Storage of carbon dioxide in geological reservoirs – dolostone and sandstone reactivity under *in situ* temperature, pCO_2 and brine, St. Lawrence Lowlands, Québec, Canada.

Séquestration géologique du CO_2
Chaire de Recherche
INRS

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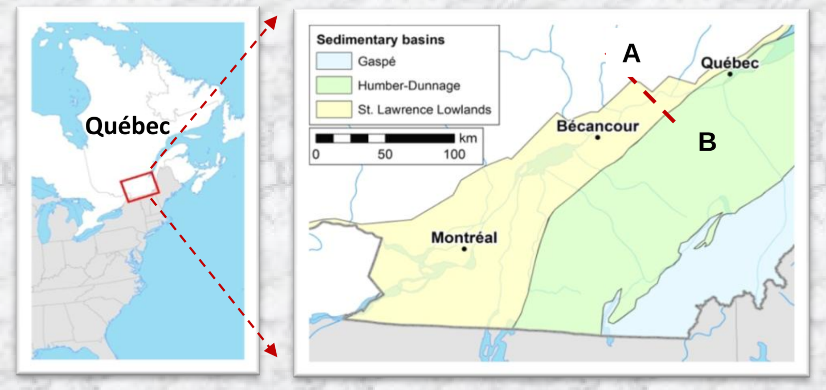
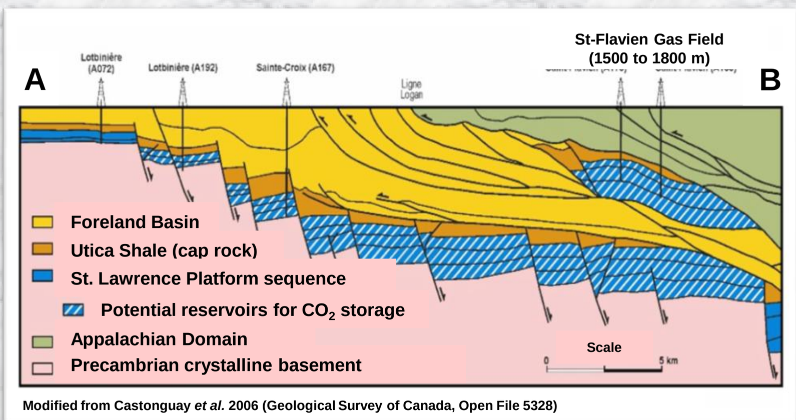
INTRODUCTION

Objective : CO_2 sequestration in geological reservoirs of the St. Lawrence Lowlands, Québec
Concern : negative rock-water interactions, following CO_2 injection
Test : monitoring of free drift reactions over several months between rock samples and pore fluid under CO_2 and *in situ* p, T conditions





Localisation map and geological cross-section

Geological setting :

- Lower Paleozoic platform sequence, including autochtonous and allochtonous series buried under Appalachian nappes
- fluvial and transgressive sandstone over Pre-Cambrian basement, followed by dolostone and limestone, then shale and siltstone of deeper environments, after platform collapse

Potential reservoirs :

- near the base of the platform sequence, at > 1000 m depth
- *Beekmantown Group* : Lower Ordovician dolostone & dolomitic sandstone, tightly cemented to porous, up to 4 - 12 %, 1.57 mD permeability
- *Potsdam Group* : Cambrian quartzite, tightly cemented to porous, up to 8 %, 1.11 mD permeability
- both units with dense brine as pore fluids

METHODS

Materials :

- artificial brines with composition similar to *in situ* brines
- sub-samples of reservoir core samples from exploration holes
- pure CO_2 gas

Sandstone (left) and dolostone (right) core and plugs.

