with taxonomy and occurrence of fossil foraminifers. About 30,000 species of foraminifers have been recognized and described in the literature, and the present rate of publication is approximately 1,000 papers/year. Not only is the volume of publication overwhelming, but also the entire field of foraminiferal study is changing dynamically as new data modify old conclusions and change taxonomic concepts.

The Western Interior Foraminiferal Project was established at Colorado School of Mines to compile selected data concerning Cretaceous foraminifers of the western interior region of the United States and Canada in order to provide an accessible information base on which future research may be built. Information relating to species described, synonyms, geographic occurrence, and stratigraphic occurrence has been abstracted from all papers published through 1968. A printed bibliography with annotations on species occurrence is planned. The abstracted data also have been compiled into an information bank which will be available for computer research workers. The compilation of such a data bank will not eliminate all of the problems of voluminous literature and changing concepts, but will aid research by providing rapid and complete automated search of the literature.

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WORLDWIDE DEVELOPMENT IN EXPLORATION FIELD

Current trends of exploration and development activity in the world's sedimentary basins reveal a major success in Alaska, important discoveries in South America and the Middle East, and increasing activity in the Canadian Arctic. A large proportion of the newer exploration activity is offshore; operations off the North American coasts are at an early stage; exploration continues at a slower tempo than previously on the shelves of northwestern Europe; and activity around Africa, in the Indonesian region, and around the Australian coast is steady. A major discovery in New Zealand is being followed up, and interest is spreading into the Pacific islands.

Exploration in these widespread areas will continue for many years, but sufficient work already has been completed to indicate that (1) offshore basins are as variable in their potential as those onshore, and (2) offshore exploration provides no automatic guarantee of discovering major reserves.

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BORDEN DELTA (LOWER MISSISSIPPIAN) IN NORTH-CENTRAL KENTUCKY

The Borden Formation in north-central Kentucky consists of 4 widespread units—a basal clay shale, a middle siltstone and silty shale, a glauconite-rich marker bed, and an upper siliceous silty carbonate. The lower 2 units are a clastic deltaic wedge, the upper limit of which is defined by the marker bed. The wedge thins gradually westward at a few feet per mile to the vicinity of Elizabethtown, where it was found by areal geologic mapping to pinch abruptly from 260 to 50 ft southwestward across a zone about 2 mi wide. This more steeply sloping surface represents the clinoform or foreset front of the Borden delta.

Recognition of this part of the fossil delta is an important adjunct to reconstructing the Late Devonian and Early Mississippian geography of the Illinois basin. Within this framework, several extrapolations are possible: (1) time planes within the delta parallel the delta front; (2) the water into which the delta prograded was at least 200 ft deep in this area; (3) the basal clay shale represents prodelta fondoform sediments; (4) the middle siltstone and silty shale represent the clinoform sediments of the delta proper; and (5) the upper silty carbonate represents resumption of sedimentation under somewhat different conditions following a period characterized by thin glauconite-rich sediment of possible nondeltaic origin.

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IMPORTANCE OF CONTINENTAL DRIFT TO PETROLEUM EXPLORATION

Continental drift is no longer academic, but is important to the oil business as exploration moves increasingly to offshore areas and to remote parts of the world. This field of study meets 2 requirements of petroleum geology: it explains certain known situations, and predicts others that are yet unknown.

Certain features of the Atlantic continental margin are clarified when the evolution of that ocean is understood. Predictions then can be made about the ages of rock and kinds of structures to be expected beneath other parts of the North Atlantic continental shelves.

Integration of submarine and terrestrial geology helps to clarify the relations between geologic features of the marine and continental realms. Examples of areas where integration of submarine and terrestrial geology is possible, are in Arctic Canada, where continental drift is in an arrested stage of development.

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GEOCHEMISTRY, MINERALOGY, AND OCCURRENCE OF CALCIUM SULFATE MINERALS

The subsurface distribution of gypsum and anhydrite, the lack of subsurface bassanite, and variations in trace-element ratios between mineral phases confirm experimentally determined stability relations and indicate that the replacement of one mineral phase by another proceeds by a dissolution-reprecipitation process. The earth surface occurrence of calcium sulfate minerals indicates that long-lived metastability is almost the rule and that in many situations kinetic factors dominate over equilibrium controls. In a standing body of brine, gypsum apparently is the only phase precipitated, either at the brine-air interface with elongate growth forms indicative of rapid rate of crystal growth, or at the brine-sediment interface, commonly as cemented layers of discs with their *c* crystallographic axes almost horizontal. Significant anhydrite deposits are known today only from the warmer salt-flat or sabkha environments of the Persian Gulf and Baja California, precipitated interstitially within host sediments as an early diagenetic mineral. The anhydrite is present as contorted layers and nodules, commonly with a felted lath texture. These structures, textures, and other associations are characteristic of anhydrite occurrences.

Experimental studies and Holocene gypsum and anhydrite occurrences provide the information needed to determine which mineral was formed first in a particular situation. Where gypsum is the mineral buried, when and at what depth did it dehydrate, in which direction did the large volumes of dehydration water move, and what diagenetic effects did this dehydration water have on adjacent rocks and pore fluids? Where

anhydrite is the mineral buried, when did it lose its large primary porosity, and has it recrystallized since initial formation? By (1) defining the first-formed mineral and its structures, textures, and chemical composition and (2) making analogous studies of ancient subsurface calcium sulfate minerals, we can, hopefully, answer some of these questions.

