DETECTION OF GEOTHERMAL COMPONENTS IN GROUNDWATERS OF DONA ANA COUNTY, SOUTHERN RIO GRANDE RIFT, NEW MEXICO

by

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SUMMARY

Dona Ana County is located in the southern part of New Mexico and occupies roughly 9,850 km^2 astride the Rio Grande rift, an area of high regional heat flow and considerable geothermal potential. Two known geothermal resource areas (Kilbourne Hole KGRA and Radium Springs KGRA) having a combined area of 141 km^2 are located within the county.

Nearly 200 chemical analyses have been completed on waters collected from Dona Ana County. The majority of samples were collected from non-thermal groundwater wells although a few thermal wells and thermal and non-thermal springs are also represented. Thermal waters in the county are represented by Radium Springs (maximum reported temperature of 85°C), two thermal wells (43°C) at the Las Alturas Estates near Las Cruces, and possibly by a cold spring near San Diego Mountain which is located near and possibly associated with late Quaternary travertine deposits.

There are two principle objectives to the present study. The first is to characterize the thermal waters of the county and then determine the extent to which any geothermal indicators can be recognized in the non-thermal groundwaters. The second objective is to assess the geothermal potential of Dona Ana County. On the basis of the data collected to date, the following conclusions can be drawn.

1. Thermal waters in the county are associated with high silica and high sodium-potassium-calcium (Na-K-Ca) geochemical temperatures and high concentrations of fluoride and boron. These four parameters are useful in geothermal reconnaissance and can be used to detect the presence of, and possibly the migration of, geothermal fluids through normal ground-water aquifers.

2. Maximum temperatures estimated by the Na-K-Ca geothermometer are in the 220-230°C range, a range well in excess of the often quoted 180°C limit for economic geothermal development.

3. A prominent north-northwest trend of high geochemical temperatures passes through the county following the path of the major Valley fault (mapped on the basis of steep gravity gradients) and the geochemical temperatures decrease rapidly and systematically away from the fault. These data indicate that the Valley fault acts as a conduit for ascending geothermal fluids. Supporting this conclusion is the fact that the geochemical trend intersects the three occurrences of geothermal water noted above.

4. Two segments of Dona Ana County are particularly promising for geothermal development. These include the above mentioned geochemical trend and an extensive area centered around the Kilbourne Hole KGRA.

5. The majority of samples collected from the northern part of the county fail to reveal any geothermal activity.

Na-K-Ca GEOTHERMOMETER

The use of Na-K-Ca geothermometer as a tool for geothermal prospecting is based on the results of Fournier and Truesdell (1973) who found that Na-K-Ca data can be used to determine the last temperature at which water-rock equilibrium was attained. For most natural waters, Fournier and Truesdell found that a plot of the function F(T) defined as

$$F(T) = \log(Na/K) + \beta \log \sqrt{Ca}/Na \qquad (1)$$

against the reciprocal of absolute temperature clustered around a straight line. In Equation (1) concentrations are expressed in molality and β = 1/3 or 4/3 depending upon whether the last water-rock equilibrium occurred above or below 100°C, and F(T) is converted to temperature (°C) using the equation (based on Fournier and Truesdell 1973, Fig. 6).

$$T(^{\circ}C) = \frac{1647}{2.24 + F(T)} - 273.15 \qquad (2)$$

Thus the only data required to estimate the temperatures expected within a geothermal system are Na-K-Ca analyses from samples of geothermal fluid. A further description of the technique and its limitations can be found in Fournier and Truesdell (1973) and Swanberg (1974).

