GL02734-3

June 3, 1983

MEMORANDUM

TO: Duncan Foley, ESL/UURI

FROM: Bruce Sibbett, ESL/UURI

SUBJECT: Geothermal Potential and Exploration at Mountain Home AFB, Idaho.

The potential for a low to moderate (approx. 90°C) hydrothermal resource under Mountain Home AFB appears very good. This conclusion is based on a considerable volume of data only part of which will be cited here. Mountain Home AFB (here after referred to a MHAFB) is located in about the center of the western Snake River Plain which has a high heat flow of about 1.7 HFU (Brott et al., 1978) and is shown as an area favorable for discovery of geothermal water (Muffler, 1978, and Mitchell et al., 1980). Geothermal Resource Areas and KGRA's are present a few miles to the east, south and west (Mountain Home, Northern Owyhee and Castle Creek respectively) of the MHAFB (Mitchell et al., 1980). Further, shallow warm water wells are present on the base (Hyde and Whelan, 1977).

Detailed geothermal and deep subsurface data are available for the Mountain Home and Bruneau-Grand View areas (which includes the Castle Creek and Owyhee area).

Resource Temperature and Gradient

Measured water temperatures at the surface for producing irrigation wells are as high as 83°C in the Bruneau-Grand View area (Young and Whitehead, 1975) a few miles south of MHAFB. Most of the wells are flowing (artesian) and discharge rates of several hundred to a few thousand gallons per minute are typical (Young et al., 1979). Geochemical thermometry results are variable for the area and have a wide range but 100°C or less appears most reasonable and recent estimates by workers in the area are about 90°C for a reservoir temperature (Don R. Mabey, personal communications). A maximum temperature of 149°C at 11,125 ft. (3391 m) was reported for the Anschutz Federal No. 1 but this is rather deep for a direct-use resource and the temperature may not be reliable (Don R. Mabey, personal communications).

The Mountain Home KGRA is 23 km (14 mi.) east of MHAFB. Measured temperatures are as high as 77°C at the well head (2268 ft. deep well), and water geochemistry indicated that reservoir temperatures are 100°C or less (Arney and Goff, 1982). Many of the wells are artesian and flow rates of hundreds to thousands gpm are reported.

A high thermal gradient of 280°C/km is reported for shallow wells in the Mountain Home KGRA but a deep well (Bostic 1A) has a linear gradient of 70°C/km (Arney and Goff, 1982). Young and Whitehead (1975) derived a gradient of 65.6°C/km (2°C/100') for the Bruneau-Grand View area. For wells deeper than 2000 feet in the Bruneau-Grand View area, there is a reasonable correlation between depth and temperature suggesting the system is conductive rather than convective and the thermal system is regional rather than confined to special structures.

Depth to Resource and Production Rates

Based on a thermal gradient of 65 to 70°C/km (approx. 2°C/100') and assuming the Banbury Basalt or associated sedimentary rocks will be the thermal aquifer under MHAFB, thermal waters of 90°C may be encountered as shallow as 4100 ft. The top of the Banbury Basalt was encountered at about 4100 ft. in the Bostic 1-A, 20 mi east of MHAFB, and a porous zone was encountered at 4750 to 4850 ft. in the Anschutz Federal No. 1, about 20 mi.

west of MHAFB (Arney and Goff, 1982; McIntyre, 1979). Structural interpretations of the western Snake River Plain (Mabey, 1976; Brott et al., 1978; Young and Whitehead, 1975) and the geologic map (Malde et al., 1963) suggest a graben or structural down warp trending northwest underlies the plain and MHAFB is more central on the structural low than either the Bostic or Anschutz holes. It is therefore possible that the desired thermal aquifer will be at a greater depth below MHAFB and a production target depth of 4100 to 6000 ft. should be planned to ensure temperature and flow. Also the thermal reservoir in the Bruneau-Grand View area is considered to be the Idavada volcanics (Young and Whitehead, 1975; Young and Lewis, 1980) which are stratigraphically several thousand feet lower than the Branbury Basalt.

Discharge rates of hundreds to thousands of gallons per minute from flowing wells are common for both the Bruneau-Grand View and Mountain Home areas (it is unclear if these rates are achieved with or without pumping) but Young and Lewis (1980) report that the potentiometric surface (artesian head) is several hundred feet above land surface near the Snake River for deeper aquifers. McIntyre (1979) reports thick porous zones in the Anschutz hole, based on log data, at depths of 2300, 2600, 3300, 4800. Thermal wells to the southwest and east of MHAFB produce from a variety of volcanic and sedimentary rock aquifers.

