environments. Subsidence was generally at the same rate as sedimentation, and all sediments were deposited near sea level. The shoreline fluctuated greatly in the eastern clastic province but shifted little in the western carbonate region after the Early Cretaceous transgression. Deltas were constructed in several segments of the Gulf Coast during earliest Cretaceous, and in the central and eastern regions during several later regressive intervals.

The tectonic-sedimentation history of the Gulf Coast Lower Cretaceous was optimum for the development and preservation of abundant organic matter adjacent to deltaic sandstone and porous carbonate rocks, creating favorable conditions for petroleum occurrence.

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NEW GEOLOGIC MAP OF UNITED STATES—PROCEDURES AND TECHNIQUES USED IN AAPG GEOLOGICAL HIGHWAY MAP PROJECT

One of the AAPG projects is the preparation of a new Geological Map of the United States with a superimposed highway network. The map, on a scale of 1: 1,875,000, will include the 48 conterminous states. It is being published in 11 parts, each covering a region of approximately 270,000 sq mi, printed on a 28 × 36-in. sheet.

Six regional maps have been published and the remaining 5 are 25–75% complete. A new base map has been prepared from information furnished by the USGS. Information from the USGS, the various state geological surveys, and other sources is synthesized to produce the various elements on the map.

Approximately 50 overlays are prepared for the front side of each regional map. Good registry is achieved by use of a pin registry system. About 50 colors are used on each regional map; over 100 colors will be used in the series. The maps are printed on a 4-color press.

Upon completion of the series AAPG will have (1) a geologic map of the United States; (2) about 50 related columnar sections; (3) a geologic cross section network of about 19,000 mi in length; (4) a set of paleogeographic maps of the United States by epochs showing deposition, uplift, and igneous activity; and (5) a subjective tectonic map of the United States.

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TECTONICS AND SEDIMENTATION IN RELATION TO OCCURRENCE OF PROLIFIC CRETACEOUS OIL FIELDS

Many large new discoveries of oil and gas during the past few years have been made in Cretaceous strata. These fields occur in many parts of the world and have very similar reservoir and entrapment characteristics.

The worldwide orogeny near the end of the Early Cretaceous produced sharp uplifts, folding, epeirogenic warps, and a general marine regression to create a complicated paleogeography. Subsidence along shelf edges allowed accelerated reef growth, evaporites were deposited in the marginal supratidal sabkhas, and sandstones derived from granitic terrane or reworked from newly uplifted older strata were widely distributed. These features were subjected to erosion in many areas and then rapidly overlapped by the widespread Albian to early Late Cretaceous marine transgression which created 4 types of traps in which Cretaceous oil and gas accumulated: (1) Lower Cretaceous sandstone overlain by upper Lower Cretaceous evaporites (Cabinda B field, offshore west Africa), (2) upper Lower Cretaceous shelf carbonates (offshore Iran and southern Persian Gulf), (3) upper Lower Cretaceous or lower Upper Cretaceous deltaic and littoral sandstones overlain by deeper water marine shale (Bell Creek, Montana; Oriente Plain, Ecuador-Colombia; Western Desert, Egypt; Barrow Island, Australia; Tyumen Province, western Siberia), and (4) folded and eroded oil-producing Triassic, Jurassic, and Lower Cretaceous beds unconformably overlain by Albian to Upper Cretaceous strata (northern Alaska).

The late Early Cretaceous tectonic history indicates that numerous large petroleum accumulations in Lower Cretaceous to Cenomanian strata await discovery throughout the world.

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ORGANIC INFLUENCES ON CARBONATE CEMENTATION

The influence of organic matrices in the secretion of polymorphs of calcium carbonate by mollusks is well known. Recent work on the ultrastructure of coralline algae indicates that an organic matrix also must be involved in the secretion of high-Mg calcite by these plants. The matrices of coralline algae are on a much lower level of organization than the matrices of the mollusks.

Two genera of coralline algae have been studied using the scanning electron microscope. The genus *Lithophyllum* is characterized by a smooth lamellar ultrastructure which is parallel with the growth surface. The genus *Goniolithon* displays a rough lamellar ultrastructure in which the lamellae are parallel with the cell walls and consist of randomly oriented, blunt prisms of calcite.

It is known that organic molecules in solution are adsorbed onto mineral surfaces. Such adsorbed molecules could act as simple organic matrices and control the mineralogy of so-called "inorganic cements." Experiments have been conducted using completely inorganic chemical systems and systems of mixed organic and inorganic solutions. These experiments indicate that the presence of organic molecules in the system does exert a definite influence upon the mineralogy of the precipitated cements. Both calcite and aragonite cements have been produced in the laboratory under ambient temperatures and pressures.

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WATER CONTENT, VOID RATIO, AND SPECIFIC GRAVITY CALCULABLE FROM BULK DENSITY MEASUREMENTS OF COHESIVE MARINE SEDIMENTS

Bulk density is a property of importance in the study of consolidation and other geotechnical aspects of marine and freshwater sediments. It is readily measured by weight/volume or nuclear methods. In addition, several other important geotechnical properties may be computed from the measurement of bulk density.