The water samples collected from Dona Ana County yield a wide range of Na-K-Ca estimated temperatures (Fig. 1). The majority of samples give temperatures of less than 50°C, whereas a few samples yield temperatures in excess of 200°C. There is a striking correlation between high Na-K-Ca estimated temperatures and mapped and postulated faults (Fig. 1). Five of the seven samples giving estimated temperatures in excess of 200°C are located on a north-northwest geochemical trend which extends for over 80 km from just west of the Franklin Mountains to San Diego Mountain. This geochemical trend is congruent with the inferred Valley fault for the southern two-thirds of the total distance. This geochemical trend also intersects nearly all known occurrences of thermal water in Dona Ana County including Radium Springs, the hot wells at Las Alturas Estates, and the Quaternary travertine deposits near San Diego Mountain (Fig. 1). The coincidence among the Valley fault, the geochemical trend, and areas of known thermal water indicate that this fault is acting as a conduit for ascending geothermal fluids. This conclusion is also supported by the rapid and systematic decrease in estimated temperatures away from the fault where presumably, the thermal waters mix with the non-thermal groundwaters. It is significant that the thermal water from Radium Springs yields the same Na-K-Ca temperature as several of the cold waters along this geochemical trend. This similarity demonstrates the use of the Na-K-Ca geothermometer in detecting the presence of geothermal water, even when water temperatures show no trace of

