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By
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July 1961

Production Evaluation Division
Grand Junction Office, AEC
Grand Junction, Colorado

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GEOLOGY AND MINERALOGY

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ABSTRACT

Geochemical data obtained from the analyses of 73 water samples collected in the Stanley area, Idaho, demonstrate the applicability of hydrogeochemical techniques to uranium exploration. Uranium concentrations in surface waters of the area ranged from 0.2 to 22.0 ppb U_3O_8. The geometric mean for 27 samples from the Basin Creek mining area was 3.9 ppb U_3O_8, and the geometric mean for the remainder of the Stanley area was 1.1 ppb U_3O_8 (39 samples). Samples from seven hot springs averaged 0.3 ppb U_3O_8. The conductivity of the surface waters ranged from 45 to 350 micromhos, with the higher conductivities generally found in water from areas underlain by sedimentary rock. The pH of the surface waters varied only slightly from the average value of 7.4.

Twelve of the most highly anomalous uranium concentrations in the Basin Creek district were found from 0.15 to 2 miles downstream from known uranium deposits. Outside Basin Creek district 2 of the 3 highest concentrations are from areas immediately adjacent to Basin Creek district; and of 4 other possible anomalies, one is along the strike of structural trends which may mark an extension of the mineralized area, and the other 3 are presumably influenced by higher conductivity of water from areas of sedimentary rocks. Hot springs waters are geochemically distinct from the surface waters of the uranium district, and apparently are neither contributing unusual amounts of uranium nor dissolving significant amounts of uranium from the surrounding rock.

INTRODUCTION

The purpose of this project was to: (1) investigate the applicability of hydrogeochemical techniques to uranium exploration in the Stanley area; and (2) make a hydrogeochemical reconnaissance survey of the Basin Creek mining district and surrounding area as a step toward evaluation of the uranium potential.

Geography

The Stanley area, as used in this report, comprises the Salmon River drainage area upstream from and including the tributary area of the East Fork Salmon River, and corresponds to the greater part of what Ross (1937, p. 2) previously has called the Bayhorse region. Lying in the mountainous region of south-central Idaho, mainly in southwestern Custer County but partly in northwestern Blaine County, the area is shown on figure 1 in reference to the rest of the state. It includes the Stanley Basin, a wide alluvium-floored depression along the Salmon River south of the town of Stanley, and also the uranium mining area northeast of Stanley.

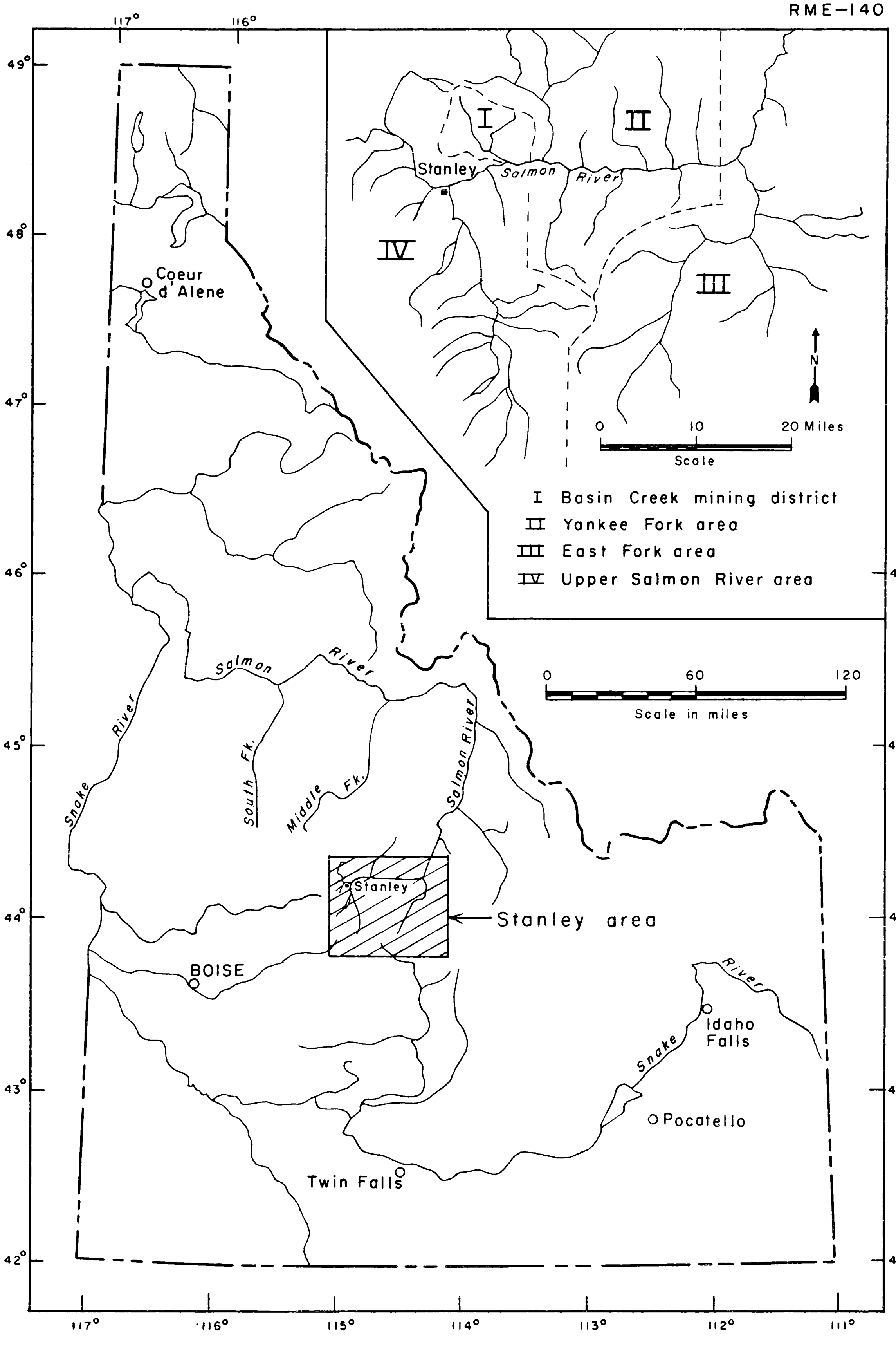

Figure 1. Index map of Idaho showing Stanley area.

