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HYDROGEOLOGIC CROSS SECTION THROUGH SUNSHINE VALLEY, TAOS COUNTY, NEW MEXICO

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INTRODUCTION

This paper presents a reinterpretation of hydrogeologic conditions in the Sunshine Valley area, east of the Rio Grande in Taos County. Winograd (1959) collected and studied an extensive suite of well records in this area and concluded that perched or partly perched aquifers are present, particularly in the large part of the area underlain by fine-grained deposits which he thought were lacustrine. Our interpretation is based on data from 145 wells (Fig. 1), including many of those studied by Winograd. We have also used the records of 16 additional wells just beyond the northern and southern boundaries of the area shown in Figure 1. Our analysis led us to doubt the lacustrine origin and hydraulic-confining function of the fine-grained sediment, and we concluded that perched conditions are much less extensive than Winograd thought. We therefore proceeded to investigate the form of the main or regional water table on the assumption that any perched aquifers are local phenomena.

We first describe our assumptions and procedures. Then we present an analysis of the vertical form of the flow field along a cross section normal to the river (Fig. 2), and discuss the difference between our interpretation and that of Winograd (Fig. 3).

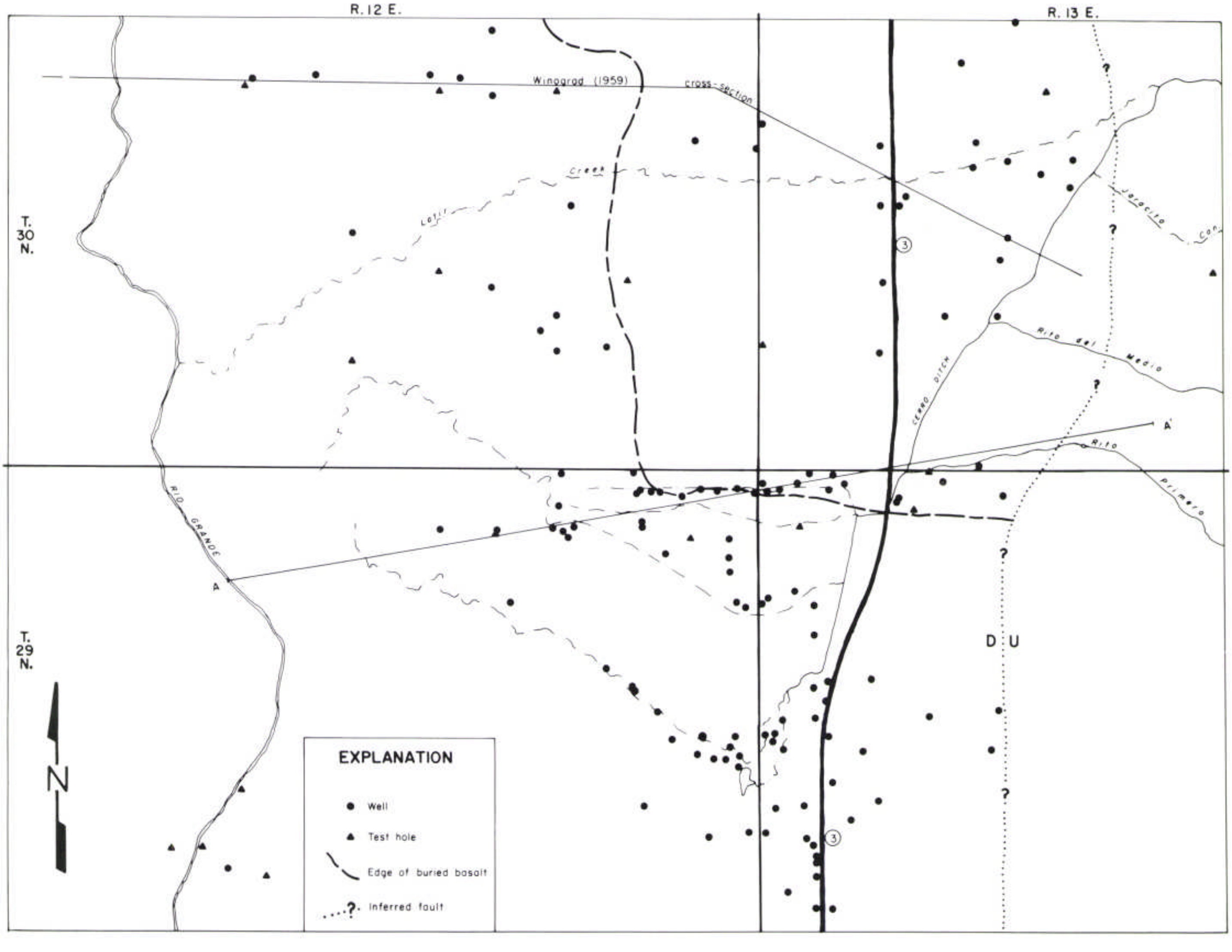

FIGURE 1. Reference map of part of Sunshine Valley, Taos County, New Mexico.

