A Reconnaissance Geochemical and Mineralogical Study of the Stanley Uranium District, Custer County, Central Idaho

Scientific Investigations Report 2005-5264

U.S. Department of the Interior
U.S. Geological Survey

Cover. View of the abandoned pit of the East Basin No. 1 mine in August 2000. In the late 1950s to the early 1960s, the open-pit mine removed a uranium-bearing, 3-ft-thick arkosic conglomerate-sandstone unit; the area removed by mining is now filled by the reed-filled pond. The uranium-bearing conglomerate is overlain by strata of the Challis Volcanic Group, visible in the slope face in the middle of the view.

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Gale A. Norton, Secretary

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Conversion Factors

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (m)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (mi^2)
	Mass	
ton, short (2,000 lb)	0.9072	megagram (Mg)

Multiply	By	To obtain
	Length	
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
square kilometer (km^2)	247.1	acre
square kilometer (km^2)	0.3861	square mile (mi^2)
	Mass	
gram (g)	0.03527	ounce, avoirdupois (oz)

In appendix 1, the datum used to record all sample locations by GPS was WGS1984 (World Geodetic Survey).

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Abstract

The Stanley uranium district in central Idaho produced a modest amount of uranium ore from 1957 to 1962. The district consisted of at least 27 uranium mines and prospect claim groups across a 10-mi^2 area, located a few miles northeast of the town of Stanley. The average grade (about 0.18 percent U_3O_8) of the uranium deposits mined in the district was comparable to other U.S. producers, but its output (no more than 8,000 tons of uranium ore per year) and its mines were relatively small.

In the district, the uranium deposits occur in two geologic settings: (1) as disseminated uranium minerals within fluvial-channel arkosic sandstones and conglomerates that rest upon the eroded surface of the Cretaceous Idaho batholith and below the Eocene Challis Volcanic Group and (2) as pockets of uranium minerals in silicified fractures that cut through the granitoid batholithic rocks. The largest uranium deposits—which had the largest mines of the district, all open-pit operations—are the strata-bound, sedimentary rock–hosted type.

Samples of uranium ore from both types of deposits in the district were collected for this study and then analyzed by using a number of geochemical and mineralogical techniques. Mineralogical analyses included X-ray diffraction, scanning electron microscopy, and electron-microprobe analysis. Several secondary (oxidized) uranium minerals were found in the ore samples, including arsenic-bearing uranium minerals of the autunite, meta-autunite, phosphuranylite, and uranophane mineral groups. Uranium minerals within two of the conglomerate-hosted deposits have distinct arsenic- and iron-rich compositions.

In addition to rocks, samples of mine wastes and waters (if present) were collected at five strata-bound deposits and three vein-type deposits. Also, sediments and waters were collected from a number of streams and springs located upstream and downstream of mined deposits.

The most notable finding of the reconnaissance geochemical study is the very high arsenic content of the strata-bound uranium deposits. Most of the rock samples from the strata-bound ore bodies contained more than 1,000 parts per million (ppm) arsenic (the highest value measured was 8,600 ppm). All of the mine-waste samples showed arsenic in excess of 120 ppm arsenic (the highest value measured was 6,400 ppm). Two water samples from a pond, which fills an open-pit mine for uranium-rich conglomerate, had 190 and 150 parts per billion arsenic in dissolved form. Anomalous arsenic concentrations were found in all of the stream-sediment samples. Leachate tests of the mine-waste materials from the strata-bound deposits indicate that the arsenic is readily soluble. Microscopic textures in the arsenic-uranium–rich minerals suggest that the arsenic (and possibly the uranium) in the strata-bound deposits is genetically linked to the widespread (arsenic-rich) hydrothermal alteration in the area that was associated with igneous intrusions related to the eruption of the Eocene Challis Volcanic Group.

In contrast, uranium-rich rocks and mine wastes sampled from the vein-type deposits all had less than 100 ppm arsenic.

None of the spring or stream waters sampled away from mine sites contained arsenic or other metal concentrations above the Environmental Protection Agency proposed drinking-water standards. However, on the basis of the results of this reconnaissance study, it is advisable that any existing or future water wells that cut through the channel deposits atop the batholith be tested for arsenic content.

Introduction

The inactive Stanley uranium district, the first commercial uranium district in Idaho, covers an approximately 10-mi^2 area located a few miles east of Stanley and north of the Salmon River in central Idaho (pl. 1). The district contains at least 27 uranium deposits (table 1; pl. 1) that were prospected and mined during the late 1950s and early 1960s.

U.S. DEPARTMENT OF THE INTERIOR
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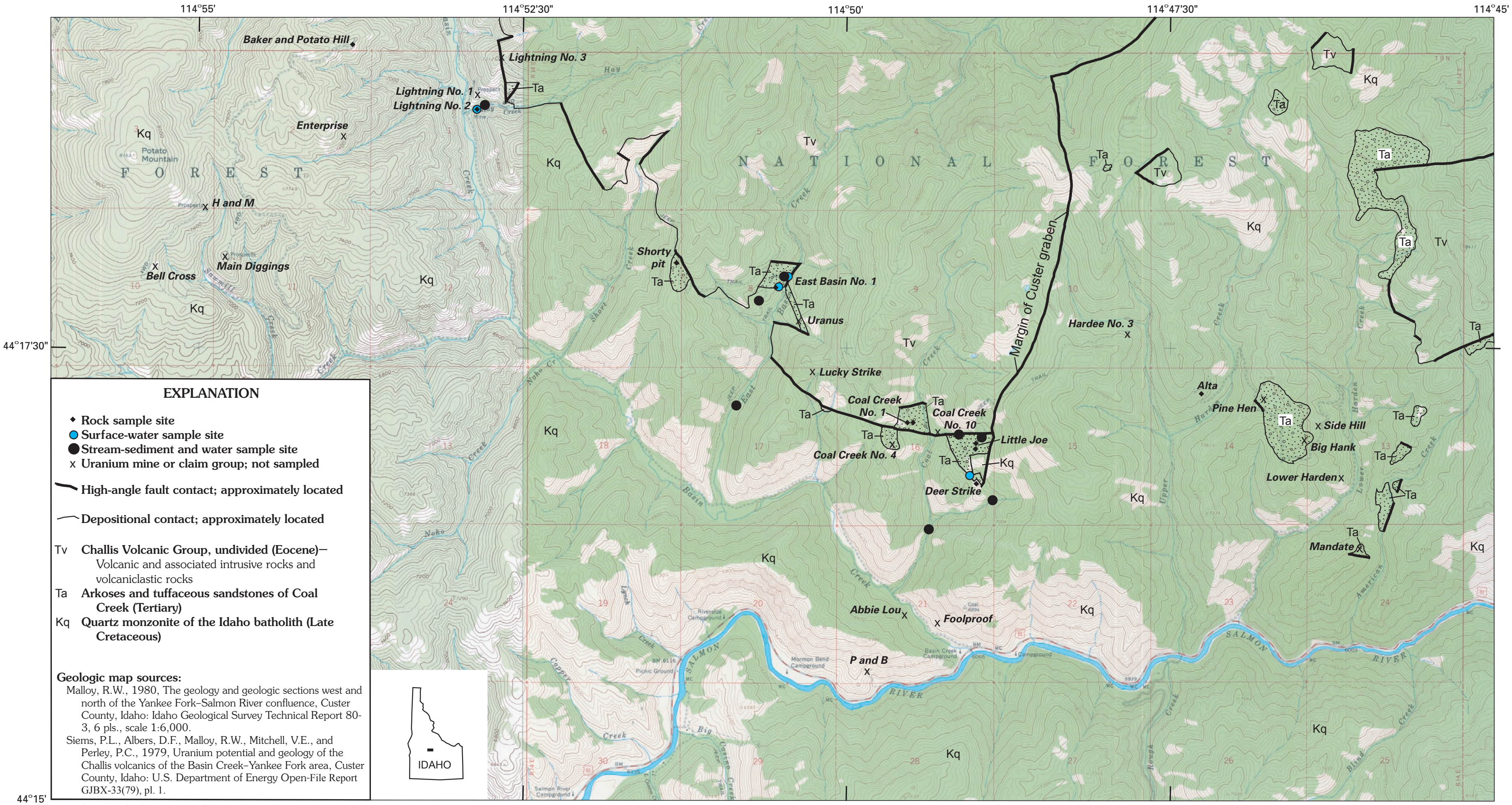
SCIENTIFIC INVESTIGATIONS REPORT 2005-5264
PLATE 1



EXPLANATION

- ◆ Rock sample site
- ● Surface-water sample site
- ● Stream-sediment and water sample site
- x Uranium mine or claim group; not sampled
- High-angle fault contact; approximately located
- Depositional contact; approximately located

Tv **Challis Volcanic Group, undivided (Eocene)**—Volcanic and associated intrusive rocks and volcaniclastic rocks

Ta **Arkoses and tuffaceous sandstones of Coal Creek (Tertiary)**

Kq **Quartz monzonite of the Idaho batholith (Late Cretaceous)**

Geologic map sources:

Malloy, R.W., 1980, The geology and geologic sections west and north of the Yankee Fork–Salmon River confluence, Custer County, Idaho: Idaho Geological Survey Technical Report 80-3, 6 pls., scale 1:6,000.

Siems, P.L., Albers, D.F., Malloy, R.W., Mitchell, V.E., and Perley, P.C., 1979, Uranium potential and geology of the Challis volcanics of the Basin Creek–Yankee Fork area, Custer County, Idaho: U.S. Department of Energy Open-File Report GJBX-33(79), pl. 1.

Base from U.S. Geological Survey,
Basin Butte, 1963; East Basin Creek, 1964
Polyconic projection.
1927 North American datum.

1 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 .5 0 1 KILOMETER
CONTOUR INTERVAL 40 FEET

Click here for full-size version of this map.

Generalized Geologic Map of the Stanley Uranium District, Idaho, Showing Uranium Mines, Claims, and Sample Sites

Compiled by
Bradley S. Van Gosen
2006

Table 1. List of uranium mines and prospects that were developed in the Stanley uranium district (pl. 1).

[Sites sampled by this study are underlined]

Site name	Location	References
Disseminated deposits hosted by fluvial sedimentary rocks underlying the Challis Volcanic Group		
Lightning No. 3 claim	NE¼NE¼ sec. 1, T. 11 N., R. 13 E.	Choate (1962, p. 63–65), Siems and others (1979, p. 123).
Shorty pit	SE¼NE¼ sec. 7, T. 11 N., R. 14 E.	Kern (1959, p. 25–26), Choate (1962, p. 69–71), Siems and others (1979, p. 126).
East Basin No. 1 mine	SW¼NE¼ sec. 8, T. 11 N., R. 14 E.	Kern (1959, p. 26–28), Choate (1962, p. 67–69), Siems and others (1979, p. 125–126).
Uranus claims	NE¼SE¼ sec. 8, T. 11 N., R. 14 E.	Choate (1962, p. 71–72), Siems and others (1979, p. 126–127).
Lucky Strike claims	NE¼NE¼ sec. 17, T. 11 N., R. 14 E.	Kern (1959, p. 28–29), Siems and others (1979, p. 127).
Coal Creek No. 1 mine	SE¼NW¼ sec. 16, T. 11 N., R. 14 E.	Kern (1959, p. 29–30), Choate (1962, p. 65–67), Siems and others (1979, p. 124).
Coal Creek No. 4 claim	SE¼NW¼ sec. 16, T. 11 N., R. 14 E.	Choate (1962, p. 67), Siems and others (1979, p. 124–125).
Coal Creek No. 10 claim	SW¼NE¼ sec. 16, T. 11 N., R. 14 E.	Choate (1962, p. 67).
Little Joe claims	SE¼NE¼ sec. 16, T. 11 N., R. 14 E.	Choate (1962, p. 74–75), Siems and others (1979, p. 122).
Deer Strike claims	NE¼SE¼ sec. 16, T. 11 N., R. 14 E.	Choate (1962, p. 60–63), Siems and others (1979, p. 121–122).
Pine Hen claims	NW¼NE¼ sec. 14, T. 11 N., R. 14 E.	Kern (1959, p. 32–34), Choate (1962, p. 72–73).
Big Hank claims	SE¼NE¼ sec. 14, T. 11 N., R. 14 E.	Kern (1959, p. 32–34), Choate (1962, p. 72–73).
Mandate claims	NE¼NW¼ sec. 24, T. 11 N., R. 14 E.	Kern (1959, p. 34–35), Choate (1962, p. 75).
Vein deposits hosted by granitic rocks of the Idaho batholith		
Bell Cross claims	SW¼NE¼ sec. 10, T. 11 N., R. 13 E.	Kern (1959, p. 21–22), Choate (1962, p. 58), Siems and others (1979, p. 116).
H and M claims	SE¼SE¼ sec. 3, T. 11 N., R. 13 E.	Kern (1959, p. 22), Choate (1962, p. 58–59), Siems and others (1979, p. 116–117).
Main Diggings claims	SW¼NW¼ sec. 11, T. 11 N., R. 13 E.	Kern (1959, p. 23), Choate (1962, p. 59), Siems and others (1979, p. 117).
Enterprise claims	NE¼SE¼ sec. 2, T. 11 N., R. 13 E.	Kern (1959, p. 23–24), Choate (1962, p. 54–55).
Baker and Potato Hill claims	SE¼SE¼ sec. 35, T. 12 N., R. 13 E.	Kern (1959, p. 24), Choate (1962, p. 50–51), Siems and others (1979, p. 117–118).
Lightning No. 1 adit	SW¼NE¼ sec. 1, T. 11 N., R. 13 E.	Kern (1959, p. 24–25), Choate (1962, p. 49–50), Siems and others (1979, p. 118–120).
Lightning No. 2 adit	SW¼NE¼ sec. 1, T. 11 N., R. 13 E.	Kern (1959, p. 24–25), Choate (1962, p. 48–49), Siems and others (1979, p. 118–120).
Abbie Lou claims	NE¼SW¼ sec. 21, T. 11 N., R. 14 E.	Kern (1959, p. 30), Choate (1962, p. 57).
Foolproof claims	NW¼SE¼ sec. 21, T. 11 N., R. 14 E.	Kern (1959, p. 30), Choate (1962, p. 57).
P and B claims	SW¼SW¼ sec. 21, T. 11 N., R. 14 E.	Choate (1962, p. 56).
Hardee No. 3 mine	SE¼SE¼ sec. 10, T. 11 N., R. 14 E.	Kern (1959, p. 30–31), Choate (1962, p. 51–52).
Alta adit	NE¼NW¼ sec. 14, T. 11 N., R. 14 E.	Kern (1959, p. 31–32), Choate (1962, p. 53–54), Siems and others (1979, p. 120).
Side Hill claims	SW¼NW¼ sec. 13, T. 11 N., R. 14 E.	Kern (1959, p. 32–33), Choate (1962, p. 55–56).
Lower Harden claims	NW¼SW¼ sec. 13, T. 11 N., R. 14 E.	Kern (1959, p. 34), Choate (1962, p. 59).

The first claims for uranium deposits in the Stanley district were filed 3 September 1955, and the first shipment of uranium ore was made during August 1957 (Kern, 1959). More than 250 uranium claims (fig. 8 of Choate, 1962) were staked in the district. Uranium was excavated from relatively small open pits and underground operations. Peak production from the district occurred in 1959. According to Choate (1962, p. 40), “A total of 7,767 tons of ore with an average grade of 0.18 percent U_3O_8 had been shipped by the end of the mining season of 1960.” Uranium production ended in the district in 1962.

Production from the Stanley uranium district, from 1957 to 1962, was a very modest part of the U.S. uranium industry of the time. In 1960, domestic uranium-ore production in the United States reached a new high, totaling nearly 8 million short tons of shipped ore and making the United States the largest free world producer of uranium at the time (Baker, 1961). New Mexico led the United States in value of uranium ore produced in 1960, while Idaho was a distant tenth (Baker, 1961); all of the Idaho production came from the Stanley district. For comparison, while the Stanley district produced about 8,000 tons of uranium ore in 1960 (Choate, 1962), 78 mines in New Mexico produced a total of about 3.8 million tons of uranium ore that same year (Kelly and others, 1961). Although the average grade of the Stanley district uranium deposits (about 0.18 percent U_3O_8) was comparable to that of other U.S. producers (0.19–0.30 percent U_3O_8; Baker, 1961, table 2, p. 1154), the Stanley district mines were obviously rather small-scale operations.

During August in 1999, 2000, and 2001, a team of geologists from the U.S. Geological Survey, Mineral Resources Program, collected samples of rock, mine waste, and natural and mine-related waters at a number of abandoned uranium mines and prospects in the Stanley uranium district. Stream sediments and waters were collected at sites upstream and downstream of deposits.

This report provides multielement analyses of the samples collected in the Stanley uranium district and data from mineralogical studies of the uranium-bearing rocks. The analytical methods applied to the solids and waters are described in appendix 1, including tables 1–1 to 1–5 that provide detection limits. The analytical results are presented in data tables grouped by sample media and deposit type (appendix 1, tables 1–6 to 1–11). These data tables are also included in Microsoft Excel (.xls) file format.

These data were collected as part of a reconnaissance study for regional characterization of a variety of mineral-deposit types in central Idaho. The methodology used and data provided in this report are *not* intended to represent a complete characterization of any particular site and do not follow Environmental Protection Agency (EPA) protocol for site investigations.

Previous Studies

During the summer of 1958, while exploration and mining were ongoing in the Stanley uranium district, geologist Billy F. Kern inspected the district and prepared a report (Kern, 1959) that described the district’s geology, mining activity, uranium deposits, and workings. A few years later, Raoul Choate published a report on the geology and ore deposits of the Stanley area (Choate, 1962); Choate’s report provides more detailed descriptions of the uranium deposits and claims.

Under the National Uranium Resource Evaluation (NURE) program, Siems and others (1979) investigated the uranium resource potential of the Stanley district and vicinity. Later, as part of a geologic and mineral resource assessment of the Challis 1° × 2° quadrangle, Johnson and Cookro (1995a, 1995b) outlined descriptive models for the Stanley uranium deposits and made a nonquantitative assessment of the uranium resources. A study within the district by Shacklette and Erdman (1982) compared the use of bryophyte (mostly moss) samples versus water samples at natural springs as an indicator of uranium occurrences.

Two master’s thesis studies, by Malloy (1979) and Leavitt (1980), described the geology and stratigraphy of parts of the Stanley uranium district. Detailed geologic maps (scale 1:6,000) of the eastern one-third of the district are shown in Malloy (1980). Other geologic maps that include the district and surrounding area are provided in Siems and others (1979, pl. 1, scale 1:24,000) and Fisher and others (1992, scale 1:250,000).

Geology of the Stanley Uranium District

The majority of the bedrock exposed in the Stanley uranium district is composed of Late Cretaceous granitic rock of the Idaho batholith (pl. 1; fig. 1). The batholith is overlain unconformably by Eocene volcanic and volcaniclastic strata of the Challis Volcanic Group, which is preserved in the north-central part and some eastern parts of the district (pl. 1). The surface of the Late Cretaceous batholith was deeply eroded before the deposition of the overlying Challis Volcanic Group. Locally exposed on this erosion surface—resting on top of the batholith and beneath the Challis Volcanic Group—are lens-shaped sedimentary units of arkosic conglomerate and (or) sandstone (map unit Ta of pl. 1) that were deposited in fluvial channels. These sedimentary units of Paleocene(?) age host the largest uranium deposits in the district. Fractures within the batholithic rocks host another type of uranium deposit in the district.

The Idaho batholith in the Stanley uranium district is composed of granitoid rocks that range in texture from equigranular medium to coarse grained to coarsely porphyritic. Fisher and others (1992) described the composition of the batholithic rocks exposed within the district as mainly biotite granodiorite, cut by bodies of porphyritic biotite granite in the eastern part of the district (east of the Custer graben). Siems and others (1979) and Malloy (1980) described the batholithic rocks in the eastern part of the district as quartz monzonite, in contrast to a description of granodiorite and granite by Fisher and others (1992, map unit Kgdp) for the same bedrock.

