THE LAMBETH GROUP OF SE ENGLAND - LESSONS FOR THE SOILS OF PERTH ?

Jacqueline Skipper
Senior Geologist, Geotechnical Consulting Group, Scientific Associate, Natural History Museum London

ABSTRACT

The Pleistocene to Holocene sediments of Perth, Australia (Guildford, Swan River and Perth Formations – formerly collectively the Guildford Formation) demonstrate striking similarities to those of the Lambeth Group (Palaeocene/Eocene) of SE England, both in regard to the lithologies themselves and their variability.

In the UK, application of oil industry stratigraphic techniques, in addition to training in the stratigraphy, has improved interpretation standards and prediction of the lithologies within the Lambeth Group. This in turn has led to refinements in design and hazard management of the sediments. This paper discusses how these techniques have evolved in the UK over the past 20 years and whether similar techniques would be advantageous in these similar sediments in Australia.

1 THE LAMBETH GROUP

The Lambeth Group sediments of SE England comprise the Woolwich, Reading, and Upnor Formations. They are approximately 55-56 million years old, overlie the Palaeocene Thanet Sand Formation and Cretaceous Upper Chalk, and are overlain themselves by the basal Eocene Thames Group – frequently by the London Clay Formation. They occupy the London and Hampshire Basins in England. Similar sediments, of similar age, occupy parts of the Paris and Belgian Basins.

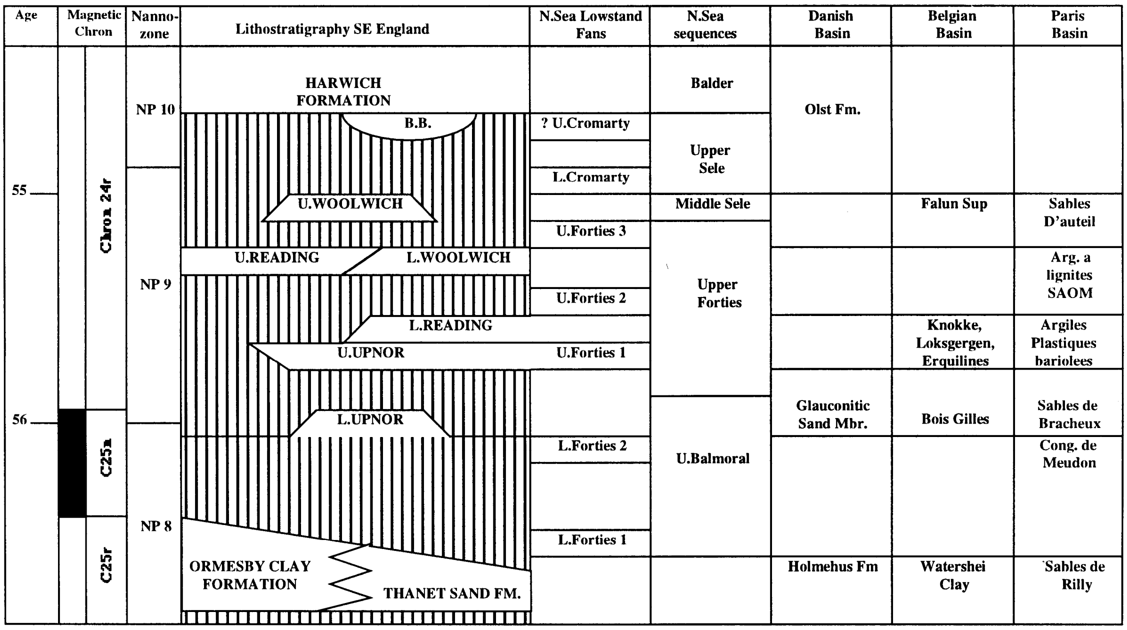

Figure 1: Palaeocene to early Eocene sediments of SE England after Knox (1996). B.B. = Blackheath Beds.

The Lambeth Group sediments consist of laterally very variable shallow marine to terrestrial deposits: they range from pure clays through sands to coarse conglomerates.

