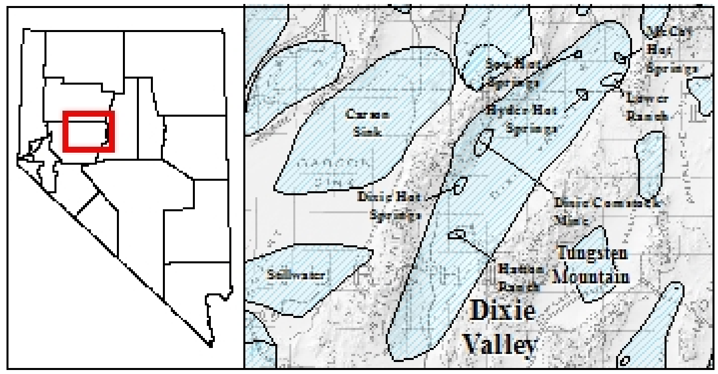
Nevada Bureau of Mines and Geology

# Site Description




## Dixie Valley

(Updated 2014)

Geologic setting:

Dixie Valley lies in the western part of the Great Basin, ~150 km east of Reno in Churchill County (Blackwell et al., 2006). The Stillwater Range bounds Dixie Valley on the west and separates it from the Carson Sink, which also hosts several significant geothermal systems. The Dixie Valley geothermal system extends ~30 km from the production plant south to Dixie Meadows Hot Springs. The Stillwater Range-front has multiple sites associated with shallow (~3 km) temperatures greater than 200°C. The resource has been partially delineated by production, injection, and exploration wells 2500 to 3500 m deep, and a rich variety of geological and geophysical data.

The Dixie Valley geothermal system is in the Stillwater Seismic Gap (Wallace and Whitney, 1984), which occurs between epicenters of several major earthquakes. The Dixie Valley Fault (aka Stillwater Fault) bounds the western side of Dixie Valley, separating the Stillwater Range bedrock from the Tertiary and Quaternary sediments that fill the basin. It is one of the most active faults in the Basin and Range Province, with historic (1954) and Holocene (~3000 ka; Caskey et al., 2000) surface-rupturing earthquakes. In fact, high temperatures concentrate along the Dixie Valley fault system between surface ruptures of (1) the 1915 Pleasant Valley earthquake and (2) the 1954 Dixie Valley-Fairview Peaks earthquake. The fault generally strikes northeasterly along the eastern front of the Stillwater Range. It extends from the southwest side of Sou Hills to ~10 km north of highway US 50, a distance of 80 km. At its northern end, the fault makes a sharp bend eastward along the south side of Sou Hills and loses coherency in several discontinuous splays and short segments. At its southern end, the fault steps ~15 km eastward along a complex structural linkage to the Fairview Fault (Caskey et al., 1996).

The Dixie Valley basin is filled with >2500 m of moderately- to poorly-lithified sediments derived from the surrounding mountain ranges (Waibel, 1987). The bedrock of the Stillwater Range is made up of allochthonous thrust plates of Triassic and Jurassic oceanic sedimentary and Jurassic igneous rocks. These are intruded by Cretaceous granodiorite, and overlain by Cenozoic volcanic rocks. The Triassic and Jurassic sequences are separated by numerous shallowly dipping thrust faults that separate thin plates, with no obvious stratigraphic continuity between plates. The southern Stillwater Range, south of Dixie Meadows Hot Springs in White Rock Canyon, contains a tilted and eroded sequence of middle Cenozoic silicic ash flow tuffs, the associated caldera, and a subvolcanic granitic pluton (John, 1995). This caldera may be the source of some or all of the silicic volcanic rocks present in the Clan Alpine Range, at depth in Dixie Valley, and above the Mesozoic rocks in the Northern Stillwater Range. The bedrock geology of the Stillwater Range is further described in maps and reports by Page (1965), Willden and Speed (1974), Speed (1976), Denton et al., 1980, Waibel (1983, 1987), Lutz et al. (1997), and Plank (1998). In addition, there are unpublished reports by Waibel (1994, and 1999) describing the geothermal geology of Dixie Valley. The rocks exposed in the Stillwater Range near the geothermal field are the same rocks as those intersected by the wells in the geothermal field (Benoit and Butler, 1983; Benoit, 1997; Plank, 1998).

