Methane hydrate as energy source and carbon dioxide capture: a good solution for the planet

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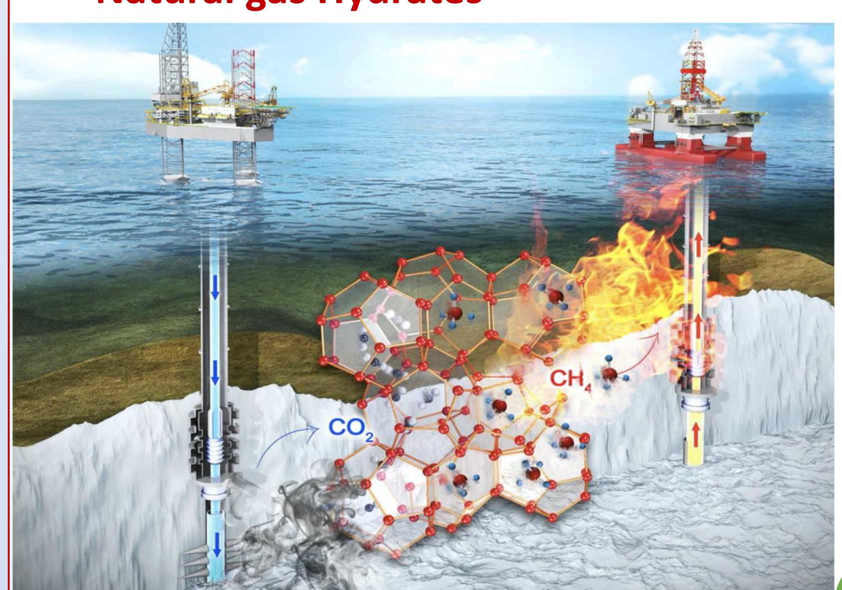
Introduction

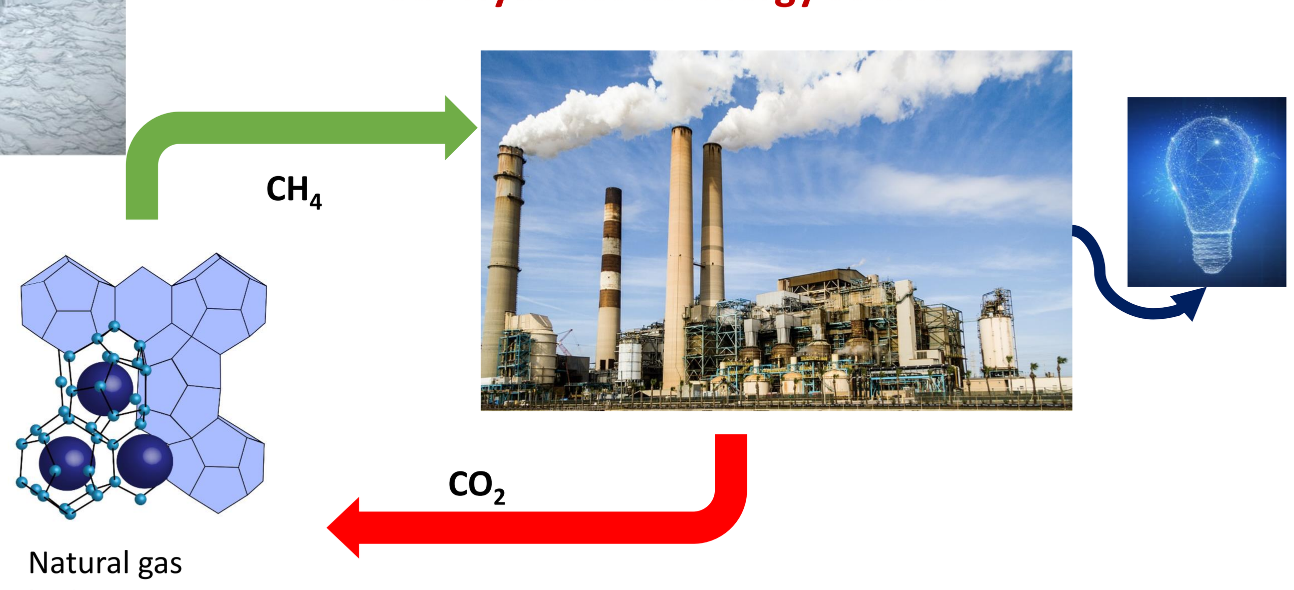
Gas hydrates, also known as clathrates, are crystalline structure, where water cages host gas molecule such as methane, propane, and carbon dioxide [1]. The cage is formed by water molecule keep together by hydrogen bond interaction while host molecule is free to rotate inside the structure. GH structures are stable at low temperature (-3 to 15 degree) and high pressure (18 to 240 atm) [2]. Hydrate structure possesses some similarities to the hydrate structure of water since it is composed by 85% of water [3]. Natural gas hydrate is an energy resource for methane that has a carbon quantity twice more than all fossil fuels combined and is distributed evenly around the world and near the cost, making recovery action easier and less expensive [4]. The most important and promising strategies to collect methane are the carbon dioxide replacement, this method is based on the high tendency of CO_2 molecule to replace methane from NGH cages. CO_2 replacement allows permanent storage of CO_2 reducing greenhouse gas without additional energy [5].

