crop samples: 1.50 to 7.95% (4.29 median) for phosphatic shales, 0.67 to 5.11% (2.64 median) for phosphorites, and 0.40 to 3.17% (1.25 median) for micrites. Hydrocarbon analyses range from 50 to 300 ppm in areas where conodont CAI values range from 1.5 to 4.

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Use of Devonian Conodonts in Petroleum Exploration, Western United States

Forty-eight Devonian conodont zones are now recognized worldwide: 11 zones in the Lower Devonian, 10 zones in the Middle Devonian, and 27 zones in the Upper Devonian. Only five of these zones have not yet been recognized in the western United States. Conodonts, which range from Cambrian to Triassic, attained their maximum faunal diversity and abundance during the Late Devonian, when each conodont zone lasted about 0.5 m.y. Because each zone represents such a short interval of geologic time, conodonts provide an indispensable tool for petroleum exploration in the Rocky Mountain, Overthrust belt, and Great Basin regions.

Conodont color-alteration index (CAI) values have been used successfully to predict cool areas of potential production in otherwise thermally overcooked regions. Their use has also been demonstrated as follows.

1. Conodonts, by providing virtual time planes, suggest the complex relations between source beds in the Pilot basin and reservoir rocks in the enclosing carbonate platform.

2. Conodonts have been used to determine rates of sedimentation of source rocks and other synorogenic sediments of the Antler orogeny. These rates range from 1 to 400 m/m.y. They also demonstrate that deposition was episodic and that there were times and areas of nondeposition within marine basins.

3. Conodonts precisely date Antler orogenic events, which governed eustacy and caused marine transgressions and regressions on the craton. For example, the emplacement of the Roberts Mountains thrust took approximately 8 m.y.

4. Conodonts are used for biofacies analysis and for paleotectonic reconstructions. For example, within the Late Devonian *Polygnathus styriacus* Zone, eight different conodont biofacies, with almost mutually exclusive faunas, have been used to reconstruct five paleotectonic settings ranging from peritidal to offshore pelagic.

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Organic Model for Roll-Front Uranium Deposits

The almost universal association of uranium with humic-type organic matter in sedimentary deposits has long been recognized. This close relation is often overlooked in some sandstone uranium deposits owing to the difficulty in recognizing the unstructured organic material, the lack of analyses for organic carbon, or the labile nature of the immature humic substance. A colloidal suspension of humic acids derived from decaying vegetal matter can be made to flocculate by a drop in pH, by local changes in cation concentration, or by adsorption on clays. Evidence shows that the roll-type deposits are essentially "organic rolls" in which the humic acids were precipitated primarily by the drop in pH associated with the redox interface. Once precipitated the humic substances are particularly efficient in the collection of metals from very dilute solutions such as natural waters.

In actively migrating oxidation fronts, the humic matter and some of the uranium appears to be remobilized and concentrated downdip from the "radiometric front." This may explain the poor correlation between organic matter and uranium in some of the Texas deposits. The humic substances, however, are believed to be an essential prerequisite for the original accumulation of the uranium in the roll fronts.

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Geologic-Seismic Exploration Model for Reworked Deltaic Sandstones—Excellent Subsurface Reservoir

Reworked deltaic sands are produced by the reworking of abandoned deltaic lobes. Criteria and models are developed for the recognition of reworked deltaic sand bodies on subsurface log and seismic data. A geologic-seismic model and a subsurface prospect example is presented.

A reworked deltaic sand sequence is composed of four depositional components. From base to top these are, prodelta shale, distributary mouth bar sandstone, reworked deltaic sandstone, and transgressive marine shale. The basal prodelta shales possess lower velocities and commonly lower density and resistivity, and are generally very thick—greater than 300 ft (91 m) and commonly 3,000 ft (914 m) or more. The thickness of overlying distributary mouth bar sands generally ranges between 200 and 400 ft (61 and 122 m) and they are depopod-shaped—2 to 4 mi (3.2 to 6.4 km) along depositional dip and 2 to 6 mi (3.2 to 9.6 km) along depositional strike. Mouth bar sands display moderate to poor sorting in contrast to the overlying reworked deltaic sands which are well sorted, possess excellent porosity and permeability, and make better reservoirs. Reworked sands are elongated along depositional strike—5 to 15 mi (8 to 24 km) long and 0.25 to 0.5 mi (0.4 to 0.8 km) wide. Their thickness ranges between 20 and 60 ft (6 and 18 m). Marine shales overlying the reworked deltaic sands possess higher velocities and exhibit higher resistivity on electric logs. They are calcareous, contain abundant oyster fragments, and reflect deposition initially in shallow brackish waters and later in deep open-marine waters.

The contrasting lithologies, velocity differences, and the geometries of various depositional units of reworked detrital sand sequences provide excellent clues for their recognition on log and seismic data.

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