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Geothermal features:

Within the larger Dixie Valley geothermal cluster lie several smaller clusters. These clusters include Hatton Ranch, Dixie Hot Springs, Dixie Comstock Mine, Hyder Hot Springs, Lower Ranch, McCoy Hot Springs, and Sou Hot Springs. Springs and wells within these clusters are outlined below.

**Geothermal Production Area**

***Dixie Valley Geothermal Plant:*** The Dixie Valley power plant produces 66 MW of energy, a higher output than any geothermal system not associated with magmatism. The Caithness Dixie Valley plant was purchased from Oxbow Geothermal Corp. in 2000, the largest single geothermal plant in Nevada. The plant produces from a 250°C resource at depths of 2400 to 3050 m. The production zone is related to highly-permeable fractures in and adjacent to the Dixie Valley fault, the major range-bounding fault on the west margin of Dixie Valley. It is uncertain whether the Dixie Valley fault is one or several faults (Blackwell et al., 2000, and Smith et al., 2001); if it is interpreted as one fault, the dip is about 50°E (Benoit, 1999). Fluid flows up the fault from depth, into fractured Mesozoic metaigneous rocks and overlying Tertiary volcanic rocks (e.g., Desormier, 1987).

Pressure augmentation combines post-flash brine with shallow well water (e.g., Goerenger Well) prior to re-injection. High-quality silica is extractable from the geothermal fluid, a process which reduces silica scaling and produces a valuable mineral product (Lin et al., 2000). Much additional research has been conducted at Dixie Valley, which cannot be summarized here. Additional information on the geothermal area is available in GeothermEx (2004).

Data from two Dixie Valley production wells are described by Goff et al. (2002):

"The DF 62-21 well is located near the middle of Dixie Valley about 10 km due east of the 66-21 well and about 4 km southeast of the Dixie Valley Production Field. This well is 3810 m (12,500 ft) deep, penetrating a sequence of basin-fill deposits, Tertiary tuffs, Jurassic gabbro and Triassic shale/slate. The bottom hole temperature is 184°C and a fluid entry occurs at 2900 m at the contact of gabbro and underlying Triassic slate. When opened the well eventually flows 140 L/min of water at about 76°C. No free gas was observed associated with this water in May 1998.

"DF 62-21 water contains moderate amounts of $SiO_2$, Br, and Li, and high contents of As and B. Concentrations of Ca and Mg are low but the Cl content is only about 80 ppm. This water does not resemble the Dixie production brines, but does resemble Hyder Hot Spring water both chemically and isotopically (oxygen-18 shift of 1.5‰). Interestingly, DF 62-21 water contains 0.83 T.U. tritium (more than most of the hot springs) suggesting it is a mixed fluid. Overall, DF 62-21 water has characteristics of moderate-temperature geothermal fluids. Chemical geothermometers suggest equilibration at temperatures ≤150°C, possibly around 135°C (Goff et al., 2002).

"The DF 66-21 well is located in the valley about 2 km southeast of an unnamed fumarole group near the south margin of the Dixie Valley Power Partners geothermal lease. "The wellhead is about 150 m southeast of the main road in Dixie Valley. The well was drilled in 1979 to a depth of 2988 m (9800 ft), penetrating roughly 1250 m of basin-fill deposits, 335 m of Tertiary volcanic rocks, 870 m of primarily

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granodiorite, and 534 m of primarily metasediments. The lower portion of the metasedimentary section contains gabbro/diorite intrusive bodies. According to S. Johnson (oral communication, 1997), the hole bottoms in the ophiolitic rocks. An obvious water entry occurs at 1463 m depth but this entry was cased off. A temperature log obtained in September 1979 indicates a rather linear conductive gradient, with a temperature of about 150°C at 2470 m (Mackay Minerals Research Institute, 1980). When sampled in 1997 and 1998, the well was producing a small amount of water (4 to 7 L/min) at 55 to 57°C (Goff et al., 2002). No free gas was observed at the wellhead, although the present configuration does not allow for clear observation of gas emissions.

