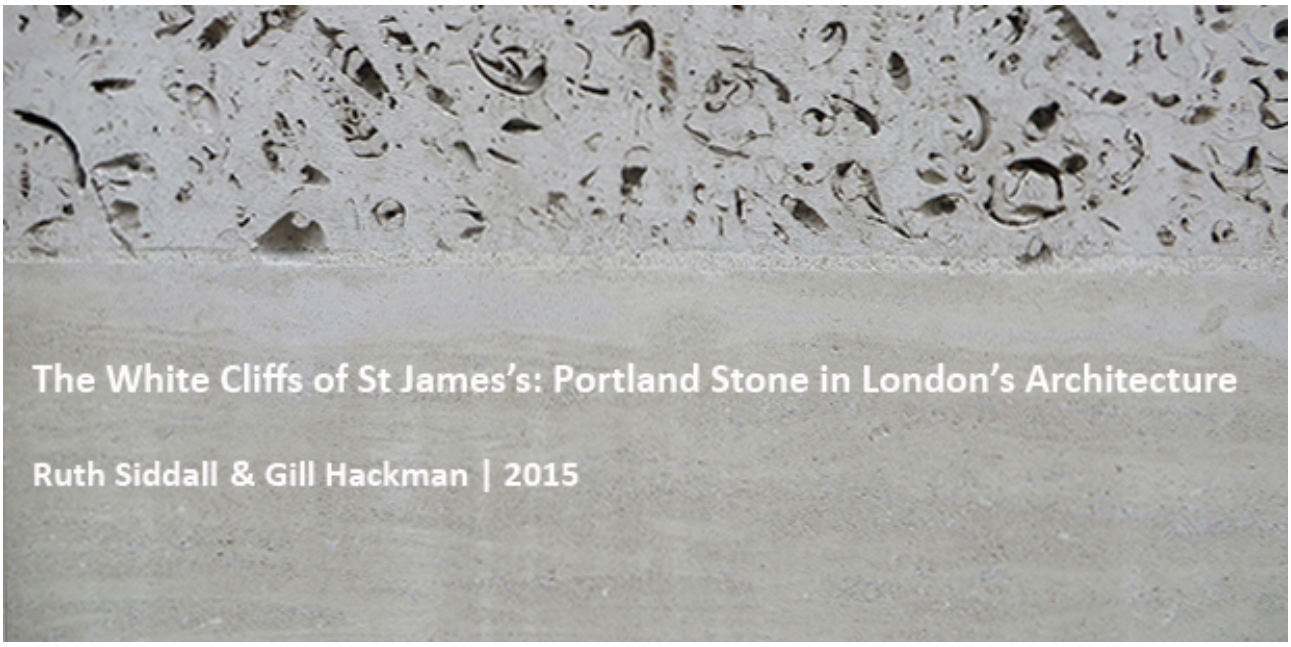

This walk has been commissioned by Artangel as part of a programme of events surrounding artist Katrina Palmer's project on the Isle of Portland and on BBC Radio 4, **End Matter**. *This takes place in April-May 2015. The walk took place on 30th May 2015.*

London does not have a good local building stone. The Roman and Medieval city was built of Kentish Ragstone and Reigate Stone. Later, the abundant clays and brickearths of the local geology were exploited and stock brick became the city's main building material. Bath Stone was brought in for some structures. However monumental buildings befitting of a capital required something special, and Portland Stone from Dorset became popular in the early 17th Century and remains London's iconic stone to this day. There are thousands of buildings in London built of Portland Stone and many others in the major cities of the British Isles. One may consider St Paul's Cathedral, the majority of the buildings on Whitehall including the Cenotaph and the Banqueting House, The Royal Naval College at Greenwich, The Bank of England, The British Museum, The National Gallery and indeed my home institution, University College London. The stone has also been exported world-wide, mainly to commonwealth countries and the USA. Here we may count amongst several Portland Stone structures the United Nations Building (1952) in New York City. Auckland's War Memorial Museum in New Zealand probably represents the use of this material most distant from the source. Portland Stone is also the standard for the Commonwealth war grave memorials. Today the stone is still used as one of London's principal building stones and architects recognise that this material imparts the 'character' of the city. Building projects using Portland Stone regularly sweep the awards in the biennial Stone Federation Stone Awards and Portland Stone has been nominated as one of the UK's Global Heritage Stones by Hughes et al (2013); the other candidate being Welsh Slate. Portland Stone is everywhere, and this walk will introduce the key characteristics of this stone as both a building and geological material.

The Geology of Portland Stone

Portland Stone is not a single, uniform rock type and in this walk we will see at least four varieties. Therefore we need to learn a little about the geological environment in which these strata formed to develop criteria by which we can identify and distinguish the different varieties of Portland Stone that we encounter.

Deposited in tropical seas 150 million years ago, the Portland limestones reveal a glimpse of a Late Jurassic ecosystem. The Portland Limestone Formation was deposited during the Tithonian stage of the Upper Jurassic. This stage is known locally as the Portlandian (Wimbledon & Cope, 1978; Cope 2012). The

stratigraphy on the Isle of Portland is described in some detail by Cope (2012), West (2012), Townson (1975) and Howe (1910).

The whole sequence of the Portland Freestone Member is an oolitic limestone or oolite (see Palmer, 2008). It is composed of round carbonate sand grains known as ooliths (or ooids). The ooliths, spherical particles of calcite, are about 0.5-1 mm diameter and are just visible to the naked eye on close inspection of the stone, especially in older, more weathered surfaces. They are easily seen using a hand lens or magnifying glass.

