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GEOLOGICAL AND ROUTINE CORE ANALYSIS OF ROTARY SIDEWALL CORES FROM THE EASTERN STATES OIL & GAS SIBLEY COAL & COKE A-15 WELL SANDY RIVER FIELD MCDOWELL COUNTY, WEST VIRGINIA

Prepared

for

Eastern States Exploration Co.

Alexandria, Virginia

RSH 3881

CONFIDENTIAL

April, 1998

Reservoirs Inc.

April 14, 1998

Mr. Dave Grogan
Eastern States Oil & Gas
2800 Eisenhower Avenue
Suite 400
Alexandria, VA 22314

Dear Mr. Grogan:

This report presents the results of geological and routine core analysis performed on sixteen (16) rotary sidewall cores from the Sibley Coal & Coke A-15 Well, located in McDowell County, West Virginia. The objectives of this study were to: 1) determine porosity, permeability, grain density and water, oil and gas saturations, and 2) provide detailed thin section and X-ray diffraction (XRD) analyses on five (5) of these samples. Rotary sidewall core analysis data are provided in Table 1, and XRD data are presented in Table 2. Thin section point count data and representative photomicrographs are found in Table 3 and Plates 1 through 5, respectively.

GEOLOGICAL ANALYSIS

Five sandstones with various textures and reservoir quality were analyzed. A summary of petrographic characteristics is presented below:

Depth (ft.)	Ø (%)	k (md)	Lithology	Pore-Filling Constituents	Dominant Pore Types	Estimated Reservoir Quality
7022	2.5	0.008	Upper fine-grained sandstone	Quartz overgrowths >> authigenic clays	Highly reduced intergranular pores	Poor
7030	6.7	0.266	Lower fine-grained sandstone	Quartz overgrowths >> authigenic clays	Reduced intergranular pores > leached-grain secondary pores	Poor to Fair
7035	8.1	86.2	Upper medium-grained sandstone	Quartz overgrowths >> authigenic clays	Intergranular pores	Good
7037	7.0	2.30	Lower coarse-grained sandstone	Authigenic clays ≥ quartz overgrowths	Intergranular pores	Fair
7040	5.3	2.14	Lower fine-grained sandstone	Quartz overgrowths >> authigenic clays	Reduced intergranular pores > leached-grain secondary pores	Fair

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Texture:
The five petrographically analyzed samples range from lower fine- to lower coarse-grained sandstones. Sorting characteristics vary widely from well to poorly (bimodal?) sorted. Compaction is estimated to be moderate (to locally heavy); point and long grain contacts abound.

Framework Grain Mineralogy:
The framework grain composition of the sandstones does not vary significantly within the sample suite. **All five of the analyzed sandstones are quartzarenites** (Figure 1), with quartz (65.6-86.0%) significantly more abundant than feldspars (0-2.8%) and rock fragments (0-1.2%). Potassium feldspar (0-2.0%) is more abundant than plagioclase feldspar (0-0.8%). Accessory grains include heavy minerals or opaques (0-2.0%) and rock fragments (0-1.2%). X-ray diffraction data (Table 1) are in general agreement with point count data.

Pore-Filling Constituents (cements plus matrix):
Authigenic phases are the main pore-filling constituents in these well-cemented sandstones. Total cement ranges from 10.0 to 25.2%, and averages 19.4%. There is little or no detrital matrix.

Quartz overgrowths and authigenic clays are the principal pore-filling agents. Petrographic observations indicate that quartz overgrowths (4.4-24.4%) are abundant throughout these sandstones. This quartz cement has severely occluded intergranular areas in all the samples except the coarse-grained sandstone from 7037 feet. Grain-coating authigenic clays (2.4-5.6%) are present in every analyzed sample in variable amounts. XRD analysis performed on two of the sandstones indicates that illite is the only clay phase present. This grain-coating clay is most abundant in the coarse-grained sandstone from 7037 feet where it may have inhibited the nucleation of quartz overgrowths. Trace amounts of pyrite cement were also observed.

Pore System Properties:
Total visible porosity ranges from 2.4 to 8.4%. Rotary sidewall core analysis shows a porosity range from 2.5-8.1%. **Intergranular pores account for the bulk of the total pore volume in these sandstones.** Most of these intergranular pores have been at least partially reduced by quartz cement. Partial dissolution of feldspars (plagioclase?) has led to the development of a small number of leached-grain secondary pores. Intergranular pores outnumber the secondary pores by an average of 8 to 1. Micropores associated with the authigenic clays are rare.

Reservoir Quality:
Quartz overgrowths and grain size appear to be the principal controls on reservoir quality. The two coarsest sandstones (7035 and 7037 feet) exhibit the highest permeabilities; these two samples also contain the least amount of quartz cement. Poor to bimodal grain sorting has negatively affected the reservoir quality.

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If you have any questions or comments concerning this report, please contact me at (713) 935-4240.

Sincerely,

Brian D. Nicoud

Brian D. Nicoud
Staff Geologist
RESERVOIRS, INC.

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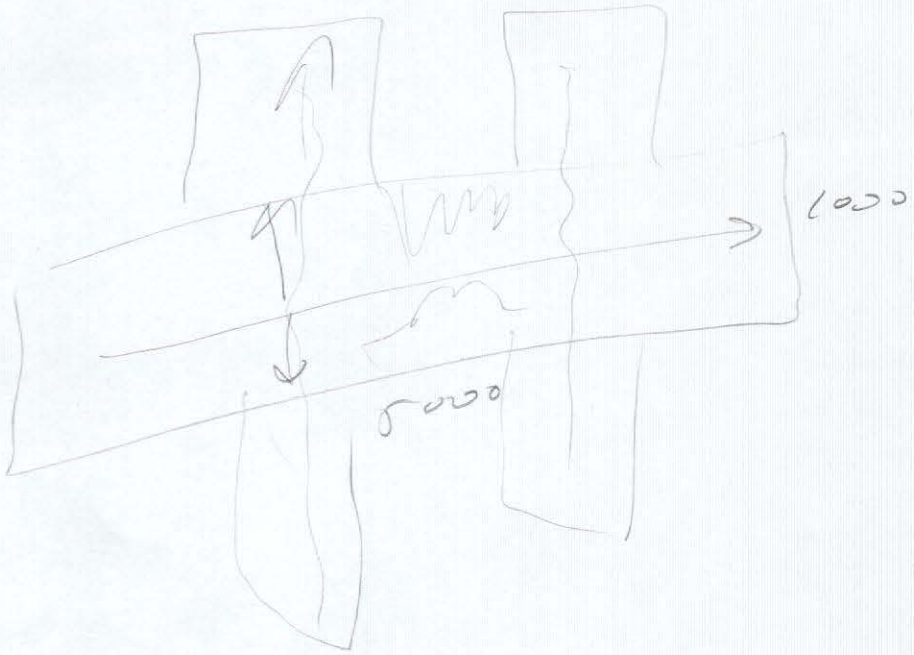
1000
5000

