Phase-1 of the Eurasia project results

Astana, 2022

INTRODUCTION

The Precaspian oil and gas megabasin is a unique, unparalleled geological structure.

It is only possible to define analogues for certain processes:

- Age and size – Perm, Tarim basins etc
- Formation conditions – Levant
- Massive halokinesis - Gulf of Mexico

✓ The total volume of hydrocarbons generated only by the Upper Paleozoic (Devonian-Lower Permian) part of the section is estimated at 8.6 trillion toe.

✓ The volume of HC emigrated is 4.7 trillion toe.

CONTENT

- The rationale for works
- World experience in prospecting for deep-seated deposits
- Territory ranking
- Basin Modeling
  - Data preparation
  - Simulation results
- Unresolved issues
- Conclusions and recommendations

THE RATIONALE FOR WORKS

The Eurasia project was initiated to assess the prospects of deep-lying subsalt deposits of the Pre-Caspian depression through special regional geological exploration using advanced, efficient, science-based and innovative exploration technologies that make it possible to reliably study the geological structure of the depression to a depth of 20-25 km and drill one ultra-deep exploratory well up to depths of 10-15 km, etc.

The project is expected to be implemented in three stages (Phases):

Phase-1. Collection, analysis, reprocessing and reinterpretation of regional geological and geophysical data

Phase-2. Processing of new regional seismic profiles

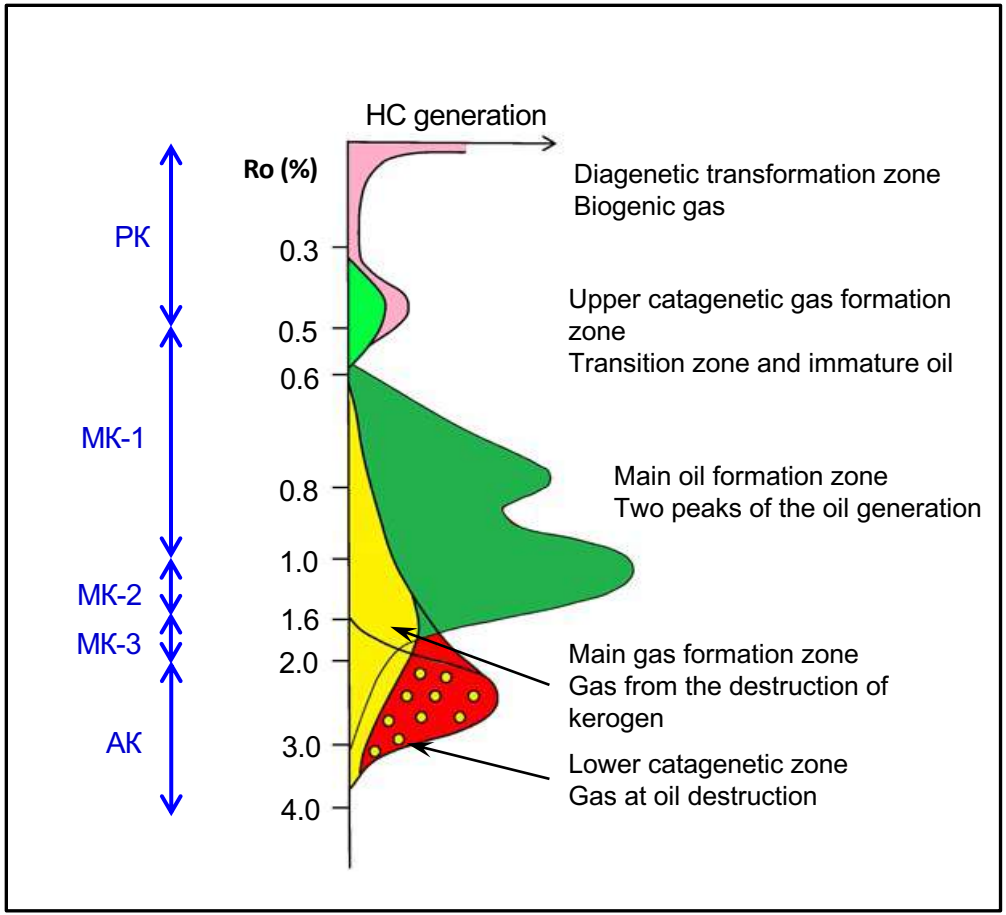
Phase -3. Drilling an ultra-deep well up to 15,000 meters deep

Comparison of basins parameters with deep hydrocarbon systems

Basin	Age	Temperature Gradient	Exposed reservoir rock depth	HC system Depth
	reservoir	°C/100m	maximum, (m)	maximum, (m)
Songliao (China)	J_3-K	3.8-4.2	5050	5400
Bohai Bay (China)	Pg	3.0-3.8	5200	5900
Ordos (China)	Pr, €-O, C_{2-3}	2.5-3.0	5350	6600
Sichuan (China)	€-O, S-C, P-T_2	2.0-2.5	6450	7700
Jungar (China)	C, P, T-K	1.8-2.8	6850	8200
Tarim (China)	€ (?), O-D, C, P, J-K	1.5-2.5	7990	9300
Williston (USA, Canada)	€, O, S, D, C-P, J-K	2.31-3.72	4900	?
Oman (Oman, UAE)	Pr,€, O, C_3-P,K	1.87-1.95	>8000	6620
Canning (Australia)	O, D_3, C_{23}-P, K	2.0-3.5	5200	?
Gulf of Mexico (USA)	N-J_2 (T)	1.16-2.1	10300	12000?
Precaspian (Kazakhstan. Russia)	D-C_{1-2}-P_1	1.8-2.2	7000	?
Precaspian (Kazakhstan. Russia)	PZ_1 (O-S) - ?	?	?	?

Justification of the possibility of formation and existence of hydrocarbon deposits at great depths

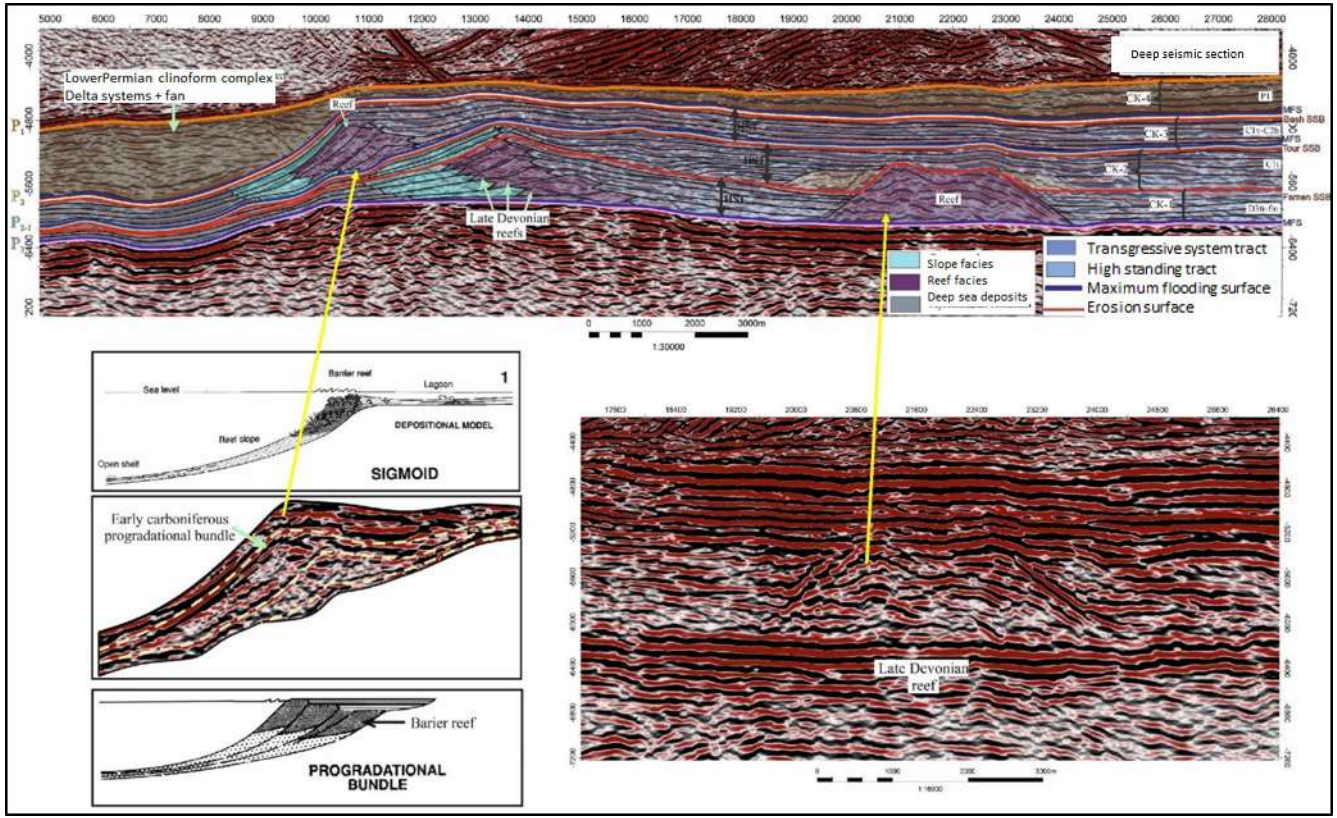
- Model of HC generation of the Chuangxin depression with a double peak of oil formation (Chuangxin); Fengcheng Formation, Lower Permian (He Haiqing, 2021).
- The arrows mark the transformation zones according to Vassoevich (1974)
- РК – proto-catagenesis
- МК – mezo-catagenesis (1-weak, 2-moderate, 3-strong)
- АК – apo-catagenesis



