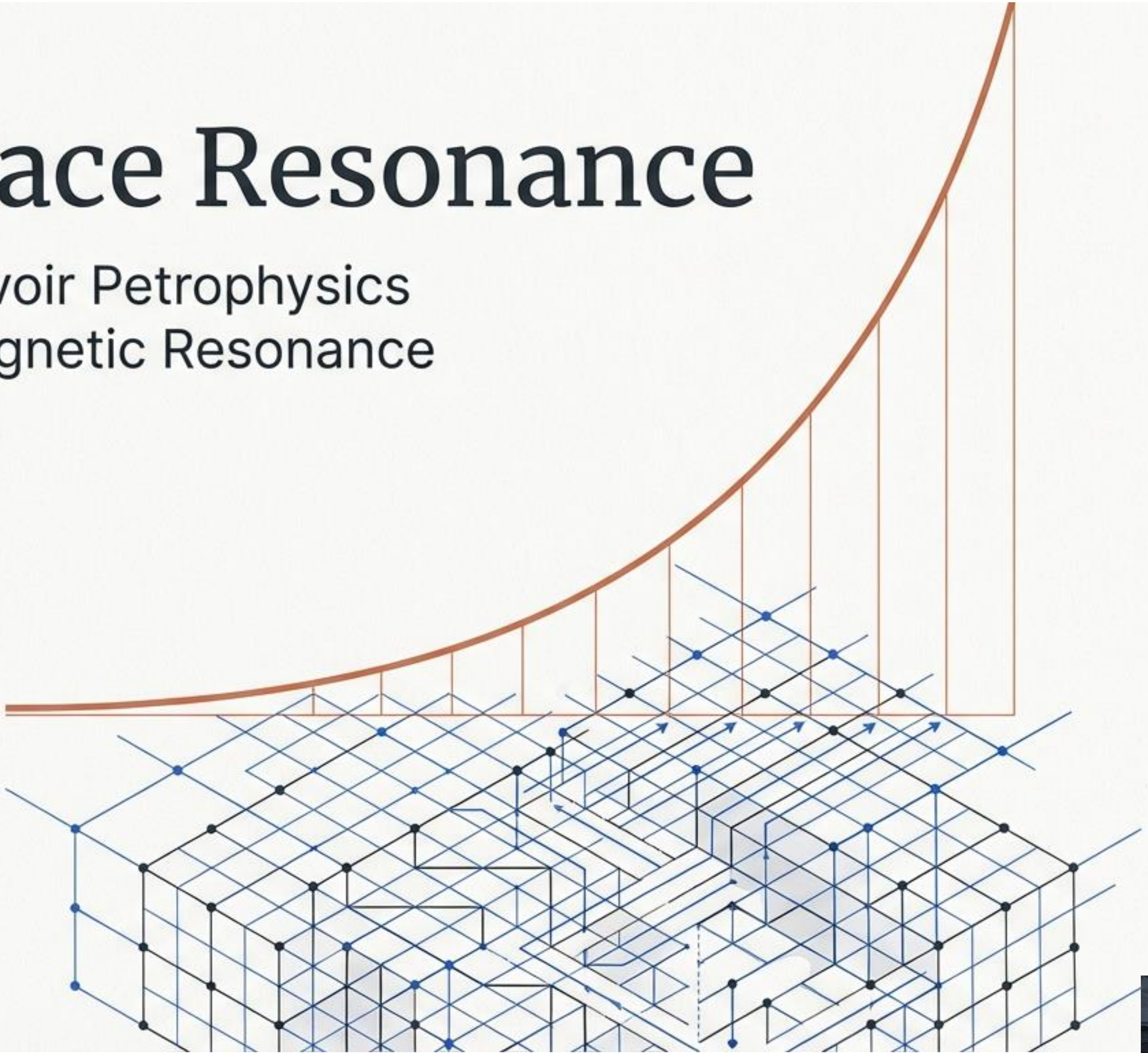
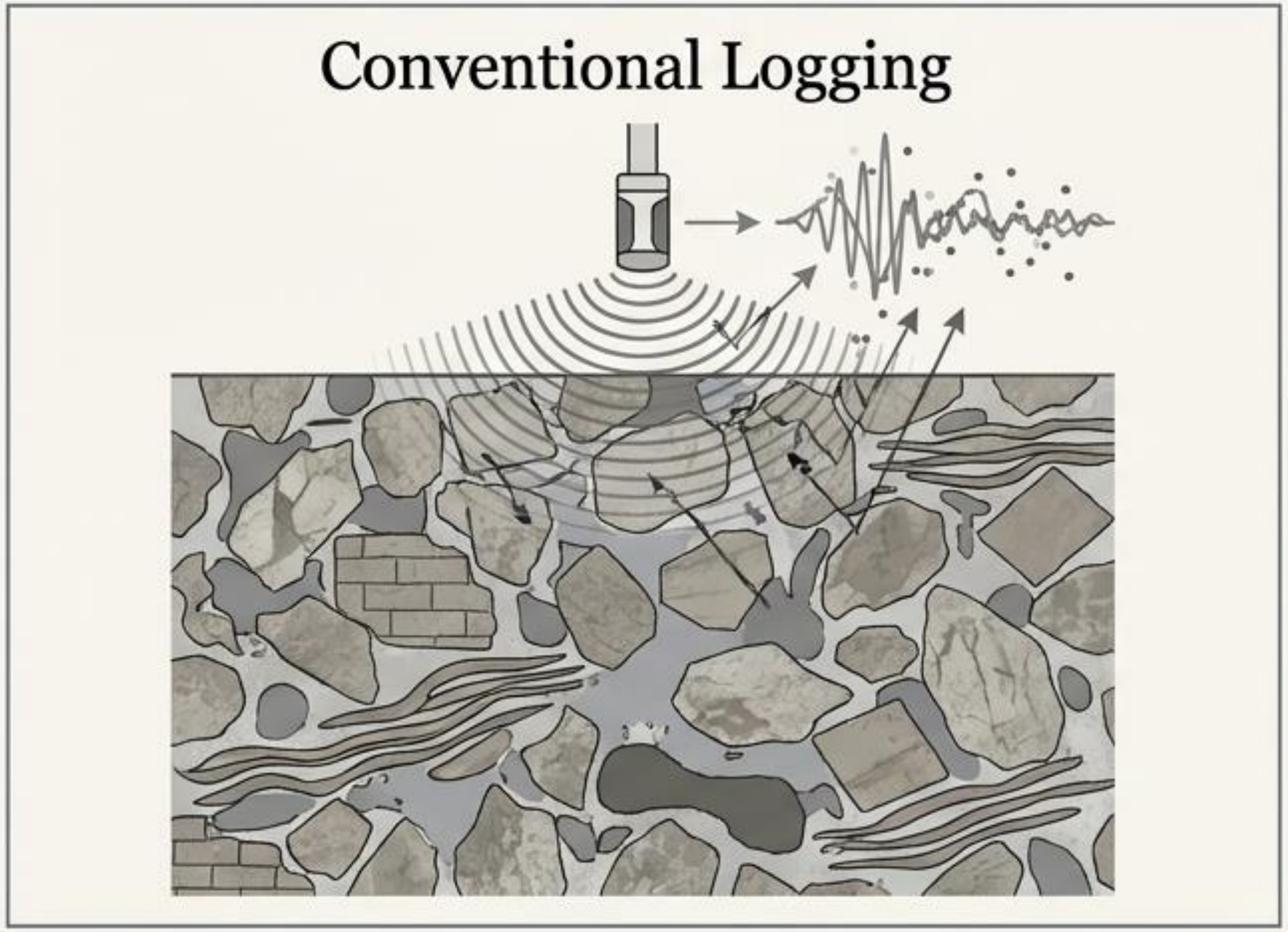
Subsurface Resonance

