MONTANA STATE UNIVERSITY

Paleochannel aquifer potential at Montana State University : a test of hypotheses

by David Allen Donohue

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Earth Sciences
Montana State University

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Abstract:
Groundwater resources in the Gallatin Valley of southwestern Montana are controlled by several factors. These include depositional controls on the Bozeman alluvial fan, tectonic activity in the block-faulted valley and erosional activity due to base level changes within the basin during the geologic past. The purpose of this study is to evaluate the presence of a postulated paleochannel within the Bozeman alluvial fan interpreted from a seismic refraction survey by Brown and others (1983). To test this hypothesis, a conceptual groundwater exploration model for the southeastern end of the Gallatin Valley was developed. Field studies included drilling of a well within the trend of the proposed paleochannel, an earth resistivity survey and shallow seismic refraction survey across the paleochannel on the campus of Montana State University.

The Roskie well is drilled to a total depth of 56 m (184 ft). Aquifer analysis indicates that the well is drilled into material that hydraulically compares with Tertiary material throughout the valley. The earth resistivity survey included resistivity profiling at the 9 m (30 ft) and 30 m (100 ft) a-spacings in order to intercept the postulated paleochannel at a relatively shallow and a relatively deep level. Interpretation of the data suggests no deep paleochannel cut into fine-grained Tertiary material and filled with a thick sequence of Quaternary gravels is present.

The seismic refraction survey utilized a 12-channel seismic recorder and did not repeat the results of the study by Brown and others (1983). Seismic results indicate material with velocities greater than 2000 m/s (6500 ft/s) are located within 3 m (10 ft) of the surface throughout the study area. The discrepancy between the results of the two studies appears to be due to the mis-interpretation of the first arrival seismic wave with the single channel recorder used in the 1983 study.

The results of this study indicate that the study area is not underlain by Quaternary Bozeman alluvial fan material. A Tertiary pediment surface underlies the area and material with seismic velocities characteristic of Tertiary sediments is found to a depth greater that 56 m (184 ft). Future wells drilled into this area cannot expect yields to be greater than 378 lpm (100 gpm) due to the hydraulic properties of the Tertiary material.

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of

Master of Science

in

Earth Sciences

MONTANA STATE UNIVERSITY
Bozeman, Montana

June, 1989

N378
D7195

APPROVAL

of a thesis submitted by

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

17 May 89

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Date 5/17/89

ACKNOWLEDGEMENTS

First and foremost, I would like to thank Dr. Stephan G. Custer for his suggestions and guidance throughout this project. Dr. Custer provided valuable encouragement when problems arose with this study. Dr. William W. Locke and Dr. Clifford Montagne provided constructive criticism that was very helpful in the preparation of this thesis. Dr. Jim Schmidt provided important suggestions for the development of the conceptual model. Carol Bibler, Jay Erickson, David Hazen, Nick Williams and John Zim assisted in the collection of field data at various times throughout the study. Earl Maher proved invaluable in redesigning and repairing the seismic energy source. The seismic and earth resistivity equipment was loaned to me by the Montana Bureau of Mines and Geology. Graduate study at Montana State University was supported in part by a teaching assistantship. The Physical Plant at Montana State University provided financial support to drill a test well. Special thanks and love are extended to my wife, Cindy, who provided support, patience and care for our daughters, Adelle and Mariah, while I worked on this project. Cindy also assisted in the collection of field data and added constructive criticism to my drafting. Finally, I would like to thank my parents, Bill and Helen Donohue, who encouraged me to achieve my fullest potential and allowed me the freedom to do it. Without their support, this project would not have been possible.

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ABSTRACT

Groundwater resources in the Gallatin Valley of southwestern Montana are controlled by several factors. These include depositional controls on the Bozeman alluvial fan, tectonic activity in the block-faulted valley and erosional activity due to base level changes within the basin during the geologic past. The purpose of this study is to evaluate the presence of a postulated paleochannel within the Bozeman alluvial fan interpreted from a seismic refraction survey by Brown and others (1983). To test this hypothesis, a conceptual groundwater exploration model for the southeastern end of the Gallatin Valley was developed. Field studies included drilling of a well within the trend of the proposed paleochannel, an earth resistivity survey and shallow seismic refraction survey across the paleochannel on the campus of Montana State University.

