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Optimizing Raman Spectroscopy for Kerogen Maturity in Carbonate-Rich Source Rocks: The Critical Role of Targeted Decarbonation

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The application of Raman spectroscopy for assessing kerogen thermal maturity is a powerful tool in organic geochemistry. However, its reliability is severely compromised in carbonate-rich source rocks due to physical sample heterogeneity [1] and overwhelming spectral interference from mineral fluorescence [2]. This uncertainty creates a methodological gap, often forcing the use of complex or aggressive chemical treatments that risk altering the kerogen's structure. This study systematically deconstructs these challenges and validates an optimal workflow on thirteen carbonate-rich source rock cutting samples from two wells (6-DEV-18P-RJS and 3-BP-11-RJS) that provide a natural gradient in thermal maturity within the Coqueiros Formation (Campos Basin, Brazil).

We evaluated three sequential preparation protocols: a) fresh (raw), b) macerated (mechanically ground), and c) decarbonated (mild acid treatment), using Rock-Eval pyrolysis as a definitive geochemical benchmark for thermal maturity (Fig. 1). The results demonstrate a clear cause-and-effect relationship between each preparation step and the resulting data quality. Direct analysis of fresh samples proved unreliable, yielding erratic data where the true kerogen signal was completely masked by the combined effects of heterogeneity and fluorescence (Fig. 2a). While mechanical maceration successfully addressed physical heterogeneity, allowing for a basic qualitative distinction between maturity levels, it was insufficient on its own. The fundamental problem of spectral interference remained unresolved, leading to quantitatively unstable data (Fig. 2b).

The decarbonated protocol, a two-step procedure involving mechanical grinding followed by targeted chemical removal of carbonates, yielded the optimal result (Fig. 2c). This approach successfully mitigated both issues, producing stable, precise, and geologically coherent maturity data that strongly correlates with the Rock-Eval Tmax benchmark, as evidenced by a high coefficient of determination ($R^2 > 0.995$). Our work validates this targeted procedure as a robust workflow that avoids aggressive chemicals attack, thus offering a more efficient and accurate analytical path that unlocks the full potential of conventional Raman spectroscopy for these common and challenging lithologies.

References:
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