ANALYSIS OF MOISTER MOVEMENT, PENETRATION DEPTH AND PHYSICAL PROPERTY IN THE PRELIMINARY STAGE OF STRENGTHENING LOW POROUS SANDSTONE

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In the preliminary stage of strengthening the historical important and valuable stonesurface and rendering of the monastery Limburg a. d. H. (Southern Palladium, Germany) it is necessary to find the optimal strengthener and application used by testing series on similar material. Preliminary investigation and the experience made at the building site showed the uncommon behaviour of the sandstone due to water adsorption. Long setting time for a strengthener (Motema 28), used on lowporous sandstone, was observed during the restoration of the southern portal at the dome of Worms.

Porosity, distribution of porespace and roughness of porewalls, influenced by special diagenetic effects during the geological history of the Rhinegraben (HOLZWARTH 1995), are considered for the explanation of the peculiarity of the stonematerial and possible reaction to water adsorption and strengthening. For the description of porespaces investigation on physical property (laboratory, building site), thinsection and image processing were used.

Modal mineralogical composition, water adsorption, modules of elasticity and compression strength of the untreated material are investigated with the aim to compare it with the strengthener treated material. Results of treated stone material were not available up to the deadline of the paper. Because of the consideration of climatic conditions the strengthener was applied, capillary and by saturation by end of September 95. Therefore the following report can only give prospects for the decision about what material to use at the building site, and explain the aim of the investigations.

The chemical composition (pH, Eh) and/or saturationpressure of the strengthener should be taken in account because they might effect the clay mineral structure within the porespaces and than cause e. G. migration of fines that can lead to scaling effects. Specially the pH-value conditions of thinner used in order to aid penetration by lowering the viscosity have to be well considered. This is just as well valid for agents used to fasten the gel formation time.

REFERENCES:

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MODAL MINERALOGICAL COMPOSITION OF THE STONE MATERIAL INCLUDING INTER- AND INTRAGRANULAR PORESPACES

Modal composition is one of the criteria used to find correspondence between the stone used at the building and the drillcore samples from quarries. Total correspondence is rather unrealistic. During the making out of the "Natursteinkataster" the experience is given to find the material most corresponding as possible. Several thinsections were analysed to quantify the modal mineralogical composition

Difference between inter- and intragranular porespaces is made in order to show different porespacetypes. The aim is to know as much as possible intern structures for the explanation of effects during water- and/or strengthener adsorption. Intragranular porespaces are placed within alterated components mostly potassium-feldspar or lithic fragments.

TABLE 1 Mean modal mineralogical composition of the comparable materials used for the investigation program, given in vol.-%

	Quarry n=10	Building n=4
Quartz (Mono-, Poly, Chert)	52.9	53.0
Feldspars	07.9	07.0
Lithic Fragments	14.6	12.6
Mica	---	00.3
opaque minerals	..--	00.3
authigenic Fe-oxide/hydroxide	06.0	06.9
authigenic quartz and feldspar	05.3	05.6
authigenic clay minerals (illite, kaolinite, chlorite)	01.9	02.3
intergranular porespace	09.0	09.6
intragranular porespace	02.3	02.0

RELATIONSHIP BETWEEN PORESPACES AND WATER ADSORPTION OF THE STONE MATERIAL

Drillcore samples from a nearby quarry and original buildingmaterial were investigated. By image processing porespacedistribution and -forms wereanalysed in order to find the explanation for the in general low water adsorption of the stone material.

Investigations on hygric swelling show low values < 0.125mm/m. Therefore any indication concerning the swelling of clay minerals is unlikely. Still the presence of authigenic clay mineral phases seems to take influence on water adsorption processes. This is supported by laminar changes of porespacedistribution, what can be explained by sedimentary and diagenetic events (Fig. 1).

The porespacedistributon in Fig. 1 shows different sections within one drillcore. Several different laminated parts were analysed within one series. Similar to the lamination the capillar water adsorption shows unconformities within laminated sandstone material. Damages like scaling happen preferred along these laminated zones.

The lamination influences ultrasonic waves too. Dry samples measured vertical to lamination show little slower velocity (2.69 km/sec) than parallel lamination (2.62 km/sec). The same samples totally saturated with water show decrease of velocity parallel to lamination (2.12 km/sec) and increase vertical to lamination (2.78 km/sec) measurement.

