

# REPORT ON SOME CARBONIC ACID TESTS ON THE WEATHERING OF MARBLES AND LIMESTONES.

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The tests registered below were made with a view of determining not merely the relative solubility of certain calcareous rocks used for building and ornamental work, but as well, the manner in which the solvent acted. The ultimate aim of the experiments, as is obvious, was to ascertain how the stones would withstand the effects of an atmosphere and its rainfall made acid through absorbed carbonic acid. To make the results appreciable within a reasonable time, it was of course necessary to exaggerate the conditions. The process was as follows: Two samples of each stone selected were cut into the form of cubes approximately an inch in diameter, though without any attempt at exact correspondence in weight. How close the approximation is shown in the accompanying table of results.

The surfaces of each cube were rubbed with flour of emery on a glass plate as smooth as the nature of the material permitted, but no attempt was made to polish. They were then thoroughly washed and dried at 100° C. The cubes were then suspended by threads, in each case passed but once around the cube, in a large jar of water kept acid by a stream of carbonic acid from a charged cylinder. The water was changed once each week. No attempt was made to have the stream of bubbles constant and continuous, but the direction was changed occasionally to make certain that all were subjected to like conditions. Twice during the trial the cubes were withdrawn and while still suspended dried out by artificial heat and again immersed. At the end of 3 months they were all withdrawn, dried at a temperature of 100 degrees, and brushed off with a soft fitch brush to remove any loosened granules or dust. The appearance of each cube was carefully noted as to color changes as well as to the manner in which the solvent acted. The tables below give the weight of the cubes before and after and the loss of material both in weight and in percentage amounts. The first table gives the results of some preliminary tests which were not carried to completion, owing to imperfection of apparatus. They are, however, included here, since so far as they go they are confirmatory of those in the second. The results in both cases agree surprisingly well. It will be noted that while the amount of material lost in the first series is less than in the second, owing to the shorter period of trial, the two are always in accord. The amount of material lost by solution is not, however,

the sole item of importance, nor indeed the item of most importance. It will be noted that in some instances a stone losing a certain amount still retains a nearly smooth surface and sharp arrises. Others become roughened, granules loosened to the point of falling away, and the arrises as a consequence left ragged. In some of the stones there is a tendency for the smaller interstitial crystals to disappear, leaving the larger standing in relief. The Tennessee samples tested are of the gray and pink spotted varieties. In these the tinted calcite, which, judged from the forms, represents fragmental fossil material, is more refractory than the colorless and is left in slight relief. In the case of the oolitic limestones the oolites are eaten out, leaving the crystalline or interstitial material and the fossil fragments in relief, the outline of the oolite being sometimes preserved by the insoluble impurities. The considerable amount of insoluble material set free from these oolitic cubes during the trial settling to the bottom of the jar as mud or remaining to be brushed off the surface when the cube was dried seems to have come wholly from the oolites, and not from the interstices. It will be noted, as might have been expected, that the dolomitic marbles were not appreciably affected and that the oolitic stones lost during the trial an amount two and three times as great as that of any other of the stones tested. In but one instance was there any marked change in color in any of the samples.

TABLE I.

PRELIMINARY TRIAL EXTENDING OVER PERIOD OF 70 DAYS.

Kind and locality.	Weight before trial in grams.	Weight after trial in grams.	Loss of weight in grams.	Percentage loss of weight.	Remarks.
White crystalline limestone: Marble, Yule, Colorado.	{ 45.053 44.313	{ 44.7075 43.8815	{ 0.3455 0.4325	{ 0.0077 .0097	} Very slightly roughened; no granulation.
White crystalline limestone: Marble, Pickens County, Georgia.	{ 42.3935 42.747	{ 41.935 42.3565	{ 0.4585 0.3905	{ .011 .009	
White crystalline limestone: Marble, West Grove, Pennsylvania.	{ 46.3455 44.7015	{ 46.2345 44.586	{ 0.1110 0.1155	{ .0024 .0026	} Effect scarcely appreciable.
Pink crystalline limestone: Marble, Knoxville, Tennessee.	{ 50.4485 48.478	{ 49.904 47.9725	{ 0.5445 0.5055	{ .0108 .0104	
Gray crystalline limestone: Marble, Concord, Tennessee.	{ 45.1075	{ 44.4765	{ 0.6310	{ .012	} White portions slightly etched, leaving the pink standing in relief.
White crystalline limestone: Marble, Rutland, Vermont.	{ 40.6655 41.1245	{ 40.1185 40.432	{ 0.547 0.6925*	{ .013 .016	
Blue crystalline limestone: Marble, Rutland, Vermont.	{ 41.414 41.0555	{ 43.8355 40.589	{ 0.6085 0.4665	{ .015 .011	} Surfaces appreciably roughened; no granulation.
White crystalline limestone: Marble, Carrara, Italy.	{ 38.6165 40.5885	{ 38.114 40.0925	{ 0.5025 0.496	{ .013 .012	
White crystalline dolomite: Marble, Cookeysville, Maryland.	{ 38.80 36.507	{ 38.7755 36.4855	{ 0.029 0.0215	{ .00062 .00058	} Not appreciably acted upon.
White crystalline dolomite: Marble, Tuckahoe, New York.	{ 42.6655 41.405	{ 42.0415 41.3795	{ 0.0240 0.0255	{ .00056 .0006	
Oolitic limestone, Bedford, Indiana.	{ 43.5785 41.1475	{ 42.2435 39.8795	{ 1.335 1.268	{ .0304 .0308	} Distinctly roughened and pitted, the fossil fragments left standing in relief. Distinctly roughened and pitted, the oolites being eaten out, leaving surface covered by circular and oval pits often with a slight residual eminence in center.
Oolitic limestone: Bowling Green, Kentucky.	{ 41.1655 37.8355	{ 40.504 37.1725	{ 0.6115 0.663	{ .014 .017	

TABLE II.

