

Materials innovation for decarbonization of the construction industry

Dr Xinyuan Ke

Lecturer in Sustainable Materials for Construction
Department of Architecture and Civil Engineering
University of Bath, UK

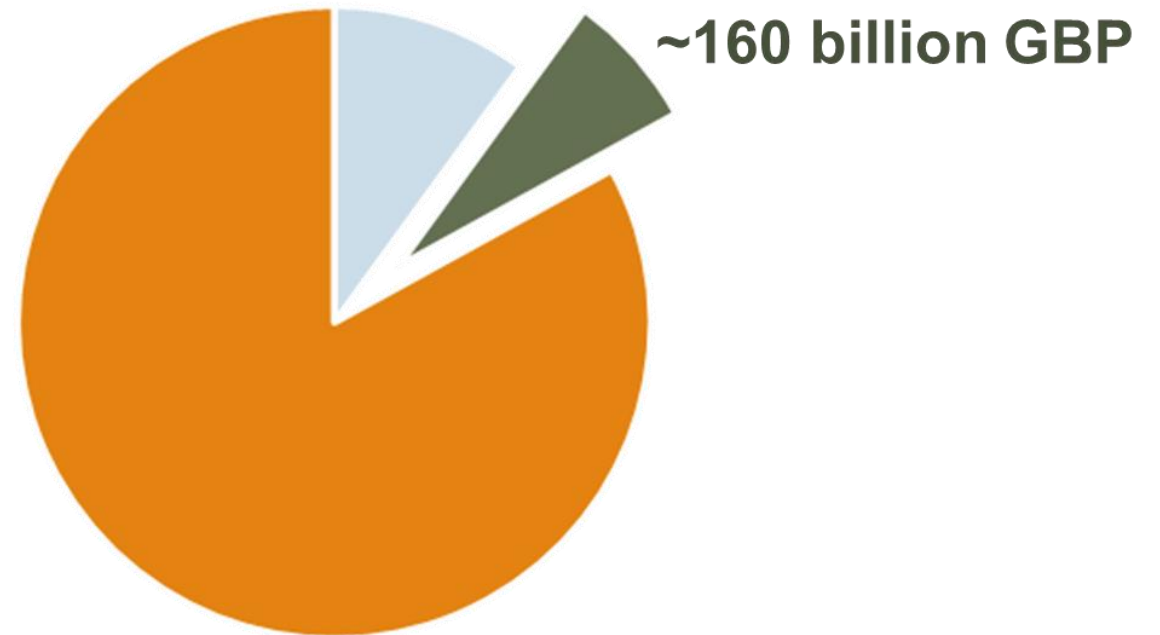


The construction industry

Worth of around **12 trillion USD** in the world economy



- Industry (exclu.construction)
- Construction
- Rest



Share of GDP in the UK

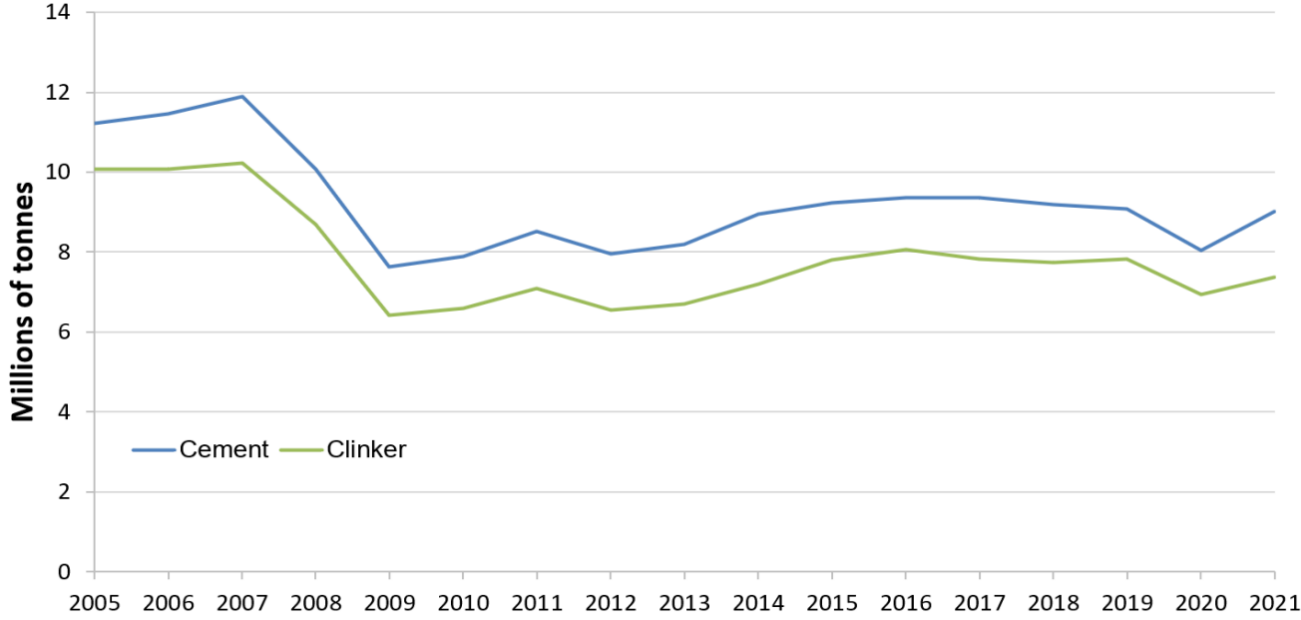
