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Enhancing the reliability of reservoir properties assessment in saline hydrocarbon-bearing formations

International Conference 2025 on Technologies for the Sustainable Use of Natural Resources

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The problem

Water-soluble salt deposits are part of the rock's solid phase and are in dynamic equilibrium with formation water

During rock analysis, core samples are saturated with synthetic formation water (brine), which leads to the dissolution of salt deposits

This results in a substantial actual increase reservoir properties and an apparent decrease in porosity coefficient according to GOST 26450.1-85 and water saturation coefficient according to OST 39-204-86.

Measurement results show underestimated or even negative values for open porosity and irreducible water saturation.

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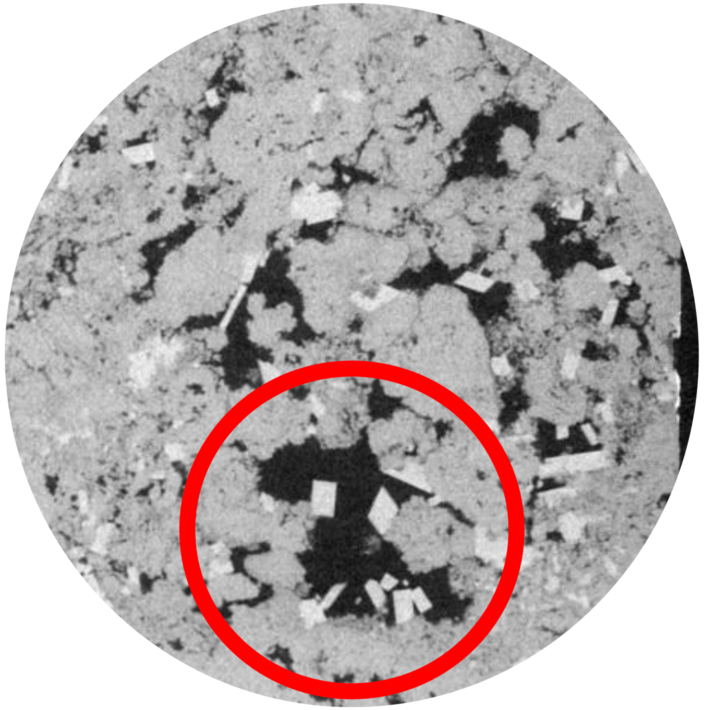
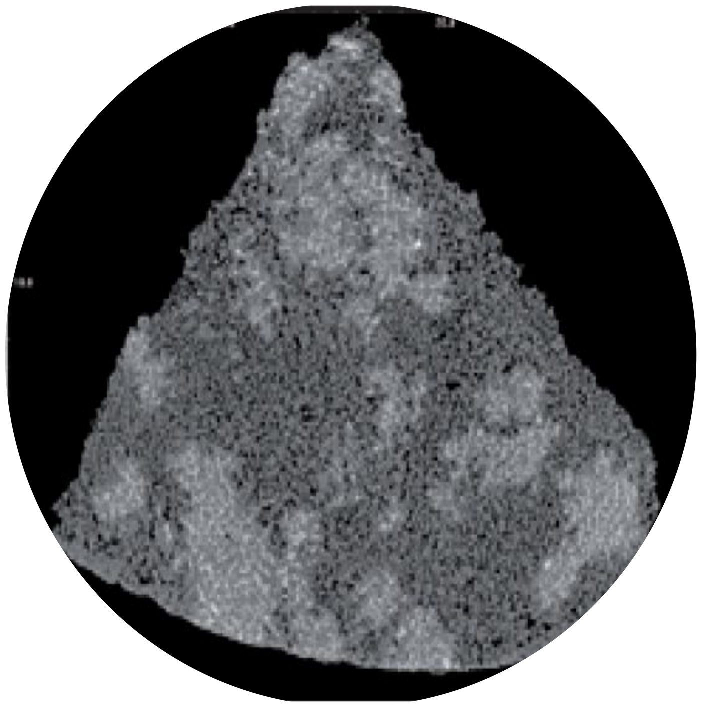
Salt deposits in rock pore space