In the contest of the PRIN 2017 project regarding "Methane recovery and carbon dioxide disposal in natural gas hydrate reservoirs", natural sediments containing natural gas hydrates and synthetic CH_4, CO_2 and CH_4-CO_2 mixed hydrates, obtained by small-scale apparatus, were largely characterized.

Natural gas Hydrates

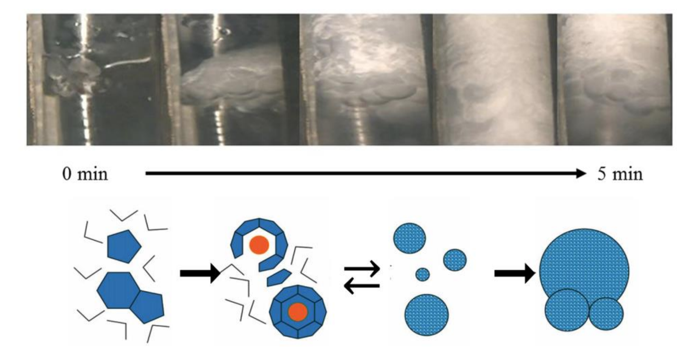


Gas Hydrates as energy source

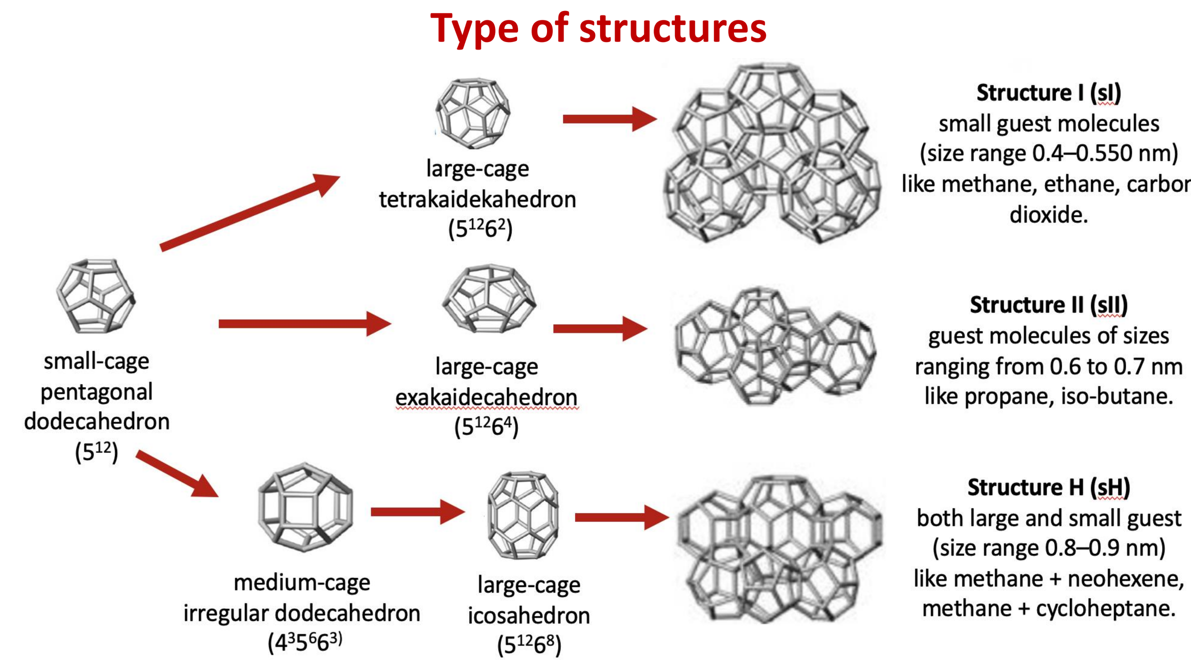


Gas Hydrates formation: three different phase

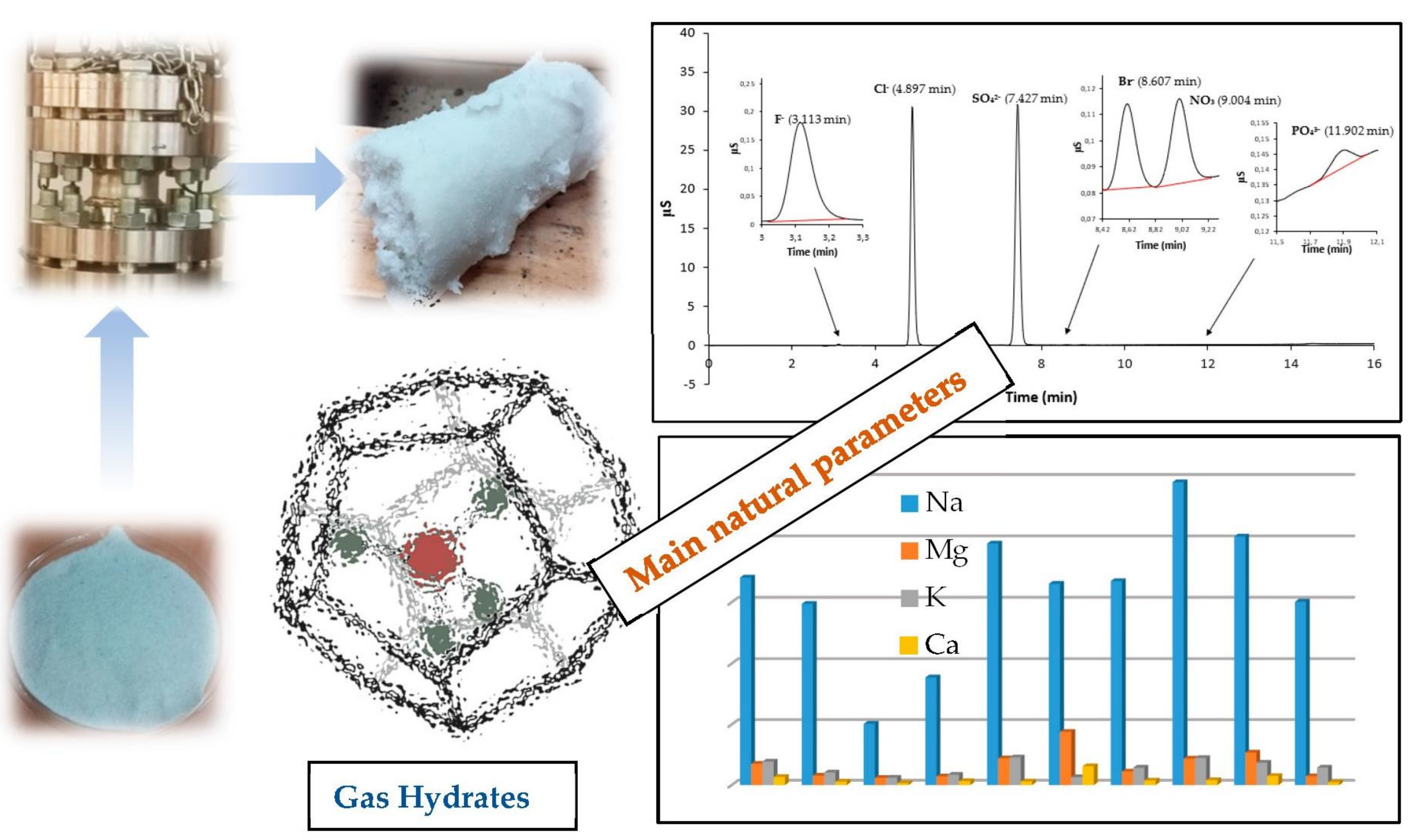
1) dissolution phase: gas molecule from the gas phase are transferred in the water phase
2) induction time: the time necessary to detect macroscopically the hydrate
3) growth phase: period in which gas is concentrated in the hydrate cages



