

## Progress Report on the Nevada Play Fairway Project: Integrated Geological, Geochemical, and Geophysical Analyses of Possible New Geothermal Systems in the Great Basin Region

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### ABSTRACT

The Great Basin region of the western USA is capable of producing much greater amounts of geothermal energy than the current ~670 MW from ~25 power plants. Most geothermal resources in this region are blind, and thus the favorable characteristics for geothermal activity must be synthesized and methodologies need to be developed to discover new commercial-grade systems. In the Nevada play fairway project, nine geologic, geochemical, and geophysical parameters were synthesized to produce a new detailed geothermal potential map of 96,000 km<sup>2</sup> from west-central to eastern Nevada. These parameters were grouped into subsets and individually weighted to delineate rankings for local permeability, regional permeability, and heat, which collectively defined geothermal play fairways (i.e., most likely locations for significant geothermal fluid flow). This work is aimed at reducing the risks in geothermal exploration and therefore facilitating discovery of new commercial-grade systems in blind settings, as well as in areas with surface expressions of geothermal activity. Twenty-four highly prospective areas, including both known undeveloped systems and previously undiscovered potential blind systems, were identified across the region for further analysis. Five of the most promising sites have been selected for detailed studies: Granite Springs Valley, Sou Hills, southern Gabbs Valley, Crescent Valley, and Steptoe Valley. Multiple techniques, including detailed geologic mapping, shallow temperature surveys, detailed gravity surveys, LiDAR, geochemical studies, seismic reflection analysis, and 3D modeling, are now being employed in these areas. The ultimate goal of these detailed studies is to determine the most likely areas for high permeability thermal fluids such that potential drill sites can be targeted. Potential new blind systems discovered in this project include southern Gabbs Valley and Granite Springs Valley currently undergoing detailed study, as well as step-overs in the Dun Glen area and along the west flank of the Humboldt Range.

### 1. INTRODUCTION

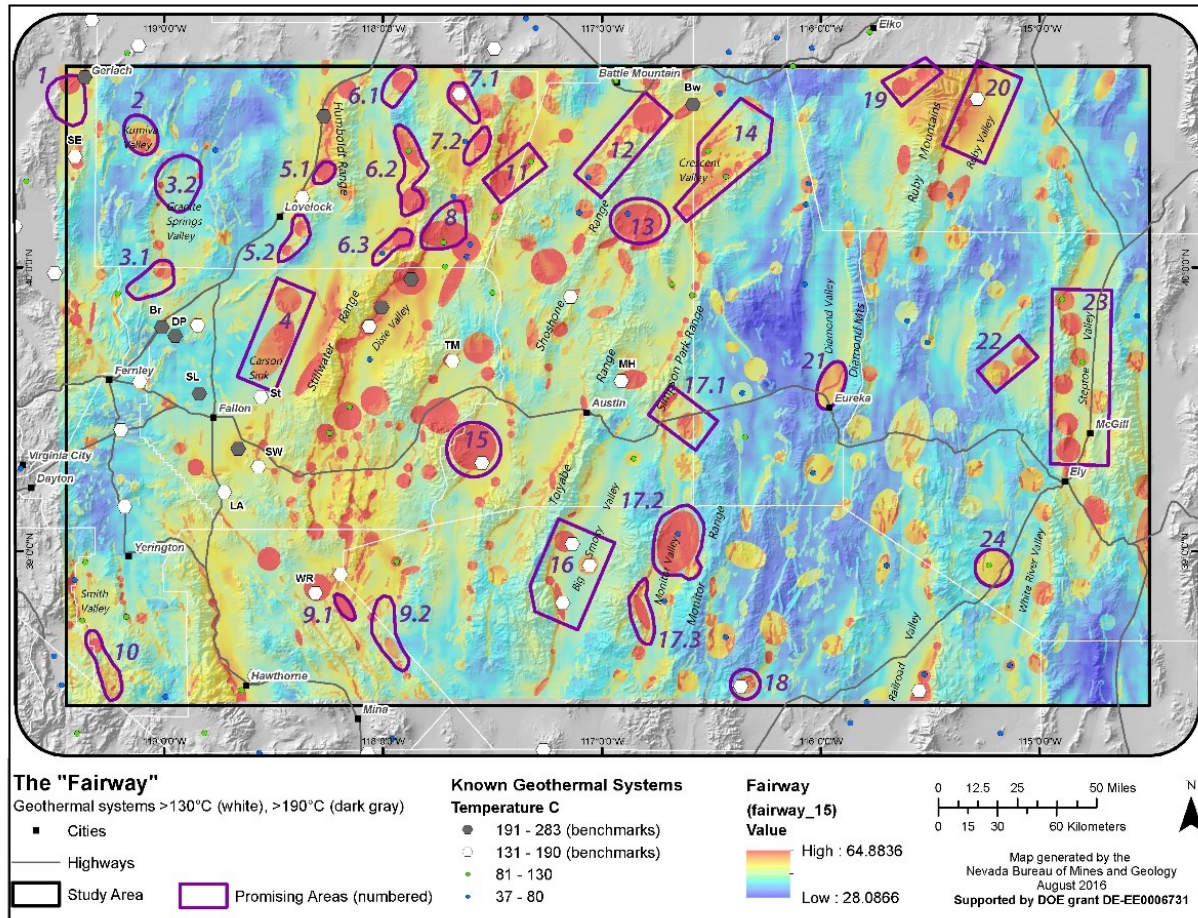
The geothermal play fairway concept involves integration of multiple parameters indicative of geothermal activity as a means of identifying the most promising areas for new geothermal development (e.g., Shervais et al., 2016; Forson et al., 2016; Lautze et al., 2016; Wannamaker et al., 2016; Faulds et al., 2016). This includes the evaluation of relative favorability of known, undeveloped geothermal systems, as well as assessing the probability of a particular area for hosting a heretofore undiscovered, blind high-temperature geothermal system (i.e., a system with no surface expression) capable of generating electricity. Compared to the hydrocarbon and minerals industries, play fairway methodologies for geothermal systems are in their relative infancy and have yet to be fully tested. It is important to note, however, that geothermal play fairway methodologies can vary widely between regions depending on the tectonic setting, structural and stratigraphic framework, quality of exposure, and effectiveness of various geophysical techniques under local geologic conditions. We are applying the play fairway methodology to the Great Basin region of Nevada, a semi-arid, well-exposed extensional to transtensional, active tectonic setting. In this paper, we provide an update of an ambitious project, which involves detailed studies of five highly prospective areas defined by play fairway analysis across a broad swath (96,000 km<sup>2</sup>) of the Great Basin (Figure 1).

