teria to stabilize vast layers of metal sulfides, the feasibility of which has been experimentally demonstrated by Baas Becking.

(c) *Epidiagenesis* (writer's term) is the "meteoric phase," during which tectonic emergence of the basin occurs. The ascending waters (of high pH) are replaced by or mixed with descending CO_2^- and oxygen-rich waters of meteoric origin (pH7, or even less when they drain from some lakes and streams). Pyrites commonly are oxidized, and the liberated iron forms Liesegang diffusion rings throughout porous rocks like sandstone, or along the joint planes of impervious types. Limestone develops karst features. Calcitic fossils that escaped syndiagenetic destruction may now be reduced to hollow casts.

Continental-shelf sediments under eustatic oscillations may pass through several epidiagenetic interludes before anadiagenesis, this leading to early lithification of carbonate layers. In a thick rock sequence containing several unconformities, multiple incidences of anadiagenesis and epidiagenesis are expected.

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Applied Carbonate Petroleum Geology Symposium: Introduction

The 1966 A.A.P.G. Research Symposium is entitled "Applied Carbonate Petroleum Geology." It consists of papers that deal with salient aspects of carbonate-rock analysis methods which can be applied clearly and readily to petroleum exploration and development. The main purpose of this symposium is to reduce much of the highly specialized, advanced work that has been accomplished over the past decade, in both methods of analysis and interpretation, into essentials meaningful to the geologist engaged in day-to-day activities of petroleum exploration and development. This includes such subjects as: petrophysics, paleoecology, petrography, geochemistry, geostatistics, simulation of depositional processes, carbonate-rock nomenclature, paleogeologic and lithofacies analyses, and area case histories.

Throughout the symposium the central theme is methods of analysis and resulting geological interpretations. Wherever possible, the occurrence of petroleum is correlated with the geological aspects discussed.

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Astronaut Training Program in Geology and Geophysics

The geologic training program for the first 29 astronauts began in February, 1964, and has consisted of four phases. The first phase emphasized training in the principles of geology, geophysics, mineralogy, and petrology. Phase II was designed to provide extensive experience in a wide spectrum of terrestrial geology having lunar application, with particular emphasis on volcanic and impact geology. Phase III emphasized training in carrying out terrestrial geologic mapping, geophysical studies, and sampling procedures. Phase IV is presently underway, and consists of terrestrial simulations of Apollo missions.

In all phases of the training program, field work has been heavily emphasized. The field trips have been to classic geologic localities and have been led by recognized experts on each area. The first three phases of the training included 14 field trips totaling 41 days in the field, in addition to 135 hours of classroom instruction.

The operation of the training course has been a cooperative effort of the Astrogeology Branch of the U.S.G.S. and the Lunar Surface Technology Branch of the Manned Spacecraft Center of N.A.S.A.

A complete geology classroom has been set up at the Manned Spacecraft Center including most of the teaching aids and equipment available in the average modern geology department.

The astronauts have strong backgrounds in the physical sciences and have proved to be excellent students. With the intensive and specialized training that they have received, they will provide the scientific community with uniquely qualified representatives for early lunar exploration.

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Foraminiferal Paleoecology of Upper Miocene Montesano Formation, Western Washington

The Montesano Formation, which ranges in age from late Miocene to questionable early Pliocene, is exposed in an area of approximately 250 square miles of Grays Harbor County in western Washington. It averages 2,500 feet in thickness and consists predominantly of fine- to medium-grained sandstone, with mudstone, pebbly sandstone, and conglomerate locally significant. The formation possibly represents the last marine incursion in a depositional basin that existed generally as a strongly negative feature through most of the Tertiary.

Paleoenvironmentally significant faunas from the Montesano Formation include: (1) rock-boring pelecypods, (2) *Chione-Spisula* molluscan assemblages, (3) a *Miliammina fusca* fauna, (4) a *Buliminella elegantissima* fauna, (5) a *Nonionella* fauna, (6) a *Bolivina* fauna, (7) a *Uvigerina peregrina hispidocostata* fauna, and (8) a *Bolivina seminuda* fauna. The succession of these assemblages, the associated quantitative microfaunal trends, and the sedimentary evidence indicate that the formation was deposited in a sea that first transgressed from west to east over Grays Harbor basin and then regressed. In the western part of the basin, water depths increased progressively from zero to more than 3,000 feet. On the east, deposition took place initially in the littoral zone, later the outer shelf, and finally under probable tidal sand-flat conditions. A local laminated mudstone unit contains an impoverished fauna suggestive of a partly closed basin about 2,000 feet deep with a sill at about 800 feet. Graded bedding, convolute structures, channels filled with shallow-water deposits, and a high percentage of displaced fauna indicate that much of the sediment was emplaced by turbidity currents and slumping. Planktonic Foraminifera indicate that late Miocene sea-surface temperatures in the Grays Harbor area were of the order of 10–15°C. A small terrestrial flora reflects a mild temperate climate.

