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Geothermal Resources and Conflicting Concerns in the Alvord Valley, Oregon: An Update

by Charles E. Wassinger and Douglas M. Koza

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CONTENTS

ILLUSTRATIONS

TABLE

CONVERSION FACTORS

English units are used in this report. For readers who prefer metric units, the conversion factors for the terms used herein are listed below:

Multiply English unit	By	To obtain metric unit
Inches (in.)	2.540	Centimeters (cm)
Feet (ft)	0.305	Meters (m)
Miles (mi)	1.609	Kilometers (km)
Acres	0.405	Hectares (ha)
Cubic Miles (mi^3)	4.168	Cubic Kilometers (km^3)
Parts/million (ppm)	1.000	Milligrams/liter (mg/l)
Degrees Fahrenheit (°F)	0.555(°F-32)	Degrees Celsius (°C)
Degrees Fahrenheit/foot (°F/ft)	1.818	Degrees Celsius/meter (°C/m)

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(Note: This paper was first presented at the 1979 Annual Meeting of the Geothermal Resources Council. It has been updated and expanded to include a geologic map and a complete geologic bibliography.)

ABSTRACT

The geothermal resource potential of the Alvord Valley is among the highest in Oregon. However, environmental concerns, litigation, and administrative requirements have delayed exploration for and development of this resource. Present estimates indicate that deep exploratory drilling may not take place on Federal lands in the Alvord Valley until 1982.

INTRODUCTION

The Alvord Valley, located in southeastern Oregon, contains numerous hot springs. Based on these surface expressions and other geologic information, a large portion of the basin has been classified as a Known Geothermal Resources Area (KGRA) by the U.S. Geological Survey (USGS). Since the early 1970's, both private industry and Federal and State agencies have conducted extensive geochemical and geophysical exploration throughout the valley. This exploration indicates that the Alvord Valley is one of the most promising geothermal energy prospects in Oregon. However, environmental groups have expressed concern over the effect of geothermal development on recreational and natural resource values in the valley and have brought the matter to litigation. Most of the area is subject to review for wilderness characteristics by the U.S. Bureau of Land Management (BLM). The U.S. National Park Service (NPS) has proposed a Desert Trail through the valley. A summary of the geothermal resource, conflicts with environmental concerns, and a complete geologic bibliography are presented.

GEOLOGIC SETTING

The Alvord Valley lies within the Great Basin section of the Basin and Range Physiographic Province. The region is characterized by north-south trending, fault-block mountain ranges separated by broad, downfaulted basins. The Pueblo Mountains and Steens Mountain border the valley on the west, forming a westward-tilted fault block. The eastern escarpment of this block rises precipitously from the valley floor as much as 5500 feet, to a maximum elevation of 9670 feet. Flanking the valley on the east, the Trout Creek Mountains form a much more subdued topographic boundary that rises roughly 3700 feet above the valley bottom.

The mountain ranges are composed of Tertiary volcanic rocks underlain by older metamorphic rocks and silicic intrusives (fig. 1). The pre-Tertiary rocks include Paleozoic metavolcanics and metasediments that have been

