sion of marine facies at all these localities developed synchronously in response to changes in global sea level.

KOURSE, LAURALEE D., Exxon Co., U.S.A., Midland, TX

Silicoflagellate Biostratigraphy of Upper Monterey and Lower Sisquoc Formations, Lompoc, California

Fifty-three samples of a late Miocene marine diatomite were processed for silicoflagellates. Four genera and 13 species: *Cannopilus schulzi, Dictyocha aspera, Dictyocha fibula, Dictyocha pentagona, Dictyocha pseudofibula, Distephanus boliviensis, Distephanus quinquangellus, Distephanus speculum, Mesocena diodon, Mesocena elliptica,* and *Mesocena polyactus* were found. Counts were made of the species present and relative and total abundances were calculated. Two biostratigraphic zones (in ascending order), *Dictyocha pseudofibula* Acme-Zone and *Distephanus speculum* Acme-Zone were recognized. These zones appear to correlate to Bukry's *Dictyocha pseudofibula* Zone and *Distephanus speculum* Zone from DSDP Leg 18, Site 173, in the northeast Pacific. These zones overlap Barron's *Nitzchia fossilis* Partial-Range-Zone, *Rhaphoneis amphiceros* var. *elongata* Partial-Range-Zone, and *Nitzchia reinholdii* Concurrent-Range-Zone.

KREBS, WILLIAM N., Amoco Production Co., Denver, CO, and J. PLATT BRADBURY, U.S. Geol. Survey, Denver, CO

Neogene Lacustrine Diatom Biostratigraphy of Western Snake River Basin, Idaho and Oregon

The western Snake River basin of Idaho and Oregon contains a thick sequence of continental sediments that range in age from at least middle Miocene to Holocene. Some of these sediments are diatomaceous and contain distinctive forms that are biostratigraphically useful. The Sucker Creek Formation (Barstovian–middle Miocene) can be characterized by the occurrence of *Coscinodiscus(?) miocaenicus.* The Poison Creek Formation of Barstovian(?)-Clarendonian age (middle to early late Miocene) contains *Coscinodiscus(?)* sp. cf. *C. gorbunovii* v. *gorbunovii.* The upper Miocene (Hemphillian) Chalk Hills Formation is highly diatomaceous and is characterized by the presence of primitive forms of *Stephanodiscus* at its base and by extinct forms of *Cyclotella* in its upper part. Ash correlations within the Chalk Hills Formation demonstrate that fossil freshwater diatoms can be used to time-correlate lacustrine sediments. The Glenns Ferry Formation of Pliocene (Blancan) age is dominated at its base by species of *Cyclotella* and *Stephanodiscus.* Benthic and epiphytic diatoms are most common in the upper Glenns Ferry Formation. The lower to middle Pleistocene (Irvingtonian) Bruneau Formation contains modern species of *Stephanodiscus, Cyclotella,* and *Melosira.* Careful morphologic comparisons of these and other diatoms of the western Snake River basin with similar forms in other regions may shed light on the feasibility of a model of worldwide Neogene lacustrine diatom biochronology.

KUPFERMAN, STEVEN A., Kaiser Cement Corp., Permanente, CA

Gypsum Deposits of Fish Creek Mountains, Imperial and San Diego Counties, California

The largest deposit of gypsum in California occurs in the Miocene Split Mountain Formation. It is located at the north end of the Fish Creek Mountains, in Imperial and San Diego Counties, about 70 mi (113 km) east of San Diego. The deposit consists of up to 200 ft (65 m) of massive rock gypsum, lying at the top of the Split Mountain Formation. Selenite and celestite occur in scattered pockets. Anhydrite is present as erratic lenses in the gypsum, and interbedded clay occurs near the top and bottom contacts of the deposit. Minor impurities in the gypsum include varying concentrations of chloride salts and fine-grained, opaque manganese and iron oxides. The deposit is underlain by nonmarine gray conglomeratic sandstone, and in complete sections is overlain by marine shale and poorly consolidated sandstone of the Miocene Imperial Formation. Both contacts appear conformable and gradational.

