INVESTIGATING AND UNDERSTANDING THE GROUND – WHY BOTHER?

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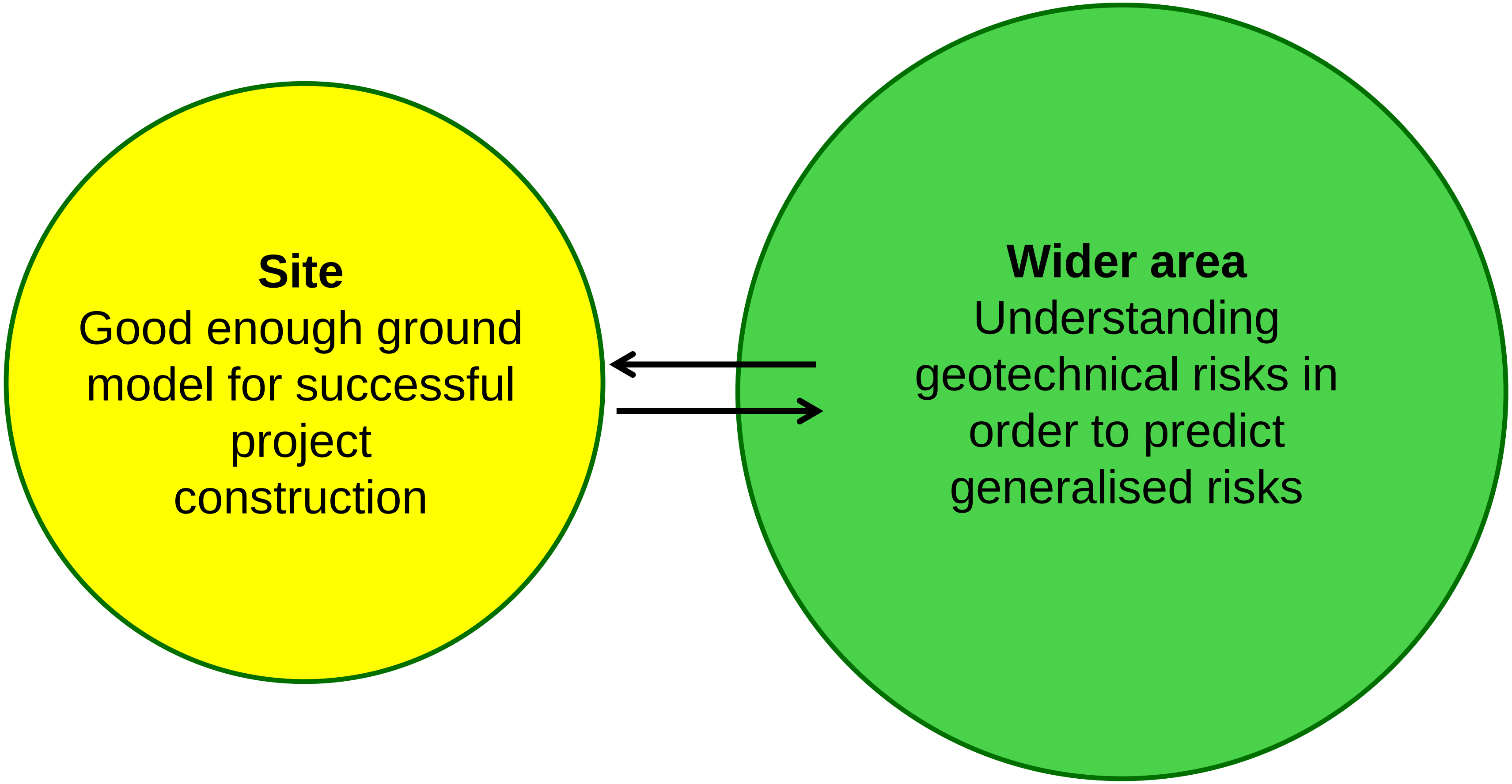
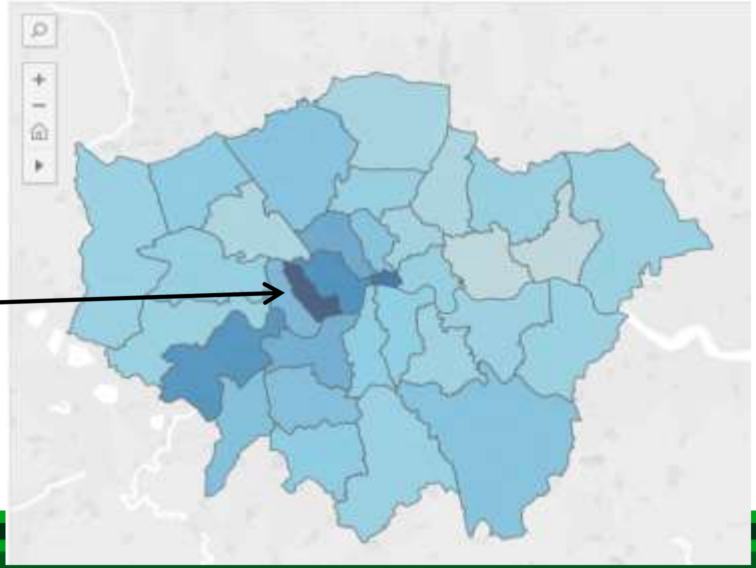
WHAT IS “UNDERSTANDING THE GROUND?”



THIS IS DEPENDENT ON:

- Geotechnical category of project - (importance/shed/house/hi-rise/tunnel?)
- Scale of project
- The *sensitivity* of the project

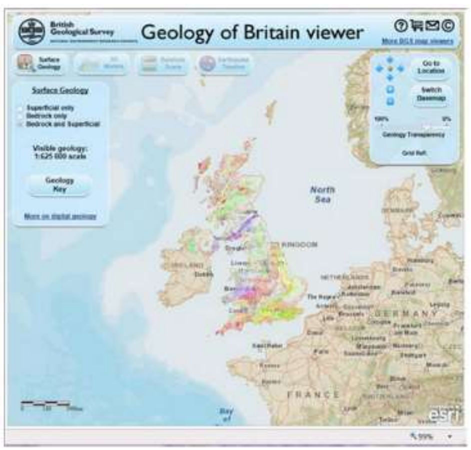


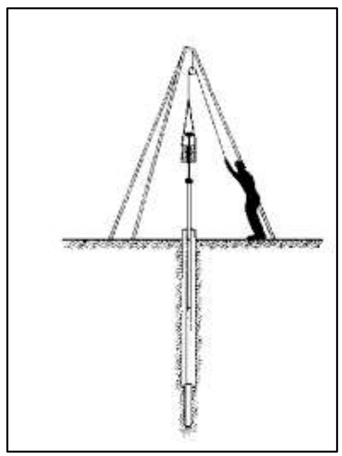
- Greenfield site?
- Under or over expensive buildings or infrastructure?
- Whose house is it near or under?
- Is this a one-off opportunity to get into the site?

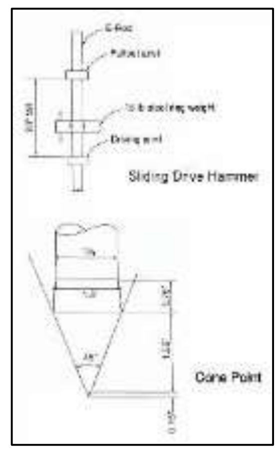
...PLUS THE GEOLOGY

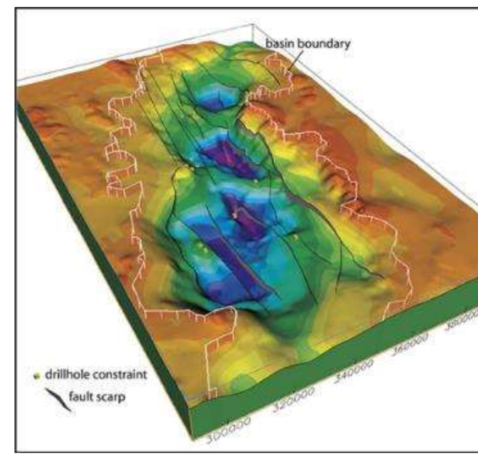
Why do we have to bother "understanding?"

- We have loads of historical geological data, maps
- We have *in-situ* testing techniques and surface geophysics
- Do we need all that expensive core and lab testing?

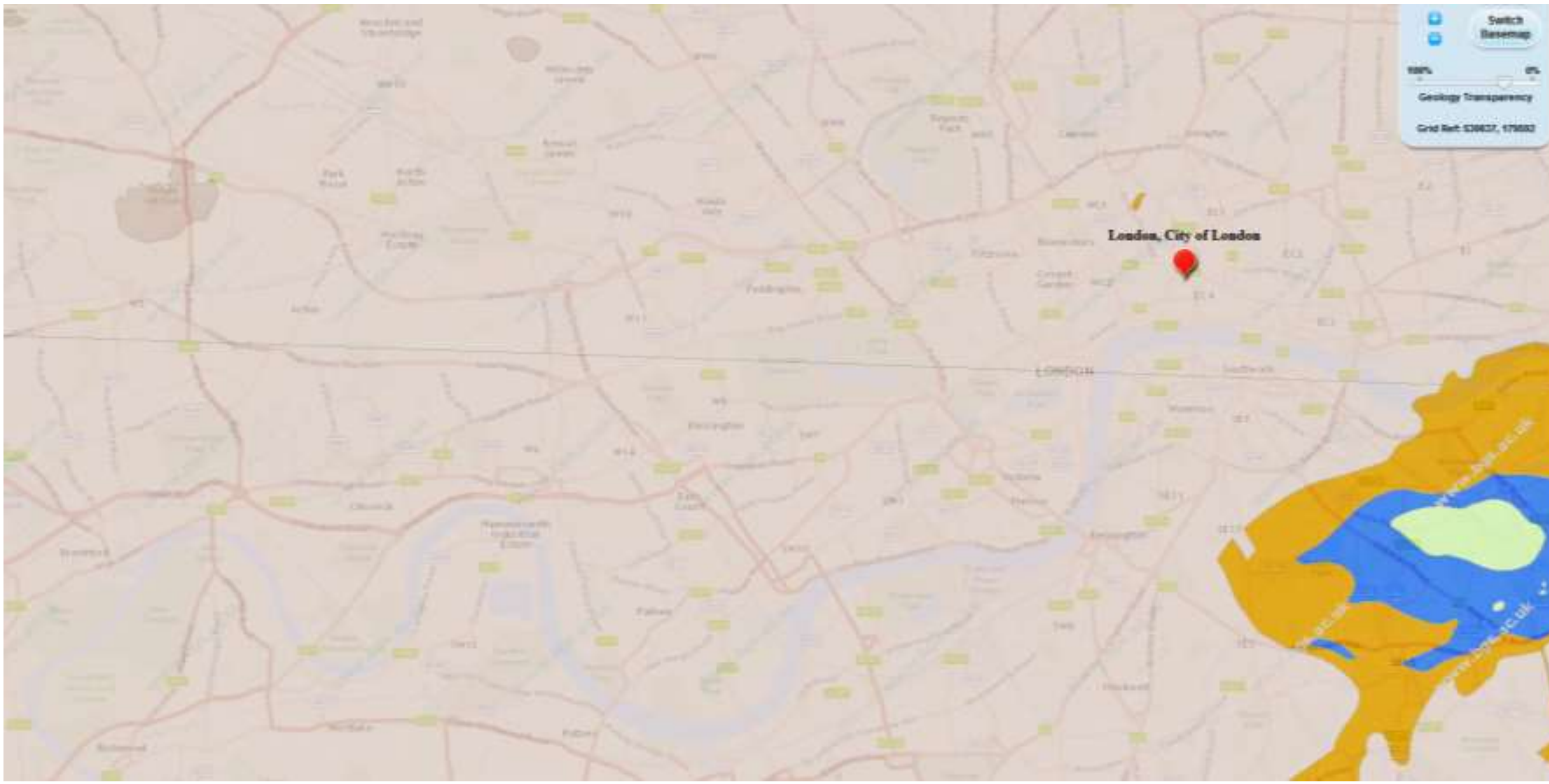








“ANYWAY, IT’S MOSTLY LONDON CLAY”



