CELEBRATING 10 YEARS
SPE Caspian Technical Conference and Exhibition
21-23 November 2023
Baku, Azerbaijan

Paper No. SPE-217596-MS

Oil & Gas Exploration and Development with the Reverse Time Holography Technology

G. Erokhin, M.Erokhina and K.Safran,

GEOMEX Technologies, Mexico

Reverse Time Holography (RTH) Technology

- RTH is approach for processing and interpreting seismic data based on the principles of holography and scattered wave reversal in time
- The technology is a further vector-based development of Reverse Time Migration and is an alternative to FWI, AVO, Acoustic Inversion etc.
- Technology fully compatible with Machine Learning geology prediction based on well-logging data
- The principles of two beams interferometry, which underlie RTH, significantly increase the spatial resolution of seismic exploration on scattered waves, which is limited only by the size of the voxels into which the entire volume is divided
- The backscattering model in RTH allows scattering to depend not only on direction (angular anisotropy), but also on frequency
- The Technology is implemented through computing programs for a specialized GPU cluster “RTH Imaging Engine” with a performance of 1 Petaflops

RTM &RTH processing workflow comparison

RTM

Common-shot gathers

Decomposition

Data decomposition based on second order wave equation with known velocity

p^f **-forward pressure**

p^b **-back pressure**

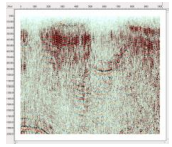
Voxel x

Common Image Gathers $(p^f, p^b) \in R^2$

Attributes Syntheses

Appling RTM Imaging Condition (integration by sources and time)

RTM Imaging



Depth Cube

RTH

Common-shot gathers

Data decomposition based on first order acoustic equation with initial velocity model

p^f **-forward pressure**

p^b **-back pressure**

$\vec{f}$ **-forward vector particle velocity**

$\vec{b}$ **-back vector particle velocity**

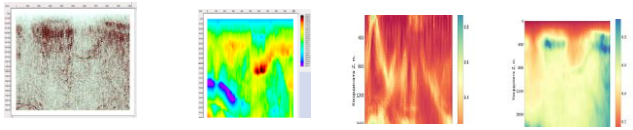
Voxel x

Vector Domain Common Image Gathers $(p^f, p^b, \vec{f}, \vec{b}) \in R^8$

Statistical parameters estimation of multidimensional stochastic distribution

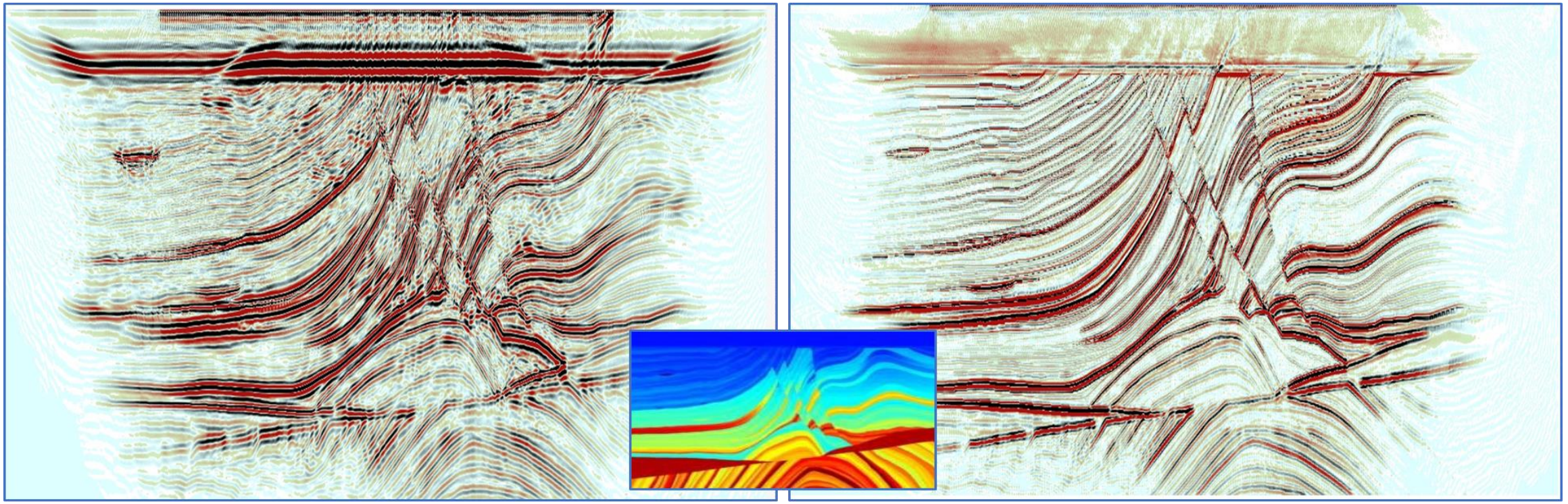
There is no summation by sources and time

