Waterloo & City | Urban Geology across the Thames

This walk, from Waterloo Station to St Paul's Cathedral grew out of an interview with author and journalist Helen Gordon and was the inspiration for an article which will appear in the Economist's *Intelligent Life* magazine in September 2014. Parts of this area have been previously described in a geological walking tour compiled by Roberts (1979) for the Geological Museum. Roberts's guide is mainly focused on the complex of office blocks to the south of the Station, much of which is still standing, 25 years on. This walk will take us north along the embankment, crossing the River Thames via Blackfriars Bridge and from there walking up to St Paul's Churchyard, where this walk will end.

As ever, the architectural information here is mined from Pevsner (Cherry & Pevsner, 2002) unless otherwise cited, and this text as well as that of the Marble Institute of America's Glossary (MIA, 2011) provide definitions of architectural and engineering terms used.

Waterloo Station: Portland Whitbed on the balcony level.

Waterloo Station

Waterloo Station was built between 1901 and 1922 by architect-engineers J. W. Jacombe-Hood and A. W. Szlumper. The Victory Arch façade, with its monumental and colossal sculpture, opening onto Station Approach is by J. R. Scott. The interior of Waterloo Station has recently been cleaned and much improved, making it a very good place to observe the Portland Stone which is the main material used in the construction of the station. A good place to see this is on the new balcony level where good examples of **Portland Whitbed** show fossil oyster of *Liostrea* sp. and fragments of cauliflower head-like *Solenopora* sp. reef-building algae. Also here is an unusual opportunity to get up close to the carved decoration on these upper walls of the station concourse; carvings of foliage, cherubs and the names of the destinations of trains from Waterloo show the excellent qualities of Portland Stone as a freestone, having no planes of weakness. Having no suitable local deposits of building stone, many of London's most iconic buildings have been built with Portland Stone brought from the Isle of Portland in Dorset, where upper Jurassic limestones

©*Ruth Siddall; July 2014*

are (and have been) extensively quarried (See Stanier, 2000). These are oolitic limestones which are composed of rounded particles of carbonate sand called ooids or ooliths. These can be seen, especially with the aid of a hand lens, in the stone on the Waterloo balcony. They are typical of tropical, shallow seas and this would have therefore be the depositional environment of the Portland Stone.

Leave Waterloo Station via the Victory Arch. This too is built from Portland Stone Whitbed, but here also the foundations of the station can be seen, below the lowest, rusticated courses of Portland Stone. These are constructed from Cornish Granite, probably **Carnsew Granite** or another variety from the 290 Ma Carnmenellis Pluton. The main quarrying area was in the south east of this granite in the Parish of Mabe, close to the wharves on the River Fal. The Carnmenellis Pluton is a two-mica granite, with both biotite and muscovite obvious in hand specimen. Also present and distinctive of this stone are the so-called 'small megacrysts'; phenocrysts of euhedral K-feldspar, around 2 cm in length. It has an overall pale-brownish colour. The outer zones of the Carnmenellis Granite are relatively free of fractures, enabling large blocks to be extracted. This also makes this a strong good load-bearing stone, perfect for foundations.

The steps up to (or down from) the Victory Arch are of Forest Pennant Sandstone. This is a fine to medium-grained, grey coloured, quartz-rich, micaceous sandstone with feldspar. **Forest Pennant Sandstone** or 'Forest of Dean Stone' may well have been worked as early as the Roman Period. The Forest of Dean is owned by the Crown and the quarries are leased on an annual rent. Under Forest Law, these leases are known as 'gales' and they were only granted to 'freeminers', born in the Hundred of St Briavel's and who had worked a year and a day in a quarry or mine. These steps were only put in place in the last five years, replacing the original Pennant Sandstone steps laid when the Victory Arch was completed as a memorial to World War I in 1922.

Leaving Waterloo Station via the Victory Arch, one emerges onto a mess of traffic and ungainly street furniture on Station Approach. Consequently, this area is scheduled for redevelopment and will no doubt look beautiful in ten years time. The historic station will of course be preserved, but Elizabeth House on the left will be demolished as part of the redevelopment.

Elizabeth House

Despite the proviso that Elizabeth House is scheduled for demolition in the very near future, it is worth a stop at present for the huge expanse of beautiful **Royal Blue Pearl Larvikite** which is used to clad the façade. This is the bluest of the larvikites quarried for the last 140 years or so from the Westfold of Southern Norway and it is a spectacular stone. Geologically this is the so-called Malerød sub-type of the Larvik Plutonic Complex, which is a hemicircular, composite intrusion with at least nine phases of injection of magma. The Complex was emplaced during the early Permian, c. 295 million years ago. Three quarries in the Malerød area currently produce this stone (see Selonen & Suominem, 2003).

Cross over York Road and follow the walk-way through the row of arches towards the Royal Festival Hall, crossing Belvedere Road onto piazza which sometimes hosts a market.

