1. Know the goals—of your company or your client;
2. Strive for good ideas—they communicate better than poor ones;
3. Improve your communication mechanics—understand vocabulary, use meaningful illustrations, and organize any presentation emphasizing salient points;
4. Know the weak points and alternate solutions, and
5. *Try* to communicate.

The Toastmasters organization, though commonly considered to be only preparation for public speaking, actually trains a man to organize his thoughts and present them clearly with poise and enthusiasm in any communication situation.

The above approach should enable geologists to perforate or bend, if not shatter, communication barriers.

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LOWER CRETACEOUS OF MONTANA, NORTH DAKOTA, AND CANADA

(No abstract submitted)

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TERTIARY FORT UNION FORMATION OF NORTHERN ROCKIES

The Tertiary Fort Union Formation of Paleocene age has yielded oil and gas fields of major significance in the northern Rocky Mountain area during the past few years. Notably, the LaBarge platform area on the west flank of the Green River basin in Wyoming is the "classic" example of productivity and an excellent subject area for stratigraphic and environmental study of the Paleocene. As of January 1, 1967, the fields on the platform had a cumulative production in excess of 43 million bbls of oil and 770 Bcf of gas, produced primarily from sandstones in the Fort Union Formation.

After the uplift and erosion of the Late Cretaceous Lance Formation in the platform area, Laramide orogenic movements began with gentle uplift and truncation which cut into the Cretaceous Hilliard Formation and established an unconformity surface which subsequently was folded in response to Laramide adjustments. Following these events, general Tertiary deposition began with the formation of coaly swamps. In the steeper synclinal parts of the Green River and other intermontane basins, large bodies of water developed and thick sequences of source-bed shales filled these troughs which approached marine conditions as inland seas. The significant Fort Union production that has been found to date in the northern Rockies is associated with a beach-type environment developed along the shorelines of these inland seas. Toward the end of the time of deposition of the Fort Union, these seas were filled with sediment and only the coaly sequence remained until additional orogenic movement folded and eroded these beds—in some places as deep as the older Fort Union-sea units. The Wasatch Formation of Eocene age was deposited on this unconformity surface.

The depositional and producing environment of the Fort Union in the LaBarge platform area is not unique to the Green River basin of Wyoming. Similar conditions are evident in many other basins in the northern Rocky Mountains where little or no exploratory effort has been made to locate lucrative production similar to that found and continuing to be developed in the Green River basin.

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PENNSYLVANIAN GEOLOGY OF WESTERN MID-CONTINENT

Pennsylvanian sediments deposited between the Sierra Grande—Frontrangia positive elements and the Central Kansas uplift–Nemaha ridge trend contain large amounts of hydrocarbons. In the Anadarko basin alone almost 2 billion bbl of oil, more than 20 trillion cu ft of gas, and up to 700 million bbl of gas liquids eventually will be recovered from Pennsylvanian reservoirs. Mocane—Laverne, Camrick, Hansford, Greenwood, Keyes, and Elk City are six major Pennsylvanian fields in the western Anadarko basin. They have up to 2 billion equivalent bbls of recoverable oil in traps ranging from anticlines to purely stratigraphic. The reservoirs range from carbonate banks to alluvial sandstone and are of Morrowan to Virgilian ages.

The Anadarko and Denver basins always have been considered to be separate geologic provinces. However, during Pennsylvanian time they were part of the same geological regimen and properly should be considered together. The Amarillo-Wichita Mountains, Sierra Grande uplift and Frontrangia comprise a tectonic rim with a common orogenic history during the Pennsylvanian. The distribution of facies and depositional environments from this rim toward the stable-shelf area is similar and closely related across a broad area covering eastern Colorado, western Kansas, western Oklahoma, and parts of Nebraska, Wyoming, and Texas.

Only the Anadarko basin part of this large area has been explored actively and most of eastern Colorado and western Kansas remains a relatively virgin area for Paleozoic exploration. Because the relations of facies and environments in the whole area are similar, because the basin structure and geologic history are closely related, and because the Anadarko basin has been the scene of prolific discoveries, it could follow that the Pennsylvanian potential of the relatively unexplored area of western Kansas and eastern Colorado is very good.

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GEOLOGY OF CANADIAN HEAVY OIL SANDS

Obvious barriers that have been or could be broken by western Canadian heavy oil are in the fields of exploitation, transportation, and marketing. A geological barrier to be broken is the problem of the origin of the oil. The heavy oils appear to be at or very near the site where a discrete oil phase first was formed. An understanding of the origin of these vast accumulations of heavy oil conceivably would supply important clues to the origin of light crude oil, condensate, and gas.

There are about 750 billion bbl of heavy oil in place in western Canada and most of this occurs in sandstones of the Lower Cretaceous Mannville Group.