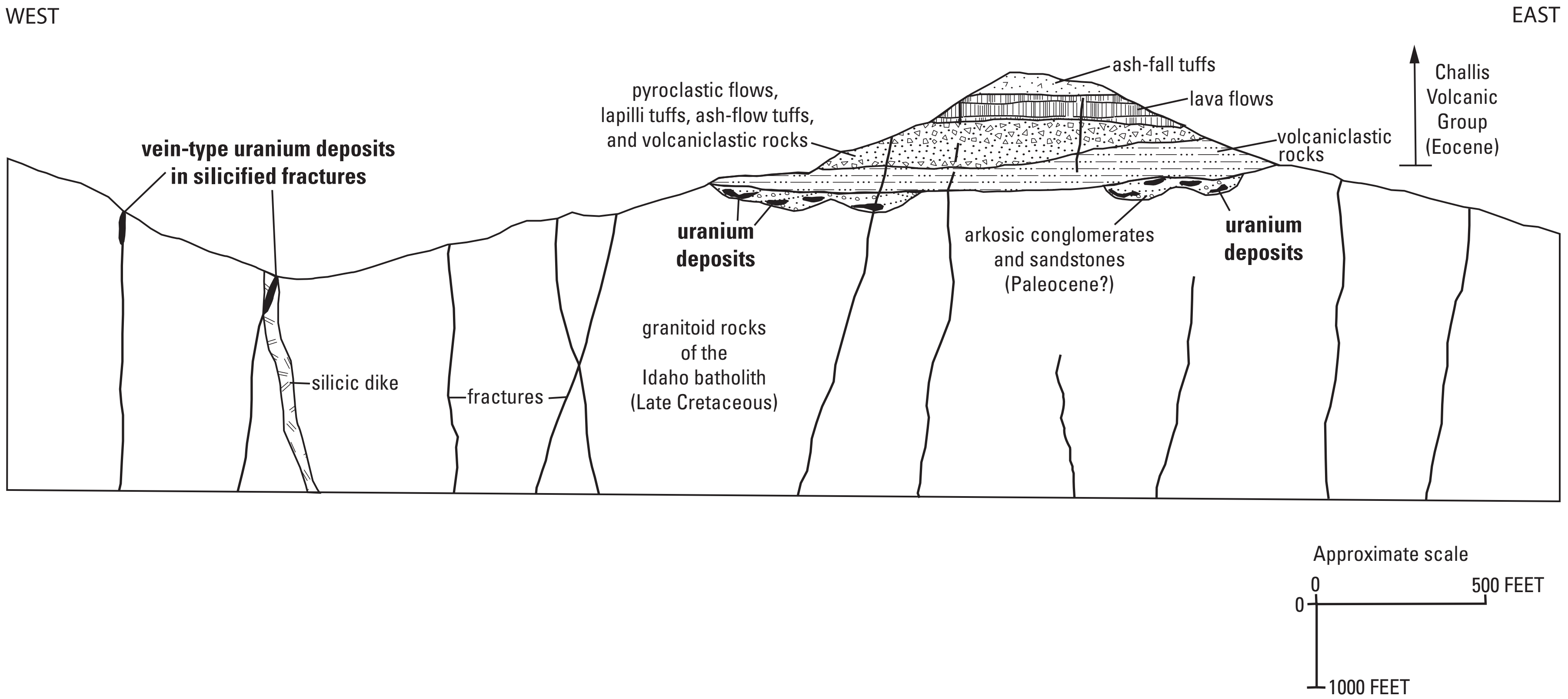


Figure 1. Schematic cross section of the Stanley uranium district, displaying the stratigraphic setting of the two types of uranium deposits in the district. Modified from Kern (1959).

Regardless of the classification, the plutonic bedrock of the district is typical of the Idaho batholith—equigranular to coarsely porphyritic granitoid rock composed primarily of quartz, plagioclase, and potassium feldspar (microcline). The principal mafic mineral is biotite, which forms as much as 25 percent of the rock; much smaller quantities of hornblende and rare muscovite constitute the remainder of the mafic minerals (Siems and others, 1979; Malloy, 1979, 1980; Fisher and others, 1992). The batholithic rocks are cut by aplite dikes from 1 in. to 20 ft wide and by pegmatite dikes from 2 in. to 3 ft wide (Siems and others, 1979).

For the batholithic rocks within and near the Stanley uranium district, several age determinations on biotites using the K-Ar method have been published. The two age ranges are 81.3 ± 2.9 to 72.5 (no error range given) Ma in samples of equigranular phases and 84.7 ± 2.9 to 79.8 ± 2.7 Ma in samples of porphyritic phases (Armstrong, 1975; Criss and others, 1982; Fisher and others, 1992).

As already noted, significant erosion occurred on the upper surfaces of the Idaho batholith in the Stanley region prior to the deposition of the Challis Volcanic Group. This erosion stripped the batholith of all overlying strata in the area of the district. East of Basin Creek (pl. 1), discontinuous, lenticular, poorly consolidated conglomerates and sandstones (map unit Ta) are situated on the eroded surface of the batholith. The characteristics of these conglomerate and sandstone bodies suggest that they were deposited in high-energy fluvial channels. The age of these channel deposits has not been determined; however, their stratigraphic position and characteristics indicate that they formed during active erosion of the batholith, which clearly followed its solidification and exhumation in the Late Cretaceous and preceded deposition of the overlying Challis Volcanic Group during the Eocene. Thus, the channel deposits may be Paleocene in age. Malloy (1979, 1980) suggested that their maximum exposed thickness is about 200 ft.

The channel deposits atop the Idaho batholith grade from cobble-pebble conglomerate to coarse-grained sandstone to fine-grained sandstone to siltstone. The cobble-pebble conglomerates host the uranium ores of the open-pit East Basin No. 1 mine and Coal Creek No. 1 mine (table 1; pl. 1). Radioactive coarse-grained sandstones form the walls of the Shorty pit, whereas fine-grained sandstones host the uranium deposits at the Deer Strike claims. The conglomerates and sandstones are usually arkosic and contain pieces of the underlying granitic pluton. Most of the pebbles and cobbles in the conglomerates are well rounded. Many of the cobbles are composed of quartzite and lesser amounts of several sedimentary rock types (see Siems and others, 1979), derived from Precambrian (Proterozoic?), Paleozoic, and Mesozoic strata eroded from the roof of the batholith. Carbonaceous material—including disseminated fine grains, wood fragments converted to vitrain, and thin coaly lenses—is common within the conglomerates, sandstones, and siltstones of the unit. The characteristics of the channel sandstones and conglomerates at each uranium mine and prospect are provided in references listed in table 1.

Lying on top of both the batholith and the discontinuous channel deposits (the unnamed conglomerate and sandstone unit) are strata of the Challis Volcanic Group. During the Eocene, a number of stratovolcanoes and the Twin Peaks Caldera formed in the southwest-trending Custer graben (Fisher and others, 1992). Rocks of the Challis Volcanic Group represent this period of extensive volcanism in the region. Detailed petrologic and petrographic descriptions of the Challis Volcanic Group in the Basin Creek area, briefly summarized next, are provided in Choate (1962), Siems and others (1979), and Leavitt (1980).

Within the Stanley uranium district, the Challis Volcanic Group generally consists of the following, from top to base:

- ash-fall tuffs,
- lava flows,
- pyroclastic flows, lapilli tuffs, ash-flow tuffs, and volcaniclastic rocks, and
- volcaniclastic rocks.

The basal Challis strata, exposed northeast of Basin Creek, are composed primarily of volcaniclastic rocks, which include tuffaceous sandstone, conglomerate, siltstone, and mudstone. The siltstone and mudstone commonly contain carbonaceous material and thin lenses of vitrain. In contrast to the underlying arkosic channel deposits, the carbonaceous siliciclastic rocks at the base of the Challis Volcanic Group have low uranium content (<100 ppm U). The pyroclastic flows, lapilli tuffs, and ash-flow tuffs range from rhyolite to quartz latite in composition, and they commonly interfinger with volcaniclastic strata. The lava flows range from andesite to dacite to rhyodacite in composition. The ash-fall tuffs near the top of the volcanic sequence in the district are mostly rhyolite.

Previous studies identified uraninite (UO_2) as the ore mineral in at least one of the bedded deposits and in some of the vein deposits, accompanied by marcasite (FeS_2) and stibnite (Sb_2S_3) in chalcedony gangue (Kern, 1959; Choate, 1962; Shacklette and Erdman, 1982). In both types of uranium deposits, several soft, green and yellow supergene (secondary) uranium minerals coat rocks and fractures as well as being distributed as disseminated grains. Kern (1959) identified the following supergene uranium minerals in the Stanley area by using microscopy and X-ray diffraction methods:

- autunite ($Ca(UO_2)_2(PO_4)_2 \cdot nH_2O$) and
- phosphuranylite-dewindtite (renardite) ($Ca(UO_2)_4(PO_4)_2(OH)_4 \cdot 7H_2O$–$Pb(UO_2)_4(PO_4)_2(OH)_4 \cdot 7H_2O$).

Kern (1959) described secondary uranium minerals near the contact between the Idaho batholith and Challis Volcanic Group at the Shorty pit and noted that these minerals impart a yellow-green color to conglomerate above the water table at the East Basin No. 1 mine. Below the water table, the rock is mottled gray and white where uraninite and marcasite constitute the main ore minerals.

Geochemical and Mineralogical Reconnaissance Study

In August of 1999, 2000, and 2001, participants in this study collected samples of uranium ore, mine wastes, and waters (when present) at eight uranium mine and prospect sites in the Stanley uranium district. Sediments and waters were also collected from a number of streams and springs at locations upstream and downstream of mined deposits. The sampling procedures, particular analytical methods used, and results of the study are described in the remainder of this report. Detailed descriptions of the analytical procedures and their limits of determination are described in appendix 1. Sample descriptions are given in tables 1–6 through 1–11 of appendix 1. Appendix 2 contains photographs of sites sampled for stream sediment or water.

Outcrop and Mine-Waste Samples

The 33 rock samples of this study were gathered to represent uranium-mineralized rock and weathered mine wastes found in the Stanley uranium district. The rock samples were collected as composites, each consisting of 30 or more handpicked, walnut-sized pieces of the uranium-enriched rocks that are exposed at the mine or prospect.

The mine-waste samples were gathered to represent the fine (<2-mm-diameter) rock materials within the upper 5 cm of the mine dumps. These samples were also collected as composites and consisted of 30 or more scoops (by hand trowel) per sample.

The rock and mine-waste samples were pulverized in the laboratory and analyzed by inductively coupled plasma–atomic emission spectrometry (ICP-AES) for 40 major, minor, and trace elements. Additionally, arsenic, antimony, selenium, tellurium, thallium, gold, mercury, total carbon, carbonate carbon, and total sulfur were analyzed by element-specific techniques. These chemical analyses of the rock and mine-waste samples were conducted by XRAL Laboratories under a contract with the U.S. Geological Survey (see appendix 1).

Stream-Sediment Samples

Nine sediment samples were collected from stream beds and natural springs in the Stanley uranium district to (1) examine the possible downstream effects of mining, prospecting, and erosion and (2) provide background data by sampling upstream of past mining sites. The sediment samples were sieved on site through a stainless steel screen, and approximately 2-lb samples of –10-mesh (<2 mm) sediment were collected in cloth bags and air dried.

Visual estimates of the geologic composition of the alluvium were made at each sample site. In the laboratory, the composite sediment samples were sieved to –80 mesh (0.177 mm), and the –80-mesh fractions were pulverized until the particles passed through a 100-mesh (0.149 mm) sieve. The samples were divided into two parts, one for chemical analysis and the second for archival purposes. The sediment samples were analyzed by the same methods as were applied to the rock and mine-waste samples (see appendix 1).

The stream-sediment data were compared with consensus-based stream-sediment quality guidelines for freshwater aquatic ecosystems (MacDonald and others, 2000). For selected elements, guidelines are defined as *probable effects concentrations* (PECs) and *threshold effects concentrations* (TECs). PEC is defined as the concentration of an element above which adverse toxic effects are likely to occur. Adverse effects are unlikely to occur if element concentrations are below TEC values.

Water Samples

Fourteen water samples were collected in the Stanley uranium district. Water sample sites included a pond that fills a mine pit, natural springs and seeps, flowing streams, and drainage from an adit. Parameters measured in the field at each sample site included pH, conductivity, alkalinity, turbidity, dissolved oxygen, acidity, water color, water odor, and flow rate (by a visual estimate or by a calculation based on measuring the time taken to fill a standard container). Conductivity, pH, and turbidity meters were calibrated at each site. Alkalinity and acidity were measured by using portable titration kits available from CHEMetrics and Hach, respectively. Dissolved oxygen was measured by using a portable colorimetric kit from CHEMetrics.

Five separate water samples were collected at each site. They were analyzed as follows:

1. Major and trace cation analyses employed a raw (unfiltered), acidified (6 drops of 16 *M* HNO_3 per 60 mL) sample (sample numbers end in “RA,” meaning “raw, acidified”) that had been collected in a new, acid-rinsed (HNO_3), clear polypropylene bottle. The sample was analyzed by inductively coupled plasma–atomic emission spectrometry (ICP-AES) and inductively coupled plasma–mass spectrometry (ICP-MS).

2. Major and trace cation analyses also employed a filtered (0.45-µm disposable filter), acidified (6 drops of 16 *M* HNO_3 per 60 mL) sample (sample numbers end in “FA,” meaning “filtered, acidified”) that had been collected in a new, acid-rinsed (HNO_3), clear polypropylene bottle. The sample was analyzed by ICP-AES and ICP-MS.

3. For Fe^{2+} analysis in 1999, a filtered (0.45-µm disposable filter), acidified (10 drops of 12 *N* HCl per 60 mL) sample was used that had been collected in a new, acid-rinsed (HCl), dark-brown polypropylene bottle, protected from sunlight. The 1999 sample was analyzed by colorimetry. In 2000 and 2001 we determined Fe^{2+} with a CHEMetrics colorimetric kit.

4. For Hg analysis, a filtered (0.45-µm disposable filter), preserved (1.5 mL of 1 percent [w/v] $K_2Cr_2O_7$-HNO_3 per 30 mL) sample was used that had been collected in an acid-rinsed (HNO_3) glass bottle with Teflon lid. The sample was analyzed by atomic fluorescence spectrometry.

5. Anion analysis utilized a filtered (0.45-µm disposable filter), unacidified sample (refrigerated). The sample was analyzed by ion chromatography.

Collection of the two types of samples for major and trace cation analyses allows for comparison of dissolved versus suspended chemical constituents (filtered versus raw sample). Collection, filtration, and preservation of the water samples followed the sampling protocol of the U.S. Geological Survey (USGS) Mineral Resources Program (Ficklin and Mosier, 1999, p. 260–262). Chemical analyses of the water samples were performed at USGS laboratories, as described in appendix 1.

Leachate Tests

Composite mine-waste samples were subjected to a passive leach procedure (Hageman and Briggs, 2000a, 2000b) in order to simulate the chemical composition of meteoric water runoff from the surfaces of uranium mines and dumps in the district. This test leached the fine (<2-mm-diameter) materials collected from the upper 5 cm of mined surfaces and waste dumps. Other than sieving the sample through a 2-mm screen on site, no preparation (such as pulverizing) was done to the sample prior to the leaching procedure. We used a streamlined procedure that mimics results of the more rigorous EPA 1312 Synthetic Precipitation Leaching Procedure (Environmental Protection Agency, 1994). Briefly, a representative 50-g subsample was collected by using a Jones splitter, added to 1 L of deionized water, and hand-shaken for 5 min. Aliquots of the leachate were then collected for chemical analysis.

Mineralogy

During site visits to eight of the deposits in the Stanley uranium district in 1999–2001, we sampled surface rocks on mine-waste dumps and outcrops. Scintillometer readings were used to identify radioactive rocks most likely to contain uranium. More than 30 samples were collected for geochemical analyses from sandstone- and conglomerate-hosted uranium deposits (Coal Creek No. 1 mine, Deer Strike claims, East Basin No. 1 mine, Little Joe claims, Shorty pit) and vein deposits (Alta adit, Baker and Potato Hill claims, Lightning No. 2 adit) (table 1). Fourteen analyzed rock samples were selected for mineralogic studies to

1. identify the uranium-bearing minerals,
2. evaluate mineralogic differences among deposits and deposit types,
3. examine geochemical associations apparent in the whole-rock analysis from a mineralogical perspective, and
4. document the weathering behavior of primary uraninite-bearing ores by identifying secondary minerals present in the oxidized ore.

Subsamples of the rock and mine-waste samples were analyzed by powder X-ray diffraction (XRD) in USGS laboratories in Denver, Colorado. The minerals identified by XRD were categorized as major, minor, and trace mineral constituents of the analyzed subsample. “Major” minerals are estimated to constitute more than 25 weight percent of the sample, “minor” minerals form 5–25 weight percent of the sample, and “trace” minerals form less than 5 weight percent of the sample. These qualitative estimates were based on the experience of the XRD operator.

Polished thin sections were prepared for the 14 analyzed rock samples. Thin sections were examined with a petrographic microscope. No uranium minerals were readily identified by optical microscopy. Geochemical analysis of these same rock samples (appendix 1, table 1–6) indicated that uranium concentrations range from <100 to 2,200 ppm. Selected samples were examined with a JEOL JSM-840 scanning electron microscope (SEM) equipped with a backscattered-electron detector, a secondary-electron detector, and a PGT X-ray energy-dispersive system (EDS). The SEM was typically operated at an accelerating voltage of 15 kV and a specimen current of 1–2 nA. In backscattered-electron mode, the uranium minerals are easily seen as bright areas because so many of their constituent elements have high atomic numbers, which contrasts sharply with the lower atomic numbers of the elements in the silicate minerals that compose the bulk of these rock samples. The SEM provides images of the uranium minerals, showing their size and texture; EDS spectra provide qualitative information on the minerals’ chemical composition. Mineral compositions were also studied by electron-probe microanalysis (EPMA) using a JEOL-JSX8900 instrument at USGS laboratories in Reston, Virginia. The microprobe, equipped with five wavelength-dispersive spectrometers, was operated at 15 kV with a beam current of 20 nA and a beam diameter of 1 µm or less. Standards included uranium metal as well as natural and synthetic silicate and sulfide minerals. The microprobe was used to map element distributions over small areas, to scan through the entire range of measurable wavelengths to identify elements present, and to analyze individual minerals.

Secondary minerals and other coatings were sampled from mine dumps at a number of sites. Minerals were handpicked under a binocular microscope, ground with an agate mortar and pestle, and analyzed by XRD in USGS laboratories in Reston, Virginia, by using a Scintag automated powder diffractometer.

Caveat.—There are hundreds of uranium minerals, which vary in chemistry, hydration state, or uranium oxidation state. The small size and complex intergrowths of uranium minerals in the Stanley uranium district samples make precise mineral identifications difficult. Without XRD data on single grains and more detailed microprobe analyses, mineral identifications for many of the uranium minerals are considered tentative.

Study Results

The uranium deposits in the Stanley uranium district occur in two general geologic settings (pl. 1; fig. 1):

1. uranium mineralization disseminated within the arkosic channel sandstones and conglomerates that rest upon the eroded surface of the Idaho batholith and below the Challis Volcanic Group and

2. pockets of uranium minerals in the fractures that cut through the granitoid batholithic rocks.

Representative examples of deposits from each geologic setting were sampled for this study (table 1). All of the known uranium deposits lie north of the Salmon River. Most deposits are located along or near creeks in the East Basin Creek drainage basin. No surface waters were present in the vicinity of the Shorty pit and the Alta adit. Geochemical data are presented, grouped by sample media, in tables 1–6 through 1–11 of appendix 1.

Strata-Bound Conglomerate and Sandstone–Hosted Uranium Deposits

Sampling Sites and Deposit Description

The largest uranium deposits discovered in the Stanley uranium district are of strata-bound type. They lie sandwiched between the Idaho batholith and the Challis Volcanic Group (fig. 1). The lens-shaped sedimentary bodies that host the uranium deposits are primarily coarse- to fine-grained arkosic sandstones, commonly accompanied by a basal unit of arkosic pebble-cobble conglomerate (described in the section on Geology of the Stanley Uranium District). Five deposits were sampled (table 1). Pits and small mine dumps are present at all of the sites (for examples, see fig. 2). The East Basin No. 1 mine is the largest deposit sampled. A standing pond fills the abandoned open pit (fig. 2*A*), and animal tracks around the pond show that the pond is used by wildlife for drinking water (fig. 2*B*). No mine-related water was present at the other sites; an intermittent stream was sampled about 600 ft downstream of the Little Joe claims (site 00CH043, appendix 2), and Coal Creek was sampled about 0.5 mi downstream of the Deer Strike claims and Coal Creek claims (site 00CH044, appendix 2). Background waters were sampled at a spring near the Deer Strike claims (site 00CH042, appendix 2) and along East Basin Creek upstream of the East Basin No. 1 mine (site 99CH030, appendix 2).

Conglomerates are the principal ore host at the East Basin No. 1 mine and Coal Creek No. 1 mine (fig. 2*C*–*F*). Scour and fill features and the well-rounded clasts and cobbles indicate that the host conglomerate and sandstone unit was deposited in a high-energy fluvial environment. The matrix of the conglomerates and sandstones commonly contains an abundance of carbonaceous materials, such as coalified wood fragments (vitrain) (fig. 2*C*), fine-grained vitreous particles, and thin coaly laminae.

At the strata-bound deposits, anomalous radioactivity is found only in the conglomerate and sandstone unit, whereas the underlying batholithic rocks and the overlying Challis Volcanic Group lack significant uranium content. For example, the open-pit East Basin No. 1 mine (table 1; pl. 1) exposed a 3-ft-thick conglomerate and sandstone unit, which is overlain by the basal layers of the Challis Volcanic Group. The conglomerate and sandstone unit contains all of the uranium ore found at this deposit and has an average grade of about 0.20 percent U_3O_8 (Choate, 1962). In contrast, the overlying layers of the Challis Volcanic Group—consisting of laminated fine-grained carbonaceous siliciclastic rocks, arkosic and tuffaceous sandstones, and ash-fall tuffs—have low uranium contents (<100 ppm U). Our composite samples of the conglomerate and sandstone unit at the East Basin No. 1 mine contained 1,600–1,800 ppm U; composite samples of the laminated tuffaceous rocks that immediately overlie the conglomerate revealed <100 ppm U (the lower limit of analytical determination; see appendix 1, table 1–6). The observation that the uranium has enriched the conglomerate and sandstone unit but not the overlying Challis strata is consistent at all of the strata-bound uranium deposits in the district (Choate, 1962; Siems and others, 1979; Shacklette and Erdman, 1982).

The average grade of the ore produced from strata-bound deposits in the district was approximately 0.18 percent U_3O_8 (table 6 of Choate, 1962). Earlier studies of the strata-bound deposits (Choate, 1962) identified the primary uranium minerals, mostly submicroscopic in size, as uraninite and coffinite; an associated yellow-green secondary uranium mineral was identified by X-ray diffraction as meta-autunite (Choate, 1962, p. 35). Intermingled with the uranium minerals are pyrite, marcasite, and the carbonaceous particles. Choate (1962, p. 32) noted that "uranium is intimately associated with carbon" in these deposits and "uranium in most beds is erratically distributed horizontally and vertically."

