ROCKS.*

Geologists and architects have at least one interest in common, they both deal in what a geologist calls "rocks" and an architect "stone." The rocks of the geologist include, however, the sand of a seashore, the soil of a field and the ice of a glacier, whereas no architect would think of building in any of these materials unless perhaps an ice palace at Quebec this or some other winter. The geologist when dealing with rocks is apt to dub himself a petrographer or a lithologist, but the architect is more modest and gives himself no special name because he builds in stone.

The petrographer divides rocks into three grand divisions,—massive or igneous rocks, resulting from the cooling of melted material; schistose rocks having their minerals arranged in a parallel way so as to split most readily in one direction; and sedimentary or clastic rocks made of fragments of other rocks deposited by water. The massive rocks show the greatest variety of minerals, and are always taken up first. Their mineral constituents are of two kinds—essential, when their absence would throw the rock into another species, and accessory when less important.

The mineral playing the largest part in the formation of rocks is quartz, rock crystal when it displays its own form, a six sided prism ending in a pyramid. It is the hardest of the essential rock-forming minerals, is almost unattacked by the weather, and therefore is the most useful constituent of many stones suitable for building. Next in importance come the felspars, orthoclase with its flesh red or white cleavage surfaces, and plagioclase showing delicate striations, on cleavage planes. The former is a silicate of alumina and potash, and the latter of alumina and soda or lime. Some of the plagioclase felspars have a magnificent play of color, as in labradorite. Of the darker rock minerals, mica, hornblende and augite are most important.

There are several kinds of mica, but we need mention only muscovite, a silicate of potash having pale colors, and biotite, a magnesian silicate very dark in color. All micas may be recognized by their very perfect cleavage into exceedingly thin elastic plates. Hornblende is a dark colored silicate having two planes of cleavage with an angle of 124 degrees between them. The scales cleft off are not elastic. Augite or pyroxene, another dark, almost black, silicate, has usually no distinct cleavage, and may be distinguished thus from hornblende. Of the accessory minerals, few are of much interest to us, though garnet, often of a fine red color, occurs in many rocks around Toronto, and tourmaline in black triangular prisms may sometimes be seen. The most important of the accessory minerals to the architect, is iron pyrites, a hard, brassy looking sulphide of iron crystallizing in cubes, which under the action of the weather may change to a sulphate and finally stain the rock where it occurs rusty brown with oxide of iron.

Turning now to the rocks themselves, granite is naturally taken up first by both petrographers and architects, as the most widespread and useful of the group. It consists essentially of quartz, felspar and mica or hornblende, and takes on grey or flesh red colors from the prevalent orthoclase felspar. It is one of the handsomest and most durable of building stones and but for its great hardness would no doubt come into much wider use. Its one defect is the ease with which it crumbles under the action of intense heat, as shown at the Boston fire. If quartz be omitted from granite the rock is called syenite, which has the same colours and uses as the previous rock, though a little softer to work. When the felspar is striated and mixed with hornblende, forming a dark green or black rock, it is named diorite; if augite is the dark mineral the rock is diabase or gabbro. All these rocks fall into the same line in the hands of the builder, who sometimes calls them black granite.

Porphyries are rocks, unlike those that have been described, in that the general mass is fine grained or compact in structure enclosing larger grains or crystals of quartz or the felspars. Some of the porphyries are very handsome stones for ornamental work, but are little used in building.

The more important ancient massive rocks have now been described; and it will scarcely be necessary to take up in detail the corresponding series of modern eruptive rocks, including the lavas, such as trachyte and basalt; since this whole group is absent from eastern Canada.

The schistose rocks, too, need only a brief mention, since only one of them, gneiss, practically granite, having a parallel arrangement of its mica plates, is used to any extent for building. In Norway one sometimes sees a whole house built of gneiss, roof as well as walls. Far more important are the fragmental or sedimentary rocks, which provide the most commonly used building stones. We may divide them into three groups, those made of clay in some form, those made up of silica or the silicates (quartz, felspar, etc), and those which consist of carbonate of lime or of this with carbonate of magnesia.

The clayey or argillaceous rocks are usually too feeble and easily acted on by the weather to be of use in building. The slates, however, which are clays consolidated and metamorphosed, are an exception, since innumerable minute crystals of mica and other minerals have begun to form in them binding the materials together and giving a resistance to the weather surpassed by no other rock. The perfect cleavage which gives slate its value as a roofing material does not correspond to the stratification, as one would expect, but has been caused probably by strong lateral pressure in mountain building. The different tones of color in slates are taken advantage of by architects to give variety in roof effects.

