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Building Stones

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BUILDING STONES

By FRANK L. CULIN, JR.

Introduction:—The term “building stone” includes all stones for ordinary masonry construction, as well as for ornamentation, roofing, and flagging. A very wide variety of stones is used for this purpose, including practically all varieties of igneous, sedimentary and metamorphic rocks. There are a few, however, which are more commonly used than others, because of their widespread occurrence and durability. The color of a building stone quite often gives it a popularity which determines, to a large degree, the extent of its use. New England brownstone is probably the best example of this.

The growth of the brick industry and also of the cement industry has opened a severe competition with building stones. Brick and concrete blocks being cheaper, are widely used in many sections of the country. Solid concrete, in many cases, has replaced stone for not only super-structures but sub-structures as well. However, there is still a very great demand for high class building stones and probably always will be.

Types of Building Stones:—The stones most desired for structural purposes are:

1. Granites.
2. Limestones and marbles.
3. Sandstones.
4. Slates.
5. Serpentines.

Description:—The term “granite,” as used by quarrymen and contractors, usually includes all igneous rocks, gneisses and often schists. A true granite is an entirely crystalline, deep seated, igneous rock, consisting of quartz, orthoclase feldspar and either mica, hornblende or augite, or all of the last three minerals. Other varieties of feldspar may be present in varying amounts, as well as various accessory minerals, such as pyrite, garnet, tourmaline, epidote and many others.

Texture:—Granites vary in texture from fine to coarse grained, and in some cases are porphyritic. They pass into gneisses by such insensible gradations that it is difficult, if possible at all, to draw a sharp line of distinction between the two.
Color:—Variable, most commonly gray, mottled gray, red, pink, white or green, according to the color and abundance of the component minerals. The color is usually, though not always, permanent.

Weight and Hardness:—The average specific gravity of granites is 2.65, or about 165.5 pounds per cubic foot. Usually quite hard.

Porosity:—Commonly contain less than 1% of water, but will absorb from 2 to 3% more.

Crushing Strength:—Variable: lies between 15,000 and 30,000 pounds per square inch.

Occurrence:—Granite usually occurs in batholithic masses, sometimes forming the cones of mountain chains. Is exposed by erosion. Shows a very wide geologic range, but is usually associated with older formations.

Determining Characteristics:—Granites may be recognized by their holo-crystalline structure, and by their composition—quartz and feldspar in, usually, almost equal amounts, with smaller amounts of mica, hornblende or augite, and accessory minerals.

LIMESTONES AND MARBLES.

The term “limestone and marble” includes a great series of sedimentary and metamorphic rocks, composed chiefly of carbonate of lime with various impurities. Dolomite contains lime and magnesia. Sedimentary limestones may contain varying amounts of iron oxide or carbonate, silica, clay, and carbonaceous matter. When of metamorphic origin, various silicates, such as mica, hornblende, pyroxene, etc., may be present.

Texture:—These rocks vary in texture from fine grained, earthy, to coarse grained, fossiliferous rocks, and from fine to coarsely crystalline varieties.

Color:—There is also a great range in color, the most common being blue, gray, white and black, also yellow, red, pink and green. The color is largely due to impurities, usually iron oxides.

Weight and Hardness:—An average specific gravity for limestone is probably 2.5—or about 150 to 160 pounds per cubic foot. Limestones are quite soft, being readily scratched by a knife.

Crystalline varieties are much harder.

Porosity:—Absorption of water is generally very low.

Crushing Strength:—Varies from 10,000 to 15,000 pounds per square inch.

