demonstrates that time migration actually degrades the image of the deep structure that lies below a complicated overburden.

In the Central American example, velocities increase nearly twofold across an arched and thrust-faulted interface. Wavefront distortion introduced by this feature gives rise to distorted reflections from depth. Even with interval velocity known perfectly, no velocity is proper for time migrating the data here; time migration is the wrong process because it does not honor Snell's law. Depth migration of the stacked data, however, produces a reasonable image of the deeper section. The depth migration, however, leaves artifacts that could be attributed to problems that are common in structurally complicated areas: (1) departures of the stacked section from the ideal, a zero-offset section, (2) incorrect specification of velocities, and (3) loss of energy transmitted through the complex zone.

For such an inhomogeneous velocity structure, shortcomings in CDP stacking are directly related to highly nonhyperbolic moveout. As with migration velocity, no proper stacking velocity can be developed for these data, even from the known interval-velocity model. Proper treatment of nonzero-offset reflection data could be accomplished by depth migration before stacking. Simple ray-theoretical correction of the complex moveouts, however, can produce a stack that is similar to the desired zero-offset section.

Overall, the choice of velocity model most strongly influences the results of depth migration. Processing the data with a range of plausible velocity models, however, leads to an important conclusion: although the velocities can never be known exactly, depth migration is essential for clarifying structure beneath complex overburden.

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Abnormally High-Pressured, Low-Permeability, Upper Cretaceous and Tertiary Gas Reservoirs, Northern Green River Basin, Wyoming

A large area of overpressured Upper Cretaceous and Tertiary rocks has been identified in the Green River basin of Wyoming. Source-rock, pressure, and temperature data from the El Paso Wagon Wheel No. 1 and Belco 3-28 Merna wells (originally proposed as nuclear stimulation sites) in the northern part of the basin reinforce previously reported conclusions regarding the cause of overpressuring: the generation of gas in low-permeability rocks. Pressure gradients in these wells exceed 0.8 psi/ft (18.1 kPa/m) and a maximum gradient of more than 0.9 psi/ft (20.4 kPa/m) may be present in the Merna well. If true, this would be the highest subsurface pressure gradient ever reported in the Rocky Mountain region.

Observations relevant to overpressuring in these wells include: (1) the coincidence of the onset of overpressuring and the top of the gas-saturated interval; (2) the source rocks of the gas are the interbedded coal and other carbonaceous lithologies; (3) the organic matter in the source rocks is predominantly a humic-type, capable of generating mainly gas; (4) the average total organic carbon content is about 2.0%; (5) the vitrinite reflectance at the top of overpressuring is 0.75 to 0.84 $R_O$, values that are consistent with the beginning of thermal gas generation; and (6) the low permeability ($< 0.1$ md), and stratigraphic and sedimentologic heterogeneity of the reservoirs provide an effective pressure seal.

Previously reported overpressuring mechanisms such as aquathermal pressuring, clay transformations, undercompaction, and dewatering of shales do not appear to be significant factors that contribute to overpressuring in this area.

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Can Hydrocarbon Migration be Recognized by Routine Geochemical Techniques?

Migration is the least understood step in the sequence of processes leading to the formation of a subsurface hydrocarbon accumulation. Hydrocarbons are redistributed by primary and secondary migration, which lead under ideal circumstances, to the formation of a reservoir accumulation. During geologic time, the reservoir accumulation may be destroyed by dissipation, that is, the leakage of hydrocarbons through the caprock (tertiary migration or dis-migration).

On the basis of case histories from geochemical analysis of exploration wells and of several shallow core holes, it is demonstrated that these hydrocarbon migration processes can be recognized by routine geochemical techniques. Certain changes with depth in light and heavy hydrocarbon composition reveal the extent and effectiveness of hydrocarbon migration. In particular, migration patterns become evident from a comparison of geochemical data of two adjacent exploration wells which penetrate the same stratigraphic sequence of interbedded source and reservoir rocks, but at different depth and maturation levels. Patterns of primary migration are evident also from regular compositional trends on either side of the contact between a source rock and a reservoir bed in a Jurassic-age sequence from Svalbard, Norway. Finally, geochemical evidence shows light hydrocarbons escaping from a gas reservoir by diffusion through the overlying seal. Based on recently determined diffusion rates for certain light hydrocarbons, one can estimate the hydrocarbon mass transport as a function of geologic time.

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A New Look for Gas in Forbes Formation, Sacramento Valley, California

The Forbes formation of Upper Cretaceous age consists of marine shale, siltstone, and interbedded sandstone, and lies stratigraphically between the younger Kione deltaic sandstone facies and the older Dobbins shale. On the west side of the Sacramento Valley, the Kione formation is truncated and the Forbes formation is overlain by the Capay (Eocene) and/or Tehama (post-Eocene) formations. In the Sacramento to Red Bluff area, the Forbes formation attains a thickness of up to 5,000 ft (1,524 m).

The importance of the Forbes formation as a source of gas production in the Sacramento Valley is well established. Gas was first produced from the Forbes formation near the south edge of the Marysville Buttes in 1953. The formation is now productive in over 20 fields in the Sacramento Valley with cumulative production to January 1, 1980, of 1.23 billion Mcfg.

The discovery and development of gas from the Forbes formation declined considerably in the late 1960s. As a result of new CDP seismic reflection profiling, however, drilling for gas from the Forbes formation has increased dramatically since 1978. Moreover, careful integration of modern seismic data with detailed subsurface stratigraphic mapping has resulted in new discoveries.

The Grimes gas field provides an example where these investigative techniques can be supplied.