Article 163

RELATION OF FLUORIDE CONTENT TO RECHARGE AND MOVEMENT OF GROUND WATER IN OASIS VALLEY, SOUTHERN NEVADA

By GLENN T. MALMBERG and T. E. EAKIN, Carson City, Nev.

Work done in cooperation with the Nevada Department of Conservation and Natural Resources

Abstract.—Although most of the ground water contains excessive fluoride, a local supply that meets Federal standards for public water supplies was located by means of a hydrogeochemical reconnaissance. Elsewhere in the Great Basin where water-quality problems exist, similar studies could be applied in locating usable ground water.

An unusually high content of certain minor constituents, such as boron or fluoride, or of total dissolved solids renders ground water unfit for various uses in many valleys in the Great Basin. In Oasis Valley, Nev., about 100 miles northwest of Las Vegas, nearly all the ground water has a fluoride content higher than permissible limits established by the U.S. Public Health Service (1962) for public supply. A hydrogeocnemical reconnaissance by the authors (1962) indicated favorable possibilities for developing ground-water supplies of low fluoride content. Subsequent test drilling has confirmed the predictions.

Oasis Valley is about 430 square miles in extent and is drained by the Amargosa River (fig. 163.1). The Amargosa is an intermittent stream which rises in a group of springs in Oasis Valley and drains southward toward the Amargosa Desert. The discharge from six springs in the alluvial fill adjacent to the flood plain of the river, about a mile northeast of Beatty, has long been the water supply for that town (population 500). As the fluoride content of this water is about 4.5 parts per million, most of the children, the native Indian population, and some adults who have resided in the community since childhood suffer from dental fluorosis. Water from wells and other springs along the Amargosa River also has high concentrations of fluoride.

Most of the Oasis Valley drainage area is underlain by Tertiary and Quaternary volcanic rocks consisting of tuff and other pyroclastic rocks, welded tuff, and flows (fig. 163.1). Minor amounts of Paleozoic limestone, dolomite, shale, and sandstone make up the rest of the bedrock. Quaternary alluvial fill underlies about 65 square miles of the valley floor. The alluvial fill is saturated with ground water to within a foot or two of the land surface and forms the principal ground-water reservoir.

Virtually all recharge to the alluvial fill is derived from precipitation in the drainage basin north and east of the Amargosa River and from ground-water underflow through bedrock from beyond the surficial drainage area to the north and northeast (Malmberg and Eakin, 1962). Only a minor amount of recharge is derived from infiltration of precipitation on the Bullfrog Hills, and virtually no recharge occurs from infiltration of precipitation on the valley floor and the low rolling hills adjacent to the valley floor.

Analysis for fluoride and other mineral constituents of water samples throughout Oasis Valley indicated that ground water beneath the floor of the valley contained up to 5 ppm of fluoride and that throughout most of the drainage area, fluoride concentrations exceeded 1.6 ppm, the safe limit for public water supplies that would apply in the Beatty area (U.S. Public Health Service, 1962). Moreover, ground-water underflow toward the Amargosa River from the principal area of recharge north and east of the river contained higher concentrations of fluoride than ground-water underflow from the Bullfrog Hills.

Fluoride in the ground water in Oasis Valley probably is derived from weathering of fluorite and fluoride-bearing minerals which commonly occur as sublimation products associated with volcanic rocks. Chemical

ART. 136 *IN* U.S. GEOL. SURVEY PROF. PAPER 475-D, PAGES D189-D191. 1964.

