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STATE OF NEW MEXICO
State Engineer Office

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State Engineer

POSSIBLE FLOW OF WATER BETWEEN RITO RESUMIDERA AND POLEO CANYON SPRING, RIO ARRIBA COUNTY, NEW MEXICO

Prepared in cooperation with the Geological Survey,
United States Department of the Interior

May 1954

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STATE OF NEW MEXICO

STATE ENGINEER OFFICE
TECHNICAL DIVISION

Possible Flow of Water Between Rito Resumidera and Poleo Canyon Spring, Rio Arriba County, New Mexico

By
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U. S. Geological Survey

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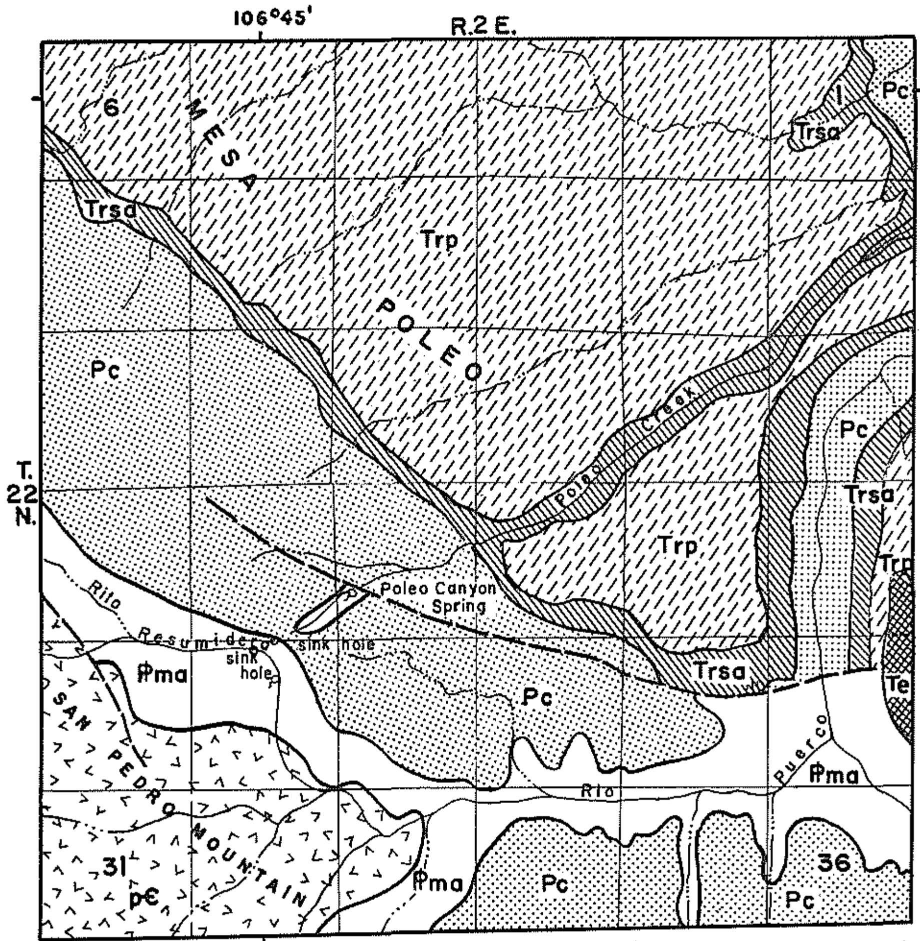
INTRODUCTION

As part of the Statewide ground-water studies in cooperation with the State Engineer of New Mexico, the writer made a reconnaissance from September 1 to 8, 1953, to determine the geological conditions influencing the movement of ground water in an area in southern Rio Arriba County, N. Mex., centered around Rito Resumidera and Poleo Canyon Spring. This investigation constitutes a part of the Rio Puerco de Chama Hydrographic Survey conducted by the State Engineer Office to provide data to the District Court for the adjudication of water rights in the Rio Puerco tributary area of the Rio Chama drainage. The area investigated is about 8 miles southwest of Coyote, in portions of secs. 20, 21, and 29, T. 22 N., R. 2 E. The names of streams used in this report conform with usage of the State Engineer Office.

