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Distinguishing between fine-grained turbidites and contourites on the Nova Scotian deep water margin

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ABSTRACT

Review of the criteria which have been proposed for distinguishing between the deposits of turbidity currents and bottom currents in deep water sedimentation shows no general agreement on their validity. It is important to compare fine-grained turbidites and contourites, to recognize that different turbidity current and bottom current mechanisms exist, and that their deposits may be closely interbedded in a continental rise environment.

Interbedded turbidites and contourites have been recognized in cores from the deep-water margin off Nova Scotia. The most useful criteria for distinguishing between the two deposits were found to be: (1) fining and sorting trends: perpendicular or parallel to the contours; (2) marked textural differences between interbedded turbidites and contourites indicating differences in source and transport distance; (3) mineralogy and textural composition: regional patterns indicating transport perpendicular or parallel to the contours; (4) grain fabric: indication of downslope or along-slope transport at the time of final deposition; (5) sedimentary structures: turbidites show a structural sequence and evidence of rapid burial; contourites are bioturbated and contain irregular lag concentrations of biogenic sand. Other criteria include grain-size parameters, and the regional setting, distribution and depositional rate of the various facies. With due care these criteria can be applied to other regions.

Previously used characteristics of silt-laminae abundance, layer thickness, heavy mineral cross lamination, sorting, and the nature of bed contacts are not applicable to fine-grained turbidites and contourites. Compositional criteria depend on regional features.

INTRODUCTION

There has been much controversy over the relative roles of turbidity currents and bottom currents[†] on deep-water continental margins. Although most workers now accept that both mechanisms are operative, there are still no generally accepted criteria for distinguishing between the two types of deposit: turbidites and contourites. This paper attempts to evolve more reliable criteria, firstly by a review of the literature and, secondly by a discussion of fine-grained sediments on the Nova Scotian outer margin in the western North Atlantic.

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[†] 'Bottom current' is used synonymously with 'contour current' in this paper.

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Submarine canyons, fans and related sediments have long provided strong evidence for the existence of competent, downslope turbidity currents (Shepard & Dill, 1966; Normark, 1970, 1974). Large sediment ridges, marginal channels around seamounts and a variety of small scale bedforms in the deep ocean have been attributed to the action of bottom currents (Davies & Laughton, 1972; Hollister & Heezen, 1972; Lonsdale & Spiess, 1977).

Numerous direct measurements have been made of periodic currents flowing up or down canyons (Gennesseaux, Guibout & Lacombe, 1971; Shepard, Marshall & McLoughlin, 1974, 1975); submarine telegraph cable breaks may occur as the result of still stronger flows (Heezen & Hollister, 1971). Deep sea, contour-following bottom currents have also been recorded in many parts of the oceans (Swallow & Worthington, 1961, 1969; Rowe & Menzies, 1968; Hollister & Elder, 1968), and their effects observed on oriented underwater photographs (Heezen & Hollister, 1971; Kolla, Moore & Curray, 1976).

Concentrations of sediment within the nepheloid layer have been related to sediment distribution by bottom currents (Ewing *et al.*, 1971; Pierce & Stanley, 1975; Eittreim, Thorndike & Sullivan, 1976), nepheloid layers have also been reported in the vicinity of submarine canyons and fans (Beer & Gorsline, 1971; Baker, 1976a, b). These latter observations suggest flow within canyons, perhaps similar to the low-density, low-velocity turbidity currents of Moore (1969) or Stow (1977).

Echogram and seismic profile characteristics have been used to distinguish between turbidites and contourites (Davies & Laughton, 1972). Turbidites show high reflectivity with sea-bed multiples and strong stratification; contourites are relatively transparent with hyperbolic or prolonged, mushy echoes indicative of a wavy upper surface. The distribution of these characters on continental margins parallel or perpendicular to the contours provides evidence for the bottom current or turbidity current control of deposition (Hollister & Heezen, 1972; Schneider *et al.*, 1967; Damuth, 1975).

Hollister & Heezen (1972), Bouma (1972, 1973) and Bouma & Hollister (1973) developed a set of sedimentary criteria to distinguish between turbidites and contourites. They contrasted thick, coarse, graded, poorly sorted turbidites with thin, sharp-topped, cross-laminated, well sorted contourites. These criteria do not satisfactorily distinguish between fine-grained turbidites and contourites (Piper & Brisco, 1975). Griggs (1969), Rupke & Stanley (1974), Hesse (1975), Nelson, Mutti & Ricci Lucchi (1975) and Piper (1978) have proposed different criteria for the recognition of fine-grained or thin-bedded turbidites. These include: evidence of rapid autoburial such as climbing ripples with no stoss side erosion, animal escape burrows, dewatering structures, bioturbation only at the top of beds, preservation of $CaCO_3$ below the carbonate compensation depth, and high organic carbon contents; the sequence of sedimentary structures and their relationship to coarse turbidites; and the composition of sand/silt layers in relation to the coarse fractions of the interbedded muds.

Field & Pilkey (1971) and Fritz & Pilkey (1975) have proposed further compositional differences: more shallow water material, organic matter and $CaCO_3$ as well as greater variability of the heavy mineral fraction, in turbidites. Yet they have not satisfactorily demonstrated that these characteristics are not controlled by regional or grain size parameters. Detailed textural studies of deep sea sands and silts have interpreted essentially the same features to indicate different processes (Hubert, 1964, 1967; Horn *et al.*, 1971; Jipa, 1974; Stow, 1976).