Varieties and Occurrence:—Geologically speaking, limestones are of sedimentary origin, while marbles and dolomites are metamorphic. In the trade, however, a marble is any calcareous rock that will take
a polish. Besides marbles and straight limestones, the following varieties are recognized:

1. **Chalk**—A fine white earthy limestone composed of fossil remains.
2. **Coquina**—Loosely cemented shell aggregate.
3. Dolomite or dolomitic limestone—composed of carbonate of lime and magnesia.
4. Fossiliferous limestones—those lime rocks which contain an abundance of fossils.
5. Hydraulic limestone—limestone with over 10% of clayey impurities.
6. Lithographic limestone—an exceedingly fine grained, crystalline limestone. Not used for structural work.
7. Oolitic limestone—composed of small rounded concretionary grains.
8. Stalactitic or stalagmitic deposits—found in the roofs and floors of caves respectively. Often of crystalline texture and beautifully colored. When of sufficient size and solidity known as onyx marble.
9. Travertine or calcareous tufa—limestone deposited from springs—often sufficiently hard and durable for building, but rarely occurs in deposits of large size.

Structural limestones usually occur in beds or lenses; sometimes, in the case of onyx marbles, as cave deposits; rarely, as spring deposits. They are very widespread, and are found in practically all the geological ages.

**Tests:** The best field test for limestone is its effervescence with hydrochloric acid, combined with the softness. The various varieties are recognized best by their color and structure.

**Sandstones.**

Most sandstones are composed of quartz grains, but some varieties contain an abundance of other minerals, such as mica, or, more rarely, feldspar. Pyrite is sometimes present, and clay often occurs in sufficient quantity to influence the hardness and dressing quality of the stone. The cement holding together the grains is siliceous or ferruginous in good building stone, but may be calcareous or carbonaceous, or a compound of various substances. Thus the chemical composition has a wide range, from nearly pure silica to sandstone with a large percentage of other compounds.

**Texture:** Sandstones vary from very fine to coarse grained. They may be very hard, or quite soft and crumbly, depending upon the character of the cementing material.
Color:—The most common colors for sandstones are light gray, white, brown, bluish gray, red and yellow.

Weight and Hardness:—The average specific gravity of sandstones is about 2.7, so that a cubic foot weighs about 160 to 170 pounds. In hardness they vary from quite hard in highly siliceous varieties to softer in other kinds.

Porosity:—Highly siliceous sandstones are usually nearly imper-vious, but the absorption of other varieties is variable.

Crushing Strength:—Very uncertain—the variation has an extremely wide range due to variable composition.

Occurrence:—Sandstones occur as beds and lenses.

Tests:—Sandstone is easily recognized by its structure. Siliceous sandstone is recognized by its hardness; ferruginous sandstone, by its color; calcareous sandstone by its effervescence with acid, and its relative softness.

SLATES.

Slates are metamorphic rocks derived from clay or shale and rarely, from igneous rocks. The composition is quite variable, due to metamorphism—silicates of iron, aluminum and magnesium are probably most common. Carbonaceous matter is often present.

Texture:—Slates are usually very fine grained. They posses a well defined plane of splitting, or cleavage, developed by pressure and the development of micaceous minerals.

Color:—The presence of carbonaceous matter colors most slates black or bluish black, but green, purple, and red slates are also found.

Weight and Hardness:—The specific gravity of slate is about 2.7, and a cubic foot weighs between 170 and 175 pounds. Slates are not very hard—they can be scratched by a knife.

Porosity:—The porosity of most slates is very low.

Crushing Strength:—The crushing strength of slates is usually given at from 3,000 to 10,000 pounds per square inch. It is rather uncertain.

Occurrence:—Slates occur as beds and lenses.

Tests:—Slates are readily recognized by the pronounced cleavage, and also by the color.

SERPENTINES.

Pure serpentine is a hydrous silicate of magnesia; but beds of serpentine are rarely pure, usually containing varying quantities of such impurities as iron oxides, pyrite, hornblende, and carbonates of lime and magnesia.
Texture:—Crystalline in structure, but usually massive, sometimes foliated, also fibrous. At times slaty.

Color:—When pure, green or greenish yellow; impure varieties various shades of black, red and brown. Also spotted in various combinations, green and white being most common. Changes color on exposure.