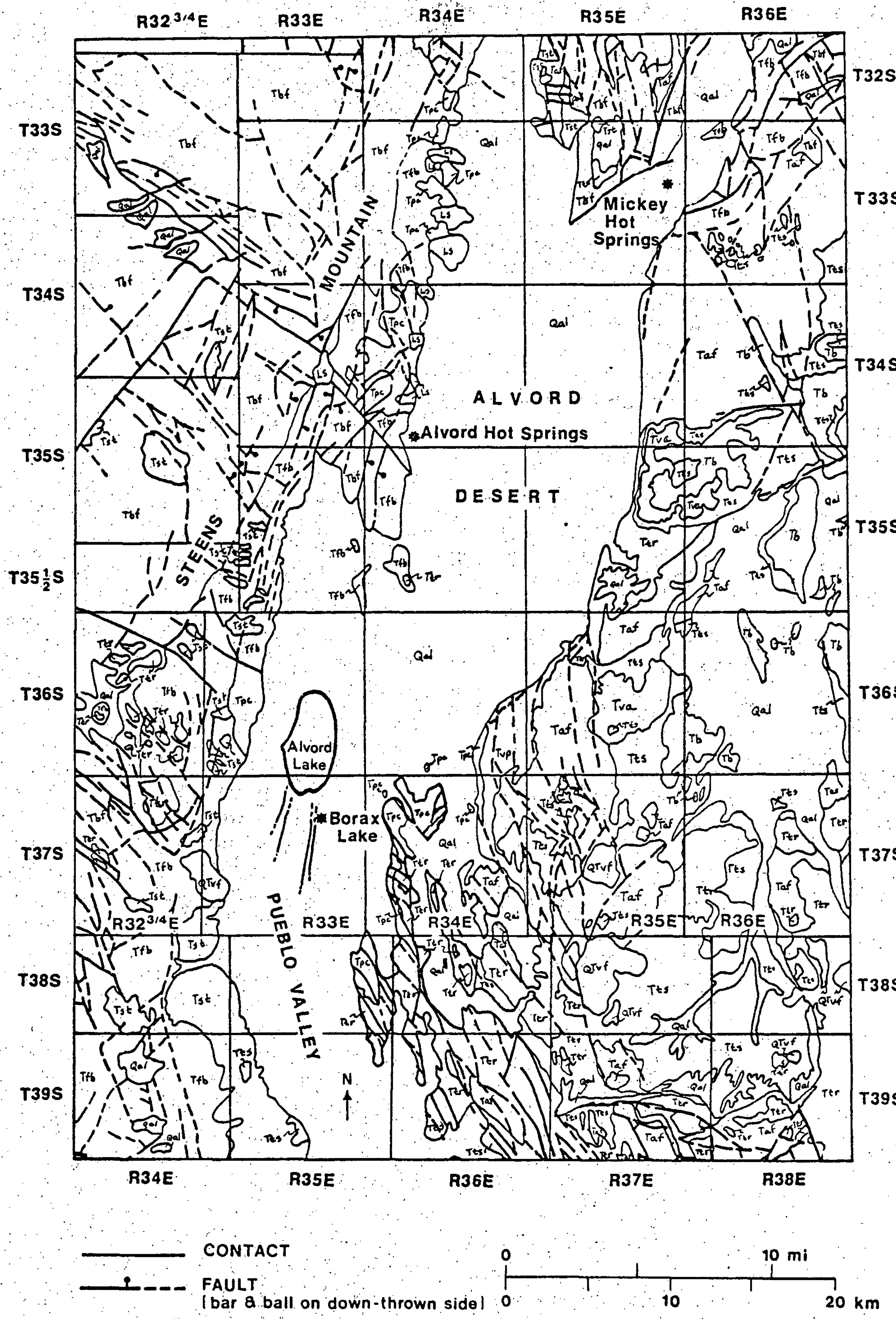

Figure 1. -- Geology (after Walker and Repenning, 1965).

Table 1.--Description of geologic map units(modified from Walker and Repenning,1965)

Quaternary and Tertiary	Qal	Includes Recent playa deposits; Pleistocene through Recent alluvium; Pliocene-Pleistocene lacustrine, fluviatile, and aeolian sedimentary rocks; and Pleistocene pediment of fluvio-glacial gravels (included are Walker and Repenning's (1965) Qp, Qal, QTs, and QTg).
	Ls	Pliocene through Recent landslide deposits. Mostly unstratified mixtures of basaltic and tuffaceous sedimentary bedrock.
	QTvf	Mostly large complex exogenous domes and related flows and flow breccias of rhyodacitic composition. Includes small vent areas composed largely of breccia and coarse, highly altered, welded tuff.
Tertiary	Tst	Semiconsolidated lacustrine tuffaceous sandstone and siltstone, ash and ashy diatomite, conglomerate and minor fanglomerate, boulder-bearing slope wash, vitric-crystal and vitric-lithic tuff, pumice lapilli tuff, and tuff breccia.
	Tb	Basalt flows.
	Tts	Mostly fine-grained tuffaceous sedimentary rocks and tuffs representing flood plain and shallow lake deposits.
	Ttr	Partly to densely welded tuffs and areally restricted rhyolite or dacite flows.
	Tfb	Basalt and andesite flows and flow breccias that are variable in texture and mineral composition.
	Taf	Mostly platy andesite flows but contains some flows of porphyritic olivine basalt, basaltic and andesitic flow breccias, and minor amounts of interbedded tuffaceous sedimentary rocks and tuff.
	Tbf	Massive basalt flows and minor interbeds of tuff and scoria.
	Tpc	Pike Creek Formation. Mostly well lithified and altered silicic tuffaceous sedimentary rocks, but including some tuffs and tuff breccias and intrusive and extrusive masses of rhyolite.
	Tva	Flows of platy andesite, basaltic andesite, and glassy black or gray dacite or rhyodacite (position within Tertiary uncertain).
	Tvp	Tuffaceous sedimentary rocks and tuffs (position within Tertiary uncertain).

