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MINERAL CARBONATION FEASIBILITY, AN ECONOMIC APPROACH

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A natural solution for an environmental problematic

Mineral carbonation is one approach proposed for tackling anthropic CO_2 emissions. It mimics the natural reaction of silicates weathering, were the gaseous CO_2 reacts with a divalent cation to form the associated carbonates following the reaction:

$$MeO + CO_2 = MeCO_3 + Heat$$

Mineral carbonation advantages/challenges are:

Advantages:

- + Various feedstock can be used:
  Natural minerals; Olivine, Serpentine, Wollastonite etc.
  Alkaline Wastes: Mining residues, Concrete, Slags, Kiln dusts etc.
- + Reaction can bedirectly performed with flue gases:
  No need for capture step.
- + Value added by-product:
  Rentability for the processes, waste valorization.

Challenges:

- △ Reactivity limited feedstocks:
  The mineral stability can greatly limit the reaction.
  Some alkaline waste have a small sequestration capacity.
- △ Slow kinetics:
  Might increase the energy needs.
- △ Needs important feedstock resources.

The process:

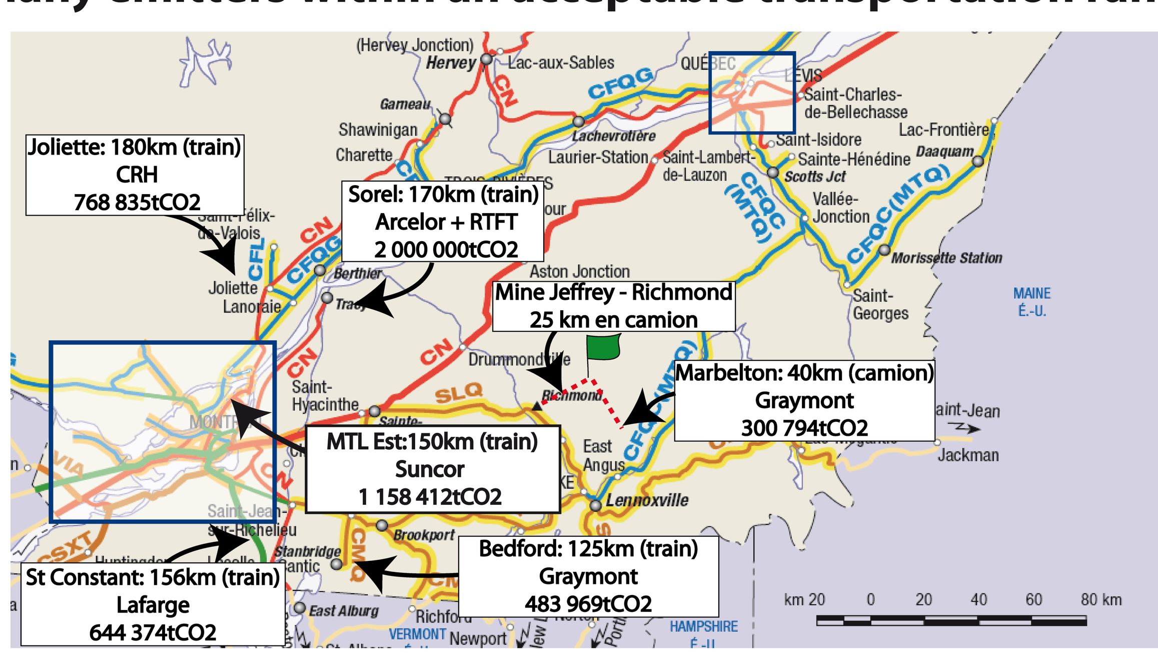
Use serpentinite mining tailings for direct industrial flue gas CO_2 capture and storage.

Pre-treatments:
Grinding (granulometry < 25µm)
Magnetic separation: Magnetite (30$/t)
Heat activation: 650°C for 30 minutes

