WGCG
Hidden wonders in the landscape of Warwickshire

Solihull Urban Geology Trail

A Geological Discussion

Ray Pratt
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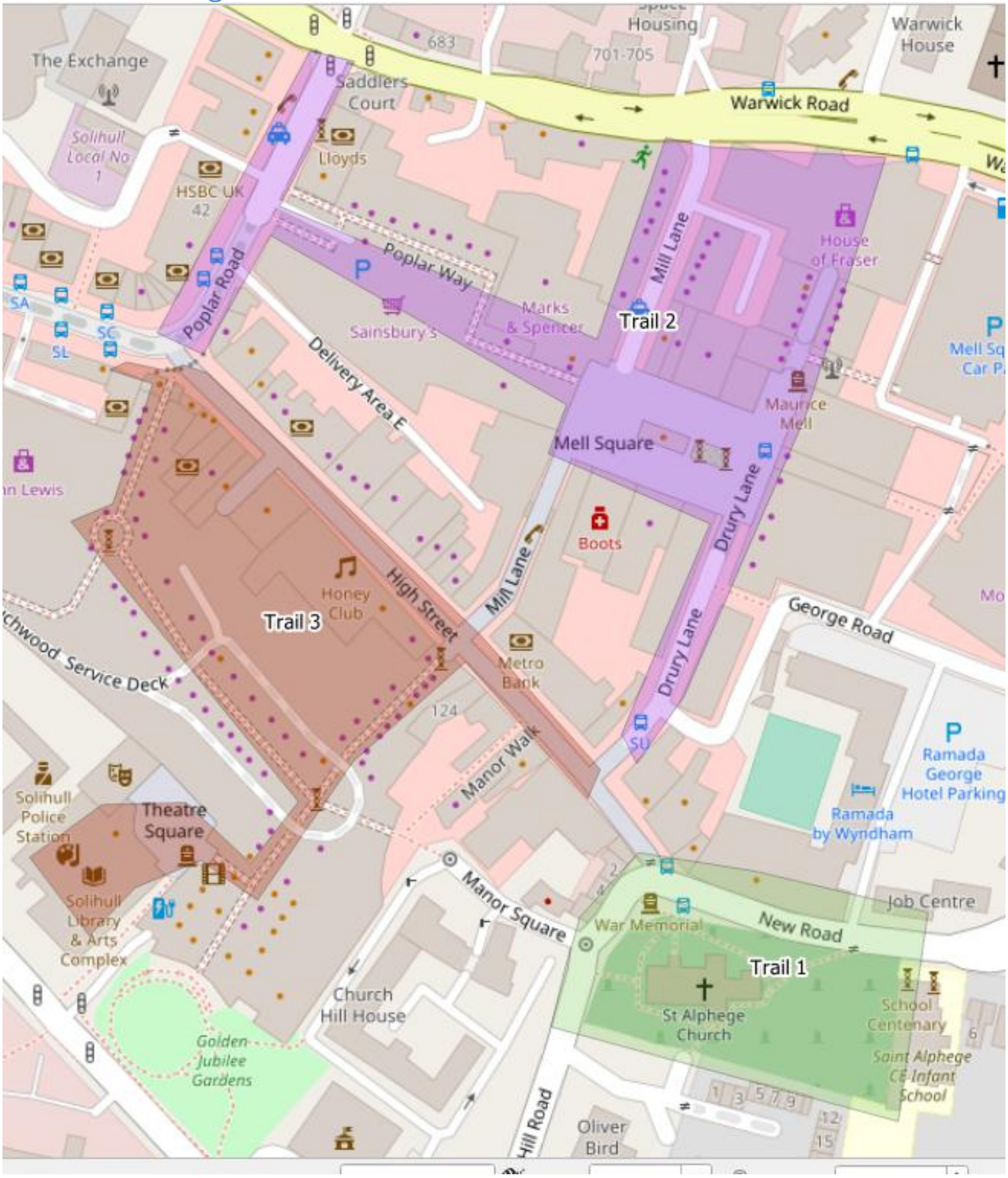
Contents

The building stones trails around Solihull.

Foreward
This work is a companion document to the "Solihull Urban Geology Trails Guide" and seeks to provide more information regarding the rocks that can be viewed along the trails.

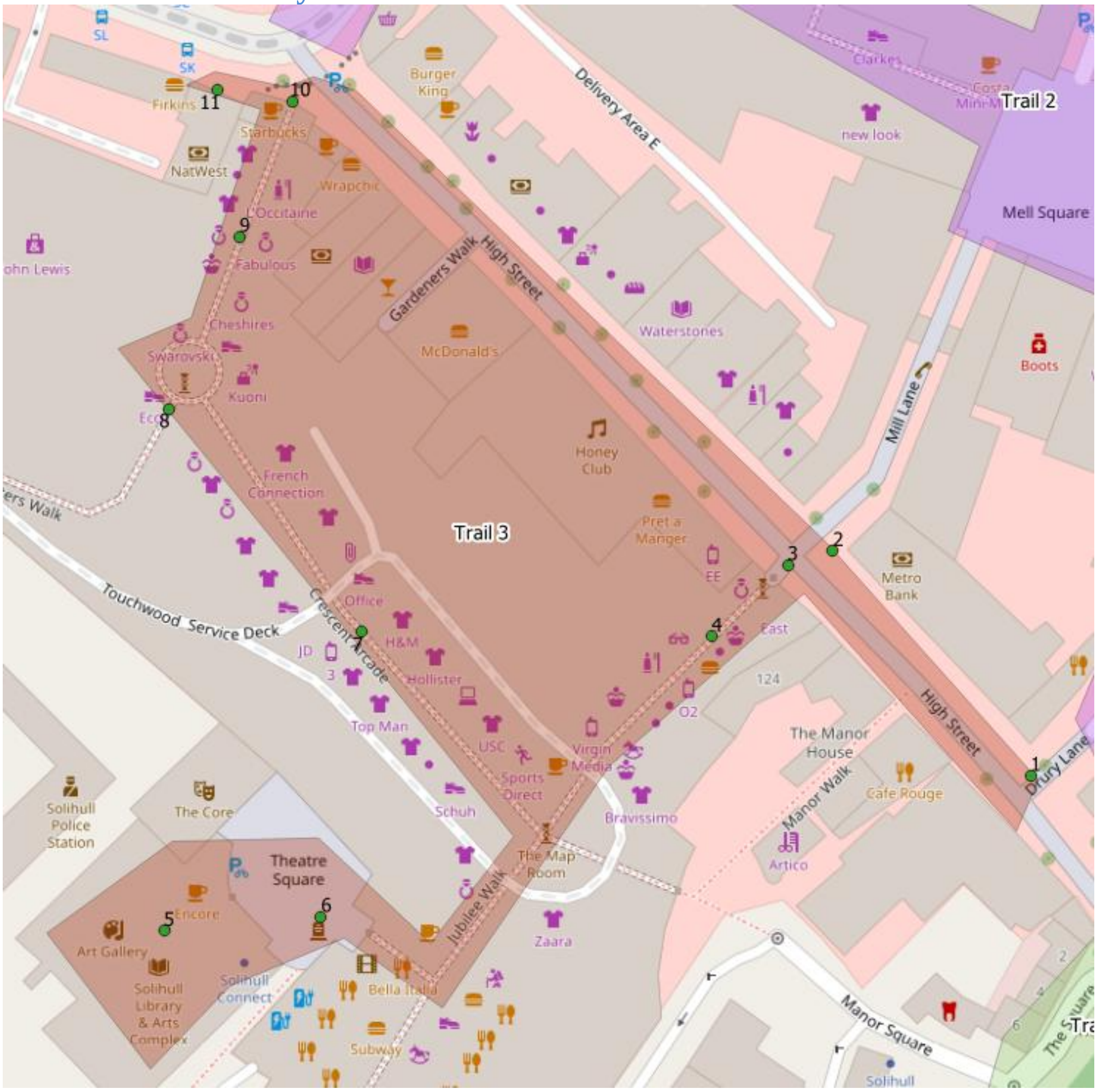
Solihull Building Stones Trails



Trail 1: The Old town of Solihull

Trail 2 - Twentieth Century Solihull

Trail 3: 21st Century Solihull



Catalogue of Building Stones found in Solihull

Sedimentary Rocks

Dolomite: Dolomite is a carbonate containing more than 50% by weight of the mineral dolomite (Magnesium carbonate)

Limestone: Limestone is a very common rock consisting of calcium carbonate (more than 50%)

Sandstone: Sandstone is composed of sand-sized (0.0625 - 2 mm) mineral grains, rock fragments, or pieces of fossils which are held together by a mineral cement.

Shale: is a fine-grained sedimentary rock that forms from the compaction of silt and clay-size mineral particles that we commonly call "mud." **Shale** is distinguished from other mudstones because it is fissile and laminated. Becomes slate when metamorphosed.

Igneous Rocks

Basalt: is a very common dark-coloured **volcanic** rock composed of calcic plagioclase (usually labradorite), clinopyroxene (augite) and iron.

Dolerite: (Diabase or micro gabbro) is a common dark-coloured igneous rock. It is compositionally equivalent to gabbro and basalt but texturally inbetween them. It occurs mostly in shallow intrusions (dykes and sills) of basaltic composition

Diorite: is a plutonic igneous rock with intermediate composition between mafic and felsic rocks. Its volcanic (fine-grained) equivalent is andesite.

Granite: is a crystalline igneous rock that consists largely of feldspar and quartz. Granite is one of the main components of the continental crust and occurs in deep seated plutons.

Larvikite: is a deep seated igneous rock, specifically a variety of monzonite, notable for the presence of thumbnail-sized crystals of feldspar. Labradorite feldspar crystals give this rock it labradorescence.

Peridotite / Dunite. A Plutonic igneous ultramafic intrusion, with coarse grained or phaneritic texture. If the mineral assemblage is greater than 90% olivine then called Dunite. Derived from the earth's mantle.

Metamorphic Rocks

Marble: is a metamorphic carbonate rock consisting predominantly of calcite or dolomite.

Phillite: is a slate that is further metamorphosed so that very fine grained white mica achieves a preferred orientation. It is primarily composed of quartz, sericite mica and chlorite

Quartzite: is a silica cemented quartz sandstone. It can also be a hard, non-foliated metamorphic rock which was originally pure quartz sandstone converted into **quartzite** through heating and pressure, e.g. in orogenic belt setting.

Serpentinite: is a metamorphic rock that is mostly composed of serpentine group minerals, (antigorite, lizardite, and chrysotile). These are produced by the hydrous alteration of ultramafic rocks.

Slate: A fine-grained metamorphic rock that can be split into thin sheets (has slatey cleavage). Slate in the vast majority of cases is a metamorphosed shale/mudstone.

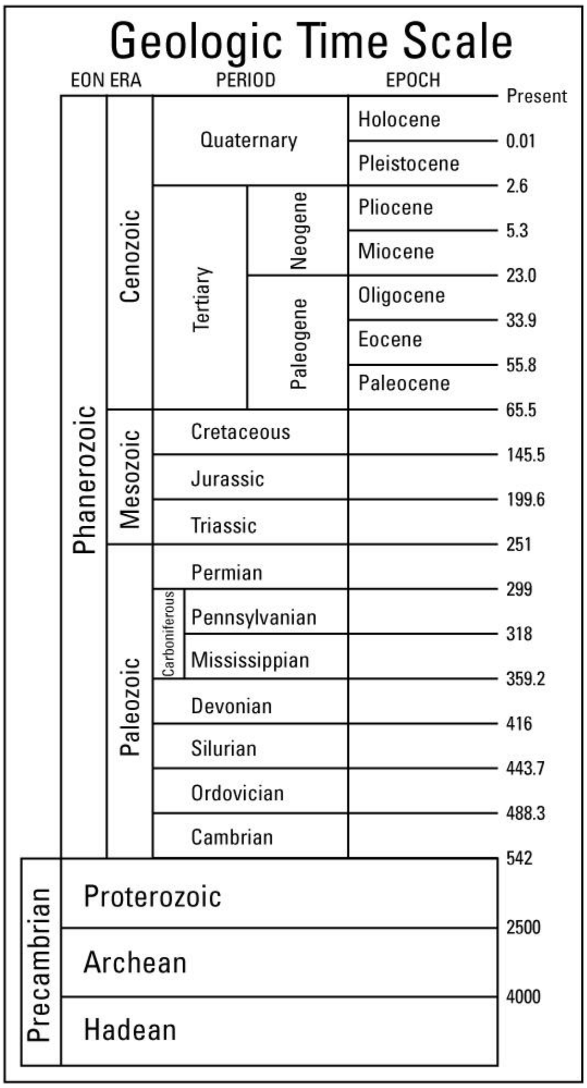
Introduction

Geological naming versus building trade naming

In the stone trade today, any carbonate rock, whether limestone or marble, is classified as a 'marble' if it takes a good polish. Similarly, various different rocks composed of silicate minerals are classified as 'granites'. Other classes of stone used by the trade include 'limestone' (if a carbonate rock doesn't polish well), 'travertine', 'sandstone' and 'slate'. This guide uses the scientific geological names. Trade names need to be used with some caution.

Trail Listings
The source of origin of building stones can sometimes be difficult to determine unless historical records are available. Research of the building stones used in Solihull has been thwarted by very poor documentation. Interpretation of the lithologies has been undertaken with only the use of a hand lens and a grain size chart. Some interpretations may not be wholly accurate and subject to modification upon further investigation. Age of rock is suggested based on the origin, which is often an educated guess.

Geological Time Scale - Stratigraphic Column



Primary Rock Types

There are three Rock Groupings; Sedimentary, Igneous and Metamorphic

Wikipedia: **Sedimentary rocks** are types of rock that are formed by the accumulation or deposition of small particles and subsequent cementation of mineral or organic particles on the floor of oceans or other bodies of water at the Earth's surface. Sedimentation is the collective name for processes that cause these particles to settle in place. The particles that form a sedimentary rock are called sediment, and may be composed of geological detritus (minerals) or biological detritus (organic matter). Before being deposited, the geological detritus was formed by weathering and erosion from the source area, and then transported to the place of deposition by water, wind, ice, mass movement or glaciers, which are called agents of denudation. Biological detritus was formed by bodies and parts (mainly shells) of dead aquatic organisms, as well as their faecal mass, suspended in water and slowly piling up on the floor of water bodies (marine snow). Sedimentation may also occur as dissolved minerals precipitate from water solution.

The sedimentary rock cover of the continents of the Earth's crust is extensive (73% of the Earth's current land surface), but the total contribution of sedimentary rocks is estimated to be only 8% of the total volume of the crust. Sedimentary rocks are only a thin veneer over a crust consisting mainly of igneous and metamorphic rocks. Sedimentary rocks are deposited in layers as strata, forming a structure called bedding. The study of sedimentary rocks and rock strata provides information about the subsurface that is useful for civil engineering, for example in the construction of roads, houses, tunnels, canals or other structures. Sedimentary rocks are also important sources of natural resources like coal, fossil fuels, drinking water and ores.

The study of the sequence of sedimentary rock strata is the main source for an understanding of the Earth's history, including palaeogeography, paleoclimatology and the history of life. The scientific discipline that studies the properties and origin of sedimentary rocks is called sedimentology. Sedimentology is part of both geology and physical geography and overlaps partly with other disciplines in the Earth sciences, such as pedology, geomorphology, geochemistry and structural geology.

Igneous rock (derived from the Latin word *ignis* meaning fire), or **magmatic rock**, is one of the three main rock types, the others being sedimentary and metamorphic. Igneous rock is formed through the cooling and solidification of magma or lava. The magma can be derived from partial melts of existing rocks in either a planet's mantle or crust. Typically, the melting is caused by one or more of three processes: an increase in temperature, a decrease in pressure, or a change in composition. Solidification into rock occurs either below the surface as intrusive rocks or on the surface as extrusive rocks. Igneous rock may form with crystallization to form granular, crystalline rocks, or without crystallization to form natural glasses. Igneous rocks occur in a wide range of geological settings: shields, platforms, orogens, basins, large igneous provinces, extended crust and oceanic crust.