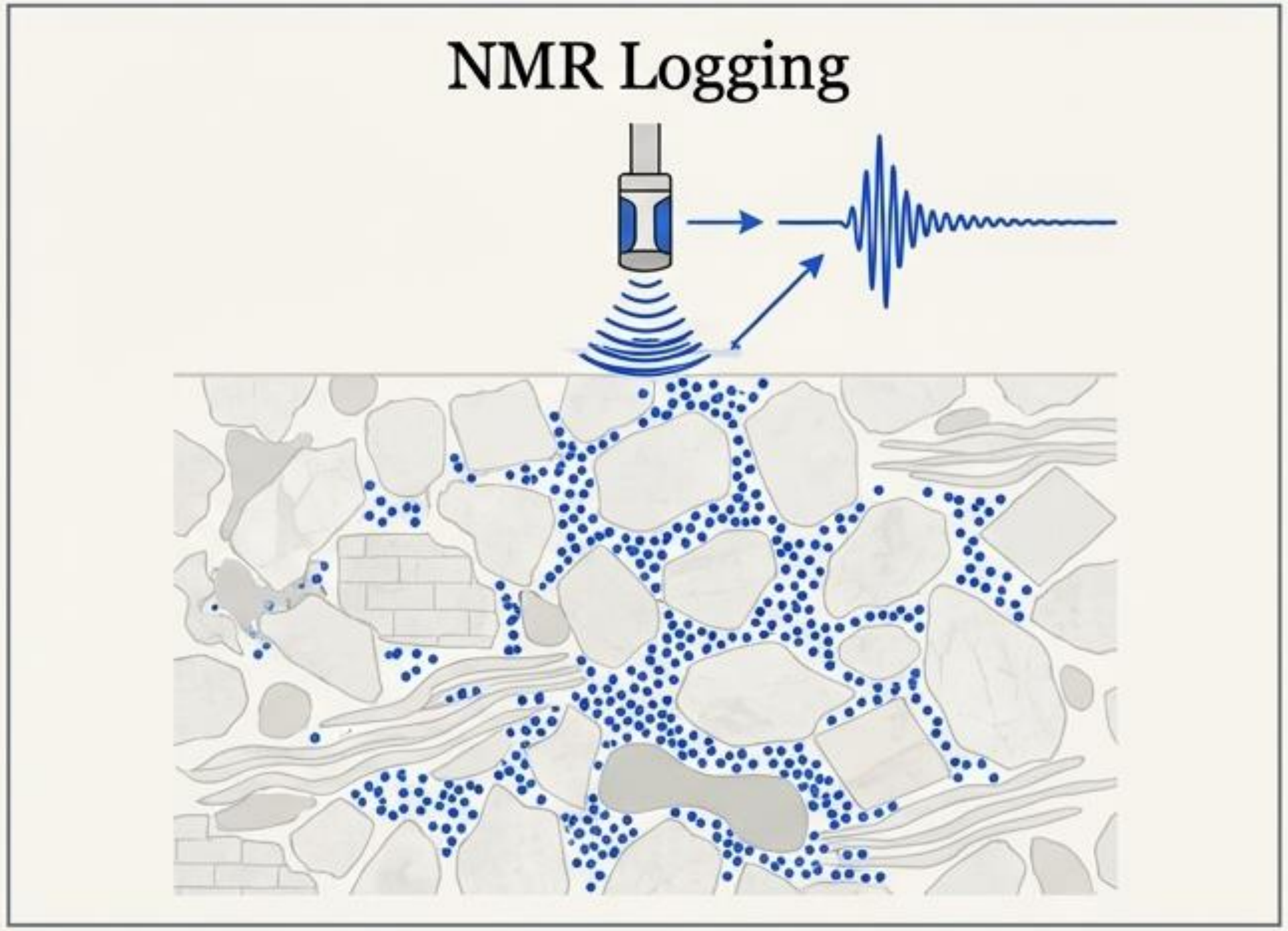
Decoding Reservoir Petrophysics with Nuclear Magnetic Resonance

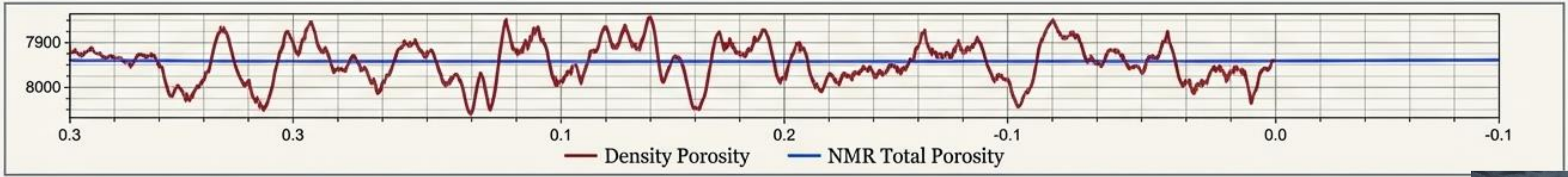


THE LITHOLOGY PROBLEM

Conventional logs depend on rock mineralogy, creating blind spots. NMR isolates the fluids.

