cations for registration. Deadline for indicating interest in filing for registration was November 13, 1969, and closing date for submitting final completed application form is April 30, 1970. The date after which it will be unlawful to practice or offer to practice geology in California, except as specifically exempted in the Act, has been extended to June 30, 1970. This was done to enable the Board to complete registration of the unexpectedly large number of geologists who have applied.

Individuals missing the "grandfathering" period may still register without examination under certain provisions of the Act. They also may apply to take the next examination, for registration in geology and/or certification in engineering geology, at any time. This test will be given between August and October 1970.

Provisions of the Act require that the "specialty" of engineering geology be established and defined by the Board, and that qualified individuals be certified as engineering geologists upon proper application. Groups of geologists desiring to have similar "specialty" certifications established in other disciplines may bring their requests before the Board, which has the authority to regulate these into existence on the basis of public need.

M. B. DOBRIN, Univ. of Houston, Houston, Tex.

GEOPHYSICS AND FUTURE OIL POTENTIAL

(No abstract submitted)

JOHN W. HARBAUGH, Dept. of Geology, Stanford Univ., Stanford, Calif.

COMPUTER SIMULATION OF MARINE SEDIMENTATION

Geology has lacked an effective experimental approach to many problems. Although some kinds of experiments can be carried out, such as sediment transport on a stream table, most geologic processes cannot be re-created in the laboratory. A mountain range can be observed in the field, but neither the mountain range nor the mountain-building processes can be duplicated in the laboratory. These are shortcomings of which geologists are fully aware.

There is, however, another shortcoming in the geologist's kit of tools—namely, his difficulty in dealing with many interdependent variables or processes that mutually and simultaneously affect each other. However, computers can be used, in conjunction with appropriate mathematical geologic models, to perform kinds of experiments which otherwise could be performed only with difficulty, or not at all. Furthermore, these computer models are ideally suited for "exploring" the effects of interdependent geologic processes that are linked together to form dynamic systems.

The processes of marine sedimentation are highly interdependent. All too commonly, geologists who study stratigraphic sequences attempt to interpret the depositional environments of the strata in terms of only one or two variables—such as water depth or wave energy. Clearly, methods of analyzing the effects of multiple interdependent geologic variables are needed.

Computerized, dynamic mathematical models which represent geologic processes and products in two- or three-dimensional space provide one method of attack. These models are philosophically identical to dynamic oil-reservoir simulation models, and they also share many of their constructional details. Most dynamic geologic simulation models can be constructed from relatively few mathematical "building blocks," which may be grouped into the following categories: (1) materials-balance accounting systems; (2) sources of random variables; (3) Markov chains; (4) flow and transport mechanisms using finite-difference methods of representing diffusion and fluid-flow processes; (5) feedback control; (6) optimization; and (7) graphic display. Virtually all models employ methods in which both space and time are compartmented into small increments.

Experiments with relatively simple sedimentation models suggest that feed-back control exerts much influence on sedimentary sequences. A lag in the isostatic adjustment of the crust in response to the load imposed by deposition of sediment may be responsible for some of the large-scale rhythms in cyclic sedimentation. Simulation models can be used effectively to explore the results of different assumed lag factors in sedimentation/isostatic-adjustment feedback loops.

OSCAR E. WESER, Standard Oil of California, La Habra, Calif.

STRATIGRAPHY AND SEDIMENTATION OF JOIDES HOLES OFF CALIFORNIA COAST

Five holes were drilled several hundred kilometers offshore near the Mendocino and Pioneer fracture zones. Situated in 3,200–4,200-m water depths, these holes penetrate most or all of the stratigraphic column present at each site. They provide pertinent geologic data concerning the age of the oceanic crust and demonstrate 200–1,200-km offset across the fracture zones in that region. The deposits range in age from Pleistocene through late Oligocene. Their rates of deposition range from 0.1 to 56.0+ cm/1,000 years. Most are of terrigenous origin, although thin pelagic intervals are present in two holes. Such sedimentation agents as biogenous productivity, tropospheric transport, bottom currents, grain-by-grain settling, and turbidity currents have contributed to the sediment accumulations. Two of the holes that are only 20 km apart are lithologically similar. Each of the other holes has distinctive lithologic characteristics and thereby reflects variations in the contributions made by the different sedimentation agents. Several holes contain intervals of porous sand as well as organic-rich mud.

DAVID W. SCHOLL and MICHAEL S. MARLOW, U.S. Geol. Survey, Menlo Park, Calif.

DIAPIRS AND DIAPIRLIKE STRUCTURES, SOUTHEASTERN BERING SEA[1]

Four diapiric folds and two folds that are probably diapiric have been located by seismic-reflection profiling beneath the edges of Umnak Plateau, a broad platform at a depth of about 1,860 m in the southeastern corner of the Bering Sea. The plateau is underlain by 2,000–3,000 m of generally flat-lying strata thought to be of Neogene age. These strata overlie an "acoustic basement" that probably consists of lithified rocks of Paleogene age or older.

The piercement cores appear to rise from, or through, the acoustic basement, or possibly from the basal beds of the strata that form the plateau. The cores rise as much as 1,500 m above the acoustic basement and to within 700 m of the sea floor. Folding above the cores decreases upward, but the plateau is gently domed in places. Intrusion of the diapiric cores probably formed these folds in late Tertiary time; how-

[1] Publication authorized by the Director, U.S. Geological Survey.

ever, the very slight folding of the upper 200–400 m of strata may simply be due to differential compaction that followed the intrusion.

