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MC COY AREA, NEVADA
Geothermal Reservoir Assessment Case History
Northern Basin and Range

ANNUAL REPORT

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DIVISION OF ENERGY TECHNOLOGY

Under Contract DE AC 08-79 ET 27010

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ABSTRACT

The McCoy geothermal prospect is located at the junction of the Augusta Mountains, Clan Alpine Mountains and the New Pass Range. The prospect was discovered in 1977, and in 1978 was made a part of the Geothermal Reservoir Assessment Case Study Program of the Department of Energy under contract DE-AC 08-79 ET 27010.

Geothermal exploration done during 1981 included additional hydrogeochemical studies and some additional geologic mapping in the southern part of the area. Geophysical work consisted of a dipole-dipole resistivity survey and continued interpretation and analysis of previous data. Exploration drilling included ten shallow thermal gradient holes and two intermediate depth exploration holes. A third hole was started and drilled to a depth of 403 feet and surface casing was run and cemented.

A shallow low-temperature geothermal reservoir was encountered in Permo-Pennsylvanian rocks north of McCoy Mine. The analysis of the exploration continued in an attempt to determine the source area for the thermal fluids.

INTRODUCTION

The McCoy geothermal prospect was discovered in 1977 during reconnaissance coverage of Nevada. The prospect was identified by thermal gradient measurements of existing holes and hydrogeochemical analysis of well water from the McCoy Mine water well. The prospect is located approximately 72 kilometers northwest of Austin, Nevada (Figure 1) and can be reached by means of a graded road which leads from U. S. Highway 50.

The McCoy prospect is located at the confluence of the Augusta and Clan Alpine Mountains and the New Pass Range. The prospect straddles the Churchill and Lander County borders.

In 1978 AMAX submitted a proposal in response to the Department of Energy's RFP No. ET-78-R-08-003, Geothermal Reservoir Assessment Case Study, Northern Basin and Range and was awarded a contract providing partial funding for exploration at the property. Detailed results of the work funded through the DOE will be published by the DOE through the University of Utah Research Institute (UURI) under DOE contract DE-AC 08-79 ET 27010.

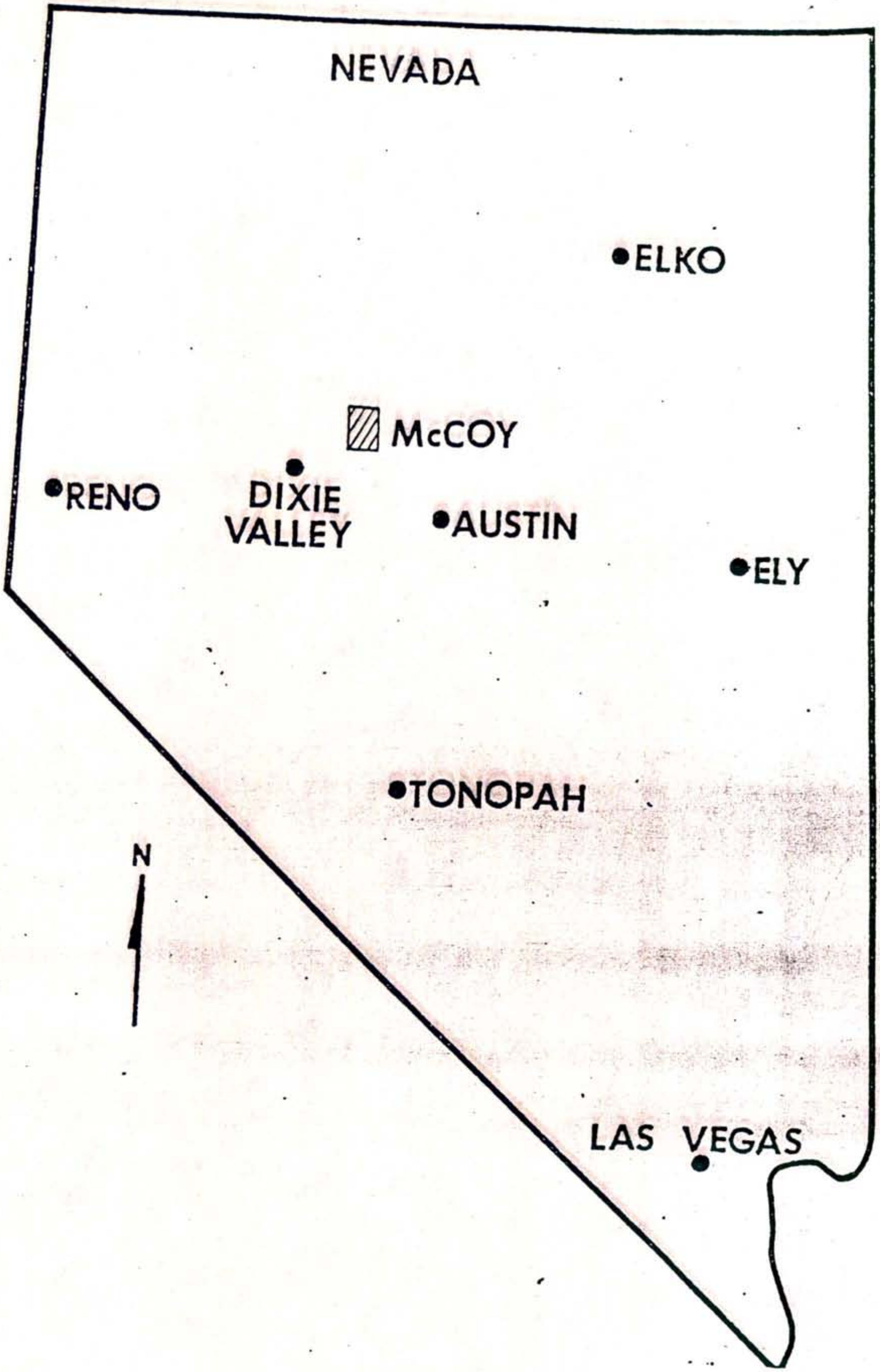


Figure 1. Location map for the McCoy geothermal project.

EXPLORATION HISTORY

The geothermal exploration partially funded under DOE contract DE AC08-79 ET 27010 was an integrated approach including geological, geochemical and geophysical studies as well as exploration drilling. For the purpose of this report the exploration will be discussed under exploration methods rather than a chronological description.

