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Beneficiation of kaolin deposits from Telaga Air and Telagus, Sarawak

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Abstract: Two kaolin deposits from the state of Sarawak were beneficiated using a laboratory hydrocyclone. The chemical, mineralogical and physical characteristics of the clays before and after a single pass through the hydrocyclone were studied. A comparison was made with a few kaolins from various sources. The Sarawak kaolin deposit from Telaga Air is reported to be derived from weathering of dacitic sills or dykes whilst the Telagus deposit is believed to be derived from sediments of the Sadong Formation. The main constituent minerals in both deposits are kaolinite and quartz, whilst the minor constituents are micaceous materials and feldspar. The hydrocyclone process is found to be very successful in the production of clay of finer particle-size distribution, increase the brightness values, removal of impurities such as feldspar and mica, and chemically increase the Al_2O_3 and reduce the SiO_2 (quartz) contents for both kaolins from Sarawak. It was found that with only a single run of the hydrocyclone process, the quality of both Sarawak kaolin samples are almost of the same quality as compared to commercial kaolin from overseas (except for the alumina content) but of better quality compared to a product from many of the local kaolin manufacturers. The analysis result indicated that both kaolin deposits in Sarawak offer a very promising potential to be mined and processed for high end quality products.

Abstrak: Dua longgokan kaolin dari Sarawak telah dibuat pencirian dengan menggunakan satu cara hidrosiklon bersaiz makmal. Kreteria-kreteria kimia, mineralogi dan fizikal bagi lempung sebelum dan selepas melepasi peringkat pertama melalui cara hidrosiklon telah dikaji. Satu perbandingan telah dibuat dengan beberapa jenis kaolin daripada pelbagai sumber. Longgokan kaolin dari Telaga Air di Sarawak telah dihasilkan melalui proses lulohawa intrusif sil batuan dasit atau dik manakala longgokan dari kawasan Telagus dipercayai berasal dari endapan Formasi Sadong. Kandungan mineral utama bagi kesemua longgokan adalah kaolinit dan kuarza, sementara kandungan secara minor terdiri dari bahan-bahan bermika dan feldspar. Proses hidrosiklon didapati sangat berjaya dalam penghasilan lempung dengan taburan saiz butiran halus, menambahkan nilai kecerahan, memisahkan benda-benda asing seperti feldspar dan mika.Secara kimia, ini menambahkan kandungan Al_2O_3 dan mengurangkan kandungan SiO_2 (kuarza) untuk kedua-dua jenis kaolin dari Sarawak. Didapati dengan hanya melepasi saringan peringkat pertama proses hidrosiklon, kualiti bagi semua sampel kaolin dari Sarawak kebanyakan nya mempunyai kesamaan kualiti dengan kemersial kaolin dari luar negara (kecuali untuk nilai alumina) dan menghasilkan kualiti yang lebih baik kalau dibandingkan dengan kebanyakan produk daripada pengeluar-pengeluar tempatan. Keputusan kajian, menunjukkan kedua-dua longgokan kaolin di Sarawak berpotensi untuk diekploit dan diproses untuk menghasilkan produk-produk hiliran yang sangat berkualiti.

INTRODUCTION

Kaolin is a term used to describe white or nearly white non-plastic clay composed essentially of kaolinite, $Al_2O_3.2SiO_2.2H_2O$. Millions of tons of these clay deposits are used annually in a very large variety of application. Kaolin of premium grades is used for paper coating and special ceramic applications such as the manufacture of fine tableware, porcelain bone china and electrical insulators. The normal grade kaolin is used in making ceramic pottery and utilized as fillers and extenders in the plastic, paper, paint and rubber industries. In Malaysia, kaolin of filler and extender grade are the most common grade of kaolin produced (JMG, 2002).

The total production of kaolin in Malaysia for 2000 was 233,885 tonnes. Eighty percent (80%) of this was from Tapah-Bidor area. Sarawak produced less than one percent (434 tonnes) of the total Malaysian production for the same year. There were 24 active kaolin producers in 2000. The state of Perak has the most number of producers (18 producers), followed by Johor (2), Selangor (1), Kelantan (1), Pahang (1) and Sarawak (1). The smaller operators sold the crude (unprocessed) kaolin to the traditional ceramic manufacturers. The price of kaolin in 2000 ranged from RM25 to RM80 per tonne for crude kaolin, and RM50 to RM400 per tonne for processed kaolin (JMG, 2001).

