# *Introducing the huge potential of slate powder as a geopolymer raw material.*

GeopolymerCamp 2025

**TUESDAY, July 8**
– Richard Wyn Huws, Penygroes, Gwynedd, UK

*Llechi Slate Evolution Cyf*

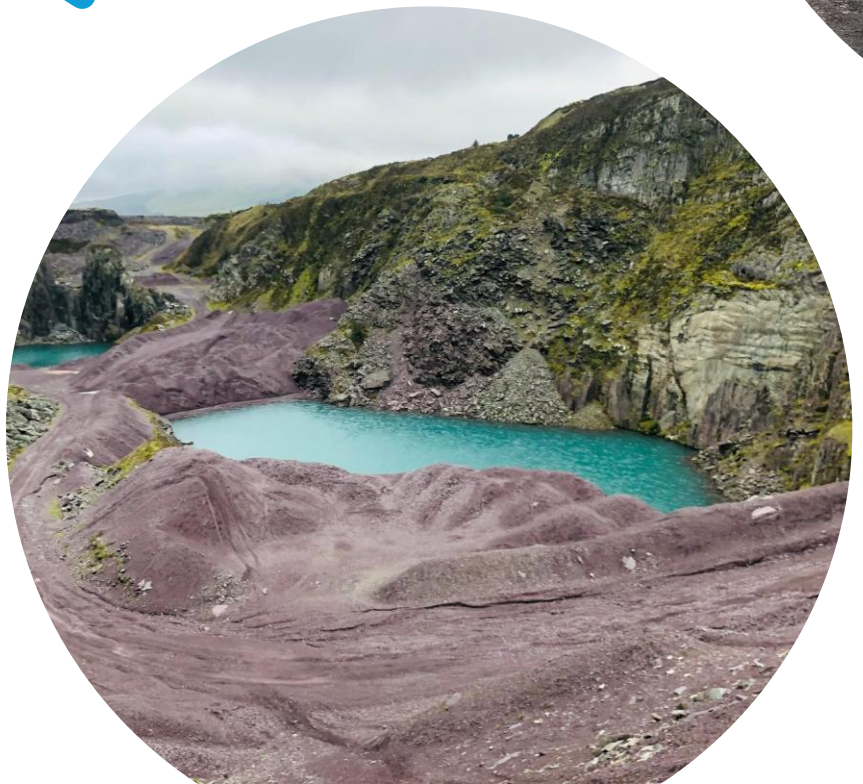
# Slate Powder: A Circular Economy Opportunity

- Just to show the material in situ and the vast/millions of tonnes of it as waste and the circular economy.
- The powder is WASTE from WASTE — no tax to produce it!!!! It is available to be used now!!!
- No high heat required to produce it like Metakaolin.
- Consistent powder from the same quarries — unlike Fly Ash.
- To be able to use this slate powder as a Geopolymer material solves huge problems for the Environmental Agency in Wales.
- Will help Government all over the world by using Slate Waste safely and INNOVATIVELY.
- Very natural Earth material can withstand heat to a temp of 1450°C before it turns to GLASS!!!

# Some of the top countries for slate quarrying include

1. China
2. United States (e.g., Pennsylvania, Vermont)
3. **United Kingdom (e.g., Wales, Cornwall)**
4. Spain
5. Brazil
6. India

These countries have significant slate deposits and active quarries, supplying material for various uses like roofing, flooring, and construction



The Slate Landscape of NorthWest Wales: Part of the World Heritage Site

# Slate can be a great material for making geopolymers

1. **Rich in aluminosilicates**: Slate contains aluminosilicate minerals, which are ideal for geopolymerisation reactions.
2. **High reactivity**: The fine-grained structure and mineral composition of slate can make it highly reactive, facilitating the geopolymerisation process.
3. **Abundant and accessible**: Slate is a relatively common rock, making it a potentially cost-effective source material.
4. **Durable properties**: Geopolymers made from slate can inherit its durability and resistance to weathering, making them suitable for various applications.

