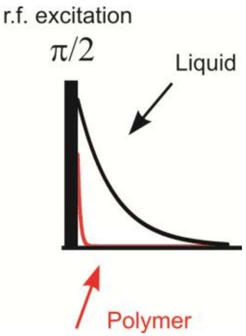
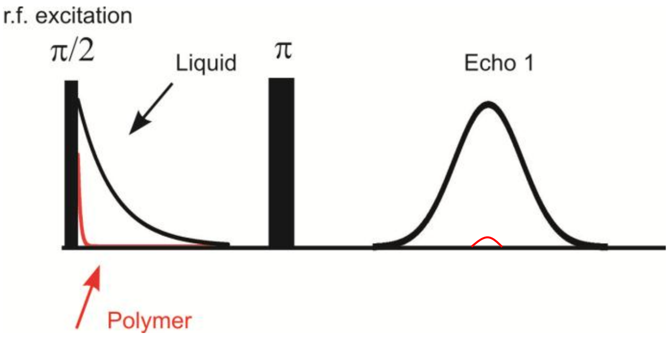
Determinación de Porosidad por RMN

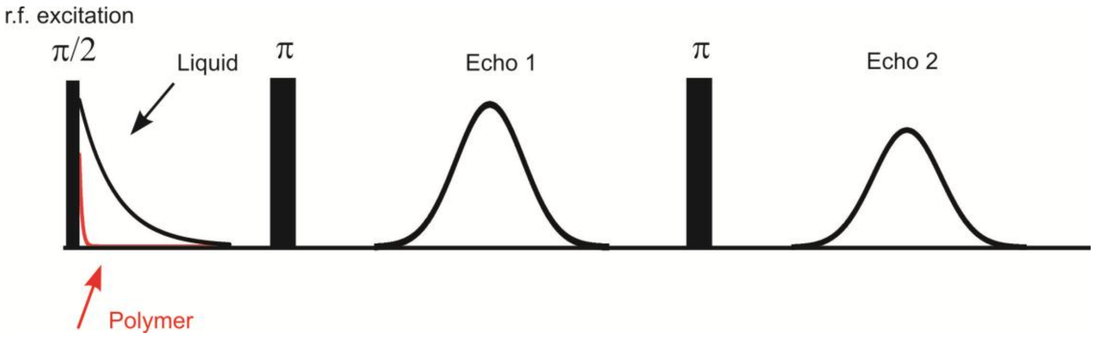
Determinación de tamaños de poro por:

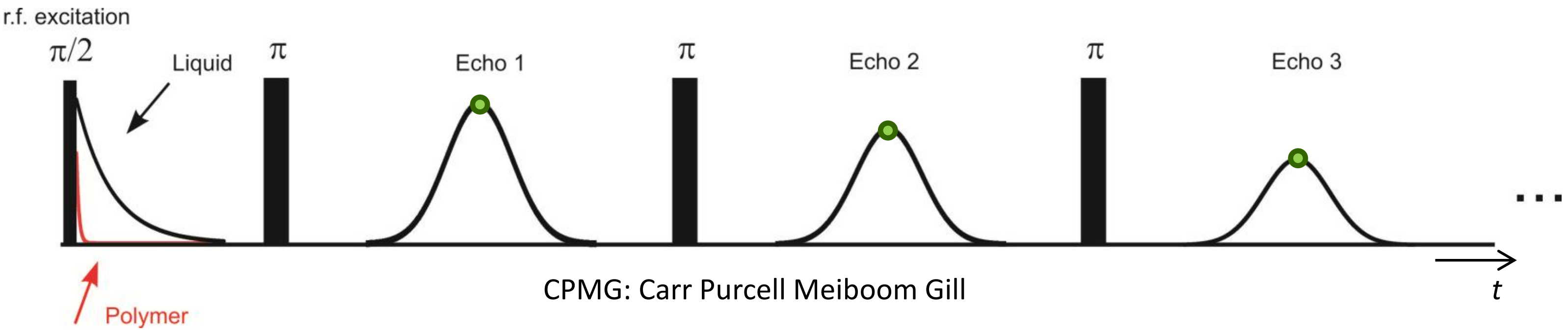
- Difusión restringida
- Relajación

Medición de T_2

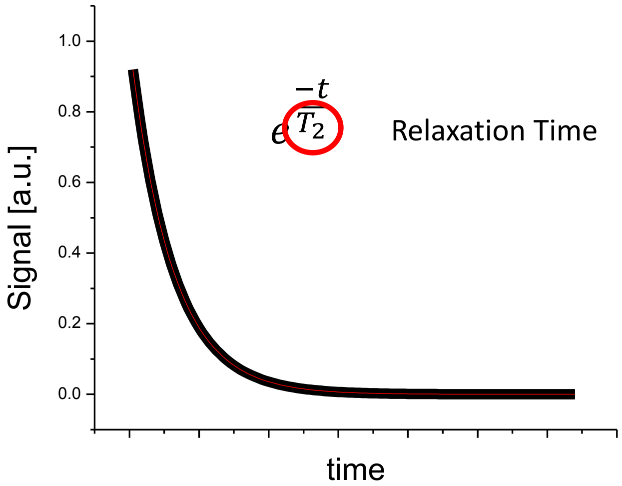



r.f. excitation
π/2
Liquid
π
Echo 1
Polymer


r.f. excitation
π/2
Liquid
π
Echo 1
π
Echo 2
Polymer



CPMG: Carr Purcell Meiboom Gill



$$\frac{1}{T_2} = \rho\frac{S}{V} \sim \frac{3\rho}{d}$$ considerando poros esféricos

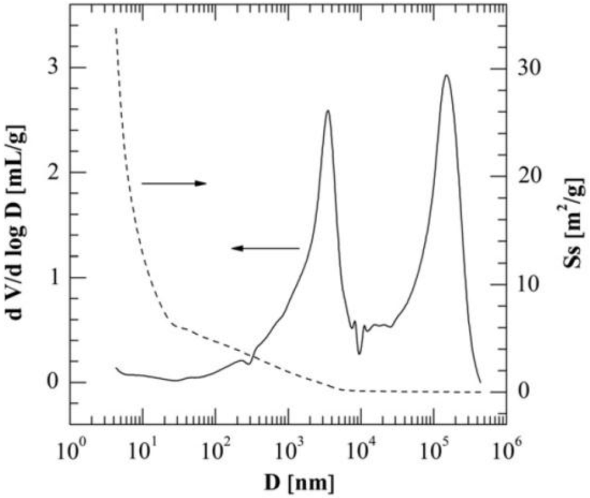
ρ : coeficiente de relaxitividad superficial. Depende de las interacciones entre el líquido y la superficie de la matriz porosa.

