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Some Natural Na-bentonites in China

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Abstract

Four bentonite deposits in China were studied, and it was found that these are Na-type bentonite. Amounts of exchangeable Na^{+} ion of these bentonite are more than 50% of total exchangeable cations. The sample from Liufangzi showed the highest value of exchangeable Na^{+} ion. This evidence indicates that the alteration of volcanic materials to montmorillonite took place after accumulation in water rich in Na ions. The presence of shared structures of ash as pseudomorphs in the caly and nonclay minerals, such as feldspars, biotite, etc., characteristic of igneous material, may provide evidence for the origin from volcanic ash.

Introduction

Bentonite is a clay rock, and dominant clay-mineral component of bentonites is montmorillonite. Other clay minerals, particularly illite and kaolinite, are present in many bentonites. Nonclay minerals characteristic of igneous material as well as of detrital origin are also present in varying amounts. Some bentonites are pure montmorillonite. The composition of the montmorillonite itself varies greatly in different bentonites, as has been shown by Ross and Hendricks (1945). The variation may be within the montmorillonite lattice itself or in the nature of the exchangeable cations. With regard to exchangeable cations, most bentonites that have been described carry Ca^{++} as the most abundant ion. Only a few are known which carry Na^{+} as the dominant ion, and of these the Wyoming bentonite is the main example. Mg^{++} is frequently present as an exchangeable ion in relatively small amounts, and this is particularly the case when Ca^{++} is the dominant ion.

Bentonite resources are rich in China, and some Na-bentonite deposits were found beside Ca-bentonite deposits. This report presents the characteristics of these Na-bentonite deposits and their origin.

Samples

We have collected some bentonite samples from Linan, Zhejing Province, Tuokexunerjian, Xinjing autonomous region, Heishan, Liaoning Province, and Liufangzi, Jilin

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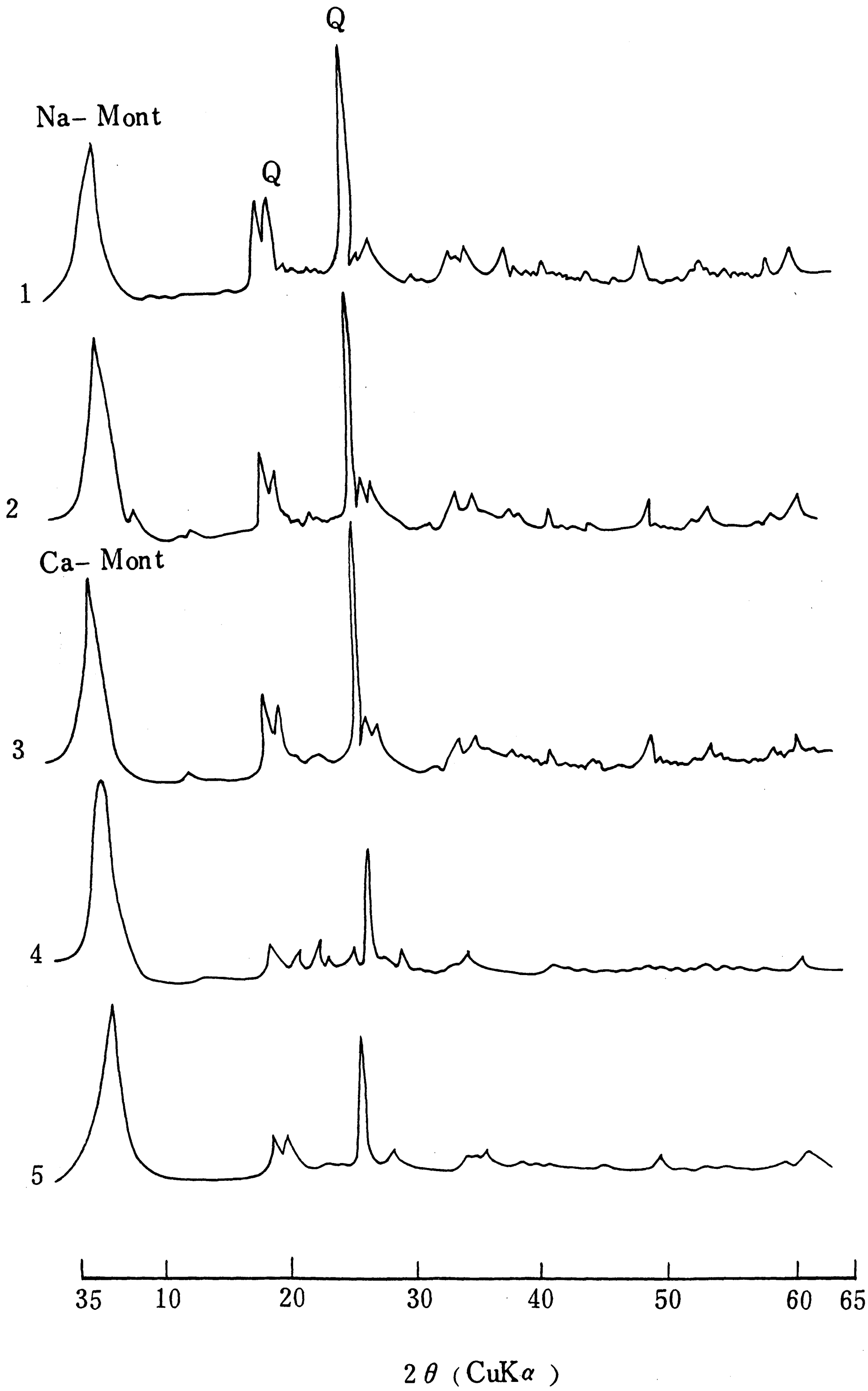