- 10 cm cores from holes A196 (1157.0 m) & A273 (972.0 m)
- plugs are 25 mm sub-samples cut into a 20 mm thick slice

Reactor :

- stainless-steel, cylindrical, high pressure vessel, with a vertical agitator
- automatic temperature and gas pressure control and monitoring

High pressure vessel used for experiments

- plugs (n=5) stacked over each other at t = 0 (left)
- cap fitted with sampling and monitoring ports (right)

Procedures :

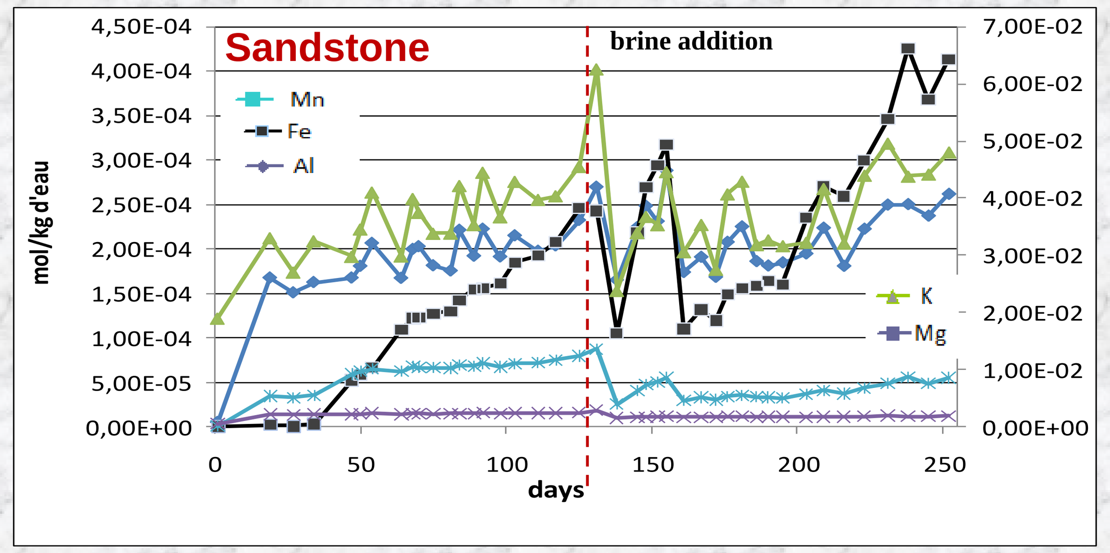
- left under N_2 for a month until equilibrium, then under CO_2 until the end
- fluid sampled once or twice a week, analyzed for Al, Ca, Cl, Fe, K, Mg, Mn, Na, S and Si
- plugs removed each 30-50 days and at end of experiment, impregnated and cut for thin sections
- scanning electron microscopy
- microprobe analysis

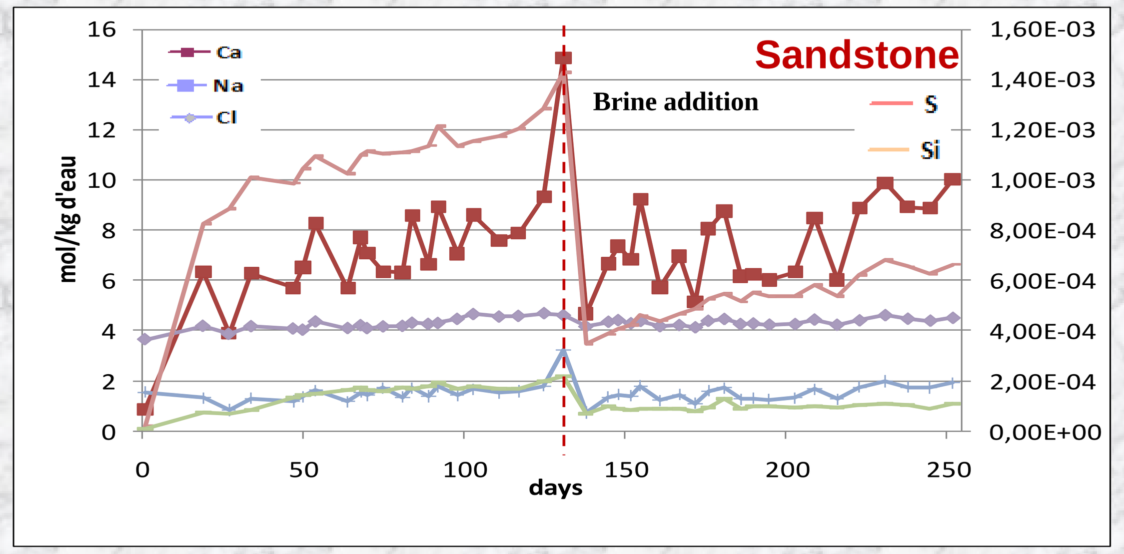
Artificial brine : filtration, filling &start up of experiment

