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THE GRANITES OF WISCONSIN

by

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Open-File Report 12-1
13 p.

1912

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MISCELLANEOUS

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W. O. Hotchkiss, State Geologist.

Whenever a people has reached a high state of civilization in the past and has desired to preserve for the future monuments recording its greatness, it has turned to granite as the one stone best suited to endure without decay in various climates and various conditions. In early days this use of granite probably developed because it was the hardest rock to quarry out of its native hills - the least broken by natural processes - and therefore, it was reasoned, the rock least likely to disintegrate when placed in a monument. I believe this reason is valid today and that we could express a general truth by saying that the harder it is to break from the quarry and work up and polish a rock, the more durable it will be - the longer it will resist the breaking down processes which nature brings to bear on all things. "To dust return thou" was not written of the soil, according to the poet, but it is an inexorable mandate that applies to all other things exposed upon the surface of the earth. It is apparently the belief of nature that the surface of the earth should be covered with soil, so she sets to work to make soil out of everything. She breaks up the rocks, even the hardest granites, by the

rain and the wind and the frost and the sun; she makes soil out of all vegetation and all living things, even of man himself and all his works.

The granite industry of Wisconsin is of recent date compared to that of the east. It was started in 1880. The very excellence of the product was a severe handicap. The rock is so hard that granite workers trained in eastern works had to practically relearn their trade. As shown by the figures of production taken from the last published report of the United States Geological Survey, it is evident that the superior qualities of Wisconsin granite are gradually becoming appreciated. Wisconsin stands first, in 1912, in sales of dressed stone for monumental purposes, with over one half million dollars worth sold. Minnesota is second, with $430,000, Vermont third with $286,000. Vermont, however, sold $1,367,000 of rough stone for monumental purposes, and $44,000 worth of paving blocks, while Wisconsin sold practically no rough stone and $497,000 worth of paving blocks,-- being exceeded in production of the latter only by Maine.

The construction of monuments is dependent upon sentiment and upon wealth. It is a far cry from the simple board marker to a beautiful shaft of Wisconsin granite. It is a transition from the lowest to the highest stages of monumental

accomplishment. The board marker is the lot of the poor -- a condition which every individual is striving to rise from, and is used not from choice but of necessity. The granite shaft is the lot of the prosperous and the great. It is the natural desire of each of us to be remembered as among the latter, and so the desire for the most enduring material of which monuments can be constructed.

As in all things human, the choice of a monument depends much upon the prevailing fashion. The public is gradually being educated to the knowledge that granite is a most durable material and granite is fashionable. A further enlightenment should follow through the efforts of the members of this association -- that there is a wide variation in the quality of granites, that some are far more durable than others. For important public monuments the harder, more durable granites are already being used, but people in general should be better acquainted with the facts. It is the purpose of every purchaser of a monument to perpetuate the memory of those he loves and honors for the longest possible time, and for this purpose the most suitable material is granite, and granite only of the most durable character. Other qualities in the granite, such as color, may play a subordinate part in his choice; but the most important element is the time which the stone will preserve the record which he wishes to endure.

All manufacturers of granite monuments realize this fact and present in different ways the durability of their product.

The qualities desirable in a granite for monumental purposes are, first of all,

1. Permanence or Durability. After this, the following are important:
2. Ability to take and hold a fine polish.
3. Uniformity of mineral composition.
4. Contrast between polished and rough surfaces so the carving and inscription will stand out.
5. Grain of proper character to take and hold fine tool-work.
6. Color. This must be pleasing, uniform throughout the stone, non fading, and not subject to stain by weathering.
7. Lack of quick-weathering minerals, such as sulphides or carbonates.