TABLE 1

ROTARY SIDEWALL CORE ANALYSIS

Eastern States Oil & Gas
Sibley Coal & Coke A-15 Well
Sandy River Field
McDowell County, West Virginia

Depth Interval: 7,013.0 - 7,042.0 ft

Sample	Depth (ft)	Porosity (%BV)	Permeability to Gas (md)	Grain Density (g/cc)	Saturation (%PV) Water	Oil	Gas	Lithological Description
W 737	7013.0	2.0	**	2.64	59.6	0.0	40.4	Sst gry fgr wl consol
W 738	7022.0	2.5	0.008	2.64	66.6	0.0	33.4	Sst gry vf-fgr wl consol
W 739	7025.5	1.7	0.001	2.66	74.9	0.0	25.1	Sst mott lt gry-blk vfgr wl consol sh lams sh incls
W 740	7028.0	5.6	0.042	2.65	66.1	0.0	33.9	Sst gry vfgr wl consol
W 741	7030.0	6.7	0.266	2.65	77.4	0.0	22.6	Sst gry vfgr wl consol
W 742	7032.0	6.4	0.025	2.65	81.5	0.0	18.5	Sst mott gry-lt gry f-vfgr sli shly
W 743	7033.0	5.8	0.745	2.64	66.9	0.0	33.1	Sst gry f-vgr wl consol
W 744	7034.0	7.4	10.3	2.64	78.4	0.0	21.6	Sst mott gry-lt gry fgr wl consol
W 745	7035.0	8.1	86.2	2.64	78.6	0.0	21.4	Sst gry m-crsgr wl consol
W 746	7036.0	7.8	0.579	2.64	84.8	0.0	15.2	Sst gry f-vfgr crsgr i.p. wl consol
W 747	7037.0	7.0	2.30	2.64	83.0	0.0	17.0	Sst gry mgr wl consol
W 748	7038.0	0.6	0.008	2.63	53.5	0.0	46.5	Sst gry mgr wl consol
W 749	7039.0	5.0	0.135	2.64	74.0	0.0	26.0	Sst gry vf-mgr wl consol
W 750	7040.0	5.3	2.14	2.65	74.8	0.0	25.2	Sst gry f-vfgr crsgr i.p. wl consol
W 751	7041.0	4.0	0.032	2.64	82.0	0.0	18.0	Sst gry f-vcrsgr wl consol
W 752	7042.0	2.7	0.266	2.64	67.2	0.0	32.8	Sst gry f-crsgr wl consol

** Broken/non-cylindrical sample, permeability to gas indeterminable.

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TABLE 2

MINERALOGICAL DATA BY X-RAY DIFFRACTION

Eastern States Oil & Gas
Sibley Coal & Coke A-15 Well
McDowell County, West Virginia

	MINERALOGY OF WHOLE ROCK SAMPLE (WEIGHT %)			MINERALOGY OF CLAY FRACTION (RELATIVE %)
Depth (ft)	Qtz	Ksp	Clay	Ill
7022	98	1	1	100
7035	98	1	1	100
Avg:	98	1	1	100

KEY:

Qtz = quartz
Ksp = K-feldspar
Clay = total clay
Ill = illite

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TABLE 3
THIN SECTION PETROGRAPHIC DATA
Eastern States Oil & Gas
Sibley Coal & Coke A-15 Well
McDowell County, West Virginia

Sample Depth (ft)	7,022	7,030	7,035	7,037	7,040
Porosity (%)	2.5	6.7	8.1	7.0	5.3
Permeability (md)	0.008	0.266	86.2	2.30	2.14
Texture					
Grain Size (mm)	UF (0.198)	LF (0.128)	UM (0.456)	LC (0.560)	LF (0.132)
Sorting	Well	Mod. Well	Poor (Bimodal?)	Poor (Bimodal?)	Mod.
Framework Constituents					
Quartz	70.8	65.6	76.0	86.0	65.6
Plagioclase	0.4	0.8	--	--	0.8
K-Feldspar	1.2	2.0	0.4	--	1.2
Sedimentary Rock Fragments	--	0.4	--	--	--
Volcanic Rock Fragments	--	--	--	--	--
Metamorphic Rock Fragments	--	--	--	--	--
Unidentified Rock Fragments	--	--	--	--	0.4
Plutonic Rock Fragments	--	--	--	--	0.4
Carbonate Grains	--	--	--	--	--
Chert	--	--	0.4	0.4	0.4
Mica	--	--	--	--	--
Fossil Fragments	--	--	--	--	--
Glauconite	--	--	--	--	--
Heavy Minerals/Opaques	--	2.0	0.4	--	1.2
Other	--	--	--	--	--
Intragranular Replacements					
Calcite	--	--	--	--	--
Dolomite	--	--	--	--	--
Kaolinite	--	--	--	--	--
Pyrite	--	--	--	--	0.4
Clay	--	--	--	--	--
Other	--	--	--	--	--
Matrix					
Clay/Organic	--	--	--	--	--
Pore-Filling Constituents					
Quartz Overgrowths	24.4	16.4	14.8	4.4	20.8
Dolomite	--	--	--	--	--
Calcite	--	--	--	--	--
Anhydrite	--	--	--	--	--
Undifferentiated Clay	0.8	4.4	2.4	5.6	3.2
Chlorite	--	--	--	--	--
Kaolinite	--	--	--	--	--
Pyrite/Opaques	--	--	--	--	--
Feldspar Overgrowths	--	--	--	--	--
Pore Space					
Intergranular	2.0	7.2	5.6	3.6	4.4
Leached Grain	0.4	1.2	--	--	1.2

