



Statistical analyses on sandstones: Systematic approach for predicting petrographical and petrophysical properties

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Sandstones are a popular natural stone due to their wide occurrence and availability. The different applications for these stones have led to an increase in demand. From the viewpoint of conservation and the natural stone industry, an understanding of the material behaviour of this construction material is very important. Sandstones are a highly heterogeneous material. Based on statistical analyses with a sufficiently large dataset, a systematic approach to predicting the material behaviour should be possible. Since the literature already contains a large volume of data concerning the petrographical and petrophysical properties of sandstones, a large dataset could be compiled for the statistical analyses. The aim of this study is to develop constraints on the material behaviour and especially on the weathering behaviour of sandstones. Approximately 300 samples from historical and presently mined natural sandstones in Germany and ones described worldwide were included in the statistical approach.

The mineralogical composition and fabric characteristics were determined from detailed thin section analyses and descriptions in the literature. Particular attention was paid to evaluating the compositional and textural maturity, grain contact respectively contact thickness, type of cement, degree of alteration and the intergranular volume. Statistical methods were used to test for normal distributions and calculating the linear regression of the basic petrophysical properties of density, porosity, water uptake as well as the strength. The sandstones were classified into three different pore size distributions and evaluated with the other petrophysical properties. Weathering behavior like hygric swelling and salt loading tests were also included. To identify similarities between individual sandstones or to define groups of specific sandstone types, principle component analysis, cluster analysis and factor analysis were applied.

Our results show that composition and porosity evolution during diagenesis is a very important control on the petrophysical properties of a building stone. The relationship between intergranular volume, cementation and grain contact, can also provide valuable information to predict the strength properties. Since the samples investigated mainly originate from the Triassic German epicontinental basin, arkoses and feldspar-arenites are underrepresented. In general, the sandstones can be grouped as follows: i) quartzites, highly mature with a primary porosity of about 40%, ii) quartzites, highly mature, showing a primary porosity of 40% but with early clay infiltration, iii) sublitharenites-lithic arenites exhibiting a lower primary porosity, higher cementation with quartz and Fe-oxides ferritic and iv) sublitharenites-lithic arenites with a higher content of pseudomatrix. However, in the last two groups the feldspar and lithoclasts can also show considerable alteration. All sandstone groups differ with respect to the pore space and strength data, as well as water uptake properties, which were obtained by linear regression analysis. Similar petrophysical properties are discernible for each type when using principle component analysis. Furthermore, strength as well as the porosity of sandstones shows distinct differences considering their stratigraphic ages and the compositions. The relationship between porosity, strength as well as salt resistance could also be verified. Hygric swelling shows an interrelation to pore size type, porosity and strength but also to the degree of alteration (e.g. lithoclasts, pseudomatrix). To summarize, the different regression analyses and the calculated confidence regions provide a significant tool to classify the petrographical and petrophysical parameters of sandstones. Based on this, the durability and the weathering behavior of the sandstone groups can be constrained.

Keywords: sandstones, petrographical & petrophysical properties, predictive approach, statistical investigation