ripples (ripple drift). *Minor flow units* (less than 3 feet thick), consisting of many different combinations of massive, laminated, small current-rippled, and silty or shaly intervals, are found in channels, over-bank deposits, and as a peripheral aureole of fringe deposits.

Flow-unit thickness, velocity, and distance of travel were controlled by the volume of sediment initially released as cataclysmic avalanches and mud flows in submarine canyons.

KILKENNY, JOHN E., Union Oil Company of California, Los Angeles, Calif.

ASPHALT JUNGLE TODAY

The small but prolific Los Angeles basin in the state of California has experienced a resurgence of exploration activity during the past decade. Most of the onshore activity has been concentrated in a part of the basin popularly called the "Asphalt Jungle" which includes approximately 100 square miles in the urban area of the city of Los Angeles west of the Civic Center.

From 1890 to 1912, when this area was largely open country, there was active wildcatting and several important oil fields were found. Westward expansion of the city's residential section prevented further exploration for many years. Triggered by the deep-zone discovery in the Beverly Hills field in 1954, town-lot lease blocks were assembled, and Los Angeles city drilling restrictions were modified to permit daylight corehole drilling and high-angle directional development drilling from sound-proofed derricks. The result has been the development of 30,000 BOPD new production, with estimated oil reserves of 170 million barrels and 300 billion cubic feet of gas reserves from eight new oil fields. At present Las Cienegas is the largest field with a production of 15,000 BOPD, although a more recent discovery on the west may equal or surpass it.

The surface of the "Asphalt Jungle" consists of flat-lying late Pleistocene and Recent alluvial deposits which conceal sharp, asymmetrically folded, faulted, generally west-east-trending anticlines in the Pliocene, late Miocene, and older rocks. The main producing zones are in the upper Miocene alternating sandstone and shale section with a maximum net pay thickness in excess of 800 feet. Producing depths range from 2,000 to 10,000 feet, and gravity of the oil from 20° to 40°.

KNIGHT, R. L., Mobil Oil Corp., Santa Fe Springs, Calif.

GAS SHOWS LEADING INDICATOR OF PRODUCTION

(Abstract not submitted.)

KNUTSON, C. F., Continental Oil Co., Ponca City, Okla.

EFFECT OF NUCLEAR ENERGY ON PETROLEUM EXPLORATION

An evaluation of the characteristics of contained nuclear explosions shows attributes that may be useful in petroleum production as well as in the recovery of wealth from deposits that may be leached *in situ*, and from "thermal" areas.

The broken rock and associated fracture zone produced in the underground "pay" zone by a nuclear explosion conceivably can (1) make commercial petroleum reservoirs out of traps that are too tight to yield commercial hydrocarbon rates with currently known completion techniques, (2) allow *in situ* reporting of oil shales, and (3) aid in commercial exploitation of tar-sand deposits.

Although nuclear explosions have not been used to date in petroleum reservoirs, the data developed from several contained shots in other media can be extrapolated to yield a picture of potential nuclear stimulation "targets." In general, these are seen to be moderately deep, thick, brittle formations located in areas of low population density.

The results of a series of generalized economic analyses are presented graphically. Thus the effects of such parameters as (1) formation thickness, (2) depth of burial, (3) volume of hydrocarbon in place, and (4) device cost on the rate of return may be determined.

KULM, L. D., and C. HANS NELSON, Department of Oceanography, Oregon State University, Corvallis, Ore.

COMPARISON OF DEEP-SEA CHANNEL AND INTERCHANNEL DEPOSITS OFF OREGON

Deep-sea channel and interchannel deposits from the southern part of the Cascadia abyssal plain have been studied through textural and coarse fraction analyses, fauna, radiocarbon dating, and stratigraphic sequence. Piston cores were taken along a line from the base of the continental slope off central Oregon to the western edge of the abyssal plain.

Faunal and color changes between the upper and lower sections of several cores take place abruptly in the cores. The horizon separating the upper and lower sections is a significant one (a change from glacial to post-glacial conditions). The ratio of planktonic foraminifers to radiolarians is less than one above the horizon and greater than one below. The radiocarbon age of the deposits just below the horizon is 15,200 B.P.

Both channel and interchannel sediments show a marked increase in the number and thickness of sand layers deposited during glacial time, whereas post-glacial deposits show a decrease in sand. Only post-glacial deposits have been observed in Cascadia and Astoria channels and in the interchannel area east of the latter. The coarsest layers in these channels consist of coarse silt and very fine sand, respectively. Two unnamed channels on the western side of the plain display a largely glacial section consisting chiefly of very fine sand and coarse silt. Interchannel deposits on the western edge of the plain are significantly finer-grained than those on the east.

The highest sedimentation rates in the area apparently occurred during glacial time. Radiocarbon dates indicate a rate of accumulation during glacial time of about 170 centimeters per 1,000 years for an interchannel area on the western edge of the plain. Post-glacial rates of deposition are highest on the eastern side of the plain, particularly in the area adjacent to the continental slope, and in Astoria and Cascadia channels.

LAMB, JAMES L., Esso Production Research Company, Houston, Tex.

PALEONTOLOGIC CONFIRMATION OF POST-OLIGOCENE MOVEMENT ALONG SAN ANDREAS FAULT

The major fault zone of California is the San Andreas. Right-lateral displacements along this fault as great as 225 miles since late Eocene time and 175 miles since Oligocene-Miocene time have been proposed. Although post-middle Miocene displacements

of about 65 miles are reasonably documented, greater displacements of older rocks are presently speculative and require more precise substantiation.