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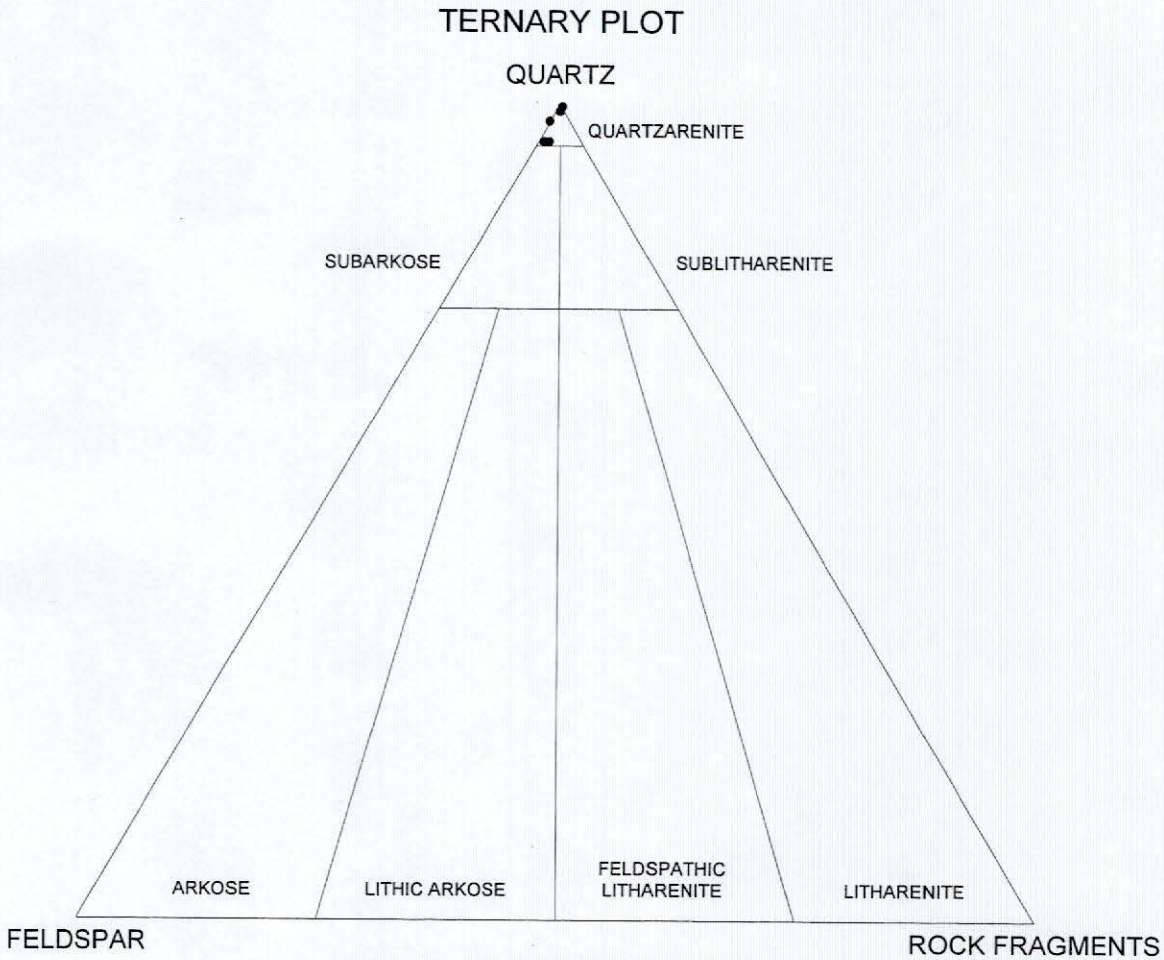
FIGURE 1

TERNARY PLOT

Eastern States Oil & Gas
Sibley Coal & Coke A-15 Well
McDowell County, West Virginia



Folk Sandstone Classification

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PLATE 1

THIN SECTION PHOTOMICROGRAPHS

Eastern States Oil & Gas

Sibley Coal & Coke A-15 Well

McDowell County, West Virginia

Core Depth: 7022 feet

Grain Size:	0.198 mm (Upper Fine Sand)	Measured Porosity:	2.5%
Sorting:	Well	Permeability:	0.008 md

Quartz overgrowths (QO) fill most of the intergranular areas in this upper fine-grained sandstone. The resultant pore structure consists of highly reduced intergranular pores and rare leached-grain secondary pores. Quartz grains far outnumber the feldspar grains.

A - 40X

B - 160X

X-RAY DIFFRACTION DATA

Bulk Mineralogy		Clay Mineralogy	
Quartz	98%	Illite	100%
Potassium Feldspar	1%		
Clay	1%		

