p 263-282

BOLLETTINO DI GEOFISICA TEORICA ED APPLICATA — VOL. VI, N. 23 - SETTEMBRE 1964

H. C. SPICER (*)

GEOTHERMAL GRADIENTS AND HEAT FLOW IN THE SALT VALLEY ANTICLINE, UTAH

RIASSUNTO

Le temperature sono state misurate in 5 pozzi dislocati sull'anticlinale di Salt Valley, Utah o nei pressi. I gradienti geotermici nella sezione dal Cretaceo al Giurassico variano da 37.4° C/km a 39.4° C/km. Invece nel sale esso varia da 15.7° C/km a 12,3° C/km. In un pozzo ad Est e fuori della struttura il gradiente geotermico è 19.4° C/km.

Il flusso di calore alla superficie è sull'anticlinale 1.32 μcal/cm² sec; nell'area a Sud 1.11; nell'area ad Est 1.01. Viene proposto un metodo per valutare le curve temperatura-profondità.

SUMMARY

Temperatures were measured 5 welles located on or near the Salt Valley anticline, Utah. Geothermal gradients in the section of Mancos Shale (Cretaceous) to Morrison Formation (Jurassic) in the graben area of the anticline ranged from 0.02053°F to 0.02160°F per foot, or 37.4°C to 39.4°C per km. In the Hermosa Formation (Pennsylvanian) in the southern area of the anticline, the geothermal gradient is 0.01621°F per foot, or 31.4°C per km. In the Paradox salt of the graben area, the geothermal gradient is 0.00861°F per ft, or 15.7°C per km. In the southern anticlinal area, the geothermal gradient in the Paradox salt is 0.00676°F per ft, or 12.3°C per km. In a well east of and off the structure, the geothermal gradient is 0.01064°F per ft, or 19.4°C per km.

Heat flow to the surface in the graben area of the anticline is 1.32 μ cal/cm² sec; in the southern area of the anticline it is 1.11 μ cal/cm² sec. To the east and off the anticlinal structure, heat flow to the surface is 1.01 μ cal/cm² sec. A method for evaluating temperature-depth curves is introduced.

INTRODUCTION

Drilling records exist for 110 wells in Grand County, Utah (Hansen and Scoville, 1955) but temperatures have been measured in only a few of them. Those measured are: Reeder No. 1 (10-61) (1), Crescent Eagle No. 1 (10-62), Brendell No. 1 (10-65), Balsley No. 1-C (10-90), and Hyde No. 1 (10-80). The first four wells listed are located on the Salt Valley anticline (Figure 1). The fifth well is between the South Cisco anticline and the Salt Valley anticline, about 11 miles southwest of the former structure and about 7 miles northeast of the latter. The Yellow Cat dome is approximately 3 miles southeast of Hyde No. 1 well (Dane, 1935, pl. II), Figure 1.

(*) U. S. Geological Survey, Washington, D.C. Publication authorized by the Director, U. S. Geological Survey

The effect of anticlinal structure on geothermal gradients and heat flow can be determined from the temperatures measured in the wells. Drilling records and geophysical studies (Joesting and Case, 1960) have shown that a thick deposit of salt underlies the anticline. Salt is a good conductor of heat in comparison wih many other rocks, and the effect of this material on the geothermal gradients and heat flow can be determined.

The wells had been idle for varying periods of time. Temperatures were measured in one well soon after drilling stopped and were again measured after several years. In another well, temperatures were measured at three different times. It was thus possible to determine the effects of idle time on the geothermal constants.

ACKNOWLEDGMENTS

Core samples from the salt section of the Reeder No. 1 well were obtained from the U. S. Bureau of Mines through the cooperation of Paul T. Allsman, J. H. East, Jr., and W. E. Rice. Outcrop samples of formations in the area were collected by J. E. Case and Robert Hite of the U. S. Geological Survey. Cores from drill holes in the area were provided by D. P. Elston of the U. S. Geological Survey and R. R. Norman of the Delhi-Taylor Company, Moab, Utah. Thermal conductivity determinations on the above specimens were made by S. A. H. Goldstein, J. S. Karp, and W. E. Huff, U. S. Geological Survey, under the direction of E. C. Robertson. The writer wishes to express his appreciation for this assistance.

GEOLOGY

The geology of the Salt Valley anticline and adjacent area is described by Dane (1935), and this brief summary is extracted therefrom. A recent stratigraphic and structural interpretation of Salt Valley and nearby structures is given by Shoemaker et al (1958).

In the vicinity of the Salt Valley anticline, the general structure, though simple, is complicated by several folds with steeply dipping flanks. The rocks are in general inclined northward, away from the Uncompahgre Plateau and the laccolithic uplift of the La Sal Mountains. The most prominent fold is the northwest-trending Salt Valley anticline. The crest of this fold has been dropped into a trough or graben by a rather complex system of normal faults which have displacements ranging from a few to more than a thousand feet. The resistant sandstone flanks of the anticline stand as ridges. Within the trough, the softer Mancos Shale is more deeply eroded and is widely covered with alluvium and valley fill.

At the northwest end of the anticline, the Mancos Shale is dropped against successively older formations and is covered with a thin layer of alluvium. The main graben of Mancos Shale to the north is separated from the intrusive salt body of the Paradox Member of the Hermosa Formation to the south by a group of cross faults and a narrow tapering wedge consisting of Morrison, Mancos, and Dakota (?) Formations. The Paradox is intruded into the graben in the Crescent area; there, below the Dakota (?) Sandstone (Cretaceous), only about 140 ft of the shales and sandstones of the Morrison were

encountered above the Paradox in the [illegible]
mal to the geologic section between them are missing.

The intrusion of Paradox salt beneath the Crescent Junction area seems to be wholly within the graben block. The minor complex faulting in Salt Valley probably was in part subsequent to the intrusion of the Paradox salt and was a result of withdrawal or redistribution underground of the plastic and soluble material, as a consequence of which overlying beds collapsed. The structure now visible is the result of deformation which took place at the end of Cretaceous time. (See Shoemaker et al, 1958, for another interpretation).

Crystalline rocks are estimated to be at a depth of approximately 16,000 ft at the Thompson No. 1 well located in Sec 33, T 21 S, R 21 E, approximately 12 mi ENE of the Reeder No. 1 well (Joesting and Case, 1960, Figure 114.2). Granite was encountered at a depth of 2,431 ft in the State No. 1 well, Utah Southern Oil Company (Dane, 1935, p. 166), about 11 mi NE of the Hyde No. 1 well, but was not reported in the log of the Hyde well.

DESCRIPTION AND HISTORY OF DRILL HOLES AND MEASUREMENTS

Well locations are shown on *Fig. 1*, a reproduction of part of Plate II from Dane (1935). Drilling was started on the Crescent Eagle No. 1 well, located in Sec 4, T 22 S, R 19 E, in 1920 and was continued intermittently by cable tools until September 1941, when drilling stopped at 4,006 ft. A log of the well is given by Dane (1935, p. 162-164). The hole was dry to 497 ft when the temperatures were measured by the writer on August 10, 1942. The hole was bridged or plugged below 1,950 ft, and deeper measurements could not be made.

The Brendell No. 1 well, located 400 ft S 10° E of Crescent Eagle No. 1, Sec 9, T 22 S, R 19 E, was started in September 1928. Drilling continued intermittently until late in 1932 with cable tools and was discontinued at 4,125 ft. This well was drilled as an exploratory test for oil and was producing a very small amount of gas and fluid when the writer measured the temperatures.

Formations penetrated in drilling are like those of the Crescent Eagle, but the top of the salt is a few feet deeper. The hole was plugged, and observations below 1,500 ft could not be obtained. Temperatures were also measured in this well by E. W. Henderson (unpublished data), U. S. Geological Survey, in December 1933.

Reeder No. 1 well, located 218 ft N 40° W of Crescent Eagle No. 1 and in the same section, was spudded in May 5, 1942. Drilling was suspended August 3, 1942, at 4,207 ft. Drilling was resumed in 1948, and the well was completed September 26, 1949, at 10,350 ft, still in salt of the Paradox Member of the Hermosa Formation. This rotary well was drilled by the Bureau of Mines and the Geological Survey for the Defense Plant Corporation to evaluate the deposits for magnesium. It was reentered and deepened later as an exploratory tests for oil, but there was no production. A complete log and other drilling information to 4,207 ft is given by Severy et al (1949). A bottom-hole temperature was obtained August 4, 1942, and a complete set of temperatures October 4 to 6, 1942, by the writer.

Balsley No. 1-C well, located in Sec 32, T 23 S, R 21 E, nearly 15 miles southeast of the Reeder No. 1 well, was started December 18, 1930. Drilling

ceased October 27, 1932, at 6,120 ft, still in salt of the Paradox Member. This well was drilled by cable tools as an exploratory test for by the Utah Southern Oil Company. The only oil and gas found was a showing at 3,410 and 3,436 ft. Temperatures were first measured in this well by W. B. Lang (unpublished data) of the Geological Survey on September 18, 1931. Next measu-

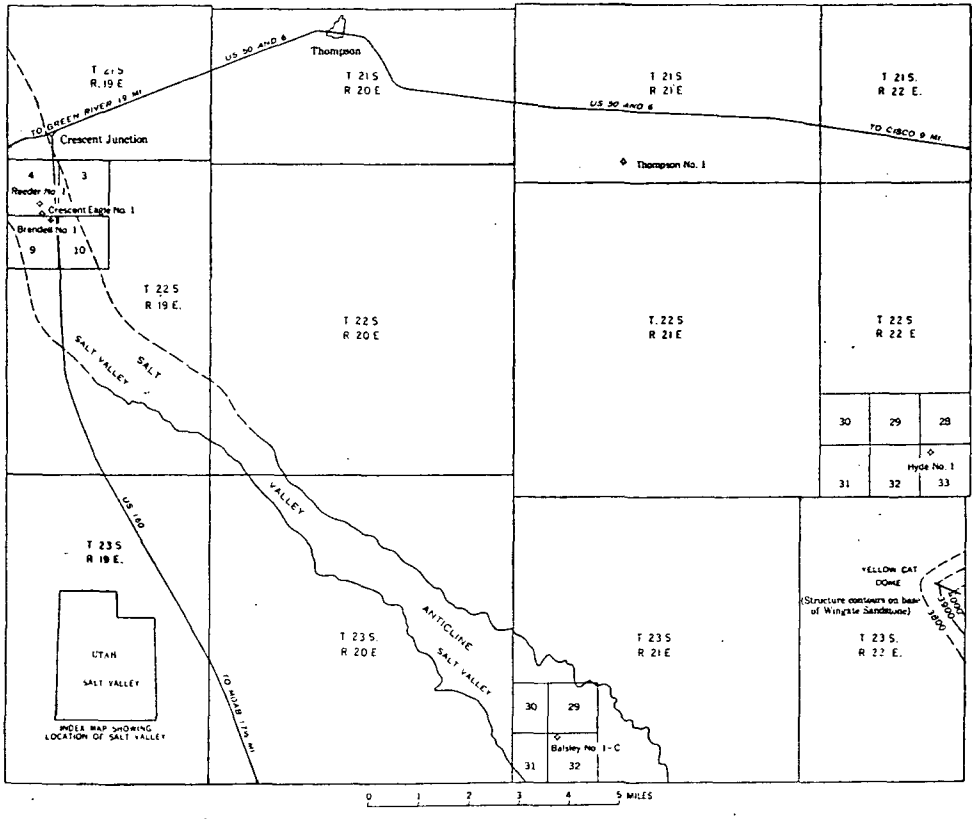


Fig. 1 - Map showing the general location of the area, the structure, and the locations of wells on the structure and in the adjacent area. After Dane (1935).

rements were by E. W. Henderson (Unpublished data) on December 7 and 8, 1933. In July 1936, a third attempt was made by Henderson and C. E. Van Orstrand (unpublished data), but the well was plugged below 3,000 ft, having been abandoned in August 1935.

The Hyde No. 1 well, located in Sec 33, T 22 S, R 22 E, about 18 mi ESE of the Reeder No. 1 well, was started October 1, 1935. Drilling ended March 31, 1937, at 6.715 ft. This well was drilled with cable tools by the Utah Southern Oil Company as an exploratory test for oil. It was a dry hole. According to the interpretation of the drilling log by E. W. Henderson (unpublished data), the well begins in shale of the Summerville Formation (Jurassic) and bottoms in the Cutler Formation (Permian). A revised interpretation of this log is shown on *Fig. 6*. Temperatures were first measured in this well by Hen-

was idle. In July 1936, Henderson and Van Orstrand (unpublished data) attempted another measurement of the well, but the hole was bridged or plugged below 1,000 ft and no deeper measurements were possible.

MEASURING EQUIPMENT

A steel tape with a container for holding three thermometers and an attached weight was used by Lang and Henderson for some of their temperature measurements in the deep wells. The thermometers in their container were also attached to the sand line for deeper observations.

Wire-line equipment designed and built in the equipment shops of the Geological Survey was used for the other temperature measurements. A description of the equipment, with modifications and applications, is given by Van Orstrand (1930). It is possible with this equipment to lower three maximum thermometers to more than 9,000 ft in an open hole without undue difficulty.

TEMPERATURE-DEPTH PROFILES AND INTERPRETATIONS

Temperature-depth profiles, hereafter termed T-D profiles, for the five wells under discussion are shown as *Figures 2 to 6*. Mean annual air temperature (M.A.T.) is taken from U. S. Weather Bureau (1960). Gradient lines having one depth zero were determined by the two-point method. A summary log is given on each figure.

The observations were adjusted by two methods to obtain the geothermal constants, by the methods of least squares and by using the temperature and depth at two selected points. The latter method may be expressed as

$$b = (T_b - T_a) / (d_b - d_a). \quad (1)$$

Each solution gives the constants for a straight line whose equations is

$$T = a + b\,d \quad (2)$$

where T is temperature at depth d; a is intercept on the temperature axis and is therefore the computed temperature at zero depth in the earth; b is the slope of the line, which is the geothermal gradient.

Another constant, which has been termed e, is obtained from the difference between mean annual temperature of the air and constant a,

$$e = (\text{M.A.T.} - a). \quad (3)$$

It may be regarded as the temperature difference required to maintain heat flow from the earth across the surface-air contact. Constant e has long been recognized and applied. Everett (1862, 1904) noted that the difference between the temperature of the ground and of the air at sea level in the humid climate of England was about —1.5°F. Benfield (1939) found e to be about —2.2°F at Holford bore near Liverpool, England. He considered this to be « ...additional evidence corroborating the systematic difference found by others ». Bullard (1939) applied a difference of —1.8°F for geothermal gradient determinations from South African temperature measurements. Krige (1939) reported observations of temperature in a South African well with an e value of —2.2°F.

Spicer (1941) reported an e value of —0.4° F obtained from temperatures measured in mines at Grass Valley, California. Van Orstrand (1951) reported an average value of —1.54° F for e that was obtained from more than 500 determinations in oil field areas. The computations by Spicer for Lang (1937) showed the value of e to be about —1.8°F in a New Mexico well. Recent measurements by Penrod et al (1960) reported e to be —1.2°F at Lexington, Kentucky. Cook (1961) reported e to be —1.2°F at Resolute, Northwest Ter-

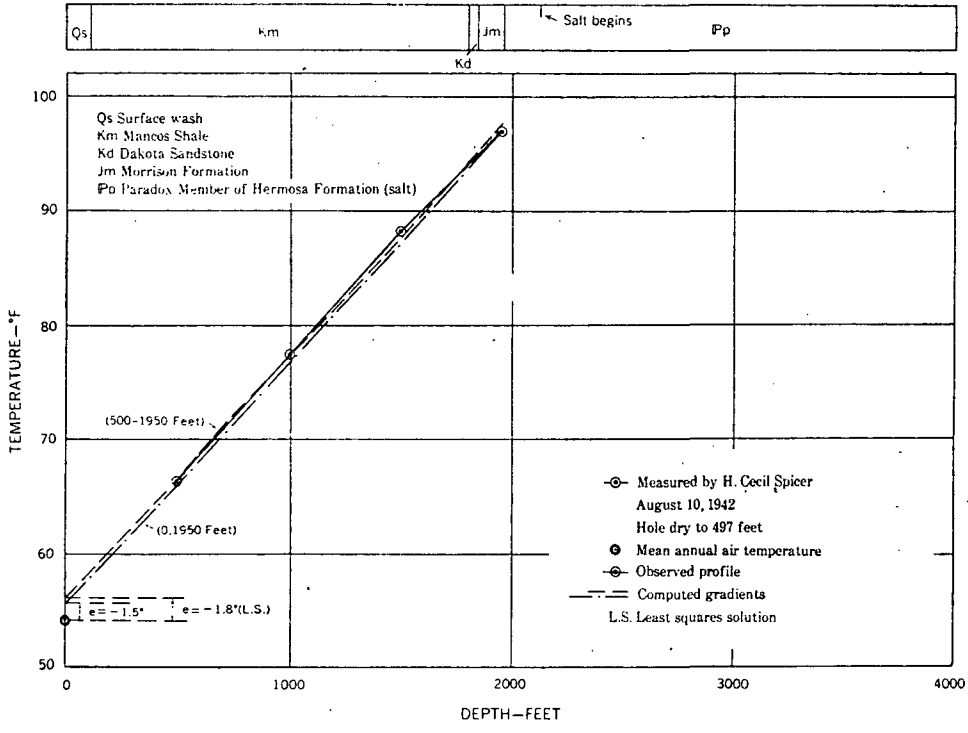


Fig. 2 - Temperature-depth profile of Crescent Eeagle No. 1 well, located on anticlinal structure.

ritories, Canada. Bullard and Niblett (1951) stated that « ... the extraploated surface temperature should agree with the observed temperature near the surface ». The observed surface temperatures they gave were derived from observations of air temperature at meteorological stations nearby. The theory for the calculation of soil temperatures at various depths from ordinary synoptic air temperatures is given by Gutman (1960), Penrod et al (1960), Lettau and Haugen (1960), Carslaw and Jaeger (1959), Ingersoll et al (1954), and others.

In the two-point solution, temperature at zero depth in the ground is assumed to be (M.A.T. + e)°F. Intervals and points used for the computation of the geothermal constants for the T-D profiles are given in Table 1. Values of e, obtained from the least squares solution, are indicated by « L.S. » on the figures. Values of the geothermal gradients in the formations of the area, computed by both methods, are given in Table 1. The probable er-

ror r_b of the gradient, from the least squares solution, is also given in Table 1.

Table 1 - *Computed geothermal gradients in formations of the area.*

Well	By least squares: Interval feet	Geothermal gradient *b* F/ft	Probable error $r_b \times 10^5$	By $(T_b - T_a)/(d_b - d_a)$ (Equation (1) p. 9): Depths feet	Geothermal gradient *b* F/ft
Mancos Shale, Dakota Sandstone, Morrison Formation					
Reeder No. 1	100 - 2,000	0.01743	± 38	0, 2,100	0.02053
Crescent Eagle No. 1	500 - 1,950	0.02117	± 36	0, 1,950	0.02119
Brendell No. 1	500 - 1,500	0.02160	± 33	0, 1,500	0.02200
Paradox Member of Hermosa Formation above salt					
Balsley No. 1-C	100 - 900	0.01621	± 11	0, 900	0.01723
Paradox salt					
Balsley No. 1-C	900 - 3,000	0.00675	± 7	900, 3,000	0.00676
Reeder No. 1	2,100 - 3,095	0.00882	± 17	2,100, 3,095	0.0861
Section off anticline					
Hyde No. 1	100 - 5,750	0.01037	± 25	0, 5,500	.01064

An inspection of *Figures 2 to 6* and *Table 1* shows the following:

1) Observed temperatures in the Crescent Eagle well differ by very small amounts from the gradient line obtained by least squares. The gradient line obtained for the points (0, 1,950 ft) is closely adjacent to the least squares gradient, and the gradients are nearly identical in numerical value. The value of *e* is —1.8°F and only —0.3°F above the mean value, —1.5°F (Van Orstrand, 1951).

2) Geothermal gradients in the Crescent Eagle, Brendell (later measurements), and Hyde wells are essentially linear and without a pronounced change in slope.

3) Geothermal gradients in the Reeder and Balsley wells show a pronounced change in slope at the Paradox salt boundary. Such a change in slope would be expected also in the Crescent Eagle and Brendell wells had it been possibile to obtain temperatures in the deeper salt section.

4) Geothermal gradients in the Paradox salt sections of the Reeder and Balsley wells are less steep than those in the two sections above. In the Reeder well the section consists of the Mancos, Dakota, and Morrison Formations, and in the Balsley it consists of the Paradox Member of the Hermosa Formation. The ratio of gradients is approximately 1 : 2.5.

5) The geothermal gradient in the Paradox Member of the Hermosa Formation of the Balsley well is less steep than those in the section of Mancos, Dakota, and Reeder wells.

6) The geothermal gradient in the Paradox salt is steeper in the Reeder than in the Balsley well.

7) If the gradients in the Reeder and Balsley wells may be considered representative of geothermal conditions in the anticlinal area, it appears that the geothermal gradient varies with location on the anticline. The cause of this variations is not apparent.

8) Geothermal gradients in the two well sections above the salt are steeper than the gradient in the section off the anticline in the Hyde well. The ratio is approximately 2 : 1.

9) The geothermal gradient obtained by least squares in the Mancos, Dakota, and Morrison section of the Reeder well 0.01743°F/ft, differs greatly in value from those obtained in this same section of the Crescent Eagle and Brendell wells, 0.02117 and 0.02160°F/ft, respectively. Also note that the value of e is —7.9°F, and that the separation of the above gradient from the one computed for points (0, 2, 100 ft) is large.

10) Temperatures in the Brendell well, as measured by Henderson (unpublished data) in 1933, depart widely and erratically from the geothermal gradient computed by least squares for this T-D profile. After the well stood idle for about 9 years, temperatures were remeasured in this well by the writer. These temperatures depart but little from the geothermal gradient computed by least squares. The gradient has steepend over the idle period, increasing from 0.01937 to 0.02160°F/ft. Note also that the value of e followed this change and has been reduced from —6.1°F to — 1.8°F. A gradient line for points (0, 1,500 ft) is not shown, as it coincides with the one for (500-1,500 ft) except near the temperature axis.

(11) In the Balsley well the geothermal gradient by least squares in the Paradox Member of the Hermosa Formation became steeper with increasing idle time. It was 0.01437°F/ft when measured about 14 months after the well was completed, and 0.01621°F/ft when measured about 2-1/2 years later. Note that, accompanying this steepening of the gradient, the value of e decreased from —3.7°F to — 2.2°F. Also note that as the idle time increased, the gradients by least squares approached coincidence ith the gradient for points (0, 900 ft).

12) Observed temperatures in the Hyde well depart rather erratically, and frequently somewhat widely, from the geothermal gradient determined by least squares. Such departures in the geothermal values are to be expected from the history of this well. Nevertheless, this gradient of 0.01037°F/ft is considered representative as the gradient computed for the points (0, 5,500 ft) is only a little steeper, 0.01064°F/ft. The value of e is —2.6°F.

These comparisons, statements, and conclusions are derived from the above observations:

The history of the Crescent Eagle well indicated it had a T-D profile which closely represented predrilling undisturbed temperature conditions in the earth. The observed temperatures differed only slightly from the gradient computed by least squares. Table 1 shows that the geothermal gradients, computed by both methods, are numerically almost identical. Furthermore, they are nearly in coincidence as seen on Figure 2. Computed and mean values of e differ by only 0.3°F on this T-D profile. As this is essen-

The Brendell well had been idle about a year when first tested in 1933 by Henderson. These temperature values are widely dispersed about the gradient computed by least squares. The gradient for points (0, 1,800 ft) is not included on Figure 3, if it as it would depart markedly from the gradient by least squares. The computed value of *e* is —6.1°F, which is —4.6°F higher than the mean value. The well had been idle almost 10 years when the writer remeasured the temperatures. The later measurements differ bf only small amounts from the gradient computed by least squares. The gradient computed for points (0, 1,500 ft) is nearly in complete coincidence with the gradient by least squares and is therefore omitted from *Figure* 3. The value of *e*, as mentioned earlier, is —1.8°F, the same as that of the Crescent Eagle well.

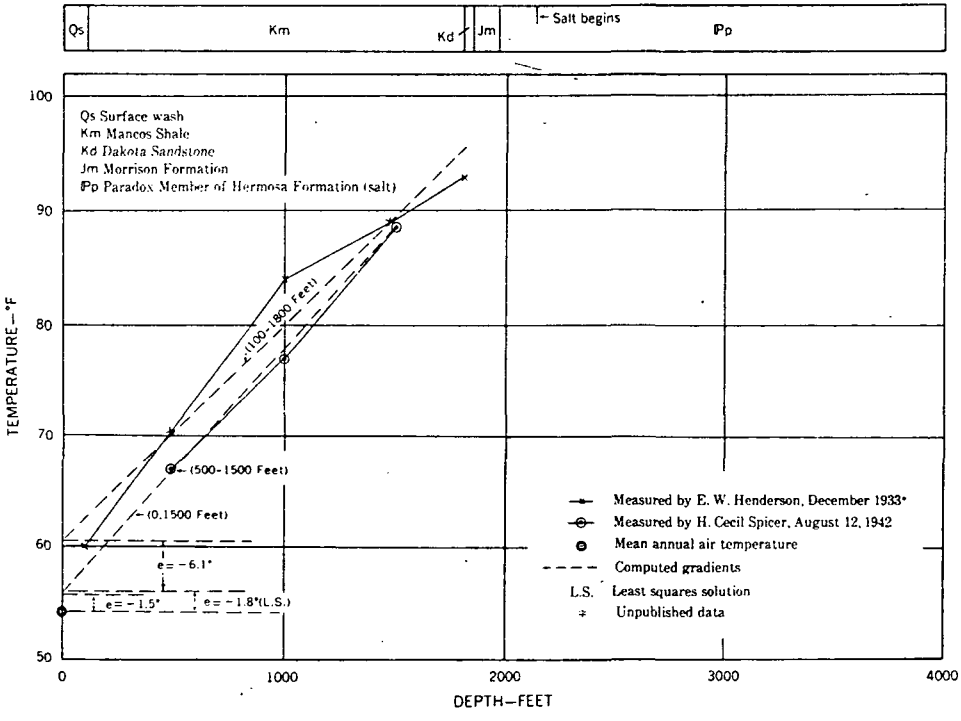


Fig. 3 - Temperature-depth profile of Brendell No. 1 well, located on anticlinal structure.

Application of these principles is next made in the Balsley well (*fig.* 5). Temperatures were measured in the section above the Paradox salt at two different times. Measurements by Lang (unpublished data) were only in the Paradox salt. Because the gradient lines computed by least squares nearly coincide with the observed temperatures, they are omitted from *Fig.* 5, but their application will be evident. The observed values depart but little from the gradient obtained by least squares in the mesareuments both of Henderson and of Henderson and Van Orstrand (unpublished data). Both gradients by least squares diverge somewhat from the gradient line obtained from the points (0, 900 ft). The value of *e* (observation 11 above) has redu-

longer interval perhaps 5 to 10 years, the gradient in the Hermosa Formation would probably coincide with the gradient for points (0,900 ft). Another principle may now be added to those given above: As the idle time for a drilled well increases, the geothermal gradient steepens and approaches the gradient for points (0 and deepest measurement). « Deepest measurement » is restricted and does not include abrupt changes in slope of the gradient, such as were found in the Balsley and Reeder wells.

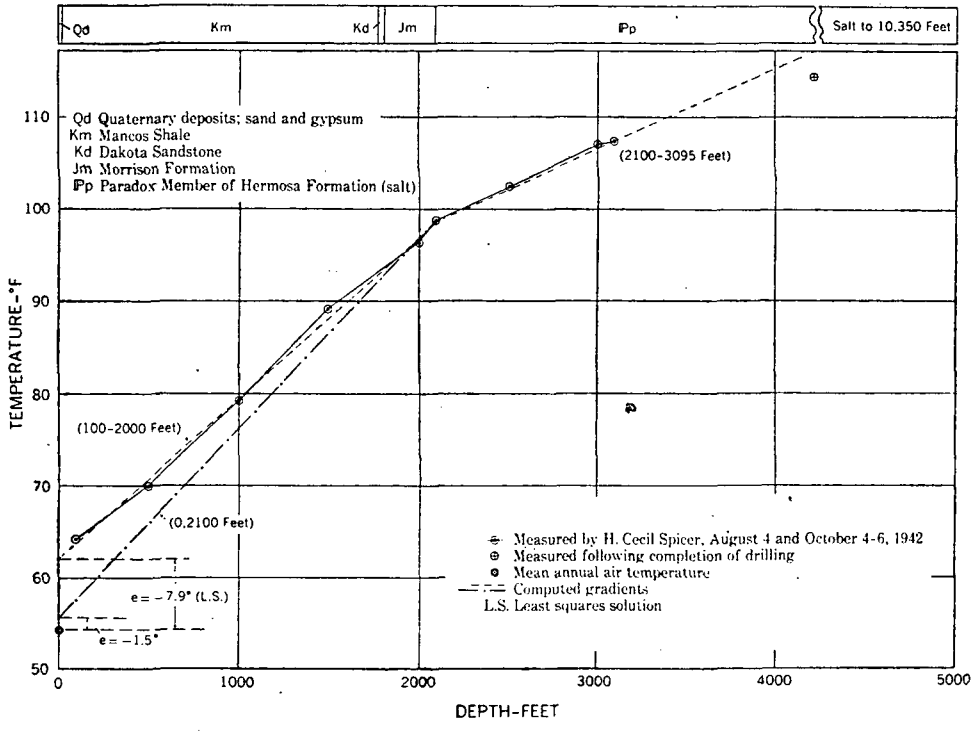


Fig. 4 - Temperature-depth profile of Reeder No. 1 well, located on anticlinal structure.

The principles given above are applied next to the Reeder well (*Fig.* 4), in the section of Mancos, Dakota, and Morrison, above the Paradox salt. Temperatures in this well were disturbed primarily by the drilling fluid used in the rotary method. The fluid had a temperature near 90°F during the entire drilling period. Circulation of this fluid in the hole caused temperatures to rise in its upper part and to fall in the lower part. Consequently, more heating than cooling took place. The zone of this change in temperatures is plainly visible on the T-D profile between 1,500 and 2,100 ft. That cooling took place in the salt is indicated by the difference of approximately 3.0°F between the bottom-hole temperature obtained when drilling stopped and the computed temperature for that depth. The idle period prior to temperature measurements was only 2 months. Such a short time is inadequate for the entire well to return to predrilling undisturbed values, as has been shown in previous examples.

The observed temperatures are dispersed relatively close to the gradient obtained by least squares, but the value of e, —7.9°f, is large; it is

—6.4°F above the mean value. A large divergence exists between the gradient by least squares and the one for points (0, 2,100 ft). However, the gradient for the points (0, 2,100 ft) is closely representative of what the undisturbed gradient should be in the Reeder well. A comparison with the gradients in the Crescent Eagle and Brendell Wells in *Table* 1 verifies this. As these wells are close together and are nearly identical in geology and location on the structure, they would be expexted to have identical gradients. The large departure of the value of *e* from the mean and the large divergence between the gradients indicates that this well has disturbed temperatures in the section above the salt. This corresponds with known conditions in the well.

In the application of these criteria to the Hyde well (*Fig.* 6), the following conditions are noted: The observed temperatures depart from the geothermal gradient obtained by least squares in a manner indicating that heating has taken place in the upper and lower sections and cooling has occurred in the middle section of the well. The gradient obtained from points (0, 5,500 ft) is located close to the gradient by least squares. The value of *e* is —2,6°F, —1.1°F above the mean. In the 2 months intervening between measurements, the temperature at 100 ft dropped 0.7°F. Temperatures were somewhat di-

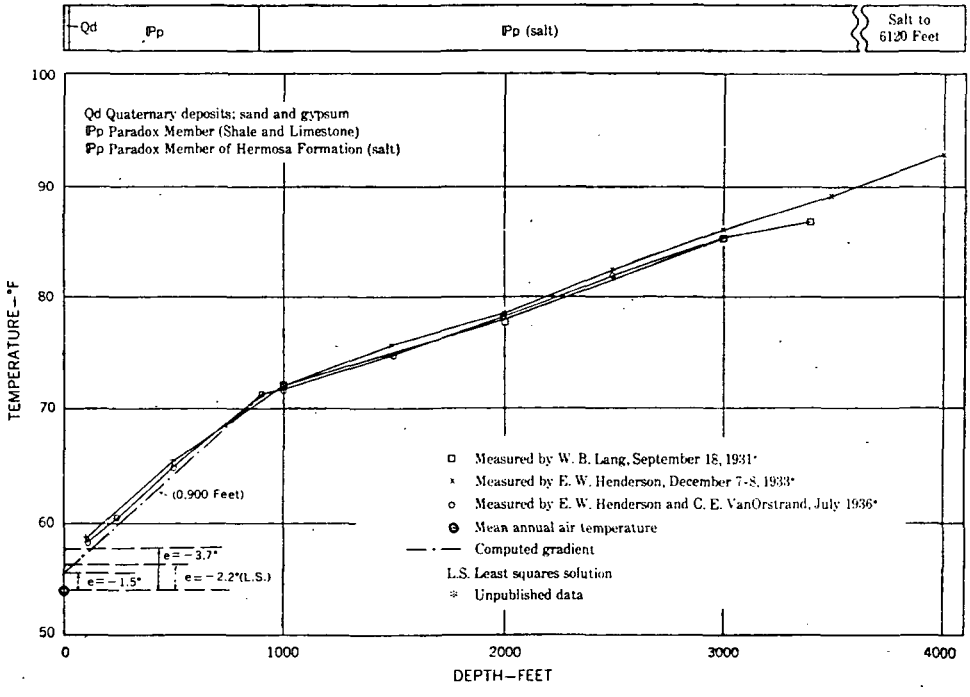


Fig. 5 - Temperature-depth profile of Balsley No. 1-C well, located on anticlinal structure.

sturbed in this well, but not to the extent found in the Reeder well. The difference is largely due to the drilling methods employed. The geothermal gradient is considered to be closely representative of geothermal conditions here. No abrupt change, such as those found in the Reeder and Balsley wells at the boundary between salt and overlying formation, occurs in the

slope of the geothermal gradient at any of the formation boundaries in the Hyde well.

A comparison of all the geothermal gradients shows that the gradient for the Hyde well, off the anticline, is lower than those in the other four wells on the anticline, which are in the formations above the Paradox salt.

Temperatures in the Paradox salt section of the Balsley well (*Fig.* 5) seem to have been undisturbed by drilling. Temperatures measured by Henderson and Van Orstrand in 1936 (unpublished data) are almost the same as Lang obtained in 1931 (unpublished data), but the slightly higher temperatures obtained by Henderson in 1933 (unpublished data) cannot be explained from the available information. Gradients computed by both methods given in *Table* 1 are nearly the same. Temperatures in the Paradox salt section of the Reeder well were also very close to predrilling values when measured. If the temperature measurement at 3,095 ft had not been about 0.5°F low, thus departing from the linearity held by the three other temperatures measured in the salt, both computed gradients would have been identical. As it is, the gradient computed for two points is slightly low. Therefore, the gradient computed by least squares is believed to represent thermal conditions better in the Paradox salt.

HEAT FLOW.

The methods used by Bullard (1939), Benfield (1939), Spicer (1941), Birch (1945), and others in computing heat flow to the surface are all based on heat-conduction theory (Carslaw and Jaeger, 1959). When the uncertainties in the measured values are negligible, the method used by Bullard and Benfield gives somewhat better results, but with uncertainties in the measurements of temperatures in the wells and in the thermal conductivities of the rocks, the method used by the other authors gives a satisfactory estimate.

Heat flow is determined by the product of geothermal gradient and thermal conductivity. Thermal conductivity of the formations in the Salt Valley area was determined from measurements made on a large number of drill cores and on outcrop samples. It was measured on equipment similar to that described by Clark (1941) and Birch (1950). Mean thermal conductivity of a series of rocks is determined with the formula given by Carslaw and Jaeger (1959).

$$1/K = \Sigma_i \, w_i/K_i \qquad (4)$$

where

K = mean conductivity over the entire interval,
K_i = conductivity of unit homogeneous bed,
w_i = (bed unit thickness) (entire interval thickness).

THERMAL CONDUCTIVITY.

Cores and outcrop samples may not be completely representative of actual thermal conductivities in a drill hole, but neither method nor equipment had been developed for *in situ* measurements of thermal conductivity in drill holes when these studies were begun. Furthermore, as most oil

wells and deep drill holes are cased throughout, and casing is cemented and mudded in place, *in situ* measurements are not feasible.

Thermal conductivities determined in the laboratory for a series of cores and samples from the Utah-Colorado area adjacent to that being studied are given in Appendix I. All values of thermal conductivity are tabulated in hundredths of a unit of K (cal/cm sec°C) as reported to the writer However, it should not be implied that the values are considered this precise. Some repeat measurements of thermal conductivity on selected samples indicated a variable accuracy which depended on the operator and condition of the equipment. Perhaps ±5 per cent is a fair estimate of the overall accuracy of the conductivity measurements.

Thermal conductivities K used in computing the mean thermal conductivity K for the various sections are given in Appendix II. In the Reeder well the lithology and thicknesses of the formations encountered in drilling were taken from the log by Ralph H. King (Severy et al., 1949). A detailed log was not available for the Crescent Eagle and Brendell wells. But the upper section above the salt is similar to and slightly thicker than in the Reeder well. A thin bed of the Paradox Member of the Hermosa Formation was reported above the Paradox salt. A log of the Balsley well provided by D. F. Russell (personal communication, 1959), showed the salt section to be slightly different in compostion from that in the Reeder well. An interpretation of the drilling log for the Hyde well is shown on *Figure 6*. The deepest formation reached in the Hyde well, indicated on the log as (X?), may be granitic rock or wash, but it was not reported as such by the driller.

Heat flow values for all the wells, and terms used in their determinations, are summarized in *Table* 2.

Table. 2 - *Summary of values for mean thermal conductivity K, geothermal gradient b, and heat flow.*

Geological material	K x 10^3 cal/cm sec °C	b °C/km	Heat flow μcal/cm² sec
	Reeder N° 1		
Formations overlying salt	3.54	37.4	1.32
Paradox salt	8.44	15.7	1.32
	Crescent Eagle N° 1		
Formations overlying salt	3.38	38.6	1.30
	Brendell N° 1		
Formations overlying salt	3.38	39.4	1.33
	Balsley N° 1-C		
Formations Mbr. Hermosa Fm.	3.51	31.4	1.10
Paradox salt	9.00	12.3	1.11
	Hyde N° 1		
Morrison through Hermosa Fms.	5.23	19.4	1.01

SUMMARY AND CONCLUSIONS.

Some interesting information and important conclusions have developed from the findings of this study of earth temperatures in drill holes of Grand County, Utah. It was fortunate that such a location was chosen for drilling a new well, for the following reasons: The location was on a previously drilled anticlinal structure. The moderately thick sediments are underlain by salt, a very good conductor of heat. A rather varied group of geological formations occur here. Two wells were present within a few hundred feet of the new well. In one of these wells temperatures had been measured previously; the other well had been idle for a long time. A well in which temperatures had been measured several times was located in a different part of the structure and another well was located a short distance from the new well and off the structure. Also, tests of thermal conductivity on the core and outcrop samples made it possible to evaluate the much earlier observations and to determine the heat flow.

Geothermal measurements in drill holes are of very questionable value, unless temperatures have returned to their predrilling state throughout the hole. This very fundamental point has been overlooked or neglected in most published reports on geothermal measurements in wells.

It has been assumed previously that drilling with cabletools produces only a small disturbance to temperatures in a well. That this may be a very misleading, or even erroneous assumption will be seen by reference to the measurements by Henderson (unpublished data) in the Brendell well, *Figure* 3, and by Henderson and others in the Hyde well, *Figure* 6.

Observations in the wells tested are inadequate to prove that definite changes occur in slope of the geothermal gradient at all boundaries between formations having different K values. When the formations are thick and

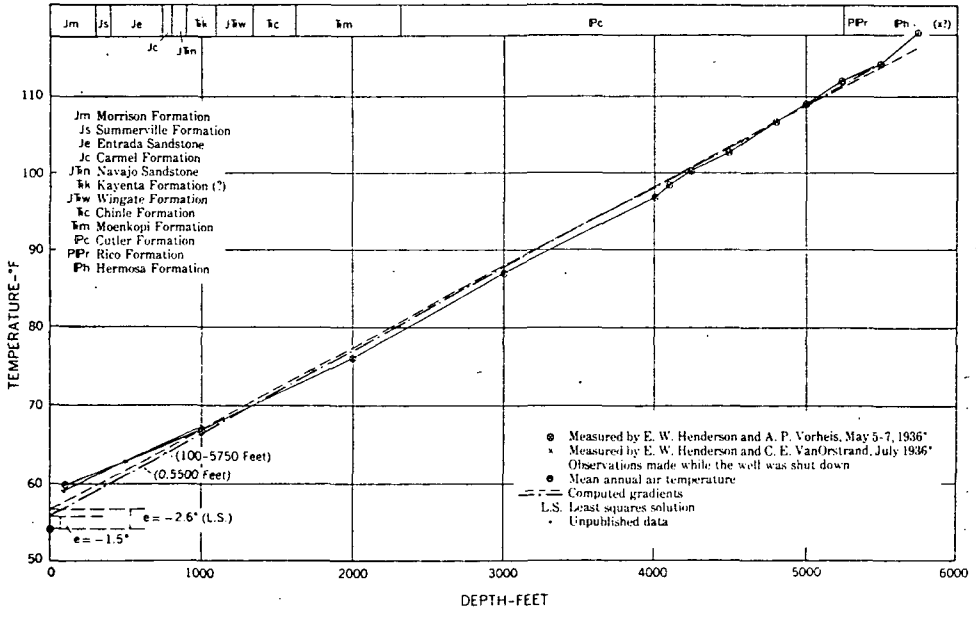


Fig. 6 - Temperature-depth profile of Hyde No. 1 well, located east of the Salt Valley anticline and off the structore.

the difference between their K values is large, as in the Reeder and Balsley wells (*Figg. 4 and 5*), there is a pronounced change in the slope of the geothermal gradient. When the differences between K values of adjacent formations is small, however, no changes in slope of the geothermal gradients is indicated. If the formations are thin and the difference between K values is large, no change in slope of the geothermal gradient is indicated. Such arrangements of the formations are found in the Hyde well (*Fig.* 6). The Paradox Member contains beds of shale, anhydrite, etc., but the geothermal gradients in it, as shown by the Reeder and Balsley wells, show no change in slope, thus indicating no apparent change in thermal conductivity within the section measured.

Thermal conductivities of the natural salt cores from the Reeder well (*Table* 2) are lower than values given elsewhere (Birch et al, 1942; Herrin and Clark, 1956; and others). The variations in these measured conductivities of salt seem to depend more on crystal arrangement and size in the samples tested than on composition when the individual measurements are compared. For example, the conductivity of sylvite in one core is 9.33×10^{-3} cal/cm sec °C, but in another it is 11.03×10^{-3}. Crystals of halite that are 7 inches in diameter (Hite and Gere, 1958, p. 223) have been measured from this area.

Moisture has an appreciable effect on the K values of certain rock samples. This is evident (Appendix II) for the Salt Wash Sandstone Member of the Morrison Formation; limestone of the Summerville Formation; Brushy Basin Shale Member of the Morrison Formation; and Mancos Shale. The area from which these rocks and cores were collected is semidesert. Natural water content of rocks from such an area is low. K values measured on dry samples that are more nearly in the natural state were used in most instances for the heat-flow calculations.

Sandstones of the area have the greatest range of K values, varying from 2.04×10^{-3} for the Burro Canyon Formation (Cretaceous) to $11.97 \times \times 10^{-3}$ for the Dakota with values for various sandstones intervening. A comparison can be made between the K values of outcrop sample and core for two sandstones. For the Entrada Sandstone (Jurassic) mean values are 2.95×10^{-3} and 6.05×10^{-3} and for sand of the Moenkopi Formation (Triassic and Triassic (?)) 5.04×10^{-3} and 6.34×10^{-3} respectively. A larger group of samples from each would give a much better comparison.

The geothermal gradient and heat flow are highest in the graben area and somewhat lower in the area of the exposed Hermosa Formation of the anticline. Lowest geothermal conductivity and disposition, apparently exerts a definite and pronounced effect on the heat flow in the anticlinal area. Heat-flow values similar to those in the Paradox salt were reported by Herrin and Clark (1956) in the Salado salt of the New Mexico-Texas area: 1.0 to 1.3 μ cal/cm^2 sec.

A temperature-depth profile may be examined for undisturbed temperature conditions, using the following as criteria: (1) the observed temperature differ only by small amounts from those computed by least squares; (2) the geothermal gradient computed by using temperatures and depths at two selected points is nearly in coincidence with the gradient computed by least squares; (3) the values of e is very close to the mean value of —1.5°F; (4) the geothermal gradient in a drilled well becomes steeper with increased idle time as temperatures approach the undisturbed pre-drilling values.

Appendix I - *Thermal conductivity of rocks of Utah and Colorado*

Speciment				Conductivity K x 10^3(cal/cm sec °C)		
Material and geologic unit	Place [a] Collected	Number	Kind[b]	Range		Mean
Chert, Summerville Fm.	ANM	2	S	10.10;	10.47	10.28
Conglomerate, Shinarump Mbr. of Chinle Fm.	ANM	2	S	4.11;	5.13	4.62
Limestone, Summerville Fm.	ANM	1	S	——		6.75[c]
Limestone, Summerville Fm.	ANM	2	S	5.42;	6.47	5.94
Sandstone, Salt Wash Mbr. of Morrison Fm.	ANM	4	S	8.95 -	9.37	9.15[d]
Sandstone, Salt Wash Mbr. of Morrison Fm.	ANM	2	S	3.12;	3.36	3.24
Sandstone, Dakota Ss.	ANM	5	S	9.20 -	11.97	10.52[d]
Sandstone, Entrada Ss.	ANM	3	S	2.36 -	3.99	2.95
Sandstone, Burro Canyon Fm.	ANM	1	S	——		2.04
Sandstone, Chinle Fm.	CR	7	S	3.92 -	5.76	4.75
Sandstone, Wingate Ss.	CR	2	S	3.27;	3.30	3.28
Sandstone, Kayenta Fm.	CR	8	S	2.48 -	5.09	3.86
Sandstone, Moenkopi Fm.	CR	2	S	4.96;	5.12	5.04
Sandstone, Navajo Ss.	CR	2	S	3.19;	3.30	3.24
Shale, Brushy Basin Mbr. of Morrison Fm.	ANM	2	S	6.03;	6.62	6.32[c]
Shale, Brushy Basin Mbr. of Morrison Fm.	ANM	1	S	——		4.59
Shale, Mancos Sh.	ANM	2	S	2.96[c];	3.23	3.23[c]
Shale, Mancos Sh.	ANM	1	S	——		2.70[d]
Shale, Carmel Fm.	ANM	4	S	2.69 -	6.18	4.11
Sandy shale, Summerville Fm.	ANM	1		——		3.70
Limestone, shaly, Cutler Fm.	CP	1	C	——		5.73
Sandstone, silty, Cutler Fm.	CP	9	C	4.68 -	5.96	5.19
Sandstone, Cutler Fm.	CP	1	C	——		6.28
Sandstone, shaly, Cutler Fm.	CP	2	C	5.48;	5.72	5.60
Sandstone, Rico Fm.	CP	2	C	4.82;	4.85	4.84
Sandstone, Entrada Ss.	CP	9	C	3.31 -	7.90	5.21
Sandstone, Moenkopi Fm.	CP	2	C	6.45;	7.10	6.78
Sandstone, Summerville Fm.	CP	3	C	3.69 -	4.03	3.92
Sandstone, Salt Wash Mbr.	CP	29	C	3.24 -	7.18	4.88
Shale, Cutler Fm.	CR	1	C	——		2.14
Shale, silty, Cutler Fm.	CR	3	C	2.88 -	3.78	3.43
Siltstone, Cutler Fm.	CR	3	C	3.66 -	4.54	4.05
Siltstone, Cutler Fm.	CP	2	C	6.05;	7.21	6.63
Siltstone, Chinle Fm.	CP	2	C	4.64;	5.77	5.21

Speciment				Conductivity K x 10^3(cal/cm sec °C)	
Material and geologic unit	Place [a/] Collected	Number	Kind[b/]	Range	Mean
Siltstone, Moenkopi Fm.	CP	1	C	———	8.32
Siltstone, Salt Wash Mbr.	CP	3	C	1.97 - 4.41	3.38
Siltstone, Summerville Fm.	CP	6	C	2.89 - 6.52	4.28
Sandstone Salt Wash Mbr.	CP	21	C	2.24 - 8.32	5.30
Sandstone, Summerville Fm.	CP	1	C	———	2.81
Salt, Paradox (containing halite, sylvite, carnallite, and anhydrite	TU	14	C	9.33 - 12.39	10.81

a/ ANM - Arches National Monument, near Moab, Utah; CR - Colorado River, near Moab, Utah; CP - Colorado Plateau, near Montrose, Colorado; TU - near Thompsons, Ut.
b/ S - Hand sample; C - Core.
c/ Wet.
d/ Partly saturated.
e/ Thin disc; chipped edge.

Appendix II - *Source of K values*[a/]

[For rock types not collected or tested, values of thermal conductivity for similar roks were taken from published tables (Birch et al., 1942].

	K x 10^3 cal/cm sec °C
Reeder No. 1	
Mancos Shale - best value	3.23
Dakota Sandstone - average value	10.52
Salt Wash sandstone - average value of partly saturated	9.15
Shale - median value of Brushy Basin shale and of Salt Wash silstone and mudstone	5.75
Limestone - from Birch et al. (1942)	4.00
Paradox salt	
Shale - mean value of Cutler Formation silty shale	3.26
Sandstone - mean value of Morrison Formation	9.15
Salt - mean value	10.61
Anhydrite - only a few streaks included with salt.	
Dolomite - only a few streaks included with sandstone	
Crescent Eagle No. 1 and Brendell No. 1	
Same as in Reeder No. 1 except Hermosa Formation - mean value determined from sandy limestone, K = 5.94, and shale, K = 2.72	3.14
Balsley No 1-C	
Sandstone - same as in Reeder No. 1 (only 4 ft in well, so value used is unimportant.)	
Gypsum - from Birch et al. (1942)	2.98
Anhydrite - from Birch et al. (1942)	10.80
Limestone - from Birch et al. (1942)	4.00
(only 2 ft in well, so value used is unimportant.)	
Paradox salt - same as for Reeder well.	

Hyde No. 1

Shale - median value of Brushy Basin, Mancos, Carmel, Summerville shales, Summerville silstones and mudstones, and Salt Wash silstones used in upper section to 1.348 ft.	3.23
Shale - mean value of Cutler, Chindle, Moenkopi siltstones used in lower section	4.96
Limestone - mean value of Summerville Formation high values	6.61
Sandy shale - mean value of Carmel, Summerville, Cutler Formations	3.70
Sandstone - average value of Morrison, Summerville, Entrada Formations used in upper section to 1.348 ft	6.05
Sandstone - average value of Navajo, Kayenta, Wingate, Chinle, Moenkopi, Cutler, Rico Formations used in lower section	6.34
Talc - from Birch et al. (1942)	2.20
Sandy limestone - average of Summerville Formation values and values from Birch et al. (1942) used in the upper section to 1.348 ft	5.45
Sandy limestone - mean value of Summerville Formation used for middle section to 2,300 ft	6.61
Sandy limestone - Summerville Formation high value used in deep section	675

a/ From Appendix I unless source is given.

Appendix III - *Temperature observations in wells.*

Well	Depth-feet	Temperature °F	Location
Crescent Eagle No. 1	100	60.1	Sec. 4, T 22
	500	66.5	S, R 19 E
	1,1000	77.2	measured by
	1,500	88.3	H. Cecil Spicer
	1,950	97.0	8-10-42
Brendell No. 1	100	62.7*a/*	Sec. 9, T 22
	500	67.1	S, R 19 E
	1,000	77.0	measured by
	1,500	88.7	H. Cecil Spicer
			1942
Reeder No. 1	4,209	114,3	Sec. 4, T 22
			S, R 19 E
			measured by
			H. Cecil Spicer
			8-4-42
Reeder No. 1	100	64.1	As above;
	500	70.0	measured by
	1,000	79,2	H. Cecil Spicer
	1,500	89,2	10-4 - 6-42.
	2,000	96,3	
	2,100	98.8	
	2,500	102.4	
	3,000	107.0	
	3,095	107.4	

a/ In error; no ice for thermometers.

Benfield, A. E., 1939 - *Terrestrial heat flow in Great Britain* - Royal Soc. (London) Proc., ser. A, v. 173, n. 955, pp. 428-450.

Birch, A. F., 1950 - *Flow of heat in the Front Range, Colorado* - Geol. Soc. America Bull., v. 61, pp. 567-630.

Birch, A. F. and Clark H., 1945 - *An estimate of the surface flow of heat in the west Texas Permian basin* - Am. Jour. Sci., v. 243 A, pp. 69-74.

Birch, A. F., Schairer, J. F., and Spicer, H. C., 1942 - *Handbook of Physical Constants* - Geol. Soc. America Spec. Paper n. 36, 325 pp.

Bullard, E. C., 1939 - *Heat flow in South Africa* - Royal Soc. (London) Proc., ser. A, v. 173, n. 955, pp. 474-502.

Bullard, E. C., and Niblett, E. R., 1951 - *Terrestrial heat flow in England* - Royal Astron. Soc. Monthly Notices, Geophys. Supp., v. 6, pp. 222-228.

Carslaw, H. S., and Jaeger, J. C., 1959 - *Conduction of heat in solids* - 2d ed., Oxford University, Clarendon Press, 510 pp.

Clark, H., 1941 - *The effects of simple compression and wetting on the thermal conductivity of rocks* - Am. Geophys. Union Trans., 22d Ann. Meeting, Pt. 2, pp. 543-544.

Cook, F. A., 1961 - *Hourly air and near-surface soil temperatures at Resolute, N.W.T.* - Arctic, v. 14, pp. 237-241.

Dane, C. H., 1935 - *Geology of the Salt Valley anticline and adjacent areas, Grand County, Utah* - U. S. Geol. Survey Bull. 863, 184 pp.

Everett, J. D., 1862 - *On the mean temperature of a stratum of soil* - Royal Soc. Edinburgh Trans., v. 23, pt. 1, pp. 21-28.

Everett, J. D., 1904 - Royal Commission on Coal Supplies, 2d Report: v. 1, 290 pp.

Gutman, L. N., 1960 - *A theory for soil temperature calculations, in* Kibel', I. A., *ed.*, A collection of articles on dynamic meteorology: New York, Consultants Bureau, pp. 1-57.

Hansen, G. H., and Scoville, H. C., 1955 - *Drilling records for oil and gas in Utah* - Utah Geol. and Mineralog. Survey Bull., n. 50, pp. 39-50.

Herrin, R., and Clark, S. P., Jr., 1956 - *Heat flow in west Texas and eastern New Mexico* - Geophysics, v. 21, n. 4, pp. 1087-1099.

Hite, R. J., and Gere, W. C., 1958 - *Potash deposits of the Paradox basin, in* Sanborn, A. F., *ed.*, Guidebook to the geology of the Paradox basin: Intermountain Assoc. Petroleum Geologists, 9th ann. Field Conf., p. 223.

Ingersoll, L. R., Zobel, O. J., and Ingersoll, A. C., 1954 - *Heat conduction, with engineering, geological, and other applications* - Madison, University of Wisconsin Press, 316 pp.

Joesting, H. R., and Case, J. E., 1960 - *Salt anticlines and deep-seated structures in the Paradox basin, Colorado and Utah* - U. S. Geol. Survey Prof. Paper 400-B, art. 114, pp. B252-B256.

Krige, L. J., 1939 - *Borehole temperatures in the Transvaal and Orange Free State* - Royal Soc. (London) Proc., ser A, v. 173, n. 955, pp. 450-474.

Lang, W. B., 1937 - *Geologic significance of a geothermal gradient curve* - Am. Assoc. Petroleum Geologists Bull., v. 21, pp. 1193-1205.

Lettau, H. H., and Haugan, D. A., 1960 - *Temperature, in* U. S. Air Force, Cambridge Research Center, Geophysics Research Directorate, Handbook of geophysics: rev. ed. New York, Macmillan, sec. 2, pp. 1-14.

Penrod, E. B., Elliott, J. M., and Brown, W. K., 1960 - *Variation of soil temperature at Lexington, Kentucky, from 1952-1956* - Kentucky Univ. Expt. Sta., Bull., n. 57, 55 pp.

Severy, C. L., Kline, M. H., and Allsmann, P. T., 1949 - *Investigation of the Thompson magnesium well* - U. S. Bur. Mines Rept. Inv., R. I. 4496, 21 pp.

Shoemaker, E. M., Case, J. E., and Elston, D. P., 1958 - *Salt anticlines of the Paradox basin, in* Sanborn, A. F., *ed.* Guidebook to the geology of the Paradox basin: Intermountain Assoc. Petroleum Geologists, 9th Ann. Field Conf., pp. 36-59.

Spicer, H. Cecil, 1941 - *Geothermal gradient at Grass Valley, Calif: A revision with a note on the flow of heat* - Washington Acad. Sci. Jour., v. 31, n. 12, pp. 495-501.

U. S. Weather Bureau, 1960 - *Climatological data* - Utah, annual summary 1959: v. 41, n. 13, pp. 188-198.

Van Orstrand, C. E., 1930 - *Description of apparatus for the measurement of temperatures in deep wells* - Am. PetroleumI Inst., Production Bull., pt. II, pp. 9-18. (See also description by Carlson, McCutchin, and Hawtoff in the same volume.)

Van Orstrand, C. E., 1951 - *Observed temperature in the Earth's crust, in* Gutenberg, Beno, *ed.*, Internal constitution of the Earth, 2d ed., chap. 6, pp. 107-149.