Type of structures

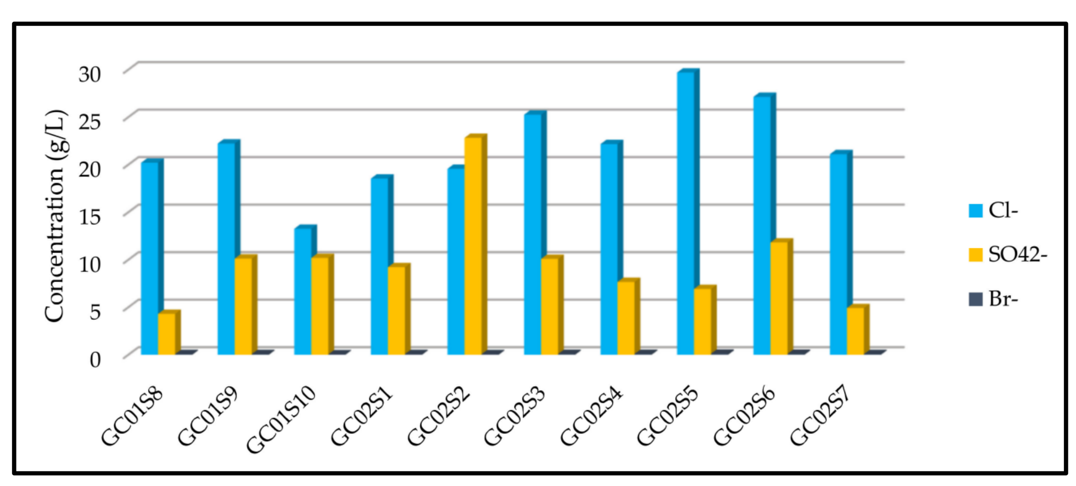


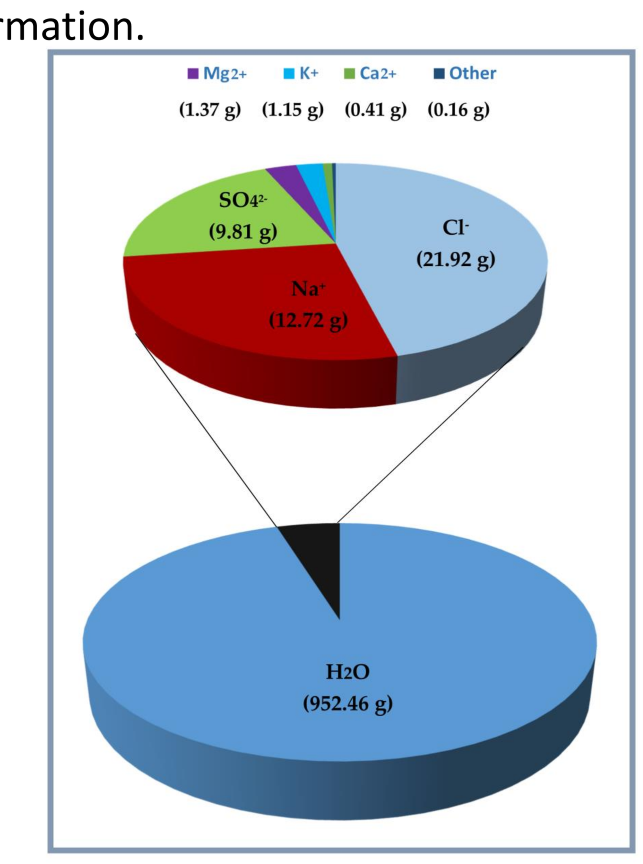
Main Natural Parameters Influencing the Formation of Gas Hydrates



Chemical composition in seawater of marine sediments, as well as the physical properties and chemical composition of soils, influence the phase behavior of natural gas hydrate by disturbing the hydrogen bond network in the water-rich phase before hydrate formation.

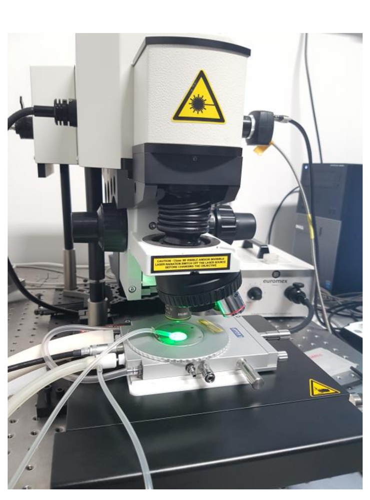
Some marine sediments samples, collected in National Antarctic in Trieste, were analyzed and properties such as pH, conductivity, salinity, and concentration of main elements of water present in the sediments were obtained.