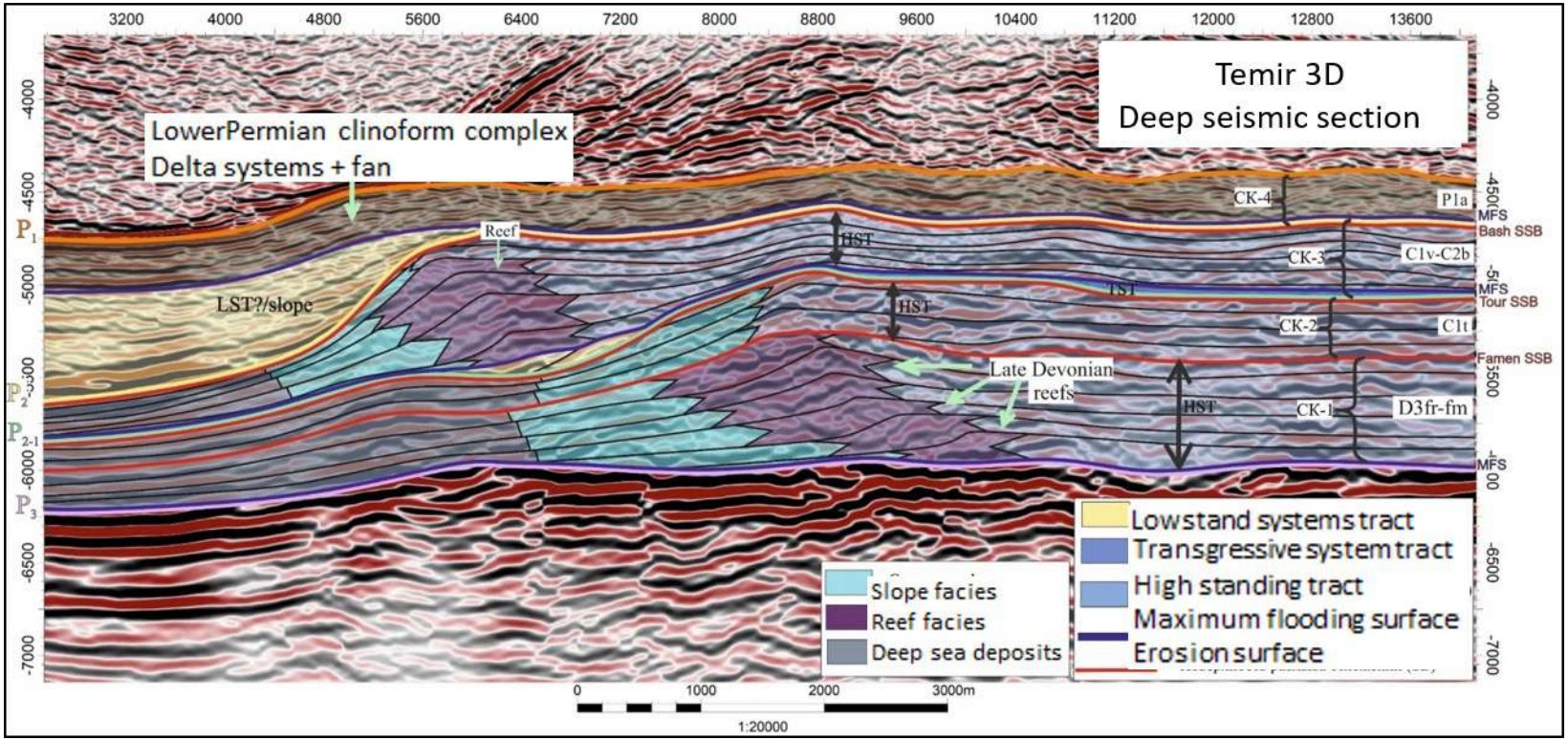
HYDROCARBON TRAP TYPES

- Temir platform:
  - **Single carbonate structures in the axial part**
  - **Barrier reefs along the periphery of the platform (D_3, C_2)**
- Northern slope of the Astrakhan-Aktobe uplift zone
  - Single build-ups of the "Tasym" type
- The Central Caspian Depression
  - **Thick clastic fans**
- Northern part of the Precaspian basin
  - Carbonate and clastic deepwater fans
  - Slope fans
  - Single build-ups of the "Karachaganak" type
  - Barrier reefs (P_1)

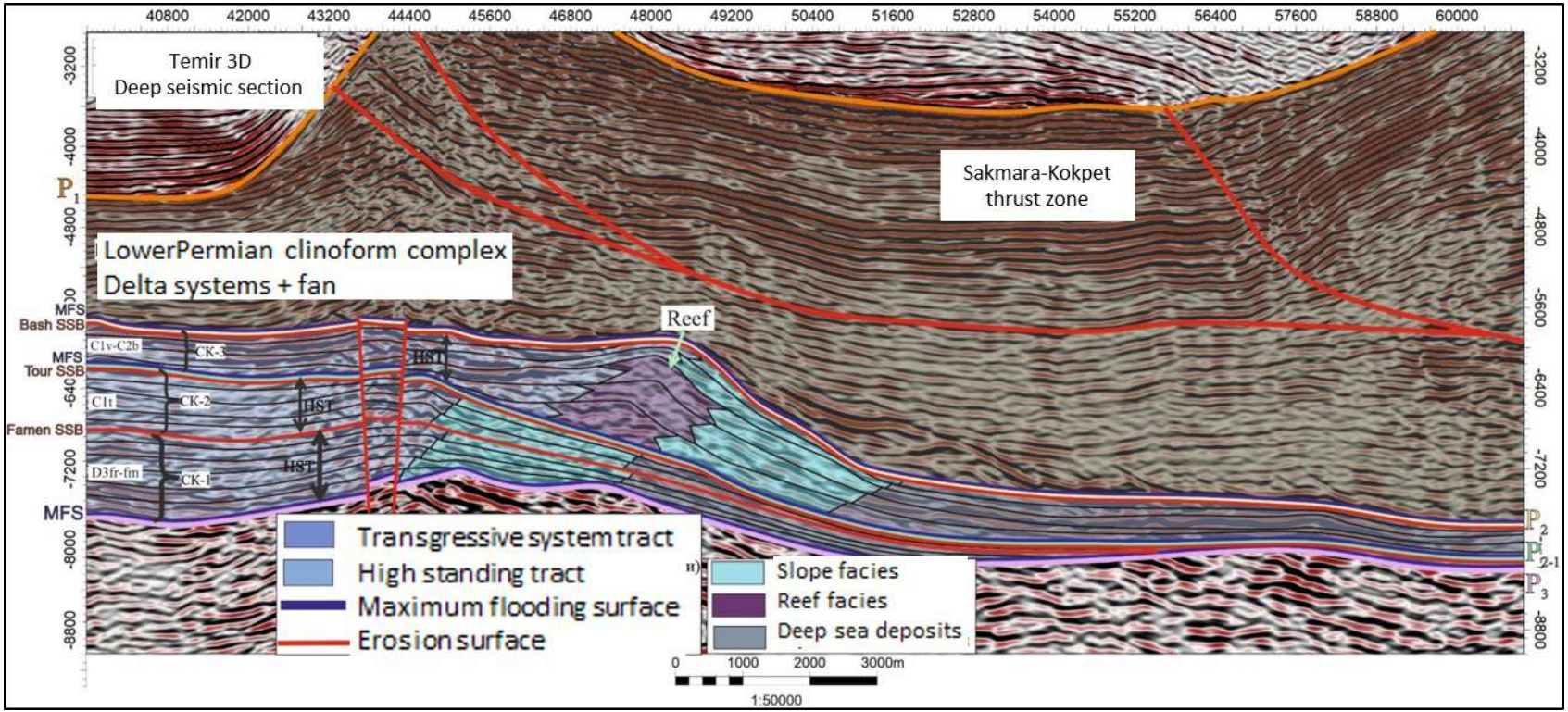
SEDIMENTATION MODEL OF THE WESTERN SIDE OF THE TEMIR CARBONATE PLATFORM



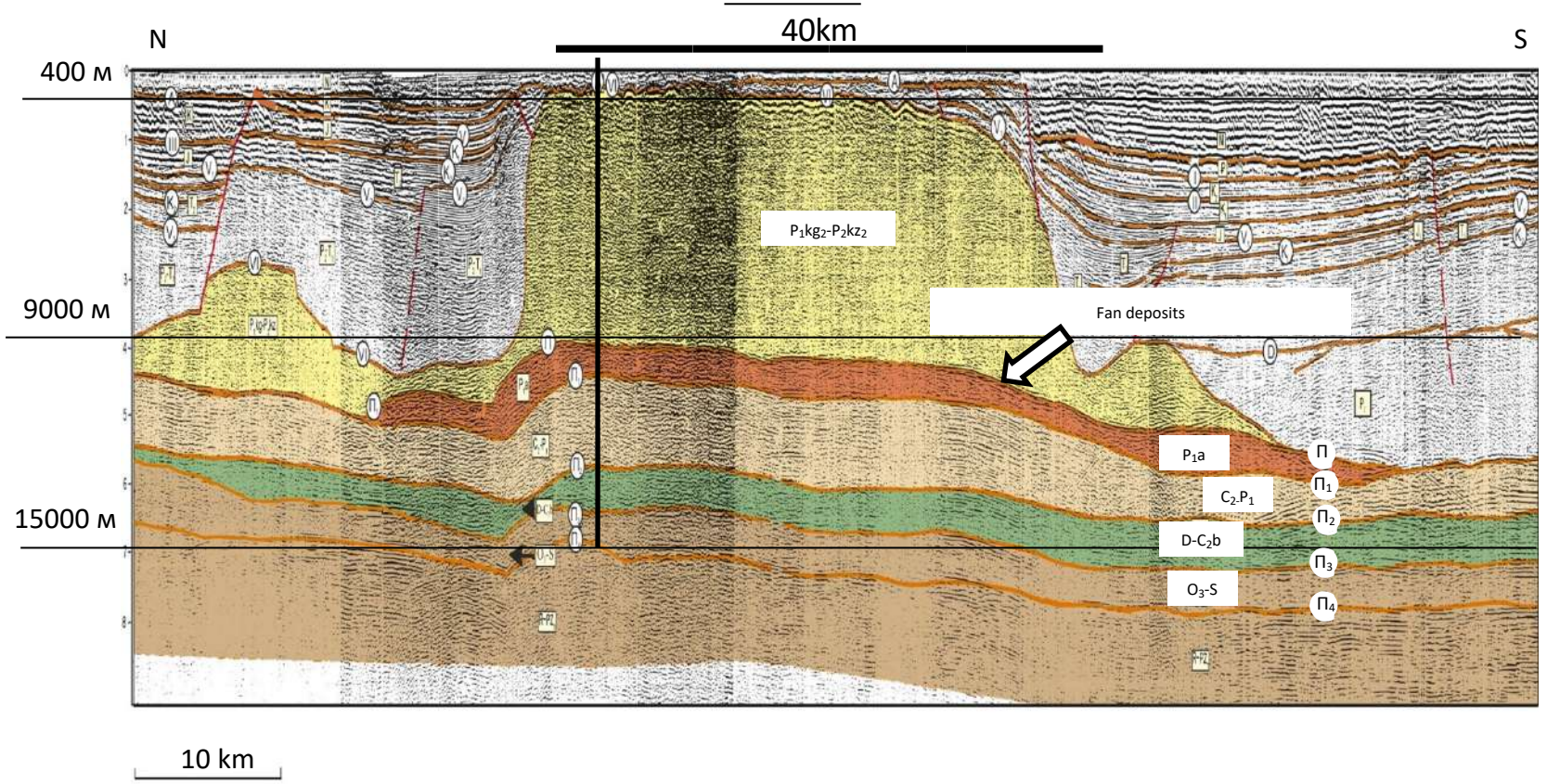
SEDIMENTATION MODEL OF THE WESTERN SIDE OF THE TEMIR CARBONATE PLATFORM along the XL-203 profile (3D)



SEDIMENTATION MODEL OF THE EASTERN SIDE OF THE TEMIR CARBONATE PLATFORM



ORIGIN OF THE DEEPWATER FANS



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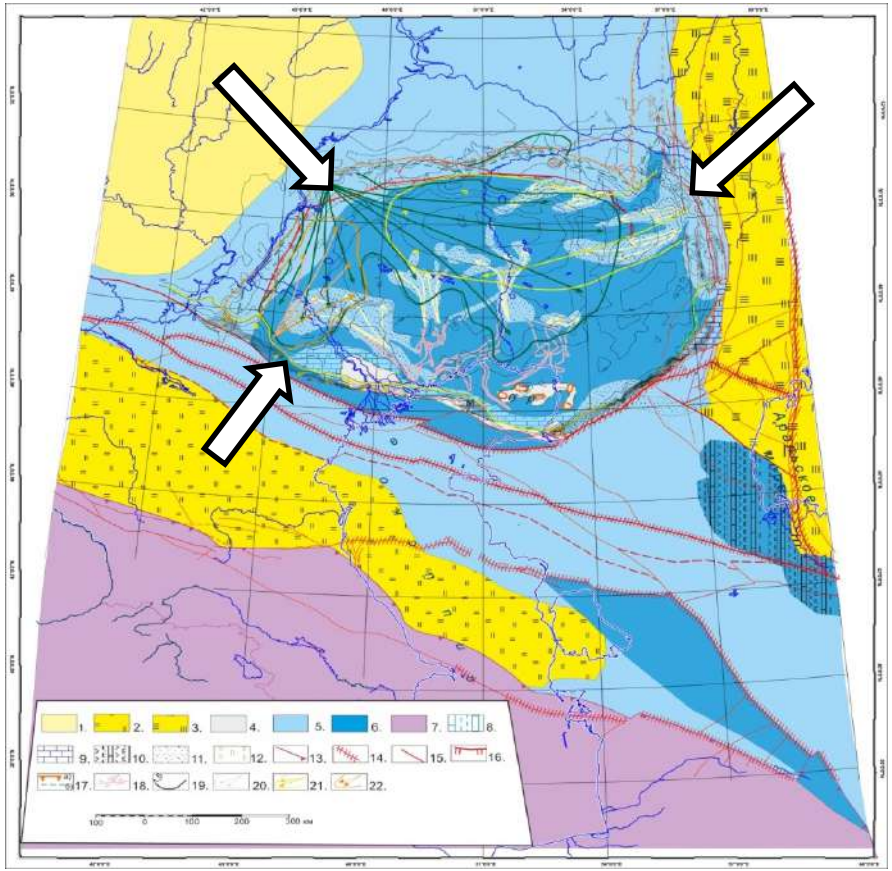


