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CLAY MINERALS AS INDICATORS OF SEDIMENT SOURCE IN TIDAL ESTUARIES OF LONG ISLAND SOUND

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Abstract—Clay minerals were used as indicators for determining the source of sediment in recently dredged harbors along the north shore of Long Island Sound. Amount and characteristics of clay minerals in sediments from the dredged channels were compared to their amount and characteristics in the surrounding soils and in sediments from Long Island Sound. Clay minerals in sediments from the channels were similar in amount and characteristics to clay minerals in sediments from Long Island Sound but differed from those in the surrounding soils in the watershed. Thus, the main source of deposits in the channels is the bottom sediment of Long Island Sound which is transported to the channels by tidal action. These conclusions are supported by recent studies of the bottom currents in the Sound.

Key Words—Clay, Sediment, Sedimentation, Soil.

INTRODUCTION

Harbors along the north shore of Long Island Sound are dredged frequently to maintain navigable depths for commercial and recreational vessels. Historically, the dredged sediments have been disposed of offshore in "dumping grounds." Recent environmental restrictions have, however, severely limited this practice. Knowledge of the source and characteristics of these sediments is essential for their future disposal, whether in the ocean or on the land, in ways that are compatible with maintaining environmental standards.

This investigation was undertaken to determine the source of sediments in recently dredged channels in three Connecticut harbors. Amount and characteristics of clay minerals in sediments from the dredged channels in the harbors were examined and compared to the clay minerals in the surrounding soils and in the sediments from Long Island Sound to determine if the sediments in the channels originate from soil runoff, riverbank erosion or from the bottom sediments of Long Island Sound. Close relationships between the clay mineralogy of the sediments transported by the rivers and the marine sediments at the mouth of the rivers have been observed in several studies (Griffin, 1962; Biscaye, 1965; Neiheisel and Weaver, 1967). Mineralogy of the fine-grained material in the sediment has also been used to obtain information on the nature of the sedimentary environment (Brown et al., 1977) and on the effects of diagenetic processes on mineralogy (Hower et al., 1976). Here, mineralogy of the clays in recent sediments, presumably unaffected by different environmental conditions, is used to gain information on their source.

MATERIALS AND METHODS

Sediments at a number of locations from recently dredged channels in the Branford, East and Norwalk Rivers, from Long Island Sound and from freshwater impoundments (unaffected by tidal action) on the rivers were obtained using an Eckman dredge. Samples of riverbanks and the upland soils were obtained using a soil bucket auger. Sediment and soil samples were separated into different size fractions by sedimentation or centrifugation and decantation procedures. Identification of clay minerals was carried out by commonly used X-ray powder diffraction methods, using parallel-oriented specimens saturated either with Mg or K. In addition, Mg-saturated samples were solvated with glycerol and K-saturated samples were heated at different temperatures before diffraction analysis. Relative amounts of different minerals were estimated from the ratios of their diagnostic diffraction peaks.

RESULTS AND DISCUSSION

Figure 1 shows typical X-ray powder diffraction traces obtained from the clay fraction of sediments from Long Island Sound (Figure 1a), sediments from recently dredged channels (Figure 1b) and sediments from river impoundments (Figure 1c). The clay fraction of soils from stream banks and upland soils in the watershed gave patterns similar to those in Figure 1c. Mg-saturated clays from sediments in Long Island Sound and dredged channels show that they contain similar proportions of 14 Å and 10 Å components and the minerals corresponding to these spacings are the main constituents of clays. Diffraction traces of samples saturated with K and heated at 100°C show that the major portion of the 14 Å spacing reduces to the 10 Å illite spacing. The 14 Å spacing did not expand further on glycerol-solvation, indicating that the 14 Å component is vermiculite. Thus, illite and vermiculite are the dominant layer silicate minerals in clays from sediments in both Long Island Sound and dredged channels.

In contrast, diffraction traces of clays from river impoundments (Figure 1c), riverbanks and from upland soils show that the 14 Å vermiculite component is 3–4 times as large as the 10 Å illite component. Furthermore, the 14 Å component is more resistant to collapse on K-saturation and heat treatment than the 14 Å component in the sediments from Long Island Sound and

