Alternative Carbon Capture and Storage Pathways Workshop

Industrial Process for CO_2 Sequestration by Aqueous Mineral Carbonation Using Alkaline wastes and By-Product Valorization

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Centre - Eau Terre Environnement

INRS
Université d'avant-garde

INRS Mineral Carbonation Research Group

Our team:

✓ INRS Scientific team:

GUY MERCIER

JEAN-FRANÇOIS BLAIS

2 Research Associates, 1 Post Doc fellow, 4 Students (M.Sc. and Ph.D.)

✓ Collaborations:

Sandra Kentish, University of Melbourne, Ian Gates, University of Calgary, Greg Dipple, University of British Columbia

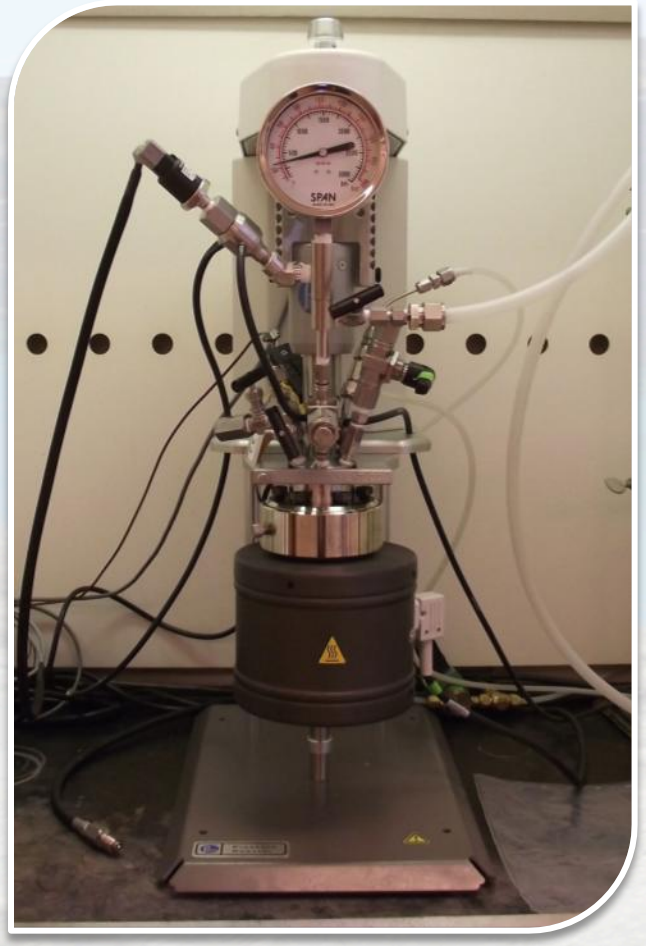
✓ Industrial Partners: Sigma Devtech, Cliffs Natural Ressources, Holcim

Our vision:

- Provide to the industry a competitive and profitable post combustion CO_2 capture and storage process :

  - ✓ Mining / industrial wastes valorization
  - ✓ Direct flue gas treatment
  - ✓ No impact on the industrial process
  - ✓ By-product with a potential sale value (Mg compounds)

Our research so far:



Laboratory scale (2010-2013)

Patent pending

August 2012-2014 (CMC)