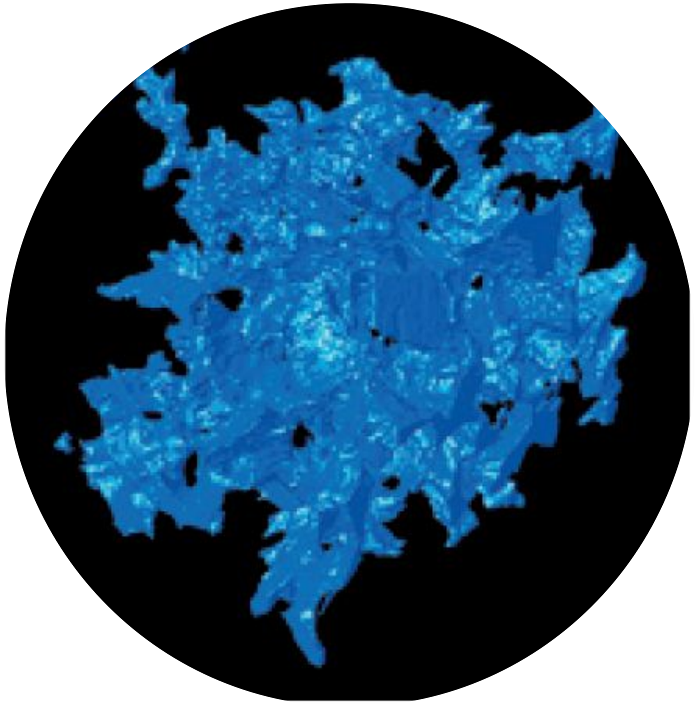
Micro-level



Macro-level



Volumetric model



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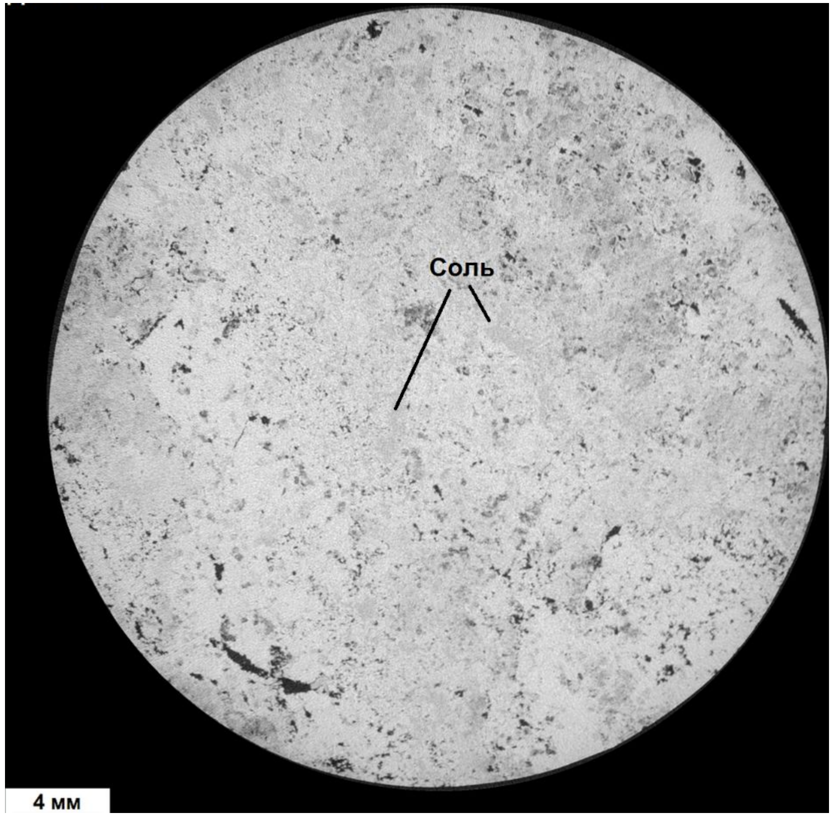
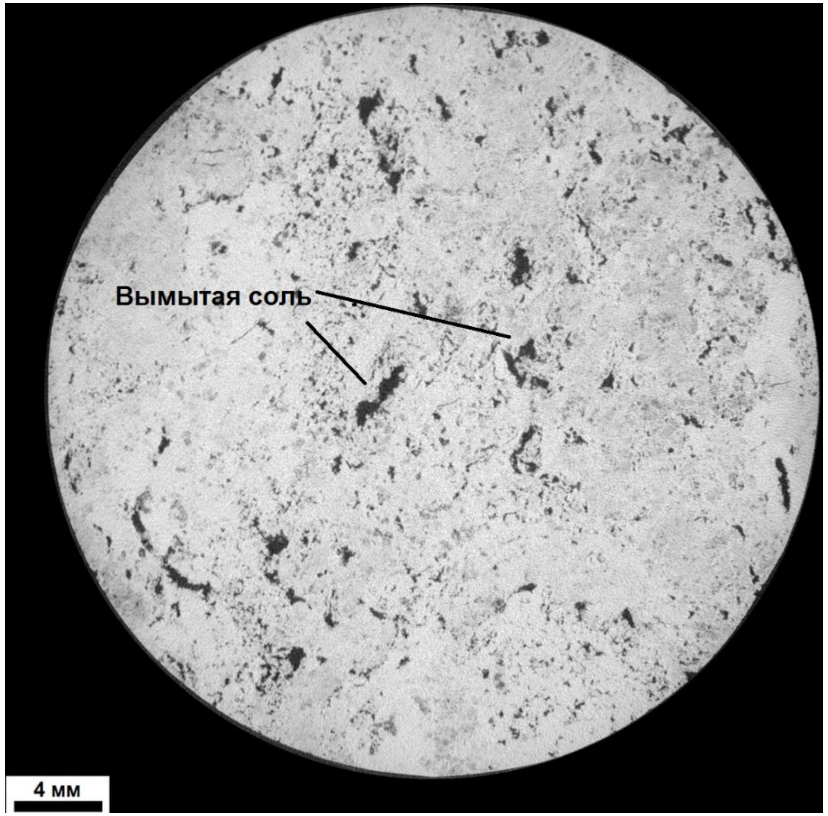
Pore Space: Before and After Salt Dissolution

Before experiments

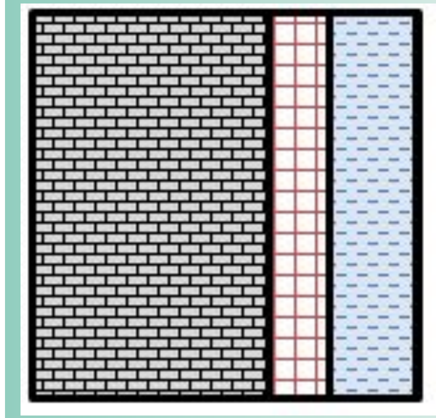


After experiments



Theoretical Background

State 1

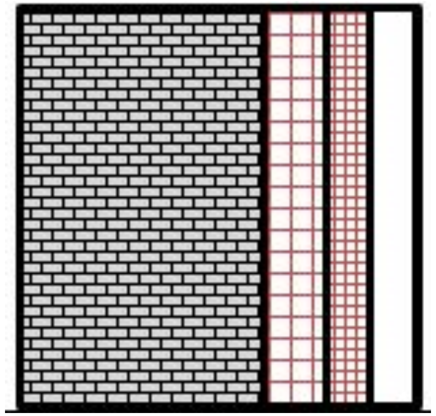


Reservoir Conditions

Formation water is a saturated brine in contact with rock salt.

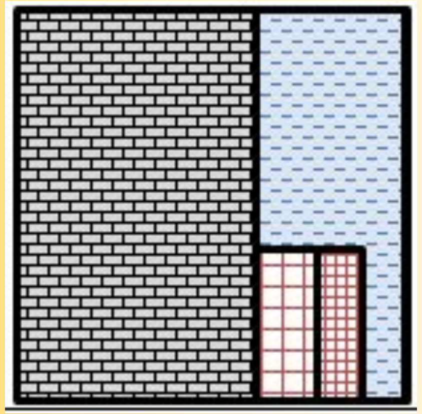
Dissolved salts are in dynamic equilibrium with solid salts.

State 2



After being brought to the surface the core sample dries, causing the formation water to evaporate and dissolved salts to precipitate in the pore space. This results in underestimated effective porosity, overestimated bulk density, and typically underestimated grain density.

State 3

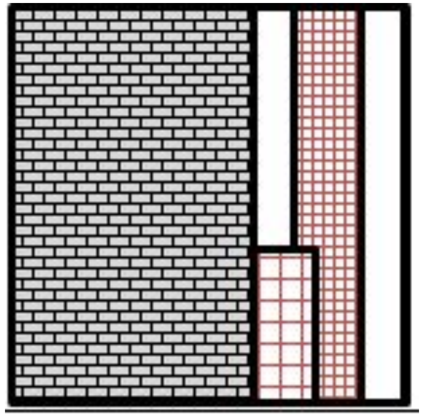


After Saturation with Synthetic Formation Water (SFW)

A portion or all salts present in the rock (in state 2) dissolve into the synthetic brine.

A new equilibrium state is established.

State 4



After Drying

The salts that were dissolved in the synthetic formation water have precipitated in the pores and on the sample surface.

Legend :

Minerals insoluble in water

Rock salt from the solid phase

Salts remaining after evaporation fromthe saturating fluid

Saturating water

Existing Solutions

The problem of salt dissolution

Description	Disadvantages
Measurments without using brine	Reduction of the study complex, study of the rock in state 2
Complete desalination	Study of a highly altered rock
Use of solutions with maximum mineralizations	Impossibility of complete dissolution exclusion
Accounting for dissolution during satiration	Calculation inaccuracies

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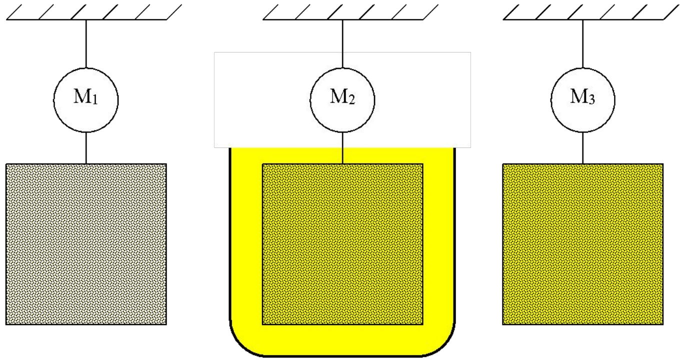
Causes of distortion occurrence

