

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 calcilitute 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 calcilitute 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 construction 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