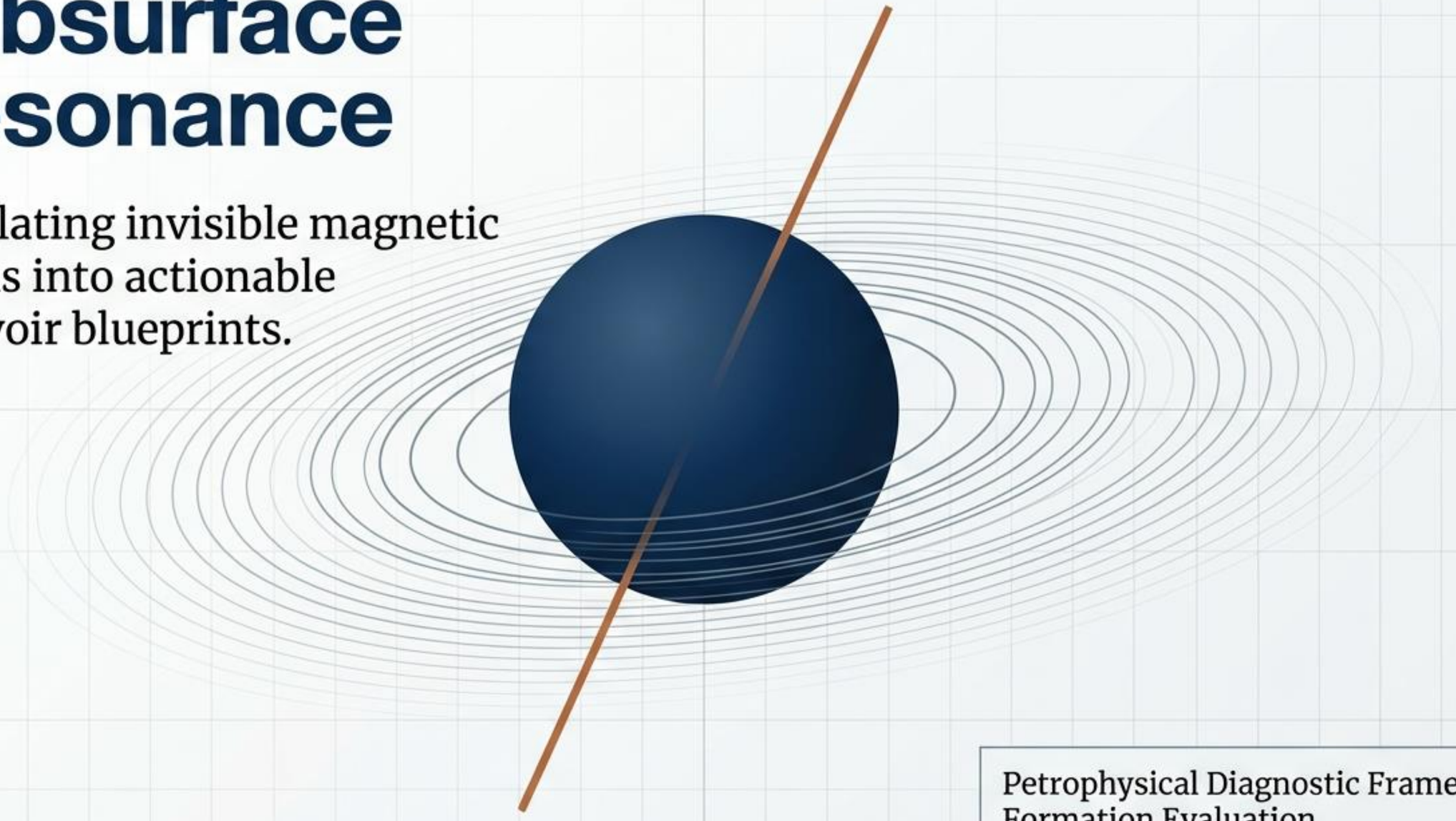
GROUP POISK
RSS-NMR SEVSU Poisk

СЕВАСТОПОЛЬСКИЙ ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ

Subsurface Resonance

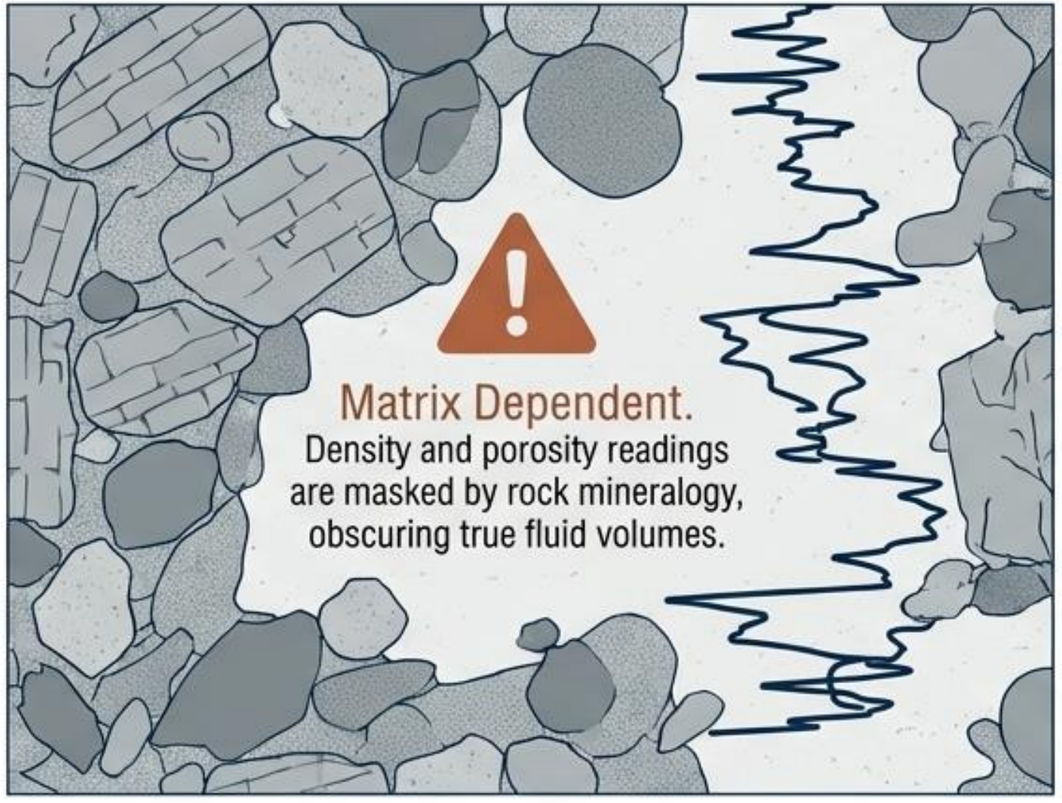
Translating invisible magnetic signals into actionable reservoir blueprints.



