Play Fairway Analysis of the Eastern Great Basin Extensional Regime, Utah: Preliminary Indications

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ABSTRACT

We are assessing the geothermal potential including possible blind systems of the Eastern Great Basin extensional regime of western Utah through a Play Fairway Analysis (PFA) of existing geoscientific data. A PFA working model is adopted where magnetotelluric (MT) low resistivity upwellings suggesting geothermal fluids may coincide with dilatent geological structural settings and observed thermal fluids with deep high-temperature contributions. Unique to this setting is the superposition of active rifting with a N-S strike over E-W oriented belts of mid-Cenozoic plutonic rocks and possible NE-SW Precambrian shear trends. Data from ~470 high-quality MT sites have been undergoing 3D inversion using a new edge finite element formulation. Inversions show that several low resistivity upwellings project in the vicinity of Crater Bench, central Sevier Desert, Cove Fort, and east flank of the northern Mineral Mountains. The former three have known thermal expressions but the latter has no such association although it is along strike to the north of the Crater Knoll-Red Knoll Quaternary eruptions. There is a strong suggestion of control of resistivity structure by ENE-oriented structural trends possibly reactivated in E-W rifting. Reanalysis of seismicity shows that both swarm and non-swarm earthquake clusters locate in close proximity to the low resistivity upwellings near Cove Fort and the northern Mineral Mountains, while there is no seismic signature near the upwelling in the central Sevier Desert. Structural geology analysis based upon compilation of mapping, gravity and high-resolution (5 m often) DEM data has identified thirty-five areas of interest within and near the project fairway representing geometries that can produce critical stresses for dilatency, some of which overlap with MT structures. Major element geochemistry of thermal waters is dominated by chloride and sulphate compositions. Silica geothermometry values correspond well with direct reservoir temperatures, but the somewhat higher Na-K inferred temperatures may reflect deeper basement equilibration. Produced fluid compositions often are not compatible solely with the reservoir rocks of production, and imply substantially larger rock volumes are contributing. Also correlated with reservoir temperature are \(^3\)He (R/Ra) values, indicating that magmatic input is associated with convective flow. To date, results appear consistent with our PFA working model described above.

Introduction

Play Fairway Analysis (PFA) in the geothermal context combines regional geological/geophysical understanding with knowledge of prospect control elements (e.g., origin of heat, source of fluids, pathways to heat up and concentrate fluids, accessible high permeability, and a sealing caprock). Its goal is to produce an inventory of prospect leads that represent collocations of relatively high probabilities of elements (see Fraser, 2010, for an oil and gas analog). A play fairway that contains high-enthalpy systems ideally should reside in an extensional tectonic environment, either regional or locally-occurring, to promote permeability. The potential for new discoveries should be increased dramatically in regions where active magmatism creating a large heat endowment occurs in conjunction with diverse structural trends some of which may be well oriented.
to create reservoir space. Thus we have been drawn to examine the active eastern Great Basin of western Utah. Here, active N-S striking extension with high-temperature, bimodal volcanism (Bendersky et al., 2012) cross-cuts E-W trending plutonic belts of mid-Cenozoic age including the large Reno-Pioche-Marysvale-San Juan (R-M-S) trend, plus possible NE-SW trending Precambrian shear trends oblique to extension (Wannamaker et al., 2008) (Figure 1).

The pursuit of blind geothermal systems necessitates being able to “see” into the third dimension: depth. Magnetotelluric (MT) surveying elsewhere in the Great Basin has revealed that high-temperature geothermal systems appear to be underlain by steep low-resistivity (conductive) structures interpreted to be fluidized fault zones that typically are connected to deep crustal low-resistivity bodies representing magmatic underplating and fluid release (Wannamaker et al., 2007, 2008, 2011; Siler et al., 2014). Hence, for PFA application, existing MT data deserve reanalysis with modern methods to seek such fluidized conductive fault zones whose surface evidence at present may be obscure. Geothermal systems of course also are expected to reside in favorably dilatent structures to create permeability, and provide a pathway connecting heat and fluid sources to a reservoir (e.g., Faulds et al., 2013). Furthermore, the high-temperature systems examined with 3D MT in the Great Basin (Dixie Valley, McGinness Hills) show evidence through soil gas or spring/well fluid chemistry of magmatic or high-grade metamorphic volatile components including elevated $^3$He (as R/Ra) (Wannamaker et al., 2013a,b; Faulds et al., 2013; Siler et al., 2014). Thus, the confluence of favorability of these three lines of evidence may be taken to imply that an area deserves further exploration assessment.