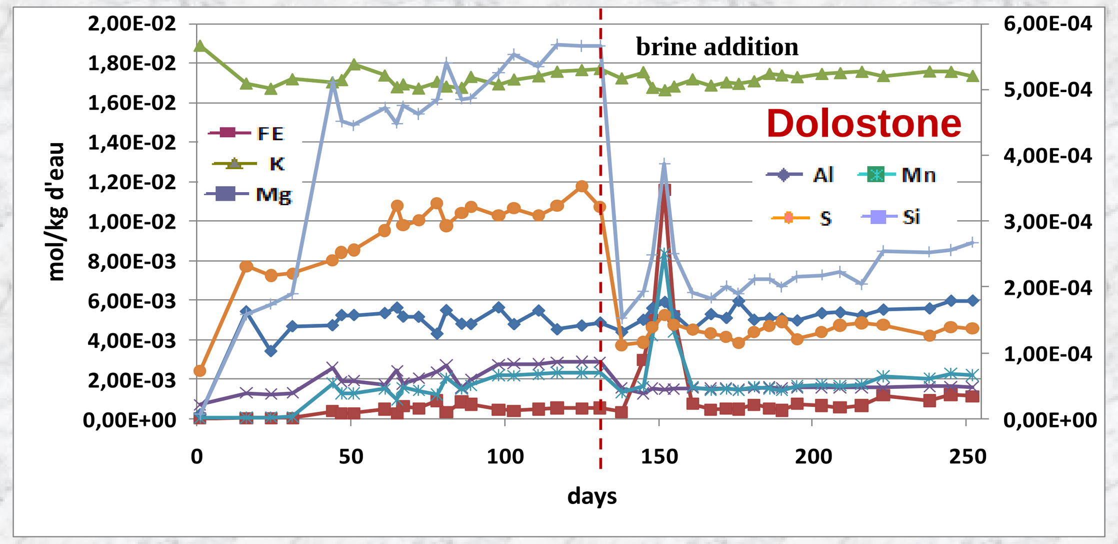
Conditions for sandstone experiment :
- brine : 14.8 mg/L $CaCl_2$, 0.84 mg/L $MgCl_2$, 0.44g/L KCl, 12.6 mg/L NaCl
- 190 bar / 50 C for 249 days; reactor refilled after 128 days