The building stones form the upper part of the Portland Limestone Formation, itself the upper part of the Portland Group (the lower part of this being sand dominated lithologies). The lower part of the Portland Limestone Formation are the basal shell bed and the so-called Cherty Series. These as the name suggests are composed of limestones with abundant chert nodules. Above these lie the building stones of the Portland Freestone Member.

The stratigraphically lowest unit of the Portland Freestone Member is known as the Basebed or 'Best Bed'. It varies from around 1.5 to 6 metres in thickness. It is slightly soft and porous and actually not the best building stone of the formation. Basebed contains few, if any fossils. It may show cross-bedding, evidence of tidal currents creating small dunes and ripples.

The Basebed is overlain by a thin, shelly, chert-rich layer, 'The Curf' which has not been exploited for building materials. Above the Curf lies the Whitbed. This is the best lithology for building and it is from this layer, varying between 1 to 5 metres thick, that much of the classic Portland Stone is derived. This is a thickly-bedded, sometimes cross-bedded, pale grey, oolitic limestone with sparse shell fossils, predominantly oysters (*Liostrea* species) and the occasional large ammonite of *Titanites* species. There is some variation in the Whitbed, with some areas showing well-developed cross-bedding and others far richer in fossils than is the norm. The currently operating quarry firms market varieties particularly rich in fossils as Grove Whitbed and those rich in varied fossil debris, also often showing cross-bedding structures as Perryfield or Fancy Beach Whitbed; the names being derived from the quarries from which they are extracted. It should be noted that fossil-poor varieties of Whitbed can be very difficult to distinguish from Basebed. Architectural records which detail the type of stone used, are extremely useful to the urban geologist, however experienced they may be!

The Whitbed passes upwards into a very distinctive facies of Portland Stone called the Roach. The name is probably a corruption of 'rough'. This rock is full of holes, which were once fossils. We need to learn some very basic chemistry to understand how this texture has formed. Sea shells are composed of calcium carbonate ($CaCO_3$) which can exists in two common forms, calcite and aragonite. The majority of living shells secrete aragonite, 'mother-of-pearl', which is not stable geologically. During fossilization aragonite reverts to the stable form, calcite. However, if lithification takes place quickly, this does not happen and the aragonite is leached away. This is what has happened in the Roach. The holes are casts and molds of once aragonitic shells. The most common, well-preserved fossils in the Portland Stone are oysters which secrete geologically stable calcite shells and therefore they are still with us. The Roach has become an important and popular architectural stone, however this is a fairly recent phenomena. The main use of the Roach prior to the 20th Century was for building breakwaters and military installations as the highly porous fabric enabled the impact of cannon balls to be absorbed by the structure. The Roach is up to 1 m thick and it often shows a gradational contact with the underlying Whitbed.

The Basebed and Whitbed represent relatively shallow-water, marine limestones, deposited in tropical seas, building up as a shoal or sand bank. In contrast the Roach represents a very shallow, high energy environment, concentrating shells and shell debris, in effect, a beach. Reefs are also known from the Whitbed. Superficially these resemble Roach but are dominated by the calcareous algae *Solenopora portlandia* (Fürsich et al., 1994). This variety of stone is the least common and will not be seen on this walk, although fragments of *Solenopora* may be seen in some examples of Whitbed. When these reefs, often around 4 m in diameter, are encountered by quarrymen, the stone is kept aside for special projects. The best example of *Solenopora* reef Portland Stone in London can be seen at Caxton House on Tothill Street, SW1 (see Siddall, 2013a).

In the quarries, the rock is dissected by widely spaced joints allowing large blocks up to 3 m square to be extracted, making it excellent for ashlar masonry. The properties as a freestone with a uniform, fine-grained texture and the lack of any plains of weakness allow Basebed and Whitbed to be cut in any direction and also be intricately carved. Another property of Portland Stone is its strength; rock strength is measured as compressional strength, effectively the load that it can take before failing. Portland Stone has an average compressive strength of ~ 45 Megapascals (MPa). Compare this with the geologically similar Bath Stone which has a compressive strength of 15 MPa.

The story of Portland Stone in London

The history of quarrying and use of the building stone has been described by Hackman (2014), Morris (2004) and Stanier (2000), and interested readers are referred to these sources for further information on these subjects. Portland Stone has been worked certainly since the Roman period and has been found in excavations in Roman Dorchester. It was used locally from the Medieval period (Hughes et al., 2013, Hackman, 2014), and it became quarried on a more industrial scale from the 16th Century. It was used in Inigo Jones's Banqueting House on Whitehall in 1622 and the construction of this building started a trend for Portland Stone. Consequently quarrying boomed in the 17th Century, and particularly after the Great Fire of London in 1666, when the stone became adopted by architects such as Christopher Wren and Nicholas Hawksmoor.

Early quarrying endeavours were small-scale, family-owned 'one-man-and-a-boy' operations. However by the late 19th Century, Hackman (2014) records over 30 firms based on the island working in quarrying and/or marketing the stone. Today, the quarry operators are reduced to two; Albion Stone and Portland Stonefirms Ltd. Much of the quarrying today is technically mining, the stone is extracted from subterranean caverns. This is good for the environment by increasing the available stone resource without destroying the surface landscape and habitat. Waste stone is used for aggregate and armourstone .

The fact that Portland Stone is attractive and that it wears well in cities has led to its use in London for more than 600 years. But the story of Portland Stone in London is a complex tale. The desires of Kings and Queens, national political intrigue, events in London, fires, wars and the state of the national economy all help to explain the pattern of London's Portland Stone buildings and of development on the island. The ancient customs of Portland itself have not been without their effects on the wider scene.

Although Portland Stone was used locally, records of the use of the stone in London do not appear until the mid fourteenth century, when it was used in works at the Tower of London and London Bridge amongst other places.

