STATE OF NEVADA

OFFICE OF THE STATE ENGINEER

GROUND-WATER CONDITIONS IN THE VICINITY OF TONOPAH, NYE COUNTY, NEVADA

By David A. Phoenix

Geologist, U. S. Geological Survey

Prepared in cooperation with the
GEOLOGICAL SURVEY
UNITED STATES DEPARTMENT OF THE INTERIOR

1948

49-98

GROUND-WATER CONDITIONS IN THE VICINITY OF TONOPAH, NYE COUNTY, NEVADA

By David A. Phoenix

INTRODUCTION AND SUMMARY

At the request of the Department of Highways, State of Nevada, through the State Engineer of Nevada, the Ground Water Branch of the United States Geological Survey, in cooperation with the State Engineer, made an examination of ground-water conditions in the vicinity of Tonopah, Nevada. The examination was made for the purpose of evaluating the possibility of developing a ground-water supply by drilling a well at the site of the proposed highway maintenance station on U. S. Highway 95, approximately 1½ miles northwest of the city limits of Tonopah. (See Pl. 1.) A field examination was made by the writer on May 11 and 12, 1948, and this was supplemented by a visit on November 9, 1948, by T. W. Robinson, District Engineer for the Ground Water Branch in Nevada.

This brief report contains statements on the general geologic and hydrologic conditions, water levels in the mine shafts of the Tonopah mining district, the early water supply for Tonopah, the depth at which water might be encountered by a well drilled at the proposed maintenance station, and the quality and temperature of the ground water in the area.

It is believed, on the basis of the data and information collected during the examination, that the water table will not be encountered by a well less than about 830 feet deep, and then only if zones of brecciated rocks are encountered by the well. Underground mine workings extend westward from the McKane shaft and other shafts in the area, and may pass beneath the proposed site of the highway maintenance station. These workings are flooded; it thus might be possible to tap them for a water supply.

In addition, several of these shafts are reported to be open, and, therefore, it might be possible to put well casing in one of the shafts and pump directly from the flooded workings.

The quality of the water in the workings may not be good, as the gangue minerals of the ore bodies are chiefly sulfides; arsenopyrite and arsenical pyrargyrite have been noted also. The water from a well used to supply cooling water for the Diesel plant at the Tonopah Extension shaft was analyzed and found to be high in dissolved solids. It is reported that the water pumped from the mine workings could not be used by the mills for flotation because it was too high in dissolved solids and organic acids. Temperature gradients in the mine workings are high, and it is expected that the temperature of the water obtained from either the mine workings or a deep well will be in the neighborhood of 100° to 110° F.

LOCATION

The proposed highway maintenance station is in the SE¼ sec. 28, T. 3 N., R. 42 E., approximately 2.4 miles west of the present highway maintenance station in Tonopah and on U. S. Highway 95. The area covered in this investigation is shown on the accompanying map (Pl. 1.) It includes an area of about 6 square miles underlain by the mine workings in the immediate vicinity of the town of Tonopah, Nye County, Nevada.

GENERAL GEOLOGY AND WATER-BEARING PROPERTIES OF THE ROCKS

The Tonopah district is underlain by a thick series of rocks that are products of volcanic activity, and are believed to be of Tertiary age. Broadly classified these rocks consist of a lower series mostly of rhyolite, which is overlain by two andesites distinguished as "earlier" andesite (termed Mizpah trachyte by Spurr[1]), and "later" andesite termed Midway. The later andesite is overlain by rhyolite, lake-deposited tuffs, and thin flows of basalt. In spite of the complicated faulting most of the volcanic formations are rather flay lying.

Data on water levels in the mine shafts

There are several mine shafts in the Tonopah area in which it is possible to get information on water levels. Data on the depth to water in these shafts were obtained from H. Budelman, mining engineer at Tonopah, who also supplied information as to the altitude of the collars of the shafts above mean sea level, and the approximate altitude of the water levels above mean sea level. The shaft-collar altitudes were determined by leveling from U. S. Coast and Geodetic Survey bench mark H-128 at the northeast corner of the bank building in Tonopah.

