NMBMMR

Open-file Report 447

Reservoir rock evaluation of Pennsylvanian sandstones

El Paso San Juan 29-5 No. 50 well and
Phillips San Juan Deep 30-6 No. 112Y
Rio Arriba County, New Mexico

Prepared for
Burlington Resources
Farmington, New Mexico

1997

NMBM-07R-447

RESERVOIRS INC.

Geotechnical
Information Center

1151 BRITTMORE ROAD ■ HOUSTON, TEXAS 77043 ■ (713) 932-7183 ■ FAX (713) 932-0520

RESERVOIR ROCK EVALUATION OF PENNSYLVANIAN SANDSTONES

EL PASO SAN JUAN 29-5 NO. 50 WELL AND PHILLIPS SAN JUAN DEEP 30-6 NO.112Y RIO ARRIBA COUNTY, NEW MEXICO

Prepared for
Burlington Resources
Farmington, New Mexico

RSH 3710

1977 - 1997
20
YEARS OF EXCELLENCE
Reservoirs, Inc.

CONFIDENTIAL
August, 1997

Geotechnical
Information Center

INTRODUCTION

This report presents the results of a reservoir characterization study performed on core chip samples from Pennsylvanian aged sandstones in the El Paso Natural Gas Company San Juan 29-5 No. 50 Well, Sec. 7, T29N, R5W, Rio Arriba County, New Mexico. Specifically, eight core chip samples were submitted for petrographic analysis from an 84 foot thick Pennsylvanian sandstone sequence spanning subsurface depths from 12,690 to 12,774 feet. Mercury injection capillary pressure measurements were made on six of these samples and converted to subsurface conditions and height above free water level. In addition, petrographic analysis was performed on four core chip samples from a stratigraphically lower Pennsylvanian sandstone from 12,900 to 12,905 feet. Finally, a drill cutting sample was petrographically analyzed from a Pennsylvanian sandstone having a gas show from 13,195 to 13,214 feet in the Phillips San Juan Deep 30-6 No. 112Y Well located in Sec 26, T30N, R6W, Rio Arriba County, New Mexico.

The objectives of this study were to:

1) Determine the texture, composition, mineralogy, and pore space properties of the sandstones,
2) ascertain the factors controlling reservoir quality,
3) evaluate the potential effect of the various sandstone components on petrophysical properties and log response,
4) based on the mineralogy of the sandstones, make recommendations concerning rock-fluid compatibility of various drilling and completion fluids,
5) determine the potential producibility of the sandstones and estimate the gas column height present in the El Paso San Juan 29-5 No. 50 Well.

In order to accomplish the above objectives, the samples were analyzed by the following methods.

1. Thin Section Petrography was performed to determine texture, composition mineralogy and pore space properties. Each of the samples was point counted 250 counts in order to semi-quantitatively determine the composition of the sandstones in terms of framework constituents, cements and types and amounts of pore space. Thin section petrographic point count data are summarized in Table 1 and representative photomicrographs are presented in Plates 1-26.

2. Scanning Electron Microscopy. SEM analysis was performed on each of the samples in order to evaluate the pore structure of the sandstones. Special emphasis was placed on the type and distribution of authigenic clays present in the pore system and their influence on reservoir quality and petrophysical properties. SEM photomicrographs are presented in Plates 2-26.

3. X-ray Diffraction. Quantitative mineralogy was determined by standard X-ray diffraction techniques of both the bulk and clay fractions. X-ray diffraction data are summarized in Table 2.

4. Mercury Injection Capillary Pressure. MICP data were also obtained on six of the samples. Clean pieces of the core chips were injected with mercury at different pressures up to 2,000 psi. Capillary pressure curves were generated for each of the samples along with calculated pore throat size distributions. The data were converted to subsurface conditions and height above free water level. These data are presented in Tables 5-10 and Figures 5-10.

5. Log Analysis. Standard log analysis was performed on the Pennsylvanian sandstone from 12,690 to 12,774 feet in the El Paso San Juan 29-5 No. 50 Well to compare water saturations with capillary pressure data.

Reservoirs job number RSH3710 has been assigned to this study. Two copies of this report have been forwarded to Mr. Michael Dawson of Burlington Resources, Farmington, New Mexico. Two copies have been sent to Mr. Peter Hawkes of Conoco, Inc., Midland, Texas. Reservoirs has retained the original copy of this report on file for possible future reference and discussions with authorized personnel. Additional copies of this report may be obtained for reproduction and assembly costs by contacting Reservoirs, Inc. All matters related to this study are considered confidential.

Randall S. Miller
Vice President, Reservoirs, Inc.

EL PASO SAN JUAN 29-5 NO. 50 WELL

Pennsylvanian Sandstone 12,690 - 12,774 Feet

The top of this sandstone was drill stem tested for 260 MCF in two hours from 12,660-705 feet (Figure 1). Thin section petrography, scanning electron microscopy, X-ray diffraction, and mercury injection capillary pressure analyses were performed on six consecutive samples spanning depths from 12,706-07 to 12,711-12 feet (core depth). In addition, thin section and X-ray diffraction analyses were performed on two core chip samples at depths of 12,738-39 and 12,742-43 feet. These two cored intervals were correlated to the open hole logs and shifted downhole approximately six feet (Figure 1). However, this correlation is very tentative due to the absence of a surface core gamma and an adequate downhole porosity tool.

Texture

All eight analyzed samples are sandstones. Grain size ranges from fine to upper-coarse sand and locally pebble size. **In the samples from 12,706-07 to 12,711-12 feet, mean grain size is typically in the lower to upper coarse sand range. These sandstones are moderate to poorly sorted and are well to very well consolidated.** The sandstones at 12,738-39 and 12,742-43 feet are slightly finer grained having mean grain size in the lower and upper medium sand range respectively. Sorting is slightly better being moderate to well. Detrital clay matrix is absent in all of the samples. All of the sandstones have a massive to possibly planar-stratified sedimentary fabric. These textural features imply very high depositional energy (current velocity) levels possibly generated in a fluvial channel system.

Framework Constituents

Compositionally the sandstones are immature, being classified as arkoses to lithic arkoses. Quartz is the most abundant framework constituent comprising 32.0 to

50.8% of the samples by volume (Table 1). Next in abundance are feldspars with total feldspar ranging from 20.4% to 32.4%. The feldspar consists mostly of unaltered plagioclase and potassium feldspar. Thin section point count data reveals that plagioclase is in concentrations of 6.4 to 17.6 volume percent compared to potassium feldspar ranging from 4.0 to 20.0%.

Both metamorphic and plutonic rock fragments are common in these sandstones but are less abundant than feldspar. Metamorphic rock fragments consisting mostly of phyllites and lesser amounts of schists range from 2.0 to 12.4 volume percent. Plutonic rock fragments, many of which are granitic, range from 0.8 to 15.2 volume percent. Other framework grains are minor in comparison and consist of chert, mica and very rare carbonate grains.

Pore Filling Constituents

There are three major types of cements in these sandstones and they are quartz overgrowths, calcite, and authigenic chlorite clay. Quartz overgrowths are present in all of the samples in low to moderate amounts ranging from 3.6 to 6.6 volume percent. Calcite however, has a very uneven and patchy distribution in the sandstones ranging from 0.4 to 18.0% in the sample at 12,707-08 feet.

Authigenic chlorite clay is ubiquitous throughout the pore system of the sandstones. Thin section point count modal analysis indicates that chlorite comprises 2.4 to 14.4 volume percent of the sandstones. X-ray diffraction analysis reveals that total clay is only 2 - 3% of the sandstones by weight and that 91 to 97% of the total clay is chlorite. Both thin section and SEM analysis reveals that **the chlorite is present in a grain-coating/pore-lining morphology throughout the pore system of the sandstones** (Plates 2, 4, 6, 8, 10, 12, 14 and 16). The chlorite is well crystallized and occurs as intergrown platelets commonly arranged edge-wise on pore walls. The chlorite platelets and coatings are on the order of 10 to 20 microns in thickness.

Other cements are relatively rare and consist of local feldspar overgrowths and pyrite. Pyrite is noticeably present (1.4 - 3.6%) in the samples at 12,710-11, 12,738-39, and 12,742-43 feet.

Pore Space

Visible pore space in the sandstones is low ranging from a high of only 5.6% in the sample at 12,706-07 feet to a low of 0.4% for the sandstone at 12,707-8 feet. The visible pore space is comprised of intergranular and leached-grain pores. **Intergranular pores have been severely reduced in size and isolated by a combination of compaction and cementation by quartz overgrowths, calcite and grain-coating chlorite clay.** Leached-grain secondary pores result from the partial dissolution of some feldspars (e.g. Plate 6, D).

Microporosity associated with the chlorite clay comprises a significant portion of the total porosity in these sandstones. This is evident from the large discrepancy between visible pore space point counted in thin section and measured porosity. Visible pore space in thin section ranges from 0.4 to 5.6%, whereas, measured porosity ranges from 5.2 to 12.2%. High magnification SEM photomicrographs (e.g. Plates 2C, 4C and 8C) document that a significant amount of micropore space is associated with the intergrown platelets of authigenic chlorite.

Measured porosities of the sandstones range from 5.2 to 12.2% and permeabilities from 0.08 to a high of 1.3 at 12,706-07 feet. This sample has the best reservoir quality due to a lack of any calcite cement. Both porosity and permeability are lower in the other samples due to higher concentrations of calcite and quartz overgrowths.

Petrophysical Properties

Both core analysis and log-derived petrophysical properties are summarized in Table 3 for the cored intervals in the sandstone interval from 12,690 to 12,774 feet. **Core porosity ranges from 0.2 to 12.2% with an average of 7.7%. Permeability ranges from 0.01 to 1.3 md.** These data are also plotted on the open hole log in Figure 1. The original core analysis data indicates that total water saturation ranges from 36.3 to 89.6% and appears to be largely a function of permeability.

Log analysis was performed with log-derived porosity computed from the sonic log. This generally gave poor results, especially in the upper 30 feet of the sandstone where gas effects and borehole conditions resulted in extremely elevated sonic porosities. Sonic porosities are in reasonable agreement with core porosities from 12,750 to 12,770 feet.

Water saturation was calculated using a standard Archie equation assuming a cementation exponent (m) of 2.0 and a saturation exponent (n) of 1.8. Rw was assumed to be 0.033 ohm-m at formation temperature based on a supplied water analysis having a total dissolved solids of 62,000 ppm. The water saturations were calculated using both the sonic porosity and the core porosity (Table 3). **Calculated water saturations utilizing core porosities are typically in the high forties to mid seventy percent range.** These values coincidentally correspond very well with the water saturations reported from the original core analysis data. **Calculation of bulk volume waters indicate relatively constant values from 0.04 to 0.06 through the sandstone interval suggesting the water saturations are at irreducible levels.**

Capillary Pressure

Mercury injection capillary pressure analysis was performed on six samples spanning the core depths from 12,706-7 to 12,711-12 feet. These data were reported in a previous report. The mercury injection capillary pressure data were converted to subsurface conditions for height above free water level calculations. The reservoir data used to convert the laboratory data to subsurface conditions is as follows:

Reservoir temperature	=	287° F
Reservoir pressure	=	6400 psi
Water salinity	=	62,000 ppm TDS
Gas composition	=	97.8% methane
Compressibility factor	=	1.1
Gas density	=	0.195 g/cc
Water density	=	0.968 g/cc
Contact angle	=	0°
Interfacial tension	=	25 dynes

The results of this conversion and calculation of height above free water level are presented in Tables 5 through 11 and Figures 5 through 10. Based on these data and calculated water saturations, these sandstones have calculated height above free water levels ranging from 45 to 316 feet. The heights of the 100% water level above the free water level typically range from only 12 to 22 feet with the exception of the sample at 12,707-8 feet. **Corresponding estimated gas column heights for these samples range from a low of 23 to a high of 148 feet. With the average calculated as 82 feet. These data imply the majority of this sandstone from 12,690 to 12,774 feet is within the gas column.** Better estimates of gas column height could be made with refined water saturation calculations and air-brine centrifuge capillary pressure tests on better quality samples.

Pennsylvanian Sandstone 12,900-12,906 Feet

Thin section petrography, scanning electron microscopy and x-ray diffraction analyses were performed on four consecutive core chip samples spanning depths from 12,900-01 to 12,905-06 feet (core depth). These sample depths appear to be approximately the same as log depths (Figure 2). Unfortunately, no core analysis data were made available for these samples.

Texture

This consecutive suite of samples appears to form an overall coarsening-upward sequence from a well sorted, upper fine-grained sandstone at 12,905-06 feet to a moderately sorted, upper medium-grained sandstone at 12,900-01 feet. All of the sandstones are very well consolidated and do not contain any detrital clay matrix.

Framework Constituents

Compositionally the sandstones are very similar to the Pennsylvanian sandstone from 12,690 to 12,774 feet (log depth). The sandstones are arkosic in composition, with quartz being the most abundant framework constituent ranging from 27.6 to 35.6%. Total feldspar is 29.6 to 31.6% by volume. Many grains, most of which are feldspar, are completely to partially replaced by calcite. The only other significant grains are metamorphic rock fragments (5.2 - 8.8%) and plutonic rock fragments (0.8 - 2.8%). Ooids are present only in the sample at 12,905-06 feet comprising 1.6%.

Pore-filling Constituents

There are three major types of cements in these sandstones which are the same cements present in the thick sandstone from 12,690 to 12,774 feet. Quartz overgrowths are present in these samples in concentrations of 0.8 to 7.2% with the majority of quartz cement occurring in the shallower samples. **Calcite has roughly an inverse relationship with quartz cement being most prominent in the lower three sandstone samples. Total pore-filling calcite ranges from 1.2 to 11.6% by volume.** Chlorite is present in concentrations of 3.6 to 8.0%. It appears to be most common in the upper most three sandstone samples. **SEM analysis reveals that the chlorite is authigenic in origin and present in a grain-coating/pore-lining morphology** (Plates 18, 20, 22 and 24). X-ray diffraction analysis reveals that total clay is 2 - 3% by weight in these samples and that the majority of clay (71-82%) is chlorite.

Pore Space

Visible pore space is extremely limited in all of the sandstones from 12,900-01 to 12,905-6 feet. Total visible pore space ranges from 0 to 0.8%. **The combination of compaction and cementation by quartz overgrowths, grain-coating chlorite clay, and calcite has resulted in an extremely poor intergranular pore structure consisting of rare isolated intergranular pores and microporosity associated with the intergrown platelets of chlorite.**

PHILLIPS SAN JUAN DEEP 30-6 NO. 112Y WELL

Pennsylvanian Sandstone 13,195-13,214 Feet

This sandstone was perforated from 13,195 to 13,214 feet (Figure 3) and flow tested 281 MCFGPD and 40 BWPD after fracture treatment. The drill cuttings from this interval were analyzed by thin section petrography and scanning electron microscopy (Plates 25 and 26). Unfortunately, the drill cutting samples were of poor quality and consisted mostly of single, coarse sand-sized grains and very small aggregates of typically only three to six grains. Therefore, very little original rock fabric has been preserved.

The sandstones represented by the drill cutting sample are upper medium- to lower coarse-grained and probably poorly sorted. The sandstone is arkosic in composition, being comprised mostly of quartz and lesser amounts of both plagioclase and potassium feldspar. **Cements consist of calcite, quartz overgrowths and grain-coating/pore-lining chlorite clay** (Plates 25 and 26). Visible pore space is limited to severely reduced in size and isolated intergranular pores and microporosity associated with the pore-lining chlorite. **Therefore, these sandstones appear very similar to those encountered in the El Paso San Juan 29-5 No. 50 Well. Porosity is estimated to be between 5 and 10% and permeability is estimated to be less than 0.5 md.**

INFLUENCE ON LOG RESPONSE

The analyzed Pennsylvanian sandstone sequences have relatively well-defined SP log response. However, the gamma-ray response from 12,690 to 12,784 feet in the El Paso San Juan 29-5 No. 50 Well is serrated with high gamma-ray values ranging from 40 to 95 API units through the sandstone. Petrographic analysis reveals that these **high gamma-ray values can be attributed to an abundance of potassium feldspar grains in the sandstones and not as a result of clay content.** In fact, the majority of the clay present in the sandstones is chlorite which is non-radioactive. Therefore, **the gamma-ray log is not a shaliness indicator in the sandstones, but rather an indicator of potassium feldspar content.**

The sandstones are cemented by a combination of calcite, quartz overgrowths and grain-coating/pore-lining chlorite clay. Both the calcite and the chlorite combine to elevate the grain densities of the these sandstones above normal sandstone values (2.65 g/cc). **Estimated grain densities for these sandstones are in the 2.67 to 2.70 g/cc range.** Therefore, an appropriate density matrix should be used in calculating porosity from density logs. If a normal sandstone matrix is used, then calculated porosities will be pessimistic probably by 1 to 2 pu. This in turn will lead to higher calculated water saturations.

The presence of authigenic chlorite throughout the pore system of the sandstone may cause a low contrast in resistivity between pay and non-pay. Associated with the chlorite is abundant intercrystalline microporosity. This microporosity presumably has a high capillarity and would retain significant amounts of irreducible formation brine unless significant gas column heights could be attained in the reservoir. This may result in the calculation of high water saturations that are on the order perhaps of 50 - 80%, yet may be irreducible. It is recommended that laboratory resistivity measurements for determination of cementation exponent (m) and saturation exponent (n) be obtained for quantitative calculation of water saturations in this type of reservoir rock.

If NMR logs such as Schlumberger's CMR or Numar's MRIL logs are run for these reservoirs, it is recommended that NMR core analysis be performed to determine T_2 cutoffs, permeability models, and the possible influence of iron-bearing minerals (chlorite and pyrite) on the T_2 distributions.

ROCK FLUID COMPATIBILITY

Potassium chloride and calcium chloride based drilling and completion fluids should be compatible with the reservoir rock. Invading fluids would preferentially contact the chlorite clay that is ubiquitous throughout the pore systems of the sandstones. The chlorite is not sensitive to these fluids. However, both chlorite and calcite are extremely sensitive to low pH waters and acid. Acidization of this reservoir rock runs the risk of 1) degrading the chlorite structure and thereby contributing to a migrating fines problem and 2) precipitation of iron oxide causing formation damage and 3) dissolution of calcite cement causing possible local disaggregation of the sandstone.

TABLE 1
THIN SECTION PETROGRAPHIC DATA
BURLINGTON RESOURCES
EL PASO SAN JUAN 29-5 NO. 50

Sample Depth (ft)	12706-7	12707-8	12708-9	12709-10	12710-11	12711-12
WWRC #	23446:61	23627:361	24527:316	24526:361	24527:163	24536:631
Porosity (%)	12.2	5.2	8.0	10.5	7.5	11.0
Permeability (md)	1.3	0.22	0.15	0.32	0.36	0.08
Texture						
Grain Size (mm)	LC (0.51)	LC (0.56)	LC (0.606)	UC (0.82)	LC (0.55)	LC (0.54)
Sorting	Moderate	Moderate	Poor	Poor	Poor	Poor
Framework Constituents						
Quartz	39.6%	32.8%	45.6%	37.2%	50.8%	38.0%
Plagioclase	14.0	17.6	6.4	6.8	8.0	16.4
K-Feldspar	11.6	14.8	18.8	20.0	17.2	4.0
Sedimentary Rock Fragments	--	--	--	T	--	1.2
Volcanic Rock Fragments	--	--	0.4	--	--	--
Metamorphic Rock Fragments	3.2	2.0	4.0	5.6	3.6	3.6
Unidentified Rock Fragments	--	--	--	0.4	--	--
Plutonic Rock Fragments	4.0	1.2	3.6	7.2	0.8	15.2
Carbonate Grains	--	--	--	0.4	0.4	--
Chert	--	--	0.8	--	--	--
Mica	0.8	--	1.2	0.8	--	0.4
Fossil Fragments	--	--	--	--	--	--
Glauconite	--	--	--	--	--	--
Heavy Minerals/Opaques	--	--	--	--	--	--
Other	--	--	--	--	--	--
Intragranular Replacements						
Calcite	0.8%	2.4%	--%	1.2%	--%	--%
Dolomite	--	--	--	--	--	--
Kaolinite	--	0.8	--	1.6	--	--
Pyrite	--	--	--	--	--	--
Clay	1.6	0.8	2.0	0.4	2.0	1.2
Other	--	--	--	--	--	--
Matrix						
Clay	--%	--%	--%	--%	--%	--%
Pore-Filling Constituents						
Quartz Overgrowths	4.0%	4.0%	6.0%	4.0%	6.6%	3.6%
Dolomite	--	0.8	--	--	--	0.4
Calcite	0.4	18.0	6.8	7.6	2.0	4.0
Siderite	--	--	--	--	--	--
Undifferentiated Clay	--	--	--	--	--	--
Chlorite	14.4	4.0	2.8	4.0	2.4	6.4
Kaolinite	--	--	--	--	--	--
Pyrite/Opaques	--	0.4	--	--	1.4	0.4
Feldspar Overgrowths	--	--	--	0.4	--	--
Pore Space						
Intergranular	4.4%	T	0.4%	1.6%	2.4%	2.0%
Leached Grain	1.2	0.4	1.2	0.8	2.4	3.2

TABLE 1 (continued)
THIN SECTION PETROGRAPHIC DATA
BURLINGTON RESOURCES
EL PASO SAN JUAN 29-5 NO. 50

Sample Depth (ft)	12738-39	12742-43	12900-1	12902-3	12903-4	12905-6
WWRC #	32637:186	33627:168	33637:613	33638:361	33638:631	42628:368
Porosity (%)	5.6	8.8	NA	NA	NA	NA
Permeability (md)	0.01	0.03	NA	NA	NA	NA
Texture						
Grain Size (mm)	LM (0.28)	UM (0.38)	UM(0.40)	LM(0.31)	LM(0.30)	UF(0.21)
Sorting	Well	Moderate	Moderate	Moderate	Moderate	Well
Framework Constituents						
Quartz	33.2%	32.0%	35.6%	27.6%	35.2%	29.2%
Plagioclase	14.0	14.8	15.2	11.6	14.0	12.4
K-Feldspar	16.4	16.8	15.2	20.0	16.8	17.2
Sedimentary Rock Fragments	0.8	0.4	T	0.4	--	T
Volcanic Rock Fragments	--	--	--	--	--	--
Metamorphic Rock Fragments	12.4	7.2	8.8	7.2	8.0	5.2
Unidentified Rock Fragments	0.8	0.8	--	--	--	--
Plutonic Rock Fragments	1.6	2.4	2.4	2.0	2.8	0.8
Carbonate Grains	--	--	--	--	--	--
Chert	0.4	--	--	--	--	--
Mica	1.2	--	0.8	T	--	T
Ooids	--	--	--	--	--	1.6
Glauconite	--	--	--	--	--	--
Heavy Minerals/Opaques	T	0.4	T	T	0.4	0.4
Other	--	--	--	--	--	4.0
Intragranular Replacements						
Calcite	0.8%	0.8%	4.0%	10.0%	4.8%	9.6%
Dolomite	--	--	--	--	--	--
Kaolinite	--	--	--	--	--	--
Pyrite	1.2	T	--	--	--	--
Clay	--	--	--	0.8	--	0.4
Other	--	--	0.4	--	--	0.8
Matrix						
Clay	--%	--%	--%	--%	--%	--%
Pore-Filling Constituents						
Quartz Overgrowths	6.0%	8.4%	7.2%	4.4%	4.4%	0.8%
Dolomite	--	--	--	--	--	--
Calcite	T	2.8	1.2	8.8	4.8	11.6
Siderite	--	0.4	--	--	--	--
Undifferentiated Clay	--	--	--	--	--	--
Chlorite	5.6	4.4	8.0	6.4	7.6	3.6
Kaolinite	--	--	--	--	--	--
Pyrite/Opaques	2.4	3.6	--	--	--	2.0
Feldspar Overgrowths	1.6	0.8	0.4	--	--	0.4
Pore Space						
Intergranular	1.6%	2.8%	0.8%	0.4%	0.4%	--
Leached Grain	T	1.2	T	T	--	--

Reservoirs Inc.