GEOLOGICAL STUDIES

The McCoy geothermal prospect is located at the junction of the Augusta Mountains, the Clan Alpine Mountains and the New Pass range. The area is underlain by Tertiary volcanics and associated sediments, Triassic sediments and Permo-Pennsylvanian eugeosynclinal sediments as shown on the county maps (Stewart, J. H. and McKee, E. H., 1977 and Wilden, R. and Speed, R. L., 1974). The county geologic maps are at a scale of 1:250,000 and, therefore, do not show much detail.

In the late fall of 1979 Joe Moore of the University of Utah Research Institute began a geologic mapping program under DOE contract DEAC 07 - 80 ID 12079. Joe Moore and Eric Struhsacker established the mapping units in the Tertiary volcanics and then Mike Adams of UURI did most of the field mapping in 1980. A detailed geologic map at a scale of 1:24,000 was completed (Fig. 2) in 1980 (Pilkington, 1981). During 1981 the geologic mapping was extended to the south in order to establish a better understanding of the relationship between the Tertiary, Traissic and Permo-Pennsylvanian rocks.

The oldest rocks mapped in the McCoy area are the cherts, volcanics, siltstones, sandstones and minor limestones of the Havallah sequence of Permo-Pennsylvanian age.

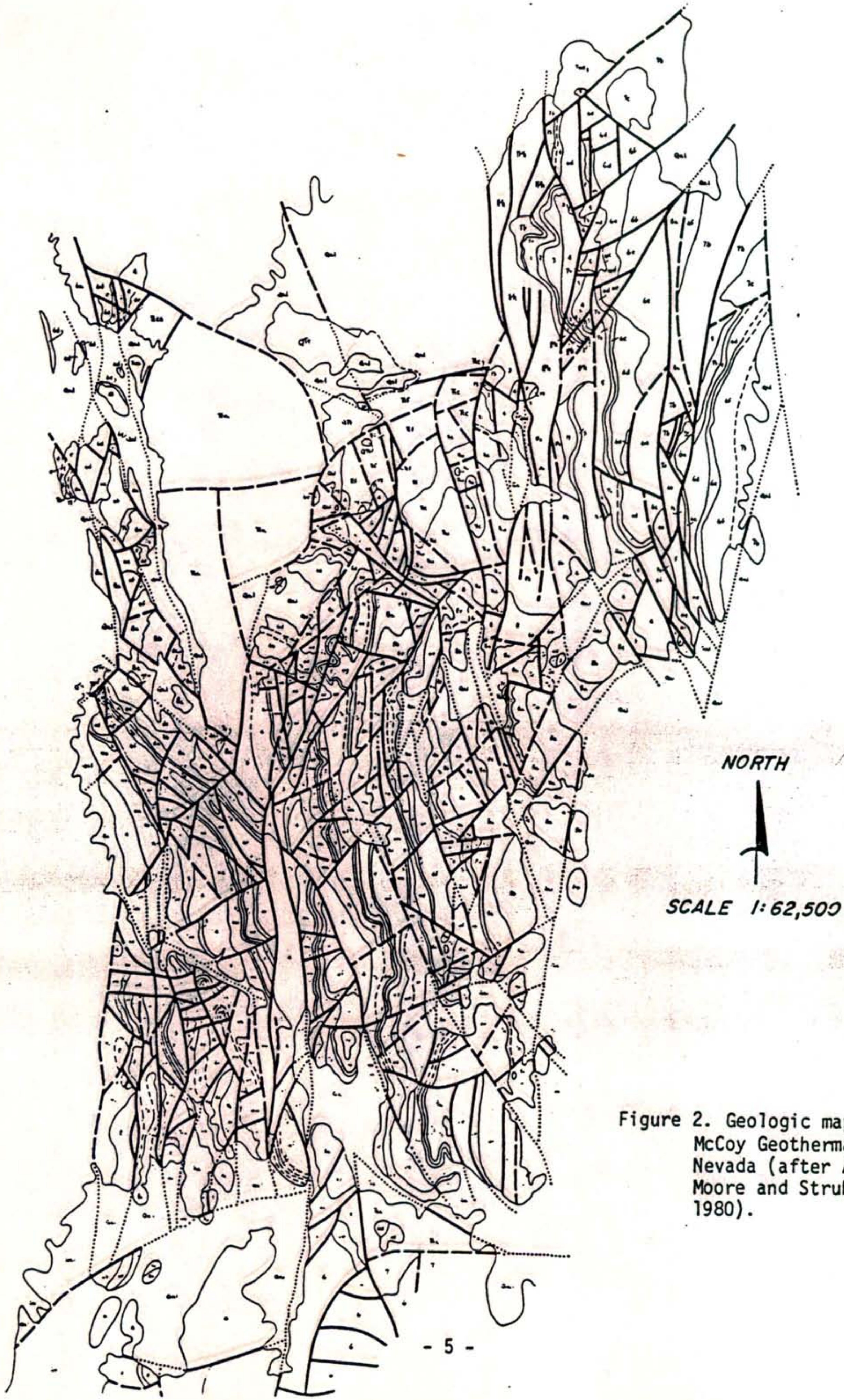
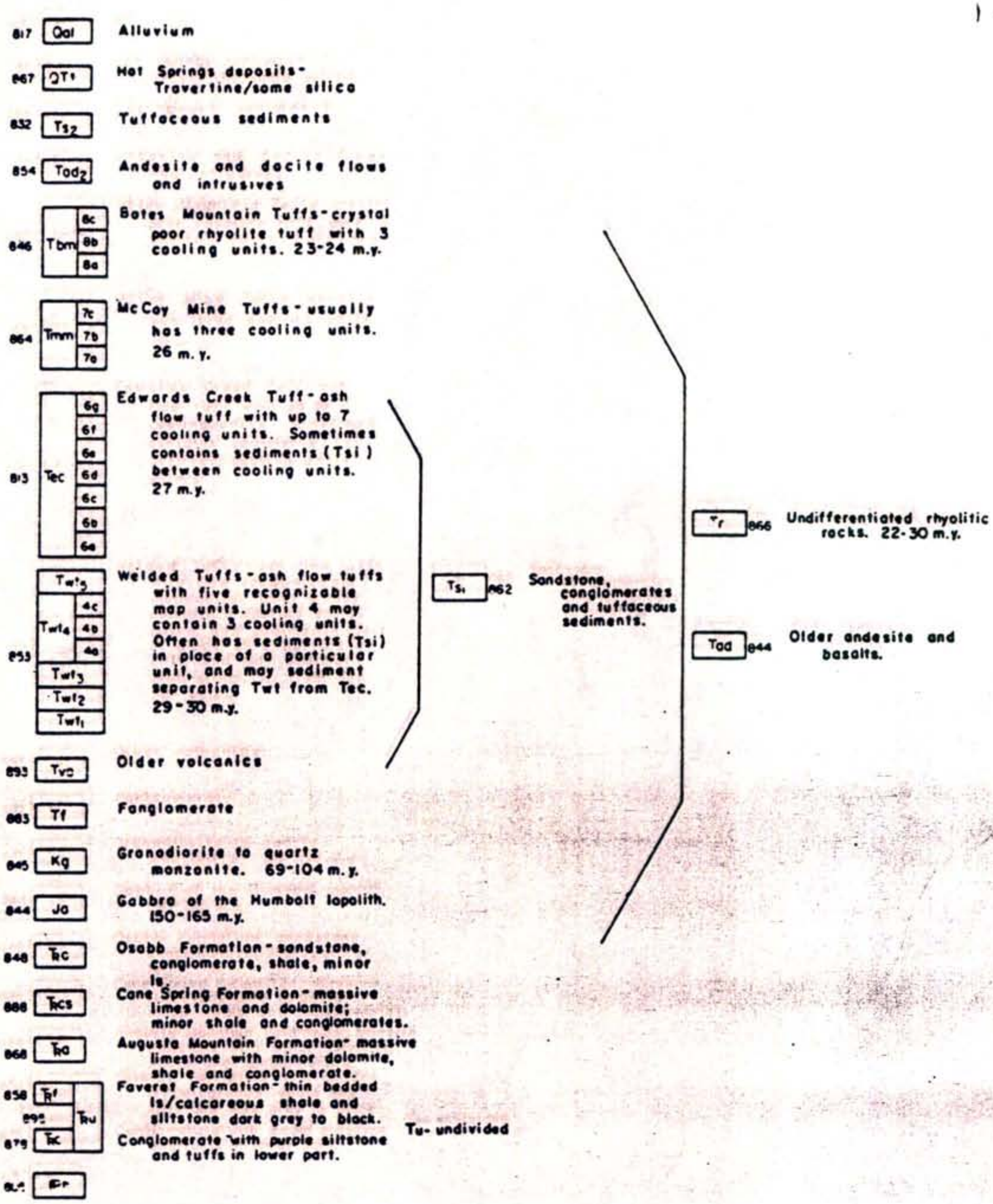


