tween the Henryhouse and Haragan follows. (1) At the specific level the two faunas are completely distinct; no species are common to both units. (2) Of the 28 genera in the Henryhouse, 13 are restricted to it. Twelve of the 27 Haragan genera are not present in the Henryhouse. (3) The two faunas are nowhere known to occur together or interfinger with one another. (4) The faunal change is abrupt. There is no evidence for an intermediate (gradational) fauna between the two distinct faunas recognized.

The stratigraphic distribution of ostracodes within the Henryhouse and Haragan Shales indicates no definite biostratigraphic zonation within either unit. Each species which is significantly abundant ranges throughout, or almost throughout, the unit in which it occurs. The Henryhouse and Haragan Shales are distinct and discrete stratigraphic units, each having its own ostracode fauna.

Detailed sampling of the Henryhouse and Haragan formations has been carried out in all the outcrop areas of the Hunton Group, which consists of four formations, in descending order: Bois d'Arc Limestone, Haragan Shale, Henryhouse Shale, and Chimneyhill Limestone. The ostracode faunas obtained are distinctive and readily identifiable. Eleven ostracode species previously described as Haragan species are now known to have come from, and to be restricted to, the Henryhouse Shale. The ostracode faunas are distinct and discrete. Therefore, the Siluro-Devonian contact in south-central Oklahoma is unconformable.

McBRIDE, EARLE F., The University of Texas, Austin, Texas

TEXTURES AND STRUCTURES IN CATAHOULA (GUEYDAN) TUFF, SOUTH-CENTRAL TEXAS

The Catahoula Tuff of Oligocene to early Miocene(?) age is composed almost entirely of volcanic rock debris or its alteration products. Pastel-colored tuffaceous clay predominates, but sandstone, conglomerate, bentonite, vitric tuff, and ash also are present. The rocks studied in outcrop have a maximum thickness of approximately 900 feet, and were deposited largely on a coastal plain not far from shore. Bed geometry and sedimentary textures and structures provide evidence that the coarse clastic sediments and some tuffaceous clay beds were deposited as mudflows. One bed of air-fall ash has been recognized by its geopetal fabric: conical piles of glass dust rest on flat shards.

Vitric tuff and tuffaceous clay beds deposited as mud flows are characterized by massive (structureless) beds 1–4 feet thick, lack of sorting in beds that have particles ranging from fine ash to pebble-size tuff intraclasts, orientation of shards in random or swirl patterns, and desiccation polygons. One variety of tuff is characterized by moderate induration and the presence of tuff pisolites. The pisolites are generally 1–5 mm. in diameter and comprise as much as 30 per cent of a rock. Pisolites differ from their matrix by having different amounts or different sizes of shards and, in places, an opaque rind. A few pisolites grade imperceptibly into matrix of identical composition and texture where part of the rind is absent. The pisolites developed in tuffs by soil-forming processes, probably in an arid climate with seasonal rainfall. Many pisolites were reworked into successive mud flows.

Another variety of tuff is well indurated and pervaded by sinuous tubules (up to 2 mm. in diameter) probably formed by plant roots. The tubules trend in all directions but are predominantly vertical. Tubules in some beds are filled with zeolite (heulandite group) or montmorillonite.

Stream-deposited tuff is recognized by faint horizontal laminations and cross-bedding and by moderate sorting and sub-parallel orientation of elongate shards and tuff intraclasts. This type of tuff is friable, non-pisolitic, and lacks tubules. Pores in many of these tuffs are now reduced in size or filled by clay skins of montmorillonite that coat framework grains.

Bentonite is free of crystal fragments, has no relic texture, and has a random orientation of montmorillonite particles. The lack of orientation of clay particles suggests that they crystallized during the *in situ* argillation of beds of glass dust rather than by sedimentation of clay particles in quiet water.

Clay dikes from 1 mm.–2 cm. wide trend vertically through tuff and sandstone at some localities. Montmorillonite grains are well-oriented parallel with the dike walls, suggesting particle-by-particle deposition from injected slurries.