More promising criteria include patterns of coarse sediment distribution related to submarine channels (Griggs & Kulm, 1970; Piper, 1970; Nelson, Mutti & Ricci Lucchi, 1975; Stow, 1976), or to bathymetry (Hollister, 1967; Damuth & Kumar, 1975; Kolla *et al.*, 1976); and directional structures in sands and silts. Oriented samples from the deep sea are rare and so fabric measurements have seldom been made on modern sediments (Bouma & Shepard, 1964; Von Rad, 1968; Rees, Von Rad & Shepard, 1968; Ellwood & Ledbetter, 1976, 1977). In ancient sediments the interpretation of directional structures has become an important way of distinguishing between turbidites and contourites (Klein, 1966; Scott, 1966; Anketell & Lovell, 1976).

Most authors agree that overall sedimentation rates for contourites are relatively slow (<10 cm/1000 years); while those for turbidites may be considerably greater (Davies & Laughton, 1972; Piper, 1978). Bouma & Hollister (1973), however, suggest rates of 10–100 cm/1000 years for their 'contourites' while deposition for low-density, low-velocity turbidity currents may be less than 10 cm/1000 years.

Problems with previous criteria

From the foregoing discussion it will be evident that there are still many contradictions within the present criteria used in distinguishing between turbidites and contourites. There appear to be four major problems.

(1) Most studies to date have compared thick, sandy turbidites with fine, silt contourites; interbedded muds have mostly been ignored. Silts and clays, however, are quantitatively between two and ten times as important as sands in the deep sea (Piper 1978), so that criteria need to be established to distinguish between *fine-grained* turbidites and contourites.

(2) Many studies have attempted to deduce overall depositional processes from regional observations which do not uniquely apply to either turbidites or contourites and which do not take into account the detailed nature of the sediments. It may be expected that turbidites and contourites will be closely interbedded in many deep sea environments.

(3) No clear distinction has been made between the different turbidity current and bottom current mechanisms that exist. These include: (a) channel overflow of the fine part of a large turbidity current; (b) deflection of the fine tail of a turbidity current by Coriolis force or by bottom currents and short lateral transport across a levee; (c) low-density, low-velocity, thin turbid-layer flows; (d) long-distance transport in the nepheloid layer by bottom currents; (e) bottom current winnowing of fines and short tractional movement of the coarser lag. Deposits from (a), (b) and possibly (c) will be very similar. Processes (d) and (e) will each result in significantly different deposits. Careful selection of criteria is necessary to distinguish between these various depositional types.

(4) General criteria for distinguishing between fine-grained turbidites and contourites are difficult to establish. Each case or locality needs to be considered separately as there may be considerable variation in the applicability of certain criteria (e.g. mineralogy) from one region to another. This problem is too often overlooked.

THE NOVA SCOTIAN DEEP WATER MARGIN

Regional setting and sediment facies

The Nova Scotian Slope and Rise (from 200 to 5000 m in depth, Fig. 1) have been

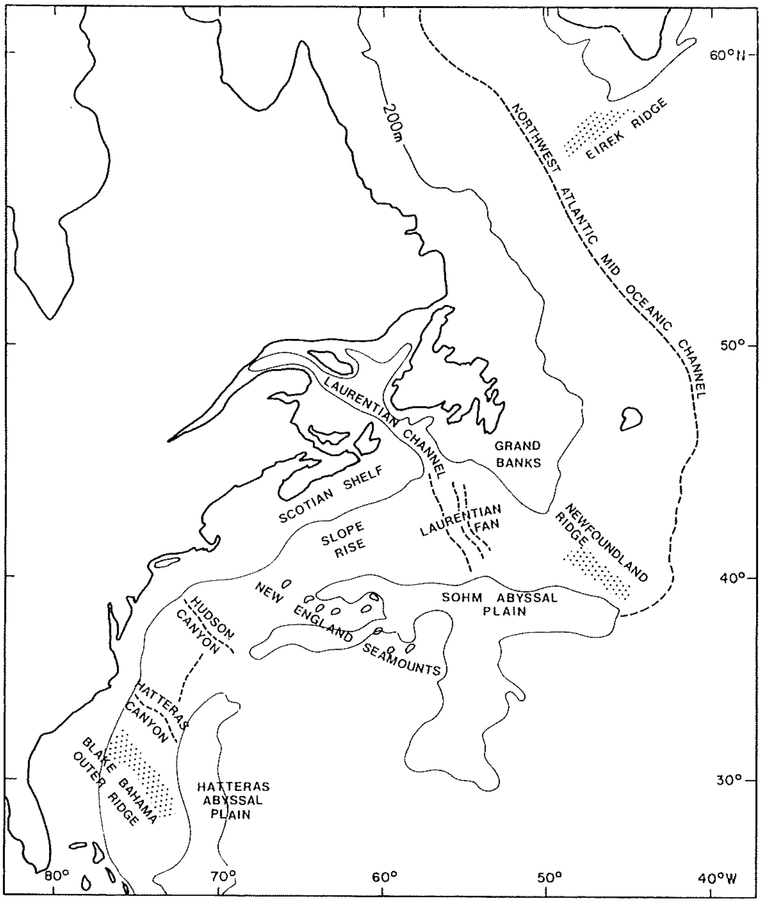

Fig. 1. Location Map: Western North Atlantic.

the site of thick sediment accumulation since the opening of the North Atlantic in the Jurassic (Jansa & Wade, 1975). This margin has been described by Emery & Uchupi (1972) as a series of overlapping Pleistocene fans. The largest is the Laurentian Fan which extends some 100 km further seawards than the adjacent continental rise.