Figure 2. Geologic map of the McCoy Geothermal Prospec Nevada (after Adams, Moore and Struhsaker, 1980).


817 Qal Alluvium
867 QTt Hot Springs deposits- Travertine/some silica
832 Ts2 Tuffaceous sediments
854 Tad2 Andesite and dacite flows and intrusives
846 Tbm 8c 8b 8a Bates Mountain Tuffs-crystal poor rhyolite tuff with 3 cooling units. 23-24 m.y.
864 Tmm 7c 7b 7a McCoy Mine Tuffs-usually has three cooling units. 26 m.y.
813 Tec 6g 6f 6e 6d 6c 6b 6a Edwards Creek Tuff-ash flow tuff with up to 7 cooling units. Sometimes contains sediments (Tsi) between cooling units. 27 m.y.
853 Twt5 Twt4 4c 4b 4a Twt3 Twt2 Twt1 Welded Tuffs-ash flow tuffs with five recognizable map units. Unit 4 may contain 3 cooling units. Often has sediments (Tsi) in place of a particular unit, and may sediment separating Twt from Tec. 29-30 m.y.
893 Tvo Older volcanics
883 Tf Fanglomerate
845 Kg Granodiorite to quartz monzonite. 69-104 m.y.
844 Jo Gabbro of the Humbolt lopolith. 150-165 m.y.
848 TRc Osobb Formation-sandstone, conglomerate, shale, minor ls.
888 TRcs Cone Spring Formation-massive limestone and dolomite; minor shale and conglomerates.
868 TRa Augusta Mountain Formation-massive limestone with minor dolomite, shale and conglomerate.
858 TRf Favoret Formation-thin bedded ls/calcareous shale and siltstone dark grey to black.
895 TRu
879 TRc Conglomerate with purple siltstone and tuffs in lower part.
Tu- undivided
Ts1 862 Sandstone, conglomerates and tuffaceous sediments.
Tr 866 Undifferentiated rhyolitic rocks. 22-30 m.y.
Tad 844 Older andesite and basalts.

The rocks were deformed, uplifted and deeply eroded prior to the deposition of the basal Triassic sediments which consist of conglomerates, siltstones, sandstones and minor tuff. The basal member is overlain by several hundred feet of dominantly carbonate sediments of the Favret Formation, the Augusta Mountain Formation and the Cone Springs Formation. The uppermost Triassic unit is the detrital sediments of the Osobb Formation.

The Tertiary volcanic rocks in the McCoy area (Fig. 2) range in age from about 36 m.y. to 15 m.y. (McKee and Stewart, 1971). Sedimentary rocks are found at various horizons within the volcanic units. A considerable thickness of sediments overlie the volcanic rocks to the northwest of the McCoy Mine area. West of the McCoy Mine over $2km^2$ of fossil Quaternary travertine is exposed. The travertine lies unconformably upon the eroded Triassic rocks. The travertine dips gently westward and is only slightly dissected.

Tectonically the area has had a long and complex history. The detailed mapping permitted the construction of detailed geologic cross section (Fig. 3). Reasonable approximations of the fault offsets could be made using the displacement of cooling units on Mike Adams geologic map.

Geochemical Studies

The hydrogeochemical analysis of a water sample from the McCoy Mine water well was one of the manifestations which attracted AMAX to the area. During the exploration drilling in 1980 water was encountered in well 66-8. Table I compares the chemical analyses of the various water samples collected to date.