The formation of fans occurred due to the massive supply of detrital material during periods of sea level fall:

- Pre-frasnian age
- Pre-moskovian age
- Pre-kungurian age

The supply was carried out along the grabens:

- Novo-Alekseevsky
- Pachelmsky
- Sarpinsky

and washout from the region of the Astrakhan-Aktobe zone of uplifts

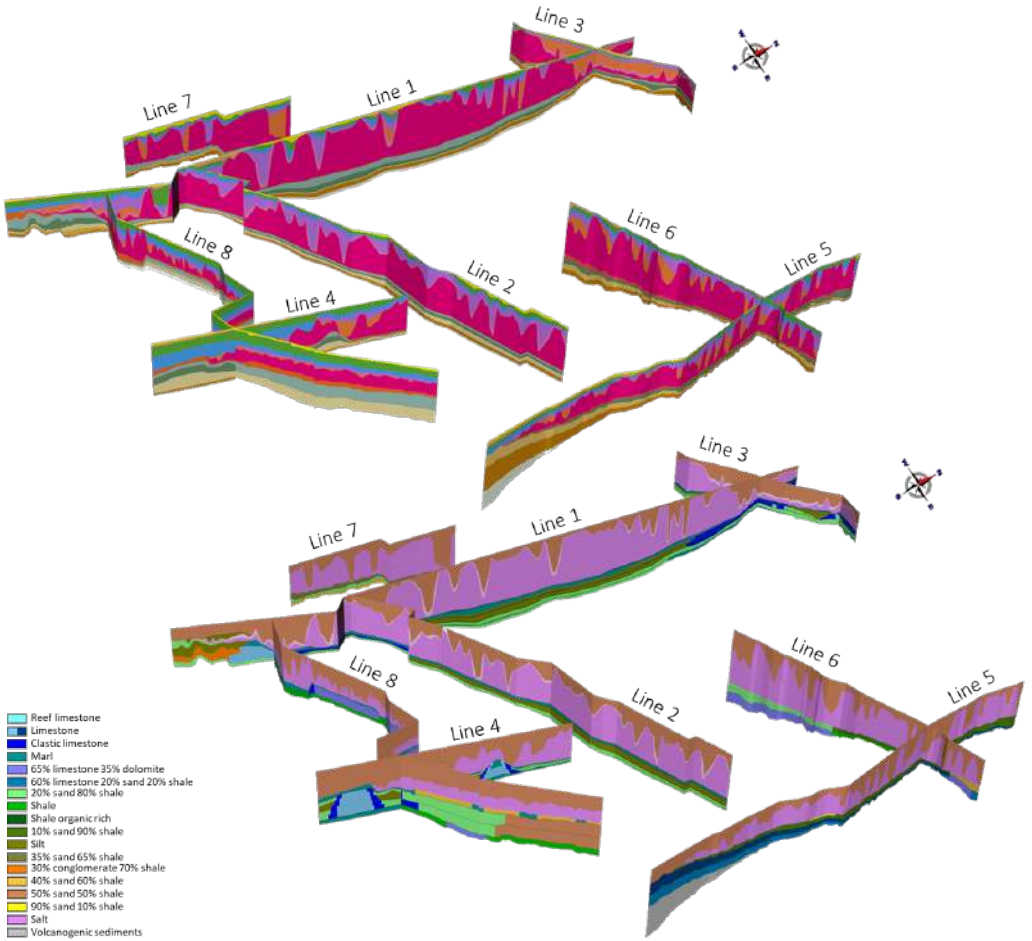
The transportation channel in the Novo-Alekseevsky trough was studied by drilling (Shyrak-1 well)

Tectonic-sedimentary model of the Middle Carboniferous-Lower Permian (Moscow-Artinsk) complex of the Caspian region
Underwater fans: 20 - Middle Carboniferous (Vereisk) age; 21 - Late Carboniferous-Early Permian; 22 - Early Permian (Sakmara-Artinsk) age

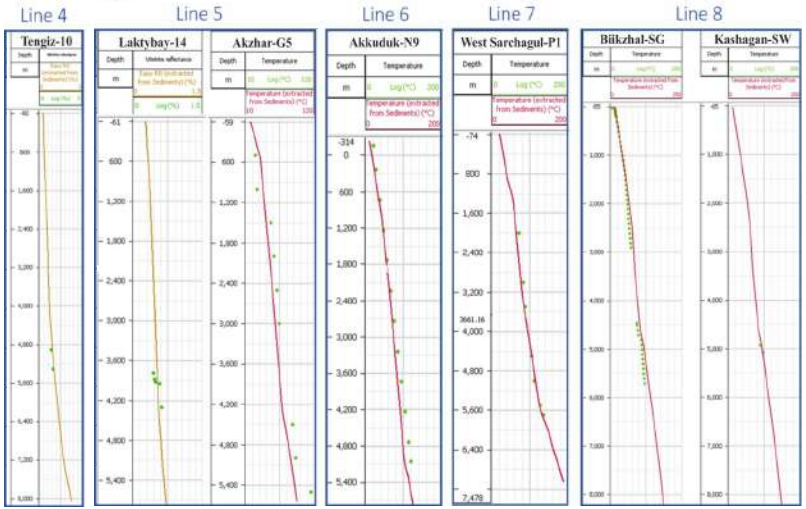
BUILDING 2D MODELS

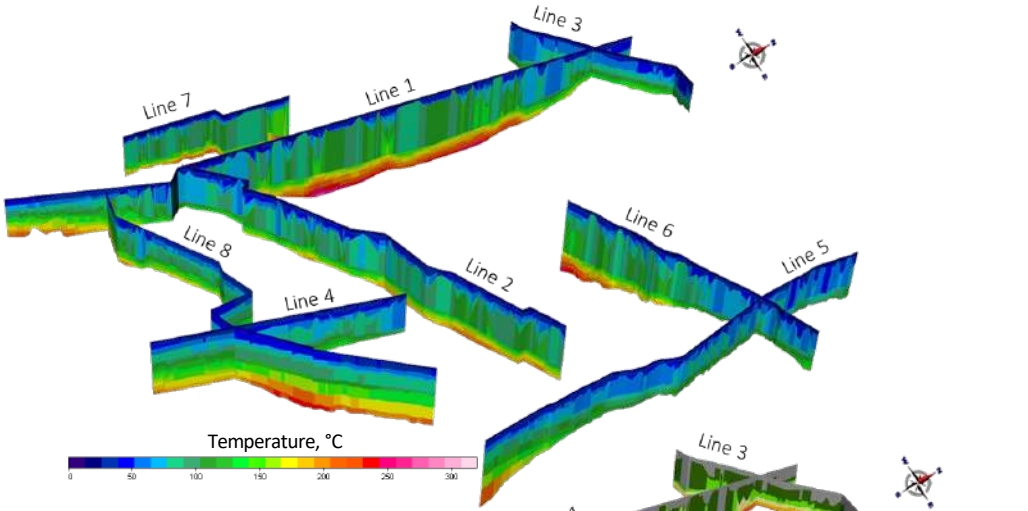
Input Data:

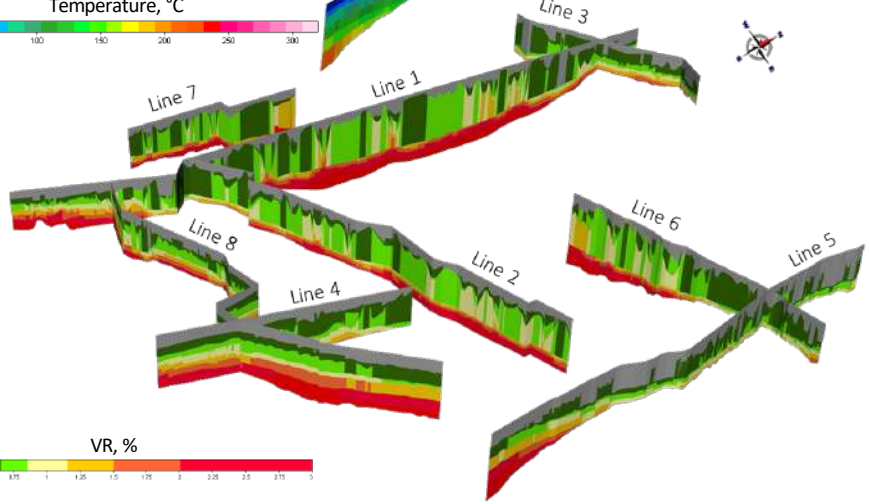
- seismic data interpretation results and **8** Lines;
- facies fill for **8** Lines ;
- measurement data T_{res} (**5 wells**) и R^{o}_{vt} (**6 wells**);
- geochemical characterization of SR for **4** Lines.



BUILDING 2D MODELS

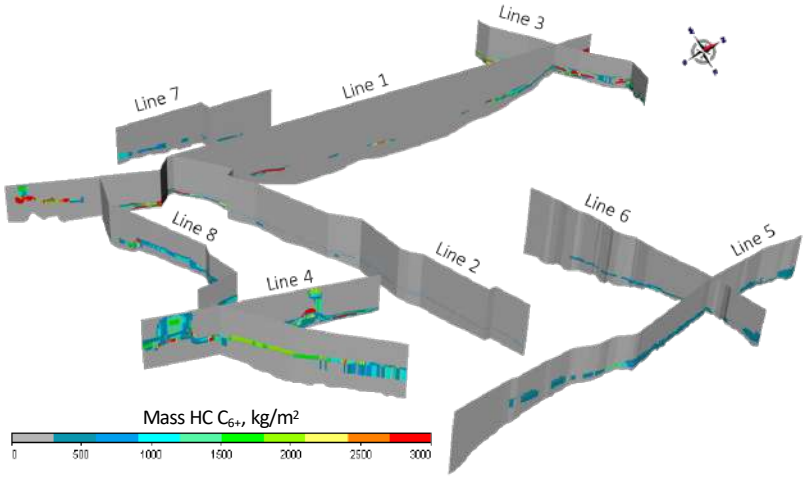


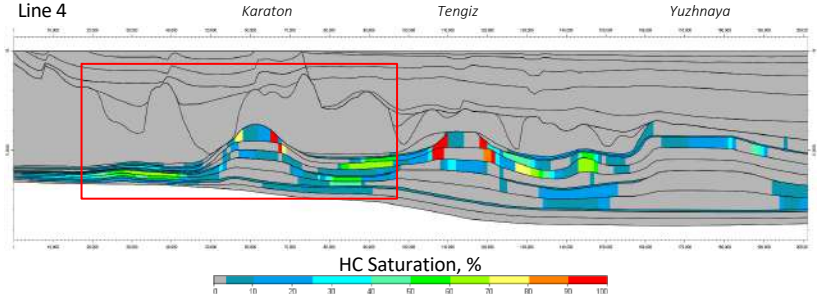




The simulated results show that Pre-Salt deposits reach late stage of catagenesis. At present, almost everywhere, the petroleum potential was **fully realized**. This conclusion is consistent with the results published earlier on the comparison of biomarkers in oils and in source rocks in the north and in the south of the Pre-Caspian Basin (Dakhnova et al., 2000, Daukeev et al., 2002).

