

Comparative clay mineralogy in different sizes of a sediment core from the Bering Sea

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Abstract

Clay minerals and quartz in a bulk sample and a <2 micron size fraction of a sediment core collected from the Bering Sea were analyzed using X-ray diffractometry (XRD). The bulk sample shows that illite concentration is the most abundant; chlorite is next abundant, followed in order by kaolinite and smectite in the clay mineral assemblage. In contrast, clay fractions less than 2 micron show that chlorite is the most abundant, followed by smectite, illite and kaolinite. The content of quartz in the bulk sample is 18%, whereas that in the < 2 micron fraction is 4%. The sediment core is characterized by high concentration of illite and chlorite of terrigenous origin and high-latitude clay minerals, whereas kaolinite, which is low-latitude clay mineral, is the least common component among clay fractions of particles smaller than 2 micron diameter. High concentrations of smectite in clay fractions under 2 micron suggest that smectite is supplied from the volcanic island arc in the region under consideration. Quartz content tends to be concentrated in samples larger than clay fractions, which is supported by results of this study.

Key words: Bering Sea, piston core, X-ray diffraction analysis, <2 micron size fraction, bulk sample, clay minerals, quartz.

Introduction

Clay mineralogical study of marine sediments have specifically examined clay fractions with particles of less than 2 micron diameter. Clay minerals are generally < 2micron. Accordingly most studies of clay minerals in marine sediments have examined clay fractions of particles smaller than 2 micron. However, clay minerals are also contained in larger than 2 micron. Aoki(1978) analyzed clay minerals in samples smaller and larger than 2 microns and reported that smectite finer than 2 micron tends to be concentrated in samples, whereas illite and chlorite show an opposite tendency, as generally confirmed by numerous researchers(e.g. Biscaye, 1965). For the present study, the author analyzed the clay minerals

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and quartz compositions in separated size fractions (< 2 micron and a bulk sample) in a sediment core collected from the Bering Sea. Results are discussed herein.

Material and Method

Samples used in this study were selected from 33 parts of the sediment core 10m long which was collected from the central Bering Sea. The original locality of the sediment core is depicted in Fig. 1. Each sample was divided into two parts: one for analysis of bulk sample and the other for analysis of clay fractions less than 2 micron. All samples were first depickled in distilled water. After depickling the bulk sample was ground in an agate mortar. The clay fractions less than 2 micron were collected by sedimentation. Each sample was analyzed using for X-ray diffractometry(XRD). All samples were mounted on glass slide for clay- mineral and quartz investigation using by XRD. Qualitative and quantitative estimations of clay minerals followed the method reported by Sudo et al.(1961) and Oinuma(1968). Quartz concentrations were also observed using XRD based on a standard curve following the content of quartz.