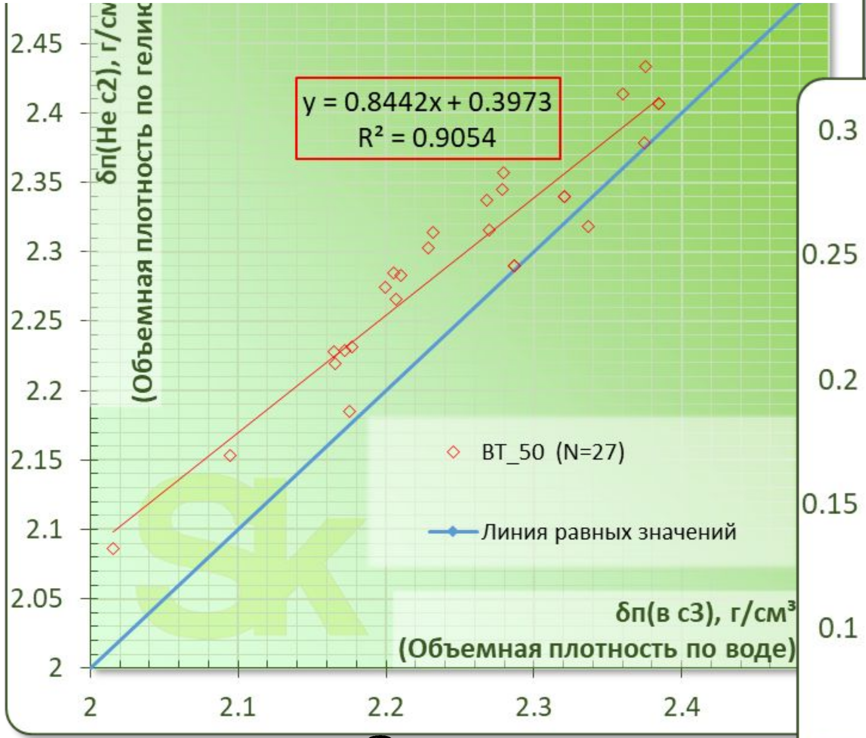


Взвешивание образца породы в трех состояниях

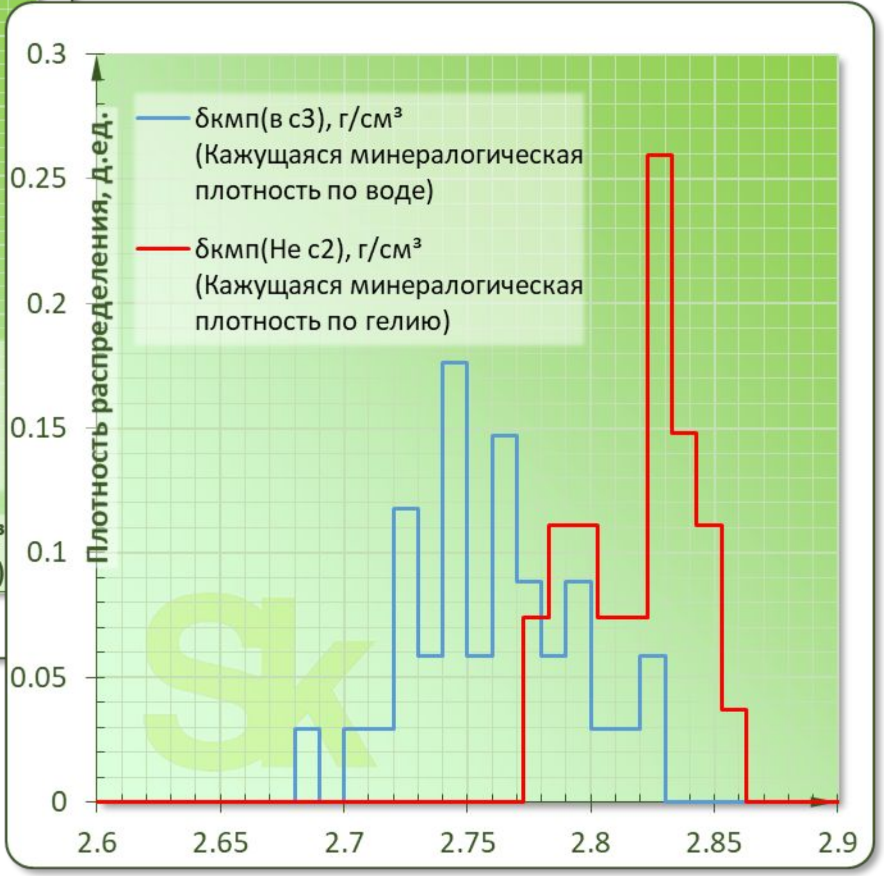
$$\delta_{п} = \frac{M_1 \cdot \delta_{ж}}{M_3 - M_2}$$

$$Kпо = \frac{M_3 - M_1}{M_3 - M_2}$$

Volumetric density by water and helium



Apparent mineralogical density by water and helium



$$\delta_{кмп} = \frac{M_1 \cdot \delta_{ж}}{M_1 - M_2}$$

Experimental collection

50 core samples
limestones, dolomites
Russian Federation, Eastern Siberia
porosity range 9 % – 26 %
permeability range $0.25 \cdot 10^{-3}$ - $346 \cdot 10^{-3}$ μm²

Synthetic formation water (sfw):

Density at 25 ° c, g/cm³	Ion content, g/l						M, g/l	pH
	Cl^-	SO_4^{2-}	HCO_3^-	Ca^{2+}	Mg^{2+}	Na + K		
1,374	327.728	0.0315	1.342	152.304	13.973	23.640	527.0	4.9