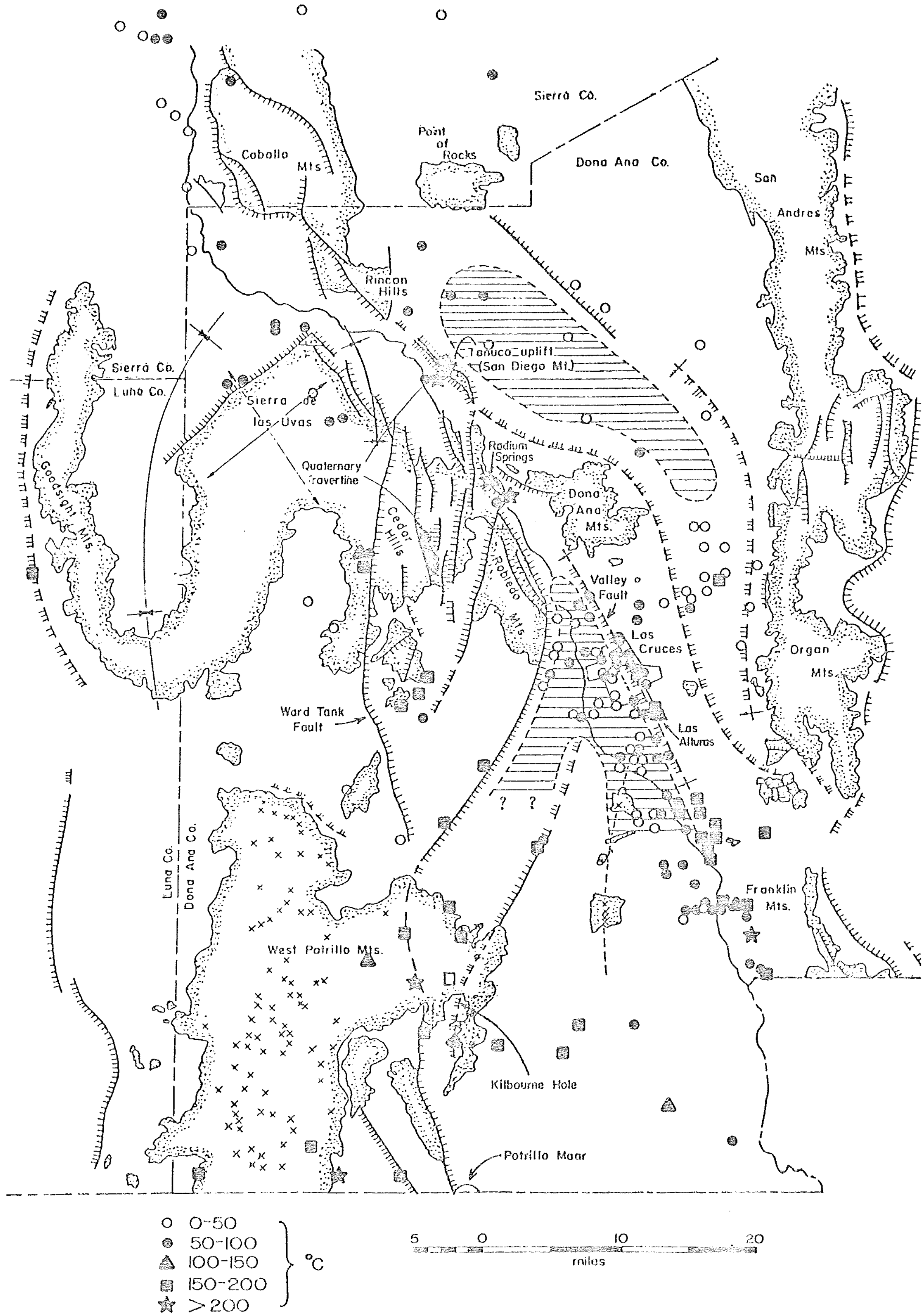

Figure 1. Temperature estimated by Na-K-Ca geothermometry. For explanation of structural symbols see Figure 1 in paper by Seager, this guidebook.