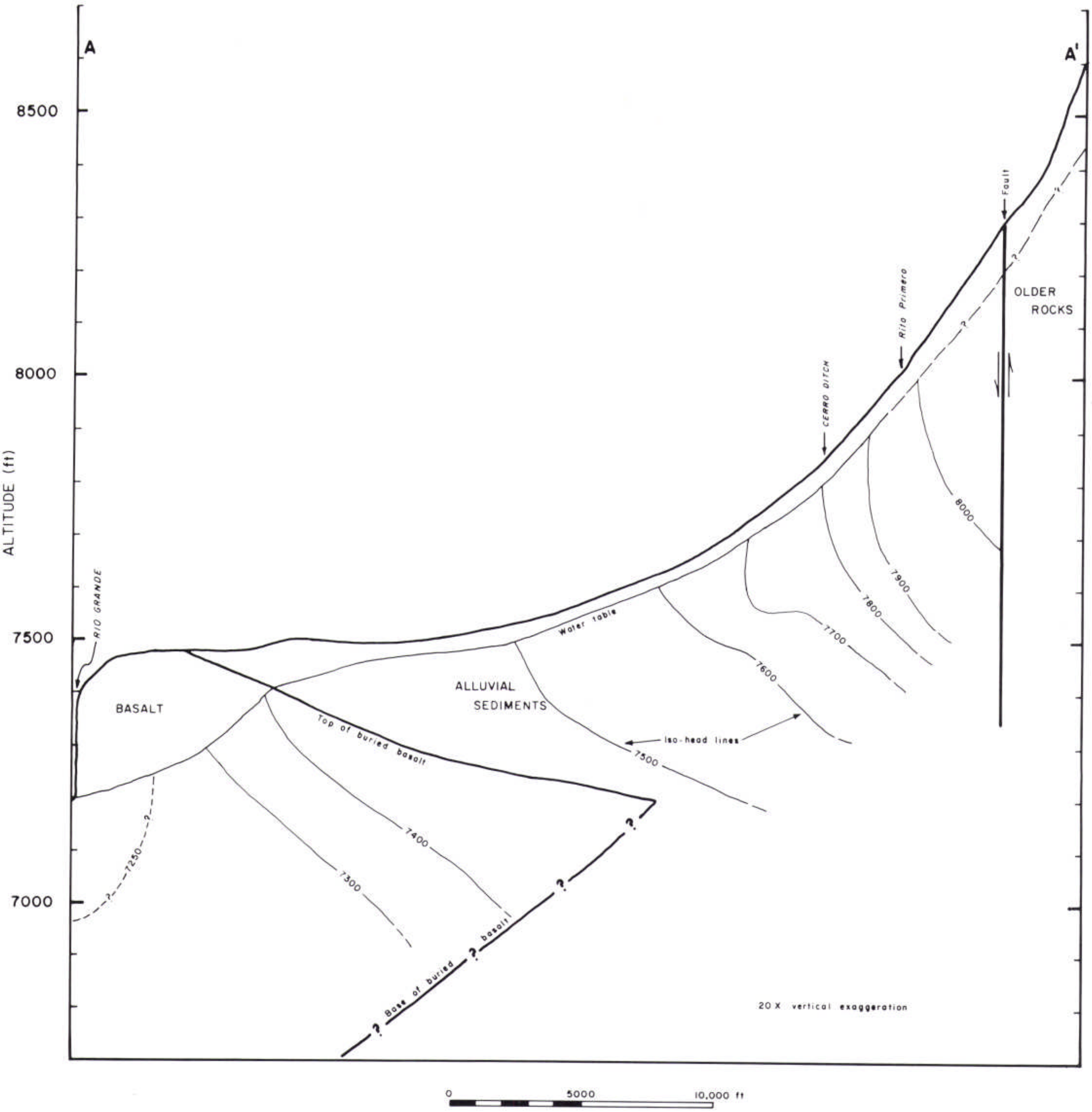

FIGURE 2. Cross section A–A′.