An empirical relation exists between bulk density (γ) and water content (w) for water-saturated marine sediments. A polynomial expression has been calculated by regression techniques to fit measurements of these parameters on over 1,500 samples of cohesive marine sediments collected from the Atlantic and Pacific oceans and from other areas. The equation is

$$\gamma = 2.232 - 0.0129w + 0.000064w^2.$$

The range of water contents covered by the measurements is from 30 to 240% by dry weight, and the range of bulk densities from 1.25 g/cm³ to 1.95 g/cm³. Using this equation, the water content can be calculated, with a standard deviation of 2.3, from a measured bulk density.

It also is possible to calculate specific gravity of solids (G) and void ratio (e) directly from water content and bulk density for water-saturated sediments. The relationships are:

$$G = \frac{100\gamma}{(100 + w - w\gamma)\rho_t}$$

and

$$e = \frac{w\gamma}{(100 + w - w\gamma)\rho_t^2},$$

where ρ_t is the density of pore water at temperature t. The use of these relations may save appreciable time by eliminating or reducing the quantity of laboratory measurements made on sediment cores by geologists and soils engineers. The study of consolidation by the use of sedimentation-compression (e log p') diagrams may also be greatly facilitated when using nuclear methods of measuring bulk density and deriving water content from these measurements.

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Environmental Quality Control and Minerals

In the past several years protection of the environment has become a major factor affecting the production, transportation, and utilization of all types of mineral commodities. Examples of its effects are found throughout the minerals industry. Zoning restrictions and public pressures are barring the production of industrial minerals from some of the most favorable sites; proposals have been made to prohibit further offshore drilling for oil and gas; and strip mining of coal has been prohibited in steep terrain. Concern for environmental damage is delaying construction of the Trans-Alaska Pipeline System and the availability of an important new source of crude oil. Air quality controls that have been proposed or placed in effect are of such a nature as to eliminate the use of much of the coal and residual oil now being consumed and ban the use of lead in gasoline as an antiknock additive.

The steady increase in the number and scope of environmental regulations will have widespread effects. They will affect the availability of resources and change the methods and sources of mineral production, which will result in shifts in the patterns of mineral consumption and, inevitably, increased costs to the consumer.

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Stratigraphic Trap Classification

A trap for hydrocarbons requires the simultaneous existence of (a) a reservoir, (b) an isolated region of low potential in the reservoir, and (c) a barrier (or seal) having high enough entry pressure to retain a commercially producible volume of hydrocarbons. Three kinds of traps may exist—structural, stratigraphic, and hydrodynamic. All 3 kinds have a reservoir bounded by a barrier, but differ in the cause of the isolated area of low potential. In classifying hydrocarbon accumulations, the conditions that determined the present location of the accumulation should be used where these conditions can be determined.

In the stratigraphic trap classification suggested here, primary emphasis is placed on usability; i.e., will the groupings help in searching for new hydrocarbon accumulations and is the suggested terminology simple and descriptive enough to be accepted? A classification using the time relations between barrier and reservoir was considered but rejected.

The suggested classification begins with the simple concept that stratigraphic traps are adjacent to unconformities or they are not. For traps that are not adjacent to unconformities, the reservoir and barrier may either be (I) primary (depositional, and usually facies related) or (II) wholly or in part secondary (diagenetic). Those traps in contact with unconformities may either be (III) below the unconformity surface or (IV) above it. This approach uses some but not all of Levorsen's ideas and eliminates some inconsistencies in his classification. These 4 major classes (facies, diagenetic, below unconformities, and above unconformities) can be subdivided with appropriate terminology to identify the different types.

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Origin of Coloration in Upper Devonian Catskill Facies, New York

Mineralogic and chemical studies of interbedded red and greenish-gray sandstone, siltstone, and mudstone from the Upper Devonian Catskill facies in New York indicate that the red coloration is a result of the presence of diagenetic red hematite pigment. Thin sections of red sandstones show hematite partly replacing rock fragments composed of fine-grained mica and chlorite, as well as coating sand grains and forming patchy interstitial matrix material. Hematite is absent at many sand-grain contacts in red rocks.

X-ray diffraction studies of powdered rock samples and oriented clay aggregates show that the greenish-gray rocks are illite poor and chlorite rich relative to interbedded red rocks. X-ray diffraction intensity data indicate that chlorite is more iron rich in green or drab rocks. There is no significant difference in the total iron content of interbedded red and greenish-gray rocks; however, small green patches in otherwise red rocks have significantly lower amounts of total iron than do the surrounding redbeds.

Iron-bearing opaque minerals are present in very small amounts in both red and greenish-gray rocks suggesting that iron precipitated as hematite was not derived from these minerals.

These results suggest that hematite in these redbeds has formed diagenetically under near-surface oxidizing conditions, largely controlled by the level of the groundwater table. Chlorite is believed to be the major source of the iron that has been precipitated as hematite. Except for localized green patches where reducing conditions prevailed because of the presence of organic matter, the greenish gray rocks are believed to be composed of detrital sediments that have undergone little alteration.