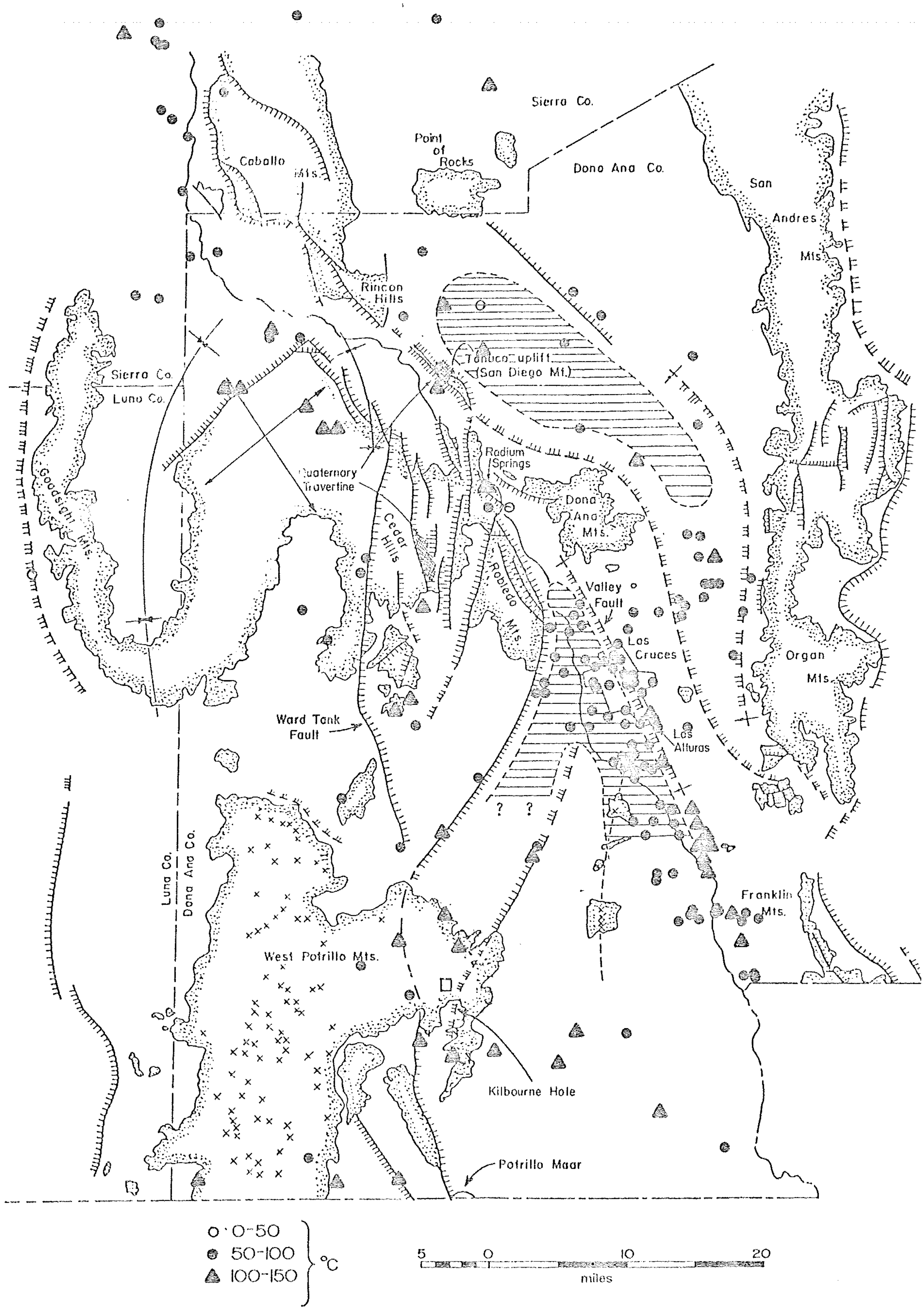

Figure 2. Temperature estimated by silica geothermometry.