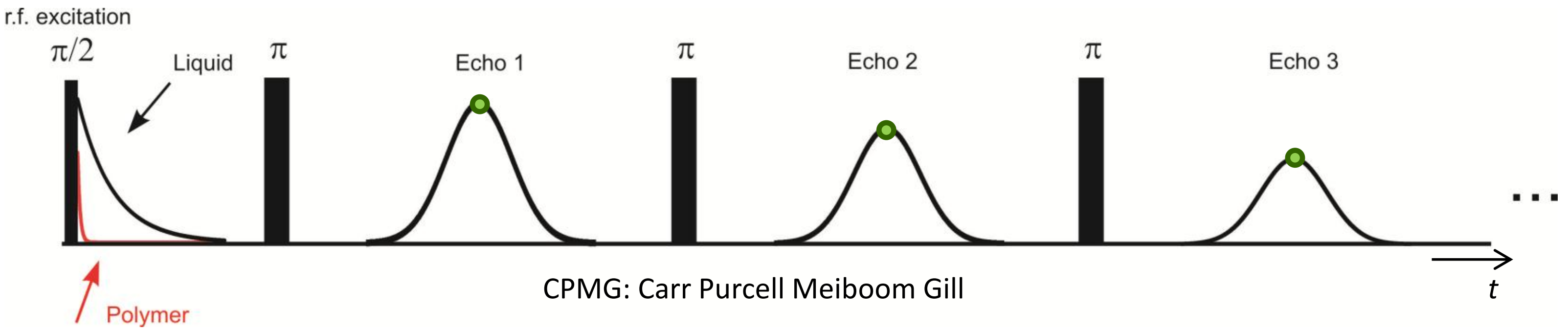
¿Estructura (S/V) o funcionalidad (ρ) ?

$$\frac{1}{T_2} = \rho \frac{S}{V}$$

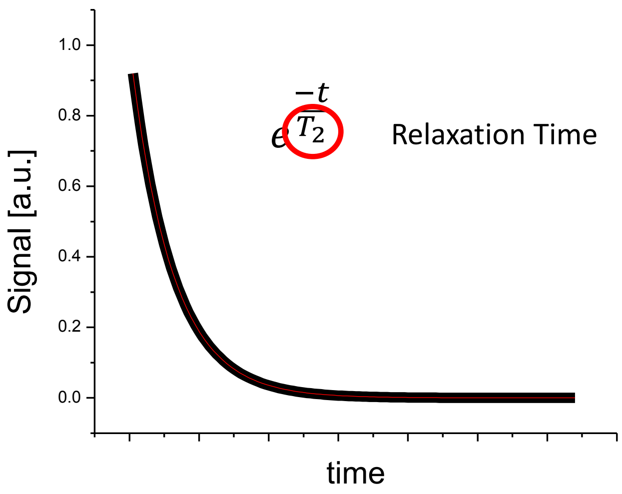
ρ conocido → caracterización de subsuelo

$\frac{S}{V}$ conocido (intrusión de Hg) → interacción líquido/matriz



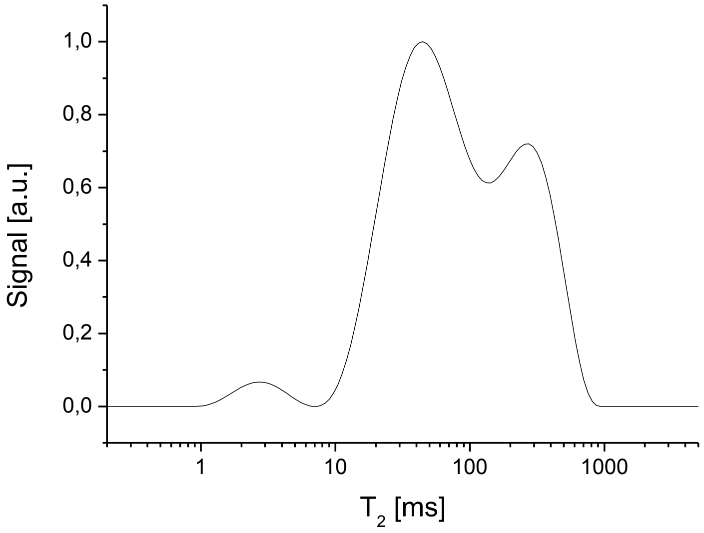


CPMG: Carr Purcell Meiboom Gill



$e^{\frac{-t}{\boxed{T_2}}}$ Relaxation Time

Inverse Laplace Transform



$$\frac{1}{T_2} = \rho\frac{S}{V} \sim \frac{3\rho}{d}$$

Transformada Inversa de Laplace

Señal temporal:

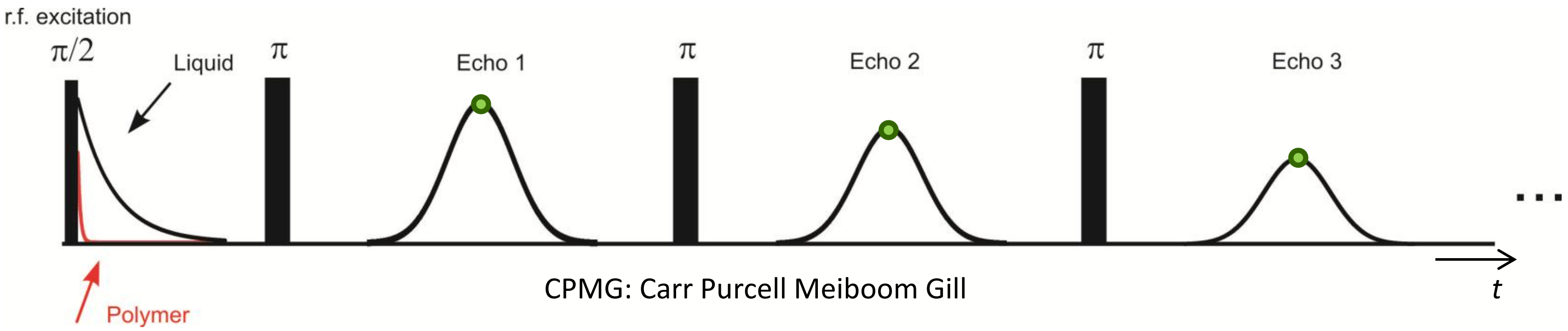
$$S(t_i) = \sum_k A(T_k) \exp\left(-\frac{t_i}{T_k} \right) + \varepsilon_i$$

Representación matricial:

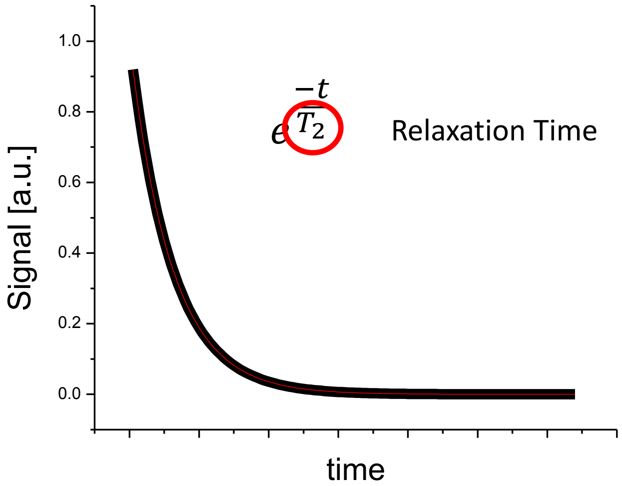
$$Y = KX + E$$

Problema mal condicionado, requiere de una constante de regularización: α

$$\chi^2 = \left\| KX + E \right\|^2 + \alpha^2 \left\| X \right\|$$

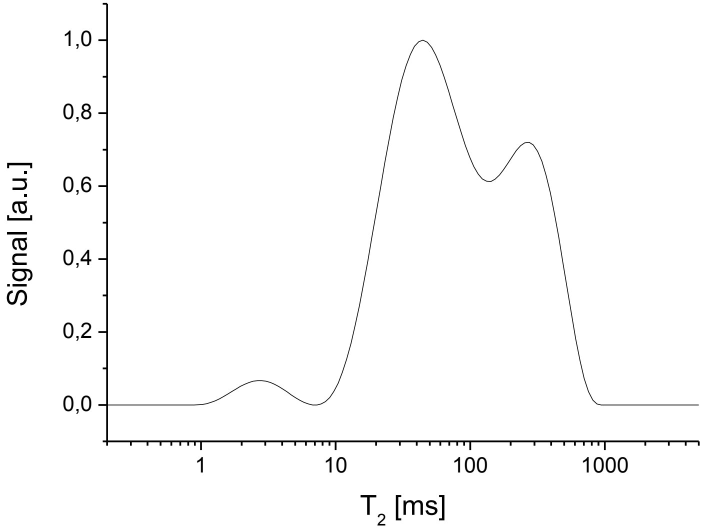


CPMG: Carr Purcell Meiboom Gill



$e^{\frac{-t}{T_2}}$ Relaxation Time

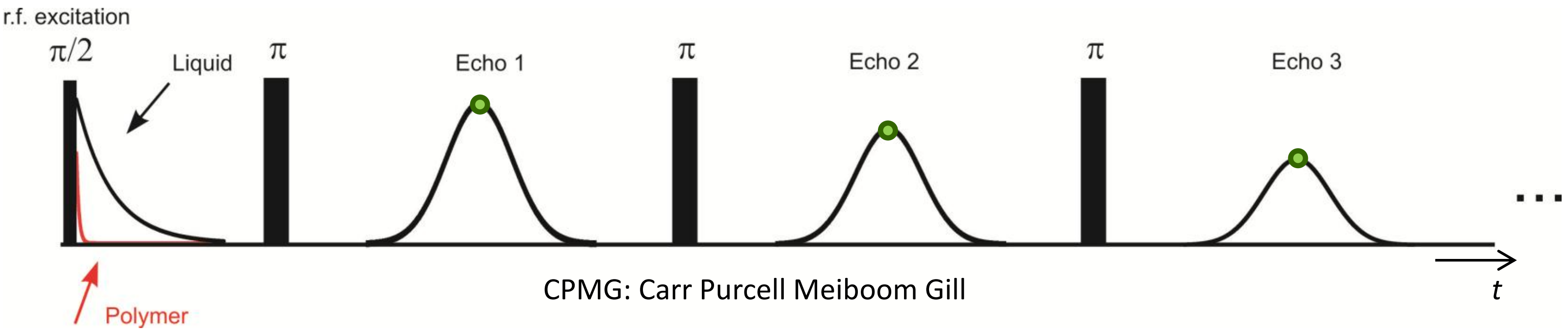
Inverse Laplace Transform



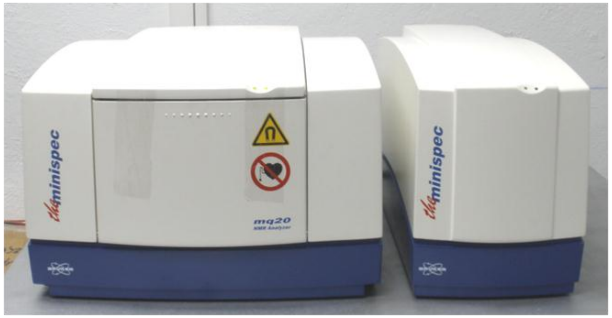
~ 10.000 datos

~ 200 puntos

No se requieren campos altos



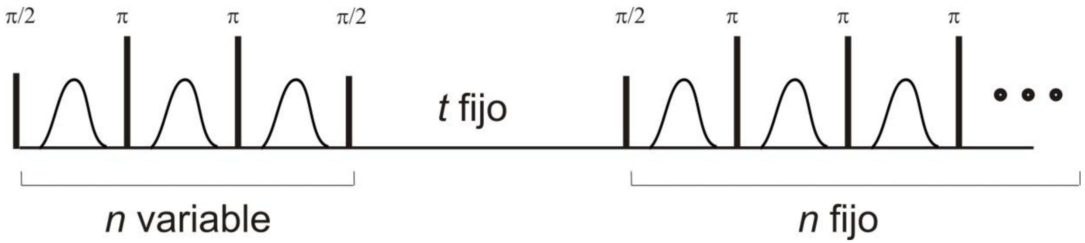
7 Tesla

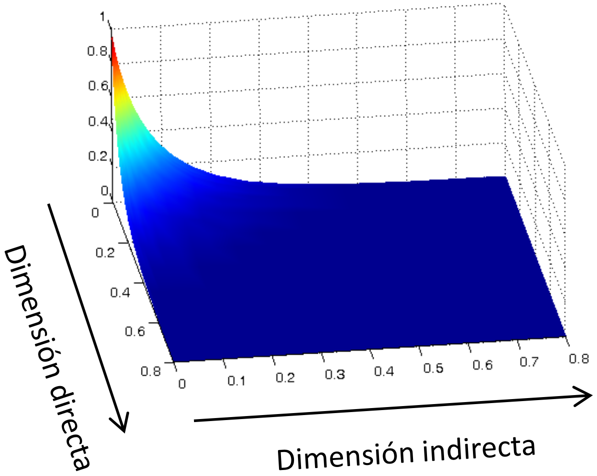


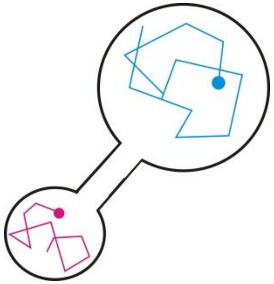
0.5 Tesla

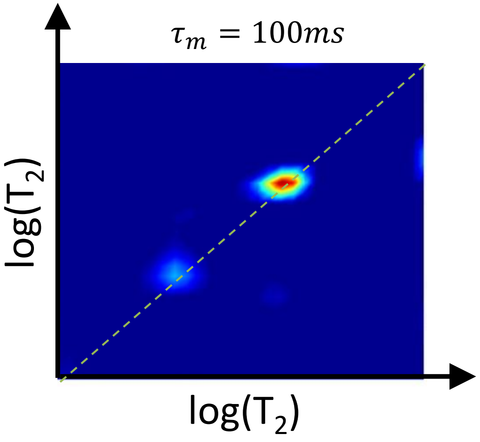
1.4 Tesla

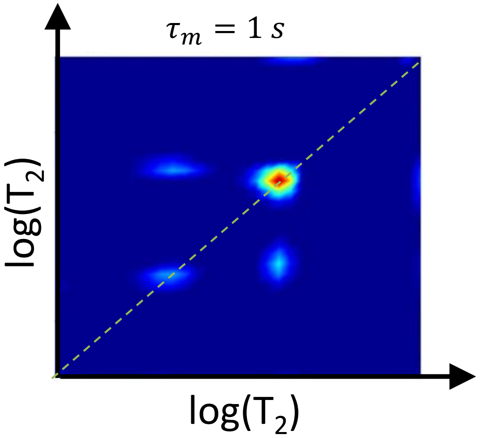
Mapas bidimensionales.
Intercambio: T2/T2