HOWEVER, SHORTCOMINGS

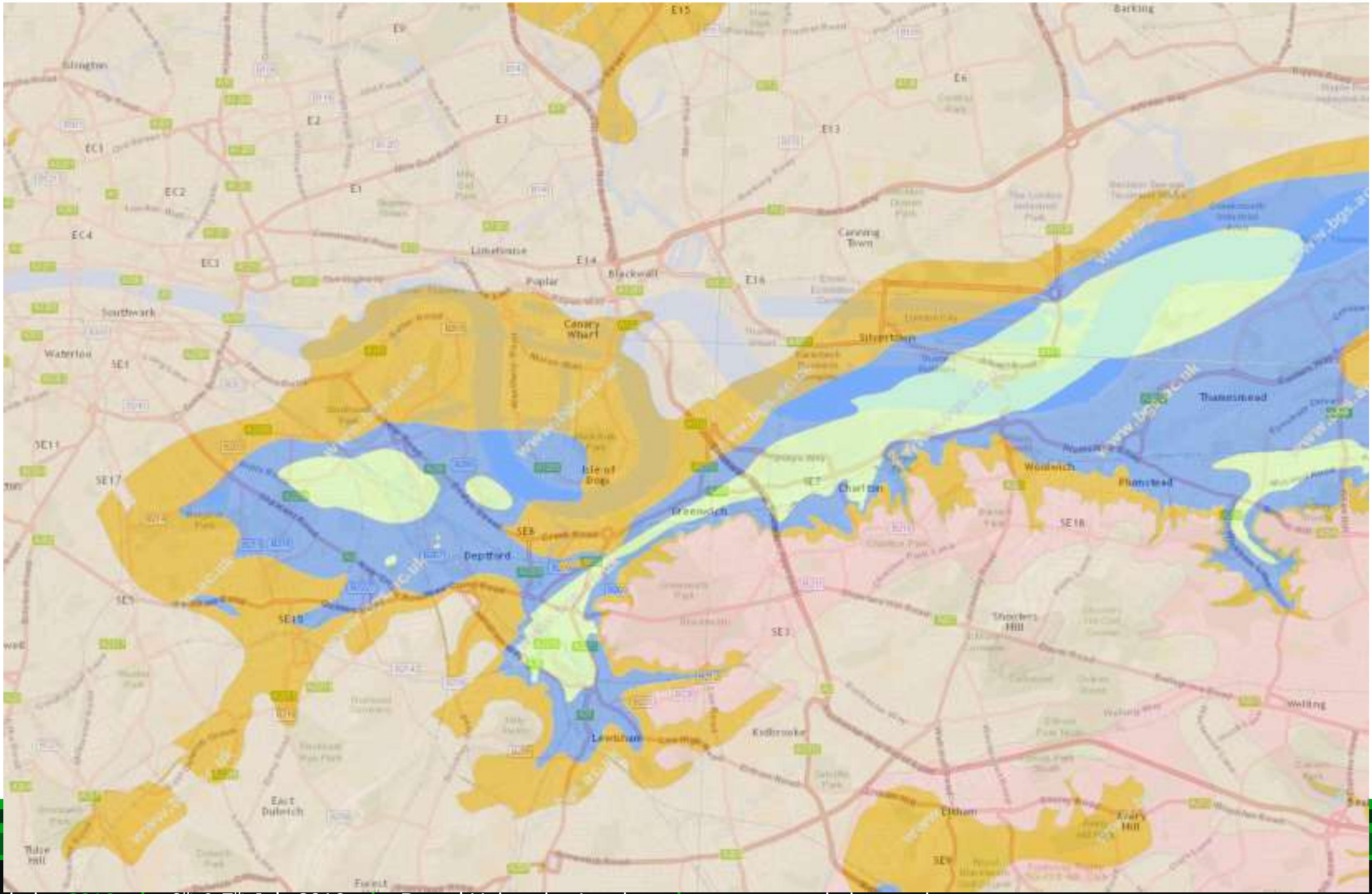
- Historical ground information can be wrong/misleading/right but ignored..

> Borehole BH3 encountered multicoloured clays to a depth of 18.40m below ground level. This clay been classified as being part of the London Clay Formation due to its geological setting however it has the structure and appearance of multicoloured clays typical of the Lambeth Group. This
>
> material has been called "Possible Destructured London Clay Formation". Whilst this is anomalous the difference appears to be in colour and not undrained shear strength.

- Geological maps are just a ‘good approximation’

e.g. A line on a 1:50,000 map = 50m = site-scale uncertainty

AND IF YOU LOOK AT SOUTH AND EAST LONDON – IT'S MOSTLY OTHER GEOLOGY



HOWEVER – SHORTCOMINGS (2)

- In-situ testing and geophysics are *part* of the GI suite but should not be a replacement
- Increased complexity of geology *makes these harder to interpret*
- *Geophysics and in situ testing alone can be misleading and delay project*
- **We don't know what we are measuring until we look at samples of the ground**

EVEN WITH INTRUSIVE GROUND INVESTIGATION AND SAMPLING – WITHOUT UNDERSTANDING, WE ARE STILL GROVELLING ABOUT IN THE GROUND

WHY THE GROUND IS SO VARIABLE

Primary (environment of deposition) variability

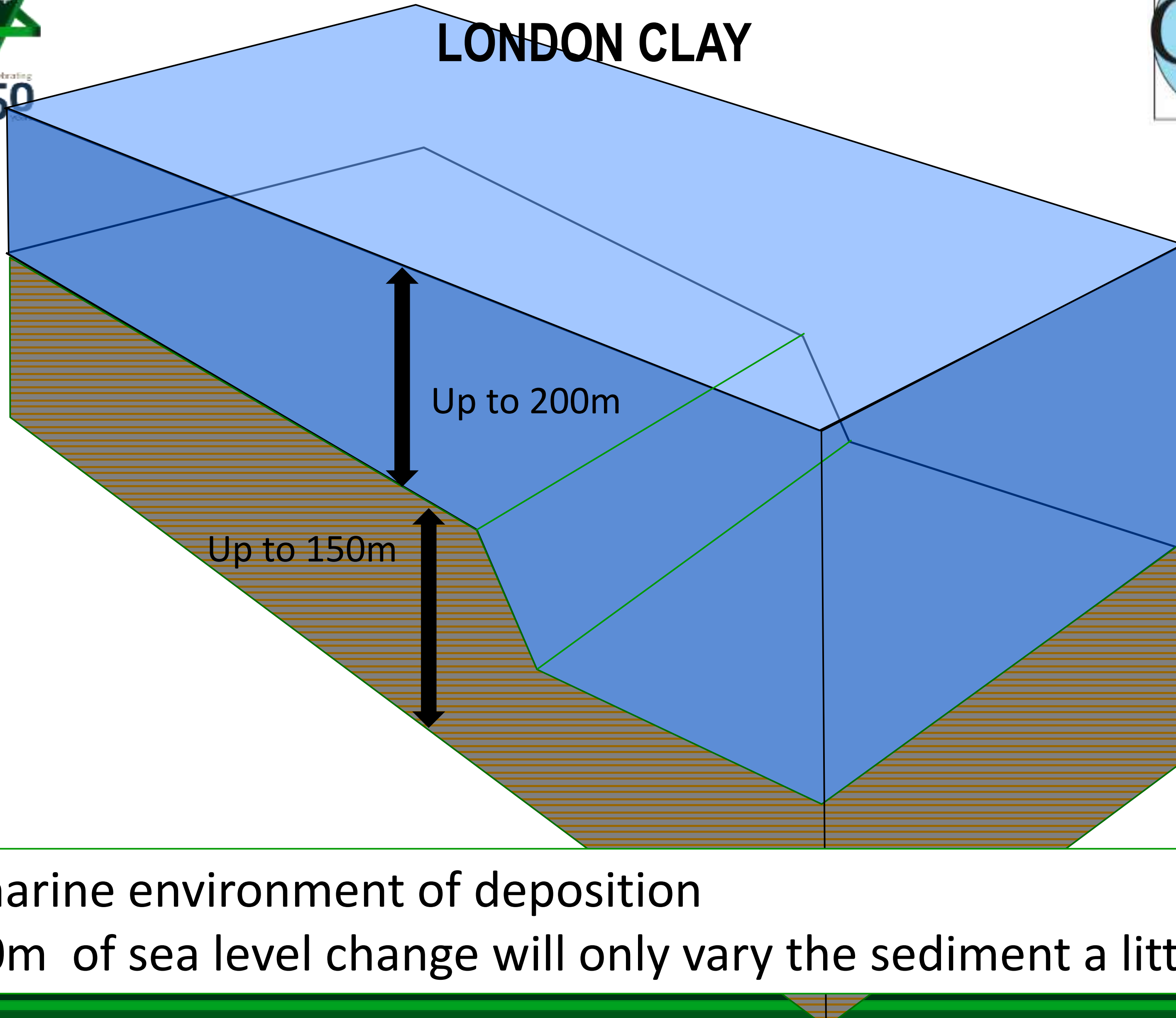
Secondary variability – cementation/weathering soon after deposition

Later variability – faulting, Quaternary weathering

PRIMARY VARIABILITY

Variability which happens during deposition

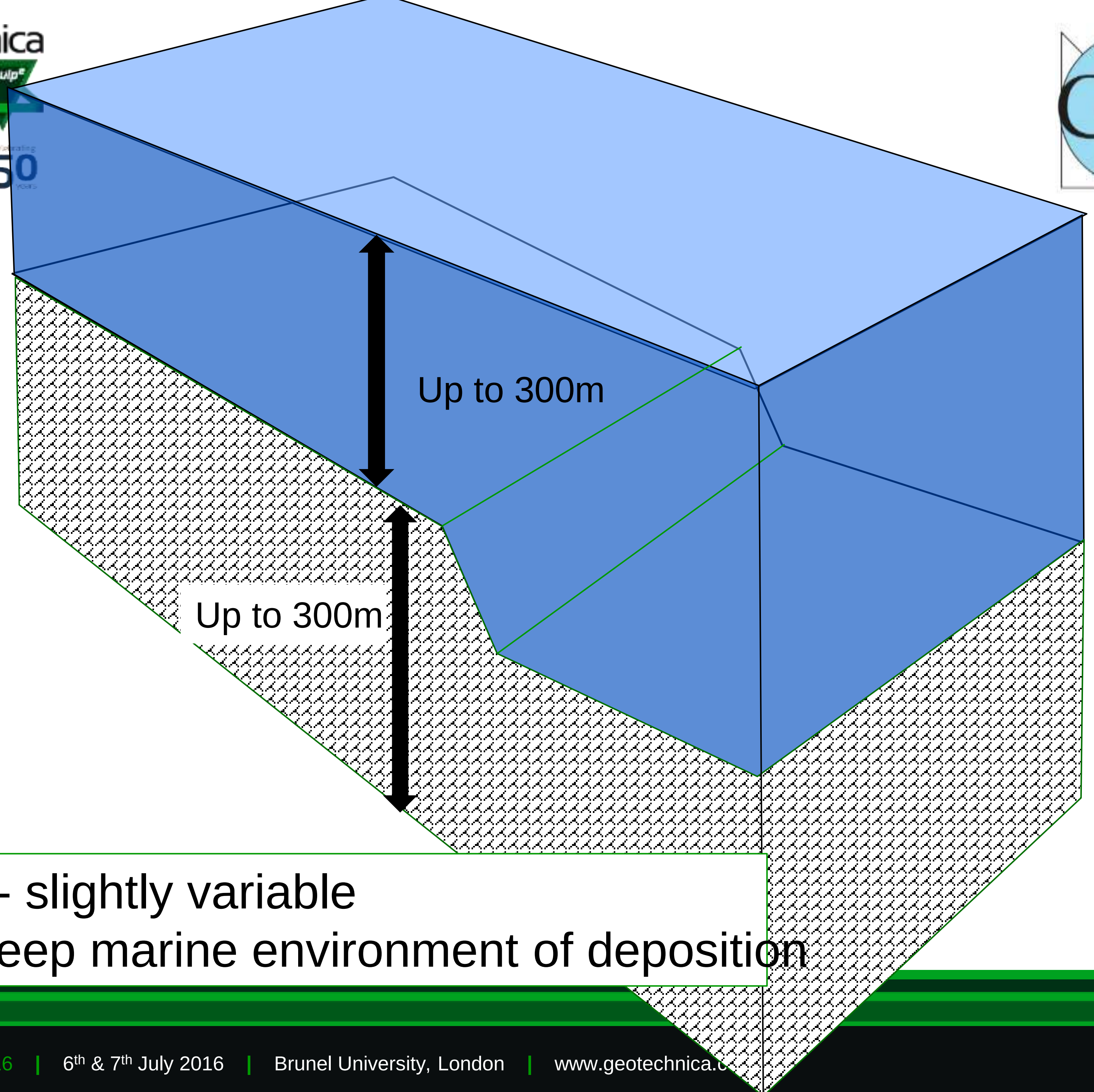
LONDON CLAY



Deep marine environment of deposition
Even 20m of sea level change will only vary the sediment a little

LONDON CLAY

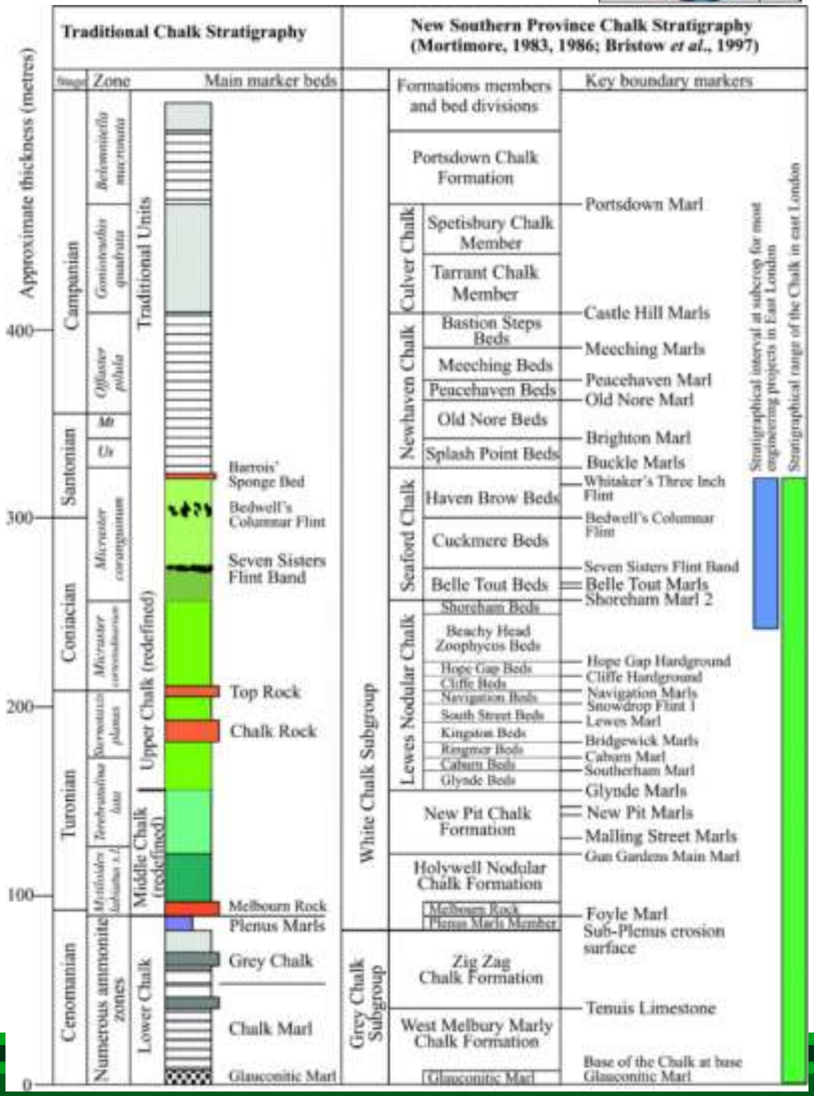
- P*rimary variability* minimal in London (silty, sandy clay, partings of silt and sand)
- *Secondary variability* – ‘claystone’ formation
- Probably more affected by *faulting* than we think
- Good logging very important



