channeled estuarine system developed landward of the retrograded shoreline trend. During this tide-dominated aggradational phase, channels migrated over the back-barrier area and produced the relatively coarser sand facies capping the Point Lookout in the study area. After the estuarine system was infilled, coastal plain facies were established in the former back-barrier zone and progradation was renewed. With the repetition of this depositional pattern through time, the coastal plain advanced in a step-wise fashion.

As a consequence of the progradational-transgressive cyclicity, a significant degree of stratigraphic rise was attained during the Point Lookout regression. Each time-stratigraphic coastal sand body acts as a discrete reservoir that interfingers landward with impermeable sediments of the coastal plain facies. Given the necessary present-day structural configuration, major stratigraphic rises corresponding to aggradational phases can act as updip migration boundaries to gas derived from the center of a basin.

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Radiolarian Preservation in Geologic Sequences

The following observations were noted during fieldwork in Tethyan regions.

1. Radiolarians are often preserved where organic matter is abundant, generally in reduced environments or microenvironments resulting from transgression or confined basins. Such an anaerobic environment preserves silica from dissolution.

2. Radiolarian localities are commonly restricted to small basins (e.g., the Gulf of California).

3. In limestones, radiolarians are commonly restricted to small "nests" preserved in pyrite. This restriction may be a result of their sedimentation within fecal pellets, reducing microenvironments.

4. Preservation is generally better in rocks rich in clays (clayey limestones, nonglassy cherts). The clays may produce a double effect: (a) to form protective varnish all around the shell, (b) to slow the opal-A to opal-CT transformation so the structure of the opal-CT is better organized and much less subject to subsequent dissolution.

5. Radiolarians in limestones are generally calcitized. However, in rich limestones where silica is not concentrated in nodules but is "diffuse," radiolarians remain preserved in silica. This results from clays which limit (a) the opal-A to opal-CT transformation which occurs in a fluid state and (b) the migration of the silica fluid.

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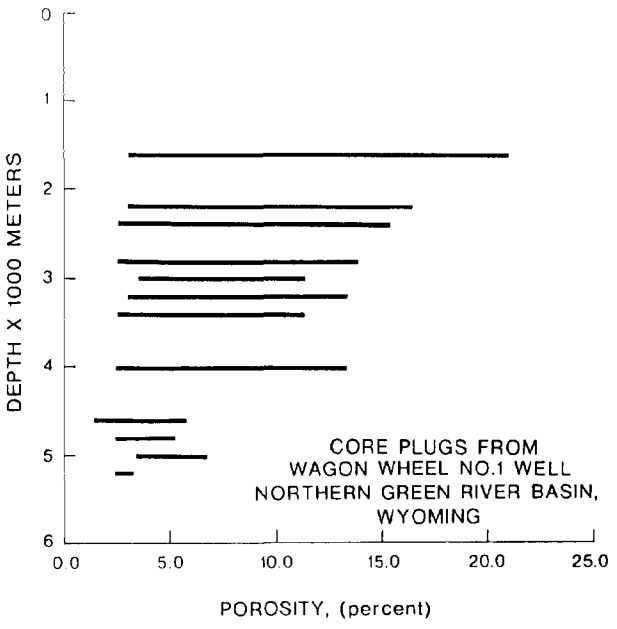
Diagenesis of Nonmarine Rocks and Gas Entrapment in Northern Green River Basin, Wyoming

More than 5,000 m (16,404 ft) of Upper Cretaceous and Tertiary nonmarine rocks have accumulated in the northern Green River basin. At depths below 3,000 m (9,842 ft), they contain large reserves of natural gas in low-permeability, overpressured sandstones and siltstones. Isotopic, petrographic, and mineralogic studies of cores from seven wells reveal that an intricate sequence of diagenetic events has acted upon mineralogically immature sediments to produce the observed low permeabilities. In large portions of the basin, this low permeability impedes the leakage of pore fluids, including gas. Gas accumulates in sandstones because it is generated from humic matter at a rate that exceeds its ability to escape. Gas entrapment due to low permeability is demonstrated by overpressuring. The overpressuring results from a combination of overburden removal and generation of fluids by organic matter maturation.



