occur where upper Minnelusa dune sands are encased in the overlying supratidal red Opeche Shale (Permian). The morphology of these sands suggests northwest-southeast-trending barchanoid sand ridges.

Thickness variations in the Opeche mirror the relief on the Minnelusa surface. Opeche isopahcous maps are one of the main methods used to explore for Minnelusa paleotopographic traps. Hand-contoured isopachous maps can be subject to ambiguous interpretations in areas of low-density control. This difficulty is partially overcome when the map is mathematically produced.

Observations from oil tests in the area indicate that Minnelusa paleotopography is cyclic with a wavelength of approximately 3 mi (5 km). Double Fourier transforms are appropriate in modeling this kind of cyclic data.

For a test township, the calculated double Fourier surfaces showed good correlation with the actual data values. This technique was then applied to a Minnelusa prospect in Campbell County, Wyoming.

Double Fourier surfaces were calculated for several structural datums and isopach intervals. Additionally, regional dip was determined from a polynomial fit, the section was restored to horizontal, and then was modeled to reveal paleotopography.

The paleotopographic-high axes and Opeche thin axes showed remarkable coincidence. This trend is believed to represent the trace of a paleo sand dune.

A test well sited using conventional geologic methods plus input from the double Fourier maps confirmed the accuracy of the calculated surface.

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United States Assessment Procedures and World Energy Resources Program

Resource assessment is a people-oriented endeavor. At every stage of the exercise, good judgment is essential to satisfactory results. There is no single procedure that can guarantee an approximation of truth, but clearly there are procedures and techniques to be selected from within the context of the problem to be solved that serve to lessen subjectivity in the final outcome.

The U.S. Geological Survey has had the responsibility of determining petroleum potential, especially for basin size areas. This determination assists in the decision process relative to lease sales, wilderness areas, and international relations. Our requirement is basin understanding, not exploration well siting. Considering the dimension of the objectives, the time frame of need, and the resources available (both people and data), volumetric analysis at the level of the play (group of prospects) is rarely practical. Rather, as described in U.S. Geological Survey assessment documents, we have utilized a variety of volumetric/analogy techniques, sometimes comparing with Klemme classifications, with specific United States or foreign basins, or internally within the basin being assessed, which in effect is a degree of maturity analysis. The petroleum geology of the basin and the results of the various number-generating processes are then subjected to the Delphi process, as reported elsewhere, for the group assessment.

The assessment so determined is the hypothesis of the petroleum potential of the area. Because the hypothesis derives from an analysis of petroleum parameters such as source rock, reservoir rock, traps, and seals (which data are published), it is subject to testing as exploration proceeds or as new data are made available. The advantage of the assessment is only partly in the number. In addition, the organization of data permits the recognition of anomalies in the exploration process or in resource reports, thus permitting ongoing adjustments in the assessment or its analysis.

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Geology and Petroleum Potential of Hanna Basin, Carbon County, Wyoming

The Hanna basin is one of the world's deeper intracratonic depressions. It contains exceptionally thick sequences of mature, hydrocarbon-rich Eocene through Paleozoic sediments, and has the requisite structural and depositional history to become a major petroleum province.

Stratigraphic traps exist within the deeper central parts of the basin in low permeability, possibly overpressured Eocene, Paleocene, and Upper Cretaceous rocks. The Eocene-Paleocene Hanna and Ferris Formations consist of up to 20,000 ft (6,100 m) of organically rich lacustrine shales, coals, and fluviatile sandstones. The Upper Cretaceous Medicine Bow, Lewis, and Mesaverde formations consist of up to 10,000 ft (3,050 m) of marine and nonmarine dark, organic-rich shales that enclose many stacked hydrocarbon-bearing sandstones.

Structural prospecting should be most fruitful around the edges of the basin where Laramide flank structures exist. Deformation of the Hanna basin sediment package into its 30-mi (50-km) wide by 8-mi (13-km) deep present configuration should have produced out-of-the-basin thrusts terminating in closed anticlines. Strata along the northern margin of the basin, located on the southward-displaced Emigrant Trail–Bradley Peak-Shirley thrust complex, were crumpled into anticlinal folds such as O'Brien Springs and Horseshoe Ridge. Oil and gas ranging in age from Pennsylvanian to Upper Cretaceous have been found in these structures.

Only 7 wells have been drilled in the deeper part of the Hanna basin. Two of these tested gas at commercial rates from Upper Cretaceous rocks at depths from 10,000–12,000 ft (3,050–3,660 m). Sparse drilling along the basin flanks has revealed structurally trapped oil and gas at depths from 3,000–7,000 ft (915–2,130 m). The encouragement from the few wells drilled indicates that a more concerted exploratory effort in the Hanna basin is justified.

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Petroleum Potential of Serpentine Plugs and Associated Rocks, Central and South Texas

During deposition of the Upper Cretaceous Austin Chalk and Taylor Marl, "serpentine plugs" formed by submarine volcanic activity along major fault zones in the ancient Gulf of Mexico. After eruption, palagonite-tuff mounds, formed by the hydration of basaltic glass, localized deposition of shoal-water carbonates on topographic highs.

The serpentine plugs occur along an arcuate belt extending approximately 250 mi (400 km) from Milam County southwestward to Zavala County, Texas

Hydrocarbon traps in and around serpentine plugs have yielded approximately 47 million bbl of oil and significant quantities of natural gas from altered volcanic tuff and associated shoal-water carbonates. Shallower production is from overlying sedimentary rocks structurally influenced by volcanic plugs.

Entrapment of hydrocarbons occurs as: (1) stratigraphic traps within porous zones of carbonate units; (2) stratigraphic traps within porous volcanic tuff (serpentine); (3) structural traps within overlying sands; and (4) traps within high-porosity fracture zones. Exploration for plugs should be concentrated along existing fault zones by either magnetic or seismic surveys.

Analysis of the plugs suggests that there are at least 3 distinctive groups: (1) a southern group characterized by well-developed and productive marginal sands; (2) a middle group characterized by hydrocarbon-saturated biocalcarenite and reworked volcaniclastic facies; and (3) a northern group in which the dominant hydrocarbon saturation is in the volcanics themselves. Each of these groups appears to reflect a somewhat different geologic history.

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Provenance and Diagenesis of Ivishak Sandstone, Northern Alaska

The Ivishak sandstone of northern Alaska is a regressive sequence of Lower Triassic fluvial and paralic deposits that constitutes an important hydrocarbon reservoir in the Prudhoe Bay area. A petrographic study of the formation, utilizing samples from wells from both reservoir and nonreservoir rocks, was undertaken to determine the provenance and diagenetic histories of the formation.

The Ivishak sandstone can be characterized as a low-rank or lithic graywacke. The major detrital species it contains include: (a) quartz (46%), dominantly reworked sedimentary and volcanic monocrystalline quartz and metamorphic polycrystalline quartz; (b) chert (22%), containing variable amounts of inclusions (clay and carbonate); (c) sedimentary rock fragments (10%), largely mudstones and silty mudstones; and (d) meta-