Infrared Spectroscopy in Engineering Geology
Nick Koor & Andy Gibson

Outline

• Background

Case Study 1
• Landslide Debris (Dorset)

Case Study 2
• Engineering NIR Stratigraphy (Hampshire)

Case Study 3
• Weathering - London Clay (London)
**NIR Spectroscopy**

**Background to NIR**

NIR

Spectral Logging

- Visible, NIR, SWIR Wavelengths (350-2500nm)
- Spectral resolution 1nm
- Measurement window 4-24 mm

- Limited/no sample contact
- No sample prep needed
  - (lab samples can be crushed)
- Measurement time 0.05 secs
Spectral Logging

Sensitive to most minerals but especially clays

Biggest applications:
- Mining – mineral exploration
- Heritage Conservation (as non-contact)
- Pharmaceuticals
- Biscuits

Typical XRD plot for London Clay
**Typical Lab Spectra**

- Sensitive to moisture, mineralogy, clay content, organics, plant health, particulate contaminants........
- Relate to weathering, water movement, vegetation growth

![Graphs of Dark Clay and Orange Sand](image)

**Landslide Debris**
Particle Size Characterization

- Possible to predict article composition from 2-3 wavelengths

\[ e.g. \text{% clay} = 130.3 - 82.754 \times R(\lambda_{2204}) + 937.388 \times R(\lambda_{1411}) \]
**Moisture Content**

![Graph showing moisture content vs. reflectance ratio]

**Next Steps**

- Black Venn Study: debris flow mobility – does the mixing of debris flow materials relate to how mobile it is? Debris flow mechanics.
- China Bailong Corridor (Zhouqu Debris Flow – Lanzhou Uni): properties of source materials with debris flow mobility.
Current Research Projects:
Engineering NIR Stratigraphy
London Clay (Hampshire Basin)
White Cliff Bay - Isle of Wight
Geological section (N-S) of the Isle of Wight (after Institute of Geological Sciences, 1976)
Geological Section White Cliff Bay – after Ian West

Whitecliff Bay, Isle of Wight, Geological Cliff Section

S.W.
Upper Chalk

London Clay Formation

Bembridge Limestone Fmn / Bouldnor Fmn

Bracklesham Group

Solent Group

Barton Beds (Hedon Hill Formation)

Reading Formation

Reading Group

Upper Chalk

London Clay Formations

N.E.

Solent Group

Bracklesham Group

Barton Beds (Hedon Hill Formation)

Reading Formation

London Clay Formation

Bembridge Limestone Fmn / Bouldnor Fmn

Upper Chalk

READING FORMATION

CLAY WITH SHELLS, POORLY EXPOSED

SHELL BEDS IN BRITTLE SAND

GREEN SANDS

NORMATIVE TERRIGENOUS

CRUDE BROWN CREAM

BRIGHT YELLOW SAND

SEABED CLOUDY CLAY WITH SOME SHELLS

RED CLAY WITH PLANTS

CRETACEOUS

TERTIARY

Thames Group

London Clay Formation

Bracklesham Group

Spectral Stratigraphy of the London Clay Fmn
Sampling Whitecliff Bay SSSI

- Proof of concept study
- Sampling at 1m along cliff exposure

Spectral Testing London Clay

- Proof of concept study
- Samples tested in ‘field’, ‘dry’ and ‘powdered’ conditions
Mineralogical Analyses

- Difficult to establish exclusive mineral relationships

'Smectite' Log, Whitecliff Bay

- Geological context is everything.....
‘Smectite’ Log, Whitecliff Bay

Logging Resolution?
Current Research Project:  
Geological controls on weathering using NIR

Geological Block Model of Hampstead
**Geological controls on weathering using NIR**

- Integrated Engineering Geological Approach
- Macro-scale (m)
- Meso-scale (mm)
- Micro-scale (µm)
London Clay Formation – Isle of Sheppey
Mineral Analyses

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<th>Test</th>
<th>Code</th>
<th>Description</th>
<th>Result</th>
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<td>D1</td>
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Smectite Peak Location

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*Note: Table and diagram details are not readable in the image.*
Mineral Analyses

Clay Minerals

Spectra Diagnostic of:

- Stratigraphy?
- Weathering history
- Contamination?
Site 1 – Boreholes N-S; Mg-Cg-Lc

Site 1 + Neighbour
Where we are now....
Next Steps

- Develop site/lab sensors
- Replace/add value to some existing tests......

Thank you

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Skempton 1953