### 2. REGIONAL SETTING

The Great Basin region of Nevada and adjacent parts of neighboring states is a world-class geothermal province with over 650 MW of current capacity at ~25 operating power plants. Although geothermal production has been trending slowly upward in recent years, all studies indicate far greater potential for both conventional hydrothermal and nonconventional EGS systems within the region (e.g. Williams et al., 2007, 2009). The Great Basin lies within the Basin and Range province of western North America, a broad region of crustal extension that has been active since the Miocene. The geothermal wealth of this region can be attributed to its active extensional to transtensional setting, including the diffusion of ~1 cm/year of dextral shear along the Walker Lane into extension in the northwestern Great Basin (Faulds et al., 2004). Dextral shear along the Walker Lane accounts for ~20% of the Pacific-North American plate motion (Hammond et al., 2009). Accordingly, strain rates increase from southeast to northwest across Nevada, ranging from much less than 1 mm/year near the Utah border to ~1 cm/year in the Walker Lane belt in the western part of the state (Kreemer et al., 2012). As such, Quaternary normal faults abound across the Great Basin and provide the most fundamental, first-order control on geothermal activity, with nearly all geothermal systems located proximal to Quaternary faults (Bell and Ramelli, 2007).

Most of the geothermal systems (>85%), especially the relatively high-temperature systems (>130°C), reside in fault interaction zones, such as fault terminations, fault intersections, fault step-overs or relay ramps, accommodation zones, and displacement transfer zones, as

opposed to the main segments of range-front faults (Curewitz and Karson, 1997; Faulds et al., 2006, 2011; Faulds and Hinz, 2015). These fault interaction zones typically contain higher densities of faults, which enhances permeability and thus provides conduits for geothermal fluids. Relatively thick (1-2 km) Tertiary volcanic sequences blanket much of the Great Basin region, but Quaternary volcanism is sparse and generally confined to the eastern and western margins of the province or to isolated, small alkaline basalt fields derived directly from the upper mantle. Thus, most of the geothermal systems in the region are amagmatic and not associated with middle to upper crustal magma chambers.



**Figure 1: Highly prospective areas (purple polygons) selected for analysis in Phase II. Numbers adjacent to the polygons refer to the following highly prospective sites: 1) northern Fox Range, 2) Kumiva Valley, 3) Granite Springs Valley with southern (3.1) and northern (3.2) portions, 4) north Carson Sink, 5) Humboldt Range-west flank, with Lovelock Meadows (5.1) and southern flank (5.2), 6) east Buena Vista Valley, with Dun Glen (6.1), Kyle Hot Springs (6.2), and New York Canyon (6.3) subareas, 7) Grass and Pleasant Valleys, with Leach Hot Springs (7.1) and Mt. Tobin (7.2) portions, 8) Sou Hills, 9) Gabbs Valley, with south Gabbs Valley (9.1) and Cedar Mountain (9.2) subareas, 10) Wellington, 11) south Buffalo Valley, 12) north Reese River Valley, 13) north Carico Valley, 14) Crescent Valley, 15) Peterson Hot Springs, 16) Big Smoky Valley, 17) Monitor Valley with north Monitor Valley (17.1), Diana’s Punchbowl (17.2), and Pine Creek (17.3), 18) Hot Creek Ranch, 19) Starr Valley, 20) Ruby Valley, 21) south Diamond Valley, 22) Butte Valley, 23) Steptoe Valley, and 24) Williams Hot Springs. After an initial analysis and down-selection, five areas were chosen for detailed studies (3, 8, 9.1, 14, and 23). Abbreviations for other geothermal systems: Br, Bradys; Bw, Beowawe; DP, Desert Peak; DV, Dixie Valley; LA, Lee-Allen; MH, McGinness Hills; RV, Ruby Valley; SE, San Emidio; SL, Soda Lake; St, Stillwater; SW, Salt Wells; TM, Tungsten Mountain; WR, Wild Rose (Don Campbell).**