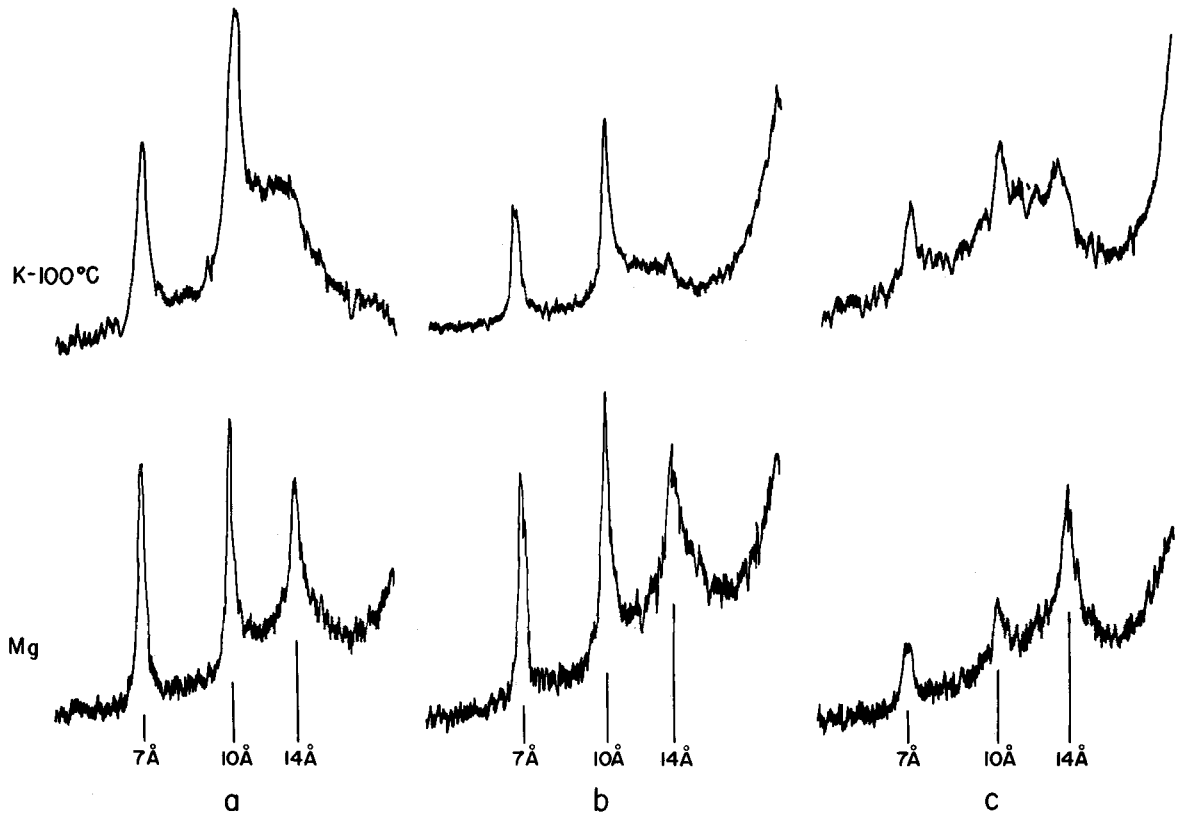

Fig. 1. X-ray powder diffraction patterns of Mg-saturated clays and clays saturated with K and heated at 100°C, in sediments from: (a) Long Island Sound; (b) recently dredged channel in Branford harbor; (c) freshwater impoundment on Branford River.

harbor channels. A careful comparison of the diffraction patterns in Figures 1a and 1b with those in Figure 1c indicates that the sediment in the harbors is nearly identical to that in the Sound.

Table 1 gives the ratios of the 14 Å/10 Å peak heights obtained from diffraction traces of a number of samples from sediments and soils. The average ratio of the 14 Å/10 Å peaks varies from 0.66 to 0.83 in samples of sediments from Long Island Sound and dredged channels whereas the average ratio of the peaks from soil samples and impoundments in about 3.8. Thus, the clay mineralogical characteristics of sediment samples from dredged channels resemble sediment samples from Long Island Sound and differ from surrounding soils and riverbank samples.

Table 1. Ratio of 14 Å/10 Å peaks from X-ray powder diffraction patterns of clays from sediments and soils.

	Sediments				
		Dredged River Channels			
Sample No.	Long Island Sound	Branford	East	Norwalk	Soils and river impoundments
1	.73	.67	.84	.78	3.8
2	.90	.57	.86	.85	2.5
3	.64	.64	.97	.94	3.1
4	.56	.89	.74	.90	5.0
5	.65	.55	.67	.76	-
6	.51	.78	.79	.76	-
Average	.66	.68	.81	.83	3.8

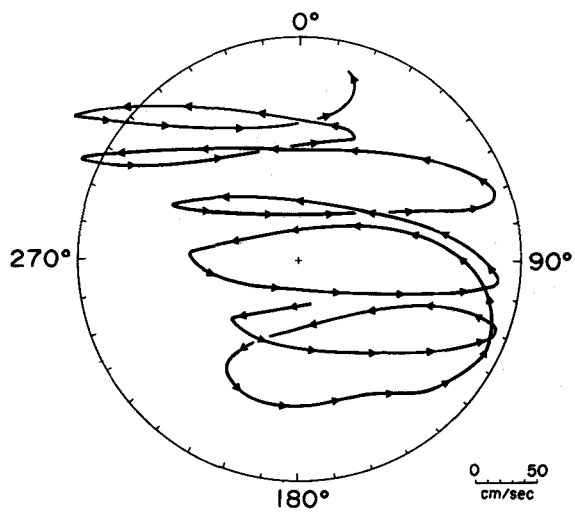

Fig. 2. Successive velocity vectors observed at 20 min intervals at the New Haven spoil ground (with permission, from Gordon et al., 1972). True north is 0°.