More than 100 RTH attributes



Depth Cubes

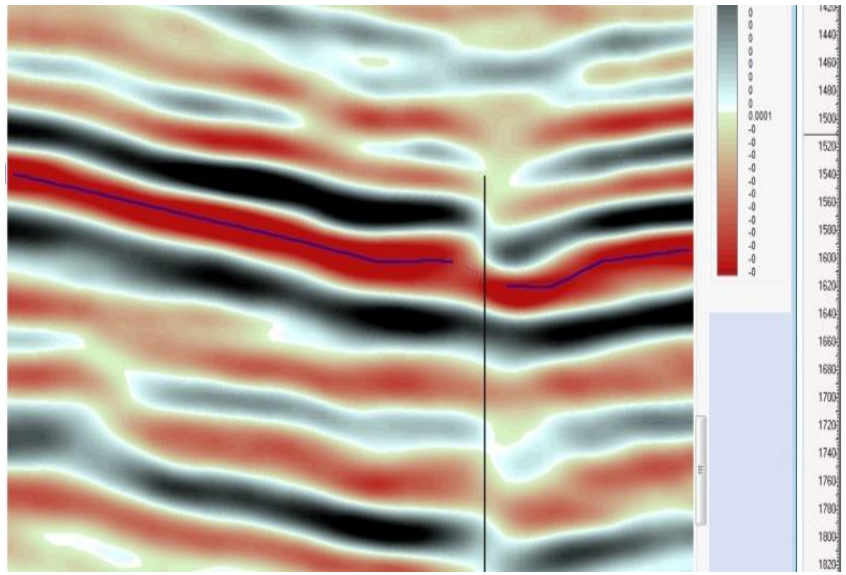
Comparison of RTM and RTH



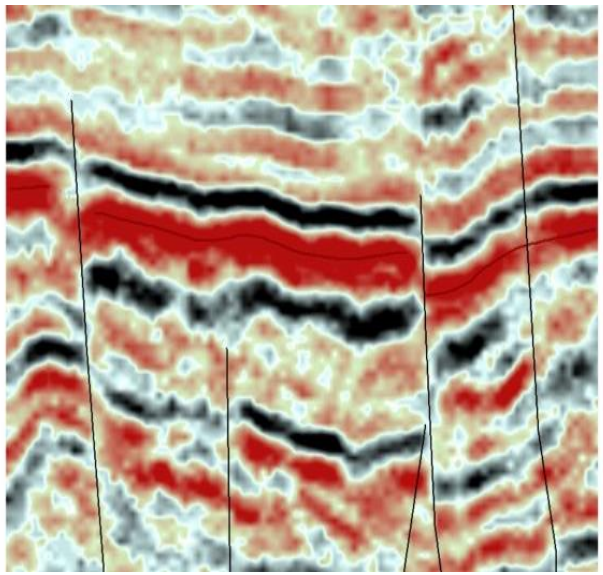
RTM

RTH

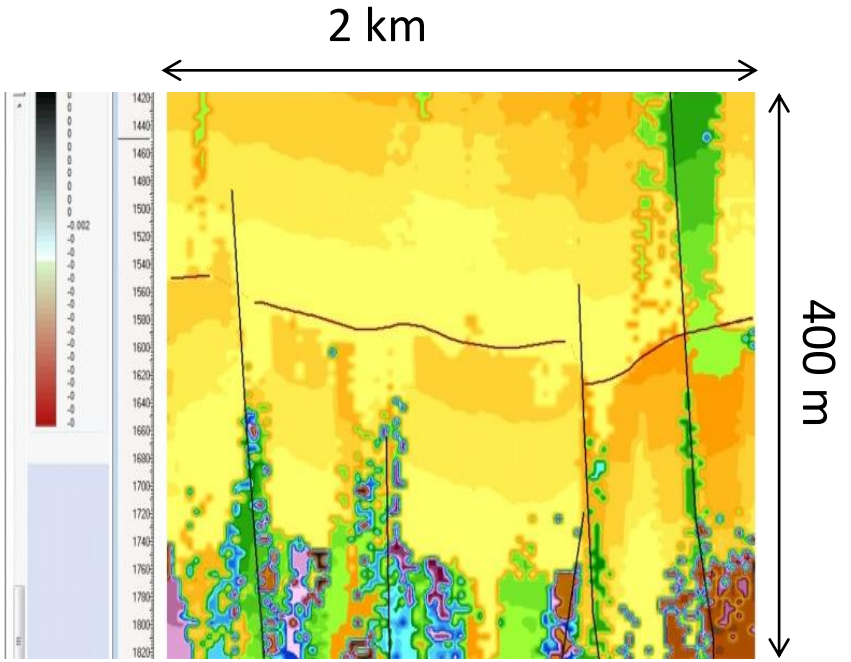
Comparison of RTM and RTH for fractured foundation