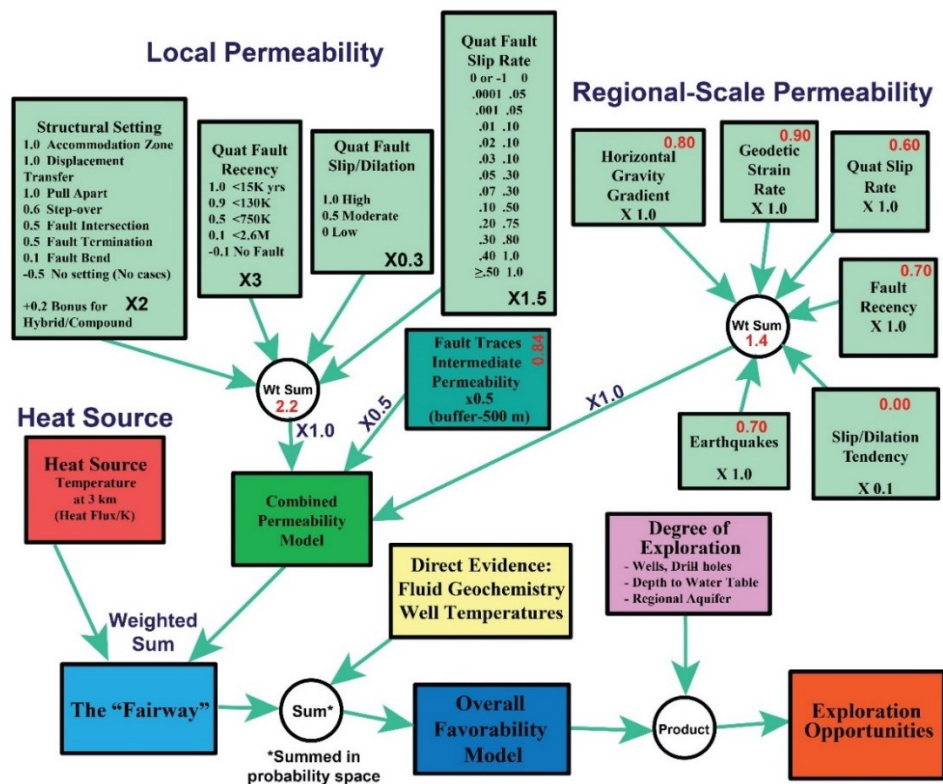
Because most of the geothermal systems in the Great Basin are controlled by Quaternary normal faults, they generally reside near the margins of actively subsiding basins. Consequently, upwelling fluids along the faults commonly flow into permeable sediments within the subsurface of the basin and do not daylight directly along the fault. Outflow from these upwellings may therefore emanate at the surface many kilometers away from the deeper source or remain entirely “blind” within the subsurface with no surface manifestations in the form of hot springs or steam vents (Richards and Blackwell, 2002; Coolbaugh et al., 2007). Thus, techniques are needed both to identify the major structural settings that typically enhance permeability (e.g., fault terminations, intersections, and step-overs) and to determine which specific areas may currently be channeling hydrothermal fluids. The recent discovery in central Nevada of the robust geothermal system at McGinness Hills, a blind geothermal field that currently produces nearly 80 MW net (104 MW of nameplate

capacity) of clean energy (Nordquist and Delwiche, 2013), suggests that many such systems are yet to be discovered in the Great Basin. Application of the play fairway methodology therefore holds promise of yielding significant results.

### 3. METHODOLOGY

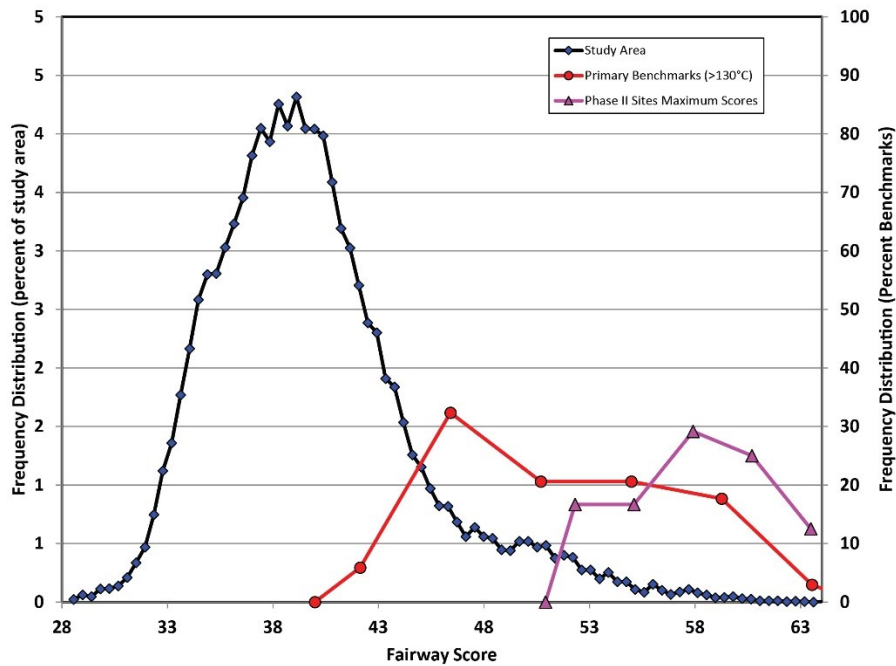
In Phase I of this project, we developed a comprehensive, statistically based geothermal potential map for 96,000 km<sup>2</sup> across the Great Basin of Nevada (Figure 1; Faulds et al., 2015, 2016). This transect extended from west-central to eastern Nevada in order to capture the major aforementioned strain gradient across the region. Further, the transect incorporates a major transition in basement rocks from primarily Mesozoic crystalline rocks (granitic and metamorphic rocks) in the west to dominantly Paleozoic carbonates and sediments in the east. This project focused on fault-controlled geothermal play fairways due to the affiliation of most geothermal systems in the region with Quaternary faults (Curewitz and Karson, 1997; Blackwell et al., 1999; Richards and Blackwell, 2002; Faulds et al., 2006, 2010, 2011, 2013; Hinz et al., 2011, 2014).