The uranium deposits are about 7 miles northeast of Stanley, along the east side of Basin Creek in what may be called the Basin Creek mining district, essentially equivalent to the Stanley uranium area described by Kern (1959, p. 2). Basin Creek, a principal tributary of the upper Salmon River, drains an area of approximately 55 square miles, within which altitudes range from 6000 to 9000 feet. West of Basin Creek the hills are rounded and have broad summits and steep lower slopes. The average gradient on these hills is 650 feet per mile. The topography east of Basin Creek comprises sharp peaks and ridges with steep slopes. The average gradient here is about 900 feet per mile, and on several slopes the gradient exceeds 2500 feet per mile. The average grade along Basin Creek is 100 feet per mile, but the relatively smooth profile is broken by occasional rapids and several flatter stretches bounded by swampy ground. Streams tributary to Basin Creek, in general, have much steeper and more irregular profiles. The drainage pattern of the Basin Creek system is dendritic and most stream junctions occur at acute angles. All the streams sampled for this study in the Basin Creek area appear to have perennial flow, and the discharge at the time of sampling was probably at the lowest level of the year.

Outside the Basin Creek mining district the Stanley area is divided, for this study, into the three subdivisions shown on figure 1. One of these, the Yankee Fork area, comprises the drainage area of Salmon River and tributaries from the Basin Creek district downstream to the mouth of the East Fork. Yankee Fork is the largest north tributary of the Salmon River, draining the area adjacent to Basin Creek on the east as well as about 100 square miles of mountainous terrain to the north. Thompson Creek, a smaller northern tributary of the Salmon River, and two southern tributaries of the Salmon, Warm Springs and Slate creeks, are also included in this subdivision. Warm Springs Creek drains an area of about 75 square miles that is topographically similar to the Basin Creek area. Elevations range from 6000 feet at the confluence with the Salmon to over 10,000 feet in the White Cloud Peaks east of Warm Springs Creek. Although this stream has a steep gradient, as is typical of the entire region, it is unique in flowing through a slightly swampy flat known as "The Meadows" in its middle reaches. In this flat, which is about three miles long and half a mile wide, the stream gradient is only 60 feet per mile as compared to 500 feet per mile upstream and 300 feet per mile downstream.

Another major subdivision is the drainage area tributary to the East Fork of the Salmon River. The East Fork flows north and joins the Salmon where the latter changes direction of flow from east to north. The East Fork and its major tributary, Germania Creek, flow for the most part through country of only moderate relief. The gradient of East Fork is about 40 feet per mile.

Finally, the upper Salmon River area comprises the drainage area upstream from the Basin Creek district. The Salmon River above Stanley flows in a wide alluvium-floored valley, called the Stanley Basin, with an average gradient of 40 feet per mile, in contrast to the narrow, steep-walled valley downstream. The western rim of the basin is formed by the extremely rugged and serrate mountains of the Sawtooth Range. This range has several peaks over 10,600 feet high and is for the most part inaccessible to normal surface exploration. The mountains forming the east flank of Stanley Basin are less formidable with only a few peaks higher than 9000 feet. Hilltops are slightly rounded, only the lower slopes are steep, and access is possible over crude roads and foot trails. Numerous small western tributaries of the Salmon have lakes in their lower reaches, the largest being Redfish Lake, about four miles long and half a mile wide.

GEOLOGY

The geology of the Stanley area can be most simply described in terms of three almost-parallel belts corresponding to three major rock types (see fig. 2). The intrusive Idaho batholith forms the basement and is exposed in a northeast-trending belt comprising most of the western half of the area. The batholith is overlain by Paleozoic sedimentary rocks, which are exposed in a belt, about five miles wide, trending northeastward across the central part of the area. The Paleozoic sedimentary rocks are overlain by the Challis volcanics, which are exposed throughout most of the eastern half of the area, and also in the Basin Creek mining district where they rest directly on the granitic rocks of the Idaho batholith.

Intrusive igneous rocks

Idaho batholith

The Idaho batholith of Cretaceous age consists primarily of calcic quartz monzonite, according to Ross (1937, p. 44), who states that "the quartz monzonite from different places is found to contain 20 to 40 percent of quartz, 30 to 45 percent of plagioclase (mainly oligoclase-andesine), 10 to rarely more than 40 percent microcline, 5 to 15 percent of biotite, exceptionally a little hornblende, and minor amounts of titanite, apatite, and epidote." Ross further describes the batholitic rocks in general as "moderately coarse-grained, gray to pinkish, and, with local exceptions, not conspicuously porphyritic." One of these local exceptions is found in the western part of the Basin Creek district where porphyroblasts of potassium feldspar, up to four inches long, occur. Some true granite is found in the southern part of the area, in the Vienna district near the headwaters of Smiley Creek (Ross, 1937, p. 45).

Silicic intrusive rocks

According to Kern (1959, p. 7), referring to what is here called the Basin Creek district, "light-colored silica-rich rocks cut the batholith throughout the Stanley area. Large bodies of silicic intrusive rock are found in the western part of the area . . . . In the southern and eastern parts of the Stanley area, the silicic intrusive rocks are represented by narrow aplite dikes . . . . The silicic intrusive rocks are regarded as early Tertiary in this report; possibly they were intruded during the Laramide orogeny." Similar aplitic dike rocks along Champion and Fourth of July creeks are reported by Ross (1937, p. 48).

Extrusive igneous rocks

Tertiary volcanic strata, designated as the "Challis volcanics" by Ross (1937, p. 49), comprise the third major rock type exposed in the area. Ross subdivides the Challis volcanics, on the basis of petrographic characteristics, into three members: (1) the lower latite-andesite member; (2) the middle Germer tuffaceous member; and (3) the upper Yankee Fork rhyolite member. Kern (1959, p. 10) tentatively correlates the Germer member with his "Challis formation" in the Basin Creek district, where he subdivides the formation into four units: (1) andesite and latite tuffs and flows; (2) quartz latite porphyry; (3) tuffaceous clastic sedimentary rocks; and (4) arkosic conglomerate. More complete descriptions of the Challis volcanics, and especially the part found in the Basin Creek district, are given in reports by Ross (1937) and Kern (1959).

