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Unifite Muds in Intraslope Basins, Northwest Gulf of Mexico

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Abstract

Uniformly structureless clayey muds, very much like those termed unifites or homogenites in the Mediterranean and other basins, occur in intraslope basins in the northwest Gulf of Mexico. Their organic carbon and carbonate contents indicate a terrigenous source. Their age (about 17,000 B.P.) approximates the time when large-scale slumping of terrigenous delta fronts formed the Mississippi Canyon (Trough). Their compositional dissimilarity to nearby hemiplagic mud precludes a homogenite-like origin involving a tsunami. However, it is uncertain whether they are end-products of bypassing (unifites) or entrapments of entire flows of sandless clays from deltaic facies of the same composition.

Introduction

Extraordinarily homogeneous mud beds have been reported in the Mediterranean [1,2] and the western equatorial Atlantic [3]. Damuth [3] found these deposits in the abyssal plains and fracture zone valleys most distal from continental shelf and slope terrigenous sources. Similarly, Stanley [2] observed uniform muds in the deepest basins of the western Hellenic Trench and in the plains of several other small Mediterranean basins. In both studies, it was concluded that the muds were redeposited by low density, highly fluid, muddy remnants of turbidity currents that had lost most of their coarser materials by deposition at sites more proximal to the sediment sources. Stanley [2] termed this process "slope-relief bypassing" and named the resulting deposits "unifites."

Unifites are most readily distinguished by their extraordinarily uniform or homogeneous structure apparent in both X-radiographic and visual observations. Damuth [3] described them as almost entirely clay. Blanpied and Stanley [1] reported them to consist of only 35 to 50% clay, but no more than 0.3% sand. Relative textural values demonstrate subtle-fining upward through the units [1], with basal parts distinctly siltier and faintly laminated. In fact, Blanpied and Stanley [1] distinguished two types of unifites; FL (faintly laminated) and U (uniform-completely structureless). Unifite deposits are seismically traceable as acoustically transparent units that occupy flat basin plains. Radiocarbon dates from unifites show narrow ranges suggesting rapid deposition [1,2].

Structureless muds called "homogenites" by Kastens and Cita [4] are essentially the same as unifites in structural, textural, and acoustic character and rates of deposition, but occur in small (approximately 1 km accross) basins on the Calabrian and western Mediterranean Ridges. More recently, homogenites have been reported in the Ionian Abyssal Plain [5,6]. These occurrences were also interpreted as redeposition, but of material eroded from adjacent bathymetric highs and basin walls, rather than from a distant, more terrigenous source. The mechanism for erosion was believed to be a tsunami that was generated by the collapse of the caldera of the Santorini Volcano. This event was chosen because its timing (3500 B.P.) was within the narrow range of ages determined for the homogenite (3100 to 4400 B.P.) and because calculated wave-ray paths from this source matched the observed distribution of the deposits.

Cita and others [5] studied the characteristics and origins of homogenites and unifites and concluded that the distinction between them "will have to be made on circumstantial evidence—physiographic, stratigraphic, and seismological setting" [5, p. 59]. The purpose of this report is to describe the circumstances of uniform muds of significant volume that occur in intraslope basins in the northwest Gulf of Mexico and discuss the constraints of their origins. Before the discussion of origin, the term unifite is used herein only descriptively as an abbreviation of uniformly structureless mud.

Observation—Northwest Gulf of Mexico

Approximately 100 basins or troughs are found on the continental slope off Texas and western Louisiana in water depths of 300 to 2000 m between the Mississippi Fan and the portion of the south Texas slope influenced by the Rio Grande, Colorado, and Brazos Rivers (Fig. 1). The highly irregular bathymetry of this slope region results from a three-dimen-