We propose that a similar confluence of indicators may exist for geothermal resources in the eastern Great Basin. Reanalysis of existing data in the region is intended to verify and calibrate a PFA working model in that regard. The project area is relatively blessed with a quantity of existing data by which to make useful assessment recommendations. The PFA approach will define common risk segments (CRS) (Fraser, 2010) for the elements of source, fluid pathways, reservoir volumes, and seal using the three primary geoscience data sets. Where the downside risk of any of the elements is deemed confidently to be high that geographic area is considered to be of poor prospectivity. Only where all elements in an area are considered to be of low risk can that area be considered firmly prospective. However, confidence in assigning risk to a sub-region may be challenging in the face of sparse data so that prospectivity cannot be confirmed or overruled without obtaining new geoscientific observations.

**Analysis of Available Magnetotelluric Data**

High quality MT data are relatively abundant in this project area. They consist of ~470 recent, high-quality soundings acquired over the past 5 years under DOE and State of Utah support, plus private data supplied to EGI for this effort (ENEL Inc, Cyrq Inc). The sites tend to be clustered over particular thermal occurrences (Crater Bench, Cove Fort, Thermo) but there also is a considerable swath at somewhat greater average spacing over the broader Sevier Basin and northern Mineral
Mountains (Figure 1) (Wannamaker et al., 2013c; Hardwick et al., 2015). The inversions utilize all twelve MT data types (four complex impedance elements and two complex tipper elements). Inversion was performed with a new algorithm developed in-house under DOE support that implements the edge finite element method solving for the vector electric (E) field (Kordy et al., 2015a,b). The solution of all system matrices is direct (non iterative), making use of the Intel MKL matrix packages PARDISO for the sparse finite element system and PLASMA for the full parameter step matrix. The latter matrix is formulated in data space for compactness. The solutions are parallelized on a single-box, 24-core Linux workstation running at 2.4 GHz with 0.5 TB RAM.

As examples, we present inversion results for two of the prospect areas. The first is Crater Bench containing Abraham (Baker) Hot Springs (AHS) while the second is the broader Sevier Desert area and onto the northernmost R-M-S plutonic belt. For Crater Bench, the central portion of the finite element mesh, and the inversion parameters and performance, are given in Figure 2. There are 50 stations over the prospect and the period range used is 0.02 through 80 s. Cell widths among the sites typically are 300 m wide and the total finite element mesh is 91 (N) x 111 (E) x 43 (Z) cells with the upper 10 element layers devoted to the air. A narrow rim of finite elements around the mesh sides and bottom is kept fixed so the inversion domain is 88 x 108 x 30 = 285,120 parameters. Error floors were 3.5% of max{ |Zij| ; |Zxy-Zyx|/2 } and 0.03 tipper for tipper. The starting model was 33 ohm-m and a final nRMS of 1.5 was achieved monotonically in 12 iterations. This convergence illustrates the strength of full direct solutions for the parameter step matrix. Run times were 4.8 hours/iteration.

Two views through the 3D resistivity model appear in the lower part of Figure 2. The north-south section in the lower left runs through the basaltic Fumarole Butte edifice toward the western portion of the station coverage. One sees a very thin veneer of resistive basalt flows at the surface under the butte, underlain by ~1 km thickness of conductive sediments. However, ~5 km south of the butte appears a steep conductive zone projecting upward from at least 6 km depth to <3 km depth. This is a (in fact the only visible) candidate for a deep heat source to the Crater Bench area. This feature disappears in additional N-S sections to the east and does not project into AHS; it in fact dips to the southwest at depth. In the lower right of Figure 2 is a section view directly through the hot springs showing that this feature is not rooted. One possibility is that convective flow associated with the conductive structure to the southwest may be capped by the basalt flow or alteration directly beneath and channeled eastward to appear at AHS. This appears consistent with the interpretation of Parry and Cleary (1978) that AHS fluids are nearly an equal proportion of cold surface waters and hot geothermal...
waters. It raises the possibility that areas near the southwest margin of the Crater Bench basalt flow should be examined further for geothermal indications.