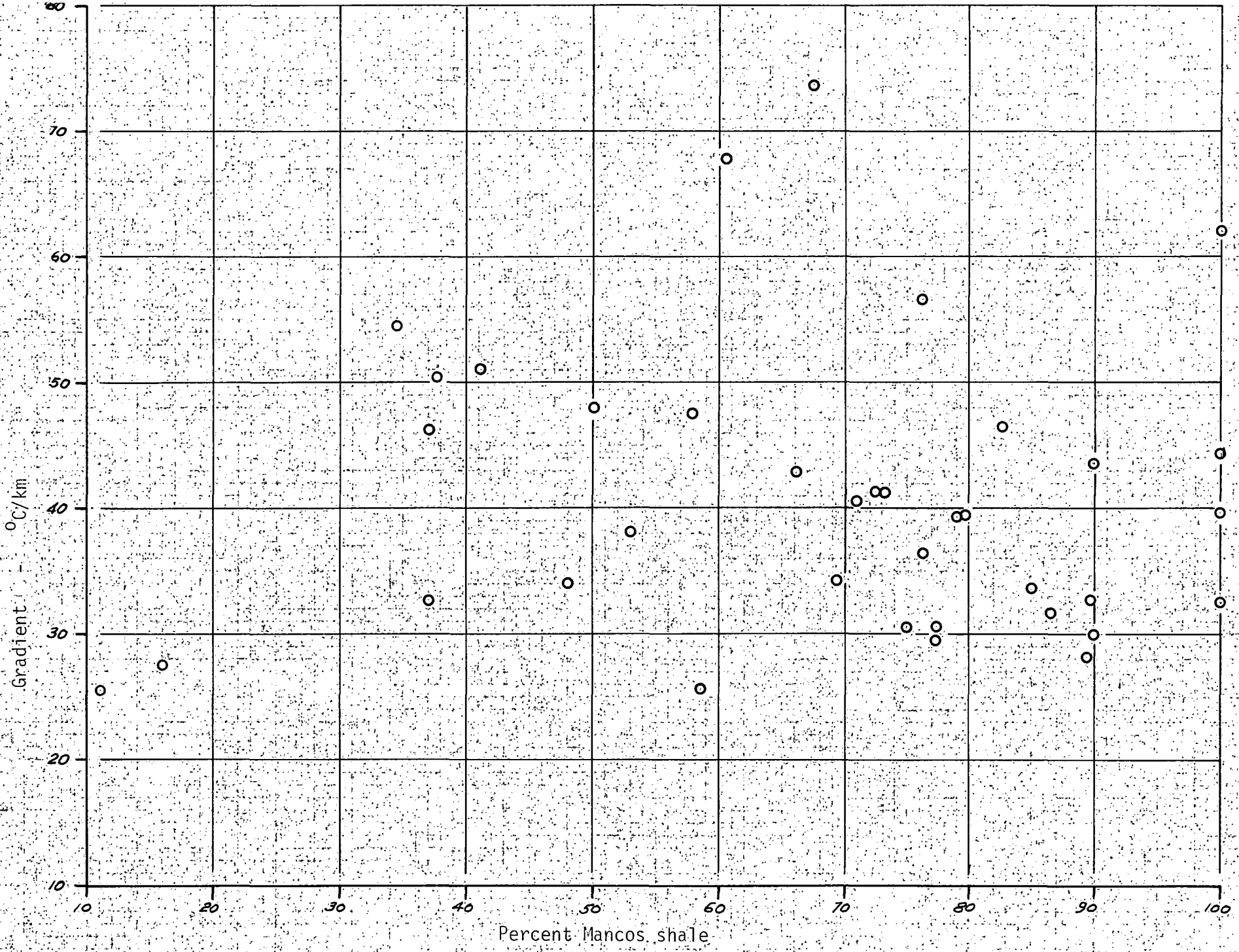
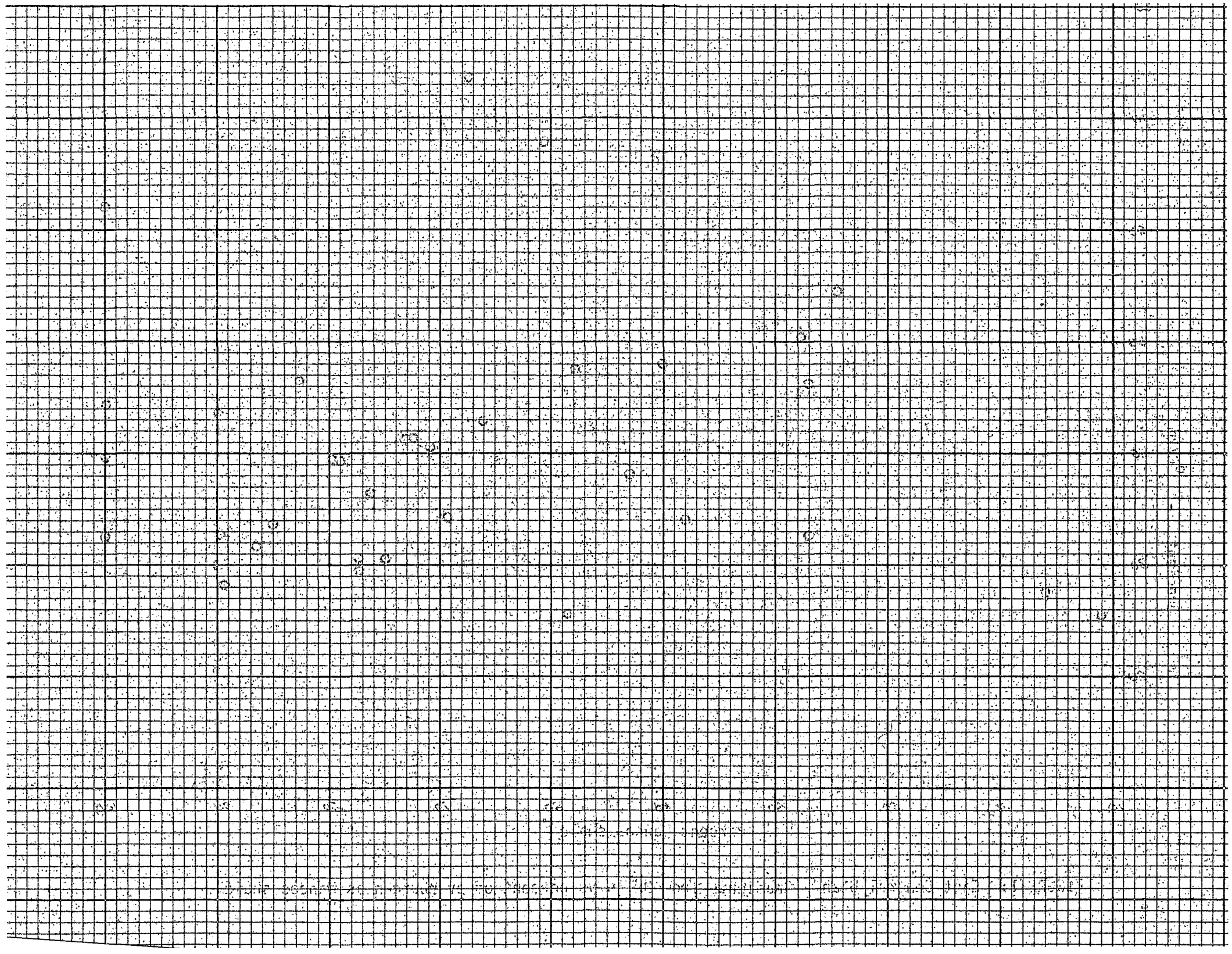
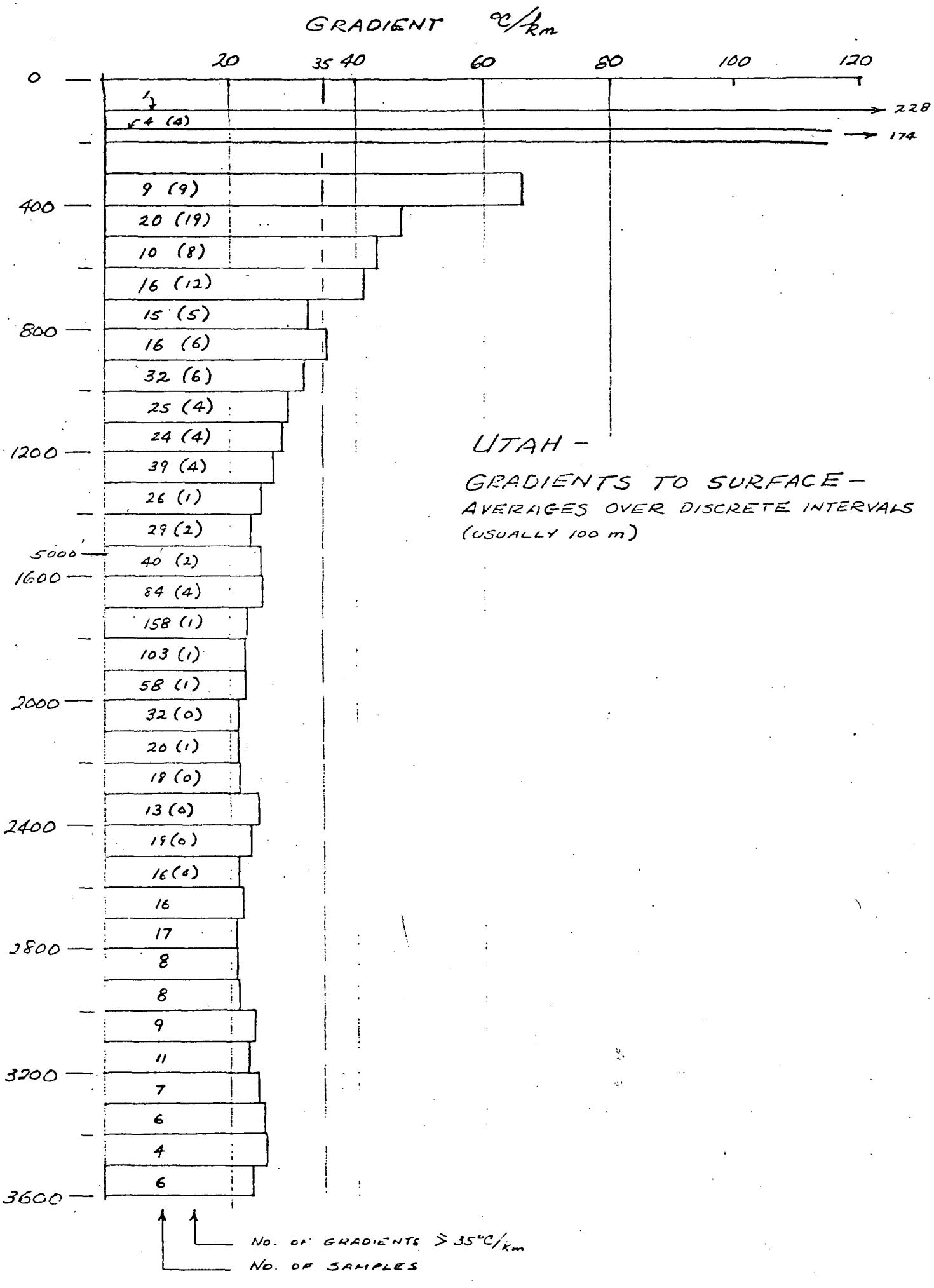


FIGURE 1: East Central Utah - Gradients from BHT's vs percent of overburden as Mancos shale.




GRADIENT °C/km
20
35
40
60
80
100
120
0
400
800
1200
1600
2000
2400
2800
3200
3600
depth - m
1
4 (4)
228
174
9 (9)
20 (19)
10 (8)
16 (12)
15 (5)
16 (6)
32 (6)
25 (4)
24 (4)
39 (4)
26 (1)
29 (2)
5000'
40 (2)
84 (4)
158 (1)
103 (1)
58 (1)
32 (0)
20 (1)
18 (0)
13 (0)
19 (0)
16 (0)
16
17
8
8
9
11
7
6
4
6
UTAH -
GRADIENTS TO SURFACE -
AVERAGES OVER DISCRETE INTERVALS
(USUALLY 100 m)
No. OF GRADIENTS ≥ 35°C/km
No. OF SAMPLES

Form 9-330
(Rev. 5-63)

71

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SUBMIT IN DUPLICA
(See other instructions on reverse side)

Form approved.
Budget Bureau No. 42-R355.5.

WELL COMPLETION OR RECOMPLETION REPORT AND LOG*

5. LEASE DESIGNATION AND SERIAL NO.: Utah 0122460

6. IF INDIAN, ALLOTTEE OR TRIBE NAME:

1a. TYPE OF WELL: OIL WELL ☐ GAS WELL ☐ DRY ☒ Other

b. TYPE OF COMPLETION: NEW WELL ☐ WORK OVER ☐ DEEP-EN ☐ PLUG BACK ☐ DIFF. RESVR. ☐ Other

7. UNIT AGREEMENT NAME: Wild Cow

8. FARM OR LEASE NAME:

2. NAME OF OPERATOR: ALPINE OIL COMPANY, INC.

9. WELL NO.: #1 Government

3. ADDRESS OF OPERATOR: 722 Patterson Building, Denver, Colorado

10. FIELD AND POOL, OR WILDCAT: Wildcat

4. LOCATION OF WELL (*Report location clearly and in accordance with any State requirements*)*
At surface
At top prod. interval reported below
At total depth

11. SEC., T., R., M., OR BLOCK AND SURVEY OR AREA: Sec. 4-T 17S - R 25E

14. PERMIT NO. | DATE ISSUED

12. COUNTY OR PARISH: Grand | 13. STATE: Utah

15. DATE SPUDDED	16. DATE T.D. REACHED	17. DATE COMPL. (*Ready to prod.*)	18. ELEVATIONS (DF, RKB, RT, GR, ETC.)*	19. ELEV. CASINGHEAD
1/30/64	2/3/64			

20. TOTAL DEPTH, MD & TVD	21. PLUG, BACK T.D., MD & TVD	22. IF MULTIPLE COMPL., HOW MANY*	23. INTERVALS DRILLED BY	ROTARY TOOLS	CABLE TOOLS
			→	0-4608	

24. PRODUCING INTERVAL(S), OF THIS COMPLETION—TOP, BOTTOM, NAME (MD AND TVD)*

25. WAS DIRECTIONAL SURVEY MADE

26. TYPE ELECTRIC AND OTHER LOGS RUN: Gamma Ray & Temperature

27. WAS WELL CORED

28. CASING RECORD (*Report all strings set in well*)

CASING SIZE	WEIGHT, LB./FT.	DEPTH SET (MD)	HOLE SIZE	CEMENTING RECORD	AMOUNT PULLED
7"		375'-surf.		70 sacs	

29. LINER RECORD

SIZE	TOP (MD)	BOTTOM (MD)	SACKS CEMENT*	SCREEN (MD)

30. TUBING RECORD

SIZE	DEPTH SET (MD)	PACKER SET (MD)

31. PERFORATION RECORD (*Interval, size and number*)

32. ACID, SHOT, FRACTURE, CEMENT SQUEEZE, ETC.

DEPTH INTERVAL (MD)	AMOUNT AND KIND OF MATERIAL USED

33.* PRODUCTION

DATE FIRST PRODUCTION	PRODUCTION METHOD (*Flowing, gas lift, pumping—size and type of pump*)	WELL STATUS (*Producing or shut-in*)

DATE OF TEST	HOURS TESTED	CHOKE SIZE	PROD'N. FOR TEST PERIOD →	OIL—BBL.	GAS—MCF.	WATER—BBL.	GAS-OIL RATIO

FLOW. TUBING PRESS.	CASING PRESSURE	CALCULATED 24-HOUR RATE →	OIL—BBL.	GAS—MCF.	WATER—BBL.	OIL GRAVITY-API (CORR.)

34. DISPOSITION OF GAS (*Sold, used for fuel, vented, etc.*)

TEST WITNESSED BY

35. LIST OF ATTACHMENTS

36. I hereby certify that the foregoing and attached information is complete and correct as determined from all available records

SIGNED [signature] TITLE DATE

*(See Instructions and Spaces for Additional Data on Reverse Side)

INSTRUCTIONS

General: This form is designed for submitting a complete and correct well completion report and log on all types of lands and leases to either a Federal agency or a State agency, or both, pursuant to applicable Federal and/or State laws and regulations. Any necessary special instructions concerning the use of this form and the number of copies to be submitted, particularly with regard to local, area, or regional procedures and practices, either are shown below or will be issued by, or may be obtained from, the local Federal and/or State office. See instructions on items 22 and 24, and 33, below regarding separate reports for separate completions.

If not filed prior to the time this summary record is submitted, copies of all currently available logs (drillers, geologists, sample and core analysis, all types electric, etc.), formation and pressure tests, and directional surveys, should be attached hereto, to the extent required by applicable Federal and/or State laws and regulations. All attachments should be listed on this form, see item 35.

Item 4: If there are no applicable State requirements, locations on Federal or Indian land should be described in accordance with Federal requirements. Consult local State or Federal office for specific instructions.

Item 18: Indicate which elevation is used as reference (where not otherwise shown) for depth measurements given in other spaces on this form and in any attachments.

Items 22 and 24: If this well is completed for separate production from more than one interval zone (multiple completion), so state in item 22, and in item 24 show the producing interval, or intervals, top(s), bottom(s) and name(s) (if any) for only the interval reported in item 33. Submit a separate report (page) on this form, adequately identified, for each additional interval to be separately produced, showing the additional data pertinent to such interval.

Item 29: "*Sacks Cement*": Attached supplemental records for this well should show the details of any multiple-stage cementing and the location of the cementing tool.

Item 33: Submit a separate completion report on this form for each interval to be separately produced. (See instruction for items 22 and 24 above.)

37. SUMMARY OF POROUS ZONES:
SHOW ALL IMPORTANT ZONES OF POROSITY AND CONTENTS THEREOF; CORED INTERVALS; AND ALL DRILL-STEM TESTS, INCLUDING DEPTH INTERVAL TESTED, CUSHION USED, TIME TOOL OPEN, FLOWING AND SHUT-IN PRESSURES, AND RECOVERIES

FORMATION	TOP	BOTTOM		DESCRIPTION, CONTENTS, ETC.
Mesa Verde Sandstone	350	0		
Mancos Shale	4010	350	3660	
Dakota Silt	4100	4010	90	
Upper Dak. Sd. Sec.(Silted out)	4132	4100	32	
Lower Dak. Sd. Sec.(Silted out)	4184	4132	32	
Cedar Mtn. Shale	4214	4184	66	
Morrison Shale	4269	4214		
Morrison Sd.(gas)	4284	4269		
Morrison Shale	4608	4284		

38. GEOLOGIC MARKERS

NAME	TOP MEAS. DEPTH	TOP TRUE VERT. DEPTH

FEB 11 1964

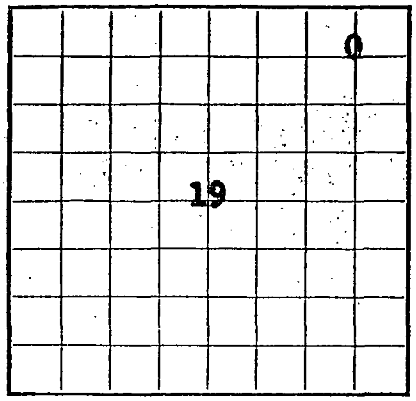
U.S. GOVERNMENT PRINTING OFFICE: 1965—O-683636

87

Budget Bureau No. 42-R-355.3.
Approval expires 12-31-55.

Form 9-330

U. S. LAND OFFICE Salt Lake City
SERIAL NUMBER SLC 067164
LEASE OR PERMIT TO PROSPECT



LOCATE WELL CORRECTLY

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

LOG OF OIL OR GAS WELL

Company American Climax Petroleum Corp. Address 1845 Sherman St., Denver 3

Lessor or Tract Government Field So. Bar-X State Utah

Well No. 3 Sec. 19 T. 17S R. 26E Meridian SL County Grand

Location 660 ft. {N. / S.} of N Line and 660 ft. {E. / W.} of E Line of Section 19 Elevation 5101' (Derrick floor relative to sea level)

The information given herewith is a complete and correct record of the well and all work done thereon so far as can be determined from all available records.

Signed W C Hubbard

Date December 12, 1958 Title Field Engineer

The summary on this page is for the condition of the well at above date.

Commenced drilling October 21, 19 58 Finished drilling October 26, 19 58

OIL OR GAS SANDS OR ZONES

(*Denote gas by G*)

No. 1, from None to ________ No. 4, from ________ to ________

No. 2, from ________ to ________ No. 5, from ________ to ________

No. 3, from ________ to ________ No. 6, from ________ to ________

IMPORTANT WATER SANDS

No. 1, from ________ to ________ No. 3, from ________ to ________

No. 2, from ________ to ________ No. 4, from ________ to ________

CASING RECORD

Size casing	Weight per foot	Threads per inch	Make	Amount	Kind of shoe	Cut and pulled from	Perforated From—	Perforated To—	Purpose
10-3/4"	32.75#	8		152.92'	Hal.	-			

MUDDING AND CEMENTING RECORD

Size casing	Where set	Number sacks of cement	Method used	Mud gravity	Amount of mud used
10-3/4"	149'	110	Disp.	Air	None

MARK | FOLD

PLUGS AND ADAPTERS

Heaving plug—Material Cement Length 78' Depth set 3200-3278'

		110		Disp.	Air	None	

87

FOLD | MA

PLUGS AND ADAPTERS

Heaving plug—Material Cement Length 78' 25' Depth set 3200-3278' 150-175'

Adapters—Material ____ Size ____

SHOOTING RECORD

Size	Shell used	Explosive used	Quantity	Date	Depth shot	Depth cleaned out

TOOLS USED

Rotary tools were used from Surface feet to 3278' feet, and from ____ feet to ____ feet

Cable tools were used from ____ feet to ____ feet, and from ____ feet to ____ feet

DATES

D & A 10-28-58

____, 19____ Put to producing Dry Hole, 19____

The production for the first 24 hours was ____ barrels of fluid of which ____% was oil; ____% emulsion; ____% water; and ____% sediment.

Gravity, °Bé. ____

If gas well, cu. ft. per 24 hours ____ Gallons gasoline per 1,000 cu. ft. of gas ____

Rock pressure, lbs. per sq. in. ____

EMPLOYEES

George Ginder, Driller C. H. Baker, Driller

W. L. Dougless, Driller ____, Driller

FORMATION RECORD

FROM—	TO—	TOTAL FEET	FORMATION
0	2468	2468	Mancos
2468	2618	150	Dakota
2618	2940	322	Morrison
2940	3149	209	Morrison - Salt Wash
3149	3264	115	Summerville
3264	3278	14	Entrada

[OVER]

16—43094-8

FORMATION RECORD—Continued

EXAMPLE - WELL 68

① 116 °F = 46.7 °C

2900' = .884 km

22.4 °F/1000 = 40.8 °C/km

$\Delta z = \frac{50 - 46.7}{40.8} = .081$, $Z_T = .965$ km (actual .960)

② 133 °F = 56.1 °C

3700' = 1.128 km

22.2 °F/1000 = 40.4 °C/km

$\Delta z = \frac{50 - 56.1}{40.4} = -.151$, $Z_T = .977$ (actual .960)

③ From Case ① above - use as Ut grad = 33 °C/km

$\Delta z = \frac{50 - 46.7}{33} = .1$, $Z_T = .984$ (actual .960)

④ From Case 2 above as Ut grad = 28 °C/km

$\Delta z = \frac{50 - 56.1}{28} = -.218$, $Z_T = .910$ (actual .960)

EXAMPLE – WELL 16

① 116°F = 46.7°C depth to 50°C isotherm

3100' = .945 km

20.97 °F/1000 = 38.2 °C/km

$$\Delta z = \frac{50 - 46.7}{38.2} = .086$$

$Z_T = .945 + .086 = \underline{1.031}$ km (actual = 1.068)

② 143°F = 61.7

4650' = 1.417

19.78 °F/1000 = 36.1 °C/km

$$\Delta z = \frac{50 - 61.7}{36.1} = -.324$$

$Z_T = 1.417 - .324 = \underline{1.093}$ (actual 1.068)

③ From case ① above use av grad. (Utah)

at .945 km = 31 °C/km (UTAH GRAPH)

$$\Delta z = \frac{50 - 46.7}{31} = .106, \quad Z_T = \underline{1.051} \text{ (actual 1.068)}$$

④ from case ① above use av grad at 1.051 km = 29 (UTAH GRAPH)

$$\Delta z = \frac{50 - 46.7}{29} = .114, \quad Z_T = \underline{1.059} \text{ (actual 1.068)}$$

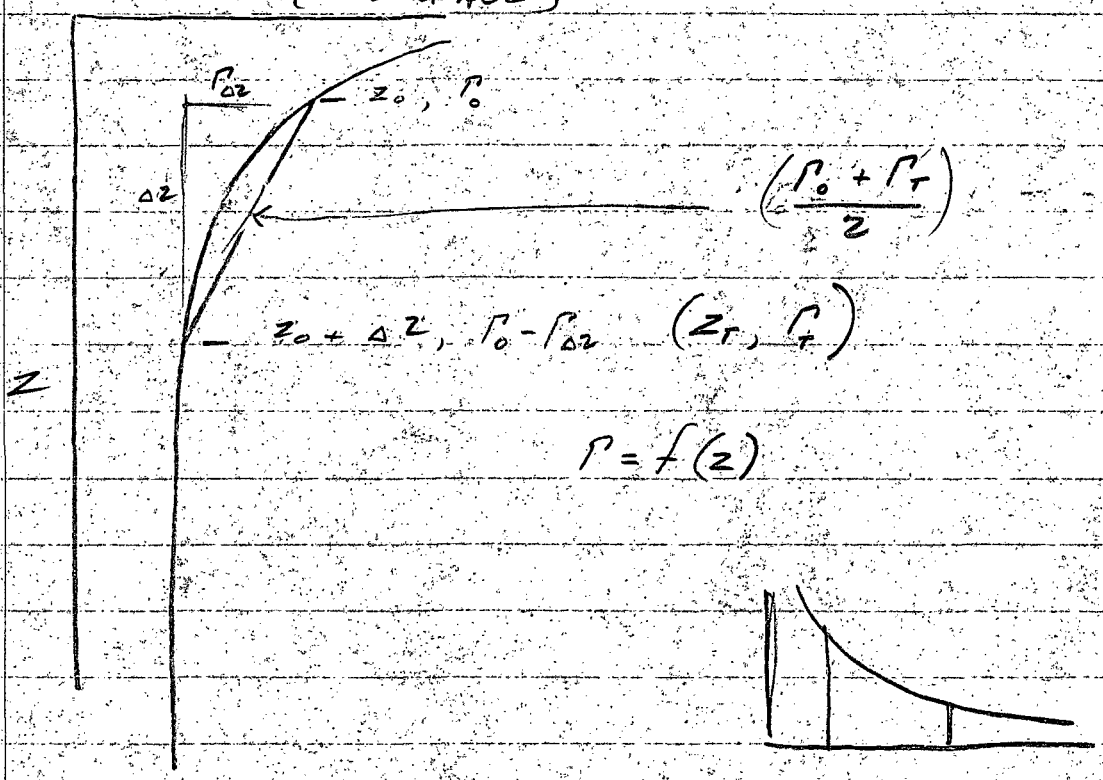
av Chart grad at 1.068 = 29 °C/km

" " " " .945 = 31 °C/km

av = 30 °C/km

$$\frac{50 - 46.7}{30} = .11$$

$Z_T = .945 + .11 = 1.055$ km actual 1068



$$\left(\frac{\Gamma_0 + \Gamma_T}{2}\right)\Delta z + T_0 = T_T = 50°C$$

TRY $\Gamma_0 \Delta z + T_0 = 50$

$$\Delta z = \frac{50 - T_0}{\Gamma_0}$$

FROM GRAPH Γ between 200 m — 3600 m

$= 17.35$

d	T
200	28
3600	87
3400	59

(Log) T_d at depth d

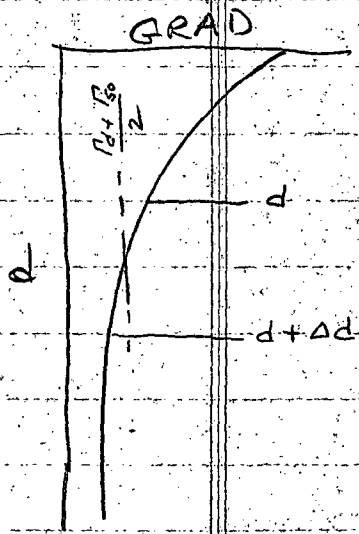
mean grad at depth d = Γ_d

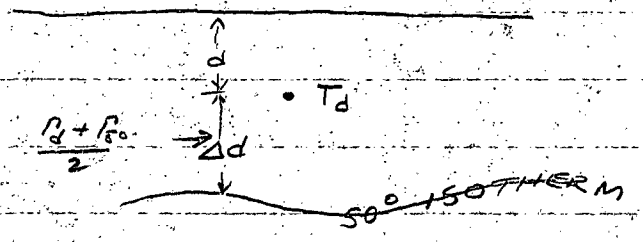
50°C ISOTHERM

$T_d < 50°C$

depth to isotherm

$(50°C - T_d) = \Delta T$





Γ_{50} = Γ at 50° isotherm (variable)

$$\left(\frac{\Gamma_d + \Gamma_{50}}{2}\right)\Delta d + T_0 = 50°$$

uniform Γ in critical region $\Rightarrow$ $\Gamma_d \Delta d + T_0 = 50°$

$$\Delta d = \frac{50° - T_d}{\Gamma_d}$$

$\Gamma_{d+\Delta d} = \Gamma_{50} = \Gamma_d$

GRAND CO., UT

COMPARISON OF T-LOG + E-LOG GRADS.

	T-LOG				E-LOGS				(METERS) DEPTH 50° @ ISOTHERM	
	1 WELL NO	2	3 AV. °C/km	4	5 NO OF BHTs	6 MAX. °C/km	7 MIN. °C/km	8 AV °C/km	9 CALC.	MEAS.
1	2		31.8		2	29.6	20.6	25.1	1239-T 1570-E	
2	3		33.2		2	31.9	21.1	26.5	1187-T 1487-E	
3	16		37.2		2	41.4	32.7	37.0	1059-T 1065-E	1031
4	18		35.4		2	34.9	34.6	34.8	1113-T 1132-E	
5	28		26.9		3	34.3	23.6	29.5	1465-T 1336-E	1500
6	43		21.2		2	26.1	19.9	23.0	1858-T 1713-E	2085
7	61		37.6		2	40.2	39.3	39.8	1049-T 990-E	
8	68		40.7		2	51.4	40.2	45.8	968-T 860-E	960
9	71		49.4		1	46.7	46.7	46.7	798-T 844-E	
10	93		20.3		4	22.8	19.7	21.5	1941-T 1832-E	
11	120		58.5		1	51.1	51.1	51.1	674-T 771-E	597
12	252		29.4		1	27.5	27.5	27.5	1340-T 1433-E	
13	327		12.3		2	17.5	11.5	14.5	3203-T 2717-E	
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										

GRAND CO

WELL No. 68

Γ from surface to	3700'	40.4 °C/km
Γ between	2900' - 3700'	38.7 °C/km

WELL No. 61

Γ from surface to	3250'	35.9 °C/km
Γ between	2000' - 3250'	30.6 °C/km

WELL No. 16

Γ from surface to	4650'	36.1 °C/km
Γ do	3100'	38.2 "
between	3100 - 4650	31.8 °C/km

WELL No. 120

Γ from Surface to	3600'	51.1 °C/km
do	3000'	56.5 °C/km
do	2000'	65.6 °C/km
do	1300'	56.1 °C/km
do	1000'	65.6 °C/km
Γ between	3000' - 3600	24 °C/km
do	2000 - 3000	38.3 °C/km
do	1300 - 2000	83.3 °C/km
do	1000 - 2000	65.6 °C/km
do	1000 - 3600	45.6 °C/km

WELL No.

GRAND CO. cont.

WELL No. 71

ρ from surface to	4607'	46.7 Ω/km
do	3800'	49.4
do	3500'	49.5
ρ between	3800 – 4607	33.9
do	3500 – 4607	37.9

EXAMPLE - WELL 120 (wild grad. near 50°C)

① 87°F - 30.56

1000' = .3048

36°F/1000 = 65.6 °C/km

$\Delta z = \frac{50 - 30.56}{65.6} = .296$, $Z_T = .601$ (actual .597 km)

② 152°F = 66.67

3600' = 1.097

28.0°F/1000 = 51.1

$\Delta z = \frac{50 - 66.67}{54.1} = -.326$, $Z_T = .771$ (actual .597)

③ 91°F = 32.78 °C

1300' = .396 km

30.8°C/1000 = 56.1 °C/km

$\Delta z = \frac{50 - 32.78}{56.1} = .307$, $Z_T = .703$ km (actual .597)

④ 94.5°F = 34.7

1500' = .457

29.0°F/1000 = 52.8 °C/km

$\Delta z = \frac{50 - 34.7}{52.8} = .290$ km, $Z_T = .747$ (actual .597)

⑤ 135°F = 57.2°C

2500' = .762 km

33.6°F/1000 = 61.2°C/km

$\Delta z = \frac{50 - 57.2}{61.2} = -.118$, $Z_T = .644$ km (actual .597)

⑥ 144°F = 62.2°C

3000' = .914 km

31°F/km = 56.5°C/km

$\Delta z = \frac{50 - 62.2}{56.5} = -.216$ km

$Z_T = .914 - .216 = .698$ km (actual, ?

OVER

(7) $123°F = 50.56°C$

$2000' = .610$ km

$36°F/1000 = 65.6°C/km$

$\Delta Z_1 = \frac{50 - 50.56}{65.6} = .008$, $Z_T = .610 - .008 = .602$ km

actual 597

(9) Use ex (2) and Γ from chart for 1100m

$\Gamma = 28$

$\Delta Z = \frac{50 - 66.67}{28} = .595$

$Z_T = 1.097 - .595 = .502$ km

FROM CHART Γ at 597 = 40 °C/km

$\Delta Z = \frac{50 - 66.67}{40} = .417$

$Z_T = .680$ km

av of $\frac{28+40}{2} = 34$

$\Delta Z = \frac{50 - 66.67}{34} = .490$

$Z_T = 607$ km (597)

(10) Use ex (1) and Γ from chart for 305m

$\Gamma = 64$

Chart Γ at 597C = 40

av of $\frac{64+40}{2} = 52$

$\Delta Z = \frac{50 - 30.56}{52} = .374$

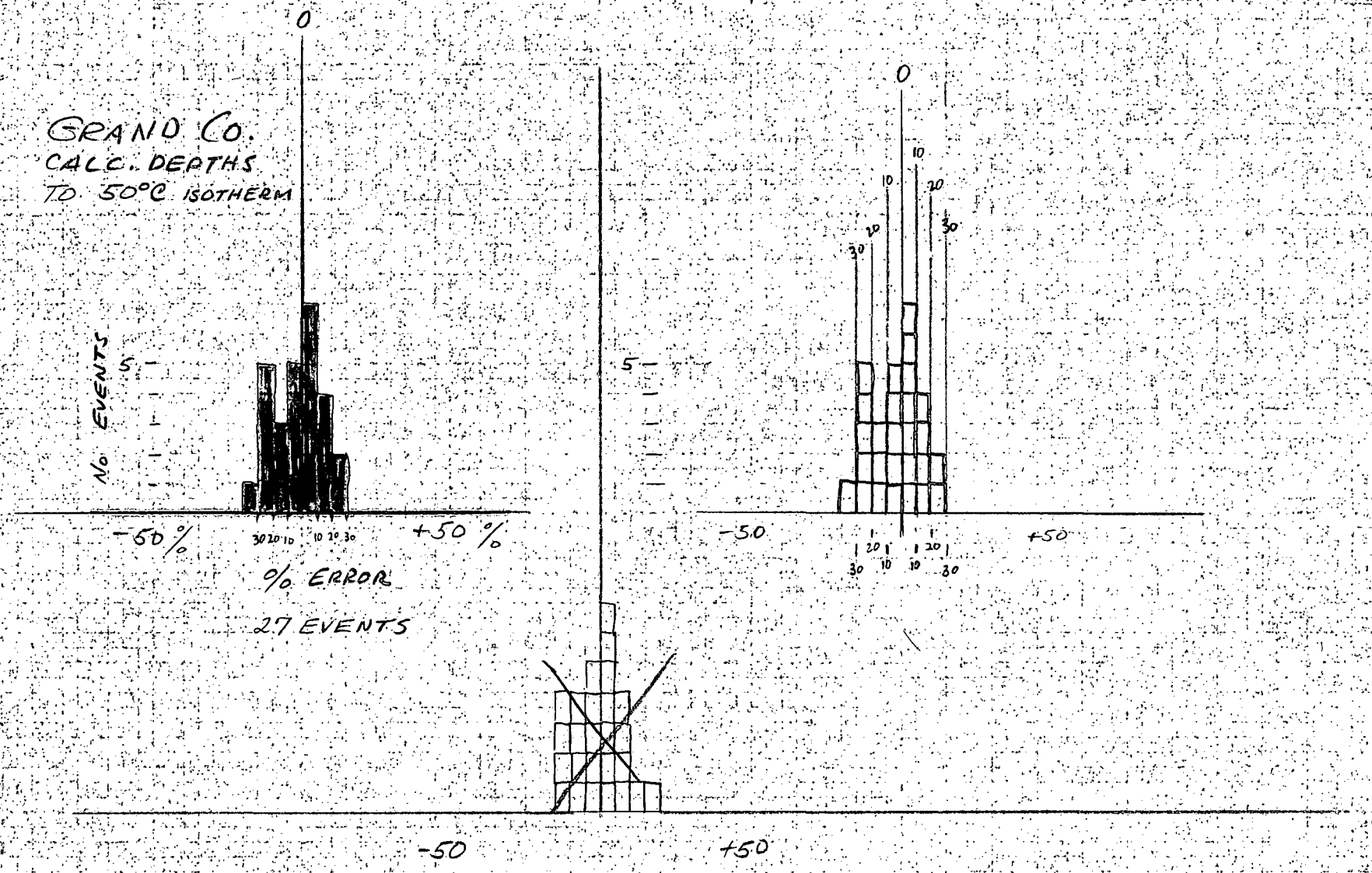
$Z_T = .374 + .305 = 679$ (597)

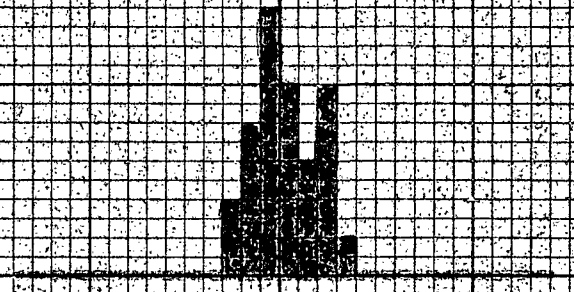
T-LOGS

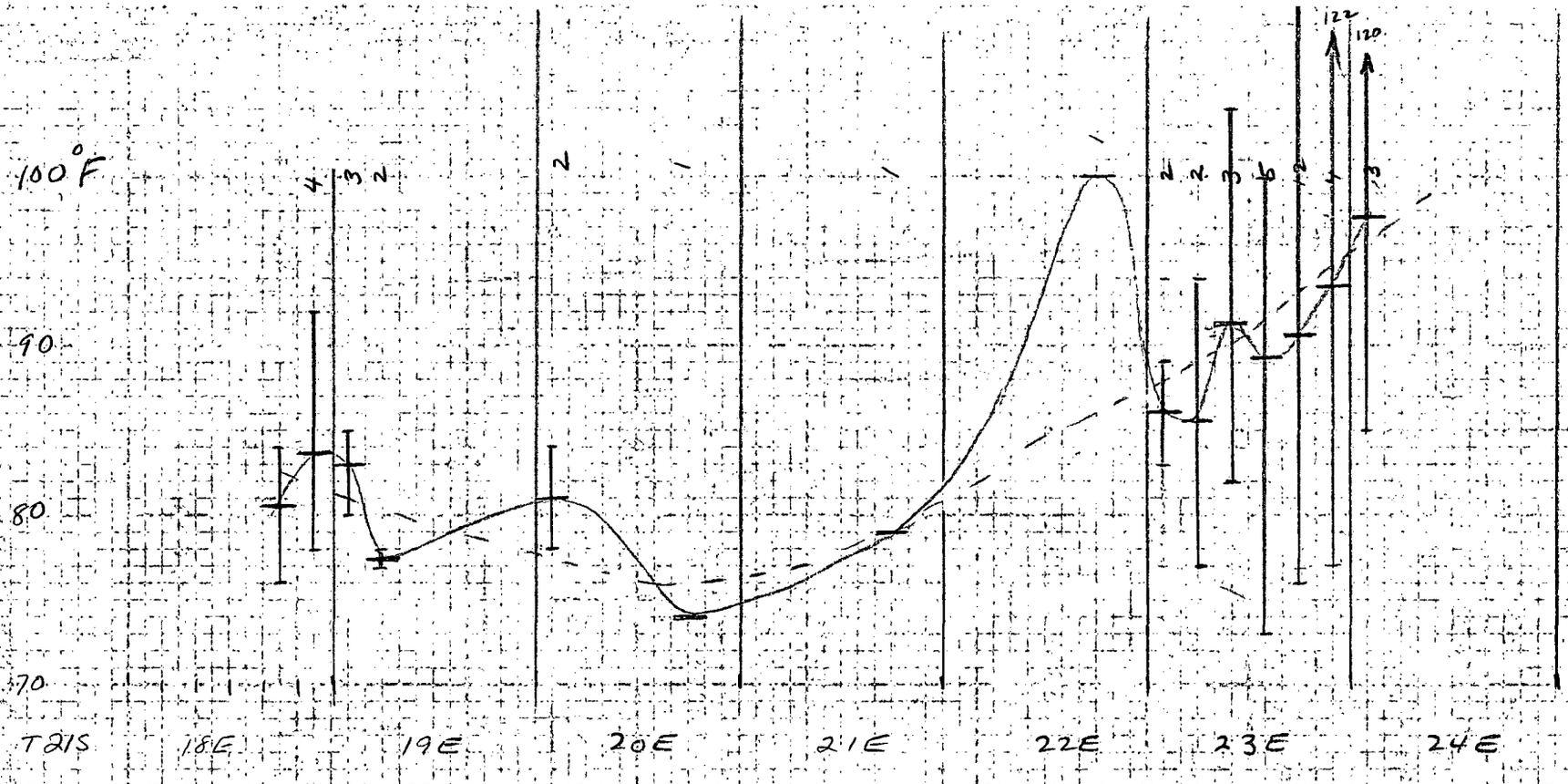
50° isotherms using mean gradient

	1 WELL	2 °C	3 d_{km}	4 d_T 50°C	5 d_o	6 d_T	7 $\frac{d_o+d_T}{2}$	8 ΔZ(km)	9 CHART GRADIENT / Calcd d_{km}	Δd m
1	16	46.7	.945	(1.068)	31	29	30	.110	(1.055)	-13
2		61.7	1.417	1.068	25	29	27	-.433	(.984)	-84
3	68	46.7	.884	(.960)	33	30	31.5	.105	(.989)	+29
4		56.1	1.128	.960	27	30	28.5	-.214	(.914)	-46
5	120	30.56	.305	(.597)	64	40	52	.374	(.679)	+82
6		32.78	.396	.597	47	40	43.5	.396	(.792)	+195
7		34.7	.457	.597	45	40	42.5	.365	(.822)	+225
8		66.67	1.097	.597	28	40	34	-.490	(.607)	+10
9		62.2	.914	.597	31	40	35.5	-.344	(.570)	-27
10										
11										
12										
13		Same points as above projecting								
14		to 50°C isotherm on basis of								
15		grad. calc. for hole								
16					50° Iso		Δd	%		
17	WELL	°C	d_{km}	°C/km	d_{calc}	d_{actual}	m	ERROR		
18	16	46.7	.945	38.2	1.031	(1.068)	-37	3 +	✓	
19		61.7	1.417	36.1	1.092	1.068	+24	2.2 +	✓	
20	68	46.7	.884	40.8	.966	(.960)	+6	0.6 +	✓	
21		56.1	1.128	40.4	.995	.960	+15	1.6 +	✓	
22	120	30.56	.305	65.6	.601	(.597)	+4	0.7 +	✓ Hole	120
23		32.78	.396	56.1	.702	.597	+105	17.6 +	Thermal anomaly	
24		34.7	.457	52.8	.746	.597	+149	(25) +	at 50°C	
25		66.67	1.097	51.1	.771	.597	+174	(29) +	region	
26		62.2	.914	56.5	.697	.597	+99	16.5 +	✓	
27	work 120	57.2	.762	61.2	643		+46	7.7 +	✓	
28		50.55	.610	65.6	601		+4	0.7 +	✓	
29										
30										
31										

EFFICIENCY® LINE No. 2636 AMPAD


GRAND CO.
CALC. DEPTHS
TO 50°C ISOTHERM
0
No EVENTS
5
-50 %
30 20 10
10 20 30
+50 %
% ERROR
27 EVENTS
0
10
10
20
20
30
30
5
-50
20
10
10
20
30
30
+50
-50
+50





T21S – GRAND CO

TEMPERATURES AT 3,000' ASL

*From E-Logs

GRAND Co — T-LOGS
Calculating d to 50°C isotherm

EFFICIENCY © LINE No. 2636 AMPAD

	1 WELL	2 °C	3 depth m	4 °C/hm	5 Depth 50°C meters	6 CALC. ERROR m	7 % ERROR	8	9
1	16	46.7	945	38.2	1031	0	✓ 0	✓	my plot
2	(1031 To 50°)	61.7 83.9	1417 1769	36.1 41.4*	1091 952	+60 -79	✓ +5.8 ✓ -7.7	✓	
3	28	41.7	1250	24.9	1582	+82	✓ +5.4	✓	
4		50	1500	26.26	(1500)	—	—		
5		51.1	1524	26.6	1368	-132	✓ -8.8	✓	
6		65	1829	29.8	1322	-178	✓ -11.9	✓	
7		44.2	979	34.3*	1149	-351	✓ -23.4	✓	
8		73.9	2068	30.6*	1288	-212	✓ -14.1	✓	
9		60	2099	23.6*	1669	+169	✓ +11.3	✓	
10	43	40.6	1859	16.1	2447	+362	✓ +17.4	✓	
11		50	2085	18.9	(2085)	—	—		
12		51.7	2134	19.3	2041	-44	✓ -2.1	✓	
13		65.6	2438	22.6	1743	-342	✓ -16.4	✓	
14		77.8	2743	24.5	1608	-477	✓ -22.9	✓	
15		85	2896	25.7	1533	-552	✓ -26.5	✓	
16		88.9	3002	26.1*	1510	-575	✓ -27.6	✓	
17		47.2	1840	19.9*	1980	-105	✓ -5.0	✓	
18	68	46.7	884	40.8	966	+6	✓ +0.6	✓	
19		50	960	41.0	(960)	—	—		
20		56.1	1128	40.4	975	+15	✓ +1.6	✓	
21		79.4	1340	51.4*	766	-194	✓ -20.2	✓	
22		64.4	1342	40.2*	980	+20	✓ +2.1	✓	
23	120	30.56	305	65.6	601	+4	✓ +0.7		
24		32.78	396	56.1	702	+105	✓ +17.6		
25		34.7	457	52.8	746	+149	✓ +25.0		
26		50	597	66.0	(597)	~~+0~~	—		
27		57.2	762	61.2	643	+46	✓ +7.7	✓	
28		62.2	914	56.5	697	+100	✓ +16.8	✓	
29		66.67	1,097	51.1	771	+174	✓ +29.1	✓	
30		64.4	1099	49.0*	804	+207	-34.7		
31		66.67	1097	51.1*	771	DUPLICATE			

N. E. LOG

FROM T LOGS — GRAND CO.

	WELL #	°F	DEPTH FT	TO SURFACE °C/km	
41 5805 -101'	16 actual 50°C at 1068m (3505')	116	3100	38.2	29.6
		129	3900	36.4	31.8
		143	4650	36.1	34.0
40 5253	61	94	2000	39.2	30.6
		115	3250	35.9	
51 4395 -19 (3150')	68 50°C 960m actual	116	2900	40.8	38.7
		133	3700	40.4	
47 4607	71	146	3500	49.5	48.6
		154	3800	49.4	37.9
		169	4607	46.7	33.9
51 3600	120 ✓	87	1000	65.6	✓✓
	✓	91	1300	56.1	✓✓
→	✓	94.5	1500	52.8	✓✓
	actual 50°C @ 597m	123	2000	65.6	
	(1960') ✓	135	2500	61.2	✓✓
	✓	144	3000	56.5	✓
		152	3600	51.1	
	28	107	4100 ✓	24.9	1.582
		122	4920	26.3	1.498
		124	5000	26.6	1368
		149	6000	29.8	1322
	43	105	6100	16.1	2447
		122	6840	18.9	2085
		125	7000	19.3	2041
		150	8000	22.6	1743
		172	9000	24.5	1608
		185	9500	25.7	1533

0.68 961 107

96° 772 180

BETWEEN 1650-1750 BIG ANOMALY ?

E LOGS		°C/km	Depth 50°C meters
111.5 °F	3213'	34.3	1149
165	6785	30.6	1288
140	6886	23.6	1669
192	9851	26.1	1510
117	6036	19.9	1980

41.3 ✓ 2000 - 2199 | 1200 ✓ 1399 | 47.4 ✓ 1400 - 1599

35.6 ✓ 2200 - 2500 | 1000 ✓ 1199 | 44.4 ✓ 1600 - 1799

43.0 ✓ 1800 - 1999

Between 0 and

WELL No	BHT	Depth	Collar	VARIENCE FROM MEAN Γ in °C/km	°C/km	
362	94	2311 ✓	7211		38.6	12.5 - 15.6
367	115	2294 ✓	6150		55.6	12 - 16
367	115	2419 ✓	6150			"
370	76	2452 ✓	6855		23.0	12 - 16
379	100	2128	6715	+11.5	47.1	13 - 17
390	97	1545	4820	+6.6	54.3	17 - 16
418	85	1393	5128		44.5	25 - 15
502	85	2163	6235	-1.9	33.7	14 - 22
503	117	1548	7022	+49.6	97.3	14 - 23
19	92	2259 ✓	6520		33.1	16 - 24
27	112	1540	6481	+24.5	72.2	16 - 25
56	90	1135	6043		69.6	17 - 24
59	90	1343	6136		52.9	17 - 24
65	90	1451	6789	+1.3	49.0	17 - 24
65	90	1770	6789		60.2	"
66	80	815	5618		64.9	17 - 24
67	80	1146	5613		46.1	17 - 24
88	82	2222 ✓	5070		25.4	17 - 26
90	121	2347 ✓	5013		54.4	17 - 26
91	102	2100	5010	+11.7	74.3	17 - 26
98	80	1797	5825		29.4	18 - 22
99	92	1802	5872		41.5	18 - 22
109	120	2350 ✓	4933		53.5	18 - 24
112	89	1880	4786		36.7	18 - 25
113	92	1973	4900		37.9	18 - 25
~~114~~	~~95~~	~~2799~~	~~4713~~		~~28.7~~	~~18 - 25~~
115	80	1490	4806	-12.2	35.5	18 - 25
104	85	1198	4813		51.7	18 - 25
117	106	2200 ✓	5975		45.6	19 - 18
125	92	2155	7473	-0.9	34.7	19 - 21
126	88	[redacted]	5706		39.9	19 - 22
136	104	2436 ✓	7892		39.6	19 - 23
139	81	1598	4576	-13.5	34.2	19 - 24
140	80	1575	4575	-14.1	33.6	19 - 24
141	107	1475	4647	+15.3	63.0	19 - 24
143	100	1954	4598		45.7	19 - 25

500 - 1950

2450

2 all wells E Cent U.

	BHT	Depth	Collar	VARIENCE	°C/hms	Loc
161	91	2238✓	5185		32.6	20-21
163	112	1800	5072		61.8	20-21
169	94	2455✓	5085		31.9	20-22
173	92	2334✓	4986		32.0	20-22
177	92	2257✓	?		33.1	20-23
178	80	1620	4584		31.3	20-24 ok
179	80	1698	4592		31.5	20-24 ok
182	90	2049	4826	-0.9	34.7	20-23
183	96	2498✓	4828		32.8	20-23
184	100	1999	4849		44.7	20-23
185	100	2119	?	+6.5	42.1	20-23
186	98	2057	4812	+6.0	41.6	20-23
187	92	2233✓	?		33.5	20-23
188	106	2449✓	4828		40.9	20-23
189	115	1998	4764		58.4	"
190	98	2105	?	+5.1	40.7	"
394	90	1632	4671		43.6	"
191	96	1766	4672		46.4	"
192	90	2283✓	4715		31.1	"
193	88	1862	4718		36.2	"
194	70	2004	?	-18.3	17.3	"
195	125	1840	?		73.3	"
196	97	2369✓	?		35.4	"
197	90	2143	?	-2.4	38.2	"
198	100	1552	4756		57.5	"
199	88	2278✓	4848		29.6	"
201	95	2345✓	4855		34.2	"
202	77	1841	4511		25.7	"
203	87	1663	4604		39.5	20-24
204	86	1623	4573		39.8	"
350	95	1583	4566		50.7	"
205	90	1330	4595		53.4	"
206	82	1496	4600		37.8	"
207	90	1753	4589		42.8	"
208	82	1678	4593		34.3	"
209	86	1678	?		39.2	"
210	88	2116	4703	-3.7	31.9	"
211	87	2078	4653	-4.0	31.6	"
			2455			

well #	BHT	d	Collar	°C/km	Loc.
212	85	1848	4642	33.5	20-24
213	84	1586	4583	37.9	"
214	88	1567	4583	43.2	"
215	87	1610	4586	40.8	"
216	82	1611	4587	35.1	"
217	85	1558	4596	39.8	"
218	87	1670	4610	39.3	"
219	86	1607	?	39.8	"
220	85	1504	4572	41.2	"
221	80	1537	4592	34.4	"
222	85	1624	4583	38.2	"
223	84	1344	4601	44.8	"
224	73	1363	4605	29.4	"
225	94	1650	4616	47.5	"
226	85	1075	4518	57.6	"
227	78	1057	4517	46.6	"
228	84	1507	4570	39.5	"
229	75	1200	4523	36.5	"
230	80	1024	4519	51.6	"
231	73	733	4521	54.7	"
232	75	802	4480	54.5	"
234	105	1777	4452	55.4	21-17
245	104	1807	4681	53.5	21-22
246	78	1411	4906	34.9	21-23
248	82	1685	4575	33.5	21-23
249	82	1425	?	39.7	21-23
250	85	1500	4650	41.3	"
251	95	1414	4577	56.7	"
252	68	1128	4487	27.5	"
253	100	1302	4206	68.6	"
254	80	1176	4484	44.9	21-23 sec 4
255	96	1828	4577	44.9	21-23 sec 5
256	106	1889	4490	53.1	" sec 5
257	85	1332	4502	46.5	" sec 7
258	82	1482	4485	38.1	" sec 9
259	85	1136	?	54.6	21-23
260	93	944	?	43.9	21-23
261	86	1186	4444	53.8	"

~~4689~~

Well #	BHT	d	Collar		°C/km	Loc.
262	85	1306	4454		47.5	21-23
263	80	1117	4458		48.0	"
264	87	1288	4419		50.9	"
265	102	[illegible]	4515		56.9	"
266	98	1164	4482		73.6	"
"	99	1290	"		67.8	"
267	76	1391	4235		32.8	"
268	74	1230	4412		34.1	"
269	75	1320	4363		33.1	"
351	92	1994	4577		37.5	"
271	90	1391	4411		51.1	"
272	73	925	4347		43.4	"
273	82	992	4666		57.0	"
274	75	704	4611		62.1	"
275	78	504	4332		97.6	"
276	78	710	4338		69.3	"
352	80	1016	4372		52.0	"
277	81	1128	4362		48.5	"
270	92	970	4467		77.0	21-24
279	80	1141	4323		46.3	"
280	82	1122	4323		50.4	"
287	94	1439	4697		54.5	22-21
288	94	1492	?		52.5	22-23
353	79	2402	4362		21.2	23-17
307	95	1474	4479		54.4	24-17
316	86	2081	5142		30.7	25-18
319	85	2375	5487	-9.5	26.1	25-18

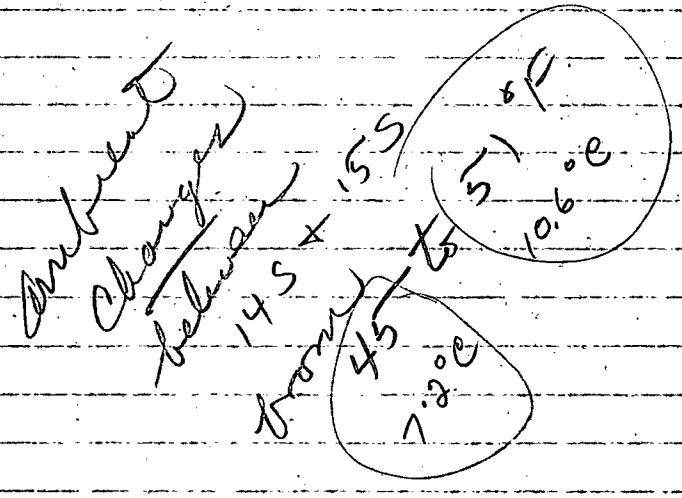
~~2402~~

Vale
Tat
2350
=716 mw
°C

21 values

Depths 2200–2500

°C	Well No	BHT	DEPTH	ELEV COLLAR	°C/km	Loc
✓34.8	362	94	2311	7211	38.6	12-15
✓47.0	367	115	2294	6150	55.6	12-16
✓44.9	367	115 ?	2419	6150	52.7	"
✓23.7	370	76 ←	2452	6855	23.0	12-16
✓34.3	19	92 ?	2259	6520	33.1	16-24
✓28.8	88	82	2222	5070	25.4 ← ?	17-26
✓49.6	90	121	2347	5013	54.4	17.26
✓48.9	109	120	2350	4933	53.5	18-24
✓43.2	117	106	2200	5975	45.6	19-18
✓39.0	136	104	2436	4892	39.6	19-23
✓33.9	161	91	2238	5185	32.6	20-21
✓33.4	169	94	2455	5085	31.9	20-22
✓33.5	173	92	2334	4986	32.0	20-22
✓34.3	177	92	2257	—	33.1	20-23
✓34.1	183	96	2498	4828	32.8	20-23
✓34.6	187	92	2233	—	33.5	20-23
✓39.9	188	106	2449	4828	40.9	20-23
✓32.9	192	90	2283	4715	31.1	"
✓35.9	196	97	2369	—	35.4	"
✓31.8	199	88	2278	4848	29.6	"
✓35.1	201	95	2345	4855	34.2	"



E Cent. UT

2000 - 2500

WITHIN YELLOW BODY

(686 mw)

of

↓ CALCULATED T at 2250'

	1 WELL No	2 BHT	3 DEPTH	4 °C/km	5 LOC	6 °C	7	8	9	
1	502	85	2163	33.7	14-22	30.3				
2	19	92	2259	33.1	16-24	33.3				
3	88	82	2222	25.4	17-26	28.0	?			
4	90	121	2347	54.4	17-26	47.9				
5	91	102	2100	44.3	17-26	41.0				
6	109	120	2350	53.5	18-24	47.3				
7	117	106	2200	45.6	19-18	41.9				
8	125	92	2155	34.7	19-21	34.4				
9	136	104	2436	39.6	19-23	37.8				
10	161	91	2238	32.6	20-21	33.0				
11	169	94	2455	31.9	20-22	32.5				
12	173	92	2334	32.0	20-22	32.6				
13	177	92	2257	33.1	20-23	33.3				
14	182	90	2049	34.7	20-23	34.4				
15	183	96	2498	32.8	20-23	33.1				
16	185	100	2119	42.1	"	39.5				
17	186	98	2057	41.6	"	39.1				
18	187	92	2233	33.5	"	33.6				
19	188	106	2449	40.9	"	38.6				
20	190	98	2105	40.7	"	38.5				
21	192	90	2283	31.1	"	31.9				
22	194	70	2004	17.3	"	22.5	?			
23	196	97	2369	35.4	"	34.9				
24	197	90	2143	33.2	"	33.4				
25	199	88	2278	29.6	"	30.9				
26	201	95	2345	34.2	"	34.1				
27	210	88	2116	31.9	20-24	32.5				
28	211	87	2078	31.6	"	32.3				
29	316	86	2081	30.7	25-18	31.7				
30										
31										

> 6000' (1)

WELL	BHT	DEPTH	LOCATION
356	132	6020	12 -14
359	190	8460	12 -15
361	130	7194	12 -15
362	134	7005	12 -15
363	150	6395	12 -15
364	207	12980	12 -15
"	304	17259	"
371	155	9089	12 - 16
374	117	6371	13 - 14
"	131	8016	"
"	148	9644	"
377	162	9114	13 - 16
379	144	8308	13 - 17
382	146	7764	11 - 14
383	125	6374	11 - 14
386	133	7955	11 - 16
388	162	8747	16 - 15
389	151	8510	17 - 14
390	146	8479	17 - 16
391	122	7082	18 - 14
392	175	9884	18 - 15
393	185	11450	18 - 16
"	212	12854	"
394	130	6523	19 - 14
395	160	8018	19 - 14
"	168	8781	"
396	141	8736	19 - 14
"	137	6902	"
397	159	10812	19 - 15
398	130	6992	20 - 14
"	125	7446	"
401	125	6578	21 - 15
"	150	9594	"
"	154	10605	"
402	141	9434	21 - 16
404	140	8900	22 - 15
405	140	8485	22 - 15

6000 - 6999

7000 - 7999

8000 - 8999

9000 - 9999

~~17259~~

>6000 (2)

WELL	°F	FT	T R
406	120	6196	22 — 15
408	118	6061	23 — 14
410	145	9449	23 — 16
411	138	8440	23 — 16
412	150	7282	24 — 14
413	162	7645	24 — 14
416	122	6991	25 — 14
417	108	6469	25 — 15
419	134	7382	25 — 16
420	132	6698	25 — 16
422	127	6697	26 — 14
425	109	6461	26 — 17
427	158	8638	11 — 19
428	139	6550	11 — 21
"	172	9812	" yellow
429	173	9601	11 — 21
430	157	8402	11 — 21
441	138	6179	11 — 23
433	146	6508	11 — 23
442	135	6540	11 — 23
"	139	7368	"
436	134	6648	11 — 23
437	126	6461	11 — 23
435	124	6238	11 — 23
440	131	6588	11 — 23
"	140	7382	"
449	130	6568	11 — 24
452	145	7720	12 — 20
456	142	6524	12 — 21
457	125	6204	12 — 21
458	138	6524	12 — 21
"	159	8294	"
459	135	7594	12 — 22
462	148	7780	12 — 22
"	275	15078	" ~~15078~~
463	142	7400	12 — 22
469	157	8297	12 — 25

>6000 (3)

WELL	°F	FT	T R
453	140	7792	13 – 20
"	148	8516	"
471	120	6901	13 – 20
"	155	7314	"
472	138	6913	13 – 20
473	142	7439	13 – 21
475	230	12236	13 – 21
476	228	12072	13 – 22
477	177	10358	13 – 22
"	218	10783	"
478	129	6601	13 – 22
479	139	[illegible]	13 – 22
480	194	10534	13 – 22
481	126	6545	13 – 22
"	238	13122	"
482	224	10746	13 – 22
483	209	8260	13 – 22
"	205	10220	"
486	168	8839	13 – 25
488	132	6139	13 – 25
489	146	8996	14 – 17
490	134	7364	14 – 19
492	169	7900	14 – 20
493	134	7298	14 – 20
494	120	6794	14 – 20
497	128	7331	14 – 20
"	224	12431	"
"	230	12884	"
499	205	11942	14 – 22
"	200	12154	"
500	120	6015	14 – 22
"	165	9322	"
501	175	9694	14 – 22
503	192	9728	14 – 23
506	164	7901	14 – 25
509	215	10302	15 – 21
511	128	6231	15 – 21

