A geologist's guide to building stone

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Stone used in buildings varies considerably from place to place throughout England, to an extent that makes it an impossible task to write a short article which will explain every aspect in sufficient detail from the perspective of a geologist. For this reason, what follows is an attempt to review the basic features and introduce some of the language used in describing stone by architects and art historians, and to a lesser extent, by the trade. Geological terminology may come a poor fourth.

Recently, the production of geological guides to the built environment has been in vogue, and these have greatly increased the engagement of the public at large with natural stone, and its geological aspects. It is the intention of this article that you shall test what is said wherever you happen to live, looking at buildings in your town centre, making your own assessment of what stone has been used in the past, and what stone is being used today. It can be useful to judge how well stone has stood up to weathering and local conditions; contrasts between regions can be quite strong. As with other practical studies, theory and book-knowledge are important, but there's nothing quite like practical experience. In this, with only a little experience, it should be possible for you to write your own stonework guide to your home town.

THE MATERIAL SUBSTANCE

In extremis, almost any stone can be used in building solid, lasting structures in place of lean-tos or shelters. In stone-poor country, anything from rounded beach boulders to erratics taken from boulder clays, can become the basis of walls, di cult as it may be to bond them together into a self-standing structure. Otherwise, sandstone so enough to cut and dress may be chosen even with doubt as to its lasting quality. In stone-poor country, man makes the best of a bad job unless he is prepared to travel afar and equally, to pay for the transport of bulky stone from the best sources. e best building stones in all parts of the world have come to be recognised by experience and by reputation to the extent that they have been sought and commissioned in spite of cost. Into this category fall the white marbles of the Greek islands and the cream coloured limestone from Caen in Normandy. In the last century, with the e ciency of rail and sea transport at low costs, there were few restrictions on the use of stone of quality from all parts of the world.

A STONEWORK VOCABULARY

In reading about stone, you will quickly nd that there are at least two distinct languages employed. ere is the geological patois which will probably be familiar to you already, but in parallel with it will be the language of the Trade which tends to have its own terms. ese include words such as ashlar, freestone, ragstone, agstone, as well as the comprehensive term, dimension stone. is last term refers to any stone (igneous, sedimentary, or, to a lesser extent, metamorphic), which can be cut from the quarry bed to precise and regular dimensions. Within this term in fact we have de ned a quality of good building stone which will determine its cost and rating in any roll. is applies especially in modern building practice, when good stone is sliced into thin cladding slabs to be attached as a skin to a steel framed building. Regular blocks of good dimension stone allow the most economical slicing from the original block with least waste in the process.

Well-jointed massive sandstones, or regularly bedded limestones qualify immediately as good dimension stones, as would the inner core of granite intrusions, criss-crossed by cooling joints along which the stone can be worked from the quarry face. In contrast, cross-bedded channel-form sandstones, or lenticular limestones all fail the dimension stone test through their irregularity of mass, which prevents the calculated supply of regular sized blocks. Also excluded would be stone with a particularly strongly bedded texture, derived either from at platy minerals such as micas, or shell content concentrated into thin beds, either of which would determine an ease of splitting which could be troublesome. Good as a flagstone, and valued for just that splitting quality, they would not reach the standard required of good dimension stone.

Within dimension stone, there are categories which are often referred to as freestone. These are stones which literally can be freely dressed in any direction, including their shaping into fully three-dimensional sculptural work if need be. Many dimension stones could qualify, but best of all must be the even-grained massive sandstones lacking strong lamination or bedding, their rounded or semi-rounded grains interlocking neatly, and their pore space filled with cementing lime of silica to give a firm bonding to the stone overall. Equally effective may be oolitic limestones (Bath Stone and Portland Stone both come to mind) simply because they share the same homogeneity of composition and texture which allows them to break in directions determined by hammer and chisel blows with a clean fracture.

Just this property in the grainy Carboniferous Limestone from Wirksworth in Derbyshire (Hopton Wood Stone) made this the chosen material of the sculptors Henry Moore and Barbara Hepworth for their larger works, often with continuous smooth surfaces which would, have been difficult to achieve in other stones with a stronger grain. Some of the best freestones are medium-to-fine grained sandstones well distributed throughout the country. To allow you to identify with all this, here are some regional examples: Grinshill Stone (Shropshire), Runcorn Stone (Cheshire), Woolton and Rainhill Stone (Lancashire), Mansfield Stone (Nottinghamshire) Stancliffe and Stanton Stone (Derbyshire), Park Spring (Yorkshire) St Bee's and Penrith Sandstone (Cumbria), Dunhouse and Springwell (Durham), Blaxter, Prudhamstone (Northumberland). All of these are sandstones and range in age from Carboniferous to Triassic (New Red Sandstone). All occur from the North Midlands northwards into Scotland.