Challis volcanics overlie Paleozoic sedimentary rocks throughout the east and north sectors of the area. In some localities, notably the Basin Creek district, Challis volcanics rest directly on the Idaho batholith. The thickness of the formation varies considerably, with a maximum of over a mile (Ross and Forrester, 1958, p. 13). In the Basin Creek district Kern (1959, p. 8) reports a thickness of at least 2000 feet exposed.

The age of the Challis volcanics has been considered to be Oligocene and Miocene although some recent evidence suggests that part of the formation, at least, may be older than Oligocene (Ross and Forrester, 1958, p. 14).

Sedimentary rocks

The eastern part of the area is underlain by a thick sequence of sedimentary rocks, which Ross (1937) has divided into twelve formations, representing six of the Paleozoic systems. No known uranium deposits occur in these formations, but general characteristics are listed in table 1 for the ten formations of significant extent upstream in the area of this investigation.

Hot springs

Hot springs are relatively abundant in the area along the Salmon River from Obsidian, in southwestern Custer County, downstream to Clayton. The principal ones are the Sullivan Hot Spring west of Clayton in sec. 27, T. 11 N., R. 17 E.; the springs at Robinson Bar, at the mouth of Warm Spring Creek; Sunbeam Hot Springs about a mile west of the mouth of Yankee Fork; a spring at the mouth of Basin Creek; the Valley Plunge springs at Stanley near the mouth of Valley Creek; and a series of springs about 2 miles southeast of Obsidian. At least three small hot springs are found along the banks of the Salmon River between Stanley and the mouth of Basin Creek; one of these is shown as the location of sample 27. Hot springs are also abundant along the upper reaches of East Fork in the area around the confluence of East Fork and West Pass Creek (T. 8 N., R. 17 E.)

Table 1. Stratigraphic section in the Stanley area, Idaho. (modified from Ross, 1937, p. 10-11)

Age	Formation	Thickness (feet)	Character
Recent and Pleistocene	Alluvium, landslides and glacial deposits	Several thousand (?)	Silt, sand, gravel, coarser detritus.
Miocene or Oligocene	Challis volcanics	Several thousand	Andesite and latite tuffs and flows, quartz latite porphyry, tuffaceous clastics, arkosic conglomerate.
Pennsylvanian	Wood River formation	8000±	Impure quartzite, argillaceous and calcareous, and some limestone.
Upper Mississippian	Brazer limestone	2000±	Generally dolomitic, rather massive; some chert.
Mississippian and older (?)	Milligen formation	3000±	Argillite and argillic quartzite with impure dolomitic beds. Most of the formation has much carbonaceous matter.
Upper Devonian	Grand View dolomite	1250	Moderately dark, well-bedded dolomite, partly quartzitic.
Middle Devonian	Jefferson dolomite	1150	Dark dolomitic limestone.
Middle Silurian	Laketown dolomite	2500±	Moderately light-colored dolomite.
Upper Ordovician	Saturday Mountain formation	3000±	Dark massive dolomite, argillite and shaly dolomite, in part carbonaceous.
Middle Ordovician (?)	Kinnikinic quartzite	3500±	Massive light-colored quartzite; local lenses of dolomite and dolomitic shale.
Lower Ordovician	Ramshorn slate	2000	Dark thin-banded slate predominant with argillite and argillic quartzite.

Ore deposits

A summary of the ore deposits in the portion of south-central Idaho covered by this investigation is taken from Ross and Forrester (1958, p. 47): "The mining districts in Custer and Blaine Counties and adjacent parts of Butte, Camas, and Elmore Counties together constitute the most active and productive mining region in Idaho outside of the Coeur d'Alene region . . . . The lodes of Custer and Blaine Counties and adjacent areas are varied, but the region is known principally for its shear zones in Paleozoic strata with ore shoots principally valuable for lead, silver, and zinc. Many of them also contain copper, gold, antimony, tungsten, arsenic and other metals . . . . "

Uranium deposits were only recently discovered in the Basin Creek district. The first claims were filed in 1955 and the first uranium ore was shipped in 1957. Kern (1959, p. 13) gives a detailed description of the ore deposits and of the local geology. He summarizes the uranium occurrences thus: "Uranium occurs: (1) in steeply dipping fractures in batholitic rocks and silicic intrusive rocks, and (2) disseminated in beds of arkosic conglomerate at the base of the Challis Formation. Uraninite is the ore mineral in at least one of the bedded deposits. Both supergene ores and hypogene ores are present . . . . "

In addition to primary and secondary uranium minerals, the ores contain disseminations of several sulfide minerals, predominantly pyrite, marcasite, stibnite and galena.

Barite occurs as an accessory mineral in at least one uranium deposit, in shear zone material at the Hardee No. 3. Preliminary spectrographic analyses indicate abnormal concentrations of barium, strontium, lead and antimony in the vein-type uranium deposits and concentrations of arsenic, cobalt and nickel in the sedimentary type deposits (E. E. Anderson, personal communication, 1959). Similar concentrations of these elements occur in the heavy-metal sulfide deposits in the area outside the Basin Creek district (Ross and Forrester, 1958, p. 47).

Zinc, copper and bismuth are common to the Stanley area as a whole, but have not been detected in the Basin Creek district. Any further hydrogeochemical study of the area possibly should include investigation of the association of uranium with the first mentioned elements, and origin of the uranium deposits should be studied in the light of this association with metallic elements, and in relation to the metal mining area as a whole.

HYDROGEOCHEMICAL RECONNAISSANCE

Sample collection

Seventy-three water samples were collected in the Stanley area between September 17 and 21, 1959. These samples include 65 stream-water samples, 1 cold-spring sample and 7 hot-spring samples. Samples were collected in one-pint polyethylene bottles. The pH and conductivity of 25 samples were measured in the field at the sampling sites.