Altitude of the collars of the various mine shafts, depth of shafts, and altitude of water levels, in feet:

Shaft	Altitude	Depth of shaft (feet)		Water level
McKane	5,899	1,200		4,898 -
Ohio Tonopah	5,958	1,212	Dry at	4,746
Belmont	6,299	1,300		4,999
Halifax	6,183	--		4,999
Tonopah Victor	5,949	--		4,898 -
Tonopah Extension	5,960	1,440		4,898 -
Cash Boy	5,927	--		4,898 -
Great Western	5,714	--		4,898 -
Tonopah Bonanza 1/	--	--		--

1/Water encountered 800 to 1,000 feet below collar of shaft.

1/Spurr, J. E., Geology of the Tonopah mining district, Nevada: U. S. Geol. Survey Prof. Paper 42, 1905.

The McKane, Tonopah Victor, Tonopah Extension, and Cash Boy shafts are all connected by underground workings; the Belmont and Halifax shafts are likewise connected.

The lower workings from the McKane, Tonopah Victor, Tonopah Extension, and Cash Boy shafts are now abandoned and flooded, the water level standing at about the 1,000-foot level, or at an altitude of about 4,898 feet above mean sea level.

Early water supply for Tonopah

The water supply for Tonopah has always been from ground-water sources. The first supply was taken from a shallow-well field about 4 miles north of the town. It furnished water for the camp from the time rich gold and silver deposits were discovered in 1900 to about 1904. In 1904, wells were sunk and a pumping plant was installed at Rye Patch in the axis of Ralston Valley about 11 miles northeast of Tonopah. This water, which was pumped through a pipe line to a reservoir on high ground north of the town, has supplied the town since 1904.

It is reported by Victor Lambertucci, a long-time resident of Tonopah, that at one time during the early days of the camp sufficient water was hauled 4 miles from the shallow-well field to supply the minimum requirements of about 12,000 residents, and about 6,000 head of horses. This water was hauled to the mining camp by barrels or in tank wagons. However, with expanding mining and milling operations, the supply was not adequate and the well field was abandoned in favor of the present source of water supply at Rye Patch.

In development of the shallow-well field numerous wells were dug, ranging in depth between 25 and 75 feet. When visited on November 9, 1948, many of the original wells had caved in but several were still preserved.

Following is a list of six wells which were found and were in a good state of preservation:

Location[a]	Name	Depth (feet)	Depth to water below land surface (feet)
Sec. 13, NW¼	Crystal Water Well	40	--
Sec. 14, NE¼	Midway No. 1	26	8.75
Sec. 14, NE¼	Spur No. 1	30	19.0
Sec. 14, NW¼	Uncle Sam No. 1	46	39.0
Sec. 15, NE¼	Checkered Cap No. 1	65	14.0
Sec. 15, NE¼	Checkered Cap No. 2	22	14.1

a/Wells are all in T. 3 N., R. 42 E.

The aquifers tapped by the shallow wells occur in a westward-trending valley which originates in the mountains north of Tonopah. The aquifers, which are believed to be beds of sand and gravel, appear to be localized in the valley and do not extend to Tonopah.

Depth of well at site for proposed highway maintenance station

The altitude of the land surface at the proposed site for the highway maintenance station is approximately 5,729 feet above mean sea level; the altitude of the standing water level in the interconnected McKane, Tonopah Victor, Tonopah Extension, and Cash Boy shafts is about 4,898 feet above mean sea level.