In the 17th Century Portland Stone began to change the face of London in ways that we can still see today and the quarrying industry on Portland struggled and grew to meet increasing requirements. Portland was, as it is today, a Royal manor, and Portland Stone appears to have been used initially largely to enhance buildings for the Crown or in which the monarch took a particular interest. Inigo Jones was the architect who first brought large quantities of Portland Stone to London. He was responsible for designing the Queen's House at Greenwich, the Banqueting house in Whitehall and was appointed as surveyor for repairs to old St Paul's Cathedral.

After the Great Fire of London in 1666 Christopher Wren was appointed as Commissioner for rebuilding the City of London and Portland Stone was used in rebuilding much of the City, including in St Paul's Cathedral and many of the churches in the City. The work did not run smoothly. It lasted until the early eighteenth century; there were constitutional and religious upheavals, financial troubles and war with the Dutch and French. The demand for Portland Stone was far greater than it had been before and there were difficulties increasing the supply. There was confusion over responsibilities, with some players very conscious of their own importance and others anxious to maximise their profits. The Commissioners for rebuilding St Paul's took charge of the detailed arrangements for obtaining stone from Portland, sending an agent to Portland so that the Commissioners could provide stone to the masons. But there were serious problems related to the arrangements for supplying stone, to the islanders' ancient customs and to transport. Maybe learning

from the experience of St Paul's, the Commissioners for the City Churches gave the masons direct responsibility for obtaining the Portland Stone specified in their contracts and paying for its transport. It seems that a private sector stone industry was developing on Portland in the late seventeenth century.

The 18th Century saw another step change in the nature of Portland Stone buildings in London and in the industry on Portland. Kings and Queens still influenced the use of stone on Crown land, but Royalty came to mean less than they had in the sixteenth and seventeenth centuries. London's increasing population needed new churches and the nation's armed forces and bureaucracy were growing, needing new buildings to house them. St Martin in the Fields, the Horse Guards and Somerset House are amongst the buildings constructed at this time. Both St Paul's and the Banqueting House were refaced, making much more use of Portland Stone than when they were originally built. The old system of management, where Sir Christopher Wren saw himself as guardian of all the quarries and supervisor of their use for buildings for the Crown and the Church, ceased. A guardian or Keeper of the Crown quarries was appointed to supply stone from the King's quarries and the commons for a wider range of projects. From 1760 the civil service took control of the King's interests on the island and attempted to maximise income from the estate.

In the first half of the 19th Century London continued to grow rapidly and Portland Stone was in demand for impressive public buildings, including art galleries, universities and museums. The role of private firms in the industry increased further. Stewards were the main firm on Portland and the family had a wharf in Abingdon Street in London, roughly on the site of the present Embankment Gardens near the Houses of Parliament. The family had close links with the London stone merchants nearby and these merchants began to acquire land on Portland. To help relieve the transport problems on Portland a new railway, known as the Merchants' Railway was built to carry stone from the top of the island down to the sea. New piers were built and in 1839 a bridge to the mainland was opened – a turning point in the history of the island.

In the second half of the 19th Century, and up to the First World War in 1914, the British Empire was at its peak. Portland Stone was in demand for Government buildings and quarrying spread rapidly across the top of the island. The building of a prison, breakwater and fortifications on Portland led to an enormous demand for Portland Stone locally. The Government quarries in the north east of the island were well equipped and the Admiralty built a railway to carry stone down from the old King's Quarries on the top of the cliffs to the sea. Private quarrying also became a seriously big business. Horse operated tramways and stone bridges were built to carry stone from the quarries and waste to the western cliffs for disposal. Gradually stone began to be cut and carved in masons' yards on Portland, rather than on building sites. In the early 1900s steam powered cranes and channelers (to cut straight edges) were introduced in the quarries. Family firms combined and in 1887 Bath Stone Firms came to Portland and bought up local companies. United Stone Company was launched in 1909, buying out a number of Portland firms, but they never became as big as the Bath and Portland Stone Firms. Transport improved with the extension of the Merchants' Railway, the arrival of the national railway, introduction of traction engines and the increasing use of Thames barges to carry stone to its place of use.

Between 1914 and 1945 there were serious ups and downs in the building industry and the Portland Stone industry. There were 2 World Wars, a general strike in 1926 and economic depression 1930-1936. Nevertheless, there were good times for the industry until 1915 and in the 1920s and late 1930s. Feeder railways in the quarries were replaced by steam traction engines and later by steam and diesel lorries. 1939 was the last year of the Merchants Railway, barges were gradually being replaced by steam coasters and the national railway increasingly carried stone to the mainland. Key London buildings included the Cenotaph, the Bank of England, Broadcasting House and Shell Mex House.

After the Second World War there were new building technologies, prefabrication and a need for cheap construction, particularly for housing. Portland Stone was used for some of the rebuilding and for office blocks in London's office boom of the 1950s and early 1960s, often where the character of surrounding buildings was to be respected. From 1960-1979 the stone industry declined, partly because new offices were not allowed in central London unless that location was essential. In 1979 a London based firm, Albion Stone, came to Portland and during the 1980s the use of Portland stone in modern architecture revived.The Hanson Group took over the old Bath and Portland Stone Group in the 1990s, but in 2004 the Portland side

of their activities was separated out as the Stone Firms Ltd. Today the masons' yards on the island are highly mechanised. One company is now mining stone rather than quarrying on the surface. They cut the stone with automated chain saws and separate the blocks with metal hydro bags, which are slowly inflated using water pressure.

