ture to sea and we today have no idea of the limit to which those explorations will carry us. Three maps are presented showing prospective areas of the world: first one, dated 1944, was prepared by the foreign division of P.A.W.; second one is from "Geography of Petroleum," 1950, by Wallace Pratt and Dorothy Good; third one is speaker's own interpretation of the data available today.

The first conclusion from all this is that the exploration of the world has just begun. The second conclusion is that instead of slackening our geological, geophysical, and engineering programs, we shall be wise to increase them and to develop wider and better training programs with particular emphasis on technical excellence.

DOTT, R. H., JR., AND OTHERS, University of Wisconsin, Madison, Wis.

Late Mesozoic Sedimentation and Orogenesis Along Southwestern Oregon Coast

Mapping, petrology, and paleocurrent investigations by the speaker and students provide new evidence of sedimentation in a continuously active orogenic belt in southwestern Oregon. Formational units have been traced into California, demonstrating that at least the northern part of the "Franciscan terrane" is divisible. Intensely sheared, northerly trending zones up to 3 miles wide have been traced from California for 100 miles north along the Oregon coast. They pass offshore beneath the seismically active northeast Pacific Basin. Paleogeology shows that these were superimposed upon arcuate Klamath Province fold trends from late Mesozoic to the present.

Extrusion of Jurassic rhyolitic to basaltic marine pillow lava and pyroclastics accompanied deposition of graded and non-graded arkosic wacke, mudstone and bedded chert (Dothan and Rogue? Formations). Associated local conglomerates contain granitic boulders, evidencing hitherto unrecognized "pre-Nevadan" granites. Laminated quartz arenite and argillite intruded by diorite contain Late Jurassic? *Foraminifera* (Galice Formation). Over large areas these units all have been metamorphosed to form the Colebrook Schist. Thus Late Jurassic orogeny is recorded by deformation, metamorphism, and ultramafic and dioritic plutons. Latest Jurassic and Early Cretaceous rocks contain excellently graded volcanic wackes, mudstone, and thick chert-volcanic conglomerates (Myrtle Group). Diorite, serpentine and schist clasts together with overlap relationships provide sensitive indicators of diastrophic pulses. Volcanism ceased during Cretaceous.

Later orogeny is recorded by severe deformation (but lack of metamorphism) of the Myrtle Group, emplacement of batholiths inland in the eastern Klamath Province, and unconformable overlap by shallow marine Late Cretaceous (Campanian) quartz arenites, quartz wackes, and mudstone. Major shear zones were developed at least by mid-Cretaceous and have been reactivated intermittently since. Post-Cretaceous warping and erosion recurred prior to widespread Eocene transgression, renewed volcanism, and deposition of graded volcanic wackes, cross-stratified volcanic arenites, and coal. Regression commenced in Late Eocene. Later Cenozoic movements along the major faults apparently formed the north-trending Coos synclinorium and were related to formation of north-trending Cascade volcanoes and plutons and to widespread faulting in eastern Oregon and Nevada.

DU BAR, JULES R., University of Houston, Houston, Tex.
CHAPLIN, JAMES R., Morehead State College, Morehead, Ky.
SOLLIDAY, JAMES R., University of Houston, Houston, Tex.

Paleoecology of Pamlico Formation (Late Pleistocene), Horry County, South Carolina

Depositional environments and paleogeography of the Late Pleistocene Pamlico Formation in Horry County, South Carolina, indicate that the formation was deposited near shore under non-marine, restricted marine, and shallow, open ocean conditions. Slight fluctuations of sea-level and other factors, such as shifting currents and migration of barriers produced sharp vertical and lateral facies.

From the observed distribution of macrofauna and microfauna, four marine environments are recognized: (1) inside intertidal, (2) shallow shelf, (3) lower bay (inlet influenced), and (4) upper bay (semi-restricted).

