

Visualizing the Stratigraphic History of Buried Depositional Units in the Amargosa Basin, SW Nevada and in Berrien County, SW Michigan

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The Amargosa Basin in southwestern Nevada and Berrien County in southwestern Michigan are two very different geologic environments that have been studied in an attempt to visualize and understand the depositional history of the subsurface geologic units. These studies are funded by the U.S. Geological Survey to not only understand and characterize the subsurface geology in the study areas, but to apply this understanding to water issues relating to quality, quantity, and contamination of the ground-water system. In both study areas, stratigraphically complex shallow aquifers have been studied using borehole data and three-dimensional (3-D) modeling of lithologic data, combined with surface geologic mapping and knowledge of the basin's depositional history.

The Amargosa Basin is a semiarid desert environment in southwestern Nevada. The study area is approximately 75 by 25 km or 1875 sq km (47 by 16 miles or 752 sq miles). The depositional history is characterized primarily by alluvial infilling of a tectonically formed basin that is intermittently internally drained, and infrequently the location of regional ground water discharge. Much of the deep basin fill is Miocene coarse-grained sedimentary rocks and tuff on Paleozoic limestone. Overlying Pliocene and younger rocks are of greater interest as aquifers because of the shallow water table in the basin. Drillholes in the northern part of the Amargosa Basin have intersected the modern water table at approximately 90 m. However ground water does intersect the surface today in the southern part of the basin. Where ground water intersects the ground surface in this arid environment, unique fine-grained deposits are formed as the vegetation at the wet soggy marsh-like environment traps eolian fines and preserve a unit of palustrine deposits characterized by the presence of freshwater limestone, fine silts and sands, and infrequent organic vegetative mats. Quaternary and Cenozoic volcanic basalts, ashes, and tuffs are also interbedded within the alluvial and palustrine units. The presence of two major intermittent drainages, the Amargosa River that enters the basin from the northwest, and Fortymile Wash that enters the basin from the northeast convolute the Amargosa Basin history. The convergence of the drainages, and the eventual exit of the Amargosa River from the basin, is tectonically controlled by buried and exposed faults expressed in geophysical interpretations as well as regional tectonism in the Death Valley area where the Amargosa River ends in a closed depression. This regional tectonic control has also caused the river to migrate from north to south across the northwest trending basin. The resulting basin fill in the Amargosa is an extremely complex interfingering of coarse- to fine-grained alluvium derived from the regional volcanic and limestone mountain ranges, fine grained playa and palustrine deposits, eolian sands, and finally, numerous interbedded volcanic units.

Berrien County in southwestern Michigan is approximately 54 by 25 km or 1350 sq km (34 by 16 miles or 544 sq miles). A variety of surficial deposits that comprise the principal aquifers in the county are the result of regional advances and retreats of the latest Pleistocene continental glaciers. The modern water table is between <1 m and 290 m below the surface, however the average depth for water is between 9 and 17 m. Glaciofluvial deposits range in thickness from 20 to 150 m above Paleozoic bedrock. The late Wisconsin glacial meltwater

deposits leave a history of till sequences, coarse to fine grained fluvial sands and gravels, and ice marginal deltaic sequences including lake sediments. Two major drainages, the Paw Paw River from the northeast and the St. Joseph River from the southeast merge in the center of the county and flow west into Lake Michigan. Alluvial terraces are preserved adjacent to the drainages, and these deposits as well as the glaciofluvial deposits are capped by fine-grained eolian fine sand. Sand dunes are found adjacent to Lake Michigan, and infrequently preserved inland. Deep oil and gas exploration drillholes completed throughout the county intersect early Mississippian to late Devonian sandstone, shale and limestone below the glacial deposits. The bedrock is nearest the surface in the southern part of the county, where it is less than 20 m below the surface. There is less than 100 m of surface elevation variability (177-271 m) over the entire county today; however, the paleosurface, expressed by the top surface of the buried Paleozoic bedrock, has a surface variability of between 125 and 145 m.

Drillhole data were compiled for both areas from a number of sources, including state records for water wells, private industry, local engineering companies, USGS and state exploratory boreholes. Mining records were available from the Nevada study area. Considerable effort was made to cull descriptions from boreholes that were poorly located or lacked detail. An attempt was made to sample sites over as broad an area as possible. In the Amargosa basin, records from 505 boreholes were used; in Berrien County records from 5919 water well holes were initially compiled. The first step in the data analyses was to simplify the driller's descriptions to an internally consistent set of lithologic descriptors that could be used as stepping-stones to geologic interpretations. These initial sedimentary lithologic descriptors, sixteen in the Amargosa Basin and thirteen in Berrien County, are defined by the characteristics of the driller's nomenclature, for example gravel, sand and gravel, clay, and sand. These lithology units were used in Rockworks 2002 to generate cross sections and 3-D lithology models. These initial lithology units were converted into stratigraphic units that have genetic facies meaning. In the Amargosa Basin for example, gravel, sand and gravel, and sand, clay and gravel were grouped to form an alluvial unit, and clay and sand into a playa unit. In Berrien County, sand and a trace gravel, and sand and clay, were grouped into a lacustrine unit, and clay and a trace gravel, into a till unit. In both study areas, subsurface stratigraphic units form a complexly interfingering sequence with poor age constraints. Because of these geologic complexities, no attempt was made to define a stacked sequence of units. Instead, the interpreted stratigraphic units were treated as interval data and using the application in Rockworks designed to visualize geochemical or interval data, 3-D images were produced to visualize the predicted distribution of these stratigraphic units. Geologic facies models and geophysical data are used to constrain the size and shape of the resulting volumes representing the stratigraphic units. This same technique has been used on the volcanic-rock units in the Amargosa Basin. Use of this technique does not result in a predictable stacked stratigraphic sequence throughout the basin, nor does it explicitly account for dipping beds. However, this technique is useful in mapping stratigraphically complex sequences where specific facies environments may be related to aquifer quality.