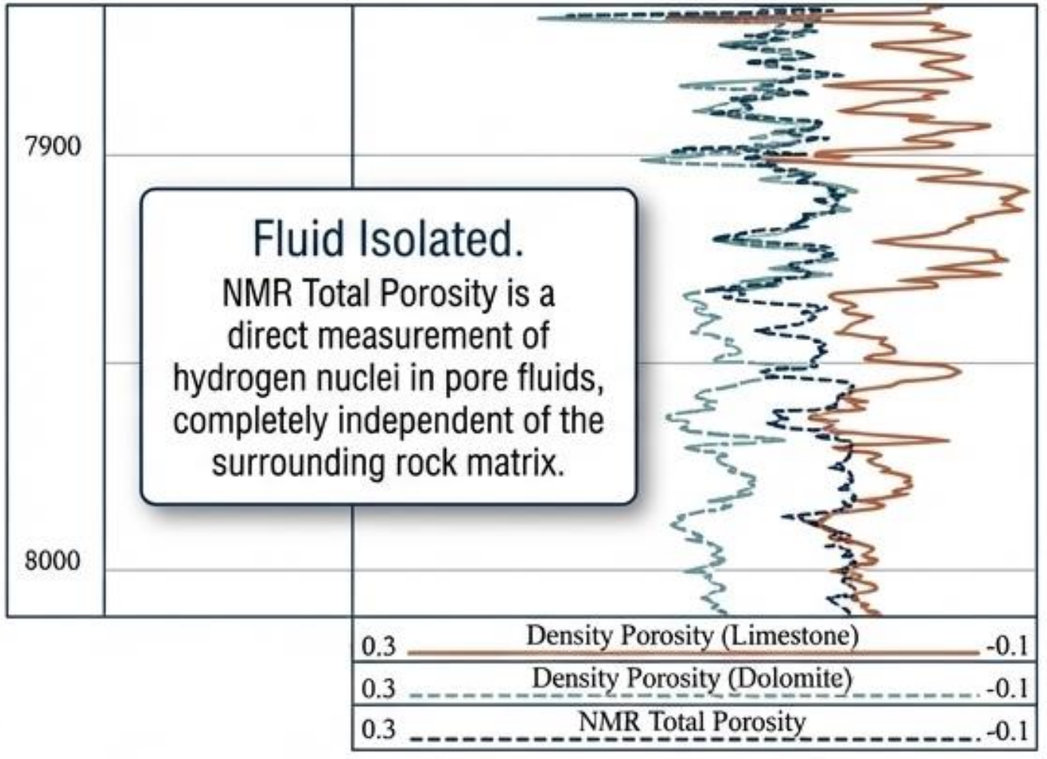
Petrophysical Diagnostic Framework
Formation Evaluation

The Mineralogy Blindspot

Conventional Logs



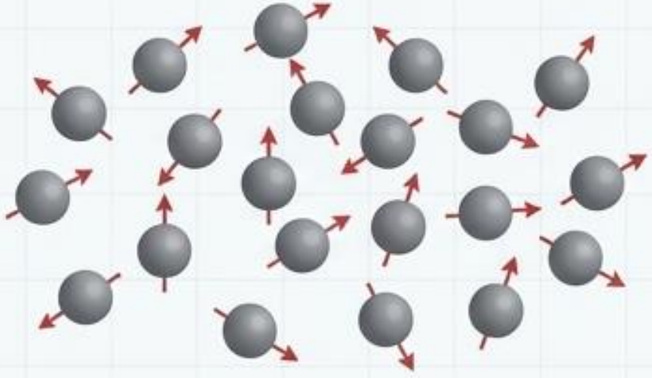
NMR Logging



Key Takeaway: Conventional tools measure the rock to guess the fluid. **NMR** measures the fluid directly.