Paleoecologic, stratigraphic, lithologic, and paleogeographic observations provide evidence that the Pamlico deposits are related to a low stand of the sea, higher than 10 feet and less than 40 feet above present sea-level. Thus it is suggested that the Pamlico Formation be correlated with the making of the Pamlico shoreline (25–30 feet above present sea-level), which on paleogeographic and subsurface evidence was never located more than 5–7 miles inland from the present shoreline in Horry County.

During deposition of the Pamlico Formation, water depth was probably not more than 40 feet and generally much less; temperature of the water was probably slightly higher than that in the same latitude today; the water was usually slightly turbid and well oxygenated; and the salinity was variable. Inland from the bay and lagoon shores cypress swamps developed so that today non-marine clays and peat beds interfinger with brackish-water deposits.

EARLEY, J. W., Gulf Research & Development Company, Pittsburgh, Pennsylvania

Automatic Acquisition, Processing, and Interpretation of Geologic Data

The study of the abundance and distribution of minerals is in an explosive phase. In the few years that have elapsed since the first interpretations of X-ray analyses of rock composition were made thousands of determinations have been reported in hundreds of published papers. The precision of stratigraphic interpretation, correlation, and determination of environment is improved by using mineral composition but the cost has been high. Utilization of automatic equipment and data processing methods makes it feasible to obtain economically a wide variety of geological information.

Ditch, air-drilled, core, and outcrop samples are ground mechanically and sieved through a 450-mesh screen as the grinding proceeds. After homogenizing, the powder samples are prepared on microscope slides for X-ray analysis. A magazine-type automatic sample-changer holding 60 samples feeds the slides in turn into the X-ray diffractometer for analysis. The resulting data are punched automatically onto IBM cards using electrical control circuits to coordinate the many sequential operations. The suitably coded IBM cards containing digital diffraction intensities taken at each 1/10 degree of scan are processed in the IBM 704 computer using a dictionary-type program to produce a summary card showing the minerals present in a sample and their abundance. The summary cards containing control information and mineralogical composition are processed on other IBM or similar-type equipment to prepare compositional logs and maps which can be used for making correlations, defining lithologic features, determining environments, interpreting responses on geophysical-type logs, and predicting the location of reservoir rocks.

Very recent advances in technology have made it possible to build systems that will obtain and handle large masses of compositional information using simpler and faster analog systems as accessories to the X-ray diffractometer. Further refinements can be expected and well-site equipment capable of keeping pace with the drill is envisaged. The potentialities of automatic acquisition, processing, and interpretation of mineralogic as well as other geologic information have not yet been realized in exploration but trends are suggested.

EDIE, RALPH W., Andrichuk and Edie, consulting geologists, Calgary, Alberta, Canada

PALEOECOLOGY OF DEVONIAN SWAN HILLS REEF, ALBERTA, CANADA

The Limestone reef reservoir at Swan Hills consists essentially of a "buildup" of successively smaller atoll-like layers. Precipitation of calcium carbonate within the lagoonal area of each layer essentially kept pace with growth of the outer organic lattice. Within the reef mass, six depositional environments characterized by specific suites of fossils (or fossil fragments) and associated limestone textures are recognized as follows.

1. Aerated moderately agitated water of normal marine salinity (widespread shelf or submerged reef-built platform). Thamnopora-type corals, *Amphipora*, "pancake" stromatoporoids, crinoids, articulate brachiopods, rare rugose cup corals, and ostracods occur in light gray-buff skeletal microgranular limestone of low permeability.

2. Semi-stagnant quiet water of normal marine salinity (leeward side of reef). Crinoids, articulate brachiopods, rare thamnopora-type corals, *Amphipora*, pancake and bulbous stromatoporoids, rugose cup corals, ostracods, and gastropods occur in impermeable dark brown argillaceous skeletal calcilutite with thin black bituminous shale beds and rare dark chert nodules.

3. Aerated highly agitated water of normal marine salinity (organic lattice). Light buff stromatoporoid bulbs and *Amphipora*, rare thamnopora-type corals, rugose cup corals, crinoids, and articulate brachiopods form permeable patch reefs and interbedded skeletal calcirudites.