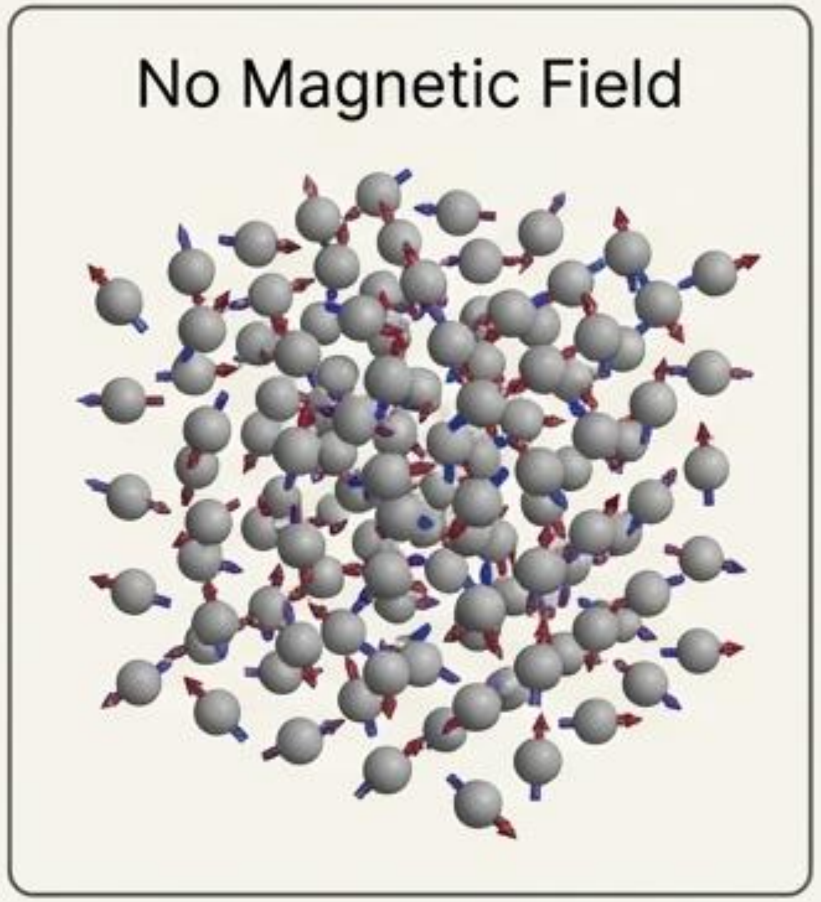


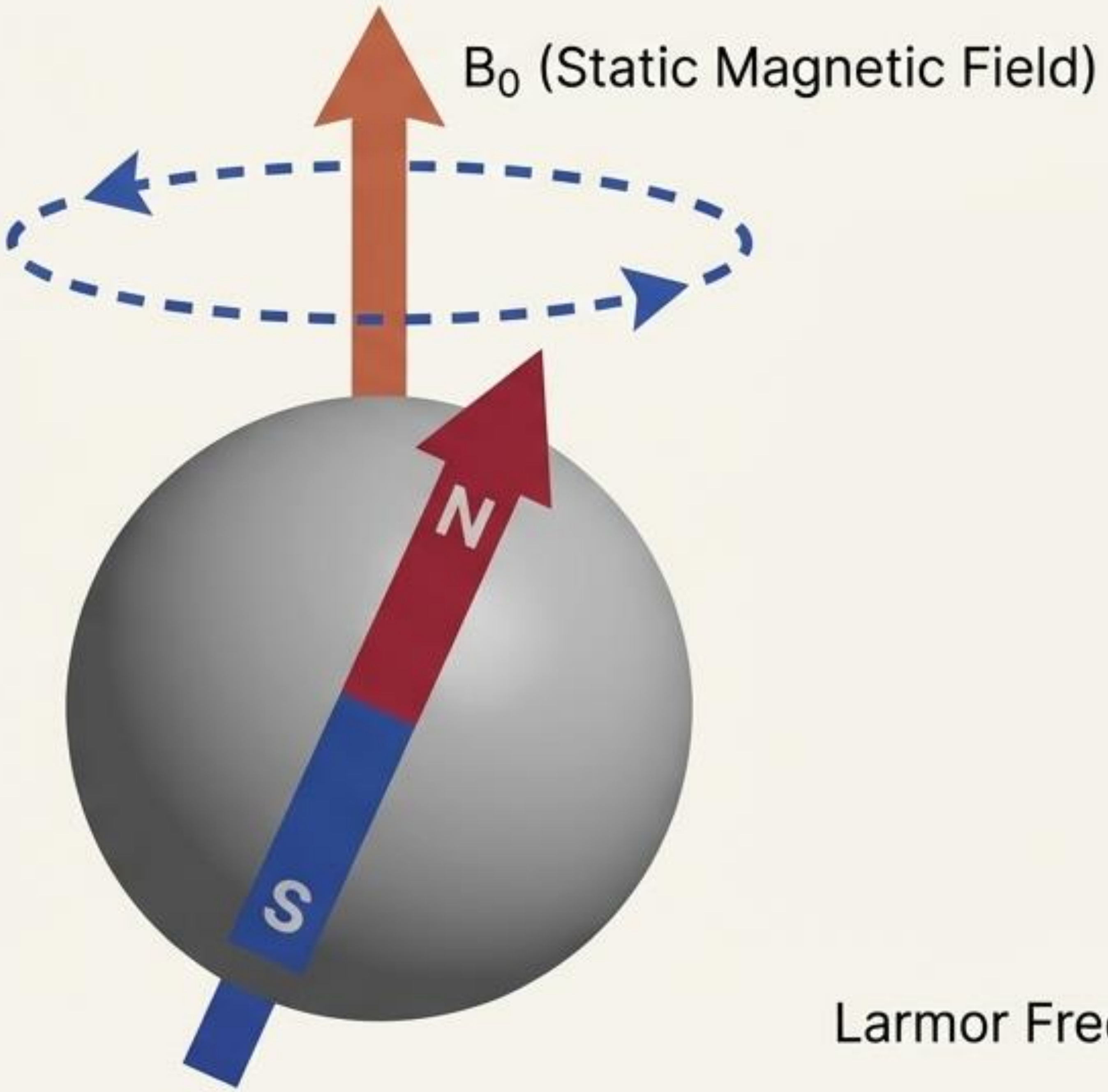




The Gyroscopic Proton

Hydrogen nuclei act as tiny magnets. An external field forces them to precess at a precise frequency.

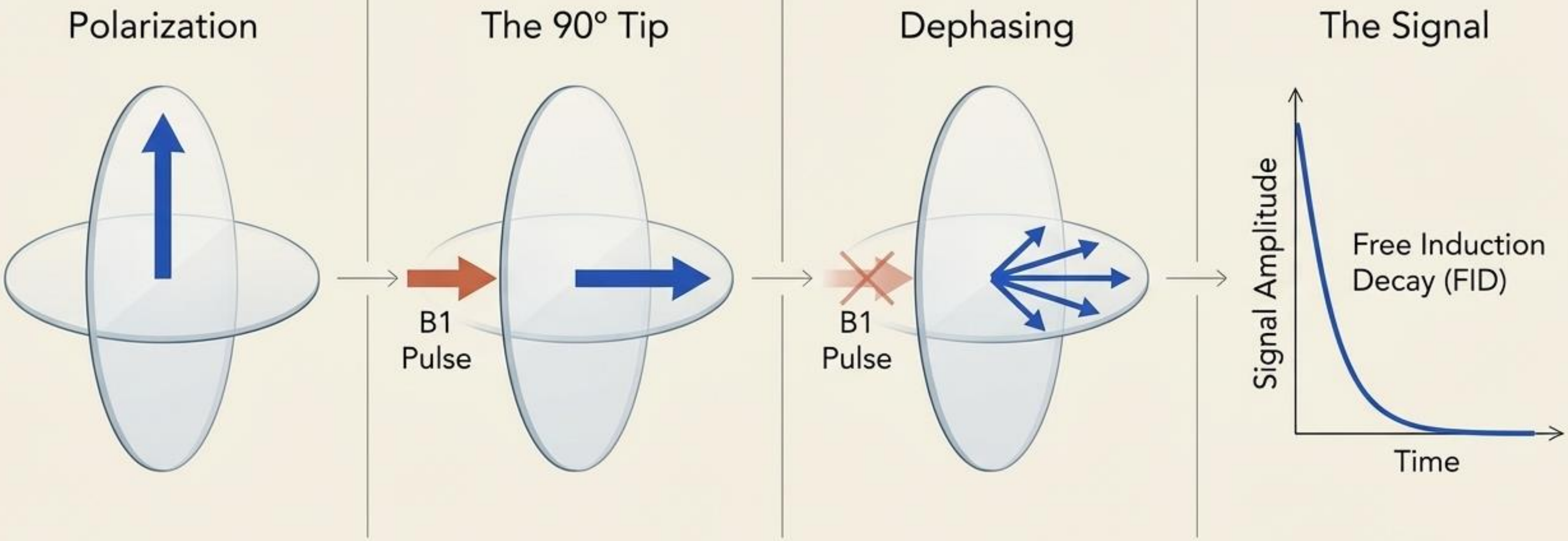




Larmor Frequency: $f = \frac{\gamma}{2\pi} \cdot B_0$

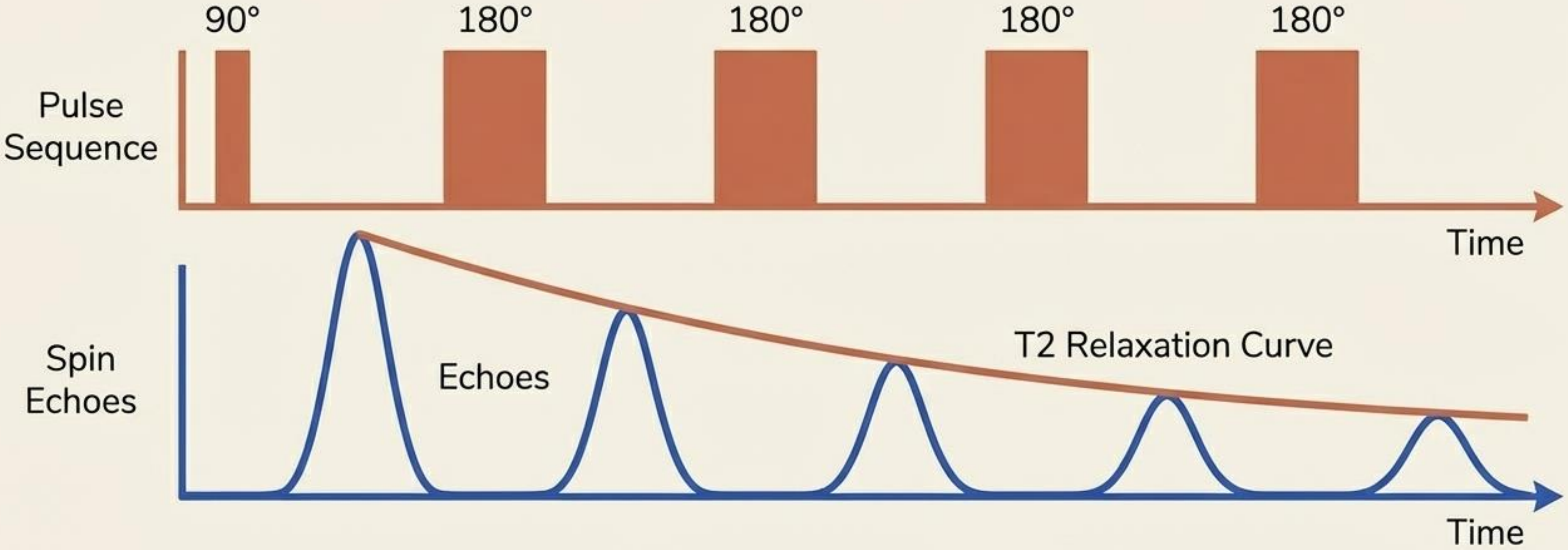
Pulse Tipping & Dephasing

A radio frequency pulse tilts the protons. When the pulse stops, they lose coherence.