~~13122~~

>6000 ④

WELL	°F	FT	T R
512	163	8584	15-22
513	168	9601	15-22
"	180	10019	15-22
515	208	9609	15-23
516	153	8485	15-23
517	186	8988	15-23
518	118	6052	15-24
"	190	8588	"
519	170	8414	15-24
2	218	10300	16-21
"	122	6279	"
3	224	9899	16-21
4	118	6150	16-21
"	207	9913	"
6	208	10345	16-21
7	190	9574	16-22
8	152	7666	16-22
"	176	9752	"
"	190	9861	"
9	196	10040	16-22
10	176	8364	16-22
11	174	8765	16-23
12	160	8801	16-23
13	185	7580	16-24
15	144	6242	16-24
18	170	6270	16-24
19	145	6602	16-24
20	150	6261	16-24
21	184	6032	16-24
22	171	8290	16-25
23	162	6643	16-25
25	160	6156	16-25
26	153	6198	16-25
28	165	6785	16-25
339	160	6456	16-25
29	145	6530	16-25
30	146	6497	16-25

End of small book

~~10345~~

>6000 (5)

WELL	°F	FT.	T R
42	118	6094	17 – 21
"	181	9803	"
43	192	9851	17 – 21
"	117	6036	"
44	135	7700	17 – 21
45	179	7643	17 – 22
47	183	6910	17 – 23
48	146	6411	17 – 23
49	190	7024	17 – 23
50	160	6439	17 – 23
52	159	6470	17 – 23
55	114	6271	17 – 24
58	151	6543	17 – 24
60	140	6323	17 – 24
62	148	6224	17 – 24
65	150	6006	17 – 24
"	170	6251	"
93	173	9869	18 – 20
"	176	10787	"
96	183	7023	18 – 22
100	147	6010	18 – 23
101	167	7056	18 – 23
118	152	6711	19 – 21
125	142	6800	19 – 21
127	165	6247	19 – 22
234	190	11885	21 – 17
"	161	8468	"
"	146	7559	"
235	149	7515	21 – 18
238	151	7788	21 – 18
241	157	8496	21 – 19
"	159	8928	"
242	144	6114	21 – 20
244	158	7416	21 – 21
282	122	6754	22 – 16
283	152	9512	22 – 16
284	170	10172	22 – 17
"	175	10291	"

~~11885~~

>6000 (6)

WELL	°F	FT.	T R
286	236	12123	22 - 20
"	245	14992	"
289	138	9056	23 - 17
290	156	9653	23 - 17
291	146	9080	23 - 17
292	142	8902	23 - 17
293	138	8908	23 - 17
354	142	8924	23 - 17
294	141	8828	23 - 17
295	130	8679	23 - 17
296	148	8842	23 - 17
297	164	10330	23 - 18
299	186	12074	23 - 19
301	135	6138	23 - 19
304	138	9262	23 - 21
305	130	8829	23 - 22
"	179	11735	"
306	154	8647	23 - 24
"	226	13580	"
307	143	9125	24 - 17
308	106	6946	24 - 19
"	119	7808	"
310	112	7197	24 - 20
"	119	7532	"
313	200	13257	24 - 23
"	288	14281	"
316	116	6561	25 - 18
"	120	7850	"
317	148	6912	25 - 18
318	122	6775	25 - 18
319	125	8126	25 - 18
320	145	8867	25 - 19
321	115	7724	25 - 19
322	131	6654	25 - 19
"	140	7238	"
"	121	7629	"
323	118	6493	25 - 23

~~14992~~

>6000 (7)

Well	°F	Ft	T R
324	114	7691	26 – 18
325	149	7282	26 – 18
326	124	8105	26 – 19
"	130	8242	"
327	100	7777	26 – 19
"	112	6371	"
328	121	6713	26 – 19
329	131	7792	26 – 20
330	112	8070	26 – 20
331	118	7888	26 – 20
"	120	8134	"
"	113	7498	"
332	121	7444	26 – 20
"	126	8043	"
333	136	8592	26 – 20
334	115	6047	26 – 20
335	113	7289	26 – 20
"	140	7348	"
"	148	8004	"
336	170	11204	26 – 22
337	140	10289	26 – 22
"	160	10703	"
"	146	10303	"
"	125	8105	"
338	115	7015	26 – 25
"	168	12719	"
"	180	14558	"
"	205	15876	"

~~15876~~

2500-5000 SMALL Book

	Well	°F	Depth	°C/km	T R Loc
	355	126	4494	32.9	12-14
	359	117	4503	29.1	12-15
	366	87	3040	25.2	12-16
	368	110	3275	36.2	12-16
	369	92	3535	24.2	12-16
	370	86	2950	25.3	12-16
	"	112	3052	40.0	"
	371	112	2986	409	12-16
	"	116	3097	41.8	"
	"	118	3258	40.8	"
	373	102	4530	22.9	12-16
	"	110	4984	23.8	12-16
	375	92	2283	31.9	13-14
	376	102	4753	21.9	13-16
	377	132	4982	31.8	13-16
	378	125	3155	46.2	13-16
	"	130	4685	33.1	"
	380	105	4840	22.6	13-17
	381	119	4504	29.9	11-14
	384	116	4859	26.6	11-15
	388	100	3777	23.6	16-15
	"	106	4334	23.1	"
	396	110	3740	28.8	19-14
	397	112	4600	24.2	19-15
	407	86	3151	20.2	23-14
	414	95	4616	17.4	24-16
	418	101	4880	18.7	25-15
	419	114	4538	25.3	25-16
	422	117	3000	40.1	26-14
Carbon	424	102	4990	18.6	26-16
Uintah	442	104	4175	25.8	11-23
	445	97	2619	36.2	11-23
	440	112	4813	25.4	11-23
	447	116	4732	27.3	11-24
	449	100	2520	39.8	11-24
	450	110	4494	26.4	11-24
	451	95	3358	27.1	11-24
	452	148	4570	41.1	12-20

2501 - 2999
3000 - 3499
3500 - 3999
4000 - 4499

~~4990~~

	WELL	°F	FT	°C/km	Loc	
DUP	152	145	4406	41.4	12 - 20	
	464	110	3329	35.6	12 - 24	
	466	90	2830	29.0	12 - 24	
	"	107	3828	29.5	"	
	468	112	3302	37.0	12 - 24	
	469	108	4317	26.6	12 - 25	
	470	105	4708	23.2	12 - 25	
	473	98	3927	24.6	13 - 21	
	474	112	3945	31.0	13 - 21	
	485	115	4414	28.9	13 - 23	
	491	100	4997	20.1	14 - 19	
	495	111	4652	25.9	14 - 20	
	496	114	4597	27.4	14 - 20	
	498	100	4747	21.1	14 - 20	
	500	105	3931	27.8	14 - 22	
	"	120	4372	31.3	"	
	505	108	4517	25.4	14 - 24	
	507	103	3497	30.2	14 - 25	
	"	115	4945	25.8	"	
	508	119	4605	29.3	14 - 25	
	512	123	4829	27.2	15 - 22	
	516	104	4640	20.8	15 - 23	
	518	103	4802	19.7	15 - 24	end small book misslocated
	1	100	4102	21.8	15 - 25	
	7	120	4899	25.7	16 - 22	
	10	118	3867	31.6	16 - 22	
	11	116	4693	25.2	16 - 23	
	14	106	3481	28.8	16 - 24	
	28	112	3213	34.3	16 - 25	
	34	153	4953	37.5	16 - 25	
	35	158	4937	39.5	16 - 25	
	36	122	4048	32.0	16 - 25	
	37	126	4692	29.1	16 - 25	
	39	133	4760	31.4	16 - 26	
	40	142	4347	38.2	16 - 26	
	41	145	4178	41.0	16 - 26	
	45	95	3435	23.3	17 - 22	
	46	110	3368	31.9	17 - 22	

4943 - 4997

ECU
2500-5000

WELL	°F	FT	°C/km	LOC
49	105	[illegible]	37.5	17-23
68	175	4395	51.4	17-24
11	148	4402	40.2	"
70	125	4117	32.8	"
71	169	4607	46.7	17-25
72	128	3804	36.9	17-25
73	121	3896	32.7	17-25
74	117	2997	40.1	17-25
11	118	3735	32.7	"
75	120	3956	31.8	17-25
76	125	3811	35.4	17-25
77	121	3682	34.7	17-25
78	122	4094	31.6	17-25
79	95	3282	24.4	17-25
81	118	2814	43.3	17-25
82	109	2960	35.7	17-25
83	152	4275	43.1	17-25
84	116	3890	30.5	17-26
85	105	3633	27.1	17-26
86	116	3600	32.9	17-26
87	100	3281	27.2	17-26
88	86	2736	23.3	17-26
89	101	2528	36.0	17-26
92	105	3137	31.4	17-26
93	110	4713	22.8	18-20
105	108	2767	37.5	18-24
106	135	4604	33.3	18-24
107	129	4773	29.8	18-24
108	128	4409	31.8	18-24
110	108	3282	31.7	18-24
111	106	2884	34.8	18-24
114	95	2799	28.7	18-25
116	98	2620	32.7	18-26
119	117	4745	25.4	19-21
120	148	3606	49.0	19-21
11	152	3600	51.1	"
123	135	4768	32.1	19-21
124	140	3944	41.1	19-21

av 150°F 3603 50.1 19-21

~~4773~~

ECU

2500 - 5000

WELL	°F	FT	°C/km	LOC
125	89	2754	25.1	19 - 21
128	120	4392	28.6	19 - 22
130	138	4679	33.9	19 - 23
131	125	4417	30.5	19 - 23
132	117	3793	31.7	19 - 23
133	110	3550	30.3	19 - 23
144	116	3318	35.7	19 - 23
134	107	3442	29.6	19 - 23
135	115	3203	36.4	19 - 23
137	122	3363	38.5	19 - 23
342	98	3197	30.6	19 - 23
138	96	2604	31.5	19 - 24
142	147	4084	42.8	19 - 25
343	127	3501	39.6	20 - 21
145	118	3670	33.3	20 - 21
146	128	3208	43.7	20 - 21
147	133	3800	39.3	20 - 21
148	125	3937	34.3	20 - 21
149	124	4191	31.7	20 - 21
150	120	4323	29.1	20 - 21
151	124	3592	37.0	20 - 21
152	145	4062	42.2	20 - 21
344	110	3290	32.7	20 - 21
153	118	3834	31.4	20 - 21
154	110	3506	30.7	20 - 21
155	117	3319	36.2	20 - 21
156	96	2988	27.4	20 - 21
157	105	2540	38.7	20 - 21
345	124	3230	41.2	20 - 21
158	121	3230	39.5	20 - 21
159	108	2922	35.6	20 - 21
160	130	2549	56.5	20 - 21
346	100	2781	32.1	20 - 21
162	113	2782	40.6	20 - 21
163	109	2761	38.3	20 - 21
164	124	3006	44.3	20 - 22
165	105	3231	30.5	20 - 22
166	108	3432	30.3	20 - 22

~~4679~~

ECU
2500 - 5000

(5)

Well	°F	FT	°C/m	Loc
167	99	2896	30.2	20 - 22
168	90	2528	28.1	20 - 22
170	98	2504	34.2	20 - 22
171	163	2844	71.8	20 - 22
172	108	2522	41.2	20 - 22
347	119	2883	43.0	20 - 22
174	116	2747	43.1	20 - 22
175	93	2602	29.4	20 - 22
348	110	2736	39.3	20 - 22
176	112	2694	41.3	20 - 23
180	100	2805	31.8	20 - 23
181	120	2530	49.7	20 - 23
"	128	3342	42.0	"
198	112	2590	42.9	20 - 23
200	92	2504	29.8	20 - 23
233	121	4983	25.6	21 - 16
237	105	3028	32.5	21 - 18
"	110	3587	30.0	"
239	112	4519	24.6	21 - 19
240	106	3490	28.7	21 - 19
"	108	3690	28.2	"
242	108	4626	22.5	21 - 20
285	114	2921	39.3	22 - 19
299	117	4378	27.5	23 - 19
300	76	2653	17.2	23 - 19
302	100	2779	32.1	23 - 20
303	97	3972	21.1	23 - 21
310	96	2938	27.9	24 - 20
311	90	4785	14.9	24 - 21
"	94	4965	15.8	"
314	86	3830	16.7	25 - 17½
315	137	4191	37.4	25 - 18
316	102	4059	22.9	25 - 18
318	102	4078	22.8	25 - 18
"	130	4916	29.3	"
319	103	4209	22.5	25 - 18
326	104	4436	21.8	26 - 19

~~4983~~

ECU
2500 – 5000.

(6)

WELL	°F	FT.	°C/km	LOC
330	80	3811	13.9	26 – 20
332	95	2716	29.5	26 – 20
"	115	3375	34.6	"
335	113	3700	30.5	26 – 20

~~3841~~

using Max depth on DST's

all perf in WSTC & DRCK

SWPI well (54) some question on position

Use 5480' 200°F (?) 49.6°C/km

in Desert Creek fm (Pennsylvanian)

ambient 51°F.

NE NE SW sec 17 T15S-R19E

Could be in younger than WSTC + GRRV

PI-(145)

21S-18E

SW NE SW sec 12 T21S-R18E

Producing Navajo

bottom Paradox at 7615

Perf: NVJO 5124-5146 WNGT 5794-5900

Top KIKOT GUESS P.

DST 551 NVJO 5140-5203 142°F 31.8°C/km

water in NVJO

DST 563 WNGT 5934-5989 140°F 27.0

PI-(104) ✓ ×

SE NW NW sec 2 T16S-R24E

producing DKOT

bottom MRSN 7250

perf: DKOT 7015-7034 COMN 7042-7062

Top DKOT GUESS: 6940 dep-14 14'/16'

DST 3220-3250 Cattlegate 180°F 72.3°C/km

(Cretaceous)

PI-(97) ✓ ×

NE SE SW sec 27, T13S-R21E

producing DKOT

bottom 553ENRD at 10605

No perf

TOP DKOT GUESS: 9700'

DST 2465-2550 in wasatch 103°F 41.4°C/km

DST 9613-9710 in Mancos 223°C 33.4

overlaps DKOT note: P higher above Mancos than below.

GRAND CO. DEEPEST BHTs/TSHP

LOCATION S	T	R	BHT °F	DEPTH FT	ELEVATIONS SURFACE	BHT	GRAD °C/Km	No. WELLS/TSHP			
23	18S	20E	176	10787	8952		21.1	2		19.8	4
	18	21						0		—	
15	18	22	183	7023	6065		34.3	5	✓	31.1	5
4	18	23	167	7056	6507		30.6	4	✓	26.7	5
5	18	24	129	4773	5058		29.8	8	⊙	—	
23	18	25	95	2799	4713		28.7	5	⊗ ✓	—	
18	18	26	98	2620	4873		32.7	1	⊗ ✓	—	
11	19	14	168	8781	5015		24.3	3	✓	22.5	5
14	19	15	159	10814	6075		18.2	1	✓	18.2	1
	19	16						0		—	
	19	17						0		—	
36	19	18	106	6427	5975		15.6	1	✓	15.6	1
	19	19						0		—	
	19	20						0		—	
9	19	21	142	6800	7473		24.4	8	✓	30.0	4
6	19	22	165	6247	6125		33.3	4	✓	31.7 ✓	3
7	19	23	138	4679	5275		33.9	10	⊙ ✓	—	
14	19	24	96	2604	4674		31.5	4	⊗	—	
4	19	25	147	4084	5603		42.8	2	⊙ ✓	—	
	19	26						0		—	
33	20	14	125	7446	?		18.1	1	✓	19.4	2
	20	15						0		—	
17	20	16	118	2640	4197		46.3	1	⊗ ✓	? —	0
	20	17 TO 20E						0		—	
4	20	21	120	4323			29.1	23	⊙ ✓	—	
14	20	22	108	3432	4863		30.3	14	⊙ ✓	—	
5	20	23	100	2805	4851		31.8	27	⊗ ✓	—	
6	20	24	88	2116	4703		31.9	31	⊗ ✓	—	
5	21	14	120	5992	4577		21.0	1	✓	21.0	1
24	21	15	154	10605	4224		17.7	1	✓	19.0	3
33	21	16	141	9434	4282		17.4	2	✓	18.6	2
26	21	17	190	11885	4452		21.3	1	✓	21.3	1
23	21	18	151	7788	4924		23.4	4	✓	26.0	6
17	21	19	159	8928	5169		22.0	3	✓	22.4	2
18	21	20	144	6114	5187		27.7	2	✓	23.9	2
11	21	21	158	7416	4963		26.3	1	✓	26.3	1

E. CENT. U. — DEEPEST WELL/TSHP

(4)

Location S	T	R	BHT °F	Depth Ft.	Elevation Surface	BHT	Grad °C/Km	No. Wells/TSHP			
2	21S	22E	104	1807	4681		53.5	1	⊗	✓	—	
19	21	23	92	1994	4577		37.5	32	⊗	✓	—	
30	21	24	80	1141	4323		46.3	4	⊗	✓	—	
9	22	15	140	8900	4441		18.2	3		✓	19.2	4
25	22	16	152	9512	4132		19.4	2			19.3	2
34	22	17	175	10291	4220		22.0	1			21.2	4
	22	18						0			—	
22	22	19	114	2921	4685		39.3	1	⊗	✓	—	
17	22	20	245	14992	4780		23.6	1		✓	25.7	2
10	22	21	94	1439	4697		54.5	1	⊗	✓	—	
	22	22 TO 26E						0			—	
19	23	14	118	6061	4378		20.1	2			21.9	2
21	23	15	116	5636	4687		21.0	1		✓	21.8	1
3	23	16	145	9449	4038		18.1	2			19.5	3
11	23	17	156	9653	4298		19.8	9			19.1	12
21	23	18	164	10330	4525		19.9	2	✓		22.4	3
15	23	19	186	12074	4589		20.4	3		✓	22.6	2
6	23	20	100	2779	4834		32.1	1	⊗		—	
5	23	21	138	9262	4707		17.1	2		✓	17.1	1
9	23	22	179	11735	4886		19.9	1		✓	18.9	2
	23	23						0			—	
31	23	24	226	13580	4307		23.5	1		✓	22.6	2
21	24	14	162	7645	4320		26.5	2			25.9	3
	24	15						0			—	
19	24	16	130	8648	4774		16.7	2			17.6	2
1	24	17	143	9125	4479		18.4	3	✓		22.1	2
	24	18						0			—	
22	24	19	119	7808	4777		15.9	1		✓	15.7	2
36	24	20	119	7532	4448		16.5	2	✓		15.5	3
7	24	21	94	4965	4855		15.8	1	⊙	✓	—	
	24	22						0			—	
13	24	23	288	14281	4569		30.2	1		✓	25.4	2
22	25	14	122	6991	4775		18.5	1	✓		18.5	1
15	25	15	108	6469	?		16.1	2	✓		18.9	2
10	25	16	134	7382	4751		20.5	2	✓		20.4	3
	25	17						0			—	

E. CENT. UTAH – DEEPEST BHT/TSHP (5)

LOCATION			BHT	DEPTH	ELEVATION		GRAD.	No WELLS/TSHP			
S	T	R	°F	FT.	SURFACE	BHT	°C/km				
35	25S	18E	125	8126	5488		16.6	5	✓	18.7	6
26	25	19	145	8867	5454		19.3	3	✓	19.1	5
	25	20 TO 22E						0	✓	—	
16	25	23	118	6493	5122		18.8	1	✓	18.8	1
26	26	14	127	6699	5645		20.7	3		23.4	3
	26	15						0		—	
31	26	16	102	4990	5157		18.6	1	✓ ◎	1 —	
5	26	17	109	6461	?		16.4	1	✓	16.4	1
4	26	18	114	7691	5302		14.9	2	✓	19.7	2
14	26	19	130	8242	?		17.5	3	✓	17.7	5
29	26	20	136	8592	5934		18.0	7	✓	17.9	13
	26	21						0	✓	—	
1	26	22	170	11204	5300		19.4	2	✓	17.4	5
	26	23 AND 24E						0		—	
12	26	25	205	15876	8594		17.7	1		17.1	4

5000-5250
5250-5500
5500-5750
5750-6000

VARIENCE FROM MEAN OF 23.8°C/km

E. CENT. UT. — 5000-6000 (YELLOW OUTLINE)

PROJ BHT column 8 +9 & 10 ON 24.0°C/km

T- PROJ. BY GRAD. TO 5500' (1676 m)

ambient this page 7.2

EFFICIENCY® LINE No. 2636 AMPAD

	1 LOC	2 WELL NO.	3 BHT	4 DEPTH	5 ELEV. COLLAR	6 °C/km	7 °C	8 Proj meters up- dn+	9 ΔT	°C
1	11-19	426	123	5363	5795 +27	26.5	51.6	41.8+	1.00+	51.6
2	11-21	430	125	5898	5726 +9	24.7	48.4	121.3−	2.9−	48.8
3	"	431	107	5016	5766 -3	22.5	44.9	147.5+	3.5+	45.2
4	11-22	432	125	5348	5358 +35	27.3	53.0	46.3+	1.1+	52.8
5	11-23	434	137	5670	5992 +58	29.6	56.8	✓		
6	"	443	128	5895	6000 +19	25.7	50.3	✓		
7	"	444	130	5856	5617 +7	26.5	51.6	✓		
8	"	438	126	5263	5964 +43	28.1	54.3	✓		
9	"	"	143	5950	5964 +62	30.0	57.5	✓		
10	"	439	123	5275	6094 +32	27.0	52.4	✓		
11	"	445	127	5851	5861 +17	25.5	49.9	✓		
12	11-24	446	128	5943	5208 +17	25.5	49.9	✓		
13	"	447	130	5839	5400 +94	26.5	51.6	✓		
14	"	450	122	5580	5579 +14	25.2	49.4	✓		
15	"	448	128	5598	5620 +32	27.0	52.4	✓		
16	12-20	452	120	5596	5648 +10	24.4	48.1	✓		
17	12-21	454	134	5831	5945 +40	27.8	53.8	✓		
18	"	455	126	5306	6027 +40	27.8	53.8	✓		
19	"	"	130	5547	6027 +41	27.9	54.0	✓		
20	"	457	123	5324	6185 +29	26.7	51.9	✓		
21	12-22	460	130	5781	— +30	26.8	52.1	✓		
22	"	461	140	5820	6036 +60	29.8	57.1	✓		
23	12-24	465	122	5199	5900 +32	27.0	52.4	✓		
24	"	"	126	5692	" +21	25.9	50.6	✓		
25	"	467	140	5270	6208 +91	32.9	62.3	✓		
? 26	~~13-20~~	~~453~~	~~140~~	~~5196~~	~~6163~~	~~33.3~~	~~63.0~~			
? 27	"	"	123	5984	6163 0	23.8	47.1	✓		
28	13-23	484	115	5835	— -19	21.9	43.9	✓		
29	13-25	486	111	5005	7290 +12	24.0	47.4	✓ 150.9+	3.6+	47.5
30	"	487	124	5797	7523 +10	24.8	48.8	✓		
31	14-24	504	128	5149	6374 +56	29.4	56.5	✓	~~5.1.0.4~~	

ECU

(2)

5000' - 6000'

PROJ. BY GRAD. TO 5500'

	1 LOC	2 WELL	3 BHT	4 DEPTH	5 COLLAR ELEV.	6 °C/km	7 °C	8	9	°C
1	14-24	505	132	5899	7306	26.7	52.3	✓121.6 –	2.9 –	52.6
2	15-21	510	116	5694	7414	20.8	45.5	✓59.1 –	1.4 –	45.3
3	16-21	3	118	5792	8129	21.1	46.0	✓		
4	"	6	124	5778	7786	23.0	49.1	✓		
5	16-22	7	106	5335	7509	18.8	42.1	✓		
6	"	8	120	5930	7325	21.2	46.1	✓		
7	"	9	147	5918	7436	29.6	60.2	✓		
8	16-24	16	183	5805	6973	41.4 ✓	80.0	✓93.0 –	2.2 –	81.7
9	16-25	24	127	5940	8357	23.3	49.6	✓		
10	"	26	148	5803	7001	30.5	61.7	✓		
11	"	31	130	5797	6844	27.7	57.0	✓		
12	"	32	158	5544	6470	35.2	69.6	✓		
13	"	33	137	5132	—	30.5	61.7	✓		
14	"	36	140	5706	6001	31.8	63.9	✓		
15	"	37	139	5892	7326	27.2	56.2	✓		
16	17-23	53	140	5526	5426	29.4	59.9	✓		
17	17-24	340	166	5935	5935	40.1	77.8	✓		
18	"	54	142	5596	6093	29.6	60.2	✓		
19	"	59	156	5680	6136	33.7	67.1	✓		
20	"	"	162	5851	"	34.6	68.6	✓		
21	"	61	167	5253	5917	40.2	78.0	✓		
22	"	63	168	5248	5838	40.7	78.8	✓		
23	"	64	133	5762	5804	29.0	59.2	✓		
24	"	69	154	5956	5759	31.5	63.4	✓139.0 –	3.3 –	64.5
P 25	~~18-20~~	~~93~~	~~98~~	~~5407~~	~~8952~~	~~15.8~~	T-LOG ON HAND — ISOTHERMAL FROM			4000'
26	"	"	110	5447	"	19.7	43.1	✓		
27	18-22	95	144	5433	5655	31.2	62.9	✓		
28	"	97	145	5597	6007	30.6	61.9	✓		
29	"	98	158	5703	5825	34.2	67.9	✓		
30	"	99	126	5386	5872	25.4	53.2	✓		
31	18-23	102	134	5947	6164	25.4	53.2	✓		~~5956~~

AMPAD EFFICIENCY LINE No. 2636

ECU

5000' - 6000'

(3)

	1 LOC	2 WELL	3 BHT	4 DEPTH	5 COLLAR ELEV	6 °C/km	7	8	9	
1	~~18-23~~	~~103~~	~~114~~	~~5461~~	~~5647~~	~~21.0~~		~~0-NAIT~~		
2	"	103	138	5410	"	27.6	56.8	✓		
3	19-21	122	165	5209	6767	39.9	77.5	✓		
4	19-22	126	147	5213	5706	33.6	66.9	✓		
5	"	129	140	5772	5570	28.1	57.7	✓		
6	21-18	235	141	5792	5155	28.3	58.0	✓		
7	"	236	145	5114	5217	33.5	66.7	✓		
8	21-20	243	108	5172	5068	20.1	44.3	✓		
9	22-16	282	108	5351	4419	19.4	43.1	✓		
10	22-17	284	109	5185	4220	20.4	44.8	✓		
11	"	"	115	5582	"	20.9	45.6	✓		
12	23-17	289	110	5320	4463	20.2	44.4	✓		
13	"	291	118	5122	4291	23.8	50.5	✓		
14	23-18	297	130	5734	4525	25.1	52.7	✓		
15	"	298	115	5282	4474	22.1	47.6	✓		
16	24-17	307	119	5218	4465	23.8	50.5	✓		
17	24-20	309	96	5606	4648	14.6	35.1	✓		
18	26-19	328	110	5895	6017	182	41.1	120.4 -	2.9 -	40.4
19	26-20	332	120	5636	4349	22.3	47.9	✓		
20										
21										
22	NOTE:									
23		THE ASSUMED AMBIENT T WILL INTRODUCE LESS								24.0°C/km
24	ERROR IF AV GRAD FOR ENTIRE STATE FOR THIS INTERVAL (5000-6000')									
25	IS USED TO PROJ MEASURED BHT FROM ITS LOCATION TO 5500'.									
26	(SEE LAST COLUMN)									
27										
28										
29										
30									~~5895~~	
31										

AMPAD EFFICIENCY® LINE No. 2636

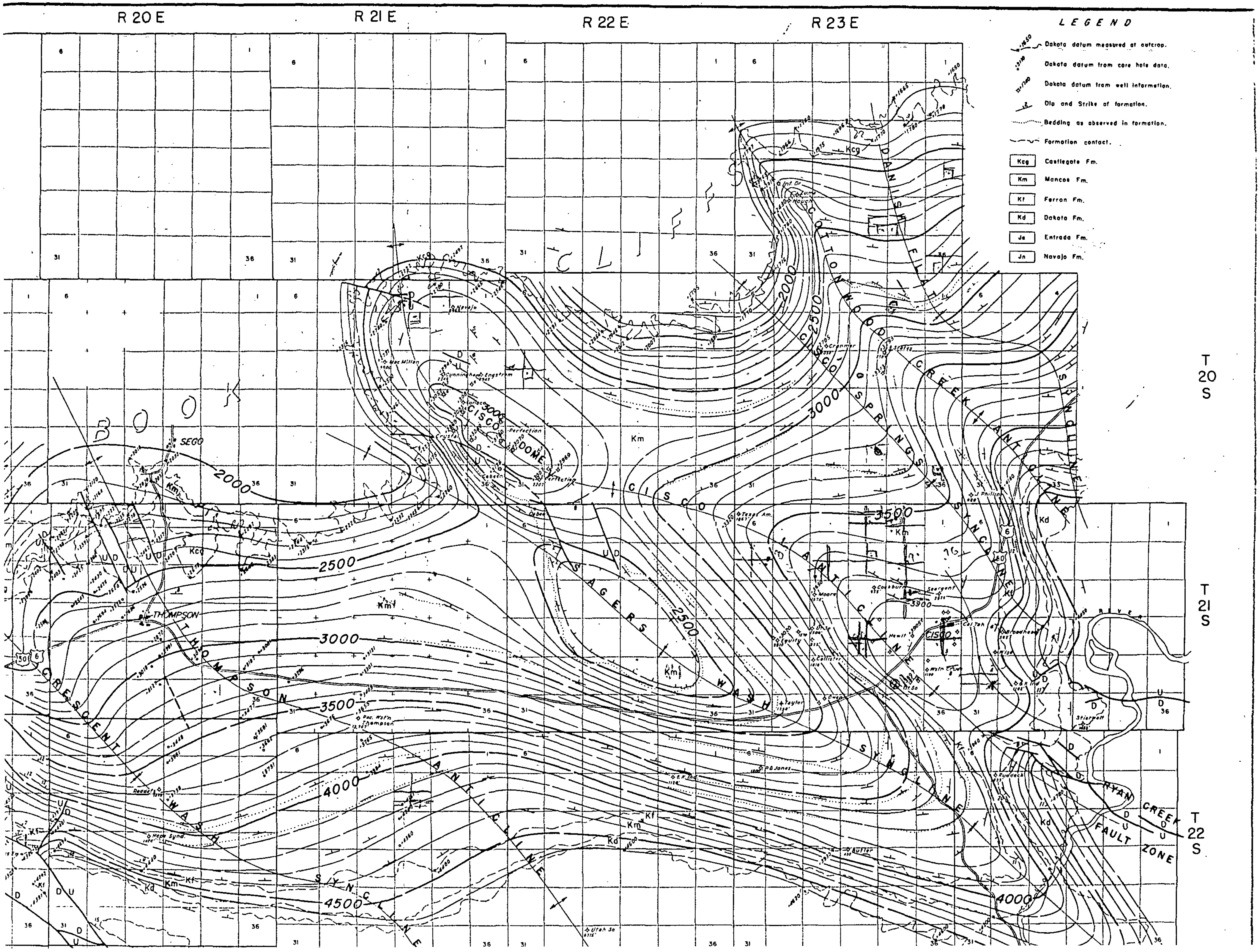
5000 - 6000

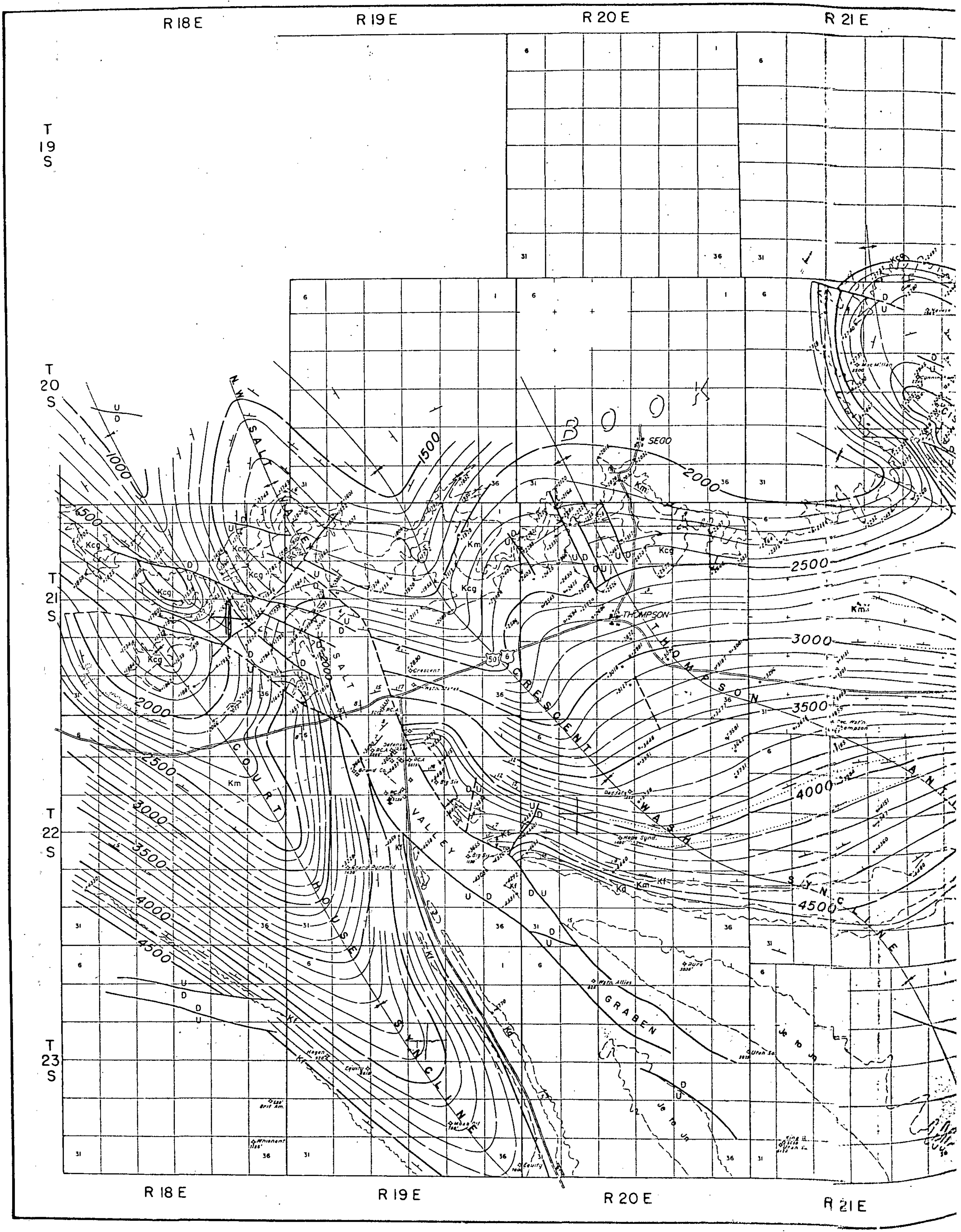
ECU
ADDITIONAL EMERY Co

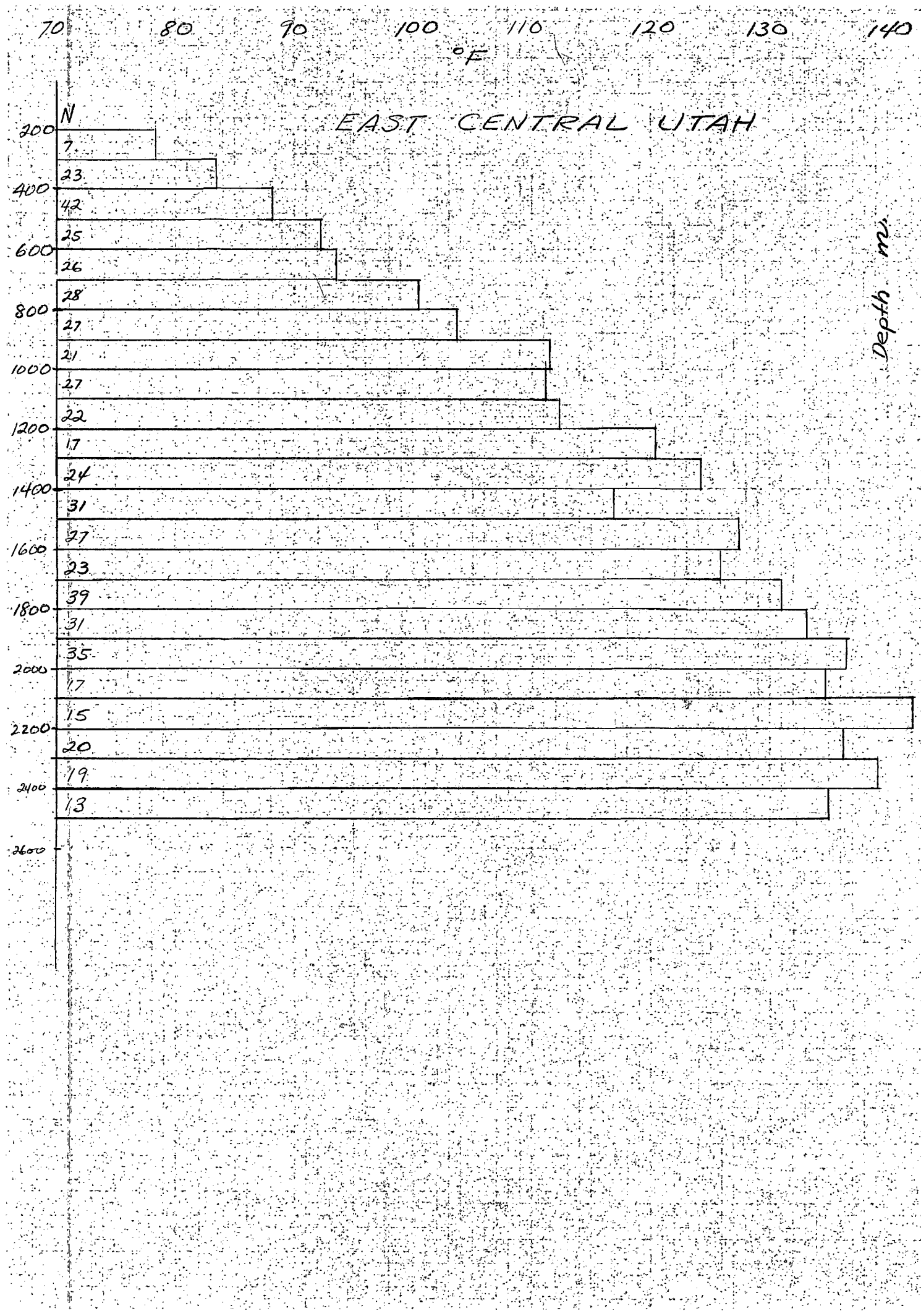
(4)

	1 LOC	2 WELL	3 BHT	4 DEPTH	5 COLLAR ELEV	6 °C/km	7 °C	8	9
1	17-16	390	118 °F	5485	4820	22.3	48.0	✓	
2	21-14	400	120	5992	4577	21.0	45.8	✓	
3	21-16	402	112	5600	4282	19.9	44.0	✓	
4	22-15	405	114	5911	4356	19.4	43.6	✓	
5	23-14	407	122	5456	4234	23.7	50.3	✓	
6	23-15	409	116	5636	4687	21.0	45.8	✓	
7	23-16	410	116	5504	4038	21.5	46.6	✓	
8	24-14	412	134	5730	4320	26.4	54.8	✓	
9	24-16	415	105	5320	4773	18.5	41.6	✓	
10	25-15	418	120	5787	5128	21.7	47.0	✓	
11	25-16	420	103	5030	4866	18.8	42.1	✓	
12	26-14	421	138	5736	5122	27.6	56.8	✓	
13	26-14	423	123	5998	5374	21.9	47.3	✓	
14									
15					T PROJ. BY GRAD.				
16					TO 5500' (1676m)				
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									~~5990~~
30									5700
31									

EFFICIENCY © LINE No. 2636 AMPAD


R 20 E
R 21 E
R 22 E
R 23 E
LEGEND
Dakota datum measured at outcrop.
Dakota datum from core hole data.
Dakota datum from well information.
Dip and Strike of formation.
Bedding as observed in formation.
Formation contact.
Kcg Castlegate Fm.
Km Mancos Fm.
Kf Ferron Fm.
Kd Dakota Fm.
Je Entrada Fm.
Jn Navajo Fm.
T 20 S
T 21 S
T 22 S
BOOK CLIFFS
SEGO
THOMPSON
CISCO DOME
CISCO
COTTONWOOD CREEK ANTICLINE
CISCO SPRINGS SYNCLINE
DANISH FLAT
CISCO ANTICLINE
SAGERS WASH SYNCLINE
THOMPSON ANTICLINE
CRESCENT WASH SYNCLINE
RYAN CREEK FAULT ZONE
RIVER
2000
2500
3000
3500
3900
4000
4500


R 18 E
R 19 E
R 20 E
R 21 E
T 19 S
T 20 S
T 21 S
T 22 S
T 23 S
BOOK
SEGO
THOMPSON
CRESCENT
THOMPSON
SALT VALLEY
COURT HOUSE SYNCLINE
VALLEY
CRESCENT WASH
SYNCLINE
GRABEN
ANTI
1000
1500
2000
2500
3000
3500
4000
4500
Kcg
Km
Kd
Kf
Je to Jn


70
80
90
100
110
120
130
140
°F
EAST CENTRAL UTAH
N
7
23
42
25
26
28
27
21
27
22
17
24
31
27
23
39
31
35
17
15
20
19
13
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
Depth, m.

(*MAX T.):

S-T-R	1 WELL #	2 ELEVS COLLAR	3 T.P KD	4 DEPTH	5 FOOTAGE Km	6 % Km	BHT °F, °C	8 °C/km	9	
25-20-21 1	162	5030	3050	2782	1980	71.1	113	40.6		
31-20-22 2	173	4986	3000	2334		85.0	94*	33.6		
10-20-21 3	154	5656	2950	3506		77.2	110	30.7		
3-20-21 4	146	5706	2820	3208	2886	90.0	128*	43.7		
2-20-21 5	147	5805	2800	3800	3005	79.1	133	39.3		
2-20-21 6	344 343	5704 5648	2750 2860	3290 3501	2954 2788	89.8 79.6	110 127	32.7 39.6		
6-20-22 7	164	5565	1880	3006	3685	100.0	124	44.3		
8	168	5091	2830	2528	2261	89.4	90	28.1		
14-20-22 9	166	4863		3432			108	30.3		
14-20-22 10	167	4840		2896			99	30.2		
5-20-24 11	176	4584		1690			80	31.3		
5-20-24 12	179	4592		1678			80	31.5		
5-20-23 13	180	4851		2805			100	31.8		
5-20-23 14	181	4972		2530 3342			120 128	49.7 42.0		
27-20-23 15	201	4855		2345			95	34.2		
36-20-23 16	202	4511		1841			77	25.7		
3-20-24 17	213	4583		1586			84	37.9		
8-20-24 18	214	4583		1562			100	43.2		
8-20-24 19	215	4586		1610			87	40.8		
8-20-24 20	216	4587		1611 1655			82	35.1 34.1		
8-20-24 21	217	4596		1558			85	39.8		
9-20-24 22	218	4610.5		1670			87	39.3		
9-20-24 23	219	NOT GIVEN		1602			86	39.8		
9-20-24 24	220	4572		1504			85	41.2		
9-20-24 25	221	4592		1537			80	34.4		
9-20-24 26	222	4583		1624			85	38.2		
5-20-24 27	223	4601		1344			84	44.8		
16-20-24 28	224	4605		1363			73	29.4		Dec:
26-21-19 29	234	4452		8468 1777			161 105	23.7 55.4		June Mar.
23-21-18 30	237	4867	1630	3028 3587	3237	100 90.2	105 110	32.5 30.0		F Mar.
7-21-19 31	240	5150		3490 3690			104 108	28.7 28.2		N N

EFFICIENCY ZONE No 2636 AMOCO

		ELEVS					BHT				
S-T-R	1 WELL #	2 COLLAR	3 TOP Kd	4 DEPTH	5 FOOTAGE Km	6 %/Km	°F	°C	8 °C/km	9	Month
17-21-19 1	241	5169		8996 8928			157 159		22.7 22.0		Jan. Jan.
11-21-21 2	244	4963		7416			158		26.3		N
1-21-23 3	246	4906		1411			78		34.9		S
~~2-21-23 4~~	~~247?~~	~~4558~~		~~1510~~							
2-21-23 5	248	4575		1685			92		33.5		D
3-21-23 6	249	Not given	—	1425			82		39.7		N
2-21-23 7	250	4650	3550	1500	1100	73.3	85		41.3		Ap.
3-21-23 8	251	4577	3500	1414	1077	76.2	95		56.7		N.
3-21-23 9	252	4487	—	1126			68		27.5		My.
4-21-23 10	253	4207	—	1302			100 or 108		60.6 or 79.8		Ap.
7-21-23 11	257	4502	3400	1332	1102	82.7	85		46.5		Ja.
9-21-23 12	258	4485	3700	1482	785	53.0	82		38.1		D.
10-21-23 13	259	Not given	—	1136			85		54.6		O.
10 21-23 14	260	"	—	1744			93		43.9		S.
10-21-23 15	261	4444	—	1186			86		53.8		N.
10-21-23 16	262	4454	3700	1306	754	57.7	85		47.5		F.
11-21-23 17	263	4458	—	1117			80.9		48.0		O.
11-21-23 18	264	4419	"	1288			50.9		50.9		Au.
11-21-23 19	265	4507	—	1634			102		56.9		Jy
11-21-23 20	266	4482	3700	1164 1290	782	67.2 60.6	98 79		73.6 67.8		Au.
12-21-23 21	267	4235	3720	1391	515	37.0	76		32.8		Oc.
14-21-23 22	268	4412	3820	1230	592	48.1	74		34.1		D
9-21-24 23	270	4467	?	870			92		77.0		Au.
22-21-23 24	271	4911	3840	1391	571	41.0	90		51.1		Ja.
24-21-23 25	274	4611	3905	704	706	100.0	75		62.1		Au.
26-21-23 26	277	4362	3800	1128	562	49.8	81		48.5		O.
~~27~~	~~278?~~										
30-21-24 28	279	4323	3900	1141	423	37.1	80		46.3		Ap.
30-21-24 29	280	4323	3900	1122	423	37.7	82		50.4		S.
17-22-20 30	286	4780	4100	12123 14992	680	5.6 4.5	236 245		27.8 23.6		D. Ja.
31											

EFFICIENCY LINE No. 26336 AMPAD

ELEVS

S-T-R		1 WELL #	2 COLLAR	3 TOP Kd	4 DEPTH	5 FOOTAGE Km	6 °/Km	°F	°C	8 °C/Km	9	Month
16-22-21	1	287	4697	4200	1439	497	34.5	94		54.5		Je.
2-22-23	2	288	not given	3[illegible]0	1492			94		52.5		Au.
15-23-19	3	299	4589	3890	4378 12074	699	16.0 5.8	117 186		27.5 20.4		Ap. Jy.
	4	395										
	5	396										
	6	397										
	7	401										
	8	404										
	9											
	10											
	11											
	12											
	13											
	14											
	15											
	16											
	17											
	18											
	19											
	20											
	21											
	22											
	23											
	24											
	25											
	26											
	27											
	28											
	29											
	30											
	31											

AMPAD EFFICIENCY® LINE No. 2636

WELLS COMPARED IN MANCOS

S-T-R	Well #	Elevs: Collar	Elevs: Top Ko	Elevs: Bottom	Depth	Footage Km	Ft out LMA	% Km	BHT: °F	BHT: °C	°C/km
19-19-23 1	70	5178	1900	~~3385~~	3793	3278	~~5~~	86.4	125		31.7
~~26-21-23 2~~	~~277~~	~~4362~~	~~3800~~	~~3072~~	~~1.28~~	~~562~~	~~128~~	~~45.8~~	~~81~~		~~48.5~~
2-20-23 3	176	4854	2900	2960	2694	1954		72.5	112		41.3
36-20-23 4	202	4511	3470		1814	1041		57.4	77		25.7
27-20-23 5	201	4855	3230		2345	1625		69.3	95		34.2
15-20-23 6	198	4756	3050		2590	1706		65.9	112		42.9
2-22-16 7	233	4067	3520		4983	547		11.0	121		25.6
8-17-26 8	84	5278	✓		3890				116		30.5
8-17-26 9	86	5158	✓		3600				116		32.9
17-17-25 10	77	5521	✓		3682				121		34.7
15-18-25 11	112	4786	✓		1888				89		36.7
19-18-25 12	113	4900	✓		1973				92		37.9
5-18-24 13	107	5058	✓		4773				129		29.8
8-18-24 14	108	5159	✓		4409				128		31.8
5-18-24 15	105	5168	✓		2767				108		37.5
5-18-24 16	106	5254	✓		4604				135		33.3
5-18-24 17	341	5147	✓		4470				126		30.6
4-19-25 18	142	5603	✓		4084				147		42.8
16-18-24 19	110	5019	✓		3282				108		31.7
21-18-24 20	111	5004	✓		2884				106		34.8
30-19-25 21	143	4598	✓		1954				100		45.7
14-19-24 22	138	4674	✓		2604				96		31.5
35-19-24 23	139	4576	✓		1598				81		34.2
35-19-24 24	140	4575	✓		1575				80		33.6
36-19-24 25	141	4647	✓		1475				102		63.0
20-19-24 26	133	5050	✓		3550				110		30.3
24-19-23 27	134	4833	2170		3442	2663		77.4	107		29.6
6-19-23 28	135	4872	2430		3203	2442		76.2	115		36.4
7-19-23 29	136	4892	2420		2436	2472		100.0	104		39.6
6-19-23 30	342	4813	2720		2797	2093		74.8	98		30.6
26-20-21 31	163	5081	?		2761				109		38.3
"	"	"			1800				112		61.8

EFFICIENCY LINE NO. 2636

AMPAD

PERCENTAGE OF HOLE IN MANCOS SHALE VS. GRADIENT TO BOTTOM

EAST CENTRAL UTAH

HOLES ON MANCOS OTC.

57

Wells Collared in Mancos

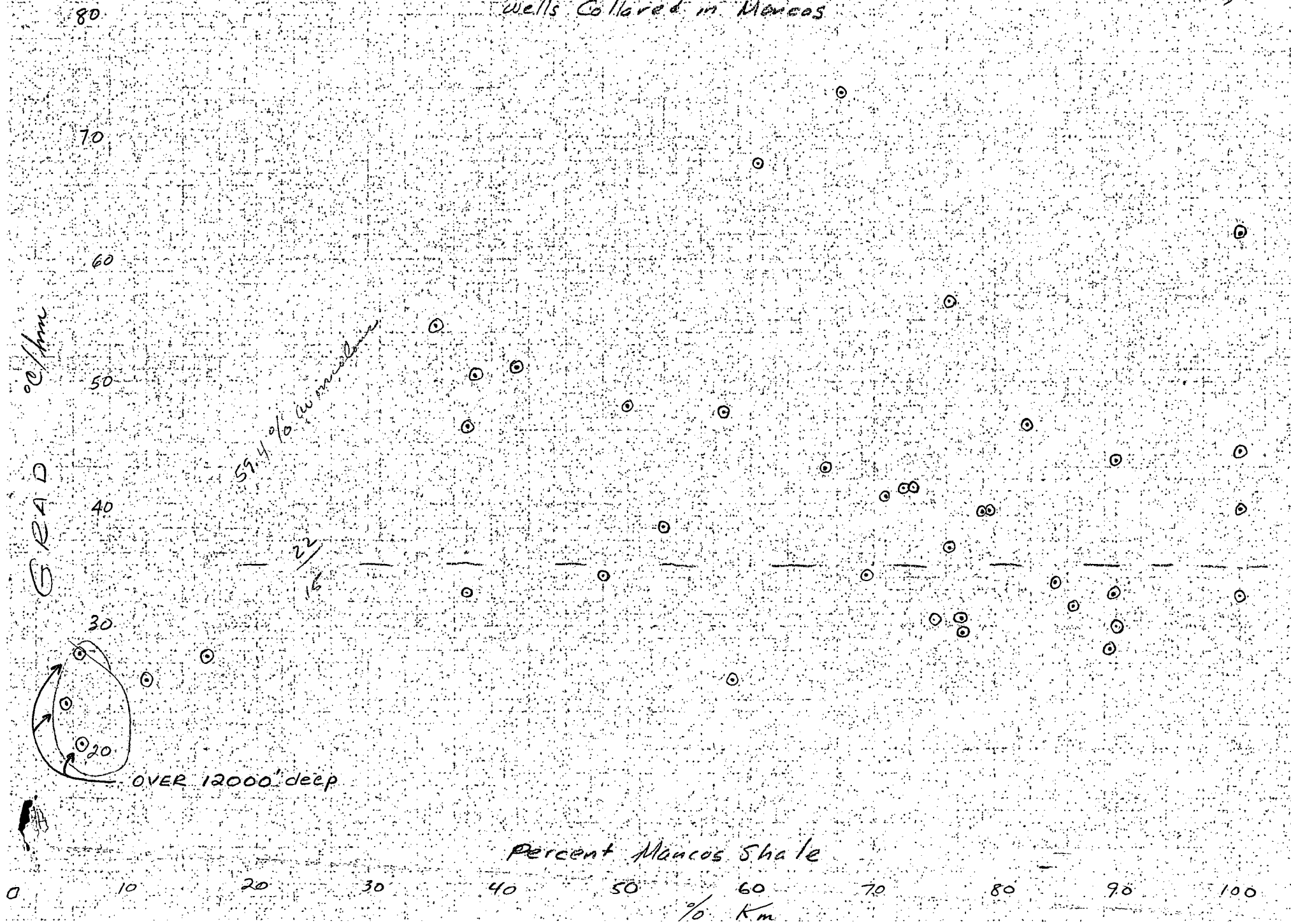


Table 1 — Generalized description and water-bearing properties of rocks in central and eastern parts of Uinta Basin, Utah

Sources: Abbott, Ward, 1957; Kay, J. L., 1934; Kinney, D. M., 1949 and 1955; MacLachlan, M. E., 1957; Sanborn, A. F., Darrow, D. L., and Liscomb, R. L., 1957; Stokes, W. L., 1952 and 1957; and Walton, P. T., 1957.

System	Series	Formation	Map symbol	Thickness (feet)	Description	Distribution and structure	Water-bearing properties
Quaternary	Recent and Pleistocene	Alluvium and outwash gravel	Qao	1 - 200	Gravel, sand, and silt; generally unconsolidated	Outwash gravel prominent along Uinta River drainage. Recent alluvium occurs in most stream valleys	Probably will supply water to shallow wells wherever it is more than 20 feet thick
Tertiary	Miocene(?)	Bishop conglomerate	Tb	1 - 800	Conglomerate of rounded to subangular boulders in sandstone matrix	South slope of Uinta Mountains dipping gently away from mountains	Unknown
	Oligocene or Eocene	Duchesne River formation	Tdr	50 - 300	Mudstone, siltstone, sandstone in beds 2 to 6 ft thick, commonly separated by unconsolidated beds of similar material	Underlies surface over northern and eastern parts of basin. Normally flat lying; maximum dips 2° - 4°	Probably poor
	Upper Eocene	Uinta formation	Tu	1,500±	Green to reddish shale capped in places by 30 to 50 ft of sandstone in beds a few inches to a few feet thick	Underlies surface over southern half of basin; underlies Duchesne River formation elsewhere. Normally flat lying; maximum dips 2° - 4°	Probably poor except that sandstone cap may supply small quantities of water to wells
	Eocene	Green River formation (divided into Evacuation Creek, Parachute Creek, Garden Gulch, and Douglas Creek members)	Tgr	About 1,500 ft where exposed; as much as 4,000 ft in subsurface (5,600 ft recorded in one well)	Black shale, sandstone, and oolitic limestone. Oil- and gas-producing sandstone and shale	Underlies entire basin but is several thousand feet below surface along axis of basin	Water occurs with oil in sandstone lenses, but it is generally too highly mineralized for use
	Lower Eocene	Wasatch formation	Tw	1,500 - 5,000	Mudstone, sandstone, conglomerate, and minor amounts of limestone; predominantly fluviatile red beds	Underlies entire basin - is more than 10,000 ft below surface at deepest part. See figure 3 for structure. May include older rocks	Unknown
Tertiary and Cretaceous	Paleocene and Upper Cretaceous	North Horn formation	Not shown on map	500 - 1,600	Interbedded sandstone conglomerate, shale, and limestone	Probably does not crop out within area of this report. May occur in the subsurface	Unknown
Cretaceous	Upper Cretaceous	Mesaverde formation	Kmv	400 - 1,200	Fine- to medium-grained sandstone, dark-gray shale, lignitic shale and lignite. Sandstone predominates in lower half of formation, and lignitic shale and lignite are present only in upper part	Crops out at eastern end of basin. Probably underlies entire basin	Probably can supply small quantities of water to wells from sandstone
		Mancos shale (includes rocks equivalent to Emery and Ferron sandstone members and Frontier sandstone member, and intertonguing sandstone lenses of the Mesaverde formation)	Kmd	3,500 - 5,000	Gray marine mudstone with eastward-thinning sandstone lenses	Crops out northeast of basin. Probably underlies entire basin	Sandstone lenses may supply water, which is likely of poor quality because enclosing shale contains gypsum, to wells
		Dakota sandstone (included with Mancos shale on generalized map)		50 - 90	Conglomeratic sandstone that represents advance of Cretaceous sea; transects time lines	Crops out north and northeast of basin. Probably underlies entire basin	Rock is probably too dense to supply water to wells in quantity
	Lower Cretaceous	Cedar Mountain formation (includes Buckhorn conglomerate member; Stokes 1952)	Not shown on map		Green, purple, and maroon mudstone with discontinuous conglomerate and conglomeratic sandstone at base	Probably underlies entire basin; thickens to southwest	Unknown
Jurassic	Upper Jurassic	Morrison formation (probably mostly equivalent to the Brushy Basin shale member of southeastern Utah)	Jm	800 - 1,000	Varicolored mudstone and claystone	Crops out north and northeast of basin. Probably underlies entire basin	Probably poor
		Curtis formation	J'Ku	250 - 300	Fossiliferous, glauconitic sandstone, shale, and sandy limestone	do.	Do.
		Entrada sandstone		100 - 175	Principally crossbedded eolian sandstone	do.	Can supply small quantities of good water to wells
	Upper and Middle Jurassic	Carmel formation		125 - 170	Red sandstone, shale, and siltstone	do.	Probably poor
Jurassic and Triassic(?)		Navajo sandstone		700 - 900	Crossbedded calcareous sandstone	do. See figure 3 for structure	Can supply moderate quantities of good water to wells near outcrop area on south slope of Uinta Mts. Quality of water may be poor where Navajo is 2,000 - 3,000 feet or more below surface
Triassic	Upper Triassic	Chinle formation (includes Shinarump member)	Tcm	250	Basal sandstone or conglomerate overlain by red-orange, purple, or green claystone to conglomerate. Conglomerate of Shinarump member fills channels in Moenkopi formation	Crops out north and northeast of basin. Probably underlies entire basin	Probably poor except in Shinarump
	Middle(?) and Lower Triassic	Moenkopi formation (included with Chinle formation on map)		700 - 800	Red beds of unfossiliferous sandstone, siltstone, and claystone both above and below a middle fossiliferous limestone member	do.	Probably poor
Permian		Park City formation	Ppp	200±	Thick limestone with intercalated quartzite and sandstone	do.	Supplies water from springs in Ashley Creek valley north of Vernal and in Whiterocks River valley
		Phosphoria formation (included with Park City formation on map)		40 - 60	Phosphatic shale with thin limestone beds	Reported as a separate unit only in well logs	Water reported from Phosphoria may come from underlying Weber sandstone or deeper limestone
Pennsylvanian		Weber sandstone	Pwm	1,000 - 1,200	Massive, crossbedded, fine- to coarse-grained sandstone	Crops out north and northeast of basin. Probably underlies entire basin	In Ashley Valley field water produced from 4,000 ft below surface is usable for irrigation
		Morgan formation (included with Weber sandstone on map)		1,100 - 1,300	Thick-bedded, cherty, fossiliferous limestone in lower member and red sandy shale, buff and red crossbedded sandstone, and thin beds of gray to pink cherty limestone in upper member	do.	Probably poor
Pennsylvanian and Mississippian		Pennsylvanian and Mississippian rocks undivided. Probably includes rocks equivalent to Manning Canyon shale, Humbug formation, Deseret and Madison limestones	PMu	1,000±	Principally massive limestone with a black fissile shale unit at top	do.	May supply water from caverns or solution channels
Cambrian	Upper Cambrian	Lodore formation	Cl	100 - 1,200	Thick-bedded, coarse-grained, arkosic sandstone and arenaceous shale	do.	Unknown
Precambrian		Uinta Mountain group	pCu	12,000 - 15,000	Red, pink, or white quartzitic sandstone, with thin shale partings, and thin-bedded sericitic and sandy shale interbedded with slabby sandstone	Forms core of Uinta Arch in eastern part of Uinta Mountains	Do.