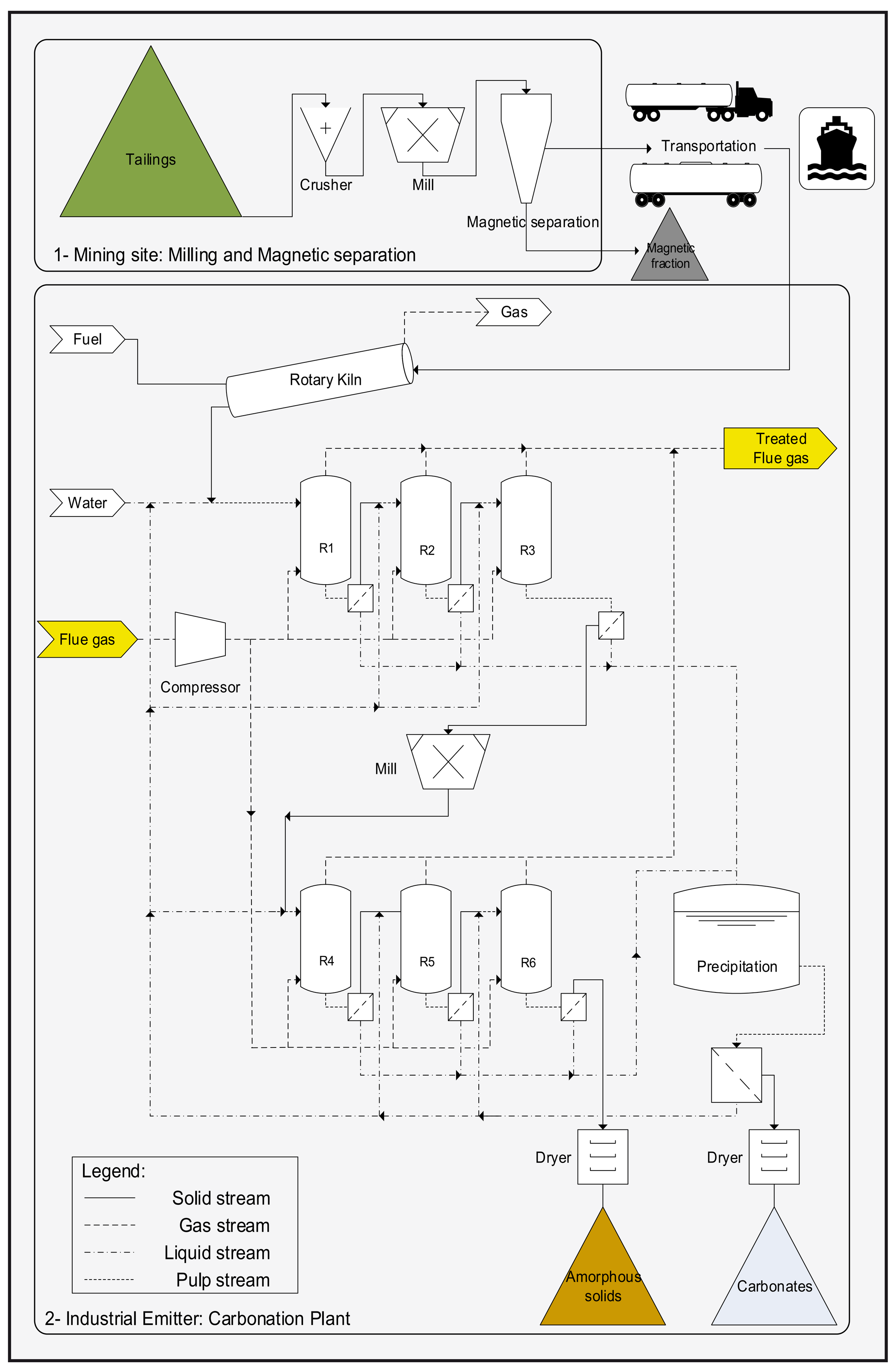
CO_2 capture and storage (3 steps):
Reaction between the flue gas and the residues in the presence of water (25°C and 10 bars for 15 minutes)
Filtration: CO_2 & Mg-saturated solution and inert solids
High purity carbonates precipitation (40°C)

Solids recirculation:
During the gas treatment step, solids are recirculated.
A reconditioning step by grinding is required to increase the Mg leaching efficiency.

Many emitters within an acceptable transportation range



Railroad network and emmiters in the southern Quebec province



Process diagram (Pasquier et al., 2016)

Results

Model principal parameters

Cost model parameters:
Plant treatment capacity: 200t rocks / h
Transportation distance: 200 Km
Sequestration efficiency: 234 kgCO_2 / t rocks
Energy unit costs (Electricity):
Hydroelectricity: 3.5 ¢ / kWh
Coal: 7.8 ¢ / kWh
Energy unit cost (Heat Activation & Precipitation):
Nat. Gas: 3.00 $ / MBtu
Biomass:1.54 $ / MBtu