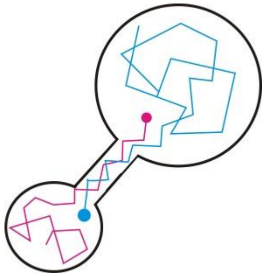




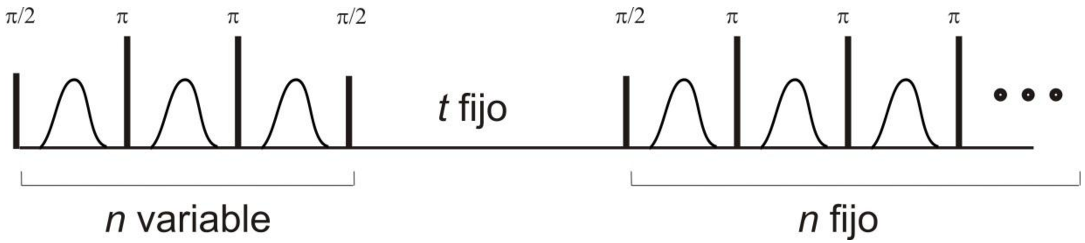


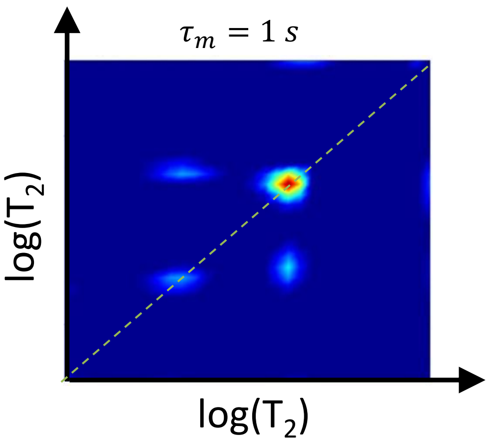

$\tau_m = 100ms$

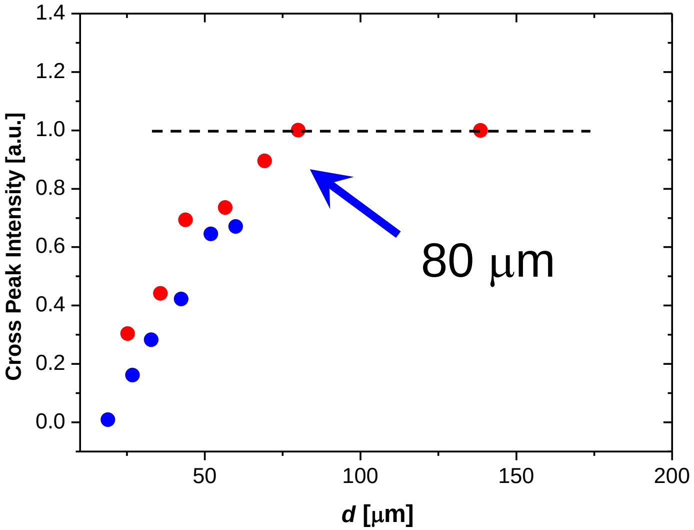

$\tau_m = 1\ s$



Mapas bidimensionales.
Intercambio: T2/T2

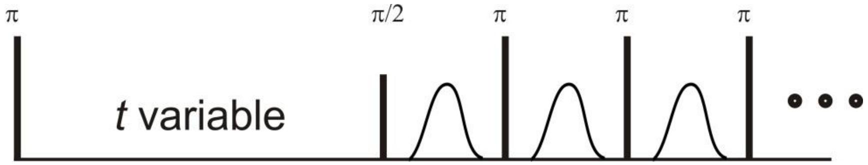


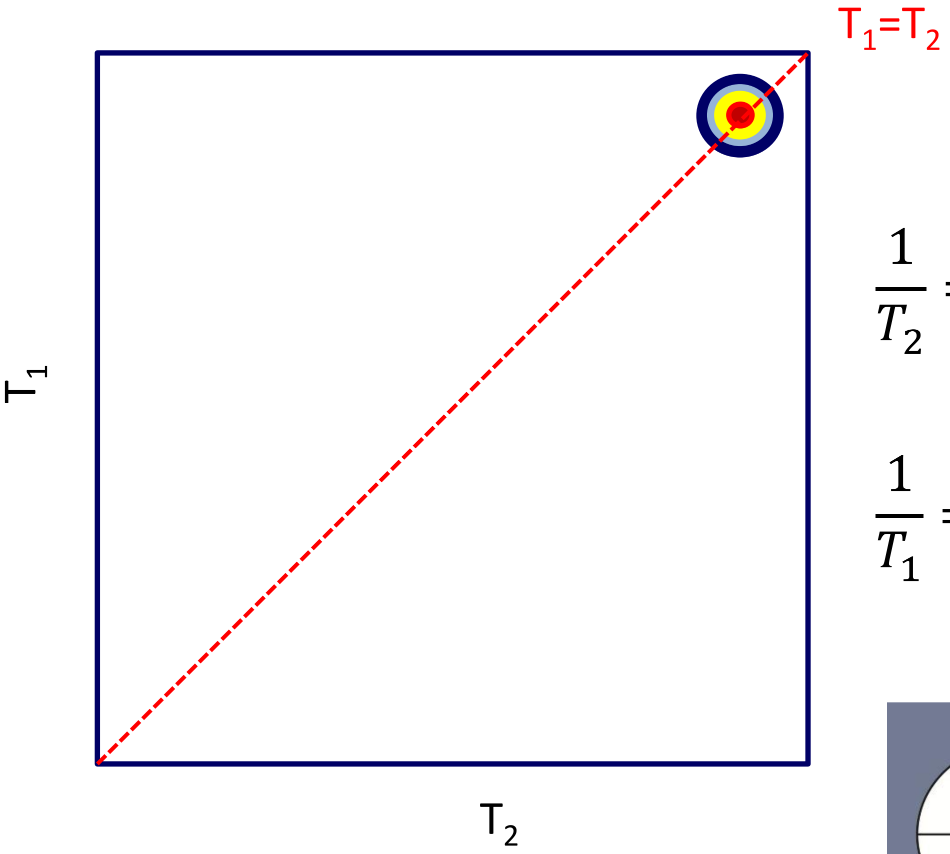




$$d = \sqrt{2Dt}$$

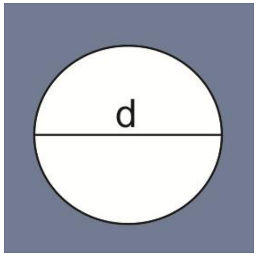
