Precambrian-Paleozoic Contact In Two Wells In Northwestern Kansas

By Robert W. Scott and
Marcus N. McElroy

DOCUMENTS DEPARTMENT
DEC 8 1964
LIBRARY
UNIVERSITY OF CALIFORNIA

STATE
GEOLOGICAL
SURVEY
OF
KANSAS

BULLETIN 170, PART 2

THE UNIVERSITY OF KANSAS
LAWRENCE, KANSAS - 1964

Generated at University of Kansas on 2023-10-04 19:30 GMT / https://hdl.handle.net/2027/uc1.b4034848
Public Domain in the United States, Google-digitized / http://www.hathitrust.org/access_use#pd-us-google

Digitized by Google

Original from
UNIVERSITY OF CALIFORNIA

STATE OF KANSAS .... John Anderson, Jr., Governor

BOARD OF REGENTS .... Henry A. Bubb, Chairman
William F. Danenbarger, Vice-Chairman

Whitley Austin	Ray Evans	Dwight D. Klinger
A. H. Cromb	Clement H. Hall	L. M. Morgan
		Clyde M. Reed, Jr.

Max Bickford, Executive Director

MINERAL INDUSTRIES COUNCIL

Howard Carey, Jr.	O. S. Fent	George K. Mackie, Jr.
Simeon S. Clarke	Bruce G. Gleissner	W. L. Stryker
Charles S. Cook	Dane Hansen	Robert F. Walters
Lee H. Cornell	Beatrice L. Jacquart	Benjamin O. Weaver

STATE GEOLOGICAL SURVEY OF KANSAS

W. Clarke Wescoe, M.D., Chancellor of The University and ex officio Director of the Survey

Frank C. Foley, Ph.D., State Geologist and Director

William W. Hambleton, Ph.D., Assoc. State Geologist and Assoc. Director

Raymond C. Moore, Ph.D., Sc.D., Principal Geologist Emeritus

John M. Jewett, Ph.D., Senior Geologist

Doris E. Nodine Zeller, Ph.D., Editor

Grace E. Muilenburg, B.S., Public Information Director

Kenneth J. Badger, Chief Draftsman

Lila M. Watkins, Secretary

Research Divisions	Division Head
Basic Geology	Daniel F. Merriam, Ph.D.
Petrography	Ada Swineford, Ph.D.
Geochemistry	Frederic R. Siegel, Ph.D.
Mineral Resources	Allison L. Hornbaker, M.S.
Oil and Gas	Edwin D. Goebel, M.S.
Ceramics	Norman Plummer, A.B.

Cooperative Studies with United States Geological Survey

Ground-Water Resources .... Robert J. Dingman, B.S., District Geologist
Mineral Fuels .... W. L. Adkison, B.S., geologist in charge

Branch Offices

Geological Survey Well Sample Library, 4150 Monroe, Wichita
Geological Survey Southwest Kansas Field Office, 310 N. 9th Street, Garden City

Generated at University of Kansas on 2023-10-04 19:30 GMT / https://hdl.handle.net/2027/uc1.b4034848
Public Domain in the United States, Google-digitized / http://www.hathitrust.org/access_use#pd-us-google

Digitized by Google
Original from
UNIVERSITY OF CALIFORNIA

BULLETIN 170, PART 2

Precambrian-Paleozoic Contact In Two Wells In Northwestern Kansas

By Robert W. Scott and
Marcus N. McElroy

Printed by authority of the State of Kansas
Distributed from Lawrence

UNIVERSITY OF KANSAS PUBLICATIONS
JULY 1964

Generated at University of Kansas on 2023-10-04 19:30 GMT / https://hdl.handle.net/2027/uc1.b4034848
Public Domain in the United States, Google-digitized / http://www.hathitrust.org/access_use#pd-us-google

Digitized by Google

Original from
UNIVERSITY OF CALIFORNIA

CONTENTS

TABLES

ILLUSTRATIONS

Generated at University of Kansas on 2023-10-04 19:30 GMT / https://hdl.handle.net/2027/uc1.b4034848
Public Domain in the United States, Google-digitized / http://www.hathitrust.org/access_use#pd-us-google

Digitized by Google

Original from
UNIVERSITY OF CALIFORNIA

ROBERT W. SCOTT
MARCUS N. McELROY

Precambrian-Paleozoic Contact In Two Wells In Northwestern Kansas

ABSTRACT

In two well cores from northwestern Kansas a basal Paleozoic sandstone, feldspathic in part, was found to be in sharp, unconformable contact with underlying Precambrian rocks. The source for part of the clastics of the basal Paleozoic sequence was nearby weathered Precambrian rocks. Altered Precambrian gneissic granite is penetrated in one well and Precambrian quartzo-feldspathic schist in the other well. Evidence is lacking to demonstrate a metamorphic rather than an igneous origin for the gneissic granite. The schist is of the almandine-amphibolite metamorphic facies. The potassium-argon ratio from the schist indicates an age of 1.24 billion years.

Résumé

Dans deux noyaux de sondages du nord-ouest du Kansas, on a trouvé un fondamental grès paléozoïque, feldspathiqu'en partie, en aigu contact discordant avec des subjacentes roches précambriennes. La source d'une partie des roches clastiques de la fondamentale série paléozoïque était des altérées roches précambriennes près de cet endroit. On a pénétré le gneissique granit altéré du Précambrien dans un sondage et du schiste du précambrien dans l'autre sondage. On manque l'évidence de démontrer une origine métamorphique plûtot qu'ignée du granit gneissique. Le schiste est du métamorphique facies almadine-amphibolite. Le rapport du potassium-argon du schiste indique un âge de 1.24 trillions d'ans.

Zusammenfassung

In zwei Bohrkernen aus dem nordwestlichen Kansas fand man einen teilweise feldspathaltigen Basalsandstein aus dem Paläozoikum in scharfem, diskordantem Kontakt mit Liegendgestein aus dem Präkambrium. Ein Teil der klastischen Sedimente der paläozoischen Basalschichtfolge stammte von nahe gelegenem, präkambrischem Gestein. Einer der Bokrkernen enthielt veränderten Gneisgranit, der anderer quarz- und feldspathaltigen Schiefer aus dem Präkambrium. Es fehlt jeder Beweis für die Annahme eines metamorphischen an Stelle eines ignischen Ursprungs des Gneisgranits. Der Schiefer ist eine metamorphische Almadin-Amphibdit Fazies. Das Kalium-Argon Verhältnis des Schiefers lässt auf ein Alter von 1.24 Billionen Jahren schliessen.

Resumen

En dos testigos de sondajes del noroeste de Kansas una arenisca basal del Paleozoico, feldspática en parte, fue hallada formando un contacto unconformable bien definido con las rocas del Precámbrico que estan debajo. La fuente de parte de los clásticos de la secuencia basal del Paleozoico fueron cercanas rocas desagregadas del Precámbrico. Granito gnéisico alterado del Precámbrico es penetrado en un pozo y esquisto cuarzo-feldespático del Precámbrico en el otro pozo. Evidencia para demostrar un origen metamórfico en lugar de un origen ígneo para el granito gnéisico es carente. El esquisto es de la facie metamófica almandina-anfibolita. Lo razón de potasio-argoń en el esquisto indica una edad de 1.24 billiones de años.

INTRODUCTION

The buried Precambrian-Paleozoic contact is difficult to identify in many places in Kansas. Because this contact is obscured, the term "granite wash" has been applied indiscriminately to differing rock types adjacent to the contact. Only two cores of the Precambrian-Paleozoic contact are available at the present time. Descriptions of the cores provide a basis for differentiation in drill samples of the detrital feldspathic sandstone and altered granitic rock in place. Thus, characteristics derived from these core descriptions make the interpretation of detrital feldspathic rock and of altered granitic rock less subjective and more consistent.