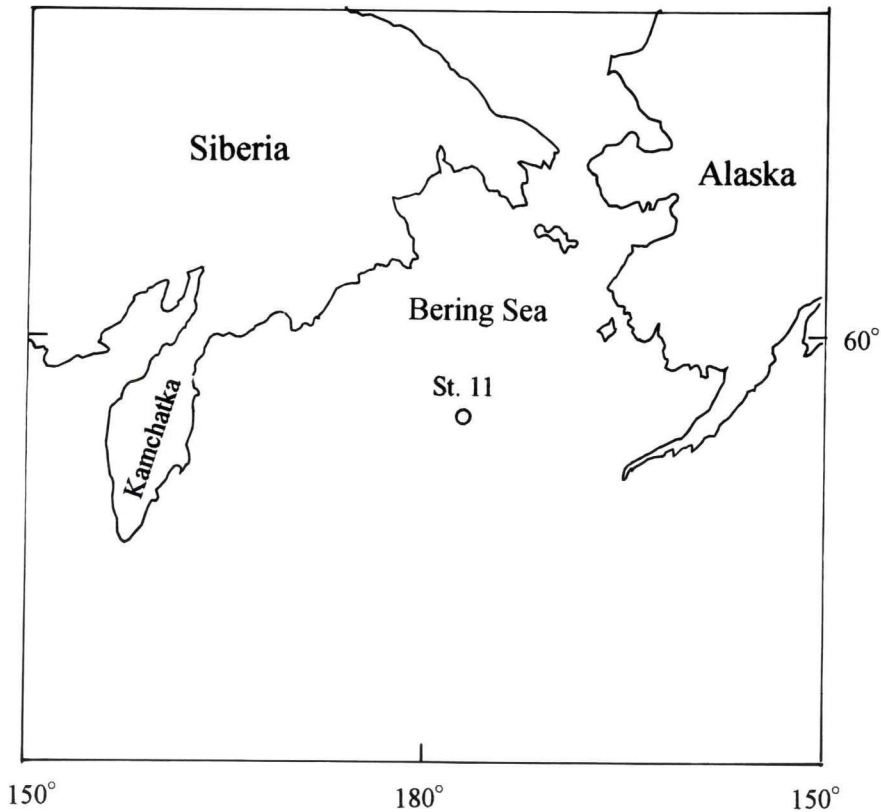


fig.1. Locality of sample in this study

Results

Analysis by XRD revealed the presence of clay minerals such as chlorite, smectite, illite, and kaolinite in both bulk samples and clay fractions less than 2 micron. Quartz also exists in the bulk sample.

A. Clay mineral composition in the bulk sample

The vertical differences of the clay mineral composition in the bulk sample are shown in Fig. 2. The illite contents were 53% - 21%(average 43%). The chlorite contents 53% - 21%(average 38%). The kaolinite cntents were 29% - 0%(average 11%). The smectite contents were 18% - 0%(average 8%). The clay mineral compositions showed no systematic change from the top to the bottom of the core. Those results suggest that the bulk sample is characterized by high concentration of illite and chlorite, which are of clastic origin. Chlorite is generally accepted to be high- latitudinal clay mineral; it is formed mechanically in high- latitudinal land areas. Illite tends to be concentrated in mid- latitudinal sea in the Pacific Ocean because it is a wind-driven clay mineral from central Asia. However, it might also have been transported by ice rafting from the northern part of the Bering Sea.

B. Clay mineral composition in clay fractions smaller than 2 micron

Vertical differences in clay mineral compositions in less than 2 micron fraction are shown in Fig. 3. The chlorite contents were 53% - 28%(average 37%). The smectite contents were 46%-13%(average 26%). The illite contents were 41% to 3%(average 6%). The kaolinite contents were 16% - 3% (average 6%). The clay mineral compositions exhibited no systematic