Cement and concrete

The indispensable carbon intensive materials



UK produces
~ 10 million tonnes of
cement per year
over the past 20 years

Equivalent to 8.3 million
tonnes of CO₂ emission

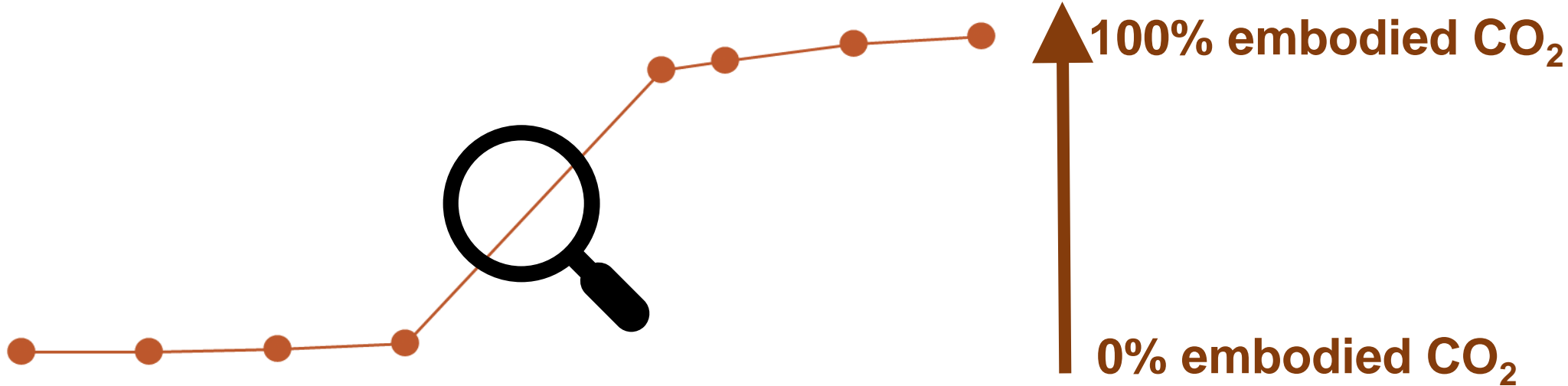


= The annual CO₂
uptake by 30% trees
in England



Why decarbonisation of cement is hard

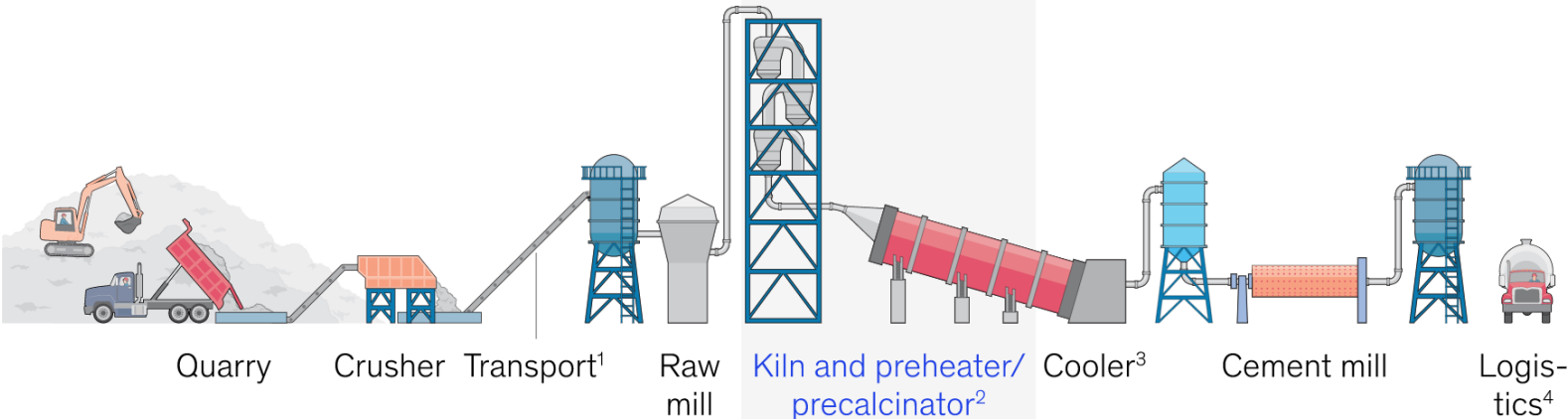
The challenges of process emissions



Cement manufacturing is a highly complex process.