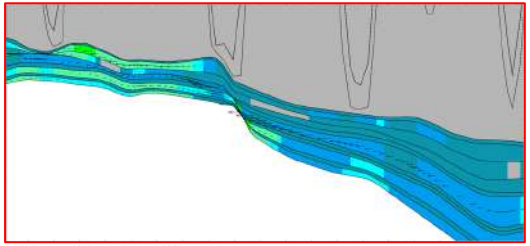
2D BASIN MODELLING RESULTS

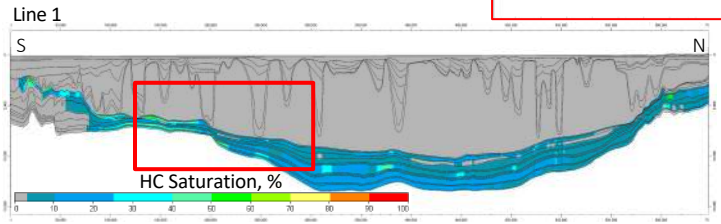




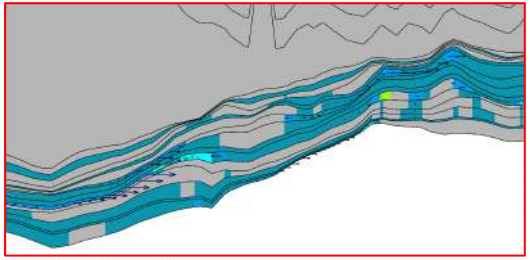
High hydrocarbon saturation is reported mainly in the facies of the Upper Devonian-Lower Permian carbonate platforms and in sandstones that belong to different ages.

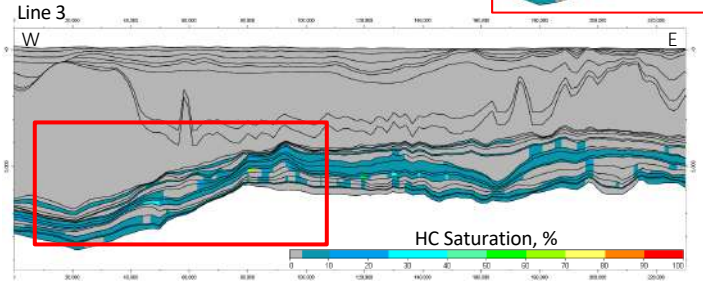
The main flow of hydrocarbon fluids goes from a deeper central region of the basin to its flanks.





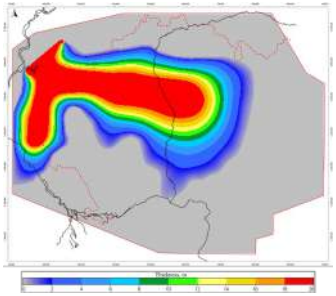
An additional contribution to the hydrocarbon generating potential of this region was due to the expulsion of fluids from local kitchens that are present between carbonate platforms.



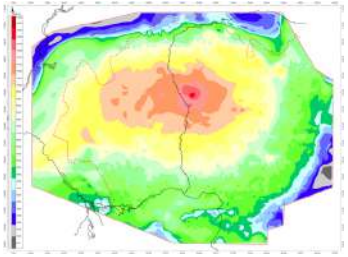


BUILDING 3D MODEL

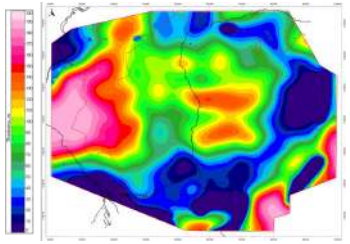
Fan thickness maps



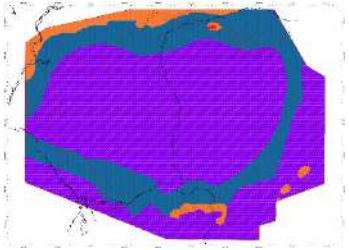
Structural surfaces

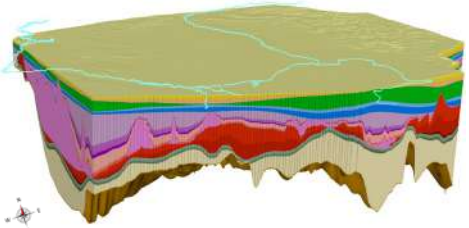


SR thickness maps

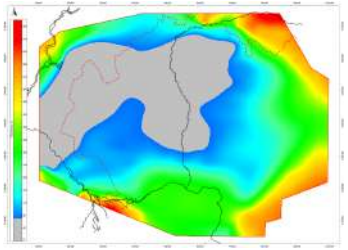


Facies maps

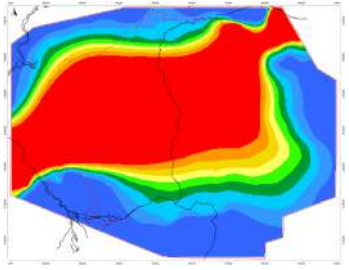




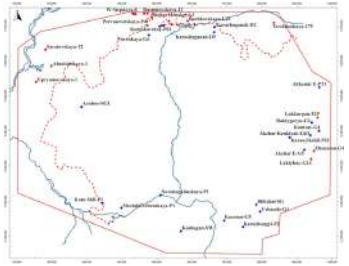
Erosion maps



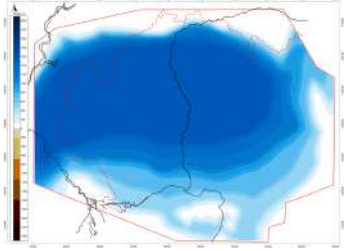
Maps TOC_0 and HI_0



Well data for model calibration



Paleodepth basin maps

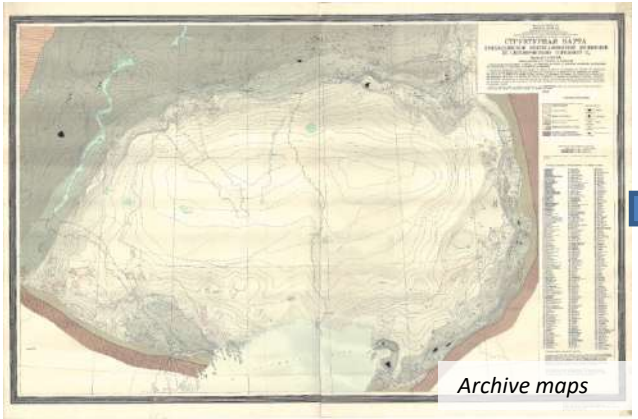


The model is based on a geological concept with a simplified tectonics and geology, because of the ordinary quality of the input data, scattered over the area:

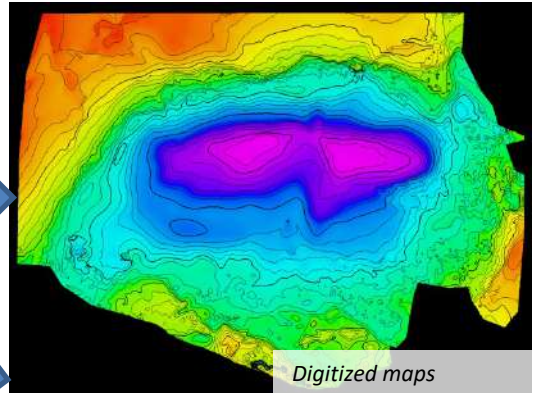
- **11** structural surfaces;
- **3** fan thickness maps;
- **4** source rock thickness maps;
- **24** facies maps;
- **5** paleodepth basin maps;
- **8** erosion maps;
- **8** maps (TOC_0 и HI_0) for 4 source rock ;
- temperature measurements in **20** wells;
- vitrinite reflectance measurements in **19** wells.

PREPARATION OF STRUCTURE MAP

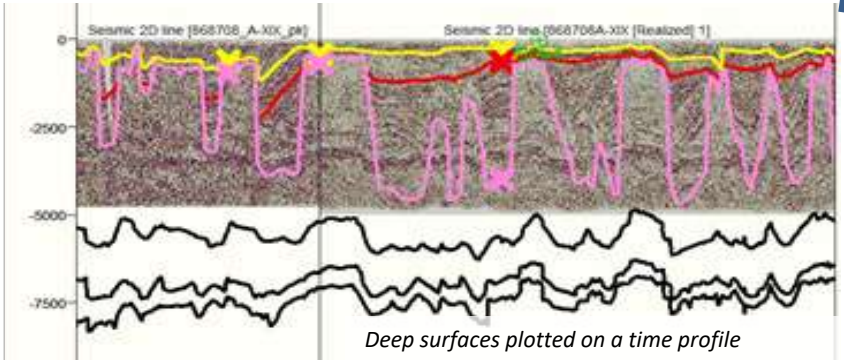
Digitization and linking of multi-scale maps