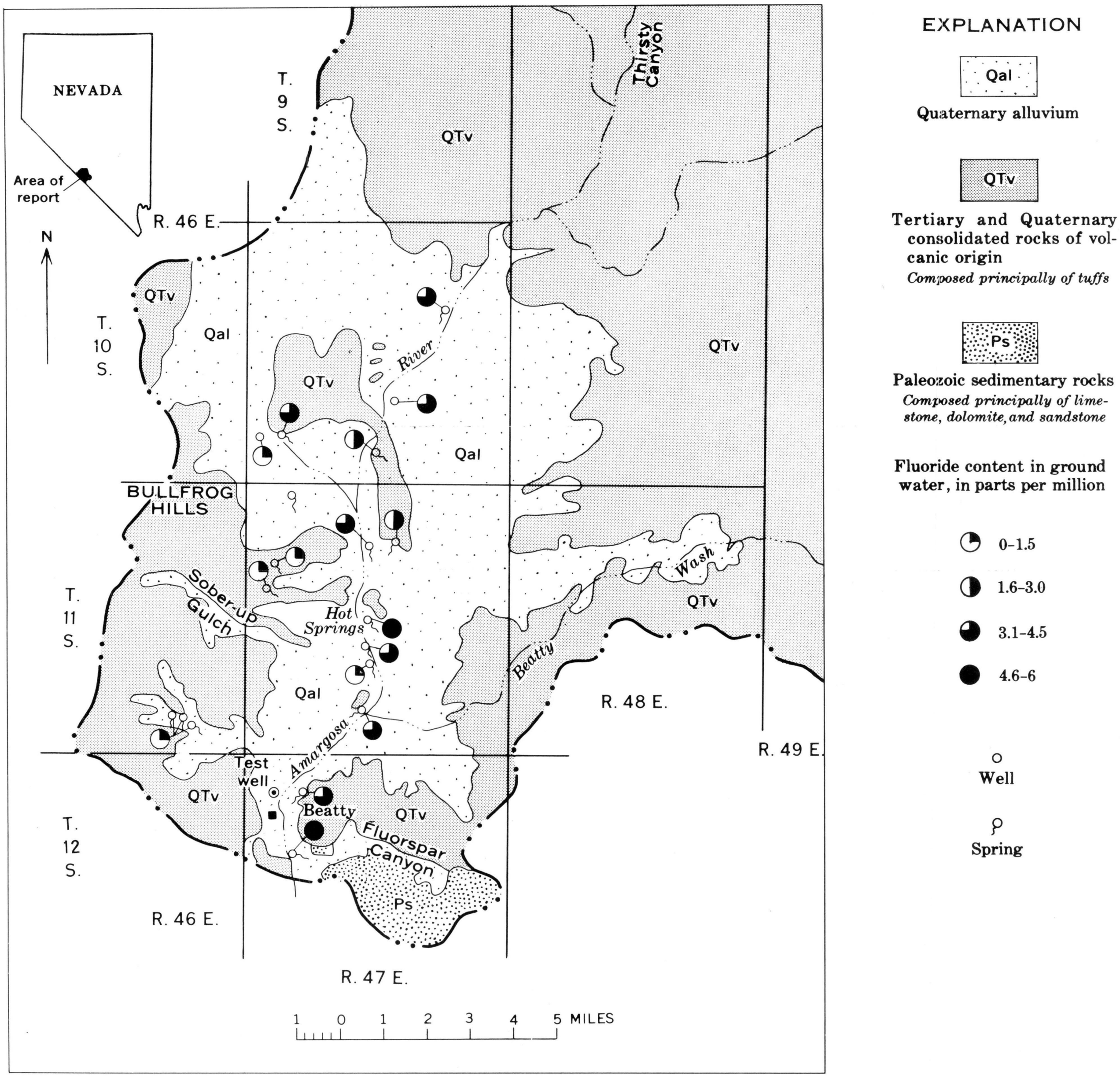

FIGURE 163.1.—Generalized geologic map of Oasis Valley, Nye County, Nev. Dashed outline enclosing patterned area is boundary of that part of the Amargosa River basin in the report area.

decomposition and subsequent leaching of fluoride-bearing minerals disseminated throughout the volcanic rocks probably are the major causes of fluoride in the ground water in the area.

The high concentration of fluoride in the water samples from the Hot Springs and other thermal springs in Oasis Valley suggests that additional fluoride may be derived from hydrothermal solutions emanating from underlying magmatic rocks. All the large springs along the flood plain of the Amargosa River issue from volcanic rocks or from alluvial fill adjacent to volcanic rocks and yield thermal waters of high fluoride content. Leaching of lenses and veins of fluorite in carbonate rocks exposed in Fluorspar Canyon southeast of Beatty undoubtedly accounts for high concentrations of fluoride in the ground water downstream from that area.

Chemical analyses of water from several small springs in the unnamed canyon about a mile north of Beatty and in Sober-Up Gulch, 4 miles north of Beatty indicated fluoride concentrations of less than 1.5 ppm (fig. 163.1). Analyses of water from a few wells in Oasis Valley suggested that fluoride concentrations in ground water near the base of the Bullfrog Hills is generally lower than in other parts of the valley but increases progressively toward the Amargosa River. This led to specific consideration of areas near the Bullfrog Hills for a possible supply of low-fluoride water. Because ground water in the volcanic rocks presumably would have a high fluoride content, only areas underlain by alluvium were considered. Accordingly, the alluvial fan at the mouth of the unnamed canyon north of Beatty and at the mouth of Sober-Up Gulch were considered the most likely places where ground-water supplies of relatively low fluoride content could be developed.

The average annual recharge from precipitation in the catchment area of each of these basins was estimated to be about 20 acre-feet per year. Although there has been some hydrothermal alteration and mineral enrichment of the rocks in the Bullfrog Hills, underflow in the alluvium of these small tributary basins is in contact with the volcanic rock for a relatively short distance and short time and, consequently, has a minimum opportunity to dissolve fluoride. Furthermore, because the ground water in and near the areas of recharge is higher than that beneath the valley floor, there is little opportunity for deep circulation through the consolidated rock and mixing with ground water of high fluoride content. Thus, the chemical, geologic, and hydrologic data suggest that the alluvial fans at the mouth of these two canyons would be the most favorable location for developing ground water with a low fluoride content.

Large withdrawals in either of the areas described above undoubtedly would cause ground-water levels to decline below the water level beneath the floor of Oasis Valley, and the resulting reversal of the hydraulic gradient would cause movement of water of high fluoride content from beneath the valley floor to the area of ground-water development. Withdrawals sufficient to meet the entire municipal demand could not be supplied entirely from this source on a perennial basis without depleting the low-fluoride water in storage and inducing inflow of high-fluoride water. However, if withdrawals in these areas were limited to the drinking-water requirements of the town of Beatty and if pumping was carefully managed to minimize drawdown, the low fluoride content might be maintained indefinitely.

Since the publication of the report by Malmberg and Eakin (1962), a test well was drilled in the lower part of the alluvial fan at the mouth of the unnamed canyon north of Beatty (fig. 163.1). The well produced about 60 gallons per minute and the fluoride content of the water from the test well was 0.04 ppm after 36 hours of pumping (W. W. White, Director, Nevada Department of Environmental Health, oral communication, 1963).

The success of the test drilling in locating low-fluoride ground water in this area is a good example of the value of the reconnaissance techniques used in this investigation.

REFERENCES

Malmberg, G. T., and Eakin, T. E., 1962, Ground-water appraisal of Sarcobatus Flat and Oasis Valley, Nye and Esmeralda Counties, Nev.: Nevada Dept. Conserv. and Nat. Resources, Ground-Water Resources Reconn. Ser. Rept. 10, 39 p.

U.S. Public Health Service, 1962, Drinking water standards: Federal Register, March 6, p. 2152–2155.

Webb, Barbara, and Wilson, Roland, 1962, Progress geologic map of Nevada: Nevada Bur. Mines Map 16.