The late Eocene-to-Oligocene depositional histories of the southern San Joaquin Valley, east of the fault, and the Santa Cruz Mountain region, west of the fault, are symptomatic of a genetic relation. The upper Tejon, San Emigdio, Pleito, and lower Temblor Formations of the San Joaquin Valley are believed to be homologous with the San Lorenzo, Vaqueros, and lower Hester Formations of the Santa Cruz Mountains. No comparable sequence of rocks is known from intervening areas adjacent to the San Andreas fault; therefore post-Oligocene movements of about 225 miles are confirmed.

The late Eocene-to-Oligocene foraminiferal lineage of *Uvigerina jacksonensis* ↔ *U. tumeyensis* ↔ *"Siphogenerina" nodifera* ↔ *"S." transversa* occurs in both regions and corroborates the age relations of the formations.

LAPORTE, LÉO F., Department of Geology, Brown University, Providence, R.I.

RECOGNITION OF TRANSGRESSIVE CARBONATE SEQUENCE WITHIN EPEIRIC SEA: HELDERBERG GROUP (LOWER DEVONIAN) OF NEW YORK STATE

The regional Late Silurian-Early Devonian marine transgression of the central Appalachians is represented in New York State by a shallow-water carbonate rock sequence (Helderberg Group) which locally transgressed north and west. The resultant stratigraphic section comprises several hundred feet of fossiliferous limestone which has several distinctive sedimentary facies.

Early workers interpreted each of the major facies as a separate time-stratigraphic lithologic unit or formation. However, from detailed field examination Rickard (1962) demonstrated that these formations are in fact time-transgressive toward the west and interfinger laterally with each other. Paleoecological study of the Helderberg Group supports this interpretation and shows that each of the formations represents a local sub-environment within the transgressive interval as a whole. These formations (facies) are:

(1) *Manlius Formation* (25–50 feet), a complex of rock types interpreted to represent supratidal, intertidal, and shallow subtidal environments within a broad shelf lagoon (Laporte, 1964; 1967).

(2) *Coeymans Formation* (20–100 feet), crinoidal-brachiopod skeletal calcarenite and carbonate siltstone which are commonly burrow-mottled toward the base of the unit but which show increasingly greater evidence of current reworking toward the top (high-and low-angle cross-stratification and sheet deposits). The Coeymans is interpreted to have been deposited in a wide belt of shallow, submerged crinoid mounds and banks which served as an effective, though discontinuous, barrier to circulation separating the more open-marine environment on the east from the restricted shelf lagoon of the Manlius on the west (Anderson, 1965).

(3) *Kalkberg Formation* (50–100 feet), highly burrow-mottled carbonate mudstone with a very abundant, diverse, and well-preserved biota. The Kalkberg is interpreted to be a shallow-water, open-marine deposit which developed on an extensive shelf seaward from the Coeymans crinoid banks and meadows.

(4) *New Scotland Formation* (50–150 feet), highly argillaceous and siliceous carbonate mudstone with a somewhat less diverse and abundant biota than the Kalkberg. The New Scotland is interpreted as having developed on a broad shelf like the Kalkberg (and marginal to it), but with significantly greater influx of terrigenous detritus which probably came from a distant easterly source.

Lateral and vertical variations in constituent carbonate-grain types, mudstone-sparite ratios, fossil abundance and diversity, and presence of primary sedimentary structures provide criteria for recognizing the transgressive nature of the major sedimentary facies of the Helderberg Group. The inferred depositional framework, moreover, is very similar to that postulated by Shaw (1964) and Irwin (1965) for "clear water" sedimentation within an epeiric sea and demonstrates the predictive validity of their generalized sedimentary model.

LEDINGHAM, GLEN W. (see Frankl and Cordry)

LOWENSTAM, H. A., California Institute of Technology, Pasadena, Calif.

ECOLOGIC CRITERIA FOR RECOGNITION OF DEPOSITIONAL ENVIRONMENTS IN CARBONATE ROCKS

Carbonate skeletons of many Recent and fossil species show morphologic characters which can be related to specific factors in their environments. Similarly, the mineralogy and chemistry of the carbonate from the skeletons are known to reflect a variety of ecologic factors.

Few attempts have been made to utilize the ecologic information from the physical and chemical properties of skeletal carbonates in the analyses of depositional environments of carbonate rocks.

Data are presented to illustrate their usefulness in recognizing certain ecologic factors in the depositional environment of carbonate rocks. In this presentation, particular emphasis is placed on comparative functional morphology of carbonate skeletons. Ecologic factors to be considered are habitat, derivation of constituent grains, rates of sedimentation, turbidity, micro-hydrography, consistency of the sediments, temperature, and depth of the accumulating sediments.

MARTIN, PAUL S., Geochronology Laboratories, University of Arizona, Tucson, Ariz.

POLLEN STRATIGRAPHY OF PLAYA LAKES

Since the discovery 15 years ago by Sears and Clisby that the dry lakes (playa lakes) of western North America contain a rich fossil pollen record, Pleistocene specialists have hoped that a definitive chronology would be forthcoming from this largely unglaciated region. Such a chronology should indicate the number of pluvial episodes and the magnitude of each. The deepest drill cores should reveal whether the Pleistocene began with a "bang" or a "whimper."

Though hopes for a continuous Pleistocene chronology go largely unrealized, the pollen record of the last glacio-pluvial maximum, the Wisconsin, is increasingly well known. It indicates a major shift in vegetation zones not once but several times during the C-14-datable part of the record. Among the areas studied to date are the San Augustin Plains, the Willcox Playa, Great Salt Lake Desert, and the Texas High Plains. Some control on the fossil pollen record can be gained from the modern pollen rain of "natural" plant communities in the southwest. Despite formidable problems of long-distance transport of certain pollen types it appears that the major vegetation zones have their own distinctive local pollen pool,