Archive maps

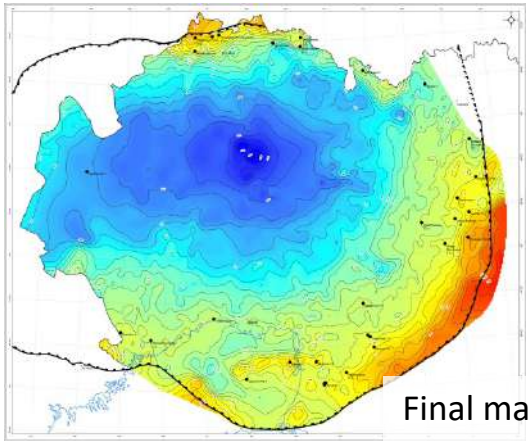


Digitized maps



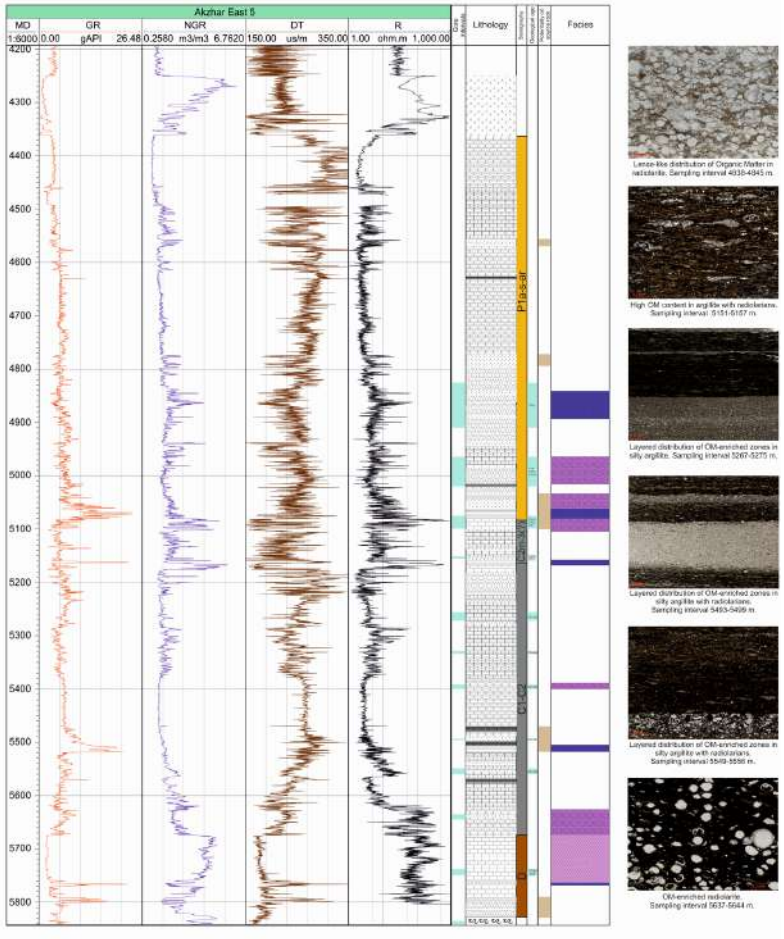
Deep surfaces plotted on a time profile

Linking maps and seismic profiles



Final map

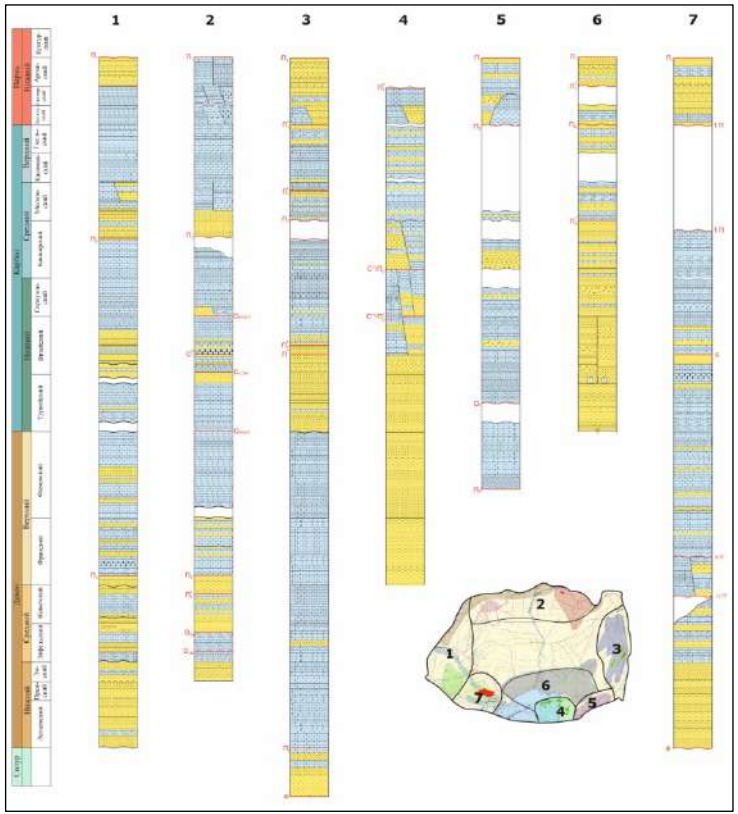
WELL DATA



- Well history and well logging data from 32 wells submitted by PGS
- Available core material, including wells Akzhar East 5, Biikzhal SG-2, Embinskaya 9, Kozhasai PGS-1 and Karaulkeldy P-21*
- Petrographic thin sections were made and lithological analysis was carried out using research methods in petrographic thin sections, including a detailed paleontological analysis.
- Rock-Eval analysis performed on existing samples
- For the other deep wells, information from reporting materials was analyzed, the history of drilling, core sampling, macro-description, laboratory studies and petrographic analysis were studied. Taking into account these data, lithological columns were compiled on summary tablets, core sampling intervals were plotted, information was added to determine the age of deposits.

**The study used data from many pre-salt wells.*
The core from these wells was specially studied additional

Summary lithological-stratigraphic columns of the pre-salt section in various parts of the Precaspian depression

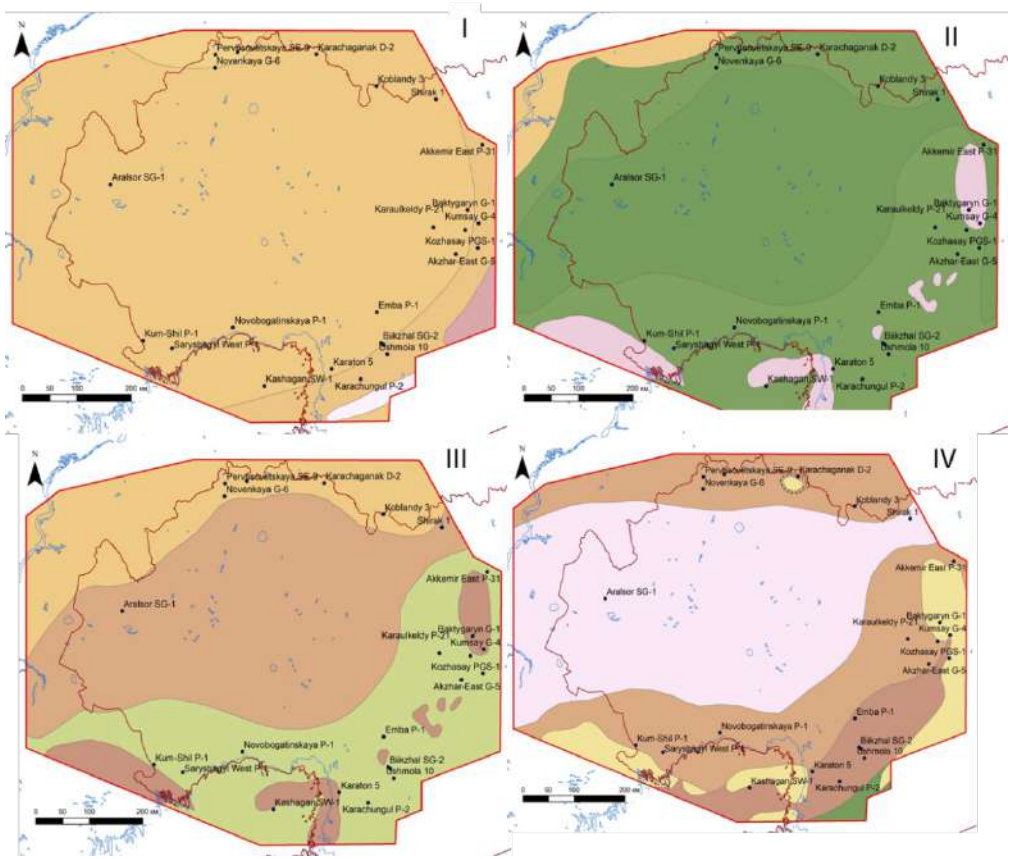


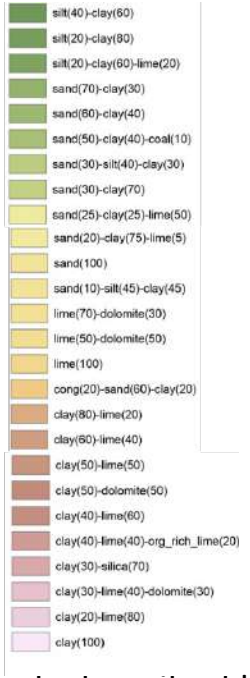
The data for filling the structural framework of the 3D model included a set of lithofacies maps, a set of paleobathymetry maps, a set of erosion maps and a set of maps with the characteristics of oil source rocks. Data collection for the construction of these maps began with the compilation of generalized lithological and stratigraphic columns characterizing the structure of the subsalt section of various parts of the Caspian depression

1 – West-north-west side
2 – North side zone
3 – East side zone
4, 5, 6 – South side zone
7 – Astrakhan massif

Yellow color shows predominantly clastic,
blue - predominantly carbonate deposits

LITHOLOGICAL-FACIAL MAPS

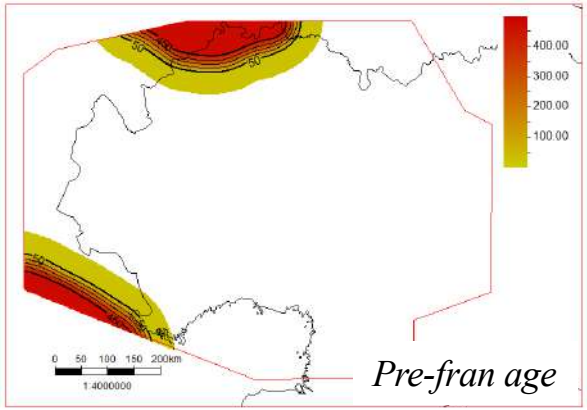




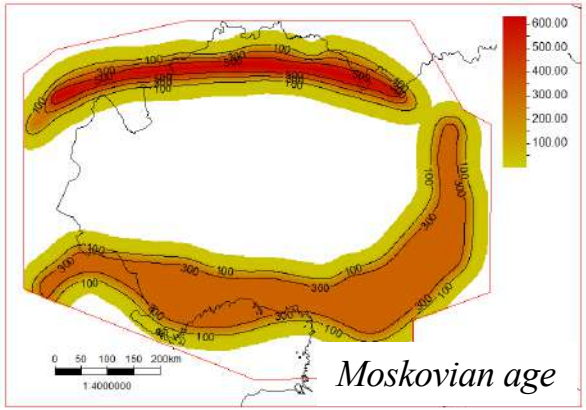
I - deposits of the Lower Devonian, II - deposits of the Eifelian stage of the Middle Devonian, III - deposits of the Givetian stage of the Middle Devonian IV - deposits of the Frasnian stage of the Upper Devonian.

Similar maps were prepared for other ages.

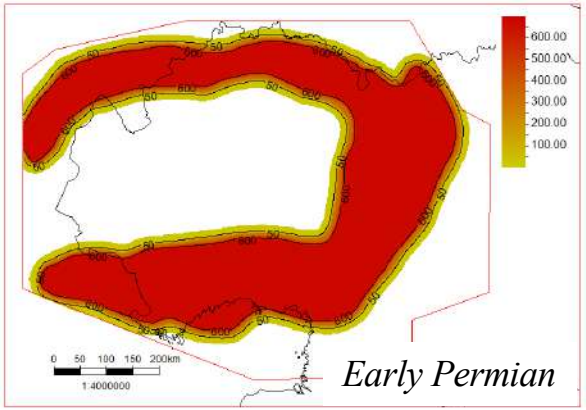
EROSIAN THICKNESS MAPS



Pre-fran age



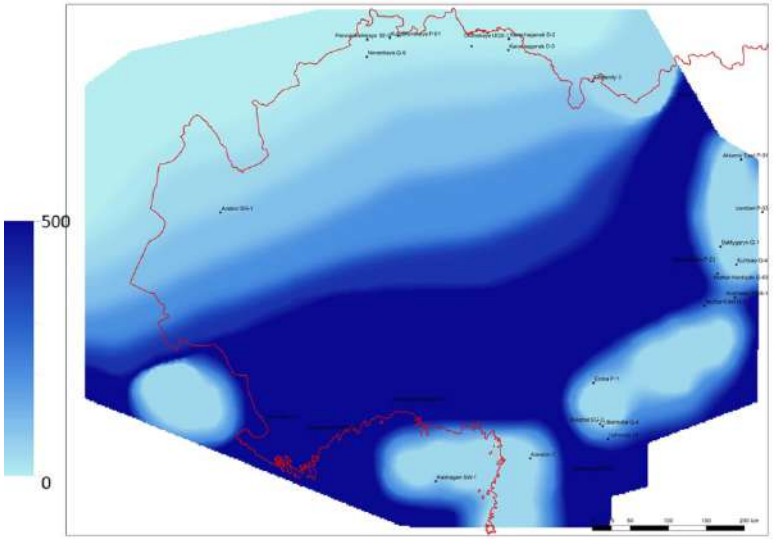
Moskovian age



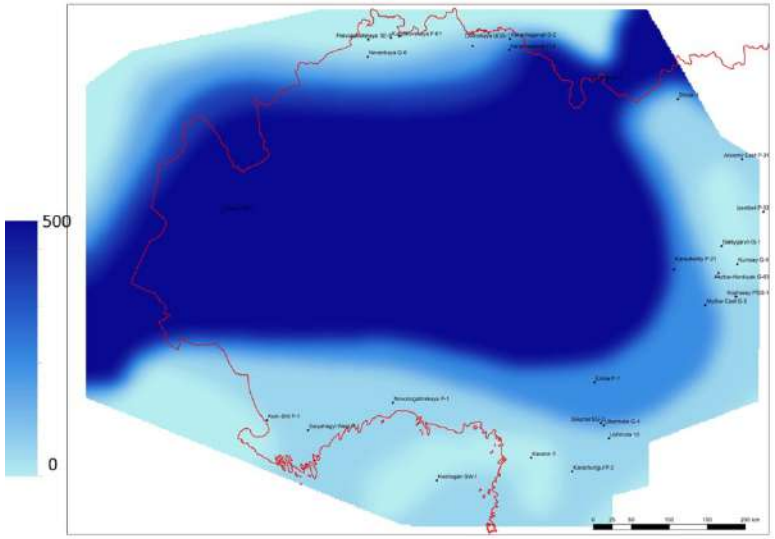
Early Permian

Similar maps were prepared for deposits of the Mesozoic-Cenozoic age.

