OR/15/010 Introduction


Rapid urbanisation has been driven by population change, socio-economic and technological development, and has impacted profoundly on the geological and geomorphological character of the urban environment. The deliberate, current and historical anthropogenic modification of the landscape and its subsurface creates sediments and landforms in the form of AMG (Price et al., 2011[1]). Artificially Modified Ground (AMG) represents those areas where the ground has been significantly changed by human activity, usually divided into the following categories on BGS geological maps:

- Made ground — human-made deposits, such as embankments and spoil heaps on the natural ground surface
- Worked ground — areas where the ground has been cut away, such as quarries and road cuttings
- Infilled ground — areas where the ground has been cut away, and then wholly or partially backfilled
- Landscaped ground — areas where the surface has been reshaped
- Disturbed ground — areas of ill-defined shallow or near surface mineral workings where it is impracticable to map Made Ground and Worked Ground separately

AMG was not consistently mapped by BGS until the 1980s although many urban areas are built on AMG (http://www.bgs.ac.uk/products/digitalmaps/digmapgb_art.html), and even the modern AMG mapping has focused primarily on mineral workings, industrial areas and transport routes (Burke, H et al., 2014[2]; Mathers et al., 2014[3]). Therefore, AMG is an important but often under represented feature in geological maps and models (Aldiss et al., 2014[4]; Ford et al., 2014[5]). Some of the factors which have caused this include:

- Education that has primarily focused on naturally occurring Quaternary and Bedrock deposits
- Training in geological surveys and commercial organisations focused on Quaternary and Bedrock mapping and modelling
- Difficulties observing AMG boundaries and during geological surveying of areas
- Cartographic issues, such as AMG obscuring natural geology on geological maps in urban areas
- Some AMG features are already recorded on topographic maps

Recent progress made by the British Geological Survey (BGS) and others around the world in this field has meant that AMG is increasingly mapped and modelled, and is now regarded by many as an important deposit or excavation likened to natural geological processes (Bridge et al., 2005[6]; Bridge et al., 2010[7]; Burke, H F et al., 2014[8]; Ellison et al., 2002[9]; Price et al., 2012[10]; Zalasiewicz et al., 2011[11]). The study described here is mainly focused on how the mapping of AMG can be increased in urban environments using borehole index information and attributes from logged boreholes. These include the presence of AMG in a borehole, the thickness of AMG recorded, the start height of a borehole and the location of boreholes (and adjacent boreholes) with AMG recorded against the modern topological features and modern geological maps. This study follows on and compliments
studies in the Fleet and Rotherhithe areas of London, which focused on land use and AMG mapping from historical and modern topological maps (Burke, H F et al., 2014[12]; Mathers et al., 2014[13]; Smith and Burke, 2011[14]; Thorpe et al., 2011[15]). By improving our knowledge of the distribution and types of AMG in urban areas, it will improve our understanding of ground conditions, which will help in construction and regeneration projects.

Why use Boreholes

There are a number of reasons to use borehole logs as a method for mapping and characterising AMG. Boreholes have been drilled for almost two millennia around the world (Loewe, 1968[16]) and BGS has borehole records dating back over 200 years. These boreholes have been drilled for a number of reasons, including:

- extraction of water or other liquid substances, such as oil
- extraction of gases
- mineral exploration
- geothermal installations
- civil engineering and site assessment
- geotechnical investigation
- scientific investigation

Not only will the purpose of a borehole indicate which type of anthropogenic activity has occurred, many of these borehole records have some kind of drill date associated with them. This will usually precede some kind of anthropogenic development or activity, meaning anthropogenic many deposits can be dated fairly accurately.

Previous studies have established that boreholes are an essential data resource for mapping AMG in urban environments. In Ford et al. (2014)[17] it was established that the distribution of boreholes and trial pits is generally concentrated in urban areas and centres of extractive industry in the UK. About 10% of registered boreholes and trial pits intersect categories of AMG on BGS 1:50 000 scale maps that are likely to include anthropogenic deposits. Although many records predate development activities (e.g. construction) that results in the subsequent creation of AMG, they provide useful information on the thickness and spatial extent of pre-existing anthropogenic deposits.

This has been supported further by Aldiss et al. (2014)[18] who suggested that in the absence of a discernible associated landform, AMG can be mapped from records of boreholes and trial pits, where there is a sufficient density of such data. Usually this will be an instance of Made Ground, perhaps of engineered fill, although it is conceivable that boreholes could demonstrate the presence of a broad area of shallow excavation with little or no surface signature (Price et al., 2010[19]).

Aldiss et al (2014)[18] went further to say that some interpretation must be made concerning the extent between or beyond boreholes of, for example, an urban ‘blanket’ of Made Ground. Where borehole records are relatively closely spaced, show a consistent thickness of Made Ground, and where there is no landform or open space of undeveloped ground that might indicate the contrary, it may be assumed that the ‘blanket’ is continuous. This is found in central London, for example, where nearly all boreholes and trial pits encounter at least 1 m of Made Ground, and locally over 10 m is present. Therefore, boreholes are a useful indicator of AMG particularly in cities and towns, and certain assumptions can be made in urban areas between boreholes where it is likely the AMG is continuous across the whole of that urban area, thus making it a mappable unit.

Ford et al. (2014)[17] supports the view that borehole records are an important resource for indicating
the presence of anthropogenic deposits. Compaction and diagenesis may reduce the thickness of these types of deposit, but, if preserved in the rock record, they would present a mappable unit similar in thickness to many natural deposits.

The following data from boreholes could be considered useful for classifying and assisting the mapped output of AMG in urban areas:

- Presence/absence of artificial AMG in borehole logs
- Thickness of AMG in borehole logs
- The start height of the borehole log
- Date of drilling
- The description of the deposits, e.g. waste, fly-ash, tipped natural materials

The presence or absence of AMG in borehole logs can be used to map out areas of continuous- semi continuous AMG and areas where it is absent. The thickness and any associated landform may indicate the type of AMG present. The start collar height of a borehole is usually the ground height in metres relative to OD. Using this start height we can infer former land levels where these have been modified, e.g. a borehole was drilled before a quarry was mined or as a cutting is excavated (Price et al., 2012). This is useful in assessing landscape evolution and classifying AMG. If this data is combined with drilling dates, then the AMG can be considered to represent a stratigraphical sequence in the landscape evolution.

In the following sections, the methods used, analysis and results are presented using the borehole information listed above for improving the mapping and classification of AMG in urban areas.

References


15. LOEWE, M. 1968. Everyday Life in Early Imperial China during the Han Period 202 BC-AD 220. (London: B.T. Batsford Ltd.)


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