*By utilising slate in geopolymer production, you can create sustainable, durable materials with potential uses in construction, infrastructure, and more.*

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**N K Astariani et al 2021 IOP Conf. Ser.: Earth Environ. Sci. 871 012002**

(58) Field of Search:
INT CL **B09B, C03C, C04B, G21F**
Other: **SEARCH-PATENT, SEARCH-NPL**

(54) Title of the Invention: **Processes, compositions and uses of slate waste**
Abstract Title: **A glass composition formed from slate or slate waste**

(57) A glass formed from slate or slate waste is disclosed which comprises, in percent by weight:
45 to 65 percent $SiO_2$;
15 to 25 percent $A1_2O_3$;
8 to 15 percent $Fe_2O_3$; and
7 to 12 percent CaO.
The composition may be formed by adding limestone, magnesium carbonate and soda ash to slate or slate waste. The composition may be formed into fibres. Also disclosed are a method of waste encapsulation using vitrified slate/slate waste glass; a geopolymer composition characterised by slate/slate waste powder and alkaline activator; and a geopolymer composition characterised by slate/slate waste powder and acidic activator.

# Properties of Slate as a Geopolymer Material

- Chemical element: SLATE
- SLATE is a fine-grained, foliated metamorphic rock.
- It is derived from shale, mudstone, or siltstone, which are sedimentary rocks.
- Non-toxic
- Already processed as a material — no extra cost to mine and prepare it as a Geopolymer Material
- NO TAX
- The size of particles of the powder will make a difference to cure time and viscosity.
- Environmental issues
- Slate does not react to or with chemicals or acid, therefore it can be mixed with many different materials.
- It is a non-conductive material, so it could be an insulator = Geopolymer Insulator!!!

# Chemical Composition of Slate Regions

NANTLLE VALLEY ($SiO_2$ 62.18 wt.%)

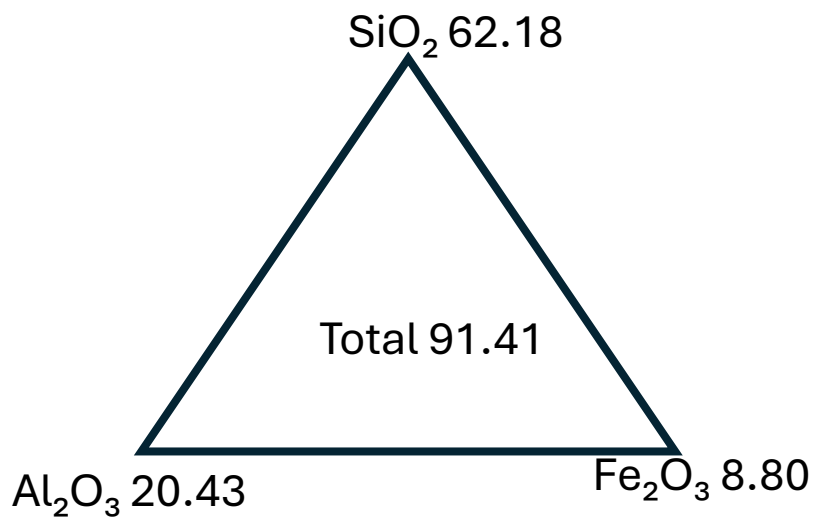
- $Al_2O_3$ 20.43
- $Fe_2O_3$ 8.80
- $TiO_2$ = 0.88
- CaO = 0.73
- $Na_2O$ = 1.58
- MgO = 2.15
- $K_2O$ = 3.24

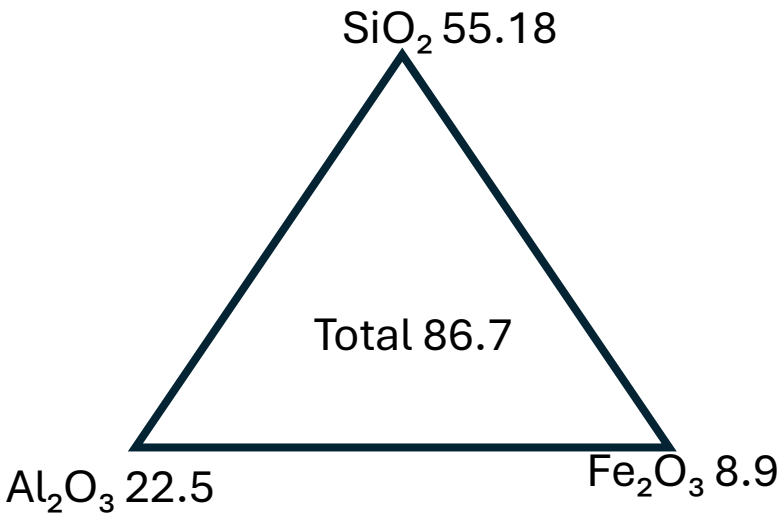
BLAENAU ($SiO_2$ 55.3 wt.%))

