sand, and Hatchetigbee formation of lower Eocene age, and the Tallahatta and Lisbon formations of middle Eocene age.

Stratigraphic sections for these studies were combined into longitudinal profiles for the left and right banks of the river, an arrangement that visually describes detailed lithology and structure. Horizontal control was from aerial photographs. Vertical control was from the river surface. The altitude of the river surface was determined from the stage of the river referenced to "the thalweg," as plotted by the U. S. Corps of Engineers, and bench marks of the U. S. Coast and Geodetic Survey. The use of "the thalweg" in determining altitudes of contacts permits rapid and accurate mapping of geologic sections along rivers.

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Geology of Parapeti Area of Bolivian Chaco

The Chaco is a vast, very gently southeastward sloping flat plain with a dense cover of semi-arid low brush and small trees which extends from the foot of the Andes Mountains eastward to the Rio Paraguay and from the 18° parallel south into Argentina. It is underlain by Tertiary and Quaternary continental sandstones and conglomerates which bury a pre-Tertiary topography. The only relief features that break the extremely flat surface of the Chaco are occasional isolated hills of pre-Tertiary rocks which project through the Tertiary and Quaternary blanket. In Bolivia only Gondwana and younger rocks are exposed in these hills; in Paraguay, Devonian and older rocks are found.

The Parapeti River comes out of the Andes Mountains at the 20 degree parallel and swings northward across the Bolivian part of the Chaco to disappear in the Izozog swamps at parallel 19. Near the mountains it crosses a major syncline in which over 8,000 feet of Tertiary and Quaternary rocks are preserved. Its northward course runs along the east limb of that syncline and just west of a major east-west trending structural high in the pre-Tertiary rocks which projects into Bolivia from northern Paraguay. This high has been active through geologic time as evidenced by the fact that the basal Gondwana unconformity cuts down into the Devonian rocks eastward onto the high and the unconformity at the base of the Tertiary also truncates the Gondwana progressively deeper toward the east. Along a line just east of the Parapeti, the Tertiary unconformity cuts all the way through the Cretaceous and Gondwana rocks, placing the Tertiary directly on the Devonian.

In Bolivia, all oil production to date is located in the extreme eastern fringe of the Andes Mountains in Devonian and Lower Gondwana sandstones. The Gondwana production is concentrated in the south of the country where suitable Devonian reservoir sands are not developed and where a thick section of impermeable gritty shales is present in the top of the Lower Gondwana. Various possibilities for production in the Parapeti area exist. Except in the very axis of the frontal syncline, the Devonian is within economic reach of the drill. Closed structures are present in the area and are especially attractive east of the Parapeti River where the Devonian lies within 1,000 feet of the surface. There is also the chance of updip pinch-outs and accumulations against the Gondwana unconformity. In the Gondwana, oil may be present in local structural traps within the major syncline, in updip sand pinch-outs or updip against the overlying unconformity.

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Continental Shelf of East Coast as Possible Future Petroleum Producing Province

Despite the negative results of more than 200 test wells drilled to date on the emerged coastal plain north of Florida, the sedimentary section as much as 17,000 feet thick that underlies the 1,100 mile-long continental shelf on the east coast of the U. S. appears from several points of view to be a likely petroleum target. A northern coastwise extension of the Paleozoic sedimentary rocks found in the subsurface of Florida and Georgia, although conjectural at present, may be of considerable size, and the strata there may also be relatively unmetamorphosed. Parts of the shelf area have probably been receiving sediments nearly continuously since the Paleozoic. Unconformities and successive updip wedgeouts of Mesozoic and Tertiary marine sediments that perhaps include reefs must be common, especially offshore, and granite washes are probably present near basement. Downfaulted Triassic basins apparently similar to those in the Piedmont are known to underlie the emerged coastal plain; other down-faulted basins containing sediments of Triassic and other ages might also be expected beneath the continental shelf. Although large structural features are present along the shoreline, for example the Cape Fear arch and the Southeast Georgia basin, there is as yet little evidence available as to smaller-scale structures. The large seismically-determined ridge with flanking troughs located near and subparallel to the outer edge of the continental shelf must have had a pronounced effect on the shelf strata either during sedimentation, by later deformation, or both.

Near-shore marine sediments interfingering updip with continental sediments, deposited in what may have been the shelf and hinge line of a mobile belt, and totalling 175,000 cubic miles (emerged coastal plain included), seemingly constitute a setting favorable for the accumulation of oil.