"Water from DF 66-21 has relatively moderate to high contents of SiO2, As, B, Br, and Li, and the Cl concentration is about 1460 ppm. This Cl level is nearly three times higher than Cl in the Dixie Valley Production Field production waters and is the most saline groundwater (other than Humboldt Salt Marsh) that Goff et al. encountered in Dixie Valley. The water has moderate Ca but low Mg concentrations. Although not part of the Dixie reservoir, DF 66-21 water has the general characteristics of high-temperature geothermal fluids. Chemical geothermometers suggest that DF 66-21 water has equilibrated at temperatures of about 210°C (Goff et al., 2002), indicating that the water comes from an entry near the bottom of the hole. Bottom hole temperature in the Dixie Valley Power Partners wells just to the northeast of DF 66-21 is over 265°C."

<u>Leasing information:</u>

Terra-Gen received a $2m DOE contract to develop and put on line the first commercial use of a supercritical bottoming cycle at its Dixie Valley power plant using inlet temperatures of less than ~150$^{o}$C. This may augment the 62MW current capacity of the plant.

Magma Energy has leased a property along the range front southwest of TerraGen's operating geothermal power plant. A deep, hot but dry production well exists on the property, but no known work has been completed recently.

RAM Power acquired a 4478 acre lease south of the main Dixie Valley power plant (the property reverted to RAM Power during its acquisition of Sierra Geothermal Power in 2010). No further information is available on the project.

***Senator Fumaroles:*** The Dixie Valley power plant was constructed at Senator Fumaroles (Senator Mine) in 1988. The fumaroles were located along a N30°E fault bounding the eastern Stillwater Range (Lawrence, 1971) at SW¼ NW¼ Sec. 32, T25N, R36E. Senator Fumaroles were the only surface indication of geothermal activity: the water table (circa 1970s) was 18m below surface and no hot springs could form.

Cinnabar was deposited around two fumaroles, along with minor sulfur and pyrite. Considerable solfataric alteration has taken place: small volumes of $H_2S$-bearing steam were emitted at the vents, and preliminary work indicates that cinnabar deposited from the vapor phase (Lawrence, 1971). Sinter is known ~5 km southwest of the fumaroles (Sec. 15, T24N, R36E; Waibel, 1987), and thin bands are also found ~10 km southwest, in alluvial fan deposits by the Dixie Valley range-front fault (Al Waibel, oral commun., 1983).

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**NE Stillwater Range-front**

***Cottonwood Canyon:*** Dead Travertine Spring and the Bolivia Well are two thermal features within Cottonwood Canyon.

From Blackwell et al. (2006): “The oldest known spring deposits in the Dixie Valley region are those currently associated with the Dead Travertine (Cottonwood Travertine) springs about 2 km upstream of the mouth of Cottonwood Canyon. The deposit drapes the northeast side of the canyon wall over an elevation range of 275 m and is roughly 400 m wide at the base (along the dirt road), 150 m wide at the crown, and 550 m long horizontally. The deposit is fault controlled because Jurassic quartzite is faulted down to the northwest against Jurassic gabbro in a narrow, northeast trending window within the travertine (F. Goff and C.J. Janik, unpublished mapping, 1999). This fault extends beyond the deposit to the northeast up the canyon wall. Rocks within the window and just above the crown of the deposit are highly fractured and contain numerous calcite veins. A sample of dense, honey-colored calcite from one of these veins yielded U/Th disequilibrium and protactinium-231 ages of 182 ± 4 ka and 161 ± 15 ka, respectively (Goff et al., 2002). More recently, Dixon et al. (2003) reported a preliminary U/Th isochron age of 100 ka from four layered travertine samples obtained throughout the deposit. Determination of whether or not these deposits were formed from spring waters of compositions and temperatures different from the cold seeps of today would require considerable additional work. However, it appears that carbonate-rich fluids have discharged in this area for 150 ka or more.”