Royal Festival Hall

The paving on the piazza is a dark grey 'granite'. Compositionally it is more likely to be a diorite or tonalite, containing plagioclase and hornblende ± quartz. Also present are wispy streaks of a more felsic rock which is clearly intruding the grey diorite. This igneous rock has not been identified, but is almost certainly Chinese in origin.

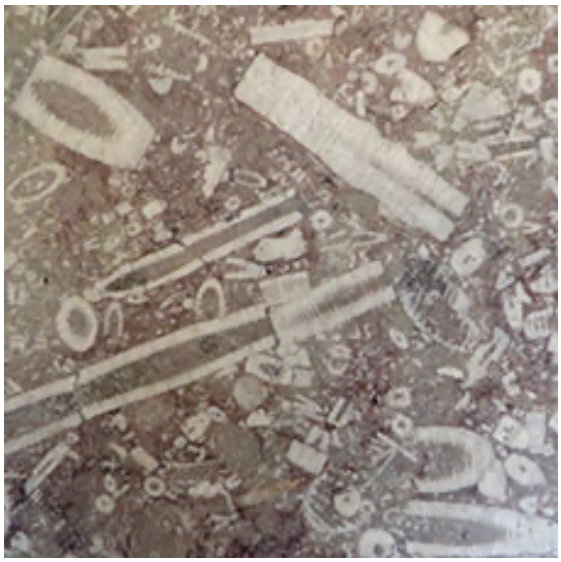
Constructed between 1948 and 1951, the Royal Festival Hall was the centrepiece of the Festival of Britain, an event envisaged to move Britain away from the austerity of the war years and into a fresh, new, modern era. The Hall was designed by architects Robert Matthew and Leslie Martin and was Britain's first building in the 'modernist' style. Architectural commentator Jonathan Meades, in typically uncompromising manner, describes the Festival of Britain as '*The Festival of Plagiarising Scandinavian Architecture*' (Meades, 2014) given the huge influence of architects such as Aarvo Alto, and particularly Hans Asplund on the

©*Ruth Siddall; July 2014*

design of the building. Hubert Bennet made modifications to the building in the 1960s, primarily moving the main entrance to the river frontage. The creation of spaces inside the building is spectacular, with the concert hall suspended within an open box which insulates the hall from sounds of the river, roads and railways. It is almost difficult to visualise, when standing in the foyer, where the 3,000 seat hall is located.

Steps lead up to the Festival Hall from the piazza. An imposing bust of Nelson Mandela, by sculptor Ian Walters (1985) stands on the right hand side, against the walls of the Festival Hall. Fittingly the bronze head sits on a plinth of South African stone, a black, medium-grained gabbro of the variety marketed as **Belfast Black**. This ancient gabbro comes from the 2 billion year old Rustenburg Layered Series, part of one the World's largest igneous intrusions, the Bushveld Complex. Belfast Black is from Wapadskloof, near the town of Belfast, to the east of Pretoria. It is composed of pyroxene and plagioclase with significant amounts of the iron oxide magnetite, the latter a major contributor to the black colouration.

Columns flank the glass doorways at the entrance to the Festival Hall. Although rather worn, these are of a spectacular, fossiliferous limestone called **Derbydene** from Derbyshire, a stone which takes a high polish. This stone was extracted from quarries owned by the Dukes of Devonshire and has been worked since the 17th Century. However its main use then was for fire surrounds and other interior decorative features. Distinctive are the abundant fragments of very large, white, crinoid stems and ossicles in a grey brown matrix. You can't miss them. Geologically this rock comes from the Monsal Dale Limestone of Carboniferous age (Thomas, 2005) and one of a series of crinoidal limestones quarried in this area. This stone was quarried from Dene Quarry, near Cromford.



Walking into the Royal Festival Hall, polished slabs of Derbydene (right, field of view, 20 cm) are seen on the floor, allowing good examination of the large fossils present. Spectacular examples of this stone is also used to clad the walls on the staircases to the upper storeys. But before going upstairs to check these out, turn left and look out for a display case against the wall, just before you come to the lifts. The case contains a geological specimen, a gift Shell Oil made to the Royal Festival Hall in 2007. This is a prepared slab revealing a concentration of *Gigantopecten restitutensis* scallop shell fossils; very similar, of course, to Shell's logo. The unit from which this stone was collected has recently been described by Bongrain (2013), who believes the shells were concentrated due to seismic activity in a shallow marine basin, now located in the Vaucluse of France. It is the **Menerbes et Lacoste Limestone** of Miocene (Burdigalian) age, around 18 million years old.