intruded by Jurassic quartz diorite and monzonite (Libbey, 1960). These rocks are overlain by Tertiary volcanic units totaling approximately 8000 feet in thickness (Williams and Compton, 1953): silicic tuffs and tuffaceous sedimentary rocks; rhyolite, andesite, and dacite flows; and olivine and augite basalts. Mafic dikes that trend parallel to the Pueblo-Steens escarpment cut the volcanics along the lower east flank to the mountain front (Williams and Compton, 1953).

The Alvord Valley is composed of unconsolidated alluvial material, primarily alluvial fan gravels and lacustrine deposits which presumably overlie bedrock similar to that occurring in the mountain ranges. This alluvium has been divided into two distinct units. The older unit consists of compacted, faulted and deformed alluvial fan gravels that dip to the west (Libbey, 1960). The younger alluvium consists of east-dipping alluvial fan gravels and flat-lying lacustrine sediments deposited in Pleistocene and younger lakes (Libbey, 1960). Magnetic profiles taken across the basin suggest a thickness for the valley fill of only 1312 to 1641 feet near the center of the basin (Griscom and Conradi, 1975).

Structurally, the Alvord region is typical of the Basin and Range province. The westward-tilted Pueblo-Steens block forms the western limb of a broad arch, the central portion of which dropped down to form the Alvord graben (Williams and Compton, 1953). The east flank of the mountains is cut by numerous discontinuous north-northeast-trending normal faults (Walker and Repenning, 1965). Major northwest-trending transverse faults transect the Pueblo-Steens Mountain block and are the dominant structural feature in the Trout Creek Mountains (Williams and Compton, 1953). Pleistocene and younger faulting is evidenced by the occurrence of a 10-foot-high fault scarp in recent alluvium north of Mickey Hot Springs (Richard Benoit, Phillips Petroleum Co., written commun., 1979) and by the periodic rejuvenation of Bone and Stone Creeks west of Alvord Lake. Many small scarplets with displacements of 3 to 20 feet occur in this area. These faults delineate a zone of crustal instability where the two most prominent transverse faults of the region intersect the mountain/basin boundary fault system (Williams and Compton, 1953).

GEOTHERMAL RESOURCES

The existence of several hot springs within the Alvord valley (fig. 1) indicates a relatively high geothermal potential. The surface temperature of these springs ranges from 97 °F at Borax Lake (also known as Hot Lake) to 206 °F at Mickey Hot Springs (Bowen and Peterson, 1970). The entire area has been identified as "prospectively valuable" for geothermal resources by the USGS, and 176,835 acres have been classified as a KGRA (fig. 2). This is the largest KGRA identified in Oregon.