McGUIRE, WILLIAM H., Lexington, Kentucky

EXPLORATION OBJECTIVES IN THE CAMBRO-ORDOVICIAN OF KENTUCKY

The Cambro-Ordovician of Kentucky is a new frontier for petroleum exploration. Dolomite, limestone, and sandstone reservoirs, both proved and potential, provide the oil-seeker with a large number of objectives ranging in age from Early Cambrian to Middle Ordovician and are present at drilling depths of 1,000–14,000 feet.

Dolomite reservoirs associated with the pre-Chattanooga unconformity have produced more than 150 million barrels of oil in Kentucky. Present activity, directed toward the testing of the Knox Dolomite, is a logical extension of exploratory effort downward to the next major unconformity.

The pre-Chazy unconformity in Kentucky was developed on dolomite beds of the Beekmantown. Traps below the unconformity are associated with pre-Chazy structures—faulting, erosional remnants, and truncated porous zones. Vuggy, intercrystalline, and fracture porosity zones occur throughout the Knox Dolomite section, and in many instances appear to be related to specific stratigraphic zones.

The predominantly clastic Conasauga-Rome section below the Knox Dolomite includes potential, but unproved, sandstone and carbonate reservoirs of wide geographic extent. Thickness variations and structural relief in the order of several thousands of feet, coupled with facies changes and known shows of oil and gas, provide the incentive for exploration.

The best guide to exploration will be the reconstruction of Cambro-Ordovician tectonic frameworks and depositional environments. Large structural surface features must be evaluated on the bases of age and structural history.

All types of exploratory techniques, from surface geology to geophysics, are applicable to the search for Cambro-Ordovician oil in Kentucky.

McINTYRE, ANDREW, and BÉ, ALLAN W. H., Lamont Geological Observatory, Palisades, New York

COCCOLITHOPHORIDS AS ECOLOGIC INDICATORS IN OCEANIC SEDIMENTS

The minute, calcitic, skeletal elements (coccoliths) of the Coccolithophoridae constitute 5–20 per cent or more of oceanic sediments in tropical and temperate zones. These planktonic algal remains have a long geologic record, as well as a high degree of evolutionary plasticity, and have been used, with some success, as stratigraphic tools. To date, however, no attempt has been made to determine their ecologic usefulness.

During investigation of the Coccolithophoridae in the Atlantic and Antarctic Oceans, the writers found several temperature-dependent species. To test the usefulness of these forms, their contemporary, postglacial and Wisconsin-glacial distribution in the North Atlantic was examined. Twelve cores, representing a range of conditions from present subarctic to tropical, were chosen from those described by Ericson, Ewing, and Wollin as representing an unbroken sequence of sediments ranging from Recent through Wisconsin in age.

The colder-water fauna is defined by the presence of *Coccolithus pelagicus* and large numbers of *Coccolithus huxleyi, Gephyrocapsa oceanica,* and *Coccolithus leptoporus.* The warmer-water fauna is typified by *Umbellosphaera tenuis, Umbellosphaera irregularis* (erroneously called *Discoaster murrayi* by some workers), and in lower concentrations, *Coccolithus annulus* and *Discolithus antillarum.* In addition, the faunal diversity increases in such a way that non-placolith coccoliths constitute an increasingly significant percentage of the fauna as the temperature increases. It is from these forms that more sophisticated ecologic inferences will be drawn.

Comparison of Recent with glacial sediments indicates a faunal shift of about 10° latitude. During the Wisconsin, the *C. pelagicus* fauna occurred as far south as 25° North latitude, whereas today it is restricted to areas north of 35° North latitude.

MacKENZIE, FRED T., Bermuda Biological Station, Bermuda, and GARRELS, ROBERT M., Northwestern University, Evanston, Illinois

Silica-Bicarbonate Balance in Oceans and Early Diagenesis

If present stream discharge and dissolved load are assumed to be representative of the geologic past, and if the volume of the oceans has remained essentially constant, many problems arise concerning the disposal of the constituents brought into the oceans by streams. Two of these problems relate to silica and bicarbonate.