*Leave the Royal Festival Hall by the front entrance onto the South Bank, turn right and walk along the embankment towards Waterloo Bridge. Next door to the Festival Hall are the complex of buildings, using split levels and connecting walkways, which are The Queen Elizabeth Hall, The Purcell Room and the Hayward Gallery. These were built between 1963 and 1968 and designed by GLC architects N. W. Engleback and E. J. Blythe in the Brutalist style. This includes walls and façades clad in cast concrete which clearly (and decoratively) show the marks of the wooden plank formwork or '*shuttering*' into which the concrete was poured and allowed to set. Although this wood grain texture on the concrete's surface is known as '*shuttering marks*' in architectural parlance, Di Clements* (pers comm.) *and the author have adopted the term '*elephant concrete*' to describe this effect, given the resemblance of these grey concrete surfaces to*

©*Ruth Siddall; July 2014*

the skin of said pachyderms. Pevsner writes that 'concrete with all the shuttering marks can never be attractive. On the contrary it is a demonstration against conventional beauty.' *(Cherry & Pevsner, 2002). Brutalist architecture is not to everyone's taste, but I rather like it (in moderation), particularly because I think concrete* can *be beautiful and is a much maligned material. For those wishing to be converted, I would highly recommend Adrian Fortey's book on the subject (Fortey, 2012). Modern concretes are made by calcining a mixture of limestone and shale at temperatures of around 1500°C. This process produces a clinker which is then pulverised to form a very fine powder. Mixing this powder with water and adding an aggregate, which adds strength and reduces shrinkage, amongst other properties (including hydraulic and aesthetic ones), results in a load-bearing material that can be poured and moulded into almost any desired shape.*

South Bank Skate Park

The Skate park is situated beneath the Queen Elizabeth Hall. On the western end of this small area is a ramp leading down to the walkway between the Festival Hall and the Hayward Gallery. A low wall runs along the ramp composed of a honed, dark grey stone with abundant phenocrysts of clinopyroxene, up to ~ 7 mm in diameter. This is a Cretaceous-aged, tholeiitic basalt from Fuding in NE Fujian Province, on the south-eastern coast of China. Here huge, columnar-jointed basalt flows, often in excess of 50 m thick are quarried. This stone, marketed as **Black Pearl** (or less romantically G684) has recently become very popular as street paving slabs and setts and today is frequently encountered in urban pedestrianized areas.

Continue along the South Bank to Westminster Bridge.

Waterloo Bridge

Waterloo Bridge, designed by Giles Gilbert Scott, was completed in 1945 and replaced a (Dartmoor?) granite bridge completed in 1817 which was on the point of collapse in the 1920s and required demolition. Pictures of the old bridge are available on The Gentle Author's blog (2013). The current bridge was built predominantly by a female construction workers during World War II and is the subject of a documentary film, 'The Ladies Bridge' (2006) by Karen Livesey[1].

The bridge is clad in a cross-bedded variety of Jurassic Portland Whitbed, showing the actions of currents in the shallow waters in which these limestones were originally deposited. This is not a typical variety of this stone. Here the oolitic limestone has been redeposited by currents, comminuting shell fragments in the process. The resulting rock is a 'calcarenite', a limestone which has been current-bedded and deposited in the manner of a sandstone. Stone of this type, **Perryfield Whitbed**, is quarried today from Perryfield Quarry on the Isle of Portland. For a short detour, venture up onto the bridge, the parapets show good, but fragmented, examples of the reef-building algae *Solenopora portlandica* weathering-out on the surfaces, somewhat resembling cauliflower florets.

Paving setts around the Bridge are of grey granite with occasional large white feldspar crystals of the granite variety **Azul Gondomar** from Braga in northern Portugal. This is a blue-grey, porphyritic, medium-grained rock with sparse but large, prismatic, euhedral white feldspar phenocrysts, up to 3-4 cm long. Mineralogically it is composed of plagioclase, quartz, K-feldspar, biotite and muscovite. Along with the majority of Portuguese granites, the Braga Pluton was intruded during the Variscan mountain building event around 310 Ma (see Dias & Letterier, 1994). This has been an important building stone, used locally in and around the city of Braga in northern Portugal since the Middle Ages, and it has more recently been exported world-wide for setts.

Beyond the Bridge is the National Theatre by Sir Denys Lasdun & Partners and built between 1961 and 1976, again in shuttered elephant concrete. The building houses the Lyttleton, Olivier and Cottesloe Theatres.

[1] See 'The Ladies Bridge' http://www.theladiesbridge.co.uk/ and a clip is available on YouTube here: https://www.youtube.com/watch?v=Xzp9NcCkqzE

©*Ruth Siddall; July 2014*

Arena

On the embankment in front of the National Theatre, 'Arena' is a circular installation by sculptor John Maine (b. 1942), constructed in situ here on the south Bank. It is made of carefully cut and fitted blocks of **Portland Stone**, with a rusticated surface texture.

Arena by John Maine in Portland Stone.