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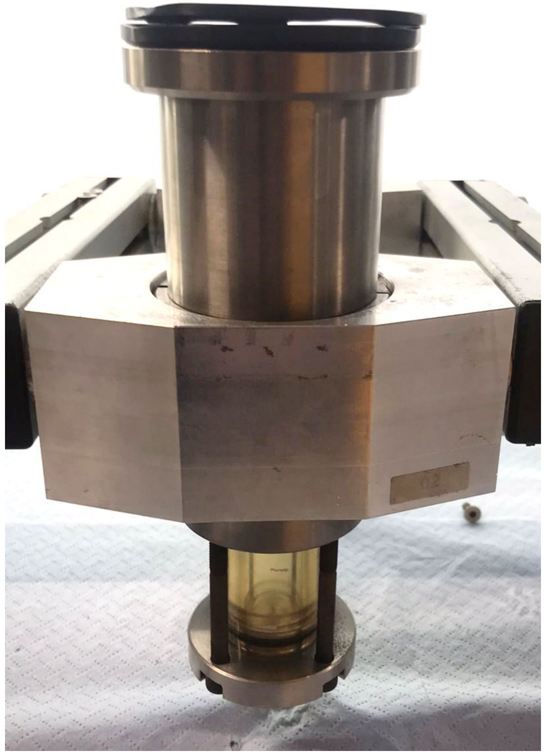
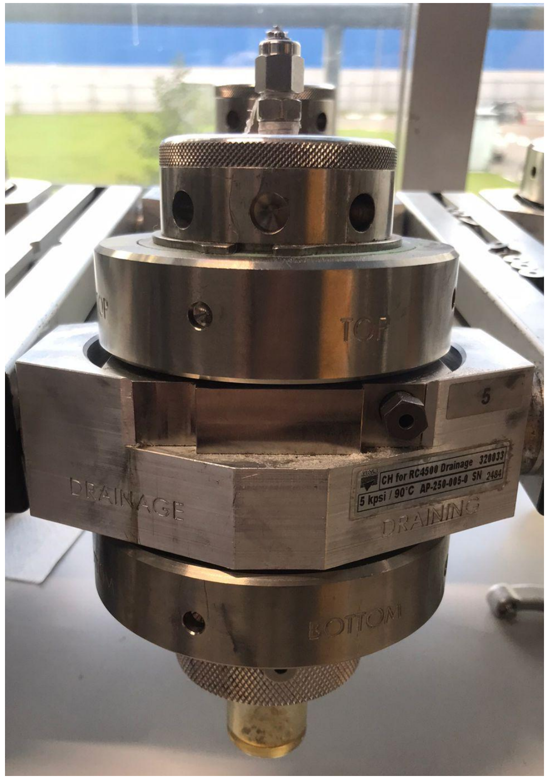
Equipment

Petrophysical centrifuge rc-4500
rotation speed: 50 – 4500 rpm
temperature range: -10 – 90 °c
rotor radius: 22.5 cm

Atmospheric coreholder



Overburdened core holder



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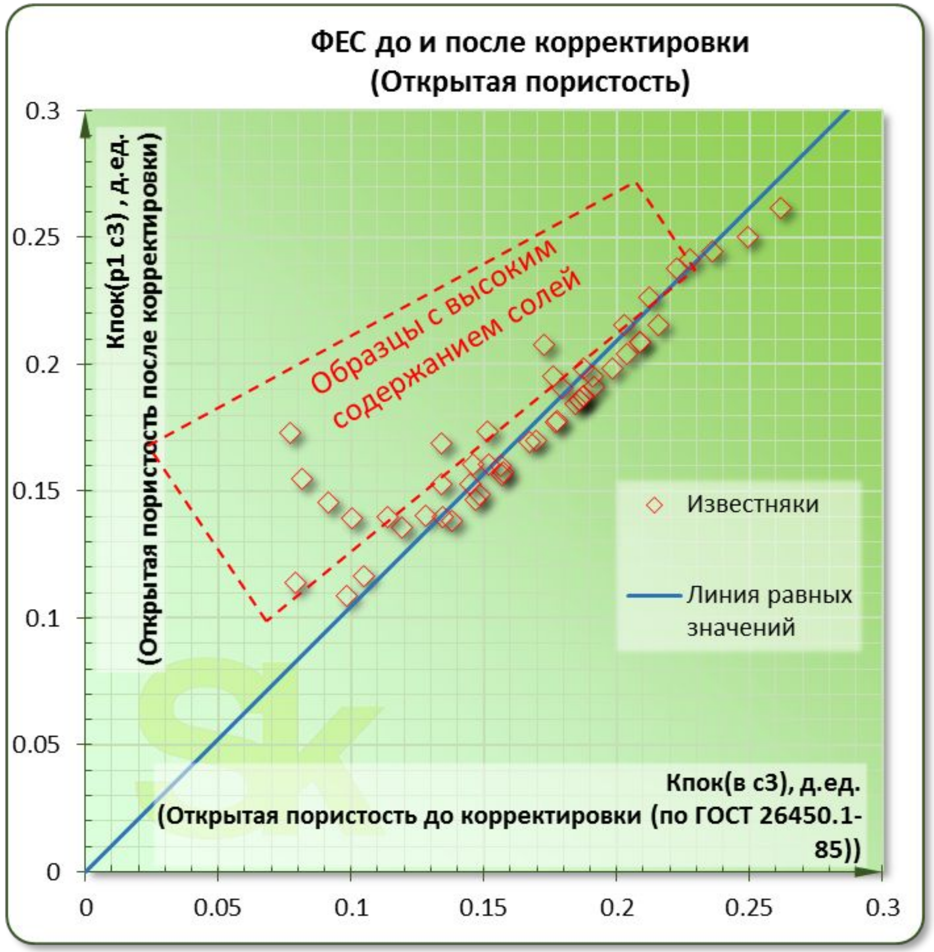
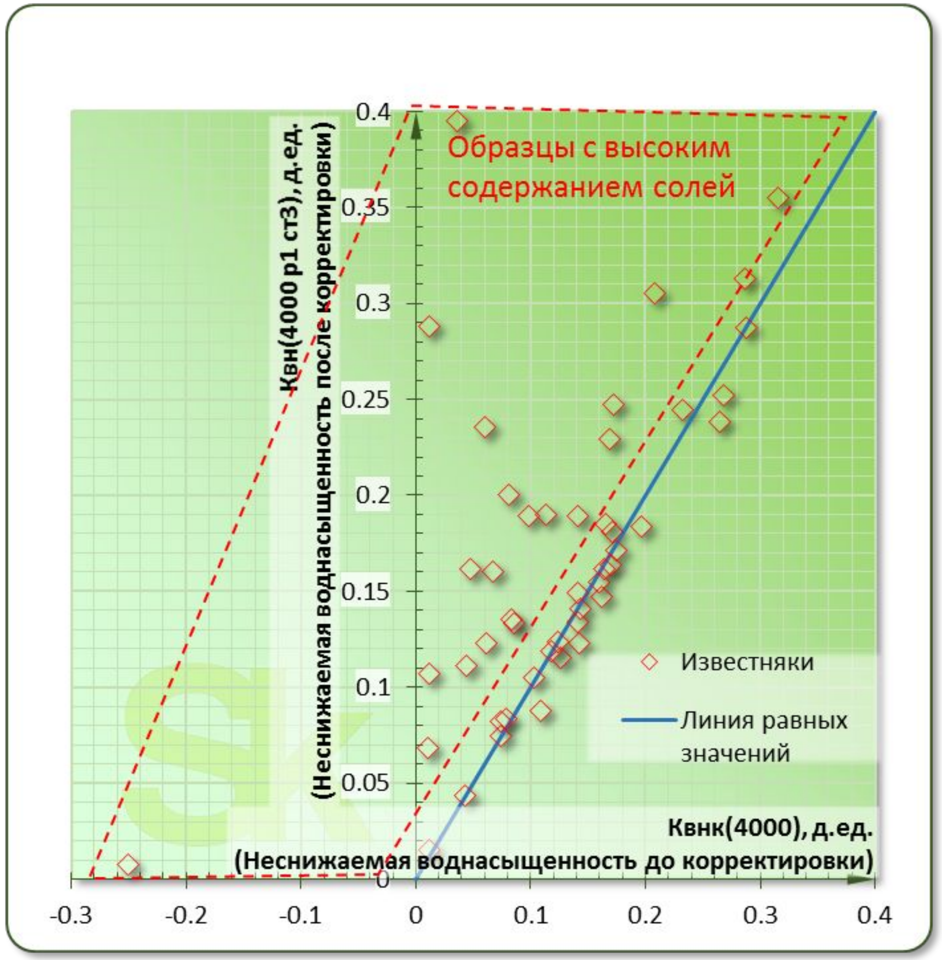
Results