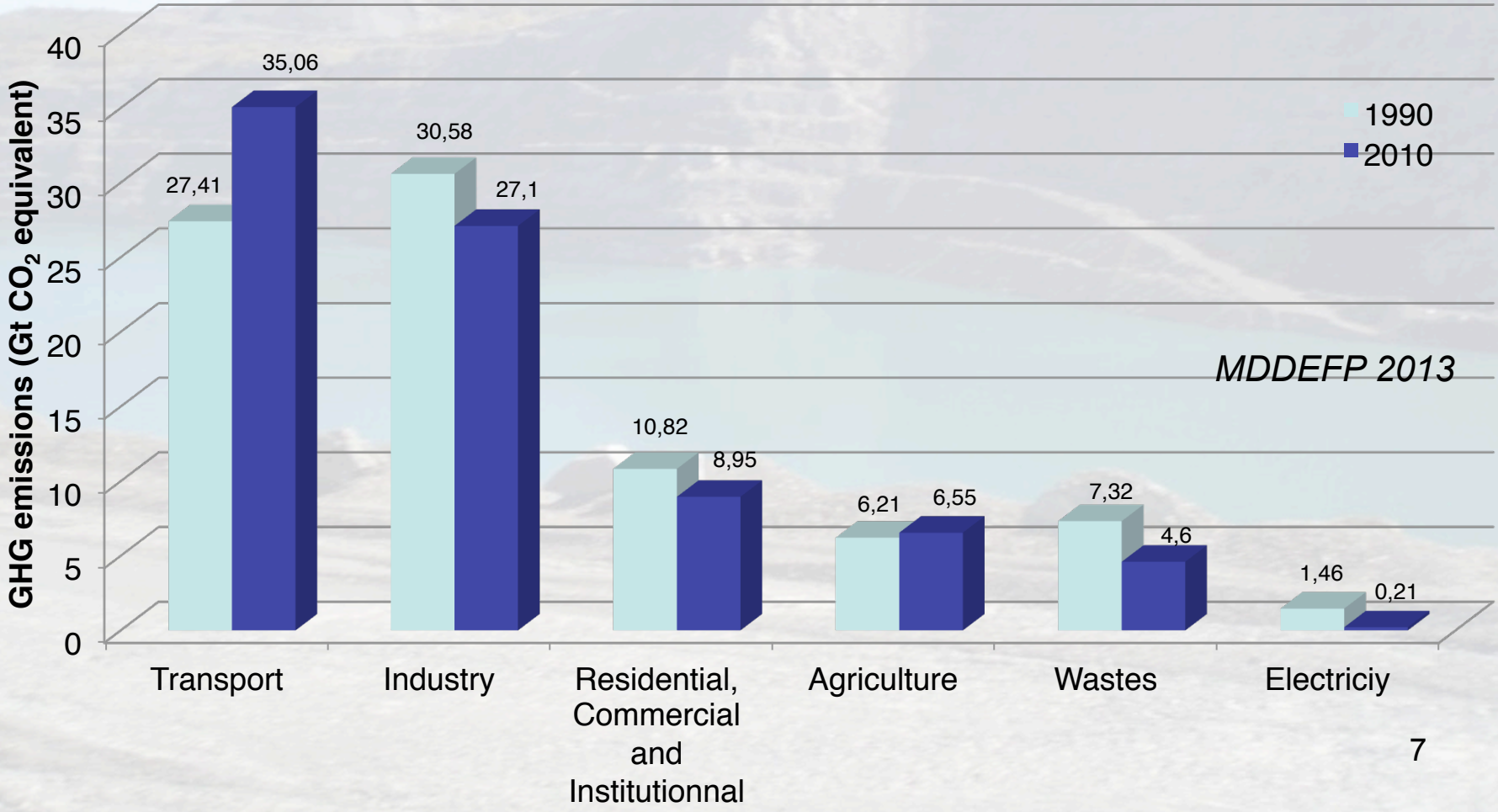
Pilot plant in a cement plant
Alternative materials experiments