Lithology and Structure Under MHAFB

A detailed stratigraphy for adjacent areas have been reported Young and Whitehead (1975) and Arney and Goff (1982), and lithologies encountered in the deep holes west and east of the air base described by McIntyre (1979) and Arney and Goff (1982) respectively. In both areas Quaternary to late Tertiary basalts and interbedded gravels, sand, shale, sandstone overlay Tertiary silicic volcanics consisting of mostly welded ash-flow tuffs with a few basalt and silicic lava flows, which overlay Cretaceous granitic rocks. The Tertiary-Quarternary section is 10,000 ft. or more thick. To the west and south of the base the silicic volcanic rocks make up most of the stratigraphic section (McIntyre, 1979), but to the east sedimentary rocks with lesser basalt flows form the upper 8000 ft. above the silicic volcanic rocks. To determine which section might be more representative of rocks under MHAFB the Anschutz well, Sec. 13, T. 55, R. 1E., and the Bostic well, Sec. 26, T. 45, R. 8E., were plotted along with the air base on the regional maps of magnetic intensity (Young and Whitehead, 1975) and gravity (Mabey et al., 1974). MHAFB is on the northwest trending gravity high which coincides with the Snake River Plain and the two deep holes are well down the flanks of the high, at about equal gravity intensity on opposite sides of the high. Hill (1963) interpreted the gravity high as produced by a thick section of basalt flows overlying a basalt-filled fissure zone. Basalt filled fissures do not fit with the eruptive mechanism of Snake River Basalts which is eruption from shield volcanic centers. Also strong north west alignment of vents is not evident on the geologic map (Malde et al., 1963). Mabey (1976) interprets the gravity high as due to thinning of the upper crust with raising of the top of the more dense lower crust. A thinned upper crust also forms a deep basin with thick high-density basaltic rocks in the lower part, but with low density silicic volcanic and sedimentary rocks above. This setting with a thick sedimentary and silicic volcanic rocks filling a deep graben over the thinned or absent upper crust fits with Brott and others (1978) interpretation of the tectonic implications of heat flow in the western Snake River Plain.

On an Aeromagnetic map MHAFB plots within an east-west magnetic low along with the sedimentary rock dominated Bostic well (Young and Whitehead, 1975).

The Anschutz well, however, is located on a northwest trending magnetic high which would fit with the thick volcanic rock section having a higher magnetic susceptibility than the sedimentary rocks. This comparison and the general indication on the geologic map (Malde et al., 1963) that a thick section of gravel and other clastic sedimentary rocks dip north along the Snake River suggest that a thick section of sedimentary rocks can be expected in the upper few thousand feet below the few hundred feet of basalt flows which cap the plain under the air base.

Exploration Plan

It is evident from the forgoing discussion that regional thermal systems which seem to have stratigraphic rather than fault controlled reservoirs are present on three sides of MHAFB. Extending the thermal system under the base has not been done in the past due to lack of data rather than negative data.

Comprehensive geochemical studies have been carried out in the region (Arney and Goff, 1982; Young and Whitehead, 1975; Young et al., 1979; Young and Lewis, 1980). The total dissolved solids are generally low (a few hundred milligrams per liter) and the reservoir temperature is about 90°C (possible near 100°C). No further geochemical studies are needed before drilling. Detailed gravity, telluric and passive seismic surveys were conducted in the Mountain Home KGRA (Arney and Goff, 1982). None of these methods showed significant anomalies which could be of use to site a geothermal test well. Broad resistivity lows in the Bruneau-Grand View area parallel the Snake River and its paleo-channels, the saturated fine sediments of which could explain the resistivity lows. Further, because the expected depth of the thermal system a dipole-dipole resistivity survey would probably not yield useful data (Claron Mackelprang, personal communications). No geophysical survey is therefore recommended.

A limited review of the available literature to design the thermal gradient drilling program and better formulate the reservoir model should be carried out. Also because all the available geothermal and deep stratigraphic data is peripheral to MHAFB and the geologic map is small scale and not-detailed, a visit to the base and nearby exposures should be made by a geologist prior to siting thermal gradient holes. Study of aerial photos and a field reconnaissance of exposures is necessary to check the conclusions reached based on the regional literature. Structures and lithologies exposed near the air base may greatly affect the siting and design of the thermal gradient holes.

