Proceedings

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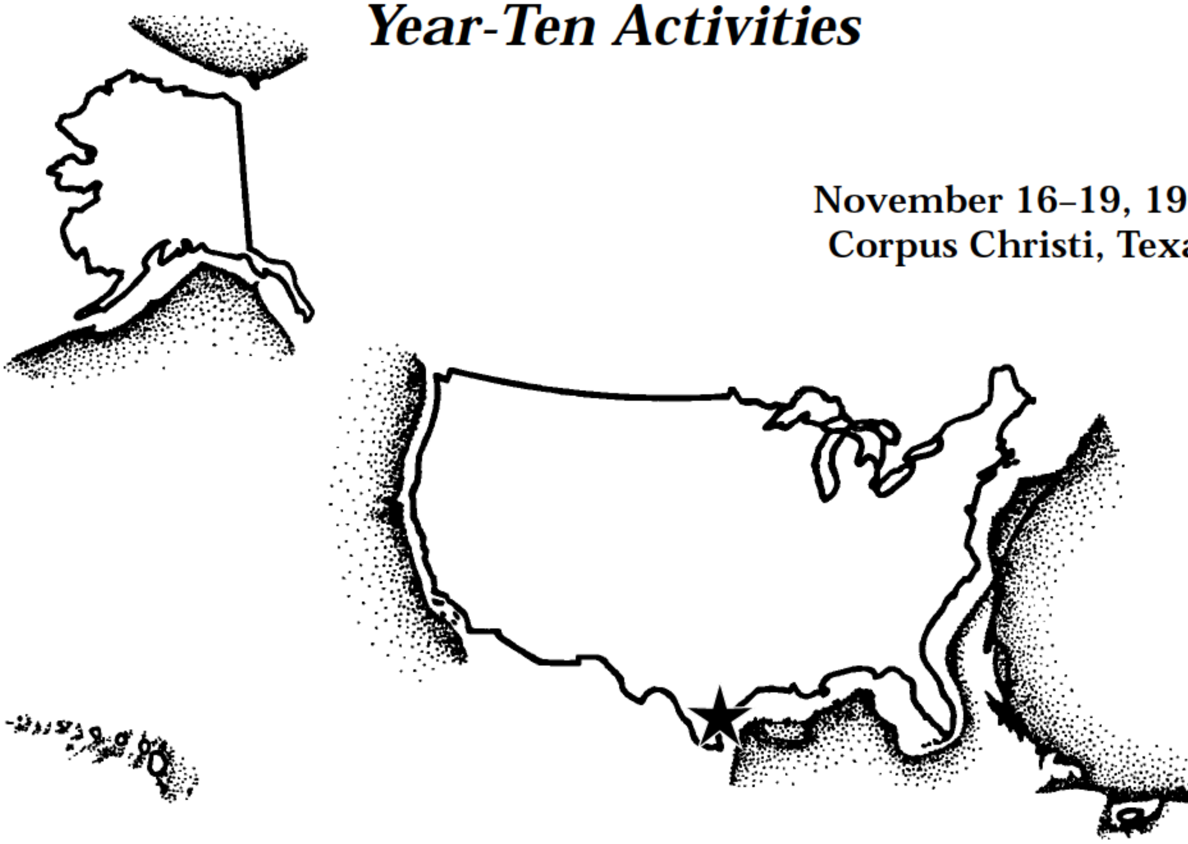
Studies Related to Continental Margins—A Summary of Year-Nine and Year-Ten Activities



November 16–19, 1997
Corpus Christi, Texas

George Dellagiarino, Lynda A. Miller, and Susann Doenges

Editors

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Submarine Sand Resources, Southeastern Virginia—Contributions from Year Nine and Year Ten of Virginia's Continental Margins Program

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Abstract

Virginia's Year-Nine and Year-Ten funds from the Continental Shelf Program were used to supplement other work funded by the Minerals Management Service in an ongoing Cooperative Agreement focused on the area offshore of southeastern Virginia. Year-Nine and Year-Ten funds facilitated interpretation of subbottom profiles and the analysis of sediment samples from cores and grabs.