Fig. 1. X-ray powder diffraction patterns for bentonites.
1. from Linan, 2. from northern part of the deposit in Tuokexunerjian, 3. from southern part of the deposit in Tuokexunerjian, 4. from Heishan, 5. from Liufangzi.

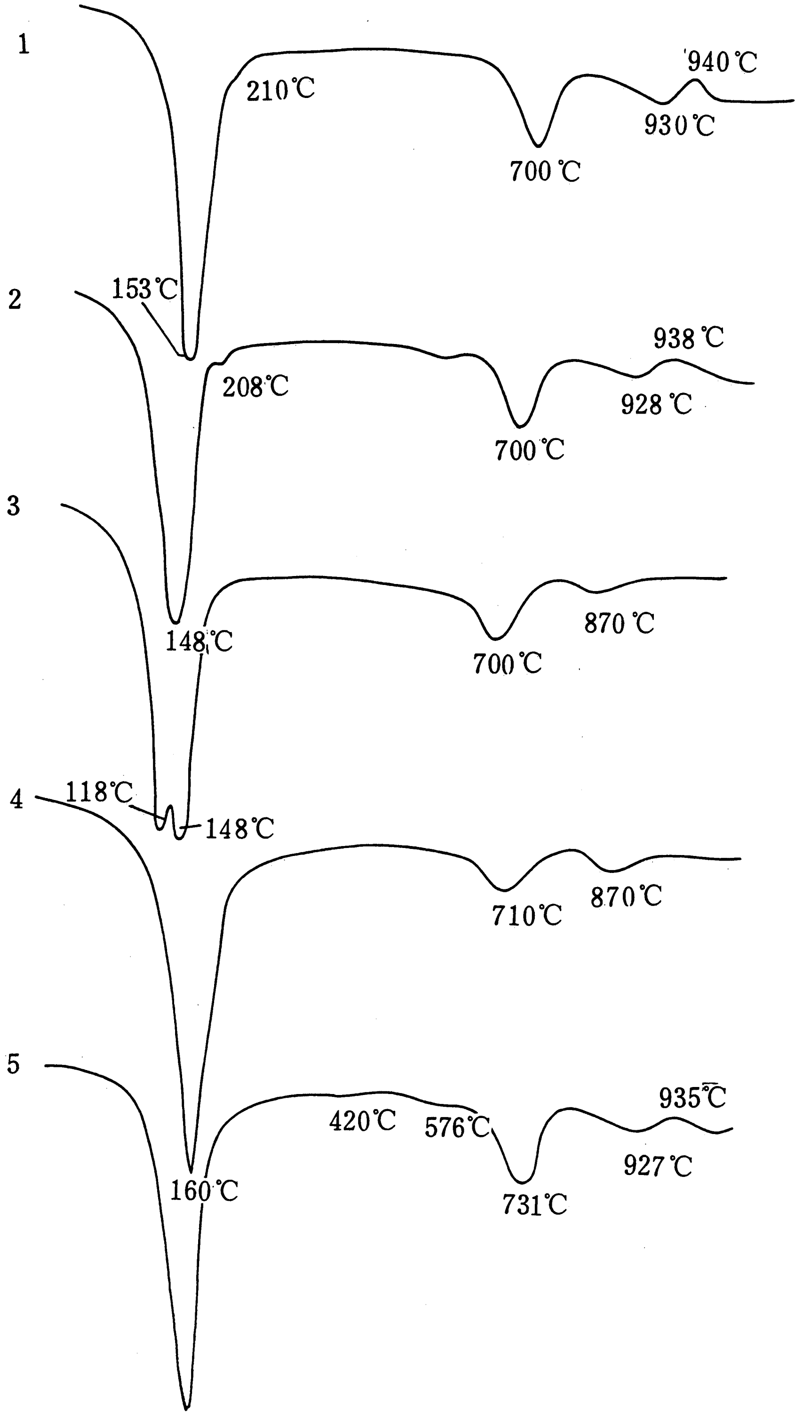

Fig. 2. Differential thermal analysis curves for bentonites.
1. from Linan, 2. from northern part of the deposit in Tuokexunerjian, 3. from southern part of the deposit in Tuokexunerjian, 4. from Heishan, 5. from Liufangzi.

