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Mineralogical analyses of drill core samples from Midlands Gas Corporation wells-- Federal 0370 No. 1 and Federal 2962 No. 1, Phillips County, Montana

TM
Twenhofel

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This report is preliminary and has not been edited or reviewed for conformity with U.S. Geological Survey standards and nomenclature.

Introduction

This report records the mineralogy of core samples from two wells in Phillips County, Montana. These wells are located in the Bowdoin gas field in north-central Montana. The gas is produced from low-permeability reservoirs at shallow depths (less than 610 m) over an area of 1554 km^2.

This information is being released to aid in improving recovery technology and well log interpretation. We acknowledge the financial support of the Department of Energy Tight Gas Sands program.

Stratigraphy

For each well, the depths of the tops of the various geologic units, all of which are of Late Cretaceous age, are given below:

Unit	Depth below Kelly bushing (in meters) Federal well 0370	Federal well 2962
Gammon Shale	257.7	172.3
Niobrara Formation	427.0	367.5
Carlile Shale	515.5	424.0
Greenhorn Formation	576.5	503.3

Table 1.--Locations and descriptions of the samples

[To convert feet to meters, multiply by 0.3048.

FNL, from north line; FWL, from west line.]

Midlands Gas Corporation Federal 0370 No. 1 well, Phillips County, Montana

Sample no.	Depth (in feet)	Description
1,715 ft FNL, 1,560 ft FWL, sec. 3, T. 37 N., R. 30 E.		
1	1,902	Calcareous shale with silt, petroliferous odor.
2	1,840.5	Shale.
3	1,840.5	Shale.
4	1,772	Shale.
5	1,761	Shale.
6	1,757	Shale with silt laminations.
7	1,755	Shale with silt laminations.
8	1,753	Shale.
9	1,752	Shale with minute silt laminations.
10	1,751	As above.
11	1,750	As above.
12	1,749	As above.
13	1,748	Shale with silt lenses.
14	1,747	As above.
15	1,746	Shale with silt laminations.
16	1,745	As above.
17	1,741	As above.
18	1,739	As above.
19	1,708	Shale.
20	1,475	Shale with silt laminations.
21	1,445	Shale with calcareous white specks.
22	1,399	As above.
23	847	Shale with shell fragments, mud clasts.
24	846	As above.

Midlands Gas Corporation Federal 2962 No. 1 well, Phillips County, Montana

Sample no.	Depth (in feet)	Description
1,560 ft FNL, 1,910 ft FWL, sec. 29, T. 36 N., R. 32 E.		
1	1,674	Shale with silt laminations.
2	1,652	Calcareous shale with carbonate parting.
3	1,651	Calcareous shale with carbonate parting.
4	1,533	Shale with silt laminations and burrows (sandstone filled)
5	1,498	No recovery.
6	1,493	Silty shale.
7	1,481	Shale with silt laminations.
8	1,480	As above.
9	1,479	As above.
10	1,478	No recovery.
11	1,477	No recovery.
12	1,476	Shale with minute silt laminations.
13	1,475	No recovery.
14	1,474	Shale with minute silt laminations.
15	1,473	Shale with silt laminations.
16	1,446	Shale.
17	1,436	Shale.
18	1,426	Shale with minute silt laminations.
19	1,419	Shale.
20	1,406	Shale.
21	1,189	Shale with calcareous white specks and shell.
22	717	Shale with dispersed silt.
23	580	As above.
24	573	As above.

Portions of each sample were taken for determination of water content and X-ray examination of the total sample. Other portions of the samples were taken for size fractionation and X-ray examination of those fractions. The portions taken for fractionation were treated with hydrogen peroxide to remove organic materials. These were then wet sieved to remove the sand fraction, and the clay and silt were separated by centrifugation. The particle size distribution is as follows:

Midlands Gas Corporation Federal 0370 No. 1 well

Sample no.	Depth (in feet)	Sand (<62μm)	Silt (2-62μm)	Clay (<2μm)	Sum
1	1,902	43.1	43.1	7.5	93.7
2	1,840.5	0.2	48.5	49.5	98.2
3	1,840.5	0.1	47.6	49.5	97.2
4	1,772	0.2	65.6	31.7	97.5
5	1,761	0.2	67.7	30.0	97.2
6	1,757	2.3	66.3	27.8	96.4
7	1,755	0.3	60.5	35.7	96.5
8	1,753	1.4	73.0	11.0	85.4 (boiled over with H_2O_2)
9	1,752	3.0	54.9	36.9	94.8
10	1,751	3.1	55.7	37.0	95.8
11	1,750	5.8	51.6	38.0	95.4
12	1,749	5.2	55.4	36.9	97.5
13	1,748	4.5	56.8	33.2	94.5
14	1,747	1.4	55.3	39.4	96.1
15	1,746	2.5	59.7	33.9	96.1
16	1,745	3.8	58.0	32.5	94.4
17	1,741	2.2	64.9	28.3	95.4
18	1,739	4.1	60.3	30.4	94.8
19	1,708	1.9	49.1	45.1	96.1
20	1,475	1.3	63.6	30.1	95.0
21	1,445	3.9	49.3	37.1	90.3
22	1,399	5.5	54.5	35.0	95.0
23	847	1.7	70.5	26.7	98.9
24	846	1.2	69.7	27.4	98.3