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Thus, these data show that the primary source of the sediments in dredged channels in the tidal estuaries is sediment transported by tidal currents from Long Island Sound and not by runoff from upland soils or from riverbank erosion. The data also demonstrate the usefulness of clay minerals as indices for understanding sedimentation processes.

These conclusions concerning the transport of Long Island Sound sediment into the dredged channels are further supported by recent studies of the bottom currents in the Sound (Gordon et al., 1972; Gordon and Pilbeam, 1975). Their observations show that an anticlockwise rotary tidal current is found at depths greater than 10 m at all stations examined. The largest component of this tidal current is in the east–west direction, with an average north–south component whose velocity is about 15% of that in the east–west direction. In the vicinity of New Haven Harbor on the North Shore, the north–south or onshore component is larger as shown in Figure 2 (reproduced from Gordon et al., 1972). Seabed drifters placed in the near-bottom waters of Long Island Sound by Gross and Bumpus (1972) show a similar pattern of westward drift with a northerly component near the Connecticut shore. Thus, sediment in Long Island Sound apparently is moved onshore by these tidal currents and deposited in the harbors and estuaries along the North Shore in a manner similar to that described by van Straaten and Kuenen (1958) for shallow protected basins in the North Sea.

The results of this investigation show that the relative amount and characteristics of the clay minerals in recent sediments in dredged channels along the north shore of Long Island Sound are similar to their amount and characteristics in the sediment from Long Island Sound. They differ from the amount and characteristics of clay minerals in the surrounding soils. It is thus concluded that the primary source of sediment in the dredged channels is the bottom sediment of Long Island Sound that is transported to the harbors by tidal action. These conclusions are supported by studies of the bottom currents in the Sound.

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Резюме- Глинистые породы были использованы как показатели для определения источника осадков в недавно углубленных гаванях вдоль северного берега пролива Лонг-Айленд. Количество и характеристики глинистых минералов в осадках из углубленных каналов сравнивались с их количеством и характеристиками в окружающих почвах и в осадках из пролива Лонг-Айленд. Глинистые минералы в осадках из каналов были аналогичны в отношении количества и характеристик глинистым минералам в осадках из пролива Лонг-Айленд,но отличались от глинистых минералов в окружающих почвах на водоразделе. Таким образом,главным источником отложений в каналах являются донные осадки пролива Лонг-Айленд, которые переносились в каналы приливами. Эти заключения подтверждаются недавними исследованиями донных течений в проливе.

Kurzreferat- Tonmineralien wurden als Indikatoren,für die Bestimmung von Sedimenten in neu-ausgebaggerten Häfen an der Nord-Küste von Long Island Sound, benutzt. Mengen und Charakteristiken der Tonmineralien in Sedimenten von den ausgebaggerten Kanälen, wurden mit den Mengen und Charakteristiken der umliegenden Erden und der Sedimente von Long Island Sound, verglichen. Die Mengen und Eigenschaften der Tonmineralien in Sedimenten von den Kanälen waren denen, der Tonmineralien in Sedimenten von Long Island Sound ähnlich, aber unterschieden sich von denen in den umliegenden Erden der Wasserscheide. Aus dem Grunde,ist der Hauptursprung der Ablagerungen in den Kanälen,die Bodensedimente des Long Island Sound, die in die Kanäle durch die Wirkung der Gezeiten transportiert werden. Diese Ergebnisse werden durch neue Untersuchungen der Bodenströme im "Sound" bestätigt.

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Résumé-Des minéraux argileux ont été employés comme indicateurs pour déterminer la source de sédiments récemment dragués dans des ports de la côte nord du Long Island Sound.Les quantités et les caractéristiques des minéraux argileux dans les sédiments dragués des chenaux ont été comparés à leurs quantités et caractéristiques dans les sols et les sédiments du Long Island Sound.Les minéraux argileux dans les sédiments provenant des chenaux étaient semblables aux minéraux argileux provenant des sédiments du Long Island Sound du point de vue de leurs caractéristiques et de leurs quantités,mais étaient différants de ceux dans les sols aux alentours dans la même zone de drainage.Par conséquent,la source principale des dépôts dans les chenaux est le sédiment de fond du Long Island Sound,transporté dans les chenaux par l'action des marrées.Ces conclusions sont appuyées par de récentes études des courants de fond du Long Island Sound.

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