Table 2. Analyses of surface water in the Stanley area, Idaho.

Sample No.	U_3O_8 (ppb)	Conductivity (Micromhos)	U/K ratio $\frac{(U_3O_8 \times 10^3)}{(Conductivity)}$	pH
59-I- 1	20.0	100	200	7.24
2	2.9	65	45	7.20
3	6.9	130	53	7.40
4	9.1	150	61	7.50
5	6.9	95	73	7.30
6	2.3	80	29	7.20
8	2.6	145	18	7.74
9	1.0	115	9	7.50
59-I-10	0.8	120	7	7.48
11	20.0	230	87	7.80
12	7.1	75	95	7.35
13	12.9	80	161	7.30
14	0.7	75	9	7.20
15	2.3	75	31	7.20
16	12.0	165	73	7.45
17	8.3	145	57	7.50
18	22.3	160	139	7.50
19	2.1	65	32	7.15
59-I-20	11.1	80	139	7.10
21	8.0	75	107	7.18
22	1.0	95	11	7.10
23	0.7	95	7	7.25
24	2.0	65	31	7.20
25	0.7	110	6	7.20
26	7.4	145	51	7.30
28	1.1	45	24	7.20
29	13.7	190	72	7.60
59-I-31	0.5	60	8	7.60
32	0.8	120	7	7.55
33	2.9	80	36	7.30
34	0.3	80	4	7.40
35	0.3	45	7	7.20
36	0.5	60	8	7.10
37	0.9	90	10	7.20
38	0.5	60	8	7.10
39	2.9	110	26	7.40

Table 2. Analyses of surface water in the Stanley area, Idaho.
(continued)

Sample No.	U_3O_8 (ppb)	Conductivity (Micromhos)	U/K ratio $\frac{(U_3O_8 \times 10^3)}{(Conductivity)}$	pH
59-I-41	4.9	220	22	7.15
42	2.9	275	11	7.90
43	0.7	180	4	7.55
44	1.3	165	8	7.80
45	5.7	350	16	7.70
46	1.1	150	7	7.60
47	0.8	145	6	7.20
48	1.1	80	14	7.20
49	0.9	60	15	7.15
59-I-50	1.3	130	10	7.40
52	1.1	140	8	7.60
53	0.7	110	6	7.40
54	3.4	100	34	7.30
55	1.7	70	24	7.10
56	2.3	80	29	7.20
57	0.2	60	3	7.00
58	2.2	80	28	7.20
59	0.3	35	9	7.00
59-I-60	1.9	65	29	7.20
61	0.5	40	13	7.00
63	1.5	135	11	7.60
65	1.7	95	18	7.75
66	1.4	170	8	7.70
67	1.5	40	38	7.15
68	1.3	60	22	7.20
69	0.9	100	9	7.60
59-I-70	1.0	130	8	8.00
71	1.4	180	8	7.85
72	4.6	80	58	7.40
73	0.4	20	20	7.00

Twenty-seven stream samples were collected in the Basin Creek district (see fig. 3) to determine the applicability of the hydrogeochemical technique, and to measure the contrast between local background uranium content of surface water and anomalous uranium concentrations near ore deposits. The sampling density was about 0.6 samples per square mile. At least one stream-water sample was collected downstream from each known uranium ore deposit in the district, and where drainage conditions permitted samples were also taken upstream from the known ore deposits.

That part of the area outside the Basin Creek drainage system was sampled only on a broad reconnaissance pattern (see fig. 2). Thirty-eight samples of stream water and one cold-spring water sample were taken in an area of about 500 square miles. This sample density is about one-sixth of that used in the Basin Creek district. In relation to the areal subdivisions shown on figure 1, the sample distribution is as follows: 12 samples from Yankee Fork and other nearby tributaries of Salmon River (including one cold spring); 9 samples from East Fork Salmon River and tributaries; and 18 samples from upper Salmon River and tributaries.

Sample analysis

Samples were returned to the geochemical laboratory at Grand Junction, Colorado, for chemical analysis. The uranium concentrations were determined fluorimetrically following ion-exchange extraction of the uranium (Illsley and Kinnaman, 1959, p. 16). The pH of each sample was measured with a Beckman model H2 glass-electrode pH meter, and the conductivity was measured with an Industrial Instruments Model RB-R104 Solubridge (table 2). All analyses were completed in September 1959.

Results

General

Surface water in the Stanley area of Idaho is relatively pure chemically. The mean conductivity of the 65 stream samples is 110 micromhos; this is approximately equivalent to a total dissolved solids (TDS) concentration of 75 parts per million, in comparison with the mean annual TDS of 236 ppm (Love, 1958, pp. 310-314) for the Snake River, to which the Salmon is tributary. Surface water in the Stanley area has a mean pH of 7.4, which is only slightly lower than the mean pH of water in the Snake River.

Study of the data on bimonthly stream discharge and TDS for the Snake River in Idaho (Love, 1958) reveals that stream discharge is in the annual low stage during September, and TDS is approaching the annual maximum. Since similar conditions prevail in the Salmon drainage system, it can be assumed that at the time of sampling for this investigation, September 17-21, 1959, the dissolved material in the water in Stanley area was close to the annual maximum concentration.

The concentration of uranium in surface water from the entire area of investigation ranges from 0.2 to 22 parts per billion U_3O_8 (table 2). Within the Basin Creek district the uranium content has an arithmetic mean of

6.8 ppb U_3O_8 and a geometric mean of 3.9 ppb U_3O_8. In other parts of the area sampled (outside the Basin Creek district) the corresponding values are 1.6 and 1.1 ppb, within the range of 0.2 to 7.4 ppb. Uranium concentrations in water, and the ratios of uranium concentration to conductivity (U/K), are known to have a log normal distribution; therefore, background for these two parameters might be taken as the values for the geometric mean. On this basis uranium background is 3.9 ppb U_3O_8 in the Basin Creek district and 1.1 ppb U_3O_8 in the rest of the area. The uranium:conductivity ratios have geometric means of 38 and 11 for the two areas.