There are no buildings of major geological interest between the National Theatre and Blackfriars Bridge, where we shall cross the Thames to the City of London. Paving setts are a decorative feature of some sections of the walkway and these are largely of a variety of Chinese granites of unknown provenance.

Thames Foreshore

Look over the parapet to the River Thames below. At low tide, the foreshore reveals sandy beaches with lags and drifts of accumulated London rubble. The sand was reputedly brought here for the Festival of Britain (Di Clements *pers. comm*.). Amongst this, and strikingly white, are blocks of **Chalk**. These are derived from structures called barge beds (and also known as 'hards'). These were artificially made hard grounds which could be used to beach barges and other boats so that they could be either loaded or unloaded with goods[2]. They were constructed of boxes, similar to raised flower beds, with low timber retaining walls, the interiors of which were filled with rammed Chalk. Having fallen out of use, the Chalk has been washed out into the river gravels.

Bernie Spain Gardens, between Gabriel's Wharf and the Oxo Tower, was once a marsh and is believed to be the source of the River Neckinger, one of the Thames's tributaries, an elusive river, largely lost today. Despite rising so close to the Thames, the Neckinger flowed due south from here, before looping back eastwards and entering the Thames at St Saviour's Dock at Shad Thames (see Bolton, 2011). Beyond, the splendid Oxo Tower, by A. W. Moore and built in 1928 is an early Art Deco classic, which does not fail to miss out on an advertising opportunity.

Black Friars Bridge

Blackfriars Bridge, by engineers Joseph Cubbitt and H. Carr, was built between 1860 and 1869. The foundations and cutwaters are almost certainly of Cornish Granite. However the pink granite columns are Scottish, in fact the **Ross of Mull Granite** from Tormore Quarry on Mull in the Hebrides (Faithfull, 1995). Ross of Mull is a coarse-grained granite, with prominent K-feldspar crystals, which range in colour from pink

[2] The Thames Discovery Programme - http://www.thamesdiscovery.org/discover/foreshore-factsheets-gridirons

©*Ruth Siddall; July 2014*

to a greyish pink. Biotite, grey-brown quartz and white plagioclase are also present. Large monolithic columns, such as these used on Blackfriar's Bridge, and also supporting the Holborn Viaduct were available on the coastal quarries on the westernmost tip of the Hebridean Island of Mull. Despite the remote location, the stone could be shipped direct from the quarries to Liverpool. Although some of the earliest uses for this stone were in the construction of the 7th Century Abbey on Iona, just across the sound, industrial-scale quarrying did not begin until the mid 19th Century. Unfortunately, the First World War brought an end to the quarrying operations on the Ross of Mull. The granite is one of the suite of Caledonian Granites of the Northern Highland Terrance of Scotland, intruded at ~420 Ma. The column capitals are intricately carved with storks and are made from **Portland Stone**, here showing this rock's characteristic and celebrated properties as a freestone.

Blackfriars Bridge

Take the steps up to road level to cross the bridge.

Paving on the bridge is **York Stone** from the Coal Measures of the Pennines. These are sandstones deposited by river systems, eroding the Variscan mountain chain during the Upper Carboniferous. York Stone is ubiquitous as paving in London (and elsewhere in the British Isles). The flagstones come from silty and sandy layers in the Pennine Lower Coal Measures Group and are extracted from numerous quarries in Lancashire and West Yorkshire. These grey-green examples show well-defined ripple and current cross-bedding as well as spectacular iron staining known as liesegang banding. The stone used here comes from Fagley Quarries near Bradford in West Yorkshire and was supplied by Hard York Quarries.

Another of London's 'lost rivers', the Fleet enters the Thames under the N side of Blackfriars Bridge and the outfall can be seen from the steps onto the embankment on the west side of the Bridge at low tide or from the ferry jetty (see Bolton, 2011). Unfortunately a really clear view is not possible without risking life and limb. The Fleet rises from two springs on Hampstead Heath, but from thence on to the Thames it runs through sewers underground, emptying into the Thames here. Also under Blackfriars Bridge are the remains of tree roots from a now buried and submerged forest, 5,000-6,000 years old, a glimpse of London during the Neolithic (Clements, 2010).

Returning back onto the Bridge, cross to the traffic island on the northern bank of the river to a monument to Queen Victoria.

Queen Victoria Statue

A full length, bronze Queen Victoria, in full regalia, stands on a substantial plinth of salmon-pink **Peterhead Granite** from Peterhead, Aberdeenshire. This stone became extremely popular during the later Victorian

©*Ruth Siddall; July 2014*

era, with the new rail links into St Pancras enabling stone to be easily transported from the Aberdeen region of North East Scotland, and it is seen all over London (and the rest of the country). Peterhead granite is medium grained with pink orthoclase feldspars, grey quartz and the mafic mineral is hornblende. Also characteristic are the rounded, dark-coloured enclaves of microdiorite, a large example of one of these may be observed on the lower moulding at the back of the plinth. Intruded around 406 Ma, Peterhead Granite is one of the Caledonian post-tectonic granites of the Cairngorm Suite of the Central Highland terrane.