Mapas bidimensionales: T1/T2



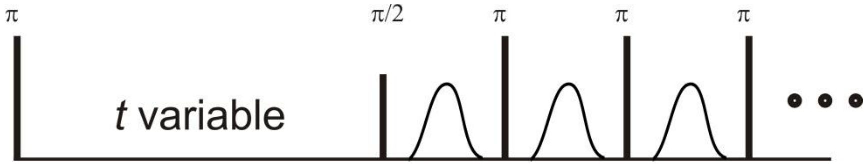


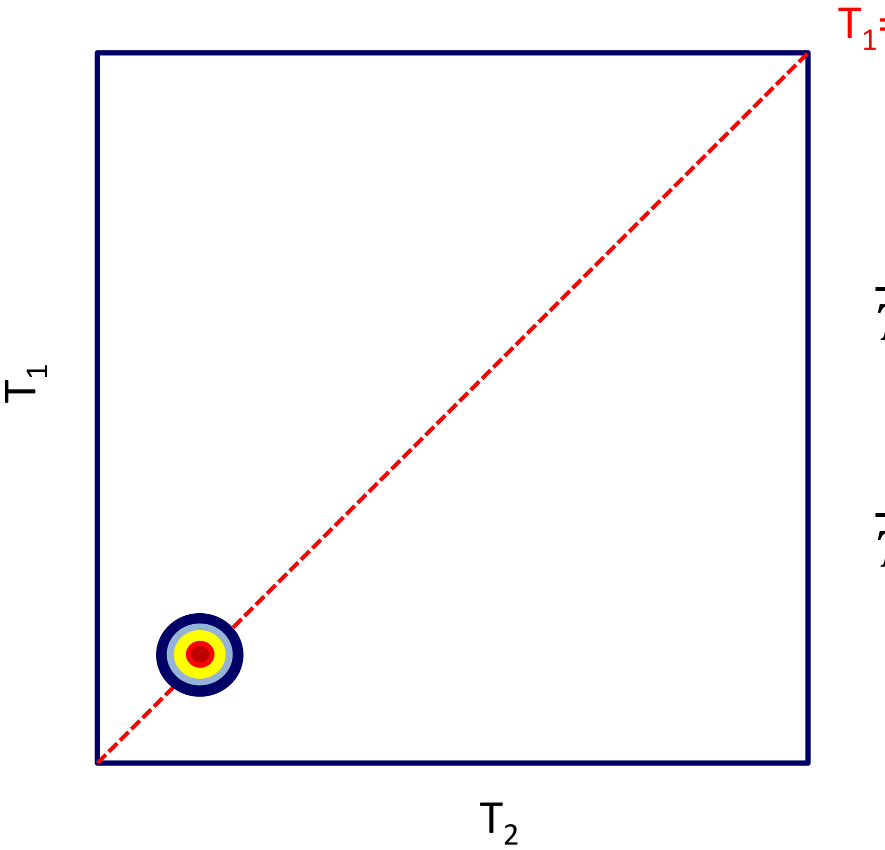
$$\frac{1}{T_2} = \rho \frac{S}{V}$$

$$\frac{1}{T_1} = \rho \frac{S}{V}$$



Mapas bidimensionales: T1/T2





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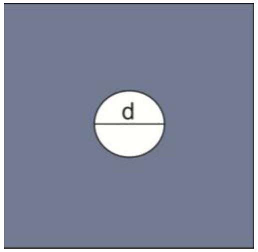
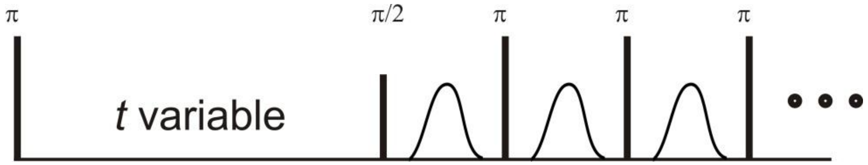
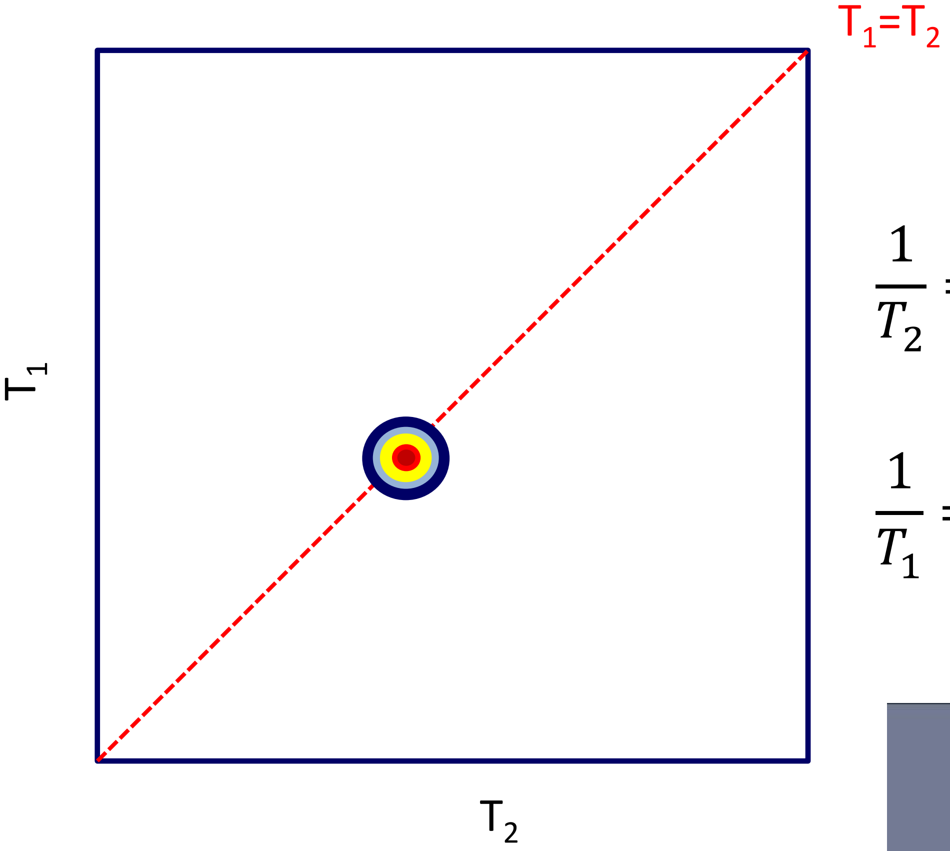