In most places a basal Paleozoic sandstone immediately overlies Precambrian rocks. This sandstone has been called variously "Reagan,"

Generated at University of Kansas on 2023-10-04 19:30 GMT / https://hdl.handle.net/2027/uc1.b4034848
Public Domain in the United States, Google-digitized / http://www.hathitrust.org/access_use#pd-us-google
Digitized by Google
Original from UNIVERSITY OF CALIFORNIA

"Lamotte," "Paleozoic basal sandstone," "Pennsylvanian basal sandstone," and "granite wash." Some of these "basal sandstones" are Cambrian in age and some are Pennsylvanian. In the two wells, the term "Paleozoic basal sandstone" is applied to the sandstone immediately overlying Precambrian rocks. The stratigraphic relationships of the basal sandstones are being studied by the junior author.

The wells in which the Precambrian-Paleozoic contact is cored are the Magnolia Petroleum Company No. 1 "B" Holsman (SE-NE-SE sec. 15, T 7 S, R 19 W) in Rooks County, on the northwestern part of the Central Kansas Uplift, and the Derby Oil Company No. 4 Schoen (C-SE sec. 35, T 3 S, R 24 W) in Norton County, on the Cambridge Arch (Fig. 1). Core from the Holsman well includes the interval from 3510 to 3538 feet and core from the Schoen well from 3762 to 3800 feet. The cores are 3.5 inches in diameter. In both wells sandy dolomite, presumably Bonneterre Dolomite of Late Cambrian age, overlies and grades downward into feldspathic sandstone. This sandstone unconformably overlies Precambrian crystalline rocks.

Walters (1946) and Keroher and Kirby (1948) touched upon the problem of the Precambrian-Paleozoic contact in Kansas. Adams

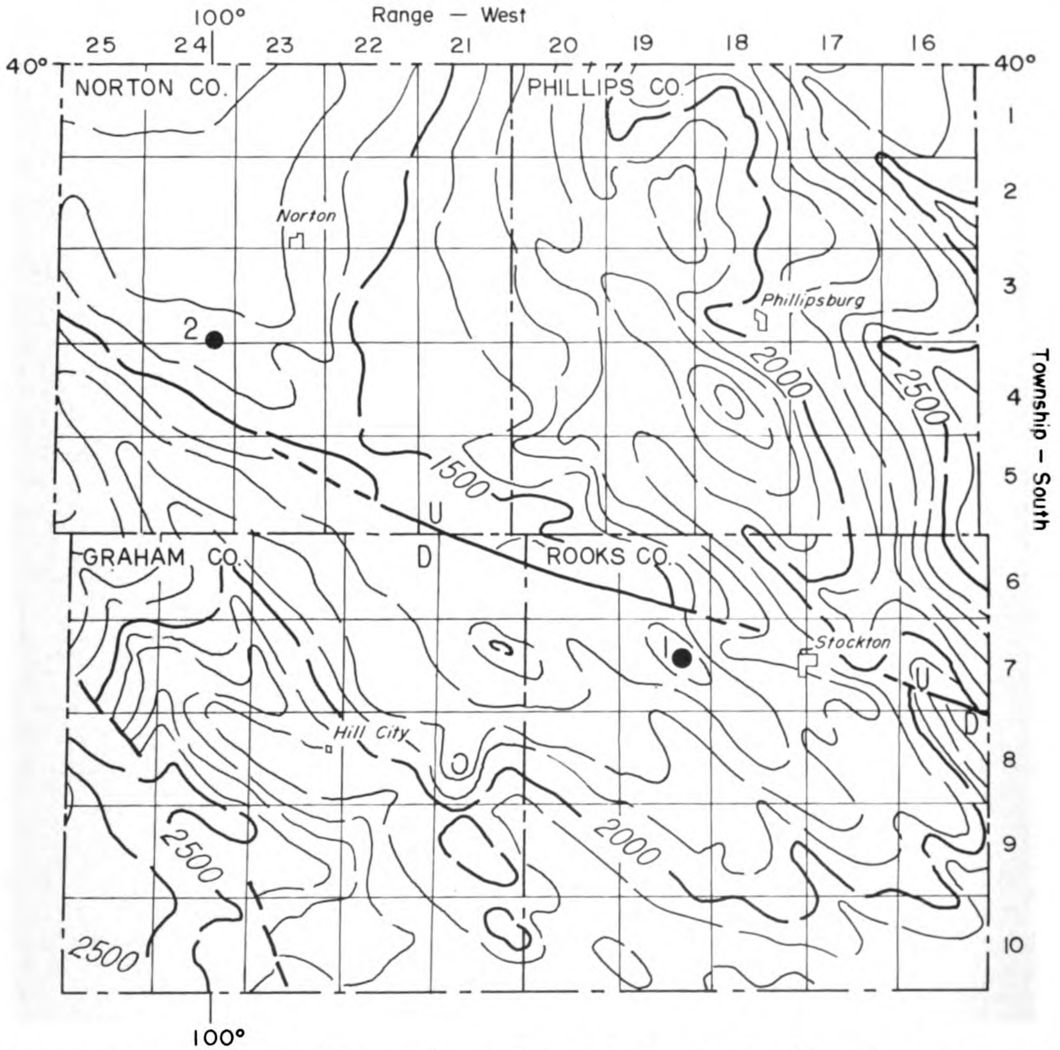


FIGURE 1.—Location of wells in which contact between "Paleozoic basal sandstone" and Precambrian crystalline rock is cored. *1*, Magnolia Petroleum Company No. 1 "B" Holsman; *2*, Derby Oil Company No. 4 Schoen. Datum is mean sea level; contour interval, 100 feet. (Configuration map of Precambrian surface adapted from Cole, 1962.)

(1959) and Ojakangas (1960) have discussed this problem in Missouri.

The Precambrian rocks were studied by Scott and the Paleozoic sandstones by McElroy. The Precambrian rocks were analyzed by means of core descriptions, thin-section studies, and x-ray powder diffraction techniques. The sandstones were studied by means of thin sections, x-ray diffraction, x-radiography, heavy mineral separation, sieve analysis, and binocular microscope observations. Size grades for the sedimentary rocks are based on the Wentworth scale. A glossary of some igneous-metamorphic rock terms is included in the report.

Acknowledgments

The study of Precambrian rocks in Kansas is supported by University of Kansas Research Project 3659-5038, directed by W. W. Hambleton. We thank Calvin Noah, of the University of Wichita Geology Department, who kindly permitted the use of the Schoen well core, and H. A. Ireland, of the University of Kansas, for constructive suggestions on the manuscript. Samples from the Holsman well core were obtained from the Kansas Geological Survey's sample library in Lawrence.

GLOSSARY

Almandine-amphibolite facies .... a mineral assemblage in metamorphic rocks characterized by various combinations of the following minerals: almandine garnet, staurolite, kyanite, sillimanite, calcic plagioclase, and hornblende; indicative of high-grade regional metamorphism (Fyfe, Turner, and Verhoogen, 1958).

Coarse-grained (igneous and metamorphic rocks) .... grain length is greater than 5 mm.

Fine-grained (igneous and metamorphic rocks) .... grain length is 1 mm and less.

Foliation .... "the (thicker) laminated structure resulting from segregation of different minerals into layers parallel to the schistosity." (American Geological Institute, 1957, p. 114)

Gneissic granite .... a rock composed of a granitic mineral assemblage that has a foliate or schistose fabric, no coarse banding recognizable.

Medium-grain (igneous and metamorphic rocks) .... grain length ranges from 1 to 5 mm.

Poikiloblastic .... a textural relationship in metamorphic rocks in which small mineral grains are enclosed by a larger grain of another mineral.

Porphyroblastic .... a textural relationship in metamorphic rocks in which larger mineral grains are set in a finer-grained matrix.

Ptygmatic folds .... folds developed in granitic and pegmatitic veins in metamorphic rocks.

Schistosity .... a planar rock fabric imparted by subparallel alignment of platy mineral grains.