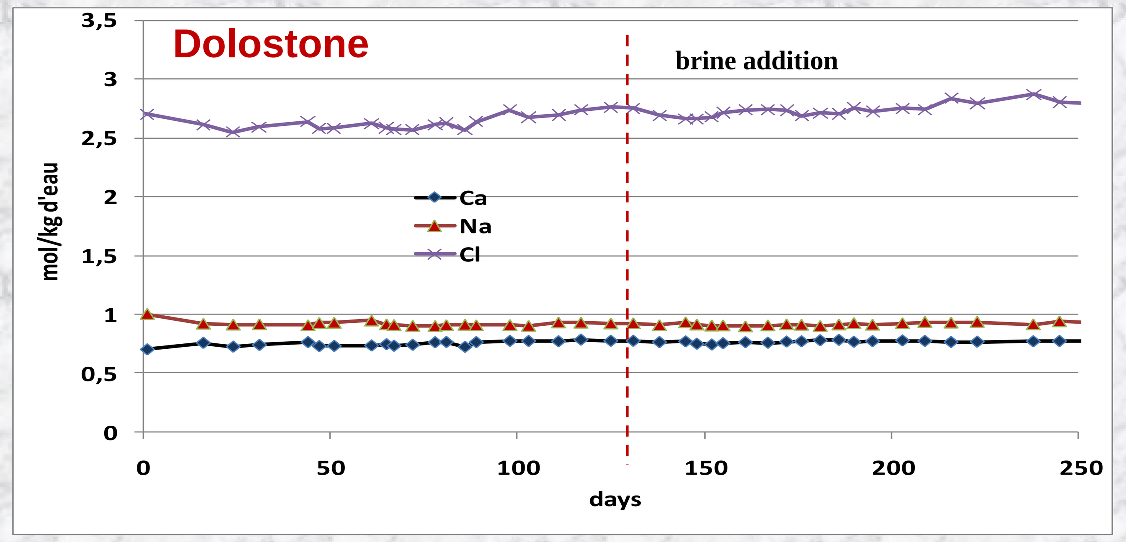
Conditions for dolostone experiment :
- brine : 15.7 mg/L $CaCl_2$, 0.72 mg/L $MgCl_2$, 0.16 mg/L KCl, 0.87 mg/L NaCl
- 120 bar / 50 C for 252 days; reactor refilled after 125 days

EVOLUTION OF BRINE COMPOSITION





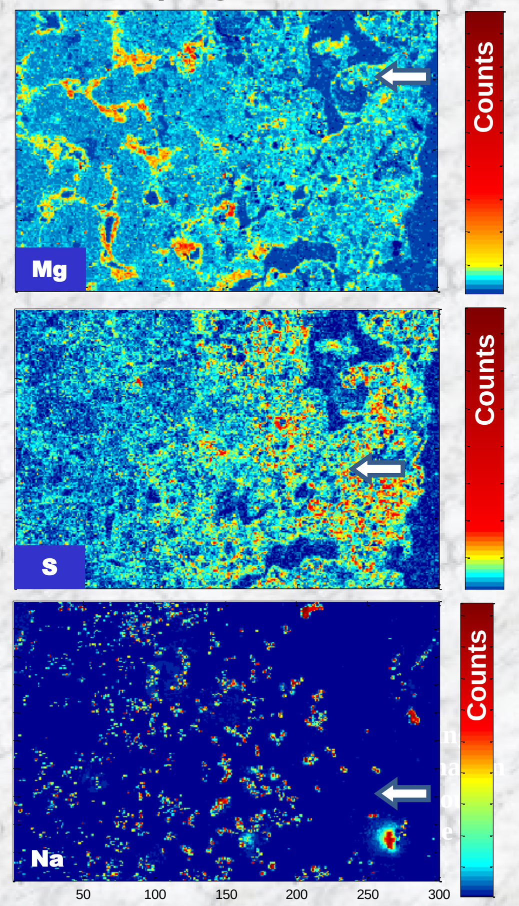




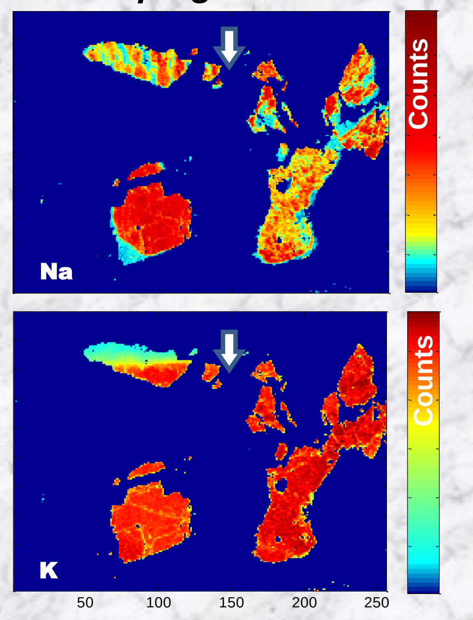
Main features :
- concentrations increase for all elements, allowing dilution effects for brine refill at days 128 and 125.
- log of (Q/K) points to under saturation with respect to most common mineral phases.
- dissolution reactions dominate in the two reservoirs and likely increase the porosity.

