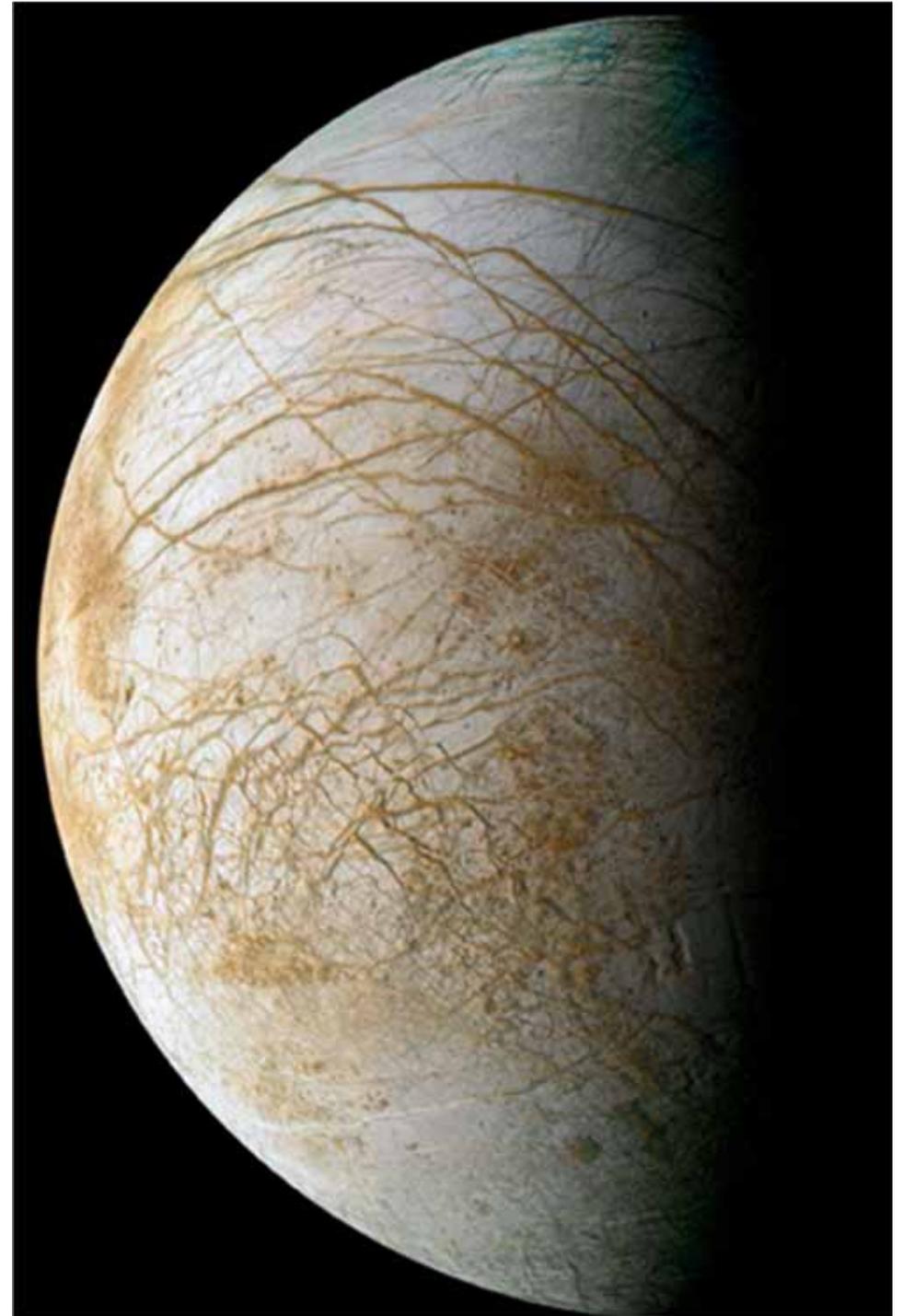


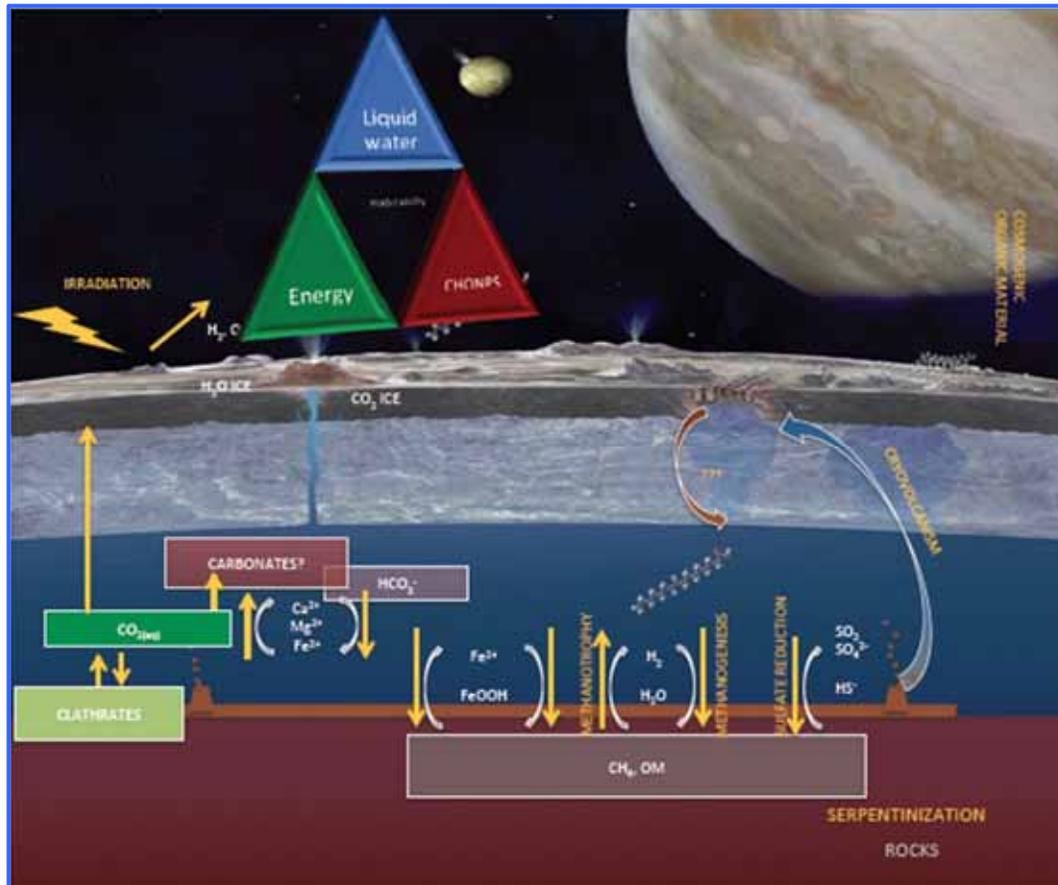
# CARACTERIZACIÓN DE LA EVOLUCIÓN DE FLUIDOS DEL INTERIOR DE LAS LUNAS HELADAS EN PRESENCIA DE CLATRATOS

