SPE International London Section

Tuesday 13th June 2023

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SPE Gaia SUSTAINABILITY PROGRAM

Using geochemistry to verify CO_2 storage

Chris Holdsworth

THE UNIVERSITY of EDINBURGH

Carbfix

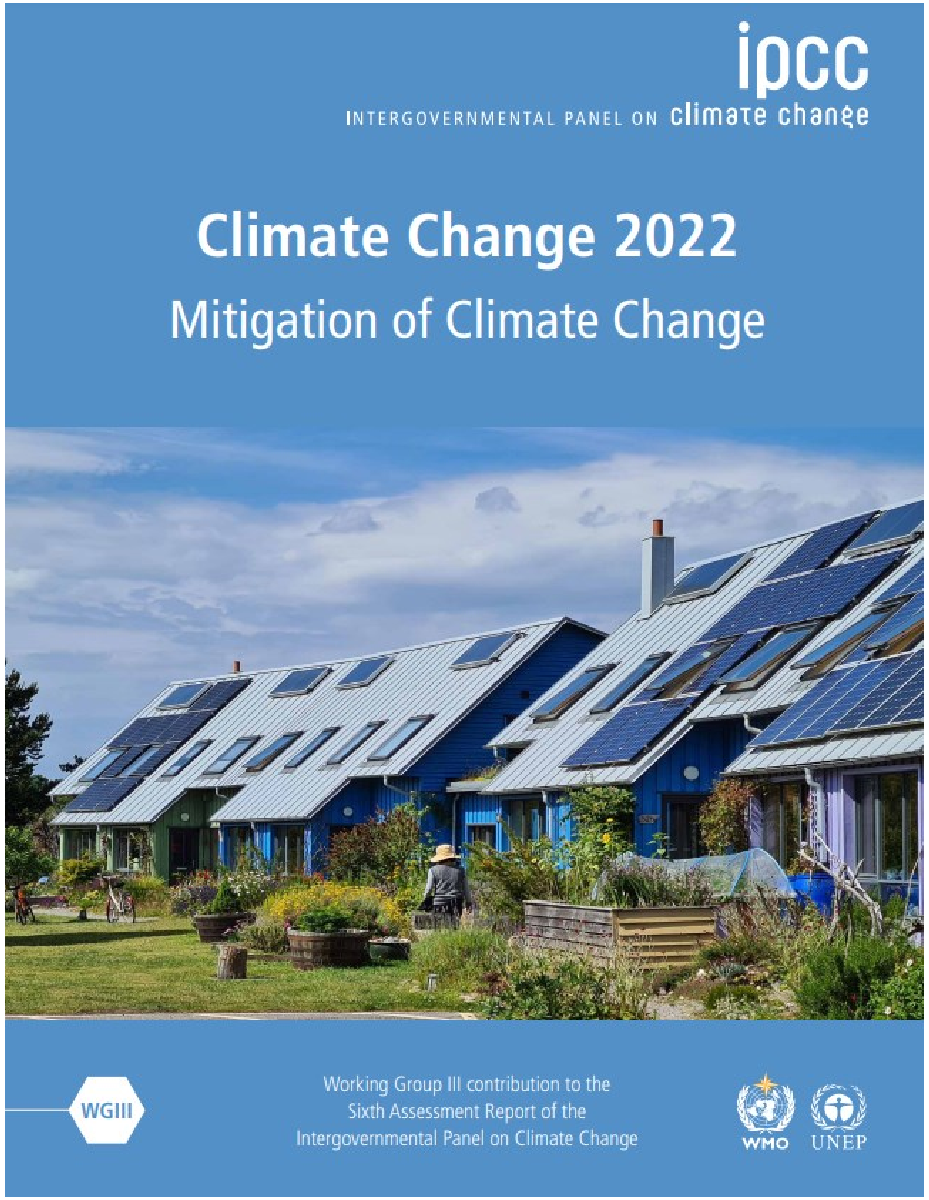
E4 DTP Edinburgh Earth, Ecology and Environment Doctoral Training Partnership

UKRI Natural Environment Research Council

Why? – Net Zero

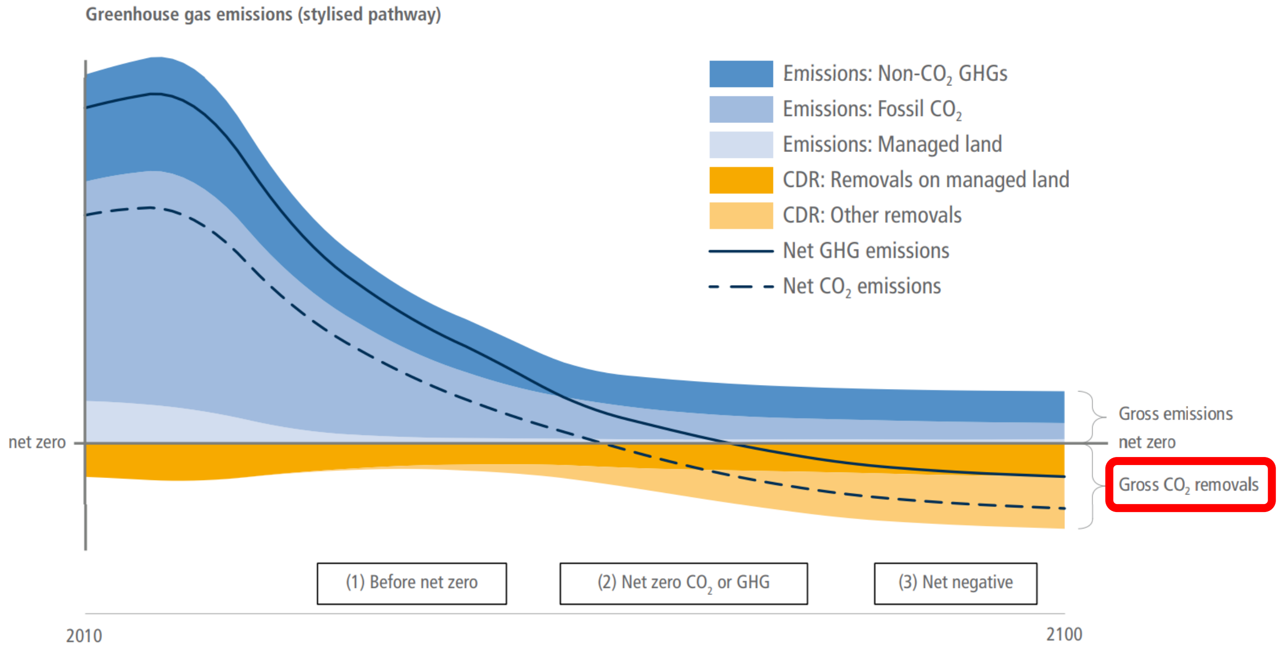
"CCS is a **necessity, not an option** for reaching net-zero GHG emissions"