Origin of the Uranium Mineralization

The possible origins of the strata-bound, sedimentary rock–hosted uranium deposits of the Stanley area have not been thoroughly studied. Two models for the uranium deposition in the district, debated during the period of active mining, were offered by Kern (1959) and Choate (1962). Kern (1959) suggested that silica- and uranium-bearing hydrothermal fluids ascended along fractures in the batholithic rocks, the fluids encountered the channel deposits (the conglomerate and sandstone unit) that overlie the batholith and spread laterally, and the uranium in solution precipitated to form discontinuous ore bodies. In this model, Kern (1959) suggested that both the vein-type uranium deposits (described in the next section) and the strata-bound uranium deposits in the district formed at the same time. In contrast, Choate (1962) proposed a process in which the vein-type uranium deposits preceded the strata-bound uranium deposits; he suggested the following scenario:

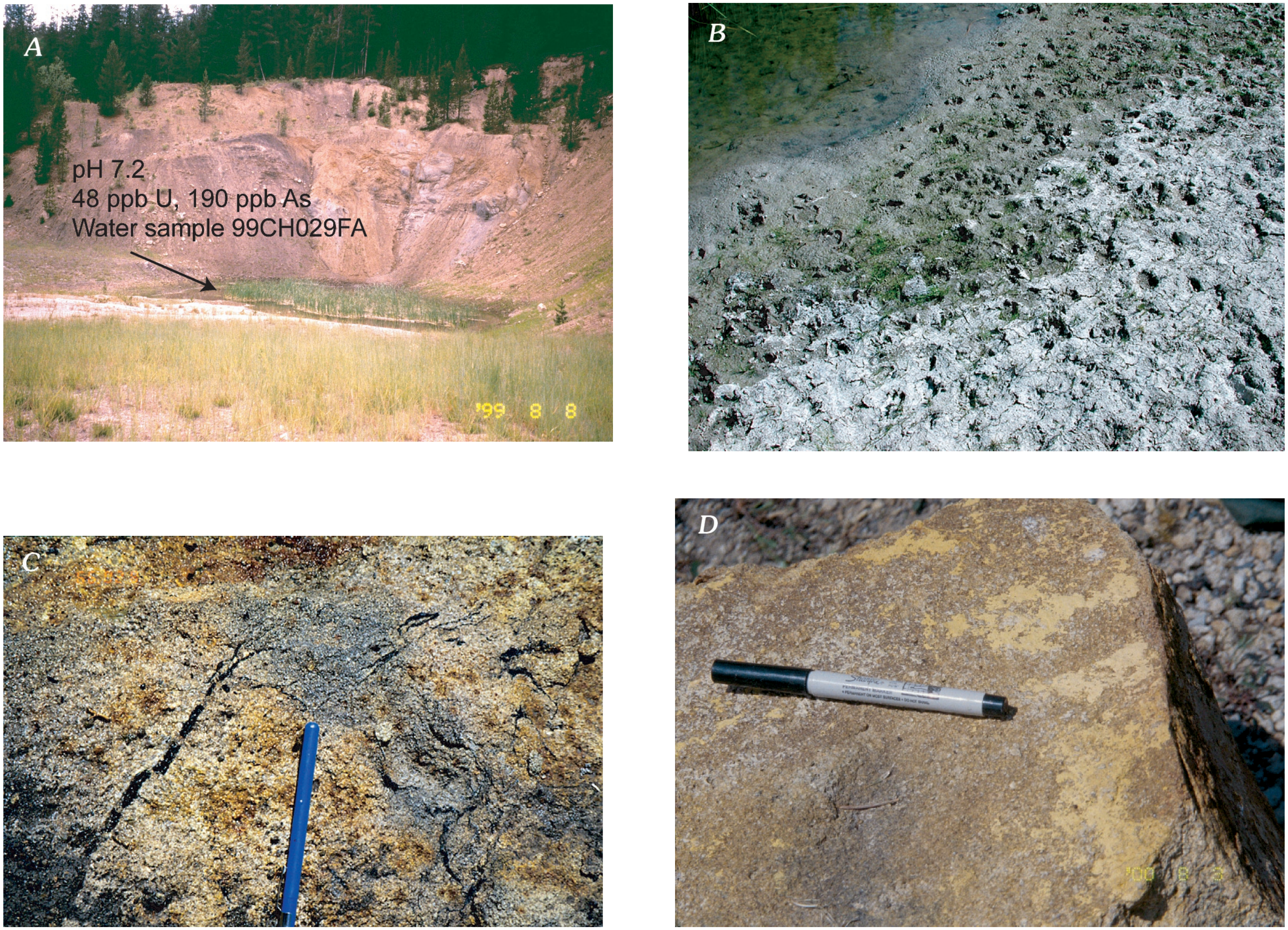


Figure 2. Photographs of strata-bound uranium deposits. *A*, East Basin No. 1 mine pit. Water samples 99CH029 and 00CH038 collected in 1999 and 2000, respectively. Composite mine-waste samples 24JH99 (1999) and 05JH00 (2000) of <2-mm-size material from the pit-wall surfaces, floor, and embankment contained >300 ppm As and variable U concentrations (160 ppm and <100 ppm for samples 24JH99 and 05JH00, respectively). *B*, Deer tracks at the edge of the pond filling the East Basin No. 1 mine pit, showing use of the pond by wildlife for drinking water. *C*, Conglomerate boulder at East Basin No. 1 mine with vitrain (black) and iron oxide staining around weathering marcasite grains. *D*, Yellow jarosite coating a conglomerate boulder at the Coal Creek No. 1 mine.

Figure 2 (continued). *E*, face of the Coal Creek No. 1 mine. Boulders in the lower left foreground are uranium-bearing conglomerates. *F*, uranium-enriched pebble-cobble conglomerate in the Coal Creek No. 1 mine. *G*, lower mine dump of Deer Strike claims. Composite mine-waste sample 11JH00 contained 140 ppm As, 540 ppm U, and 0.05 percent S.

1. Uranium was precipitated along fractures in the batholith from hydrothermal fluids, thereby forming the vein deposits.
2. Subsequently, the batholith was eroded, and the channel deposits were laid down on the erosion surface.
3. Continued deep erosion of the veins released some of their uranium into ground and surface waters.
4. The uranium in solution was redeposited when the solution moved into the reducing conditions afforded by the presence of the carbonaceous materials in the channel deposits.

By examining the chemistries of potential uranium source rocks, Siems and others (1979) attempted to resolve the origin of the uranium in the Stanley basin. A noteworthy observation made by Siems and others (1979) is that the uranium in the strata-bound deposits is closely associated with carbonaceous material, yet other overlying stratigraphic units in the Challis Volcanic Group are similarly carbonaceous but lack high concentrations of uranium. They suggested that, “These observations make it clear that the source of the uranium in the orebodies is unlikely to be the overlying volcanic strata and that vertical downward migration of uranium-enriched ground water is not involved in ore deposition in the Stanley Basin” (Siems and others, 1979, p. 111). They decided that uranium deposition in the Stanley area can be explained by either of two models:

The uranium was supplied by the lateral flow of uranium-enriched surface and ground water across the surface of the batholith within the basin during the Eocene.

Uraniferous hydrothermal solutions rose upward through fractures in the batholith at some time after the deposition of the incised channels.

Johnson and Cookro (1995a, 1995b) provided basic descriptive models of the strata-bound and vein-type uranium deposits of the Stanley district, but they did not speculate on the origin of either deposit type. They did imply that structures were important controls for the strata-bound deposits, saying, “In the deposits near Stanley, uranium occurs in paleo-stream channels that followed preexisting faults in the underlying rocks of the Cretaceous Idaho batholith” (Johnson and Cookro, 1995a, p. 167).

Our current study did not attempt to resolve the origin of the Stanley uranium deposits. Our geochemical analyses found high arsenic contents and the presence of mercury and antimony in the strata-bound uranium deposits of the district (described later). This suite of metals, more typical of hydrothermal deposition than ground water, suggests a possible link between the uranium deposits and the widespread hydrothermal alteration in the area associated with intrusive activity related to the eruption of the Eocene Challis Volcanic Group. Our reconnaissance geochemical study of the region found that significant enrichments of arsenic can occur locally in hydrothermally altered areas (that is, epithermal deposits) within the Challis Volcanic Group (Hammarstrom and others, 2004). Notice that our samples of the basal Challis rocks that directly overlie the uranium- and arsenic-rich conglomerate at the East Basin No. 1 mine contain 250 and 110 ppm As (appendix 1, table 1–6, samples 03BV00 and 04BV00). The presence of euhedral arsenopyrite within the uranium- and arsenic-rich conglomerate at the East Basin No. 1 mine (discussed later) provides further evidence that heated fluids likely once passed through this unit.

Age of the Uranium Mineralization

Isotopic dating or analyses of the uranium mineralization in the Stanley area have not been conducted. However, the relative age of the host conglomerate and sandstone bodies seems straightforward—they are channel deposits formed by the erosion of the Idaho batholith and its cover during a period of regional erosion that followed the Late Cretaceous solidification and exhumation of the batholith and preceded deposition of the blanketing Eocene Challis Volcanic Group. Thus, the primary uranium mineralization occurred at some time after the Late Cretaceous, Paleocene, or early Eocene deposition of the sediments that form the channel sandstone and conglomerate now hosting the uranium.

Other Similar Uranium Deposits

Uranium deposits of similar geologic setting are in the Tallahassee Creek mining district of Fremont County, south-central Colorado (Nelson-Moore and others, 1978). The Tallahassee Creek deposits occur within arkosic, carbonaceous, and tuffaceous sandstones, conglomerates, and siltstones. These strata are interpreted as sediments deposited in late Eocene paleodrainages that crossed a prevolcanic erosional surface atop crystalline rocks (Hon, 1984). The uranium-bearing channel deposits are overlain by extrusive rocks of the Thirtynine Mile volcanic field (Dickinson, 1987). In addition to stratigraphic and petrologic similarities between the Tallahassee Creek deposits and Stanley uranium district deposits, their mineral assemblages and uranium grades are also similar. Regarding the origin of the uranium deposits of the Tallahassee Creek mining district, Colorado, Dickinson (1987) and Hon (1984) each concluded that the dissolution of volcanic tuffs by ground waters was the source of uranium in these deposits. The interpreted origin of the Tallahassee Creek uranium deposits is analogous to one model proposed for the uranium deposits of the Stanley district, in which the uranium was supplied by surface and ground water flowing along the top of the batholith (Siems and others, 1979, p. 111).

The uranium deposits of the Marysvale volcanic field in west-central Utah are another uranium district with geologic characteristics generally similar to those of the Stanley district. Uranium in the Marysvale volcanic field occurs in a variety of geologic settings, including hydrothermal vein deposits and sedimentary-trap deposits in basin-fill sediments (Steven and others, 1981). All of the uranium occurrences in the Marysvale volcanic field were derived from igneous sources, such as rhyolites and associated epizonal intrusions (Steven and others, 1981; Rasmussen and others, 1985). Hydrothermal activity within calderas of the Marysvale field locally formed vein-type uranium deposits that cut the underlying quartz monzonite and granite; the veins extend upward into younger rhyolite tuffs. Uranium was also leached from host rocks and transported by surface and ground water into nearby basins, where the uranium was redeposited in sedimentary channel-fill rocks. The geologic setting and uranium distribution within the Marysvale volcanic field are much more complex than briefly described here (Steven and others, 1981). However, parts of the Marysvale volcanic field are generally similar to the geologic environment of the vein-type and strata-bound uranium deposits of the Stanley district.

Geochemistry

Rocks and Composite Mine Wastes

Uranium concentrations in arkosic conglomerates sampled for this study range from <100 ppm to 2,700 ppm (0.27 percent) U (appendix 1, table 1–6). Choate's tabulation of uranium grades from six strata-bound deposits in the district that were mined during 1958–1960 (Choate, 1962, table 6) indicated an average grade of 0.18 percent U_3O_8. Uranium concentrations in the <2-mm-size surface materials of the mine dumps ranged from <100 to 740 ppm U (appendix 1, table 1–7). Base-metal concentrations in rocks and mine wastes are low (typically <200 ppm total; zinc is higher than lead, which is higher than copper). Cadmium is elevated (100 ppm) in some rocks from the Coal Creek No. 1 mine. Mercury and antimony were detected at all of the sites. Elements that typically are enriched in sandstone-hosted uranium deposits include selenium, molybdenum, and vanadium (Turner-Peterson and Hodges, 1986). In the Stanley uranium district ores and mine wastes, selenium is below detection limits (<0.2 ppm), molybdenum contents are low (<2 to 6 ppm), and vanadium ranges from 15 to 67 ppm. Total carbon content is highly variable (0.06 to 17 weight percent), reflecting the erratic distribution of vitrain in the sediments. Carbonate carbon generally constitutes <10 weight percent of the total carbon. Total sulfur concentrations are <0.5 weight percent in all of the samples except those from the East Basin No. 1 mine, which contain as much as 3.4 weight percent S.

Stream Sediments

Arsenic values, considered anomalous when compared to an average soil (table 2 of Shacklette and Boerngen, 1984), were measured in all of the stream-sediment samples collected in the study (appendix 1, table 1–8). Natural springs located near the East Basin No. 1 mine, apparently uninfluenced by the mine workings, yielded sediment samples (00CH039 and 00CH040; appendix 2, figs. 2–3 and 2–4, respectively) with high arsenic contents (45 and 37 ppm). Stream sediments collected within and downstream of the Little Joe claims (samples 01CH091 and 00CH043) had arsenic concentrations (170 and 110 ppm) that exceed the consensus-based probable effects concentration (PEC) guideline for arsenic (33 ppm) in sediments in freshwater aquatic ecosystems (MacDonald and others, 2000). (Water samples from sites 01CH091 and 00CH043 contained 7.2 and 7.6 parts per billion [ppb] As, respectively.) Other metals in the stream sediments were found in concentrations below the PEC guidelines of 4.98 ppm Cd, 149 ppm Cu, 128 ppm Pb, 1.06 ppm Hg, 48.6 ppm Ni, and 459 ppm Zn (MacDonald and others, 2000).

Threshold effects concentrations (TECs) are values below which harmful effects are unlikely to be observed. The consensus-based TEC guidelines for metals in sediments in freshwater ecosystems are 9.79 ppm As, 43.4 ppm Cr, 31.6 ppm Cu, 35.8 ppm Pb, 0.18 ppm Hg, 22.7 ppm Ni, and 121 ppm Zn (MacDonald and others, 2000). On the basis of these values, stream sediments collected from the vicinity of strata-bound uranium deposits (samples 00CH039, 00CH043, and 01CH091) exceeded the TEC guidelines for arsenic, but not for any of the other metals (appendix 1, table 1–8). The same sediment samples contain <100 ppm U (the analytical limit of determination) (appendix 1, table 1–8).

Waters

Surface water and ground water associated with the strata-bound uranium deposits are nearly neutral; the pH values range from 7 to 8.4 (appendix 1, table 1–9). Samples of pond water in the open-pit East Basin No. 1 mine (fig. 2*A*) contained 190 and 150 ppb As in dissolved form, measured in 1999 and 2000, respectively. These concentrations are at, or above, the national recommended freshwater-quality criterion for aquatic life for chronic exposure to arsenic, which has been set at 150 µg/L (ppb) (U.S. Environmental Protection Agency, 2002). The samples of pond water contained 48 and 61 ppb U in dissolved form, in excess of the concentrations in background water samples, which all contained <1 ppb U. Spring waters forming a bog at the Little Joe claims (site 01CH091, appendix 2) contained 7.2 ppb As in dissolved form (11 ppb in the raw sample) and 4 ppb U in dissolved form (appendix 1, table 1–9). Background waters contained <2 ppb As. With the exception of high concentrations of total aluminum (>500 ppb) in a seep in a boggy area near the Deer Strike claims (site 00CH042, appendix 2), none of the other samples contain any metal concentrations that approach, let alone exceed, the recommended freshwater quality guidelines for aquatic life (U.S. Environmental Protection Agency, 2002). In fact, among the metals of environmental concern—silver, aluminum, arsenic, cadmium, chromium, copper, iron, mercury, nickel, lead, antimony, selenium, thallium, and zinc—only the concentrations for aluminum, arsenic, iron, and antimony were consistently above the analytical detection limits (appendix 1, tables 1–4, 1–5, and 1–9). Comparison of the results from raw samples versus the filtered samples shows that arsenic and antimony are carried primarily in solution, whereas much of the aluminum and iron is suspended in the water, likely in clay and iron oxide phases. The anion concentrations (chloride, fluoride, nitrate, and sulfate) in the water samples were unremarkable (appendix 1, table 1–10), except that higher sulfate concentrations were found in the pond water samples from the East Basin No. 1 mine (31 and 43 ppm sulfate) in comparison to the other water samples (all with less than 7 ppm sulfate).

Mine-Waste Leachates

As described previously under the heading "Leachate Tests," mine wastes were leached with deionized water (pH ≈ 5.7) by using the procedure developed by Hageman and Briggs (2000a, 2000b). This simple leach test attempts to simulate the possible chemical composition of rain or snowmelt runoff from weathered surfaces of the mine wastes. Leaching of the strata-bound uranium mine wastes produced solutions that contained 24 to 230 ppb As and 2.6 to 21 ppb U (appendix 1, table 1–11) with a final pH ranging from 5.3 to 6.7. Other than a small release of antimony (4.4 ppb), the remaining environmental metals showed little tendency to leach into the solute. The results suggest that arsenic is readily leachable from the strata-bound uranium mine wastes. In contrast to arsenic, uranium showed a minor tendency to leach from these wastes. This finding may be a reflection of the specific uranium minerals in these oxidized mine wastes, because uranyl arsenates such as autunite (identified as a major uranium-bearing phase in these deposits) are known to be very insoluble in most natural waters (Finch and Murakami, 1999, p. 124).

Mineralogy

Quartz is the dominant mineral in the conglomerates, along with potassium feldspar, sericitized plagioclase, albite, muscovite, kaolinite, marcasite, arsenopyrite, and clasts of black vitrain as long as several centimeters. Variably altered micas and clays enclose rounded marcasite grains. Photomicrographs of samples from the East Basin No. 1 mine illustrate typical mineral assemblages and textures for the conglomerate-hosted deposits (fig. 3). Quartz, potassium feldspar, plagioclase, and kaolinite are identified in XRD patterns of the bulk mine-waste composite samples (appendix 1, table 1–11). Trace amounts of a uranyl hydrogen arsenate were identified in XRD analyses of rock samples. The uranium minerals in these samples are indistinguishable by routine petrographic microscope examination owing to their small size and lack of distinctive optical properties. The SEM in backscattered-electron mode readily shows the uranium minerals because of the high atomic number of uranium in comparison to the lower atomic numbers of elements in other minerals in the sample (fig. 4).

Uraninite, nominally UO_2, was reported as the primary ore mineral in the Stanley uranium district. No uraninite was identified in any of the samples included in this study. This result is not surprising because all of the samples were collected at the surface from weathered materials, where uraninite readily oxidizes. SEM and EPMA analyses show that all of the uranium- and arsenic-bearing mineral phases include minor amounts of other elements that may be present in the uranium- and arsenic-bearing mineral or in fine-grained mixtures. A yellow-green coating on rocks at the Deer Strike claims was identified by XRD as abernathyite ($K(UO_2)(AsO_4){\cdot}4H_2O$), an autunite-group mineral. Members of the autunite mineral group (Finch and Murakami, 1999) are secondary minerals consisting of uranyl phosphates and arsenates with the following general formula:

$$A(UO_2)_2(XO_4)_2{\cdot}8\text{–}12H_2O,$$

where

A = Ca, Ce, Ba, K, NH_4, Sr, Pb, Mg, Na, Co, Zn, Fe^{2+}, and (or) H_3O^+,

and

X = P, As, and (or) V.

Autunite-group minerals typically are distinctly lemon yellow in color, whereas uraninite is black. Some autunite-group minerals fluoresce yellow-green or yellow under ultraviolet (UV) light. Most of the autunite-group minerals have variable densities that range from 3.0 to 3.2, depending on hydration. Phosphuranylite ($Ca(UO_2)_4(PO_4)_2(OH)_4{\cdot}7H_2O$), a secondary mineral identified by Kern (1959) in the Stanley uranium district ores, has a density of about 4.1. Examination under the binocular microscope and XRD analysis of the heavy-mineral concentrates (density > 3.3) obtained from subsamples of selected rock powders analyzed for this study identified marcasite, zircon, and apatite but no primary or secondary uranium minerals. Yellow coatings on rocks from the Deer Strike claims and Little Joe claims fluoresce (green) under a UV light, which is consistent with the XRD identification of abernathyite ($K(UO_2)(AsO_4){\cdot}4H_2O$). Yellow coatings on rocks at the Coal Creek No. 1 mine were identified as jarosite by XRD (fig. 2*D*).

SEM and microprobe data on polished thin sections show that the uranium mineral in the samples from the Shorty pit is autunite, where A = Ca and X = P. Minor amounts of Fe and As are present. The autunite forms bundles of rectangular laths that resemble micas in texture. A likely source of the phosphorus is apatite. Arsenopyrite, arsenian pyrite (2.4–3.1 weight percent As_2O_5), and arsenic-free pyrite are present in these rocks.