Our predictive geothermal play fairway map (Figure 1) included consideration of 9 major parameters: 1) structural settings, 2) age of Quaternary faulting, 3) Quaternary fault slip rates, 4) regional geodetic strain rates, 5) slip and dilation tendency of Quaternary faults, 6) earthquake density, 7) gravity data, 8) temperature gradient data, and 9) geochemistry from springs and wells. As described in previous contributions (Faulds et al., 2015, 2016), these parameters were grouped into key subsets to define regional permeability, intermediate-scale permeability, local permeability, and heat, which were then combined to define the fairway (Figure 2). Results compared favorably against a group of 34 benchmark sites, representing systems in the region with temperatures  $\geq 130^{\circ}\text{C}$ . The fairway model provides a dynamic prediction over multiple scales, including local, intermediate, and regional. Fairway values range from a low of ~28 to near 65, with the 34 high-temperature ( $\geq 130^{\circ}\text{C}$ ) benchmarks yielding an average of 51.4.



**Figure 2: Nevada play fairway modeling workflow (Faulds et al., 2016). Red numbers indicate relative weights determined from weights of evidence. Black numbers indicate expert driven weights used in the analysis. In all cases, the expert driven weights took into account the statistical analyses. This paper focuses on the fairway model (light blue box in lower left).**

Numerous highly prospective areas emerged in the model of this target-rich region (Figure 1) and represent the focus of the ongoing Phase II of the project. The main objective of Phase II is to conduct detailed studies of several of the most promising areas for potential high-temperature ( $>130^{\circ}\text{C}$ ), commercial-grade geothermal systems, as identified on the detailed geothermal potential map produced in Phase I. Figure 1 shows the general locations of 24 highly prospective, potential systems, from which we selected the final areas for detailed study. All of these areas have high fairway values relative to the benchmarks (Figure 3). Potential blind systems in this group include the northernmost Fox Range, Kumiva Valley, parts of the western flank of the Humboldt Range, Granite Springs Valley, and southern Gabbs Valley in western Nevada, the northern Carico Valley-Red Mountain area and southeastern Simpson Park Range in central Nevada, and the Starr Valley, southern Diamond Valley, and Butte Valley in eastern Nevada. Known undeveloped non-blind systems in this group include the Sou Hills and Leach Hot Springs in western Nevada, Peterson Hot Springs, Hot Creek Ranch, and Big Smoky Valley in central Nevada, and Ruby Valley, Steptoe Valley, and Williams Hot Springs in eastern Nevada (Figure 1).



**Figure 3: Distribution of play fairway scores for the primary benchmark (>130°C) systems (red) compared to scores for the study area as a whole (blue) and the maximum values within the 24 highly prospective sites selected for analysis in Phase II (purple) (Faulds et al., 2016).**

#### 4. SITE SELECTION PROCESS

Initially, 24 of the most promising sites were appraised with field reconnaissance, limited reconnaissance-level shallow temperature measurements in key areas, limited geochemical analyses, and review of existing geologic, geochemical, and geophysical data. We employed several criteria to rank these sites, including: 1) type of favorable structural setting with the more complex settings receiving higher rankings; 2) extent of available geological, geochemical, and geophysical data; 3) proximity to Quaternary faults with evidence for rapture in the past ~750 ka; 4) quality of exposure; 5) evidence of thermal anomalies from 2-meter temperature surveys, 6) observation of surface geothermal features, 7) presence of thermal or non-thermal springs and wells with anomalous geothermometry, 8) distance from an electrical transmission power corridor; and 9) land status including % of area considered primary sage grouse habitat. These criteria were semi-quantitatively combined to broadly estimate potential for geothermal development.

The following five areas were down-selected for detailed studies: 1) Granite Springs Valley, 2) Sou Hills, 3) Crescent Valley, 4) Steptoe Valley, and 5) southern Gabbs Valley. Several additional sites were chosen as runner ups. These include Dun Glen in Buena Vista Valley, two areas on the west flank of the Humboldt Range, and Wellington (Figure 1). It should be noted that 10 to 12 sites ranked very favorably in our analysis and thus it was difficult to make the final selections. This is one minor caveat to working in a target-rich region with high heat flow, active extensional tectonism, and overall high geothermal potential. Considering the multitude of favorable sites, our final selection was based partially on having representative sites across the entire region, thus affording analysis of individual areas across the regional strain gradient and across the transition in the nature of the basement rocks. The final selection also contains a mix of known but little explored systems (e.g., Sou Hills and Crescent Valley), as well as previously unrecognized, potential blind systems (e.g., Granite Springs Valley and southern Gabbs Valley).

#### 5. SITE DESCRIPTIONS AND INITIAL FINDINGS

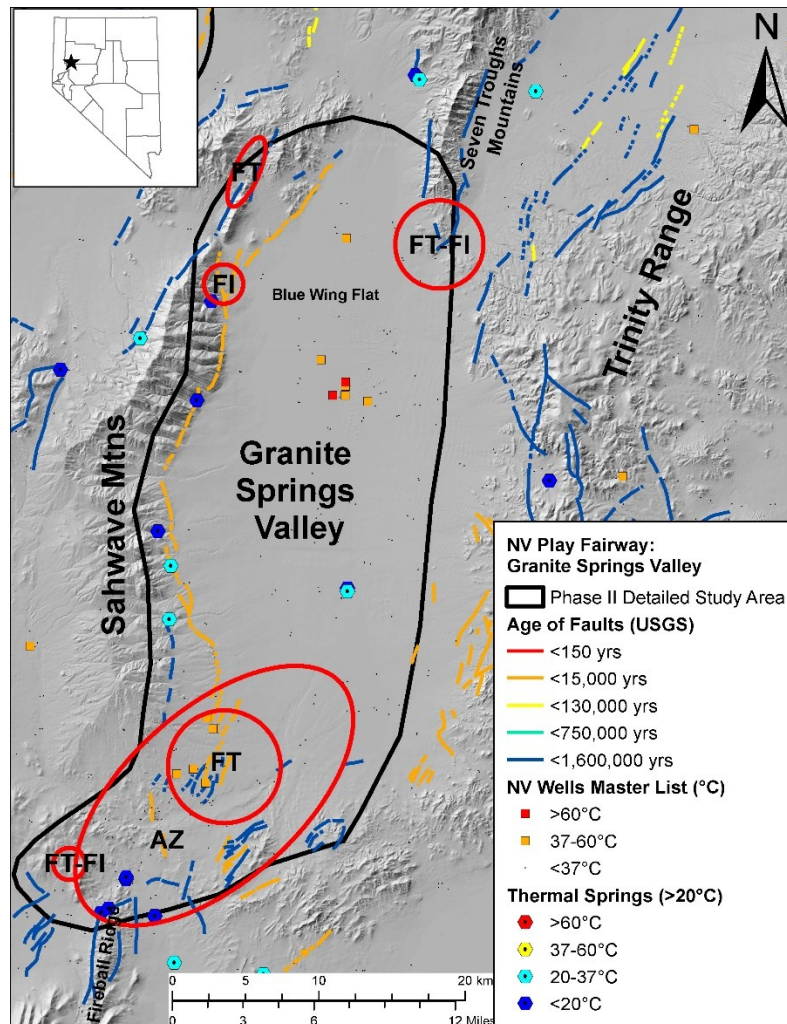
This section contains brief descriptions of the five detailed study areas, as well as a brief review of some initial findings. The ultimate goal of the detailed studies is to provide a framework with which to select the most optimal sites for drilling temperature-gradient holes in a potential Phase III of this project.