"The deployment of CDR to counterbalance hard-to-abate residual emissions is **unavoidable** if net zero CO_2 and GHG emissions are to be achieved"



Ensuring Net Zero

From Chapter 12 of IPCC AR6 WGIII full report, cross chapter box 8, Figure 2



Monitoring, Reporting and Verification (MRV)

1. Carbon accounting – prove the ‘net’ in Net Zero
2. Evidence base for CCS and CDR business models

CLIMATE • POLICY

The Inflation Reduction Act Includes a Bonanza for the Carbon Capture Industry

World’s biggest ‘direct air capture’ plant starts pulling in CO2

Developer of Orca project in Iceland plans much larger facility in next few years

Jan Wurzbacher, co-chief of Climeworks, left, with his counterpart Christoph Gebald. Wurzbacher said commercial demand had been so high that the Orca plant was nearly sold out of credits for its entire 12-year lifespan

Geological CO_2 storage

Trapping:

Monitoring:

Example:

Aminu et al. (2017)

(a) Structural/stratigraphic trapping **(b) Residual trapping**

Carbfix – in-situ CO_2 mineralisation

Basalt

Ca, Mg and Fe

$Ca^{2+}/Mg^{2+}/Fe^{2+}{}_{(aq)}$

+

Sparkling water

Dissolved CO_2

$CO_3^{2-}{}_{(aq)}$

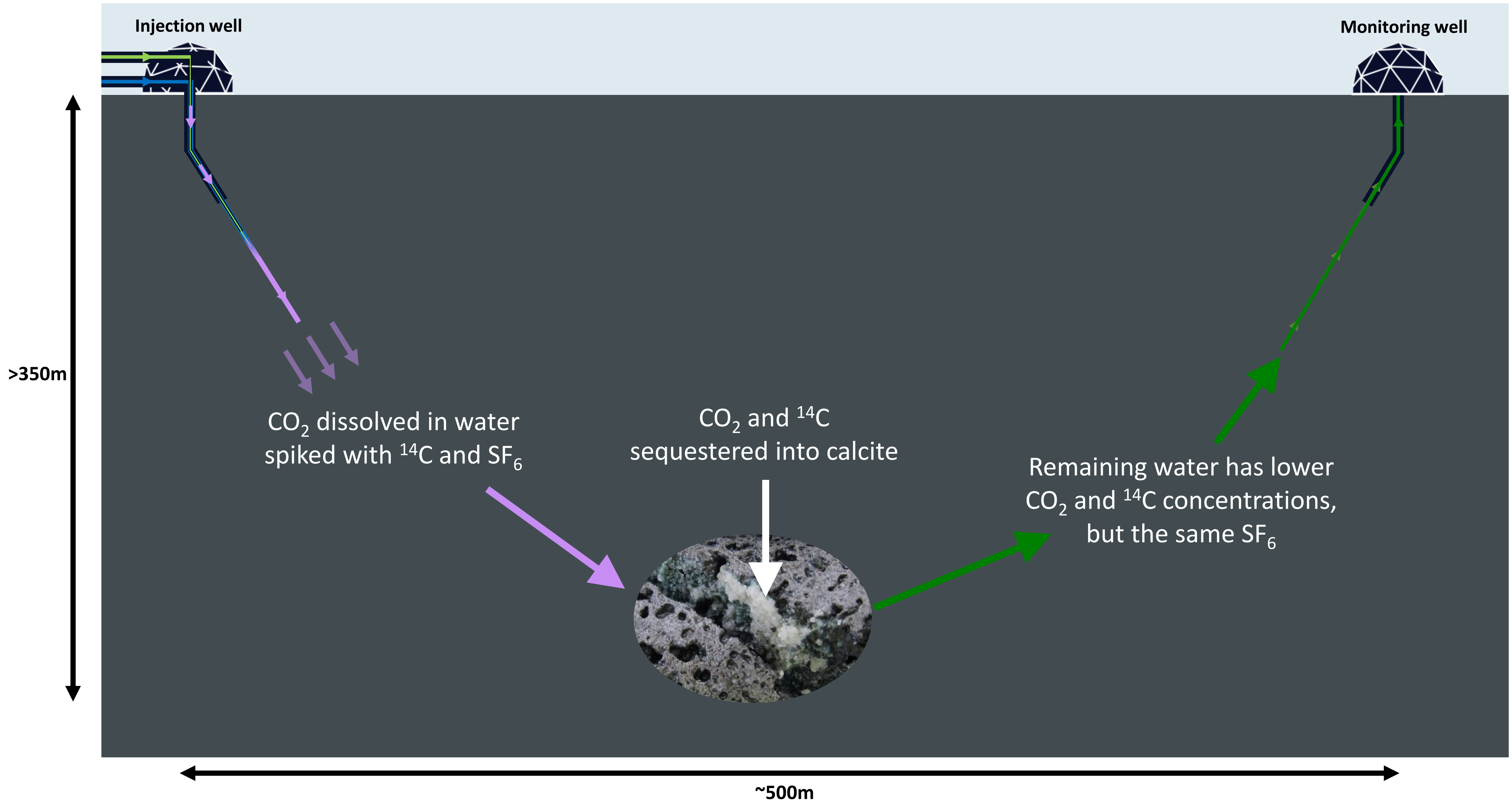
=

Mineralised CO_2

$CaCO_3$

$CaCO_3/MgCO_3/FeCO_3{}_{(s)}$

Carbfix verification



Carbfix verification

Science

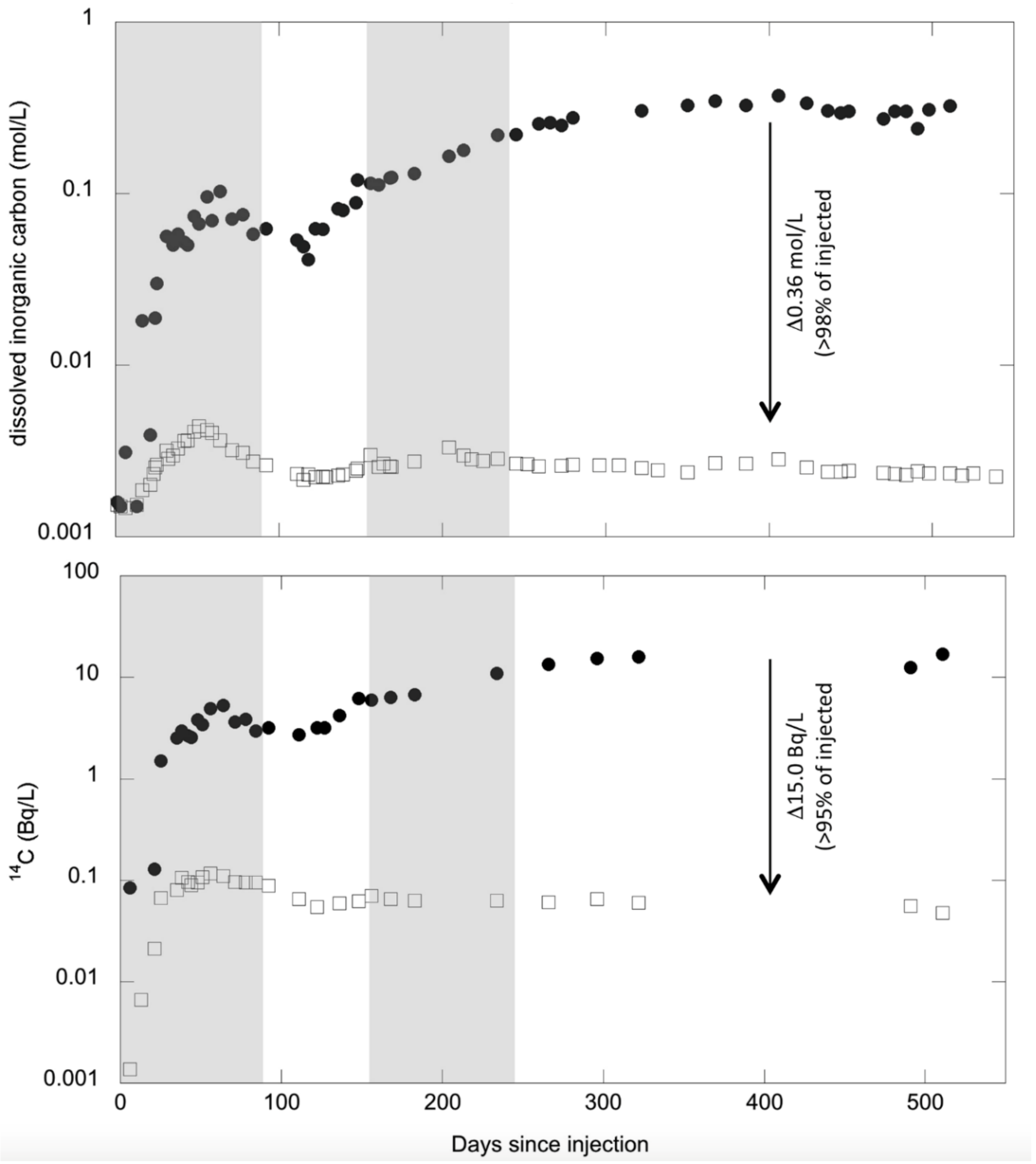
Rapid carbon mineralization for permanent disposal of anthropogenic carbon dioxide emissions

