muds covered the bioherms. Upon regression of the sea, the shoal environment moved basinward over the bioherms, terrigenous quartz sands were washed into the channels, and finally, evaporites were precipitated from the waters trapped in the basin.

By considering the Paradox basin as a vast lagoon, marginal to the open waters of the Cordilleran miogeosyncline, we may visualize the *Ivanovia* bioherms as algal masses or banks growing on lagoonal shoals comparable with the current habitat of the green algae *Halimeda*.

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CONODONTS FROM TRANS-PECOS PALEOZOIC OF TEXAS

This is a preliminary summary of the distribution of conodonts in Lower to Upper Ordovician, Middle and Upper Devonian, Mississippian, Pennsylvanian, and Permian strata in the Trans-Pecos area of West Texas. Conodonts are now known to occur in the following formations: El Paso (Lower Ordovician), Montoya (Upper Ordovician), Canutillo (Middle Devonian), Helms (Upper Mississippian), Rancheria (Lower Mississippian), Tesnus (in part Mississippian), Magdalena and Gaptank (both Pennsylvanian), and Wolfcamp (Lower Permian) Formations. In addition, previously described faunas from the Marathon (Lower Ordovician), Fort Pena and Woods Hollow (Middle Ordovician), Maravillas (Upper Ordovician), Caballos (Devonian) and Dimple (Lower Pennsylvanian) Formations have been re-studied. Comparisons of these conodont faunas have been made with similar conodont faunas in central and eastern United States, and in western Europe. Detailed biozones like those proposed by other workers for the Illinois basin and for western Europe have not yet been established in West Texas. Furthermore, the abundance of conodonts in the stratigraphic column in West Texas is considerably less than that of the central United States and Europe.

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GEOLOGY AND TECTONICS OF TRINIDAD MOUNTAINS, LAS VILLAS PROVINCE, CUBA

The Trinidad Mountains in south-central Cuba include the San Juan, Trinidad, and Banao-Sancti Spiritus Mountains. The mountain system has steep south and west slopes and gentle north and east slopes. Karst topography characterizes the areas which are underlain by limestone.

The oldest rocks are Middle Jurassic (pre-Oxfordian) metasediments with micaschists at the base of the section and carbonate rocks above. Tentative correlation suggests the presence of a geosyncline during Middle Jurassic time. The metasediments are overlain unconformably by Middle to lower Upper Cretaceous sediments and pyroclastics (Albian to Santonian). Both are intruded by basic and acidic plutonics of middle Upper Cretaceous (pre-Maestrichtian) age. Sediments of younger Cretaceous and Tertiary age cover the margins of the mountain system.

At the close of the Lower Cretaceous, compressive forces oriented north-south, produced isoclinal folds and elevated the original Trinidad Mountains. Renewed orogenic activity during the middle Upper Cretaceous was accompanied by additional folding, cross-faulting, and jointing. Later intrusion of pyroxenites and periodotites was followed by acidic differentiates. At the end of the lower Eocene, tangential forces oriented southward produced a series of major overthrusts on the north coast of Las Villas Province and reverse structures in the Trinidad Mountains. Left-lateral strike-slip normal faults on the southwest margin of the mountains were developed during early Miocene time. They are part of a shear zone crossing Cuba in a northwest-southeast trend from the Bay of Cardenas to Cienfuegos.

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DINOFLAGELLATES AND THEIR USE IN PETROLEUM GEOLOGY

Dinoflagellates are a group of chiefly planktonic one-celled organisms abundant in modern seas and lakes. Their fossil organic shells range from 15 to 150 microns or more and are commonly found in Jurassic and younger marine sediments by the same techniques as those currently more widely used for spores and pollen. Commonly they occur in the same samples. Being surface-dwellers, dinoflagellates are relatively independent of the type of bottom sediment, although most abundantly found in marine shales; fresh-water fossil types are very rare. Rapid evolutionary changes, combined with wide geographic distribution of many species, make them excellent fossils for zonation and correlation. This is exemplified by successions of distinctive assemblages in the late Mesozoic and Cenozoic of Australia, by two assemblages containing many identical species in the Upper Jurassic of Utah and France, and by the world-wide distribution of a particularly distinctive form in the Upper Cretaceous. The value of dinoflagellates for environmental interpretation is as yet largely unexplored.

Two major types of dinoflagellate fossils occur. One is the resistant shell, or theca, of the free-swimming organisms. This is commonly divided into polygonal plates and may contain a thick-walled and much ornamented protective structure, the cyst. The second type consists of isolated cysts, freed of their surrounding thecae. The latter type includes many of the minute spiny objects that have been called hystrichospheres. In fact, the majority of (but by no means all) post-Paleozoic hystrichospheres appear to be dinoflagellate cysts. Important criteria for distinguishing dinoflagellate genera and species include: the over-all shape, the number and arrangement of plates or of spine-like projections, the type of cyst, and the character of a special opening, the archeopyle, by which the protoplasm left the theca or cyst.

The literature on fossil dinoflagellates and the number of described genera and species are still small, but now explosively expanding as interest in the group increases. Although fossil dinoflagellates are already useful tools of the applied paleontologist, our understanding of them and the full development of their potentialities for applied paleontology are in early stages.

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APPLICATION OF DIGITAL COMPUTERS TO EXPLORATION OPERATIONS

The use of digital computers in exploration is oriented toward furnishing the geologist an additional tool. Two types of operations are performed by digital computer installations. Data processing involves filing, sorting, and comparing a large volume of data that require a small number of arithmetical calculations for each of many data entries. Computing involves the solution of mathematical formulas and includes problems requiring relatively few data but many arithmetical calculations.

