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Water-supply investigation at Lukachukai, Navajo Indian Reservation, Arizona

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INTRODUCTION

Since January 1948, the Geological Survey has been studying the ground-water resources of the Navajo Indian Reservation, with particular emphasis on obtaining adequate water supplies for schools. The area near Lukachukai was investigated briefly in July 1948, in order to determine if a more adequate supply of water could be obtained.

Location

Lukachukai is situated on the Navajo Indian Reservation, about 25 miles northeast of Chinle and about 60 miles north of Window Rock, in Apache County, Arizona. The community is located near the western base of the Chuska Mountains and at the northeast end of the Defiance uplift.

Problem

The present water supply for the Lukachukai school is derived from a 15-foot dug well in alluvial fill. Additional water is needed to supply a proposed total population of 150 to 200. On the basis of a population of 200, and an estimated daily requirement of 150 gallons per day per person, about 30,000 gallons per day will be required. In order to produce the water during an 8-hour period each day, a supply of about 60 gallons per minute is needed.

Field work

The work was under the supervision of L. C. Halpenny, engineer in charge of Navajo work. G. A. Lerua, engineer, and S. C. Brown, geologist, began work in the Lukachukai area on June 23, 1948, and completed the field reconnaissance on June 27.

Acknowledgments

The quality-of-water section of this report was written by J. D. Hem, District Chemist, Southwestern Laboratory of the Geological Survey. S. F. Turner, District Engineer for ground-water investigations in Arizona, was consulted during the course of the investigation and reviewed the report. C. B. Read of the Geologic Branch gave advice on the stratigraphy of the region and reviewed the geologic section of the report. H. V. Peterson, geologist of the Division of Water Utilization, gave helpful suggestions in planning the investigation.

GEOLOGY AND ITS RELATION TO GROUND WATER

Stratigraphy

The rocks exposed in the Lukachukai area are as follows:

QUATERNARY	Alluvium
TRIASSIC	(Chinle formation (Shinarump conglomerate
PERMIAN	DeChelly sandstone member of Cutler formation

The DeChelly sandstone member of the Cutler formation is a massive, highly cross-bedded medium- to coarse-grained sandstone. The color ranges from light gray to medium brown. The upper 75 feet of the sandstone is exposed on the flank of the Defiance uplift. The total thickness is estimated to be between 400 and 500 feet. The exposure on the uplift affords good opportunity for recharge and the investigation showed that the member is water bearing in the Lukachukai area. The sandstone dips 3 to 5 degrees east and northeast and the overlying Chinle formation acts as a confining bed. Water in the DeChelly sandstone member is believed to be under artesian pressure near the Lukachukai school, although the pressure is probably not sufficient to cause a well in that locality to flow.

The Shinarump conglomerate in the Lukachukai area is a light-gray to buff coarse-grained to pebbly sandstone, with a maximum thickness of 10 feet. The formation has been removed by erosion in many places and is too thin and too limited in extent to be an important aquifer in the area.

The Chinle formation consists largely of variegated shales and sandy shales, with occasional thin sandstone beds. A section of the Chinle formation north of Lukachukai was measured with the plane table and was found to be 750 feet thick (see fig. 1.) Several small seeps and springs that issue from the formation were observed within a 3-mile radius of the school. The discharge of the springs fluctuates during the year and many of the seeps go dry. The largest of these springs is about half a mile south of the school and has an estimated flow of about 4 gallons per minute. The discharge is reported to fluctuate between 4 and 10 gallons per minute. The spring issues from joints in a sandstone bed about 200 feet above the base of the Chinle formation.

The Quaternary alluvium is relatively thin. It forms an outwash slope and consists of poorly sorted, uncemented boulders, sand, and silt. A 15-foot dug well in this material furnishes water for the school. The driller's log of the well at Kennedy's Trading Post, about three-quarters of a mile west of the school, shows 18 feet of boulders above the Chinle formation (see table 1.)

Structure

Dip slopes of 3° to 5° are common in the DeChelly sandstone member in the Lukachukai area. The northeast-dipping sedimentary beds represent the northeast end of the Defiance uplift. No faults were observed in the area.

POSSIBILITIES FOR OBTAINING ADDITIONAL WATER

The water-bearing character of the rocks in the Lukachukai area has been discussed briefly in the geologic section of this report. The Chinle formation and the Shinarump conglomerate cannot be considered as a source of ground water in the area. The following discussion outlines the possibilities of obtaining additional water from the outwash alluvium and from the DeChelly sandstone member of the Cutler formation.

