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Water geochemistry of hydrothermal systems, Wood River District, Idaho

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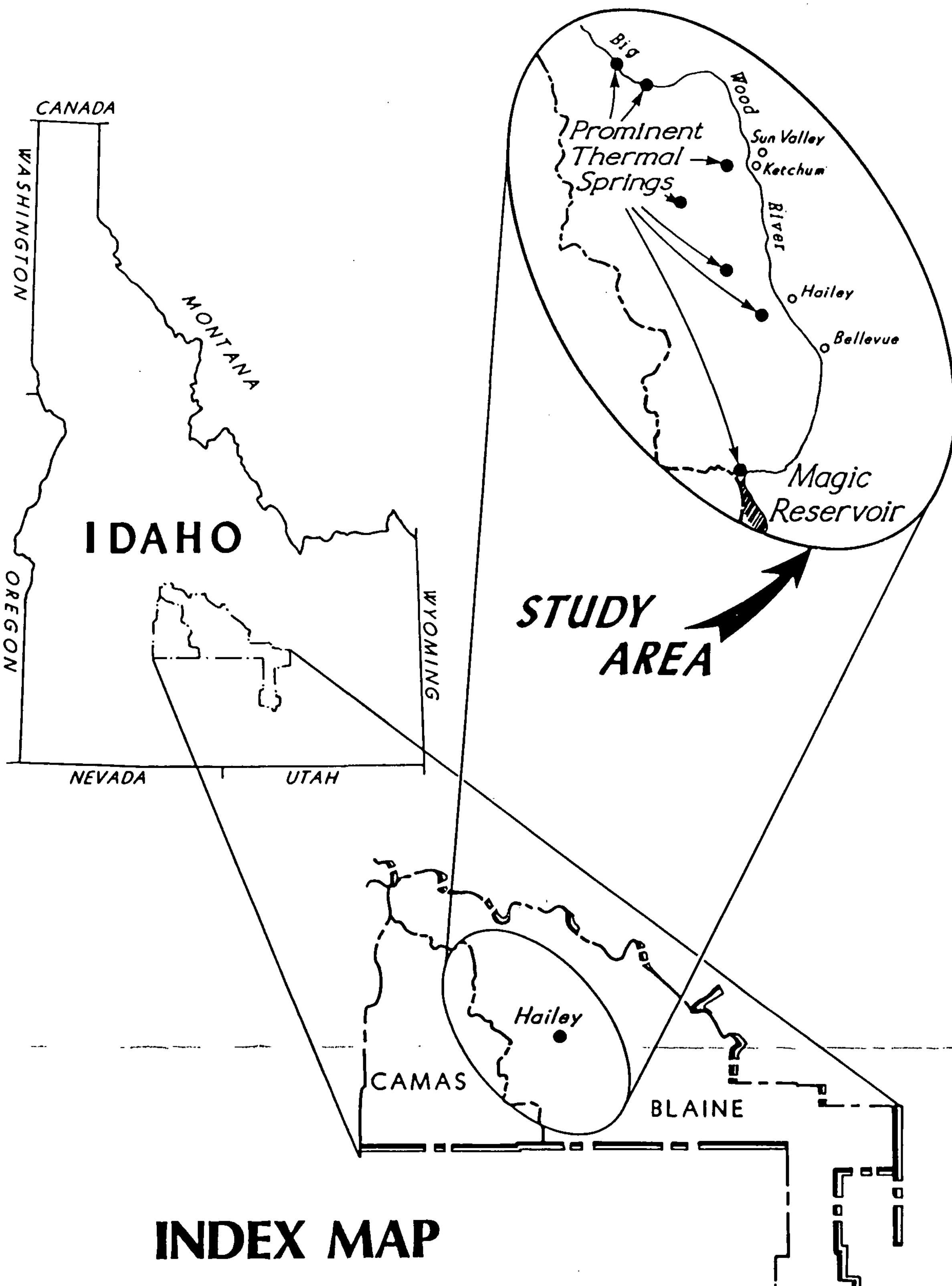
Introduction

Hydrothermal systems of the Wood River District, central Idaho (Figure 1), have been studied by geologic mapping of thermal spring areas and geochemical investigations of thermal and non-thermal waters. This report summarizes the new geochemical data gathered during the study. Previous studies in the area include those of Mitchell (1976), Mitchell and others (1980), Blackett (1981), Struhsacker and others (1982), and Foley and others (1983).

Bedrock in the Wood River district is composed of the Paleozoic Wood River and Milligen Formations, the Mesozoic Idaho Batholith, and the Cenozoic Challis volcanics. Structural relations of the units include extensive thrust faults in the Paleozoic units, which in turn have been intruded by batholith rocks, and are overlain by the volcanics. Tertiary and Quaternary(?) normal faults cut the rocks.

Integration of the results of geological and geochemical studies has led to development of a target model for hydrothermal resources on the margin of the Idaho Batholith. Warfield Hot Springs, with temperatures up to 58°C, flow from a major shear zone along the margin of an apophysis of the batholith. Hailey Hot Springs, with temperatures up to 60°C, occur in an area of multiple thrust faults and newly recognized, closely spaced normal faults in the Paleozoic Milligen and Wood River Formations, 2.5 km from a highly brecciated batholith contact. Other Wood River district hydrothermal systems also occur along the margins of batholith apophyses or in adjacent highly fractured Paleozoic rocks, where there are indications of batholith rocks at shallow depths (100-300 m) in water wells.



INDEX MAP
WOOD RIVER DISTRICT
FIGURE 1

The Wood River district thermal waters are geochemically distinct from the local ground water. Thermal waters circulate through batholith rocks, with little or no equilibration with Paleozoic sedimentary or Tertiary volcanic rocks. The thermal waters are high F (11-19 ppm), low TDS (190-322 ppm) $NaHCO_3$-SO_4 waters, with up to half of the TDS as silica. The Magic Hot Springs system is higher TDS (about 1000 ppm) than the other sites. Geochemical thermometers for most systems are below 100°C; Magic Hot Springs is about 150°C. Thermal waters at the margin of the batholith are chemically similar to those in the interior of the batholith.

The location of thermal systems at the margin of small apophyses of the Idaho Batholith is similar to other thermal systems in the western U.S. The waters circulate deep in the batholith rocks, and surface in either the intrusive or intruded rocks (Blackett, 1981; Figure 4). Specific thermal systems are controlled by the most favorable fracture permeability for the circulation of water.

Geochemistry of waters

Samples of thermal and non-thermal water were collected from selected springs and wells during this study, and analyzed for major and trace element constituents. Table 1 presents the results of the analyses; sample locations are indicated on Figures 2 through 7.

Samples were collected following the procedures of Kroneman (1981). All analyses were performed at Earth Science Laboratory facilities. Cations were determined by Induction Coupled Plasma Spectrophotometry. Total dissolved solids were determined by gravimetric methods, SO_4 and Cl by Mohr titration, HCO_3 by titrimetric techniques, and F by specific ion electrode.

Figure 8 is trilinear plot of the geothermal data. This diagram illustrates the distinct nature of the thermal and cold waters, suggesting deeper circulation for the thermal systems, as would be expected. The high fluoride content of the thermal waters suggests equilibration with granitic rocks of the Idaho Batholith, rather than the overlying sedimentary or volcanic rocks.

The samples from the Magic Hot Springs area are distinct in both TDS levels and relative constituents, suggesting the possibility of partial equilibration with rock types other than granite. Geochemical thermometry also suggests that the waters of the Magic Hot Springs area are distinct, as they apparently equilibrated at higher temperatures (117-140°C for equilibration with quartz followed by conductive cooling; 130-157°C for Mg corrected cation geothermometer) than the other thermal systems.

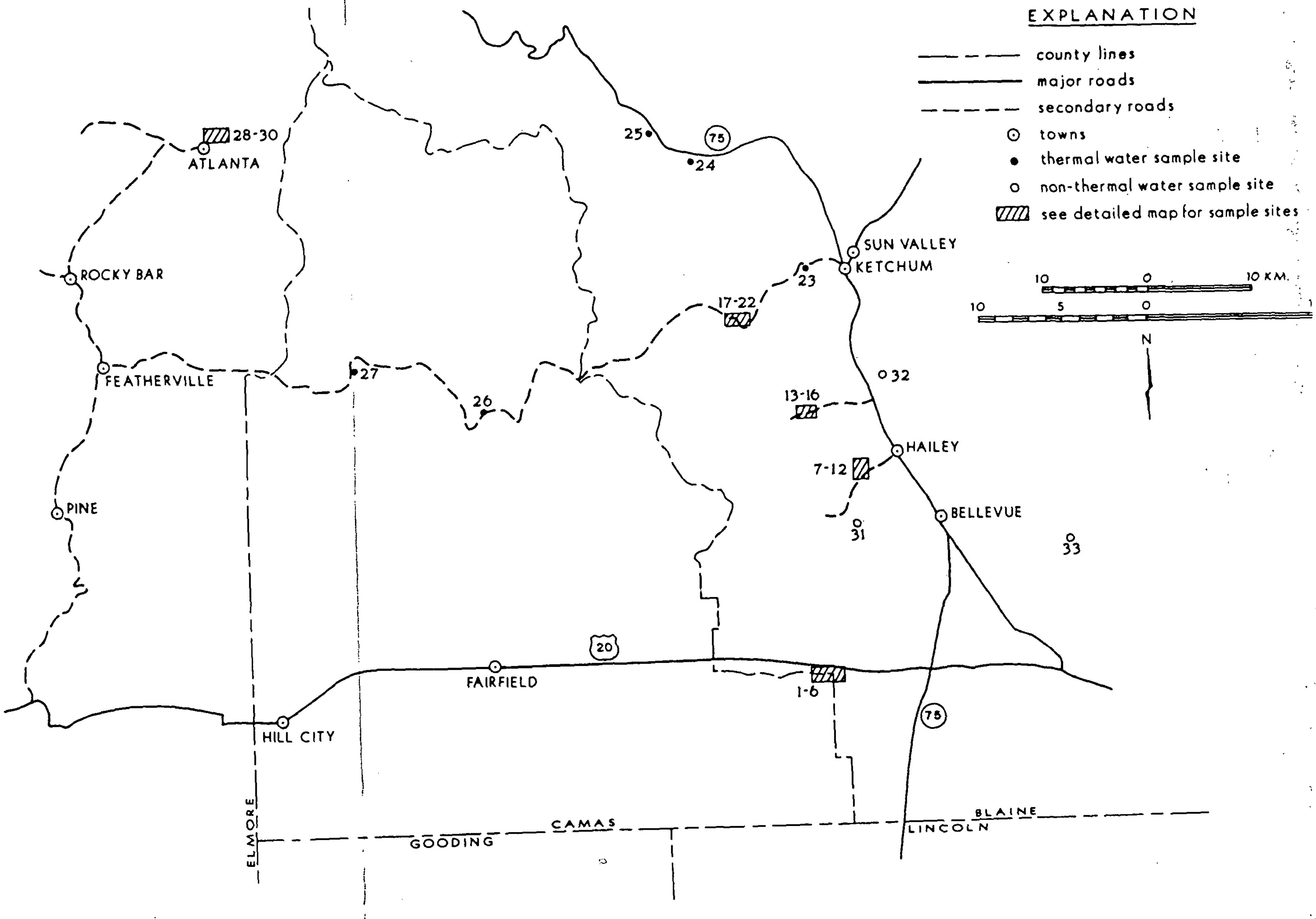


FIGURE 2. WATER SAMPLE SITES, WOOD RIVER DISTRICT AND VICINITY

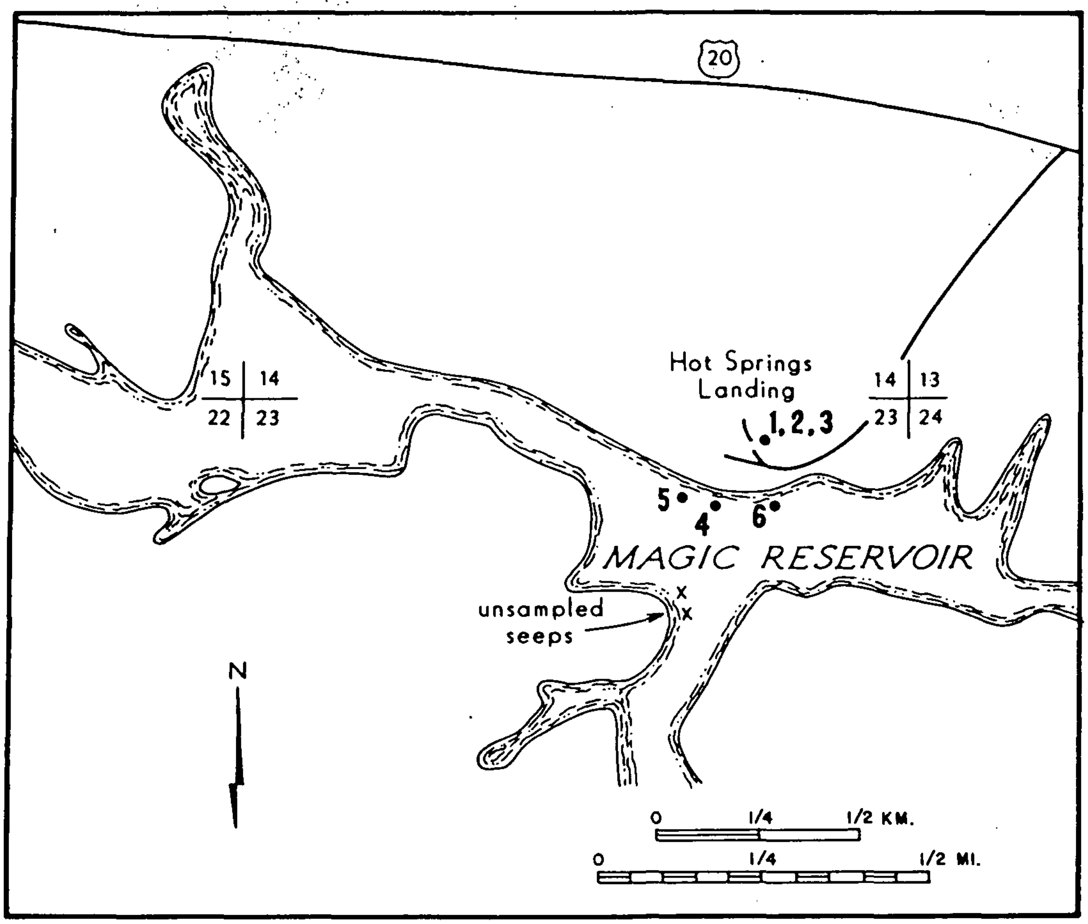


FIGURE 3. WATER SAMPLE SITES, MAGIC RESERVOIR AREA

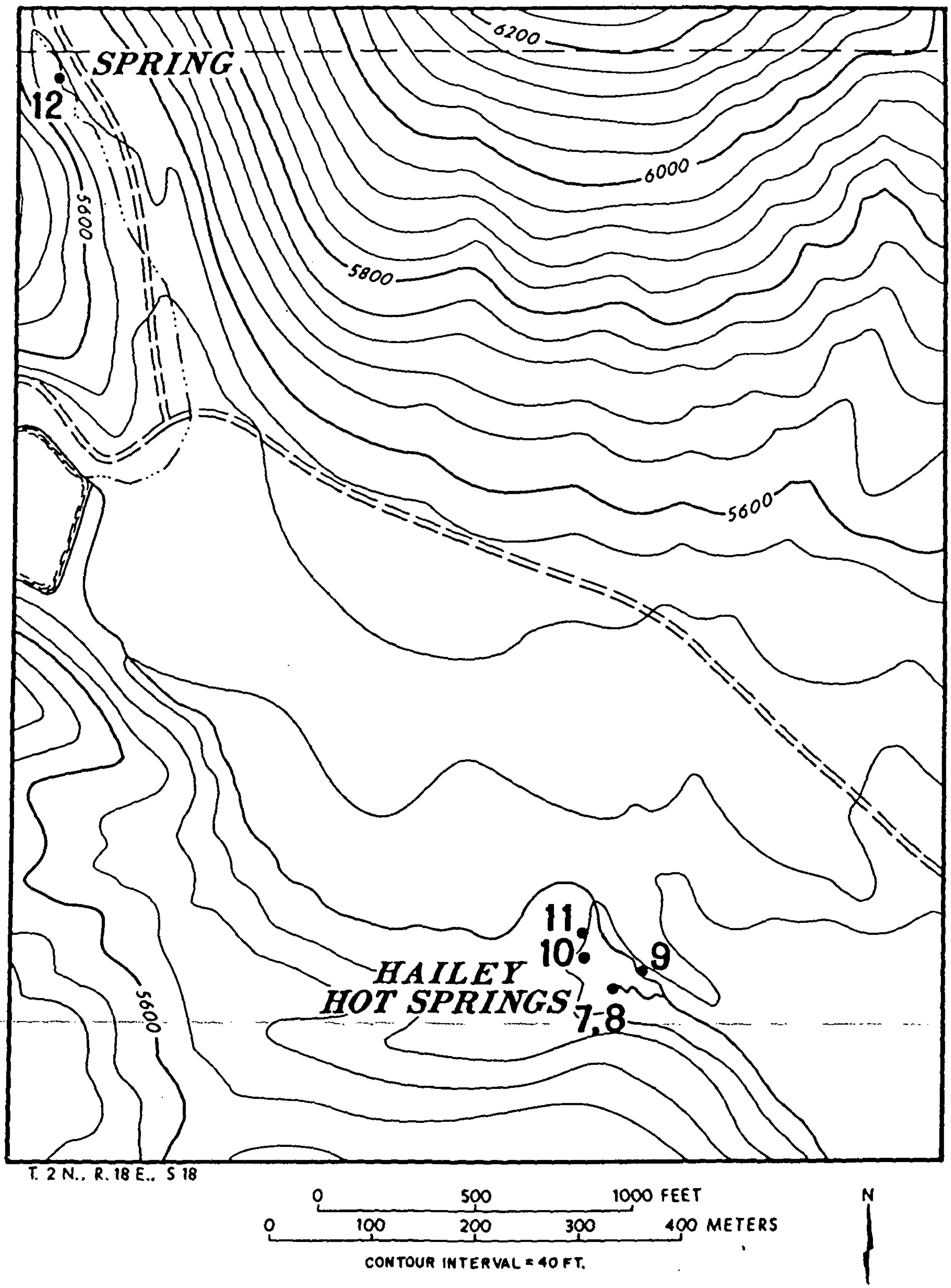


FIGURE 4. WATER SAMPLE SITES, HAILEY HOT SPRINGS AREA

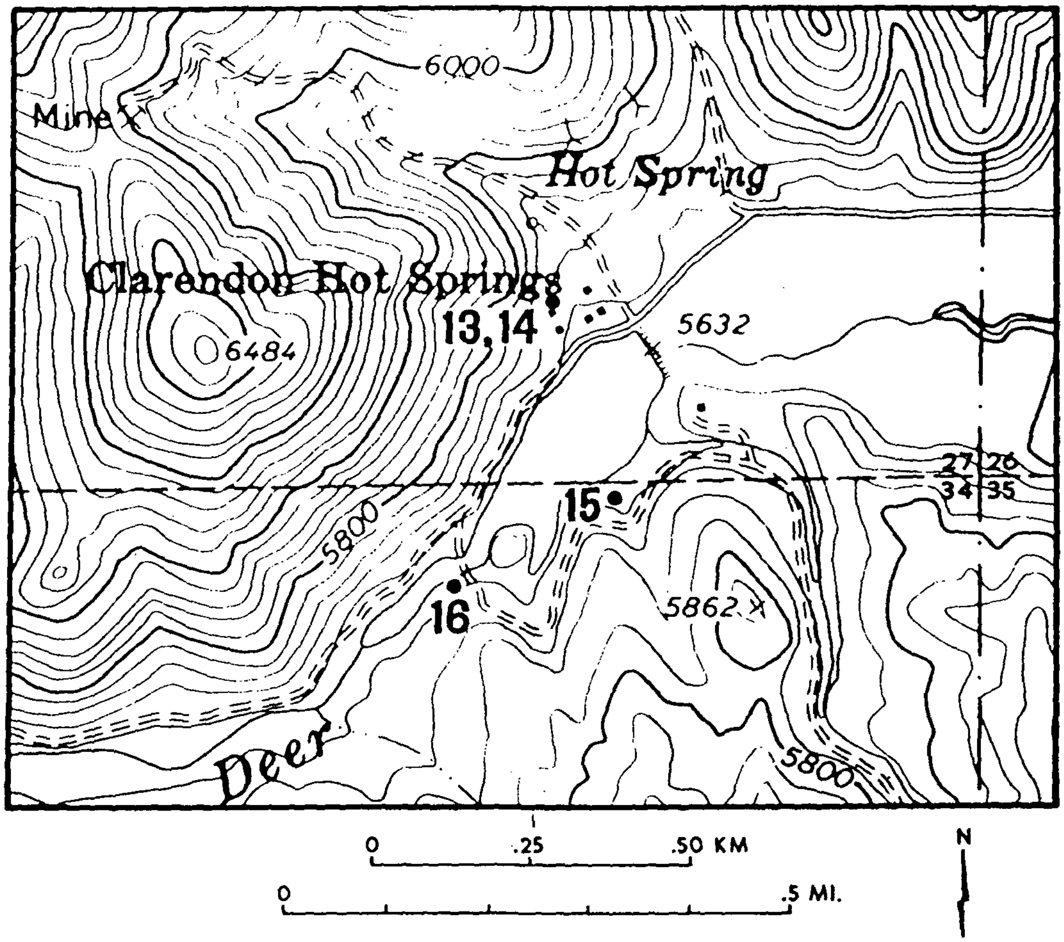


FIGURE 5. WATER SAMPLE SITES, CLARENDON HOT SPRINGS AREA

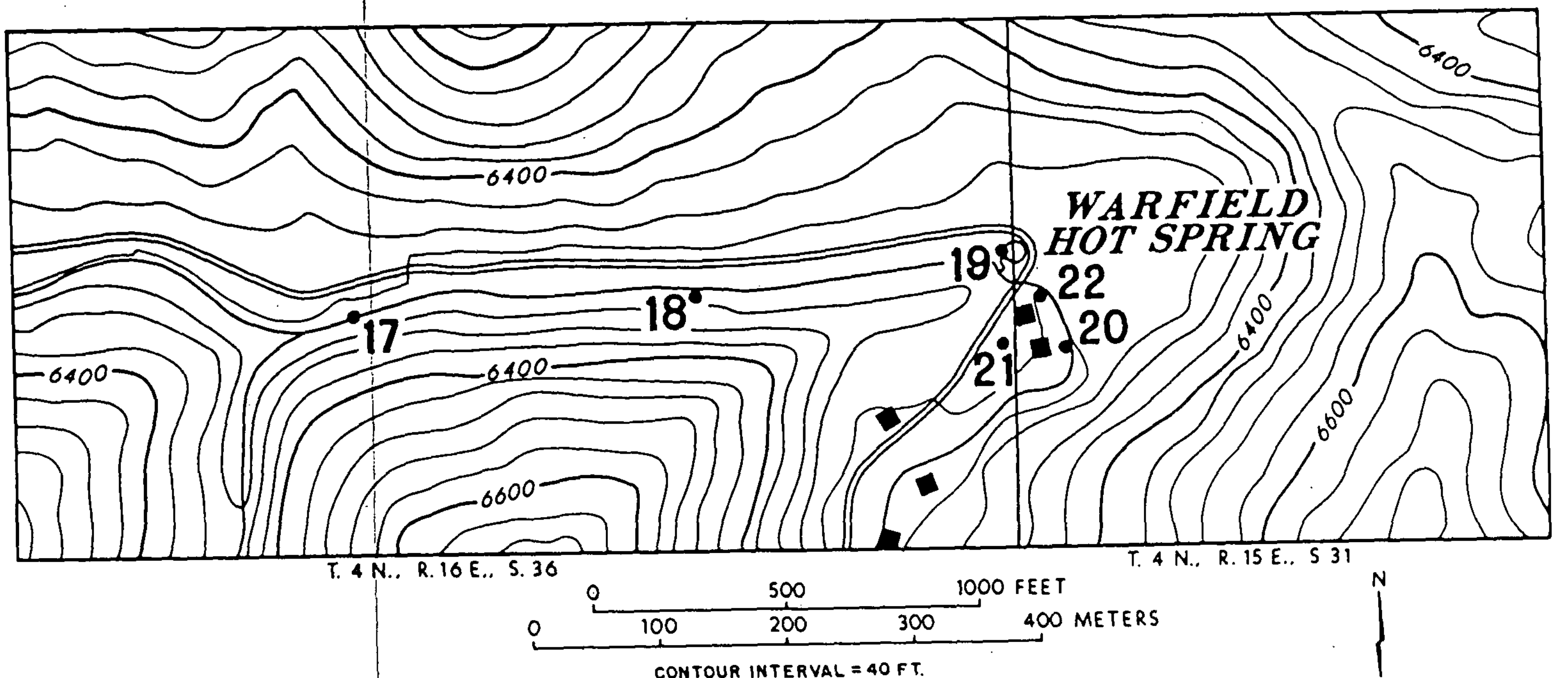


FIGURE 6. WATER SAMPLE SITES, WARFIELD HOT SPRING AREA

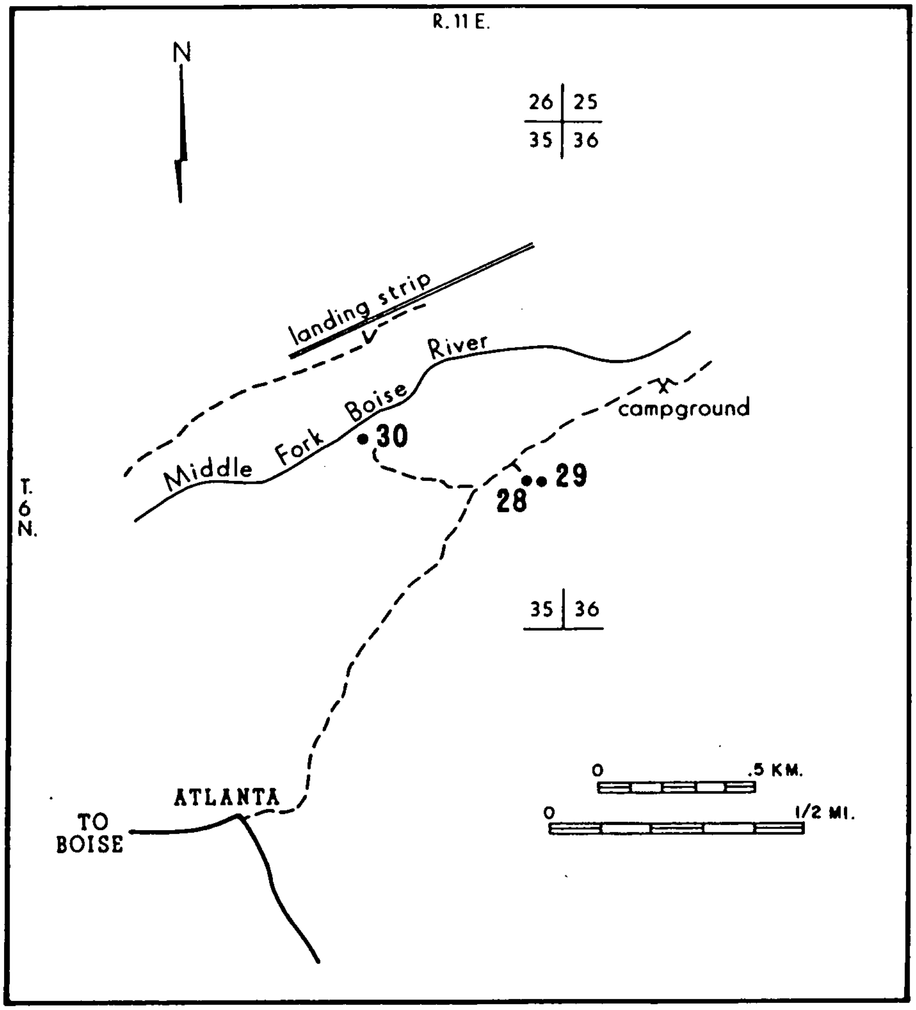


FIGURE 7. WATER SAMPLE SITES, ATLANTA AREA

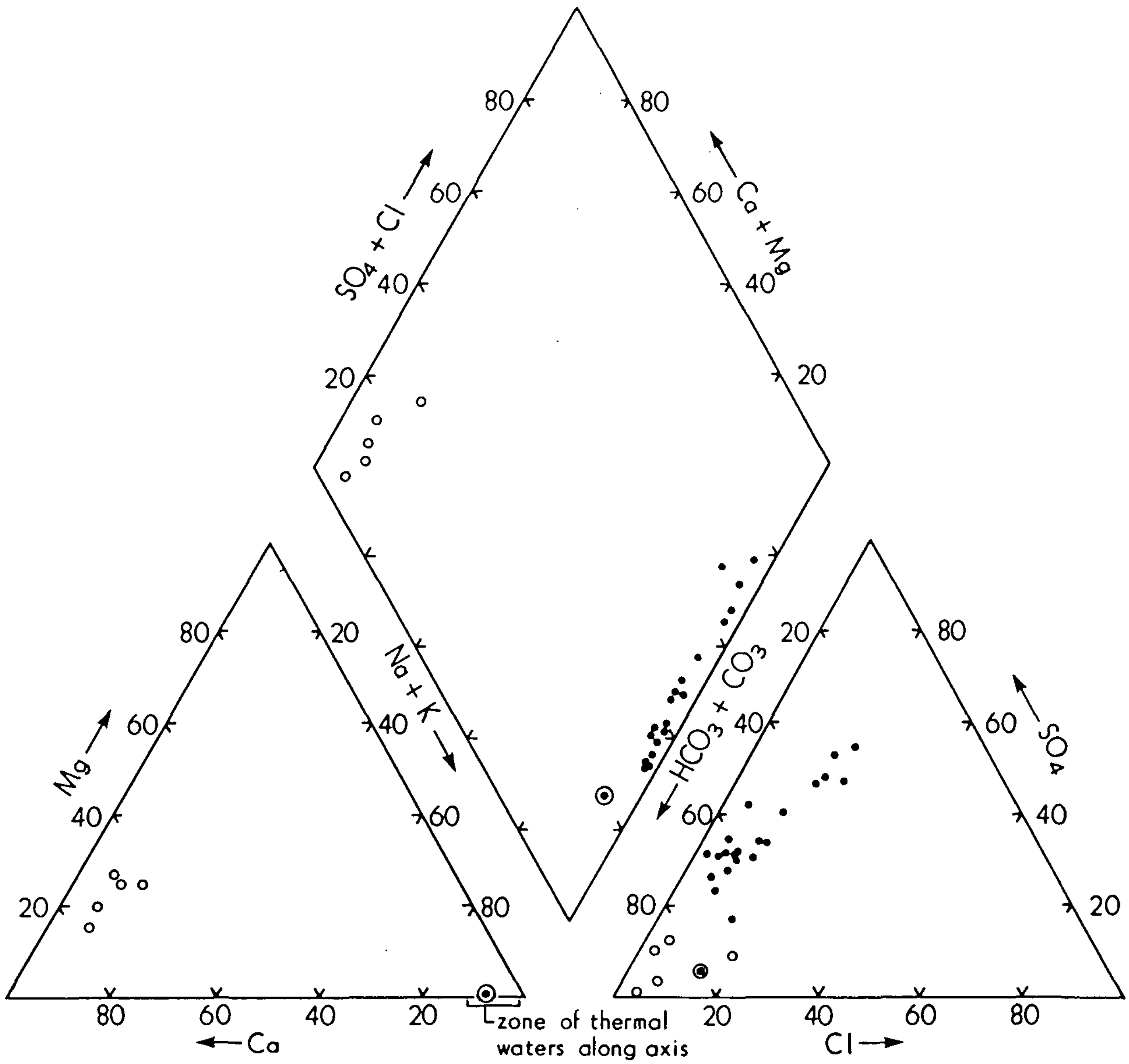


FIGURE 8. TRILINEAR DIAGRAM
WOOD RIVER DISTRICT WATERS

⊙ Magic Hot Springs Landing
4 analyses of thermal waters

• Thermal waters

○ Cold waters

Table 1
Chemistry of Wood River District
Water Samples

Sample Number	1	2	3	4	5
Site Name	Magic Well	Magic Well	Magic Well	Magic Seep 1	Magic Seep 2
Location[1]	01S 17E 23 AAB	01S 17E 23 AAB	01S 17E 23 AAB	01S 17E 23 AAB	01S 17E 23 AAB
Collection Date	15 Oct. 1981	20 Jan. 1982	13 July 1982	4 Nov. 1981	4 Nov. 1981
Collection Temp. (°C)	74.5	70	74	39	32
Flow (1/m)	57[2]	57[2]	57[2]	4 est.	4 est.
Na	339	324	387	352	340
K	21	20	20	20	18
Ca	22	19	20	22	22
Mg	1	1	1	2	2
Fe	0.38	0.25	0.16	nd[3]	nd
SiO_2	78	75	105	76	69
B	1.2	1.1	1.2	1.5	1.4
Li	1.29	1.15	0.97	1.42	1.38
Sr	1.08	1.0	1.09	1.49	1.51
W	0.1	nd	0.3	nd	nd
HCO_3	747	766	764	765	782
SO_4	49	48	51	51	49
Cl	81	80	82	81	83
F	12	11	14	13	12
TDS (meas.)	994	984	980	1026	1014
pH (lab)	8.4	8.6	7.6	7.1	7.2

Table 1 (cont.)
Chemistry of Wood River District
Water Samples

Sample Number	6	7	8	9	10
Site Name	Magic Reservoir	Hailey Hot Spr.	Hailey Hot Spr.	Hailey Well 1	Hailey Well 2
Location[1]	01S 17E 23 AAB	02N 18E 18 DBB	02N 18E 18 DBB	02N 18E 18 DBB	02N 18E 18 DBB
Collection Date	13 July 1982	15 Oct. 1981	17 July 1982	25 Sept. 1982	25 Sept. 1982
Collection Temp. (°C)	20	57	59	42	55
Flow (1/m)	--	265[2]	265[2]	low	low
Na	8.3	71	84	73	73
K	1.4	1.9	1.3	1.2	1.4
Ca	27	3	2	7.0	2
Mg	5	nd	nd	nd	nd
Fe	nd	0.04	nd	nd	0.04
SiO_2	12	67	107	101	100
B	nd	0.1	nd	nd	nd
Li	nd	0.12	0.1	0.06	0.07
Sr	nd	0.08	0.07	0.03	0.06
W	nd	nd	0.2	nd	nd
HCO_3	122	90	88	95	90
SO_4	9	35	33	31	33
Cl	4	4	--	10	8
F	0.6	12.6	16.2	11.5	11.5
TDS (meas.)	134	294	--	210	198
pH (lab)	7.8	9.3	9.3	9.2	9.4

Table 1 (cont.)
Chemistry of Wood River District
Water Samples

Sample Number	11	12	13	14	15
Site Name	Hailey Well 3	Lambs Gulch Spring	Clarendon Main Well	Clarendon Main Well	Clarendon Warm Well
Location[1]	02N 18E 18 DBB	02N 18E 18 BBA	03N 17E DCB	03N 17E DCB	03N 17E 34 ABB
Collection Date	25 Sept. 1982	17 July 1982	15 Oct. 1981	20 July 1982	20 July 1982
Collection Temp. (°C)	60.5	9	52.5	53	26
Flow (l/m)	190 est.	55 est.	40	40	25
Na	72	4.7	86	98	97
K	1.3	0.4	2.1	1.6	1
Ca	3	42	4	2	2
Mg	nd	7	nd	nd	nd
Fe	nd	nd	0.21	nd	nd
SiO_2	96	19	64	78	72
B	nd	nd	0.2	0.2	0.1
Li	0.06	nd	0.13	0.08	0.07
Sr	0.05	0.14	nd	0.04	0.04
W	nd	nd	0.1	nd	0.4
HCO_3	73	156	93	92	83
SO_4	31	19	38	37	38
Cl	7	5	5	7	4
F	11.2	0.3	17	16.1	19
TDS (meas.)	222	190	304	302	288
pH (lab)	9.0	7.6	9.6	9.5	9.6

Table 1 (cont.)
Chemistry of Wood River District
Water Samples

Sample Number	16	17	18	19	20
Site Name	Clarendon Pool Well	Warm Sprs. Creek	Warfield Hot Spring (upstream)	Warfield Bathhouse Hot Spring	Warfield Cistern 1
Location[1]	03N 17E 34 BAD	04N 16E 36 BDB	04N 16E 36 AAC	04N 16E 36 AAD	04N 17E 31 BBC
Collection Date	20 July 1982	14 Oct. 1982	16 July 1982	14 Oct. 1981	25 Sept. 1982
Collection Temp. (°C)	54	5.5	58	41.5	49
Flow (1/m)	22	--	21	40 est.	--
Na	99	3.5	85	70	72
K	1.6	0.8	1.8	2.3	1.6
Ca	2	32	2	2	3
Mg	nd	4	nd	nd	nd
Fe	nd	0.29	nd	nd	nd
SiO_2	82	14	99	72	109
B	0.2	nd	nd	nd	nd
Li	0.07	nd	nd	0.19	0.12
Sr	0.05	0.12	0.09	0.08	0.06
W	nd	nd	nd	nd	nd
HCO_3	97	98	102	104	98
SO_4	38	9	32	36	35
Cl	8	2	5	8	9
F	19	0.2	16.5	13	14
TDS (meas.)	310	138	284	290	200
pH (lab)	9.5	9.8	9.6	9.6	9.5

Table 1 (cont.)
Chemistry of Wood River District
Water Samples

Sample Number	21	22	23	24	25
Site Name	Warfield Cistern 2	Warfield Hot Spring	Guyer Hot Springs	Easley Warm Springs	Russian John Warm Spring
Location[1]	04N 16E 36 AAD	04N 17E 31 BBC	04N 17E 15 AAC	05N 16E 10 DBC	06N 16E 33 CCA
Collection Date	25 Sept. 1982	25 Sept. 1982	14 Oct. 1981	14 Oct. 1981	14 Oct. 1982
Collection Temp. (°C)51	51	51	69	38	33.5
Flow (1/m)	--	10 est.	3785[2]	68[2]	4[2]
Na	77	72	90	71	71
K	1.6	1.6	2.4	0.8	0.8
Ca	3	2	4	3	2.0
Mg	nd	nd	nd	nd	nd
Fe	nd	nd	0.05	nd	0.08
SiO_2	109	110	67	47	47
B	nd	nd	0.3	0.2	0.2
Li	0.11	0.12	0.17	0.18	0.19
Sr	0.06	0.06	0.15	0.1	0.08
W	nd	nd	nd	nd	0.10
HCO_3	96	94	90	84	81
SO_4	31	31	59	42	41
Cl	7	8	5	10	11
F	14	13.5	17	16	16
TDS (meas.)	190	206	322	236	240
pH (lab)	9.5	9.4	9.5	8.5	9.7

Table 1 (cont.)
Chemistry of Wood River District
Water Samples

Sample Number	26	27	28	29	30
Site Name	Worswick Hot Springs	Lightfoot Hot Spring	Atlanta Hot Springs	Atlanta Warm Seep	Chattanooga Hot Spring
Location[1]	03N 14E 28 CAA	03N 13E 7 DCA	06N 11E 35 DAD	06N 11E 35 DAD	06N 11E 35 DBB
Collection Date	13 Oct. 1981	13 Oct. 1981	14 July 1982	14 July 1982	14 July 1982
Collection Temp. (°C)	79	62	58	34	45
Flow (l/m)	1764[2]	38[2]	--	--	large
Na	74	80	79	57	77
K	2.4	2.4	1.4	0.9	1.6
Ca	2	2	2.0	3	2.0
Mg	nd	nd	nd	nd	nd
Fe	nd	nd	nd	nd	nd
SiO_2	74	58	74	43	75
B	nd	0.1	nd	nd	nd
Li	nd	0.22	0.2	nd	0.21
Sr	0.08	0.13	0.1	0.16	0.13
W	nd	nd	nd	nd	nd
HCO_3	111	126	87	62	83
SO_4	31	26	33	27	34
Cl	8	16	2	8	7
F	16	13	18	11.2	18
TDS (meas.)	286	268	240	164	238
pH (lab)	9.6	9.0	9.3	8.8	9.3

Table 1 (cont.)
Chemistry of Wood River District
Water Samples

Sample Number	31	32	33
Site Name	McCoy Mine (stream)	Ohio Creek Spr.	Seeps E. of Bellevue
Location[1]	02N 18E 31 DBC	03N 18E 16 ACC	01N 20E 5 CC
Collection Date	18 July 1982	18 July 1982	17 July 1982
Collection Temp. (°C)	10	19.5	13
Flow (l/m)	12	2	low
Na	3.5	2.4	3.5
K	1.4	1.2	0.8
Ca	26	12	32
Mg	6	3	8
Fe	nd	nd	nd
SiO_2	18	30	34
B	nd	nd	nd
Li	nd	nd	nd
Sr	0.11	0.08	0.27
W	nd	nd	nd
HCO_3	116	40	142
SO_4	4	4	2
Cl	5	6	3
F	0.7	0.2	0.3
TDS (meas.)	179	134	156
pH (lab)	7.4	7.2	7.6

1 See Mitchell and others, 1980, p. 4, for explanation of Idaho well- and spring-numbering system.
2 Flow estimate from Mitchell and others, 1980.
3 Not Detected

Acknowledgement

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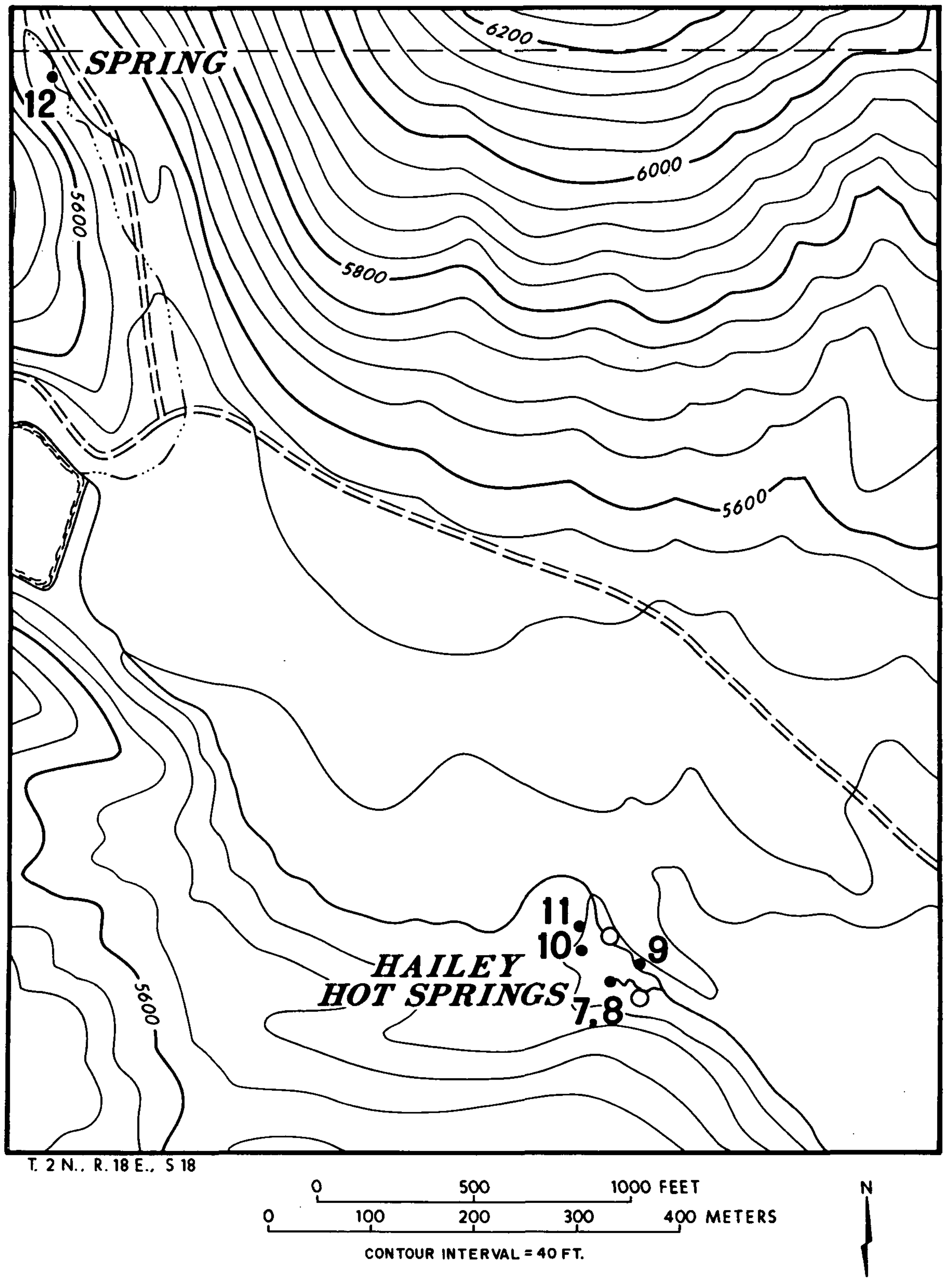

FIGURE 4. WATER SAMPLE SITES, HAILEY HOT SPRINGS AREA