RAY P. WALTERS, Atherton, California

Surani, Rumania, Anticline with Two Erosion-Depleted, Non-Contemporaneous Oil Reservoirs

The Surani anticline has two formations exposed with sands containing a residue of oil—Meotic of the Pliocene and Kliwa of the Oligocene. These represent oil reservoirs which have been depleted by erosion. The oil sands of the upper reservoir bear a normal relation with the anticline but those of the lower do not.

The sand series in which the lower reservoir occurs is oil-free along the crest of the anticline at its highest point and down the north flank, but in going down the south flank and down the plunge to the northeast these sands suddenly are found to carry the oil residue. The break from white "barren" sand to oil sand is along a sharply defined plane. This plane, where it can be seen clearly in a bed dipping 15° south, is inclined 45° to the bedding plane and 60° to the horizontal, with the oil sand being on top and on the downdip side. The plane is thought to represent a former oil-water contact.

These conditions are interpreted to mean that the oil was originally collected in some trap to the south of the Surani anticline and furthermore that this reservoir was formed and depleted before the Surani anticline came into existence. This latter event took place in pre-middle Miocene time. The oil sands one sees today were at the north limit of the reservoir and at the time of depletion were dipping 45° north.

ROBERT J. WEIMER, Colorado School of Mines, Golden, Colorado

Geometric Patterns, Upper Cretaceous Sandstones, Rocky Mountain Region

The Cretaceous of the Rocky Mountain region contains sandstones that were deposited in marine, transitional, and non-marine environments. Geometric patterns of sandstones deposited in shallow neritic and transitional environments are regular in character and are easily defined. Only these sandstones are here considered and units illustrating their minimum and maximum geometric aspects are treated.

Minimum-size sand bodies are well shown by the Fox Hill sandstone where it is exposed on the northeast flank of the Rock Springs uplift, Wyoming. This formation consists of a series of barrier-bar sandstones that change northwestward to lagoonal shales (Lance formation) and change southeastward to marine shale (Lewis shale). Detailed surface analysis of one barrier bar shows a thickness ranging from 30 to 50 feet and a width of 5 miles from the lagoonal shale and sandstone facies to the marine shale and siltstone facies. Each bar is believed to have extended along much of the western margin of the Cretaceous seaway.

The Judith River formation of central and eastern Montana exemplifies a transitional and marine sandstone unit have a maximum width. The unit is 50–75 miles wide and was deposited between lagoonal shale facies to the west and marine shale facies (Pierre shale) to the east. Thickness of the unit varies from 50 to 100 feet.

The geometric pattern of most of the sand bodies that accumulated along the Cretaceous shoreline is similar in character to the above examples and ranges in size between these extremes.

J. LAMAR WORZEL and MANIK TALWANI, Lamont Geological Observatory, Palisades, New York

Gravity Measurements on Continental Margins

Gravity sections are presented for 10 profiles off the east coast of North America. The gravity effects for the upper sedimentary layers and the basement rocks, observed by seismic refraction measurements, are computed and subtracted from the gravity sections. The residual anomalies are attributed to fluctuations of the mantle surface. The shape of this surface which accounts for this residual anomaly is computed. The transition from a continental type crust to an oceanic type crust occurs fairly abruptly within a distance of about 200 km. The true continental edge is located at about the 1,000-fathom depth curve in the ocean.

Sections across continental margins of the west coast of Central America, the west coast of Chile, and the west coasts of Europe and Africa are compared with those of the east coast of the United States. Though differing considerably in details, the main features are somewhat similar.

A.A.P.G. HONOREES, 1960

HENRY VAN WAGENEN HOWE

SIDNEY POWERS MEMORIAL MEDALIST[1]

H. N. FISK[2]
Houston, Texas

HENRY VAN WAGENEN HOWE

In bestowing the Sidney Powers Medal award upon Henry Howe, our Association is paying homage to a man truly dedicated to geology, and to one who has contributed greatly to advancing petroleum geology by teaching, by administrative ability, and through outstanding research in stratigraphy and paleontology.

"Heinie" or "Doc," as he is affectionately known to many of us, was born in Fulton, New York, in 1896. Most of his early life was spent in Oregon where he graduated from the University in 1916 with a degree in humanities. After briefly studying law at Yale and teaching in an eastern Oregon high school, his interest in geology led him to return to the University of Oregon for graduate studies. Later he attended the University of California, and then Stanford University, where he studied under the noted James Perrin Smith, receiving his Ph.D. in 1922. That same year he accepted an appointment at Louisiana State University, and by 1931 had organized a School of Geology designed to provide broad training and to fulfill the petroleum in-

[1] Citation before the Association at Atlantic City, April 26, 1960.

[2] Humble Oil and Refining Company.