Journal of the Arkansas Academy of Science

Volume 26 Article 11

1972

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ABSTRACT

The study will consist of determining the relationship between fracture patterns and porosity-permeability changes in carbonate rocks with emphasis on groundwater movement. These porosity-permeability changes will be measured by relative groundwater movement, in the form of either springs, artesian wells, municipal supplies, or private wells. Relationships will be determined by plotting the positions of the measuring sites and correlating these sites with mapped fractures. Water yield is expected to be markedly greater for sites along fracture traces than for those located at random.

RECENT STUDIES

Several fracture pattern-groundwater studies completed in recent years provided the impetus and background information for this study. For example, in northern Alabama, Sonderegger (1970) used fracture traces in a carbonate terrain to interpret the occurrence and movement of groundwater. He concluded that the use of the fracture trace method for the location of high-yield water wells in carbonate aquifers is substantially more effective than a random approach. He noted also that wells drilled along fracture traces yielded greater quantities of water than the average of the randomly located wells. Lattman and Parizek (1964) concluded that the capacity of wells and the frequency of cavities in the rock increased for wells drilled along fracture traces and were maximized where fracture traces intersect. Methods similar to those of Lattman and Parizek were employed in Brazil where municipal wells were developed by drilling on photo-lineament sites suspected to reflect faults and fracture zones in the crystalline basement complex (Setzer, 1966). Artesian conditions were encountered at the more successful wells having recorded capacities in excess of 660 gal/min.

INTRODUCTION

Carbonate rocks are erratic aquifers in most areas. Wells drilled a few feet apart into a limestone aquifer may differ in specific capacity by a factor of ten or more because generally these rocks have very low primary porosity and permeability. Both surface and subsurface zones of fracture concentration should provide avenues for greater solution and weathering, thereby causing an increase in porosity and permeability. These solution conduits in turn facilitate vertical and lateral groundwater movement. Therefore, the capacity of dolomite and limestone aquifers to transmit groundwater to wells depends largely on the size, number, and interconnection of water-yielding joints, fractures, and solution cavities intersected during the drilling operation. Furthermore, if fracture traces are the surface reflection of a concentrated zone of subsurface fractures, they also should delineate zones of increased porosity and permeability. The position for a maximum-yield well, therefore, is directly on fracture traces; the optimum position is at the intersection of two or more lineations.

Lineations include both fracture traces and lineaments mapped or inferred on aerial photographs. Fracture traces are lineations less than 1 mi long; they generally represent bedrock joints or small faults. Lineaments are lineations more than 1 mi. long; they generally represent regional zones of shatter or faults of deep-seated origin. These differentiations, taken from Lattman (1958), are recognized in most of the literature, the distinguishing characteristic being length. In any case, lineations are linear trends of topographic features, soil tones, stream courses, and vegetation visible on aerial photographs. Nonrelated photo lineations would include such things as outcrop patterns of inclined strata, stratigraphic contacts, and man-made features such as railroads or highways.

TECHNIQUE

The method of study involves intital mapping of lineations from high-altitude photo mosaics for Benton, Boone, Carroll, Marion, and parts of Baxter, Izard, Madison, Newton, Searcy, Stone, and Washington Counties of northern Arkansas. Whether a lineation represents a zone of regional shear or a bedrock joint, it represents a fracture in the rock. If the surface bedrock is a carbonate, the fracture undergoes rapid weathering and solutioning, and if the solutioned fracture lies within a drainage basin, it will be accentuated by the drainage pattern. Initially, the drainage is used as a guide for mapping the major lineations.

Not all mapped lineations were reflected by the drainage patterns, however, and Figure 1 illustrates the results when the superimposed drainage pattern is removed. On general observation, two major sets of linear trends are expressed, one in the northeast direction and the other in the northwest direction. Two minor sets, E-W and N-S, also are represented. The regional fracture pattern for northwest Arkansas found in the field consists of five sets of fractures: N70° W, N30° W, N5° W, N7° E, and N55° E. (Gibbons, 1962). Radar lineaments mapped for the Ozark Province (Kirk and Walters, 1968) generally show trends similar to those reported by Gibbons. Several smaller lineaments are actually discontinuous segments of larger reional trends. For example, the discontinuous lineament at points "x" in Figure 1 represents the White River fault which is an extensive fault zone extending from northwest Mississippi, through northern Arkansas, and terminating in southern Missouri (Fig. 2).

Figure 1. Lineations mapped from high-altitude photo mosaics.

APPLICATIONS

The results of this investigation could have applications for such diverse fields as economic geology, hydrology, and environmental geology. Fresh water in many areas is in critically short supply. Urban development and groundwater utilization would be enhanced greatly by accurate prediction of groundwater movement and sites for high-yield wells. Other environmental applications include pollution control. Groundwater sources which ultimately feed a public water supply or a recreational area may be in proximity to garbage dumps, landfills, or sewage treatment basins. Because the mapped lineations represent zones of increased porosity and permeability, they may also represent zones of natural groundwater recharge. Consequently, the exact location of these zones provides not only a tool for locating sites for optimum groundwater discharge, but also invaluable information for land use planning.

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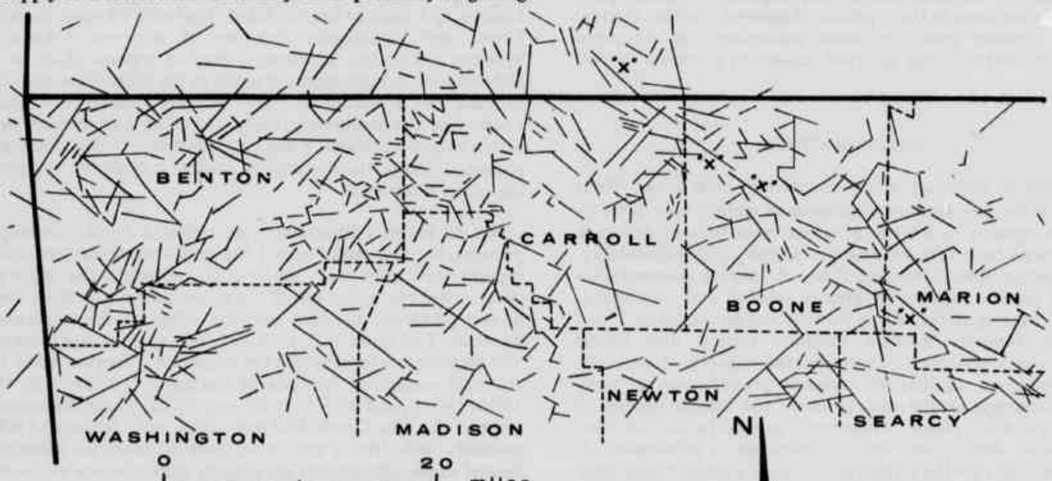

Figure 2. Radar lineament zone (B-C) on south flank of Ozark Dome, Arkansas. Lineament zone ties a mapped fault (AB) in southwestern Missouri to White River fault zone (CD), and represents a concept of a single fracture zone approximately 450 mi long (after Dellwig et al., 1968).