2014-2016

Prototype
New project with CNR

The Québec province context

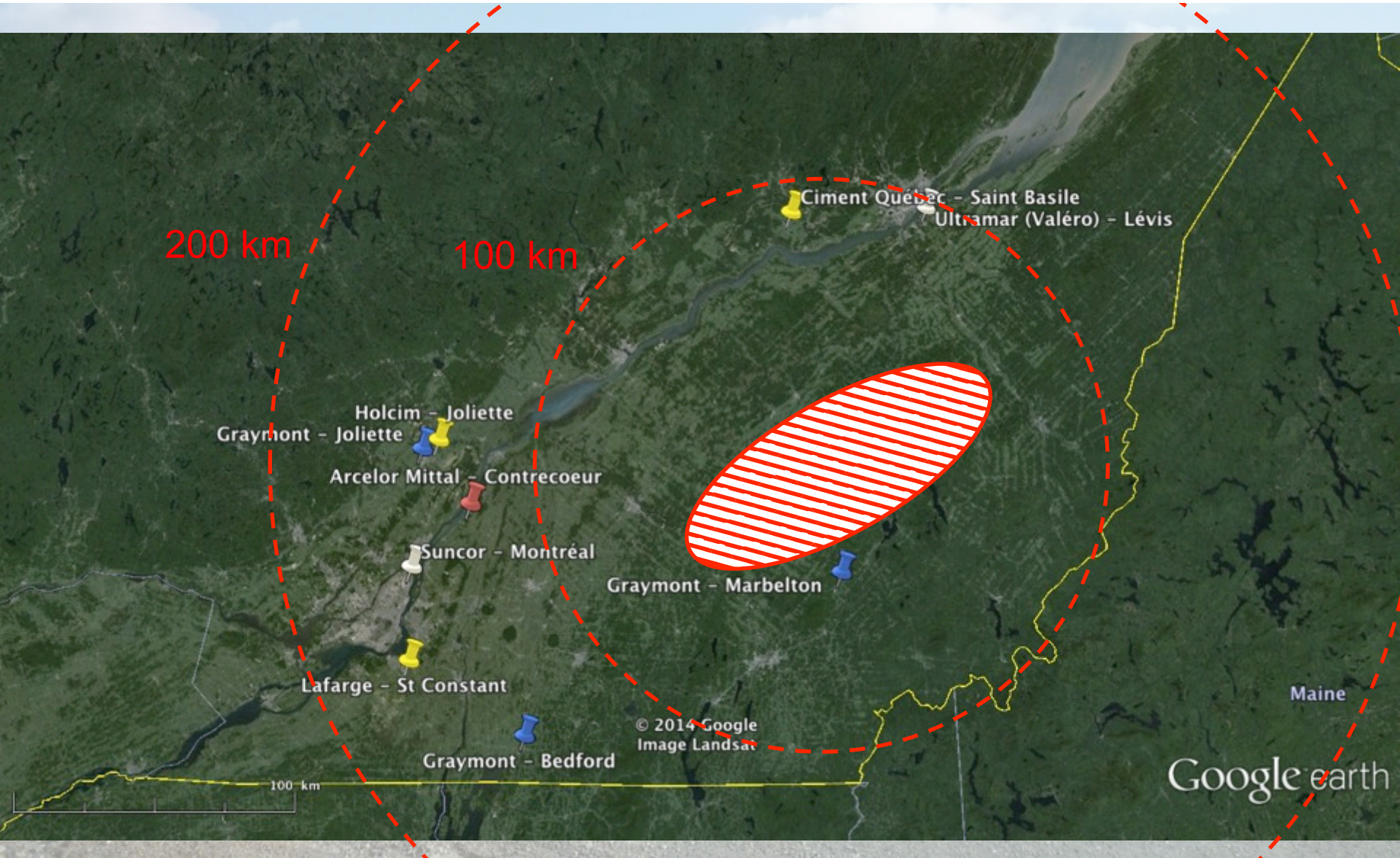
Context: Québec's GHG emissions



Context:

Why mineral carbonation represents a solution for Québec's industrial GHG emissions?

- Intensive mining exploitation in the southern region.
- About 2Gt of residues mostly composed of serpentinite were accumulated. The Mg contained within the residue could sequester about 700Mt CO_2 equivalent.
- Yet no valorization of residues.

