Department of Mines, Industry Regulation and Safety
GOVERNMENT OF WESTERN AUSTRALIA

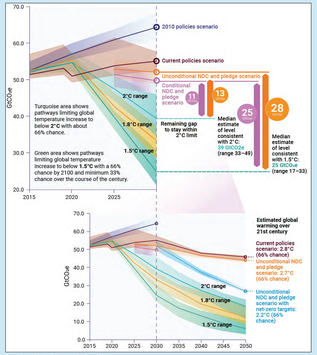
MINERAL CARBONATION

A PROSPECTIVE TECHNOLOGY FOR MITIGATING GREENHOUSE GAS EMISSIONS

Geological Survey of Western Australia

The climate challenge

There is a huge gap between greenhouse gas (GHG) emission reductions required to meet climate mitigation goals, and current global community commitments



Source: figure 4.3 - UNEP Emissions Gap Report 2021

The deficit must be acquitted using large-scale GHG capture and storage

Mineral carbonation could potentially sequester gigatonnes of CO_2

What is mineral carbonation?

Carbonate-filled fractures in the Samail Ophiolite (Credit: University of Colorado, Boulder)

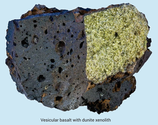
CO_2 reacts with Ca^{2+}, Mg^{2+} or Fe^{2+} in silicate rocks, soils and industrial wastes, to produce carbonate minerals (e.g. calcite, magnesite, siderite)

$$(Ca, Mg, Fe)^{2+}\text{-silicate(s)} + CO_2 + H_2O \rightarrow (Ca, Mg, Fe)\text{-carbonate(s)} + SiO_2(aq) + \text{heat}$$

CO_2 is 'permanently' sequestered

Mineral carbonation occurs naturally, but slowly
Rapid, large-scale CO_2 sequestration requires an industrial approach

Mafic and ultramafic rocks contain abundant minerals favourable for carbonation, e.g. olivine, pyroxene, talc, serpentine, amphibole (including asbestos)



Vesicular basalt with dunite xenolith

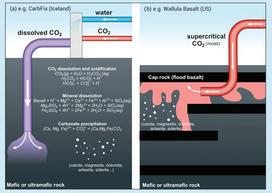
Tailings storage facility at the Mt Keith nickel mine, WA (Google Earth image)

Certain industrial wastes may also be favourable, e.g. mine tailings, ash from coal-fired power stations or waste incinerators, blast furnace slags, cement calcination residues

Industrial processing routes

In situ

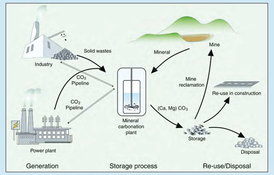
CO_2 is injected into favourable rocks at elevated temperatures and pressures



Source: modified from figure 4 in Snæbjörnsdóttir et al., 2020

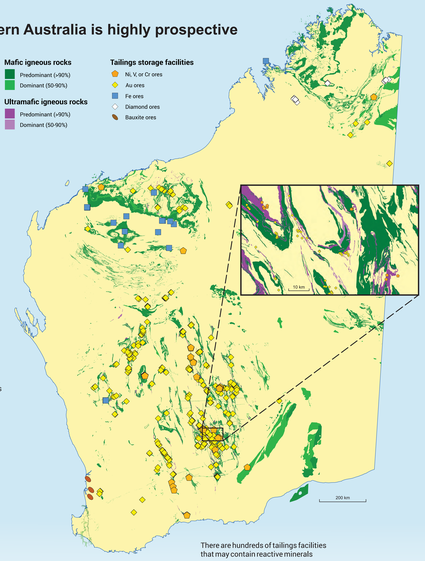
Ex situ

CO_2 and solid feedstocks are combined in artificial reactors (processing plants, industrial waste piles, deep boreholes)



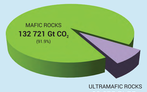
Source: figure TS.10 - IPCC Special Report on Carbon Capture and Storage

Western Australia is highly prospective



There are hundreds of tailings facilities that may contain reactive minerals

Western Australian mafic and ultramafic rocks could sequester trillions of tonnes of CO_2



The carbonation challenge

Mineral carbonation is technically feasible, but still economically challenged because of:

- Low values of CO_2 and carbonation products
- Inadequately characterized feedstock resources (e.g. abundance, chemical and physical properties)
- Mismatched resources and infrastrucure
- Lagging government policy

Responses

Curtin University is developing a Mineral Carbonation Roadmap (MRIWA Project M10462)

CSIRO's CarbonLock program is researching technical and economic aspects on mineral carbonation

CSIRO and Edith Cowan University are testing relevant physical properties of potential bedrock resources

Geological Survey of Western Australia is:

- Mapping relevant bedrock and mine waste resources
- Contributing data and advice to third-party projects

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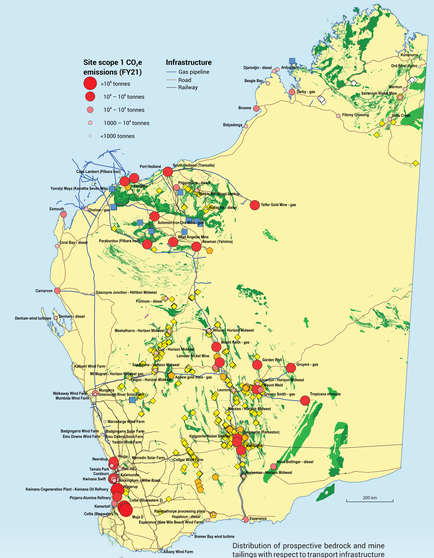

Distribution of prospective bedrock and mine tailings with respect to transport infrastructure and sites emitting significant CO_2

Eastward view along the Great Victoria Sandplains, Yeo Hill West EPZ proposed, Goldfields region

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