The gypsum outcrops as erosional remnants, which have been preserved in a shallow synclinal basin 3 mi (4.8 km) long and 1 mi (1.6 km) wide. The general dip is 15 to 30° toward the synclinal axis, with sharp local contortions. The overlying Imperial Formation has been eroded away making estimates of the original thickness impossible. Overburden is nonexistent and the gypsum forms smoothly rounded hills, capped by a thin layer of gypsite.

The origin of this deposit appears to fit the "modified bar hypothesis," which suggests that calcium sulfate was precipitated in seacoast lagoons where evaporation took place rapidly, and periodic influx of seawater across shallow bars added new increments of salts. Gradual sinking of the lagoon allowed accumulations of great thicknesses.

The rock is mined in a side-hill bench quarry, crushed at the quarry site, and then shipped by private narrow-gauge railway to a calcining and wallboard plant at Plaster City, 25 mi (40 km) to the south.

LAGOE, MARTIN B., Stanford Univ., Stanford, CA

Miocene Geologic History of Southern Salinian Block, California—Perspectives from a Stratigraphic Study of Monterey Formation

A better understanding of the Miocene geologic history of the southern Salinian block is aided by a stratigraphic and paleoenvironmental study of the Monterey Formation. Extensive subsurface and surface data enable construction of isopach, paleobathymetric, age-relationship, and paleogeographic maps that document the depositional history of the Monterey Formation. Isopach maps show that the formation ranges up to 1,400 m (4,500 ft) thick beneath Cuyama valley. Other areas of maximum accumulation occur in the northwest Caliente Range and the Indian Creek area. Offset of isopachs north of Barrett Ridge suggests approximately 15 km (9 mi) of post-middle Miocene right slip on the San Juan fault.

Age-relationship maps of the upper and lower contacts of the Monterey Formation for the area from Cuyama Valley to the northern La Panza Range indicate that both the top and base of the formation become younger toward the northwest—the base ranging from Saucesian to Relizian and the top from Relizian to Mohnian. Paleobathymetric maps, based on the distribution of benthic Foraminifera, are plotted on four time slices: late Saucesian, Relizian, Luisian, and early Mohnian. These maps also indicate that the Cuyama basin filled from the southeast to the northwest, and they reflect the migration of maximum subsidence in that direction during the Miocene.

The relationship of general stratigraphy to structural features in the Cuyama basin shows that certain faults and anticlines were active during the deposition of the Monterey Formation. Specifically, the Cox fault zone and South Cuyama

anticline show evidence of such movement, beginning in the early Miocene, which affected the distribution of the formation. These relationships reflect an episode of structural deformation preceding the late Neogene episode associated with movement on the San Andreas fault system, and they may be related to the earliest activity on this system.

LOHMAR, JOHN M., Exxon Co., U.S.A., Ventura, CA

Thermal Recovery of Heavy Oil at Edison Field, Bakersfield, California

Thermal recovery of heavy oil is, to date, the most successful enhanced oil recovery process. Both steam stimulation and steam-flooding are widely used in California. They add almost 300,000 BOPD to the state's production. The Edison field, located on the eastern side of the San Joaquin valley, is just one of many heavy oil fields being produced by thermal recovery methods.

The Edison heavy oil sands are offshore-bar and alluvial-fan deposits. There are two textural controls on the reservoir quality of these rocks: (1) grain sorting and (2) the amount of dispersed silt and clay. The reservoir properties affected by rock texture are permeability and capillary pressure. Capillary pressure is particularly important, as it traps oil, controls oil saturation, and limits oil mobility.

The heavy oil at Edison is currently being produced by cyclic steam stimulation. The heat from the steam improves production by lowering the viscosity of the oil. Steam stimulation has doubled the recovery of heavy oil.

The enhanced oil recovery project at Edison was recently expanded to include a pilot steam-flood. The pilot project was designed with the aid of a computer model. The model was used to simulate the movement of steam through the reservoir and predict oil and water production. Simulated production trends indicate that the success of the project will depend on the oil saturation in the reservoir at flood start.

