parameters in combination. These results are achieved by using a new quantitative approach based on concentrations and ratios of specific biomarkers by integration of mass chromatograms. The assessment of all parameters in combination results in a well-documented, internally consistent picture permitting the above conclusions. In addition, these biomarker data permit in hindsight a reasonable interpretation of the wide range of carbon isotope data. All results are consistent with the geologic setting. The approach adds a new dimension in assisting the petroleum explorationist toward paleoreconstruction.

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South-Aniuy Suture (West Chukotka)

The geologic data indicate that Phanerozoic and probable late Proterozoic rocks of Chukotka and Alaska are very similar. The paleomagnetic results indicate that during most of the Phanerozoic, the drift of the North American craton did not conform to the drift of the Siberian craton. This contradiction can be settled only by searching for a suture within the bounds of northeastern Siberia, along which the North American plate once apparently collided with the Siberian plate. To the west of the Okhotsk-Chukotka belt there is only one suture possessing all the features of an ophiolitic suture—the South-Aniuy. Its characteristic features are linearity, large extent, and abundant ophiolites and turbidites. It is probably the site of the collision of the Hyperborean and North Asiatic plates. During the Late Jurassic these plates collided with the accompanying subduction of the oceanic lithosphere southwestward and the formation on the northern margin of the Omolon massif of a zone of island arcs and back-arc basins with characteristic sedimentation and magmatism. On the whole the geologic data on the structure, metallogeny, and history of development of West Chukotka agree with the hypothesis of a marginal-continental location of wide regions of the northern part of the Omolon massif over a former subduction zone. The Late Jurassic (Volgian) volcanism fixes the most active deformation along this zone and the bringing together of the plates. More clear becomes also the position of the Triassic volcanism of the Oloy-Aniuy interfluve which probably reflects another, but more transitory appearance of a subduction zone on the margin of the continent.

After collision (possibly with some transcurrent movements) of the Hyperborean and Asiatic plates, the geodynamic conditions in the northeastern part of Asia changed and the whole territory to the west and the north of the Okhotsk-Chukotka belt was already a united continental monolith with an old "cicatrice"—the South-Aniuy suture zone.

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Changing Patterns of Phosphogenesis in Mesozoic and Cenozoic

During the Mesozoic and Cenozoic Eras, major global phosphogenic episodes occurred during the Upper Cretaceous-Eocene and Miocene Epochs. A minor phosphogenic episode occurred during the Jurassic Period.

The Jurassic and Miocene phosphogenic provinces were primarily located on the eastern sides of oceans on continental shelves where upwelling ocean paleocurrents were associated with paleotrade winds. Major exceptions are the Miocene phosphorites of the southeastern United States which probably were associated with the paleo-Gulf Stream, and the Miocene phosphorites of the Chatham Rise, New Zealand, which possibly were associated with the Antarctic circumpolar paleocurrent. The Miocene phosphorites probably were the result of increased vertical oceanic circulation, mainly trade-wind belt coastal upwelling. Jurassic phosphorites appear to be paleo-oceanographically analogous to the Miocene phosphorites.

The Late Cretaceous-Eocene phosphogenic province was primarily an east-west equatorial circumglobal province of Tethys and Pacific seamounts. The Upper Cretaceous-Eocene phosphorites of the Atlantic paleo-ocean continental shelves in Togo, Gabon, Senegal, and Brazil are an exception to this distribution. The major Upper Cretaceous-Eocene phosphorites probably were the result of vertical circulation due to equatorial divergent upwelling.

Tertiary and Mesozoic phosphogenic episodes appear to be due to a combination of the onset of increased rates of oceanic circulation after periods of oceanic stability, periods of high sea level, and favorable paleogeography.

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Economics of Small-Scale Oil Shale Retorts

A graphic portrayal of conventional oil in the United States and Saudi Arabia since 1880, vis-a-vis a series of predictions since 1918 of the economic feasibility of obtaining oil from shales, has been used to examine the problems and prospects for commercialization of oil shale in the United States. Time series analysis, and analogy to R. M. Catlin's 1920 commercial plant and Union Oil's 1957-58 aborted commercial entry reveal that the economic infeasibility of shale oil is not merely the result of inflation; subjected solely to the influences of inflation, oil from shale would today cost only slightly more than $8.00 per barrel.

Given this rejection of inflation as the prime deterrent to commercialization, the most critical factors which continue to cause cost projections for shale oil to exceed even OPEC's escalation of oil prices since 1973 are identified. The work of Edward W. Merrow and the RAND Corp., have identified some of these constraints. A review of state-of-the-art extraction and environmental technology, and the more common theories as to the continued economic infeasibility of commercial scale plants lead to a focus on seven specific factors—two economic and one each of technologic, financial, logistic, environmental, and socio-economic/political.

A potential resolution or significant mitigating influence has been identified for each of these factors, the proposal's synergism examined and commercial operation under it compared to more conventional alternatives. A conceptual feasibility study and computer sensitivity analysis reveals the potential for oil shale prices well below those of conventional oil. Based on current oil industry statistics, a forecast of the long-run market potential of shale oil and a surprising estimate of eventual market segmentation have been made.

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Highlights in History of Geophysical Exploration

While some preliminary geophysical studies were made in

the 19th century and even earlier, exploration geophysics first became important about 1922-23 with the mapping of salt domes in the United States and Mexico by torsion balance and seismic refraction methods. This paper will recount highlights of the history and will attempt to explain why events occurred when and as they did, and will speculate on what may be expected in the future.