May 8, 1979

MEMORANDUM

TO: Ross Whipple
FROM: Lorie Cahn
SUBJECT: Conversation with Jim Hood, USGS Water Resources Division, SLC, regarding ground water in Grand Co., Utah.

SUMMARY

The Water Resources division of the USGS has not conducted any field investigation in the Cisco Dome area of Grand County, Utah. Both the Mancos Shale and the Dakota Sandstone are extremely poor aquifers in this area. The water bearing members of the Mancos Shale (the Ferron and Emery Sandstones) thin to the east. The Emery member is nonexistent and the Ferron member is extremely thin near Cisco. Hood suggested that shale hydration (anhydrite hydrating to gypsum) might be a source of heat.

NOTES

Conversation with Jim Hood, Water Resources, USGS, 5-3-79.
Lithology and relation to aquifers in East Central Utah

Km - Mancos sh

Ferron and Emery ss members are best aquifers but pinch out and disappear to east.

Kd - Dakota ss

Discount as reliable aquifer.

K - Cedar Mtn. Fm

Bottom of fm - not reliable as aquifer but could carry water.

J - Morrison Fm

Has bentonite but Salt Wash ss memb. yields small quantities of water under artesian pressure. Some water due to poor sorting.

J - Summerville Fm

Minutely interbedded ss, slts. Fractures filled with gypsum. Yields little water.

J - Curtis Fm

Not good aquifer.

J - Entrada ss

Varies in thickness. Potential aquifer of low permeability.

J - Carmel ss

Thins eastward, <100' in Cisco area. Not very permeable, okay for stock well.

J - Navajo ss

Best aquifer but not too good. Thins to east, thin in Cisco area. Very jointed and fractured. Extremely uniform grn size and is more permeable than poorly sorted material of same grain size.

T - Kayenta Fm

Zone of lower permeability between Navajo and Wingate.

T - Wingate ss

Not as good aquifer as Navajo but permeability enhanced by fracturing and jnting.

T - Chinle

Tight ss layer, nothing much for ground water.

P - Kaibab Ls

Not in Cisco area.

P - Cutler Fm

Upper ss memb. middle sh, slst memb. Thickens to S. As good as Navajo for water. Poor sorting, reduces permeability. Potential for flow of water upward thru column.

P - Hermosa Fm

Paradox Salt mem. is~2000' thick out of Cisco. Flows plastically, low permeability. Well in Green River got good flow of brine in Paradox. Mostly tight.

P - Molas Fm

Dolomite ls, sh, ~200' thick, Karst topog.

Mississippian - A lot of permeability, but water moves slowly. Is major aquifer in NW Colorado.

HYDRAULIC CONDUCTIVITIES

(figures are off the top of his head)

Navajo - 0.2 to 2.0 ft/day; highest hydr. K due to fracture permeability.

Mancos - 10^{-10} to 0.01 ft/day

Norm. - 1 ft/day

Fracturing as a local anomaly can triple hydral. K.

OTHER FACTORS WHICH MAY CONTROL THERMAL ANOMALIES

Faulting - Many compression and tension faults west of Cisco and Crescent Junction and probably in Cisco. In Green River find deep fluids leaking to surface along faults (tar seeps, brine seeps). Thrusting to west.

- young igneous activity in subsurface??
- interformational transfer of water at depth.
- shale hydration-- Anhydrite hydrating to gypsum is exothermic under certain conditions. Find old fractures filled w/ gypsum, selenite.
- radioactive heat generation from plutons.

Lorie Cahn
Geologist

LC/kg

BIBLIOGRAPHY

GROUND WATER IN GRAND CO.

ESL lib. Conroy, L. S., and Fields, F. K., 1977, Climatologic and hydrologic data, southeastern Uinta Basin, Utah and Colorado, water years 1975 and 1976: U.S. Geol. Survey Utah Basic-Data Release No. 29, 244 p.

UU lib. TA7U77 Feltis, R. D., 1966, Water from bedrock in the Colorado Plateau of Utah: Utah State Engineer Tech. Pub. No. 15, 79 p.

ESL lib. Goode, H. D., 1978, Thermal waters of Utah: Utah Geol. and Min. Survey Report of Investigation No. 129, 183 p.

UU lib. TD 224 U8A3 Goode, H. D., and Feltis, R. D., 1962, Water production from oil wells of the Uinta Basin, Uintah and Duchesne Counties, Utah: Utah Geol. and Min. Survey Water-Resources Bull. 1, 31 p.

UU lib. TA7U77 Hood, J. W., 1976, Characteristics of aquifers in the northern Uinta Basin area, Utah and Colorado: Utah Dept. Nat. Resources Tech. Pub. No. 53, 63 p.

ESL lib. Hood, J. W., Mundorff, J. D., and Price, D., 1976, Selected hydrologic data, Uinta Basin area, Utah and Colorado: U.S. Geol. Survey Basic-data Release No. 26, 321 p.

Intermountain Association of Petroleum Geologists, 1956, Geology and economic deposits of East Central Utah, Peterson, J. A., (ed.), Seventh Annual Field Conf. Guidebook, 225 p.

Intermountain Association of Petroleum Geologists, 1964, Geology and mineral resources of the Uinta Basin -- Utah's hydrocarbon storehouse: Thirteenth Annual Field Conf. Guidebook.

ESL lib. Price, D. and Arnow, T., 1974, Summary appraisals of the nation's groundwater resources--Upper Colorado Region: U.S. Geol. Survey Prof. Paper 813-C, 40 p.

ESL lib. Price, D., and Miller, L. L., 1975, Hydrologic reconnaissance of the southern Uinta Basin, Utah and Colorado: Utah Dept. Nat. Resources Tech. Pub. No. 49, 59 p.

ESL lib. Stokes, W. L., and Cohenour, R. D., 1956, Geologic atlas of Utah, Emery County: Utah Geol. and Min. Survey Bull. No. 52, 92 p.

ESL lib. United States Geological Survey, 1974, Catalog of information on water data, Water resources region 14 (Upper Colorado): Office of Water Data Coordination, 11 p.

GEOLOGIC MAP OF EAST CENTRAL UTAH

Compiled by: Lorie S. Cahn

From: Stokes, W. L., et. al., 1964, Geologic Map of Utah

Quaternary

Q = Quaternary undivided

Tertiary

Tu = Uinta Fm

Tgu = Green River Fm undivided

Tw = Wasatch Fm

Tc = Colton Fm

Cretaceous & Tertiary undifferentiated

TK = North Horn Fm and Tuscher Fm

Cretaceous

Ky = Late Cretaceous undivided

Km = Mancos Shale

Kmf = Ferron Sandstone member of Mancos Shale

Kd = Dakota Sandstone

Jurassic

Ju = Jurassic undivided. Morrison Fm through Navajo Sandstone

Triassic?

JTr = Kayenta Sandstone and Glen Canyon Group

Triassic

$\overline{\text{Tr}}$u = Triassic undivided. Includes Chinle Fm and Moenkopi Fm.

Paleozoic

Pu = Paleozoic undivided

Precambrian

p€ = Precambrian undivided

CISCO-WESTWATER, GRAND CO., UTAH
BOOK CLIFFS - GREEN RIVER DESERT

Age	Formation	Member	Thickness (ft)	Remarks
PALEOCENE-EOCENE	Green River Formation		0-2000	oil shale
PALEOCENE-EOCENE	Colton Fm ("Wasatch" Fm)		1000	varicolored mudstone and shale
PALEOCENE-EOCENE	Ohio Creek Conglomerate		0-100	red & black chert pebs
CRETACEOUS	Tuscher Fm		270	mostly light colored ss
CRETACEOUS	MESAVERDE GROUP, Price River Fm	Farrer Memb	470	
CRETACEOUS	MESAVERDE GROUP, Price River Fm	Neslen Memb	300	coal coal
CRETACEOUS	MESAVERDE GROUP, Price River Fm	Sego Ss M	170	
CRETACEOUS	MESAVERDE GROUP, Price River Fm	Buck Sh Tong	200	Mancos tongue
CRETACEOUS	MESAVERDE GROUP, Price River Fm	Castlegate Ss	100	Upper Blackhawk tongue
CRETACEOUS	MESAVERDE GROUP	Desert Ss	50	
CRETACEOUS	Mancos Shale	Early Pierre fauna		Lingula Inoceramus sandstone beds
CRETACEOUS	Mancos Shale	Telegraph Creek fauna	3100	Inoceramus lobatus
CRETACEOUS	Mancos Shale	Niobrara fauna		Inoceramus Baculites
CRETACEOUS	Mancos Shale	Ferron Ss M	50	cuesta former
CRETACEOUS	Mancos Shale	Tununk Sh Member	350	Gryphaea newberryi
CRETACEOUS	Dakota Ss		100	
CRETACEOUS	Cedar Mtn Fm		120	Oil producer at Cisco and Agate fields
JURASSIC	Morrison Fm	Brushy Basin M	275	dinosaurs
JURASSIC	Morrison Fm	Salt Wash M	300	
JURASSIC	Summerville Fm		20	
JURASSIC	Entrada Sandstone	Moab Memb	100	white ss
JURASSIC	Entrada Sandstone		100-400	Arches Nat'l Mon; Dewey Bridge Memb 30-50'
JURASSIC	Navajo Sandstone		0-100	
TRIASSIC	Kayenta		100	
TRIASSIC	Wingate Ss		300	
TRIASSIC	Chinle Shale		100	
TRIASSIC	Moenkopi Fm ?		0-100	Prob no Moenkopi or Cutler here. all Chinle
P	Cutler Fm ?		0-100	arkose
	Precambrian			Uncompahgre Complex; Black Canyon Schist

FRUITA - GRAND JUNCTION, COLORADO
COLORADO NATIONAL MONUMENT

Age	Formation	Member / Facies	Thickness (ft)	Remarks
Tert	basalt flows		0-1000	Pliocene 10 MY B.P.
PALEO-EOCENE	Green River Fm	Evacuation Creek M.	0-2000	oil shale; Gilsonite in Bonanza area to north
PALEO-EOCENE	Green River Fm	Parachute Creek M.		
PALEO-EOCENE	Green River Fm	Garden Gulch M		
PALEO-EOCENE	Green River Fm	Douglas Creek M.		
PALEO-EOCENE	Wasatch Fm	Shire M.	600	maroon, green and gray shale; mammal fossils
PALEO-EOCENE	Wasatch Fm	Molina M.		
PALEO-EOCENE	Wasatch Fm	Atwell Gulch M.		
PALEO-EOCENE	Ohio Creek Cg		100	
CRETACEOUS	"MESAVERDE GROUP" Price River Formation	Farrer facies: Undivided	1000	
CRETACEOUS	"MESAVERDE GROUP" Price River Formation	Neslen facies: Cameo M.	1000	"Cameo" coal; "Rollins" Ss at base
CRETACEOUS	"MESAVERDE GROUP" Price River Formation	Neslen facies: Cozzette M.		Viviparus; coal
CRETACEOUS	"MESAVERDE GROUP" Price River Formation	Neslen facies: Corcoran M.		Ophiomorpha; coal
CRETACEOUS	"MESAVERDE GROUP" Price River Formation	Upper Sego Ss	50	
CRETACEOUS	"MESAVERDE GROUP" Price River Formation	Anchor Mine T	50-100	
CRETACEOUS	"MESAVERDE GROUP" Price River Formation	Lower Sego Ss	100	Baculites Scotti
CRETACEOUS	Mancos Shale	Early Pierre fauna (Smokey Hills Chalk)	4000	Serpula; Lingula; Baculites obtusus; Scaphites pulcherrimus
CRETACEOUS	Mancos Shale	Eagle fauna		Inoceramus sagensis; Ostrea; Baculites; Scaphites hippocrepis
CRETACEOUS	Mancos Shale	Telegraph Creek fauna		Inoceramus lobatus; Ostrea; Desmoscaphites
CRETACEOUS	Mancos Shale	Niobrara fauna		Inoceramus exogyroides
CRETACEOUS	Mancos Shale	Carlisle fauna		Inoceramus; Ostrea
CRETACEOUS	Mancos Shale	Greenhorn fauna		Ferron SS M.; Gryphaea newberryi
CRETACEOUS	Naturita Fm		150	= Dakota
CRETACEOUS	Cedar Mountain Fm		50-120	= Burro Cyn
JURASSIC	Morrison	Brushy Basin M	260-340	Brachiosaurus; Apatasaurus
JURASSIC	Morrison	Salt Wash M	190-310	Stegosaurus
JURASSIC	Summerville Fm		40-60	Due flesh
JURASSIC	Entrada Ss		60-200	Moab M (white); Slick Rock Mem (pink)
TR	Kayenta		0-130	
TR	Wingate Ss		210-370	
TR	Chinle Shale		80-120	red siltstone, ls
PC	Precambrian Complex			schist, gneiss, granite, pegmatite dikes; Black Canyon Schist etc.

© LF

Cisco area after Young (1955) Geol Soc Amer Bull 66; Utah Geol Survey Bull 75 (1965); Fisher and others (1960) USGS Prof Paper 332
Fruita area after Lohman (1965) USGS Prof Paper 451; Fisher, Erdmann, and Reeside (1960) USGS Prof Paper 332; Abbott (1957)
Intermountain Assoc Petrol Geol Guidebook 8

FROM:

FELTIS, R. D., 1966, Water from bedrock in the Colorado Plateau of Utah:

Utah State Engineer, Tech. Pub. No. 15,

pp. 82.

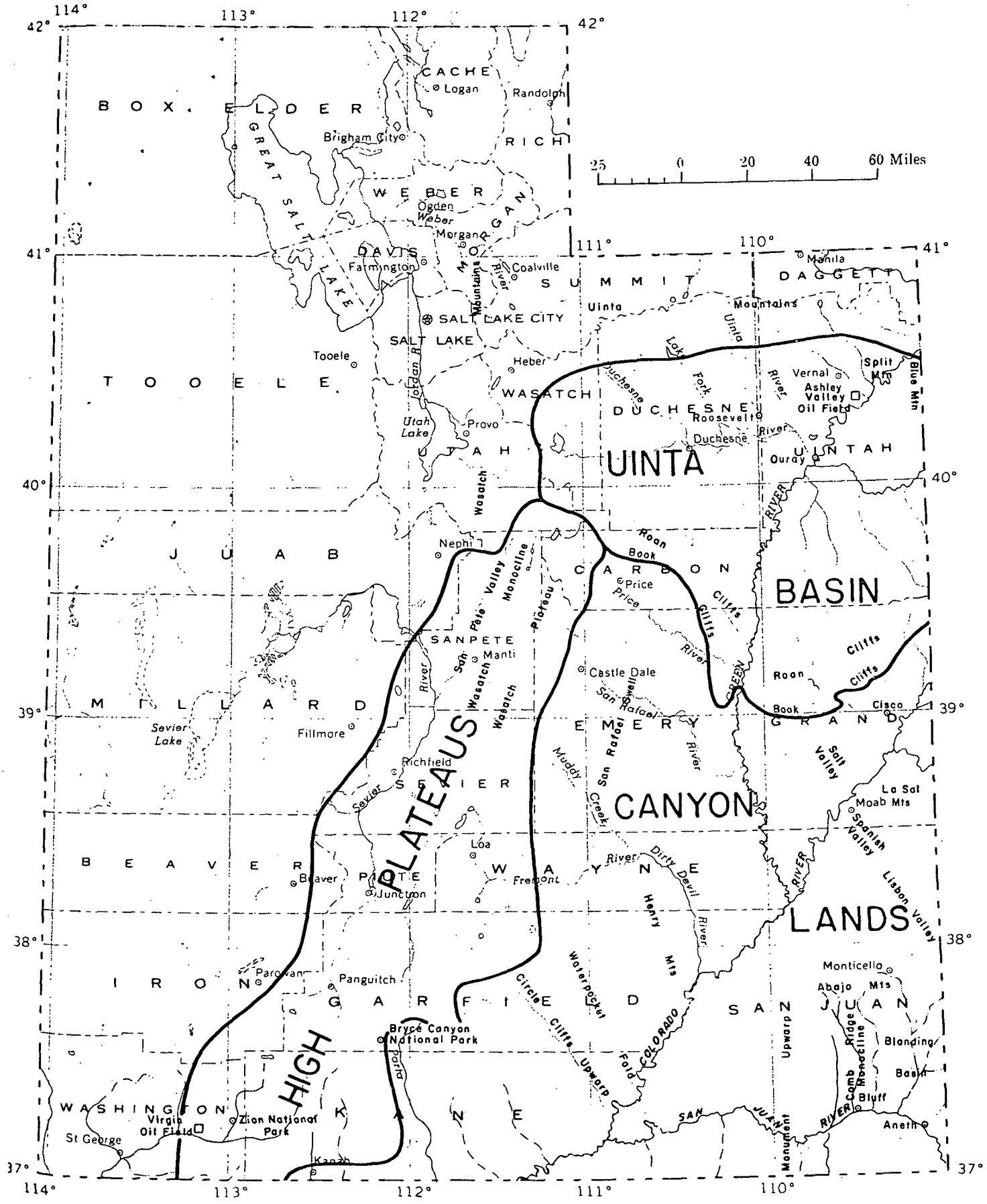


Figure 1. — Index map of the Colorado Plateau in Utah.

The chemical quality of water in the Uinta Formation is determined principally by the lithology of the formation and local recharge conditions. In the central part of the basin, the formation is composed predominantly of fine-grained lake deposits that contain large quantities of soluble salts; but it yields fresh and slightly saline water where local precipitation or runoff from the Uinta Mountains recharges the formation. In the eastern part of the basin, where there is little precipitation, wells may yield fresh or slightly saline water from coarse-grained fluvial deposits that contain few soluble salts (Picard, 1957, p. 128).

Duchesne River Formation

Sandstone beds in the Duchesne River Formation are a source of fresh water for the city of Roosevelt and for private domestic wells. Data from five water wells indicate a range in dissolved solids from 234 to 528 ppm (fig. 6 and table 2) and a range in yield from about 60 to 340 bwpd (2 to 10 gpm). The source of water in the formation is from recharge by surface streams that cross the area of outcrop and by precipitation directly on the area of outcrop along the north flank of the basin. The formation dips southward, and artesian conditions occur where water wells tap the aquifer in T. 2 S., R. 1 W. (USM). Water wells penetrate the Duchesne River to a maximum known depth of 810 feet; however, logs of oil wells show the formation to be as much as 4,000 feet thick. The electrical log of the well in sec. 5, T. 1 N., R. 2 W. (USM) in figure 4 indicates that the base of the slightly saline water in the Duchesne River may be as much as 3,460 feet deep.

WATER FROM BEDROCK IN THE CANYON LANDS SECTION

The Canyon Lands section is the most structurally complex part of the Colorado Plateau in Utah. Three upwarps—the San Rafael Swell and Circle Cliffs and Monument Upwarps—are the major structural elements in the section. The upwarps and adjacent basins are modified by numerous subsidiary folds and faults and by the intrusives that formed the Abajo and Henry Mountains. In the northeastern part of the Canyon Lands section is a northwest-trending belt of faulted anticlines, including Salt, Spanish, and Lisbon Valleys. Near the center of this area is the La Sal Mountains, also formed by an intrusive. Sedimentary rock of Cambrian and Devonian through Cretaceous age are exposed in the Canyon Lands section or have been identified in oil wells. Table 1, columns 6, 7, 8, and 9, show the stratigraphic section for the Canyon Lands.

Chemical analyses of water from water wells, oil and gas wells, and springs show that fresh water is in the Hermosa Group, the Rico and Cutler Formations, the Cedar Mesa Sandstone Member, Organ Rock Tongue, and De Chelly Sandstone Member of the Cutler Formation, Chinle Formation, Shinarump Member of the Chinle Formation, Wingate Sandstone, Kayenta Formation, Navajo Sandstone, Carmel Formation, Entrada and Bluff Sandstones, Morrison and Burro Canyon Formations, and the Dakota Sandstone. Many of the analyses are for water from scattered springs and stock wells that are the only source of ground water for hundreds of square miles.

The electrical logs of oil and gas tests used in constructing figure 8 indicate that water in bedrock in the Blanding Basin ranges from fresh to saline in chemical quality.

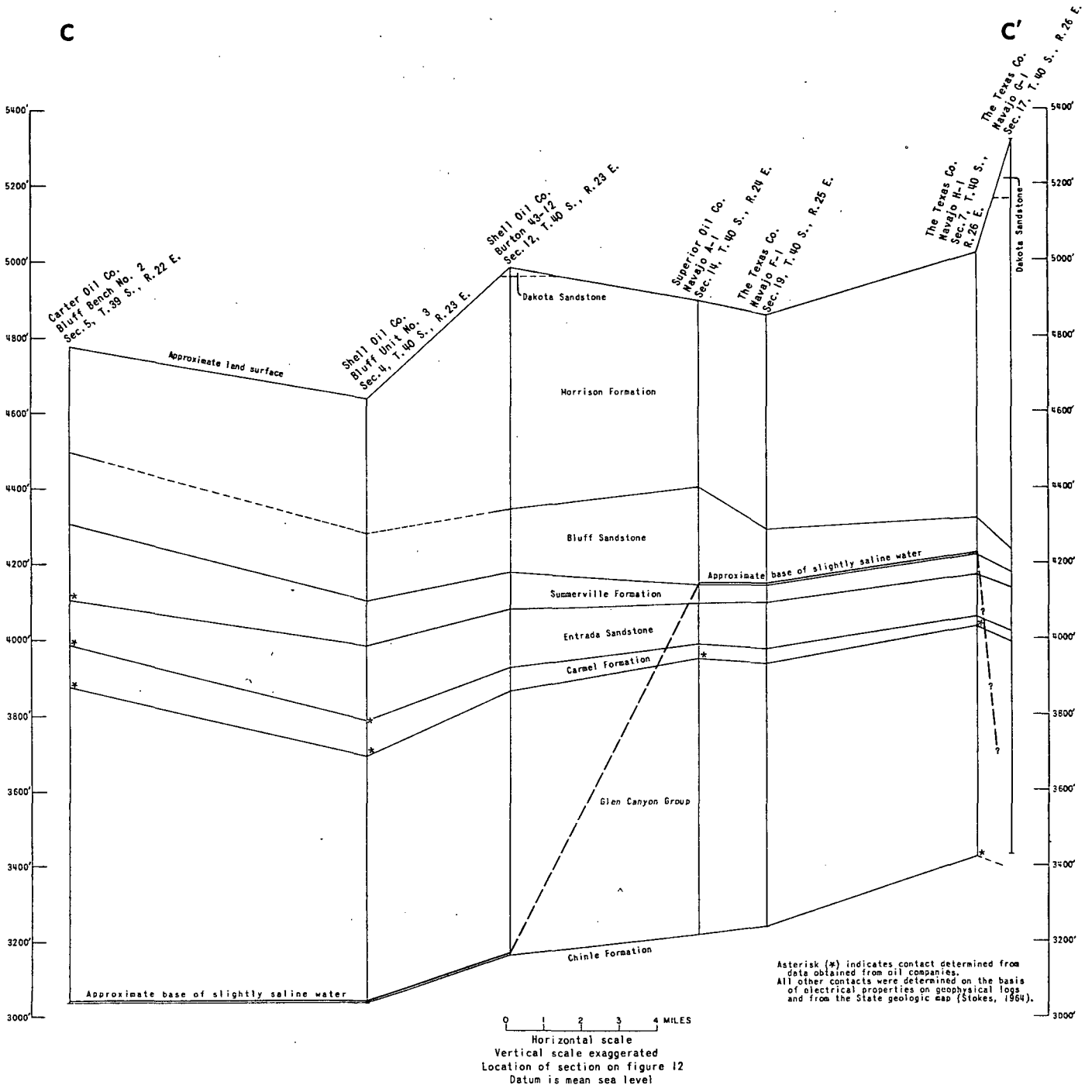


Figure 8. — Geologic section C-C′ of the Blanding Basin in the Canyon Lands section.

Ground-water data are not available for many areas in the Canyon Lands, mainly because water wells have not been drilled to test the quantity or quality of water and because such data were not collected during oil and gas exploration.

Recharge to bedrock aquifers in the Canyon Lands occurs where permeable formations crop out along the flanks of the Abajo, Henry, and La Sal Mountains, along the flanks of folds such as the Comb Ridge Monocline, San Rafael Swell, or Waterpocket Fold, and on the wide expanse of flat-lying aquifers that are exposed between the major structural elements. Except near the mountains, however, the amount of recharge is generally small because of the low normal annual precipitation (fig. 2).

The area of greatest development of ground water in the Canyon Lands section is the Blanding Basin, an artesian basin east of Comb Ridge in San Juan County. In T. 40 S., R. 21 E., wells in the Glen Canyon Group yield water having less than 500 ppm of dissolved solids. Eastward from Bluff, the Entrada and Bluff Sandstones and Morrison Formation also yield fresh and slightly saline water to wells. Near Aneth, however, the ground water has as much as 8,640 ppm of dissolved solids.

Artesian conditions have also been encountered in wells drilled in formations that crop out on the flanks of the Abajo, Henry, and La Sal Mountains. The relatively high precipitation on the mountains is a source of recharge to the formations, and in or near the area of outcrop the ground water is generally fresh or slightly saline. Few wells have been drilled near the mountains, however, and the areal extent of the fresh and slightly saline water is unknown.

Table 3 contains selected hydrogeologic data for bedrock formations in the Canyon Lands section, and the locations of the sampling sites are shown in figures 9, 10, 11, 12, 13, 14, and 15. Following is a summary of the data by formation.

Rocks of Cambrian and Devonian age

Water samples from oil wells have been collected from the Aneth and Elbert Formations, the McCracken Member of the Elbert Formation, and the Ouray Limestone of Devonian age, and from sedimentary rocks of Cambrian and Devonian age that are not differentiated.

Chemical analyses of 9 water samples collected from 8 wells in these formations indicate that 6 of the samples are briny and the other 3 are moderately or very saline (fig. 9 and table 3). The moderately saline samples were from the western part of the Canyon Lands section in T. 36 S., R. 10 E., and T. 26 S., R. 7 E. (Water samples from rocks of Devonian and Mississippian age are discussed in the next section.)

Rocks of Mississippian age

Water samples from oil wells have been collected from the Leadville, Madison, and Redwall Limestones of Mississippian age. These formations, however, generally have not been differentiated when the samples were collected. The individual formations, therefore, are stipulated where known, but otherwise they are considered as a unit called "rocks of Mississippian age."

Chemical analyses of water from three oil wells in the Leadville Limestone in T. 29 S., R. 10 E., T. 42 S., R. 23 E., and T. 43 S., R. 21 E., showed 8,470, 84,516, and 56,500 ppm of dissolved solids (fig. 9 and table 3). In T. 40 S., R. 26 E., and T. 42 S., R. 22 E., water from

the Leadville Limestone and the Ouray Limestone of Devonian age contained 31,583 and 71,948 ppm of dissolved solids.

The Madison Limestone yielded water containing 54,624 and 8,037 ppm of dissolved solids to oil wells in T. 16 S., R. 12 E., and T. 29 S., R. 10 E. (fig. 9 and table 3).

In T. 16 S., R. 9 E., and T. 36 S., R. 10 E., oil wells in the Redwall Limestone yielded water containing 73,653 and 4,669 ppm of dissolved solids and in T. 15 S., R. 12 E., an oil well in the Redwall Limestone and Elbert Formation of Devonian age yielded water containing 67,769 ppm of dissolved solids (fig. 9 and table 3).

Chemical analyses of 52 water samples from the undifferentiated rocks of Mississippian age showed a range of from 7,172 to 327,283 ppm of dissolved solids (fig. 9 and table 3). Six of the water samples were moderately saline, 16 samples were very saline, and 30 samples were brines.

In T. 40 S., R. 7 E., rocks of Mississippian and Devonian age yielded water containing 2,339 ppm of dissolved solids; and in T. 40 S., R. 26 E., and T. 41 S., R. 21 E., rocks of Mississippian age and the Ouray Limestone of Devonian age yielded water containing 39,869 and 83,940 ppm of dissolved solids (fig. 9 and table 3).

An oil well in rocks of Mississippian age and the overlying Molas Formation in T. 35 S., R. 3 E., yielded water containing 9,378 ppm of dissolved solids (fig. 9 and table 3) at a rate of 528 bwpd (16 gpm).

Hermosa Group

Most of the water samples from the Hermosa Group for which chemical analyses are available are from oil wells in the Paradox Formation. Analyses of 34 samples show a range of 5,342 to 397,061 ppm of dissolved solids (fig. 10 and table 3); and 25 of the samples were brines containing more than 35,000 ppm of dissolved solids. A spring in the Hermosa in T. 33 S., R. 16 E., yielded water at a rate of 15,300 bwpd (450 gpm) that contained 414 ppm of dissolved solids.

Molas Formation

A water sample from the Molas Formation in an oil well in T. 39 S., R. 13 E., contained 6,035 ppm of dissolved solids (fig. 10 and table 3).

Rico Formation

Chemical analyses of water from the Rico Formation are available for water from five springs and one water well. Three springs in T. 33 S., R. 15 E., yielded water with 1,220, 3,920, and 4,770 ppm of dissolved solids at rates of about 70, 510, and 850 bwpd (2, 15, and 25 gpm) (fig. 10 and table 3). Two springs in T. 40 S., R. 17 E., and T. 41 S., R. 19 E., yielded water containing 719 and 3,070 ppm of dissolved solids, each at a rate of about 170 bwpd (5 gpm). A water well in T. 35 S., R. 15 E., yielded water containing 318 ppm of dissolved solids at a rate of 350 bwpd (10 gpm).

Coconino Sandstone

Chemical analyses of water from three oil wells in the Coconino Sandstone in T. 16 S., R. 12 E., T. 18 S., R. 14 E., and T. 27 S., R. 15 E., showed 17,249, 49,902, and 3,378 ppm of dissolved solids (fig. 10 and table 3).

Toroweap Formation

Water from an oil well in the Toroweap Formation in T. 35 S., R. 3 E., contained 7,583 ppm of dissolved solids (fig. 10 and table 3).

Kaibab Limestone

Water from four oil wells in the Kaibab Limestone in T. 29 S., R. 10 E., T. 37 S., R. 2 E., T. 18 S., R. 14 E., and T. 20 S., R. 7 E., contained 3,720, 14,179, 35,985, and 72,000 ppm of dissolved solids (fig. 10 and table 3). A spring in T. 24 S., R. 10 E., yielded water having 2,150 ppm of dissolved solids at a rate of about 170 bwpd (5 gpm). (A water sample from the Kaibab Limestone and the Sinbad Limestone Member of the Moenkopi Formation is discussed in the section on the Sinbad Limestone Member.)

Cutler Formation

A water well in the Cutler Formation in T. 25 S., R. 23 E., yielded water having 931 ppm of dissolved solids at a rate of about 6,800 bwpd (200 gpm) (fig. 10 and table 3). The Cutler probably contains fresh or slightly saline water in other areas around the flanks of the La Sal Mountains. A spring in T. 33 S., R. 16 E., yielded water containing 770 ppm of dissolved solids at a rate of 12,200 bwpd (360 gpm). In T. 29 S., R. 26 E., and T. 28 S., R. 23 E., water from two oil wells in the Cutler contained 4,957 and 16,331 ppm of dissolved solids.

Cedar Mesa Sandstone Member of Cutler Formation

Two water wells in the Cedar Mesa Sandstone Member in T. 41 S., R. 16 E., and T. 43 S., R. 14 E., yielded water of 1,890 and 656 ppm of dissolved solids at rates of about 100 and 70 bwpd (3 and 2 gpm) (fig. 10 and table 3). Seven springs (in Tps. 36, 37, and 42 S., Rs. 16-18 E.) in the sandstone in San Juan County yielded water containing 298 to 596 ppm of dissolved solids at rates generally less than 170 bwpd (5 gpm).

Organ Rock Tongue of Cutler Formation

A water sample from an oil well in the Organ Rock Tongue in T. 29 S., R. 10 E., contained 4,487 ppm of dissolved solids (fig. 10 and table 3). Two springs, one in T. 43 S., R. 16 E., and another in T. 34 S., R. 14 E., yielded water containing 944 and 375 ppm of dissolved solids. The former yielded less than 3 bwpd (0.1 gpm), but the latter flowed at a rate of about 1,000 bwpd (30 gpm).

De Chelly Sandstone Member of Cutler Formation

In T. 41 S., Rs. 24 and 25 E., the De Chelly Sandstone Member yielded water containing 17,262 and 52,187 ppm of dissolved solids from two oil wells (fig. 10 and table 3). The yield of the well in T. 41 S., R. 24 E., was 270 bwpd (8 gpm). Three springs in the sandstone in T. 43 S., Rs. 14 and 19 E., yielded fresh water at rates generally less than 140 bwpd (4 gpm).

At Chinle, Ariz., about 90 miles south of Bluff, Utah, water wells in the De Chelly yielded water containing less than 400 ppm of dissolved solids. Electrical logs of oil wells in the Blanding Basin indicate that the De Chelly contains fresh or slightly saline water along the Comb Ridge Monocline, but the water becomes more saline toward the center of the basin.

White Rim Sandstone Member of Cutler Formation

The dissolved-solids content of water from six oil wells in the White Rim Sandstone Member in the west-central Canyon Lands section ranged from 2,045 to 6,045 ppm of dissolved solids (fig. 10 and table 3). Water from two springs in the White Rim in T. 40 S., R. 10 E., yielded water containing 2,470 and 4,060 ppm of dissolved solids at rates of about 70 and 5,100 bwpd (2 and 150 gpm).

Moenkopi Formation

In T. 24 S., R. 13 E., water sampled at two depths in an oil well in the Moenkopi Formation contained 12,472 and 15,999 ppm of dissolved solids. The latter sample was obtained with a reported yield of 94 bwpd (2.8 gpm). In T. 24 S., R. 14 E., however, another oil well yielded water from the formation that contained only 4,187 ppm of dissolved solids (fig. 11 and table 3). Two springs in T. 35 S., Rs. 13 and 14 E., yielded water containing 1,700 and 1,860 ppm of dissolved solids at rates of 15,300 bwpd (450 gpm) and 1,700 to 13,700 bwpd (50 to 400 gpm). Another spring in T. 31 S., R. 14 E., yielded water containing 2,355 ppm of dissolved solids; and a spring in T. 20 S., R. 11 E., yielded water containing 2,250 ppm of dissolved solids at a rate of 680 bwpd (20 gpm).

Sinbad Limestone Member of Moenkopi Formation

In T. 16 S., R. 12 E., oil wells in the Sinbad Limestone Member yielded very saline to briny water. In T. 24 S., R. 13 E., an oil well in the Sinbad yielded water containing 18,125 ppm of dissolved solids (fig. 11 and table 3). In oil wells in T. 29 S., Rs. 10 and 12 E., the Sinbad yielded water containing 4,437 and 9,130 ppm of dissolved solids, with the latter at the rate of 432 bwpd (13 gpm). A water sample collected from the Kaibab Limestone, the Sinbad Limestone Member, and undifferentiated beds in the Moenkopi Formation in an oil well in T. 29 S., R. 11 E., contained 6,167 ppm of dissolved solids.

Chinle Formation

Water from the Chinle Formation in oil tests in T. 22 S., R. 22 E., and T. 26 S., R. 7 E., contained 20,070 and 20,797 ppm of dissolved solids (fig. 11 and table 3), with the former at the rate of 34 bwpd (1 gpm). A spring in T. 39 S., R. 14 E., yielded water containing 747 ppm of dissolved solids. The water from this spring, however, may be discharging at the top of the Chinle after percolating downward through rocks of the overlying more permeable Glen Canyon Group.

Shinarump Member of Chinle Formation

Water has been produced in oil wells, water wells, springs, mines, and test holes from the Shinarump Member of the Chinle Formation (fig. 11). The dissolved-solids content of the water from the several sources were: oil well in T. 24 S., R. 13 E., 5,750 ppm; two water wells in T. 43 S., R. 4½ W., 646 and 710 ppm, with one well yielding 15,300 bwpd (450 gpm); springs in T. 31 S., R. 14 E., 1,613 ppm; and T. 41 S., R. 12 E., 840 ppm with the latter spring yielding 100 bwpd (3 gpm); mines in T. 35 S., R. 7 E., 8,510 ppm, and T. 37 S., R. 16 E., 5,840 ppm; and test holes in T. 41 S., R. 12 E., 1,670 and 3,340 ppm (table 3).

Moss Back Member of Chinle Formation

Water from the Moss Back Member in an oil test in T. 27 S., R. 14 E., yielded water containing 4,980 ppm of dissolved solids (fig. 11 and table 3).

Glen Canyon Group

The Glen Canyon Group consists of the Wingate Sandstone, the Kayenta Formation, and the Navajo Sandstone. This widespread sequence of predominantly sandstone is one of the most important aquifers in the Canyon Lands section because it generally yields fresh water to springs, and in many areas it yields water to wells that is at least suitable for livestock[1] (fig. 12).

In some wells, the subsurface data available are not detailed enough to identify the aquifer other than as the Glen Canyon Group. Five water wells in T. 40 S., Rs. 21-22 E., yielded water containing from 239 to 403 ppm of dissolved solids at rates of 750 to 3,400 bwpd (22 to 100 gpm) (table 3). A water well in T. 39 S., R. 25 E., yielded water containing 791 ppm of dissolved solids at a rate of 4,320 bwpd (130 gpm). In an oil well in T. 41 S., R. 25 E., the sandstones yield water containing 3,815 ppm of dissolved solids. An oil well in T. 16 S., R. 13 E., yielded very saline or briny water at a rate of 1,680 bwpd (50 gpm).

Wingate Sandstone

Four water wells in T. 23 S., R. 21 E., T. 30 S., R. 24 E., T. 31 S., R. 23 E., and T. 43 S., R. 24 E., yielded water from the Wingate Sandstone that contained from about 300 to 400 ppm of dissolved solids (fig. 12 and table 3). The yield of two of the wells was 70 and 140 bwpd (2 and 4 gpm). Sixteen springs in the Wingate yielded water containing from 133 to 914 ppm of dissolved solids at rates ranging from 17 to 3,840 bwpd (0.5 to 113 gpm). In T. 26 S., R. 7 E., water from an oil well in the Wingate contained 4,079 ppm of dissolved solids. Water produced from a well that taps the Wingate and also the Entrada and Navajo Sandstones is discussed in the section on the Entrada Sandstone. Recharge to the Wingate is restricted by the overlying relatively impermeable Kayenta Formation. Where fracturing and faulting extend through the Glen Canyon Group, however, water moves downward from the Navajo Sandstone through the Kayenta into the Wingate.

[1]According to the Western Australia Department of Agriculture (1950), beef cattle and adult sheep will tolerate water containing 10,000 and 12,000 ppm of dissolved solids, respectively.

Kayenta Formation

The Kayenta Formation generally acts as a barrier to the vertical movement of ground water rather than as an aquifer (M. E. Cooley, written commun., 1965). Many springs in the Glen Canyon Group issue at the base of the Navajo Sandstone or near the top of the Kayenta because the more impermeable rock of the Kayenta restricts or stops the downward flow of water. Three springs in the Kayenta in T. 31 S., R. 15 E., T. 39 S., R. 11 E., and T. 42 S., R. 12 E., yielded water containing 220, 115, and 144 ppm of dissolved solids at rates of 70 bwpd (2 gpm) or less (fig. 12 and table 3).

Navajo Sandstone

Most water wells in the Glen Canyon Group draw water from the Navajo Sandstone, probably because it is the shallowest and most permeable formation in the group. Twenty-one water wells in the Navajo yielded water containing from 171 to 7,250 ppm of dissolved solids at rates ranging from 70 to 45,400 bwpd (2 to 1,335 gpm) (fig. 12 and table 3). Five of the wells in Tps. 41 and 42 S., Rs. 21 to 23 E., are in the Blanding Basin, east of Comb Ridge. These five wells in the Navajo yielded water containing from about 170 to 500 ppm of dissolved solids at rates ranging from 70 to 1,200 bwpd (2 to 35 gpm). The chemical quality deteriorates toward the east, however, and two water wells in the Navajo in T. 41 S., R. 25 E., yielded water containing 7,080 and 7,250 ppm of dissolved solids at rates of 2,000 and 2,450 bwpd (60 and 72 gpm). The recharge area for the aquifer in the Blanding Basin is in the area of outcrop of the sandstone along the length of Comb Ridge Monocline. Ten wells drilled in the Navajo in Arizona and Utah to supply water at the Glen Canyon Dam construction facility in Arizona yielded water containing from 216 to 1,814 ppm of dissolved solids at rates ranging from 1,200 to 45,400 bwpd (35 to 1,335 gpm) (Goode, 1964, p. 45 and 60).

Chemical analyses of water from 14 springs in the Navajo Sandstone showed a range of dissolved solids from 129 to 354 ppm. The yield of the springs ranges from less than 34 bwpd (1 gpm) to 1,700 bwpd (50 gpm); but most of the springs yield 340 bwpd (10 gpm) or less.

Chemical analyses are available for four water samples from the Navajo Sandstone obtained from oil wells. Two wells in T. 41 S., R. 24 E., yielded water containing 3,410 and 3,890 ppm of dissolved solids, and wells in T. 15 S., R. 11 E., and T. 26 S., R. 7 E., yielded water containing 3,607 and 320 ppm of dissolved solids. Water produced from the Navajo in wells that also tap other formations is discussed in the section on the Entrada Sandstone.

Carmel Formation

The Carmel Formation has yielded water that ranges from fresh to moderately saline. The dissolved-solids content of water from three water wells in T. 25 S., R. 12 E., and T. 27 S., R. 11 E., ranged from 2,730 to 6,360 ppm (fig. 13 and table 3). The yields of two of the wells were 100 and 580 bwpd (3 and 17 gpm). Chemical analyses of water from three springs in T. 22 S., R. 8 E., T. 24 S., R. 13 E., and T. 28 S., R. 14 E., showed 7,450, 437, and 2,390 ppm of dissolved solids. The yield of the springs ranged from 34 to 170 bwpd (1 to 5 gpm). In most areas, however, the Carmel forms an aquiclude above the Navajo Sandstone. An example of this is the Blanding Basin, where the water in the Navajo is confined under artesian pressure by the overlying Carmel.

Entrada Sandstone

The Entrada Sandstone has yielded fresh water to water wells in some areas and saline water in others. The sandstone yielded water having 360 to 801 ppm of dissolved solids from six wells in eastern San Juan County; 380 to 3,500 ppm from seven wells in Emery, Kane, and Wayne Counties; and from 9,470 to 14,300 ppm from two wells in Grand County (fig 13 and table 3). Although the Entrada contained saline water in northeastern Grand County, in the Grand Junction area of Colorado water from the sandstone contained from 291 to 1,210 ppm of dissolved solids (Lohman, 1965, p. 115).

Data for eight wells indicate that yields from the Entrada Sandstone range from about 85 to 40,000 bwpd (2.5 to 1,200 gpm). Five of these wells are in San Juan County, and their yields average 4,860 bwpd (143 gpm).

Chemical analyses of water from nine springs, which issue from the Entrada Sandstone at rates ranging from 17 to 170 bwpd (0.5 to 5 gpm), indicate a range in dissolved solids from about 190 to 740 ppm (fig. 13).

Several wells in the Blanding Basin produce water from the Entrada Sandstone and one or more other formations, including the Bluff, Navajo, and Wingate Sandstones. In T. 39 S., R. 26 E., the Navajo and Entrada yielded water containing 1,070 ppm of dissolved solids at a rate of 990 bwpd (29 gpm); but in T. 41 S., R. 23 E., these formations yielded water containing 6,851 ppm at a rate of 1,070 bwpd (31.5 gpm). In T. 40 S., R. 24 E., and T. 41 S., R. 23 E., wells in the Navajo, Entrada, and Bluff Sandstones yielded water containing 4,526 and 1,735 ppm of dissolved solids; and in T. 41 S., R. 25 E., water from the Entrada, Navajo, and Wingate Sandstones contained 8,640 ppm. In T. 41 S., R. 25 E., a well in the Entrada and Bluff Sandstones yielded water containing 2,180 ppm of dissolved solids at a rate of 34 bwpd (1 gpm).

Bluff Sandstone

The Bluff Sandstone in Utah is found only in southern San Juan County. Two wells in T. 40 S., R. 23 E., yielded water containing 1,850 and 7,350 ppm of dissolved solids at rates of 440 to 850 bwpd (13 to 25 gpm) (fig. 13 and table 3). Two springs in the Bluff in T. 40 S., R. 22 E., and T. 41 S., R. 21 E., yield water containing 139 and 241 ppm of dissolved solids, and the latter discharges less than 34 bwpd (1 gpm). Water produced from the Bluff in wells that also tap other formations is discussed in the sections on the Entrada Sandstone and the Morrison Formation.

Morrison Formation[1]

In Grand County, water from five wells in the Morrison Formation in Tps. 19-22 S. contained from 2,090 to 25,700 ppm of dissolved solids (fig. 13 and table 3). A sixth well in T. 22 S., R. 22 E., yielded water containing only 517 ppm, and this probably indicates that recharge to the formation is at or near the well site. Yields from three of the wells were 70 bwpd (2 gpm) or less. In San Juan County, in T. 36 S., R. 21 E., and T. 40 S., R. 25 E., the Morrison yielded water containing 844 and 1,460 ppm of dissolved solids, the latter at a rate of 70 bwpd (2 gpm).

[1]In this discussion, data for wells and springs in all members of the Morrison Formation are treated as a unit. In figure 13 and table 3, however, the specific member is identified when possible.

Eight springs in the Morrison Formation in southeastern San Juan County yielded water containing from 216 to 712 ppm of dissolved solids. Seven of the springs yielded less than 10 bwpd (less than 1 gpm), and the other yielded 120 bwpd (3.5 gpm). A spring in Emery County in T. 19 S., R. 10 E., yielded water containing 768 ppm of dissolved solids at a rate of 34 bwpd (1 gpm).

In Grand and San Juan Counties, in T. 22 S., R. 22 E., T. 23 S., R. 22 E., and T. 37 S., R. 21 E., water from three mines in the Morrison Formation contained 1,430, 759, and 1,400 ppm of dissolved solids.

In T. 39 S., Rs. 24 and 25 E., and T. 40 S., Rs. 23 and 24 E., five water wells in the Bluff Sandstone and Morrison Formation yielded water containing 354, 450, 362, 438, and 2,035 ppm of dissolved solids at known rates of 1,000, 170, 5,100, 5,100, and 370 bwpd (30, 5, 150, 150, and 11 gpm). Two wells in the Morrison Formation, the Dakota Sandstone, and the Burro Canyon Formation in T. 33 S., R. 24 E., yielded water containing 292 and 414 ppm of dissolved solids at rates of 750 and 510 bwpd (22 and 15 gpm).

Dakota Sandstone

The Dakota Sandstone has yielded fresh to slightly saline water to springs and wells. Four springs in T. 34 S., R. 11 E., T. 39 S., R. 26 E. (two springs), and T. 41 S., R. 6 E., yielded water containing 199, 1,760, 1,220, and 186 ppm of dissolved solids (fig. 14 and table 3). The spring in T. 34 S., R. 11 E., flowed 510 bwpd (15 gpm), whereas the other three yielded 34 bwpd (1 gpm) or less.

Eight water wells east of Monticello penetrate the Dakota Sandstone and the Burro Canyon Formation, and two of the wells were drilled down into the Morrison Formation. For the six wells penetrating the Dakota and Burro Canyon, the dissolved-solids content of the water ranged from 290 to 453 ppm and the yields ranged from 750 to 4,250 bwpd (22 to 125 gpm). The two wells drilled to the Morrison produced water containing 292 and 414 ppm of dissolved solids at rates of 750 and 510 bwpd (22 and 15 gpm).

The Dakota Sandstone is not differentiated from the Cedar Mountain Formation in logs of oil wells along the north edge of the Canyon Lands section. The combined formational unit is reported to contain "salty" or "brackish" water.

Burro Canyon Formation

The Burro Canyon Formation has yielded fresh to slightly saline water to springs and wells. Six springs in San Juan and Garfield Counties yield water that ranges from 324 to 2,890 ppm of dissolved solids (fig. 14 and table 3) at known rates of 34 bwpd (1 gpm) or less.

Water produced from the Burro Canyon Formation in wells that also tap other formations is discussed in the section on the Dakota Sandstone.

Mancos Shale

The preponderance of fine-grained sediments and water soluble salts in the Mancos Shale suggests that this formation generally is not a fresh-water aquifer. Water wells in T. 15 S., R. 12 E., and T. 18 S., R. 14 E., yielded water containing 6,280 and 4,710 ppm of dissolved solids (fig. 14 and table 3).

Ferron Sandstone Member of Mancos Shale

Two water samples were collected while drilling an oil well with air through the Ferron Sandstone in T. 14 S., R. 9 E. (fig. 15). Chemical analyses of water showed a dissolved-solids content of 37,860 and 51,950 ppm (table 3). A gas well in T. 20 S., R. 7 E., yielded water containing 21,534 ppm of dissolved solids. The Ferron yielded water containing 3,454 ppm of dissolved solids in a coal mine in T. 22 S., R. 6 E.

Tununk Shale Member of Mancos Shale

Two water samples were collected while drilling an oil well with air through the Tununk Shale in T. 14 S., R. 9 E. (fig. 14). Chemical analyses of the water showed a dissolved-solids content of 11,117 and 12,093 ppm (table 3).

WATER FROM BEDROCK IN THE HIGH PLATEAUS SECTION

The High Plateaus section is divided into three longitudinal strips, each consisting of two to four plateaus that generally are separated by escarpments or valleys. The variations in relief generally are controlled by faults, but a few escarpments were formed solely by erosion. Except where distorted locally along faults, the rocks generally are horizontal or gently dipping, as indicated by the attitude of the tops of the individual plateaus. An exception is along the west edge of the Wasatch Plateau where for 50 miles strata of the Wasatch monocline plunge downward from the top of the plateau into Sanpete Valley.

Rocks exposed in the High Plateaus section range from Permian to Tertiary in age, and oil and gas wells have penetrated rocks of Cambrian, Devonian, Mississippian, and Pennsylvanian ages. The rocks include sedimentary and igneous types. Table 1, columns 10, 11, and 12, show the stratigraphic sections for the High Plateaus.

Chemical analyses of water from water wells, oil and gas wells, and springs show that fresh water is in limestones of Paleozoic age, Wingate and Navajo Sandstones, Carmel Formation, Tropic Shale, Wahweap and Straight Cliffs Sandstones, Emery Sandstone Member of the Mancos Shale, Blackhawk, Price River, Kaiparowits, and North Horn Formations, Flagstaff Limestone, Wasatch, Brian Head, Green River, and Crazy Hollow Formations, and igneous rocks of Tertiary age. The extent of fresh water in these formations is poorly known because few water wells penetrate bedrock, and oil and gas exploration has not been extensive in most of the section.

The electrical logs of oil and gas wells used in constructing figure 16 indicate that water in bedrock in the Wasatch Plateau ranges from fresh to saline in chemical quality.

Many communities in the High Plateaus section obtain their water supplies from springs that issue from bedrock. Sedimentary rocks of Tertiary age yield water to most of these springs in the northern part of the Plateaus, and igneous rocks of Tertiary age are the source of most springs in the central part of the High Plateaus. In the southern part of the High Plateaus, limestones of Tertiary age yield water to springs atop the plateaus, but along the escarpments sandstones of Mesozoic age are the principal aquifers. The numerous springs that yield large quantities of fresh water in the High Plateaus is a reflection of the great amount of precipitation on this area (fig. 2).

Table 4 contains selected hydrogeologic data from springs, water wells, and oil and gas wells in bedrock in the High Plateaus section; locations of the sampling sites are shown in figures 9, 10, 11, 12, 13, 14, 15, 17, and 18. Following is a summary of the data by formation.

Table 1. — Correlation chart of bedrock formations in the Uinta Basin and adjacent areas (See fig. 12 for location of areas)

Geologic age (1)	Northwestern Uinta Basin (2)	Eastern and central Uinta Basin (3)	Book Cliffs at Green River, Utah (4)	Book Cliffs at Utah-Colorado State line (5)	Cane Creek and Big Flat (6)
Tertiary	Currant Creek Formation (?); Colton Formation; Flagstaff Limestone	Browns Park Formation; Duchesne River Formation; Uinta Formation			
	North Horn Formation	Green River Formation; Wasatch Formation	Green River Formation; Wasatch Formation	Green River Formation; Wasatch Formation	
Cretaceous	Mesaverde Group	Mesaverde Group	Mesaverde Group	Mesaverde Group	
	Mancos Shale	Mancos Shale; Frontier Sandstone Member; Mowry Shale	Mancos Shale	Mancos Shale	
	Dakota Sandstone	Dakota Sandstone	Dakota Sandstone; Cedar Mountain Formation; Buckhorn Conglomerate	Dakota Sandstone; Cedar Mountain Formation	
Jurassic	Morrison Formation	Morrison Formation	Morrison Formation	Morrison Formation	
	Curtis Formation	Curtis Formation	Summerville Formation; Curtis Formation		
	Entrada Sandstone	Entrada Sandstone	Entrada Sandstone	Entrada Sandstone	
	Twin Creek Formation	Carmel Formation	Carmel Formation	Carmel Formation	
	Nugget Sandstone	Navajo Sandstone	Glen Canyon Group: Navajo Sandstone; Kayenta Formation; Wingate Sandstone	Glen Canyon Group: Navajo Sandstone; Kayenta Formation; Wingate Sandstone	Glen Canyon Group: Navajo Sandstone; Kayenta Formation; Wingate Sandstone
Triassic(?)					
Triassic	Chinle Formation; Shinarump Member	Chinle Formation; Shinarump Member	Chinle Formation; Moss Back Member	Chinle Formation	Chinle Formation; Moss Back Member
	Ankarah Shale; Thaynes Limestone	Moenkopi Formation	Moenkopi Formation; Sinbad Limestone Member		Moenkopi Formation; Sinbad Limestone Member
Permian	Park City Formation; Phosphoria Formation	Park City Formation; Phosphoria Formation	Coconino Sandstone; "Permian carbonate"		Cutler Formation; White Rim Sandstone Member
					Rico Formation
Pennsylvanian	Weber Sandstone	Weber Sandstone	Hermosa Group: Honaker Trail Formation; Paradox Formation		Hermosa Group: Honaker Trail Formation; Paradox Formation; Ismay Zone; Desert Creek Zone; Akah Zone; Pinkerton Trail Limestone
	Morgan Formation	Morgan Formation			
	Round Valley Limestone	Round Valley Limestone	Molas Formation		Molas Formation
	Manning Canyon Shale	Manning Canyon Shale			
Mississippian	Humbug Formation	Humbug Formation			
	Deseret Limestone	Deseret Limestone	Deseret Limestone		
			Leadville Limestone		Leadville Limestone
	Madison Limestone	Madison Limestone	Madison Limestone		Madison Limestone
Devonian			Ouray Limestone; Elbert Formation		Ouray Limestone; Elbert Formation; McCracken Member; Aneth Formation
Silurian					
Ordovician					
Cambrian	Ophir Formation; Tintic Quartzite	Lodore Formation	Lynch Dolomite; Maxfield Limestone; Tintic Quartzite		Lynch Dolomite
Precambrian	Uinta Mountain Group	Uinta Mountain Group		Granite	

Table 2. — Continued

Location T	Location R	Location Section	Source	Operator or owner	Name or number	Producing formation	Depth to top of formation (feet)	Depth to bottom of formation (feet)	Interval sampled (feet)	Yield (bwpd/gpm)	Method or point of collection	Date of collection	Temperature (°F)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	NA + K: Sodium (Na)	NA + K: Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids[1]	Hardness as $CaCO_3$	Noncarbonate hardness as $CaCO_3$	Percent sodium	Sodium-adsorption ratio (SAR)	Specific conductance (micromhos/cm at 25°C)	Resistivity (ohmmeter at 68°F)	pH	Analysis by[2]	Remarks
														Parts per million																				
10S	22E	C NE¼NE¼ 17	W	Bureau of Land Management	2	Green River Fm.	1,100	4,318	2,311-3,405	340/10(M)	Flow	11-30-64	-	3.4	-	0.0	97	4,070		2,270	263	119	4,840	8.2	10,500	399	0	96	89	16,400	-	8.5	GS	Water from annulus behind 7-inch casing.
10S	23E	NW¼SW¼NE¼ 2	O	Humble Oil and Refining Co.	1	Wasatch Fm.	4,252	-	4,592-4,614	-	DST 3	11- -61	-	-	-	702	126	10,305		415	-	5,103	13,500	-	29,941	-	-	-	-	-	0.29	7.7	CGL	DST 3 recovered 150 feet of mud and 1,553 feet of gas-cut brackish water.
10S	23E	NE¼NW¼NW¼ 24	O	Shell Oil Co.	7	Green River Fm.	375	3,115	3,066	-	Return line	10-15-61	-	-	-	2	1	572		1,078	48	145	99	-	1,941	8	-	-	-	-	11/4.2	8.9	ShO	
10S	24E	SE¼SW¼SE¼ 28	O	ElPaso Natural Gas Co.	5	Mesaverde Gr.	4,560	-	5,295-5,305	-	Swab test	6-11-59	-	-	-	1,923	82	5,194		19	-	480	11,250	-	19,536	-	-	-	-	-	.44	4.8	RME	Mud, water, and oil emulsion filtered to clear water.
10S	24E	C NE¼SW¼ 32	O	Shell Oil Co.	8	Wasatch Fm.	3,306	4,938	4,390-4,497	-	DST 2	1-21-62	-	-	-	21	11	3,068		1,220	72	620	3,550	-	8,562	96	-	-	-	-	14/.85	8.7	ShO	DST 2 recovered 374 feet of slightly gas-cut mud, 280 feet of heavily gas-cut and water-cut mud, 93 feet of very slightly gas-cut muddy water, and 93 feet of muddy water. Water sample collected at tool.
						Mesaverde Gr.	4,938	-	5,230-5,303	-	DST 3	1-28-62	-	-	-	304	63	10,580		1,244	0	770	15,762	-	28,723	1,020	-	-	-	-	13/.27	7.8	ShO	DST 3 recovered 236 feet of gas-cut mud, 308 feet of highly gas-cut, oil-cut, and mud-cut water, and 186 feet of slightly oil-cut and slightly gas-cut muddy water.
						do	4,938	-	6,187-6,494	38(R)/1	Production water	4-30-62	-	-	-	648	238	7,917		903	0	308	13,312	-	23,326	2,600	-	-	-	-	15/.31	6.6	ShO	
						Mesaverde Gr. Castlegate Ss.	4,938 6,830	- -	6,570-6,947	-	Swab test	3-22-62	-	-	-	1,040	298	6,323		464	0	470	11,857	-	20,452	3,825	-	-	-	-	10/.26	6.2	ShO	
11S	12E	NE¼NE¼NW¼ 14	O	King Oil Co.	1	Green River Fm.	0	-	635-650	17/0.5(E)	Flow	7-22-65	-	9.8	-	6.4	4.4	221		392	0	179	5.1	.1	619	34	0	93	16	942	-	7.8	GS	
11S	21E	C SW¼NE¼ 7	O	Humble Oil and Refining Co.	2	Wasatch Fm.	3,892	6,901	4,715-36	-	DST 2	10- -61	-	-	-	804	211	12,457		329	-	4,827	17,500	-	35,961	-	-	-	-	-	.23	7.0	CGL	DST 2 recovered 300 feet of gas-cut muddy water and 554 feet of muddy, slightly salty water. Analysis from bottom sample.
									5,119-47	-	DST 5	10- -61	-	-	-	925	138	13,738		573	-	4,605	19,500	-	39,188	-	-	-	-	-	.21	6.0	CGL	DST 5 recovered 1,230 feet of muddy salt water. Water sample from 90 feet above tool.
11S	24E	SW¼NW¼SE¼ 6	O	Shamrock Oil and Gas Corp.	5	Green River Fm.	-	2,677	223-2,207	-	Flow	8-26-65	-	12	-	3.2	.5	438		644	0	334	60	1.6	1,170	10	0	99	60	1,800	-	8.2	GS	
11S	24E	SW¼NE¼SW¼ 7	O	do	3	do	-	2,578	216-2,396	See Remarks	do	8-26-65	-	12	-	3.2	.5	418		691	0	310	21	1.4	1,110	10	0	99	58	1,720	-	8.2	GS	Report yield of 250 barrels of water per hour (175 gpm) while drilling at 1,159 feet.
11S	24E	NE¼NE¼SW¼ 8	O	do	1	do	0	2,518	At 1,275	-	do	9- 6-61	-	13	0.36	3.6	1.5	437	1.6	606	12	422	4.0	.6	1,200	15	0	98	49	1,820	-	8.5	GS	Analysis includes 0.41 ppm boron, 1.8 ppm fluoride, and 0.00 ppm manganese. Sample collected when water flow was encountered while drilling well.
11S	25E	NE¼SE¼SW¼ 22	O	Continental Oil Co.	22-1	Mancos Sh.	4,632	-	At 6,225	-	See Remarks	8- 1-61	-	-	154	49	78	1,500	62-	375	-	2,900	186	-	5,800	-	-	-	-	-	1.7	7.6	CO	Sample collected from "blooie line" while drilling with air.
12S	14E	C SW¼NE¼ 13	O	Carter Oil Co.	1	Mesaverde Gr.	6,814	9,446	8,505-8,617	-	DST 22	6-27-52	-	-	-	350	64	8,198		1,015	-	2,523	11,000	-	26,636	-	-	-	-	-	.34	6.9	CGL	DST 22 recovered 375 feet of gas-cut slightly oil-cut mud and 2,440 feet of salt water.
									8,604-8,789	-	DST 25	7- 9-52	-	-	-	139	26	4,596		915	60	1,638	5,600	-	12,511	-	-	-	-	-	.59	7.8	CGL	DST 25 recovered 600 feet of gas-cut and slightly oil-cut mud, 450 feet of water-cut mud, and 5,970 feet of slightly mud-cut water.
13S	23E	SE¼SW¼NE¼ 26	O	Skyline Oil Co.	1	Green River Fm.	0	2,170	2,000	-	-	6- -60	-	40.8	-	10.4	7.1	261		-	-	423	17	-	1,086	-	-	-	-	-	-	7.6	UC	
14S	20E	NW¼SE¼NE¼ 7	O	Phillips Petroleum Co.	1	Castlegate Ss.	7,033	7,285	7,080-7,180	-	DST 3	9-17-62	-	-	-	8	2	1,672		964	264	2,150	140	-	4,711	-	-	-	-	-	2.65	9.3	CGL	DST 3 recovered 630 feet of water-cut mud (estimated to be 75 percent water).
14S	20E	C SW¼NE¼ 30	O	do	2	Wasatch Fm.	2,390	4,320	3,790-3,820	See Remarks	See Remarks	7-13-65	-	23	-	614	91	11,900		530	0	1,490	18,300	25	32,700	1,910	1,470	93	119	48,900	-	7.3	GS	Water collected at discharge line to disposal pit after treatment to remove oil. Yield was 1 bwpd (less than 1 gpm).
						Flagstaff Ls.	4,320	4,635	4,530-80	48(R)/1.4	Swab test	12-13-62	-	-	-	11	12	2,897		598	360	4,650	320	-	8,245	-	-	-	-	-	1.02	9.4	CGL	
14S	20E	C NE¼NW¼ 30	O	do	4	Green River Fm.	0	2,100	1,883-1,910	360(R)/11	do	7-22-63	-	-	-	10	7	274	13	366	12	290	32	-	818	-	-	-	-	-	9.35	8.7	CGL	Fluid level 700 feet, unable to lower with swabbing rate of 15 barrels of water per hour.
15S	21E	C SW¼SE¼ 22	O	Atlantic Refining Co.	22-2	Wasatch Fm.	1,610	3,602	3,134-42	-	DST 1	9-26-63	-	-	-	20	36	664		149	12	2	1,065	-	1,966	-	-	-	-	-	1.97	8.4	CL	DST 1 recovered 1,482 feet of gas-cut water.
									3,466-80	-	DST 2	9-28-63	-	-	-	80	36	3,766		156	14	7,579	355	-	11,986	-	-	-	-	-	.66	8.6	CL	DST 2 recovered 525 feet of brackish water with sulfur water.
						Castlegate Ss.	5,518	-	5,518-41	-	DST 4	10-12-63		-	-	600	109	11,643		107	0	5,813	14,981	-	33,253	-	-	-	-	-	.23	7.3	CL	DST 4 recovered 150 feet of slightly gas-cut muddy water and 950 feet of slightly gas-cut brackish water.
15S	22E	W½NE¼SE¼ 36	O	Texaco, Inc.	1	Entrada Ss.	9,194	9,360	9,232-9,349	100(R)/3	Swab test	4- -60		-	-	5,115	534	28,237		190	-	72	54,000	-	88,052	-	-	-	-	-	.10	7.3	CGL	Swabbed 4½ barrels of water per hour from 8,800 feet with fluid level standing at 8,000 feet.
15S	23E	SE¼SE¼ 36	S	-	PR Spring	Green River Fm.	0	-	-	34/1(M)	Flow	9-17-64	47	17	-	65	36	17		302	0	94	2.8	.5	381	312	64	11	.4	606	-	7.7	GS	
15½S	23E	NE¼SW¼SE¼ 33	O	Texaco, Inc.	3	Morrison Fm. Entrada Ss.	8,100 8,706	8,706 -	8,630-8,714	-	-	9- -61	-	-	-	5,789	454	34,077		207	-	16	64,000	-	104,438	-	-	-	-	-	.09	6.3	CGL	Report of analysis lists the Entrada Sandstone as the water-bearing formation.
16S	17E	SW¼ 3	S	-	Camel Rock Spring	Wasatch Fm.	0	-	-	7,700/225(R)	-	9-25-48	-	26	-	70	41	73		321	0	220	7	.7	596	343	80	32	1.7	842	-	-	GS	
17S	17E	SW¼SW¼ 20	S	-	-	Mesaverde Gr.	0	-	-	-	-	9-25-48	-	18	-	10	5.7	250		492	0	176	5	.1	707	48	0	92	16	1,060	-	-	GS	
17S	24E	NE¼SW¼SE¼ 9	O	Trend Oil Co.	6-A	Entrada Ss.	5,240	-	5,247-90	-	DST 1	11-21-60	-	-	-	2,570	-	30,200		244	-	2,112	51,500	-	86,626	-	-	-	-	-	.08	6.8	RME	DST 1 recovered 40 feet of drilling mud and 1,460 feet of slightly gas-cut salt water.
17S	24E	NW¼SW¼SE¼ 12	O	do	5-A	do	5,070	-	At 5,160	-	See Remarks	11- 2-60	-	-	-	2,304	-	20,200		13	-	2,352	33,500	-	58,369	-	-	-	-	-	.14	6.0	RME	Drilled with air from 930 to 5,161 feet; encountered water at 5,100 feet and the water rose 300 feet.
20S	20E	17	S	-	Thompson Spring	Mesaverde Gr.	0	-	-	-	-	10-20-33	-	-	.10	55	64	104		552	-	156	8.0	1.2	660	400	-	-	-	-	-	-	GS	
20S	20E	27	S	Chesterfield Coal Co.	Sego Spring	do	0	-	-	-	-	2-24-41	-	11	-	44	79	198		664	-	323	26	.0	9/1,090	432	-	-	-	-	-	7.5	DH	Analysis includes 0.1 ppm fluoride

1/ Dissolved solids calculated from determined constituents except as noted.
2/ Analysis by: CaO, Carter Oil Co.
CGL, Chemical and Geological Laboratories, Caspter, Wyo.
CL, Core Laboratories, Inc., Dallas, Tex.
CO, Continental Oil Co.
GS, U.S. Geological Survey
DH, Utah State Department of Health
PA, Pan American Petroleum Corp.
RME, Rocky Mountain Engineering Co., Grand Junction, Colo.
ShO, Shell Oil Co.
SOG, Stanolind Oil and Gas Co.
UC, Utah State Chemist
3/ Uinta Special Meridian.
4/ Trace.
5/ In solution at time of analysis.
6/ Analysis supplied by Carter Oil Co.
7/ Total iron.
8/ Resistivity at 72°F.
9/ Residue at 180°C.

