

sequences. The procedure is used in conjunction with standard methods of environmental and diagenetic analysis, both in petrographic description and reservoir-map construction.

The first step in the procedure is largely petrographic in nature. The pore network is examined to determine the critical rock properties that influence hydrocarbon volume and productivity, pore type, pore arrangement, pore abundance, and pore size. Samples with similar pore networks are grouped together for use in the next step.

In the second step, representative samples are selected from each pore network group for porosity, permeability, and capillary-pressure measurements. The 3-dimensional and quantitative characteristics of the pore network are established in this way and basic data are obtained for reserves calculations.

The petrophysical data are interpreted in the third step by means of porosity-permeability cross plots and capillary-pressure graphs. The use of well logs at this point is recommended as an additional reference base. The output from this step is the identification of the reservoir facies and the determination of its range of quality. The development of a set of reference samples at this time aids cuttings description later on.

Finally, the reservoir and nonreservoir rock groups just identified are linked with their environmental facies counterparts (step 4). When this is accomplished for cored wells, the relations are extended to uncored wells by means of the reference set established previously. Cuttings samples, and even additional cores, can usually be described adequately with a low-power microscope once the reference set is available.

Because the procedure is based on experimental pore-size studies as well as on subsurface and surface studies of several areas and rock types, the system of description should have general application. Studies of fine-grained carbonate sequences are aided particularly with this approach, and helpful information commonly is obtained for evaluating well-test and pressure-production history data.

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**AEROMAGNETIC SURVEYS IN LABRADOR BASIN**

The combined study of a detailed aeromagnetic survey and available geologic, seismic and other geomagnetic data has indicated the presence of grabens, perhaps of late Paleozoic or early Mesozoic age. The study suggests the presence of salt, defines 3 important trends associated with Appalachian or post-Appalachian orogeny, and appears to support the present concepts of plate tectonics, although this latter point has not yet been studied in detail. Much of the information has been interpreted from detailed aeromagnetic data.

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**UNDERWATER IMAGERY BY MAPPING SONAR**

The unique long range of the mapping sonar now allows seabottom imagery to be obtained which is comparable to air photography or radar imagery on land. The sonar scans out to a 0.5 mi on each side of a towed fish, making the instrument practical for regional geologic sea-floor mapping. When the sonar is used in conjunction with a vertical-profile sparker, submarine geologic interpretations can be made that are superior to photogeologic interpretations on land. There are 2 modes of operation of the sonar. (1) With proper placement of ship traverses, continuous imagery can be obtained comparable to a stapled air-photo mosaic. (2) The sonar fish can be pulled behind a seismic vessel, producing mile-wide strip-type control. For use in this fashion, the increase in cost per mile is small. There are many geologic and geophysical benefits in this use of the sonar. Practical development of the wide-scan-mapping sonar heralds the beginning of sea-floor mapping comparable to aerial photographic land mapping.

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**TRANSPOSITION—A SOMEWHAT NEGLECTED MECHANISM OF SEDIMENTARY EMPLACEMENT**

Transposition is the mechanism of postdepositional or syndepositional intrastratal sediment movement caused either by gravitationally unstable stratification or by liquefaction. Movement may be upward, downward, or lateral. Transposition structures include sand dikes, sand sills, and sand plugs (formed by injection), sand and mud volcanoes and water-expulsion pipes (formed by ejection), and some convolute stratification and load structures. Slump structures or structures formed by fluid-drag action on the sediment surface are not included.

All of the above structures previously have been described as separate phenomena. They are, however, genetically interrelated; they commonly are found together and form a spectrum of secondary inorganic sedimentary structures. Rapidly deposited, alternate water-rich muds and fine sands in alluvial, lacustrine, deltaic, and turbidite sequences seem to be most suitable for their occurrence.

The similarity of some transposition structures to common primary sedimentary structures is striking. However, they may easily be confused. For example, polygonal patterns of sand dikes may resemble sand-filled mudcracks; cross-stratification caused by ejection may resemble current-formed cross-stratification; some sand dikes may resemble vertically walled channels; downward collapse structures may resemble wave-excavated scoops.

