potential of different source rocks containing dissimilar kerogen types and for rapidly estimating a basin's regional charging capacity. On a global scale, a general correlation exists between the magnitude of SPI and basinwide petroleum reserves.

The dominant *migration drainage style* can be predicted from the structural and stratigraphic framework of a basin. Vertical-migration drainage, which occurs mainly through faults and fracture systems breaching a seal, is characteristic of rift basins, deltaic sequences, salt-dome provinces, and fold-and-thrust belts. Lateral migration drainage dominates wherever continuous seal-reservoir "doublets" extend over large areas in a tectonically undisturbed regime (e.g., commonly found in foreland or intracratonic platform basins). Recognition of the dominant migration style helps to predict the location of zones of petroleum occurrence in relation to the "hydrocarbon kitchens."

The *entrapment style*, which is also dependent on the structural framework and the presence of seals, describes the degree of resistance (i.e., impedance) working against dispersion of the petroleum charge.

Application of these working concepts should help significantly reduce geologic risk, particularly in new ventures-type exploration.

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Prevalent Lebensspuren on Beaches of the Mediterranean Coast of Languedoc, France, and the Influence of the Winds on Their Preservation

The beaches considered herein are located between the town of Palavas (Hérault) and the Petit Rhône (Gard).

They are of a very fine (less than 1/10 mm) siliceous sand ($\approx$85%). As the Mediterranean Sea does not present obvious lunar tides, variations of sea level are due to variations of the barometric pressure. Also, large parts of the beaches can sometimes overflow.

Two realms must be distinguished: one, always wet, can be very large; the other, dry, comprises small dunes.

The ichnocoenose reveals a poor fauna limited to small animals, vertebrates and invertebrates, living in the dunes; the watery part is a pathway used by other creatures.

If the traces in dry sand are more or less promptly destroyed after a rounding of the shape, in the watery part of the beach, they undergo many changes owing to the effect of the winds. Under their influence, the shape of the traces is considerably modified: for instance, horse footprints become tridactyl, dog prints tend to be chirotherioid, simple tunnels of worms become double, or natural molds can change into casts (inverted reliefs).

The transformations produced by the winds over the ichnites show the instability of these remains when they are not quickly consolidated. If the consolidation appears after the transformations, in the future misinterpretations are possible.

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Hydrodynamic Trapping in Mission Canyon Formation (Mississippian) Reservoirs: Elkhorn Ranch Field, North Dakota

Hydrocarbons in Mission Canyon dolomite reservoirs in the Elkhorn Ranch field area are trapped by downdip flow of formation water to the northeast.

Elkhorn Ranch field is located on a north-plunging anticline with only 10 ft (3 m) of crestal closure. The Mission Canyon is a regressive, shallowing upward sequence of subtidal dolomitized mudstones and wackestones grading upward into sebkha-salina evaporites. Mission Canyon oil production is localized on the north and northeast side of the structure.

Maps of porosity pinch-outs and permeability barriers defined from core data, superimposed upon the Mission Canyon structure, show that most of the oil cannot be trapped by stratigraphic facies change. Southwest-trending, updip porosity pinch-outs cross the north-plunging structural axis at an angle so low that hydrocarbons would leak out to the southwest under hydrostatic conditions. Downdip hydrodynamic flow to the northeast provides the critical trapping component.

Regional maps of apparent formation water resistivity and water salinity show a region of fresher water south and southwest of the field. A regional potentiometric map constructed using Horner-plot extrapolated shut-in pressure data indicates a head gradient of about 20 ft/mi (4 m/km) to the northeast at Elkhorn Ranch field. This gradient corresponds to a calculated water-oil tilt of about 50 ft/mi (20 m/km). Observed tilt of the oil accumulation is actually about 25 ft/mi (5 m/km) to the northeast. This discrepancy might be the result of the field having not yet reached equilibrium with the invading water.

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The Relationship between Hydrocarbon and Stratabound Metal Sulfide Deposits: The Upper Smackover as an Analog

A genetic link between hydrocarbon and stratabound metal sulfide deposits has often been suggested. Both are thought to result from similar processes operating during the evolution of sedimentary basins, yet exploitable hydrocarbon and metal sulfide deposits are not found together. Consequently, the nature of their genetic relationship remains unclear. The Upper Jurassic Smackover Formation of the North Louisiana Salt Basin—a prolific hydrocarbon producer—contains disseminated authigenic sulfide minerals reminiscent of stratabound metal sulfide deposits. The close association of these sulfide minerals with hydrocarbon deposits provides an opportunity to examine the relation between the two.

The mineralogy and chemistry of late-stage authigenic phases in the Upper Smackover are similar to ore and "gangue" minerals of Mississippi Valley-type sulfide deposits. The sulfide minerals consist of replacement or pore-filling sphalerite, galena, pyrite, marcasite, and chalcopyrite. The associated "gangue" minerals are dolomite, calcite, anhydrite, barite, celestite, and fluorite. Sphalerite is cadmium-rich and relatively iron-poor and its cathodoluminescence reveals compositional zoning. Analysis of fluid inclusions in "gangue" calcite suggests precipitation temperatures (90°-120°C) similar to those for Mississippi Valley-type deposits. The mineralogy and chemistry of the sulfides and their related minerals vary spatially throughout the basin.

These variations reflect local processes and the sources of the sulfide minerals' constituents. The same source rocks from which hydrocarbons are derived are likely sources of base metal ions. Likewise, reduced sulfur is related to hydrocarbons by either a common source or by thermochemical sulfate reduction. Thus, spatial variations in chemistry and mineralogy of the late-stage authigenic sulfides of the Upper Smackover may be the key to understanding the relationship between hydrocarbons and stratabound metal sulfide deposits.

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The Association of Calcite Veins with Stylolites in the Smackover Formation of North Louisiana

Small calcite veins in the grainstones of the Upper Smackover Formation of north Louisiana provide insight into the role of stylolites in the late stages of diagenesis of these carbonate rocks.

The veins always occur in groups, ranging from a few to swarms. In the two cores examined, vein widths varied from 5 μm to 1 mm and lengths varied from 100 μm to several millimeters. Most veins have one end that terminates at a stylolite; some have both ends terminated by stylolites. The same vein never appears on both sides of a large stylolite, although some veins do cut smaller stylolites. Sets of parallel veins occur at angles to each other in the same swarm—one set cutting the other.

The original mineralogy of the veins is calcite. It appears lenticular in thin-section with the long axis of the grains perpendicular to the vein length. Preliminary electron microprobe analyses show the calcite to be relatively pure, containing less than 1% by weight $MgCO_3$. However, the calcite does contain slightly more iron than the surrounding micritic matrix. Anhydrite and dolomite frequently replace the calcite in the vein. This replacement generally occurs at the terminus of a vein in a stylolite. Dissolution of the calcite in the veins to produce fracture porosity is also common.

The veins are remnants of localized episodic fluid pressure increases that occurred during the latter stages of diagenesis of the Smackover.