MAGNOLIA PETROLEUM COMPANY NO. 1 "B" HOLSMAN WELL

"Paleozoic Basal Sandstone"

The basal sandstone is 24 feet thick in the Holsman well and includes the interval from 3513 to 3537 feet (Fig. 3). The contact with the underlying Precambrian rock is sharp and distinct (Fig. 2, *A*), whereas the contact with the overlying Arbuckle Group (Bonneterre) is gradational. The basal sandstone grades upward into a dolomitic sandstone and to a sandy dolomite and, above the described interval, into dolomite. Only the lower 3 feet of the Arbuckle Group is included in the core. More than 90 percent of the basal sandstone is quartzose sandstone; the remainder of the core is feldspathic sandstone and arkose. The rock is white to gray, buff, pink, or red, depending upon the amount of feldspar and nature and amount of cementing material.

Quartz is the predominant mineral present in the core; potassium feldspar, muscovite, biotite, and illite occur as accessory minerals. Heavy minerals, identified by petrographic examinations, include hornblende, tourmaline, ziron, magnetite, and garnet.

Grain size of the basal sandstone ranges from fine to very coarse, with scattered granules and pebbles of quartz and feldspar. The larger quartz grains are rounded and frosted and contain inclusions of magnetite, garnet, and potassium feldspar. Many of the smaller grains are angular to subangular and have clear surfaces resulting from secondary quartz overgrowths.

Sorting of the basal sandstone ranges from good to poor with the least degree of sorting in the coarse layers. Thickness of bedding ranges from laminae to thin beds. The irregular to contorted illite laminae can be seen on Figure 2, *B*. Graded bedding is present, but no orderly repetition of graded bedding was observed (Fig. 2, *A*). The coarse layers of graded bedding generally contain grains of quartz and microcline 2 to 5 mm in diameter. Variations in the nature, amount, and kind of cementation produce an apparent "bedding" in some parts of the core.

The cement is dolomitic, calcareous, siliceous, sideritic, limonitic, or illitic, and there is no uniformity with respect to the type and amount of cement in the sandstone. Dolomite, however, does occur throughout the interval. The amount of dolomite increases upward to such an extent that in the upper few feet of the

Generated at University of Kansas on 2023-10-04 19:30 GMT / https://hdl.handle.net/2027/uc1.b4034848
Public Domain in the United States, Google-digitized / http://www.hathitrust.org/access_use#pd-us-google
Digitized by Google
Original from UNIVERSITY OF CALIFORNIA

sandstone it makes up approximately 50 percent of the rock. Secondary silica is present as an intergranular cement and as quartz overgrowths. Calcite is present in local areas both as an intergranular cement and as fracture filling. Limonite is present in fractures and associated locally with siderite, which was identified by x-ray diffraction. In the interval from 3525 to 3526 feet the sandstone appears dark red as a result of ferruginous cement (Fig. 3). The green material, identified by x-ray diffraction as a 10-angstrom mineral of the illite type, forms a cement coating on the quartz grains and also occurs in laminae 1 to 5 mm thick.

Porosity ranges from 11 to 20 percent; permeability ranges from 3 to 65 millidarcys[1] (Fig. 3). Variations in porosity are primarily a result of the type and amount of cementing material and, to a lesser extent, of sorting and packing. The argillaceous material is not present in sufficient quantity to affect the porosity.

[1] Data on porosity and permeability, courtesy of J. P. Anderson, Mobil Oil Co., Wichita, Kansas.

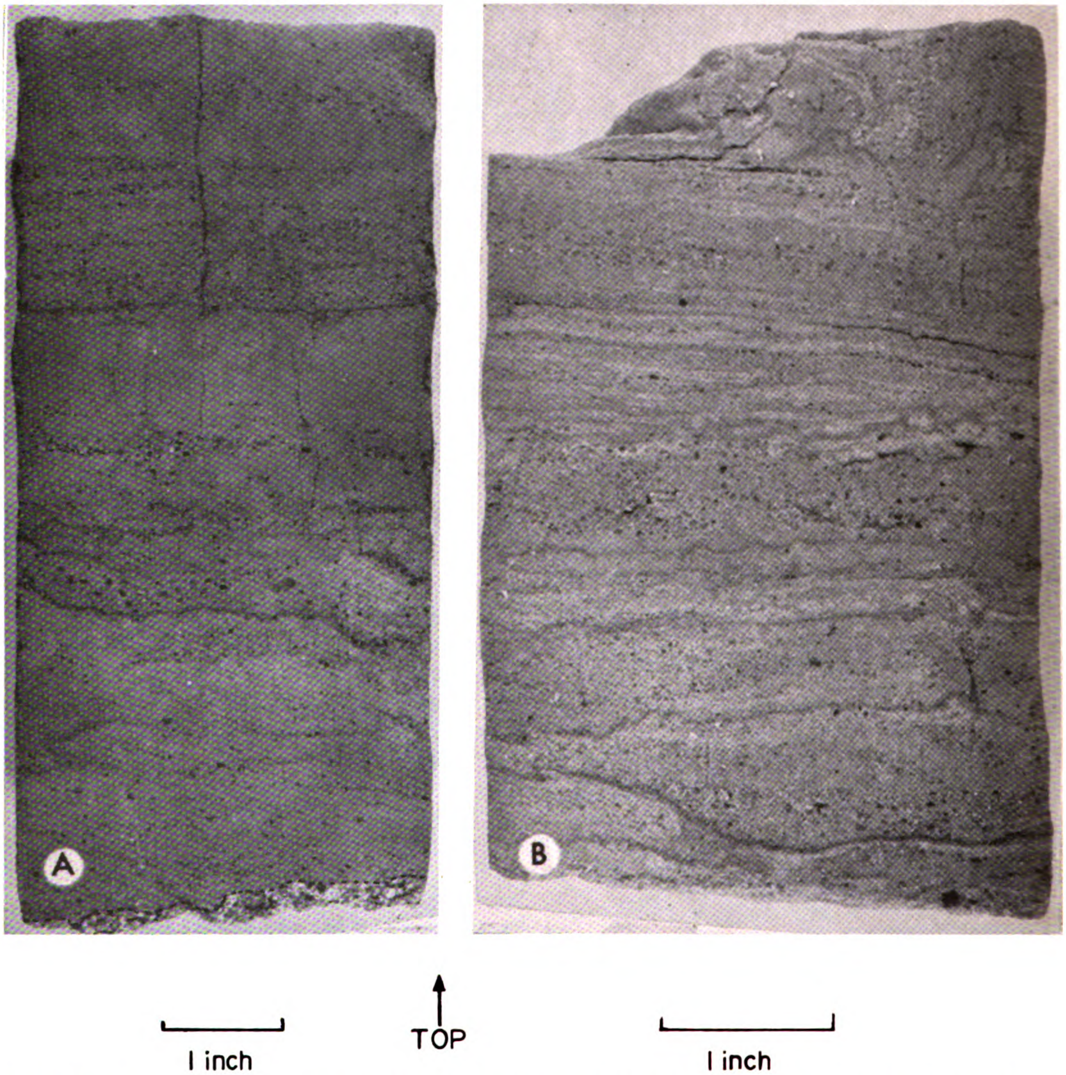


FIGURE 2.—Core from Holsman well: *A*, showing contact (dotted line) between Paleozoic sandstone and gneissic granite. Note grain size distribution and graded nature in upper part (depth 3536.3-3537 feet); *B*, showing size distribution of grains, illite laminae, and contorted nature of illite layers. Note coarse grains overlying concave illite layer in lowermost part of photograph (depth, 3534.6-3535 feet).

Generated at University of Kansas on 2023-10-04 19:30 GMT / https://hdl.handle.net/2027/uc1.b4034848
Public Domain in the United States, Google-digitized / http://www.hathitrust.org/access_use#pd-us-google
Digitized by Google
Original from
UNIVERSITY OF CALIFORNIA

TABLE 1.—Percentages and grain-size data for the Precambrian rocks. (Percentages for each thin section based on 200 point counts.)