Midlands Gas Corporation Federal 2962 No. 1 well

Sample no.	Depth (in feet)	Sand (<62μm)	Silt (2-6μm)	Clay (<2μm)	Sum
1	1,674	6.0	62.2	18.7	86.9
2	1,652	42.5	52.6	2.4	97.5
3	1,651	51.9	44.4	2.8	99.1
4	1,533	2.8	71.7	20.6	95.1
5	1,498	No recovery			
6	1,493	15.5	56.4	18.8	90.7
7	1,481	3.0	61.9	29.9	94.8
8	1,480	5.8	64.7	25.8	96.3
9	1,479	9.3	60.9	25.1	95.3
10	1,478	No recovery			
11	1,477	No recovery			
12	1,476	7.2	60.2	28.4	95.8
13	1,475	No recovery			
14	1,474	6.6	53.1	34.1	93.8
15	1,473	7.4	62.6	27.1	97.1
16	1,446	0.5	46.0	48.1	94.6
17	1,436	1.1	55.4	40.9	97.4
18	1,426	3.3	54.1	38.4	95.8
19	1,419	3.2	46.4	48.7	98.3
20	1,406	1.3	46.9	48.5	96.7
21	1,189	5.9	47.6	43.4	96.9
22	717	18.3	49.5	30.2	98.0
23	580	2.6	73.4	22.5	98.5
24	573	6.3	60.2	32.1	98.6

A portion of the clay fraction was used to make oriented mounts for better identification of the clay minerals. X-ray diffraction patterns were made of these oriented mounts before and after glycolation, heating, and potassium acetate intersalation treatments. X-ray diffraction patterns were also made of randomly oriented mounts of each dried fraction, sand, silt, and clay, as well as of the total sample. Amounts of the minerals present were estimated from these X-ray diffraction patterns and are listed below as parts in ten.

tr = trace = <5%
<1 = 5-9%

Because the fractions used for random orientation mounts had been dried at 110°C, the gypsum in the samples was converted to bassanite. This mineral will be reported as "bassanite (gypsum)."

Midlands Gas Corporation Federal 0370 No. 1 well

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
1	1,902	Sand	Calcite	9+
			Dolomite	tr
		Silt	Calcite	9+
			Dolomite	tr
			Quartz	tr
			Kaolinite	tr?
			Illite	tr
		Clay	Calcite	8+
			Quartz	<1
			Kaolinite	<1
			Illite	tr
			Montmorillonite	tr
		Total	Calcite	8+
			Dolomite	tr
			Quartz	tr
			Kaolinite	tr
			Illite	tr
			Montmorillonite	tr
2	1,840.5	Sand	Quartz	2+
			Kaolinite	tr
			Illite	tr
			Pyrite	7
		Silt	Quartz	7+
			Feldspar	<1
			Kaolinite	<1
			Illite	1
			Chlorite	tr
		Clay	Quartz	2+
			Feldspar	tr?
			Kaolinite	1+
			Illite	4+
			Chlorite	tr
		Total	Quartz	5
			Feldspar	tr
			Kaolinite	1+
			Illite	2+
			Chlorite	tr
			Pyrite	tr

Midlands Gas Corporation Federal 0370 No. 1 well

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
3	1,840.5	Sand	Quartz	10
		Silt	Quartz	7+
			Feldspar	tr
			Kaolinite	1+
			Illite	<1
			Chlorite	tr
		Clay	Quartz	2+
			Kaolinite	2+
			Illite	4+
			Chlorite	<1
		Total	Quartz	4+
			Feldspar	tr
			Kaolinite	1+
			Illite	2+
			Chlorite	tr
4	1,772	Sand	Quartz	3+
			Illite	1
			Pyrite	5+
		Silt	Quartz	7+
			Feldspar	tr
			Kaolinite	1
			Illite	<1
			Chlorite	tr
		Clay	Quartz	3+
			Kaolinite	1+
			Illite	4
			Chlorite	1
		Total	Quartz	6+
			Feldspar	tr
			Kaolinite	1+
			Illite	1+
			Chlorite	tr
			Pyrite	tr

Midlands Gas Corporation Federal 0370 No. 1 well

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
5	1,761	Sand	Dolomite	tr
			Quartz	6+
			Kaolinite	tr
			Illite	tr
			Chlorite	tr?
			Pyrite	2+
		Silt	Quartz	7+
			Feldspar	<1
			Kaolinite	<1
			Illite	<1
			Chlorite	tr
			Pyrite	tr?
			Amphibole	tr?
		Clay	Quartz	2+
			Feldspar	tr
			Kaolinite	1+
			Illite	4+
			Montmorillonite	2
			Chlorite	<1
			Amphibole	tr?
		Total	Dolomite	tr
			Quartz	6+
			Feldspar	<1
			Kaolinite	1
			Illite	1+
			Montmorillonite	tr
			Chlorite	tr
			Pyrite	tr
			Amphibole	tr?
6	1,757	Sand	Quartz	8+
			Feldspar	<1
			Kaolinite	tr
			Illite-mica	<1
			Chlorite	tr
			Pyrite	tr?
		Silt	Quartz	7+
			Feldspar	<1
			Kaolinite	<1
			Illite-mica	<1
			Chlorite	tr
			Pyrite	tr
			Amphibole	tr?