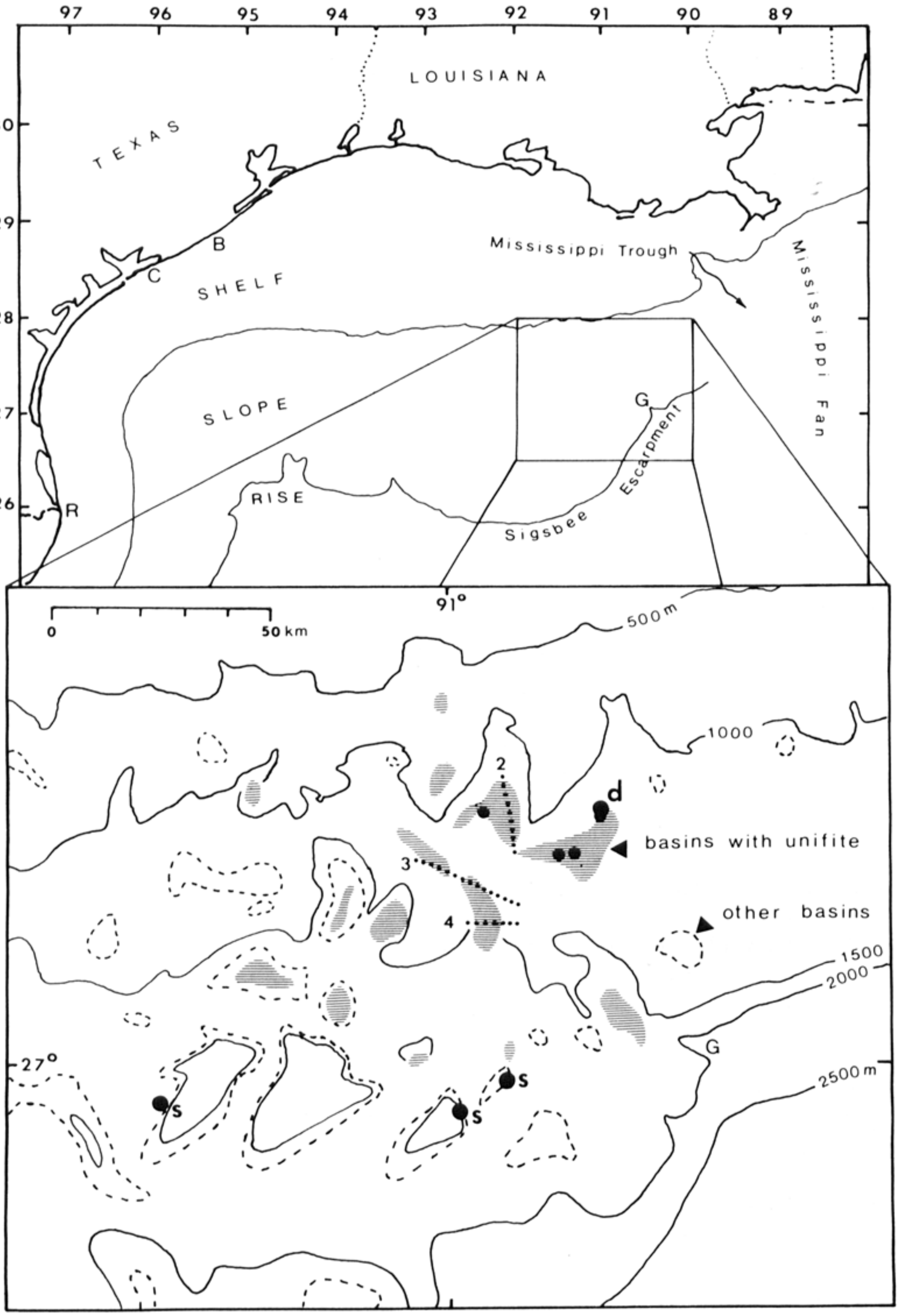

Figure 1. Location and index maps of the study area. In upper map *R*, *C*, and *B* are at the mouths of the Rio Grande, Colorado, and Brazos Rivers, respectively. The indentation in the Sigsbee Escarpment at G (both maps) is Green Canyon. Numbered dotted lines (2,3, and 4) in the lower map are the locations of the profiles in Figures 2, 3, and 4, respectively. Contours (in meters) are after Holland [15]. The solid circles are piston-core locations; s = with sand beds; d = with dated unifites; unlettered = with unifites.

sional complex of salt diapirs that separates and partially or completely isolates the basin depocenters. This continental margin is in a passive intraplate position; yet it is tectonically very active. However, the salt tectonics are essentially aseismic.

