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Title of Paper Geology of MacFarlane's Spring Thermal Area, Nevada

Author(s) and Affiliation(s) Bruce S. Sibbett, Jon Zeisloft (both Earth Science Lab, UURI), and Roger L. Bowers, Hunt Energy Corporation.

Name of Speaker Bruce Sibbett and Jon Zeisloft (Poster Session)

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Name of person to receive all correspondence in connection with this Paper:

Name Bruce S. Sibbett

Address Earth Science Laboratory/UURI, 420 Chipeta Way, Suite 120, Salt Lake City, UT 84108

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ABSTRACT

MacFarlane's Spring in northwestern Nevada is located near a recently active normal fault which has about 400 m of Quaternary offset. Tertiary basalt flows and tuffaceous sedimentary rocks near the spring have been faulted and tilted 22 to 40° to the east during the Tertiary. The 77°C water flows from a 4 m high and 180 m long travertine mound. Associated eroded travertine veins which cut Lake Lahontan deposits and wave-rounded travertine clasts indicate the hot spring has been active for thousands of years. Geothermometer calculations suggest a maximum reservoir temperature of less than 140°C.

INTRODUCTION

MacFarlane's Spring is located 94 km west of Winnemucca, Nevada, on the east edge of the Black Rock Desert (Fig. 1). The geology of the area around the hot springs and extending to the Jackson Mountains, 10 km to the east, was mapped to determine structures and lithologies which control the thermal system. Water samples were collected and analyzed to determine water chemistry and to calculate the reservoir temperature.

REGIONAL GEOLOGY

MacFarlane's Spring is located in the northwestern Basin and Range province, west of the Jackson Mountains which consist of Permian mafic volcanic and associated clastic rocks (the Happy Creek Volcanic Series), Mesozoic clastic and carbonate rocks, and Cretaceous to Tertiary intrusives (Willden, 1963). The Black Rock Desert is a large basin filled with Quaternary alluvium and Lake Lahontan sediments. About 3 km^2 of Tertiary basalt and tuffaceous sedimentary rocks are exposed 1 km southeast of the hot springs (Fig. 2). These Tertiary rocks are 5 km west of the Jackson Mountains.

LITHOLOGIES

Coarsely porphyritic basalt and andesite lava flows (Tba) in part vesicular to scoriaceous are exposed on the ridge 1 km south east of the hot spring. The flows maintain very uniform thickness of 3 to 6 meters. A stratigraphic thickness of at least 366 m is exposed on the ridge. These flows dip to the east 22-40 degrees and strike N10W to due N. If a 30 degree dip is assumed for the 550 m of volcanic rock penetrated in borehole 3452 (Table 1), this would indicate a stratigraphic thickness of 475 m. Lensoid voids in the basalt flows and flow breccias are filled with coarsely crystalline, yellow-brown calcite.

Tertiary bentonitic claystone, tuffaceous siltstone, sandstone and conglomerate (Tt) overlie the basalt flows east of the hot spring (Fig. 2). The unit consists of three sediment types. The basal one third is a pale olive to pale yellow-brown bentonitic claystone. The middle third of the unit contains thin beds of tuffaceous siltstone and claystone with a few 1/2 to 2 m thick beds of coquina near the top. These beds seem to represent a shallow lacustrine environment. The upper third of the exposure consists of interbedded siltstone and sandstone exhibiting festoon crossbedding and conglomerate lenses. This portion of the deposit may have formed in a shallow near-shore lacustrine to fluvial environment.

This sequence of sedimentary rocks has been dated as late-middle Miocene to early Pliocene by diatoms collected from the south end of the Jackson Mountains (Willden, 1963). A coquina bed exposed in the study area contains mollusk shells similar to *Goniobasis taylori* (Dall, 1924), *Pisidium leslieae* and *Goniobesis leslieae* (Firby, 1967), all of which are late Miocene to early Pliocene. On the basis of comparable age and lithology the unit is correlated with the Truckee Formation (Morrison, 1964). The Tertiary rocks are overlain with angular unconformity by a Quaternary Lake Lahontan strand line and bar deposits of sand and gravel, and deep water sand, silt and clay.

