Mountain system, and includes an almost continuous belt of granitic batholiths and a chain of active and recently active volcanoes. Though numerous, granitic intrusive masses between the Alaska and Brooks ranges are small, except a few in the southeastern part of the Yukon-Tanana upland. Relatively few igneous rocks are known within and north of the Brooks Range.

The Paleozoic and much of the Mesozoic tectonic history of Alaska, involving a broad geosynclinal tract that lay between the Pacific Ocean on the south and west and a stable platform region on the north and east, can be considered conveniently in three major stages: Cambrian through Silurian, Middle Devonian through Permian, and Triassic through early Cretaceous. The mobile belt encroached northward at the expense of the stable region, until by mid-Mesozoic time eugeosynclinal conditions extended over most of Alaska. In mid-Jurassic time in southern Alaska, and in early Cretaceous time in central and northern Alaska, Alaska became differentiated into positive and negative tracts of erosion and deposition that were maintained through the rest of the Mesozoic era. Basins of known Tertiary marine deposition are limited to the northern and southern borders of Alaska. Inland, Tertiary basins were sites of accumulation of continental sediments.

35. General Geology and Hydrocarbons of Cook Inlet Basin, Alaska: Thomas E. Kelly, Halbouty Alaska Oil Company, Anchorage, Alaska

The Cook Inlet basin of south-central Alaska is an intermontane structural basin approximately 14,000 square miles in area, encompassing almost 80,000 cubic miles of sedimentary rocks ranging in age from upper Triassic to Recent. The basin coincides with most of the northern part of the Matanuska geosyncline, an arcuate Mesozoic trough located at the northwestern end of the Pacific Cordilleran mobile belt.

The Cook Inlet sedimentary trough, in contrast to the structural basin, is defined as a Paleozoic-early Mesozoic eugeosyncline that received sediments from emergent volcanic islands which were part of the volcanic archipelago belt bordering the Pacific Coast of North America. Middle Jurassic epeirogeny transformed southern Alaska into arcuate geanticlinal and geosynclinal belts with the Cook Inlet basin beginning as a half-graben created by complex faulting on the east flank of the Talkeetna geanticline.

The Mesozoic embayment that collected marine sediments and occasional non-marine wedges abutting cratonic source areas was semi-enclosed or silled as the Kenai and Chugach ranges began to emerge following the early stages of the Laramide orogeny. During the early Tertiary, an abundant supply of non-marine clastic sediments and carbonaceous material was widely distributed in the subsiding intermontane basin.

The structural grain of the major tectonic elements describing the basin architecture is preserved in trends of local structure throughout the basin. Intense folding and faulting are exhibited on the north, east, and west flanks of the basin. Several major buried anticlinal trends extend in a northeasterly direction through the interior of the basin.

Mesozoic hydrocarbon accumulations associated with anticlinal traps are found on the western side of the basin. Minor quantities of oil, gas, and condensate have been produced from sandstones of the middle Jurassic Tuxedni formation. The oil is believed to be indigenous to Jurassic beds, the exact age and position of which are questionable on the basis of present-day stratigraphic relations.

Oil and gas accumulations in Tertiary beds will determine the significance of the Cook Inlet basin as an oil and gas province. Present oil production comes from the Hemlock zone, a distinct sandstone and conglomerate unit near the base of the Tertiary Kenai formation. Entrapment has been influenced by folding and faulting along trend of an interior basin high which lies adjacent to and parallel with an early Tertiary hinge belt. The Tertiary crudes were probably derived from Eocene marginal marine strata or from upper Cretaceous marine shales which are unconformably overlain by the Tertiary sediments.

Significant quantities of gas, predominantly methane, are present in the loosely consolidated sands of the upper Kenai formation. The two conditions necessary for gas accumulation anywhere in the basin are (1) abundance of lignite or coal beds in the section to serve as source rocks, and (2) a suitable trap.