Rito Resumidera loses a portion of its surface flow underground through a sinkhole (fig. 1). The problem was to determine whether surface waters that disappeared into the sinkhole passed underneath the drainage divide between Rito Resumidera and Poleo Creek and reappeared in Poleo Canyon Spring. Poleo Canyon Spring, which discharges into Poleo Creek, is approximately three-fourths of a mile northeast of, and 425 feet lower in elevation than, the sinkhole in the bed of Rito Resumidera. Rito Resumidera and Poleo Creek are tributary to the Rio Puerco, which is tributary to the Rio Chama.



Base and Geology modified from Wood and Northrop, Oil and Gas Prelim. Map 57, U.S.G.S., 1946.

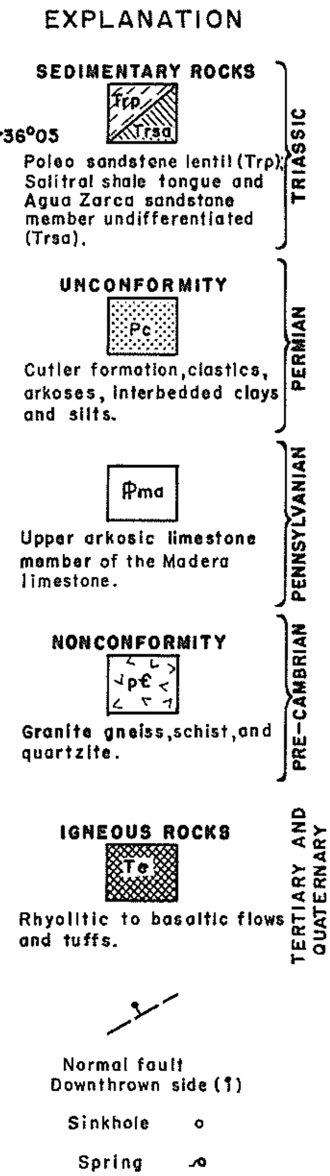


Fig. 1, GEOLOGY OF A PART (T.22N., R.2E.) OF THE RIO PUERCO DE CHAMA AREA, RIO ARRIBA COUNTY, NEW MEXICO.

1953

Physiographically, the area is in the southernmost part of the Rocky Mountain province (Fenneman, 1931), a region of intermontane basins and complex mountains. Dominating the area is the Nacimiento uplift and its northern and eastern extensions in the Rio Chama basin. Here mountain-building forces have elevated and deformed the underlying basement granites and overlying sedimentary rocks into a convex-upward flexure whose linear trend is essentially north-south (Darton, 1928).

San Pedro Mountain, headwater source of the Rio Puerco tributaries discussed in this reconnaissance study, is a part of the northern extension of the Nacimiento uplift. Because of the high altitude of San Pedro Mountain it receives more precipitation than the lower country to the east and northeast. The vegetative cover and the gradual melting of snow tend to retard runoff and thus facilitate the underground infiltration of surface waters into the rocks. The movement of runoff in the area investigated is influenced by the topographic slope which is approximately 10° to 15° to the northeast.

GEOLOGY

The areal distribution of rock formations is shown in figure 1, adapted from a map by Wood and Northrop (1946). The oldest known sedimentary rocks in the area, and in the region generally, are of Pennsylvanian age. These Pennsylvanian sedimentary rocks rest upon the older pre-Cambrian igneous and metamorphic rocks which form the core of the Nacimiento-San Pedro Mountain range. The Nacimiento-San Pedro land area has been involved in at least three different periods of mountain-building activity in the geologic past. Because of these structural movements the rocks of Paleozoic age in the area strike approximately north-south and dip about 10° E.