A. S. J. Méndez and O. Prieto-Ballesteros



# Introducción

Exploración futura- Caracterización de la habitabilidad- fluidos endógenos

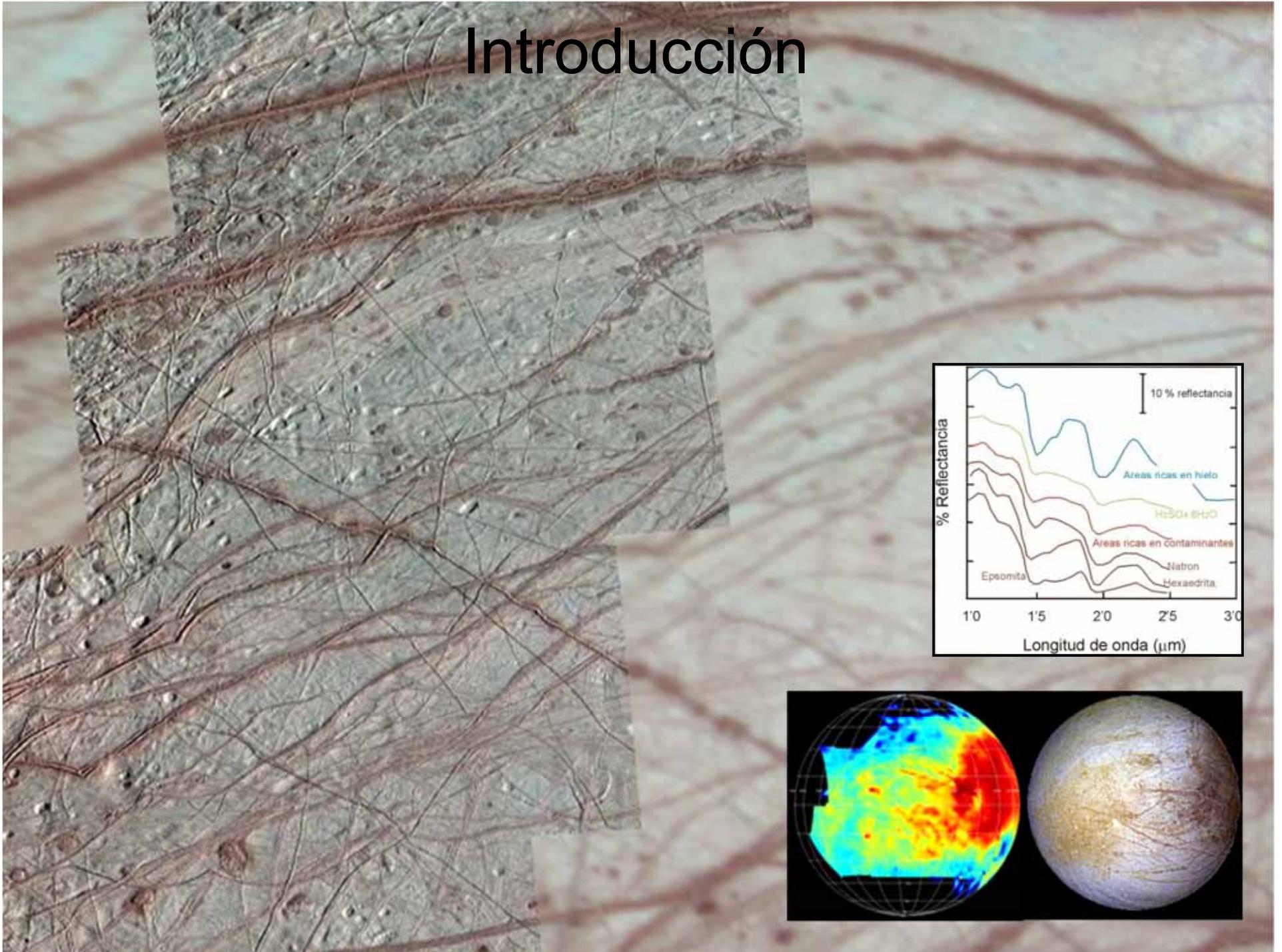


Fluidos acuosos con gases e iones

Ascenso. Plumas, criovolcanes

Evolución: diferenciación?

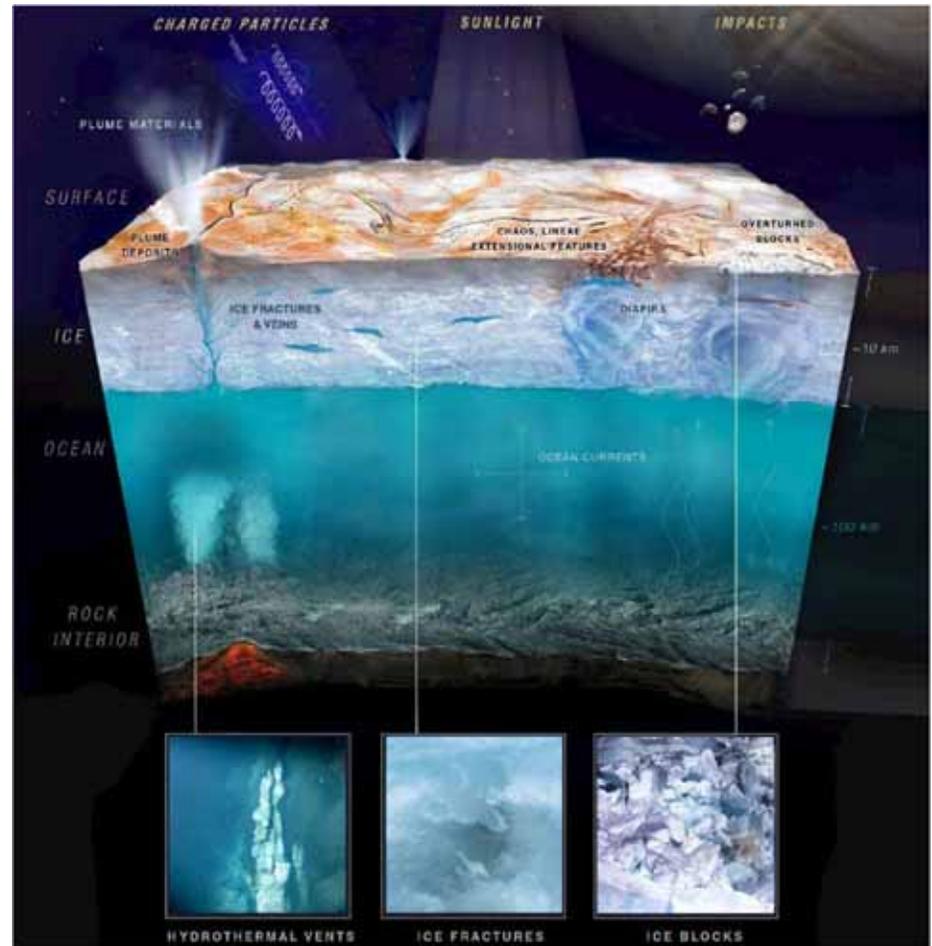
# Introducción





# Objetivos

- Caracterización del salting-out inducido por la formación de clatratos de  $\text{CO}_2$  a partir de una disolución salina de  $\text{MgSO}_4$
- Reconocer los minerales asociados a la actividad geológica
- Determinar la evolución y diferenciación de los fluidos
- Relacionar estos mecanismos con su huella geológica en superficie