Since 1974, BLM and USGS have issued 29 permits for

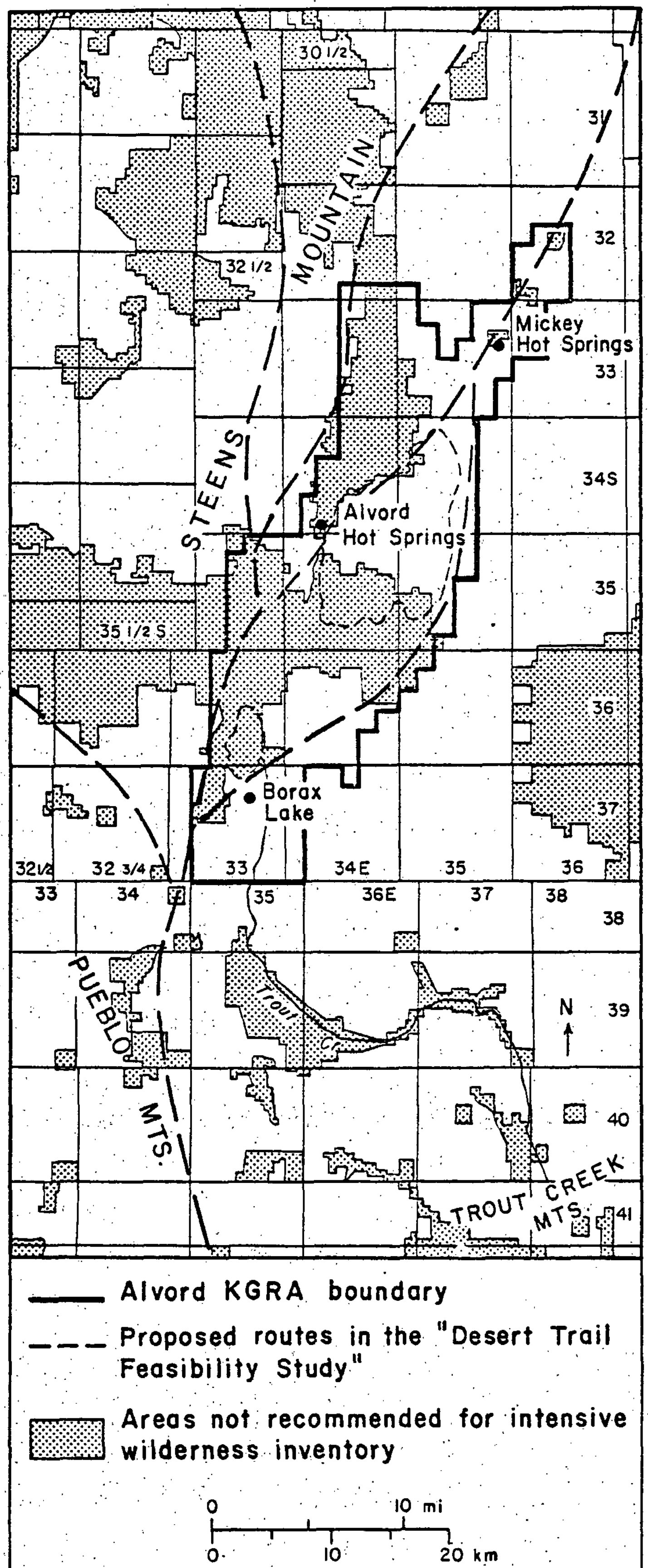

Figure 2.--Conflicts.

geophysical and temperature gradient hole drilling on Federal lands in the basin. Under these permits 82 temperature gradient holes have been drilled. In addition, an unknown number of gradient holes have been drilled on private lands within the valley during the past 9 years. However, no deep exploratory wells have yet been drilled anywhere in the valley. Twelve competitive and 17 noncompetitive Federal geothermal leases are currently in effect in the Alvord valley.

The average geothermal gradient associated with the Basin and Range in southeastern Oregon is 0.0503°F/ft (Blackwell and others, 1978), which compares with a world average of 0.0165°F/ft (Bowen and others, 1977). Within the Alvord Valley, the gradient is locally variable but in the range of 0.044°F/ft to 0.055°F/ft in the sediments (Sass and Munroe, 1973). In the basalts of the Pueblo Mountains, the geothermal gradient has been measured at 0.033°F/ft (Sass and Munroe, 1973). Water chemistry analyses of hot spring samples collected by Mariner and others (1974) show that the water is a mixed anion type with variable bicarbonate, sulfate, and chloride. These springs are among the most saline in Oregon (Oregon Department of Geology and Mineral Industries, 1979), containing up to 2980 ppm total dissolved solids. These springs also contain unusually high concentrations of lithium, boron, and fluoride (Mariner and others, 1974). Cleary (1976) suggests that the boron has probably been leached from basement volcanic rocks. Sulfur isotopic values for waters from 5 springs in the Alvord Valley show that there is apparently no magmatic component in the waters (Cleary, 1976). Cleary indicates that the sulfate is probably leached from playa evaporite deposits. Both Mariner and Cleary agree that the thermal waters in the Alvord Valley are most likely of the mixed-water type.

