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Differential Transport of Sand Grains: Ripples and Dunes, A Suspension Criterion

Differential transport of sand grains by unidirectional water flow over a cohesionless bed material having superimposed ripples or dunes results in hydraulic sorting. Hydraulic sorting occurs on many scales in natural fluvial systems, e.g., flood plain vs. channel deposits, bed vs. load in transit, various parts of cross-bed sets or individual laminae, etc. The mechanisms of hydraulic sorting include differential entrainment at the source, differential deposition and differential transport rates which are sensitive to prevailing bed configurations. By comparing transport rates of individual grain sizes calculated from size analysis of bed material and load under ripple and dune conditions, it is shown that the sampled load may be differentiated into two subpopulations of grains moved by different transport mechanisms, namely, those particles confined to transport within bed forms, and intermittent suspension load. Due to practical limitations in the flume, this study is limited to the two coarsest subpopulations observed in typical samples of river sediment. Theory and results of flume experiments suggest the following approximate hydraulic criterion for separating the two mechanisms of sediment transport: the point where the relative difference in transport rates between size fractions increases abruptly. This criterion is confirmed by flume experiments for flow conditions spanning the stability fields for ripples and dunes.

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Washover of Deltaic Barriers on Louisiana Coast

Washover processes are an important factor in the transgressive development of barrier coastlines. Sea level elevation necessary for overwash is composed of a storm surge component, a wave setup component, a wave runup component, and an astronomical tide component. The nature and severity of overwash are a function of overwash elevation, its frequency of occurrence, and regional barrier geometry.

Washover deposits on Louisiana barriers commonly account for over 50% of total sediment storage. Louisiana barriers have evolved by deltaic distributary abandonment; continuing sequential evolution of Mississippi delta complexes has generated a corresponding sequence of transgressive barriers. The resulting spectrum of barrier geometries has provided an ideal field site for the examination of washover form variability and its controlling processes.

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Permeability and Microfabric of Clayey Sediments

Most clayey marine sediments being deposited in today's oceans will eventually make excellent seals for hydrocarbons. Extensive consolidation testing of marine sediments indicates that most fine-grained marine deposits of the oceans are underconsolidated indicating the presence of excess pore water pressures. This condition is attributed to the low permeability of the sediments and indicates the potential of these sediments as seals for hydrocarbons.

Analyses of the consolidation, permeability, and microstructure characteristics of clayey marine sediments from most of the world's oceans show that the permeability decreases under an imposed load 7 to 8 order of magnitude faster than porosity. This decrease in permeability is controlled by the amounts and type of clay present as well as its microstructure. Clay microstructure refers to two important properties of a sediment—the fabric and physicochemistry. The fabric, a geotechnical property of the sediment is defined as the orientation and arrangement of the solid particles and the particle to particle relation. The relation between depth of burial, porosity, permeability, and fabric of marine clays will be discussed in relation to seals for hydrocarbons.

The consolidation tests have shown that the compressibility and permeability of the three clay types, kaolinite, illite, and bentonite, can be represented by power law functions of the porosity (n). They are $\sigma = An^B$ (psi) for the vertical stress supported by the mineral grains and $K = Cn^D$ (md) for the absolute permeability measured in the vertical direction with seawater. For these different clay types the following table lists the constants A, B, C, and D.

	A	B	C	D
Kaolinite	8.10	−5.43	0.296	5.71
Illite	3.07	−5.10	0.836	7.34
Bentonite	5.45	−6.09	0.0098	8.64

CASEY, RICHARD, Rice Univ., Houston, TX, and CAMILLE HUENI and ANN LEAVESLEY, Cities Service Co., Houston, TX

Brizalina lowmani, a Meroplanktonic Foraminiferan Useful as Indicator of Shelfal Circulation and Eutrophication (with Comments on Biostratigraphy and Evolution)

Brizalina lowmani was found to be the most abundant living foraminiferan of the south Texas outer continental shelf, both in the sediment and in the water column. *B. lowmani,* considered a nearshore benthonic foraminifer, evidently possesses a meroplanktonic stage which allows it to take advantage of the pelagic and benthonic environments. Our study indicates that standing crops of *B. lowmani* in the water column can be used to determine provenance and direction of shallow and deep shelf currents.

Standing crops of *B. lowmani* in the sediment can be used as indicators of bottom shelf current and direction, depth and area of winter water column mixing, and degree of eutrophism of bottom and overlying waters.

The meroplanktonic nature of *B. lowmani* allows a wide dispersal of the form, suggesting why similar forms can be utilized as biostratigraphically useful index fossils. The form, *B. lowmani,* may be reminiscent of the early evolution of planktonic foraminiferans.

CASEY, RICHARD, Rice Univ., Houston, TX, et al

Radiolarian Species Composition, Density, and Diversity as Indicators of Water Structure and Circulation on South Texas Shelf

Radiolarian species composition, density, and diversity can be used to define the structure of the water column and circulation patterns of waters overlying the south Texas shelf. Radiolarian species that occur in the western North Atlantic, Caribbean, and Gulf of Mexico are also found in the south Texas shelf waters. The radiolarian assemblage from the western North Atlantic has the greatest density and diversity. Radiolarian densities and diversities are lower in the Caribbean and Gulf of Mexico, and are lowest in the waters over the shelf. Radiolarian densities and diversities on the shelf reflect incursions of open ocean waters at varying depths. Certain

radiolarian assemblages and their position on the shelf, as well as radiolarian density and diversity can be used to identify winter, spring, and fall physical oceanographic conditions on the south Texas shelf. Radiolarians can also be used as indicators of physical oceanographic conditions in studies of ancient shelves.