Midlands Gas Corporation Federal 0370 No. 1 well

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
6 (cont)		Clay	Quartz	2+
			Feldspar	tr?
			Kaolinite	2+
			Illite	4+
			Chlorite	<1
			Amphibole	tr?
		Total	Quartz	6
			Feldspar	tr
			Kaolinite	1
			Illite-mica	1+
			Chlorite	tr
			Pyrite	<1
			Amphibole	tr?
7	1,755	Sand	Quartz	4+
			Feldspar	<1
			Kaolinite	1+
			Illite-mica	2+
			Pyrite	1+
		Silt	Quartz	7+
			Feldspar	<1
			Kaolinite	<1
			Illite	<1
			Chlorite	tr?
		Clay	Quartz	2+
			Feldspar	tr?
			Kaolinite	1+
			Illite (with <5% expandable interlayers)	5+
			Chlorite	tr
		Total	Quartz	5+
			Feldspar	tr
			Kaolinite	1
			Illite-mica	2+
			Chlorite	tr
			Pyrite	1

Midlands Gas Corporation Federal 0370 No. 1 well

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
8	1,753	Sand	Quartz	7+
			Feldspar	tr
			Kaolinite	<1
			Illite-mica	<1
			Bassanite (gypsum)	1
		Silt	Quartz	8
			Feldspar	<1
			Kaolinite	<1
			Illite-mica	<1
			Chlorite	tr?
		Clay	Quartz	2+
			Kaolinite	2
			Illite (with <5% expandable interlayers)	5
			Chlorite	tr
		Total	Quartz	6+
			Feldspar	tr
			Kaolinite	<1
			Illite	1+
			Chlorite	tr
			Bassanite (gypsum)	tr
			Pyrite	1+
9	1,752	Sand	Quartz	2
			Kaolinite	1+
			Illite	<1
			Bassanite (gypsum)	6
			Amphibole	tr?
		Silt	Quartz	7
			Feldspar	<1
			Kaolinite	1+
			Illite	1
			Chlorite	tr
		Clay	Quartz	2+
			Kaolinite	1+
			Illite	5+
			Chlorite	tr
		Total	Quartz	4+
			Feldspar	tr
			Kaolinite	1+
			Illite	2
			Chlorite	tr
			Bassanite (gypsum)	tr
			Pyrite	<1
			Amphibole	tr?

Midlands Gas Corporation Federal 0370 No. 1 well

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
10	1,751	Sand	Quartz	2+
			Kaolinite	<1
			Illite-mica	<1
			Bassanite (gypsum)	6+
		Silt	Quartz	7+
			Feldspar	<1
			Kaolinite	<1
			Illite-mica	<1
			Chlorite	tr
			Pyrite	tr?
		Clay	Quartz	2+
			Kaolinite	1+
			Illite	5+
			Montmorillonite	tr
			Chlorite	tr
		Total	Quartz	5+
			Feldspar	tr
			Kaolinite	1
			Illite-mica	2
			Montmorillonite	tr
			Chlorite	tr
			Bassanite (gypsum)	tr
			Pyrite	<1
11	1,750	Sand	Quartz	1+
			Feldspar	tr?
			Kaolinite	<1
			Illite-mica	<1
			Bassanite (gypsum)	7
			Pyrite	tr
		Silt	Quartz	6+
			Feldspar	<1
			Kaolinite	1
			Illite-mica	<1
			Chlorite	tr
			Pyrite	tr

Midlands Gas Corporation Federal 0370 No. 1 well

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
11 (cont)		Clay	Quartz	2+
			Feldspar	tr?
			Kaolinite	2
			Illite	5
			Chlorite	<1
		Total	Quartz	4+
			Feldspar	tr
			Kaolinite	1+
			Illite	2
			Chlorite	tr
			Bassanite (gypsum)	<1
			Pyrite	<1
12	1,749	Sand	Quartz	2
			Feldspar	tr
			Kaolinite	<1
			Illite-mica	tr
			Bassanite (gypsum)	7
			Pyrite	tr?
		Silt	Quartz	7+
			Feldspar	<1
			Kaolinite	1+
			Illite-mica	<1
			Chlorite	tr
			Bassanite (gypsum)	tr
			Pyrite	tr?
		Clay	Quartz	2+
			Kaolinite	1+
			Illite (with <5% expandable interlayers)	5+
			Chlorite	tr
		Total	Quartz	5+
			Feldspar	<1
			Kaolinite	<1
			Illite-mica	1+
			Chlorite	tr
			Bassanite (gypsum)	<1
			Pyrite	1