At the time of their deposition, SE England stood at 40°N - 10° nearer the equator than today – compared to Perth at 30° S. The climate at the time, (inferred from isotope work and fossils) indicate that the climate was sub-tropical (Thomas, 1998). The North Atlantic at this time was far narrower than today and the Mid Atlantic spreading ridge of that time would have been present just to the north-west of Scotland (Stott *et al.*, 1990). Volcanism was prevalent in Scotland during this period and ash from the volcanoes regularly fell over SE England (Knox, 1998). While many of these environmental details appear very different to Perth the similarity is in the environments of deposition – both were deposited in marginal marine to fluvial and terrestrial environments.

This wide range of environments is the primary reason for these sediments' (and all terrestrial-to-shallow marine sediments worldwide) variability. This extreme variability is reflected both in the behaviour of the Lambeth Group lithologies, in their hydrology and historically has caused them to be problematic in civil engineering situations. Indeed, the presence of Lambeth Group sediments in a near-surface position in south London is one of the principal reasons that this area has not, historically, had as extensive an underground railway network as the north of London.

2 LAMBETH GROUP – HISTORIC ENGINEERING PROBLEMS

The historic engineering problems associated with the Lambeth Group can be summarised as follows:

- Laterally and vertical variability has meant the sediments have been difficult to classify.
- Because they are difficult to classify, logging sediments and identifying boundaries has been problematic – and this in turn has led to inadequate characterisation.
- Because of the aforementioned factors, a frequent problem is poor anticipation of ground conditions, such as hard beds, pebble beds and water-bearing sand channels.
- Because ground conditions are poorly understood, hydrological gradients and dewatering problems are seldom well anticipated.
- Because of the presence of volcanic ash and post-depositional conditions, clay mineralogy content varies from very high- to very low- swelling clays.
- Because ground conditions are frequently unforeseen, risk assessments are difficult to undertake.
- Finally, because of confidentiality and the risk of litigation, there has historically been little communication of these problems and therefore poor transfer of knowledge between contracts.

It is clear that many of these problems are common to all sediments of this type and the 'Coming to Grief in the Guildford Formation' workshop papers made clear that these problems are also typical of the 'Guildford Formation' sediments.

3 LITHOLOGIES OF THE LAMBETH GROUP AND 'GUILDFORD FORMATION'

To date, at least 24 different distinct lithologies have been identified in the Lambeth Group across SE England. Here are just a few examples (from the bottom up, so oldest first):

Figure 2: Laminated shallow marine to estuarine sediments of the Upnor Formation. Rotary core from King's Cross, north London.

Figure 3: Upnor Formation/Lower Mottled Beds Pebble Beds – Canada Water Station excavation, Jubilee Line Extension Project.

Figure 4: Blue and brown mottled clay/silts. Lower Mottled Beds, Reading Formation, rotary core from King's Cross, north London.

Figure 5: Hard beds. Calcretes in a Crossrail cored borehole in east London. (Lower Mottled Beds, Reading Formation).

Figure 6: Intertidal Laminated Beds (Woolwich Fm).Excavation for Limehouse Link, east London.

Figure 7: Organic channel sands, in air shaft for Bermondsey Station, Jubilee Line Extension project (Upper Mottled Beds, Reading Formation).

Figure 7a: Organic channel sands in Laminated Beds, Woolwich Formation, from borehole for Thames Water Ring Main Extension project, Brixton, south London. Grey sand shows black fossil root remains.

There are many comparable lithologies in the Guildford Formation – examples include:

Figure 8: Guildford Formation. Shallow marine to estuarine sediments.

Figure 9: Guildford Formation Pebble Beds, All Saints Church, Henley Brook.

Figure 10: Blue and brown mottled clays/silts, Guildford Formation.

Figure 10a: Comparison of virtually identical dark grey/red mottled clays from the Lambeth Group (top), Guildford Formation (bottom).

Figure 11: Guildford Formation., estuarine laminated beds.

Figure 12: Organic channel sands, Guildford Formation. As in the Lambeth Group the black areas are fossil roots.