Weight and Hardness:—Weight is variable, from 2.2 to 2.65 specific gravity; or from about 137 to 165 pounds per cubic foot. Usually quite soft (2.5 to 4) but in some crustals up to 5.5 (rare).

Porosity:—Usually very low.

Crushing Strength:—Very low, as a general rule.

Occurrence:—Serpentine is always a secondary mineral, resulting from the alteration of silicates containing magnesia. It occurs as large rock masses, and as irregular veins or lenses.


USES OF BUILDING STONES.

Building stones are used for structural work of various kinds—the stone to be used depending largely, in most cases, on its nearness to the market.

Because of its massiveness and durability, granite is much employed for massive masonry construction. Some varieties that take and preserve a high polish are much more used for ornamental and monumental purposes. Due to its greater durability, granite is largely replacing marble for monumental work. The refuse of granite quarries is often made into paving blocks or crushed for roads and railroad ballast.

Limestones are used mainly for ordinary dimension blocks, although in some cases it is suitable for carving. The quarry refuse is often used for road material, lime, or for Portland cement. The use of marble for structural work has been increasing. It is much used for monumental work, and also for interior decorations, as wainscoting, paneling, sometimes flooring, and table tops.

Due to their wide distribution, sandstones are an important source of local structural material. They are chiefly used for ordinary building work, and but little for masonry or monuments. The thin bedded varieties are much used for flagging, and some of the harder sandstones are made up into paving blocks. Sandstones are also used as abrasives, but that is apart from our purpose.

Slate is most widely known as roofing material, but it is also used for mantles, billiard table tops, floor tiles, steps, flagging, slate boards
and pencils, acid towers, washtubs, etc. There is much waste in quarrying slate. This refuse is sometimes used for paints, and in the manufacture of brick and Portland cement.

Serpentines are largely used for interior decorations, due to their uneven weathering, when exposed.

METHODS OF MINING AND PREPARATION.

Practically all building stones are obtained by quarrying. The rocks may be cut out of the deposits by saws or channeling machines, or it may be blasted out, depending on bedding planes and later dressing to obtain blocks of proper size.

In preparing building stones for market, they are usually cut to some special size or shape, as cubical or oblong blocks, panels, tiles, flagging, and other shapes. The stones are shaped by means of saws, or by chipping.

THE BUILDING STONE INDUSTRY.

The production of granite, marble, limestone, and sandstone for building purposes in 1913 amounted to about $18,000,000, a decrease in value of about $200,000 over 1912. No figures later than 1913 are available, and no figures for slate can be found.

GRANITE.

About 32% of the value of the total granite output is used for building stone, amounting to $6,661,415 in 1913, as compared with $6,125,841 in 1912. The production of granite for building stone is therefore about 40% of the entire building stone output.

Vermont produces most of the granite used for building stone, followed by Massachusetts, Maine and New Hampshire. The production of these states is mostly dressed stone. Pennsylvania produces most of the rough granite.

The value of the dressed granite production was $5,369,179, and of the rough stone was $1,292,236.

MARBLE.

The values for marble production include also the value of serpentine and onyx marble. The total value of the marble production for 1913 was $7,870,890, of which 63.3% was used for building purposes, representing a value of $4,892,462. The value of marble used for exterior building work was $1,822,214, as compared with $2,771,645 in 1912. The 1913 production was divided
as follows: $993,214 for rough and $829,244 for dressed building stone. The total value of marble used for interior decoration work in 1913 was $3,160,005, a gain of $1,215,844 over 1912, when the value amounted to $1,944,161.

The commercial output of marble came from Vermont (44.64%), Tennessee (18%) and Georgia (14%). Other states producing were Colorado, Alabama, Massachusetts, New York, Pennsylvania, Alaska, California, Maryland, North Carolina, Utah, Arkansas, New Mexico, Washington, Virginia and Oregon.

