making it possible to interpret Pleistocene vegetation history, at least in rough terms. The results are best illustrated in a Pleistocene full-glacial vegetation map.

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ROLE OF PETROLEUM GEOLOGIST IN PUBLIC EDUCATION

Public education is geology's best public-relations tool, and the need for increased public awareness of geology has never been more acute than it is today. The American Geological Institute, the National Association of Geology Teachers, and The American Association of Petroleum Geologists are doing much to place geology in the public eye, but individual geologists can play an active part in disseminating geologic information at the local level.

Petroleum geologists, because of their background and experience, could and should assume an active role in public education. Lay teaching in the community might include work with (1) Boy Scouts, (2) college "career days," (3) civic clubs, (4) television programs, (5) museum classes and field trips, (6) non-technical writing, (7) public and school libraries, (8) rock and mineral clubs, (9) public-school science teachers, (10) public-school science classes, and (11) science fairs.

Activities of this sort not only will help to attract brighter high school graduates into the geological sciences, but also will strengthen the public image of the petroleum geologist.

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MULTIPLE COMPONENT ANALYSIS AND ITS APPLICATION IN CLASSIFICATION OF ENVIRONMENTS

Multiple component analysis has been used to classify samples drawn from multivariate populations where the underlying populations were unknown and were to be determined. This type of analysis is effective in environmental studies where the variables of interest exhibit separate, but systematic patterns of variation through the total environment. A multiple component is defined as a sub-set of variables having maximum intercorrelation. The number of such components is determined by cluster analysis. Distinct sample groups are identified by the bimodal character of the distribution of factor scores calculated for each sample for each component. Using this approach, the number of samples that can be classified is unlimited.

The method was compared with a regular Q-mode-type analysis in a study of Recent carbonate sediments (Imbrie and Purdy, 1962) which involved 216 samples and 12 variables. In the original study, five facies were recognized: (1) coralgal, (2) oölite, (3) grapestone, (4) mudstone, and (5) pellet mudstone. Assuming that the mudstone and pellet mudstone facies are indistinguishable, the two methods are in 90 per cent agreement in their classification of the 216 samples. When all five groups are considered, there is an 83 per cent agreement. The anomalous samples are the result of the transitional nature of the facies boundaries where sediment mixing occurs. In either case, the facies patterns are similar.

Two other methods were compared: (1) principal components and (2) hierarchical grouping. Of the four methods, multiple components yielded the classification with the smallest partition variance. This was true whether four or five facies groups were assumed to be present.

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BANK TO BASIN TRANSITION IN PERMIAN (LEONARDIAN) CARBONATES, GUADALUPE MOUNTAINS, TEXAS

Light-colored, parallel-stratified, non-reef marine limestone and dolomite (Victorio Peak Formation) grade southeastward abruptly into dark cherty limestone (Bone Spring) along the northwestern margin of the Delaware basin (King, 1948). Study of the well-exposed transition zone in the Guadalupe Mountains suggests the presence of three major contemporaneous environments along a gentle basinward slope: bank, and bank margin (0.5–1 mile wide), both Victorio Peak; and euxinic basin, Bone Spring. Basinward regression of transition facies was 2–3 miles during accumulation of 1,500 feet of section. Middle Permian erosion truncated the transition strata creating basin-sloping unconformities on which limestone, megabreccia, and sandstone (Cutoff and Brushy Canyon Formations) were deposited.

Principal lithologic facies of the transition zone are successively: carbonate grainstone and dolomite packstone (bank); dolomite wackestone and mudstone (bank margin); and carbonate mudstone (basin). Paucity of desiccation or solution features, algal laminates, oölites, and coated or composite grains suggests prevalence of sub-tidal bank environments. Allochthonous channel fills and sheet deposits of skeletal packstone and wackestone occur in bank-margin and basin-edge facies. Sand-size skeletal grains and carbonate silt are dominant constituents in bank and bank-margin rocks. Carbonate silt predominates in basin facies. Characteristics of bank relative to basin strata are lighter color, dominance of grain-supported rocks, coarser grain size, normal-marine fauna, more dolomitization, less chert (but larger, more rounded nodules), and thicker, more massive beds. Undulatory bedding and disturbed laminations characterize many basin strata adjacent to the bank margin.

Two major controls on sedimentation and subsequent diagenesis were diminished turbulence with depth, and an abrupt change along the depositional slope from normal-marine to euxinic water at inferred depths of a few hundred feet. Bank proximity and finer particle size favored dolomitization. Low permeability of organic-rich basin facies apparently inhibited downdip dolomitization. Cementation obliterated most depositional porosity.

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PALEOECOLOGY OF SANTA BARBARA ZONE, PLIOCENE OF SOUTHERN CALIFORNIA

The Santa Barbara fauna is used to define a widespread zone in the Plio-Pleistocene rocks of the Ventura basin. This fauna is characterized by extinct, northern extra-limited, and submergent species of Mollusca. The characteristic species are accompanied by some locally extant species.