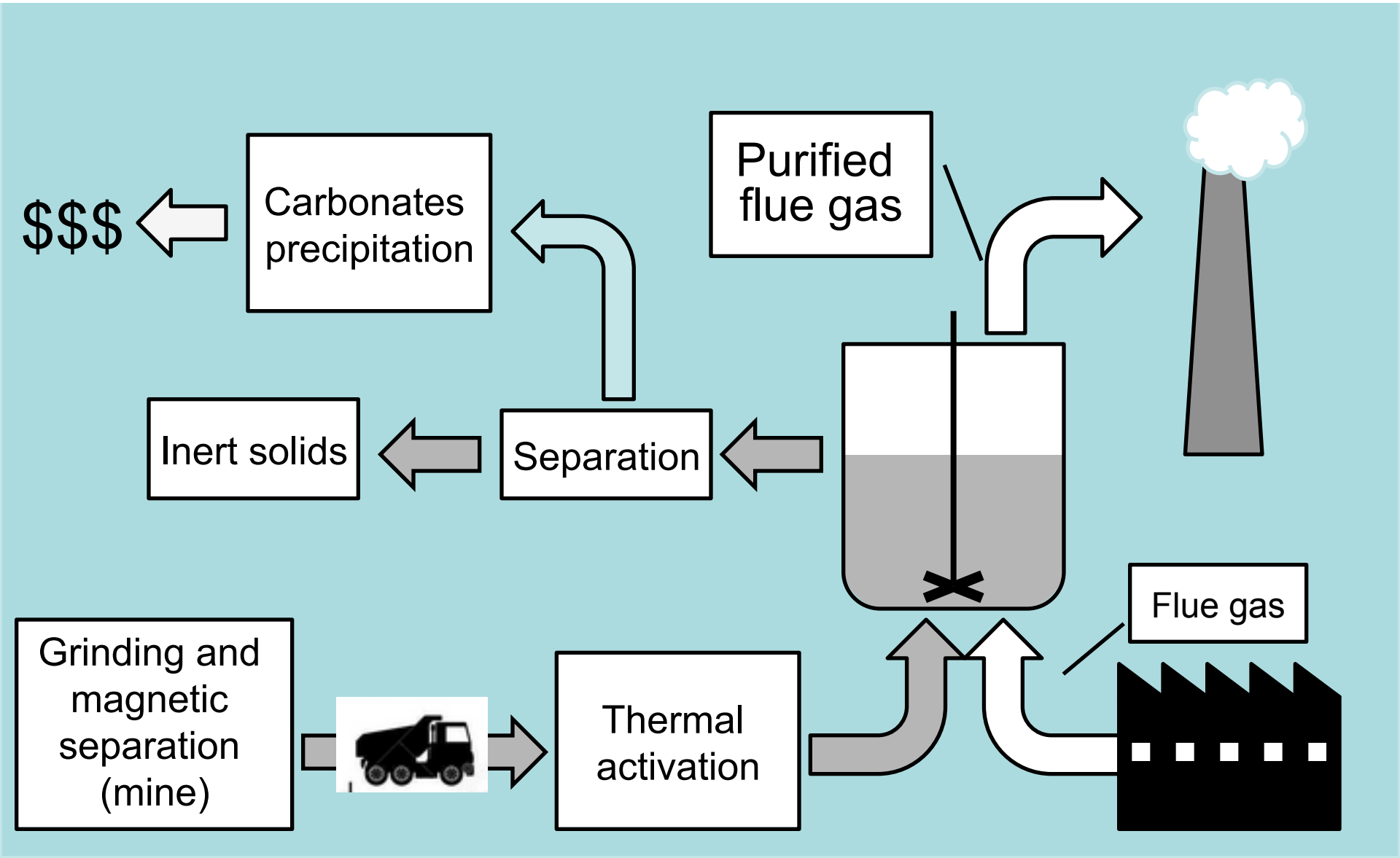

200 km
100 km
Ciment Québec - Saint Basile
Ultramar (Valéro) - Lévis
Holcim - Joliette
Graymont - Joliette
Arcelor Mittal - Contrecoeur
Suncor - Montréal
Graymont - Marbelton
Lafarge - St Constant
Graymont - Bedford
Maine
© 2014 Google
Image Landsat
100 km
Google earth

Context: Alternatives sources

- Construction wastes: concrete, bricks
- Industrial wastes: steel slags, cement kiln dusts, waste incinerator dusts

Different opportunities for different issues!

The technology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Carbonates precipitation
Purified flue gas
Inert solids
Separation
Grinding and magnetic separation (mine)
Thermal activation
Flue gas

Reaction parameters:

Low partial pressures ➔ Low temperatures!

