

THE GEOLOGICAL SURVEY OF WYOMING
S.H. Knight, State Geologist
University of Wyoming
Laramie, Wyoming

GEOLOGIC REPORT

on the

LOVELL WATER WELL,

BIG HORN COUNTY, WYOMING

by

Arthur M. Morgan

INTRODUCTION

In November, 1935, the State Geologist, Dr. S. H. Knight, was requested to make a comparison of the well logs of the Prairie Oil and Gas well on Little Sheep Mountain and the water well being drilled for the town of Lovell on the north end of the same mountain, and to give an estimate on the probable depth to possible water bearing horizons. The well at that time was drilled to a depth of 3260 feet. From the comparison of the two well logs and the study of samples of the Lovell well cuttings Dr. Knight estimated the depths to the tops of two probable water bearing sandstones in the base of the Deadwood formation as "...first water sand should be encountered within depth of less than 3450 feet. Second water sand at depth of less than 3850 feet. Granite at depth of less than 4000 feet."

In April, 1936, another request for interpretation was received. At this time the hole was drilled to a depth of 3774 feet. Scattered samples between 3260 and 3550 feet, and fairly regular samples from 3550 to 3773 feet were submitted with the request for an opinion. No log for the space between 3260 and 3774 feet was made available. From the available data Dr. Knight concluded that the "...well has penetrated 50 feet into the basal Cambrian sandstone. Estimate position of granite floor not more than 3900 feet."

Early in June, 1936, in response to a request for an independent geological report on the Lovell water well the writer spent several days in the region. No well log from 3260 to 3774 feet could be found in Lovell and attempts to locate a copy in the office of the P.W.A. Inspection Engineer at Lander, and the State P.W.A. office in Cheyenne were also

fruitless. An attempt to locate the missing samples for the intervals 0 to 800 feet, 1675 to 3000 feet, 3260 to 3344 feet, 3344 to 3400 feet, 3400 to 3550 feet (available samples at 3410, 3425, 3445, 3520, 3530 and 3550 feet) and 3600 to 3641 feet was of no avail. The samples available are of little value for correlation as none of the critical samples at the contacts between formations are included in those submitted to the State Geologist's Office. The group of samples between 800 and 1675 feet come entirely within the Madison formation and all others submitted are from the Deadwood. Absence of these data makes it difficult to determine the position of the bottom of the hole and the probable depth to the granite.

The Lovell water well is located in the S $\frac{1}{2}$ Sec. 16, T. 56 N., R. 95 W. A well drilled by the Prairie Oil and Gas Company, the log of which is available for comparison, is located in the NE $\frac{1}{4}$ Sec. 35, T. 56 N., R. 95 W. Both wells are on the northern part of Little Sheep Mountain, which is situated in the northeast portion of the Big Horn Basin.

REGIONAL GEOLOGY

Stratigraphy.— The surface rock at both the Prairie Oil and Gas Company and the Lovell water well is the limestone of the Embar formation. In this report only the Embar and underlying formations will be described.

The oldest rocks with which this report is concerned is the granite upon which the sediments were deposited. The rock is a moderately coarse grained red granite. The outcrops nearest the well location are found in the upper part of Devils Canyon and along the upper part of Five Springs Creek. The granite had undergone long continued erosion before the deposition of the sediments and was planed to a remarkably even surface upon which the sandstones and shales of the Deadwood were laid down.

The Deadwood formation averages about 900 feet in thickness and consists of a basal sandstone, a middle shale member with interbedded sandstones in the lower portion and an upper slabby limestone member. The basal sandstone averages from 20 to 50 feet in thickness and is made up of a reddish brown sand, usually coarse textured, which merge into conglomerate at the base. The middle shale member consists of greenish gray shales and sandy shales with inter bedded sandstones in the middle portion. This member averages 600 to 700 feet in thickness. The shales merge upward into slabby gray buff and pink limestones containing many layers of "edgewise" conglomerate. The limestones range from 20 to 200 feet in thickness.

The Big Horn formation overlying the Deadwood consists of a basal member 200 feet in thickness, made up of a hard resistant massive-bedded dolomite and an upper member of softer thinner-bedded limestone 100 feet in thickness. There is often a thin white sandstone at the base of the formation. The dolomite is a light buff color and is filled with a coarse matted network of siliceous masses which gives the weathered rock a rough network pattern on the surface.

The Madison formation averages 1,000 feet in thickness and is made up of an upper member of 250 feet of light colored moderately pure massive bedded limestone and a lower member of 700 to 800 feet of darker, harder limestone in beds 3 feet thick or less. There are some sandy beds and locally there are shaly limestones in the formation.