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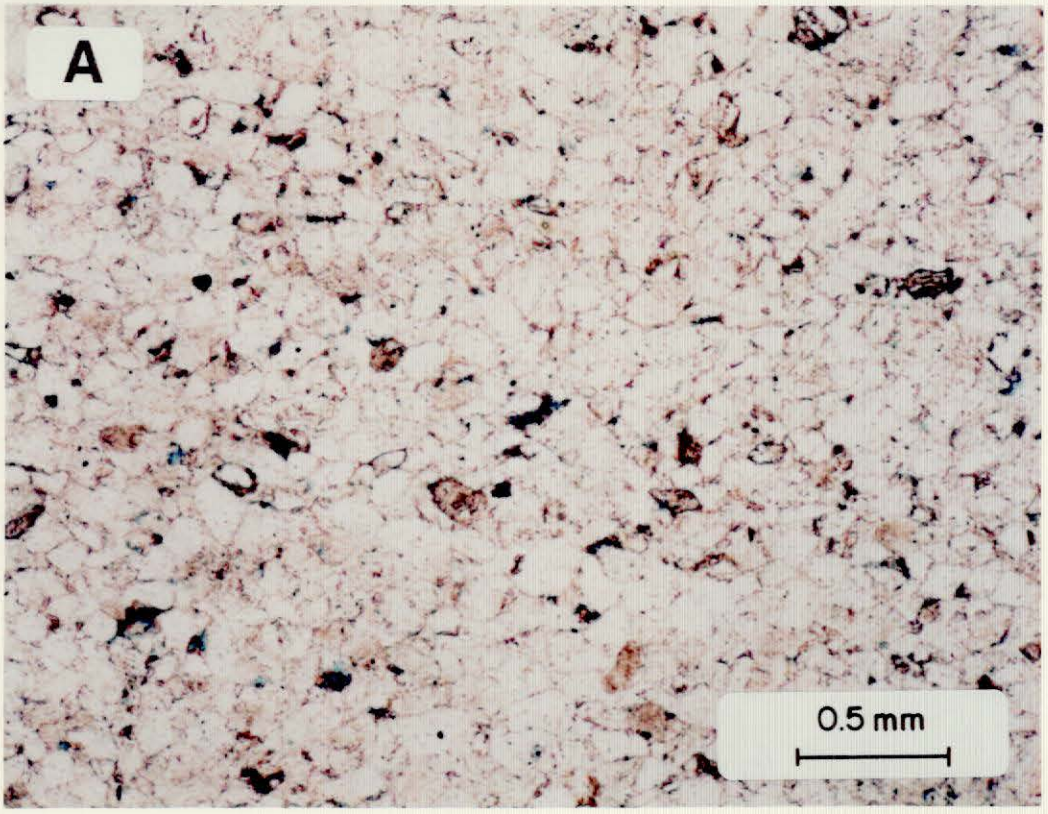
A
0.5 mm

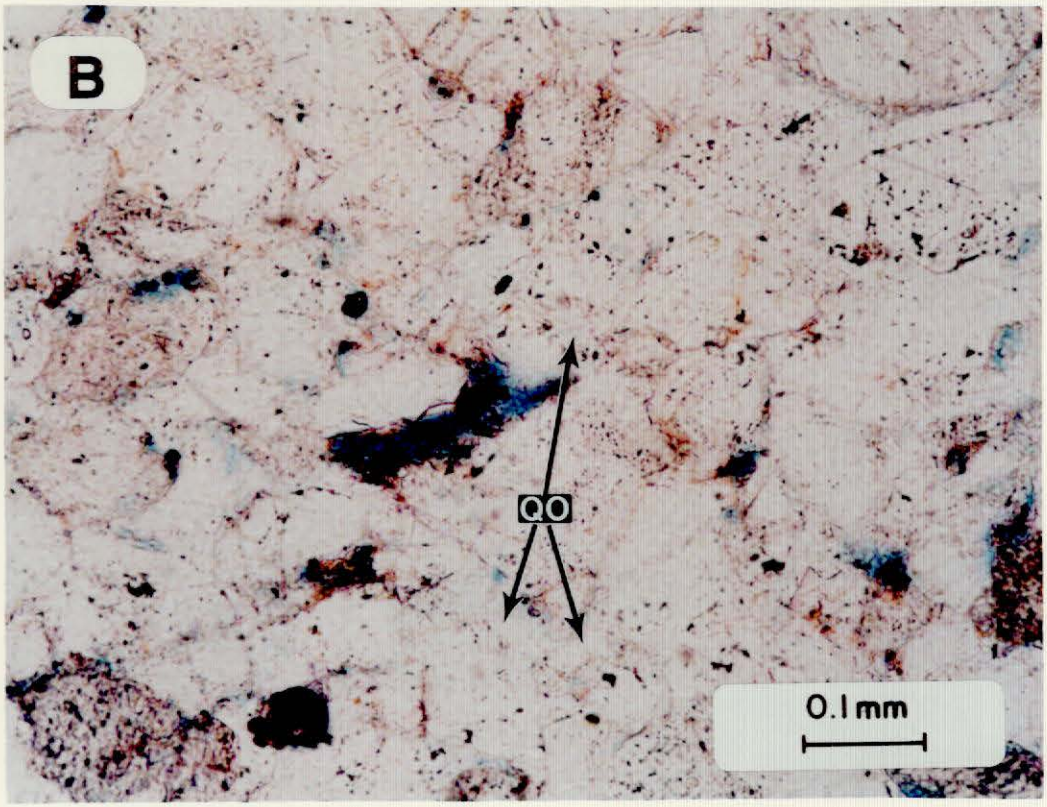
B
QO
0.1 mm

PLATE 2

THIN SECTION PHOTOMICROGRAPHS

Eastern States Oil & Gas

Sibley Coal & Coke A-15 Well

McDowell County, West Virginia

Core Depth: 7030 feet

Grain Size:	0.128 mm (Lower Fine Sand)	Measured Porosity:	6.7%
Sorting:	Moderately Well	Permeability:	0.266 md

Quartz overgrowths and authigenic clays (AC) are the principal pore-filling constituents in this well-cemented, lower fine-grained, quartzarenite. These grain-coating, authigenic clays are heterogeneously distributed throughout this sample. Note the reduced size of the intergranular pores; this pore structure results in moderate to low porosity and low permeability.