On Virginia's sediment-starved continental shelf, deposits of material potentially suitable for use as beach nourishment or, perhaps, as construction aggregate occur in three stratigraphic settings, each with specific characteristics of morphology, grain-size gradients, likelihood of discovery, and physical ease of exploitation. All must be verified with a careful program of coring. Modern shoals generally are easier to identify, prove, and access than either filled channels or lenticular facies. Shoals usually are identifiable on nautical charts and characteristically have a definite lower boundary that can be seen in subbottom profiles. In most cases, the base of the shoal coincides with the level of the surrounding sea floor. Filled channels are readily identifiable on subbottom profiles but may have a narrow, sinuous form and steep lateral gradients in sediment properties. Buried lenticular facies of good-quality sand usually are found only fortuitously. As the lateral and often vertical gradients in geotechnical properties usually are low, the lenticular facies can be mined with a lesser concern for the consequences of violating the deposit's limits than with the other two types of deposit.

There are three types of filled paleochannels in the study area: (1) Relatively near surface, generally small, roughly shore normal channels most likely mark the migration of tidal inlets across the shelf during the most recent transgression. (2) Small, relatively wide and relatively shallow generally shore parallel channels may be filled back-barrier or lagoonal channels. (3) Larger channels trending across the shelf probably result from riverine flow.

The complexity of the seismo-stratigraphy of the Quaternary deposits on southeastern Virginia's inner continental shelf is a result of series of high-frequency (fifth-order, 10–20,000 y), low-amplitude (20–30 m) variations in sea level that occurred during the last highstand, roughly 80,000 to 130,000 B.P. The evidence of the small oscillations in sea level is best seen in the regions that were between the shoreline and wave base, today's inner shelf; however, the very low rates of deposition on the shelf make it difficult to correlate specific reflectors or beds or, at times, to distinguish between fifth- and fourth-order changes.

Results for the continuing studies already have been used in the determination to mine several hundred thousand cubic meters of sand from Sandbridge Shoal for use on a Navy-owned facility and in consideration of mining greater quantities of sand from Sandbridge and other shoals for use in the local beach nourishment and hurricane protection efforts.

Introduction

The inner continental shelf offshore of southeastern Virginia (fig. 1) is a focus of both applied and academic studies. Increasing demands for large quantities of sand to nourish the region's valuable beaches have resulted in surveys designed to identify potential sand sources. This work has facilitated the collection of data that enhance the understanding of the area's Quaternary geological history. It is the intent of this paper to provide a means for the characterization of the sand resources and to provide an updated interpretation of the stratigraphic record.

Portions of this paper have been presented in the dissertation of one of the authors (Hobbs, 1997) and in various contract reports (Hardaway and others, 1995; Hobbs, 1996, among others) or meeting presentations (Hobbs and Hardaway, 1996; Hobbs and others, 1997, among others).

Previous Work

Shepard (1932) depicted the sediments offshore of southeastern Virginia as being "shells, sand & gravel," "gravel," near the Virginia–North Carolina border, and "shells & sand" near the mouth of Chesapeake Bay. Shepard based the portrayal on information recorded on navigation charts augmented by examination of samples collected by the United States Coast Survey but provided no indication of the number or spacing of samples. Milliman and others (1972) and Milliman (1972), using a grid of grab samples with an 18-km (10-n-mi) spacing, mentioned a plume of very fine sand with coarse silt extending seaward from Chesapeake Bay and a band of arkosic sediments in the sand portion also extending outward from the bay. With 10 or so samples within the present study area, the reports described the nearshore subarkosic to arkosic fine-grained sediments and sands as being derived from modern, nearshore, fluvial sources and the similarly composed materials found farther offshore as relict fluvial sediments. Amato (1994), in describing the sand and gravel resources of the Atlantic Continental Shelf, provided a summary and review of earlier works and included maps showing the distribution of sediment types. As is the nature of a compilation and review, his work basically echoes the above-referenced studies but does specifically consider the sediments as a resource.

Swift, Shideler, and their co-workers (Shideler and others, 1972; Shideler and Swift, 1972; Swift and others, 1970; 1971; 1972a,b; 1977) performed a series of studies of the Virginia continental shelf. Shideler and others (1972) proposed a standard stratigraphic section for the area, which most subsequent workers have used. The standard section consists of a sequence of four stratigraphic units, termed units A, B, C, and D, separated by major reflectors.

Oaks and others (1974) described the terrestrial, post-Miocene geology of southeastern Virginia (more recent interpretations [Johnson and others, 1985] consider the same sequence to be post-Pliocene). Oaks and others (1974) discussed 10 stratigraphic units that were formed during "6 distinct periods of submergence" and "6 important periods of emergence." The major sea-level lows occurred before the Sedley, Moorings, Windsor, Great Bridge, Londonbridge, and modern units. Johnson and Berquist (1989) summarized the stratigraphic nomenclature used since 1928 in studies of Virginia's coastal plain. Table 1 compares Johnson and Berquist's (1989) terminology, modified with the inclusion of the Chowan Formation from Johnson and others (1985), with the stratigraphy discussed by Oaks and others (1974).