A dug well (1, table 2) in the alluvium now furnishes water for the school. A second dug well (2, table 2) about 50 feet from well 1 furnishes water for the nearby mission. Recharge to the alluvium, derived from perennial springs in the Chuska Mountains, is believed to be sufficient to supply these two wells indefinitely under existing conditions. If additional wells were sunk into the alluvium in the immediate vicinity, overdevelopment

and a lowering of the water table probably would occur.

A study of the well log (table 1) indicates that the water in the well at the Kennedy Trading Post is produced from the DeChelly sandstone member of the Cutler formation. The well is 304 feet deep and the sandstone was encountered at a depth of about 175 feet. The yield was reported to be 10 to 15 gallons per minute. The deep well at Round Rock (6, table 2) was drilled into the DeChelly sandstone member and flows 4 gallons per minute. Bitter Water Spring (8, table 2) issues from an exposure of the DeChelly sandstone member on the north end of the Defiance uplift, but it is believed that the water is derived from underlying rocks. A well drilled in the vicinity of the Lukachukai school should encounter the DeChelly sandstone member at about 200 feet below the surface. The well should be drilled through the sandstone to the top of the underlying Supai formation, which lies between 600 and 700 feet below the land surface at the school. Two wells spaced an adequate distance apart may be needed to produce the required 60 gallons per minute. The first well should be thoroughly tested before a second well is drilled.

QUALITY OF WATER

By J. D. Hem

Analyses of eight samples of water from wells and springs in the Lukachukai area are given in table 2. The analyses show the amounts of dissolved mineral matter contained in the water from the various sources.

The water from the alluvial fill contains moderate quantities of dissolved matter and, although hard, it is reasonably satisfactory for domestic use.

Water from the Chinle formation is moderately hard, and two of the samples contain considerable amounts of sodium, sulfate, and bicarbonate. The three samples of water from the DeChelly sandstone member of the Cutler formation show a wide range in concentration. The sample from the well at the Kennedy Trading Post, nearest the school site, contains about the same amount of mineral matter as water from the alluvial fill. However, analysis 6 indicates that the water from the DeChelly sandstone member is likely to be much softer and, therefore, would be better suited for domestic use. The extremely high mineralization of the sample from Bitter Water Spring indicates that the water may be derived from beds below the DeChelly sandstone member.

CONCLUSIONS AND RECOMMENDATIONS

1. The existing supply of water at Lukachukai school appears to be adequate for existing needs. The water is obtained from alluvial fill and, although hard, is suitable for domestic use.

2. If the school is enlarged so that the population of the community totals 200, a total water supply of 60 gallons per minute will be needed.

3. The alluvial fill and the Chinle formation in the vicinity of Lukachukai cannot be depended upon to furnish a continuous supply of 60 gallons per minute.

4. It is not believed to be economically feasible to pipe water to Lukachukai from the springs in the Chuska Mountains.

5. The DeChelly sandstone member of the Cutler formation is believed to be sufficiently permeable and to receive sufficient recharge to supply the required 60 gallons per minute. The quality of the water probably would be suitable for domestic use.

6. It is recommended that a well be drilled into the DeChelly sandstone member of the Cutler formation. The well should be drilled through the entire thickness of the sandstone, to the top of the underlying Supai formation. The selection of the well site can be based on the most advantageous arrangement of power lines, storage tank, and well house. If the well is drilled within 750 feet of the school, the top of the sandstone will be encountered at a depth of about 200 feet, and the top of the Supai formation at about 600 to 700 feet.

7. Water samples should be collected from each water-bearing bed, and a sample of the well cuttings should be collected for each 10 feet of depth and for each change in formation.

8. After completion, the well should be thoroughly tested by pumping, in order to determine proper spacing if an additional well is needed.

Table 1. Driller's log of well at Kennedy Trading Post, three-fourths mile west of school at Lukachukai, Arizona

Material	Thickness (feet)	Depth (feet)	Formation
Boulders	18	18	Quaternary alluvium
Gray sandrock	8	26	Chinle formation
Red shale	74	100	Do.
Sandy shale	10	110	Do.
Red sandstone	65	175	Do. (?)
Gray sandstone, water	125	300	DeChelly sandstone member of Cutler formation
Boulders, hard a/	4	304	Do.
TOTAL DEPTH		304	