The Sevier Desert data set, collected predominantly with State of Utah funds, is of a significantly larger scale than Crater Bench. It covers an elongate swath from Delta city southward through the desert and onto the northern Mineral Mountains where basement rock may be dominated by mid-Cenozoic granodiorites of the RMS trend (Figure 1). The central portion of the finite element mesh is given in Figure 3. There are 143 stations over the prospect and the period range used is 0.08 through 212 s. Cell widths among the sites typically are 800 m wide and the total finite element mesh is 140 (N) x 101 (E) x 62 (Z) cells with the upper 12 element layers devoted to the air. A narrow rim of finite elements around the mesh sides and bottom is kept fixed so the inversion domain is 137 x 98 x 46 = 617,596 parameters. Error floors were 3.5% of max{ |Zij| ; |Zxy-Zyx|/2 } and 0.03 tipper for tipper. The starting model was 25 ohm-m and a final nRMS of 1.7 was achieved monotonically in 12 iterations. Run times were 13.5 hours/iteration.

At relatively shallow levels (1.4 km), the model is dominated by low resistivity of the late Tertiary sediments of the Sevier Basin and, in the southwestmost corner of the model, the Milford Valley sediments (Figure 4). At deeper upper crustal levels (4.5 km), we are below the Cenozoic sedimentary section but a conductive albeit fainter N-S axis remains below the trend of Quaternary basalts through the Sevier Desert. It was seen in the previous inversion by Wannamaker et al (2013c) using an independent algorithm on the northern two-thirds of the coverage. The Pavant Butte 1 well is located at the eastern margin of this axis. Within MT station sampling and inversion smoothing, we do not believe there is a fundamental conflict with well log readings showing resistive rocks at ~3 km depth (Hardwick et al., 2015). Additional MT sounding data could improve inversion resolution here. This large conductive axis largely terminates to the south at the latitude of Twin Peaks Quaternary bimodal volcanic center (northing 4295 km), at and beyond which any conductive structures are more clumped and non-lineated. Such localized conductors appear associated with Twin Peaks and with Cove Fort. There also is a third conductor not associated with a previously investigated geothermal occurrence north along strike from the Quaternary Crater Knoll-Red Knoll basaltic intrusive (CK). In this general area, the conductors

Figure 3. Central section of finite element model inversion mesh for the Sevier Desert MT data set. Topography is represented through gradual distortion of the hexahedral elements and color coded for elevation. Wells from Cove Fort (42-7) and Pavant Butte (PB-1) thermal areas noted.

Figure 4. Plan views of 3D MT inversion model for the broader Sevier Basin area, Utah. Z refers to depth in km. MT stations are black dots with white rims. Physiographics locations are Pavant Butte (PB), Twin Peaks (TP), Meadow-Hatton (MW), Crater Knoll-Red Knoll (CK), Cove Fort (CF) and Roosevelt Hot Springs (RH). Pavant Butte 1 and Cove Fort 42-7 wells are located as black-rimmed white circles with black dot centers near the PB and CF symbols.
reside in what should be predominantly mid-
Tertiary granodioritic basement of the RMS belt.

An alternate view of the broader Sevier resistivity structure is given in Figure 5 as a series of stacked perspective plan views. In this figure, the additional view at elevation -1250 m reinforces that at -3750 m by showing subsidiary NE-SW low resistivity lineaments intersecting the generally N-S trends. In particular we note one entering the rift axis from the NE just south of the Pavant Butte 1 well. Others can be discerned on both east and west sides of the rift. Under a regime of E-W extension, these auxiliary structures may suffer dilatancy and provide conduits for upward geothermal fluid flow. Because these are seen under the north-central Sevier Basin which is considered a non-plutonic area (MUMG of Figure 1), they should not be directly related to the mid-Cenozoic plutonism of the R-M-S belt and so may be older. Similar structural geometries will show up at greater depth, as discussed next.