The Amsden, overlying the Madison, is a variable series of red limestones, sandstones, and cherty beds. The lower member is a red sandy shale 50 to 100 feet thick, which is succeeded by an alternating series of slabby limestones, shales, and sandstones. The formation averages 200 feet in thickness.

The next formation is the Tensleep sandstone which averages 100 feet in thickness throughout the northern Big Horn Mountains. It is made up principally of white to buff sandstone in thick massive beds. In places the formation includes a lower member of 50 feet or more of softer buff to flesh colored sandstone.

The Embar formation which forms the surface rock over most of Little Sheep Mountain is made up principally of buff limestones with interbedded buff to red shales. Near the base there are locally developed gypsum beds. The formation at Little Sheep Mountain is 100 feet in thickness.

Structure.-- Little Sheep Mountain, on which both the Lovell water well and the Prairie Oil and Gas Company well are located, is an anticlinal ridge, the axis of which is parallel to the front of the Big Horn Mountains. The crest and the flanks at the north end of Little Sheep Mountain are formed by the limestones of the Embar formation. At several places on the west side of the ridge the Embar is breached by deep gullies and the upper part of the Tensleep is exposed. On the east side of the ridge the Embar has been removed and the Tensleep is exposed for several miles. In Sections 34 and 35, T. 56 N., R. 95 W. the top of the Amsden formation is exposed for some distance where erosion has cut through the Tensleep and the Embar.

The anticline is asymmetric, with the steepest dip on the east flank. On the north end of the mountain for a distance of 8 miles along the top of the anticline the beds dip slightly to the west over a belt from several hundred yards to approximately a mile wide. The beds break off abruptly at the crest with a steep dip to the east and also dip steeply to the west at the west margin of the low dip belt mentioned above. Beginning in Sec. 16, T. 56 N., R. 95 W. the structure plunges rapidly to the north. At the nose of the anticline where the Embar limestone plunges beneath the Chugwater the dip on the crest is 22° to the northwest.

The Lovell water well is located in the S $\frac{1}{2}$ of Sec. 16 T. 56 N., R. 95 W. on the nose of the anticline approximately on the contact between The Embar and the Chugwater. The Prairie Oil and Gas Company well is located in the NE $\frac{1}{4}$ Sec. 35, T. 56 N., R. 95 W. on the top of the ridge, on the flat-lying beds approximately at the top of the Embar formation.

To the east the beds plunge beneath a wide flat valley where they are overlain by younger rocks. They appear again on the west flank of the Big Horn Mountains. In that portion of the west flank of the Big Horn Mountains that parallels Little Sheep Mountain the beds dip west at a low angle for some distance then steepen abruptly through a horizontal distance of approximately one mile to flatten out again to a low westward dip for 3 to 6 miles then rising again to form Little Sheep Mountain.

Several small faults were noted at the north end of Little Sheep Mountain. One fault cuts diagonally across the nose of the structure just north of the Lovell well location. The strike of the fault is approximately N. 75° W. The fault could not be traced into the beds on the west side of the structure. The fault is to be seen in the sandstone at the top of the Chugwater where the dip changes from 30° on the south side of the fault to 10° on the north side. The bed is not appreciably displaced. The same change in dip was observed where the fault cuts the sandstones at the top of the Sundance and the ridge formed by the sandstone is offset approximately 50 feet. With depth, if the fault persists, there would be an increase in displacement of the beds. The fault lies between the Lovell well location and the Big Horn Mountains and it is possible that it offsets the sandstones of the Deadwood enough to hinder any direct flow of water from the outcrop on the Big Horn Mountains.

COMPARISON OF WELL LOGS

The collar of the Prairie Oil and Gas Company well is approximately at the top of the Embar formation. The log shows the following sections through the underlying rocks.

Prairie Oil and Gas Company Well - NE 1/4 Sec. 35, T. 56 N., R. 95 W.