From S. Johnson, personal communication (1997): The Bolivia Well, an artesian well, is located 1 km upstream of the abandoned town Bolivia in northeast Cottonwood Canyon. Rocks in the adjacent cliffs consist of highly altered Jurassic gabbro and limestone. The 29°C well water flows at ~40 L/min without visible gas discharge, and deposits Fe-oxides near the wellhead casing. Chemical analysis of well water indicates low concentrations of $SiO_2$, As, B, Br, and Li. The water is distinct from Dixie production fluids and displays little, if any, oxygen-18 shift due to high-temperature isotopic exchange. The water contains 0.10 T.U. tritium yielding a minimum age of about 75 y. The subsurface equilibration temperature based on chemical geothermometers is <45°C (Goff et al., 2002, Table 12).

***Dixie Hot Springs:*** Numerous hot springs are located in SE¼ Sec. 5 and Sec. 8, T22N, R35E along the west side of Dixie Valley, ~12 km north of the Dixie Valley community. The springs have a reported temperature of 72ºC (Mariner et al., 1974). Cold springs are present about 1.6 km to the south in Sec. 17, T22N, R35E (Dixie Valley 7.5-minute Quadrangle). The springs follow a northeast-trending line, which may be the continuation of a range-front fault at the Dixie Comstock Mine. Movement was reported along this fault in the 1954 Dixie Valley earthquake (Willden and Speed, 1974). The estimated reservoir temperature is 144-145°C, using the silica and Na-K-Ca geothermometers (Mariner et al., 1974).

In the early 1980s, Sunoco Energy Development Company (Sunedco) drilled several exploration wells at Dixie Hot Springs as part of a larger exploration of Dixie Valley geothermal area (Blackett et al., 1986, p. 14). Seismic emission and micro-earthquake surveys were also performed (1983). Seismic emission anomalies commonly occur at cross faults, and results suggest that Cottonwood Canyon, about 5 km southeast, is fault-controlled (Katz, 1984, p. 507). The range-front fault dips 35º to the east, and fluids moving up the fault plane boil in the shallow subsurface. Native sulfur is deposited today from fumaroles, and ground temperatures have been measured at 94ºC (Kennedy-Bowdoin et al., 2003, 2004).

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***White Rock Canyon:*** The Dixie Comstock Mine is situated in the eastern Stillwater Range. The range margin is sharply curvilinear, locally very steep, and the site of several thermal springs. The mine was discovered in 1934 by panning drainages along the Stillwater Range margin, and yielded nearly five thousand ounces of gold during intermittent operations between 1938 to 1970 (Vikre, 1994, p. 707). The geology of the Dixie Comstock Mine is extensively discussed by Vikre (1994).

Mining in the Dixie Comstock Mine was hindered by intense heat and large volumes of hot water less than 23 m from the surface (Vanderburg, 1940; p. 48). These workings are in NW¼ Sec. 14, T23N, R35E near a major range-front fault, which had movement in the 1954 Dixie Valley earthquake (Willden and Speed, 1974). This fault and related parallel faults continue south 8.8 km to Dixie Hot Springs, and north to Senator Fumaroles. Waring (1965) reported a small spring in T23N, R35E, which may possibly be near the Dixie Comstock Mine. In 1979, Thermal Power Co. drilled a 2750-m well (Dixie Federal 45-14; NE¼ SW¼ Sec. 14, T23N, R35E) 762 m southeast of the mine. The well recorded a 176°C fluid entry zone at 1774-1789 m and 197°C at total depth (Edmiston and Benoit, 1984).

