ANCIENT EGYPTIAN MORTARS

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Writing of the mortar of the ancients, Professor W. N. Hartley F. R. S. says on the authority of Vicat: « An examination of the mortar lying between the stones of the pyramid of Cheops has shown it to be identical with that in use in Europe at the present day, although its preparation must have taken place more than two thousand years before the Christian era ». Later on however in the same article Professor Hartley writing of plaster of Paris says: « It was used to some extent for building purposes by the ancient Egyptians, as is evident from the analyses of Dr W. Wallace of a specimen of plaster from the pyramid of Cheops ». The following are the results alluded to:

ANALYSES OF PLASTER FROM THE PYRAMID OF CHEOPS [1].

CONSTITUENTS.	FROM THE INTERIOR.	FROM THE EXTERIOR.
	p. 100.	p. 100.
Hydrate calcium sulphate	81.50	82.89
Silicic acid	5.30	4.30
Calcium carbonate	9.47	9.80
Alumina	2.41	3.00
Ferric oxide	0.25	0.21
Magnesium carbonate	0.59	0.79
TOTAL	99.52	100.99

The two opinions quoted above seem contradictory, and unfortunately there are no analyses by Vicat to show what the composition of the mortar was to which he referred.

An opportunity has recently occurred of examining numerous specimens of old Egyptian mortar, and the results obtained do not confirm Vicat's

(1) Article on Cements in *A Dictionary of Applied Chemistry,* by Dr T. E. Thorpe, C. B. F. R. S, London, 1890, vol. I, p. 467 and 468.

statement that it is «identical with that in use in Europe at the present day». Dr Wallace more correctly calls the material plaster of Paris, although this definition will not strictly apply in every instance.

At the present time, many of the samples are essentially hydrated calcium sulphate mixed with varying proportions of sand : others of the samples however contain in addition from 25 to 50 p. 100 of calcium carbonate.

Since, according to our modern and western ideas, the use of plaster of Paris as a mortar is somewhat strange, the question naturally suggests itself whether the ancient Egyptians knew the use of lime and sand mortar at all. It may be useful therefore to ascertain what evidence is furnished on this point by the samples examined.

The whole question turns on the origin of the calcium carbonate.

There are two ways in which the presence of calcium carbonate may be accounted for, the first of these is by supposing that slaked lime was used in the first instance, and that this gradually absorbed carbon dioxide from the atmosphere until it became in great part converted into carbonate. This is what takes place in the ordinary lime and sand mortar of today; the lime sets by drying, and subsequently hardens by the absorption of carbon dioxide from the air and the conversion of the hydrate in part into carbonate.

Another possible view of the composition of the mortar in the first instance is to suppose that the calcium carbonate was originally present as an impurity in the sulphate.

The origin of the calcium sulphate used is unknown, and hence it cannot be stated with certainty whether or not it contained carbonate as an impurity. That Egyptian plaster as used at the present day however does contain carbonate is shown by the following analyses :

EGYPTIAN PLASTER OF PARIS FROM HELWAN.

CONSTITUENTS.	No 1.	No 2.	No 3.
	p. 100.	p. 100.	p. 100.
Silica (Sand)	7.60	3.74	2.14
Oxide of Iron and Alumina	1.02	0.98	0.52
Calcium Sulphate	67.97	78.78	82.16
Calcium Carbonate	15.24	9.41	7.46
Water	7.46	6.43	8.29
TOTAL	99.29	99.34	100.57

If then this impure calcium sulphate was used, the necessary preliminary calcination would convert some part at least of the carbonate into quick lime, this would slake on the addition of water and would subsequently become converted into carbonate; the rest of the carbonate present remaining unchanged after calcination would simply be added as such.

From the above analyses it will be seen too that native Egyptian plaster also contains sand; and since in most of the samples of mortar analysed there is less than 10 p. 100 of sand, it seems likely that the sand also was introduced as an impurity in the plaster.

It will be noticed that in most of the samples there is a little lime in excess of that required to combine with both the sulphuric acid and carbon dioxide taken together, as though some of the lime were still left uncarbonated even after so many centuries of exposure. In one sample there is 22 p. 100 of lime still uncombined; this however may be of later origin and may indicate some comparatively recent repairs.