PALEOBATHYMETRY MAPS



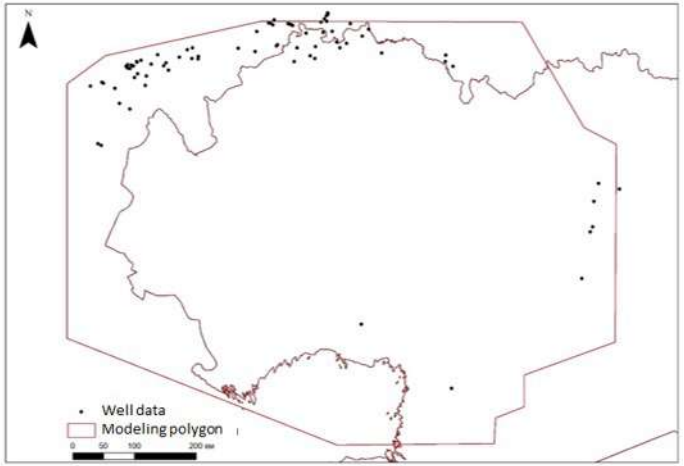
Early-Middle Devonian



Late Devonian

Similar maps were prepared for deposits of the Carboniferous and Permian ages

Geochemical data, including the results of pyrolysis carried out within the framework of the project



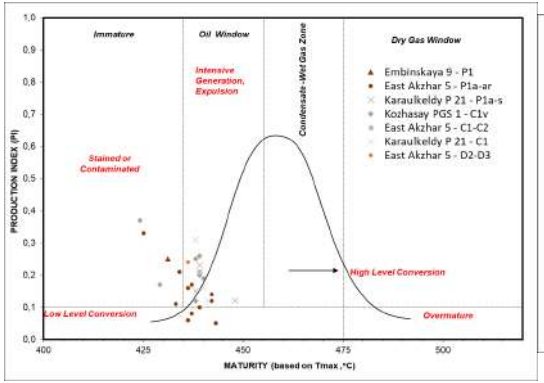
Layout of sampling areas

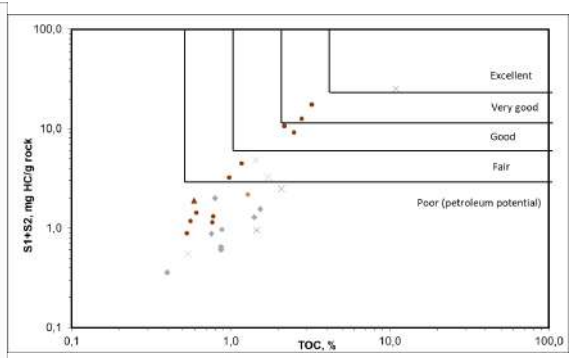
Source rock parameters used in modeling

Source rock	TOC initial, %	HI initial, mg HC/g TOC	Thickness, m
C_2m-P_1	2	300	10-200
C_1v-C_2b	2	350	20-100
D_3-C_1t	5	600	60-120
D_2	5	500	25-100

It should be noted that the measured values of geochemical parameters directly in the core of wells are not enough, and they are distributed unevenly over the area and section, which significantly reduces the reliability and detail of the constructions.
A brief geological and geochemical description is given for oil and gas source deposits, which are most clearly defined in the frame of the depression in the interval of the Middle - Upper Devonian, Lower Carboniferous and Lower Permian.

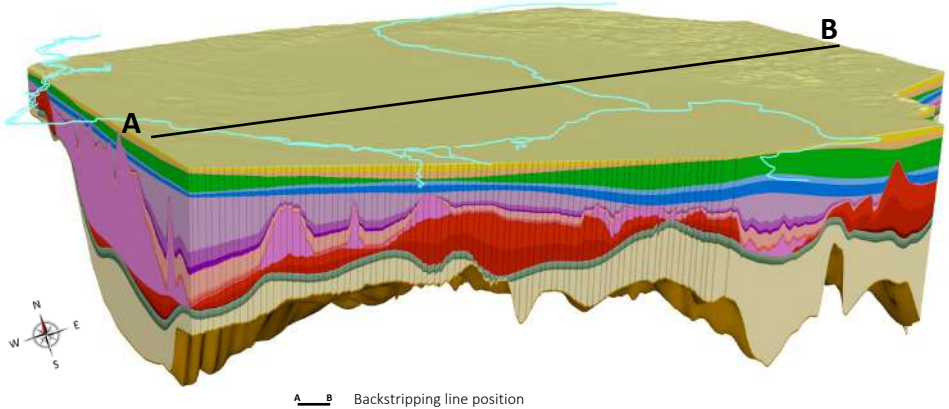
Pyrolytic studies to establish the generation potential of rocks using the Rock-Eval method



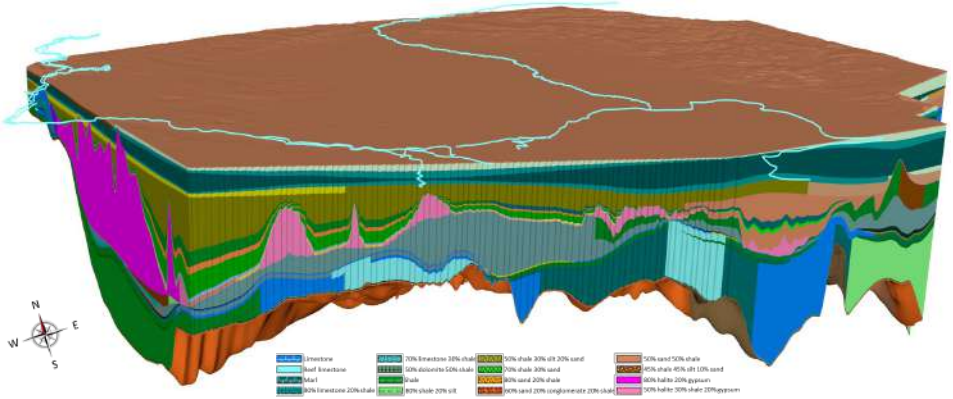


Additional studies of 30 rock samples taken from wells Embinskaya 9, Kozhasai PGS 1, East Akzhar 5, Karakulkeldy P 21 were carried out using the Rock-Eval method with further interpretation.

BUILDING 3D MODEL

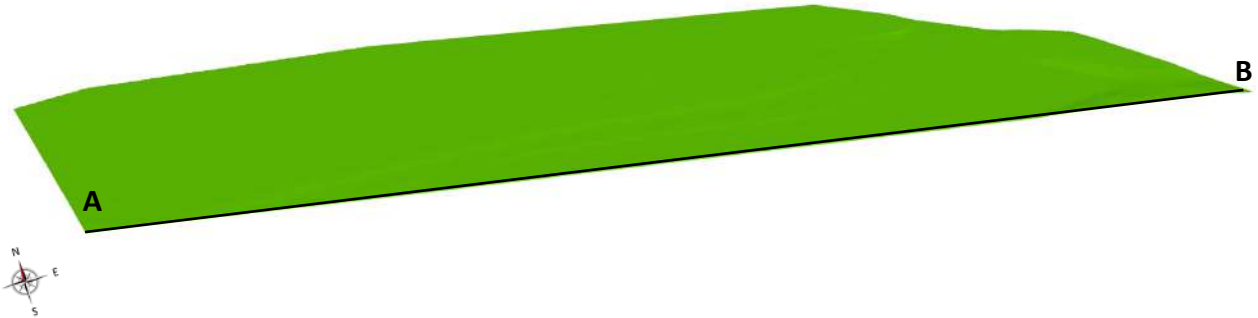


Structural framework



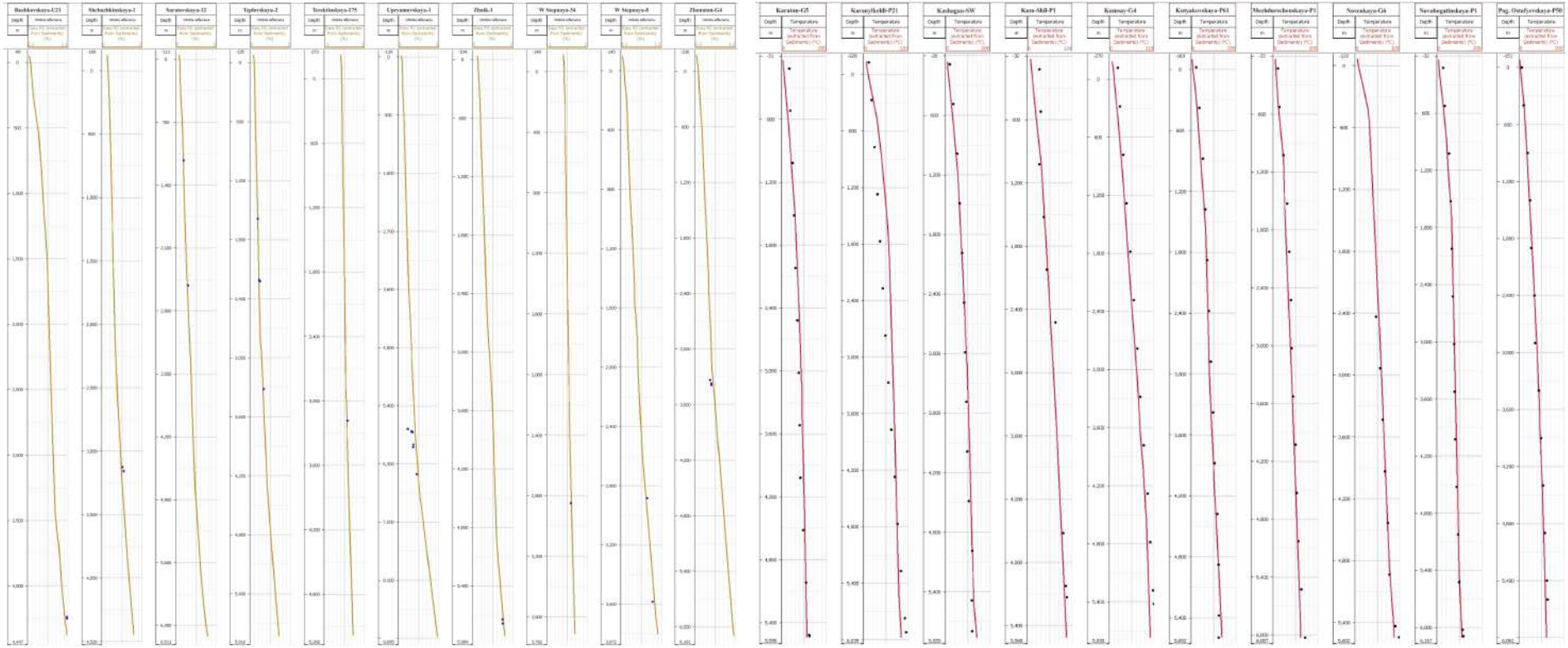
Lithology Distribution of model

Once the structural framework was built and the lithological and geochemical parameters of the model defined, the basin's paleostructure restoration was completed using the backstripping approach. This step took into account the sediment compaction, erosion events, and paleobathymetry.



