ALTERNATIVE STORAGE TECHNOLOGIES

Long-term storage of CO_2 as magnesium carbonate in Finland

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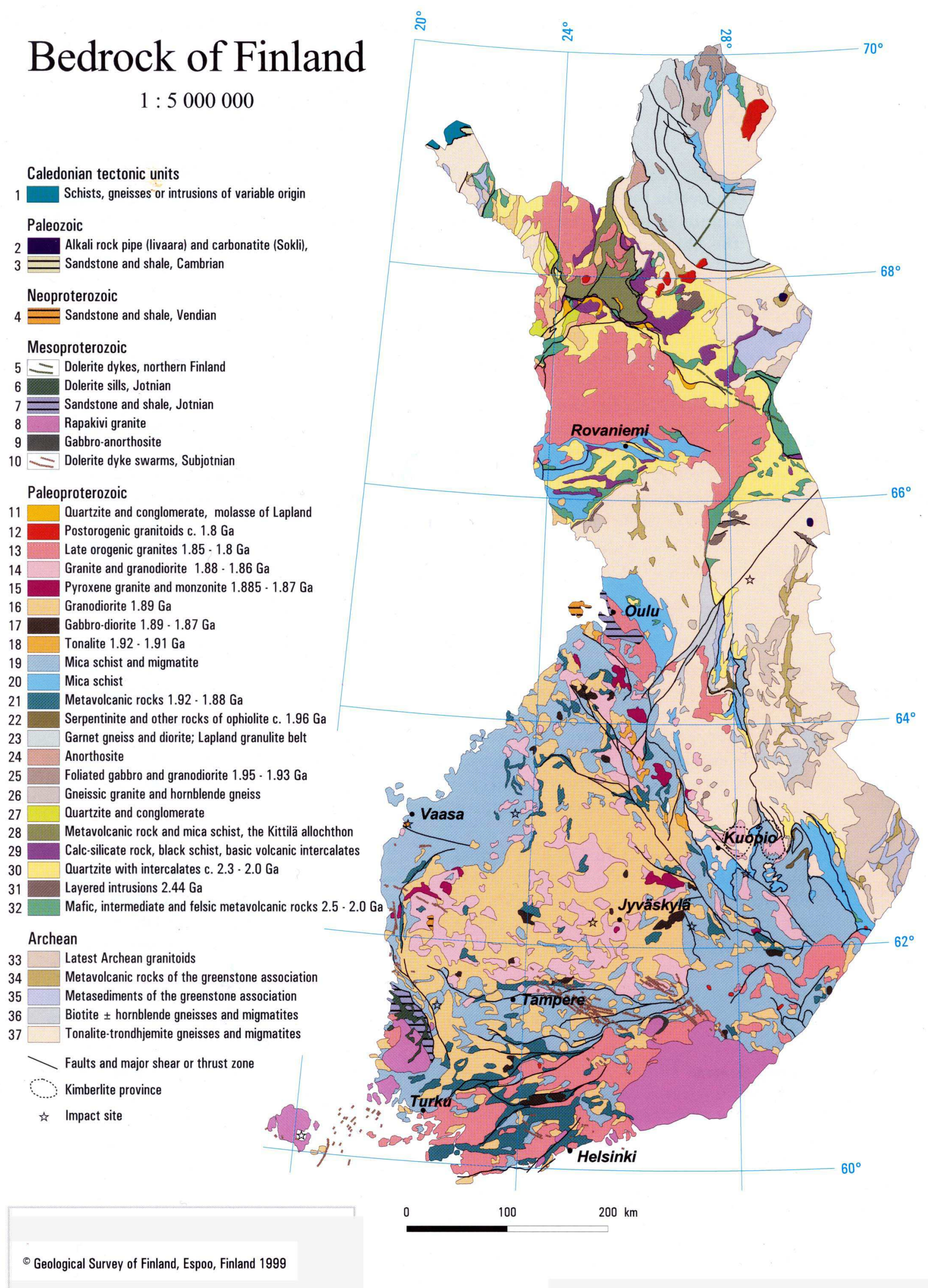
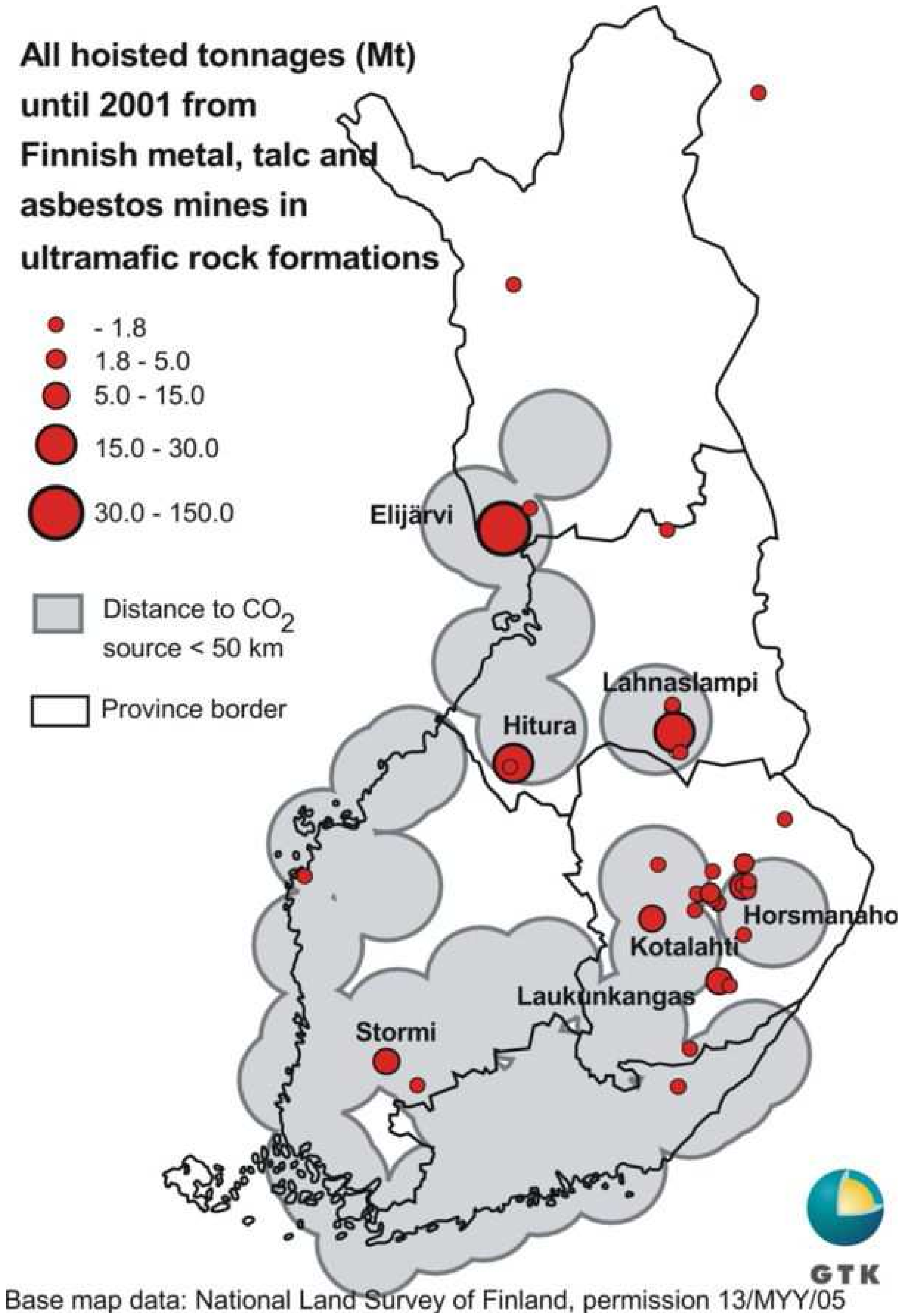
CCS from Finland’s perspective

