

Comments on “Understanding the source of water for selected springs within Mojave Trails National Monument, California” by Andy Zdon, M. Lee Davisson and Adam H. Love. *Environmental Forensics* 19(2): 99-111.

Brian Schroth, Ph.D., R.G., C.Hg.

The specific comments below focus primarily on the geochemical material in the paper, as hydrogeologic commentary has been supplied by Dr. David Kreamer. I am in general agreement with Dr. Kreamer’s commentary. On 1 June 2018, I participated in a tour of the area, including Cadiz and Fenner Valleys, the Clipper Mountains, and the Bonanza and Lower Bonanza Springs. I was accompanied by Dr. Kreamer, along with Dr. Miles Kenney and Terry Foreman. The comments below follow the structure of the paper itself, with commentary on the Geochemistry, Isotopic Composition, and Conclusions sections in order of appearance.

Geochemistry

Temperature

The authors report a temperature for Bonanza Spring of 27.5°C, but the precise location and date/time of sampling are not provided. On the basis of this measurements, the authors conclude that “*Bonanza Spring water temperature is indicative of waters that have been at depths of greater than 750 feet below the spring vent and risen to groundwater surface despite being in such a small catchment.*” However, other measurements report much lower temperature, including that of Zdon and Associates (2016), who reported 14.2°C. These varying measurements demonstrate that the temperature of Bonanza Spring water is not consistent with a deep, regional source as the authors postulate, but rather varies either with the season, indicating a local source, or possibly with measurement location and method. A conclusion of a deep, regional source requires multiple data that account for possible seasonal and precipitation factors, and cannot be made on the basis of a single measurement as described in this paper. Additional data would need to be collected from a precisely documented, consistent location over time to present a defensible hypothesis.

Major Ions

The discussion on this topic includes the statement “*The Bonanza Spring water is also similar in type to waters from the basin fill in the Fenner and Cadiz Valleys...*”

The actual concentrations of major and minor constituents are not provided for the reader’s review. Independent analysis of Bonanza Spring samples, collected February 2013 and March 2018, do show that the most abundant cation and anion are sodium and bicarbonate, respectively, similar to most basin fill well samples in the area. However, a sodium-bicarbonate chemistry is a generally common chemistry given the compositions of both local and regional source rocks, and therefore does not necessarily link the spring water to a regional source. Closer examination of the Bonanza Spring chemistry shows that this spring (and the associated Little Bonanza Spring) has a significantly higher sodium percentage than any of the other samples, as shown in the Piper diagram on Figure 4, and from other available well data surveyed among Fenner Valley and Cadiz Valley. The sulfate percentage for Bonanza Spring (approximately 30% of anions from Figure 4) is also higher than all nearby springs and wells.

Independent data from Bonanza Spring show the water to be undersaturated with respect to calcite, while all other regional aquifer groundwater samples from Fenner and Cadiz Valley show saturation with this common mineral. This characteristic further supports the Bonanza Spring water reflecting a more localized source, specifically the calcite-poor rocks of the Clipper Mountains.

The notably high percentages of sodium and sulfate in Bonanza Spring, along with its undersaturation with calcite, suggest a more localized source rather than a regional source, since this combination of major ion chemistry does not appear in wells of the flow regime proposed by the authors.

Isotopic Composition

The authors state that “*isotopic signatures of precipitation collected in the Clipper Mountains are much higher than those at Bonanza Spring (Rose, 2017)*”. In contrast to the authors’ conclusions based on other data, the regional estimates of winter rainfall deuterium del values shown by the contours on Figure 5 correlate well with the value measured at Bonanza Spring, with the δD of -80 ppt contour overlapping with the spring location, which has a -82 ppt measured value. These data support a localized rainfall source rather than a regional source.

That general point aside, isotope data commonly will vary by season and by rainfall event, and source signature conclusions should take these factors into account. The date of sample collection for this study was not provided, but the result is similar to that measured in February 2000 by Rose (2017). As the flowpath of the spring source is not clearly defined, there are likely multiple pathways and flow travel times that contribute to the spring discharge. This will likely produce a range of isotopic signatures that will vary with time and location along the Bonanza Spring discharge pathway.

In summary, the conclusions of Zdon et al. are based on incomplete and poorly documented data. The authors use the similarity between two undated Bonanza Spring isotope measurements to those of single undated samples from selected locations to the north to support their conclusion of a regional source for Bonanza Spring. Identification of potential sources using stable isotopes requires a careful presentation of data from multiple events to consider the range of values for each source and the significance of correlation with the target water (in this case Bonanza Spring). The data as presented do not support a regional spring source, and in the case of regional rainfall deuterium contours presented in the paper, the data support the opposite conclusion.

Conclusions

Rebuttal to the conclusions regarding Bonanza Spring are in **bold** print below:

Main Statement: “...water within Bonanza Spring is from a basin-fill water source, deriving its water from recharge north of the Clipper Mountains, such as the Providence and New York Mountains, and could be impacted if groundwater levels decrease at, or near, the spring...” **No independent data are presented to support the final statement that the water from Bonanza Spring could be impacted by a decrease in water levels in the alluvial aquifer in the valley miles to the east.**

According to the authors, the statement is supported by the following:

- (a) “Groundwater elevations in the basin-fill north of the Clipper Mountains is at higher elevations than Bonanza Spring **No regional groundwater levels to support this claim are provided in this report – only reference to a single report. Had a more complete set of publicly available data been collected and plotted on a map, it would be clear that the elevation of Bonanza Spring is nearly 150 feet higher than mine borehole water level measurements located approximately one mile north in the Clipper Mountains (Kenney and Foreman, 2018). There is no mechanism described in the text that explains the sharp rise in groundwater elevation required for regional groundwater from the north to meet the Bonanza Spring elevation. In fact, the regional gradient shows no such sharp rises but rather a steady decent, passing beneath the elevation of the Bonanza discharge location in its inferred flowpath through Fenner and Cadiz Valleys.**

- (b) *“isotopic signatures consistent with past studies...indicating waters derived from sources north of the Clipper Mountains such as the New York Mountains or Providence Mountains”* **Similarity of two deuterium samples from Bonanza Spring to those of some well samples from regional fill aquifers several miles to the north does not constitute proof of the spring having a regional source. This must be supported by hydraulic evidence (see previous bullet) and a more complete isotopic data set that accounts for seasonality and rainfall, as described in the Isotopic Composition section above.**
- (c) *“isotopic signatures of precipitation collected in the Clipper Mountains are much higher than those at Bonanza Spring (Rose, 2017)”* **The values of the isotope data for the precipitation, though referenced, are not provided in the report, and no mention is made for what date and exact location the measurements were made. Precipitation isotopic composition varies strongly with elevation and with season.**
- (d) *“site field conditions related to large size of the spring and associated small watershed size indicate that the spring flow observed is not compatible with its watershed and the low volume of precipitation anticipated in that watershed”* **Groundwater flow emanating from a spring is not necessarily or often related to the surface watershed catchment area surrounding the spring. The highly fractured nature of the Tertiary intrusive volcanic units in the Clipper Mountains facilitates the storage and transport of groundwater within the fractured unit, which extends well beyond the topographic boundaries of the surface drainage. The recharge area is therefore most likely much larger than the topography suggests.**
- (e) *“absence of ^3H indicating that the spring water has a composite age greater than 65 years old despite the limited size of the watershed”* **As described in the previous bullet, geologic data indicate that the recharge area for the spring is much larger than the topographic surface drainage area. Tritium ages exceeding 65 years are common in saturated fractured media, which contains a mixture of transmissive fractures and very narrow micro-fracture networks that can have very slow transport velocities.**
- (f) *“Bonanza Spring flow has been consistent for more than 100 years despite multi-year wet periods and longer periods of drought...”* **Published estimates of Bonanza Spring flow have varied widely, ranging from less than 1 gpm (Zdon and Associates, 2016) to over 47 gpm (Rose, 2017), so this statement is patently false.**
- (g) *“Bonanza Spring water temperature is indicative of waters that have been at depths of greater than 750 feet below the spring vent and risen to groundwater surface despite being in such a small catchment”* **Recently published temperature values for Bonanza Spring water have ranged from 14.2 °C (Zdon and Associates, 2016) to 27.5 °C in the reviewed paper. This inconsistency directly conflicts with the conclusion that the source water is from an exclusively deep, regional source.**

References

- Andy Zdon and Associates, Inc. 2016. Mojave Desert Springs and Waterholes: Results of the 2015–16 Mojave Desert Spring Survey, Inyo, Kern, San Bernardino and Los Angeles Counties, California. Prepared for Transition Habitat Conservancy and U.S. Bureau of Land Management. November 11.
- Kenney, M.D. and T. L. Foreman. 2018. Updated Assessment of Cadiz Water Project’s Potential Impacts to Bonanza Spring; prepared for Cadiz, Inc. January.
- Rose, T. P. 2017. Data Measured on Water Collected from Eastern Mojave Desert, California. Lawrence Livermore National Laboratory, LLNL-TR-737159. August 18.