Mapas bidimensionales: T1/T2





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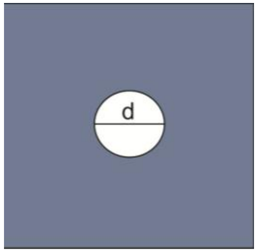
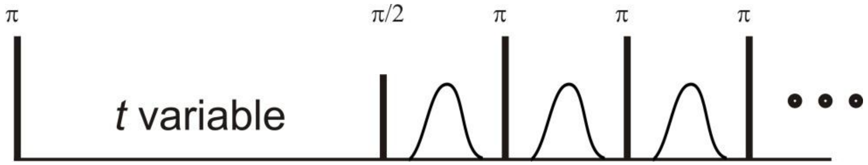
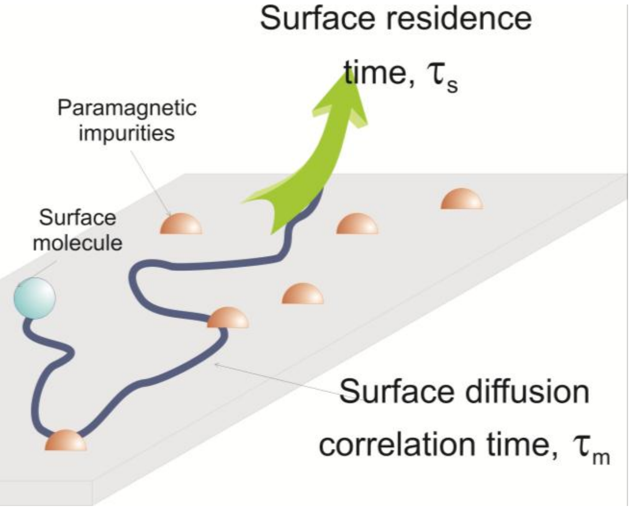
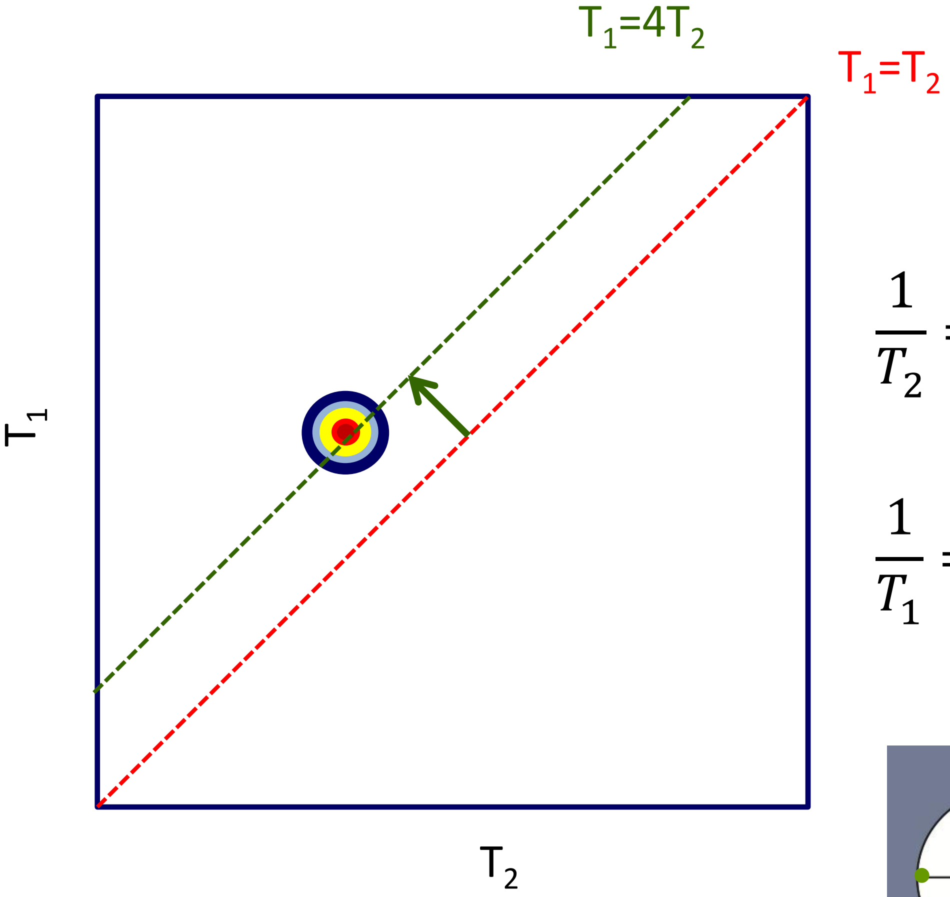