Basin Creek district

Thirteen water samples from the Basin Creek district contain uranium in concentrations greater than 3.9 ppb U_3O_8 with a U/K ratio greater than 38. Ten of these thirteen higher uranium concentrations in the Basin Creek district are found in waters downstream from the known uranium deposits, and this is believed to indicate that hydrogeochemical techniques for uranium exploration are applicable throughout the Stanley area. The lowest among these 13 higher concentrations is sample 3 (U_3O_8 = 6.9 ppb, U/K = 53), from Lower Harden Creek downstream from three groups of claims, Side Hill, Big Hank and Little Spring. Although no ore has been mined from these claims, concentrations of easily mobilized uranium are present as autunite, and Kern (1959, p. 32) reports the presence of two radioactive cold springs in the locality.

Another means of interpretation would be to select the values for sample 59-I-15 as the threshold of significance since this sample might be expected to contain an anomalous amount of uranium because it was collected only 0.2 mile downstream from a known ore deposit. Although both the uranium content (2.3 ppb U_3O_8) and the U/K value (31) are slightly less than the geometric means for the Basin Creek area, they are both appreciably higher than the mean values for samples from the remainder of the Salmon area. By this interpretation only three additional samples would be added to the original thirteen probable anomalies. These three additional samples would not change the overall interpretation to any great extent because two of them are downstream from known uranium deposits. This method of interpretation would indicate the presence of four anomalies in the Basin Creek district not related to known uranium deposits, instead of the three anomalies indicated previously.

The probable anomalies obtained by the two methods of interpretation are tabulated below:

	Related to known uranium deposits	No known uranium	Total anomalies
Method 1 (samples vs. geometric mean)	10	3	13
Method 2 (samples vs. 59-I-15)	12	4	16

In the group of probable anomalies related to known uranium deposits, several geochemical irregularities are apparent on the sample distribution map (see fig. 3). The most noticeable of these is an inverse gradient in the geochemical values for samples 59-I-13, 59-I-14 and 59-I-15. The highest values are found in sample 59-I-13 rather than in 59-I-15 which is immediately downstream from the East Basin Creek claims. Additional water samples would be required from East Basin Creek to verify this apparent inverse relationship.

Sample 59-I-11 was taken from a small unnamed stream, which joins Basin Creek between the East Basin and Coal creeks. Drainage from the Lucky Strike prospect flows into this stream. Kern (1959, p. 28) summarizes this prospect by stating, "ore-grade mineralization is found at the base of the Challis Formation. An insufficient tonnage has been developed to warrant any immediate mining plans . . . . " The geology and mineralization are similar to that at the East Basin mine, but the grade and tonnage are considerably lower. The magnitude of the geochemical values (U_3O_8 = 20 ppb and U/K = 87) is difficult to explain on the basis of the known uranium deposit when compared to the results from East Basin Creek. Additional water samples are required from this stream for complete geochemical evaluation.

Similar conditions are found in two small tributaries of upper Basin Creek. Water samples 59-I-20 and 59-I-21 were taken from small streams which receive dissolved uranium from the Potato and Baker claims and the Enterprise claims, respectively, but once again it is uncertain whether those deposits are sufficient to account for the magnitude of the uranium concentrations (11.1 and 8 ppb U_3O_8).

The results obtained with samples from Coal Creek deserve some discussion for none of the results appear to be anomalous despite the fact that the Coal Creek claims have produced a few tons of ore. Although mining operations have ceased, it is difficult to believe that all the uranium was removed from the area; at least sufficient uranium should be left to produce several parts per billion U_3O_8 in the surface water. Sample 59-I-8 with 2.8 ppb U_3O_8 may represent the low-grade waste at Coal Creek No. 4, but sample 59-I-10 with only 0.8 ppb U_3O_8 is abnormally low for the locality.

One of the highest concentrations detected in the Stanley area was in sample 59-I-1, collected from a west fork of Upper Harden Creek. This sample contains 20 ppb U_3O_8 and has U/K ratio of 200. The sample site is about 300 feet upstream from the recently driven adit on the Hardee claims. The adit is supposedly located on a radioactive shear zone in granodiorite of the Idaho batholith. This structure may intersect the stream above the sample site if the local strike of N. 20° W. is followed. Several other uranium occurrences are found on the Hardee claims, some of which contain ore-grade material. The contact between the Idaho batholith and the Challis formation is only about half a mile west of the water sample site. Detailed water sampling upstream from 59-I-1 would be necessary for complete evaluation of the Upper Harden Creek area.

Sample 59-I-2 was collected from the east fork of Upper Harden Creek about half a mile east of 59-I-1 (see fig. 3). This stream drains an area of granitic and volcanic rock containing no known uranium deposits. Geochemically the sample ranks fourteenth in the group of U/K ratios from the Basin Creek area. The uranium content is 2.9 ppb U_3O_8 and the U/K value is 45. These relatively low values should be checked out by resampling and additional sampling upstream.

Sample 59-I-29 from American Creek (fig. 3) ranks tenth among the higher values. Bedrock within the drainage area of this stream consists of granitic and volcanic rock. The area is only about one mile east of the major uranium occurrences. The high uranium content (13.7 ppb U_3O_8) and the high U/K value (72) both suggest the presence of significant amounts of uranium within the drainage basin. Additional sampling from American Creek, at about one-half mile intervals, would be necessary in order to locate the source of the uranium.

The two remaining high values are found in waters draining an area of unknown uranium potential. This area lies north of Salmon River, south of Kelley Creek, and west of Basin Creek (fig. 3). Waters draining the area either flow directly into the Salmon or into Basin Creek. Two unnamed tributaries of Basin Creek, which drain the area, were sampled. The uppermost of these (sample 59-I-18) has the third highest U/K value and has a uranium content of 22.3 ppb U_3O_8, which is the highest uranium concentration detected in the Stanley area. The second tributary of Basin Creek, sampled at its junction with the latter (59-I-16), ranks eighth in U/K value and contains 12 ppb U_3O_8. Outside Basin Creek the only other stream draining the interior of the area flows down Joe's Gulch and joins the Salmon about one mile downstream from Stanley. The sample from this stream (59-I-26) ranks fourteenth in U/K value and contains 7.4 ppb U_3O_8.