The Cook Inlet basin is in its earliest stage of exploration and development. It is anticipated that many new oil and gas fields will be discovered. Regional isopach maps of the interval between the Mesozoic beds and the base of the Hemlock zone are suggested as a basic approach to delineating old basin highs that may be sound Hemlock prospects. The Cook Inlet basin should become a major gas basin regardless of its future as an oil province.

36. Tectonic Summary of Backbone of Americas: Carey C. Croneis, The Rice University, Houston, Texas

Thursday Afternoon, April 27

Presiding: Orlo E. Childs, Daniel S. Turner

37. Challenge of Exploration for Natural Gas: B. W. Beebe, Consultant, Boulder, Colorado

During the year 1959, more than 11.44 trillion cubic feet of natural gas was marketed in the United States. This is equivalent in energy on a British Thermal basis to approximately 5,300,000 barrels of oil daily. More than six times as much natural gas will be delivered to consumers in 1960 than was delivered in 1935. The current oil production in the United States is approximately 6,800,000 barrels daily. The impact of this tremendous growth of natural-gas consumption on the market for crude oil is obvious.

The American Association of Petroleum Geologists published a symposium, "Geology of Natural Gas," in 1935. During the 25 intervening years, gas transmission systems have been constructed to all of the heavily populated areas in the United States. Consumers have recognized natural gas as a premium source of energy, not only because of its ease of handling and its cleanliness, but because natural gas is so grossly underpriced when compared with other sources of energy. The executive committee of A.A.P.G., recognizing the importance of natural gas, has authorized a new multi-volume symposium, "Natural Gases of North America," now in preparation. This massive authoritative work will be by far the most comprehensive documentation of all of the facets of the natural-gas industry which has ever been attempted.

The greatest source of natural gas in the past has been the so-called Appalachian geosyncline province. For the immediate future, Tertiary rocks of the Gulf Coast embayment will continue to be major sources of natural gas. However, as the reserves of the Permian basin of West Texas and the immense Hugoton-Panhandle field of Kansas, Oklahoma, and Texas are depleted, it appears that the huge intermountain basins of the Rocky Mountain area will become increasingly important as sources of natural gas. Recent discoveries in Tertiary and upper Cretaceous strata in this immense, relatively unexplored area suggest a shift in major sources of supply. Thus in the future, the Tertiary Gulf Coast embayment and the Rocky Mountain area will be the major source of new gas reserves in the United States, excluding Alaska.

The importance of Alaska, this great new frontier, as a source of natural gas can not be predicted at this time, but tremendous physical obstacles, both in exploration and transmission must be surmounted before Alaska can be exploited for the benefit of our ever increasing demands.

Vast untapped reserves exist in both Canada and Mexico, but only a small fraction of these reserves will be available to consumers in the United States.

The ever increasing demand in our own country must depend on new discoveries within the contiguous 48 states of our country. The geologist responsible for discovering the necessary reserves to satiate an ever increasing demand faces a unique and unprecedented challenge. Not only must he deal with and understand the problems and risks inherent in all exploration, but he is beset by the series of confusing and contradictory economic conditions which often appear to defy solution.

38. Oil Accumulations along Abo Reefing, Southeastern New Mexico: WILLIAM J. LE MAY, Hondo Oil and Gas Company, Roswell, New Mexico

During Abo (lower Leonard) time, clastic deposition in the Delaware basin was separated from the lagoonal deposits on the Northwest shelf by a transgressive barrier reef. A lithologic study within the Abo formation reveals facies changes from shelf to reef to basin. Shelf, or back-reef deposits, consist of interbedded green shale and light gray to tan, fine crystalline, anhydritic dolomite. The interfingering of shelf and reef dolomites forms an effective permeability barrier to the migration of fluids back-reef. The Abo reef is a clean white to light tan, anhydritic, fine to coarse crystalline dolomite exhibiting secondary porosity development due to fracturing and solution activity. Interconnecting vertical fractures and vugs give the reef excellent reservoir characteristics which would otherwise be absent in the tight reef matrix. Basin deposits (fore-reef) include black to dark brown argillaceous and cherty dolomites and limestones interbedded with fine-grained sandstones. Fore-reef deposits are called "Bone Spring formation" and are believed to be Abo equivalent.