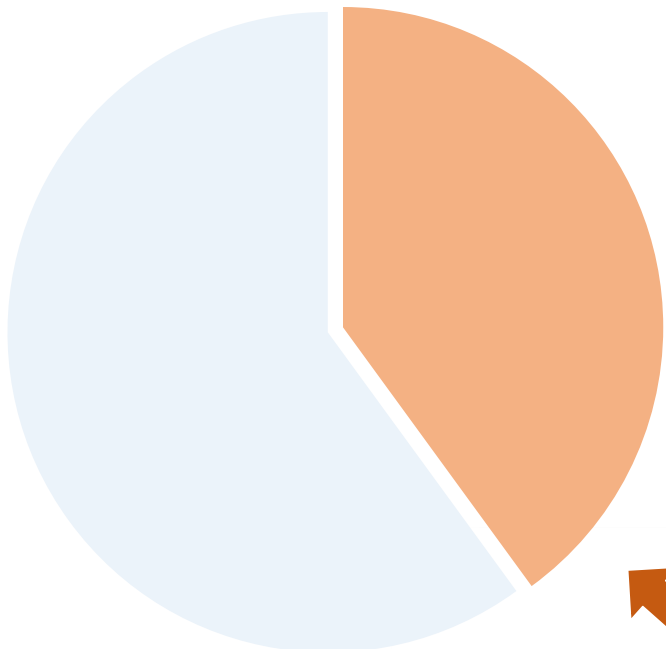
Raw materials, energy, and resources

Clinker and cement manufacturing



Why decarbonisation of cement is hard

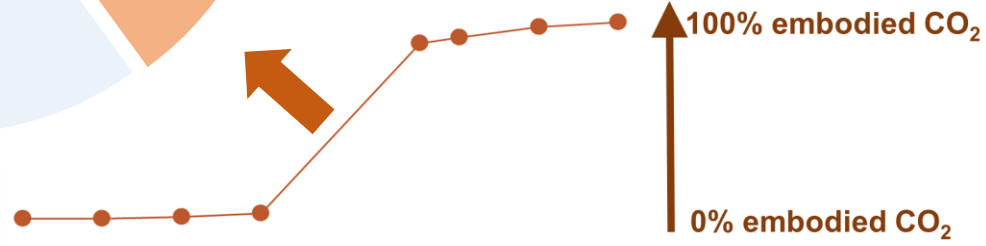
The challenges of process emissions



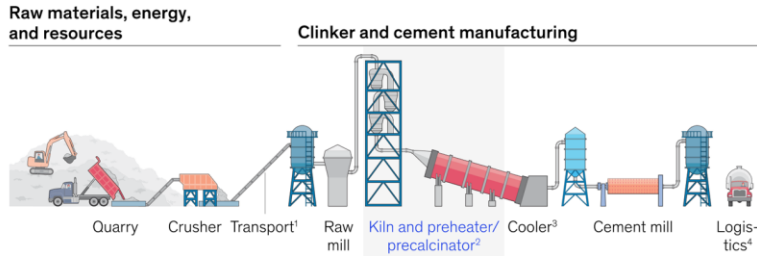
40% due to use of fossil fuels

***Can be reduced by electrification**

60% due to
Calcination of limestone



Cement manufacturing is a highly complex process.



Difficult to reduce!

The future of low-carbon concretes

The **challenge** for the coming decades

By-products from coal combustion & steel-making are effective cement replacement with good performances

**~20-40%
reduction potentials**



The future of low-carbon concretes

The **challenge** for the coming decades

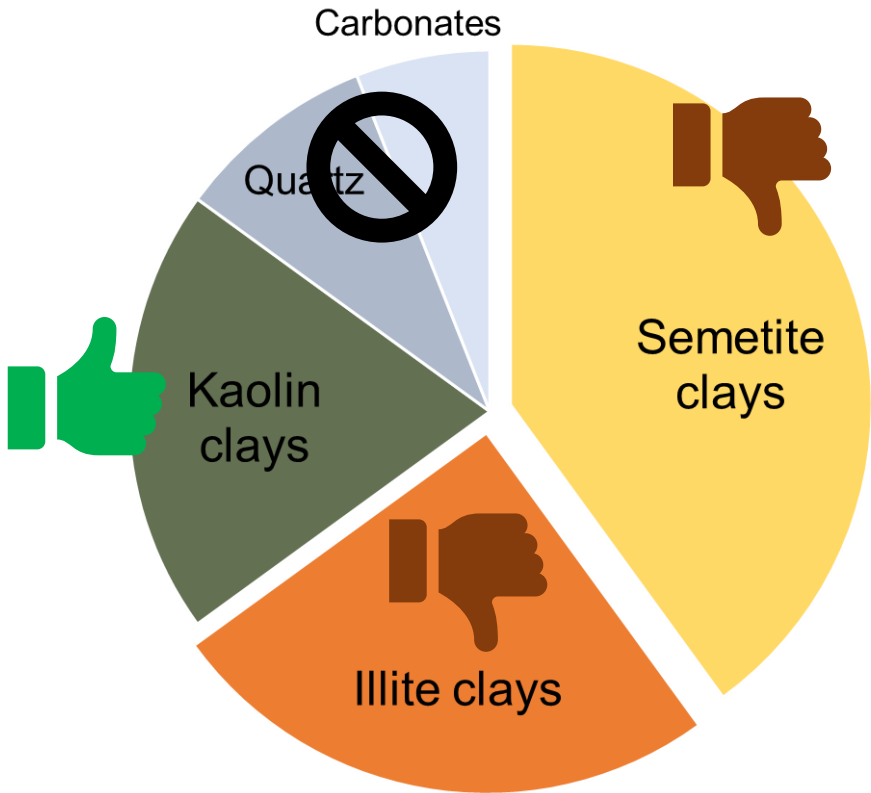
The global decline of “go-to” resources for low-carbon concrete

What will be the new cement replacement?

