

retain moisture and relatively constant water conditions. The Foraminifera were fed mixed planktonic algae from cultures started at each station and sub-cultured into filtered *in situ* sea water.

Because *G. bulloides* was the most common species encountered in tows, it was predominant in the cultures. Young transparent specimens gave the best results. They commonly developed tenuous, elongate pseudopodia, measuring up to 10 times the test diameter in length, which supported the specimens in flotation for periods up to 3 months. Some specimens in culture developed into orbuline stages previously identified in the literature as *Orbulina universa* d'Orbigny. Other orbuline stages were collected in the tows. Most lived approximately 3 weeks, during which time they passed through a series of developmental stages. Changes in the morphology of the globigerinids and their orbuline phases were photographed.

Bright orange-yellow zooxanthellae were present in most of the plankton studied. They were most obvious in newly formed orbuline phases, as well as in healthy globigerinids, and appeared to be related in numbers to metabolic activity of the host organism.

Several radiolarian species from different families also were maintained floating for more than a month, and preliminary observations were made on their structures.

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N.A.S.A. LUNAR AND EARTH-ORBITAL PROGRAMS OF SPECIAL INTEREST TO EXPLORATION GEOLOGISTS AND GEOPHYSICISTS
(No abstract submitted.)

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THE COMPUTER AND THE SUBSURFACE GEOLOGIST

Much has been written pertaining to the geologist and the computer. Most research divisions in oil companies, universities, and governmental agencies are working on methods and techniques which will make it practical for the geologist to use the computer. The fact still remains, however, that only a very small percentage of subsurface geologists are using computers as a means of retrieval of data.

Management and geologic departments probably are equally at fault for the slow development in the use of the computer by geologists. The geologist, because of his lack of knowledge of how the computer will be of direct value to the exploration department, hesitates to approach management for the personnel and equipment that would be required. Management, because it is not being pressured, is willing to let the geology department function without the computer. Management should be providing trained computer personnel to the exploration departments.

Sufficient experimental, as well as practical, work has now been carried out so that there is no longer any doubt that the computer is a necessity in nearly all exploration departments. Companies which do not become computer-oriented will find it more difficult to compete, especially with the new techniques being adopted and the ever-increasing volume of data.

Methods of data acquisition and storage vary and can become complicated, depending on the volume of data stored. The geologist will not have to concern

himself with how the data are stored, but will need to have a complete knowledge as to what data are stored. The programming to retrieve data also can become highly technical; however, the geologist should concern himself more with how he will use the data than how he will retrieve it.

The geologist relies on a variety of sources for his basic information. Probably the most fundamental and important source is from the stratigraphic section. Time needed for preparing and digesting large quantities of stratigraphic data always has been a major problem for the exploration departments. A service has been in operation in Canada since January, 1964, which provides the industry with detailed processed stratigraphic data on punch cards. An outline is presented on the type of data processed, method of processing, and some of the practical applications.

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BRITISH LOWER CARBONIFEROUS CONODONT FAUNAS AND THEIR VALUE IN CORRELATION

Six hundred samples of limestone and shale from the Lower Carboniferous of southwestern England and Wales and central Scotland were processed for conodonts. The samples yielded over 25,000 identifiable specimens, referable to 170 species, representing 26 genera. Two genera, 22 species, and 12 subspecies are new.

The faunas have been divided into a succession of 16 conodont assemblage zones, which are used as a basis for correlation between standard sections in various Carboniferous provinces of Great Britain. They also make possible correlation with the successions in Germany and North America, to which faunas there is a strong general similarity. Local differences are attributed to sedimentary breaks, limited geographic distribution, and conodont phylogeny.

In the southwestern province of Britain, the greater part of the K zone is correlated with the Cu-I goniatite zone of Germany; the uppermost K, Z, and C zones with the Cu-II zone; and the C₂S₁, S₂, D₁, D₂, and lower D₃ zones with the Cu-III zone. The upper D₃ zone is of E₁ (Namurian) age.

The upper part of the Calciferous Sandstone Series of the Midland Valley of Scotland is of Cu-III α age, the Lower Limestone Group of Cu-III β/γ age, and the Upper Limestone Group of E₁/E₂ (Namurian) age.

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BASE OF PLEISTOCENE IN LOS ANGELES BASIN, CALIFORNIA

Populations of *Globigerina pachyderma* (Ehrenberg) are consistently left-coiling, cool-water types in sections of the lower Pleistocene of the Los Angeles basin, California; right-coiling, warm-water populations are predominant in the upper Pliocene. The base of the Pleistocene, defined in this way, indicates a major change in water masses of the southern California area at that time. Recent radiometric dates by Obradovich place this boundary about 3 m.y. ago.

Populations of *Globigerina pachyderma* reflect bathyal conditions generally; modern populations in

typical form live suspended deeper than about 50-100 m. Basing the beginning of the Pleistocene on planktonic foraminiferal criteria, benthic Foraminifera indicate that outer-shelf conditions prevailed at the beginning of the Pleistocene in some areas, upper-bathyal depths existed in other places, middle-bathyal depths in some areas, and lower-bathyal depths at still other locations. Thus, a boundary based on upper limits of benthic species (*Epistominella pacifica* and *Uvigerina peregrina*), and defined by comparing sections from different parts of the Los Angeles basin, differs hundreds of meters in stratigraphic position.