Midlands Gas Corporation Federal 0370 No. 1 well

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
13	1,748	Sand	Calcite	2+
			Dolomite	tr
			Quartz	2+
			Kaolinite	tr
			Illite	tr
			Chlorite	tr
			Bassanite (gypsum)	4+
			Pyrite	tr
		Silt	Calcite	<1
			Dolomite	<1
			Quartz	5+
			Feldspar	tr
			Kaolinite	<1
			Illite	<1
			Chlorite	tr
			Pyrite	<1
		Clay	Calcite	1+
			Quartz	2+
			Kaolinite	1+
			Illite (with 5-10% expandable interlayers)	4+
			Chlorite	tr
		Total	Calcite	1+
			Dolomite	<1
			Quartz	4+
			Feldspar	tr
			Kaolinite	<1
			Illite	1+
			Chlorite	tr
			Bassanite (gypsum)	tr
			Pyrite	<1
14	1,747	Sand	Quartz	3+
			Kaolinite	<1
			Illite	1
			Bassanite (gypsum)	3+
			Pyrite	1
		Silt	Calcite	tr
			Quartz	6+
			Feldspar	<1
			Kaolinite	1+
			Illite	1
			Chlorite	tr
			Pyrite	<1

Midlands Gas Corporation Federal 0370 No. 1 well

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
14 (cont)		Clay	Quartz	2+
			Kaolinite	2
			Illite (with <5% expandable interlayers)	5+
			Chlorite	<1
		Total	Calcite	tr
			Quartz	5
			Feldspar	tr
			Kaolinite	1+
			Illite	2
			Chlorite	tr
			Bassanite (gypsum)	tr
			Pyrite	<1
15	1,746	Sand	Quartz	1+
			Kaolinite	tr
			Illite-mica	tr
			Bassanite (gypsum)	6
			Pyrite	1+
		Silt	Quartz	7+
			Feldspar	tr
			Kaolinite	<1
			Illite-mica	<1
			Chlorite	tr
			Pyrite	<1
		Clay	Quartz	2+
			Feldspar	tr
			Kaolinite	1+
			Illite (with <5% expandable interlayers)	5
			Montmorillonite	tr
			Chlorite	tr
		Total	Quartz	5+
			Feldspar	tr
			Kaolinite	1
			Illite	1+
			Montmorillonite	tr
			Chlorite	tr
			Bassanite (gypsum)	tr
			Pyrite	<1

Midlands Gas Corporation Federal 0370 No. 1 well

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
16	1,745	Sand	Quartz	1+
			Kaolinite	tr
			Illite	tr
			Bassanite (gypsum)	6+
			Pyrite	1
		Silt	Quartz	6+
			Feldspar	tr
			Kaolinite	1
			Illite	1+
			Chlorite	tr
			Pyrite	<1
		Clay	Quartz	2+
			Feldspar	tr?
			Kaolinite	1+
			Illite (with 5-10% expandable interlayers)	5+
			Chlorite	tr
		Total	Calcite	tr
			Quartz	5
			Feldspar	tr
			Kaolinite	1+
			Illite	2
			Chlorite	tr
			Bassanite (gypsum)	tr
			Pyrite	<1
17	1,741	Sand	Quartz	2+
			Kaolinite	tr
			Illite	<1
			Bassanite (gypsum)	5+
			Pyrite	1
		Silt	Quartz	7
			Feldspar	tr
			Kaolinite	<1
			Illite	<1
			Chlorite	tr
			Pyrite	<1

Midlands Gas Corporation Federal 0370 No. 1 well

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
17 (cont)		Clay	Quartz	2+
			Kaolinite	1+
			Illite (with 5-10% expandable interlayers)	5+
			Chlorite	tr
		Total	Calcite	tr
			Quartz	5+
			Feldspar	tr
			Kaolinite	<1
			Illite	2
			Chlorite	tr
			Bassanite (gypsum)	tr
			Pyrite	1

Midlands Gas Corporation Federal 0370 No. 1 well

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
18	1,739	Sand	Quartz	1
			Kaolinite	tr
			Illite	tr
			Chlorite	tr
			Bassanite (gypsum)	7
			Pyrite	1
		Silt	Quartz	7+
			Feldspar	tr
			Kaolinite	<1
			Illite	<1
			Chlorite	tr
			Pyrite	<1
		Clay	Quartz	2
			Kaolinite	1+
			Illite (with 5-10% expandable interlayers)	6
			Chlorite	tr
		Total	Calcite	tr
			Quartz	5+
			Feldspar	tr
			Kaolinite	1
			Illite	2
			Chlorite	tr
			Bassanite (gypsum)	tr
			Pyrite	<1
19	1,708	Sand	Quartz	tr
			Pyrite	9+
		Silt	Quartz	7+
			Feldspar	tr
			Kaolinite	1
			Illite	1
			Chlorite	tr
			Pyrite	tr
		Clay	Quartz	2+
			Kaolinite	1+
			Illite (with <5% expandable interlayers)	5+
			Chlorite	tr