##### 5.1 Granite Springs Valley

Granite Springs Valley is a large, northerly trending basin in northwestern Nevada (Figure 1) bound on the west by a major east-dipping, range-front fault (the Sahwawe fault) that has ruptured in the Holocene (Figure 4). Preliminary analysis of seismic reflection profiles indicate that the Granite Springs basin is largely a composite west-tilted half graben. However, the southernmost part of the basin is tilted to the east, suggesting that an accommodation zone is present in the south-central part of the basin in the vicinity of some anomalous temperature-gradient holes. No hot springs or steam vents are present in the Granite Springs Valley area, and thus it represents a potential blind geothermal system. Granite Springs Valley is a topographically and hydrologically closed basin, although limited water level data indicate that some groundwater input from Kumiva Valley from the north into Granite Springs Valley is possible. Groundwater generally flows southward, with ages increasing toward the south end of the valley. Available temperature data from Granite Springs Valley varies considerably. Water samples from the central part of the area are available from recent sampling and additional sources. The highest temperature spring or well in the study area with a complete chemical analysis is a 22.6°C domestic

water well. However, publicly available gradient well data (SMU database) show temperatures of up to 89.7°C at 550 m. This suggests that a viable geothermal system may be present in the area, but company exploration data that include water chemistry have not become available.

Favorable structural settings in the area include 1) the northern and southern terminations of the Sahwawe fault, including several step-overs in the fault zone, 2) the apparent accommodation zone in the southern part of the basin, and 3) a broad accommodation zone between Granite Springs Valley and Fireball Ridge directly south of the basin. The broad accommodation zone near Fireball Ridge is particularly prospective, as it contains a complex network of oppositely dipping north- to north-northeast-striking normal faults, silicified late Miocene sedimentary rocks, and two well defined phreatic explosion craters. Unpublished shallow-temperature surveys show anomalously high temperatures in parts of this area. The phreatic explosion craters appear to lie at the intersection of the northern horse-tailing termination of a west-dipping Quaternary normal fault, where strands of that fault intersect easterly striking oblique-slip faults. The study of Granite Springs Valley incorporates new detailed geologic mapping, interpretation of nine seismic reflection profiles from the basin (~144 km), both existing and anticipated new gravity surveys, geochemical analyses, shallow temperature surveys, MT data from the northern part of the basin (Wannamaker, unpublished data), and analysis of available well data.

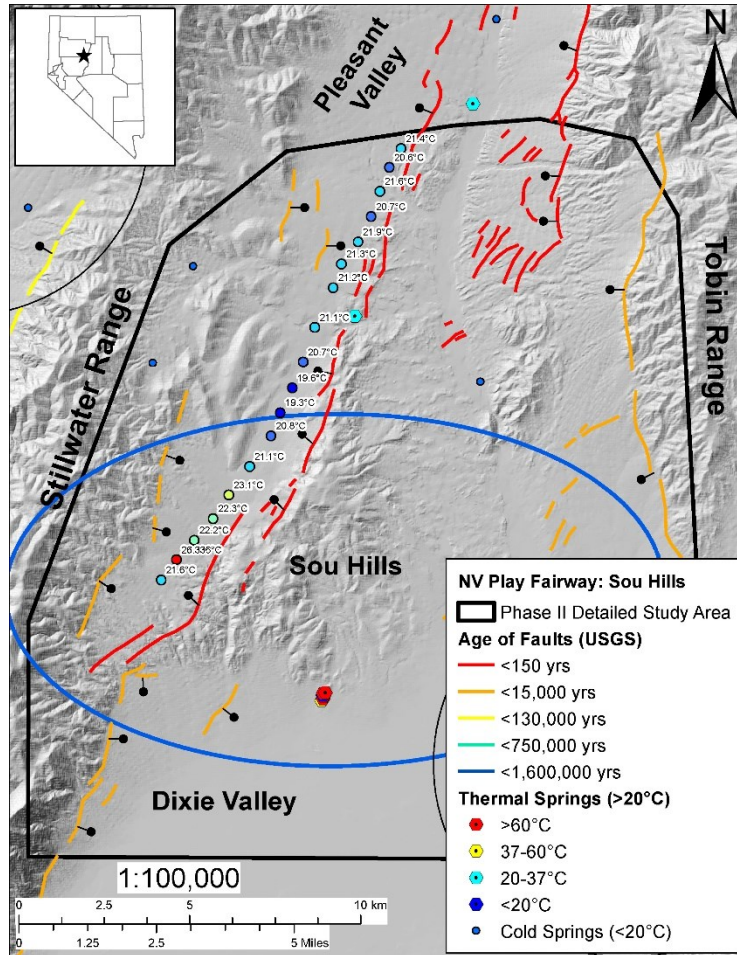


**Figure 4: Granite Springs Valley study area, showing Quaternary faults, relative well temperatures, and favorable structural settings. Abbreviations for favorable structural settings: AZ, accommodation zone; FI, fault intersection; FT, fault termination. Phreatic explosion craters discussed in the text are located in the FT-FI favorable setting in the southwestern part of the study area.**

