tem. The test of the experiment lies in how closely the two patterns coincide.

BRUNSTROM, R. G. W., AND P. J. WALMSLEY, British Petroleum Co. Ltd., London E.C.2, England

## PERMIAN EVAPORITES IN NORTH SEA BASIN

Thick evaporites are present in the Permian beneath the North Sea, and can be correlated with the known successions in Germany and in England. The evaporites are more widespread in the upper division (Zechstein) than in the lower (Rotliegendes). This paper deals chiefly with the Zechstein of the English side of the basin, in which four main evaporite cycles are present.

Zechstein salt movement commenced near the end of the Early Triassic when the overburden was only about 2,000 ft, and continued throughout the Mesozoic and Tertiary. Movement was earlier in the west than in the east. Salt plugs are associated particularly with the margins of a large NNW-SSE-trending trough which became fully developed during the Jurassic.

Important structural features and thickness changes in the Mesozoic and Tertiary rocks originated as a result of the salt movement, and are compensated almost entirely by salt at depth. As a result, the base of the Permian nearly is parallel, on a regional scale, with the base of the Quaternary though separated from it by about 10,000 ft of moderately complicated strata.

BUBB, JOHN N., AND DONALD K. ATWOOD, Esso Production Research Co., Houston, Tex.

RECENT DOLOMITIZATION OF PLEISTOCENE LIMESTONES
BY HYPERSALINE BRINES, GREAT INAGUA ISLAND,
BAHAMAS

Pleistocene carbonate rocks were sampled beneath a shallow saline lake on Great Inagua Island, Bahamas, to test the hypothesis of dolomitization by seepage refluxion. Commercial salt has been pro-duced in part of the lake by solar evaporation of sea water for more than 100 years; hence, the writers reasoned that brines formed might have affected the Pleistocene carbonate bedrock. The upper few inches of rock beneath salt ponds consists of fine-grained, moldic dolomite; no dolomite was found in the Pleistocene limestone marginal to the lake or in rock underlying the lake in areas away from the salt ponds. Relict structures in the moldic dolomite show that it formed by replacement of partly cemented, aragonitic, oölitic limestone identical with the underlying and adjacent Pleistocene limestone. The dolomite crystals are cryptocrystalline ( $< 5 \mu$ ) in size and have a calcium-rich composition (about Can Mg40 to CaseMgss). The dolomite is enriched in 018; measured apparent fractionation values for  $\delta 0^{18}$  between the dolomite and the aragonite and calcite of the parent oölitic limestone range from 3.8 to 4.6%. This 018 enrichment should be expected from dolomitization resulting from interaction of carbonate material with hypersaline brines formed by solar evaporation. Radiocarbon dates of the dolomite range from 2,930 to 3,420 yr B.P. These dates, older than anticipated if the dolomitization is controlled by brines formed since salt production began, may be in error because of incorporation of "old" carbon atoms from the replaced Pleistocene limestone.

CARROLL, DOROTHY, U. S. Geological Survey, Menlo Park, Calif.

CLAY MINERALS IN ARCTIC OCEAN SEA-FLOOR SEDI-MENTS\*

Sediments of the sea floor of the Alpha Rise, 500 mi north of Point Barrow, Alaska, were cored to a depth of about 3 m below the sea-sediment interface beneath Ice Island T-3, where the ocean is slightly deeper than 2,000 m. The sediments contain about 80 percent clay and silt, the remainder being fine sand. They are either gray or brownish gray in color, the brown color being caused mainly by the oxidation of ferrous monosulfide. Although organic matter seems plentiful, it is of colloidal size and amounts to about 3 percent of the sediments. The clay minerals present are mica (both muscovite and biotite), mixed-layer mica and organic matter, vermiculite, chlorite (two polytypes), together with quartz, feldspar, and, in some samples, dolomite. The predominant clay minerals are mica and mixed-layer micas. Chlorite commonly is present, but vermiculite is scarce. Dolomite appears to be authigenic, but the micas, most of the chlorite, quartz, and feldspar are detrital. The mixedlayer mica with organic matter is authigenic.

\* Authorized by the Director, U.S. Geological Survey.

COLQUHOUN, DONALD J., Dept. of Geology, University of South Carolina, Columbia, S.C.

## FAUNAL ISOLATION NEAR PRIMARY STRANDLINES\*

Faunal isolation near primary strandlines has been studied quantitatively in Miocene, Pleistocene, and Recent sedimentary units in the Carolinas and Georgia. The contact between sediments deposited in marine and continental environments is sharp in most areas. The marine sequence consists of a basal transgressive sand dipping abruptly from the contact zone and flattening seaward, about 45 ft below the interpreted maximum mean sea level. The contained megafauna consists of (1) taxa living within the sea during the transgression; (2) taxa living within landward estuaries and swamps being eroded during the transgression; and (3) taxa derived from previous stratigraphic units. At the base of the sand, (1), (2), and (3) are present, (2) and (3) comprising most of the paleobiotal assemblage. A few feet above the unconformity, (2) and (3) comprise less than 5 percent of the assemblage, but a few forms are in place. Littoral and sublittoral sand-silt gradationally overlies the basal transgressive sand seaward and upward. Microfaunal content rises from less than 1 percent (by weight) in the basal sand to 3-5 percent in the overlying sand-silt. The species consist almost entirely of calcareous shallow-marine Foraminifera.

Few pelagic forms are present. Faunal preservation progressively becomes better, and exogenic forms are rare. Overlying the sand-silt facies is bar and barrier island, generally unfossiliferous sand. Intervening areas, isolated from the open ocean, accumulate silt-clay. The fauna consists of less than 0.5 percent shallow-marine Foraminifera, abundant oyster species,

<sup>\*</sup> Support by the NSF is acknowledged.

and marine and shoreline grasses. The assemblages are controlled by tidal drainage.