4. Semi-stagnant quiet marine water of slightly increased salinity (partly restricted shelf). Dark gray biostromal "buildups" of stromatoporoid bulbs and minor *Amphipora* occur in impermeable black shaly matrix.

5. Aerated, quiet to highly agitated marine water of increased salinity (mud flats, tidal channels, and shoals within atoll-lagoon). *Amphipora*, rare ostracods and gastropods occur in light buff impermeable to highly permeable precipitated limestone (lithographic, microgranular, pseudo-oölitic, and intra-formational conglomerate).

6. Semi-stagnant quiet marine water of increased salinity (deeper protected pools in atoll-lagoon). *Amphipora*, rare stromatoporoid bulbs and ostracods occur in impermeable dark brown slightly argillaceous calcilutite of precipitated origin.

Mapping of these environments is of great value in outlining field extensions and evaluation of acreage during development drilling. Use of these techniques, in addition to contruction of isopach maps of critical intervals, should also be highly effective in exploration for undiscovered reef oil and gas fields.

EATON, J. P., PAKISER, L. C., JACKSON, W. H., STEWART, S. W., AND STUART, D. J., U. S. Geological Survey, Denver, Colo.

EXPLORING THE CONTINENTAL CRUST OF WESTERN UNITED STATES

Seismic-refraction measurements have been made by the U. S. Geological Survey along 10 profiles, each 300 km. long or more, in California and adjacent Nevada, and Colorado and adjacent New Mexico, as a part of the Vela Uniform program of the Advanced Research Projects Agency, Department of Defense. Initial interpretation of results along a line from Fallon to Eureka, Nevada, defines an intermediate crustal layer at a depth of about 22 km. with a velocity of 7.2 km. per sec., and the Mohorovicic discontinuity at a depth of about 40 km., below which the velocity is 8.0 km. per sec. Interpretation of the first profile completed in Colorado defines an intermediate crustal layer at a depth of about 31 km. with a velocity of 6.9 km. per sec., and the Mohorovicic discontinuity at a depth of about 48 km., below which the velocity is 8.0 km. per sec. The velocity in the upper crustal layer, below the near-surface rocks, is 6.1 km. per sec. along both profiles.

ELIAS, GREGORY K., Durango, Colo.

PALEOECOLOGY, AN EXPLORATION TOOL IN SOUTHERN PARADOX BASIN, FOUR CORNERS AREA

In the southern Paradox basin many of the oil and gas fields produce from bioherms. Extensive coring operations in the Ismay-Flodine Park field have permitted a detailed inspection of a typical bioherm in the lower Ismay zone of the Pennsylvanian Paradox Formation. The four basic depositional environments that have been differentiated are shoal, bioherm, basin, and channel environments. Variations of chemical composition, particle size, allochems, degree of winnowing, biological remains, color, and terrigenous clastics are used to differentiate the environments. Distribution of environments in relation to tectonic features leads to a reconstruction of the ecologic conditions that produced the bioherms. The bioherms are not considered to be reefs, but remains of algal forests.

Diagnostic parameters for identifying the major environments are: (1) shoal—light-colored calcareous muds and disturbed calcareous muds interbedded with poorly winnowed intraclasts, pellets, and Foraminifera (*Glomospira*); (2) bioherm—light-colored, slightly winnowed to well winnowed algal remains (*Ivanovia*); (3) basin—dark, argillaceous, calcareous muds near the biohermal front, with anhydrite followed by halite farther basinward; and (4) channel—light gray brown calcareous muds with siliceous sponge remains, in places overlain by relatively thick quartzose sands.

The depositional history begins with a transgressive sea, during which the green algae *Ivanovia* found favorable growth conditions on the slopes of calcareous shoals. The algae grew upward and shoreward as the sea rose. Near shore, the very gentle waves formed intraclasts and pellets from calcareous muds. These particles, together with fine fossil debris, then were loosely cemented in a matrix of contemporaneous calcareous mud. In the channels between the masses of algae, siliceous sponges were nourished by circulatory waters. During maximum transgression, calcareous