FIGURE 1

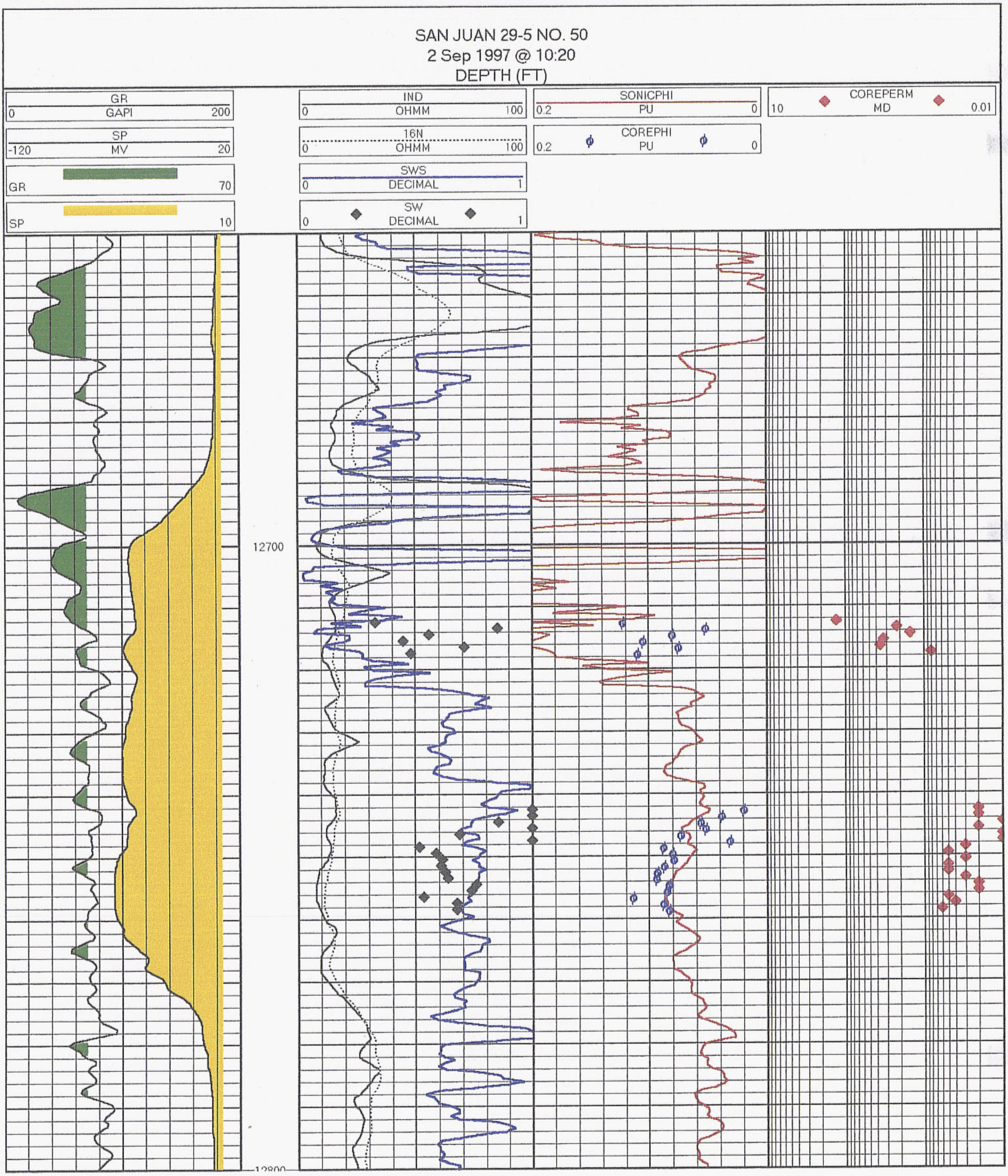

SAN JUAN 29-5 NO. 50
2 Sep 1997 @ 10:20
DEPTH (FT)
GR
0 GAPI 200
SP
-120 MV 20
GR 70
SP 10
IND
0 OHMM 100
16N
0 OHMM 100
SWS
0 DECIMAL 1
SW
0 DECIMAL 1
SONICPHI
0.2 PU 0
COREPHI
0.2 PU 0
COREPERM
10 MD 0.01
12700
12800

TABLE 2

X-RAY DIFFRACTION DATA

Burlington Resources
San Juan 29-5 No. 5
Rio Arriba, NM

MINERALOGY OF WHOLE ROCK SAMPLE (WEIGHT %)								MINERALOGY OF CLAY FRACTION (REL %)		
Depth (Ft)	Qtz	Ksp	Plag	Cal	Dol	Pyrite	Clay	Chl	Ill	Kaol
12706 - 7	56	12	28	1	1	0	2	91	3	6
12707 - 8	43	13	26	15	0	0	3	95	5	0
12708 - 9	52	12	26	7	1	0	2	93	7	0
12709 - 10	55	11	22	9	1	0	2	94	6	0
12710 - 11	61	16	19	2	0	0	2	96	4	0
12711 - 12	63	8	24	3	0	0	2	97	3	0
12738 - 39	39	6	47	2	0	4	2	90	10	0
12742 - 43	44	10	39	4	0	1	2	91	9	0
12900 - 01	48	6	40	4	0	0	2	76	24	0
12902 - 03	42	10	37	9	0	0	2	81	19	0
12903 - 04	45	6	39	7	0	0	3	82	18	0
12905- 06	34	3	47	14	0	0	2	71	29	0
Min	34	3	19	1	0	0	2	71	3	0
Max	63	16	47	15	1	4	3	97	29	6
Avg	49	9	33	6	0	0	2	88	11	1

KEY:

Qtz = quartz
Ksp = K-Feldspar
Plag = plagioclase
Cal = calcite
Dol = dolomite
Clay = total clay

Chl = chlorite
Ill = illite
Kaol = kaolinite

FIGURE 2

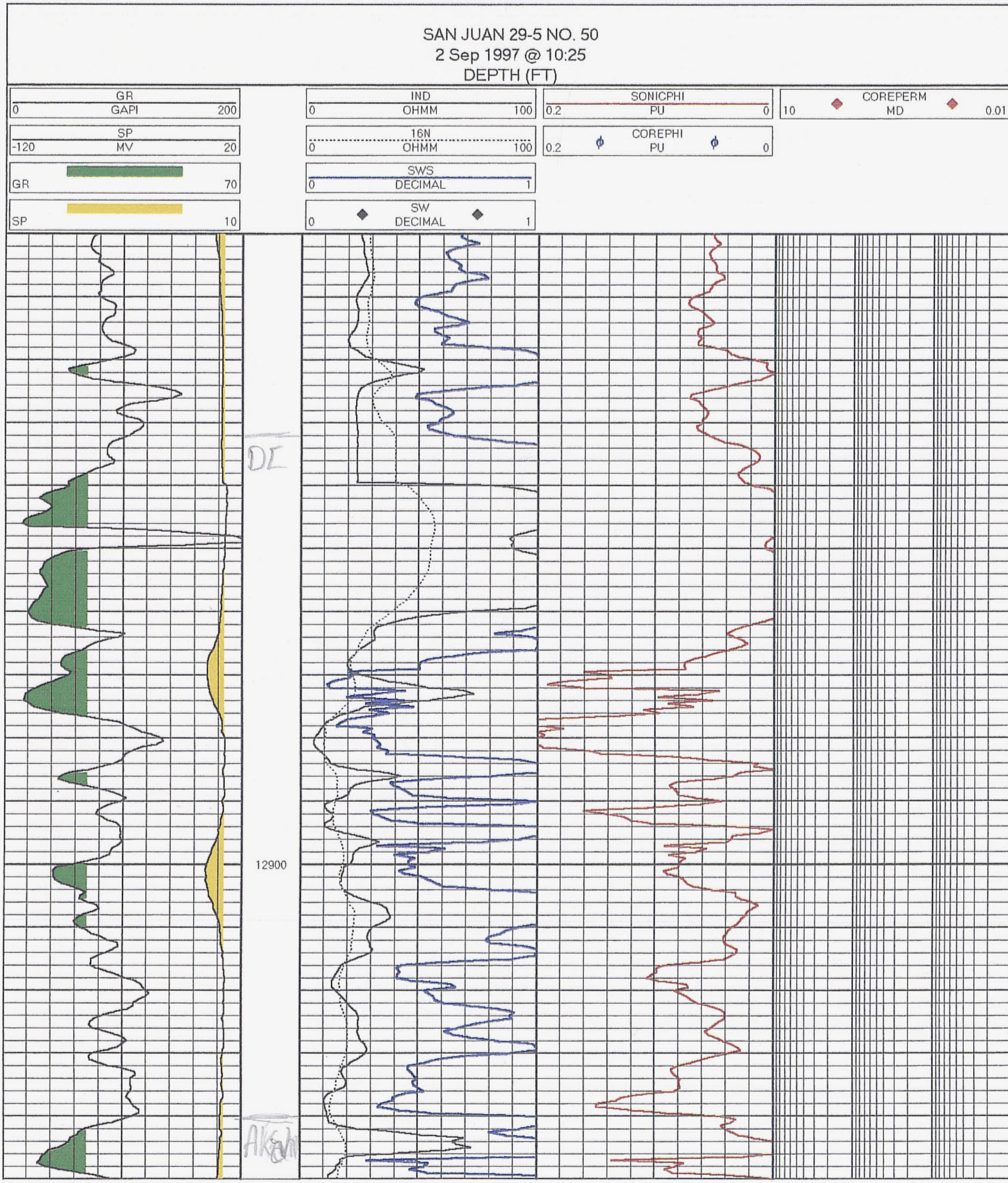

SAN JUAN 29-5 NO. 50
2 Sep 1997 @ 10:25
DEPTH (FT)
GR
0 GAPI 200
SP
-120 MV 20
GR 70
SP 10
IND
0 OHMM 100
16N
0 OHMM 100
SWS
0 DECIMAL 1
SW
0 DECIMAL 1
SONICPHI
0.2 PU 0
COREPHI
0.2 PU 0
COREPERM
10 MD 0.01
12900

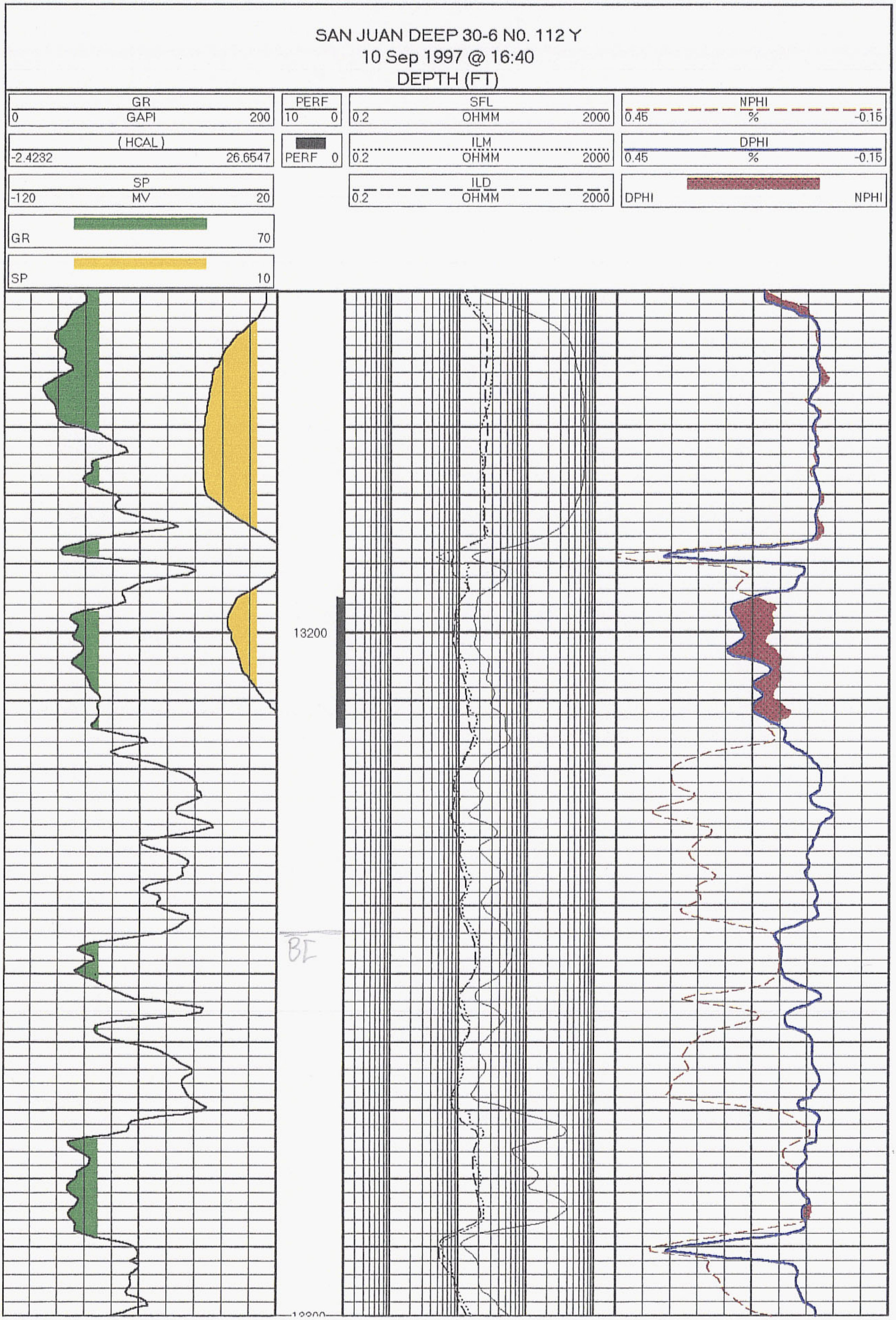
TABLE 3

PETROPHYSICAL SUMMARY
EL PASO SAN JUAN 29-5 NO. 50

Depth (ft)	Induction Resistivity	Sonic Ø (pu)	Core Ø (pu)	Core K (md)	Water Saturation (1)	Water Saturation (2)
12712.5	16.285	0.257	0.122	1.300	0.144	0.330
12713.5	16.285	0.411	0.052	0.220	0.086	0.852
12714.5	14.758	0.185	0.080	0.150	0.220	0.558
12715.5	12.723	0.220	0.105	0.320	0.197	0.448
12716.5	10.941	0.330	0.075	0.360	0.136	0.707
12717.5	10.178	0.181	0.110	0.080	0.277	0.481
12742.5	15.990	0.048	0.019	0.020	0.937	2.634
12743.5	15.990	0.055	0.038	0.020	0.804	1.219
12744.5	13.959	0.064	0.056	0.010	0.737	0.855
12745.5	12.183	0.072	0.052	0.020	0.695	1.001
12746.5	12.183	0.066	0.073	0.010	0.765	0.687
12747.5	13.452	0.067	0.031	0.010	0.718	1.683
12748.5	13.959	0.062	0.088	0.030	0.758	0.517
12749.5	13.452	0.062	0.080	0.050	0.774	0.587
12750.5	12.723	0.067	0.079	0.030	0.740	0.614
12751.5	10.687	0.071	0.087	0.050	0.767	0.608
12752.5	8.906	0.077	0.093	0.050	0.769	0.624
12753.5	8.397	0.080	0.094	0.030	0.764	0.638
12754.5	7.888	0.084	0.083	0.020	0.746	0.758
12755.5	7.888	0.084	0.085	0.020	0.746	0.738
12756.5	7.888	0.087	0.114	0.050	0.720	0.533
12757.5	8.651	0.084	0.088	0.040	0.708	0.675
12758.5	9.669	0.082	0.083	0.060	0.691	0.677

1 = Sw calculated using sonic porosity
2 = Sw calculated using core porosity

FIGURE 3



SAN JUAN DEEP 30-6 N0. 112 Y
10 Sep 1997 @ 16:40
DEPTH (FT)
GR
0 GAPI 200
(HCAL)
-2.4232 26.6547
SP
-120 MV 20
GR 70
SP 10
PERF
10 0
PERF 0
SFL
0.2 OHMM 2000
ILM
0.2 OHMM 2000
ILD
0.2 OHMM 2000
NPHI
0.45 % -0.15
DPHI
0.45 % -0.15
DPHI NPHI
13200
BE

TABLE 4

CAPILLARY PRESSURE SUMMARY
EL PASO SAN JUAN 29-5 NO. 50

Sample	Sw (%)	Height Above Free Water Level	Height of 100% Water Level (ft)	Estimated Gas Column Height (ft)
12706 - 7	46	160	12	148
12707 - 8	85	316	238	78
12708 - 9	56	80	22	58
12709 - 10	45	80	12	68
12710 - 11	71	45	22	23
12711 - 12	48	126	12	114

FIGURE 4

POROSITY - PERMEABILITY RELATIONSHIP
EL PASO SAN JUAN 29-5 NO. 50
12706-12753 FEET

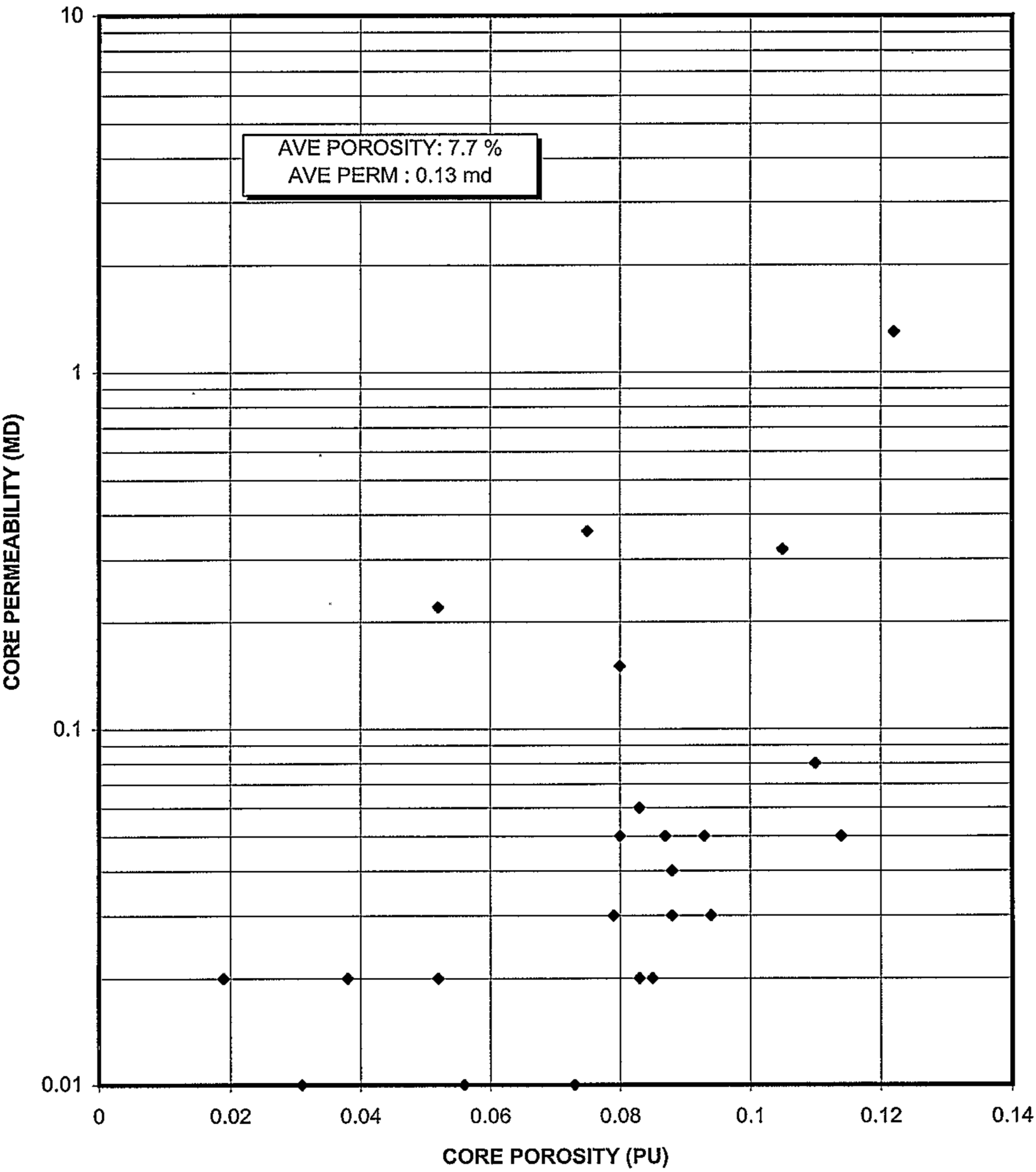


TABLE 5

HEIGHT ABOVE FREE WATER LEVEL

Burlington Resources
San Juan 29-5 No. 50 Well
Rio Arriba County, New Mexico
SRS 2358 / RSH 3710

Sample: S 130
Depth, ft: 12706-07

Porosity, %BV: 12.2
Perm to gas, md: 1.3

CAPILLARY PRESSURE (psia)	HEIGHT ABOVE FREE WATER LEVEL (ft.)	WETTING PHASE SATURATION (%PV)
1.86	0.4	100.0
3.09	0.6	100.0
5.59	1.1	100.0
10.6	2.1	100.0
15.6	3.1	100.0
20.6	4.1	100.0
25.6	5.1	100.0
30.6	6.1	100.0
44.6	8.9	100.0
60.6	12.0	97.6
74.6	14.8	95.2
111	22.0	86.6
161	32.0	72.1
201	39.9	65.1
301	59.7	58.9
401	79.6	55.4
601	119.3	50.5
801	159.0	46.6
1001	198.7	45.5
1201	238.4	43.2
1501	297.9	38.3
2001	397.2	22.1

FIGURE 5

HEIGHT ABOVE FREE WATER LEVEL

Burlington Resources
San Juan 29-5 No. 50 Well
Rio Arriba County, New Mexico
SRS 2358 / RSH 3710

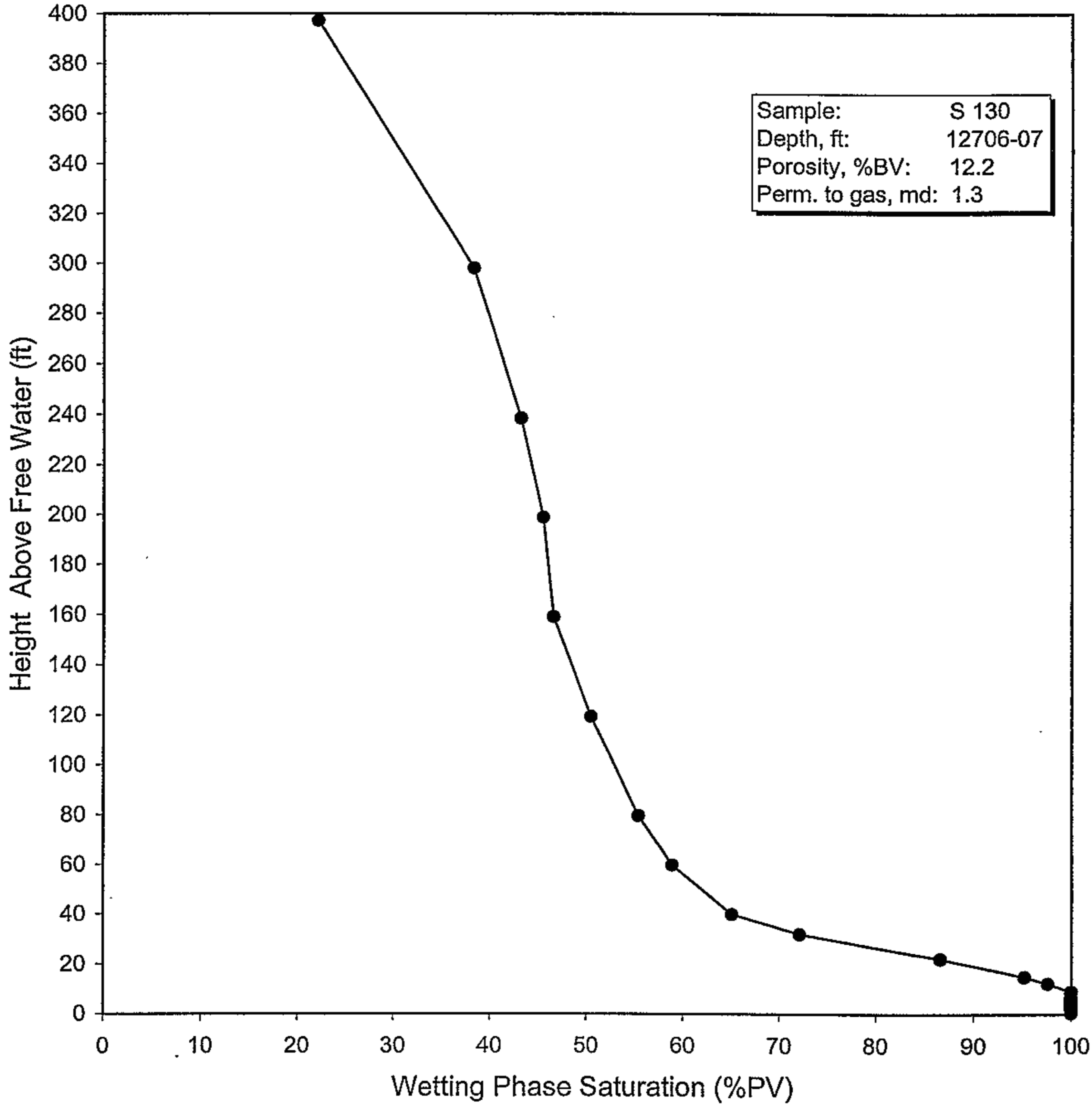


TABLE 6

HEIGHT ABOVE FREE WATER LEVEL

Burlington Resources
San Juan 29-5 No. 50 Well
Rio Arriba County, New Mexico
SRS 2358 / RSH 3710

Sample: S 131
Depth, ft: 12707-08

Porosity, %BV: 5.2
Perm to gas, md: 0.22

CAPILLARY PRESSURE (psia)	HEIGHT ABOVE FREE WATER LEVEL (ft.)	WETTING PHASE SATURATION (%PV)
1.57	0.3	100.0
2.05	0.4	100.0
5.05	1.0	100.0
10.0	2.0	100.0
15.0	3.0	100.0
20.0	4.0	100.0
25.0	5.0	100.0
30.0	6.0	100.0
34.9	6.9	100.0
39.9	7.9	100.0
45.4	9.0	100.0
50.4	10.0	100.0
54.8	10.9	100.0
60.2	11.9	100.0
65.3	13.0	100.0
70.0	13.9	100.0
74.7	14.8	100.0
80.3	15.9	100.0
85.2	16.9	100.0
90.1	17.9	100.0
95.1	18.9	100.0
100	19.9	100.0
160	31.8	100.0
219	43.5	100.0
279	55.4	100.0
339	67.3	100.0

TABLE 6 (continued)

HEIGHT ABOVE FREE WATER LEVEL

Burlington Resources
San Juan 29-5 No. 50 Well
Rio Arriba County, New Mexico
SRS 2358 / RSH 3710

Sample: S 131
Depth, ft: 12707-08

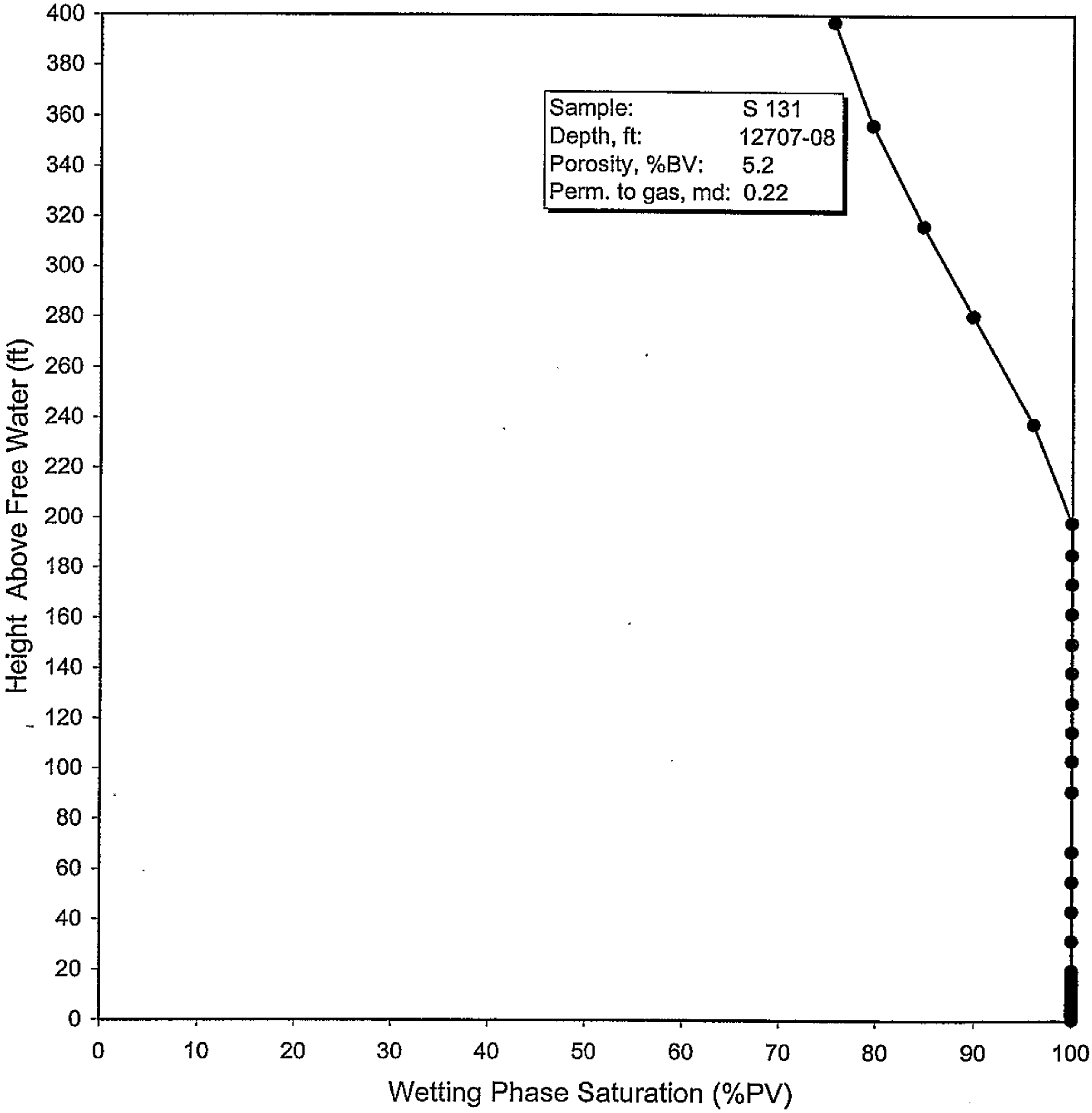
Porosity, %BV: 5.2
Perm to gas, md: 0.22

CAPILLARY PRESSURE (psia)	HEIGHT ABOVE FREE WATER LEVEL (ft.)	WETTING PHASE SATURATION (%PV)
459	91.1	100.0
521	103.4	100.0
579	114.9	100.0
637	126.4	100.0
699	138.8	100.0
756	150.1	100.0
816	162.0	100.0
876	173.9	100.0
935	185.6	100.0
999	198.3	100.0
1198	237.8	96.0
1414	280.7	89.8
1595	316.6	84.7
1796	356.5	79.5
2001	397.2	75.5

FIGURE 6

HEIGHT ABOVE FREE WATER LEVEL

Burlington Resources
San Juan 29-5 No. 50 Well
Rio Arriba County, New Mexico
SRS 2358 / RSH 3710



Reservoirs Inc.

