Programme Area: Carbon Capture and Storage

Project: Mineralisation

Title: Mineralisation Project Final Summary Presentation.

Context:

CCS by mineralisation has been identified as a promising additional method of sequestering CO2 emissions. Minerals and CO2 can react together to permanently store CO2 as a solid carbonate product, which can then be safely stored, used as an aggregate or turned into useful end products such as bricks or filler for concrete. This £1m project, launched in May 2010 carried out a detailed study of the availability and distribution of suitable minerals across the UK along with studying the technologies that could be used to economically capture and store CO2 emissions. The project consortium involved Caterpillar, BGS and the University of Nottingham. The objective was to investigate the potential for CCS Mineralisation to mitigate at least 2% of current UK CO2 emissions and 2% of worldwide emissions over a 100- year period. The project has found that there is an abundance of suitable minerals available in the UK and worldwide to meet these mitigation targets. However, challenges remain to make the capture process economically attractive and to reduce its energy use. Significant niche opportunities exist where waste materials are used as feedstock and/or the process produces value-added products, but markets would not be at the level required to meet the mitigation targets.

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Mineralisation Project

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Project Background

- Commissioned and funded by the ETI to carry out a detailed study of the availability and distribution of mineral deposits across the UK and technologies that could be used to economically capture and permanently store CO_2 emissions.
- Led by Caterpillar, with two other participants (BGS and University of Nottingham).
- The project started in May 2010, and concluded in September 2012
- Final Project Outputs shared in full with ETI members

Project objectives

- To identify accessible mineralisation reactant quantities and locations in the UK and potential power and industrial applications where mineralisation could be applied based on the relative locations of the reactants and CO_2 sources;
- To assess the specific technology development needs to overcome the barriers to implementation of CCSM;
- To produce a techno-economic case for CCSM so that an economic determination of the suitability of further research can be made;
- To identify potential ETI focus areas; and
- To produce a technology development roadmap to demonstration stage including cost/benefit and risk analysis.

Project Structure

- Stage 1
  - Mineral resource Assessment
  - Technology Landscape
  - Stage Gate 1
- Stage 2a
  - Techno economic scenarios and experimental plan
  - Stakeholder Review
- Stage 2b
  - Laboratory evaluation of mineralisation process
  - Techno economic assessment
  - Life cycle analysis
  - Review of UK and Global Reactant reserves
  - Stage Gate 2
- Stage 3
  - Final report
  - Dissemination Plan
  - Presentation to Members

Mineral Suitability & Resource Assessment

- Project was to investigate the potential for CCSM to mitigate at least 2% of current UK CO_2 emissions and 2% of worldwide emissions over a 100-year period. The project investigated:
  - The availability of serpentinite rock to satisfy the UK target for CCSM. This equates to 22–33 Mt/yr of rock.
  - Evidence of deposits of sufficient size, suitable minerals, and practically extractable rock outside of the UK for the application of CCSM.
- Project team assessed how mineral type affected the leaching time, then re-evaluated the availability of minerals
  - In the UK there are suitable and potentially extractable rock resources to capture approx 10% of current emissions for over 100 years
  - Global resource exists to capture nearly 400 years of total global emissions (2006 levels)

Evaluation of Processes

- CCSM Groups
  - Direct Carbonation (single step)
    - ~~1: Gas-solid <40%~~
    - Aqueous (gas-liquid-solid)
      - ~~2: No additives <50%~~
      - 3: With additives 60-85%
  - Indirect Carbonation (multi step)
    - ~~4. Gas-solid 40-60%~~
    - 5. Aqueous with additives (gas-liquid-solid)
      - Double step 60-80%
      - Multi step 60-80%

