sions of the current system and planktonic facies, and (5) the shallow-water facies west of the San Andreas fault at the south end of the San Joaquin Valley are anomalous. The facies anomaly across the San Andreas fault is consistent with the concept of major right lateral-slip movement since the middle Tertiary.

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GEOLOGY OF SHELDER FIELD, DIMWITT COUNTY, TEXAS

Although it has received very little publicity, Shelder field, discovered in the early 1930s, should be studied by all geologists and geophysicists because it represents clearly the link between the old oil-finding method and the new or modern exploration technique. Many recently developed exploratory tools first were introduced experimentally at Shelder field. In chronological summary, the successful culmination of the well-coordinated efforts of the Surface Party, Geiger Counter, Torsion Balance, Magnetometer, Seismograph, and Core Drill coverage is described. The productive history of this type of reservoir is demonstrated graphically, and a brief review of its economic significance is presented.

An amazing similarity between the discovery, development, and performance of Shelder field and many fields throughout the world will be noted.

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GEOLOGY OF MIDDLE DEVONIAN REEFS, RAINBOW AREA, ALBERTA, CANADA

Data obtained from comparatively recent discovery and exploitation of hydrocarbon-bearing Rainbow Member reefs in northern Alberta provide an excellent opportunity to examine the regional sedimentary and structural setting of the Black Creek basin, and specifically, the development of varied reef forms within the Rainbow sub-basin.

An intracratonic basin first developed during pre-Middle Devonian (lower Elk Point) time. Basin "growth" continued through this period and into Middle Devonian (upper Elk Point) time, when it reached its maximum expansion during deposition of the lower Keg River carbonates. Minor thickness and faunal changes take place in this unit; in some places, the areas where these changes take place are believed to have been loci for later Rainbow Member reef growth. In other places, such as the Hay River bank, the coincidence of reef growth and major structural elements indicates tectonic control.

The Rainbow Member reefs are characterized by high relief (up to 800 ft) and two basic geometrical forms: pinnacle (large and small) and atoll. A third form may be in the Shekilie barrier and Hay River bank reefs, but little information is available.

The increasing salinity of the seas, caused by development of the Shekilie barrier and lowering of the sea level, gradually terminated Rainbow Member reef growth. Muskeg evaporites (the Black Creek Member salt at the base, overlain by the Muskeg anhydrite) filled the Black Creek basin. The origin of the Black Creek salt beds and the time relations of reef and off-reef beds have been interpreted differently by different authors.

Detailed lithologic studies reveal the presence of 14 facies representing six depositional environments: basin, forereef, organic reef, backreef, lagoon, and shoal. Superimposed on the original facies is a variable diagenetic history: an early stage of penecontemporaneous dolomitization and a later stage of white dolomite infilling. Both are common to the atoll reefs. Geological rock types are classified in terms of five reservoir facies. The link established between rock and reservoir properties leads to a better understanding of fluid-flow behavior and recoveries in the pools. At present, there are in excess of 1.2 billion bbl of in-place reserves in the Rainbow field, whereas in the Rainbow South field, in-place reserves are in excess of 200 million bbl.

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PLANKTONIC FORAMINIFERA — A HISTORY OF OCEANS

The presence or absence of certain planktonic Foraminifera in marine sedimentary layers is indicative of oceanic conditions prevailing during the time of deposition. The oceanic conditions are in turn related to broad climatic conditions prevailing during the same time interval. Planktonic assemblages in sediments from the Scotian shelf and slope, South Atlantic, Caribbean Sea, and Mid-Atlantic Ridge are related to oceanic fluctuations during both Tertiary and Pleistocene times. Subtropical faunas in sediments from northern areas indicate the existence of warm oceanic conditions at least 15° farther north than previously believed; also, cool-temperate to boreal faunas in southern latitudes are indicative of general ocean cooling.

Analyses of several core and dredge samples show the simultaneous occurrence in northern latitudes of cold-brackish benthonics and warm West Indian planktonics during and after Wisconsin glaciation. Moreover, faunal extinctions and evolutionary changes are indicative of both abrupt and gradual climatic changes during the past 15 million yr. Faunal evidence clearly shows the nonpermanence of, and recurrence of, oceanic currents. Consequently, evidence of drastic and relatively abrupt planktonic faunal changes in marine cores must be related to changes in ocean circulation, climatic changes, continental glaciation, and other catastrophic events such as volcanism and extreme variations in salinity.

Data gathered from the Recent distribution of planktonic Foraminifera are utilized in interpreting the environments of deposition of ancient sediments. Most previous studies have suggested a relatively abrupt climatic change at the onset of the glacial period (represented by extinctions and additions in relatively short core intervals) and restriction during the Tertiary of warm subtropical waters to latitudes south of 34°00′N. The similarity of both planktonic and benthonic assemblages in northern latitudes with those in the Caribbean area during both the Pleistocene and Tertiary strongly suggests the presence (for lengthy periods) of a warm climatic belt or proto-Gulf Stream extending from the Caribbean to at least latitude 46°00′N.