Hydrocarbons are trapped where porosity has been well developed in relatively high structural areas along the reef. At present there have been four fields discovered along the Abo reef trend in New Mexico: (1) Lovington Abo, (2) Empire Abo, (3) Corbin Abo, and (4) Turner Abo. The latter three are currently being developed. The size and reserves of these fields are dependent on the following factors: (1) thickness of reef above water, (2) structural configuration of the reef, and (3) quality of the reef pay. In the Corbin and Turner Abo fields, oil is trapped along the crest of an elongate reef ridge, one or two locations wide. The productive limits are defined by their respective water tables. The reef in Empire and Lovington is characterized by the same steep dip toward the basin (10°–30°) but has a gentle slope toward the shelf; thus, the productive limits are wider (3–6 locations wide) and production is limited shelfward by an effective permeability barrier.

A successful exploratory procedure has been to estimate a well's proximity to the reef crest by defining its relative stratigraphic position through correlation with areas of close control which traverse the reef. The intermediate drilling depth (4,000–8,500 feet) and high reserves (average 500,000 barrels per location) account for the acceleration of activity along the Abo reef trend.

39. Faulting Associated with Deep-Seated Salt Domes in Northeast Part of Mississippi Salt Basin: DUDLEY J. HUGHES, Triad Oil and Gas Company, Jackson, Mississippi

Faulting in the northeast part of the Mississippi salt basin is principally local graben-type resulting from salt doming. On deep-seated salt-dome structures, the faulting has common characteristics throughout the area which can be applied to great advantage in subsurface interpretations.

Faults are localized over each dome. The general fault strike is usually parallel with the long axis of the deep-seated dome with which it is associated. Faulting over deep-seated salt domes can usually be related to derivative gravity minimums which are expressions of the salt uplifts causing the faulting. Generally, the relative intensity of the derivative gravity minimum becomes greater as the complexity of the faulting becomes greater.

Fault dips over deep-seated domes in the northeast part of the Mississippi salt basin average approximately 45° in the Upper Cretaceous and 60° in the Lower Cretaceous.

The increase in throw with depth is principally a result of lengthening of stratigraphic section in the downthrown block relative to the same section in the upthrown block. This lengthening of section is caused by thickening of the downthrown beds, and by preserved wedges below unconformities in the downthrown block which are absent in the upthrown block.

The crests of structures at Lower Cretaceous horizons through this area are commonly located near one side of a graben system. The faults on this side, termed "axial faults," generally bisect the anticlinal crest so that closure is present on both their upthrown and downthrown sides. Lower Cretaceous production is most commonly found along the structural crest on both sides of the axial faults.

Faults with opposing dip on the opposite side of the graben, termed "flank faults," are farther removed from the structural crest and exhibit closure only on the upthrown side. Flank faults provide potential traps if upthrown reservoir beds remain against impervious strata in the downthrown segment during growth of the fault.

40. Geomorphic Expression of Selected Concealed Structures in Western Canada: ROBERT H. BARTON* and ANDY J. BROSCOE, Geophoto Services, Ltd., Calgary, Alberta, Canada

Analysis of drainage patterns can be used to delineate concealed structures. To do this effectively, a thorough understanding of the regional geology and general geomorphic history is necessary. In glaciated areas, air photographs and mosaics can be used to determine the general glacial history so that glacially controlled patterns are not confused with structurally controlled patterns. As with any unconventional technique, drainage pattern interpretation has been misunderstood, misused, and handicapped by the lack of a generally acceptable theory to explain the reflection of buried structures in surface stream patterns.

Geomorphic analyses are used in both regional and detailed studies. Regionally, the area between Fort St. John and Fort Nelson in northeastern British Columbia exhibited a pre-Pleistocene trellis drainage pattern, adjusted to structural conditions. Glaciation altered the existing base-level equilibrium. After the ice melted, large-scale stream piracy took place. Due to glaciation and subsequent piracy, non-structurally controlled

* Denotes speaker.