FIG. 1 Image processing of several sections within on drillcore showing the difference of porespace-distribution according to lamination. Long side of the pictures = 2,5 μm

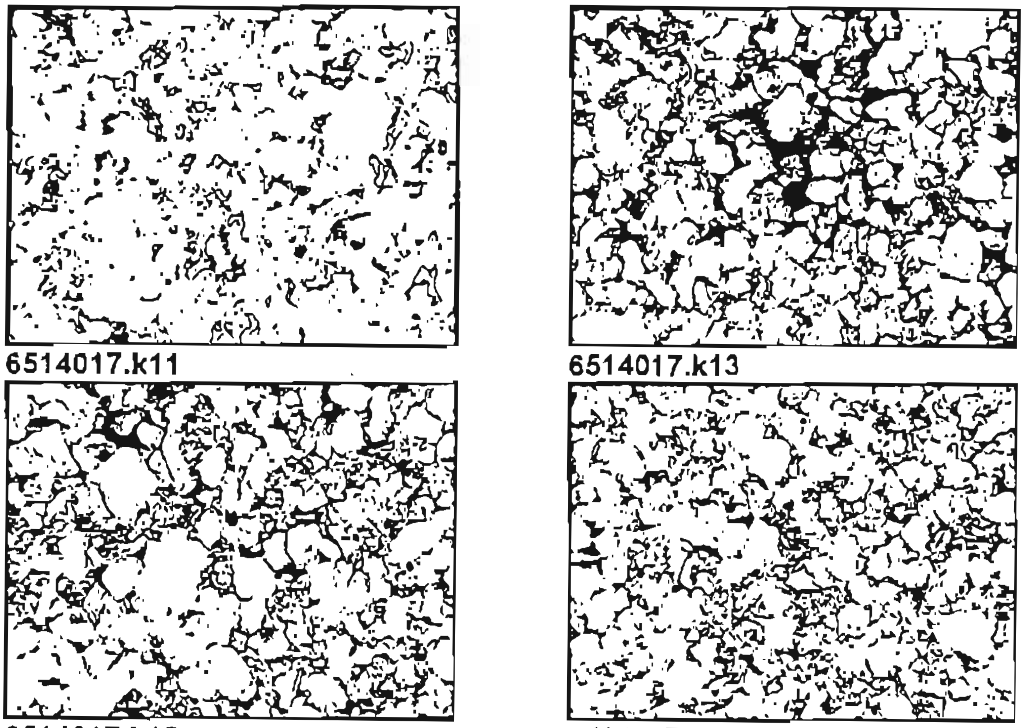

Fig. 1 Image processing of several sections within on drillcore showing the difference of porespace-distribution according to lamination. Long side of the pictures =2,5 μm

The influence of authigenic clay mineral phases is supplementary confirmed by difference in water adsorption capacity of material dried at 60° C and material dried at 105° C. All samples had to reach constant weight-% before starting the investigation program. Clay minerals within samples dried at 60° C still show intact interlayers. Radial illite morphotype e. G. doesn´t change to coating morphotype what would influence the roughness of porewalls (HOWARD, J., 1992, DEUTRICH, T., 1993).

Table 2 shows that samples dried at 60° C show lower water adsorption values than the samples dried at 105° C specially under the pressure of a vacuum pump. The pressure of the vacuum pump can cause migration of "fines". These "fines" are blocking the pore gussets. This effect has been observed measuring the permeability of similar stone material (HOLZWARTH, 1995). Change in pressure leads to blockage or flushing out of the pore gussets. The permeability of the measured material differs among 0.6 and 8 mD what is very low compared to other German sandstone varieties.

TABLE 2 Mean water adsorption under consideration of the drying temperature

T °C	W atmospheric. weight %	W vacuum weight %	Saturation S-value
60° C	5.50	6.27	0.88
105° C	4.93	8.67	0.57

Similar effect was observed at the building measuring Karsten water penetration on scales and "fresh" stone surface of the same stone block. Scaling parts with blocked porespaces show half the value of water adsorption than surface without any compression. In general the capillary water adsorption coefficient W (kg/m2/ √sec) from building and from quarry show correspondence (Table 3). This is very important interpreting the results given by the strengthener treated samples. Specially because the scaling parts of the building shall be strengthened and brought into bound with the underlying stone.

TABLE 3 Mean capillary water adsorption (Karsten) after 1800 sec

	scales building	"fresh" stone building	quarry
(kg/m2/ √sec)	0.5	1.0	1.2

PROSPECT

The investigations made on untreated stone material will be compared with the results from the same investigationprogram applied to the strengthened material.

The two strengtheners used for the mentioned investigations (Funcosil300 and Motema 28) were chosen because they facilitate to control gel formation time individual and suited to the material. For strengthening the historic rendering and the intrusion mortar of the monastery Motema 28 thinned with isopropanol and catalysed with ammonia (recipe restorer Hangleiter) was used.

For the bonding of the scaling stonesurface Motema 28 and Remmers 300 shall be used together with tüllose-net. As mentioned above Motema showed good results during the rstoration at the southern portal of the dome of Worms, where it was not fastened by ammonia.

Additional the strengthener and the materials used besides for e. G. intrusion mortar will be investigated in view of possible microbiological infestation.

The change of clay mineral morphotype will be investigated in order to see if the content and structure of clay minerals take influence on physical and chemical behaviour of the strengtheners used.

LITERATURE

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