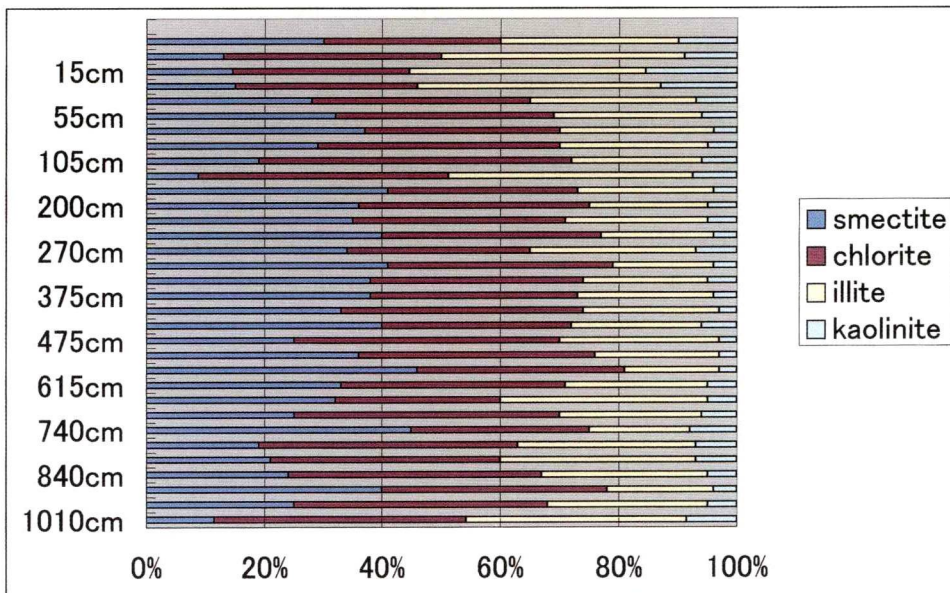


fig.2. Vertical change in clay mineral composition in < 2 micron fraction

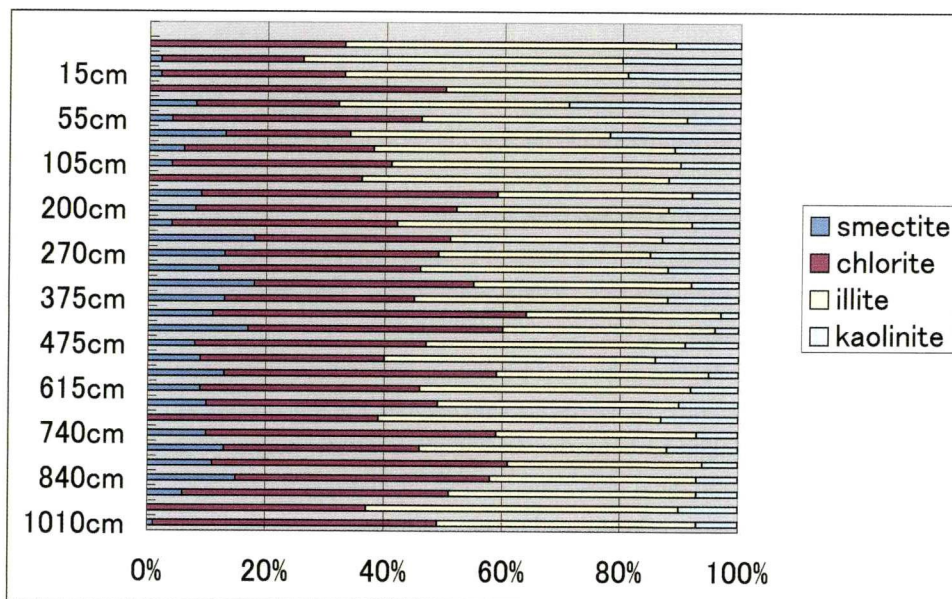


fig.3. Vertical change in clay mineral composition in bulk sample

differences from the top to the bottom of the core. Fractions of clay particles smaller than 2 micron are characterized by high concentrations of chlorite and smectite. The predominance of chlorite is also confirmed in the clay fraction. High concentrations of smectite in the clay fractions are inferred to have arisen from the influence of volcanism on surrounding land areas such as the Kamchatka Peninsula and the Aleutian islands.

C. Quartz concentration

Vertical differences of quartz concentrations in bulk and clay sized samples are shown in Fig. 4. Quartz concentration in bulk sample were 45% - 4% (average 18%); that of the clay fraction ranges was 16% - 1%(average 4%). Quartz concentration in samples of bulk and clay fractions show no systematic change from the top to the bottom of the core. To the author's knowledge, the quartz contents of marine sediments are generally less than 5% in samples of particles less than 2 micron, as is apparent in samples from the Sea of Japan and the central Pacific Basin (Aoki et al., 1974; Aoki and Kohyama 1998).

