of the 5–3-m. y.-interval or upper Pliocene of southern California. (7) Coiling preferences of *Globigerina pachyderma* are predominantly dextral during the past 11,000 years, mostly sinistral from this point back to 3 m. y. B.P. (Pleistocene), dextral although somewhat variable in the 3–5 m. y. interval (upper Pliocene), sinistral in the 5–7 m. y. interval (middle Pliocene), dextral in the 7–10 m. y. interval (lower Pliocene and uppermost Miocene), sinistral in the 10–11 m. y. interval (upper Mohnian-Delmontian transition), and dextral in its earliest occurrences of about 11–12 m. y. B.P. (within the Mohnian).

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FUTURE OF PETROLEUM GEOLOGISTS

The future of the petroleum industry continues to be bright because of the ever-increasing demand for energy both in the United States and the rest of the free world. There will continue to be a demand for well-trained petroleum geologists both in this country and abroad.

The large oil companies will continue to offer high salaries and increasing technical challenge to those petroleum geologists who can put "Rocks and Dollars" together.

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SEDIMENTARY PROCESSES OPERATIVE ALONG WESTERN LOUISIANA SHORELINE

The western Louisiana shoreline represents the complex interaction of low-energy wave turbulence along a broad, shallow shelf, a small tidal range, and a varying sediment supply of very fine sand and mud. These are in turn modified by shoreline orientation and complex offshore bathymetry, proximity to brackish estuary tidal efflux, and varying nearshore salinity.

Three dominant types of strand-line sedimentation have been chosen as typical of the modern shoreline in the study area. Mud flats, both tidal and subaqueous, form one type. Another dominant type of strand-line deposit is described as a sand-rich, "normal" beach. Facies relations of the "normal" beach are similar to the shoreface sequence described for the tidal mud-flat setting. Intermediate between mud flats and "normal" beaches is a transitional type of strand line consisting of thin swash-zone and breaker-bar deposits resting on eroded, earlier-formed mud-flat and marsh sediments.

Mud-flat progradation is initiated by establishment of a shallow-water breaker-bar system, providing a protected site for subaqueous deposition of mud. As sedimentation raises the level of the mud flat to an intertidal level, sand-rich breaker-bars of low amplitude slowly migrate shoreward across the flat. The flat ultimately becomes intertidal. Thin washover-fan sands associated with this setting constitute one form of strand-line ridge found in the Recent chenier plain.

Shoreface sedimentation in the "normal" beach differs from that of the mud flat in having fewer but considerably larger breaker-bars and a rapid shoreward transition into swash-zone, berm, and thick washover-fan sands. The pronounced increase in thickness of washover-fan sands in the "normal" setting provides a second distinct type of strand-line ridge or "chenier."

The intermediate nature of the transitional beach setting is emphasized as a temporal, highly dynamic phase in strand-line development. Although apparently retrogradational, it nevertheless represents a dominantly progradational strand line which builds seaward at an intermediate rate compared with quickly prograding mud flats and relatively slowly prograding "normal," sand-rich beaches.

A classification of progradational shoreline types based on "energy of coastal processes" *versus* "sediment supply" (*e.g.* Bernard, 1965) can be used to typify rates of progradation in the study area. Energy of coastal processes include (1) deep-water wave period, (2) orientation of shoreline with respect to prevailing wave front, (3) width of inner shelf, and (4) tidal range. Sediment supply includes (1) fresh-water efflux and salinity variation, (2) suspended mud supply, and (3) sand supply

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SEDIMENTS OF NHA TRANG BAY, SOUTH VIET NAM

Textural and chemical analyses of 115 sediment samples from Nha Trang Bay on the central coast of South Viet Nam have permitted detailed mapping of the sediment characteristics within this relatively small area. The results show marked juxtapositions of sediment types and ages. Two areas of relict sand left from a time of glacially lowered sea-level are surrounded by Recent detrital and carbonate material. The exposure of these relict sands is a result of the sweeping away of sediment entering the bay by strong currents that develop during the summer and winter monsoons.

Sediments within the bay fall into four basic groups: (1) clayey silt in low-energy areas between islands and in deeper water on the fringes of the bay, (2) sandy silt to silty sand extending out from the river mouths, (3) sand with low carbonate percentages including the relict sand in areas of vigorous currents; and (4) sand with high carbonate percentages; some of this sand occurs on shallow banks and exposed peninsulas and is in equilibrium with the energy environment, whereas that in shallow protected areas does not reflect the energy system. The distribution of organic materials in the bay is closely related to these sediment types. The highest concentrations of carbon and nitrogen occur consistently in the clayey silt areas with intermediate and low concentrations in the sandy silt-silty sand and sand areas, respectively. Exceptions to this are revealed in the plot of carbon/nitrogen ratios where high organic carbon contents occur in coarse-grained sediments of the nearshore and shallow-bank areas.

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ROLE OF MEMBRANE HYPERFILTRATION ON ORIGIN OF THERMAL BRINES, IMPERIAL VALLEY, CALIFORNIA

Unique saturated Na-Ca-K Cl thermal brines (380°C.) are recovered from geothermal wells near the Salton Sea, Imperial Valley, California. The reservoir chamber is fractured metamorphic rock (mainly greenschist facies) at 3,900–8,000 feet. The shallow waters are relatively dilute $NaHCO_3$-Cl, high in B; NH_4, I, and F are present; the Na/K ratio is less than in the brines; CO_2 gas is abundant. The waters of these brines are dominantly meteoric, as evidenced by

the previously reported deuterium content of the brines and local surficial waters.