## 5.2 Sou Hills

The Sou Hills in northern Nevada (Figure 1) consist of a series of low ridges that forms an interbasinal high between Dixie Valley on the south and Pleasant Valley on the north (Figure 5). The Sou Hills occupy an accommodation zone between a) the west-dipping Quaternary fault zone that bounds Pleasant Valley on the east and ruptured in 1915 in a M7.2 earthquake (Wallace, 1984), and b) the east-dipping Quaternary fault zone that bounds Dixie Valley on the west and has also experienced historic ruptures (Caskey et al., 1996). Essentially, the Sou Hills contain the horse-tailing terminations of two major Quaternary normal fault zones (Fonseca, 1988). As such, the area is characterized by multiple, closely-spaced, west- and east-dipping faults, which generate highly fractured conduits

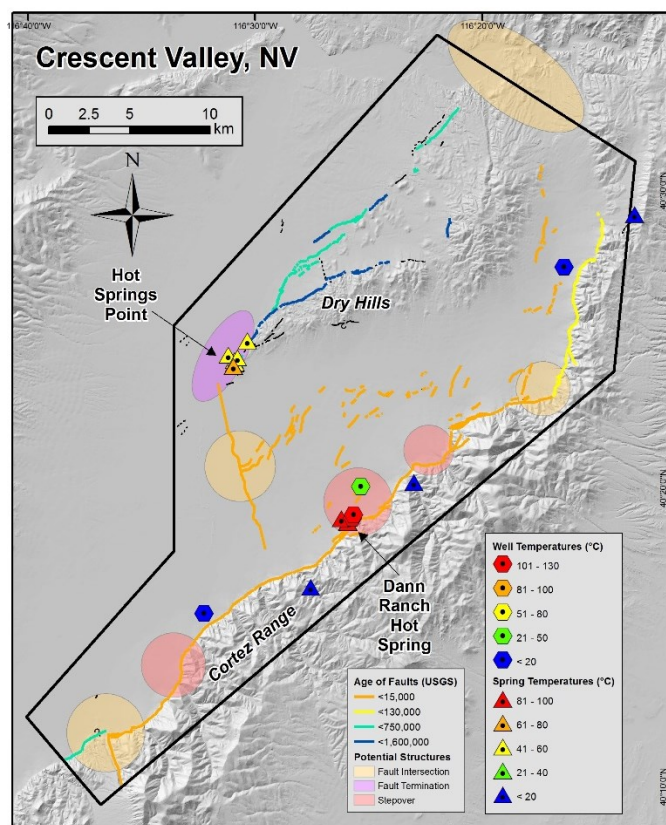
favorable for hydrothermal fluid flow. A localized cluster of ~7 hot springs in the southernmost part of the Sou Hills are marked by travertine mounds and have a maximum surface temperature of 76.7°C and Na-K-Ca geothermometry that agrees well with the chalcedony temperatures of about 85°C, only slightly higher than discharge temperatures. Preliminary analysis of seismic reflection profiles directly south of the Sou Hills reveals an extensional anticline within the axial part of the accommodation zone, which may be conducive for high-temperature geothermal activity. The study of Sou Hills incorporates new detailed geologic mapping integrated with some existing mapping in the area (Fosdick and Colgan, 2008), interpretation of 10 seismic reflection profiles (~120 km) from northernmost Dixie Valley, both existing and new gravity surveys, geochemical analyses, shallow temperature surveys, analysis of available well data, and an anticipated LiDAR survey at QL2 resolution.



**Figure 5: Sou Hills study area, showing Quaternary faults, thermal springs, and results of a preliminary 2 m temperature survey. Blue ellipse outlines the accommodation zone between the west-dipping Pleasant Valley and east-dipping Dixie Valley fault systems, respectively.**

### 5.3 Crescent Valley

Crescent Valley is a large composite southeast-tilted half graben in north-central Nevada (Figure 1) bounded on the east by a major northwest-dipping, Quaternary normal fault along the west flank of the Cortez Range (Figure 6). This range-front fault contains several discrete right steps that represent favorable structural settings for geothermal activity. One such step hosts Dann Ranch Hot Spring, which has a surface temperature of 87°C and quartz and Na-K-Mg geothermometry of approximately 180°C. Silica sinter has been observed in the northern part of this particular step-over. U.S. Geothermal is currently conducting exploration in this area for a possible geothermal power plant. In addition, several hot and warm springs proximal to travertine deposits occur in the southern part of the Dry Hills along and near a west-dipping Quaternary fault that bounds the Dry Hills on the west at Hot Springs Point where travertine is accumulating. Springs at Hot Springs Point have a maximum measured temperature of 60.8°C and chalcedony geothermometry of ≤100°C. The Dann Ranch and Hot Springs Point areas appear to be separate systems such that Hot Springs Point does not represent an outflow of the higher temperature system on the east side of the valley. Preliminary analysis of seismic reflection and gravity data indicate that the fault bounding the Dry Hills on the west continues southward across the basin and intersects the Cortez Range fault. We are assessing the potential of both Hot Spring Point and Dann Ranch Hot Spring, as well as several other favorable structural settings in Crescent Valley (Figure 6). The study of Crescent Valley incorporates new detailed geologic mapping integrated with existing mapping in the area (Muffler, 1964), interpretation of four seismic reflection profiles (~92 km), both existing and new gravity surveys, geochemical analyses, shallow temperature surveys, and analysis of available well data.