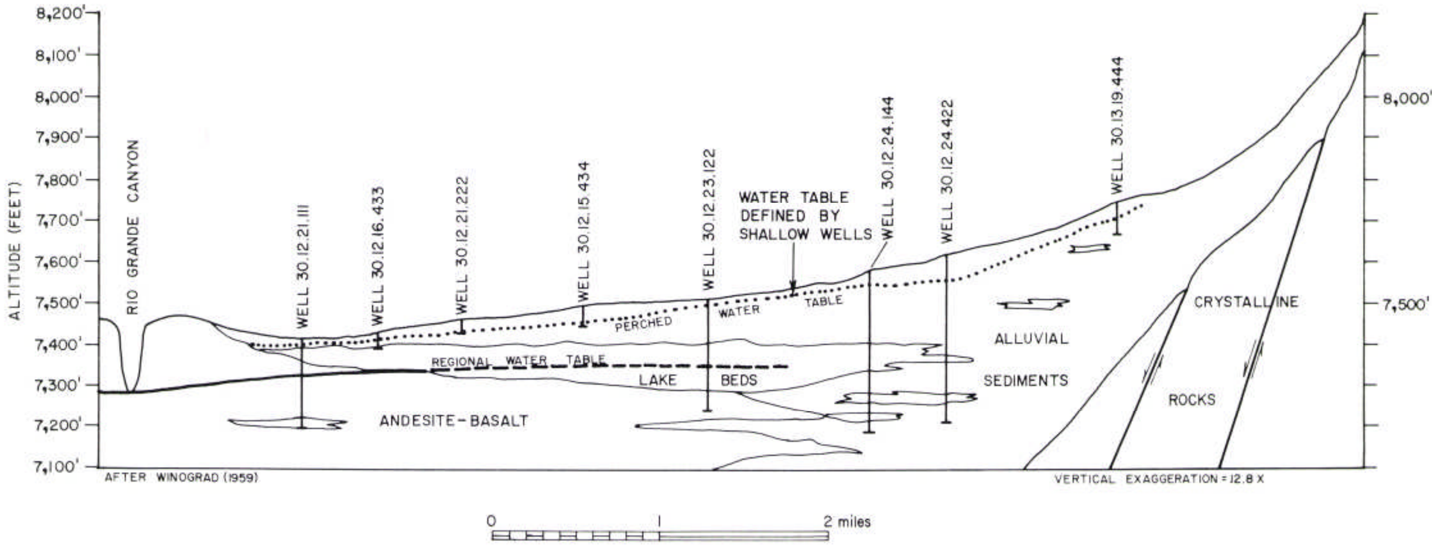

FIGURE 3. Winograd's cross section.

BACKGROUND

Winograd presented an east—west cross section through Township 30 North that showed his interpretation of hydrogeologic conditions in the Sunshine Valley, Taos County, New Mexico. Figure 3 of this paper shows the salient features of Winograd's cross section east of the Rio Grande. As the figure shows, he recognized two water tables; one he labeled as "Water table in alluvial sediments. Semiperched where underlain by saturated andesite—basalt. Perched in vicinity of test hole 30.12.21.111." The other he labeled as "Water table in andesite—basalt. Solid line indicates water table; dashes indicate piezometric surface of water confined in andesite—basalt under subnormal artesian pressure. Water in alluvium is semiperched from well 30.12.16.433 to a point east of well 30.12.23.122; perched from about well 30.12.16.433 to a point west of well 30.12.21.111."

Winograd came to this conclusion using data from 141 wells that he inventoried during 1955 and 1956 in an area of about 800 mil. He also came to the conclusion that clay beds in the western part of the area were lacustrine in origin and referred to them on his cross section as "lake beds."

Figure 1 shows the location of (1) wells in the area, (2) Winograd's cross section (our Fig. 3), (3) our cross section (Fig. 2), (4) the eastern edge of the basalt, and (5) the approximate location of the western bounding fault that separates rocks of Tertiary age from the rocks of Precambrian age.

METHODS

Figure 2 shows the land surface, the water table, the top of the basalt, and the approximate location of the fault. It also shows lines of equal total hydraulic head, which we call "iso-head contours."

The topographic profile came from U.S. Geological Survey topographic maps. We inferred the location of the fault from Winograd's geologic map and cross section. The water table, top of the basalt, and iso-head contours came from maps we drew using data from the wells shown in Figure 1.