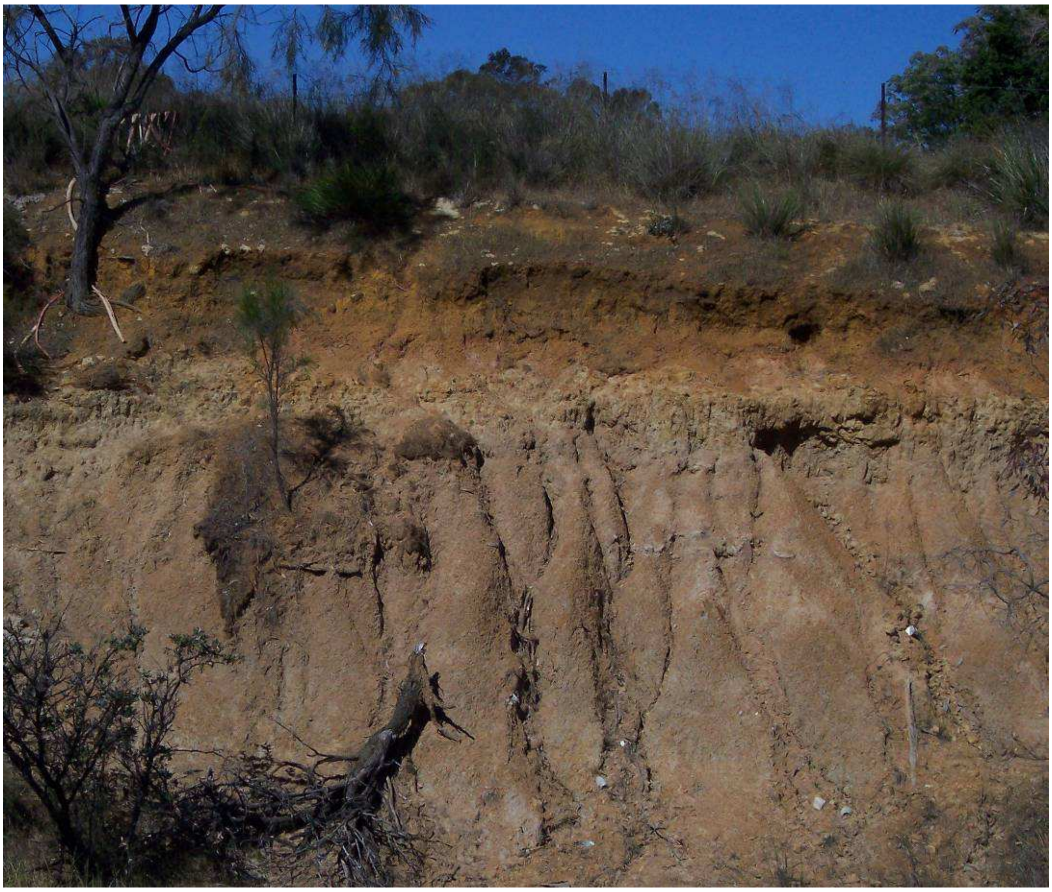

Figure 13: Hard bed - indurated calcareous mudstone in the upper third of this section in the Guildford Formation, in the railway cutting, Hallatt Gardens, Upper Swan River.

Although these are just a very few examples, it is clear that the Guildford Formation sediments are comparably as variable as those of the Lambeth Group.