Thin section no.	Quartz	Microcline	Plagioclase	Biotite	Accessories	Alteration products	Depth in feet
PC-120, Holsman Gneissic granite	32% 2.2-0.08 mm	38% 2.1-0.16 mm		6% 0.2-0.04 mm	6% (magnetite, hematite, leucoxene, muscovite)	18% (kaolin)	3538
PC-46-1, Schoen Schist	32% 1.0-0.04 mm	43% 1.2-0.1 mm		25% 1.0-0.1 mm	Trace of leucoxene	Trace of kaolin	3770
PC-46 Schist	33% 1.2-0.8 mm	49% 1.2-0.12 mm		18% 0.6-0.14 mm	Trace of magnetite, hematite	Trace of kaolin	3771-3775
PC-46a Schist	46% 5.0-0.16 mm	45% 2.0-0.04 mm		6% 0.5-0.3 mm	3% (muscovite, magnetite)	Trace of kaolin	3781-3782
PC-46b Schist	54% 1.6-0.08 mm	2% 0.4-0.08 mm	24% 1.7-0.2 mm	20% 0.7-0.3 mm	Trace of muscovite, sericite		3788-3789
Granitic lens	40% 7.3-0.2 mm	2% 1.2-0.08 mm	50% 7.8-0.4 mm	7% 0.8-0.1 mm	1% muscovite		
PC-46c Schist	45% 1.2-0.08 mm	14% 0.8-0.12 mm	16% 0.8-0.16 mm	24% 1.5-0.04 mm	1% (garnet, magnetite, leucoxene, zircon?)		3792-3794
PC-46d Schist	59% 1.2-0.04 mm	Trace 0.2-0.04 mm	14% 0.6-0.04 mm	27% 0.6-0.04 mm	Trace of muscovite, sericite, leucoxene		3798-3799
Granitic lens	25% 6.8-0.3 mm	16% 5.6-0.3 mm	58% 9.3-0.3 mm	1% 1.1-0.1 mm	Trace of muscovite, sericite, chlorite, leucoxene		

PRECAMBRIAN ROCKS

General Core Description. In the Holsman well core the contact between the feldspathic sandstone and gneissic granite is undulose and has about 5 mm of relief. The contact surface intersects the core axis at an angle of about 84 degrees. The fabric of the moderate orange-pink gneissic granite is an inequigranular, fine- to medium-grained, foliate mosaic of feldspar, quartz, biotite, and clay. The foliation, which is imparted by stringers and blebs of biotite up to 10 mm long and 2 mm thick, intersects the core axis at an angle of about 65 degrees. Feldspar occurs in the matrix and as porphyroblasts up to 5 mm long. Very light-gray clay occurs in irregular patches. Coarse, dusty-red iron-oxide mottles are locally up to 3 mm long. Borders between the iron-rich and iron-poor areas are gradational and irregular. An iron oxide-stained fracture surface dips about 78 degrees from the core axis and transects foliation. Three inches of granitic core were recovered, representing a penetration of 1 foot (Fig. 3).

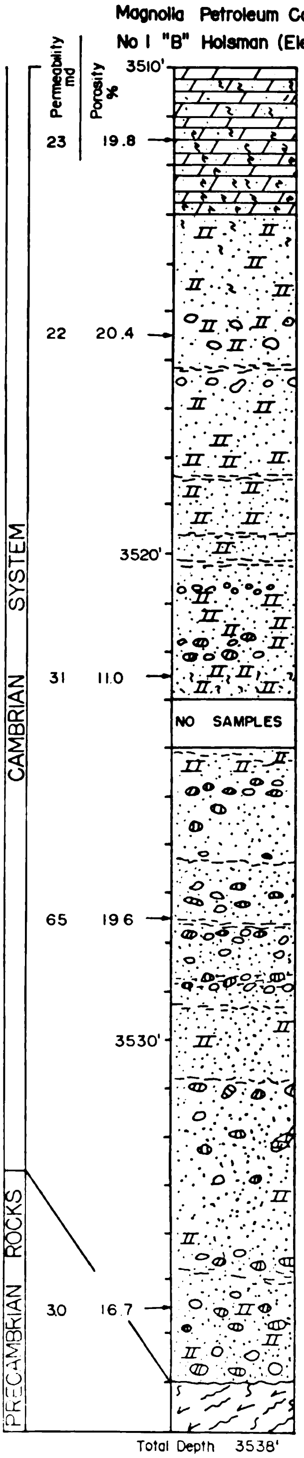
Petrographic Description. The mineralogy and fabric of the rock in thin section are the same as described above. Mineral percentages and grain sizes are presented in Table 1.

The unaltered feldspar is grid-twinned microcline that is ovoid to elongate and locally sericitized. The quartz has undulose extinction; some biotite "books" are bent, and biotite is commonly interlayered with chlorite. Magnetite, hematite, and leucoxene, occurring as disseminated grains or as mineral aggregates, form irregular, interstitial patches. Muscovite and zircon occur in trace amounts. Very fine-grained kaolin, identified by x-ray powder camera, forms irregular, interstitial masses intermixed with hematite. The kaolin probably is an alteration product of plagioclase.

Interpretation. Potassium-argon analyses on granite samples from the Holsman well are not yet completed. The gneissic granite is believed to be late Precambrian in age (about 1.2 billion years) because the rock is petrographically similar to other rocks of this age in Kansas that have been dated by J. L. Kulp (written comm., 1963).

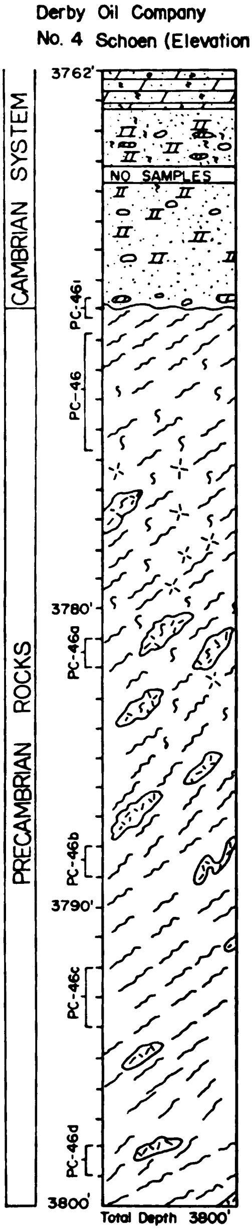
At least two origins are possible for the foliate gneissic granite in the Holsman well. The rock may represent a border phase of an intrusive body, with foliation caused by late-stage flowage within the partly crystallized magma; or the granite may be of metamorphic origin and the texture and fabric of the rock has resulted from recrystallization under stress. This kind of metamorphic rock could be derived either by metamorphism of an original granite or by metasomatism of an igneous or metamorphic rock.

Generated at University of Kansas on 2023-10-04 19:30 GMT / https://hdl.handle.net/2027/uc1.b4034848
Public Domain in the United States, Google-digitized / http://www.hathitrust.org/access_use#pd-us-google
Digitized by Google
Original from UNIVERSITY OF CALIFORNIA