In the central part of the basin, normal hydrostatic pressures exist down to about 2,500 m (8,200 ft). Sandstone porosities in this zone range from 10 to 15% and permeabilities usually exceed 10 md. Below this depth, sandstones have greatly reduced porosities and permeabilities and become increasingly overpressured. At depths of about 3,500 m (11,483 ft), overpresssuring and gas accumulation are associated with sandstones that have average porosities of about 7% and in-situ permeabilities of approximately 0.005 md. This transition is not marked by a depositional boundary.

Porosity reduction, which is assumed to be paralleled by permeability loss, proceeds by some combination of three principal processes: (1) precipitation of calcite or silica cements early in the burial history; (2) porosity loss through grain deformation and compaction; and (3) the filling and coating of residual and secondary pores by illite, chlorite, microcrystalline quartz, or ferroan carbonates.

A wide range of porosities is present in each depth interval, but maximum sandstone porosity follows a relentless course of destruction with depth. Only locally has the magnitude of grain and cement dissolution been great enough to reverse the porosity-depth trend. Zones of conventional reservoir porosity and permeability have not been recognized in areas of overpressuring and gas accumulation, nor are they to be expected. Because the gas is diagenetically entrapped, the search for economic accumulations should, paradoxically, be limited to sandstones of low porosity and permeability.

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Acritarchs from Ponta Grossa Formation and Their Stratigraphic Significance—Devonian of Parana Basin

The Devonian fossil record in the Parana basin of Brazil is

restricted to the Ponta Grossa Formation, a potential source rock unit.

The subsurface distribution, the character and the stratigraphic limits of this formation are not precisely known yet.

Paleontological studies of the macrofauna from this formation indicated an Early Devonian age. Previous palynological analysis has been exclusively based on chitinozoans, spores, and the acritarchs of the leiofusidae group and the *Maranhites* genera.

Other microplankton have not been considered.

This paper intends to fill this lack in the palynological record of the Devonian for the Parana basin.

For this paper a wide range of surface samples and core samples from eight wells drilled by PAULIPETRO (a CESP-IPT joint venture) have been studied.

Microplankton from the Devonian of the Parana basin never before described are presented here, together with their biostratigraphical and paleoecological implications. Intrabasinal and interbasinal correlations are also made.

From a total of 60 species identified until now, twenty forms having well-defined stratigraphic ranges and broad (intercontinental) geographic representation are described herein. This assemblage is marked by the presence and diversity of the Subgroups Polygonomorphitae and Pteromorphitae. The Subgroup Acanthomorphitae is also well represented.

The Emsian-Frasnian age previously established for the Ponta Grossa Formation through other palynological studies is further confirmed by the paleomicroplankton evidence. Moreover, the chronostratigraphic limits of these sediments may now be refined even further. Thus, despite the presence of long-ranging forms, other species, such as *Triangulina alargada*, which is restricted to the Emsian in the "La Vid" Formation in northern Spain, allow a better chronostratigraphic subdivision of the Ponta Grossa Formation.

The microplankton assemblage is very similar to others known from the Maranhão basin, Brazil; the province of Leon, Spain; and Ghana, Africa.

The abundance of forms of *Tasmanites* together with a large quantity and diversity of microplankton provides the basis for the paleoecologic interpretations.

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Effects of Depositional and Diagenetic History Upon the Reservoir Properties of Parkman Sandstone, Powder River Basin, Wyoming

The depositional system within which the Upper Cretaceous "Parkman Formation" (= Parkman Sandstone Member of the Mesaverde Formation) of the Wyoming part of the Powder River basin was formed, was delineated using a combination of outcrop data, subsurface core data, and geophysical well logs. The post-depositional history of these rocks was determined, semiquantitative compositional analyses of authigenic components were made, and paragenetic sequences were established with the aid of scanning electron and transmission electron microscopy.