Chalk - slightly variable

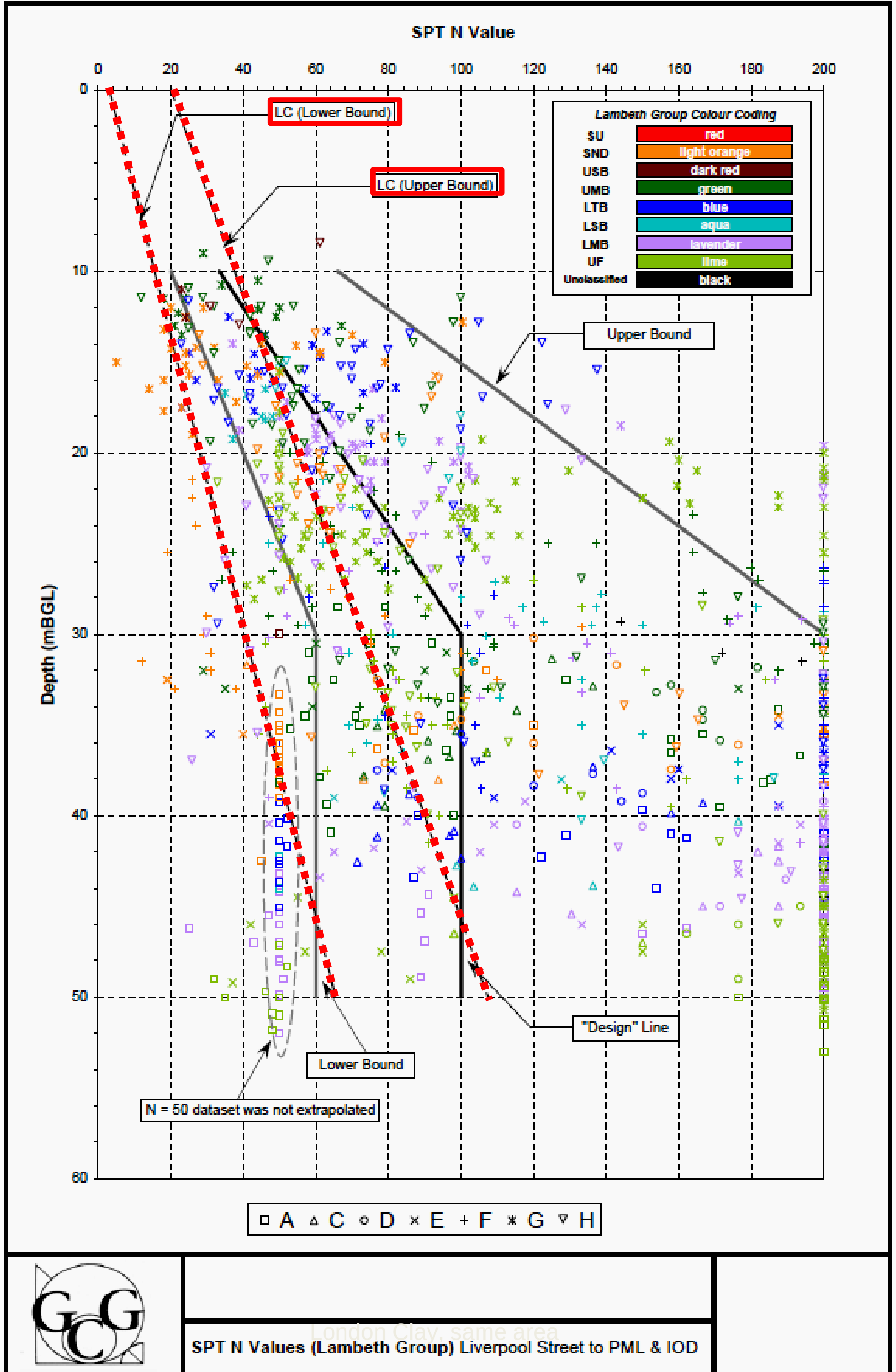
Very deep marine environment of deposition

CHALK



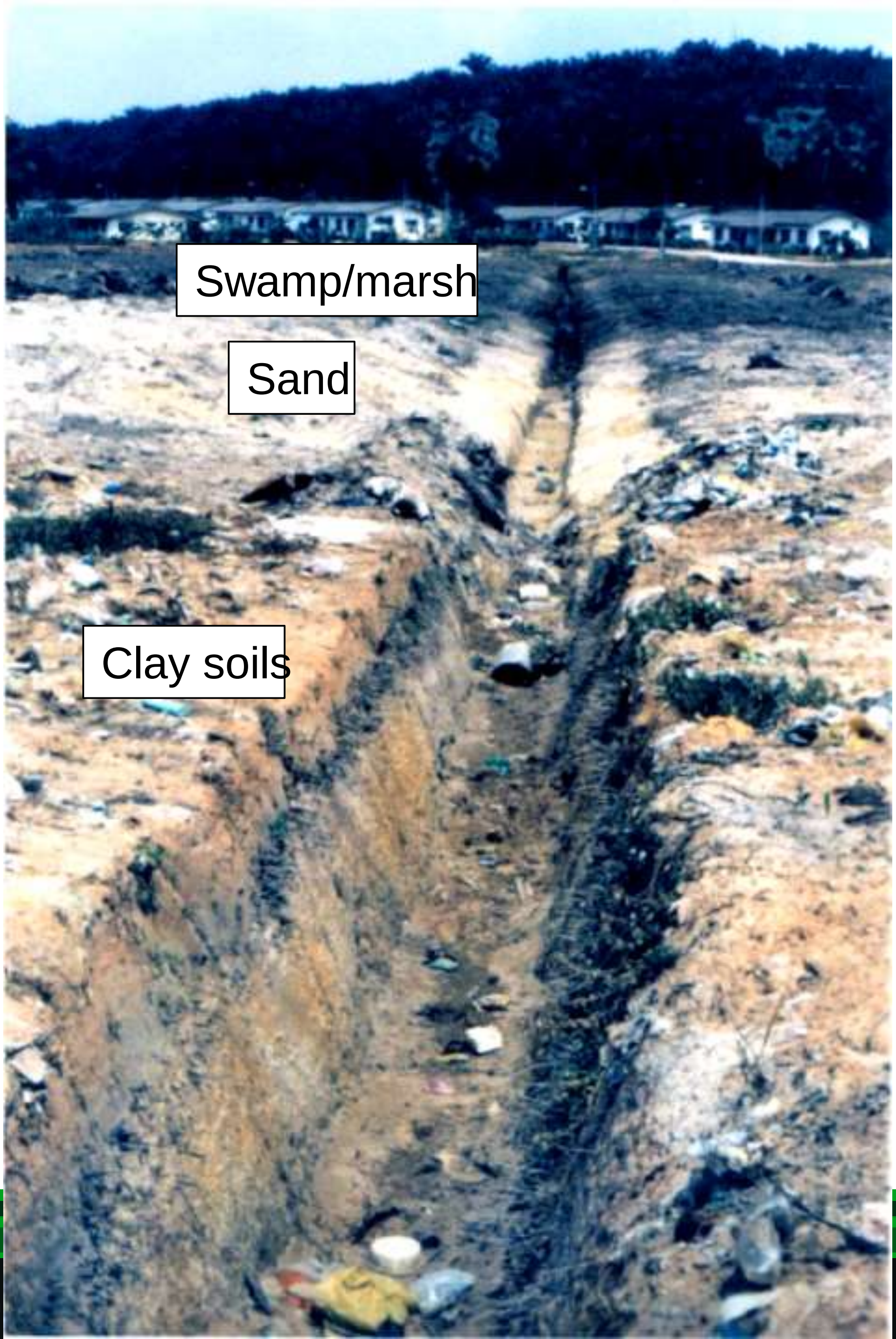
- Low(ish) primary variability
- High vulnerability to late stage variability – solution, freeze thaw