3510-13	Dolomite, whitish-gray, medium-crystalline; sandy, glauconitic.
3513-15	Sandstone, white, fine- to medium-grained, angular to subangular, poorly sorted, dolomitic, quartzose, glauconitic.
3515-16	Sandstone, white, fine- to medium-grained, angular to subangular, moderately sorted, dolomitic, quartzose; scattered quartz pebbles and granules.
3516-18	Sandstone as above, slightly ferruginous; green illite layer at top 3-5 mm thick.
3518-18.4	Sandstone, white, fine-grained, angular to subangular, dolomitic, quartzose; scattered microcline and quartz overgrowths.
3518.4-19	Sandstone as above, very dolomitic; scattered illite.
3519-20.7	Sandstone, white, fine- to medium-grained, angular to subrounded, poorly sorted, dolomitic, quartzose; differential ferruginous staining (siderite); scattered illite layers 2-4 mm thick.
3520.7-22.4	Sandstone, white, fine- to medium-grained, angular to subrounded, moderately sorted, dolomitic, feldspathic; scattered quartz granules and angular microcline grains 2-3 mm long.
3522.4-23	Sandstone, white, fine- to medium-grained, subangular to subrounded, moderately sorted, dolomitic, quartzose; glauconite coatings on scattered quartz grains.
3524-24.4	Sandstone, white to gray, fine- to medium-grained, subangular to subrounded, dolomitic, quartzose; glauconite coating on some quartz grains.
3524.4-24.8	Sandstone as above; feldspathic.
3524.8-26.4	Sandstone, red, fine- to medium-grained, subangular to subrounded, moderately sorted, ferruginous (siderite), quartzose; scattered microcline grains and quartz pebbles; quartz overgrowths on smaller quartz grains.
3526.4-27.6	Sandstone, white, fine- to medium-grained, subangular to subrounded, calcareous, feldspathic; quartz pebbles; microcline grains with broken edges partly altered to kaolin; scattered illite bands 2-4 mm thick.
3527.6-28	Sandstone, white, medium- to coarse-grained, poorly sorted, feldspathic; abundant pyrite and quartz overgrowths.
3528-28.6	Sandstone, red, fine-grained, poorly sorted, calcareous, quartzose; some quartz grains 3-4 mm long.
3528.6-29	Sandstone, white, very fine-grained to very coarse-grained, angular to subangular, calcareous, feldspathic; illite matrix.
3529-33	Sandstone, white to pink, fine- to coarse-grained, subangular to subrounded, poorly sorted, siliceous, quartzose; some illite, minor amount of muscovite and weathered feldspar; calcite veins.
3533-34.1	Sandstone, white to buff, fine- to medium-grained, angular to subangular, moderately sorted, calcareous, quartzose; minor amount of feldspar.
3534.1-35.1	Sandstone, white to buff, fine- to medium-grained, subangular to subrounded, poorly sorted, quartzose; large grains are clear to frosted.
3535.1-35.7	Sandstone, light-gray, fine- to medium-grained, subangular to subrounded, poorly sorted, calcareous, quartzose with numerous quartz overgrowths.
3535.7-36.4	Sandstone, white to buff, fine- to coarse-grained, poorly sorted, subangular to rounded, porous, siliceous, quartzose; illite occurs in irregular, wavy bands; feldspar abundant.
3536.4-37	Sandstone, white to buff, fine- to coarse-grained, subangular to rounded, calcareous, quartzose; scattered grains of microcline and biotite flakes.
3537-38	Gneissic granite, moderately orange-pink to dusky-red, mottled very light gray; fine- to medium-grained, inequigranular, foliate mosaic of feldspar, quartz, biotite, clay, and hematite.

FIGURE 3.—Basal Arbuckle Group (3510-3513 feet), basal Paleozoic sandstone (3513-3537 feet), and Precambrian gneissic granite (3537-3538 feet) from Magnolia No. 1 "B" Holsman well, SE-NE-SE sec. 15, T 7 S, R 19 W, Rooks County, Kansas (see Fig. 3 for explanation).



3762-63.2	Dolomite, gray to buff, medium-crystalline, porous; sandy, oil stained; abundant glauconite.
3763.2-63.5	Dolomite as above; sand more abundant.
3763.5-65.3	Sandstone, buff, fine-grained to very coarse-grained, angular to subangular, moderately sorted, dolomitic, quartzose; porous, abundant glauconite, minor amounts of muscovite, biotite, and potassium feldspar (oil stain occurs in most sandy parts).
3765.8-66.2	Sandstone, tan, very fine-grained to fine-grained, angular to subangular, poorly sorted, dolomitic, siliceous, quartzose; glauconite, biotite, and minor amounts of pyrite.
3766.2-68	Sandstone, green, fine-grained to very coarse-grained, angular to subrounded, poorly sorted, hard, dolomitic; glauconitic; scattered quartz pebbles up to 5 mm long.
3768-70	Arkose, gray to pink, fine- to coarse-grained, angular to subrounded, poorly sorted, hard, dolomitic; abundant biotite, quartz; some feldspar pebbles longer than 5 mm; glauconite absent.
3770-74	Schist, medium dark-gray, streaked light gray, fine-grained, nearly equigranular; quartz-feldspar matrix with biotite laminae 1-3 mm thick, discontinuous, and locally wavy.
3774-76	Schist as above; feldspar partly argillized; rock fractures parallel schistosity; fractures coated with pyrite and green, glauconitic clay.
3776-80	Schist as above; intercalated with lenses (5-25 mm thick) of pinkish-gray porphyroblastic feldspar in quartz groundmass, granitic lenses of medium- to coarse-grained feldspar and quartz, both paralleling schistosity; biotite laminae commonly concentrated along contact with granitic lenses.
3780-85	Schist, very light-gray to yellowish-gray, streaked dark-gray by biotite lenses; porphyroblasts of highly argillized feldspar in medium-grained groundmass of quartz; lenses of altered, light-gray, medium- to coarse-grained feldspar and quartz intercalated with fine-grained schist; locally, schistosity nearly parallel to core axis; degree of alteration decreases from 3783 to 3785 feet; potassium-argon age of 1.10 billion years from a granitic lens at 3783 feet.
3785-91	Schist, dark-gray, mottled light-gray, fine-grained, nearly equigranular; schistosity imparted by unaltered elongate quartz and biotite grains; granitic lenses with moderate-orange-red, medium- to coarse-grained feldspar and quartz paralleling schistosity make up 15-20 percent of core samples; ptygmatic folds developed in some granitic lenses; fractures coated with "dead" oil, pyrite, calcite, and glauconitic clay.
3791-96	Schist as above; garnetiferous; granitic lenses make up 1-5 percent of core samples.
3796-3800	Schist as above; granitic lenses make up 5-10 percent of core samples; potassium-argon age of 1.24 billion years from schist at 3799 feet.

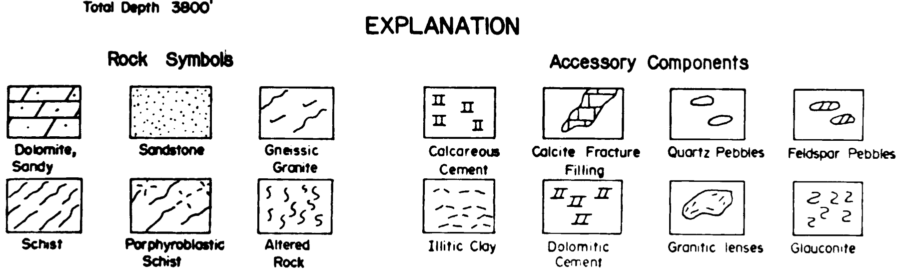


FIGURE 4.—Basal Arbuckle Group (3762-3763 feet), basal Paleozoic sandstone (3763-3770 feet), and Precambrian schist (3770-3800 feet) from Derby No. 4 Schoen well, C-SE sec. 35, T 3 S, R 24 W, Norton County, Kansas. (Thin section numbers are indicated along left margin of lithologic column.)

Generated at University of Kansas on 2023-10-04 19:30 GMT / https://hdl.handle.net/2027/uc1.b4034848
Public Domain in the United States, Google-digitized / http://www.hathitrust.org/access_use#pd-us-google
Digitized by Google
Original from UNIVERSITY OF CALIFORNIA

Following metamorphism or intrusion, the rock was weathered and eroded. Kaolin has partially replaced feldspar, hematite has partly replaced magnetite, and additional hematite has been introduced into fractures and along grain boundaries. This added iron oxide is concentrated in zones within the rock but does not completely permeate it.

DERBY OIL COMPANY NO. 4 SCHOEN WELL

"Paleozoic Basal Sandstone"

Eight feet of Paleozoic basal sandstone was cored in the Schoen well (3762-3770 feet) (Fig. 4). The sandstone-schist interval in this well differs from the sandstone-gneissic granite interval in the Holsman well in the following ways: type of Precambrian rock present; thickness of sandstone; percentage of dolomite, biotite, and pyrite; nature and amount of glauconitic material; and character of sandstone-Arbuckle contact. The sandstone is lithologically similar to the uppermost part of the basal sandstone in the Holsman well and may possibly be stratigraphically equivalent to it. Composition of the Paleozoic sandstone ranges from a quartzose sandstone, to an arkose, to a quartz-glauconite sandstone. The color of the sandstone is gray, buff, or green, depending upon the type of cement present.