Crossing over the road to the east, a Victorian drinking fountain stands outside a (currently) derelict sandwich bar.

Drinking Fountains

This is one of the many fountains in London, unfortunately most no longer in action, which supplied free drinking water and were erected by the Metropolitan Drinking Fountain Association, this one was installed in 1861. It is adorned with a bronze nymph dispensing water into a basin supported by bronze, classical-style dolphins. The Metropolitan Drinking Fountain Association was founded in 1859 to provide drinking water for people and animals and still exists today, as the Drinking Fountain Association. The fountain here is made of pink **Peterhead Granite** (pedestal and basin) as described above, with steps and upper part of a grey variety of Cornish granite. A small-megacrystic granite is used here and stones of this type are derived from several intrusions in the 300 Ma Cornubian Batholith of SW England. Most of these either came from the Quarries at De Lank on Bodmin Moor or from the Carnmenellis intrusion near Falmouth. This may be the variety **Penryn Granite** from the latter locality. It has aligned, euhedral phenocrysts, 1-2 cm in length set in a medium grained, brown-coloured matrix of quartz and biotite.

Walk past the new Blackfriars Station and cross over Queen Victoria Street to the Black Friar Public House. In the beer garden outside, alongside New Bridge Street, is another drinking fountain.

Outside the Black Friar Pub, another granite drinking fountain has also been erected by the Metropolitan Drinking Fountain Association. This is surmounted by an urn, from which the drinking water is dispensed into a circular basin. At the base of the plinth, a small U-shaped bowl allows for water to be provided to dogs. This fountain is constructed entirely in a polished, pale grey granite, from Craignair near Dalbeattie in SW Scotland. Andrew Newall is credited with starting the first commercial granite quarrying operation in Dalbeattie in 1800. The Newall's opened Craignair Hill Quarry in 1810. The Newall's were also the first firm ever to produced polished granite (from the 1840s) and they exhibited in the Great Exhibition in 1851. **Craignair Granite** contains plagioclase, pinkish orthoclase, grey quartz, biotite and hornblende. It was intruded late in the Caledonian mountain building phase at 391 Ma.

The Black Friar Pub, 174 Queen Victoria Street

A wedge-shaped building stands at the junction of Black Friars Bridge and Queen Victoria Street. This is the Black Friars public house which stands on the site once occupied by a Blackfriars (Dominican order) Monastery. The Black Friar Pub was originally built in 1873 but was extensively modelled in the Arts and Crafts Style by H. Fuller Clark in 1905. It is a spectacular example of early 20th Century decorative architecture and is indeed worthy of a stand-alone description of the stones used in the interior and exterior. Another time maybe… In the meantime, this makes a good location to break for a pint or even lunch and take in the interior.

The exterior of the pub is clad in slabs of pink and grey-green granite. To my shame, I have no idea of either their names or origin. Both are medium grained. The pink variety has equal amounts of pink feldspar and white, fractured quartz, with flecks of black biotite. It has a homogeneous, non-foliated texture. The green variety has blurred crystal boundaries and appears to be slightly altered. It too contains pink feldspars and white quartz, and indeed maybe another facies of the latter-mentioned granite. Distinctively it contains, blotchy greenish aggregates of minerals and appears to be rich in chlorite and probably hornblende. A possible contender for the pinkish granite is Trowlesworthy, from the SW of the Dartmoor Pluton (Lee

©*Ruth Siddall; July 2014*

Moor Granite), but the match is not perfect. Any further information would be most welcome, so please do contact me if you know the origin of these stones.

The pink and grey- green granites of the exterior of the Black Friars Pub.

The marbles of the interior were supplied by the prominent Victorian firm of marble contractors and stone carvers, Farmer & Brindley. Although originally a sculptor (Farmer) and his apprentice (Brindley) the firm expanded to include exploration and procurement of marbles. William Brindley (1832-1919) travelled extensively in the later 19th Century, seeking out the fabled marbles quarries of ancient Greece and Rome, located in Italy, North Africa and Greece and working with local companies to reopen them. As a consequence, these stones became extremely popular and were supplied to the monumental buildings of the emerging Greek State as well as many a church interior civic hall, and indeed pub, in the British Isles. Inside the pub, a feast of decorative marbles are used to great effect with copper bas-relief sculpture by Frederick Callcott and Henry Poole, showing cheerful monks going about their daily chores. There is not space in this guide to give full descriptions of these stones and the list given below is not exhaustive, however initial observations has identified the following stones on the walls and archways:

English Alabaster: Quarried in Chellaston, Derbyshire and Fauld in Staffordshire since the Middle Ages, English Alabaster comes from the Triassic Tutbury Gypsum Beds. It is typically a cream colour, streaked with red brown, iron oxide-rich seams. This is the main material used on the walls.

