



**British  
Geological Survey**

NATURAL ENVIRONMENT RESEARCH COUNCIL

Applied geoscience for our  
changing Earth

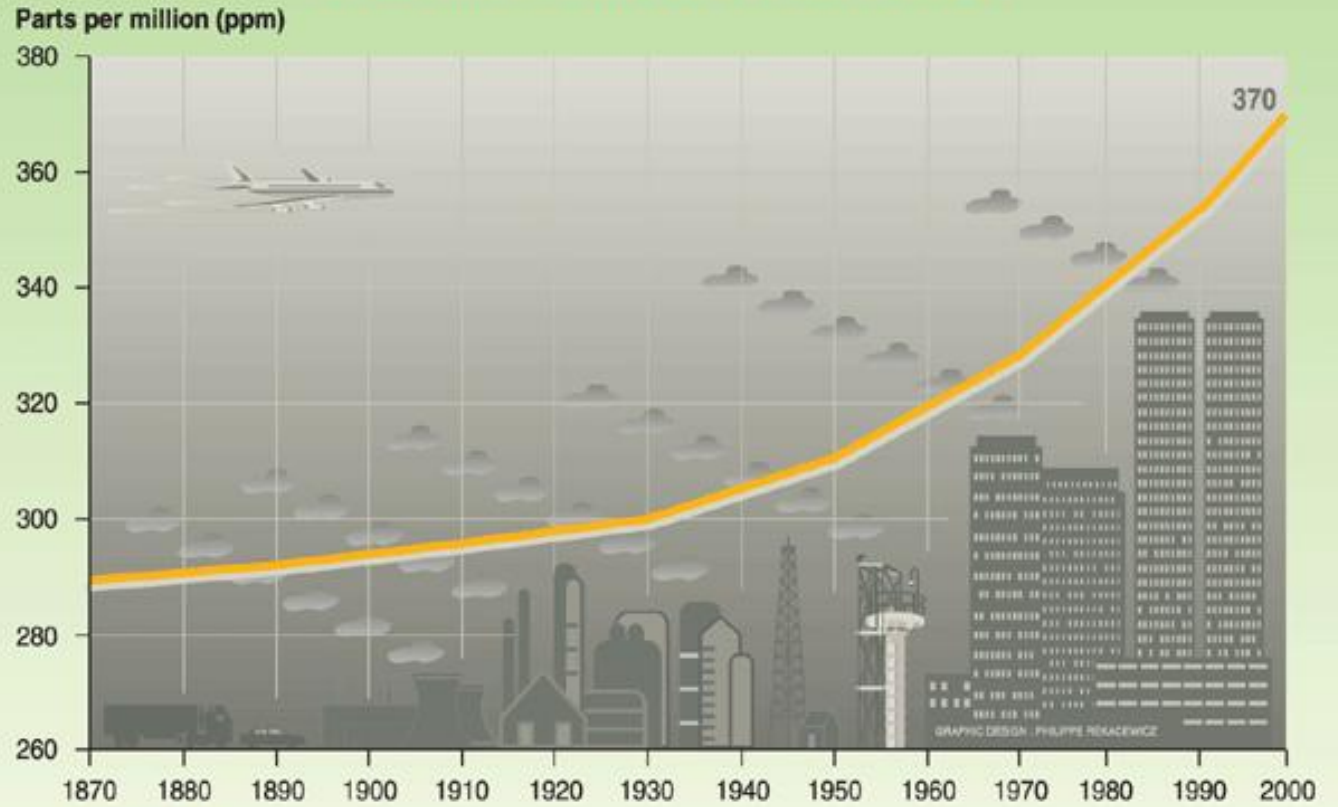
# Barzaman Formation in the UAE: a natural analogue for permanent CO<sub>2</sub> fixation using ultramafic rocks.

