definition of carbonate sediments to include those containing more than 50 per cent carbonate minerals, many new parameters can be studied and new and useful information can be incorporated in studies of carbonate rocks.

It is obvious that, by enlarging the definition, consideration of insoluble residues and stratigraphic associations is possible. Further, the geographic range of carbonate sediments is enlarged, permitting study of a wider variety of environmental conditions. Finally, a greater variation in thickness of Recent carbonate sediments is found, a fact which should allow a better understanding of sedimentation rates.

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AGE RELATIONS OF MID-ATLANTIC RIDGE SEDIMENTS

Age relations of Mid-Atlantic Ridge sediments were established by means of planktonic Foraminifera in several selected areas between 22° N. lat. and the equator. Sediment types containing planktonic Foraminifera include unconsolidated ooze, consolidated ooze ranging from loosely friable aggregates to hard limestone, breccia, and palagonite-rich rock.

In the 22° N. area, consolidated sediments ranging in age from late Miocene to probable middle Pliocene were dredged from the flank of the ridge. Associated with the consolidated sediments in the dredges were basalts. Where an age relation could be inferred, the basalt overlies the late Miocene. Studies of Sr/Rb isotopes in the basalts are still in progress at M.I.T. Results thus far, however, indicate that these isotopes do not permit an age assignment. On the crest of the ridge there is no evidence of the presence of sediments older than Quaternary. Materials examined from the crest of the ridge include indurated detrital tuff and palagonitic rock.

Examination of sediments collected from the 11° N. area, Romanche trench and St. Paul's Rocks, are still in progress. In the Romanche trench, late Tertiary planktonic Foraminifera mixed with Quaternary assemblages were recovered from foraminiferal ooze in a core. In the St. Paul's Rocks area, the matrix of a conglomerate containing pebbles of the St. Paul's Rocks type yielded a Pleistocene foraminiferal assemblage. In the same area a vesicular basalt was filled with limestone. The limestone in the vesicles contained a mixed assemblage of late Tertiary and Pleistocene.

It is difficult to arrive at definite conclusions on the basis of the relatively little material thus far examined. Yet, it is interesting to note that the oldest assemblages recognized are late Miocene. Though not conclusive, the present data agree with other evidence suggesting a relatively young tectonic and volcanic history for at least parts of the Mid-Atlantic Ridge.

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GRAIN FABRICS IN TURBIDITE SANDSTONE BEDS AND THEIR RELATION TO SOLE-MARK TRENDS ON SAME BEDS

Grain orientations were determined quantitatively for 62 turbidite sandstone beds that exhibited sole marks (19 beds with flute casts and 43 beds with groove casts). Statistically significant alignment of elongate grains within these beds tend to parallel the trends of the sole marks on the base of the beds.

Grain fabrics of six beds were determined quantitatively for multiple levels (a minimum of four levels in each bed). The mean grain trends were observed to parallel approximately the trend of the sole marks on the base of these beds.

Deviations in the mean grain trend from the trend of the sole marks were noted for most of the beds studied, but the mean deviation for all beds was less than 10°. Moreover, there was no systematic sense of deviation such as that reported by Bouma (1962), Spotts (1964), and Spotts and Weser (1964). The deviations were grouped in normal fashion about the zero deviation point.

Dip direction of imbricate grains was determined at three levels in one of the sandstone beds studied. The imbricate grains in the middle and lower intervals dip in one direction whereas those in the upper interval dip in the opposite direction. However, statistically significant data were obtained only from the lowest interval in the bed. The current sense indicated by the dip direction of the imbricate grains in the lower and middle intervals is the same as that inferred from the flute casts on the base of the bed.

Grain fabric exhibited in the rock slices was determined according to the technique described by Spotts (1964). The statistical technique used to evaluate the grain trends was patterned after the method described by Curray (1956). The writer and his assistant, Monty Hampton, devised the statistical technique used to evaluate the dip direction of imbricate grains.

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EARLY DIAGENETIC CHANGES IN FRESH-WATER CLAY DEPOSITS

Cored borings of Recent fresh-water swamp deposits that accumulated in the Atchafalaya River basin, Louisiana, revealed the existence of numerous early diagenetic changes in clay deposits and the formation of various types of syngenetic and epigenetic inclusions. The deposits, approximately 100 feet thick, range in age from contemporary to slightly greater than 10,000 years and were deposited in four major environments of deposition: poorly drained (stagnant) swamp, well-drained swamp, lacustrine, and lacustrine delta fill. Many of these environmentally controlled facies are repeated several times in a single vertical sequence and offer the unusual possibility of studying diagenetic changes at different stages of development within a particular environment. The most common diagenetic change is the replacement of plant rootlets and other organic fragments by pyrite and calcium carbonate. Pyrite replacement is most common in the poorly drained swamp sediments, whereas carbonate replacement occurs most commonly in the well-drained swamp deposits. These changes took place rapidly, probably within a few years after deposition. Both pyrite and calcium carbonate tend first to be formed in the open spaces within the organic fragments, second to invade the pore spaces, and last to replace most of the original organic material. Vivianite ($Fe_3P_2O_8 \cdot 8H_2O$) forms fairly rapidly and also replaces organic material.

