able 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-