The Quantum Gyroscope

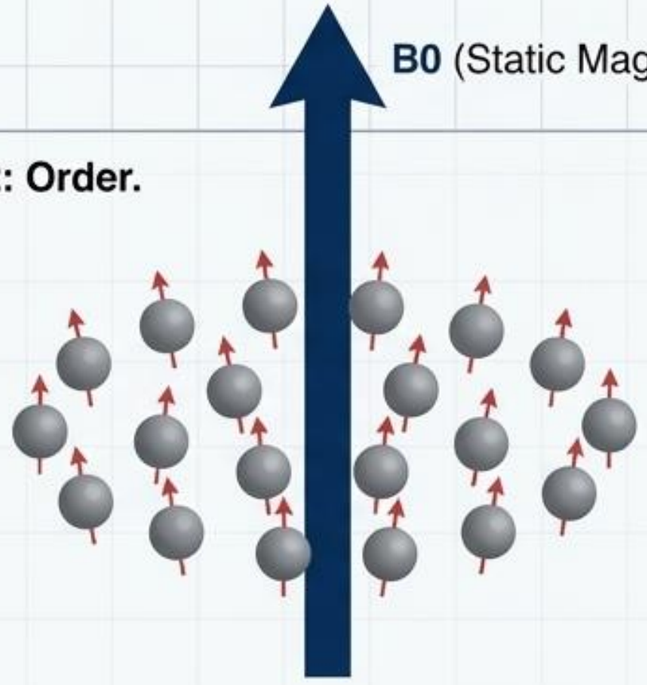
Step 1: Chaos.



Natural State: Random Alignment.

B0 (Static Magnetic Field)

Step 2: Order.



Order. Magnetic Polarization.

The Larmor Frequency

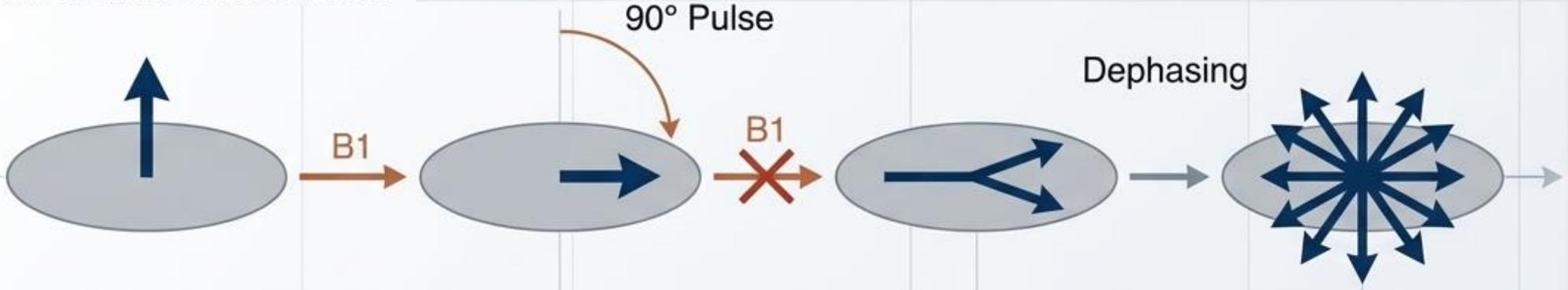
$$f = \frac{\gamma B_0}{2\pi}$$

For hydrogen, the gyromagnetic ratio (γ/2π) is a highly precise 42.58 MHz/tesla.

Key Concept: To read the fluids, we must first align their hydrogen protons using a powerful external magnetic field.

