Site Description

Hot Springs Mountains

(updated 2012)

Geologic setting: Geothermal production wells at Bradys are 300 to 1800 m deep, in permeable Tertiary volcanics (Oligocene? and Miocene pyroclastic rocks). Temperatures up to 210°C have been reported in the low-permeability footwall of the Bradys Fault (Robertson-Tait and Lovekin, 2000). All successful steam wells were collared in the Bradys Fault hanging wall (Anctil and others, 1960), a steeply dipping, north-northeast-striking fault with down-to-the-northwest normal displacement (Olmsted and others, 1975). Left lateral strike-slip offset is also possible, as the fault appears continuous with a possible drag fold ~7 km to the northeast (Stewart and Perkins, 1999). The stratigraphic displacement (throw) on the fault is believed to be about 150 m (Benoit and others, 1982, p. 8), and northwest-striking cross faults and hanging-wall faults may control fluid flow parallel to the Bradys fault. The fault underwent recent movement: it cuts spring sinter and the alluvial fan deposits in the spring area and just north. Rocks exposed near Bradys consist of Tertiary basalt and andesite, Tertiary sedimentary rocks, Pleistocene lake sediments, and Quaternary alluvial deposits and siliceous sinter (figure and figure). The geology of the area is further discussed by Faulds and others (2002).

At Desert Peak, Tertiary volcanic and sedimentary rocks are present to ~1000 m depth (Benoit and others, 1982; Faulder and Johnson, 1987), and they overlie a basement of Mesozoic metavolcanic, metasedimentary, and plutonic rocks whose complex relationships are poorly understood. The reservoir is 900-1000 m deep and fracturing, particularly in greenstones, is believed to be a major control on porosity and permeability (Faulder and Johnson, 1987). Three geothermal wells drilled in 1974-1976 encountered Mesozoic metavolcanic and metasedimentary rocks at depths of 915 to 1372 m, below a sequence of Miocene volcanic rocks (cross section). Wells 21-1 and 21-2 produce a mixture of steam and water from fractured meta-andesite. Tertiary volcanic rocks may act as a seal for the reservoir. The geology of surface rocks, however, has not been helpful in predicting the subsurface geology.

Geothermal features:

Bradys Hot Springs (Map)

Hot springs along Highway I-80, 32 km northeast of Fernley, have been referred to as Hot Springs, or Bradys, Springers, Nightingale or Fernley Hot Springs, and are the Emigrant Springs of the Forty-

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Mile Desert (NE¼ NE¼ SW¼ Sec. 12, T22N, R26E). Bradys is the currently-accepted name of the area. Early travelers called it the Spring of False Hope: oxen of the wagon trains could smell moisture before reaching the springs, but found the water scalding. Emigrants collected water in casks to cool, but pushed on to the Truckee River, as there was no forage at the springs (Work Projects Administration, 1940).

Russell (1885) reported that boiling water issued from Bradys Hot Springs orifices, and when these became obstructed steam escaped with a hissing and roaring sound. In later years, hot water was used in a bathhouse and pool (the concrete pool, built in 1929, is all that remains today). Today, the hot springs do not flow, though abundant steam vents can be seen on cool mornings from the highway.

Thermal groundwater is centered on Bradys Hot Springs, extending NE-SW over an area 15.5 to 20.5 km^2 (figure). The elongate thermal area parallels the Bradys Thermal Fault mapped by Anctil and others (1960). Hydrothermal alteration is aligned along this fault, and the trace is outlined by areas of observed snowmelt, indicating warm ground (Olmsted and others, 1975, fig. 37). Soil gas in the vicinity of Bradys Fault has anomalous mercury (John Robbins, Scintrex Limited, written commun., 1973). Bailey and Phoenix (1944, p. 51) reported cinnabar and sulfur in Sec. 6(?), T22N, R27E about 0.4 km southeast of Highway I-80, 0.8 km east of the hot springs. The best showings of cinnabar are reported in hydrothermally-altered tuff near an active spring vent. The spring sinter at Bradys is predominantly opal, and is quite extensive. Sinter concentrates along Bradys Fault and a small subsidiary fault to the east (Oesterling and Anctil, 1962).