Data processing is often merely a system for rapid recall of information and as such is being investigated as a means of handling scout information. Well locations, formation tops, rock-type thicknesses within a stratigraphic interval, and paleontological and depth zone data can be recorded in numerical form on cards or tape for computer input. From such input the computer can calculate structure, isopach, and various types of lithofacies, biofacies, and environmental data for map preparation. Card or tape computer output can be printed rapidly on data sheets and then plotted manually on maps, or automatic plotting equipment may be used to print the output directly on base maps.

Second derivative calculations based on gravity and magnetic data can be performed rapidly on a computer. The results can be automatically plotted so that the maxima and minima are readily apparent without manual contouring.

Computer-automatic plotter systems can accept locations and data values for large numbers of points and produce contoured maps based on the input values.

For a map containing 1,000 irregularly spaced data points, several months would be required to perform the computations on a desk calculator to separate the observed data into regional and local components. These calculations are performed on the IBM 650 in one hour and on the IBM 704 in two minutes.

Computers are available within major companies, and to smaller organizations and independents through service bureaus. Converting large volumes of geological data to a form suitable for computer input can be done economically with proper planning by computer-oriented geologists. The exploration geologist should become sufficiently familiar with computers to recognize problems in which they can be used advantageously.

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Paleoecology of Scottish Mississippian Marine Transgression

A complete vertical column of the 2.8 mm. thick shale grading upward into the Upper Mississippian Second Abden Limestone at Fife, Scotland, was studied in an attempt to elucidate changes in its depositional environment and fauna from that of a near-shore terrestrial area (represented by the underlying fireclay) to the minor reefal development in the limestone.

Three thousand macrofossils belonging to 50 species, and 8,000 microfossils comprising 70 species were collected. The relative abundance of all species was calculated for equal quantities of rock in each of the 125 shale layers, which are approximately 2 cm. thick.

On the basis of certain indigenous macrofossils as well as on the microfauna and lithologic character, 4 topozones were recognized: (1) *Lingula squamiformis* and *Streblopteria ornata;* (2) *Crurithyris urei* and *L. squamiformis;* (3) *Schizophoria resupinata* and *Eomorginifera longispina;* (4) *E. longispina*, corals and bryozoans. Each succeeding topozone is more truly marine than its predecessor. The lowest (number 1) indicates deposition in conditions similar to those of the intertidal Wattenschlick deposits of the north German coast whereas the uppermost topozone (number 4) reflects conditions fast approaching those developing in the overlying limestone.

The succession of faunas in the shale indicates the marine transgression of the area. Reversal of such a series would indicate regression of the sea on shoaling. Recognition of a similar succession of faunas—perhaps over a much longer stratigraphic interval—may be useful in determining the position of the margins of former basins of sedimentation and in determining former transgressions and regressions of the sea.

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Sedimentary Basins and Petroleum Exploration in Japan

Deposition of marine sediments has occurred in different parts of Japan and its offshore areas at intervals from early Paleozoic time to the present. Most rocks of the Paleozoic sedimentary basins are now complex in structure and many have been metamorphosed; no indications of oil have been discovered in these rocks and they hold little promise for the future. Mesozoic sedimentary rocks are also complex in structure. Although no oil has been produced from them, a limestone of Jurassic age is slightly petroliferous and oil seeps are known from Cretaceous rocks in Hokkaido.

During Tertiary time thousands of meters of marine sediments were deposited in a geosyncline which extended along the western part of northern Japan. In late Pliocene and Pleistocene time crustal movements separated the Tertiary rocks into several basins. Petroleum exploration is presently concentrated in these Tertiary basins and their extensions offshore beneath the Japan Sea. Most oil so far discovered is trapped in small anticlinal structures which trend north-northeast.

Oil production in Japan was first officially recorded in 1874. Production in 1891 was 63,523 barrels. Development continued and in 1936 production reached 2,457,503 barrels. Much of this oil came from the Yabase field which was discovered in 1934. After 1939 production fell.

Exploration received new impetus during the American Occupation of Japan, especially through the leadership of Hubert G. Schenck. Deeper producing horizons were discovered in old fields, including the Yabase, and study and exploration of untested areas, particularly in Hokkaido, were undertaken.

Current exploration is carried on principally by the Japan Petroleum Exploration Co., Ltd., and the Teikoku Oil Co. The former is drilling anticlinal structures that were located by seismic surveys off the northwestern coast of Honshu. Tests of an offshore well completed in 1960 produced 1,800 b/d. Teikoku Oil Co. has concentrated its exploration program on the extension of proved fields. Total production has increased and 3,675,047 barrels of petroleum were produced in 1960.

Future exploration will include additional offshore drilling, testing of deeper formations in proved fields, and further exploration of unproved areas of Cretaceous and Tertiary sediments.

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Fluid Flow in Variable Density Ground-Water Systems

Current hydrodynamic theory is valid, in part, only for systems in which ground-water density is constant. Ground-water density is a function of salinity, temperature, and pressure. In the strict sense, constant density systems do not exist in nature on a regional scale.

A new concept of hydrodynamic analysis is presented in which actual flow-inducing pressure gradients are mapped. These gradients are, in reality, the flowing pressure forces that cause ground waters to migrate through rocks. Basic data needed to map these flowing pressure forces are (1) structural configuration of the aquifer, (2) ground-water density distribution in the aquifer, and (3) formation pressures. The flowing pressure gradients are both modified by and used to interpret changes in aquifer transmissibility (permeability-thickness/viscosity) between pressure control points.