of about 65 miles are reasonably documented, greater displacements of older rocks are presently speculative and require more precise substantiation.

The late Eocene-to-Oligocene depositional histories of the southern San Joaquin Valley, east of the fault, and the Santa Cruz Mountain region, west of the fault, are symptomatic of a genetic relation. The upper Tejon, San Emigdio, Pleito, and lower Temblor Formations of the San Joaquin Valley are believed to be homologous with the San Lorenzo, Vaqueros, and lower Hester Formations of the Santa Cruz Mountains. No comparable sequence of rocks is known from intervening areas adjacent to the San Andreas fault; therefore post-Oligocene movements of about 225 miles are confirmed.

The late Eocene-to-Oligocene foraminiferal lineage of *Uvigerina jacksonensis* ↔ *U. tumeyensis* ↔ *"Siphogenerina" nodifera* ↔ *"S." transversa* occurs in both regions and corroborates the age relations of the formations.

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RECOGNITION OF TRANSGRESSIVE CARBONATE SEQUENCE WITHIN EPEIRIC SEA: HELDERBERG GROUP (LOWER DEVONIAN) OF NEW YORK STATE

The regional Late Silurian-Early Devonian marine transgression of the central Appalachians is represented in New York State by a shallow-water carbonate rock sequence (Helderberg Group) which locally transgressed north and west. The resultant stratigraphic section comprises several hundred feet of fossiliferous limestone which has several distinctive sedimentary facies.

Early workers interpreted each of the major facies as a separate time-stratigraphic lithologic unit or formation. However, from detailed field examination Rickard (1962) demonstrated that these formations are in fact time-transgressive toward the west and interfinger laterally with each other. Paleoecological study of the Helderberg Group supports this interpretation and shows that each of the formations represents a local sub-environment within the transgressive interval as a whole. These formations (facies) are:

(1) *Manlius Formation* (25–50 feet), a complex of rock types interpreted to represent supratidal, intertidal, and shallow subtidal environments within a broad shelf lagoon (Laporte, 1964; 1967).

(2) *Coeymans Formation* (20–100 feet), crinoidal-brachiopod skeletal calcarenite and carbonate siltstone which are commonly burrow-mottled toward the base of the unit but which show increasingly greater evidence of current reworking toward the top (high-and low-angle cross-stratification and sheet deposits). The Coeymans is interpreted to have been deposited in a wide belt of shallow, submerged crinoid mounds and banks which served as an effective, though discontinuous, barrier to circulation separating the more open-marine environment on the east from the restricted shelf lagoon of the Manlius on the west (Anderson, 1965).

(3) *Kalkberg Formation* (50–100 feet), highly burrow-mottled carbonate mudstone with a very abundant, diverse, and well-preserved biota. The Kalkberg is interpreted to be a shallow-water, open-marine deposit which developed on an extensive shelf seaward from the Coeymans crinoid banks and meadows.

(4) *New Scotland Formation* (50–150 feet), highly argillaceous and siliceous carbonate mudstone with a somewhat less diverse and abundant biota than the Kalkberg. The New Scotland is interpreted as having developed on a broad shelf like the Kalkberg (and marginal to it), but with significantly greater influx of terrigenous detritus which probably came from a distant easterly source.

Lateral and vertical variations in constituent carbonate-grain types, mudstone-sparite ratios, fossil abundance and diversity, and presence of primary sedimentary structures provide criteria for recognizing the transgressive nature of the major sedimentary facies of the Helderberg Group. The inferred depositional framework, moreover, is very similar to that postulated by Shaw (1964) and Irwin (1965) for "clear water" sedimentation within an epeiric sea and demonstrates the predictive validity of their generalized sedimentary model.

LEDINGHAM, GLEN W. (see Frankl and Cordry)

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ECOLOGIC CRITERIA FOR RECOGNITION OF DEPOSITIONAL ENVIRONMENTS IN CARBONATE ROCKS

Carbonate skeletons of many Recent and fossil species show morphologic characters which can be related to specific factors in their environments. Similarly, the mineralogy and chemistry of the carbonate from the skeletons are known to reflect a variety of ecologic factors.

Few attempts have been made to utilize the ecologic information from the physical and chemical properties of skeletal carbonates in the analyses of depositional environments of carbonate rocks.

Data are presented to illustrate their usefulness in recognizing certain ecologic factors in the depositional environment of carbonate rocks. In this presentation, particular emphasis is placed on comparative functional morphology of carbonate skeletons. Ecologic factors to be considered are habitat, derivation of constituent grains, rates of sedimentation, turbidity, micro-hydrography, consistency of the sediments, temperature, and depth of the accumulating sediments.

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POLLEN STRATIGRAPHY OF PLAYA LAKES

Since the discovery 15 years ago by Sears and Clisby that the dry lakes (playa lakes) of western North America contain a rich fossil pollen record, Pleistocene specialists have hoped that a definitive chronology would be forthcoming from this largely unglaciated region. Such a chronology should indicate the number of pluvial episodes and the magnitude of each. The deepest drill cores should reveal whether the Pleistocene began with a "bang" or a "whimper."

Though hopes for a continuous Pleistocene chronology go largely unrealized, the pollen record of the last glacio-pluvial maximum, the Wisconsin, is increasingly well known. It indicates a major shift in vegetation zones not once but several times during the C-14-datable part of the record. Among the areas studied to date are the San Augustin Plains, the Willcox Playa, Great Salt Lake Desert, and the Texas High Plains. Some control on the fossil pollen record can be gained from the modern pollen rain of "natural" plant communities in the southwest. Despite formidable problems of long-distance transport of certain pollen types it appears that the major vegetation zones have their own distinctive local pollen pool, 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 character-