(≃10 m) lithologic units of the upper Mannville in the Wainwright area indicate that these beds were deposited in a marine depositional environment. The same interval in a nearby well (11-21-47-2W4) has been confirmed as marine (contains dinoflagellates) and also contains dicotyledonous tricolpate pollen grains. The presence of this type of pollen grain means that, at least locally, the disconformity that is supposed to occur at the base of the overlying Joli Fou Formation occurs instead within the sandstones at the top of the Mannville, as suggested by Stelck.

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Correlation of Lower Ordovician Rocks to Their Geophysical Log Signature

To create meaningful structural maps related to geologic processes from well log data, one must consistently select the boundaries of the formations in question. Different workers use a variety of names and markers for the Lower Ordovician strata in Ohio, causing confusion and discrepancies in correlation and interpretation. So, it is apparent that some standard must be established.

The currently accepted nomenclature, in ascending order, is the Knox Dolomite (upper region), Glenwood or Wells Creek Formation, Black River Limestone, and Trenton Limestone. The Ohio Geological Survey has generated a sample log for these formations based on data from several wells in Licking County of central Ohio. One cannot use this as a type log for the entire state, particularly when choosing the top of the Black River Limestone. Previously, a very thorough chemical description and correlation was made and several bentonite beds were used to define the Black River. Still, this description is not easily distinguished on the geophysical logs. However, assuming the postulate that the Trenton and Black River were deposited contemporaneously and those names have no time significance, only three formations need be considered and can be consistently recognized on any log in the state.

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Transition from Slope to Fan Facies, Lower Cretaceous Sediments, Andean Foothills, Southern Chile

In southern South America, mid-Cretaceous compressional deformation transformed an Early Cretaceous back-arc basin-slope-platform setting into a protocordillera-foreland basin. The Lower Cretaceous sedimentary rocks exposed in the Andean foreland fold and thrust belt at lat. 51°S record an abrupt transition from back-arc basin-slope facies to foreland-basin submarine-fan facies.

The Zapata Formation of Portlandian to Albian age represents deposition on the slope of a coeval back-arc basin which formed to the west. The 600-m section consists predominantly of rhythmically interbedded and extensively bioturbated mudstone and siltstone. The siltstone beds are laterally continuous and contain sedimentary structures suggesting deposition by turbidity currents. Sporadic turbidite sandstones occur as shallow channel-fill sequences or as thin, laterally persistent graded beds rich in coarse detrital mica. Slumped intervals are common, and show a northwest-southeast trend of slump fold axes, which parallels the axis of the back-arc basin to the west.

The overlying Punta Barrosa Formation of Albian to Cenomanian age was deposited contemporaneously with deformation in the cordillera to the west. It represents a rapid change in depositional regime, signaled by an abrupt increase in sandstone beds. The thick sandstone beds are lenticular, commonly amalgamated, and show thickening/coarsening-upward and thinning/fining-upward cycles indicative of deposition in a submarine-fan environment. NNW to SSE paleocurrent trends indicate a longitudinal basin-fill pattern; this persists through the Upper Cretaceous flysch sequence. The Punta Barrosa Formation thus represents the establishment of submarine-fan deposition associated with the initiation of a foreland basin on the site of the preexisting back-arc basin slope.

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Fluvial Model for Lower Cretaceous Lignite, Northern Ontario

The Mattagami Formation is an erosional remnant of unconsolidated sand, clays (commonly kaolinitic), lignite, and rare conglomerate, extending 180 km east-west and 70 km north-south. The maximum known thickness is 130 m and the formation thins to the north. Outcrops are rare and drill-hole data are limited regionally. Devonian carbonates and shales and Jurassic shales underlie the Mattagami Formation and thick Pleistocene tills and clays overlie it.

An east-west-trending post-Mesozoic fault forms the south boundary of the Mattagami with Archean gneisses. Small isolated Mesozoic outliers occur farther south. The Grand Rapids arch trends northwest from the southeast corner, which is defined by Precambrian inliers and outcrops of Middle Devonian carbonates.