A - 40X

B - 160X

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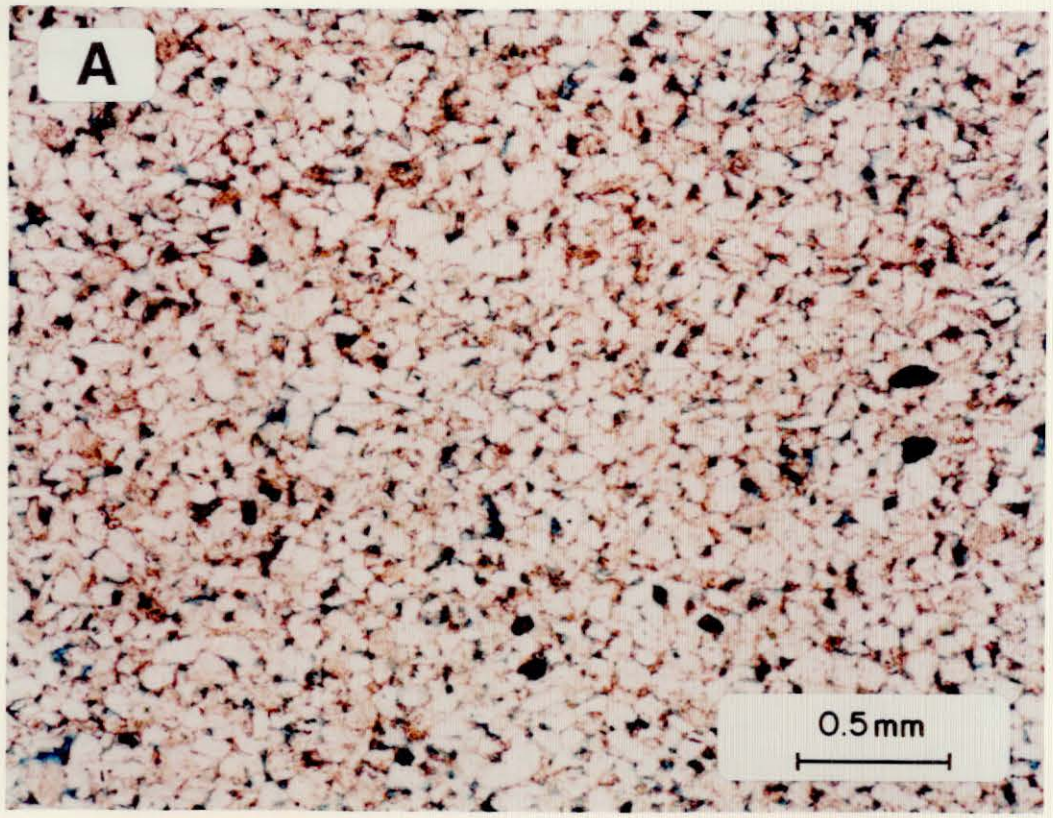
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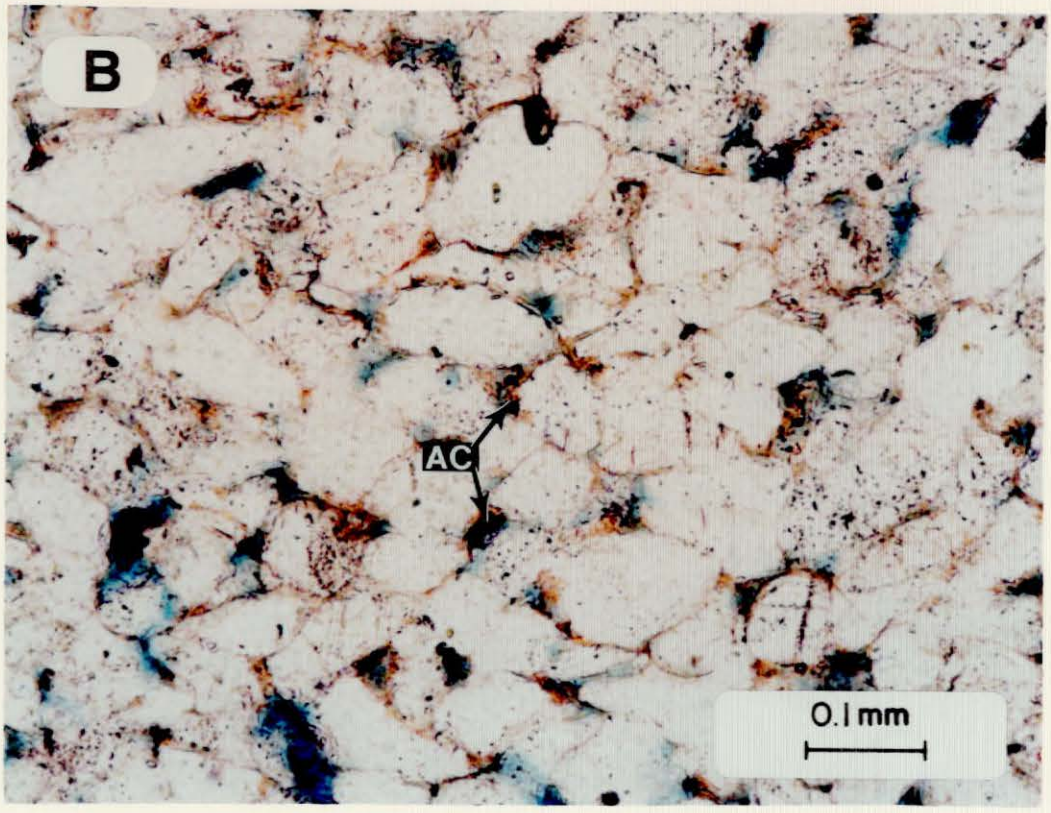
B
AC
0.1 mm

PLATE 3

THIN SECTION PHOTOMICROGRAPHS

Eastern States Oil & Gas

Sibley Coal & Coke A-15 Well

McDowell County, West Virginia

Core Depth: 7035 feet

Grain Size:	0.456 mm (Upper Medium Sand)	Measured Porosity:	8.1%
Sorting:	Poor (bimodal?)	Permeability:	86.2 md

Intergranular pore space has been relatively well preserved in this poorly sorted, upper medium-grained quartzarenite. Large, open intergranular pores (P) abound in the areas that contain the larger grains. Pore size decreases significantly in the finer-grained laminations. Quartz overgrowths (QO) and grain-coating, authigenic clays are the principal cementing agents.