The depth to which a well would have to be drilled to encounter the present standing water level would be in the neighborhood of 830 feet. Additional depth would be required to allow for drawdown of the water level during pumping. No assurance can be given, however, that a well will encounter any substantial amounts of water at this depth, as in general rocks are highly impermeable. From the evidence given by Spurr (see appendix) and that obtained from Mr. Budelman, ground water underlying the Tonopah mining district occurs in faulted and brecciated zones. Unless the well happened to enter the flooded mine workings or shafts, its success would depend entirely upon encountering zones of faulting or brecciation at some point below the regional water table. The geologic mapping is not on a sufficiently detailed scale to predict the position of these faults or brecciated zones below water table as represented by the water level in the mine workings. Little or no water can be expected to enter the well from fracture zones above the regional water table, as it is believed that they have been drained by the extensive underground workings throughout the district. It might be possible to insert well casing in one of the shafts that are still open, and thus to pump directly from the workings.

Expected quality of the ground water

The expected quality of the ground water to be obtained from a well in the vicinity of the proposed maintenance station is not good. A sample of water, collected on January 28, 1932, was submitted by V. Lambertucci, and reported to be taken from a well which supplied the Diesel plant of the Tonopah Extension shaft with cooling water. The following analysis, in parts per million, was made by Wayne B. Adams, of the State Food and Drug Laboratory:

SiO_2	58
Fe and Al	Tr.
Ca	258
Mg	80
Na and K	523
CO_3	0
HCO_3	646
SO_4	915
Cl	443
Dissolved solids	2,918
Alkalinity as $CaCO_3$	530
Hardness as $CaCO_3$	974

It is reported that the water pumped from the mine workings of the Belmont and Halifax shafts could not be used by the mills for flotation because it was too high in dissolved solids and organic acids.

The gangue minerals of the ore bodies are chiefly sulfides; arsenopyrate and arsenical pyrargyrite have been noted also. The ground waters may be expected to contain considerable sulfate and at least small amounts of metallic ions.

Temperature of the ground water

It was reported by H. Budelman that the water pumped from the Tonopah Victor shaft was thermal, having a temperature of 110° F. Data given by Spurr, as shown in the appendix, indicate that for the Ohio Tonopah shaft the average increase in temperature in depth was 1° F. in 37 feet, whereas in the Mizpah Extension shaft the average increase in temperature in depth was 1° in 51.3 feet. It is believed that the water obtained from a well on the site of the proposed highway maintenance station will be thermal, the temperature probably approaching the temperature of the water pumped from the Tonopah Victor shaft. In addition, the Lambertucci brothers of Tonopah report that, while mining operations were carried on in the Tonopah Bonanza shaft, water was encountered between 800 and 1,000 feet below the land surface. It was further reported that the temperature of this water was so high that the miners could not work in it.

APPENDIX

The following statements on the occurrence of ground water in the Tonopah mining district are quoted from Spurr, J. E., Geology of the Tonopah mining district, Nev.: U. S. Geol. Survey Prof. Paper 42, pp. 105-108, 1905.

PRESENT SUBTERRANEAN WATER

Water Encountered In Mining Operations

The Desert Queen shaft is 1,114 feet deep. It is perfectly dry, except at the contact of the rhyolite and later andesite at a depth of a little over 300 feet, where water following the contact zone was encountered. Along the watercourse, which strikes north and south and dips 60° east, the rocks have been altered to clay. Fragments of rocks in the channel show fresh pyrite on cracks, indicating that these waters have deposited the sulphide. The water tasted very slightly astringent; when first encountered it was tepid, but afterwards it became cool.

The water was encountered in October 1902, when the flow was about 3,000 gallons per 24 hours; it gradually diminished, till in 6 weeks it was only 250 gallons, and later in the fall shrunk to 100 gallons. In the spring, however, the flow increased to 250 gallons, and the water was cold.

These data show that the water of the contact zone was contained in a comparatively small basin or reservoir, whose surface was quickly lowered, and the increase in the spring with the melting snow indicates that this basin is fed from the surface.

The Halifax shaft encountered water below 600 feet; at 640 feet the flow, on July 17, 1903, was estimated by the manager at 12,000 to 15,000 gallons a day, and on July 20 at 20,000 to 30,000, so it was necessary to stop work pending the arrival of a pump.