Pre-Cambrian Rocks

Although pre-Cambrian rocks do not crop out in the area covered by this report, the pre-Cambrian crystalline rocks are important, because they function as a barrier or lower limit below which downward-percolating waters cannot easily penetrate.

The uplifted and rugged surface of the pre-Cambrian rocks was eroded and reduced to a plain prior to the deposition of rocks of Pennsylvanian age (Wood and Northrop, 1946). The easterly dip of the Pennsylvanian strata agrees fairly closely with the slope of the bedrock surface.

Pennsylvanian System

The Pennsylvanian strata in the region rest upon the pre-Cambrian crystalline rocks and are overlain by sediments of Permian age. These in turn are overlain by still younger deposits of Triassic age, but only the Pennsylvanian and Permian rocks crop out in the area investigated. Rocks of Pennsylvanian age are exposed along the eastern slopes of the Nacimiento-San Pedro Mountain range and are represented in the region by the Magdalena group, which is composed of the Sandia formation below and the Madera limestone formation above (Wood and Northrop, 1946). In the area investigated the Sandia formation is absent.

The Madera limestone consists of two members: a lower gray member which is not present in the area, and an upper arkosic limestone member which is present in the area and rests directly upon the pre-Cambrian rocks. This upper arkosic limestone member consists of an alternating series of limestone, arkosic limestone, gray and red shale, and arkose. Its thickness varies, but in the area investigated it is approximately 200 feet (Wood and Northrop, 1946).

The limestone, the arkosic limestone, and the arkose (whose constituent minerals are cemented with calcium carbonate) are significant in the movement of ground water in the area. These rocks have been jointed and fractured as a result of the stresses produced during periods of mountain building after their deposition. These secondary openings in the rocks permitted the downward seepage of surface waters which dissolved the calcium carbonate and gradually enlarged the joint and fracture openings. As solution by downward moving waters continued, sinkholes developed in the limestone.

An open sinkhole in the channel of Rito Resumidera in the NW$\frac{1}{4}$ sec. 29, T. 22 N., R. 2 E. (see fig. 1), has developed in arkosic strata near the top of the Madera limestone. The arkosic strata strike approximately N. 1° W. and dip approximately 11° E. Two nearly vertical joints intersect in the sinkhole. One joint trends about N. 30° E. and the second trends approximately N. 30° W. Water has moved downward along these joints and has enlarged them by dissolving the calcium carbonate cement. The greatest enlargement has occurred where the joints intersect. The Madera limestone in the area is characterized structurally by a system of joints which are more or less parallel to the joints comprising the joint pattern in the sinkhole. Underground these joints and other irregular fractures, as well as the partings along bedding planes, have been enlarged by the action of downward-moving water, and because of their interconnecting, crisscrossing nature they provide a means whereby water can move freely through the formation.

No other open sinkholes were noted in the Madera limestone in the channel of Rito Resumidera. However, the probable existence of filled sinkholes in Rito Resumidera is suggested by a slackened flow or by the disappearance of the stream above their inferred positions. Such a filled sinkhole probably exists about 100 yards upstream from the observed sinkhole in Rito Resumidera; it is developed in the same arkosic beds of the Madera limestone as the observed sinkhole.

Another sinkhole (fig. 1) is near the head of Poleo Creek approximately 800 feet northeast of the open sinkhole in Rito Resumidera. It is partially filled, and has developed in the Madera limestone in fossiliferous limestone strata which lie immediately above the arkosic strata exposed in the unfilled sinkhole in Rito Resumidera. The Madera limestone is well exposed in Poleo Creek above Poleo Canyon Spring.

Permian System

Clastic sediments, which have been included in the Cutler formation (Wood and Northrop, 1946), rest on the Madera limestone in the area. The Cutler formation is considered by Wood and Northrop to be of doubtful Permian age. These rocks consist of gray, greenish-gray, and brownish-red arkose interbedded with brownish-red and red clay and silt. The arkosic strata in the Cutler formation are predominantly coarse grained and consist of quartz and decomposed granite and feldspar. In most exposures these rocks are moderately to strongly fractured. The bedding varies from dominantly platy or flaggy to massive. Because of these physical characteristics the arkosic strata in the Cutler formation have a relatively high permeability.