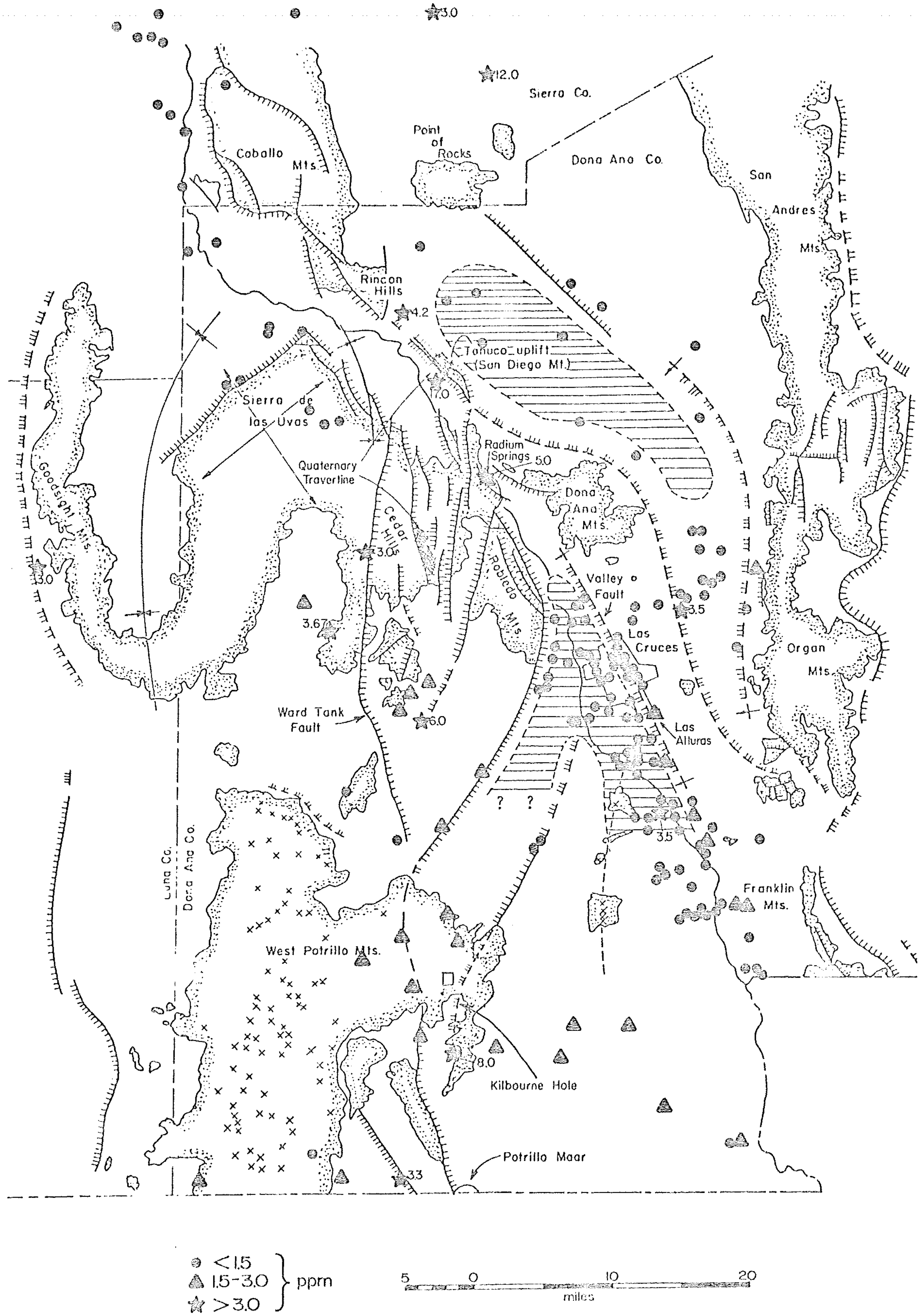

Figure 3. Concentration of fluoride in groundwater of Dona Ana County.