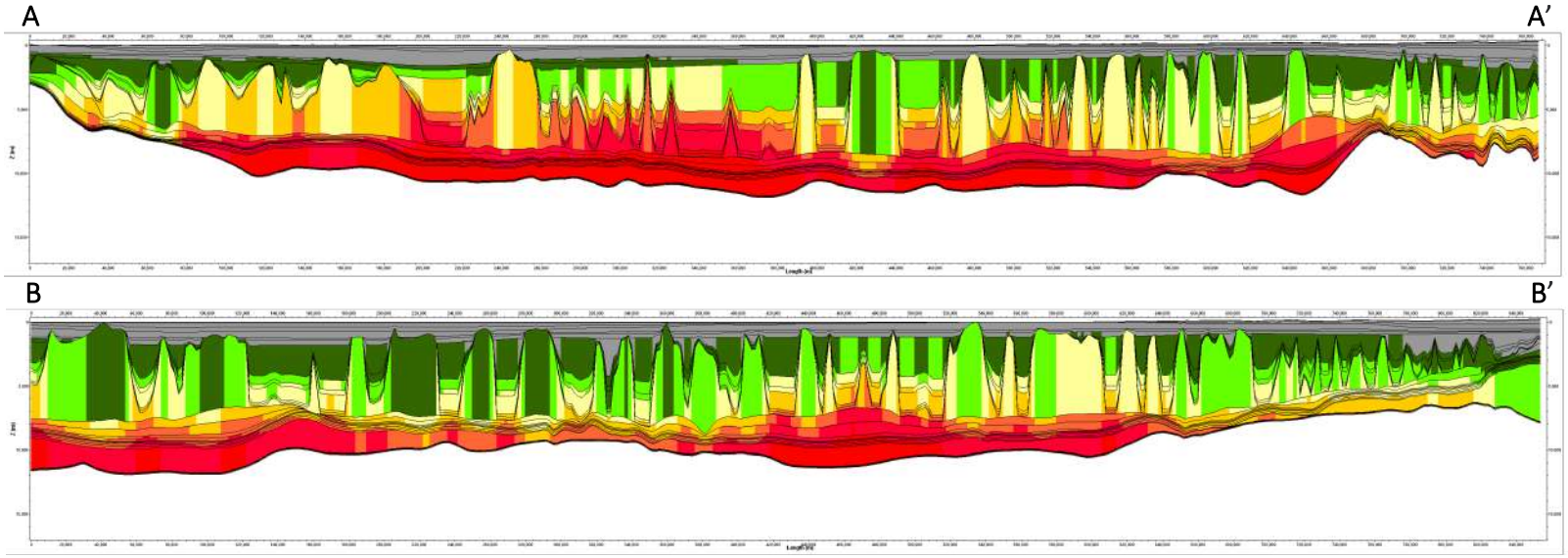
- Model size: **615 072 km^2**;
- Layers: **31**;
- Cell size: **2 ×2 km**;
- Total number of grid cells: **4 766 808**

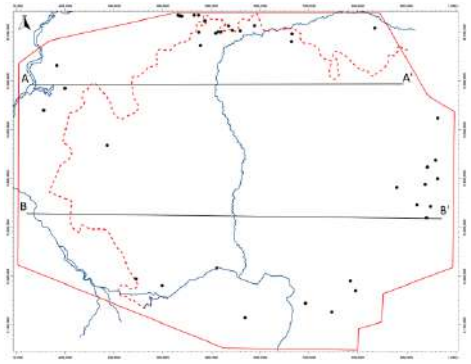
BASIN'S GEOTHERMAL HISTORY CALIBRATION



3D Model Calibration (points show the actual measurements, the curve shows the modeled data): on the left – based on Vitrinite Reflectance, on the right – based on Temperatures

3D BASIN MODELLING RESULTS

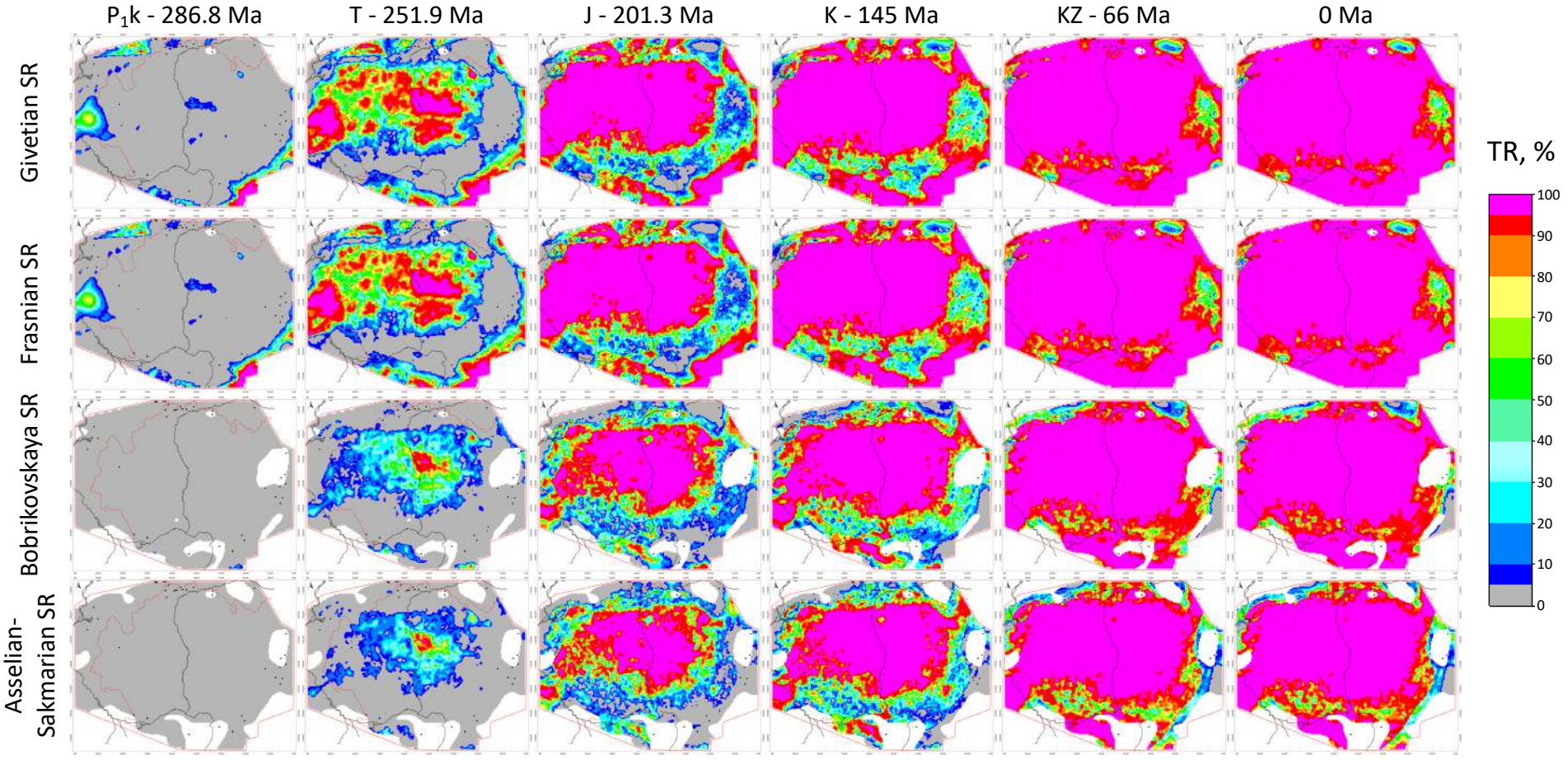




The processes of halokinesis significantly affected the level of catagenesis in both underlying and overlaying intervals. Salts impact the temperature distribution not only through cooling the pre-salt interval down, but also through significant heating of the Mesozoic interdome sediments, which reduces the depth-related catagenetic zonal distribution.

3D BASIN MODELLING RESULTS

Transformation ratio through geological time



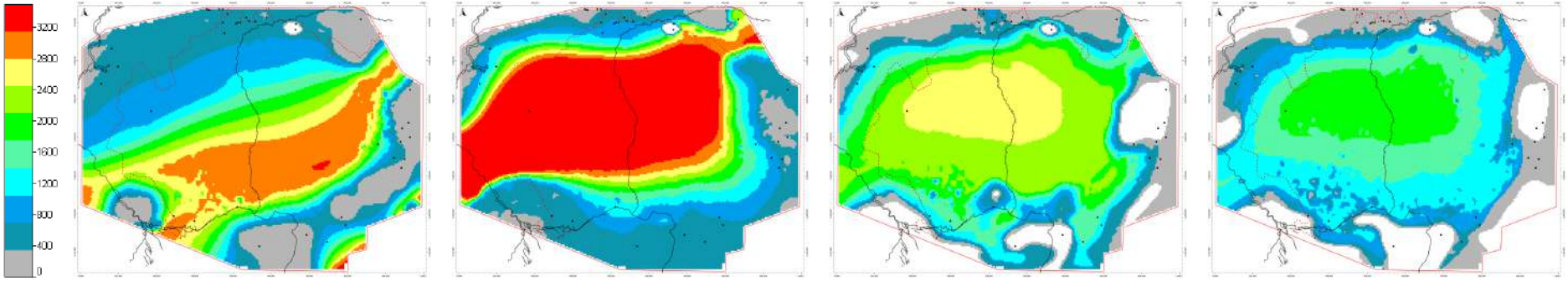
3D BASIN MODELLING RESULTS

Mass of expelled HC estimated for Devonian-Lower Permian sequence

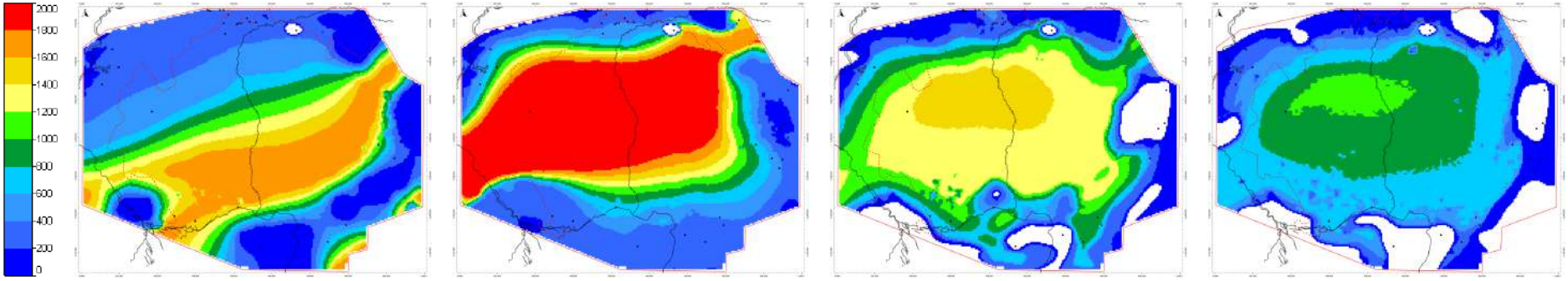
In accordance with modelling results **4.70 trillion tons** expelled out of 4 main source rocks (SR) in total: **1.69 trillion tons** of liquid fluid and **3.01 trillion tons** of gaseous fluid, respectively. The zones of the maximum expulsion generally coincide with the areas of the maximum generation. The total quantities of generated HC is 8.58 trillion tons.

Givetian SR ***Frasnian SR*** ***Bobrikovskaya SR*** ***Asselian-Sakmarian SR***

Gaseous Hydrocarbon Expulsion Density (kg/m^2)

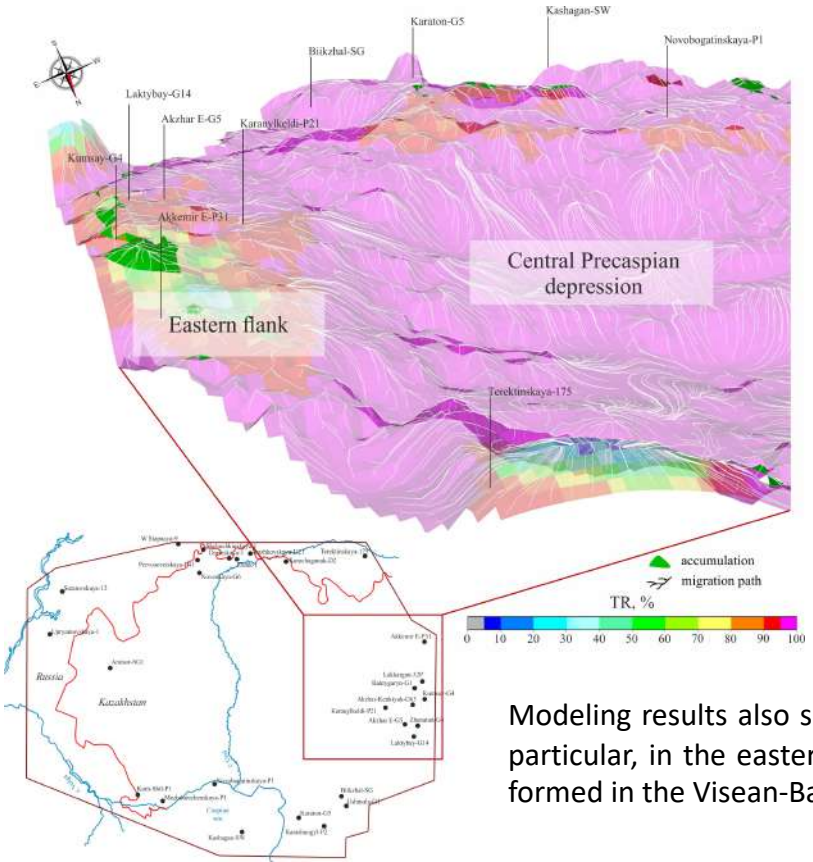


Liquid Hydrocarbon Expulsion Density (kg/m^2)

