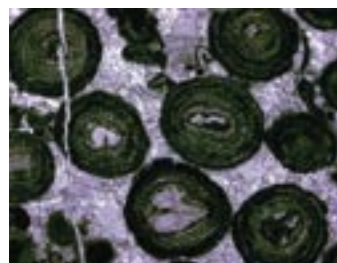


THE GEOLOGY OF LIMESTONE

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For many centuries, the properties of natural stone have been exploited for the construction of attractive, long-lasting structures. Take the Romans for example. Whilst for many their humble dwellings were constructed of travertine from small nearby excavations, the wealthy displayed their status by lavishly furnishing the interiors with facades and pillars of brightly coloured stone from the far reaches of the Empire.



Oolitic limestone - Concentric growth rings of ooids held in a calcite cement

Back to the present day and we can see that it's not just the impressive buildings that are finished off in natural stone. The popularity of enhancing our homes with stone floors, worktops and fireplaces is on the increase.

Over the coming editions each of the main rock types will be discussed in turn, relating the qualities that make a stone useable to the processes by which that stone formed.

By definition, a limestone is a sedimentary rock made of calcium carbonate, CaCO₃. All limestones began as a sediment on the sea floor of shallow tropical seas and were lithified (turned

to stone) through the binding of the constituent grains with calcite. Sea water contains carbon dioxide (CO₂) which escapes as the water is warmed up by the sun. As this happens, calcium and bicarbonate ions in the water combine to form calcium carbonate, in much the same way as limescale forming in a kettle.

The amount of calcium carbonate within a limestone may vary from 100% as in the Chalk of the southeast of England, to 70% in the Magnesian Limestones and to as little as 30% in sandy limestones, such as Ham Hill stone.

Limestones, exemplified by the warm tones of Ketton stone and many of the 'Bath stones', are dominated by inorganic grains called ooids. These spherical grains are composed of a series of concentric growth rings of calcite usually around a nucleus of a minute sand grain. Ooids can be seen forming today in the warm tropical seas of the Bahamas, where the gentle currents roll the grains across the sea floor as the calcium carbonate is deposited uniformly around the nucleus.

Skeletal limestones, on the other hand, are those whose grains are dominated by the remains of marine animals. That is to say, they contain fossils. Shelly limestones include stones such as Portland and Purbeck Stone, and Portuguese Beige. Coral-rich limestones include Rouge Royale of Belgium and the

colourful limestones of the Torquay area of Devon (e.g. Ashburton and Petitor). The 'Birdseye' and Derbydene limestones of Derbyshire contain fossils of crinoids, a plant-like animal that used to live on the sea floor about 300 million years ago.

From the type and amount of unbroken fossils it is possible to infer the kind of environment in which the stone was formed. Intact corals preserved in life-position in a stone clearly indicate formation within a reef environment. But a limestone of broken skeletal material suggests the animals had been moved from their life position by ocean currents. Broadly speaking the more broken and disaggregated the fossils, the closer the rock was formed to the high-energy waves of the shoreline. These currents kept the shells in constant motion, swirling around and knocking against each other resulting in abraded fragments aligned in layers at an angle to the bedding. At the other end of the 'energy spectrum' you have limestones that were formed in the deep ocean by the slow accumulation of a carbonate 'rain' of microscopic organisms. Larger organisms that died and fell to the sea floor were rapidly buried and preserved relatively intact.

Strongly defined fabric has implications on whether the rock is best cut parallel or perpendicular to the bedding but one needs to consider its intended purpose. The gradual accumulation of carbonate mud

in the deep ocean entombs and preserves the shells of floating creatures that have reached the end of their life cycle and settled to the sea floor, producing a hard, finely laminated limestone with qualities that make the Jura limestones suitable for flooring. Whereas the gentle environment in which ooids form and are natural graded according to grain size produces a rock whose uniformity in all directions makes it perfect for carving - a freestone!

Selection of a limestone may be purely based on its colour. For example, the uniform black of Noir Belge makes a bold statement for a fire surround. The colour is acquired early on in the formation of the limestone. The cream, buff, brown, orange and red tints are all caused by varying amounts of iron oxides dissolved in the fluids within the sediment. The greys and blacks are due to the presence of very fine particles of organic matter and varying amounts of iron sulphide.