RTM



RTH Phase



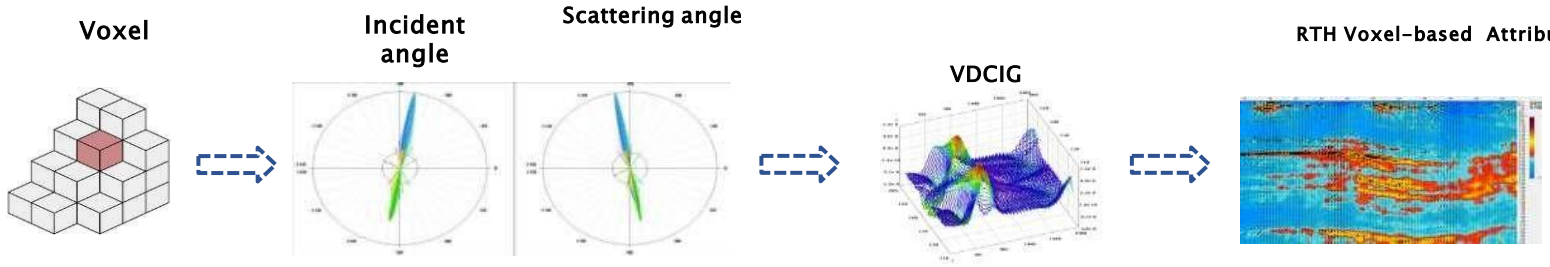
RTH velocity

Voxel size is 12.5x12.5x2.5 m

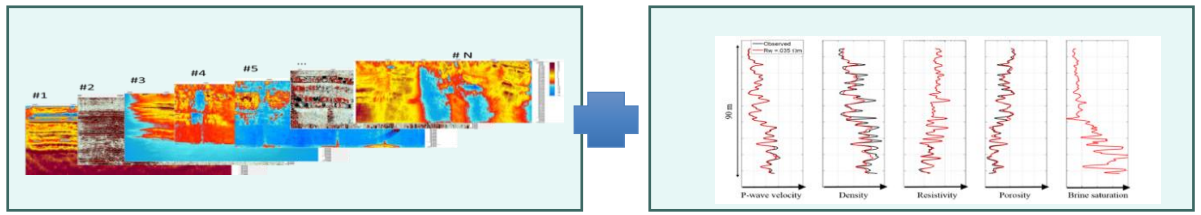
RTH & Artificial Intelligence

The uniqueness of RTH technology for geological prediction using artificial intelligence (AI) methods is based on two RTH properties:

1. **RTH is the voxel-based approach**: RTH attribute information is known in geocoded cells (voxels) of arbitrary size (up to 2 meters) fixed in space which simplifies integration with drilling data

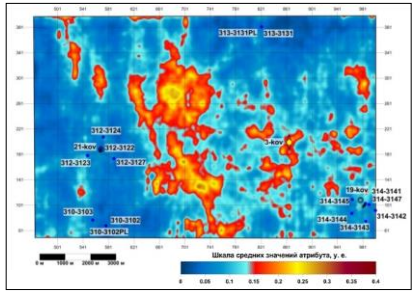


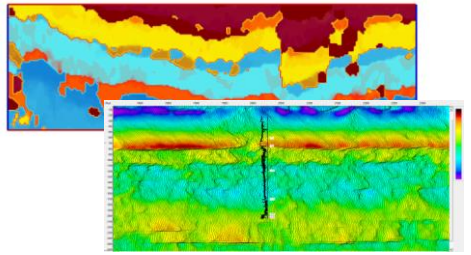
2. **RTH is the hyper attributes approach:** Each voxel contains the values of a large number (more than 100) of RTH attributes

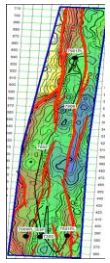


AI TECHNOLOGY!

RTH-prediction Roadmap





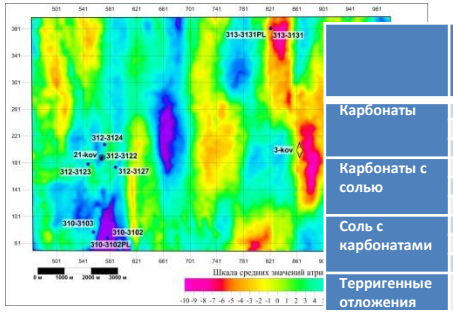


Step 1. RTH processing and interpretation

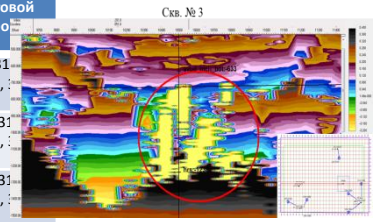
Result: RTH cubes, stratigraphic boundaries, fracture zones, fault zones, angular anisotropy, frequency

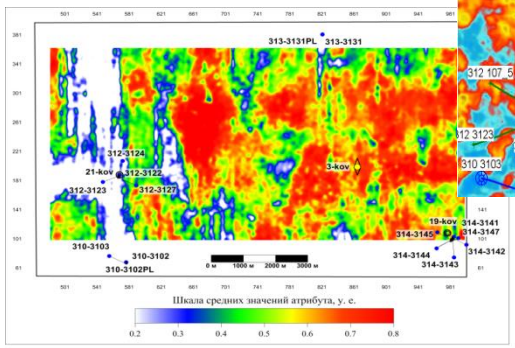
Step 2. Selecting a prediction object, preparation geological data and RTH attributes