From these samples therefore there is no evidence that the ancient Egyptians understood the use of lime in making mortar, but there is a certain amount of evidence to the contrary, and which tends to show that where lime or carbonate of lime occurs it was used unconsciously.

Several years ago a sample of mortar from one of the pillars in the hypostyle hall at Karnak was examined by the writer with the following result. From the analysis it will be seen that this too is evidently a plaster of Paris.

Mortar from Karnak.

Silica and insoluble	13.54	per cent
Oxide of Iron and Alumina	2.90	
Lime	27.70	
Magnesia	0.42	
Sulphur Trioxide	36.54	
Soda	0.37	
Chlorine	trace	
Loss on Ignition, being Carbon Dioxide and Combined Water	19.19	
Total	100.66	

All of the samples analysed with the exception of the native plaster of Paris and the mortar from Karnak, were taken by Mr. Dow Covington in the course of his work on the Sphinx, Pyramids, etc. and it was at his suggestion that the analyses were made.

ANALYSES OF ANCIENT EGYPTIAN MORTARS.

CONSTITUENTS.	PLACE FROM WHICH TAKEN. SPHINX.						TEMPLE OF SPHINX.			SECOND PYRAMID.		GREAT PYRAMID.		
	REAR.	LEFT side.	RIGHT side.	PAW.	LEFT shoulder.	RIGHT shoulder.	1	2	3	Exterior.	Interior.	Exterior.	Interior.	Grotto.
	p. 100.	p. 100.	p. 100.	p. 100.	p. 100.	p. 100.	p. 100.	p. 100.	p. 100.	p. 100.	p. 100.	p. 100.	p. 100.	p. 100.
Sand and Insoluble Silicates.........	9.97	23.06	12.14	9.32	17.34	9.29	3.96	7.06	1.67	7.48	1.62	8 31	4.17	8.73
Soluble Silica..............	2.67	2.39	3.23	2.97	3.35	2.25	0.85	0.38	1.52	0.36	0.40	1.16	2.68	4.03
Oxide of Iron and Alumina.........	1.48	1.95	1.76	1.43	1.30	1.33	0.70	1.07	0.55	2.16	0.75	2.64	1.08	1.22
Lime........................	35.60	23.55	28.15	29.37	41.61	36.67	44.10	35.72	39.99	35.61	32.45	30.60	37.14	28.38
Magnesia......................	0.56	0.35	0.78	1.01	0.96	trace	1.81	1.82	trace	trace	trace	0.61	trace	trace
Sulphur Trioxide................	21.79	31.09	34.03	36.25	22.73	21.96	10.85	26.61	25.33	25.26	41.53	32.89	37.00	37.23
Carbon Dioxide..................	16.34	trace	3.03	1.88	2.65	17.00	25.53	13.38	17.41	11.73	trace	3.54	1.52	trace
Combined Water (by difference).....	11.59	17.61	16.88	17.77	10.06	11.50	12.20	13.96	13.53	17.40	23.25	20.25	16.41	20.41
TOTAL.....	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur Trioxide calculated as Calcium Sulphate (Anhydrous)...........	37.04	52.85	57.85	61.62	38.64	37.33	18.44	45.23	43.06	42.94	70.60	55.91	62.90	63.29
Carbon Dioxide calculated as Calcium Carbonate...................	37.09	trace	6.87	4.26	6.01	38.59	57.95	30.37	39.52	26.62	trace	8.03	3.45	trace
Lime left uncombined............	.....	1.79	0.49	1.62	22.34	.....	4.09	0.11	0.15	3.04	3.38	3.09	9.31	2.32

NOTES. — The sample from the left side of the Sphinx contained fragments of pottery; sample n° 2 from the Temple of the Sphinx contained small pieces of calcite; the sample from the grotto of the great Pyramid contained small pebbles.

A further sample of mortar from the south air channel of the King's chamber of the great Pyramid was examined qualitatively and was very similar in composition to the above.

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