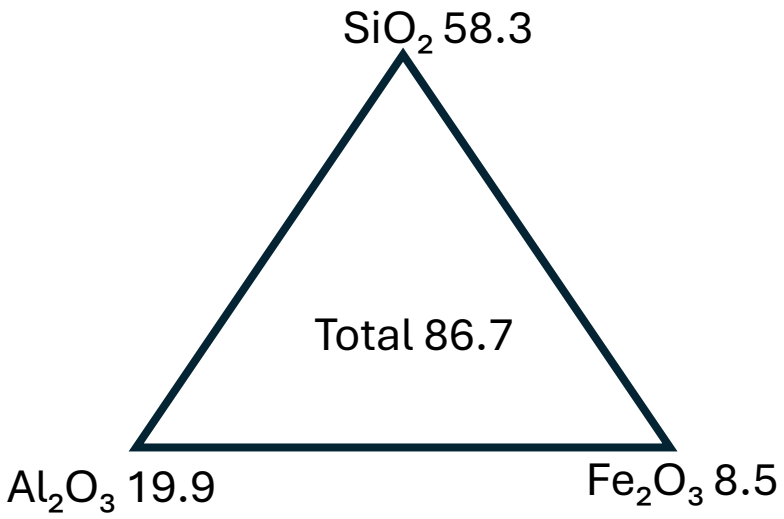
- $Al_2O_3$ 22.5
- $Fe_2O_3$ 8.9
- $TiO_2$ = 1.0
- CaO = 0.4
- $Na_2O$ = 2
- MgO = 2.3
- $K_2O$ = 3

BETHESDA ($SiO_2$ 58.3 wt.%)

- $Al_2O_3$ 19.9
- $Fe_2O_3$ 8.5
- $TiO_2$ = 0.9
- Ca = 0.7
- Na = 0.9
- Mg = 1.9
- $K_2O$ = 3



# Thermal Properties and Microwave Curing

- It can withhold heat for a long time
- Great for insulation in the construction world or sector
- Density of Nantlle valley slate = 2.7 - 2.8 g/cm3.
- The other secret of slate is that it can be cured via microwaves!!!
- Description of how this is possible
- BUT BE VERY VERY CAREFUL — small seconds at a time at less than <300 watts/ 90 Watts good


1:01
Time cook
Time defrost
Weight defrost
Power
Clock
Kitchen timer
Popcorn
Jacket potato
Porridge
Frozen vegetables
Hot drink
Dinner plate
Express cook
1 2 3
4 5 6
7 8 9
Stop
0
Memory
Start
+30 secs
JOHN LEWIS
& PARTNERS


12:30
Time cook
Time defrost
Weight defrost
Power
Clock
Kitchen timer
Popcorn
Jacket potato
Porridge
Frozen vegetables
Hot drink
Dinner plate
Express cook
1 2 3
4 5 6
7 8 9
Stop
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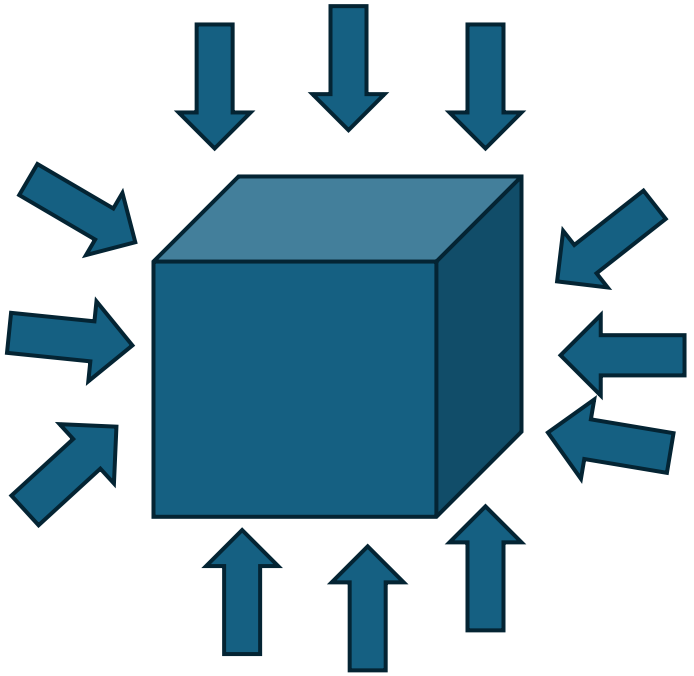
# Slate and Microwave Compatibility