Tipping the Axis: The 90° Pulse

The Action & Reaction

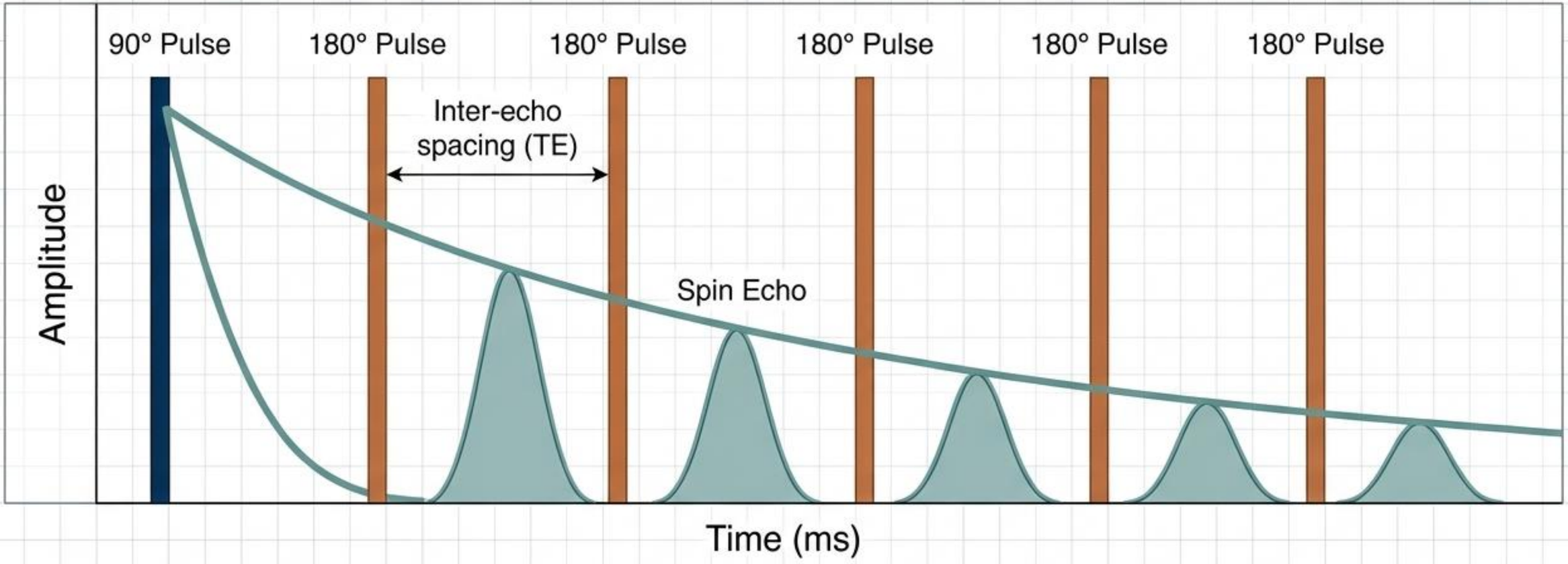


The Signal

The tip angle (θ) is directly controlled by the energy of the B1 pulse.