STRUCTURE

Normal faults trending N10E to N20W form a small graben in the ridge east of the hot spring (Fig. 1). Truckee Formation beds have been warped into an asymmetrical syncline within the graben which has a stratigraphic throw of at least 305 m on the east side. The continuation of the east side fault to the south trends N10E and has offset the Tba-Tt contact 335 m down to the west. Tertiary tilting of the range to the east 22 to 40 degrees has overturned the west boundary fault of the graben (Fig. 3).

A recent fault scarp which curves along a general northeast trend cuts Lake Lahontan deposits and alluvium 1 km west of MacFarlane's Spring and another fault scarp extends from 500 m northeast of the hot spring to north of the study area (Fig. 2). Judging from the extent of scarp degradation, 1 m of vertical offset may have occurred as recently as several hundred to a thousand years ago. A dip of 56 degrees to the west with striations indicating dip slip movement was measured on a segment of the fault west of the hot spring. Greater offset occurring during late Pleistocene is indicated by over 6 m of offset of an algal tufa horizon in the lake beds 2.4 km northeast of the hot spring.

MacFarlane's Spring is located near a bend in the recently active fault where the fault trace turns from a N34°E trend to a westerly trend (Fig. 2). Most of the travertine veins parallel the westerly trending fault segment. Thermal gradient hole lithology logs (holes 3409, 3408 and 3446, Table 1) suggest a covered extension of the north-easterly trending portion of the fault continues to the south of the hot spring, offsetting the top of the basalt flows about 400 m down to the west (Fig. 3).

HOT SPRING DEPOSITS

MacFarlane's Spring thermal system has deposited a series of east-west trending travertine veins, which are dipping 80 degrees north to vertical. The present spring produces water of 77°C (170°F) at an estimated rate of several gallons per minute and issues from a central fissure atop the west end of a 4 m high, 180 m long travertine mound. The travertine veins cut lake sediments. The presence of wave-rounded travertine clasts indicate the hot springs were active during Lake Lahontan time. The orifice (1/3 m in diamter) of the hot spring is presently choked with loose calcite pisolites which appear to be forming as a result of agitation of the water by the rapid effervescence of the spring water. The gases escaping from the water have only a slight sulfurous odor and are thought to be largely carbon dioxide. On older, smaller veins, erosion has revealed several vertical funnel-shaped or cylindrical bodies of cemented pisolites, very similar in overall geometry to the present spring orifice. These pisolite occurrences provide evidence of genetic relationship between the older inactive travertine bodies and the currently active one. That, plus the presence of wave-rounded travertine clasts, indicates that the MacFarlane hot spring system has been active for a long period of time, well into the Lake Lahontan period (15-60 thousand years ago according to Morrison, 1964).

GEOCHEMISTRY

A water sample collected from the hot springs was analyzed to enable calculation of a reservoir temperature. The thermal waters are sodium-bicarbonate-chloride type and contain 3650 TDS. Results of Na-K-Ca and quartz mixing geothermometers are in close agreement yielding a maximum temperature of about 140°C. The Na/K, quartz and chalcedony geothermometers suggest a reservoir temperature in the range of 80 to 120°C.

CONCLUSION

The location of MacFarlane's Spring appears to be controlled by a flexure or split in a northeast trending normal fault that has at least 400 m of Quaternary offset and a meter of offset in the last thousand years. The thermal anomaly is centered near borehole 3408 (Swanberg, this issue) which is near the projected intersection of northeast trending Quaternary fault and the northwest-trending Tertiary graben.

The thermal system was active during Lake Lahontan time which was about 15-60 thousand years ago (Morrison, 1964). Geothermometer calculations indicate subsurface temperatures of 80 to 140°C. The structure and temperature data suggest deep circulation along Quaternary faults for the origin and control of the thermal waters. The Jackson Mountains to the east provide the most likely recharge area. Subsurface runoff from these mountains probably flows to great depth along the range front fault then rises as thermal waters to the west at MacFarlane's Spring.

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Table 1. Depth to the basalt flows (Tba) in thermal gradient holes.

Drill Hole #	T.D.(m)	Depth to the Top of Basalt
3408	152	(not reached)
3409	610	454
3414	610	(not reached)
3415	122	(not reached)
3446	150	15
3447	150	85
3452	585	38

Source: Hunt Energy Corporation