Twelve geothermal wells were drilled at Bradys prior to 1979, ranging from 104 to 2218 m deep, and approaching 214°C (Koenig, 1971). Following the 1959 drilling of Magma Power Co. Brady No. 2 well, thermal activity spread along 5-km of the Bradys Fault. Fumaroles developed as cooler, near-surface groundwater was withdrawn to deeper areas of hotter rock (Olmsted and others, 1975). A similar line of fumaroles developed after a well blow-out in 1978; these are observed today along the Brady Fault. At present all discharge is subsurface (Harrill, 1970) due to production-related drawdown. Groundwater discharge is partly evapo-transpiration and partly lateral subsurface outflow to the south. Boiling water reportedly stands 6 m below the surface in one well (Willden and Speed, 1974, p. 55).

Prior to drilling in the late 1950s and early 1960s, White estimated a spring flow of ~78 L/min (White, written commun., 1974, in Olmsted and others, 1975) and Waring (1965), 190 L/min. Olmsted and others (1975) describe the 1959 drilling activity based on a 1960 unpublished report by Allen. Well tests indicated 77,000 to 317,000 kg/hr of fluid shortly after drilling, with a well head pressure of 0.6 to 1.3 kg/cm^2 gage (psig) (Middleton, undated report). The steam flashover was

reported to be 5% (Koenig, 1971). Calcite formed rapidly in the well bores during flow, requiring reaming after a short time. However, scaling decreased once wells produced for some time (Oesterling, 1962). The thermal water at Bradys is of sodium chloride type, with total dissolved solids exceeding 2400 ppm in some steam wells. The silica concentration at C Sec. 12, T22N, R26E (Harrill, 1970) indicates a reservoir temperature of about 182°C (Olmsted and others, 1975). This seems somewhat low in view of a 204°C down-hole temperature (Welch and Preissler, 1986).

Leasing information: Following exploration drilling in the 1980s, the Bradys double flash plant came on-line in 1992, producing 21 MW from a 186°C resource. Bradys recently added a 5-MW binary Ormat Energy Conversion unit (OEC) with pentane as the working fluid. Plant construction began in May 2002 and was completed in August 2002. The plant was purchased by ORMAT Nevada, Inc. in July 2001(GeothermEx, 2004).

In 1977, Geothermal Food Processors, Inc. of Reno, Nevada received a $2,836,800 federally guaranteed loan to construct a geothermal food dehydration plant at Bradys, which is still operational today.

Desert Peak (Map)

The Desert Peak geothermal prospect is located in the northern Hot Springs Mountains ~6.4 km southeast of Bradys Hot Springs, and is named for a prominent peak 3-5 km northwest of the steam wells. Phillips Petroleum Co. discovered anomalous temperatures, centered on Secs. 21,29, T22N, R27E (map), from ~50 temperature gradient holes. Their drilling began at the Bradys geothermal area, north of Desert Peak (Benoit and Butler, 1983).

Desert Peak has no surface thermal indications, other than minor occurrences of opal-cemented sand and travertine, probably from springs that are now inactive. The reservoir is believed to have a temperature of 208°C, and the production fluid is a sodium chloride type containing ~7500 ppm total dissolved solids.

Leasing information: Following exploration drilling in the 1970s and early 1980s, the Western States Geothermal Co. Desert Peak double flash power plant came on line in 1985, producing 9.9 MW from a 205°C resource. The two production wells are located east-northeast of the power plant. The plant was purchased by ORMAT Nevada, Inc. in July 2001. An area to the east of the present plant and production wells is being evaluated for the feasibility of creating an artificial geothermal

reservoir development as an Enhanced Geothermal System (Carlson and others, 2004; Robertson-Tait and Morris, 2003; Robertson-Tait and Lovekin, 2000; Robertson-Tait and Johnson, 2005).