Well-exposed examples of transposition structures are present in the Mississippian Horton Group of Nova Scotia and in the late Precambrian Cabot Group of eastern Newfoundland.

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**EFFECTS OF POSTDEPOSITIONAL SUBAERIAL WEATHERING AND INTRASTRATAL SOLUTION ON PALEOCLIMATIC AND PALEOTECTONIC INTERPRETATION**

In the nonlithified Cretaceous and Tertiary sediments of eastern and southeastern United States, two different, readily recognizable mineral assemblages are nearly ubiquitous. One, termed a "full" suite, generally contains the following minerals: (1) epidote, garnet, staurolite, zircon, kyanite, hornblende, sillimanite, tourmaline, rutile, and monazite among the heavy nonopaque minerals; (2) quartz, muscovite, and feldspar among the light minerals; and (3) the clay minerals montmorillonite and kaolinite. The other mineral suite contains an impoverished or "limited" assemblage: (1) the heavy, nonopaque minerals zircon, tourmaline, staurolite, kyanite, rutile, sillimanite, and monazite; (2) the light minerals quartz and muscovite; and (3) the clay mineral kaolinite.

The full assemblage is characteristic of sediments of distinctly marine origin, whereas the limited suite commonly is associated with sediments interpreted as originating in a fluvial or littoral environment.

Analysis of outcropping sediments demonstrates that, upward in a section, a full assemblage may change to a limited assemblage where the strata are porous, permeable, and stand topographically high. Fluvial or littoral sands in outcrop or in the shallow subsurface contain limited assemblages, whereas their down-dip marine equivalents contain a full suite. These two distinctly different mineral suites are not necessarily the result of changes in provenance, source-area climate, or tectonic stability. Instead, they should be attributed in large part to postdepositional subaerial weathering and intrastratal solution.

Reevaluation of mineral analyses of Cretaceous and Tertiary sediments in the eastern and southeastern United States to include consideration of postdepositional subaerial weathering

and intrastratal solution will require revision of some previous interpretations of their provenance and of some prior reconstructions of the paleoclimate and paleotectonics.

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#### FOOD SUPPLY—LIMITING FACTOR OF FORAMINIFERAL POPULATIONS

The standing crop of benthonic Foraminifera declines during the fall and increases during the early spring in Great Bay, New Jersey. Population sizes correlate with seasonal variations in phytoplankton and particulate organic carbon abundances, but do not correlate with changes in temperature or salinity or with differences in substrate textures.

Foraminiferal populations at 7 stations were repeatedly examined from the head to the mouth of the bay. The substrate ranged from a silty clay to a shelly, gravelly sand. Maximum salinity-temperature range within the bay on any sampling day never exceeded 8 ‰ or 2°C, although salinities and temperatures varied from a maximum of 31 ‰ and 26°C in late summer to a minimum of 10 ‰ and 0°C in mid-winter, respectively.

The foraminiferal fauna is a typical midlatitude estuarine assemblage. The dominant species differ among stations and appear to be controlled by substrate texture and salinity; however, the standing crop at all stations exhibits a consistent seasonal variation. The live percentage of the total foraminiferal population decreases by more than 30% in the fall and winter and increases more than 10% in late winter-early spring. The decrease coincides with a decrease in chlorophyll *a*, but not with any marked change in temperature or salinity. In early March the increase coincides with an increase in chlorophyll *a* or particulate organic carbon, although temperatures in the bay are 5–6°C and salinities are depressed by runoff. The dominant zooplankton, copepods and nauplius larvae, as determined by others, exhibit a similar seasonal pattern.