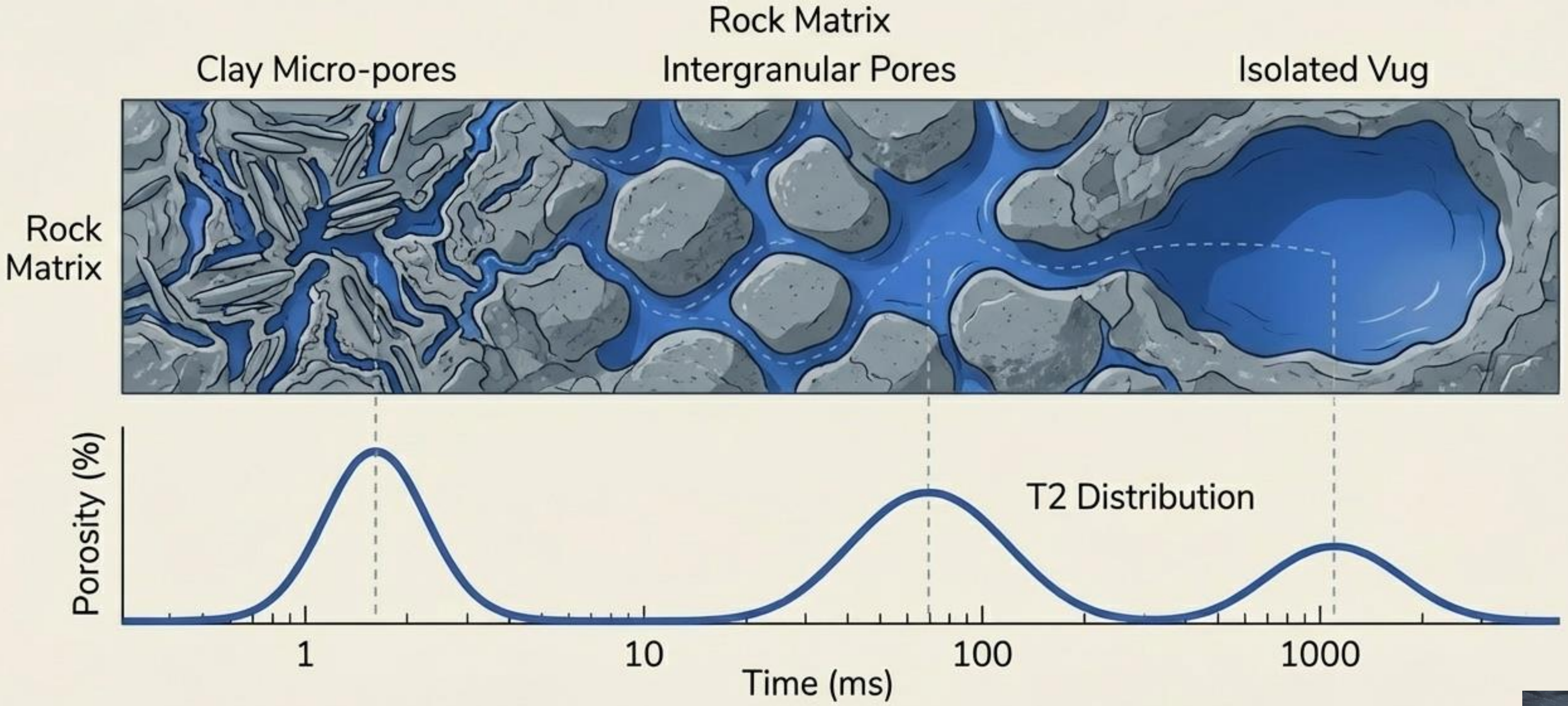
The CPMG Echo Train

A sequence of 180° pulses forces the protons to re-align, generating a series of decaying echoes.



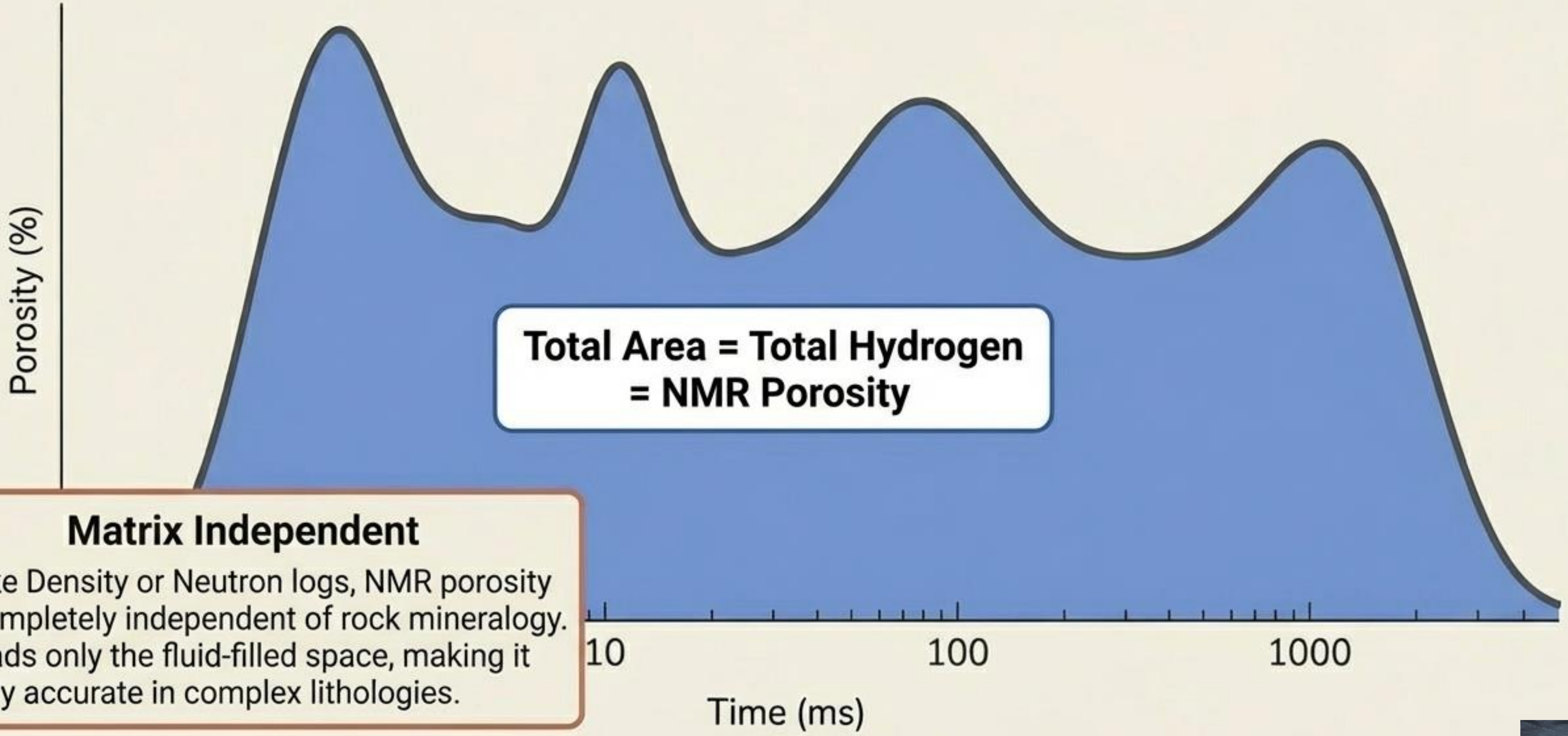
The Time = Size Principle

Protons in small pores collide with rock walls and relax quickly. Protons in large pores relax slowly.



Fluid Quantification: Absolute Porosity

The total area under the T2 curve equals the total fluid volume, yielding true rock porosity.



