15 existing giant fields in various parts of the world and interpreting whatever geologic data the images provided.

At this writing (December 8, 1978), the study has not been completed, but it seems apparent that the images would have been of considerable value in exploring for and pin-pointing the locations of most of the giant fields under study. Such a conclusion indicates that land-satellite images and remote-sensing data should be a top priority in the search for the future giants to be found in the remaining prospective areas of the earth.

HUBBARD, CLYDE, R. E. SHERIFF, and HOWARD BRISTER, Seiscom Delta Inc., Houston, Tex.

High-Resolution LANDSAT for Geologic Studies

LANDSAT images show large areas under the same illumination conditions and from a nearly constant viewpoint, thereby making it possible to see large but very subtle geologic features. Geometrically corrected images with resolving power as great as the intrinsic pixel size can be displayed in false color with the colors so distributed as to maximize the visibility of features. Evidence of geologic features as portrayed in LANDSAT images is obvious when shown with overlays.

JAMISON, H. C., and L. D. BROCKETT, Arco Oil and Gas Co., Dallas, Tex., and R. A. MCINTOSH, Arco Oil and Gas Co., Anchorage, Alaska

Prudhoe Bay, a Ten-Year Perspective

The Prudhoe Bay field is recognized as the largest oil field in the United States. The Permo-Triassic reservoirs, estimated to contain reserves of 9.6 billion bbl of oil and 26 Tcf of gas, have overshadowed other known substantial accumulations of hydrocarbons in formations ranging in age from Mississippian to Cretaceous in the general area of Prudhoe Bay. Reservoirs are in the Lisburne carbonate rocks, as well as the Kuparuk River sandstone. Other Permo-Triassic and Cretaceous accumulations are less significant.

Perhaps unrecognized, except in retrospect, is the significance of the planned sequential availability of both federal and state lands on the North Slope beginning in 1958. An 11-year period of land availibility followed a 14-year moratorium. Exploration that led to the discovery in 1968 culminated with the September, 1969, State of Alaska "Billion Dollar Sale."

The post-discovery sequence of exploration, development, and production in the area has been characterized by environmental, social, legal, political, and economic complexity and controversy. Comparison of the status of petroleum exploration today on the North Slope of Alaska with the history of the 1950s through the early 1970s is an object lesson for explorationists.

JONES, VICTOR T., and R. J. DROZD, Gulf Research & Development Co., Harmarville, Pa.

Predictions of Oil or Gas Potential by Near-Surface Geochemistry

A near-surface hydrocarbon soil-gas technique developed by Gulf Research & Development Co. has been shown to be capable of predicting whether oil or gas is more likely to be discovered in the prospect area. These predictions are made by using the percent compositions and ratios of methane to ethane and propane. Typical average values are:

	Methane	*Methane/Ethane*	*Propane/Methane (X1,000)*
dry gas	100-90	200-20	2-20
gas-cond.	90-75	20-10	2-15
oil	75-45	10-4	60-500

Intermediate values are expected for many hydrocarbon accumulations.

Extensive studies compiled and reported in the literature have clearly shown that reservoired hydrocarbons contain varying amounts of methane and heavier homologs. Frequency histograms of the sum or ratio of methane homologs illustrate that gas from gas deposits is quite distinguishable from gas in oil deposits. Gases from gas-condensate or combined oil and gad provinces plot intermediate between those of gas or oil only provinces as expected.

Light-hydrocarbon ratios have been used successfully to predict the petroleum potential of a formation by monitoring C_1 to C_5 hydrocarbons from a steam-still reflux gas sampling system during routine mud-logging operations. Individual ratios of the C_2 to C_5 light hydrocarbons with respect to methane have been demonstrated to provide discrete distributions which reflect the true natural variations of formation hydrocarbons between oil and gas deposits. Analyses of these same ratios for soil-gas hydrocarbons yield nearly the same limits for delineation of oil and gas potential. This correspondence with the actual formation gases shows that the upward migration of reservoired light hydrocarbons into near-surface soils represents a viable mechanism, allowing near-surface geochemical exploration techniques to be utilized for prospect evaluation.

Normalized histograms of composition data have been constructed which better represent the actual near-surface hydrocarbon populations.

MOUSSEAU, RICHARD J., and JOHN C. WILLIAMS, Gulf Research & Development Co., Harmarville, Pa.

Dissolved Hydrocarbons in Coastal Waters of North America

Dissolved methane and propane concentrations were measured aboard Gulf's exploration vessels, the R/V *Hollis Hedberg* and the M/V *Gulfrex*, on the continental margins of North America. Propane concentrations of less than 0.5 nL/L were observed in a majority of the samples in many of the areas studied. This observation is in agreement with open ocean concentrations reported by Swinnerton and Lamontagne. However, in a highly petroliferous area such as the Louisiana offshore, higher propane concentrations are more common with one-third of the samples exceeding 2 nL/L. In the Louisiana offshore, three-fourths of the samples contained

over 250 nL/L of methane, whereas the reported open-ocean concentrations show a majority of the samples contained less than 50 nL/L.