A section of the Fernando Formation exposed in Balcom Canyon in the central Ventura basin is composed of rocks deposited in water depths greater than 100 fathoms. Turbidite sandstones contain fossil Mollusca derived from all depth zones, from the depth of deposition on up to the intertidal. These mixed faunas were separated into depth associations on the basis of the depth ranges of living members of the faunas and on apparent associations in the faunas. The characteristic species of the Santa Barbara fauna are generally part of an association that lived in the deep-inner to shallow-outer sub-littoral depth zones (15–50 fathoms).

The lower part of the section studied contains fossils from the same depth zone as the Santa Barbara fauna. These fossils indicate that water temperatures were not detectably different than at present. The upper part of the section contains the Santa Barbara fauna, which indicates that waters at these depths were considerably colder in this region than at present. Most of the characteristic extra-limited species do not range south of Puget Sound. Associated with the characteristic species are others that do not live that far north today. This association of species not now living together must indicate either that the temperature tolerances of some have changed or that their distributions are controlled by some factor other than mean annual temperature.

The upper part of the section also contains numerous mollusks that lived in shallower water. The present distributions of extant members of these faunas indicate water temperatures not detectably different from temperatures today.

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DEPOSITIONAL PROCESSES IN DELTAIC ENVIRONMENT

Factors controlling depositional processes are analyzed for three of the world's major river delta systems: the Mississippi, Ganges-Brahmaputra, and Mekong. Despite variations in amount of factual data available it is apparent that these three river systems have developed different delta types which are of interest to the geologist attempting to compare ancient with modern deltaic environments.

Four basic factors control and influence delta formations: (1) *sediment load*—both quantity and particle sizes transported by the river to its delta; (2) *river regime*—in particular its sediment-carrying ability and seasonal variations in that ability; (3) *coastal processes*—essentially the influence of waves, currents, and tides in the deltaic environment, and (4) *structural behavior* of the depositional site—progradation across a stable platform or subsidence contemporaneously with sediment deposition.

Although the deltas which are considered here differ to some degree in most of the parameters involved, certain factors play dominant roles. The Mississippi delta area is characterized by rapid subsidence and its deposits are subject only to minor modification by coastal processes. Several overlapping deltas have formed during the Recent as sedimentation sites have shifted systematically during progradation. Rapid burial and minor modification by coastal processes preclude the development of laterally continuous sand bodies.

The Ganges-Brahmaputra delta is tectonically controlled. River courses and sedimentation sites have shifted erratically in response to structural change. Coastal processes are dominated by high tides which have created an extensive tidal plain of predominantly fine-grained sediments. Laterally continuous sands are not typical of this delta.

The Mekong has created a single delta system which has prograded across an essentially rigid platform. Contemporaneously, coastal processes (tides, waves, and currents) have reworked the delta front creating sand beaches which merge laterally to form sheet sands in the deltaic plain.

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CLASSIFICATION OF GRAVITY-FORMED SECOND-CYCLE BEDDING FEATURES IN MISSISSIPPIAN ROCKS OF OUACHITA MOUNTAINS, ARKANSAS

Stratigraphic studies in the Ouachita Mountains of Arkansas indicate the presence of a diverse assortment of rocks which have moved by gravity subsequent to initial deposition. A tentative classification of these subaqueous gravity features is proposed which, hopefully, gives a qualitative measure of downslope distance. By plotting thickness, types, and numbers of post-depositional sedimentary structures, a better understanding of basin geometry during deposition will be obtained.

One major deposit resulted from failure of both soft muds and interbedded incompetent sands. Slight downslope movement produced mixed masses of sand with flow structures and squeezed mud which might be pulled into clay "galls." Continued movement possibly caused disintegration of sand blocks to produce sandy mud and pebbly sand, finally becoming subaqueous turbidity flow as viscosity decreased. A second class of disruptive bedding resulted from plastic flow of soft mud only. Some interbedded sand behaved incompetently, failing by folding; the more competent sand eventually was pulled apart to become exotic blocks.

Slight movements generally can be determined by the character of slides, slumps, and contortions of interbedded sand. Longer-distance movement by mass flow produced contorted mud with exotic blocks of all sizes, shapes, and compositions. A third deposit had failure confined to fine-grained sand with high internal clay content. Some beds show minor plastic flow; others are visibly contorted. The downslope beds also would be turbidity-current deposits.

The Ouachita trough possibly consisted of an offsetting series of unstable mud slopes deepening southwest toward Oklahoma, laced with sand-feeder channels opening into laterally migrating submarine fans characterized by massive sand. More lateral or distal deposits generally are rhythmic and contain few second-cycle bedding features.