...and oil and gas wells in bedrock in the Canyon Lands section

..., S, spring; T, test hole; W, water well.
... owner: Name of operator or owner at time water sample was collected for chemical analysis.
Producing formation: Fm., Formation; Gr., Group; Ls., Limestone; Mbr., Member; sed., sedimentary; Sh, Shale; Ss., Sandstone. Many formation names were reported in records of oil and gas companies and State and Federal agencies do not necessarily agree with the identification.

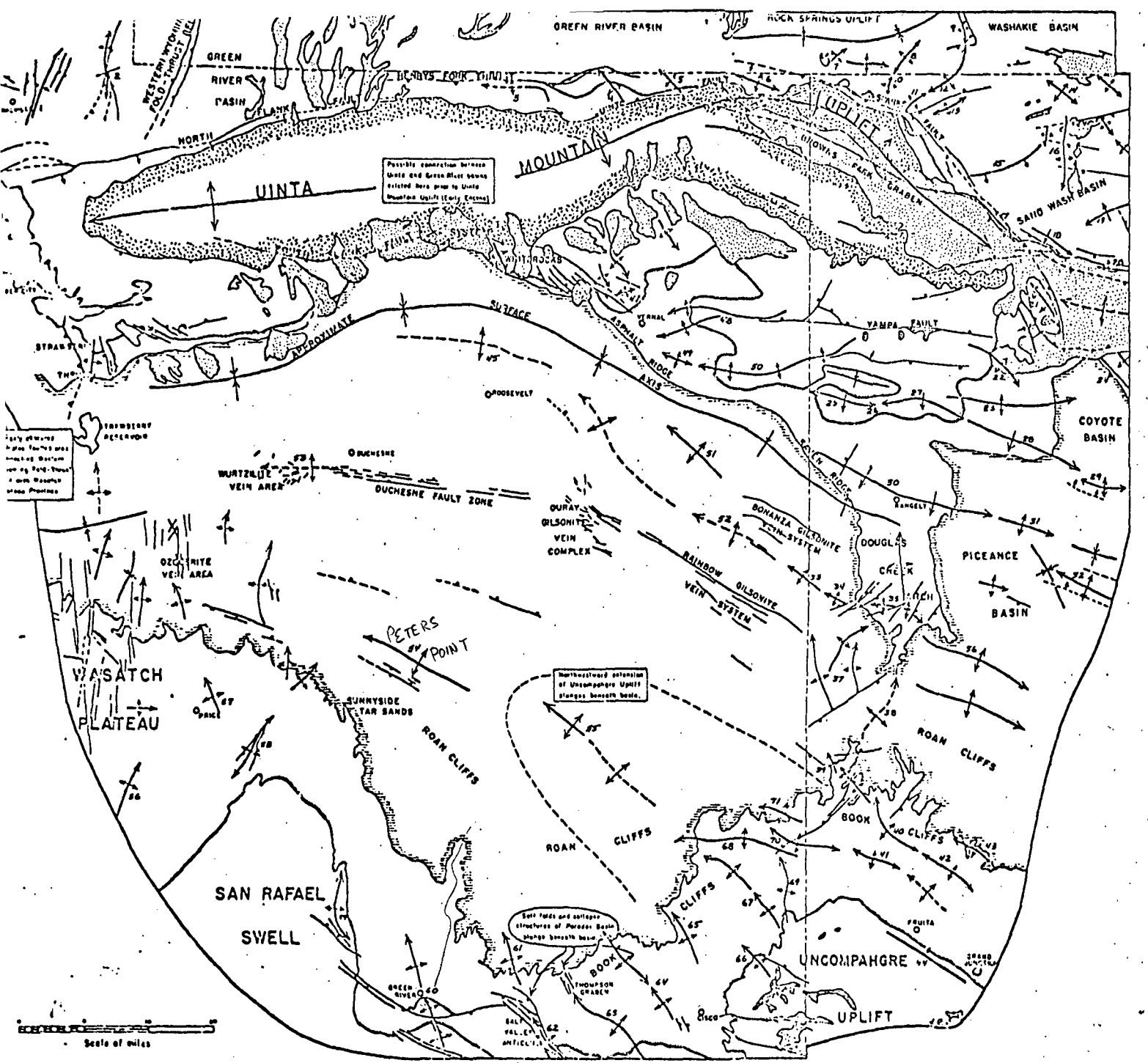
Yield: bwpd, barrels of water per day; gpm, gallons per minute; (E), estimated; (M), measured; (R), reported at time water sample was collected for chemical analysis. The (E), (M), or (R) is beside the given unit. The other unit is calculated on the basis of 1 gpm equals 34 bwpd and 1 bwpd equals 0.03 gpm.
Method or point of collection: Flow, indicates collection at a spring or flowing well; DST, drill-stem test for oil or gas.
Remarks: DST, drill-stem test data reported by oil or gas company.

Location T	Location R	Location Section	Source	Operator or owner	Name or number	Producing formation	Depth to top of formation (feet)	Depth to bottom of formation (feet)	Interval sampled (feet)	Yield (bwpd/gpm)	Method or point of collection	Date of collection	Temperature (°F)	Parts per million: Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Na + K: Sodium (Na)	Na + K: Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids 1/	Hardness as $CaCO_3$	Noncarbonate hardness as $CaCO_3$	Percent sodium	Sodium-adsorption ratio (SAR)	Specific conductance (micromhos/cm at 25°C)	Resistivity (ohmmeter at 68°F)	pH	Analysis by 2/	Remarks
43S	4½W	SE¼SE¼SE¼ 31	W	F. Hamblin	1	Shinarump Mbr. of Chinle Fm.	217	269	217-269	See Remarks	Flow	8-13-57	-	8.4	0.24	14	1.0	215		224	0	272	26	0.1	646	38	0	92	15	1,020	-	6.9	GS	Reported yield on 7-17-56 was 450 gpm (15,300 bwpd). Analysis includes 0.8 ppm fluoride.
43S	4½W	NW¼NW¼NE¼ 33	W	Richard Von Hake	1	do	-	-	28-79	-	Pumped	8-13-57	-	23	.24	119	21	28		6	0	490	22	.4	710	384	384	14	.6	962	-	3.9	GS	Analysis includes 0.5 ppm fluoride.
14S	9E	S½NW¼NE¼ 29	O	Amerada Petroleum Co.	1	Ferron Ss. Mbr. of Mancos Sh.	2,664	3,023	At 2,756	-	Flowline	12- -62	-	-	0	320	24	19,978		488	144	40	30,956	-	51,950	-	-	-	-	-	3/ 0.14	7.0	CL	Sample collected while drilling with air.
									At 2,806	-	do	12- -62	-	-	0	280	24	14,975		3,514	240	40	21,300	-	37,860	-	-	-	-	-	3/ .18	8.0	CL	Do.
						Tununk Sh. Mbr. of Mancos Sh.	3,023	3,416	At 3,054	-	do	12- -62	-	-	0	120	24	6,537		1,220	336	40	2,840	-	11,117	-	-	-	-	-	3/ .62	8.0	CL	Do.
									At 3,325	-	do	12- -62	-	-	0	80	24	7,549		1,464	96	40	2,840	-	12,093	-	-	-	-	-	3/ .54	8.0	CL	Do.
15S	10E	C NE¼NE¼ 26	O	Shell Oil Co.	1	Mississippian sed. rocks	8,950	10,763	10,058-10,165	-	DST 3	5-13-58	-	-	-	1,530	396	6,583		634	0	2,825	11,600	-	23,568	-	-	-	-	-	4/ .30	7.1	ShO	
15S	11E	NE¼SE¼SW¼ 12	O	Carbon Dioxide and Chemical Co.	2	Navajo Ss.	3,095	3,114	3,095-3,114	-	See Remarks	1-21-39	-	-	(5)	874	61	422		3,070	-	568	172	-	3,607	-	-	-	-	-	-	-	GS	Carbon dioxide well. Water sample bailed from hole at 2,320 feet under pressure by using temperature observation machine.
15S	12E	SW¼SW¼SW¼ 7	O	Pan American Petroleum Corp.	1	Mississippian sed. rocks	7,042	8,154	7,433-7,986	-	DST 1	4- -63	-	-	(5)	1,144	311	10,956		2,269	-	8,400	13,100	-	35,778	-	-	-	-	-	.26	7.3	CGL	DST 1 recovered very cloudy water, dark brown organic filtrate.
15S	12E	SE¼SW¼SW¼ 8	O	Shell Oil Co.	1-A	Redwall Ls. Elbert Fm.	7,970 9,130	9,130 -	8,323-9,174	-	DST 1-A	8-18-59	-	-	-	3,496	716	21,583		2,147	-	2,346	38,571	-	67,769	-	-	-	-	-	.12	7.2	CGL	DST 1-A recovered 6,750 feet of slightly gassy, slightly muddy salt water with trace of oil and sulfurous odor.
15S	12E	15	W	-	-	Mancos Sh.	0	-	0-30	-	-	8- 8-58	-	11	-	481	502	743		486	0	3,530	305	466	6,280	3,260	2,870	39	5.7	6,580	-	7.5	GS	Dug well, 30 feet deep. Analysis includes 0.2 ppm fluoride.
16S	9E	W½NE¼NW¼ 12	O	Pure Oil Co.	1-A	Redwall Ls.	9,800	11,125	10,117-10,259	-	DST 2	3- 9-62	-	-	3,013	3,680	462	22,050		3,221	0	1,640	42,600	-	73,653	-	-	-	-	-	6/ .14	6.5	CL	DST 2 recovered 450 feet of heavy gas-cut mud (carbon dioxide) and 360 feet of salt water.
16S	12E	C NE¼NW¼ 1	O	Cities Service Oil Co.	1	Sinbad Ls. Mbr. of Moenkopi Fm.	4,014	-	4,014-83	-	DST 3	1- -53	-	-	-	-	-	-		-	-	-	9,700	-	-	-	-	-	-	-	-	-	(7)	DST 3 recovered 80 feet of slightly sulfur gas-cut mud, 90 feet of sulfur water-cut mud, and 450 feet of sulfur water.
						Mississippian sed. rocks	6,372	-	7,831-7,930	-	DST 5	5- -53	-	-	-	-	-	-		-	-	-	44,000	-	-	-	-	-	-	-	-	-	(7)	DST 5 recovered 270 feet of gas (carbon dioxide) and salt water-cut mud and 1,910 feet of gas-cut (carbon dioxide) salt water from Deseret(?) Formation
16S	12E	C NE¼NW¼ 4	O	Equity Oil Co.	2	Sinbad Ls. Mbr. of Moenkopi Fm.	4,141	-	4,138-75	-	-	1- -53	-	-	-	-	-	-		-	-	6,400	78,000	-	-	-	29,200	-	-	-	-	6.5	PL	Analysis includes 2,410 ppm magnesium as magnesium carbonate and 180 ppm free carbon dioxide.
									4,138-75	-	-	1- -53	-	-	-	-	-	-		-	-	72,000	75,200	-	-	-	38,400	-	-	-	-	6.7	PL	Analysis includes 2,680 ppm magnesium as magnesium carbonate and 210 ppm free carbon dioxide.
									4,185-4,207	-	-	1- -53	-	-	-	-	-	-		-	-	10,400	88,000	-	-	-	51,320	-	-	-	-	6.4	PL	Analysis includes 3,620 ppm magnesium as magnesium carbonate and 430 ppm free carbon dioxide.
16S	12E	C NW¼NE¼ 27	O	Carter Oil Co.	1	Coconino Ss.	3,975	4,830	4,442-58	-	DST 2	1-14-57	-	-	-	1,355	377	4,749		2,490	-	642	8,900	-	17,249	-	-	-	-	-	.40	7.9	CGL	DST 2 recovered 30 feet of water-cut mud and 360 feet of water.
						Madison Ls.	6,585	-	6,998-7,133	-	DST 5	2- -57	-	-	-	1,936	454	18,537		4,030	-	2,712	29,000	-	54,624	-	-	-	-	-	.16	6.8	CGL	DST 5 recovered 140 feet of mud and 840 feet of salt water.
16S	13E	E½SW¼SW¼ 21	O	Reserve Oil and Gas Co.	1	Glen Canyon Gr.	1,777	2,644	At 2,400	1,680(R) / 50	See Remarks	5- -63	-	-	-	480	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	(8)	While drilling with air an estimated flow of 70 barrels of water per hour (50 gpm) was produced from the Navajo Ss. below 1,784 feet. The analysis includes 10,000 ppm sodium chloride.
						Moenkopi Fm. Sinbad Ls. Mbr. of Moenkopi Fm.	2,912 3,516	3,896 3,574	3,494-3,550	-	DST 1	5-17-63	-	-	-	-	-	-		-	-	-	18,000	-	-	-	-	-	-	-	-	-	(8)	DST 1 recovered 60 feet of rat-hole fluid and 403 feet of emulsified mud and black sulfur water slightly gas cut.
18S	14E	SE¼SW¼SE¼ 9	W	-	Roadside Geyser	Mancos Sh.	0	-	-	-	-	3-14-47	82	-	-	908	288	360		2,840	0	1,540	215	.0	4,710	3,450	1,120	19	-	5,640	-	-	GS	Reported well depth 180 feet. Analysis includes 0.4 ppm boron.
18S	14E	NW¼SW¼SW¼ 30	O	Humble Oil and Refining Co.	2	Kaibab Ls.	3,606	3,710	3,606-73	-	DST 1	10-25-62	-	-	-	2,400	486	9,672		4,050	0	60	18,815	-	35,985	-	-	-	-	-	9/ .20	6.0	CL	DST 1 recovered 1,620 feet of heavy gas-cut dark sulfur water, 721 feet of mud-cut and heavy gas-cut sulfur water, 180 feet of slightly gas and water-cut mud, and 120 feet of mud.
						Coconino Ss.	3,710	4,159	3,717-3,868	-	DST 2	10-29-62	-	-	-	2,400	486	12,070		3,026	0	200	22,720	-	49,902	-	-	-	-	-	9/ .19	6.0	CL	DST 2 recovered 160 feet of mud, 450 feet of slightly salty water, 270 feet of gas-cut and slightly mud-cut water.
						Mississippian sed. rocks	6,872	-	6,963-7,083	-	DST 7	12-20-62	-	-	368	2,400	486	16,174		3,270	0	80	29,110	-	51,888	-	-	-	-	-	9/ .13	6.0	CL	DST 7 recovered 90 feet of mud and 3,366 feet of salt water.
19S	10E	6	S	-	Red Seep	Brushy Basin Sh. Mbr. of Morrison Fm.	0	-	-	34 / 1(E)	Flow	10-31-58	57	7.3	-	7.2	.0	287		329	28	181	94	.7	768	18	0	97	29	1,240	-	8.8	GS	Analysis includes 1.9 ppm fluoride.
19S	13E	SE¼SE¼SE¼ 12	O	Humble Oil and Refining Co.	1	Paradox Fm.	5,317	6,407	5,518-5,608	-	DST 11	8-11-62	-	-	0	960	1,021	8,450		2,196	0	320	16,188	-	29,135	-	-	-	-	-	10/ .20	7.5	CL	DST 11 recovered 180 feet of mud and 5,120 feet of slightly salty water.
						Mississippian sed. rocks	6,407	7,242	6,736-6,915	-	DST 12	8-13-62	-	-	0	2,640	365	16,169		1,903	0	800	28,968	-	50,845	-	-	-	-	-	11/ .11	7.0	CL	DST 12 recovered 300 feet of mud and 5,160 feet of mud-cut salt water.
19S	24E	SW¼NW¼SE¼ 35	O	Promontory Oil Co.	3	Brushy Basin Sh. Mbr. of Morrison Fm.	1,370	-	1,484-1,508	See Remarks	Flow	10-27-64	-	7.2	-	683	96	9,210		79	0	49	15,600	9.4	25,700	2,100	2,030	91	87	38,800	-	6.8	GS	Estimated yield less than 1 gpm (less than 34 bwpd).
19S	25E	SE¼NW¼NE¼ 10	W	E. Elizondo	1	Morrison Fm.	-	-	595-602	1(E) / <1	Bailed	6-23-65	-	1.7	-	56	92	2,690		0	101	1,120	1,750	.7	7,350	520	-	92	51	61,000	-	12.3	GS	Analysis includes 875 ppm hydroxide.
						Entrada Ss.	875	-	875-905	85 / 2.5(R)	do	6-23-65	-	5.8	-	64	34	3,620		1,290	0	270	4,840	.0	9,470	300	0	96	91	51,300	-	7.8	GS	
20S	7E	NE¼SE¼NE¼ 21	O	Pan American Petroleum Corp.	3	Kaibab Ls.	7,150	7,300	7,170-7,220	See Remarks	Separator valve	11- 6-64	-	35	-	1,320	528	25,700		2,800	0	4,210	38,800	12	72,000	5,470	3,170	91	152	84,600	-	7.3	GS	Estimated yield less than 1 gpm (less than 34 bwpd).
20S	7E	SW¼NE¼SW¼ 27	O	English Oil Co.	23-27	Ferron Ss. Mbr. of Mancos Sh.	790	951	804-806	-	-	4- -62	-	-	-	49	23	8,484		2,562	192	24	11,500	-	21,534	-	-	-	-	-	.34	8.5	(12)	
20S	11E	4	S	-	Buckhorn Wash	Moenkopi(?) Fm.	0	-	-	680 / 20(E)	Flow	10-31-58	-	12	-	329	124	194		232	22	1,430	36	.3	2,250	1,330	1,140	-	2.3	2,550	-	8.4	GS	Analysis includes 1.7 ppm fluoride.
20S	22E	C SE¼NW¼ 30	O	Cabeen Exploration Corp.	I-1	Morrison Fm.	2,064	-	2,388-2,456	-	DST 2	9- -57	-	-	-	531	251	7,904		1,160	-	527	12,800	-	22,584	-	-	-	-	-	.33	7.4	CGL	DST 2 recovered 65 feet of slightly gas-cut mud and 480 feet of brackish water.
20S	24E	NE¼SE¼SW¼ 29	O	G. Hertzke	2	do	300	-	384-400	-	Bailed	11- -63	-	1.1	-	820	17	2,050	105	0	112	146	2,800	44	6,880	2,120	2,120	66	19	17,700	-	12.4	GS	Analysis includes 0.11 ppm boron, 0.6 ppm fluoride, and 790 ppm hydroxide.
									762-772	-	do	11- -63	-	2.4	-	565	9.7	1,650	83	0	87	299	2,240	51	5,510	1,450	1,450	70	19	13,400	-	12.3	GS	Analysis includes 0.14 ppm boron, 0.1 ppm fluoride, and 527 ppm hydroxide.
									872-888	-	do	11- -63	-	1.5	-	9.6	0	794	30	0	277	607	612	3.2	2,090	24	0	97	70	3,500	-	10.3	GS	Analysis includes 2.0 ppm boron, 4.7 ppm fluoride, and 31 ppm hydroxide.
21S	15E	NW¼SW¼SW¼ 24	O	Superior Oil Co.	14-24	Mississippian sed. rocks	9,533	10,205	9,555-9,652	-	DST 7	4- -61	-	-	101	4,370	1,604	120,957		1,452	0	2,400	196,400	-	327,283	-	-	-	-	-	9/ .04	5.5	CL	DST 7 recovered 173 feet of mud, 81 feet of water-cut mud, and 118 feet of muddy water.
									9,705-52	-	DST 8	4- -61	-	-	3.4	10,120	1,410	86,825		366	0	300	155,500	-	254,525	-	-	-	-	-	9/ .04	5.0	CL	DST 8 recovered 600 feet of water-cut mud and 5,700 feet of salt water.
21S	16E	NE¼SE¼SE¼ 34	W	G. Ruby	Crystal Geyser	Entrada Ss.	59	487	59-97	40,000(R) / 1,200	Flow	3-22-48	64	13	-	1,000	225	4,070		4,400	0	2,410	4,370	-	14,300	3,420	0	72	30	19,400	-	-	GS	The geyser is an open [illegible]
21S	19E	SE¼SE¼SW¼ 33	O	Potash Co. of America	2	do	1,736	-	1,736-58	-	See Remarks	7-20-43	-	-	-	244	107	3,654		500	-	946	5,390	-	[illegible]									
22S	6E	NW¼ 33	[illegible]	[illegible]		Ferron Ss. Mbr. [illegible]						1-22-52				[illegible]	[illegible]																	

Location T	Location R	Location Section	Source	Operator or owner	Name or number	Producing formation	Depth to top of formation (feet)	Depth to bottom of formation (feet)	Interval sampled (feet)	Yield (bwpd/gpm)	Method or point of collection	Date of collection	Temperature (°F)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Na + K: Sodium (Na)	Na + K: Potassium (K)	Bicarbonate	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids[1]	Hardness as $CaCO_3$	Noncarbonate hardness as $CaCO_3$	Percent sodium	Sodium-adsorption ratio (SAR)	Specific conductance (micromhos/cm at 25°C)	Resistivity (ohmmeter at 68°F)	pH	Analysis by[2]	Remarks
22S	16E	SE¼NW¼NW¼ 2	O	Amerada Petroleum Co.	1	Paradox Fm.	5,100	-	At 5,250	-	Flow	10- -48	-	16	-	68,459	9,090	55,950			137	231,200	-	367,475	208,406	-	-	-	-	-	-	CTL	Analysis includes 1,891 ppm borate, 73 ppm hydroxide, and 76 ppm iron and aluminum oxide.
22S	16E	NE¼SW¼SW¼ 2	O	do	2	do	5,054	-	5,792-5,896	See Remarks	do	7- -49	-	10	-	76,176	9,484	58,301			49	249,600	-	397,601	229,301	-	-	-	-	-	-	CTL	Analysis includes 2,362 ppm borate and 160 ppm iron and aluminum oxide. Flowed salt water at 1,000 to 5,000 bwpd (30 to 150 gpm) from July 3 to 17, 1949, from a depth of 5,792 to 5,896 feet.
22S	17E	E½SE¼NW¼ 34	O	Superior Oil Co.	22-34	Mississippian sed. rocks	10,020	-	10,053-10,173	-	DST 3	8- -58	-	-	-	9,757	1,441	66,729		0	670	123,703	-	202,907	30,284	-	-	-	-	13/0.10	6.5	SO	DST 3 recovered 500 feet of muddy salt water and 2,670 feet of salt water. Analysis includes 0.0 ppm sulfide and 348 ppm iron and aluminum oxide.
22S	19E	NW¼NW¼NE¼ 16	O	Potash Co. of America	1	Morrison Fm.	703	1,363	1,118-55	-	Bailed	8-12-43	-	-	(5)	329	175	4,913			457	8,036	-	13,910	-	-	-	-	-	-	-	GS	
22S	22E	NW¼NE¼ 33	M	-	Cactus Rat Mine	Salt Wash Ss. Mbr. of Morrison Fm.	0	-	-	17/0.5(E)	-	6-29-50	56	10	0.03	101	15	343	3.4		306	47	5.8	1,430	314	146	70	8.5	2,030	-	7.9	GS	Analysis includes 0.02 ppm boron, 0.3 ppm fluoride, and 0.00 ppm manganese.
22S	22E	SE¼NW¼NW¼ 33	O	Utah Southern Oil Co.	1	Morrison Fm.	0	-	298-319	70/2(E)	Pumped	12-29-35	-	-	-	-	-	205			97	54	-	517	-	-	-	-	-	-	-	GS	
						Chinle Fm.	1,100	-	1,109-40	34/1(E)	Bailed	11-18-35	-	-	-	474	137	6,993			1,830	10,442	-	20,070	-	-	-	-	-	-	-	GS	
23S	10E	8	S	-	Cliff Dweller Spring	Wingate Ss.	0	-	-	34/1(E)	Flow	10-31-58	-	7.5	-	127	112	39			285	24	.2	914	778	247	10	.6	1,380	-	8.1	GS	Analysis includes 0.2 ppm fluoride.
23S	15E	C NE¼NW¼ 21	O	Shell Oil Co.	1	Mississippian sed. rocks	7,452	-	7,500-7,702	-	DST 1	8-31-59	-	-	-	1,444	208	7,283			3,090	11,670	-	24,074	-	-	-	-	-	.31	6.9	CGL	DST 1 recovered 3,240 feet (34 barrels) of salt water.
23S	16E	NE¼SW¼NW¼ 3	O	Mobil Oil Co.	12-3	do	8,355	9,042	8,530-8,715	-	DST 1	8- -61	-	-	-	9,588	1,265	55,921			951	106,000	-	173,905	-	-	-	-	-	.06	6.4	CGL	DST 1 recovered 1,150 feet of mud-cut salt water and 7,000 feet of salt water.
23S	16E	NE¼SW¼SE¼ 15	O	do	34-15	White Rim Ss. Mbr. of Cutler Fm.	2,540	2,860	See Remarks	See Remarks	Flow	9- -61	-	-	-	474	86	681			1,778	410	-	3,784	-	-	-	-	-	2.60	7.1	CGL	Estimated water flow of 200 gallons per hour (3 gpm or 100 bwpd) encountered while drilling between 2,530 and 2,570 feet.
						Mississippian sed. rocks	8,028	-	8,210-8,440	-	DST 1	10- -61	-	-	-	5,092	2,916	65,021			2,086	116,000	-	191,344	-	-	-	-	-	.05	6.9	CGL	DST 1 recovered 651 feet of mud and 6,929 feet of salt water.
23E	17E	C NW¼SW¼ 15	O	Pan American Petroleum Corp.	1	do	8,422	8,988	8,678-8,768	-	DST 3	3- -61	-	-	-	3,469	752	84,656			[illegible]	136,224	-	228,517	-	-	-	-	-	.05	7.7	CGL	DST 3 recovered 668 feet of heavy gas-cut mud, 704 feet of amber colored gas-cut emulsion, 1,858 feet of oil, and 610 feet of salt water.
23S	17E	C SE¼NE¼ 17	O	Texaco, Inc.	1	do	8,458	-	8,732-38	-	-	12- -62	-	-	-	6,302	1,002	56,175			1,240	99,500	-	164,478	-	-	-	-	-	.06	6.5	CGL	
23S	17E	C NW¼SE¼ 17	O	do	2	do	8,447	-	8,709-16	-	Swab test	12- -62	-	-	-	5,781	1,453	56,854			1,275	101,000	-	166,549	-	-	-	-	-	.06	6.5	CGL	
23S	21E	SE¼SW¼NW¼ 27	W	National Park Service	1	Wingate Ss.	765	-	790-900	140/4(E)	Well head	10-31-62	61	5.0	-	28	18	54			36	62	.3	283	142	8	45	2.0	530	-	7.3	GS	Cloudy yellow water with iron oxide precipitate.
23S	22E	NW¼ 6	M	-	Telluride No. 18	Salt Wash Ss. Mbr. of Morrison Fm.	0	-	-	See Remarks	Pumped	6-29-50	50	11	14/.20	89	20	129	6.1		383	13	2.6	759	304	138	47	-	1,100	-	7.9	GS	Water pumped from mine sump at rate of 300 gallons per day (0.2 gpm or 76 bwpd). *Analysis includes 0.04 ppm boron, 0.4 ppm fluoride, and 0.00 ppm manganese.*
23S	23E	8	S	-	Squaw Park Spring	Entrada Ss.	0	-	-	34/1(E)	Flow	6- 5-59	-	33	-	51	4.9	9.1			8.2	3.0	4.6	204	148	0	12	.3	316	-	8.4	GS	Analysis includes 0.10 ppm boron and 0.4 ppm fluoride.
23S	24E	NW¼NW¼SW¼ 8	S	-	Dewey Bridge Spring	do	0	-	-	-	do	4-24-59	56	10	-	13	2.4	.147			44	64	.5	417	42	0	88	9.9	693	-	7.6	GS	
24S	10E	SE¼NE¼ 4	S	-	Tan Seep	Kaibab Ls.	0	-	-	See Remarks	do	10-30-58	44	11	-	257	224	88			1,380	42	.7	2,150	1,560	1,310	11	1.0	2,500	-	8.4	GS	Yield on 10-27-44 was estimated at 5 gpm (170 bwpd). Analysis includes 1.3 ppm fluoride.
24S	13E	NW¼NE¼SW¼ 2	O	Superior Oil Co.	23-2	Shinarump Mbr. of Chinle Fm.	1,527	1,562	1,527-47	-	DST 1	8- -58	-	-	-	76	89	275		4,0	270	526	-	5,750	556	-	-	-	-	13/.62	7.8	SO	DST 1 recovered 110 feet of 8.9 pound water-cut mud. Analysis includes 0.0 ppm sulfide and 90 ppm iron and aluminum oxide.
						Moenkopi Fm.	1,562	2,200	1,942-82	-	DST 4	9- -58	-	-	-	294	3.6	4,289		0	2,029	5,374	-	12,472	748	-	-	-	-	13/1.58	7.4	SO	DST 4 recovered 280 feet of mud and 1,542 feet of black sulfur water. Analysis includes 0.0 ppm sulfide and 14 ppm iron and aluminum oxide.
						do	1,562	2,200	1,800-85	94(R)/2.8	Pumped	11- 9-58	-	-	-	358	36	5,149		4,0	324	6,079	-	15,999	1,041	-	-	-	-	13/.48	7.0	SO	Well pumped at rate of 56 3/4 barrels of water in 14½ hours. Analysis includes 5.0 ppm sulfide and 13 ppm iron and aluminum oxide.
						Sinbad Ls. Mbr. of Moenkopi Fm.	2,038	-	2,041-65	-	DST 5	9- -58	-	-	-	239	3.6	5,910		5,0	325	6,137	-	18,125	611	-	-	-	-	13/.59	15/7.7	SO	DST 5 recovered 85 feet of mud and 1,225 feet of black sulfur water. Analysis includes a trace of sulfide and 63 ppm iron and aluminum oxide.
24S	13E	NW¼ 29	S	-	Red Rock Spring	Carmel Fm.	0	-	-	70/2(E)	Flow	10-28-58	62	9.8	-	54	50	35			94	14	2.1	437	340	43	18	.8	700	-	8.5	GS	pH at point of collection was 7.5. Analysis includes 0.2 ppm fluoride.
24S	14E	NE¼NE¼SE¼ 21	O	Carter Oil Co.	1	Moenkopi Fm.	1,688	2,375	2,114-2,340	-	DST 2	10- -58	-	-	.0	400	97	729		1,0	1,620	341	-	4,187	-	-	-	-	-	.92	7.0	CL	DST 2 recovered 180 feet of mud, 630 feet of mud-cut water, and 740 feet of brackish water.
24S	16E	C SE¼NW¼ 19	O	Shell Oil Co.	1	Mississippian sed. rocks	7,570	8,263	7,968-8,067	-	DST 2	11-12-58	-	-	-	1,957	384	54,697			5,131	85,000	-	147,313	-	-	-	-	-	.07	7.1	CGL	DST 2 recovered 6,900 feet (95.3 barrels) of salt water with hydrogen sulfide odor.
24S	20E	SW¼NE¼NE¼ 20	S	-	Courthouse Spring	Navajo Ss.	0	-	-	-	-	10-16-33	-	-	.42	44	35	.12			68	17	1.9	288	254	-	-	-	-	-	-	GS	
24S	22E	6	S	-	Turnbow Cabin Spring	Entrada Ss.	0	-	-	170/5(E)	-	8- 1-62	-	-	14/.00	-	-	-			-	2.0	.5	-	156	18	-	-	271	-	7.7	GS	Spring is series of seeps in stream bed. Analysis includes 0.3 ppm fluoride.
24S	24E	22 and 23	S	-	Onion Creek Spring	Paradox Fm.	0	-	-	-	-	9- -27	-	-	-	965	132	4,490			2,350	6,990	-	15,170	2,950	-	77	36	-	-	-	GS	
25S	12E	SW¼ 14	W	J. Marsing	Temple Junction	Carmel Fm.	-	-	-	-	-	10-30-58	62	13	-	481	642	339			3,900	105	41	6,360	3,840	3,510	16	2.4	5,640	-	7.6	GS	pH of water at point of collection was 7.0. Analysis includes 0.2 ppm fluoride.
25S	12E	SE¼SW¼SW¼ 34	W	Bureau of Land Management	Gilson Butte	Entrada Ss.	0	298	See Remarks	See Remarks	-	10-30-58	58	9.6	-	240	372	105			1,980	36	42	3,500	2,130	-	-	1.0	3,160	-	7.8	GS	Depth of well is 290 feet with casing perforated from 230 to 290 feet. Reported yield in March 1953 was 360 bwpd (11 gpm). pH of water at point of collection was 7.0. Analysis includes 1.4 ppm fluoride.
25S	15E	C NW¼NE¼ 15	O	Superior Oil Co.	31-15	Hermosa Gr. Ismay Zone of Paradox Fm.	4,018 4,840	6,196 5,070	4,819-55	-	DST 1	7- -63	-	-	.0	9,680	5,637	68,749		0	120	124,960	-	209,682	-	-	-	-	-	16/05	7.0	CL	DST 1 recovered 290 feet of water.
25S	15E	C SW¼NE¼ 22	O	Continental Oil Co.	2	Hermosa Gr.	3,283	5,916	4,345-67	-	DST 6	6- -58	-	-	-	801	460	7,192			7,843	7,800	-	24,318	-	-	-	-	-	.36	7.6	CGL	DST 6 recovered 3,570 feet of mud-cut salt water and salt water.
						Paradox Fm.	4,955	5,916	4,950-5,062	-	DST 2	6- -58	-	-	-	876	444	7,183			5,384	9,400	-	23,943	-	-	-	-	-	.33	8.7	CGL	DST 2 recovered 60 feet of mud-cut sulfur water and 750 feet of slightly gas-cut sulfur water. Sample was clear reddish-brown water from lower part of column.
						Mississippian sed. rocks	5,916	-	6,085-6,220	-	DST 5	7- -58	-	-	-	1,382	234	9,689			3,811	15,000	-	30,332	-	-	-	-	-	.26	7.6	CGL	DST 5 recovered 5,460 feet of mud-cut sulfur water and sulfur water. Sample was clear water.
25S	15E	NW¼NE¼SW¼ 32	W	Standard Oil Co. of California	1	Navajo Ss.	250	-	680-720	-	Pumped	7-11-56	-	-	-	125	86	28			394	26	-	827	-	-	-	-	-	6.90	7.5	CGL	Well is 720 feet deep and perforated from 680 to 720 feet. Reported depth to water was 650 feet in 1956.
25S	16E	C NE¼NW¼ 10	O	Shell Oil Co.	2	Mississippian sed. rocks	6,707	7,365	6,898-7,092	-	DST 1	3- 2-59	-	-	-	2,227	750	4,251			4,251	54,000	-	94,667	-	-	-	-	-	.88	6.9	CGL	DST 1 recovered 1,470 feet of muddy salt water and 4,395 feet of salt water.
25S	16E	C SE¼SW¼ 29	O	Standard Oil Co. of California	1	do	6,359	-	6,480-6,594	-	DST 3	10-21-57	-	-	-	1,623	41	13,742			4,024	21,000	-	40,617	-	-	-	-	-	.20	7.6	CGL	DST 3 recovered 180 feet of watery mud, 900 feet of [illegible] black sulfur water.
25S	17½E	NW¼NE¼SE¼ 20	O	Superior Oil Co.	43-20	do	6,050	6,664	6,361-86	-	DST 5	1-25-61	-	-	-	560	1,069	9,655			5,000	15,052	-	31,775	-	-							
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	6-12-63	-	16	-	174	52	1,050	[illegible]		-												

Table 3. — Continued

Location			Source	Operator or owner	Name or number	Producing formation	Depth to top of formation	Remarks
T	R	Section						
25S	19E	C NW¼SE¼ 27	O	Pure Oil Co.	5	Mississippian sed. rocks	7,39	240 feet of slightly salty black sulfur water.
25S	20E	- 4	S	-	Seeping Spring	Wingate Ss.		
25S	21E	SE¼SE¼NE¼ 20	W	National Park Service	2	Navajo Ss.		
25S	21E	SE¼NW¼ 26	S	-	Moab Bridge Spring	Wingate Ss		
25S	21E	NE¼NE¼NE¼ 35	S	D. Parriot	-	do		
25S	21E	SW¼SW¼SE¼ 36	S	M. R. Fish	-	do		ed by a tunnel that was driven 116 feet into sandstone.
25S	23E	NE¼NE¼NW¼ 8	W	A. Sarten	-	Cutler Fm.		0.06 ppm boron, 0.2 ppm fluoride, and 0.00 ppm manganese.
26S	7E	C NW¼NW¼ 19	O	Shell Oil Co.	1	Mississippian sed. rocks	5,0	2.0 ppm ammonium and 2 ppm boron. DST 3 recovered 3,890 feet (54 -cut mud, mud-cut sulfurous water, and sulfurous water with ppm sodium chloride.
						Devonian sed. rocks	6,2	
						Cambrian sed. rocks	6,6	1 ppm ammonium and 1 ppm boron. DST 2 recovered 4,540 feet (60 ut water with a salinity of 1,320 ppm sodium chloride.
26S	7E	C NE¼SE¼ 20	O	Shumway Uranium Mining Corp.	1	Navajo Ss.		235 ppm of alkalinity as calcium carbonate.
						Wingate Ss.	1,1	1,875 ppm of alkalinity as calcium carbonate.
26S	13E	NW¼SE¼SW¼ 19	W	-	Jeffery Well	Chinle Fm.	1,5	410 ppm of alkalinity as calcium carbonate.
						Entrada(?) Ss.		0.9 ppm fluoride.
26S	14E	C NW¼NW¼ 7	O	Odessa Natural Gas Co.	1	Mississippian sed. rocks	5,6	0 feet of mud-cut sulfur water and 2,595 feet of sulfur water.
26S	14E	C SW¼SW¼ 30	O	Humble Oil and Refining Co.	7	do	5,8	628 feet of slightly mud-cut water.
26S	17E	SW¼SW¼SW¼ 5	O	Superior Oil Co.	14-5	do	6,6	f gas immediately increasing to strong in 2 minutes, fluid to es--90 percent water, 10 percent mud and asphaltic residue. hanged to small spray of sulfur water. 0 feet of water.
								f gas immediately increasing through test. Fluid to surface in
								340 feet of sulfur water; sample from bottom of fluid column. nd middle of fluid column contained 39,876 and 22,242 ppm of respectively.
26S	18E	S½NE¼SE¼ 7	O	Pure Oil Co.	1	do	6,-	0 feet of muddy water and 5,600 feet of slightly salty sulfur
26S	20E	SE¼SE¼NW¼ 9	O	Southern Natural Gas Co.	1	See Remarks	7,-	reported to be "Cane Creek Member" of Paradox Formation.
26S	22E	NW¼NW¼SW¼ 15	S	J. Westwood	-	Navajo Ss.		.07 ppm boron and 0.1 ppm fluoride.
27S	11E	NE¼SW¼SE¼ 34	W	Civil Aeronautics Administration	1	Carmel Fm.		18-46 was 17 gpm (580 bwpd).
27S	11E	NW¼SE¼SE¼ 34	W	do	1	do		
27S	12E	SW¼NE¼NE¼ 9	O	Carter Oil Co.	1	Mississippian sed. rocks	5	feet of water-cut mud and 4,920 feet of slightly brackish water.
27S	13E	NE¼NE¼ 4	W	Bureau of Land Management	91	Entrada Ss.		5 to depth of 795 feet, cased to 456 feet; depth of water in 720 feet.
27S	13E	C NW¼NE¼ 30	O	Superior Oil Co.	31-30	Mississippian sed. rocks	6	feet of mud and water-cut water and 5,000 feet of brackish
27S	13E	C SE¼SW¼ 36	O	Continental Oil Co.	1	do	6	feet of salty sulfur water.
27S	14E	NE¼NE¼NW¼ 5	W	G. H. Franz	Franz Well	Navajo Ss.		.5 ppm fluoride.
27S	14E	NE¼SW¼NW¼ 5	O	Carter Oil Co.	1	Mossback Mbr. of Chinle Fm.		th bottom of drill hole at 2,256 feet in the Moenkopi Formation 2142 feet in Chinle Formation; however, Mossback Member of Chinle ted producing formation. DST 1 recovered 510 feet of mud-cut
27S	14E	C SW¼SW¼ 17	O	Amerada Petroleum Corp.	5	White Rim Ss. Mbr. of Cutler Fm.	2	65 feet of muddy fresh water.
27S	15E	C SE¼NE¼ 32	O	Texaco, Inc.	6	Coconino Ss.		from 2,330 feet in Moenkopi Formation to 2,366 feet in Coconino , the latter formation was the reported producing formation. 50 feet of muddy fresh water. 00 feet of water and 100 feet of mud.
						Mississippian sed. rocks		
27S	15E	C SW¼NW¼ 35	O	Carter Oil Co.	2	do		feet of drilling fluid and 3,085 feet of brackish water with last 290 feet.
27S	16E	NW¼SW¼NE¼ 33	O	Superior Oil Co.	32-33	do		feet of brackish muddy water and 3,653 feet of brackish water. d middle of recovery column contained 203,592 and 72,949 ppm of respectively.
27S	18E	NE¼NE¼NW¼ 26	O	Husky Oil Co.	1	do		from 6,260 feet in Pennsylvanian rock to 6,400 feet in however, the latter rock was the reported producing formation. 27 feet of black salty sulfur water.
27S	21E	SW¼SE¼SW¼ 3	O	Humble Oil and Refining Co.	3	do		feet of slightly gas-cut drilling mud, 270 feet of highly water- nd 4,980 feet of salt water with sulfur odor; sampled just above
27S	22E	NW¼SE¼SE¼ 17	O	do	1	do		l feet of black salty sulfur water; sampled



NUMERICAL KEY TO STRUCTURAL FEATURES
(Anticlines and domes unless otherwise indicated)

1 Coalville	24 Grand Hogback Monocline	48 Split Mountain
2 Porcupine Mountain	25 Willow Creek	49 Ashley Valley
3 Ledgepole	26 Blue Mountain	50 Section Ridge
4 Linwood	27 Skull Creek	51 Red Wash
5 Spring Creek (Dutch John)	28 Massadonna	52 Chapita Wells
6 Clay Basin	29 White River	53 Duchesne
7 Middle Mountain	30 Rangely	54 Peters Point
8 Canyon Creek	31 Yellow Creek	55 Hill Creek
9 Atkali Creek	32 Pocenco	56 Huntington
10 Haymaker	33 Hells Hole	57 Price
11 Sugarloaf	34 West Douglas Creek	58 Farnham
12 Hiawatha	35 Douglas Creek	59 Woodside
13 Shell Creek	36 East Douglas Creek	60 Green River
14 Powder Wash	37 Uvado	61 Northwest Salt Valley
15 Sand Wash Monocline	38 Twin Buttes	62 Salt Valley
16 Yellowcat	39 Carbonera	63 Thompson
17 Dry Mountain	40 Garmesa	64 Cisco
18 Two Bar	41 Highline Canal	65 Cottonwood Creek
19 Nine Mile Hill	42 Asbury Creek	66 Sulfur
20 Maybell Monocline	43 Hunter Canyon	67 Horley
21 Cross Mountain	44 Fruita Monocline	68 Westwater Creek
22 Elk Springs	45 Roosevelt	69 Bitter Creek
23 Pinyon Ridge (Coyote Basin)	46 Whiterocks	70 Bar X
	47 Neal	71 San Arroyo

ALPHABETICAL KEY TO STRUCTURAL FEATURES
(Anticlines and domes unless otherwise indicated)

Alkali Creek 9	Green River 60	Rangely 30
Asbury Creek 42	Horley 67	Red Wash 51
Ashley Valley 49	Haymaker 10	Roosevelt 45
Bar X 70	Hells Hole 33	Salt Valley 62
Bitter Creek 69	Hiawatha 12	San Arroyo 71
Blue Mountain 26	Highline Canal 41	Sand Wash Monocline 15
Canyon Creek 8	Hill Creek 55	Section Ridge 50
Carbonera 39	Hunter Canyon 43	Sulfur 66
Chapita Wells 52	Huntington 56	Shell Creek 13
Cisco 64	Linwood 4	Skull Creek 27
Clay Basin 6	Ledgepole 3	Split Mountain 48
Coalville 1	Massadonna 28	Spring Creek (Dutch John) 5
Cottonwood Creek 65	Maybell Monocline 20	Sugarloaf 11
Cross Mountain 21	Middle Mountain 7	Thompson 63
Douglas Creek 35	Neal 47	Twin Buttes 38
Dry Mountain 17	Nine Mile Hill 19	Two Bar 18
Duchesne 53	Northwest Salt Valley 61	Uvado 37
East Douglas Creek 36	Peters Point 54	West Douglas Creek 34
Elk Springs 22	Piceance 32	Westwater Creek 68
Farnham 58	Pinyon Ridge (Coyote Basin) 23	White River 29
Fruita Monocline 44	Price 57	Whiterocks 46
Garmesa 40	Porcupine Mountain 2	Willow Creek 25
Grand Hogback Monocline 24	Powder Wash 14	Woodside 59
		Yellowcat 16
		Yellow Creek 31

FOLDS
- Anticline
- Syncline
- Asymmetric anticline
- Asymmetric syncline

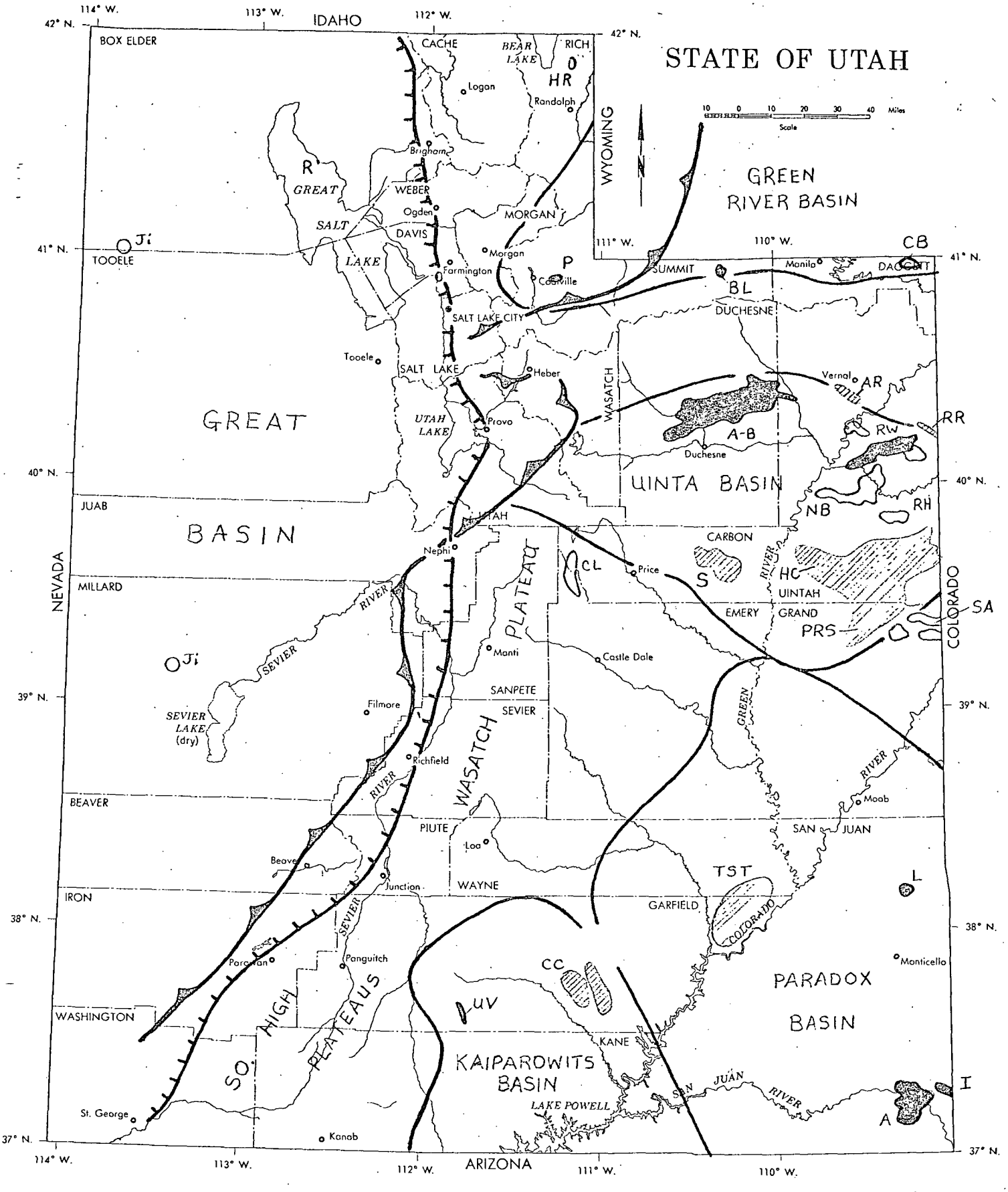
FAULTS
- Normal — Hachures down
- High angle reverse — Arrow shows dip of fault
- Low angle thrust — on thrust plate

OUTCROP PATTERNS
- Pre-Cambrian
- Base of Cretaceous
- Base of Early Tertiary
- Late Tertiary
- Tertiary volcanics

TECTONIC MAP
UINTA BASIN, NORTHEAST UTAH
AND ADJOINING PORTIONS OF NORTHWEST COLORADO AND SOUTHWEST WYOMING

PREPARED FROM ALL AVAILABLE SOURCES
FOR I.A.P.G. GUIDEBOOK, JUNE 1957

HOWARD R. RITZMA
CONSULTING GEOLOGIST
DENVER, COLORADO
MAY 1, 1957



J. A Campbell 1977

STRUCTURAL PROBINCES OF UTAH
WITH MAJOR PETROLEUM ACCUMULATIONS

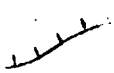

OIL FIELD


GAS FIELD


OIL-IMPREGNATED ROCK DEPOSIT


APPROXIMATE STRUCTURAL BOUNDARY


EASTERN LIMIT OF THE FOLD AND THRUST BELT


EASTERN LIMIT OF THE BASIN-RANGE PROVINCE

OIL AND GAS FIELDS

A Aneth

A-B Altamont

BL Bridger Lake

CB Clay Basin

CL Clear Creek

I Ismay

L Lisbon

NB Natural Buttes

P Pineview

R Rozel

RW Red Wash

SA San Arroyo

UV Upper Valley

OIL-IMPREGNATED ROCKS

AR Asphalt Ridge

CC Circle Cliffs

HC Hill Creek

PRS P.R. Spring

RR Raven Ridge

S Sunnyside

TST Tar Sand Triangle

FROM

HOOD, JAMES W., 1976,

CHARACTERISTICS OF AQUIFERS IN THE NORTHERN UINTA BASIN AREA, UTAH AND COLORADO:

STATE OF UTAH DEPT. OF NATURAL RESOURCES, TECHNICAL PUB. No. 53,

71 pages

Table 1.--Description of major lithologic units that crop out in the northern Uinta Basin area

[Location of data sites cited are shown on plate 1. Interpretations of chemical quality of water are based on analyses given in Hood, Mundorff, and Price (1976).]