Located ~1 km southeast of the abandoned mine and 12 km southwest of the Dixie production zone, the DF 45-14 well was drilled in 1979 in alluvium near the margin of fanglomerate. It was drilled "to a depth of 2750 m (9022 ft) penetrating 335 m of unconsolidated basin-fill sediments, 457 m of Tertiary volcanic rocks, and 1982 m of Upper Triassic metasedimentary rocks locally intruded by gabbro/diorite sills and dikes (Mackay Minerals Research Institute, 1980). The well was cased and fluids entered the well near the bottom of the hole. Temperature surveys show a maximum temperature of 196°C at total depth. The well has been discharging intermittently (surging) through a pipe into a pond surrounded by desert shrubs on the eastern side of the wellhead since it was drilled.

The wellhead was opened in April 1998 and a mini separator was attached to obtain fluid and gas samples at a separation temperature of 125°C (Goff et al., 2002). The brine contains high concentrations of $SiO_2$, As, B, Br, and Li, and low concentrations of Ca and Mg. The Cl content is 481 ppm. Of all thermal waters outside the immediate area of the Dixie production zone, DF 45-14 water is the most similar in general composition to deep reservoir waters. Although the compositions are similar, chloride variation plots generally show that the DF 45-14 fluid is not derived from or part of the 245°C reservoir. Because sampling conditions were unstable, the gas sample is not considered completely representative (28 mol-% air contamination). Nonetheless, the sample is relatively rich in $CO_2$, $H_2S$, $H_2$, and $CH_4$, typical of high-temperature geothermal gases. Chemical geothermometers indicate a subsurface equilibration temperature of about 200°C for DF 45-14 fluids, essentially identical to the measured BHT.

Leasing information: N/A

**Northernmost Dixie Valley**

***Hyder Hot Springs:*** Hyder Hot Springs (SW¼ Sec. 28, T25N, R38E) are a grouping of seeps, pits, and two or more springs with reported temperatures of 28-79°C (Cohen and Everett, 1963). They sit along a zone of Quaternary faults which cross-cut alluvium (Stewart and Carlson, 1978). GeothermEx (2004) reports carbonate mounds and travertine terraces, and an estimated reservoir temperature of 84ºC (chalcedony geothermometer), similar to the spring temperature.

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From Blackwell et al. (2006): "Hyder Hot Springs discharge from the top and edges of a broad hill of soft travertine about 15 m high and 700 m in diameter. The site is located near the middle of Dixie Valley, about 4 km east of the Dixie Valley Production Field. The travertine hill is interbedded with alluvium and loess at the margins, and the base of the deposit is not exposed. The travertine is stained with minor amounts of Fe-oxides. Maximum discharge temperature and flow rate of the summit spring is 77°C and 40 L/min, whereas total flow of group is ~120 L/min. Free gas emerges from the summit spring. The spring system and travertine hill lie at the northernmost end of a positive aeromagnetic anomaly caused by a buried basement block of mafic igneous rock [ophiolite]. Several faults of various depths beneath the surface are interpreted in this area from the aeromagnetic data, and the location of the hot spring system may be controlled or influenced by intersections of some of these faults.

"Hyder Hot Spring waters have rather modest concentrations of $SiO_2$, Br, and Li. B contents are rather high but As contents are quite low. The waters contain only 47 ppm Cl and do not resemble Dixie Valley Production Field production fluids in their trace element relations. Hyder Hot Spring gas contains 95 mol-% $CO_2$, 4 mol-% $N_2$, and 0.5 mol-% $CH_4$. However, concentrations of $H_2S$ and $H_2$ are <0.004 and <0.0006 mol-%, respectively. High-temperature geothermal gases are generally rich in these two compounds. The tritium content of the water is 0.12 T.U. indicating the water is relatively old.

"Stable isotope relations of two Hyder samples show an oxygen-18 isotope shift of about 1.5‰, by far the largest shift of any hot spring water in the region. The isotope values are nearly identical to those of water from well 62-21, suggesting that it is possible that Hyder water is a mixed fluid derived from a parent fluid similar to that in 62-21 but mixed with shallow aquifer water (Goff et al., 2002)."

***Lower Ranch Hot Spring:*** The Lower Ranch Hot Spring group consists of five hot springs and several seeps that issue from an impressive, faulted travertine in eastern Dixie Valley 1.5 km west of the Augusta Range. The travertine forms a northeast-trending deposit ~2 km long with a faulted scarp ~40 m high on the southwest. The east side of the deposit is partly buried in alluvium (Blackwell et al., 2006).