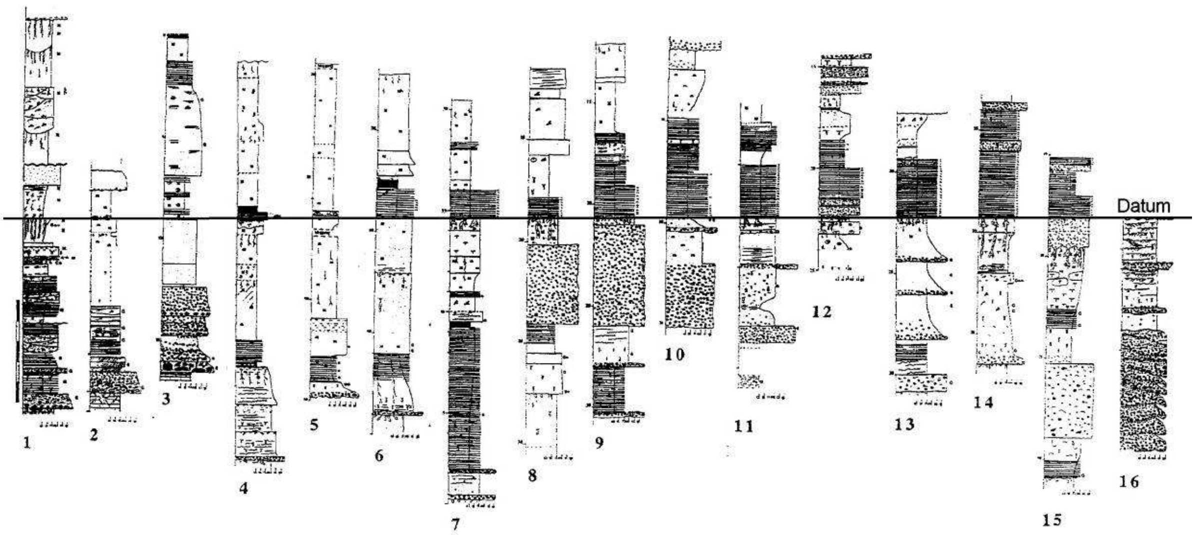

Figure 14: Cross section across north London showing extreme variability both horizontally and vertically. Scale bar on far left equals 5 m. The datum line is the Mid Lambeth Hiatus (see text). From Skipper (1999).

Figure 14 illustrates lithological variability in the Lambeth Group. Each of these logged sections are drawn with grain-size along the x-axis, (the wider the column, the coarser the sediments), which accentuates the variability. These borehole and exposure sections are across north London, with logs 7 to 11 in Figure 14 within a kilometre of each other. It is clear that under these circumstances, using the normal method of lithostratigraphical correlation (i.e. correlating lithologies in adjacent boreholes that look the same) is ineffective.

4 SEQUENCE STRATIGRAPHY, VARIATION AND CORRELATION

Sequence Stratigraphy is "the subdivision of sedimentary basin fills into genetic packages, bounded by unconformities and their correlative conformities" (Emery *et al.* 1996). In real terms, sequence stratigraphy entails the correlation of surfaces and tracts of sediment which were deposited in a cycle of rising and falling sea level, rather than correlating rocks of similar lithology (which may be of different ages), as is the case in lithostratigraphy. This is particularly useful in the correlation of shallow marine to terrestrial sediments, which are very variable laterally.

Modern-day Perth is a classic example of a multitude of environments of deposition – rivers, lakes, marsh, estuaries, coastal dunes and sandbars, then the shallow sea shelf. Using sequence stratigraphy, all of these depositional environments may be correlated since they are being deposited today at the same time (i.e. are *isochronous*). As sea level rises, these environments will all migrate landwards (the sea, rivers etc will all go inland) on top of the underlying sediments, and if sea level falls, seawards. These processes explain why the original complex lithologies get stacked up – giving the vertical and horizontal variability.

Increasing this primary sedimentary variability, terrestrial environments are subject to pedogenesis – weathering. This process is commonly seen in Australia (laterites being a good example) and has also clearly affected the 'Guildford Formation' sediments, leading to the colour, textural and mineral changes present, e.g. mottling and duricrusts. Pedogenically altered sediments are common in the Lambeth Group, especially in the Reading Formation Mottled Beds, and pedogenesis is also responsible for the presence of duricrusts such as calcretes, silcretes (see Figure 5) and ferricretes at one particular horizon (the Mid Lambeth Hiatus – see below).