During Pleistocene glacial maxima, sea level was lowered by up to 120 m. This exposed much of the shelf to sub-aerial erosion (King, 1969; Prest & Grant, 1969), and increased considerably the volume of sediment delivered to the deep ocean margin. A floating ice shelf probably developed in the Laurentian Channel (King, 1976) and may have extended beyond the shelf break during certain glacial maxima, dumping sediment directly onto the upper slope above the Laurentian Fan.

The Scotian Slope and Rise are crossed by numerous, small, V-shaped canyons, originating on the upper slope or at the shelf break and mostly dying out on the lower rise. The slope above the Laurentian Fan is irregular, slump-scarred and has a dendritic network of small tributary channels. These merge into three large, meandering channels which cross the lower fan and extend to the Sohm Abyssal Plain. These channels are extremely asymmetric in cross-section, with right-hand levees often several hundred metres higher than left-hand ones. The asymmetry is probably caused by the deflection of the fine-grained tails of large turbidity currents, partly by Coriolis force and partly by the Western Boundary Undercurrent (Edgar & Piper, 1979).

Seismic reflection profiles in interchannel areas show strong stratification and mostly flat beds, some of which appear to thin away from the channel axes.

Few previous studies have been made of the late Quaternary stratigraphy and sediments in this area (Stanley *et al.*, 1972; Piper, 1975; Stow, 1975, 1976, 1977). Over most of the region there is an upper, olive-grey, biogenic-rich mud facies (10–200 cm thick) which is largely Holocene in age. The dominant Wisconsin facies is a red-brown mud with frequent silt laminae and occasional thin sand beds. On the Laurentian Fan there is a close relationship between the distribution of the coarse layers and the channels: the numbers and thickness of silt laminae decrease away from the channel axes. Thick, graded sand and gravel beds are restricted to the channels. Paucity of data makes this relationship less clear on the Scotian Slope and Rise, although there is some suggestion of a depth related trend.

The red-brown sediment of the Fan was derived from the Carboniferous and Triassic red beds of the Gulf of St Lawrence via the Laurentian Channel (Heezen, Hollister & Ruddiman, 1966; Conolly, Needham & Heezen, 1967). A date of 9000 ^{14}C years b.p. at the base of one of the thicker olive-grey mud sections indicates that parts of the Fan were receiving red-brown sediment in early Holocene time. On the Scotian Slope and Rise deposition of the olive-grey facies began 16 000 to 18 000 ^{14}C years b.p. This suggests that the red-brown muds of Wisconsin age were transported across Nova Scotia and the Scotian Shelf from Triassic and Carboniferous basins in northern Nova Scotia and Prince Edward Island (Stanley *et al.*, 1972), rather than being derived from the reworking of Laurentian Fan sediments by the Western Boundary Undercurrent (Hollister, 1967; Needham, Habib & Heezen, 1969).

A facies similar to the upper olive-grey muds occurs at various horizons within the red-brown Wisconsin sediment. From foraminiferal evidence these horizons are thought to have been deposited during interstadial (and possibly interglacial) periods within the late Pleistocene. They are much thicker on the Scotian Slope and Rise than on the Laurentian Fan, and often contain thin sand beds.

Absolute rates of deposition for the different facies in the area have not been determined with certainty. ^{14}C dates suggest rates of less than 10 cm/1000 years for the upper olive-grey muds. Estimates of 10–30 cm/1000 years have been made for the red-brown facies on the Laurentian Fan (Stow, 1975, 1977), while the equivalent slope-rise facies may have been deposited more slowly. The degree of bioturbation in the lower olive-grey muds indicates relatively slow rates of deposition, although some of the thicker, interbedded sands were probably emplaced instantaneously.

Distinguishing between turbidites and contourites on the Scotian margin

From the foregoing discussion of regional setting and morphology, the distribution of coarse layers, and the relative ages, distribution and depositional rates of the main sediment facies, it may be argued that the red-brown, silt-laminated muds are turbidites, while the olive-grey muds have been deposited by a combination of hemipelagic settling and bottom currents.

The majority of the sedimentary sequences examined show no features immediately characteristic of either turbidites or contourites, although careful analysis of selected silt and mud laminae, thin sands and interbedded muds does allow a distinction to be made. It is believed that the examples chosen are representative of the facies in which they occur.

Distribution of textural parameters

The red-brown facies shows distinctive trends in fining and sorting over distances greater than 1000 km. The silt laminae become both finer and more poorly sorted downslope (Fig. 2a). The fining trend is still more pronounced in the muds (Fig. 2b). Similar patterns are tentatively recognized vertically through 2–5 cm thick graded, laminated units, and laterally across 20–50 km of levee. These results are different from those of Piper (1978) who suggests that more distal, finer silts show better sorting. No similar trends have been observed for the olive-grey facies.