Two or preferably three thermal gradient holes, each about 2200 feet deep, are recommended to determine if a thermal system is present under MHAFB. In addition to demonstrating a favorable thermal gradient, the slim holes will furnish valuable data on subsurface lithologies. Such data will be needed to interpret temperature gradient and design the drilling program for the reservoir test well if conditions are favorable for an economic resource. Temperature variation for water wells shallower than 2000 feet, particularly in the Bruneau-Grand View area (Young and Whitehead, 1975), indicate that thermal gradient holes should be 2000 feet or deeper to ensure reaching below near surface cold water aquifer affects.

Two or more gradient holes are needed to indicate that any thermal gradient observed in one is not a special condition of local extent. Also budgeting for two or three holes is insurance against drilling difficulties causing the loss of one hole and all the subsurface data needed.

Summary and Conclusions

The character of known thermal systems to the east, south and west of

MHAFB indicate that regional, stratigraphically controlled, low to moderate temperature hydrothermal systems are present in the area and may extend under the air base. Producing wells (up to 83°C) and geochemistry indicate a 90°C resource, or possible a little warmer, can be expected. The thermal waters contain only a few hundred mg/lit TDS and generally don't form scale. A production depth of 4100 to 6000 ft. (1250-1829 m) appears likely. Production rates of several hundred to over a thousand gallons per minute can be expected and it will probably be a flowing well.

The exploration program should start with a brief review of the most recent geoscience literature on the region, followed by aerial photo and ground reconnaissance checks to site three intermediate depth thermal gradient holes. The thermal gradient holes should be a little over 2000 feet deep (about 2200') to ensure reaching below affects of near surface cold water aquifers. Water samples for geochemistry will be collected from these holes if possible.

Bruce S. Sibbett

Bruce S. Sibbett

BSS/hmb

cc: Jack Ramsthaler

REFERENCES CITED

Arney, B.H., and Goff, F., 1982, Evaluation of the hot dry rock geothermal potential of an area near Mountain Home, Idaho: Los Alamos Nat. Lab., LA-9365-HDR, Site Selection Rept. No. 6, 65 p.

Brott, C.A., Blackwell, D.D., and Mitchell, J.C., 1978, Tectonic implications of the heat flow of the western Snake River Plain, Idaho: Geol. Soc. Bull., v. 89, p. 1697-1707.

Hill, D.P., 1963, Gravity and crustal structure in the western Snake River Plain, Idaho: Jour. Geoph. Res., v. 68, p. 5807-5819.

Hyde, J. and Whelan, J.A., 1977(?), Geothermal potential of Mountain Home Air Force Base and Saylor Creek Air Force Range, Final Report: China Lake Naval Station Report, unpublished, 17 p.

Mabey, D.R., 1976, Interpretation of a gravity profile across the western Snake River Plain, Idaho: Geology, v. 4, p. 53-55.

Mabey, D.R., Peterson, D.L., and Wilson, C.W., 1974, Preliminary gravity map of southern Idaho: U.S. Geol. Survey, OFR 74-78.

Malde, H.E., Powers, H.A., and Marshall, C.H., 1963, Reconnaissance geologic map of west-central Snake River Plain, Idaho: U.S. Geol. Survey, Misc. Geol. Inves., Map I-373.

McIntyre, D.H., 1979, Preliminary description of Anschutz Federal No. 1 drillhole, Owyhee County, Idaho: U.S. Geol. Survey, OFR-79-651, 15 p.

Mitchell, J.C., Johnson, L.L., and Anderson, J.E., 1980, Geothermal investigations in Idaho, Part 9: Idaho Depart. Water Res. Inf. Bull. 30.

Muffler, L.J.P., ed., 1979, Assessment of geothermal resources of the United State--1978: U.S. Geol. Survey, Cir. 790, 163 p.

Young, H.W. and Lewis, R.E., 1980, Hydrology and geochemistry of thermal ground water in southwestern Idaho and north-central Nevada: U.S. Geol. Survey, OFR 80-2043, 40 p.

Young, H.W., Lewis, R.E., and Backsen, R.L., 1979, Thermal ground-water discharge and associated convective heat flux, Bruneau-Grand View area, southwest Idaho: U.S. Geol. Survey, OFR 79-62, 17 p.

Young, H.W. and Whitehead, R.L., 1975, Geothermal investigations in Idaho, Part 2, An evaluation of thermal water in the Bruneau-Grand View area, southwest Idaho: ID Dept. Water Res., Water Inf. Bull. No. 30, 124 p.