	Feet		Feet	
Embar	140	. . . . .		limestone
Tensleep	95	. . . . .	35	sandstone
			10	limestone
			50	sandstone
Amsden	185	. . . . .	55	limestone
			15	shale
			35	limestone
			55	red shale
			20	brown sandstone
			5	black sand
Madison	1070	. . . . .	535	limestone
			5	shale
			275	limestone
			25	shale and lime
			230	limestone

	Feet	Feet	
Big Horn	320	145	alternating limestone and sandy limestone
		10	sandstone
		170	sandy limestone
Deadwood	1165	769	alternating beds of limestone and shale
		51	salt and pepper sandstone
		48	broken sand and slate
		180	blue brown and pink shale
		20	black sandstone
		22	gray sandstone
		75	reddish sandstone

Water was encountered at several horizons in the well but the greatest amount in two sandstones in the base of the Deadwood. The upper of the two sandstones is 99 feet thick and consists of 50 feet of light brown "salt and pepper" sand underlain by 48 feet of rusty brown sand with some shale. This sandstone is separated from the basal sand by 180 feet of blue and brown shale. The basal sand consists of 148 feet of gray and reddish sandstone with conglomeratic arkosic sand in the lower portion. This sand rests directly upon the granite. It is reported that the water rose to within 300 feet of the surface from the sands described above. The surface elevation at the collar of the well is 5140 feet so the water rose to an elevation 4840 feet.

From the log of the Lovell water well it is difficult to determine the contacts of all the formations encountered. The samples in the upper part of the well are not available and comparison of the log to the nearby exposures of the upper Tensleep and Embar shows little agreement. The contacts to the base of the Madison are drawn arbitrarily. None of the contacts between the various formations are included in the samples submitted.

Lovell Water Well - S $\frac{1}{2}$ Sec. 16, T. 56 N., R. 95 W.

	Feet	Feet	
Embar	180	110	lime
		20	red shale
		18	gray lime
		15	hard lime
		17	blue shale
Tensleep	123	20	blue and gray shale
		25	black sand
		38	gray sandy lime
		34	sand - sulphur water
		6	fine gritty sand

	Feet	Feet	
Amsden	240 (?)	22 . .	blue shale
		20 . .	lime
		65 . .	sandy lime
		133 (?)	gray lime (?)
Madison	1197 . .	182 . .	gray lime
		15 . .	brown lime
		340 . .	gray lime
		20 . .	sand - <u>fresh water</u>
		630 . .	lime, some shale
Big Horn	420 . .	255 . .	alternating hard lime (dolomite) and sandy lime (siliceous dolomite)
		93 . .	lime
		15 . .	fine sand - <u>water</u>
		28 . .	hard sandy lime (siliceous dolomite)
		29 . .	sand
Deadwood	530 . .		alternating lime and blue and gray shale
	563 . .		blue and gray shale and sandy shale
	- . .		below this point the log is not available
	84 . .		blank - no samples
	186 . .		scattered samples - mixture of shale and fine quartzite
	30 . .		sample - gray shale
	65 . .		gray shale with some fine quartzite
	55 . .		dark green and maroon shale
	34 . .		blank
	16 . .		gray shale and fine white quartzite
	7 . .		black shale
	51 . .		medium to coarse sand, slightly arkosic

Water was encountered in this well at several horizons including the sandstone in which the well is now bottomed. It is reported that water rose from 600 to 400 feet of the surface in nearly all cases where water in quantity was encountered. The water level at present is reported to be within 400 feet of the surface (elevation of water 3700 feet).

Comparison of the two well logs shows considerable thickening of the formations in the Lovell well. This increase in thickness is due to the dip of the beds at the Lovell well location. At the surface the beds dip 22° to the NW. The proportion of increase becomes greater with depth and

it is probable that due to the inclination of the axial plane of the fold the well at the bottom is on the east flank of the structure rather than on the crest as is the case at the surface.

ARTESIAN WATER POSSIBILITIES

Water is taken into the porous beds of the series above described where they outcrop on the flanks of the Big Horn Mountains. It percolates down the dip of the beds, saturating the sands and forming a potential reservoir beneath the valley below. Where fissures or wells penetrate to the sandstones the water is forced up by hydrostatic pressure, coming to the surface if the head is great enough to bring the water to that elevation. Thus, to obtain an artesian flow of water there must be a source of water at the outcrop of a given sand and there must be sufficient head to force water to the surface.

From Five Springs Creek north along the outcrop of the Deadwood formation few streams cross the sandstones and for some distance the Deadwood is faulted out. In the light of the above conditions it is believed that the sandstones would collect little water in this zone and it is not anticipated that any large artesian flow of water will be encountered in wells in the area directly down the dip of the beds. The north half of Little Sheep Mountain comes within this zone. South of Five Springs Creek the Deadwood is crossed by numerous streams, providing an abundance supply of water. The elevation along the outcrop varies from 7,000 to 8,500 feet. Some water percolating down the dip from this belt would spread out laterally, saturating the sandstones for some distance north and south of the zone directly below the source. The saturated zone would be fan shaped and the hydrostatic head would be cut down rapidly to the north and south of the zone below the source of supply. It is probable that the water reported from the Prairie Oil and Gas Company well was derived from the belt of supply south of Five Springs Creek. The head, however, had diminished to a point that brought the water only to an elevation of 4840 feet. Four miles north at the Lovell well location the head had further dropped, forcing the water only to an elevation of approximately 3700 feet.