Unifites occur in an eastern group of 10 or more of these basins (Fig. 1) and have most of the same characteristics of the Mediterranean and south Atlantic deposits. In high resolution (3.5 KHz) seismic profiles (Figs. 2 to 4), they are acoustically transparent, occupy basin bottoms, and range in thicknesses of up to 40 m. This usually represents manyfold thickening of laterally traceable strata in the basin margins and bathymetric highs. The youngest unifite occupies the same stratigraphic position in each basin (i.e., just above the highest amplitude reflection in the seismic section) (Figs. 2 to 4). Within the largest basin, the volume of this unifite is approximately 5 km^3, and the total volume of this unit is roughly 30 km^3.

Only two of five cores sampling these unifites penetrated to underlying strata. The muds are unifites *sensu stricto* in that they are structureless both visually and in X-ray studies. The somewhat coarser, finely laminated, lower portions of the structureless muds described by other [1,4] were not observed. However, at some sites these beds may be deeper than we sampled rather than absent. Core sections recovered show very clayey (86%) muds, generally without sand (i.e., usually 0% and almost always <1/4% sand). Mean grain size values are more than 10 phi, with almost 60% of each sample finer than this size. These textural parameters differ from those of nearby hemiplagic muds only in almost com-

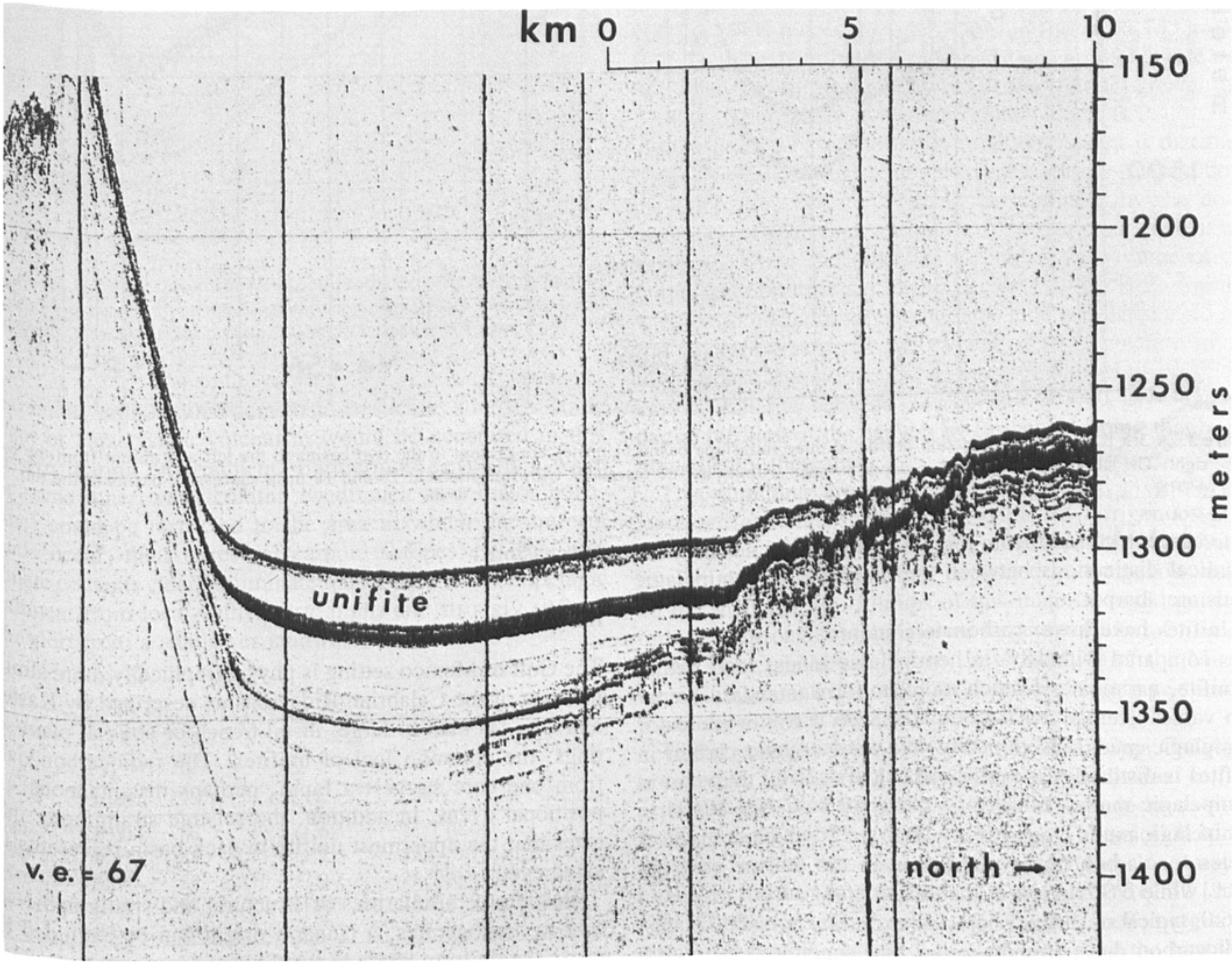

Figure 2. A 3.5 KHz vertical reflection profile through one of the larger basins with unifite (v.e. is vertical exaggeration). The unifite is about 16 m thick. Subjacent units also show much thickening from basin margin to basin plain.