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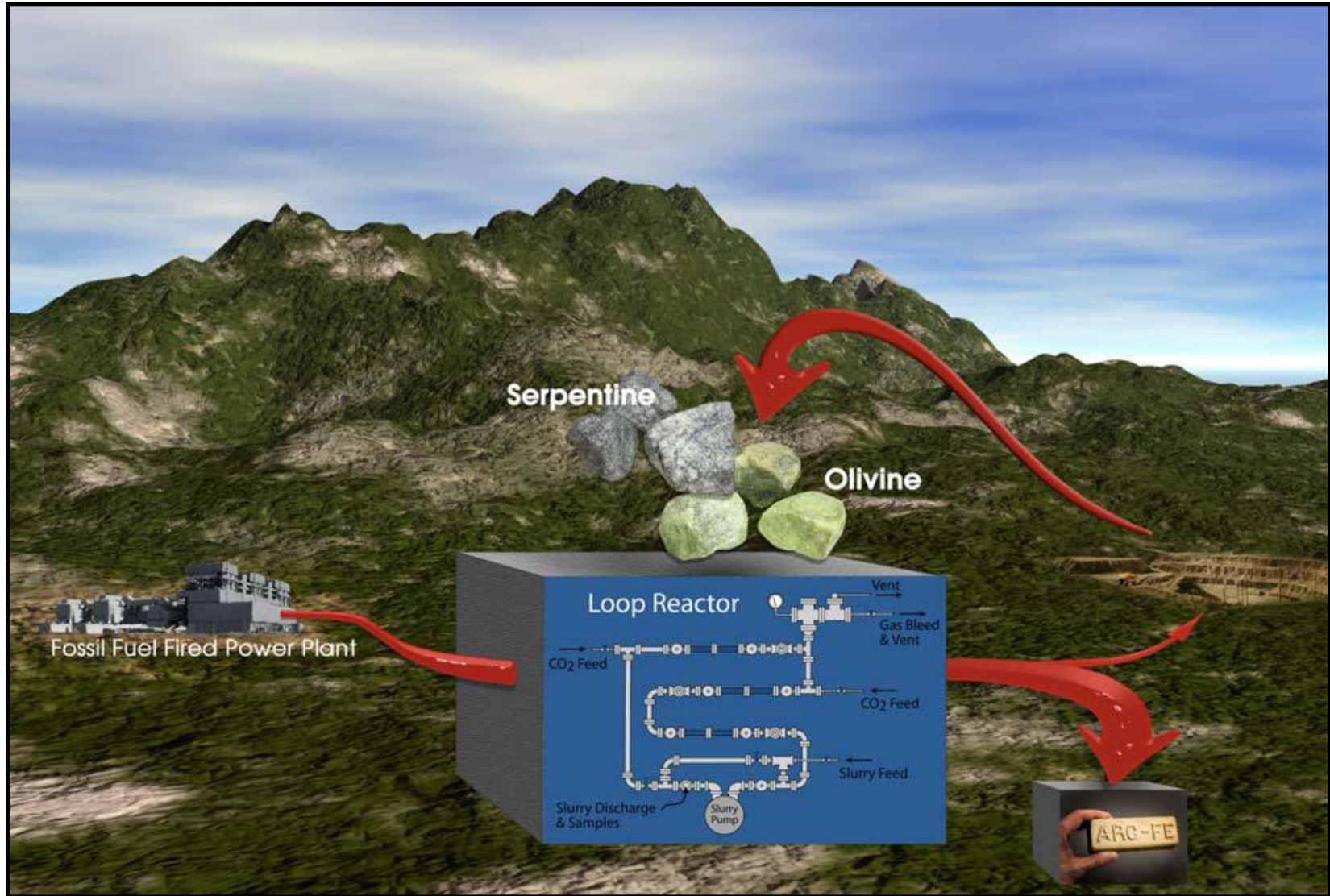
# Global atmospheric concentration of CO<sub>2</sub>



# Carbon Capture and Storage (CCS)

- Capture of CO<sub>2</sub> and storage as supercritical CO<sub>2</sub> in deep saline aquifers and/or depleted gas or oil reservoirs [e.g. Permo-Triassic rocks of UK North Sea]
- Capture of CO<sub>2</sub> reaction by mineral carbonation and disposal in landfill, or re-use reacted materials
- Capture of CO<sub>2</sub> by injection into reactive rocks and mineral carbonation in situ [e.g. Injection into ultrabasic rocks - ophiolites]

