

CHEMICAL COMPOSITION OF STUCCO IN SUKHOThai 'S MONUMENTS

A Preliminary Report by
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A study of building materials, chiefly brick and laterite as well as stucco, used in the monuments in Ancient Sukhothai, together with the factors responsible for their deterioration, is necessary for conservation work of the Sukhothai Historical Park Project. A preliminary survey for the purpose of collecting data needed for scientific research was carried out in 1980 by the Conservation Laboratory of the National Museum, with the co-operation of the Sukhothai Historical Park Project. The survey data shows that the decorated stuccos are all in ruins and a study has been undertaken to analyse the chemical composition of the stucco so that the result can be utilized in conservation work.

Following is the report of the stucco study.

Method and Materials

1. Twelve stucco samples from twelve places have been collected from two chedis in Wat Mahathat which is the largest temple of Ancient Sukhothai. Four samples from the first chedi were taken from the fifth terrace on the east side, (MT3) in Table 1, north side (MT4), south side (MT6) and west side (MT8). Samples MT13; MT14, MT16 and MT18 were taken from the north, west, south and east side of the small wall surrounding the chedi.

The other four samples (MT20, MT22, MT24 and MT26) belonging to the second chedi were collected from the south, east, north and west side of the chedi.

2. Ten stucco samples have been selected from the northern Prang decorated with stucco figures in Wat Phra Phai Luang which is second in importance to Wat Mahathat.

Samples P1, P2, P3, and P4 in Table 2 were taken from the western side and samples P5, P6, P7 and P8 were taken from the south side. Sample P9 was on the east side and the other one (P10) was collected from the north side.

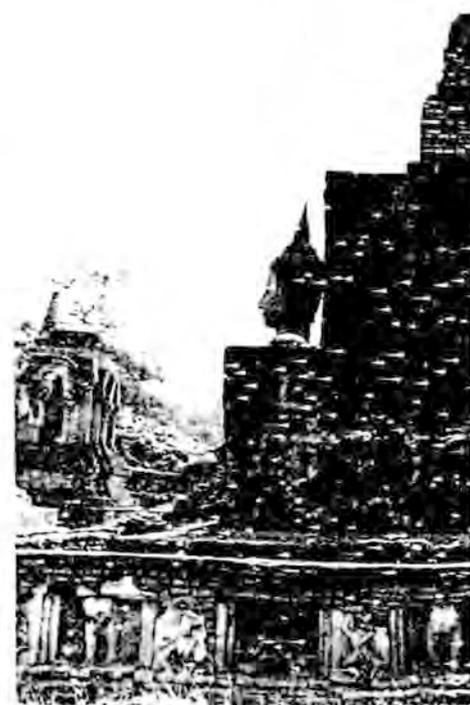


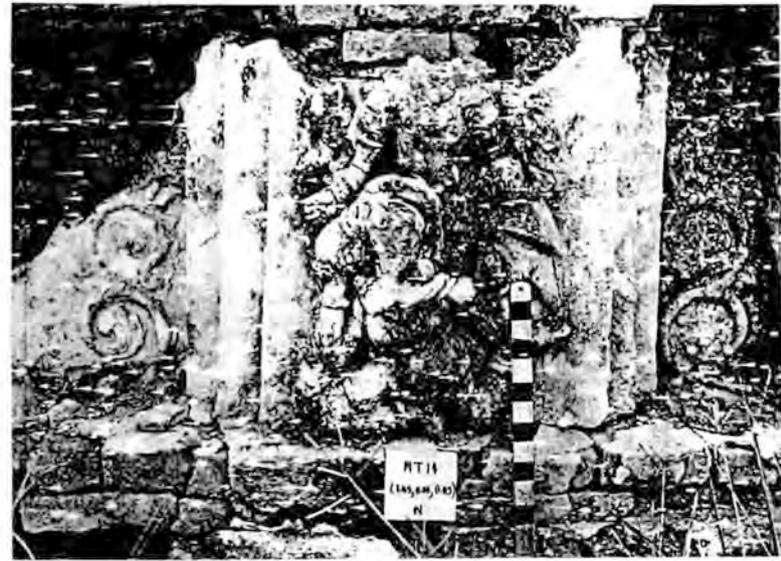
Table 1. Chemical composition of stucco sampling from Wat-Mahathat.