ELEMENT MAPPING IN THIN SECTIONS

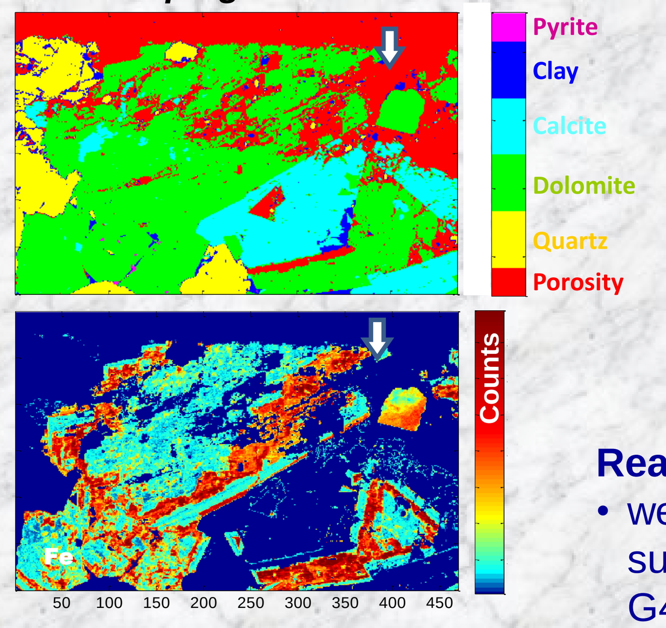
plug G2



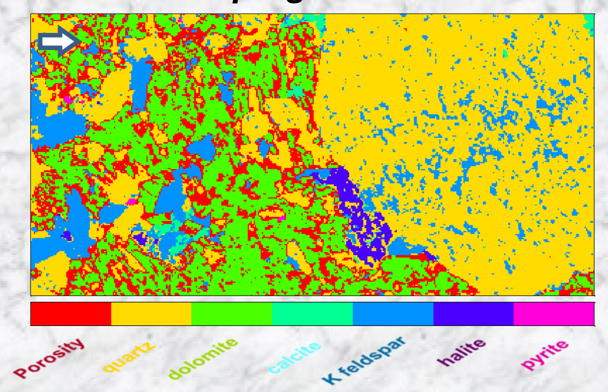
plug G4



plug D5



plug D3



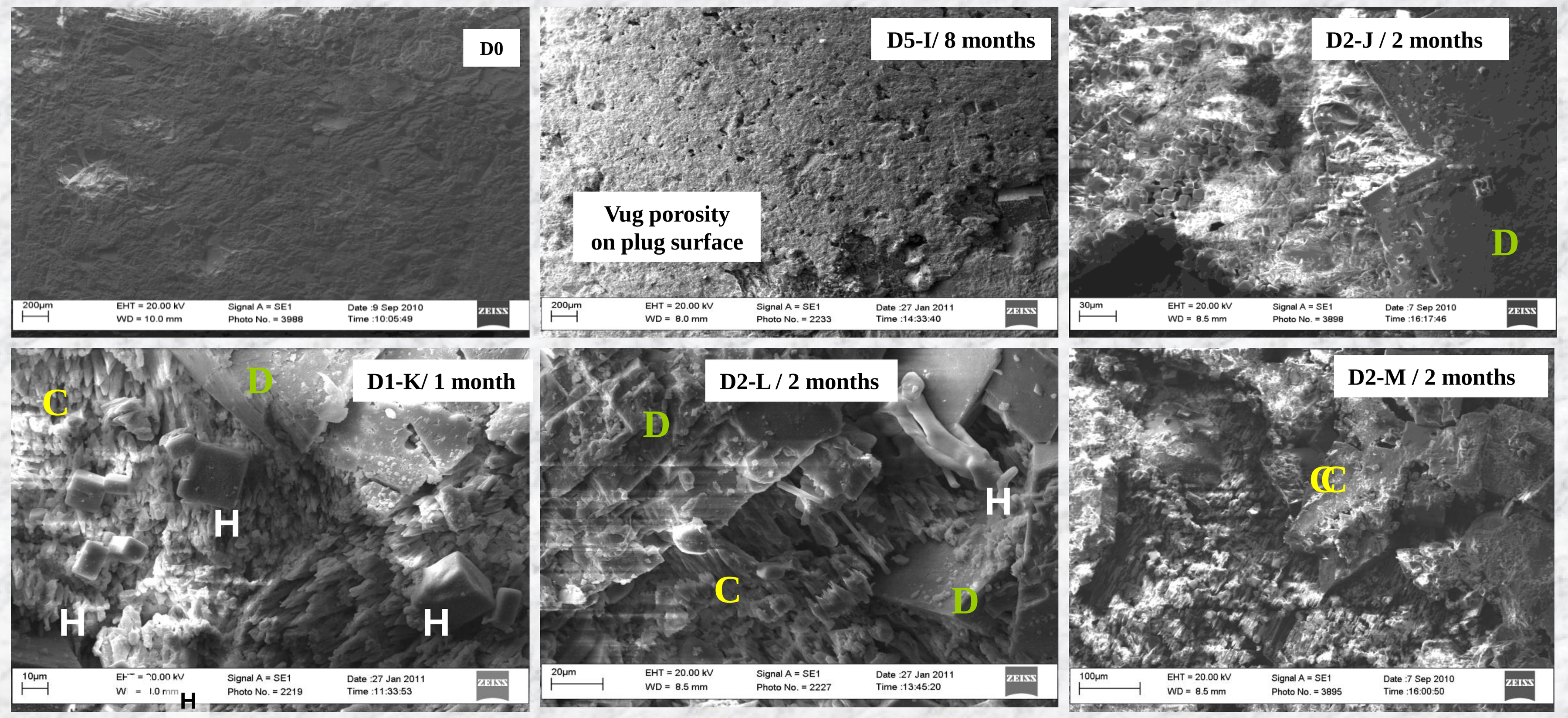
Reaction fronts :
- well defined with respect to plug surfaces : G2, from right to left G4 and D5, from top to bottom

Dissolution features :
- leaching mainly of interstitial clay minerals in sandstone (Mg distribution in G2)
- dolomite dissolution in coarse-grained (D5) and fine-grained (D3) dolostone
- enhanced porosity in iron-poor zones of individual dolomite crystals, relative to iron-rich zones (D5)
- partly controlled by crystallographic orientations (K and Na concentrations vary parallel and perpendicular to plug surface, upper left feldspar in G4)

Precipitation features :
- halite, coarser in the newly available pore space than inward (Na distribution in G2)
- sulphate minerals, more abundant in the newly available pore space than inward (S distribution in G2)
- salt distribution points to post-experimental precipitation, following plug removal and drying