# Experimento de Salting-out



Disolución acuosa 17% MgSO<sub>4</sub> (eutéctico)

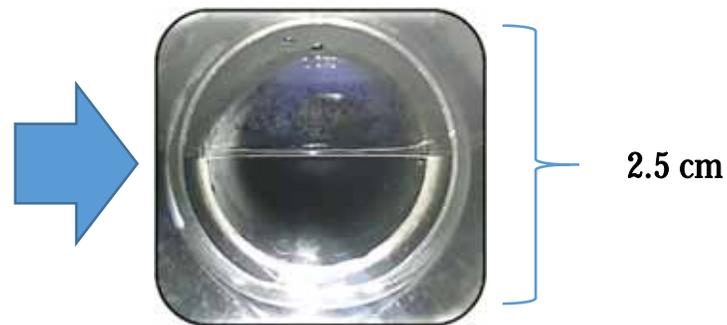
Saturación de gas burbujeando CO<sub>2</sub>

Control termodinámico

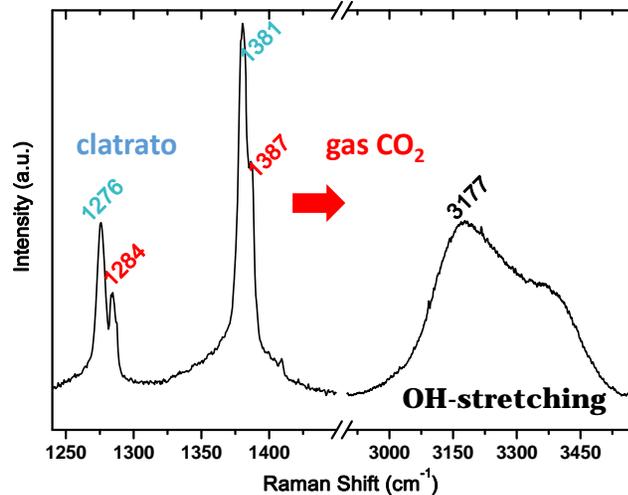
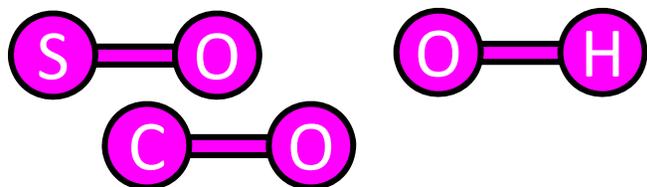
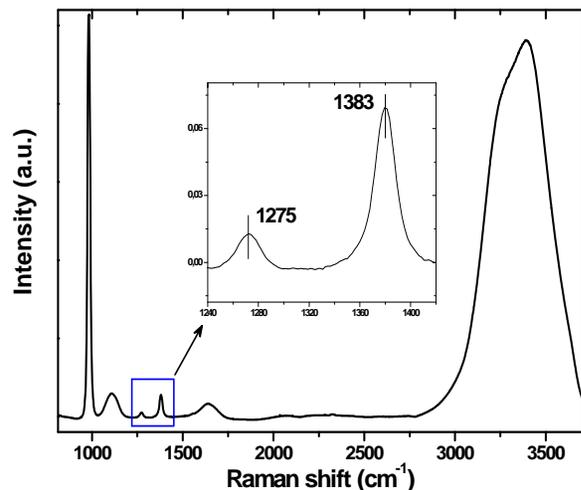
Diagramas P-T-tiempo

Espectroscopía Raman para el análisis de fases in situ

Estudio textural visual



# Análisis in situ: Espectroscopía Raman



Vibration mode	Raman shift (cm <sup>-1</sup> )
$\nu_1$ -SO <sub>4</sub> <sup>2-</sup>	981.9 (aqueous)
	983 (MgSO <sub>4</sub> ·6H <sub>2</sub> O)
	986 (MgSO <sub>4</sub> ·7H <sub>2</sub> O)
	990 (MgSO <sub>4</sub> ·11H <sub>2</sub> O)
Fermi doublet-CO <sub>2</sub>	1285/1388 (gas)
	1280/1386(liquid)
	1275/1383(aqueous)
	1276/1381(clathrate)
O-H stretching	2900-3900

# Calibración salinidad

[SO<sub>4</sub>]  
(%wt)

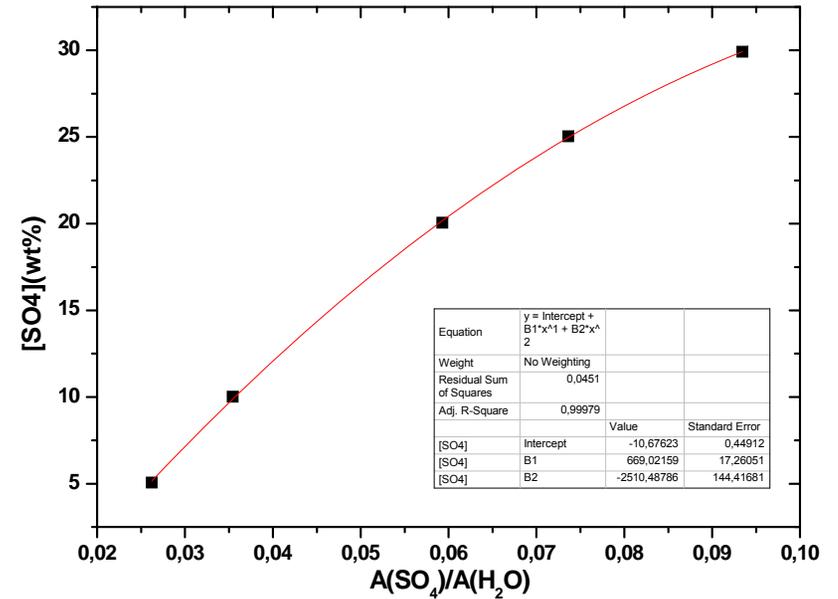
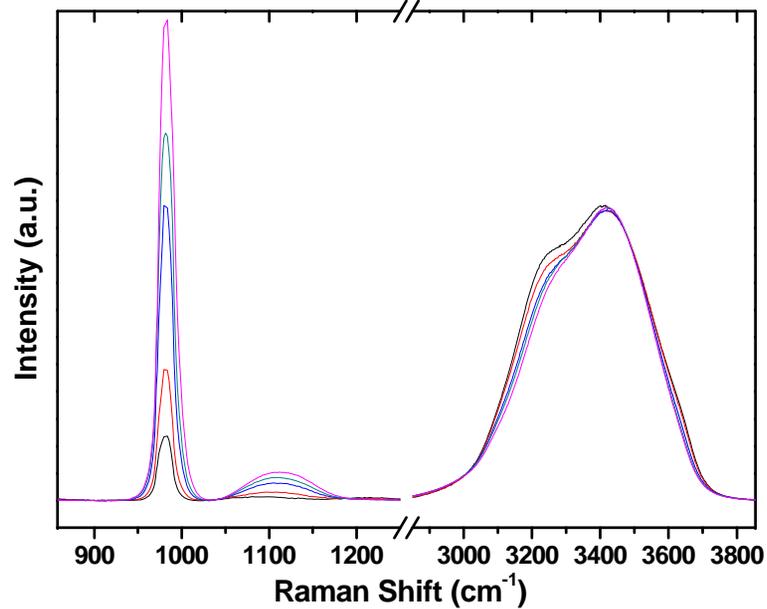
5