Portland Stone in St James's

When Artangel asked me to lead a walking tour of London's Portland Stone, I was given a blank slate and could have taken it anywhere in London. There are thousands of buildings in London constructed of Portland Stone and I could have led a similar walk almost anywhere in Zone 1. The main reasons for choosing St James's over, say, the St Paul's area of the city, or Great Portland Street, was mainly down to two key buildings which are important in the 20th and 21st Century history of Portland Stone. These are the Green Park tube station pavilion (2011), which uses almost whole range of Portland Stone quarried today (and is also a work of art in its own right) and the Economist Buildings (1964), famous for being the first major building to use Roach as its main cladding stone. The area also contains a range of old and new buildings using Portland Stone, so the effects of age and weathering can be observed. St James's can also offer a capsule view of the architectural history and development of London from the 16th Century brick-built Palace, to the earliest residential London Square, through Edwardian shopping streets and modern office complexes. Although we do not see any early 17th Century Portland Stone structures (nearby, the original Burlington House, The Royal Academy of Arts, was built in 1664, but was re-faced in the 18th Century), we can take in vistas which show us how a city of brick was transformed to a city of Portland Stone.

Architectural notes given here, unless otherwise cited, are from Pevsner (Bradley & Pevsner, 2005). A companion guide to this walk describes the fossils of the Portland Stone and of course can be applied to the understanding of this stone in any urban outcrop (Siddall, 2015).

The walk begins at Green Park Underground Station.

Green Park Underground Station

This construction has been much praised by London's geologists and rightly so, it is a splendid contribution to the Urban Geology of the Capital. It has been described elsewhere (Stevenson, 2013 & Siddall, 2013b) but its presence here is the main reason for starting this walk at Green Park. The new pavilion housing the Southern entrance to Green Park Underground Station was completed in 2011, by Capita Architecture and Acanthus LW with art by Royal Academician John Maine (see Transport for London, 2011). It won a special award from the Stone Federation in 2012 for Art in Stone (Natural Stone Awards, 2012). The building houses lift and step access to Green Park station and is clad entirely in Portland Limestone, supplied by Albion Stone[1]. The stones used were quarried from Jordans and Bowers Quarries on the Isle of Portland. On this building we can see the whole range of building stones extracted, in stratigraphic order, these are Basebed, three varieties of Whitbed (Jordans, Grove and Fancy Beach) and Roach. John Maine's installation, called 'Sea Strata' forms a frieze around the buildings and features large images etched into Basebed of the typical Portland fossils, predominantly the Portland Screw and *Solenopora* algae.

The foundations of the building are Aberdeenshire Kemnay Granite and the surrounding paving is a variety of granite varieties, engraved with a spiral. This area was once used as a reservoir and the spirals reflect this watery history. Above the foundations are courses of Portland Stone ashlar masonry; first Whitbed, then Roach (which also forms the coping on the surrounding walls). Above this is John Maine's frieze. Above this

[1] http://www.albionstone.com/files/9013/7699/5191/Green_Park_Tube_Station.pdf

there is a band of Fancy Beach Whitbed and another layer of Whitbed above this. Closer views of these stones can be seen in the stairway down to the station.

Green Park underground station and John Maine's frieze 'Sea Strata'.

The Wolseley, 160, Piccadilly

Once the head offices of Wolseley Motors, this building has also been a bank before being converted into a restaurant. It was completed in 1921 by architect W. Curtis Green. The façade is in a Classical style with three full-storey arches decorated with egg-and-dart moulding, the central one of these forming the entrance. The first storey is finished with a Greek key frieze. Above this is a colonnade of Corinthian columns, stretching three storeys. Portland Whitbed is used as a facing stone throughout. The Wolseley is very typical of London's Portland Stone buildings. It is constructed from Whitbed and shows the typical pale-grey weathering of this stone, which accentuates the scattered fossil fragments in this stone.

The building was constructed between 1919 and 1921 at a time when the Portland Stone industry was reviving just after the First World War. Much of the quarrying on the island was still undertaken in the same way as it was hundreds of years earlier. The quarry gangs provided their own hand tools. The stone firms provided a hand crane, chains for lifting and a hut. There were steam cranes in the masonry works – but most of the work was done by hand.

We take the next turn right onto St James's Street. Looking down we see Henry VIII's St James's Palace, built in c. 1540. This view takes us back in time to what London would have looked like before Portland Stone, when brick was the main building material. St James's Street would once have been the driveway to the entrance of this building. Across the road from the Palace, in Marlborough Road, is the Queen's Chapel, built largely of rendered brick as early as 1623-25. Inigo Jones was the architect and Portland Stone was used for quoins and dressings. At that time stone from the Royal Manor of Portland was largely used for buildings for the Royal family and it was usual for relatively small pieces of Portland Stone to be used in

brick or rendered buildings. Other examples are the Queen's House at Greenwich and the Banqueting House in Whitehall as originally built. Constructed between 1619 and 1622, the Banqueting House originally had only ornamental details and a balustrade of Portland Stone. It was refaced entirely in Portland Stone in 1774.

We are brought with a jolt back to the 20th Century as we cross over and approach the Economist Plaza on the left hand side of the street.

The Economist Plaza

This is an iconic group of buildings dating from the mid-1960s and it is particularly notable in the context of this walk for being one of the earliest buildings of the modern era to use Portland Roach as an architectural stone. Indeed, it is one of the few 1960s office complexes to still remain standing in central London. It was designed by architects Alison & Peter Smithson and constructed between 1962-4. The complex comprises three towers on a raised podium, enclosing and creating a public space. A mechanical water-powered sculpture by Angela Conner (1992), is located in the northern part of the plaza. This is sadly poorly maintained and is no longer operating at the time of writing. The plaza is also used for changing displays of sculpture. At the time of writing, a number of works by Eduardo Paolozzi (1924-2005) are on display.