Steam injection into the pilot site began in February 1982. It is just one of many enhanced oil recovery projects being attempted by industry to try and offset a steady decline in new oil field discoveries.

MACFADDEN, BRUCE J., Florida State Museum, Univ. Florida, Gainesville, FL, and MICHAEL O. WOODBURNE, Univ. California, Riverside, CA

Magnetic Polarity Stratigraphy of Middle Miocene Barstow Formation of Mojave Desert, Southern California

The Barstow Formation, of medial Miocene age, crops out in a band about 53 mi (85 km) long, from the Mud Hills on the west to West Cronese basin on the east. Because of its excellent exposures, abundant fossils, and important radiometric calibrations, the Barstow Formation is one of the more important rock units to consider when evaluating the geologic evolution of the central Mojave Desert. The stratotype of the Barstow Formation, in the Mud Hills north of Barstow, consists of about 4,265 to 6,560 ft (1,300 to 2,000 m) of highly fossiliferous terrigenous and volcaniclastic sediments that have been folded into a syncline and offset in a right-lateral sense by several northwest-trending faults. The fossil mammals from this formation are central to the concept of the middle Miocene "Barstovian" Land Mammal Age.

During the fall of 1980, about 100 separately oriented hand samples were collected from 32 sites, spaced at stratigraphic intervals of about 49 to 165 ft (15 to 50 m). Analysis of the paleomagnetic characteristics (using the ScT cryogenic magnetometer and associated instruments at the University of Florida) indicates that the principal components of the NRM result from DRM carried by magnetite. In most cases, site polarities can be unambiguously determined after A.F. demagnetization in peak-alternating fields of 250 oe and/or thermal demagnetization at 250°C (482°F). Preliminary results indicate that at least six magnetozones (3 N, 3 R) are represented in the Barstow Formation.

Further work is planned to increase the density of sampling in order to correlate the magnetic polarity stratigraphy of the Barstow Formation to the GMPTS. This study will provide a basis for refined correlation of Holarctic mammalian faunal evolution as well as for an analysis of late Cenozoic tectonic evolution of southern California.

MANKIEWICZ, P. J., Global Chemistry Corp.

Use of Stable Isotopes in Assessing Petroleum Biodegradation

Samples from petroleum spills in the Gulf of Mexico and controlled experiments in both arctic and temperate waters were separated on silica gel into saturate and aromatic fractions. These column eluates were analyzed for their $\delta^{13}C$ and deuterium content to assess the atomic change with increase in the degree and type of degradative process. The isotopes of both fractions became heavier as degradation increased, with the saturate fraction showing a greater effect when compared with the aromatic fraction. Although degradation affects the isotope composition, the effect in even the most severely degraded oils is less than a part permil for carbon. The isotopic properties of seep oils detected in exploration programs should be correlatable to known crude oils in reservoirs in an area, even when the molecular properties have been badly altered by biodegradation.

MCDONALD, JOHN A., Seismic Acoustics Lab., Univ. Houston, Houston, TX

Physical Modeling and Its Role in Solving Geologic Problems

Scaled physical models have rapidly become recognized as an efficient way in which some geologic problems can be approached.

Models were originally built of readily malleable materials, and at first these models represented simplistic geologic features such as domes or two-dimensional synclines. The models were then immersed in a water tank where ultrasonic transducers were passed over them in such a way that the data resembled those collected by a seismic crew on the surface of the earth. These sets of data were used in the development of some of the earliest successful three-dimensional migration programs. It soon became apparent that the single interface of the early models could be replaced by layered models which more nearly resembled sedimentary sequences of rocks. Such models became very useful in developing interactive interpretation devices with which cubes of seismic information could be examined from different vantage points. This improvement was a definite aid to interpretation.

Recently it has become clear that the physical modeling technique can be applied just as readily to lithologic problems. Subtle changes in physical properties can manifest themselves on the model seismic section just as they do on the real sections.