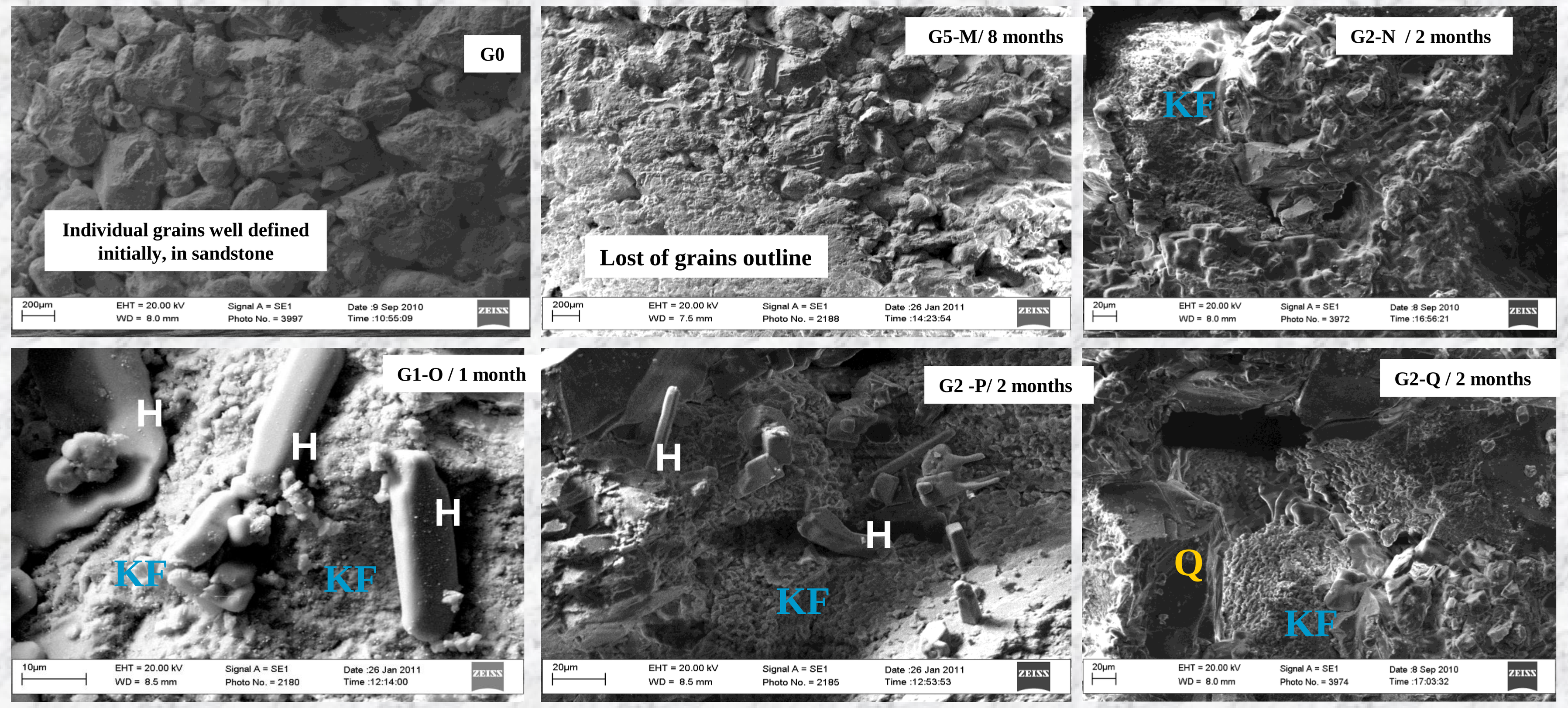
SCANNING ELECTRON MICROSCOPY AND EDS

dolostone



C = Calcite | D = Dolomite | H = Halite

sandstone



KF = K Feldspar | Q = Quartz | H = Halite

CONCLUSION AND PERSPECTIVE

➢ Our experiment permit to conclude: that dissolution reactions dominate in the two reservoirs and likely increase the porosity D5-(G,H); D3-F; D5-F; D5-I; D2-J; D2-M; G2-M; G2-N

➢Precipitations minerals observed are only due to salt crystallization during the drying phase when plug are retired from the vessel D1-K; D2-L; G1-O; G2-P;

➢ Kinetics dissolution coefficient must be estimated, caprock must be tested, and numerical simulation must be done (with data extracted from this experiment) to predict the reservoir behaviour in a long term