Across 50 km west of the arch, the Mattagami Formation contains many clean quartz cross-bedded sands, which lack correlative beds between drill holes. On Adam Creek, sand cross-cutting dark-gray shales suggests laterally migrating streams eroding flood-plain deposits. Lignite beds are thin and discontinuous.

East of the arch, the Mattagami is mainly clay with minimal sand, and total thickness is much less than in the west. Two lignite beds comprise the Onakawana deposit (185 million tons proved, approximately 5,000 BTU dry basis) with a total thickness of 16 m and known lateral continuity of 12 km. These are flood-plain and associated swamp deposits.

The paleogeomorphic Grand Rapids high was a barrier for the great northwest-trending river system meandering across 50 km, and preventing the river's incursion in the flood-plain and swamp environment to the east. North of the Onakawana lignite deposits and parallel with them, the interpreted trend of the river system is a prime target for exploration drilling.

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Depositional-Tectonic Setting of Clastic-Hosted Lead-Zinc Sulfide Deposits

Clastic-hosted, stratiform lead-zinc sulfide deposits (MacArthur River H.Y.C., Mt. Isa, Broken Hill, Australia; Sullivan, Howard's Pass, Anvil Range, Jason-Tom, Canada) precipitated from exhaled, hydrothermal fluids in similar depositional and tectonic settings. Host rocks suggest sedimentation in anoxic water below storm waves in areas devoid of active bottom currents. Depths were at least 150 to 200 m as inferred from the absence of storm-influenced deposits. Such numbers are suggested by calculations involving fetch distances of the ancient basins and by effective wave base in modern seas. Supporting evidence comes from the lack of bottom-dwelling metazoans in Phanerozoic examples indicating anaerobic conditions.

In the examples, laminated to thickly bedded sulfides are interstratified with shales, siliciclastic or carbonate-sediment gravity-flow deposits, and some cherts. Where not obscured by deformation and metamorphism, sandstones show grading, flutes and grooves, load casts, and Bouma sequences. Submarine mudflow units may be common. Lacking are hummocky cross-stratification, wave ripples, mudcracks, abundant medium-scale cross-stratification, or other evidence in ore zones of shallow-marine processes or of subaerial exposure. Thicknesses of clastics point to basin depths much greater than 200 m.

These deposits apparently formed in extensional tectonic regimes. Stratigraphic thickness variations, facies changes (especially the presence of local, fault-derived slumps), or geophysical evidence suggest the presence in many of active faults during ore genesis. These faults formed the basins or formed local traps, provided conduits for hydrothermal fluids, and positioned convective cells.

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Reservoir Diagenesis and Convective Fluid Flow

Pore fluids in reservoir rocks are unstable under normal geologic conditions and, in the absence of forced flow, convective fluid flow can be expected as a general rule. Calculations suggest that fluid velocities on the order of 10^{-8} m-sec^{-1} should be typical scale velocities for convective rolls due to normal geothermal gradients (25°C - km^{-1}). Velocities of this magnitude are shown to be sufficient to reduce porosity significantly in less than 5 million years if quartz is the pore-filling cement. If exsolved hydrocarbons are pore-filling materials, the time to complete fill decreases to about 2 million years, while pore filling with both exsolved hydrocarbons and quartz (72% HC) requires about 1.43 million years.

Mass transfer by convective fluid flow alone appears to be sufficient to account for the bulk of diagenesis in the deep subsurface. However, it can also be argued that many diagenetic reactions occur solely as a consequence of moving fluids maintaining chemical equilibrium with their dissolved load as the fluids cycle through temperature and pressure gradients. Phases are precipitated or dissolved during the cycle depending on the sign of the solubility coefficients of a mineral with respect to temperature or pressure. Quartz solubility, for example, increases with T and P under normal reservoir conditions and can be expected to move from hot to cold zones while calcite would be expected to show the opposite behavior. In particular, it is shown that the diagenesis in a convecting system is not a function of mineral solubilities, but rather the temperature and pressure coefficients only. This observation may be of considerable importance in assessing the significance of hydrocarbon transport and accumulation by molecular solution in the aqueous phase because it appears that the components of a petroleum phase exhibit similar temperature and pressure behavior.