Table I. Chemical Analyses of McCoy Area Waters

	W10981 McCoy HW Sec.9T20NR40E	W13453 Well 66-8, 1630' NWSE8T22NR40E	W13454 Well 66-8, 2050' NWSE8T22NR20E	W13456 Well 66-8,2410' NWSE8T22NR40E
Temp°C	39	±100	--	--
Flow (gpm)	-	25	--	--
pH	7.05	9.4	9.1	9.0
Cl	22.0	38.0	31.0	31.0
F	4.4	5.6	3.0	4.1
SO_4	54.0	100.0	100.0	80.0
HCO_3	611.6	144.0	142.0	204.0
CO_3	0.0	72.0	24.0	20.0
SiO_2	44.0	120.0	75.0	62.0
Na	260.0	160.0	98.0	110.0
K	15.0	21.0	14.0	14.0
Ca	43.0	6.6	9.6	6.0
Mg	9.0	2.6	16.0	18.0
Li	0.3	0.7	0.4	0.5
B	1.3	--	-	-
NH_3	0.74	--	-	-
TDS	1065.3	670.0	513.0	550.0
Tq SiO_2	98	148	120	112
Tc SiO_2	66	122	94	83
T Na-K	174	242	250	239
T Na-K-Ca	153	206	197	197

Table I. Continued

	W14377 Gilbert Spr. SE34T21NR40E	W14378 Spring NE2T20NR40E	W14379 Spring NWSW9T22NR38E	W14380 Shoshone Spring SE2T22NR38E
Temp°C	10	17	18	25
Flow (gpm)	12.0	25.0	2.0	1.0
pH				
Cl				
F				
SO_4				
HCO_3				
CO_3				
SiO_2	15.0	20.0	37.0	38.0
Na	22.0	17.0	170.0	130.0
K	0.6	0.9	3.3	1.8
Ca	43.0	37.0	4.0	3.0
Mg	7.0	7.0	1.0	1.0
Li				
B				
Ec(K)				
TDS				
Tq SiO_2	53	63	88	89
Tc SiO_2	21	31	57	59
T Na-K	126	168	108	91
T Na-K-Ca	-2	6	116	87

Table I. Continued

	W14381 Spring SWSW18T21NR39E	W14382 Smooth Canyon Spr. NW10T21NR38E	W14383 Spring SE16T25NR38E	W14384 Spring NW1T25NR39E
Temp°C	14	15	14	15
Flow (gpm)	5.0	--	20	1.0
pH				
Cl				
F				
SO_4				
HCO_3				
CO_3				
SiO_2	91.0	38.0	15.0	23.0
Na	52.0	88.0	57.0	170.0
K	8.4	4.5	3.0	24.0
Ca	35.0	62.0	190.0	82.0
Mg	2.0	12.0	71.0	58.0
Li				
B				
Ec(K)				
TDS				
Tq SiO_2	132	89	53	69
Tc SiO_2	105	59	21	37
T Na-K	262	166	168	248
T Na-K-Ca	74	49	17	187

Table I. Continued

	W14385 Thompson WW Sec10T25NR41E	W14386 Hess Spr. Sec29T26NR41E	W14387 Red Butte WW SE26T25NR41E	W14750 Shoshone Pass WW NW32T22NR39E
Temp°C	10	15	10	26.5
Flow (gpm)	500.0	2.0	1000	65.0
pH				7.6
Cl				31.0
F				1.1
SO_4				98.0
HCO_3				206.0
CO_3				0.0
SiO_2	35.0	51.0	69.0	85.0
Na	39.0	62.0	59.0	77.0
K	2.6	2.6	9.8	18.0
Ca	19.0	40.0	33.0	40.0
Mg	5.0	7.0	3.0	10.0
Li				0.1
B				0.4
Ec(K)				689.0
TDS				566.6
Tq SiO_2	86	103	117	128
Tc SiO_2	55	73	89	101
T Na-K	185	152	265	302
T Na-K-Ca	48	39	81	208

Table I. Continued

	W14991 Hole-in-Wall SENE2T23NR39E	W14992 McCoy Mine WW Sec9T20NR40E	W14993 Edwards Cr.WW NWNW3T21NR39E	W14994 Water Well Sec2T21NR39E
Temp°C	20.5	42.5	14.5	15.5
Flow (gpm)	3.0	25.0	5.0	5.0
pH	7.5	7.2	8.0	7.6
Cl	78.1	24.0	39.0	26.0
F	0.5	4.2	1.3	0.8
SO_4	87.0	47.0	80.0	42.0
HCO_3	120.0	580.0	178.0	130.0
CO_3	0.0	0.0	0.0	0.0
SiO_2	48.0	40.0	80.0	61.0
Na	78.0	230.0	110.0	71.0
K	7.7	15.0	9.4	4.8
Ca	50.0	43.0	23.0	14.0
Mg	7.8	8.7	2.1	2.7
Li	0.1	0.3	0.1	0.1
B	0.4	1.3	0.6	0.3
Ec(K)				
TDS	477.5	993.5	523.5	352.7
Tq SiO_2	101	94	122	111
Tc SiO_2	70	61	97	82
T Na-K	216	183	204	186
T Na-K-Ca	68	157	95	79

Table I. Continued

	W14995 Well 25-9, 1640' NWSW9T22NR40E	W14996 Well 25-9, 1840' NWSW9T22NR40E	W14997 Well 25-9, 2000' NWSW9T22NR40E
Temp°C	44.4	48.	54.
Flow (gpm)	25.	30.	30.
pH	8.7	8.2	8.2
Cl	29.0	34.0	45.0
F	2.9	1.7	1.0
SO_4	64.0	75.0	86.0
HCO_3	182.0	158.0	156.0
CO_3	12.0	0.0	0.0
SiO_2	17.0	25.0	35.0
Na	85.0	69.0	58.0
K	14.0	11.0	12.0
Ca	8.4	19.0	34.0
Mg	20.0	16.0	29.0
Li	0.3	0.2	0.1
B	0.8	0.5	0.4
Ec(K)	624.0	570.0	655.0
TDS	435.4	409.4	456.5
Tq SiO_2	64	77	89
Tc SiO_2	25	40	55
T Na-K	264	261	288
T Na-K-Ca	69	53	50