This paper describes the beneficiation of kaolin from Telaga Air (TA) and Telagus (TE) using a laboratory scale hydrocyclone. The hydrocyclone process is selected and used for this study. It is more efficient in concentrating the kaolinite mineral and is much more commonly used commercially (Bloodworth *et al.*, 1993). The chemical, mineralogical and physical characteristics of the raw clay and the products (underflow and overflow) are studied. Besides that, comparison was also made with commercial products from local and overseas sources. The data presented was gathered from one single pass through the hydrocyclone.

LOCATION AND GEOLOGY OF THE STUDY AREAS

The Telaga Air kaolin deposit is located 20 kilometres northwest of Kuching City and the site is easily accessible by the Matang-Kuching Road and the Telagus deposit is about 180 km south-east of Kuching City and situated at the 77th mile Kuching – Sri Aman trunk road (Fig. 1).

The TA area is underlain by the Pedawan Formation and the Kayan Sandstone. The kaolin in this area is probably derived from intense weathering of Tertiary dacitic sills or dykes. The TE area is underlain by argillaceous and tuffaceous sediments of the Sadong Formations which are mainly arkose, subarkose and shale with minor amounts of acid to basic volcanic rocks. Subsequently, the kaolin in this area is believed to be derived from intense weathering of these materials (Grubb, 1972).

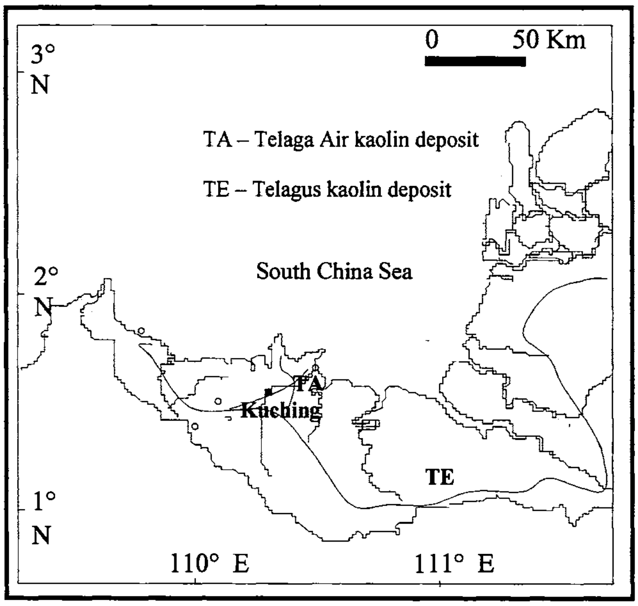

Figure 1. Location map of the study areas.

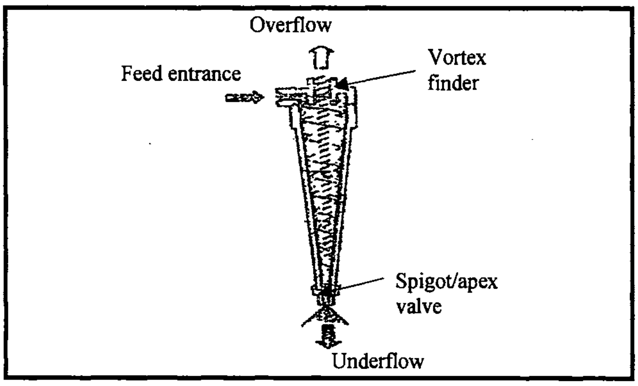

Figure 2. Hydrocyclone for beneficiation.

SAMPLES AND METHODS

All the representative kaolin samples used in this study were collected from the TA and TE kaolin deposits; two samples from TA and two samples from TE.

The laboratory hydrocyclone model that was used in this beneficiation is a Mozley hydrocyclone Cornwall TR 15 ISS as shown schematically in Figure 2. The vortex finder (overflow) is 5.5 mm and the spigot/apex valve (underflow) is 3.2 mm.

The raw kaolin samples were first air-dried under the sun for two days. A small portion of the undisturbed sample was taken from every sample for microstructural investigation. After that the rest of the sample was poured into a bucket with water and stirred to produce a slurry (kaolin and water) with 10% solid content before beneficiation using the hydrocyclone. The slurry was then poured into the hydrocyclone tank and left to flow for a few minutes to get a uniform flow before conducting the actual test run. For the test, the pressure was adjusted to 50 psi and the hydrocyclone was left to run for a few minutes before the underflow and overflow samples were taken out. The samples were then dried in an oven at 50°C before weighing for the dry weight.