Open porosity



Irreducible water saturation



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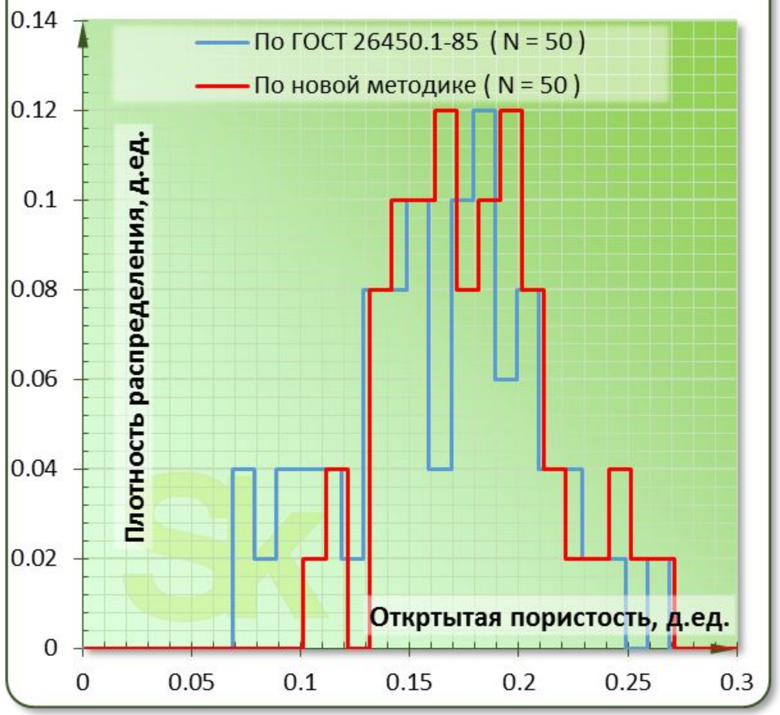
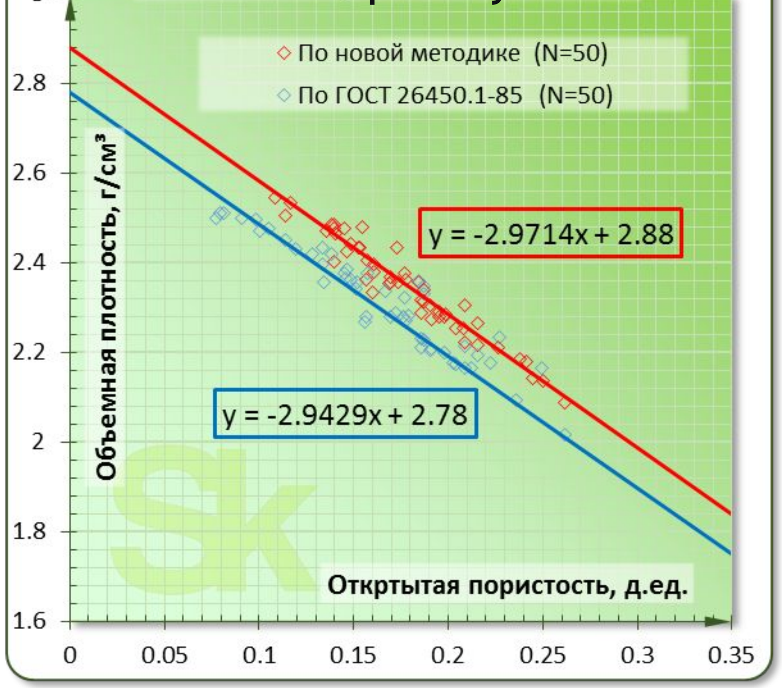
Results