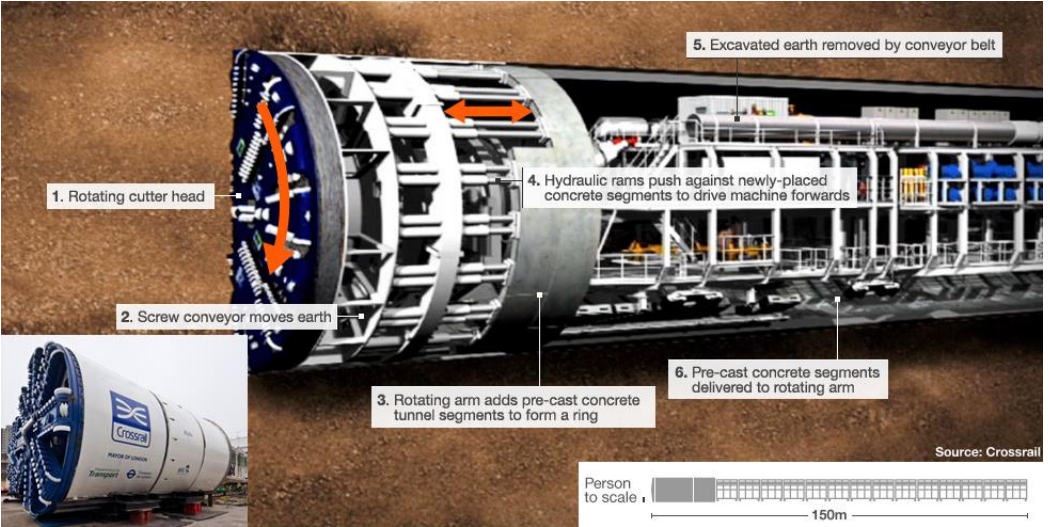


The future of low-carbon concretes

A solution from the **nature**

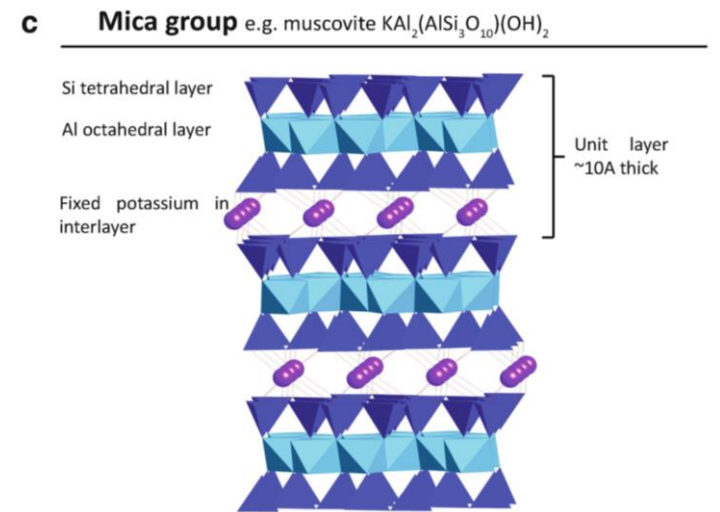
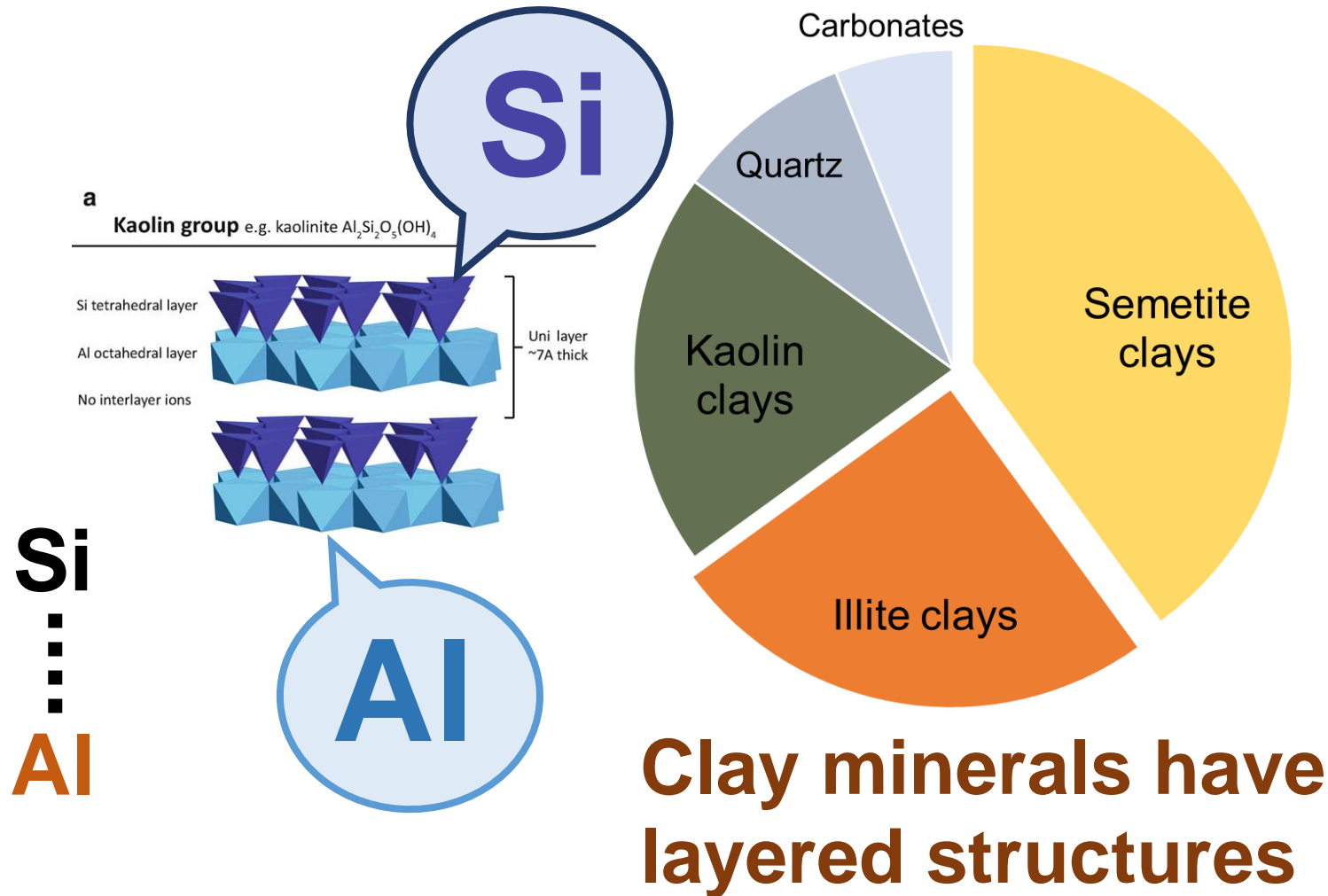