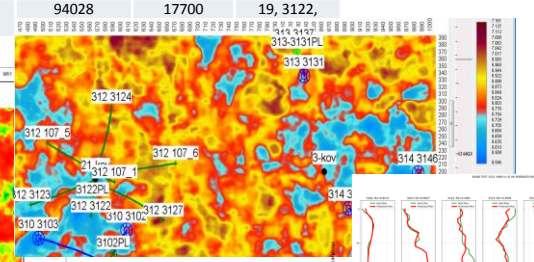
Result: generation of sufficient data sets for training using AI algorithms

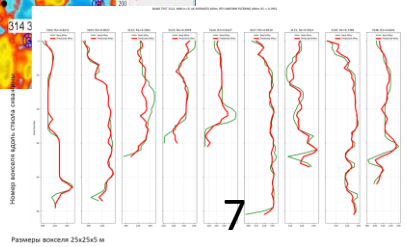


	Радиус окружности, м	Число отсчётов в обучающей выборке	Число отсчётов в тестовой выборке	Скважины тестовой выбо
Карбонаты	200	63334	24010	3, 31
	300	146688	55370	3145,
	400	251932	96580	
Карбонаты с солью	200	30966	10682	19, 31
	300	72390	24634	3145,
	400	125974	42946	
Соль с карбонатами	200	65568	26410	19, 31
	300	151870	59630	3145,
	400	262338	102950	
Терригенные отложения	700	94028	17700	19, 3122,