In discussing these qualities, it is necessary to point out first the composition of a granite and its chemical and physical properties. As shown by the table, the chief minerals of a granite are quartz and feldspar. The accessory minerals, which usually make up less than 20% of the rock, are legion in number. The more important ones are mica, hornblende, augite, hematite, magnetite, pyrite, and the alteration products such as kaolin, calcite, mica and chlorite. The

quartz is a clear glassy mineral, usually in somewhat round and equidimensional grains, with no cleavage, but an uneven, glassy fracture. The feldspar is usually somewhat rectangular and oblong in shape and has an excellent cleavage which causes the smooth reflecting surfaces on the broken rock surface. It is most frequently flesh colored, dull white or gray, pink, or brownish. The quartz is much the hardest of these two and is not subject to chemical decomposition. The feldspar is softer and its excellent cleavage and its susceptibility to alter chemically at a slow rate make it a subject of much interest from the present point of view. In the weathering of a granite the potash, alumina and silica of the feldspars are altered to kaolin -- and from this source comes most of the clay that is such an important and common constituent of the soil and the sedimentary rocks. The calcium unites with CO_2 from the air and is one of the sources of limestone. The decomposition of the feldspar leaves the quartz grains practically untouched, but the incoherent grains are washed away and blown away to form sand and sandstone. Many of the granites in use as monumental stone show feldspars that are much fractured along cleavage planes so as to permit the ready entrance of water and thereby promote their rapid disintegration. And many of them are already altered to a high degree. The presence of

similar fractures is what gives the glistening, snowflake appearance to marble that has been exposed to weather for a few years. The presence of cracks in the feldspars may be identified by the same glisten from below the polished surface or by iridescent reflections when looked at from certain angles. The feldspars in all granites are more or less cracked in this manner. For the greatest durability those having the fewest cracks should be selected. One way in which badly cracked feldspars manifest their presence is in a notably low crushing strength for the rock.

The accessory minerals are chiefly of interest from the view point of the monument trade because they give the color to the granites, and because they are in general the most easily weathered minerals present. For these reasons it is apparent that an excess of accessory minerals is not desirable from the standpoint of durability. The minimum amount necessary to give desired colors is all that should be present. The amount necessary depends upon the kind of mineral and the way in which it is distributed. If the coloring mineral is in exceedingly fine grains well distributed, its coloring effect is much stronger than if it is in coarse crystals. Some of the light colored granites contain 30 % or more of accessory minerals, while the Wausau Red of Wisconsin, one of the most brilliantly colored

stones in the trade, contains only 16% of accessory minerals.

The hornblende, augite, and some of the micas are black or nearly so. The light and dark gray granites owe their color to these accessory minerals which are scattered in greater or less profusion through the white of the feldspar and quartz. The alteration products named are colorless, white or light in color, except the chlorite. When this is present in appreciable amounts it gives a greenish cast to the stone.

Hematite is responsible for the prevailing red and pink colors in granites. It is usually disseminated in exceedingly fine microscopic particles through the feldspars and gives them the common flesh or pinkish color. The state of dissemination of the particles is the important factor with hematite. The Wausau Red owes its color to this iron oxide, yet the chemical analysis shows it to contain only two-thirds as much iron oxide as one of the whitest granites in use. The iron in the white granite is undoubtedly in larger particles and also united chemically to make other accessory minerals which are not so brilliant in color.

Magnetite is almost universally present, and shows as minute black metallic appearing specks. Pyrite is commonly present to a slight extent. It looks like small particles of gold, as it has a yellowish color and a metallic luster.

The weathering of the accessory minerals is one of the elements that lessen the durability or permanence of granite monuments. The effect of the various accessory constituents is quite different. The presence of even minute quantities of some practically spoils a stone for monument purposes. Of this kind is pyrite. This is very promptly attacked on exposure to weather. The iron in it is oxidized and makes unsightly rust stains. The sulphur is oxidized and makes a strong acid that attacks the surrounding minerals and corrodes them.

Hornblende, augite and the dark micas lose their luster and take on a coating of grayish green. When they occur in groups of crystals as they often do, their well developed cleavage causes them to break out and make rough spots and pits in polishing.

Hematite and magnetite are stable minerals and are not affected by the weather.

Physical Tests.

These show that Wisconsin's best granites are harder to crush than any others in the United States, with almost no exceptions. Only one test, so far as my knowledge extends, shows a higher crushing strength. The high crushing strength is due to the fact that the minerals in the rock are not separated by tiny

cracks nor broken by cleavage cracks but are solid and tightly grown together. The hardness thus indicates that there are few openings for the penetration of water and organic substances which promote decay of the stone.

