additive technologies as a modern tool in architecture and design, opening up new opportunities for research, reconstruction, and visualisation of historical objects [4].

Conclusions. Additive technologies (3D printing) demonstrated high effectiveness in reproducing objects of the 18th century wooden architecture in the Chernihiv region, enabling to reproduce the forms, proportions, and decorative elements of the monuments accurately. The created 3D models and church samples demonstrated the potential to reconstruct structures that have not been preserved. The study confirmed that additive technologies open up new prospects for the innovative development in architecture and design, combining historical accuracy with modern approaches to visualisation and material experimentation.

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QUANTITATIVE ASSESSMENT OF ROBUSTNESS OF OIL DISPLACEMENT EFFICIENCY PREDICTION METHODS

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Introduction. The inaccuracy of analytical forecasting of Oil Displacement Efficiency (E_D) using standard methods (GSTU, classical Buckley-Leverett) is largely associated with geological uncertainty and the inadequate response of models to the integration of detailed input information. This research identifies a philosophical dilemma between two model classes: Empirical GSTU Model and Physically-Based Buckley-Leverett Model [1 - 2]. Empirical GSTU Model ("Black Box") is Simple and fast, but contains empirically derived correction coefficients that can suppress uncertainty. Physically-Based Buckley-Leverett Model ("White Box") is Complex, based on fundamental equations, more transparent, and sensitive to input data quality [3 - 4].

The goal of this work is to develop and test a structured methodology for the quantitative assessment of a fundamental property of these models—their robustness (stability) to the integration

of detailed Litho-Facies Zoning (FZ), and to quantitatively prove the effectiveness of the developed improved methodology [5 - 6].

Computational Experiment Methodology. To ensure objective comparison, a computational experiment design was developed, including 6 calculation scenarios (with/without FZ and with/without gravity). To account for geological uncertainty, 100 stochastic calculations of E_D were performed for each scenario, yielding a total of 600 predicted values. A system of standardized metrics, was used for the quantitative evaluation of model properties:

1) Robustness Criterion (Stability of Mean Prognosis):

1.1) Cohen's Standardized Shift (d) measures the magnitude of the mean (μ) shift when transitioning from the baseline "no facies" (NF) to the modified "with facies" (WF) scenario [7].

1.2) Coefficient of Overlap (OVL) measures the percentage of overlap between distributions [8].

2) Accuracy Criterion (Uncertainty Reduction):

2.1) Relative Reduction of the 95% Predictive Range due to FZ ($RRPR_{95.Facies}$) measures the relative reduction of the standard deviation (σ) upon FZ integration [9].

Results and Discussion.

Robustness Analysis (Resistance to Shift). The results, summarized in Table 1, unequivocally confirm the hypotheses regarding the fundamental model properties.

Table 1. Quantitative analysis of model robustness to the integration of facies zoning

Model Type	Baseline Scenario (NF)	Modified Scenario (WF)	$\Delta\mu$ (WF - NF)	Cohen's d	OVL, %	Robustness
GSTU	GSTU_NF_NG	GSTU_WF_NG	+0.0159	2.924	14.37	Critical Fragility
BL (No Grav.)	BL_NF_NG	BL_WF_NG	-0.0103	-0.408	83.84	High Robustness

The GSTU method ("Black Box") demonstrated a critically large statistically significant shift in the mean prognosis (d = 2.924), exceeding the threshold for a "large effect" by more than three times. This proves that its empirical structure is unable to correctly assimilate detailed geological information, generating a systematic bias (see Fig. 1, GSTU NF vs WF comparison).

The Buckley-Leverett method ("White Box") showed high stability to modification. Its shift is within the range of a moderate effect (d ≈ -0.4), and the high OVL (≈ 84%) confirms that the physically-based model correctly utilizes additional data to refine the prognosis without fundamentally changing its expected value.

Accuracy Analysis (Uncertainty Reduction). The $RRPR_{95.Facies}$ metric is positive for both models (> 1.0 % for BL and > 3.4 % for GSTU), which is direct quantitative proof that accounting for geological heterogeneity always reduces the stochastic uncertainty of the E_D prognosis.

Selection of the Best Approach. Despite GSTU showing the greatest σ reduction, its prognosis is statistically unreliable due to the critical shift in μ. The final conclusion is based on a combination of robustness and accuracy: the most reliable and accurate prognosis is provided by the improved Buckley-Leverett methodology with FZ and gravity integration (BL_WF_WG scenario), as it combines physical robustness (stable μ) and the maximum possible uncertainty reduction among the robust approaches.
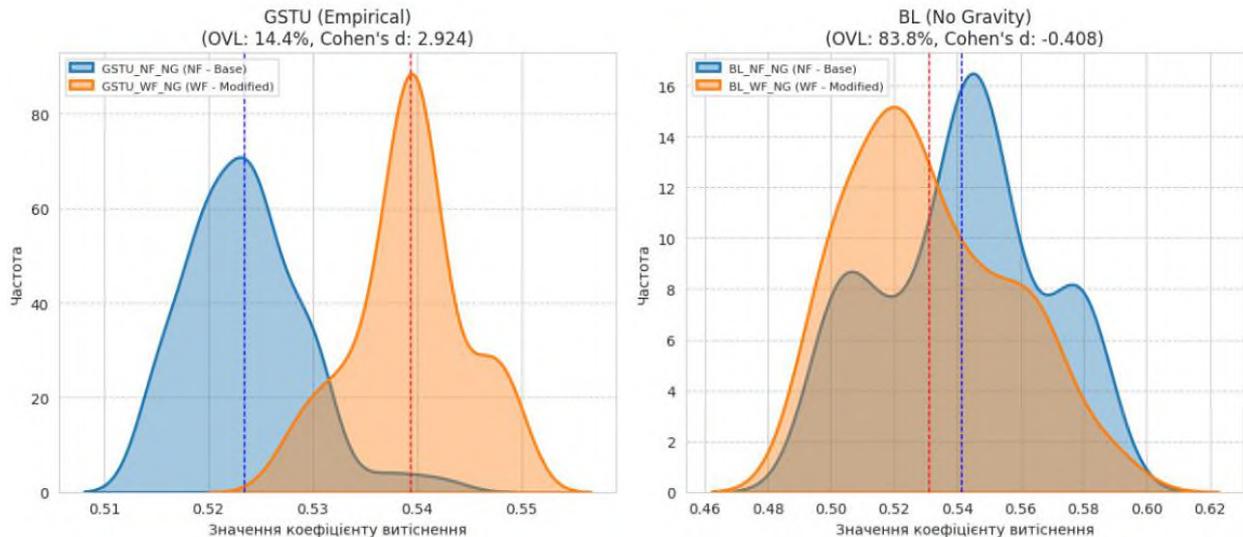
Fig. 1. Quantitative comparison of the robustness (shift) of GSTU and Buckley-Leverett models upon integration of facies zoning (using Cohen's d and OVL)

Conclusions. It is quantitatively proven that the empirical GSTU model is statistically fragile (d = 2.924), while the physically-based Buckley-Leverett model is robust (d ≈ -0.4). This resolves the philosophical dilemma in favor of physical adequacy. The integration of litho-facies zoning is a key factor that increases the accuracy (positive $RRPR_{95.Facies}$) of the E_D prognosis for both model classes. The improved methodology based on the Buckley-Leverett method (BL_WF_WG) provides the most reliable and credible prognosis of E_D under conditions of geological uncertainty.

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