

# Global Orbital Remote Sensing: Principles of Passive Mobile NMR

*Combination of depth frequency calibration and hydrogen relaxation for tank marking*

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## 1. The Principle of In-Depth Investigation (Frequency Calibration)

In passive, large-scale observation (without ground contact), the ability to probe the subsurface to specific depths (up to 7 km) relies on a fundamental physical law: the Larmor relation. The magnetic resonance frequency ( $\omega_0$ ) of hydrogen nuclei is directly proportional to the intensity of the magnetic field ( $B_0$ ) in which they are immersed.

$$\omega_0 = \gamma \cdot B_0$$

Since the static component of the Earth's magnetic field or induced gradients varies predictably with sedimentary depth, the orbital system performs precise geometric selection by adjusting the frequency of the emitted radio frequency pulse. By modulating this tuning frequency, the waves pass through the upper layers without significant interaction (transparent dielectric media) and only resonate at the exact depth where the Larmor condition is met, causing exclusive excitation of the protons in that subsurface layer.

## 2. Spectral Marking by Relaxation Time (T1 and T2)

Once the radio frequency pulse is interrupted, the excited protons return to their initial state. This process releases a return radio wave detected by orbital sensors. Analyzing the attenuation of this signal allows the measurement of transverse (T2) and longitudinal (T1) relaxation times, providing a profile of the fluid environment:

- Elimination of sterile environments (Short times): Water trapped in the minute pores of clays or confined in ultra-compact rocks undergoes aggressive surface relaxation. Its T2 time is less than 10 or 33 milliseconds. The signal disappears instantly, classifying these areas as non-productible.
- Identification of reservoirs and "Sweet Points" (Long times): In a good-quality reservoir rock (sandstone or carbonates with open porosity), fluids have a great deal of freedom of movement. Interactions with the rock wall are limited, resulting in long relaxation times (T2 > 33 ms in sandstone, T2 > 92 ms in carbonates). These areas are reflected by high-amplitude anomalies in the readings.

## 3. Direct Physical Discrimination of Fluids

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Exploration by satellite

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Beyond simply detecting a porous area, the precise combination of T1 and T2 signatures makes it possible to certify the nature of the fluid present in the imaged porosity:

- Light oil: Exhibits a stable T1/T2 ratio, generally between 1 and 2, associated with a stable intermediate relaxation. This specific signature directly reflects the accumulation of marketable crude oil.
- Natural gas: Under the influence of strong molecular diffusion dynamics induced by the micro-field gradients of porous matrices, the gas displays a unique asymmetry with a very stretched longitudinal T1 (several seconds) and a drastically shortened transverse T2. This spectral anomaly cannot be confused with water or waste rock.

## 4. Strategic Operational Methodology: Step Zero

The industrial integration of this technology reconfigures large-scale sedimentary exploration according to a funnel-shaped protocol:

1. *Global Scan (Stage Zero): Complete survey of a large-scale sedimentary exploration block using satellites, passively mapping global structural variations.*
2. *Geophysical Filtering: Instant masking of all areas characterized by short NMR responses (fast T2), eliminating over 70% of areas without potential.*
3. *Mobile Fluid Mapping: Identification of long-relaxation spectral signatures, validating the presence of exploitable fluids.*
4. *Surgical Targeting: Delineation of the contours of "sweet spots." Large-scale 3D seismic acquisition campaigns or exploration drilling are thus precisely guided toward targets with a high probability of success.*

## 5. Major Advantages for Industrial Exploration

- Profitability and Time Savings: Creating this map in 4 to 6 months avoids the colossal investments associated with deploying blind seismic grids across thousands of barren square kilometers.
- Total Discretion & Zero Impact: The process operates remotely and passively. It requires no extensive environmental permits on the ground, eliminates the ecological impact of vibratory trucks, and prevents land speculation.
- Revitalization of Mature Domains: The system allows for scanning older blocks already in operation to identify bypassed hydrocarbon pockets or undetected deep satellite reservoirs, without disrupting ongoing industrial activity.