This is true not only for exploration studies, but also for crustal studies. However, the seismic time section is not an undistorted cross section of the earth.

Seismic sections across most geologic structures are distorted by sideswipe and/or lateral velocity changes in the subsurface. Invariably, the distortion on the 2-D migrated section hides the features that are most desired. However, through seismic models of similar geologic structures, the interpretational pitfalls caused by sideswipe and velocity are turned into practical prediction tools.

Migrated seismic lines across domes and anticlines normally exaggerate the size of the anomalies. Migrated seismic lines across synclines and basins are characterized with false expressions that include grabens, contemporaneous deformation, cross-stratification, high amplitudes, and crossing reflections. Geologic areas that have large lateral velocity contrasts, such as reefs, diapirs, or fault blocks, exhibit false seismic expressions. These include relief faults, basement-controlled tectonics, facies changes, and structures that are located in geologically ambiguous positions. Even the polarity of the seismic reflection is 3-D dependent.

Modeling examples show that interpretational pitfalls, such as mapping from migrated sections and interpreting from the basement upward, must be supplemented with pseudo-3-D interpretational techniques. Geologic models and their seismic analyses from salt provinces, reefs, overthrusts, etc, illustrate these pseudo-3-D interpretational tools.

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Dynamics of Cretaceous Epicontinental Seas

Acceleration of plate spreading and hot spot activity during the Cretaceous produced topographically elevated regions of the sea floor, which episodically displaced global sea level upward as much as 300 m (980 ft), broadly flooding the world's cratons with shallow epicontinental seas. Episodes of relative plate quiescence accompanied destruction of these topographic features and sea level fall. Ten such eustatic rise-fall events, third-order cycles averaging 10 m.y. in duration, are defined from coincident transgressive-regressive strandline migrations and various types of sedimentary cyclothems on many of the world's cratons; epicontinental seas and their sedimentary record comprise the most sensitive tools for defining sea level fluctuations. Precise correlation of these eustatic fluctuations, and determination of rates of sea level change, are possible through a new technique of high-resolution event stratigraphy, integrated through graphic correlation with refined biostratigraphy and geochronology. The best documented record of Cretaceous eustasy, and the most refined system of geologic time and event correlation, is associated with the great Western Interior seaway of North America. This sea occupied a major foreland basin east of the North American Cordillera.

In this basin, strong evidence exists for near-simultaneous response of regional tectonic and volcanic activity, sedimentation patterns, eustatic fluctuation, strandline migration, climate history, and variations in paleobathymetry, temperature, and water chemistry in the Western Interior seaway, with episodes of active vs. passive spreading and subduction. The dynamics of basin history documented in the Western Interior seaway serve as a new model for epicontinental marine history worldwide. Basin analysis suggests that, coincident with active plate spreading and subduction along the Pacific margin of North America, active thrusting, plutonism, and vulcanism characterized the western Cordillera; the foreland basin was subsiding at rates greater than predicted by tectonic/sedimentologic loading; basement block faulting was initiated in the tectonic hinge zone; and the basin reached its deepest phase as sea level rose and marine transgression overprinted regional tectonic and sedimentologic features. Major thermal and chemical fluctuations, including regional and global anoxic events, characterized the seaway at this time, producing extensive source rocks. Subsequent phases of relative plate quiescence were coincident with major reduction in Cordilleran tectonics, vulcanism, and basin subsidence, as well as with eustatic fall and epicontinental regression. Resultant filling of the seaway with sediments allowed extensive eastward progradation of clastic wedges across the basin axis and onto the stable eastern platform, forming the major Cretaceous hydrocarbon reservoirs. Most major coal deposits formed on delta and strand plains during relative eustatic stillstand at peak transgression and peak regression. The integrated study of basin dynamics in epicontinental seas, linked to eustatic history, allows the development of powerful exploration models for fossil fuels.

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Anschutz Ranch East—Finding and Defining a Giant Oil Field in Thrust Belt

Anschutz Ranch East is the giant oil field of the western United States thrust belt, with over 3/4 billion bbl of oil equivalent in place. The original prospect was not so impressive. Extensive Tertiary cover precluded precise prospecting by surface mapping. An early well penetration of a shallow recumbent fold tied to conventional 2-D seismic reflection lines hinted at a Triassic-Jurassic structure 1,500 acres (600 ha.) in extent. Soon after Amoco discovered Anschutz Ranch East in 1979, production pressure data revealed that the field was very large; but it was development drilling and 3-D seismic that prompted the geologic interpretation of 14,600 acres (5,900 ha.) under closure. Still being delineated nearly 5 yr after its discovery, the current size estimate is near 4,000 acres (1,600 ha.). The field, therefore, serves as a good case example of the difficulties involved in geologic mapping using remote data.

Anschutz Ranch East is part of a prolific oil trend extending more than 40 mi (64 km) along the leading edge of a major regional thrust plate. Situated in the extreme southwest corner of Wyoming and adjacent Utah, the field produces from separate reservoirs in two en echelon structures. The more significant west lobe is a highly overturned, narrow anticline with more than 2,000 ft (610 m) of hydrocarbon column. The producing Triassic-Jurassic Nugget Sandstone, largely eolian in origin, is just over 1,000 ft (305 m) thick, with more than 75% of the rock capable of contributing to production. Geologically, the field has passed through several stages of geometric interpretation: the faulted stage, the concentric fold stage, and the angular stage. Development of these three interpretations was based largely on outcrop examples of fold geometries in thrust belts of both the eastern and western United States.

Production rates in the first half of 1984 averaged approximately 36,000 bbl of condensate, 6,500 bbl of natural gas liquid, and 215 mmcf of gas per day. The reservoir fluid is a rich gas condensate originally about 150 psi (1,034 kPa) above the dew-point pressure. Complexities involving reservoir fluid properties, stratigraphic influences on fluid flow, effects of structural deformation, and fracture systems have required close cooperation between geologists and reservoir engineers in planning for field development. With this cooperation to maximize recovery, the recovery factor for hydrocarbons in place is expected to be about 70%.

More than 90% of the field's recovery will come from the west structure, which is just over 1 mi (1.6 km) wide and probably less than 6 mi (9.7 km) long. Fields of this size might be easily missed in thrust belt exploration.

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Ancient Turbidite Systems: Models and Problems

An understanding of turbidite depositional systems is important for both geologic reconstructions of ancient margins and for exploration in clastic deep-water basins. In the last 10 yr, ancient turbidites have been interpreted in terms of modern depositional settings such as submarine fans, slope basins, trenches, and basin plains. However, the lack of common ground between models for modern and ancient turbidite deposits has resulted in a nonuniform application of models, facies distinctions, morphologic criteria, and depositional processes. As a consequence, most ancient turbidite systems are still difficult to frame within models derived from modern settings.

Ancient turbidite systems display a variety of sedimentary patterns. Most commonly, these systems consist of channel-fill sediments that are replaced in a downcurrent direction by nonchannelized deposits. Despite this common overall pattern, turbidite depositional systems differ considerably in terms of size, types of facies and facies associations, and geometry and distribution of sandstone bodies. The volume of gravity flows appears to be the main factor in controlling the distribution pattern of sandstone facies within each system.

Substantial accumulations of turbidite sandstone facies are invariably related to periods of lowstand of sea level and are common in those basins where slope instability is enhanced by tectonic uplift. Most predominantly fine-grained systems, and particularly channel-levee complexes, are conversely deposited during periods of highstand and are generally associated with active seaward progradation of deltas on adjacent shelves.