Igneous and metamorphic rocks make up 90–95% of the top 16 km of the Earth's crust by volume.[1] Igneous rocks form about 15% of the Earth's current land surface. Most of the Earth's oceanic crust is made of igneous rock.

Igneous rocks are also geologically important because:

- their minerals and global chemistry give information about the composition of the mantle, from which some igneous rocks are extracted, and the temperature and pressure conditions that allowed this extraction, and/or of other pre-existing rock that melted;
- their absolute ages can be obtained from various forms of radiometric dating and thus can be compared to adjacent geological strata, allowing a time sequence of events;
- their features are usually characteristic of a specific tectonic environment, allowing tectonic reconstitutions (see plate tectonics);

- in some special circumstances they host important mineral deposits (ores): for example, tungsten, tin, and uranium are commonly associated with granites and diorites, whereas ores of chromium and platinum are commonly associated with gabbros.

Metamorphic rocks arise from the transformation of existing rock types, in a process called metamorphism, which means "change in form". The original rock (protolith) is subjected to heat (temperatures greater than 150 to 200 °C) and pressure (100 megapascals (1,000 bar) or more), causing profound physical or chemical change. The protolith may be a sedimentary, igneous, or existing metamorphic rock.

Metamorphic rocks make up a large part of the Earth's crust and form 12% of the Earth's land surface. They are classified by texture and by chemical and mineral assemblage (metamorphic facies). They may be formed simply by being deep beneath the Earth's surface, subjected to high temperatures and the great pressure of the rock layers above it. They can form from tectonic processes such as continental collisions, which cause horizontal pressure, friction and distortion. They are also formed when rock is heated by the intrusion of hot molten rock called magma from the Earth's interior. The study of metamorphic rocks (now exposed at the Earth's surface following erosion and uplift) provides information about the temperatures and pressures that occur at great depths within the Earth's crust. Some examples of metamorphic rocks are gneiss, slate, marble, schist, and quartzite.

Sedimentary Rocks

Sandstone

Sandstone is a consolidated sand. It is a very widespread and well-known sedimentary rock. It should be no surprise because sandstones make up 10…20% of all sedimentary rocks and sedimentary rocks are by far the most common rocks at the surface.

Sandstone is composed of sand-sized (0.0625mm to 2mm) mineral grains, rock fragments, or pieces of fossils which are held together by a mineral cement. It grades into siltstone, shale or mudstone (grains less than 0.0625 mm in diameter) and conglomerate (or breccia if the clasts are angular) if the average grain-size exceeds 2 mm.

Sandstone contains a network of pores which are at least partly filled with a mineral cement. However, sandstone does not need to contain open pores, they may be, and often are, completely filled with a cementing material. The definition of sandstone is based on the size of the framework grains. No reference is made to the genesis.

Composition: Sandstones are a product of the erosion of existing rocks and transportation to place of deposition. Many minerals break down into clays during this process and only the toughest are found in sandstones

Sandstone that contains more than 50% of sand-sized carbonate grains is usually named calcarenite which is a type of limestone.

Feldspars are quite common in sandstone. A sandstone that contains more than 25% feldspar is named arkose.

Quartz is a common rock-forming mineral (although not as widespread as feldspars) and it is almost insoluble in water and physically very hard. This is why quartz is so abundant in sand. Some sandstones (quartz arenite) are almost exclusively composed of quartz grains.

Micas are common minerals in rocks and can form a significant part of certain micaceous sandstones or flagstones.

Clastic rocks are classified by grain size. There are several scaling systems in use, such as the one shown below. A popular system is called the Wentworth Scale, which is incorporated into the Krumbein scale below, (see boxed and green shaded part of table below). Many of the pictures taken in this study can be seen to have a scale included. This is a handy Wentworth Scale for use in the field.

Krumbein phi scale

φ scale	Size range (metric)	Size range (approx. inches)	Aggregate name (Wentworth class)	Other names
<−8	>256 mm	>10.1 in	Boulder	
−6 to −8	64–256 mm	2.5–10.1 in	Cobble	
−5 to −6	32–64 mm	1.26–2.5 in	Very coarse gravel	Pebble
−4 to −5	16–32 mm	0.63–1.26 in	Coarse gravel	Pebble
−3 to −4	8–16 mm	0.31–0.63 in	Medium gravel	Pebble
−2 to −3	4–8 mm	0.157–0.31 in	Fine gravel	Pebble
−1 to −2	2–4 mm	0.079–0.157 in	Very fine gravel	Granule
0 to −1	1–2 mm	0.039–0.079 in	Very coarse sand	
1 to 0	0.5–1 mm	0.020–0.039 in	Coarse sand	
2 to 1	0.25–0.5 mm	0.010–0.020 in	Medium sand	
3 to 2	125–250 μm	0.0049–0.010 in	Fine sand	
4 to 3	62.5–125 μm	0.0025–0.0049 in	Very fine sand	
8 to 4	3.9–62.5 μm	0.00015–0.0025 in	Silt	Mud
10 to 8	0.98–3.9 μm	3.8×10^{-5}–0.00015 in	Clay	Mud
20 to 10	0.95–977 nm	3.8×10^{-8}–3.8×10^{-5} in	Colloid	Mud

Solihull Examples: (1-2, 1-10, 1-1b, 1-1c, 2-24, 1-5)
(1-2 refers to Trail 1, Location 2)

Sandstone has been used in older buildings of the city, primarily in the construction of St Alphege church 1-2. Small amounts have been used in The George Hotel 1-10, The war memorial 1-1(b & c) and Zizzi in Poplar Road 2-24, and a number of older gravestones in St Alphege churchyard. Use of the stone had fallen from favour by the time Mell Square was built in the 1960's in preference of rocks that could take a better polish and that are more resilient to wear.

1-2 St Alphege Church

The nave, chancel, transepts and lower tower of Saint Alphege Church are built from 300 million year old red Carboniferous sandstone created at the same time as the Warwickshire Coal Measures in the north of the county. Oxides of iron and other elements in the naturally occurring cement impart colour to the stone.

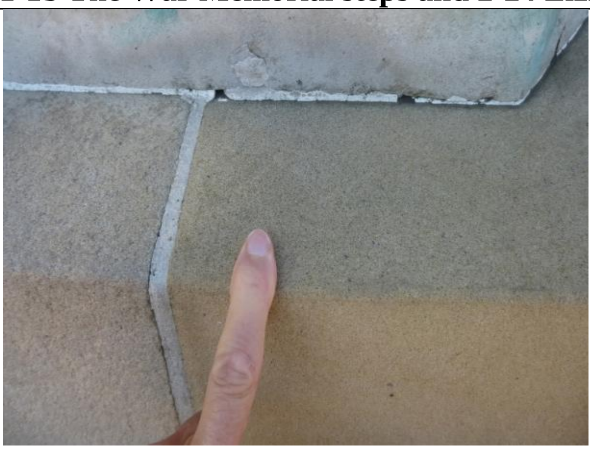
In contrast to the red sandstones of the nave, the 15th century upper tower was built from buff coloured Triassic Warwick stone, Bromsgrove Sandstone Formation, Sherwood Sandstone Group. The steeple was re-built in the 18th century using pale Arden sandstone, Mercia Mudstone Group, a Triassic rock found in parts of the Arden landscape.

The grey/red sandstone of the 1940s external buttresses is probably from Grinshill in Shropshire. Grinshill stone is available in a broad range of colours from almost pure white through cream and light brown to deep red. Grinshill stone is a Triassic Sherwood sandstone.

1-10 The George Hotel

Opposite the church is the 16th century George Hotel half-timbered and originally built on foundation of sandstone. During renovation about 20 years ago the foundations were replaced using engineering bricks then faced with Triassic Kenilworth ? Sandstone, (Bromsgrove Formation), a fluvial deposit. The facing has weathered badly and has proven to be a poor choice for the cladding.

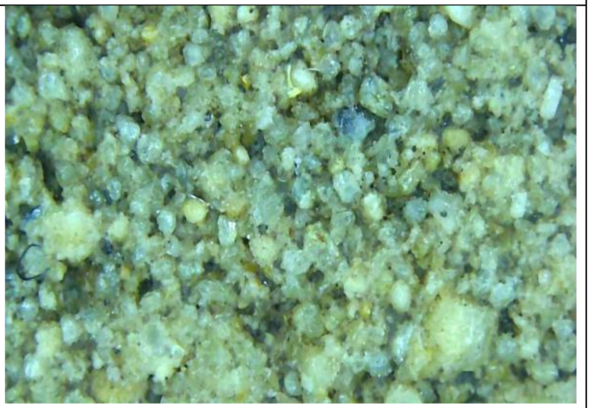
1-1b The War Memorial steps and 2-24 Zizzi Restaurant window frames



These two building stones are very similar sandstones. However there are some differences other than colour. Zizzi consists dominantly of fine subrounded grains whereas the war memorial consists of medium subangular grains. There also appears to be some organic material within the war memorial stone whereas in the Zizzi stone this is less obvious.

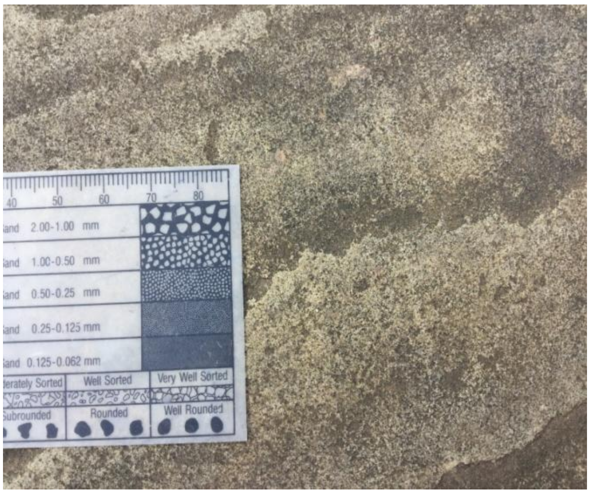
Both are dominantly light coloured, clean, well sorted, lacking clay, lacking fossils and lacking sedimentary features. Both are probably of fluvial origin deposited in a moderately high energy environment with a high sediment source with possible winnowing conditions. Possible as a deltaic system close to the sea, with possible wave / tidal influence. Both are classed as Freestone, indicating that the rock can be cut in any direction.

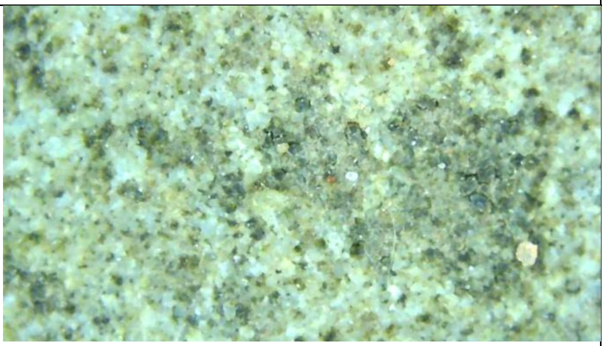
Probably of Carboniferous age ?   318-299 mmybp

1-1b Steps around the War Memorial	**2-24 Zizzi Restaurant window frames**
	
Magnified images (*500) show the rock to have high porosity and moderately good permeability. The grains are fine to medium, angular to sub angular grains, moderately well sorted, with some lithic fragments. The stone is infused with algae giving it the brownish green colour	Magnified images (*500) show the rock to have high porosity and moderately good permeability with only rare traces of white calcite cement on edges of the quartz grains. The grains are dominantly fine, subrounded and moderately well sorted. Some of the magnified images show variation indicating the rock is not entirely a homogeneous suggesting some fluctuation in the depositional environment / current strength.

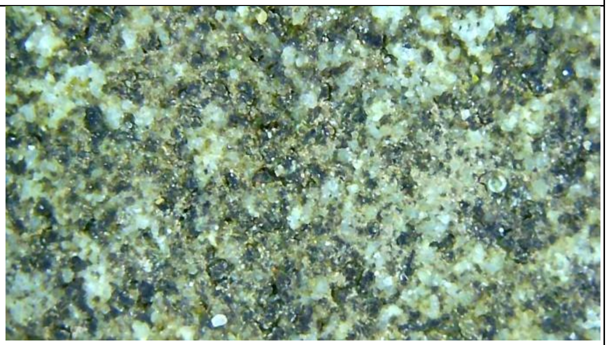
1-1c The War Memorial paving

This Sandstone, commonly known as York stone, is the most popular UK derived paving stone (or flagstone) found in British cities. It is a buff yellow colour, very fine grained sandstone with varying amounts of micro mica, silt and carbonaceous material, enabling it to be readily split. Red iron stained Leisegang banding can occasionally be seen. It is fluvial in origin, from the Upper Carboniferous, (318-299 mmybp), from deposits found in the South Pennines around the Lancashire-Yorkshire border





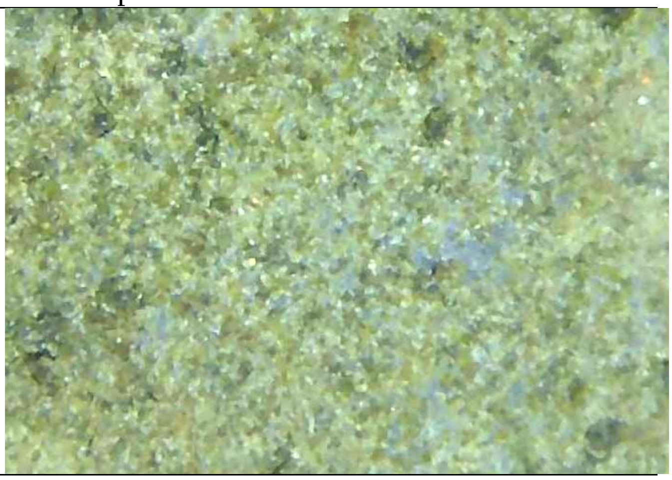
Cleaner light brown sandstone



Darker organic rich layers in the sandstone

1.5 Gravestone (North side of St Alphege)

This gravestone from 1749 located by the north side of the church is composed of silty sandstone. At that time gravestone options were very limited in Solihull. There are other gravestones in the churchyard from around the same period.



When wet it has a slaty grey - dull brown look, but when dried it is light brown. This silty sandstone is well sorted, fossil free and appears carbon free. Fluvial. Probably a mature fluvial river channel sand. Halesowen Formation, North Warwickshire, Westphalian D, Carboniferous 313 to 304 MMYBP

Limestone

Limestone is a very common sedimentary rock consisting of calcium carbonate (more than 50%). It is the most common non-siliciclastic sedimentary rock. (Sandstone and shale are common siliciclastic rocks). Limestones are rocks that are composed of mostly calcium carbonate, (minerals calcite or aragonite). Carbonate rocks where the dominant carbonate is dolomite, (calcium magnesium carbonate), are named dolomite rock. Carbonate rocks together make up one-fifth of all sedimentary rocks in the stratigraphic record.

There are other rocks that are composed of calcium carbonate. Carbonatite is a rare type of igneous rock and marble is a common metamorphic rock. Both are chemically composed of calcium carbonate, but they are not limestones because they are not sedimentary rocks. The process of metamorphism tends to destroy fossils, so if fossils are observed in the rock it is not a marble.

Some limestones are clastic (or detrital) just like sandstone. However, there is an important difference. Most detrital limestones are made of biogenic grains rather than weathered bits and pieces of pre existing rocks. Calcium carbonate in the form of aragonite and calcite are extremely common bio-minerals. They are used to build tests, shells, exoskeletons, etc. of millions of marine (mostly) species. These tests sink to the bottom of oceans or other water bodies and form a limy sediment (named ooze if the tests are microscopic) which becomes limestone after burial and lithification. However, some detrital limestones (oolites) are composed of abiogenic particles like ooids. Biogenic limestone may grow *in situ* by the growth of carbonate skeletons (coral reefs) or by trapping of sediments in bacterial mats (stromatolites).

