CHILINGAR, GEORGE V., RIEKE, HERMAN H., III, and OLSON, ELDON K., University of Southern California, Los Angeles, California

HIGH-PRESSURE COMPACTION STUDIES AND CHEMISTRY OF SOLUTIONS SQUEEZED OUT OF MUDS AT DIFFERENT STAGES OF COMPACTION

Remaining moisture content (% dry basis) was determined for various clays (montmorillonite, hectorite, illite, kaolinite, dickite, halloysite), marine mud, and soil samples and plotted versus the logarithm of pressure (up to 500,000 psi.). The straight-line relation at pressures above 40–1,000 psi. (depending on type of clay) suggests that compaction is more or less a simple continuous process in the pressure range studied. The resistance to compression apparently increases with higher packing density and more strongly coalesced structures. Most of the water is squeezed out during a relatively short period of time (1–4 days), and equilibrium is reached after about 7–60 days (depending on type of clay). The calculated (from water loss) permeability of clay at high overburden pressures (15,000–400,000 psi.) is in the order of 10^{-10}–10^{-13} darcys, values characteristic of nearly impervious soils. Consequently, compaction appears not to be limited by low permeability, but rather by resistance to grain deformation.

The salinity of squeezed-out solutions (using fresh marine mud, various types of clay, and sea water) progressively decreases with increase in overburden pressure. Consequently, mineralization of interstitial solutions in shale should be less than that of waters in associated sandstone. Reliable results in determining the chemistry of interstitial solutions of marine mud require that nearly all fluid be squeezed from each sample and require pressures in the 150,000–400,000 psi. range.

Experiments concerning X-ray analysis of compacted clay for deciphering the magnitude of overburden pressure were inconclusive.

COLLINSON, CHARLES, Illinois State Geological Survey, Urbana, Illinois, and DRUCE, E. C., Bureau of Mineral Resources, Canberra, Australia

UPPER SILURIAN CONODONTS FROM WELSH BORDERLAND

In recent years, correlation of the Silurian-Devonian boundary from its type section with areas outside Britain has been the subject of considerable discussion accompanied by some opinion favoring transfer of the Silurian standard to the European mainland. Difficulty arises partly because the boundary in Britain is placed at a pronounced facies change and partly because zonal graptolites, which are widely used to correlate the Silurian in continental Europe and elsewhere, occur in Britain no higher than the middle of the Ludlow. A most significant advance toward clarifying the situation was made in 1964 by Walliser, who published a detailed conodont zonal succession from the Silurian of the Carnic Alps of Austria and related it to the standard graptolite zones in Bohemia and Germany.

In 1963, the authors collected 50 pounds of calcareous siltstone from the upper part of the Whitcliffe Flags at Diddlebury, 6 miles north of Ludlow in Shropshire, and acidized it in order to recover the conodonts present. The 850 specimens that were extracted clearly refer the fauna to Walliser's uppermost Silurian conodont zone, the *eosteinhornensis* zone. This reference indicates that the top of the Ludlovian Series correlates essentially with the top of the Bohemian Budňany (E-beta-two) and implies that the Ludlow and Budňany are approximately equivalent. In terms of graptolite zones, the Silurian-Devonian boundary should occur at the base of the *Monograptus uniformis* zone inasmuch as it marks the upper limit of Walliser's *eosteinhornensis* zone. Walliser, who has studied *eosteinhornensis*-zone conodonts from other localities in Britain, proposes that the Silurian-Devonian boundary in continental Europe be fixed by the earliest occurrence of *Monograptus uniformis*. In this context, the Skala Formation of Podolia (Russia) is essentially late Ludlovian in age as are the Calcaire de Liévin of northern France and the Untere Steinhorn-Schichten of the German Kellerwald.

CONANT, LOUIS C., U. S. Geological Survey, Washington, D.C., and GOUDARZI, GUS H., U. S. Geological Survey, Owensboro, Kentucky

STRATIGRAPHIC AND TECTONIC FRAMEWORK OF LIBYA

Libya is situated on the unstable Mediterranean foreland of the African shield. Marine strata of Paleozoic, Mesozoic, and Cenozoic ages abound in northern Libya, but continental rocks of Paleozoic and Mesozoic ages predominate in southern Libya. Several marine incursions, mainly in Silurian, Middle Devonian, Carboniferous, Late Cretaceous, and Eocene times, reached far into the country, some crossing the southern border.

Compression folds are almost wholly absent; however, uplift, subsidence, block faulting, and tilting have occurred, and angular and parallel unconformities are common. The major diastrophic disturbances include the Caledonian and Hercynian, as well as disturbances during Late Cretaceous and Oligocene through Miocene or Recent times.

The chief regional structures are the Gefara-Gabese basin, Hamada basin, Gargaf arch, Marzuk basin, Tibesti-Haruj uplift, Kufra basin, north Cyrenaican uplift, and Sirte basin. Several large flows and intrusions of Cenozoic basalt and phonolite are present. Sand and gravel conceal the bedrock in about a third of the country.

In the Sirte basin, marine sedimentation, differential compaction, reef development, subsidence, and block faulting, beginning in Late Cretaceous time, favored the development of source and reservoir rocks. Recoverable oil has been found chiefly in limestone and sandstone of Late Cretaceous and Tertiary ages, but also is reported in some knobs of lower Paleozoic sandstone and fractured Precambrian granite. In the Hamada basin, many oil accumulations have been found in sandstone beds of several Paleozoic systems. Most or all of the oil discovered to date probably is in anticlinal structures, but accumulations may exist in other types of traps.