Mapas bidimensionales: T1/T2





$$\frac{T_1}{T_2} = f(\omega_0, \tau_s, \tau_m)$$



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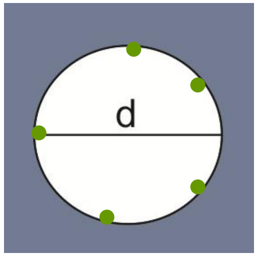
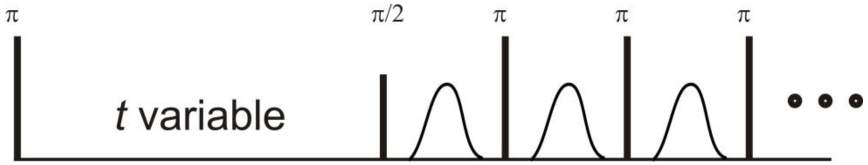
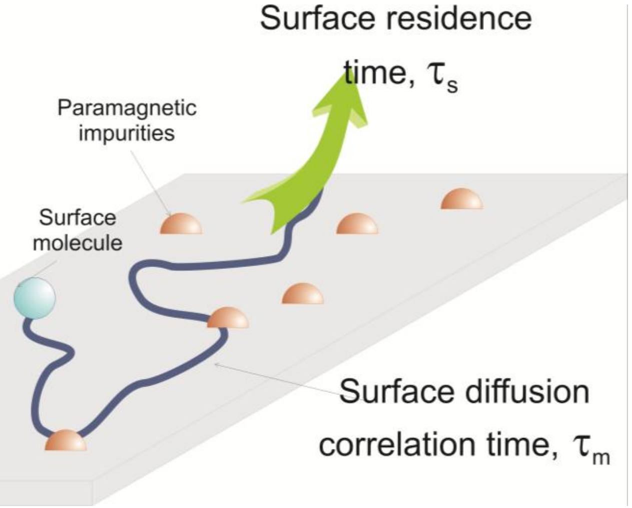
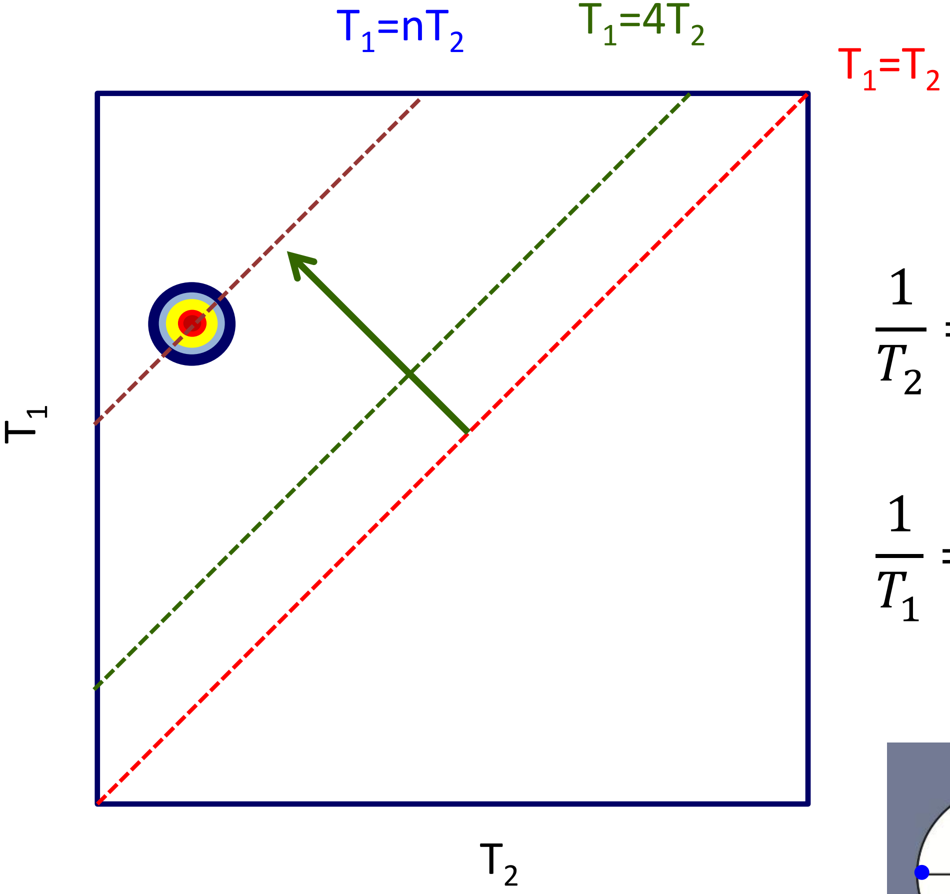


Mapas bidimensionales: T1/T2





$$\frac{T_1}{T_2} = f(\omega_0, \tau_s, \tau_m)$$



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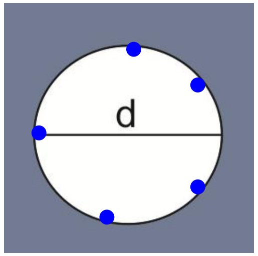
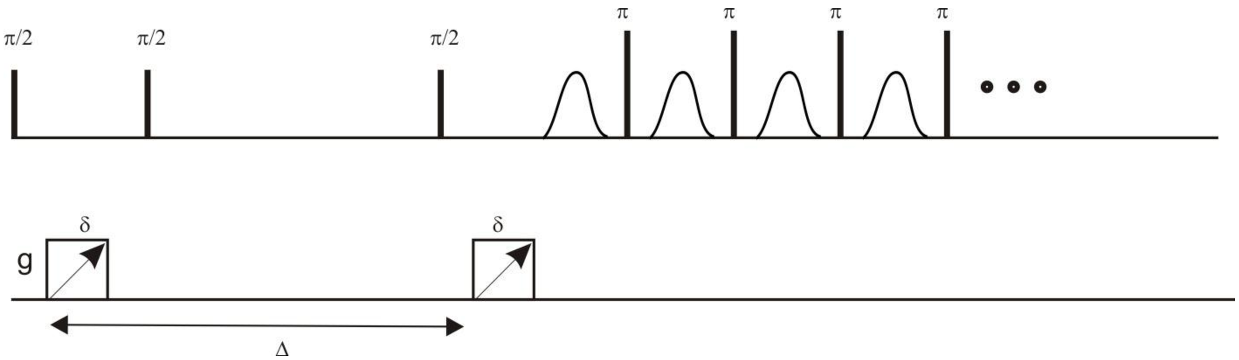
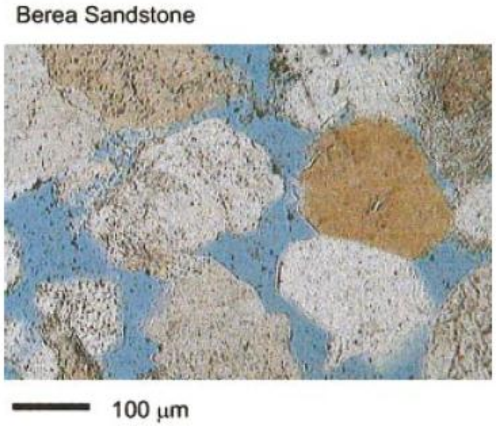
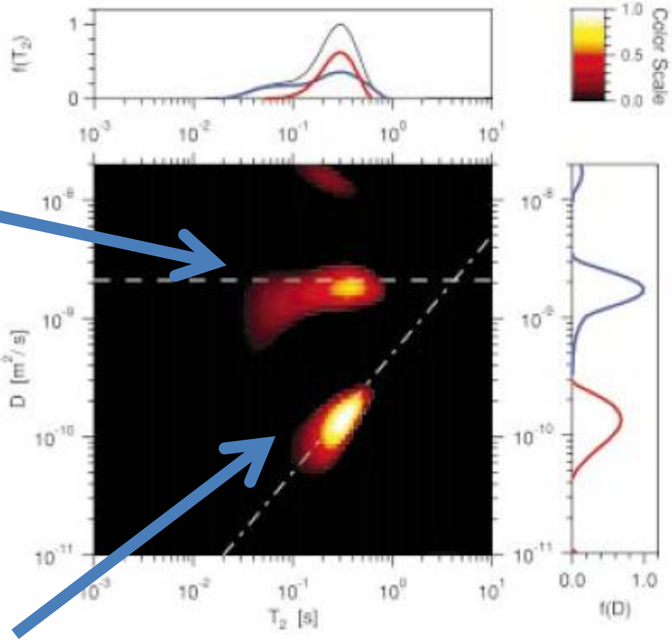


