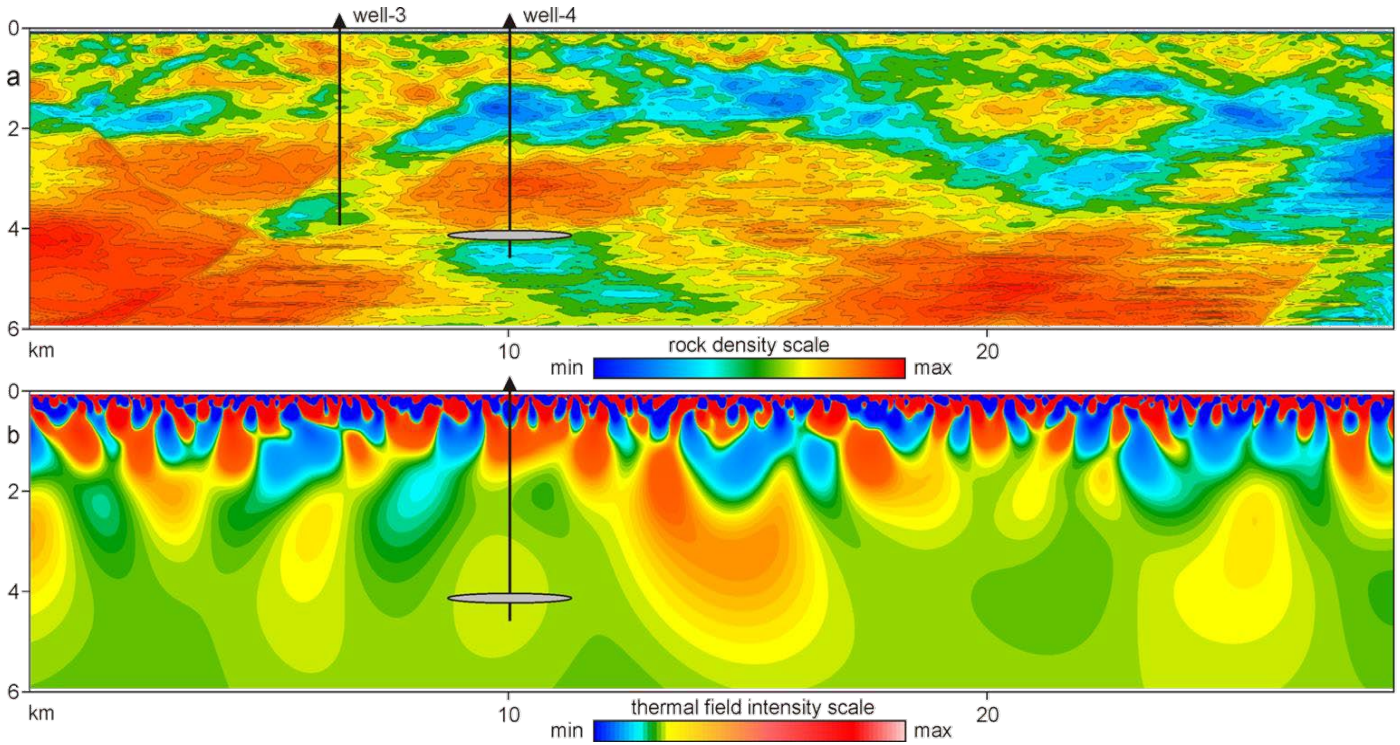
Drilling of a new well-2 was recommended

14 SEARCH FOR HYDROCARBONS

DIFFERENTIAL FIELD MODELS OF BLOCK-FAULT STRUCTURES (A) AND HEAT SOURCES (B)

Differential field models of block-fault structures (a) and heat sources (b)

Profile 3



Legend:
Dense rocks are colored red and yellow, decompacted rocks are blue and green.

A trap consisting of dense rocks (red color) is clearly visible above the promising area (gray oval).

Drilling of a new well-4 was recommended

Second new zone B, promising for hydrocarbons (gray oval), is shown on profile 3. It has all the geothermic signs of collector formation in the depth interval from 3.6 to 4.2 km. The thermal model of the medium has the following structural features:

- there are fractured layers in the foundation section;
- in the roofing part of the sedimentary cover, traps appear in the form of dense layers;
- listric zones connect separate decompacted horizons of the environment;
- anomalies of local sources of the thermal field control hydrocarbon deposits.