also indicate recent movement along a fault parallel with the principal trace of the Whittier fault in the Puente Hills. However, no major earthquakes or rupturing of the ground surface have occurred along the Whittier-Elsinore fault in historic time. A destructive earthquake occurred in 1929 along the Norwalk fault 6 mi south of the Whittier fault.

Analysis of precise level lines run by the Los Angeles County Engineers since 1951 indicates that the Puente and Montebello Hills area and the Santa Fe Springs-Coyote Hills trend are rising at a rate of 0.01 to 0.04 ft/year relative to the synclinal area between the Puente and Montebello Hills on the north and the Santa Fe Springs-Coyote Hills trend on the south. This relative motion may be caused by tectonic motion, or by withdrawal of ground water and compaction of sediments within the synclinal area. Because of oil production and waterflood activities, motion of the ground over oil fields also was detected.

Several oil fields are located along the Whittier fault and on anticlinal structures along the Santa Fe Springs—Coyote Hills trend southwest of the Whittier fault. The Whittier and Coyote (west) oil fields are undergoing extensive waterfloods. The Whittier fault provides the updip closure for oil sands in the Whittier oil field. Thus, the Whittier fault area was considered an ideal test site to search for a relation between subsurface pressure and the distribution and frequency of microearthquakes.

A network of portable seismometers was operated in the Whittier fault area between July, 1971 and April, 1972. Because of the background noise, the smallest event that could be reliably located had a magnitude of 1.0. Epicenters of 31 microearthquakes with a maximum magnitude of 3.0 were determined, but no direct evidence could be established for a relation between oil production and waterflood activities and the distribution of microearthquakes. Sufficient data were available to determine hypocentral depths for 17 events. Assuming a range of 60-70° north dip on the Whittier fault, 8 of the 17 hypocenters are on the subsurface projection of the Whittier fault; one hypocenter is on the Norwalk fault. Eight of the hypocenters cannot be related to any known structure. On the basis of the microearthquakes detected during this study, the Whittier fault must be considered active.

LAND, LYNTON S., Dept. Geol. Sci., Univ. Texas, Austin, Tex.

HOLOCENE METEORIC DOLOMITIZATION OF PLEISTOCENE LIMESTONES, NORTH JAMAICA

Wholesale stabilization of the unstable carbonate phases aragonite and magnesium calcite, and reprecipitation of calcite and dolomite are currently taking place where the phreatic zone (modern water table) invades 120,000-year-old Pleistocene biolithites (Falmouth Formation), north Jamaica.

Pleistocene rocks in the vadose zone are relatively unaltered, and consist of *in situ*, mineralogically unstable scleractinian biolithites. At the water table, a narrow zone of solution, a "water-table cave," commonly is present. Below the water table, the rocks are invariably more highly altered than those above. Magnesium-calcites are very scarce, and considerable dissolution of aragonite commonly has occurred.

Dolomite occurs as 8-25-micron, subhedral crystals precipitated as void linings. The isotopic composition of the dolomite (O^{18} = −1.0 °/oo, δC^{13} = 8.4 °/oo) and its high-strongtium content (3,000 ppm) suggest precipitation as CO_2-oversaturated meteoric groundwaters invade the mineralogically unstable biolithites, dissolve magnesium-calcites and strontium-rich aragonites, and remove the gas. Because some dolomitized rocks are enriched in magnesium relative to primary biolithites, magnesium addition to the system is necessitated and probably is derived from seawater in the mixing zone.

LAPLANTE, ROGER E., Research Dept., Amoco Production Co., Tulsa, Okla.

HYDROCARBON GENERATION RELATED TO CARBONIZATION AND FACIES TYPES IN DENVER BASIN UPPER CRETACEOUS

The mechanisms of kerogen carbonization in Gulf Coast Tertiary sediments have been studied. The principal phase of hydrocarbon generation was found to occur at carbonization levels of 75% carbon and greater, and the quantities generated were indicated to depend largely on the hydrogen content of the kerogen. Low-hydrogen kerogen, similar to coal, was suggested as a better source for gas than oil. High-hydrogen kerogen, similar to that of oil shales, was suggested as a better source for oil. The study has been extended to Upper Cretaceous sedimentary rocks of the Denver basin, where additional support for these conclusions was obtained.

In the Denver basin Upper Cretaceous, differences in the depositional environment affect the composition of the kerogen, its carbonization track, and the type of the hydrocarbons generated. The Pierre Shale generally contains low-hydrogen kerogen that is cellular or highly structured in appearance. These characteristics indicate a major contribution from terrestrial organic detritus. This type of kerogen has been correlated with gas generation, suggesting that the Pierre Shale is principally a gas generating facies.

The Niobrara-Graneros interval contains high-hydrogen kerogen that is amorphous in appearance. These characteristics indicate a major contribution from lipid-rich detritus of aquatic organisms. This type of kerogen has been correlated with oil generation, suggesting that the Niobrara-Graneros interval is principally an oil generating facies. Rock-extract to oil-correlation measurements indicate the Niobrara-Graneros interval may be a source of Cretaceous oil in the Denver basin.

LATTMAN, LAURENCE H., Dept. Geology, Univ. Cincinnati, Cincinnati, Ohio

EVALUATION OF REMOTE SENSORS FOR EXPLORATION GEOMORPHOLOGY

Remote-sensor imagery embraces black and white aerial photography—including black and white infrared photography and various film-filter combinations—color aerial photography, color infrared aerial photography, thermal infrared, and radar. For the 3 general types of geomorphic exploration techniques—drainage analysis, tonal analysis, and fracture analysis—no single remote sensor is best. Terrain, vegetative cover, and extent of human activity influence the selection of imagery for analysis.

Black and white and color photography seem best for routine surface—drainage analysis, especially of low-order streams. Thermal infrared and color infrared give considerable information on groundwater-discharge locations and soil-drainage characteristics. Radar imagery allows excellent mapping of higher order drainage patterns of large areas, and is least affected by vegetative cover.

Tonal anomalies are best seen on black and white infrared and black and white panchromatic photography. Color photography is less useful for this technique, and color infrared is poor to unusable, especially in grass-covered regions. Thermal infrared is very poor, and radar cannot be used for tonal studies in exploration geomorphology.

Fracture-trace analysis is done best on stereo-aerial photography of all types, and least well on thermal-infrared and radar imagery. Lineament analysis is done best on aerial photographic mosaics, and particularly well on radar.

Radar and aerial photographic mosaics are well-suited for regional studies, as are images from satellites; aerial photographs and thermal infrared imagery are best for local, detailed studies.

LIPPS, JERE H., Dept. Geology and Bodega Marine Lab., Univ. California, Davis, Calif.