phologies have specific roles in one or more of the following phases of reef development: (stage 1) mud trapping; (stage 2) substrate stabilization; and (stage 3) reef building. Important parameters that probably influenced this succession were intensity and periodicity of sedimentation, energy as a function of depth, light availability, and substrate characteristics.

Ideal succession of stages is better developed in the eastern Peran section. Detrital matrix of these reefs is generally grain-supported, whereas interreefal deposits consist of fossiliferous marls. Organic banks of the western Luanco section contain a muddy matrix, and true reef development (stage 3) is rarely attained. Interbank deposits include gray bioturbated mud which contains tentaculitids, trilobites, and clearly transported elements. These observations suggest that the Peran section was formed under very shallow-water conditions on the shelf edge, facing deeper waters toward the west. This shelf edge thins eastward toward a major topographic high in the present-day vicinity of the Picos de Europa. Such a paleogeographic picture is decidedly reversed to that of the now famous Devonian reefs of Belgium and Germany.

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Hydrodynamic Flow in Lower Cretaceous Muddy Formation, Northeast Powder River Basin, Wyoming and Montana

Hydrodynamic flow in the Muddy aquifer is generally downdip to the west with an average gradient of 25 ft/mi (5 m/km). Flow patterns are controlled by the distribution of porous sandstone so that the regional patterns of flow reflect the total thickness of the Muddy aquifer. Local potentiometric highs appear to represent isolated areas of high pressure and downward flow from Mowry Shale (source rock) to the Muddy aquifer.

Lenticular Muddy sandstones form stratigraphic oil traps, but oil columns are determined largely by hydrodynamic flow. Calculations suggest that hydrodynamic flow accounts for 130 ft (40 m) of the total 150 ft (46 m) of the oil column at Recluse field; for 230 ft (70 m) of the total 250 ft (76 m) at Gas Draw field; and for 100 ft (30 m) of the total 150 ft (46 m) at Bell Creek field. Larger oil columns are the result of vertical flow. A potentiometric high of 6,000 ft (1,830 m) occurs at Kitty field, about 4,000 ft (1,220 m) in excess of the expected hydrostatic head, and the vertical pressure gradient probably accounts for a large part of the total 850 ft (259 m) of oil column. Vertical flow results in updip gradients and reduction of total oil column as at LX Bar field.

Potentiometric surface maps show that the Muddy aquifer is a dynamic system of both downdip and vertical, cross-formational flow. Observed oil columns are in equilibrium with present flow. Migration of oil downward from Mowry source rock has taken place in relatively recent time and is still occurring; it may result from montmorillonite dehydration at temperatures in excess of 200°F (94°C). The early history of fluid migration is obscured by present flow but may have been updip, eastward toward the basin flank. Flow of compaction waters may have been great enough to have prevented early oil accumulation. Exposure of the Muddy aquifer was post-Laramide and resulted in recharge by meteoric waters. Therefore Muddy oil fields are late accumulations as suggested by their present equilibrium with basinward flow.

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Early Paleozoic Conodont Biostratigraphy, Biogeography, and Paleoecology

Extensive work, particularly during the last 25 years, has led to the recognition of several hundred species and more than 100 genera of Cambrian, Ordovician, and Silurian conodonts. Wide distribution, short vertical range, and abundant occurrence have made conodonts some of the best early Paleozoic index fossils known. Most detailed conodont work has been done in North America and Europe but significant data are available from South America, Asia, and Australia. Cambrian conodonts, still poorly known and apparently not greatly varied taxonomically, are less useful biostratigraphically than Ordovician and Silurian conodonts. No Cambrian conodont zone succession has been proposed but some conodonts have considerable stratigraphic potential in the Late Cambrian. Ordovician conodonts are characterized by explosive taxonomic diversification and striking provincial differentiation. Two sequences of 15 to 20 conodont zonal units are in common use, one in each main province. Conodonts permit, in many places, a greater stratigraphic resolution than is achieved using any other fossils. Silurian conodonts are less diversified taxonomically (about 15 genera) and less differentiated provincially than those of the Ordovician. They form the basis of a succession of about 15 standard zones. Both Ordovician and Silurian conodonts have been tied into graptolite biostratigraphy producing a detailed and regionally useful framework.

Apart from various aspects of biostratigraphy, biogeography, and taxonomy, current early Paleozoic conodont research includes paleoecology which has resulted in a greatly improved understanding of the environmental significance of these enigmatic fossils.

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Devonian Paleogeography and Paleoenvironments in Northern Arizona

Devonian strata in the northern half of Arizona are mostly early Upper Devonian (Frasnian) carbonate rocks up to 160 m thick but include some terrigenous clastics of latest Middle Devonian (Givetian) and Frasnian age. Devonian sediments were deposited on a shallow-marine cratonic platform bordered by the Defiance lowland area to the east and by the continental shelf adjacent to the Cordilleran geosynclinal belt to the west.

The Beckers Butte Member of the Martin Formation accumulated as fluvial to subtidal sands in a small em-