GEOLOGY OF THE DEVILS HOLE AREA, NEVADA

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ABSTRACT

Detailed and reconnaissance mapping of the Devils Hole area has improved definition of the local geologic structure within a regional carbonate aquifer near its primary discharge points--the springs of Ash Meadows. Several formerly unmapped calcite veins, and other young calcite-lined paleo-spring feeder zones were found, as well as a number of previously unknown small collapse areas in the limestone. Although the predominant structural grain of the area is oriented northwest, the importance of the very subordinant northeast-striking faults and fractures is underscored by their association with Devils Hole itself, with most of the collapse depressions, and with many of the calcite veins in "lake beds" and alluvium. Probable channeling of ground-water flow may occur along one important northeast-striking fault zone. The persistent tendency for opening or pulling apart of the northeast-striking faults and fractures, possibly together with some carbonate-rock solution, has pro-produced a very transmissive and complex carbonate aquifer. These openings may have been facilitated by underlying low-angle faults that separate brittle carbonate rocks from underlying, less-competent clastic rocks.

STRATIGRAPHY

Bonanza King Formation

Bedrock of the study area consists entirely of the Banded Mountain Member of the Bonanza King Formation of Middle and Late Cambrian age (Barnes and Palmer, 1961). Approximately 1,500 feet of the member are exposed in the mapped area, and at least 500 more feet are exposed to the northwest and southeast, where, respectively, the upper contact with the Upper Cambrian Dunderberg Shale Member of the Nopah Formation (Barnes and Christiansen, 1967), and the lower contact with the Papoose Lake Member of the Bonanza King Formation are exposed. Denny and Drewes (1965), who mapped the Ash Meadows quadrangle (fig. 1), divided the Bonanza King into upper and lower parts, but placed the contact within the Papoose Lake Member, as presently used. Denny and Drewes (1965) did not map the Dunderberg Shale Member of the Nopah Formation. Burchfiel, Hamill, and Wilhelms (1982), who mapped an area southeast of Ash Meadows, locally divided the Bonanza King into its members but not in the area adjacent to the mapping reported here.

The Banded Mountain Member consists almost entirely of limestone and subordinate dolomite (description of map units for figures 2 and 3), the proportions of which vary both vertically and laterally, mainly as a result of alteration. The only clastic materials of any consequence in the member are siltstone, fine-grained sandstone, and minor shale in the lowest part (unit a, figs. 2 and 3). Some silty material is found in the carbonate beds at a few places higher in the member, especially in unit c. The silt tends to color some carbonate beds pale yellowish-brown. Subdivision of the member into map units a through f is somewhat arbitrary, and is not necessarily recognizable in the surrounding region, although unit a, with its noticeable clastic material, is a widespread zone (Barnes and others, 1962). Map units a, b, and c in this report appear to correspond approximately to all but the upper 200 feet of unit 1 as described by Barnes and others (1962, fig. 127.2) in the Yucca Flat area 50 miles to the north. The upper 200 feet of their unit 1 may be equivalent to unit d in this report. If this is correct, Barnes and others' unit 2 would be roughly equivalent to units e and f in this report, but unit c would be significantly thinner than in the Yucca Flat area. For the present study, a section of the Bonanza King Formation in the Specter Range, 4 miles northeast of Lathrop Wells (fig. 1), was examined; that section was found to be considerably different from that exposed 15 miles to the south near Devils Hole. This may result from a major thrust fault --the Specter Range thrust--that passes between the two areas.

A distinctive marker bed (fig. 4), extremely useful in mapping small structures, was found in the upper part of unit c. It consists of cuspate structure in a limestone bed 8 to 18 inches thick. It was given the informal field name of the "curly limestone bed", and was recognized, not only throughout the Devils Hole study area, but also in the ridges 1 mile or so to the east. It was not found, however, in a cursory examination of the Banded Mountain Member 8 miles southeast of Devils Hole. The bed may be a stromatolitic, or algal limestone.