A brownish-red, coarse-grained and weathered arkosic sandstone, too small in extent to be shown on figure 1, crops out on the southeast rim of the sinkhole near the head of Poleo Creek. This erosional remnant of the Cutler formation, which rests on the fossiliferous limestone strata in which the unfilled sinkhole has developed, indicates that the fossiliferous limestone section forms the top of the Madera limestone in the area investigated. The remnant must lie at or near the base of the Cutler formation. A rough field test indicated that this coarse-grained arkosic sandstone absorbs water readily.

The Cutler formation crops out also about 200 yards downstream from Poleo Canyon Spring. In this area an outcrop of brownish-red arkose has been severely fractured and broken along a fault zone (see figs. 1 and 2). The relatively high permeability of the arkose thus has probably been further enchanced by crushing and shearing.

DRAINAGE AND GROUND WATER

Rito Resumidera and Poleo Creek head on the eastern slopes of San Pedro Mountain (see fig. 1). Rito Resumidera originates at the junction of Corralitos and Vega del Oso creeks. From that point it flows almost directly east for nearly 1 3/8 miles and then turns almost at a right angle to the south and flows south and east approximately $1\frac{1}{2}$ miles to join the Rio Puerco. Poleo Creek, which heads in the SE$\frac{1}{4}$ sec. 20, T. 22 N., R. 2 E., flows northeastward about 0.8 mile, where it is joined by an eastward flowing tributary, and thence continues northeastward approximately 6 miles to join the Rio Puerco.

Surface drainage in the flat divide area (see fig. 2) between Rito Resumidera and Poleo Creeks, and immediately north and northeast of the east-to-south right-angle bend of Rito Resumidera, is away from Rito Resumidera and in the direction of Poleo Creek. During the period of the investigation the flow of water in Poleo Canyon was fed not only by Poleo Canyon Spring but also by seepage from the Madera limestone upstream from the spring. The surface divide area is in the NE$\frac{1}{4}$ sec. 29 and SE$\frac{1}{4}$ sec. 20, T. 22 N., R. 2 E.