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FIBROUS ARAGONITE IN SEALED PLIOCENE *Glycymeris yessoensis*: POSTMORTEM

About 300 jointed bivalves of *Glycymeris yessoensis* were collected from a lenticle of an almost unispecific shell bed in the Onma Formation, central Japan. Most of the valves were partly open and completely infilled with the surrounding sandy silt; 5 were sealed and contained only a small amount of aragonite-cemented siltstone. The void in the chamber of the sealed valves is occupied with acicular needles of aragonite overgrown on the inner surface of the valves and on the surface of parasitic boreholes within the shells. The fibrous aragonite on the inner surface of the shells is in optical continuity with the aragonite crystals at both inner and outer structural layers. The fibrous aragonite indicates strong depletion of O^{18} and slight depletion of C^{13} compared with the shell. A cold to temperate open sea comparable with that off the western coast of Hokkaido at present is zoogeographically indicated for the Onma molluscan fauna. These isotopic depletions differ from that of aragonite cement generally found in grapestone clusters, reef rocks, and beachrocks, all of which are typically tropical. The textural evidence suggests that precipitation of the aragonite postdated the partial infilling by sediments, but took place when the sediments were plastic; hence a freshwater origin of the aragonite is excluded. A plausible interpretation is aragonitic growth from a solution trapped and warmed within the chamber during an early stage of fossilization. Aragonite cementation may occur in a localized space such as a shell chamber in nontropical seawater.

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MORPHOLOGY AND VERTICAL SEDIMENTARY SEQUENCES IN HOLOCENE TRANSGRESSIVE SAND BARRIERS

Studies of the barrier ridges and beaches along the presently transgressing mid-Atlantic coastal area have been used to formulate morphologic and vertical sequence models for transgressive beaches. Each type of barrier is a response to the topography being inundated in the ongoing transgression as well as to wave and current conditions. Four major types of sand-gravel barriers may be identified in coastal Delaware: (1) bay-mouth barriers, (2) beach against highlands, (3) estuarine barriers, and (4) spit complex.

The bay-mouth barriers, between enclosed lagoons and the open Atlantic Ocean, are characterized by a vertical transgressive sequence of sedimentary environments identical with the horizontal sequence in the direction of the transgression. In the beach against highland barrier, beach-bern system impinges on low-lying Pleistocene highlands (20–30 ft) which are being eroded and provide a partial source of sediment to the beach system. Estuarine barriers occur as long arcuate shorelines of large estuaries such as Delaware Bay. A barrier of sand and gravel is formed with small width (30 ft) and thickness (< 10 ft) but extreme length (50–75 mi). The internal structure of these thin but extremely long sand barriers is complex and mainly comprised of washover features. A modified version of the estuarine barriers is found in places near the leading edge of transgression on the landward shorelines of lagoons. The spit complex intrudes into the open marine and bay area. The spit-dune-barrier-marsh tract includes all of the expected coastal environment sediments of a normal barrier-lagoonal area in addition to typical spit-accretion sand and gravel. However, vertical sequences are disrupted and not in order.

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GEOCHEMISTRY AND DEPOSITION OF LOWER SALINA GROUP, SOUTHWESTERN ONTARIO AND MICHIGAN

Calcite, dolomite, insoluble residue, and clay minerals of lower Salina (A_1 and A_2) and upper Niagaran rocks of southwestern Ontario and Michigan were analyzed. Analysis of variance, trend surface analysis, and factor analysis were carried out on the above constituents, as well as on color and oil and gas production. Dark units contain more carbonate and calcite than light units. Light units contain more dolomite than dark units. Dark units typically contain a 13.4 Å clay, whereas light units more typically contain a 10.8 and 9.4 Å clay. Light units are associated with proposed marine outlets from the Salina basin. Light/[dark + light] ratios show very good correlation with reported oil and/or gas production. Dark carbonate units (suggesting a restricted lagoon) lie behind (east of) the known reef arc. High-dolomite-content light units may be related in origin to a shallow-water, subaerial environment currently termed "supratidal."

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DEVONIAN CARBONATE COMPLEXES OF CENTRAL EUROPE

The carbonate complexes in the Rhenish trough of the Variscan geosyncline (central Europe) range from late Givetian to early Frasnian and are restricted to the external and internal shelves and isolated submarine volcanic rises. On the western part of the external shelf (southeast margin of the Old Red continent), the carbonates form a widespread shelf-lagoon facies on deltalike clastic deposits (Belgium, Aachen, Eifel); in the eastern part they are isolated reef complexes and shelf-margin reefs on locally higher exposed platforms (Bergisches Land, Sauerland). On the internal shelf (northwest margin of the "Mitteldeutsche Schwell") the carbonates overlie crystalline rocks (borehole Sarr 1) or clastic Devonian strata (Giessen). The Middle to Upper Devonian carbonates generally are 350–400 m thick, and at Balve (Sauerland) they are more than 1,000 m. In the internal part of the trough the carbonates form isolated submarine volcanic rises on submarine ophiolites (Lahn-Dill syncline, Elbingerode in the Harz Mountains).

Carbonate sedimentation starts everywhere with a widespread carbonate bank (Schwelm facies). This bank is the foundation for the subsequent younger true reefs. The well-bedded bank carbonates are commonly dark and fine grained. The potential reef builders—stromatoporoids and tabulate and rugose corals—built flat, widespread biostromal structures in a muddy environment rather than wave-resistant structures. Within the bank, 8 subfacies can be distinguished.

Overlying the bank, isolated and locally restricted true reefs (Dorp facies) show mostly atoll-like features. At the western margin of the Old Red continent