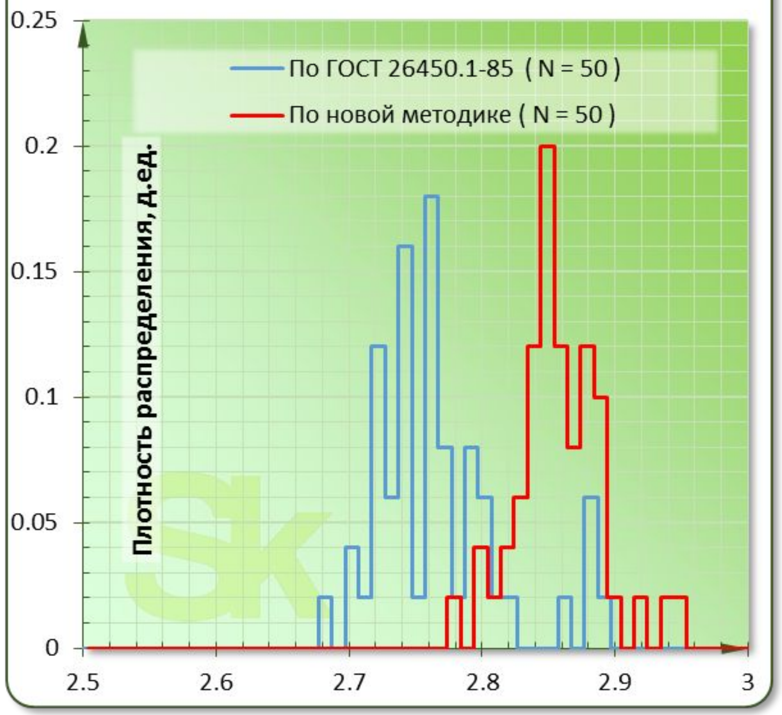
Open porosity



Correlation of bulk density with porosity



Apparent mineral density



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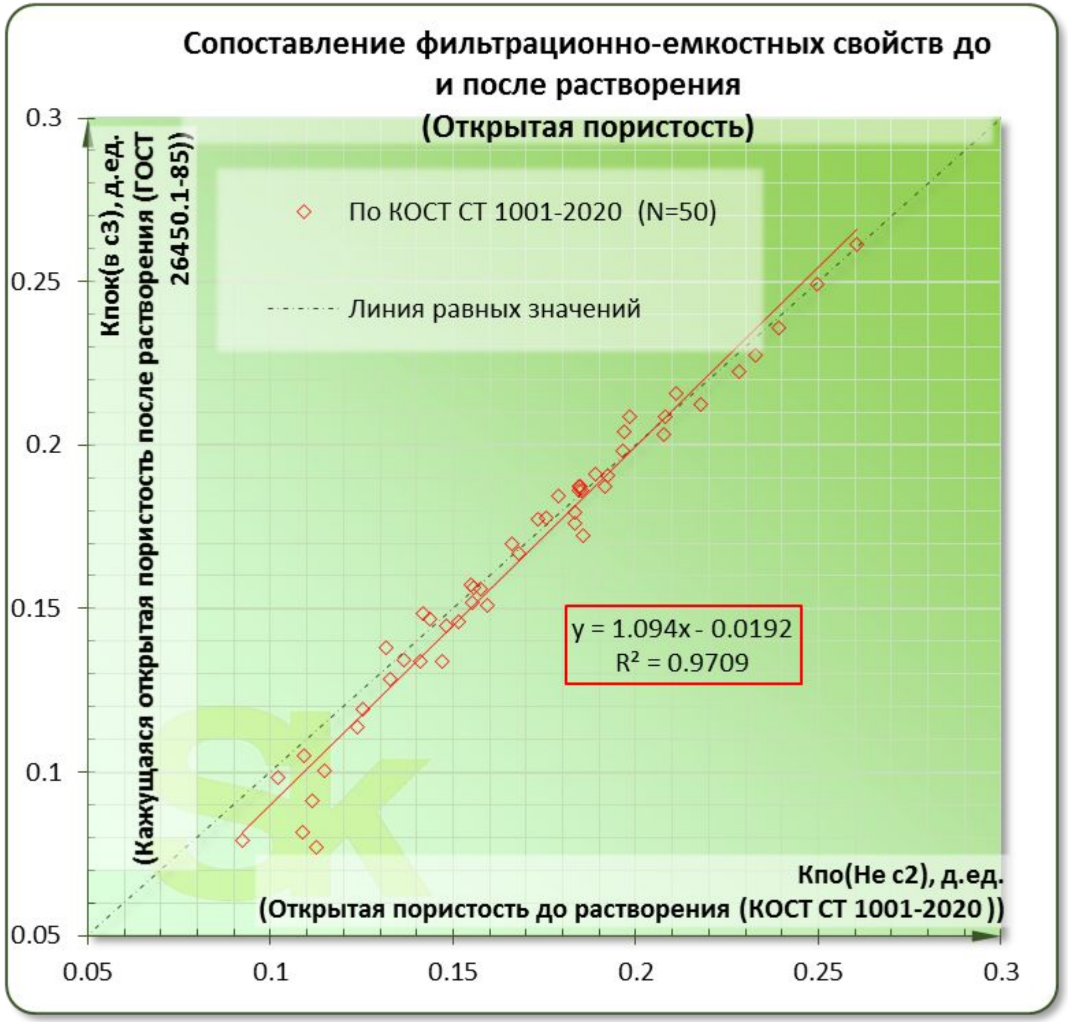
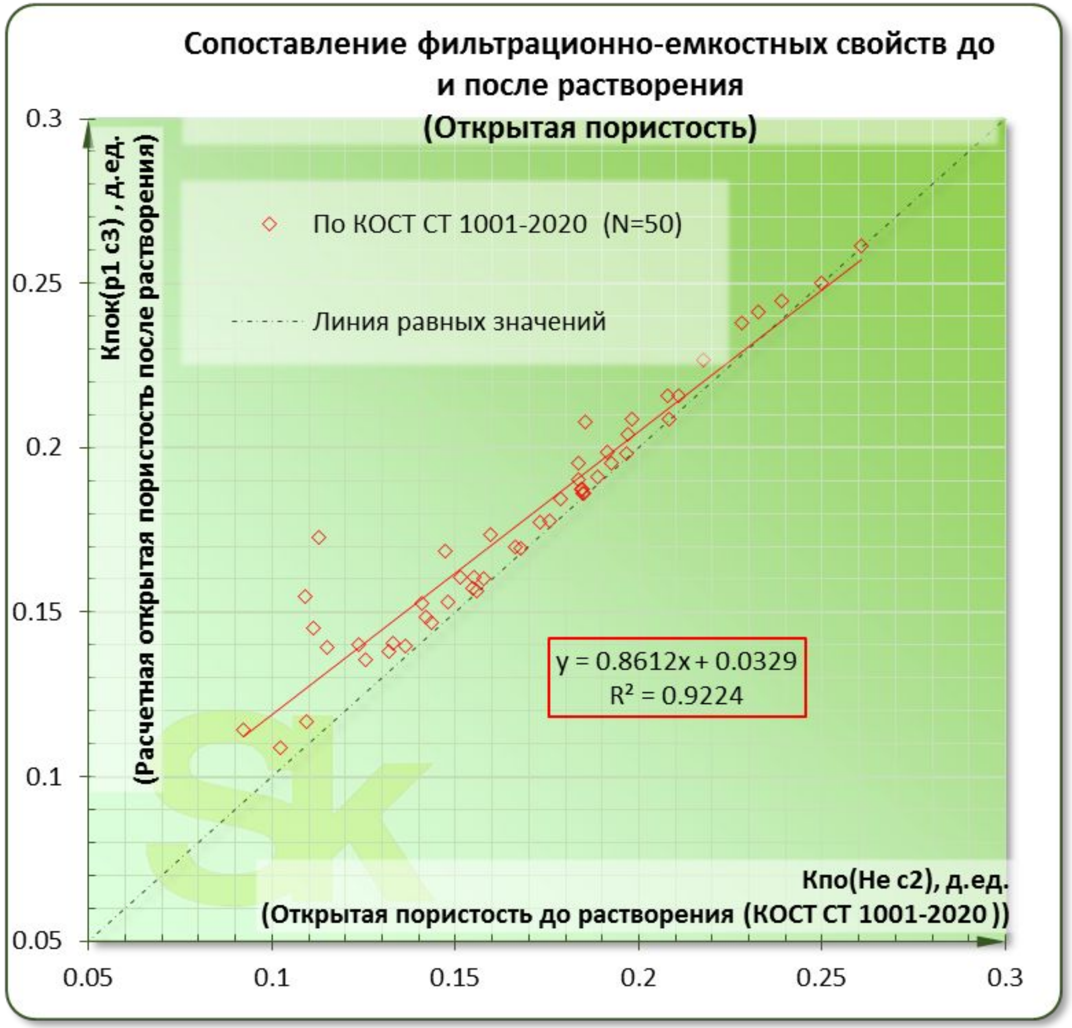
Results

