acter are apparent, including from north to south the following.

(1) Arctic coastal region
(2) Brooks Range isostatic minimum
(3) Central Alaska region of low gravity relief
(4) Southeastern Alaska region of large complex gravity anomalies due to local isostatic and geological adjustments
(5) Bristol Bay positive area
(6) Aleutian Islands maximum
(7) Aleutian Trench minimum

Proper recognition of the types of large gravity anomalies to be expected in each region will greatly improve the interpretations of gravity meter surveys run in local areas for petroleum exploration.

F. J. HORTIG, State Lands Commission

California Offshore Oil—Present and Future

The base for report of the status of present development of offshore oil and for prediction of future developments is contained primarily in the past history of California offshore development, starting with the first tideland well drilled in 1896. Current annual (1959) production from State-leased offshore lands is 15 million bbls. from Orange, Ventura, and Santa Barbara counties. In addition, production has been developed from offshore lands granted by the State to municipalities at Newport Beach, Long Beach, and Redondo Beach.

Five leases, comprising 19,200 acres, are under exploration development in Santa Barbara County. Potential lease offers are under review by the State Lands Commission in both Santa Barbara and Ventura counties. Submarine seismic and geological (core drilling) surveys are being continued over the majority of the Southern California offshore area extending seaward to the Channel Islands. Exploration and technological developments in drilling and production indicate that the maximum California offshore development will be achieved in the future.

JOHN C. HAZZARD, Union Oil Company of California

Bioherms in Middle Devonian of Northeastern Spanish Sahara, Northwest Africa

Two groups of Middle Devonian (Eifelian) bioherms, here defined as the Gor Loutad and the Gor Morehba reef areas, have been recognized east and southeast of Semara, a village about 160 km. east-southeast of El Aaiun. The Gor Loutad reef area (Lat. 26°45′ N.; Long. 10°45′ W.) which was seen only from the air, comprises about 20 biohermal mounds and ridges distributed in a narrow northeast-southwest trending belt. To the southwest is the Gor Morehba reef area (Lat. 26°30′ N.; Long. 11°25′ W.) which was visited on the ground.

The Gor Morehba reefs are expressed topographically as an elongate area of low hills trending northeast-southwest for approximately 52 km.; the width of the belt ranges from 10 to 15 km. This area comprises more than 15 elongate reef ridges and elliptical to circular reef mounds. The ridges are as much as 5–6 km. in length and 1 km. in width; the mounds have an average maximum diameter of 1–2 km. Topographically, these reefs stand as much as 100 meters above present drainage levels.

The reef-forming limestone averages less than 30 meters in thickness and the total thickness of section affected in any way by the reefing is about 100 meters. Flank dips on the ridges are as much as 20° while dips on the flanks of the mounds are as great as 50°; such dips are in contrast with the average 2° regional dip of the Devonian section. The core of the reef mounds and ridges is a massive light gray limestone made up of broken fragments of coral, calcareous algae, and clastic limestone. It is overlain by, and grades down the flanks into, well bedded dark gray limestone which in turn passes into the shaly limestones and calcareous shales of the inter-reef areas.

Well exposed sections of the ridges and mounds suggest that the pattern of reef development was partly controlled by submarine channeling prior to deposition of the reefs. The inter-channel ridges and more isolated "highs" became the loci for growth of carbonate-secreting organisms. Such limestone (or reef) growth continued for a relatively short time until the influx of clastic material filled the inter-reef areas and eventually passed over the centers of reef development. Locally, initial dips exposed in the overlying clastic section reflect the underlying reef pattern.

STANLEY J. LASTER and FREEMAN GILBERT, Geophysical Service, Inc.

Line Source Problem for Solid-Solid Interface

This paper deals with the elastic waves propagated along an interface between two solid elastic half-spaces (Cagniard's problem). Classically it has been shown that interface (Stoneley) waves should exist only for those limited values of the elastic parameters of the two solids for which the Stoneley pole is real and lies on the sheet of integration. Solutions for the similar, but algebraically simpler, Lamb's problem indicate that interface waves may also be associated with complex poles not on the sheet of integration. Exact solutions are presented for Cagniard's problem for a large number of materials, lying both inside and outside the classical existence diagram. These seismograms support the conclusion that attenuated Stoneley waves can be propagated at the interface of almost any two solid materials. Additional information on critical refraction phenomena is also presented.

JOHN SILCOX, Standard Oil Company of California

General Geology and Development of West Thornton and Walnut Grove Gas Fields Sacramento Valley, California

The West Thornton and Walnut Grove gas fields occupy a position astride the east-west–trending Thornton arch which extends from Lodi to Rio Vista and is one of the major structural features of the Sacramento Valley gas province. Production along this trend was first established in 1943 at the Thornton and Lodi fields which are areas of anticlinal closure. Down plunge to the west, additional production was subsequently developed in 1956 and 1958 with discoveries at West Thornton and Walnut Grove respectively.

The productive section at the West Thornton and Walnut Grove fields includes the Domengine and Midland sands of Eocene age, Paleocene Martinez sands, and Cretaceous Winters-Millar sands. Gas accumulation in these intervals is controlled by a combination of faulting and stratigraphic changes on the plunge of the Thornton arch. Cretaceous production of the Thornton arch was first established at Walnut Grove from the Winters-millar sands in the Brazos Locke Unit No. 1 well in 1959. Three wells are presently productive from this interval. Erratic sand distribution in the lower Eocene Meganos sediments, attributable to either rapid facies changes or channel development similar to the "Markley Chan-

nel," delayed definition of the West Thornton gas field for four years until further development drilling was undertaken in April of this year. Since this time five additional wells have been completed in the Midland pool.