Samples from the East Basin No. 1 mine and Coal Creek No. 1 mine are highly altered and contain more sulfide minerals and more total sulfur than the samples from the Shorty pit (appendix 1, table 1–6). At these two sites the uranium minerals are difficult to characterize. These two deposits contain complex intergrowths of alteration products that do not always conform to known mineral stoichiometry. SEM and EPMA analyses reveal a wide range of textures and uranium contents (fig. 4). In some cases, compositions reflect the adjacent mineral phase. For example, the EPMA analyses of three spots on the uranium-bearing material surrounding rounded, mottled marcasite in vitrain (sample 01BV00, fig. 4*A*) average 24

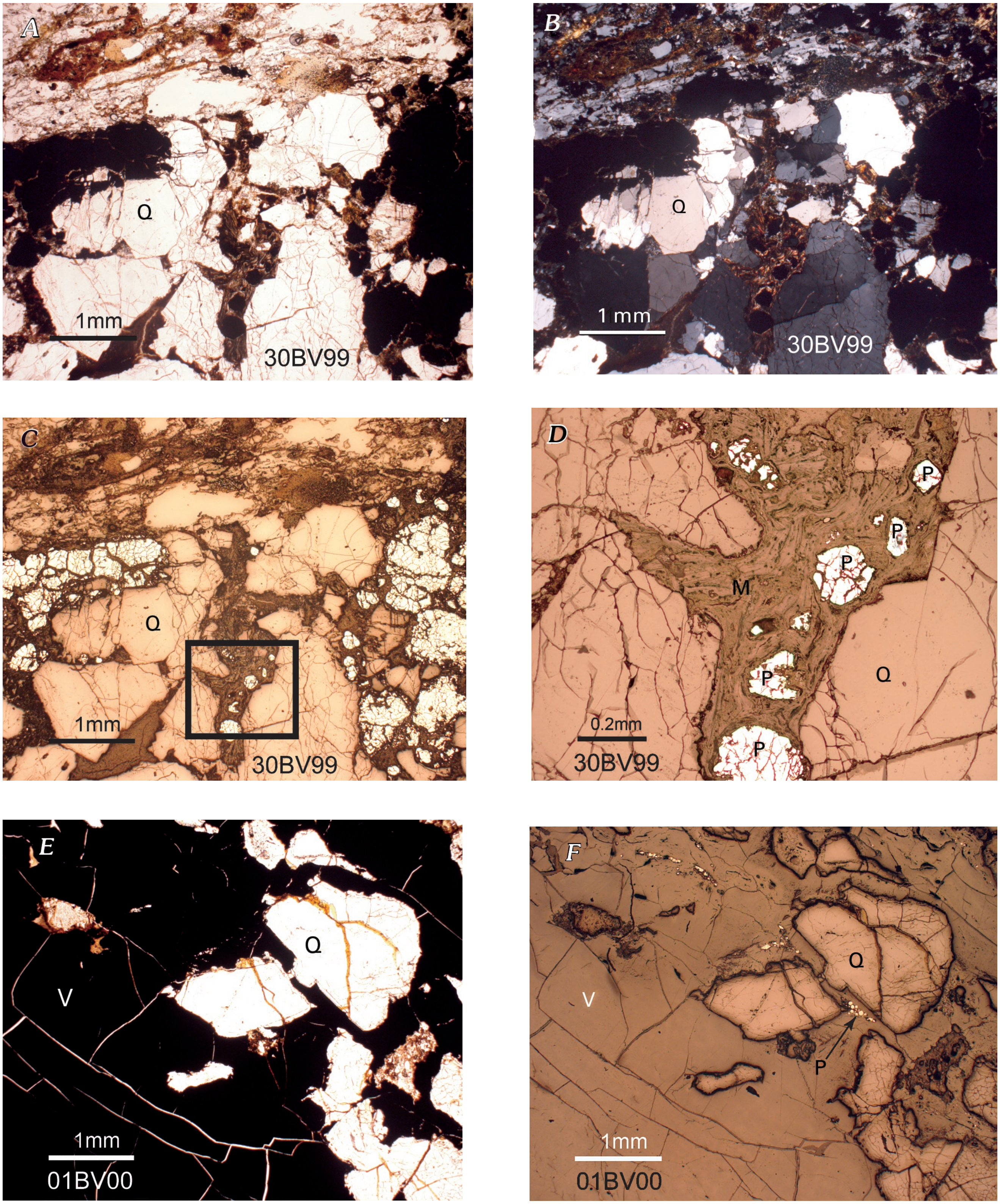


Figure 3. Photomicrographs of samples from the East Basin No. 1 mine (conglomerate-hosted deposit). Labels: M, altered mica-clay matrix; Q, coarse quartz grains; P, pyrite grains; V, vitrain. (*A*–*D*) Sample 30BV99. *A*, Plane-polarized light. *B*, Same view, crossed nicols. *C*, Same view, reflected light. *D*, Close-up of boxed area in *C*, showing rounded pyrite enclosed in matrix, reflected light. (*E*–*F*) Sample 01BV00. *E*, Quartz in vitrain, plane-polarized light. *F*, Same view, reflected light, showing small pyrite grains (white) in vitrain.

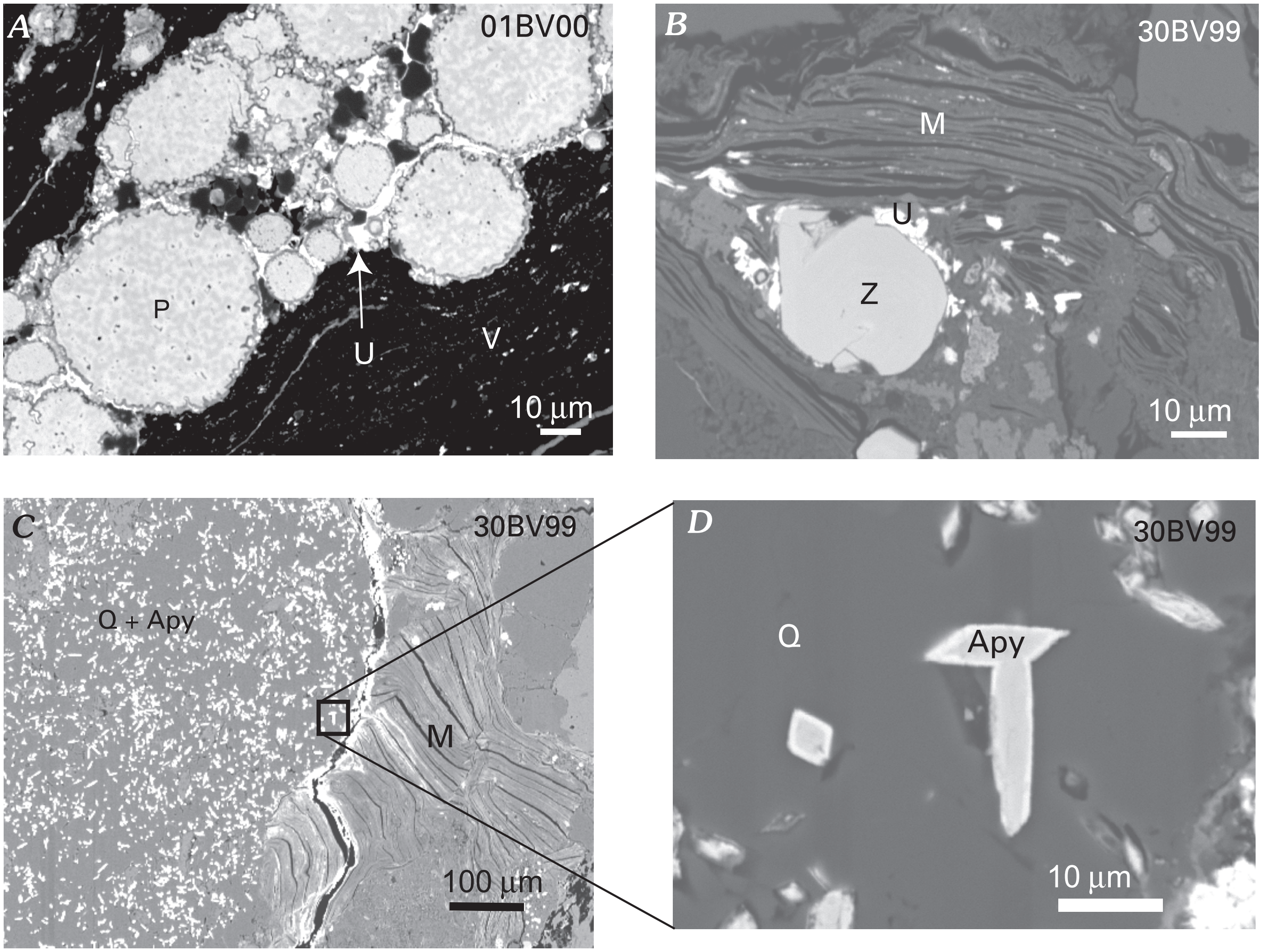


Figure 4. Backscattered-electron SEM images of secondary uranium minerals in strata-bound deposits at the East Basin No. 1 mine. Labels: Apy, arsenopyrite; M, muscovite; Q, quartz; P, pyrite (or marcasite); V, vitrain; Z, zircon. *A*, Sample 01BV00. Uranium alteration (bright white, U) at margins of rounded marcasite or pyrite in vitrain. (*B–D*) Sample 30BV99. *B*, Uranium alteration (bright white, U) along cleavages in muscovite and rimming rounded zircon. *C*, Clast of quartz enclosing small (<10 µm long) euhedral arsenopyrite grains. *D*, Close-up of boxed area in *C*.

weight percent UO_2, 24 weight percent As_2O_5, 13 weight percent SO_3, 20 weight percent FeO, and 2 weight percent SiO_2. Similarly, uranium-rich material intergrown with zircon and mica (sample 30BV99, fig. 4*B*) incorporates silicon, arsenic, iron, zirconium, and sulfur. High-magnification (×5,000) backscattered-electron images show that the uranium-rich areas appear mottled, which suggests that these areas are mixtures of different minerals. EDS spectra obtained (at ×30,000) for two spots on a clot of uranium-rich material in sample 46BV01 illustrate this point (fig. 5). The EDS spectrum for the brightest spot (pt. 1, fig. 5), an area of about 2 µm in diameter, shows peaks for uranium, arsenic, phosphorus, and iron. The spectrum for the host material (point 2, fig. 5) is arsenic rich but incorporates some uranium, phosphorus, and iron. These textures and compositions suggest that alteration fluids reacted with preexisting arsenopyrite and pyrite/marcasite as well as with detrital apatite in the host rock. Reactions were not pervasive throughout the rocks. In other places in the same samples, the uranium- and arsenic-bearing minerals occur as narrow veins cutting pyrite or quartz with no apparent reaction with the crosscut mineral. Electron-microprobe maps show that the arsenic is not homogeneously distributed throughout the uranium mineral in these veinlets (fig. 6). Uranium minerals also are deposited along curved, hairline fractures in vitrain (fig. 4*A*). Uranium was not detected in EDS spectra of vitrain; only carbon peaks were detected. Euhedral, stoichiometric arsenopyrite is observed in quartz (fig. 4*C–D*). Zircon is ubiquitous; some grains are euhedral and complexly zoned (Idaho batholith zircons?); others are rounded (fig. 4*B*) and lack obvious zoning (older zircons?).

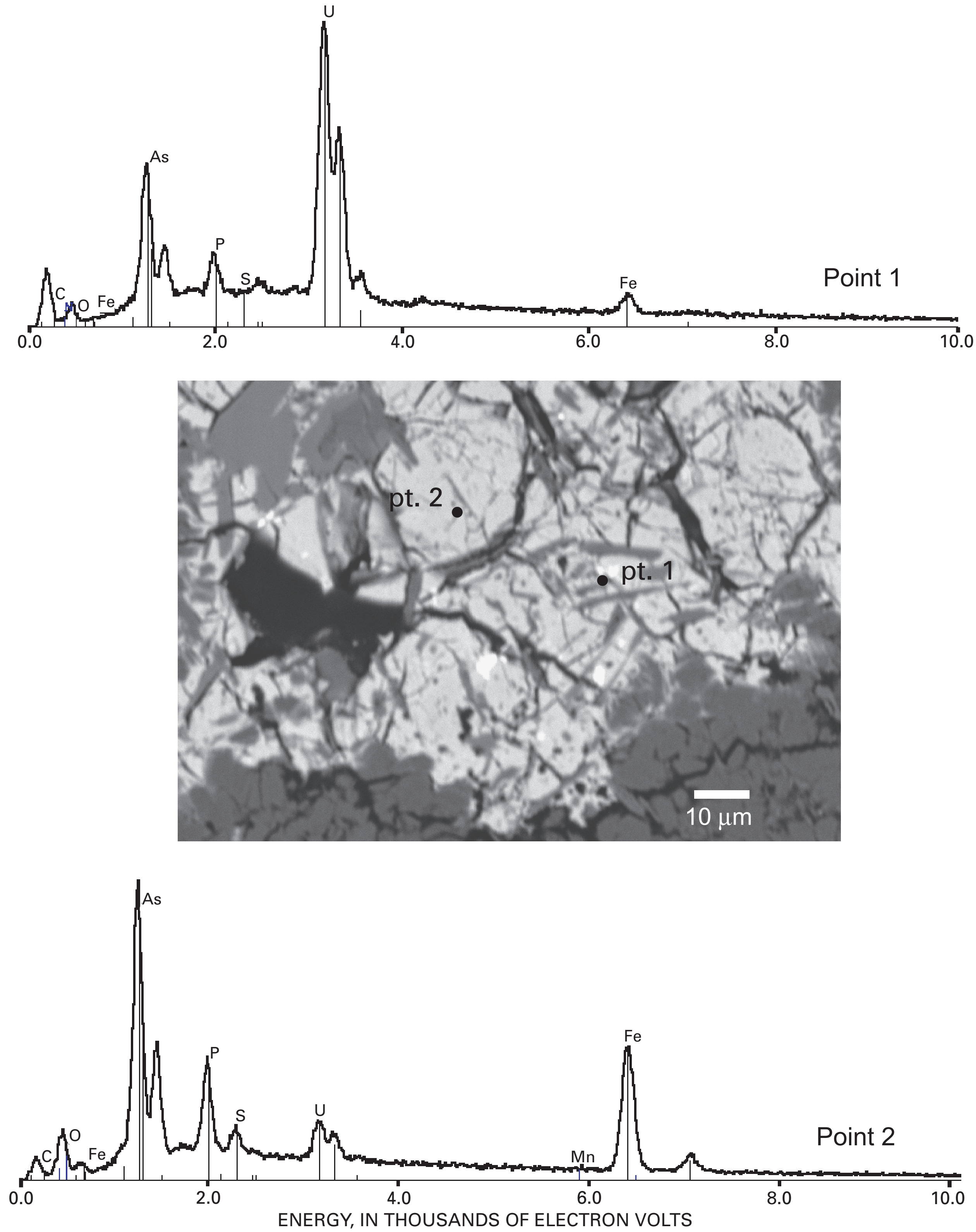


Figure 5. EDS spectra and backscattered-electron image of a clot of uranium-rich material in conglomerate-hosted ore (sample 46BV01) at the Coal Creek No. 1 mine. The EDS spectrum for one bright spot (pt. 1), an area of about 2 µm in diameter, shows peaks for uranium, arsenic, phosphorus, and iron. The spectrum for the host material (pt. 2) shows that it has more arsenic, phosphorus, and iron, but its uranium content is lower. These textures and compositions suggest that uranium-rich fluids reacted with arsenopyrite and pyrite or marcasite.

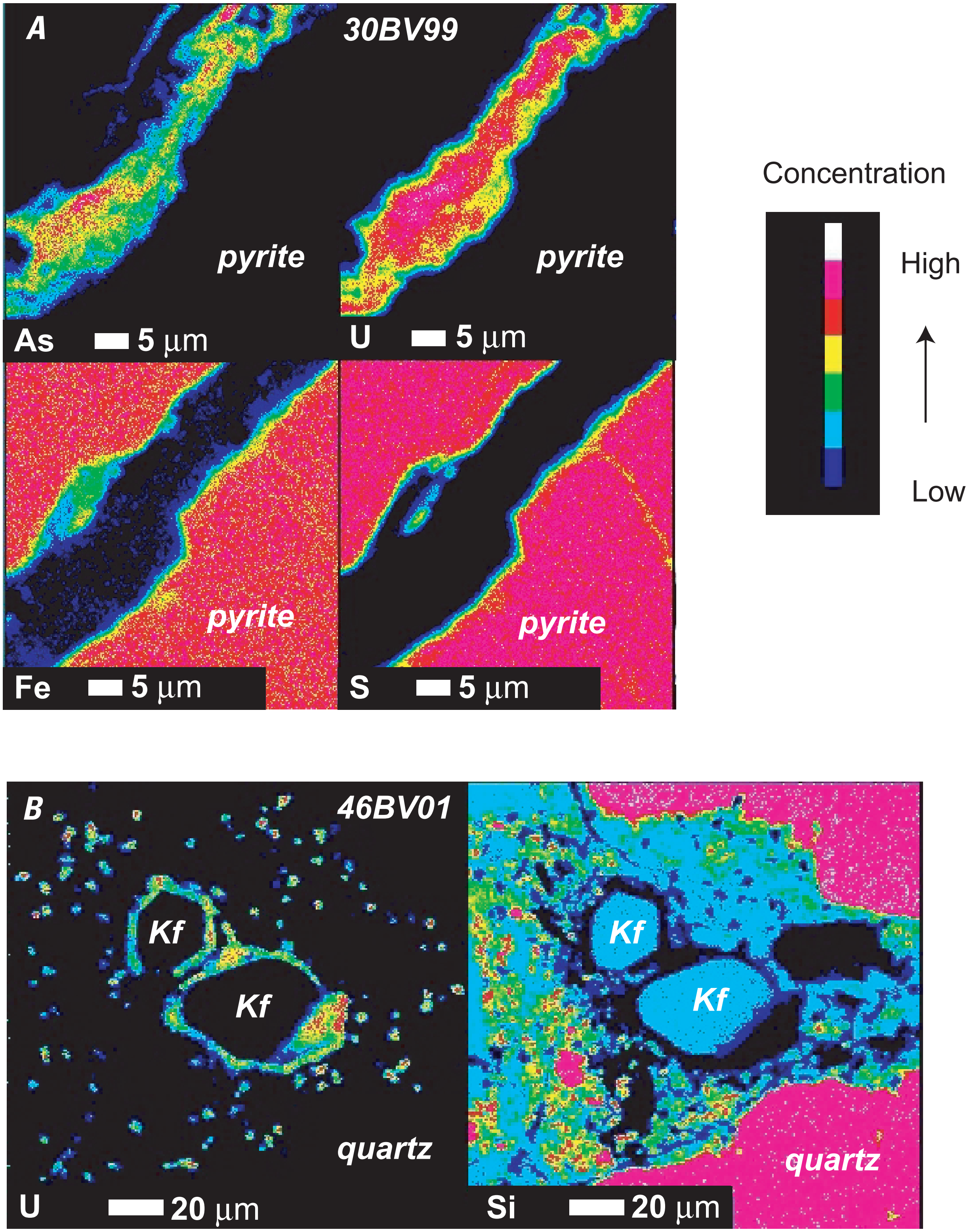


Figure 6. Electron-microprobe maps, showing the distribution of uranium minerals in conglomerate-hosted ore. *A*, Sample 30BV99. Veinlets of a uranium- and arsenic-bearing phase cutting arsenic-free pyrite from the East Basin No. 1 mine. No calcium or potassium was detected; elsewhere in the sample, the uranium- and arsenic-bearing mineral typically contains as much as 5 percent Fe. *B*, Sample 46BV01. Disseminated 1- to 5-µm grains and rims of uraniferous minerals around potassium feldspar (Kf) in conglomerate matrix from the Coal Creek No. 1 mine.

Vein-Type Uranium Deposits

The second type of uranium deposit in the Stanley uranium district occurs within fractures in rocks of the Idaho batholith (table 1; pl. 1; fig. 1). Choate (1962, p. 29) distinguished two types of fracture-hosted uranium deposits in the district: “veins with substantial amounts of quartz, and veins with little or no quartz.” At least some of these deposits are spatially associated with aplitic dikes (Kern, 1959; Choate, 1962). The primary uranium mineral in the vein-type deposits has been identified as uraninite, accompanied by quartz, chalcedony, and trace amounts of pyrite, stibnite, molybdenite, sphalerite, gold, and silver in some deposits (Choate, 1962). Several secondary uranium minerals have been identified in these deposits, including kasolite, a member of the phosphuranylite-renardite series, uranophane, beta-uranophane, clarkeite, schoepite, and vandendriesscheite (see Choate, 1962, p. 31).

Uranium-mineralized veins, fractures, and fault gouge are typically <2 ft wide, but zones of radioactive fractures can extend for a few tens of feet across the face of some mines (Kern, 1959; Choate, 1962). The ores produced from vein-type deposits in the district averaged approximately 0.18 percent U_3O_8 (table 6 of Choate, 1962).

Three vein-type uranium deposits were sampled for this study—the Lightning No. 2 adit, the Alta adit, and the Baker and Potato Hill claims. Geologic descriptions of the individual mines and prospects are provided in Choate (1962). The Lightning No. 2 adit consists of a pit gouged into the hill slope (fig. 7*A*). Mine drainage emanates from a collapsed adit (fig. 7*B*) that was apparently destroyed by the pit construction. At the Alta adit, two adits are present. The upper adit is driven into a shear zone in altered granite of the Idaho batholith (fig. 7*D*). The lower adit is collapsed about 15 m (50 ft) from the opening (fig. 7*C*). Slumped, <2-mm-size material was sampled from within the adit, and a composite sample was taken of the mine-waste dump. Mine waste was sampled from the weathered face of a prospect trench at the Baker and Potato Hill claims, where aplite veins cut weathered granite of the Idaho batholith with anomalous radioactivity.