The typical compositions of London clays



The future of low-carbon concretes

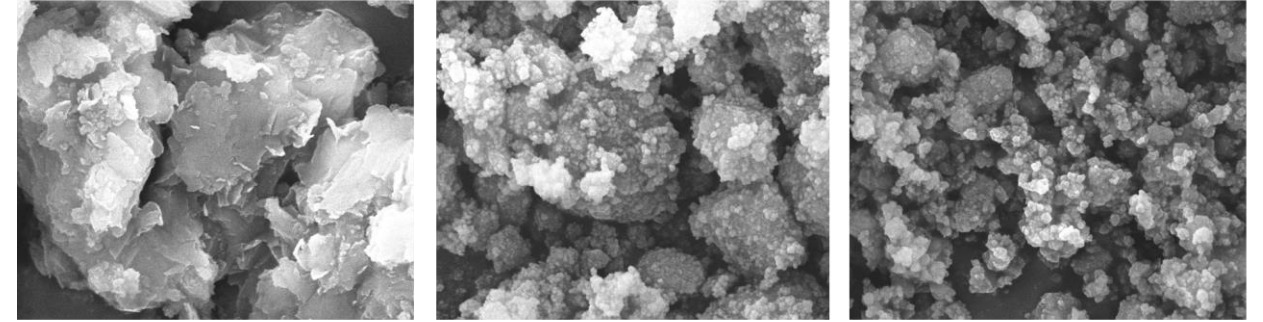
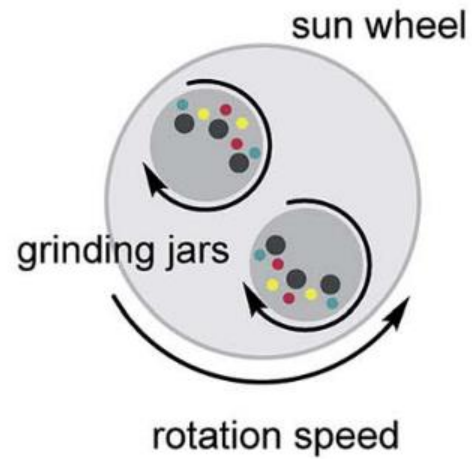
A solution from the **nature**



Mechanochemical activations (microstructures)