A similar copious flow was encountered in the Rescue, situated just south of Mizpah Hill. At a depth of 250 feet an estimated flow of 6,000 to 7,000 gallons a day was encountered along a crevice in the rhyolite, striking northeast and dipping southwest at an angle of about 40°. Below this there was no water till a depth of 300 feet was reached, at which depth more water came in along fractures striking northwest and dipping northeast. When this second water zone was struck the supply of water in the first was reduced, showing that the two zones are connected. On July 10, 1903, the combined flow from the two was about 8,000 gallons; on July 17 it was estimated by the manager to be from 25,000 to 30,000 gallons.

Outcropping Water Zones

Previous to the discovery of the water in some of the shafts described the entire water supply of the town of Tonopah was obtained from wells 4 miles to the north, where geologic and topographic conditions are similar to those at Tonopah. Here, in a distance of a half mile or more, along a small east-west valley, are a number of wells, most of which reach water within 30 to 40 feet of the surface. The wells are in solid later andesite, and the water circulates along a fractured (probably faulted) zone. The trend of the water zone corresponds with that of the valley, which has probably been eroded along this belt of fractures.

These water zones can often be recognized at the surface by the presence of taller and greener vegetation, or by plants requiring so much water that they would not thrive under the usual arid conditions.

Distribution and Explanation of Water Zones

The above data show that while some of the Tonopah shafts have reached depths of over 1,000 feet (in the case of the Desert Queen over 1,100 feet) no general body of ground water has been encountered, though the rocks are extremely fractured; yet along certain steeply inclined fracture zones water is found sometimes quite near the surface and occasionally in considerable quantity. This water is cool, is sufficiently nonmineral to be fair drinking water, and is undoubtedly the storage of precipitation.

These water zones appear to be widely spaced. They have been noted only in rigid and brittle rock--rhyolite and andesite. They seem to occur especially along intrusive contacts, where one rock has been shattered by the intrusion of another. They are often, perhaps usually, accompanied by a clayey state of the decomposed rock. This decomposed rock, while itself undoubtedly due to the waters, now forms an impervious bottom or foot wall of the fractured zone and keeps these waters from penetrating the underlying dry and fractured rocks. Thus the water channel or basin has a dike-like shape. It appears probable that similar clays may limit these water basins in depth, limiting the downward extent of the zone-shaped basins, and thus explain why they are found sometimes so near the surface in a region apparently without universal ground water.

Usual Absorption of Precipitation by Rocks

In the southern half of the area shown on the Tonopah map,.......in the depressed area capped by volcanic breccias, no water has been encountered, even in shafts over 700 feet deep, although some shafts, as the Ohio Tonopah for instance, have passed through the soft breccia to a rigid and fractured rock below. Furthermore, in the breccia-covered region to the south, the writer does not know of any water or water signs, while to the north, in the hard rock, water zones outcrop in various places, both on and beyond the area mapped. The explanation of this is probably that the porous breccias and tuffs absorb the scanty precipitation like a sponge.

Even where rigid fractured rocks outcrop, the scanty descending water normally sinks as through a sieve, using itself up in kaolinization, the formation of limonite, and other hydration processes, and moistening the dry rocks with interstitial water. Fresh rock taken from the Fraction and other shafts in frosty weather was observed by the writer to steam vigorously in the cold air, though the mines are perfectly dry. It is doubtful if there is enough of this water left to form a standing body of ground water at any depth. Where, however, kaolinization and other processes have formed clay seams, the water may be detained and even stored at any depth from the surface downward; and other impervious rock materials may operate in the same way.

CHAPTER VIII

INCREASE OF TEMPERATURE WITH DEPTH

Some measurements were made by Mr. Leon Dominian, field assistant, under the direction of the writer, with a view to ascertaining the increment of temperature with depth in this district.