TABLE 7

HEIGHT ABOVE FREE WATER LEVEL

Burlington Resources
San Juan 29-5 No. 50 Well
Rio Arriba County, New Mexico
SRS 2358 / RSH 3710

Sample: S 132
Depth, ft: 12708-09

Porosity, %BV: 7.8
Perm to gas, md: N.A.

CAPILLARY PRESSURE (psia)	HEIGHT ABOVE FREE WATER LEVEL (ft.)	WETTING PHASE SATURATION (%PV)
1.86	0.4	100.0
3.09	0.6	100.0
5.59	1.1	100.0
10.6	2.1	100.0
15.6	3.1	100.0
20.6	4.1	100.0
25.6	5.1	100.0
30.6	6.1	100.0
44.6	8.9	100.0
60.6	12.0	100.0
74.6	14.8	100.0
111	22.0	96.2
161	32.0	88.4
201	39.9	78.3
301	59.7	65.1
401	79.6	55.2
601	119.3	40.4
801	159.0	29.5
1001	198.7	23.9
1201	238.4	20.3
1501	297.9	18.2
2001	397.2	15.0

FIGURE 7
HEIGHT ABOVE FREE WATER LEVEL

Burlington Resources
San Juan 29-5 No. 50 Well
Rio Arriba County, New Mexico
SRS 2358 / RSH 3710

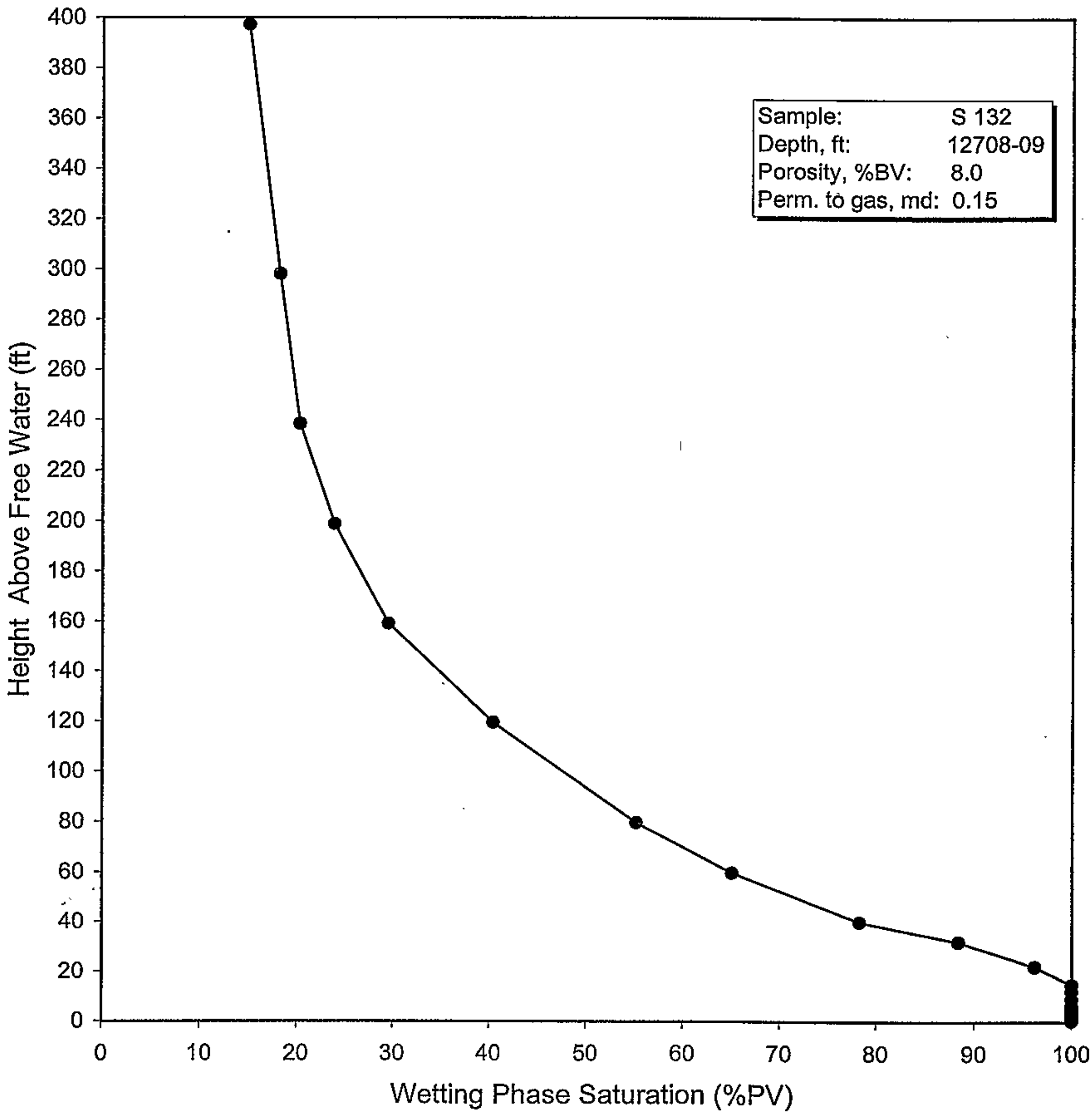


TABLE 8

HEIGHT ABOVE FREE WATER LEVEL

Burlington Resources
San Juan 29-5 No. 50 Well
Rio Arriba County, New Mexico
SRS 2358 / RSH 3710

Sample: S 133
Depth, ft: 12709-10

Porosity, %BV: 10.5
Perm to gas, md: 0.32

CAPILLARY PRESSURE (psia)	HEIGHT ABOVE FREE WATER LEVEL (ft.)	WETTING PHASE SATURATION (%PV)
1.90	0.4	100.0
3.13	0.6	100.0
5.63	1.1	100.0
10.6	2.1	100.0
15.6	3.1	100.0
20.6	4.1	100.0
25.6	5.1	100.0
30.6	6.1	100.0
44.6	8.9	100.0
60.6	12.0	98.9
74.6	14.8	97.6
111	22.0	87.4
161	32.0	72.5
201	39.9	65.8
301	59.7	54.2
401	79.6	46.2
601	119.3	34.5
801	159.0	26.3
1001	198.7	20.9
1201	238.4	18.0
1501	297.9	15.2
2001	397.2	12.7

FIGURE 8

HEIGHT ABOVE FREE WATER LEVEL

Burlington Resources
San Juan 29-5 No. 50 Well
Rio Arriba County, New Mexico
SRS 2358 / RSH 3710

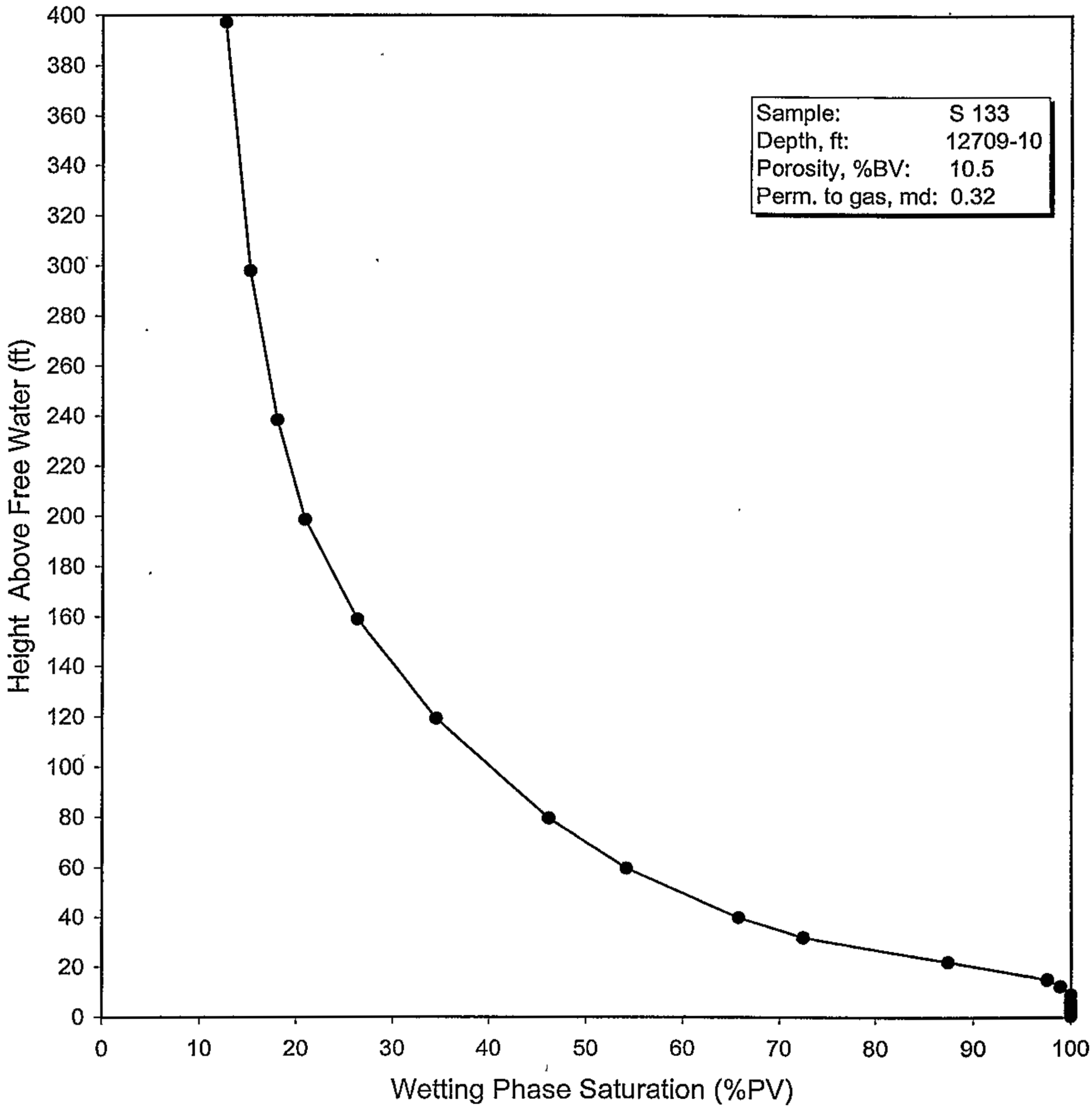


TABLE 9

HEIGHT ABOVE FREE WATER LEVEL

Burlington Resources
San Juan 29-5 No. 50 Well
Rio Arriba County, New Mexico
SRS 2358 / RSH 3710

Sample: S 134 Porosity, %BV: 7.5
Depth, ft: 12710-11 Perm to gas, md: 0.36

CAPILLARY PRESSURE (psia)	HEIGHT ABOVE FREE WATER LEVEL (ft.)	WETTING PHASE SATURATION (%PV)
1.86	0.4	100.0
3.09	0.6	100.0
5.59	1.1	100.0
10.6	2.1	100.0
15.6	3.1	100.0
20.6	4.1	100.0
25.6	5.1	100.0
30.6	6.1	100.0
44.6	8.9	100.0
60.6	12.0	100.0
74.6	14.8	100.0
111	22.0	96.6
161	32.0	84.3
201	39.9	73.6
301	59.7	63.5
401	79.6	56.2
601	119.3	46.6
801	159.0	34.9
1001	198.7	24.0
1201	238.4	15.8
1501	297.9	8.1
2001	397.2	2.4

FIGURE 9

HEIGHT ABOVE FREE WATER LEVEL

Burlington Resources
San Juan 29-5 No. 50 Well
Rio Arriba County, New Mexico
SRS 2358 / RSH 3710

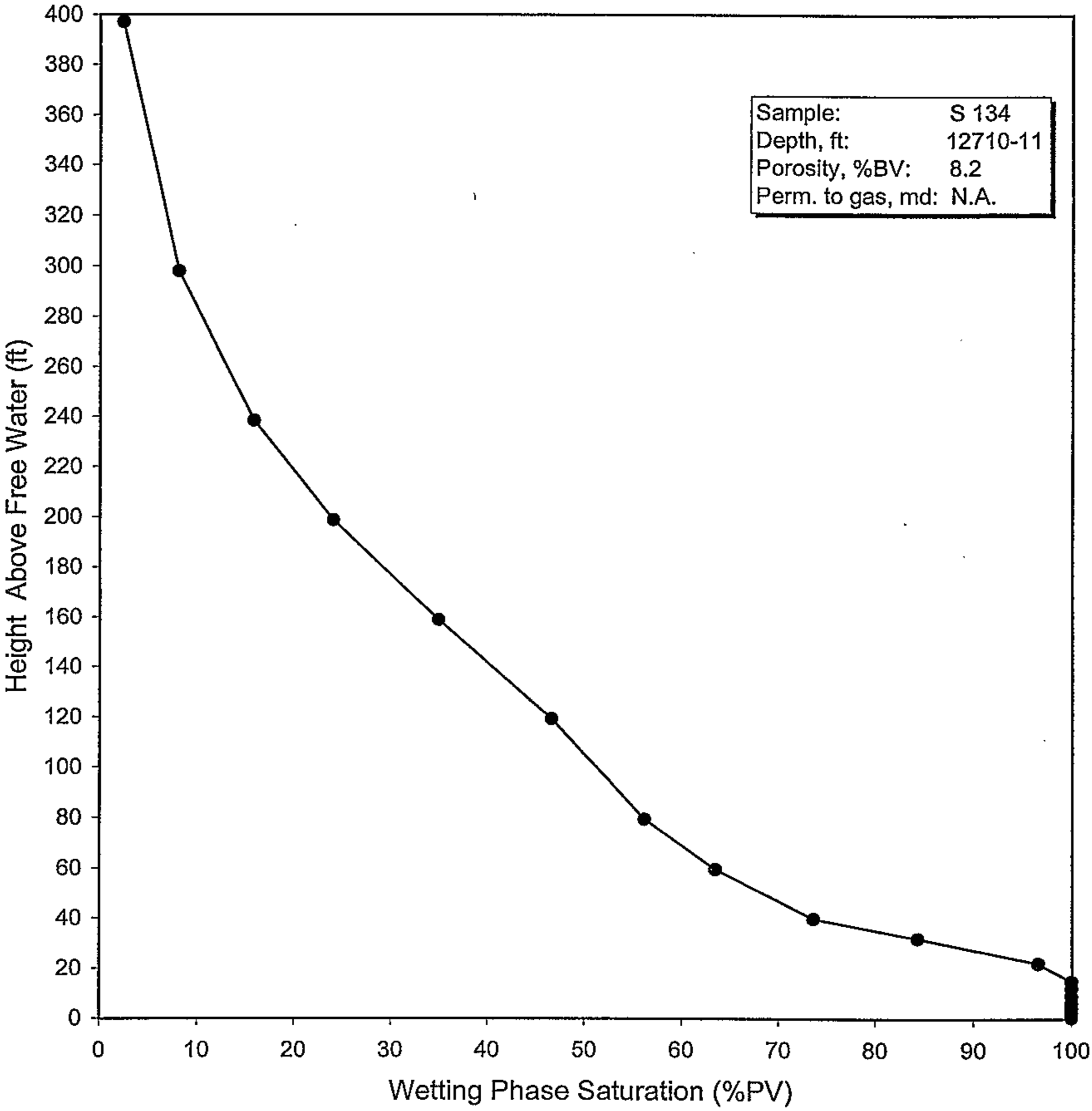


TABLE 10

HEIGHT ABOVE FREE WATER LEVEL

Burlington Resources
San Juan 29-5 No. 50 Well
Rio Arriba County, New Mexico
SRS 2358 / RSH 3710

Sample: S 135 | Porosity, %BV: 11.0
Depth, ft: 12711-12 | Perm to gas, md: 0.08

CAPILLARY PRESSURE (psia)	HEIGHT ABOVE FREE WATER LEVEL (ft.)	WETTING PHASE SATURATION (%PV)
1.57	0.3	100.0
2.05	0.4	100.0
5.05	1.0	100.0
10.0	2.0	100.0
15.0	3.0	100.0
20.0	4.0	100.0
25.0	5.0	100.0
30.0	6.0	100.0
35.0	6.9	100.0
39.9	7.9	100.0
45.5	9.0	100.0
50.4	10.0	100.0
54.9	10.9	99.3
60.2	11.9	98.8
65.3	13.0	98.3
70.1	13.9	97.8
74.7	14.8	97.1
80.3	15.9	96.4
85.2	16.9	95.7
90.1	17.9	94.7
95.0	18.9	94.0
100	19.9	93.1
159	31.6	80.4
219	43.5	73.0
278	55.2	68.4
338	67.1	64.8

TABLE 10 (continued)

HEIGHT ABOVE FREE WATER LEVEL

Burlington Resources
San Juan 29-5 No. 50 Well
Rio Arriba County, New Mexico
SRS 2358 / RSH 3710

Sample: S 135
Depth, ft: 12711-12

Porosity, %BV: 11.0
Perm to gas, md: 0.08

CAPILLARY PRESSURE (psia)	HEIGHT ABOVE FREE WATER LEVEL (ft.)	WETTING PHASE SATURATION (%PV)
398	79.0	61.5
458	90.9	58.4
520	103.2	55.0
578	114.7	51.9
636	126.2	48.8
697	138.4	45.7
755	149.9	43.3
814	161.6	40.9
874	173.5	38.8
934	185.4	36.6
997	197.9	34.9
1196	237.4	30.6
1412	280.3	27.5
1593	316.2	25.6
1794	356.1	23.9
1999	396.8	23.0

FIGURE 10

HEIGHT ABOVE FREE WATER LEVEL

Burlington Resources
San Juan 29-5 No. 50 Well
Rio Arriba County, New Mexico
SRS 2358 / RSH 3710

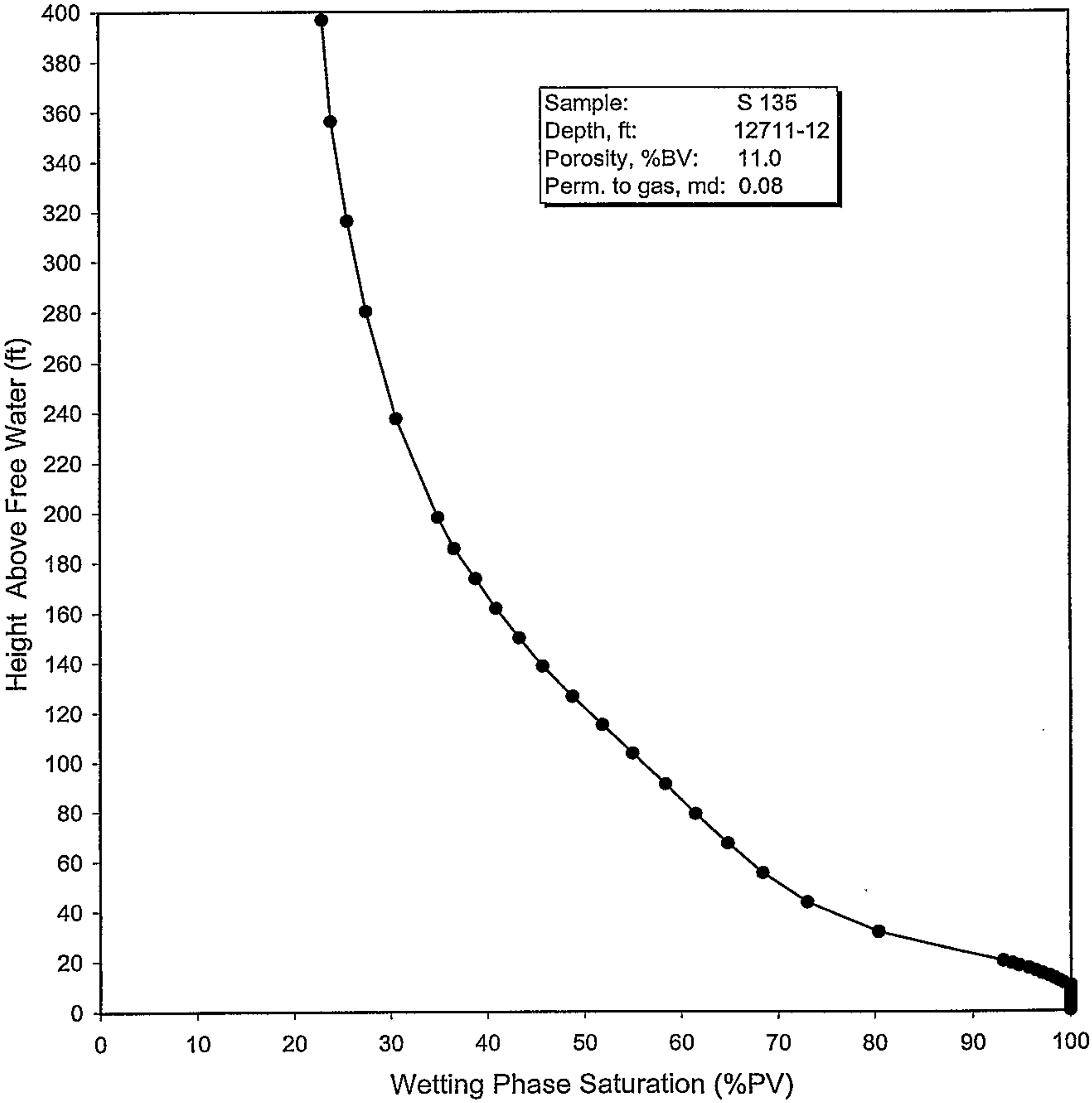


PLATE 1

THIN SECTION PHOTOMICROGRAPHS

EL PASO SAN JUAN 29-5 NO. 50 WELL

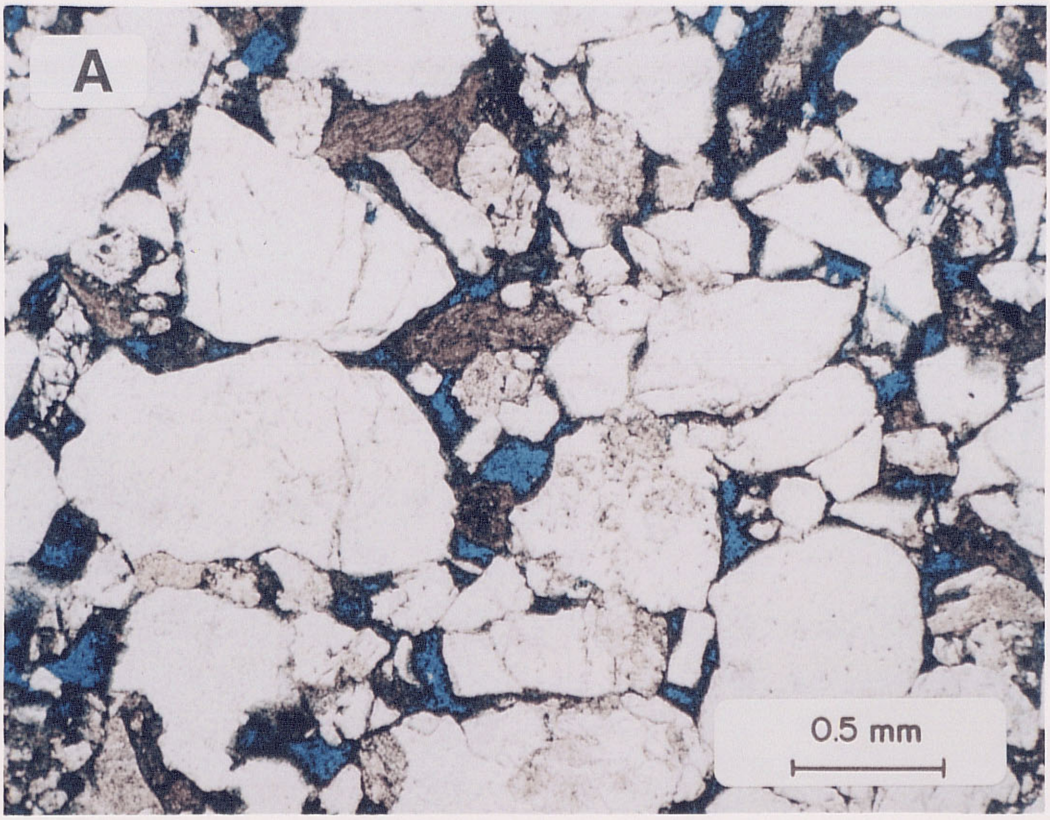
Core Depth: 12,706-7 feet
Grain Size: Lower Coarse
Sorting: Moderate

WWRC: 23446:61
Porosity: 12.2%
Permeability: 1.3 md

Intergranular pores (blue) are evident among moderately-sorted framework grains consisting predominately of quartz, feldspar and rock fragments. Feldspars are abundant and consist of both plagioclase and potassium feldspar. Rock fragments are plutonic and metamorphic (MRF) in origin. The grains are cemented by thin isopachous coatings of chlorite clay (arrow) and quartz overgrowths.