The most critical geochemical questions concern the mechanism for brine concentration, the origin of the Cl ion, and the surprisingly high Ca/Mg, K/Na, and Ca/K ratios of the brine. The arkosic sedimentary fill of the Imperial Valley graben contains ample material to provide by solution every chemical in the brines except for the Cl ion. Models of the brine column *versus* original material contained in the encompassing rock column suggest a deficiency of Cl ion. A high degree of interchange between the host rock and the thermal waters exists, as evidence by previously reported data (^{18}O and B content) and the similarity of the Rb/K ratios of the brines to those of arkosic materials.

The Cl ion must be either juvenile in origin, or a result of the concentration of meteoric interstitial water of the sedimentary fill, or derived from Cl absorbed onto silicate surfaces. The similarity of the Br/Cl ratio of the brines to local meteoric surface and ground waters, and its complete dissimilarity to those of Cl evaporites, suggest that the brines are dominantly interstitial meteoric water concentrated manyfold. Doubtless some of these brine halogens also were obtained by desorption of absorbed material at high temperatures.

Hyperfiltration of relatively dilute hydrothermal solutions through electrostatic semi-permeable membranes composed of abundant montmorillonitic and illitic clays in the sedimentary fill provides the best mechansim for concentrating the brines within the proposed thermal convection cell and of affecting the relative composition of the brine and the relatively dilute waters underlying the thermal anomaly. In particular, this mechanism best explains the Ca/Na ratios of the brine; the relative abundance of Sr, Ca, and Mg within the brines possibly may be a result of this mechanism; the increase of HCO_3/Cl, F/Cl, and B/Cl ratios in the dilute overlying waters, which would be effluent to the proposed membrane system, probably is a result of such hyperfiltration. High-temperature metastable equilibria between the thermal brine and its enclosing rocks strongly affect the specific composition of the brine. Such reactions probably control completely the trace-element metal content of the brines. The relative abundance of the alkali-metals appears to be strongly influenced by such rock-water reactions as well as by relative hyperfiltration. Experimental investigations are needed to understand further the origin of these waters.

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EFFECT OF E.S.C.P. ON GEOLOGIC PROFESSIONS

Earth science is a popular and effective medium for teaching science in secondary schools. With the finalization of the E.S.C.P. materials in 1967, thousands of secondary schools will be added to the thousands that already have adopted earth science. What will this trend mean to the geologic professions?

The science of the earth deals with the materials of the planet and the processes which bring about changes. Youngsters who learn their basic science principles by studying earth materials and processes will develop an appreciation for the problems which man faces in coping with his environment and in finding and extracting useful materials from the earth's crust. Laboratory investigations and field experiences will put geology in a science framework, divorcing it from rock-collecting and dinosaur-naming. Universities can expect greater numbers of students with geologically oriented interests and a greater depth of appreciation for the science of geology.

A secondary school earth science course such as E.S.C.P. will not teach well logging, for example, but will prepare the student to understand why someone might want to detect differences in rock layers with depth and what these differences might mean. Principles are stressed; technical aspects are not. The effect that E.S.C.P. will have in changing the image of the geologic professions and in interesting more youngsters in studying various aspects of man's environment may be a tidal wave.

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PALEOZOIC AGE DETERMINATIONS

The integration of classical paleontological methods and "absolute" radiometric methods for the establishment of the time parameter for geologic processes during the Paleozoic Era has been barely initiated. Sufficient preliminary radiometric data have been obtained on stratigraphically assignable materials to give approximate time interval assignments to the Paleozoic Era and its constituent periods. Yet there are fewer than half a dozen correlation points which begin to possess the documentation from both approaches that is necessary and feasible.

For each of the various Paleozoic systems it is a reasonable estimate that 20 ± 10 resolvable faunal zones can be distinguished consistently. Accepting present estimates for the duration of the Paleozoic in absolute time, this could provide the corresponding average resolving power of $\pm$ 2-3 m.y. if the faunal zones were successfully calibrated. Utilizing optimal geological materials and adequate sampling and analytical procedures, it should be possible to establish radiometric ages with precisions of $\pm$ 5 to $\pm$ 2 m.y. from the beginning to the end of the Paleozoic. Discrepancies in radioactive decay constants can be normalized to $\lambda\ U^{238}$, adequately, for such purposes. Thus the potential resolving power of the radiometric and paleontologic methods is comparable.

A successful effort at cross-calibration could provide the basis for the determination of the important time constants for the great host of significant geologic processes ranging from faunal evolution to orogeny recorded for the Paleozoic interval. The keys to such an effort are: (1) a careful geologic search for the definitive sampling sites; (2) realistic evaluation of stratigraphic assignments using as many independent faunal elements as possible; and (3) persistent application of several radiometric methods to materials whose geologic context at the sample site has been established by careful mapping and petrologic study. A preliminary evaluation suggests that numerous sites containing intraformational tuffs, intercalated volcanic rocks, and stratigraphically assigned plutonic rocks exist in North America and Europe. A coordinated interlaboratory effort should be a major geological objective in the next 5 years.

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