The amount of dissolved silica delivered to the oceans in 10^9 years, if precipitated chemically or biochemically as SiO_2, would produce a much greater volume of sediment than is observed in the geologic column. The bicarbonate ion transported to the oceans either must be recycled through the atmosphere as CO_2, or removed in calcareous sediments. Yet the precipitation of carbonate minerals, with concomitant loss of CO_2 to the atmosphere, leaves about 40 per cent of the HCO_3^- unaccounted for.

These two problems can be solved by assuming that a small but significant fraction of the suspended load of streams consists of weathered aluminosilicates, probably poorly crystalline, that react with silica and bicarbonate prior to deposition, by reactions of the type: Al-silicate $+ SiO_2 + HCO_3^- +$ cations $=$ cation-Al-silicate $+ CO_2 + H_2O$.

Reactions of this type can be considered "reverse weathering," and are representative of chemical changes commonly considered to take place *after* deposition.

MALEK-ASLANI, M., Tenneco Oil Company, Houston, Texas

Habitat of Oil in Carbonate Rocks

The Kemnitz field in Lea County, New Mexico, is a typical example of stratigraphic entrapment of oil in a carbonate reservoir rock. To understand the reason for entrapment of oil in fields such as Kemnitz, one should analyze geological factors in terms of depositional environment, diagenetic history, and structural history.

Environments favorable to deposition of reservoir-type carbonate formations include reefs, bioherms, oölite bars, and porous skeletal calcarenites. Production of organic material in such environments (with the exception of oölite bars) is prolific; however, under normal conditions most of the organic soft parts are destroyed by bacteria and scavengers, so that only skeletal parts are preserved.

Hydrocarbons are found in cyclic carbonates which were deposited on unstable shelves which were subject to recurrent sea-level fluctuations and periodic influxes of terrigenous clastic sediments. A reef bank or oölite bar can be covered by transgression of basin sediments, suffocated by regressive evaporites, or smothered by influx of terrigenous clastic sediments. Biogenic carbonates which are overlain by evaporites, black sapropelic shale, or basin sediments reflect an early diagenetic history which was favorable for the preservation of animal and plant remains. Early diagenesis is also important in dolomitization and modification of primary porosity of limestone.

Petrologic studies of the Kemnitz reef indicate that this stratigraphic trap is caused by a barrier reef crossing a plunging structural nose. The lower Wolfcamp (Permian) is slightly transgressive and the reef top is covered by basin sediments. Thus this reef retained its porosity and organic source material.

In the North Anderson Ranch field, Lea County, New Mexico, the upper Cisco (Pennsylvanian) is a reef-type porous carbonate but is non-productive because of unfavorable diagenetic history. The younger lower Wolfcamp also is of reefoid nature and occupies a position along the flank of the structure lower than the porous Cisco reef at the crest. The Wolfcamp had a favorable early diagenetic history and therefore contains commercial accumulations of oil.

Elusive stratigraphic traps in carbonate rocks can be explored effectively only after thorough subsurface and structural analyses are supplemented with studies of the environment and diagenetic history of prospective carbonate beds.

MANHEIM, FRANK T., U. S. Geological Survey, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts

Distribution of Interstitial Salts in Drill Cores from Atlantic Ocean Floor off Florida

Interstitial water from five Paleocene to Recent core series, taken on the J.O.I.D.E.S. offshore drilling project, has been analyzed for chloride and major cations. The cores were obtained at depths to 300 meters below the sea bottom on the continental shelf, the Florida-Hatteras slope, and the Blake plateau.

Samples from several holes show a marked downward increase in chloride concentrations, with maximum Cl^- greater than 26 ‰, equivalent to a salinity greater than 47 ‰. It appears that forces