**Figure 6: Crescent Valley study area, showing Quaternary faults, well and spring temperatures, and favorable structural settings for geothermal activity.**

#### 5.4 Steptoe Valley

Steptoe Valley is a complex, northerly trending composite basin in eastern Nevada (Figure 1) consisting of several west-tilted half grabens and associated depocenters. It is bound on the west by a highly segmented, east-dipping Quaternary normal fault zone (Figure 7) that flanks the Cherry Creek and Egan Ranges on the east and last ruptured in the late Pleistocene. Several step-overs or relay ramps punctuate the fault zone and represent favorable settings for geothermal activity. In addition, a few Quaternary faults cut across parts of the Steptoe basin. Our study is focused on an elongate north-south depocenter ~25-95 km north of Ely, Nevada. This area contains both Cherry Creek and Monte Neva Hot Springs, with both situated in small step-overs along the range-front fault. Monte Neva Hot Springs contains a relatively extensive travertine mound and has a surface temperature of 91°C and interestingly geothermometry of 59-65°C, possibly complicated by carbonate aquifers at depth (Hinz et al., 2015). Cherry Creek Hot Spring has a surface temperature of 60.5°C and chalcedony geothermometer temperatures of ~110°C. In addition to potential hydrothermal systems in some of the step-overs, the Steptoe basin also appears to be a favorable site for sedimentary hosted geothermal systems (Allis et al., 2012). Our work will provide a foundation upon which to analyze the relationships between structurally controlled and sedimentary hosted geothermal systems. The study of Steptoe Valley incorporates new reconnaissance mapping of Quaternary faults integrated with existing mapping in the area (Fritz, 1968; Hose et al., 1976), interpretation of more than 20 seismic reflection profiles (>300 km), a new gravity survey, geochemical analyses, thermal modeling, analysis of available well data, and a possible shallow temperature survey.

#### 5.5 Southern Gabbs Valley

Southern Gabbs Valley is a complex structural basin in west-central Nevada (Figure 1) situated near the intersection of northwest-striking, Quaternary dextral faults within the Walker Lane and north-northeast-striking Quaternary normal faults (Figure 8). The primary area of interest appears to occupy a “displacement transfer zone”, whereby a major dextral fault within the Walker Lane terminates in an array of normal faults, thus reflecting the diffusion of dextral shear from the Walker Lane into west-northwest-directed extension. Gabbs Valley is a blind geothermal area with no surface hot springs or steam vents. Evidence of a geothermal system comes from elevated temperatures (32.1°C) and geothermometry (>110°C [chalcedony], possibly up to 140°C based on mixing models) in irrigation wells in the western part of the study area, as well as from elevated 2-m deep temperatures (5°C above background) in the southeastern part of the basin (Figure 8). The 2-m deep temperature anomaly appears to lie within a fault intersection, as suggested by newly acquired gravity data for the area. Southern Gabbs Valley lies within a zone of thermal anomalies, including most notably the Wild Rose geothermal system, where the 16 MW (net) Don Campbell power plant is currently operating (Orenstein and Delwiche, 2014), and the Rawhide Hot Springs area to the north, with measured temperatures of 62.2°C. The Wild Rose area is located approximately 11 km to the west-northwest of the warm wells within the study area (Figure 8), whereas Rawhide Hot Springs is located 11 km to the north. Preliminary geochemical analyses and probable groundwater flow paths suggest no connection between southern Gabbs Valley and either the Wild Rose or Rawhide Hot Springs areas. The study of southern Gabbs Valley incorporates new geologic

mapping integrated with existing mapping in the area (Ekren and Byers, 1985, 1986; USGS, 2010; Payne, 2013), a new gravity survey, geochemical analyses, and a shallow temperature survey.

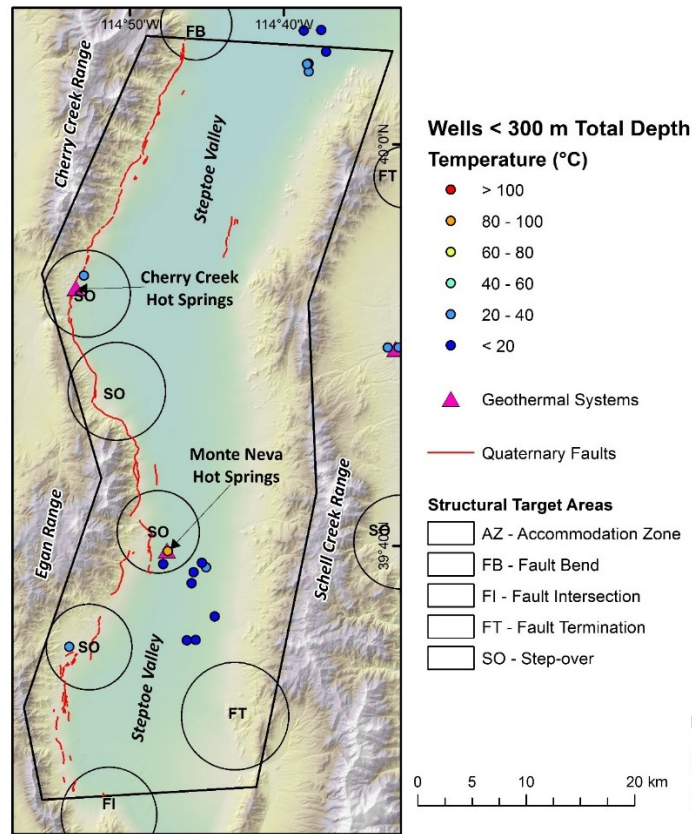


Figure 7: Steptoe Valley study area, showing Quaternary faults, well temperatures, and favorable structural settings for geothermal activity.