Mechanically-induced chemical reactions

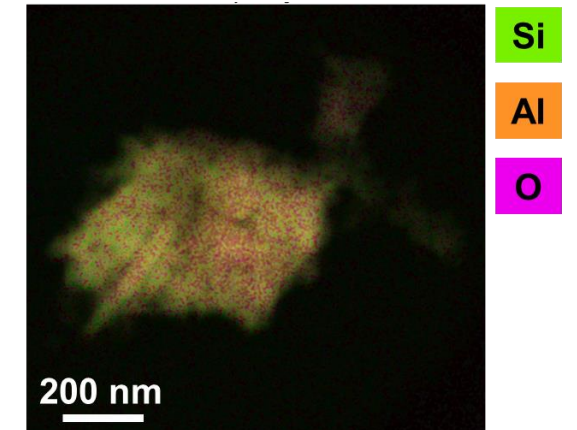
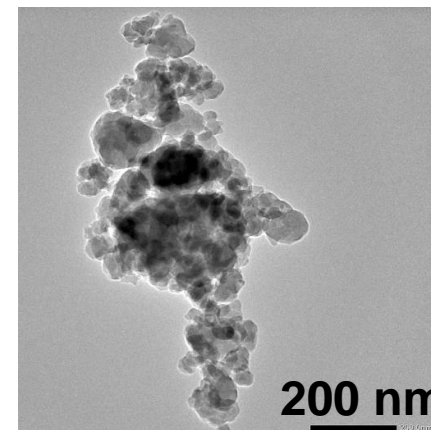
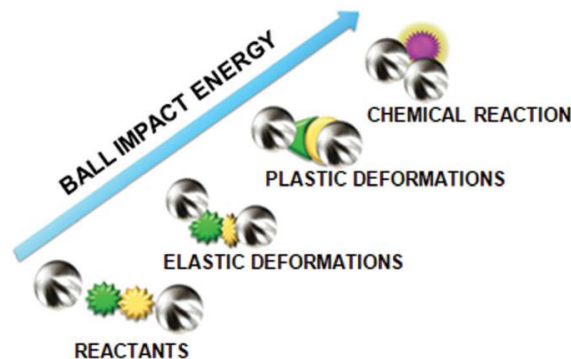
Planetary Mill schematic



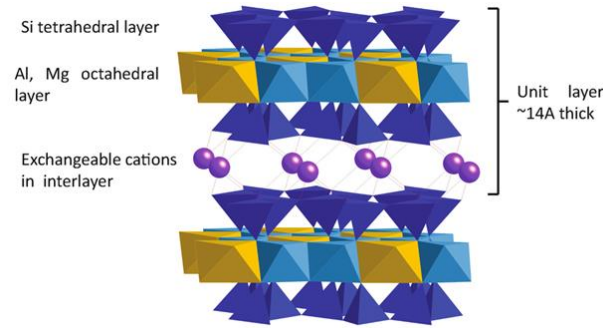
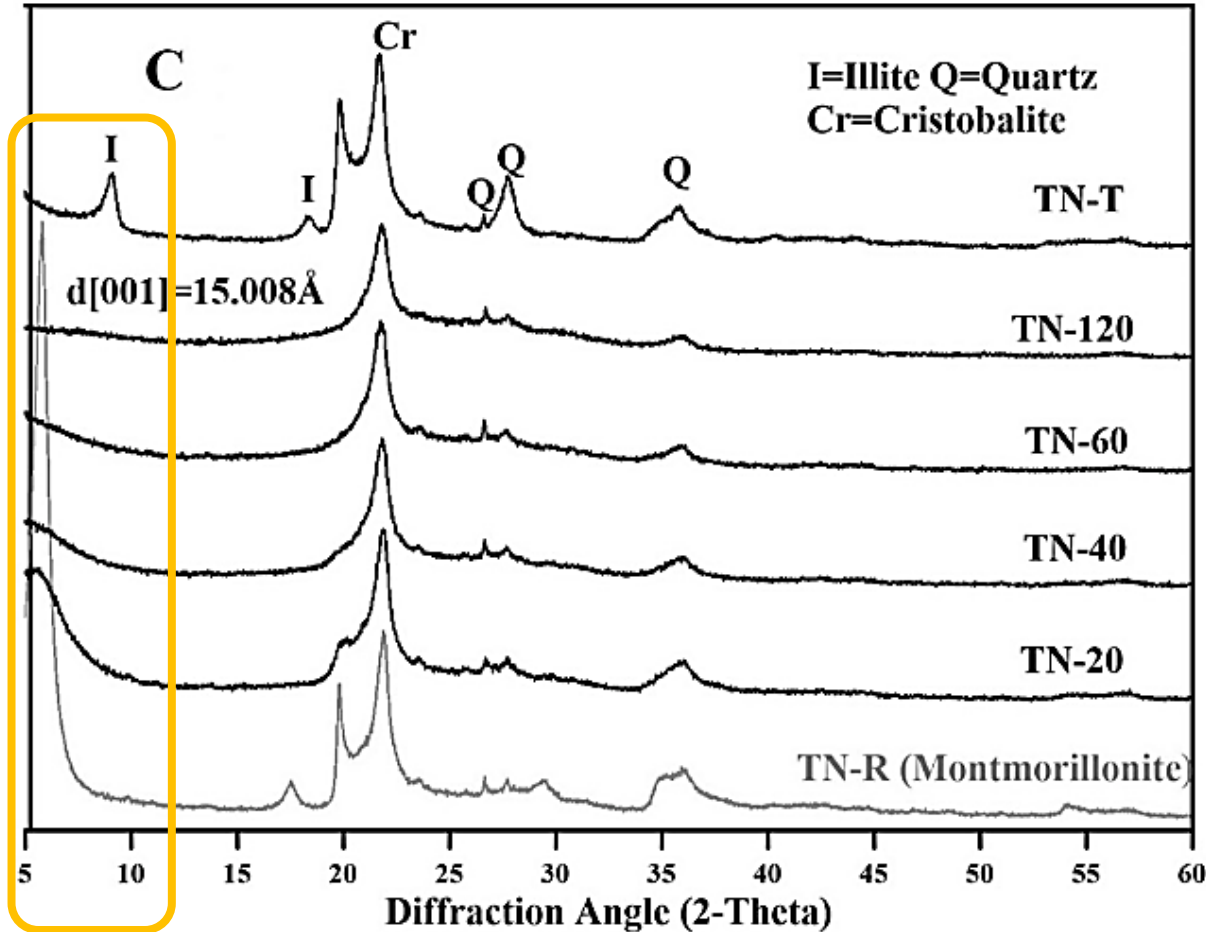
Increased mechanochemical activation time, resulting in dispersed fractured particles with surface features at nano-scale