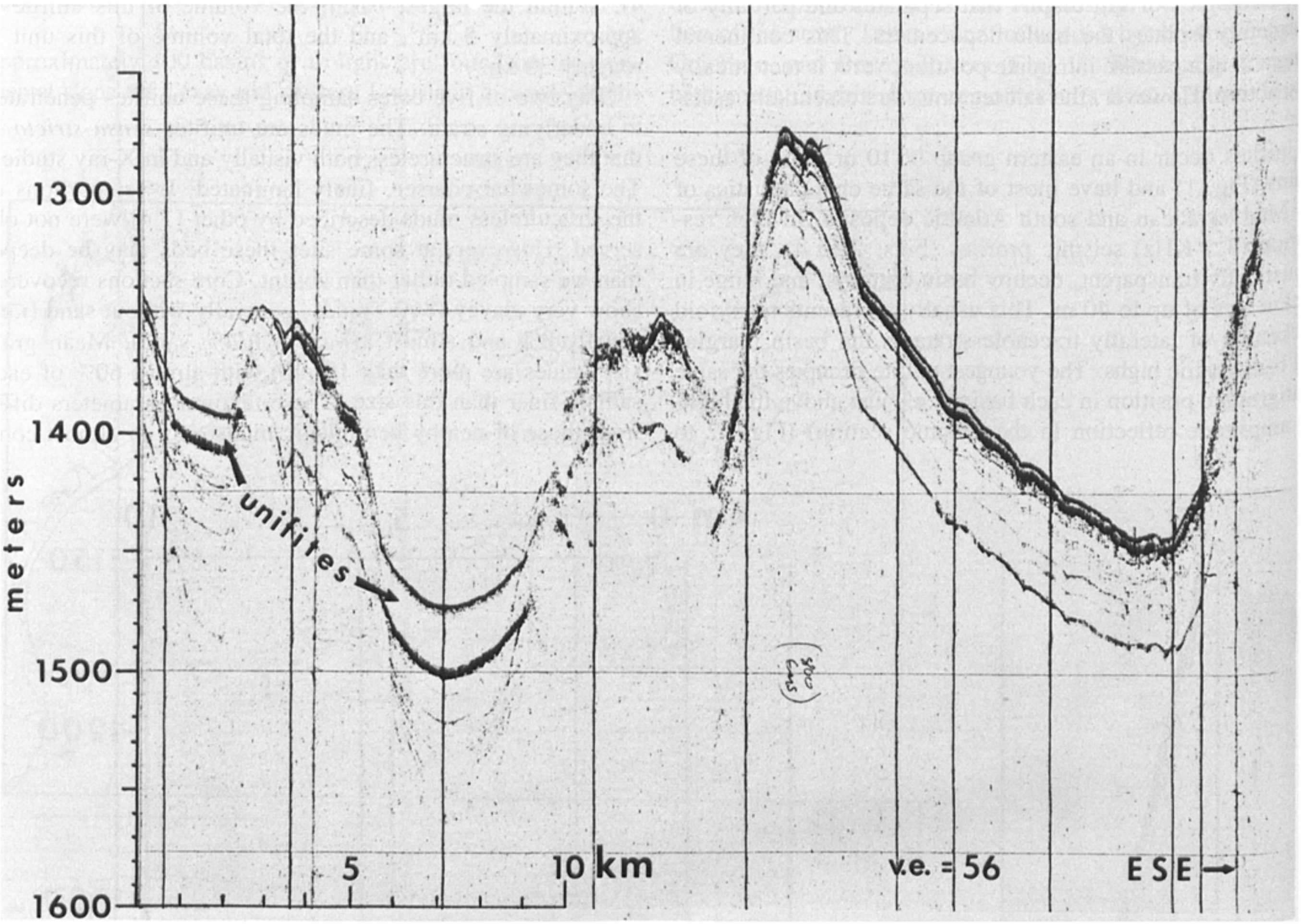

Figure 3. A 3.5 KHz vertical reflection profile of three intraslope basins. Unifites are present in the two basins to the left and absent from the basin to the right. The strong reflection at 5 m depth in basin without unifite correlates with reflections at 28 and 14 m in successive basins to the left.

plete absence of sand from the unifites (Table 1). However, chemical distinctions between the unifites and hemipelagic muds are sharper.

Unifites have lower carbonate contents (8 to 13% in unifites compared with 18% in hemipelagic muds), and within a unifite, carbonate is much more uniform (standard deviation values average 1.2% compared with 2.6% or more for hemiplagic muds). Isotopically, the total organic carbon in unifites is distinctly lighter (more negative $\delta^{13}C$) than that in hemipelagic muds (Table 1). Values for $\delta^{13}C$ (vs. PDB) in hemipelagic muds range from −20 to −22, which are typical values for carbon photosynthesized in the marine environment, while $\delta^{13}C$ values in the unifites range from −25.7 to −26.0, typical of carbon photosynthesized by terrestrial plants. Radiocarbon dates from the core that penetrated through a unifite (Table 2) clearly show that it is redeposited older material.

Discussion

Homogenites?

The Gulf of Mexico setting is physiographically more similar to some of the Calabrian Ridge basins described by Kastens and Cita [4] than to large, distal trench or abyssal plain settings, the common loci of unifites. The radiocarbon dates from one core suggest a rapid, perhaps instantaneous, depositional event. In addition, the seismic stratigraphy indicates that the uppermost unifite in each basin represents the same event.

Despite the similarities of structural and stratigraphic setting to homogenites, a tsunami origin can be excluded because the uniform muds in the Gulf of Mexico are restricted to a relatively few of the large number of similar intraslope basins that would be equally exposed to such a wave. It is