Geochemistry

Rocks and Composite Mine Wastes

The most striking chemical difference between the two types of uranium deposits in the Stanley uranium district is their arsenic content (fig. 8). Although arsenic concentrations locally reach approximately 1 percent in the strata-bound uranium ores, the vein-type deposit samples contain <0.01 percent (<100 ppm) As (appendix 1, table 1–6). Although the arsenic concentrations within the vein-type uranium ores (6.5–80 ppm in the samples of this study) would be anomalous by the standards of many rock and uranium deposits, these arsenic values are minor compared to the high concentrations in the strata-bound deposits.

The selenium and vanadium concentrations in rocks and mine wastes from vein deposits overlap the concentrations detected in strata-bound deposits. Granitic rock at the Alta and Lightning No. 2 adits contains elevated molybdenum (up to 560 ppm). The brecciated granitic rock at the Alta adit contains arsenic (52 ppm), mercury (54 ppm), antimony (1,200 ppm), thallium (43 ppm), and lead (560 ppm) (appendix 1, table 1–6), concentrations that reflect some degree of hydrothermal activity. These potentially toxic elements occur in much lower concentrations in the composite mine-waste samples (appendix 1, table 1–7). The fact that the total carbon concentrations (0.62 weight percent C or less) of the vein-type deposits are lower than the total carbon concentrations of the strata-bound deposits (as high as 17 weight percent C, appendix 1, table 1–6) reflects the organic-poor character of the vein deposits. Most of the vein-type deposit samples contain <0.05 weight percent total sulfur.

Stream Sediments

Some stream sediments collected in the Idaho batholith terrane of the district contain fairly high concentrations of chromium (130, 150, and 170 ppm; appendix 1, table 1–8). Although these sediments likely reflect natural erosion of the batholith, such chromium concentrations exceed the PEC guideline value (111 ppm Cr) for sediments in freshwater aquatic ecosystems (MacDonald and others, 2000). Siems and others (1979) noted that Idaho batholithic rocks of the Stanley area contain more strontium and lead than average granitoid rocks.

Waters

Drainage from the Lightning No. 2 adit (fig. 7*B*)—a batholith-hosted, vein-type uranium deposit—had low arsenic content (1 ppb), but higher concentrations of molybdenum (3.7 ppb), lead (1.2 ppb), antimony (1.3 ppb), and zinc (9 ppb) than waters associated with the strata-bound uranium deposits (appendix 1, table 1–9). The uranium concentration in this adit drainage (19 ppb) was the highest measured in waters of this study.

The drainage from the Lightning No. 2 adit and the waters of Hay Creek upstream of the adit contained low anion (chloride, fluoride, nitrate, and sulfate) concentrations (appendix 1, table 1–10).

Mine-Waste Leachates

The field leaching test by the method of Hageman and Briggs (2000a, 2000b) showed that mine wastes from the Lightning No. 2 adit produced solutions that mimic the geochemical signature of the adit drainage; for example, these leachates contained higher concentrations of molybdenum, lead, antimony, thallium, and zinc than the leachates of strata-bound uranium mine wastes (appendix 1, table 1–11). The leachate produced from the sample of mine waste collected from the dry, collapsed Alta adit had the highest mercury concentration (0.02 ppb) of all the leachate samples (appendix

Figure 7. Field photographs of vein-type uranium deposits. *A*, Open-pit gouge on hillslope at the Lightning No. 2 adit (where sample 30JH99 was collected). *B*, Mine drainage from collapsed adit, Lightning No. 2 adit (where water sample 99CH032 was collected). The water had a pH of 6.9 and contained 16 ppb U and 0.9 ppb As. *C*, Partly collapsed lower adit at the Alta adit (where sample 20JH00 was collected). *D*, Sheared granite of the Idaho batholith at the Alta adit; object (camera) for scale is 15 × 10 cm. Inset shows the porphyritic texture of the granite.

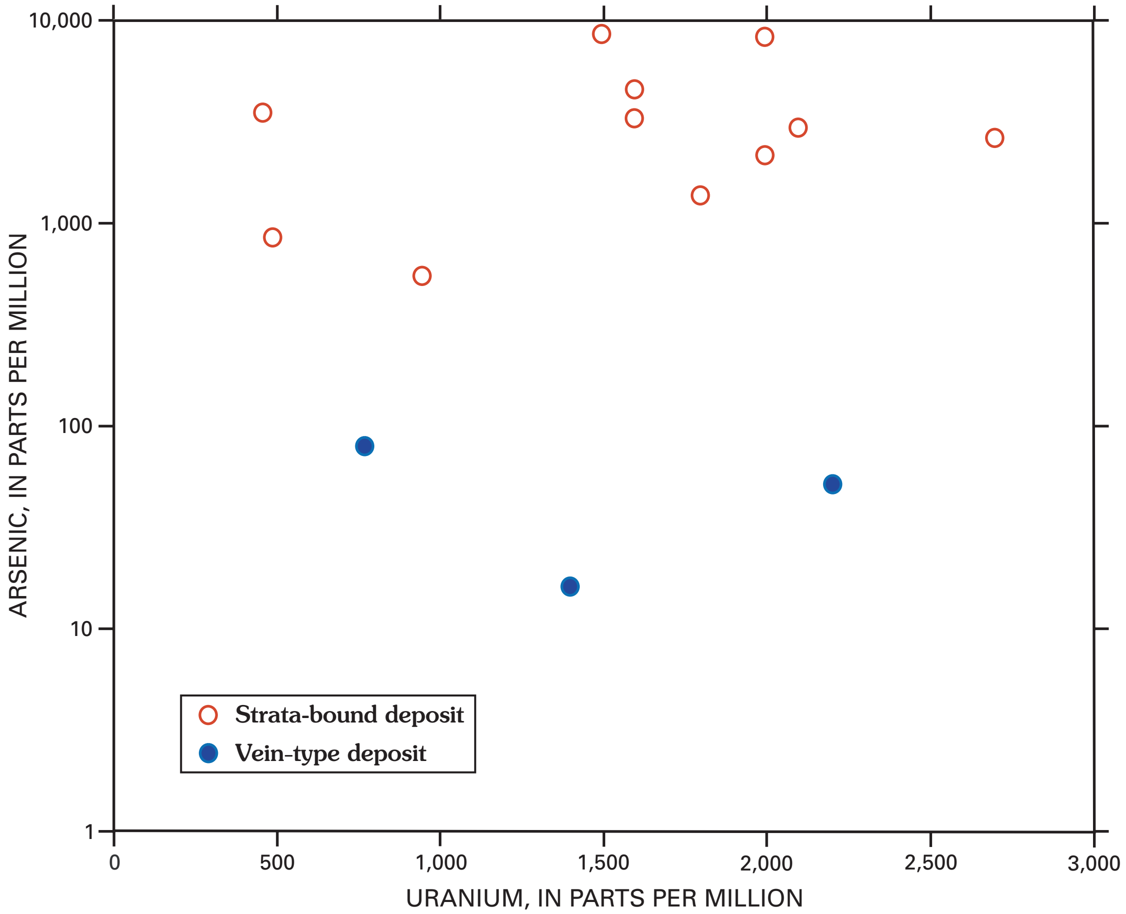


Figure 8. Scatter plot of uranium versus arsenic concentrations in ore samples collected from the Stanley uranium district.

1, table 1–11). However, the metal concentrations of leachate from the surface mine-waste dumps at the Alta adit were similar to background waters, excepting only a higher phosphorus content (66 ppb).

Mineralogy

Pervasively altered granite at the Baker and Potato Hill claims is composed of quartz, potassium feldspar (Or_{97}), albite (Ab_{99}), sericite, monazite, apatite, and rutile(?) after titanite (fig. 9). A secondary uranium mineral is ubiquitous, occurring as disseminated, pale yellow-green grains that fluoresce green under short-wave ultraviolet light. An XRD pattern of material scraped off of rock chips under UV light identified the material as meta-autunite intergrown with muscovite and clay. The meta-autunite occurs as laths as long as 120 µm (fig. 10*A*) and as narrow (≈5-µm-wide) veinlets. Laths typically form bundles associated with apatite in a matrix of potassium feldspar or quartz (fig. 11). Although rounded apatite crystals are associated with meta-autunite crystals, no uranium was detected in the apatites within the EPMA's lower limit of detection (≈200 ppm).

The rock at the Alta adit is a silicified breccia cut by 0.1-mm-wide veins. The breccia contains disseminated, 5-µm-diameter crystals of a potassium-uranium phosphate mineral (chemical components identified by SEM) in quartz as well as rosettes and veinlets of a calcium-uranium phosphate mineral (autunite? phosphuranylite?) that contain minor amounts of cerium and antimony (fig. 10*B*). Apatite crystals are veined and rimmed by rare earth element-bearing uranium minerals (fig. 10*C*). Stibnite as well as trace amounts of galena are present, which explain the distinctive antimony and lead contents of the rock at the Alta adit. A yellow-white coating scraped from a rock surface was identified as uranophane ($Ca(UO_2)_2Si_2O_7{\cdot}6H_2O$) by XRD. SEM study of a cluster of secondary surface minerals shows that some of the uranophane crystals contain potassium as well as calcium, and they grow as radiating bundles of fibers on a matrix of euhedral quartz pyramids (fig. 12). Microprobe analyses of uranium minerals in a polished section cut from the interior surface of the breccia indicated calcium, phosphorus, and uranium, but no detectable potassium.

No fluorescent coatings were observed in rock samples from the Lightning No. 2 adit. Electron-microprobe data indicate that the uranium mineral is a calcium silicate, consistent with the expected composition for uranophane.

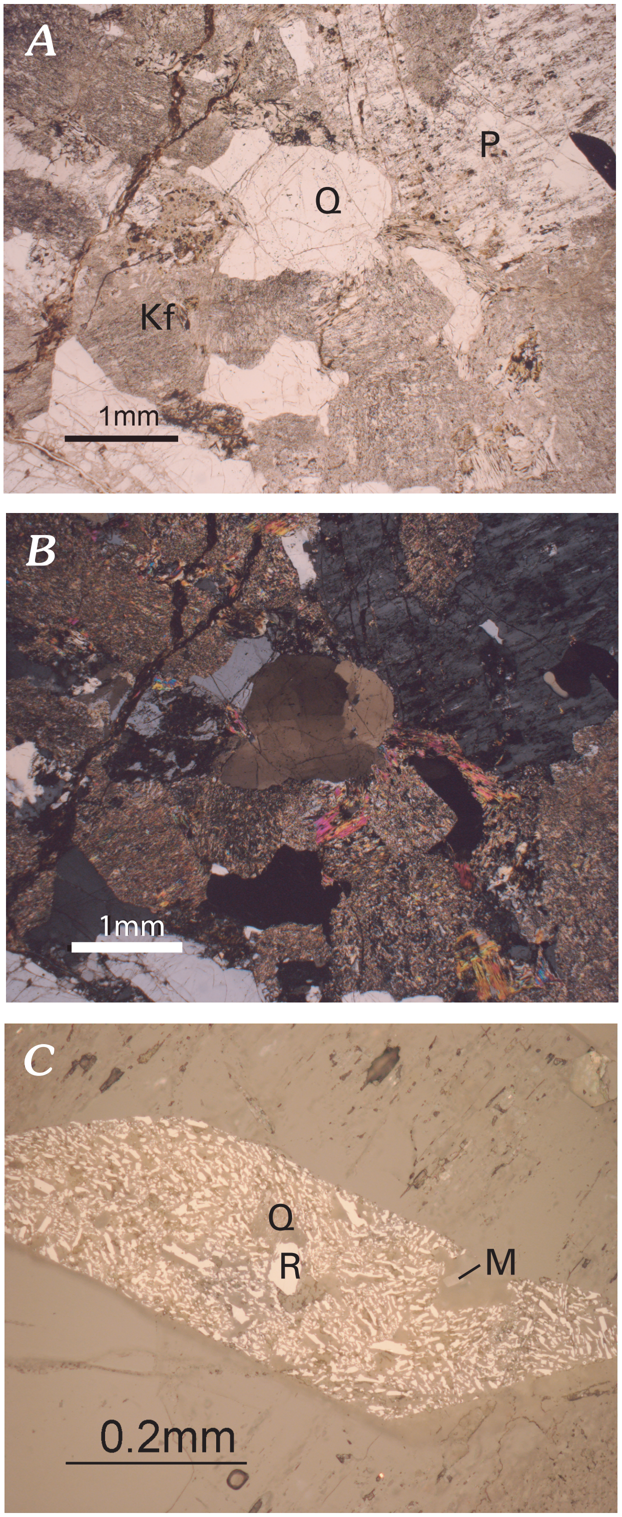


Figure 9. Photomicrographs of sample 16BV01 from the Baker and Potato Hill claims (vein deposit), showing highly altered granitic rock. Labels: Kf, potassium feldspar; M, monazite; Q, quartz; P, plagioclase; R, rutile. *A*, Plane-polarized light, showing quartz, plagioclase, and strongly sericitized potassium feldspar. *B*, Same view, crossed nicols. *C*, Reflected light, showing replaced titanite(?) crystal altered to rutile and quartz. Monazite inclusion lacks uranium.

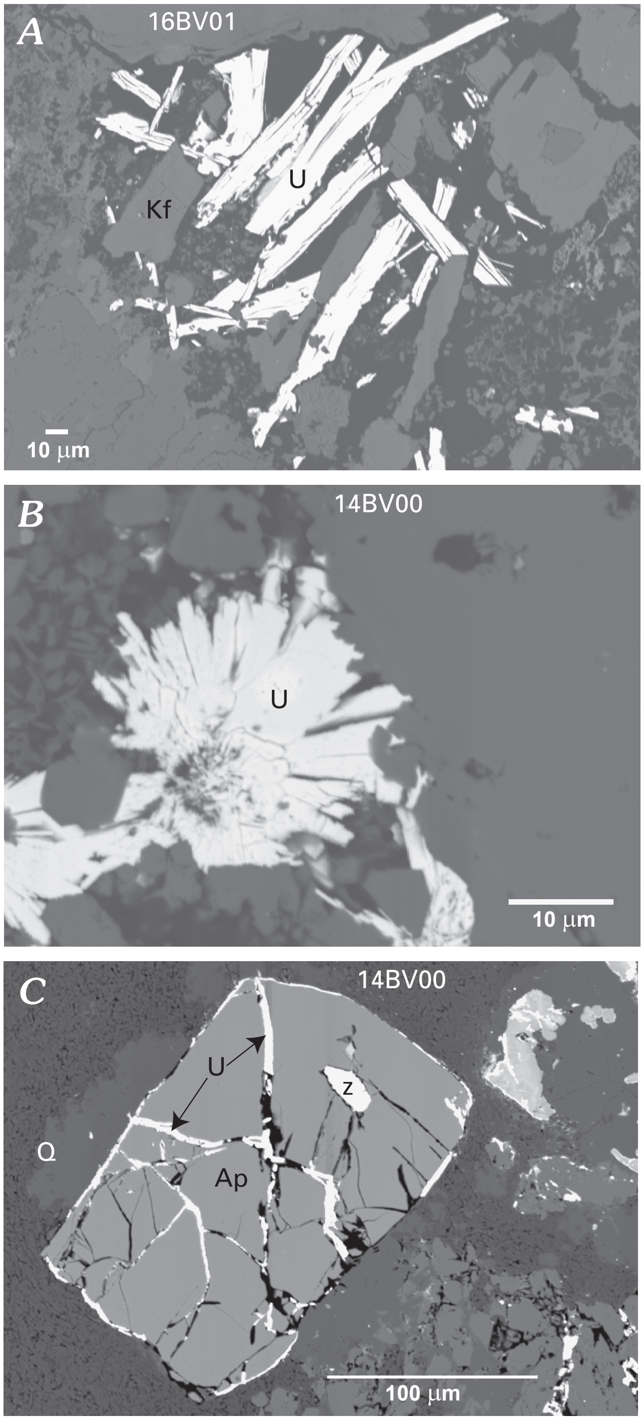


Figure 10. Backscattered-electron SEM images of secondary uranium minerals in vein-type deposits. *A*, Sample 16BV01, Baker and Potato Hill claims. Meta-autunite laths (labeled U) and potassium feldspar (labeled Kf). *B*, Sample 14BV00, Alta adit. Rosette of calcium-, uranium-, and phosphorus-bearing (autunite? phosphuranylite?) crystals (labeled U) that contain minor amounts of cerium and antimony. *C*, Sample 14BV00, Alta adit. Fluorapatite crystal with zircon inclusion and veined and rimmed by a rare earth element–, calcium-, uranium-, and phosphorus-bearing mineral (labeled U) (autunite? phosphuranylite?). Ap, fluorapatite; Q, quartz; Z, zircon.

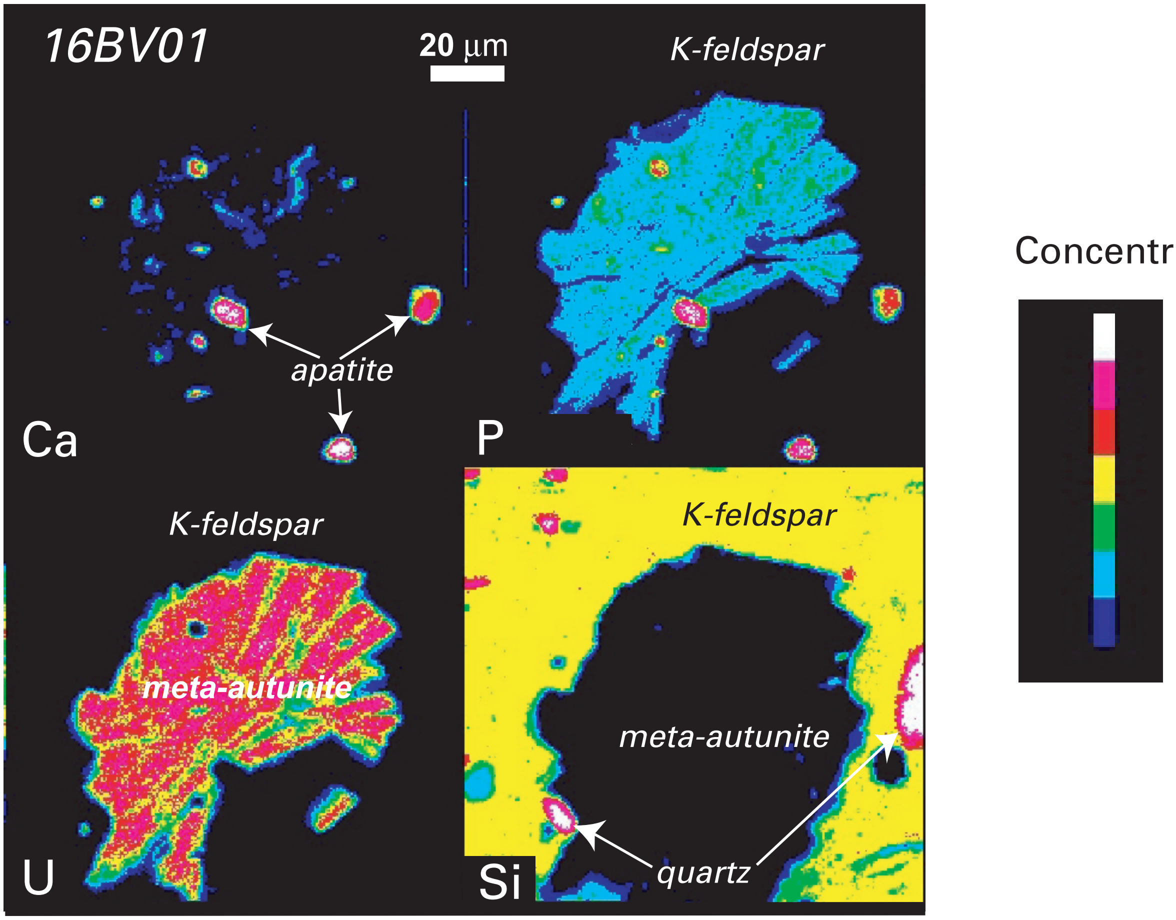


Figure 11. Electron-microprobe maps, showing the distribution of calcium, phosphorus, uranium, and silicon for a rosette of meta-autunite in potassium (K-) feldspar of sample 16BV01 from the Baker and Potato Hill claims. Note apatite inclusions in and near the meta-autunite and the heterogeneity of calcium, phosphorus, and uranium within the meta-autunite.

Discussion

The major environmental impacts associated with uranium deposits globally include

1. radon emanation and gamma radiation from ore and waste piles,
2. redistribution of mine wastes and mill tailings by wind and water, and
3. contamination of local drainages and aquifers with acid-mine drainage from sulfidic deposits (Wenrich and others, 1995; Ripley and others, 1996).

Uranium ores can also contain significant concentrations of nonradioactive elements of environmental concern, such as copper, vanadium, molybdenum, arsenic, lead, and nickel.

The uranium deposits of the Stanley district are small and isolated from populated areas. All of the surface material is oxidized. No extensive mineral processing was done on-site. There are small piles of mine waste, but no extensive tailings deposits. Mine waste at all of the deposits visited for this study registered radioactivity on a scintillometer, although in most cases it was highly localized. Most of the deposits were dry when visited. The exceptions are the East Basin No. 1 mine, where a perennial pond fills the open pit, and the collapsed Lightning No. 2 adit, which contains two small ponds. Both sites serve as a drinking-water source for wildlife. All three ponds had a nearly neutral pH and contained <100 ppb U in dissolved form. Background water samples in the district contained <3 ppb U in dissolved form.