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Anoxic Sedimentation in Eagle Ford Group (Upper Cretaceous) of Central Texas

Anoxic conditions prevailed during Eagle Ford deposition. Environmental indicators include the generally dark color of Eagle Ford shale, millimeter laminations, a general absence of infauna, authigenic pyrite, and the high ratio of pelagic to benthic fossils. Benthic fossils are rare and are represented mainly by the bivalve *Inoceramus* and the foraminifer *Cibicides*. In marked contrast, pelagic fossils occur abundantly. Particularly distinctive are the foraminifers *Globigerina* and *Heterohelix* but ammonites and fish scales also occur.

The Eagle Ford Group exposed along the Balcones fault zone in central Texas is subdivided into two formations. The older formation is the Lake Waco Formation consisting in ascending order of the Bluebonnet flags, Cloice Shale, and Bouldin flags Members, and the younger is the South Bosque Shale. The South Bosque Shale is brown to dark gray or black. This contrasts markedly with the fissile, thinly laminated dark gray shales that characterize the Cloice. Interbedded thinly laminated shale and millimeter laminated, pelletal mudstone are typical of the Bluebonnet and Bouldin Members.

The vertical sequence is interpreted to represent a single transgressive-regressive event with the deepest water conditions existing during deposition of the Cloice. We suggest that minimum water depths during deposition of the group were 60 to 100 ft (18 to 30 m) and that the anoxic conditions resulted from a combination of water depth, upwelling, and possibly silled conditions due to the San Marcos arch.

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Provenance and Diagenesis of Clay Minerals in Sediments from Anclote River and Anchorage, West-Central Florida

Surface and subsurface sediments from a small river basin and lagoon (the Anclote River system in west-central Florida) were examined by X-ray diffraction methods to reveal the factors controlling clay minerals distribution in paludal (swamp), fluviatile, estuarine, and nearshore marine environments.

In the swamp environment, smectite is the predominant clay mineral in surface sediments. Relative concentration and crystallinity of smectite increase with a corresponding decrease in kaolin minerals (including kaolinite, halloysite, and kaolinite-montmorillonite mixed-layer) from the surface down the cores indicating kaolinization is prevalent in the upper swampy sediments. In the fluviatile environment, clay minerals in surface sediments are transported from upper stream swamps and mixed with the residual clays of the bed rock. Subsurface clay minerals in the Tampa Limestone are mainly illite with minor amounts of smectite. In downstream estuarine surface sediments, smectite decreases while chlorite, chlorite-vermiculite mixed layer, and illite increase. This change results from the combined effects of tidal inflow and transport by the river as indicated by the study of suspended sediments in this area. The relatively high concentration of smectite in the subsurface sediments of the lower Anclote River, an estuarine environment, suggests that the distribution pattern of clay minerals in this area may have been affected by the lower stand of sea level during the last glacial period.

Clay mineral assemblages in the Anclote Anchorage are a combination of residual sedimentary clays mixed with riverborne and marine clays. The uniformly distributed clays indicated a mixed and reworked environment (by current and wave) rather than one formed by a uniform, single source.

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Response of Bottom Waters on West Louisiana Shelf to Transient Wind Events and Resulting Sediment Transport

The predominantly longshore near-bottom currents in 10 m of water off the southwest Louisiana coast exhibited seasonal variability. Currents in winter were primarily westward, although easterly currents were generated rapidly by cold-front passages. Velocities increased during the spring, and the current motion was to the south-southwest as stratification developed and mechanisms other than the wind became active in the shallow waters. The summer current regime was characterized by slow, easterly motion in response to generally west and southwest winds.

Sediments were entrained by wave action and bottom currents during transient wind events, such as summer storms, winter cold-front passages, and persistent southeasterly wind events during the spring. The summer storm and spring wind events transported sediments to the west at a rate of approximately 30 km/day. Sediments suspended in early winter were moved east and west by bottom currents, but little net transport occurred. Frontal passages in March and early April transported suspended sediments more than 250 km to the west.

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Early Precipitation of Authigenic Clay by Meteoric Water, Pictured Cliffs, San Juan Basin, New Mexico and Colorado

The Pictured Cliffs, which is exposed around the San Juan basin in New Mexico and Colorado, was deposited in a variety of nearshore environments during the last of a series of major regressions of the Cretaceous epicontinental seaway. The Pictured Cliffs is a prolific producer of natural gas. The permeability of the Pictured Cliffs sandstones decreases from the southwest to the northeast, apparently in response to a progressive increase in the amount of authigenic grain-coating clay to the northeast. Gas-production trends are oriented parallel to depositional strike and cut across present-day structure contours. Thus, it appears that most of the authigenic clay was precipitated before the formation of the San Juan Basin.

Oxygen and hydrogen isotopic analyses of eight samples from different parts of the basin suggest strongly precipitation of the clays by meteoric water. The early precipitation of authigenic clay in marine sandstone by meteoric water has not been previously described. However, there are significant differences between the Cretaceous Western Interior basin and marginal basins such as the Gulf Coast basin which might help explain this occurrence. The highest rates of sedimentation and subsidence in the Cretaceous Western Interior basin were near the adjacent highlands, resulting in the stratigraphic rise of the marine sandstones toward the basin. Also, marine