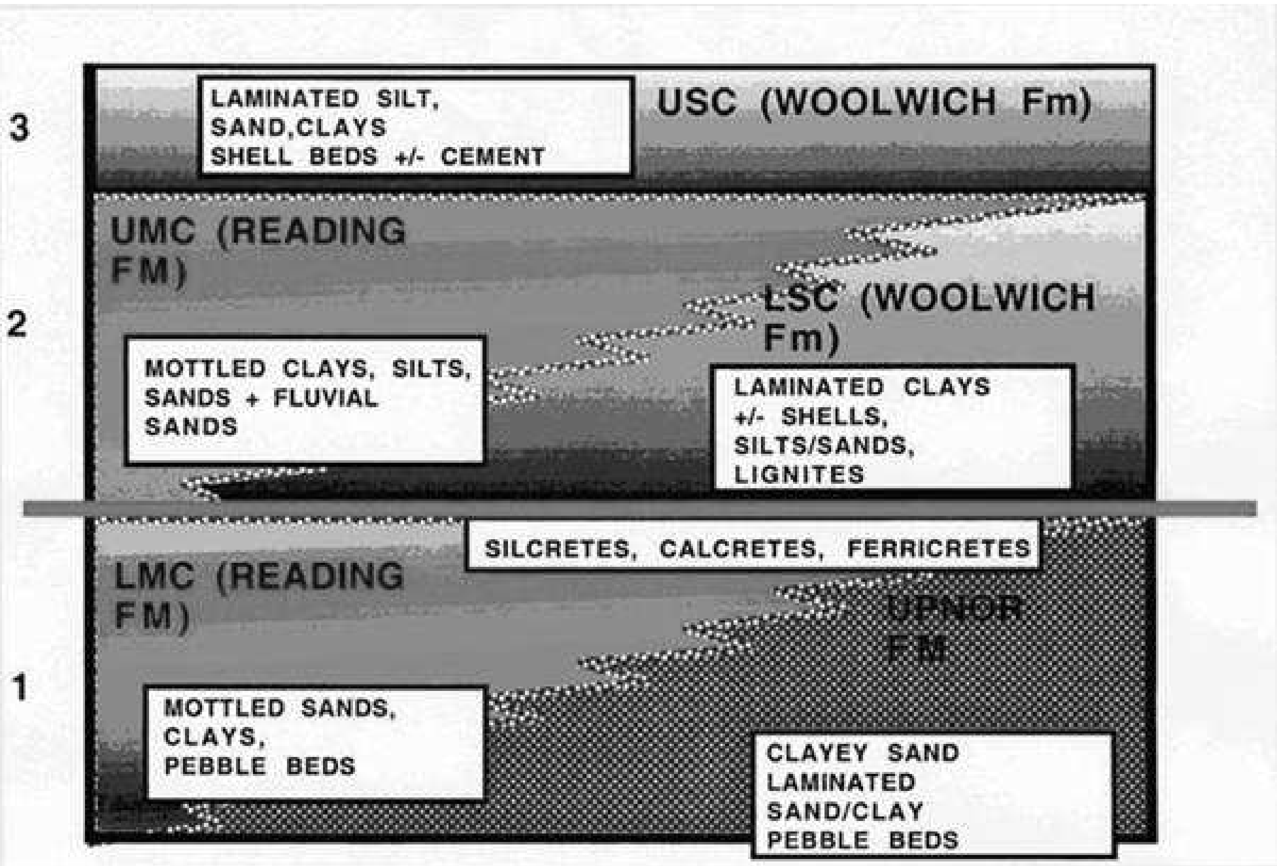

Figure 15. Simplified sequence stratigraphy of the Lambeth Group showing stacked-up variability.

Despite this variability, using sequence stratigraphical techniques has enabled the identification of at least three cycles of sea level rise and fall within the Lambeth Group sediments (see Figure 15), and in particular the identification of a marker horizon – the Mid Lambeth Hiatus, which is recognisable in boreholes throughout SE England (Page & Skipper 2000).

This clearer stratigraphical framework has enabled the following:

1. The development of a clear classification that can be used to correlate the sediments all over SE England.
2. The development of a straightforward model to train geotechnical staff and engineering geologists, allowing improved location within the stratigraphy.
3. Improved characterisation and prediction of sediments and hazards, because of improvements in logging and classification.

So far more than 200 people have attended these CPD (continuous professional development) training courses.

Other strategies that have helped include using **the best available ground investigation method**, preferably with continuous sampling. Sampling at say, at 2 m spacing in a shell and auger borehole in these sorts of sediments is at best misleading and certainly unrepresentative. A cheap method with continuous sampling will be more use than a more expensive method with widely spaced samples.

Rigorous logging and supervision of the ground investigation has proved to be a good investment. Many major projects in the Lambeth Group now insist on check-logging by a specialist to maintain best standards. Poor standards in logging lead to lost information and wasted time and money.

Communication across projects. Our experience in the UK suggests that developing a sound ground model and communicating this to staff across all the companies involved in a project leads to better communication and assessment of risks.

5 CONCLUSIONS

The lessons that have been learnt from the Lambeth Group of the UK are:

- Formulate a sound geological model, using sequence stratigraphical techniques where necessary.
- Train as many grades of staff as possible to understand the common classification of lithologies and risk.
- Maintain high standards in ground investigation by supervision.
- Communicate at all levels in projects.

6 ACKNOWLEDGEMENTS

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