Quartz and feldspar are the predominant minerals in the core; biotite and pyrite are accessory minerals. Glauconite is abundant throughout the interval and at 3766 feet comprises approximately 40 percent of the rock. Heavy minerals, identified by petrographic examination, include garnet, zircon, and hornblende.

Grain size of the basal sandstone ranges from fine to very coarse sand with scattered granules and pebbles of quartz and feldspar. Many of the larger quartz pebbles contain inclusions of garnet, magnetite, and potassium feldspar. Most of the quartz grains larger than medium sand size (greater than 0.5 mm) are subrounded to well rounded and the smaller grains have quartz overgrowths.

Sorting is poor throughout the sandstone. Distinct bedding is absent in most of the rock, but locally, graded bedding can be observed. Variations in the kind and amount of cementing material produce an apparent layering in some parts of the core.

Cementing minerals are calcite, dolomite, glauconite, and minor amounts of illite. Cementation has been selective and seems to be related to the original sediment porosity derived from the various degrees of sorting and packing. Glauconite occurs as a grain coating and as semi-spheroidal and free-form shapes, which range in size from 0.125 to 0.250 mm. X-ray diffraction patterns indicate that this glauconite is similar in structure to the well-ordered type described by Burst (1958, p. 312) in the Franconia Formation (Cambrian) of Wisconsin.

Porosity is highly variable and is related to cementation and sorting. Overall, porosity and permeability are low.

Nearby Precambrian rocks served as one of the sources for the sandstone in the two wells, as evidenced by both angular and rounded quartz and feldspar grains scattered throughout the sandstone. Extensive abrasion would not be required to alter the somewhat ovoid nature of quartz in the underlying schist in order to produce the angular to rounded pebbles that occur in the overlying sandstone.

Contact Between Precambrian and Paleozoic Rocks In The Derby Well

Megascopically, the friable, pale yellow-brown arkose is readily distinguishable from the indurated, medium-gray schist (Fig. 5, *A*). The sharp, irregular contact between the arkose and the schist has about 5 mm of relief, and the surface intersects the core axis at an angle of 85 degrees. In thin section (Fig. 5, *B*), the contact does not appear sharp because the quartz and feldspar grains in both rock types immediately adjacent to the contact are ovoid and of about the same size. However, there are several changes at the contact: (1) the fabric of the arkose is characterized by poor sorting of grains and by biotite parallel to the bedding, whereas the schist contains a metamorphic fabric dominated by subparallel biotite "books" that dip about 30 degrees from the core axis; (2) the arkose contains more quartz than feldspar and a small amount of biotite, but the schist has nearly equal amounts of quartz and feldspar and a large amount of biotite; and (3) there is an abrupt change in grain size locally at the contact, with the arkose having the smaller grain size. Local relief between adjacent grains in the schist forms irregularities at the contact.

Precambrian Rocks

General Core Description. The sequence of Precambrian rocks (Fig. 4) penetrated from the contact downward is (1) a slightly altered microcline schist, 3770-3780 feet; (2) a highly

Generated at University of Kansas on 2023-10-04 19:30 GMT / https://hdl.handle.net/2027/uc1.b4034848
Public Domain in the United States, Google-digitized / http://www.hathitrust.org/access_use#pd-us-google
Digitized by Google
Original from UNIVERSITY OF CALIFORNIA

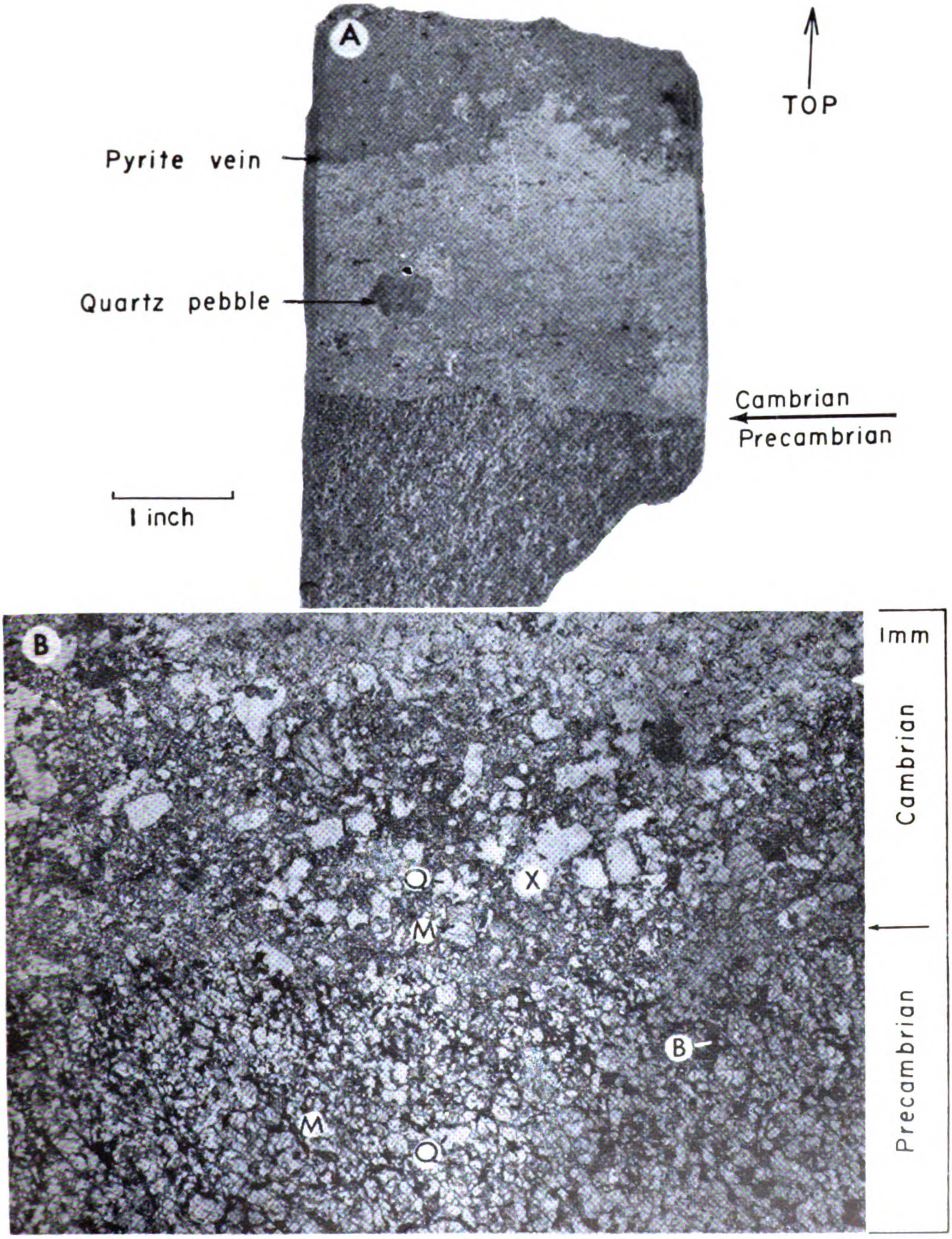


FIGURE 5.—Core from Schoen well: *A*, showing contact at 3770 feet (arrow) between Paleozoic arkose and Precambrian schist. Note quartz pebbles, lighter-colored band of calcareous cement, dark specks of biotite, and pyrite vein above calcareous band in arkose and steeply dipping schistosity in Precambrian rock; *B*, photomicrograph of thin section PC-46-1 of Precambrian-Paleozoic contact (arrow), ×4, plain light. B, biotite, M, microcline, Q, quartz, X, points where thin section has broken away.

Generated at University of Kansas on 2023-10-04 19:30 GMT / https://hdl.handle.net/2027/uc1.b4034848
Public Domain in the United States, Google-digitized / http://www.hathitrust.org/access_use#pd-us-google
Digitized by Google
Original from UNIVERSITY OF CALIFORNIA

altered porphyroblastic schist with granitic lenses, 3780-3784 feet; and (3) an unaltered plagioclase schist with granitic lenses, 3784-3800 feet.

