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Application of a rapid methodology for preliminary appraisal of kaolinite deposits

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Abstract. An approach that facilitates the mineralogical-compositional analysis and beneficiation-classification procedure was used for fast assessment of the evaluation possibility of kaolin deposits. The approach was applied on two different kaolin deposits from the Aegean region in Turkey. The kaolin samples were characterized using XRD and XRF analyses to determine the key mineralogical characteristics and major components such as Al_2O_3. The samples were then subjected to the attrition-scrubbing-hydrocycloning procedure to identify the -2 μm matter yielding potential and undesired +10 μm particle contents. Through this fast methodology, it was found that Al_2O_3 content of both deposits were below the acceptable limits and both reserves consisted of alunite as an undesired component in kaolin. The XRD analysis of attrition scrubbing-hydrocycloning products showed the cyclone overflow fractions, which were relatively finer in size, were enriched in terms of kaolinite content. The extent of +10 μm particles in the cyclone overflows was within acceptable limits for both deposits. However, the critical -2 μm matter content was found to be extremely low in the cyclone overflows. The findings confirmed the benefit of this fast methodology to make a quick decision regarding the potential of any kaolin deposit: whether to eithr continue with further verifications through specific tests/analyses or to end the assessment in case of an unpromising deposits, as those investigated in this work.

1 Introduction

Kaolin, white clay composed of mineral kaolinite ($Al_2Si_2O_5(OH)_4$), is primarily used in paper manufacturing and, to a lesser extent, in ceramics, paint, rubber and plastics industries. The content of Al_2O_3 in the kaolin sample and the amount of -2 μm and +10 μm sized particles obtained after beneficiation of kaolin are the three important criteria considered for the preliminary evaluation of a kaolin deposit and for determination of marketable kaolinite product content [1].

Generally, for obtaining products with acceptable quality, Al_2O_3 content should be between 35 to 40% in the kaolin deposit and in some cases 30% of Al_2O_3 may also be considered as sufficient. The amount of -2 μm material directly indicates the quality of the kaolin deposits and the required extent of -2 μm differs with respect to the utilization area. Similarly, the tolerable percentage of undesirable +10 μm sized particles varies with respect to the end use of kaolin. Roughly, the limits for -2 and +10 μm particles with respect to utilization area of are given in Table 1.

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Table 1. Acceptable limits of -2 μm and +10 μm material amount from a kaolin deposit.

Particle Size	Acceptable limits in different industries (%)			
	Filler (paper)	Coating (paper)	Ceramics	Paint
-2 μm	25-60	75-95	40-85	15-70
+10 μm	6-25	0-6	1-20	1-30

Depending on the area of usage a vast number of tests would be required to justify the kaolin deposit as a potentially promising reserve. However, these tests are specific, extremely time consuming and expensive. These tests may also require a sophisticated equipment and expertise. In this respect, such tests should be conducted only if the kaolin deposit of question could qualify from the above mentioned three major pre-requisites, i.e. the extent of Al_2O_3, the amount of -2 and +10 μm particles. The mineralogical characteristics and chemical composition may also be evaluated along with these three criteria for a better idea regarding the potential quality of products from a kaolin deposit.

This study aims to introduce a systematics for a preliminary evaluation of the kaolinite deposit. Based on the results achieved from this methodology, the necessity for more specific and detailed tests, related to the anticipated utilization area, could be justified, i.e. if positive indications cannot be achieved from these preliminary tests, further steps and sophisticated evaluations become obsolete.

2 Material and methods

In this work, a methodology is facilitated that consists of the XRD/XRF analyses for mineralogical and compositional diagnosis, and attrition scrubbing-hydrocyclone classification procedure [1], is facilitated for determining the -2 and +10 μm yielding potential of the kaolin deposits. This methodology is tested on two different kaolin deposits from the Aegean region of Turkey. The exact name and location of the deposits were not disclosed due to commercial restrictions and coded as K1 and K2 in the text. Firstly, the K1 and K2 samples were subjected to controlled size reduction to 80% of -75 μm, followed by XRF and XRD analyses and attrition scrubbing-hydrocyclone classification application. Attrition scrubbing is highly effective in breaking up and releasing kaolinite particles from relatively harder phases. Pulps including 10% kaolin samples (by weight) were prepared and subjected to attrition scrubbing for 10 hours. Subsequent classification, using a laboratory scale hydrocyclone, yielded overflow (finer) and underflow (coarser) products. These products were further subjected to a laser size analysis to determine the extent of -2 and +10 μm particles. In addition to the feed, the overflow and underflow products of classification were analyzed in terms of chemical composition and mineralogy and the results were compared to the feed.