A - 40X

B - 160X

X-RAY DIFFRACTION DATA

Bulk Mineralogy		Clay Mineralogy	
Quartz	98%	Illite	100%
Potassium Feldspar	1%		
Clay	1%		

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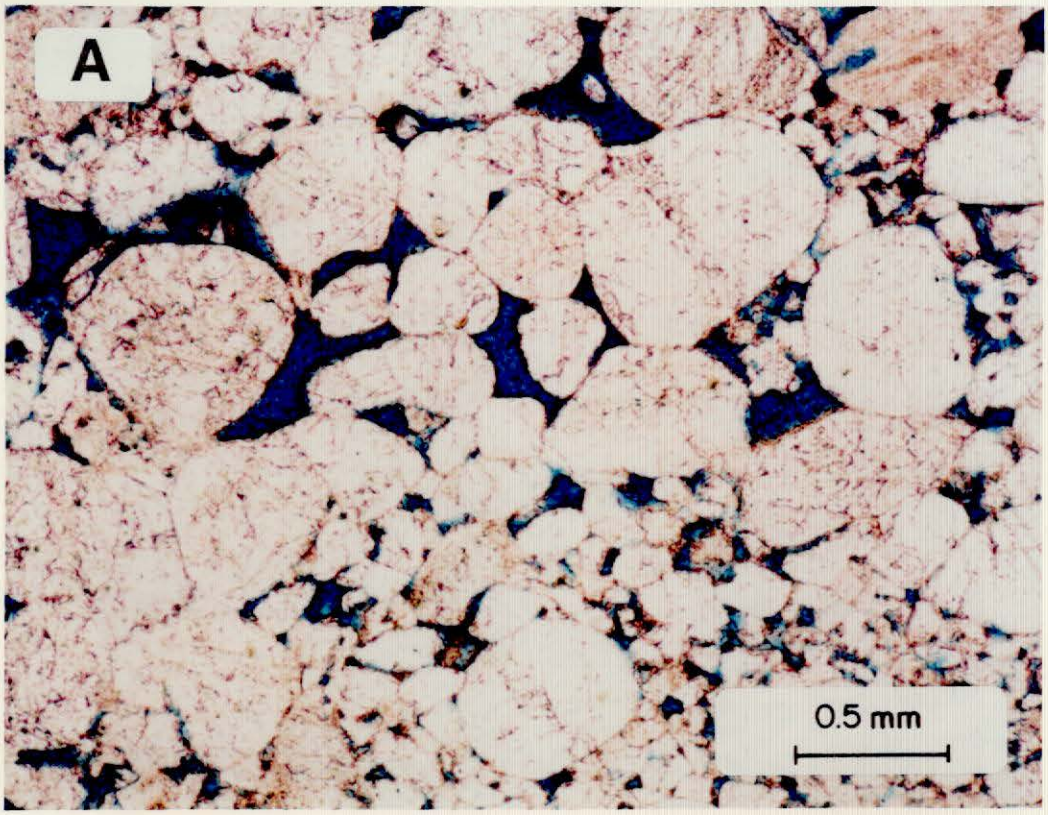
A
0.5 mm

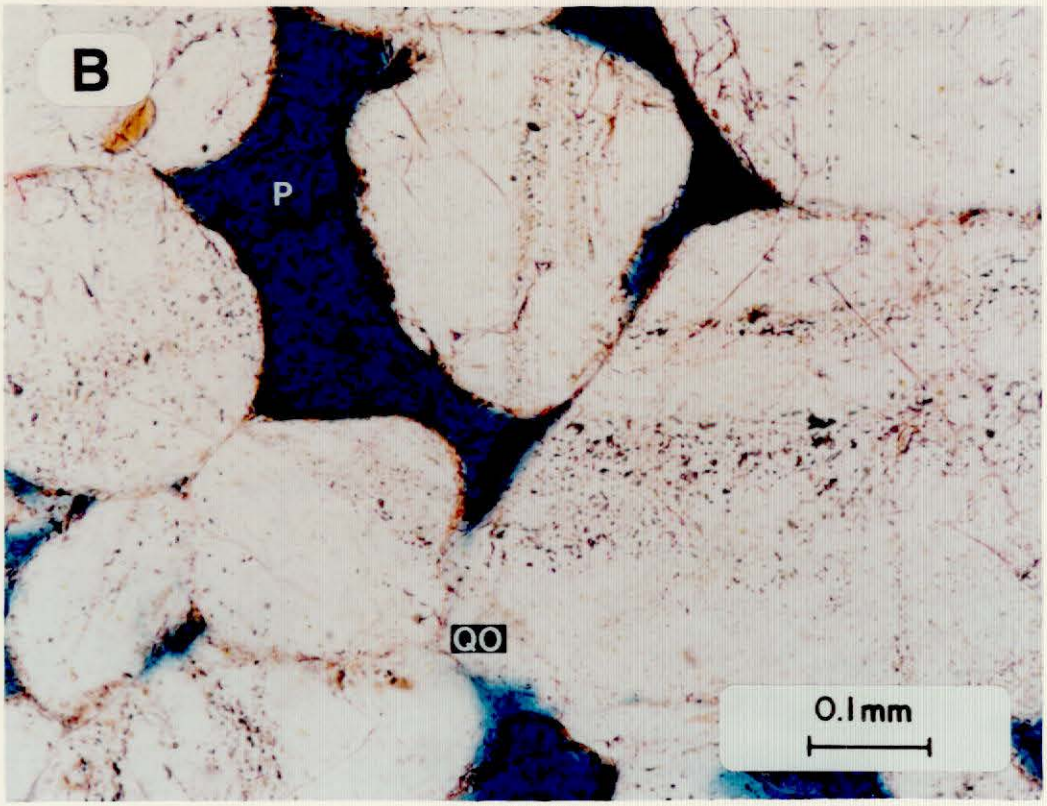
B
P
QO
0.1 mm

PLATE 4

THIN SECTION PHOTOMICROGRAPHS

Eastern States Oil & Gas

Sibley Coal & Coke A-15 Well

McDowell County, West Virginia

Core Depth: 7037 feet

Grain Size:	0.560 mm (Lower Coarse Sand)	Measured Porosity:	7.0%
Sorting:	Poor (bimodal?)	Permeability:	2.30 md

Grain-coating, authigenic clays (AC) are the principal pore-filling constituents in this sample, and may have inhibited the nucleation of quartz overgrowths. These clays are present throughout this sample and are probably illitic. The poor grain sorting of this sandstone has negatively affected the size and interconnectivity of the intergranular pores (P). The framework grain mineralogy is dominated by monocrystalline quartz.