Juerg M. Matter, Martin Stute, Sandra Ó. Snæbjörnsdottir, Eric H. Oelkers, Sigurdur R. Gislason, Edda S. Aradottir, Bergur Sigfusson, Ingvi Gunnarsson, Holmfridur Sigurdardottir, Einar Gunnlaugsson, Gudni Axelsson, Helgi A. Alfredsson, Domenik Wolff-Boenisch, Kiflom Mesfin, Diana Fernandez de la Reguera Taya, Jennifer Hall, Knud Dideriksen and Wallace S. Broecker

Science **352** (6291), 1312-1314.
DOI: 10.1126/science.aad8132

Inject, baby, inject!
Atmospheric CO_2 can be sequestered by injecting it into basaltic rocks, providing a potentially valuable way to undo some of the damage done by fossil fuel burning. Matter *et al.* injected CO_2 into wells in Iceland that pass through basaltic lavas and hyaloclastites at depths between 400 and 800 m. Most of the injected CO_2 was mineralized in less than 2 years. Carbonate minerals are stable, so this approach should avoid the risk of carbon leakage.
Science, this issue p. 1312

>95% CO_2 mineralised within 2 years



Carbfix M.R.V. methodology

Carbfix

PERMANENT AND SECURE GEOLOGICAL STORAGE OF CO_2 BY IN-SITU CARBON MINERALIZATION

Processes and requirements for greenhouse gas emissions accounting for CO_2 capture, transport, and geological storage by rapid in-situ carbon mineralization.

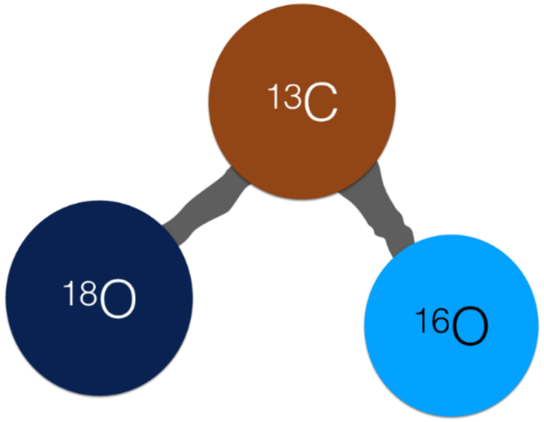
Abstract

This methodology outlines processes, requirements, and emission quantification for permanent and secure CO_2 capture, transport, and geological storage by rapid in-situ carbon mineralization. In-situ carbon mineralization replicates and accelerates natural processes, in which carbon dioxide is dissolved in water and interacts with reactive rock formations to form stable minerals providing a permanent and safe carbon sink.

https://www.carbfix.com/dacs-certification-methodology

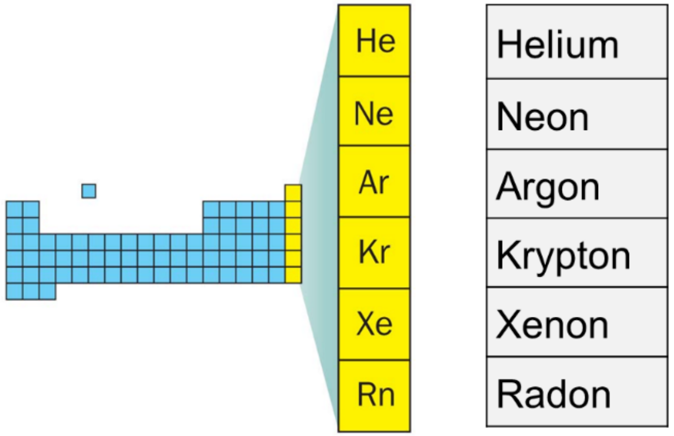
Tracking CO_2 injection, migration and fate at Carbfix using isotopes of CO_2, water and noble gases