Deeper in the model (10.2 km) of Figure 4, the Cove Fort and Crater Knoll-Red Knoll conductors persist although that of Twin Peaks has merged with a pronounced E-W linear conductor bounding highly resistive basement rocks of the R-M-S belt immediately to the south. At its east end, this linear conductor underlies the Meadow-Hatton thermal springs. Below the Sevier Basin to the north, the central linear basement conductor has bifurcated into two parallel N-S conductors that have divergent dips west and east. This split was observed also in the inversion model of Wannamaker et al (2013c) using a different algorithm. The abrupt, E-W oriented northern boundary of the R-M-S plutonic belt appears to continue to the east and separate the Cove Fort area from the Sevier Basin. At the deepest levels shown (18.9 km), a second E-W linear conductor of high amplitude unites the Crater Knoll-Red Knoll and Cove Fort conductors. In fact, it appears to continue eastward and project toward the Joseph and Monroe geothermal occurrences in Sevier Valley. This structure appears to bear a close relationship to the Cove Fort transverse zone, one of several major E-W structural lineaments in the eastern Great Basin comprised of large-scale faulting, downwarps and igneous centers (Rowley et al., 1998; Rowley and Dixon, 2001). Further MT data coverage is needed to the south to determine if fundamental low resistivity structures may be associated with the Roosevelt Hot Springs or reveal further controlling lineaments and exhibit a relationship to those shown by the current data.

Seismicity Cluster Analysis

We also are pursuing crustal fluid movement that may be suggested by the presence of seismic swarms such as seen along the northern margin of the Marysvale volcanic field and CFtv (Arabasz et al., 2007). Swarms are generally associated with changes in fluid pressures, weak heterogeneous crust, or as the result of aseismic creep (e.g. Mogi, 1963; Waite and Smith, 2002; Hainzl, 2004; Vidale and Shearer, 2006; Lohman and McGuire, 2007). Fluid-driven swarms can be modeled using a diffusion relation (e.g. Patotidis et al., 2005; Shapiro and Dinske, 2009; Shelly et al., 2013) where the distance between the first event and subsequent events is proportional to the square root of the time delay between events and the hydraulic diffusivity. Shelly et al. (2013) used that relation to not only explain the migration of a Yellowstone swarm, but also to constrain the fluid source as aqueous versus magmatic. The swarms shown by Arabasz et al. (2007) were derived for the time period 1981–2006 using the cluster-recognition algorithm of Veneziano and VanDyck (1985). A cluster was defined as 10 or more events that occurred within 10 km and 30 days of an M ≥ 3.0 main event. To be considered a swarm the cluster must contain at least four events within 1.0 magnitude unit of the main event.

We expand the work of Arabasz et al. (2007) by performing cluster analysis of the University of Utah earthquake catalog for the years 1981–2014 for earthquakes in and near the PFA study area (N>6000) (Figure 6). In this analysis, we use the Cluster2000 algorithm (Reasenberg, 1985). In Cluster2000, both the duration and distance range for cluster-

Figure 5. Stacked perspective plan views of 3D MT resistivity model through the reconnaissance Sevier Basin data set to an elevation of ~3750 m (depth of ~5200 m). Several deep well temperature profiles are included also. MT stations are black dots with white rims.
ing are controlled by the maximum event in the cluster and a user defined scaling factor. For this analysis, we use a scale factor of 100 and allow the location errors to be considered in the clustering. We keep all clusters with N ≥ 5 events. We do not have a maximum magnitude constraint. Similar to Arabasz et al. (2007), we define a swarm as a cluster containing at least four events within 1.0 magnitude unit of the main event. With this approach we find 89 (41 swarms and 48 non-swarm) clusters. The number of events per cluster ranges from 5 to 102 events and the maximum magnitude for each cluster ranges from 1.0 to 4.6. In the area of overlap with MT data coverage, swarm and non-swarm clusters appear to correspond with conductors in the Crater Knoll and Cove Fort areas (red symbols, Figure 6). The epicentral location error (95% C.I.) for the largest earthquake in each cluster closest to the Crater Knoll and Cove Fort conductors ranges from 1.2 to 2.9 km. Vertical locations are poorly constrained.

In order to track swarm seismicity in space and time and to resolve structures with depth, we need high-quality hypocentral locations for a reasonably low magnitude of completeness. To achieve this requires further reanalysis of the catalog. To improve event detection, we use subspace detection (Harris, 2006; Harris and Paik, 2006, Chambers et al, 2015). Unlike cross-correlation detectors that use individual template events to find repeating events (e.g. Shelley et al., 2013; Kubacki et al., 2014), a subspace detector uses a group of events to form a set of orthogonal basis templates. The benefit of this method is that instead of looking for repeating events (same location and source

Figure 6. Seismic swarm and non-swarm cluster results using the Cluster2000 algorithm for the general play fairway project area. Seismometer locations are black triangles. Swarm clusters are stars and non-swarm clusters are open circles. Pink boxes denote approximate lateral location of middle to upper crustal conductors resolved with MT in the Crater Knoll (left) and Cove Fort area (right). Red symbols highlight clusters discussed in the text: those located near the conductors identified with MT (near pink boxes) and the 2003 Marysville Swarm.

