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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ROLE OF COMPACTION IN DEVELOPMENT OF GEOMETRY OF SUPERPOSED ELONGATE SANDSTONE BODIES

Pennsylvanian and Permian nearshore facies on the eastern shelf of north-central Texas contain channel-fill sandstone bodies, which have been mapped from the outcrop westward down the paleoslope for 50 miles. These elongate sandstone bodies range in width from several yards to 3–4 miles and in a few places are more than 100 feet thick. Where the thickness values of the subsurface dendritic (distributary) sandstone bodies are unusually great, sandstone from subjacent bar-finger deposits probably has been included.

Within shallow, poorly developed synclines, which apparently provided primary paleotopographic control of channels, superposed channel systems commonly are offset laterally as a result of (1) interchannel subsidence by differential sandstone (channel)-shale (interchannel) compaction and (2) channel subsidence by compaction of sediments beneath massive channel-fill sandstones. The common offset patterns of superposed channel pairs is mainly a result of dominant interchannel compaction. Stacked or cross-over relations of channel pairs are less common and occur where the lower member is unusually thick. Channel-pair intersect maps illustrate the persistent geographic position of stacking and cross-overs, which may reflect tectonic control of channel location.

Because of differential sandstone-shale compaction, axes of sandstone bodies commonly coincide with maximum thicknesses of thin, conformity-bounded sequences which enclose the elongate sandstone body. Axes representing maximum thickness of these enveloping strata, supplemented by high sandstone percentage trends, and synclinal axes, are useful in outlining the general position of channel-fill sandstone systems, but sandstone isopachous maps, paleotopographic maps, and cross sections (necessitating denser well control) are more definitive.

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PALEOECOLOGY AND STRATIGRAPHY OF HOLOCENE CARBONATES, FRAZERS HOG CAY, BAHAMAS

Vibro-coring and water-jet probing of the unconsolidated Holocene section in a 22-square-mile area of the southern Berry Islands region of the Great Bahama Bank have yielded data on the thickness and facies relations of this section, and the geometry of the underlying Pleistocene karst topography.

Six sedimentary facies are recognized on the basis of petrographic examination of grain types and amount of fine carbonate material smaller than 1/8 mm. Bankward from the bank margin, the facies are, in order: (1) an "algal-skeletal" facies, a thin veneer overlying the rock surface of the outer platform; (2) a much thicker (*ca.* 9 feet) "grape-rich oölite" facies which apparently is separated in the subsurface from the algal-skeletal facies by knoll-like features of the karst surface; (3) an "oölitic" facies which both overlies and replaces bankward the grape-rich oölitic facies; (4) a transitional "pellet" facies; and (5) a "grapestone" facies which occupies the most bankward position in the study area. Beneath part of the grapestone facies, and evidently occupying an interior swale in the karst surface, is (6) a "muddy-sand" facies which has the highest percentage of fine carbonate (up to 40 per cent) observed.

The anomalous position of the grape-rich oölitic facies is judged to be an effect of the "knolls" in the underlying karst surface. As sea-level rose after the Wisconsin low and began to cover the bank, these irregularities served as at least a partial barrier to strong currents—sufficient to allow the process of grapestone formation to proceed in an area much farther seaward than the modern site of formation. Similar irregularities (including nearby modern islands, or cays, which are exposed elements of the karst surface), and distance from the bank margin, are thought to account for the position of the muddy sand facies. The effect of these irregularities decreased as sea-level approached its present height.

Preliminary examination of the foraminiferal faunas indicates that marine waters of essentially normal salinity reached interior positions over the inundated karst surface early in the transgressive history in spite of the irregularities of that surface.

The study has revealed the existence of crusts or lenses of indurated sediment within the unconsolidated section which have cementation fabrics similar to modern beachrock at other Bahamian localities.

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FROM SHORE TO ABYSS: NEARSHORE TRANSPORT, SLOPE DEPOSITION AND EROSION, CANYON TRANSPORT, AND DEEP-BASIN SEDIMENTATION

NEARSHORE TRANSPORT

Along the Southern California coast "slugs" of poorly sorted sediment are injected periodically into the littoral zone. This river-borne sediment is subjected to transport and sorting in the nearshore area by currents generated by progressive surface waves, tides, and winds. The wave-induced currents dominate and are powerful enough to move boulders in the breaker zone and sand in depths greater than 150 feet. Net transport of water along the bottom is shoreward and results in net transport of sand to the beach. Waves not parallel with the shore transport sand along the beach. Silt and clay tend to be kept in suspension by wave-induced surge and form a dense turbid layer at the bottom. The turbid layer is believed to flow slowly down the sloping sea floor into deeper water. Sand is known to be removed from the nearshore where it is trapped in the heads of submarine canyons. Thus separation of sand from silt and clay results. (*Vernon*)

SLOPE DEPOSITION AND EROSION

The shoreward margin of the California continental borderland, termed a basin slope because it does not descend to the abyssal sea floor like true continental slopes, appears to be primarily a depositional feature, silt being the predominant sediment. A profile from the beach seaward usually shows a narrow rocky shelf thinly covered with sand or sandy silt, and in some places with rock cropping out at the shelf edge. The basin slope itself continues as a bedrock surface which becomes increasingly buried under an encroaching prism of sediment building up from the basin floor. Sea gullies found locally on the upper parts of the slope, but not on the shelf, are attributed to subaerial erosion during periods of exposure when lowered sea-