level and local tectonic movements combined to permit stream erosion. Bedrock outcrops have been seen from research submersibles. These outcrops are in the walls of the gullies as deep as 400 meters below sea-level. Only a thin film of silt covers the gullies which show a very youthful V-shape cross section. Their identity also is lost at depth beneath the encroaching prism. The gullies do not extend inshore close enough to trap sand, but may serve as channels for funneling silt to the basin in concentrated turbid flow. Likewise considerable transport may result from sheet flow of turbid layers down the slope itself. (*Buffington*)

CANYON TRANSPORT

Coarse-grained sediments moving parallel with the beach are intercepted by the nearshore heads of submarine canyons. Diverted seaward, coarse sand is known to be mixed with large amounts of plant material. The fill in these canyons accumulates rapidly and is marginally stable. Periodic failure causes mass movement of sediment down the canyons. The dominant present-day processes of sediment movement are (1) slow gravity creep of the entire sedimentary fill of the canyon, (2) progressive slumps and slides of parts of the fill, (3) sand flows and falls in areas where the bottom slopes exceed 30°, and (4) traction resulting from strong bottom currents of various origins. This mass movement of sediment causes both downward and headward erosion of the canyon walls. Box cores from basins fed by nearshore canyons suggest that the coarser and cleaner sand occupies the seaward side of the basin and fine-grained clay the nearshore side. Approximately 70 per cent of the sand contains current-derived structures, indicating reworking after deposition. (*Dill*)

DEEP-BASIN SEDIMENTATION

The California continental borderland contains 17 major basins 20–80 miles long, with depths to more than 1,600 fathoms and distances to sediment source 0–110 nautical miles. Numerous gullies and several large canyons are associated with the basins. Earlier investigations led to conclusions that the coarser silt- and sand-size sediments of the inner basins were largely turbidity-current deposits, whereas the finer sediments were hemipelagic. A recent study, based on the interpretation of more than 1,700 miles of continuous reflection profiles, has produced new data on the structure of both the regional rocks and the basin sediments. The principal objective has been to differentiate between sequences of folded and faulted pre-orogenic rocks which form the present topographic basins, and post-orogenic sedimentary fill of these basins. Sections accepted as post-orogenic fill are divided into turbidity-current and hemipelagic deposits. Post-orogenic sediment thickness is also determined areally to define geographic distribution and relation to topographic features. It is concluded that deposition by turbidity currents has been of paramount importance, virtually to the exclusion of hemipelagic deposition. Because relatively fine sediments constitute the bulk of the basin fill, this conclusion is incompatible with earlier theories which classify only the relatively coarse-grained layers as turbidites. It is postulated (1) that the fine turbidites are of a very low-density, low-velocity variety with a shelf-depth origin, (2) that these layers travel diagonally from the shoreline under control of downslope gravity flow, orbital wave motion, and local tidal currents, (3) that these turbid layers commonly intercept canyon and gully systems where they then flow long distances down distributary systems to basin floors and basin-slope aprons where gradual dissipation occurs, and (4) that they do not erode or carry shallow-water forms into the deep basins, but are deposited slowly and gently enough to be incorporated with the benthonic forms. (*Moore*)

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EXPERIMENTAL INVESTIGATION OF EFFECTS OF COATINGS ON QUARTZ GROWTH

Observations made on sandstones indicate that in many places coatings on quartz grains may have inhibited the development of secondary quartz. Experimental data substantiate these observations in that thin synthetic coatings of muscovite, chlorite, kaolinite, and illite inhibit the development of synthetic secondary quartz. Basal plates of quartz were coated with these materials and placed in the growth zone of hydrothermal reactors at temperatures ranging from 300°C. to 330°C. and pressures from 6,000 psi. to 10,000 psi. Solutions of 0.03M K_2CO_3 were used as the solvent.

The precise effects of calcium carbonate and iron oxide coatings could not be determined because these materials altered to calcium silicate and iron silicate. However, thin coatings of these silicates were effective in restricting the formation of secondary quartz. Quartz grains naturally coated with clay minerals and iron oxide also showed practically no growth; whereas clean sands became highly cemented under the same experimental growth conditions.

If the various mechanisms for the formation of coatings are understood and environmental conditions of deposition are known, then it may be possible to predict the location of zones in which considerable porosity would be preserved by grain coatings which restricted the development of secondary quartz.

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RECENT SHALLOW-WATER CARBONATE SEDIMENTS

The "feedback" from studies of Recent carbonate sediments to studies of ancient carbonate rocks is small. The reason for this unfortunate state of affairs is that the approaches used in the two problems are so different. For example, the materials are different; carbonate sediments are conventionally nearly pure carbonate, whereas carbonate rocks contain up to 50 per cent non-carbonates.

Sediment studies usually involve rather elaborate size analyses, mineralogic studies, and individual particle descriptions. For most carbonate rocks diagenetic alteration has made size analysis difficult or meaningless, the minerals have changed, and only a part of the original particles can even be recognized.

The best understanding of carbonate rocks comes from conventional isopachous maps, stratigraphic associations, insoluble-residue studies, and fossil content. Only in a few cases can petrographic studies of size or particle type do more than support conclusions based on field relations.

The writers do not see any immediate way of changing drastically the methods for studying carbonate rocks. However, new approaches are possible in the study of sediments. By simply enlarging the 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 irregular-