Erathem	System	Series	Geologic unit: Western part of basin	Geologic unit: Eastern part of basin	Character of material	Hydrologic characteristics
CENOZOIC	Quaternary	Holocene	Younger alluvium, gravel surfaces, landslide and talus deposits, and dune sand and windblown deposits		Surficial deposits of clay, silt, sand, gravel, and large angular blocks. Along stream valleys, younger alluvium is often well sorted, but rarely is more than about 15 ft (4.6 m) thick. Gravel surfaces are the upper parts of terrace deposits and appear in many places to be separated from deeper older gravels by a layer of clay or material of low permeability and are generally less than 10-20 ft (3.0-6.1 m) thick. Landslide and talus deposits found only in higher mountain areas; largest landslides are associated with outcrop areas of the Manning Canyon(?) Formation and consist of a chaotic mixture of soils, shale flowage, blocks of rocks, and other materials of indeterminate thickness. Talus deposits are accumulations of angular blocks at the base of cliffs and steep slopes. Dune sand generally is a well-sorted thin veneer that accumulates near sandstone outcrops.	Low to very high permeability. In many areas these deposits are above the water table; but in stream valleys and on some terraces, the younger alluvium is part of the deposits that yield water to shallow wells (dug wells in particular) and are less permeable than the underlying glacial outwash. Landslide deposits, because of poor sorting, have low permeability but locally yield water to springs. Talus deposits generally are above the water table but are good recharge areas for other formations. Dune sand also is a good recharge medium but only locally stores ground water. Chemical quality of water in most of these deposits is variable, depending on the sources of debris making up the deposit. In most areas, the water is fresh, but where the water table is shallow the water may be saline.
			Terrace deposits		Alluvial deposits ranging in grain size from silt to boulders 1 ft (0.3 m) or more in diameter. Generally are part of caps of upland areas (fig. 4), locally called benches. Locally cemented; lie partly upon and also grade laterally from deposits of glacial origin. For purposes of hydrologic discussion in this report these deposits are lumped with glacial deposits and other coarse-grained unconsolidated deposits.	Low to very high permeability. Sources of much of the water yielded by shallow wells on benches around Roosevelt-Myton-Duchesne part of basin. The water generally is fresh.
		Pleistocene	Glacial deposits and alluvium		Glacial outwash, moraines, and undifferentiated deposits of glacial origin (include glaciated ground). Outwash is generally coarse grained (fig. 5), and consists of sand, gravel, cobbles, and boulders that underlie and grade into terrace deposits in upland areas. Thickness ranges from a few feet on edges of terraces to about 200 ft (60 m) near the mouths of major river canyons. These deposits and terrace deposits are discontinuous with those on adjacent benches and stream valleys (fig. 6). Beneath stream valleys, outwash forms the basal section of the unconsolidated valley fill; thicknesses there rarely exceed 50 ft (15 m). Other glacial deposits are found mainly in canyons (fig. 7), or on the mountains, where they are generally poorly sorted veneers on glaciated rock surfaces.	Low to very high permeability. Glacial outwash and related coarse-grained deposits comprise the most prolific aquifer in the northern Uinta Basin area in localities where the outwash is sufficiently thick to store and transmit water. Water is generally under unconfined conditions but locally may be confined or partly confined. It comprises the main aquifer in Ashley Valley, on upland slopes and outwash plains (as around Neola and Altamont), beneath the flood plains of the streams (such as the Duchesne and Uinta Rivers), and beneath the floors of the mountain canyons (near their mouths). Values for K are estimated to be in the range of 2 to 1,800 ft/d (0.61 to 550 m/d) (table 6). Wells near Neola yield as much as 3 ft^3/s (0.0085 m^3/s). The water in the outwash is fresh except where the outwash receives inflow from older rocks, as in the Duchesne River valley below Bridgeland. The other glacial deposits have lower permeability, but locally their permeability may approach that of the outwash. These less-permeable deposits generally act as a recharge medium, but locally they yield some water to springs and act as a transfer medium for water from underlying older rocks. The water in these other glacial deposits generally is fresh.
			Older terrace deposits		Similar to overlying terrace deposits and lumped for hydrologic discussion with the other coarse-grained deposits. Position in section here based on old gravel surfaces given in Stokes (1964)	
		Pliocene(?)				
		Miocene	Browns Park Formation		Includes both rocks of the type present in far northeastern Utah and those sometimes referred to the Bishop Conglomerate (Kinney, 1951). Extremely variable deposits of sandstone, tuffaceous rocks, and conglomerate; present in irregular areas along south flank of Uinta Mountains. Thickness is less than 1 to about 800 ft (0.3 to 240 m).	Very low to moderate permeability. Not thoroughly explored by water-well drilling. Yields small quantities of freshwater to springs and stock wells in Brush Creek-Diamond Mountain area north and northeast of Vernal. Probable source of some springs in slopes of central Uinta Mountains.
		Oligocene(?)	Extrusive igneous rock		Chiefly andesitic pyroclastics. May be the Keetley Volcanics, or equivalent. Erosional remnants on highest hills near Wolf Creek Pass. Thickness unknown, but estimated to be generally less than 100 ft (30 m) in study area.	Yields water to some small springs. Baker (1970, table 1) estimated transmissivity to be 270 ft^2/d (25 m^2/d) for area to west, where formation is thicker; there, also, he states most springs were observed along fractures or contacts.
	Tertiary		Duchesne River Formation		Shale, mainly red, but including green and other pale colors, siltstone, sandstone, and conglomerate, unconformably underlying younger rocks from near the Colorado State line to near Strawberry Reservoir. (See Warner, 1966, and Andersen and Picard, 1972, for most recent descriptions). Coarsest grain sizes (fig. 8) found near basin margins where the formation interfingers with other formations. In central part of basin, formation grades up from underlying Uinta Formation and consists of interbedded sandstone and shale (fig. 9). Sandstone most abundant in lower part and, with conglomerate, in upper part. Sandstones are of two basic types--a light-colored (generally yellow) channel deposit (fig. 10) and a darker, more compact, better cemented interchannel(?) lenticular deposit. A few thin beds of sandstone are loose to friable. Formation in most areas is slightly to strongly fractured. Fractures locally contain secondary deposits of calcium sulfate, as near the Roosevelt-Bluebell road east of Dry Gulch. Maximum thickness is more than 3,000 ft (910 m).	Very low to very high permeability. The horizontal hydraulic conductivity of 19 sandstone samples ranged from 0.000033 to 3.28 ft/d (0.00001 to 1.0 m/d) (table 3). Total porosity ranged from 7 to 32 percent. However aquifer permeability is enhanced by fracturing, and yields to wells and springs range from less than 1 to more than 300 gal/min (0.06-19 l/s), generally with large drawdown (table 6). Highest permeabilities generally are near edges of outcrops west of Roosevelt in the central basin, and lowest are in areas north and east of Fort Duchesne. Water movement may be impeded locally by gilsonite dikes. Near recharge areas, and where the formation is fractured or moderately permeable, the water generally is fresh. At greater depths where the formation is of very low permeability, the water is slightly saline to briny. Confined conditions are common; in the lower parts of the basin such as near Roosevelt) artesian heads may exceed 100 ft (30 m) above land surface, but in higher areas of the basin, water levels are below land surface.
		Eocene	Uinta Formation		Calcareous shale, some limestone, claystone, siltstone, and sandstone. Fluvial facies in eastern and western ends of basin interfinger with rocks similar in appearance to Duchesne River Formation and with other formations. Grades laterally into thinner bedded calcareous lake deposits in center of basin (Jones, 1957, p. 32). Maximum thickness is nearly 4,000 ft (1,220 m) near center of basin axis.	Very low to very high permeability. Highest primary permeability of the sandstone seems to approximate that of the median for sandstone in the Duchesne River Formation (table 3). Bulk of formation, however, is finer grained than the Duchesne River Formation. Permeability is enhanced by fracturing (fig. 11), which is evident in many areas; for example, Stinking Spring area along Strawberry River in secs. 14 and 15, T. 4 S., R. 7 W., Uintah meridian, where the Uinta Formation discharges water from the underlying Green River Formation. In most of the area, the formation yields only a few gallons per minute of saline water to wells

Table 1.--Description of major lithologic units that crop out in the northern Uinta Basin area--Continued

Erathem	System	Series	Geologic unit: Western part of basin	Geologic unit: Eastern part of basin	Character of material	Hydrologic characteristics
CENOZOIC	Tertiary	Eocene	Uinta Formation--Continued			and springs. In places (as near Arcadia) the water has high fluoride and boron concentrations. Locally (as near Arcadia and the Myton Water Association well field at U(C-2-2)24ccc), flowing wells yield fresh to slightly saline water. In the fluvial facies, particularly where fractured (as at well U(C-3-9)6cbc-1), yields are higher (table 6) and the water is fresh.
		Paleocene and Eocene	Green River Formation		Mainly lacustrine shale with some limestone, siltstone, and sandstone. Includes beds of oil shale and carbonate evaporites. Interfingers with both the overlying Uinta Formation and the underlying Wasatch Formation and laterally with other formations near the edges of the basin. Maximum thickness is about 5,000 ft (1,520 m); thickness depends on location in the Eocene fluvial-lacustrine complex.	Very low to low permeability. Weir (1970, table 2) reports approximate transmissivities of 0.08-0.22 m^2/d (equivalent to 0.9-2.4 ft^2/d) for sandstones near the oil-shale horizon. Permeabilities are enhanced by fracturing (Peterson, 1973a, b). In most of the basin, the formation yields only saline--in many cases briny--water to petroleum wells. Price and Miller (1975, pl. 3) report fresh to slightly saline water in and near the outcrop area in the southern Uinta Basin. In the far western end of the basin, in the outcrop area near Strawberry Reservoir, the water is fresh where the formation is fractured (as at spring U(C-4-11)33bda-S1).
			Wasatch Formation		Crops out only in far eastern end of northern Uinta Basin area; in most of basin consists mainly of lacustrine shale, sandstone, and conglomerate. Interfingers with overlying and underlying formations and laterally with the North Horn and Colton Formations and the Flagstaff Member of the Green River Formation (not exposed in northern Uinta Basin area). The combined Wasatch-Green River section in the western part of the basin is reported by Pouch and Ryder (1973) to approach 10,000 ft (3,050 m) in thickness.	Very low to low permeability. Peterson (1973a) reports that in the Bluebell oil field the "Wasatch sands" have 4 to 5 percent porosity, but that permeability results mainly from fracturing. Much of the water yielded from petroleum wells is moderately saline to very saline, but, on the whole, water in the formation appears to be less mineralized than that in the overlying Green River Formation.
MESOZOIC	Cretaceous(?)	Upper Cretaceous(?)	Currant Creek Formation		Very coarse conglomerate (fig. 12) and crossbedded conglomeratic sandstone, tightly cemented. May interfinger with underlying Mesaverde Group. Thins southeastward from northwest corner of basin. Some writers have regarded the formation as a fluvial facies of the rocks of Eocene age, but Walton (1964, p. 139-143) indicates that coarse-grained rocks of Eocene age lie unconformably on the Currant Creek Formation. Maximum thickness is approximately 5,000 ft (1,520 m).	Low to very high permeability. Primary, or matrix permeability, of a sample from the outcrop in the Duchesne River valley was indicated in a K of 1.44 ft/d (0.44 m/d) and a total porosity of 23.6 percent. These coefficients are probably maximum primary values for the formation. Fracturing, the principal cause of secondary permeability, is reflected in a K of more than 200 ft/d (61 m/d) at well U(C-2-10)20aac-1 (table 6). An open fracture, about 1 ft (0.3 m) wide, was reported in the Currant Creek-Layout Canyon tunnel by J. R. Wagner of S. A. Healy Co. (oral commun., November 1973). This opening had an updraft of air toward the surface far above the tunnel and also took all water flowing in that section of tunnel until the tunnel was lined. Water probably is unconfined in most areas. Water in and near the outcrop area is fresh.
	Cretaceous	Upper Cretaceous	Mesaverde Group		Shale, sandstone, and coal beds. Interfingers with upper shale of Mancos Shale. Thickness is 550-4,000 ft (168-1,220 m) in western part of basin (Huddle and McCann, 1947) and 400-1,160 ft (122-354 m) north of Vernal (Kinney, 1951).	Very low to high permeability. Little is known about aquifer properties. Well U(C-1-8)13dcc-1 has a high estimated K, but the well also may derive water from overlying glacial outwash. Covington (1957, p. 174) gives a porosity of 34 percent and says that the formation in the oil-bearing beds of Asphalt Ridge has a water-wetted matrix. Data in Feltis (1966) indicate that in outcrop areas water is fresh to slightly saline, but samples from petroleum tests in the eastern part of the basin were very saline to briny.
		Lower and Upper Cretaceous	Mancos Shale		Gray soft shale. Contains an unnamed upper shale member, a middle member, the Frontier Sandstone Member, and a lower member, the Mowry Shale Member. Total thickness is 2,900-3,700 ft (884-1,130 m) in the western part of the basin and up to 4,900 ft (1,490 m) in the vicinity of Vernal. In the western Uinta Basin, the Frontier Sandstone Member consists of crossbedded, lenticular thick sandstone beds with a local middle shale unit and some coal in the upper part. It thickens westward from 450 to 600 ft (137 to 183 m) (Huddle and McCann, 1947) and interfingers with the upper shale member of the Mancos. In the eastern part of the basin (Kinney, 1951), the Frontier consists of 210-250 ft 64-76 m) of fine-grained sandstone with thin beds of coal in the upper part and some shale interbeds. It thins and becomes more shaly southeastward.	The shale members have very low permeability. Inhibits infiltration of precipitation, and where that is the only source of water, the outcrop of the Mancos is almost devoid of vegetation. (See fig. 13.) Such water as issues from the formation and that from younger rocks containing erosional derivatives from the Mancos is saline. Very low to moderate permeability. Not thoroughly explored by water-well drilling. Well U(C-1-8)12cdb-1 indicated a moderate transmissivity (table 6). Well (D-5-23)10aaa-1 flows from 733 ft (223 m) and provides slightly saline water together with natural gas. Well U(A-2-2)32aca-1 near the intake area also flows from only 19 ft (5.8 m) and it yields freshwater.
			Dakota Sandstone and Cedar Mountain Formation, undivided		In western Uinta Basin, the section consists of a basal sandstone, which is fine to coarse grained, locally conglomeratic, and friable; a thick, variegated soft shale; and an upper unit of interbedded fine-grained sandstone and siltstone, which is locally conglomeratic and crossbedded. The total thickness is about 200 ft (60 m). In the eastern basin, the section is somewhat similar, but it is only 50-90 ft (15-27 m) thick. May be well-fractured locally.	Very low to moderate permeability. Not thoroughly explored by water well drilling. Table 6 shows variation in K from 0.08 to 80 ft/d (0.024 to 24 m/d). Specimen from outcrop at east side of Steinaker Reservoir had a K of only 0.00018 ft/d (0.000055 m/d) and porosity of only 8.2 percent (table 3). Well (D-5-23)21caa-1 yielded slightly saline water from a depth of 352 ft (107 m). Chemical quality of water unknown elsewhere but would be expected to be fresh near outcrop areas and saline where deeply buried.
	Jurassic	Upper Jurassic	Morrison Formation		In western Uinta Basin consists of 1,450-1,550 ft (442-472 m) of multicolored shale, siltstone, sandstone, conglomerate, and a few thin beds of freshwater limestone. Formation thins eastward to 830-890 ft (253-271 m) of variegated shale and siltstone, red and gray fine-grained silty sandstone, medium- to coarse-grained pebbly sandstone, and thin beds of gypsum. Formation is variable in character and individual beds are highly lenticular. Probably fractured in most areas.	Very low to moderate permeability. Not thoroughly explored by water-well drilling. Wells known to be finished in formation mainly are in eastern end of basin. The few water samples taken from this aquifer were from areas near outcrops and were fresh. Water probably is saline and mainly a sulfate type where the formation is deeply buried.
		San Rafael Group	Curtis Formation (Stump Sandstone of Stokes, 1964)	Curtis Formation	In western basin includes a lower fine-grained friable sandstone of variable thickness and an upper section of shale and thin-bedded limestone; aggregate thickness is 140-200 ft (43-61 m). In the eastern part of the basin, section is about the same, but sandstone is medium to coarse grained, general color is darker; section is as much as 270 ft (82 m) thick.	Very low to moderate permeability. Estimate based on general lithology. Yields freshwater to springs in outcrop area.

Table 1.--Description of major lithologic units that crop out in the northern Uinta Basin area--Continued

Erathem	System	Series	Geologic unit: Western part of basin	Geologic unit: Eastern part of basin	Character of material	Hydrologic characteristics
MESOZOIC	Jurassic	Upper Jurassic	Entrada Sandstone (Preuss Sandstone of Stokes, 1964)	Entrada Sandstone	In the west, 700-800 ft (213-244 m) of silty and sandy shale, thin-bedded, nonresistant siltstone, and fine- to medium-grained sandstone, with lenticular beds of white sandstone in upper part. Mostly red-colored. Redbeds appear to grade eastward into white sandstone. Section thins eastward, and in eastern part of basin consists of 100-160 ft (30-49 m) of massive crossbedded, fine- to medium-grained friable sandstone. Probably strongly fractured in areas of faulting and sharp folding.	Low to moderate permeability. Yields water to wells and springs in eastern end of basin. Yields freshwater of calcium bicarbonate type to wells and springs near Dinosaur National Monument bone quarry in eastern part of basin. Two samples from oil tests show the formation contains fresh to slightly saline calcium bicarbonate water 2,000-2,300 ft (610-701 m) below the Ashley Valley oil-field area. Chemical quality of water elsewhere in the northern Uinta Basin area unknown, but it could be expected to be good in and near outcrop areas.
		Middle and Upper Jurassic	Twin Creek Limestone	Carmel Formation	In western part of Uinta Basin, section consists of 700-800 ft (213-244 m) of limestone, shale, and sandy shale with a few redbeds near top; section thins eastward in center of basin and includes gypsum and more redbeds. Near Vernal, section is 125-170 ft (38-52 m) of limy shale, siltstone, and fine-grained silty sandstone. The formation thins eastward.	Very low to moderate permeability. Limestone should have very low permeability where undisturbed and moderate to high permeability where fractured. The water should be saline where deeply buried and where gypsum is present.
	Triassic(?) and Jurassic(?)	Lower Jurassic(?)	Nugget Sandstone	Upper Triassic and Lower Jurassic: Glen Canyon Sandstone (formerly called Navajo Sandstone in this area)	In the west, formation is about 1,100 ft (335 m) of light-orange fine- to medium-grained sandstone; massive with large-scale crossbedding, and generally is friable in the outcrop. Thickens eastward slightly and an incressing part of section becomes white. In eastern part of basin, section thins to 700 to about 900 ft (213-274 m) of white to gray, massive, crossbedded sandstone, generally friable at the outcrop. Some cliff outcrops have near-surface "case-hardening" and a desert varnish on surface. Strongly jointed at places, fractured where flexed and, on basis of a well in Dry Fork canyon, probably strongly fractured.	Very low to moderate permeability. Samples give K values ranging from 0.002 to 1.44 ft/d (0.00061 to 0.44 m/d) with total porosity above 20 percent. Yields water to wells and springs in eastern part of basin north of Lapoint, near Vernal, and eastward into northwestern Colorado. Water probably is confined in most areas. At and near outcrop, water is a fresh calcium bicarbonate type. Deeper within basin, water at a depth of about 6,000 ft (1,830 m) in well (D-4-21)16ccc-1 was a slightly saline sodium sulfate type; and in well (D-9-20)22cbb-1, near Ouray, a drill-stem sample was a briny sodium chloride type at 17,350 ft (5,290 m).
		Upper Triassic(?)				
	Triassic	Upper Triassic	Chinle Formation		In the west, 300-380 ft (91-116 m) of variegated mudstone and siltstone, mainly thin-bedded. Appears to thicken toward center of basin and to thin toward east near Vernal, where it consists of about 260 ft (79 m) of variegated shale with the upper one-third red ripple-marked sandstone and thin beds of red shale. Contains a basal conglomerate member (see below).	Very low to low permeability. Probably yields only small quantities of saline water.
			Gartra Grit Member of Chinle Formation (formerly called Shinarump Conglomerate)		In west, consists of a few feet to about 40 ft (12 m) of massive, crossbedded, coarse-grained arkosic sandstone and conglomerate. Thickens slightly toward middle of basin and then thins toward the east, where it consists of from less than 1 in to 60 ft (2.5 cm to 18 m) of crossbedded, medium- to coarse-grained sandstone with streaks of quartzite pebbles. Locally, occupies channels cut 20-25 ft (6.1-7.6 m) into the underlying Moenkopi Formation.	Low to moderate permeability. Largest yields to wells probably would be where it is thickest and fractured. Wells have modest yields of calcium bicarbonate and sodium bicarbonate sulfate-type waters
		Middle(?) Triassic	Mahogany Formation (Ankareh Formation of Stokes, 1964)	Moenkopi Formation	The Mahogany Formation consists of red to purple thin-bedded shale and siltstone. Thickness is about 700 ft (213 m). Partly equivalent to the Moenkopi Formation.	Low permeability. Little known about aquifer properties, but the formation probably will yield small quantities of saline water to wells.
		Lower Triassic	Thaynes Formation (or Group)		Upper member of the Thaynes Formation is 350-400 ft (107-122 m) of partly variegated shale and siltstone. Lower member is 75-200 ft (23-60 m) of fine-grained silty sandstone interbedded with thin-bedded limestone. Gypsum veins and salt casts are present locally. Lower member thickens westward. Partly equivalent to the Moenkopi Formation.	Do.
			Woodside Formation (Woodside Shale of Stokes, 1964)		The Woodside Formation consists of thin-bedded red-brown siltstone and shale. Thickness is 700-1,000 ft (213-305 m) and thins westward across upper Duchesne River area. Partly equivalent to the Moenkopi Formation.	Low permeability. Little known about aquifer, but yields may be enhanced by fracturing. Spring U(B-1-8)27cda-S1 yields freshwater of the calcium bicarbonate type.
					The Moenkopi Formation is the eastern facies of the three formations listed above. Near Vernal, section consists of about 175 ft (53 m) of thin-bedded siltstone and very fine grained sandstone, overlain by 570 ft (174 m) of thin-bedded red shale, red siltstone, and fine-grained sandstone. A few thin beds of gypsum in a narrow stratigraphic zone near the middle of the section appear to be the local facies equivalent of the Thaynes Formation. The lower light-colored part of the Moenkopi is gradational with the underlying Park City Formation and appears to thicken eastward. Total thickness is about 700 to about 1,100 ft (213-335 m).	Very low to low permeability. Most water from the formation probably would be saline.
PALEOZOIC	Permian		Park City Formation (or Group)--partly(?) equivalent to Phosphoria Formation	?	In western part of the Uinta Basin, consists of three members. Lower member is about 270 ft (82 m) of brecciated, very fine grained, friable, porous sandstone and dolomitic, locally brecciated, silty to sandy thin-bedded sandstone. The middle member is about 40 ft (12 m) of black phosphatic shale interbedded with gray shale and thin bedded limestone. The upper member is 100-150 ft (30-46 m) of thin-bedded to massive, silty and sandy, cherty, dolomitic limestone. Total thickness is 400-425 ft (122-130 m). In eastern part of basin, the formation is 24-28 ft (7.3-8.5 m) of phosphatic shale and phosphate rock overlain by about 100 ft (30 m) of thin-bedded cherty and sandy dolomitic limestone interbedded with shale and fine-grained sandstone (Brush Creek section). Formation in general area is about 120-340 ft (37-104 m) thick, and it thins eastward.	Very low to high permeability. The undisturbed limestones have a very low permeability, but where they contain fractures that have been enlarged by solution, yields can be relatively large. Samples from the Ashley Valley oil field and from well U(B-2-3)22dcc-1 show that the zone adjacent to the Weber Sandstone contains fresh to slightly saline water.

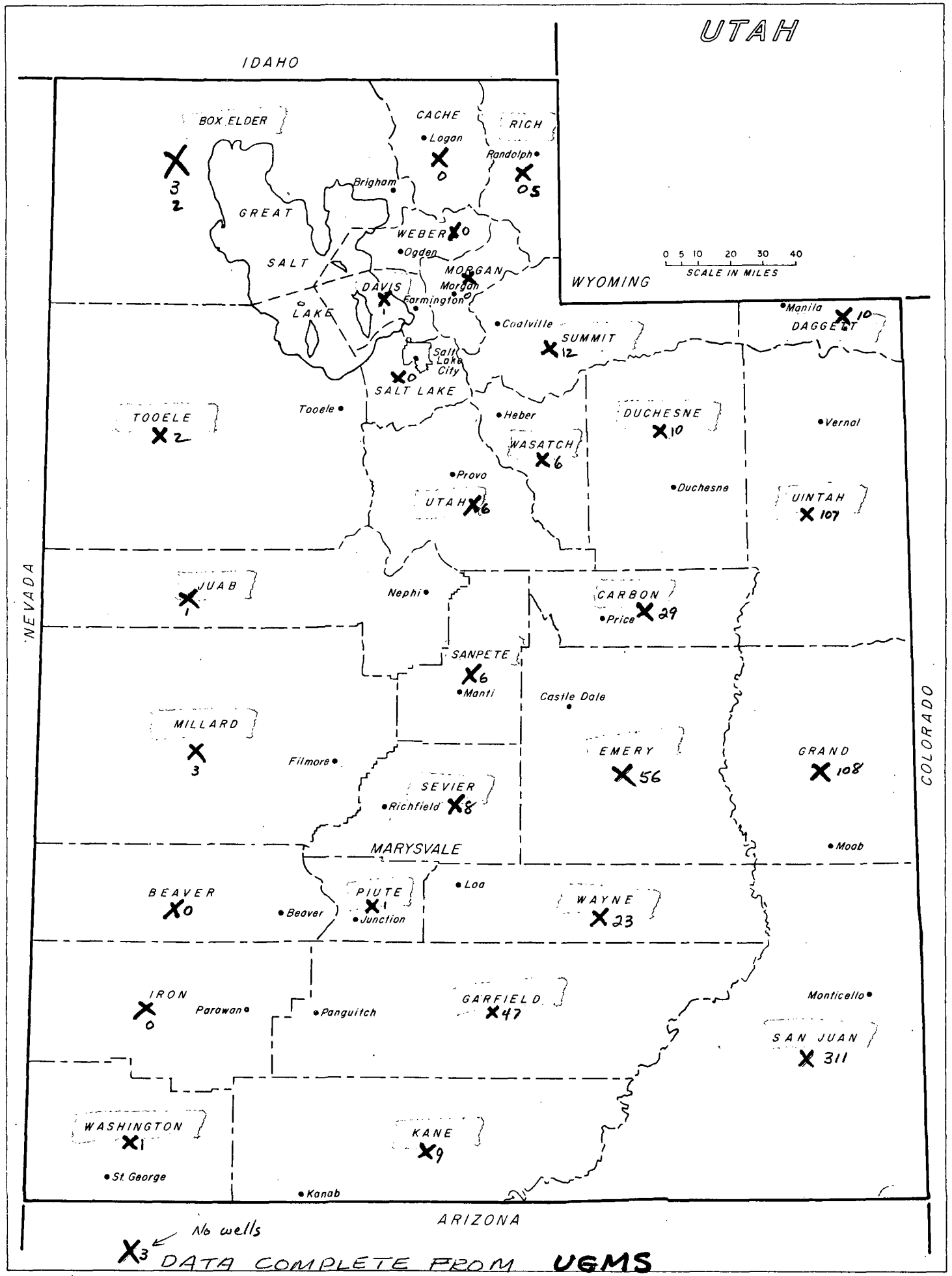
Table 1.--Description of major lithologic units that crop out in the northern Uinta Basin area--Continued

Erathem	System	Series	Geologic unit: Western part of basin	Geologic unit: Eastern part of basin	Character of material	Hydrologic characteristics
PALEOZOIC	Permian	Diamond Creek Sandstone; Lower Permian Kirkman Limestone	Weber Quartzite (or Sandstone or Formation)		In western part of basin, 1,400-1,600 ft (427-488 m) of very fine grained, medium-bedded, partly crossbedded sandstone, with chert and, locally, thin-bedded, cherty limestone, mainly near top. Also reported as locally massive and friable. Strongly fractured, especially near faults and folds (fig. 14). In eastern part of basin, about 1,200 ft (366 m) of massive, fine- to coarse-grained sandstone with well-developed crossbedding locally, especially in upper part. In vicinity of Dinosaur National Monument, Untermann and Untermann (1954, p. 46) describe the formation as poorly cemented, friable, and jointed. Some cores show deeply buried formation as dense, very fine grained sandstone. (See discussion by Bissell, 1964, p. 67-91.)	Very low to very high permeability. Primary permeability is very low to moderate, depending on location in the basin and the section. Samples had K of 0.000021 to 0.28 ft/d (0.0000064 to 0.085 m/d), with total porosity in the range of 11 to 19 percent (table 3). Moderate to very high K is inferred from the existence of large-yield springs that discharge from the formation in areas that are strongly faulted and fractured. Water is under confined conditions in most areas. Most wells and springs that discharge water from this formation yield freshwater. Yields fresh to slightly saline water at depths of 4,000-5,000 ft (1,220-1,520 m) in the Ashley Valley oil field and near well U(B-2-2)22dcc-1, where water circulates through faults and fractures. Yields very saline to briny water at depths of 7,500 ft (2,286 m) at well S(B-2-102)32bcd-1 and at 18,500 ft (5,640 m) at well (D-7-24)21dda-1.
	Pennsylvanian	Oquirrh Formation			North of Strawberry Reservoir, the easternmost tip of a thrust plate includes several thousand feet of rocks assigned by Bissell (1952, p. 581-589) to the Oquirrh Formation through the Diamond Creek Sandstone. The section is not included in the composite section for the basin because Sadlick (1959, p. 82-89) equates the Oquirrh-Diamond Creek section with the locally derived thinner Madison-Weber section in the Uinta Mountains.	Little known about aquifer properties. Locally a source of springs in adjacent drainage basin.
			Morgan Formation		In west, consists of a lower member of about 240 ft (73 m) of cherty limestone with some interbedded shale and an upper member of about 200 ft (60 m) mainly of red very fine grained sandstone interbedded with some mudstone and siltstone. In east, it also consists of two members --a lower member of thick-bedded cherty limestone and an upper member of red sandy shale, crossbedded sandstone, and a few thin beds of limestone. Total thickness is about 1,100-1,400 ft (335-427 m). This formation, like all the Paleozoic section, is locally strongly faulted and fractured.	Very low to very high permeability. Primary or intergranular permeability is judged to be very low to low. Fracturing and possibly cavernous zones in limestone locally cause high permeability. Acts mainly as a transfer medium for water from underlying rocks. The formation is involved in the movement of water to large springs such as Big Brush Creek Spring, (D-2-21)24cbb-S1, and it is the source of about 30 ft³/s (0.85 m³/s) of water from fractures associated with faulting at the Jones Hole Spring area, (D-3-25)1b. Water from sources in edge of the outcrop area is fresh and generally contains less than 200 mg/l of dissolved solids.
	Mississippian and Pennsylvanian		Manning Canyon(?) Formation (of Stokes, 1964)		This, the "black shale unit" of previous investigators, consists of black shale interbedded with a few thin beds of limestone, siltstone, and sandstone. Thickness ranges from 350 to 400 ft (107 to 122 m) in the western Uinta Basin and is about 300 ft (91 m) in Whiterocks Canyon. The formation thins eastward from about 100 ft (30 m) north of Vernal to 25 ft (7.6 m) or less in the far eastern part of the basin.	Very low(?) to low permeability. Little is known about aquifer properties, but it is estimated to act mainly as a deterrent to ground-water movement. Based on lithology, water from the formation would be saline.
	Mississippian	Upper Mississippian; Lower Mississippian	Upper Mississippian rocks, undivided; Lower Mississippian rocks, undivided	Mississippian rocks, undivided	In the western basin, Huddle and McCann (1947) divided these rocks (in descending order) into the Humbug Formation (Upper Mississippian), Deseret Limestone (Upper? and Lower Mississippian), and the Madison Limestone (Lower Mississippian). Stokes (1964) lumped the rocks only by age. The Humbug consists of 350-400 ft (107-122 m) of limestone breccia, sandstone breccia, and limestone. The Deseret is 600-650 ft (183-198 m) of thin-bedded to massive limestone and dolomitic limestone. The Madison is about 250 ft (76 m) of thin-bedded limestone with locally abundant chert and shaly partings. The sequence appears to be about 1,200 ft (366 m) thick in the center of the Uinta Mountains, but it thins toward the east, where Kinney (1951) describes a 960-ft (293-m) section of limestone, partly cherty and dolomitic, that has interbedded fine- to medium-grained sandstone in the upper part.	Very low to very high permeability. The predominantly limestone section in its undisturbed state has a very low permeability. The extensively fractured sections, however, have been dissolved locally to provide extremely permeable zones, which in some cases contain large active caves (figs. 15 and 16). Section is extensively faulted, fractured, and riddled locally with cavernous zones. Much of the uplands outcrop areas, from the Soapstone Basin west of the upper Duchesne River to the heights above Rock Creek, have a karst topography that is developed mostly in the lower part of the Humbug Formation and the Deseret Limestone. Intake of water in these areas provides the water discharged from springs such as Big Spring, U(B-1-8)17cbb-S1, on the upper Duchesne River and U(B-2-7)25cab-S1 and 36-S1 on Rock Creek. Less is known about the outcrop area between Rock Creek and the Uinta River, but karst development is certain, and the large spring, U(B-2-2)5dbb-S1, is associated with an outcrop of Mississippian rocks on the Uinta River. In the Pole Creek-Dry Fork-Brush Creek area, karst development and movement of water into the cave system has been described by Maxwell, Bridges, Barker, and Moore (1971). In general, almost all water associated with these rocks in the south slope of the Uinta Mountains is fresh and of the calcium bicarbonate type. However, where the rocks are deeply buried, they seem to be tight because the water is briny. For example, in well (D-9-20)22cbb-1 near Ouray, a drill-stem sample of brine was obtained from the Madison Limestone at a depth of about 20,000 ft (7,000 m) (Hood and others, 1976, table 9).
	Cambrian		Tintic Quartzite	Lodore Formation	In the western Uinta Basin, the Tintic Quartzite (Lower and Middle Cambrian) is about 400-500 ft (122-152 m) of quartzitic sandstone of wide range in grain size with some shale partings (Lockman-Balk, 1959, p. 42-43). Thins and disappears eastward. In the east, the Lodore Formation (Upper Cambrian) near Diamond Mountain area is 155 ft (47 m) of thick-bedded coarse-grained sandstone that thins westward.	Very low to high permeability. Little is known about aquifer properties, but it can be inferred that intergranular permeability is low and fracturing locally produces high permeability. In the recharge area, water should be fresh.
PRECAMBRIAN	Upper Precambrian	Uinta Mountain Group	Red Pine Shale		In the western end of the basin, about 1,700-3,000 ft (518-914 m) of dark sericitic shale interbedded with thin beds of dark arkosic sandstone. Probably fractured near major fault zones. Thins eastward, and only a few hundred feet may be present in eastern part of basin.	Very low(?) to low permeability. Probably impeds ground-water movement in most areas but may transmit water in fractures. Erosional derivatives from this formation appear to be mixed with stream-valley fill in the Duchesne River valley above West Fork, resulting in a degradation of the chemical quality of water in the valley fill.
			Unnamed quartzite unit (Mutual Formation of Stokes, 1964)		Chiefly a purple to dark reddish-brown quartzite, but includes white to red quartzitic sandstone. Some of formation retains original(?) bedding(?) and at a distance looks very much like an unaltered sedimentary formation. (See fig. 17.) Strongly faulted and has numerous shattered zones associated with the faulting. Thickness in western end of basin is about 4,000 ft (1,220 m) (Cohenour, 1959, p. 36).	Very low to moderate permeability. Most of formation where deeply buried probably has very low permeability, but near-surface effects of weathering and jointing probably cause moderate permeability. A specimen from a road cut near the drainage divide on State Road 44 north of Vernal had visible pores, apparently due to leaching. Wells and springs in this zone have water with a low concentration of dissolved solids--19 to 88 mg/l. Well (D-1-20)12dca-1 yielded an acidic water with a high iron concentration. Where the formation is fractured, local high yields are possible, as at

Table 1.--Description of major lithologic units that crop out in the northern Uinta Basin area--Continued

Erathem	System	Series	Geologic unit: Western part of basin	Geologic unit: Eastern part of basin	Character of material	Hydrologic characteristics
PRECAMBRIAN	Upper Precambrian	Uinta Mountain Group	Unnamed quartzite unit (Mutual Formation of Stokes, 1964)--Continued			the Smoky Springs area, U(B-3-2)19cbd, in the east wall of the Uinta River canyon where the springs discharge 3-5 ft^3/s (0.08-0.14 m^3/s) of water that contains less than 100 mg/l of dissolved solids.
			Lower part of the Uinta Mountain Group, undivided		Chiefly quartzite. Character probably similar to the Mutual Formation of Stokes (1964). Exposed only in highest parts of the west-central Uinta Mountains. Aggregate thickness of the Uinta Mountain Group estimated by Cohenour (1959, p. 36) to be about 12,000-15,000 ft (3,660-4,570 m) in the western mountains and about 21,000 ft (6,400 m) in the eastern part.	Not known but probably similar to Mutual Formation.

Figure 4.—Coarse-grained terrace deposits (possibly glacial outwash) overlying eroded Duchesne River Formation in canal cut above west side of Hancock Cove at U(C-1-2)6bad.



2 NUMBER WELLS - DOG+M

Grand Co.

for climate (not Chehalem map)

ALL 51° AMBIENT HISTORY

°C/km		Sec	T	R	DEPTH		T °F	
						known obstruction		
31.9	✓1.	17	18S	25E	2799	✓	100	19.6
35.5	✓2.	29	18S	25E	1490	20.1	80	23.5
34.7	✓3.	9	19S	21E	2155	19.8	92	21.8
—					2754	✓	89	✓ 15.9
—					6800	✓	142	✓
39.9	✓4.	4	19S	22E	1690	22.5	88	25.4
—					5213	✓	147	✓ 19.6
45.6	✓5.	36	19S	18E	2200	25.4	106	27.7
15.3	✓6.	12 SESW	19S	22E	4658	✓	90	✓ 9.7
	✓7.	19	20S	24	1057	21.4	78	31.2
	✓8	19	20S	24E	1075	32.5	85	37.2
	✓9.	14	19S	24E	2604	✓	96	19.5
	✓10	35	19S	24E	1598	19.3	81	22.5
	✓11.	35 NESWSE	19S	24E	2134	20.1 ✓	93	22.5
	✓12	16	20S	21E	2719	19.4	104	21.7
					3409	✓	109	✓ 18.7
	✓13.	23	20S	21E	4744	✓	118	✓ 15.3
	✓14.	36	20	21E	2524	25.8	115	27.7
	✓15	15	20S	23E	1552	32.2	100	35.4
					2590	23.9	112	25.9
	✓16.	2 CNE NW	20S	20E	1371	35.0	98	38.6
	✓17.	3	20S	24E	1648	21.2	85	24.2
	✓18.	5 NWSESE	20S	24E	1678	✓	80	20.8
	✓19.	8	20S	24E	1370	23.4	82	27.0
					1610	23.0	87	26.1
—	✓20.	9	20S	24	1670	22.2	87	25.1

Grand Co p2

	Sec	T	R	DEPTH		°F	
✓ 21	15 NWNWNW	20S	24E	1344	25.3	84	
✓ 22	19	20S	24E	1505	22.6	84	
✓ 23	19 NW SW SE	20S	24E	1200	20.8	75	
✓ 24	20 SWSWSW	20S	24	1024	22.3	80	
✓ 25	23	21S	18E	3028	✓	105	19.8
				3587	✓	110 ✓	
✓ 26	7	21S	19E	3294	✓	100 ✓	
				4136	✓	111 ✓	
✓ 27	7	21	19	3169	✓	96 ✓	
✓ 28	6	21S	22E	3097	✓	100 ✓	
✓ 29	3 SE SW NE	21S	23E	1425	22.4	82	26.0
✓ 30	3	21S	23E	1414	31.8	95	
✓ 31	10 SW SW NE	21S	23E	1136	30.8	85	
✓ 32	20 C NW SW	21S	23E	3808	✓	123 ✓	20.5
✓ 33	34 SW	21S	24E	1454	29.5	93	
✓ 34	2 NW	22S	16E	4983	✓	121 ✓	
✓ 35	2 NW	22S	16E	4848	✓	130 ✓	
✓ 36	34 NW	22S	17E	5182	✓	109 ✓	11.2
				5577	✓	115 ✓	11.5
				10172	✓	170 ✓	11.7
				10291	✓	175 ✓	12.0
✓ 37	22 NW	22S	19E	10280	✓	176 ✓	12.1
				2921	21.9	114	23.6
✓ 38	10	22S	21E	525	64.8	84	74.3
				1439	30.5	94	
✓ 39	15	23S	17E	9084	✓	146 ✓	10.4
				9523	✓	148 ✓	10.2

Grand p 3

	Sec	T	R	DEPTH	°F	
✓40	15 SW	23S	17E	5121	118 ✓	13.0
				9520	148 ✓	
✓41	16	23	17	8902	142 ✓	
✓42	16 SW	23	17	8777	143 ✓	
✓43	16 NW	23	17	8908	138 ✓	
✓44	17 NE	23	17	8829	141 ✓	
✓45	17	23	17	8679	130 ✓	
✓46	20 NE	23	19	6615	137 ✓	
✓47	36 SE	23	19	6138	135 ✓	
✓48	2 NW	23	20	3037	100 ✓	
✓49	5 SE	23	21	9262	138 ✓	
✓50	12	24	20	5603	96 ✓	
✓51	10	25	18	4191	20.8 137 ✓	22.0
✓52	27 SE	25	19	6654	131 ✓	12.0
				7238	140 ✓	
✓53	18 SW	25S	21E	4145	105 ✓	
				9417	140 ✓	
✓54	16 NE	25S	23	6493	118 ✓	
✓55	9	26	20	7498	113 ✓	
				7884	118 ✓	
				8131	120 ✓	
✓56	14	26	20	5636	120 ✓	
✓57	29	26	20	8450	125 ✓	
				8592	136 ✓	
✓58	31	26	20E	4043	105 ✓	
59	12	26	25	7019	115 ✓	
				12719	168 ✓	
				14563	180 ✓	
				15878	205 ✓	

END

Grand p 4

	Sec	T	R	DEPTH	°F	
✓60	31 SW	15S	25E	7804	160 ✓	
				4102	100 ✓	
✓61	33 SE	15½ S	23E	8608 (19.6)	219 ✓	20.2 T LOG
		SONIC LOG		8740	182 ✓	
				4650	125 ✓	
✓62	15	16S	21E	6275	122 ✓	
✓63	22 NW	16	21E	6150	118 ✓	
✓64	36	16	22E	3867	118 ✓	17.32
				8364	176 ✓	
✓65	14	16S	23E	4699	116 ✓	13.8
				8772	174 ✓	
✓66	12 SE	16S	24E	5907	157 ✓	18.9
✓67	13	16S	24E	6040	155 ✓	
✓68	24	16S	24E	6270 (✓)	170 ✓	19.9
✓69	29	16S	24E	2259 (✓)	92 NO	
				6602	145 ✓	
				6032 ✓ (22.2)	184 ✓	23.0
✓70	2	16S	25E	6643	162 ✓	
✓71	8	16S	25	5940	127 ✓	
✓72	11 NE	16S	25E	5803	148 ✓	
✓73	13	16S	25E	1540 (40.2 ✓)	112	43.5
✓74	17	16S	25E	6886	140 ✓	
✓75	21	16S	25E	6574	143 ✓	
✓76	21 NE	16S	25E	6530	145 ✓	
✓77	21 SW	16S	25E	6497	146 ✓	
✓78	22	16	25	6019	124 ✓	12
				6831	160 ✓	

Grand Co p 5

	Sec	T	R	DEPTH		°F	
✓ 79	22 NE	16S	25E	5199		130 ✓	
✓ 80	23 NW	16S	25E	5544	(19.5 ✓)	158 ✓	20.38
✓ 81	23 SW	16	25	5132		137 ✓	
✓ 82	24	16	25	4953	(20.8 ✓)	153 ✓	21.8
✓ 83	25	16	25	4937	(21.88 ✓)	158 ✓	22.9
✓ 84	26	16	25	4048		122 ✓	
				5106		140 ✓	
				5806	(21.0 ✓)	172 ✓	21.9
✓ 85	27	16	25	4692		126 ✓	5.98
				5892		139 ✓	
✓ 86	30	16	26E(?)	4760		133 ✓	
✓ 87	35	16	25	4543		122 ✓	
✓ 88	9	17	21	6245		130 ✓	
✓ 89	14 NW	17	22	3368	(✓)	110	19.3
✓ 90	25	17	22	2935		93 ✓	
✓ 91	13	17	23	5166	(19.4 ✓)	150 ✓	20.3
✓ 92	6	17	24	5596		142 ✓	
✓ 93	7 SE	17	24	864	(39.4)	84	45.1
				5282	(21.6 ✓)	164 ✓	22.5
✓ 94	12 SW	17	25	2997	(22.4)	117	24.0
				3735	(✓)	118	19.5
✓ 95	15	17	25	3814	(19.4 ✓)	125 ✓	21.0
✓ 96	21 NW	17	25	4094	✓	122 ✓	18.8
✓ 97	7 NE	17	26	3723	(22.3 ✓)	133 ✓	23.5
✓ 98	8 NE	17	26	3849		116 ✓	
✓ 99	17 NE	17	26	3633		105 ✓	

Grand p 6

	Sec	T	R	DEPTH	OF	
✓100	18	17S	26E	3600 ✓	116	19.7
✓101	19 NE	17	26	3281	100 ✓	
✓102	4	18	22	5436	144 ✓	
✓103	29	18	22	5597	145 ✓	
✓104	33 NE	18	22	1802 (23.3)	92	
				5386	126 ✓	
✓105	3	18S	23E	6010	147 ✓	
✓106	16	18S	24E	3282	108 ✓ close	
✓107	21	18S	24E	2900	100 ✓	
				4500 (19.3 NO)	137 ✓	20.4
✓108	21	18	24	2884 (19.4 NO)	106	21.2 ✓

end

plotted

GRAND CO

P.I.

No		
104	▲	72.7°C/hour
145	○	
146	○	
147	△	
149	○	
151	○	

UGMS

No		
1	△	
2	△	35.5°C/hour
3	△	
4	△	39.9°C/hour
5	▲	45.6°C/hour
6	○	
7	▲	46.5°C/hour
8	▲	57.6
9	△	
10	△	
11	△	35.9
12	△	35.5
13	○	
14	▲	46.2
15	▲	57.5
16	▲	62.5
17	△	37.6
18	△	
19	△	41.2
20	△	39.3
21	▲	44.8
22	△	40.0
23	△	36.5
24	▲	51.6
25	△	
26	○	
27	△	
28	△	
29	△	39.6
30	▲	56.7
31	▲	54.6
32	○	
33	▲	52.6
34	○	
35	○	
36	○	

Continued

Not in Subfile !

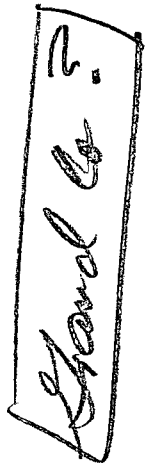
United Energy Corp.

SW SW Sec 29, T20S
R22E

Millard Peace - Contr.

163° F BHT (log) @ 2944'

28-42 GPM
~160-180° F water



GRAND CO. Cont.
UGMS

No.			No.			No.		
37	△	39.3	64	○		91	○	
38	▲	114.6	65	○		92	○	
39	○		66	○		93	▲	69.6
40	○		67	○		94	△	40.1
41	○		68	○		95	○	35.4
42	○		69	◐	40.7	96	○	
43	○		70	○		97	○	40.1
44	○		71	◔		98	○	
45	○		72	○		99	○	
46	○		73	▲	72.2	100	○	
47	○		74	○		101	▲	
48	○		75	○		102	○	
49	○		76	○		103	○	
50	○		77	○		104	△	41.5
51	○	37.3	78	○		105	○	
52	○		79	○		106	○	
53	○		80	○	35.2	107	○	
54	○		81	○		108	△	
55	○		82	○	37.5			
56	○		83	○	39.5 use 39.			
57	○		84	○	GREEN 37.9			
58	○		85	○				
59	○		86	○				
60	○		87	○				
61	○	35.6	88	○				
62	○		89	○				
63	○		90	○				

✓ ↑163° @ 2944
FROM CAMPBELL
▲ 69.3 °C/hr

ANOM WELLS

GRAND CO.

TOTAL ALL WELLS: 115

" ANOMALOUS " : 38

Sec	T	R	depth (m)	°C	°C/km	Amb
29	20S	22E	897	72.8	69	10.6
2	16S	24E	986	82.2	73	
29	18S	25E	454	26.7	35	
4	19S	22E	515	31.1	40	
36	19S	18E	670	41.1	46	
19	20S	24E	322	25.6	46	
35	19S	24E	650	33.9	36	
19	20S	24E	327	29.4	58	
16	20S	21E	829	40.0	36	
36	20S	21E	769	46.1	46	
15	20S	23E	473	37.8	58	
2	20S	20E	418	36.7	62	
3	20S	24E	492	29.4	38	
8	20S	24E	418	27.8	41	
9	20S	24E	509	30.6	39	
15	20S	24E	410	28.9	45	
19	20S	24E	459	28.9	40	
19	20S	24E	366	23.9	36	
20	20S	24E	312	26.7	52	
3	21S	23E	434	27.8	40	
3	21S	23E	431	35.0	57	
10	21S	23E	345	29.4	55	
34	21S	24E	443	33.9	53	
22	22S	19E	890	45.6	39	
10	22S	21E	160	29.0	115	

ANOMALOUS WELLS

GRAND CO., CONT.

Sec	T	R	d (m)	°C	°C/km	Amb
10	25S	18E	1277	58.3	37	10.6
33	15½S	23E	2624	103.9	36	
29	16S	24E	1838	84.4	40	
13	16S	25E	469	44.4	72	
23	16S	25E	1690	70.0	35	
24	16S	25E	1510	67.2	38	
25	16S	25E	1505	70.0	39	
26	16S	25E	1770	77.8	38	
7	17S	24E	263	28.9	70	
12	17S	25E	913	47.2	40	
15	17S	25E	1162	51.7	35	
7	17S	26E	1135	56.1	40	
33	18S	22E	549	33.3	41	

GRAND CO.; CISCO

Grade 10.6°C

	S	T	R	°C	depth m	°C/km	depth to 60°C		S	T	R	°C	depth m	°C/km	
3	9	19S	21E	33.3	657	34.6	1139	33	34	21S	24E	33.9	443	52.6	749
4	4	19S	22E	31.1	515	39.8	990	38	10	22	21	28.9	160	114.4	344
5	36	19S	18E	41.1	670	45.5	866	★	29	20	22	72.8	897	69.3	569
6	12	19S	22E	32.2	1420	15.2	2592 PI 104		2	16	24	82.2	986	72.6	543
7	19	20	24	25.6	322	46.6	845								
8	19	20	24	29.4	328	57.3	688								
9	14	19	24	35.6	794	31.5	1251						1700	1799	
10	35	19	24	27.2	487	34.1	1155						1800	1899	
11	35	19	24	33.9	650	35.8	1101						1900	1999	
12	16	20	21	40.0	829	35.5	1110						2000	2099	
13	23	20	21	47.8	1446	25.7	1533								
14	36	20	21	46.1	769	46.2	853						100	299	
15	15	20	23	37.8	473	57.5	685						300	399	
16	2	20	20	36.7	418	62.4	631						400	499	
17	3	20	24	29.4	502	37.4	1053						500	599	
18	5	20	24	26.7	511	31.5	1251						600	699	
19	8	20	24	27.8	418	41.1	959						700	799	
20	9	20	24	30.6	509	39.3	1003						800	899	
21	15	20	24	28.9	410	44.6	883						900	999	
22	19	20	24	28.9	459	39.9	987						1000	1099	
23	19	20	24	23.9	366	36.3	1085						1100	1199	
24	20	20	24	26.7	312	51.6	764						1200	1299	
28	6	21	22	37.8	944	28.8	1368						1300	1399	
29	3	21	23	27.8	434	39.6	995						1400	1499	
30	3	21	23	35.0	431	56.6	696						1500	1599	
31	10	21	23	29.4	346	54.3	726						1600		
32	20	21	23	50.6	1161	34.4	1145								

GRAND CO., NE CORNER (ALL)

	S	T	R	°C	depth m	°C/km			S	T	R	°C	m	°C/km	
1	17	18S	25E	37.8	853	31.9	1235	85	27	16S	25E	52.2	1430	29.1	1354
2	29	18S	25E	26.7	454	35.5	1110	86	30	16	26(?)	56.1	1451	31.4	1254
60	31	15S	25E	71.1	2379	25.4	1551	87	35	16	25	50.0	1385	28.4	1387
61	33	15½	23	103.9	2624	35.6	1107	88	9	17	21	54.4	1903	23.0	1713
62	15	16	21	50.0	1913	20.6	1913	89	14	17	22	43.3	1026	31.9	1235
63	22	16	21	47.8	1874	19.8	1990	90	25	17	22	33.9	894	26.1	1510
64	36	16	22	47.8	1179	31.6	1247	91	13	17	23	65.6	1574	34.9	1129
65	14	16	23	78.9	2674	25.5	1545	92	6	17	24	61.1	1706	29.6	1331
66	12	16	24	69.4	1800	32.7	1205	93	7	17	24	28.9	263	69.6	566
67	13	16	24	68.3	1841	31.3	1259	94	12	17	25	47.2	913	40.1	983
68	24	16	24	76.7	1911	34.6	1139	95	15	17	25	51.7	1162	35.4	1113
69	29	16	24	84.4	1838	40.2	980	96	21	17	25	50.0	1248	31.6	1247
70	2	16	25	72.2	2025	30.4	1296	97	7	17	26	56.1	1135	40.1	983
71	8	16	25	52.8	1810	23.3	1691	98	8	17	26	46.7	1173	30.8	1279
72	11	16	25	64.4	1769	30.4	1246	99	17	17	26	40.6	1107	27.1	1464
73	13	16	25	44.4	469	72.1	546	100	18	17	26	46.7	1097	32.9	1198
74	17	16	25	60.0	2099	23.5	1677	101	19	17	26	37.8	1000	27.2	1429
75	21	16	25	61.7	2004	25.5	1545	102	4	18	22	62.2	1657	31.1	1267
76	21	16	25	62.8	1990	26.2	1504	103	29	18	22	62.8	1706	30.6	1288
77	21	16	25	63.3	1980	26.6	1481	104	33	18	22	33.3	549	41.3	954
78	22	16	25	71.1	2082	29.0	1359	105	3	18	23	63.9	1832	29.1	1354
79	22	16	25	54.4	1585	27.6	1428	106	16	18	24	42.2	1000	31.6	1247
80	23	16	25	70.0	1690	35.1	1123	107	21	18	24	58.3	1372	34.8	1132
81	23	16	25	58.3	1564	30.5	1292	108	21	18	24	41.1	897	34.7	1135
82	24	16	25	67.2	1510	37.5	1051	PI 104	2	16	24	82.2	986	72.6	543
83	25	16	25	70.0	1505	39.5	997								
84	26	16	25	77.8	1770	38.0	1037								

GRAND Co, CISCO

	#	elev. on map (ft)	Depth to 50°C (m)	elev. of 50°C (m)	
	3	7400 ±500 *	1139	1117	•
	4	6000	990	839	•
	5	6400	866	1085	•
SE SW	6	5400	2592	-946 B.S.L.	
	7	4550	845	542	•
	8	4550	688	699	•
	9	4800	1251	212	
	10	4600	1155	247	
NE SW SE	11	4600	1101	301	•
	12	5300	1110	505	•
	13	5100	1533	21	
	14	4950	853	656	•
	15	4700	685	748	•
NE NW	16	7100	631	1533	•
	17	4550	1053	334	•
NW SE SE	18	4650	1251	166	•
	19	4640	959	455	•
	20	4600	1003	399	•
W NW NW	21	4600	883	519	•
	22	4550	987	400	•
WSW SE	23	4535	1085	297	•
WSW SW	24	4550	764	623	•
SW	33	4300	749	562	•
	38	4720	344	1095	•
→	✗	4900	569	925	•
	28	4950	1368	141	
	29	5200	995	590	•
	30	4400	696	645	•

* – Large variation in elevation in section.

> 1000 —

750 – 1000 —

500 – 750 —

250 – 500 —

0 – 250

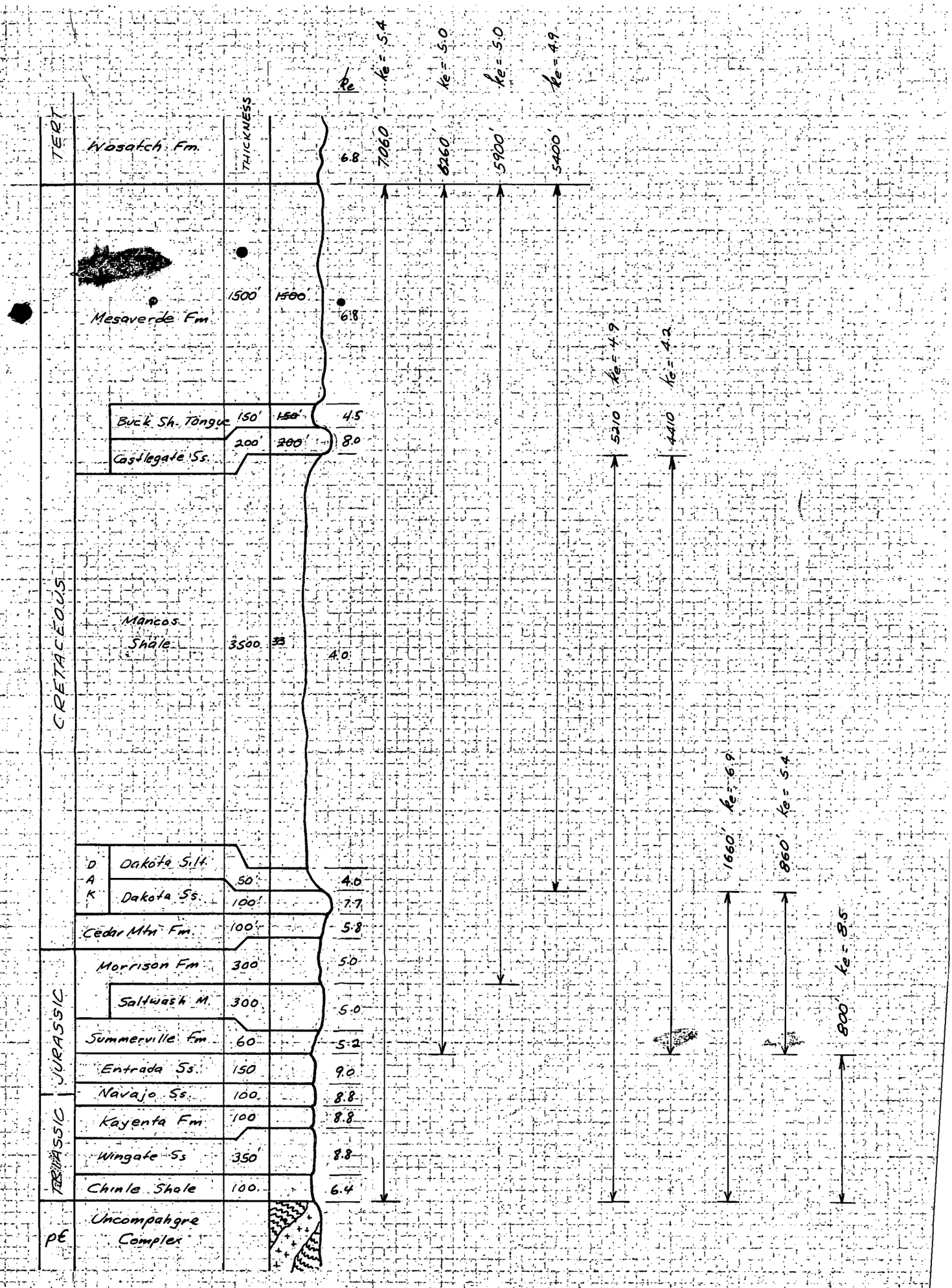
SWSWNE	31	4400	726	615	•
ENWSW	32	4500	1145	227	•
	1	5045	1235	303	•
	2	4900	1110	384	•
SW	60	8200	1551	948	•
SE	61	7800	1107	270	•
	62	7600	1913	403	•
NW	63	7800	1990	387	•
	64	7000	1247	887	•
	65	8000	1545	893	•
SE	66	7600	1205	929	•
	67	6800	1259	814	•
	68	7000	1139	995	•
	69	7400	980	1276	•
	70	8000*	1296	1142	•
	71	8000*	1691	747	•
NE	72	7600*	1296	1020	•
	73	6200*	546	1344	•
	74	7500*	1677	609	•
	75	7400*	1545	711	•
NE	76	7600	1504	812	•
SW	77	7000	1481	653	•
	78	7000*	1359	775	•
NE	79	6480	1428	523	•
NW	80	6800	1123	950	•
SW	81	6400	1292	659	•
	82	6300*	1051	869	•
	83	6000	997	832	•

84	6300*	1037	883	
SE/NW/NW PI 104	8400	543	2017	
85	6300*	1354	566	
86	6000	1254	575	
87	5800	1387	381	
88	8400	1713	647	
NW 89	7000	1235	899	
90	7000	1510	624	
91	6600	1129	883	
92	7000	1331	803	
SE 93	6600*	566	1446	
SW 94	5300	983	632	
95	5350	1113	518	
NW 96	5300	1247	368	
NE 97	5260	983	620	
NE 98	5280	1279	330	
NE 99	5235	1454	142	
100	5200	1198	387	
NE 101	5100	1449	105	
102	7000*	1267	867	
103	6600*	1288	724	
NE 104	6400	954	997	
105	6000	1354	475	
106	5100	1247	307	
107	5100	1132	422	
108	5100	1135	419	

GRAND CO UT.