Devils Hole, and all but 1 of 10 collapse depressions in carbonate rock found in this study are present in unit c of the Banded Mountain Member, suggesting some lithostratigraphic control for dissolution of the carbonate rock. Detailed work would be needed to determine the role, if any, of carbonate composition in the development of these cavities. The depressions are described in more detail in a later section.

"Lake Beds"

Fine-grained, poorly indurated clastic and calcareous sediments are present below an elevation of about 2,400 feet in Ash Meadows and Amargosa Flat. Most of these beds were deposited in shallow lakes, ponds and playas (Hay and others, 1986). Although their general distribution near the southwestern edge of Devils Hole ridge is shown on figure 3, these deposits were not mapped in detail. Their stratigraphy is described by Hay and others (1986), Swadley (1983), Denny and Drewes (1965), Naff (1973), and R.E. Pexton (1984). All but one spring (at Point of Rocks) issues from these sediments. One small area of poorly indurated sandstone (unit QTs; fig. 3) (perhaps a shoreline facies of the "lake beds") was mapped about 2,200 feet west-northwest of Devils Hole.

Colluvium and Alluvium

Alluvial units, which overlie the "lake beds", were divided into only two units in this mapping (fig. 2): colluvium and alluvium (QTa) of Pleistocene and Pliocene (?) age, and alluvium (Q1), largely of Holocene age. These units are described by Swadley (1983) and Hoover, Swadley and Gordon (1981). The older beds (QTa) contain numerous spring-related deposits, including calcite veins, to elevations as high as 2,460 feet (fig. 3) north of Devils Hole. Reworked fragments of calcite veins are locally present in Q1 deposits along the present washes. No veins were observed in Q1 deposits.

Calcium Carbonate Deposits Related to Groundwater

Deposits of calcium carbonate as pervasive cement (tufa) in or on alluvium, laminated veins or coatings, and circular "eyes" or ojos occur at many locations in the region, especially in the area around Devils Hole. The Quaternary deposits, of calcium carbonate, particularly the laminated veins of Pleistocene age, are being studied in detail as clues to the Quaternary paleohydrology and climate of the region (Winograd and Doty, 1980; Winograd and others, 1985; Winograd and Szabo, 1986). For this report I mapped (figs. 2, 3, and 4) all young (Pliocene-Pleistocene) veins and other calcium carbonate spring-related deposits found in the Devils Hole area to establish possible structural influences on their location. Although layered carbonate veins are common in the bedrock along many of the faults, those above an elevation of 2,540 feet invariably are yellowish, relatively coarse grained, and appear largely recrystallized. Many of the northwest-striking faults contain wide, coarsely crystalline, irregular veins; the best examples are at higher elevations on the ridge northeast of Devils Hole, outside the mapped area. These older veins commonly show several stages of brecciation. One example, in the mapped area, is in a northwest-striking fault on Point of Rocks ridge 0.5 miles east of Devils Hole (fig. 2). At that location, a gray limestone zone in unit b of the Bonanza King Formation coincides with the downward limit of the vein in the fault; the fault continues on the hillside below the gray limestone but contains no vein material. Viewed from a distance, and on aerial photos, it appears that the gray limestone, though nearly parallel to stratification, actually crosscuts the bedding at a very small angle and consists of a slightly lighter or bleached zone about 25 feet thick. Both the bedding and the lighter gray limestone zone are displaced about

20 feet vertically. The calcite vein in the fault contains Paleozoic bedrock clasts and appears to have undergone brecciation and recementation. Close examination of the lighter gray limestone showed that, in addition to being slightly lighter in color compared with rocks above and below, it contains scattered small (1/4-in. to 2-in.-wide) white calcite "eyes" and "squiggles". The lighter zone may represent an exhumed planar alluvium-bedrock contact, or a former water table; if the latter, it has been displaced by faulting and tilted slightly to the north or northwest. Where exposed, it ranges from about 2,500 to 2,610 feet in elevation. The fact that the vein does not continue below the possible former water table could be coincidental, but it is also possible that the older veins are not directly related to the presence of spring or ground water, but originated by downward movement of calcium carbonate from the land surface or by leaching of the host country rock and redeposition of the carbonate above the water table.

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