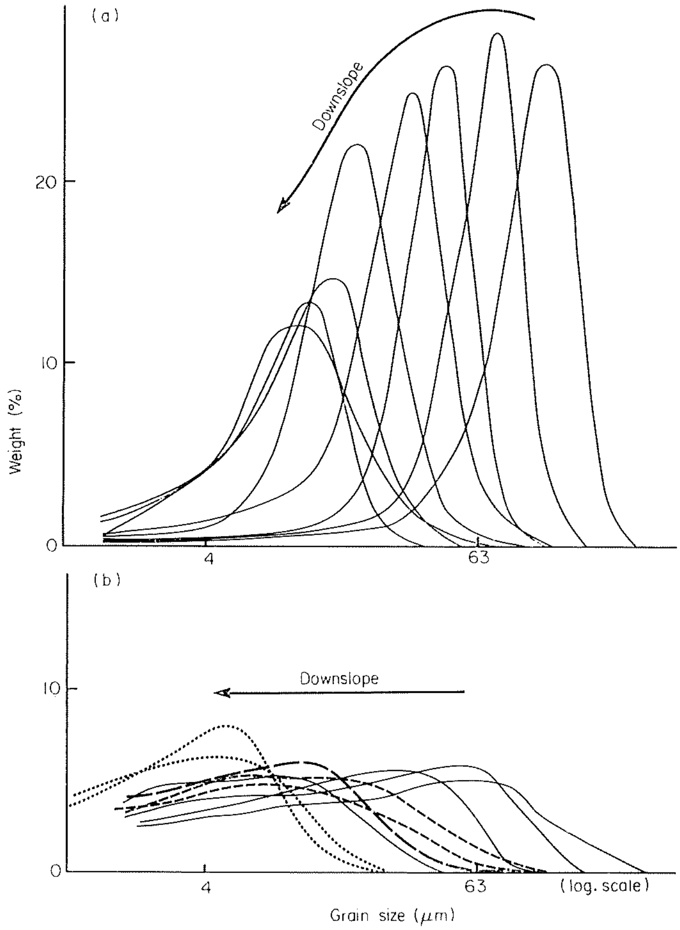

Fig. 2(A) Grain-size distributions for silt laminae. Note that distributions have a finer mode and broader spread (i.e. poorer sorting) in a downslope direction. Sample distances from the shelf break are, from right to left, 75, 110, 250, 270, 310, 500, 990 and 990 km. (B) Grain-size distributions for muds. Note pronounced fining downslope. Sample distances from shelf break are, from right to left, 30, 30, 50, 75, 75, 115, 250, 1500 and 1500 km.

Textural reflection of source material (Fig. 3)

The systematic textural variations observed in a down-current direction are very similar to those predicated on theoretical grounds by McCave & Swift (1976) for deep sea deposition of fine-grained sediments. In turbidites the trend should be downslope; while for long distance transport in bottom currents parallel to the contours the trend will be along-slope.

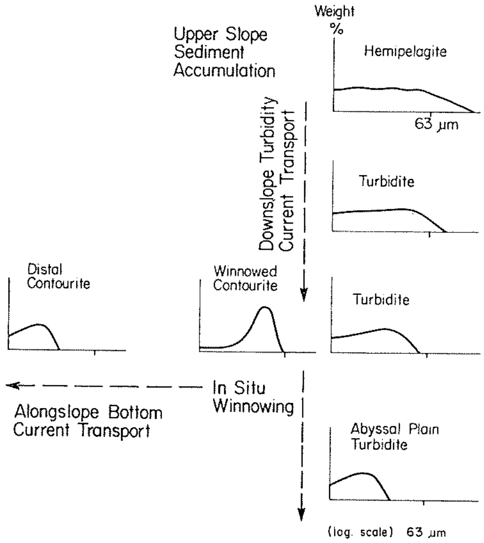

Fig. 3. Schematic representation of variation in grain-size distributions during downslope turbidity current transport and reworking or alongslope transport by bottom currents. Each grain size curve represents total sediment analysis (i.e. one or more sedimentation units).

Analyses of contourites from the Blake Bahama Outer Ridge show very similar textural patterns to turbidites from the southern Sohm Abyssal Plain. Thus, if a far travelled contourite is interbedded with turbidites in a continental rise environment it will appear texturally out-of-phase.

The upper slope source material for the Scotian Margin sediments is composed of equal amounts of all size grades up to medium sand (Sheldon, Parkash & Sutcliffe, 1972; Kranck, 1975; Stow, 1977). Analysis of the red-brown Rise facies show similar even size distributions but with less coarse sediment. The olive-grey facies shows a pronounced coarse mode and relative lack of fine sediment, indicative of winnowing and removal of fines by bottom currents.

Mineralogy and composition

Heavy mineral provinces are fairly well defined for the Scotian Shelf, Gulf of St. Lawrence, Grand Banks of Newfoundland and for potential terrestrial sources of sediment supplied to the outer continental margin (Nota & Loring, 1964; Cok, 1970; Stanley *et al.*, 1972; Emery & Uchupi, 1972). The differences in mineralogy between these areas are maintained in sediments of the deeper margin (Fig. 4) indicating that the dominant movement of material is perpendicular to the shelf break. A few sands in the olive-grey Rise facies show greater mineralogical similarity to the Laurentian