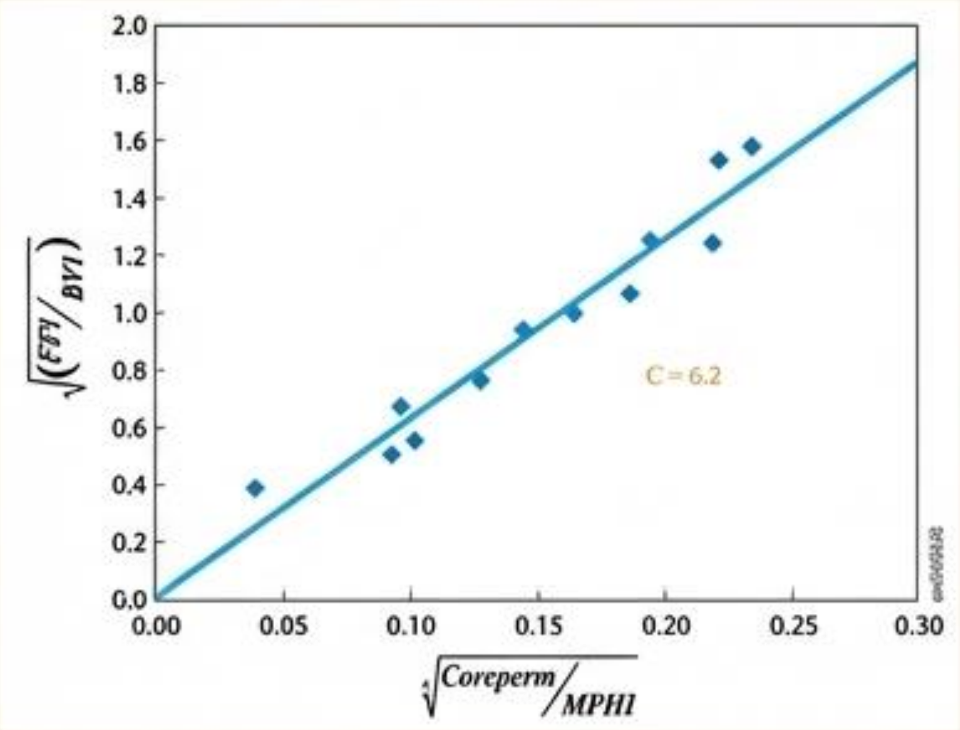
Matrix Independent

Unlike Density or Neutron logs, NMR porosity is completely independent of rock mineralogy. It reads only the fluid-filled space, making it highly accurate in complex lithologies.

RSS NMR

Fluid Mobility: Permeability Diagnostic

Translating porosity and T2 distributions into permeability using empirical models.

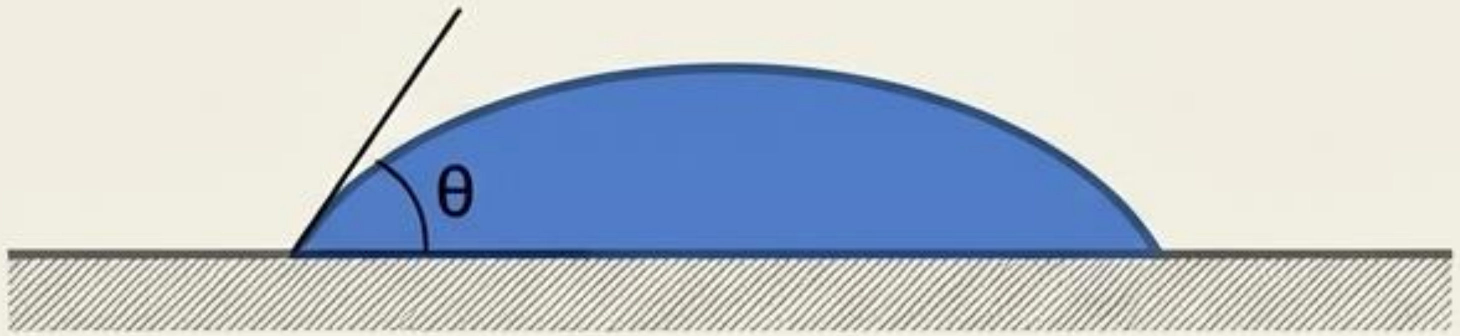


[Blank]	Timur-Coates Model	SDR Model
Primary Variable	Ratio of Free Fluid to Bound Fluid (FFI / BVI)	Geometric Mean of T2 (T2LM)
Best Use Case	Formations containing water and/or hydrocarbons.	Pure water-saturated zones.
Critical Limitations	Fails in fractured media.	Fails in oil/gas zones due to partial polarization (overestimates permeability).

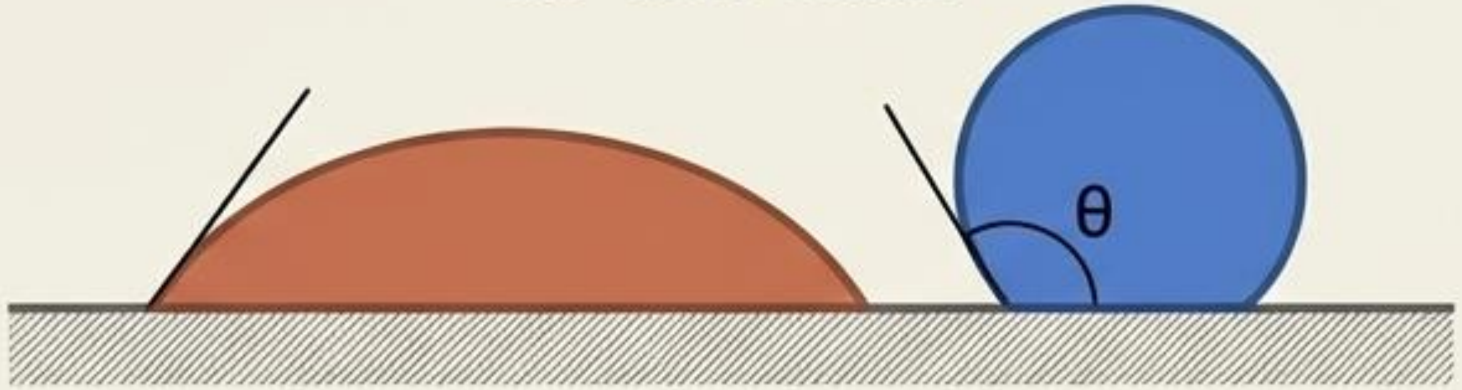
Fluid-Rock Interaction: Wettability

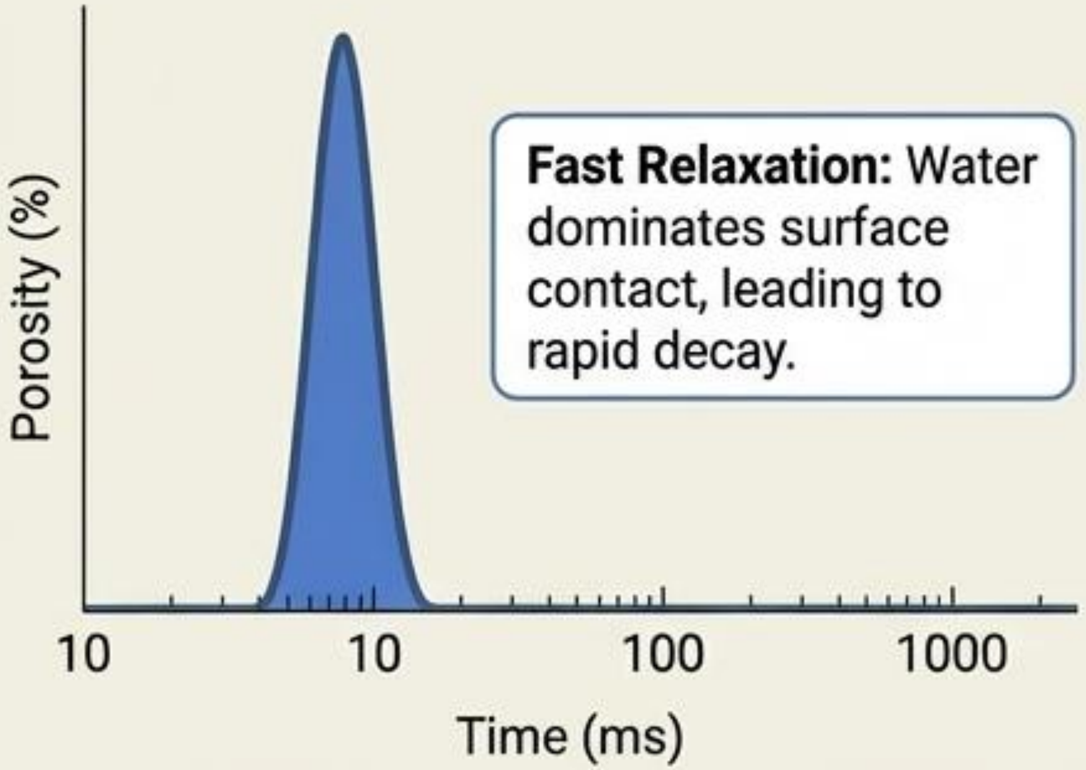
Fluids that touch the rock grain surface relax faster. Contact angle directly dictates the T2 decay rate.

