

STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
Carson City



Humboldt River Valley near Winnemucca, Nevada

GROUND-WATER RESOURCES – INFORMATION SERIES
REPORT III

CONTRIBUTIONS TO THE HYDROLOGY OF NORTHERN NEVADA

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By
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Geologist
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OCTOBER 1962

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FOREWORD

This publication, Report No. III in the Water Resources-Information Series, consists of five short papers by Philip Cohen, geologist with the U. S. Geological Survey.

Two of these papers report on phases of an investigation of the waters of Truckee Meadows in western Nevada. The data given in the other three papers were collected in the course of a study of the hydrology and geology of the Winnemucca section of the Humboldt River Basin under the Humboldt River Cooperative Research Project. This project, which involves cooperation with a number of federal and state agencies, is sponsored and coordinated by the Department of Conservation and Natural Resources. The hydrological work in this project is being conducted by the U. S. Geological Survey with the field investigations under the direct supervision of Mr. Cohen.

We feel that workers in the field of geohydrology will find these papers of interest and value.

Hugh A. Shamberger, Director,
Department of Conservation and Natural Resources

STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

URANIUM IN THE WATERS OF THE TRUCKEE MEADOWS AREA, NEVADA

by
Philip Cohen

Prepared Cooperatively by the
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URANIUM IN THE WATERS OF THE TRUCKEE MEADOWS AREA, NEVADA ^{1/}

by
Philip Cohen

ABSTRACT

Forty-seven water samples collected in the Truckee Meadows area, an alluviated intermontane basin in western Nevada, were analyzed for uranium and for the principal dissolved constituents. Some of the relationships between uranium and other chemical constituents described by other writers are verified in the study of the hydrogeochemistry of the Truckee Meadows area; others are not.

The following relationships between uranium and bicarbonate-plus-carbonate content, uranium and chloride content, and uranium and sulfate content were observed in the waters of the Truckee Meadows area: (1) Uranium content tends to increase as the bicarbonate-plus-carbonate content increases, (2) thermal, chloride-rich waters of the Steamboat Springs area are relatively deficient in uranium, (3) some waters high in sulfate content are relatively rich in uranium; others are not.

Because of the variability in concentration and the complex interrelationships between the bicarbonate, carbonate, sulfate, and chloride anions, and because uranium content appears to be dependent upon these variables, uranium has little value as a tool for studying the hydrogeochemistry of the area.

INTRODUCTION

Purpose and Scope of the Report

This report discusses the occurrence of uranium in the waters of the Truckee Meadows area and evaluates the use of uranium as a tool for studying the hydrogeochemistry of the area. The study is a supplement to an investigation of the water resources of the Truckee Meadows area which currently is being made by the U.S. Geological Survey in cooperation with the Nevada Department of Conservation and Natural Resources. The report is based largely on a study of chemical and radiochemical analyses of 47 water samples. The samples were collected from selected sites after evaluating more than 200 analyses of waters of the area that had been made prior to the present study.

Previous Investigations and Acknowledgments

Barker and Scott (1958) discussed the potential value of uranium as a tool for studying the geochemistry of ground water and showed a theoretical and statistical relationship between uranium and the bicarbonate content, and between

^{1/} Expanded version of a paper published in the Journal of Geophys. Research, v. 66, no. 12, p. 4199-4206, Dec. 1961.

uranium and dissolved-solids content. Their report is the framework upon which the present study is based. Scott encouraged the use of radiochemical analyses in the study of the hydrogeochemistry of the Truckee Meadows area and arranged for the analysis of all but one of the samples discussed in this report.

Brannock, Fix, Gianella, and White (1948) and White (1957a; 1957b) developed several important geochemical concepts relative to the Steamboat Springs area in the southern part of the Truckee Meadows area. In addition, White made a considerable amount of unpublished material available to the writer. Thompson (1956) discussed some aspects of the geochemistry of the area. His geologic maps have been significant aids in the present study.

O. J. Loeltz, district engineer in charge of U.S. Geological Survey ground water investigations in Nevada, in the course of his collaboration with the writer on the investigation of the water resources of the Truckee Meadows area, provided valuable assistance in the preparation of this report.

GEOGRAPHIC SETTING

Truckee Meadows, an alluviated intermontane basin in western Nevada, is bordered on the west by the Carson Range--an offshoot of the Sierra Nevada, on the east by the Virginia Range, and on the north and south by spurs of these two ranges. The valley is drained by two perennial streams, Steamboat Creek and the Truckee River. The Truckee River, which is the master stream, heads in the Sierra Nevada and follows a meandering course eastward through Reno and across Truckee Meadows. It leaves the valley through a bedrock gorge in the Virginia Range. Steamboat Creek enters the valley from the south and joins the Truckee River near the railroad siding of Vista. (See fig. 1.)

GEOLOGIC FEATURES

Truckee Meadows is at the western margin of the Great Basin section of the Basin and Range physiographic province. The valley is bordered by maturely eroded fault-block mountains and is partially filled with unconsolidated and partly consolidated alluvial deposits.

The bordering mountains are composed of igneous, metamorphic, and sedimentary rocks that range in age from Mesozoic (?) to Quaternary. The Carson Range consists in large part of granitic rocks of Cretaceous (?) age that were emplaced into a complex sequence of metamorphic rocks of Triassic (?) age. Pyroclastic rocks, lava, and lake beds cover much of the older granitic and metamorphic rocks. The Virginia Range is composed predominantly of volcanic rocks of intermediate to basic chemical composition. Granodiorite of Miocene (?) age has intruded and, in part, hydrothermally altered the volcanic rocks. The ore bodies of the famous Comstock lode, which is about 20 miles southeast of Reno, are associated with this intrusive.

The deposits of the valley fill, which probably are more than 3,500 feet thick, range in age from Pliocene to Recent. The predominantly fresh-water lake deposits of the Truckee formation are of Pliocene age and consist of relatively

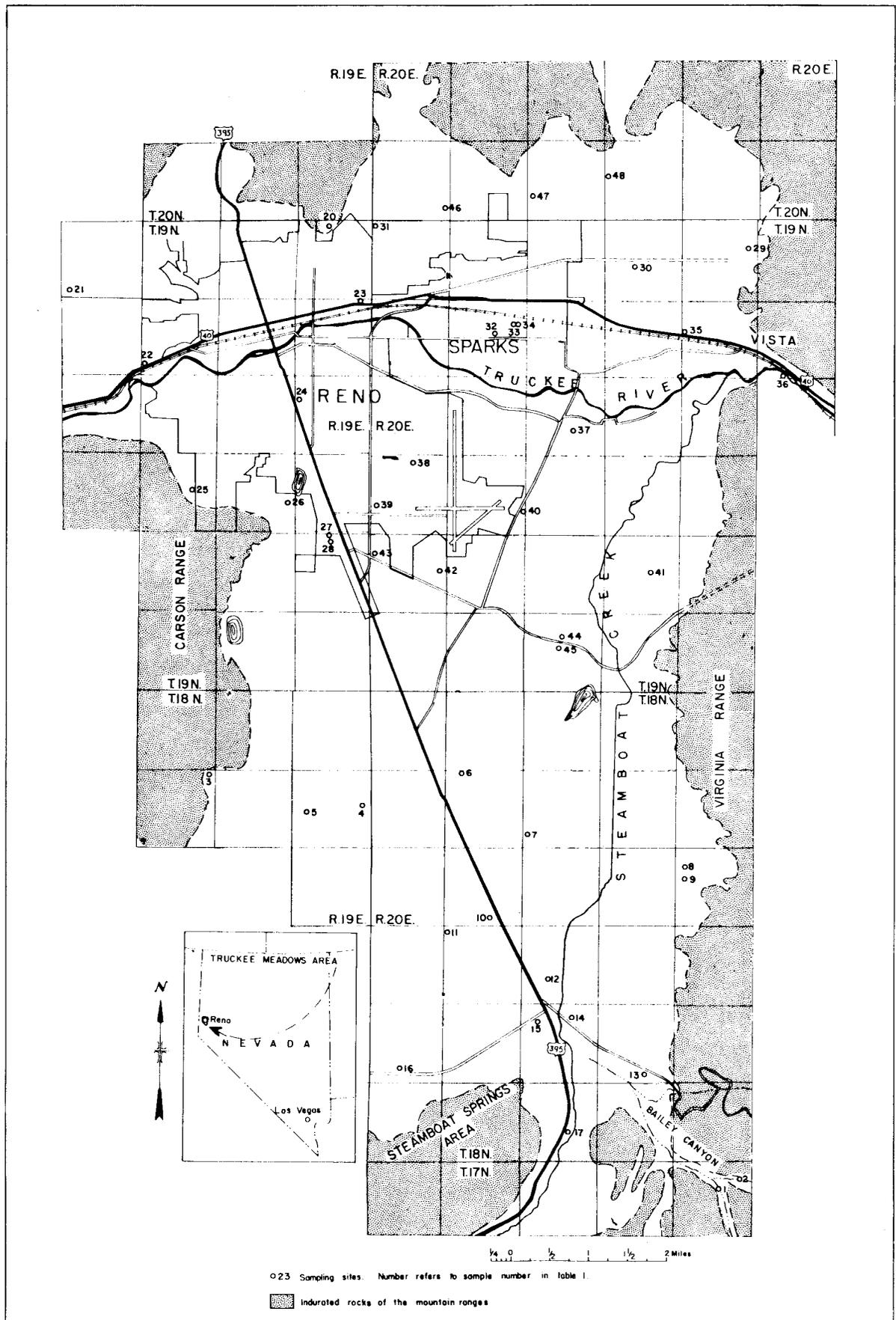


Fig. 1. Map of the Truckee Meadows area showing the location of sampling sites.

impermeable diatomite and partly cemented gravel, sand, silt, clay, and tuff. Moderately permeable alluvial deposits of late Pliocene, Pleistocene, and Recent age overlie the Truckee formation with pronounced angular unconformity.

The rocks of pre-Tertiary age have been intensely folded and thrust-faulted. Younger, normal faults have broken the mountain ranges into distinct structural troughs and ridges which trend roughly northward. Normal faults also have deformed and cut much of the alluvium which forms the valley fill.

