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Drei Gleichen Area (Germany/Thuringia): Petrology, petrophysics and weathering phenomena of dimension stones

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The construction suitability of a dimension stone in general depends on its weathering properties, which go along with the petrology and petrophysical properties. The aim of this study was threefold: (1) to determine the petrological, petrophysical and weathering properties of the regional mined dimension stones from the "Drei Gleichen" area (Germany/Thuringia), (2) to investigate the relation between petrological and petrophysical properties and their depositional and diagenetic condition for natural dimension stones as well as (3) to evaluate the suitability of the analysed rocks for construction and replacement purposes. We analysed six sandstones (Ingersleben, Wachsenburg, Hindfelden, Seeberg, Röhnberg, Gleichenberg) as well as two carbonates (Wachsenburg sinter, Wandersleben dolomite), which are regional mined as dimension stones and record a broad range of depositional and diagenetic conditions. All rocks are from the Thuringian Basin and are, with one exception, Keuper (Triassic/ Upper Ladinium-Rhatium) in age. Analyses were focused on the detailed mapping of deterioration phenomena in the field as well as on determination of mineralogical composition, fabric, pore space-, water balance-, strength- and weathering properties.
Our results show, that stratigraphical and compositional very similar or equal rocks can show major differences in their petrophysical and weathering properties (e.g. Seebergen, Röhnberg, Gleichenberg). We attribute these differences to their different diagenesis, resulting e.g. in varying pore space- and water balance properties. The porosity evolution of the six sandstones investigated in this study can be classified into mature and immature rocks: The Seebergen, Gleichenberg, Röhnberg and Wachsenburg Sandstones represent quartz-arenites to subarkoses and are characterized by a pronounced textural and compositional maturity, sandstones from Hindfelden and Ingersleben are litharenite in composition and compositionally immature. Pore size distribution can be divided into four types: i) unimodal with one maximum in the range of macropores (Wandersleben Dolomite, Ingersleben, Gleichenberg Sandstone), ii) unequal unimodal with one maximum in the range of capillary pores (Wachsenburg sandstone), iii) unequal bimodal (Hindfelden sandstone) and iv) unequal unimodal with one maximum in the range of macropores (Seebergen, Röhnberg Sandstone). The ability for capillary water uptake, saturation degree as well as sorption of the rocks strongly depends on the porosity as well as on type of mentioned pore size distributions. The strength of the sandstones depends on porosity (medium pore radii), the grain contact and cementation, whereas the strength of the two carbonates is, beside the amount of porosity and micritic/sparitic areas, controlled by the heterogeneous distribution of large pores. These compositional and petrophysical differences also result in a high difference of weathering properties. The decay phenomena observed during salt attack tests are different in shape and intensity, and are also specific for each rock. Furthermore quartz-rich rocks (Rät sandstones) show only slight moisture expansion, whereas rocks with a high content of altered lithoclasts are characterised by large values of moisture expansion.
From the analysed sandstones only the Seebergen Sandstone is suitable for construction purposes due to its good availability, suited strength properties as well as a low porosity. Also the Wachsenburg Sandstone shows suitable petrophysical and petrological properties, but exploitable deposits are too sparse to be of commercial interest. From the carbonates, the Wachsenburg Sinter exhibits suitable properties (e.g. high strength, low water uptake), but also only sparse outcrops, which are not suitable for mining.