10

20

25

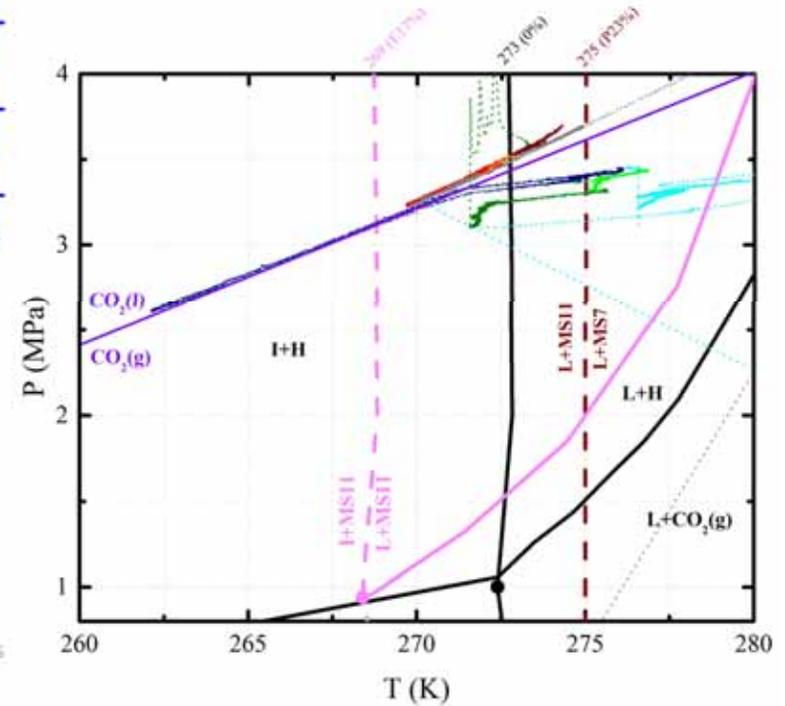
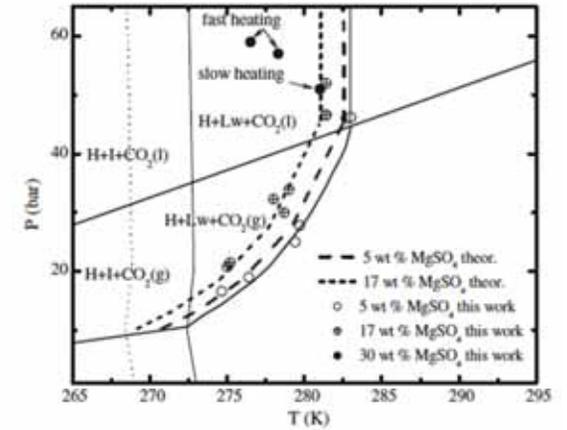
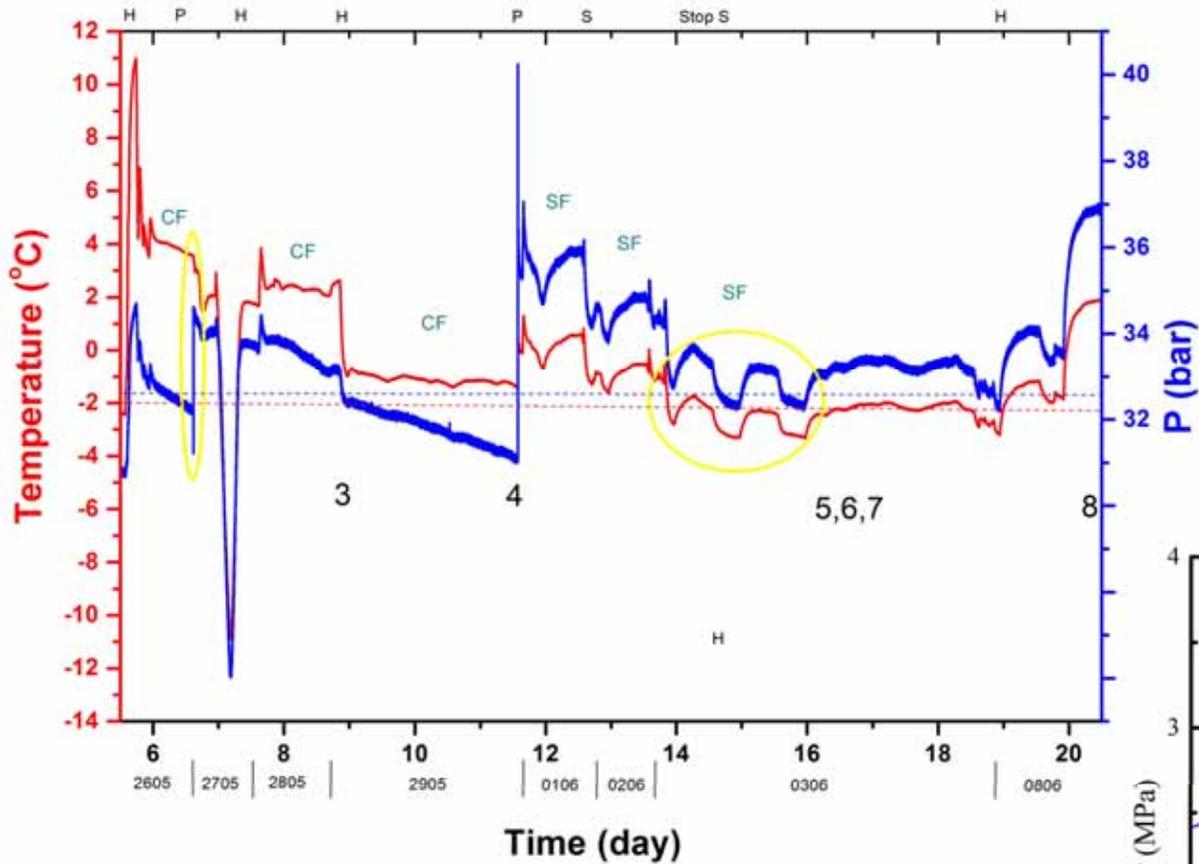
30



$$\text{wt\%} = A + B \cdot A(\text{SO}_4)/A(\text{H}_2\text{O}) + C \cdot (A(\text{SO}_4)/A(\text{H}_2\text{O}))^2$$