Toscano and others (1989) and Toscano (1992) discussed the Quaternary history of inner continental shelf offshore of Maryland and the inner shelf of the mid-Atlantic. One facet of these studies that has specific bearing to the inner shelf off southeastern Virginia is the set of small-scale fluctuations of sea level, -23 to +6 m, during Oxygen Isotope Stage 5, roughly 75,000 to 130,000 years B.P. This period corresponds to the North American Sangamon (Richmond and Fullerton, 1986). These oscillations, three highs and two intervening lows within 23 m of today's sea level, should be evident on the inner shelf. Those sections of the shelf less than 20 m in depth would have been exposed and the areas at slightly greater depth would have been subjected to shallow-water wave and current energy. Toscano and York (1992) presented a correlation chart for middle Atlantic coastal plain and inner shelf strata. Their work suggests some of the problems of interpretation and correlation. Specifically, the correlation shows "unit C" (Shideler and others, 1972) as existing across major regressions; that is, unit C continues in time through the formation of the Exmore and Eastville (and by extension, Belle Haven [Oertel and Foyle, 1995]) paleochannels. This lack of differentiation in unit C possibly results from the inability of Shideler and others' (1972) equipment to image or resolve some reflectors.

Chen (1992) and Chen and others (1995), using some of the same data as used for the present paper, described a set of filled channels on Virginia's inner