CONCLUSIONS

Lacking a log of the Lovell water well from 3260 feet to the bottom of the well and having inadequate samples from 3200 feet to 3520 feet it is difficult to make a definite correlation of the position of the bottom of the well. The data available indicates that the well has penetrated 70 feet into the sandstone at the base of the Deadwood formation. The position of the granite floor is estimated at approximately 150 feet below the present bottom of the well (depth of 3922 feet).

It is possible that a larger quantity of water will be encountered by drilling to the granite. It is not expected that water encountered in the remaining 150 feet will rise much above the present reported level.

SAMPLE DETERMINATIONS

Lovell Water Well

0 to 800 feet	No samples. This interval includes the Embar, Tensleep, Amsden and Upper Madison formations.
at 800 feet	Dark brown limestone and buff clay
" 810 "	Dark brown limestone and buff clay
" 820 "	Cream colored limestone
" 830 "	Cream colored limestone
" 840 "	Cream colored limestone and brown limestone with buff clay
" 850 "	Brown limestone
" 860 "	Cream colored limestone
" 870 "	Cream colored and brown limestone
" 885 "	Oil stained limestone
" 895 "	Oil stained limestone
" 905 "	Oil stained limestone
" 910 "	Oil stained limestone
" 915 "	Gray fine textured limestone - some pyrite
" 925 "	Gray fine textured limestone
" 935 "	Gray fine textured limestone
" 945 "	Gray fine textured limestone
" 960 "	Flesh colored limestone which contains pyrite
" 970 "	Mottled blue and gray limestone
" 980 "	Mottled pink and gray limestone
" 990 "	Blue-gray limestone
" 995 "	Blue-gray limestone
" 1005 "	Buff limestone
" 1015 "	Cream limestone with considerable opaline silica
" 1020 "	Cream limestone some opal
" 1035 "	Buff and gray limestone
" 1040 "	Cream colored limestone
" 1050 "	Cream colored limestone
" 1060 "	Cream colored and dark gray limestone
" 1070 "	Cream colored clay and oil stained limestone
" 1080 "	Oil stained clay and limestone
" 1090 "	Oil stained limestone, some cream colored limestone
" 1100 "	Oil stained limestone, some cream colored limestone
" 1110 "	Cream colored clay and limestone
" 1120 "	Gray limestone
" 1130 "	White limestone
" 1160 "	Dirty buff clay
" 1170 "	Blue limestone
" 1180 "	Oil stained limestone
" 1190 "	Oil stained limestone with clean cream colored limestone
" 1200 "	Cream colored limestone
" 1210 "	Flesh colored limestone
" 1220 "	Flesh colored limestone
" 1225 "	Fine lime-sand (not quartz)
" 1230 "	Fine lime-sand and blue limestone

at 1240 feet	Blue limestone
" 1285 "	Cream colored and blue limestone
" 1300 "	Cream colored limestone
" 1310 "	Cream colored limestone
" 1315 "	Cream colored limestone
" 1325 "	Cream colored limestone
" 1330 "	Cream colored limestone
" 1340 "	Cream colored limestone
" 1350 "	Blue-gray limestone
" 1360 "	Blue-gray limestone
" 1370 "	Blue-gray limestone
" 1380 "	Blue-gray limestone
" 1390 "	Blue and cream colored limestone
" 1400 "	Blue and cream colored limestone
" 1410 "	Blue and cream colored limestone
" 1420 "	Blue and cream colored limestone
" 1430 "	Blue and cream colored limestone
" 1450 "	Buff limestone
" 1455 "	Blue-gray limestone
" 1470 "	Blue-gray limestone
" 1480 "	Blue-gray and buff limestone
" 1490 "	Blue-gray and buff limestone
" 1500 "	Gray limestone
" 1510 "	Cream colored limestone
" 1520 "	Cream colored limestone
" 1540 "	Cream colored limestone
" 1550 "	Cream colored limestone
" 1560 "	Cream colored limestone
" 1570 "	Cream colored limestone
" 1585 "	Cream colored limestone
" 1595 "	Mottled blue and cream colored limestone
" 1600 "	Cream colored limestone
" 1610 "	Cream colored limestone
" 1615 "	Cream colored limestone
" 1625 "	Buff limestone
" 1635 "	Buff limestone
" 1640 "	Dark buff limestone
" 1650 "	Cream colored limestone
" 1660 "	Cream colored limestone
" 1675 "	Cream colored limestone
1675 to 3000 "	No samples. This interval includes the Basal Madison, Big Horn and Upper Deadwood formations.
at 3000 "	Dark gray shale and sandy shale
" 3010 "	Dark gray shale and sandy shale
" 3020 "	Dark gray shale and sandy shale
" 3030 "	Dark gray shale and sandy shale
" 3040 "	Dark gray shale and sandy shale with some fragments of fine grained gray quartzite
" 3050 "	Dark gray shale and sandy shale with some fragments of fine grained gray quartzite