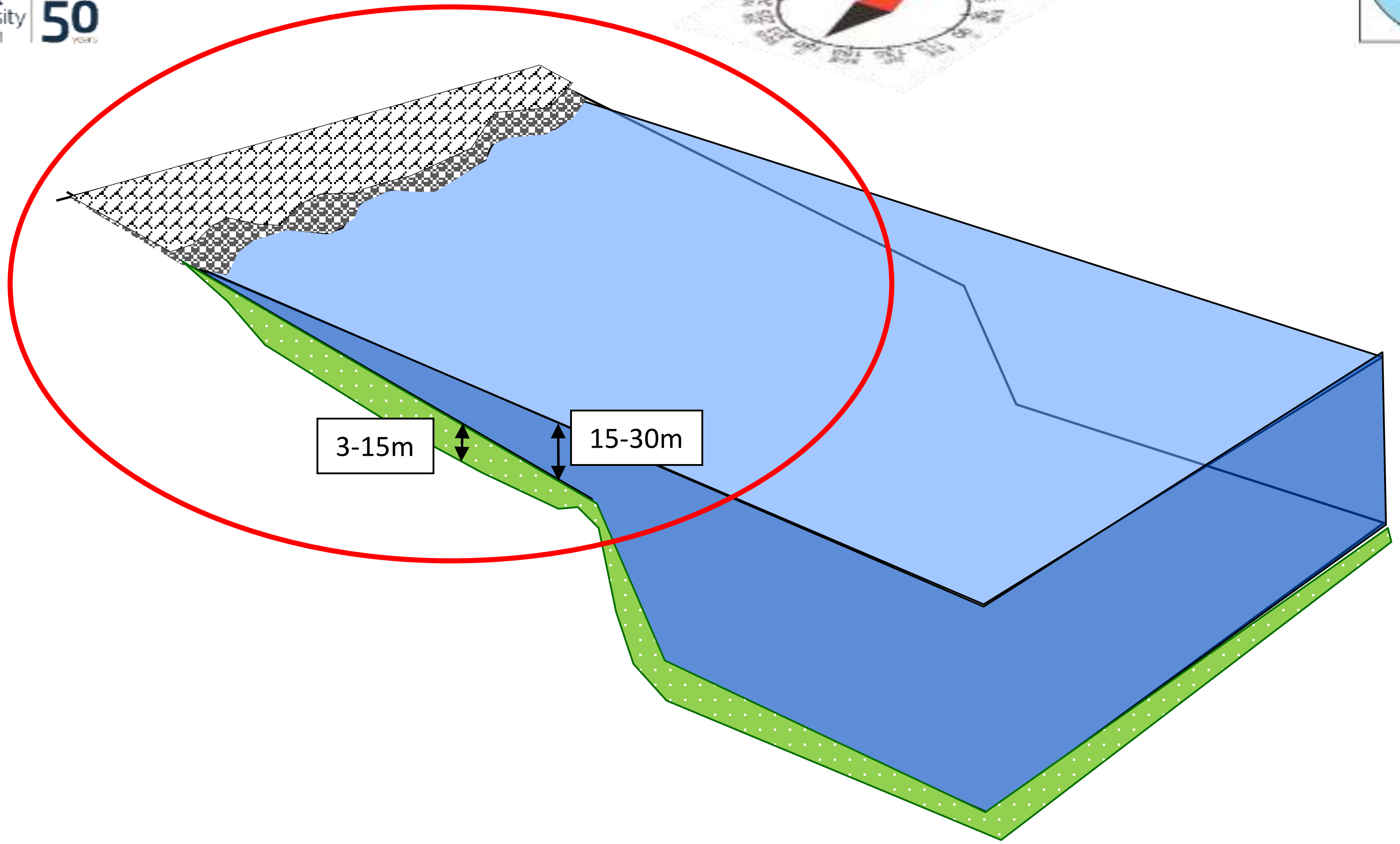
Lambeth Group sediments. Quite variable



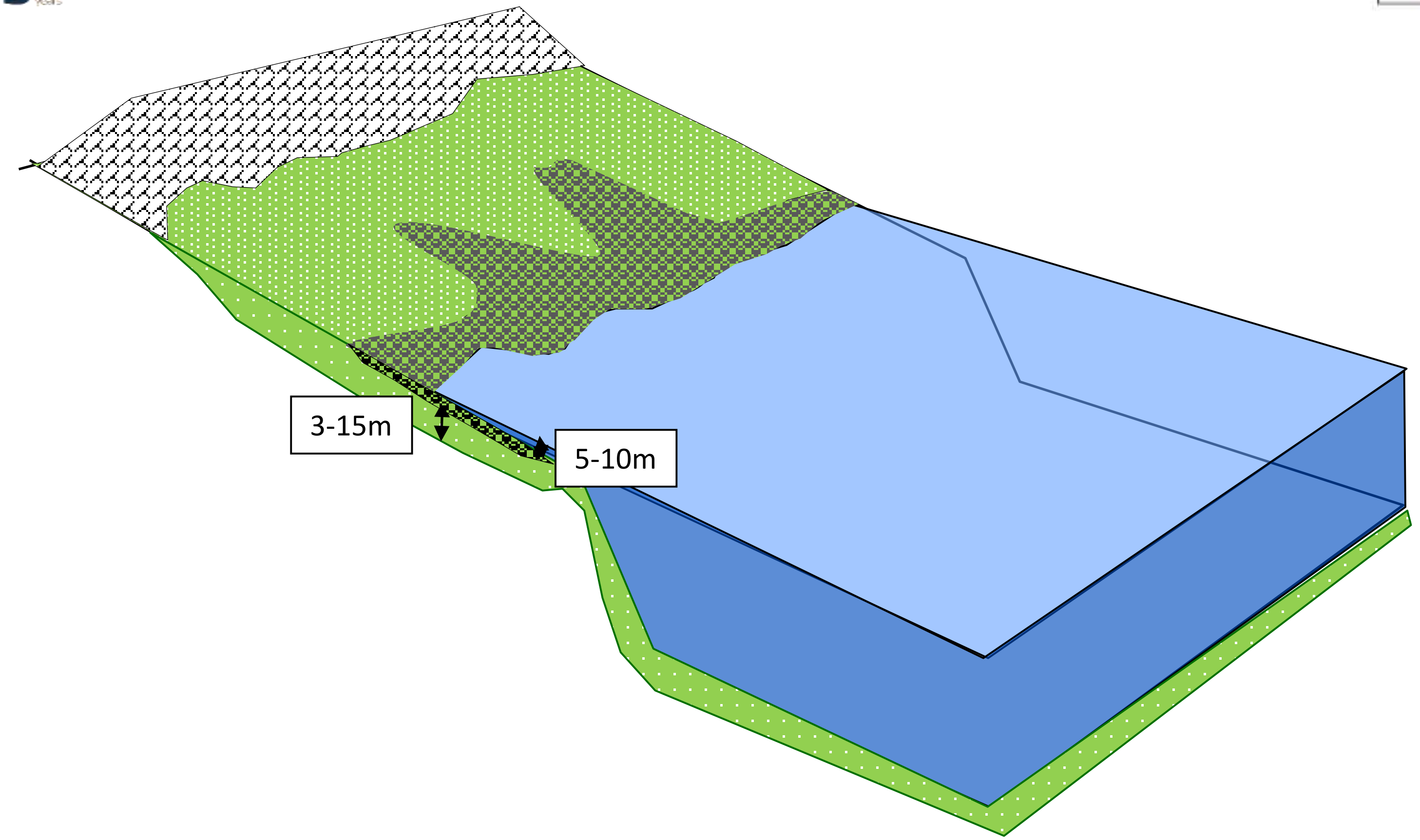
Wide range of SPT values compared to London Clay (same area)

LATERAL VARIATION IN COASTAL PLAIN AREA, MALAYSIA



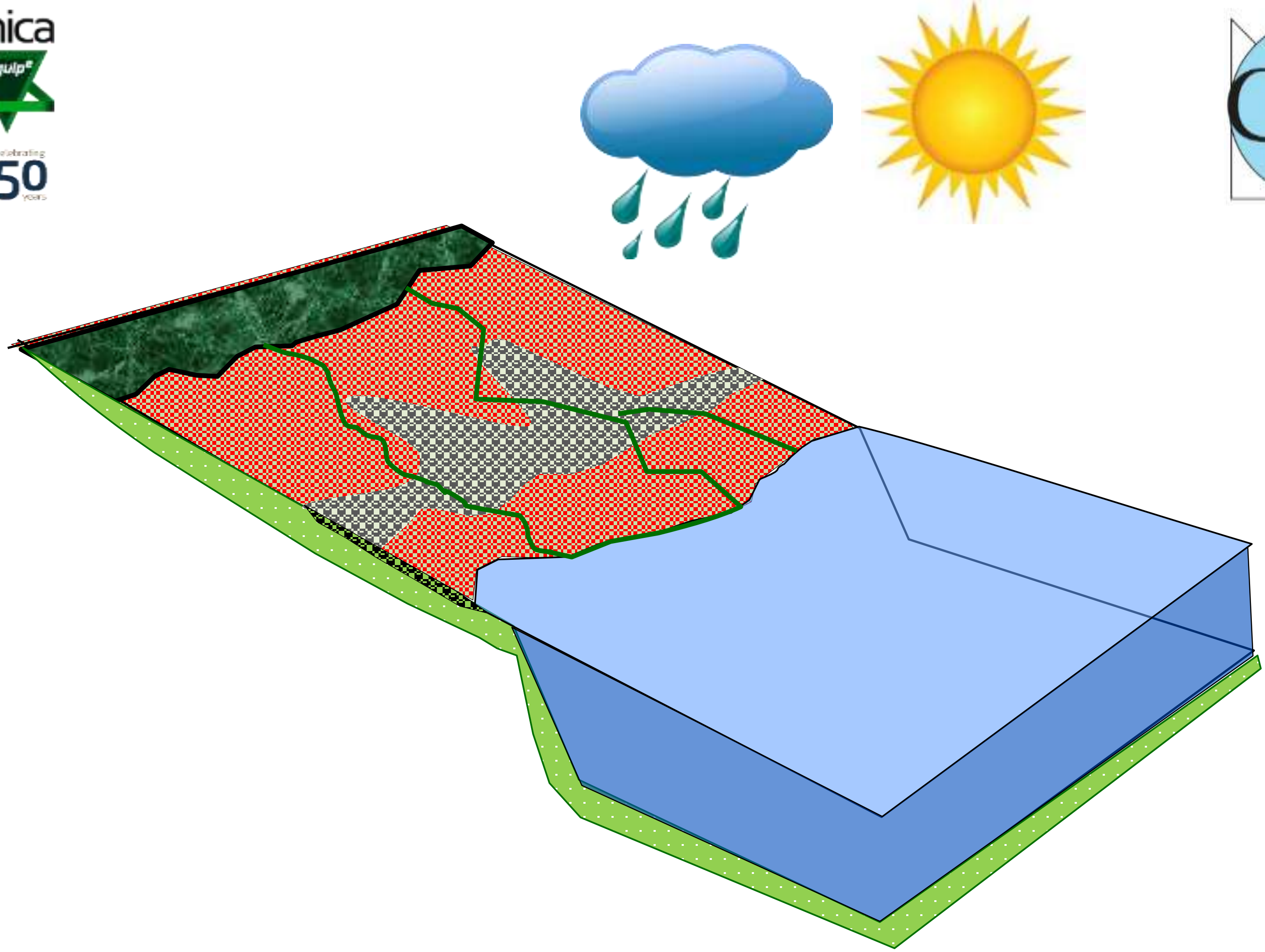


Upnor Formation - Shallow marine, sand flats to estuarine environment of deposition with occasional ash falls

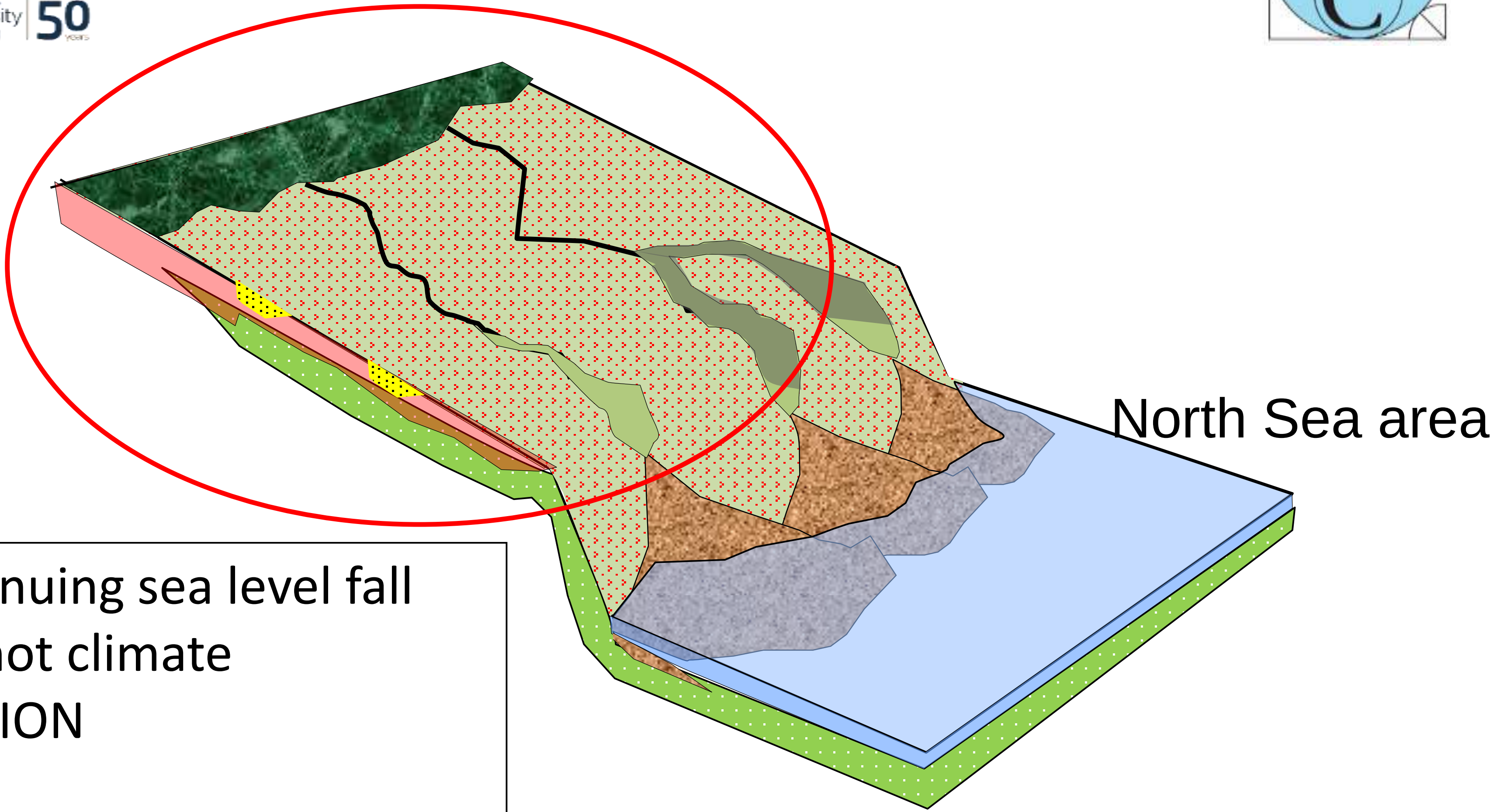


Sea level fall and uplift of Chalk –

Upnor Pebble Beds and shallower marine or estuarine sediments



More sea level fall and **weathering –**
Reading Formation **Mottled Upnor and Lower Mottled Beds**



