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# POSSIBLE RELATIONS BETWEEN ANOMALOUS SPRING WATER CHEMISTRY IN THE STILLWATER RANGE AND THE DIXIE VALLEY GEOTHERMAL SYSTEM, NORTHERN NEVADA

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## Abstract

Electrical conductivities of spring waters in the Stillwater Range, the Augusta, Clan Alpine and Desatoya Mountains, indicating varying levels of ionic concentration, were compiled. Anomalously high ionic concentrations are largely limited to the northern Stillwater Range. High levels of sulfate, chloride, and bicarbonate may to a certain extent be derived from mineralized and scapolitized zones and limestones in Mesozoic sedimentary and igneous rocks. However, the highest bicarbonate levels are found in springs emerging from igneous rocks. Their close proximity to a major fault and the occurrence of high $CO_2$ pressures in the Dixie Valley geothermal system may suggest a geothermal source of $CO_2$ beneath the Stillwater Range.

## Introduction

Geothermal exploration in the Dixie Valley geothermal system initiated in the late 1970's has stimulated interest in the hydrologic system of the Dixie Valley region. A large amount of hydrochemical data from hot springs, wells and mountain springs and creeks have been gathered (Bohm et al., 1980). Anomalously high concentrations of ions in mountain springs in the Stillwater Range led to the speculation that geothermal activity occurs in some parts of the Stillwater Range. However, the evidence available at that time remained inconclusive. Since then the author has collected more field data in order to substantiate the presumptions made earlier. It is the purpose of this paper to preview ongoing research and compare the area with regional trends of mountain spring chemisty around northern Dixie Valley.

## Discussion

The chemical composition of the groundwaters in the northern Stillwater Range is unusual in that the ionic concentrations are much higher than what would be expected in a high mountain recharge area. Chloride ranges between 28 and 605 mg/l, sulfate ranges between 20 and 725 mg/l and bicarbonate alkalinity ranges between 134 and 436 mg/l. These concentration ranges were compared with cumulative frequency distributions of groundwaters from the Sierra Nevada and western and central Nevada (literature data gathered by Bohm, 1982). Within these frequency distributions the chloride values fall within the 14 to 68 percentile, sulfate within the 78 to 89 percentile and bicarbonate within the 51 to 87 percentile. This is indeed unusual since levels of chloride, sulfate and bicarbonate in recharge areas in western and central Nevada generally were found to be below 3, 21 and 245 mg/l, respectively (Bohm, 1982).

Electrical conductivities measured in groundwaters in mountain regions were gathered by the Bureau of Land Management in 1982 (B. Sularia and D. Schafersman, personal communication, March 1984). These data were augmented with data collected by the author during field work in 1983/84. The data were normalized to a temperature of 25°C and plotted on a map in Figure 1, covering the northern Stillwater Range, the Augusta, Clan Alpine and Desatoya Mountains. The northern Stillwater Range and a small section in the Clan

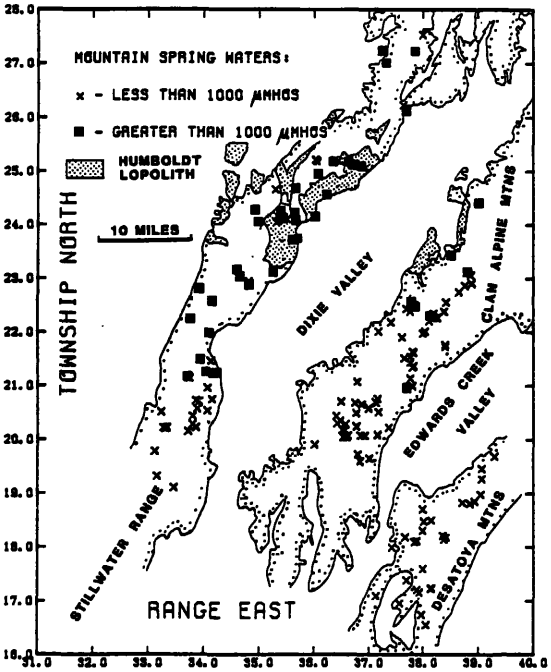

FIGURE 1
ELECTRICAL CONDUCTIVITIES OF SPRING WATERS IN THE STILLWATER RANGE AND THE CLAN ALPINE AND DESATOYA MOUNTAINS. GEOLOGY AFTER SPEED (1976).

Alpine Mountains clearly stand out as areas of highly concentrated groundwaters, i.e., electrical conductivities greater than 1000 micromhos. These waters seem to occur in close proximity to outcrops of the Humboldt Lopolith. However, they also occur in areas underlain by Triassic and Jurassic pelites. In some instances these argillites contain intercalated limestones and dolomites.

The high anion levels can be explained in several ways. Stable isotope data indicate some evaporation in the mountain creeks (Ingraham, 1982). Evaporation from shallow ground water tables in the vicinity of spring orifices is unlikely to happen, since the levels of pH and temperature (below 7.9 and 10°C, respectively) in the mountain springs appear to be too low to indicate evaporation. Even if some evaporation may occur, it could not explain why it would raise ion concentrations in only one limited area in such a persistent and drastic manner. Instead, scapolitized zones (Speed, 1976) in the Humboldt gabbroic complex could provide high levels of chloride, and weathering reactions may be enhanced significantly by acidity provided by the oxidation of sulfides in mineralized zones. Anomalous concentrations of bicarbonate alkalinity could be derived from dissolution of intercalated limestones, particularly in the very northern end of the northern Stillwater Range.