Mapas bidimensionales: D/T2



$$D \approx 5 \times 10^{-10} \, \frac{\mathrm{m}^2}{\mathrm{s}^2} \, T_{2,b} \, .$$





agua

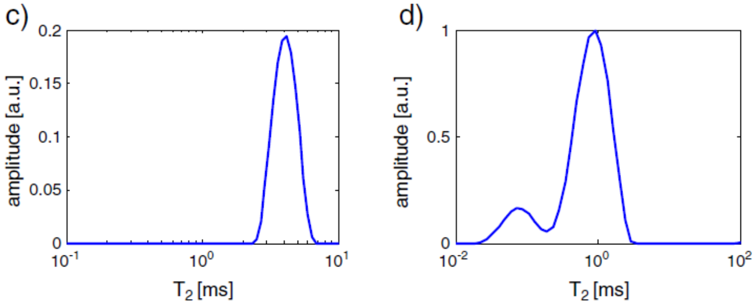
aceite

The roles of hydration and evaporation during the drying of a cement paste by localized NMR

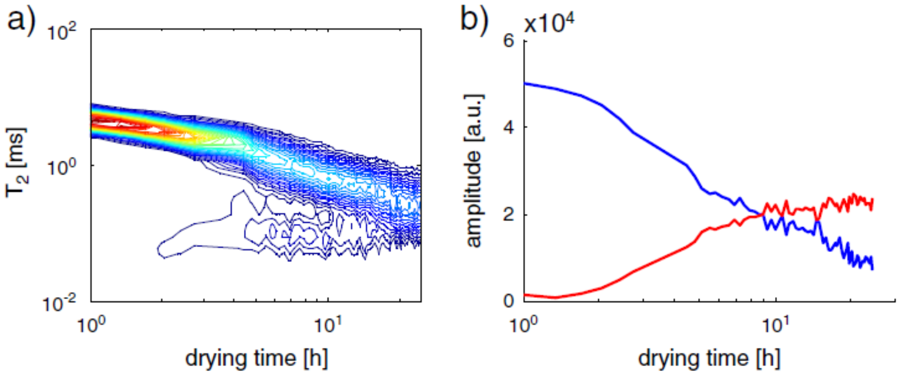
Cement and Concrete Research 48 (2013) 86–96

Maxime Van Landeghem [a,b,c], Jean-Baptiste d'Espinose de Lacaillerie [a], Bernhard Blümich [b], Jean-Pierre Korb [d], Bruno Bresson [a,*]

0.4 h 8 h de secado

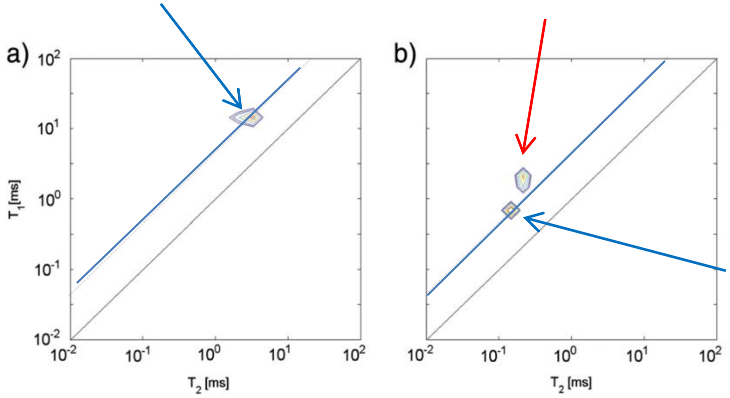


La resistencia mecánica del cemento está relacionada con la densidad de C – S –H



Agua confinada

CSH

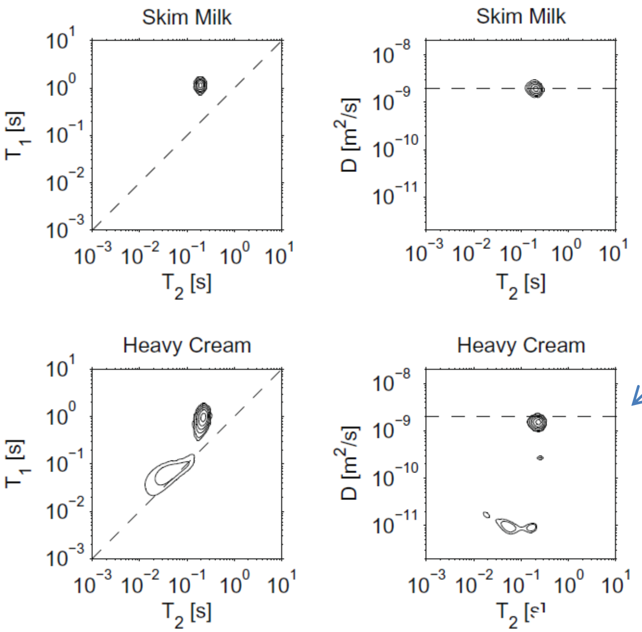


Agua confinada

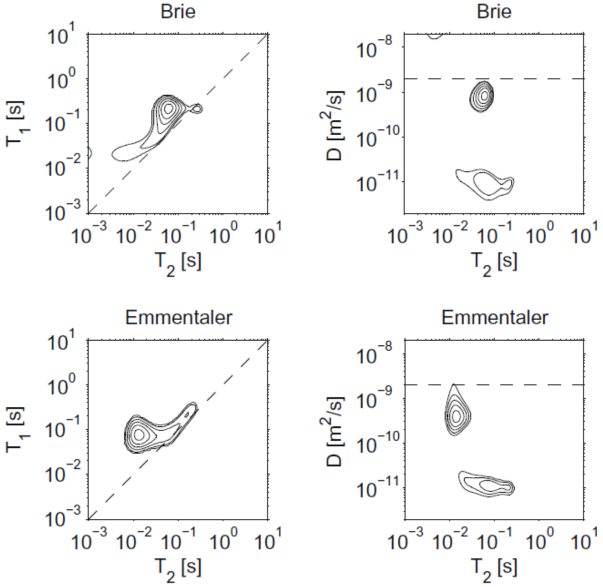
A 2D NMR method to characterize granular structure of dairy products

Yi-Qiao Song

Progress in Nuclear Magnetic Resonance Spectroscopy 55 (2009) 324–334



D(H2O)



Crema de leche

50% dilución