Carbon isotopes



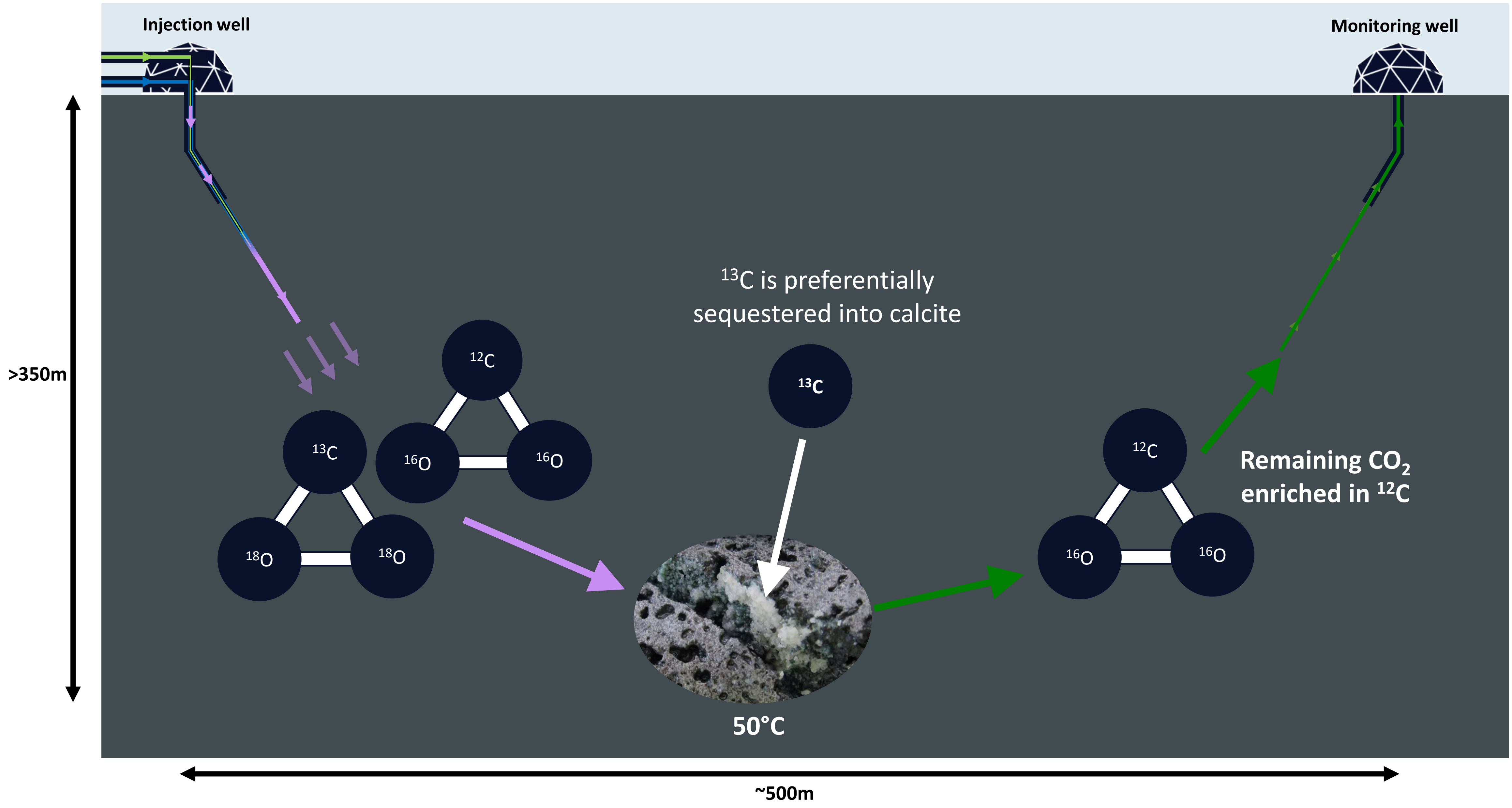
Reactive tracer

Noble gases

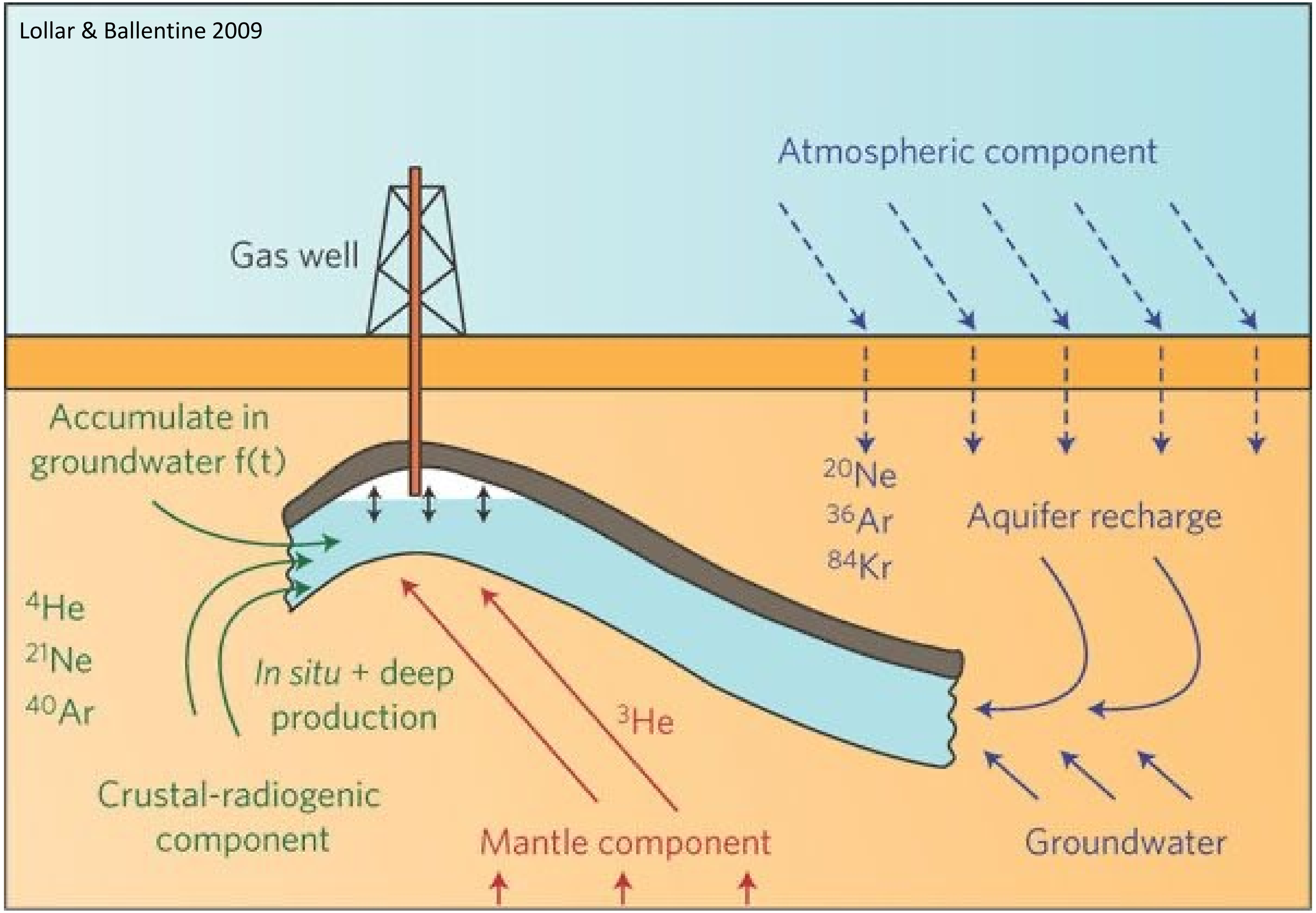