UGMS WELL	°C/km Γ	depth to 50°C (m)
1	31.9	1235
2	35.5	1110
3	34.7	1135
4	39.9	987
5	45.6	868
6	15.3	2575
7	46.5	847
8	57.6	684
9	31.5	1257
10	34.2	1152
11	35.9	1097
12	35.5	1110
13	25.7	1533
14	46.2	853
15	57.5	685
16	62.5	630
17	37.6	1048
18	31.5	1251
19	41.2	956
20	39.3	1002
21	44.8	879
22	40.0	985
23	36.5	1079
24	51.6	764
25	32.5	1219
26	27.1	1454
27	25.9	1521
28	28.8	1368
29	39.6	995
30	56.7	695
31	54.6	722
32	34.5	1142
33	52.6	749

WELL #	°C/km Γ	depth to 50°C
34	25.6	1539
35	29.7	1326
36	22.0	1790
37	39.3	1002
38	114.6	343
39, 40	23.8	1655
41	18.6	
42	19.1	
43	17.8	
44	18.6	
45	16.6	
46	23.7	
47	24.9	
48	29.4	
49	17.1	
50	14.6	
51	37.3	
52	22.4	
53	23.7	
54	18.8	
55	15.5	
56	22.3	
57	18.0	
58	24.3	
59	17.7	
60	25.4	
61	35.6	
62	20.6	
63	19.8	
64	27.2	
65	25.6	
66	32.7	

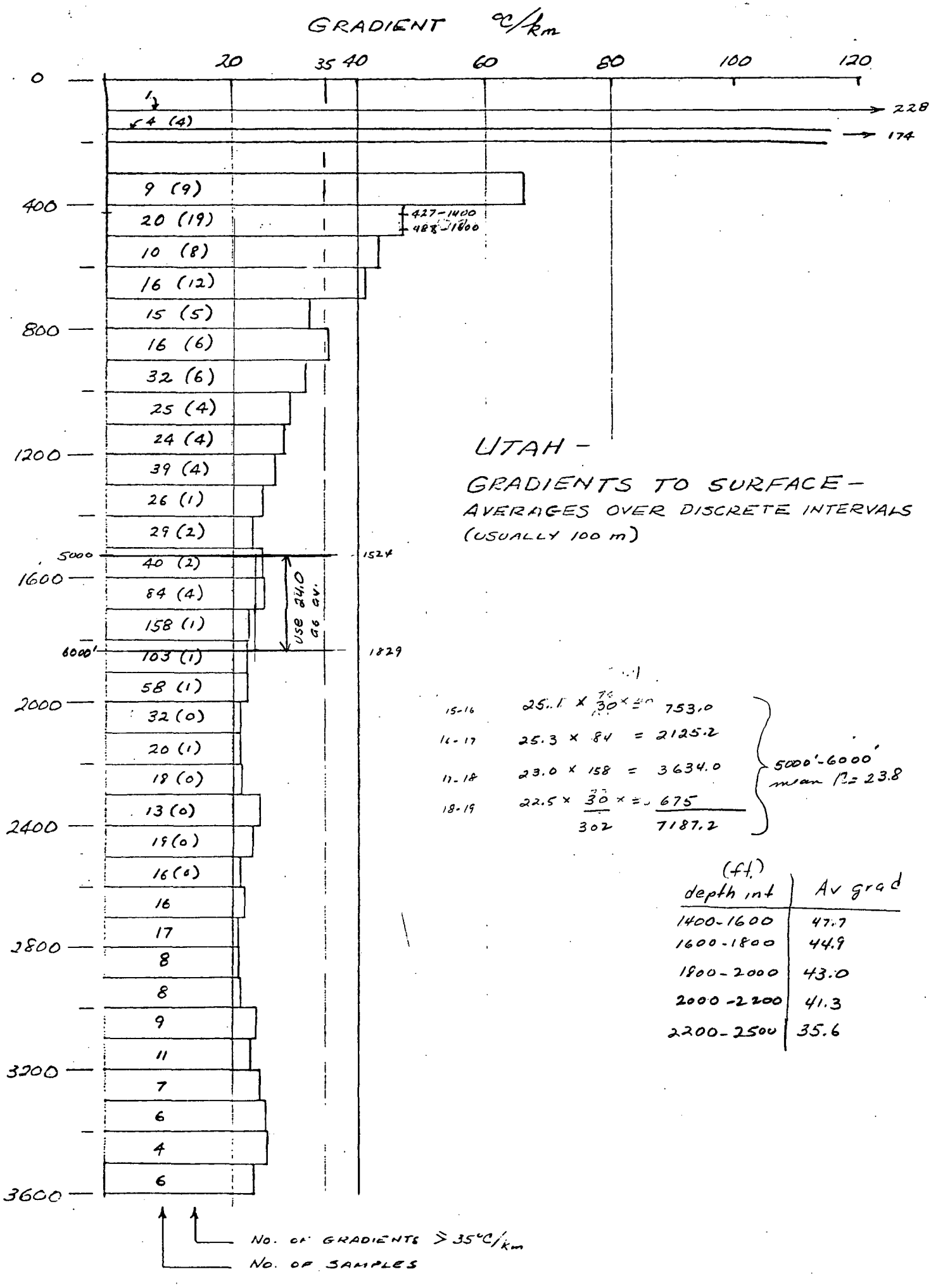


CISCO - BAR-X AREA, GRAND CO.

SECTION AS TYPICALLY RECORDED IN WELLS

AND ESTIMATED THERMAL CONDUCTIVITIES

IN $\frac{\text{mcal}}{\text{Cm sec °C}}$



UTAH -

GRADIENTS TO SURFACE -

AVERAGES OVER DISCRETE INTERVALS

(USUALLY 100 m)

15-16	$25.1 \times \frac{30}{30} \times 30 =$	753.0
16-17	$25.3 \times 84 =$	2125.2
17-18	$23.0 \times 158 =$	3634.0
18-19	$22.5 \times \frac{30}{30} \times 30 =$	675
	302	7187.2

5000'-6000'
mean T = 23.8

(ft.) depth int	Av grad
1400-1600	47.7
1600-1800	44.9
1800-2000	43.0
2000-2200	41.3
2200-2500	35.6

2nd calc. of ke's for BHT's using avs (chart) from 0-2810

93 surface Green River began logging at 2810

0-2140 Green River (assumed) ke = 7.0

(670) 2140-2810 wasatch (assumed) ke = 5.8

(2220) 2810-5030 wasatch - top castlegate(mean) ke = 7.0

BHT ① 110 @ 4713 ke = 6.8

2140	@ 7.0	14980
670	@ 5.8	3886
1903	@ 7.0	13321
4713		32187

6.8

(300) 5030-5330 Castlegate (mean) 7.6

(3490) 5330-8820 Mancos (mean) 4.1

BHT ② 110°F @ 5447 ke = 6.8

2140	@ 7.0	14980
670	@ 5.8	3886
2220	@ 7.0	15540
300	@ 7.0	2280
117	@ 4.1	480
5447		37

(190) 8820-9010 Dakota ke = 7.

(632) 9010-9642 Morrison (mid Entrada) k

(58) 9642-9700 Summerville

(130) 9700-9830 Entrada

9830-9920 Navajo

BHT ③ 173° @ 9869

Continued

BHT (3) 1730 @ 9869 $k_e = 5.8$

	5330 @	6.9	36777
	3490 @	4.1	14309
	190 @	7.0	1330
	632 @	5.2	3286
	58 @	6.4	371
Entrada	130 @	8.2	1066
	39 @	8.8	343
	9869		57482

(45) 9920 - 9985 unidentified $k_e = 7.0$

(118) 9985 - 10103 Kayenta $k_e = 8.8$

(466) 10103 - 10568 wingate $k_e = 8.8$

(95) 10568 - 10663 Chinle $k_c = 6.4$

124 | 10663 - 10787 PE $k_e = 7.0$

BHT (4) 176 @ 10787 $k_e = 6.0$

9830	@	5.8	57014
90	@	8.8	792
65	@	7.0	455
118	@	8.8	1038
463	@	8.8	4092
95	@	6.4	608
124	at	7.0	868
10787			64857

Schlumberger

SIMULTANEOUS

COMPENSATED NEUTRON-FORMATION DENSITY

COUNTY GRAND
FIELD WILDCAT
LOCATION SW/NE
WELL STATE 411-2
COMPANY ANSCHUTZ

COMPANY THE ANSCHUTZ CORP

WELL STATE 411-2

FIELD WILDCAT

COUNTY GRAND STATE UTAH

LOCATION SW/NE

API SERIAL NO.	SEC.	TWP.	RANGE
	23	18S	20E

Other Services:
DIL, BHC-GR
TAPING, CNL

Permanent Datum: GL ; Elev.: 8934
Log Measured From KB, 18 Ft. Above Perm. Datum
Drilling Measured From KB

Elev.: K.B. 8952
D.F. -
G.L. 8934

Date	10-19-78	10-31-78	12-5-6-78	12-19-20-78
Run No.	ONE	TWO	THREE	FOUR
Depth—Driller	4705	5453	9870	10786
Depth—Logger	4714	5449	9871	10789
Btm. Log Interval	4713 228	5447 197	9869 225	10787 5453
Top Log Interval	80	3418	5453	9770 647
Casing—Driller	20" @ 68	20 @ 58	13 3/8 @ 5452	13 3/8 @ 5452
Casing—Logger	80	80	5453	5453 5453
Bit Size	17½	17½	12¼	SEE REMARKS
Type Fluid in Hole	FRESH MUD	FGM	KCL AQUAGEL	FGM
Dens. / Visc.	8.9 / 60	9.0 / 59	9.3 / 38	9.0 / 56
pH / Fluid Loss	8.2 / 10ml	9.0 / 7.6ml	10 / 6-8ml	10 / 6.4ml
Source of Sample	PIT	TANK	TANK	TANK
Rm @ Meas. Temp.	2.90@ 76°F	2.47@ 65F	.434 @~58°F	.84 @ 56F
Rmf @ Meas. Temp.	2.47@ 69°F	1.74@ 60F	.369 @~58°F	.386@ 59F
Rmc @ Meas. Temp.	- @ °F	3.70@ 65F	- @ °F	1.26@ 56F
Source: Rmf / Rmc	MEAS / -	M / C	MEAS / CALC	M / C
Rm @ BHT	2.4 @ 110°F	1.55@ 110F	.16 @ 173F	- @ 176F
TIME Circulation Stopped	0030	1030	0500	830
TIME Logger on Bottom	1900	1930	1730	2330
Max. Rec. Temp.	110°F	110F	173F	176F
Equip. / Location	5768 / FARM	7759 / G.J.	7759 / G.J.	7759 / G.J.
Recorded By	BRAAF	KRABACHER	KRABACHER	OLSON/KRAB.
Witnessed By Mr.	HELMKE	HELMKE	HELMKE	HELMKE

The well name, location and borehole reference data were furnished by the customer.

FOLD HERE

SWS—1872-J

ECU 93

			°F/1000
(1)	4713, 110°	$T_7 = \frac{7}{7}(110-51)+51$	= 110°F	12.5
(2)	5447, 110°	$T_7 = \frac{6.9}{7.0}(110-51)+51$	= 109°	10.6
(3)	9869, 173°	$T_7 = \frac{5.9}{7}(173-51)+51$	= 154°	10.4
(4)	10787, 176°	$T_7 = \frac{6.1}{7.0}(176-51)+51$	= 160°	10.1

5447
5330
117

ECO 93

(1)	114 at 1600			
(2)	110 at 4713	above castlegate		ke
	109 at 1600 110 at 5447	5030'		7.0
	Cost To 1600 = -1	300'	castlegate	7.0 = 35210
		117'	Maroon	7.6 = 2280
		5447		4.1 479.7
				37969.7
				6.9

(3)	173 at 9869	5030	7.0	35210
		300	7.6	2280
		3490	4.1	14309
	(127)	190	7.0	1330
9869	at 1600	325	5.2	1690
9830		307	5.2	1596
39	Cost To 1600 = -46	58	6.4	371
		130	8.2	1066
		39 Navajo	8.8	343
		9869	(5.9)	58195

(4)	176 at 10787	5030	7.0	35210
		300	7.6	2280
		3490	4.1	14309
		190	7.0	1330
		325	5.2	1690
		307	5.2	1596
		58	6.4	371
10787		130	8.2	1066
10663		90	8.8	792
124		118	8.8	1038
		465	8.8	4092
		95	6.4	608
	pc	124	8.0	992
		10787	(6.1)	65394

Form 9-330
(Rev. 5-68)

935

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SUBMIT IN DUPLICATE (See other instructions on reverse side)

Form approved.
Budget Bureau No. 42-R355.5.

WELL COMPLETION OR RECOMPLETION REPORT AND LOG*

5. LEASE DESIGNATION AND SERIAL NO.: State 27411

6. IF INDIAN, ALLOTTEE OR TRIBE NAME:

1a. TYPE OF WELL: OIL WELL ☐ GAS WELL ☐ DRY ☒ Other

b. TYPE OF COMPLETION: NEW WELL ☒ WORK OVER ☐ DEEP-EN ☐ PLUG BACK ☐ DIFF. RESVR. ☐ Other

7. UNIT AGREEMENT NAME: Queant

8. FARM OR LEASE NAME: State 411

2. NAME OF OPERATOR: The Anschutz Corporation

9. WELL NO.: 2

3. ADDRESS OF OPERATOR: 2400 Anaconda Tower, Denver, Colorado 80202

10. FIELD AND POOL, OR WILDCAT: Wildcat

4. LOCATION OF WELL (*Report location clearly and in accordance with any State requirements*)*
At surface: 802' FWL & 1572' FNL
At top prod. interval reported below
At total depth

11. SEC., T., R., M., OR BLOCK AND SURVEY OR AREA: Sec. 23, T. 18S-R. 20E

14. PERMIT NO. | DATE ISSUED

12. COUNTY OR PARISH: Grand | 13. STATE: Utah

15. DATE SPUDDED: 9-10-79 | 16. DATE T.D. REACHED: 12-19-79 | 17. DATE COMPL. (*Ready to prod.*): 1-24-80 | 18. ELEVATIONS (DF, RKB, RT, GR, ETC.)*: 8934 GR | 19. ELEV. CASINGHEAD: 8904' EST

RECEIVED FEB 7 1979 DIVISION OF OIL, GAS & MINING

20. TOTAL DEPTH, MD & TVD: 10,786 | 21. PLUG, BACK T.D., MD & TVD: Surface | 22. IF MULTIPLE COMPL., HOW MANY* | 23. INTERVALS DRILLED BY → ROTARY TOOLS: 0-10,786 | CABLE TOOLS: -0-

24. PRODUCING INTERVAL(S), OF THIS COMPLETION—TOP, BOTTOM, NAME (MD AND TVD)*

25. WAS DIRECTIONAL SURVEY MADE: Yes

26. TYPE ELECTRIC AND OTHER LOGS RUN: FDC-CNL-GR, CNL, BHC-GR. DIL

27. WAS WELL CORED: No

28. CASING RECORD (*Report all strings set in well*)

CASING SIZE	WEIGHT, LB./FT.	DEPTH SET (MD)	HOLE SIZE	CEMENTING RECORD	AMOUNT PULLED
20"	94	61	30"	250 sx	-0-
13-3/8"	54.5	5452	17½	635 sx	-0-

29. LINER RECORD

SIZE	TOP (MD)	BOTTOM (MD)	SACKS CEMENT*	SCREEN (MD)

30. TUBING RECORD

SIZE	DEPTH SET (MD)	PACKER SET (MD)

31. PERFORATION RECORD (*Interval, size and number*)
5280-5300 - 2 SPF
5040-5050 - 2 SPF
5054-5066 - 2 SPF
5072-5082 - 2 SPF
4" casing gun

32. ACID, SHOT, FRACTURE, CEMENT SQUEEZE, ETC.

DEPTH INTERVAL (MD)	AMOUNT AND KIND OF MATERIAL USED

33.* PRODUCTION

DATE FIRST PRODUCTION	PRODUCTION METHOD (*Flowing, gas lift, pumping—size and type of pump*)	WELL STATUS (*Producing or shut-in*)

DATE OF TEST	HOURS TESTED	CHOKE SIZE	PROD'N. FOR TEST PERIOD →	OIL—BBL.	GAS—MCF.	WATER—BBL.	GAS-OIL RATIO

FLOW. TUBING PRESS.	CASING PRESSURE	CALCULATED 24-HOUR RATE →	OIL—BBL.	GAS—MCF.	WATER—BBL.	OIL GRAVITY-API (CORR.)

34. DISPOSITION OF GAS (*Sold, used for fuel, vented, etc.*) | TEST WITNESSED BY

35. LIST OF ATTACHMENTS

36. I hereby certify that the foregoing and attached information is complete and correct as determined from all available records

SIGNED Peter B. Doty (mkE) TITLE Operations Coordinator DATE February 5, 1979

*(See Instructions and Spaces for Additional Data on Reverse Side)

INSTRUCTIONS

General: This form is designed for submitting a complete and correct well completion report and log on all types of lands and leases to either a Federal agency or a State agency, or both, pursuant to applicable Federal and/or State laws and regulations. Any necessary special instructions concerning the use of this form and the number of copies to be submitted, particularly with regard to local, area, or regional procedures and practices, either are shown below or will be issued by, or may be obtained from, the local Federal and/or State office. See instructions on items 22 and 24, and 33, below regarding separate reports for separate completions.

If not filed prior to the time this summary record is submitted, copies of all currently available logs (drillers, geologists, sample and core analysis, all types electric, etc.), formation and pressure tests, and directional surveys, should be attached hereto, to the extent required by applicable Federal and/or State laws and regulations. All attachments should be listed on this form, see item 35.

Item 4: If there are no applicable State requirements, locations on Federal or Indian land should be described in accordance with Federal requirements. Consult local State or Federal office for specific instructions.

Item 18: Indicate which elevation is used as reference (where not otherwise shown) for depth measurements given in other spaces on this form and in any attachments.

Items 22 and 24: If this well is completed for separate production from more than one interval zone (multiple completion), so state in item 22, and in item 24 show the producing interval, or intervals, top(s), bottom(s) and name(s) (if any) for only the interval reported in item 33. Submit a separate report (page) on this form, adequately identified, for each additional interval to be separately produced, showing the additional data pertinent to such interval.

Item 29: *"Sacks Cement":* Attached supplemental records for this well should show the details of any multiple stage cementing and the location of the cementing tool.

Item 33: Submit a separate completion report on this form for each interval to be separately produced. (See instruction for items 22 and 24 above.)

37. SUMMARY OF POROUS ZONES:
SHOW ALL IMPORTANT ZONES OF POROSITY AND CONTENTS THEREOF; CORED INTERVALS; AND ALL DRILL-STEM TESTS, INCLUDING DEPTH INTERVAL TESTED, CUSHION USED, TIME TOOL OPEN, FLOWING AND SHUT-IN PRESSURES, AND RECOVERIES

FORMATION	TOP	BOTTOM	DESCRIPTION, CONTENTS, ETC.
Castlegate	5030	5330	Wet
Dakota	8820	9010	Wet
Morrison	9010	9335	Wet
Salt Wash	9335	9642	Wet
Summerville	9642	9700	Tite
Entrada	9700	9830	Wet
Navajo	9830	9920	Wet
Keyenta	9985	10,103	Tite
Wingate	10103	10,568	Wet
Chinle	10568	10,663	Tite

38. GEOLOGIC MARKERS

NAME	TOP	
	MEAS. DEPTH	TRUE VERT. DEPTH
Castlegate	5030	
Dakota	8820	
Morrison	9010	
Salt Wash	9335	
Summerville	9642	
Entrada	9700	
Navajo	9830	
Kayenta	9985	
Wingate	10103	
Chinle	10568	
Granite	10663	

★ U.S. GOVERNMENT PRINTING OFFICE: 1974-780-680/VIII-238

ECU - FROM LITHO LOGS

ESTIMATED COMPOSITIONS

WELL ECU-93, Sec 23, T18S-R 20E

	THICKNESS	%sh	%ss	%CARB	GYP	ke
(Tertiary) BOTTOM WASATCH	330					6.8
Mesaverde ~~SURFACE TO CASTLEGATE~~	5030 1890	~~50~~	50			7.0
CASTLEGATE (BUT NO MATTER) TOO THICK ✓	300'	40	60			7.6
MANCOS	3490'	98	2			4.1
DAKOTA	190'	48	48	4	✓	7.0
MORRISON	325'	80	20			5.2
SALT WASH	307'	80	20			5.2
SUMMERVILLE	58'	60	~~40~~			6.4
ENTRADA ✓	130'	30	70		✓	8.2
NAVAJO ✓	90'	20	80			8.8
KAYENTA ✓	118'	20	80			8.8
WINGATE ✓	465'	20	80			8.8
CHINLE	95'	60	40			6.4

LOG BY ROCKY MTN. GEO-ENGINEERING CO. - Surface - Green River

BOTTOM IN pC 10663' - 10786'

k_e = thermal conductivity in $\frac{\text{millical}}{\text{cm sec °C}}$

estimated from:

100% shale = 4.0

100% sand = 10.0

ls = 7.0

BHTs — wtd from surface

1. 110°F @ 4713' k_e = 6.8 7.0 — k_e = 7.0
2. 110°F @ 5447 k_e = 6.8 6.9
3. 173°F @ 9869 k_e = 5.8 5.9
4. 176°F @ 10787 (TD) k_e = 6.0 6.1

} INDEPENDENT CALCULATION

surface Green River

log begins at 2810 in Wasatch

assume	Green R	0 – 2140	2140
Wasatch	2140	– 3140	1000
Mesaverde	3140	5030	1890
Castlegate	5030	– 5100	70
Mancos	5100	– 8600	3500
Dakota	8820		

96 began logging surface w/ water

375	5.5	2062
1000	6.7	6700
959	5.6	5370
230	4.0	4920
182	5.4	983
3444	4.0	13776
166	8.9	1477
75	6.1	458
197	5.2	1024
266	4.6	1224
62	5.2	322
74	8.8	651
7030		38967

BHT 183° @ 7023 $k_e = 5.5$

ECU 96 Sec. 15, T18S - R 22E ✓

EST COMPOSITIONS - LITHO BY POWELL & COLLINS

	THICKNESS	% sh *	% ss	% CARB. **	GYP	Re	
SURFACE - WASATCH	BOTTOM 375	69	20	11		5.5	
	1/2 TOP 1959	55	45			6.7	TOP 1/2
MESAVERDE	1/2 BOTT	74	26			5.6	BOTTOM 1/2
BUCK TONGUE	230	100	0			4.0	
CASTLE GATE	182	77	23		✓	5.4	6.7 5.6 5.4
MANCOS	3416	100	0	✓		4.0	
B/DAKOTA SILT	28	100	0			4.0	
DAKOTA	166	18	82			8.9	
CEDAR MTN.	75	65	35			6.1	
MORRISON ?	197	80	20			5.2	
SALT WASH ?	266	90	10			4.6	
SUMMERVILLE ?	62	80	20			5.2	
ENTRADA ?	TOP — 74'	20	80			8.8	

BOTTOM IN ENTRADA AT 7030

* Siltstone & sh

** includes quartzite

est. therm. conductivity

Re in $\frac{\text{millical}}{\text{cm sec °C}}$

sh = 4.0

ss = 10.0

ls = 7.0

~~BHTS~~

TIOF

96 Anschutz Fed 078 #1
sec 15, T18S-R22E Grand

Drilling application
Estimated emp. geol markers

Wasatch	surface
Castle gate	1740
Mancos	1805
Dakota	5265
Cedar mtn	5338
Jm	5418
Salt Wash	5725
Summerville	6011
Je	6070
Est TD	6200

Duplicate try to get actual

Est depths of ant. water oil gas

Dakota	5265	gas and/or oil H_2O
Jm	5418	gas or H_2O
Je	6070	gas

Schlumberger

SIMULTANEOUS

COMPENSATED NEUTRON-FORMATION DENSITY

COMPANY THE ANSCHUTZ CORP

WELL NO. 1 FEDERAL 078

FIELD DIAMOND CANYON UNIT

COUNTY GRAND STATE UTAH

LOCATION 3850FWL 730FSL

API SERIAL NO.	SEC.	TWP.	RANGE
	15	18S	22E

Other Services:
DIL
CDR 96

COUNTY GRAND
FIELD DIAMOND CANYON UNIT
LOCATION 3850FWL 730FSL
WELL NO. 1 FEDERAL 078
COMPANY THE ANSCHUTZ CORP

Permanent Datum: GL ; Elev.: 6055
Log Measured From KB, 10 Ft. Above Perm. Datum
Drilling Measured From KB

Elev.: K.B. 6065
D.F. --
G.L. 6055

Date	6-8-78		
Run No.	ONE		
Depth—Driller	7030		
Depth—Logger	7025		
Btm. Log Interval	~~7023~~ 7027		
Top Log Interval	112		
Casing—Driller	7" @ 2760	@	@ @
Casing—Logger	--		
Bit Size	6¼		
Type Fluid in Hole	FGM		
Dens. / Visc.	9.2 / 44		
pH / Fluid Loss	7.6 / 10.6ml	ml	ml ml
Source of Sample	MUDTANK		
Rm @ Meas. Temp.	.554 @ 71°F	@ °F	@ °F @ °F
Rmf @ Meas. Temp.	.482 @ 71°F	@ °F	@ °F @ °F
Rmc @ Meas. Temp.	-- @ --°F	@ °F	@ °F @ °F
Source: Rmf / Rmc	M / --		
Rm @ BHT	.21 @ ~~183°F~~	@ °F	@ °F @ °F
Circulation Stopped	~2000 6-8		
Logger on Bottom	0530 6-9		
Max. Rec. Temp.	183°F	°F	°F °F
Equip. / Location	7759 / G.J.		
Recorded By	GRTAYLOR		
Witnessed By Mr.	ALLRED/COLLINS		

FOLD HERE

The well name, location and borehole reference data were furnished by the customer.

Form 9-3
(Rev. 5-

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SUBMIT IN DUPLICATE* (See other instructions on reverse side)

Form approved.
Budget Bureau No. 42-R355.5.

96 15

WELL COMPLETION OR RECOMPLETION REPORT AND LOG*

RECEIVED
JUL 21 1978
DIVISION OF OIL, GAS, & MINING

1a. TYPE OF WELL: OIL WELL ☐ GAS WELL ☐ DRY ☒ Other

b. TYPE OF COMPLETION: NEW WELL ☐ WORK OVER ☐ DEEP-EN ☐ PLUG BACK ☐ DIFF. RESVR. ☐ Other

2. NAME OF OPERATOR: The Anschutz Corporation

3. ADDRESS OF OPERATOR: 1110 Denver Club Bldg., Denver, Colorado 80202

4. LOCATION OF WELL (*Report location clearly and in accordance with any State requirements*)*
At surface
At top prod. interval reported below 3850' FWL + 730' FSL
At total depth

5. LEASE DESIGNATION AND SERIAL NO.: U-14078

6. IF INDIAN, ALLOTTEE OR TRIBE NAME:

7. UNIT AGREEMENT NAME: Diamond Canyon

8. FARM OR LEASE NAME: Federal 078

9. WELL NO.: 1

10. FIELD AND POOL, OR WILDCAT: Wildcat

11. SEC., T., R., M., OR BLOCK AND SURVEY OR AREA: SW¼ SE¼ Sec.15T 18S R22E

14. API NO.	DATE ISSUED	12. COUNTY OR PARISH	13. STATE
43-019-30371	6-15-77	Grand	Utah

15. DATE SPUDDED	16. DATE T.D. REACHED	17. DATE COMPL. (*Ready to prod.*)	18. ELEVATIONS (DF, RKB, RT, GR, ETC.)*	19. ELEV. CASINGHEAD
5-8-78	6-9-78	P&A 6-9-78	6055 GL 6064 KB	6055

20. TOTAL DEPTH, MD & TVD	21. PLUG, BACK T.D., MD & TVD	22. IF MULTIPLE COMPL., HOW MANY*	23. INTERVALS DRILLED BY	ROTARY TOOLS	CABLE TOOLS
7030			→	Surface-TD	None

24. PRODUCING INTERVAL(S), OF THIS COMPLETION—TOP, BOTTOM, NAME (MD AND TVD)*: NONE

25. WAS DIRECTIONAL SURVEY MADE: Yes

26. TYPE ELECTRIC AND OTHER LOGS RUN: DIL - GR, CNL-FDC-GR

27. WAS WELL CORED: No

28. CASING RECORD (*Report all strings set in well*)

CASING SIZE	WEIGHT, LB./FT.	DEPTH SET (MD)	HOLE SIZE	CEMENTING RECORD	AMOUNT PULLED
9-5/8	36	112	12½	65sks circulated	None
7	23	2760	8-3/4	75sks est. top 2100'	1056'

29. LINER RECORD

SIZE	TOP (MD)	BOTTOM (MD)	SACKS CEMENT*	SCREEN (MD)

30. TUBING RECORD

SIZE	DEPTH SET (MD)	PACKER SET (MD)

31. PERFORATION RECORD (*Interval, size and number*)

32. ACID, SHOT, FRACTURE, CEMENT SQUEEZE, ETC.

DEPTH INTERVAL (MD)	AMOUNT AND KIND OF MATERIAL USED

33.* PRODUCTION

DATE FIRST PRODUCTION	PRODUCTION METHOD (*Flowing, gas lift, pumping—size and type of pump*)	WELL STATUS (*Producing or shut-in*)

DATE OF TEST	HOURS TESTED	CHOKE SIZE	PROD'N. FOR TEST PERIOD →	OIL—BBL.	GAS—MCF.	WATER—BBL.	GAS-OIL RATIO

FLOW. TUBING PRESS.	CASING PRESSURE	CALCULATED 24-HOUR RATE →	OIL—BBL.	GAS—MCF.	WATER—BBL.	OIL GRAVITY-API (CORR.)

34. DISPOSITION OF GAS (*Sold, used for fuel, vented, etc.*)

TEST WITNESSED BY

35. LIST OF ATTACHMENTS: Logs

36. I hereby certify that the foregoing and attached information is complete and correct as determined from all available records.

SIGNED RBD Peter B. Doty TITLE Operations Coordinator DATE 7-19-78

*(See Instructions and Spaces for Additional Data on Reverse Side)

INSTRUCTIONS

General: This form is designed for submitting a complete and correct well completion report and log on all types of lands and leases to either a Federal agency or a State agency or both, pursuant to applicable Federal and/or State laws and regulations. Any necessary special instructions concerning the use of this form and the number of copies to be submitted, particularly with regard to local, area, or regional procedures and practices, either are shown below or will be issued by, or may be obtained from, the local Federal and/or State office. See instructions on items 22 and 24, and 33, below regarding separate reports for separate completions.
If not filed prior to the time this summary record is submitted, copies of all currently available logs (drillers, geologists, sample and core analysis, all types electric, etc.), formation and pressure tests, and directional surveys, should be attached hereto, to the extent required by applicable Federal and/or State laws and regulations. All attachments should be listed on this form, see item 35.
Item 4: If there are no applicable State requirements, locations on Federal or Indian land should be described in accordance with Federal requirements. Consult local State or Federal office for specific instructions.
Item 18: Indicate which elevation is used as reference (where not otherwise shown) for depth measurements given in other spaces on this form and in any attachments.
Items 22 and 24: If this well is completed for separate production from more than one interval zone (multiple completion), so state in item 22, and in item 24 show the producing interval, or intervals, top(s), bottom(s) and name(s) (if any) for only the interval reported in item 33. Submit a separate report (page) on this form, adequately identified, for each additional interval to be separately produced, showing the additional data pertinent to such interval.
Item 29: *"Sacks Cement":* Attached supplemental records for this well should show the details of any multiple stage cementing and the location of the cementing tool.
Item 33: Submit a separate completion report on this form for each interval to be separately produced. (See instruction for items 22 and 24 above.)

37. SUMMARY OF POROUS ZONES:
SHOW ALL IMPORTANT ZONES OF POROSITY AND CONTENTS THEREOF; CORED INTERVALS; AND ALL DRILL-STEM TESTS, INCLUDING DEPTH INTERVAL TESTED, CUSHION USED, TIME TOOL OPEN, FLOWING AND SHUT-IN PRESSURES, AND RECOVERIES

FORMATION	TOP	BOTTOM	DESCRIPTION, CONTENTS, ETC.
Dakota	6192	6342	Sand + Shale - Wet
Morrison	6342	6628	Tite Sands + Shale
Salt Wash	6628	6950	Tite Sands + Shale
Entrada	6950	TD	Wet

38. GEOLOGIC MARKERS

NAME	TOP	
	MEAS. DEPTH	TRUE VERT. DEPTH
Wasatch	Sur	+6055
Mesaverde	350	+5705
Mancos	2710 Est.	+3345
Dakota	6192	- 137
Morrison	6342	- 287
Salt Wash	6628	- 573
Entrada	6950	- 895
TD	7030	- 975

U.S. GOVERNMENT PRINTING OFFICE: 1963—O-683636

GPO 870-401

96

Form 9-330
(Rev. 5-63)

121

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SUBMIT IN DUPLICATE (See other instructions on reverse side)

Form approved.
Budget Bureau No. 42-R355.5.

WELL COMPLETION OR RECOMPLETION REPORT AND LOG*

5. LEASE DESIGNATION AND SERIAL NO.: U-0149769

6. IF INDIAN, ALLOTTEE OR TRIBE NAME:

1a. TYPE OF WELL: OIL WELL ☐ GAS WELL ☐ DRY ☒ Other

b. TYPE OF COMPLETION: NEW WELL ☐ WORK OVER ☐ DEEP-EN ☐ PLUG BACK ☐ DIFF. RESVR. ☐ Other

7. UNIT AGREEMENT NAME: East Willow Creek

8. FARM OR LEASE NAME: Federal 769

9. WELL NO.: 1

10. FIELD AND POOL, OR WILDCAT: Wildcat

2. NAME OF OPERATOR: The Anschutz Corporation

3. ADDRESS OF OPERATOR: 1110 Denver Club Building, Denver, Colorado 80202

4. LOCATION OF WELL (*Report location clearly and in accordance with any State requirements*)*
At surface 1630' FWL, 1490' FSL
At top prod. interval reported below
At total depth

11. SEC., T., R., M., OR BLOCK AND SURVEY OR AREA: Sec. 19, T.19S-R.21E.

RECEIVED JUL 25 1978 DIVISION OF OIL, GAS, & MINING

14. PERMIT NO.	DATE ISSUED	12. COUNTY OR PARISH	13. STATE
API 43-019-30352	4-19-77	Grand	Utah

15. DATE SPUDDED	16. DATE T.D. REACHED	17. DATE COMPL. (*Ready to prod.*)	18. ELEVATIONS (DF, RKB, RT, GR, ETC.)*	19. ELEV. CASINGHEAD
4-7-78	5-2-78	P & A 5-3-78	6514 GL, 6523 KB	6514'

20. TOTAL DEPTH, MD & TVD	21. PLUG, BACK T.D., MD & TVD	22. IF MULTIPLE COMPL., HOW MANY*	23. INTERVALS DRILLED BY	ROTARY TOOLS	CABLE TOOLS
5400'			→	Surface-TD	None

24. PRODUCING INTERVAL(S), OF THIS COMPLETION—TOP, BOTTOM, NAME (MD AND TVD)*: None

25. WAS DIRECTIONAL SURVEY MADE: Yes

26. TYPE ELECTRIC AND OTHER LOGS RUN: DIL, CNL/FDL, BGT

27. WAS WELL CORED: No

28. CASING RECORD (*Report all strings set in well*)

CASING SIZE	WEIGHT, LB./FT.	DEPTH SET (MD)	HOLE SIZE	CEMENTING RECORD	AMOUNT PULLED
8-5/8"	24#	1600		Circulated to surface	

29. LINER RECORD

SIZE	TOP (MD)	BOTTOM (MD)	SACKS CEMENT*	SCREEN (MD)

30. TUBING RECORD

SIZE	DEPTH SET (MD)	PACKER SET (MD)

31. PERFORATION RECORD (*Interval, size and number*)

32. ACID, SHOT, FRACTURE, CEMENT SQUEEZE, ETC.

DEPTH INTERVAL (MD)	AMOUNT AND KIND OF MATERIAL USED

33.* PRODUCTION

DATE FIRST PRODUCTION	PRODUCTION METHOD (*Flowing, gas lift, pumping—size and type of pump*)	WELL STATUS (*Producing or shut-in*)

DATE OF TEST	HOURS TESTED	CHOKE SIZE	PROD'N. FOR TEST PERIOD →	OIL—BBL.	GAS—MCF.	WATER—BBL.	GAS-OIL RATIO

FLOW. TUBING PRESS.	CASING PRESSURE	CALCULATED 24-HOUR RATE →	OIL—BBL.	GAS—MCF.	WATER—BBL.	OIL GRAVITY-API (CORR.)

34. DISPOSITION OF GAS (*Sold, used for fuel, vented, etc.*)

TEST WITNESSED BY

35. LIST OF ATTACHMENTS
LOGS

36. I hereby certify that the foregoing and attached information is complete and correct as determined from all available records

SIGNED R B D TITLE OPERATIONS COORDINATOR DATE 7-18-78

*(See Instructions and Spaces for Additional Data on Reverse Side)

INSTRUCTIONS

General: This form is designed for submitting a complete and correct well completion report and log on all types of lands and leases to either a Federal agency or a State agency, or both, pursuant to applicable Federal and/or State laws and regulations. Any necessary special instructions concerning the use of this form and the number of copies to be submitted, particularly with regard to local, area, or regional procedures and practices, either are shown below or will be issued by, or may be obtained from, the local Federal and/or State office. See instructions on items 22 and 24, and 33, below regarding separate reports for separate completions.

If not filed prior to the time this summary record is submitted, copies of all currently available logs (drillers, geologists, sample and core analysis, all types electric, etc.), formation and pressure tests, and directional surveys, should be attached hereto, to the extent required by applicable Federal and/or State laws and regulations. All attachments should be listed on this form, see item 35.

Item 4: If there are no applicable State requirements, locations on Federal or Indian land should be described in accordance with Federal requirements. Consult local State or Federal office for specific instructions.

Item 18: Indicate which elevation is used as reference (where not otherwise shown) for depth measurements given in other spaces on this form and in any attachments.

Items 22 and 24: If this well is completed for separate production from more than one interval zone (multiple completion), so state in item 22, and in item 24 show the producing interval, or intervals, top(s), bottom(s) and name(s) (if any) for only the interval reported in item 33. Submit a separate report (page) on this form, adequately identified, for each additional interval to be separately produced, showing the additional data pertinent to such interval.

Item 29: *"Sacks Cement":* Attached supplemental records for this well should show the details of any multiple stage cementing and the location of the cementing tool.

Item 33: Submit a separate completion report on this form for each interval to be separately produced. (See instruction for items 22 and 24 above.)

37. SUMMARY OF POROUS ZONES:
SHOW ALL IMPORTANT ZONES OF POROSITY AND CONTENTS THEREOF; CORED INTERVALS; AND ALL DRILL-STEM TESTS, INCLUDING DEPTH INTERVAL TESTED, CUSHION USED, TIME TOOL OPEN, FLOWING AND SHUT-IN PRESSURES, AND RECOVERIES

FORMATION	TOP	BOTTOM	DESCRIPTION, CONTENTS, ETC.

38. GEOLOGIC MARKERS

NAME	TOP	
	MEAS. DEPTH	TRUE VERT. DEPTH
		Subsea
Mesa Verde	Surface	
~~Mancos~~	~~Surface~~	+6514 GL
Dakota	4571	+1943
Morrison	4694	+1820
Salt Wash	4846	+1668
Entrada	5326	+1188
T.D.	5400	+1114

U.S. GOVERNMENT PRINTING OFFICE: 1963—O-683638

GPO 870-401

Schlumberger

COMPENSATED NEUTRON-FORMATION DENSITY

COUNTY GRAND
FIELD WILDCAT
LOCATION NESW 1630FWL 1490FSL
WELL FEDERAL 769-1
COMPANY THE ANSCHUTZ CORP

COMPANY THE ANSCHUTZ CORP

WELL FEDERAL 769-1

FIELD WILDCAT

COUNTY GRAND STATE UTAH

LOCATION NE SW
1630FWL 1490FSL

API SERIAL NO.	SEC.	TWP.	RANGE
	19	19S	21E

Other Services:
DIL 121

Permanent Datum: GL ; Elev.: 6514
Log Measured From KB , 9 Ft. Above Perm. Datum
Drilling Measured From KB

Elev.: K.B. 6523
D.F. --
G.L. 6514

Date	5-1-78			
Run No.	ONE			
Depth—Driller	5400			
Depth—Logger	5399			
Btm. Log Interval	5398 28.4			
Top Log Interval	50			
Casing—Driller	8 5/8 @ 1600	@	@	@
Casing—Logger	--			
Bit Size	7 7/8			
Type Fluid in Hole	FGM			
Dens. / Visc.	9.0 / 39	/	/	/
pH / Fluid Loss	11.0 / 9.8 ml	/ ml	/ ml	/ ml
Source of Sample	MUDTANK			
Rm @ Meas. Temp.	.547 @ 70°F	@ °F	@ °F	@ °F
Rmf @ Meas. Temp.	.299 @ 70°F	@ °F	@ °F	@ °F
Rmc @ Meas. Temp.	-- @ --°F	@ °F	@ °F	@ °F
Source: Rmf / Rmc	M / --	/	/	/
Rm @ BHT	.28 @ 135°F	@ °F	@ °F	@ °F
TIME Circulation Stopped	1400 5-01			
TIME Logger on Bottom	2100 5-01			
Max. Rec. Temp.	135°F	°F	°F	°F
Equip. / Location	7759 / G.J.	/	/	/
Recorded By	GRTAYLOR			
Witnessed By Mr.	ALLRED/POWELL			

The well name, location and borehole reference data were furnished by the customer.

FOLD HERE

SWS-1872-H

121

log began surface mi Kmw

BHT 135° @ 5398 mi Entrada $k_e = 5.0$

874	6.7	5856
122	5.3	647
286	8.3	2374
3259	4.1	13362
30	4.0	120
104	7.1	738
19	6.2	118
152	4.6	699
404	5.4	2182
72	4.7	338
78	9.7	757
5400		27191
		5.03

ECU 121

sec. 19, T19S - R21E

EST. COMP. - LITHO LOG BY WAYNE POWELL

	THICKNESS	% sh+st	% ss	% CARB	% GYP	ke	
SURFACE - MESAVERDE	BOTTOM 874	54.5	45.5			6.7	lower 874'
BLACK TONGUE	122	79	21			5.3	
CASTLEGATE	286	29	71			8.3	
MANCOS	3259	98	2			4.1	
B/DAKOTA SILT	30	100	0			4.0	
DAKOTA	104	49	51			7.1	
CEDAR MTN	19	63	37			6.2	
MORRISON	152	90	10			4.6	
SALT WASH	404	74	22	4		5.4	
SUMMERVILLE	72	89	11			4.7	
ENTRADA	TOP 78	5	95			9.7	upper 78'

BOTTOM IN ENTRADA AT 5400

ke in millical / cm sec °C

sh = 4.0

SS = 10.0

ls = 7.0

121 Anschutz Fed 796-1
sec 19, T19S-R21E

Actual

~~Mancos~~	~~surface~~ NO (mesaverde)
Kd	4571 OK
dm	4694
Salt wash	4846
Je	5326
TD	5400

USGS H_2O evaluation

USGS H_2O evaluation (prior to drilling)

Unit	Qual H_2O
Mesa Verde group	fresh/saline
Km	saline
Kd	saline
dm	saline/brine
Je	brine

No H_2O wells vicinity
prev. oil tests found brackish
or saline water at depths greater
than 300 ft Useable water for
stock (sheep) may be found
as deep as 500'

150 2

Form 9-330
(Rev. 5-63)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SUBMIT IN DUPLICATE* (See other instructions on reverse side)

Form approved.
Budget Bureau No. 42-R355.5.

WELL COMPLETION OR RECOMPLETION REPORT AND LOG*

5. LEASE DESIGNATION AND SERIAL NO.: U-15104

6. IF INDIAN, ALLOTTEE OR TRIBE NAME:

1a. TYPE OF WELL: OIL WELL ☐ GAS WELL ☒ DRY ☐ Other

7. UNIT AGREEMENT NAME:

b. TYPE OF COMPLETION: NEW WELL ☒ WORK OVER ☐ DEEP-EN ☐ PLUG BACK ☐ DIFF. RESVR. ☐ Other

8. FARM OR LEASE NAME: Federal 104

2. NAME OF OPERATOR: The Anschutz Corporation

9. WELL NO.: 1

3. ADDRESS OF OPERATOR: 2400 Anaconda Tower, Denver, Colorado 80202

10. FIELD AND POOL, OR WILDCAT: Wildcat

4. LOCATION OF WELL (*Report location clearly and in accordance with any State requirements*)*
At surface: 768' FNL, 1520' FEL
At top prod. interval reported below
At total depth

11. SEC., T., R., M., OR BLOCK AND SURVEY OR AREA: Sec. 4, T.20S-R.21E

14. PERMIT NO. | DATE ISSUED

12. COUNTY OR PARISH: Grand | 13. STATE: Utah

15. DATE SPUDDED	16. DATE T.D. REACHED	17. DATE COMPL. (*Ready to prod.*)	18. ELEVATIONS (DF, RKB, RT, GR, ETC.)*	19. ELEV. CASINGHEAD
4-29-78	5-10-78	6-22-78	6159 GR 6205 KB	6195

20. TOTAL DEPTH, MD & TVD	21. PLUG, BACK T.D., MD & TVD	22. IF MULTIPLE COMPL., HOW MANY*	23. INTERVALS DRILLED BY	ROTARY TOOLS	CABLE TOOLS
4300'	3920'		→	0-4300'	

24. PRODUCING INTERVAL(S), OF THIS COMPLETION—TOP, BOTTOM, NAME (MD AND TVD)*
Dakota 3520'-3526' MD
3549'-3555' MD

25. WAS DIRECTIONAL SURVEY MADE: Yes

26. TYPE ELECTRIC AND OTHER LOGS RUN: DILL-GR, FDC-CNL-GR, Geologic Report, Geologic Well Log

27. WAS WELL CORED: No

28. CASING RECORD (*Report all strings set in well*)

CASING SIZE	WEIGHT, LB./FT.	DEPTH SET (MD)	HOLE SIZE	CEMENTING RECORD	AMOUNT PULLED
8-5/8"	24#	319	12¼"	230 sx	None
4½"	10.5#	4119'	7-7/8"	300 sx	None

29. LINER RECORD

SIZE	TOP (MD)	BOTTOM (MD)	SACKS CEMENT*	SCREEN (MD)

30. TUBING RECORD

SIZE	DEPTH SET (MD)	PACKER SET (MD)
2.375	3565'	

31. PERFORATION RECORD (*Interval, size and number*)
3520-26 3/8" holes 2 SPF
3549-55 3/8" holes 2 SPF

32. ACID, SHOT, FRACTURE, CEMENT SQUEEZE, ETC.

DEPTH INTERVAL (MD)	AMOUNT AND KIND OF MATERIAL USED

33.* PRODUCTION

DATE FIRST PRODUCTION	PRODUCTION METHOD (*Flowing, gas lift, pumping—size and type of pump*)	WELL STATUS (*Producing or shut-in*)
	Flowing	S.I. W.O. PL Connection

DATE OF TEST	HOURS TESTED	CHOKE SIZE	PROD'N. FOR TEST PERIOD →	OIL—BBL.	GAS—MCF.	WATER—BBL.	GAS-OIL RATIO
7/20/78	18	28/64		0	3600	0	------

FLOW. TUBING PRESS.	CASING PRESSURE	CALCULATED 24-HOUR RATE →	OIL—BBL.	GAS—MCF.	WATER—BBL.	OIL GRAVITY-API (CORR.)
343	600		0	4800	0	------

34. DISPOSITION OF GAS (*Sold, used for fuel, vented, etc.*): Flared

TEST WITNESSED BY: J. N. Burkhalter

35. LIST OF ATTACHMENTS

36. I hereby certify that the foregoing and attached information is complete and correct as determined from all available records

SIGNED R B Dot TITLE Production Coordinator DATE 12-4-78

*(See Instructions and Spaces for Additional Data on Reverse Side)

INSTRUCTIONS

General: This form is designed for submitting a complete and correct well completion report and log on all types of lands and leases to either a Federal agency or a State agency, or both, pursuant to applicable Federal and/or State laws and regulations. Any necessary special instructions concerning the use of this form and the number of copies to be submitted, particularly with regard to local, area, or regional procedures and practices, either are shown below or will be issued by, or may be obtained from, the local Federal and/or State office. See instructions on items 22 and 24, and 33, below regarding separate reports for separate completions.

If not filed prior to the time this summary record is submitted, copies of all currently available logs (drillers, geologists, sample and core analysis, all types electric, etc.), formation and pressure tests, and directional surveys, should be attached hereto, to the extent required by applicable Federal and/or State laws and regulations. All attachments should be listed on this form, see item 35.

Item 4: If there are no applicable State requirements, locations on Federal or Indian land should be described in accordance with Federal requirements. Consult local State or Federal office for specific instructions.

Item 18: Indicate which elevation is used as reference (where not otherwise shown) for depth measurements given in other spaces on this form and in any attachments.

Items 22 and 24: If this well is completed for separate production from more than one interval zone (multiple completion), so state in item 22, and in item 24 show the producing interval, or intervals, top(s), bottom(s) and name(s) (if any) for only the interval reported in item 33. Submit a separate report (page) on this form, adequately identified, for each additional interval to be separately produced, showing the additional data pertinent to such interval.

Item 29: *"Sacks Cement":* Attached supplemental records for this well should show the details of any multiple stage cementing and the location of the cementing tool.

Item 33: Submit a separate completion report on this form for each interval to be separately produced. (See instruction for items 22 and 24 above.)

37. SUMMARY OF POROUS ZONES:
SHOW ALL IMPORTANT ZONES OF POROSITY AND CONTENTS THEREOF; CORED INTERVALS; AND ALL DRILL-STEM TESTS, INCLUDING DEPTH INTERVAL TESTED, CUSHION USED, TIME TOOL OPEN, FLOWING AND SHUT-IN PRESSURES, AND RECOVERIES

FORMATION	TOP	BOTTOM	DESCRIPTION, CONTENTS, ETC.
Dakota	3522'	3706'	Sandstone - Gas
Morrison	3706'	3889'	Wet - Tite
Salt Wash	3889'	4266'	Wet - Tite
Entrada	4266'	Not Reached	Wet - Tite

38. GEOLOGIC MARKERS

NAME	TOP	
	MEAS. DEPTH	TRUE VERT. DEPTH
Dakota	3522'	3522'
Morrison	3706'	3706'
Salt Wash	3889'	3889'
Entrada	4266'	4266'

★ U.S. GOVERNMENT PRINTING OFFICE: 1974-780-680/VIII-238

ECU 150

Sec 4, T20S - R21E

EST. COMP. LITHO BY A.W. POWELL

logged only below 3,000'

	THICKNESS	% sh	% ss	% carb	gyp	Re	
SURFACE - BUCK TONGUE	—						
CASTLEGATE	72						
log begins here → MANCOS	BOTTOM 3226 ~~3326~~	100	0			4.0	BOTTOM 522'
B/DAKOTA SILT	50	100	0			4.0	
DAKOTA	102	: N	E	S			
CEDAR MTN.	82	75	25			5.5	
MORRISON	183	90	10		✓	4.6	
SALT WASH	315	83	17			5.0	
SUMMERVILLE	60	90	10			4.6	
ENTRADA	TOP 65	0	100			10.0	TOP 65'

BOTTOM IN ENTRADA AT 4329'

BHTs

120°F @ 4323 (TD)

Schlumberger

DUAL INDUCTION - LATEROLOG
WITH LINEAR CORRELATION LOG

COUNTY GRAND
FIELD or LOCATION WILDCAT
WELL FEDERAL 104-1
COMPANY ANSCHUTZ CORP

COMPANY THE ANSCHUTZ CORP

WELL FEDERAL 104-1

FIELD WILDCAT

COUNTY GRAND STATE UTAH

Location: 500FNL 1400FEL
Sec 4 Twp. 20S Rge. 21E

API Serial No.

Other Services:
FDC-CNL-GR
150

Permanent Datum: GL ; Elev.: 6159
Log Measured From KB, 10 Ft. Above Perm. Datum
Drilling Measured From KB

Elev.: K.B. 6169
D.F. --
G.L. 6159

Date	5-10-78					
Run No.	ONE					
Depth—Driller	4320					
Depth—Logger	4329					
Btm. Log Interval	~~4323~~ 4327					
Top Log Interval	322					
Casing—Driller	8 5/8 @ 319	@		@		@
Casing—Logger	322					
Bit Size	7 7/8					
Type Fluid in Hole	FGM					
Fluid Level	FULL					
Dens. / Visc.	-- / --					
pH / Fluid Loss	-- / -- ml		ml		ml	ml
Source of Sample	CIRCULATED					
R_m @ Meas. Temp.	1.06 @ 67 °F	@	°F	@	°F	@ °F
R_{mf} @ Meas. Temp.	.822 @ 67 °F	@	°F	@	°F	@ °F
R_{mc} @ Meas. Temp.	1.59 @ 67 °F	@	°F	@	°F	@ °F
Source: R_{mf} / R_{mc}	M / C					
R_m @ BHT	0.60 @ 120 °F	@	°F	@	°F	@ °F
Time Since Circ.	3 HOURS					
Max. Rec. Temp.	120 °F		°F		°F	°F
Equip. / Location	5642 / G.J.					
Recorded By	LAUDE					
Witnessed By	POWELL					

150

log begins at 3000'

surface in mesaverde

(74)	0-74	Buck Tongue	5.3	392
(72)	74-146	Castlegate	8.0	576
(3326)	146-3472	Mancos	4.0	13304
	50'	B/Dak silt	4.0	200
	102'	Dakota	7.7	785
	82	Cedar Mtn	5.5	451
	183	Morrison	4.6	842
	315	Saltwash	5.0	1575
	60	Summerville	4.6	276
	65	Entrada	10.0	650
	4329			19051

BHT 120° F @ 4323 $R_e = 4.4$

SCHLUMBERGER GAMMA RAY - NEUTRON

COUNTY S7-1-2152
FIELD or LOCATION
WELL
COMPANY

COMPANY SHELL OIL COMPANY (1)

WELL FEDERAL # 1-26

FIELD WILDCAT

COUNTY GRAND STATE UTAH

Location: 2050' SLY & 800' WLY FROM NE CORNER

Sec. 26 Twp. 21S Rge. 17E

Other Services:
7
234

Permanent Datum: GL ; Elev.: 4439
Log Measured From KB , 13 Ft. Above Perm. Datum
Drilling Measured From KB

Elev.: K.B. 4452
D.F.
G.L. 4439

Date	6-20-69	
Run No.	TWO	
Type Log	GRN	
Depth—Driller	10,767	
Depth—Logger	10,787	
Bottom logged interval	~~10,786~~ 10,783	(5)
Top logged interval	9300	
Type fluid in hole	SOM	
Salinity, PPM Cl.	-	
Density	17.2	
Level	FULL	
Max rec. temp., deg F.	~~165~~	
Operating rig time	2 1/2	
Recorded by	PROBST	
Witnessed by	MCLEHANEY & MASON	

RUN	BORE-HOLE RECORD			CASING RECORD			
No.	Bit	From	To	Size	Wgt.	From	To
2	6 3/4	CSG	TD	7		SURFACE	8271

SCHLUMBERGER — GAMMA RAY - NEUTRON

COMPANY Shell Oil Company (1)

WELL Federal 1-26

FIELD Wildcat

COUNTY Grand STATE Utah

COUNTY / FIELD or LOCATION / WELL / COMPANY

Location: 2050' SLY. & 800' WLY. From NE Cornor

Sec. 26 Twp. 21S Rge. 17E

Other Services: 234, 7

Permanent Datum: G.L. ; Elev.: 4439

Log Measured From K.B., 13 Ft. Above Perm. Datum

Drilling Measured From K.B

Elev.: K.B. ~~4452~~

D.F.

G.L. 4439

Date	7-7-69		
Run No.	3		
Type Log	GRN		
Depth—Driller	11,895		
Depth—Logger	11,886		
Bottom logged interval	~~11,885~~ 217		
Top logged interval	10,786		
Type fluid in hole	SBM		
Salinity, PPM Cl.	>200,000		
Density	17.2		
Level	Full		
Max rec. temp., deg F.	~~190~~ @ 7-7-1800		
Operating rig time	2hr		
Recorded by	Thomas		
Witnessed by	McLehaney		

RUN	BORE-HOLE RECORD			CASING RECORD			
No.	Bit	From	To	Size	Wgt.	From	To
3	6 1/4	CSG	T.D	7	-	Surf.	8271

SCHLUMBERGER

BOREHOLE COMPENSATED SONIC LOG GAMMA RAY

S7-1-2152

COMPANY Shell Oil Company

WELL Federal 1-26

FIELD Wildcat

COUNTY Grand STATE Utah

COUNTY / FIELD or LOCATION / WELL / COMPANY

LOCATION 2050'sly - 800'wly fr N.E. Cor

Sec. 26 Twp. 21S Rge. 17E

Other Services: IES ST 234

Permanent Datum: K L, Elev. 4439

Log Measured From K.B, 13 Ft. Above Perm. Datum

Drilling Measured From K.B

Elev.: K.B. 4452 D.F. G.L. 4439

Date	3-21-69			
Run No.	1			
Depth—Driller	1780			
Depth—Logger	1780			
Btm. Log Interval	1777 564			
Top Log Interval	1222			
Casing—Driller	13 3/8 @ 1223	@	@	@
Casing—Logger	1222			
Bit Size	9"			
Type Fluid in Hole	FGM			
Dens. / Visc.	9.5 / 72			
pH / Fluid Loss	9.5 / 6.4 ml	ml	ml	ml
Source of Sample	C.F			
R_m @ Meas. Temp.	2.00 @ 61 °F	@ °F	@ °F	@ °F
R_{mf} @ Meas. Temp.	1.48 @ 61 °F	@ °F	@ °F	@ °F
R_{mc} @ Meas. Temp.	1.2 @ 61 °F	@ °F	@ °F	@ °F
Source: R_{mf} / R_{mc}	M / C			
R_m @ BHT	0.81 @ 105 °F	@ °F	@ °F	@ °F
Time Since Circ.	3 hr			
Max. Rec. Temp.	105 °F	°F	°F	°F
Equip. / Location	4529 / 4316			
Recorded By	G. Thomas			
Witnessed By	Koerperich & Fouch			

SCHLUMBERGER INDUCTION-ELECTRICAL LOG

COUNTY 37-1-2152
FIELD or LOCATION
WELL
COMPANY

COMPANY Shell Oil Company (1)

WELL Federal 1-26

FIELD Wildcat

COUNTY Grand STATE Utah

LOCATION 2050' s/y - 800' w/y fr N.E Cor. (9)

Sec. 26 Twp. 21S Rge. 17E

Other Services:
BHC/GR
DIL 21 234

Permanent Datum: G.L., Elev. 4439
Log Measured From K.B., 13 Ft. Above Perm. Datum
Drilling Measured From K.B

Elev.: K.B. ~~4452~~
D.F.
G.L. 4439

Date	4-30-69			
Run No.	1			
Depth—Driller	7560			
Depth—Logger	7560			
Btm. Log Interval	~~7559~~ 7229	(2)		
Top Log Interval	1400			
Casing—Driller	13 3/8 @ 1220	@	@	@
Casing—Logger	1222			
Bit Size	9"			
Type Fluid in Hole	FGM			
Dens. | Visc.	9.7 | 62			
pH | Fluid Loss	11.0 | 9.0 ml	ml	ml	ml
Source of Sample	Circ.			
R_m @ Meas. Temp.	1.03 @ 76 °F	@ °F	@ °F	@ °F
R_{mf} @ Meas. Temp.	0.54 @ 76 °F	@ °F	@ °F	@ °F
R_{mc} @ Meas. Temp.	0.90 @ 76 °F	@ °F	@ °F	@ °F
Source: R_{mf} R_{mc}	M | C			
R_m @ BHT	0.51 @ ~~146~~ °F	@ °F	@ °F	@ °F
Time Since Circ.	14 hr			
Max. Rec. Temp.	146 °F	°F	°F	°F
Equip. | Location	4529 | Vernal			
Recorded By	B. Thomas			
Witnessed By	E. Koepernick			

SCHLUMBERGER

SIDEWALL NEUTRON POROSITY LOG

S7-1-2152

COUNTY
FIELD or
LOCATION
WELL
COMPANY

COMPANY SHELL OIL COMPANY

WELL FEDERAL #1-26

FIELD WILDCAT

COUNTY GRAND STATE UTAH

Location: 2050' SLY. & 800' WLY. FROM NE CORNER

Sec. 26 Twp. 21S Rge. 17E

Other Services: LL, MLL, BHC-GR, FDC-GR 234

Permanent Datum: GL ; Elev.: 4439

Log Measured From KB, 13 Ft. Above Perm. Datum

Drilling Measured From KB

Elev.: K.B. 4452 D.F. G.L. 4439

Date	5-11-69
Run No.	ONE
Type Log	EPITHERMAL-NEUTRON
Depth—Driller	8271
Depth—Logger	8270
Bottom logged interval	~~8268~~ 8275
Top logged interval	SURFACE
Type fluid in hole	SBM
Salinity, PPM Cl.	85,000
Density	13.0
Level	FULL
Max rec. temp., deg F.	~~153°~~
Operating rig time	6 HR
Recorded by	PROBST
Witnessed by	KOEPERICH

(3)

TIGHT HOLE

RUN No.	BORE-HOLE RECORD Bit	From	To	CASING RECORD Size	Wgt.	From	To
1	9"	CSG	TD	13 3/8	34	SURFACE	1220

SCHLUMBERGER

BOREHOLE COMPENSATED SONIC LOG - GAMMA RAY

S7-1-2152

COUNTY
FIELD or LOCATION
WELL
COMPANY

COMPANY Shell Oil Company

WELL Federal No. 1-26 (2)

FIELD Wildcat

COUNTY Grand STATE Utah

LOCATION 2050'SLY & 800'WLY From NE Corner

Sec. 26 Twp. 21S Rge. 17E

Other Services:
ICS
GRN 234

Permanent Datum: GL, Elev. 4439
Log Measured From KB, 13 Ft. Above Perm. Datum
Drilling Measured From KB

Elev.: K.B. ~~4452~~
D.F. —
G.L. 443

Date	6-6-69			
Run No.	4			
Depth—Driller	9653			
Depth—Logger	8470			
Btm. Log Interval	8468			
Top Log Interval	7800			
Casing—Driller	7" @ 8271	@	@	@
Casing—Logger	8273	(4)		
Bit Size	6 1/4"			
Type Fluid in Hole	SBM			
Dens. | Visc.	17.1 | 100			
pH | Fluid Loss	9.5 | 5.2ml	ml	ml	
Source of Sample	Flow Line			
R_m @ Meas. Temp.	0.34 @ 72°F	@ °F	@ °F	@
R_{mf} @ Meas. Temp.	0.14 @ 72 °F	@ °F	@ °F	@
R_{mc} @ Meas. Temp.	0.16 @ 72 °F	@ °F	@ °F	@
Source: R_{mf} R_{mc}	M | M			
R_m @ BHT	0.15 @ [illegible] °F	@ °F	@ °F	@
Time Since Circ.	4 HR			
Max. Rec. Temp.	161 °F	°F	°F	
Equip. | Location	4529 | Verna			
Recorded By	Godfrey			
Witnessed By	Roberich			

ECU-234

Sec 26, TRIS-RITE

EST. COMP. - LITHO LOG BY UNDERWOOD

log begins 45'

	THICKNESS	% sh silt st	% ss	% carb	% cong ~~GTA~~	ϕe
SURFACE - MANCOS	BOTTOM	100	0	✓		4.0
DAKOTA ?						
MORRISON (INCL. SALTWASH)	800	45	55			7.3
CURTIS	340	25	75			8.5
ENTRADA	315	15	85			9.1
CARMEL	130	40	60			7.6
NAVAJO	395	5	95			9.7
KAYENTA	95	10	90			9.4
WINGATE	455	10	90			9.4
CHINLE	273	90	10			4.6
SHINARUMP	37	90	10			4.6
MOENKOPI	748	72	14	11	3*	5.3
WHITE RIM	202	10	90			9.4
CUTLER	230	49	48	3		7.0
ELEPHANT CAN.'	790	14	20	66		7.2
HONAKER TR	1670	25	20	55		6.8
PARADOX	?	15?		10	salt anhyd 75	8.8

SALT AT 7920

TD ~~12~~ 12,000' IN PENNSYLVANIAN

BHTS 61° @ 1777 ①

146 @ 7559 ②

153 @ 8265 ③

161 @ 8468 ④

165 @ 10786 ⑤

* prob shale

ls = 7

ss = 10

sh = 4

Form 9-331 C
(May 1963)

SUBMIT IN TRIPLICATE*
(Other instructions on reverse side)

Form approved.
Budget Bureau No. 42-R1425.