A - 40X

B - 160X


A
0.5 mm

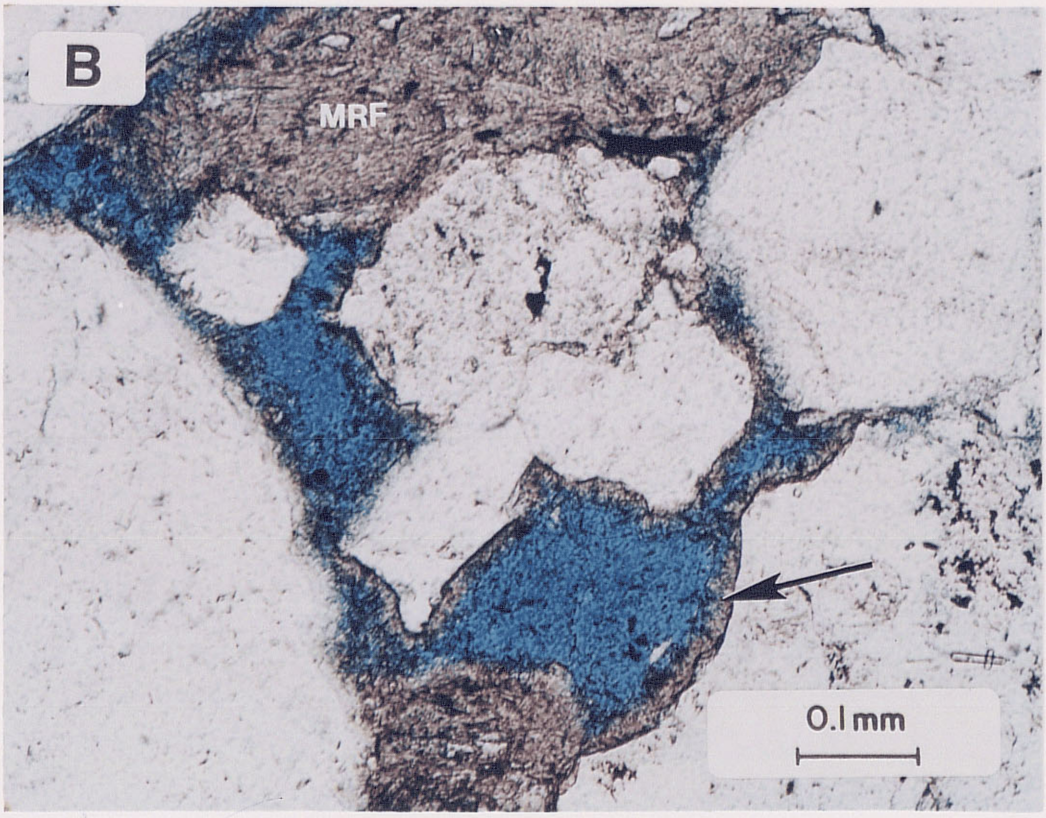

B
MRF
0.1mm

PLATE 2

SEM PHOTOMICROGRAPHS

EL PASO SAN JUAN 29-5 NO. 50 WELL

Core Depth: 12,706-7 feet	WWRC: 23446:61
Grain Size: Lower Coarse	Porosity: 12.2%
Sorting: Moderate	Permeability: 1.3 md

Macropores (P) have been severely reduced in size and isolated by a combination of compaction and cementation. The most predominant cement is authigenic chlorite (CH) clay. This clay is ubiquitous throughout the pore system of the sandstone creating a high surface area to pore volume ratio and replacing macropore space with abundant microporosity. Associated with the chlorite are minor amounts of authigenic kaolinite (K).

A - 100X, First Area

B - 500X

C - 1,000X

D - 500X, Second Area

X-RAY DIFFRACTION DATA

Bulk Mineralogy		Clay Mineralogy	
Quartz	56%	Chlorite	91%
K-Feldspar	12%	Illite	3%
Plagioclase	28%	Kaolinite	6%
Calcite	1%		
Dolomite	1%		
Clay	2%		

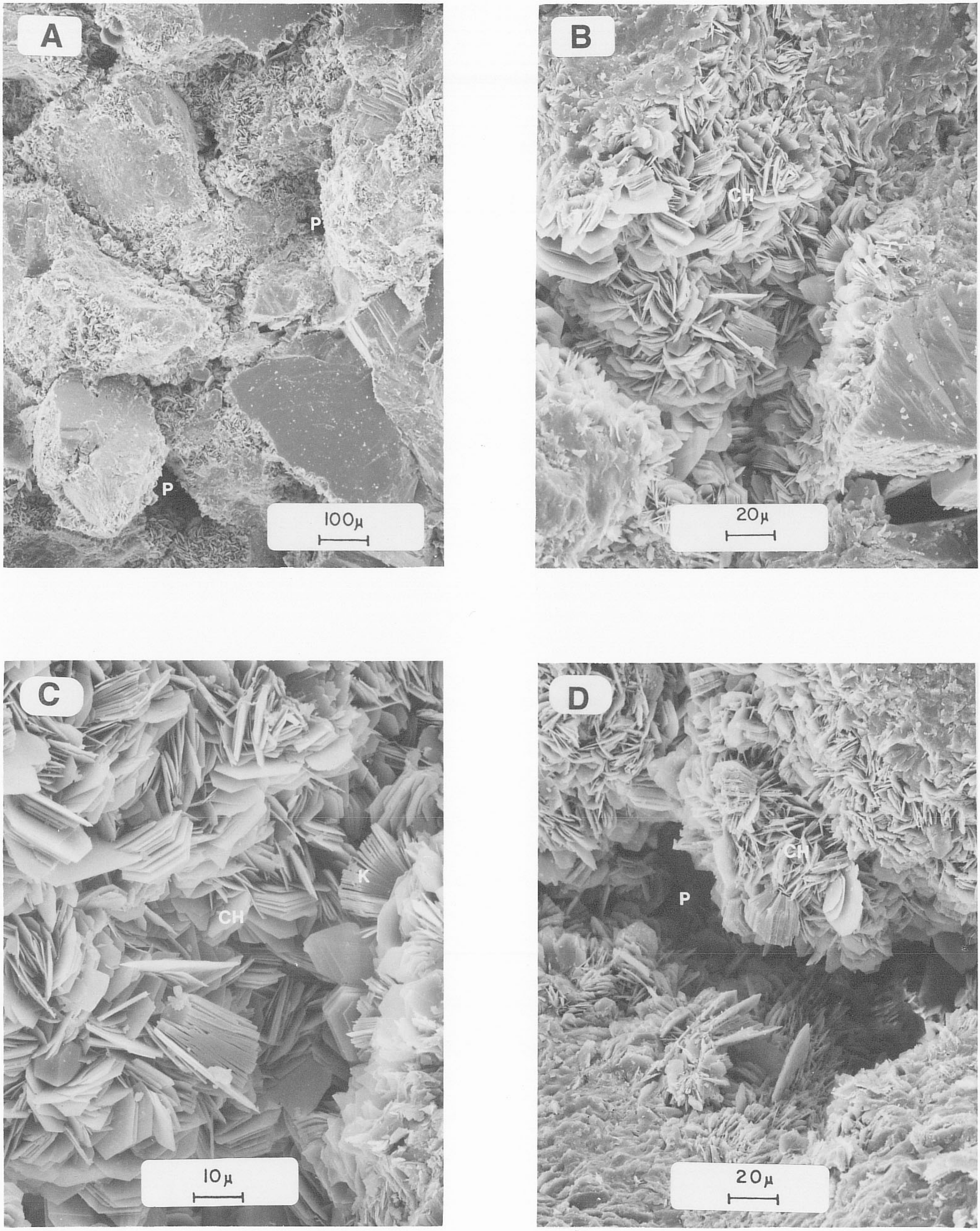

A
P
P
100μ
B
CH
20μ
C
K
CH
10μ
D
CH
P
20μ

PLATE 3

THIN SECTION PHOTOMICROGRAPHS

EL PASO SAN JUAN 29-5 NO. 50 WELL

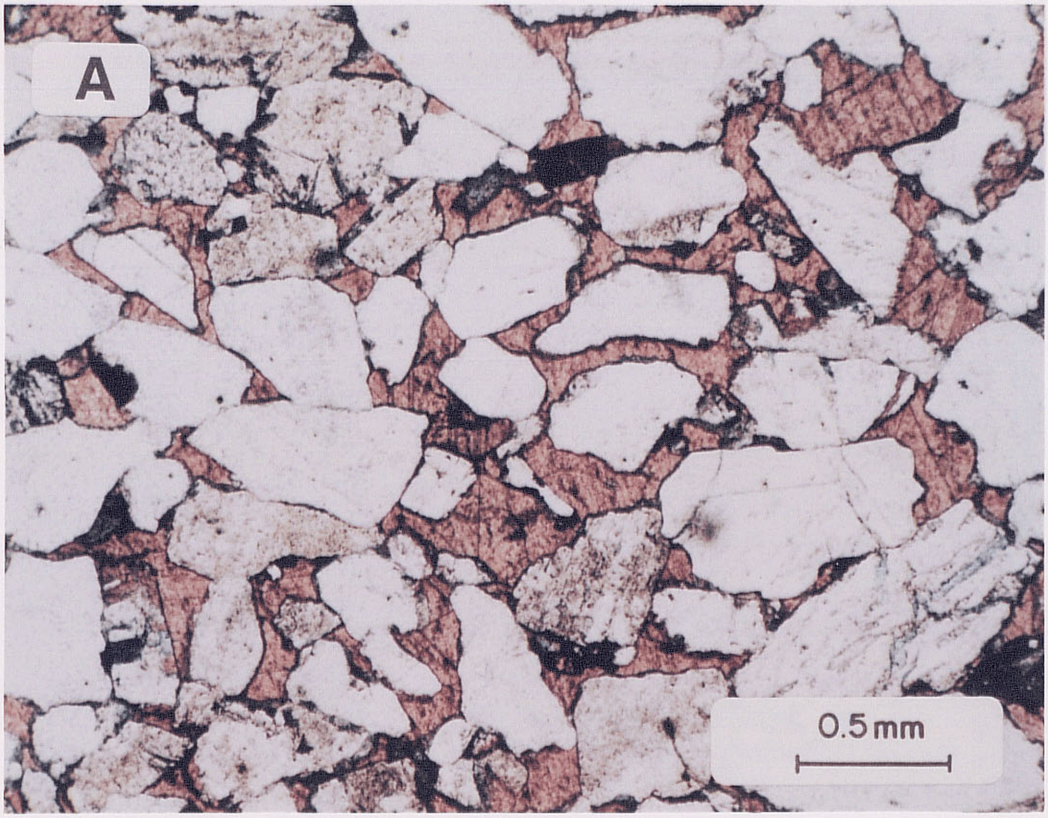
Core Depth: 12,707-8 feet
Grain Size: Lower Coarse
Sorting: Moderate

WWRC: 23627:361
Porosity: 5.2%
Permeability: 0.22 md

Abundant quartz and common feldspar comprise the majority of framework grains in this moderately-sorted, lower coarse-grained sandstone. These grains have been extensively cemented first by authigenic, grain-coating chlorite (arrow) and subsequently by pervasive calcite (red). Remaining pore space consists of only trace amounts of intergranular and leached grain pores. Microporosity is associated with the chlorite.

A - 40X

B - 160X


A
0.5mm

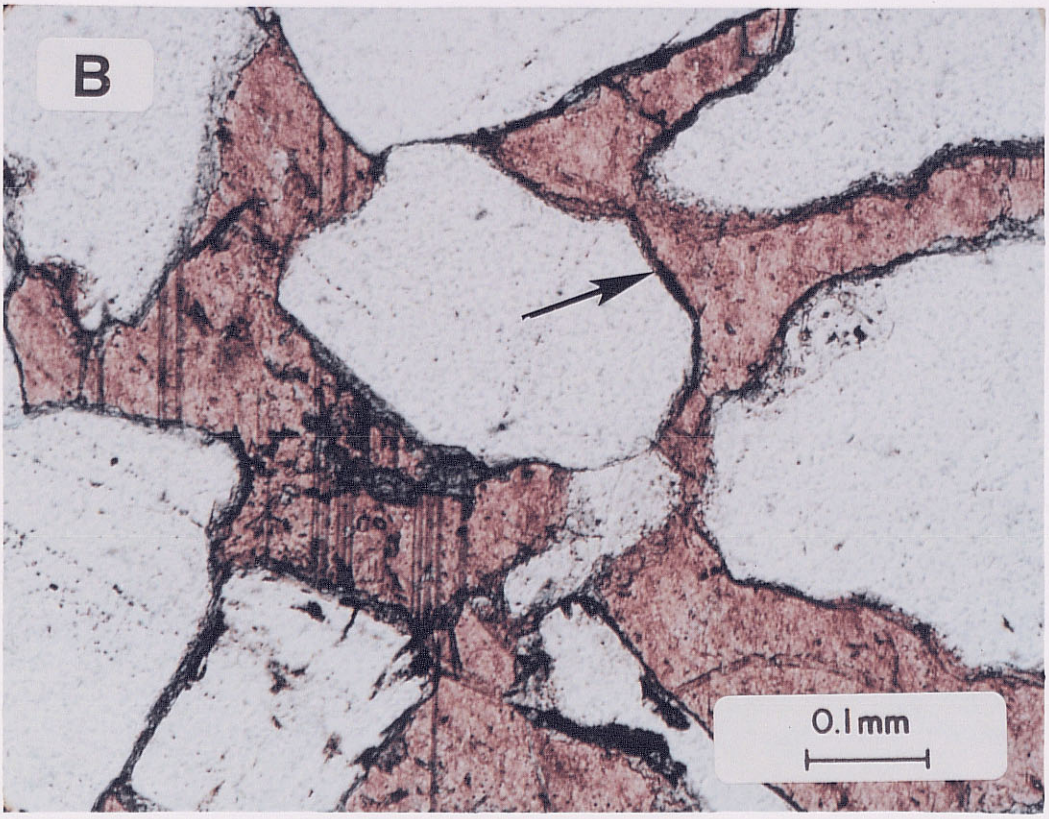

B
0.1mm

PLATE 4

SEM PHOTOMICROGRAPHS

EL PASO SAN JUAN 29-5 NO. 50 WELL

Core Depth: 12,707-8 feet	WWRC: 23627:361
Grain Size: Lower Coarse	Porosity: 5.2%
Sorting: Moderate	Permeability: 0.22 md

Macropores are virtually absent in this sandstone as a result of extensive cementation by grain-coating chlorite (CH) and especially calcite (C). Lesser amounts of authigenic quartz (Q) also contribute to pore space reduction. Remaining porosity is in the form of micropores (Pm) associated with the intergrown platelets of authigenic chlorite.

A - 100X, First area

B - 500X

C - 1,000X

D - 1,000X, Second Area

X-RAY DIFFRACTION DATA

Bulk Mineralogy		Clay Mineralogy	
Quartz	43%	Chlorite	95%
K-Feldspar	13%	Illite	5%
Plagioclase	26%	Kaolinite	--
Calcite	15%		
Dolomite	--		
Clay	3%		

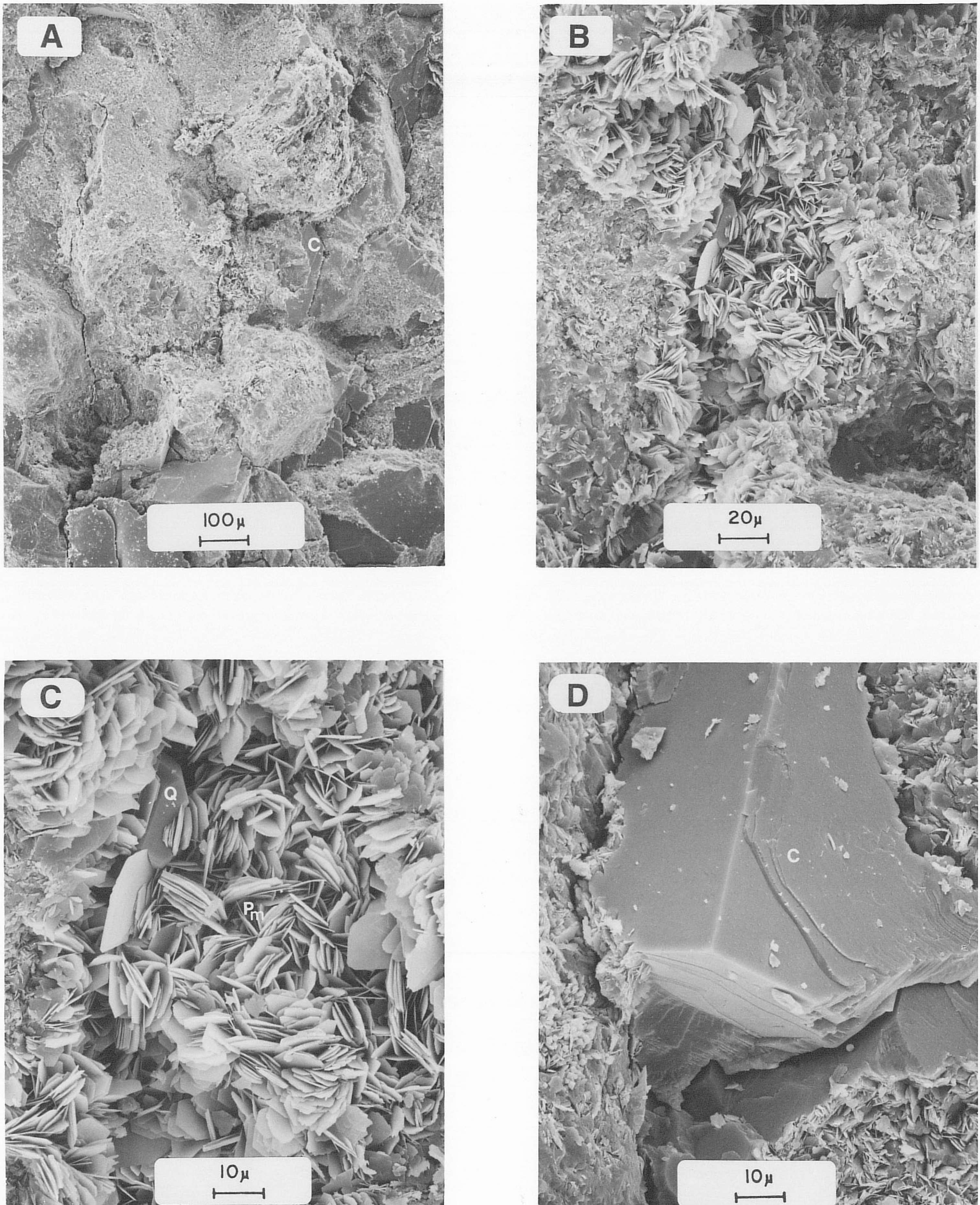

A
C
100µ
B
CH
20µ
C
Q
Pm
10µ
D
C
10µ

PLATE 5

THIN SECTION PHOTOMICROGRAPHS

EL PASO SAN JUAN 29-5 NO. 50 WELL

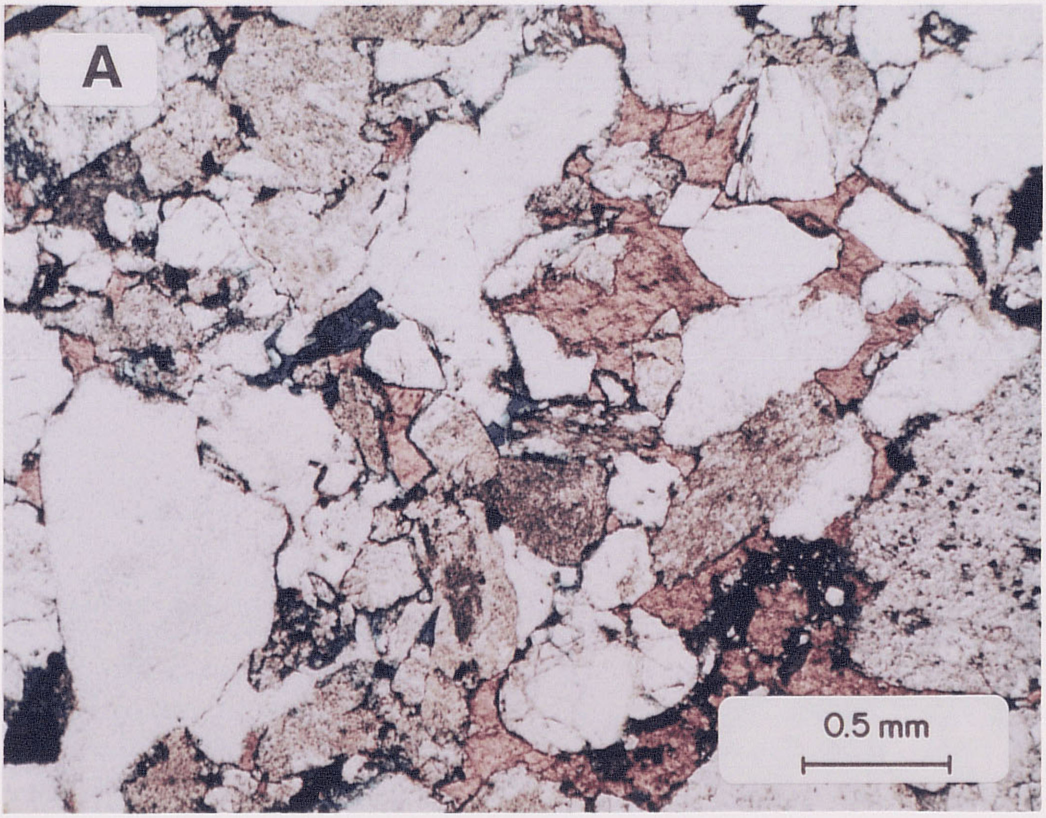
Core Depth: 12,708-9 feet
Grain Size: Lower Coarse
Sorting: Poor

WWRC: 24527:316
Porosity: 8.0%
Permeability: 0.15 md

This sandstone is also poorly sorted with a mean grain size in the lower coarse sand range. Framework grains are a mixture of quartz, abundant potassium feldspar, and equal proportions of plutonic and metamorphic (MRF) rock fragments. These grains are cemented by a combination of calcite (C, red), quartz overgrowths and grain-coating chlorite clay. Remaining pore space consists of reduced and isolated intergranular pores, leached-grain secondary pores, and microporosity.

A - 40X

B - 160X


A
0.5 mm

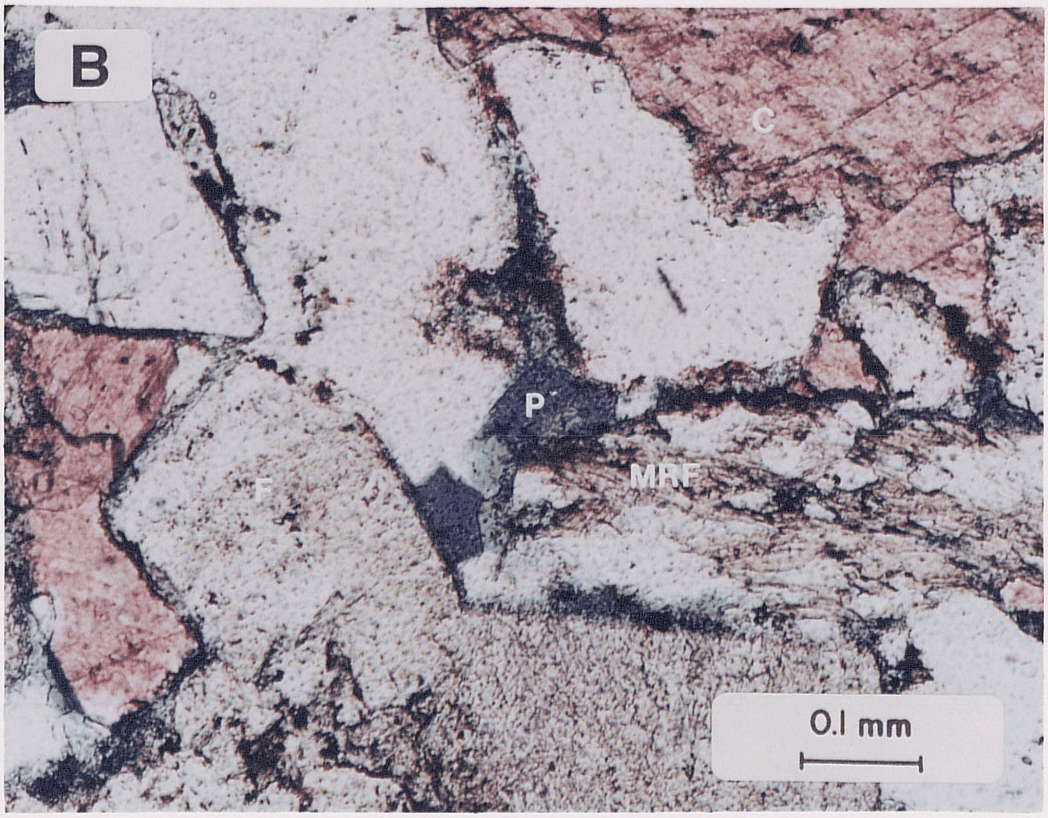

B
C
P
MRF
F
0.1 mm

PLATE 6

SEM PHOTOMICROGRAPHS

EL PASO SAN JUAN 29-5 NO. 50 WELL

Core Depth: 12,708-9 feet	WWRC: 24527:316
Grain Size: Lower Coarse	Porosity: 8.0%
Sorting: Poor	Permeability: 0.15 md

Macropores in this low porosity and low permeability sandstone consist of severely reduced intergranular pores (P) and leached-grain secondary pores (Ps) after feldspar. Authigenic chlorite (CH) is present in a grain-coating/pore-lining morphology and has associated abundant microporosity. Other cements include quartz overgrowths (Qo) and calcite.