# The aim of industrial processing mineral sequestration

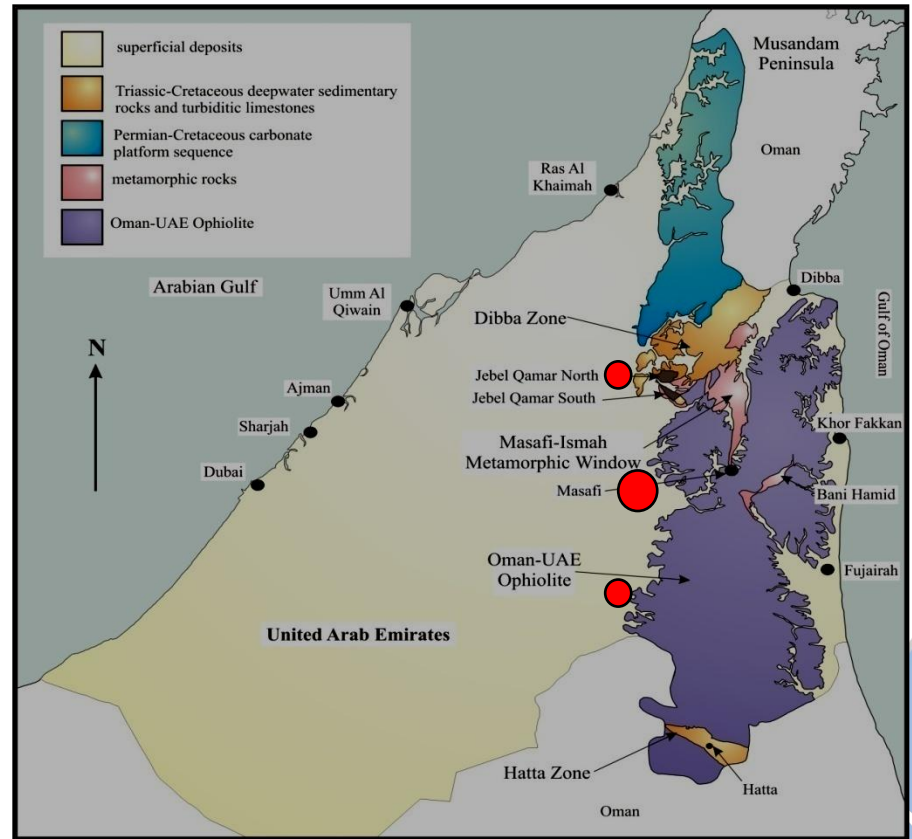


THE AQUEOUS MINERAL CARBONATION PROCESS DEVELOPED BY THE ALBANY RESEARCH CENTER (ARC)

# Can MINERAL CARBONATION be part of the solution?

## Ultramafic rocks in the UAE

and their relevance to the mineral carbonation of Mg-rich silicates.





Peridotite (dunite, harzburgite,  
serpentinite)



Most peridotites contain:

39-44 wt% SiO<sub>2</sub>

**42-50 wt% MgO**

7-9 wt% FeO (total Fe)

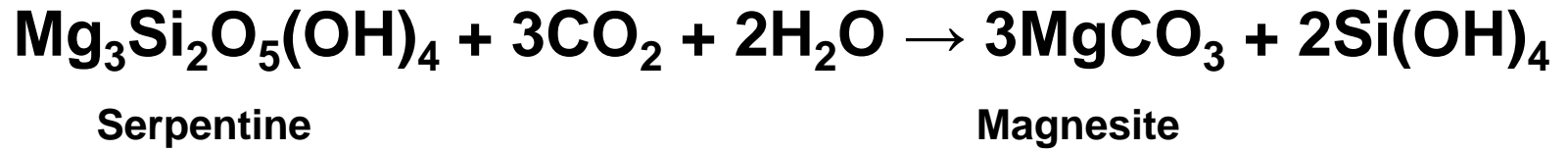
CaO, Al<sub>2</sub>O<sub>3</sub> ≤ 1.5wt%

traces of Cr, Ni, Mn

(Goff, Lackner, 1998)



Magnesite, dolomite



**heat/mol CO<sub>2</sub> = -63.6 kJ**  
**EXOTHERMIC**

Industrial mineral carbonation requires significant pre-treatment of peridotite/serpentinite to speed up the reactions:

- Size reduction by grinding and milling
- Heat activation
- pH swing

In our study we present a **natural analogue** for CO<sub>2</sub> sequestration by mineral carbonation.



## Barzaman Formation

Strongly **dolomite**-cemented conglomerate with ophiolite-derived clasts dominated by:

- serpentinite,
- silicified serpentinite,
- harzburgite,
- gabbro
- minor quartzite, chert and limestone.

# Hajar Mountains

N ←

Hzb

Gb

Hills of Barzaman Formation

Proximal fans

Distal fans

Arabian Gulf

10km

Dubai

Barzaman Formation hills

Barzaman Formation hills:

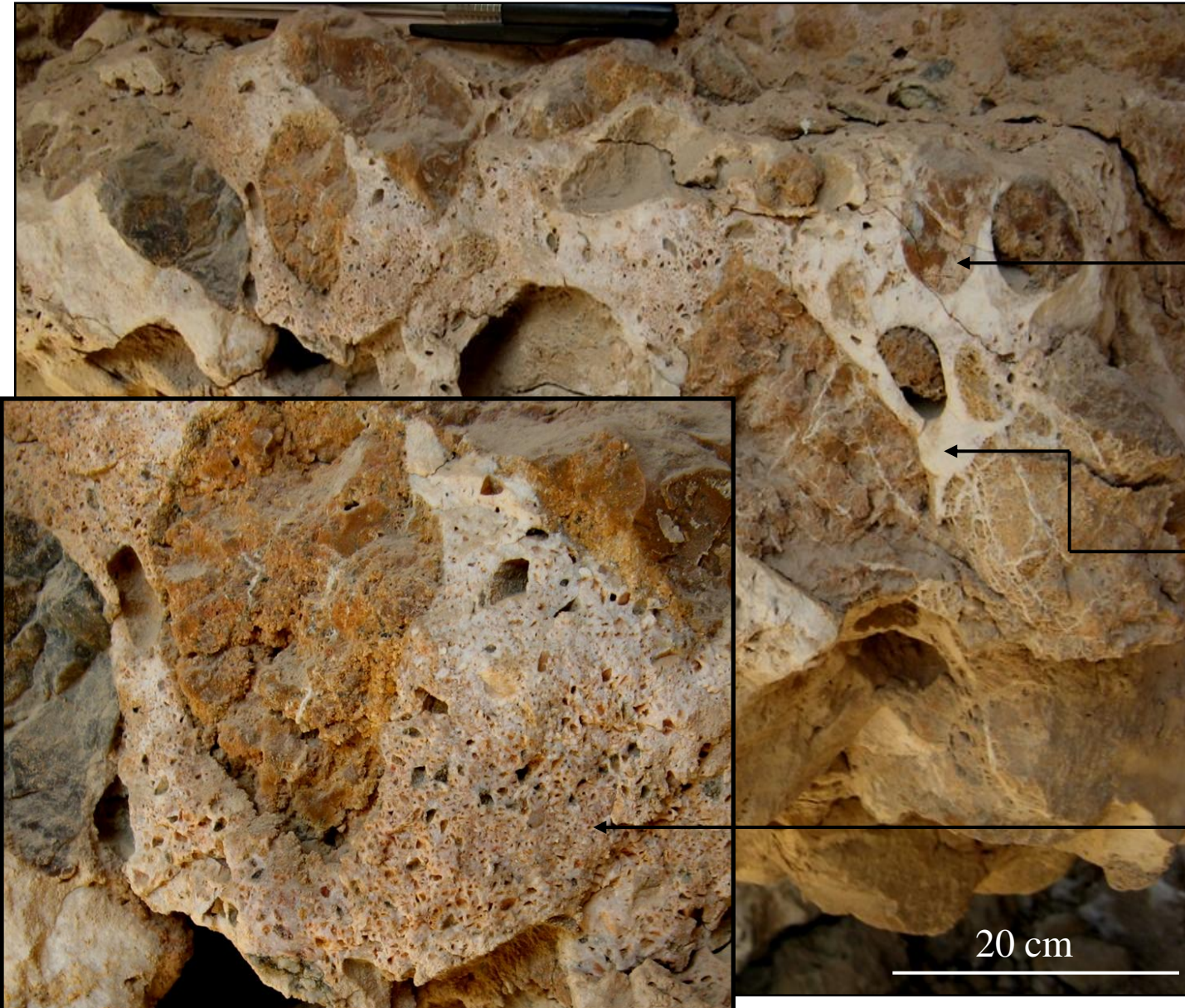
≤ 10 m thick

outcrop area ~ 154 km<sup>2</sup>

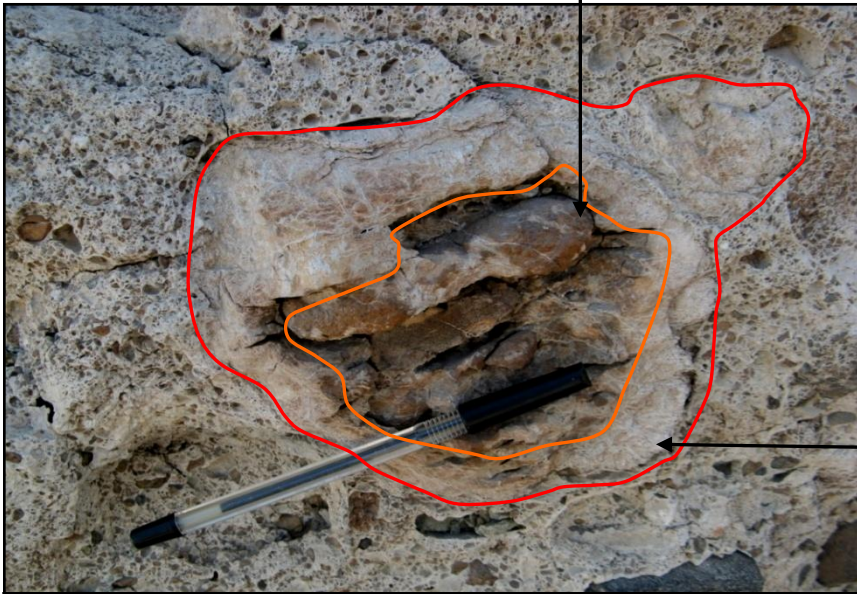


## Dolomite replacement patterns:

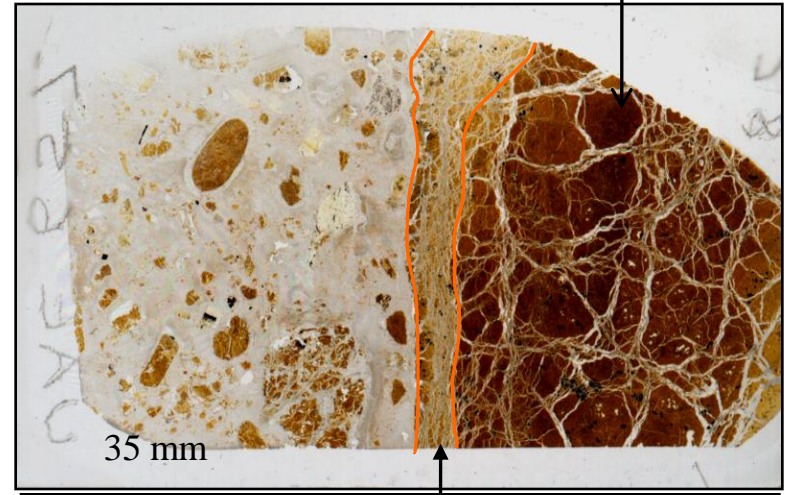