Transportation unit cost:
Truck: 0.12 $ / km
Train: 0.07 $/ km

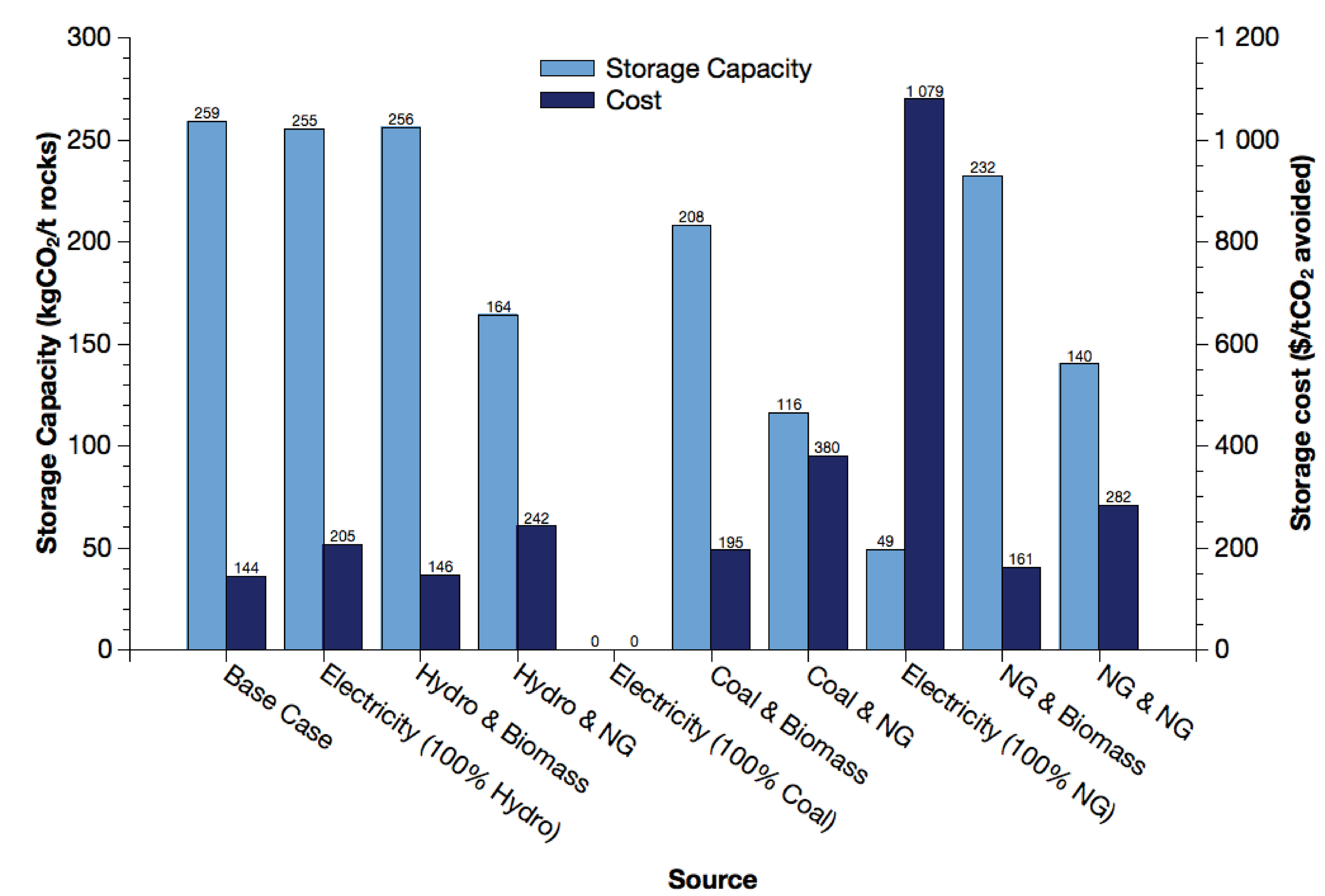
Profitability analysis parameters:
Carbon credit price: 10.75 $ / tCO_2
Magnesium carbonate sale price: 275 $ / t $MgCO_3$
Magnetic fraction sale price: 30 $ / t

Energy and GHG balance

Process power and heat consumptions :

Process Step	Power (MJ/t.rock)	Heat (MJ/t.rock)
Crushing / Grinding and Magnetic sep.	83	
Heat Activation		1 143
Gas compression	68	
Carbonation reactors (R1- R6)	0.4	
Reconditionning	36	
Precipitation		467
Others (pumps, conveyors etc.)	76	
Total	**263**	**1610**

- The process energetical demand is mostly heat.
- The energy source is greatly impacting the process net storage capacity and cost.



Effect of the energy source on the process storage capacity and global process cost

Economics analysis

Process economics for base case scenario :

	Train & NG	Train & Biomass	Truck & NG	Truck & Biomass
Total process costs ($/t$CO_2$)	152	143	191	182
Net profit ($/t$CO_2$)	490	502	450	462
Annual sequestration capacity (tCO_2/year)	246 152	385 512	189 754	329 114
Capital costs (M$)	203	203	203	203
Payback Period (years)	1.39	1.36	1.51	1.47

- The process is economically **profitable**
  Profitability relies on the carbonates sale
- The sensitivity analysis highlights the importance of the sequestration efficiency.
- The process costs remain below 200$ for a capacity up to 50t/h.

Conclusions

Mineral Carbonation can be a feasible and profitable approach for industrial direct CO_2 emissions abatement.
One step capture and storage strategy is a key→ Energy consumption reduced.
The energy efficiency of the process can be increased.

For more details: Pasquier, L. C., Mercier, G., Blais, J. F., Cecchi, E., & Kentish, S. (2016). Technical and economic evaluation of a mineral carbonation process using southern Québec mining wastes for CO_2 sequestration of raw flue gas with by.product recovery. International Journal of Greenhouse Gas Control, 50, 147-157. doi:10.1016/j.ijggc.2016.04.030

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