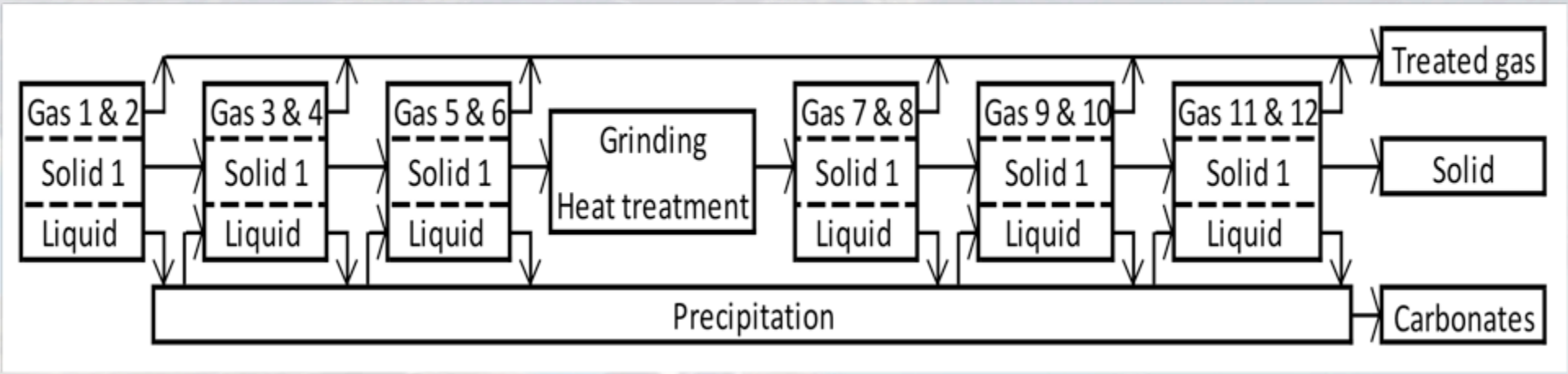
Moderate pressure: 10.2 bars

After 15 minutes reaction time :

- ✓ **88% CO_2 uptake**
- ✓ **75% of the carbon is in the liquid phase**
- ✓ **7% of the Mg is leached**

Lab scale results: Recirculation scenario

- The treatment of successives batches of gas allow to increase the amount of dissolved CO_2 and thus increases the Mg leaching.



- **After 12 batches of gas treated:**
  - **CO_2 cumulative uptake = 62.5 ± 0,5%**
  - **Mg cumulative leaching = 64 ± 7%**