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Petrologic Controls of Reservoir Properties of Mid-Continent Pennsylvanian Sandstones

Petrographic analyses of Middle Pennsylvanian (Desmoinesian) Cherokee Group sandstones in the Mid-Continent show that effective liquid porosities, liquid permeabilities, and pore-size distributions are controlled by sedimentologically influenced petrologic parameters and subsequent diagenetic alterations. Deltaic complexes contain two distinct sandstone-bearing lithologies: (1) subarkosic-quartzarenitic channel sandstones, and (2) sublitharenitic sandstones interstratified with shales representing overbank and interdistributary deposits. The sandstones in these two settings underwent different diagenetic histories, which enhanced original differences in their reservoir properties.

Overbank deposits commonly contain soft, argillaceous rock fragments which underwent plastic deformation during compaction, causing the clogging of some pore-throats and pores. In addition, extensive silica cementation, perhaps due to diagenetic clay mineral conversions, caused further destruction of primary pores. In channel sandstones, porosity reduction was less extensive and apparently proceeded at a slower rate. Chlorite coatings on many grains prevented destruction of original pore spaces by inhibiting further silica cementation. Individual sandstone bodies with abundant coatings fall within a porosity range of 20 to 25%, whereas bodies with uncoated grains rarely exceed 18%. Permeabilities in clay-coated reservoir rocks fall within a 100 to 200 md range, whereas uncoated or sparsely coated rocks are in the 1 to 30 md range. The diagenetic histories of these rocks are further complicated by the development of secondary porosity caused mainly by dissolution of the feldspathic grains and carbonate cements.

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Cenozoic Calcareous Nannofossils from Klamath, Southern Oregon

All four reconnaissance samples, from west to east, of almost vertically dipping turbidites exposed in road cuts along the Rogue River of southern Oregon between Gold Beach and the crest of the Coast Range, contain Tertiary calcareous nannofossils. The first assemblage, taken nearest the Pacific Ocean and located near Tom East Creek, includes *Coccolithus pelagicus, Coronocyclus nitiscens, Cyclocargolithus floridanus, Dictyoccoccites abisectus, Discoaster deflandrei, D.* cf. *druggi, Sphenolithus belemnos, S. capricornutus, S. heteromorphus, S. conicus, S.* n. sp., and *Triquetrorhabdulus carinatus,* indicating NN 2-3 zone. The second sample, from west of the first between Tom East Creek and the town of Agnes is sparser, but contains *Coccolithus pelagicus, Cyclocargolithus floridanus, Discoaster deflandrei, D.* cf. *druggi, Sphenolithus belemnos, s. capricornutus, S. heteromorphus,* and *Triquetrorhabdulus carinatus,* also indicative of NN 2-3. Eastward, the third sample, taken at the bridge across the river near Agnes, is sparse but contains *Coccolithus pelagicus, Cyclocargolithus floridanus,* and *Sphenolithus heteromorphus,* indicating an early to mid-Miocene age. The fourth sample, from near the crest of the Coast Range, probably represents the Tyee Formation and contains *Discoasteroides keupperi, Helicosphaera seminulum, Lanternithus minutus, S. radians, Zygolithus dubius,* and *Zygrhablithus bijugatus,* suggesting mid-Eocene NP 12-15.

These samples represent the first reported occurrence of calcareous nannofossils from the Klamath melange, and more important, the youngest strata yet dated from within the Klamath. Detailed collecting, which will commence shortly, should greatly enhance understanding of the Cenozoic and perhaps Mesozoic history of this tectonically complex area.

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