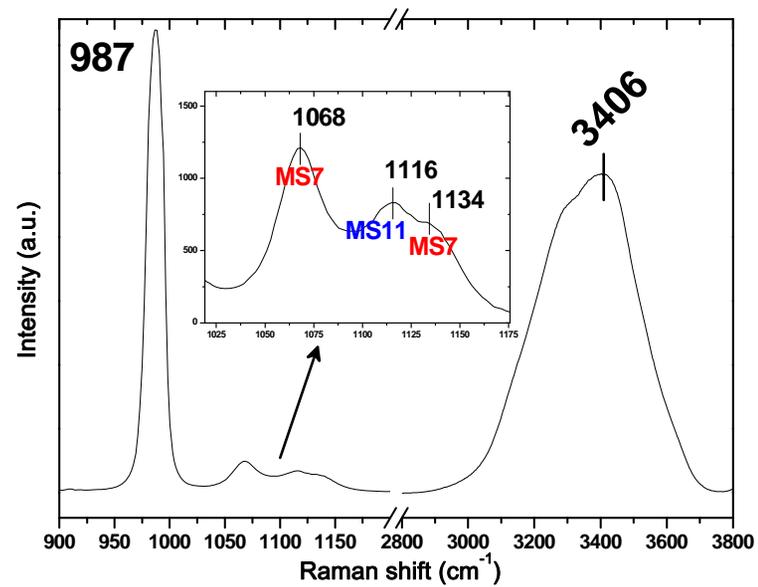
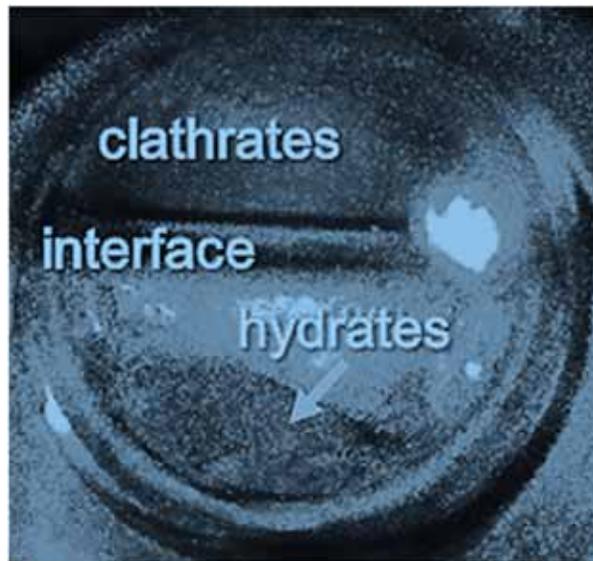
Isosbestic point = 3468 cm<sup>-1</sup>; G.E. Walrafem et al. J. Chem. Phys. 85 (1986) 6964

# Resultados. Trayectorias P/T/t

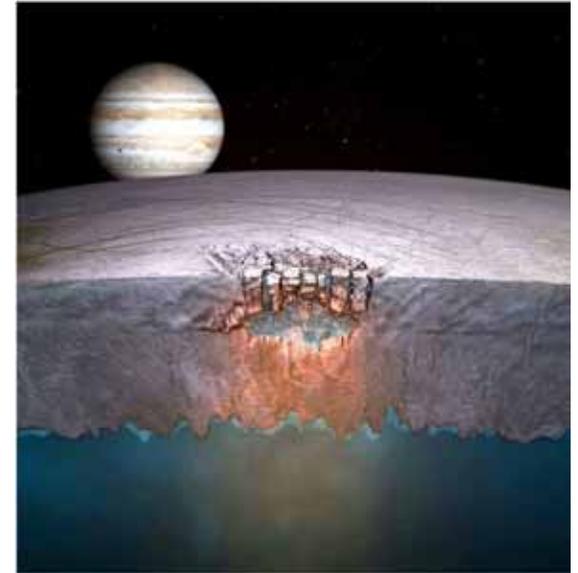
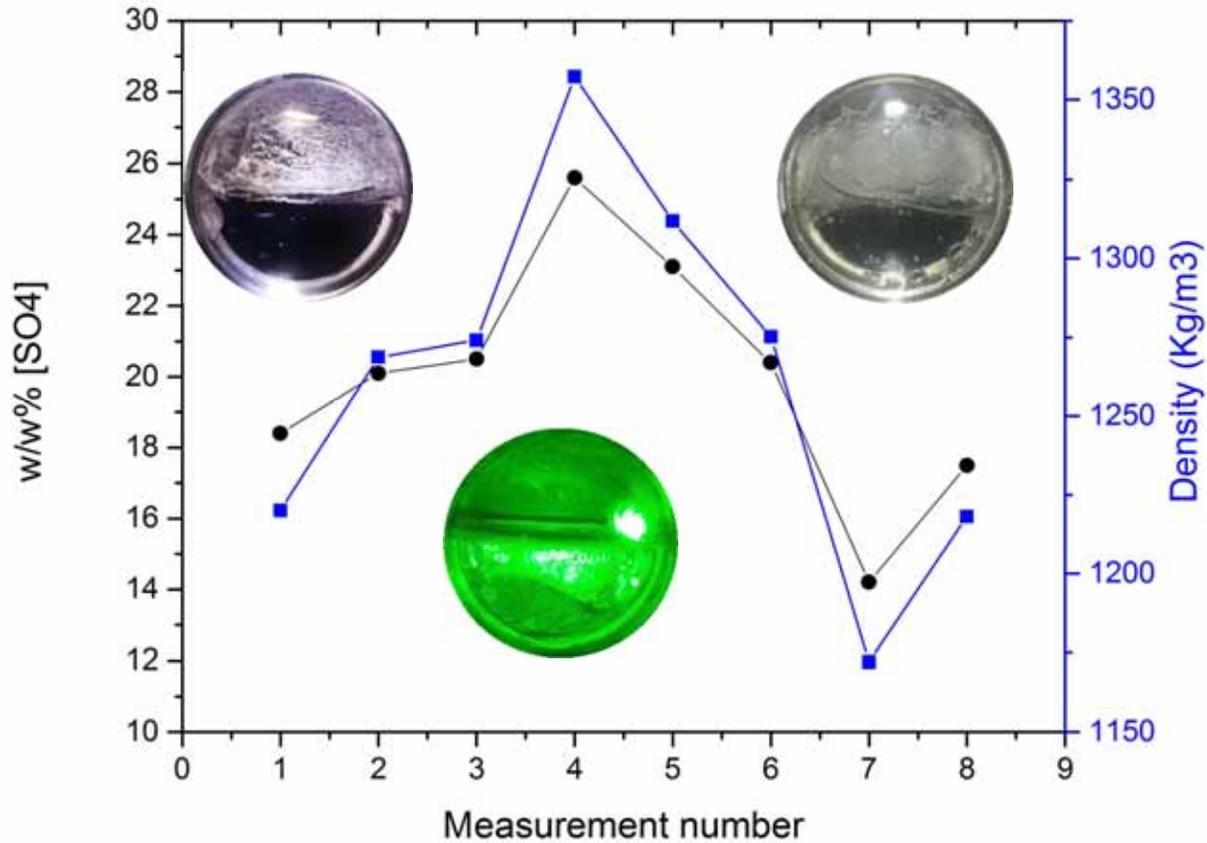