Generally, on the continental shelf a local contribution is more common for methane than for propane.

The seawater hydrocarbon concentrations have been compared with the U.S. Geological Survey estimates of undiscovered oil and gas resources in each of the offshore geologic provinces where data were collected.

PLAFKER, GEORGE, G. R. WINKLER, P. R. CARLSON, T. R. BRUNS, U.S. Geol. Survey, Menlo Park, Calif., and GEORGE CLAYPOOL, U.S. Geol. Survey, Denver, Colo.

Petroleum Potential of Eastern Gulf of Alaska Shelf Based on Dredge Samples from Adjacent Continental Slope

Bedrock dredging in water depths between 4,060 and 550 m along the continental slope in the eastern Gulf of Alaska has revealed the existence of a previously unknown Eocene sequence that locally includes potential source and reservoir rocks. Argillaceous rocks in the sequence are soft to moderately indurated dark-brown shales and commonly glauconitic, pyritic, and in part concretionary or laminated siltstones. They locally contain extremely abundant microfossils, large fish scales, and carbonized plant fragments. Associated with the argillaceous rocks are relatively clean quartzofeldspathic sandstones that are in part carbonaceous and calcareous, sandstone matrix cobble-boulder conglomerate, and palagonitized basaltic tuff. The rocks range in age from late early Eocene to late Eocene and were deposited in relatively warm water at depths ranging from shallow to bathyal.

Source-rock analyses indicate that argillaceous rocks from six of the dredge hauls located between Yakutat Seavalley and Alsek Canyon contained more than 1% and as much as 1.6% organic carbon; the rocks are thermally mature to slightly immature and one sample contained extractable saturated hydrocarbons. Sandstone porosities are generally moderate and permeabilities are very low. However, recovery of one friable sandstone with 23.8% porosity and 35.9 md permeability suggests the presence of possible reservoirs in the sequence.

Seismic reflection data indicate that the Eocene sequence with the most favorable source potential dips northward from the slope beneath the adjacent Yakutat shelf where it could be a possible petroleum source and exploratory target.

RICE, G. W., and B. M. BRANDT, Continental Oil Co., Ponca City, Okla.

Wave-Form Factor Analysis—Quantitative Approach to Seismic Stratigraphy

Stratigraphic prospecting methods have made extensive use of seismic reflection data during recent years. Although many of these qualitative concepts have helped geoscientists define lithologic patterns and their characteristics with improved accuracy, quantification of the methodologies has been difficult. Multivariate statistical methods are useful in delineating and characterizing wave-form patterns from a multiplicity of seismic reflection lines. Recursive factor-analysis methods are used first to identify the number of wave-form patterns that exist in a particular zone of seismic data and then to assign each seismic trace to a particular wave-form group (or seismic facies).

This analysis yields two products: average and end-member wave forms for each of the various groups and a distribution map of the classified wave forms. Resulting average and end-member wave forms can be used in conjunction with well information and/or seismic models to infer a lithologic meaning for the seismic facies. The map of classified wave forms can effectively augment other geologic data and concepts in establishing environments of deposition and other distributional information. Further quantification of the wave-form patterns can be established through discriminant-analysis procedures. These resulting classification functions are useful when new data are integrated into the analysis and when correlating well information with the wave-form data.

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Quantitative Comparison of Geologic Maps to Petroleum Prospects

The problem of deciding on the best geologic parameter and mapping procedure for prospect location can be simplified by the use of similarity maps and comparison functions. Structural or other geologic data are contoured by digital computer, filtered to extract and enhance specific features, then tested against areas of known production. Tests include the application of similarity maps that can be used to locate the specific areas that are most similar to those that are known to have production. Statistical comparison functions help to minimize personal bias in choosing the best mapping procedure.

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Tertiary and Cretaceous Ocean Temperatures

Oxygen-isotope paleotemperature studies of marine microfossils, primarily from DSDP cores at several laboratories, have in the past few years yielded a great deal of information about the three-dimensional temperature structure of the oceans and its evolution during the past 100 m.y. As expected, because of problems of sample preservation, climatic information is progressively less detailed for successively older times.

The general trend of ocean temperatures since middle Cretaceous time has been downward. However, the downward trend has not been uniform, but has been punctuated by frequent intervals of rising temperatures. Temperatures fell and then rose again near the time of transition from Tertiary to Cretaceous, but the magnitude of the temperature decline was much smaller than other temperature declines observed in the marine isotopic record of the past 100 m.y. Two striking features