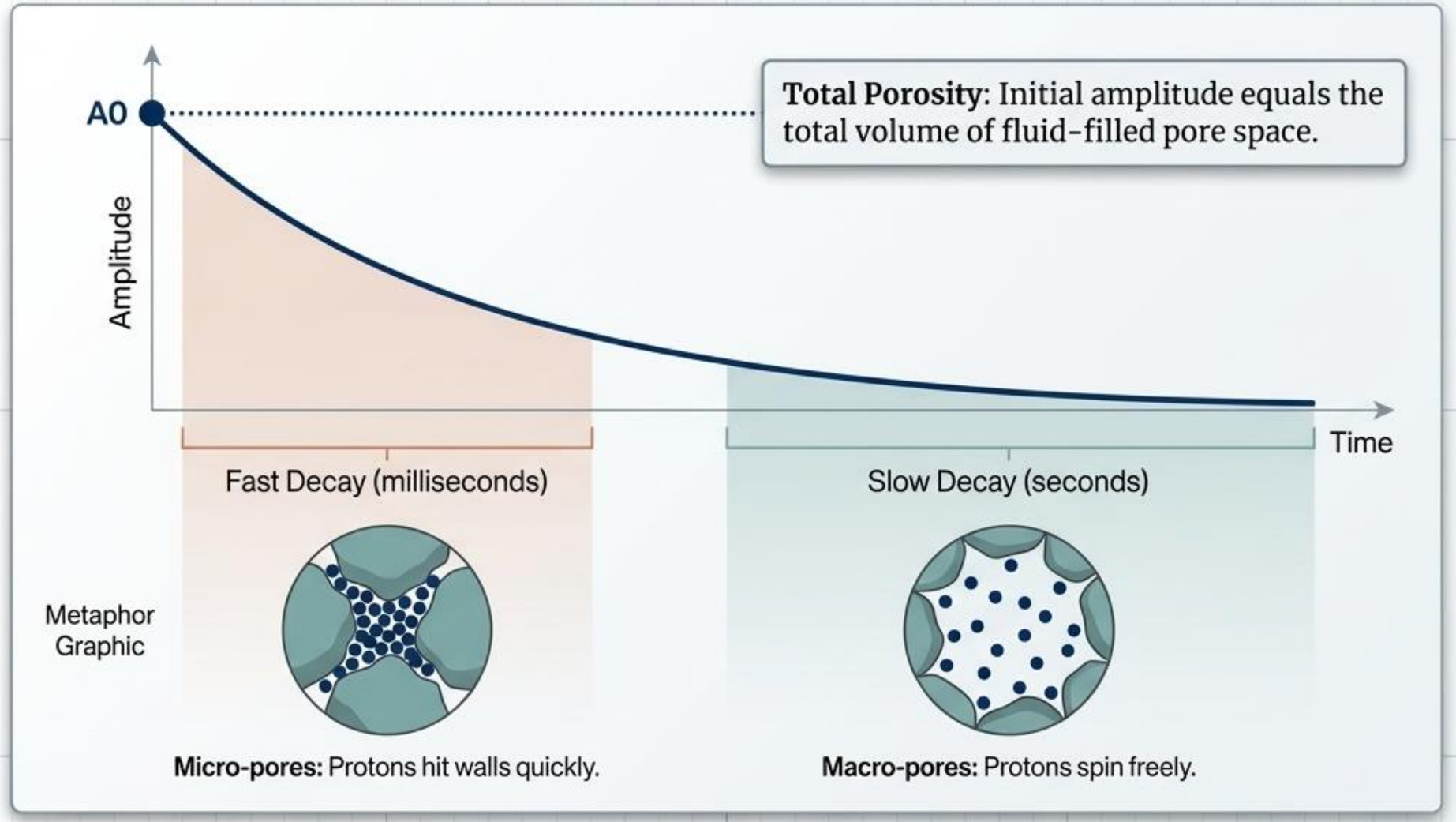
$$\theta = \gamma B1 \tau$$

The Spin-Echo Rhythm (CPMG)



Key Concept: This degrading envelope is the T2 relaxation curve. The rate at which these echoes fade contains the blueprint of the reservoir.

Decoding the Decay Curve



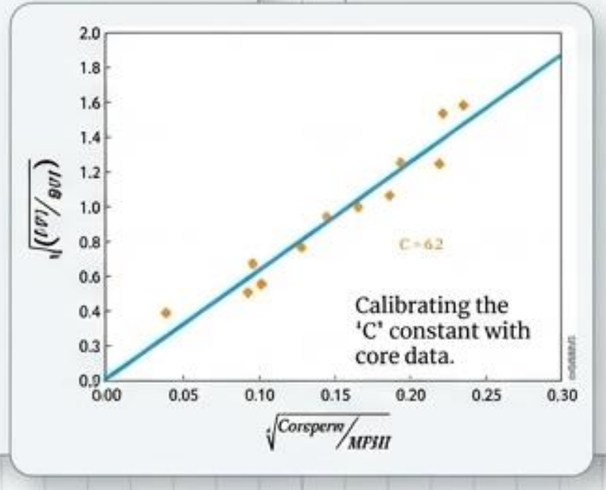
Takeaway: Amplitude = How much fluid. **Time** = How large the container.

The Permeability Engine

Schlumberger-Doll Research (SDR) Model

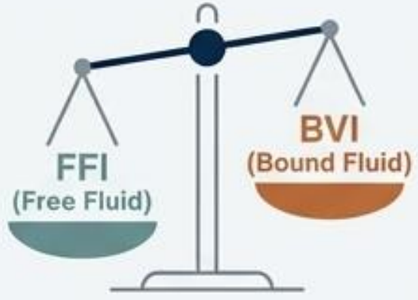
$$k = C\,\Phi^4\,T_{2LM}^2$$

- **Best for:** Water-saturated systems.
- **Limitation:** Overestimates in oil zones due to partial polarization.



