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Damage phenomenon and salt deterioration at the Michaelis church in Zeitz (Germany)

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The Michaelis church at Zeitz represents a 10^{th} century building, whereas consistently modifications at the façade through time took place. The walls are made of regional sandstone (Buntsandstein Formation). Today the sandstone bricks show a strong decay in form of relief weathering. The main cause for the deterioration is an extreme salt attack by magnesium sulphate. The small town Zeitz is located in the neighbourhood of a brown coal district in middle Germany. In the past 200 years the coal was intensely used for energy generation in plants as well as domestic fuel in the region of Zeitz. This combustion resulted in a strong atmospheric load of SO_x, which is the main anion source of the magnesium sulphates within the masonry. The used sandstone exhibit a partly dolomitic matrix which can be regarded as the manganese source. Another distributor is possibly the used mortars which also partly formed by dolomite minerals.

The aim of the investigations at the Michaelis church was to get more information about the salt weathering depending on the salt distribution and the rock fabric. For the registration and evaluation of weathering damages the monument mapping method was applied at a selected sub area of the building. The amount of soluble salts was determined quantitatively by ion chromatography. For this purpose drilling dust samples from different depth were used. In order to identify the crystalline salt phase's x-ray diffraction was carried out. Furthermore drilling cores were taken from different weathering forms and the micro fabric, the porosity and the pore size distribution were analysed.

The sandstone bricks show severe deterioration with weathering depth up to 15 cm. The main decay phenomenon's are to different forms of relief weathering. Only of subordinate importance are dark crusts and discolorations. The first type of relief weathering is characterised by heterogeneous back-weathering, which depends on the bedding of the sandstone. The material loss is dominated by granular disintegration. For relief type I the weathering intensity is slight with up to 3 cm. The relief type II represents a modified alveolar weathering, which is characterised by deep gorges surrounded by bars, which represent the original stone surface. The gorges follow also the bedding of the sandstone and achieve back-weathering rates up to 15 cm. The material loss in the gorges is dominated by flaking to contour scaling.

The damage mapping shows, that both types of relief weathering correlate with building properties. Relief type I is located at areas of direct water action, whereas relief type II occurs in water protected exposition. The quantitative salt analyses by ion chromatography show, that the soluble salt content of magnesium sulphate of samples from relief type II is much higher than of relief type I. This clearly identifies the interaction of water flows and salt enrichment at the building. The x-ray diffraction shows that different magnesium sulphate hydrate phases are detectable. Beneath epsomite ($MgSO_4$ x hexahydrate ($MgSO_4$ x also kieserite ($MgSO_4$ x exists.

Concerning the investigations at drilling cores three samples were analysed. One originated from relief type I (core 1), one from a gorge (core 2) and one from a bar (core 3) of relief type II. In the micro fabric no significant differences are observable. The sandstone is made of primarily fine grained quartz components. The matrix is heterogeneous and consists of various amounts of dolomite, quartz and clay minerals. The ochre colour can be attributed to a slight content of iron oxide. Differences of the porosity and the pore size distribution of the samples is an indicator for increased solution/precipitation processes of relief type II.