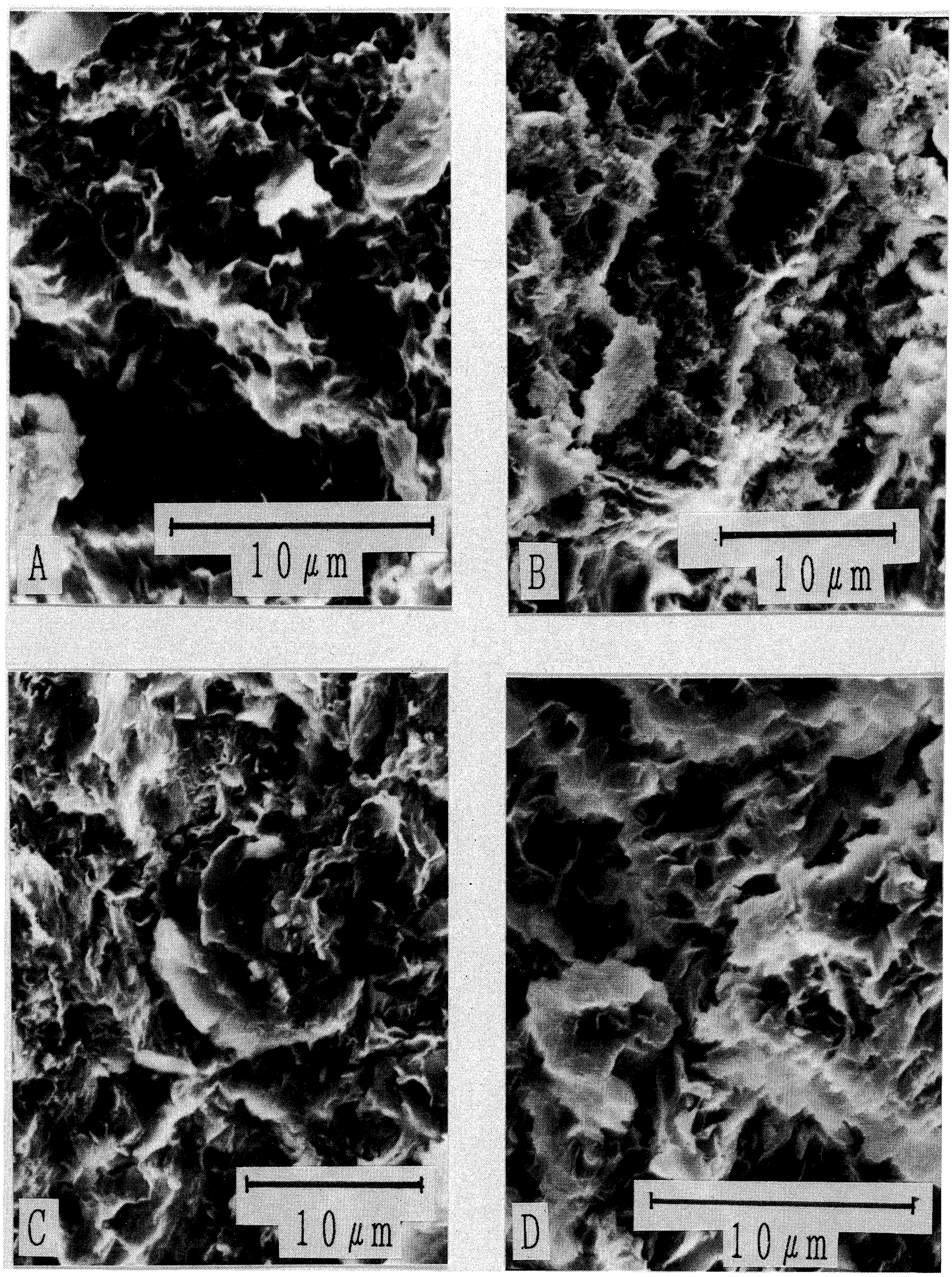

Fig. 3. Scanning electron micrographs of bentonites.
A. from Linan, B. from northern part of the deposit in Tuokexunerjian, C. from Heishan, D. from Liufangzi.

Province.

Results

Na-bentonite deposit in Linan, Zhejing Province.

The deposit is situated in a terrestrial fault-trough basin of Cretaceous, and was formed in an Upper Jurassic strata. It was formed from intermediate-acidic tuffaceous pyroclastic rocks by alteration in the alkaline water medium. Several layers of relative stable deposits are present here. The deposits show green-grey, red or mottled color, and clayey, silty, sandy, gravel-bearing or brecciated texture. They are compact and hard. Quartz, feldspar and a small amount of biotite are present with montmorillonite.

X-ray powder diffraction pattern for the sample is shown in Fig. 1. D (001) and d (060) show 12.94Å and 1.506Å respectively at room temperature. This fact suggests that the montmorillonite is Na-type montmorillonite (Pezerat and Méring, 1954; Méring and Brindley, 1967). Differential thermal analysis curve for the sample is shown in Fig. 2 and it shows single endothermic peak below 200℃. This phenomenon indicates that exchangeable cations in interlayers of montmorillonite are univalent cations (Hendricks et al., 1940). Result of chemical analysis is listed in Table 1. Na_2O is about 1.88%, and content of K_2O is 1.94%. Scanning electron microphotograph of the