# Resultados. Salting-out

$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$  y  $\text{MgSO}_4 \cdot 11\text{H}_2\text{O}$

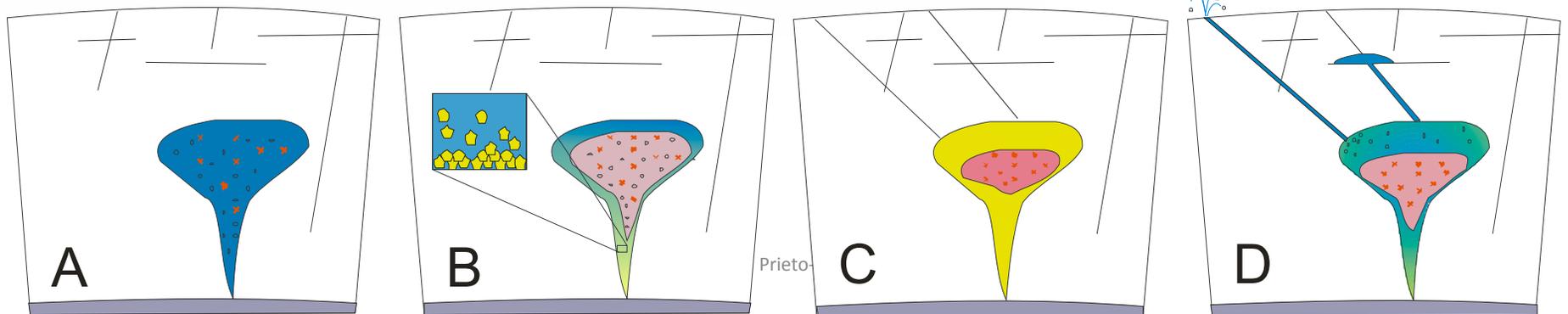


# Cuantificación del Salting-out



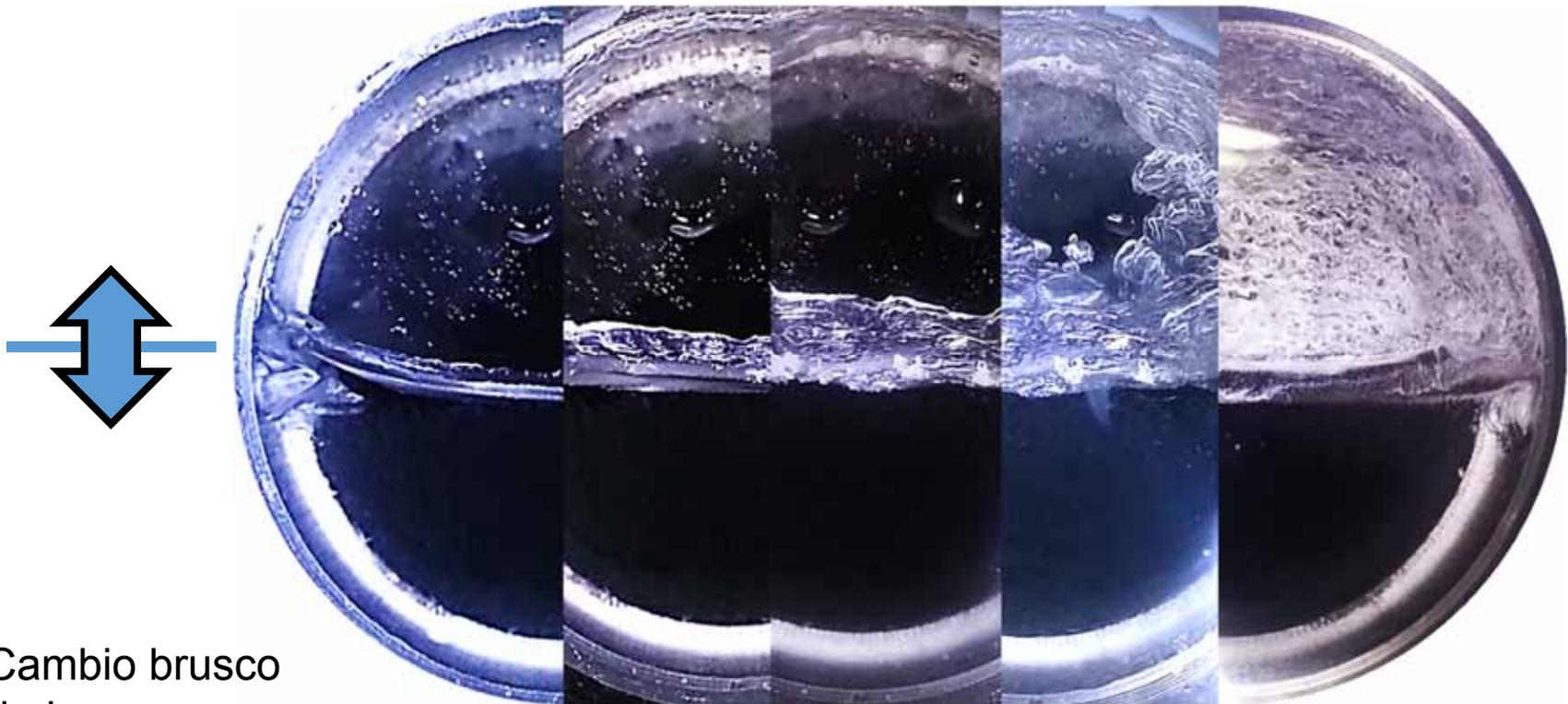
$\Delta$ (DENSIDAD)