Limestone freestones include Portland Stone (Dorset), Beer Stone (Devon), Doulting Stone (Somerset, although rather coarse in grain), Bath Stone (Gloucestershire/Somerset), Taynton Stone (Oxfordshire), Ketton Stone (Rutland), Ancaster Stone (Lincolnshire). To redress any North-South imbalance, all of these prime limestone freestones are from south of the Trent, and are of Jurassic age except for Beer Stone, which is a harder form of chalk. Freestones of any age or character allow what is termed an ashlar finish, which simply means that they have the quality to allow the production of a smooth even surface by tooling and rubbing down. Well-laid ashlar, accurately finished, produces the narrowest of joints between blocks in masonry, and the sheerest of unbroken walling.

In marked contrast to ashlar, some excellent building stones possess a coarser, rougher texture that can be exploited in quite a different finish to cut blocks. The terms covering this range include rock-faced, rusticated and bolstered, such facings taking into account the rougher texture of the stones. All these treatments are designed to give a rugged, solid appearance to masonry and are often seen to best effect in the older banks in town centres seeking to give an air of solid security to potential customers. Amongst the stones that lend themselves to such treatments are the granites, but also the shelly limestones which are often termed ragstone on account of their rough textures derived from the wealth of shell debris which they contain. Good examples would be Kentish Ragstone (a Cretaceous greensand), or Barnack Rag (Jurassic Lincolnshire Limestone).

Flagstone has been mentioned already, and is a term that hardly needs definition, except to say that its flat, slabstone character, the very thing that makes it most suitable for paving, is not confined to sandstones (a geological definition), but can equally apply to slates, limestones, and some igneous rocks (ashes and tuffs). Again, we are dealing with a 'usage' term and one which is descriptive and as such, quite independent of composition.

As much is true of marble, which to the Trade and to architectural historians, often simply means a stone which can take and retain a polish. As such, it can apply to limestones or igneous rocks without there needing to have been alteration by heat or pressure – the basis of the metamorphism required to fulfill the geological definition of marble. One other detail that is important for marbles must be the pattern of veining or streaks of contrasting colour, which give a distinctive 'figure' to the rock. Usually such patterns stem from the mineral impurities that occur in most limestones (often clay minerals), these separating out in the course of recrystallisation of the original limestone.

Marbles are often the decorative touches added to buildings, most often in the entrance foyer or facing the lift shafts of the interiors where they are protected from aggressive weathering. As a rule, in a British-type climate, marbles are not for external use as they were in history in the Mediterranean countries.

True marbles one is likely to meet in English buildings include the grass-green Iona, or the very similar Connemara Marbles of similar Dalradian age (i.e. of late Precambrian or early Palaeozoic age). Other named marbles are almost entirely unaltered or only slightly altered limestones such as the Devonian-age Torquay and Plymouth Marbles of South West England, famous for their richness in fossil corals, and their rich deep colours. Derbyshire and Pennine Marbles are invariably unaltered Carboniferous Limestones in which the 'figure' is contributed by crinoid ossicles (Dene Stone or Derbyshire Fossil is the distinctive polished stone which faces the foyers and the stair cases of the Royal Festival Hall on the South Bank, adding a touch of geology to what might otherwise be a purely artistic outing). Other so-called marbles, often referred to for their colour as 'red' or 'black' marble, may turn out to be igneous rocks including basalt, dolerite, gabbro or serpentinite.

A BASIS FOR THE STUDY OF BUILDING STONES

One very sound approach, is one which looks at use through time. In any community, the church, the almshouses, the town hall, being the oldest local structures may reflect the good stone most readily available in the district in medieval times when transport costs would rule out most distant sources of stone. In this way, unique and some-what unlikely stones such as Hertfordshire Puddingstone figure prominently in the churches of South Hertfordshire, with sharp limits to its extent corresponding closely to its occurrence sub-surface. The slaty ashes of the Lake District, or the slabby greywackes and slates of Central Wales, can be equally 'local' when we look at what would be called vernacular architecture in the countryside.

Possible sources grew with the expansion of the canals in the eighteenth century (Midlands' rocks south to London via the Grand Union Canal), while the railway network of the nineteenth century had the effect of making Scottish and Cornish Granites liable to turn up in towns only at the opposite end of the country at a modest expense. For our present times, the world is literally open to the trade and architects are able to select from a wide range of colours and textures drawn from either Brazil, South Africa, or India whereas Scandinavia or Italy were ' exotic' but sixty years ago. Such histories may be traceable where you live.

In quite a different way, building stones can be regarded as an open-air museum of geological structures and textures. Often discussed at length in textbooks they are less easy to see in natural geological outcrop. In the weathered or polished surfaces of building stones, it is often possible to observe features such as sedimentary structures (graded-bedding, cross-bedding, slump structures, erosional surfaces, intraformational conglomerates and desiccation structures). In carbonate rocks, the contribution of organisms to the build-up of the limestone can be assessed through the recognition of shell banks, incipient reef associations, and the inter-relationship of different grades of lime muds. Tracks and trails left by sediment-eating organisms (trace fossils) are often best seen in the polished slabs of limestones (the 'marbles' of many foyers) where several metres of surface are available for study.