  - **Sequestration capacity = 0.28 g CO_2 / g of residues**

Pasquier L.C., Mercier, G., Blais, J. F., Cecchi, E., & Kentish, S. K. (2014). Parameters optimisation for direct flue gas CO2 capture and sequestration by aqueous mineral carbonation using activated serpentinite based mining residue. *Submited in Applied Geochemistry*.

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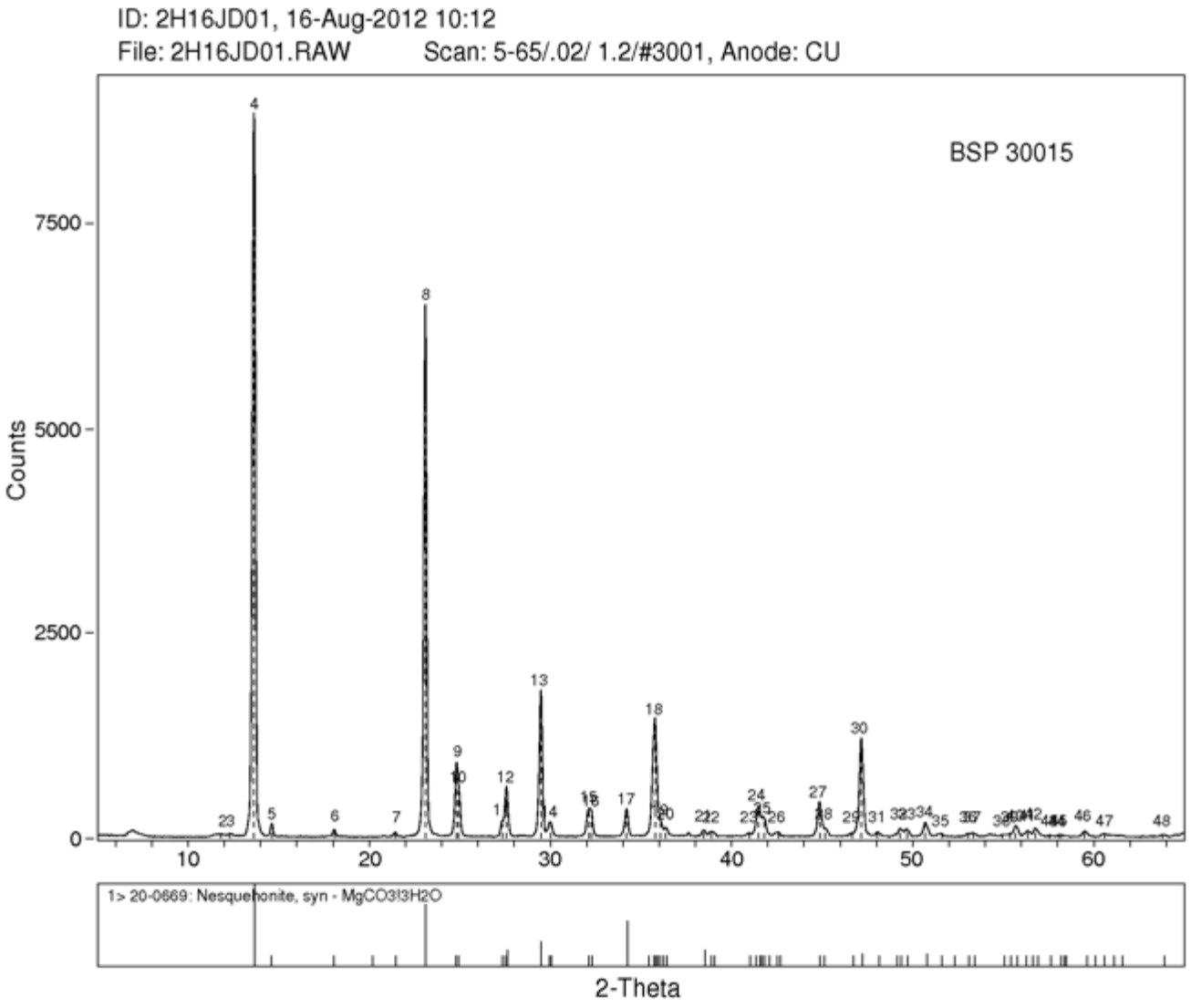
	n
n	*2*
%	*1*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2-Theta