The weight per cubic foot is nearly the same in all granites. The generally low weight of Wisconsin granites is due to the fact that there is a small amount of heavy accessory minerals present, and is a desirable feature in any granite providing it is not due to porosity rather than to lack of heavy minerals. This test has little significance by itself, however.

Chemical Analyses.

From what has been previously stated, it is evident that a high per cent of silica in a rock analysis means little when taken by itself. The highest silica in the table shown is found in a rock which has almost the least quartz. Since quartz is the hardest and most durable mineral in granite, it is well to have a large amount of it if a rock of great permanence is desired. A rock may have a high percentage of silica, but if it has sufficient alumina and alkalies as well it will be largely feldspar and accessory minerals. A pure feldspar may contain as much as 68.7% of silica. Consequently it is important to note the amounts of alumina,

lime, and magnesia, and if these are high you can be sure that it means a lessening in the amount of quartz.

The approximate amount of quartz, feldspar and accessory minerals as computed from the analyses are given in the last three columns. While these are not exact they are probably correct within three or four per cent. These show that the granites from Wisconsin have the highest percentages of quartz of any on the list. And this list was selected to be representative of the principal monumental granites of the United States.

Hardness and Polish.

The granites of Wisconsin are very hard and much more expensive to polish than other granites. The reason for this is not known with assurance, but in a careful study of a number of granites both from this state and elsewhere, two factors were noted which appear to be sufficient to explain the matter. One of these is the per cent of quartz present in the rock. As quartz is the hardest a harder mineral than feldspar it makes a granite with much of it harder to polish than one with little. As the quartz takes a more perfect polish than feldspar and as it is not affected by weathering, its presence in large amounts in a granite is desirable. The other

factor is the condition of the feldspar. If it is unaltered and fresh it is apparently harder to grind down than if it is filled with alteration products. The dense, fresh feldspar also takes a better polish than the altered.

An examination of any granite will show more or less of alteration products in the feldspars. The less there is the better the stone for monument purposes.

Resume.

It will be worth while before showing some illustrations of Wisconsin granites, to name again the list of qualities desired in a granite and briefly state the reason for each.

1. Durability or Permanence. Due to unaltered condition of the rock and its component minerals, and to the absence of cracks or pores through which weathering solutions could get a start. A high crushing strength is thus an indication of durability. For purposes of interior decorative work the factor of durability loses its paramount importance and is superceded by the factors of color, pattern, etc., which in general influence the beauty of the polished surface.

2. Contrast; This demands a rock composed of minerals which are light colored when pure, and which has a strong color produced with as small an amount of colored minerals as

possible. The powdery broken surface of the rough dressed or hammered parts of the rock will then show white or very light in color against which the color of the polished surface will stand out strongly. If the rock contains much dark mineral that gives a dark powder on breaking, or if it s polished surface is white or light colored, it will show less of contrast.

3. Color: Due to the kinds of accessory minerals present and to the compactness of the rock. The browns and reds and grays are most permanent colors, the greens are likely to be less permanent. If the feldspars are badly cracked, these cracks are apt to open wider and this causes an apparent lightening of the shade, or fading. Evenness of color is due to an equal distribution of the colored minerals. Rust spots or iron stains are usually due to the oxidation of particles of pyrite. A crystal of this the size of a pinhead will stain a spot an inch or two across.

4. Polish: To take and hold a fine polish a granite must be hard, unweathered, have few minerals other than quartz and feldspar and these accessory minerals must not occur in bunches. The more quartz present and the fresher the feldspars, the better the polish -- and I might add, the more expensive to polish.

(Slides of thin sections and monuments.)

In concluding I can do no better than to quote Dr. Buckley, the author of the report on Building and Ornamental Stones of Wisconsin - "No more beautiful granite for monumental purposes can be found anywhere, than that which is quarried in Wisconsin. The brilliant and subdued red colored granites are unsurpassed in beauty by any which are imported from foreign countries or the eastern states. The dark colored rhyolites and gray granites are equal in every respect to similar varieties quarried elsewhere."