A - 100X, First Area

B - 500X

C - 1,000X

D - 500X, Second Area

X-RAY DIFFRACTION DATA

Bulk Mineralogy		Clay Mineralogy	
Quartz	52%	Chlorite	93%
K-Feldspar	12%	Illite	7%
Plagioclase	26%	Kaolinite	--
Calcite	7%		
Dolomite	1%		
Clay	2%		

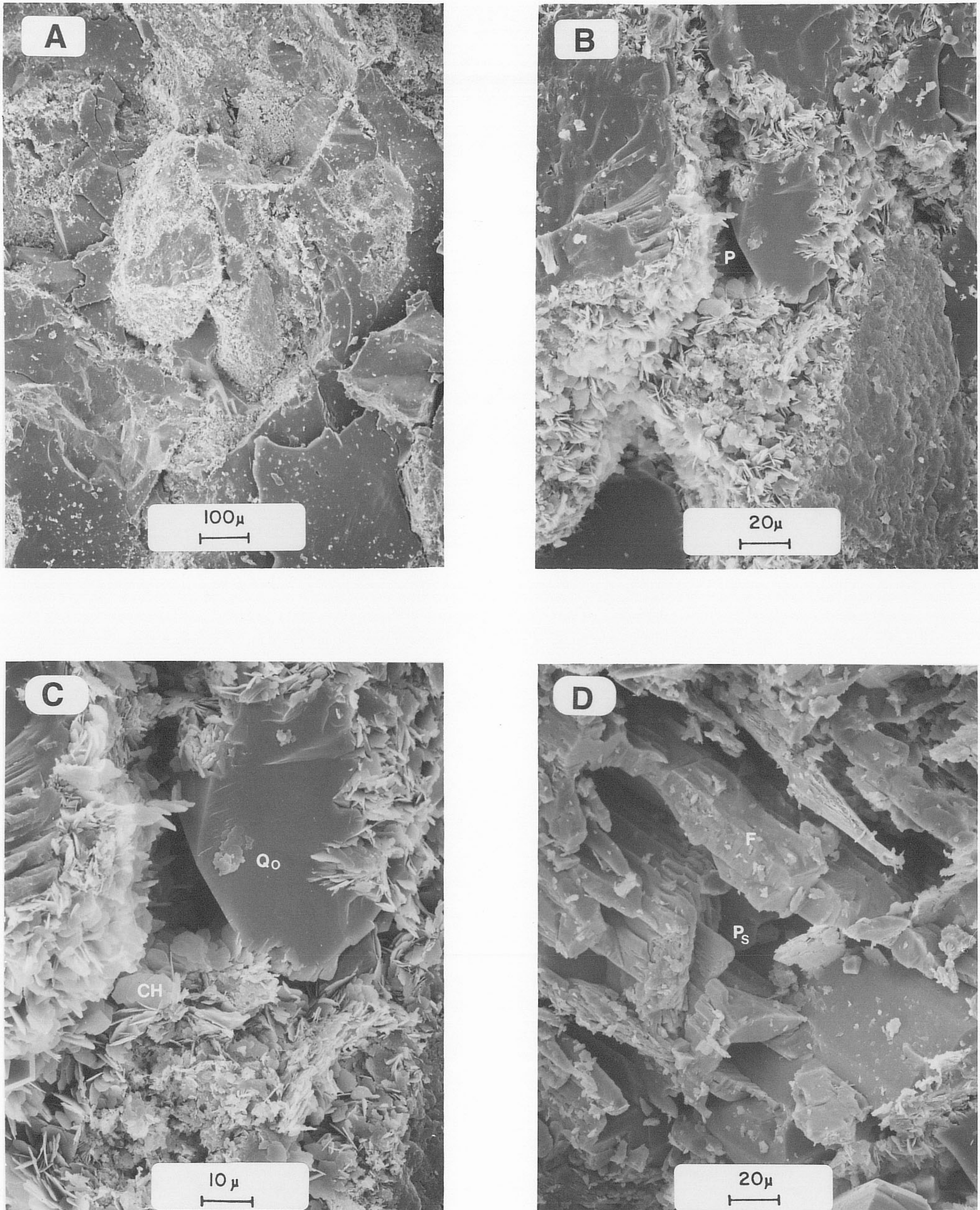

A
100μ
B
P
20μ
C
Qo
CH
10μ
D
F
Ps
20μ

PLATE 7

THIN SECTION PHOTOMICROGRAPHS

EL PASO SAN JUAN 29-5 NO. 50 WELL

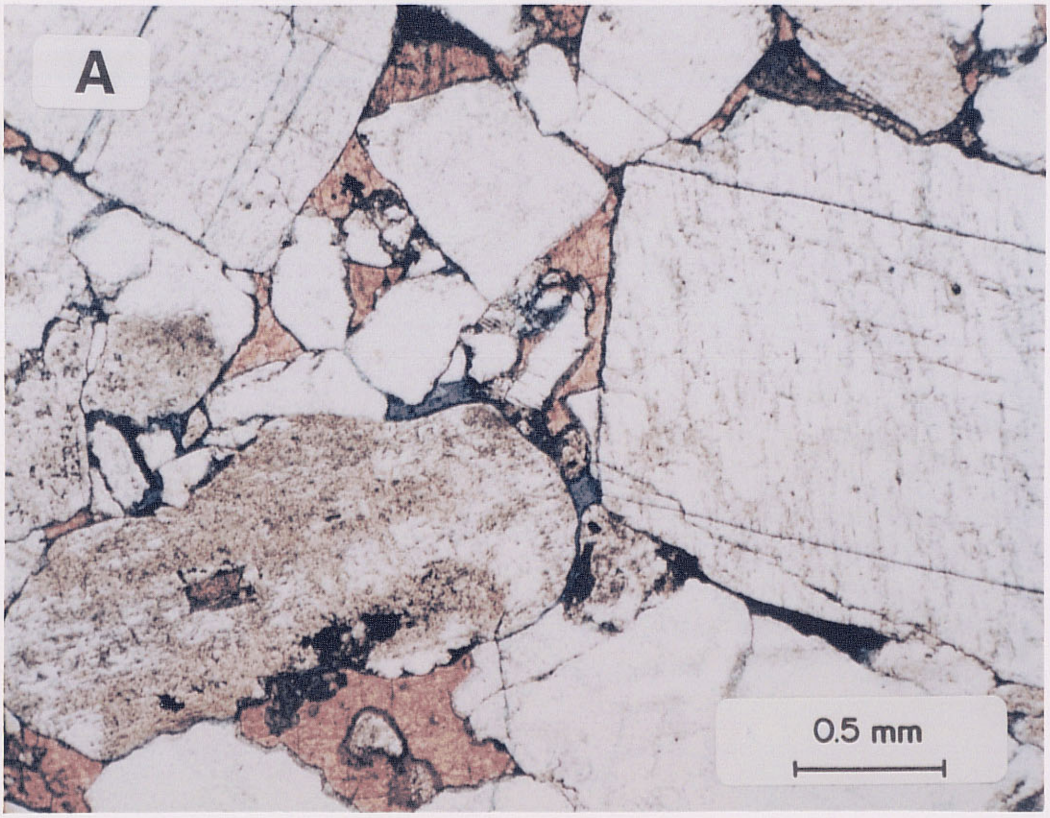
Core Depth: 12,709-10 feet
Grain Size: Lower Coarse
Sorting: Poor

WWRC: 24526:361
Porosity: 10.5%
Permeability: 0.32 md

Upper coarse-grained feldspars are clearly evident in this poorly sorted sandstone. Other framework grains consist of quartz and an assortment of plutonic and metamorphic rock fragments. These grains are cemented by a combination of calcite (C, red), grain-coating/pore-lining chlorite clay (arrow) and quartz overgrowths. Note that both the calcite and quartz overgrowths postdate the formation of authigenic chlorite. The resulting pore structure of the sandstone consists of severely reduced and isolated intergranular pores and leached-grain secondary pores. Microporosity associated with the chlorite comprises a significant amount of the total pore space.

A - 40X

B - 160X


A
0.5 mm

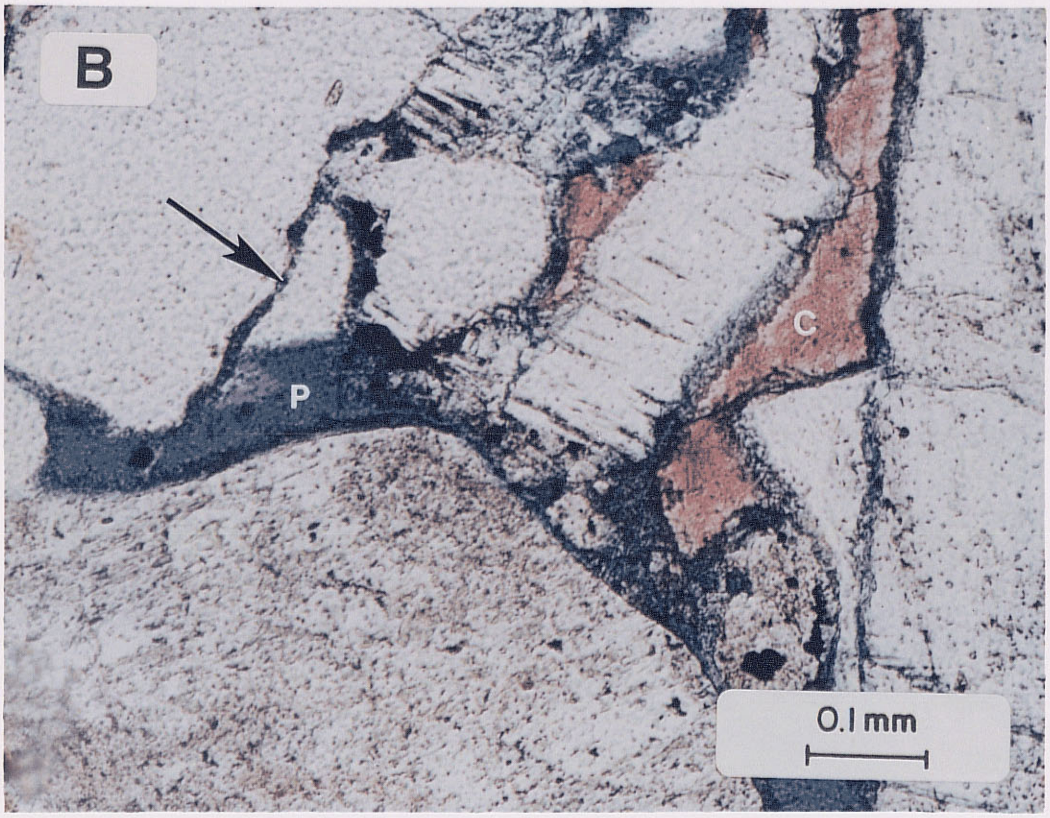

B
P
C
0.1 mm

PLATE 8

SEM PHOTOMICROGRAPHS

EL PASO SAN JUAN 29-5 NO. 50 WELL

Core Depth: 12,709-10 feet	WWRC: 24526:361
Grain Size: Lower Coarse	Porosity: 10.5%
Sorting: Poor	Permeability: 0.32 md

Intergranular areas in this sandstone are commonly lined by well developed authigenic chlorite (CH). The chlorite consists of intergrown platelets with abundant intercrystalline micropores. These micropores presumably would contain irreducible formation brine. Also occluding pore space are smooth, euhedral quartz overgrowths.

A - 100X, First Area

B - 500X

C - 2,000X

D - 1,000X, Second Area

X-RAY DIFFRACTION DATA

Bulk Mineralogy		Clay Mineralogy	
Quartz	55%	Chlorite	94%
K-Feldspar	11%	Illite	6%
Plagioclase	22%	Kaolinite	--
Calcite	9%		
Dolomite	1%		
Clay	2%		

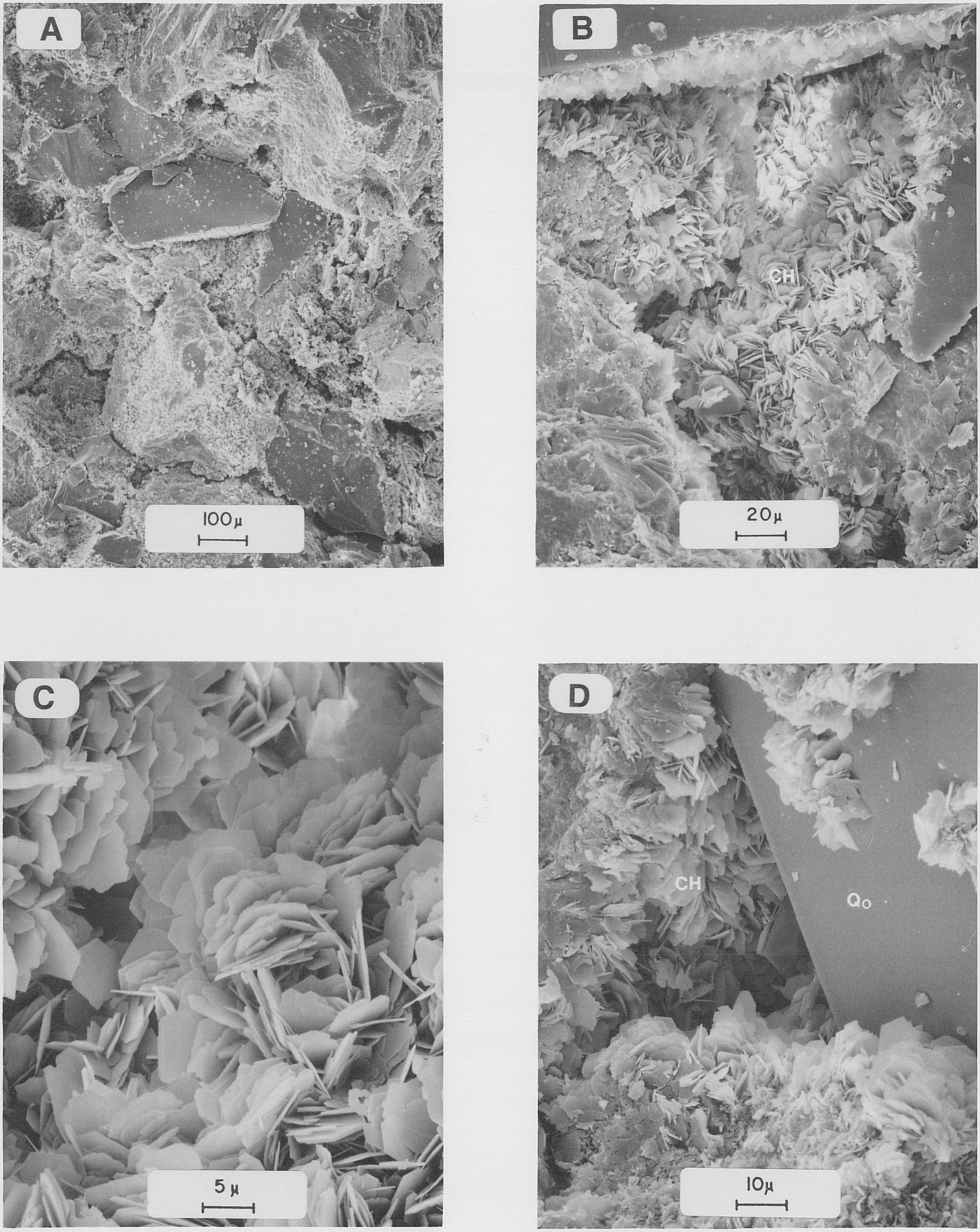

A
100μ
B
CH
20μ
C
5μ
D
CH
Qo
10μ

PLATE 9

THIN SECTION PHOTOMICROGRAPHS

EL PASO SAN JUAN 29-5 NO. 50 WELL

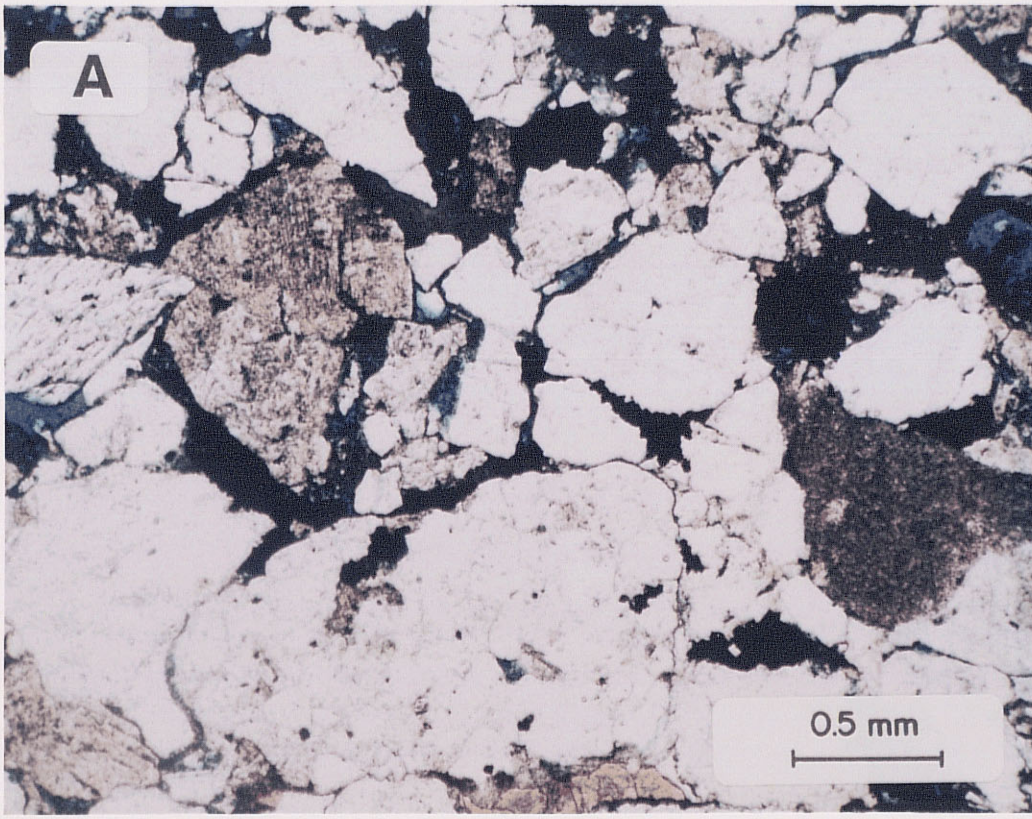
Core Depth: 12,710-11 feet
Grain Size: Lower Coarse
Sorting: Poor

WWRC: 24527:163
Porosity: 7.5%
Permeability: 0.36 md

Poorly-sorted framework grains of predominantly quartz, feldspar and lesser amounts of rock fragments appear well compacted and cemented. The cements consist of quartz overgrowths, calcite (red), grain-coating/pore-lining chlorite clay, and local pyrite (PY, black). Visible pore space is confined to reduced and isolated intergranular pores (P) and leached-grain secondary pores.

A - 40X

B - 160X


A
0.5 mm

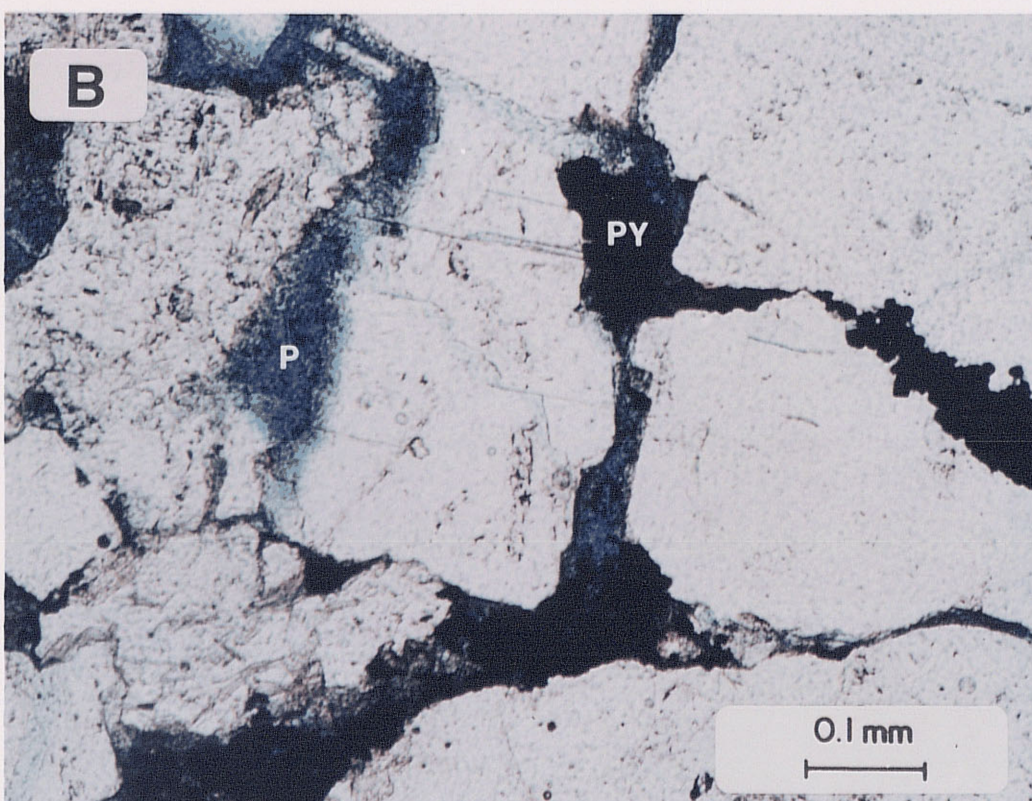

B
PY
P
0.1 mm

PLATE 10

SEM PHOTOMICROGRAPHS

EL PASO SAN JUAN 29-5 NO. 50 WELL

Core Depth: 12,710-11 feet
Grain Size: Lower Coarse
Sorting: Poor

WWRC: 24527:163
Porosity: 7.5%
Permeability: 0.36 md

Pervasive grain-coating chlorite (CH) can be seen extensively lining pores (P) that are also reduced in size by calcite (C) and quartz overgrowths (Qo). Note that the chlorite predates both the calcite and the quartz overgrowths. Porosity is mainly in the form of intercrystalline micropore space associated with the chlorite and lesser amounts of reduced macropores (P).

A - 100X, First Area

B - 500X

C - 1,000X

D - 500X, Second Area

X-RAY DIFFRACTION DATA

Bulk Mineralogy

Quartz	61%
K-Feldspar	16%
Plagioclase	19%
Calcite	2%
Dolomite	--
Clay	2%

Clay Mineralogy

Chlorite	96%
Illite	4%
Kaolinite	--

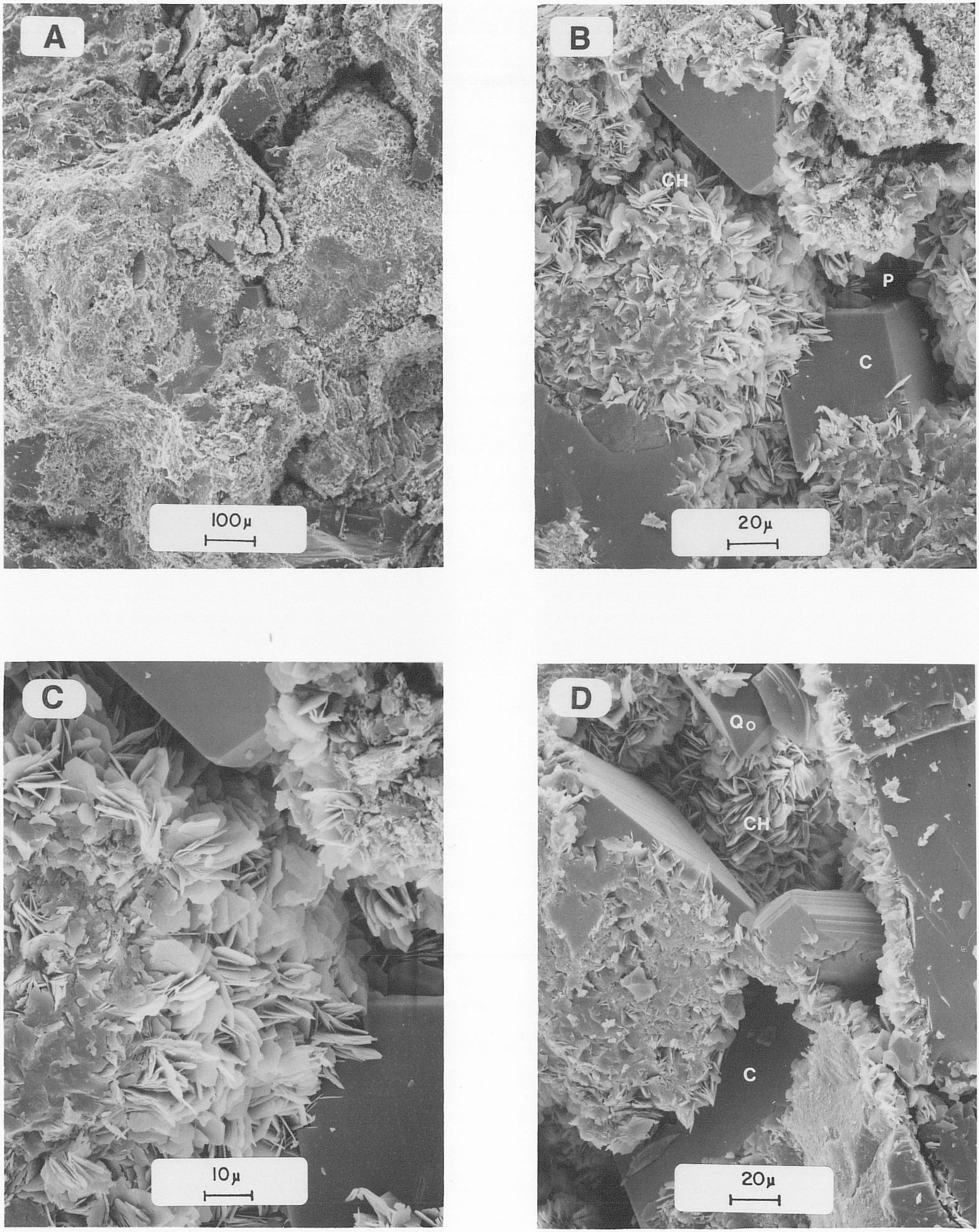

A
100μ
B
CH
P
C
20μ
C
10μ
D
Qo
CH
C
20μ

PLATE 11

THIN SECTION PHOTOMICROGRAPHS

EL PASO SAN JUAN 29-5 NO. 50 WELL

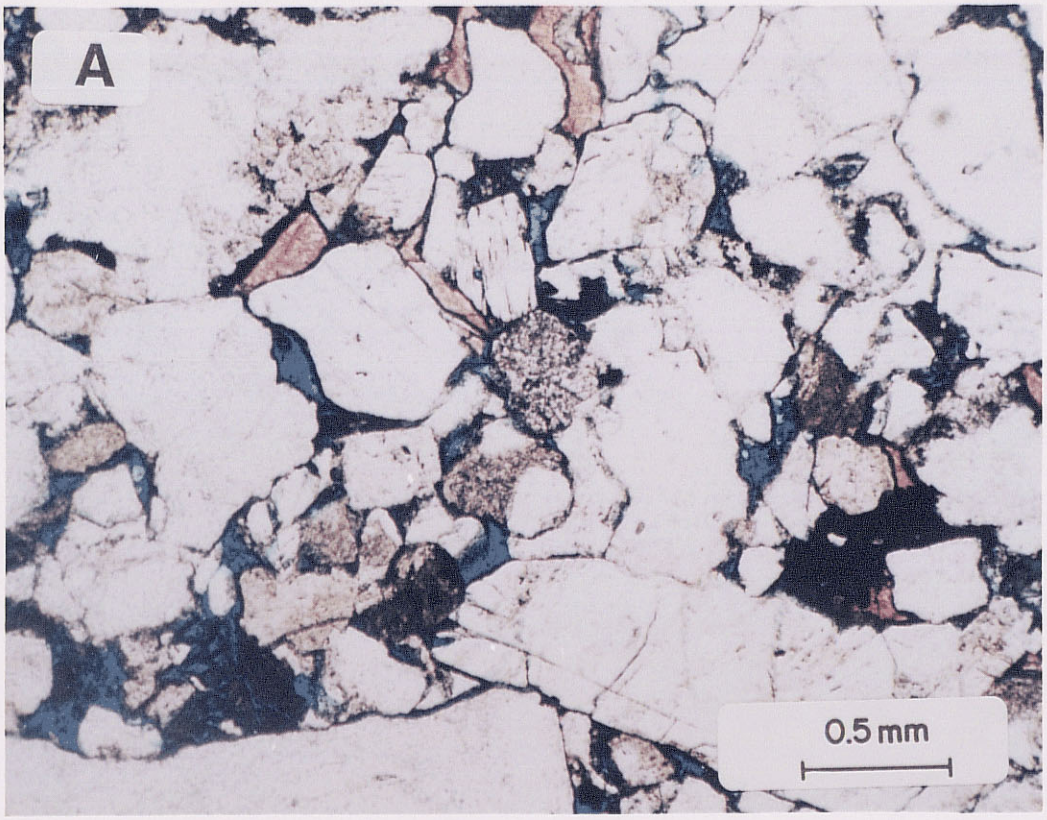
Core Depth: 12,711-12 feet
Grain Size: Lower Coarse
Sorting: Poor

WWRC: 24536:631
Porosity: 11.0%
Permeability: 0.08 md

Quartz, plutonic rock fragments and feldspar comprise the majority of framework grains in this poorly sorted, lower coarse-grained sandstone. Intergranular pores (P, blue) are evident despite compaction and cementation. Framework grain boundaries are well defined due to isopachous rims of chlorite clay (CH). Other cements include quartz overgrowths and calcite (C, red) which have a patchy distribution in the sandstone. Note the feldspars have undergone very little alteration or weathering.