Table 1. Chemical composition of bentonites

	1	2	3	4	5
SiO_2	69.10%	56.88%	61.78%	62.12%	62.30%
TiO_2	0.20	0.14	0.25	0.15	—
Al_2O_3	15.14	19.69	14.36	15.62	23.50
Fe_2O_3	1.69	3.21	3.09	1.32	3.35
FeO	0.20	0.19	1.22	0.17	0.37
MnO	0.04	0.04	0.02	0.03	—
CaO	0.70	0.10	2.02	0.32	0.31
MgO	2.27	3.32	2.42	3.42	1.95
K_2O	1.94	0.10	0.83	0.12	0.03
Na_2O	1.88	1.68	1.45	1.92	0.40
P_2O_5	0.05	0.02	—	0.03	—
$H_2O(+)$	4.19				6.45
$H_2O(-)$	1.84				
Ig. Loss		14.46	12.48	14.70	
Total	99.96%	99.83%	99.92%	99.92%	98.66%

1. Bentonite from Linan, Zhejing Province.
2. Bentonite from Tuokexunerjian, Xinjing autonomous region.
3. Bentonite from Heishan, Liaoning Province.
4. Bentonite from Liufangzi, Jilin Province.
5. Bentonite from Wyoming, U. S. A. (after Osthaus, 1955).

Table 2. Abrasion pH, cation exchange capacity and exchangeable cations of bentonites

Sample No.	Abrasion pH	Cation Exchange Capacity (m.e./100g)	Exchangeable Cation (m.e./100g)				$\frac{Na^+}{K^+ + Na^+ + Ca^{2+} + Mg^{2+}} \times 100$
			K^+	Na^+	Ca^{2+}	Mg^{2+}	
1	9.95	86.20	0.33	55.45	14.20	2.20	64.33
2	10.1	82.80	1.75	46.60	17.50	2.50	56.28
3	9.97	56.80	0.30	36.40	9.80	2.10	64.08
4	10.2	87.10	0.73	60.0	5.70	3.10	68.88
5	10.1	105.59	1.74	82.60	12.45	8.80	78.22

1. Bentonite from Linan.
2. Bentonite from Tuokexunerjian.
3. Bentonite from Heishan.
4. Bentonite from Liufangzi.
5. Bentonite from Wyoming, U.S.A, (after Osthaus, 1955).

sample is shown in Fig. 3, and characteristic thin flakes of montmorillonite are clearly observed. Results of cation exchange capacity and abrasion pH for the sample are listed in Table 2. The cation exchange capacity of the sample is about 86.20 m.e./100g, and the amount of exchangeable Na^+ to total amount of exchangeable cations ratio is about 64.33%.

Na-bentonite deposit in Tuokexunerjian, Xinjing autonomous region.

The strata containing bentonite deposits are mainly composed of pyroclastic rocks of Lower Carboniferous and discordantly overlying medium-fine grained sandstones, and silty mudstones of Lower Jurassic are overlying them. The bentonite deposit was formed in pyroclastic rock series of Lower Carboniferous. Two bentonite belts exist showing stratified and/or lenticular forms. They show green-grey, blue-green, yellow-greenish and grey-white color. Small amounts of clastic materials such as andesite and andesitic tuff are present besides montmorillonite in the bentonite deposits. Small amounts of clinoptilolite, mordenite, biotite, quartz, feldspar and carbonates are present in the bentonite.

X-ray powder diffraction pattern of a sample collected here is shown in Fig. 1. D-value of (001) reflection shows 12.99Å, and that of (060) shows 1.505Å. Differential thermal analysis curve for the specimen is shown in Fig 2. A strong single endothermic peak at 148℃ and a very weak endothermic peak at 208℃ are observed. Scanning electron microphotograph of the specimen is shown in Fig. 3. The montmorillonite shows aggregates of thin flakes and folding and/or curling shapes. In the southern part of the deposit dominant clay mineral is Ca-montmorillonite, and its X-ray powder diffraction pattern of the specimen is shows in Fig. 1. The value of d (001) of the specimen is 15.4Å. Illite, quartz and feldspars are present in the specimen. The chemical analysis data are listed in Table 1. Cation exchange capacity of a sample collected in the northern deposit is 82.8m.e./100g, and exchangeable Na^+ is 56.28% of total exchangeable cations.

