attention to this lamentable state, to plead for wider employment of clearly defined names, and to offer a general system of nomenclature which could provide a means of achieving greater uniformity and precision in terminology.

This system is not in the least revolutionary but merely proposes restricted meaning for many existing names and a general scheme for systematically deriving other names. Guiding principles are: (1) names should be based on petrographic features; (2) these features should be established, not inferred; (3) the system for naming rocks should be flexible enough to apply both in the field and in the laboratory; and (4) names should be just as quantitative as the means of examination permits.

The classical concept of sedimentary rocks as mixtures of mechanical and chemical fractions is the principal nomenclatural basis in this system. The main name reflects the most abundant constituent of the dominant fraction. A finer division of silicate sandstone than is customarily made is believed practical and desirable.

Three terms are proposed to fill a conspicuous gap in terminology. *Aggregal* and *integral* describe textures of mechanical and chemical origin, respectively, but are defined petrographically. *Accretic,* a correlative term with clastic, describes aggregal textures composed of grains formed by accretion. Integral textures include those which are crystalline and amorphous.

The most important point concerning nomenclature is that the reader understand the terminology employed by the writer. This can be assured by reference to an explicit classification or nomenclatural system.

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CRITERIA USEFUL IN INTERPRETING ENVIRONMENTS OF UNLIKE BUT TIME-EQUIVALENT CARBONATE UNITS, CAPITAN REEF COMPLEX, WEST TEXAS AND NEW MEXICO

The Tansill Formation and the Lamar Member of the Bell Canyon Formation are the uppermost carbonate units equivalent to the Capitan Formation of West Texas and southeastern New Mexico. The Lamar is restricted to the Delaware basin and is equivalent to the lower and middle parts of the Tansill. Surface and subsurface stratigraphic studies by many workers show the Tansill-Capitan-Lamar to represent classic examples of shelf, shelf-margin, and basin deposits.

Because these units will continue to serve as a model for environmental studies of ancient rock, this paper reviews some of the criteria useful in distinguishing the various environments.

In the Guadalupe Mountains area, carbonate units of the Tansill Formation are predominantly light colored, well-bedded dolostone which grades shelfward into evaporite. Along the margin of the Northwestern shelf, the Tansill quadruples in thickness and becomes less dolomitic before grading into the Capitan Formation. Well-preserved depositional textures and sedimentary structures in Tansill carbonates suggest shallow-water environments ranging from supratidal flats and evaporite lagoons to shoal-water areas.

The Capitan Formation of Tansill-Lamar age consists of light-colored, massive to thick-bedded carbonate along the shelf margin and steeply dipping, massive beds of carbonate detritus along the basin margin. Texture and skeletal components of the Capitan are different from those of the Tansill. The Capitan generally is interpreted to be a shelf-edge and slope deposit.

The Lamar Member is a basinward-thinning tongue of limestone debris derived largely from shelf (Tansill) and shelf-edge (Capitan) deposits. It tends to be dark-colored, cherty, and evenly bedded but contains some slump structures. Units of micritic skeletal-intraclast calcarenite grading upward to micrite are common near its transition with the Capitan Formation. Farther basinward, the Lamar is characterized by evenly laminated micrite. Relative to the Tansill the Lamar is interpreted to have been deposited in deeper water (partly by turbidity currents) on a smooth basin floor.

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RELATION OF GRAIN SIZE TO SEDIMENTARY PROCESSES

Sand samples from known environments of deposition along the Gulf and East Coasts of the United States were collected to determine the effects of provenance, tidal range, average wave height, and sand supply on grain-size distributions. More than 300 samples were collected along profiles across 26 different tidal inlets, bays, and beaches. Samples were taken from the dune ridge to the plunge point, and in many places beyond the breaker zone. Additional samples were analyzed from the mouth of Southwest Pass of the Mississippi River.

At each sample locality information was collected on (1) the beach profile, (2) sedimentary structures, (3) tidal cycle, (4) average breaker height, and (5) relation to sources of sediment supply. The information gathered was compared with log-probability plots of the size distributions. Probability plots of similar form were grouped to determine how different physical conditions affected the size distribution, and to determine the presence of genetic associations.

Specific aspects of the grain-size distributions were found to be uniquely associated with differing depositional environments. The dune, swash zone, plunge zone, and wave-rippled sands exhibit characteristic size distributions even though they included samples from widely divergent provenance, energy, and tidal conditions.

Grain-size distributions of samples collected from both the Gulf and East Coasts illustrate the environmental and provenance variations. Localities with high wave energy and limited supply include Cape Hatteras, North Carolina, Long Beach, North Carolina, and Pensacola Beach, Florida. These three areas show a limited fine fraction and a large coarse fraction. Other beaches close to a major source of supply and of lower average breaker height include Folly Beach, North Carolina, Forest Beach, South Carolina, Indian Beach, Florida, and Grand Isle, Louisiana. These show a large fine fraction and little coarse material.

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TIME SURFACES, VACUITY, AND MAPPABILITY IN STRATIGRAPHY

Recognition of regional lithologic marker beds is accelerated by refined mechanical logging techniques and adequate drilling density. These correlative "punctuations" are considered to be geologically instantaneous, and to yield time surfaces bounding reliable stratigraphic units. The enclosed units represent longer intervals of time, and their lithologic gradations represent the diluted total environmental impress.