Continuing sea level fall
and hot climate
EROSION

The MID LAMBETH HIATUS
– regionally recognisable
erosion boundary

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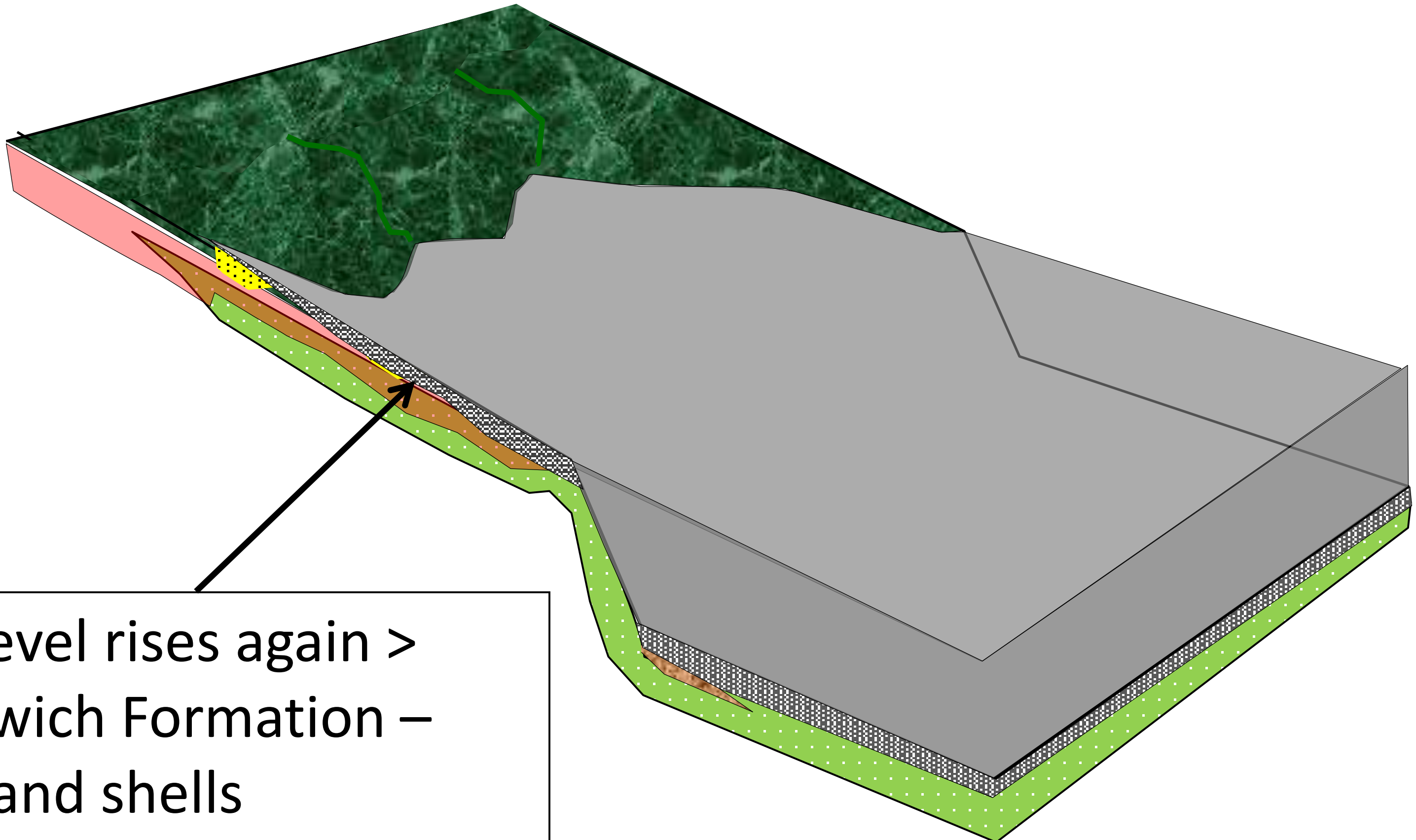
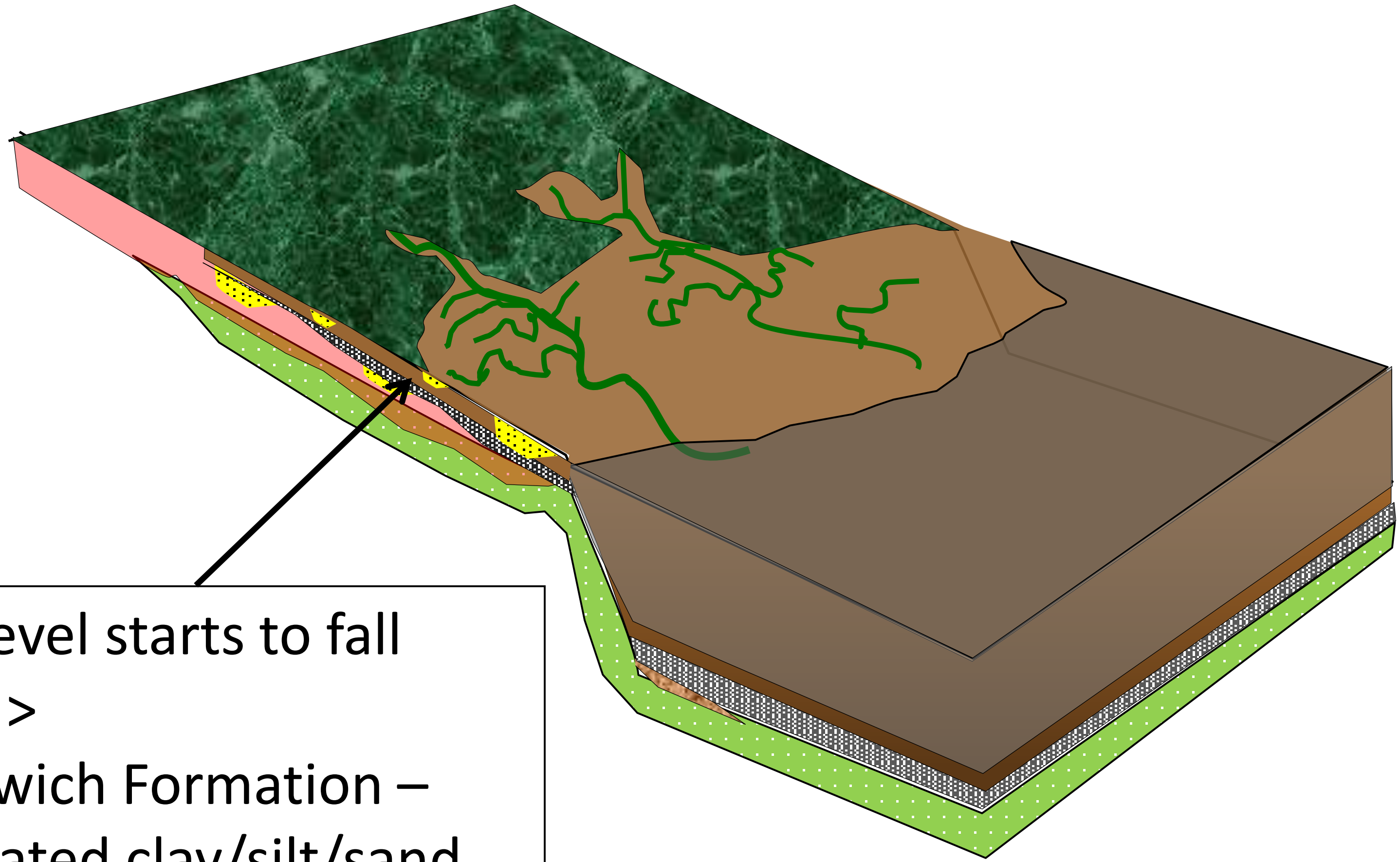
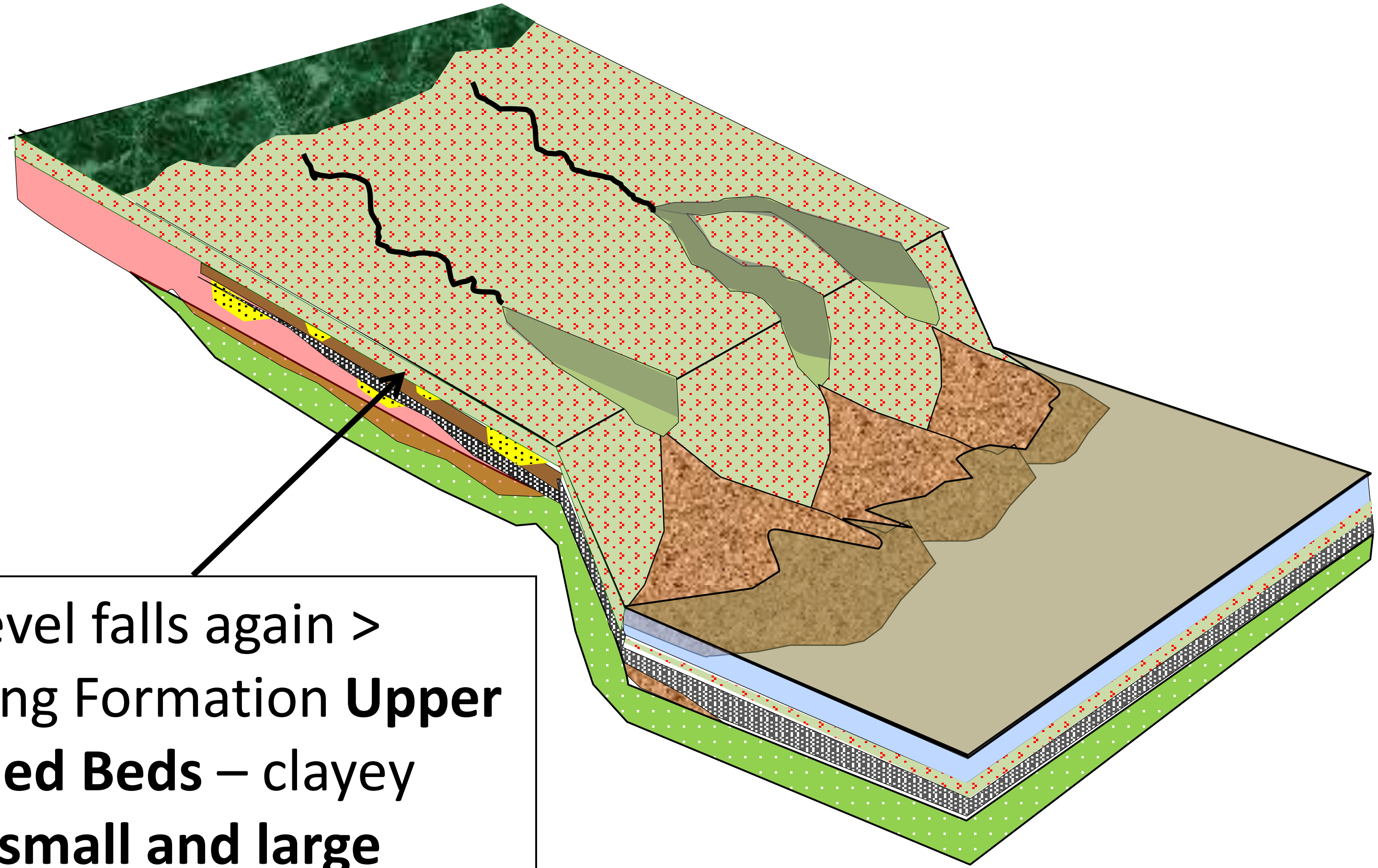


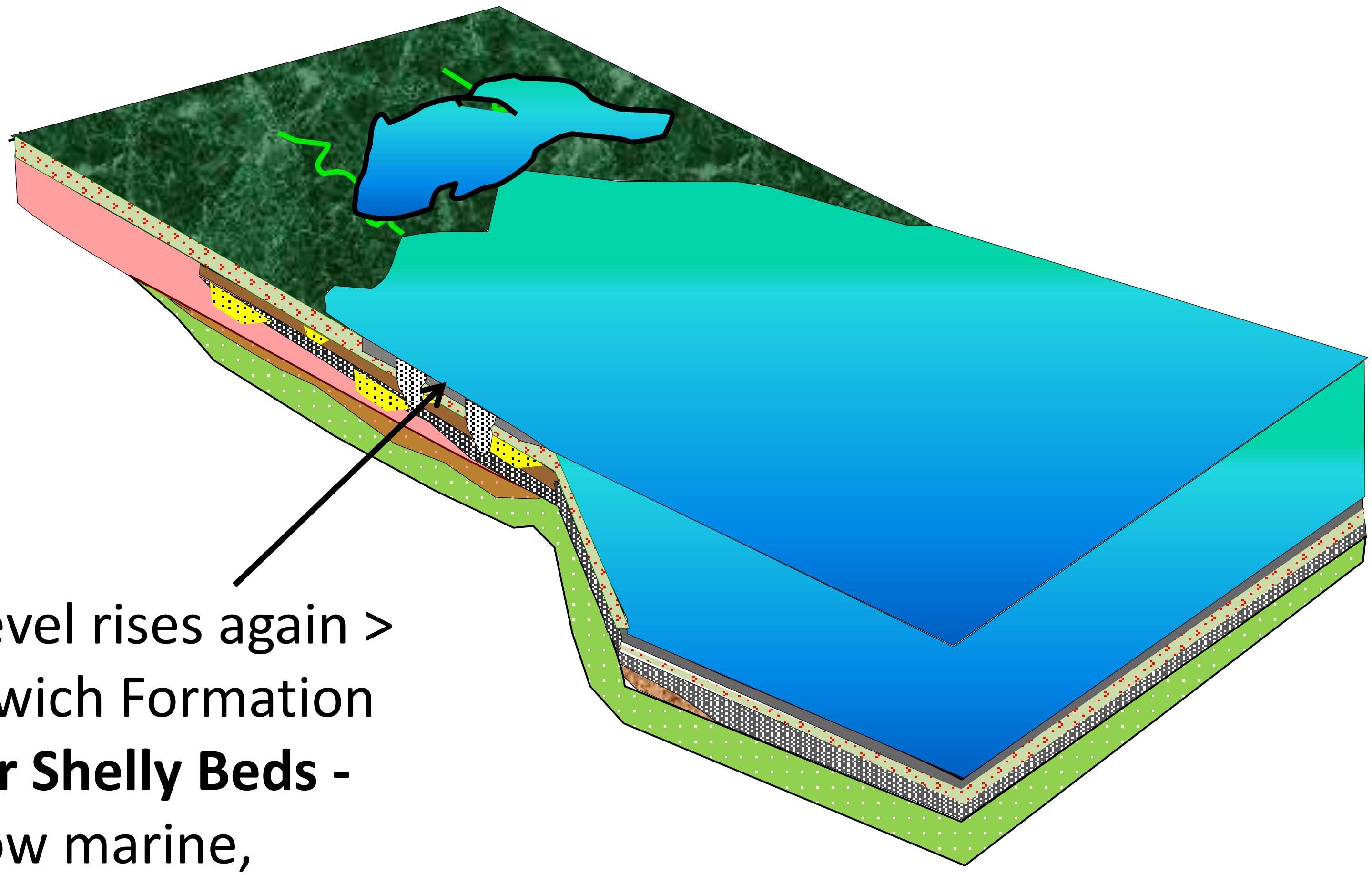
Sea Level rises again > Woolwich Formation – clays and shells (Woolwich Formation **Lower Shelly Beds**) deposited. Gets thinner westwards across London



Sea Level starts to fall again >
Woolwich Formation – laminated clay/silt/sand (**Laminated Beds** and Sand Channels)



Sea level falls again > Reading Formation **Upper Mottled Beds** – clayey with **small and large channels**



Sea level rises again > Woolwich Formation

Upper Shelly Beds - shallow marine, estuarine, river and lake sediments plus cemented layers

SECONDARY VARIABILITY

- Weathering that happens soon after deposition
- Cementation- e.g. with calcium, iron, silica

