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PROPERTIES STUDY OF A LOCAL BENTONITE AS AN ADDITIVE IN OIL AND GAS INDUSTRY

Sarimah Man, Radzuan Junin, Ariffin Samsuri, & Adil Mohamed Osman
Department of Petroleum Engineering, Faculty of Chemical & Natural Resources Engineering
Universiti Teknologi Malaysia, 81310 Skudai Johor

ABSTRACT

This paper present the results of local bentonite potential as an additive in an oil and gas industry study. Two area of sampling had been study, Andrassy and Mansuli of Sabah. A standard additive of Wyoming bentonite had been used for potential comparison. The study includes mineralogical, chemical composition, cation exchange composition and Atterberg limit. The results show that bentonite sample from Mansuli area is close to the Ca-montmorillonite, sample from Andrassy area is close to plastic kaolin, while Wyoming bentonite is a Na-montmorillonite. However the Na-content in a local bentonite and its CEC value increased after dry and wet treatment process. In general, local bentonite has a potential to be used as an additive in oil and gas industry through treatment process, particularly dry cation exchange process. Therefore, the total cost of oil and gas well development will be reduced since the additive is a local material.

KEYWORDS

Montmorillonite, mineralogy, physical, chemical, exchangeable cation

INTRODUCTION

Bentonite is a rock composed essentially of a crystalline clay-like mineral formed by diversification and accompanying chemical alteration of a glassy igneous mineral, usually a tuff or volcanic ash; and it often contains variable proportion of accessory crystal grains that were originally pheno-crystals in the volcanic glass. These are feldspar, quartz, pyroxenes, zircon and other typical minerals of volcanic rocks. The clay-like mineral has a micaceous habit and facil cleavage, high birefringence and a texture inherited from volcanic tuff or ash, and it is usually a montmorillonite mineral, but less often beidelide. It has many uses in various industries, including use to decolorize oils, fats and greases, in a petroleum well drilling mud and completion cement, ceramic material, foundry moulding and ore pelletes.

The occurrence of bentonite clay deposits in some areas of east Sabah had been reported by several authors (Ang *et al,* 1988; Godwin & Yan, 1994 and Yusairi & Yan, 1995). In general, the indicated reserve is about 5.3 million tones in the Segama area, 1.9 million tones in Sepagaya area, 1.5 million tones in Mansuli area and 3.6 million tones in Andrassy area. Based on forecasting of 50 development and 10 exploration wells per year, the requirement of bentonite as an additive material is about 16,000 metric tonne per year, with cost about RM 15.40 million per year. Because of promising economic potentiality of the material and the absence of a solid knowledge of the clay properties, it was decided to undertake a study with the objective to determine the mineralogical, chemical and physical properties, potential of the clay (bentonite) as an additive for various uses in a gas and oil industry. The Wyoming bentonite of USA has been used as comparison, since it is a standard additive used in the gas and oil industry.

GEOLOGICAL SETTING

In this investigation, two groups of local bentonite samples were collected, namely SA5 (N4^{0}18.97'- E 117^{0}57.37') from Andrassy area in Tawau district and M4 (N5^{0}7.35'- E118^0 12.03') from Mansuli area in Lahad Datu district. The sample was collected exactly at 0.5m depths for Andressy and Mansuli at 0.3m.

The area of local bentonite sampling can be seen in Fig.1 and Fig.2. The field sampling from Mansuli area were taken mainly in area underlain by the Ayer Formation, which collectively form the Segama Group and is interpreted to be Miocene in age (Khairuddin & Radzuan, 1992). The Ayer Formation has two distinction lithofacies; the bedded tuffaceous facies comprising bedded tuff, tuffite, tuffaceous sedimen, and volcanic breccias and the polymict boulder-bed facies comprising slump brecia. An additional lithofacies is the calcareous facies comparising the Tempadong Limestone Member, which is believed to occur as massive lenses within the bedded tuffaceous facies (Godwin, 1994). Yusairi & Yan (1995), reported that the Andrassy area is underlain mainly by the high level of alluvium and volcanic rock, and occur in a bed underlying by Pleistocene to Holocene in age.