By classical methods



By novel methods



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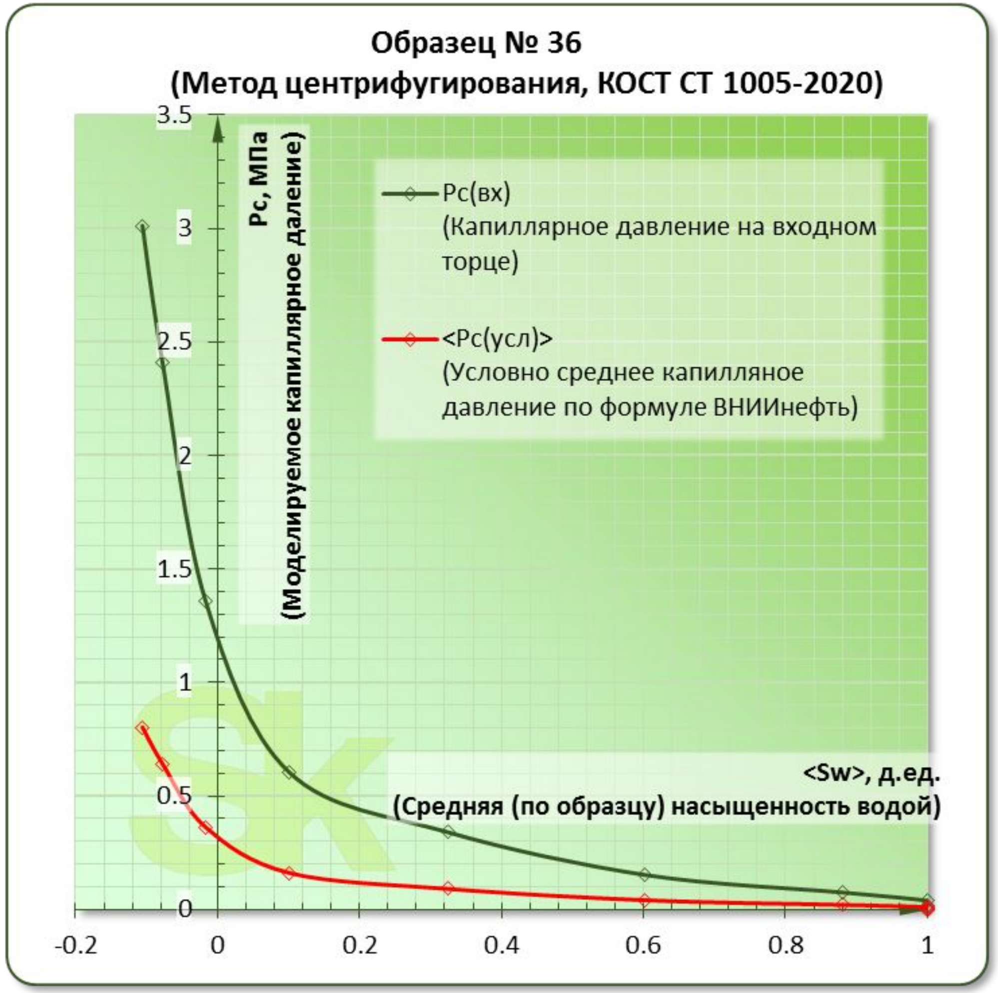
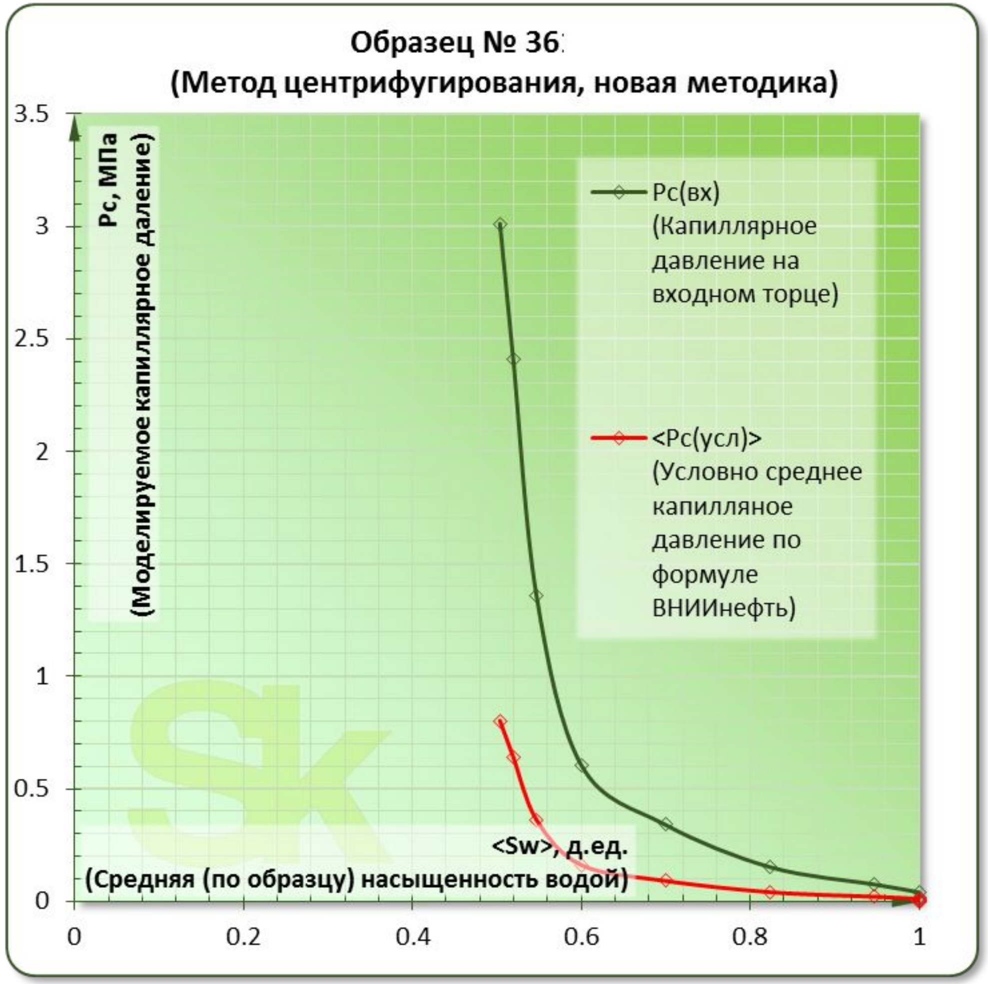
Results