Actividad geológica



# Texturas. Crecimiento de clatrato

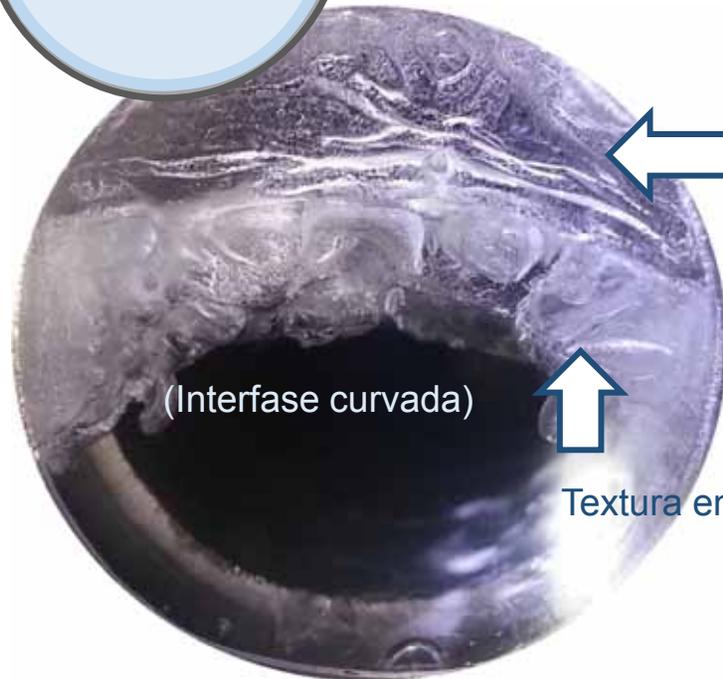
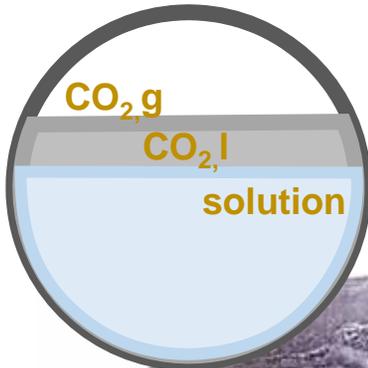
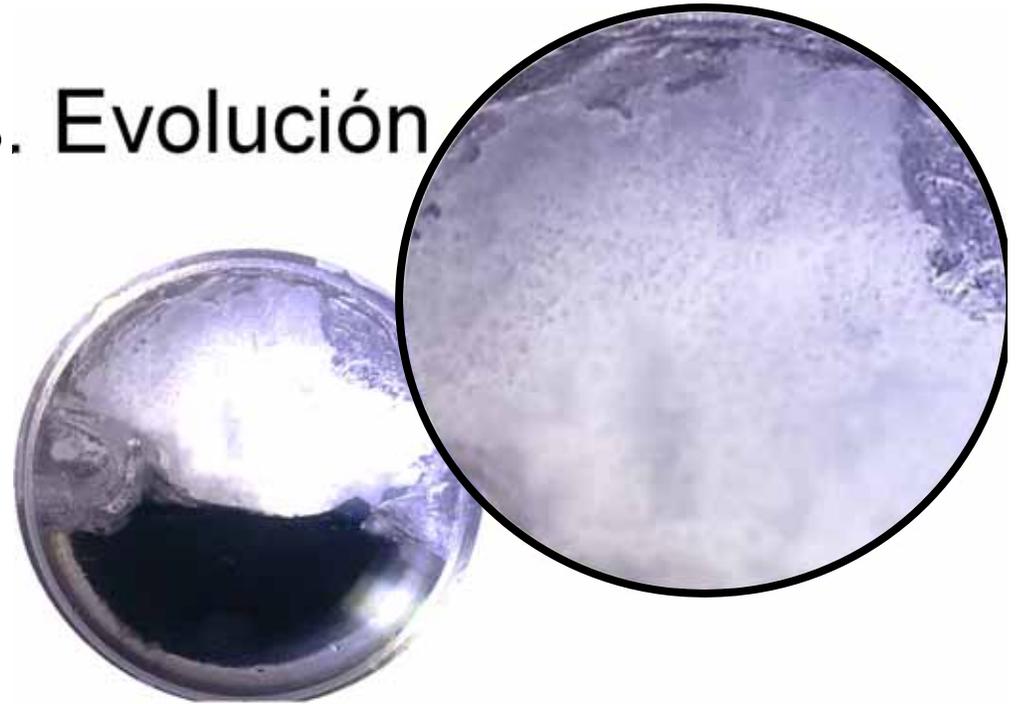
Textura laminar



Cambio brusco  
de los  
coeficientes de  
difusión

# Texturas. Evolución

Textura masiva  
Textura porosa

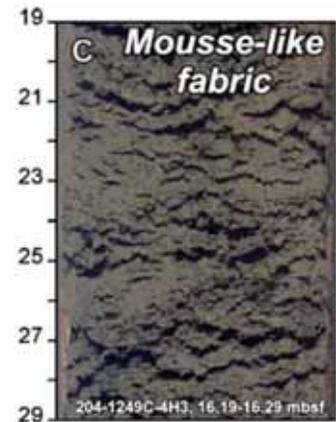


Textura tipo mousse

La curvatura se transmite hacia arriba

(Interfase curvada)

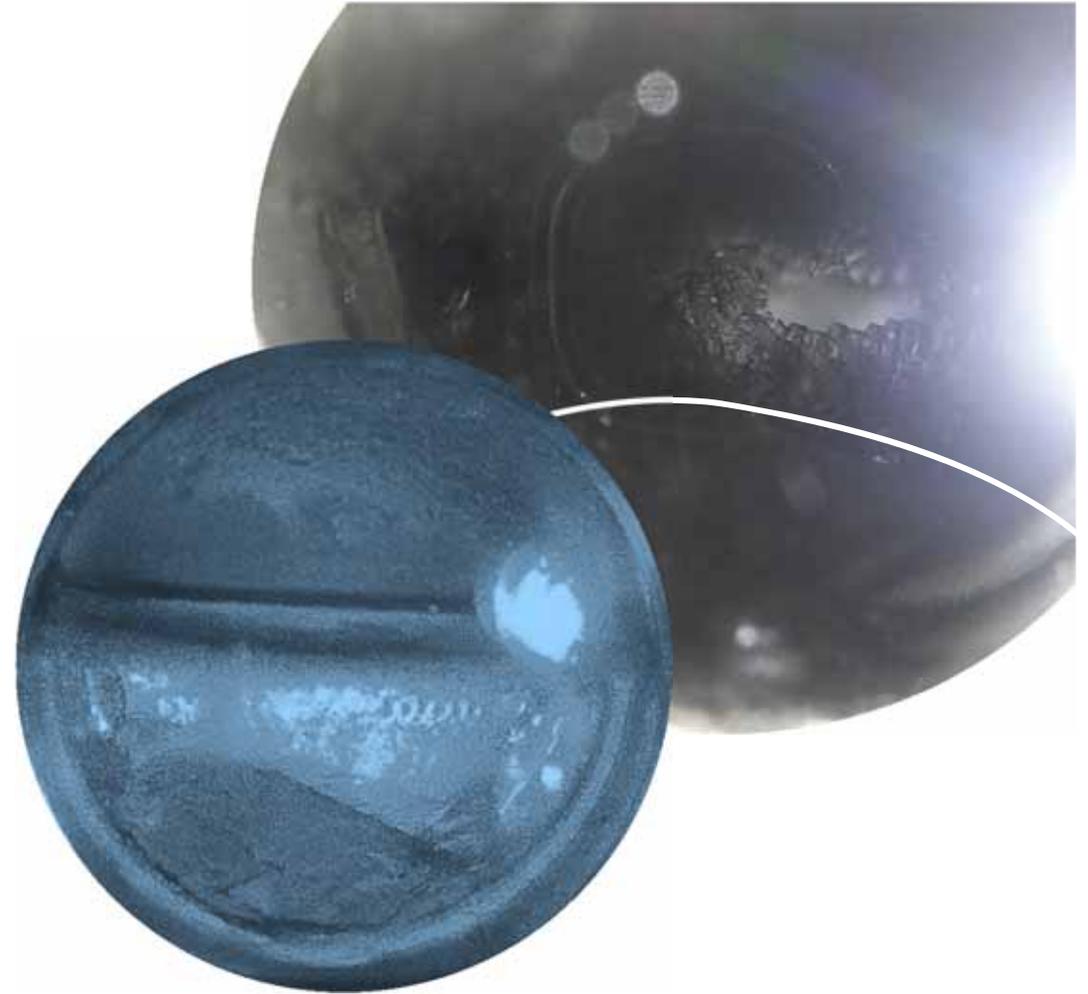
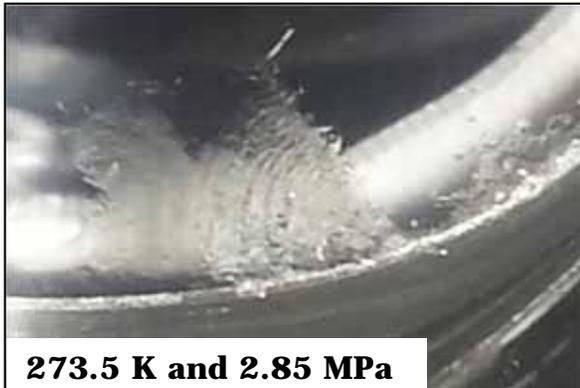
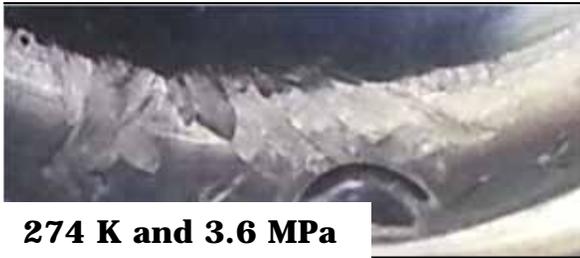
Textura en bloques