We are confronted with cliffs of Portland Roach and this is an excellent place to view (and photograph) the variety of fossils seen in this stone. Most obvious are the finger-length, arrow shaped Portland Screw (*Aptyxiella portlandica*). Look for the cork screw-like internal casts which gave the Portland Screw its vernacular name. A bench along the London stock brick wall that forms the northern side of the plaza is made from and oyster shell-rich variety of Whitbed, very similar to the stone now marketed as Grove Whitbed by Albion Stone. Crossing the plaza and descending the steps onto Ryder Street, some good 'exposures' of the stone are seen around some air vents. These give us some more information about the stratigraphy of the Roach; it is a layer of variable thickness, up to around 1 m thick. However in an ashlar block above an air vent we can see it forms (several?) bands only around 20 cm thick, alternating with less

fossiliferous layers. Also here is a nice example of a Portland Screw infilled with coarsely crystalline calcite spar. This has crystallised in the cavity left by the shell after the lithification of the rock.

Above: Portland Roach used for cladding on the Economist Plaza entrance of Ryder Street. Below: detail of a Portland Screw infilled with secondary calcite spar.

The building was one of the last buildings of London's post war office boom, before the introduction of Office Development Permits, Capital Gains Tax and the Betterment Levy led to a rapid reduction in office building in London. The need for economy, speedy construction and changing fashion also led to greater use of glass and concrete. Both changes led to a major reduction in the use of Portland Stone.

Leave the Plaza on Ryder Street and turn right down to King Street.

23, King Street

This block has been recently developed by Trehearne Architects in 2014. Portland Stone has been used to clad the façade, using Whitbed with decent oyster fossils at pavement level with higher parts of the piers, from around eye-level, clad with Roach. The Portland Stone is very well cross-bedded here. Indeed West (2014a) suggests that all the Portland Whitbed and Basebed are cross-bedded, but that this is not clearly visible in rough quarry sections and geological exposures. However the evidence of building stones disputes this, as few examples on London's buildings show this degree of cross-bedding.

Geologists use cross-bedding like this to determine the direction of flow of palaeocurrents, as the cross-beds or 'foresets' dip in the direction of flow. Here the pattern is more complex. Most of the foresets dip in

the same direction, but they alternate with layers where the foresets dip in the opposite direction. This suggests an oscillating current which would have been expected in a tidally dominated lagoon environment. This is evidence of ripples forming in the Tithonian Portland seas.

Above the Whitbed, good fresh examples of Roach are used, typically rich in moulds and casts of Portland Screw and Trigonid bivalves. A photo of this forms the title image of this guide.

23, King Street was once the site of the St James's Theatre. In the narrow passage of Angel Court, salvaged panels, carved in bas-relief in sugary-textured, white Carrara Marble, commemorate the Theatre, which was demolished in 1957. These are by sculptor E. Bainbridge Copnall and they were created in 1959.

Almack House, 28, King Street

Next to the Golden Lion Pub is Almack House at 28, King Street. It was erected in 1992 by Trollope & Colls Construction Ltd. and designed by architects Scott Brownrigg & Turner. Portland Whitbed is used to clad this building and good examples of fossil fragments are seen around the porch. Here the Portland Stone has a structure, but it is more disordered than the cross-bedded Whitbed seen at number 33, King Street above. This is bioturbated, meaning that the layering of the rock has been destroyed by animals (worms and other sealife) burrowing through it.

To be honest, however, the main event geologically at this building is the spectacular pink and green streaked gneiss used for the foundations of this building. It is Verde Tropical from Campo Belo in Brazil and is almost 3 billion years old.

Almack House, and Cleveland House, which we will see shortly, were built in 1992 and 1998. This was a time of revival for the Portland Stone industry. After the lean times of the late 1960s and 1970s there was a second office building boom, stimulated by financial deregulation, the computer revolution and the abolition of the Greater London Council. Stone veneers were used increasingly as a result of changing fashion and the availability of new building technologies. The traditional way of raising stone using pig iron bars and wedges had been replaced. The rock was now worked by first drilling holes with a pneumatic drill. Long narrow plates, called feathers, were placed in each hole and steel plugs were tapped into them until the stone broke.

Christie's Auctioneers, 8-9, King Street

Christie's occupies three adjacent buildings on King Street. The middle of these is built from Portland Whitbed and was constructed at the end of the 19th Century by J. Macvicar Anderson. Very much in the style of the 15th Century Italian Renaissance; the doorway is surrounded by an impressive porch with an open pediment, surmounted with an urn. There are masks above each window and bands of rustication across the frontage.

'Rustication' is a decorative stone-dressing technique. This can range from 'plain rustication' of this sort to blocks carefully carved or dressed to give the appearance of rough-cut stone (see Hopkins, 2012). Such traditions in stone dressing go back to Classical times, where it has been used to make rock look more 'rocky' especially in fountains and grottoes, or to give the effect of venerability to buildings. However it became popular during the Italian Renaissance (15th-16th Centuries) and in British architecture the style was adopted along with Palladian-style architecture in the 17th Century. Rustication can take the form of blocks dressed with chamfered edges (plain-rustication), blocks with a pyramidal surface (diamond-point rustication) and blocks roughly chiselled to give a 'rock-face' or 'quarry-face' effect or elaborately drilled and carved to give a vermiculated or reticulated pattern . More elaborate forms resemble stalactites or icicles, known as congelated (or glacial) rustication. The intention of this stone dressing technique is to give an appearance of strength or weightiness to the building, over that of smooth, ashlar masonry.

The Survey of London suggests that the original building was being leased from the Crown from 1809. It was damaged by bombs in 1941 and rebuilt in 1952-53. The main façade escaped – it was retained and

reconstructed. When the façade was first built in the early nineteenth century private quarrying on Portland was growing, Portland's stone merchants were busy in Westminster and London stone merchants were quarrying on the island.