- MICROWAVE is OK with igneous, sedimentary, and metamorphic rocks — and they can all react differently.
- Microwave heating works because polar molecules (like water) absorb microwave irradiation and convert it into thermal energy.
- When you heat with microwaves, it does not heat from the top or bottom, but all around.
- Depends on material volume
- 2 min – 10 min at 90 WATTS
- Microwave radiation is an efficient method to accelerate the geopolymer reaction.

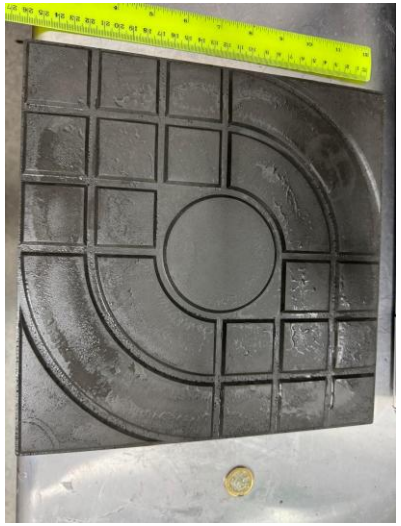
# Mixing and Optimisation

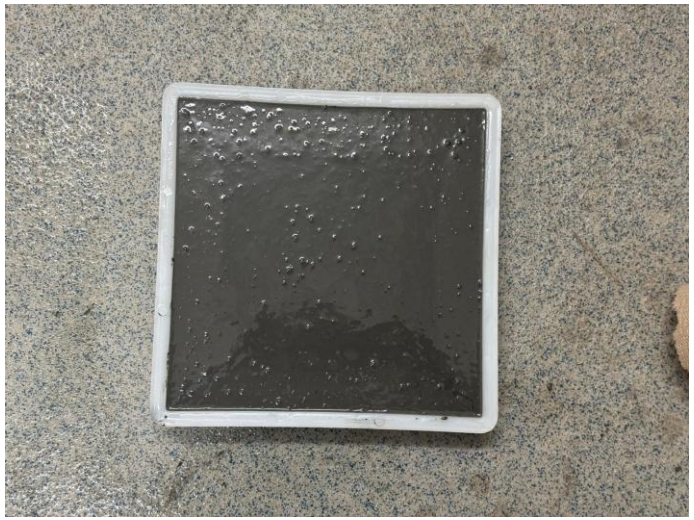
- A high-shear mixer is the best mixer for geopolymer preparation.
- It could be stated that the reaction between slate and alkaline or acid was optimized in the best possible manner.
- Calcium (Calcium Carbonate) needs to be added to get the best geopolymer from slate.