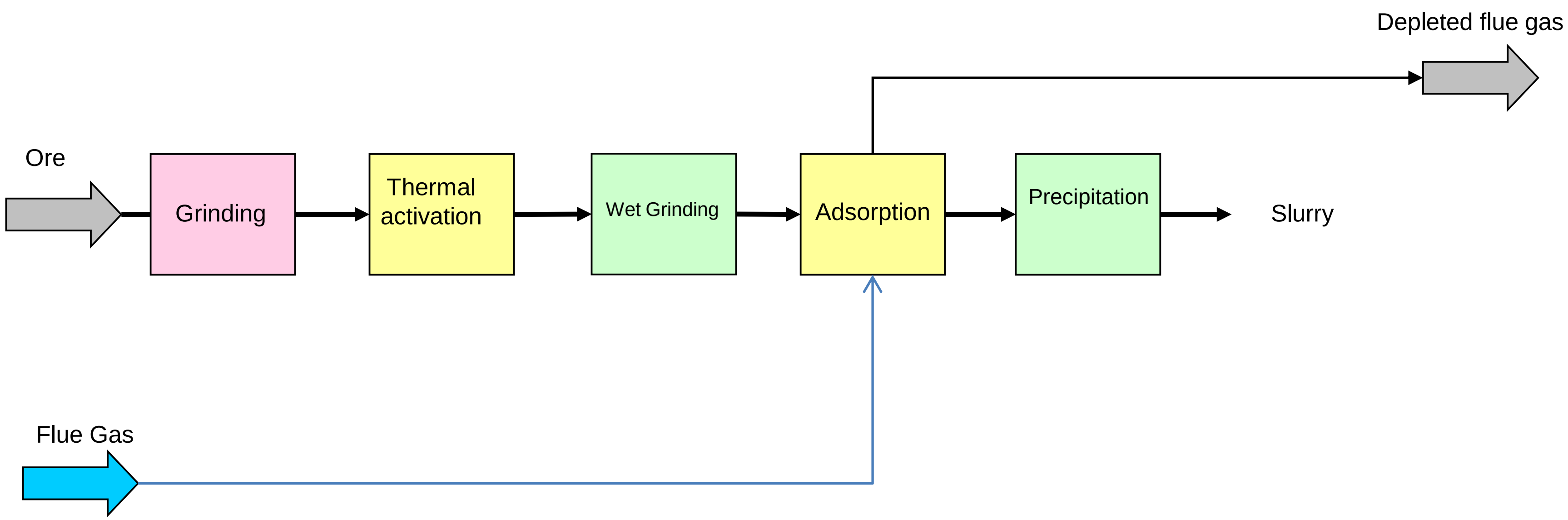
Proprietary Process A

High T=150-700°C
High P=20-180 bar
Long residence time 1-20hr
Small particles 5-75 μm