The samples were also analysed for particle size distribution, surface area, brightness values, chemical and mineralogical contents. The particle size distribution analysis was carried out using a Micromeritics (model Sedigraph 5100) particle size analyzer and surface area was observed by N_2BET method with micromeritics Flowsorb II 2300. Chemical analysis of the raw and beneficiated samples were determined using a Philips PW 1480 x-ray fluorescence spectrometer whilst the mineralogical analysis was performed on a Philips PW1010 diffractometer. Brightness test was carried on an Elrepho equipment using wavelength of 457 nm and $BaSO_4$ standard.

RESULTS AND DISCUSSION

The particle size analysis results of the two kaolin deposits is shown in Table 1. The raw kaolin from TA (TA1 & TA2) has 15-18 wt% of clay with particle size < 2 µm, 39.5 to 45.5 wt.% of clay particles <10 µm and 56.5 to 63.0 wt.% of clay particles < 20 µm. After beneficiation, about 45.2 to 42.7 % of the overflow consist of clay particles that are < 2 µm. The comparison of the clay samples before and after beneficiation is shown in Table 1.

After beneficiation the kaolins from TA and TE have higher percentage of < 10 µm fraction compared to the product from Kaolin M'sia Sdn. Bhd., ECC (Grolleg; earthenware and tableware) and ECC (Remblend: Sanitaryware) except for the ECC (super standard porcelain). The overflow recovery of the TA kaolin ranges

Table 1. Particle size distribution of kaolin from TA,TE and other sources (*Sources: Bloodworth *et al.*, 1993).

Area	Samples		Particle size distribution(µm)			Recovery (%)
			< 20	< 10	< 2	
TA 1	Raw		56.5	39.5	18	-
	Beneficiated	Overflow	99.1	97.1	45.2	36
		Underflow	67.0	40.2	8.5	59
TA 2	Raw		63.0	45.5	15	-
	Beneficiated	Overflow	98.3	96.3	42.7	29
		Underflow	69.5	37.3	3.8	64
TE 1	Raw		45.1	37.3	14.1	
	Beneficiated	Overflow	99.3	99.0	57.6	20
		Underflow	31.8	22.9	9.0	78
TE 2	Raw		76.9	69.7	47.5	
	Beneficiated	Overflow	99.6	99.1	75.6	58
		Underflow	N.A	N.A	N.A	37
Kaolin M'sia Sdn. Bhd.	Ceramic grade		83.0	61.0	22.0	15 to 20
	Filler grade (plastic & rubber)		91.0	82.0	32.5	15 to 20
*English China Clay (ECC)	Super standard porcelain; high quality tableware, porcelain& bone china		N.A	99	85	-
	Grolleg; earthenware & tableware		N.A	90	57	-
	Remblend: Sanitaryware		N.A	80	40	-

Table 2. Surface area values of kaolin from Sarawak and other known kaolin (*Sources: Bloodworth *et al.*, 1993).

Areas/products	< 2 µm (%)	Surface area (m²/g)
Telaga Air / TA 1	45.2	12
Telaga Air / TA 2	42.7	10
Telagus / TE 1	57.6	14
Batang Padang / BP	55.4	13
Kaolin M'sia (filler grade)	32.5	9
*SPS (paper coating)	-	13
*Filler M (paper filler)	-	10

from 29 to 36% and the TE kaolin is from 20% to 58%. These recovery figures are higher compared to the recovery as reported by Kaolin M'sia Sdn. Bhd. This can be attributed to two main factors, i) the kaolin deposits in Sarawak are of better quality as compared to that of Bidor and ii) due to difference in efficiency between the laboratory and industrial hydrocyclones.

The surface area of all the kaolin samples ranges from 9.11 to 14.66 m^2/g and the values increase as the particle size of the kaolin decreases. Table 2 gives the surface area values of the kaolin from Sarawak as compared to other known kaolin.

The chemical composition of the two kaolin deposits in Sarawak and some products from other sources is shown in Table 3. The SiO_2 content in both Sarawak kaolin samples decreases after beneficiation and ranges from 46 to 49%. The Al_2O_3 content of TA kaolin after beneficiation ranges from 36 to 38% whilst the TE kaolin ranges from 33 to 38%. When compared to the ECC clays the Al_2O_3 content of both Sarawak kaolin deposits are considered to be slightly lower except for samples TA2 and TE1. But of particular significance are the lower content of Fe_2O_3 and the higher content of K_2O in both Sarawak deposits as compared to the product from Kaolin M'sia Sdn. Bhd. and all the products from ECC.