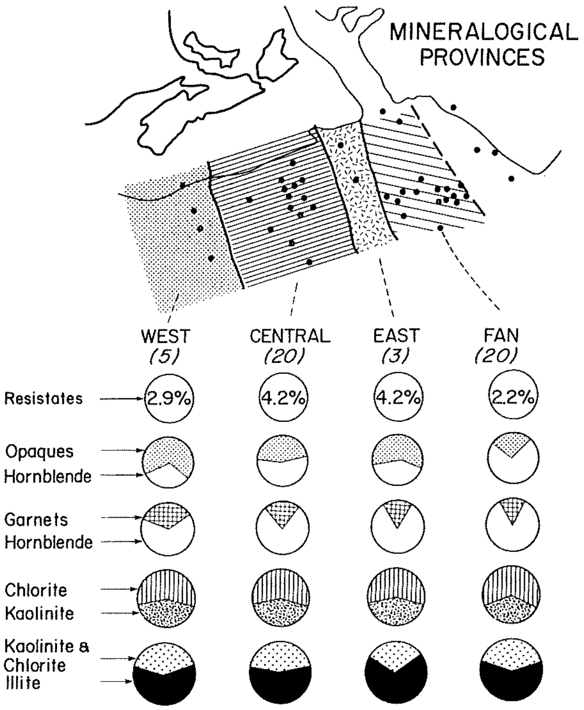

Fig. 4. Mineralogical provinces of outer Scotian margin. Each column of pie diagrams shows the mineralogy of one of the four regions outlined, averaged from the number of analyses indicated at the top of the column. The samples were taken from the core locations indicated by solid circles.

Fan; it is clear that any significant reworking by bottom currents did not involve long-distance lateral transport.

Clay mineral differences also exist between the various source areas (Biscaye, 1964; Stanley *et al.*, 1972; Zimmerman, 1972; Loring & Nota, 1973; Piper & Slatt, 1977). A greater amount of homogenization, however, appears to take place in clay-sized material by the time it reaches the outer margin. Some slight mineralogical differences are observed between the Fan and Rise (Fig. 4), while a possible offshore trend is noted in both red-brown and olive-grey facies (Fig. 5). These data suggest, less conclusively, dominant downslope transport and only minor lateral displacement by bottom currents. There is evidence from montmorillonite valley/peak ratios (Biscaye, 1964) that at least some of the montmorillonite in the contourite facies has been brought from more northern sources in the Western Boundary Undercurrent.

The organic carbon content of the red-brown facies for both the Fan and the Rise averages 0·4%; that of the olive-grey facies is 0·7%, which probably reflects the greater contribution of planktonic organisms to this facies, and the barren nature of the glacial source for the material for the red-brown muds.

Grain fabric in oriented cores

Cores from the Laurentian Fan and Scotian Slope and Rise have been oriented to geographical north using mean values of magnetic declination and assuming a mean axial dipole field (Ellwood & Ledbetter, 1976, 1977). This system appears to work

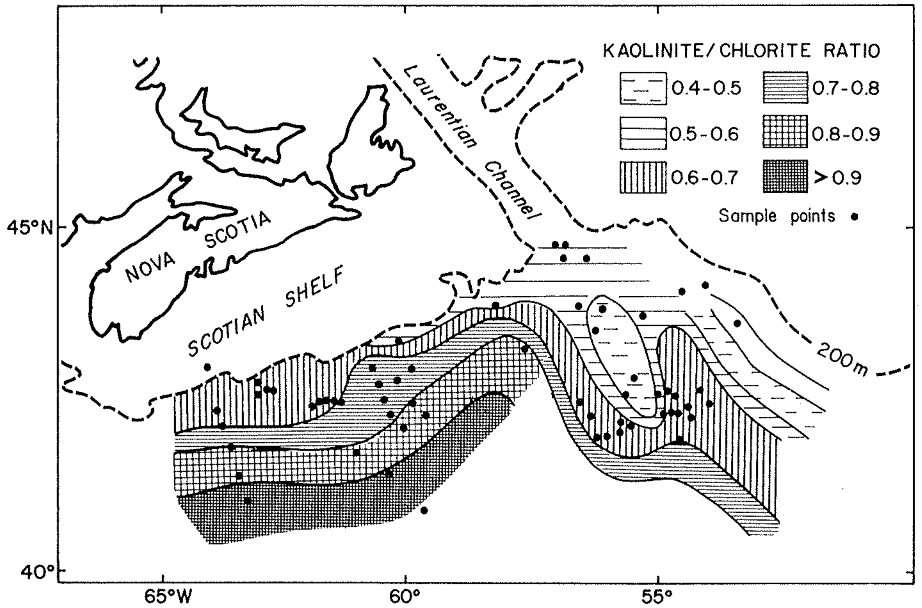

Fig. 5. Contour map of kaolinite/chlorite ratios in the clay fraction of the outer Scotian margin sediments. Note the offshore trend and the 'low' over the Laurentian Fan. Contours drawn from analyses of more than 100 samples from nearly fifty cores indicated by solid circles.

well for undisturbed cores, and may even be applied to sections showing uniform rotation of sediment. Once a core has been oriented then grain fabric can be measured to determine current directions.

Cylindrical plugs of sediment from thin sand beds were impregnated with bioplastic resin; the direction of grain elongation was determined from thin sections cut parallel to the bedding. Small chips of dried silt laminae were mounted on stubs; grain elongation directions in bedding plane sections were measured on a scanning electron microscope (Stow, 1979). In some cases, current lineations were visible on the surfaces of silt laminae. A few sections have been examined perpendicular to the bedding plane and in the direction of maximum elongation. Long grains in both turbidites and contourites appear to be oriented parallel to the bedding plane, although an imbricate pattern was not clear. Limited success was achieved in obtaining current azimuths from the assumption that pear-shaped grains are oriented with their bulbous end facing up-current.

The results from five cores are shown in Fig. 6a and b. Silts and sands in the red-brown facies show north–south current directions suggesting downslope transport with slight deflection to the right of the channel trend. The coarse layers in the olive-grey facies commonly show an east–west current direction, and frequently have a secondary mode at right angles to this. In other cases the directions in these beds appear polymodal. These results are consistent with reworking of turbidite sands by bottom currents within the olive-grey facies.