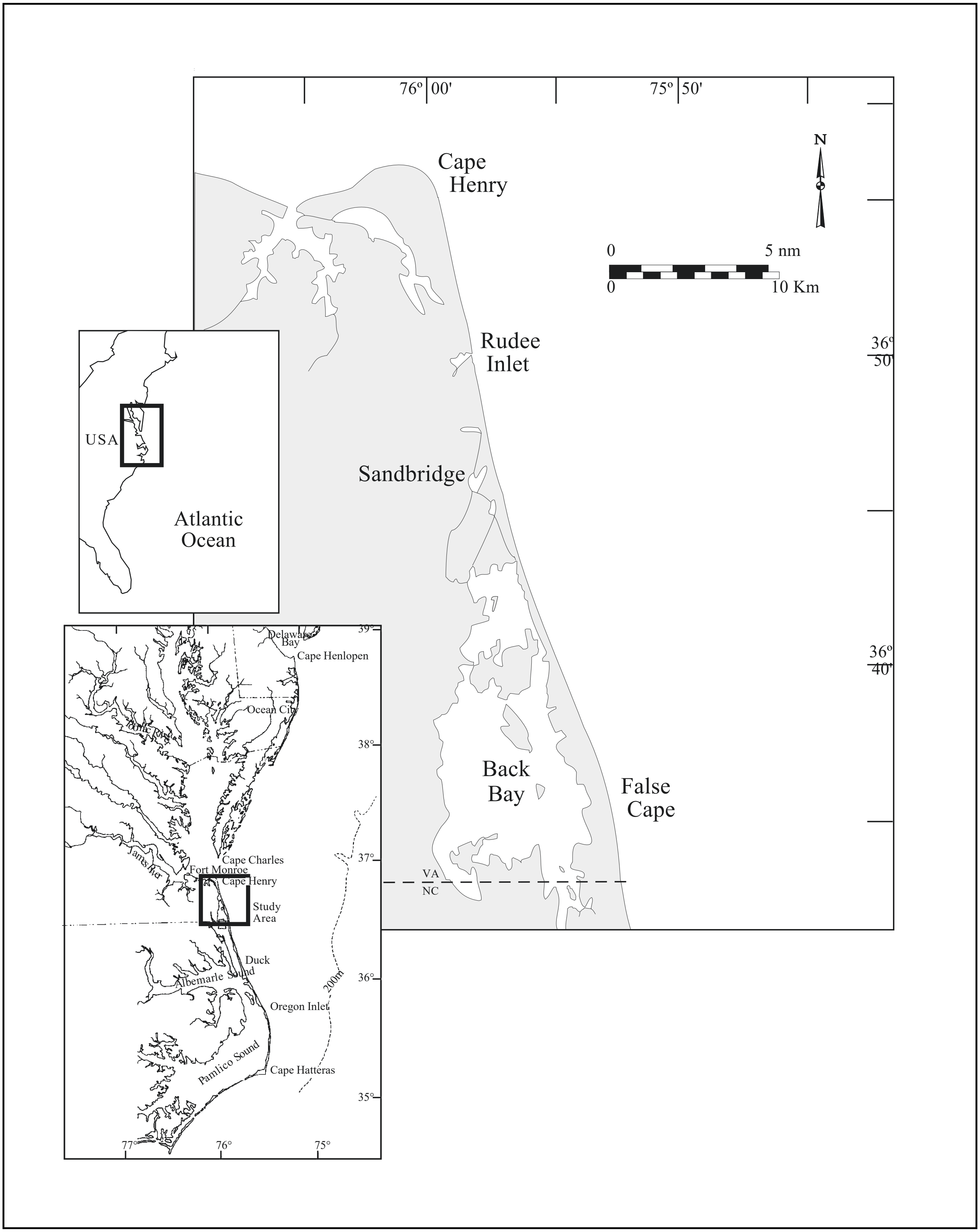

Figure 1. Map depicting the location and extent of the study area.

Table 1. Comparison of nomenclature for the stratigraphy of Virginia's coastal plain.

	Oaks and Coch (1973) Oaks and others (1974)	Johnson and Berquist (1989) Johnson and others (1985)		
HOLOCENE	Unnamed Holocene and Dismal Swamp peat	Unnamed Holocene deposits		HOLOCENE
	Sandbridge Fm.	Tabb Fm.	Poquoson Mbr.	
	Londonbridge Fm.		Lynnhaven Mbr.	
	Kempsville Fm.		Sedgefield Mbr.	
	Norfolk Fm.			
PLEISTOCENE		Shirley Fm.		PLEISTOCENE
	Great Bridge Fm.			
		Chuckatuck Fm.		
	Windsor Fm.	Charles City Fm.		
		Windsor Fm. (restricted)		
PLEISTOCENE AND/OR PLIOCENE	"Moorings" unit	"Moorings" unit		
	Bacons Castle Fm.	Bacons Castle Fm.		
				PLIOCENE
		Chowan River Fm.		
	Sedley Fm.	Yorktown Fm.		
MIOCENE				
	Yorktown Fm.	Eastover Fm.		MIOCENE

shelf and attempted to correlate them to the Cape Charles, Exmore, and Eastville paleochannels in Chesapeake Bay of Colman and Hobbs (1987, 1988), Colman and Mixon (1988), and Colman and others (1990). Foyle (1994) and Oertel and Foyle (1995) furthered the understanding of the regional channel systems with the recognition of the Belle Haven paleochannel.

Kimball and Dame (1989), Dame (1990), and Kimball and others (1991) investigated some of the sand resources potentially available within the present study area and provided an initial description and geological history of Sandbridge Shoal. Hardaway and others (1995) and Hobbs (1996) continued the series of studies of the region's sand resources.

Methods

This study is based upon approximately 1,100 km (595 n mi) of high-resolution, 3.5 kHz, seismic-reflection profiles obtained with an analog DataSonics system and printed upon either or both an EPC 4800 or 3202 graphics recorders. Loran-C was used to obtain position information for the earlier profiles, and GPS was used for the more recent. Fixes generally were logged at 2-minute intervals. This data set was augmented by two sets of cores. The first were 9-cm-diameter (3.5-in) vibracores of up to 6 m (20 ft) length collected in the summer of 1987. The second group of cores were 7.5-cm-diameter (3-in) vibracores up to 9 m (30 ft) length that were acquired in the spring of 1994. Additionally, we collected and determined the granule:sand:silt:clay ratios of a set of 380 grab samples of the surface sediments.

Results and Discussion

Plots of the granulometric analyses of the surficial samples indicate that the region is dominated by coarser sediments, most of the samples being in excess of 90 or 95 percent sand. Only 5 of the 380 samples would not plot as "sand" on Shepard's (1954) ternary classification. The sands usually are coarser than 2 phi with the finer sands occurring generally south of False Cape and in a large area adjacent to the mouth of Chesapeake Bay. Fine-grained sediments occur very near shore near locations where marsh or lagoonal sediments crop out through the beach.