Table 2. Compositional analysis results and loss on ignition values of kaolin deposits.

Sample	LOI (%)	Al_2O_3 (%)	Fe_2O_3 (%)	CaO (%)	Cl (ppm)	MgO (%)	K_2O (%)	SiO_2 (%)	Na_2O (%)	TiO_2 (%)
K1	7.96	14.97	0.56	0.22	1310	0.11	0.16	74.55	0.01	0.5
K2	8.35	15.22	0.48	0.17	1293	0.05	0.35	72.80	0.06	0.5

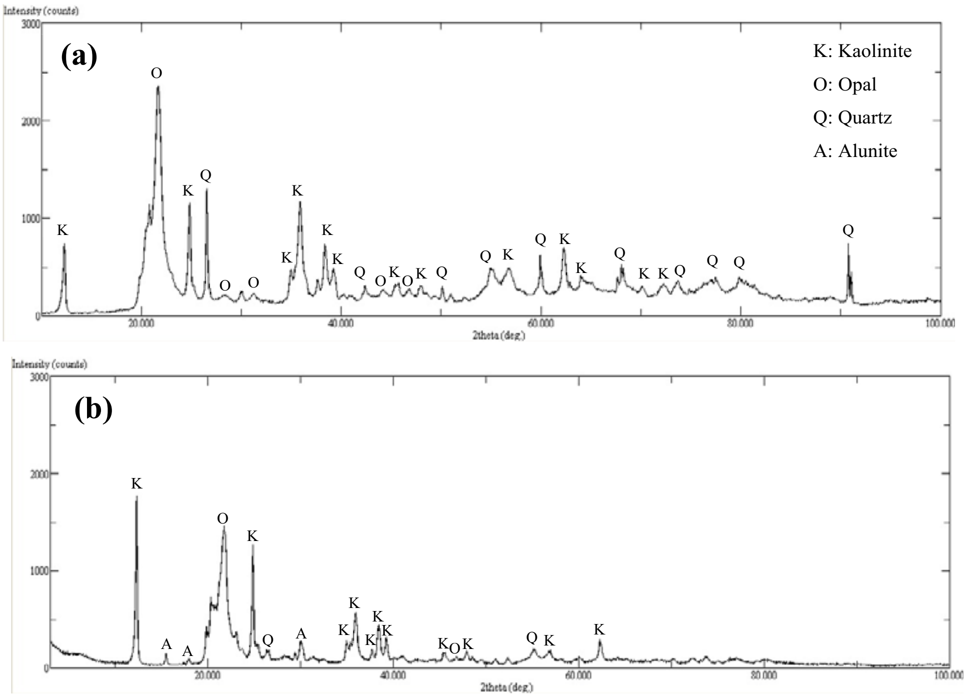

Figure 1. X-ray diffractograms of K1 kaolin: a) original sample b) cyclone overflow.