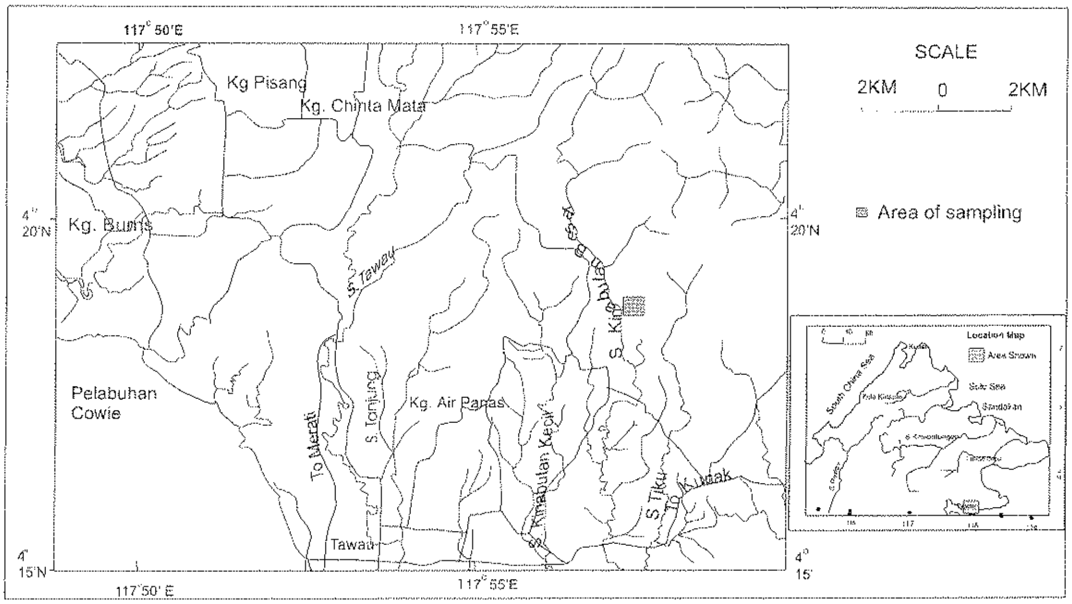

Fig 1: Location of sampling, Andressy Area, Tawau Sabah

RESEARCH METHODOLOGY

The local bentonite samples were collected from required exact depth by using Dormer auger. Then the sample was dried overnight in the oven before crushed and ground into the powder form. The powder was sieved for particle size at 75 μ m for XRD (X-ray diffraction) and XRF (X-ray fluorescene). Then the mineralogy content of bentonite had been determined using X-ray diffraction

(SIMEN D500 X-ray diffractometer unit) meanwhile XRF technique (Philips PW 1480 x-ray fluoresecence meter unit) to determine the chemical contents of the bentonite material. They were chosen because of their relative simplicity and sufficient precision. Methylene Blue test was carried out to measure the cation exchange capacity (CEC). The physico-chemical properties of bentonite with 425μm particle size were determined to detect the values of plastic limit (PL) and liquid limit (LL) by using Atterberg limit method (Annual book Of ASTM Standard D 4318-84, 1992).