The most notable finding of this reconnaissance study is the very high arsenic content within the strata-bound uranium deposits of the Stanley uranium district. Arsenic concentrations of 120 ppm or more were found in all rock samples collected from uranium ore zones hosted by conglomerate and sandstone strata (appendix 1, table 1–6). Most of the rock samples contained >1,000 ppm As; the maximum measured arsenic concentration was 8,600 ppm (0.86 weight percent). About half of the mine-waste samples (<2-mm-size material) from the strata-bound uranium deposits (appendix 1, table 1–7) contained arsenic in excess of the U.S. Environmental Protection Agency (EPA) preliminary remediation goal for

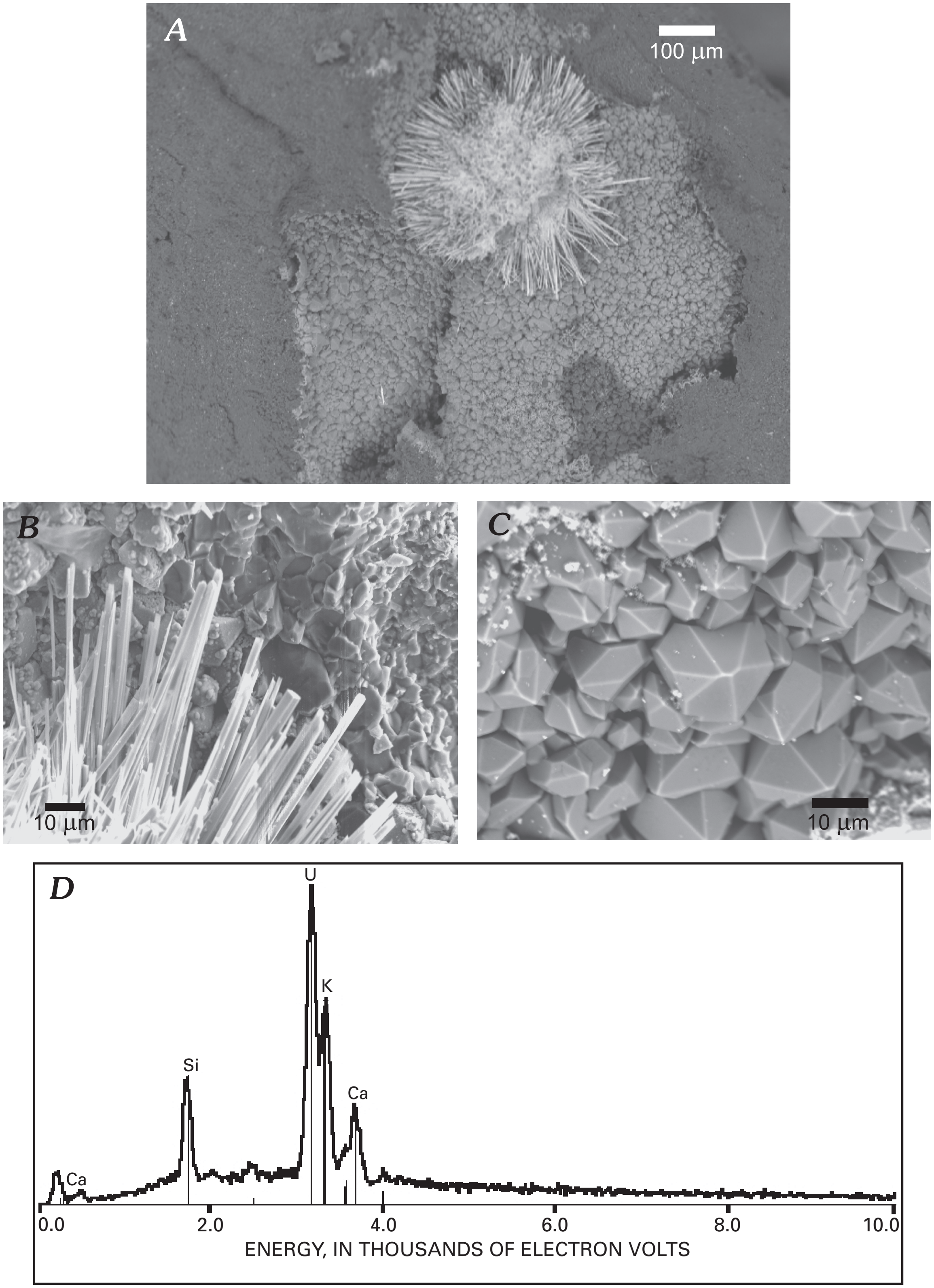


Figure 12. Surface coatings of secondary uranium minerals on brecciated granite at the Alta adit. *A*, Low-magnification, backscattered-electron image of radiating crystals of uranophane on quartz. *B*, High-magnification SEM image of uranophane. *C*, High-magnification SEM image of quartz substrate. Note the euhedral, pyramidal form of the quartz. Some quartz crystals are coated with a thin veneer of uranophane (bright, irregularly shaped spots). *D*, EDS spectrum of one of the uranophane laths shown in *B*.

arsenic in industrial soils (260 ppm As). The highest value measured in the mine-waste samples was 6,400 ppm. For comparison, a study of soils and other surficial materials from the western United States (730 samples) found their mean arsenic content to be 5.5 ppm; the maximum value was 97 ppm (table 2 of Shacklette and Boerngen, 1984). The high arsenic content of the strata-bound uranium deposits in the Stanley uranium district is a reflection of their unusual mineral assemblage. Although pyrite or marcasite is ubiquitous in many uranium deposits, arsenopyrite is less commonly reported. The strata-bound uranium ores contain uranium-bearing arsenopyrite, which subsequently was altered to produce secondary uranium arsenate minerals. Although uranium and arsenic coexist in the strata-bound deposits, arsenic content greatly exceeds uranium content in some of the deposits, whereas the reverse is true in other deposits (appendix 1, table 1–6). The vein-type deposits contain very minor amounts of sulfide minerals and low total sulfur concentrations.

Summary and Conclusions

Composition of the Deposits

Uranium is present in the Stanley uranium district as secondary (oxidized) minerals of the autunite, phosphuranylite, and uranophane mineral groups. The minerals are predominantly composed of uranium, calcium, iron, phosphorus, and (or) silicon. Figure 13 illustrates the compositional range of the uranium minerals in the different deposits, in terms of molar proportions of major elements determined by electron microprobe. The uranium minerals at the conglomerate-hosted deposits of the East Basin No. 1 mine and Coal Creek No. 1 mine are distinct by virtue of their arsenic- and iron-rich compositions. In contrast, the secondary uranium minerals in the sandstone-hosted deposit at the Shorty pit are phosphorus- and calcium-rich meta-autunites that overlap the compositions of uranium minerals at the Baker and Potato Hill claims and Alta adit, which are vein-type deposits. Both uranophane and autunite-like minerals are present at the Lightning No. 2 adit.

Water-Quality Issues

The national recommended water-quality criteria for arsenic content in fresh water (affecting aquatic life) are 150 ppb As (chronic level) and 340 ppb As (acute level) (U.S. Environmental Protection Agency, 2002). Elevated arsenic concentrations (190 and 150 ppb) measured in the pond at the East Basin No. 1 mine pit may pose a threat to wildlife because the animals use the pond as a source of drinking water. The current enforceable maximum contaminant level (MCL) for arsenic allowed in drinking water has been 50 ppb (equal to 0.05 mg/L), as set by the U.S. EPA (Environmental Protection Agency, 2002). On 23 January 2006, the MCL for arsenic in drinking water was lowered to 10 ppb (U.S. Environmental Protection Agency, 2001). A test for arsenic would help determine the safety of existing and any future wells emplaced into the channel deposits (unit Ta, pl. 1) that sit atop the batholith. Our data for mine waters and mine-waste leachates from the conglomerate-hosted deposits, as well as Shacklette and Erdman's (1982) data on element uptake in moss, indicate that uranium and arsenic are mobile in Stanley uranium district waters. Data for uranium and arsenic dissolved in water samples from this study are summarized in table 2.

None of the springs or streams sampled away from mine sites contained arsenic in excess of proposed drinking-water standards. However, all sampling was accomplished in August during low flow. Seasonal monitoring of waters in the Stanley uranium district would help determine whether the waters are safe as drinking-water sources.

Origin of the Two Types of Deposits

The relationship between the strata-bound, sedimentary rock–hosted uranium deposits and the vein-type uranium deposits in the Stanley uranium district is not clear. Several observations lend some insight to their origin:

1. Although the uranium-mineralized veins and fractures in batholithic rocks are commonly found in the *vicinity* of strata-bound deposits, uranium-enriched veins have not been observed to extend into or to underlie the mined-out bedded deposits.

2. Uranium-enriched bodies have not been noted in other stratigraphic units of the Challis Volcanic Group. The uranium mineralization has only occurred within the channel conglomerate and sandstone bodies that are sandwiched between the top of the Idaho batholith and the base of Challis Volcanic Group.

3. Organic material (vitrain) in the sedimentary deposits provided a locally reducing environment that could have promoted deposition of sulfide minerals and uraninite.

4. Uranium in the strata-bound deposits is closely associated with vitrain and carbonaceous detritus, yet other units of the overlying Challis Volcanic Group are similarly carbonaceous but lack significant uranium mineralization.

5. All of the strata-bound uranium deposits sampled by the study contained arsenopyrite and arsenian pyrite, which are typically relatively high temperature mineral phases; these minerals contribute to the high arsenic content of the strata-bound deposits (arsenic concentrations of thousands of parts per million; appendix 1, table 1–6).

6. The strata-bound uranium deposits in the district cluster along the southwestern margin of the Custer graben.

7. Epithermal precious metal deposits hosted by Challis Volcanic Group rocks in the Custer graben also contain elevated arsenic concentrations (Hammarstrom and others, 2004).

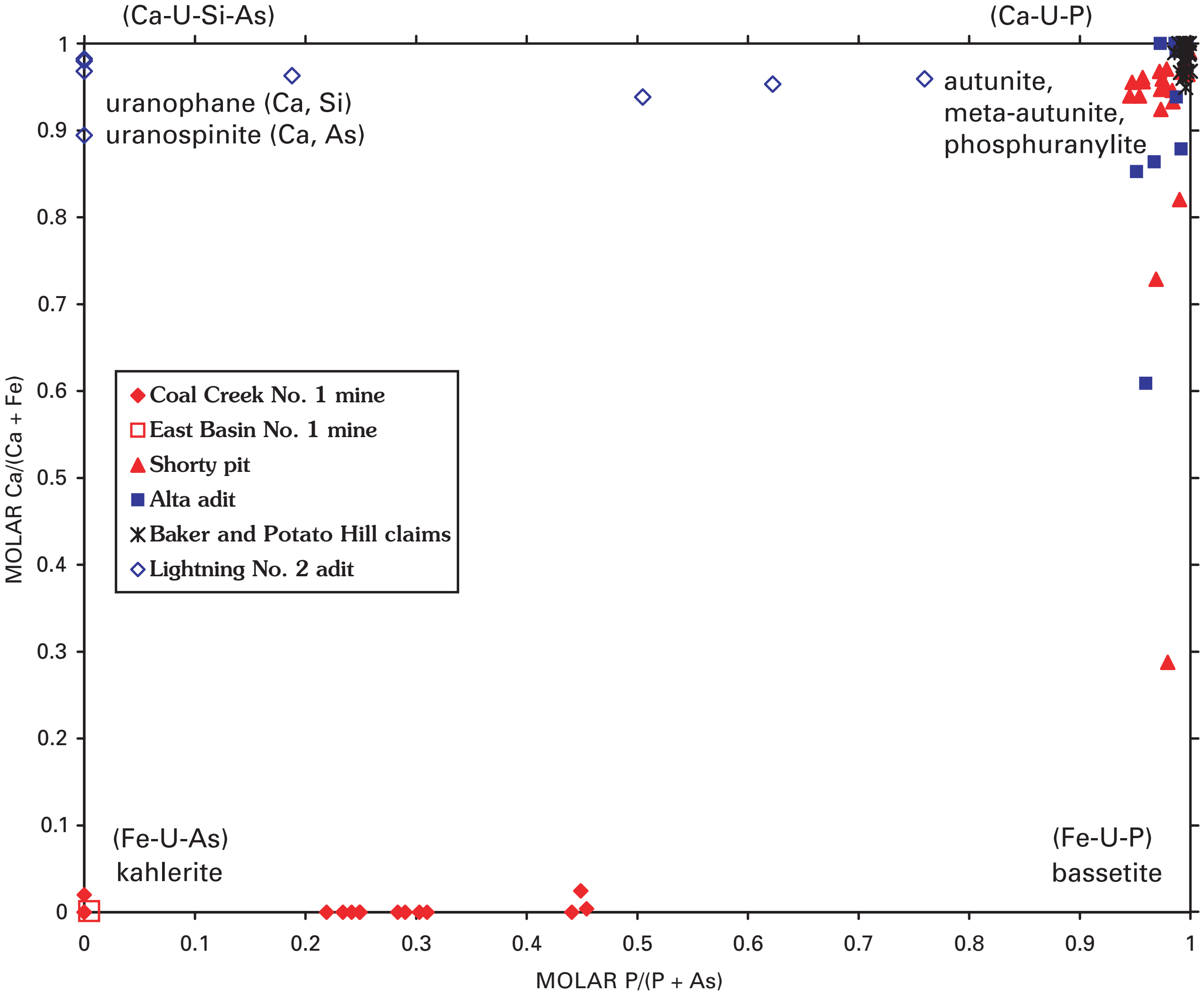


Figure 13. Plots of molar proportions of Ca/(Ca + Fe) versus P/(P + As) for secondary uranium minerals from the Stanley uranium district, based on electron-microprobe data that indicate that these cations are the major components of the uranium minerals. Locations of selected end-member uranium minerals in calcium-iron-phosphorus-arsenic space are shown for reference. Minerals plotting along the *x*-axis are low in calcium, high in iron, and variable in phosphorus. Autunite-group minerals include uranospinite ($Ca(UO_2)_2(AsO_4)_2 \cdot 10H_2O$), autunite/meta-autunite ($Ca(UO_2)_2(PO_4)_2 \cdot 10–12H_2O$), kahlerite ($Fe^{2+}(UO_2)_2(AsO_4)_2 \cdot 10–12H_2O$), and bassetite ($Fe^{2+}(UO_2)_2(PO_4)_2 \cdot 8H_2O$).

Given these observations, one could conclude that hydrothermal alteration associated with the Eocene Challis Volcanic Group contributed the arsenic, and perhaps the associated uranium, found in the strata-bound uranium deposits of the Stanley district.

The lack of arsenic in the vein deposits may be a function of rock permeability and distal location relative to the Custer graben's marginal faults, which likely served as conduits for hydrothermal fluids. The vein-type uranium deposits could have formed prior to (as proposed by Choate, 1962) or coeval with the strata-bound uranium deposits (Kern, 1959), as either model is possible from the available evidence. The relative ages of the two deposit types are not yet known. Thus, the relationship between the vein and strata-bound deposits, and their genesis, may not be resolved until age determinations are conducted on the uraninite (the primary uranium mineral) in both deposit types.

Table 2. Dissolved uranium and arsenic (in ppb) within waters of the Stanley uranium district.

Sample	Site	Water type	U (ppb)	As (ppb)
Disseminated deposits hosted by sedimentary rocks of the Challis Volcanic Group				
99CH029	East Basin No. 1 mine, pond filling pit	Mine water	48	190
00CH038	East Basin No. 1 mine, pond filling pit	Mine water	61	150
00CH039	Spring above mining, background site	Background ground water	0.17	0.5
00CH040	Spring above mining, background site	Background ground water	0.22	2
99CH031	East Basin Creek downstream of East Basin No. 1 mine	Surface-water impact	0.43	1
99CH030	East Basin Creek upstream of East Basin No. 1 mine	Background surface water	0.24	1
00CH044	Coal Creek downstream of Deer Strike claims	Surface-water impact	0.74	2
00CH041	Spring above mining, background site	Background ground water	2.4	<0.2
00CH042	Seep near Deer Strike claims	Ground-water impact	1.4	2
00CH043	Intermittent drainage downstream of Little Joe claims	Surface-water impact	4.2	7.6
01CH091	Boggy area at Little Joe claims	Mine water	4	7.2
Vein deposits hosted by granitic rocks of the Idaho batholith				
99CH032	Water in Lightning No. 2 adit	Mine water	16	0.9
99CH033	Hay Creek upstream of Lightning No. 2 mine	Background surface water	0.52	0.6

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Appendix 1. Summary of Analytical Methods and Results of Analyses

Methods Used on Solid Media (Rocks, Mine Waste, and Stream Sediments)

Chemical analyses of solid samples—such as rocks, mine dump and mill tailings, and stream sediments—were performed by XRAL Laboratories of Don Mills, Ontario, Canada (XRAL), under a contract with the U.S. Geological Survey (USGS).

In this study, analytical results obtained from XRAL passed two levels of validation for precision and accuracy. The laboratory's quality-control protocol is to insert a reagent blank and reference material with every batch of 20 samples to measure the analytical accuracy. Duplicate samples were analyzed at the end of the sample set to measure analytical variance as well as sample variance. Data that passed the quality-control criteria from XRAL are sent to the USGS.

The second level of data validation was performed at the USGS. All samples submitted to XRAL are accompanied by a set of blind, in-house reference samples. The data for the reference samples are evaluated for accuracy. The values must fall within the range of acceptance, which varies between ±5 percent and ±20 percent depending on analytical method. Analytical results that meet the accepted quality control are released to the submitter. Analytical results with rejected quality control are reanalyzed by XRAL. In the following discussion and tables 1–6 through 1–11 of appendix 1,

- "ppm" signifies parts per million,
- "ppb" is parts per billion,
- " percent" is weight percent of sample, and
- "<" represents an undetermined value below the specified limit of determination.

ICP-AES Analyses for 40 Elements

Forty major, minor, and trace elements were determined in geologic materials by inductively coupled plasma–atomic emission spectrometry (ICP-AES). In this analytical method, the 0.2-g sample is decomposed by using a mixture of hydrochloric, nitric, perchloric, and hydrofluoric acids at low temperature. The digested sample is aspirated into the ICP-AES discharge where the elemental emission signal is measured simultaneously for the 40 elements. Calibration is performed by standardizing with digested-rock reference materials and with a series of multielement solution standards. Upper and lower determination limits for this method are listed in table 1–1 of appendix 1.

Table 1–1. Reporting limits for 40 elements by ICP-AES.

Element	Lower determination limit	Upper determination limit
	Concentration, in weight percent	
Al	0.005	50
Ca	0.005	50
Fe	0.020	25
K	0.010	50
Mg	0.005	5
Na	0.005	50
P	0.005	50
Ti	0.005	25
	Concentration, in parts per million	
Ag	2	10,000
As	10	50,000
Au	8	50,000
Ba	1	35,000
Be	1	5,000
Bi	50	50,000
Cd	2	25,000
Ce	5	50,000
Co	2	25,000
Cr	2	25,000
Cu	2	15,000
Eu	2	5,000
Ga	4	50,000
Ho	4	5,000
La	2	50,000
Li	2	50,000
Mn	4	50,000
Mo	2	50,000
Nb	4	50,000
Nd	9	50,000
Ni	3	50,000
Pb	4	50,000
Sc	2	50,000
Sn	50	50,000
Sr	2	15,000
Ta	40	50,000
Th	6	50,000
U	100	100,000
V	2	30,000
Y	2	25,000
Yb	1	5,000
Zn	2	15,000

Hydride AA Analyses for Arsenic, Antimony, Selenium, Tellurium, and Thallium

Hydride-generation atomic absorption spectrometry (hydride AA) was the analytical technique used to resolve the concentrations of these elements. Arsenic, antimony, and thallium are determined by measuring 0.1 g of sample into a zirconium crucible. Approximately 0.75 g of sodium peroxide is added and mixed. The mixture is heated for 4 min in a muffle furnace set at 750°C. The fusion cake is cooled; then 15 mL of water and 5 mL of concentrated HCl is added. The mixture is shaken, and 0.25 mL of an ascorbic acid ($C_6H_8O_6$) + KI solution is added, then diluted with 20 percent HCl and allowed to stand overnight.

Arsenic, antimony, and thallium are then measured by using hydride AA. The optimum concentration ranges without sample dilution for these elements in various solid-phase sample media are arsenic, 0.6 to 20 ppm; antimony, 0.6 to 20 ppm; and thallium, 0.1 to 10 ppm.

Selenium and tellurium are determined by measuring 0.25 g of sample into a Teflon tube, adding a mixture of nitric, hydrofluoric, and perchloric acids, and heating the solution to dryness (≈110°C). After the solution has dried, additional hydrochloric and nitric acids redissolve the sample, and the solution is heated again and cooled. The samples are diluted and analyzed by using hydride AA. The expected analytical range for selenium is 0.2 to 4 ppm, and the lower reporting limit for tellurium is 0.1 ppm.

Fire-Assay Analyses for Gold

Gold was determined by direct-current plasma (DCP) or atomic absorption spectrophotometry after collection by fire assay. An assay fusion consists of heating a 15-g mixture of the finely pulverized sample with about three parts of a flux until the product is molten. One of the ingredients of the flux is a lead compound, which is reduced by other constituents of the flux or sample to metallic lead. The lead collects all the gold, together with silver, platinum-group metals, and small quantities of certain base metals present in the sample, and then falls to the bottom of the crucible to form a lead button. The gangue of the ore is converted by the flux into a slag sufficiently fluid so that all particles of lead may fall readily through the molten mass. The choice of a suitable flux depends on the character of the ore. The lead button is placed in a cupel to oxidize the lead, leaving behind a dore bead containing the precious metals. The dore bead is then transferred to a test tube and dissolved with aqua regia. The solution is diluted to a specific volume, and gold is determined by DCP or atomic absorption spectrophotometry. The lower reporting limit for a 15-g sample charge is 5 ppb by DCP and atomic absorption. The upper reporting limit is 10,000 ppb.

