fore do not yield oily pyrolysis residues. The disappearance of pyrolysis residues from rock samples representing deep-burial and high-temperature histories relative to those which yield good residues at shallower depths and lower temperatures may be utilized to determine the depth of the oil-generating to gas-condensate-generating maturity threshold.

The technique has been utilized to map source-rock distributions and maturity thresholds in the Pennsylvanian of the western Anadarko basin.

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Development of Petroleum Resource Appraisal Methods in U.S. Geological Survey and Role of Appraisal Group in Resource Assessment Studies

In 1973 the Oil and Gas Resource Appraisal Group was originated within the U.S. Geological Survey (USGS) to develop resource appraisal methodology and apply these methods in assessing the nation's petroleum resources on a regional basis. The resource appraisals were published in USGS Circular 725 on the undiscovered oil and gas resources of the United States for 102 geologic provinces. Since this first assessment, the evolution in the development of petroleum resource appraisal procedures within the Resource Appraisal Group has been significant.

The appraisal methods are designed to evaluate all the known geologic and geophysical data available for a prospective petroleum basin or province. Resource appraisals can be made with any amount of data. However, the amount and kinds of data available will determine the method or methods to be used in the appraisal for any basin or stratigraphic unit. Methods will also change with time, as the amount and nature of the information in a specific area will vary with exploration activity and availability of data.

In frontier areas of exploration (where only gross interpretation of the basin geology is available) by applying the principles from worldwide experience for the occurrence of oil and gas it is feasible to use subjective judgment with minimum data to provide an estimate of the potential petroleum resources. More advanced methods employing objective data and statistical analysis are being employed when increased exploration provides an expanded data base. The methods used in making resource assessments are evolving in complexity to the point that we can deal with exploration plays by stratigraphic units within each prospective province. In areas where data are extremely abundant, the choice of methods used may become more a function of the objectives of the resource assessment and the availability of staff for the study. If data and time permit, the ultimate approach for a complete resource assessment is to use as many methods as possible as a means of cross-checking results.

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Geochemical Exploration in Powder River Basin, Northeastern Wyoming and Southeastern Montana

Combined geochemical and geologic information from this structural basin accurately delimited areas and stratigraphic sequences prospective for crude oil and thermal hydrocarbon gases. Using volumetric and performance data for each effective source sequence, quantities of expelled oil and gas were calculated which readily account for in-place oil reserves of more than 6 billion bbl and minor amounts of associated gas.

Oils expelled from Lower and Upper Cretaceous source beds are similar. The Mowry siliceous shale and Niobrara calcareous shale and marl expelled most of the oil indigenous to the basin. A second major oil type is correlated to the remote Permian Phosphoria source area centered in southeastern Idaho. Oil migration paths have been mapped, gathering areas identified, and time of migration determined. Three of five giant oil fields—Salt Creek, Lance Creek, and Bell Creek—are located on separate gathering areas around the basin periphery. Hilight and Hartzog Draw fields are stratigraphic traps paralleling structural strike on the basin's eastern flank, oriented to receive maximum flow of migrating oil.

An Early Jurassic regional migration emplaced Phosphoria oil in upper Paleozoic reservoirs before the basin formed. Expulsion from deepest Cretaceous source rocks began in Eocene time and probably continued into Pliocene time as the expulsion front moved upsection and updip. Laramide structure controlled migration of Cretaceous oil.

Recharge water affected oil preservation. Consequently, temperature and salinity anomalies are commonly associated with accumulations in recharge areas, where two types of bacterial alteration are recognized.

More than 20 mutually supporting chemical and physical parameters from rocks and fluids proved useful in defining prospective areas.

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Domestic Oil Reserves Forecasting Method and Assessment of Regional Potentials

The forecasts of undiscovered giant oil fields in the United States, beginning with the initial study in 1960, seemingly have predicted subsequent exploration results with considerable accuracy. The probable number of undiscovered giant fields was predicted from the trend in discovery rates during previous decades.

The forecast number of undiscovered giants, multiplied by the average recoverable oil content in discovered giants, approximates the amount of recoverable oil in undiscovered giants. This value is then enlarged by the proportion of recoverable oil discovered in nongiant fields relative to giant fields. The resultant is the total undiscovered resource of new oil, using existing recovery capabilities. The quotient was adjusted upward for anticipated improvements in enhanced recovery technology to obtain the amount of ultimately recoverable oil in all undiscovered domestic fields.

Remaining reserves of discovered oil also were adjusted upward using a similar enhancement value. Based on established trends, future additions to existing reserves resulting from extensions, deeper pool, and