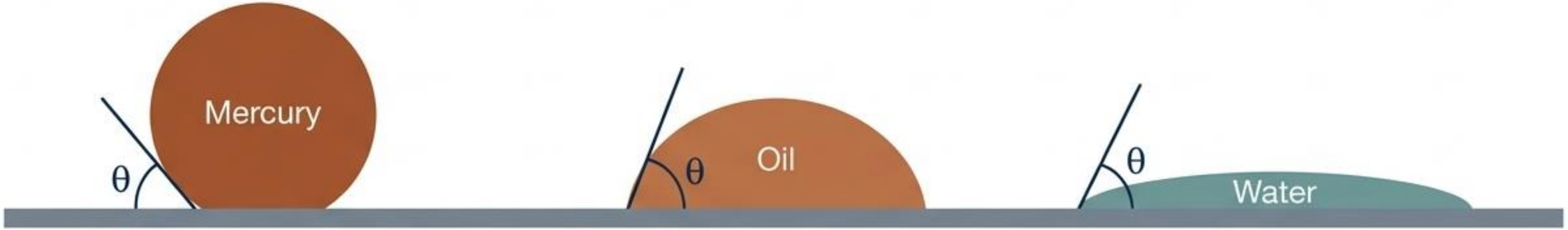
Timur-Coates Model

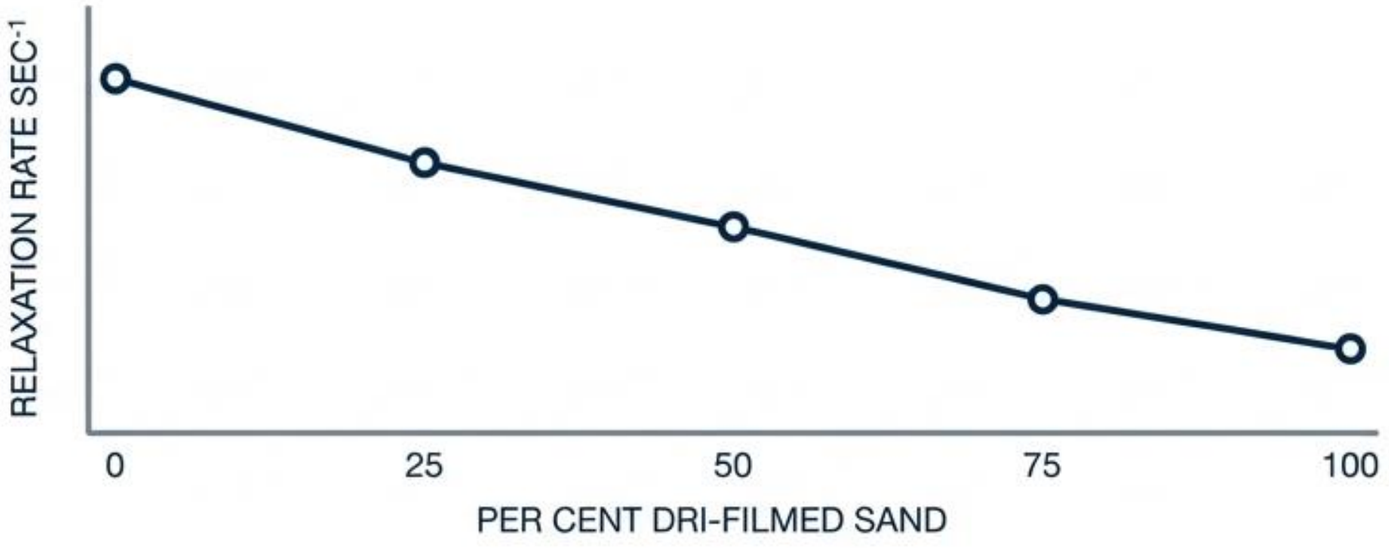
$$k = [(\Phi/C)^2(FFI/BVI)]^2$$



- **Best for:** Formations containing hydrocarbons.
- **Focus:** Weighs Free Fluid Index against Bulk Volume Irreducible.

Diagnosing Wettability





Key Concept: Because fluids relax faster when touching a solid surface, NMR detects which fluid is actively 'wetting' (sticking to) the pore walls.

The Fluid Signature Matrix

Brine

T1: 1 - 500 ms

T2: 1 - 500 ms

Ratio (T1/T2): ~1-2

Note: Dominated by surface relaxation; highly sensitive to paramagnetic impurities.

Crude Oil

T1: 3000 - 4000 ms

T2: 300 - 1000 ms

Ratio (T1/T2): ~4

Note: Spread correlates directly with viscosity (higher viscosity = shorter T2).