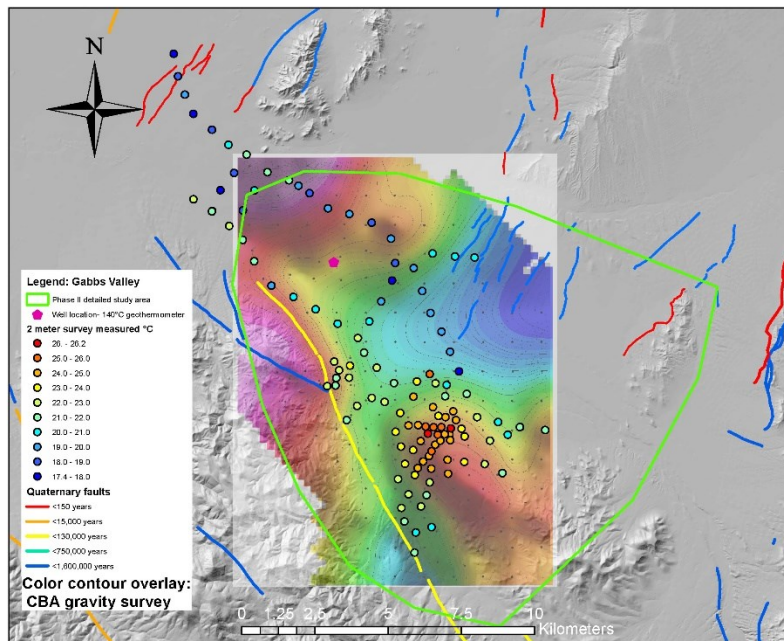
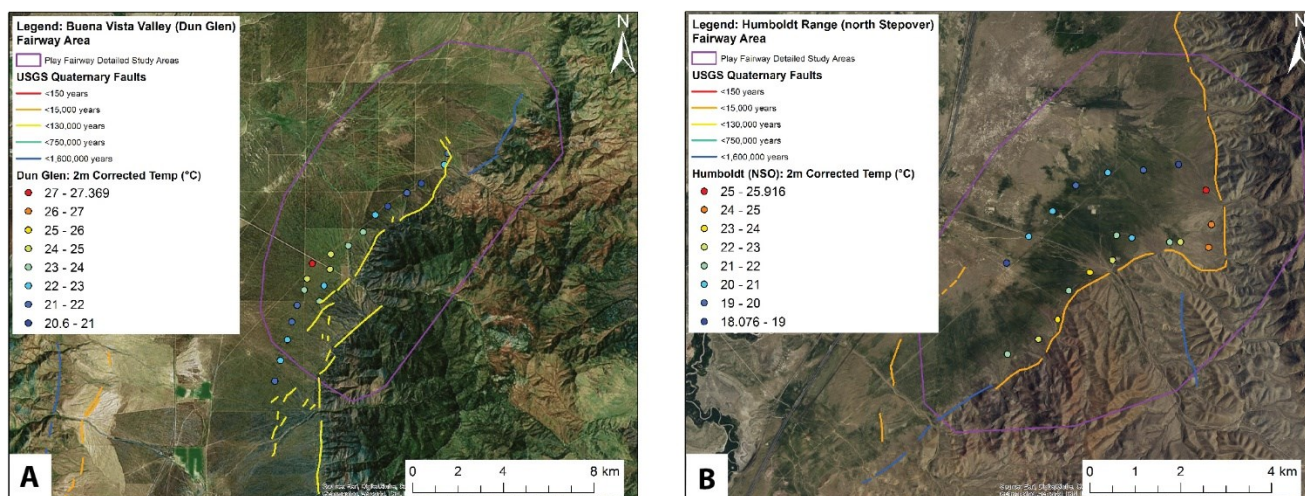


Figure 8: Southern Gabbs Valley study area, showing Quaternary faults, 2-m deep temperatures, and complete Bouguer gravity anomaly utilizing new data acquired in this study.

## 5.6 Runner-up areas

It is noteworthy that reconnaissance shallow temperature surveys at Dun Glen in Buena Vista Valley and two areas on the west flank of the Humboldt Range showed potentially significant temperature anomalies in the vicinity of step-overs in adjacent range-front faults (Figure 9). Although these areas could not be studied within the required timeframe of this project, we suggest that these thermal anomalies warrant additional investigations in the future.



**Figure 9: Shallow (2-m deep) temperature anomalies in the Dun Glen area (A) in Buena Vista Valley and Lovelock Meadows (B) along the west flank of the Humboldt Range. See Figure 1 for locations.**

## 6. CONCLUSIONS

On the basis of our preliminary findings, our play fairway methodology appears to have yielded positive results for identifying both potential new blind geothermal systems and particularly promising known, but undeveloped systems in the Great Basin region of west-central to eastern Nevada. Potential new blind systems include southern Gabbs Valley and Granite Springs Valley currently undergoing detailed study, as well as step-overs in the Dun Glen area and along the west flank of the Humboldt Range (Figure 1). Hot springs are present in our detailed study areas in Crescent Valley, Steptoe Valley, and Sou Hills, but our work is providing important data with which to vector into the most promising sites within these areas for high-temperature geothermal systems. Investigations will be completed this spring in the five detailed study areas, and locations will be selected for temperature-gradient holes. The results will also be synthesized into a comprehensive report for the Department of Energy.

## 7. ACKNOWLEDGMENTS

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