Alternate warm and cold sequences in sediments from both the Scotian slope and Mid-Atlantic Ridge support the hypothesis of a fluctuating subarctic convergence in close proximity to a mid-Atlantic gyral during the Pleistocene and late Tertiary. It is the writer's contention that oscillating cooling conditions

in northern latitudes were developing in late Miocene time approximately 15 million yr ago, that the Pliocene-Pleistocene boundary is approximately 1.8 million yr old, and that the warm latitudinal belt postulated for the Tertiary must be extended to at least 46°00′N. If these conclusions are valid, they demand a re-evaluation of paleoclimatology, paleogeography, and paleoceanography.

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CLAY MINERALOGY OF KOPE AND FAIRVIEW FORMATIONS (CINCINNATIAN) IN CINCINNATI AREA

Detailed clay mineralogical analyses were conducted on shales and mudstones of the Kope and Fairview Formations in the Upper Ordovician standard of the Cincinnati area. X-ray-diffraction, electron-microscopy, cation-exchange, and DTA studies reveal a suite composed mainly of illite, chlorite, and lesser amounts of illite-montmorillonite and vermiculite.

Clay-mineral ratios show consistent changes approximately 3–4 ft above the presently accepted and mappable boundary between the Kope and Fairview Formations. Increases in combined chlorite-vermiculite amount to about 15 percent and are accompanied by a general increase in the proportion of limestone in the section.

In addition, cation-exchange and X-ray data reveal up to 3 percent vermiculite in the upper part of the Fairview, compared with 0–1 percent in the lower part. These clays probably represent degraded flakes of chlorite due to weathering in the source area.

Paleocurrent measurements reported by Hofmann (1966) show a dominantly eastern source direction for the Kope carbonates and a dominantly northern source for the Fairview carbonates. Differences in clay-mineral constituents in the associated shales and mudstones appear to correspond to these data and may indicate differences in source-area lithologic characteristics in those directions. Further, it is not unlikely that some volcanic influence may account for variations in mixed-layer illite-montmorillonite.

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SHO-VEL-TUM OIL FIELD, OKLAHOMA

Prolific oil and gas production is obtained in the Sho-Vel-Tum area of eastern Stephens and western Carter Counties, Oklahoma, from rocks of Permian, Pennsylvanian, Mississippian, Siluro-Devonian, and Ordovician ages. This large, complexly folded and faulted area is in the northwest part of the Ardmore basin between the Arbuckle Mountains on the east and Wichita Mountains on the west. The first production was discovered in July 1914 from Permian rocks at a depth of 400 ft in Sec. 21, T. 3 S., R. 2 W. The area has had two periods of major structural movement: post-Morrow, pre-Deese; and post-Hoxbar, pre-Cisco. Production is from stratigraphic traps, fault closures, anticlines, and combinations of these. Geologically this is one of the most interesting areas of the world, and economically it has produced 742,835,000 bbl of oil with an estimated reserve of 158,288,000 bbl. The area is still active and new reserves are being found.

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SELECTIVE SOLUTION IN PLANKTONIC FORAMINIFERA: LIABILITY AND ASSET IN RECONSTRUCTION OF ANCIENT ENVIRONMENTS

On the ocean floor, solution of foraminiferal ooze takes place at depths considerably above the $CaCO_3$ compensation depth. Solution is selective and the common planktonic Foraminifera are dissolved in the following order (least resistant species listed first): *Globigerinoides ruber, Orbulina universa, Globigerinella siphonifera, Globigerinoides sacculifer, G. conglobatus, Globigerina bulloides, Globigerinita glutinata, Globorotalia hirsuta, G. truncatulinoides, G. inflata, G. menardii, Globoquadrina dutertrei, Globigerina pachyderma, Pulleniatina obliquiloculata, Globorotalia crassaformis, Sphaeroidinella dehiscens,* and *Globorotalia tumida.*

Selective solution will change the apparent latitudinal origin of a sample toward higher or lower latitudes, depending on the original composition of a sediment assemblage. Solution also will change the aspect of the sample with respect to the original depth habitat of the Foraminifera. This is true especially for morphological variants. Any argument resting on the comparison of living planktonic faunas and their counterparts in the sediment must take these solution effects into account.

The selectivity of solution provides a tool with which the relative $CaCO_3$ undersaturation of the ocean water may be measured. In the central Atlantic, the depth at which this undersaturation increases markedly is at about 4,400 m. In the past this depth fluctuated between at least 4,500 and 4,000 m, which reflects the changing thickness of the Antarctic bottom-water layer.

Similar studies are possible for the more distant past. The bases for such studies are laboratory experiments establishing the relative solution resistance of the extinct species.

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SHELF-TO-BASIN LOWER TRIASSIC SEDIMENTS ACROSS LAS VEGAS HINGELINE, NEVADA

Lower Triassic Moenkopi (Formation of McKee, 1954; Group of Poborski, 1954) changes facies with increase in thickness from mostly nonmarine and minor marine character east of Las Vegas, Nevada, to progressively more marine character toward the west as the Las Vegas hingeline is crossed. The thickness of Moenkopi strata east of this hinge in the Rainbow Garden area (east of Frenchman Mountain) is 1,810 ft, of which about 350 ft is the marine Virgin Limestone. About 20–22 mi farther east, Moenkopi aggregates about 1,250 ft; this section contains more red-bed but less carbonate and gypsiferous facies than at Rainbow Gardens.

Outcrops west of the hinge in the expanse between Las Vegas and east Blue Diamond Mountain show a progressive increase in Moenkopi thickness, with more marine sediments; Virgin Limestone is about 500 ft thick. A much more striking change takes place west-