Limy mud is often purely chemical precipitate. Tufa and travertine are varieties of chemical limestones. Tufa is soft and porous variety that is associated with springs.
Ground water may contain thousand times as much carbon dioxide as would be in equilibrium with air. Such groundwater is acidic and dissolves limestone. Limestone (or more precisely limy mud) precipitates out of ground water when it emerges above ground as a spring and loses much of its CO_2. Travertine is a hard variety of chemical limestone. Travertine is the material speleothems of karst caves are made of. Speleotherms is the collective name for stalactites, stalagmites, and other dripstones and flowstones. Travertine is simply the result of a complete evaporation of water containing mainly calcium carbonate. Travertine deposited from hot springs may be a result of the loss of carbon dioxide from the water as pressure is released upon emerging at the surface.

Limestones are strongly affected by diagenetic processes that accompany lithification. Aragonite will commonly be replaced by calcite, dissolution may be significant, and calcite may be replaced with dolomite. However, calcite is resistant to metamorphism. Marble is a metamorphosed limestone, but it is still composed of carbonate minerals. The crystals are just bigger, they are recrystallized, and original structures (like fossils) are obliterated.

Classification of Limestones: Dunham classification

Robert J. Dunham published his classification system for limestone in 1962. The original Dunham classification system was developed in order to provide convenient depositional-texture based class names that focus attention on the textural properties that are most significant for interpreting the depositional environment of the rocks.

The three criteria used to define the original Dunham classes were:

- the supporting fabric of the original sediment
- the presence or absence of mud (the fraction <20 µm in size)
- evidence that the sediments were organically-bound at the time of deposition

On the basis of these criteria, the following four classes were defined:

Mudstone
: a mud-supported carbonate rock containing <10% grains

Wackestone
: a mud-supported carbonate lithology containing >10% grains

Packstone
: a grain-supported fabric containing 1% or more mud-grade fraction

Grainstone
: a grain-supported carbonate rock with <1% mud.

Recognising that these classes did not encompass all carbonate lithologies, Dunham defined two additional classes within his scheme:

Boundstone
: where there is any evidence that the carbonate sediments were bound at the time of deposition

Crystalline dolomite or Crystalline limestone
: where recrystalisation has resulted in the original depositional fabric of a carbonate rock cannot being identified

Dunham specifically stated that, where appropriate, these six textural class names are intended to be combined with modifiers describing grains and mineralogy. The original classification can be summarized as follows:

<table>
<tr><th colspan="6">Original Dunham classification (Dunham 1962)</th></tr>
<tr><td colspan="5">Depositional texture recognizable</td><td rowspan="5">Depositional texture not recognizable</td></tr>
<tr><td colspan="4">Original components not bound during deposition</td><td rowspan="4">Original components were bound during deposition</td></tr>
<tr><td colspan="3">Contains mud</td><td rowspan="3">Lacks mud and is grain-supported</td></tr>
<tr><td colspan="2">Mud-supported</td><td rowspan="2">Grain-supported</td></tr>
<tr><td>Less than 10% grains</td><td>More than 10% grains</td></tr>
<tr><td>Mudstone</td><td>Wackestone</td><td>Packstone</td><td>Grainstone</td><td>Boundstone</td><td>Crystalline Carbonate</td></tr>
</table>

Solihull Examples: (1-1a, 2-26a, 2-23a, 2-23b, 3-2)
(1-2 refers to Trail 1, Location 2)
Limestones are the most commonly used rocks in the buildings of Solihull. They were rarely used in buildings in the city before 1960, but were widely used in the development of Mell Square, The Core and Touchwood.

Oolitic Limestone: Portland Stone (1-1a & 2-26a)

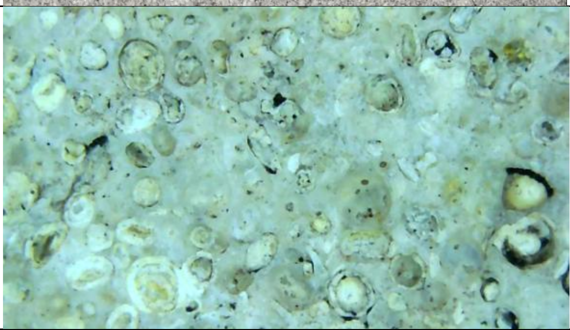
Portland Stone was one of the most popular building stones in use in the UK during the 1800's & 1900's. Many city centres such as London and Birmingham have widely used this stone to create an impression. Solihull was only a small market town up to the 1960's and consequently did not participate in the building of such impressive public and corporate buildings. Only two small examples of this stone can be found within Solihull.

1-1a War Memorial, The Square	**2-26a Dixons, Poplar Road**
	 The white Portland stone has been used alongside the brown Hornton ironstone giving a pleasing contrast to the eye.

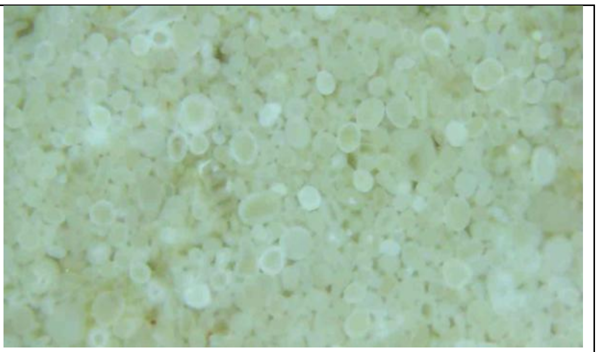
Portland stone is a white fossil rich Late Jurassic limestone (152-146 mmybp) quarried at Portland in Dorset. The specific zone that these building stones were derived from within the Portland succession is called Whit bed. This is a durable and readily carved stone (freestone) formed in warm shallow seas, where calcite, precipitated from the seawater and built up around sand particles and fragments of shell. It also contains lots of oolites and bryozoa.

Oolitic Limestone: Bathstone (Lloyds Bank, Poplar Rd. 2-23a & 2-23b)

The Lloyds bank building in Poplar Road was constructed in 1877, using two types of Bathstone for decorative purpose. Bathstone was also a popular building stone in use in many cities within the UK during the 1800's & 1900's. Both rocks are Jurassic oolitic limestones formed under similar warm marine depositional environments. Oolites form in warm, supersaturated, shallow, highly agitated marine water intertidal environments. The mechanism of formation starts with a small fragment of sediment acting as a 'seed', e.g. a piece of a shell. Strong intertidal currents wash the 'seeds' around on the seabed, where they accumulate layers of chemically precipitated calcite from the supersaturated water. Both are freestones from Coombe Down in Somerset.

2-23a Lloyds Bank window frames	**2-23b Lloyds Bank lower beading course**
	
	
The window frames have been carved from a well cemented cream coloured oolitic limestone. The deeper yellow colours are most likely to be given by inclusions of limonite. The porosity has been destroyed by secondary calcite cementation giving it a smooth feel	The Lower beading course consists of oolite with lots of bioclastic material and a small amount of quartz. Ooids and tests clearly visible in the magnified image. There is significantly less cement in this lower course which explains why it has weathered more than the window frames.

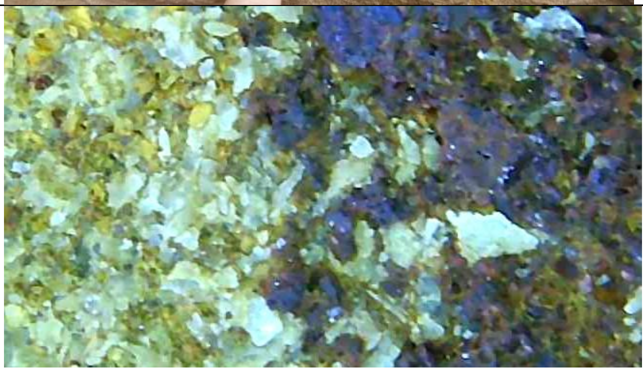
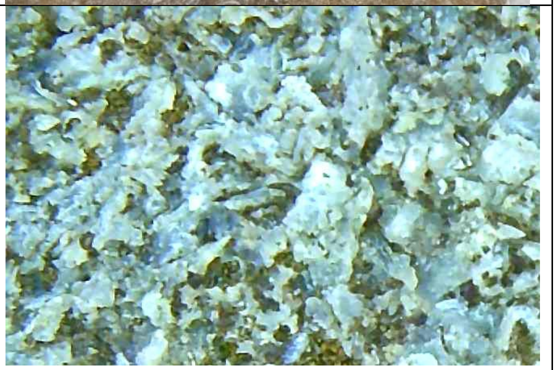
Oolitic Limestone: Metro Bank Mill Lane (3-2)



A buff coloured oolitic limestone, packed with oolites in a marl matrix with occasional shells This is thought to be Middle Jurassic Candeeiros Limestone from Porto de Mos, Portugal.

This oolite has not been cemented and does not appear to be as competent as the Bathstone. Micro fractures can be seen in a number of places. In addition, wetting of the stone by capillarity is very visible in the lower courses of the cladding.

Hornton Stone. Iron rich Limestone: (2-8 & 2-26b)

2-8 Old Post Office, Drury Lane	**2-26b No 2 Station Road / Poplar Rd Bible Centre & Dixons,**
	
 The blue coloured mineral in the right side of the photograph is Limonite, seen in the upper picture as red brown iron veins. The white is shell debris.	 Lots of blue white calcite and shell fragments

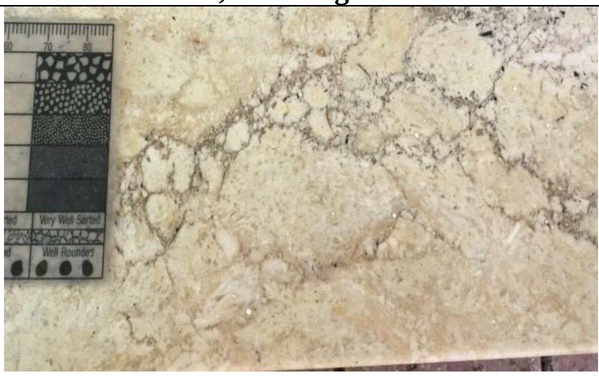
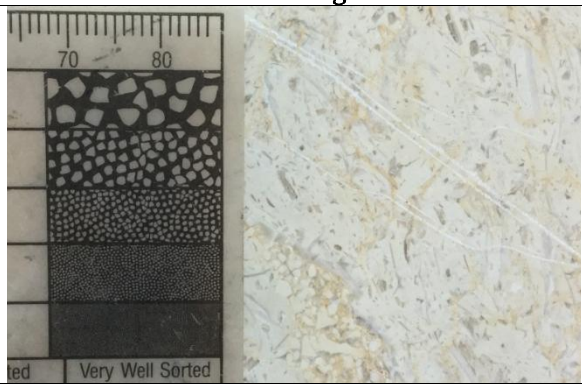
Bioclastic middle Jurassic (178-157 mmybp) iron-rich limestone, from near Edge Hill, commonly used as a building stone in south Warwickshire and Northamptonshire. Sometimes referred to as Hornton stone. It has a rusty brown colour and contains veins rich in limonite. Green coloured blocks are chamosite which have not become oxidised. Look for pockets of pale coloured brachiopod fossils, commonly called lamp shells for their similarity to the shape of Roman oil lamps. Deposited in warm shallow marine environment.

Bioclastic Limestone Drury Lane & Drury Arcade (2-2c, 2-13, 2-10a, 2-10b)

2.2c Bridge Boutique, Drury Lane	**2-13 Katherine Draisey, Drury Arcade**
	

The bioclastic limestone cladding along Drury Lane and Drury Arcade is the same stone. It is a off white, creamy buff, limestone containing lots of shell fragments and bivalves and some small stromatolites. Bioturbated. Low energy warm shallow marine environment

The veins run sub bed parallel wavy laminations caused by impurities and recrystallised associated in part with stylolites - a diagenetic solution process. Note stylolites and lineaments are prevalent in areas with less shall material. Stylolites are a diagenetic solution feature. Fossil shells indicate way up.

2-10a Zebra Kids, Cladding under window	**2-10b Zebra Kids Cladding on wall**
	
Limestone. Cream, brownish, fractured, brecciated, shelly, lots of stylolites, shells Warm shallow marine, tectonically fractured.	Limestone. Cream, buff, very fossiliferous, sponges. Warm shallow marine.

The wall cladding at 2-10b is the same rock type as 2-2c and 2-13. The sample at 2-10a looks similar but appears to be brecciated. It is likely that this is replacement cladding following renovation of the shop frontage.

Bioclastic Jura Limestone: (3-1a, 3-1b, 3-4, 3-7, 3-8)

All these lithologies are considered to be from the same formation as they all have the same fossils, all-be-it in different proportions. The Jura limestone is from southern, Germany and comes from the Late Jurassic Treuchtlingen Formation (Upper Kimmeridgian). There are some differences in appearance due to a slight difference in the depositional environments.

"Stratigraphy and Palaeoenvironments of the Upper Jurassic of Southern Germany – A Review. Dieter U. Schmid[1] , Reinhold R. Leinfelder[1,2] & Günter Schweigert[3.]
Article in Zitteliana Reihe B: Abhandlungen der Bayerischen Staatssammlung fur Palaontologie und Geologie · January 2005"

Starting already in the early Late Jurassic, a reefal facies dominated by siliceous sponges established on the southern German part of the northern Tethys shelf (LEINFELDER et al. 2002), being characterised by massive fabrics in contrast to the otherwise bedded limestones and marls (Fig. 2, 3). Starting with small and isolated patch-reefs, the reefal facies extended through time to form large and continuous reef complexes in the Middle and Upper Kimmeridgian (GWINNER 1976, MEYER & SCHMIDT-KALER 1989, 1990a). The main reef builders were siliceous sponges (both hexactinellids and lithistids), actually owing their reef-building capacity to the intergrowth with thrombolitic to stromatolitic microbial crusts (cf. SCHRAMMEN 1924, ALDINGER 1961, LEINFELDER et al. 1993, 1994, 1996, SCHMID 1996, KRAUTTER 1997, LEINFELDER 2001). In general, these reefs can be classifi ed as *siliceous sponge-microbialite reef mounds. Hermatypic corals do only appear within the reefal facies diachronously from the late Kimmeridgian onwards to become increasingly abundant towards the Tithonian. This trend is interpreted by most authors as mirroring a general shallowing trend on the northern Tethys shelf where the siliceous sponge reefs represent a deeper ramp setting with a range of approximately 50-150 m water depth (B. ZIEGLER 1967, GYGI & PERSOZ 1987, SELG & WAGENPLAST 1990, LEINFELDER 1993, LEINFELDER et al. 1994, 1996, 2002, WERNER et al. 1994, SCHMID 1996, KRAUTTER 1997, PITTET & MATTIOLI 2002; see also discussion in KEUPP et al. 1990).*

Tuberoids which represent a special type of intraclasts, namely disintegrated pieces of microbial crusts and/or siliceous sponges, are not generated by wave action and reworking, but formed in situ, as was already recognized by FRITZ (1958) and ALDINGER (1961) and is also indicated by their occurrence which is restricted to the closest vicinity of the reefs.

In the Bavarian realm, a large platform consisting of thickbedded carbonates developed, thus characterising the Treuchtlingen Formation (up to 60 m; formerly 'Weißjura delta'). In contrast to all other bedded carbonates described here, this formation is characterised by a succession of thick beds with an average thickness of 1 m (KOTT 1989, MEYER & SCHMIDTKALER 1990b, 1996). These beds represent a succession of biostromes formed by siliceous sponges and thrombolites, interrupted by micritic sediment layers (HENSSEL et al. 2002); bioherms are only locally developed. Considering the fauna predominated by siliceous sponges and cephalopods, and the lack of unequivocal shallow-water elements, this platform can be assigned to an average water depth just below storm wave base (MEYER & SCHMIDT-KALER 1990a, SELG & WAGENPLAST 1990), contrasting the shallow-water interpretation of KOTT (1989) as discussed above. Such bathymetric interpretation is further corroborated by the sessile foraminifer Tubiphytes morronensis which is found throughout the Upper Jurassic, but whose bright white tests occur in rock-forming abundance here. Since the test thickness of this special foraminifer depends on light and thus water depth, it can be used as a palaeobathymetric indicator (SCHMID 1996). This time slice also marks the first occurrences of hermatypic corals in the Upper Jurassic of Southern Germany in SE Franconia (outside the Upper Rhine area, see above).