Sedimentary structures

Graded, laminated units (Piper, 1972) may be distinguished in the red-brown muds

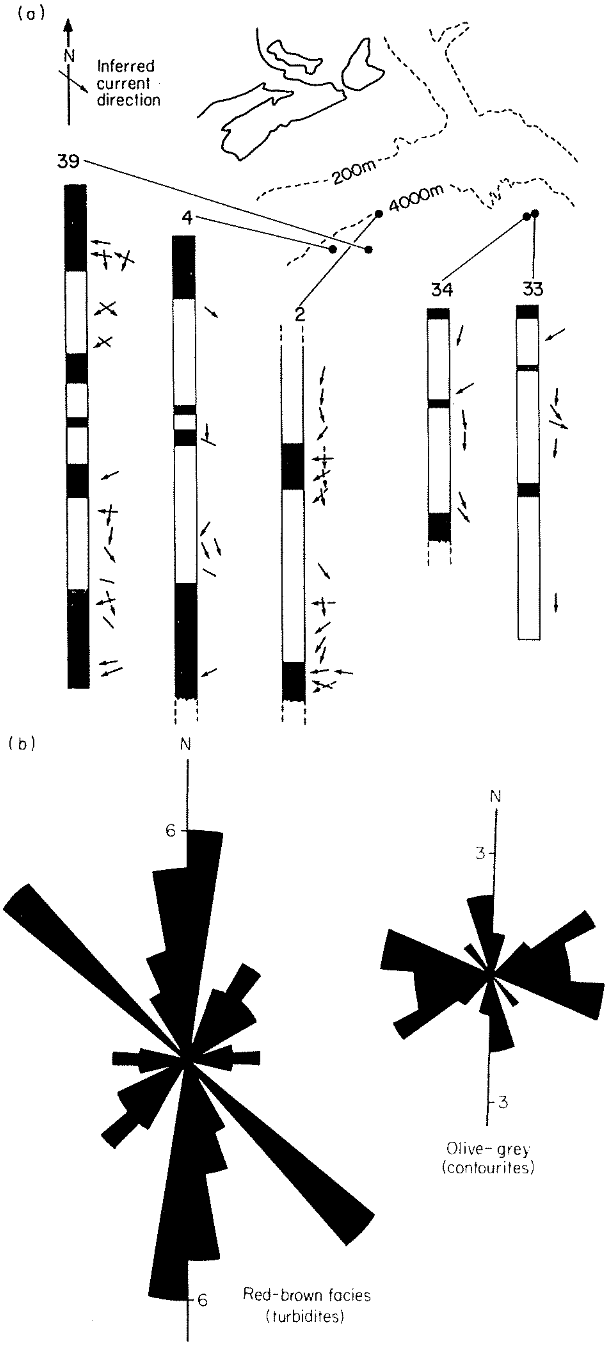

Fig. 6. (a) Current directions inferred from long axis grain orientations and current lineations in sand and silt layers from outer Scotian margin cores. Note the dominant downslope trend in the red-brown facies (blank), and alongslope or polymodal trends in the olive-grey facies (shaded). Cores have been oriented using mean values of palaeomagnetic declination in the sediments. (b) Summary rose diagrams of the current directions shown in Fig. 6a. The linear scales refer to the number of measurements recorded in each 10° segment. Note the secondary, north–south, mode in the olive-grey facies. The three, random-orientation measurements have been omitted.

(Fig. 7a). The laminae decrease in thickness and coarseness upwards and are overlain by a non-laminated mud which may be bioturbated near the top. These units are usually between 1 and 8 cm thick. On the Slope and Rise they are sometimes picked out by distinct colour grading, from a laminated greyish mud with a sharp base to non-laminated reddish mud. These sequences approximate that suggested by Piper (1978) for a mud turbidite overlying sand. In some cases they may be correlated exactly between adjacent levee cores more than 10 km apart (Fig. 7b).