Cleveland House

The final building we shall look at on King Street is Cleveland House by Trehearne Architects (1998) which forms the corner onto St James's Square. Of interest is the archway entrance to Cleveland Court which feature a delicate, leaf-like stone carving by Robin Conelly. This is executed in fossil free Basebed, however much of the building is clad in Whitbed. Moving to the porch at the main entrance, good examples of fossils can be seen on the soffits including spiny oysters (*Plicatula damoni*) and cockles (*Protocardia dissimilis*). The latter are originally aragonitic shells and they have been infilled by secondary sparry calcite.

The porch floor is paved with a French Cretaceous Limestone, Hauteville, from the Jura and the columns are of an unknown red granite.

Robin Conelly's carving in Basebed at Cleveland Place.

Turn left into St James's Square and walk to the corner.

13, St James's Square

St James's Square is one of the oldest squares in London. It was laid out by Henry Jermyn, Earl of St Albans (1605-1684) in 1665, however most of the buildings here now date from the 18th and 19th Centuries. The plan of the square with the streets (on three sides at least) emerging from the centres of the sides (rather than the corners) was inspired by Italian piazzas and went on to be the standard for later London Squares.

In the north-west corner stands the Cypriot Embassy, 13, St James's Square. This building was built in the 1730s for Henry Liddell, 1st Lord Ravensworth. The upper storeys are in London stock brick, but stained black with painted white joints. Some of these joints are fake; a row a stretchers forms the first course but above the appearance is of all headers. This effect is notable in other London buildings of similar age (i.e. Numbers 10 and 11 Downing Street and also in Bedford Square). Little is know about this trend and also when this staining was applied. Cox (1997) suggests it may have been a Victorian fashion, based on the fact that paintings of Downing Street in the 1850s show more typical yellow stock brick walls.

The Portland Whitbed blocks used on the ground storey have been cut in such a way that they are chamfered, so that the joints between each block has a v-shaped cross-section. Such stone dressing is a form of what is known as 'plain rustication'. It certainly gives the Whitbed used in this structure a look of strength. This building, though typical of many in London's Georgian Squares, could be taken as a classic combination of the city's principal building materials.

13, St James's Square was constructed at a very interesting time in the history of the Portland Stone industry. Demand for stone was growing and the industry was working hard to meet demand. In 1730, twelve new churches, known as the Queen Anne churches had just been completed, as well as St Martin in the Fields in Trafalgar Square. In 1734 the Dean and Chapter of Westminster Abbey ordered the north west tower on the west front of the Abbey to be built of Portland Stone. But there were problems obtaining the stone and in 1735 the workmen were given other work "until a supply of Portland Stone can be had".

St James's Piccadilly

The parish church of St James Piccadilly is the oldest building using Portland Stone that we will see at close quarters on our walk. In 1672 Christopher Wren was commissioned to design and build it and the church was completed in 1684. It is built of red brick with Portland Stone dressings, for window architraves doorcases, plinths and quoins. Damaged in 1940-41, during the war, it was restored between 1947 and 1954. When the church was first built it was a very busy time for Portland and for Sir Christopher Wren. St Paul's Cathedral and the City churches were being rebuilt after the Great Fire of London. The building accounts for this particular church have not survived but we know from other building accounts of the period that there were great difficulties obtaining Portland Stone. The construction of St Paul's caused particular problems with its demands for numerous large blocks of stone. Even transporting the stone to London caused immense problems. War with the French sometimes halted traffic. The narrow arches of the then London bridge meant that ships had to unload below the bridge. Just after this church was completed a major landslide on Portland destroyed the roads cranes and piers used by the stone industry.

99, Jermyn Street

The office block on the corner of Duke of York Street and Jermyn Street is by Frederick Gibberd architects and uses Jordan's Basebed to clad the façade. The fossil-free Basebed is not used very often these days in exterior settings as it is the softest and therefore least resistant to erosion of the Portland Stone varieties. The cladding used here was supplied by Albion Stone[2]. The architects specifically chose Basebed over Whitbed as they wanted to exploit the stone's 'clean and uniformed appearance'.

33, Jermyn Street (198-202 Piccadilly)

This building which incorporates shops on its Piccadilly façade and an entrance to offices at 33 Jermyn Street was constructed in the post-modern style in 2008, though it rather looks like it was built in the 1980s. Typical of this style it uses trim in brightly coloured and exotic granites, namely Sanhe Red from China and Kashmir Gold from Tamil Nadu in India (see Siddall, 2013b). Perryfield Whitbed, supplied by Portland Stonefirms Ltd[3]., is used to clad the building, but it is in fact just a thin veneer, one centimetre thick, fixed onto panels or precast concrete. These panels were made by UK firm the Marble Mosaic Company Ltd[4]. This building's brief was to be stylish but low budget. The contractors could have used reconstituted stone, but the veneer of real stone was chosen as it would have better resistance to weathering. This building was commended for its use of stone by the Stone Federation in 2008 (Natural

[2] http://www.albionstone.com/portland-stone-projects/98-100-jermyn-street

[3] http://www.stonefirms.com/portfolios/piccadilly-jermyn-street/

[4] http://www.architecturalconcrete.co.uk

Stone Awards, 2008). It provides a good example of the use of traditionally quarried stone and modern building techniques as the Portland Stone industry moved into the 21st century.

Walking up Church Place to the front elevation on Piccadilly, a very good examples of the spiny oyster or spondylus *Plicatula damoni* can be seen on the third course of Whitbed up, on the rectangular section engaged column, to the left of Costa Coffee.

Left: 198, Piccadilly, the spondylus fossil shown in the image, Right is indicated by the arrow.