Swedish Green Marble: A Palaeoproterozoic, green, dolomitic marble from Marmorbruket, Södermanland in Sweden. This marble has been quarried since the 17th Century, when it was used to furnish the Royal Palace at Drottningholm. It became an important export, following mechanisation of the quarries in the early 20th Century. It is used on the walls along side the alabaster and behind the copper reliefs.

Campan Marble: Another green and white carbonate rock, but not a true marble, the Devonian Campan Marbles come from the French Pyrenées and have undergone deformation and thermal metamorphism, Several quarries are active around the village of Espiadet. It is used here to frame the copper, full length figures of monks on the partition wall between the main room and the snug.

Cipollino: This green and white banded marble is the real thing. It used for the pilasters in the snug, and as bands with alabaster on the walls. The name derives from the Italian for 'little onion', with reference to similarity of the stone's markings, picked out by layers of schist. This has been an ever popular building stone from the Roman period to the present day and it is quarried at Styra, Marmari & Karystos on the island of Evvia (Euboea) in Greece. Triassic limestones were metamorphosed during the Alpine Orogeny at high pressures and relatively low temperatures during Miocene collision.

Skyros Marble: Also from Greece and representing a similar geological history to Cipollino, the Skyros Marbles from the island of the same name, show a very wide variety of colours and textures, from almost pure whites through golden and deep red breccias. The examples here, for instance, framing the fire place, fall into the later category.

©*Ruth Siddall; July 2014*

Irish Green: A particularly green variety of Connemara Marble, from the west of Ireland is used on the fire surround. It contains almost no white areas. Late Proterozoic limestones and basic rocks were metamorphosed during the Ordovician, quarries are located along the outcrop around Lough Derryclare at Lissoughter, at Barnanoraun and at Streamstown, just north of the small town of Clifden.

Whilst ordering your drink, you will also notice the following decorative marbles used on the bar …

Fior de Pesco Apuane: This marble is used on the front of the bar. It is a purple and white marble from the Serravezza region of the Alpi Apuane, in the Carrara region of Italy. Price (2007) describes the appearance of this marble aptly as 'drops of violet-pink ink spreading on the surface of water'. It has been quarried since the 17th Century from Stazzema and Seravezza, and from the 20th Century from Versilia and Garfagnana.

Perlato Sicilia: This is a cream-coloured limestone with abundant brown shell fragments and frequent stylolites also concentrating brown iron oxides. Perlato comes from a series of shelf to slope, peri-reefal calcarenites and calcilutites, deposited in the area around Custonaci in northern Sicily. It has only been worked since WWII and therefore dates the bar top as a recent addition.

Dragging yourself away from this lovely pub, the walk continues east along Queen Victoria Street.

160 Queen Victoria Street

This large block is by Skidmore Owings & Merrill LLP (SOM) for American bankers Merrill Lynch. A wealth of interesting decorative stones are used in the finish of this building, but unfortunately emails to the architects remained unanswered and consequently confirmed identifications of these stones have not been made. The foundations are clad in a green and black banded gneiss, probably Brazil's **Verde Maritaca**. If so, then this rock is from the Candeias Gneiss of the Campo Belo Metamorphic Complex in Minas Gerais state. A rock of charnockitic origin, in that it contains both orthopyroxene and quartz, it is 2.75 billion years old. The green colour is primarily imparted by chlorite. For the hard-core structural geologist, some of these slabs show lovely examples of ductile deformation, with kinematic indicators in the form of C-S and C-C' structures.

Left: oolitic limestone on the façade of 160, Queen Victoria Street (right). The dark green Verde Maritaca is seen in the foundations.

Above this, the lower storeys of the building are clad in a particularly coarse-grained and porous oolitic limestone. Individual ooids and fossil shell fragments are visible to the naked eye, supported in a sparse calcite cement. Oolitic limestones form in shallow, warm, tropical lagoons, where current oscillations are sufficient to winnow sand grains back and forth, whilst carbonate is precipitated onto them. Unfortunately the origin of this stone is unknown, but it strongly resembles '**Semi-Rijo'** an important building stone from

©*Ruth Siddall; July 2014*

the Middle Jurassic Valverde Formation of the Lusitanian Basin, Portugal, as described by Figueiredo *et al*. (2010).