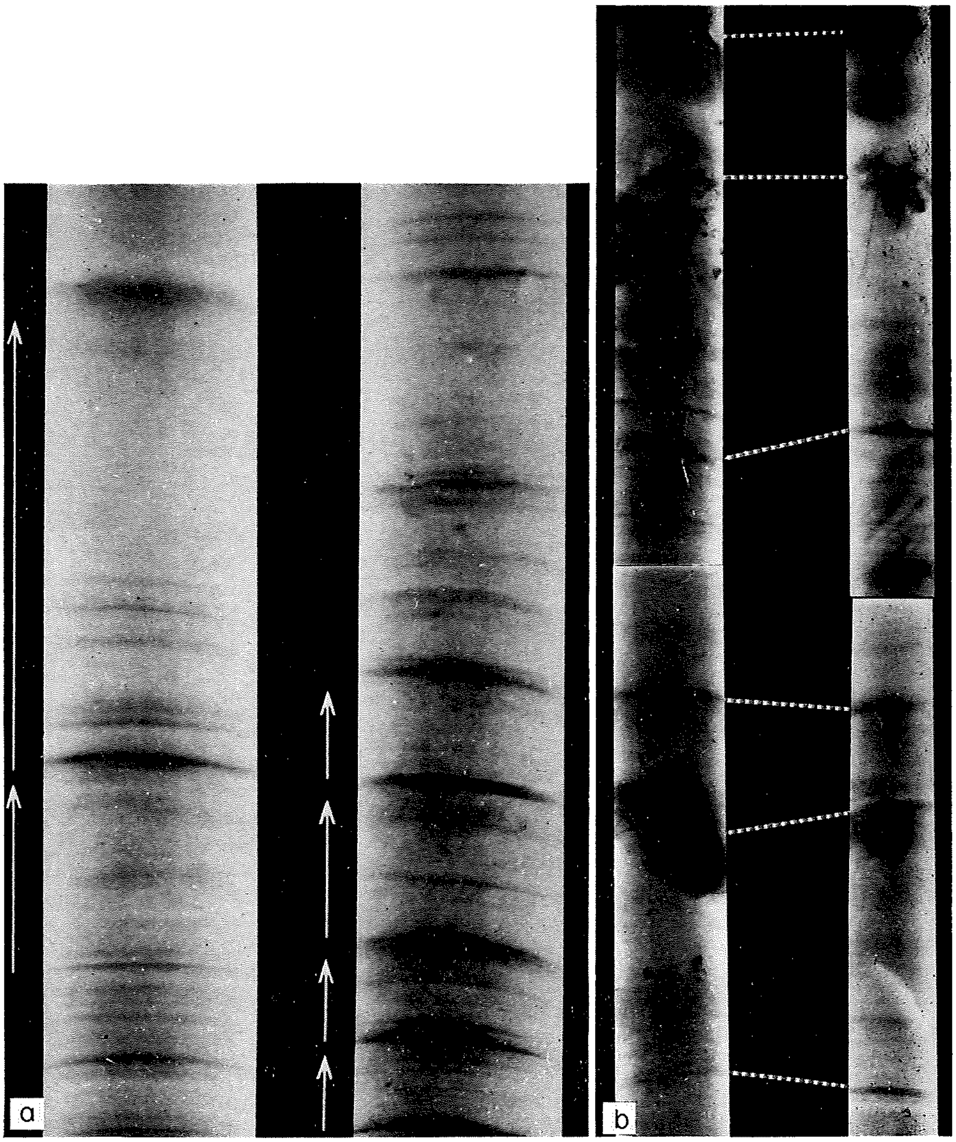

Fig. 7. (a) Graded, laminated units in red-brown muds; prints from X-radiographs. Width of core sections is 5 cm. (b) X-radiograph prints of correlatable sections from two interchannel cores more than 10 km apart. Note that the sand or silt at the base of units may be correlated while individual laminae cannot. Width of core sections is 5 cm (left) and 4 cm (right).

The silt laminae within these units (Fig. 8) commonly show micrograding. Both upper and lower contacts are usually sharp, although the upper contact may be gradational. Laminae which are only a few grains thick are mostly discontinuous and have gradational contacts. The bases of laminae are often irregular with well developed scour marks, load casts and mud 'flame' structures. Mud clasts sometimes 'float' near the base of the layer.

Some of the thicker silt laminae are internally parallel or cross laminated, with laminae accentuated by lutite or, less frequently, by concentrations of heavy minerals. Cross-lamination may occur as a restricted unit at the base of the layer, or as a wavy upper surface. Convolute lamination is frequently developed and may involve one or more silt laminae.

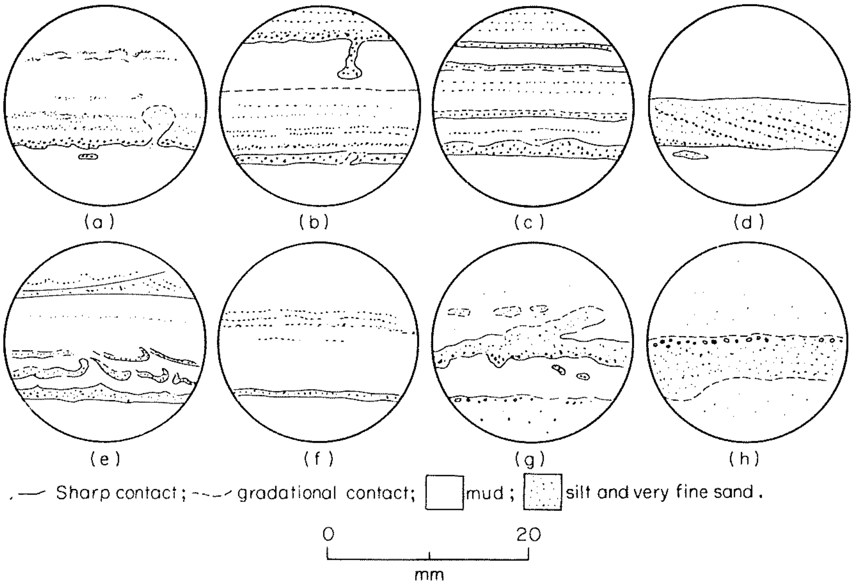

Fig. 8. Structures in silt laminae, (a) to (e) are from the red-brown facies; (f) to (h) are from the olive-grey facies. Note the following features: (a) wispy and irregular laminae, mud injection structure, sandstone ball load cast; (b) sharp upper and lower contacts, thin graded laminated unit, pseudonodule; (b) sharp and gradational contacts, wavy (rippled) surface of lowermost silt lamina; (d) heavy mineral micro-cross-lamination: (e) convolute lamination; (f) thin discontinuous laminae; (g) thick irregular lamina, sandstone lenses; (h) coarse lag concentration at top of sandstone layer.