No known uranium deposits occur in the area drained by the above three streams, and little or no surface exploration has been carried on in this particular sector. The geologic map by Ross (1937) showing only quartz monzonite of the Idaho batholith in most of the area does not cover the most northern part, and Kern (1959, p. 36) states, "I have seen outcrops of Challis rocks west of the mapped area, across Stanley Creek." Based on the hydrogeochemical anomalies and the favorable geologic environment, detailed geochemical and geological studies of this area should be considered if any further evaluation is undertaken.

Area outside Basin Creek district

The area outside the Basin Creek mining district was sampled on a broad reconnaissance basis. A total of 39 samples from an area of over 500 square miles does not provide a sample density of sufficient magnitude for statistical interpretation of the geochemical data. For the purpose of the present reconnaissance project, however, it is possible to appraise the area generally by comparing these data with those from Basin Creek. Only 3 of the 39 samples in the group exceed the possible threshold of significance based on the values for sample 59-I-15, 2.3 ppb U_3O_8 and a U/K ratio of 31. These are sample 59-I-33 from Rankin Creek, a tributary of Yankee Fork, sample 59-I-72 from Gold Creek, a tributary of upper Salmon River (fig. 2), and sample 59-I-26 from Joe's Gulch (fig. 3). The latter stream drains an area contiguous to the Basin Creek mining district, but no uranium deposits are now known within the Joe's Gulch drainage area.

The water sample from Rankin Creek contains 2.9 ppb U_3O_8. This stream drains an area of granitic and volcanic rock adjacent to the Basin Creek district on the east (see fig. 2). Nothing is known concerning the uranium potential within this drainage basin. Additional geochemical study of this area would seem advisable because of the hydrogeochemical and geological similarity to the known uranium district, if further evaluation studies are undertaken.

Gold Creek contains 4.6 ppb U_3O_8 and the U/K value is 58. The area drained by this stream lies about fourteen miles south of Basin Creek on the east flank of Stanley Basin (see fig. 2). Most of the drainage basin is underlain by quartz monzonite, but the map by Ross (1937) shows a small area of Challis latite andesite along the east margin of the floor of the basin. No deposits of uranium have been reported in the area, but there are several abandoned gold and base-metal sulfide properties near the top of the mountains forming the east side of Stanley Basin. The uranium content of water in Gold Creek is four times higher than that of water from seven other tributaries of the upper Salmon River. Additional water sampling upstream on Gold Creek is advisable if further studies are undertaken.

The data reveal that four other samples possibly are anomalous. Their uranium content is greater than the 2.3 ppb U_3O_8 limit, but the U/K ratio is lower than 31. These low U/K ratios are caused by high conductivities. Since the samples in question represent areas underlain largely by Paleozoic sedimentary rocks and Tertiary volcanic rocks, the conductivity of the water is not abnormally high as it might appear to be in comparison with waters from an area of granitic rock. On this ground, comparison of the U/K values between the Basin Creek area and parts of the surrounding areas might be misleading, and perhaps comparison should be made only between the uranium concentrations in the waters. These samples also contain uranium in amounts greater than twice the regional geometric mean ($2 \times 1.1 = 2.2$ ppb U_3O_8), and should be investigated further if more intensive hydrogeochemical sampling is undertaken in the Stanley area.

One of these additional samples is from Warm Springs Creek (59-I-39), which was sampled near the confluence with Salmon River at Robinson Bar. Warm Springs Creek drains an area of about 75 square miles underlain by the Idaho batholith and Paleozoic sedimentary rocks. No known uranium occurrences have been reported in the area, but Warm Springs Creek should be sampled in more detail in order to determine whether or not the uranium content of the water in this stream increases upstream. The rate of discharge in this stream is greater than that in Basin Creek, and dilution would be expected to reduce uranium concentration.

The second sample is from Snyder Springs (59-I-41), which is on the north side of the Salmon River three miles downstream from Robinson Bar. The uranium content of this water is 4.9 ppb U_3O_8 and the U/K ratio is 22. The water temperature was only 45° F. This was the only cold spring sampled in Stanley Basin. The spring issues from granitic rock but outcrops of volcanic and sedimentary rock are only a few miles distant. Additional water sampling in the area should include other cold springs and small streams, which were not sampled during the present broad reconnaissance.

Another sample is from Slate Creek which was sampled near its junction with Salmon River. Slate Creek drains an area of about 50 square miles underlain by Paleozoic sedimentary rocks. The uranium content of this water (sample 42) is 2.9 ppb U_3O_8 and the U/K ratio is 11. The low U/K ratio is caused by the high conductivity (275 micromhos) and gives some indication that the amount of uranium in the water may not be anomalous but only shows increased solution of uranium and other elements from a normal source rock. Additional sampling upstream on Slate Creek would be necessary for evaluation, however, because the discharge of this stream is greater than most of the others with which it is compared and it does drain a relatively large area of unknown uranium potential.

A sample from Road Creek (59-I-45) completes this group of possibly anomalous water samples. The uranium concentration of this water is 5.7 ppb U_3O_8 and the U/K ratio is 16. This is the highest uranium concentration detected outside the Basin Creek area. Road Creek heads in Brazer limestone of Late Mississippian age and flows across Tertiary basalt and tuffaceous sediments (Germer member) into the East Fork Salmon River. The source of the high uranium concentration is probably the tuffaceous material, but whether it represents disseminated uranium distribution or an ore-grade concentration is uncertain. The similarity between the arkosic conglomerate in Basin Creek and the Germer conglomerate has been noted by Kern (1959, p. 10). The presence of impure lignite and petrified wood in the Germer member in this eastern sector of the area may also indicate potential uranium host rock. The geochemistry of both the stream water and the tuffaceous sediments should receive attention if further studies are undertaken.

Waters from hot springs

Table 3 lists results of two chemical analyses cited by Ross (1937, p. 65) and another reported by Hem (1959, p. 95), which illustrate the character of the water of the hot springs. Additional analytical data obtained during the present investigation, pertaining to the same three spring waters plus five others in the area, are presented in table 4.