Markers represent (1) widespread, essentially contemporaneous deposition of thin lithologic components, and (2) virtually contemporaneous contact phenomena resulting from halmyrolic chemical alteration, replacement, and syngenetic emplacement proximal to the sediment-water interface during times of non-deposition. Time markers may indicate such short-interval lithologic inflictions as changes in water depth, climatic variations, migration of shoreline, and influx of suspensoids with chemical or physical character sharply differing from that of sediments within the body of the marker-bounded unit. Unit thickness of sediment deposited at any locale is dependent on sediment availability, fluxes of the scattering agent, rate of regional variation in chemical impress of depositing medium, and amplitude of local and regional structural change.

Lithologic variations occur in any unit, but the mechanical-log characters of the units are remarkably consistent through an entire sedimentary basin. If log character of unit sequence is similar, one may consider the unit to be areally equivalent not only in duration but in simultaneity. Log character is a function of space and environment, and the time markers signal massive changes in the vertical continuity of these environmental controls.

Stratigraphic analysts are able to use these "time slices" to create isopachous and lithofacies maps of short-interval synchronous units. These maps are rigidly controlled for unit initiation, termination, and time span. Thickness variations represent a measure of competitive sedimentation resulting from an interplay of environmental factors which involve the allogens and syngens in sedimentary prisms of a marine basin. Paleontologic and sedimentologic characteristics in these geosynchronous units yield environmental and geographic patterns important in the delineation of porosity trends. Geosynchron maps permit analysis of intra-basin structural growth which influences first-phase oil migration. Time-length vacuity becomes susceptible to quantitative analysis.

If the generally accepted concepts of uniformitarian geology are approximately correct, these maps systematize haphazard lithologic patterns into geographic- and time-controlled stratal units whose internal characteristics make it possible to determine rates of sedimentation, facies gradation, lateral intensities of environmental impress, origins of sediments, depth of water, distance to shore, and a host of other sedimentational variables not otherwise easily susceptible to quantification.

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DISH STRUCTURE, A PRIMARY SEDIMENTARY STRUCTURE IN COARSE TURBIDITES

Some clean but poorly sorted sandstone beds in California contain vertical progressions of thin lens-shaped structures, here termed *dish structures*. Individuals are 4–50 centimeters long, 1 to a few centimeters thick, oval in plan, and are oriented parallel with bedding. Each dish has a fine-grained, slightly clayey lower surface that is concave-up, and from which clay content decreases and sand size increases upward to a coarse, clay-free top. The size of the structures decreases and the concavity of their bottoms increases higher in the bed. The margins of each dish are truncated by adjacent and overlying dishes, except where they occur along individual horizons with their joined margins forming upward-pointing peaks. Steeply oriented elutriation columns lacking clay and finer sand commonly accompany dish structure. They disrupt or turn up dish surfaces through which they pass, and terminate beneath overlying dishes.

Typical sandstone beds containing dish structure are about 1 meter thick and progress upward from a base of coarse, structureless sand (interval *a* of Bouma, 1962) through flat lamination, dish structure, and overlying flat lamination (*b*), to a top of very fine-grained sand containing convolute lamination (*c*). Dish structure also occurs as a central interval within an otherwise nearly structureless, very thick bed.

Antidunes may produce simple dish structure by alternate scour, and by breaking and deposition in the troughs during aggrading suspension flow in a turbidity current that has declined from dispersion flow (after Bagnold). Middleton (1965) reports structures similar to some dish structures in size and shape resulting from antidune flow. Some characteristics, possibly including clay distribution, may result from sporadic water expulsion, related sediment flowage, and general de-watering of the bed. Dish structure between structureless intervals would require dispersion flow to progress to antidune flow, then revert to dispersion flow.

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COLUMBIA RIVER SAND WAVES

Large-scale sand waves (dunes) occur over much of the Columbia River bottom from near the mouth at Astoria, Oregon, upstream to The Dalles (including Bonneville Reservoir), a distance of 280 kilometers. The waves range in height from less than a meter to 7 meters, but most are 2–2½ meters high. Common lengths are 40–60 meters. Virtually all waves are asymmetrical, with steep slopes facing downstream. The mean particle size of bottom sediment is in the range of fine to very coarse sand. The migration rate for a group of waves in Bonneville Reservoir was approximately 0.6 meter/day during a 2-week period of high water in mid-June, 1966 (average current speed, 0.7 meter/second), decreasing to 0.3 meter/day in the following month at lower stages of the river.

Sand waves are not uniformly developed throughout the river. Within Bonneville Reservoir the location of waves apparently is determined by the availability of sand-size sediment and the river's flow characteristics. Just below Bonneville, the patchy wave distribution may be caused by coarse sediment (gravel) and (or) high current speed; near the mouth, waves apparently are not well developed because of variable directions of current flow during the tidal cycle. Water depth has no consistent effect on the location or size of the waves.

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MICROFACIES AND SEDIMENTARY STRUCTURES IN DEEPER-WATER LIME MUDSTONES

Limestone deposited in downslope or in basinal positions possesses several distinctive criteria based on microfacies, bedding, and fauna. The microfacies include (1) homogeneous lime mudstone, (2) millime-