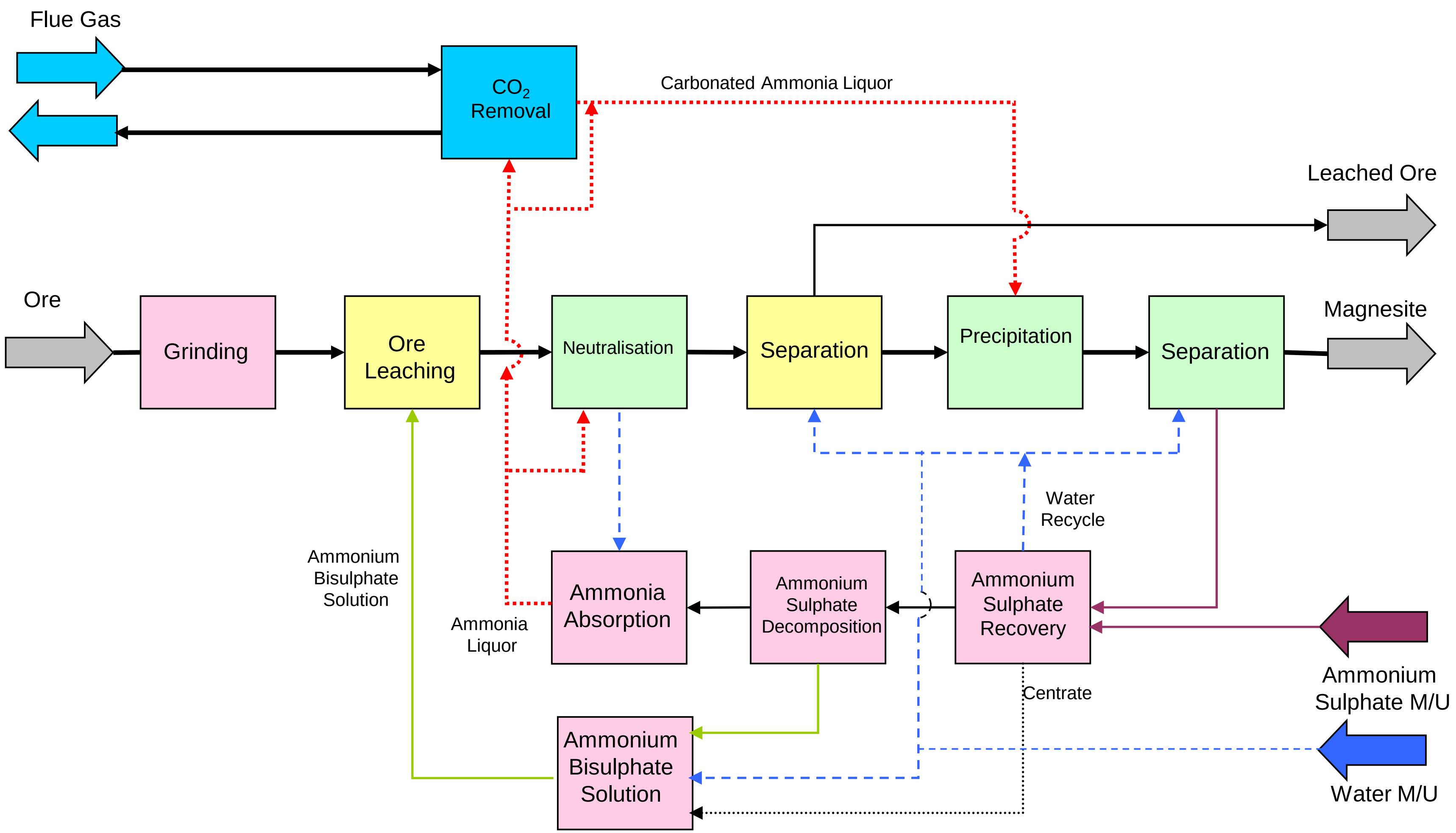
Ammonia based process

Lower T=70-400°C
Lower P=1-40 bar
Lower residence time 1-3hr
Larger particles 75-250 μm

Technology Overview – Direct Carbonation (Process A)



Technology Overview – Ammonia Process



Lab based experimentation

- Pre-treatment
  - Thermo-mechanical activation of minerals, including grinding and heat treatment in simulated flue gas.
- Dissolution
  - Mineral activation by chemical leaching using Na and NH_4 additives.
- Carbonation
  - Investigation of the carbonation of active minerals

Output of the experimental work fed into the process design examined during the TEA and LCA

Techno economic Assessment

	Direct Carbonation Process A	Indirect Aqueous Carbonation Ammonia
Capital (£M)	1125	1161
CO_2 captured	80%	80%
CO_2 parasitic load	30%	88%
CO_2 avoided	50%	(-8%)
£/te CO_2 avoided	306	n/a
Significant energy users	•Thermal pretreatment •Flue gas blower	•Ammonium sulphate concentration and decomposition •Recovery of carbonate solution

GCCS for a small remote emitter calculated at £143/te CO_2 avoided

Life Cycle Analysis

- Conducted using ISO standard methods, of the whole CCSM value chain
- Evaluated both Geological CCS life cycle and CCSM life cycle
- Geological CCS
  - 0.367 tonneCO_2 per tonne CO_2 sequestrated
- CCSM
  - 1.830 tonneCO_2 per tonne CO_2 sequestrated
    - Grinding 108 kgCO2
    - NG in CCSM process 771 kgCO_2
    - Electricity in CCSM process 779 kgCO_2

Conclusions

- In principle CCSM highly attractive proposition as it provides safe, long-term, stable storage of CO_2.
- In the UK and globally there are sufficient ultramafic rocks that could be used as a feed material
- The economics of technologies investigated were not competitive in terms of cost and/or net CO_2 sequestration compared to GCCS
- Important to carry out a full evaluation of a process, including TEA to understand the impact of ancillary processes
- GCCS is not possible in many parts of the world, and alternative strategies are required; CCSM could be part of the solution if technology improvements can be made.
- This project did not investigate the possibilities of making useful products from the CCSM process.
  - Local source materials and a valuable product would still be of interest

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