The chemical data show that in general these hot springs yield sodium and potassium carbonate water. Silica is a major constituent, the normal range of silica concentrations being 1 to 30 ppm. All the spring waters are abnormally alkaline except sample 51 which is close to neutral. These springs, for the most part, issue from quartz monzonite, and the high pH probably is partly due to hydrolysis of silicate minerals since the concentration of carbonate is insufficient to account for pH values greater than 9. The average uranium concentration of the waters is 0.3 ppb U_3O_8, which is 75 percent lower than the regional mean for uranium in surface waters. The hot-spring waters are geochemically quite different from the surface waters and do not show any apparent relation to the uranium deposits.

Table 3. Previous analyses of hot-spring water, Stanley area.
(parts per million)

	Robinson Bar 1/	Sunbeam Hot Springs 1/	Unnamed Spring 2/
Silica	87	84	75
Iron	.05	.08	.05
Calcium	3.0	3.6	1.3
Magnesium	0.4	0.7	0.3
Sodium & Potassium	65	79	74
Carbonate	41	40	38
Bicarbonate	28	44	20
Sulfate	49	51	32
Chloride	6.0	12	6.5
Nitrate	Tr	Tr	0
Hardness (calculated)	9.1	12	4
Total Solids	296	320	254

1/ Modified from Ross (1937, p. 65).
2/ Same as 59-I-27; modified from Hem, 1959.

Table 4. Analyses of hot-spring water from present investigation, Stanley area.

Sample No.	59-I-7	59-I-27	59-I-30	59-I-40	59-I-51	59-I-62	59-I-64
U_3O_8 (ppb)	0.4	0.2	0.1	0.3	0.2	0.2	0.7
Conductivity	300	280	375	300	550	260	220
pH	9.35	9.30	9.05	9.20	7.70	9.40	9.10
T (°F)	130	130	130	130	124	108	110

59-I-7 Mouth of Basin Creek; sec. 21, T. 11 N., R. 14 E.
59-I-27 Near Joe's Gulch on Salmon River; sec. 36, T. 11 N., R. 13 E.
59-I-30 Sunbeam Hot Springs, sec. 19, T. 11 N., R. 15 E.
59-I-40 Robinson Bar Hot Springs, sec. 27, T. 11 N., R. 15 E.
59-I-51 Mouth of West Pass Creek; sec. 29, T. 8 N., R. 17 E.
59-I-62 Valley Plunge at Stanley; sec. 3, T. 10 N., R. 13 E.
59-I-64 Southeast of Obsidian; sec. 27, T. 8 N., R. 14 E.

CONCLUSIONS

Results of this preliminary reconnaissance study indicate that higher uranium concentrations and uranium-conductivity ratios are generally found in surface waters downstream from uranium deposits, and that average values for the Basin Creek mining district are appreciably higher than for the remainder of the Stanley area. These results are believed to demonstrate the applicability of hydrogeochemical techniques to uranium exploration and evaluation of potential uranium resources in the Stanley area.

The geochemistry of the hot springs in the Stanley area bears no relation to the waters in the uranium district. The hot waters are neither contributing unusual amounts of uranium nor are they dissolving significant amounts of uranium from the surrounding rock. Cold-water springs, however, may be related to several sources of uranium in surface waters. Any future detailed geochemical investigation in the Basin Creek area should include sampling all available cold-water springs. Analyses for radon and radium, as well as for uranium should be obtained for complete evaluation of the hydrogeochemical environment.

Specific areas suggested for additional sample collection in the Basin Creek area include: (1) East Basin Creek downstream from the known ore deposits; (2) an unnamed stream from which sample 59-I-11 was taken; (3) northwest tributaries of Basin Creek sampled previously with 59-I-20 and 59-I-21; (4) upper Harden Creek upstream from samples 59-I-1 and 59-I-2; (5) American Creek; and (6) all streams draining the area west of Basin Creek, north of the Salmon River and northeast of Stanley. In the area outside Basin Creek at least the Rankin and Gold creeks should receive additional attention. Other possible anomalies would merit further checking only if a large-scale evaluation project is undertaken for the entire area.