30, Jermyn Street

This block is now occupied by the book shop Waterstones and is the back entrance to 203-206 Piccadilly. The store was originally constructed for outfitters Simpson's Ltd. and was designed by art deco architect Joseph Emberton. It was completed in 1936. The interior is clad with Tivoli Travertine from the immense and ancient quarries near Rome. However the exterior as observed here on Jermyn Street is of Portland Whitbed on a socle of black 'granite', probably a dolerite from either Finland or Sweden. Varieties from both countries were marketed as Ebony Black. The Whitbed here shows the characteristic weathering of Portland Stone of this age, with the shell fossils standing slightly proud of their oolitic limestone matrix. These are relatively thin calcitic shells of bivalves, probably fragments of pecten and spondylus shells. The thicker laminated shells are oysters.

The timing of the building is interesting as it was built during the depression of the early 1930s when the Portland Stone industry faced lean times and many quarry men and masons were laid off. Even in 1935 quarries were closing and the few quarrymen employed worked a 3 day week. On Portland mechanisation was increasing with overhead gantries, and travelling cranes in the masonry works. A great deal of stone was leaving the island by train, and diesel lorries were beginning to appear. Mechanisation was also creeping in for the peripheral activities to quarrying. But many of the old ways continued. Horses took stone to the Merchants Railway for carriage down to the pier and traction engines carried stone around the island.

It is also worth noting that this site was once the site of the Museum of Practical Geology founded by Henry de la Bèche in 1845. The building became too cramped for displaying the collections as well as housing teaching and research laboratories, and bit by bit, collections were moved over the museums complex in South Kensington. The museum was demolished in 1935.

111-112, Jermyn Street

This building occupies the corner of Jermyn Street and Babmaes Street. It demonstrates impressive 'rock-face' rustication at street level, with the upper storeys in smooth ashlar masonry; the rough, chiselled

effect of the rustication is very effective in this building, giving the Portland Whitbed here the appearance of granite. But close inspection of these rough surfaces reveal the stone to be composed of ooliths. Built in the style of a 'Florentine Palazzo', this building was designed by architect Reginald Morphew in 1900, for his family's knitwear firm, Standen's. It is currently owned by Jones the boot makers (*below*).

Eagle Place

The block fronting on to Eagle Place, between Piccadilly and Jermyn Street is by Eric Parry Architects for the Crown Estate, who are the main landowners in this area. It was completed in 2013 and has also been described in Siddall (2013b). The building is clad with Portland Grove Whitbed and Jordan's Whitbed supplied by Albion Stone[5]. The high point of this building is the Grove Whitbed, a variety of Whitbed packed with fragments of grey fossil oyster shells plus a few cavities where aragonitic shells have weathered out.

Above: Grove Whitbed on Eagle Place

Some of these cavities have infills of sparry secondary calcite. This facies represents a winnowed lag of oyster shell debris accumulated in a hollow in the sea floor. A few fragments of *Solenopora* algae are also

[5] http://www.albionstone.com/files/9014/0811/2595/Eagle_Place_St_Jamess_Gateway.pdf

present, resembling white, cauliflower florets. Some of these are best observed in the porch soffits of the Eagle Place entrance.

Completed in 2013 this is a cutting edge 21st Century Portland Stone building. Some of the limestone comes from Jordan's mine, cut by automated chain saws and displaced by hydro bags, large steel bags slowly inflated by water under pressure and capable of detaching blocks weighing up to 16 tonnes, so minimising wastage of stone.

Leaving Eagle Place, we are confronted with a view of caverns and canyons in Portland Stone on Piccadilly and Air Street. Cross over Piccadilly to Cordings on the corner of Air Street.

Cording's, 19-20, Piccadilly

On Piccadilly, the Meridien Hotel, with alternating layers of ashlar-dressed and rusticated masonry and giant columns on the upper storeys, was designed by Norman Shaw in 1905-8, is in Portland Whitbed. Next door to the Meridien Hotel is Cording's gentlemen's outfitters. This building and particularly the bronzy larvikite used on the shop front has previously been described by Siddall (2013b). However, our attention is drawn here to the Portland Stone used on the upper storeys. This is probably Basebed, unfortunately it is too high up to be sure. However the delicately and intricately carved grapevine frieze, above the shop windows and the frieze of acanthus leaves above that, shows off Portland Stone's excellent qualities as a freestone (*see image below*). The frieze is also suffering from the effects of weathering, again suggesting that the softer less resistant Basebed has been used here. 19-20 Piccadilly, Denman House, was built in the 1890s by architect H. A. Woodington in the 'Neo-Baroque' style.

Both 111-112 Jermyn Street and Cordings were constructed around 1900. The population of London doubled from around 3 million to around 7 million between 1861 and 1911. Massive buildings were built to run the British Empire and new buildings for public service, education and leisure. The Royal Courts of Justice alone used 62,000 tons of Portland Stone. Other well known Portland Stone buildings of the time include Admiralty Arch, the stone front of Buckingham Palace and the Foreign and Commonwealth Office. Between 1847 and 1914 Portland too changed in ways which would have been unimaginable to islanders in the first half of the nineteenth century. The Government built a new harbour and breakwater, a prison and fortifications on top of the island, all creating a massive demand for Portland Stone. To build the original breakwater nearly 6 million tons of stone were quarried in the Admiralty's quarries, although much of it

was not high quality building stone. The industrial revolution was arriving in the private quarries too, with electricity and steam to operate machinery and traction engines to move stone.

This walk formally finishes here. It is not intended to have been an exhaustive tour of Portland Stone in this area, a glance down Piccadilly in either direction reveals acres of the characteristic pale grey of Portland Stone in both directions. Other notable buildings using this stone are Burlington House (housing the Royal Academy of Arts and the Geological Society of London amongst other venerable institutions), the entrance to the Burlington Arcade and the former Institute of Painters in Watercolour, with busts of artists in roundels across the largely windowless third storey. For those wishing to travel back using the underground, the nearest tube station is Piccadilly Circus.