Positive magnetic and gravity anomalies (Griscom and Conradi, 1975) and negative resistivity anomalies (Long and Gregory, 1975) are associated with the known hot spring areas. Griscom and Conradi (1975) suggest that small gravity highs superimposed on regional gravity gradient may be the result of SiO_2-$CaCO_3$ cementation of alluvium in the near surface. In every case, the anomalies are directly associated with faults in the alluvium containing thermal waters. In most cases, the geothermal fluids appear to ascend to the surface at the junction of transverse faults and basin faults that trend parallel to the boundary faults. Cleary (1976) suggests that these thermal waters originate in the mountains as meteoric waters, percolate to depth along transverse faults in the mountains, circulate at depth through a zone of high-temperature gradient, and return to the surface along basin faults. The three main centers of geothermal fluid discharge---Mickey Hot Springs, Alvord Hot Springs, and Borax Lake--are estimated to have mean reservoir temperatures of 401°F, 358°F, and 376°F, respectively (Muffler and others, 1979). Muffler and others (1979) suggest that the volumes of the reservoirs associated with Mickey, Alvord, and Borax Lake Hot Springs are 3.07 mi^3 ($\pm$1.61 mi^3), 1.20 mi^3 ($\pm$0.50 mi^3), and 1.99 mi^3 ($\pm$0.84 mi^3) respectively.

LEGAL AND ENVIRONMENTAL CONFLICTS

SIERRA CLUB LAWSUIT - On May 21, 1975, the Sierra Club filed suit (Sierra Club, et al. v. Hathaway, et al., Civ. 75-489) in the U.S. District Court for the State of Oregon, seeking a temporary injunction to stop geothermal leasing by the BLM in the Alvord area. The Sierra Club charged that the Environmental Analysis Record prepared by BLM was inadequate and requested that an Environmental Impact Statement be prepared prior to leasing. The injunction was denied by Judge James M. Burns, subject to the submission by BLM and the USGS of a monthly report of geothermal exploration activities within the Alvord KGRA. A motion for reconsideration was filed and denied on September 15, 1975. That decision was then appealed to the U.S. 9th Circuit Court of Appeals which ruled that the decision to deny a temporary injunction against leasing was correct. The case was then remanded to Judge Burns for disposition. In a hearing held in December 1979, the Federal government made a motion that the case be dismissed or brought to trial immediately. The Sierra Club was given approximately 30 days to decide to go to trial or allow dismissal. On January 21, 1980, Judge Burns dismissed the case.

GETTY AND UNION APPEAL TO IBLA - The Oregon State Office of BLM held three separate lease sales in the Alvord KGRA during May and June of 1975. A total of 44 lease units were offered, of which 20 units received bids. Unit #43 was withdrawn prior to the sale due to possible cultural resource conflicts. USGS recommended that BLM reject the high bids on units 4, 5, and 6 in the Mickey Hot Springs area and units 35, 40, and 41 in the Borax Lake area as being "insufficient in dollar amount." Phillips Petroleum Company, Union Oil Company, and Getty Oil Company were the high bidders on these units. Getty and Union protested the rejection to the Oregon State Office of BLM. That office dismissed the protests, and each company then appealed the decision to the Interior Board of Land Appeals (IBLA). The Getty and Union appeals were decided on October 26, 1976 (27 IBLA 269), and on December 29, 1978 (38 IBLA 373), respectively. Both IBLA decisions upheld the BLM rejection of bids on the following points: (1) the decision to lease geothermal resources is discretionary with the Secretary of the Interior, and (2) the companies did not show that the decision by BLM was arbitrary or capricious. The burden of proof rested with the companies to show that the USGS had no rational basis for recommending that BLM reject the high bids. The USGS recently released the evaluation report on which the recommendation was based (Firek, 1979). A reoffer of these and other lease units was held on January 8, 1980, but due to an administrative error by BLM in prematurely opening some of the lease bids, 7 units were withdrawn. A lease sale for the withdrawn units and units not receiving bids will be held on April 29, 1980.

ALVORD WILDERNESS INVENTORY - The Federal Land Policy and Management Act of 1976 (FLPMA) required that BLM review roadless areas of at least 5,000 acres for their wilderness potential. This review process is to be completed in three phases: inventory, study, and submission of a report to Congress.

On April 6, 1979, a proposed decision was announced by the Oregon State Office of BLM identifying those inventory units not having wilderness characteristics. In late August 1979, a final decision was made by the BLM State Director on areas excluded from further wilderness review.