- Incomplete, concentric replacement of peridotite clasts
- Complete replacement of conglomerate matrix
- Partial replacement of matrix



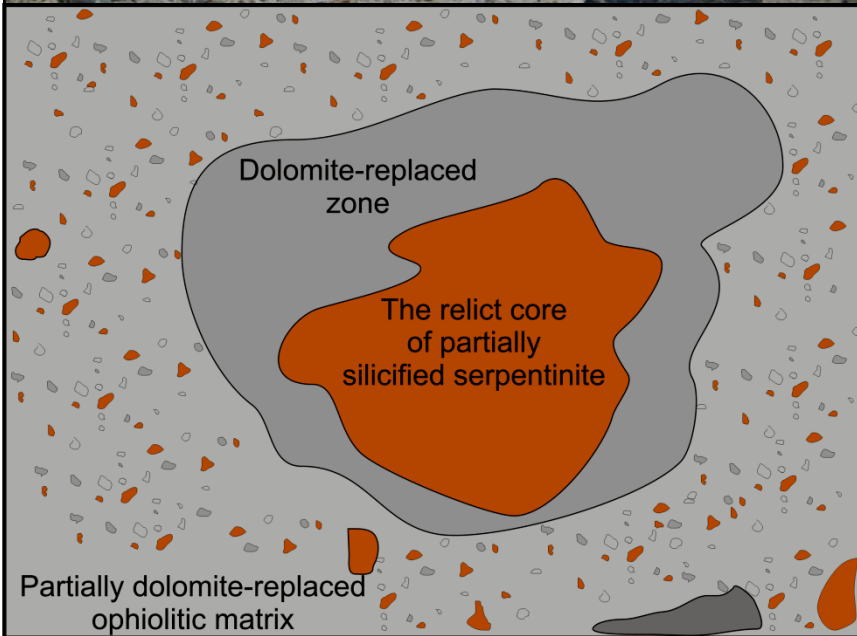
# Irregular, concentric dolomite replacement of peridotite clast