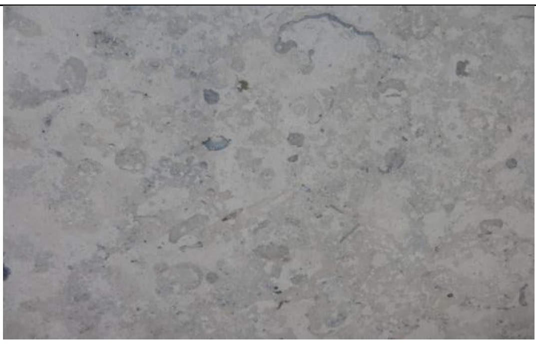
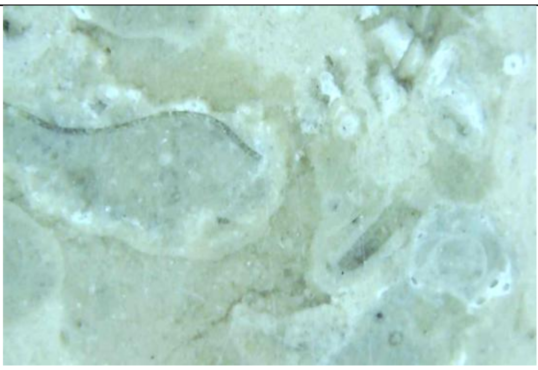
The lack of thick cross-bedded oolitic grainstones, features occurring amply in genuine shallow-water facies, e.g. in the neighbouring Swiss Jura and Upper Rhine area, indicates that a true shallow water marine environment is not represented.

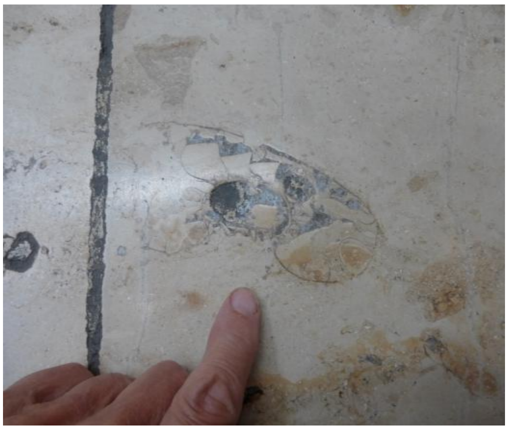
Solitary (Scleractina) coral fossils identified. **Scleractinia** ("hard-rayed") **corals** first appeared in the Middle Triassic and refilled the ecological niche once held by tabulate and rugose **corals**.) They are also referred to as **stony corals** or hard corals, are marine animals in the phylum Cnidaria that build themselves a hard skeleton. The individual animals are known as polyps and have a cylindrical body crowned by an oral disc in which a mouth is fringed with tentacles.

Ammonites and **sponges** drift around in open sea (mostly in depths between 50-200m). Ammonites range from Devonian to Cretaceous, but mostly associated with Jurassic

Shell fragments result from break up on a beach – could be transported into area of deposition.

Muds accumulate in low energy environments (below wave height or protected environment). They can also be deposited in a back reef low energy environment.

1a Carluccio's Restaurant, Drury Lane.	**1b Carluccio’s Upper Level Wall Cladding**
	
	**3-4 Mill Lane Arcade Flooring** 
Jurassic marly / micritic Limestone. Pinky grey, light - medium grey, very fossiliferous, common ammonites, shell fragments, sponges, Scleractina corals, tubifyte worms.. Muds accumulate in low energy environments (mid shelf below wave height or protected environment e.g. back reef). Shell fragments result from break up in high energy zone such as a beach or fore reef – could be transported into area of deposition. If back reef then ammonites come in on high tides or are swept in during high seas.	Limestone. Cream to beige, contain fossil sponge, biostromes, tubiphyte worms, ammonites and belemnites. Stylolites. Deposited in warm deeper open marine tropical seas.

3-7a Crescent Arcade  Open marine mid self setting is suggested in close proximity to a shoal is likely for this Jura limestone (ammonite presence rare, occasional belemnites, some corals and sponges). The common vuggy porosity could be the result of a root system of sea vegetation (Tuberoids). Lineaments of vuggy porosity along vertical suture lines. Joined together by stylolites. These vertical features / vugs / porosity are not bed parallel. Black organic carbon lining .	**3-7b Joe The Juice island** 
3.8 Cloister Walk 	Pale Cream Bioclastic limestone. Lots of ammonites, sponges & scleractina corals. suggesting open marine conditions, below wave base probably 50 m - 200m depth Sporadic vuggy porosity. Mottled appearance

Travertine & Tufa Limestone: (2-14b, 2-14e, 3-5b, 3-5a)

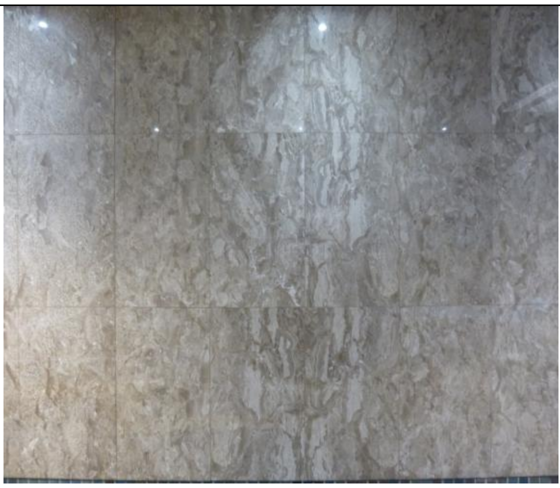
2-14b House of Fraser, Warwick Road	**2-14e House of Fraser, Mill Lane**
	

3-5b Library Travertine	**3-5a Library Stairwell - Tufa**
	

Travertine is a popular cladding material as the wavy patterns of contrasting shades give a very attractive appearance. Travertine often has a fibrous or concentric appearance and exists in white, tan, cream-colored, and even rusty varieties. It is formed by a process of rapid precipitation of calcium carbonate, often at the mouth of a hot spring or in a limestone cave or cliff faces. Vuggy porosity is common in some travertine deposits. Stylolites can develop through diagenetic processes. Travertine is sometimes called Alabaster (although this is scientifically incorrect as alabaster is composed of Gypsum).

Tufa precipitates out of calcium rich waters flowing over organic matter such as moss growing over cave entrances and waterfalls. It is normally so porous as not to be suitable for cutting and polishing. Impurities such as iron give it colouration. Most ornamental forms are Travertine.

Limestone Breccia: (2-14d, 2-22)

2-14d House of Fraser - Mill Lane	2-22 **Poplar Way (Poplar Road) - Tiling**
	
This limestone breccia has been formed by the initial erosion of travertine deposits. Tectonic activity or sea cliff erosion is a likely cause of the travertine blocks to accumulate. These have collected in a watery environment that has enabled smaller pieces of limestone to pack the spaces. There are lots of small pea sized curved inclusions, possibly shells. Some wavy patterns may suggest deposition and later disturbance whilst saturated, e.g. seismic event (seismite). Rapid burial and secondary calcite precipitation has preserved this rock.	This rock looks like a number of small stromatolites sitting on top of a limestone breccia. There are trails of round grains. All the porosity has been filled with white and clear calcite during post depositional mineralisation

Dolomite

Dolomite (also known as **dolostone**, **dolomite rock** or **dolomitic rock**) is a sedimentary carbonate rock that contains a high percentage of the mineral dolomite, $CaMg(CO_3)_2$. In older publications, it was referred to as *magnesian limestone*, a term now reserved for magnesium-deficient dolomites or magnesium-rich limestones. Dolomite has a stoichiometric ratio of nearly equal amounts of magnesium and calcium. Most dolomites formed as a magnesium replacement of limestone or lime mud before lithification. Dolomite is resistant to erosion. It is less soluble than limestone in weakly acidic groundwater, but it can still develop solution features (karst) over time. Dolomite can act as an oil and natural gas reservoir as the process of Mg replacement of Ca is reported to increase the porosity by 10%

The dominant dolomitic limestone found in the UK is the Permian Zechstein Magnesian Limestone that runs from Nottingham to South Shields in North East England. Many older buildings in the area of which it outcrops have been constructed from this stone, e.g. Durham Cathedral.

Solihull Examples: (1-2 refers to Trail 1, Location 2)
Only 1 example of dolomite is to be found in Solihull, a German imported stone used for the flooring in **Poplar Arcade of the Touchwood centre (3-9).**

This grey brown rock contains plenty of shelly fragments in shell mounds as on a beach. This is an impure carbonate as seen by the magnified image below. Fractures in this rock are filled with veins of white calcite, crystallised out from mineral-rich hot water permeating through the rocks during phases of tectonic activity. Offsets in the calcite veins indicate more than 1 phase of tectonism

Shale

Shale is a lithified mud — a sedimentary rock composed mostly of clay- and silt-sized grains. It is a laminated, indurated rock with >67% clay-sized minerals. Mudstone / Claystone is a similar rock but without notable lamination. It also separates shale from siltstone, which is a mudstone in which the silt sized particles predominates over clay.

Shale is an economically important rock. It may be mined as a fossil fuel (oil shale), but even more importantly, it is a source rock of crude oil and natural gas. Shale is also the rock from which we are extracting hydrocarbons via the use of hydraulic fracturing (fracking).

Shale is not a suitable facing or flooring material for buildings.

Solihull Example: (2-6 Cotswold Outdoors, Drury Lane)
(1-2 refers to Trail 1, Location 2)
Cotswold Outdoors have used floor tiles to the entrance of their store made from Shale. The same material has been used as a facing under the windows. The unsuitability of the material is quite evident as the floor tiles show severe wear and the facing is splitting due to capillary absorption of water. It is suspected that these were sold to the buyer as slate, which it clearly isn't
.

Ineous Rocks

Common igneous rocks classified by silicon dioxide content					
Type	**Ultramafic** **<45% SiO_2**	**Mafic** **45–52% SiO_2**	**Intermediate** **52–63% SiO_2**	**Intermediate–felsic** **63–69% SiO_2**	**Felsic** **>69% SiO_2**
Volcanic rocks:	Picrite basalt	Basalt	Andesite	Dacite	Rhyolite
Subvolcanic :		Diabase (Dolerite)	Microdiorite	Microgranodiorite	Microgranite
Plutonic rocks:	Peridotite	Gabbro	Diorite	Granodiorite	Granite

Grain size is a key tool in differentiating igneous rocks. **Volcanic rocks** are extrusive rocks and tend to cool rapidly. Consequently the minerals are not allowed time to grow and form a sugary groundmass with unrecognisable individual minerals. Subvolcanic Intrusive rocks are generally dykes and sills. These occur at a variety of depths, are generally of limited thickness. They cool slower than extrusive flows thus allowing some recognisable mineral growth. Plutonic rocks occur as batholiths are solidify at depth. Magmatic differentiation occurs with some minerals forming before others. The grain size is commonly coarse.

Basalt & Dolerite

Basalt is a very common dark-coloured volcanic rock composed of calcic plagioclase (usually labradorite), clinopyroxene (augite) and iron ore (titaniferous magnetite).Basalt may also contain olivine, quartz, hornblende, nepheline, orthopyroxene, etc. Basalt is a volcanic equivalent of gabbro.

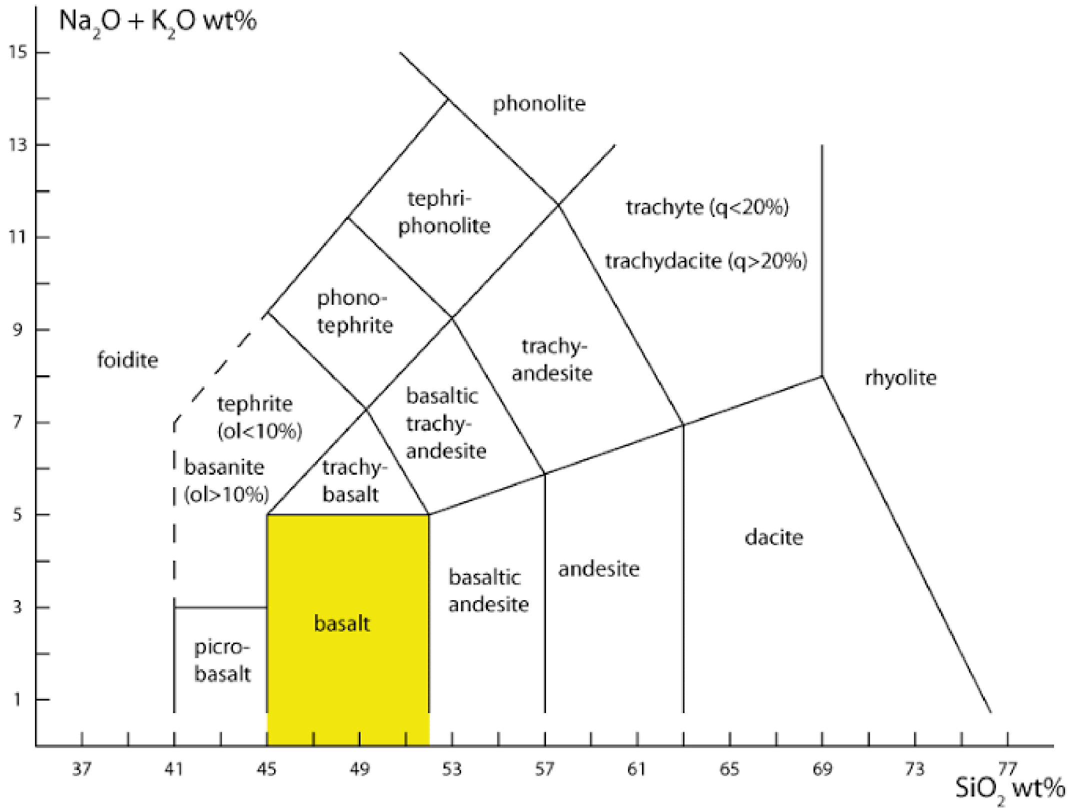
Basalt is usually black or dark gray and relatively featureless. It is composed of mineral grains which are mostly indistinguishable to the naked eye. Basalt may also contain volcanic glass. Basalt may contain phenocrysts (larger crystals within fine-grained groundmass) and vesicles (holes that were filled by volcanic gases).

Black colour is given to basalt by pyroxene and magnetite. Both of them contain iron and this is the reason why they are black. So this is iron again which is responsible for the coloration of basalt. Plagioclase, volumetrically usually the most important constituent, is mostly pale gray in colour.

Basalt is a major rock type that occurs in virtually every tectonic setting. Basalt is clearly the most common volcanic rock on Earth and basaltic rocks (including gabbro, diabase and their metamorphosed equivalents) are the most common rocks in the crust. Basalt is also common on the Moon and other rocky planets of the Solar System.

What makes basalt so common? Basalt is the original constituent of the crust from which almost all other rock types have evolved. Basalt forms when mantle rocks (peridotite) start to melt. Rocks melt incongruently. It basically means that melt that forms has a different composition from the source rocks. Of course, it can only happen if rocks melt only partially, but this is exactly what happens in the upper mantle. It melts partially to yield basaltic magma which is less dense and rises upward to form new oceanic crust in mid-ocean ridges or volcanoes and intrusives (dykes, sills) in many other tectonic regimes. Basalt is the source rock of other more evolved volcanic rocks like dacite, rhyolite, etc.

Classification



Basalt has a strict chemical definition. It is defined in the TAS diagram shown above. Basalt is an igneous rock that contains more than 45 and less than 52% of SiO_2 and less than five percent of total alkalies (K_2O + Na_2O). **TAS stands for Total Alkali Silica**

Neighbouring rock types like basaltic andesite, basanite, picrite (picrobasalt), trachybasalt and even more distant rocks like phonotephrite or andesite may have very similar look and can be easily mistaken for basalt in many cases.