Nodules are abundant throughout the section, but are more common in lacustrine sediments. The size of the nodules differs, generally being smaller in the younger units, and increases in size in the older units. The shape changes, ranging from round, flattened, lenticular masses (lacustrine) to round and irregularshaped masses (swamp). Although hardness tends to increase with increasing burial depth and age, some nodules in relatively young deposits are very hard. Preliminary chemical analyses and X-ray diffraction studies indicate that they are composed of various carbonates, mainly calcium, manganese, magnesium, calcium-magnesium, and iron. Iron carbonates are abundant and appear to be more common in the older deposits. The change in proportion of the various carbonates presently is being investigated but this change must be abrupt. Other inclusions, such as iron oxides. iron hydroxides, *etc.*, also are abundant.

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SEDIMENTATION IN MALAYSIAN HIGH-TIDE TROPICAL DELTA

The Klang-Langat delta empties into the Straits of Malacca at 3° N. lat. along the west coast of the Malay Peninsula. Both the delta and its catchment basin are located in the wet tropics with mean annual rainfall ranging from 80 to 140 inches. The subaerial delta occupies about 160 square miles. Wave energy levels along this coast are low to moderate; the range of mean spring tides is 15 feet. Tidal processes dominate sediment dispersal patterns and control delta form. An extensive tongue-shaped sand bank or shoal (Angsa Bank) is down-drift from the delta. The subaerial delta displays a maze of criss-crossing tidal channels separating mangrove islands. Although the system has the configuration of an estuary, it is in reality a complex delta of the Klang and Langat Rivers.

Six major environments and facies are recognized in the active delta. The most seaward of these consists of well-sorted medium-grained sand deposited on extensive shoals or banks. Sorting reflects intensity of tidal currents. Local concentrations of shell and transported organic debris also are characteristic. This marine sand forms the bulk of the subaqueous delta deposits. Fringing the subaerial delta are broad low tidal flats composed of irregular-bedded, fine-grained sand, silt, and clay. Networks of small tidal creeks dissect the flats; shellfish and other burrowing organisms abound. Bottom sediment in major tidal channels is predominantly clayey sand with local concentrations of shell and transported organic debris. Mangrove-covered islands constitute most of the active subaerial delta. Although organic production is high, it is overshadowed by fine-grained detritus resulting in accumulation of organic clay, rather than peat. On the margins of the islands small sandy accretion beaches border channel mouths. Central parts of large islands and backswamp areas between major channels in the older parts of the delta are occupied by large fresh-water jungle-covered swamps. These are the sites of woody peat accumulations which attain thicknesses of 20 feet or more.

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ATLANTIC COASTAL PLAIN TERRACES AND TERRACE FORMATIONS

The relation between coastal-plain terraces and their underlying formations has long been obscure. Atlantic coastal-plain terraces are underlain by "cyclic formations" in the sense proposed by Stephenson (1928). They consist of continental and marine contemporaneous cyclic sequences. The continental sequence consists of stream, fresh-water, marsh, lacustrine, estuarine, and deltaic sedimentary facies. The marine cycle consists of littoral, sublittoral, bar, barrier island-lagoon, and barrier-island tidal-marsh sedimentary facies. The two sequences are gradational within estuarine facies and disconformable along former strandlines.

The cyclic formations overlie an unconformity that has been cut into older stratigraphic units. Landward the unconformity surface consists of stream valleys and divides over which the continental sequence was deposited during a rise in sea-level. Seaward the unconformity has been modified by marine scour. The marine sedimentary sequence occurs on this scoured surface. Initial marine erosion proceeds landward during a rise in sea-level until estuaries are filled and sediments supplied to the ocean balance sediments being eroded. From this stage onward, during slow transgression through subsequent regression, coastal-plain accretion takes place seaward with construction of one or more barrier-island and tidal-marsh stages and seaward growth of deltas.

The terminal surface of the cyclic formation is the terrace which contains both continental and marine land forms representing the last processes operative in the area during regression. Thus geomorphology and pedology reflect the terminal nature of the underlying litho-, bio-, and environmental facies. The underlying stratigraphic facies illustrate the cyclic sequence of environmental stages necessary to develop the terminal land form.

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RECONSTRUCTION OF AN ANCIENT SHALLOW-WATER MARINE ENVIRONMENT*

It is commonly possible to decide that an ancient body of rock was laid down in a shallow-water marine environment but in many cases it is impossible to determine precisely which shallow-water marine environment.

The Ordovician Stairway Sandstone, a shallow-water marine formation of the Amadeus basin, central Australia, contains appreciable, though so far non-commercial, quantities of oil, gas, and phosphate. It is therefore desirable to have a detailed knowledge of the depositional environment of this formation. For this reason, extensive field and laboratory studies were undertaken.

These studies have revealed that the sedimentary rocks, mainly orthoquartzite and phosphatic shale, were deposited during a regressive-transgressive cycle which resulted in the migration of a single shallow-marine depositional environment across at least 40,000 square miles of the basin. This has profoundly influenced facies distribution. Using a detailed graphic-log approach, the numerous sedimentation units in the Stairway Sandstone can be grouped into six composite units. These, in turn, comprise a single compound sedimentation unit whose characteristics are the result of a particular depositional environment.

The characteristics of this compound unit, compared with those of modern sediments, show that the modern lagoon-barrier and intertidal-flat sediments

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