A - 40X

B - 160X


A
0.5 mm

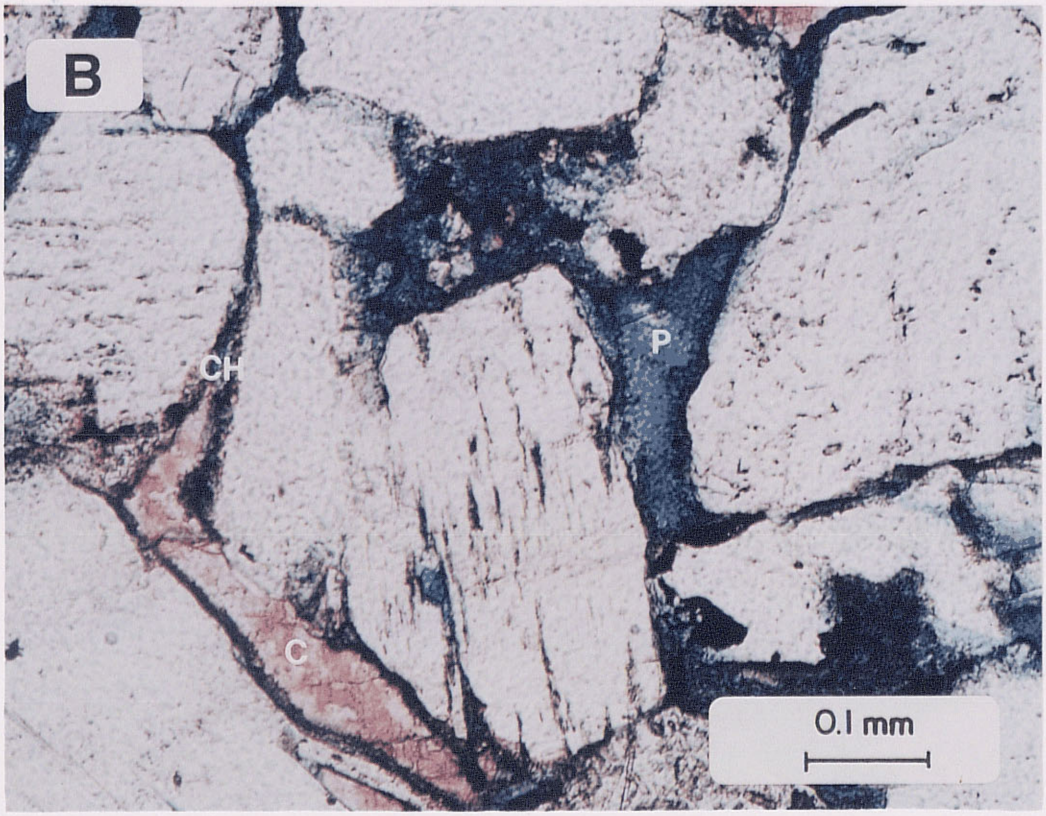

B
CH
P
C
0.1 mm

PLATE 12

SEM PHOTOMICROGRAPHS

EL PASO SAN JUAN 29-5 NO. 50 WELL

Core Depth: 12,711-12 feet	WWRC: 24536:631
Grain Size: Lower Coarse	Porosity: 11.0%
Sorting: Poor	Permeability: 0.08 md

These SEM photomicrographs illustrate the ubiquitous nature of the grain-coating/pore-lining chlorite clay throughout the pore system of the sandstone. This clay, coupled with compaction and cementation by quartz overgrowths (Qo) and calcite have reduced intergranular pores and created abundant microporosity. The high surface area to pore volume ratio and narrow pore throats has lowered permeability. The intercrystalline micropore space presumably contains a relatively high amount of irreducible capillarity bound water.

A - 100X, First Area

B - 500X

C - 1,000X

D - 500X, Second Area

X-RAY DIFFRACTION DATA

Bulk Mineralogy		Clay Mineralogy	
Quartz	63%	Chlorite	97%
K-Feldspar	8%	Illite	3%
Plagioclase	24%	Kaolinite	--
Calcite	3%		
Dolomite	--		
Clay	2%		

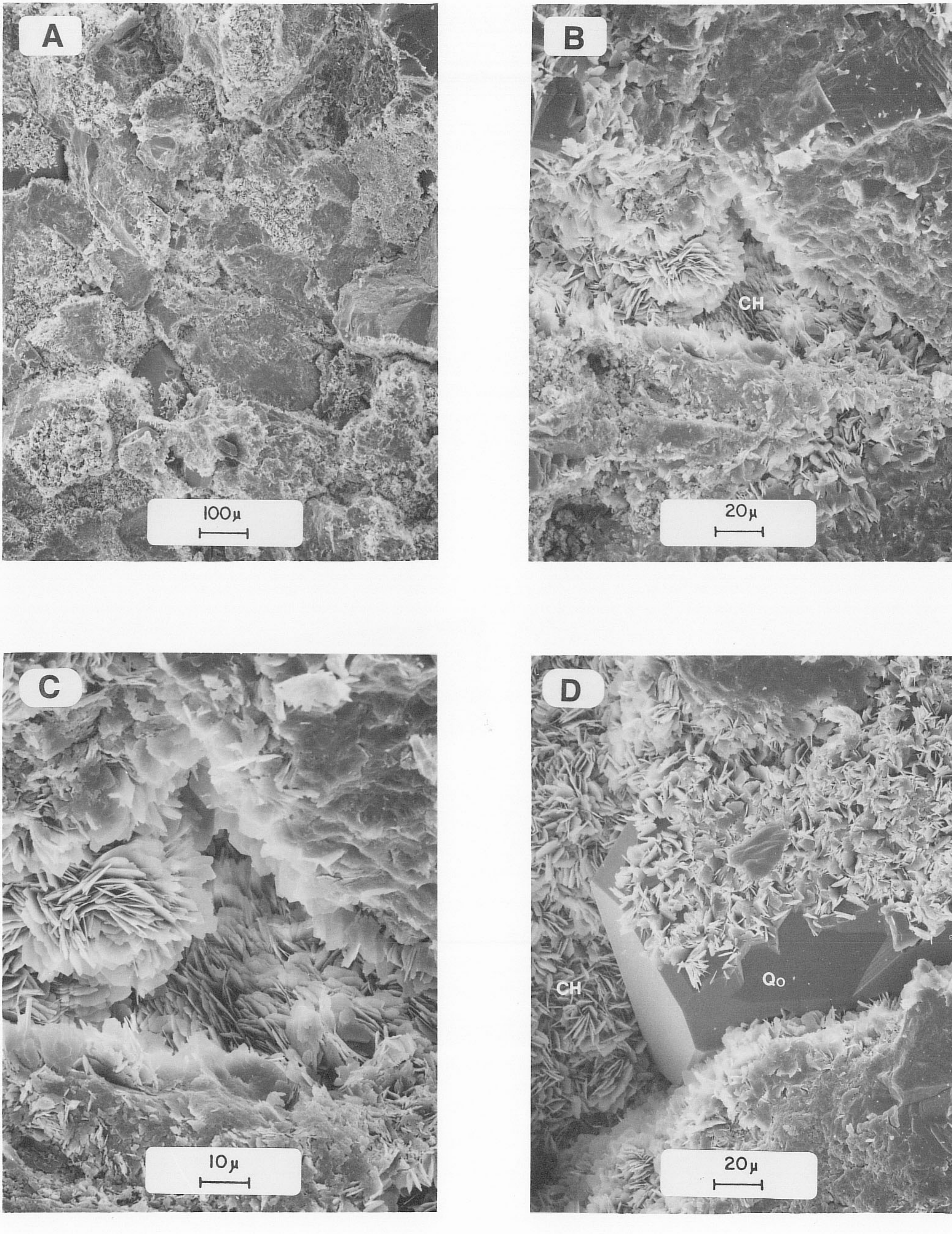

A
100µ
B
CH
20µ
C
10µ
D
CH
Qo
20µ

PLATE 13

THIN SECTION PHOTOMICROGRAPHS

EL PASO SAN JUAN 29-5 NO. 50 WELL

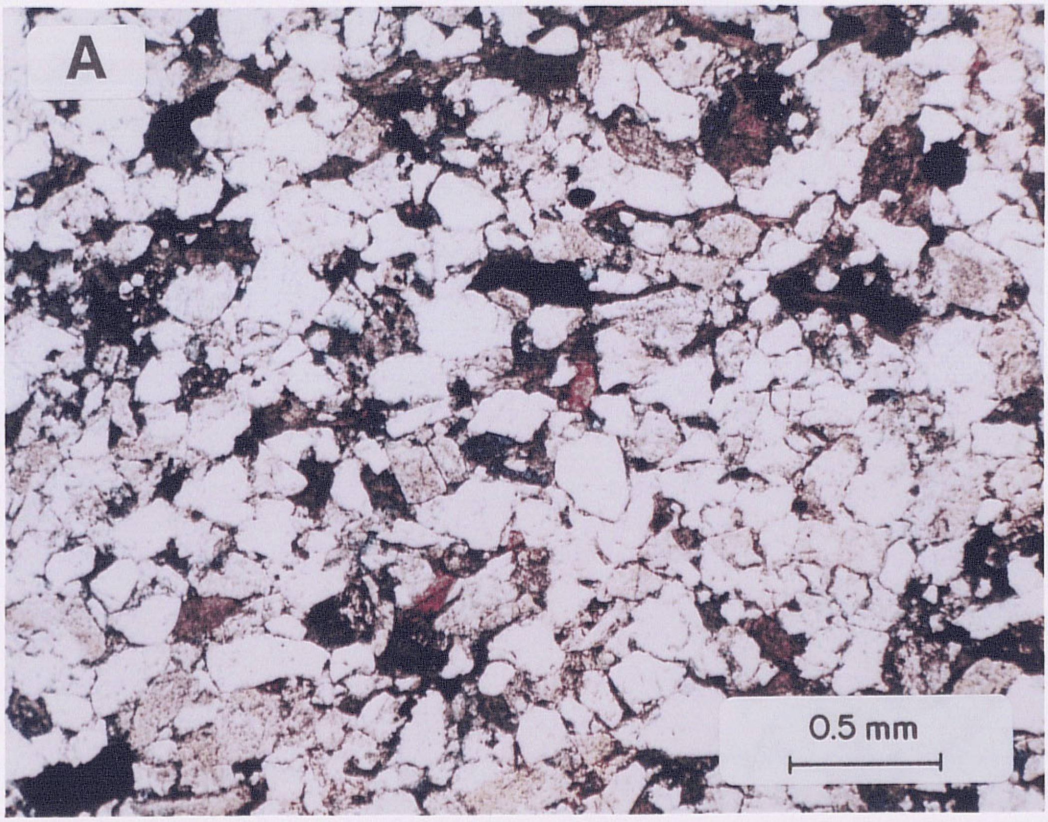
Core Depth: 12,738-39 feet
Grain Size: Lower Medium
Sorting: Well

WWRC: 32637:186
Porosity: 5.6%
Permeability: <0.01 md

This well sorted, lower medium-grained sandstone is well compacted and has a very limited amount of visible pore space (P, blue). Framework grains of quartz, feldspar, and mostly metamorphic rock fragments (RF) are well compacted and cemented by a combination of quartz overgrowths (arrow), calcite (C, red), and grain-coating/pore-lining chlorite clay. Intergranular pores (P, blue) are isolated and very poorly interconnected.

A - 40X

B - 160X


A
0.5 mm

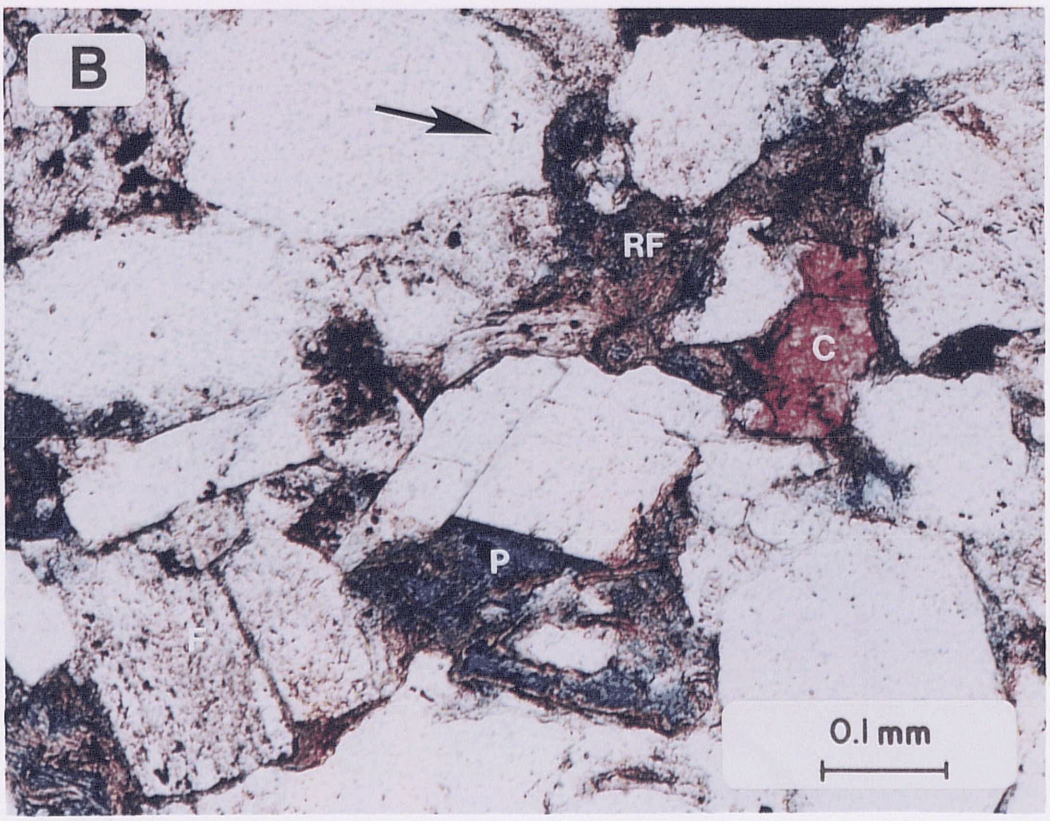

B
RF
C
P
F
0.1 mm

PLATE 14

SEM PHOTOMICROGRAPHS

EL PASO SAN JUAN 29-5 NO. 50 WELL

Core Depth: 12,738-39 feet	WWRC: 32637:186
Grain Size: Lower Medium	Porosity: 5.6%
Sorting: Well	Permeability: ≤0.01 md

The majority of pore space in this very well consolidated sandstone consists of micropores associated with pore-lining chlorite (CH) and microporous (MP) grains. Macropores are rare and isolated among well compacted grains such as quartz (Q), feldspar, and mica (M). Intergranular pores are partially to totally occluded by chlorite (CH), quartz overgrowths (Qo), and minor calcite.

A - 100X, First Area

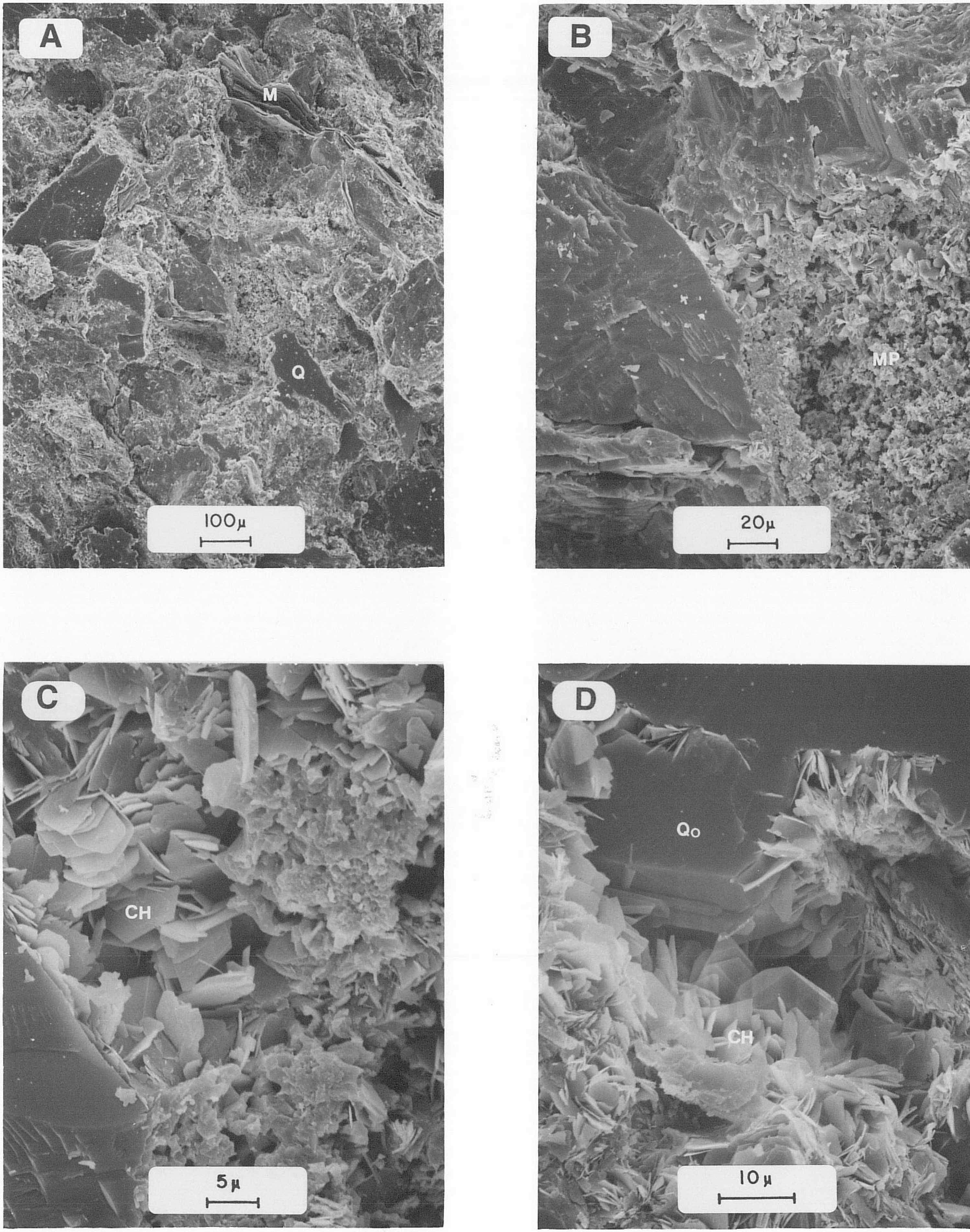
B - 500X

C - 2,000X

D - 1,500X, Second Area

X-RAY DIFFRACTION DATA

Bulk Mineralogy		Clay Mineralogy	
Quartz	39%	Chlorite	90%
K-Feldspar	6%	Illite	10%
Plagioclase	47%	Kaolinite	--
Calcite	2%		
Dolomite	--		
Pyrite	4%		
Clay	2%		



A
M
Q
100µ
B
MP
20µ
C
CH
5µ
D
Qo
CH
10µ

PLATE 15

THIN SECTION PHOTOMICROGRAPHS

EL PASO SAN JUAN 29-5 NO. 50 WELL

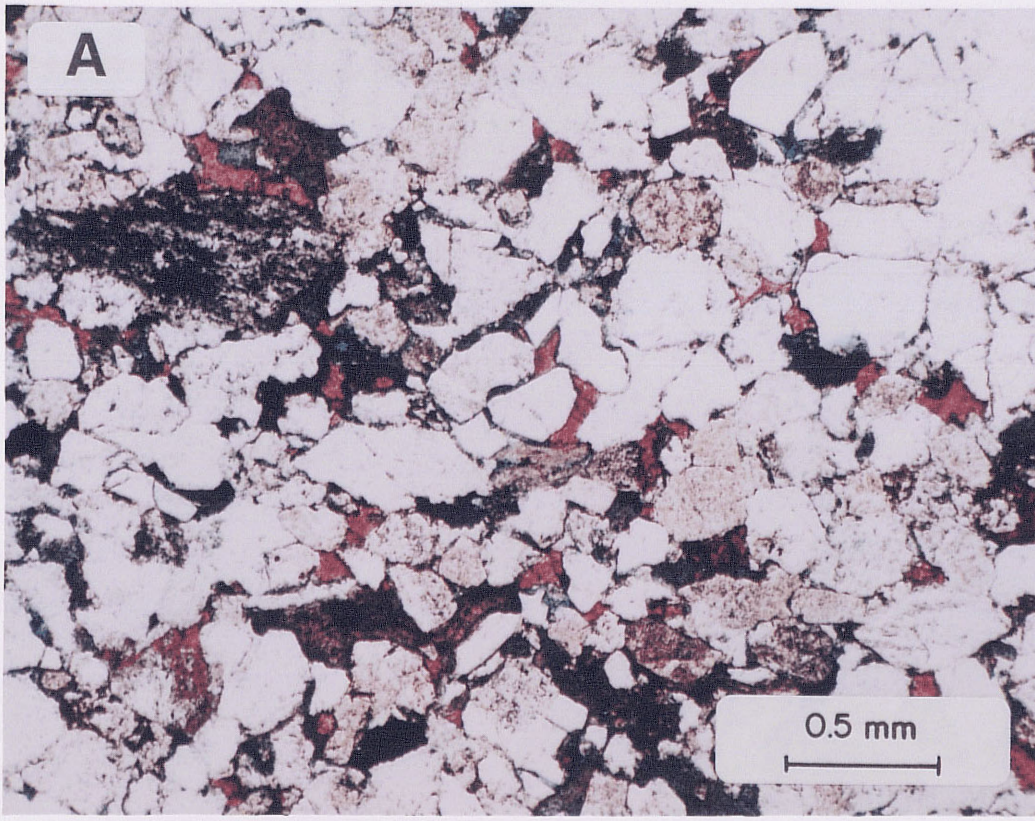
Core Depth: 12,742-43 feet
Grain Size: Upper Medium
Sorting: Moderate

WWRC: 33627:168
Porosity: 8.8%
Permeability: 0.03 md

Intergranular pore space is also poorly developed in this sandstone that is cemented by a combination of quartz overgrowths (arrow), calcite (C, red), and grain-coating/pore-lining chlorite (CH) clay. Remaining pore space consists of isolated and poorly interconnected intergranular pores and microporosity associated with the grain-coating/pore-lining chlorite.

A - 40X

B - 160X


A
0.5 mm

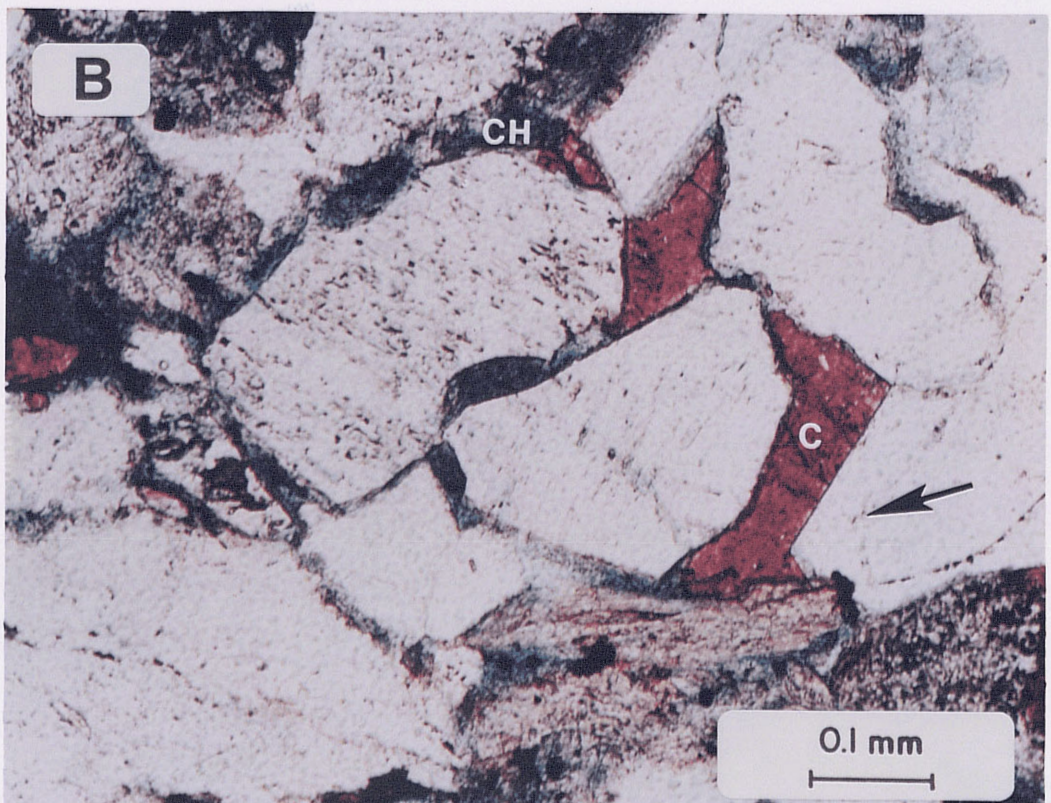

B
CH
C
0.1 mm

PLATE 16

SEM PHOTOMICROGRAPHS

EL PASO SAN JUAN 29-5 NO. 50 WELL

Core Depth: 12,742-43 feet
Grain Size: Upper Medium
Sorting: Moderate

WWRC: 33627:168
Porosity: 8.8%
Permeability: 0.03 md

These SEM photomicrographs reveal the general absence of macropores. Porosity is confined to severely reduced in size intergranular pores (P) and microporosity associated with the intergrown platelets of grain-coating/pore-lining chlorite (CH). The chlorite is common throughout the pore system of the sandstone along with quartz overgrowths (Qo) and calcite.

