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CO_2 Utilisation and Mineralisation

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Mineralisation reacts un-saturated minerals with CO_2 to form new minerals - CCUS

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Mineralisation reactions take place in nature... over millions of years

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Natural stalactites and stalagmites $CaCO_3$ formed from Carbonate and bicarbonate reactions

Limestone and magnesite – some rocks are saturated with CO_2

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Limestone
$CaCO_3$

Magnesite
$MgCO_3$

Cement making converts limestone ($CaCO_3$) to calcium oxide (CaO) and CO_2 is released

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Serpentinite and olivine – ultramafic rocks can absorb CO_2 during mineralisation

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Serpentinite
$(Mg,Fe,Ni,Al,Zn,Mn)_{2-3}(Si,Al,Fe)_2O_5(OH)_4$

Olivine
$(Mg,Fe)_2SiO_4$

Ultramafic rocks, such as serpentinite exist in many locations

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Kynance Cove is famous for its serpentine rock - Cornwall, UK

Olivine is also naturally occuring in many locations

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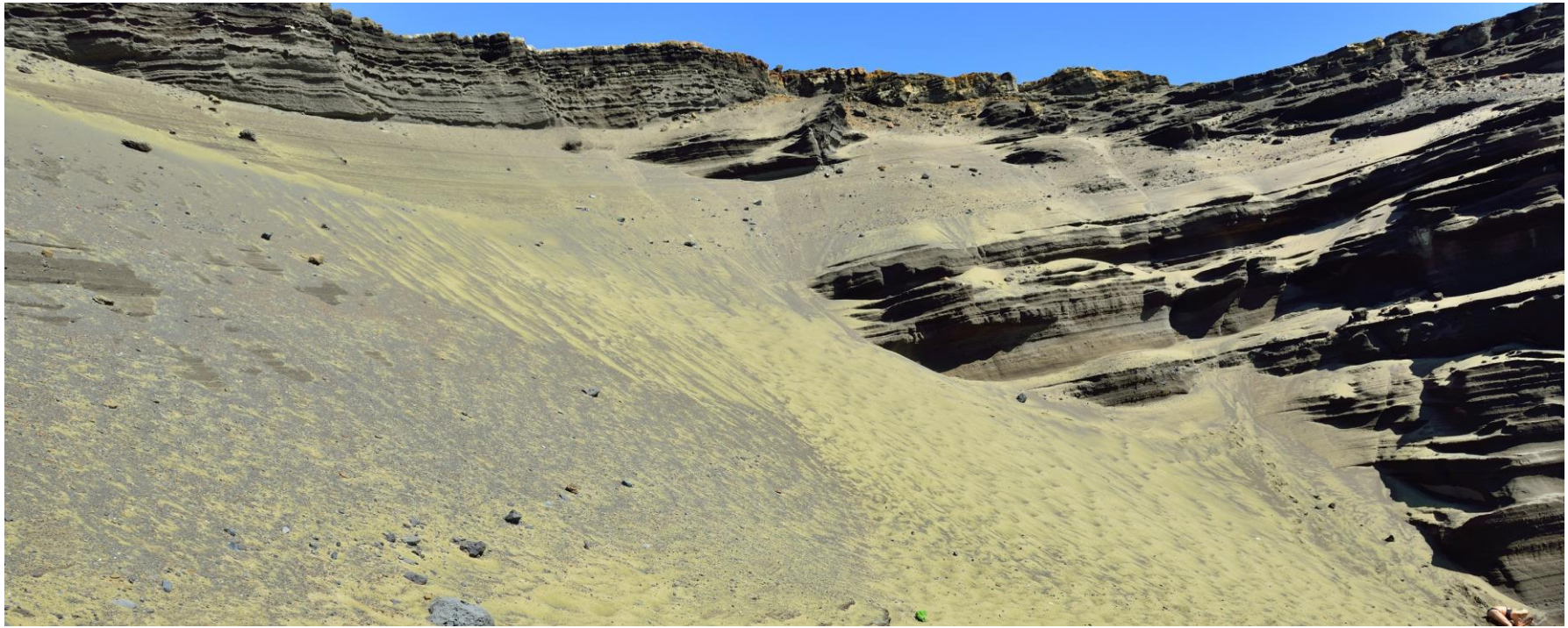