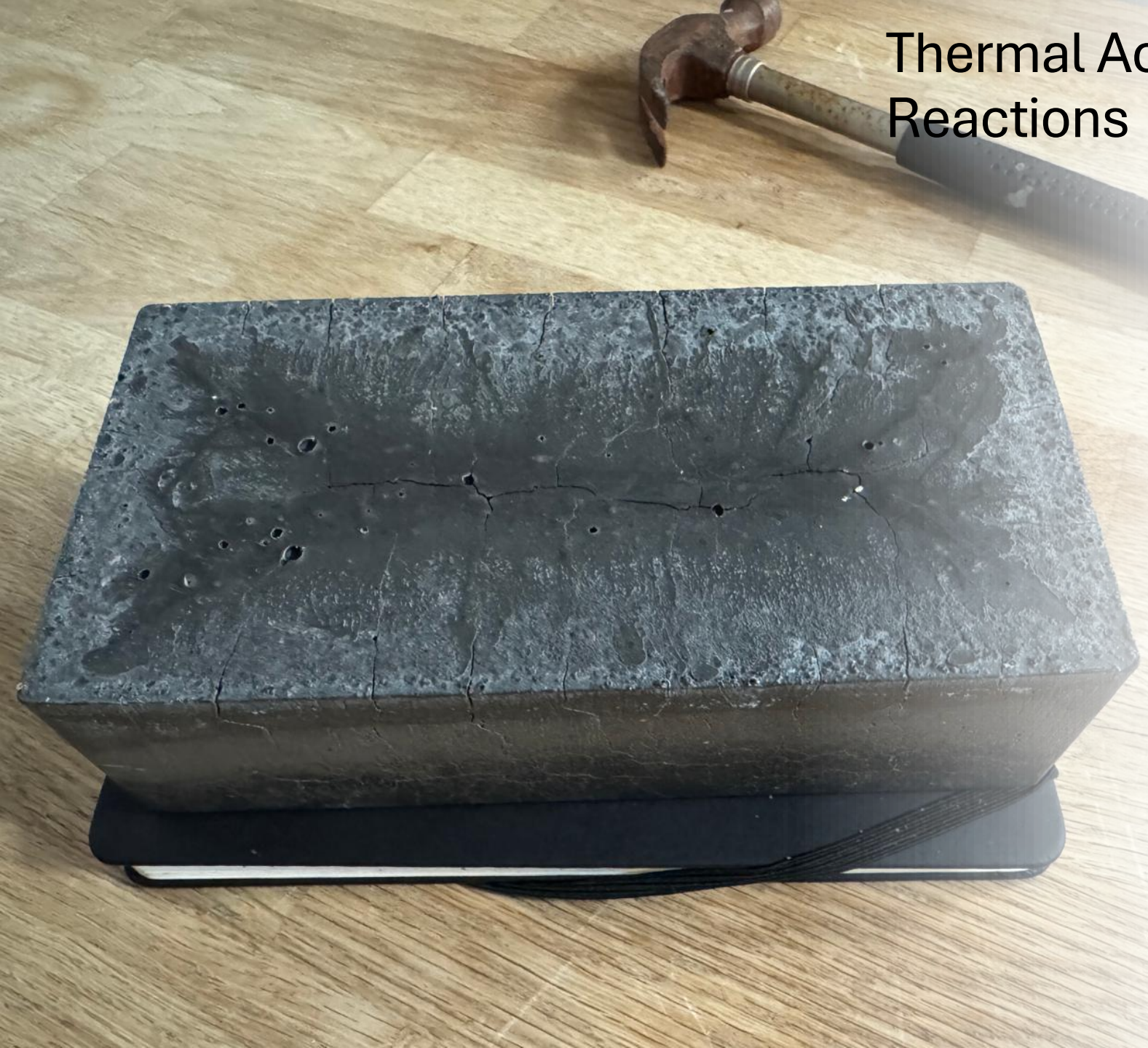
# Experimental validation and practical applications

After 7 days of curing, we can conclude that the slate Geopolymer has a promising compressive strength value of at least 27 MPa. This will be a great chance/opportunity to use it in the construction world/sector.

The interaction of a slate powder as an aluminosilicate from the circular economy with an alkali solution gives us a promising sustainable solution for managing otherwise problematic waste product to a new alternative cementitious and encapsulating material.







# Thermal Acceleration of Geopolymer Reactions

- Through higher temperatures, the hydration reaction occurs faster, and the concrete sets within hours instead of days.
- Geopolymer curing occurs through a polycondensation reaction.
- Thermal treatment contributes to the faster evaporation of water.
- Heat increases the movement of atoms and molecules, making effective collisions more likely.
- Microwave heating results in less heat loss compared to conventional heating, as there is no heat transfer from an external source (like an oven) to the sample.
- The material heats faster and more effectively through energy conversion from electromagnetic to thermal energy.

# Pyroxene and Microwave Effects

- PIROXENE
- The melting of minerals and the closure of original natural cracks mainly lead to the increase in compressive strength of pyroxene after microwave heating.
- With the increase in irradiation temperature, pyroxene fracture gradually transitions from:
- Wire-like drawing
- Step-like fracture
- To water ripple-like fracture
- Pyroxene occurs predominantly in intermediate and mafic (llechi) igneous rocks and in high-grade metamorphic rocks.
- Quadrilateral pyroxenes are fundamental constituents of basalts (llechi as well?).

# Exploration and Innovation

- Since this is a recently new material in the geopolymer world there are huge opportunities to experiment and explore.
- ENJOY THE JOURNEY. Especially in the modern technology world such as 3D Printing.
- Pob lwc, best of luck and Bonne chance
- Mwynhewch, Enjoy and Profitez bien.

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