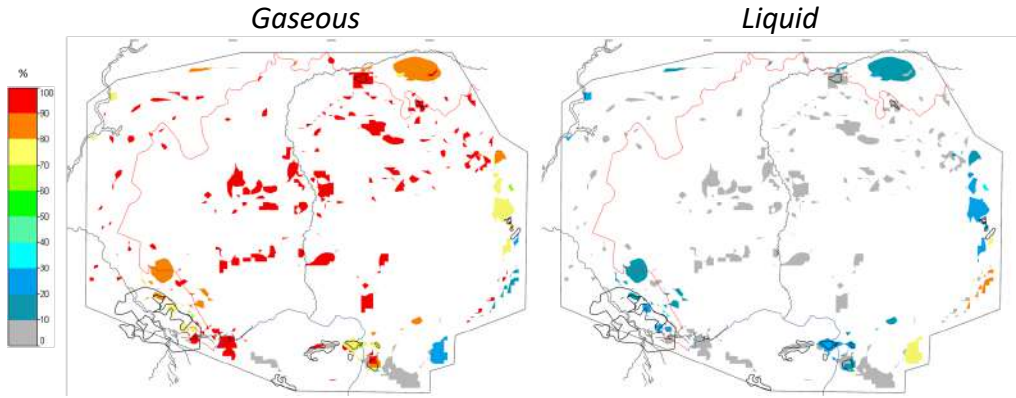


3D BASIN MODELLING RESULTS

Potential Accumulations within the Temir Carbonate Platform



Simulated HC traps in the Pre-Caspian Clastic Pre-Salt Sequence



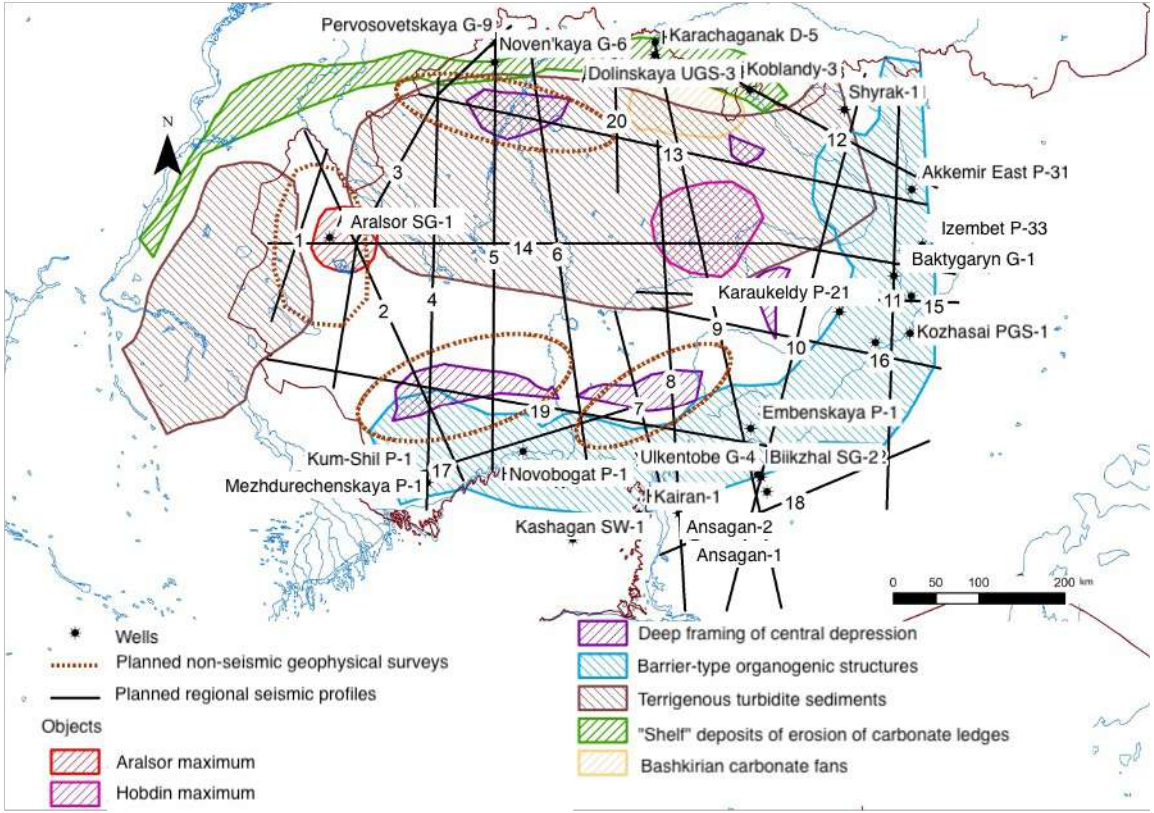
Also, as part of the work, the prospects in the clastic intervals were evaluated : the Upper Carboniferous and Lower Permian fans. It is very important to note that in the model, these intervals normally had relatively good reservoir properties over the entire area of extent. In reality, the presence of extended continuous migration pathways remains questionable for this play.

Modeling results also show the presence of new prospective intervals at various stratigraphic levels. In particular, in the eastern flank of the Pre-Caspian Basin, within the Temir carbonate platform, oil traps formed in the Visean-Bashkirian and Famennian.

RESULTS OF PHASE-1

- Based on the analysis and basin modeling, priority zones are identified and a separate forecast is given for three main oil and gas levels and types of traps, the share of gas in the total volume of emigrated hydrocarbons is 64%;
- Taking into account the prioritization, proposals have been prepared for the location of future regional works (Phase 2);
- The optimal design and location map for regional seismic surveys and possible non-seismic studies are substantiated;
- Five options of the design forseismic geotraverses have been developed, the results of full-vector modeling have been taken into account when preparing recommendations (VNIGNI, S.A. Kaplan);
- Advanced processing technologies based on Deep Migration before Summation (GMDS) are proposed.

PROSPECVIVE AREAS



East and South-East side

- Internal framing of the Astrakhan-Aktobe uplift zone;
- Organogenic barrier-type buildings;
- Temir Carbonate Platform;
- Guryev Vault;

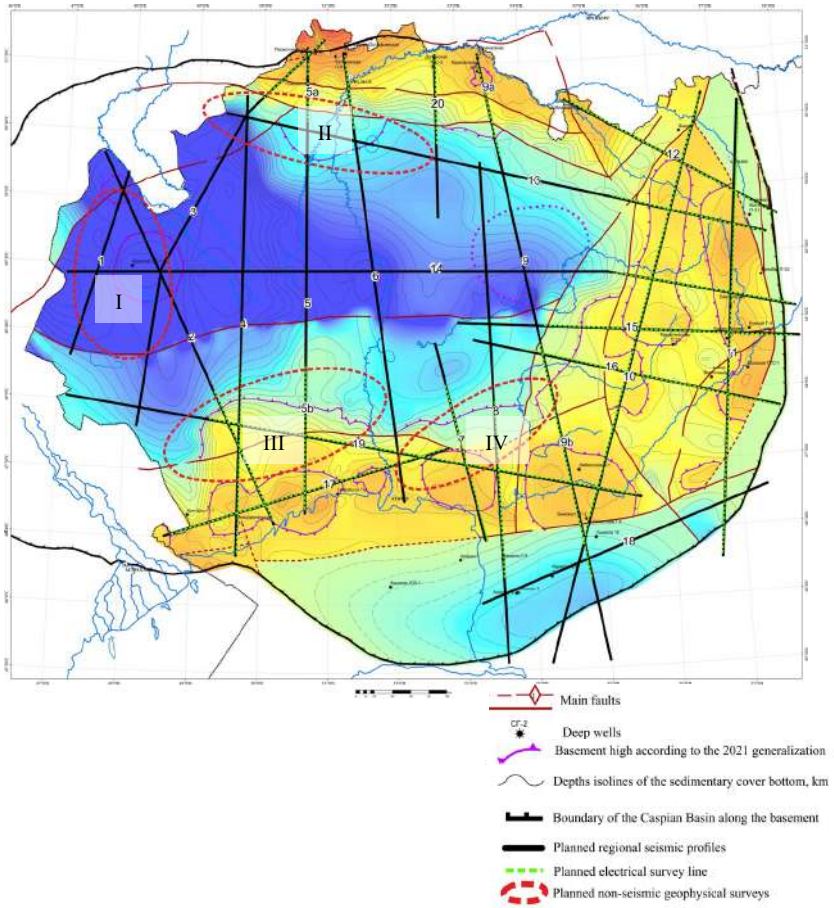
North side

- Carbonate cones of Bashkir age removal;
- "Shelf" deposits of erosion of carbonate ledges;
- Terrigenous removal cones (Bobrikov deposits);

Central depression

- Terrigenous turbidite sediments with a capacity of hundreds of meters;
- Deep framing of the central depression (large tectonically shielded uplifts identified according to the refraction correlation method data);
- Aralsor and Hobdinsky gravitational maxima.

SCOPE OF WORK FOR THE PHASE-2



SEISMIC	
Profile number	**Length, km**
1	210
2	448
3	485
4	505
5	511
6	497
7	223
8	550
9	680
10	647
11	501
12	264
13	605
14	803
15	375
16	344
17	327
18	340
19	638
20	177
Sum	9130

ELECTRICAL EXPLORATION MTS	
Profile number	**Length, km**
2	158
3	91
4	199
5a	80
5b	161
6	80
7	177
8	197
9a	115
9b	267
10	512
11	495
12	264
13	172
14	204
15	276
16	288
17	321
19	480
20	99
Sum	4636

NON-SEISMIC GEOPHYSICAL RESEARCH	
Zone	**Area, km^2**
I	15920
II	14273
III	20902
IV	12307

SUMMARY

- The estimated total volume of hydrocarbons that emigrated from all the oil and gas source rocks of the Devonian-Lower Permian part of the section is estimated at 4.7 trillion tons o.e.
- Various options for estimating the proportion of hydrocarbons accumulated in traps (depending on the type and condition of hydrocarbon systems (HC), including:
- – Traditional for "traditional" oil and gas bearing another option is the accumulation of about 5% of the generated HC that emigrated from the oil and gas source rocks. In this case, the total forecast resources are estimated at about 230 billion tons.;
- – "Autoclave" (without removing the generated hydrocarbons outside the generation zones). In this case, the so-called generation suppression occurs, but most of the HC remains within the generation zones. In this case, the hydrocarbon potential may exceed 1000 billion tons, which in large part will be "unconventional".
- The analysis allows us to specify the geological task of an ultra-deep well: establishing the type and condition of the HCS (including the Predevonsky section). Passing searches for hydrocarbon deposits are permissible.

SUMMARY

The Caspian oil and gas megabasin is a unique, unparalleled geological structure.

- The main part of the generated volume of hydrocarbons falls on the central part uncovered by wells. The estimation of the initial total resources, depending on the type and condition of the initial total resources, varies 4-5 times; in the maximum version (autoclave HC system) Initial cumulative resources may exceed 1000 billion tons.o.e.
- Quality options and development opportunities also differ significantly;
- Verification of the validity of hypotheses is possible only by the direct method, that is, by drilling a parametric well;
- The implementation of the Phase-2 program will allow you to more accurately determine the its location.

ONE TRILLION TONS OF POTENTIAL O.E.I.P. RESOURCES
–THIS IS EXACTLY WHAT YOU CAN THINK
AT THE END OF THE WORKING WEEK!!

Thanks for your attention!