A - 100X, First Area

B - 500X

C - 1,500X

D - 1,000X, Second Area

X-RAY DIFFRACTION DATA

Bulk Mineralogy	
Quartz	44%
K-Feldspar	10%
Plagioclase	39%
Calcite	4%
Dolomite	--
Pyrite	1%
Clay	2%

Clay Mineralogy	
Chlorite	91%
Illite	9%
Kaolinite	--

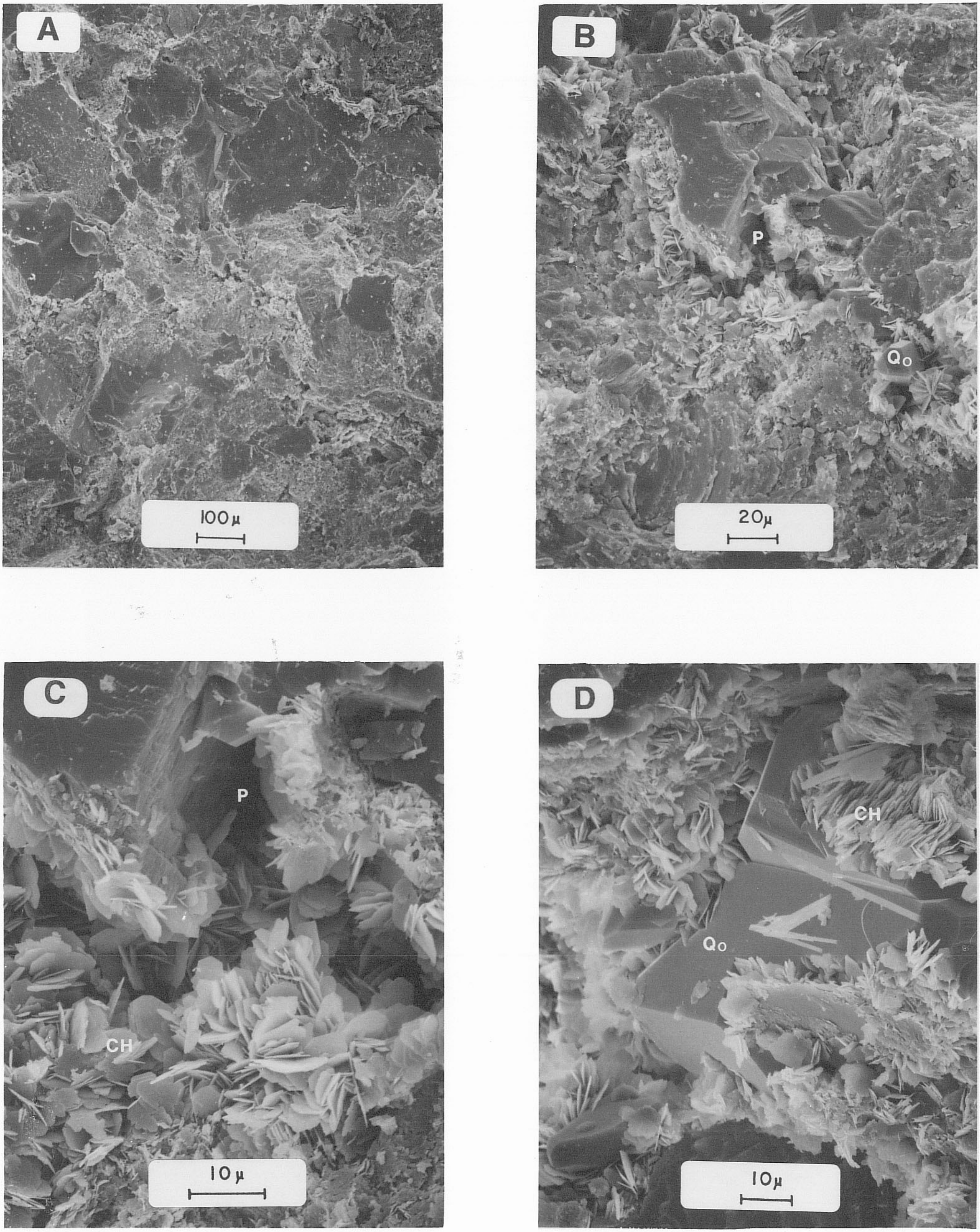

A
100μ
B
P
Qo
20μ
C
P
CH
10μ
D
CH
Qo
10μ

PLATE 17

THIN SECTION PHOTOMICROGRAPHS

EL PASO SAN JUAN 29-5 NO. 50 WELL

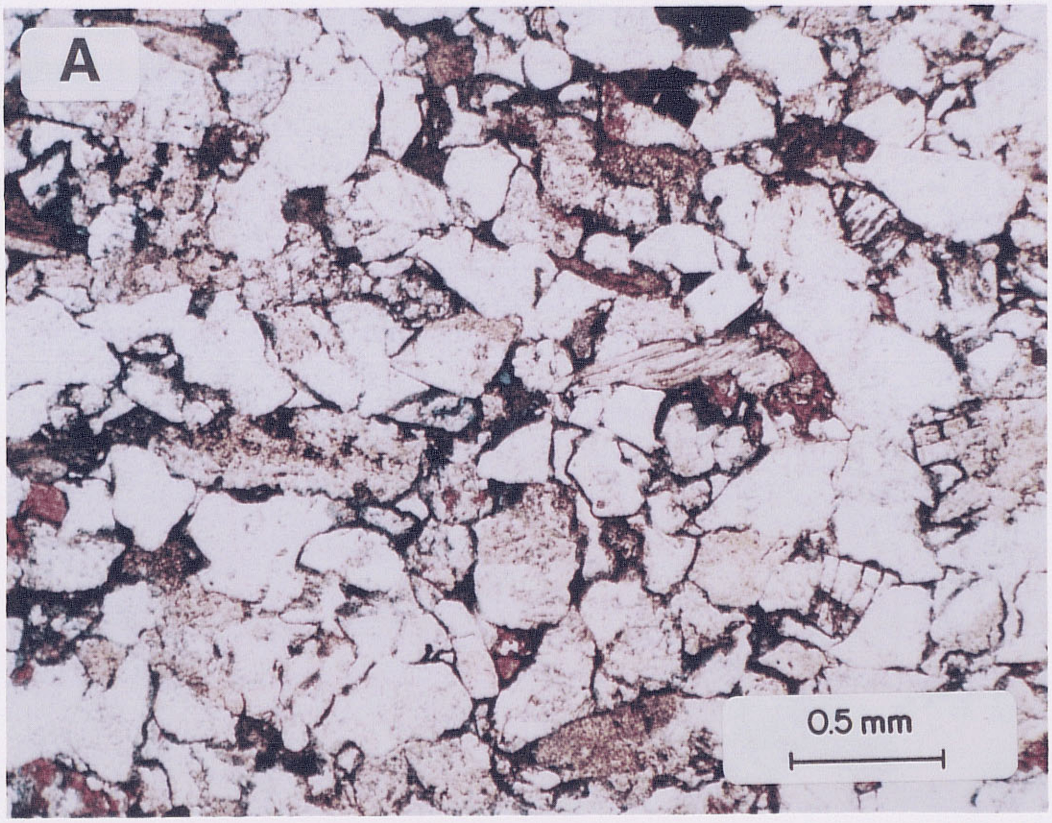
Core Depth: 12,900-01 feet
Grain Size: Upper Medium
Sorting: Moderate

WWRC: 33637:613
Porosity: NA
Permeability: NA

Quartz and abundant feldspar followed by lesser amounts of metamorphic rock fragments comprise the majority of framework constituents in this very well consolidated sandstone. These grains appear well compacted and are cemented by a combination of grain-coating/pore-lining chlorite clay (arrow), patchy quartz overgrowths and local calcite. The combination of these cements has severely occluded intergranular areas resulting in the pore structure characterized by severely reduced and isolated intergranular pores (P) and common microporosity associated with the authigenic chlorite.

A - 40X

B - 160X


A
0.5 mm

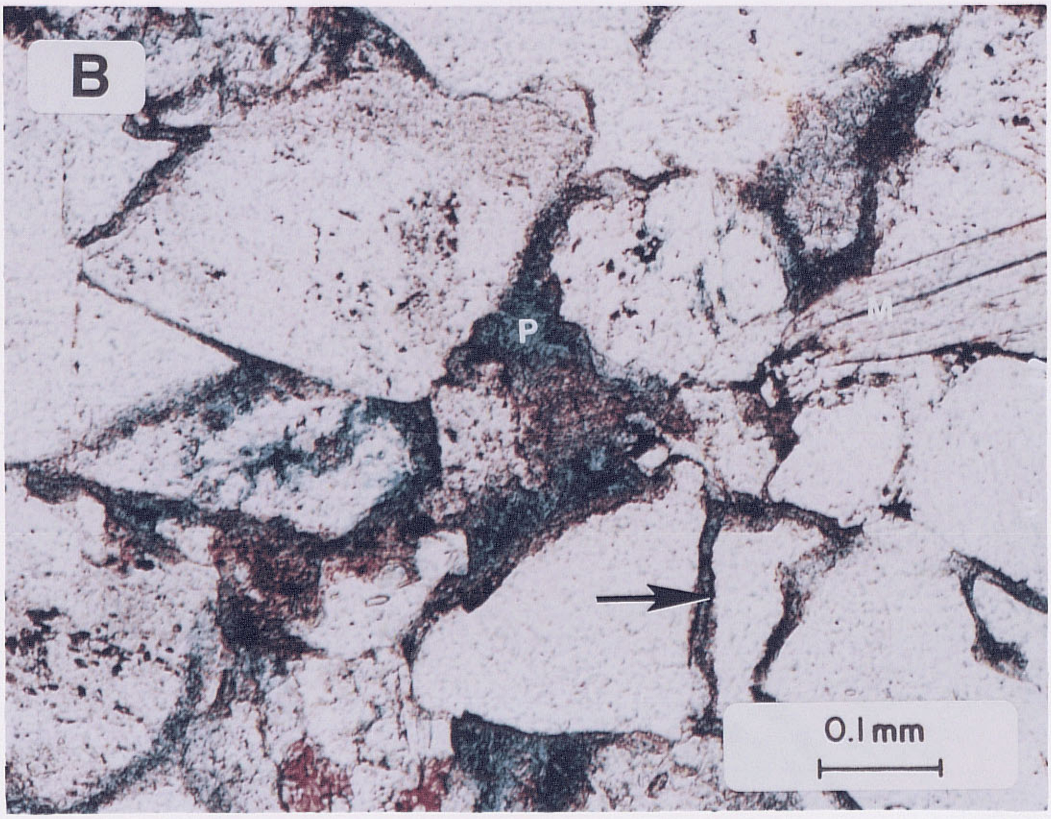

B
P
M
0.1 mm

PLATE 18

SEM PHOTOMICROGRAPHS

EL PASO SAN JUAN 29-5 NO. 50 WELL

Core Depth: 12,900-01 feet	WWRC: 33637:613
Grain Size: Upper Medium	Porosity: NA
Sorting: Moderate	Permeability: NA

The severe occlusion of intergranular pore space is readily evident in the SEM photomicrographs. Calcite and quartz overgrowths (Qo) have severely filled in intergranular pores after the pores were lined by authigenic chlorite (CH). The majority of pore space remaining in this sandstone consists of rare, severely reduced intergranular pores and common intercrystalline micropores associated with the chlorite (CH).

A - 100X, First Area

B - 500X

C - 1,500X

D - 1,000X, Second Area

X-RAY DIFFRACTION DATA

Bulk Mineralogy		Clay Mineralogy	
Quartz	48%	Chlorite	76%
K-Feldspar	6%	Illite	24%
Plagioclase	40%	Kaolinite	--
Calcite	4%		
Dolomite	--		
Clay	2%		

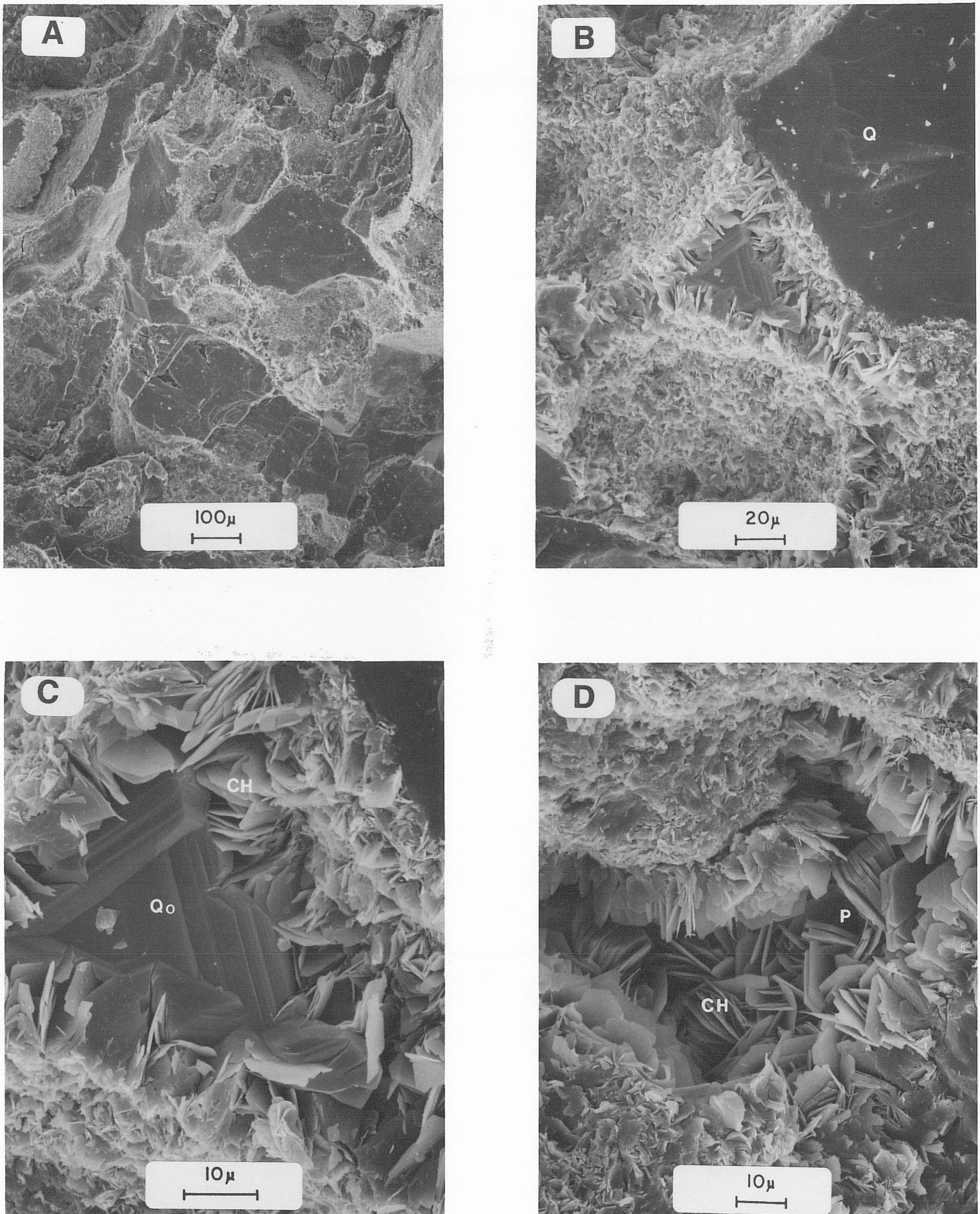

A
100μ
B
Q
20μ
C
CH
Qo
10μ
D
P
CH
10μ

PLATE 19

THIN SECTION PHOTOMICROGRAPHS

EL PASO SAN JUAN 29-5 NO. 50 WELL

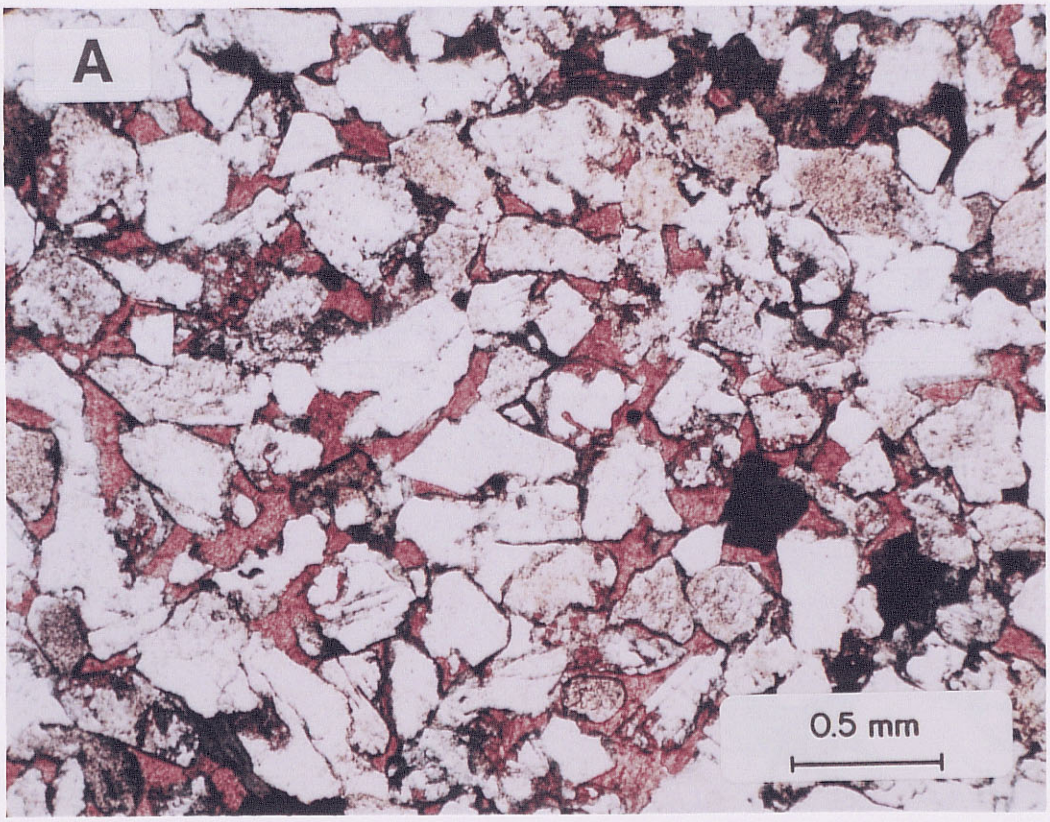
Core Depth: 12,902-03 feet
Grain Size: Lower Medium
Sorting: Moderate

WWRC: 33638:361
Porosity: NA
Permeability: NA

This moderately sorted, lower medium-grained sandstone is cemented mostly by calcite (C, red) followed by lesser amounts of grain-coating/pore-lining chlorite (arrow) clay and quartz overgrowths. In addition, the calcite is an extensive grain replacing agent having partially to completely replaced many feldspar and other grains. Remaining pore space is extremely rare and the majority of pore space is associated with the chlorite as microporosity.

A - 40X

B - 160X


A
0.5 mm

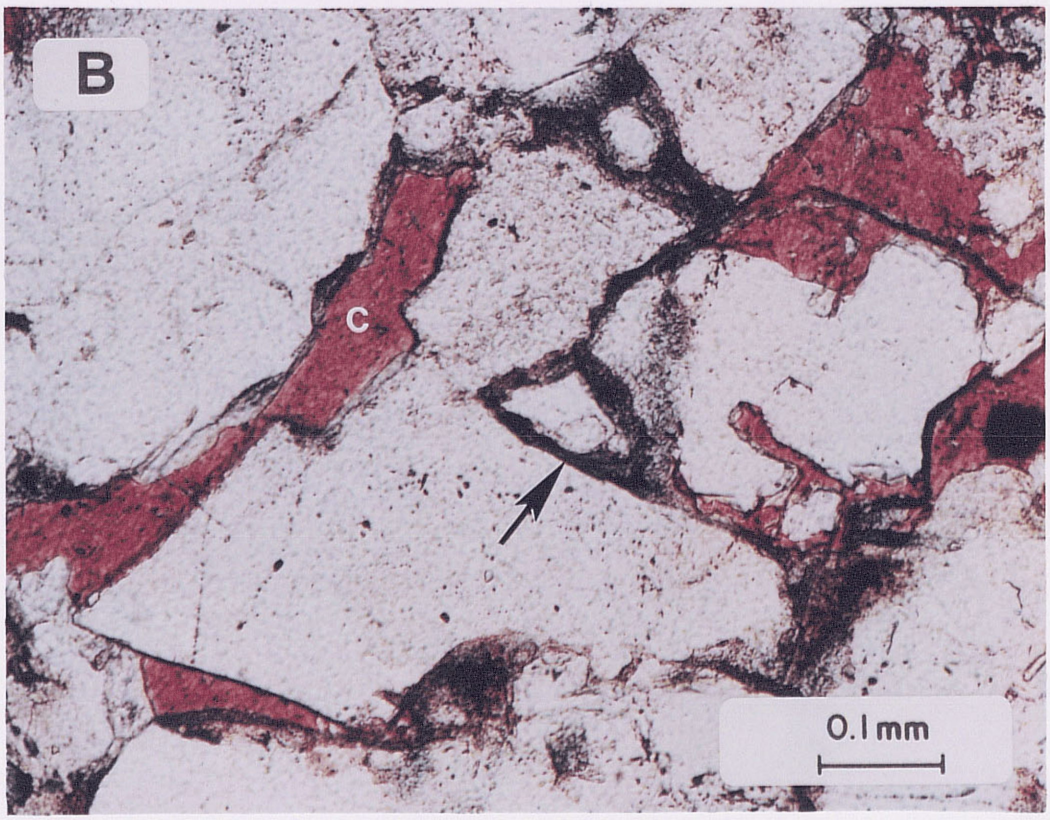

B
C
0.1 mm

PLATE 20

SEM PHOTOMICROGRAPHS

EL PASO SAN JUAN 29-5 NO. 50 WELL

Core Depth: 12,902-03 feet	WWRC: 33638:361
Grain Size: Lower Medium	Porosity: NA
Sorting: Moderate	Permeability: NA

Intergranular pore space has been almost totally occluded in this sandstone by abundant calcite(C), authigenic chlorite clay (CH), and lesser amounts of quartz overgrowths (not shown). The only remaining pore space that can be seen is intercrystalline microporosity associated with the intergrown platelets of chlorite (CH).

A - 100X, First Area

B - 500X

C - 2,000X

D - 1,000X, Second Area

X-RAY DIFFRACTION DATA

Bulk Mineralogy		Clay Mineralogy	
Quartz	42%	Chlorite	81%
K-Feldspar	10%	Illite	19%
Plagioclase	37%	Kaolinite	--
Calcite	9%		
Dolomite	--		
Clay	2%		

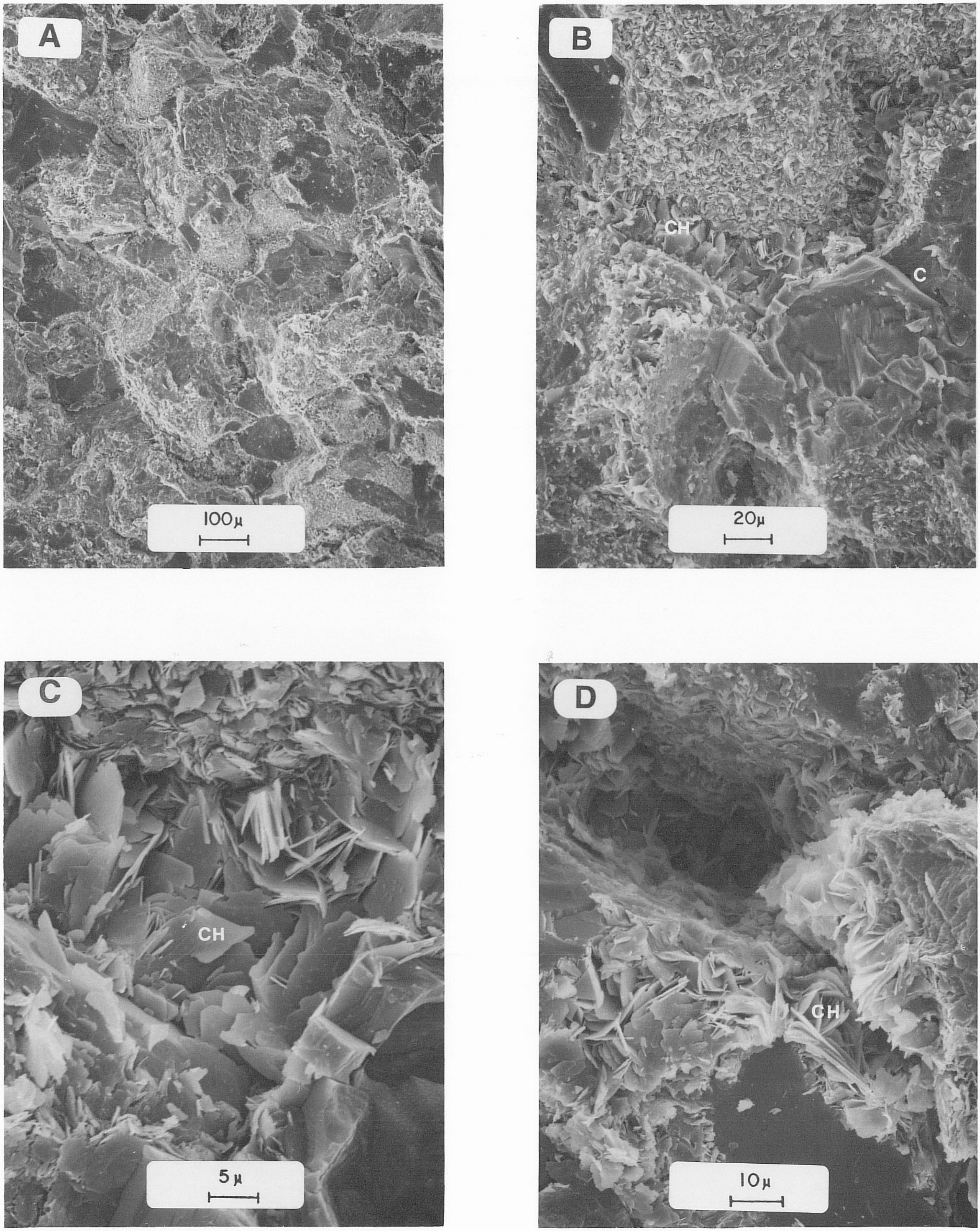

A
100μ
B
CH
C
20μ
C
CH
5μ
D
CH
10μ

PLATE 21

THIN SECTION PHOTOMICROGRAPHS

EL PASO SAN JUAN 29-5 NO. 50 WELL

Core Depth: 12,903-04 feet
Grain Size: Lower Medium
Sorting: Moderate

WWRC: 33638:631
Porosity: NA
Permeability: NA

This sandstone is similar to the previous one compositionally, and in terms of pore-filling constituents and pore structure. Quartz, abundant feldspar and common metamorphic rock fragments comprise the majority of framework constituents. These grains appear well compacted and cemented by a combination of grain-coating/pore-lining chlorite clay (arrow), calcite (C, red) and quartz overgrowths (arrow). As a result, pore space consists of rare, isolated, severely reduced intergranular pores and microporosity associated with the chlorite clay.