Basalt is widespread in many tectonic regimes, but there are slight variations in chemical composition which allow more precise classification. MORB is an acronym for “mid-ocean ridge basalt” and OIB for “oceanic island basalt”. MORB is a result of partial melting of the upper mantle which is already recycled many times while OIB is at least partly from more deeper part of the mantle (deep-sourced mantle plumes that feed hot spots like Hawai’i or the Canary Islands) and is therefore less depleted in incompatible chemical elements.

Dolerite (Diabase or Microgabbro)

Dolerite (Diabase) is a dark-coloured igneous rock. It is compositionally equivalent to gabbro and basalt but texturally between them. Dolerite is a common rock type. It occurs mostly in shallow intrusions (dykes and sills) of basaltic composition. It grades to basalt when it solidifies rapidly and to gabbro when more time is given to the crystals to grow. The term “microgabbro” is sometimes used to refer to such rocks.

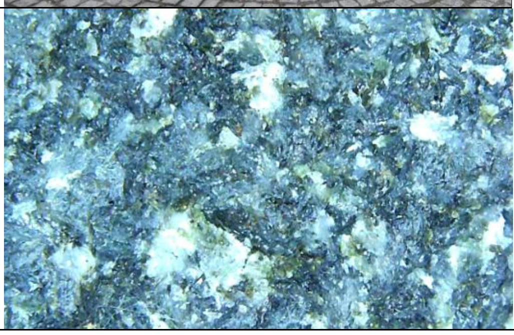
Dolerite dykes and sills are typically shallow intrusive bodies and often exhibit fine grained to aphanitic chilled margins which may contain tachylite (dark mafic glass). *Diabase* is the preferred name in North America, while *dolerite* is the preferred name in the rest of English-speaking world, where sometimes the name *diabase* is applied to altered dolerites and basalts. Some geologists prefer the name *microgabbro* to avoid this confusion. These two terms are synonymous.

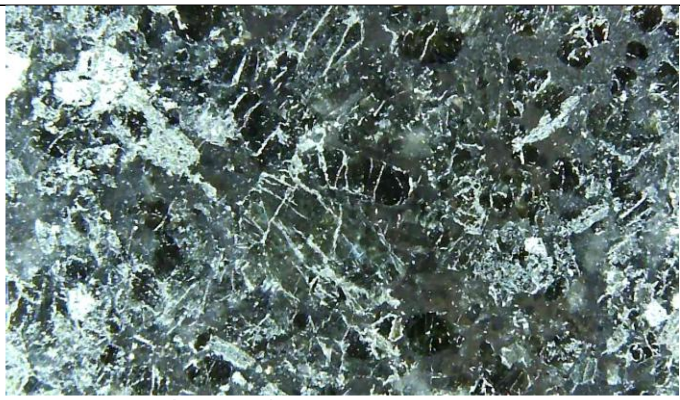
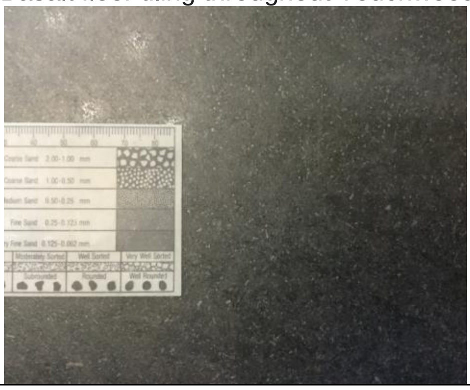
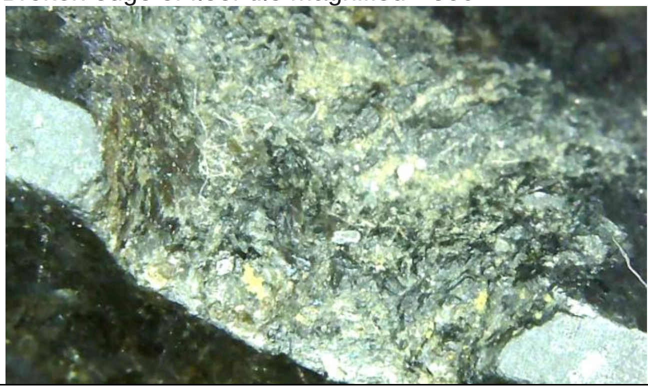
Dolerite is composed of plagioclase feldspar (mostly labradorite) and pyroxene (augite). The crystals that make up dolerite are usually visible to the naked eye, but sometimes porphyritic rocks of basaltic composition with pyroxene and especially plagioclase phenocrysts are also named that way. Ophitic texture (randomly oriented plagioclase laths enclosed by pyroxene grains) is a characteristic feature of dolerite. Minerals of lesser importance are magnetite, olivine, ilmenite, hornblende, biotite, chlorite, etc. Diabase is a popular ornamental stone. Crushed stone is often made of it and it seems to be a popular choice to use in sauna heaters

Solihull Examples: (2-7a, 3-4b & 3.6)

(1-2 refers to Trail 1, Location 2)

Viewing rocks in-situ we would always refer to the extrusives as basalt and the intrusives as dolerite. Samples from thick lava flows can look the same as from a volcanic sill, as the grain size is determined by the speed of cooling. Therefore, in practice distinguishing a basalt from a dolerite is not always simple from hand specimens. Of the 3 samples in Solihull, the floor tiles in Touchwood are the finest grained and shall be referred to as basalt. The statue plinth and memorial stone are both dolerite.

2.7a Mell Square: Dolerite plinth	3.6 Core Theatre Courtyard: Dolerite memorial
	
	

 A plinth of cobbles of coarse black **dolerite** possibly from Rowley Regis Late Carboniferous Ca 290 mmybp ?	 Core courtyard Memorial stone * 500
Basalt floor tiling throughout Touchwood 	Broken edge of floor tile magnified * 500 

Diorite

Diorite is a plutonic igneous rock with intermediate composition between mafic and felsic rocks. It is visibly crystalline and usually has a granular texture (composed of roughly equally sized crystals) although the appearance may vary widely. Its volcanic (fine-grained) analogue is andesite.

Diorite (Wikipedia) is an intrusive igneous rock composed principally of the silicate minerals plagioclase feldspar (typically andesine), biotite, hornblende, and/or pyroxene. The chemical composition of diorite is intermediate, between that of mafic gabbro and felsic granite. Diorite is usually grey to dark-grey in colour, but it can also be black or bluish-grey, and frequently has a greenish cast. It is distinguished from gabbro on the basis of the composition of the plagioclase species; the plagioclase in diorite is richer in sodium and poorer in calcium. Diorite may contain small amounts of quartz, microcline, and olivine. Zircon, apatite, titanite, magnetite, ilmonite, and sulfides occur as accessory minerals. Minor amounts of muscovite may also be present. Varieties deficient in hornblende and other dark minerals are called *leucodiorite*. When olivine and more iron-rich augite are present, the rock grades into *ferrodiorite*, which is transitional to gabbro. The presence of significant quartz makes the rock type *quartz-diorite* (>5% quartz) or tonalite (>20% quartz), and if orthoclase (potassium feldspar) is present at greater than 10 percent, the rock type grades into *monzodiorite* or granodiorite. A dioritic rock containing feldspathoid mineral/s and no quartz is termed *foid-bearing diorite* or *foid diorite* according to content.

Diorite has a phaneritic, often speckled, texture of coarse grain size and is occasionally porphyritic.
Orbicular diorite shows alternating concentric growth bands of plagioclase and amphibole surrounding a nucleus, within a diorite porphyry matrix.
Diorites may be associated with either granite or gabbro intrusions, into which they may subtly merge. Diorite results from the partial melting of a mafic rock above a subduction zone. It is commonly produced in volcanic arcs, and in cordilleran mountain building, such as in the Andes Mountains, as large batholiths. The extrusive volcanic equivalent rock type is andesite.

Granodiorite

(Wikipedia): Granodiorite is a phaneritic-textured intrusive igneous rock similar to granite, but containing more plagioclase feldspar than orthoclase feldspar. According to the QAPF diagram, granodiorite has a greater than 20% quartz by volume, and between 65% to 90% of the feldspar is plagioclase. A greater amount of plagioclase would designate the rock as tonalite.
Granodiorite is felsic to intermediate in composition. It is the intrusive igneous equivalent of the extrusive igneous dacite. It contains a large amount of sodium (Na) and calcium (Ca) rich plagioclase, potassium feldspar, quartz, and minor amounts of muscovite mica as the lighter coloured mineral components. Biotite and amphiboles often in the form of hornblende are more abundant in granodiorite than in granite, giving it a more distinct two-toned or overall darker appearance. Mica may be present in well-formed hexagonal crystals, and hornblende may appear as needle-like crystals. Minor amounts of oxide minerals such as magnetite, ilmenite, and ulvöspinel, as well as some sulfide minerals may also be present.

Solihull Examples: (1-1d, 2-3b, 2-4b, 2-11, 2-12, 2-14c, 2-17a, 2-25b, 2-27d)
(1-2 refers to Trail 1, Location 2)

Diorite has been used as the facing underneath most of the shop windows of Solihull.. All the facings were assumed to be Diorite from a visual inspection, but some could be granodiorite. Differentiating between the two rocktypes was not straight forward. Outcrops of Diorite occur in the Malvern hills to the SW of Solihull and in the Charnwood Forest area to the north east. It was assumed that these sources would have provided the facing stones for the developments during the 60's. This was this time period that most of these examples would have been installed. However, it is possible they could have been imported.

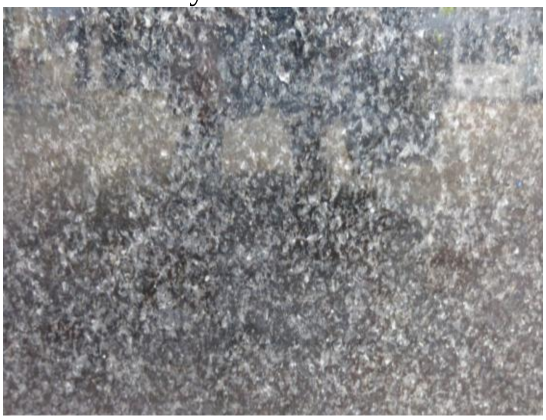
1.1d Kerbstone of the War memorial, The Square 	Diorite (Markfieldite). A dark greenish grey, speckled appearance composed of green hornblende and pink orthoclase, with minor epidote appearing as bright green patches. A Pre Cambrian intrusion, 600 mmybp, quarried from Markfield, Leicestershire

2-3 Entertainment Exchange &Regis, Drury Lane - Diorite

2-4b Hinds Drury Lane

2-12 Madeleine Ann, Drury Arcade

2-11 Onu Drury Arcade



Reflectivty and proximity of camera effect the image

2-14C House of Fraser, Warwick Rd

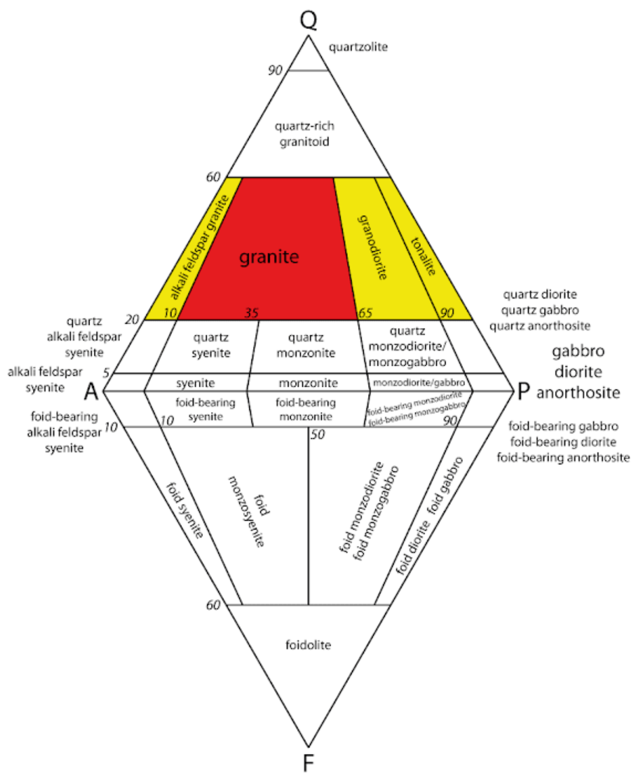
2-11 Onu, Drury Arcade

2-17a Marks & Spencer 	2-25b Danes, Poplar Road 
All the above facing stones are found under windows at ground level. The varying reflectivity and lighting don't make for an easy comparison and the grain size is different. Visual inspection suggests the composition of all are the same.	2-26d Dixons, Poplar Rd 

Granite

Granite is a crystalline igneous rock that consists largely of feldspar and quartz. These two are the most common minerals in the crust which means that granite too is among the most ubiquitous rock types, especially in the upper continental crust. It is crystalline (composed of visible mineral grains) and always contains quartz which usually is gray and also feldspar which is either reddish, white or yellow in most cases. Dark spots are generally the mineral biotite.

Classification
Granite is a coarse-grained quartzo-feldspathic igneous rock which contains 20-60% quartz of total quartz + feldspar (other minerals are neglected) and 35-90% of the feldspar is alkali feldspar (orthoclase or microcline). Rocks which fulfil the quartz content requirement but have a different ratio of feldspars have different names although they are known as granitoids or granitic rocks too. Granitic rocks which contain less than 10% plagioclase feldspar are named alkali feldspar granite and granitic rocks where the dominant feldspar is clearly plagioclase (over 65%) are named either granodiorite (65-90% of feldspar is plagioclase) or tonalite (over 90% of feldspar is plagioclase). See the diagram below:



QAPF diagram for plutonic rocks
Quartz (Q), alkali feldspars (A), plagioclase feldspars (P), and feldspathoids (F). F and Q for chemical reasons cannot exist together in one plutonic rock.

Classification of granite (red field) and granitic rocks (red+yellow) is based on the content of quartz (Q) (in relation to feldspar) and the mineralogy of the feldspar group minerals (A and P).

These rocks are known as granitoids (rocks resembling granite) because it may not be easy to distinguish different feldspar group minerals in the hand sample. But it should remain just a field term. It makes sense to classify granitic rocks based on the feldspars because rocks from different tectonic regimes tend to have different feldspar content. True granites, for example, are virtually absent in the oceanic crust although there are granitic rocks which are rich in plagioclase (tonalite).

Similarly coarse-grained igneous rocks that contain less quartz are named syenite (feldspar is mostly alkali feldspar), monzonite (contains both feldspars in roughly equal amounts) and diorite (plagioclase-rich). Rocks that contain more than 60% quartz as an average of voluminous igneous intrusion are uncommon because silicic magma from which granite crystallizes almost always contains enough potassium, sodium and calcium to form lots of feldspars in addition to pure silica (quartz). Feldspars actually precede quartz in the crystallization order from magma. So quartz can form only if there is free silica left after other cations have already satisfied their need for silica. In the vast majority of cases it contains more feldspar than quartz.

Texture

Granite is a coarse-grained igneous rock with average grain size ranging from 1 to 25 millimetres. These rocks crystallize from a very slowly cooling magma within the crust where they are well insulated. Time gives crystals a chance to grow. Volcanic rocks with a similar composition exist as well. These are known as rhyolite (volcanic equivalent of granite) and dacite (similar in composition to plagioclase-rich granitoids). The groundmass of these rocks is very fine-grained although they frequently contain phenocrysts (larger crystals that were already formed before the extrusion to the surface) embedded in the finer

matrix. Granite that crystallized in a narrow dike may be fine-grained because the heat was rapidly lost to the adjacent rocks. Such granite is known as aplite. Sometimes granite is very coarse-grained. That too happens usually close to the margins of a granitic pluton, but the coarseness is mostly a result of volatiles in the magma which greatly reduce its viscosity and therefore enhance crystal growth. These coarse-grained granites are known as pegmatites.
It has often roughly uniformly sized crystals which show no preferred orientation but that is not always the case. Some granites just like rhyolites contain phenocrysts – crystals that are clearly bigger than the material surrounding it. These phenocrysts are usually feldspar crystals. The difference between granite and rhyolite is that in granite even the finer material is visibly crystalline, but in rhyolite the individual crystals within the groundmass are not visible to the naked eye.