The hot springs (NW¼ Sec. 16, T25N, R39E, Cain Mountain 7.5-minute Quadrangle) have a reported temperature of 40.0ºC (Reed et al., 1983, p. 44). According to Blackwell et al. (2006), the largest spring discharges 41ºC water at 120 L/min, and is used by Kelley Ranch for irrigation and bathing. Total flow is estimated at 400 L/min for the entire group. A slightly cooler spring (39ºC) issues from a shallow vale at 10 L/min. No free gas emerges from any spring sources.

A related group of cooler waters (≤29°C), informally named the Fault Line spring group, issues 2 to 3 km west of Lower Ranch Hot Springs along a 1-km, northeast-trending alignment that is probably fault-controlled. An unnamed spring in Sec. 19, T25N, R39E, about 6 km southwest, has a reported temperature of 28ºC (Cohen and Everett, 1963). That spring is near the end of a long line of northwest-trending, fault-controlled springs that cut the alluvium and intersect McCoy Springs about 7.2 km to the northwest (Cohen and Everett, 1963; Stewart and Carlson, 1976b).

Waters from Lower Ranch and the Fault Line spring contain low to very low concentrations of $SiO_2$, As, B, Br, and Li, and Cl contents are only 30 ppm based on samples collected in November of 1997 (Goff et al., 2002). The waters do not resemble Dixie production fluids and do not show any oxygen-18 isotope shift. Two samples (one from each group) contain ≤0.07 T.U. tritium indicating a minimum age of roughly 80 y, but likely considerably older. Chemical geothermometry indicates subsurface equilibration temperatures of only 60ºC. Estimated reservoir temperatures using older data for the silica and Na-K-Ca geothermometers, respectively, are 94ºC and 100ºC (Mariner et al., 1974).

Detailed mapping of the Lower Ranch travertine deposit (Goff and Janik, 1999, unpub.) shows the northeast end of the deposit devoid of active springs. Within this area, layering of the deposit is best exposed in a ravine cutting the west side. There, the base is exposed on top of alluvial fan materials and consists of mixed travertine and sinter. A sample of the mixed material was cleaned of the $CaCO_3$ fraction for dating, which yielded U-Th and U-Pr disequilibrium dates of 54 and 39 ka, respectively (Goff et al., 2002).

***McCoy Springs:*** McCoy (J. Saval) Springs, located in SW¼ of NW¼ of Sec. 33, T26N, R39E, have reported temperatures of 48.9ºC (Reed et al., 1983, p. 44), 48.3ºC (Cohen and Everett, 1963), and 46ºC (Blackwell et al., 2006), with a flow rate of 50 L/min. The springs are located at the northwest terminus of a northwest-striking fault system in Quaternary alluvium (Stewart and Carlson, 1976b). The main spring issues from a modified pool 40 m in diameter, 8 km due north of Lower Ranch Hot Springs and 1.5 km southeast of McCoy Ranch (abandoned). According to Blackwell et al. (2006), the pool is excavated into alluvial fan deposits. There are no deposits of travertine or sinter and no free gas emerges from the source.

McCoy Hot Spring water contains low to very low concentrations of $SiO_2$, As, B, Br, and Li. However, Cl contents are 220 to 230 ppm, more than any other hot spring in the Dixie and Jersey Valleys. The waters do not resemble Dixie production fluids and do not display any oxygen-18 shift due to high-temperature isotope exchange. The geothermometers suggest subsurface equilibration temperatures of no more than 60ºC.