The kaolin samples from Sarawak consist kaolinite, quartz and micaceous mineral. Trace amount of feldspar is also detected in both kaolin samples but trace amount of gibbsite is only detected in the Telagus deposit (Table 4).

The brightness of the two kaolin deposits (raw and beneficiated) is listed in Table 5. By comparing the brightness values of the two kaolin deposits, it is observed that the brightness values of the overflow fraction for the kaolin from both Sarawak deposits is much higher compared to the brightness values of the kaolin from Kaolin M'sia Sdn. Bhd. As a matter of fact, even the underflow fractions from TA 1 and TE 1 samples are comparable if not better than the filler grade kaolin from Kaolin Malaysia Sdn. Bhd.

CONCLUSIONS AND RECOMMENDATION

A simple hydrocyclone process used in this study found to be very successful in producing kaolin with finer particle-size distribution, increased the brightness values, and removal of impurities such as feldspar and mica. The process also able to increase the Al_2O_3 and reduces the SiO_2 contents of the kaolin from Sarawak.

Going through a single run of the hydrocyclone process, had improve the quality of both kaolin samples from Sarawak to the quality comparable to that of the English China Clay products (except for the alumina content) and of a much better quality compared to the product from Kaolin M'sia Sdn. Bhd. The result indicated that both kaolin deposits from Sarawak have the potential to be processed to kaolin products of premium grades with simple beneficiation. It is recommended that the kaolin and clay suppliers in Sarawak to look into the possibility of upgrading their product instead of just selling their kaolin or clay in raw form.

Table 3. Chemical composition of kaolin from TA, TE (raw and beneficiated) and other kaolin (*Sources: Bloodworth *et al.*, 1993).

Area	Samples	Chemical composition (%)					
		SiO_2	Al_2O_3	Fe_2O_3	K_2O	TiO_2	LOI
TA1	Raw	65.6	24.2	0.21	2.13	0.25	7.26
	Beneficiated	48.8	35.9	0.27	2.42	0.18	12.5
TA2	Raw	58.8	30.5	0.46	1.60	0.18	8.17
	Beneficiated	46.0	38.1	0.59	1.58	0.18	13.7
TE1	Raw	62.4	27.9	0.42	3.81	0.86	6.29
	Beneficiated	46.1	37.5	0.73	3.65	0.12	12.2
TE2	Raw	55.2	31.5	0.41	2.61	0.93	7.91
	Beneficiated	50.8	32.9	0.83	3.68	1.17	8.69
Kaolin M'sia Sdn Bhd.	Ceramic grade	49.6	34.7	0.90	1.37	0.59	12.5
	Filler grade (Plastic & rubber)	46.3	36.4	0.96	1.15	0.61	14.4
*English china clay (ECC)	Super standard porcelain; high quality tableware, porcelain& bone china	47	38	0.39	0.80	0.03	13.0
	Grolleg; earthenware & tableware	48	37	0.70	1.85	0.02	12.2
	Remblend: Sanitaryware	48	37	1.00	2.00	0.05	12.1

Table 4. Mineralogy of Sarawak kaolin deposits.

Areas	Samples	Mineral constituents		
		Major	Minor	Trace
TA	Raw	Kaolinite	Quartz and micaceous	Feldspar
	Overflow	Kaolinite	Quartz	Micaceous
	Underflow	Quartz	Kaolinite	Feldspar
TE	Raw	Kaolinite	Quartz and micaceous	Feldspar and gibbsite
	Overflow	Kaolinite	Quartz	Feldspar, micaceous and gibbsite
	Underflow	Quartz	Kaolinite	Feldspar

Table 5. The brightness of the kaolins from TA, TE as compared to other kaolin (*Sources: Bloodworth *et al.*, 1993).

Areas	Brightness (%)		
	Raw samples	Overflow	Underflow
TA 1	80.7	83.9	78.2
TA 2	73.4	79.8	72.9
TE 1	81.0	85.0	76.1
Kaolin M'sia Sdn Bhd.	Ceramic grade	74.6	
	Filler grade	76.7	
*ISO brightness %	Coating clays	81.5-90.5	

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