CONOLLY, JOHN R., Louisiana State University, Baton Rouge, Louisiana, and EWING, MAURICE, Lamont Geological Observatory, Palisades, New York

MODERN GRADED BEDS AND TURBIDITY CURRENTS: CASE HISTORY

Modern turbidity-current deposits are well known from the deep sea but, in most areas, core control is insufficient to establish correlation between individual graded beds. Color, texture, and composition of beds in 10 cores, 3–10 m. thick, from the floor of the Puerto Rico trench form the basis for correlation of graded beds from several millimeters to 7 m. thick over distances of 200 miles. The largest unit is 2–7 m. thick and covers an area of approximately 4,000 square miles. Variations in bottom topography and sediment properties show that the layers were deposited by turbidity currents originating near the Puerto Rico-Virgin Islands shelf. These currents flowed through numerous canyons northwestward down a high-level abyssal plain and into the lower main trench plain where they spread laterally. In at least two places the turbidity currents were powerful enough to deposit 20–50 cm. of fine sand 60 miles away from and 30 feet higher than the place near which they entered the main trench floor. There is a general decrease in the grain-size of the coarsest detritus as well as the thickness of the basal sandy section in each graded bed down the high-level abyssal plain, into and along the trench floor. Thick beds of homogeneous clay, commonly burrowed in the uppermost 10–20 cm. of the beds, make up most of the graded beds in the deepest part of the lower trench floor. The basal sections of most graded units consist of layers of graded or laminated sand whose modal grain-size decreases upward within each graded bed. Cross-stratified fine sand occurs mainly at the base of the graded beds at the distal margins of the lower trench floor.

CRAIG, R. W., Pan American Petroleum Corporation, Anchorage, Alaska

Alaska, New Frontier for Oil

Effective exploration in a frontier such as Alaska is not a result of happenstance or luck. A careful geologic and economic evaluation is a prerequisite in any new frontier. The decision of an aggressive management to explore actively the potential of the area and to commit qualified, experienced, geological and geophysical personnel well versed in the modern integrated techniques of exploration is essential to a successful exploration program.

The explorationist must be versatile and adaptable to operations in an area of excessive costs, where exploration is completely dependent on climatic conditions, and where transportation facilities are poor to non-existent. These conditions are a challenge to the most competent explorationist, even with all the modern exploration techniques at his command. The most modern techniques are needed in Alaska.

CRONEIS, CAREY, Rice University, Houston, Texas, and RESO, ANTHONY, Tenneco Oil Company, Houston, Texas

Physical and Biological Evidence for Major Mid-Cretaceous Stratigraphic Break

A sequence of essentially worldwide, major diastrophic episodes, which had a considerable influence on biological events, occurred during or near mid-Cretaceous time. Mountain ranges were built and a concurrent 95–105-million-year-old episode of granitization is confirmed by accumulated radiogenic data. There is also evidence of widespread withdrawal of seas at or near the end of the Early Cretaceous. Late Early Cretaceous and initial Late Cretaceous times were characterized by diastrophic events, which resulted in the deposition of clastic facies and in the formation of unconformities of different magnitude, the magnitude depending on proximity of the areas involved to mobile belts. Moreover, the Cenomanian or basal Late Cretaceous sediments widely overlap Early Cretaceous beds, or the rocks of older systems, in many geographic locations. A major biological "crisis" also occurred during an interval which may be considered to include Albian-Cenomanian time. The paleontologic record indicates that the resultant biological changes are as significant as those which distinguish most other systemic boundaries. Thus the physical and biological evidence generally suggests that, according to classical concepts, the more than 70-million-year-long Cretaceous time interval should be regarded as comprising two periods.

Significant biological changes (*i.e.*, those involving the higher taxonomic categories) tend to occur at or near system boundaries. Such worldwide organic "crises" probably are caused by major diastrophic episodes which alter environments faster than highly specialized groups in the lower evolutionary categories can adapt to them. The primitive representatives of highly evolved organisms then invade and occupy the vacated ecological niches. The importance of mass extinctions resulting in conspicuous paleontological breaks between periods or eras probably has been overemphasized, compared with the importance of newly introduced and rapidly expanding types of plants and animals.

The mid-Cretaceous paleontological break is expressed in several ways. For example, among the higher taxa which were present but greatly restricted during the Early Cretaceous, and which are marked by population explosion in the Late Cretaceous, are the planktonic Foraminifera, pelagic crinoids, and angiosperms. Groups which were present in some abundance in the Early Cretaceous, but which expanded in the Late Cretaceous, are teleostei fish, bryozoans, and pulmonate gastropods. Significant declines occurred, however, in the abundance of ammonites, stromatoporoids, and sponges. Both extinctions and introductions occurred, for example, among the heterodont pelecypods, scleractinian coelenterates, opisthobranch gastropods, ostracods, and red algae. Examples of introductions during the Late Cretaceous include the ceratopsian dinosaurs, and the octopi and baculitids among the cephalopods.

The accumulating physical and biological evidence for a major mid-Cretaceous stratigraphic break, detailed in this paper, is more noteworthy than has commonly been appreciated in recent years.

DAVIS, RICHARD A., JR., Western Michigan University, Kalamazoo, Michigan

Ordovician Algal Stromatolites in Upper Mississippi Valley

Algal stromatolites locally comprise as much as half of the Willow River Dolomite (Prairie du Chien Group) in the upper Mississippi Valley. They exhibit two basic forms: mounds which may range up to 4 feet in diameter and mats which may be extensive. Laminations in both range from one to several millimeters in thickness and exhibit a variety of textures and compositions in thin section.

The structure of the mounds is distinctive in that the laminations are irregular and non-parallel. Thin sections show them to consist of fine silt-size dolomite debris and recrystallized micrite, and significant quantities of coarse debris including biogenic sand-size material and large pieces of shell material. Small spherical pellets are rare. Most samples contain some