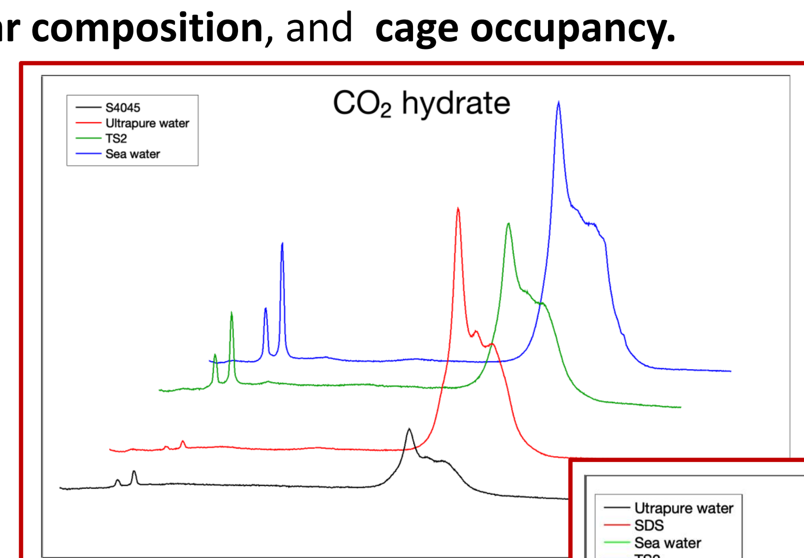


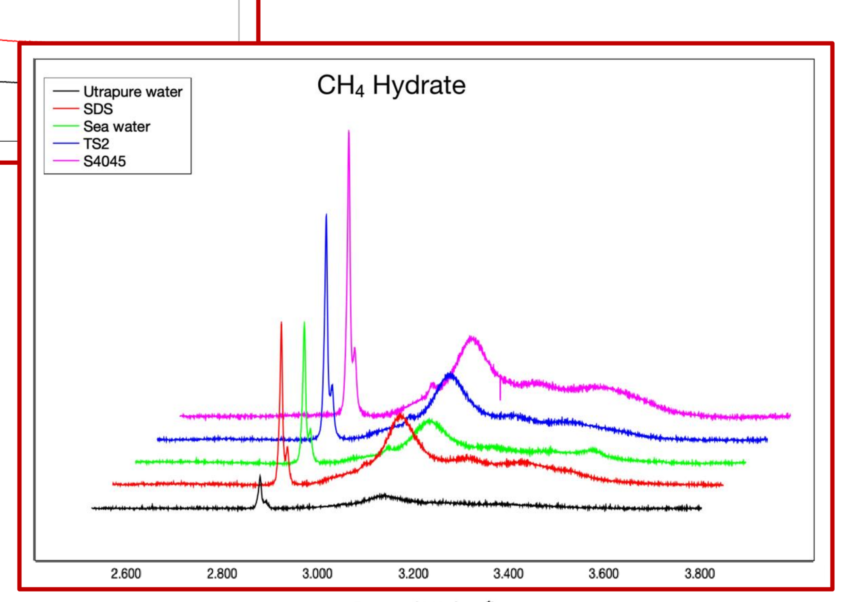
Gas hydrates characterization

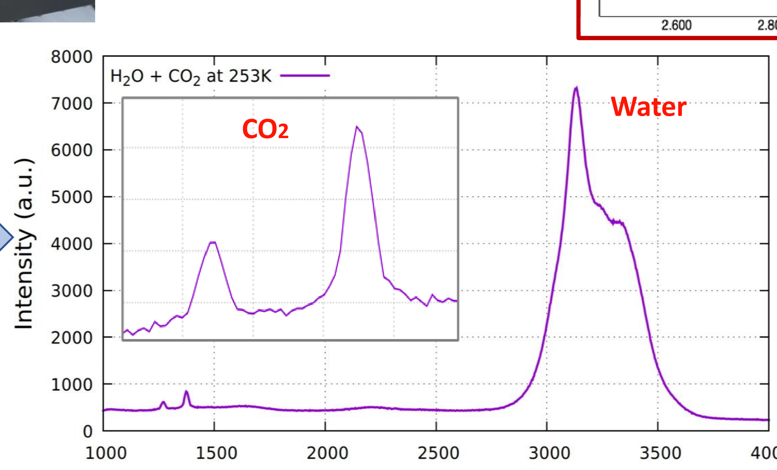
Raman measurements to investigate:
both synthetic and natural GH at the **molecular level** - obtained information: **existence of hydrate**, **structure type**, **molecular composition**, and **cage occupancy.**