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INTRODUCTION

Problem

Alluvial fan deposits are the principal groundwater reservoir for many areas of the western U.S. (Bull, 1972). These deposits are economically important to farmers, ranchers, and the general public who depend upon them as a source for water. The alluvial fans and their streams control much of the groundwater recharge in the adjacent groundwater basins (Bull, 1972; Cehrs, 1979). In the block-fault basins of southwestern Montana alluvial fans are an integral part of the groundwater system. An important source of groundwater in the Gallatin Valley is the Bozeman alluvial fan located at the base of the Gallatin Range (Hackett and others, 1960). Groundwater within the alluvial fan is withdrawn for both domestic and irrigation use. Understanding groundwater controls on the Bozeman alluvial fan as well as locating optimal sites for groundwater withdrawal can have considerable benefits for local groundwater users.

Previous scientific investigations regarding the availability of groundwater from the Bozeman alluvial fan began with Hazen (1942) who examined the Gallatin River basin on a reconnaissance basis. Wantland (1953) ran several refraction seismic and resistivity surveys across the alluvial fan and other parts of the Gallatin Valley to support the groundwater resource investigation by Hackett and others (1960).

Wantland was concerned with locating the depth to Precambrian bedrock in the valley and determining the extent of valley fill. Hackett and others (1960) explored recharge on the alluvial fan and recognized that irrigation, stream loss and rainfall were important. Brustkern (1977) modeled the impact of land use change on groundwater resources of the Bozeman area, in particular the Bozeman alluvial fan. His model was concerned with how the aquifer would respond to various land use changes but was limited by the availability of geohydrological and geophysical data. Much more complete information regarding inflow, outflow, recharge, discharge and the details of the geology are needed. Dunn (1978) examined changes in groundwater levels and groundwater chemistry in the Gallatin Valley to determine if any changes in the groundwater had occurred since the study by Hackett and others (1960). His findings indicate no significant changes in water availability and water chemistry have occurred.

Purpose

Groundwater is needed on the Montana State University campus to supply chlorine-free water for research purposes and to supplement the present water supply. The primary concern was the report that Precambrian gneiss had been encountered in building foundations near the site where the wells were planned. Water wells drilled into such material would be expensive and would potentially yield little water. Brown and others (1983) used refraction seismic techniques to assess the distribution of this near-surface bedrock feature. They found that a 4500 m/s (15000 ft/s) velocity, suggestive of Precambrian bedrock, is present under parts of the MSU campus, but the seismic energy sources used could not detect this feature on all parts of the campus. During this study, preliminary interpretations suggested that a 60 m (200 ft) deep channel might exist near Roskie Dormitory at the west end of campus. The channel interpretation was based on time-velocity plots and their relations to a topographic depression in the area. Such a channel or channels might serve as an important groundwater resource on the fan. The difficulty with the interpretation was the sparse data and potential alternative interpretations of the geophysical data. Additional work is needed. The purpose of this investigation is to further test these ideas. Several questions need to be addressed.

1. Do additional hydrologic investigations confirm or deny the presence, size, extent and trend of the postulated channel?

2. Do additional geophysical studies confirm or deny the postulated channel, and if the channel is confirmed, can it be better delineated?

3. Can an understanding of the alluvial fan setting postulated by Hackett and others (1960) be refined to better understand the groundwater potential on the west side of the MSU campus based on the hydrologic and geophysical data?

Location

The Bozeman alluvial fan was mapped on the basis of surface morphology by Hackett and others (1960). They found a Quaternary alluvial fan with an apex at the mouth of Hyalite (Middle) Creek at the north end of the Gallatin Range, Montana. The alluvial fan was mapped with an elongate shape and is approximately 18 km (11 mi) long and 10 km (6 mi) wide at its widest section (Figure 1). The alluvial fan is bounded on the east by Sourdough Creek, on the west by South Dry Creek, on the south by the Gallatin Range, on the northeast by the floodplain of the East Gallatin River, and on the northwest by the West Gallatin River. The city of Bozeman straddles the east-central portion of the fan.

The specific area on the Bozeman alluvial fan chosen to test the presence of the paleochannel interpreted by Brown and others (1983) is located on the property of Montana State University (Figure 2). The site extends across Roskie field, bound on the east by Roskie Dormitory, on the west by Marsh Laboratory field, on the south by Lincoln Avenue and on the north by Garfield Street. This area was chosen because Brown and others (1983) had mapped the trend of the buried paleochannel through this area. Only a minor amount of development has occurred here previous to this study so that geophysical lines could be run. This site is also located where Montana State University was interested in drilling an exploratory irrigation well to test the model proposed by Brown and others (1983).