S. R. SILVERMAN, California Research Corporation

Critical Review of Contemporary Theories of Petroleum Origin

The present status of chemical, geological, and biological information on the origin of petroleum strongly favors the theory of organic (or biogenic origin over that of inorganic origin. There is no general agreement, however, on the mechanism or mechanisms by which biologic products become petroleum. Among the various hypotheses offered to explain this conversion, two have received most attention and occupy the forefront of present-day theories of petroleum origin. One, which may be designated as the "Direct-Accumulation" hypothesis, contends that petroleum consists of a selective accumulation of relatively unchanged organic compounds produced by living organisms. Opposed to this explanation are the so-called "Transformationists" who believe that biologic source materials must undergo marked chemical transformations, under the influences of temperature, pressure, and lithologic environment, before they are converted into petroleum. A critical review of available chemical and geologic information on petroleum and other organic materials in ancient and modern sediments suggests that chemical transformations play an important role in petroleum formation.

JOHN W. GROESCH, Union Oil Company of California

Economics of Marketing

The Pacific Coast market today is highly competitive. Price wars have been with us so long that depressed prices seem normal. Marketing margins are low. Refiners margins are seriously depressed. Eastern oil companies are seeking Pacific Coast outlets for their product. This contrasts with the stable Pacific Coast market of 10 years ago.

The turning point came at about the time of the Korean War. With the big Middle East oil strikes, productive capacity exceeded consumption. Combined with a surplus of tankers, a shift from production orientation to marketing was inevitable. Concurrently, petroleum companies have been seeeking greater efficiency in all phases of their operation.

For the next 20 years, California continues to have the greatest growth prospects in our market. Following 1980, a similar expansion is expected for the Pacific Northwest. Marketing prospects are virtually unlimited.

RICHARD R. THORUP, consulting geologist

King City Oil Field, Monterey County, California

The King City oil field, also referred to as the San Bernabe oil field, is 20 miles northwest of the San Ardo oil field, and 6 miles south of the town of King City, Monterey County, California. The field was discovered in December, 1959, the discovery well being the Thomas Doud Estate No. 2, which produced 16° gravity oil at the rate of 76 b/d net oil cutting 16% from a depth of 2,000 feet. The No. 3 was also completed in December, 1959, with an I.P. of 531 b/d cutting 0.1%. The No. 4 was completed in June, 1960, as a gas well indicating the possibility of a gas cap in the field. Cumulative production through September, 1960, is 43,000 bbls. of net oil and 10,000 bbls. of water. The producing sand is middle Miocene in age with a total thickness of 330 feet, about 150 feet of which is oil saturated. Porosity averages 23% and permeabilities have been found as high as 2,100 millidarcys. Accumulation is believed to be due to a combination of structure and stratigraphy. The discovery well was located primarily on the basis of field and subsurface geology.

EUGENE M. SHOEMAKER, U. S. Geological Survey, Menlo Park, California.

Interplanetary Correlation of Geologic Time

Asteroid impact has produced a significant number of medium and large craters on the earth in comparatively recent geologic time, and the rate of impact can be interpreted to have remained fairly steady for at least the last half-billion years. By extrapolation of this rate, the age of major stratigraphic units on the moon may be estimated from the number and distribution of superimposed primary impact craters. With appropriate modification, the same principle should be applicable to Mars when detailed photographs become available for photogeologic mapping.

A second potential method of interplanetary correlation depends on the actual transport of impact debris from other planets to the earth, where the debris becomes incorporated in the terrestrial stratigraphic record. Some rock debris is ejected at escape velocity by asteroid impact on the Moon and probably also on Mars; part of the lunar ejecta must land on earth and a very small fraction of Martian ejecta is probably also swept up by Earth. Some tektites are probably formed by ablation of ejects thrown into orbit around the earth. It may be possible to identify the craters from which ejecta are derived at some advanced stage of lunar and planetary exploration and thus tie the age of these craters directly to the terrestrial time scale. A ray crater in the size range from Aristarchus to Tycho is the probable source of the ejecta from which the australites and associated Pleistocene tektites were formed.

GORDON R. BELL, Gulf Oil Corporation of California

Trends in Geological Society Membership in Oil Industry of California

Membership in the Pacific Section of the American Association of Petroleum Geologists has declined 18.8% from its all-time high of 1,362 members in 1956. The rate of decline appears to have leveled off during the year 1959–60. During the 15 years prior to 1956, the Pacific Section grew rapidly from 247 members in 1941. This rate of growth was at least equal to the phenomenal growth rate experienced by national A.A.P.G. The present analysis shows the trends of Pacific Section membership throughout California during the 9-year period 1951–1960. Trends by areas corresponding with those of local geological societies and oil-compnay operations are shown. Statistics used are obtained from membership lists, newsletter mailing lists, and five Pacific Section directories published to date.

By the use of these statistics, it is possible to show that while the number of members has changed, the percentage distribution of Pacific Section members in each of the Los Angeles, San Joaquin Valley, Coastal, and Northern California operational areas over the past 9 years has remained fairly constant, but that members outside of California have increased from 4% to about 15% of the total organization. A study of the percentage distribution of members by organizational affiliation shows that between 40 and 50% of the members worked