The cores of the folds do not noticeably affect the magnetic field: hence, we doubt that they are igneous bodies. Nonetheless, an igneous origin cannot be discounted; the cores are close to late Tertiary and Quaternary volcanic and intrusive structures along the adjacent Aleutian Ridge, and near the historically active volcano, Bogoslov, which forms an island nearby. Shale or even salt cores may be present beneath the folds; however, salt diapirs probably would have to be derived from a deeply buried parent body of Paleozoic or early Mesozoic age. All the diapiric and diapirlike folds that have been found are along major structural trends; these trends delineate the principal physiographic elements of the southeastern region of the Bering Sea.

R. O. LINDSETH, Computer Data Processors, Calgary, Alta.

MULTICHANNEL FILTERING

(No abstract submitted)

RAYMOND W. WALKER, Deep Oil Technology, Inc., Long Beach, Calif.

ECONOMIC ADVANTAGES OF SUBSEA PRODUCTION METHODS

Most offshore development drilling and production has continued to use onshore technology and equipment. The development of a field in moderate water depths has been substantially more expensive than a comparable field onshore. Although costs per well continue to rise, in most cases they have remained within the economic limits required to justify the invested capital.

There does exist, however, for any given field, a water depth beyond which it is not economically feasible to consider development from fixed platforms.

The proper location of the platform in relation to the reservoir can be determined only by exploratory drilling. This location becomes increasingly important as the platform costs in deep water escalate. The costs add further to the penalty for attempting to meet the problems of deep-water development with conventional platform techniques.

There are economic attractions associated with ocean-floor installations that have not been fully realized. The minimization of the investment required prior to drilling, the installation of specialized sea-floor production systems, and the use of highly efficient maintenance units throughout the producing life of the field, all combine to present a solution to the recovery of petroleum from otherwise prohibitive locations.

DONALD S. MCDOUGALL, Texaco, Inc., Los Angeles, Calif., and ROBERT H. OSBORNE, Univ. of Southern California, Los Angeles, Calif.

STATISTICAL ANALYSIS OF CALCISILTITES FROM BIRD SPRING GROUP, MOUNTAIN SPRINGS, NEVADA

Seventeen petrographic variables observed in duplicate thin sections for each of 62 calcarenites and calcisiltites collected from the Monte Cristo Limestone and the Bird Spring Group are the basis for this study. The samples are assigned to 6 microfacies, of which 31 and 17 belong to microfacies 0 and 1, respectively. R-mode cluster analysis grouped the variables into 7 clusters; 5 are composed of various organic and inorganic grains and associated alteration products, 1 is composed of acid insolubles, and 1 of sparite and micrite. Interclass and intraclass variation was tested by means of the Mahalanobis D^2 and associated F statistics. The null hypothesis was accepted for all diagonal elements and rejected for all nondiagonal elements. Initial clustering of raw- and transformed-data sets by means of Q-mode factor analysis—first using 17 primary variables, and then using 2 derived variables—indicated that the 2-variable case provided the best separation between microfacies 0 and 1. Null hypotheses concerning group dispersion and the equality of sample centroids were rejected for both the raw and transformed 2-variable case; consequently, an appropriate form of the T^2 statistic was employed to test for a significant difference between these two microfacies. Associated F values indicate a statistically significant difference between these microfacies for both raw- and transformed-data sets. Computed discriminant functions are approximately 98 and 79% efficient for the raw and transformed cases, respectively. The upper Monte Cristo Limestone was deposited under relatively stable environmental conditions that produced massive, low-energy micrites with very few biogenic grains. After an interval of erosion, the alternate quartzose sandstones and biomicrites of the lower Bird Spring Group were deposited under relatively unstable conditions. Environmental stability increased during the deposition of the upper Bird Spring Group, which consists of an almost unbroken sequence of micrites and biomicrites.

DAVID A. PHOENIX, U.S. Geol. Survey, Menlo Park, Calif.

PROBLEMS IN SELECTING ENVIRONMENTAL BENCH MARKS FOR REMOTE SENSING SYSTEMS

(No abstract submitted)

ERNEST W. PEIKERT, IBM Industry Development—Petroleum, Houston, Tex.

INTERACTIVE COMPUTER GRAPHICS AND THE FAULT PROBLEM

The treatment of faults is one of the greatest problems in the application of computers to petroleum exploration. Typically, too little information and too many alternative interpretations make analytic solutions economically unfeasible or otherwise unsatisfactory. Most computer techniques treat XYZ data points as though they are samples from a continuous surface. As a result, data points on opposite sides of faults are treated together with consequent distortion of analytically derived surfaces in the fault vicinity. Interactive computer graphics offers a solution. The geologist uses a light pen to interact with a series of graphic displays which enables him to (1) collect data on the position of fault surfaces from well logs, contour maps, and cross sections; (2) build numerical models of fault surfaces; (3) use the fault surfaces to separate data points on opposite sides of a fault; (4) build separate numerical surfaces from data points thus separated; (5) composite these surfaces with the fault surface to obtain a final model in which the surface is not distorted by the influence of points on opposite sides of the fault; (6) display the resultant model in the form of contour maps, cross sections, or perspective displays; and (7) iterate on the above process by altering