southwest margins of the basin. The occurrence of gas correlates reasonably well with this finding. Both the marine and nonmarine Mesaverde are within the window of oil generation for most of the basin, except in the deeper parts where the upper limit of oil stability has been exceeded. Oil, however, is seldom encountered in the basin, probably because of a lack of abundant source beds with oil-generating capabilities.

The vitrinite values are much too high to have formed under the present geothermal gradient, which averages about 1.7°F/100 ft (3°C/100 m), and appear to reflect a paleothermal gradient of between 2.2 and 3.5°F/100 ft (4 and 6.3°C/100 m), with the highest gradients in the southern part of the basin. It is suggested that this high gradient occurred during Oligocene time when the southeastern part of the basin was extensively intruded by magmas of intermediate composition.

Overpressuring has thus far only locally been encountered in the basin. The lack of a well-defined overpressured area may be a combination of: (1) a decrease in the geothermal gradient since Oligocene time, and (2) uplift and removal of overburden during the last 10 million years. As much as 5,000 ft (1,500 m) of overburden has been removed in some parts of the Colorado River drainage.

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Eocene Chuckanut Formation of Northwest Washington—Sedimentation in a Large Strike-Slip-Fault Controlled? Basin

The Eocene Chuckanut Formation of northwest Washington comprises as much as 6,000 m (20,000 ft) of alluvial strata and is one of the thickest nonmarine sequences in North America. It is exposed in several disconnected outcrop belts that are probably remnants of a regionally extensive fluvial system. Four distinct periods of sedimentation are represented in the main (50 × 20 km, 31 × 12 mi) Chuckanut outcrop belt near the town of Bellingham. These include: (1) early Eocene: rapid sedimentation in west-southwest-flowing fine-load meandering rivers; (2) early-middle Eocene: sedimentation in braided rivers draining northern fault blocks in the western part of the outcrop belt, synchronous with continued fine-load meandering-river sedimentation to the east; (3) middle Eocene: sedimentation in a south-flowing, coarse-load meandering river system in the western part of the outcrop belt, synchronous with continued sedimentation in west-flowing, fine-load meandering rivers of reduced size and competence to the east; and (4) middle to late(?) Eocene: sedimentation in alluvial fans and braided rivers in the eastern part of the outcrop belt draining uplifted pre-Tertiary basement north of the Boulder Creel fault. Following period 4, but still in the Eocene, the Chuckanut was first folded and then truncated by faulting.

It is proposed that the Chuckanut basin formed in an extensional zone of right lateral shear between major strike-slip faults. Consistent with this interpretation are: (1) rapid sediment accumulation rates; (2) rapid facies changes; (3) an irregular basin margin characterized by dip-slip faults and intraformational unconformities; (4) deformation consistent with predicted structural patterns; (5) rapid changes between extensional and compressional tectonics; and (6) interbedded and intrusive relationships with extension-generated(?) volcanic rocks. The Chuckanut basin is considerably larger than most pull-apart basins generally associated with strike-slip faulting, yet shares many of the same attributes. Similar large basins might be found in other continental margins characterized by strike-slip faults.

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Ranking South Louisiana Trends by Probability of Economic Success

Hydrocarbon exploration is an economic and a probabilistic enterprise. Especially in mature provinces, where the giant discoveries have mostly already been made, we must incorporate probability and economics into exploration if our efforts are to be successful. Not even the largest companies have the resources to be active in all the exploratory plays possible; we find ourselves concentrating on only a small number of the available plays.

This choice of where to explore should be made by defining the objective of exploration and then concentrating on those plays which have the highest probability of achieving that objective. For a limited partnership drilling fund, the objective was formulated as a 3:1 present worth return on the money risked by the investors. A trend analysis process was developed which combines the probability of making a discovery with the probability distribution of reserves found to determine the probability of obtaining a desired return.

The industry's performance was analyzed for the years 1970 through 1981. For the foreseeable future we will be using the same technology as the 1970s and can reasonably expect the continuation of the trends of physical results (success ratios and the size distribution of discoveries). These physical results were combined with price and cost forecasts for the 1980s to obtain a realistic projection of expected exploratory success.

The steps in the analysis are as follows. (1) Geological Classification—A data base was developed containing the well information on 4,800 new-field and other exploratory wells drilled in south Louisiana. Each well was classified as to the objective formation and as to the producing formation(s) if successful. Twenty-nine separate trends were identified and analyzed. (2) Exploratory Drilling Data Analysis—A computer program was written to sort the well data by trend, project and exploratory success ratios for oil and gas, and prepare depth and cost analysis. (3) Reserves Added Analysis—Reserve estimates were made for 858 (557 gas, 301 oil) discoveries by projecting rate-cumulative production decline curves. Discovery sizes for the trends exhibited the expected log-normal frequency distributions. (4) Economic Projections—Using projected costs and product prices, a profile was developed for each trend of present worth profit as a function of discovery size. As usual, many discoveries can be expected to be "geologic successes but economic failures." (5) Probabilistic Analysis—Utilizing the Monte Carlo technique, a computer program was written to realistically simulate an n-well exploration program. The result for each trend was a cumulative frequency distribution of the return per exploration dollar. Using the same exploratory budget for all trends allowed us to rank trends based upon the probability of achieving the desired present worth return or better. Examples are presented for trends of varying rank.

In summary, computer data banks were used, along with thorough geologic analysis and some common sense, to provide a sound basis for concentrating exploration effort on those trends where we are most likely to achieve our objective.

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Frontiers in Organic Geochemistry

During the past 20 years, an explosion has occurred in both the