Separated Cold-Vapor Analyses for Mercury

Mercury was determined by the method of separated cold-vapor analysis. A small amount of sample (0.1 g) is digested with a mixture of sulfuric acid, nitric acid, 5 percent potassium permanganate, and 5 percent potassium peroxydisulfate in a water bath for 1 h. The excess of potassium permanganate is reduced with hydroxylamine sulfate solution, and then Hg^{2+} is reduced with stannous chloride. In the cold-vapor method, the mercury vapor is separated by chilling and measured by using a LEEMAN PS200 automated mercury analyzer. The technique offers a lower reporting limit of 0.02 ppm Hg in solid-phase samples. Samples exceeding the working range of 0.02 to 1.8 ppm Hg require dilution before analysis.

Total Carbon Analyses

Total carbon was determined by the use of an automated carbon analyzer. A measured sample (0.25 g sample used) is combusted in an oxygen atmosphere at 1,370°C to oxidize carbon to carbon dioxide. Moisture and dust are removed, and the carbon dioxide gas is measured by a solid-state infrared detector. The operating range is 0.05 percent to about 30 percent total carbon.

Carbonate Carbon and Organic Carbon Analyses

Carbonate carbon was determined as carbon dioxide by coulometric titration. The sample is treated with hot 2 *N* perchloric acid, and the evolved carbon dioxide is passed into a cell containing a solution of monoethanolamine. The carbon dioxide, quantitatively absorbed by the monoethanolamine, is coulometrically titrated by using platinum and silver electrodes slightly above potassium iodide crystals. The lower reporting limit is 0.01 percent carbon dioxide, and samples containing as much as 50 percent carbon dioxide may be analyzed. Sample size is 0.5 g for the range 0.01 to 5 percent carbon dioxide, 0.1 g for the range 5 to 10 percent carbon dioxide, and 0.02 g for samples with >10 percent carbon dioxide.

Organic carbon content is determined by subtracting the measured carbonate carbon concentration from the measured total carbon concentration.

Total Sulfur Analyses

Total sulfur was determined by using an automated sulfur analyzer. Approximately 0.25 g of sample is mixed with iron chips and LECOCEL and is heated in a combustion tube in a stream of oxygen at high temperature. Sulfur is oxidized to sulfur dioxide. Moisture and dust are removed, and then the sulfur dioxide gas is measured with a CS-244 infrared detector. The reporting range for total sulfur is from 0.05 percent to about 35 percent.

Methods Used on Water and Leachate Samples

The USGS laboratories in Denver, Colorado, performed the chemical analysis of aqueous samples, including waters and leachate solutions. All of the analytical methods used and their analytical performance are described in Taggart (2002). Quality assurance for the samples was addressed through the individual laboratory that performed the analysis and the submitter. The submitter used field blanks and site duplicates as a measure of quality assurance. The individual laboratory used standard reference materials (to assess accuracy) and analytical duplicates (to assess precision) to address quality assurance. Accuracy of the standard reference material used for the particular method is plotted on a control chart. An excellent discussion of quality-assurance and quality-control measures used by the USGS can be found in Arbogast (1990). Values of the reference material must fall within the upper and lower control limits (generally, ±3 standard deviations of the pooled results for that reference material) that have been previously established through the analytical performance. Should a value fall outside of the control limits, the analysis is terminated, the problem is corrected, and the sample run is repeated. Duplicates are deemed acceptable if the variance is ±5 percent to ±10 percent, depending on the method.

Ion-Chromatography Analyses for Chloride, Fluoride, Nitrate, and Sulfate

The anions Cl^-, F^-, NO_3^-, and SO_4^{2-} were determined sequentially by ion chromatography (IC) on unfiltered, unacidified water samples (Theodorakos and others, 2002). The raw water samples are kept cool (below 4.5°C) from the time of collection until they are analyzed. Ions of interest separate in an ion-exchange column because of differing affinity of each species for the ion-exchange resin. Eluted anions are detected in a flow-through conductivity cell, and peak heights are recorded. Unknown samples are compared with peak heights of reference standards to determine sample concentrations. Limits of determination for anions in raw water samples are shown in table 1–2 of appendix 1.

Table 1–2. Limits of determination for anions in raw-water samples when analyzed by sequential ion chromatography.

Anion	Lower determination limit	Upper determination limit
Cl^-	0.1	4
F^-	0.05	2
NO_3^-	0.1	[1]10
SO_4^{2-}	0.5	[1]20

[1] Samples with high concentrations were diluted and reanalyzed.

Flow-Injection Cold-Vapor AF Analyses for Mercury

Mercury was determined by flow-injection cold-vapor atomic fluorescence (AF) analyses. In the laboratory, preserved samples are mixed with stannous chloride to reduce Hg^{2+} to Hg^0. The mercury vapor is purged from the aqueous phase with argon, passed through a drying tube, separated, and measured by using flow-injection cold-vapor atomic fluorescence (AF) spectrometry. For water samples, the lower limit of determination for this method is 5 parts per trillion. Operational details on this method are found in Hageman (2002). Limits of determination are shown in table 1–3 of appendix 1.

Table 1–3. Lower and upper determination limits for mercury by the atomic fluorescence (AF) spectrometric technique, ferrous iron by colorimetry (CO), and alkalinity by titration.

Element	Method	Lower determination limit	Upper determination limit
Hg	AF	0.1 ppb	None[1]
Fe^{2+}	CO	[2]0.01 ppm	None[1]
Alkalinity	Titration	1.0 ppm	None[1]

[1] Samples with high concentrations were diluted and reanalyzed.

[2] Lower determination limit for Fe^{2+} was 0.01 ppm for samples collected and analyzed in 1999 but 0.1 ppm for 2000 and 2001 samples (see appendix 1 for method differences).

Colorimetry Analyses for Ferrous Iron

For the samples collected in 1999, ferrous iron was determined in the laboratory by colorimetry (CO) through the use of a microprocessor-controlled, single-beam Hach spectrophotometer (Theodorakos, 2002b). Samples are introduced into an AccuVac Ampul and mixed quickly. Phenanthroline in the ampul reacts with ferrous iron in the sample to form an orange color, the intensity of which is proportional to the ferrous iron concentration. Ferric iron does not react. For concentrations higher than 3 ppm, solutions are diluted and reanalyzed. The lower limit of determination for this method is 0.01 ppm (table 1–3 of appendix 1).

Starting in 2000, ferrous iron was determined in the field by visual colorimetry through the use of a portable CHEMetrics test method (Kit K-6210, CHEMetrics, Inc.). As in the laboratory method used for the 1999 samples, ferrous iron reacts with phenanthroline to form an orange-colored complex, the intensity of which is proportional to the ferrous iron concentration. The sample is collected in a glass ampul containing the reagent and mixed for 1 min. Then the ampul is placed into a comparator containing standards of known ferrous iron concentration, and the concentration is visually estimated. The lower limit of determination for this method is 0.1 ppm.

Alkalinity Determined by Titration

On-site alkalinity tests were done on all samples collected throughout the study by using a field-portable CHEMetrics titration kit. For comparison, some water samples were also collected for laboratory alkalinity determination. For the laboratory alkalinity, an Orion 960 Autochemistry System is used for endpoint titration analysis (Theodorakos, 2002a). The titrant is added to 50 mL of sample until a pH of 4.5 is achieved. Alkalinity is then calculated and reported in units of parts per million as $CaCO_3$. Limits of determination are shown in table 1–3 of appendix 1.

ICP-AES Analyses for 27 Elements

Acidified water samples were analyzed for major (aluminum, calcium, iron, potassium, magnesium, sodium, and silicon) and selected trace elements following the inductively coupled plasma–atomic emission spectrometry (ICP-AES) method of Briggs (2002). Water samples are aspirated into a plasma, and element concentrations are determined directly by ICP-AES. Limits of determination for the multielement ICP-AES method for water samples are shown in table 1–4 of appendix 1.

Table 1–4. Limits of determination for the multielement ICP-AES method for water samples.

Element	Lower determination limit	Upper determination limit
Concentration, in parts per million		
Al	0.01	1,000
Ca	0.1	1,000
Fe	0.02	1,000
K	0.1	1,000
Mg	0.1	1,000
Na	0.1	1,000
P	0.1	1,000
Si	0.1	1,000
Concentration, in parts per billion		
Ag	10	10,000
As	100	10,000
B	5	10,000
Ba	1	10,000
Be	5	10,000
Cd	5	10,000
Co	10	10,000
Cr	10	10,000
Cu	10	10,000
Li	10	10,000
Mn	10	10,000
Mo	20	10,000
Ni	10	10,000
Pb	50	10,000
Sb	50	10,000
Sr	1	10,000
Ti	50	10,000
V	10	10,000
Zn	10	10,000

ICP-MS Analyses for 53 Elements

Acidified-filtered (indicated by “FA” appended to the sample number) and acidified-unfiltered (indicated by “RA” for “acidified, raw”) waters, and leachates were analyzed to determine 53 elements by inductively coupled plasma–mass spectrometry (ICP-MS). The method, developed by the U.S. Geological Survey (A.L. Meier, personal commun., 1995; Meier and others, 1994; Lamothe and others, 2002), is used to determine numerous elements directly in the water sample without the need for preconcentration or dilution. Element detection limits are in the sub–part-per-billion range, and the working linear range is six orders of magnitude or more. By using derived response curves, percent of ionization, and natural isotopic abundances, estimates of concentrations for the elements can be determined in samples without the need of a calibration standard for every element. The method is most useful for trace elements in the parts-per-billion range; analyses for major elements in the parts-per-million range are less accurate, and ICP-AES data should be used instead. Limits of determination for elements by ICP-MS are shown in table 1–5 of appendix 1.

Table 1–5. Limits of determination for elements in water samples by the ICP-MS method.

Element	Lower determination limit	Element	Lower determination limit
Concentration, in parts per million		Concentration, in parts per billion	
Ca	0.05	K	0.30
Mg	0.01	La	0.01
Na	0.01	Li	0.50
Si	0.25	Mn	0.02
Concentration, in parts per billion		Mo	0.02
Ag	0.01	Nd	0.01
Al	1.0	Ni	0.10
As	0.20	P	3.0
Au	0.01	Pb	0.05
Ba	0.02	Pr	0.01
Be	0.05	Rb	0.01
Bi	0.01	Re	0.02
Cd	0.02	Sb	0.02
Ce	0.01	Se	0.4
Co	0.02	Sm	0.01
Cr	1.0	Sr	0.02
Cs	0.01	Tb	0.005
Cu	0.50	Th	0.03
Dy	0.005	Ti	0.05
Er	0.005	Tl	0.05
Eu	0.005	Tm	0.005
Fe	30	U	0.01
Ga	0.02	V	0.20
Gd	0.005	W	0.02
Ge	0.02	Y	0.01
Ho	0.005	Yb	0.01
In	0.01	Zn	0.50

Geochemical Analyses

The following tables present the results of the geochemical analyses for the Stanley uranium district. The tables also give sample and laboratory numbers, locations, sample and site descriptions, and other details.

Table 1–6	chemical analyses for uranium ore and altered rocks
Table 1–7	chemical analyses for radioactive mine-waste samples
Table 1–8	(top half) (bottom half) chemical analyses for stream-sediment samples
Table 1–9	analyses of surface waters
Table 1–10	anion analyses of surface waters by ion chromatography
Table 1–11	analyses of leachates from composite mine-waste samples

Table 1–6. Chemical analyses for uranium ore and altered rocks from the Stanley uranium district.

[Datum for all latitude and longitude values is WGS 1984. See appendix 1 for description of analytical procedures. Abbreviations: n.d., no data; ppm, parts per million; %, weight percent of sample]

Sample no.	Lab. no.	Site name	Sample description	Latitude (°N)	Longitude (°W)	Al[1] (%)	Ca[1] (%)
30BV99	C-138026	East Basin No. 1 mine	Radioactive arkosic conglomerate; contains sulfide minerals and vitrain	44.2970	114.8435	4.5	0.99
01BV00	C-174844	East Basin No. 1 mine	Radioactive arkosic conglomerate; contains sulfide minerals and vitrain	44.2970	114.8435	4.4	0.70
02BV00	C-174845	East Basin No. 1 mine	Radioactive arkosic conglomerate; contains large pieces of vitrain	44.2970	114.8435	3.7	0.75
03BV00	C-174846	East Basin No. 1 mine	Fine-grained, layered rhyolitic rock of basal Challis Volcanic Group	44.2970	114.8435	6.7	0.74
04BV00	C-174847	East Basin No. 1 mine	Massive rhyolitic welded tuff of lowermost Challis Volcanic Group	44.2970	114.8435	8.3	4.60
10BV00	C-174851	Coal Creek No. 1 mine	Radioactive pebble conglomerate; sandy matrix; contains pieces of vitrain	44.2849	114.8255	2.5	0.03
11BV00	C-174852	Coal Creek No. 1 mine	Radioactive pebble conglomerate; sandy matrix; contains pieces of vitrain	44.2849	114.8255	4.2	0.12
12BV00	C-174853	Coal Creek No. 1 mine	Radioactive conglomerate; shows much Fe staining	44.2849	114.8260	4.9	0.15
45BV01	C-194662	Coal Creek No. 1 mine	Radioactive pebble conglomerate; sandy matrix; contains pieces of vitrain	44.2849	114.8255	6.7	0.22
46BV01	C-194663	Coal Creek No. 1 mine	Radioactive pebble conglomerate; sandy matrix; contains pieces of vitrain	44.2849	114.8255	4.6	0.05
07BV00	C-174850	Deer Strike claims	Radioactive, dark gray, carbonaceous siltstone; contains vitrain	44.2793	114.8176	11.0	0.32
43BV01	C-194660	Little Joe claims	Radioactive, arkosic pebble conglomerate; contains abundant vitrain	44.2826	114.8178	5.00	0.21
44BV01	C-194661	Little Joe claims	Radioactive, arkosic pebble conglomerate; contains abundant vitrain	44.2828	114.8178	3.8	0.12
05BV00	C-174848	Shorty Pit	Radioactive arkosic sandstone; contains thin lenses of coaly material	44.2993	114.8562	5.8	1.70
06BV00	C-174849	Shorty Pit	Radioactive, arkosic, very coarse grained sandstone; shows Fe-Mn staining	44.2993	114.8562	6.2	0.13
14BV00	C-174854	Alta adit	Radioactive breccia composed of sheared, recemented granitic rock	44.2873	114.7886	4.0	0.16
15BV01	C-194636	Baker and Potato Hill claims	Radioactive granitic vein cutting granitic rock of Idaho batholith	44.3194	114.8980	5.9	0.46
16BV01	C-194637	Baker and Potato Hill claims	Radioactive, weathered granitic rock; associated with aplite veins	44.3194	114.8980	6.7	0.51
36BV99	C-138875	Lightning No. 2 adit	Medium-grained granitic wallrock; fractured and weakly altered	44.3136	114.8819	8.5	1.70
37BV99	C-138876	Lightning No. 2 adit	Granitic wallrock; fractured, weakly altered; cut by thin aplite veinlets	44.3136	114.8819	8.0	2.20
38BV99	C-138877	Lightning No. 2 adit	Fault gouge composed of fragmented granitic rock	44.3136	114.8819	8.8	0.60
39BV99	C-138878	Lightning No. 2 adit	Radioactive, brecciated granitic rock with secondary U minerals	44.3136	114.8819	6.5	0.30

Sample no.	Fe[1] (%)	K[1] (%)	Mg[1] (%)	Na[1] (%)	P[1] (%)	Ti[1] (%)	Ag[1] (ppm)	As[2] (ppm)	As[1] (ppm)	Au[3] (ppm)	Au[1] (ppm)	Ba[1] (ppm)	Be[1] (ppm)	Bi[1] (ppm)	Cd[1] (ppm)	Ce[1] (ppm)	Co[1] (ppm)	Cr[1] (ppm)
30BV99	3.60	2.2	0.11	0.61	0.06	0.21	<2	3,300	3,900	0.013	<8	150	2	<50	49	87	26	35
01BV00	3.60	2.3	0.09	0.89	0.09	0.16	<2	4,600	4,300	<0.005	<8	510	2	<50	50	70	24	<2
02BV00	1.60	1.8	0.10	0.52	0.05	0.15	<2	1,400	1,200	0.012	<8	460	2	<50	14	72	5	3
03BV00	2.60	1.9	0.26	1.00	0.04	0.29	<2	250	260	<0.005	<8	670	3	<50	3	71	6	26
04BV00	1.60	1.8	0.31	2.00	0.07	0.24	<2	110	120	<0.005	<8	440	2	<50	<2	62	11	12
10BV00	0.83	1.1	0.07	0.14	0.04	0.14	<2	3,500	3,700	0.065	<8	330	2	<50	43	54	4	15
11BV00	1.10	1.7	0.06	0.31	0.10	0.14	<2	>5,000	8,600	0.045	<8	500	2	<50	100	35	13	5
12BV00	1.70	2.7	0.13	0.45	0.12	0.16	<2	>5,000	8,300	0.016	<8	970	3	<50	120	53	29	8
45BV01	0.33	3.2	0.06	1.50	0.08	0.15	<2	2,200	2,100	0.020	<8	710	3	<50	<2	38	<2	9
46BV01	0.38	2.1	0.07	0.32	0.08	0.12	<2	3,000	2,700	0.024	<8	780	2	<50	<2	22	<2	2
07BV00	1.00	2.9	0.27	0.63	0.02	0.37	<2	850	760	0.005	<8	610	4	<50	9	110	6	4
43BV01	0.44	3.1	0.12	0.42	0.02	0.21	<2	130	130	0.023	<8	1,200	1	<50	<2	74	5	3
44BV01	0.25	2.7	0.09	0.32	0.01	0.16	<2	180	150	0.022	<8	1,100	1	<50	<2	55	<2	15
05BV00	1.30	2.8	0.17	1.00	0.07	0.22	<2	550	580	0.030	<8	1,000	2	<50	6	110	3	<2
06BV00	2.60	3.6	0.11	0.29	0.11	0.15	<2	2,700	2,500	<0.005	<8	1,100	2	<50	29	62	7	<2
14BV00	0.52	1.6	0.02	0.36	0.05	0.19	<2	52	57	<0.005	<8	570	2	<50	7	57	2	3
15BV01	0.22	4.7	0.03	1.40	0.01	0.03	<2	6.5	<10	<0.005	<8	420	1	<50	<2	13	<2	3
16BV01	1.00	4.3	0.26	1.30	0.05	0.16	<2	16	21	<0.005	<8	1,200	3	<50	<2	92	3	4
36BV99	1.80	2.2	0.43	2.50	0.08	0.31	<2	25	24	<0.005	<8	1,600	2	<50	2	130	6	22
37BV99	1.60	2.3	0.42	2.50	0.07	0.29	<2	11	<10	<0.005	<8	1,600	2	<50	<2	110	5	17
38BV99	1.40	3.5	0.37	1.40	0.08	0.18	<2	60	26	0.021	<8	870	3	<50	<2	210	8	18
39BV99	2.50	2.8	0.32	0.85	0.06	0.11	<2	80	39	0.170	<8	1,100	2	<50	4	95	4	19

[1] ICP-AES (inductively coupled plasma–atomic emission spectrometry).

[2] Hydride-generation atomic absorption spectrometry.

[3] Atomic absorption spectrophotometry after collection by fire assay.