Occurrence

Granite is one of the main ingredients of the continental crust. Although continental landmasses are composed of many different igneous, sedimentary and metamorphic rocks, originally they were derived from the mantle by a process called partial melting which will step-by-step lead to the generation of granitic magma. When rocks melt the liquid that forms has different composition than the original source rock. When peridotite melts, basaltic rocks form which contain more silicon and aluminium and less iron and magnesium. Basalt is because of its chemical composition more light-weight and moves upward and solidifies as a lava on the surface or as dikes in the crust. When basalt melts even lighter magma forms which will lead to the formation of granite. It is therefore a result of a remelting of the material from the continental crust.

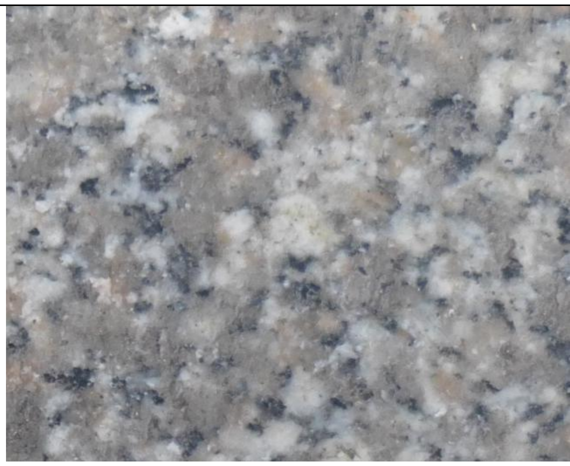
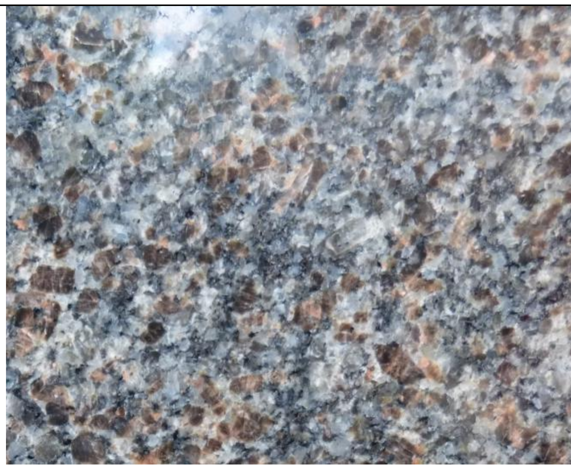
Granite is so light-weight when compared to the original peridotite that it cannot subduct back to the mantle. So it remains buoyant as a young continent. These continents will go through multitude of processes. Continents collide and metamorphose, they are worn down by weathering and igneous processes add new material. It has taken a very long time. The process started probably right after the formation of the Earth as a planetary body. The cores of continents formed in the Archaean and they tend to grow bigger because the continental crust that has already formed cannot sink to the mantle again. As a result continents are structurally complex mixtures of virtually every rock type known to us, granite being perhaps the most important of them.

Not all of these rocks are granites in the strict petrological sense. A major part of this material is clearly metamorphosed and should be described as gneiss. However, our knowledge about the interior of the crust mostly comes from the seismic studies and for the seismic waves it does not make any difference whether it is granite or a granitic gneiss. This is why it is often assumed that the continental crust is granitic. Furthermore, the composition of this material is not necessarily granitic in the strict sense. Plagioclase feldspar is more common in the crust than alkali feldspar. So it is fair to assume that the dominant rock type in the continental crust is a metamorphic rock with a granodioritic composition.

True granites occur mostly in plutons which are pancake-shaped igneous intrusions in the upper crust. Sometimes they reach the surface when the material above them has been removed by the weathering processes. These plutons vary enormously in size (1-1,000,000 km^3). The mechanism how they formed has been very controversial. The dominant hypothesis has been that they are the result of igneous diapirism – igneous material rises through the crust like a hot balloon. The formation of some granite plutons may be partly explained that way, but it seems more likely that the migration of granitic melt took place in the network of narrower cracks in the rocks. It seems rather difficult to understand how can very large balloon of hot magma move through the cold and rigid rocks of the upper crust. The formation process of granitic melt is known as migmatization and the rocks that contain metamorphic rocks mixed with magmatic veins are known as migmatites.

Solihull Examples: (1-4, 1-6, 1-7, 1-8, 1-9, 2-7b, 2-17b, 2-18, 3-3, 3-10, 3-11)
(1-2 refers to Trail 1, Location 2)
There are quite a number of granitoids to be seen in the churchyard where it is a popular rock for the use of memorial headstones. In Mell Square, M&S and adjoining Costa are clad in granite, it is also used as a flooring tile at all entrances to Touchwood Shopping Centre. NatWest bank, the last location for trail 3 is also clad in this decorative stone.

1-4 & 1-9 Peterhead Granite	1-6 Pegmatitic Granite, St Levens Cornwall ?
 Crystalline. Pink feldspar, clear quartz, black biotite . From Stirlinghill, near Boddam, Aberdeenshire. Caledonian 400mmya	
1-7 Pegmatitic Granite, Aberdeenshire ?	1-8 Ben Cruachan – Argyleshire ?
	
All above examples are from gravestone memorials in St Alphege Churchyard	

2-7b Granite Setts. Mell Square	3-3 & 3-10 Touchwood Entrances Granite Tiles
 Cornwall or Aberdeen ?, Variscan or Caledonian ? (Ca 290 mmybp? or 470 mmybp ?)	 **Rosa Beta Granite** from Italy is a Pink, gray coloured slab with a polished, leathered or honed finish. Used at all entrances to Touchwood shopping Centre.
2-17b M&S Swan Grey Granite, Cornwall ?	2-18 Costa & M&S Violetta Granite ?
 Granite is formed from the slow cooling and solidification of magma below the Earth's surface. Because it cools slowly it grows large crystals and, in this example, we can identify the white crystals of quartz, pink feldspar and black hornblende, plus a sparkle from particles of mica	 The closest match is a - As a kind of lilac granite from Saudi Arabia, Violetta Granite can also be called Tropical Violetta Granite, Violetta Red, Havana Red. Violetta Granite from Brazil is a red, black, lilac coloured slab with a polished, leathered or honed finish. It's a durable granite

3-11 NatWest Pegmatitic Granite

The pink feldspars are large phenocrysts. Name of the stone and source unknown. Looks like Porkkala Granite form Rapakivi Finland, which would make it Carboniferous Variscan

Larvikite / Labradorite

(Wikipedia): **Larvikite** is an igneous rock, specifically a variety of monzonite, notable for the presence of thumbnail-sized crystals of feldspar. These feldspars are known as *ternary* because they contain significant components of all three end member feldspars. The feldspar has partly unmixed on the micro-scale to form a perthite, and the presence of the alternating alkali feldspar and plagioclase layers give its characteristic silver blue sheen (Schiller effect, labradorescence) on polished surfaces. Olivine can be present along with apatite, and locally quartz. Larvikite is usually rich in titanium, with titanaugite and/or titanomagnetite present.

Larvikite occurs in the Larvik Batholith (a.k.a. Larvik Plutonic Complex), a suite of 10 igneous plutons emplaced in the Oslo Rift (Oslo Graben) surrounded by ~1.1 billion year old Sveconorwegian gneisses. The Larvik Batholith is of Permian age, about 292–298 million years old. Larvikite is also found in the Killala Lake Alkalic Rock Complex near Thunder Bay in Ontario, Canada.

The name originates from the town of Larvik in Norway, where this type of igneous rock is found. Many quarries exploit larvikite in the vicinity of Larvik.

Larvikite is prized for its high polish and the labradorescence of its feldspar crystals, and is used as dimension stone, often cladding the facades of commercial buildings and corporate headquarters. It is known informally as *Blue Pearl Granite*, although this is not an accurate description.

Labradorite ((Ca, Na)(Al, Si)$_4$O$_8$), a feldspar mineral, is an intermediate to calcic member of the plagioclase series. It has an anorthite percentage (%An) of between 50 and 70. The specific gravity ranges from 2.68 to 2.72. The streak is white, like most silicates. The refractive index ranges from 1.559 to 1.573 and twinning is common. As with all plagioclase members, the crystal system is triclinic, and three directions of cleavage are present, two of which are nearly at right angles and are more obvious, being of good to perfect quality. (The third direction is poor.) It occurs as clear, white to gray, blocky to lath shaped grains in common mafic igneous rocks such as basalt and gabbro, as well as in anorthosites.

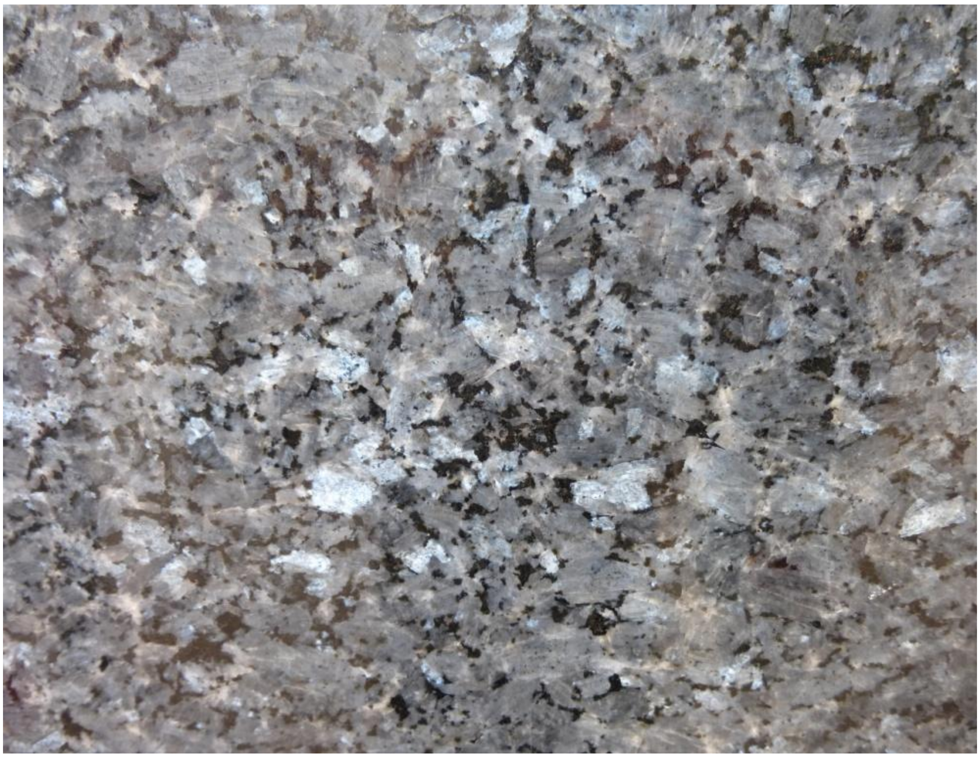
The geological type area for labradorite is Paul's Island near the town of Nain in Labrador, Canada. It has also been reported in Norway, Finland and various other locations worldwide.

Labradorite occurs in mafic igneous rocks and is the feldspar variety most common in basalt and gabbro. The uncommon anorthosite bodies are composed almost entirely of labradorite. It also is found in metamorphic amphibolites and as a detrital component of some sediments. Common mineral associates in igneous rocks include olivine, pyroxenes, amphiboles and magnetite.

Labradorite can display an iridescent optical effect (or *schiller*) known as labradorescence. The term *labradoresence* was coined by Ove Balthasar Bøggild, who defined it (labradorization) as follows:

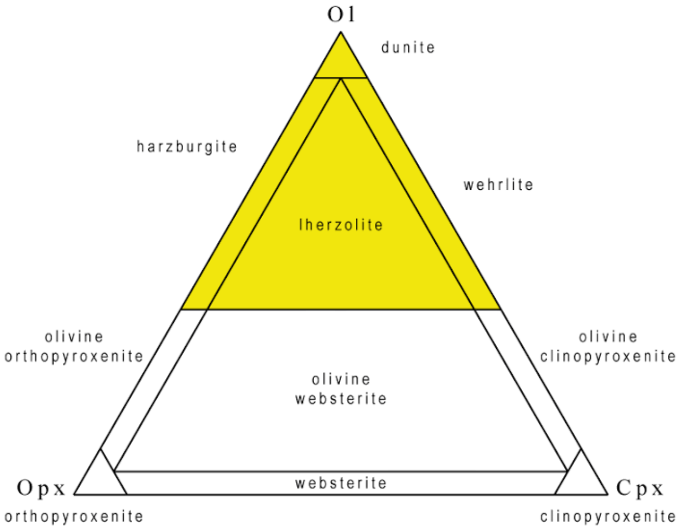
Labradorization is the peculiar reflection of the light from submicroscopical planes orientated in one direction (rarely in two directions); these planes have never such a position that they can be expressed by simple indices, and they are not directly visible under the microscope.

Solihull Examples: (2-26c No 2 Station Road, Bible Centre)
(1-2 refers to Trail 1, Location 2)



Peridotite.

This is a dark-coloured igneous rock consisting mostly of olivine and pyroxene. It is an important rock type because the Earth's mantle is predominantly composed of it.



A classification diagram of ultramafic rocks. Note that neither peridotite nor pyroxenite are single rock types. They are further divided into subtypes. There are four subtypes: dunite, harzburgite, lherzolite, and wehrlite. How to read this diagram? It is a typical ternary plot which are often used in geology. Ol, Opx, and Cpx represent olivine, orthopyroxene, and clinopyroxene respectively. Dunite is a type of peridotite that is almost monomineralic (more than 90% of it is olivine). Wehrlite contains almost no orthopyroxene but is rich in clinopyroxene and olivine. Harzburgite is rich in olivine and orthopyroxene but there can be only up to 5% clinopyroxene. Lherzolite is the least pretentious of them — it is a mixture of two pyroxenes and olivine.

This rock is relatively rare at the surface and is often altered by hydrothermal metamorphism or weathering because its constituent minerals are unstable at the weathering environment.

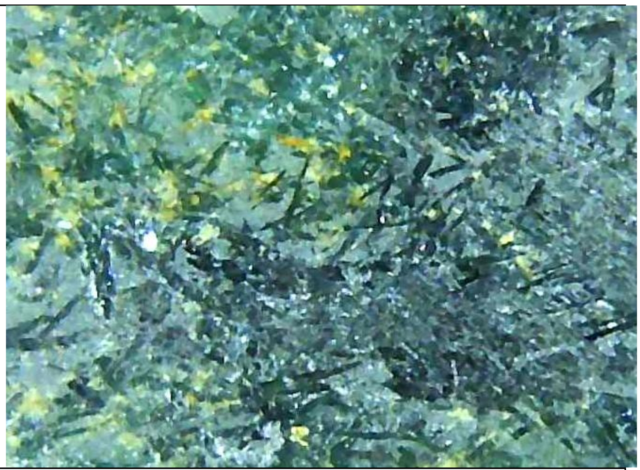
Olivine, the principal component of peridotite, makes up more than 40% of the pair olivine + pyroxene (or amphibole). A rock type with less olivine is named pyroxenite (or hornblendite if there are more amphiboles than pyroxenes). Peridotite is a plutonic rock, it is mostly composed of visible mineral grains. Other notable minerals that are often present are chromite, garnet, and plagioclase. It is an ultramafic rock (mafic minerals make up more than 90% of the rocks composition).

Peridotite is often massive (homogeneous) just like other plutonic rocks, but it can be also layered. Layered peridotite is a cumulate rock formed by crystal settling from magma. Layered ultramafic typically occur at the base of gabbroic intrusions. The Troodos ophiolite in Cyprus is a well-known locality where such rocks can be seen at the surface. Massive samples are often brought to the surface as xenoliths inside basalt.

