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# ON SOME TESTS OF BUILDING STONES.

J. A. DODGE.

[Read April, 1882.]*

These tests were made in the chemical laboratory of the University of Minnesota for the state geological survey. They were partly of a physical and partly of a chemical nature. They included the following determinations and processes:

1. Specific gravity of the stones.
2. Absorption of moisture by exposure to a damp atmosphere.
3. Absorption of water by soaking.
4. Effect of carbonic acid.
5. Effect of stronger acids in state of vapor.
6. Effect of frost.
7. Effect of heat.
8. Chemical analysis.

In outline the methods pursued were as follows:

1. The specific gravity of the samples of stone was determined by the usual method for solid bodies. The specimens were air-dried, then weighed in air; then soaked until air bubbles ceased to come from them, then weighed in water. The specific gravity equals the weight in air divided by the loss of weight in water.

2. To determine the absorption of moisture, the pieces were first dried by means of a water bath at 212° Fahrenheit for six days, then weighed. They were then supported on glass shelves under an inverted air-tight cylinder whose mouth was sealed by

* For the complete sets of results of the tests above mentioned, as applied to about sixty samples of building stones, I refer to the first volume of the Final Report of the Geological and Natural History Survey of Minnesota, 1884.—J. A. D.

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water. In this apparatus the stones were kept for seven weeks at a nearly uniform temperature, about 65° F. They were then again weighed, and the increase of weight showed the amount of moisture absorbed. It was computed as per cent. It was found to range from .03 per cent. to 3.94 per cent., the latter per cent. being that shown by a sandstone. The pieces were not of exactly the same size, as they were simply split out with a chisel and not accurately shaped or dressed, though an endeavor was made to split them approximately to a cubical shape. Their average size was about one and one-fourth inches on a side. The number of specimens operated on was forty.

3. To determine the amount of water absorbed, the pieces were first dried, like the last, then weighed. They were then soaked in water for four days, then again weighed. Each piece, before weighing, was gently wiped to remove surface moisture. The pieces were in size and shape similar to the last. The minimum absorption of water was .03 per cent., shown by a species of trap rock. Some granites showed a degree of absorption but little greater than this. The maximum absorption was 12.69 per cent., shown by a sandstone. Several other sandstones came near to these figures. Several limestones showed 4 to 5 per cent. absorption.

4. To ascertain the effect of carbonic acid on the stones, these were dried and weighed as before. They were then suspended by strings in jars of distilled water, and streams of carbonic acid gas were kept running through the water, with some interruptions, for six weeks. The water was occasionally drawn off, and fresh water substituted. The stones were finally again dried and weighed. The loss of weight showed the effect of carbonic acid, which was in most cases small, being, of course, greatest in the case of limestone. It should be mentioned that limestones were placed in a different vessel from sandstones and granites. The minimum loss of weight was .01 per cent., the maximum 3.58 per cent.

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5. To determine the effect of strong acid fumes, the pieces were dried and weighed like the previous sets. They were then placed in an apparatus similar to that used in determining the absorption of moisture (2), being placed on glass shelves, and the cylinder having its mouth sealed by strong muriatic acid, while a small bottle of nitric acid was placed on one of the shelves. The idea of this arrangement was borrowed from a report of a series of tests made upon building stones by Professor G. Hinrichs, for the state of Iowa. The object was to condense into a brief period of time the more powerful corroding and disintegrating action to which building stones might under some circumstances be exposed. After seven weeks, the stones were removed from the apparatus and placed in water to soak. They were then dried thoroughly and weighed. At the same time a note was made of the *visible* effect produced by the corrosive vapors, consisting in change of color, or staining, and crumbling. Some of the stones passed through this severe test with little change either in appearance or weight; others were greatly injured.

6. To determine the effect of frost, the pieces were weighed in the dry state, as before, then placed in a shallow pan and nearly covered with water, and thus exposed to freezing and thawing for a period of eight weeks. It should be said that during this period no very great degree of cold was experienced. After the exposure in this way, the stones were carefully observed and a note made of any crumbling or scaling shown by any of them. They were then dried and weighed. For the most part the effects observed or shown by the balance were slight. The maximum loss of weight, by scaling of small parts, was 2.21 per cent.