Key parameters include:

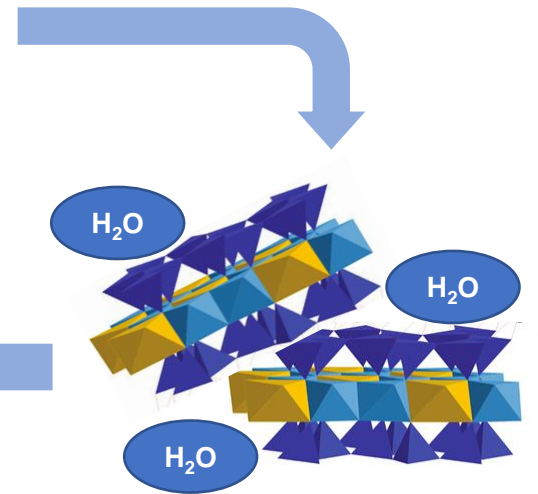
- Milling ball diameters
- Milling jar/ball materials
- Ball to sample charge ratio
- Rotation speed
- Milling frequency
- Milling time
- Chemical additives



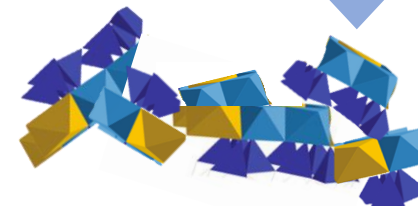
Mechanochemical activations (crystallinity) Mechanically-induced chemical reactions



Delamination & Dehydroxylation
>20min



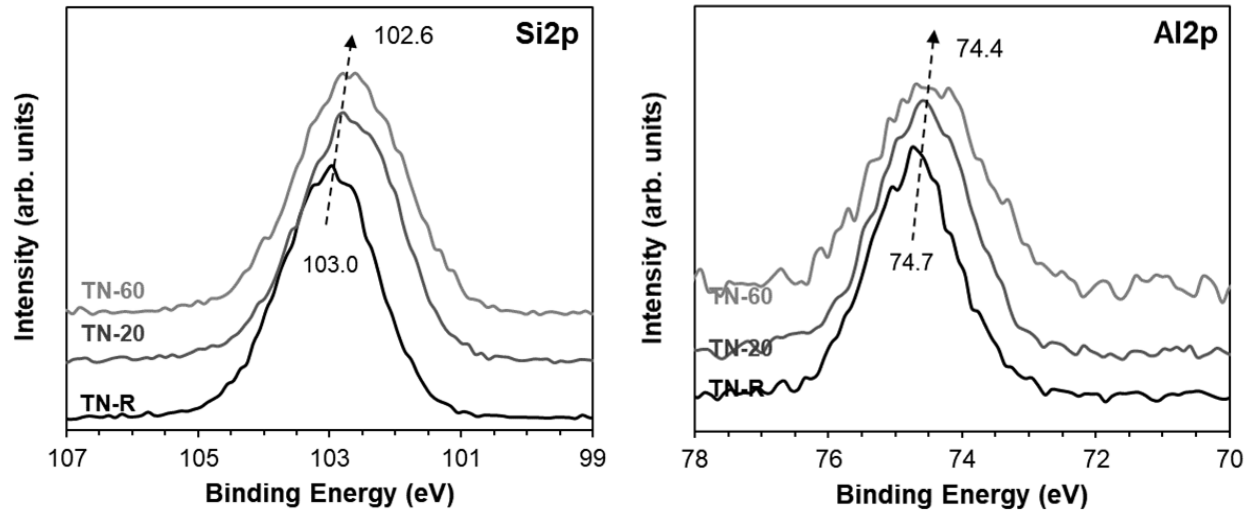
Amorphization
>40min



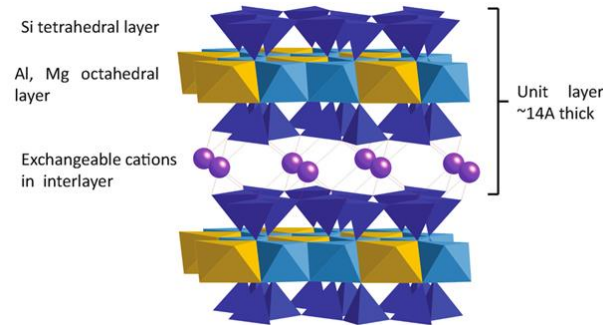
Exposure of internal Al layers

Mechanochemical activations (at atomic levels)