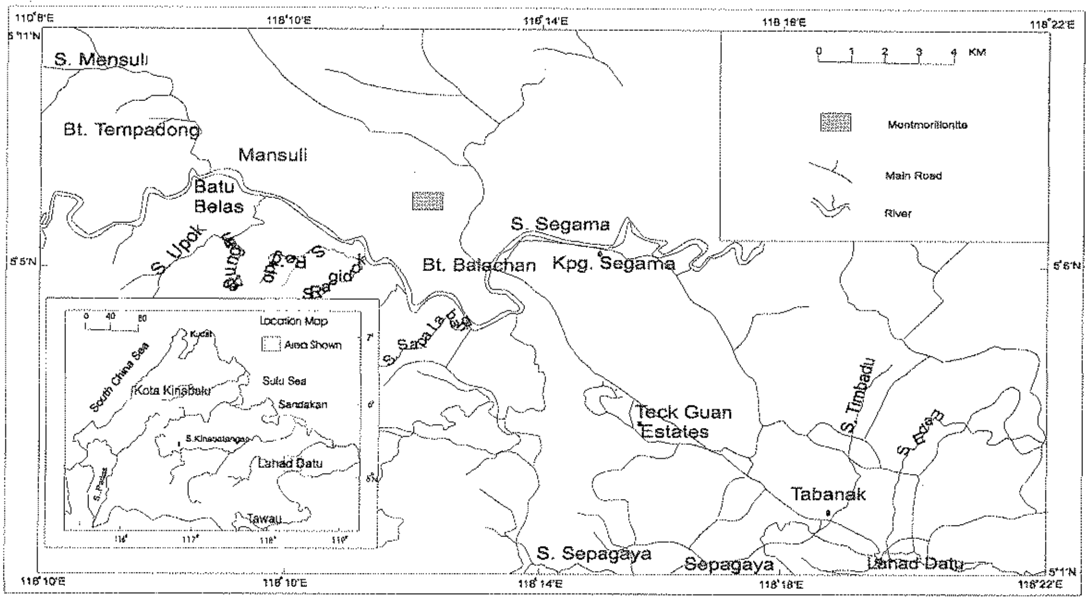

Fig. 2: Localition of Sampling, Mansuli Area, Lahad Datu, Sabah

RESULTS & DISCUSSIONS

Physico-chemical Study

The physico-chemical study values are used to obtain additional information on the nature and quality of the mineral. The results in Table 1 shows that the Atterberg limit of Wyoming bentonite samples (WY-BEN) contains more montmorillonite mineral than local bentonite. Atterberg limits can provides a good indication of the clay purity, where clays with high montmorillonite showed high Atterberg limit values. From Fig. 3, it is shown that sample M4 falls close to the Ca-montmorillonite, SA5 falls close to the region of plastic kaolin, while Wyoming bentonite falls in the region of Na-montmorillonite.

Table 1: Plastic Limit (PL), Liquid Limit (LL) and Plasticity Index (PI)

Location of sampling		LL(%)	PI(%)	PL(%)
U.S.A	Wyoming	479.3	33.9	445.5
Local Bentonite	Mansuli	116.4	36.2	80.1
	Andrassy	77.0	25.6	51.4

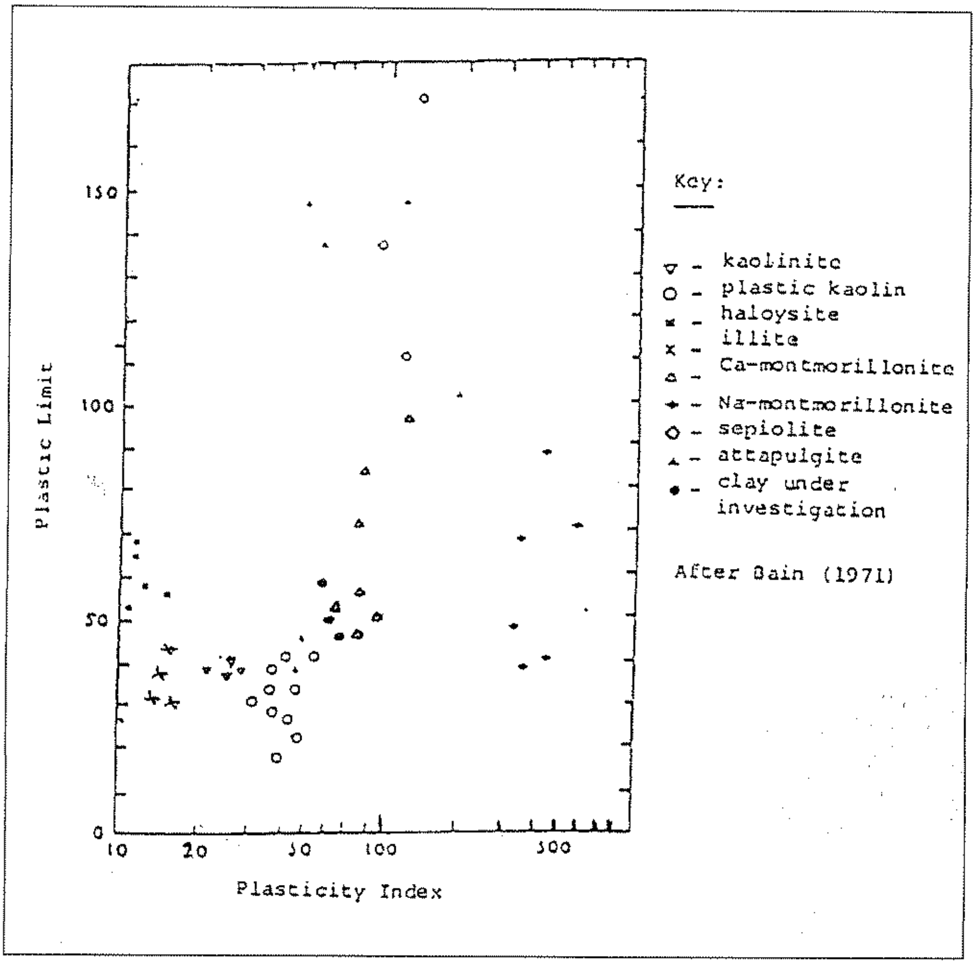

Fig 3: Plastic limit versus plasticity index

Mineralogical Study

The XRD analysis results of local and Wyoming bentonite compositions are summarized in Table 2. The major minerals present in the local bentonite are montmorillonite and quartz, and kaolinite and illite are present in subordinate amount. Other mineral presents in minor quantities include feldspar, orthoclase, albite and muscovite. However, the Wyoming sample shown that montmorillonite is the dominant, and minor in quartz.