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Comparison of Solution-Mineral Equilibria with Single-Element and Statistical Methods in Hydrogeochemical Exploration for Uranium

Hydrogeochemical data, generated by the Department of Energy's National Uranium Resource Evaluation program, for the Millett 1° × 2° NTMS Quadrangle in Nevada can be used to identify geologic environments which might contain uranium deposits.

Saturation indices (SI) were calculated for uraninite, pitchblende, coffinite, autunite, tyuyamunite, and carnotite using a modified version of the WATEQF computer program. Uranium mineral SI's correlated well with the logarithm of total U concentration in ground water. Ground waters from the Austin Mining District possess the highest autunite SI values, although undersaturation is indicated. A spring in the Toquima Range (Tertiary rhyolites) is supersaturated with respect to uraninite and coffinite, and has the highest (but slightly undersaturated) SI value for pitchblende.

Samples within the Austin Mining District are anomalous with respect to U, As, Cu, Mo, and U/conductivity. The Toquima Range sample is anomalous in U, Mo, As, Cd, Fe, and U/conductivity. In a factor analysis of the Millett data, water temperature (Tw), U, Eh, Si, and V load on factor 3. High factor 3 scores are found in, but are not restricted to, the Austin Mining District and the Toquima Range. Multiple regression analysis of the data resulted in the equation: $U_{calc} = f(Tw, Cl, Ca, Mg)$. High residuals ($U_{obs} - U_{calc}$) are located in the Austin Mining District and in the Toquima Range.

Calculated SI's reinforce, but are apparently not a substitute for, the standard statistical interpretation of reconnaissance ground water data, and may indicate the type of uranium mineralization present.

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Sedimentary Processes in Restricted Gulf Coast Estuarine System: Corpus Christi Bay, Texas

Corpus Christi Bay is a shallow (< 5 m), restricted estuary that is typical of estuaries on the Texas Gulf Coast. The distribution pattern of bay-floor sediments indicates that the bay's interior is a depocenter for mud derived from multiple sources; the bay's marginal areas are composed mainly of residual sandy deposits derived from shoreline erosion of a Pleistocene substrate (Beaumont Formation) and a modern baymouth barrier (Mustang Island).

Synoptic time-sequence measurements of the bay's suspended sediment and hydrographic characteristics were taken by helicopter at 15 monitoring stations; the measurements represent 8 surveys conducted during a 2-year observation period. The measurements show a high degree of spatiotemporal variability and indicate a wind-dominated sediment-dispersal system. During all surveys, the bay was consistently turbid (mean baywide transmissivity <15%/m); the mean baywide concentration of suspended sediment during individual surveys ranged from 11 mg/l to 52 mg/l. The suspended-sediment concentrations were primarily controlled by wind speed which determines the extent of wave-induced resuspension of bay-floor deposits; wind direction and tidal phase controlled the sediment-dispersal patterns.

Texturally, the baywide mean grain size of suspended sediments during individual surveys ranged from very fine silt to clay (7.63 to 8.22ϕ), and mean silt/clay ratios were within the 0.68 to 1.38 range; the sediment was consistently poorly sorted. In contrast to suspended-sediment concentrations, which largely appear to be a short term response to recent wind conditions, sediment textures appear to be a longer term response to earlier wind conditions, thus suggesting that finer grained particulate matter has substantial residence time within the shallow water column.

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Delta-Front Shelf Storm Deposits of Subsurface Woodbine-Eagle Ford Interval (Upper Cretaceous), Damascus Field, Northern Polk County, Texas: Success from Combined Development Geology and Sedimentologic Core Analysis

Gas production from several, 6 to 23 ft (2 to 7 m), single to multistory sandstone bodies of the Woodbine-Eagle Ford interval, 160 to 200 ft (49 to 61 m) thick at 9,000 to 9,600 ft (2,743 to 2,926 m) in the Damascas field has been developed since discovery in 1976. Subsequent offset drilling resulted in a few gas wells and several dry holes. In February 1979 the entire Woodbine-Eagle Ford interval was cored in the No. 7A Dorrance well. Sedimentologic core study generated a predictive depositional model which has guided field development of the subtle stratigraphic traps at a 5 to 1 well success ratio. Present gas reserves are 40 Bcf with 440,000 bbl of condensate.

The productive area is located slightly southwest of the Sabine uplift and just updip from the Lower Cretaceous continental shelf edge. Seismic sections and foraminiferal paleoecology establish a middle-shelf depositional setting. Bioturbated, silty, shelf shales comprise the upper and lower Woodbine-Eagle Ford interval. The middle is a complex of (1) graded, medium to very fine-grained, massive to laminated sandstone beds; (2) contorted, soft-sediment-deformed intervals; (3) swirled and sheared siltstone beds; and (4) thin diamict conglomerate beds. Genetic units indicate periodic rapid deposition by debris flows and low to high-concentration density currents. The several distinct productive sandstone bodies (porosities 9 to 14%; permeabilities 2 to 10 md) are northward-thickening, dip-oriented lobes.

The localized deposition in the shelf setting was controlled by delta development slightly to the north. Periodic major storms generated delta flooding which contributed high-energy reservoir-quality deposits to the shelf. Similar shelf sand build-ups should occur throughout the area; however, recognition must rely on detailed sedimentologic study of core sequences.

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Cherts in Wishart Formation (Aphebian) of Labrador: Example of Rapid Shallow-Water Silica Sedimentation

The Wishart Formation of the Labrador trough (early Pro-