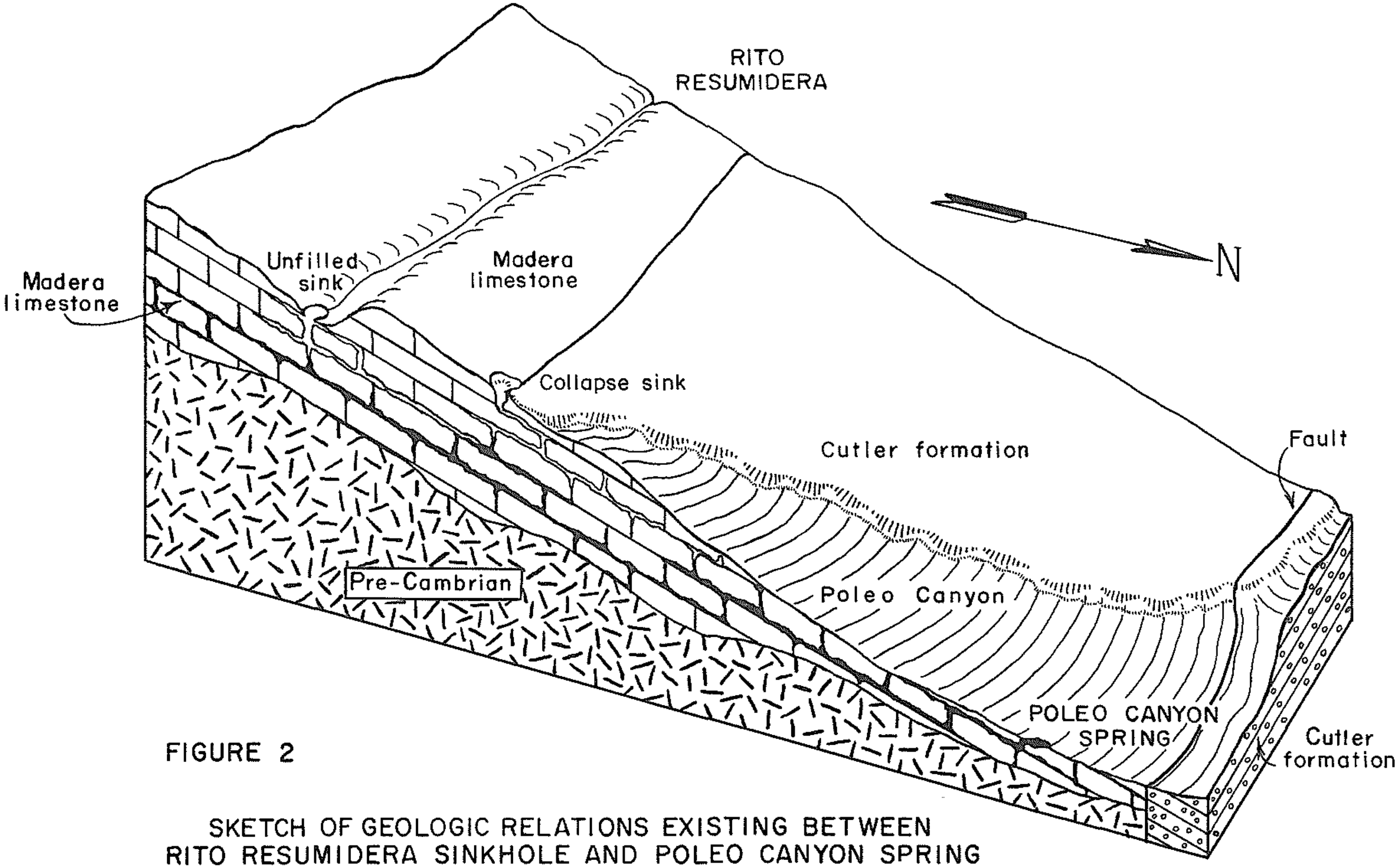


FIGURE 2

SKETCH OF GEOLOGIC RELATIONS EXISTING BETWEEN
RITO RESUMIDERA SINKHOLE AND POLEO CANYON SPRING

Limestone of Pennsylvanian age shown resting on pre-Cambrian complex. Vertical scale approximately 1 inch = 250 feet; horizontal scale approximately 1 inch = 600 feet.

In this area Rito Resumidera has cut its channel into the Madera limestone. The stream bed, however, is covered with a permeable fill composed of coarse sand, gravel, cobbles, and boulders derived from the pre-Cambrian and Pennsylvanian rocks that crop out in the upstream reaches of Rito Resumidera and its tributaries. At high stages the stream is continuous, but at low stages the seepage loss into the channel fill and underlying Madera limestone is great enough at some points in its course to cause the stream to disappear underground. A part of the seepage loss into the Madera limestone enters that formation through sinkholes.

The open sinkhole (see p. 5) in the bed of Rito Resumidera in the NW$\frac{1}{4}$ sec. 29, T. 22 N., R. 2 E., is a few feet south of the deepest part of the stream, where a small earthen dam diverts the surface flow into an irrigation ditch on the north side of the stream. Water enters this unfilled sinkhole and disappears underground into the Madera limestone during periods when the stream flow is somewhat above low stage. When the writer visited the area, the surface runoff feeding Rito Resumidera was in low supply so that the flow failed to reach the sinkhole but was ponded approximately 100 yards upstream at the site of a stream-gaging station erected by the State Engineer Office. This made it possible to enter and examine the sinkhole.

The sinkhole connects with one or possibly two underground channels that trend approximately N. 30° E., parallel to one of the two joints observed to intersect in the sinkhole. This joint trends from the Rito Resumidera sinkhole in the general direction of Poleo Canyon Spring but may not be continuous between these two locations. However, the sinkhole probably connects with the underground network of joints and fractures characteristic of the Madera limestone, because water that enters the sinkhole disappears rapidly. Otherwise the water entering the sinkhole would be ponded and disappear slowly as a result of evaporation and seepage. Thus, the joint and fracture system in the Madera limestone provides a means whereby water could move from the sinkhole to the spring in Poleo Creek.

The Madera limestone is exposed in the north bank of Rito Resumidera adjacent to the sinkhole. Unlike the arkosic section exposed in the sinkhole these beds are predominantly limestone and contain a great many fossils typical of the Madera limestone. These fossiliferous beds rest conformably upon the subjacent arkosic strata but are more severely jointed and fractured. They strike north-south and dip approximately 10° E., in conformity with the underlying arkosic strata exposed in the sinkhole.

The fossil-bearing limestone strata also underlie the grass-covered slope of the divide area between Rito Resumidera and the head of Poleo Creek. The distance between the sinkhole in Rito Resumidera and the head of Poleo Creek is about 800 or 900 feet. The soil cover is very thin on this slope, and the dip and strike of the limestone strata (approximately 10° E. and N. 2° W., respectively) are in agreement with measurements made at the open sinkhole and in the north bank of Rito Resumidera adjacent to the sinkhole. The difference in elevation between the top of the north bank of Rito Resumidera and the head of Poleo Canyon is approximately 135 feet. A 10° slope will drop approximately this amount over a horizontal distance of 800 feet, which suggests that the slope of the surface of the divide area is structurally controlled and that apparently no discontinuities exist in the Madera limestone from the north bank of Rito Resumidera to the head of Poleo Creek. Structural continuity in the Madera limestone between these two locations is also suggested by the dip and strike measurements.

The sinkhole on the northeastern edge of the divide area between Rito Resumidera and the head of Poleo Creek, near the descent into Poleo Canyon, is a saucer-shaped depression about 50 to 60 feet in diameter whose surface is about 12 to 15 feet below the surrounding land surface. The material which partially fills the sinkhole is composed of minor amounts of material washed in from the surrounding land surface. It is covered with grass and contains a fairly thick stand of young aspen and pine. There is no surface outlet or gap through which water may drain out of the sinkhole.

Good exposures of the Madera limestone crop out at progressively lower horizons in the stratigraphic section downstream in Poleo Canyon, and measurements of dip and strike were made on limestone beds between the head of Poleo Canyon and Poleo Canyon Spring. Near the head of the canyon the strata strike about N. 5° W. and dip about 9° E., and at Poleo Canyon Spring the beds strike approximately N. 6° W. and dip about 8° E. Strike and dip measurements made at intervening points agree closely with the above values and they are also in close agreement with the strike and dip measurements between the sinkhole in Rito Resumidera and the head of Poleo Creek. Thus, all strike measurements are nearly north-south and all dip measurements are approximately 8° to 11° E. Faults are absent in the area investigated between the sinkhole in Rito Resumidera and Poleo Canyon Spring.

Poleo Canyon Spring issues from the base of a cliff of Madera limestone approximately 25 feet high on the east side of the stream channel. The flow of the spring was small when observed and was accompanied by bubbles. It was impossible to investigate the spring closely because beavers had dammed and ponded the waters of Poleo Creek below the spring.