Dunite is an igneous, plutonic rock, of ultramafic composition, with coarse-grained or phaneritic texture. The mineral assemblage is greater than 90% olivine, with minor amounts of other minerals such as pyroxene, chromite, magnetite, and pyrope. Dunite is the olivine-rich end-member of the peridotite group of mantle-derived rocks. Dunite and other peridotite rocks are considered the major constituents of the Earth's mantle above a depth of about 400 kilometers. Dunite is rarely found within continental rocks, but where it is found, it typically occurs at the base of ophiolite sequences where slabs of mantle rock from a subduction zone have been thrust onto continental crust by obduction during continental or island arc collisions (orogeny). It is also found in alpine peridotite massifs that represent slivers of sub-continental mantle exposed during collisional orogeny. Dunite typically undergoes retrograde metamorphism in near-surface environments and is altered to serpentinite and soapstone.

Solihull Examples: (2-16 Edinburgh Woolen Mill, Mill Lane)
(1-2 refers to Trail 1, Location 2)

This is quite a spectacular facing. It is seen on the inside surfaces covering the pillar at the doorway. Probably the result of maintenance at some point, as the columns elsewhere along this section of Mill Lane are clad in Serpentinite.

	
Peridotite / Dunite: Green - coppery brown shiney surface. Lots of olivine noticeable. Yellow colours are altered olivine's.	Magnification *500. Olivine, a magnesium iron silicate, is commonly green, weathering to yellow. The dark lenticular shards are thought to be chromite or possibly magnetite

Metamorphic Rocks

Marble

Marble is a metamorphic rock consisting predominantly of calcite or dolomite. It is a metamorphosed carbonate rock (limestone or dolomite rock).

The term “marble” in geology is restricted to true metamorphic rocks in which the carbonate minerals have recrystallized. This process generally increases the average grain size, which gives marble its sparkling and attractive appearance. The sparkle is the reason why we call it that way — Greek *marmaros*, sparkling. In commerce, coarse-grained sedimentary carbonate rocks that take polish (grainstone, travertine) and sometimes even alabaster (gypsum) are also treated as marble.

Pure calcitic limestone generally yields phaneritic (visibly crystalline) rock. Dolomitic rocks may metamorphose to dolomarble (dolomite marble) or calcitic marble if impure. Younger rocks are usually calcitic. Dolomarbles are more frequent in older (precambrian) terranes

Impurities in carbonate protoliths (mud, sand, organic matter) considerably complicate the metamorphic reactions. Reaction between calcite and silica (sand) yields wollastonite and liberates carbon dioxide:

$$CaCO_3 + SiO_2 \rightarrow CaSiO_3 + CO_2$$

(Although in real rocks the sequence of reactions is more complicated. Wollastonite is not among the first minerals to form during the marmorization process.)
Similar reaction with dolomite rock yields calcitic marble with Mg-rich olivine (forsterite):

$$2CaMg(CO_3)_2 + SiO_2 \rightarrow Mg_2SiO_4 + 2CaCO_3 + 2CO_2$$

Thermal metamorphism of dolomite rocks around contact aureoles produces calcite with periclase (MgO) which is later hydrated to brucite ($Mg(OH)_2$):

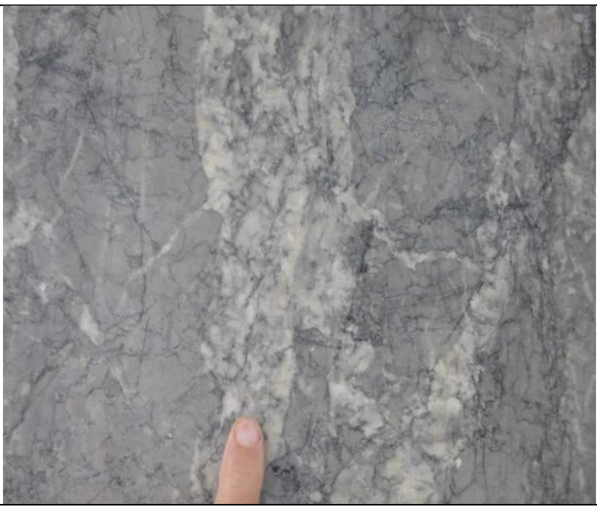
$$CaMg(CO_3)_2 \rightarrow CaCO_3 + MgO + 2CO_2$$

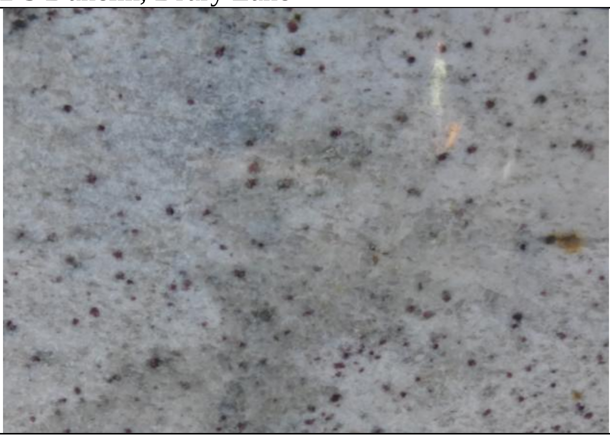
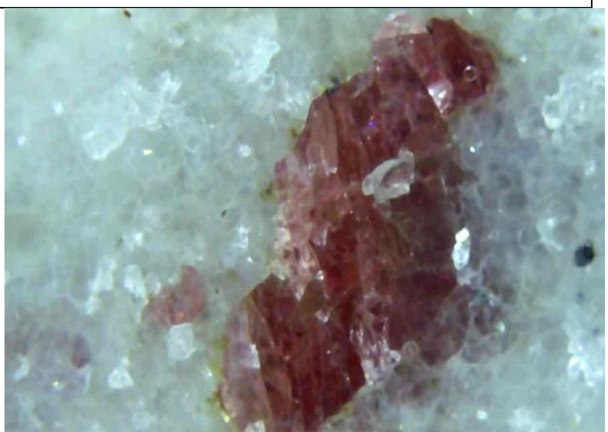
Metamorphism of impure dolomite rock may (in addition to forsterite) also yield tremolite, diopside, talc, serpentine, monticellite, merwinite, humite, and anthoPhillite. Ophicalcite is a variety that contains serpentinized forsterite or diopside.

If the calcitic protolith contained clay, Al-rich phases like Ca-garnets (grossular, andradite) and several other minerals like scapolite, melilite, and epidote may form. In dolomitic mudstones, spinel and amphiboles may form in addition to the aforementioned minerals. Iron-bearing phases in protoliths metamorphose to magnetite.

Rocks closely related to marbles are skarns. They form when silicate fluids from hot igneous intrusions react with carbonate country rocks. The result is a mineralogically complex and very diverse mixture of calc-silicate minerals with calcite. Skarns are often mined because they contain valuable ore minerals. Skarns are too rich in silicate minerals to be called marble and sometimes they contain no carbonate minerals at all (used up in metamorphic reactions).

Solihull Examples: (2-1, 2-2a, 2-4a, 2-4c, 2-5, 2-14a, 2-20, 2-21, 2-25)
(1-2 refers to Trail 1, Location 2)
Most true marbles are imported. These, along with polished limestones, were commonly used in the construction of Mell Square during the 1960s. Most of the Solihull marbles and polished limestones have probably originated in Italy.

2-1 Drury Lane & 2-20 Mill Lane The shops on one side of each street are clad with this intensely veined metamorphic brecciated Marble	**2-2a Drury Lane**. The columns outside the shops on the right side of the street are clad in **Carrara Marble**
	
Grey marble matrix rich in iron pyrite, intensely fractured with veins of white calcite of more than one event as evidenced by the offsets. Both grey and white zones are intensely veined with thin dark grey& black veins of probably of iron oxide. Tectonic breccia formed along a thrust plane then metamorphosed at greenschist facies Arabescato - Carrara Marble ? Tuscany, Italy ? Mesozoic limestone, Oligocene and Miocene tectonic event?	Pieces brick shaped blocks of white unpolished crystalline limestone **Carrara Marble.** These have a naturally broken surface which does catch the light well and makes for an interesting texture. This variety is white with faint, grey streaks, it is known as Carrara ‘Sicilian’ Marble (the links with Sicily are unknown and probably tenuous). This marble is derived from the Apulian Tectonic Window

2-5 Dunelm, Drury Lane	
	
This white crystalline marble contains lots of red garnets, (almandine), indicating that it is a high grade metamorphic rock. Almandine is a common mineral in metamorphic rocks that formed when buried in crust under the load of at least 10 km of rocks and sediments The Photo on the right has a magnification of *500	

2-4a, Hinds, Drury Lane	2-4c Hinds Drury Lane Pencil Vein Marble
	
Marble Breccia Creamy white angular blocks of various sizes surrounded by very fine darker grained impurities such as clay, silt, sand, iron oxides,. Note that the blocks are all aligned with the stress direction.	Inner wall panels. Heavily stylolite sutured pencil vein marble
2-14a House of Fraser, Warwick Road. Bianco Carrara **Pencil Veined Marble**	**2-21 Inside Poplar Way - Mell Square.** Bianco Carrara **Pencil Veined Marble**
	
2-25 Danes, Poplar Road. Bianco Carrara **Pencil Veined Marble** 	Bianco Carrara **Pencil Veined Marble** White to very light grey, crystalline. Veins in marbles are usually due to various mineral impurities such as clay, silt, sand, iron oxides, or chert which were originally present as grains or layers in the limestone. From Carrara, Tuscany Italy. Low - moderate grade metamorphism.

Quartzite

Quartzite is a metamorphic rock consisting largely or entirely of quartz. In the vast majority of cases, it is a metamorphosed sandstone.

The transition from sandstone to quartzite is gradational. There is little mineralogical change. Quartz, the main constituent of sandstone, is not altered to other minerals if the sandstone is relatively pure, but it is recrystallized during the metamorphism. Original grainy look of sandstone is lost to a variable degree. Some quartzites are still similar to sandstones, only more strongly held together, while others are completely recrystallized so that all the features like fossils or original texture are obliterated and grain boundaries have disappeared. It is difficult to say where the boundary between these rocks exactly is. Rock sample that may be quartzite for one geologist might be strongly cemented sandstone for another. Quartzite usually is the result of metamorphism if the source material is relatively pure sandstone.

Quartzite is a common metamorphic rock because its protolith sandstone is very widespread. Quartzite outcrops can be found in many mountain ranges all over the world. It usually is associated with current or former mountain ranges because mountain-building is the process that is responsible for the deep burial and associated metamorphism that transforms sandstone to quartzite. Quartzite is a very hard rock. It tolerates weathering well because its main constituent quartz is very resistant to both physical and chemical disintegration. These properties make quartzite a useful building stone which is used to build walls, stair steps and floors. It is used in road construction and as a railway ballast.

You may encounter terms like orthoquartzite and metaquartzite. The former is actually a very pure unmetamorphosed quartz-rich sandstone which is more commonly known as quartz arenite. Metaquartzite is more or less synonymous with quartzite. These terms are old-fashioned and little used nowadays.

Solihull Examples: (1-3 St Alphege - Glacial Erratic)
(1-2 refers to Trail 1, Location 2)

Quartzite is not commonly used as a decorative building stone and as such does not feature in any of the buildings in Solihull. The one example is located on the south side of St Alphege Church where a small glacial erratic can be seen (picture above). This was found nearby and has been placed in its current location, and labelled by the WGCG.

This is thought to be a ganister (hard pan) found in the Carboniferous coal measures of northern England. This is to have originated in the north Midlands and brought south by pre-Devensian glacial ice. Its economic use is primarily for the lining of furnaces.

Phillite (Wikipedia)

This is a type of foliated metamorphic rock created from slate that is further metamorphosed so that very fine grained white mica achieves a preferred orientation. It is primarily composed of quartz, sericite mica, and chlorite.

Phillite has fine-grained mica flakes in a preferred orientation, whereas slate has extremely fine mica flakes that achieve a preferred orientation, and schist has large mica flakes in a preferred orientation. Among foliated metamorphic rocks, it represents a gradation in the degree of metamorphism between slate and schist

The minute crystals of graphite, sericite, or chlorite, or the translucent fine-grained white mica impart a silky, sometimes golden sheen to the surfaces of cleavage, called "phillitic luster".

The word comes from the Greek *phyllon*, meaning "leaf".

The protolith (or parent rock) for Phillite is shale or pelite, or slate, which in turn came from a shale protolith. Its constituent platy minerals are larger than those in slate but are not visible with the naked eye. Phillites are said to have a texture called "phillitic sheen," and are usually classified as having formed through low-grade metamorphic conditions through regional metamorphism metamorphic facies.

Phillite has good fissility (a tendency to split into sheets). Phillites are usually black to gray or light greenish gray in colour. The foliation is commonly crinkled or wavy in appearance.

Phillite is commonly found in the Dalradian metasediments of northwest Arran. In north Cornwall, there are Tredorn Phillites and Woolgarden Phillites.

Solihull Examples: (2-2b, 2-3a, 2-25c)
(1-2 refers to Trail 1, Location 2)

2-2a Drury Lane Pillars	
	The Philite is greenish black with a phillitic lustre. It has been used effectively at the base of the columns to prevent water rising by capillary forces and discolouring and damaging the columns. It also provides an attractive contrast with the Carrere marble above

2-3a Entertainment Exchange Drury Lane	**2-25C Danes Poplar Road,**
	
These phyllitic slates have been used as floor tiles. They are light to dark grey, green grey, brown grey, have a slightly uneven to even cleavage with a micaceous (phillitic) lustre. They are a low grade metamorphic rock	

Slate

A fine-grained metamorphic rock that can be split into thin sheets (has slaty cleavage). Slate in the vast majority of cases is a metamorphosed shale/mudstone. Shale is a lithified mud — a sedimentary rock composed mostly of clay- and silt-sized grains.

Wikipedia: Slate is a fine-grained, foliated, homogeneous metamorphic rock derived from an original shale-type sedimentary rock composed of clay or volcanic ash through low-grade regional metamorphism. It is the finest grained foliated metamorphic rock. Foliation may not correspond to the original sedimentary layering, but instead is in planes perpendicular to the direction of metamorphic compression.

The foliation in slate is called "slaty cleavage". It is caused by strong compression causing fine grained clay flakes to regrow in planes perpendicular to the compression. When expertly "cut" by striking parallel to the foliation, with a specialized tool in the quarry, many slates will display a property called fissility, forming smooth flat sheets of stone which have long been used for roofing, floor tiles, and other purposes. Slate is frequently grey in colour, especially when seen, en masse, covering roofs. However, slate occurs in a variety of colours even from a single locality; for example, slate from North Wales can be found in many shades of grey, from pale to dark, and may also be purple, green or cyan. Slate is not to be confused with shale, from which it may be formed, or schist.

