TRANSFERABILITY FROM PURE METAPHASES TO CALCINED COMMON CLAYS – NEW INSIGHTS INTO PARTICLE PROPERTIES AND PREDICTION MODELS

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1. Introduction

Clays exhibit an enormous variety of paragenesis with complex mineralogy. This leads combined with the calcination and grinding to individual physical properties of calcined clays, which significantly affect their suitability as SCM: while calcined kaolinitic clays generally show a higher reactivity [1], they stronger reduce the flowability than those dominated by 2:1 phyllosilicates [2]. For application in concrete, it is crucial to evaluate the physical parameters of calcined clays and how they influence, in particular, the properties of the fresh state. A finer particle size is often correlated to a higher specific surface area and water demand, but a comparative assessment of parameters is missing, especially considering different types of clays.

2. Materials & methods

This study correlates the median particle size (d_{50}) obtained by static laser scattering (ISO 13320:2020) and the specific surface area according to the BET method (DIN ISO 9277:2014), such as the water demand as determined according to Puntke for different calcined clays with a focus on their dominating phyllosilicate. The classification is given in Table 1. The measured parameters are further compared to values that were calculated from the properties of pure materials (metakaolin, metaillite, metamuscovite and quartz powder) and their normalized content [wt%] in the respective clay. These results are not presented here due to limited space. Detailed analysis of 78 calcined clays stems from two research groups from Argentina and Germany and can be provided on demand. All clays were calcined at temperatures for optimum reactivity and the calcination temperature itself has a significant impact on physical parameters besides the type of phyllosilicate [3]. Origin, calcination procedures and grinding process, however, differ significantly and rather demonstrate the wide variety of “ready-to-use” calcined clays.

Table 1 Classification of calcined clays based on their main phyllosilicate (normalized content)

Class	Main phyllosilicate and further essential information
Kaolinitic	Kaolinite > 45 wt% (hd = highly disordered)
Moderate kaolinitic	Kaolinite 20 – 45 wt%, significant amounts of 2:1 phyllosilicates and quartz
Illitic	Kaolinite < 20 wt%, Illite > 35 wt%, quartz as the third main phase
Smectitic	Smectite > 35 wt%, quartz as the second main phase, minor kaolinite content
Micaceous	Muscovite (mica) > 35 wt%, quartz as the second main phase

3. Results & discussion

The BET specific surface area of calcined kaolinitic clays increases with finer particle size with values around 40 m²/g for highly disordered kaolinite [4], whereas the opposite trend is observed for other kaolinitic clays (Figure 1a and b). For calcined clays with moderate kaolinite content, the BET values are mostly < 10 m²/g despite fine particle size and fairly high phyllosilicate content. Calcined illitic clays, but especially pure metaillite, possess a tremendously high BET with increasing phyllosilicate content, regardless of the median particle size. Compared to this, calcined smectitic and micaceous clays have a lower BET at comparable fineness and phyllosilicate content. It hence necessitates a further differentiation between 2:1 phyllosilicate dominated clays. The water demand depends neither only on the median particle size and no trend is observed for calcined kaolinite-rich or moderate kaolinitic clays (Figure 2a). These types of clays rather appear as point clouds and show a water demand range of 28 – 52 wt% at d_{50} < 30 µm.

Those calcined illitic clays with water demand < 30 wt% contain 50 wt% phyllosilicates (Figure 2b) and significant proportions of quartz, that has an extremely low water demand due to its smooth surface.

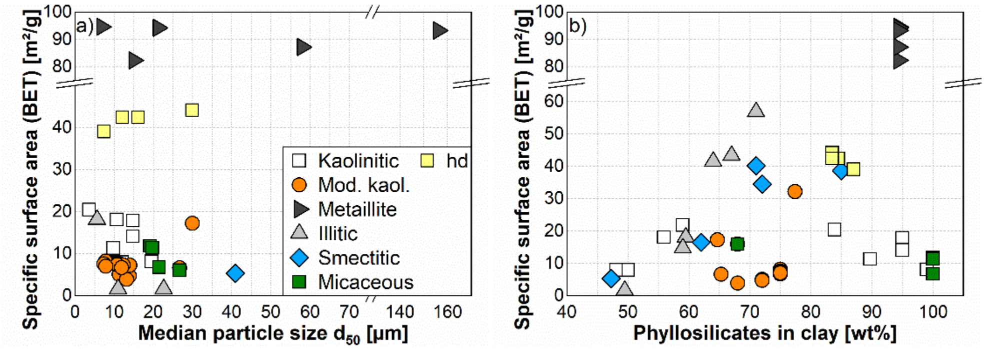

Figure 1 Correlation of a) the median particle size and b) phyllosilicate content in clay with the BET specific surface area

The calcined 'pure' illitic clays have a higher water demand, which hardly changes with $d_{50} > 20$ µm. Calcined 'pure' micaceous clays possess the highest water demand of all calcined clays. The sample, that has a water demand of 40 wt%, contains in total 65 wt% phyllosilicates. Figure 2b demonstrates that the water demand rather increases with higher phyllosilicate content, where the influence of the types of phyllosilicates, especially micaceous clays, needs to be emphasized.

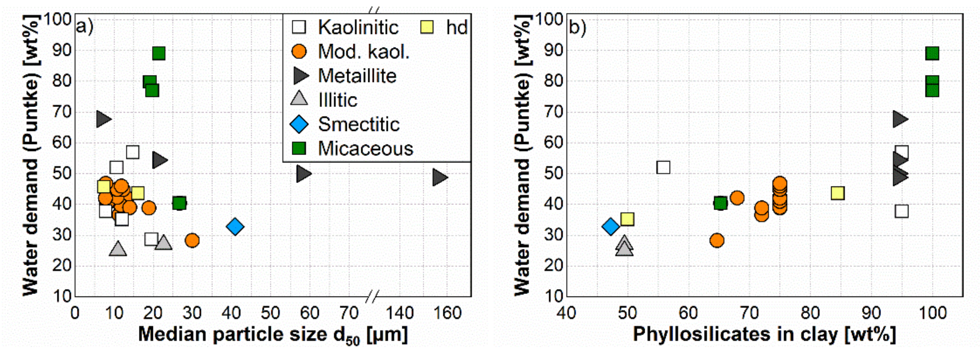

Figure 2 Correlation of a) the median particle size and b) phyllosilicate content in clay with the Puntke water demand

4. Conclusion

The curated data demonstrate the need to analyze calcined clays towards mineralogical composition and physical parameters. The particle size plays here a subordinate role as it does not necessarily influence typical physical parameters, like BET specific surface area or water demand. In fact, the total phyllosilicate content and type of dominating phyllosilicate needs to be considered when using calcined clays as SCM.

Keywords: particle size; phyllosilicates; specific surface area; water demand;

5. References

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