Hard-bentonite deposit in Heishan, Liaoning province

Heishan bentonite is formed in the intermediate-acidic volcanic materials of Lower Cretaceous. The base rock is granite-gneiss of Lower Proterozoic. Volcanic eruption occurred three times in early late Jurassic in this region. Andesite rocks were extruded in early stage, and various types of intermediate-acidic tuffaceous materials were extruded in middle stage. Rhyolite was extruded in later stage.

These rocks were intruded by andesite dikes. The tuffaceous materials have undergone alteration into bentonites. Two types of bentonite deposits exist in this region. One is soft bentonite which is present in the upper part. It shows grey to white color, and is Ca-bentonite. The other one is hard bentonite which is present in the lower part. The bentonite is sodium type and montmorillonite content is high. Plagioclase, biotite, cristobalite, quartz and magnetite are present in the bentonite. X-ray powder diffraction pattern for a sample collected from the hard bentonite is shown in Fig. 1, and value of d(001) is 12.81Å and that of d(060) is 1.49Å. Differential thermal analysis curve of the sample is shown in Fig. 2. A strong endothermic peak at 160℃ is observed. Chemical analysis data are listed in Table 1. The content of Na_2O is about 1.45%. The values of exchangeable cations are listed in Table 2. The cation exchange capacity is 56.8m.e./100g and the amount of exchangeable Na^+ ion is 64.08% of total exchangeable cations. Scanning electron microphotograph of the sample is shown in Fig. 3. Na-bentonite shows foliated appearance.

Na-bentonite deposit in Liufangzi, Jilin province

The bentonite deposit is located in eastern end of the Tianshan-Yinshan complex. Liufangzi bentonite was formed in the coal-bearing river and/or lake sediment of late Jurassic. The bentonite layers are interbedding with sandy conglomerate, sandy mudstone and coal layers. The contact between the bentonite layers and these layers are distinct, and bentonite layers are about 1 to 2m thick. Toward edge of the basin, the bentonite layers change gradually to coal fragments bearing fine sandstones and siltstones. X-ray powder diffraction pattern of a sample collected from a bentonite layer is shown in Fig. 1. The pattern shows 12.45Å of d (001) reflection indicating Na-montmorillonite and 1.50Å of d(060). The sample contains small amounts of quartz and feldspars. Differential thermal analysis curve of the sample is shown in Fig. 2. An endothermic peak at 134℃ due to dehydration of interlayer water is observed. The result of chemical analysis is listed in Table 1. The content of Na_2O is 1.92%. Scanning electron microphotograph of the sample is shown in Fig. 3, and it shows thin flakes and the edges of the flakes are curling. The cation exchange capacity of the sample is 87.1m.e./100g and the exchangeable Na^+ ion is 68.88% of total exchangeable cations.

Discussion

Four bentonite deposits in China were studied, and it was found that these are Na-type bentonite. Amounts of exchangeable Na^+ ion of these bentonite are more than 50% of total exchangeable cations. The sample from Liufangzi showed the highest value of exchangeable Na^+ ion. This evidence indicates that the alteration of volcanic materials to montmorillonite took place after accumulation in water rich in Na ions. The presence of shared structures of ash as pseudomorphs in the clay and nonclay minerals, such as feldspars, biotite, etc., characteristic of igneous material, may provide evidence for the origin from volcanic ash. Most monovalent and divalent cations in interlayers of smectites are completely exchangeable from smectite by other cations. The natural saturation of smectites is usually Ca^{2+} and Mg^{2+}. Marine formation is indicated for Wyoming bentonite, which is largely Na saturated, but Nemecz (1981) explains that Mg-smectite will form in sea water and Na-smectite is formed in fresh-water lakes. The bentonite deposits in China were probably formed from volcanic materials such as ash in water under alkaline conditions, especially rich in Na ions. The composition of acid plagioclases in fresh water gives rise to a solution poor in Ca and Mg but relatively rich in Na, leading to the formation of a Na-smectite.

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