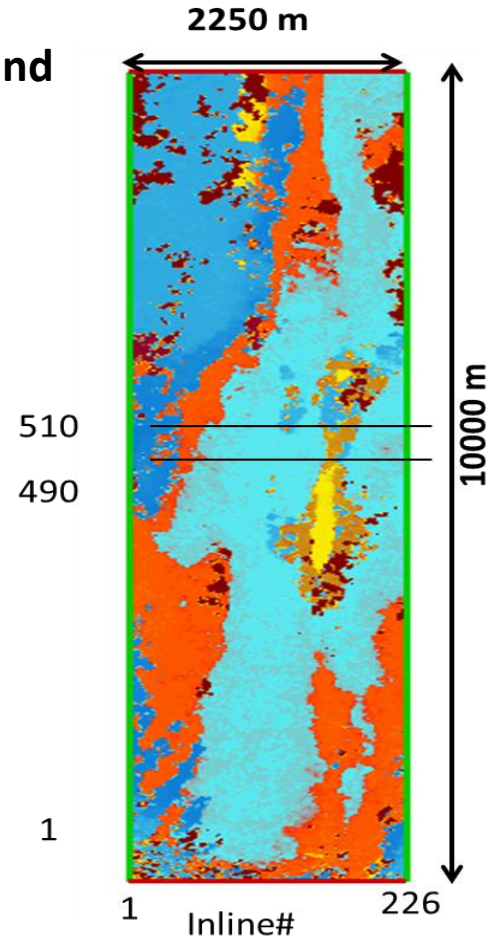


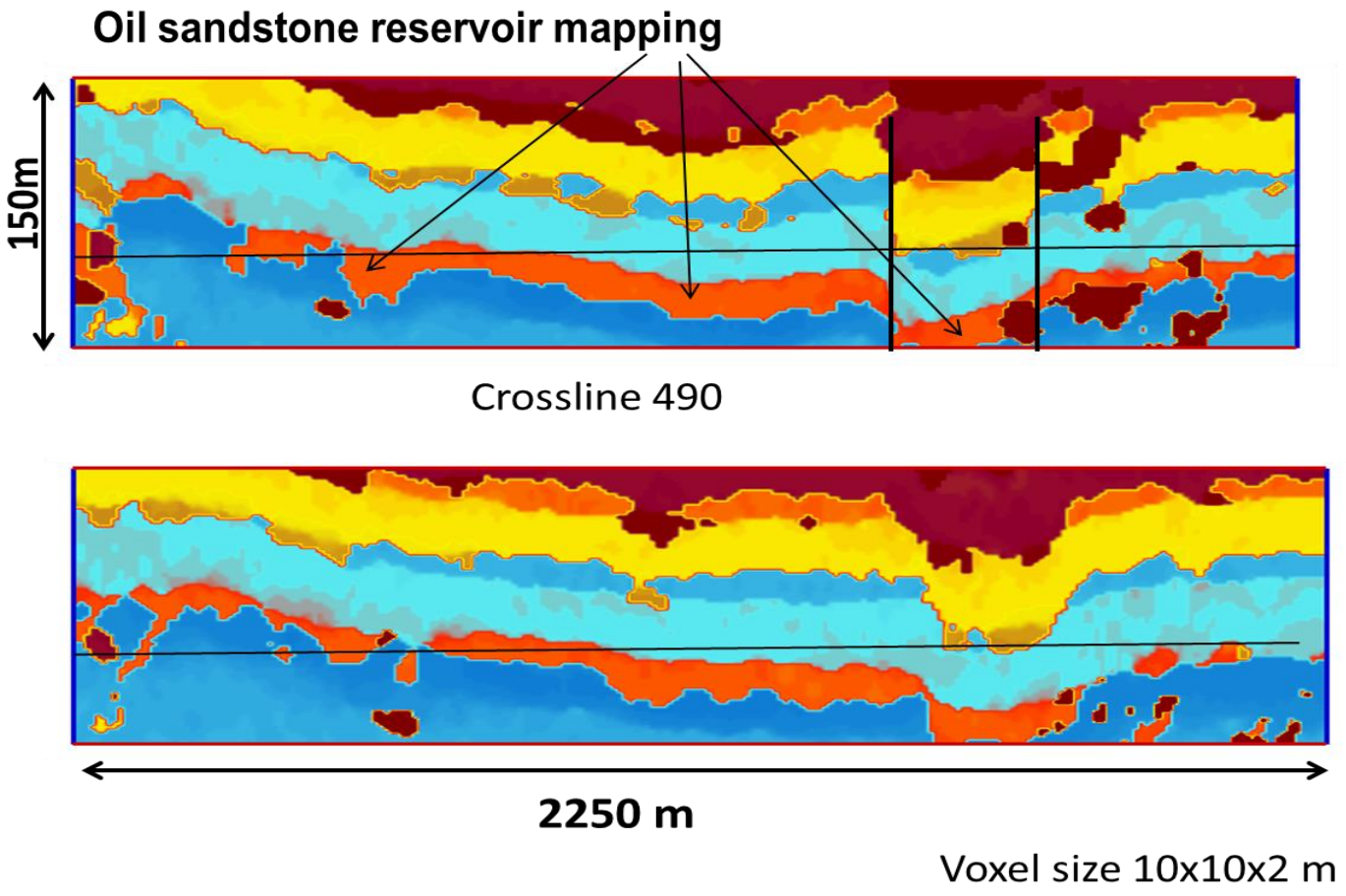
Step 3. AI Prediction

Result: predicted cubes of porosity, gas, oil, permeability, fluid show, flow rates, possible drilling accidents

Identification of target horizon and faults

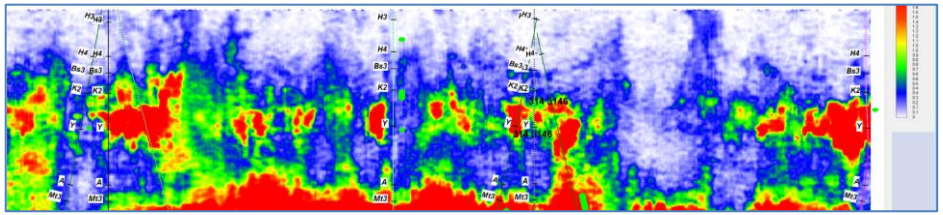
Step 1. RTH processing and interpretation



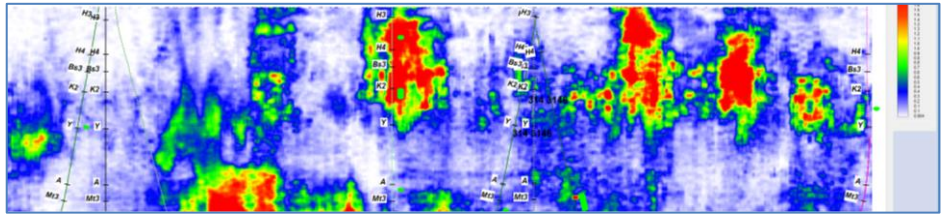


Prediction of Gas, Brine and Fluid based on RTH attributes and well-log

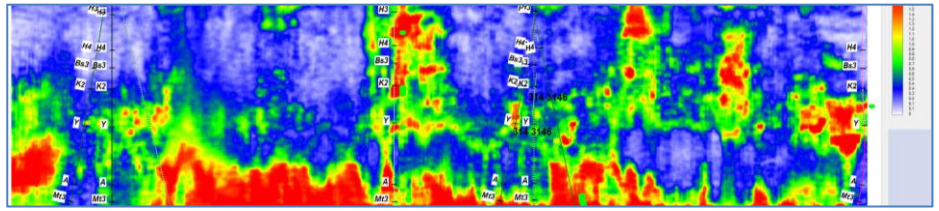
Step 3. AI Prediction



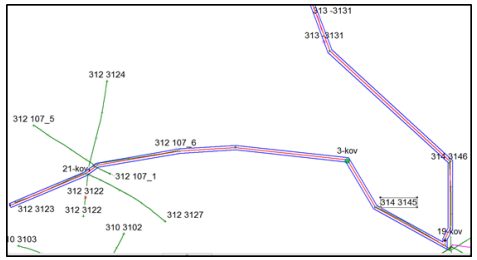
Gas manifestation prediction. Mean 0.018, deviation 0.23