Green sand Olivine beach, Hawaii

Quarrying or mining ultramafic rocks is possible for use in mineralisation of CO_2

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Moving thousands of tonnes of rocks and minerals requires cost-effective logistics infrastructure

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Rocks must be milled to powders to react quickly with CO_2 in mineralisation reactions

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Ball mill at a copper mine - Chile

Mine tailings are a potential source of pre-ground minerals to absorb CO_2

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Mine tailings dam, Australia

Iron and steel making slag contains materials that are not saturated with CO_2

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Blast furnace slag from iron and steelmaking
CaO (30-50%), SiO_2 (28-38%), Al_2O_3 (8-24%), and MgO (1-18%)

Iron and steel making slag is ideal to absorb CO_2 in mineralisation reactions

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Blast furnaces will need to be decarbonised, CO_2 mineralisation with their own slag can help

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Waste incineration slag is also suitable to absorb CO_2 in mineralisation reactions

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Cement making uses limestone rock

Energy is needed to grind limestone – using $CaCO_3$ powder from mineralisation reduces energy need

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Vertical mill in cement plant

Valuable products can be produced through mineralisation of CO_2

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Rising sea levels caused by CO_2 emissions will call for additional sea defences

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Natural sea defences might need assistance from man-made solutions

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Rocks are not always available and natural sea defences may not be sufficient, cement and concrete can help

How much cement and concrete will we need in the future?

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CCUS – mineralisation to absorb CO_2 to generate materials that can be utilised

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- Mineralisation is an example of CCUS – carbon capture, utilisation and storage
- CO_2 emissions are permanently sequestered as stable minerals, mimicking a natural process that has generated rocks over millions of years
- Mineralisation reacts CO_2 emissions with mineral type materials that are not saturated with CO_2
- Ultramafic rocks, steel slag and incinerator slag are all potential materials to absorb CO_2
- CCUS mineralisation reactions can be accelerated with elevated temperature, elevated pressure, catalysts and size reduction of the solid feedstock
- The powders generated through mineralisation can be utilised commercially as chemical products
- The powders generated through mineralisation can be utilised as industrial feedstocks to conserve natural raw materials and reduce the energy intensity of mineral processing, eg cement and refractory materials
- Moving tonnes of minerals to and from the CO_2 capture site requires major logistical infrastructure – shipping, barges, trains
- The ideal economic case for mineralisation is a location where three things exist in proximity: the CO2 emission source; the un-saturated material and potential to utilise the mineralisation product
- If utilisation of the mineralisation products is not practical, the minerals can be safety disposed of

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Introduction to Stephen B. Harrison and sbh4 consulting

Stephen B. Harrison is the founder and managing director at sbh4 GmbH in Germany. His work focuses on decarbonisation and greenhouse gas emissions control. Hydrogen and CCUS are fundamental pillars of his consulting practice. He has served as the international hydrogen & CCS expert and team leader for multiple ADB projects related to renewable hydrogen deployment and CCS in several Asian nations.

With a background in industrial and specialty gases, including 27 years at BOC Gases, The BOC Group and Linde Gas, Stephen has intimate knowledge of hydrogen and carbon dioxide from commercial, technical, operational and safety perspectives. For 14 years, he was a global business leader in these FTSE100 and DAX30 companies.

Stephen has extensive buy-side and sell-side M&A due diligence and investment advisory experience in the energy and clean-tech sectors. Private Equity firms and investment fund managers and green-tech startups are regular clients.

As a member of the H2 View and **gas**world editorial advisory boards, Stephen advises the direction for these international publications. Working with Environmental Technology Publications, he is a member of the scientific committees for CEM 2023 - the leading international conference for Continuous Emissions Monitoring.