As more and more sediment settles to the seafloor, the grains in lower layers become compacted together,



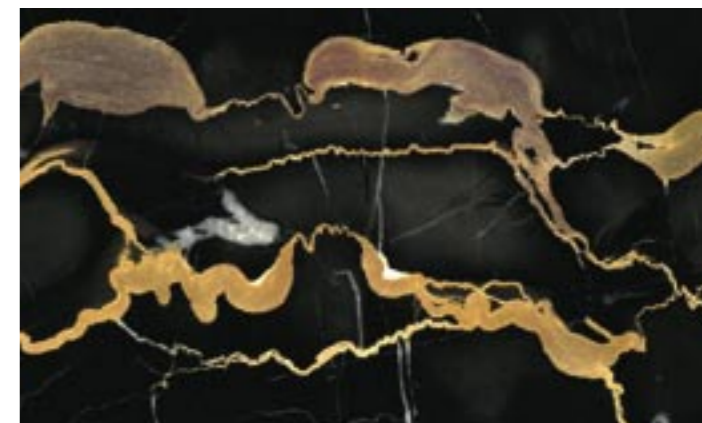
Petitor - As good as any foreign stones, the coral-rich limestones of Devon were once very popular

the fluid is squeezed out and the sediment hardens. As the migrating fluids move through the rock, they may precipitate a fine calcite cement that holds the grains together. Over time the fine cement gives way to coarser crystals that allow the stone to take a good polish. Interestingly, it is not the cement that gives limestones such as Portland and Ketton strength, but the ooids. Used in buildings under compression it does not matter that they lack good cement providing that they have strong grains. In fact, such stones have the added benefit of being relatively easy to cut and carve. Conversely, limestones such as Bath stone gain their strength from the cement and not the ooids, which are soft and weak and prone to weathering.

Similar fluids to those that precipitate a cement may also dissolve the weaker grains leaving casts of their ornate form and opening up the porosity of the rock. This is typified by the Portland Roach in which the 'corkscrew' holes render it useless for external use but adds an interesting texture to sculptures. From a building point of

view, the most important aspect of stone is the pores, particularly those of less than 0.005mm across. Fine-grained muddy limestones contain a high proportion of interconnecting micropores that can carry moisture far back into the stone, making it susceptible to frost and pollution attack. Thus in selecting stone it is important to look at it under a microscope and put it through several standard tests to determine the stone's suitability for the intended use.

So just how does a limestone that was being buried on the sea floor end up being quarried several tens, or even hundreds, of metres above sea level? Such uplifting movements of the Earth's crust are possible as the jigsaw pieces that form the rind of the Earth move independently and collide with each other. The collision of Africa with Europe over the past 50 million years has resulted in some highly sought after limestones that take a good polish. As the crust was buckled and folded to form the Alpine Mountain chain, some of the limestones became buried and heated causing the growth of large calcite crystals. They retained some of their origi-



Portoro - Striking gold veins in Portoro due to the presence of iron

nal features from when they were a sediment, unlike the true marbles which are the result of recrystallisation of limestone under higher temperatures.

During burial, limestones can obtain other characteristic features. The wispy, zig-zag lines seen in limestones such as Jaune Jaspe and Trani are the concentration of muddy particles from within the limestone, and are called stylolites. Cracks in the rock are often filled with white calcite. However the presence of impurities can colour these veins red, green and even gold as in the stunning black Italian stone, Portoro.

Limestones used today for

construction or decoration exhibit features that, to the trained eye, tell a long story of their formation. The type of fossils, how intact they are, and their arrangement within the stone reflect, to some degree, where in the ocean the limestone sediment was formed. The extent of cementation, the crystal size of the cement and the presence of veins indicates processes that have occurred since the limestone was buried and then uplifted to its present position. So next time you come across a limestone put your face right up to it and look at the finer details. See if you can determine the events that gave it the qualities suitable for the purpose intended.

The images are courtesy of The Natural History Museum, home to the national Building and Decorative stone Collection of some 10,000 samples, which record the changing trends and diverse use of dimension stone since 1834. In addition to highlighting the increasing use of overseas material in UK architecture, the collection's strength and importance lie in the wide variety of British and European rocks, the sources of which are no longer available.

The Collection can be viewed by appointment and is supported by a wide range of curatorial and analytical services - from comparative identification to the rapid quantification of mineral constituents.

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