Pilot scale experiments:

Since September 2013, experiments realized in a 20 liters reactor using the cement plant flue gas.

Challenges:

- ✓ **Verify lab scale results**
- ✓ **Real gas treatment**
- ✓ **Raw water use**

☑ **The lab results are being confirmed and the process optimization ongoing**

Technical and economical analysis

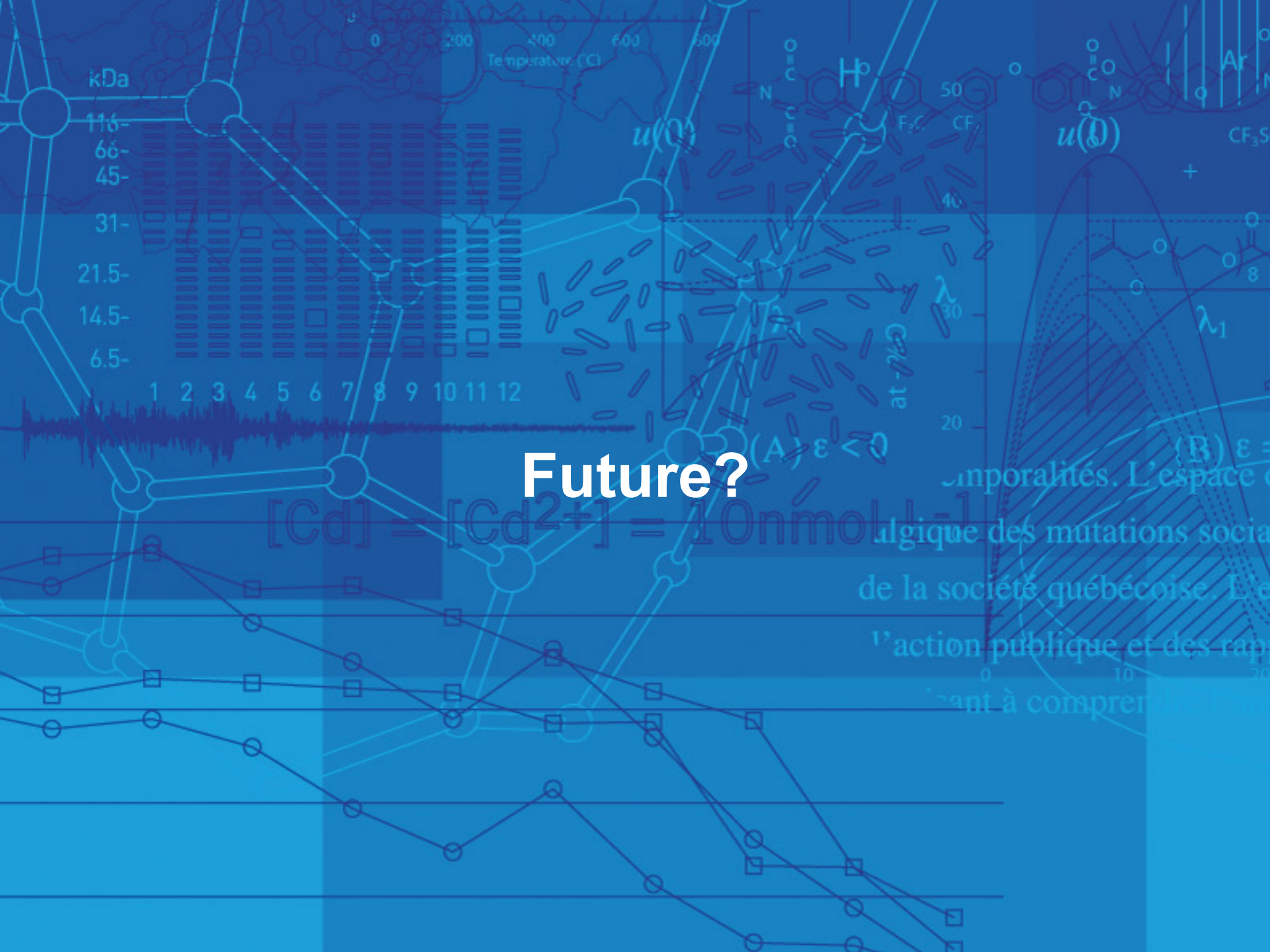
Results: Model inputs parameters (Pasquier et al., 2014)

Parameters	Units	Base case scenario
Cost model parameters		
Plant treatment capacity	t rocks/ h	200
Annual period of operation	days	350
Daily period of operation	hours	24
Manpower rate	$ / h	25
Electricity unit cost	cent$ / kWh	3.5
Distance	Km	171
Sequestration efficiency	%	62
Energy unit cost	$ / MBtu	*Natural Gas:* 3.00 *Biomass:*1.54
Transport unit cost	$ / km	*Truck:* 0.12 *Train:*0.07
Profitability analysis costs		
Incoming taxes	%	30
Carbon credits	$ / tCO_2	20
Mg carbonates sale price	$ / t	100
Magnetic fraction sale price	$ / t	30

Results: Technical/economical analysis (Pasquier et al., 2014 b)

Parameters	Units	Base case scenario			
		Trucks & NG	Train & NG	Truck & Biomass	Train & Biomass
Process total costs	$ / tCO_2	122	99	114	91
Sequestration rate		0.56	0.65	0.91	0.99
Annual sequestration capacity	tCO_2 / year	307 492	356 192	489 551	537 571
Profit	$ / tCO_2	89	114	104	129
Capital cost	$M	148			
Net Present Value	$M/10 years	182	253	223	293
IRR	%	40	55	49	65
Payback period	years	3.5	2.8	3.1	2.6

Pasquier L.C., Mercier G., Blais J.F., Cecchi E. & Kentish S.K. (2014) Economic evaluation and feasibility of a mineral carbonation process using southern Québec mining waste for direct flue gas CO_2 sequestration with by product recovery. *submited in Journal of Cleaner Production*.


Future?

Objectives:

- ✓ Continuity
- ✓ Precision
- ✓ Opening

- Conception and operation of a prototype plant for the commercial demonstration by 2015

A pessimist sees the difficulty in every opportunity; an optimist sees the opportunity in every difficulty.

Winston Churchill

•Pasquier L.C., Mercier G., Blais J.F., Cecchi E. & Kentish S.K. (2014) Economic evaluation and feasibility of a mineral carbonation process using southern Québec mining waste for direct flue gas CO_2 sequestration with by product recovery. *submited in J. of cleaner production*.

Thank you for your attention!

Questions?

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