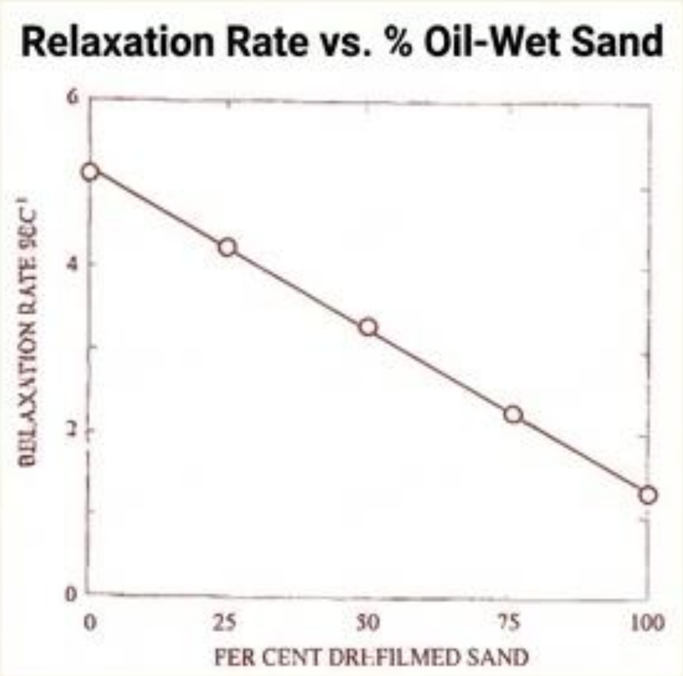
Water-Wet State



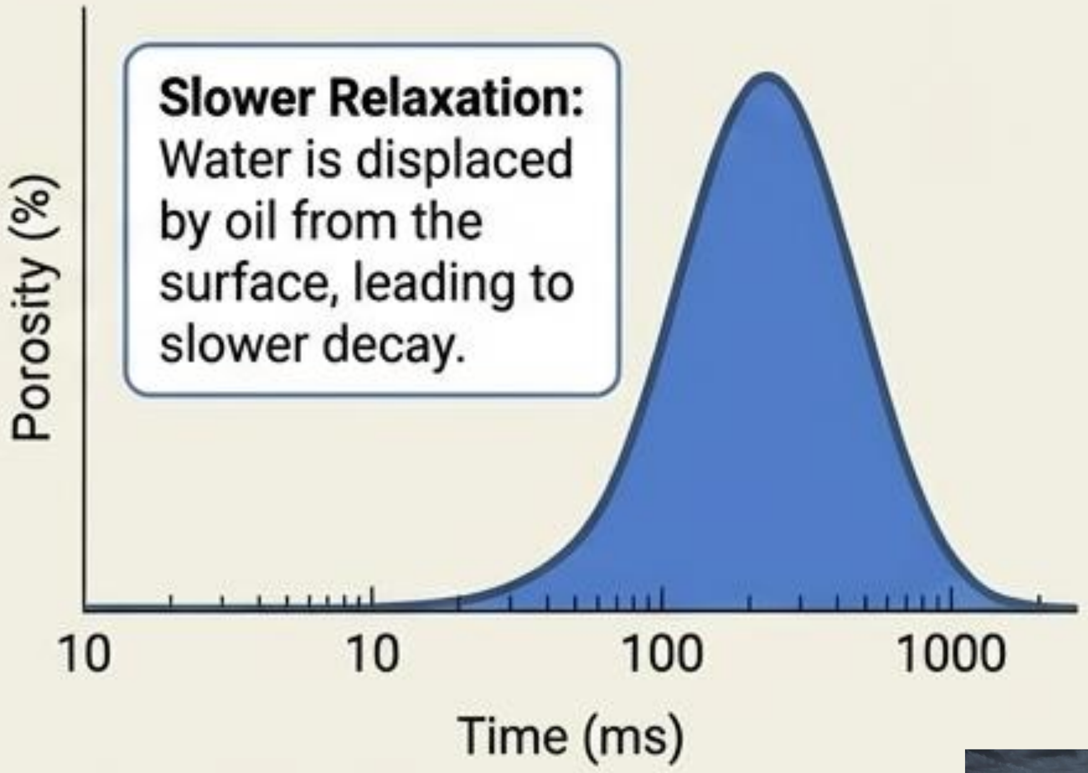
Oil-Wet State





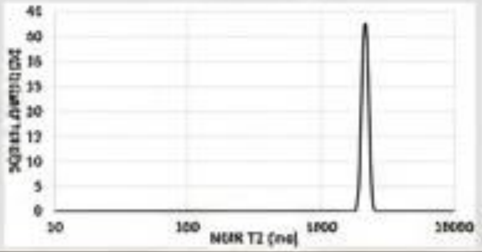
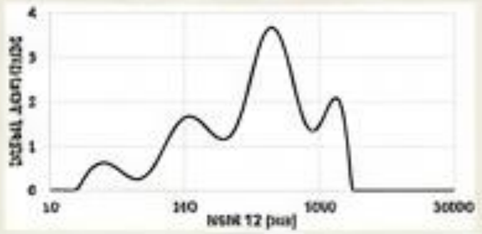


Water relaxation rate drops as rock becomes increasingly oil-wet.



The Fluid Signature Matrix

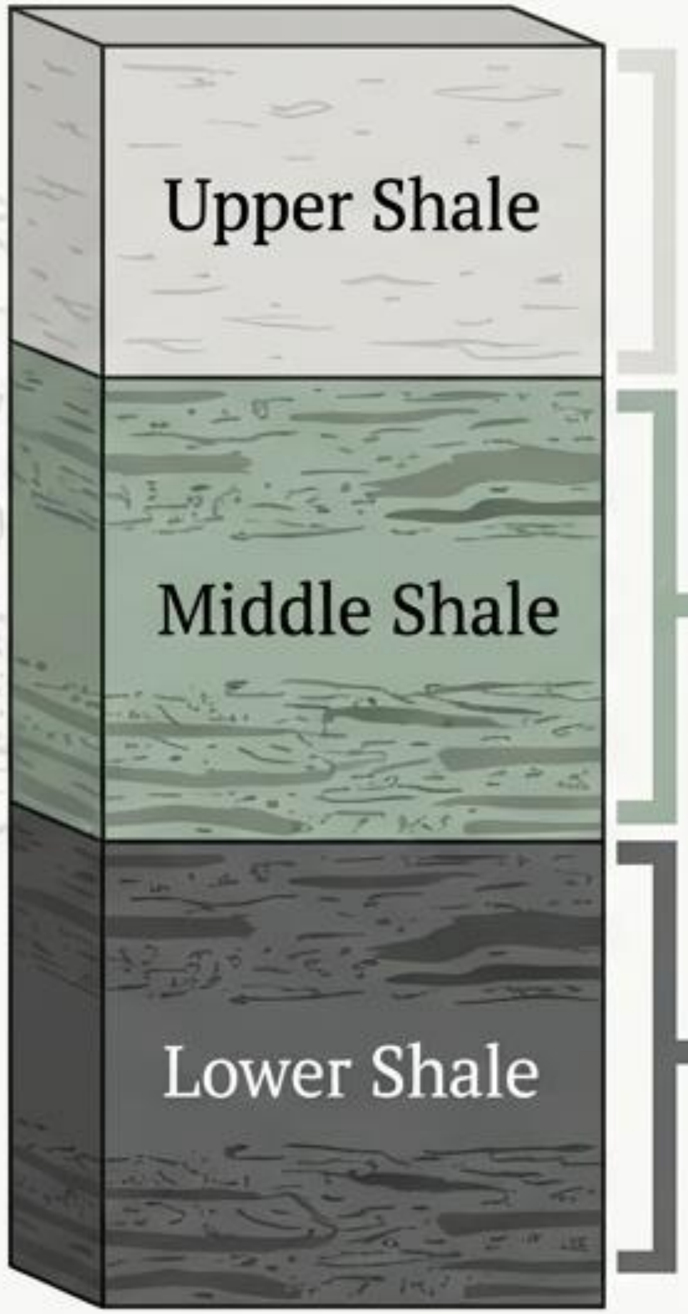
Differentiating reservoir fluids by leveraging contrasts in relaxation times and diffusion coefficients.