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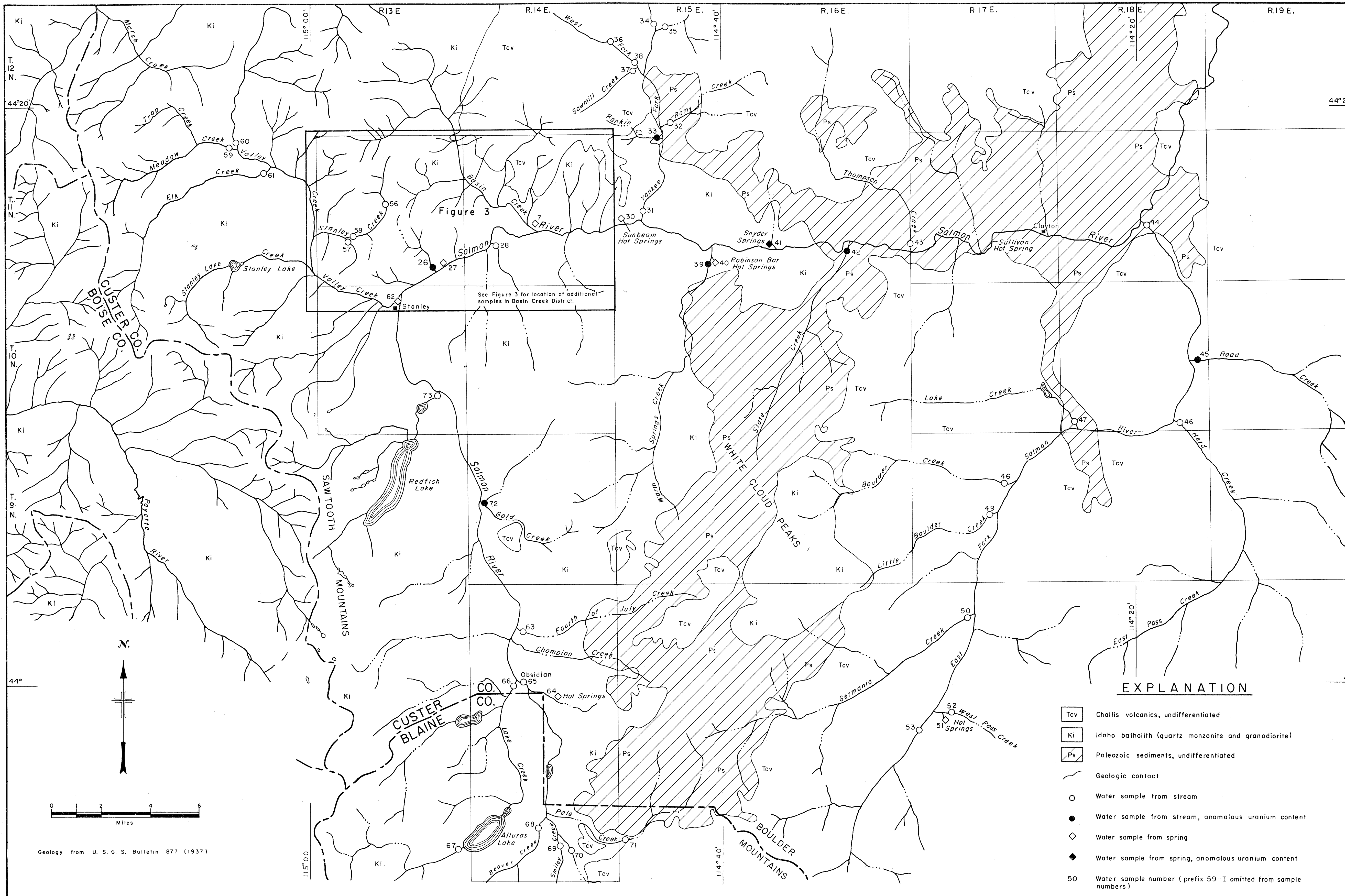

Figure 2. Hydrogeochemical reconnaissance and geologic map of the Stanley area, Idaho.

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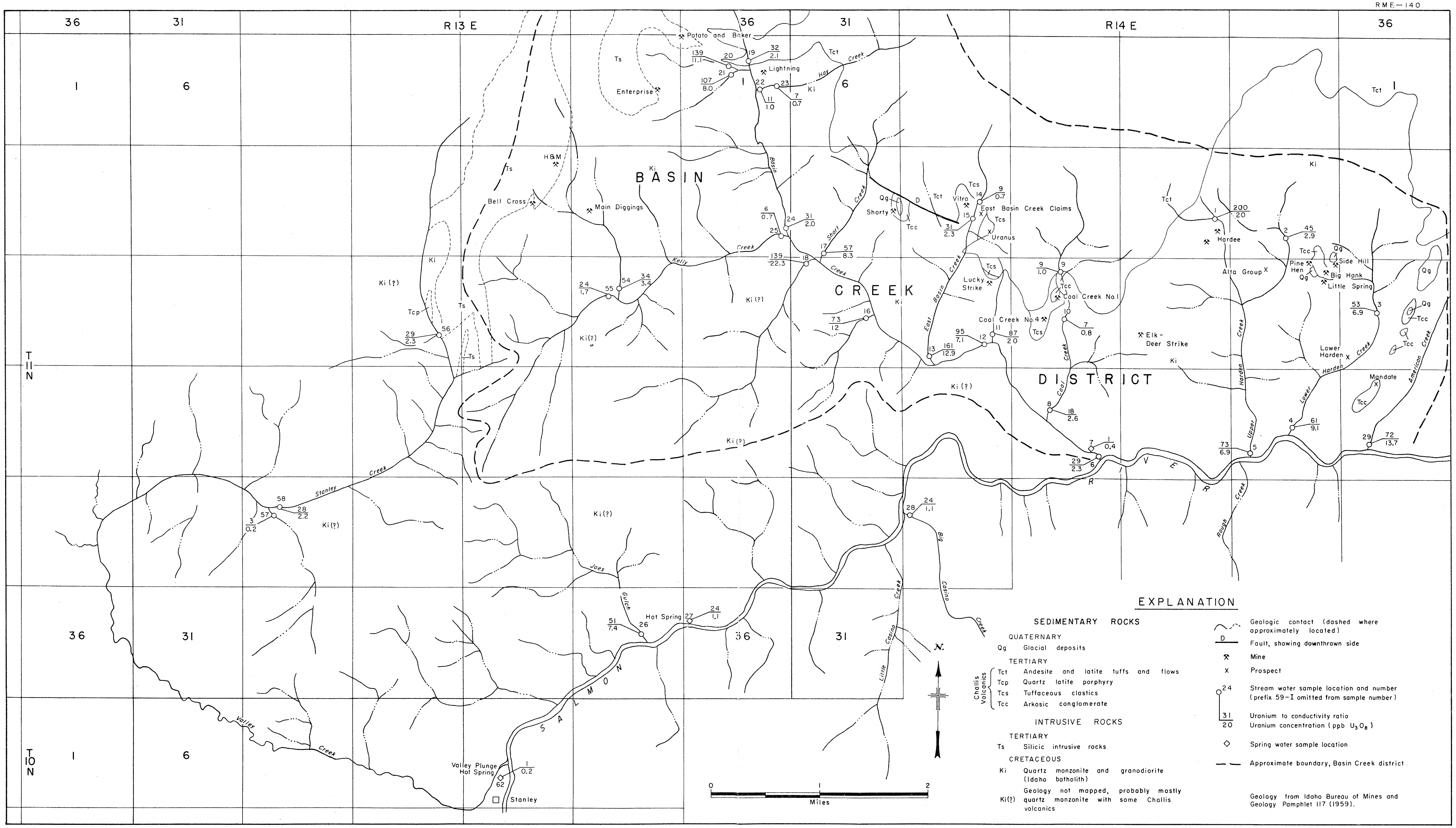

Figure 3. Hydrogeochemical reconnaissance and geologic map of the Basin Creek district, Custer County, Idaho