Landward from the primary strandlines, inundated river valleys contain few fossils either in bed-load or floodplain deposits. Major valleys near the primary strandlines contain extensive fresh-water swamps, bearing grasses, shrubs, and herbs characteristic of Recent marsh environments together with vertebrate bones and teeth. Estuarine environments as reflected by oysters, and mixed marine and fresh-water assemblages are of minor aerial extent, and usually are buried by sediments deposited in a deltaic environment.

Considering Miocene and Pleistocene sequences up to 20 mi seaward of the primary strandline, only about 10 percent of their associated rock units were formed in continental environments. Bedload and floodplain environments are represented by less than 1 percent. Estuarine environments comprise 3–5 percent and deltaic environments about 5–7 percent. Approximately 90 percent of the associated rock units were formed in marine environments of which 20–25 percent is basal transgressive sand, 15–20 percent littoral-sublittoral sand-silt, and 45–55 percent barrier island and marsh. Considering the Recent, the continental shelf is floored by a basal transgressive sand; little sand-silt and few barrier-island-marsh sequences are present.

CRAIG, D. H., Marathon Oil Co., Littleton, Colo., AND G. R. SCHOONMAKER, Marathon Oil Co., Findlay, Ohio

YATES OIL FIELD, PECOS COUNTY, TEXAS

The Yates field, discovered in October 1926, is extraordinary in amount of oil produced, size of original oil accumulation, and well productivity. During the 41 years since discovery, it has produced more than 500 million bbl of oil. Material balance calculations, based on past performance of the Yates field reservoir, indicate an oil-in-place of between 3.7 and 4.3 billion bbl. It has been estimated that ultimate recovery from the reservoir will be betweeen 1.5 and 2 billion bbl. The Yates field reservoir, mostly dolomite, may be the largest single oil accumulation ever found in a North American carbonate. It occurs as a gentle dome with structural closure in excess of 350 ft and covers an area of about 21,700 acres. The principal marker in the reservoir is found at depths ranging from approximately 1,000 ft to about 1,900 ft. Nearly a third of the 637 wells potentialed for more than 10,000 bbl of oil per day, and 26 potentialed for volumes ranging from 80,000 to 205,000 bbl per day. Cavernous and high matrix porosity in the reservoir contributes significantly to the remarkable productivity of some wells in the field. The cavernous porosity probably is related to subaerial erosion.

Both the Yates field reservoir and its seal are of middle Permian age. The reservoir is largely marine bioclastic dolomite equivalent to the San Andres-Grayburg. It also includes sandstone approximately equivalent to the Queen, between the Grayburg and Seven Rivers anhydrite, the latter forming the reservoir seal.

The huge Yates field reservoir oil accumulation probably resulted from favorable location relative to coarse beds and regional migration routes. The trap, a local and regional structural high, adjoins basinal strata on two sides and is situated at the southern tip of the northward-tilted Central Basin platform.

CUTBILL, JOHN L., Dept. of Geology, Sedgwick Museum, Cambridge, England

TECHNICAL AND THEORETICAL OBSTACLES TO CON-STRUCTION OF ADEQUATE CLASSIFICATION OF FUSU-LINID FORAMINIFERA

Progress in the classification of fusulinid Foraminifera is hampered by difficulties of access to the original observations on which the numerous taxa are based. An estimate has been made of the work involved to collect a suitable new data base for a classification of the whole group.

A reasonably full description of a single fusulinid test needs serial sections and involves about 800 measurements and about 40 descriptive terms. A satisfactory classification could be based on morphological information from approximately 50,000 individuals taken from 500 rock samples. A data base for determining the stratigraphical distribution of taxa would need information from an additional 100,000 individuals from about 50 major stratigraphical sequences. In all, 150,000 individuals must be serial sectioned and more than 100,000,000 measurements made.

Using available techniques for the serial sectioning of rocks to 250-micron intervals and for semiauto-matic measurement of morphological features, it would be possible to collect the data in about 40 man-years of laboratory work. Spread through a 5-yr period this is well within the resources now deployed on the study of fusulines. The outstanding obstacles are the coordination of the collection and communication of the data, and the obtaining of some measure of agreement on what to collect. However, it is not necessary to decide on a method of constructing a classification before making the observations. Indeed if such a large data base was available readily, a classification in the conventional sense would no longer be needed for many purposes. Moreover the data-processing system which would be necessary to manage the data also would enable multiple classifications to be maintained should this be necessary.

DAVIES, DAVID K., Dept. of Geology, Texas A & M University, College Station, Texas

Selective Dispersal of Quartz

Polycrystalline, undulatory, and nonundulatory quartz extinction varieties are characterized during transport by differing degrees of resistance to degradation. Polycrystalline quartz, the most unstable variety, is the first to be broken down and, in the examples discussed, is not modified significantly during transport. Undulatory quartz is being reduced continually in size during transport, and within a particular grain size there will be a concomitant enrichment in the more resistant nonundulatory variety.

Such a selectivity in the dispersal of quartz extinction types characterizes Pleistocene sediments of the Mississippi cone and Sigsbee Deep of the Gulf of Mexico. Proximal to input source (the Mississippi) the sediments have 8 percent less nonundulatory quartz than distal sediments on the western edge of the Sigsbee Deep. This variation is attributed to the differing degree of resistance to degradation of each of the monocrystalline quartz varieties. The westerly increase in nonundulatory quartz is not, however, a simple linear trend. Within the grain-size limits of this study  $(74-37\mu)$ , there is no marked enrichment of nonundulatory quartz along the whole of the Missis-