234

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

APPLICATION FOR PERMIT TO DRILL, DEEPEN, OR PLUG BACK

1a. TYPE OF WORK: DRILL ☒ DEEPEN ☐ PLUG BACK ☐

b. TYPE OF WELL: OIL WELL ☒ GAS WELL ☐ OTHER — SINGLE ZONE ☐ MULTIPLE ZONE ☐

2. NAME OF OPERATOR
Shell Oil Company

3. ADDRESS OF OPERATOR
1600 Norris Road, Bakersfield, California 93308

4. LOCATION OF WELL (Report location clearly and in accordance with any State requirements.*)
At surface **820± ft. from east line and 2140± ft. from north line, Section 26, T. 21 S., R. 17 E., S.L.B. &M. (location plat to follow)**
At proposed prod. zone **Same.** SW SENE

5. LEASE DESIGNATION AND SERIAL NO.
Samford C.R. #1. Salt Lake U7121

6. IF INDIAN, ALLOTTEE OR TRIBE NAME
N.A.

7. UNIT AGREEMENT NAME
N.A.

8. FARM OR LEASE NAME
Federal

9. WELL NO.
No. 1-26

10. FIELD AND POOL, OR WILDCAT
Wildcat

11. SEC., T., R., M., OR BLK. AND SURVEY OR AREA
Section 26, T. 21 S., R. 17 E., S.L.M.

12. COUNTY OR PARISH
Grand

13. STATE
Utah

14. DISTANCE IN MILES AND DIRECTION FROM NEAREST TOWN OR POST OFFICE*

15. DISTANCE FROM PROPOSED* LOCATION TO NEAREST PROPERTY OR LEASE LINE, FT. (Also to nearest drlg. unit line, if any)
820± ft. from east line

16. NO. OF ACRES IN LEASE
2000 Ac.

17. NO. OF ACRES ASSIGNED TO THIS WELL
80

18. DISTANCE FROM PROPOSED LOCATION* TO NEAREST WELL, DRILLING, COMPLETED, OR APPLIED FOR, ON THIS LEASE, FT.

19. PROPOSED DEPTH
12,000 Ft.

20. ROTARY OR CABLE TOOLS
Rotary

21. ELEVATIONS (Show whether DF, RT, GR, etc.)
4440 Ft. ground.

22. APPROX. DATE WORK WILL START*
March 1, 1969

23. PROPOSED CASING AND CEMENTING PROGRAM

SIZE OF HOLE	SIZE OF CASING	WEIGHT PER FOOT	SETTING DEPTH	QUANTITY OF CEMENT
26"	20"		40±'	
17-1/2"	13-3/8"	54.5#	1200±'	800 sacks

Surface formation: Mancos

1. **Drill 26" hole to 40±' and set 20" conductor pipe.**
2. **Drill 17-1/2" hole to 1200±'. Run and cement 13-3/8", 54.5#, J-55 casing with 800± sacks.**
3. **Install 12" Series 900 double hydraulic gate with blank and pipe rams and 12" Series 900 GK Hydril. Test BOPE and casing with 1000 psi for 15 min.**
4. **Drill 9-7/8" hole to 12,000±' (Mississippian).**

This is a prospect well, and casing program will depend upon formations encountered. Please keep all information private and confidential.

IN ABOVE SPACE DESCRIBE PROPOSED PROGRAM: If proposal is to deepen or plug back, give data on present productive zone and proposed new productive zone. If proposal is to drill or deepen directionally, give pertinent data on subsurface locations and measured and true vertical depths. Give blowout preventer program, if any.

24.
SIGNED Robert L Spotswood TITLE Division Exploration Engr. DATE 2/18/69

(This space for Federal or State office use)

PERMIT NO. 43-019-30029 APPROVAL DATE

APPROVED BY TITLE DATE

CONDITIONS OF APPROVAL, IF ANY:

*See Instructions On Reverse Side

NOT FOR PUBLIC INSPECTION

ORAL APPROVAL TO PLUG AND ABANDON WELL

Operator Shell Oil Co Representative Ed Koerperich

Well No. 1-26 Located SE NW Sec. 26 Twp. 21 S Range 17 E

Lease No. U-7121 Field WC State

Unit Name and Required Depth N/A Base of fresh water sands —

T.D. 11,895 Size hole and Fill per sack — — Mud Weight and Top 10+

Casing Size	Set At	Top of Cmt	To Be Pulled	Plugging Requirements
13 3/8"	@ 1220'	surface	none	— set 100' plug in top of 7" & under
7"	@ 8271	5475	none	— set 100' plug in 7"–13 3/8" annulus

Formation	Top	Remarks
Morrison	1440 ✓	
Curtis	2240 ✓	
Entrada	2580 ✓	
Carmel	2895 ✓	
Navajo	3025 ✓	— will perforate & circulate at least 100' plug across top of Navajo
Kayenta	3420 ✓	
Wingate	3515 ✓	
Chinle	3970 ✓	
Shinarump	4243 ✓	
Moenkopi	4280 ✓	
White Rim	5028 ✓	— Will perforate & circulate at least 100' plug across top of White Rim – base Moenkopi
Cutler	5230 ✓	
Elephant Can.	5460 ✓	
Honaker Tr.	6250 ✓	— set CIBP topped w/300' cmt in base of 7"
Salt	7920	
L. Hermosa	?	11,895 – 11,795 if able to get loose

Prob. did not penetrate Mississippian

Remarks: DST's, lost circulation zones, water zones, etc. No soluable salts below 8275. DST ± 8200-8300? showed no permeability (ran on shale gas show). DST @ 6455 rec salt water. No sig shows of hydrocarbons. lost 3' 11,893-95' lost circulation & have been having hole problems. At TD & stuck. Will run γ ray-neutron

Approved by Rodney A. Smith Date 7/7/69 Time 9:00

sidewall shots, gravimeter & try to get loose. If

234

0 – 1270 Mancos (incl Dak Silt) 4.1

1270 – 1440 Dakota

1440 – 2240 Morrison (highest for Jm) 7.3

BHT ① 61 at 1770 k_e = 5.0

1270	× 4.1	5207
170	× 7.7	1309
330	× 7.3	2409
1770		8925

BHT ② 146 @ 7559 k_e = 7.2

1270	× 4.1	5207	
170	× 7.7	1309	
800	× 7.3	5840	
340	× 8.6	2890	$\frac{22932}{3420} = 6.7$
315	× 9.1	2866	
130	× 7.6	988	
395	× 9.7	3832	
4139	× 7.6	31456	
7559		54390	7.2

Jn

(use for Glen Can → Nonaker

BHT ③ 153° @ 8268 k_e = 7.2

3420	× 6.7	22914
4848	× 7.6	36845
8268		59759

continued

BHT (4) 161° @ 8468 $k_e = 7.3$

3420 x 6.7	22914
4500 x 7.6	34200
548 x 9.0	4932
8468	62046

BHT (5) 165 @ 10786 $k_e = 7.7$

3420 x 6.7	22914
4500 x 7.6	34200
2866 x 9.0	25794
10786	82908

~~50 (?) Anschutz Fed 104 #1~~

Shell Fed # 1-26 sec 26, 21S-17E

Water encountered

6465-6615 2100' Lod (30 Bbl)

NaCl 177,000 ppm

	depth
Jm	1440
Curtis	2240
Je	2580
Carmel	2895
Jn	3025
Kayenta	3420
Wingate	3615
Chinle	3970
Shinarump	4243
Moenkopi	4280
White Rim	5028
Cutler	5230
Elephant C	5460
Honaker	6250
Salt	7920

prob did not penetrate Mississippian

total depth 11895

Duplicated

log is 14' long

cardboard box loose copies

100% Sh 0-1270

20% Sh 1270-1460

30% Sh 1460-2200

15% Sh 2200-3000

90% SS - 3000-3960

90% Sh - 3960-4940

95% SS - 4940-5200

50-50 Sh/SS - 5200-5450

60 ls / 40 sh } 5450-7920

7920 ↓ salt

SCHLUMBERGER

BOREHOLE COMPENSATED SONIC LOG - GAMMA RAY

COUNTY
FIELD or LOCATION
WELL
COMPANY

57-1-2153

COMPANY SHELL OIL CO.

WELL MOUNTAIN FUEL FEDERAL 1-21

FIELD WILDCAT

COUNTY GRAND STATE UTAH

LOCATION
627 FWL, 608 FNL
Sec. 21 Twp. 23-S Rge. 18E

Other Services:
DIL 297

Permanent Datum: GL, Elev. 4510
Log Measured From KB, 15 Ft. Above Perm. Datum
Drilling Measured From KB

Elev.: K.B. 4525
D.F. 4524
G.L. 4510

Date	8-1-69						
Run No.	ONE						
Depth—Driller	1821						
Depth—Logger	1822						
Btm. Log Interval	1820						
Top Log Interval	120						
Casing—Driller	@		@		@		@
Casing—Logger	32						
Bit Size	12¼						
Type Fluid in Hole	LIME						
Dens. / Visc.	9.1	36					
pH / Fluid Loss	11.0	12.4 ml		ml		ml	
Source of Sample	FLOW LINE						
R_m @ Meas. Temp.	3.07 @ 80 °F		@	°F	@	°F	
R_{mf} @ Meas. Temp.	3.13 @ 80 °F		@	°F	@	°F	
R_{mc} @ Meas. Temp.	4.10 @ 80 °F		@	°F	@	°F	
Source: R_{mf} R_{mc}	M	CB					
R_m @ BHT	— @ — °F		@	°F	@	°F	
Time Since Circ.	2½ HRS						
Max. Rec. Temp.	TLTM °F			°F			
Equip. / Location	3860 FARH						
Recorded By	WELLS & LEBSACK						
Witnessed By	MR. McLEHANEY						

TIGHT HOLE

FIELD PRINT

SCHLUMBERGER

BOREHOLE COMPENSATED SONIC LOG - GAMMA RAY

COUNTY
FIELD or LOCATION
WELL API No 43-019-30038
COMPANY

57-1-2153

COMPANY Shell Oil Company

(1)

WELL Mountain Fuel Federal 1-21

FIELD Wildcat

COUNTY Grand STATE Utah

LOCATION 627 FWL
608 FNL

Sec. 21 Twp. 23S Rge. 18E

Other Services:
FDC/GR
SNP/GR
DIL 297

Permanent Datum: G.L., Elev. 4510
Log Measured From K.B., 15 Ft. Above Perm. Datum
Drilling Measured From K.B.

Elev.: K.B. 4525
D.F.
G.L. 4510

Date	8-24-69			
Run No.	1			
Depth—Driller	5732			
Depth—Logger	5737			
Btm. Log Interval	~~5734~~ 5734			
Top Log Interval	1823			
Casing—Driller	9 5/8 @ 1821	@	@	@
Casing—Logger	1823			
Bit Size	8 3/4			
Type Fluid in Hole	Clay Base			
Dens. / Visc.	8.9 / 40	/	/	/
pH / Fluid Loss	11.0 / 8.8 ml	/ ml	/ ml	/ r
Source of Sample	Circ.			
R_m @ Meas. Temp.	0.816 @ 66 °F	@ °F	@ °F	@
R_{mf} @ Meas. Temp.	0.645 @ 76 °F	@ °F	@ °F	@
R_{mc} @ Meas. Temp.	0.86 @ 66 °F	@ °F	@ °F	@
Source: R_{mf} R_{mc}	M / C	/	/	/
R_m @ BHT	0.414 @ 130 °F	@ °F	@ °F	@
Time Since Circ.	20 hr			
Max. Rec. Temp.	130 °F	°F	°F	
Equip. / Location	5616 / 4316	/	/	/
Recorded By	G. Thomas			
Witnessed By	D McElhaney			

surface probably Morrison —

began logging at 30'

	Interval	sh	ss	ls	Anhyd Salt		
670	30 – 700	40	50	5		7.0	4690
300	700 – 1700	5	95			9.7	2910
300	1700 – 2000	60	20	20		5.8	1740
1000'	2000 – 3000	50	45	5		6.8	6800
1000'	3000 – 4000	45	40	15		6.8	6800
BHT 1000'	4000 – 5000	20	20	60		7.0	7000
735	5000 – 5735	10	30	60		7.6	5586
5005 265'	5735 – 6000			40	60 35520	8.8	2332
1000'	6000 – 7000		Paradox	20	80	9.4	9400
1000'	7000 – 8000	15			85	9.1	9100
1000'	8000 – 9000	5			95 41542	9.7	9700
1000'	9000 – 10000	15		25	60	9.1	9100
330	10000 – 10330	—	—	100	—	7.0	2310

4595

9600

ke (above Paradox) = 7.1

ke (Paradox) = 9.1

Total hole = 7.9

sh 4

ss 10

ls 7

salt anhyd 10

BHTs

130 @ 5734 ke = 7.1

164 @ 10330 ke = 8.1

ECU 307

sec 1, 24S-17E

surface on Glen Canyon

salt 5216 – 8600

TD 9125

	% sh	% ss	% ls	Ke		
0 – 1000'	10	90		9.4	9400	
1000 – 2000	75	25		5.5	5500	
2000 – 3000	60	30	10	6.1	6100	
3000 – 4000	25	15	55	6.4	6400	$K_e = 7.0$
4000 – 5000	5	25	70	7.6	7600	
5000 – 5216	45	25	30	6.4	1382	
					36382	

Note 7.6 on 318

BHTs

	Ke weighted from surface
95°F @ 1474	8.4
119° @ 5218	7.0
143 @ 9125	7.7

SCHLUMBERGER

BOREHOLE COMPENSATED SONIC LOG - GAMMA RAY

S7-1-216

COMPANY SHELL OIL COMPANY

(3)

WELL SHELL - QUINTANA # 1-1

FIELD WILDCAT

COUNTY GRAND STATE UTAH

COUNTY
FIELD or LOCATION
WELL
COMPANY

LOCATION 1602'E & 1566'N FROM SW CORNER

Sec. 1 Twp. 24S Rge. 17E

Other Services: DIL

(307)

Permanent Datum: GL, Elev. 4465

Log Measured From KB, 14 Ft. Above Perm. Datum

Drilling Measured From KB

Elev.: K.B. 4479
D.F.
G.L. 4465

Date	10-6-69			
Run No.	ONE	API No. 43-019-30042		
Depth—Driller	1475			
Depth—Logger	1476			
Btm. Log Interval	~~1474~~ 54.4			
Top Log Interval	SURFACE			
Casing—Driller	20" @ 10	@	@	@
Casing—Logger	20			
Bit Size	12 1/4			
Type Fluid in Hole	FGM			
Dens. / Visc.	9.5 / 43	/	/	/
pH / Fluid Loss	11 / 12.2 ml	/ ml	/ ml	/ ml
Source of Sample	FLOW LINE			
R_m @ Meas. Temp.	2.36 @ 66 °F	@ °F	@ °F	@ °F
R_{mf} @ Meas. Temp.	1.93 @ 58 °F	@ °F	@ °F	@ °F
R_{mc} @ Meas. Temp.	3.65 @ 63 °F	@ °F	@ °F	@ °F
Source: R_{mf} R_{mc}	M / M	/	/	/
R_m @ BHT	1.65 @ ~~95~~ °F	@ °F	@ °F	@ °F
Time Since Circ.	3 HR			
Max. Rec. Temp.	95 °F	°F	°F	°F
Equip. / Location	4544 / VERNAL	/	/	/
Recorded By	PROBST			
Witnessed By	MC LEHANEY			

SCHLUMBERGER

BOREHOLE COMPENSAT
SONIC LOG - GAMMA R

5/1-2160

COUNTY
FIELD or LOCATION
WELL
COMPANY

COMPANY SHELL OIL COMPANY
307

WELL QUINTANA #1-1 (2)

FIELD WILDCAT

COUNTY GRAND STATE UTAH

LOCATION 1602'E & 1566'N FROM SW CORNER

Sec. 1 Twp. 24S Rge. 17E

Other Servi
DIL
SNP-G
FDC-G
CST

Permanent Datum: GL, Elev. 4465
Log Measured From KB, 14 Ft. Above Perm. Datum
Drilling Measured From KB

Elev.: K.B. 4
307 D.F. 4
G.L. 4

Date	10-23-69		API NO.		43-019-30042			
Run No.	TWO							
Depth—Driller	5216							
Depth—Logger	5220							
Btm. Log Interval	~~5218~~ 5218							
Top Log Interval	1479							
Casing—Driller	9 5/8 @ 1475		@		@			
Casing—Logger	1479							
Bit Size	8 3/4							
Type Fluid in Hole	GEL							
Dens. | Visc.	9.1	41						
pH | Fluid Loss	11.0	7.8 ml		ml		ml		
Source of Sample	FLOWLINE							
R_m @ Meas. Temp.	1.03 @ 64 °F		@	°F	@	°F		
R_{mf} @ Meas. Temp.	0.80 @ 64 °F		@	°F	@	°F		
R_{mc} @ Meas. Temp.	1.24 @ 66 °F		@	°F	@	°F		
Source: R_{mf} R_{mc}	M	M						
R_m @ BHT	0.55 @ ~~119~~ °F		@	°F	@	°F		
Time Since Circ.	14 H							
Max. Rec. Temp.	119 °F			°F		°F		
Equip. | Location	3860	FARM						
Recorded By	WELLS							
Witnessed By	MCLEHANEY & DOGAN							

FIELD PRINT

SCHLUMBERGER

BOREHOLE COMPENSATED SONIC LOG - GAMMA RAY

57-1-2160

COUNTY
FIELD or LOCATION
WELL
COMPANY

COMPANY SHELL OIL COMPANY

(1)

WELL QUINTANA # 1-1

FIELD WILDCAT 307

COUNTY GRAND STATE UTAH

LOCATION
1602'E & 1566'N FROM SW CORNER
Sec. 1 Twp. 24S Rge. 17E

Other Services:
L-GR
SNP-GR
FDC-GR
CIS
PDT 307

Permanent Datum: GL, Elev. 4465
Log Measured From KB, 14 Ft. Above Perm. Datum
Drilling Measured From KB

Elev.: K.B. 4479
D.F.
G.L. 4465

Date	11-9-69			
Run No.	THREE			
Depth—Driller	9140			
Depth—Logger	9134			
Btm. Log Interval	9125			
Top Log Interval	5218			
Casing—Driller	9 5/8 @ 1475	@	@	@
Casing—Logger	-			
Bit Size	8 3/4"			
Type Fluid in Hole	SALT BASE			
Dens. / Visc.	10.6 / 38			
pH / Fluid Loss	11.0 / 9.2 ml	ml	ml	ml
Source of Sample	FLOWLINE			
R_m @ Meas. Temp.	.057 @ 70 °F	.030 @ 143 °F	@ °F	@ °F
R_{mf} @ Meas. Temp.	.051 @ 70 °F	.028 @ 143 °F	@ °F	@ °F
R_{mc} @ Meas. Temp.	.080 @ 70 °F	.041 @ 143 °F	@ °F	@ °F
Source: R_{mf} R_{mc}	M / M			
R_m @ BHT	.030 @ 143 °F	@ °F	@ °F	@ °F
Time Since Circ.	19 HRS			
Max. Rec. Temp.	143 °F	°F	°F	°F
Equip. / Location	5625 / FARM			
Recorded By	WELLS & MCRAE			
Witnessed By	MCELHANEY & DOGAN			

FIELD PRINT

ECU 311 (new)

Sec 7, T 24S - R21E

Began logging at 1000' in Kayenta

	THICK	sh %	ss %	ls %
Kayenta	BOTTOM 173'	20	80	88
Wingate	397	35	65	7.9
Chinle	810	50	50	7.0
Moenkopi ?	?	80	20	5.2
White Rim	Top 155	45	55	7.3

Bottom in White Rim at 4964'

~~4809~~

155

BHTs' 90° F @ 4785

94° F @ 4965

311

① 90° @ 4785 $R_e = 6.6$

94 @ 4964 $R_e = 6.6$

log begins at 1000' in Kayenta Surface

ut	Jurassic	373	@ 8.0	2984
	Navajo	500	@ 9.5	4750
	Kayenta	300	@ 8.8	2640
	Wingate	397	@ 7.9	3136
	Chinle	810	@ 7.0	5670
	?	2429	@ 5.2	12631
		4809		31811

use for both 6.6

Form 9-330
(Rev. 5-63)

311

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SUBMIT IN DUPLICATE* (See other instructions on reverse side)

Form approved.
Budget Bureau No. 42-R355.5.

WELL COMPLETION OR RECOMPLETION REPORT AND LOG*

5. LEASE DESIGNATION AND SERIAL NO.: Utah #0140959

6. IF INDIAN, ALLOTTEE OR TRIBE NAME:

7. UNIT AGREEMENT NAME:

8. FARM OR LEASE NAME: Cullen-H.S. Pet.-Gov't

9. WELL NO.: #1

10. FIELD AND POOL, OR WILDCAT: Wildcat

11. SEC., T., R., M., OR BLOCK AND SURVEY OR AREA: Sec. 7, T.24S-R.21E SLB&M

1a. TYPE OF WELL: OIL WELL ☐ GAS WELL ☐ DRY ☒ Other

b. TYPE OF COMPLETION: NEW WELL ☐ WORK OVER ☐ DEEP-EN ☐ PLUG BACK ☐ DIFF. RESVR. ☐ Other

2. NAME OF OPERATOR: Ferguson & Bosworth

3. ADDRESS OF OPERATOR: P.O. Bin 2427, Bakersfield, California 93303

4. LOCATION OF WELL (*Report location clearly and in accordance with any State requirements*)*
At surface 660'S of N. Line & 660'W of E Line of Sec. 7
At top prod. interval reported below
At total depth

14. PERMIT NO. | DATE ISSUED

12. COUNTY OR PARISH: Grand | 13. STATE: Utah

15. DATE SPUDDED	16. DATE T.D. REACHED	17. DATE COMPL. (*Ready to prod.*)	18. ELEVATIONS (DF, RKB, RT, GR, ETC.)*	19. ELEV. CASINGHEAD
12-9-72	2-20-72	Abd. 2-21-72	4855' K.B.	--

20. TOTAL DEPTH, MD & TVD	21. PLUG, BACK T.D., MD & TVD	22. IF MULTIPLE COMPL., HOW MANY*	23. INTERVALS DRILLED BY	ROTARY TOOLS	CABLE TOOLS
4964'			→	Rotary	--

24. PRODUCING INTERVAL(S), OF THIS COMPLETION—TOP, BOTTOM, NAME (MD AND TVD)*: None

25. WAS DIRECTIONAL SURVEY MADE: NO

26. TYPE ELECTRIC AND OTHER LOGS RUN: Electric Log & Gamma-Ray Neutron

27. WAS WELL CORED: NO

28. CASING RECORD (*Report all strings set in well*)

CASING SIZE	WEIGHT, LB./FT.	DEPTH SET (MD)	HOLE SIZE	CEMENTING RECORD	AMOUNT PULLED
9-5/8"	32.30	254'	13-3/4"	225 Sacks Class A	None

29. LINER RECORD

SIZE	TOP (MD)	BOTTOM (MD)	SACKS CEMENT*	SCREEN (MD)
None				

30. TUBING RECORD

SIZE	DEPTH SET (MD)	PACKER SET (MD)
None		

31. PERFORATION RECORD (*Interval, size and number*): None

32. ACID, SHOT, FRACTURE, CEMENT SQUEEZE, ETC.

DEPTH INTERVAL (MD)	AMOUNT AND KIND OF MATERIAL USED

33.* PRODUCTION

DATE FIRST PRODUCTION	PRODUCTION METHOD (*Flowing, gas lift, pumping—size and type of pump*)	WELL STATUS (*Producing or shut-in*)

DATE OF TEST	HOURS TESTED	CHOKE SIZE	PROD'N. FOR TEST PERIOD →	OIL—BBL.	GAS—MCF.	WATER—BBL.	GAS-OIL RATIO

FLOW. TUBING PRESS.	CASING PRESSURE	CALCULATED 24-HOUR RATE →	OIL—BBL.	GAS—MCF.	WATER—BBL.	OIL GRAVITY-API (CORR.)

34. DISPOSITION OF GAS (*Sold, used for fuel, vented, etc.*)

TEST WITNESSED BY

35. LIST OF ATTACHMENTS

36. I hereby certify that the foregoing and attached information is complete and correct as determined from all available records

SIGNED John R Amundsen TITLE Engineer DATE 4-06-73

John Amundsen

*(See Instructions and Spaces for Additional Data on Reverse Side)

INSTRUCTIONS

General: This form is designed for submitting a complete and correct well completion report and log on all types of lands and leases to either a Federal agency or a State agency, or both, pursuant to applicable Federal and/or State laws and regulations. Any necessary special instructions concerning the use of this form and the number of copies to be submitted, particularly with regard to local, area, or regional procedures and practices, either are shown below or will be issued by, or may be obtained from, the local Federal and/or State office. See instructions on items 22 and 24, and 33, below regarding separate reports for separate completions.

If not filed prior to the time this summary record is submitted, copies of all currently available logs (drillers, geologists, sample and core analysis, all types electric, etc.), formation and pressure tests, and directional surveys, should be attached hereto, to the extent required by applicable Federal and/or State laws and regulations. All attachments should be listed on this form, see item 35.

Item 4: If there are no applicable State requirements, locations on Federal or Indian land should be described in accordance with Federal requirements. Consult local State or Federal office for specific instructions.

Item 18: Indicate which elevation is used as reference (where not otherwise shown) for depth measurements given in other spaces on this form and in any attachments.

Items 22 and 24: If this well is completed for separate production from more than one interval zone (multiple completion), so state in item 22, and in item 24 show the producing interval, or intervals, top(s), bottom(s) and name(s) (if any) for only the interval reported in item 33. Submit a separate report (page) on this form, adequately identified, for each additional interval to be separately produced, showing the additional data pertinent to such interval.

Item 29: "*Sacks Cement*": Attached supplemental records for this well should show the details of any multiple stage cementing and the location of the cementing tool.

Item 33: Submit a separate completion report on this form for each interval to be separately produced. (See instruction for items 22 and 24 above.)

37. SUMMARY OF POROUS ZONES:
SHOW ALL IMPORTANT ZONES OF POROSITY AND CONTENTS THEREOF; CORED INTERVALS; AND ALL DRILL-STEM TESTS, INCLUDING DEPTH INTERVAL TESTED, CUSHION USED, TIME TOOL OPEN, FLOWING AND SHUT-IN PRESSURES, AND RECOVERIES

FORMATION	TOP	BOTTOM	DESCRIPTION, CONTENTS, ETC.

38. GEOLOGIC MARKERS

NAME	TOP	
	MEAS. DEPTH	TRUE VERT. DEPTH
Kayenta	885'	
Wingate	1173'	
Chinle	1570'	
Moenkopi	2380'	
White Rim	4809'	

APR 16 1973

U.S. GOVERNMENT PRINTING OFFICE: 1953—O-883636

31

Schlumberger

GAMMA RAY—NEUTRON

COUNTY GRAND
FIELD or LOCATION WILDCAT
WELL CULLEN H.S.-PETRO -GOVERNMENT NO. 1
COMPANY FERGUSON & BOSWORTH

COMPANY FERGUSON AND BOSWORTH

311

WELL CULLEN-H. S. PETROLEUM-GOV'T. NO. 1

FIELD WILDCAT

COUNTY GRAND STATE UTAH

Location:
NE/4
Sec. 7 Twp. 24S Rge. 21E

Other Services:
ES
31

Permanent Datum: GL ; Elev.: 4845
Log Measured From KB , 10 Ft. Above Perm. Datum
Drilling Measured From KB

Elev.: K.B. 4855
D.F. ----
G.L. 4845

Date	2-19-73	2-21-73
Run No.	ONE	TWO
Type Log	G.R.N.	G.R.N.
Depth—Driller	4785	4964
Depth—Logger	4786	4966
Bottom logged interval	4785 14.9	4965 15.8
Top logged interval	20	4500
Type fluid in hole	FRESH GEL	FRESH GEL
Salinity, PPM Cl.	NIL	----
Density	9.0	9.2
Level	FULL	FULL
Max rec. temp., deg F.	90	94
Operating rig time	5 HOURS	6 HOURS
Recorded by	DANTI	YATCHAK & WILLIAMS
Witnessed by	AMUNDSEN & TONIETTE	AMUNDSEN & TONIETTE

RUN No.	BORE-HOLE RECORD Bit	From	To	CASING RECORD Size	Wgt.	From	To
1	8-3/4	250	2410	9-5/8	32	SURF	250
1	7-7/8	2410	2937				
1	6-3/4	2937	4785				
2	6-3/4	4500	4964	9-5/8	---	SURF	4500

SWS—687-F

ECU 316

use Values 318

Surface Glen Canyon

Paradox (salt) 4060 – 7100

TD 7850

BHTs		fe weighted from surface
86°F @	2081	8.5
102°F @	4059	7.6
116 @	6165	8.1
120 @	7850	8.0

SCHLUMBERGER

DUAL INDUCTION-LATEROLOG — GAMMA RAY

57-1-2154

COUNTY
FIELD or LOCATION
WELL
COMPANY

COMPANY SHELL OIL COMPANY

316

WELL FEDERAL #1-20

FIELD WILDCAT

COUNTY GRAND STATE UTAH

LOCATION
1430' FNL, 892' FEL

Sec. 20 Twp. 25S Rge. 18E

Other Services:
L-GR
SNP-GR
FDC-GR
FDT, SRS

Permanent Datum: GL, Elev. 5125
Log Measured From KB, Ft. Above Perm. Datum
Drilling Measured From KB

Elev.: K.B. 5143
D.F. 5142
G.L. 5125

Date	10-25-69	API No. 43-019-30043	
Run No.	TWO		
Depth—Driller	7856		
Depth—Logger	7852		
Btm. Log Interval	7850		
Top Log Interval	6560		
Casing—Driller	7" @6563	@	@
Casing—Logger	6560		
Bit Size	6 1/8"		
Type Fluid in Hole	SALT BASE		
Dens. / Visc.	10.5 / 36		
pH / Fluid Loss	6.4 / 6.0 ml	ml	ml
Source of Sample	FLOWLINE		
R_m @ Meas. Temp.	.058 @ 69 °F	@ °F	@ °F
R_{mf} @ Meas. Temp.	.044 @ 75 °F	@ °F	@ °F
R_{mc} @ Meas. Temp.	.055 @ 75 °F	@ °F	@ °F
Source: R_{mf} / R_{mc}	M / M		
R_m @ BHT	.634 @ 120 °F	@ °F	@ °F
Time Since Circ.	12 HRS		
Max. Rec. Temp.	120 °F	°F	°F
Equip. / Location	3860 / FARM		
Recorded By	WELLS		
Witnessed By	MCELHANEY		

FIELD PRINT

SCHLUMBERGER

NEUTRON POROSITY LOG

S7-1-2154

COUNTY
FIELD or LOCATION
WELL
COMPANY

COMPANY SHELL OIL COMPANY

316

WELL FEDERAL #1-20

FIELD WILDCAT

COUNTY GRAND STATE UTAH

Location: 1430 FNL & 892 FEL

Sec. 20 Twp. 25 S Rge. 18 E

Other Services
IHLL-3, GR
FDC-GR
SNC-GR-
DOT

Permanent Datum: GL ; Elev.: 5125

Log Measured From KB, 17 Ft. Above Perm. Datum

Drilling Measured From KB

Elev.: K.B. 5142
D.F. 5141
G.L. 5125

Date	10-7-69	API-43-019-3007
Run No.	TWO	
Type Log	SNP-GR	
Depth—Driller	6564	
Depth—Logger	6562	
Bottom logged interval	~~6561~~ 6561	
Top logged interval	3500	
Type fluid in hole	SALT-SAT.	
Salinity, PPM Cl.	130,000	
Density	10.5	
Level	FULL	
Max rec. temp., deg F.	~~146~~ 146°F AT 1300 HOURS	
Operating rig time	4 HRS	
Recorded by	KUSEV & LEBSACK	
Witnessed by	MCLEHANEY & MASON	

RUN No.	BORE-HOLE RECORD Bit	From	To	CASING RECORD Size	Wgt.	From	To
2	8 3/4	2085	6564	9 5/8	—	SURF	2085

SCHLUMBERGER

BOREHOLE COMPENSATED SONIC LOG - GAMMA RAY

57-1-2154

COUNTY
FIELD or LOCATION
WELL
COMPANY

COMPANY SHELL OIL COMPANY

WELL FEDERAL #1-20 316

FIELD WILDCAT

COUNTY GRAND STATE UTAH

LOCATION
1430' FNL, 892' FEL
Sec. 20 Twp. 25-S Rge. 18 E

Other Services:
DIL
SNP-GR
FDC-GR
316

Permanent Datum: GL, Elev. 5125
Log Measured From KB, 17 Ft. Above Perm. Datum
Drilling Measured From KB

Elev.: K.B. 5142
D.F. 5141
G.L. 5125

Date	9-26-69		
Run No.	ONE		
Depth—Driller	4057		
Depth—Logger	4062		
Btm. Log Interval	~~4059~~	22.9	
Top Log Interval	2085		
Casing—Driller	9 5/8 @ 2085	@	@ @
Casing—Logger	2085		
Bit Size	8 3/4		
Type Fluid in Hole	FGM		
Dens. / Visc.	9.0 / 41		
pH / Fluid Loss	11.0 / 8.6 ml	ml	ml
Source of Sample	FLOW LINE		
R_m @ Meas. Temp.	0.71 @ 79 °F	0.55 @ 102 °F	@ °F @
R_{mf} @ Meas. Temp.	0.64 @ 80 °F	0.50 @ 102 °F	@ °F @
R_{mc} @ Meas. Temp.	0.55 @ 102 °F	@ °F	@ °F @
Source: R_m / R_{mf}	M / C		
R_m @ BHT	0.55 @ ~~102~~	@ °F	@ °F @
Time Since Circ.	16 HRS		
Max. Rec. Temp.	102 °F	°F	°F
Equip. No. & Location	4542 FARM		
Recorded By	RUSEN & LEBSACK		
Witnessed By	MR. McLEVANEY & MR. MASON		

Dresser Atlas

Dual Induction Focused Log

FILE NO.

FIELD PRINT

57-1-2154

?

THANKS

COMPANY SHELL OIL COMPANY

WELL FEDERAL 1-20

FIELD WILDCAT

COUNTY GRAND STATE UTAH

LOCATION: SW SE NE

1430' S. and 892' W. FROM N.E. CORNER OF SLBM

SEC 20 TWP 25 S RGE 18 E

Other Services:

GR-BHC-AL

316

Permanent Datum G.L. Elev. 5125

Log Measured from KB 17.0 Ft. Above Permanent Datum

Drilling Measured from KB

Elevations:

KB [redacted]

DF —

GL 5125

Date	9-16-69			
Run No.	ONE			
Depth—Driller	2085			
Depth—Logger	2083			
Bottom Logged Interval	[redacted] 30.7			
Top Logged Interval	31			
Casing—Driller	20" @ 29	@	@	@
Casing—Logger	31			
Bit Size	12 ¼"			
Type Fluid in Hole	WATER GEL			
Density and Viscosity	9.3 / 47			
pH and Fluid Loss	8.8 / 9.2 cc	cc	cc	cc
Source of Sample	PIT			
Rm @ Meas. Temp.	3.84 @ 70 °F	@ °F	@ °F	@
Rmf @ Meas. Temp.	3.55 @ 70 °F	@ °F	@ °F	@
Rmc @ Meas. Temp.	3.90 @ 70 °F	@ °F	@ °F	@
Source of Rmf and Rmc	M / M			
Rm @ BHT	3.41 @ [redacted] °F	@ °F	@ °F	@
Time Since Circ	—			
Max. Rec. Temp. Deg. F.	86 °F	°F	°F	
Equip. No. and Location	1245 CASPER			
Recorded By	NEILL			
Witnessed By	Mr. MASON & Mr. LEHANEY			

ECU 316

low weight on values
very poor print of log

Surface – Glen Canyon Group

began logging at 40'

		sh	ss	ls	Sidewall analysis		kc	
960	40 – 1000	10	90				9.4	9024
1000	1000 – 2000	15	85				9.1	9100
1000	2000 – 3000	10	50	40			8.2	8200
BHT → 1060	3000 – 4060		40	60			8.2	8692
4020 940	4060 – 5000		5	5	90		9.8	9212 35016
1000	5000 – 6000	2		3	95		9.8	9800
BHT → 560	6000 – 6560	5		5	95		9.7	5432
6520 440	6560 – 7000	10		5	85		9.2	4048 59460
850	7000 – 7850	10		55	35		7.8	6630
7810								70138

Paradox

Below Pdx?

weight low – log almost illegible

ke to 4060 = 8.7

ke (Paradox) = 9.7 $\frac{28492}{2940}$ ft

ke overall = 8.9

BHT's

86°F @ 2081 ke = 9.2

102 @ 4059 ke = 8.7

116 @ 6561 ke = 9.1

120 @ 7850 ke = 8.9

bottom apparently below Paradox

ECU 317

Begum 310 feet above top wungate
cutting ss, siltstone + sh

sh	ss
40%	60%

Wungate 228'

sh	ss
0	100%

Chinle 310'

sh	ss
81	19

Shinarump 10'

sh	ss
0	100

Moenkopi 552'

sh	ss
79	21

White Rim 210'

sh	ss
5%	95%

Cutler 1226'

sh	ss	carb
65	19	16

HERMOSA 1260'

sh	ss	carb
20	20	60%

Hermosa

SALT 4106 to 6915

SALT	Sh	Ss	Carb	Gyp Anhyd
70	15	0	15	✓

ECU 317 Sec 21, T25S-R18E

EST COMP - LOG BY B.F. LATCH

	THICKNESS	% sh	% ss	% carb	% salt	% Gyp Anhyd	ke
Surface to 310'	310	40	60				7.6
WINGATE 310 –	228	0	100				10.0
CHINLE	310	80	20				5.2
SHINARUMP	10	0	100				10.0
MOENKOPI	552	80	20				5.2
WHITE RIM	210	5	95				9.7
CUTLER	1226	65	19	16			5.6
HERMOSA	1260	20	20	60			7.0
SALT TO TD (6915')	TOP 2809	15	0	15	70	✓	8.6

BOTTOM IN SALT AT 6915

millical
conversion

sh = 4.0

ss = 10.0

Carb = 7.0

Salt = 10.0

BHT

148°F @ 6912

weighted ke to surface

7.4

OGCC-3

STATE OF UTAH

OIL & GAS CONSERVATION COMMISSION

SUBMIT IN DUPLICATE* (See other instructions on reverse side)

WELL COMPLETION OR RECOMPLETION REPORT AND LOG*

1a. TYPE OF WELL: OIL WELL ☐ GAS WELL ☐ DRY ☒ Other

b. TYPE OF COMPLETION: NEW WELL ☒ WORK OVER ☐ DEEP-EN ☐ PLUG BACK ☐ DIFF. RESVR. ☐ Other

2. NAME OF OPERATOR: Read & Stevens, Inc.

3. ADDRESS OF OPERATOR: P. O. Box 2126, Roswell, New Mexico 88201

4. LOCATION OF WELL (Report location clearly and in accordance with any State requirements)*
At surface: 1970' FNL & 1060' FWL Sec. 21, T-25-S, R-18-E, S.L.M.
At top prod. interval reported below: Same
At total depth: Same

5. LEASE DESIGNATION AND SERIAL NO.: U-5949

6. IF INDIAN, ALLOTTEE OR TRIBE NAME: -

7. UNIT AGREEMENT NAME: -

8. FARM OR LEASE NAME: Shenandoah-Bowknot

9. WELL NO.: 1

10. FIELD AND POOL, OR WILDCAT: Wildcat

11. SEC., T., R., M., OR BLOCK AND SURVEY OR AREA: Sec. 21, T-25-S, R-18-E, S.L.M.

12. COUNTY OR PARISH: Grand

13. STATE: Utah

14. PERMIT NO.: | DATE ISSUED:

15. DATE SPUDDED: 8-1-73

16. DATE T.D. REACHED: 8-22-73

17. DATE COMPL. (Ready to prod.): 10-9-73

18. ELEVATIONS (DF, RKB, RT, GR, ETC.)*: 5161' GR - 5178' RKB

19. ELEV. CASINGHEAD: -

20. TOTAL DEPTH, MD & TVD: 6915' RKB

21. PLUG, BACK T.D., MD & TVD: -

22. IF MULTIPLE COMPL., HOW MANY*: -

23. INTERVALS DRILLED BY: → 0'-6915'

ROTARY TOOLS:

CABLE TOOLS: None

24. PRODUCING INTERVAL(S), OF THIS COMPLETION—TOP, BOTTOM, NAME (MD AND TVD)*: None - Plugged & Abandoned

25. WAS DIRECTIONAL SURVEY MADE: No

26. TYPE ELECTRIC AND OTHER LOGS RUN: Ray, Caliper-Comp. Density, Neutron Porosity; Compensated Density Log, Acoustic cement Bond, Micro-Seismogram; Gamma

27. WAS WELL CORED: Yes

CASING RECORD (Report all strings set in well)

28. CASING SIZE	WEIGHT, LB./FT.	DEPTH SET (MD)	HOLE SIZE	CEMENTING RECORD	AMOUNT PU
13 3/8"	48# & 60#	290' RKB	17"	315 sx. - circulated	None
8 5/8"	32#	2790' RKB	11"	300 sx. Class "C"	714'
5 1/2"	17# & 20#	6915' RKB	7 7/8"	400 sx. Class "B"	3993'

LINER RECORD

29. SIZE	TOP (MD)	BOTTOM (MD)	SACKS CEMENT*	SCREEN (MD)

TUBING RECORD

30. SIZE	DEPTH SET (MD)	PACKER

31. PERFORATION RECORD (Interval, size and number)
6845'-6855', w/20 jet shots
6830'-6838', w/16 jet shots
6818'-6825', w/14 jet shots
6804'-6812', w/16 jet shots
6785'-6795', w/20 jet shots
6592'-6600', w/16 jet shots
6312'-6326', w/28 jet shots
6186'-6200', w/28 jet shots

ACID, SHOT, FRACTURE, CEMENT SQUEEZE

32. DEPTH INTERVAL (MD)	AMOUNT AND KIND OF MA
See attachment	for description

PRODUCTION

33.* DATE FIRST PRODUCTION: None | PRODUCTION METHOD (Flowing, gas lift, pumping—size and type of pump)

DATE OF TEST	HOURS TESTED	CHOKE SIZE	PROD'N. FOR TEST PERIOD →	OIL—BBL.	GAS—MCF.	W

FLOW. TUBING PRESS.	CASING PRESSURE	CALCULATED 24-HOUR RATE →	OIL—BBL.	GAS—MCF.

34. DISPOSITION OF GAS (Sold, used for fuel, vented, etc.)

35. LIST OF ATTACHMENTS: 2 copies of above logs, deviation report

36. I hereby certify that the foregoing and attached information is complete and correct as determined fr

SIGNED John L. Anderson Jr. TITLE Agent

*(See Instructions and Spaces for Additional Data on Reverse Side)

...correct well completion report and log on all types of lands and leases to either a Federal agency or a State agency, ...Federal and/or State laws and regulations. Any necessary special instructions concerning the use of this form and the number of copies to be ...submitted, particularly with regard to local, area, or regional procedures and practices, either are shown below or will be issued by, or may be obtained from, the local Federal and/or State office. See instructions on items 22 and 24, and 33, below regarding separate reports for separate completions.

If not filed prior to the time this summary record is submitted, copies of all currently available logs (drillers, geologists, sample and core analysis, all types electric, etc.), formation and pressure tests, and directional surveys, should be attached hereto, to the extent required by applicable Federal and/or State laws and regulations. All attachments should be listed on this form, see item 35.

Item 4: If there are no applicable State requirements, locations on Federal or Indian land should be described in accordance with Federal requirements. Consult local State or Federal office for specific instructions.

Item 18: Indicate which elevation is used as reference (where not otherwise shown) for depth measurements given in other spaces on this form and in any attachments.

Items 22 and 24: If this well is completed for separate production from more than one interval zone (multiple completion), so state in item 22, and in item 24 show the producing interval, or intervals, top(s), bottom(s) and name(s) (if any) for only the interval reported in item 33. Submit a separate report (page) on this form, adequately identified, for each additional interval to be separately produced, showing the additional data pertinent to such interval.

Item 29: *"Sacks Cement":* Attached supplemental records for this well should show the details of any multiple stage cementing and the location of the cementing tool.

Item 33: Submit a separate completion report on this form for each interval to be separately produced. (See instruction for items 22 and 24 above.)

37. SUMMARY OF POROUS ZONES:
SHOW ALL IMPORTANT ZONES OF POROSITY AND CONTENTS THEREOF; CORED INTERVALS; AND ALL DRILL-STEM TESTS, INCLUDING *DEPTH INTERVAL TESTED, CUSHION USED, TIME TOOL OPEN, FLOWING AND SHUT-IN PRESSURES, AND RECOVERIES*

FORMATION	TOP	BOTTOM	DESCRIPTION, CONTENTS, ETC.
	0'	310'	Gray & red sand, siltstone & shale
Wingate	310'	538'	Red sand
Chinle	538'	848'	Red siltstone, red sand, red & green shale
Shinarump	848'	858'	Gray sand
Moenkopi	858'	1410'	Red & Gray sand,red & green shale
White Rim	1410'	1620'	White sand
Cutler	1620'	2846'	Red & gray sand, red & gray shale, gry-brn. lime.
Hermosa	2846'	4106'	Gray shale, lt. & drk. gray lime, gray sand
Salt	4106'	TD	Clear crystalline salt w/anhy., shale & dolomite inclusions.
Cane Creek	6800'	6867'	Interbedded black shale, anhydrite & dolomite.
Core #1	6804'	6858'	See attachment for description.
Core #2	6858'	6915'	See attachment for description.
			No DST's

38. GEOLOGIC MARKERS

NAME	TOP MEAS. DEPTH	TOP TRUE VERT. DEPTH
T/Wingate	310'	+4868
T/Chinle	538'	+4640
T/Shinarump	848'	+4330
T/Moenkopi	858'	+4320
T/White Rim	1410'	+3768
T/Cutler	1620'	+3558
T/Hermosa	2846'	+2332
T/Salt	4106'	+1072
T/Cane Creek zone	6800'	-1622
B/Cane Creek zone	6867'	-1689

Welex

COMPENSATED DENSITY POROSITY AND NEUTRON POROSITY LOG

COMPANY READ & STEVENS INCORPORATED
WELL SHENANDOAH-BOWKNOT # 1
FIELD WILDCAT
County GRAND State UTAH

COMPANY READ AND STEVENS, INCORPORATED

WELL SHENANDOAH-BOWKNOT # 1

FIELD WILDCAT

COUNTY GRAND STATE UTAH

Location

Sec. 21 Twp 25S Rge 18E

Other Services:
COMP. DENSITY
317

Permanent Datum GROUND LEVEL Elev. 5161'
Log Measured From KELLY BUSHING 17 Ft. Above Perm. Datum
Drilling Measured From KELLY BUSHING

Elev.: K.B. 5178
D.F. 5177'
G.L. 5161'

Date	8-22-73			
Run No.	GAMMA-GAMMA, NEUTRON			
Depth—Driller	6915'			
Depth—Welex	6913'			
Btm. Log Inter.	6912 25.6			
Top Log Inter.	0'			
Casing—Driller	13-7/8"@ 290'	8-5/8"@ 2790'	@	@
Casing—Welex	2792'			
Bit Size	7-7/8"			
Type Fluid in Hole	SALT BASE MUD			
Dens. | Visc.	10.6 | 36			
pH | Fluid Loss	| ml	| ml	| ml	| m
Source of Sample	PIT			
R_m @ Meas.Temp.	.07 @ 84 °F	@ °F	@ °F	@ °F
R_{mf} @ Meas.Temp.	.06 @ 86 °F	@ °F	@ °F	@ °F
R_{mc} @ Meas.Temp.	.095 @ 84 °F	@ °F	@ °F	@ °F
Source R_{mf} R_{mc}	FILTER PRESS			
R_m @ BHT	.04 @ 148F	@ °F	@ °F	@ °F
Time Since Circ.	7 HOURS			
Max. Rec. Temp.	148°F @ TD	°F @	°F @	°F @
Equip. | Location	7757 | FARMINGTON			
Recorded By	LEEPER			
Witnessed By	MR. LATCH			

SCHLUMBERGER

BOREHOLE COMPENSATED SONIC GUARD — GAMMA RAY

S7-1-2159

COUNTY
FIELD or LOCATION
WELL
COMPANY

COMPANY Shell Oil Company

WELL Federal 1-21

FIELD Wildcat

COUNTY Grand STATE Utah

LOCATION 1978' S, 735' E Fr. N.W. Cor.
S.L.B.M SW NW

Sec. 21 Twp. 25S Rge. 18E

Other Services:
DIL
FDC
CST 318

Permanent Datum: G.L. , Elev. 5152
Log Measured From D.F. , 18.3 Ft. Above Perm. Datum
Drilling Measured From D.F

Elev.: K.B. [redacted]
D.F. 5169.8
G.L. 5152

Date	6-26-69			
Run No.	1			
Depth—Driller	4081			
Depth—Logger	4081			
Btm. Log Interval	[redacted] 22.8			
Top Log Interval	848			
Casing—Driller	10 3/4 @ 847	@	@	@
Casing—Logger	848			
Bit Size	8 3/4			
Type Fluid in Hole	EGM			
Dens. | Visc.	8.95 | 44			
pH | Fluid Loss	8.5 | 6.8 ml	ml	ml	ml
Source of Sample	Circ.			
R_m @ Meas. Temp.	1.43 @ 76 °F	@ °F	@ °F	@ °F
R_{mf} @ Meas. Temp.	1.17 @ 65 °F	@ °F	@ °F	@ °F
R_{mc} @ Meas. Temp.	1.62 @ 71 °F	@ °F	@ °F	@ °F
Source: R_{mf} R_{mc}	M | M			
R_m @ BHT	1.1 @ [redacted] °F	@ °F	@ °F	@ °F
Time Since Circ.	7 hr			
Max. Rec. Temp.	102 °F	°F	°F	°F
Equip. | Location	4529 | Vernal			
Recorded By	B. Thomas			
Witnessed By	D. McLehaney & Mason			

Dresser Atlas

COMPENSATED

Densilog

FILE NO. S7-1-2159

COMPANY SHELL OIL COMPANY

WELL FEDERAL 1-21

FIELD WILDCAT

COUNTY GRAND STATE Utah

LOCATION: 1978'S & 735'E from NW corner

SEC 21 TWP 25 S RGE 18 S/L

Other Servic
LL
BHC-A/L
SWN-GR
D.plog
318

Permanent Datum G.L. Elev. 5152

Log Measured from KB or 18.3 Ft. Above Permanent Datum

Drilling Measured from KB

Elevations:
KB 5170
DF 5169.
GL 5152

Date	7-10-69			
Run No.	one.			
Depth—Driller	4919			
Depth—Logger	4914			
Bottom Logged Interval	4921 29.3			
Top Logged Interval	0			
Casing—Driller	10 3/4 @ 847	@	@	@
Casing—Logger	846			
Bit Size	8 3/4			
Type Fluid in Hole	SALT SAT			
Density and Viscosity	11.2 -			
pH and Fluid Loss	- - cc	cc	cc	
Source of Sample	P.T			
Rm @ Meas. Temp.	.06 @ 84 °F	@ °F	@ °F	@
Rmf @ Meas. Temp.	.013 @ 78 °F	@ °F	@ °F	@
Rmc @ Meas. Temp.	.10 @ 80 °F	@ °F	@ °F	@
Source of Rmf and Rmc	M M			
Rm @ BHT	.036 @ 130 °F	@ °F	@	@
Time Since Circ.	5 hr.			
Max. Rec. Temp. Deg. F.	130 °F	°F		
Equip. No. and Location	1245 CHEY			
Recorded By	Wetter - Call			
Witnessed By	Mr. McLehan			

ECU 318

EST COMPOSITIONS

depth	sh	% some anhyd. ss	ls	ke ↓ surface		Glen Canyon
0-1000	25	70	5	8.4	8400	
1000-2000	20	75	5	8.6	8600	
2000-3000	55	40	5	6.6	6600	$k_e = 7.6$
3000-4000	45	40	15	7.3	7300	
4000-5000	30	15	55	6.6	6600	
5000-5735	5	35	60	7.9	5806.5	
					43306.5	

5735 TOP PARADOX

	sh	ss	ls	anhyd. salt			
5735-6000	0	0	20	80	9.4	2491	
6000-7000	10	0	10	80	9.1	9100	
7000-8000	20	0	0	80	8.8	8800	$k_e = 9.0$
8000-9000	15	0	0	85	9.1	9100	
9000-9755	20	0	✓	80	8.8	6644	
	4020					36135	

9755 BOTTOM PARADOX (SALT)

	sh	ss	ls				
9755-10000	13	12	75	7.0			$k_e = 7.0$
10000-10330	0	0	100	7.0			

BHTS

115° F	@ 6850	Pdx	
122°	@ 6775	Pdx	
130°	@ 4916	above Pdx	
102°	@ 4078	"	

ke weighted to depth

7.8
7.8
7.5
7.7

SCHLUMBERGER

BOREHOLE COMPENSATED SONIC LOG GAMMA RAY

COMPANY SHELL OIL COMPANY

WELL QUINTANA 1-35

FIELD WILDCAT

COUNTY GRAND STATE UTAH

COUNTY S7-1-2161
FIELD or LOCATION
WELL
COMPANY

LOCATION 1814'E & 1603'N of SW

Sec. 35 Twp. 25S Rge. 18E

Other Services:
DIL 319
FDC-GR
SHP-GR

Permanent Datum: GL , Elev. 5471
Log Measured From KB , 17 Ft. Above Perm. Datum
Drilling Measured From KB

Elev.: K.B. 5488
D.F.
G.L. 5471

Date		11-20-69	API. 43-019-30045
Run No.		TWO	
Depth—Driller		4209	
Depth—Logger		4210	
Btm. Log Interval		4209	
Top Log Interval		2375	
Casing—Driller	@	9 5/8 @ 2375	@ @
Casing—Logger		2375	
Bit Size		8 3/4	
Type Fluid in Hole		F.C.M.	
Dens. | Visc.		9.2 | 39	
pH | Fluid Loss	ml	9.0 | 6.0 ml	ml
Source of Sample		CIRC.	
R_m @ Meas. Temp.	@ °F	1.37 @ 69 °F	@ °F @
R_{mf} @ Meas. Temp.	@ °F	1.26 @ 69 °F	0.85 @ 103 °F @
R_{mc} @ Meas. Temp.	@ °F	0.90 @ 103 °F	@ °F @
Source: R_{mf} R_{mc}		M | C	
R_m @ BHT	@ °F	0.93 @ 103 °F	@ °F @
Time Since Circ.		12 HRS	
Max. Rec. Temp.	°F	103 °F	°F
Equip. | Location		5625 | FARM	
Recorded By		RUSEN	
Witnessed By		DOGAN	

SCHLUMBERGER

RUN 1 PERFORATING RECORD
GAMMA RAY

S7-1-2161

COUNTY
FIELD or LOCATION
WELL
COMPANY

COMPANY SHELL OIL COMPANY

4

WELL QUINTANA 1-35

FIELD WILDCAT

COUNTY GRAND STATE UTAH

LOCATION 1814'E & 1603'N of SW

Sec. 35 Twp. 25S Rge. 18E

Other Services:
LL-3-GR
SNP-GR
FDC-GR

31

Permanent Datum: GL, Elev. 5471
Log Measured From KB, 17 Ft. Above Perm. Datum
Drilling Measured From KB

Elev.: K.B. 5488
D.F. 5487
G.L. 5471

Date	12-6-69		API - 43-019-					
Run No.	3		30045					
Depth—Driller	8140							
Depth—Logger	8129							
Btm. Log Interval	~~8126~~ 8126		16.4					
Top Log Interval	4000							
Casing—Driller	9 5/8 @ 2375		@		@		@	
Casing—Logger	2375							
Bit Size	8 3/4							
Type Fluid in Hole	SALT H2O							
Dens. / Visc.	10.4	39						
pH / Fluid Loss	6.0	9.8 ml		ml		ml		
Source of Sample	CIRC.							
R_m @ Meas. Temp.	.06 @ 60 °F		@ °F		@ °F		@	
R_{mf} @ Meas. Temp.	.05 @ 59 °F		.024 @ 125 °F		@ °F		@	
R_{mc} @ Meas. Temp.	.03 @ 125 °F		@ °F		@ °F		@	
Source: R_{mf} / R_{mc}	M	C						
R_m @ BHT	.028 @ 125 °F		@ °F		@ °F		@	
Time Since Circ.	12 HRS							
Max. Rec. Temp.	125 °F		°F		°F			
Equip. / Location	5625	FARM						
Recorded By	RUSER							
Witnessed By	DOGAN							

SCHLUMBERGER

BOREHOLE COMPENSATED SONIC LOG - GAMMA RAY

57-1-2161

COUNTY
FIELD or LOCATION
WELL
COMPANY

COMPANY SHELL OIL COMPANY

WELL QUINTANA 1-35

FIELD WILDCAT

COUNTY GRAND STATE UTAH

LOCATION NE SW
1814'E & 1603'N of SW CORNER

Sec. 35 Twp. 25S Rge. 18E

Other Services:
DIL 319

Permanent Datum: GL, Elev. 5471
Log Measured From KB, 16 Ft. Above Perm. Datum
Drilling Measured From KB

Elev.: K.B. ~~5487~~
D.F.
G.L. 5471

Date	11-11-69		API-43-019-30045								
Run No.	ONE										
Depth—Driller	2375										
Depth—Logger	2376										
Btm. Log Interval	~~2375~~ 2364										
Top Log Interval											
Casing—Driller	20" @ 25		@		@			@			
Casing—Logger											
Bit Size	12 1/4										
Type Fluid in Hole	GEL-WATER										
Dens. / Visc.	9	46									
pH / Fluid Loss	8	12.6 ml		ml		ml			ml		
Source of Sample	MUD PIT										
R_m @ Meas. Temp.	8.57 @ 67 °F		@	°F	@	°F		@	°F		
R_{mf} @ Meas. Temp.	8.54 @ 67 °F		@	°F	@	°F		@	°F		
R_{mc} @ Meas. Temp.	8.20 @ 63 °F		@	°F	@	°F		@	°F		
Source: R_{mf} / R_{mc}	M	M									
R_m @ BHT	10.8 @ ~~85~~ °F		@	°F	@	°F		@	°F		
Time Since Circ.	3 1/2 HRS										
Max. Rec. Temp.		°F		°F		°F			°F		
Equip. / Location	5625	FARM									
Recorded By	WELLS										
Witnessed By	MCELHANEY										

FIELD PRINT

ECU 319

Surface Glen Canyon

Salt at 4340 – 7550

TD about 8140

ke above paradox	4340'	7.6
ke Paradox	3210'	9.0
ke Below Paradox	590'	7.0

BHTS	ke's weighted (surface to BHT)
85° at 2375	8.2
103° at 4209	7.7
125° @ 8126	8.1