Unreactive tracer

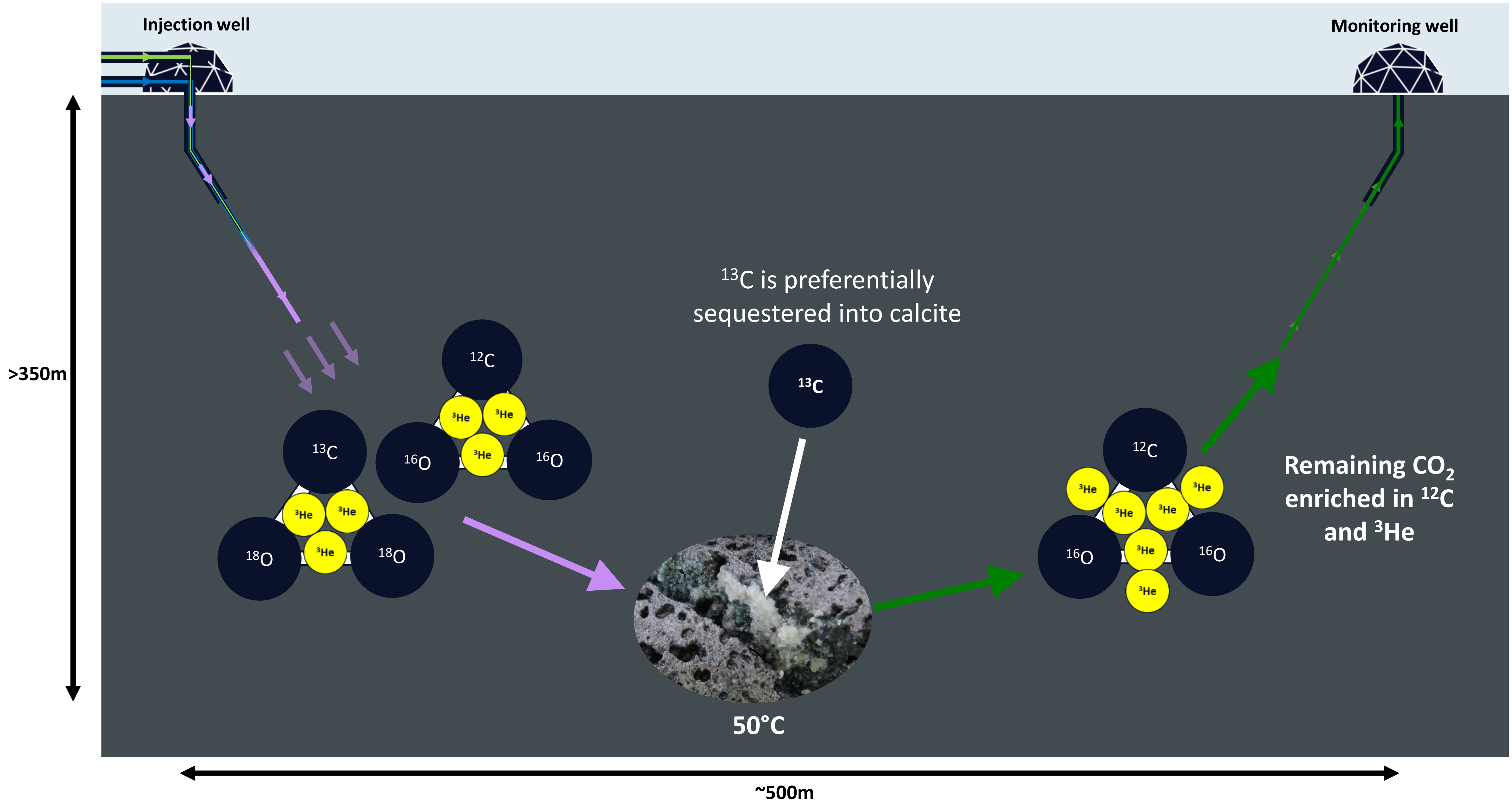
Carbon isotope verification



Noble gas tracers

