Real soils versus fake soils: Does something other than clay minerals influence geopolymerisation behavior in real soils?

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REAL SOILS VERSUS FAKE SOILS:

Does something other than \textit{clay minerals} influence alkali activation behaviour in real soils?

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Lead supervisor: Prof. Andrew Heath

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What’s it for?
What is it?

Soil + NaOH(aq.) --> Mix --> Mould --> Cure (80°C, 24hr) --> Alkali-activated soil
What are we doing?

• **Why soils?**
  • Soil is abundant
  • Locally sourced material

• **Why not calcined?**
  • Lowest possible environmental impact?
  • Don’t need high strengths

• **Why no soluble silicate (NaOH only)?**
  • Simple system
  • Understand behaviour of soil components
Coming up...

• Introduction to alkali-activated soils
• **Aims of the study**
• Meet the soils
• Alkali activation of individual clays
• Alkali activation of soils
• Conclusions
• What next?
What are the aims of this study?

In alkali activation of soils...

1. What is the influence of \textit{clay minerals} and \textit{non-clay components} on phase formation?

2. Can we explain behaviour of soils using refined clay minerals?
How did we do it?

FAKE SOILS
How did we do it?

Real soils v. fake soils

Real soils
= clay minerals
+ associated minerals

Fake soils
= Same clay minerals composition...
... but no associated minerals (as far as possible) – just quartz
# Common clay minerals in soils

<table>
<thead>
<tr>
<th>Si:Al molar ratio</th>
<th>1:1</th>
<th>2:1</th>
<th>2:1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay used for fake soils</td>
<td>Speswhite Kaolin <em>Imerys</em></td>
<td>K10 Montmorillonite <em>Sigma-Aldrich</em></td>
<td>Illite IMt-2 <em>Clay Minerals Society</em></td>
</tr>
</tbody>
</table>
How did we do it?

Alkali activation
• Na:Al molar ratio = 1
• Wet mix consistency at plastic limit
→ NaOH solutions from 4 - 13 M

Curing
• 80 °C
• 24 hours

Ageing
• 20 °C
• 50% relative humidity
• 28 days
The soils

Karnataka Soil

Cattybrook Soil

Mayoo Soil

REAL SOILS = associated minerals

FAKE SOILS = quartz only

inc. quartz, feldspars, iron compounds...

Kaolinite  Montmorillonite  Illite

Non-clay components
Coming up...

- Introduction to alkali-activated soils
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- **Alkali activation of individual clays**
- Alkali activation of soils
- Conclusions
- What next?

Product phase
- XRD
- SEM

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Activation of kaolinite

Kaolinite

Sodalite

$\text{NaOH}_{(\text{aq.})}$

$80 \, ^\circ\text{C, 24 hr}$

28/05/2018

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Activation of montmorillonite

Montmorillonite

Geopolymer

NaOH\(_{(aq.)}\)

80 °C, 24 hr
Activation of illite

Illite

Structural breakdown

NaOH\(_{\text{(aq.)}}\)
80 °C, 24 hr
Coming up…

• Introduction to alkali-activated soils
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• Alkali activation of individual clays
• **Alkali activation of soils**
• Conclusions
• What next?

Real v. fake soils
Control + activated samples
• XRD
• SEM
• Photos
Alkali activation of Karnataka soils

Fake soil → Sodalite
Real soil → Sodalite
Karnataka soils

Real-control

Real-activated

SIMILAR

Finer scale sodalite phase

7 m$^2$g$^{-1}$
Cattybrook soils

Fake soil $\rightarrow$ Sodalite
Real soil $\rightarrow$ Sodalite
Cattybrook soils

Slightly different sodalite phases formed

SIMILAR
Mayoo soils (work in progress)
Mayoo soils (work in progress)

Real-control

DIF\text{FERENT}

Real-activated

Clear change in phase morphology

Particles edges more ‘ragged’
What did we find out?

**Aim 1:** What is the influence of clay minerals and non-clay components on phase formation?

😊 Nature of **clay mineral** influences the exact **product phase** formed

😊 **Iron oxide phases** do not seem to prevent formation of **zeolitic phases**

😊 **Non-clay components** of soil *sometimes* affect reaction products
What did we find out?

**Aim 2**: Can we explain behaviour of soils using refined clay minerals?

😄 **Refined clays** can be used to explain behaviour of some real soils

😢 **Other soils** are a work in progress
What next?

• More **soil types**

• **Strength and durability** testing

• Geological approach - which regions have most suitable resources?
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  • Applied Mineralogy Group
Any questions?

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