Table 2: Semi-quantitative mineral composition of samples by XRD

Minerals	Standard	Local Bentonite					
		Untreated		Treated by dry process		Treated by wet process	
	Wyoming	Andrassy	Mansuli	Andrassy	Mansuli	Andrassy	Mansuli
Mont	****	**	*	**	**	**	*
Quartz	*	**	**	***	***	***	***
Feldspar	Nd	Nd	Tr Or	* albite	* M	Tr M	* M
Kaolinite	Tr	*	*	**	*	*	*
Others	Tr illite	* illite	* illite	nd	* illite	* illite	* illite

Key:- **** : Dominant; ** : Major; *: Minor; nd: not detected; Tr: trace; Or: orthoclase; M: muscovite; Mont: montmorillonite

Chemical Study

Major element Chemical Analysis.

X-ray Fluorescence (XRF) analyzed bentonite samples for major element, as shown given in Table 3. As a whole, SiO_2 content in the samples is relatively high. These results are from the high proportions of quartz composition in the sample. Local Bentonite also shows high Fe_2O_3 content which can be attributed to the presence of hematite mineral. Meanwhile, Na_2O content is higher in a Wyoming Bentonite as compared to the untreated local Bentonite samples. But Na_2O content increased in treated local Bentonite especially in dry process samples (SA5-DP and M4-DP). The contents of SiO_2 and Na_2O are inversely related to each other. The value of SiO_2 decreases when Na_2O increases. CaO existed in the exchangeable cation form as found in montmorillonite.

Table 3: Chemical Analysis by X-ray Fluorescence (XRF).

Mineral Compound	Standard Wyoming Composition (%)	Composition of Local Bentonite (%)					
		Untreated		Treated by dry process		Treated by wet process	
		Andrassy	Mansuli	Andrassy	Mansuli	Andrassy	Mansuli
SiO_2	65.48	55.22	63.10	48.20	53.86	63.06	55.52
TiO_2	0.13	0.70	0.71	0.60	0.60	0.68	0.69
Al_2O_3	18.77	22.21	16.94	19.26	16.10	16.60	20.59
Fe_2O_3	3.79	8.35	7.11	7.21	6.79	7.60	8.14
MgO	1.04	0.55	1.12	<0.01	0.54	1.04	0.50
CaO	1.48	0.53	0.19	0.49	0.27	0.20	0.50
Na_2O	2.03	<0.01	0.29	9.96	7.73	1.30	2.42
K_2O	0.78	0.47	2.35	0.46	1.60	2.29	0.75
MnO	0.02	0.04	0.07	0.03	0.05	0.06	0.04
P_2O_5	0.06	0.02	0.03	0.01	0.02	0.03	0.02
L.O.I	6.63	11.92	8.12	14.61	11.46	7.15	10.85
Total	100.21	100.01	100.03	100.83	99.04	100.01	100.02

Cation Exchange Capacity (CEC).

Cation exchange capacities were determined using methylene blue test method. In General CEC value of montmorilonit is in the range of 70-150meq/100g. Based on the result shown in Table 4, it can be seen that local bentonite has low CEC even though after treatments. The treated local bentonite with dry process have higher values of CEC as compared with the wet process samples but still lower than Wyoming bentonite. The dry process produces higher value than the wet process, because of a few element in wet process still at filtrate paper or in the solution, but in the dry process, treated samples have been used directly to test for cation exchange capacity.

Table 4:The Average of Capacity Exchange Cation (CEC) data

Values of CEC	Area of sampling						
	Standard	Untreated		Treated by dry process		Treated by wet process	
	Wyoming	Andrassy	Mansuli	Andrassy	Mansuli	Andrassy	Mansuli
CEC (meq/100g)	60-70	30	25	40	35	35	30

CONCLUSION

Based on the results of XRD test showed the presence of montmorillonite in the local bentonite, while kaolinite, illite and feldspar are present as the main impurities. The treated local bentonite with dry process have higher values of CEC as compared with the wet process samples but still lower than Wyoming. In general, CEC value of local bentonite, can be improved through optimized dry process. The contents of SiO_2 and Na_2O are inversely related to each other, which is the value of SiO_2 decreases when Na_2O increases. Physico-chemical study shows that sample from Mansuli area are falls close to the Ca-montmorillonite, while sample from Andrassy are falls close to the region of plastic kaolin, while Wyoming bentonite falls in the region of Na-montmorillonite. After optimized treatment, the local bentonite is possible to be used as an additive in gas and oil industry. However, further studies must be made to confirm the optimized treatment process.

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