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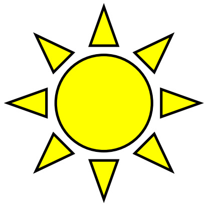
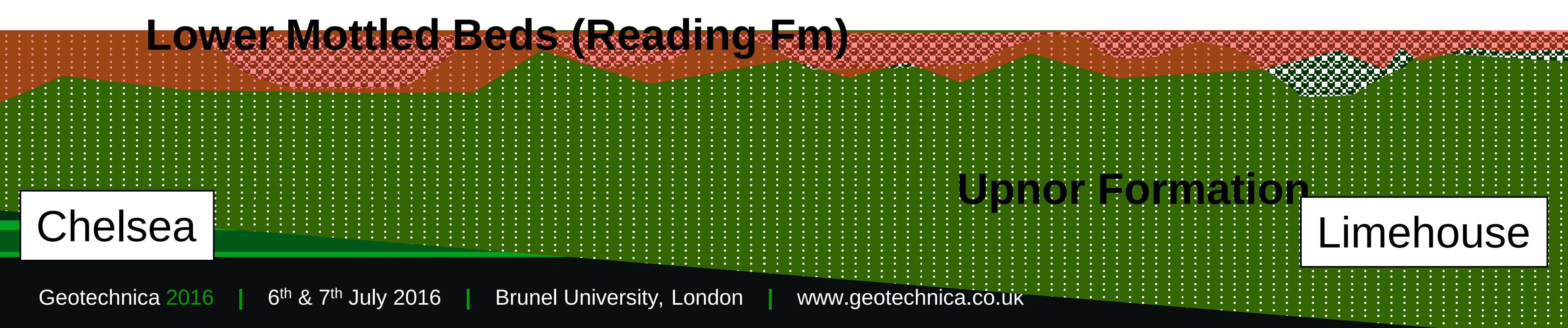
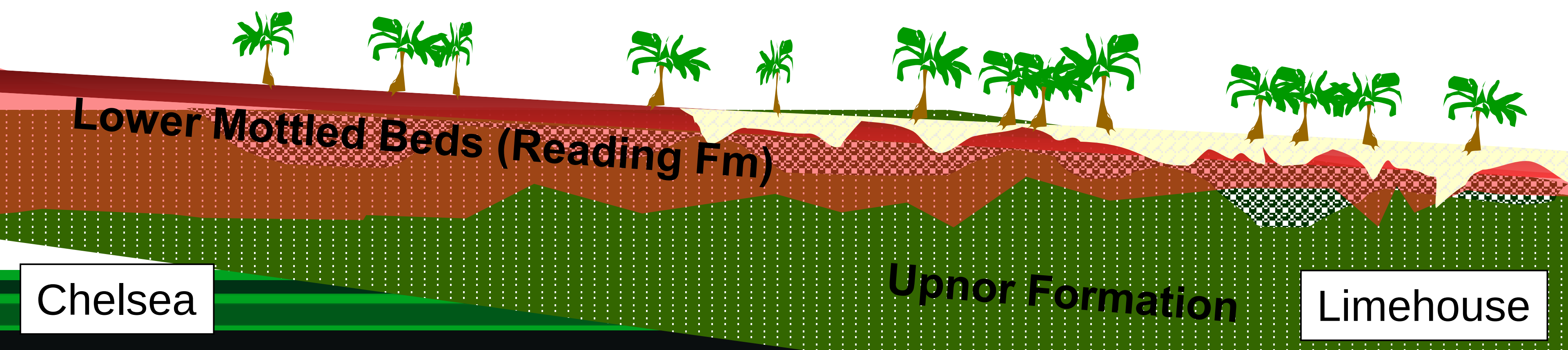


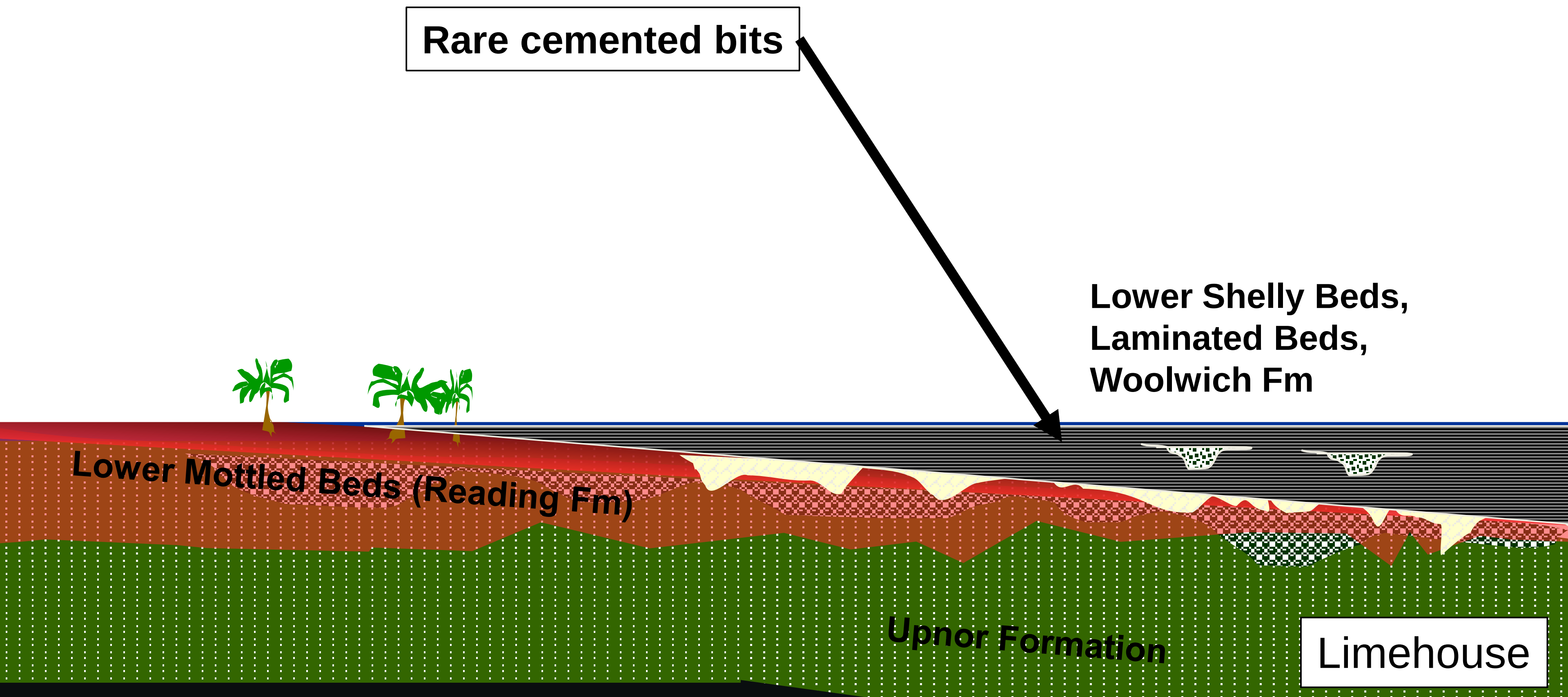
Upnor Formation emerges above sea level, gets weathered



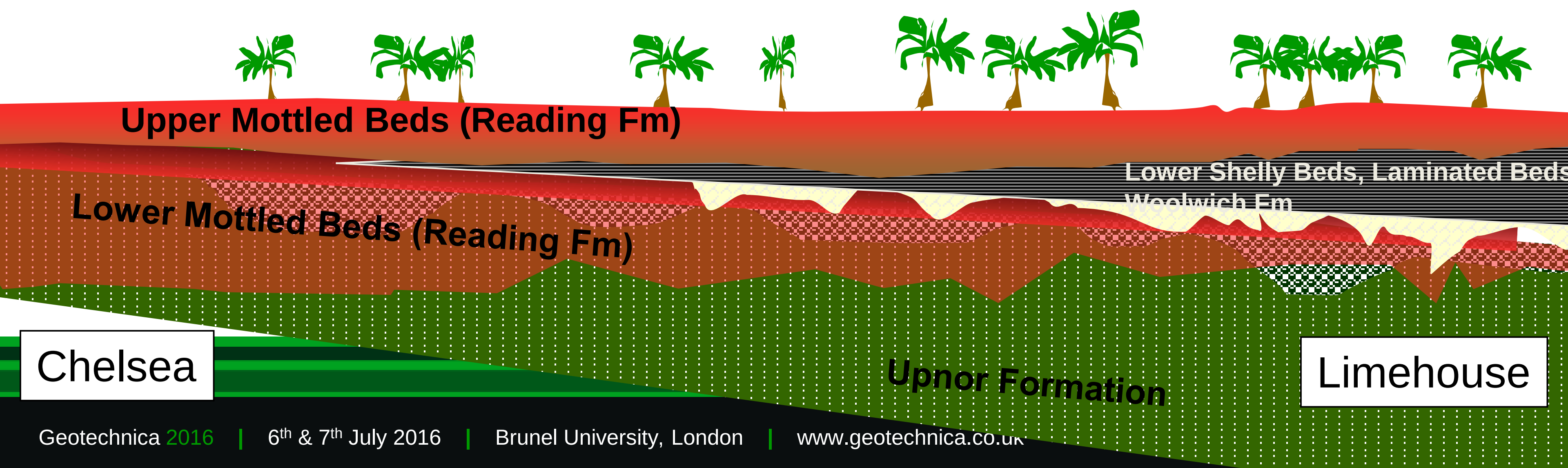
Even more weathering –cementation with calcium, silica



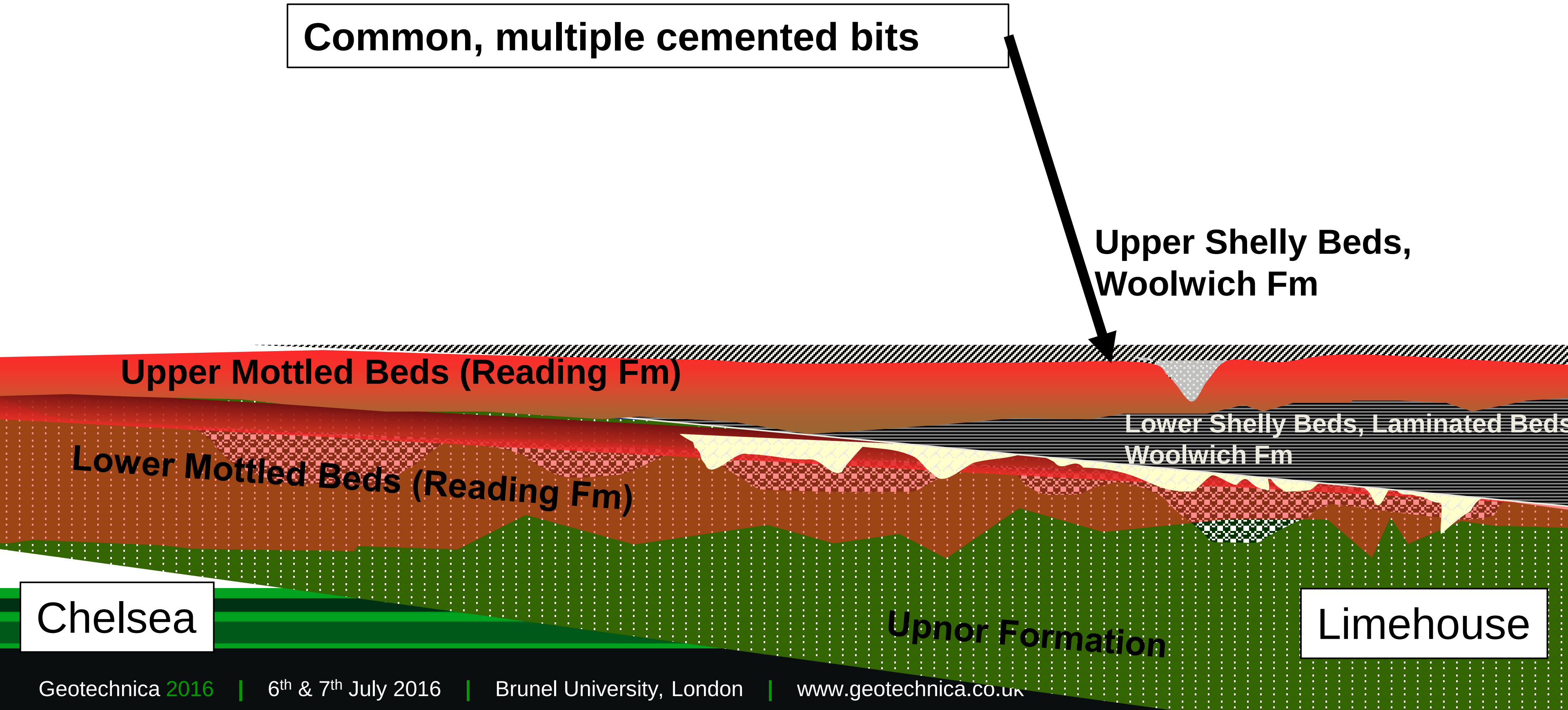
Cycle 2:
Sea level rises, estuaries form



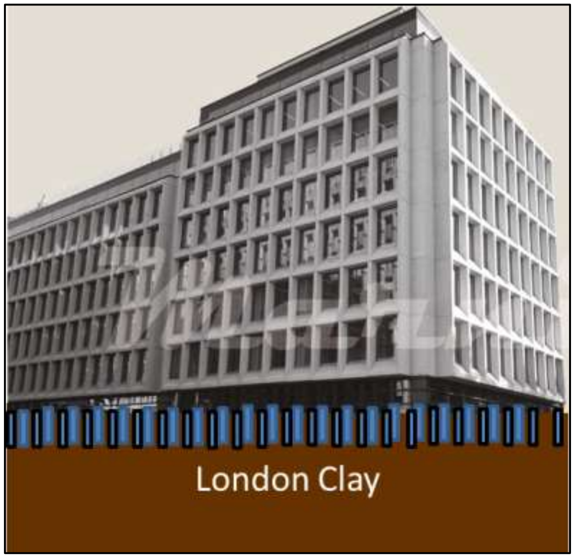
Cycle 2:
- More weathering



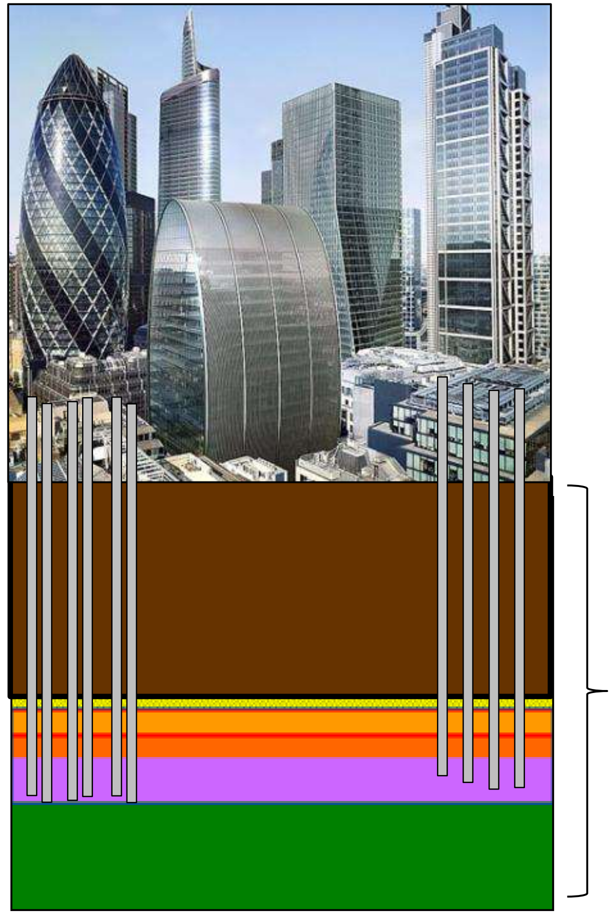
Cycle 3:
Sea level rises again, a bit



"BUT WE'VE GOT OLD DATA FROM THE SAME SITE!"