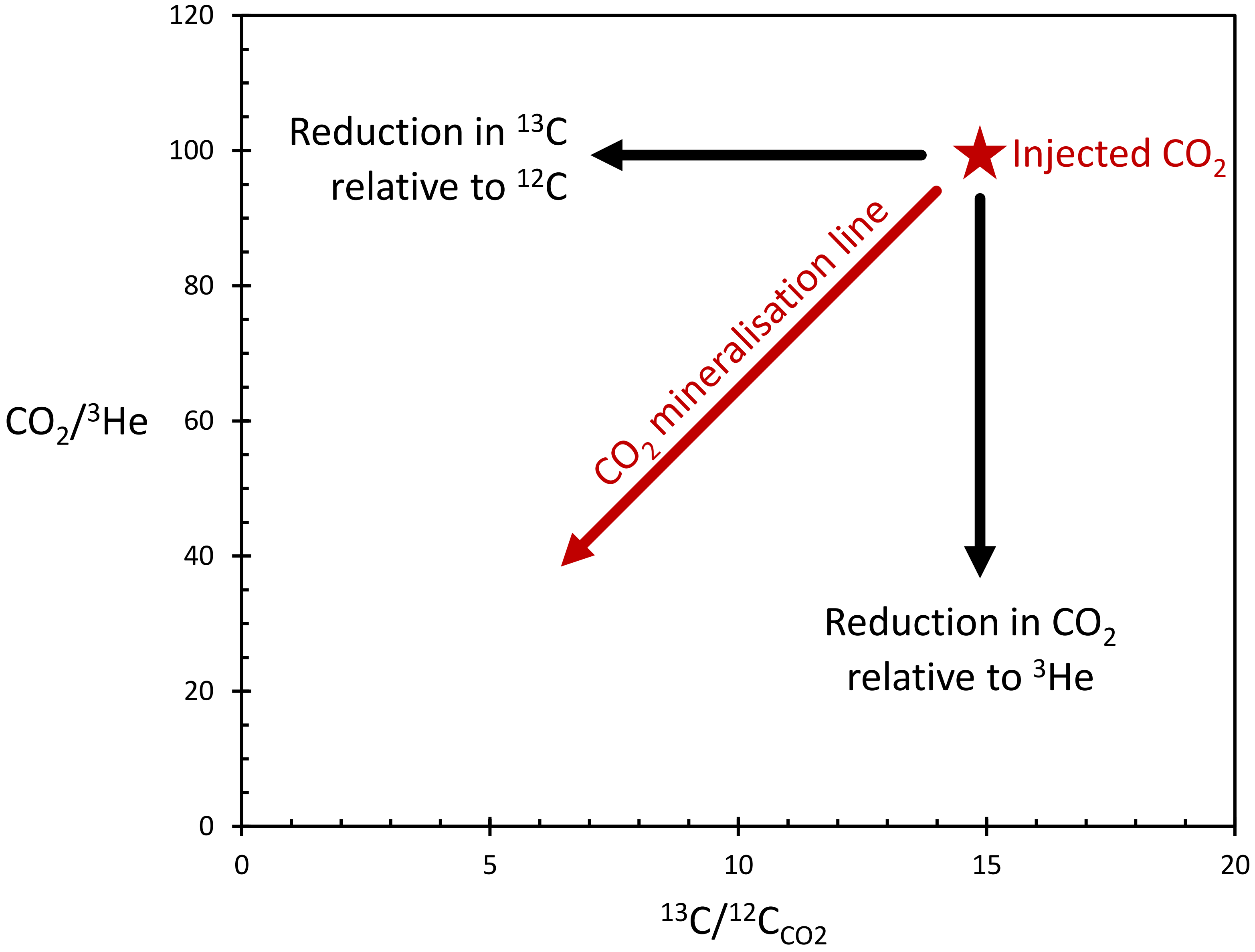


Carbon isotopes & noble gases



Example data

(numbers are hypothetical)