Perhaps the most useful group of rocks in architecture is that of the sandstones. Breccias, made up of large angular fragments are too rare to find much place as a building material; and conglomerates, formed of rounded pebbles cemented together, are also rarely put to use, though some notable buildings, such as the Pitti Palace, are built of them. Our brilliant jasper conglomerate from Lake Huron with its red pebbles in a white ground might give striking effects, though it would be very hard to work. It would probably last for eternity, however, if put into a building. Sandstones, on the other hand, are among the most favored building materials. They consist chiefly of grains of quartz, often with a large admixture of fragments of felspar or other silicates, and result from the destruction of the older massive rocks. The cement binding the particles together has a great effect on the durability of the stone and should receive more attention than it does from architects. A siliceous cement forms a rock difficult to work but that will practically last forever. A ferruginous cement consisting of oxides or carbonate of iron is a durable one and occurs in many reddish or brownish sandstones. The cement is said to be calcareous when carbonate of lime is deposited between the sand grains. Such sandstones effervesce with cold, dilute acid, and the lime is more or less easily attacked by rain charged with carbonic acid from the air of cities, allowing the stone to crumble. The least efficient cement of all is argillaceous or clayey, and sandstones containing it readily disintegrate when exposed to the weather in a climate like ours. The clayey odor when breathed upon affords a rough test for the argillaceous cement. It is an unhappy fact that the durability of a sandstone is often in inverse ratio to the ease with which it is worked, so that the builder is tempted to use the poorer qualities.

Last come the carbonates, consisting of calcium carbonate in limestone, and of calcium and magnesium carbonates in dolomite. The two may be distinguished by the action of cold acid, which effervesces strongly with the carbonate of lime, but hardly at all with dolomite. The limestones are generally formed of broken shells, though in many compact varieties, such as lithographic stone, the fossils have completely disappeared. Porous modern limestones, formed by springs are called travertine. The most ancient limestones have been so metamorphosed as to become thoroughly crystalline, and when very fine grained and pure white are statuary marbles. Many of the colored varieties of so called marble are really, however, uncrystalline limestones. The limestones are often admirable building stones, durable and handsome, but are apt to be attacked by the atmosphere of great cities charged with acid fumes. The dolomites resist this action somewhat better. A very handsome variety of chemically deposited carbonate of lime, sometimes used for interior decoration, is called Mexican onyx in the trade, though incorrectly, since the true onyx is a variety of silica.

The coloring matter of rocks is usually some compound of iron. Reds are caused by the sesquioxide, hematite; browns and yellows by the hydrous or brown oxide. Red and brown sandstones are good examples of this, the paler they are the less oxide of iron they contain, while pure white ones are practically free from this metal. The flesh color of orthoclase felspar in the granites arises also from the red oxide of iron. On the other hand silicates and other compounds of iron in the monoxide state show various shades of green or gray, or almost black, as in the diorites and other greenstones, in green slates, and greenish grey sandstones. These green monoxide compounds of iron tend to weather into the ruddier sesquioxides. One often notices that pale greenish sandstones turn yellowish or brownish on exposure, a result of slow oxidation of ferrous oxide. The darker limestones are usually colored with bituminous or coaly matter, which on exposure gradually oxides; so that a blue limestone, like that of Kingston, eventually bleaches to a pale grey, almost white; Kingston by moonlight seems built of marble.

The weathering quality of rocks is a matter of great interest to architects, for on this turns the permanence of their work. Certain rocks, such as quartz'des and sandstones with a siliceous cement are practically indestructible by the weather, as one can see on surfaces scoured by glaciers during the ice age 7000 years ago, but still showing the polish and scratches then given them. Rocks formed of silicates, like granite and syenite, are also very resistant; others like the limestones and marbles are slowly dissolved by rain and are more rapidly acted on by the impure air of large cities, which contains traces of sulphuric acid. The dolomite of the English parliament buildings is said to be suffering badly from this cause. Sandstones with clayey cements are readily disintegrated in moist and changeable climates; and stone containing much iron pyrites should be looked on with suspicion, since it is very apt to weather into brown oxide of iron, weakening the stone and giving rusty stains, as in the parliament buildings at Ottawa. The porosity of a stone is a matter of prime importance in a climate like ours where water soaked walls may be quickly crumbled under the action of frost.

In rocks composed of several different minerals, like granite, great changes of temperature tend toward disintegration through unequal expansion. Quartz has a cubic expansion of ·000036 for one degree centrigrade, orthoclase only 17 parts in a million. In case of a great fire where the temperature may be raised suddenly 1000 degrees or more, this unequal expansion sets up strains which splits off the surface, as in the great fires of Boston and Portland, where massive granite buildings crumbled to ruins. One would expect limestones to burn to quicklime and thus fall to pieces, but actually they resist far more heat than granite, while sandstones resist fire best of all.

The last point to be referred to is the best means of testing a rock intended for building purposes. The test of time is of course the most convincing of all, but then one cannot always wait a thousand years to see how durable a building stone is. The resistance of a cube of stone to crushing strain gives useful evidence as to its strength, and the amount of water it absorbs helps to a decision as to its durability in frosty climates; but the most valuable test of a scientific kind is a petrographical examination. The lithologist unlike other men can look through stone walls. By the microscopic study of thin rock sections one can determine the actual minerals that make up a rock, their relationship to one another, their state of freshness or decay and the character of the cement that binds the particles together. No other method will give such complete evidence as to the internal structure of a rock, on which its durability depends, as a careful examination of sections under the microscope.

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