Analysed by : Chemical section, Geological Survey Division, Department of Mineral Resources, Ministry of Industry, Thailand

Sample code	in per cent									
	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	TiO ₂	P ₂ O ₅	CaO	MgO	SrO	H ₂ O	Loss on ignition
MT3	37.67	2.30	1.78	0.23	0.24	31.52	0.43	nil	0.17	25.65
MT4	26.58	2.07	1.89	0.15	0.18	37.00	0.52	nil	0.38	31.22
MT5	21.52	1.08	1.15	0.13	0.26	41.26	0.55	nil	0.28	33.74
MT8	36.17	2.57	1.70	0.19	0.31	31.61	0.48	nil	0.17	26.62
MT13	39.47	2.34	1.69	0.16	0.23	30.61	0.30	nil	0.41	24.78
MT14	28.39	1.42	1.42	0.19	0.22	35.32	0.57	nil	2.20	29.83
MT16	37.99	1.64	1.18	0.16	0.22	31.13	0.49	nil	0.61	26.31
MT18	44.52	2.31	1.19	0.18	0.11	28.08	0.25	nil	0.31	22.72
MT20	40.09	1.58	1.41	0.17	0.16	30.62	0.39	nil	0.26	25.34
MT22	31.60	3.44	3.56	0.20	0.22	30.33	0.56	nil	1.32	28.19
MT24	30.37	1.79	1.21	0.16	0.27	35.68	0.41	nil	0.37	29.72
MT26	37.87	2.61	1.16	0.17	0.31	30.69	0.63	nil	0.22	26.18



Fig 1-2
The first chedi in Wat Mahathat that was selected for taking samples MT3-MT16.



Sample code	in per cent				
	SiO ₂	CaO	MgO	Mixed oxide R ₂ O ₃	Loss on ignition
P ₁	23.7	37.5	0.6	6.3	31.2
P ₂	23.1	38.6	0.4	3.6	33.6
P ₃	15.9	42.1	1.3	3.5	37.0
P ₄	0.9	53.9	0.2	1.6	43.3
P ₅	0.2	52.7	0.4	1.5	44.5
P ₆	30.4	35.4	0.3	4.3	28.9
P ₇	31.8	33.4	0.9	5.3	28.4
P ₈	0.7	53.9	1.1	1.0	43.0
P ₉	3.1	50.5	traces	1.7	41.4
P ₁₀	19.4	40.0	1.2	4.8	33.7

Table 2. Chemical composition of stucco sampling from Wat-Phra-Phai-Luang.

Analysed by : Reseach Division, Department of Science Service, Ministry of Science, Technology and Energy, Thailand

Results and Conclusion

1. The results are summarized in Tables 1 and 2.
2. The results are from comparative studies because samples were taken from different monuments, and also from various points of the same monument facing different directions-east west, north and south.
3. The major chemical components of the stucco are calcium oxide (calcium carbonate) and silica and the minor components or impurities are aluminium oxide, iron oxide, titanium oxide, phosphorus oxide and magnesium oxide.
4. The value of loss on ignition indicates high carbonates or high organic compounds contained in samples.
5. We can conclude that ancient stucco was prepared by mixing slaked lime with sand. The composition of this mixture could be changed continuously depending on a modeller. Water or some binding agents such as animal glue or gum made from sap of plants or molasses could be added to give the mixture the consistency of paste. It dried and became hard when exposed to the air by absorbing carbon dioxide and forming crystalline calcium carbonate. The calcium carbonate cemented together the particles of sand and unchanged calcium hydroxide. Many years were required for the complete conversion of the calcium hydroxide to carbonate, especially in heavy construction.

Fig 3
The second chedi in Wat Mahathat that was selected for taking samples MT 20-MT 26.