Fluid Type	T1 (ms)	T2 (ms)	T1/T2 Ratio	Diffusivity (D0)
Brine 	1 - 500	1 - 500	~2	High
Crude Oil 	3000 - 4000	300 - 1000	~4	Variable (Viscosity dependent)
Gas	4000 - 5000	30 - 60	~80	Very High

- **Key Insight:** The massive T1/T2 ratio of Gas (~80) makes it instantly identifiable against liquids when applying dual wait-time polarization techniques.

The Unconventional Frontier

Applying NMR to highly complex marine-continental transitional shales:
The Shan 23 Case Study.



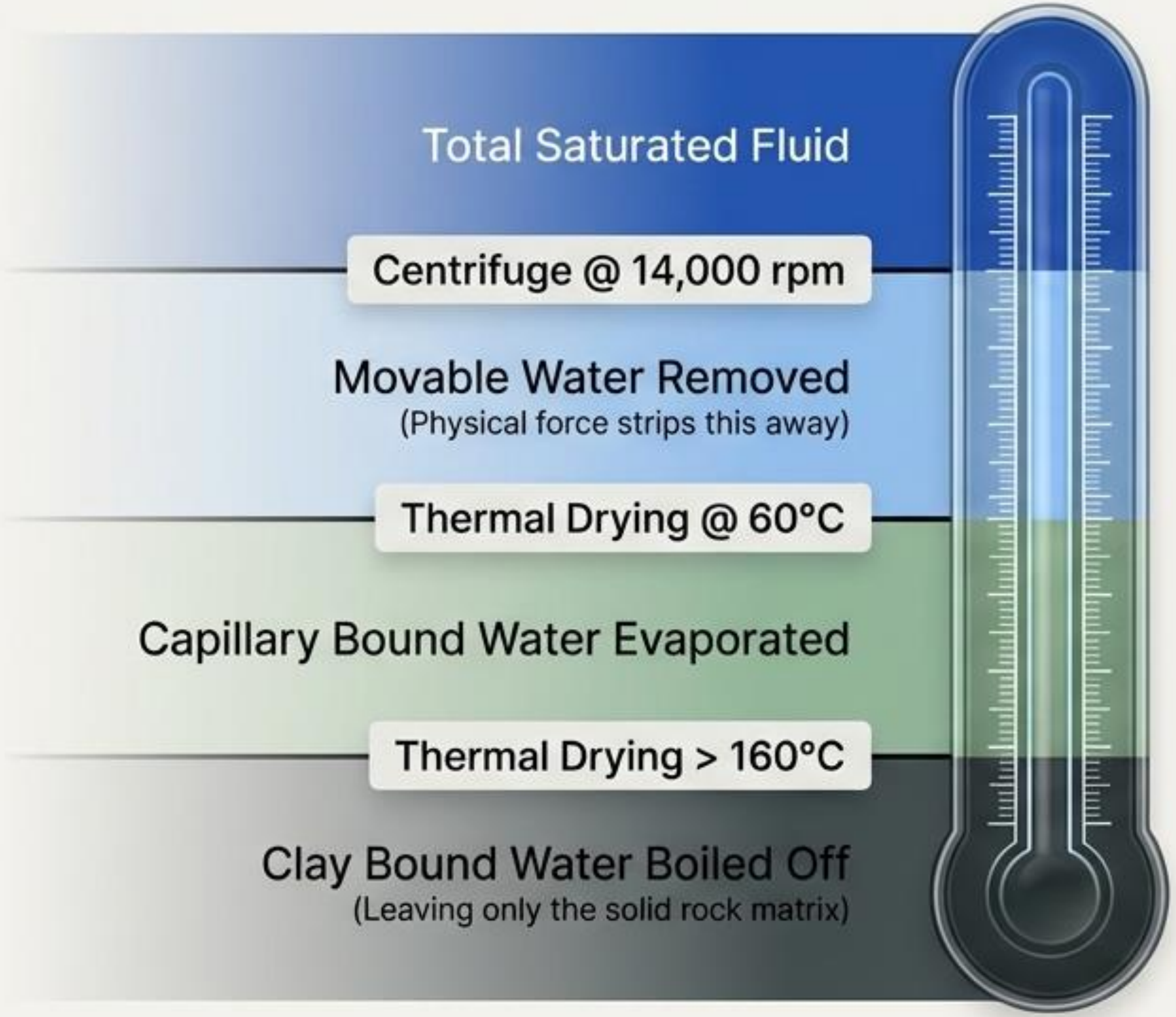
High Potential Zones: Shan 23 Submember

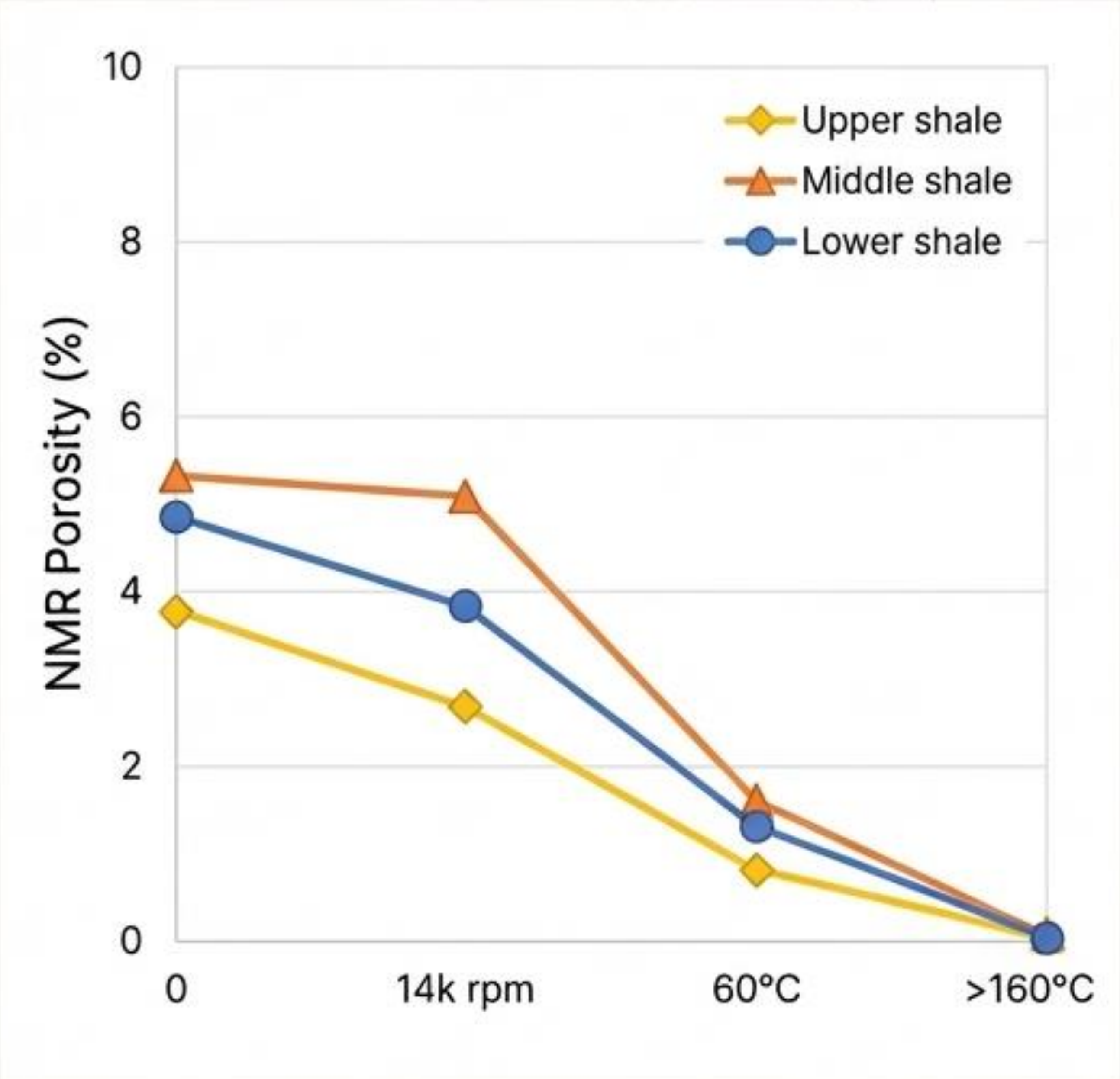
The Middle and Lower shales exhibit the highest Total Organic Carbon (TOC) and Brittleness Index. NMR analysis is required to distinguish movable hydrocarbons from locked fluids in these nano-scale pore networks.