A - X40

B - X160

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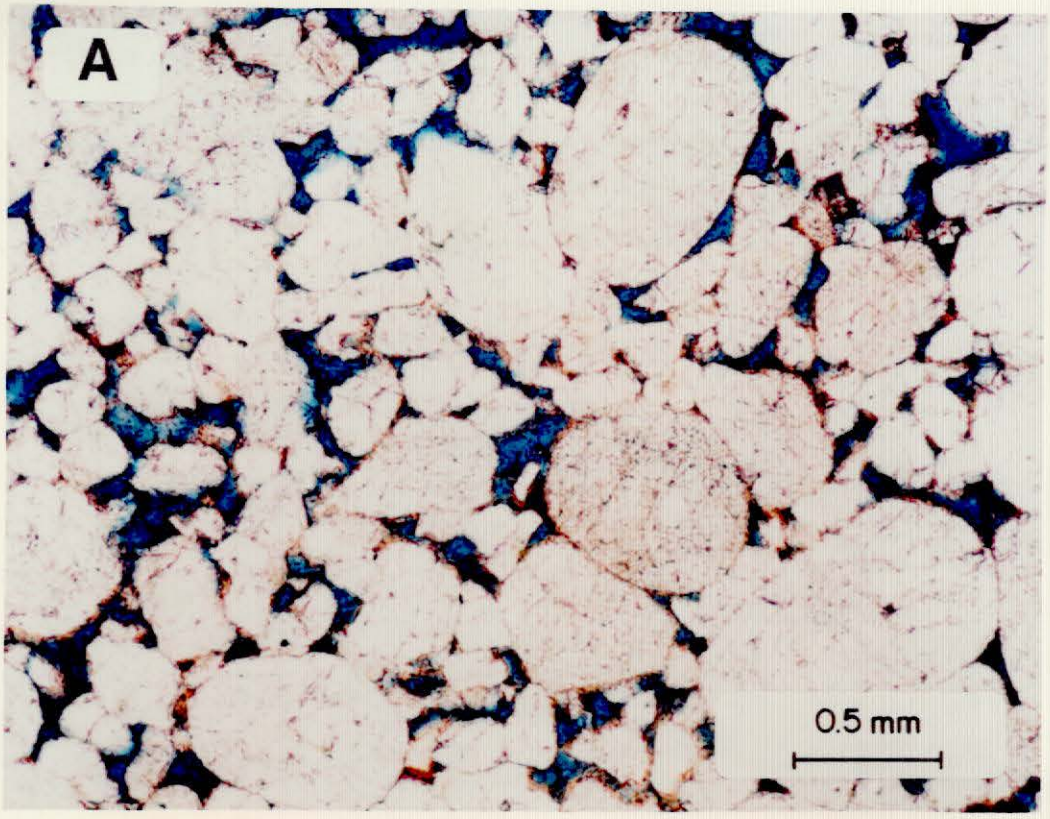
A
0.5 mm

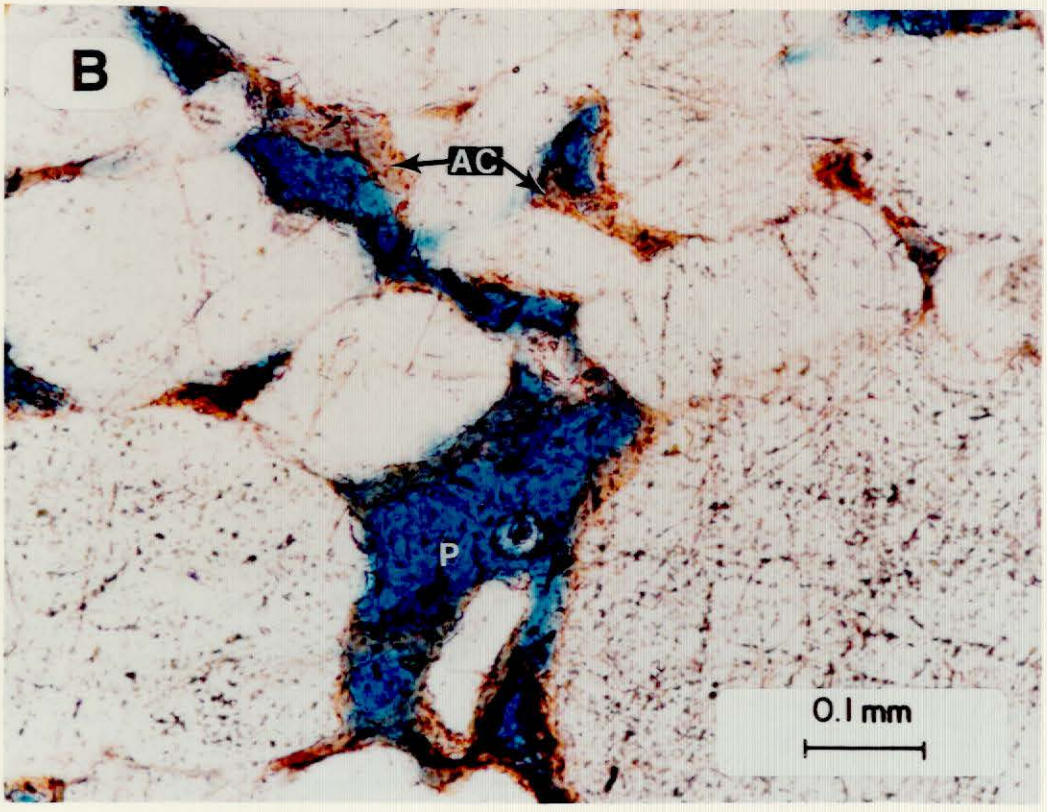
B
AC
P
0.1 mm

PLATE 5

THIN SECTION PHOTOMICROGRAPHS

Eastern States Oil & Gas

Sibley Coal & Coke A-15 Well

McDowell County, West Virginia

Core Depth: 7040 feet

Grain Size: 0.132 mm (Lower Fine Sand)
Sorting: Moderate

Measured Porosity: 5.3%
Permeability: 2.14 md

Highly silica-cemented laminae stand out in these views of a lower fine-grained sandstone. Grain compaction, quartz overgrowths (QO), and brown, grain-coating authigenic clays are the primary reducers of reservoir quality. Leached-grain secondary pores supplement the reduced intergranular pore (P) network.