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
19 (cont)		Total	Calcite	tr
			Quartz	5
			Feldspar	tr
			Kaolinite	1+
			Illite	2+
			Chlorite	tr
			Pyrite	tr
20	1,475	Sand	Calcite	3
			Dolomite	tr
			Quartz	4+
			Feldspar	tr
			Kaolinite	tr
			Illite-mica	<1
			Montmorillonite	<1
			Chlorite	tr
			Bassanite (gypsum)	tr
			Pyrite	tr
		Silt	Calcite	tr
			Dolomite	<1
			Quartz	5+
			Feldspar	tr
			Kaolinite	<1
			Illite-mica	1+
			Montmorillonite	<1
			Chlorite	tr
			Pyrite	<1
		Clay	Calcite	<1
			Dolomite	1
			Quartz	2+
			Feldspar	tr?
			Kaolinite	<1
			Illite	2+
			Montmorillonite	2+
			Chlorite	tr
			Pyrite	tr?
		Total	Calcite	1+
			Dolomite	<1
			Quartz	4+
			Feldspar	tr
			Kaolinite	<1
			Illite-mica	1+
			Montmorillonite	1+
			Chlorite	tr
			Bassanite (gypsum)	tr
			Pyrite	tr

Midlands Gas Corporation Federal 0370 No. 1 well

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
21	1,445	Sand	Calcite	2+
			Quartz	<1
			Kaolinite	tr
			Illite-mica	1
			Bassanite (gypsum)	6+
		Silt	Calcite	3
			Dolomite	<1
			Quartz	4+
			Feldspar	tr
			Kaolinite	<1
			Illite-mica	<1
			Montmorillonite	tr
			Chlorite	tr
			Pyrite	tr
		Clay	Calcite	4+
			Quartz	2
			Kaolinite	<1
			Illite	2
			Montmorillonite	<1
			Chlorite	tr
		Total	Calcite	2+
			Dolomite	tr
			Quartz	3
			Feldspar	tr
			Kaolinite	<1
			Illite	1
			Montmorillonite	tr
			Chlorite	tr
			Bassanite (gypsum)	<1
			Pyrite	<1
22	1,399	Sand	Calcite	2+
			Dolomite	tr
			Quartz	<1
			Illite-mica	tr
			Bassanite (gypsum)	5+
			Pyrite	<1
		Silt	Calcite	2
			Dolomite	tr
			Quartz	5
			Feldspar	tr?
			Kaolinite	<1
			Illite-mica	<1
			Montmorillonite	tr
			Chlorite	tr
			Pyrite	tr

Midlands Gas Corporation Federal 0370 No. 1 well

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
22 (cont)		Clay	Calcite	2+
			Dolomite	tr
			Quartz	3
			Kaolinite	<1
			Illite	2+
			Montmorillonite	<1
			Chlorite	tr
		Total	Calcite	2+
			Dolomite	tr
			Quartz	3+
			Feldspar	tr?
			Kaolinite	<1
			Illite	1+
			Montmorillonite	tr
			Chlorite	tr
			Bassanite (gypsum)	<1
			Pyrite	tr
23	847	Sand	Dolomite	tr
			Quartz	8
			Feldspar	<1
			Kaolinite	tr
			Illite-mica	<1
			Chlorite	tr
			Pyrite	tr
		Silt	Dolomite	tr
			Quartz	7+
			Feldspar	<1
			Kaolinite	<1
			Illite-mica	<1
			Montmorillonite	tr
			Chlorite	tr
			Pyrite	tr
		Clay	Quartz	2+
			Kaolinite	2
			Illite	4
			Montmorillonite	1+
			Chlorite	tr
		Total	Dolomite	tr
			Quartz	6
			Feldspar	tr
			Kaolinite	1
			Illite	1+
			Montmorillonite	tr
			Chlorite	tr
			Pyrite	tr

Midlands Gas Corporation Federal 0370 No. 1 well

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
24	846	Sand	Quartz	7+
			Feldspar	tr
			Kaolinite	tr
			Illite-mica	<1
			Chlorite	tr
			Pyrite	1+
		Silt	Dolomite	<1
			Quartz	7+
			Feldspar	<1
			Kaolinite	<1
			Illite-mica	<1
			Chlorite	tr
		Clay	Quartz	2+
			Kaolinite	1+
			Illite	5
			Montmorillonite	<1
			Chlorite	tr
		Total	Dolomite	tr
			Quartz	6
			Feldspar	tr
			Kaolinite	1
			Illite	1+
			Montmorillonite	tr
			Chlorite	tr
			Pyrite	tr

Midlands Gas Corporation Federal 2962 No. 1 well

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
1	1,674	Sand	Calcite	1+
			Dolomite	tr
			Quartz	4
			Feldspar	tr
			Illite	<1
			Montmorillonite	3
			Bassanite (gypsum)	tr
			Pyrite	tr
		Silt	Calcite	1
			Dolomite	tr
			Quartz	4+
			Feldspar	tr
			Illite	<1
			Montmorillonite	3+
			Bassanite (gypsum)	tr
			Pyrite	tr
			Weddellite[1/]	tr?
		Clay	Calcite	<1
			Quartz	2+
			Illite	<1
			Montmorillonite	5+
			Bassanite (gypsum)	tr
			Weddellite[1/]	tr?
		Total	Calcite	2
			Dolomite	tr
			Quartz	3+
			Feldspar	tr
			Illite	<1
			Montmorillonite	3+
			Bassanite (gypsum)	tr
			Pyrite	<1

[1/] Weddellite may be formed when calcium is present during the peroxidation of samples (Jones, R. L., and Beavers, A. H., 1963, Soil Science Society of American Proceedings, v. 27, p. 356; Martin, R. T., 1954, Soil Science, v. 77, p. 143).

Midlands Gas Corporation Federal 2962 No. 1 well

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
2	1,652	Sand	Calcite	9+
			Ankerite	tr
		Silt	Calcite	8+
			Ankerite	1
			Quartz	<1
			Montmorillonite	tr
		Clay	Calcite	6+
			Quartz	2+
			Montmorillonite	1+
		Total	Calcite	8+
			Ankerite	<1
			Quartz	tr
			Montmorillonite	tr
3	1,651	Sand	Calcite	9+
			Ankerite	tr?
			Quartz	tr?
		Silt	Calcite	8+
			Ankerite	<1
			Quartz	<1
			Kaolinite	tr
			Montmorillonite	tr
		Clay	Calcite	3
			Quartz	2+
			Kaolinite	<1
			Illite	1+
			Montmorillonite	2+
		Total	Calcite	9
			Ankerite	tr
			Quartz	<1
			Kaolinite	tr
			Illite	tr
			Montmorillonite	tr
			Pyrite	tr?

Midlands Gas Corporation Federal 2962 No. 1 well

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
4	1,533	Sand	Quartz	7
			Feldspar	tr
			Kaolinite	tr
			Illite-mica	<1
			Pyrite	1+
		Silt	Quartz	7+
			Feldspar	<1
			Kaolinite	<1
			Illite-mica	<1
			Chlorite	tr
			Pyrite	tr
		Clay	Quartz	3+
			Kaolinite	1+
			Illite	4+
			Chlorite	tr
		Total	Quartz	6+
			Feldspar	tr
			Kaolinite	<1
			Illite	1+
			Chlorite	tr
			Pyrite	<1
5	1,498	No recovery		
6	1,493	Sand	Calcite	tr
			Dolomite	tr
			Quartz	2+
			Kaolinite	<1
			Illite	tr
			Chlorite	tr
			Bassanite (gypsum)	5+
			Pyrite	<1
		Silt	Dolomite	<1
			Quartz	5+
			Feldspar	tr
			Kaolinite	<1
			Illite	<1
			Mixed-layered illite-montmorillonite	tr
			Chlorite	tr
			Bassanite (gypsum)	<1
			Pyrite	<1

Midlands Gas Corporation Federal 2962 No. 1 well

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
6 (cont)		Clay	Quartz	1+
			Kaolinite	2
			Illite	4
			Mixed-layered illite-montmorillonite	2
			Chlorite	tr
			Bassanite (gypsum)	tr
		Total	Calcite	tr
			Dolomite	<1
			Quartz	4
			Feldspar	tr
			Kaolinite	1
			Illite	1+
			Mixed-layered illite-montmorillonite	<1
			Chlorite	tr
			Bassanite (gypsum)	1
			Pyrite	1+
7	1,481	Sand	Quartz	1+
			Feldspar	tr?
			Kaolinite	tr
			Illite-mica	<1
			Bassanite (gypsum)	6+
			Pyrite	1
		Silt	Quartz	6+
			Feldspar	tr
			Kaolinite	1+
			Illite-mica	1+
			Chlorite	tr
			Pyrite	<1
		Clay	Quartz	2+
			Kaolinite	1+
			Illite	4+
			Montmorillonite	<1
			Chlorite	tr
		Total	Quartz	5
			Feldspar	tr
			Kaolinite	1+
			Illite-mica	1+
			Montmorillonite	tr
			Chlorite	tr
			Bassanite (gypsum)	tr
			Pyrite	<1

Midlands Gas Corporation Federal 2962 No. 1 well

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
8	1,480	Sand	Quartz	2+
			Kaolinite	tr
			Illite-mica	<1
			Bassanite (gypsum)	6
			Pyrite	<1
		Silt	Quartz	7+
			Feldspar	tr
			Kaolinite	<1
			Illite-mica	1
			Chlorite	tr
			Pyrite	<1
		Clay	Quartz	2+
			Kaolinite	1+
			Illite	4+
			Mixed-layered illite-montmorillonite	<1
			Montmorillonite	tr
			Chlorite	tr
		Total	Quartz	5+
			Feldspar	tr
			Kaolinite	<1
			Illite-mica	1+
			Mixed-layered illite-montmorillonite	tr
			Montmorillonite	tr
			Chlorite	tr
			Bassanite (gypsum)	<1
			Pyrite	<1
9	1,479	Sand	Calcite	tr?
			Dolomite	tr
			Magnesian kutnahorite	tr?
			Quartz	3+
			Feldspar	tr
			Kaolinite	tr
			Illite	tr
			Chlorite	tr?
			Bassanite (gypsum)	5+
			Pyrite	tr

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
9 (cont)		Silt	Dolomite	tr
			Quartz	7+
			Feldspar	tr
			Kaolinite	1
			Illite	<1
			Chlorite	tr?
			Bassanite (gypsum)	<1
			Pyrite	tr
		Clay	Quartz	2+
			Kaolinite	2+
			Illite	3+
			Montmorillonite	1+
			Mixed-layered chlorite-montmorillonite	tr
		Total	Calcite	1
			Dolomite	tr
			Magnesian kutnahorite	tr?
			Quartz	5
			Feldspar	tr
			Kaolinite	1
			Illite	1+
			Montmorillonite	tr
			Mixed-layered chlorite-montmorillonite	tr
			Chlorite	tr
			Bassanite	<1
			Pyrite	<1
10	1,478	No recovery		
11	1,477	No recovery		
12	1,476	Sand	Quartz	2+
			Kaolinite	tr
			Illite	<1
			Chlorite	tr
			Bassanite (gypsum)	6+
			Pyrite	<1
		Silt	Quartz	7+
			Feldspar	tr
			Kaolinite	<1
			Illite	<1
			Chlorite	tr
			Pyrite	<1

Midlands Gas Corporation Federal 2962 No. 1 well

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
12 (cont)		Clay	Quartz	2+
			Kaolinite	1+
			Illite	4+
			Mixed-layered illite-montmorillonite	1+
			Montmorillonite	tr
			Chlorite	tr
		Total	Quartz	5+
			Feldspar	tr
			Kaolinite	<1
			Illite	1+
			Mixed-layered illite-montmorillonite	tr
			Montmorillonite	tr
			Chlorite	tr
			Bassanite (gypsum)	<1
			Pyrite	<1
13	1,475	No recovery		
14	1,474	Sand	Quartz	2
			Kaolinite	tr
			Illite-mica	tr
			Bassanite (gypsum)	6+
			Pyrite	tr
		Silt	Quartz	7+
			Feldspar	tr
			Kaolinite	<1
			Illite-mica	<1
			Chlorite	tr
			Pyrite	<1
		Clay	Quartz	2+
			Kaolinite	1+
			Illite	4+
			Mixed-layered illite-montmorillonite	tr
			Chlorite	tr
			Pyrite	tr

Midlands Gas Corporation Federal 2962 No. 1 well

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
14 (cont)		Total	Quartz	5
			Feldspar	tr
			Kaolinite	1
			Illite-mica	1+
			Mixed-layered illite-montmorillonite	tr
			Chlorite	tr
			Bassanite (gypsum)	<1
			Pyrite	<1
15	1,473	Sand	Quartz	2+
			Kaolinite	tr
			Illite-mica	tr
			Bassanite (gypsum)	5+
			Pyrite	1+
		Silt	Dolomite	tr
			Quartz	6+
			Feldspar	tr
			Kaolinite	<1
			Illite-mica	<1
			Chlorite	tr
			Pyrite	<1
		Clay	Quartz	3+
			Kaolinite	1+
			Illite	3+
			Mixed-layered illite-montmorillonite	<1
			Chlorite	<1
		Total	Calcite	tr
			Dolomite	tr
			Quartz	5+
			Feldspar	tr
			Kaolinite	1
			Illite-mica	1+
			Mixed-layered illite-montmorillonite	tr
			Chlorite	tr
			Bassanite (gypsum)	<1
			Pyrite	<1

Midlands Gas Corporation Federal 2962 No. 1 well

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
16	1,446	Sand	Quartz	1+
			Kaolinite	tr
			Illite-mica	tr
			Pyrite	7+
			Amphibole	<1
		Silt	Quartz	6+
			Feldspar	tr
			Kaolinite	1+
			Illite-mica	1+
			Chlorite	tr
			Pyrite	tr
		Clay	Quartz	2+
			Kaolinite	2+
			Illite	3+
			Mixed-layered chlorite-mica	<1
		Total	Calcite	tr
			Quartz	4+
			Feldspar	tr
			Kaolinite	1+
			Illite-mica	2+
			Chlorite	tr
			Mixed-layered chlorite-mica	tr
			Pyrite	tr
			Amphibole	tr
17	1,436	Sand	Calcite	tr
			Quartz	4
			Kaolinite	<1
			Illite-mica	1+
			Pyrite	3+
		Silt	Dolomite	tr
			Quartz	6+
			Feldspar	tr
			Kaolinite	1+
			Illite-mica	1+
			Chlorite	tr
			Pyrite	tr
		Clay	Quartz	2+
			Kaolinite	2+
			Illite	4+
			Chlorite	tr

Midlands Gas Corporation Federal 2962 No. 1 well

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
17 (cont)		Total	Calcite	tr
			Dolomite	tr
			Quartz	5
			Feldspar	tr
			Kaolinite	1+
			Illite	2+
			Chlorite	tr
			Pyrite	tr
18	1,426	Sand	Quartz	3+
			Kaolinite	1
			Illite-mica	1+
			Chlorite	tr
			Pyrite	3+
			Amphibole	<1
		Silt	Quartz	5+
			Feldspar	tr
			Kaolinite	1+
			Illite-mica	1+
			Chlorite	tr
			Pyrite	<1
			Amphibole	tr?
		Clay	Quartz	2+
			Kaolinite	2+
			Illite	4+
			Chlorite	tr
		Total	Quartz	4+
			Feldspar	tr
			Kaolinite	1+
			Illite-mica	2+
			Chlorite	tr
			Pyrite	1
			Amphibole	tr
19	1,419	Sand	Quartz	6+
			Feldspar	tr
			Kaolinite	<1
			Illite-mica	2
			Chlorite	tr
			Pyrite	tr

Midlands Gas Corporation Federal 2962 No. 1 well

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
19 (cont)		Silt	Quartz	7+
			Feldspar	tr
			Kaolinite	<1
			Illite-mica	<1
			Chlorite	tr
		Clay	Quartz	2+
			Kaolinite	2
			Illite	4+
			Chlorite	<1
		Total	Quartz	5
			Feldspar	tr
			Kaolinite	1+
			Illite-mica	2+
			Chlorite	<1
			Pyrite	tr
20	1,406	Sand	Quartz	6+
			Kaolinite	<1
			Illite-mica	2
			Chlorite	tr
			Pyrite	tr
		Silt	Quartz	7
			Feldspar	tr
			Kaolinite	1+
			Illite-mica	1
			Chlorite	tr
			Pyrite	tr
		Clay	Quartz	3+
			Kaolinite	1+
			Illite	4+
			Mixed-layer illite-montmorillonite	<1
			Chlorite	tr
		Total	Quartz	5+
			Feldspar	tr
			Kaolinite	1+
			Illite-mica	2+
			Mixed-layer illite montmorillonite	tr
			Chlorite	tr
			Pyrite	tr

Midlands Gas Corporation Federal 2962 No. 1 well

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
21	1,189	Sand	Calcite	1+
			Dolomite	tr
			Quartz	3+
			Feldspar	tr
			Kaolinite	tr
			Illite-mica	1+
			Bassanite (gypsum)	2+
			Pyrite	<1
		Silt	Calcite	<1
			Dolomite	<1
			Quartz	6
			Feldspar	tr
			Kaolinite	<1
			Illite-mica	<1
			Montmorillonite	tr
			Bassanite (gypsum)	tr
			Pyrite	<1
		Clay	Calcite	1+
			Dolomite	tr?
			Quartz	3+
			Kaolinite	1+
			Illite	3+
			Montmorillonite	<1
		Total	Calcite	1+
			Dolomite	tr
			Quartz	4+
			Feldspar	tr
			Kaolinite	<1
			Illite-mica	1+
			Montmorillonite	tr
			Bassanite	<1
			Pyrite	<1
22	717	Sand	Dolomite	tr
			Quartz	9+
			Feldspar	tr
			Kaolinite	tr
			Illite-mica	tr

Midlands Gas Corporation Federal 2962 No. 1 well

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
22 (cont)		Silt	Dolomite	<1
			Quartz	7+
			Feldspar	tr
			Kaolinite	<1
			Illite-mica	<1
			Montmorillonite	<1
		Clay	Quartz	2+
			Kaolinite	1+
			Illite	4+
			Montmorillonite	1
			Chlorite	tr?
		Total	Dolomite	<1
			Quartz	6
			Feldspar	tr
			Kaolinite	<1
			Illite-mica	1+
			Montmorillonite	tr
			Chlorite	tr?
23	580	Sand	Quartz	9
			Feldspar	tr
			Kaolinite	tr
			Illite-mica	tr
			Chlorite	tr
			Pyrite	tr
		Silt	Dolomite	tr
			Quartz	7+
			Feldspar	tr
			Kaolinite	<1
			Illite-mica	<1
			Mixed-layer illite-montmorillonite	tr
			Chlorite	tr
		Clay	Quartz	3
			Kaolinite	1+
			Illite	3+
			Mixed-layer illite-montmorillonite	1+
			Chlorite	tr

Midlands Gas Corporation Federal 2962 No. 1 well

Sample no.	Depth		Minerals present	Estimated amounts (parts in tens)
23 (cont)		Total	Dolomite	tr
			Quartz	7
			Feldspar	tr
			Kaolinite	<1
			Illite-mica	1+
			Mixed-layer illite-montmorillonite	tr
			Chlorite	tr
			Pyrite	tr
24	573	Sand	Quartz	8+
			Feldspar	tr
			Kaolinite	tr
			Illite-mica	1
			Chlorite	tr
		Silt	Dolomite	tr
			Quartz	7+
			Feldspar	tr
			Kaolinite	1
			Illite-mica	1
			Chlorite	tr
		Clay	Quartz	3
			Kaolinite	1+
			Illite	3+
			Montmorillonite	1+
			Chlorite	tr
		Total	Dolomite	tr
			Quartz	6+
			Feldspar	tr
			Kaolinite	1
			Illite	1+
			Montmorillonite	tr
			Chlorite	tr