Table I. Continued

	W14998 Well 38-9, 550' SESW9T23NR40E	W14999 Well 38-9, 1200' SESW9T23NR40E	W15000 Well 38-9, 1300' SESW9T23NR40E
Temp°C	34	47	47
Flow (gpm)	25	115	125
pH	8.4	7.9	7.8
Cl	22.0	23.0	23.0
F	4.2	4.2	4.2
SO_4	58.0	53.0	57.0
HCO_3	472.0	538.0	530.0
CO_3	28.0	0.0	0.0
SiO_2	44.0	35.0	35.0
Na	230.0	230.0	230.0
K	18.0	16.0	16.0
Ca	24.0	33.0	35.0
Mg	13.0	11.0	12.0
Li	0.3	0.3	0.3
B	1.2	1.2	1.2
Ec(K)	1128.0	1190.0	1201.0
TDS	914.7	944.7	963.7
Tq SiO_2	97	89	89
Tc SiO_2	66	55	55
T Na-K	197	188	188
T Na-K-Ca	171	163	162

Chemically the waters appear to fall into three distinct groups (Fig. 3 and Table II). The majority of non-thermal ground waters are mixed cation-anion waters of low salinity and low SiO_2 content (Type I). The thermal waters in the MCoy areas fall into two groups (Fig. 3 and Table II). The thermal waters from the McCoy Mine area (Type III) are characterized by a higher sodium content (Fig. 3) and a low Cl/HCO_3 (Mole) ratio (Table II).

The second groups of thermal waters (Type II) are low to intermediate in sodium content and intermediate to high in potassium content (Fig. 3). Several spring samples fall within the boundary of the Type II waters suggesting a mixing of thermal and meteoric waters. Type II waters tend to have a high Cl/SO_4 (Mole) ratio (Table II); however, the waters from well 66-8 have Cl/SO_4 mole ratio values in the same ranges as those from the McCoy Mine area (Table II).

The hydrological regime in the McCoy area appears to be quite complicated. Chemically, two distinct parent fluids are suggested. One parent fluid diluted with meteoric water gives use to Type II waters and the second gives rise to the Type III waters.

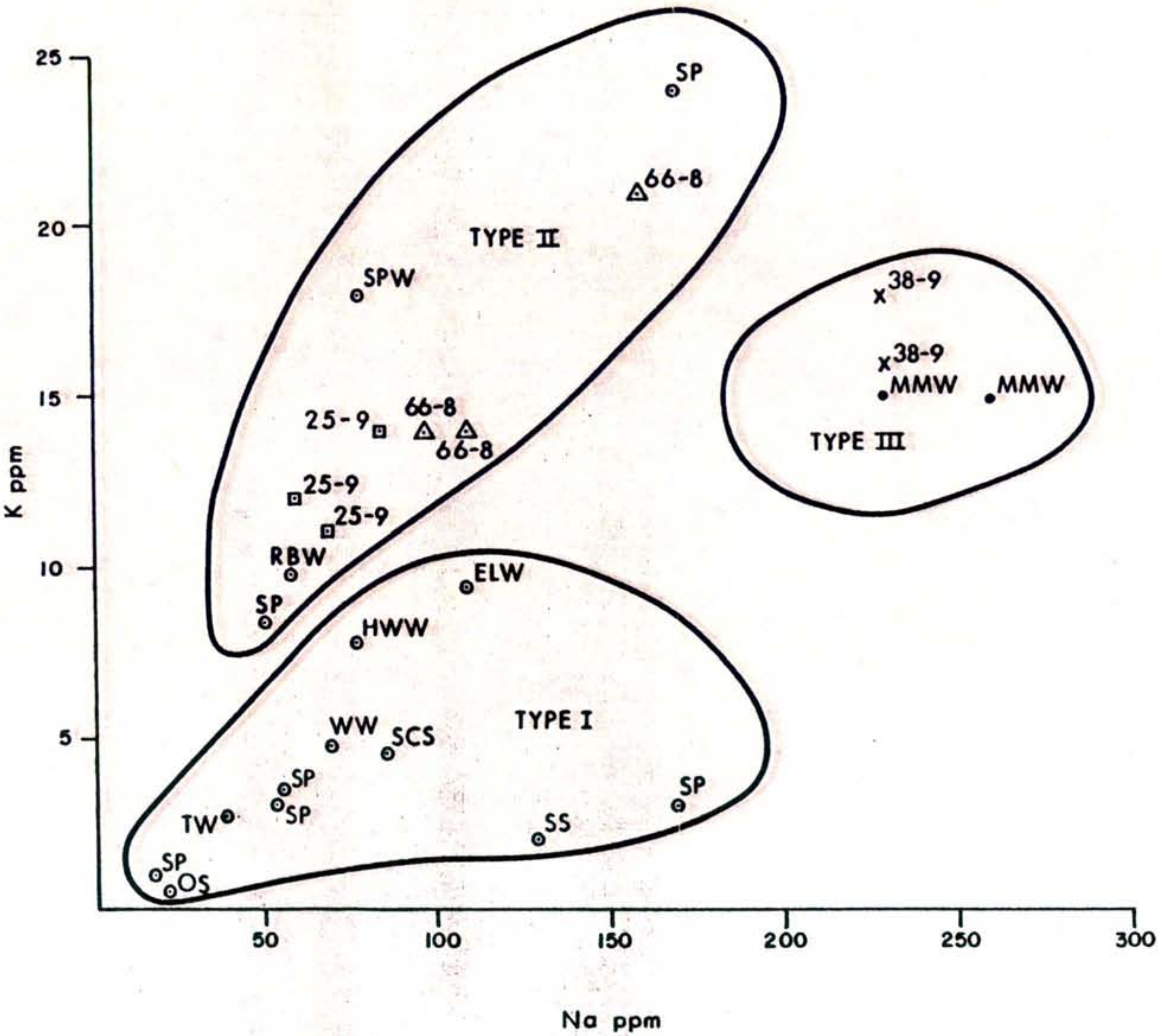


Figure 3. Na versus K in waters of the McCoy area, Nevada

Table II. Cl/HCO_3 and Cl/SO_4 Mole Ratio Comparison for McCoy Waters

Sample #	Area of Well #	Cl/HCO_3 Mole Ratio	Cl/SO_4 Mole Ratio
W10981	McCoy Mine Well	0.06	1.10
14992	" "	0.07	1.38
14998	38-9	0.08	1.03
14999	38-9	0.07	1.18
1500	38-9	0.07	1.09
13453	66-8	0.45	1.03
13454	66-8	0.38	0.84
13456	66-8	0.26	1.05
14995	25-9	0.27	1.23
14996	25-9	0.37	1.23
14997	25-9	0.50	1.42
14750	Shoshone Pass Well	0.26	0.86
14991	Hole in the Wall Well	1.12	2.43
14993	Edwards Creek Well	0.38	2.25
14994	Edward Creek Valley Well	0.34	1.68

Geophysical Studies

A resistivity survey was run by Mining Geophysical Survey, Inc. during the period February 2 to March 3, 1981. Two profiles were run along lines B-B' and C-C' of the MT survey (Pilkington, 1981). The third profile was done along an east-west line to the south (Figure 4).