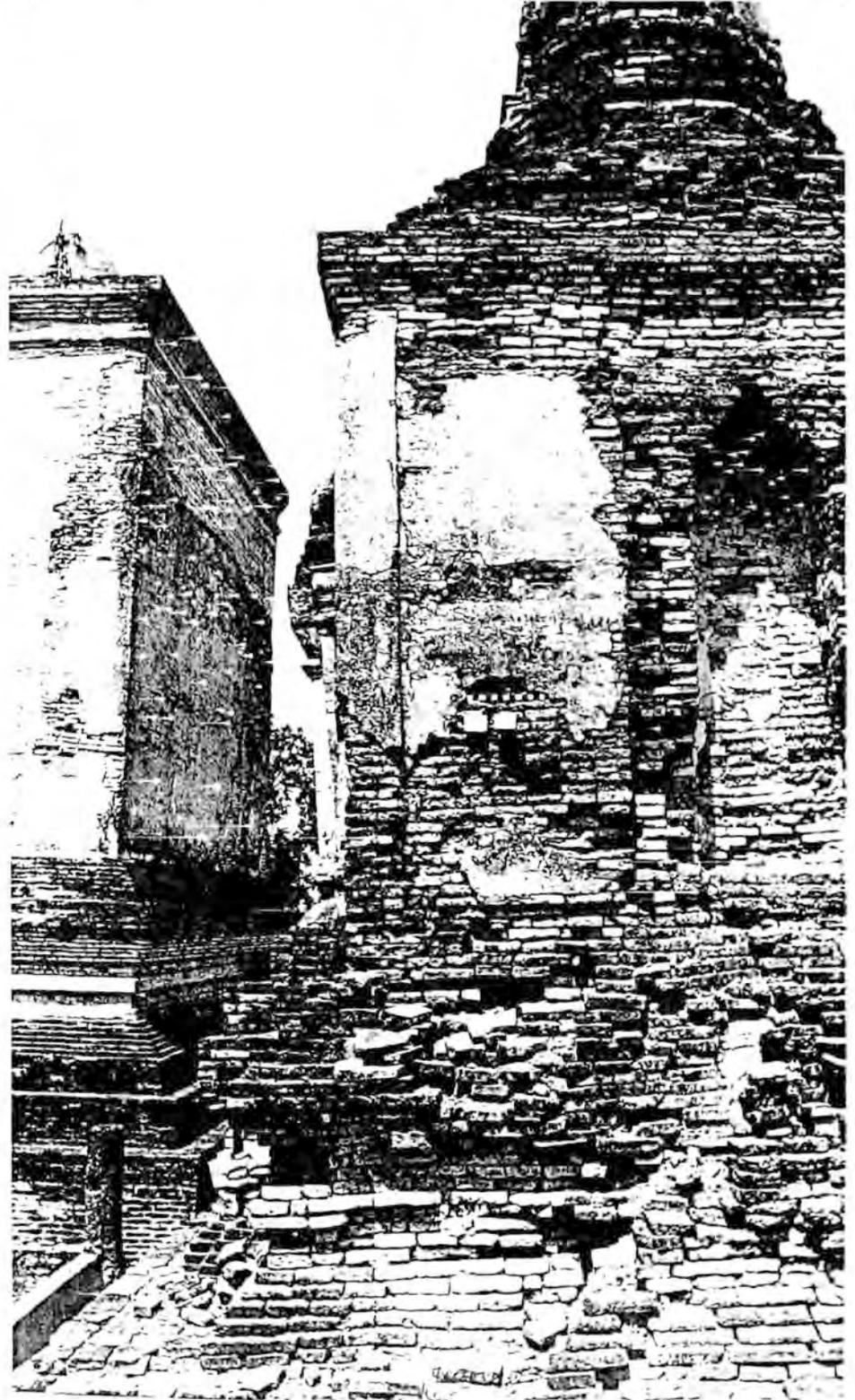
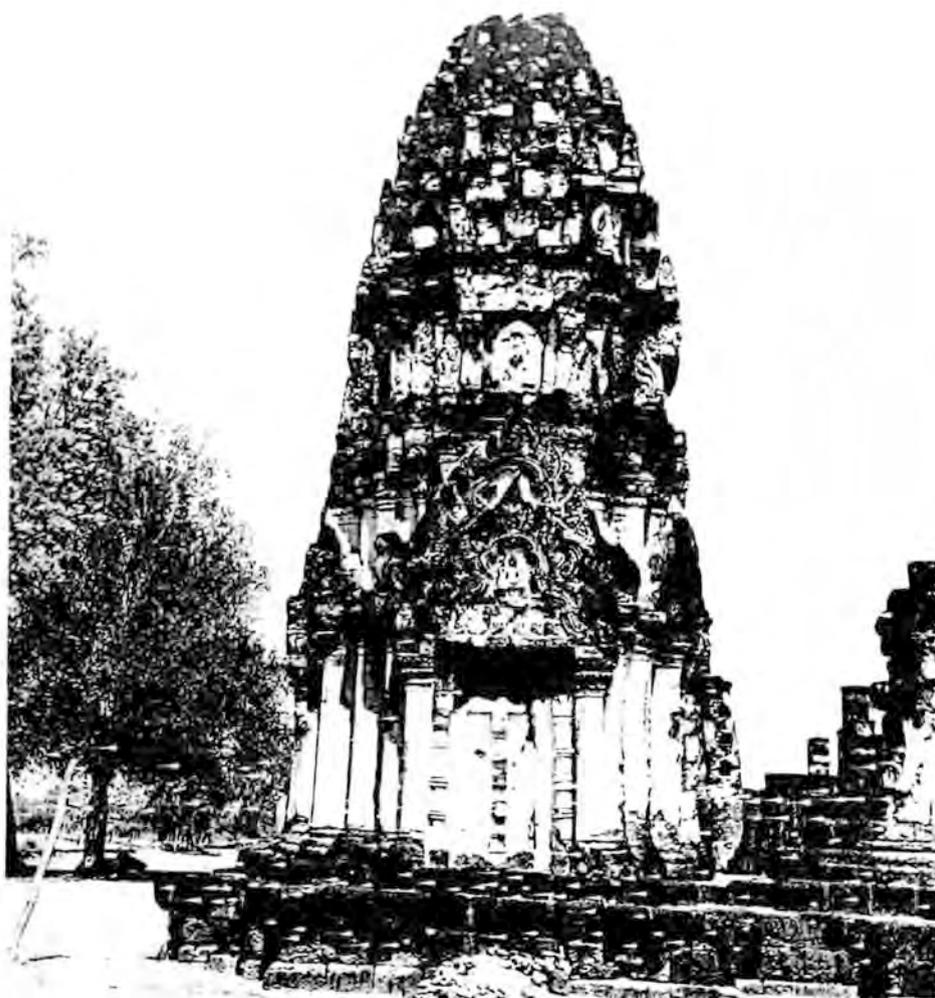


Fig 4-5
The northern prang decorated with stucco figures in Wat Phra-Phai-Luang.



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