Gas / Methane

T1: 4000 - 5000 ms

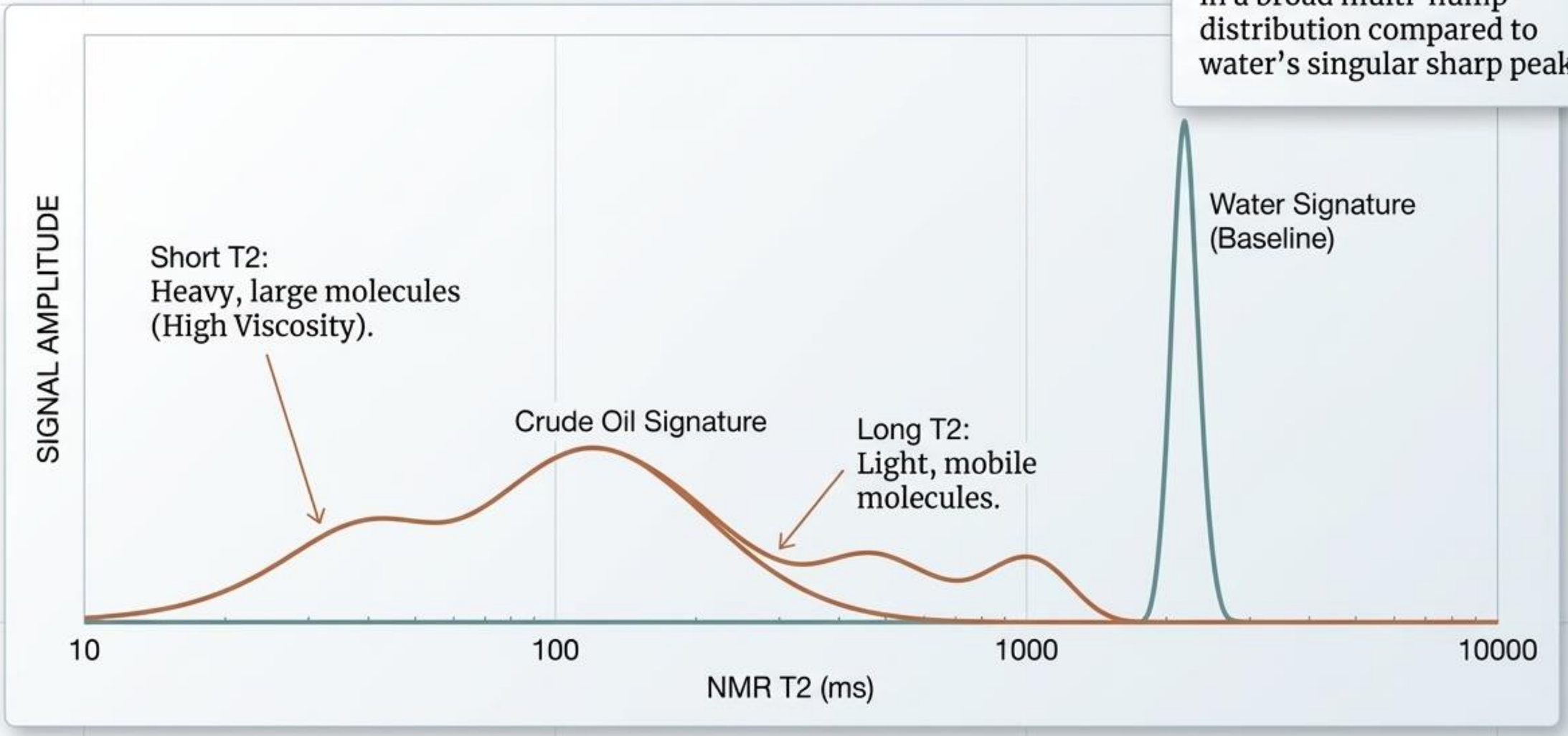
T2: 30 - 60 ms

Ratio (T1/T2): ~80

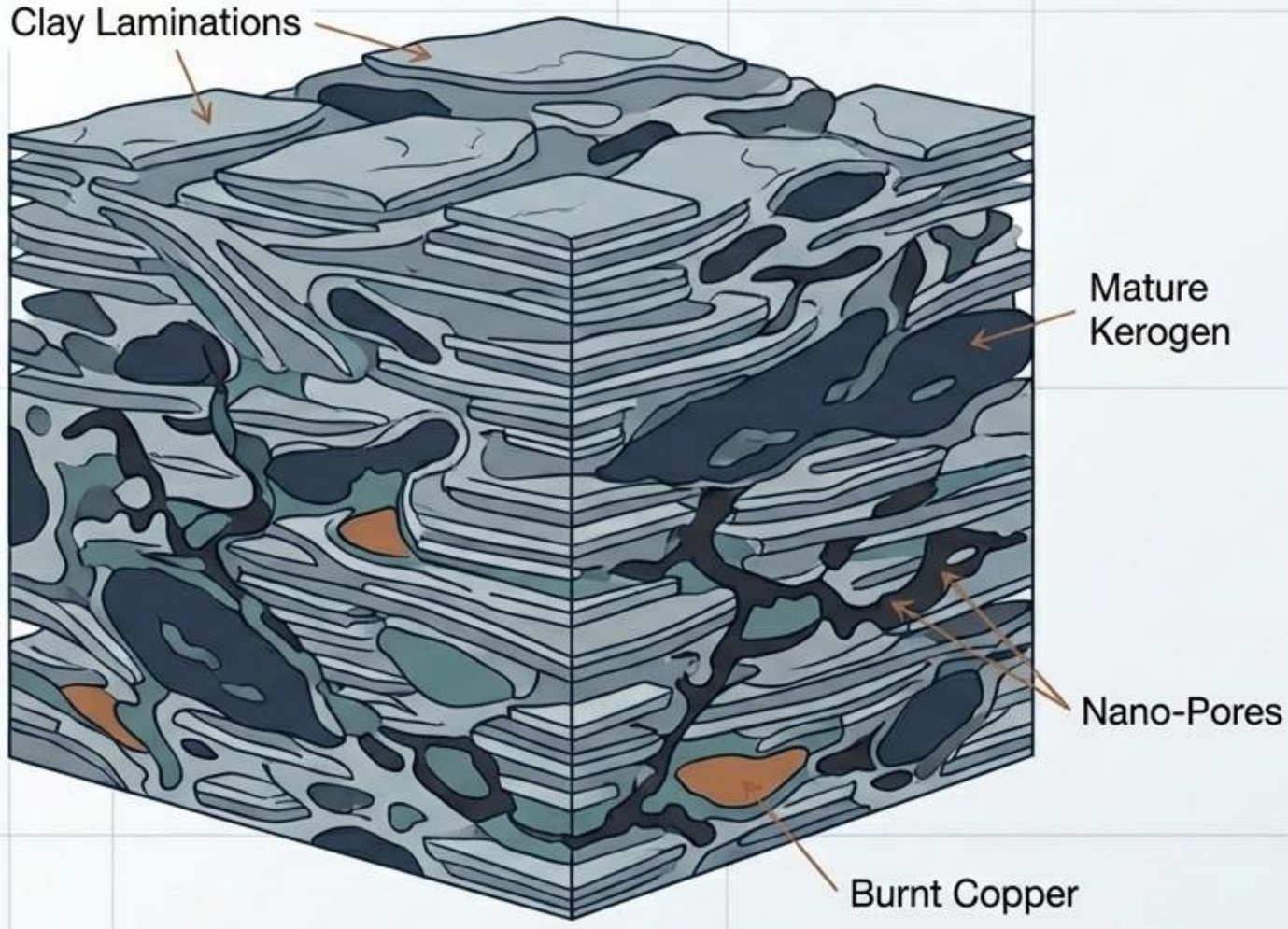
Note: Relaxes via spin-rotation interaction. High T1/T2 contrast is the definitive fingerprint for gas.

