ing aquifer is the Waiora Formation, a porous pumice breccia with buried flows of andesite in the lower part. Underlying the reservoir is the Wairakei Ignimbrite Formation, consisting of impervious dense ignimbrite sheets.

The Geysers, California, was described by McNitt (1963) as having Pleistocene and Pliocene volcanic vents, with rhyolite flows and tuffs, basaltic, dacitic, and andesitic lavas in outcrop in the hydrothermal area. The stratigraphic sequence consists of (1) Cretaceous, massive, yellow-brown sandstone and gray shale, 1,700–3,000 meters thick; (2) Knoxville Formation (Upper Jurassic), thin-bedded graywacke and shale, intruded by 150–300 meters of serpentine sills, thickness 1,700 meters; and (3) Franciscan Group (Upper Jurassic), interbedded graywacke and spilitic basalt, and small amounts of shale, conglomerate, and chert; intruded by serpentine sills; thickness, 9,000 meters. The Mesozoic rocks were folded gently, then intensely faulted. Surface thermal activity consists of hot springs, fumaroles, and hydrothermal rock alterations. The producing zone is a sandstone in the Franciscan, shattered severely by faulting, and altered by hydrothermal activity. The sandstone is dense, indurated, with some interbedded shale. Fractures to 0.5 inch wide have been cored. The BHT average is 208°C. (401°F.), pressure is 60 to 150 psi.

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PALEOCURRENTS AND SHORELINE ORIENTATIONS IN GREEN RIVER FORMATION (EOCENE), RAVEN RIDGE AND RED WASH AREAS, NORTHEASTERN UINTA BASIN, UTAH

Paleocurrent data from ripple marks and cross-stratification are related to orientations of shorelines and sandstone-body trends in the lacustrine and fluvial setting of the Green River Formation (Eocene). In the Red Wash field and the adjacent outcrops along Raven Ridge, northeastern margin of the Uinta basin, 125 paleocurrent directions were measured from cross-stratification and asymmetrical ripple marks in the Douglas Creek and Garden Gulch Members and the lower part of the Parachute Creek Member.

Vertical stratigraphic variation of paleocurrent directions at each locality is small, indicating that the over-all current system was stable. A plot of measurements of 84 asymmetric and 68 symmetric ripple marks shows that their distribution is very similar, which is interpreted to be the result of their formation by the same current system. Based on arcs of azimuths, there is essentially no difference between paleocurrent directions from cross-stratification and from ripple marks. The dominant paleocurrent directions are toward the north, south, and southeast. Of all observations, 25 per cent range from 331° to 30°, and 51 per cent range from 121° to 210°.

The shorelines in the northeastern Uinta basin area are interpreted to have been generally perpendicular to the dominant paleocurrent directions. Therefore, essentially all of the shorelines had bearings of 31° to 120°. An arc of 61° to 90° would contain about 40 per cent of the bearings of the shorelines, based on the paleocurrent data. Trends of single sandstone bodies, the total number of feet of sandstone, sandstone plus siltstone, and net sandstone in the Red Wash field, and the trends of major facies in the northeastern Uinta basin, support the generalizations about the orientations of shorelines and sandstone-body trends.

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SHORELINE PROCESSES

Shoreline can be considered to include the entire sedimentary regime encompassing the actively forming subaerial shore features, as well as the seaward extent of wave conditions capable of causing significant bottom disturbance. This offshore area corresponds to Dietz's "active surf lens," the seaward boundary of which commonly is at a 10-meter depth. The relatively narrow strip of the continent known as the shoreline is an area of extremely complex and variable sedimentation with highly variable morphology and sediment types. The importance attached to the understanding of shoreline processes by geologists is indicated by the large volume of literature concerned with this subject. In addition to being of interest to petroleum geologists because of the role of ancient shorelines as traps and reservoir rocks, the study of nearshore processes has immediate application toward solving the ever-growing shoreline engineering problems now being found along populated coasts.

The forces involved in shoreline processes are both subaerial and subaqueous and include wind, waves, tides, and chemical and biological agents. Important recent approaches to the study of these forces have been the quantitative works of Bagnold and Inman and the fluorescent grain-movement studies by Ingle and others.

Emphasis of the discussion of shoreline processes is on the Atlantic Coast of the United States between Cape Hatteras and Miami. Among other interesting aspects of this area is the particularly sharply defined "active surf lens," characterized by relatively fine grain size, in a "band"—usually less than 12 miles wide. Little sand-size material presently is being contributed by rivers and evidence is presented indicating that most shoreline sediment here, including beach and estuarine sand, is derived through winnowing and shoreward transport of central and outer-shelf material. The effect of varying wind and wave energies, tidal amplitudes, longshore current activities, and other factors is also exhibited along the southern Atlantic Coast of the United States.

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MINERALOGY OF 140-FOOT CORE FROM WILLCOX PLAYA, COCHISE, ARIZONA

The Willcox basin in southeastern Arizona is a closed drainage system of approximately 1,600 square miles. A core, consisting almost entirely of black mud with a silt-clay ratio of 3:7, was recovered from the playa at the south end of the basin. The diagenetic environment of the core sediments is characterized by high pH (9.0–9.5) and negative Eh (−100 to −300 mv) values.

The dominant clay mineral is illite, with montmorillonite, mixed-layer illite-montmorillonite, and vermiculite in decreasing order of abundance. Two distinct monoionic divalent montmorillonite complexes occur with basal spacings of 14.2–14.7Å and 15.2–15.4Å, respectively. A moderately well-crystallized trioctahedral vermiculite occurs in about half of the core samples. Kaolinite and chlorite are present only in trace amounts, the kaolinite occurrences being restricted to the upper few feet of core. Comparison of the clay minerals of the core with those of the source area suggests that the former are of detrital origin.