The somewhat friable microcline schist (Fig. 5, *A*) is medium-gray, equigranular, and fine grained; the intensity of alteration increases with depth. Schistosity is imparted by thin, discontinuous, alternating laminae of biotite-quartz and of feldspar, and intersects the core axis at an angle of 30 degrees. The underlying very friable, highly altered, porphyroblastic schist is light gray, mottled very light gray, fine to medium grained, and moderately schistose. The underlying plagioclase schist is dark gray to medium dark gray streaked by gray-black biotite. The rock is equigranular, fine grained, unaltered, and well indurated. Schistosity intersects the core axis at about 10-20 degrees. The schist contains granitic lenses of moderate orange-red to pink-gray, medium- to coarse-grained feldspar and quartz. The lenses, which are 1.0-4.2 mm thick, parallel schistosity. Locally, ptygmatic folding is developed. The contacts between the schist and the granitic lenses are irregular and sharp, although laminae of biotite extend into the lenses. The conformable granitic lenses make up 5-20 percent of the core samples below 3776 feet.

Fracture planes, which in part parallel schistosity, commonly intersect the core axis at an angle of about 30 degrees. Fractures are partially coated with pyrite, calcite, "dead" oil, and a dark green-gray film of glauconitic clay (interpreted from x-ray powder diffraction). This glauconitic clay is similar to the glauconitic clay in the sandstone. Locally, fractures are speckled with pink-gray feldspar? grains about 1 mm long. The aggregate length of the core fragments is about 19 feet, and there are samples from each of the 30 feet of penetrated Precambrian rock. Spontaneous-potential, laterolog, and gamma-ray logs were recorded in the Schoen well, and the highs and lows of the curves clearly differentiate the lithologies (Fig. 6).

Petrographic Description. The thin sections, made of samples from specific depths, are listed in Table 1, together with mineral percentages and grain-size data derived from the sections.

Thin sections PC-46-1 (Fig. 5, *B*) and PC-46 (Table 1) are similar in fabric and mineralogy. The fine-grained microcline schist has a fabric marked by subparallel mica "books" and is composed mainly of feldspar, quartz, and biotite. Grid-twinned microcline commonly is enclosed by cloudy feldspar overgrowths. Kaolin (interpreted from powder-camera data) and altered feldspar form local interstitial patches. The quartz has undulose extinction and includes rare zircon grains; biotite commonly is bent around other mineral grains.

Thin section PC-46a (Fig. 7, *A*), a porphyroblastic schist, is medium to fine grained, inequigranular and composed of feldspar, quartz, biotite, and clay. Schistosity is imparted by elongate quartz with undulose extinction and biotite. Each feldspar porphyroblast is composed of several grains of altered microcline and masses of clay after feldspar, which take on the stain for potash feldspar presumably because of remnant potassium oxide. Relict patches of unaltered microcline with grid-twinning are included in the altered masses.

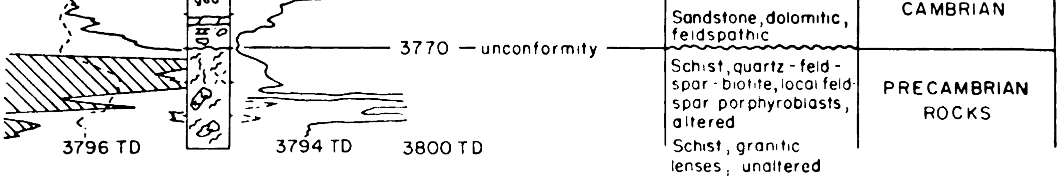


FIGURE 6.—Correlation of mechanical logs and lithology in Derby No. 4 Schoen well. Interval from 3740 to 3762 feet interpreted by means of mechanical logs; low laterolog curve indicates feldspathic sandstone; high "kick" on gamma-ray curve indicates top of Precambrian rocks; high "kick" on laterolog curve indicates unaltered Precambrian rocks. (Solid line is gamma-ray curve.)

Generated at University of Kansas on 2023-10-04 19:30 GMT / https://hdl.handle.net/2027/uc1.b4034848
Public Domain in the United States, Google-digitized / http://www.hathitrust.org/access_use#pd-us-google
Digitized by Google
Original from UNIVERSITY OF CALIFORNIA

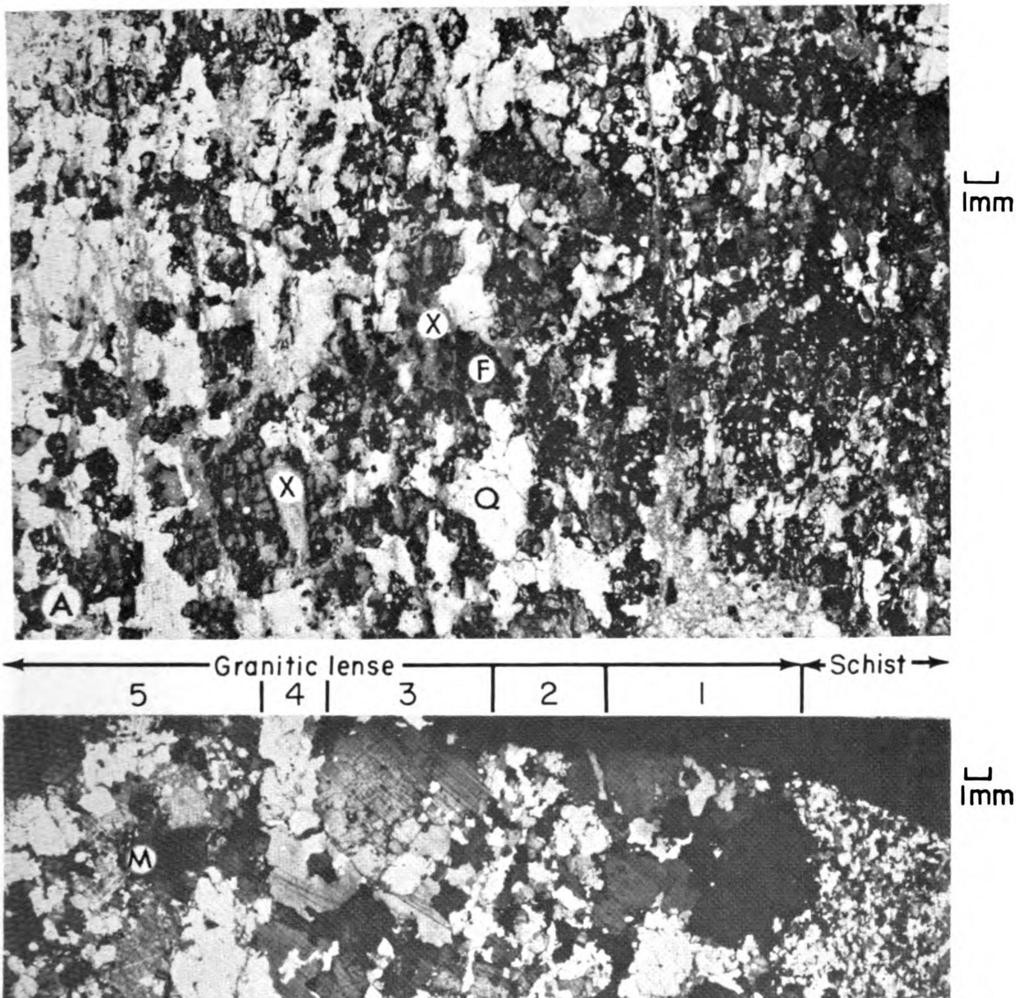


Figure 7.—Photomicrographs of thin sections: ***A***, PC-46a, porphyroblastic schist, section cut normal to schistosity, which dips 10-30 degrees from core axis, ×4.3, plain light. F, feldspar, Q, quartz, X, points where thin section has broken away. ***B***, PC-46d, plagioclase schist in contact with granitic lens. Note foliation in lens; layer numbers correspond to text description; section cut normal to schistosity, which dips about 30 degrees from core axis. B, biotite, M, microcline, P, plagioclase, Q, quartz, ×3.2, crossed nicols.

