forming in a coastal salina (Halite Lake) less than 2 km (1 mi) from the area where the thickest Coorong dolomites are forming. Obviously evaporite filled ponds can occur in an ancient Coorong-type facies mosaic, and the distribution of evaporites versus dolomites could be a good palaeoslope indicator.

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Variability of Internal Geometry of Duplexes

Duplexes are imbrications of the footwall of a thrust fault (or series of connected thrust faults) in which the minor faults connect to or intersect with the master thrust surface at both their leading and trailing edges. Within this closely constrained definition, there is considerable geometric variation. The current classification scheme recognizes the variation in postdeformational arrangement of horses in two dimensions, but ignores variations in the size and shape of the horses and in the displacement on the imbricate fault surfaces. Compilation of the geometric arrangement of horses in known duplexes shows that such variations are common and result in several geometric variations that do not fit into the current classification. Additional geometric variations can be found in 3-dimensional framework.

These geometric variations can be correlated with mechanical properties of the footwall material in which the duplex formed. Since the deformational style within the horses is also controlled by the same mechanical factors, the internal structure of the horses can be correlated with the gross geometry of the duplex. Recognition of the range of duplex geometries and the correlation with deformational patterns should aid exploration in complex thrust belts.

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Calcareous Nannofossil Paleobiogeography of the Cretaceous Greenhorn Sea

Two distinctive, laterally traceable bentonite beds were used to construct two isochronous time slices through the marine sediments of the Upper Cretaceous Greenhorn cyclothem of the United States Western Interior basin. Calcareous nannofossil assemblages from these time slices were examined from more than 40 outcrop localities. Nannofossil presence and assemblage diversity and composition were statistically analyzed to examine the paleooceanographic conditions within the basin.

The lower time slice (X bentonite) is at the stratigraphic horizon which approximately corresponds to the time at which free communication between the basin and open oceanic systems first occurred. The most striking trend in the nannofossil distribution is delineated by the presence or absence of nannofossils. The presence of common to abundant nannofossils in the center of the basin (i.e., near the hingeline of the basin) and the absence of nannofossils from the eastern and western basin margins indicate that open marine conditions conducive to significant standing crops of calcareous phytoplankton occurred only in a narrow, centrally located zone. Conditions at the basin margins were probably unsuitable for large populations due to environmental instability. Evidence indicates that *Watznaueria barnasae* was the most ecologically tolerant form.

The upper time slice (HL-3 bentonite) samples the nannofossil distributions at a point at or near the maximum transgression of the Greenhorn Sea. Similar, basinward increases in diversity and abundance are evident but more subtly expressed. Paleolatitudinal differences in diversity and the relative abundances of some taxa indicate contributions from both tropical and boreal oceanic water masses.

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Submarine Fans in a Developing Extensional Regime—Their Significance in the North Sea Hydrocarbon Province

The North Sea is a major hydrocarbon province with estimated proven recoverable reserves of approximately 23 billion bbl of oil and 50 tcf of gas. A significant proportion (22%) of these reserves occurs in reservoirs interpreted as submarine fan deposits. These include both oil and gas fields that are among the largest discovered in the province.

The North Sea basin provides a classic example of long-term development of an extensional basin. Major tectono-sedimentary sequences can be broadly matched to pre-, syn- and post-rift phases of the Viking and Central grabens. Development of submarine fan systems within the basin can in turn be related to this framework.

Submarine fans developed in the Viking graben within the syn-rift tectonic setting during the late Jurassic. The major controlling factor at this time is considered to be internal tectonics of the graben with subordinate influence from sea level changes. Small, coarse, scarp-fed fans formed a sediment apron along the fault-controlled graben margins. Finer-grained, rather better developed fan systems were also formed during this period, reflecting the relative importance of different controlling influences.

The post-rift cycle in the North Sea basin is characterized by Late Cretaceous-Tertiary thermal subsidence of the graben as well as the former rift margins. The major influences on fan development in this phase were external tectonics in the source area, and, of equal importance, sea level changes which controlled sediment input to deeper parts of the basin. Late Paleocene and early Eocene fans developed in association with major prograding delta systems.

The variability in space and time of submarine fan types in the North Sea highlights the importance of identifying the most appropriate fan model. This is critical to reservoir distribution in field development, as well as in future exploration where predictive models will be required to identify time periods and areas most likely for the development of submarine fans.

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Computer-Assisted Attribute-Coincidence Mapping (ACM) in the Search for Massive-Sulfide Exploration Targets in Appalachian Devonian Rocks

Attribute-coincidence mapping (ACM) is a powerful tool commonly used by geologists when they visually compare map data from diverse sources by use of a series of transparent overlays. The same geologists using computer-assisted ACM (particularly the MAPSS = MAGIC software system) can consider, evaluate, and replot or store for later retrieval many more kinds of data with less time and effort than with manual methods. Because the MAPSS = MAGIC system organizes and manages information by orthogonal patterns, standard CRT terminals or high-speed line printers enable users to view complex grid-cell patterns of derivative maps almost instantaneously, and thus facilitate rapid decision making.

ACM with the MAPSS = MAGIC system can be used at any scale to compute, analyze, and plot derivative patterns. For regional analysis the standard U. S. Geol. Survey 7½-minute quadrangle is used as the information cell for data manipulation. A demonstration of the system shows map patterns of some of the various attributes of sediment-associated massive-sulfide ore deposits that have been combined through ACM to identify potential exploration targets in Appalachian Devonian rocks. The massive-sulfide model was developed by the West German Federal Geol. Survey and recently modified by Wedow for computer use by the U. S. Geol. Survey. This ACM study of the Appalachian Devonian has revealed several significant exploration targets.

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A View on Oil Shale Development

An examination of energy statistics shows clearly that the United States is on the edge of an impending energy crisis. This appears preposterous in the face of a world oil glut and probable world oil price decreases over the next year or so. However, oil supply, oil demand and United States economy statistics support the scenario of a rapidly occurring energy crisis in the United States should oil imports be shut off even partially. This is not an unlikely happening under present world tensions.

Oil and gas exploration and production statistics support the view that domestic oil reserves will continue to decline even if concentrated oil exploration activity were maintained.

The shortest avenue for United States energy independence is through the development of synthetic fuels. However, a detailed study shows that, under present technology, synthetic fuels cannot be produced economi-