Method of Measurement

The best opportunities were offered by the Mizpah Extension and the Ohio shafts, both fairly deep shafts with (at that time) very little side workings and no through system of ventilation. Holes were drilled dry into the rock at the sides of the shafts at the points where the temperature was to be taken, deep enough to take in the thermometers, which were especially procured for this purpose. After the thermometer was inserted the hole was stopped up, and the reading was taken after fifteen to twenty-five minutes—in some cases twenty-four hours. Check measurements were taken in every case. In the Ohio Tonopah the holes were driven 18 inches; in the Mizpah Extension not so deep.

The Ohio Tonopah shaft is perfectly dry. The Mizpah Extension encountered a very little water on a contact zone at a depth of 300 feet, but is otherwise quite dry.

The Gold Hill shaft was dry to the bottom (490 feet), but a drift running nofthward from the bottom struck water in fractures a short distance from the shaft. The south drift was dry. The water here was estimated at one time to be 7,000 to 8,000 gallons a day.

The Belle of Tonopah shaft encountered water along fractures at a depth of 150 feet. This was drained, and another water seam was cut at 190 feet. The rock is soft later andesite, very full of pyrite, indicating, as at the Desert Queen shaft, that these waters deposit pyrite.

The Golden Anchor struck water at a depth of 130 feet and also farther down along fractures. One fracture from which water issued, seen by the writer at 200 feet, was perpendicular, and had a course of N. 70° W. This fracture had been cemented by calcite and reopened. The Silver Top, east of the Golden Anchor, encountered water at a depth of 180 feet.

The Mizpah Extension encountered water at a depth of 430 feet at the contact of Oddie rhyolite and Tonopah rhyolite-dacite. The water runs on top of 14 feet of wet clay, formed by rock decomposition. The water zone strikes N. 30° W. and dips northeast at an angle of 40°. At the time of the writer's inquiry, in November 1902, the flow was about 300 gallons a day. The shaft was sunk to a depth of 800 feet without encountering any more water.

The other shafts in the district were quite dry at the time the writer made his observations. The depths at that time, or soon afterwards, were as follows:

King Tonopah	300 feet
Boston Tonopah	300
Belmont	340
North Star 1/	1,050
Siebert	938
Valley View	700
Stone Cabin	400
Molly	468
Montana Tonopah	765
Midway	635
Tonopah Extension	485
MacNamara	500
West End	780
Fraction	400
Wandering Boy	500
Tonopah and California 2/	650
Tonopah City 2/	500
Ohio Tonopah	756
Big Tono 2/	300
Fraction Extension 2/	300
New York Tonopah 2/	745

1/A little seepage along a fault zone at a depth of 720 feet.

2/Not shown on Plate 1 of the present report.

Temperatures in the Mizpah Extension and the Ohio Tonopah are abstracted from Spurr, J. E., Geology of the Tonopah mining district, Nev.: U. S. Geol. Survey Prof. Paper 42, pp. 105-108, 1905.

The results of the measurements of temperatures are given in the following table:

	Temperature (degrees F.)	
Feet below surface	Mizpah Extension	Ohio Tonopah
100	60.25	60
200	61.75	61
300	64	62.5
400	66.5	64
500	69	66.5
600	70.5	69
700	72	74
766 a/	—	78
780 b/	73.5	—

a/Bottom Ohio Tonopah
b/Bottom Mizpah Extension

Average increase:

Mizpah Extension	Ohio Tonopah
1° in 51.3 feet	1° in 37 feet

Temperatures in the Montana Tonopah

Some observations were also taken in the Mizpah and the Montana Tonopah workings, but with a less range of depth. Those in the Montana Tonopah, however, were taken at intervals along the vertical shaft, in holes drilled for the purpose, and the thermometers were left in place 15 minutes, check readings corresponding exactly. They are therefore, worthy of confidence, and are given in the following table:

Feet below surface	Temperature (degrees F.)
317	64
460	68
600	70.5

Although the average increment of temperature (1° F. in 43.5 feet) for the Montana Tonopah measurements differs from that shown by the Mizpah Extension measurements (1° in 51.3 feet), comparison of the tables shows that the temperatures for the corresponding levels in each case practically coincide.