- The Kyoto protocol binds Finland to reduce its greenhouse emissions. The production and utilization of power and heat is already efficient and no suitable geological formations are known to exist for CO_2 sequestration.

- The only currently known long-term CO_2 storage alternative for Finland is mineral carbonation. Finland has widespread deposits of the minerals needed for carbonation (Aatos et al., 2006, Teir et al., 2006). The process still requires too much energy.





All hoisted tonnages (Mt) until 2001 from Finnish metal, talc and asbestos mines in ultramafic rock formations
- 1.8
1.8 - 5.0
5.0 - 15.0
15.0 - 30.0
30.0 - 150.0
Distance to CO_2 source < 50 km
Province border
Elijärvi
Lahnaslampi
Hitura
Horsmanaho
Kotalahti
Laukunkangas
Stormi
GTK
Base map data: National Land Survey of Finland, permission 13/MYY/05

Research in Finland

- Aalto University, laboratory of energy engineering and environmental protection, since 2000
- Åbo Akademi (ÅA), heat engineering laboratory, since 2005
- Technical Research Centre of Finland (VTT)
- Geological Survey of Finland (GTK)
- And others

- Climbus project (Ex situ mineral carbonation 2004-2010)
  - ECOSERP (Screening of resources 2004-2006)
  - CCS Finland (Application of CCS in Finland 2008-2011)

Carbonation of silicate minerals

$$(Mg,Ca)_x Si_y O_{x+2y+z} H_{2z}(s) + xCO_2(g) \rightarrow x(Mg,Ca)CO_3(s) + ySiO_2(s) + zH_2O$$

- Calcium- and magnesium-based silicates react with CO_2 to form environmentally harmless carbonates.
- Analogies are known in natural weathering processes of Ca- and Mg-silicates. The most promising Mg-mineral for mineral carbonation in Finland is serpentine.
- For carbonation of 1g CO_2 2,1g serpentine is needed. There are huge serpentine resources, of several gigatonne, in Finland.
- The major hold-up for this technology is the large amounts of material involved and the carbonation reaction kinetics.

Finnish research on long-term storage of CO_2 as magnesium carbonate

- The aqueous carbonation route seems promising due to fast reaction kinetics, but the energy economy of this approach is unattractive (Fagerlund et al., 2010). Recent development involve applying CO_2 mineral sequestration to flue gases directly.

- The direct carbonation is exothermic allowing for a process with a zero or negative overall energy input but suffers from too slow chemical kinetics and poor energy economy even at high temperatures and pressures (Zevenhoven et al., 2008).

- A staged process of CO_2 mineralisation via production of $Mg(OH)_2$ followed by gas/solid carbonation is under development at the Åbo Akademi University (Zevenhoven et al., 2010).

Stepwise magnesium silicate carbonation via $MgSO_4$ & $Mg(OH)_2$ (Zevenhoven et al., 2010)

- Preheated serpentine rock is thermally treated with ammonium sulphate at 400-500 °C at atmospheric pressure. A significant amount of the magnesium (Mg) in the serpentine is converted to sulphate which is further converted to $Mg(OH)_2$.

- The $Mg(OH)_2$ produced is converted into $MgCO_3$ in a pressurised fluidised bed reactor at pressures > 20 bar and temperatures 450-600 °C.

- The process has many benefits compared to the carbonation route of superheated aqueous suspensions but requires still too much energy.

References

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