The belt of accumulations extends 600 mi from Peace River, Alberta, to Lloydminster, Saskatchewan. Individual accumulations appear to be controlled by early formed structural and stratigraphic traps that served as loci of deposition for the oil. The Lower Cretaceous oils belong to a single oil system and all appear to be young and immature. The most acceptable hypothesis of origin is that hydrocarbons moved out of the deep basin in micellar of colloidal solution in compaction waters and were deposited on anticlinal structures or in sandstone pinchouts. There has been only limited adjustment in the position of the oil in the traps since a discrete oil phase was formed.

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RATES OF SEDIMENTATION AND INTRABASIN DEFORMATION, UPPER CRETACEOUS, ROCKY MOUNTAIN REGION

Rates of sedimentation during the Late Cretaceous in the Rocky Mountain-Great Plains region compare favorably with rates of sedimentation shown by Quaternary sediments of the Atlantic Ocean basin margins. An average rate of about 1 in./1,000 yr is reported for Quaternary deep-water sedimentation in the Atlantic Ocean by Ericson *et al.* (1964). This rate is prevalent in regions where sediments are largely biogenetic, consisting mainly of coccoliths and foraminifers with few land-derived minerals. In contrast, rates 20–40 times greater are reported in the shoreline zones of the Atlantic. Similar rates are inferred from radiometric dates for Late Cretaceous sedimentation in the region of the Rocky Mountains-Great Plains. Slow rates approximating 1 in./1,000 yr were prevalent near the geographic center of the basin during the time of deposition of rock units such as the Greenhorn, Niobrara, and Mobridge. These units consist largely of coccoliths and foraminifers with small quantities of land-derived minerals. In the equivalent shoreline zone for each time-stratigraphic unit, rates of sedimentation are at least 20 times greater than depositional rates in the basin.

The differential rates of sedimentation greatly influenced the rates of subsidence within the Cretaceous basin. Tectonic downwarping of the basin was accentuated in some areas by sediment loading resulting from deposition in the general shoreline zone, especially in the deltaic areas. Large-scale intrabasin warping developed with structural dips as great as 50 ft/mi. Early migration of petroleum was influenced by these early intrabasin tectonic elements before destruction of the large depositional basin by Laramide folding.

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LOWER CRETACEOUS OF WYOMING AND SOUTHERN ROCKIES

Lower Cretaceous strata (essentially the Dakota Group) of Wyoming and the Southern Rockies are of considerable economic importance. To date recoverable reserves of about 450 million bbl of oil and 1½ trillion cu ft of gas have been discovered in these rocks.

Lower Cretaceous sediments were deposited in the incipient Rocky Mountain geosyncline which seemingly began to subside in this region in Aptian time. The first sediments to be laid down were inland floodplain conglomerate, sandstone, and variegated mudstone (Cloverly, Lakota, Lytle, lower Cedar Mountain, *etc.*) transported into this depression by river systems from the Sioux uplift on the east and from the Mesocordilleran geanticline on the west.

As the transgressing arboreal sea entered this part of the trough, and ultimately joined the southern sea, environmental relations became more complex. Marine shale and siltstone (Skull Creek, lower Thermopolis, and Kiowa) formed in the deeper part of the trough occupied by the sea and graded landward (eastward and westward) into sandstone, shale, and coal of the transitional littoral-marine-lagoonal, paludal, and deltaic environments (Fall River, upper Cedar Mountain, Plainview, upper Cheyenne, *etc.*). These, in turn, graded laterally into sandstone and variegated mudstone of the now restricted floodplain environment.

Toward the end of Early Cretaceous time, a low arch rose in southern Kansas and southern Colorado, separating the trough into two parts. However, continuing subsidence allowed the sea to spread greatly both east and west. Floodplain deposits (now composed of sandstone and mudstone) continued to accumulate between the source areas and the arboreal sea and interfinger seaward with shale and sandstone of the transitional environments (Omadi, "Dakota," Naturita, *etc.*). These in turn interfinger with the marine upper Thermopolis and Mowry Shales. Tongues of these formations (Newcastle, Muddy, "J," *etc.*) project seaward into the marine shale and probably represent deltaic wedges formed during minor regressions of the sea.

Petroleum has been produced from nearly all the units mentioned, representing deposits of marine, littoral, deltaic, paludal, lagoonal, and floodplain environments. Most production has come from Newcastle, "J," and Muddy sandstones which probably are deltaic and littoral marine complexes.

17TH ANNUAL MEETING OF GULF COAST ASSOCIATION OF GEOLOGICAL SOCIETIES
AND
SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS—GULF COAST SECTION
AND
REGIONAL MEETING OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
SAN ANTONIO, TEXAS, OCTOBER 25-27, 1967

GENERAL

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