As of 2006, Ormat Nevada, Inc. has constructed a new 23-MW binary power plant near the old 9.9-MW dual flash geothermal power plant at Desert Peak. The original geothermal power plant at Desert Peak came online in 1985 and was decommissioned in May 2006. Power generated from this project will be sold to Nevada Power Co.

The DOE awarded ORMAT ~$3.8m in late 2009 to increase power at its Desert Peak power plant through EGS stimulation of Well 15-12. This well was drilled for production, but was non-commercial based on poor permeability; hopes are that favorable geologic units can be stimulated to increase permeability.

Desert Queen (Map)

A pilot study was conducted in the Desert Queen geothermal area east of Desert Peak (T22-T23N, R28E), where a 1974 temperature gradient hole identified a thermal aquifer at ~70 m depth. A survey conducted in October and November of 2006 identified a strong 2m-deep temperature anomaly near the temperature gradient hole. Peak temperatures reached 43^{o} C against a background of less than 23^{o}C (Coolbaugh and others, 2007).

Leasing information: The property, leased by Magma Energy, consists of 10,935 acres of both BLM and private land. Phillips Petroleum drilled 12 TG and eight stratigraphic holes in the Desert Queen area. One of these holes reached a temperature of 101°C at a bottom depth of 425 meters. The property got back on exploration radar when the Great Basin Center ran a pilot study for their shallow (2m) temperature survey method, which delineated an interesting surface thermal anomaly. Magma is planning a 13 TG well program and estimates a 36 MW inferred resource at the property.

Eagle Salt Works

Temperature-gradient data (Benoit and others, 1982; Olmsted and others, 1986) indicates cold groundwater near the abandoned Eagle Salt Works. Three salt wells in NW¼ NE¼ NE¼ Section 35, T22N, R23E have temperatures of 16.3–18.6°C (Mark Coolbaugh, written commun., 2003). Benoit and others (1982, table 5) reported a 15.6 ºC temperature for one of these, and high NaCl.

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One cold-water sample yielded estimated reservoir temperatures of 148ºC (Na-K-Ca geothermometer) and 137ºC (quartz geothermometer) (R.H., Mariner, unpubl. data, 1983). Benoit and others (1982) suggested that groundwater reflects discharge from the Desert Peak thermal aquifer, located northeast. Wood-cribbed salt wells (NW¼ NE¼ NE¼ Sec. 35) were full-to-overflowing in 2005; the present flow may be influenced by injection of spent geothermal fluid from Bradys power plant. Shallow (ca. 275 m) injection wells, located about 1.8 km to the northeast, began injecting a portion of the Bradys spent fluid in early 2000 (Krieger and Sponsler, 2002).

A NE-SW lineation of 5+ playa seeps begins ~2.5 km southwest of Eagle Salt Works, in the Fortymile Desert. Surface temperatures are cold, at 13.2^{o}C and 13.3^{o}C for two sites sampled in July 2007, but geothermometer values are high, at 107 ± 2°C (Na-K-Ca) and 110 ± 2°C (quartz). The seeps range from 6 x 12m to 15 x 15m area, with cattails and bullbrush surrounding the seepage zone.

Adams (1944) reported a hot spring at Eagle Salt Works in northeastern Fortymile Desert. No location data were reported, but Garside and Schilling (1979) assumed the spring to be near Eagle Rock (Sec. 35, T22N, R26E). We now suggest, however, that Adams analyzed Bradys Hot Springs. The water analysis is similar to those reported for Bradys Hot Springs 6 km northeast, and considerably lower in NaCl than later analyses of Eagle Salt Works springs (e.g., Harrill, 1976, table 9). Adams (1944) only reported on hot springs from 21 well-known Nevada geothermal areas, and Bradys, although well known at the time, was not one of them.

Leasing information: N/A

Bibliography: