NORTH DAKOTA GEOLOGICAL SURVEY CIRCULAR NO. 237

Summary of the Arrowhead Exploration Co. - Edwin Engstrom #1
Bottineau County, North Dakota
Well No. 2330 - Permit No. 2342

by William P. Eastwood
June, 1960

Arrowhead Exploration Co. - Edwin Engstrom #1 located in SE1/4, NW 1/4, Section 24, T. 163N., R. 83W., (1980 feet from north line and 1980 feet from west line) Bottineau County, North Dakota. Elevation of G.L. 1569; K.B. 1579. Contractor Signal Drilling and Exploration, Inc., Denver, Colorado.

The drilling permit was issued on May 11, 1959. The well was drilled to a total depth of 4030 K.B., plugged back to 3955 K.B. and completed on June 11, 1959, as a development well in the North Haas field.

Drill Stem Tests:

#1 3858-3893 (Frobisher-Alida Interval). Tool open 65 minutes. Weak blow throughout test. Recovered 255 feet of water-cut mud and 120 feet of muddy salt water. IHP 2115#, ISI 2035#/65 min., IFP 48#, FFP 109#, FSI 1895#/90 min., FHP 2091#.

#2 3929-3950 (Frobisher-Alida Interval). Tool open 60 minutes. Strong initial blow decreasing to fair in 20 minutes. Gas to surface in 30 minutes burning 2 foot flare to end of test. Recovered 1305 feet of oil and gas, calculated to be 700 feet of oil and 250 feet of heavily oil-cut drilling mud. IHP 2197, ISI 1483#/55 min., IFP 70#, FFP 310#, FSI 1430#/90 min., FHP 2178#.

Completion Data:

1. Perforated 3964-66 with 10 shots per foot. Treated with 250 gallons mud acid and 750 gallons regular acid. Swabbed 10 barrels fluid per hour, 85% to 95% water, no gas.

2. Set bridge plug at 3955.

3. Perforated 3936-38 with 8 holes per foot. Pumped 30 barrels in 5 hours, 45% water. Estimated GOR-50. API gravity of oil - 26.5.

Casing and Tubing Record:

662 feet of 8 5/8 inch surface casing cemented with 200 sacks.
4018 feet of 4 1/2 inch production casing cemented with 150 sacks.

Mechanical Logs:

Induction - Electrical (372-4023)
Microlaterolog - (3250-4026)

Core Record:

3923-4002 - Full recovery.

The formation tops were determined from samples and mechanical logs. Color names are those used in the Rock Color Chart of the National Research Council. Limestone petrography terms are those proposed by Folk (1959)Bull. Amer. Assoc. Petroleum Geologists, vol. 43, no. 1, pp. 1-38.

FORMATION TOPS

Cretaceous	
Niobrara formation	1726
Greenhorn formation	2004
Fall River formation	2503
Jurassic	
Piper formation	3381
Triassic (?)	
Spearfish formation	3597
Mississippian Unconformity	3750
Midale subinterval	3750
Frobisher-Alida interval	3790
Top “Massive Anhydrite”	3825
Total Depth	4030

0-400 No samples.

400-490 Shale, medium gray (N6) silty, soft. Rare pieces of very light gray (N8) to pinkish gray (5YR8/1) limy siltstone. Very rare black plant fragments.

490-520 Shale as above with common limy siltstone as above.

520-1240 Shale, medium light gray, clayey, subfissile. Rare shale and siltstone as above. Rare small nodules of white clay at 730-790. Common white limy bentonitic material at 940-70.

1240-1360 Shale as above with common very light gray (N8) slightly limy shale.

1360-1450 Medium light gray shale as above. Rare brownish gray (5YR4/1) siltstone.

Niobrara formation 1726

1450-1900 Dark gray to grayish black (N2) shale. Rare bentonite 1540-1660.

1900-1960 Shale, medium light gray, fissile. Rare dark gray shale as above.

Greenhorn formation 2004

1960-2080 Shale, grayish black, subfissile, very rare brownish gray fine-grained sandstone. Abundant Inoceramus fragments at 2050-80.

2080-2140 Dark gray shale as above by containing common small Inoceramus fragments.

2140-2380 As above. Rare Inoceramus fragments. Common large subangular, quartz grains at 2350-80.

2380-2500 Shale, light olive gray (5Y6/1) with common quartz grains and black shale as above.

Fall River formation 2503

2500-2610 Shale, grayish back, as above; common quartz grains and olive gray shale as above.

2610-2750 Grayish black shale as above; rare white microgranular limestone, rare large quartz grains as above. Rare light olive gray shale. Rare medium grained quartz sandstone.

2750-2850 Black shale as above. Rare reddish brown shale and medium grained sandstone.

2850-2900 Quartz sand grains, medium to coarse, rounded, subspherical to angular. Common black shale as above.

2900-2910 Black shale as above, rare to common quartz grains as above.
2910-2940 As above, common white sublithographic (micrite) limestone.
2940-2990 Black shale as above, common light gray shale. Rare sandstone and limestone as above.
2990-3080 As above, with common, greenish gray waxy shale.
3080-3150 As above, rare greenish gray shale, rare yellowish gray (5Y8/1) soft siltstone.
3150-3160 Black shale as above, common light olive gray (5Y6/1) silty shale.
3160-3190 Common greenish gray (5GY6/1) and moderate reddish brown (10R4/6) shale. Common black and olive gray shale as above.
3190-3290 Abundant greenish gray shale, common reddish brown, gray, and black shale. Rare white sublithographic (micrite) sandy limestone 3230-3290.
3290-3300 Abundant olive gray shale, rare black, greenish gray, and red shale as above. Rare white limy bentonite.
3300-3350 Abundant greenish gray shale as above, common reddish brown shale as above. Rare white sandy limestone.

Piper formation 3381
3350-3510 Limestone as above, common shale as above. Limestone is slightly dolomitic. Limestone becomes less sandy and less dolomitic with increasing depth.

Spearfish formation 3597
3510-3610 Abundant shale as above, common to rare limestone as above, rare white fine-grained friable quartz sandstone ? Rare white gypsum at 3560-3600.
3610-3650 Black shale as above, common reddish brown shale. Rare pink and white gypsum. Common reddish brown fine-grained, friable, silty quartz sandstone at 3630 and below.

Midale subinterval 3750
3650-3770 Abundant reddish brown sands;one as above. Common black shale (cavings ?) as above. Common medium-sized rounded subspherical quartz grains at 3680-3730, less common below this.

Frobisher-Alida interval 3790
3770-3793 Limestone, very pale orange (10YR8/2) to white, micrite or microsparite, tight, low porosity. Black shale cavings as above. Rare pieces of pale yellowish brown (10YR6/2) pelmicrite limestone.
3793-3800 Circulated 1 hour. As above with abundant pale red (5R6/2) anhydrite.
3800-3820 Abundant anhydrite as above, rare limestone as above. Black shale cavings. Common olive gray silty soft shale 3810-3820.
3820-3830 Limestone, pale yellowish brown (10YR6/2), micrite with patches of pelmicrite, tight and dense. Rare pale red anhydrite.

Drill stem test #1 (3858-3893) Recovered water cut mud and muddy salt water.
3830-3923 Common white anhydrite, rare limestone and pale red anhydrite as above. Badly caved.
3923 Circulated 1 hour. Common white anhydrite, abundant black shale cavings.

Drill stem test #2 (3929-3950) Recovered 700 feet of oil and 250 feet oil cut mud.

Core chips

3923-3938	Anhydrite, pale yellowish brown to very light gray, dense and tight. Becomes dark gray at 3936.

Perforated interval 3936-38.

3938-3939	Sandstone, white, quartzitic, medium to fine-grained. Composed of angular quartz grains. Cement in one chip is anhydrite, in another chip is probably silica. Low intergranular porosity and permeability.
3939-3940	Sandstone, as above, common concentrations of small pyrite crystals. No stain.
3940-3941	Sandstone as above. Parts of the rock have less cement and are therefore more porous. These more porous areas have a good oil stain.
3941-3942	Sandstone as above, good stain and good cut. Oil stained portion is very friable.
3942-3943	Sandstone as above, no stain.
3943-3944	Anhydrite, sandy, contains many fine quartz grains floating in the anhydrite matrix.
3944-3945	Anhydrite, no quartz grains but common masses of small pyrite crystals.
3945-3946	Anhydrite, medium gray, dense, tight.
3946-3947	Anhydrite, medium gray, mottled with medium light gray slightly dolomitic laminae and veins.
3947-3948	Anhydrite, dark gray, with contorted laminae of white micro-granular dolomite. The dolomite contains abundant small pyrite crystals.
3948-3949	Dolomite and anhydrite intermixed. Anhydrite is medium gray, fine crystalline. Dolomite is very pale orange (10YR8/2) microgranular and slightly limy.
3949-3950	As above.
3950-3951	Dolomite, medium light gray, microgranular, anhydritic. Fair intergranular porosity.
3951-3952	Dolomite, white, as above.
3952-3953	Dolomite, white, as above, with abundant brown dolomitic pellets and common medium sized pyrite crystals.
3953-3954	As above, no pyrite seen.
3954-3955	As above, limy.
3955-3956	Dolomite, limy. Medium-sized masses of microgranular dolomite in a calcitic cement. Abundant brown shaly laminae.
3956-3957	Limestone, dolomitic, white, microgranular to sucrosic. Common small anhydrite crystals.
3957-3958	Anhydrite, medium gray, translucent, with veins and laminae of very pale orange microgranular dolomite.
3958-3959	Dolomite, very light gray. With common large masses of anhydrite.
3959-3960	Anhydrite. Rare dolomite laminae as above.
3960-3961	Dolomite, white, limy, microgranular to sucrosic. Parts of the chip show white dolomitized pellets closely packed in clear cement.
3961-3962	Dolomite, white, common brown dolomitic pellets.
3962-3963	Anhydrite, fine crystalline, medium gray to pale yellowish brown. Common very pale orange dolomite laminae.

3963-3964	Dolomite, pale yellowish brown, common large acicular and rectangular anhydrite crystals. Rare medium pyrite crystals.
3964-3965	Anhydrite, white, fine crystalline.
3965-3966	As above.
3966-3967	As above, rare brown dolomite laminae.
3967-3968	Dolomite(?), microgranular, Heavily oil-stained. Low porosity and permeability.
3968-3969	As above, common brown anhydrite (?) crystals.
3969-3970	As above.
3970-3971	Anhydrite, medium crystalline.
3971-3972	As above.
3972-3973	Anhydrite as above, with common laminae and interbeds of very pale orange microgranular “pelletoidal” limy dolomite.
3973-3974	Anhydrite, medium crystalline. Coon laminae of microgranular to sucrosic dolomite.
3974-3975	Dolomite, very light gray, sucrosic, limy.
3975-3976	Dolomite, white, with common small crystals of halite.
3976-3977	Anhydrite, gray, with contorted laminae of very light gray micro-granular dolomite.
3977-3978	As above.
3978-3979	Dolomite, white, limy, sucrosic with remnants of a previous pelletoidal texture. Calcite filled fractures.
3979-3980	As above, very limy.
3980-3981	Dolomite, white, veins of halite (?)
3981-3982	Dolomite, white, limy, clear anhydrite masses.
3982-3983	As above.
3983-3984	As above.
3984-3985	Dolomite, pale yellowish brown, slightly limy, microgranular, pelletoidal.
3985-3986	Dolomite, limy, medium light gray, sucrosic.
3986-3987	Dolomite, limy. Pelletoidal texture very evident. Large included anhydrite crystals.
3987-3988	Dolomite, white, sucrosic. Common small halite crystals.
3988-3989	As above.
3989-3990	Limestone, very pale orange, pelmicrosparite, dolomitic. Closely packed pellets with microsparite cement. Fair intergranular porosity.
3990-3991	Limestone, very pale orange, microsparite, common brown dolomite and clear anhydrite crystals.
3991-3992	Limestone, very pale orange, intrapelmicrosparite. Intraclasts and pellets floating in a microsparite matrix.
3992-3993	As above.
3993-3994	Limestone, dolomitic, white, oil stained, good cut.
3994-3995	As above, rare anhydrite crystals.
3995-3996	As above, good pinpoint porosity and common large pores. Rare anhydrite crystals.
3996-3997	Dolomite, limy, white, no oil stain. Common small angular quartz crystals.
3997-3998	As above.
3998-3999	Limestone, very pale orange, dolomitic, microsparite.
3999-4000	As above, common large pores.
4000-4001	Limestone, white, oointramicrosparite. Oolites and intraclasts floating in a microsparite matrix. Common large pores. Common anhydrite masses.

4001-4002 As above.

End of core.
4000-4030 Abundant limestone as above. Common black shale cavings.
4030 Total depth.
3955 P.B.T.D.