By classical methods



By novel methods



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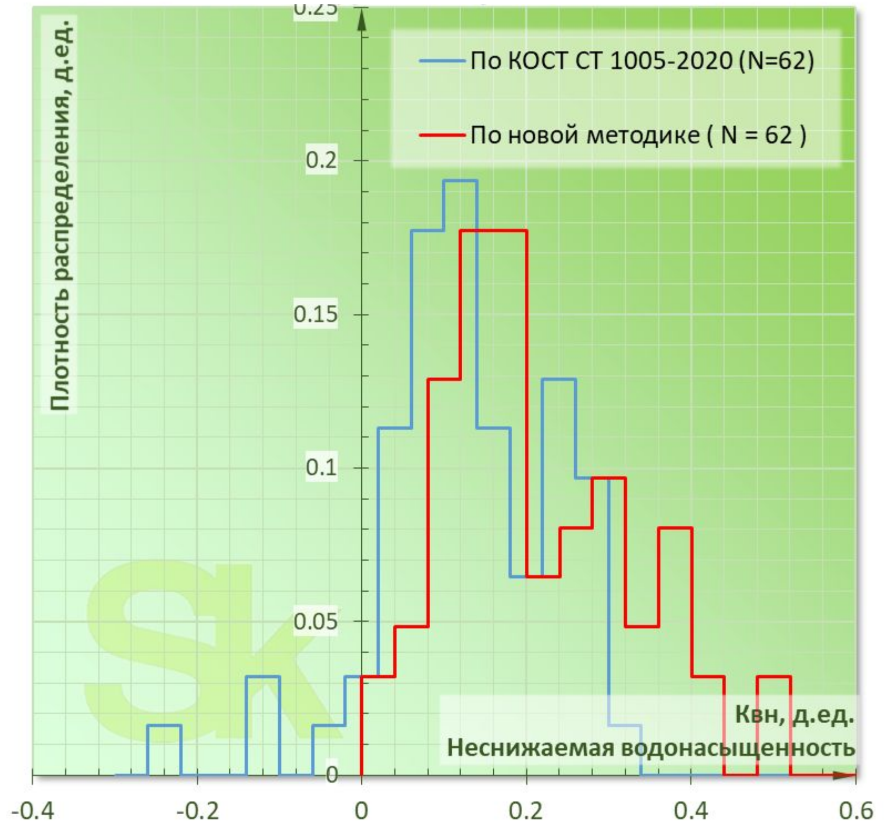
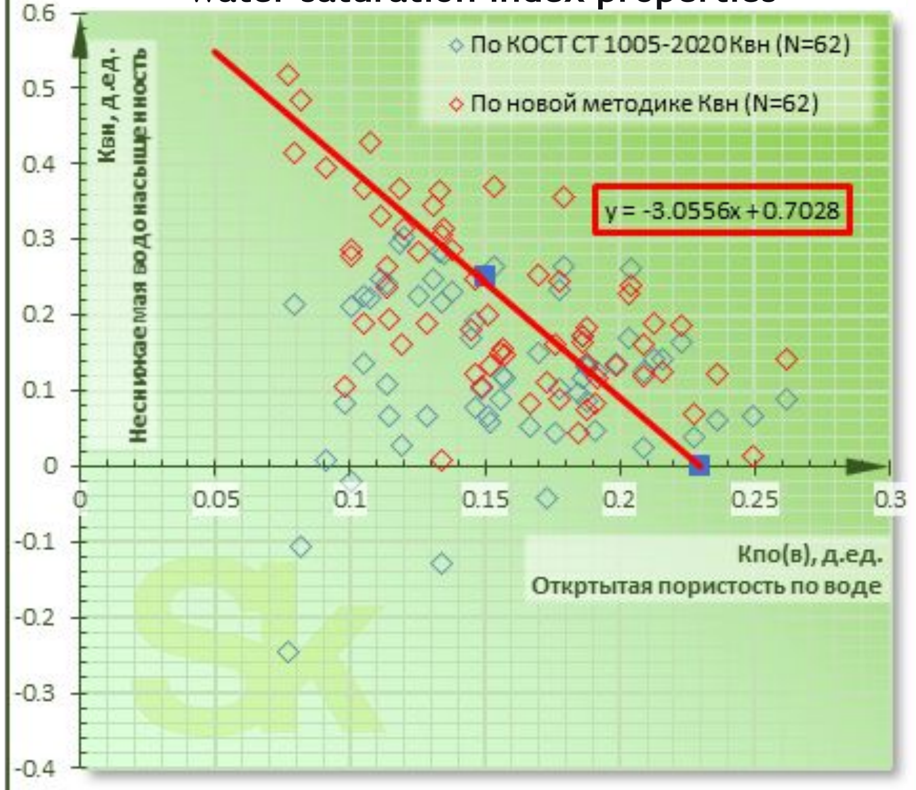
Results

Irreducible water saturation distribution



Correlations of porosity index and irreducible water saturation index properties



Conclusions

- A methodology has been developed for studying the effective porosity and capillary characteristics of rocks containing water-soluble salts.
- This methodology is recommended for application in fields with formation water mineralization exceeding 300 g/l
- Application of this methodology will enable more efficient investigation of oil and gas fields and enhance the quality of obtained petrophysical data

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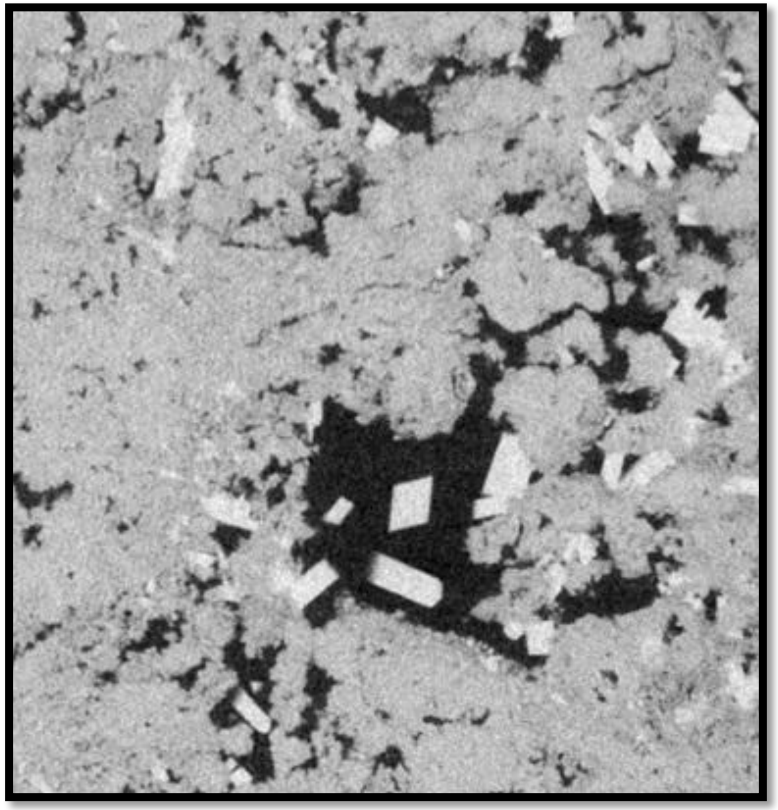
Thank you for your attention!



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Science is a path!

Методика

- Алгоритм расчета поправок за растворение солей

$$\Delta M_{(\text{с}2-\text{с}3)} = V_{c(\text{с}2-\text{с}3)} \cdot (\delta_\text{В} - \delta_\text{С})$$

$$\text{К}_{\text{пок(в с3)}} = \frac{M_{3(\text{с}3)} - M_{1(\text{с}2)}}{M_{3(\text{с}3)} - M_{2(\text{с}3)}} = \frac{M_{3(\text{с}2)} + \Delta M_{(\text{с}2-\text{с}3)} - M_{1(\text{с}2)}}{M_{3(\text{с}2)} + \Delta M_{(\text{с}2-\text{с}3)} - M_{2(\text{с}2)} + \Delta M_{(\text{с}2-\text{с}3)}} = \frac{M_{3(\text{с}2)} + \Delta M_{(\text{с}2-\text{с}3)} - M_{1(\text{с}2)}}{M_{3(\text{с}2)} - M_{2(\text{с}2)}},$$

$$\text{К}_{\text{по(р с3)}} = \text{К}_{\text{по}(He\ \text{с}2)} + \frac{\left(\text{К}_{\text{пок(в с3)}} - \text{К}_{\text{по}(He\ \text{с}2)}\right) \cdot \left(M_{3(\text{с}3)} - M_{2(\text{с}3)}\right)}{(\delta_\text{В} - \delta_\text{С})} \cdot \frac{1}{V_{\text{обр}}},$$

$$\delta_{\text{п(р с3)}} = \delta_{\text{п}(He\ \text{с}2)} - \left(\text{К}_{\text{по(р с3)}} - \text{К}_{\text{по}(He\ \text{с}2)}\right) \cdot \delta_\text{С},$$

$$\delta_{\text{кмп(р с3)}} = \frac{M_{1(\text{с}2)} - V_{\text{обр}} \cdot \left(\text{К}_{\text{по(р с3)}} - \text{К}_{\text{по}(He\ \text{с}2)}\right) \cdot \delta_\text{С}}{V_{\text{обр}} \cdot \left(1 - \text{К}_{\text{по(р с3)}}\right)},$$