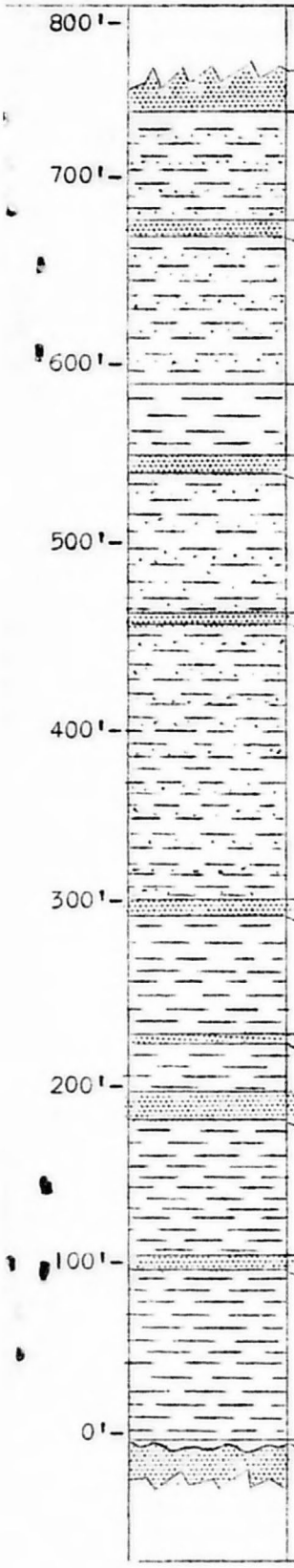
a/ Probably hard sandstone

Table 2. Analyses of waters from Lukachukai area, Apache County, Arizona
Analyzed in Southwestern Laboratory of Geological Survey, Albuquerque, New Mexico
(Parts per million except specific conductance)

Sample No.	Water-bearing formation	Date of collection (1948)	Temperature °F.	Specific conductance (Micromhos @ 25°C.)	Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na + K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$
1	Valley fill	June 27	53	925	56	31	118	482	56	46	0	5.7	599	267
2	do.	do.	62	925	-	-	-	481	-	45	-	-	-	-
3	Chinle fm.	do.	63	340	51	9.7	14	217	11	5	0	.9	242	167
4	do.	June 23	59	1,070	-	-	-	496	-	35	-	-	-	-
5	do.	June 24	-	1,410	13	17	297	407	328	49	.5	4.4	930	102
6	DeChelly ss.	do.	-	401	11	4.0	80	209	34	7	0	.6	257	44
7	do.	June 27	64	859	-	-	-	420	-	10	-	-	-	-
8	DeChelly ss.(?)	do.	65	10,600	388	988	1,460	489	6,770	530	.8	2.4	10,400	5,030

1. Dug well, depth 15 feet, at Lukachukai School. Discharge about 10 gallons per minute.
2. Dug well, depth 15 feet, at Mission adjacent to Lukachukai School. Discharge about 10 gallons per minute.
3. Spring near abandoned CCC camp, about 1 mile southeast of Lukachukai. Estimated discharge, 2 gallons per minute.
4. Spring in south bank of wash, ½ mile south of Lukachukai. Four openings, estimated discharge, 3 gallons per minute.
5. Drilled well, depth 160 feet, at Round Rock Trading Post, 12 miles west of Lukachukai. Reported discharge, 5 gallons per minute.
6. Drilled well, depth 500 feet, at Round Rock Trading Post. Flows about 4 gallons per minute.
7. Drilled well, depth 304 feet, at Kennedy Trading Post, 3/4 mile west of Lukachukai. Reported discharge, 5 to 10 gallons per minute.
8. "Bitter Water Spring", on south side of road to Round Rock, about 5 miles west of Lukachukai. Estimated discharge, 8 gallons per minute.

Figure 1.- Section through Chinle formation near Lukachukai, Arizona.
(Measured with plane table by S. C. Brown, June 1948)
(Total thickness of Chinle formation=750 feet).



	THICKNESS (FEET)
Base of Glen Canyon group; massive, red cross-bedded sandst.	
Brick-red and light - to medium-gray shale with lenses of sandy shale	60
Red sandstone	10
Brick-red and light - to medium-gray shale with lenses of sandy shale	82
Red shale	40
Red sandstone	10
Red shale with sandy shale lenses	77
Red and green mottled sandstone and sandy shale	5
Red shale with sandy shale lenses	155
Blue-gray sandstone composed of volcanic material	8
Variegated and mottled shale (blue, light to medium gray, pink, and maroon)	68
Gray sandstone	3
Red shale	25
Light-gray sandstone a/	15
Variegated light-gray and green shale in upper part; red to maroon shale in lower part	86
Dark-gray sandstone of volcanic material; agatized	3-5
Dark-gray, brown, and reddish-maroon shale	103
Shinarump conglomerate: coarse-grained to pebbly ss.	b/0-10
DeChelly sandstone member of Cutler formation: light-gray to medium-brown cross-bedded sandstone	75+

a/ *Approximate position of well site in section.*
b/ *Not everywhere present.*