SECOND TRIAL EXTENDING OVER PERIOD OF THREE MONTHS.

Kind of stone and locality.	Original weight in grams.	Final weight in grams.	Loss of weight in grams.	Percentage loss in weight.	Remarks.
White crystalline limestone: Marble, Yule Creek, Colorado.	51.551	50.6465	0.9045	.017	A very slight roughening of the surface, but no granulation and but slightly attacked on the edges or arrises.
	48.194	47.2465	0.9475	.019	
White crystalline limestone: Marble, Pickens County, Georgia.	44.034	43.315	0.719	.0165	Surfaces very slightly roughened, but no granulation.
	43.6675	42.946	0.7215	.017	
White crystalline limestone: Marble, Cherokee County, Georgia.	43.3885	42.7335	0.655	.015	Surfaces very slightly roughened, a slight yellowing.
	44.400	43.683	0.717	.016	
White crystalline limestone: Marble, West Grove, Pennsylvania.	47.8385	47.615	0.2235	.0047	Surfaces roughened, but no granulation.
	47.9695	47.768	0.2015	.0042	
White crystalline limestone: Marble, Proctor, Vermont.	44.4945	43.62	0.8745	.019	Surfaces distinctly roughened and granulated, small particles loosened and falling away when handled or brushed; arrises roughened.
	44.1085	43.3125	0.796	.018	
White crystalline limestone: Marble, Proctor, Vermont.	44.974	43.9295	1.0445	.023	Surfaces distinctly roughened and granulated, small particles loosened and breaking away when handled or brushed; arrises strongly attacked.
	45.172	44.001	1.171	.026	
White crystalline limestone: Marble, Pittsfield, Vermont.	42.536	41.705	0.831	.019	Surfaces distinctly roughened and granulated, small particles loosened and breaking away when handled or brushed; arrises strongly attacked.
	43.97	42.9715	0.9985	.022	
White crystalline limestone: Marble, Carrara, Italy.	43.5085	42.598	0.9105	.021	Surfaces distinctly roughened and granulated, small particles loosened and breaking away when handled or brushed; arrises strongly attacked.
	42.462	41.4885	0.9735	.023	
Gray crystalline limestone: Marble, Knoxville, Tennessee.	46.796	45.8765	0.9245	.019	Surfaces roughened by the corrosion of the colorless granules leaving the pink tinted standing in relief. No granulation or mechanical loosening of particles.
	45.1725	44.2975	0.875	.019	
Gray crystalline limestone: Marble, Knoxville, Tennessee.	44.069	43.226	0.843	.019	Surfaces roughened by the corrosion of the colorless granules leaving the pink tinted standing in relief. No granulation or mechanical loosening of particles.
	44.3095	43.4545	0.855	.019	
Gray crystalline limestone: Marble, Knoxville, Tennessee.	45.7165	44.52	1.1965	.026	Surfaces distinctly roughened by corrosion along planes of cleavage and color changed to a decided buff.
	45.5565	44.609	0.9475	.021	
Pink crystalline limestone: Marble, Concord, Tennessee.	42.7345	41.808	0.9265	.021	No perceptible change.
	42.9635	42.1675	0.796	.0185	
White crystalline dolomite: Marble, Cockeysville, Maryland.	40.724	40.687	0.037	.00091	No perceptible change.
	38.4355	38.3995	0.036	.00093	
White crystalline dolomite: Marble, Berkshire, Massachusetts.	45.529	44.8385	0.6905	.015	Surfaces distinctly roughened by corrosion along planes of cleavage and color changed to a decided buff.
	45.052	44.378	0.674	.015	
White crystalline dolomite: Marble, Lee, Massachusetts.	43.659	43.625	0.034	.00077	No perceptible change.
	44.493	44.4415	0.0525	.0011	
White crystalline dolomite: Marble, Tuckahee, New York.	43.442	43.4025	0.0395	.00091	No perceptible change.
	44.792	44.7465	0.0455	.0010	
Oolitic limestone, Bedford, Indiana.	46.438	46.3815	0.0575	.0012	No perceptible change.
	47.053	47.0105	0.0425	.0009	
Oolitic limestone, Bowling Green, Indiana.	36.0945	34.493	1.6015	.044	Surfaces much roughened and pitted owing to solution of the oolites leaving the fossil fragments and crystalline material of the interstices in relief; arrises strongly attacked.
	38.3245	36.4495	1.875	.049	
Oolitic limestone, Salem, Indiana.	38.4375	37.1775	1.26	.033	The same, only that the stone is more distinctly oolitic and the surface becomes covered with circular and oval pits.
	38.6845	37.44	1.2445	.032	
Oolitic limestone, Salem, Indiana.	37.2795	35.39	1.8895	.0506	
	37.45	35.591	1.869	.050	