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#### PETROLEUM INDICATORS IN FORMATION WATERS FROM ALBERTA, CANADA

A statistical study, including discriminant analysis, was carried out on a suite of 438 formation waters from Alberta, Canada, which had been analysed for Cl, Br, I, HCO<sub>3</sub>, SO<sub>4</sub>, Ca, Mg, and Na. The analyses were divided into 2 populations, depending on whether the initial status of the well was producing oil and/or gas (322 samples) or nonproducing, i.e., abandoned (116 samples). The populations were further subdivided into Paleozoic and Mesozoic groups, and these 2 groups, together with the entire suite of analyses, were subjected to statistical study. With 95% assurance, the Alberta formation waters associated with producible hydrocarbons are chemically different, in a multivariate sense, from the formation waters from abandoned wells. Further, iodine and magnesium are the most important discriminators in the Paleozoic group, whereas sodium and chlorine are the most important in the Mesozoic group. These discriminators reflect the different organic geochemical, geologic, and hydrodynamic history of the Paleozoic and Mesozoic strata. Reclassification of the analyses using the discriminant functions resulted in only a 0.65 success ratio, thereby indicating that the chemical analysis of formation water is not a completely reliable predictor of the occurrence of hydrocarbons, at least at the Paleozoic-Mesozoic level. The 0.65 probability of successful classification may be increased with the acquisition of a larger data base and consequent statistical analysis at the formation level.

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#### COMPARISON OF NATURAL HUMIC ACIDS WITH AMINO ACID—GLUCOSE REACTION PRODUCTS

Amino acids and carbohydrates disappear rapidly in recent marine sediments. Most of the organic matter exists as a high-molecular weight, insoluble polymer which has properties similar to humic acids. Glucose and amino acids react rapidly at neutral pH in the laboratory by the Maillard reaction, to produce a polymer that has many properties common to natural humic acids.

Both form gels that bind large quantities of water. They have comparable elemental compositions. The synthetic reaction produces a polymer with a wide molecular weight range extending to very high values similar to humic acids. They react rapidly with added amino acids. Both give a similar electron spin resonance spectrum. Degradation of the natural and synthetic humic acids by methylation, chlorination, and mild oxidation yields a similar suite of low-molecular-weight, chlorinated organic acids.

Carbohydrate-amino acid-reaction products are likely precursors of part of the polymeric organic matter in recent sediments.

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#### PHYSICAL AND BIOGENIC CHARACTERISTICS OF SEDIMENTS FROM OUTER GEORGIA CONTINENTAL SHELF

Eighty-eight box cores were taken on the outer Georgia continental shelf, in water depths from 15 to 200 m. Textural analysis indicates that the midshelf area is covered by medium to coarse sand, evenly distributed, with no north-south linear trends. Areas of fine sand are present on the inner and outer shelf edges, and in 2 distinct lobes extending seaward from the Georgia coast. Parts of the lobes suggest that the finer material forming them was supplied by the Savannah and Altamaha Rivers. Local patches of semiconsolidated mud indicate the location of remnant marsh or estuary deposits.

Offshore shell assemblages indicate a mixing of faunas in terms of both environment and age. Pleistocene regressions and transgressions across the shelf resulted in alternate oceanward and landward migrations of nearshore and estuarine faunas, reworked subsequently with open-ocean faunas. Live animals offshore are adding their shells to the already mixed assemblages.

Biogenic sedimentary structures significantly exceed those of primary physical structures. All box cores show some degree of biogenic reworking, and most were more than 60% bioturbated. Physical sedimentary structures include crossbedding, ripple lamination, interbedded sand and mud, wavy bedding, and graded bedding.

Physical and biogenic reworking of the outer Georgia continental shelf sediments has removed or greatly modified most of their original depositional characteristics. Thus, reference to these sediments as "relict" is misleading.

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#### DIAGNOSIS OF PROCESSES MODIFYING DISTRIBUTION OF ATMOSPHERICALLY TRANSPORTED VOLCANIC GLASS IN DEEP-SEA SEDIMENTARY CORES

Analysis has been made of tephra in deep-sea sedimentary cores downwind from Pleistocene and late Pliocene eruptions on the Balleny Islands in the southwest Pacific. The volcanic glass is finely dispersed and megascopically indistinguishable in the cores examined. Despite modification of the vertical distri-