Figure 7. Top row: dendrogram showing waveform dissimilarity for all 24 events in the Marysville swarm (left); waveforms colored coded by cluster based on 0.78 correlation coefficient (middle); each cluster is used to form a subspace, the four subspace detectors find 469 additional detections (right). Bottom row: Examples of detected events (red) and comparison of the three detected events to subspace vectors (orange).
type), new events are found that are linear combinations of basis templates, so event location and source type are allowed to vary within the domain of all events in the subspace.

The subspace detector has been applied to the 2003 Marysvale swarm (Batchelor et al., 2015) (Figure 7). In initial work, the catalog of 25 events was used to obtain over 450 detections. While not all detections are real events in the swarm, the number of events in the swarm is increased by over an order of magnitude. In subsequent analysis, subspace detectors will be formed using the other clusters (both swarm and non-swarm) and applied to continuous data that is available for 2001 to present. Each enhanced cluster will be relocated using a relative relocation technique (Waldhauser and Ellsworth, 2000). We will then determine the distance to the first event to see fluid migration is contributing to the genesis of the seismic sources. Swarm locations and detailed analysis will be compared to the results determined in the MT analysis. We also plan to examine non-swarm seismicity for fault-zone related trends plus tendency to associate with margins of swarms and low-resistivity bodies as indicators of fluid-enabled failure (Ogawa and Honkura, 2004; Wannamaker et al., 2009).

Structural Geology Analysis

Geothermal systems are inherently 3D and occupy reservoirs created through brittle deformation. Recognized structural settings favorable to dilatancy for geothermal reservoirs of the Great Basin include relay ramps, horse-tailing terminations, step-overs, fault tips, accommodation zones, and fault intersections (e.g., Faulds et al., 2013). We expect these structural styles are candidates for some geothermal systems in the eastern Great Basin region, but other structural controls may well be operating. To identify these, a GIS database has been developed, where the following data have been georeferenced to a common projection and datum and clipped to cover the study area: (1) regional dilation, (2) regional shear, (3) regional strain, (4) total fault offsets, (5) mapped faults, (6) regional gravity data, (7) regional magnetic data, (8) digital elevation models, and (9) heat flow/thermal gradients. We have identified 35 areas with promising structural geometries for fracture permeability within the play fairway and nearby areas, interpreted from geomorphology and gravity data, including step-overs, a relay ramp, an accommodation zone, and fault tips.

A particularly interesting confluence of structural and geophysical indicators lies on the northeast side of the Mineral Mountains (Figure 8). Here a NNW-striking Quaternary normal fault is intersected by an older ENE-striking shear zone and is coincident with a strong, steeply-inclined MT low-resistivity anomaly. The southerly extent of the MT anomaly is difficult to judge as it appears at the southern limit of the MT array, and the anomaly also is imaged extending considerable to the east. In plan view in Figure 4, this anomaly is labeled CK as it is along strike to the north from the Crater Knoll-Red Knoll extrusive. The MT low-resistivity zone is bordered and perhaps essentially coincident with a seismic swarm anomaly (Figure 6). The east-dipping Quaternary fault continues to the south where it transitions through an apparent accommodation zone to a west dipping fault on northeast side of Cunningham Wash (Figure 8). The ENE shear zone corresponds with the Cove Fort transverse zone described above.

Emplacement of the pronounced E-W belts of middle Cenozoic plutonic rocks such as the R-M-S or the Eureka-Tintic (E-T) (Figure 1) must either have created or been controlled by large-scale E-W trending structures. Age may perhaps be constrained if E-W structures can be resolved geophysically beneath the non-plutonic Sevier Basin region; in this case
they could be pre-Cenozoic (see Whitmeyer and Karlstrom, 2007). With the N-S striking modern rift axes, this confluence of trends should create unique opportunities for dilatency, geothermal fluid flow and reservoir rocks in the eastern Great Basin. We plan closer inspection of the Twin Peaks area, as there is observed sinter, bedded opal, and altered fresh-water limestone with cross-cutting opal fillings.