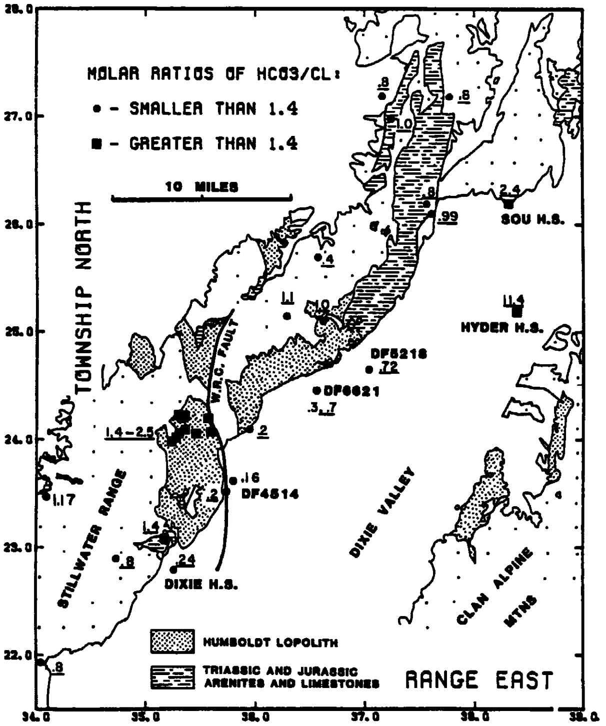

FIGURE 2

MOLAR RATIOS OF $HCO_3/Cl$ IN SPRINGS AND GEOTHERMAL WATERS IN DIXIE VALLEY AND THE STILLWATER RANGE GEOLOGY AFTER WILLDEN AND SPEED (1974), JOHNSON (1977) AND SPEED (1976).

The molar ratios of $HCO_3/Cl$ of spring waters from the Stillwater Range were plotted on a map in Figure 2. Ratios of 1.4 and greater occur only in spring waters in the vicinity of the White Rock Canyon Fault. These springs have the highest bicarbonate alkalinities in the northern Stillwater Range (more than 400 mg/l at 7000 feet around White Rock Canyon). This is somewhat unusual since they are all located in igneous rocks of the Jurassic Humboldt Lopolith and Tertiary rhyolites. Derivation of alkalinity from dissolution of limestones in surrounding formations seems unlikely, since the ratios of $(Ca+Mg)/HCO_3$ are too low. Additionally, bicarbonate alkalinities derived from biogenic $CO_2$ in the soil zone of an arid environment are not expected to be that high.

The White Rock Canyon Fault (Whitney, 1980) is believed to provide a barrier for fluid flow within the Dixie Valley geothermal system (Bell et al., 1980). It could explain why Dixie Hot Springs, located west of the fault, produces sulfate-chloride waters, whereas Sou Hot Springs, McCoy Hot Springs and Hyder Hot Springs located east of the fault produce bicarbonate waters. The geothermal well DF6621, located east of the fault and completed in igneous rocks of the Humboldt Lopolith, was a strong $CO_2$ and $HCO_3$ producer (up to 1100 mg/l $HCO_3$), whereas DF4514, completed in metasediments west of the fault produced very little $CO_2$ and $HCO_3$. This indicates that the eastern part of the geothermal reservoir(s) is in many instances rich in $CO_2$. Even DF5218, completed east of the fault, produced around 400 ppm $HCO_3$ (Mariner et al., 1983).

One explanation could be that fracture zones associated with the White Rock Canyon Fault serve as conduits for geothermal waters to emerge from depth. A similar mechanism has been proposed by Barnes et al. (1981) for carbon dioxide rich soda springs in the Sierra Nevada. However, the levels of silica never exceed 25 mg/l and the temperatures do not appear to indicate geothermal waters. Rather, it is suggested that $CO_2$ emerges from the geothermal reservoir at depth and is dissolved in shallow ground waters in the mountain ranges. At slightly alkaline pH levels the $CO_2$ is in part converted to bicarbonate. This would readily explain the high carbon dioxide pressures computed for these springs (more than $10^{-2}$ atmospheres). Therefore the apparent association of high bicarbonate alkalinities in spring waters with a deep reaching fault structure may suggest geothermal activity below the northern Stillwater Range.

The source of $CO_2$ at depth could be metamorphic reactions in sediments, e.g. the limestones of the Boyer Ranch Formation. The Boyer Ranch Formation is in part overlain by and in part integrated into the Humboldt Lopolith (Speed, 1976). The Humboldt Lopolith is believed to act partially as a reservoir rock for the Dixie Valley geothermal system (Bell et al., 1982). It is likely that effects similar to those suggested for the White Rock Canyon Fault occur to a much lesser extent throughout the northern Stillwater Range.

## Summary and Conclusions

In summary, it can be said that the spring water chemistry in the northern Stillwater Range stands out as an anomalous feature relative to other groundwater chemistries in high mountain ranges around the Dixie Valley geothermal system. The anomaly can not be explained fully at this stage. It appears that in some instances particular rock types may contribute high levels of sulfate and chloride. Additionally, evaporation may raise ionic concentrations in creek waters. However, the high levels of bicarbonate alkalinity are difficult to explain with these processes. It appears as though some of the high bicarbonate in the spring waters is associated with a major fault structure in the Dixie Valley geothermal system. It is thus concluded that the anomalous spring water chemistry in the northern Stillwater Range may indicate geothermal activity at depth.

The same effects are probably masked in the Dixie Valley graben by large accumulations of cold groundwater in the alluvial deposits. The hot springs in the valley appear to be exceptions. In other words, certain geothermal phenomena may in some cases be detectable in a mountain range. The hypothesis should be tested with detailed collection of environmental isotope data. This understanding may eventually lead to new approaches in targeting geothermal exploration well sites.

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