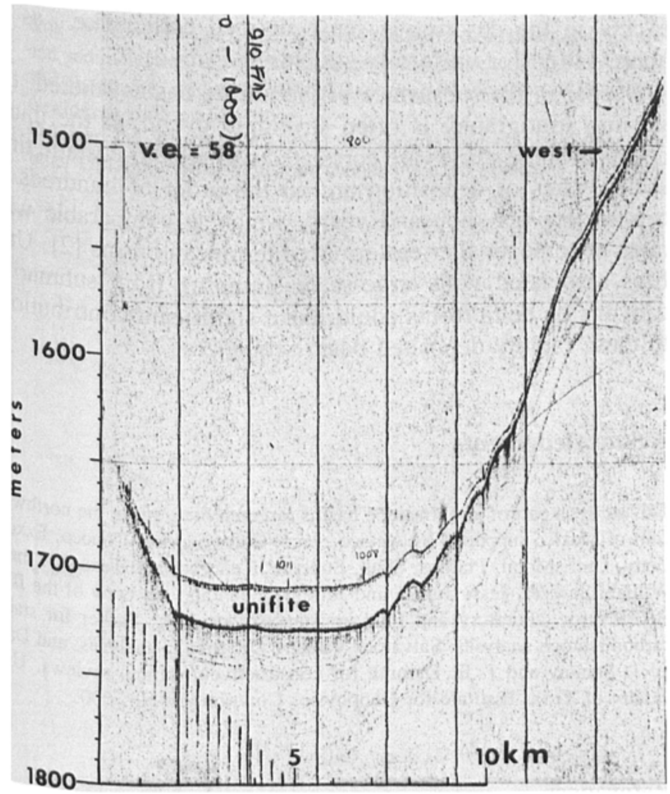

Figure 4. A 3.5 KHz vertical reflection profile of a basin with unifite, showing expansion of uppermost stratigraphic unit from 5 m on the basin margin to 20 m in the basin plain. Location is shown in Figure 1.

also highly unlikely that a mechanism such as a large seismic event or cataclysmic volcanism would be generated in this passive margin environment. Furthermore, even if a wave (or some other water-column event such as a major hurricane) could be restricted to the area in which the uniform muds occur, their terrestrial carbon isotopes and low carbonate contents clearly eliminate redeposition of hemipelagic sediment from local bathymetric highs and strongly suggest transport from a shallower landward source.

Table 1. Textural and Chemical Parameters of Unifites

Core	% Sand	% Clay	% $CaCO_3$	$\delta^{13}C$	Number of Samples
IG45-7	0.00	88	13.5 (1.6)*	−25.7 (0.0)†	4
IG45-8	0.03	88	11.6 (1.2)*	−25.7 (0.1)†	4
IG46-6	0.06	83	10.4 (2.0)*	−25.7 (0.1)†	5
IG36-8	0.04	87	10.5 (1.0)*	−25.9 (0.2)†	6
IG36-7	0.04	83	11.3 (0.7)*	−26.0 (0.1)†	2
Core of hemipelagic mud from a bathymetric high					
IG45-22	1.59	84	15.8 (8.8)*	−21.2 (2.8)†	5–9

*Standard deviation; †total range of values.

Table 2. Radiocarbon Ages from Core IG46-6

Depth (cm)	^{14}C Age (B.P.)	Material
137	11,600 ± 160	Mottled mud
263	>40,000	Unifite*
509	>40,000	Unifite*
625	22,820 ± 590	Irregularly bedded mud

*The uniformly structureless mud extends from 200 to 560 cm.

Terrestrial Source

To test the hypothesis of a terrestrial source, the radiocarbon data were used to interpolate a time for the depositional event. Assuming zero-time for unifite deposition, the accumulation rate (all rates are for a constant porosity of 70% [7] for the Holocene (since 11,600 B.P.) is 8.3 cm/1000 yr, and that for the latest Pleistocene (11,600 to 22,820 B.P.) is 9.0 cm/1000 yr. This places the age of the unifite at 16,755 ± 210 B.P. To the extent that the pre-unifite accumulation rate may be higher, the unifite age may be greater (but not greater than 22,000 and probably not greater than 18,000 B.P.).

A prediction based on this depositional event is that there was a corresponding erosional event of large magnitude at the same time. This hypothesis is supported by the documentation of such events from the Mississippi delta shelf and slope. Coleman and other [8] estimated the volume of one failure at 8600 km^3 and date it at post-35,000 B.P. Another widespread unconformity in the same area was dated at 15,500 B.P. These workers also documented the formation of the Mississippi Canyon (Trough) by the slumping of at least 1500 km^3 of material between 25,000 and 20,000 B.P. and the partial refilling of the canyon by further slumping that began immediately thereafter.

