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.

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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.

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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.

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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.

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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.