Geophysical Framework Based on Analysis of Aeromagnetic and Gravity Data, Upper and Middle Verde River Watershed, Yavapai County, Arizona

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Abstract

Analysis of aeromagnetic and gravity data provides new insights into the geometry of geologic structures of the upper and middle Verde River watershed, Yavapai County, Arizona. Magnetic anomalies reveal hidden volcanic rocks lying at shallow depths beneath the ground surface in Williamson, Little Chino, Big Chino, and Verde Valleys in the upper Verde River watershed. Concentrations of shallowly buried volcanic plugs or centers are located down-gradient of springs (Del Rio) and perennial flow (Williamson Valley), suggesting that these volcanic centers or plugs may retard ground-water flow. Magnetic data also map paleochannels that were filled with basalt (6 to 4 Ma) as Big Chino Valley formed and subsided during late Tertiary. The magnetic data reveal a predominantly northeast- to north-striking structural grain within Proterozoic basement rocks, in contrast to the generally northwest strike of late Tertiary faults in this region. The magnetic grain may serve as a proxy for fracturing and faulting, an important source of permeability in these generally impermeable rocks.

Magnetic and gravity data also delineate exposed and concealed faults within the study area. The Big Chino Fault and Verde Fault Zone have the largest amounts of vertical throw of the faults in the study area on the basis of gravity, magnetic, and limited well data. These faults bound deep (1-2 km) basins in Big Chino and Verde Valleys. The geophysical data also reveal concealed faults in Williamson Valley that bound a previously undiscovered basin with approximately 1 km of Cenozoic fill inferred from inversion of gravity data. Little Chino and Lonesome Valleys, including the upper reach of the Agua Fria Basin, are characterized by basin fill that has an irregular distribution, with local, north- to northwest-striking pockets of thicker sediment, but nowhere exceeds 1 km of thickness. A 15- to 20-km-long northwest-striking magnetic lineament that passes through Page Springs in Verde Valley can be used to project a mapped fault 5-10 km northwest and southeast of its mapped trace. The colocation of the lineament, mapped fault, and Page Springs suggests structural influence on the location of this large spring.

Introduction

Yavapai County, Arizona, is one of the fastest growing rural counties in the United States, with population growth concentrated in Verde Valley, the Prescott area, and Sedona (fig. 1). Rapid population growth has led to a concurrent increase in water-resources development. Although the Verde River provides surface water to water-rights holders in Verde Valley and Phoenix, ground water is the major source of most public and domestic water supplies in Yavapai County, according to the Arizona Department of Water Resources (2000). In order to improve understanding of the geologic framework and its effect on ground-water flow, the county contracted the U.S. Geological Survey to conduct geophysical and geologic studies to aid construction of a model for ground-water flow in the region.

The goal of this study is to improve understanding of the geologic framework of the upper Verde River region (fig. 1) from analysis of geophysical data. This work builds upon earlier geohydrologic studies (Twenter and Metzger, 1963; Owen-Joyce and Bell, 1983; Water Resources Associates, 1989; Ostenaa and others, 1993) and geologic studies (Krieger, 1965; Ed DeWitt and others, unpub. data) that focused on geologic mapping and water well information. This study concentrates on projecting surficial structures and stratigraphy into the subsurface using geophysical data. This includes a more quantitative and detailed interpretation of aeromagnetic and gravity data collected by the U.S. Geological Survey in 1999-2001 than that outlined in Langenheim and others (2000, 2002) and expands the area of interpretation beyond that presented in Langenheim and others (2005).

The isostatic gravity anomaly data reflect density variations in the upper and middle crust. Interpretation of these anomalies provides information on the depth of Cenozoic basins and on the nature of pre-Cenozoic basement rocks. The aeromagnetic data are sensitive to the distribution of magnetic rocks, primarily those containing magnetite. In Yavapai County, these rocks are Tertiary volcanic rocks and certain rock types within the Proterozoic crystalline basement. In particular, aeromagnetic anomalies mark abrupt spatial contrasts in magnetization that can be attributed to lithologic boundaries, often caused by faulting and fracturing of these rocks. These two geophysical datasets, in concert with information from geologic mapping, wells, and other types of geophysical data, are effective tools in defining hidden structures important to ground-water studies, such as the configuration and structural fabric of basement and and the distribution of volcanic rocks concealed beneath Tertiary sedimentary deposits.