The Parkman Formation in the study area is composed of a progradational deltaic complex of interstratified sandstone, siltstone, and shale that overlies the extensive marine shelf deposits of the Steele Shale. Four distinct units within the Parkman have been delineated: (1) interbedded shale, siltstone, and very fine grained, well-sorted sandstone, which were deposited in prodeltaic environments; (2) coarsening-upward sequences of sandstone with lenticular siltstone beds and some shale interbeds, which were deposited in distributary mouth-delta front environments; (3) fine-grained, moderately sorted, horizontal to cross-bedded sandstones deposited in beach environments; and (4) dark lignitic shales, carbonaceous siltstones, and fining-upward sandstone sequences deposited in floodplain, swamp, and distributary channel environments.

The timing and intensities of diagenetic alterations have profound effects upon reservoir properties of the Parkman Sandstone in the Wyoming part of the Powder River basin. In the subsurface samples, major authigenic minerals observed in the Parkman Sandstone are clay minerals (chlorite, illite, montmorillonite, kaolinite), quartz, feldspar, calcite, dolomite, and iron-oxides, whereas in the surface samples there was no authigenic chlorite and only rare quartz overgrowths, but rather more kaolinite, calcite, and iron-oxide.

The generalized diagenetic sequence can be summarized as follows: (1) ductile grain deformation and original porosity reduction due to settling and mechanical compaction; (2) authigenic chlorite formation as grain coatings or pore linings; (3) authigenic quartz overgrowths from dissolution of silica grains, and clay diagenesis, as well as pressure solution; (4) authigenic feldspar overgrowths; (5) minor authigenic mineral deformation due to continued mechanical compaction; (6) authigenic feldspar alterations to clay minerals; (7) calcite cementation; (8) dolomitization; (9) calcite replacement of siliciclastic grains; and (10) iron-oxide development.

All of the authigenic minerals in the Parkman Sandstone, where they are abundant, reduce the effective primary porosity and permeability of potential reservoir sandstones prior to petroleum generation, migration, and accumulation. In the subsurface samples where authigenic chlorite occurs, the pore space was reduced by 5 to 10 μ. However, where chlorite is thin or absent, quartz overgrowths tend to grow larger to a maximum crystal diameter of 30 to 40 μ, filling most of the pore space. Therefore chlorite coatings actually prevent the porosity from being completely destroyed with quartz overgrowths. In surface samples, chlorite coatings have not been observed, but late-stage calcite cement replaced most of the siliciclastics and, along with iron-oxide cements, further reduced porosity and permeability.

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Experimental Low-Altitude Aeromagnetic Reconnaissance for Petroleum in Arctic National Wildlife Refuge, Alaska, Using Horizontal Gradients—A Progress Report

Variations in the earth's magnetic field arising from areally restricted increased amounts of shallow-buried magnetite over hydrocarbon deposits have been mapped in the Arctic National Wildlife Refuge and elsewhere is northern Alaska. The anomalies have been delineated with a low-flying (90 m; 295 ft) magnetic horizontal gradiometer mounted on a fixed-wing airplane. Limited data from stable carbon isotope and remanent magnetism measurements of rock cores from the Cape Simpson region strongly suggest that the magnetic anomalies result from the chemical reduction of iron oxides in the presence of seeping hydrocarbons. Relatively large magnetic contrast between typical sedimentary rocks and those locally enriched with this epigenetic magnetite results in distinctive high wave-number and low-amplitude total field anomalies. Magnetometers extended from each wingtip and in a tail stinger permit calculation of the resultant horizontal gradient vector relative to the flight path. This calculation provides data for the unmeasured area between adjacent flight lines spaced at 1.5 km (.9 mi), thereby allowing