Generated at University of Kansas on 2023-10-04 19:30 GMT / https://hdl.handle.net/2027/uc1.b4034848
Public Domain in the United States, Google-digitized / http://www.hathitrust.org/access_use#pd-us-google
Digitized by Google
Original from
UNIVERSITY OF CALIFORNIA

Thin sections PC-46b and PC-46d (Fig. 7, *B*) contain plagioclase schist in contact with granitic lenses, and section PC-46c (Table 1) is schist only. The schist is fine grained and equigranular, with a fabric dominated by subparallel mica "books." Plagioclase, quartz, and biotite are the dominant minerals. Garnet, which is anhedral and pale pink (almandine?), is present in section PC-46c. The granitic lenses are composed of a mosaic of coarse- to medium-grained, inequigranular plagioclase, microcline, and quartz. Foliation is developed in the lens in section PC-46d (Fig. 7, *B*) by a sequence of layers differing in grain size and composition. From the schist contact into the lens the layers are: (1) medium- to coarse-grained quartz, feldspar, and biotite; (2) fine-grained quartz, feldspar, and mica; (3) medium- to coarse-grained quartz and feldspar; (4) predominantly medium-grained quartz, and (5) fine- to medium-grained quartz and feldspar. The contact between schist and granite is marked by a nearly continuous lamina of biotite "books" that are warped by larger grains projecting from the lens into the schist. Locally along the contact, grain size increases gradually from the schist into the lens. No intrusive or thermal metamorphic effects are apparent.

In the three thin sections, PC-46b, PC-46c, and PC-46d (Table 1), plagioclase, locally sericitic, is oligoclase (An 18-23, Michel-Levy method) in both the schist and the lenses. Albite, pericline, and Carlsbad-albite twinning are common, and locally the twins are bent, as are some biotite grains. Antiperthites are common and contain patch-shaped microcline. Microcline occurs interstitially with other mineral grains. In section PC-46d, a few quartz grains in the granitic lens have sutured margins, and some grains contain poikiloblasts of plagioclase or biotite. Chlorite is interlayered with biotite and occurs as discrete grains within the lenses.

Interpretation. Two potassium-argon analyses on biotite by J. L. Kulp (written communication, 1963) indicate that the schist has been affected by regional metamorphism of late Precambrian age. A sample of an altered granitic lens at 3783 feet was dated as 1.10 billion years, and a sample of plogioclase schist at 3799 feet as 1.24 billion years. The age variance is interpreted by us to be due to the difference in degree of alteration of the two samples.

This schist probably originated from quartzo-feldspathic sedimentary rocks. Mineralogical and textural variations among the three main types of schist (microcline schist, porphyroblastic schist, and plagioclase schist) seem to be gradational and may in part represent original variations in the parent rocks. The rocks were deformed and metamorphosed, possibly in the same orogenic event. The schist seems to be of the almandine-amphibolite facies, which indicates high-grade regional metamorphism.

The conformable granitic lenses could have originated in several ways. Emplacement as pegmatitic veins seems difficult to reconcile with petrographic evidence, unless the veins were subsequently metamorphosed with the host rock. Localized areas of fusion after metamorphism could have produced the lenses; however, because these rocks lack evidence of several stages of high-grade metamorphism, the most likely process seems to be localized partial fusion during metamorphism of the schist, perhaps associated with limited metasomatism.

Some time after regional metamorphism the rocks were weathered. Permeability in the coarser grained porphyroblastic schist may have been greater, allowing more intense alteration. Then, during deposition of the overlying sediments, pyrite, calcite, and glauconitic clay were deposited in fractures.

CONCLUSIONS

Comparison of the Precambrian-Paleozoic Contact in Core and Drill Samples. The contact between the overlying sandstone and the underlying altered igneous or metamorphic rock is readily identifiable in the two described cores. From well cuttings alone, however, the contact would have been difficult to interpret, and the interval including the contact might have been described as "granite wash." The two cores furnish characteristics that enable distinction of feldspathic sandstone from altered Precambrian rock in cuttings.

Cutting samples were not available from the Holsman well, but descriptions of the cores provide some characteristics to distinguish cuttings of feldspathic sandstone from cuttings of altered gneissic granite. Utilizing our experience in logging several hundred Precambrian wells we can infer the type of cuttings to be expected from rocks penetrated in the Holsman well. The description of the hypothetical cuttings from the interval of 3524 to 3538 feet is as follows:

> *feldspathic sandstone*—single mineral grains and equant rock fragments up to 5 mm long, angular to subrounded; frosted quartz abundant, local over-

Generated at University of Kansas on 2023-10-04 19:30 GMT / https://hdl.handle.net/2027/uc1.b4034848
Public Domain in the United States, Google-digitized / http://www.hathitrust.org/access_use#pd-us-google
Digitized by Google
Original from UNIVERSITY OF CALIFORNIA

growths; dull feldspar, few grains, locally partly argillized; green-gray illitic clay.

gneissic granite—elongate to equant rock fragments and few single mineral grains up to 7 mm long, angular to subangular; feldspar abundant, vitretous to dull luster, locally intergrown with very light gray clay; vitreous quartz; biotite flakes; the 3 minerals generally intergrown, forming rock fragments.

In wells adjacent to the Schoen well, which also penetrate schist, the cuttings are described as follows :

feldspathic sandstone—single mineral grains and equant rock fragments up to 2 mm long, subangular to subrounded; frosted quartz; a small amount of dull, frosted feldspar and biotite.

schist—elongate to equant rock fragments and a few single mineral grains up to 5 mm long, angular to subangular; abundant vitreous feldspar; translucent quartz; biotite flakes common; very light-gray to gray-pink clay, which is speckled dark gray.

In most wells these characteristics are sufficient to distinguish feldspathic sandstone or arkose from altered granitic rocks. Thus, the ambiguous term, "granite wash," can be replaced by the name of an actual rock type. Identification of actual rock type is important and fundamental to studies of basal Paleozoic stratigraphy, Precambrian rock-type distribution, and the influence of Precambrian rocks on Phanerozoic structures, many of which are petroleum reservoirs.

REFERENCES

Adams, J. W., 1959, Rocks of the Precambrian basement and those immediately overlying it in Missouri and parts of adjacent states: unpubl. Master's thesis, Univ. Missouri, 342 p.

American Geological Institute, 1957, Glossary of Geology and Related Sciences: Natl. Research Council Pub. 501, 325 p.

Burst, J. F., 1958, "Glauconite" pellets; their mineral nature and applications to stratigraphic interpretations: Am. Assoc. Petroleum Geologists Bull., v. 42, no. 2, p. 310-327.

Cole, V. B., 1962, Configuration of top of Precambrian basement rocks in Kansas: Kansas Geol. Survey Oil and Gas Invest. No. 26, map.

Fyfe, W. S., Turner, F. J., and Verhoogen, Jean, 1958, Metamorphic reactions and metamorphic facies: Geol. Soc. America Memoir 73, 259 p.

Kerohfr, R. P., and Kirby, J. J., 1948, Upper Cambrian and Lower Ordovician rocks in Kansas: Kansas Geol. Survey Bull. 72, 140 p.

Ojakangas, R. W., 1960, The stratigraphy and petrology of the Lamotte Formation in Missouri: Unpubl. Master's thesis, Univ. Missouri, 271 p.

Walters, R. F., 1946, Buried Precambrian hills in northeastern Barton County, central Kansas: Am. Assoc. Petroleum Geologists Bull., v. 30, no. 5, p. 660-710.

Generated at University of Kansas on 2023-10-04 19:30 GMT / https://hdl.handle.net/2027/uc1.b4034848
Public Domain in the United States, Google-digitized / http://www.hathitrust.org/access_use#pd-us-google

Digitized by Google
Original from
UNIVERSITY OF CALIFORNIA