***Sou Hot Springs:*** Sou Hot Springs is located in northern Dixie Valley about 1.6 km north of the Seven Devils Ranch (SW 1/4 Sec. 29, T26N, R38E). This group of seven or more hot springs emerges from the summit and flanks of a north-trending travertine deposit 1 km in length, 1-2 km south of Sou Hills. The alignment suggests fault control but no structure could be seen at the springs. From Blackwell et al. (2006), the hot springs are found in circular vertical tubes or discharge from isolated springs and small ponds, mostly on the south end of the travertine deposit. The water level in one tube is 3 m below the crest of the travertine, with a surface temperature of 57°C and no obvious discharge. This pool is insidious because it does not appear hot, yet any animal or person that would mistakenly fall into this pool is certain to die. This fact has probably resulted in the alternate name Seven Devils.

Other temperature measurements indicate maximum temperatures are about 73°C (Ficklin et al., 1986), although Hague and Emmons (1877, p. 705) reported that the hottest springs and pools are 71-85°C, and there was a great variation of temperatures within a short distance. The area consists of a low mound of travertine covering about 5 hectares which is built up to a height of at least 20 m above the plain. Ten to twelve circular hot-spring pools from 2 to 20 m in diameter are reported; however, Nosker (1981) reported eight springs, with only three active

In November 1997, the source temperature of the largest pool could not be safely measured but the discharge temperature is roughly 45°C. The hottest spring, located about 20 m northwest of the largest pool behind heavy brush, is only 1 m in diameter but has a discharge temperature of 73°C and a flow of 4 L/min. This spring also discharges free gas, whereas none of the others do. Total discharge of the entire group is approximately 200 L/min. The travertine is locally colored bright orange from co-deposited Fe-oxides.

Sou Hot Spring water contains relatively low values of $SiO_2$, As, B, Br, and Li, and Cl content is only 80 ppm. The waters do not resemble Dixie Valley Production Field fluids, but display an oxygen-18 shift of about 0.5. Tritium analysis from the hottest site suggests a minimum age 110 y (Shevenell and Goff, 1995). The gas contains 52 mol-% $CO_2$, 46 mol-% $N_2$, and 0.8 mol-% $CH_4$; $H_2S$ and $H_2$ contents are <0.02 and <0.005 mol-%, respectively. Chemical geothermometers indicate subsurface temperatures of ~85°C (Goff et al., 2002; Tables 8 and 12). Mariner et al. (1974) estimate that the minimum thermal-reservoir temperatures may be in the 100-114°C range; Reed et al. (1983, p. 107) report the most likely reservoir temperature to be 78°C.

Leasing information: Dixie Valley North, a former Sierra Geothermal Power property, reverted to RAM Power during SGP’s acquisition by RAM in 2010. The 14,170 acre project is located south of Sou Hot Springs.

The 11,418 acre McCoy Property, leased by Magma Energy, is in advanced development stages. Magma received a $5m DOE grant at McCoy to include geophysics, soil gas, and angled TG holes. In the late 1970’s, AMAX performed geophysical, geochemical, and geological surveys, and drilled 52 shallow temperature gradient holes. Well temperatures reached 102°C and temperature gradients ranged up to 522°C per kilometer. AMAX estimated the area within the 200°C isotherm to be more than 30,000 acres.

**Southernmost Dixie Valley**

***Elevenmile Canyon:*** In a group of 33 temperature-gradient drill holes drilled near the southern end of Dixie Valley, two 610 m holes have bottom-hole temperatures of 77.7-81.7ºC (Richards and Blackwell, 2002; GeothermEx, 2004). Location: 39.42ºN, 118.24ºW.

***Hatton Ranch:*** A number of flowing wells 10-15 km south of Dixie Hot Springs (T21N, R34E and R35) have slightly anomalous temperatures of 21-24.4°C. These may be part of a larger thermal system within western Dixie Valley.

***Pirouette Mountain:*** Hunt Energy Co. drilled temperature-gradient and slim drill holes in an area near the south end of Dixie Valley (SMU data). Anomalous subsurface temperatures are found in an area about 8.8 km north-south by 5.6 km east-west. Temperatures as high as 87.2ºC at 610 m are reported. Data from this well taken together with adjacent wells suggest approximately isothermal conditions of 76.7-87.8ºC at 150-600 m (GeothermEx, 2004). Location: 39.51ºN, 118.16ºW.

Leasing information: N/A

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