LIMESTONE.

The total production of limestone in 1913 had a value of $38,745,429, as compared with $36,729,800 in 1912. About 11% of this value is represented by building stone, or $4,509,339 in 1913, as compared with $5,051,896 in 1912, a decrease of $542,557. The production of rough building stone had a value of $1,943,064, and of the dressed stone, $2,566,275.

Indiana and Missouri are the largest producers of building limestone, Indiana yielding 68.9% of the product of the United States. This is the famous Bedford oolitic limestone.

SANDSTONE.

The value of sandstone in 1913 was $7,033,067, as compared with $6,893,511 in 1912. Although this is an increase, the production of sandstone has fallen off quite considerably in the past 12 years. The value of the sandstone production of 1904 was $10,273,891. Thus the 1913 production shows a decrease of over 30% for the 10 years.

The largest product of the sandstone industry is building stone. The value of this product in 1913 was $1,860,924, as compared with $2,263,289 in 1912. Ohio, Pennsylvania and New York produced most of this stone.

ARIZONA DEPOSITS.

The stone resources of Arizona are undoubtedly quite extensive, but as yet are little developed. The major part of the stone product of Arizona up to the present time, has been used locally. The stones quarried in Arizona are granite, basalt, tuffs, and other igneous rocks, slate, marble, onyx, limestone and sandstone.

GRANITE.

Granite and related rocks occur in many areas in Arizona. In the Bradshaw mountains, at and near Prescott, in the Mule moun-
tains, near Bisbee, near Globe, and near Clifton. There is a broad band of grayish coarse grained porphyritic granite found in the Santa Rita mountains at Helvetia, in the Huachuca mountains, in the Santa Catalina mountains, near Oracle, and northward to the Superstition mountains. Granodiorite is found near Tombstone and in the Dragoon mountains. Quartz diorite is found in great masses in the Bradshaw mountains.

The granite output of Arizona is not large at present, and is confined chiefly to supplying local demands for monumental work, and for an occasional building.

DARK VOLCANIC ROCKS.

There are many large areas of basaltic lava flows in Arizona. These rocks are locally termed “malpais.” This type of rock is used to some extent in Arizona for building purposes, usually on residences.

LIGHT VOLCANIC ROCKS.

These rocks are largely rhyolite tuffs, and occur quite extensively in Arizona. They are light; can be easily quarried and trimmed, and are much used for building stone. The specific gravity of this stone varies from 1.7 to 2.55, giving a weight of about 105 to 160 pounds per cubic foot. The absorption varies from about 23% in the lighter varieties to 57 in the heavier.

SLATE.

Slate occurs in Arizona in the region from the Yuma to the Bradshaw mountains; on Cave Creek, Maricopa County; near Walnut Grove, Yavapai County; and in the Rincon mountains, near Dragoon. Arizona slate has only been quarried near Phoenix, and has been used to some extent as a building stone.

MARBLE.

There are many deposits of marble in Arizona, some of them of very high grade. Near Helvetia, Pima County; in the Santa Catalina mountains, on Marble Peak; in and near the Chiricahua mountains at Bowie and Whitetail Canyon; and at Dragoon. Much marble has been shipped from the quarries near Bowie.

ONYX MARBLE.

Onyx deposits in Arizona are, in some cases, well known, but none are developed on any extensive scale. Near Mayer, on Big Bug
Creek, Yavapai County; at Cave Creek, Yavapai County; and near Greaterville, at Cave Hill, Santa Cruz County.

**LIMESTONE.**

There are many extensive deposits of limestone in Arizona, but so far as known, no limestone has been quarried as building stone. The major portion of limestone quarried in Arizona is used for producing lime or as a smelter flux. Some crushed stone is produced.