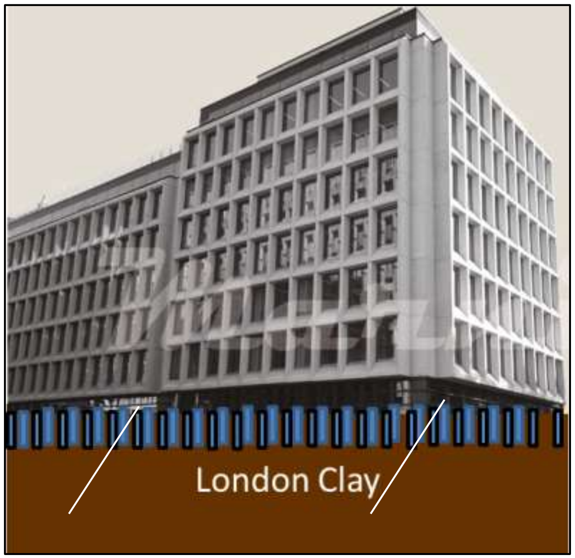
Loads spread - shallow piles over wide area



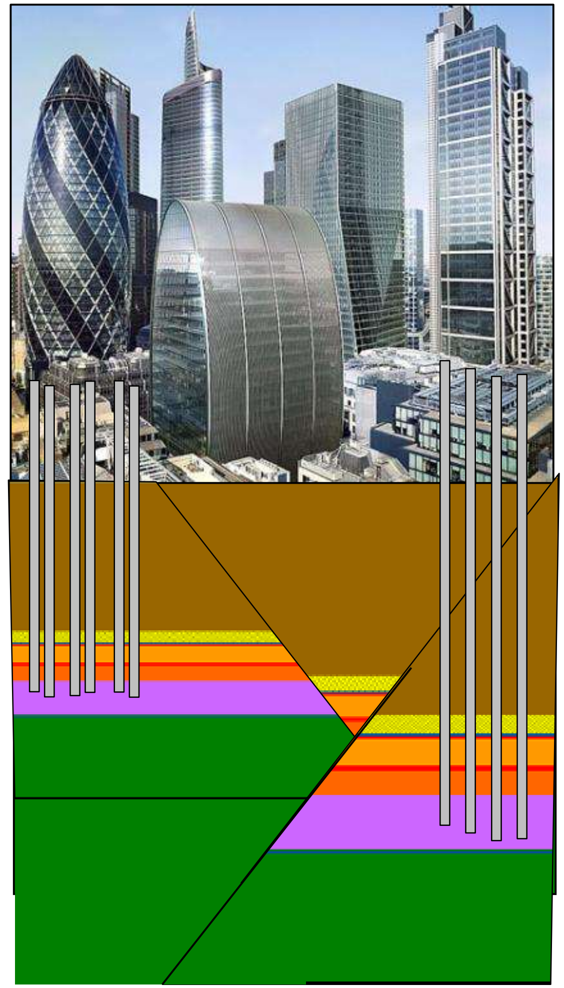
Increased number of geological strata, each with own risks, multiplies ground risk

Now, loads taken on fewer cores and deeper piles into ?Thanet Sand

SAME SITE, ACTUALLY FAULTED



- Shallow SI
- Faults unnoticed in London Clay



Faulting further increases number of geological risks, multiplies ground risk

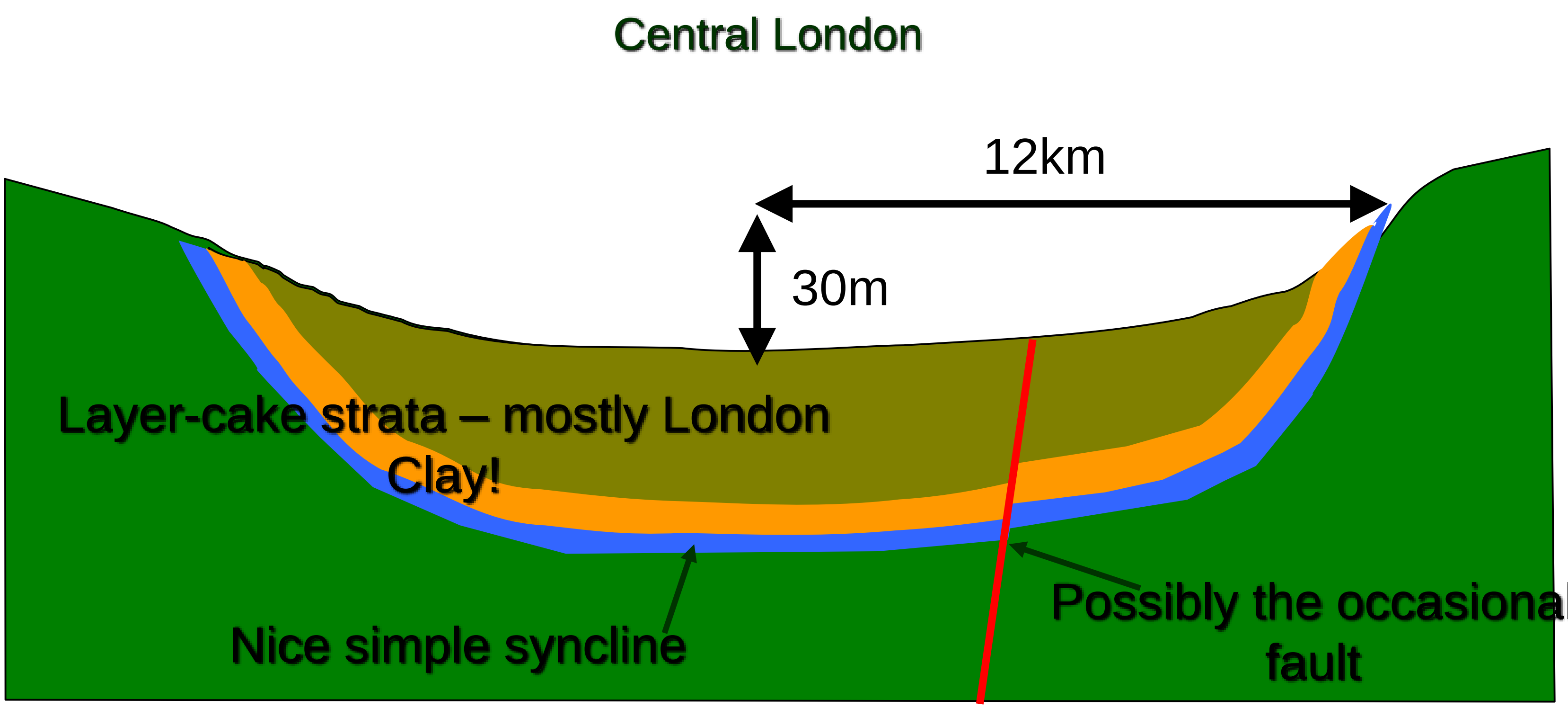
London Clay (not showing faulting)

...FAULTING

- The Lambeth Group is *the unit that makes faulting visible*
- Further complicates existing variability

Lambeth Group (showing faulting)