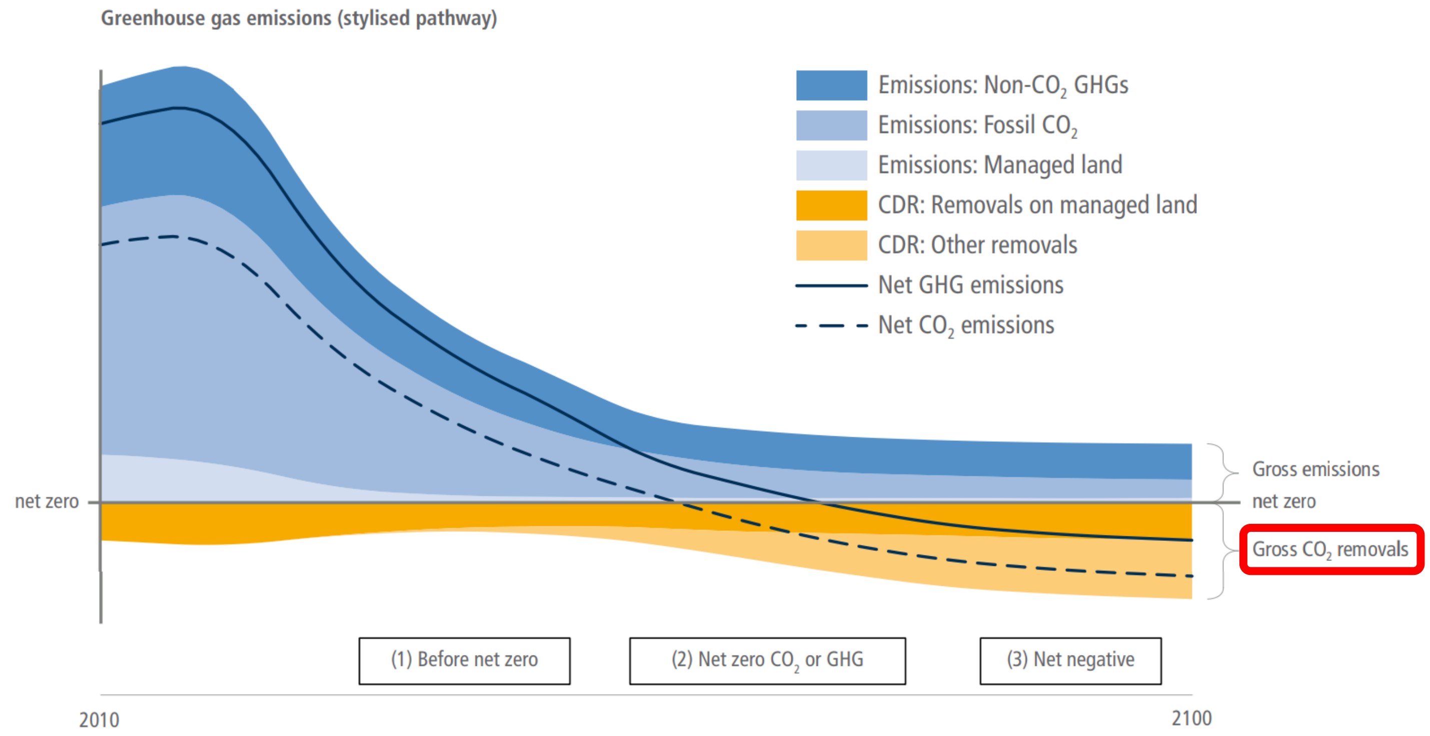


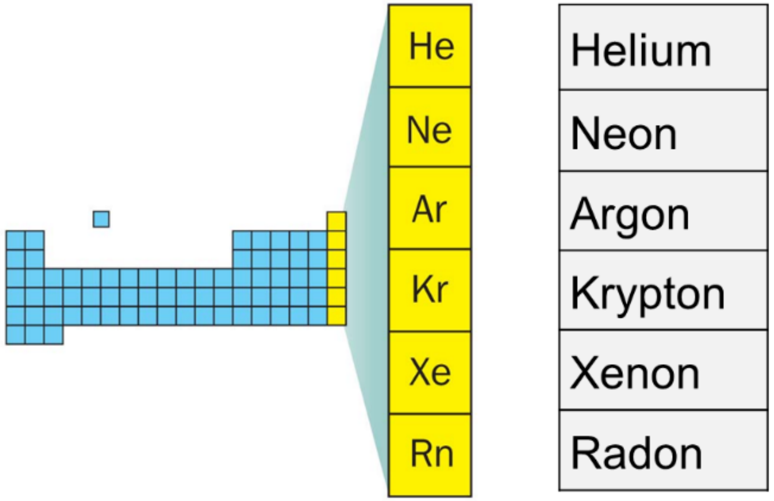
Sampling

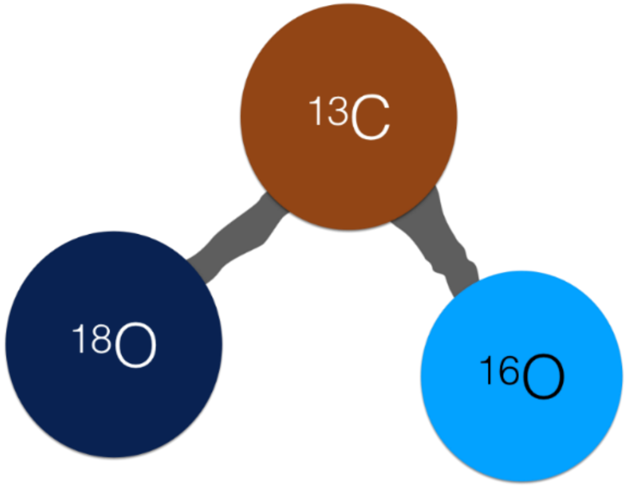

Produced fluid and steam
Dry gas (CO_2 and noble gases)
Condensed steam
Steam

Take home message

From Chapter 12 of IPCC AR6 WGIII full report, cross chapter box 8, Figure 2







We need **reliable** and **deployable** M.R.V. techniques for all forms of CO_2 storage.

Natural isotope tracers can be a **key method** for M.R.V. particularly when CO_2 is **chemically sequestered**.

Literature examples

nature Vol 458|2 April 2009|doi:10.1038/nature07852

LETTERS

Solubility trapping in formation water as dominant CO_2 sink in natural gas fields

Stuart M. V. Gilfillan[1,2], Barbara Sherwood Lollar[3], Greg Holland[1], Dave Blagburn[1], Scott Stevens[4], Martin Schoell[5], Martin Cassidy[6], Zhenju Ding[1,7], Zheng Zhou[1], Georges Lacrampe-Couloume[3] & Chris J. Ballentine[1]

Research article

PG *Petroleum Geoscience*

https://doi.org/10.1144/petgeo2020-120 | Vol. 27 | 2021 | petgeo2020-120

Quantification of solubility trapping in natural and engineered CO_2 reservoirs

Check for updates

Rory Leslie[1]*, Andrew J. Cavanagh[1], R. Stuart Haszeldine[1,2], Gareth Johnson[3] and Stuart M. V. Gilfillan[1]

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Applied Geochemistry 78 (2017) 116–128

Contents lists available at ScienceDirect

Applied Geochemistry

journal homepage: www.elsevier.com/locate/apgeochem

ELSEVIER

Tracking the interaction between injected CO_2 and reservoir fluids using noble gas isotopes in an analogue of large-scale carbon capture and storage

CrossMark

Domokos Györe [a,*], Stuart M.V. Gilfillan [b], Finlay M. Stuart [a]

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[b] *School of GeoSciences, University of Edinburgh, Edinburgh EH9 3JW, UK*

International Journal of Greenhouse Gas Control 63 (2017) 215–225

Contents lists available at ScienceDirect

International Journal of Greenhouse Gas Control

journal homepage: www.elsevier.com/locate/ijggc

ELSEVIER

Using noble gas fingerprints at the Kerr Farm to assess CO_2 leakage allegations linked to the Weyburn-Midale CO_2 monitoring and storage project

CrossMark

Stuart M.V. Gilfillan[a,*], George William Sherk[b], Robert J. Poreda[c], R. Stuart Haszeldine[a]

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