7. To determine the effect of heat, a muffle furnace was used, the same being a part of our assaying outfit at the chemical laboratory. The muffle was raised to a moderate red heat. Each stone was placed first at the mouth of the muffle for a time, and

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gradually moved inward, a note being made of any changes which the stone underwent, either in the way of cracking or changing color, until at last the stone was raised to a red heat. Most of the samples passed through this ordeal with no great injury. Only two or three were badly cracked. Many of them, especially the limestones, blackened in moderate heat, then later they burned whiter. But after reaching the high temperature referred to, they were made to undergo a much more severe test. They were severally withdrawn from the muffle and, when their temperature had so far fallen as to show no further redness, they were immersed in water and held in this for a few moments, whereupon a note was again made of their appearance. The majority of the stones suffered badly by this treatment. Quite a number, however, withstood it well, this number including some of each class; limestones, sandstones and granites.

8. Of the chemical analyses there is no need to give particulars.

In the discussion which followed this paper, W. A. Pike said:

"The specific gravity experiments are of great value to the architect and engineer, as furnishing means for obtaining the weight to be supported by foundations and as an element in determining the proper stone to use in a given case. For instance, other things being equal, the lightest stone would always be used, for the simple reason that the weight of a structure is just as truly a part of its load as is any external force it may have to sustain.

The results obtained with regard to the absorption of water are very interesting and not a little surprising, as it is generally considered that the smallness of the weight of water absorbed is a test of the probable durability of a given stone. If we can accept this test as a fair indication of the durability, we must look with some doubt upon our Minnesota stones, since their average absorption is at least as great as that which authorities

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give as the maximums. For instance, if the speaker remembers correctly, sandstones were reported as absorbing from 3 per cent. to over 12 per cent. of their weight of water, while Professor Rankin gives from 1⅝ per cent. to 3⅓ per cent. as the range. The speaker believed, however, that this great discrepancy must be due to the small size of the specimens tested rather than to the quality of the stone. The absorption must be principally near the surface, and as the surfaces of similar stones increase as the squares of their dimensions while the volumes and weights increase as their cubes, it is easy to see that larger specimens would have given smaller results.

The results as given would serve as comparative tests of the different Minnesota stones, but would not serve in the comparison with those of other places.

The tests for the disintegrating effects of frost, it was suggested, might be added to by trying the effect of immersing the stones in a solution of sulphate of sodium, which has been found to closely imitate the action of frost. This method the speaker thought was used for testing building stones for the Capitol at Washington."

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[THE FOLLOWING RESOLUTIONS AND DISCUSSION WERE EXTRACTED FROM THE MINUTES OF THE SECRETARY FOR MAY, 1883.

"The first item of miscellaneous business was the offering of the following resolutions by Professor Winchell:

*Resolved*, by the members of the Minnesota Academy of Natural Sciences;

That in common with the scientific laborers of the civilized world we lament the death of Charles H. Darwin of England: and we wish hereby to express our profound admiration of his scientific labors. His high attainment of success in that sphere in which few men reach fame and his industrious genius in

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grouping the facts of animated nature were only equalled by the quiet modesty of his life and the Christian fortitude with which he endured, without resentment, misrepresentation and calumny. We regard him as one of the few men the world has seen who have been able to lift their vision above the level of the "common herd" and to recite intelligibly the new truths which they beheld. He lived in England but he belonged to the world and especially to every English-speaking country.

*Resolved*, That the foregoing expression of our sense of loss to the world of science be entered on our records and published in our *Bulletin*.

Professor Winchell in moving the resolutions made some appropriate remarks on the character and scope of Darwin's work —making a comparison between the biological investigations of Darwin and the geological studies of Lyell; while the latter overthrew the old theories of catastrophies and built up on a lasting basis the uniformitarianism of modern geologists, the former labored to bring out the proofs that long eras of time had been necessary to establish the present condition of animal and plant life on the globe.

Judge Hemuip. in seconding the resolutions, said that this Academy owed to itself something more than the passage of the resolutions;—that some member should be appointed to prepare a memoir to give an outline of the great man's life and works.

The resolutions were unanimously adopted.

Judge Hemuip was appointed to prepare a memoir on the life and works of Darwin, to be read at some future meeting of the Academy."

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