E. Piñero et al. (2007) *Geo-Mar Lett.* 27, 279-288

# Texturas. Salting-out

Cristales anhedrales y euhedrales

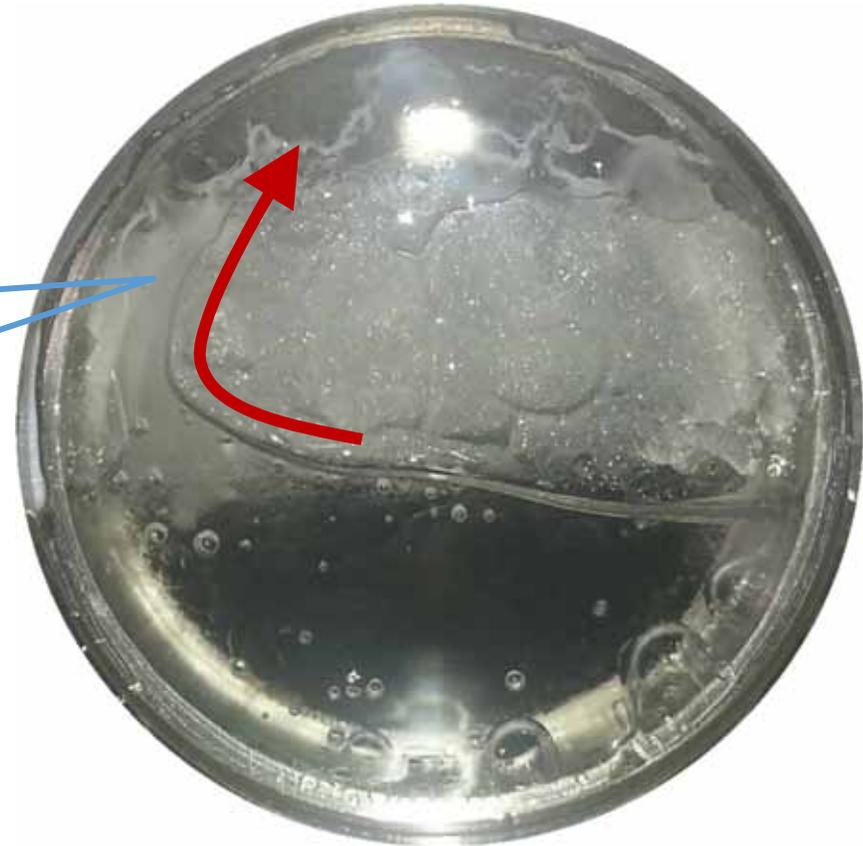


# Texturas. Disociación

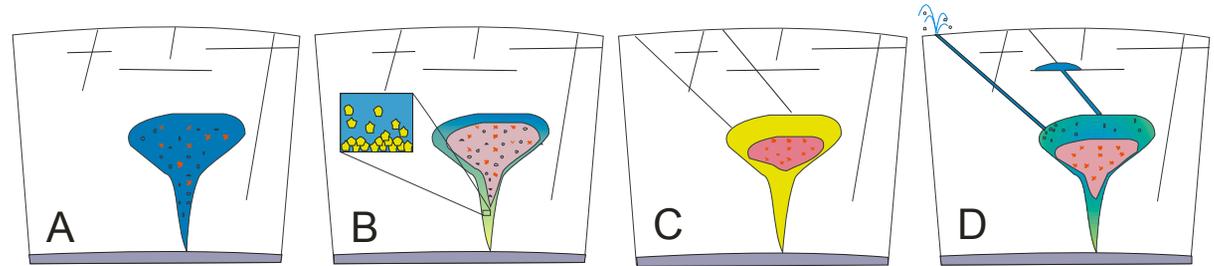
Flotabilidad del fluido gasificado”

Burbujas de  $\text{CO}_2 \rightarrow \downarrow \rho$

El fluido asciende alcanzando la superficie



# Discusión. Actividad geológica



Geological features formed because of volume changes occurring when a salty cryomagma at several concentrations of  $\text{MgSO}_4$  freezes in the absence or presence of  $\text{CO}_2$ -clathrate hydrates.

		Volume liquid solution	Volume solid assemblage	Volume change	Geological feature formed
5 wt% $\text{MgSO}_4$	Ice	96	103	(+)	Fracture
	$\text{CO}_2$ -clathrate	38	23	(-)	Collapse
17 wt% $\text{MgSO}_4$	ICE	84	90	(+)	Fracture
	$\text{CO}_2$ -clathrate	48	41	(-)	Collapse
30 wt% $\text{MgSO}_4$	ICE	67	76	(+)	Fracture
	$\text{CO}_2$ -clathrate	29	60	(+)	Fracture