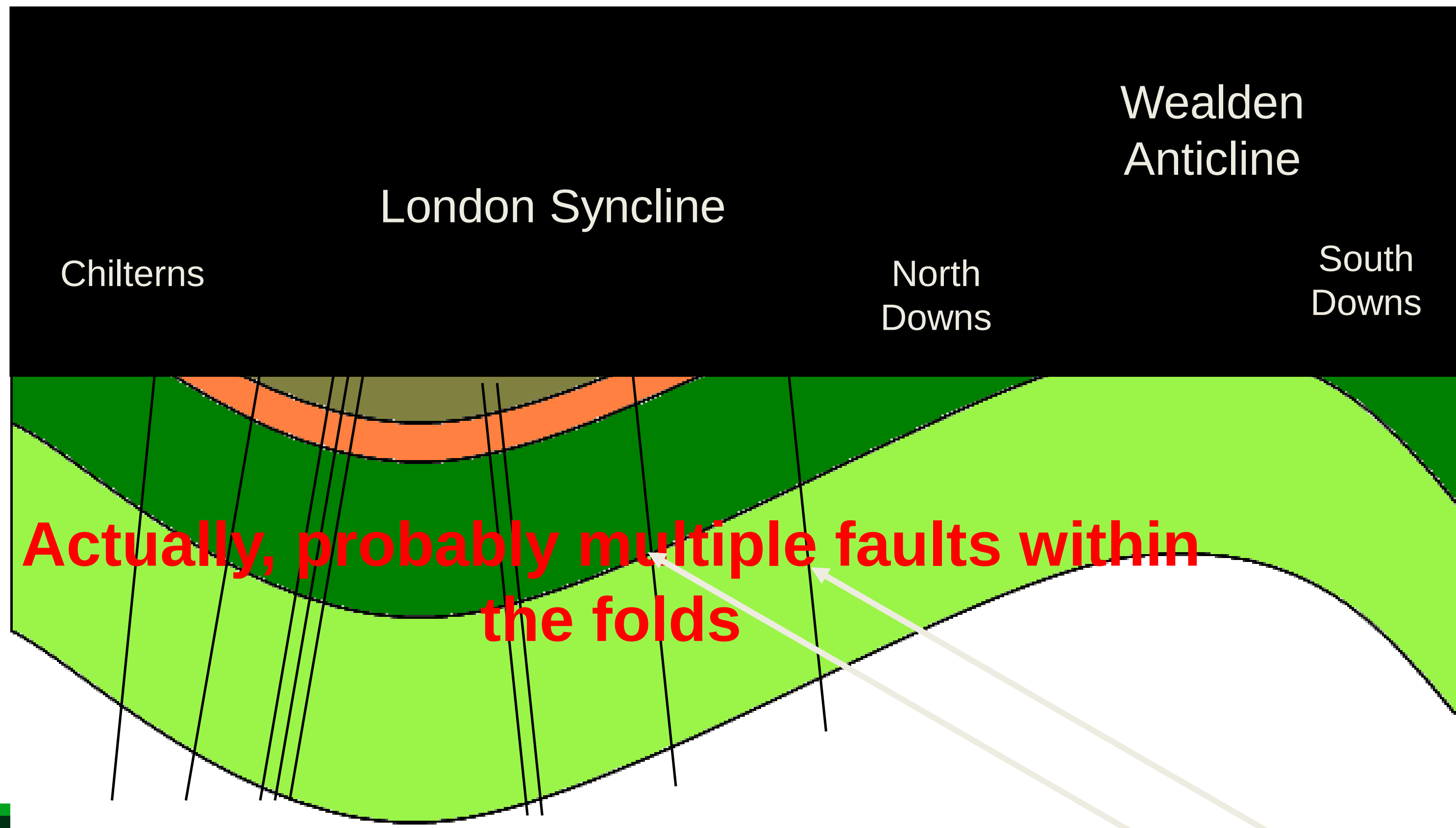
FAULTING AND THE LONDON BASIN – THE VIEW UNTIL QUITE RECENTLY



North of London

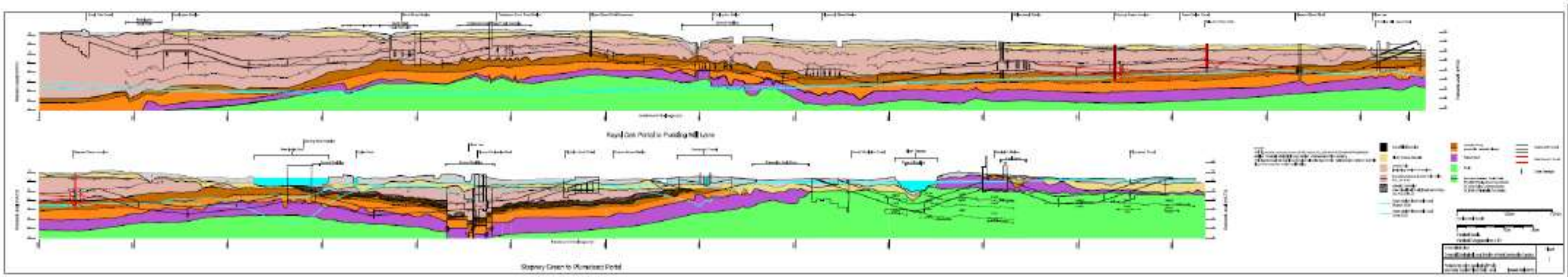
The South Coast

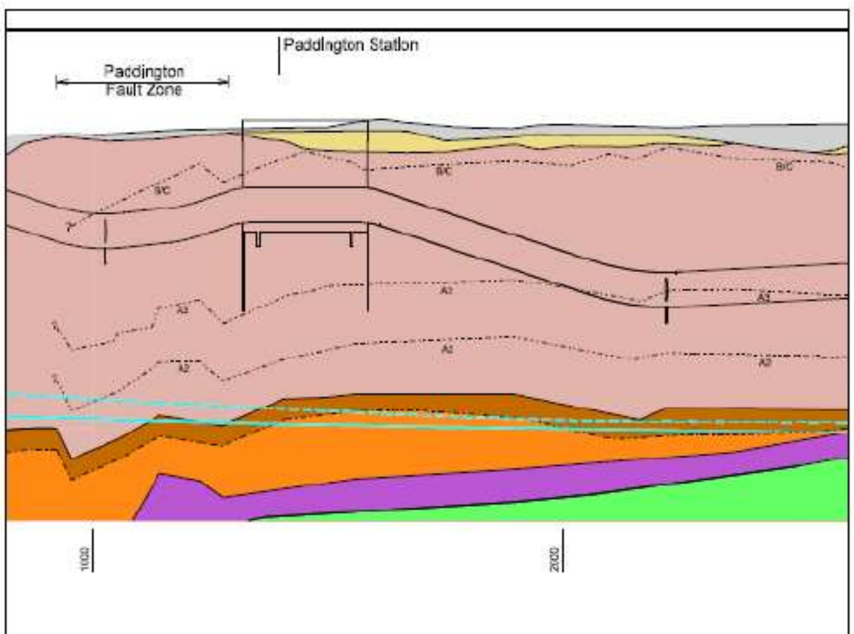
Erosion

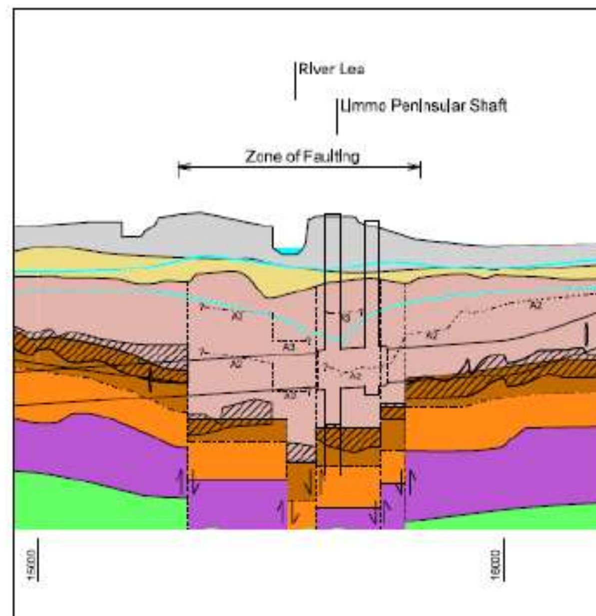


White Cliffs of Dover

CROSSRAIL – AT LEAST MAJOR 6 FAULTED ZONES





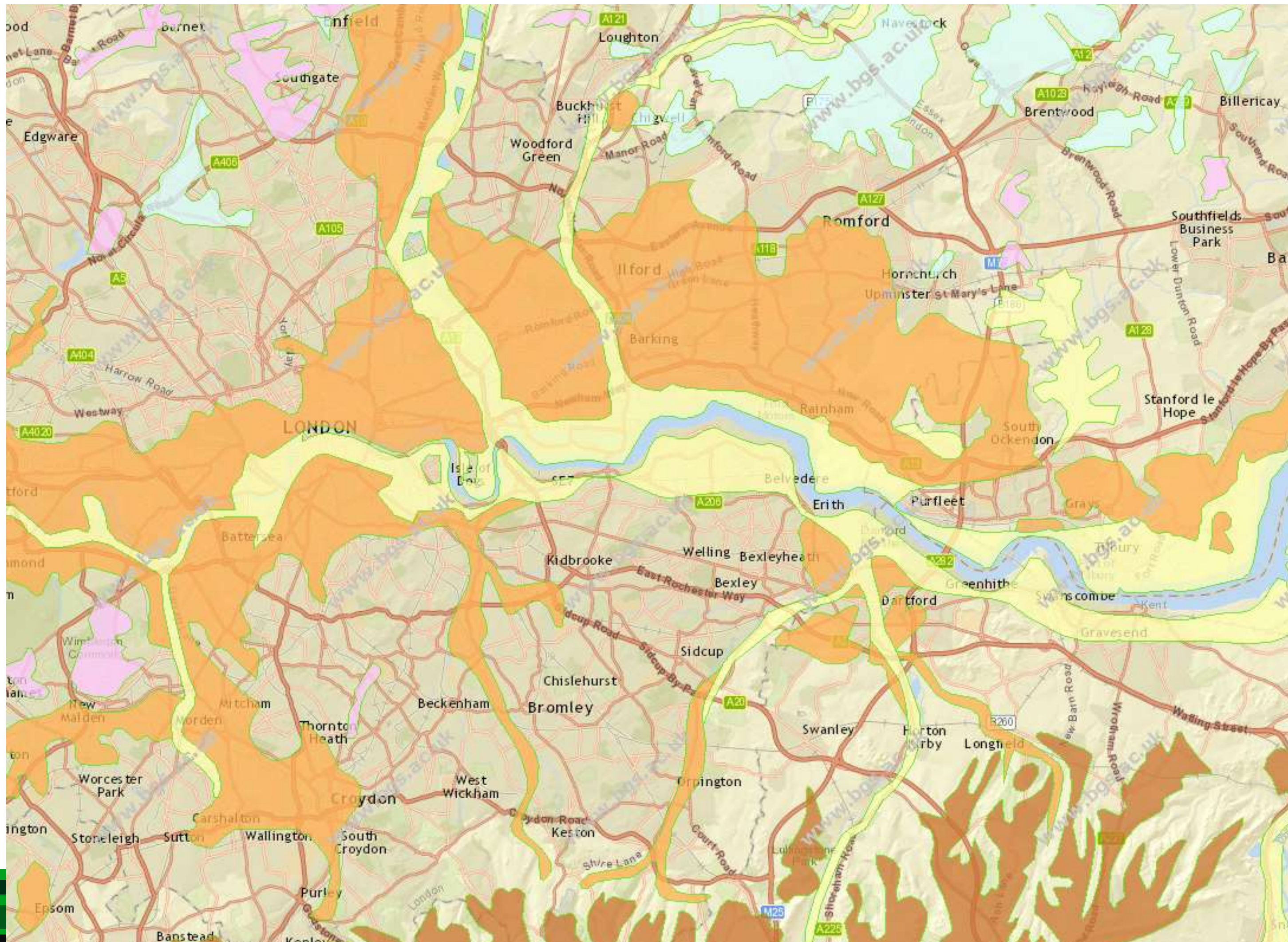


LATER STAGE VARIABILITY

Quaternary (ice age) weathering, faulting etc, last 800,000 years

- Sediments of (mostly) cold, some warmer phases in London
- *Large scale* sea level fall and rise - **90m**
- Periglacial features
- Erosion

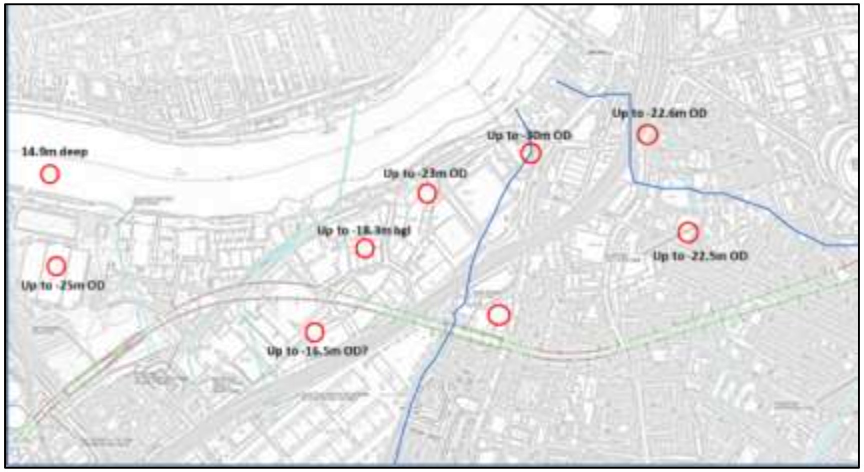
COMPLEX THAMES RIVER TERRACES

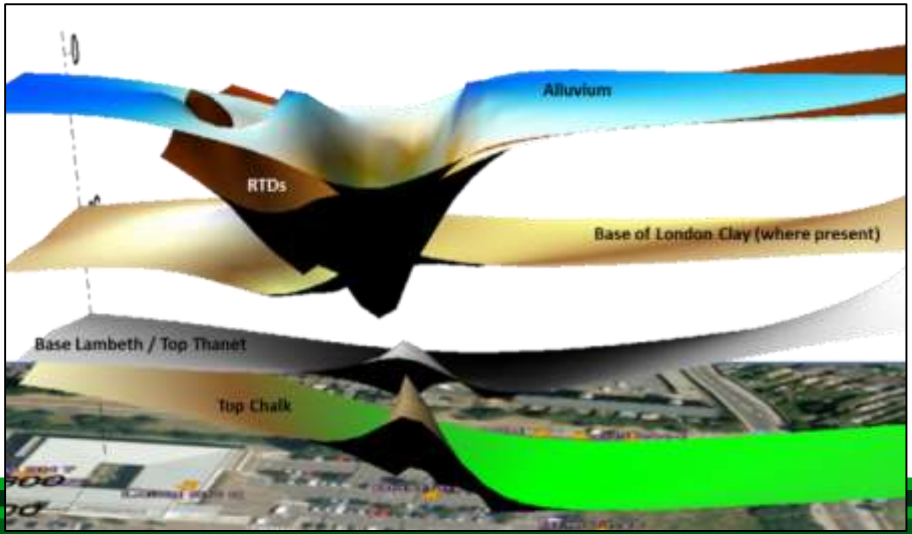


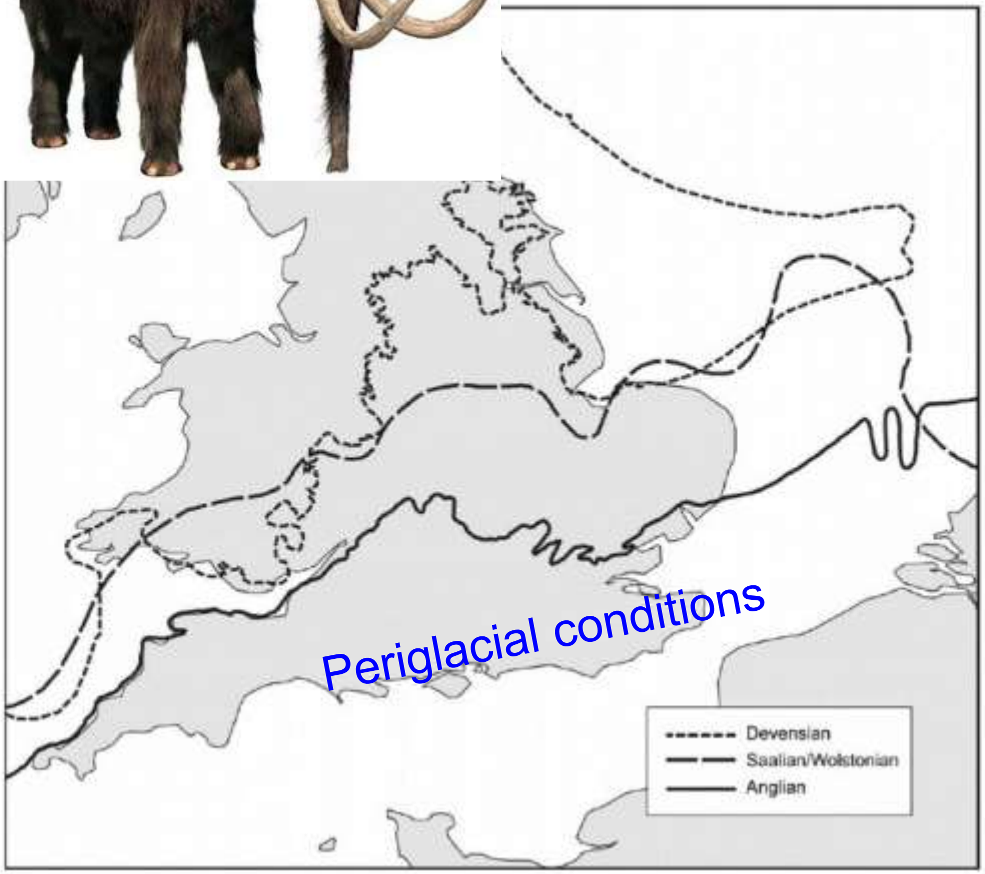
DRIFT FILLED HOLLOWS – "JUST A HOLE FULL OF GRAVEL"

Recently examined large DFHs show us-

- Not just 'scours'
- Complex 3D features often surrounded/underlain by weak materials
- Potentially involving solution, faults, complex infill materials
- May follow faulted zones







Reconstruction of extent of Devensian ice sheet (dashed line) (Gibbard and Clark 2011)

Ice wedges, Essex

Solution/sinkhole features, K

AND THE ANSWER IS?

In order to understand normal ground variability we *still* need:

- historical data
- well planned, interpreted intrusive site investigations
- and laboratory testing, for successful construction

In situ testing and geophysics are excellent tools used in conjunction with the above