This slumping process presumably eroded progressively landward and into shelf margin deltas of terrigenous sediment. Thus, the unifites described here could be the result of slumping of sediment first deposited in terrigenous deltas on the shelf margin. Slumps of this material could generate turbidity currents that transferred large quantities of material to the slope and abyssal plain. Less than 1% of the Mississippi Canyon material could account for the youngest unifite muds deposited in the intraslope basins.

Unfortunately for this scenario, the Mississippi Canyon is not directly upslope from the unifite-bearing basins. In fact, sediment transport from that site would have to be as much or more alongslope as/than downslope. The solution to this problem may be that a source more directly upslope may be available for the same mechnism. Suter and Berryhill [9,10] reported that at least five deltas occupied shelf margin positions west of the Mississippi Canyon during the late Wisconsin low sea-level stands. One of these deltas was served by the Mississippi River and lay to the west of the unifite basins between 92 and 93°W longitude. Furthermore, it is associated with a large trough that crosses the shelf-break and is now filled with sediment [11]. Sediment transport from this source would also involve a rather long alongslope vector; but the position of this feature demonstrates the broad longitudinal range of the Mississippi River mouth positions within which lie the intraslope basins containing unifites.

Bypassing?

A remaining question is: does the deposition of the structureless muds in the northwestern Gulf of Mexico intraslope basins involve the slope-relief bypassing mechanism? If this is the case, the genetic implications of the term "unifite" remain unchallenged. However, if it is not, referring to these deposits as "unifites" becomes problematic.

The involvement of slope-relief bypassing is questioned because the midslope position of the Gulf of Mexico basins with uniform muds is where some coarse fractions are traditionally expected to be retained or sorted from downslope-flowing turbidity currents that would be expected to deposit unifites ultimately in distal environments. Indeed, upslope from the basins with uniform muds, there are no intraslope basins, only irregular, rugged bathymetry to the shelf-break. If bypassing separated coarser material from the uniform muds here, it would seem that the processes must be like those that occur on submarine fans. On the Amazon, Indus, and Mississippi Fans, for example, sand is channeled to and deposited on the lower fans, and mud is selectively retained on the upper and middle fans [12–14]. These muds are distinctly different from unifites; but uniformity may result from ponding as opposed to the continued flow which would disperse overbank interdistributary muds on fans.

Some features on the lower slope in the study area lend support to this hypothesis. A possible sediment conduit, Green Canyon, interrupts the Sigsbee Escarpment at the base of the slope. Also, I have piston-cored sands (some Holocene) in lower slope basins in this area (Fig. 1). However, no obvious channel system is attached to the basins or Green Canyon, and the pathway by which sand- and mud-flow separation could occur is not apparent with the present data.

If bypassing did not occur, the uniform muds could result only from redeposition of material with the same clayey sandless texture. This type of sediment does occur in the Mississippi Delta environment in the prodelta facies [8] and in terrestrial interdistributary basins [Elisabeth C. Kosters, personal communication, 1984]. Thus, it is possible that the unifites represent entrapment of homogenized but unsorted flows of deltaic clays. If this happened, either the bypassing requirement for use of the term "unifite" would have to be abandoned, or the term should not be used for these deposits. In the present case, information is insufficient to use the term except in the descriptive sense defined earlier (i.e., as an abbreviation for uniformly structureless mud).

Deeper in the subsurface of the unifite basins studied, the seismic stratigraphy is often strikingly cyclic. If the thicknesses of these cycles are correlated with glacio-eustatic time scales, rates of deposition are on the order of hundreds of centimeters per thousand years, which is comparable with rates in some smaller eastern Mediterranean basins [2]. Unifites associated with large-scale slumping from submarine canyons on delta fronts could make significant contributions to these rapidly deposited basin sequences.

Acknowledgments

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