The fault below Poleo Canyon Spring (see figs. 1 and 2) is downthrown to the north (Wood and Northrop, 1946). The fault involves the Cutler formation and the Madera limestone and probably originated in the pre-Cambrian basement rocks. At the surface the Cutler strata are faulted against other Cutler strata, and the fault line is marked by a zone of fractured and shattered brownish-red clastic rocks. The permeability of the arkose strata in the Cutler formation has probably been increased in the fault zone by crushing and shattering forces of the fault movement, so that the fault probably does not impede seriously the flow of ground water in these beds. Where the clay and silts of the Cutler formation abut against the Madera limestone there possibly is a damming effect that restricts the flow of ground water up-gradient from the fault. This would not affect the movement of ground water from the sinkhole in Rito Resumidera toward Poleo Canyon Spring, if the spring waters issue from a channel in the Madera. If the flow of Poleo Canyon Spring is derived from the saturated zone the effect of damming by the fault would be to insure a flow from the spring. Because of the fault it might be thought that all the water that disappears into Rito Resumidera should reappear in Poleo Canyon Spring. This does not necessarily follow, because part of the water may join the underflow of Rito Resumidera and move southward out of the area investigated and conceivably reappear in that stream farther downstream; a part may reappear in another spring that is in the Madera limestone in the valley of Rito Resumidera about 800 to 1,000 feet south of the collapse sink near the head of Poleo Creek. The waters of this spring were not subjected to a tracer test, however. Also, some water flowing through the Madera limestone could infiltrate the shattered, permeable arkosic strata of the Cutler formation along the fault zone.

The geologic data thus suggest that water entering Rito Resumidera sinkhole flows, at least in part, toward Poleo Canyon Spring through the enlarged interconnected fractures and fissures in the Madera limestone. Some of this water probably emerges at Poleo Canyon Spring. The flow of Rito Resumidera did not reach the sinkhole at the time of the writer's visit to the area, and as a result the amount of water entering the sinkhole could not be compared with the discharge from Poleo Canyon Spring, which was then about 0.25 cubic foot per second according to T. P. Gerber of the State Engineer Office. However, Mr. Gerber stated that increases in the discharge from Poleo Canyon Spring have been preceded regularly by periods of increased flow at the stream-gaging station a short distance above the sinkhole on Rito Resumidera. This suggests that there may be hydrologic continuity between the sinkhole and the spring.

Tracer Tests

Tracer tests were made to determine whether water that disappears into the sinkhole in Rito Resumidera would reappear in the discharge of Poleo Canyon Spring.

Two substances, fluorescein and common salt, were used in making the flow-tracer tests at the Rito Resumidera sinkhole. Fluorescein is probably the most effective and reliable substance that has been used for tracing the flow of underground streams through calcareous rocks (Dole, 1905). It diffuses rapidly and it can be detected even when diluted to 1 part in 10 billion. The effectiveness of fluorescein is also due to its stability for relatively long periods of time during exposure to calcium in solution in ground water. Relatively long exposure to underground waters in such rocks will not destroy fluorescein. Because the color of fluorescein can be destroyed in the presence of acid solutions (such as from peaty soils), common salt (sodium chloride), was used as a precautionary check even though no such acid waters were expected to be present.

Sodium chloride is an effective flow-tracer substance. It dissolves and diffuses readily, can be detected readily in moderate concentration in the field by means of compact, portable, battery-powered meters, and chemical tests will reveal concentrations as low as one part in 10 million. It must be used with care where the water to be tested already has a high chloride content. Such a high chloride concentration did not exist in the waters discharging from Poleo Canyon Spring when the tracer tests were made.

Because Rito Resumidera did not flow as far as the sinkhole, an earthen dam was constructed upstream to store water for release to the sinkhole. A total of 100 pounds of sodium chloride and approximately four pounds of fluorescein dye were introduced into water released in slugs from the earthen dam and channeled into the sinkhole. The first slug of water was released from the dam on September 2, 1953, at 5:10 P.M.; a second slug was released on September 3 at approximately 5:00 P.M.; and a third slug was released on September 4 at approximately 1:00 P.M.

Water samples were taken for 11 days from Poleo Creek a short distance downstream from Poleo Canyon Spring. Chloride-ion concentrations in these samples were determined at the laboratory of the U. S. Geological Survey at Albuquerque, N. Mex. The analytical results (table 1) show slight fluctuations in the chloride concentrations from September 4 to September 8, and a great increase in the chloride concentration from September 8 to September 9, after which the concentration started to decrease. According to Mr. T. P. Gerber, hydrographer of the State Engineer Office, the preliminary field tests he made for fluorescein in the discharge from Poleo Canyon Spring also appeared to be positive. The fluorescein was detected in the samples from Poleo Creek approximately five days after it had been introduced into the sinkhole in Rito Resumidera.