HYDROLOGIC FEATURES

Virtually all the economically recoverable ground water in Truckee Meadows occurs in the alluvial deposits of the valley fill. The principal source of recharge to both the confined and the unconfined aquifers of the valley fill is the Truckee River. Recharge occurs by infiltration directly from the Truckee River and also by seepage from irrigation ditches and by infiltration of excess water diverted from the Truckee River for irrigation. Lesser amounts of ground-water recharge occur as a result of infiltration of precipitation and seepage loss from ephemeral streams flowing across the alluvial aprons.

The principal means of ground-water discharge include seepage directly into the Truckee River and Steamboat Creek, seepage into irrigation and drainage ditches in the lower parts of the valley, and evapotranspiration. Lesser amounts of ground water are discharged by wells and springs.

CHEMICAL QUALITY OF THE WATERS

Location of Sampling Sites

The location of most of the water sampling sites is shown in figure 1. Two sites are outside of figure 1; sample 18 was collected from Lawton's Hot Springs, and sample 19 was collected from the Truckee River near the hot springs. Lawton's Hot Springs is in the canyon of the Truckee River, in sec. 13, T. 19 N., R. 18 E., about 2 miles west of the northwest corner of the map.

The 47 radiochemical analyses, one additional analysis, plus other pertinent data are shown in table 1.

Classification of the Waters

Some of the more important factors considered in evaluating the geochemistry of the waters of the Truckee Meadows area are enumerated below:

1. The complex chemical composition of the deposits of the valley fill and the rocks of the bordering mountains.
2. The complex stratigraphy and structural deformation of the aquifers.

Table 1.--Chemical analyses of waters of the Truckee Meadows area

Sample number	Location	Source	Depth (feet)	Date of collection	Temperature (°F)	Calcium (Ca)		Magnesium (Mg)		Sodium (Na)		Potassium (K)		Uranium (U)		Bicarbonate (HCO ₃)		Carbonate (CO ₃)		Sulfate (SO ₄)		Chloride (Cl)		Dissolved solids (residue at 180° C)		Diagram field
						ppm	epm	ppm	epm	ppm	epm	ppm	epm	ppb	ppm	epm	ppm	epm	ppm	epm	ppm	epm	ppm	epm	ppm	
1	SW ₂ NE ₂ sec. 2, T. 17 N., R. 20 E.	Stream--south branch of Bailey Canyon	--	1-27-58	46	101	5.04	26	2.14	31	1.35	2.6	0.07	--	286	4.69	0	0.00	191	3.98	6.4	0.18	543	II		
2	SE ₂ NE ₂ sec. 2, T. 17 N., R. 20 E.	Stream--north branch of Bailey Canyon ²	--	4-17-59	54	290	14.47	116	9.54	90	3.92	3.2	.08	0.4	0	.00	0	.00	2,570	53.51	10	.28	4,020	II		
3	NE ₂ NE ₂ sec. 10, T. 18 N., R. 19 E.	Lone Tree Spring	--	1-14-58	60	18	.90	6.6	.54	19	.83	4.1	.10	.3	138	2.26	0	.00	6.4	.13	3.0	.09	176	III		
4	SE ₂ NE ₂ sec. 12, T. 18 N., R. 19 E.	Well-----	135	6- 3-58	59	26	1.30	14	1.15	14	.61	2.9	.07	.7	164	2.69	0	.00	8.8	.18	7.1	.20	210	III		
5	NW ₂ SW ₂ sec. 12, T. 18 N., R. 19 E.	----- do -----	240	1-14-58	59	42	2.10	14	1.15	19	.83	3.3	.08	1.9	222	3.64	0	.00	8.4	.18	4.0	.11	264	III		
6	NW ₂ NW ₂ sec. 8, T. 18 N., R. 20 E.	----- do -----	20	5-13-58	63	25	1.25	14	1.15	14	.61	5.9	.15	2.9	183	3.00	0	.00	4.1	.09	1.5	.04	236	III		
7	SW ₂ SW ₂ sec. 9, T. 18 N., R. 20 E.	----- do -----	84	5-19-58	80	10	.50	4.6	.38	160	6.96	14	.36	1.7	224	3.67	0	.00	17	.35	160	4.51	709	I		
8	NW ₂ NW ₂ sec. 14, T. 18 N., R. 20 E.	----- do -----	--	5-14-58	75	63	3.14	46	3.78	313	13.62	31	.79	2.0	264	4.33	0	.00	151	3.14	511	14.41	1,540	I		
9	SW ₂ NW ₂ sec. 14, T. 18 N., R. 20 E.	----- do -----	48	-- do --	71	68	3.39	43	3.43	202	8.79	24	.61	3.3	258	4.23	0	.00	125	2.60	360	10.15	1,230	I		
10	SW ₂ SE ₂ sec. 17, T. 18 N., R. 20 E.	Spring-----	--	1-14-58	94	9.3	.46	2.1	.17	130	5.66	15	.38	2.0	224	3.67	0	.00	17	.35	94	2.65	514	I		
11	NW ₂ NW ₂ sec. 20, T. 18 N., R. 20 E.	Well-----	107	6- 3-58	57	26	1.30	11	.90	16	.70	6.0	.15	4.0	164	2.69	0	.00	4.4	.09	3.5	.10	187	III		
12	NE ₂ SW ₂ sec. 21, T. 18 N., R. 20 E.	----- do -----	44	5-19-58	73	19	.95	4.6	.38	22	.96	5.7	.15	4.1	126	2.07	0	.00	5.8	.12	6.0	.16	221	III		
13	SW ₂ SE ₂ sec. 27, T. 18 N., R. 20 E.	----- do -----	195	3-29-59	85	114	5.69	36	2.96	100	4.35	5.8	.15	.2	148	2.54	0	.00	508	10.58	6.2	.17	929	II		
14	NW ₂ NE ₂ sec. 28, T. 18 N., R. 20 E.	----- do -----	80	5-14-58	72	34	1.70	9.2	.76	83	3.61	6.6	.17	1.6	241	3.95	0	.00	22	.46	73	2.06	439	I		
15	NE ₂ NW ₂ sec. 28, T. 18 N., R. 20 E.	----- do -----	151	6- 3-58	271	1.4	.07	0	.00	660	28.71	68	1.74	.7	172	2.82	65	2.17	130	2.71	836	23.58	2,230	I		
16	SE ₂ SW ₂ sec. 30, T. 18 N., R. 20 E.	----- do -----	300	2-11-58	67	26	1.30	4.9	.40	22	.96	2.5	.06	.3	162	2.66	0	.00	.4	.01	2.9	.08	172	III		

Table 1.--Chemical analyses of waters of the Truckee Meadows area--continued

Sample number	Location	Source	Depth (feet)	Date of collection	Temperature (°F)	Calcium (Ca)		Magnesium (Mg)		Sodium (Na)		Potassium (K)		Uranium (U)		Carbonate (CO ₃)	Sulfate (SO ₄)	Chloride (Cl)		Dissolved solids (residue at 180° C)		
						ppm	epm	ppm	epm	ppm	epm	ppm	epm	ppm	epm			ppm	epm		ppm	epm
17	NW $\frac{1}{2}$ SE $\frac{1}{4}$ sec. 33, T. 18 N., R. 20 E.	Spring (Steamboat Springs)	--	2-5-57	136	14	.70	1.9	.16	644	28.01	59	1.51	<.1	328	0	.00	2.96	790	2,130	I	
18	SW $\frac{1}{2}$ NE $\frac{1}{4}$ sec. 13, T. 19 N., R. 18 E.	Lawton Hot Springs	--	2-11-58	120	6.2	.31	.1	.01	117	5.09	5.4	.14	.1	12	.20	.67	3.00	57	1.61	361	II
19	SW $\frac{1}{2}$ NE $\frac{1}{4}$ sec. 13, T. 19 N., R. 18 E.	Truckee River	--	4-17-59	53	7.6	.38	3.4	.28	7.6	.33	1.6	.04	.2	47	.77	.00	.18	2.0	.06	75	II
20	NE $\frac{1}{2}$ NW $\frac{1}{4}$ sec. 1, T. 19 N., R. 19 E.	Well-----	23	5-20-58	57	354	17.66	137	11.27	400	17.40	4.0	.10	.43	435	7.13	.00	1,680	96	2.70	3,420	II
21	SW $\frac{1}{2}$ SW $\frac{1}{4}$ sec. 4, T. 19 N., R. 19 E.	----- do -----	295	5-19-58	61	62	3.09	20	1.64	25	1.09	1.0	.03	.3	133	2.18	.00	173	5.8	.16	429	II
22	SW $\frac{1}{2}$ SW $\frac{1}{4}$ sec. 10, T. 19 N., R. 19 E.	----- do -----	90	2-11-58	55	42	2.10	14	1.15	19	.83	2.5	.06	3.6	233	3.82	.00	8.2	.17	3.4	249	III
23	NE $\frac{1}{2}$ NE $\frac{1}{4}$ sec. 12, T. 19 N., R. 19 E.	----- do -----	583	6-2-58	57	71	3.54	17	1.40	23	1.00	2.2	.06	6.8	240	3.93	.00	69	1.44	.39	367	II
24	SW $\frac{1}{2}$ NW $\frac{1}{4}$ sec. 13, T. 19 N., R. 19 E.	----- do -----	213	5-21-58	65	38	1.90	16	1.32	16	.70	3.2	.08	3.8	176	2.88	.00	38	.79	6.7	251	II
25	SW $\frac{1}{2}$ NE $\frac{1}{4}$ sec. 22, T. 19 N., R. 19 E.	----- do -----	184	2-13-58	74	51	2.55	7.1	.58	23	1.00	2.6	.07	2.9	156	2.56	.00	48	1.00	.62	307	II
26	NE $\frac{1}{2}$ SE $\frac{1}{4}$ sec. 23, T. 19 N., R. 19 E.	----- do -----	103	5-20-58	99	21	1.05	4.1	.34	199	8.66	3.7	.10	3.5	211	3.46	.00	325	6.77	.90	856	II
27	NE $\frac{1}{2}$ NW $\frac{1}{4}$ sec. 25, T. 19 N., R. 19 E.	----- do -----	700	2-11-58	114	15	.75	.1	.01	150	6.53	8.2	.21	.2	134	2.20	.00	221	4.60	.68	581	II
28	NE $\frac{1}{2}$ NW $\frac{1}{4}$ sec. 25, T. 19 N., R. 19 E.	----- do -----	67	-- do --	96	16	.80	.7	.06	130	5.66	2.6	.07	.6	165	2.70	.00	153	3.19	.45	532	II
29	SE $\frac{1}{2}$ NE $\frac{1}{4}$ sec. 2, T. 19 N., R. 20 E.	----- do -----	210	5-13-58	62	21	1.05	3.4	.28	59	2.57	3.2	.08	1.0	128	2.10	.00	59	1.23	.68	259	II
30	NE $\frac{1}{2}$ SW $\frac{1}{4}$ sec. 3, T. 19 N., R. 20 E.	----- do -----	213	2-13-58	58	28	1.40	7.4	.61	25	1.09	6.1	.16	.1	76	1.25	.53	66	1.37	6.5	256	II
31	NW $\frac{1}{2}$ NW $\frac{1}{4}$ sec. 6, T. 19 N., R. 20 E.	----- do -----	147	5-20-58	58	69	3.44	26	2.14	52	2.26	4.1	.10	6.6	246	4.03	.00	144	3.00	.59	524	II
32	SW $\frac{1}{2}$ NE $\frac{1}{4}$ sec. 8, T. 19 N., R. 20 E.	----- do -----	41	1-14-58	53	32	1.60	11	.90	12	.52	2.6	.07	1.0	155	2.54	.00	11	.23	7.4	187	III

Table 1.--Chemical analyses of waters of the Truckee Meadows area--continued

Table 1.--Chemical analyses of waters of the Truckee Meadows area--continued

Sample number	Location	Source	Depth (feet)	Date of collection	Temperature (°F)	Calcium (Ca)		Magnesium (Mg)		Sodium (Na)		Potassium (K)		Uranium (U)	Bicarbonate (HCO ₃)		Carbonate (CO ₃)		Sulfate (SO ₄)		Chloride (Cl)		Dissolved solids (residue at 180°C)	Diagram field ¹
						ppm	epm	ppm	epm	ppm	epm	ppm	epm		ppb	ppm	epm	ppm	epm	ppm	epm	ppm		
33	SE $\frac{1}{2}$ NE $\frac{1}{4}$ sec. 8, T. 19 N., R. 20 E.	Well-----	451	1-14-58	68	11	.55	2.9	.24	48	2.09	9.4	.24	4.1	106	1.74	0	.00	59	1.23	3.1	.09	250	II
34	SE $\frac{1}{2}$ NE $\frac{1}{4}$ sec. 8, T. 19 N., R. 20 E.	----- do -----	18	2-13-58	54	42	2.10	13	1.07	94	4.09	4.6	.12	.6	135	2.21	0	.00	14	.29	170	4.79	511	I
35	SW $\frac{1}{2}$ NW $\frac{1}{4}$ sec. 11, T. 19 N., R. 20 E.	----- do -----	340	-- do --	--	51	2.54	27	2.22	43	1.87	7.6	.19	3.2	190	3.11	0	.00	153	3.02	33	.93	467	II
36	SE $\frac{1}{2}$ SW $\frac{1}{4}$ sec. 12, T. 19 N., R. 20 E.	Truckee River	--	4-17-59	56	19	.95	6.3	.52	22	.96	4.8	.12	.7	100	1.64	0	.00	21	.44	13	.37	171	II
37	NW $\frac{1}{2}$ SE $\frac{1}{4}$ sec. 16 T. 19 N., R. 20 E.	Well-----	18	5-19-58	--	35	1.75	12	.99	17	.74	3.9	.10	5.1	167	2.74	0	.00	25	.52	7.2	.20	216	II
38	NW $\frac{1}{2}$ NE $\frac{1}{4}$ sec. 19 T. 19 N., R. 20 E.	----- do -----	197	1-14-58	60	28	1.40	7.7	.63	25	1.09	5.1	.13	1.9	139	2.28	0	.00	39	.81	7.8	.22	223	II
39	NW $\frac{1}{2}$ SW $\frac{1}{4}$ sec. 19, T. 19 N., R. 20 E.	----- do -----	24	1-13-58	67	40	2.00	5.0	.41	120	5.22	9.5	.24	.3	222	3.64	0	.00	174	3.62	20	.56	584	II
40	NE $\frac{1}{2}$ SE $\frac{1}{4}$ sec. 20 T. 19 N., R. 20 E.	----- do -----	61	-- do --	51	26	1.30	7.6	.63	48	2.09	5.1	.13	3.1	181	2.97	0	.00	51	1.06	5.1	.14	302	II
41	SW $\frac{1}{2}$ NE $\frac{1}{4}$ sec. 27, T. 19 N., R. 20 E.	----- do -----	650	-- do --	72	107	5.34	41	3.37	160	6.96	21	.54	3.3	241	3.95	0	.00	225	4.68	264	7.44	1,061	I
42	SE $\frac{1}{2}$ NE $\frac{1}{4}$ sec. 30, T. 19 N., R. 20 E.	----- do -----	83	-- do --	54	33	1.65	21	1.73	31	1.35	5.6	.14	3.4	256	4.20	0	.00	26	.54	4.5	.13	305	III
43	SW $\frac{1}{2}$ NW $\frac{1}{4}$ sec. 30, T. 19 N., R. 20 E.	----- do -----	600	-- do --	76	18	.90	.3	.02	170	7.40	9.5	.24	.2	116	1.90	0	.00	280	5.83	30	.85	655	II
44	SE $\frac{1}{2}$ NW $\frac{1}{4}$ sec. 33, T. 19 N., R. 20 E.	----- do -----	70	5-13-58	58	36	1.80	13	1.06	75	3.26	8.0	.20	2.0	260	4.26	0	.00	18	.37	62	1.75	418	I
45	SE $\frac{1}{2}$ NW $\frac{1}{4}$ sec. 33, T. 19 N., R. 20 E.	Spring-----	--	-- do --	62	21	1.05	8.7	.72	60	2.61	4.9	.13	1.4	207	3.39	0	.00	15	.31	29	.82	306	I
46	SE $\frac{1}{2}$ SE $\frac{1}{4}$ sec. 31, T. 20 N., R. 20 E.	Well-----	66	5-20-58	56	122	6.09	24	1.97	56	2.44	2.6	.07	9.5	289	4.74	0	.00	239	4.98	20	.56	696	II
47	NW $\frac{1}{2}$ SW $\frac{1}{4}$ sec. 33, T. 20 N., R. 20 E.	----- do -----	85	5-13-58	56	62	3.09	15	1.23	92	4.00	3.8	.10	8.4	397	6.51	0	.00	82	1.71	7.0	.20	503	II
48	SW $\frac{1}{2}$ NW $\frac{1}{4}$ sec. 34, T. 20 N., R. 20 E.	----- do -----	39	2-13-58	50	92	4.59	34	2.80	43	1.87	3.6	.09	4.1	185	3.03	0	.00	271	5.64	18	.51	729	II

1 See figure 2.

2 Contains 105 ppm SiO₂ and 160 ppm Al; pH 3.1.

3. Exchange between ions in the waters and those in the rocks in which the waters occur.
4. Mixing of highly mineralized waters from hot springs and areas of bleached rock with relatively dilute irrigation waters.

Partly because of these factors, a chemical classification system of the waters of the area was needed. Many classification systems were tested before one was found to be suitable. The classification adopted is based solely upon the major anions - sulfate, chloride, bicarbonate, and carbonate. Each water sample is shown on a trilinear diagram in which the vertexes of the triangle represent a composition of 100 percent equivalents per million of sulfate, chloride, or bicarbonate plus carbonate. (see fig. 2.) The diagram is subdivided into three fields as follows:

(1) Waters in which the percentage of chloride is greater than the percentage of sulfate, and the percentage of bicarbonate plus carbonate is less than 80 percent of the sum of the major anions. Waters of this composition are plotted in field I on figure 2 and are classified as chloride waters.

(2) Waters in which the percentage of sulfate is greater than the percentage of chloride, and the percentage of bicarbonate plus carbonate is less than 80 percent of the sum of the major anions. Waters of this composition are plotted in field II and are classified as sulfate waters.

(3) Waters in which the percentage of bicarbonate plus carbonate is greater than 80 percent of the sum of the major anions. Waters of this composition are plotted in field III and are classified as bicarbonate-carbonate waters.

Mixtures and Sources of the Waters

It is convenient to use the terms "high bicarbonate-carbonate waters," "high chloride waters," and "high sulfate waters" to describe some of the waters of the Truckee Meadows area. The high bicarbonate-carbonate waters are relatively rich in bicarbonate (or bicarbonate plus carbonate), have a low dissolved-solids content, and are indicative of waters from the Truckee River and some of the smaller streams in the area. High chloride waters are rich in chloride, have a high dissolved-solids content, and are associated with the thermal waters of the Steamboat Springs system. High sulfate waters are rich in sulfate, have a high dissolved-solids content, and are associated with bleached rocks.

Most of the samples shown in figure 2 are mixtures of either high sulfate or high chloride waters and high bicarbonate-carbonate waters. Samples 18 and 41 are exceptions. They are mixtures of high chloride and high sulfate waters. Samples 15 and 17 are considered typical high chloride (predominantly sodium chloride) waters. Sample 15 is from a relatively deep well, and sample 17 is from a hot spring. Both sample sources are in the Steamboat Springs area.

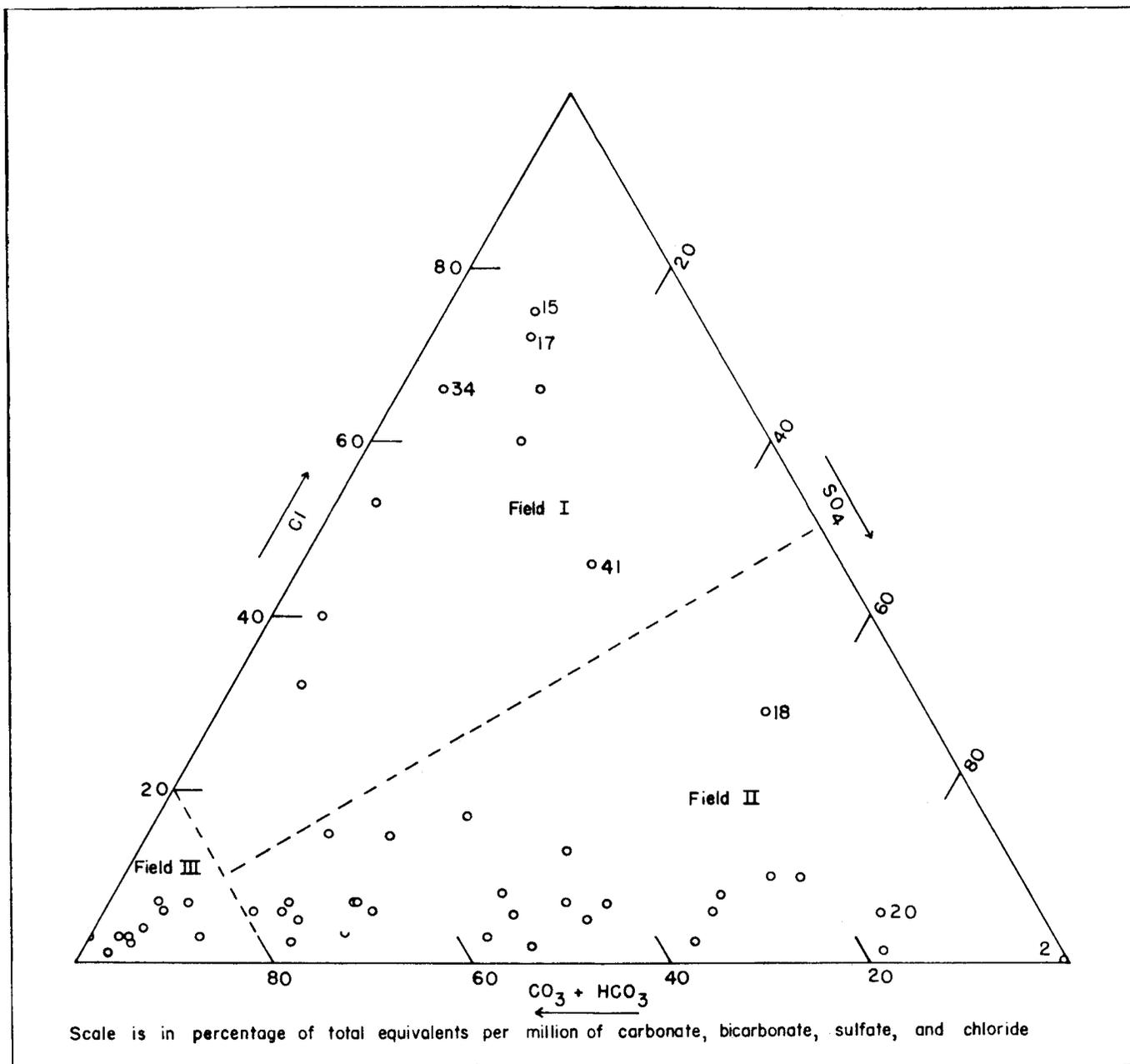


Fig. 2. Classification of the waters of the Truckee Meadows area.

Samples 2 and 20 are considered to be typical of the high sulfate waters of the area. Sample 2 is from the stream in the north branch of Bailey Canyon, and sample 20 is from a shallow well in hydrothermally altered andesite.

All the samples in field I, except sample 34, are associated with or are downgradient from Steamboat Springs. Sample 34 was obtained from an 18-foot deep dug well adjacent to a railroad siding. Much of the ground near the well is covered with sodium chloride, which was used to ice railroad cars. Presumably, the chloride in the sample was derived from leaching of the sodium chloride.

Bleached rocks are the principal source of sulfate in the waters that are plotted in field II. The mineral assemblages of most of the rocks older than the Truckee formation have been modified to some degree by hydrothermal alteration. For example, andesitic rocks of early and middle Tertiary age commonly contain minerals indicative of secondary alteration, such as albite, clinozoisite, chlorite, epidote, calcite, and some zeolites (Thompson, 1956, p. 63). Pyrite (FeS_2) was introduced into these rocks coincident with or soon after the formation of these minerals, and as a result of the near-surface oxidation of pyrite and the formation of sulfuric acid, almost all the hydrothermally altered rocks exposed to weathering have been bleached. The end products of the bleaching are dominantly clay and some quartz and opal.

Unlike the chloride waters that are mostly derived from a single source (Steamboat Springs), sulfate waters are found throughout the area. Samples having the greatest percentage and the largest concentration of sulfate are closest to areas of bleached rock. Because areas of bleached rock are present in all the mountains bordering the valley, many, but not all, of the streams that drain these mountains and recharge the ground-water system contain waters having high concentrations of sulfate.

The relationship between bleached rock and high sulfate water is illustrated by samples of water from Bailey Canyon. Sample 1, containing 3.98 epm (equivalents per million) sulfate, was obtained from the small stream in the south branch of Bailey Canyon. This stream drains an area underlain by rock that, for the most part, is not bleached. Sample 2, containing 53.51 epm sulfate, was obtained from a stream of similar size in the north branch of Bailey Canyon. This stream drains an area underlain for the most part by bleached rock.

Uranium

The uranium content of 47 samples collected in the Truckee Meadows area ranged from less than 0.1 to 43 ppb (parts per billion); the median was 1.7 ppb. This compares with a range of 0.9 to 12 ppb and a median of 6.2 ppb for 47 samples of the ground waters of the Ogallala formation of Texas and New Mexico, and a range of less than 0.1 to 22 ppb and median of 1.6 ppb for 67 random samples from fluvial deposits throughout the United States (Barker and Scott, 1958, p. 462).

The uranium content of the waters of the Truckee Meadows area tends to increase as the bicarbonate-plus-carbonate content increases. (See fig. 3) This verifies the findings of Barker and Scott (p. 463), who state that this relationship is a function of the increased solubility of uranium as the bicarbonate content increases, presumably because uranium and bicarbonate form relatively soluble uranyl carbonate complexes.

Other relationships involving uranium are suggested by comparing figures 2 and 3. Most of the analyses that plot in field II of figure 2 tend to fall to the left or above the curve in figure 3, indicating that most of the sulfate waters sampled tend to contain relatively more uranium than the chloride or bicarbonate-carbonate waters having the same concentration of bicarbonate plus carbonate. Sample 20, which had the third highest percentage and second largest concentration of sulfate, was richest in uranium, containing 43 ppb. All points in field I, except sample 24 whose anomalous chloride content is explained on page 8, fall to the right or below the curve, suggesting that the chloride waters contain less uranium than either sulfate or bicarbonate-carbonate waters of comparable concentrations of bicarbonate plus carbonate. Samples 15 and 17, which contained the highest percentages and highest concentrations of chloride, fall farthest to the right of the curve in figure 3. Thus, although the amount of uranium in the waters of the Truckee Meadows area appears to be a function of bicarbonate-plus-carbonate content, it also is related to the chloride and sulfate contents. However, plots of uranium in ppb against chloride in epm and of uranium in ppb against sulfate in epm show little or no correlation. Therefore, it is concluded that of the three variables, bicarbonate-plus-carbonate content is more important than either sulfate or chloride content in affecting the quantity of uranium in the waters of the Truckee Meadows area.

The reason for the relative deficiency of uranium in the chloride waters of the Truckee Meadows area is not known. It is possible that chloride may inhibit the solution of uranium or that the high temperatures of the chloride waters at their source (Steamboat Springs) may in some way be related to the deficiency. The deficiency also may be due to other factors related to the springs system.

Sample 20 contained 34.98 epm of sulfate and 43 ppb of uranium. On the other hand, sample 2 contained 53.51 epm of sulfate and only 0.4 ppb of uranium. However, sample 20 contained 7.13 epm of bicarbonate plus carbonate, whereas sample 2 was reported to contain zero bicarbonate plus carbonate. The ground waters downgradient from the site at which sample 20 was collected tend to be relatively rich in uranium. The uranium content of the ground waters downgradient from the site at which sample 2 was collected is not unusually high. (See analysis of sample 13.) It is hypothesized that the sulfate waters near sampling site 20 are relatively rich in uranium because the hydrothermally altered rocks in that locale are relatively rich in uranium compounds probably associated with metallic sulfide compounds. The uranium content of many of the other sulfate waters of the Truckee Meadows area is not unusually high because some of the hydrothermally altered rocks probably have not been enriched with uranium. It does not seem unusual that in an area of regional hydrothermal alteration, heavy metallic compounds, such as those of uranium, are emplaced only in relatively small, localized areas.

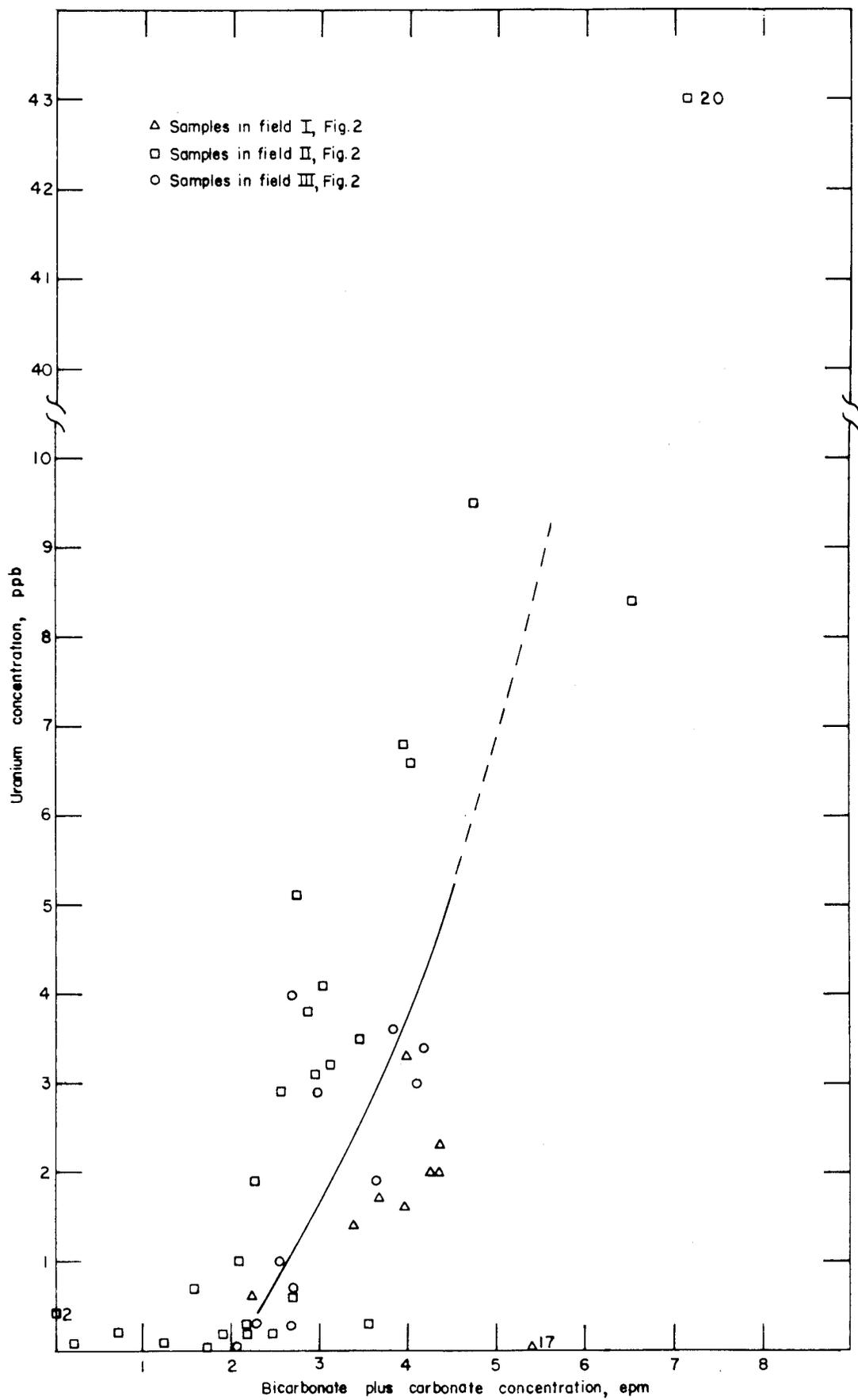


Fig. 3. Relationship between uranium concentration and bicarbonate-carbonate concentration in the waters of the Truckee Meadows area.

The waters studied by Barker and Scott (1958, p. 463-464) showed a tendency toward an increasing concentration of uranium with an increase in dissolved solids. Barker and Scott observed that, in general, waters at successive down-gradient sampling sites were relatively richer in uranium than those at up-gradient sites. They state, "The down-gradient increase in uranium content probably is a result of the water at successive down-gradient locations having been in the aquifer longer than water obtained from up-gradient sources."

Figure 4 relates uranium content in ppb against dissolved-solids content in ppm. According to the method used by Barker and Scott (1958, p. 464), two groups of points are shown in figure 4--one group in which bicarbonate plus carbonate is greater than 50 percent (open circles), and one group in which bicarbonate plus carbonate is equal to or less than 50 percent of the principal anions (solid circles). There appears to be a slight indication of correlation between uranium content and dissolved-solids content in the former group but not in the latter group. Barker and Scott determined that there was a correlation between uranium and dissolved-solids content in both groups; however, the correlation was better in the former group.

Some probable reasons for the relatively poor correlation between the uranium and dissolved-solids content of the waters of the Truckee Meadows area are as follows: (1) Chloride waters tend to have a high dissolved-solids content and are relatively deficient in uranium. (2) Some of the sulfate waters of high dissolved-solids content are relatively rich in uranium, but other sulfate waters of high dissolved-solids content are not. (3) The uranium content of the rocks of the area probably is extremely variable.

CONCLUSIONS

The uranium content of the waters of the Truckee Meadows area is not a significant aid in itself for evaluating the hydrogeochemistry of the area. It is inferred, therefore, that uranium alone will not be very useful for evaluating the hydrogeochemistry of similar alluviated intermontane basins in the Basin and Range physiographic province. However, uranium may be useful for evaluating the hydrogeochemistry of monolithologic or near-monolithologic terranes. In addition, an evaluation of uranium in the waters of an area, if closely related to a study of the geology of the area, may result in a better understanding of the hydrologic factors that control the occurrence, movement, and chemical quality of those waters.

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STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

SOURCE OF SULFATE IN GROUND WATER OF THE
TRUCKEE MEADOWS AREA, NEVADA

by
Philip Cohen

Prepared Cooperatively by the
Geological Survey, U. S. Department of the Interior

October, 1962

SOURCE OF SULFATE IN GROUND WATER OF THE ^{1/} TRUCKEE MEADOWS AREA, NEVADA

by
Philip Cohen

In many of the intermontane valleys in Nevada, the dissolved-solids content of ground water increases with increasing distance from recharge areas (for example, see Zones, 1961, p. 38). However, in the Truckee Meadows area the dissolved-solids content of the ground water tends to decrease with increasing distance from recharge areas largely because the recharge areas contribute water having a high dissolved-solids and a high sulfate content.

Figure 114.1, a trilinear diagram, shows the percentage of the major anions, $\text{CO}_3 + \text{HCO}_3$, SO_4 , and Cl (in equivalents per million) in 113 surface-water and ground-water samples from the Truckee Meadows area. The diagram is divided into three fields as follows: Field 1--chloride water, in which the percentage of Cl is greater than the percentage of SO_4 , and the percentage of $\text{CO}_3 + \text{HCO}_3$ is less than 80 percent of the major anions; field 2--sulfate water, in which the percentage of SO_4 is greater than the percentage of Cl, and the percentage of $\text{CO}_3 + \text{HCO}_3$ is less than 80 percent of the sum of the major anions; field 3--carbonate-bicarbonate water, in which the percentage of $\text{CO}_3 + \text{HCO}_3$ is greater than 80 percent of the sum of the major anions.

The consolidated rocks of the mountains bordering the area are dominantly basalt, andesite, and granodiorite, but include lesser amounts of metamorphic and sedimentary rocks. Hydrothermal alteration of these rocks has resulted in the formation of such minerals as chlorite, epidote, some zeolites, and pyrite and other metallic sulfides. Sulfurous and sulfuric acid and ferrous and ferric sulfate, which formed as a result of oxidation and hydration of the metallic sulfides, have bleached the hydrothermally altered rocks. The bleached rocks are rich in sulfate compounds and consist predominantly of clay, opal, and some quartz.

Areas of bleached rock occur locally in all the mountains bordering the Truckee Meadows area, and the dissolved-solids and sulfate content of the streams draining these areas is high. Also, the water from wells penetrating bleached rock has a high dissolved-solids and sulfate content. Samples A and B on figure 114.1 are from a stream draining an area of bleached rock and from a shallow well in bleached rock, respectively. The dissolved-solids content of the

^{1/} Reprint of Art. 114 in U.S. Geol. Survey
Prof. Paper 450-C, 1962.

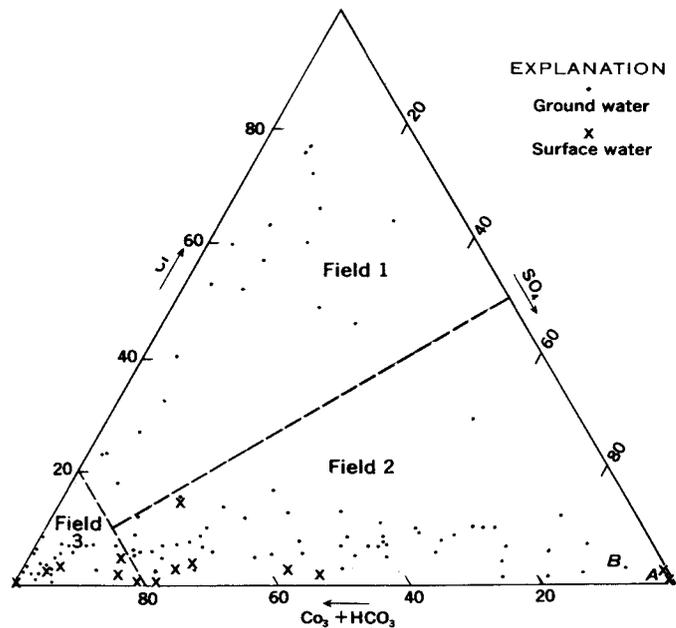


FIGURE 114.1.—Relative concentration of major anions in water of the Truckee Meadows area, Nevada.

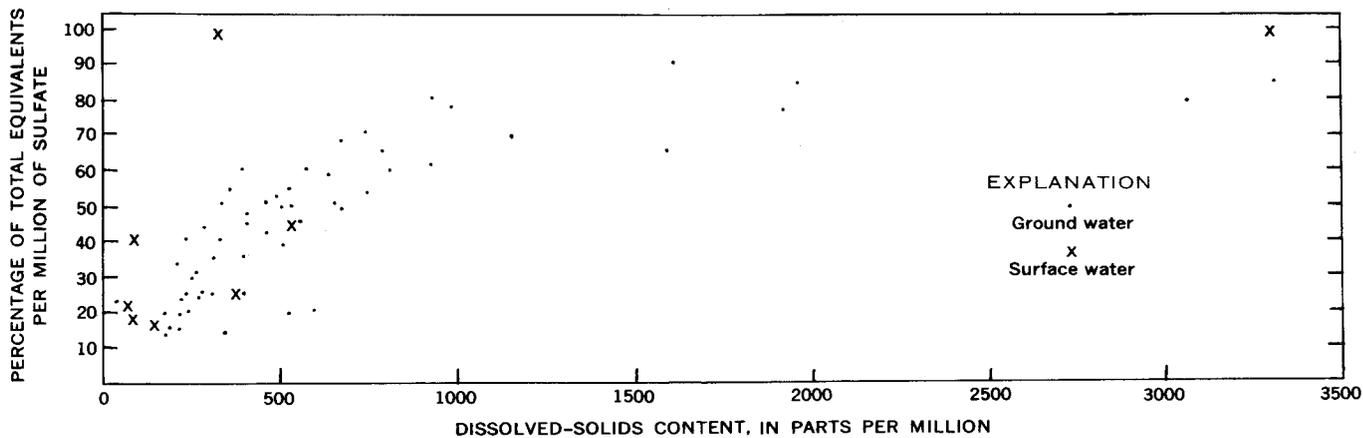


FIGURE 114.2.—Relation between the percentage of equivalents per million of sulfate and the dissolved-solids content in the sulfate water of the Truckee Meadows area, Nevada.

samples is 3,300 and 3,060 parts per million, and the sulfate content is 2,570 and 1,680 parts per million, respectively.

The sulfate-rich streams draining areas of bleached rock discharge onto the alluvial apron bordering the valley; part of the water recharges the alluvial deposits of the ground-water reservoir and moves down-gradient toward the axis of the valley. As the sulfate-rich water moves down-gradient, it is diluted by infiltration of irrigation water of low dissolved-solids content diverted into the basin from the Truckee River, which drains the Sierra Nevada west of the Truckee Meadows area.

Virtually all the carbonate-bicarbonate water is derived from the Truckee River or from streams draining areas of unbleached rock. All the water has a low dissolved-solids content, commonly less than 250 parts per million. The relatively continuous band of points along the base of the triangle represents samples that are mixtures of highly mineralized sulfate water and dilute carbonate-bicarbonate water. The percentage of sulfate decreases from right to left in the samples represented by the band of points. In addition, the dissolved-solids content decreases from right to left, as is shown on figure 114.2.

Although there are some exceptions, most of the samples that plot in field 2 are, from right to left, progressively farther down-gradient from areas of bleached rock. This strongly suggests that most of the sulfate is derived from streams draining areas of bleached rock rather than from the solution of sulfate compounds in the alluvial deposits of the ground-water reservoir.

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STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

HYDROGEOLOGIC EVIDENCE OF THE EXTENSION OF THE EAST RANGE
FAULT, HUMBOLDT AND PERSHING COUNTIES, NEVADA

by
Philip Cohen

Prepared Cooperatively by the
Geologic Survey, U. S. Department of the Interior

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HYDROGEOLOGIC EVIDENCE OF THE EXTENSION OF THE EAST RANGE

FAULT, HUMBOLDT AND PERSHING COUNTIES, NEVADA ^{1/}

by
Philip Cohen

Faults and associated phenomena are known to influence the occurrence and movement of ground water, and apparent hydrologic anomalies commonly are explained on the basis of inferred faults. Less commonly, as in this report, hydrogeologic evidence is used to demonstrate the existence or extension of a fault.

A northward-trending, westward-dipping, high-angle normal fault, herein referred to as the East Range fault (fig. 4.1) borders the western slope of the East Range, Humboldt and Pershing Counties, Nev., where it was mapped by Ferguson, Muller, and Roberts (1951). Evidence of the fault includes fault scarps, displaced strata, slickensides, brecciated zones, and hydrothermal mineralization.

During current hydrologic studies, about 175 test borings were drilled in the unconsolidated deposits of the Humboldt River basin near Winnemucca, Nev. Some of the hydrogeologic data thus collected suggest that the East Range fault extends at least about 2 miles farther northward than previously mapped.

The Krum Hills, the unnamed hills north of the Humboldt River, and that part of the East Range shown in figure 4.1 are composed of dense sedimentary and igneous rocks of Mesozoic age and basaltic lava flows of late Tertiary or Quarternary age. These rocks generally have low permeability and therefore do not transmit appreciable amounts of water, except perhaps through fractured zones.

Most of the ground water of the area is in relatively unconsolidated sedimentary deposits that range in age from Pliocene to Recent. These strata include fanglomerate of Pliocene or Pleistocene age, lacustrine deposits of Pleistocene Lake Lahontan age, and fluvial and subaerial flood-plain deposits of Recent age.

The fanglomerate ranges from well-sorted moderately permeable sand and gravel to poorly sorted relatively impermeable slope wash. The Lake Lahontan deposits include three stratigraphic units: A so-called lower silt and clay, a medial gravel, and an upper silt and clay; the lower two units are recognized

^{1/} Reprint of Art. 4 in U.S. Geol. Survey
Prof. Paper 450-B, 1962.

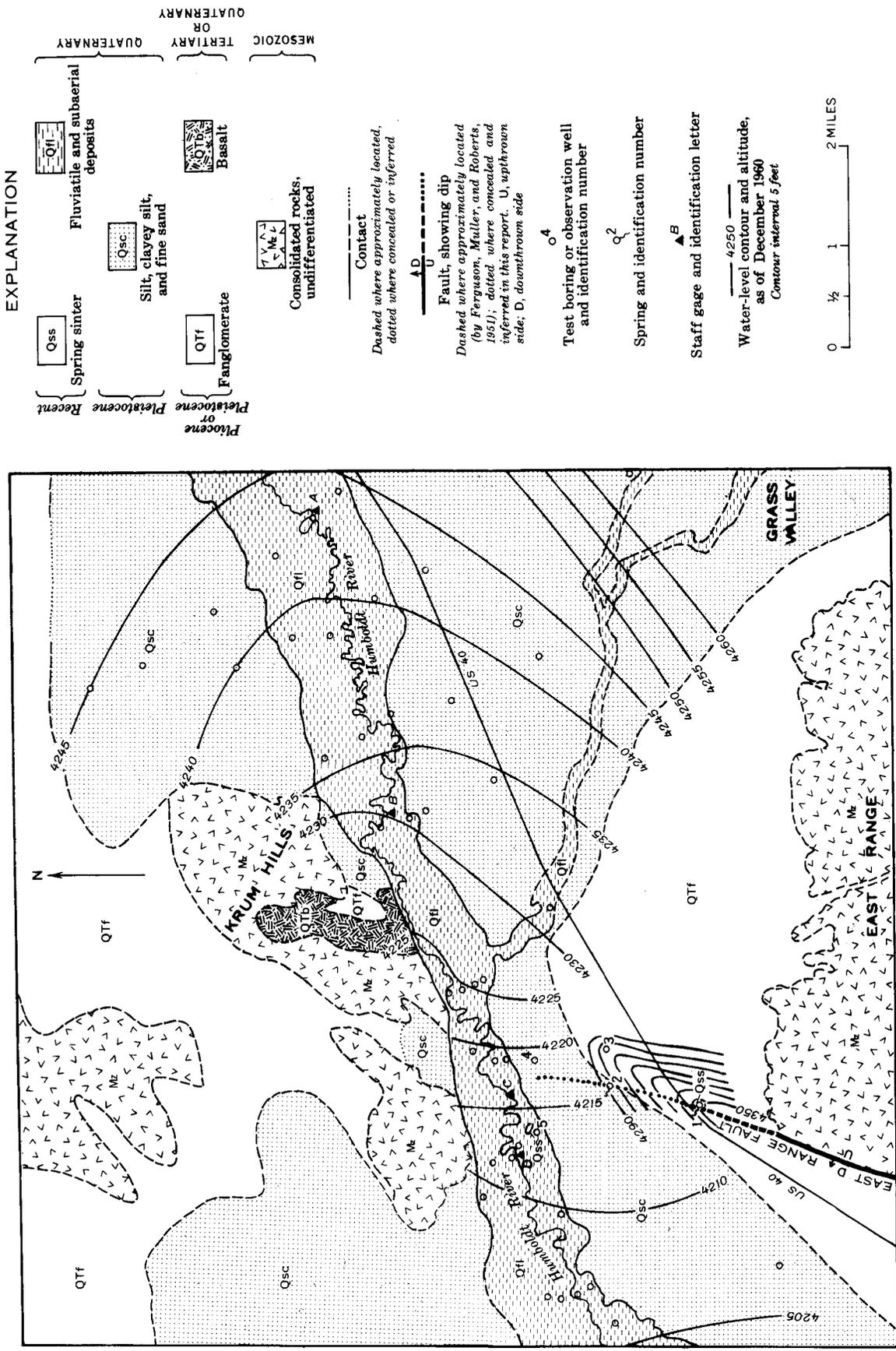


FIGURE 4.1.—Generalized hydrogeologic map of a segment of the Humboldt River valley.

only in the subsurface. The lower silt and clay unit, whose thickness is uncertain, and the upper silt and clay unit, which is about 55 feet thick, consist largely of dense relatively impermeable silt, clayey silt, and clay. The medial gravel, whose maximum thickness is about 150 feet, consists of well-sorted highly permeable sand and gravel. The flood-plain deposits range from highly permeable stringers of sand and gravel to relatively impermeable lenses of silty clay and clay.

The water-level contours of figure 4.1 show the shape of the piezometric surface in December 1960 and suggest that the principal ground-water movement is westward and southwestward, roughly parallel to the course of the Humboldt River.

Streamflow of the Humboldt River tends to increase, especially during periods of low flow, between the east margin of the mapped area shown on figure 4.1 and staff gage D. The increase of streamflow, about 5 to 6 cubic feet per second, is largely a result of the discharge of ground-water underflow from Grass Valley into the Humboldt River. Part of the increase, however, may be due to a partial ground-water barrier beneath the channel of the Humboldt River, the barrier being related to the northward extension of the East Range fault.

Other hydrogeologic evidence which suggests that the East Range fault probably extends farther northward than previously mapped includes (a) an area of rising thermal ground water partly indicated by springs 1 and 2, (b) dense siliceous rock exposed in the flood plain about 300 feet north of well 5, (c) thermal water and iron oxide-coated pebbles found in well 5, (d) intense hydrothermal alteration of the material penetrated in well 3, (e) the occurrence of a bedrock high as indicated by the material penetrated in well 4, and (f) the dissolved-solids content of the waters of the area.

A local ground-water mound, as defined by the water levels at springs 1 and 2 and well 3, is about 100 feet above the regional water table. The temperature of the water at springs 1 and 2 and well 3 is 83° F, 82° F, and 82° F, respectively, about 20° F to 25° warmer than the water in all but one of the other wells shown in figure 4.1. The relatively high temperature of the thermal waters presumably is due largely to the contribution of deeply circulating ground water moving through fractured zones associated with the fault and discharging into the alluvium.

Calcareous and siliceous spring sinter is exposed at and near the orifice of spring 1. The previously mentioned siliceous rock exposed in the flood plain north of well 5 suggests former hot-spring activity at least as far north as that exposure.

The medial gravel unit of Lake Lahontan age was penetrated in well 5 from the land surface to a depth of 83 feet. The pebbles and sand grains are almost completely coated with iron oxide. The temperature of the water in the well is 84° F. This is the only test boring in the flood plain in which thermal

water was observed in the medial gravel and in which the particles of the deposit are coated with iron oxide. The iron oxide coatings probably are related to the thermal water, and the thermal water is interpreted as being associated with the fault.

Well 3 penetrated poorly sorted coarse fanglomerate from the land surface to a depth of 32 feet. The stratum beneath the fanglomerate is a dense plastic variegated clay containing small fragments of amorphous silica. The occurrence, texture, and color of the clay, plus the relatively high temperature of the water in the well, also suggest hydrothermal activity--activity that probably is related to the fault.

Well 4 penetrated the upper silt and clay unit of Lake Lahontan age from the land surface to a depth of 42 feet, fanglomerate from 42 to 75 feet, and basalt at a depth of 75 feet. The basalt is believed to be part of the upthrown side of the fault block bounded by the East Range fault, and it is tentatively correlated with the basalt exposed to the northwest across the Humboldt River.

The dissolved-solids content of the waters of springs 1 and 2 and wells 3, 4, and 5 is about 4 to 5 times greater than the dissolved-solids content of the waters of the other wells and of the water of the Humboldt River. Also, the chemical character of the waters of springs 1 and 2 and wells 3 and 4 differs markedly from the chemical character of the other waters in the area. The waters associated with the fault are sodium bicarbonate waters, whereas the other waters of the study area are mixed types.

On the basis of the aforementioned hydrogeologic evidence, it is postulated that the East Range fault extends at least as far northward as shown in figure 4.1. It may extend northward across the Humboldt River, but this is uncertain.

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STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

ESTIMATING POROSITY FROM SPECIFIC GRAVITY

by
Philip Cohen

Prepared Cooperatively by the
Geological Survey, U. S. Department of the Interior

October 1962

ESTIMATING POROSITY FROM SPECIFIC GRAVITY ^{1/}

by
Philip Cohen

As a part of a hydrologic study, 115 samples of the unconsolidated deposits of a 40-mile segment of the flood plain and terraces of the Humboldt River, Humboldt County, Nev., were collected in the summer of 1960. Eighty-two undisturbed samples were collected by means of a 2-inch-diameter Pomona core barrel; 33 disturbed samples also were collected. All of the samples were collected from a depth less than 20 feet below land surface.

For all samples the dry unit weight (apparent specific gravity) and the average unit weight of the particles comprising each sample (absolute specific gravity), were determined at the Hydrologic Laboratory of the Ground Water Branch of the Survey at Denver, Colo. From these data, porosity was determined by the following formula:

$$n = 100 \frac{y_s - y_d}{y_s}$$

where n = porosity, in percent by volume;

y_s = average unit weight of the particles comprising the sample in grams per cubic centimeter (absolute specific gravity);

y_d = dry unit weight of the dry undisturbed or repacked sample, in grams per cubic centimeter (apparent specific gravity).

The absolute specific gravity of the samples was determined by the pycnometer method (Krumbein and Pettijohn, 1938, p. 501). The dry unit weight of the undisturbed cores was determined by measuring the volume and weighing the oven-dried cores; the dry unit weight of the disturbed samples was determined by measuring the volume and oven-dried weight of samples that were repacked in the laboratory.

It is apparent from the above equation that a graph with porosity as the abscissa and dry unit weight as the ordinate will plot as a straight line for samples having the same absolute specific gravity (average unit weight of particles). This relationship is true irrespective of other factors such as particle size, particle shape, degree of assortment, sedimentary structures, or degree of compaction. For mineralogically or lithologically heterogeneous deposits, the points tend to be scattered--the degree of scattering being related to differences in the absolute specific gravity of the samples.

^{1/} Reprint of Art. 15 in U. S. Geol. Survey
Prof. Paper 450-B, 1962.

Figure 15.1 is a graph showing the relation of porosity and dry unit weight of the samples of the Humboldt River valley. The points on the graph tend to define a straight line and fall in a very narrow band, indicating that the absolute specific gravity of the samples does not vary substantially. The deposits of the flood plain of the Humboldt River contain many different minerals and rock types derived largely from the erosion of Quaternary and Tertiary alluvial fans and Pleistocene lake deposits. It appears from the graph that the older deposits were thoroughly reworked and mixed by the Humboldt River, causing the resulting flood-plain deposits to have a fairly constant absolute specific gravity.

Dry unit weight is equal to the average unit weight when porosity is equal to zero (see equation), and the approximate average unit weight of the particles comprising all the samples can be obtained by extending the line shown in figure 15.1 so that it intersects the ordinate. Thus, the average unit weight of particles of the samples plotted is about 2.67.

The aforementioned relations between porosity and dry unit weight can be useful in future hydrogeologic studies in the Humboldt River valley. In the present area of study, it is possible to use figure 15.1 to estimate porosity from dry unit weight with an approximate accuracy of ± 1.5 percent. This degree of accuracy is adequate for the present study. In order to estimate porosity from dry unit weight in other areas it will be necessary to determine dry unit weight, absolute specific gravity, and porosity of a sufficient number of samples to define the relation between these parameters. Once this relation is defined, it is necessary only to determine dry unit weight in order to estimate porosity.

The relation between porosity and dry unit weight also may be useful in other areas where lithologic and stratigraphic control permits an accurate estimate of average unit weight of particles. If this value alone is known for any deposit, a straight-line graph similar to figure 15.1 can be drawn showing the relation between the dry unit weight and the porosity of the deposit. From the equation, it is apparent that the line must intersect the abscissa, or zero dry unit weight line, where porosity equals 100 percent, and the line must intersect the ordinate, or zero porosity line, at the value of the average unit weight of particles (absolute specific gravity) for the deposit.

At present, dry-unit-weight data are being collected by means of the nuclear density meter in many areas. A few determinations of dry unit weight (apparent specific gravity) then may make it possible to obtain a fairly accurate estimate of the porosity and the absolute specific gravity of all the materials tested with the meter by use of a plot similar to that described. The absolute specific gravity of any sample represented by a point plotted on a graph similar to figure 15.1 could be ascertained by drawing a straight line from the 100-percent porosity value on the abscissa through the point to the ordinate. The dry-unit-weight value at the point of intersection of the line and the ordinate is equal to the absolute specific gravity of the sample.

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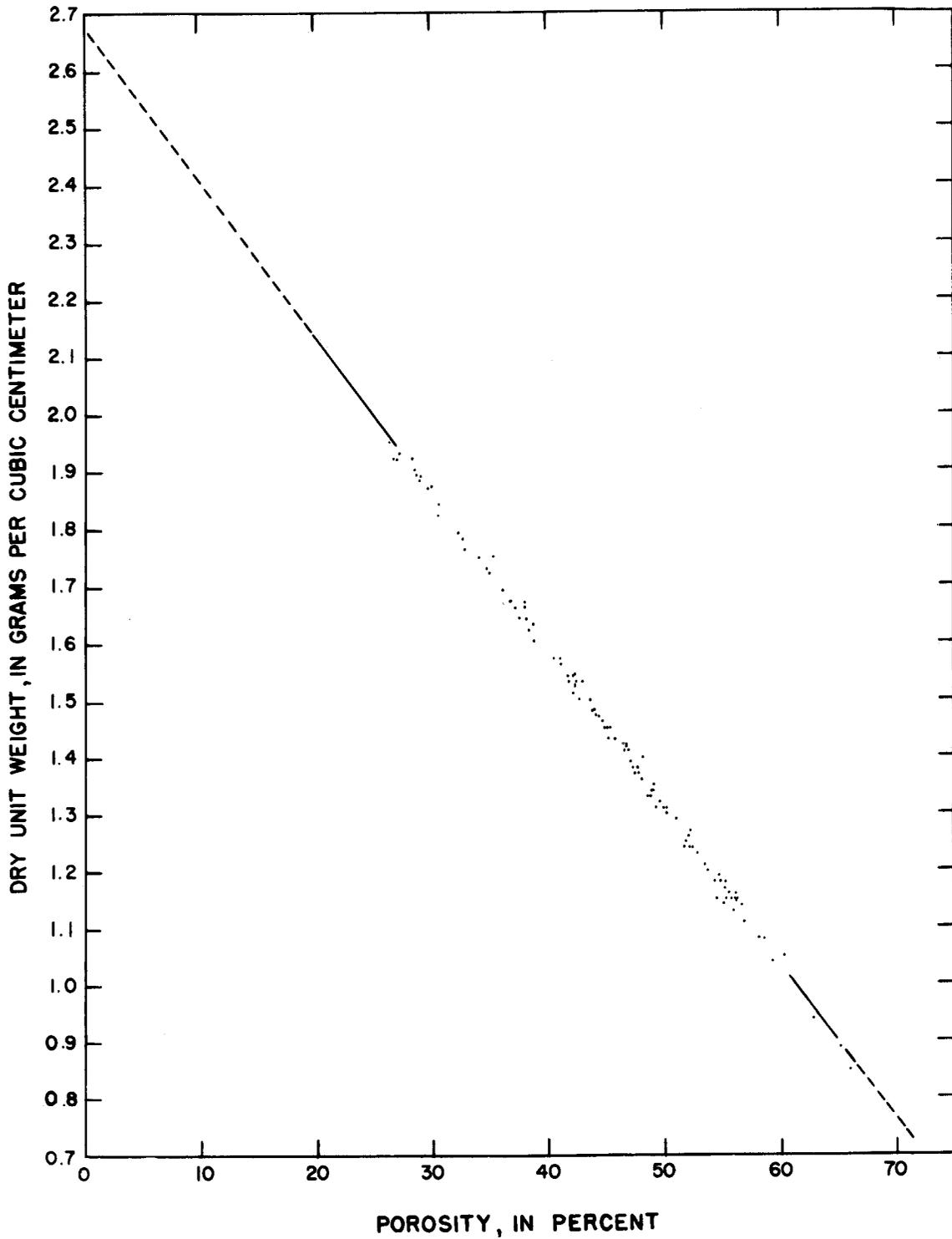


FIGURE 15.1.—Relation between porosity and dry unit weight in the Humboldt River Valley, Humboldt County, Nev.

STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

STRATIGRAPHY AND ORIGIN OF LAKE LAHONTAN DEPOSITS OF THE
HUMBOLDT RIVER VALLEY NEAR WINNEMUCCA, NEVADA

by
Philip Cohen

Prepared Cooperatively by the
Geological Survey, U. S. Department of the Interior

1962

STRATIGRAPHY AND ORIGIN OF LAKE LAHONTAN DEPOSITS OF THE
HUMBOLDT RIVER VALLEY NEAR WINNEMUCCA, NEVADA^{1/}

by
Philip Cohen

Russell (1885) described the deposits of Lake Lahontan, a large Pleistocene lake that covered much of northwestern and north-central Nevada, and Morrison (1961) described the Lake Lahontan deposits in the Carson Desert near Fallon, Nev. However, only the youngest Lake Lahontan deposits are exposed in the Winnemucca area (fig. 81.1) and little was known about the geology of the Lake Lahontan deposits except for a few details about the uppermost units.

As part of a hydrogeologic investigation, test holes ranging in depth from about 15 to 120 feet were drilled in 1959 and 1960 at 175 locations in the area shown on figure 81.1. The drilling program yielded considerable information about the geology of the Lake Lahontan deposits. Five major lithologic units were recognized (three in the subsurface); the character and distribution of these units give a fairly clear picture of the history of Lake Lahontan within the area. The stratigraphic relations among most of these units are shown diagrammatically in figure 81.2.

The oldest Lake Lahontan deposit, recognized only in the subsurface in the study area, is termed the Lahontan lower silt and clay (fig. 81.2 Q11). This unit is correlated with the lower lacustral clays of Russell and the Eetza Formation of Morrison. It was penetrated with certainty in only two wells in Grass Valley. One of the wells was drilled with a cable-tool drill and this afforded an opportunity to examine fairly sizable fragments of the unit. The unit is about 20 feet thick and consists of alternating beds of silt, clayey silt, and silty clay. The beds of clayey silt and silty clay are gray to dark gray, blocky, and contain ostracodes.

A second unit of Lake Lahontan age, recognized only in the subsurface in Grass Valley, interfingers with upper beds of the Lahontan lower silt and clay. This unit, termed Lahontan alluvium (fig. 81.2, Q1a), is tentatively correlated with the upper part of the Eetza Formation and the lower part of the Wyemaha Formation as described by Morrison (1961, p. 111-112). Its maximum thickness is about 35 feet, and it consists of interfingering fluvial and windblown deposits of gravel, sand, silt, and clay.

The upper part of the Lahontan alluvium interfingers with the thickest Lake Lahontan unit, which is termed Lahontan medial gravel (fig. 81.2, Q1g). This unit is correlated with Russell's medial gravels and Morrison's Wyemaha Formation. More details are known about the character and distribution of this

^{1/} Reprint of Art. 81 in U.S. Geol. Survey Prof. Paper 450-C, 1962.

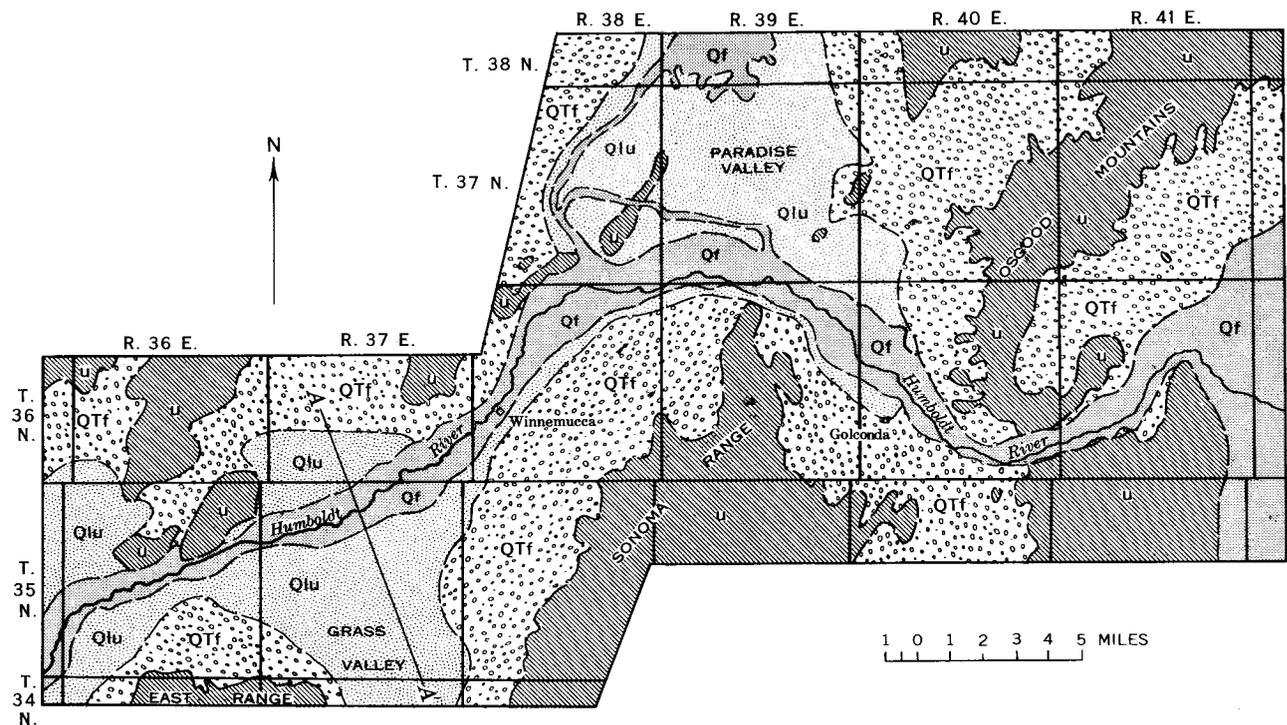


FIGURE 81.1.—Generalized geologic map of a segment of the Humboldt River valley, Humboldt and Pershing Counties, Nev. U, undifferentiated consolidated rocks ranging in age from Cambrian to Pleistocene(?). QTf, undifferentiated Tertiary and Quaternary alluvial-fan and lacustrine deposits. Qlu, Lahontan upper silt and clay. Qf, fluvatile and lacustrine deposits of post-Lake Lahontan age.

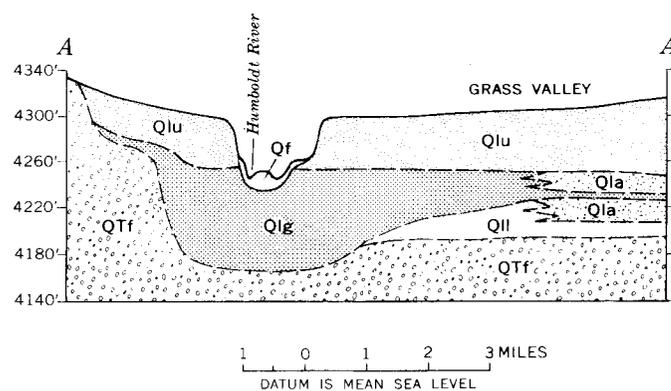


FIGURE 81.2.—Diagrammatic geologic cross section of the Humboldt River valley near the mouth of Grass Valley. QTf, undifferentiated Tertiary and Quaternary alluvial-fan and lacustrine deposits. Qll, Lahontan lower silt and clay. Qla, Lahontan alluvium. Qlg, Lahontan medial gravel. Qlu, Lahontan upper silt and clay. Qf, fluvatile and lacustrine deposits of post-Lake Lahontan age.

unit than the two previously described units because it was penetrated by more than 50 test holes and wells in the area. It ranges in thickness from a few inches to about 150 feet and consists of lenses of moderately to well-sorted gravel and coarse to medium sand. It extends from the western margin of the area eastward to the vicinity of Golconda and perhaps as far eastward as the eastern margin of the study area. The deposit probably is thickest beneath the flood plain of the Humboldt River, having filled a deep, broad pre-Lake Lahontan valley of the Humboldt River.

A fourth unit, termed the Lahontan upper silt and clay (fig. 81.2, Qlu), disconformably overlies the Lahontan medial gravel. This unit is correlated with Russell's upper lacustral clays and Morrison's Sehoo Formation. It is exposed throughout much of the area, and thick sections of the unit are exposed along river-cut scarps bordering the flood plain of the Humboldt River (fig. 81.1). The unit consists of beds of clay, silty clay, clayey silt, and very fine to medium sand. Individual beds, which range in thickness from a few inches to about 10 feet, can be traced for as much as 10 miles along the scarps bordering the Humboldt River, and the contacts between beds commonly are sharp. The thickness of the unit ranges from a few inches to about 60 feet. Although it contains silty and sandy beds throughout the area, the percentage of coarse-grained material tends to increase markedly upstream from Winnemucca and along the margins of Grass Valley and Paradise Valley.

The fifth lithologic unit of Lake Lahontan age is termed Lahontan gravel-bar deposits. It interfingers with and is partly of the same age as the Lahontan upper silt and clay. The gravel-bar deposits commonly are covered by a thin layer of the upper silt and clay and are exposed chiefly in gravel pits, where they commonly consist of steeply dipping beds of sand and gravel. Cobbles up to 6 inches in diameter and imbricate structure are common. The lateral and vertical extent of this unit is small, and it is not shown on figures 81.1 and 81.2.

The following history of Lake Lahontan is inferred from the distribution and character of the deposits:

1. In Pleistocene time an early deep stage of Lake Lahontan covered the study area, probably in response to a change of climate corresponding to the Wisconsin continental glaciation. The Lahontan lower silt and clay unit was deposited at this time.

2. Subsequently, the level of the lake declined and the unit termed Lahontan alluvium was deposited, largely by streams flowing across the former lake bottom.

3. In response to increased precipitation, the flow of the Humboldt River increased, and the river probably carried large volumes of coarse sediments that channeled underlying deposits. Most of the medial gravel was deposited in this manner. The level of the lake rose slowly, and fluctuations of the level of the lake resulted in rapidly transgressing and regressing shorelines.

Beaches and bars associated with shifting shorelines were formed as wave action reworked the sediments brought into the area by the river. In addition, waves reworked some of the alluvial-fan deposits along the margin of the lake.

4. As the level of the lake rose, the medial gravel was covered by the upper silt and clay. The gravel-bar deposits were formed near the shore of this deep stage of the lake.

5. Probably at the end of Wisconsin time the climate became more arid. Lake Lahontan receded from the study area, and the Humboldt River cut into the upper silt and clay. The present terraces along the Humboldt River probably were formed during pauses in the decline of the level of the lake downstream from the study area.

REFERENCES

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Russell, I. C., 1885, Geological history of Lake Lahontan, a Quaternary lake of northwestern Nevada: U.S. Geol. Survey Mon. 11, 228 p.