Serpentinite  
partially silicified

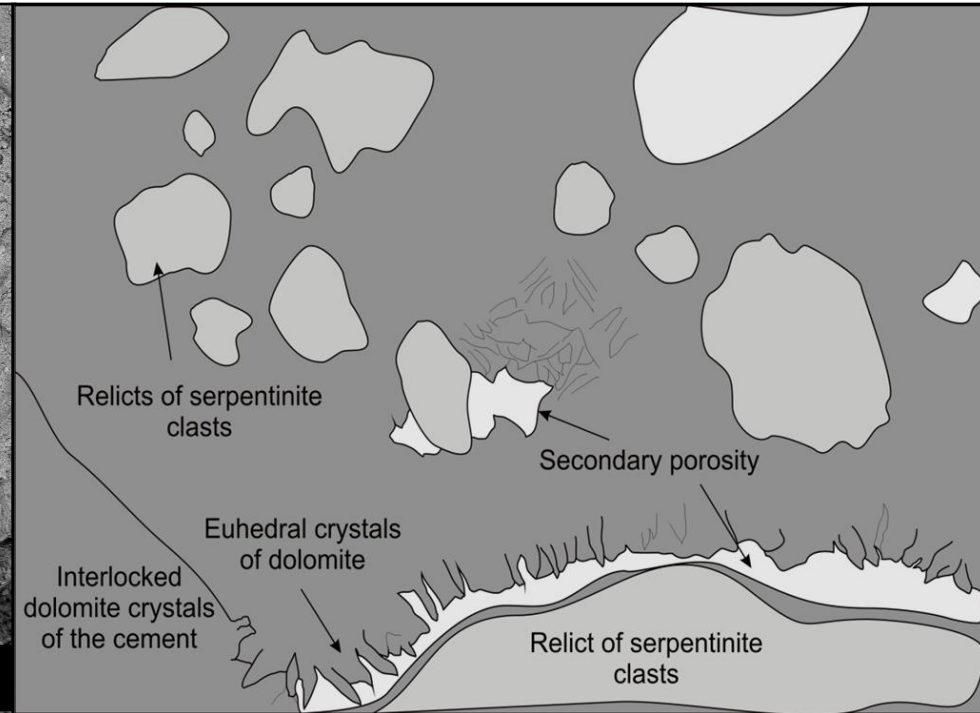
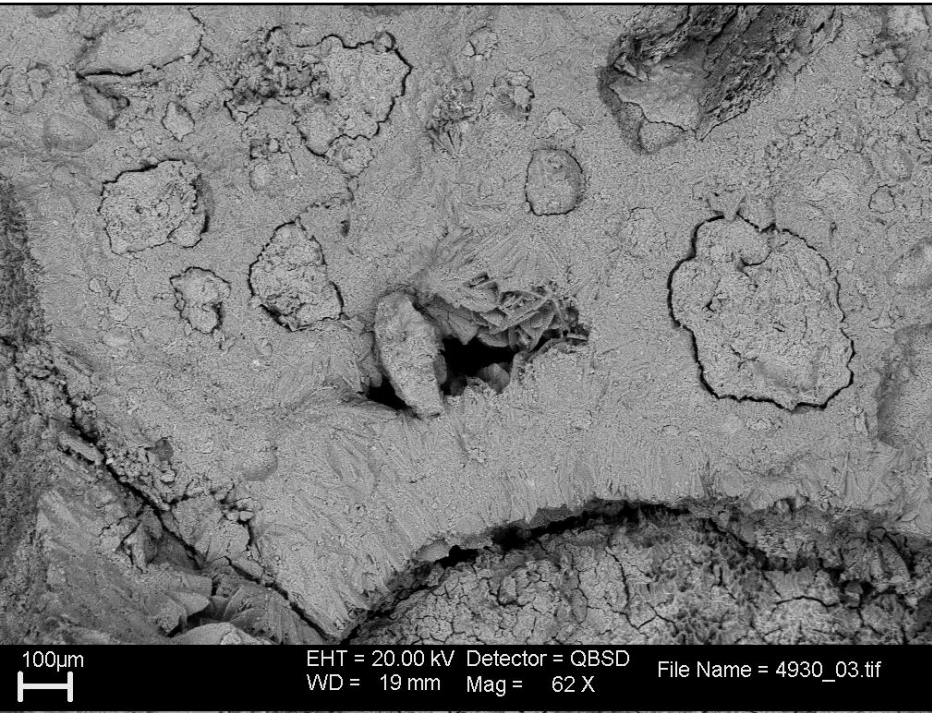


Dolomite replaced  
serpentinite  
(partially silicified)