The theme of expensive decorative stone continues to the interior. Security is high, but if you are not content in peering through the windows, the security guard may let you in as long as you agree not to take photographs. The main stone used to clad the lobby is a variety of **Carrara Calacatta Marble** from the Hettangian Marble of the Alpi Apuane tectonic window. Far more striking is the bright red travertine lining the walls of the lift lobby. This beautiful stone must be **Rosso Persiano** (or Persian Red Travertine) from Arzarshahr in NW Iran, the worlds most important producer of red travertines. The travertines are formed around hot springs associated with volcanism at Sahand Volcano, a large stratovolcano active since c. 12 Ma and part of the Urmia Dokhtar Magmatic Arc. The colouration is imparted by hematite and other iron oxides. The geological setting of this stone has been described by Hoseinie & Aghababaie (2007) and Mehdipour Ghazi et al. (2013).

Cross over St Andrew's Lane to Rudd's Bar.

Rudd's Bar, Queen Victoria Street

Rudd's occupies a converted Victorian pub, and outside pilasters are clad with pink **Peterhead Granite** on pedestals of grey **Cairngall Granite** also derived from the north Aberdeenshire region. Peterhead granite has been described above, for the monument to Queen Victoria on the north end of Blackfriars Bridge. Cairngall Granite comes from the Forest of Deer Granite intrusion, which at 470 Ma is considerably older than the Peterhead Granite and cross-cut by it. In his description of building stones in London, Howe writes that this granite is "... a very beautiful cool grey colour, with small, irregular-shaped white feldspars [sic] sprinkled in the grey ground ...' (Howe, 1910). This aptly describes this stone. Cairngall is often used in conjunction with Peterhead Granite as seen here.

Turn up St Andrew's Lane, between 160 Queen Victoria Street and Rudd's. A minor geological diversion are some slabs of ***Verde Alpi*** *serpentinite on one of the buildings on the Lane. Turn right into Carter Lane past the former St Paul's Choir school built in 1874-5 by Victorian architect Penrose. This building, with its Renaissance-type, Italianate design was built in what was known as the South Kensington Style. It is now a Youth Hostel and was restored in 1992 by Niall Phillips Associates. The sgraffito work on the façade is unusual and it features some rather ungainly restoration using a red Permian or Triassic Sandstone (image below). From Carter Lane, walk left up Dean's Yard to St Pauls Churchyard. This walk now links up with the geology of the buildings in the vicinity of St Paul's Cathedral described by Robinson & Bishop (1980), Robinson (1997) and Siddall (2014). Alternatively, the nearest public transport links are buses on Ludgate Hill or St Paul's Underground station, on the north side of the Cathedral.*

Carter Lane YHA, formerly St Paul's Choir School. Note the masonry using red sandstone below the windows.

©*Ruth Siddall; July 2014*

References & Further Reading

Banerjee, J., 2007, The Black Friar Pub, remodeled by Herbert Fuller-Clark (b.1869), 3 pp., http://www.victorianweb.org/art/architecture/pubs/9.html

Bolton, T., 2011, London's lost rivers: a walker's guide., Strange Attractor Press, London., 269 pp.

Bongrain, M., 2013, Les accumulations de Gigantopecten restitutensis (Fontannes, 1884) (Mollusca: Bivalvia: Pectinidae) dans le Burdigalien supérieur des carrières de Ménerbes et de Lacoste (Vaucluse, bassin d'Apt, SE France) : analyse et hypothèse explicative., Geodiversitas, 35 (3), 607-628.

Bristow, C. M., 2013, The geology of the building and decorative stones of Cornwall, UK., in: Cassar, J., Winter, M. G., Marker, B. R., Walton, N. R. G., Entwisle, D. C., Bromhead, E. N. & Smith, J. W. N. (eds) Stone in Historic Buildings: Characterization and Performance. Geological Society, London, Special Publications, 391.

Cherry, B. & Pevsner, N., 2002, The Buildings of England: London No. 2, South., Yale University Press, Newhaven & London., 808 pp.

Clements, D., 2010, The Geology of London., Geologists' Association Guide No. 68., The Geologists' Association., p. 147.

Dias, G. & Letterier, J., 1994, The genesis of felsic-mafic plutonic associations: a Sr and Nd isotopic study of the Hercynian Braga Granitoid Massif (Northern Portugal)., Lithos, 32, 207-223.

Faithfull, J., 1995, The Ross of Mull Granite Quarries., The New Iona Press., 56 pp.

Figueiredo, C., Folha, R., Mauricio, A., Alves, C. & Aires-Barros, L., 2010, Contribution to the technological characterization of two widely used Portuguese dimension stones: the 'Semi-rijo' and 'Moca Creme' stones., in: Prikryl, R., & Török, A., (Eds.) Natural Stone Resources for Historical Monuments., Geological Society, London, Special Publications, 333, 153–163.

Fortey, A., 2012, Concrete and culture: A material history., Reaktion Books Ltd., London., 335 pp.

Hard York Quarries: http://www.hardyorkquarries.co.uk/quarries/

Hoseinie, S. H. & Aghababaie, H., 2007, Geological Surveying and Determining Physical and Chemical Specifications of Ornamental Travertine of Azarshahr., Journal of Geosciences, Geological Survey of Iran., 16 (62). (*in Arabic*).