Discussion

Concentrations of smectite in the clay fraction and in bulk sample differ greatly; also, the average content of smectite in the former sample is larger than that in the latter one. This difference shows that smectite

particles tend to concentrate in clay fractions of particles smaller than 2 micron. Some reports have described conditions in marine sediment. (Biscaye, 1965; Aoki, 1973). In

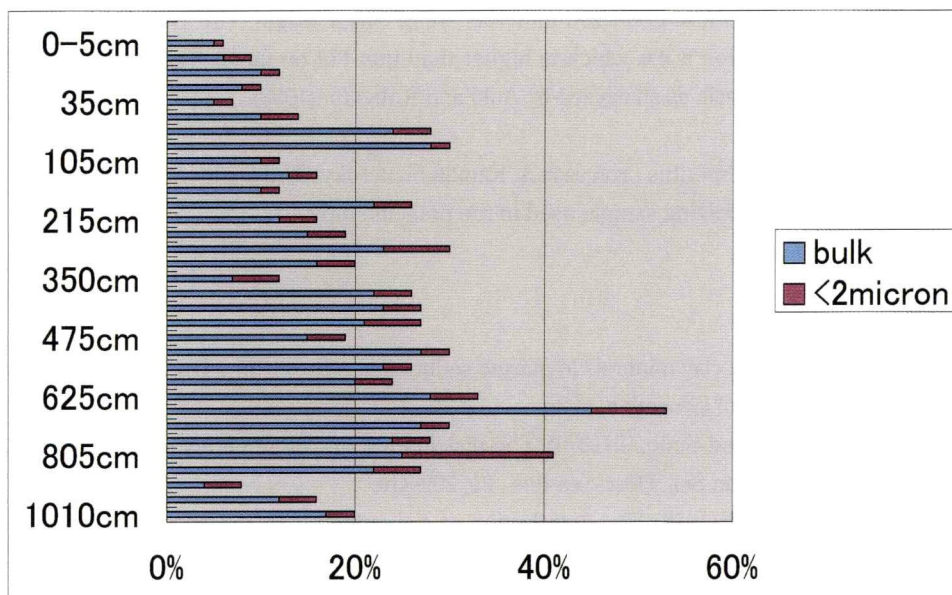


fig.4. Vertical change in quartz contents in bulk (blue) and < 2 micron fraction (red)

contrast, clay minerals aside from smectite tend to increase their contents in larger particles. In this paper, the author describes the clay mineral composition in the clay fractions of particles smaller than 2 micron. Chlorite is the most abundant constituent, followed in order by smectite and illite, with kaolinite as the least common constituent in the clay mineral assemblage. The clay mineral composition seems to reflect geological environments on land areas near the study area. The Bering Sea and Okhotsk Sea belong to high-latitude seas in the northern hemisphere, which have the most abundant chlorite concentration (Gorbunova, 1962; Aoki and Oinuma, 1978). Chlorite is readily formed by mechanical weathering at high latitudinal land areas (Papadakis, 1969). The chlorite in the present core sample may have been derived from weathering products or metamorphic rocks of the Alaskan Peninsula. Smectite is thought to have been derived from volcanic materials of the Aleutian Islands and Kamchatka Peninsula. Some layers of volcanic ash, transported from somewhere, are recognizable in the present core. Three volcanic ash layers (70-75cm, 125-130cm, and 265-270cm) are recognized in the present core; the smectite concentration (34% average) of these layers is richer than those of other layers (30% average). The low illite content is attributable to a dilution effect by high concentration of chlorite and smectite. Kaolinite, which is the least common constituent in the clay mineral assemblage, is generally acknowledged as a low-latitude clay mineral. However, in the area to volcanic belt zone, kaolinite can exist as a product transformed from halloysite. It is a natural result that the quartz content in the bulk sample is greater than that in the clay fraction. The lack of systematic differences in vertical variations of the clay mineral composition and quartz

contents suggests that these clay-sized minerals are of clastic origin. The average content of quartz in the clay fraction is 4%, which is higher than that (2% on the average) in sediments of the central Pacific Basin as analyzed by Aoki and Kohyama(1998).

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