A - 40X

B - 160X

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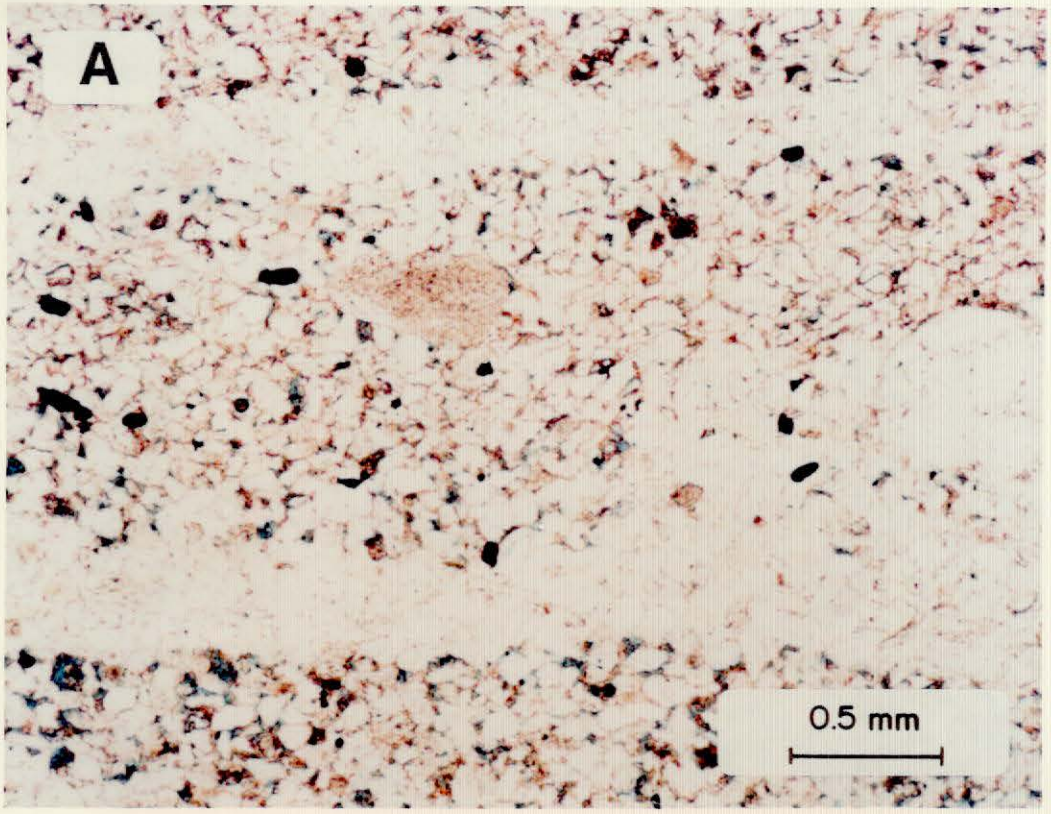
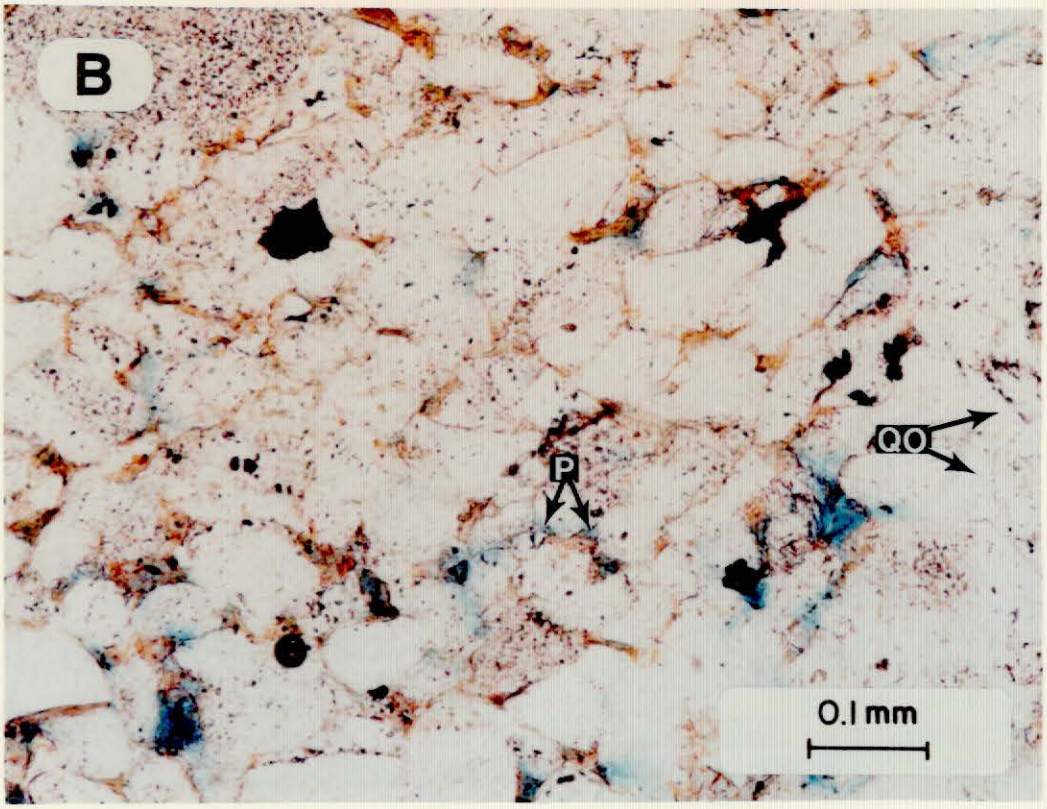

A
0.5 mm


B
P
QQ
0.1 mm