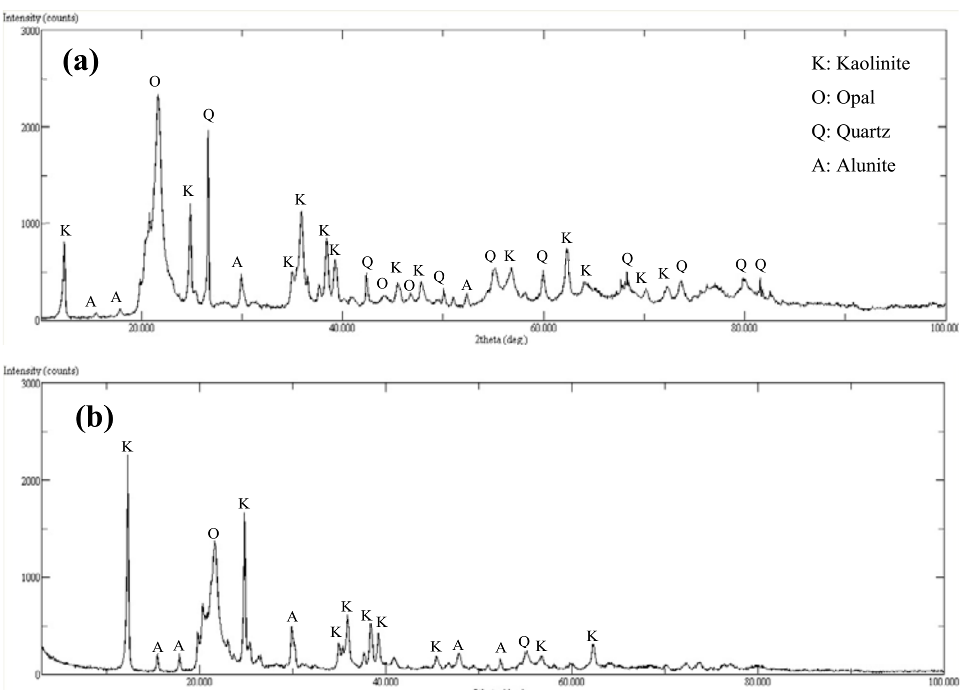

Figure 2. X-ray diffractograms of K2 kaolin: a) original sample b) cyclone overflow.

3 Results and discussion

XRD analysis revealed that K1 sample mostly consists of quartz (SiO_2) and opal ($SiO_2 \cdot nH_2O$) minerals, and additionally contains kaolinite ($Al_2Si_2O_5(OH)_4$ (Fig. 1a). In terms of chemical composition determined by the XRF analysis (Table 2), K1 kaolin is principally composed of SiO_2 (74.55%) and Al_2O_3 (14.97%). The only clay mineral detected in this sample is kaolinite, therefore, the amount of Al_2O_3 could be linked to kaolinite content (Fig. 1a). Similar to K1, quartz (SiO_2) and opal (SiO_2nH_2O) are the major minerals in the K2 sample (Figure 2.a). The only difference is the presence of alunite ($KAl_3(SO_4)_{2.}(OH)_6$) in K2, in addition to kaolinite ($Al_2Si_2O_5(OH)_4$) as the minor minerals. Chemically, SiO_2 (72.80) and Al_2O_3 (15.22) are the most dominant constituents of the K2 kaolin (Table 2). Contrary to K1, Al_2O_3 cannot be directly correlated with kaolinite, since alunite is another clay mineral observed in K2 (Fig. 2a). The mineralogical and compositional analyses of phase showed that Al_2O_3 content in both kaolin reserves were below 30%, indicating that these two reserves were unlikely to be promising deposits even before investigating the -2 µm particles yielding potential of these two reserves.

After attrition scrubbing-hydrocyclone classification, the XRD analysis of the overflow of K1 sample showed that the extent of kaolinite and alunite increase, while quartz and opal minerals were hardly observed (Fig. 1b). This suggests that attrition scrubbing contributes to the release and liberation of clay-rich entities from harder phases and relatively finer overflow product of cycloning became enriched with respect to clay entities. Despite this, the laser size analysis pointed to very low extent of -2 µm material in the overflow product. The -2 µm particles in K1 were only 1.73% (by weight) of the total feed introduced to the scrubbing stage (9.12 % of the cyclone feed). The amount of +10 µm material in the K1 cyclone overflow corresponded to 5.16% (by weight) of the cyclone feed.

From the mineralogical point of view, the K2 sample was quite similar to K1. Attrition scrubbing-classification resulted in relative enrichment of kaolinite and alunite in the cyclone overflow and quartz and opal became almost unrecognizable (Fig. 2b). The extent of -2 µm particles in the cyclone overflow was again quite limited and corresponded to only 2.62% (by weight) of the total attrition scrubbing feed (14.29 % of the cyclone feed). The size fraction +10 µm material in the overflow was 2.39 % (by weight) of the cyclone feed.

Overall, it was seen that the K1 and K2 samples had quite low potentials in terms of yielding -2 µm material, despite favorable +10 µm particles content. The XRD analysis indicated the alunite content in both kaolin samples (Figs. 1 and 2), which was another obstacle against potential utilization of these deposits.

4 Conclusions

The analytical work and lab other studies showed that assessment of kaolin samples by relatively simple mineralogical-compositional analysis and beneficiation-classification procedure, as given elsewhere [1], was a highly applicable and time-saving methodology for preliminary assessment of reserves. The results attained from this methodology allowed the decision for either conducting further tests or leaving the deposit aside without wasting time and financial resources for potentially exploitable kaolin reserves.

Reference

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