Shale Zone	Average TOC (%)
Middle Shale	**Average TOC: 6.87%**
Lower Shale	**Average TOC: 3.37%**
Upper Shale	**Average TOC: 2.30%**

Energy Stripping: Isolating Fluid Types

Applying physical and thermal energy sequentially strips away layers of fluid to define exploitable pore limits.





Shale Pore Fluid Taxonomy

Codifying the Shan 23 energy stripping results into actionable reservoir classifications.

Movable Pores

(T2 > Tc1)

Represents easily produced fluids. The lower limit of exploitable pore size is ~10nm.

The Middle Shale contains the highest movable water volume at 32.58%, indicating strong flow capacity.

Bound Pores (Capillary)

(Tc2 < T2 < Tc1)

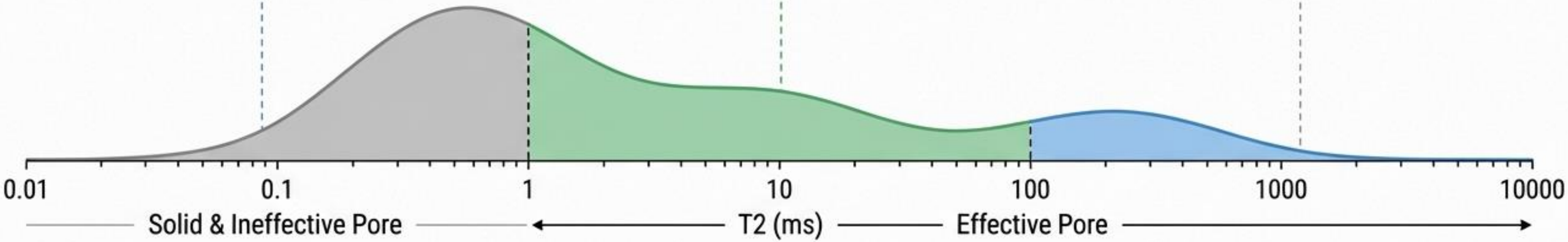
Requires aggressive fracturing to exploit. Trapped in the nano-matrix.

The Lower Shale is dominated by capillary bound volume, reaching up to 57.52%.

Immovable Pores (Clay)

(T2 < Tc2)

Non-producible space occupied by hydration water bound directly to clay minerals.



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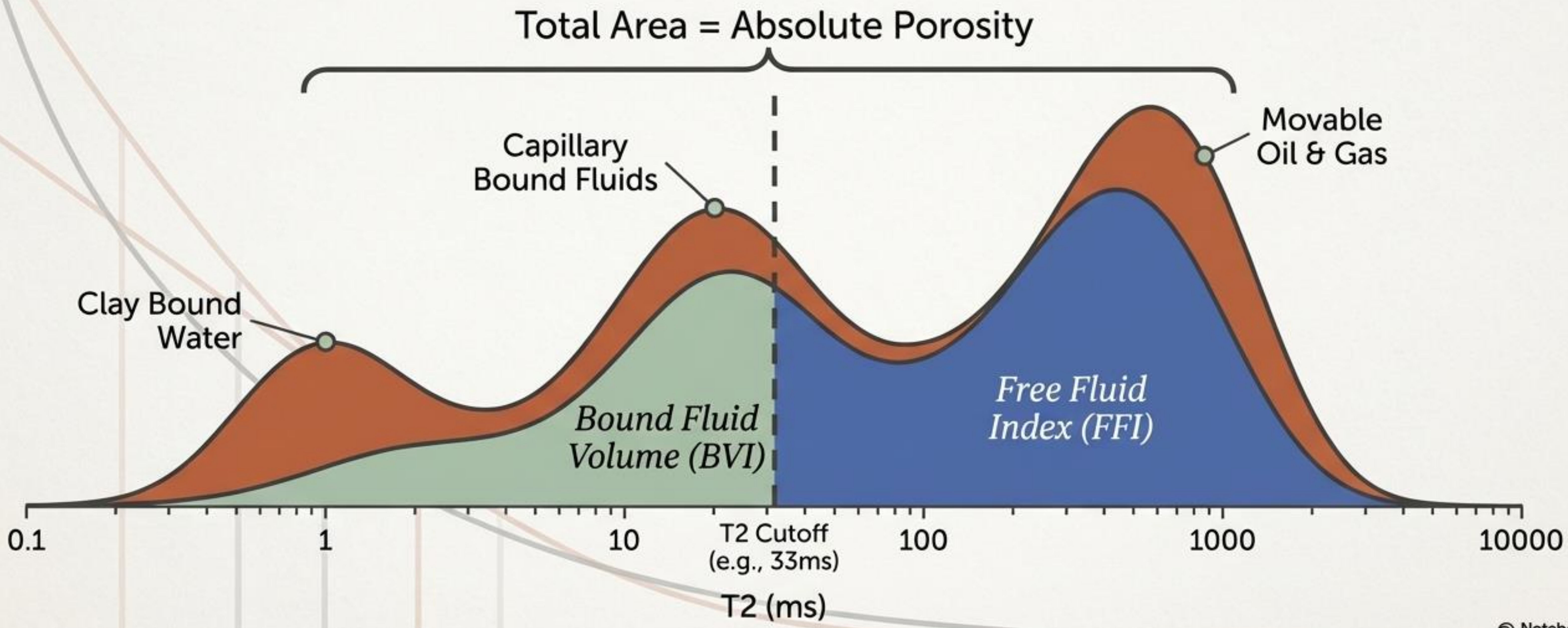
The Master T2 Distribution

Physics, rock properties, and fluid signatures converge. A single NMR measurement maps the entire petrophysical universe.



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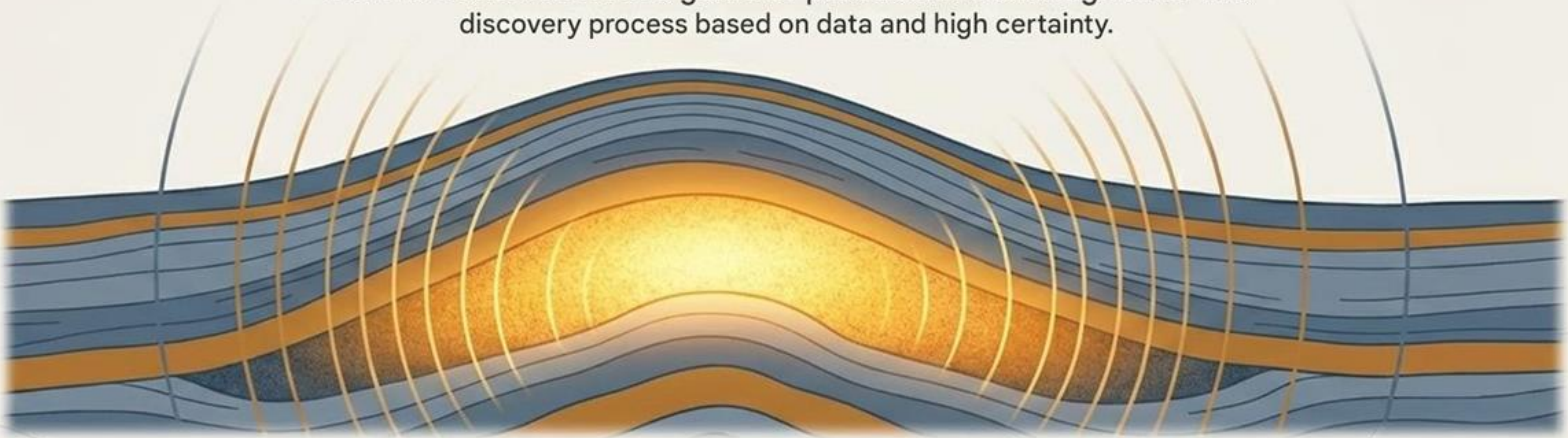
Stop searching for anomalies.
Start finding hydrocarbons.

RSS/NMR technology represents a fundamental change in exploration.
It is the transition from a game of probabilities and high risks to a discovery process based on data and high certainty.



The future of exploration is not in interpreting shadows better, but in turning on the light.

RSS NMR
THE SIMPLE WAY OF EXPLORATION
By Fands-LLC