**SANDSTONE.**

Most of the sandstone produced in Arizona comes from Flagstaff. This is a fine grained reddish stone, is easily sawed and tooled, and has been exported to some extent. It is used in some California cities, as at Sacramento and Los Angeles. There is also a gray sandstone quarried near Flagstaff, which finds a local use. Other sandstone deposits are at Globe, Morenci, Bisbee, Winslow, Sunshine and Penzance.

The total production of stone in Arizona in 1913 was valued at the quarries at $107,989, as compared with $67,124 in 1912. As nearly as can be figured, the production of building stone was valued at $13,495 in 1913.

The following table, taken from the United States Geological Survey for 1913, lists the rock quarries of Arizona:

**GRANITE.**

4. Yuma Co., Dome (about 2 miles east of).

**DARK VOLCANIC ROCKS (BASALTS, ETC.)**


**LIGHT VOLCANIC ROCKS (TUFF, ANDESITE, RHYOLITE)**

1. Cochise Co.
2. Coconino Co.
3. Gila Co.
   1. Huachuca
   2. Tufa
   3. Flagstaff (6 miles east of)
   4. Roosevelt
   5. San Carlos
Maricopa Co. 6. Phoenix (near)
7. Tempe (near)
8. Mohave Co.
Pima Co. 9. Near Tucson
10. Tucson (6 miles southwest of)
11. Yavapai Co. Kirkland
Slate
1. Maricopa Co. Phoenix (7 miles north of)
Marble and Onyx
Cochise Co. 1. Bowie (12 miles southeast of)
2. Dragoon (2 miles southeast of)
3. Paradise (5 miles northwest of)
Gila Co. 4. Globe (10 miles west of at foot of Sleeping Beauty mountain)
Pima Co. 5. Helvetia (6 miles northeast of)
Santa Cruz Co. 6. Greaterville (4½ miles south of)
Yavapai Co. (onyx)
7. Cave Creek (onyx)
8. Mayer (onyx)
Yuma Co. 9. Bouse (10 miles north of)
Limestone
Cochise Co. 1. Lee
2. Charleston
Maricopa Co. 3. Phoenix (2) near
Yavapai Co. 4. Humboldt
5. Delrio (near)
Limestone and Lime Kilns
Coconino Co. 1. Flagstaff (2)
Yavapai Co. 2. Puntenney
3. Nelson
Sandstone
Coconino Co. 1. Flagstaff (1¼ miles east of)
2. Flagstaff (3 miles north of)
3. Sunshine
Gila Co. 4. Globe (2)
Mohave Co. 5. Haviland
Navajo Co. 6. Penzance
7. Winslow
Economic Series No. 10

PRICES.

Building stone is usually sold by the cubic foot or cubic yard, although sometimes the rough product is sold by the cord or ton. The prices quoted here are for the cubic foot.

Granite:    Rough—about 20 cents per cu. ft.
            Dressed—about $2.50 per cu. ft.

Marble:    Rough—$1.36 per cu. ft.
            Dressed—$4.28 per cu. ft.

Limestone: Rough—22 cents per cu. ft.
            Dressed—57 cents per cu. ft.

Sandstone: (No figures available)

There are many considerations affecting the production of building stone. Building stone must be durable and of a pleasing color; it must be easily worked; it must be nearly free from flaws. This last is particularly so when the stone is to be used for interior work.

Building stone is a product which has to suit the market—it is almost, if not quite, impossible to create a market for it.

Also, ordinary precautions as to transportation, labor, etc., should be looked after. The extent and quality of a deposit should be carefully ascertained before a commercial output is contemplated. The stone should be tested for color, weight, hardness, porosity and crushing strength.

FUTURE OF THE INDUSTRY

There always has been, and probably always will be, a great demand for stone for building purposes. The value of the output depends largely on local usage, as it is too bulky a product to be readily transported.

In Arizona, there is a promising outlook for the quarries. Many varieties of stone of very fine quality are found in readily accessible places, and in such a growing community, should find a ready market.