Maine, John: http://www.johnmaine.co.uk

Meades, J., 2014., The incredible hulks: Jonathan Meades's A-Z of brutalism., The Guardian, Thursday 13th February 2014., http://www.theguardian.com/artanddesign/2014/feb/13/jonathan-meades-brutalism-a-z

Mehdipour Ghazi, J., Olafsdottir, R., Tongkul, F. & Mehdipour Ghazi, J., 2013, Geological Features for Geotourism in the Western Part of Sahand Volcano, NW Iran., Geoheritage, 5, 23–34.

MIA, 2011, Marble Institute of America; Glossary of Stone Industry Terms; https://www.marble-institute.com/consumers/glossary.pdf

Price, M. T., 2007, Decorative Stone: The Complete Sourcebook. Thames and Hudson, p. 132.

Roberts, R. H., 1979, London Geology: Stone on the South Bank., Institute of Geological Sciences., 23 pp.

Robinson, E. & Bishop, C., 1980. Geological walks around St Paul's, Proceedings of the Geologists' Association, 91(4), 241-260.

Robinson, E., 1997, Holiday Geology Guide: St Paul's Cathedral., Earthwise., British Geological Survey.

Rogers, P., 2008, William Brindley: Sculptor, Marble Merchant, Explorer., http://www.westminstercathedral.org.uk/tour_brindley.php

Selonen, O. & Suominen, V., 2003, Nordic Stone., UNESCO | IAEG | Geological Survey of Finland., 64 pp.

Siddall, R., 2014, Geology in St Paul's Churchyard and Paternoster Square., Urban Geology in London no. 12.,

Stanier, P., 2000, Stone Quarry Landscapes: The Industrial Archaeology of Quarrying., Tempus Publishing Ltd. Briscombe, Gloucestershire., 160 pp.

The Drinking Fountain Association; http://www.drinkingfountains.org

The Gentle Author, 2013, The Bridges of Old London, Spitalfields Life., http://spitalfieldslife.com/2013/01/05/the-bridges-of-old-london/

©*Ruth Siddall; July 2014*

The Thames Discovery Programme 2010: http://www.thamesdiscovery.org/discover/foreshore-factsheets-gridirons

---

Index of Stones

Azul Gondomar – below Waterloo Bridge.

Belfast Black - Nelson Mandela Statue, Royal Festival Hall.

Black Pearl – South Bank Skate Park.

Cairngall Granite - Rudd's Bar, Queen Victoria Street.

Campan Marble - The Black Friar Pub, 174 Queen Victoria Street.

Carnsew Granite – Waterloo Station Foundations (Victory Arch).

Carrara Calacatta Marble - 160 Queen Victoria Street.

Chalk – Thames Barge Beds.

Cipollino - The Black Friar Pub, 174 Queen Victoria Street.

Craignair Granite – Drinking Fountain, New Bridge Street.

Derbydene – Entrance and interior, Royal Festival Hall.

English Alabaster - The Black Friar Pub, 174 Queen Victoria Street.

Fior de Pesco Apuane - The Black Friar Pub, 174 Queen Victoria Street.

Forest Pennant Sandstone – Waterloo Station, Victory Arch.

Irish Green - The Black Friar Pub, 174 Queen Victoria Street.

Menerbes et Lacoste Limestone – Royal Festival Hall.

Perlatto - The Black Friar Pub, 174 Queen Victoria Street.

Perryfield Whitbed – Waterloo Bridge.

Peterhead Granite – Queen Victoria statue, Black Friars Bridge; Drinking Fountain, Black Friars Station; Rudd's Bar, Queen Victoria Street.

Portland Whitbed – Waterloo Station Concourse and Victory Arch, John Maine's Arena, Black Friars Bridge.

Ross of Mull Granite – Black Friars Bridge.

Rosso Persiano - 160 Queen Victoria Street.

Royal Blue Pearl Larvikite – Elizabeth House.

Semi Rijo - 160 Queen Victoria Street.

Skyros Marble - The Black Friar Pub, 174 Queen Victoria Street.

Swedish Green Marble - The Black Friar Pub, 174 Queen Victoria Street.

Verde Maritaca – 160 Queen Victoria Street.

Verde Alpi – St Andrew's Lane

York Stone - Black Friars Bridge.

Left: Victorian drinking fountain at the north end of Blackfriars Bridge, composed of Cornish and Peterhead granites. The Blackfriars Pub is the four-storey building in the centre background.

Acknowledgements

Thanks are due to Helen Gordon who was the inspiration for this walk.

How to cite this article:

Siddall, R, 2014, Waterloo & City: Urban Geology across the Thames, Urban Geology in London No. 17., 12 pp (*insert web address and date accessed here*).

©*Ruth Siddall; July 2014*