In the igneous rocks, we are looking for crystal growths, twinning in crystals, and relationships between early-formed minerals and what became the groundmass in the final cooling. For igneous rocks in particular, it is important to look at surfaces in different lights and from oblique directions. In this way, it is possible to see ghostly outlines in recrystallised and altered minerals, which would not be seen at first in direct scrutiny. It is surprising how effective a damp cloth can be in heightening the clarity of textures, and if it isn't actually raining, it can be useful to carry a garden hand spray to wet dusty and dry surfaces. Equally useful equipment would be a reading glass-type magnifier, the larger surface area being more useful than the normal compact hand lens which geologists usually carry.

PROBLEMS WITH NATURAL STONE

Architects and their clients may seek to express the company image through their buildings, producing a tendency to go for striking designs as well as colour and textural contrasts in stone, which may not turn out to be sound choices in terms of lasting qualities. This brings us to a consideration of long recognised and relatively new problems as stone weathers in buildings.

Good building practice always insists that bedding or any strong banding within a stone should be handled so that such 'grain' will always be set horizontally within the building. Up-ended blocks, or odd blocks out of such consistent alignment, are always liable to suffer excessive weathering damage; wind or particularly rain selectively opening up planes of weakness. This failing is termed face bedding. Of equally harmful consequences can be the setting of stones of different qualities and character side-by-side. Interaction at its simplest could produce decay at contact surfaces between porous, absorptive stone (such as most sandstones) and dense, compact limestone with low absorption of moisture. The contrasts can promote the leaching of cementing mineral matter from the porous rock, as well as frosting of the saturated stone of the pair. Hard Portland Stone string-courses in buildings of softer limestone or sandstone often produce interaction effects, as do isolated blocks brought in to repair damage.

Equally damaging can be infill repairs using mortars or stone pastes which inevitably have different porosities and mineral character from the stone which they purport to repair. There is seldom a good colour match, and often materials which commence harmonious, grow less so with age. In all of this, it would seem better policy to patch and repair from stockpiles of mature stone perhaps recovered from demolished buildings built from the same stone, rather than fresh new-quarried blocks.

Weathering in stone can vary considerably from place to place in the country, and from point to point in any one building, being a complex response to aspect and microclimate of the site, and the quality of the atmosphere. Many stones with an excellent reputation in the countryside surrounding the quarry, failed dramatically in the polluted air of city centres when coal smoke produced an early form of acid rain. At its simplest, the attack weakens the cementing matter, allows deeper penetration of subsequent rain-washing, and results in a rain of loosened grains from the surface of the blocks. At ground level, capillary action may draw up into the stone, mineral salts from the soil, which may in turn promote further breakdown of the stone through its cement.

Most visible of all the weathering effects, however, are the sooty crusts which may form upon projecting surfaces and overhangs not directly washed by the rains Apart from Direct deposits of carbon, crusts of gypsum may form from a chemical reaction between oxidised pyrite and the calcium carbonate of limestones. Such crusts of gypsum can actually become protective against further erosion and penetrative weathering, unless the crusts blister and break to expose unweathered limestone at the broken surface. This brings us to the question of stone cleaning.

TO CLEAN OR NOT TO CLEAN?

In recent years, there has often seemed to have been an unnecessary association of darkness of tone in stone with pollution and potential damaging decay. This has promoted extensive schemes of stone cleaning which have made this a growth industry. Once one building has been 'cleaned', those adjacent become candidates for similar treatment of necessity, whether they need be or not. Old established stone firms possess the basic knowledge and skills to clean in appropriate ways which differ according to the stone and the age of the building, but such has been the pressure of work that many new companies have sprung up to meet the need, often without the fullest understanding of the problem or the varied techniques. Some results have been more damaging than any thought to have existed in the first instance, although it has to be said that agreed standards set up by the Trade have now brought some sense into procedures.

Quite simply, darkening in colour is often a natural weathering response in stone cut from the quarry bed and maturing in the exposure given it in buildings. For example, sandstones usually come from the quarry a pale corn-colour, only for the air to oxidise the iron cementing minerals to produce the darker tones. Coal Measure sandstones, amongst the best freestones available, become velvety black with time without that signifying decay or potential weakness. In spite of this, beautiful black buildings such as St George's Hall Liverpool, and the very heart of Victorian Newcastle have been sand-blasted into an anaemic yellow on the pretext that such treatment was ' necessary protection'.

Sand-blasting, bombarding a surface with dry sand under pressure, must be one of the sternest cleaning techniques, only just acceptable for sandstones deeply engrimed, defying milder treatments. It should never be employed for any limestones or softer cemented sandstones, simply because this could destroy the protective 'skin' which cut stone acquires when allowed to mature between extraction and placement in a building. For the softer stones, spraying with a haze of water, followed by bristle brushing are the kindest cleaning operations, with precautions taken that water does not penetrate weakness of the fabric to any serious extent: It is worthwhile remembering that like you or I, buildings 'age' and in that process, change their appearance. It is difficult if not impossible to arrest the effects of time, or turn back the clock. If we look at as well-known a building as St Martin in the Fields church in Trafalgar Square, when new, it was as white as Portland.