CONCLUSIONS

The topographic slope in the divide area between Rito Resumidera and Poleo Canyon Spring affords a steep hydraulic gradient from the sinkhole in Rito Resumidera to the spring. The lower limit of appreciable movement of ground water is determined by the top of the buried pre-Cambrian rocks, which here are not more than 250 feet below the surface. Structurally, the Pennsylvanian strata in the area are extensively and prominently jointed in at least two directions.

TABLE 1.--ANALYSES OF WATER FROM RITO RESUMIDERA AND POLEO CANYON SPRING, RIO ARRIBA COUNTY, N. MEX.

SINKHOLE ON RITO RESUMIDERA

DATE	TIME	CONDUCTANCE (micromhos)	CHLORIDE (ppm)
1953			
Sept. 2	5:10 p.m.1/	230	0.0
SPRING ABOVE CONCRETE DIVERSION DAM. POLEO CANYON (sec. 21, T. 22 N., R. 2 E.)			
Sept. 2	7:20 p.m.	315	.5
	10:00 p.m.	318	.5
Sept. 3	2:00 a.m.	320	.5
	6:00 a.m.	305	.5
	10:00 a.m.	316	.5
	2:00 p.m.	323	.5
	6:00 p.m.	318	.5
	10:00 p.m.	332	.5
Sept. 4	2:00 a.m.	337	1.0
	6:00 a.m.	346	4.0
	10:00 a.m.	340	2.0
	2:00 p.m.	329	2.0
	6:00 p.m.	337	2.5
	10:00 p.m.	338	2.5
Sept. 5	2:00 a.m.	343	3.0
	6:00 a.m.	346	3.0
	10:00 a.m.	341	3.0
	2:00 p.m.	338	3.0
	6:00 p.m.	341	2.5
	10:00 p.m.	338	1.5
Sept. 6	2:00 a.m.	338	1.5
	6:00 a.m.	339	.5
	10:00 a.m.	346	3.5
	2:00 p.m.	335	3.0
	6:00 p.m.	346	4.0
	10:00 p.m.	339	2.0
Sept. 7	2:00 a.m.	340	1.0
	6:00 a.m.	343	1.0
	10:00 a.m.	339	.5
	2:00 p.m.	332	2.0
	6:00 p.m.	342	3.0
Sept. 8	11:00 a.m.	422	26
Sept. 9	10:00 a.m.	508	53
Sept. 10	10:00 a.m.	474	42
Sept. 11	9:30 a.m.	412	20

1/ Prior to adding salt.

There can be no doubt that solution channels exist in the Madera limestone. It is plainly evident that they have developed along the joints in the arkosic limestone section of the Madera limestone in the sinkhole in Rito Resumidera. Active solution and removal of rock are proceeding beneath the surface between the sinkhole in Rito Resumidera and the spring in Poleo Canyon. This is suggested by the collapse sinkhole near the head of Poleo Canyon and by the U-shaped cross-sectional form of the valley at the head of Poleo Canyon.

No structural discontinuities such as faults, marked changes in the attitude of the strata, or variations in the joint pattern were noted between Rito Resumidera sinkhole and Poleo Canyon Spring. The fault below Poleo Canyon Spring, shown on the geologic map and section (figs. 1 and 2), apparently does not affect or seriously offset the course of the flow of underground water between the Rito Resumidera sinkhole and Poleo Canyon Spring.

The geologic evidence thus strongly suggests that there is hydrologic continuity between the sinkhole and the spring, and the tracer tests prove that at least some of the water that disappears into the sinkhole does discharge at Poleo Canyon Spring. An intensive study would be required to estimate, with any degree of reliability, the proportion of the water that does so discharge.

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