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Relations Among Shear Strength, Physical, and Acoustical Properties of Sediment Cores from Eastern Pacific

A series of sediment cores ranging in length from several meters to more than 18 meters was raised from the ocean floor between Panama and Antofagasta, Chile. Sediment types represented in the cores are silty and sandy lutite of terrigenous origin, globigerina ooze, and red clay. A variety of bottom environments was sampled, including those from the continental slope and rise, trenches and marginal basins, and the Carnegie and Nasca ridges.

Shear strength was measured aboard ship with a Swedish Fall Cone Penetrometer at 20-cm. intervals down the length of the core immediately after extrusion from the core pipe. Bulk and dry density, moisture content, porosity, and particle-size distribution were determined for each lithologic unit represented in the core. These data are correlated with bottom and sub-bottom reflecting horizons identified on the records of the precision echo sounder.

The data indicate that strong acoustic reflectivity is obtained at the boundary between a lithologic unit of low shear strength and an underlying layer of relatively high shear strength. Zones of high shear strength are characterized by lower moisture content and porosity, and by an increase in the coarse size fraction. Layers of volcanic ash and layers of manganese oxide were identified as strong reflecting horizons. At least one reflecting layer identified in the cores could be identified for several hundred miles, and other reflecting horizons for shorter distances. A layer of volcanic ash just a few centimeters thick was sufficient to provide a strong reflecting horizon.

Although the porosity of the sediment differed from core to core, there was no significant decrease in the porosity or moisture content with increasing depth below the bottom in a single core. This suggests that little if any compaction of the sediment has occurred within the zone that was sampled. However, in several cores there was a gradual increase in shear strength with depth.

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Porosity Changes During Lithification from Unconsolidated Carbonate Sediment to Consolidated Limestone

As carbonate sediments are lithified to limestone, two major porosity changes commonly occur. First, interstitial pore space is partly or, less commonly, totally obliterated as the grains are bound together; second, moldic porosity usually is developed. In sediments devoid of $CaCO_3$ mud, porosity development tends to be more pronounced than porosity elimination; yet preliminary studies indicate that, where $CaCO_3$-mud matrix is found, the moldic pore space is more likely to be retained. Moldic porosity is formed by the dissolution of aragonitic grains which are abundant in shallow-water marine sediments, but is not formed at the expense of grains composed of the two types of calcite (high-magnesian and low-magnesian). Aragonite and both types of calcite are synthesized predominantly by organisms. Because different biologic groups selectively synthesize carbonate material of either aragonite or one of the two types of calcite, a predictable relation exists between biological activity and the tendency to form moldic porosity.

The tendency for aragonitic grains to develop porosity is variable. Shell material is more strongly affected by dissolution and consequent moldic porosity development than are the more finely crystalline oöids, which may resist dissolution. Yet, oöids are more likely to form moldic ("oömoldic") porosity than are pelletal and cryptocrystalline grains. Where the process of diagenesis continues, the newly created pore spaces are occluded by drusy calcite mosaic.

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Nannofossils from Upper Cretaceous of Texas

Eight samples from the Upper Cretaceous of the northwestern Gulf Coast were studied intensively by electron and light microscopy. The samples, ranging in age from Eaglefordian to Navarroan, yielded 93 species, of which 35 are new. All are assignable to 31 genera, of which four are new. Most of the species and genera fit readily and naturally into a small number of higher taxa. Forms are distinguished primarily on the basis of gross morphology and secondarily on variations visible only by using crossed nicols on a light microscope or an electron microscope. Reworking of specimens is common with the result that a reliable zonation must be based on the entire assemblage including relative abundance of all species.

The Eaglefordian sample is characterized by two elliptical, placolith-like species related to the genus *Coccolithus,* which is rare or absent in younger deposits. *Arkhangelskiella, Cribrosphaerella, Marthasterites,* and *Micula,* four typical Upper Cretaceous genera, are lacking. The middle part of the Austin Chalk is marked by the first occurrence of *Lucianorhabdus cayeuxi* Deflandre, *Micula decussata* Vekshina, and a new species of *Zygodiscus.* The first occurrence of *Cretarhabdus? decorus* (Deflandre) and abundant specimens of *Microrhabdulus* mark the upper part of the Taylor Marl. The late Navarroan is distinguished by the appearance of *Lithraphidites quadratus* Bramlette and Martini and a new genus apparently related to *Arkhangelskiella. Lucianorhabdus cayeuxi* Deflandre and several new species common to both the Austin Chalk and Taylor Marl are absent.

Many of the species appear to have notably restricted stratigraphic ranges and wide geographic distribution. Nannofossils, therefore, are a good criterion for refined zonation and intercontinental correlation.

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Foraminiferal Species Diversity Distributions, Eastern Gulf of Mexico

Species diversity is a mathematical expression of the internal variability of biotic communities. It is a relative measure of the degree of concentration of species within an assemblage. Diversities have been calculated for each of more than 400 death accumulation-samples of benthonic Foraminifera from the eastern Gulf of Mexico. Diversities were calculated for each sample, based on previously published population data, using the reciprocal of Simpson's (1949) modification of Yule's (1944) statistic,

$$\frac{N(N-1)}{\text{Diversity} \sum_{i=1}^{K} n_i(n_i - 1)},$$

where N is the total number of individuals counted, n_i is the number of species of the i-th species, and K is the number of species.