The silt laminae within the olive-grey muds (Fig. 8) show many of the same structures. However, they are usually disturbed by bioturbation so that their original nature is not preserved. Cross-lamination is sometimes observed near the tops of the layers, as well as coarser (?lag) concentrations of foraminifera or sand. There are no clear sequences of sedimentary structures in this facies, other than an alternation of sandy and muddy beds, the latter sometimes with irregular biogenic-rich silt or sand layers.

Internal sedimentary structures in the thin sand beds are similar. Grading is ubiquitous, partial Bouma (1962) sequences may be developed, and laminations are accentuated by heavy minerals, lutite or foraminifera. Two or more pulses of deposition are sometimes apparent.

Grain size parameters

Cumulative frequency plots of thin sands show well sorted Gaussian distributions with very small coarse tails and moderately large fine tails (Fig. 9). The silt laminae, with slightly larger fine tails, show similar curves (Fig. 9) to those given by Piper (1973) and Piper & Brisco (1975) for silt turbidites. The interbedded muds have a more or less even distribution of grain sizes.

In general, there are no striking differences between sediments of the different facies or different regions studied. Analyses of silt and mud laminae from 'known' contourite deposits on the Blake–Bahama Outer Ridge and in the southern Labrador Sea show the same textural characteristics as the very fine turbidite silts and muds from the Sohm Abyssal Plain (Fig. 9).

A few sands in the olive-grey facies, however, show some evidence of reworking by bottom currents. They display low values of skewness near the tops of beds, only very slight grading, and sharp textural breaks between sand and overlying mud.

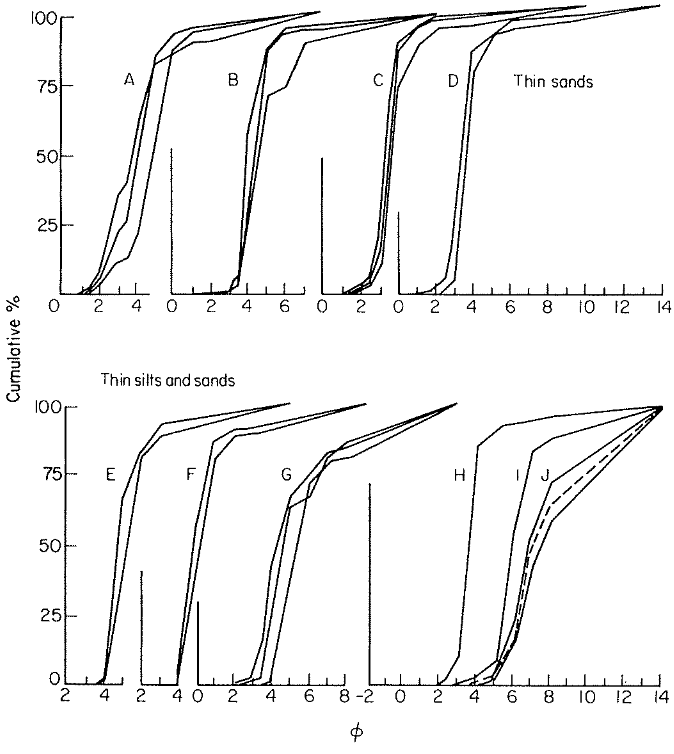

Fig. 9. Cumulative frequency curves from grain-size analyses of selected Scotian margin sands and silts. A to D show grading in 5 to 10 cm thick sand beds. E and F show grading in grouped silt laminae in the red-brown muds: G, H, and I are from silts within the olive-grey facies. In J the dashed line is a silt from the Sohm Abyssal Plain, while the solid lines are 'contourite' silts from the Blake-Bahama Outer Ridge. Further details of grain size data in Stow (1977).

SUMMARY

Interbedded turbidites and contourites have been recognized in cores from the deep water margin off Nova Scotia. The most useful criteria for distinguishing between the two deposits were found to be: (1) fining and sorting trends: perpendicular or parallel to the contours; (2) marked textural differences between interbedded turbidite and contourite facies indicating differences in source and distance of transport; (3) mineralogy and textural composition: regional patterns indicating transport perpendicular or parallel to the contours; individual facies differences and relationship between the composition of coarse and fine layers; (4) grain fabric: indication of down-slope or along-slope transport at the time of final deposition. (5) sedimentary structures: turbidites occur in graded laminated units with a distinct sequence of structures, and show evidence of relatively rapid deposition and burial; contourites, with slower rates of accumulation, are more thoroughly bioturbated; (6) grain size parameters: showing evidence of reworking in the case of winnowed contourites (7) regional setting, morphology, coarse layer distribution, and the relative ages, distribution and depositional rates of the main sediment facies.

From the present study it is apparent that some of the currently used criteria are not applicable to fine-grained turbidites and contourites. An abundance of thin silt laminae is more indicative of turbidite than contourite deposition; bed thickness in both cases is less than 10 cm. The sedimentary structures of distal turbidites and contourites can be very similar; heavy mineral and foraminiferal laminae are found in both; silt layers commonly have sharp upper contacts; and the Bouma sequence of structures is not present. Most contourite deposition probably takes place slowly so that the resulting sediment is homogenized by bioturbation; in turbidites an original structural sequence is preserved.

Sorting is related to transport distance and grain size, so that far-travelled turbidite or contourite silts are both poorly sorted. Compositional criteria depend on regional features; on the outer Scotian margin the turbidites are generally lower than contourites in organic carbon, calcium carbonate and biogenic remains.

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