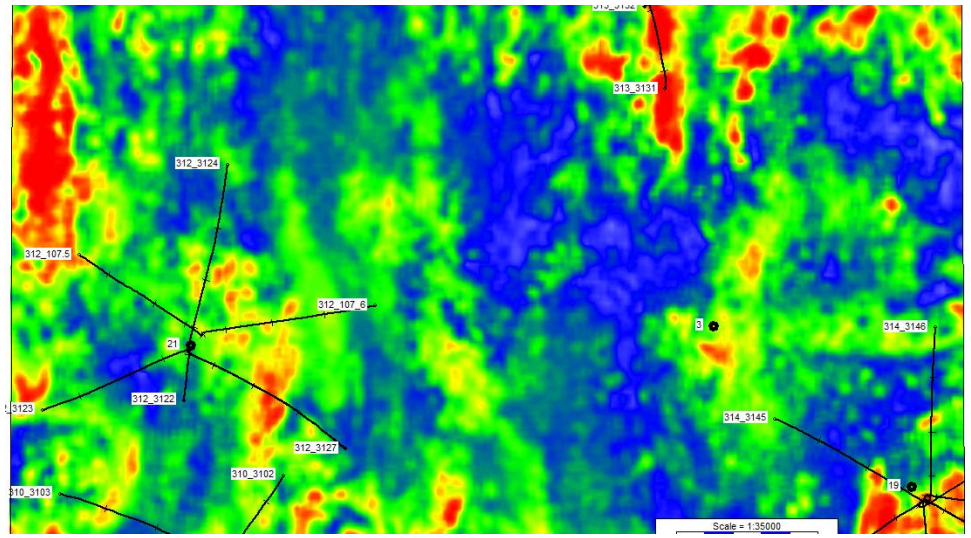
Brine manifestation prediction. Mean 0.015, deviation 0.03



