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MORPHOLOGY AND GENESIS OF KAOLINITE IN COALS: A SEM STUDY

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Abstract

Three types of crystal morphology, viz., stacks or books, elongated crystals, and card-house structure are observed. These morphological forms characterise the kaolinite as free slacking type. The occurrence of stacks or books as well as elongated crystals in vitrain suggest formation of vitrain and development of these morphological forms under a low electrolyte water condition, whereas, the dominance of card-house structure in durain is suggestive of coagulative processes and flocculation and high electrolyte concentration during the development of dull bands.

Introduction

Indian coals are rich in mineral matter. Among the inorganic fractions of coal, clay minerals constitute more than 90% of the entire mineral species where kaolinite is most common, Kaolinite shows wide variation in texture, genesis and physical properties. Morphological forms or textures of kaolinite are good indicators of their physical properties and chemical conditions of the interstitial water as well as the depositional basins. They also throw light on the compressional history of the basin. The physical characters of kaolinite indicate whether it is slacking or non-slacking. These two varieties behave differently during coal washing.

Keeping in view the above object, the SEM of the coal samples from Jharia coalfield of the Damodar valley was studied. For the original morphology of kaolinite, unpolished and freshly broken surfaces of bulk coal samples were used.

Method of Study

The lithotypes, viz., vitrain, durain, clarain and fusain were isolated from the bulk coal samples with the help of a light hammer, chisel and forcep. The separated lithotypes of 1 cm size were washed and mounted on aluminium stubs using silver paste as sticker. After coating the specimens with silver in the vacuum coating machine, they were studied under a high performance Scanning Electron Microscope (PSEM 500).

Results

Three types of crystal morphology, viz., stack or book structure (Pl. I e and f), elongate crystals (Pl. I c and d) and card house structure (Pl. I a and b) were recorded. The former two were more common in vitrain, whereas card-house structure was found in durain. Among these morphological forms stack or book structure has been most common (Table I). The morphological forms of kaolinite

EXPLANATION OF PLATE I

Figs. a and b.	Photomicrographs showing card-house structure in durain.
Figs. c and d.	Elongate crystals of koalinite in vitrain.
Fig. e.	Randomly oriented kaolinite flakes in vitrain.
Fig. f.	Stack or book morphology of kaolinite in vitrain.

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PLATE I

TABLE I. Occurrence of morphological forms of kaolinite in the lithotypes of Jharia coals.

Sample Number	Character of the sample	Lithotype	Occurrence of morphological forms		
			Card-house structure	Stack or book structure	Elongate crystals
M_1	Bright coal	Vitrain			√
		Clarain			
		Durain			
M_2	Bright coal	Vitrain		√	
		Clarain			
		Durain			
M_3	Semi-bright coal	Vitrain		√	
		Clarain			
		Durain	√		
		Fusain			
M_4	Semi-dull coal	Vitrain		√	√
		Clarain			
		Durain			
		Fusain			
N_1	Semi-bright coal	Vitrain			
		Clarain		√	
		Durain	√		
		Fusain			
N_2	Semi-bright coal	Vitrain			
		Clarain			
		Durain	√		
		Fusain			
N_3	Semi-dull coal	Vitrain		√	
		Clarain			
		Durain			
		Fusain			
N_4	Semi-dull coal	Vitrain		√	
		Clarain		√	
		Durain			
		Fusain			

indicate that these are free-slackiug type with porous and open structure and are mostly randomly oriented.

Discussion

The orientation and morphology of the clay particles in sediments depend upon the type of mineral (s), grain-size and shape, interstitial water content, electrolyte concentration, status of initial clay-water system, and the intensity of overburden pressure. O'Brien (1963) and Martin (1965) carried out experiments on the paste and slurries of kaolinite as well as illite and opined that with sufficient initial water content clay minerals react with pressure and get reoriented at a pressure less than 1,422 p.s.i. (100 kg/cm^2). Further, Martin (1965) showed that grain orientation occurred at 14.22 p. s. i. (1 kg/cm^2) and did not change even after a pressure of 455 p. s. i. (32 kg/cm^2).

The clay minerals in Jharia coals might have been added mechanically by river as suspended or colloidal particles, or by wind as dust or adsorbed onto organic gels or humus. The texture of kaolinite also suggests its origin as the weathering product of primary feldspar mineral in these coals. Lambe (1958a, b), Meade (1968), Pusch (1966, 1970), Moon (1972) and Ricke and Chilingarian (1974) have proposed and reviewed various types of models for clay microstructures. According to them, the card-house structure develops due to flocculation in the presence of electrolyte-rich solution. Due to the flocculation effect, clays form random open structures, and edge-to-face particle contacts. This edge-to-face contact develops due to the attraction of positively charged plate edges to negatively charged plates (Tan, 1959; Rosenguist, 1962). Later, Rosenguist (1966) suggested the development of card-house structure to be the result of erratic behaviour of 'quick clays' which develops due to a flocculation in marine environment, where this structure becomes stable. According to Pusch (1966, 1970) and others, the quick clays become highly unstable due to the presence of organic substances which act as a dispersing agent. The card-house in Jharia coals appear to have developed due to flocculation in the presence of organic material and high electrolyte concentration.

Aylmore and Quirk (1960), van Olphen (1963, 1964) and Keller (1982) have described the piling of flakes or plates as 'domains', 'books' or 'stacks'. According to them, piling of these flakes is controlled by electrolyte concentrations. The feebly developed book or stack morphology in the vitrains of Jharia coals is suggestive of moderate electrolyte concentration during the development of vitrain vis-a-vis stack or book morphology. Further, according to Keller (1982) elongate crystal morphology of kaolinite is a stage between non-crystalline clay particles and platy morphology. These elongates may, in due course, recrystallize to plates under favourable conditions. The occurrence of these morphological forms in Jharia coals leads to the following interpretations.

The formation of durain under an electrolyte-rich water condition led kaolinite to develop card-house structure in them. The presence of stack or books and elongate crystals in vitrain indicates that during the formation of vitrain bands the concentration of electrolytes was low in the depositional basin. It is thus evident that fluctuation of the surface water cover accompained by variation of electrolyte concentrations were responsible for the banding of coals.

Conclusion

The results lead to the conclusion that the surface microstructural study of coals and the morphology of the clay minerals may be helpful in getting an idea of the chemistry (electrolyte concentration) of the depositional basin. The morphology or textures also suggests the physical property of kaolinite as slacking and non-slacking. Depending upon the dominance of slacking and non-slacking variety, a better and appropriate technique of coal washing can be adopted for a particular coal type.

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