# Dolomite replaced conglomerate matrix

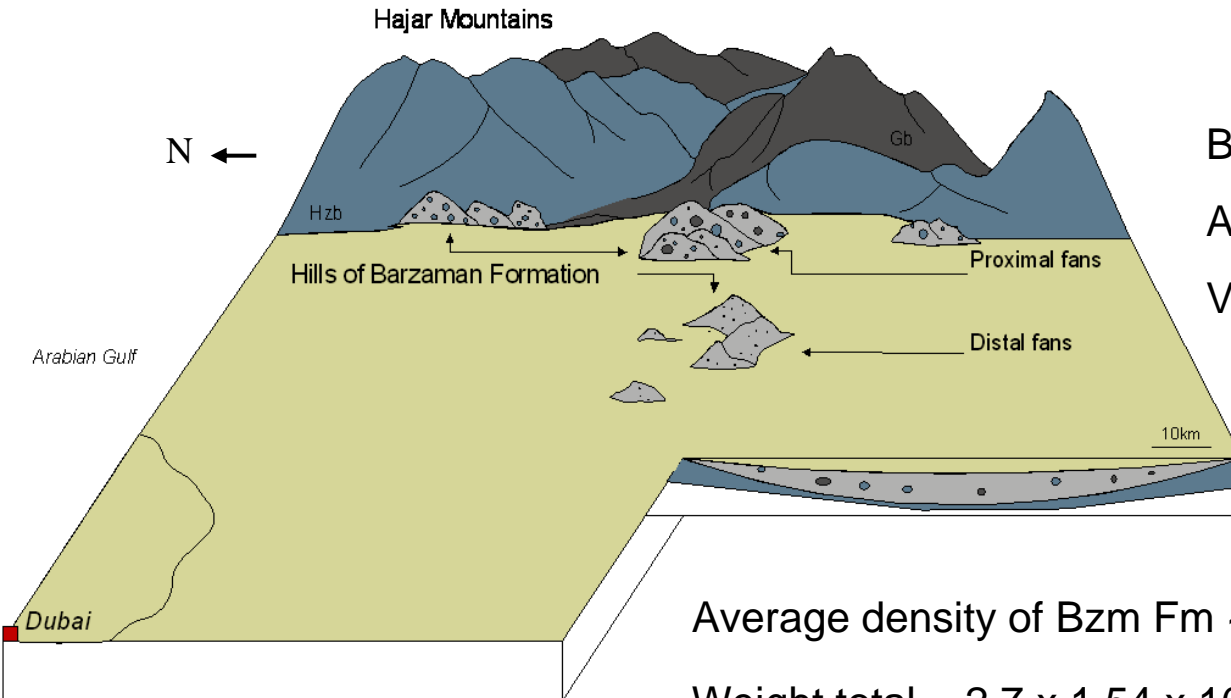
## Partially dolomite replaced serpentinite clasts



Time of deposition – probably 10Ma years ago in Miocene.

Time of cementation - ?

# How much CO<sub>2</sub> is sequestered?



Bzm Fm outcrop ~ 154 km<sup>2</sup>  
Average thickness 10 m  
Volume of Bzm Fm  $1.54 \times 10^9$  m<sup>3</sup>

Average density of Bzm Fm ~ 2.7 tonnes/m<sup>3</sup>

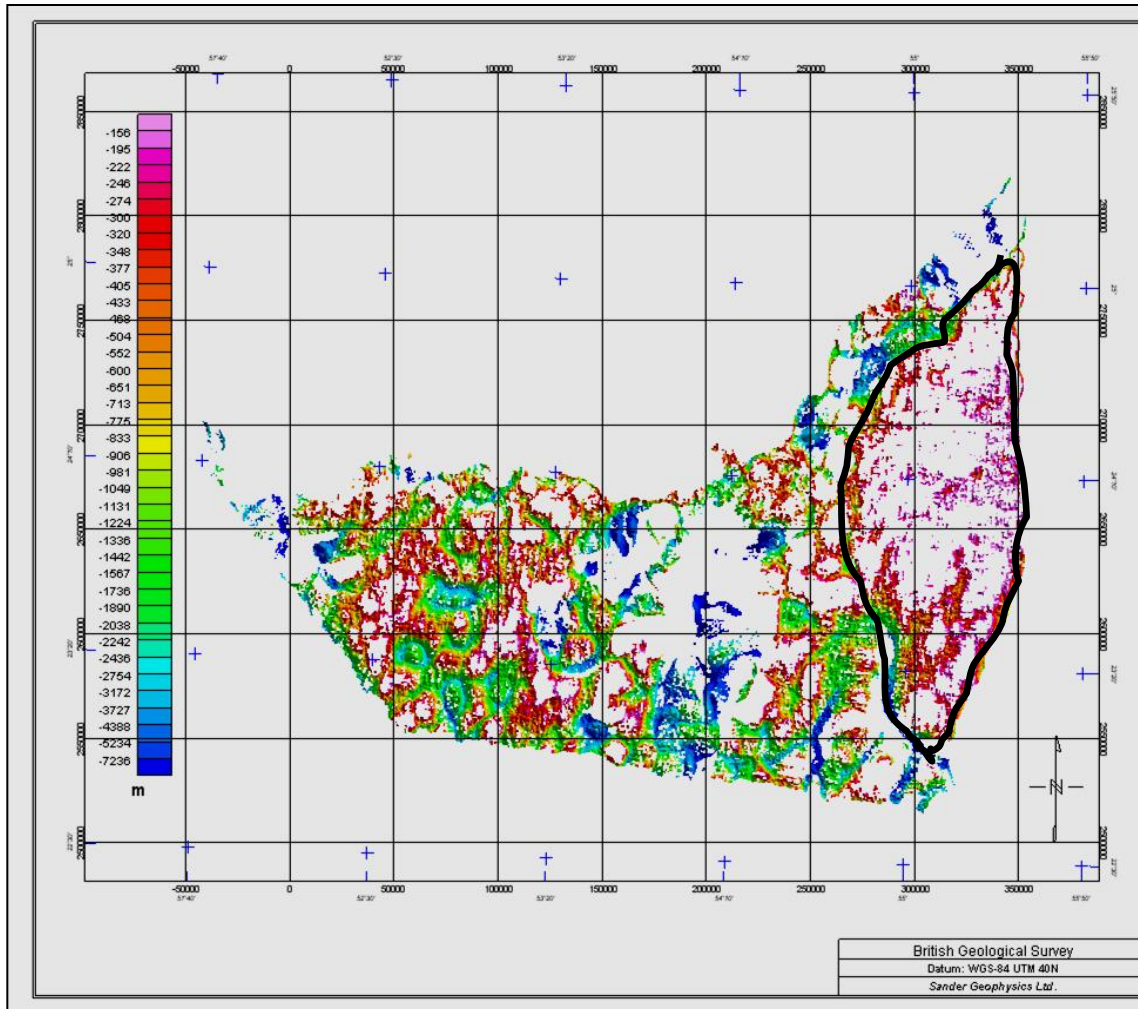
Weight total =  $2.7 \times 1.54 \times 10^9 = 4.16 \times 10^9$

Dolomite ~ 25%

- $1.04 \times 10^9$  tonnes of dolomite
- 47.6% CO<sub>2</sub> in dolomite

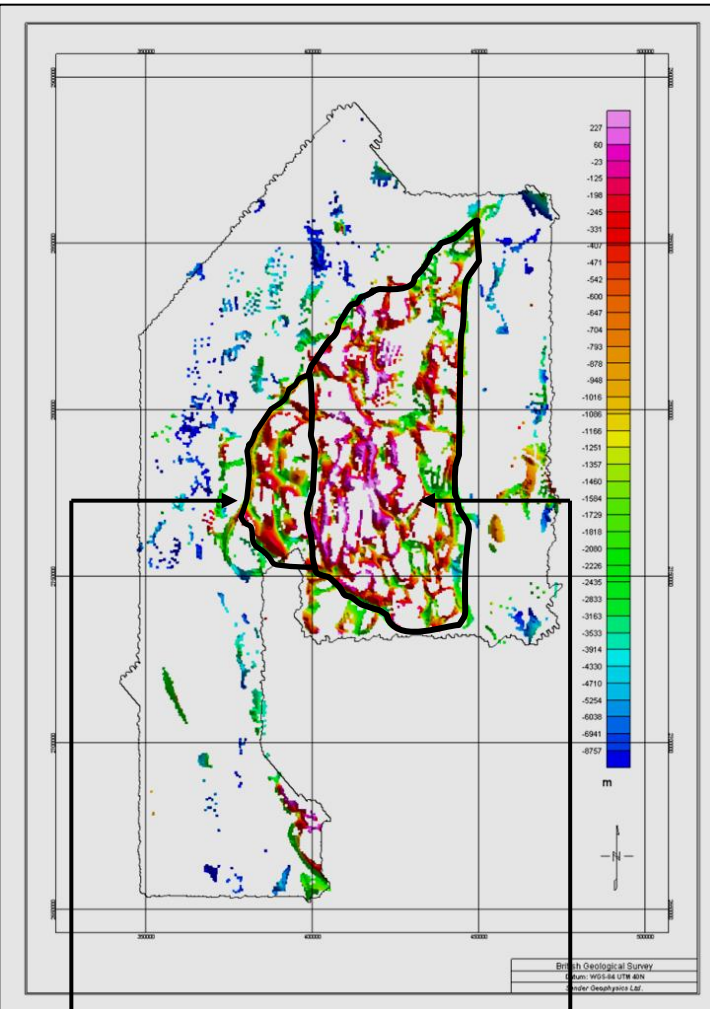
**$0.5 \times 10^9$  tonnes of CO<sub>2</sub>**

# Possible extent of Barzaman Formation



Concealed fans possibly 1500 km<sup>2</sup>

**5 Gt of CO<sub>2</sub> could be fixed**



Concealed ophiolite  
and exposed fans

Exposed ophiolite



# Conclusions

- **In the Barzaman Formation – silicate has been naturally converted to carbonate**
- **Possibly 5 Gt of CO<sub>2</sub> is contained within the formation  
This is 10 x the current annual CO<sub>2</sub> emission from the UK**
- **The source of the carbonate is not yet clear**
  - Reaction of high pH groundwater associated with serpentinization of ultrabasic rocks (cf. Troodos) with atmospheric CO<sub>2</sub>
  - Dissolution of CO<sub>2</sub> into “normal” bicarbonate groundwater and reaction with ultrabasic rocks
  - Dissolution of local limestones
  - a mixture of both

*The carbon pathways are a topic for future research...*





**Thank you for  
your attention**