Units not eliminated in the initial inventory are being intensively inventoried. These inventories are scheduled to be completed by September 1980. A few units which include pending land exchanges will be given priority. However, only one such unit (#2-74) is in the area of known geothermal interest in the Alvord KGRA and includes Borax Lake. The final determination as to whether or not they should be designated Wilderness Study Areas (WSAs) could be completed on these units in 1980. Those designated as WSAs will then be analyzed using the BLM land-use planning system. Criteria for selection are taken from Section 2(c) of the Wilderness Act of 1964. Those units that are suitable or not suitable for designation as wilderness may be recommended to the President as early as 1982, but no later than October 1991.

BLM recently published the FINAL "Interim Management Policy and Guidelines for Wilderness Study Areas" (December 12, 1979), which applies to all BLM lands which have not been eliminated from inventory until September 30, 1980, and thereafter applies to WSAs. The guidelines set two criteria for deciding whether or not an activity will be allowed in a WSA. In the case of geothermal resources, if a Federal lease existed on October 21, 1976 (the effective date of FLPMA), activities can continue as before. However, if a Federal lease or permit was issued after that date, the activity can be permitted only if it "can take place without impairing the suitability of the area for preservation as wilderness." These criteria do not preclude leasing of Federal lands in potential WSAs. However, any leasing would be subject to a wilderness protection stipulation, contained in the Interim Guidelines, that provides for limited exploration activity only; power plant development is specifically excluded. Unlike the Rare II Wilderness Studies prepared by the U.S. Forest Service, the restrictions applying to WSAs can be removed only by action of Congress.

In the Alvord KGRA and surrounding area, most of the Federal lands and approximately one-third of the Federal acreage now under lease are within the areas to be intensively inventoried. The existing leases (with the exception of those leases issued as a result of the January 8, 1980, reoffer) predate the October 21, 1976, deadline. In the spring of 1980, the BLM Oregon State Office will announce a proposed decision on inventory units which should be designated as WSAs. The areas around Mickey Hot Springs and Borax Lake are within intensive inventory units.

THE DESERT NATIONAL SCENIC TRAIL (P.L. 94-527, October 1976) - The National Park Service is preparing a "Desert National Scenic Trail Feasibility Study" with recommendations to go to Congress in 1980. As proposed the Desert Trail will pass through parts of Idaho, Washington, Oregon, Nevada, California, and Arizona. Four routes have been proposed in the Alvord area (fig. 2), from which one will be selected. Two of the proposed routes are west of the Alvord KGRA, one route passes Borax Lake, and one route passes both Borax Lake and Mickey Hot Springs.

If the Desert Trail is approved by Congress, geothermal exploration and development could be significantly curtailed; activities that harm the scenic, historic, natural, or cultural qualities of the Trail will not be allowed. Which activities will and will not be allowed will be decided on a case-by-case basis.

ENVIRONMENTAL STUDIES OF INTEREST - The Department of Fisheries and Wildlife, Oregon State University, is preparing a report for the U.S. Fish and Wildlife Service to develop options for protection of the Borax Lake Habitat. This area of approximately 160 acres of privately owned land is a unique biological habitat. The "Alvord Chub," a rare and endangered species of fish, found in and around Borax Lake, is the subject of a doctoral thesis by Jack Williams at Oregon State University.

Other studies include: (1) a "Preliminary Ecological Survey of Alvord Basin" by Eastern Oregon State College (1976), funded by the National Science Foundation (includes botany, mammals, herpetology, ornithology, entomology, algology, and water chemistry), (2) "A Survey of Bat Population and Their Habitat Preferences in Southern Oregon" by Southern Oregon College, Ashland, (3) the "Malheur Basin, Steens Mountain Prehistory Project" by University of Washington (covers the archeological and paleonotological environment), and (4) the "Population Characteristics and Habitat Utilization of Bighorn Sheep, Steens Mountain, Oregon" by Walter Von Dyke (this master's thesis was completed May 8, 1978, at Oregon State University).

CONCLUSIONS

Exploration has shown that the geothermal potential of the Alvord Valley is among the highest in Oregon. Because of legal, environmental, and other resource conflicts, no deep exploratory wells have yet been drilled in the area to prove this resource. Initiation of more extensive exploration on Federal lands in the Alvord Valley may be delayed until 1982 or later.

ACKNOWLEDGMENTS

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