Fluid manifestation prediction. Mean 0.059, deviation 0.064



12 km



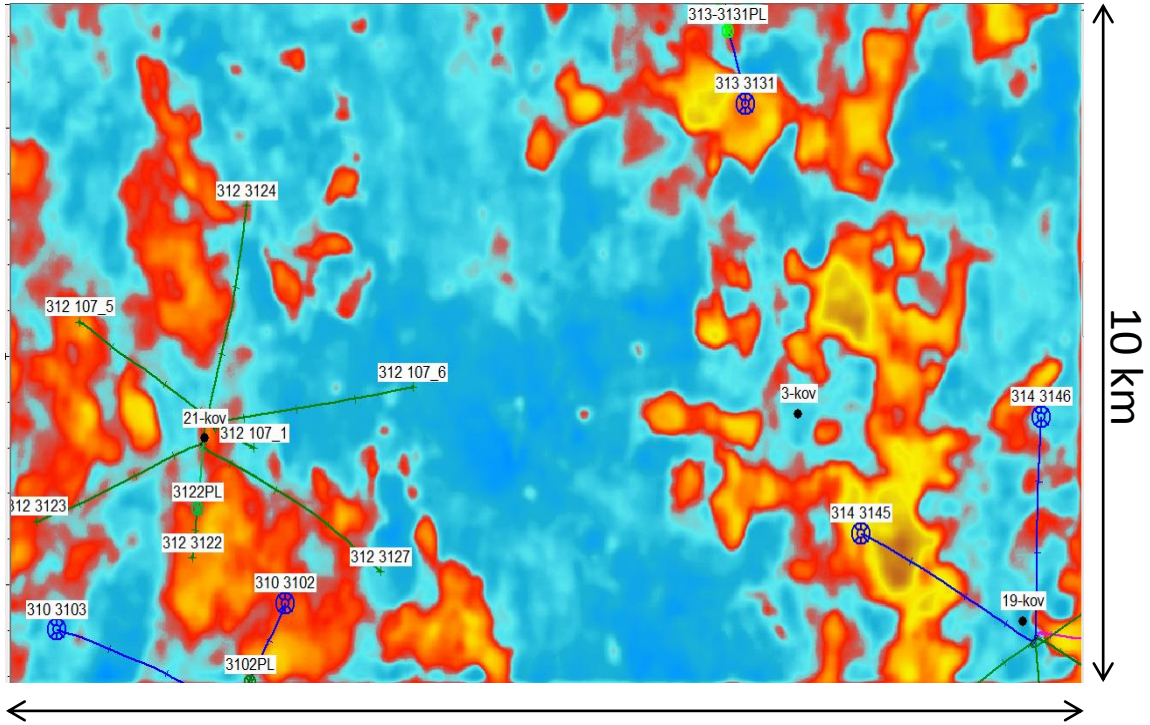
10 km

Fluid manifestation prediction in target horizon.
Mean 0.059, deviation 0.064

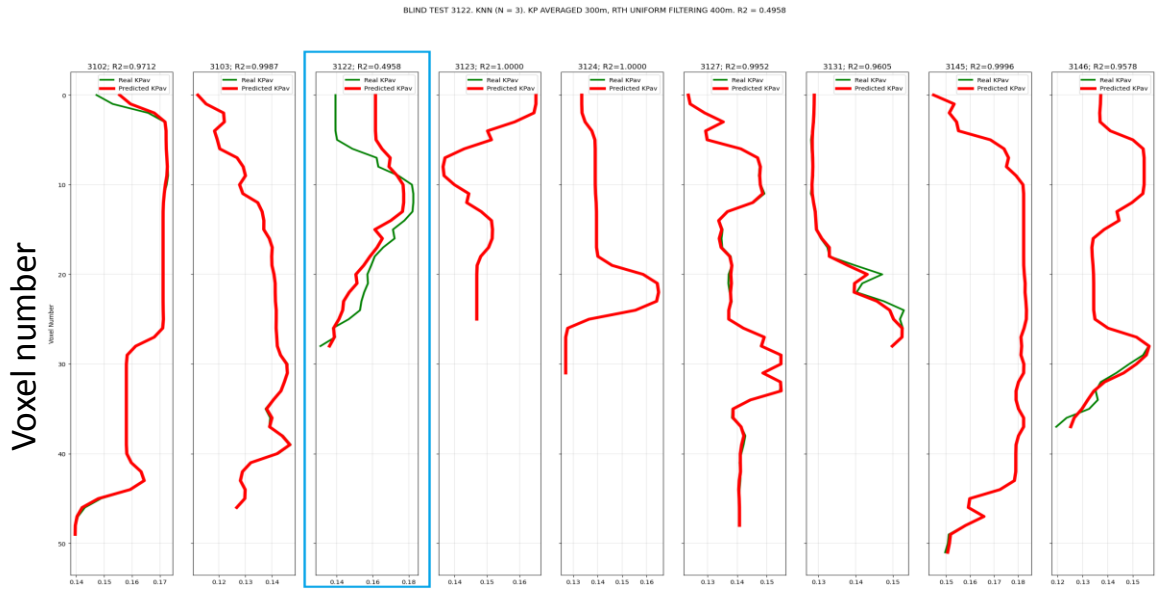
Voxel size is 25x25x5 m

Porosity prediction in Target Horizon based on RTH attributes and well-log data

Step 3. AI Prediction



Predicted porosity coefficient



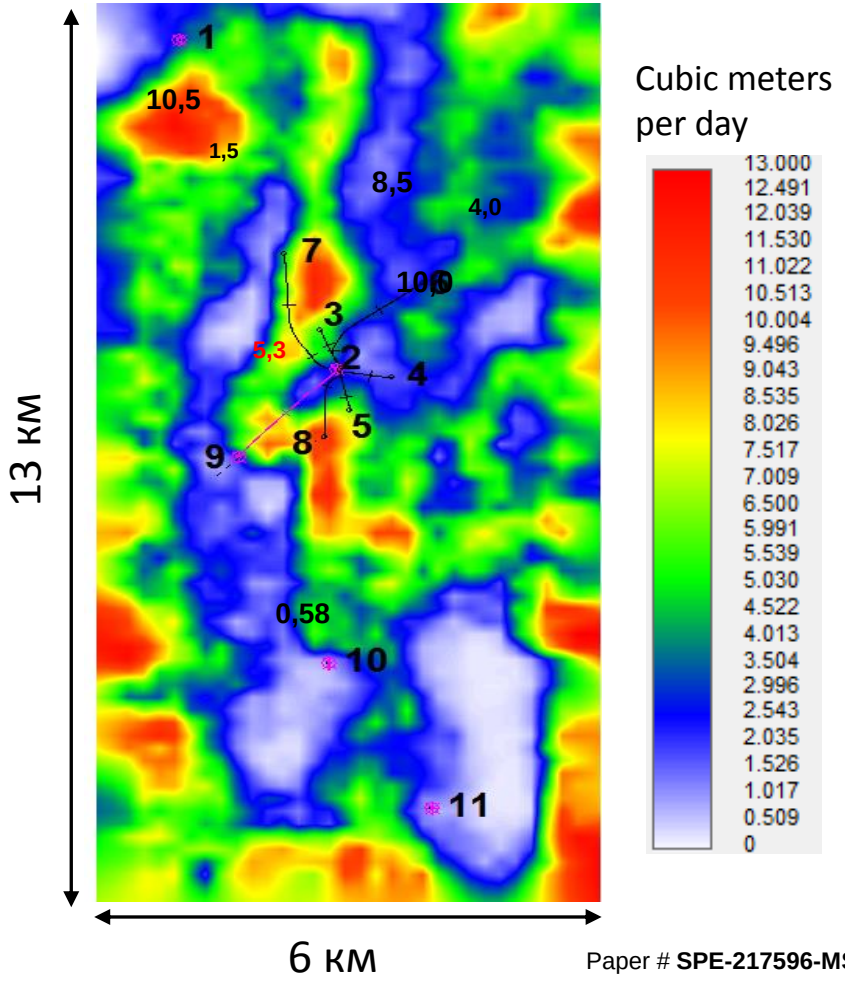
Comparison of predicted porosity in Sandstone 2 (red) and well-log data (green)

- the blind test well

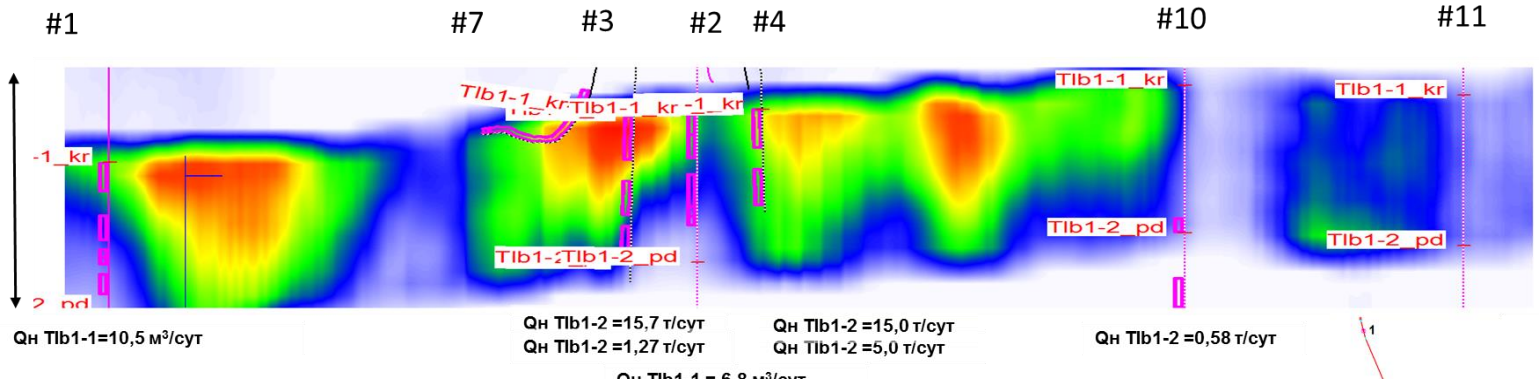
Voxel size is 25x25x5 m

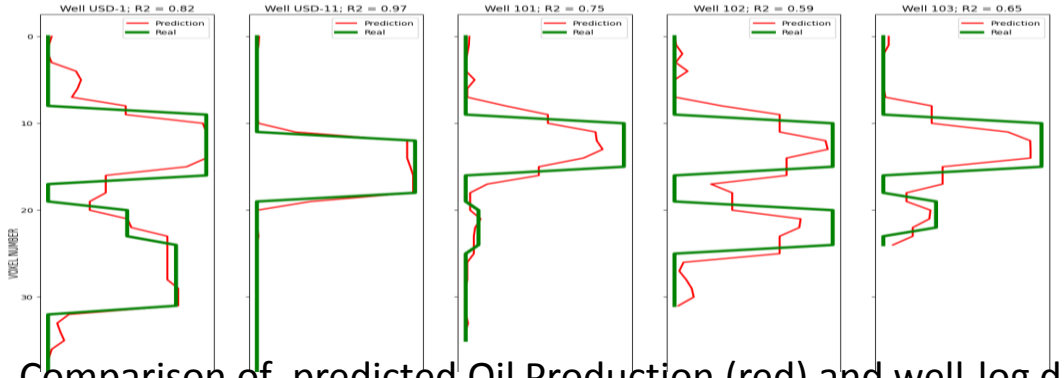
Prediction of Oil Production in Target Horizon

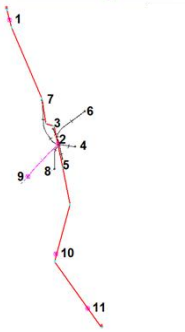
Step 3. AI Prediction



Cubic meters per day







Comparison of predicted Oil Production (red) and well-log data (green)

Voxel size is 25x25x5 m

RTH Imaging Engine

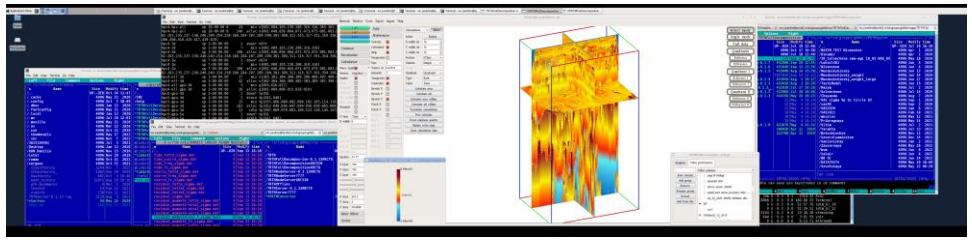
20 GPU nodes,
1.2 Petaflops.

Data Storage, 1.2 Petabytes.

Device settings:

- Operating system -Linux.
- Power consumption - 6 kW.
- Size - 12U in rack system.
- Weight - 100 kg.

The RTH Imaging Engine software has its own developed graphical interface for setting processing parameters, launching programs and viewing calculation results.



RTH IE Graphical Interface

ACKNOWLEDGEMENTS

The authors thanks colleagues Bitaly Bryksin, Sergey Sergeev, Aleksandr Yakovlev and Svetlana Shevchenko for help and useful participation.

GEOMEX Technologies , Mexico

WWW.GEOMEXTECH.COM