A - 40X

B - 160X

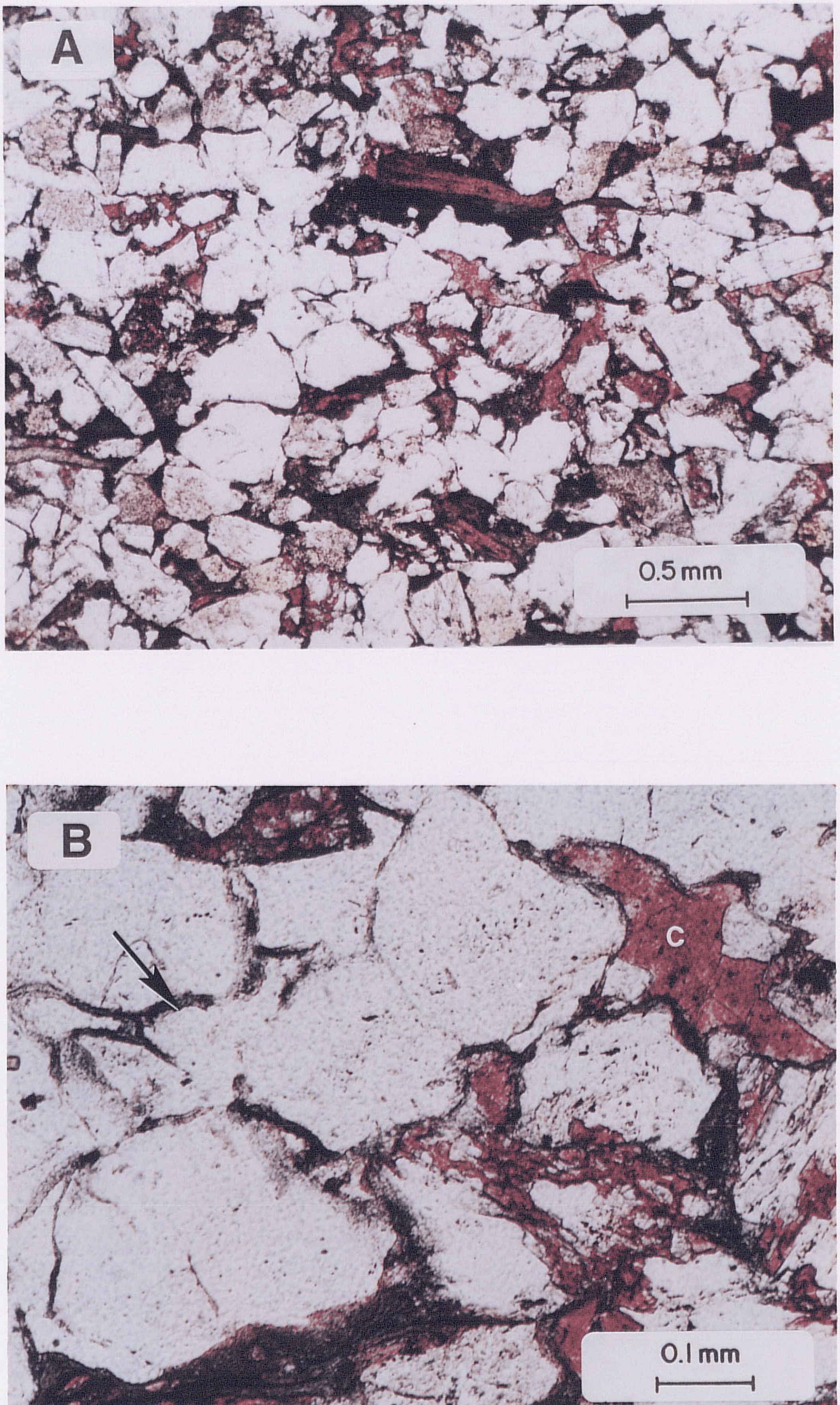

A
0.5 mm
B
C
0.1 mm

PLATE 22

SEM PHOTOMICROGRAPHS

EL PASO SAN JUAN 29-5 NO. 50 WELL

Core Depth: 12,903-04 feet
Grain Size: Lower Medium
Sorting: Moderate

WWRC: 33638:631
Porosity: NA
Permeability: NA

No visible macropores are evident in these SEM photomicrographs. Grains of predominately quartz and feldspar (F) are tightly cemented by a combination of quartz overgrowths (Qo), calcite, and grain-coating/pore-lining chlorite (CH) clay. Paragenetic relationships suggest that the quartz overgrowth cement postdates the grain-coating chlorite (arrow).

A - 100X, First Area

B - 500X

C - 2,000X

D - 1,000X, Second Area

X-RAY DIFFRACTION DATA

Bulk Mineralogy

Quartz	45%
K-Feldspar	6%
Plagioclase	39%
Calcite	7%
Dolomite	--
Clay	3%

Clay Mineralogy

Chlorite	82%
Illite	18%
Kaolinite	--

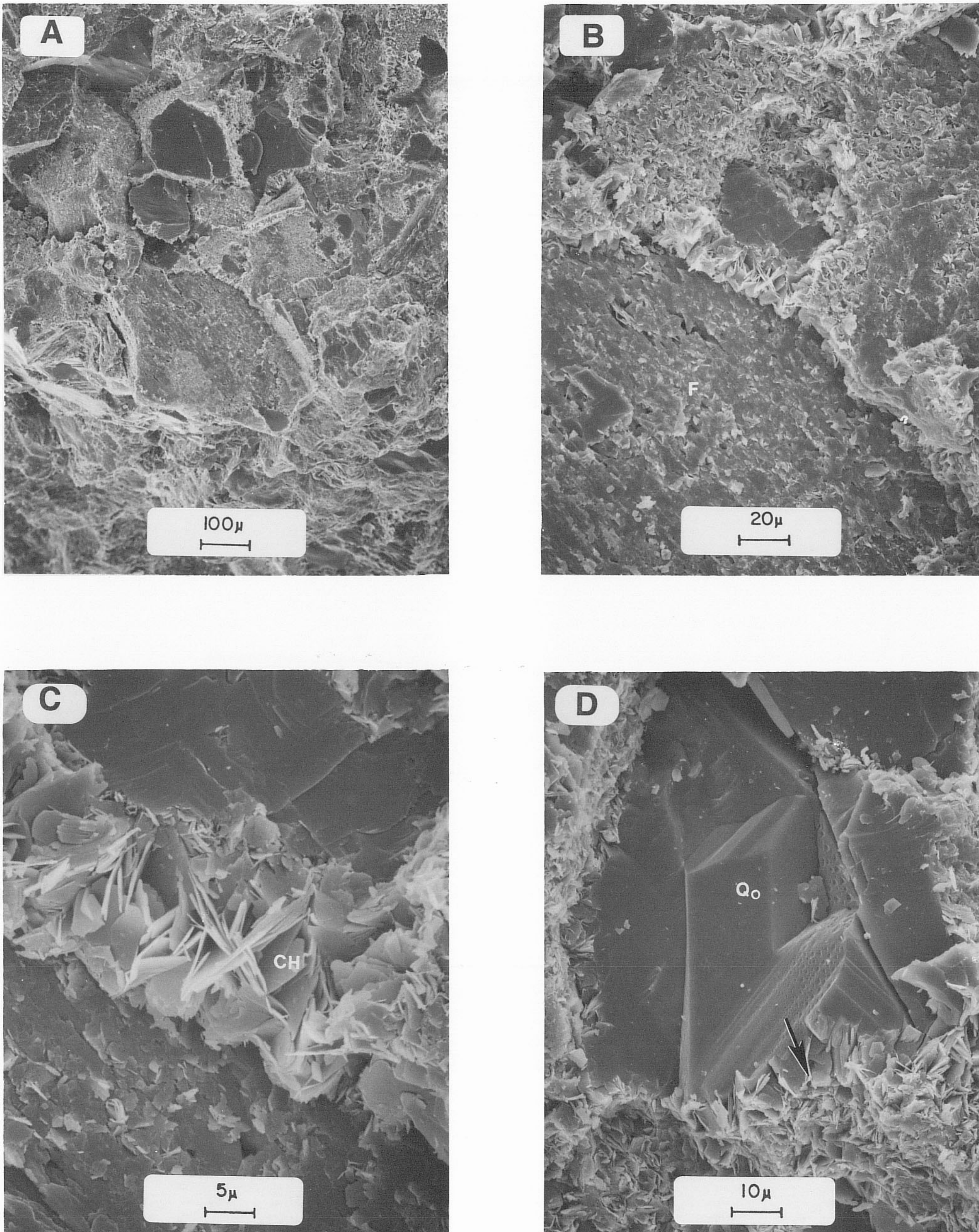

A
100μ
B
F
20μ
C
CH
5μ
D
Qo
10μ

PLATE 23

THIN SECTION PHOTOMICROGRAPHS

EL PASO SAN JUAN 29-5 NO. 50 WELL

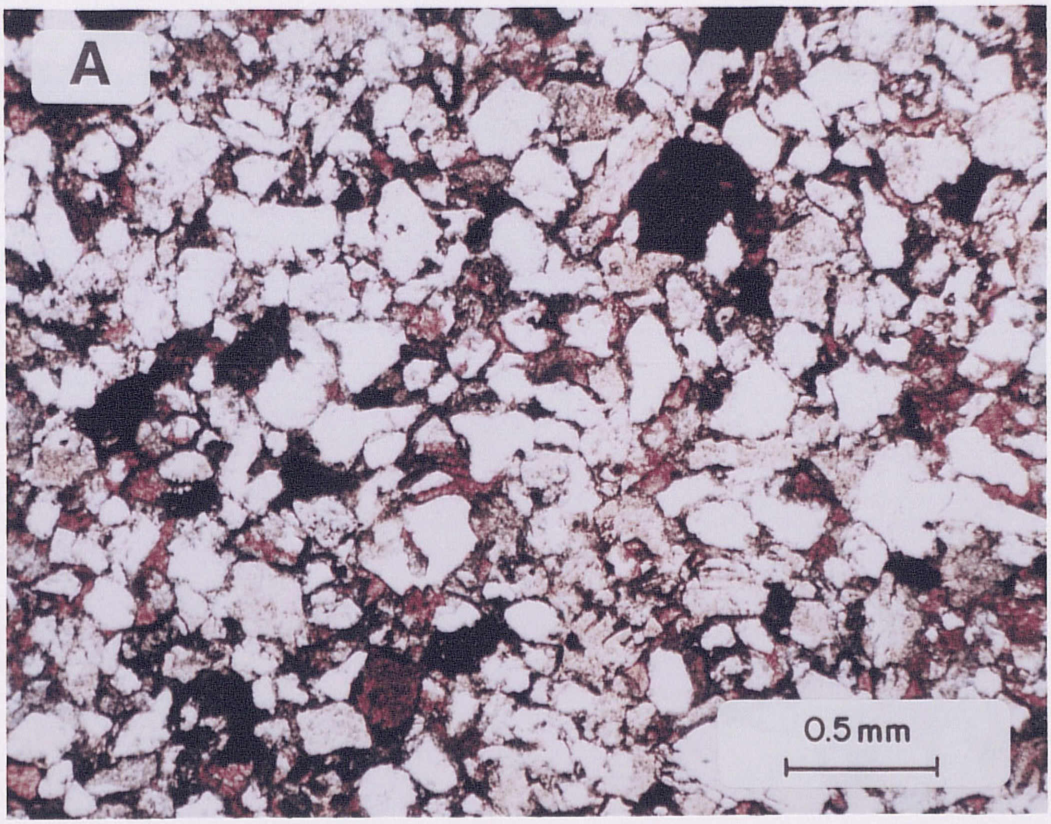
Core Depth: 12,905-06 feet
Grain Size: Upper Fine
Sorting: Well

WWRC: 42628:368
Porosity: NA
Permeability: NA

This well sorted, fine-grained sandstone is very well consolidated having been extensively cemented by calcite (C, red) and lesser amounts of authigenic clay (CL). Framework constituents are predominately quartz, feldspar, metamorphic rock fragments and lesser amounts of ooids and unidentified altered grains. Visible pore space was not detected in this tightly cemented sandstone.

A - 40X

B - 160X


A
0.5mm

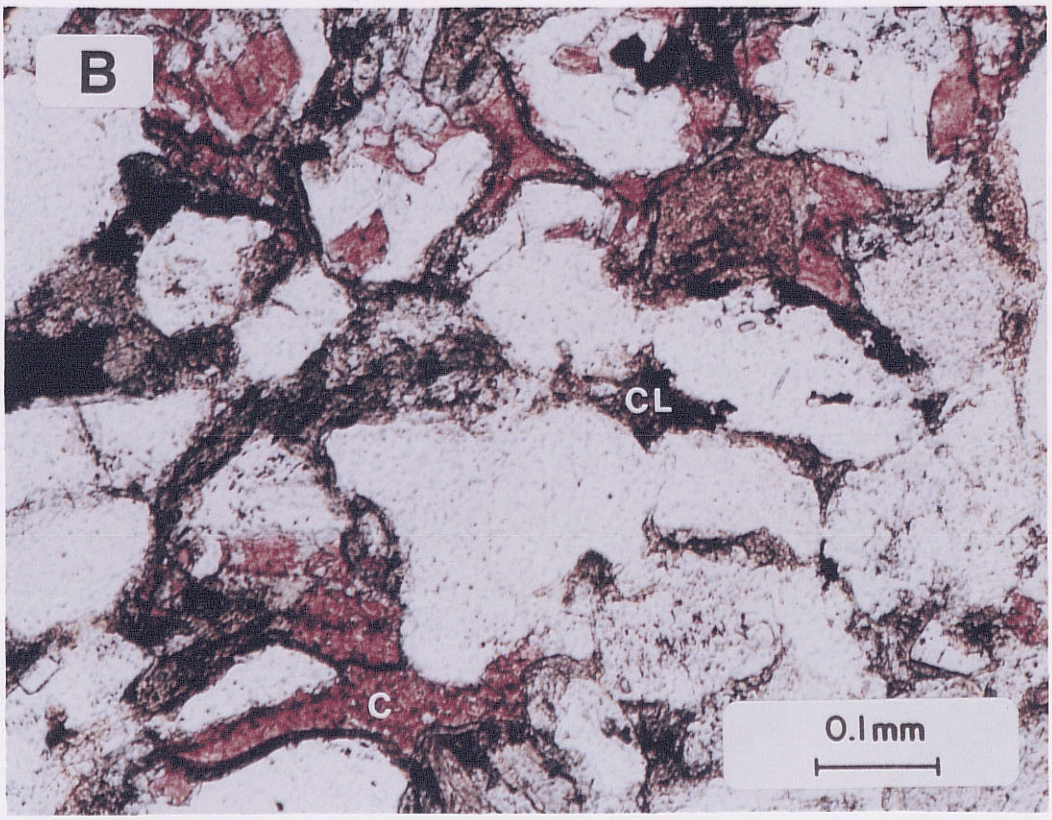

B
CL
C
0.1mm

PLATE 24

SEM PHOTOMICROGRAPHS

EL PASO SAN JUAN 29-5 NO. 50 WELL

Core Depth: 12,905-06 feet
Grain Size: Upper Fine
Sorting: Well

WWRC: 42628:368
Porosity: NA
Permeability: NA

These SEM photomicrographs reveal that porosity is extremely low in this sandstone. The smooth surface of this upper fine-grained, moderately sorted sandstone is due to extensive cementation mostly by calcite (C). Locally, intergranular pore space is partially to completely filled with chlorite (CH). Note that the grain-coating/pore-lining chlorite clay is not as well developed in this sample or is obscured by the pervasive calcite cement.

A - 100X, First Area

B - 500X

C - 1,500X

D - 1,500X, Second Area

X-RAY DIFFRACTION DATA

Bulk Mineralogy	
Quartz	34%
K-Feldspar	3%
Plagioclase	47%
Calcite	14%
Dolomite	--
Clay	2%

Clay Mineralogy	
Chlorite	71%
Illite	29%
Kaolinite	--

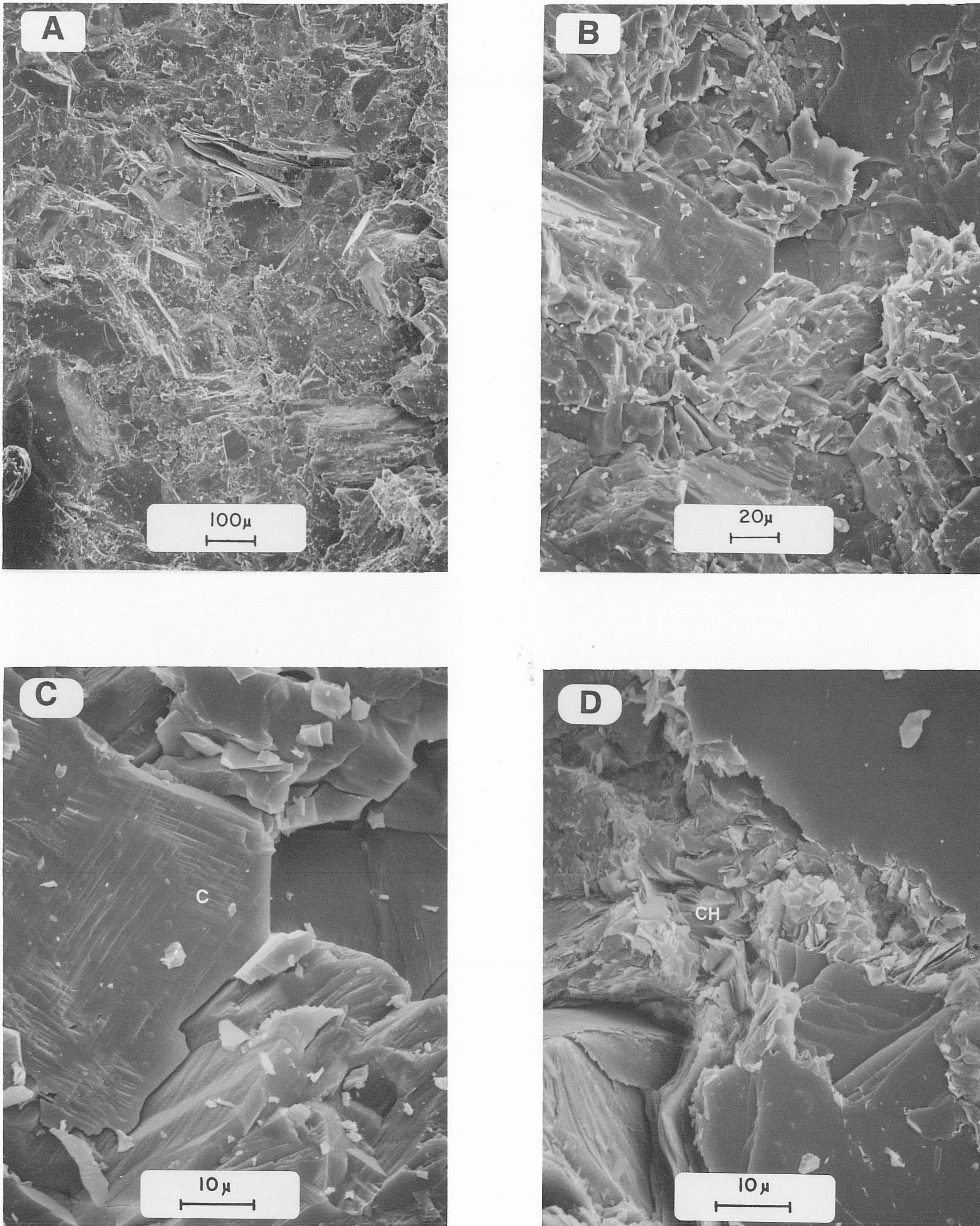

A
100μ
B
20μ
C
C
10μ
D
CH
10μ

PLATE 25

THIN SECTION PHOTOMICROGRAPHS

PHILLIPS SAN JUAN DEEP 30-6 NO. 112Y WELL

Drill Cuttings Depth: 13,200-10 feet
Grain Size: Upper Medium to Lower Coarse
Sorting: Poor

WWRC: 24627:613, 24627:361
Porosity: NA
Permeability: NA

Drill cutting fragments consist of single, coarse sand-sized grains and aggregates of only three to six grains. Estimated mean grain size is in the upper medium to lower coarse sand range and sorting is estimated as poor. Some fragments are cemented and have grains replaced by calcite (red) while others are cemented by a combination of quartz overgrowths and grain-coating chlorite (CH). Visible pore space consists of severely reduced and isolated intergranular pores (P) and microporosity associated with the pore-lining chlorite.

A - 40X

B - 160X

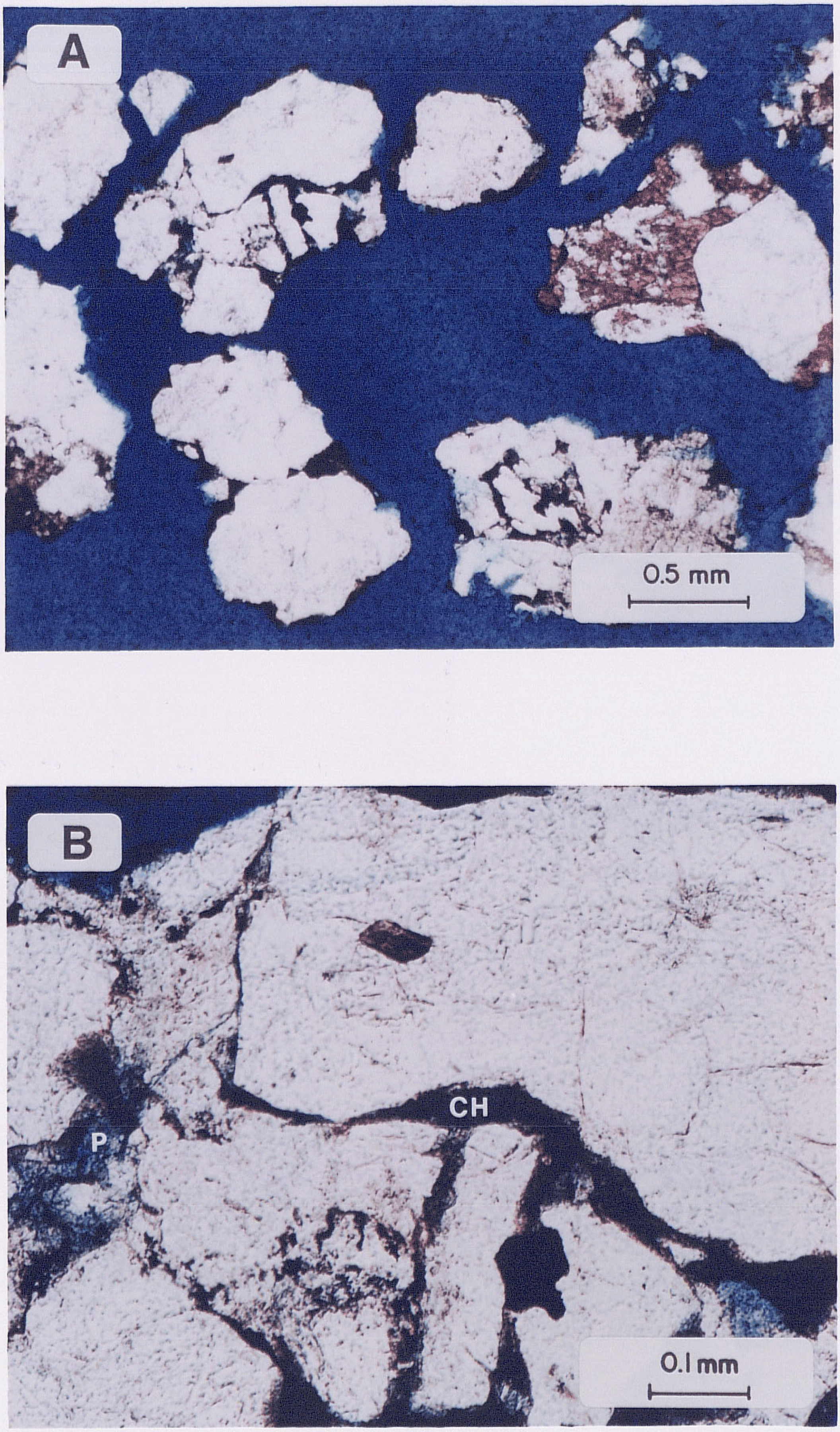

A
0.5 mm
B
CH
P
0.1 mm

PLATE 26

SEM PHOTOMICROGRAPHS

PHILLIPS SAN JUAN DEEP 30-6 NO. 112Y WELL

Drill Cuttings Depth: 13,200-10 feet
Grain Size: Upper Medium to Lower Coarse
Sorting: Poor

WWRC: 24627:613, 24627:361
Porosity: NA
Permeability: NA

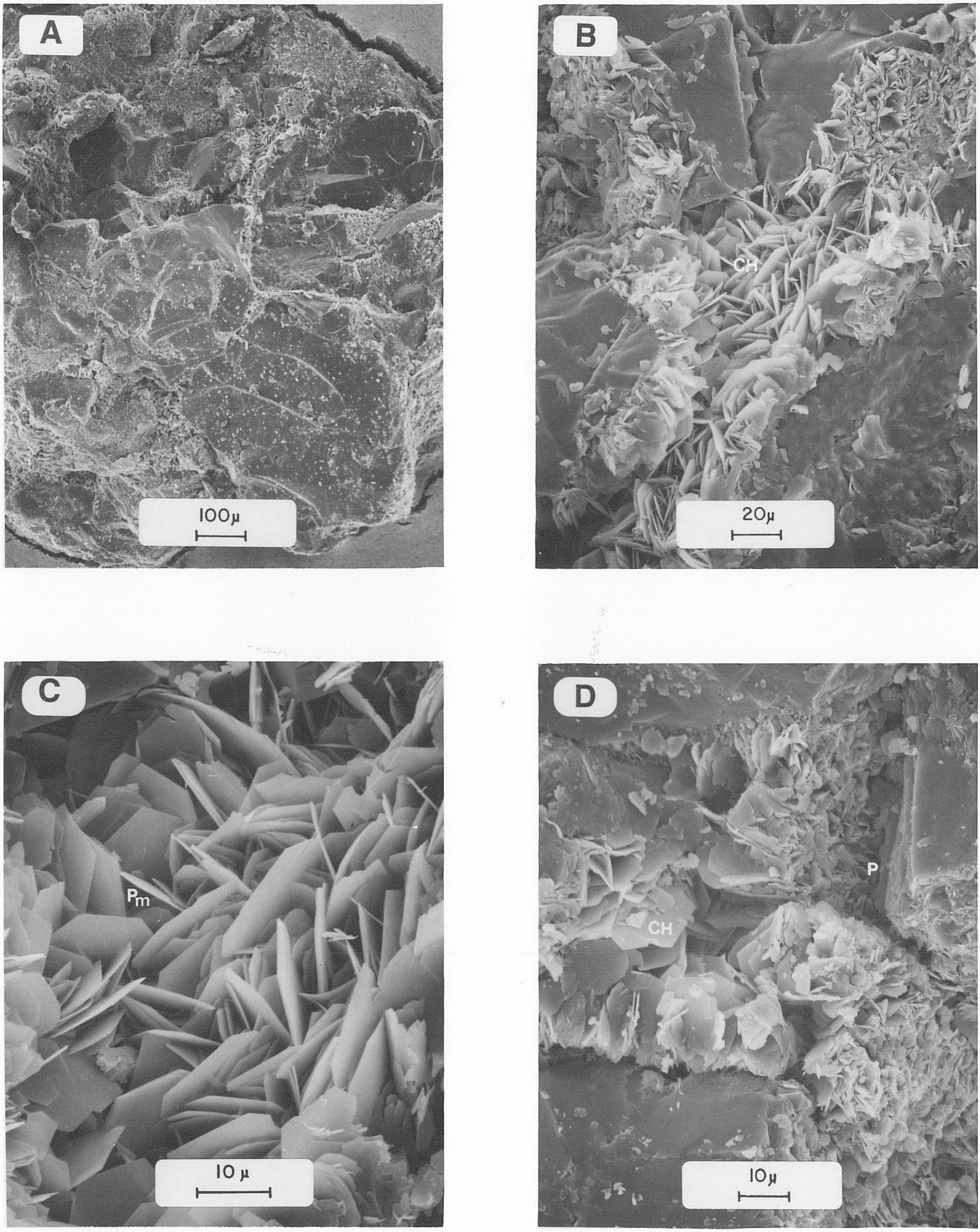
Intergranular pores have been completely to partially occluded in this poorly sorted, upper medium- to lower coarse-grained sandstone. Framework grains are predominately quartz and feldspar which are cemented by a combination of quartz overgrowths, calcite and grain-coating/pore-lining chlorite clay. The pore structure of the sandstone consists of severely reduced intergranular pores (P) and common microporosity (Pm) associated with the intergrown platelets of chlorite.

A - 100X, First Area

B - 500X

C - 1,500X

D - 1,000X, Second Area


A
100µ
B
CH
20µ
C
Pm
10 µ
D
P
CH
10µ