We based the basalt map on the altitude of the basalt in outcrop, the depths to basalt reported in wells, and the altitudes of the bottoms of wells that did not reach basalt. The edge of the basalt shown in Figure 2 agrees fairly well with the edge of the basalt that Winograd shows. To draw the water table map we made four assumptions:

(1) The water table exists everywhere and is a smooth, continuous surface that intersects the Rio Grande.
(2) Except where it intersects the Rio Grande, the water table is below the land surface.
(3) The altitude of the water level in a well whose depth is 100 ft or less equals the altitude of the water table.
(4) The water table in a well must be higher than the altitude of the bottom of the well.

We raised a basic question: If the water table is a smooth, continuous surface and flow occurs from recharge to discharge areas, how can we go about defining the hydraulic-head distribution beneath the water table using existing well data? To answer this question, we began by reasoning that:

(1) The water-level altitude in any well is some sort of a vertical average of the head in the rocks to which the well is open (that is of the slotted, screened, perforated, or open-hole interval).
(2) In areas such as the Sunshine Valley where we would expect the hydraulic gradient to have a large vertical component directed downward, the head at the bottom of the well must be lower than the head at any point above the bottom.

Therefore, the water-level altitude of a well is larger than the head at the bottom, but if we represent the water-level altitude of the well as the head at the bottom, we will be making a conservative estimate of the head at the bottom of the well.

To draw the iso-head contours on the cross section, we drew a series of four water-level altitude maps based on the depths of the wells. The water-table map was based on the depth interval from I to 100 ft, so the first iso-head map was based on wells ranging in depth from 101 to 150 ft. Other depth intervals used were 151-200 ft, 201-300 ft, and 301-500 ft.

To draw the iso-head contours in the plane of the cross section, we plotted the values of the contours at the bottom of their depth range below the land-surface profile. Then, starting at the water table, we drew lines through points of equal value. Making the iso-head contour interval 100 ft circumvented the problem of using water-level data obtained over several years. Because U.S. Geological Survey records show that seasonal water-level fluctuations and the variation in water level caused by pumping in the area are less than 50 ft, we estimate that the contours should be within approximately 50 ft of the mean annual condition.

The 7,250-ft iso-head contour line on the cross section reflects the existence downstream of the 7,200-ft iso-head contour on two of the iso-head maps.

DISCUSSION

Figure 2 shows a dynamic ground-water system. Water moves downward from the land surface to the Rio Grande. In the immediate vicinity of the river the vertical component of hydraulic gradient is directed upward.

The cross section differs from Winograd's in the following ways:

(1) It shows one continous water table.
(2) It shows a continuous uninterrupted zone of saturation.
(3) It does not discriminate between lake beds and other sediments of Tertiary age.

If we argue that the water table is the top of the zone of saturation, then the water table of Figure 2 marks the top of the zone in which the rocks are saturated. Winograd believed that beneath the water table in the alluvium are rocks in which the degree of saturation is less than 100%. Moreover, his water table implies movement of water toward the river through the sediments. However, no springs occur in the wall of the Rio Grande gorge, and we have no reason to believe that water evaporates or transpires from the water table, so the water must be moving downward. Figure 2 shows that the physics of the system need not require perching to explain the observed water levels. However, to resolve the question, several suites of piezometers would have to be installed.

Another problem posed by Winograd's interpretation is: What happens to the water table in the basalt at its eastern extremity? Winograd recognized that recharge from the streams that drain the Sangre de Cristo Range must move to the Rio Grande. The head distribution depicted in Figure 2 shows water moving from the water table at higher altitudes toward the river, taking some of the mystery from Winograd's interpretation of recharge, but in no way diminishing its significance.

The term "lake beds" implies that the rocks include clays that are less permeable than the alluvial clays elsewhere in the valley, that the clay beds are more continuous than elsewhere, and that as a result they should cause "perching" of ground water. After studying the well logs of the area, which includes geologists' lithologic descriptions, electric logs, and drillers' logs, we cannot justify the term "lake beds" for the rocks that overlie the basalt. Perhaps even more important, we could not establish criteria for defining the top of the lake beds so that we could map the top. The beds consist of clays plus variable amounts of sand and gravel, which are much like the alluvial deposits we see elsewhere in the Rio Grande valley. The rocks between the mountains and the Rio Grande consist of stream deposits that reflect the changes in stream velocity (or sediment-carrying capacity) as well as the sediment source and climatic variables. Ponds or playas may have developed locally, but they do not constitute the primary environment of deposition. These beds serve to "perch" ground water no better than do other fine-grained alluvial deposits in the valley.

ACKNOWLEDGMENTS

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