Mechanically-induced chemical reactions

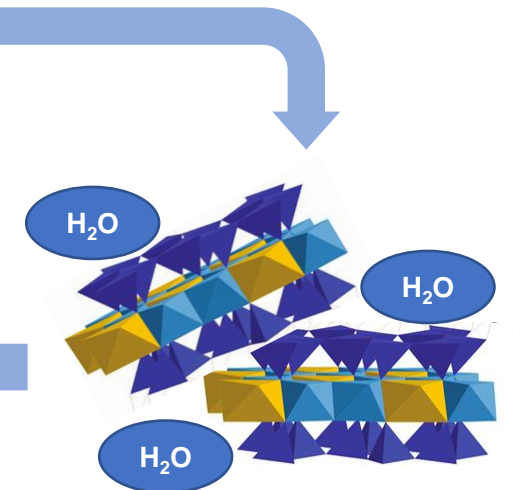
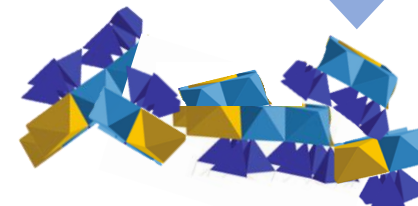


XPS surface characterisations (5-10nm) indicates reduced binding energy for both Si and Al element, suggesting **surface Al enhancement**



Delamination & Dehydroxylation
>20min

Amorphization
>40min

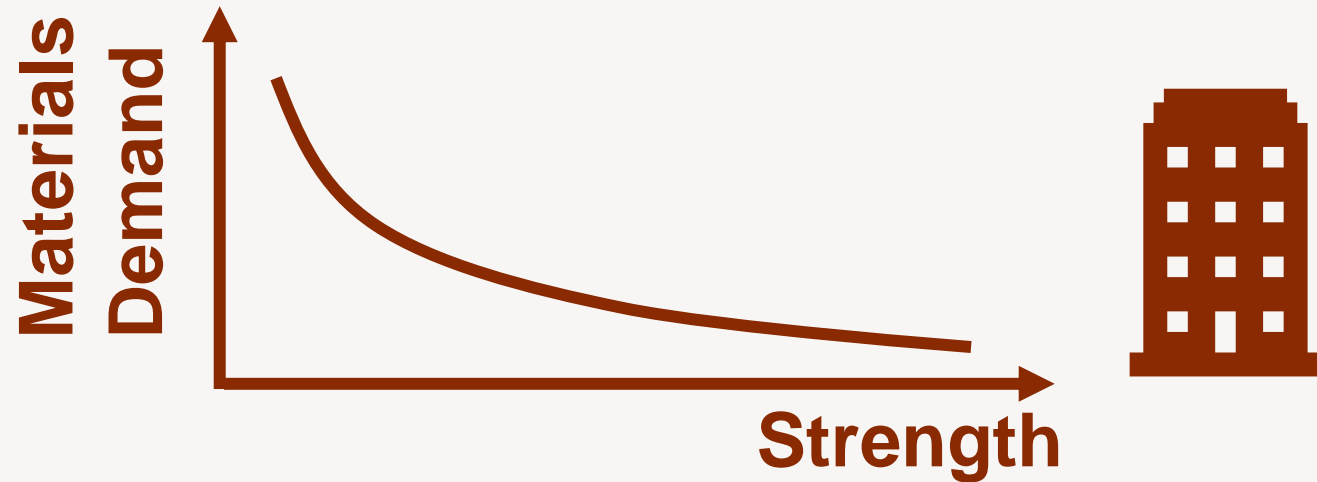


Exposure of internal Al layers



Superior mechanical performances

- ~ 500% (5 times) higher than untreated clays
- ~ 30% higher than the existing techniques



Improved sustainability

- Better materials efficiency
- Lower embodied carbon
- Reduced cost

Acknowledgement

Meet The Team



Group Leader
Dr Xinyuan Ke



Research Associate
Miss Lorena Skevi



PhD researcher/
Research Assistant
Mr Vahiddin Alperen Baki



PhD researcher
Mr Jamie Wilson



PhD researcher
Mr Brian Ding



PhD researcher
Miss Yuxi Lu



Current vacancies



Current vacancies

Funding support:



Engineering and
Physical Sciences
Research Council



UK Research
and Innovation

Research collaborators and partners:



Materials Science and Technology



UNIVERSITY OF
BIRMINGHAM



Swansea University
Prifysgol Abertawe