The low conductivity zone seen spread 2 line C (Fig. 5) may represent the same zone of low conductivity seen in the MT and the EM-60 survey (Pilkington, 1981). The more resistive zones between the center of spread 2 and spread 1 are over the horst block of pre-Tertiary rocks. On line B the near surface resistivity responses are characteristic of inclined blocks of varying resistitivy and probably relate to the block faulting. On line D the area of low resistivity on the west end of the line coincides with an increasing thickness of Tertiary volcanic rocks. The deeper zones of conductive material are probably the same as seen on the MT.

The low resistivity zones may represent conduits for the thermal waters; however, interpretation is complicated by lateral and apparent resistivity effects. Model studies are planned for early 1982.

Exploration Drilling

Two intermediate depth exploration wells were completed in 1981, and a third well was spudded, drilled to 403 feet, cased, and suspended. Well 25-9 located in the NWSW Sec. 9 T22N R40E had a TD of 610 meters (2000') and well 38-9 located in the SESW Sec. 9 T23N R40E had a TD of 620m (2040'). and well 28-18 located in the SWSW Sec. 18 T22NR40E was drilled to 403', cased and suspended.

The exploration wells were drilled as unit wells for the McCoy

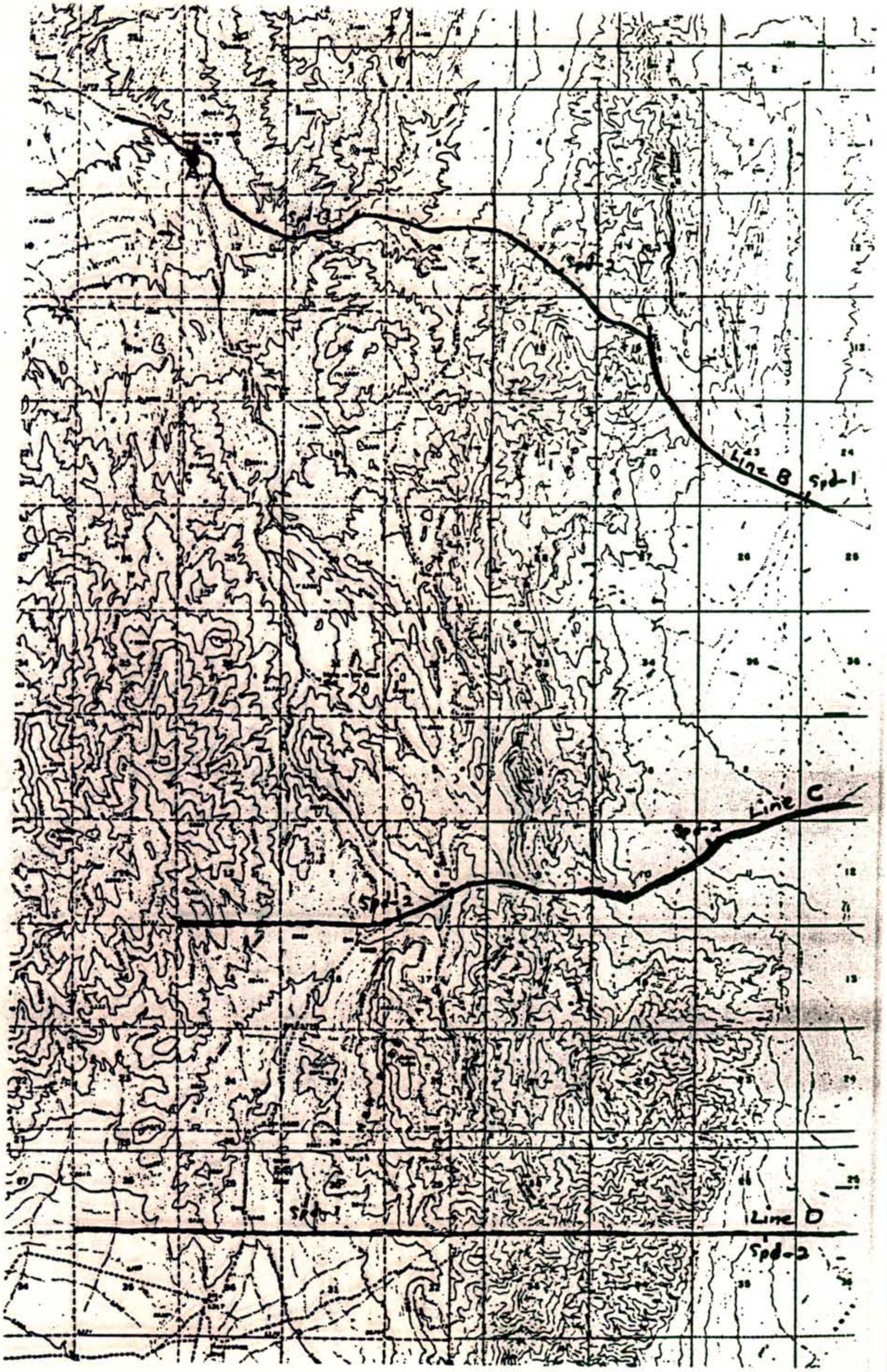


Figure 4. Location of resistivity profile lines.