The subbottom profiles depict a set of thin, sometimes discontinuous strata above a widespread sharp reflector that most likely is Shideler and others' (1972) reflector 1 that is assumed to mark the bottom of the Pleistocene record. The Pleistocene strata are cut by and overlay filled channels of various orientations and scales. A large fragment of wood from 3.7 m below the sea floor (approximately 15.2 m below sea level) in a core almost directly offshore from Rudee Inlet had a carbon-14 date of 9,440 $^+$/- 50 yr BP. The wood was at the base of a coarse-sand channel fill immediately above a thick, fine-grained muddy section. The upper portion of the seismic profiles contains many closely spaced, difficult-to-correlate reflectors. The subbottom profiles also display shoals, corresponding to Shideler and others' (1972) Unit D, atop an older substrate.

Conclusions

Although the surficial sediments within the study area are dominantly sands, their textures are more varied than has been indicated by previous studies. The density of the sample grid used in this study allowed identification of a degree of spatial variability that was not afforded by the earlier studies. The patterns of distribution indicate that Chesapeake Bay probably is the source of a plume of generally finer grained sediments extending from the bay mouth, that isolated patches of much finer grained materials very near shore are related to outcrops of older marsh or back-barrier sediments similar to those exposed along some of the shoreline, and that small offshore areas of differing sediments may indicate either outcrops of older materials or topographically controlled local deposits of modern sediment.

The Pleistocene history of the inner continental shelf of southeastern Virginia and the resulting stratigraphy are more complex than has been suggested by the previous literature. The impact of the Exmore, Belle Haven, and Eastville channel-forming events on the stratigraphy, especially submarine Unit C, has not been fully understood. Similarly the several high-frequency, low-amplitude fluctuations in sea level during Oxygen Isotope Stage 5 have resulted in a complex pattern of thin yet regionally continuous seismostratigraphic units that most likely echo the lithostratigraphy. These fifth-order stratigraphic sequences are difficult to discern in the relatively sediment starved shelf. Furthermore, because the individual sequences are so thin, drainage channels are likely to cut several strata.

There are three distinct types of filled paleochannels within the inner continental shelf. Relatively near surface, generally small, roughly shore normal channels, such as seen near Rudee Inlet, are most likely the courses of tidal inlet channels, in this instance dating from the last lowstand of sea level. Small, relatively wide and relatively shallow, generally shore parallel channels, some of which are evident in the records, may be back-barrier or lagoonal channels. The third type of channel results from riverine flow.

There are substantial resources of sand on the inner continental shelf of Virginia. The deposits occur in three distinct stratigraphic settings (table 2). The most easily discernible type of deposit is the discrete, surficial shoal, as exemplified by Sandbridge Shoal. Shoals are well-defined topographic features on the surface of the inner shelf. In the seismic records they have clear bottom boundaries. After the grain-size characteristics of such deposits are verified by coring, the physical process of mining should be relatively straightforward: dredge the shoal to the depth of the bottom contact.

Filled channels, such as those offshore of Rudee Inlet, are another class of deposit. The fluvial sands filling the channels can be a very clean, high-quality sand suitable for use in beach restoration or nourishment and in construction aggregate. Although there is

Table 2. Inner shelf sand bodies.

	Shoal	Filled channel	Gradational
Visibility	On surface	Buried	Buried
Lateral limits		Sharp	Undefined
Top	Sea floor	Varied	Varied
Bottom	Sharp	Usually sharp	Varied
Seismic definition	Good	Good	Poor
How found	Bathymetry	Seismics Geology	Serendipity Geology (?)
How proved	Coring through bottom reflector	Coring	Coring
Dredging	"Easy" Remove shoal to predetermined depth	"Difficult" Stay within channel	"Very Easy" Stay within broad vertical and horizontal limits

no surface expression of the deposit, the extent of the deposit is fairly clear in subbottom profiles. Mining the filled channels is more difficult than the surficial shoals. Overburden would have to be removed or mixed with the more desirable channel fill. The lateral extent of the deposit is small relative to its length, and the boundaries are sharp. Dredging requires careful mapping of the lateral and vertical limits of the deposit through seismic profiling and coring and careful control of the dredge.

The third type of sand deposit, a lenticular facies, is the most difficult to find. A bed may grade from sediments of unacceptable quality for use to acceptable quality and back to unacceptable. There is no surface expression of the deposit, the top of which could be buried or could be the sea floor. There are no reliable indicators in the seismic records. This class of deposit is discovered serendipitously and only by coring. However, once the deposit is discovered and defined, the process of mining is relatively easy. Changes in sediment type are apt to be gradual with the result that the limits of the area to be dredged are set arbitrarily on the basis of sedimentary characteristics determined by analysis of core samples.

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