The clay mineral assemblage at the playa surface is dominated by illite with less than 5 per cent expansible phases present. Illite also is the predominant mineral in the source area; however, significant amounts of montmorillonite, chlorite, and kaolinite are being generated in the drainage basin. Discrepancies between the clay minerals of the lake bed and those of its source area are best explained by selective removal of finer colloidal material at the playa surface. The coarse sediment fraction contains detrital quartz, feldspar, heavy minerals, authigenic calcite, and ostracod valves. Saline minerals occur only as crusts at the playa surface.

Authigenic analcime is an ubiquitous constituent of the —2-micron fraction in amounts of the order of 10 per cent by weight. The absence of tuffaceous sediments in the core precludes alteration of volcanic glass to form analcime. Evidence is presented which suggests that analcime is a reaction product of kaolinite in the diagenetic sedimentary environment.

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SEDIMENTATION IN ANDAMAN BASIN, NORTHEASTERN INDIAN OCEAN

The northeastern corner of the Indian Ocean is contained in the Andaman basin which has an area of 900,000 square kilometers. The northern and eastern third of the Andaman basin is composed of the shallow Irrawaddy delta shelf and Malay shelf, respectively 200 and 170 kilometers broad from the coasts to the 200-meter deep-shelf break. Along this terrace the bottom drops to the topographically complex basin floor with a maximum depth of 4,400 meters east of the Andaman-Nicobar Ridge.

Principal sediment source for the basin is the load of the Irrawaddy River, estimated during the last century at 265,000,000 metric tons per year, a figure which may be in error by a large amount. The subaerial delta is accumulating very little of the sediment, which reaches the sea and is displaced eastward by monsoon-driven currents. A 12,000-square-kilometer area southeast of the subaerial delta is the main depositional site. Marked shoaling of this area during the past century is too great to be explained by sediment accumulation alone, and it is suggested that localized tectonism is distorting the delta shelf. Deposition also is localized in the disturbed area, as sedimentation strives to re-establish and maintain a stable delta-shelf gradient of less than 0°01′.

A radiocarbon date from a basin core and foraminiferal data indicate a deep-basin depositional rate of 15 centimeters per 1,000 years. Sediment carbonate contents provide a rough comparison of relative depositional rates for the basin floor and the delta, indicating that sediment accumulates on the delta shelf at least 10 times faster than in the deep basin, or at a rate of from 100 to 200 centimeters per 1,000 years. Approximately 90 per cent of the Irrawaddy's load is deposited on the delta and only 10 per cent reaches depositional sites beyond the delta.

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CONCEPTS IN LATE PALEOZOIC CORRELATIONS

Correlation of late Paleozoic strata presents two contrasting sets of concepts, one of intra-regional correlation and the other of inter-regional correlations. Correlation within a region, exemplified by a basin, segment of a geosyncline, or an epicontinental shelf, follows most of the classical procedures developed during the last 180 years. Where abundant well-log data or surface exposures permit the tracing of individual beds, development of three-dimensional facies analysis, key beds, and recognition of individual cycles within cyclical deposits provide accurate and detailed information for lithologic correlation. Where lithologic data are sparse, correlation based on fossil occurrence and abundance furnishes an additional type of correlation. Attempts to quantify fossil correlation include (1) presentation of the percentage of forms that two different localities have in common and (2) an analysis of the population in terms of the number of individuals. Individual guide fossils or sets of guide fossils with overlapping stratigraphic ranges also are widely used. Many of the most widely used guide fossils are pelagic, *e.g.*, the ammonoids. However, some benthonic fossils also are excellent guide fossils, particularly along depositional strikes.

Inter-regional correlations in the late Paleozoic, in contrast, are challenging in other aspects, because the tectonic and fossil history in one region may have virtually no similarity with nearby regions. Nevertheless, fossils still are the most reliable criteria for inter-regional correlation in late Paleozoic strata although the fossil yardstick as a time-stratigraphic scale commonly seems considerably less precise. One problem of particular concern is the development of faunal provinces and subprovinces in what appear to be isolated and semi-isolated regions segregated by late Paleozoic orogenic activity. Threshold levels of evolutionary adaptation and changes in physical environments seem to have enabled sporadic and irregular dispersal of different parts of these semi-isolated biotas, so that first appearances of one group in an adjacent region may have little relation to the first appearance of other groups.

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EXPLORATION IN AUSTRALIA

(Abstract not submitted)

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VILLAFRANCHIAN AGE AND ITS RADIOMETRIC DATING, II

The Villafranchian, though identified by non-marine phenomena, was one of the most precisely typified of the commonly used European Cenozoic Stages-Ages. Pareto (1865) gave exact geographic location and characteristic rocks of his stratotype for Villafranchian and listed the fossils that were known (three proboscidean species).

Villafranchian has been applied throughout Eurasia and Africa on the basis of a characteristic array of species of mammals. These species were obtained first from sites in Italy and France that were believed to be the same age as Pareto's Villafranchian. Validity and utility of the Villafranchian, as recognized through most of the Eastern Hemisphere, are not vitiated because some of its characterizing mammalian assemblages are younger than the type or because its lower boundary may not coincide with the currently accepted lower boundary of the Quaternary.

Large mammals now known from the stratotype, together with small mammals, mollusks, and plants