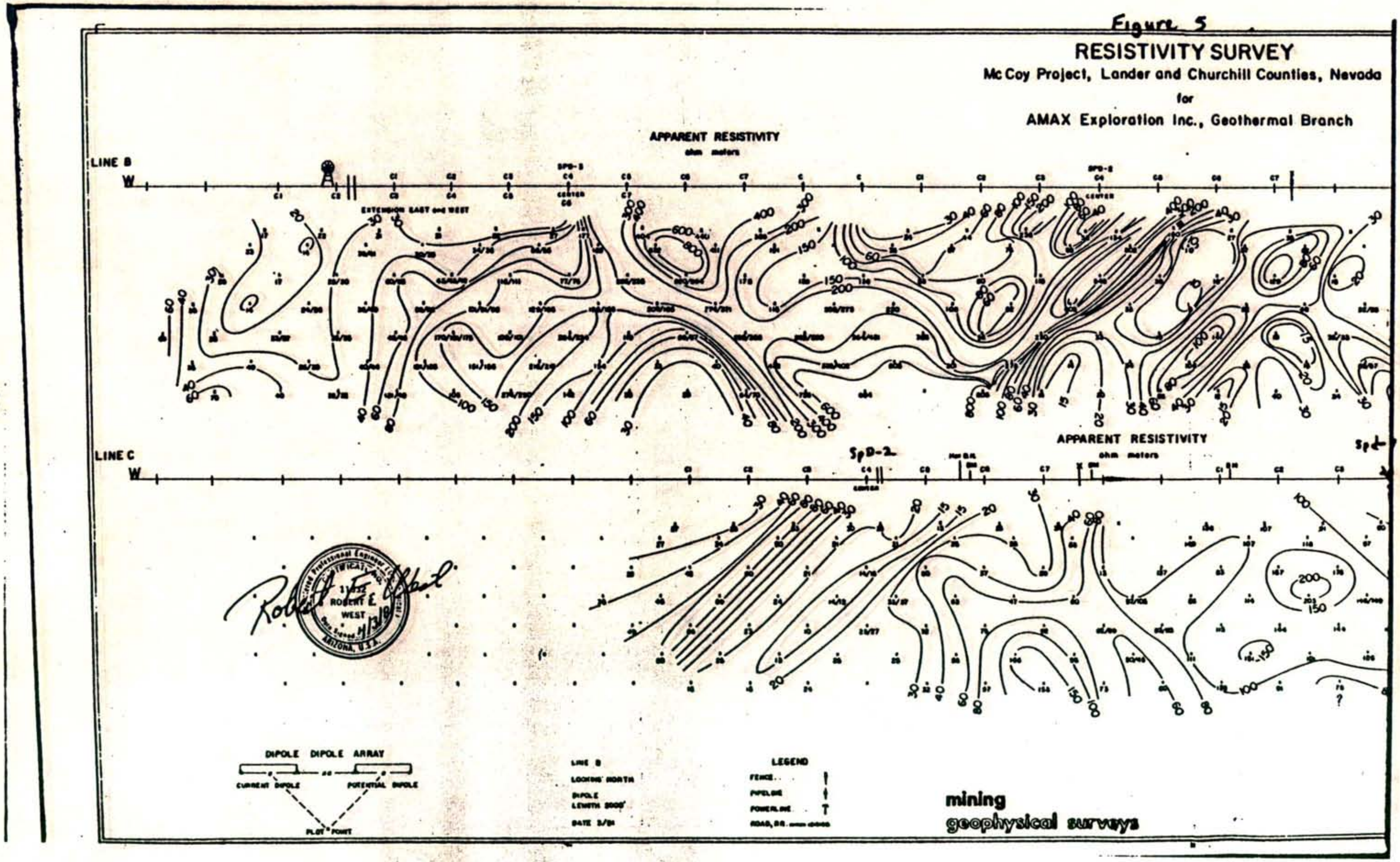


Figure 5. Resistivity survey McCoy Project, Nevada Line B and C

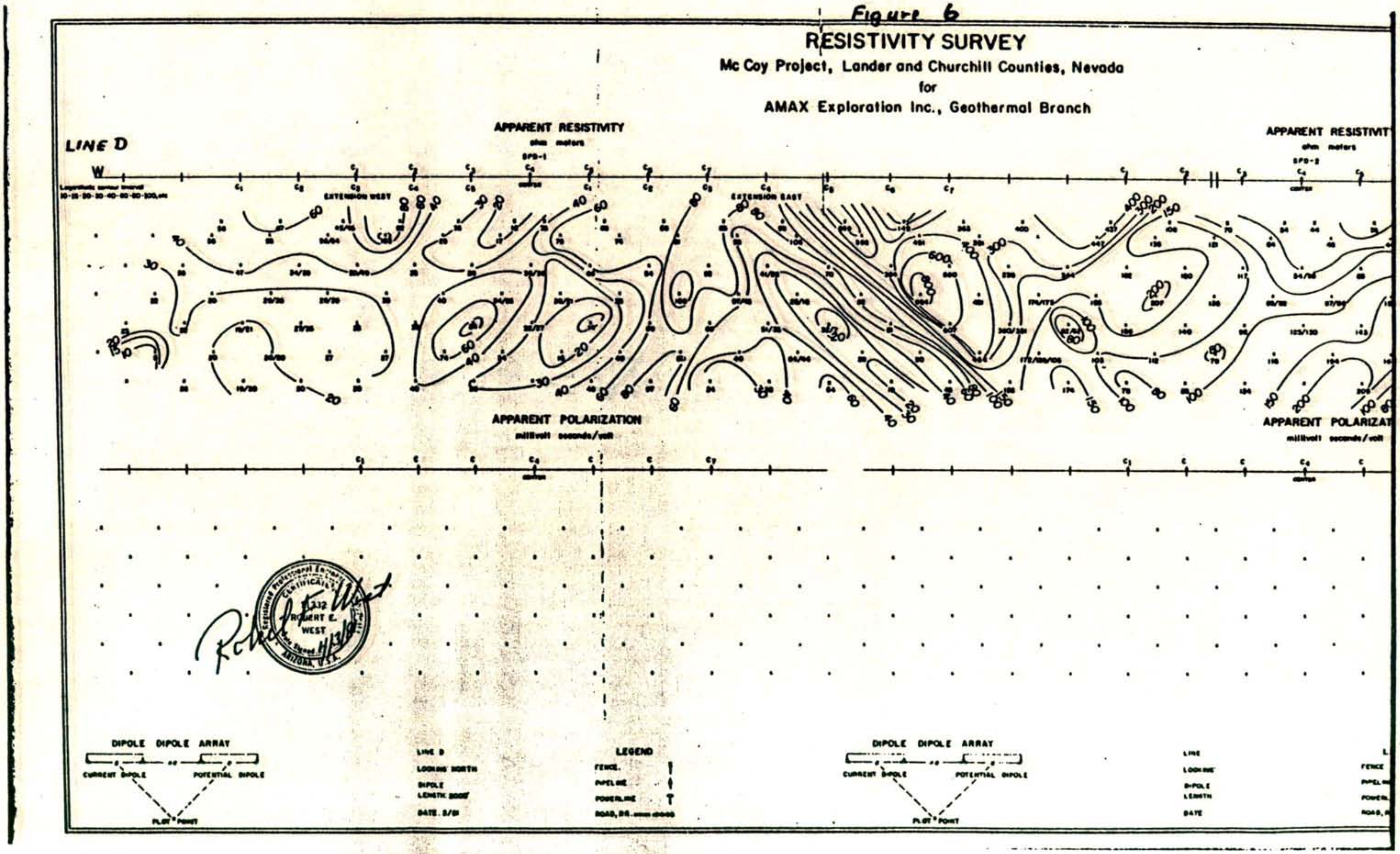


Figure 6. Resistivity survey McCoy Project, Nevada Line D

Federal Geothermal Unit under a Plan of Exploration approved by the U.S. Geological Survey. The generalized drilling plan for the holes was:

1. Move on and rig up.
2. Drill 17-1/2" hole to 20 ft.
3. Run 20 ft. surface conductor.
4. Drill 12-1/2" hole to 10% of TD.
5. Run 9 5/8" casing, cement.
6. Install BOP test.
7. Drill 8-5/8" hole to TD.
8. Run electric logs.
9. Run 2 3/8" tubing, fill with water.
10. Cement top 10 feet of annulus.
11. Install gate valve on top of tubing.

