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Abstracts

DOTT, ROBERT H., JR., Univ. Wisconsin, Madison, WI

Episodic Sedimentation of Ancient Shelf Sandstones

At casual glance, modern shelves dominated by clastic deposits seem exceedingly dull, especially when compared to carbonate-dominated shelves. During the past 10,000 yr, the Holocene transgression has resulted in modest reworking of relict, pre-Holocene material and only trivial additions of new material. Instead, most new clastic sediment has been trapped in estuaries formed by Holocene drowning of rivers. Thus, clastic shelves appear to be boring because 10,000 yr is too short a time for estuary filling and significant new shelf sedimentation, and also because knowledge of modern shelf processes is biased toward bland, fair-weather conditions. Such a dismal view is dispelled, however, by a second glance at either outcrops or cores of ancient shelf sequences. Abrupt changes of lithology attest to countless changes of process types, magnitudes, and rates. This, coupled with a large share of petroleum reserves trapped in shelf clastics, offers ample reason for a more positive view.

What is needed is a fresh perspective of one of the longest studied of all sedimentary realms. Once the constraints of Lyellian constancy and of the fair-weather bias are broken, we can appreciate the great importance of episodic processes on both modern and ancient shelves. Episodic events are so common on a geologic time scale, in fact, that it is a mistake to refer to them as catastrophic, which has become increasingly popular in recent years. The ancient record provides important insights especially by allowing us to penetrate the 10,000-yr Holocene barrier and to assess the important question of preservation potential; i.e., can everyday processes obliterate the evidence of an episodic event? Episodic sedimentation may result from any event whose magnitude deviates significantly from the norm. Both positive deviations, such as storms and tsunamis, and negative deviations, such as nondeposition, constitute episodes. Of most interest to the sedimentary geologist are events recorded at the spatial scale of cores and outcrops and whose recurrence frequencies range on a temporal scale from decades to millenia. Excluded at one extreme are regular annual processes (such as varve formation), and, at the other extreme, phenomena with time scales on the order of at least a million years (such as Vail curve cycles). Important questions concern assessment of recovery time, preservation potential, and determining whether recurrences are periodic or episodic. Also, we must distinguish instantaneous depositional rates from net accumulation (or preservation) rates.

Some preserved features that attest to episodic sedimentation include conglomerate lenses resedimented by storm surges; intraclast, shell, or glauconite concentrations, as well as rare graded sandstone and shelly beds produced by scour and winnowing; and hummocky stratification resulting from abnormally large waves. All of these reflect positive deviations from normal process intensities. Negative deviations typically result in surfaces of nondeposition, such as mineralized hardgrounds and polygonally cracked emergence surfaces. Bioturbated zones alternating with unburrowed intervals also attest to important episodic deviations, and provide insight into relative process rates. The former reflect fair-weather conditions with slow accumulation, whereas the latter reflect episodic rapid accumulation that outpaced burrowing activity. Both physical and biologic processes can produce complex amalgamation patterns through the overprinting of effects of multiple events, resulting in records that are challenging to decipher.

Association among episodically produced features can provide important tools for basin analysis—for example, clues to relative proximality of shelf clastics analogous to those for deep-water turbidites. Relative proximality diagnosis in turn allows prediction of sandstone thickening and possible permeability trends, which could enhance exploration success. Some puzzling sandstone bodies encased in shale and isolated from any paleoshorelines (i.e., distal) seem explicable only by episodic emplacement; they are ready-made petroleum reservoirs. Thus, ancient shelf deposits are not so boring after all, and sharper tools for basin analysis should enhance our ability to explore for new petroleum reserves trapped within them.

GINSBURG, ROBERT N., Univ. Miami, Miami, FL

Sedimentary Models of Pattern, Process, and Succession Derived from Bahamian Carbonates

Three decades of research on the Cenozoic carbonate platforms of the Bahamas have produced several models of deposition and diagenesis. The models are sufficiently varied and numerous that they can be categorized and their interactions evaluated. The models can be divided into three types: two-dimensional patterns of depositional facies; process models of sediment formation, deposition, and diagenesis; and concepts of facies succession.

Patterns of depositional facies range in scale from a kilometer or less in the bar and channel morphology of ooid sand spreads, to a few kilometers in channeled tidal flats, to as much as 100 km (62 mi) in the platform to basin zonation of reefs and sediments.

The spectrum of process models extends from grain formation (peloids and ooids), to major modes of accumulation (net shoreward movement of lime mud with attendant seaward progradation of shoaling cycles), to sea-floor cementation that yields aggregate grains and hardgrounds.

Vertical facies successions on the scale of several meters are seen in the shoaling deposits of tidal flats and in the coarsening-upward sequences of sand shoals. Larger scale changes in facies, from skeletal to nonskeletal deposits that are tens of meters thick, occur in the subsurface Pliocene-Pleistocene carbonates.

These three kinds of sedimentary models interact in various ways. An example of the influence of pattern on process is seen in the channels between tidal bars of ooid sand. The growth of tidal bars of ooid sand leads to accelerated tidal currents in the intervening channels; the result is a channel lag of coarser sediments that limits traction movement of lime sands and especially the nuclei for continued formation of ooids. Deceleration of ooid formation can in time lead to stabilization of the moving sands with attendant alterations of grains and sedimentary structures. An example of the effect of process on pattern is seen in the formation of extensive hardgrounds on lime sands of the platform interior by submarine cementation. These hardgrounds are rapidly colonized by attached organisms, including reef-building corals; the end result is a major transformation of sediment type and the appearance of the preferred substrate for reefs. An example of the interaction between facies is seen in two aspects of reefal deposits: the preferential development of some reefs seaward of islands or growing sand shoals and the burial of other reefs that fringe leeward margins of the platforms by off-bank transport of lime sands from the interiors.

HILTERMAN, FRED J., Geophysical Development Corp., Houston, TX

Seismic Modeling: Geologic Predictions and Pitfalls

Structural geologists have made tremendous strides in unraveling the architecture of the earth with recent studies of seismic reflection data.