at 3060 feet	Dark gray shale with some limestone fragments
" 3070 "	Dark gray shale and sandy shale
" 3080 "	Greenish-gray shale and sandy shale, some red shale
" 3090 "	Greenish-gray sandy shale
" 3100 "	Greenish-gray sandy shale
" 3110 "	Greenish-gray sandy shale, some fragments of gray quartzite
" 3120 "	Greenish-gray sandy shale, some fragments of gray quartzite
" 3130 "	Greenish-gray sandy shale, some fragments of gray quartzite
" 3140 "	Greenish-gray sandy shale, some fragments of gray quartzite
" 3150 "	Greenish-gray shale
" 3160 "	Greenish-gray shale
" 3170 "	Greenish-gray sandy shale
" 3180 "	Greenish-gray sandy shale, some fragments of gray quartzite
" 3190 "	Greenish-gray sandy shale
" 3200 "	Greenish-gray sandy shale
" 3210 "	Greenish-gray sandy shale, some gray quartzite
" 3220 "	Greenish-gray sandy shale, some gray quartzite
" 3230 "	Greenish-gray sandy shale, some gray quartzite
" 3240 "	Greenish-gray sandy shale, some gray quartzite
" 3250 "	Greenish-gray sandy shale
" 3260 "	Greenish-gray sandy shale, some gray quartzite
" 3344 "	Mixture of gray shale and white fine textured quartzite speckled with glauconite
" 3400 "	Mixture of gray shale and white fine textured quartzite, many fragments of which are speckled with glauconite
" 3410 "	(Cavings) Mixture of gray micaceous shale and white glauconitic quartzite
" 3425 "	Mixture of gray shale and white fine textured glauconitic quartzite
" 3445 "	Mixture of gray shale and white fine textured glauconitic quartzite
" 3520 "	Mixture of gray shale and white fine textured glauconitic quartzite
" 3530 "	Dark greenish gray shale
" 3550 "	Black micaceous shale and white quartzitic sand
" 3560 "	Dark gray shale with some fine grained white, glauconite quartzite fragments
" 3567 "	Dark gray shale and white fine textured glauconitic quartzite
" 3573 "	Dark gray shale and white fine textured glauconitic quartzite
" 3580 "	Dark gray shale with some white fine textured glauconitic quartzite, mostly shale
" 3587 "	Dark gray shale with fine white quartz sand, few large fragments of quartzite
" 3595 "	Gray shale
" 3600 "	Gray shale, a little fine sand in sample
" 3615 "	Gray shale
" 3641 "	Gray shale and dark maroon shale
" 3650 "	Gray shale and dark maroon shale
" 3655 "	Gray shale and dark maroon shale

at 3665 feet	Dark green and dark maroon shale
" 3670 "	Dark green and dark maroon shale
" 3704 "	50-50 mixture dark gray shale and fine grained white angular quartz sand
" 3715 "	Mixture dark gray shale and fine white angular quartz sand, some feldspar
" 3720 "	Mixture dark shale and fine angular quartz and feldspar sand
" 3725 "	Black shale with some quartz sand
" 3727 "	Black shale
" 3732 "	White quartz sand, medium textured, some feldspar and shale
" 3738 "	White quartz sand, medium textured, some feldspar and shale
" 3742 "	Medium to fine textured quartz sand, some feldspar and shale
" 3745 "	Coarse textured somewhat arkosic sandstone, some shale
" 3750 "	Coarse to medium textured slightly arkosic sandstone, some red shale
" 3752 "	Coarse to fine textured sandstone, some feldspar and reddish micaceous shale
" 3755 "	Medium to fine textured sandstone, some feldspar and some green shale
" 3760 "	Medium textured slightly arkosic iron stained sand
" 3762 "	Medium textured slightly arkosic iron stained sand
" 3768 "	Dark green and maroon shale
" 3770 "	Medium texture to fine texture arkosic sand, some dark green shale
" 3773 "	Medium to fine textured arkosic sand