Generalized stratigraphic sections for wells 25-9 and 38-9 are given in Figure 7. Well 25-9 encountered low temperature geothermal fluids at 1640 feet, 1840 feet and 2000 feet. The maximum temperatuare fluids were at 2000 feet where temperatures are estimated to be 54^{o}C. Chemically the waters are thought to be meteoric waters which circulated to depths sufficient to heat them to the observed temperatures.

Well 38-9 encountered fluids at depths of 550 feet, 1200 feet and 1300 feet. Chemically the geothermal fluids are comparable with those from the McCoy Mine water well.

Well 28-18 will be completed to at least 3000 feet during 1982 in order to effectively test the geophysical anomalies.

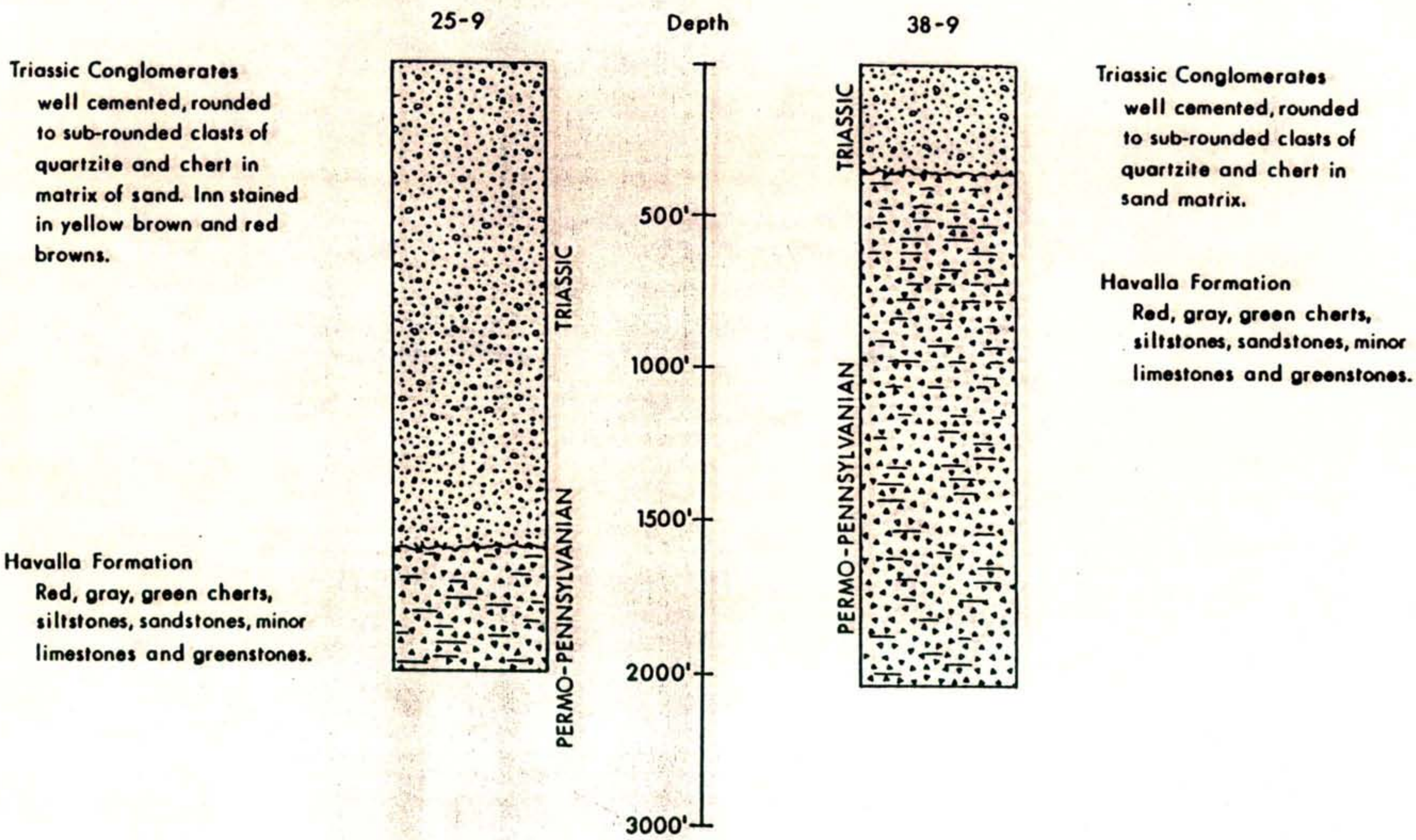


Figure 7. Generalized stratagraphic sections for well 25-9 and 38-9

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