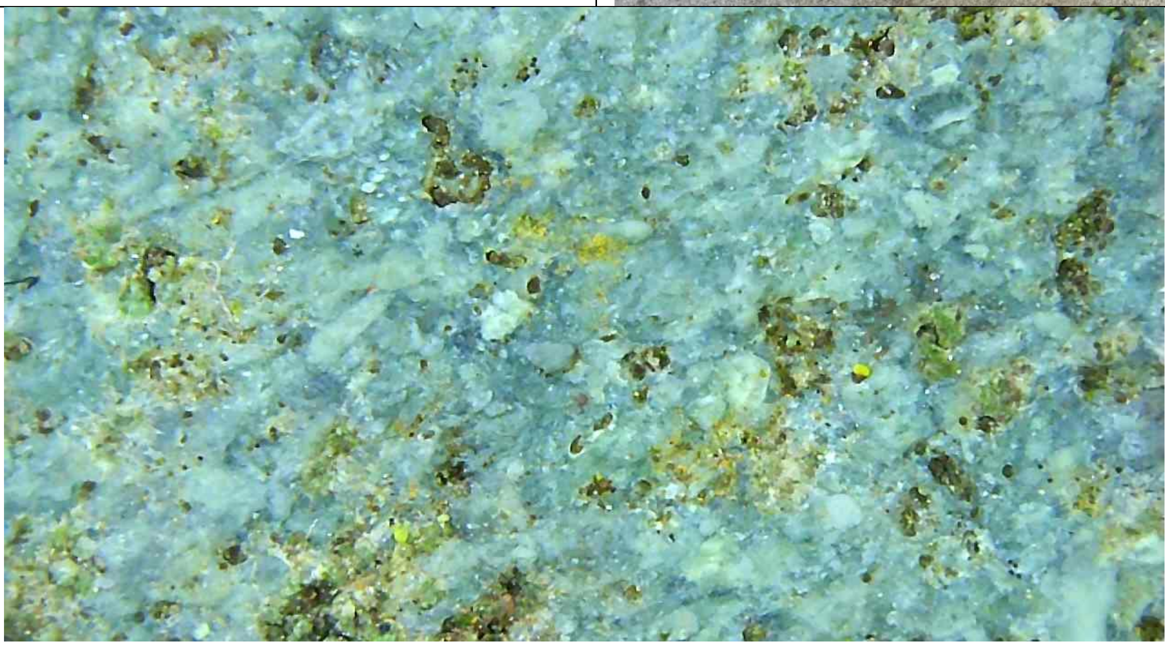
The word "slate" is also used for certain types of object made from slate rock. It may mean a single roofing tile made of slate, or a writing slate. They were traditionally a small, smooth piece of the rock, often framed in wood, used with chalk as a notepad or notice board, and especially for recording charges in pubs and inns. The phrases "clean slate" and "blank slate" come from this usage.

Solihull Examples: (2-8a & 2-19 Old GPO & Boots, Mell Square)
(1-2 refers to Trail 1, Location 2)

Both examples in Solihull are Westmoreland Slate , also known as Honister Slate. This is variety of slate from the Borrowdale Volcanic Group of Cumbria. Unusually it is formed from a tuff (volcanic ash deposit) – erupted during the Caradoc Age of the Ordovician (458 to 448 million years ago) – which has been subjected to high pressure and heat during the Caledonian orogeny (490–390 million years ago), metamorphosing it to a slate. Large amounts of the mineral chlorite give the slates a green-grey or green colour.

The green-grey slates are from the lower seam quarried near the Honister Pass (and now marketed as Honister Slate) while the green slates are from the upper seam near Ambleside. Relict igneous crystals give individual slates a much bumpier surface than a typical mudstone slate (e.g. Welsh Slate) and in some cases roof pitches may be steeper than their smooth slate equivalent as a result.

2-19 & 2-8b Westmoreland Slate, Mell Square. Metamorphosed between 440 - 400 mmybp



Westmorland slate magnified *500. Note the preferred alignment of the minerals

Serpentinite

Wikipedia: Serpentinite is a rock composed of one or more serpentine group minerals, the name originating from the similarity of the texture of the rock to that of the skin of a snake. Minerals in this group, which are rich in magnesium and water, light to dark green, greasy looking and slippery feeling, are formed by **serpentinization**, a hydration and metamorphic transformation of ultramaficrock from the Earth's mantle. The mineral alteration is particularly important at the sea floor at tectonic plate boundaries.

Sandatlas: Serpentinite is a metamorphic rock that is mostly composed of serpentine group minerals. Serpentine group minerals antigorite, lizardite, and chrysotile are produced by the hydrous alteration of ultramafic rocks. These are igneous rocks that are composed of olivine and pyroxene (peridotite, pyroxenite). Serpentine group minerals occur less commonly in some olivine-bearing marbles (ophicalcite) and kimberlites, but these rocks are normally not considered to be serpentinites.

Serpentinites form as a result of serpentinization. These are chemical reactions which convert anhydrous ferromagnesian silicate minerals (pyroxene, olivine) into hydrous silicate minerals (serpentine) plus some other possibilities like brucite and magnetite. Brucite forms if the precursor rocks are rich in magnesium (dunite, for example).Magnetite forms if there is enough iron present (pyroxenite). Usually serpentinite contains iron in the form of magnetite which gives dark colour to serpentinites.
Serpentinite is probably very widespread rock deep below, but not nearly as common in the upper parts of the crust. Here it occurs mostly where ultramafic rocks occur (ophiolite complexes). Serpentine minerals along with other green-coloured alteration minerals (talc and chlorite) are still pretty widely distributed because olivine and pyroxenes are readily available in many places. Serpentinites have been important sources of asbestos, but nowadays the use of asbestos has diminished considerably because of health concerns. These concerns may actually be greatly exaggerated because there is not much good evidence that chrysotile (serpentine asbestos which makes up more than 90% of all asbestos mined) poses any significant risks to our lungs. The danger associated with asbestos comes mostly form amphibole asbestos minerals. Given that this technicality is probably too complex for society to understand then we will continue to see dangers in harmless amounts of chrysotile asbestos in floor tiles while we neglect or happily tolerate far more important health risks associated with lifestyle choice.

Solihull Examples: (2-9, 2-15)
(1-2 refers to Trail 1, Location 2)

Serpentinite has been used for the cladding around shops in and around Mell square, Drury Arcade and Mill Lane

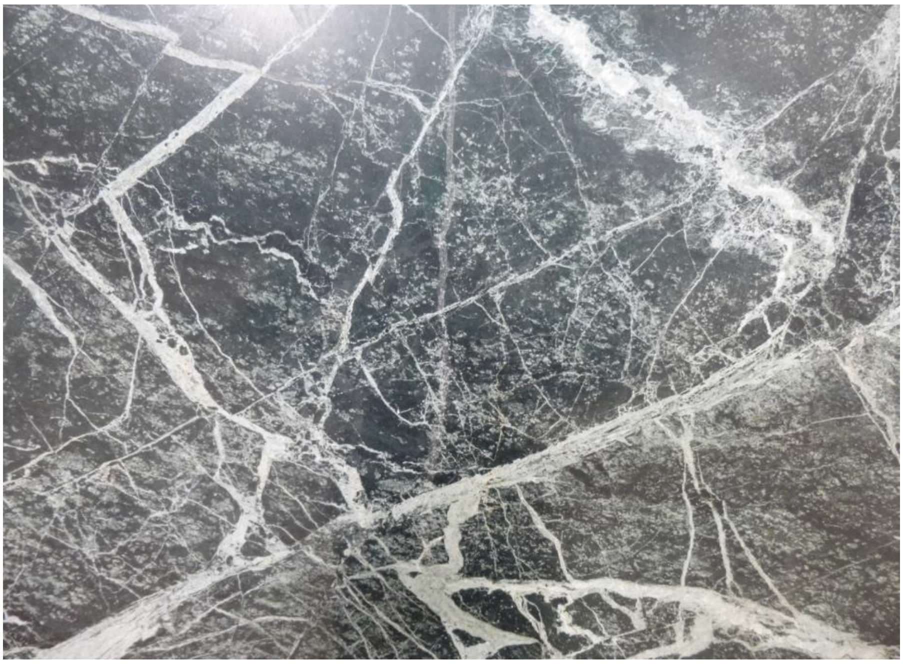
The cladding is a veined greenish crystalline stone called **Serpentinite**, that resulted from a transformation of ancient ocean crust thrust upwards under intense pressure by tectonic plate movements. It can be found in the mountains of Italy and Greece, and in the Lizard peninsular of Cornwall. It is named for its snake-like patterns and colouring.

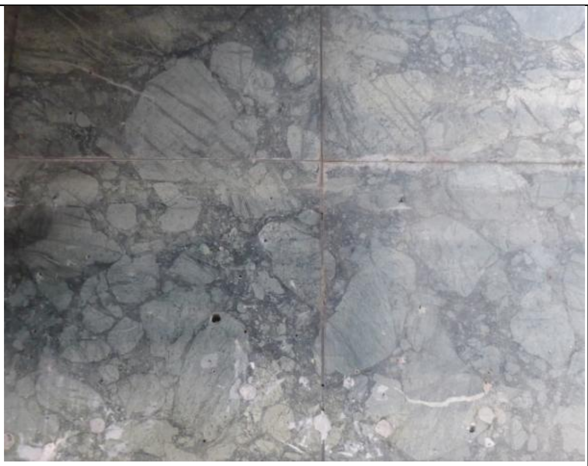
It is greenish grey with numerous off white veins, thin dark grey & black lined fractures.

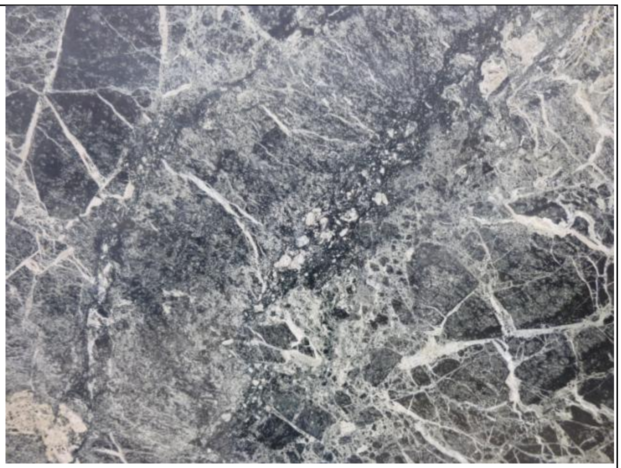
It is a Metamorphic rock, specifically a hydrated Peridotite which is a product of subduction. It results from a transformation of ancient ocean crust thrust upwards under intense pressure by tectonic plate movements.

It is also known as Verde Alpi and the source is probably the Piedmont Zone of the French and Italian Alps, which will make it Cretaceous in age

Verdi Alpi is a rich green "marble" with light green veins and markings.







Appendix 1 Glossary of Terms

(Definitions from Wikipedia)

Alabaster Archaeologists and the stone industry use the term to includes varieties of two different minerals: the fine-grained massive type of gypsum and the fine-grained banded type of calcite. Geologists define alabaster only as the gypsum type.

The calcite type is geologically described as either a compact banded travertine[or "a stalagmite limestone marked with patterns of swirling bands of cream and brown"

Breccia is a rock composed of broken fragments of rock cemented together by a fine-grained matrix that can be similar to or different from the composition of the fragments.

A breccia may have a variety of different origins, as indicated by the named types including sedimentary breccia, tectonic breccia, igneous breccia, impact breccia, and hydrothermal breccia.

Crystal twinning occurs when two separate crystals share some of the same crystal lattice points in a symmetrical manner. The result is an intergrowth of two separate crystals in a variety of specific configurations. The surface along which the lattice points are shared in twinned crystals is called a composition surface or twin plane.

Dolomitisation. This is a geological process by which the carbonate mineral dolomite is formed when magnesium ions replace calcium ions in a carbonate. It is common for this mineral alteration into dolomite to take place due to evaporation of water in the sabka area. Dolomitization involves a substantial amount of recrystallization. This process is described by the stoichiometric equation:

$$2\ CaCO_{3(calcite)} + Mg^{2+} \leftrightarrow CaMg(CO_3)_{2(dolomite)} + Ca^{2+}$$

Dolomitization depends on specific conditions which include low Ca:Mg ratio in solution, reactant surface area, the mineralogy of the reactant, high temperatures which represents the thermodynamic stability of the system, and the presence of kinetic inhibitors such as sulphate.

Erratic. This is a piece of rock that differs from the size and type of rock native to the area in which it rests. Erratics are carried by glacial ice often over distances of hundreds of kilometres. Erratics can range in size from pebbles to large boulders.

Ganister. A hard, fine-grained quartzose sandstone, or orthoquartzite, used in the manufacture of silica brick typically used to line furnaces. Ganisters are cemented with secondary silica and typically have a characteristic splintery fracture.

Miners originally coined this term for hard, chemically and physically inert silica-cemented quartzose sandstones, commonly, but not always found as seatearths within English Carboniferous coal measures. This term is now used for similar quartzose sandstones found typically as seatearths in the Carboniferous coal measures of Nova Scotia, the United States, and the Triassic coal-bearing strata of the Sydney Basin in Australia.

Greenschists are metamorphic rocks that formed under the lowest temperatures and pressures usually produced by regional metamorphism, typically 300–450 °C (570–840 °F) and 2–10 kilobars (14,500–58,000 psi). Greenschists commonly have an abundance of green minerals such as chlorite, serpentine, and epidote, and platy minerals such as muscovite and platy serpentine

Pegmatite is an igneous rock, formed underground, with interlocking crystals usually larger than 2.5 cm in size (1 in). Most pegmatites are found in sheets of rock (dikes and veins) near large masses of igneous rocks called batholiths.

Most pegmatites are composed of quartz, feldspar and mica, having a similar silicic composition as granite. Crystal size is the most striking feature of pegmatites, with crystals usually over 5 cm in size. Individual crystals over 10 metres.

Phaneritic textured rocks are comprised of large crystals that are clearly visible to the eye with or without a hand lens or binocular microscope.

Phenocryst. This is an early forming, relatively large and usually conspicuous crystal distinctly larger than the grains of the rock groundmass of an igneous rock. Phenocrysts often have euhedral forms, either due to early growth within a magma, or by post-emplacement recrystallisation. Normally the term *phenocryst* is not used unless the crystals are directly observable, which is sometimes stated as greater than 5 millimetre in diameter.

Porphyritic texture is an igneous rock **texture** in which large crystals are set in a finer-grained or glassy groundmass. Porphyritic textures occur in coarse, medium and fine-grained igneous rocks. Usually the larger crystals, known as phenocrysts, formed earlier in the crystallisation sequence of the magma.

Stromatolites and biostromes are layered mounds, columns, and sheet-like sedimentary rocks that were originally formed by the growth of layer upon layer of cyanobacteria, a single-celled photosynthesizing microbe. Fossilized stromatolites provide records of ancient life on Earth. Lichen stromatolites are a proposed mechanism of formation of some kinds of layered rock structure that are formed above water, where rock meets air, by repeated colonization of the rock by endolithic lichens

Stylolites are serrated surfaces within a rock mass at which mineral material has been removed by pressure dissolution, in a process that decreases the total volume of rock. Insoluble minerals, such as clays, pyrite and oxides, as well as insoluble organic matter remain within the stylolites and make them visible.

A **subduction zone** is a region of the Earth's crust where tectonic plates meet. Tectonic plates are massive pieces of the Earth's crust that interact with each other. **Subduction** is a geological process that takes place at convergent boundaries of tectonic plates where one plate moves under another and is forced to sink due to high gravitational potential energy into the mantle.

Travertine is a form of limestone deposited by mineral springs, especially hot springs. Travertine often has a fibrous or concentric appearance and exists in white, tan, cream-colored, and even rusty varieties. It is formed by a process of rapid precipitation of calcium carbonate, often at the mouth of a hot spring or in a limestone cave. In the latter, it can form stalactites, stalagmites, and other speleothems. It is frequently used in Italy and elsewhere as a building material. It is a terrestrial sedimentary rock sometimes called "flowstone"

Tufa is a variety of limestone formed when carbonate minerals precipitate out of ambient temperature water. Geothermally heated hot springs sometimes produce similar (but less porous) carbonate deposits, which are known as travertine. Tufa is sometimes referred to as (meteogene) travertine. It should not be confused with hot spring (thermogene) travertine.

A **xenolith** is used to describe inclusions in igneous rock during magma emplacement and eruption. Xenoliths may be engulfed along the margins of a magma chamber, torn loose from the walls of an erupting lava conduit or explosive diatreme or picked up along the base of a flowing body of lava on the Earth's surface. A xenocryst is an individual foreign crystal included within an igneous body.

St Alphege . Church building terminology.

Nave, central and principal part of a Christian **church**, extending from the entrance (the narthex) to the **transepts** (transverse aisle crossing the **nave** in front of the sanctuary in a cruciform **church**) or, in the absence of transepts, to the chancel (area around the altar).

The **chancel** is the space around the altar, including the choir and the sanctuary, at the liturgical east end of a traditional Christian church building. It may terminate in an apse. It is generally the area used by the clergy and choir during worship, while the congregation is in the nave.

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