**Fluid Geochemistry**

Chemical and isotopic analyses can provide information on the compositions of the rocks hosting the geothermal reservoirs, fluid sources, ages, and pathways, and deep reservoir temperatures (Figure 9) (Simmons et al., 2015). Geochemical data from two sets have been compiled and filtered with emphasis on summarizing geochemical trends for thermal waters with temperatures >40°C. The UGS data set contains >100 chemical analyses comprising major cations (Na, K, Ca, Mg, Li), anions (Cl, HCO₃, SO₄), and weak acids (B, SiO₂) for thermal springs in and around the study area (Blackett and Wakefield, 2002). A second smaller data set comprises chemical analyses of thermal waters, including stable isotope and helium isotope data (Cole, 1983).

Most of the 100+ compiled thermal water samples can be classified as chloride, sulfate or hybrid chloride-sulfate waters (Figure 10a). Cove Fort and Roosevelt Hot Springs (RHS) waters have similar chloride-sulfate concentrations, despite different reservoir rocks (carbonates versus siliceous gneiss/granite). Oxygen and hydrogen isotope ratios of thermal waters indicate a meteoric origin modified by high-T water-rock exchange, but because the reservoir waters are isotopically lighter than modern meteoric water they either derive from high elevation precipitation or paleo-glacial melt-water. Elevated ³He/⁴He isotope ratios at RHS (2.25 R/Ra), Cove Fort (0.62) and Thermo (0.9 R/Ra) imply a mantle-sourced magmatic component. The positive correlation between aqueous silica, reservoir temperature, and the quartz solubility curve for production waters (Cove Fort, Roosevelt, Thermo) indicates that quartz-silica geothermometry will give the most reliable minimum resource temperatures when applied to spring waters (Figure 10b). Na/K geothermometry is consistent with measured temperatures at RHS, but excessive apparent Na/K values for Cove Fort and Thermo require further evaluation. We speculate that the Na/K values may suggest yet higher temperatures below the producing reservoir (Simmons et al., 2015).

![Figure 9. Map showing locations of springs and thermal areas within the study area, based on the UGS (Blackett and Wakefield, 2002) and Cole (1983). Numbers represent R/Ra ³He/⁴He data (Kennedy and van Soest, 2007).](image)

![Figure 10. Left (a): Cl-HCO₃-SO₄ ternary diagram showing the compositions of thermal waters in southwestern Utah using data from the UGS data base (Cole, 1983; Blackett and Wakefield, 2002), Cove Fort (Moore et al., 2000), Roosevelt (Capuano and Cole, 1982), and Thermo (Moore, unpublished). Right (b): Comparison of aqueous silica concentrations and temperatures for thermal waters, the highest silica values correspond to production waters from Roosevelt. Solubilities of quartz, chalcedony and cristobalite (Fournier, 1991) are shown for comparison.](image)
Preliminary Synthesis and Conclusions

Ideally, we would identify locales in the eastern Great Basin region where there is a confluence of upwelling low MT resistivity, geological structures pointing to dilatency and permeability, and fluid geochemistry indicative of prospective high temperatures at depth. A special set of opportunities are present in this region of active basaltic and bimodal volcanism, together with oblique pre-existing trends and good reservoir rocks represented by the plutonic intrusive belts. Substantial data are available to define play characteristics including MT, seismicity, structural geology, and fluid geochemistry. In some regards, the setting for geothermal occurrences appears quite different in the Sevier Basin of the north-central project area occupying the mid-Utah magmatic gap (MUMG) than it does for the southern portion of the project area where the basement is dominated by Cenozoic plutonic rocks. However, ENE resistivity structural trends appear significant in both domains and may be important representations of dilatency created by structural intersections and E-W extension. In this regard, we currently give more weight to fundamental structural intersections as mechanisms for dilatency compared to along-strike variations in basin-bounding fault geometries (cf. Faulds et al., 2013). Tentatively we observe correlation between MT conductivity and seismicity clusters and swarms but this deserves further analysis of the continuous seismic records. Among other things, results to date call for further geophysical data to be collected in the southern project area past the Roosevelt Hot Springs and through the R-M-S plutonic belt.

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References


Hardwick, C. L., R. Allis, and P. E. Wannamaker, 2015, Observations and Implications of Magnetotelluric data for resolving Stratigraphic Reservoirs beneath the Black Rock Desert, Utah, USA: Geothermal Resources Council Transactions, this volume.