Read more about Portland Stone

West (2014b) provides a complete bibliography of geological publications on the Portland Stone. The list below includes all references cited in the text, plus a few other useful links and references.

Albion Stone: Eagle Place, London W1; http://www.albionstone.com/files/9014/0811/2595/Eagle_Place_St_Jamess_Gateway.pdf

Albion Stone: Green Park Tube Station, London W1; http://www.albionstone.com/files/9013/7699/5191/Green_Park_Tube_Station.pdf

Albion Stone: 99, Jermyn Street, London W1; http://www.albionstone.com/portland-stone-projects/98-100-jermyn-street

Arkell, W.J., 1947, The Geology of the Country around Weymouth, Swanage, Corfe and Lulworth. Memoir of the Geological Survey, HMSO, 386 pp.

Artangel: Katrina Palmer|End Matter 2015: http://www.artangel.org.uk/projects/2015/end_matter

Bradley, S. & Pevsner, N., 2005, The Buildings of England: London 6; Westminster., Yale University Press., 556-566 pp.

Cope, J. C. W., 2012, Geology of the Dorset Coast; Geologists' Association Guide No. 22., Chapter 5, South Dorset; Isle of Portland, 94-103.

Cox, A., 1997, A vital component: stock bricks in Georgian England., Construction History, 13., 57-66.

Fürsich, F. T., Palmer, T. J. & Goodyear, K. L., 1994, Growth and disintegration of bivalve dominated patch reefs in the Upper Jurassic of Southern England., Palaeontology, 37 (1), 131-171.

Hackman, G., 2014, Stone to build London: Portland's legacy., Folly Books Ltd., Monkton Farleigh., 311 pp.

Hopkins, O., 2012, Reading architecture; a visual lexicon., Laurence King Publishing, London., 175 pp.

Hughes, T., Lott, G. K., Poultney, M. J. & Cooper, B. J., 2013, Portland Stone: A nomination for "Global Heritage Stone Resource" from the United Kingdom., Episodes, 36 (3), 221-226.

Morris, S., 2004, Portland: An illustrated history. (Second Edition), Dovecote Press., 160 pp.

Natural Stone Awards, 2008, Souvenir Programme, Stone Federation of Great Britain., 36 pp.

Natural Stone Awards, 2012, Souvenir Programme, Stone Federation of Great Britain., 28 pp. http://www.stonefed.org.uk/uploads/Website%20Brochure.pdf

NHM Fossil Folklore: Bivalves; http://www.nhm.ac.uk/nature-online/earth/fossils/fossil-folklore/fossil_types/bivalves02.htm

Palmer, K., 2015, End Matter., Bookworks, London, 96 pp.

Palmer, T.J., 2008, Limestone petrography and durability in English Jurassic freestones, pp. 66-78. *In* Doyle, P. (ed). England's Heritage in Stone. A Publication of the English Stone Forum., 66-78.

Portland Stone Firms: Piccadilly & Jermyn Street; http://www.stonefirms.com/portfolios/piccadilly-jermyn-street/

Siddall, R, 2013a, Urban Geology on Victoria Street, SW1; Urban Geology in London No. 10, http://www.ucl.ac.uk/~ucfbrxs/Homepage/walks/VictoriaStreet.pdf

Siddall, R, 2015, An Urban Geologist's Guide to the Fossils of the Portland Stone., Urban Geology in London No. 30, http://www.ucl.ac.uk/~ucfbrxs/Homepage/walks/PortlandFossils.pdf

Siddall, R., 2013b, From Eros to Eternity: Piccadilly's Stone Heritage. Great Geowalk 12th October 2013 for the Geological Society of London in association with London Walks., Urban Geology in London No. 11., 9 pp. http://www.ucl.ac.uk/~ucfbrxs/Homepage/walks/PiccadillyWalk.pdf

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

Stevenson, N., 2013, Green Park London – Portland Stone; http://www.greengeology.org.uk/#/green-park/4574706030

The Marble Mosaic Company Ltd.; http://www.architecturalconcrete.co.uk

Townson, W.G. 1975. Lithostratigraphy and deposition of the type Portlandian. Journal of the Geological Society, London, 619-638.

Transport for London, 2011, Art on the Underground: John Maine, Sea Strata: http://art.tfl.gov.uk/projects/detail/3948/

West, I. M. 2013. Fossils of the Portland Group, Upper Jurassic: Geology of the Wessex Coast (including the Dorset and East Devon UNESCO World Heritage Coast - Jurassic Coast). Internet field guide: http://www.southampton.ac.uk/~imw/portfoss.htm Version: 26th August 2014.

West, I. M. 2014a, The Isle of Portland: General. Geology of the Wessex Coast (part of Jurassic Coast, Dorset and East Devon World Heritage Site). Internet field guide. http://www.southampton.ac.uk/~imw/Portland-Isle-Geological-Introduction.htm Version: 24th August 2014.

West, Ian M. 2014b, Geology of the Isle of Portland - Bibliography: Geology of the Wessex Coast (Jurassic Coast, Dorset and East Devon World Heritage Site): http://www.southampton.ac.uk/~imw/portbib.htm Version: 15th August 2014

Wimbledon, W.A. & Cope, J.C.W. 1978. The ammonite faunas of the English Portland Beds and the zones of the Portlandian Stage. Journal of the Geological Society, London 135, 183-190.

Wright , V.P. 1985. Seasonal banding in the alga *Solenopora jurassica* from the Jurassic of Gloucestershire, England. Journal of Palaeontology, 59, 721-732.

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