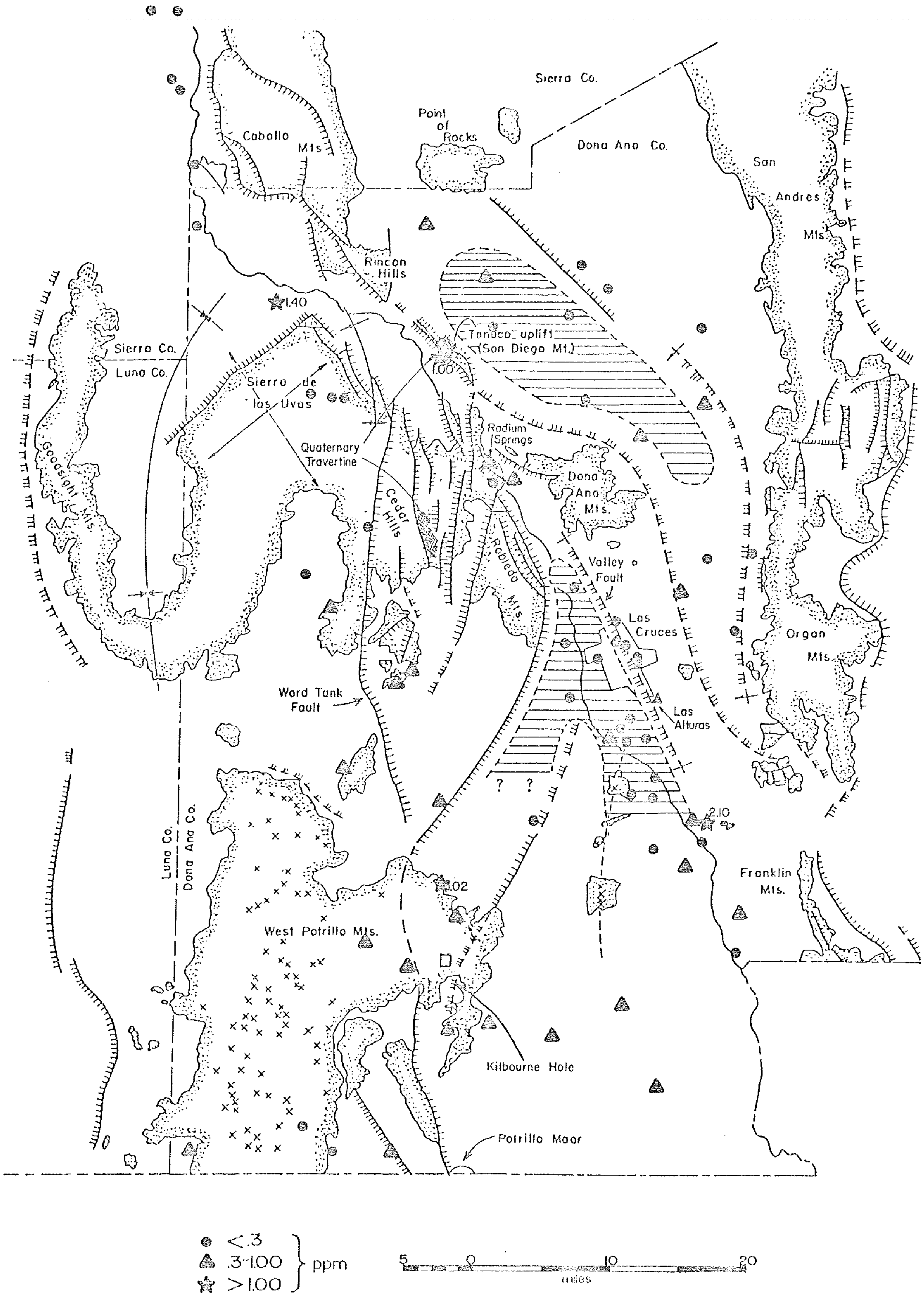

Figure 4. Concentration of boron in groundwater of Dona Ana County.

geothermal activity. This similarity also indicates that the entire geochemical trend has essentially the same geothermal potential as the Radium Springs KGRA.

The remaining two samples giving Na-K-Ca estimated temperatures in excess of 200°C are located in the Kilbourne area (Fig. 1). One of these samples is located just west of the KGRA and the other is located near the international boundary not far from a major "Kilbourne Hole-type" maar—the "Potrillo maar" (Reeves and DeHon, 1965) in Mexico. These samples are part of an extensive geochemical anomaly, which extends south from the Cedar Hills area (Fig. 1) to the international boundary; it is apparently bounded on the west by the Ward Tank fault.

In contrast to the high Na-K-Ca temperatures which dominate the geochemical anomaly surrounding the Kilbourne Hole KGRA and the linear geochemical trend, are the low Na-K-Ca temperatures which dominate the remainder of the county, particularly to the north. These cold areas provide a good contrast to the high temperature areas and indicate the general reliability of the data in addition to outlining broad regions of apparent low geothermal potential.

SILICA GEOTHERMOMETER

A second approach to assessing the geothermal potential of Dona Ana County is the application of the silica geothermometer (Fournier and Rowe, 1966). The temperatures estimated by the silica geothermometer are shown in Figure 2. These temperatures are generally lower than those estimated by the Na-K-Ca geothermometer. This reflects (1) the more rapid reequilibration of the silica geothermometer to lower temperatures, (2) the fact that the silica geothermometer is based on absolute concentrations of silica (the Na-K-Ca geothermometer is based on atomic ratios) and is thus more strongly affected by dilution with non-thermal, near-surface waters, and (3) the fact that the silica geothermometer is based on results from hot springs and wet-steam wells and all of the present samples except Radium Springs and Las Alturas represent cold waters. Thus the actual temperatures estimated by the silica geothermometer cannot be expected to accurately reflect expected temperatures at depth.

Despite these shortcomings, the silica geothermometer can be used as a relative indicator of geothermal activity. In fact, the same trends are apparent in the silica data (Fig. 2) that were observed for the Na-K-Ca geothermometer. The geochemical trend which extends from just west of the Franklin Mountains in the south to San Diego Mountain in the north is well defined by the silica data. Furthermore, comparable estimated temperatures are obtained for Radium Springs, the wells at the Las Alturas Estates, the cold spring near the Quaternary travertine deposits near San Diego Mountain, and the remainder of cold wells along the geochemical trend. The estimated temperatures also decrease very rapidly away from the Valley fault as they did for the Na-K-Ca data. Similarly, the broad region south from Cedar Hills to the international boundary and including the Kilbourne Hole KGRA yield high estimated temperatures, while the remainder of the county generally gives low silica temperatures.

FLUORIDE AND BORON

Total concentrations of fluoride and boron have been examined to determine their potential use as geothermal indicators. A fluoride concentration of 1.55 ppm is the Environmental Protection Agency's limit for potable water and it has been reported that hot springs in New Mexico are routinely high in fluoride (W. K. Summers, personal communication). Relatively high boron concentrations have also been linked with high ground-water temperatures (Mahon, 1970).

Concentrations of fluoride and boron in Dona Ana County are shown in Figures 3 and 4, and high concentrations of both ions generally reinforce the pattern of distribution of geothermal water as indicated by the chemical geothermometers and the pattern of known thermal waters.

ACKNOWLEDGEMENTS

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