Visualizing Fluid Fingerprints

Oil is not a single molecule but a complex mixture, resulting in a broad multi-hump distribution compared to water's singular sharp peak.



The Unconventional Challenge



1. Matrix Interference

Unlike sandstones, clay and mature kerogen in shale have their own hydrogen protons, creating ultra-short signals (< 0.1 ms) that overlap with reservoir fluids.

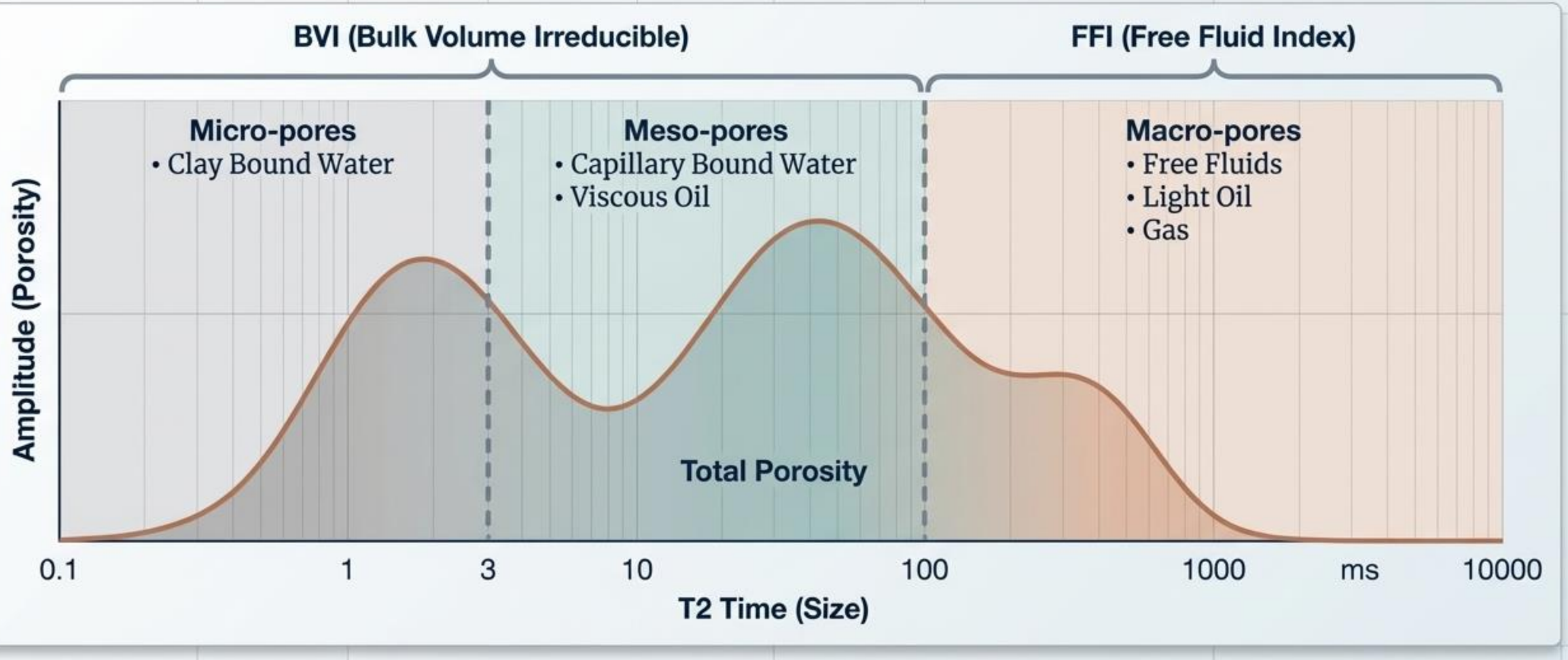
2. Fractional Wettability

Illite (water-wet) and Kaolinite (oil-wet) exist side-by-side at a microscopic level, completely scrambling traditional surface relaxation rules.

3. Nano-Scale Confinement

Fluids are so tightly restricted within nano-pores that bulk relaxation virtually disappears; surface relaxation entirely dominates the signal.

SYNTHESIS: The T2 Master Interpretation Map



Takeaway: A single glance at this topological map reveals the total storage capacity, the flow potential, and the exact fluid makeup of the reservoir.

Customized version

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