Gas hydrates by Raman







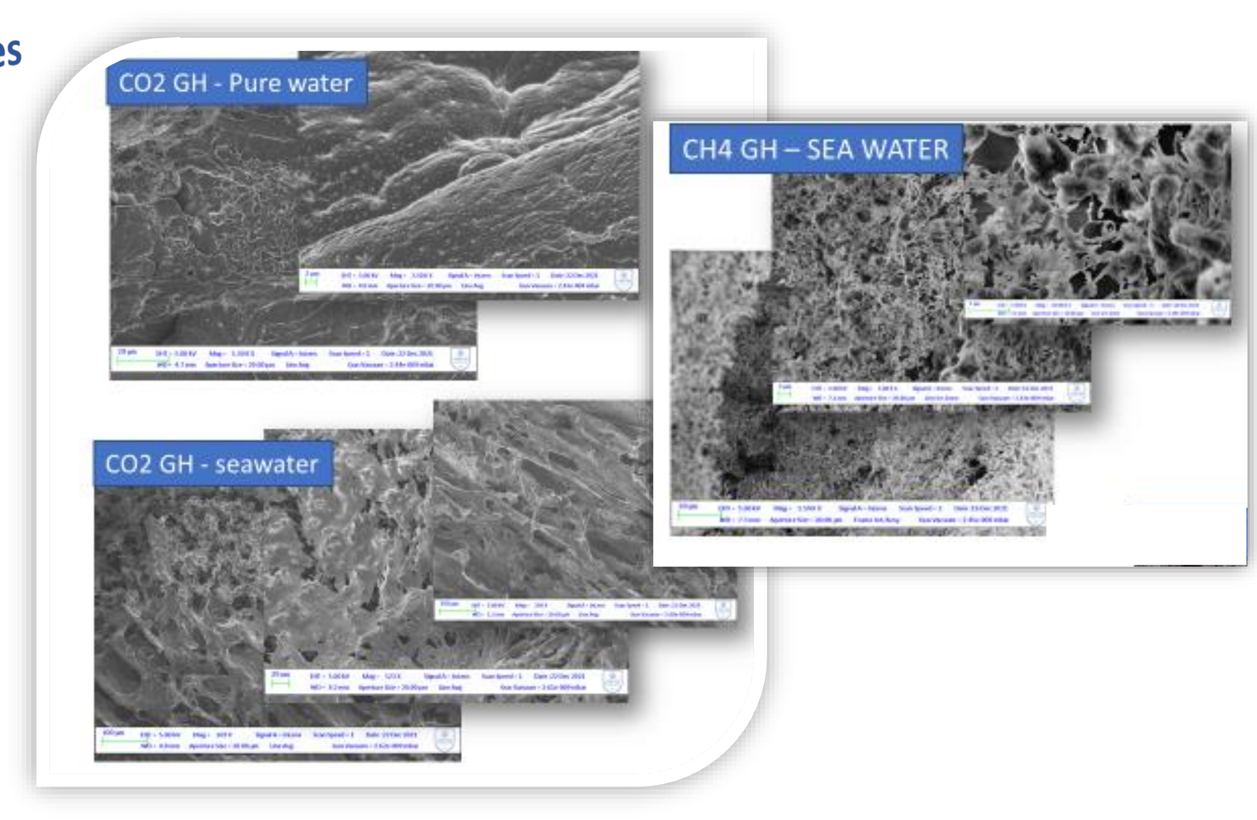
CO_2 Fermi dyad: expansion or contraction of the CO_2 cages

OHs bands: simmetric and asimmetric components

SEM measurements to investigate:

- hydrate morphology resulting from different hydrate condition
- progress of gas hydrate formation and dissociation reactions
- comparison between natural gas hydrate and synthetic one and hence determining how closely synthetic sample emulate those from nature.

Gas hydrates by SEM



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