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LIVING PLANKTONIC FORAMINIFERA IN SOUTH ATLANTIC

The distribution of living planktonic Foraminifera from equatorial to Antarctic waters of the South Atlantic has been determined from plankton tows. Of 24 species recognized, the faunal diversity is greatest in subtropical and temperate waters and is least in the Antarctic region.

Four faunal zones were established. The tropical-subtropical fauna consists mainly of *Globigerinoides sacculifer*, *G. ruber*, *Globigerinella aequilateralis*, *Hastigerina pelagica*, *Globorotalia menardii*, and *Globigerinoides conglobatus*. Indicator species of the temperate fauna are *Globorotalia inflata*, *G. truncatulinoides*, and *G. hirsuta*. The sub-Antarctic fauna is characterized by *Globigerina bulloides*, and the Antarctic assemblages are dominated by left-coiling *Globigerina pachyderma*.

The relations between living populations and dead assemblages in bottom sediments were examined, and their implications for paleo-oceanographic interpretation are considered.

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WORLD OCCURRENCE OF PETROLEUM IN PRE-SILURIAN ROCKS

Marine sedimentary rocks of Precambrian, Cambrian, and Ordovician ages constitute a major frontier for petroleum exploration. In regions where appreciable thicknesses of such rocks exist, the distribution of test wells ranges from sparse in most Ordovician sections to virtually non-existent in Precambrian rocks. The prospects for petroleum occurrence within these strata appear to improve with decreasing age. However, the fact that the environment favorable for shelf sedimentation expanded progressively through the same space of time suggests that time is not the overriding factor and that no region of marine sedimentary rocks should be discounted simply on the basis of age.

Petroleum hydrocarbons in apparently commercial quantities are known from pre-Silurian rocks of four continents: North America, Africa, Asia, and Australia.

In Asia and Australia, pre-Silurian rocks have not been tested adequately, and production of petroleum to date is negligible. In Africa, although the presence of pre-Silurian petroleum has been established only recently, very significant production rates already have been achieved.

Approximately 94 per cent of all oil produced from

pre-Silurian rocks has come from North America, where the lower Paleozoic rocks have been important petroleum reservoirs for many years. Trillions of cubic feet of gas and an estimated 4.8 billion barrels of oil had been produced by the end of 1963 from pre-Silurian rocks of North America. The most significant area of pre-Silurian oil production is a belt occupying parts of Kansas, Oklahoma, Texas, and New Mexico, where productive beds are found in the Arbuckle, Ellenburger, and Simpson. Elsewhere in North America, the Trenton Limestone of Ohio, Indiana, and Michigan has yielded more than a half billion barrels of oil and more than a trillion cubic feet of gas.

Only in North America has the pre-Silurian section been extensively explored, and it is in North America that most of the known pre-Silurian hydrocarbon accumulations have been found. It would seem reasonable to anticipate that newly discovered petroleum from pre-Silurian rocks in Africa, Asia, and Australia will lead to intensive exploration programs and result in significant discoveries.

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GEOLOGY OF LOWER PERMIAN MINNELUSA OIL FIELDS, POWDER RIVER BASIN, WYOMING

Upper Minnelusa sandstone reservoirs of the Powder River basin produce oil from structural and unconformity traps. This sandstone probably is Wolfcampian in age and was deposited in shallow-neritic to littoral environments which characterized eastern Wyoming. Post-Wolfcampian erosion left remnants of Minnelusa sandstone beds which were covered by red shales and evaporites of younger Permian age.

Minnelusa oil fields of the northeastern Powder River basin, such as Raven Creek and Halverson, are mainly unconformity traps. Updip truncation of the Minnelusa is reflected by abrupt thickening of the overlying Opeche red shale, basal member of the Goose Egg Formation. Minnelusa fields of the western Powder River basin, such as North Fork, are largely structural traps, but post-Wolfcampian truncation may account for as much as half of the closure. In these fields Minnelusa sandstone is preserved on top of structures, and truncation on the flanks is reflected by abrupt thickening of the entire overlying Goose Egg section.

More than 100 million barrels of oil has been found in the upper Minnelusa. As productive trends are revealed by drilling, more oil will be discovered in structural, unconformity, and combination traps throughout the Powder River basin.

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PHYLOGENETIC AND TAXONOMIC PROBLEMS OF SOME TERTIARY PLANKTONIC FORAMINIFERAL LINEAGES

The basic phylogeny and classification of five major lineages of Tertiary planktonic Foraminifera are considered and several revisions are suggested. The definition of *Globorotalia* is broadened to include keeled and non-keeled forms; its range is Danian to Recent. *Globorotalia pseudobulloides* (Plummer) is interpreted to be highly polytypic and ancestral to all later Tertiary members of the Globigerinacea with