Table 1–6. Chemical analyses for uranium ore and altered rocks from the Stanley uranium district.—Continued

[Datum for all latitude and longitude values is WGS 1984. See appendix 1 for description of analytical procedures. Abbreviations: n.d., no data; ppm, parts per million; %, weight percent of sample]

Sample no.	Cu[1] (ppm)	Eu[1] (ppm)	Ga[1] (ppm)	Ho[1] (ppm)	La[1] (ppm)	Li[1] (ppm)	Mn[1] (ppm)	Mo[1] (ppm)	Nb[1] (ppm)	Nd[1] (ppm)	Ni[1] (ppm)	Pb[1] (ppm)	Sc[1] (ppm)	Sn[1] (ppm)	Sr[1] (ppm)	Ta[1] (ppm)	Th[1] (ppm)
30BV99	4	<2	7	<4	47	15	330	3	13	30	<3	44	3	<50	130	<40	49
01BV00	3	<2	12	<4	38	14	220	<2	19	38	4	47	3	<50	130	<40	21
02BV00	4	<2	8	<4	39	12	190	2	19	40	3	52	2	<50	100	<40	18
03BV00	8	<2	24	5	32	31	150	3	23	29	6	33	12	<50	190	<40	11
04BV00	7	<2	24	<4	25	26	590	<2	15	32	8	34	6	<50	350	<40	<6
10BV00	3	<2	12	<4	70	9	35	4	18	15	<3	35	4	<50	61	<40	13
11BV00	6	<2	8	<4	20	29	22	3	25	17	<3	36	3	<50	74	<40	17
12BV00	4	<2	8	<4	19	25	380	5	22	23	4	49	5	<50	140	<40	25
45BV01	13	<2	15	<4	17	17	39	3	19	19	<3	37	3	<50	120	<40	19
46BV01	16	<2	8	<4	13	20	45	2	12	11	<3	33	3	<50	110	<40	9
07BV00	3	<2	34	<4	59	110	91	3	39	42	<3	63	5	<50	210	<40	26
43BV01	31	<2	11	<4	42	14	240	<2	21	27	3	22	<2	<50	220	<40	12
44BV01	14	<2	8	<4	31	10	77	<2	15	19	<3	13	<2	<50	170	<40	9
05BV00	8	<2	12	<4	55	32	430	3	21	47	4	40	4	<50	210	<40	19
06BV00	7	<2	10	<4	24	45	130	6	25	16	3	60	5	<50	150	<40	28
14BV00	9	<2	5	<4	35	29	32	560	21	32	4	560	6	<50	120	<40	21
15BV01	4	<2	12	<4	6	16	89	<2	4	<9	<3	43	<2	<50	290	<40	17
16BV01	7	<2	13	<4	37	29	260	3	25	26	<3	250	4	<50	390	<40	22
36BV99	4	<2	24	<4	85	32	290	4	22	46	<3	29	4	<50	680	<40	23
37BV99	2	<2	23	<4	71	33	250	<2	19	40	<3	23	3	<50	790	<40	18
38BV99	5	2	30	<4	130	13	140	120	12	75	<3	480	4	<50	180	<40	26
39BV99	6	<2	22	<4	62	16	150	27	6	28	<3	88	3	<50	190	<40	27

Sample no.	U[1] (ppm)	V[1] (ppm)	Y[1] (ppm)	Yb[1] (ppm)	Zn[1] (ppm)	Hg[4] (ppm)	Sb[2] (ppm)	Se[2] (ppm)	Te[2] (ppm)	Tl[2] (ppm)	$C_{carbonate}$[5] (%)	C_{total}[6] (%)	S_{total}[7] (%)
30BV99	1,600	26	13	2	38	2.4	2.9	<0.2	<0.1	2.6	n.d.	0.47	3.3
01BV00	1,600	15	13	2	24	2.5	6.3	<0.2	0.3	3.2	0.13	0.5	3.4
02BV00	1,800	35	16	2	31	0.72	2.1	<0.2	0.2	1.7	0.18	1.3	1.3
03BV00	<100	58	17	2	55	0.1	2	<0.2	<0.1	0.4	0.06	17	0.24
04BV00	<100	43	13	1	89	<0.02	0.6	<0.2	0.2	0.2	1.4	3.2	0.11
10BV00	460	23	5	<1	11	0.04	1.6	<0.2	0.4	1.9	<0.003	1.1	0.11
11BV00	1,500	19	11	2	13	0.02	2.2	<0.2	0.3	2.4	<0.003	0.29	0.5
12BV00	2,000	28	11	2	68	0.16	2.1	<0.2	0.3	2.2	<0.003	0.32	0.32
45BV01	2,000	17	15	2	24	0.07	3.3	<0.2	<0.1	1.6	<0.003	0.19	0.06
46BV01	2,100	15	8	2	27	0.03	1.4	<0.2	<0.1	0.7	<0.003	0.13	0.05
07BV00	490	61	15	2	71	0.07	0.9	<0.2	0.2	1.2	0.01	4.8	0.16
43BV01	<100	16	5	<1	48	0.06	0.7	<0.2	<0.1	0.6	<0.003	0.06	<0.05
44BV01	<100	18	5	<1	25	0.04	0.6	<0.2	<0.1	0.3	<0.003	0.4	<0.05
05BV00	950	16	23	3	78	5.2	6.2	<0.2	0.3	6.5	0.44	0.67	0.16
06BV00	2,700	27	15	3	75	3.6	3.1	<0.2	0.2	4.8	<0.003	0.13	<0.05
14BV00	2,200	26	14	2	280	54	1,200	<0.2	<0.1	43	<0.003	0.03	0.05
15BV01	<100	4	10	<1	190	0.38	7.7	<0.2	<0.1	1.6	<0.003	0.02	<0.05
16BV01	1,400	27	36	4	110	0.57	38	<0.2	<0.1	3.8	<0.003	0.02	<0.05
36BV99	<100	37	11	<1	150	<0.02	25	<0.2	0.1	4.3	n.d.	0.07	<0.05
37BV99	<100	30	8	<1	68	<0.02	12	<0.2	<0.1	1.6	n.d.	0.13	<0.05
38BV99	<100	48	16	2	140	<0.02	46	<0.2	<0.1	6	n.d.	0.11	<0.05
39BV99	770	29	5	<1	600	0.05	30	<0.2	<0.1	5.7	n.d.	0.03	0.32

[1] ICP-AES (inductively coupled plasma–atomic emission spectrometry).

[2] Hydride-generation atomic absorption spectrometry.

[3] Atomic absorption spectrophotometry after collection by fire assay.

[4] Cold-vapor analysis.

[5] Coulometric titration.

[6] Automated carbon analyzer.

[7] Automated sulfur analyzer.

Table 1–7. Chemical analyses for radioactive mine-waste samples collected in the Stanley uranium district.

[Datum for all latitude and longitude values is WGS 1984. See appendix 1 for description of analytical procedures. Abbreviations: n.d., no data; ppm, parts per million; %, weight percent of sample]

Sample no.	Lab. no.	Site name	Sample description	Latitude (°N)	Longitude (°W)
24JH99	C-138042	East Basin No. 1 mine	<2-mm-diameter material on surfaces of pit wall, floor, and embankment	44.2970	114.8435
05JH00	C-174814	East Basin No. 1 mine	<2-mm-diameter material on surfaces of pit wall, floor, and embankment	44.2970	114.8435
13JH00	C-174818	Coal Creek No. 1 mine	<2-mm-diameter material of surfaces of open-pit wall, floor, and dumps	44.2849	114.8255
13JH00d	C-174819	Coal Creek No. 1 mine	Duplicate field sample of sample 13JH00	44.2849	114.8255
10JH00	C-174816	Deer Strike claims	<2-mm-diameter material on surface of upper mine-waste dump	44.2793	114.8176
11JH00	C-174817	Deer Strike claims	<2-mm-diameter material on surface of lower mine-waste dump	44.2793	114.8176
07JH00	C-174815	Shorty pit	<2-mm-diameter material on surfaces of open-pit mine-waste dumps	44.2993	114.8562
20JH00	C-174820	Alta adit	<2-mm-diameter rock from slumped material on floor inside of adit	44.2873	114.7886
21JH00	C-174821	Alta adit	<2-mm-diameter material from surfaces of mine-waste dumps	44.2873	114.7886
17BV01	C-194608	Baker and Potato Hill claims	<2-mm-diameter material in weathered face of prospect trench	44.3194	114.8980
30JH99	C-138045	Lightning No. 2 adit	<2-mm-diameter material from surfaces of mine-waste dumps	44.3136	114.8819

Sample no.	Al[1] (%)	Ca[1] (%)	Fe[1] (%)	K[1] (%)	Mg[1] (%)	Na[1] (%)	P[1] (%)	Ti[1] (%)	Ag[1] (ppm)	As[2] (ppm)	As[1] (ppm)	Au[3] (ppm)	Au[1] (ppm)	Ba[1] (ppm)	Be[1] (ppm)	Bi[1] (ppm)	Cd[1] (ppm)
24JH99	13.0	0.88	2.5	3.60	0.46	1.30	0.06	0.61	<2	350	440	<0.005	<8	1,400	5	<50	8
05JH00	9.2	0.63	1.9	2.70	0.38	1.20	0.06	0.34	<2	390	410	<0.005	<8	880	3	<50	6
13JH00	9.5	0.17	1.6	3.80	0.23	0.73	0.06	0.31	<2	5000	5000	<0.005	<8	960	3	<50	59
13JH00d	11.0	0.23	1.9	3.90	0.28	0.85	0.07	0.34	<2	>5000	6400	<0.005	<8	890	4	<50	74
10JH00	9.1	0.65	1.5	3.60	0.34	1.40	0.05	0.35	<2	120	120	<0.005	<8	890	3	<50	3
11JH00	8.7	0.40	1.0	3.60	0.26	0.84	0.04	0.34	<2	140	120	<0.005	<8	930	3	<50	4
07JH00	12.0	0.31	1.1	2.40	0.26	0.42	0.03	0.41	<2	130	140	<0.005	<8	660	3	<50	<2
20JH00	10.0	1.90	3.3	2.30	0.88	2.50	0.15	0.61	<2	27	36	<0.005	<8	510	3	<50	2
21JH00	9.4	2.40	3.6	2.50	1.10	3.10	0.17	0.63	<2	10	18	<0.005	<8	540	3	<50	<2
17BV01	11.0	1.50	2.2	2.80	0.68	2.60	0.09	0.37	<2	17	20	<0.005	<8	560	4	<50	<2
30JH99	10.0	1.60	2.7	2.30	0.58	2.40	0.13	0.42	<2	48	55	0.020	<8	1,400	4	<50	11

Sample no.	Ce[1] (ppm)	Co[1] (ppm)	Cr[1] (ppm)	Cu[1] (ppm)	Eu[1] (ppm)	Ga[1] (ppm)	Ho[1] (ppm)	La[1] (ppm)	Li[1] (ppm)	Mn[1] (ppm)	Mo[1] (ppm)	Nb[1] (ppm)	Nd[1] (ppm)	Ni[1] (ppm)	Pb[1] (ppm)	Sc[1] (ppm)	Sn[1] (ppm)
24JH99	140	12	120	15	<2	38	<4	87	51	530	5	45	54	9	63	9	<50
05JH00	91	10	19	7	<2	29	<4	48	34	380	3	28	38	7	51	7	<50
13JH00	110	9	<2	<2	<2	30	<4	56	26	140	3	34	41	<3	56	5	<50
13JH00d	120	9	3	5	<2	32	<4	67	31	160	3	39	49	<3	69	6	<50
10JH00	110	16	3	8	<2	27	<4	51	60	310	2	42	37	3	53	4	<50
11JH00	87	18	3	4	<2	26	<4	46	68	210	2	37	27	3	58	5	<50
07JH00	79	5	13	6	<2	37	<4	39	81	87	5	40	31	5	63	7	<50
20JH00	190	9	7	4	3	33	<4	110	65	570	8	53	79	6	61	7	<50
21JH00	190	8	12	2	3	37	<4	110	73	560	3	53	67	6	39	7	<50
17BV01	150	3	8	3	<2	25	<4	82	63	600	3	54	54	<3	88	6	<50
30JH99	250	23	38	8	3	34	<4	150	49	690	190	29	88	<3	500	6	<50

Sample no.	Sr[1] (ppm)	Ta[1] (ppm)	Th[1] (ppm)	U[1] (ppm)	V[1] (ppm)	Y[1] (ppm)	Yb[1] (ppm)	Zn[1] (ppm)	Hg[4] (ppm)	Sb[2] (ppm)	Se[2] (ppm)	Te[2] (ppm)	Tl[2] (ppm)	$C_{carbonate}$[5] (%)	C_{total}[6] (%)	S_{total}[7] (%)
24JH99	270	<40	36	160	67	16	2	190	0.2	4.6	<0.2	<0.1	0.9	n.d.	1.2	0.14
05JH00	200	<40	17	<100	49	13	2	69	0.16	4.9	<0.2	0.1	0.9	0.02	2.0	0.07
13JH00	170	<40	23	330	35	10	1	50	0.02	47	<0.2	0.7	1.5	<0.003	0.4	0.06
13JH00d	170	<40	33	740	37	12	2	58	0.03	1.3	<0.2	0.5	<0.1	0.01	0.46	0.07
10JH00	260	<40	34	300	40	20	2	76	0.1	0.9	<0.2	0.2	1.8	0.03	0.49	<0.05
11JH00	220	<40	25	540	46	29	3	100	0.06	0.8	<0.2	0.3	1.5	0.02	0.61	0.05
07JH00	140	<40	22	210	46	11	1	49	0.37	1.1	<0.2	<0.1	1.5	<0.003	0.85	<0.05
20JH00	480	<40	35	<100	74	19	2	180	1.5	75	0.2	0.2	20	<0.003	0.18	<0.05
21JH00	580	<40	43	<100	78	16	1	95	0.12	25	<0.2	<0.1	2.3	0.01	0.5	<0.05
17BV01	440	<40	43	630	54	24	2	94	0.14	16	<0.2	<0.1	5.4	<0.003	0.21	<0.05
30JH99	570	<40	45	300	51	26	3	810	0.04	95	<0.2	0.1	18	n.d.	0.62	<0.05

[1] ICP-AES (inductively coupled plasma–atomic emission spectrometry).

[2] Hydride-generation atomic absorption spectrometry.

[3] Atomic absorption spectrophotometry after collection by fire assay.

[4] Cold-vapor analysis.

[5] Coulometric titration.

[6] Automated carbon analyzer.

[7] Automated sulfur analyzer.

Table 1–8. Chemical analyses on nine stream-sediment samples collected in the Stanley uranium district.

[Datum for all latitude and longitude values is WGS 1984. See appendix 1 for description of analytical procedures. Abbreviations: n.d., no data; ppm, parts per million; %, weight percent of sample]

Site no.	Lab no.	Latitude (°N)	Longitude (°W)	Deposit name	Location information	Site description	Sample description
00CH039	C-176695	44.2981	114.8424	East Basin No. 1 mine (vicinity of mine)	Small spring along old road about 380 ft north from East Basin No. 1 mine (approximately at mine level)	Small spring near mine, about at mine level; a background site adjacent to, but unaffected by mine	Fine, gray sediment and dark, organic-rich mud; boggy; abundant vegetation (grass, willow, monkey-flower, composites) on banks
00CH040	C-176696	44.2956	114.8451	East Basin No. 1 mine (vicinity of mine)	About 800 ft southwest of East Basin #1 mine, along road to mine	Spring in intermittent drainage just above road; a background site adjacent to, but unaffected by mine	Grus-like alluvium below a 1- to 2-in.-thick organic mat; pebbles and fines on granitic bedrock
99CH031	C-137671	44.2862	114.8488	East Basin No. 1 mine	East Basin Creek about 3/4 mile downstream of the East Basin No. 1 mine	Flowing stream through mature forest; next to road	Sediment from active channel; collected from gravel bar; moderate gradient
99CH031D	C-137672	44.2862	114.8488	East Basin No. 1 mine	Site duplicate of sample no. 99CH031	Site duplicate of sample no. 99CH031	Sediment from active channel; sediment is site duplicate of sample no. 99CH031
00CH044	C-176699	44.2753	114.8236	Coal Creek No. 1 mine and Deer Strike claims	Coal Creek at 6,300 ft elevation, adjacent to road, and below junction with unnamed drainage below Deer Strike claims (0.5 mi downstream of mines)	Small flowing stream in fir forest	Well-developed, generally granitic, stream gravels
00CH041	C-176697	44.2778	114.8154	Deer Strike claims (vicinity of mine)	Unnamed tributary about 800 ft southeast of Deer Strike claims, at about same elevation as the mine	Spring in intermittent drainage; a background site adjacent to, but unaffected by mine	Grus-like stream sediment; pebbles and fines underlie an organic mat; soily in places; elk/moose droppings, sticks, leaves, moss
00CH043	C-176698	44.2836	114.8197	Little Joe claims	Intermittent drainage about 600 ft downstream of Little Joe claims	Intermittent drainage	Slightly stained granitic rocks; moss-covered
01CH091	C-192540	44.2834	114.8169	Little Joe claims	Boggy area on old road within the Little Joe claims	Small pool in wet, boggy depression in intermittent drainage	From active channel; soil and fine granitic gravel in organic-rich boggy area overgrown by willow and alder
99CH033	C-137673	44.3141	114.8808	Lightning No. 2 adit (upstream of mine)	Hay Creek, about 600 ft upstream of Lightning No. 2 adit	Stream flowing through a willow/tree thicket; a background site	Sediment of active channel; from small gravel bars, moderate gradient

Site no.	Al[1]	Ca[1]	Fe[1]	K[1]	Mg[1]	Na[1]	P[1]	Ti[1]	Ag[1]	As[2]	As[1]	Au[3]	Au[1]	Ba[1]	Be[1]	Bi[1]	Cd[1]	Ce[1]	Co[1]	Cr[1]	Cu[1]	Eu[1]	Ga[1]	Ho[1]	La[1]
	(%)								(ppm)																
00CH039	8.5	1.1	3.5	1.8	0.93	1.4	0.04	0.47	<2	30	45	0.014	<8	1,000	2	<50	<2	81	11	35	5	<2	23	<4	31
00CH040	8.8	1.9	3.4	2.5	0.82	2.2	0.15	0.48	<2	29	37	<0.005	<8	840	4	<50	<2	150	8	23	5	3	21	<4	85
99CH031	7.4	3.7	5.2	1.8	1.8	1.7	0.15	1.5	<2	24	29	<0.005	<8	970	<1	<50	<2	140	18	150	18	2	12	6	82
99CH031D	8	3.9	5	1.8	1.9	1.8	0.14	1.4	<2	23	32	<0.005	<8	1,100	1	<50	<2	120	20	170	19	<2	12	6	65
00CH044	8.4	2.3	3.4	2.1	1.1	2	0.13	0.62	<2	22	21	<0.005	<8	820	2	<50	<2	100	9	67	5	<2	21	<4	48
00CH041	8.2	2.6	3.8	1.8	0.5	2.2	0.28	0.38	<2	14	12	<0.005	<8	540	3	<50	<2	120	6	8	2	<2	17	<4	76
00CH043	8.4	2.4	2.8	2	0.63	2.1	0.24	0.4	<2	110	110	<0.005	<8	790	3	<50	<2	120	6	22	5	<2	19	<4	68
01CH091	8.1	3.1	3.7	1.3	0.6	2.4	0.3	0.34	<2	170	150	<0.005	<8	440	2	<50	<2	87	10	15	7	2	23	<4	55
99CH033	8.2	2.7	3.6	2.2	1.2	1.6	0.11	0.73	<2	16	18	<0.005	<8	980	2	<50	<2	150	12	130	12	<2	16	4	84

[1] ICP-AES (inductively coupled plasma–atomic emission spectrometry).

[2] Hydride-generation atomic absorption spectrometry.

[3] Atomic absorption spectrophotometry after collection by fire assay.

[4] Cold-vapor analysis.

[5] Coulometric titration.

[6] Difference between carbonate carbon and total carbon concentrations.

[7] Automated carbon analyzer.

[8] Automated sulfur analyzer.

Table 1–8. Chemical analyses on nine stream-sediment samples collected in the Stanley uranium district.—Continued

[Datum for all latitude and longitude values is WGS 1984. See appendix 1 for description of analytical procedures. Abbreviations: n.d., no data; ppm, parts per million; %, weight percent of sample]

Site no.	Source	Organic content	Sample character	Sample increments	Sample area (ft^2)	Staining on alluvium	Sediment lithologies
00CH039	active alluvium	high	composite	30	10	none observed	No notes
00CH040	active alluvium	high	composite	34	12	none observed	Leucocratic granite; abundant quartz, feldspar, and tarnished biotite
99CH031	active alluvium	low	composite	30	90	minor iron and manganese oxides	75% intermediate porphyritic Challis Volcanic Group, 20% quartz monzonite of the Idaho batholith, 5% siltstone and sandstone
99CH031D	active alluvium	low	composite	30	90	minor iron and manganese oxides	75% intermediate porphyritic Challis Volcanic Group, 20% quartz monzonite of the Idaho batholith, 5% siltstone and sandstone
00CH044	active alluvium	low	composite	27	400	moderate manganese and iron oxides	80% quartz monzonite of the Idaho batholith, 15% Challis Volcanic Group sedimentary rocks (sandstone, siltstone), 5% quartzite clasts in conglomerate
00CH041	active alluvium	high	composite	30	20	none observed	Leucocratic granitic pebbles and fines
00CH043	active alluvium	moderate	composite	25	30	slight iron oxides	80% quartz monzonite of the Idaho batholith; 20% fine- to medium-grained sandstone and siltstone (representing reworked Challis Volcanic Group)
01CH091	active alluvium	high	composite	17	12	none observed	100% granitic sand up to 2 mm in diameter
99CH033	active alluvium	low	composite	30	60	minor iron oxides	98% Challis Volcanic Group (mostly intermediate-composition to rhyolitic porphyritic rocks; crystal-rich rhyolite common); 2% quartz monzonite of the Idaho batholith

Site no.	Li[1]	Mn[1]	Mo[1]	Nb[1]	Nd[1]	Ni[1]	Pb[1]	Sc[1]	Sn[1]	Sr[1]	Ta[1]	Th[1]	U[1]	V[1]	Y[1]	Yb[1]	Zn[1]	Hg[4]	Sb[2]	Se[2]	Te[2]	Tl[2]	$C_{carbonate}$[5]	$C_{organic}$[6]	C_{total}[7]	S_{total}[8]
	(ppm)																						(%)			
00CH039	33	240	<2	12	17	16	32	10	<50	280	<40	8	<100	85	10	2	77	0.02	74	0.8	0.2	0.3	0.04	2.3	2.4	<0.05
00CH040	45	670	<2	31	63	15	33	9	<50	470	<40	28	<100	73	25	3	85	0.02	3.5	0.3	<0.1	0.5	0.01	1.4	1.4	<0.05
99CH031	21	840	<2	46	66	18	7	24	<50	480	<40	20	<100	210	22	2	78	0.04	2.6	<0.2	<0.1	0.4	n.d.	n.d.	0.37	<0.05
99CH031D	22	840	<2	46	54	18	8	24	<50	530	<40	13	<100	200	24	2	91	0.05	2.5	<0.2	<0.1	0.3	n.d.	n.d.	0.35	<0.05
00CH044	36	490	<2	32	33	19	34	11	<50	510	<40	22	<100	90	17	2	72	0.06	2.4	0.4	<0.1	0.4	0.02	2.2	2.2	0.1
00CH041	50	2,200	<2	30	60	8	33	4	<50	510	<40	32	<100	58	21	2	79	0.11	4.1	0.2	<0.1	0.5	0.07	7.4	7.5	0.06
00CH043	40	1,200	<2	29	44	13	34	6	<50	470	<40	27	<100	61	16	2	78	0.08	2	0.4	<0.1	0.6	0.05	6.0	6.1	0.06
01CH091	42	1,300	<2	22	44	4	11	6	<50	560	<40	19	<100	77	13	<1	64	0.08	1.7	0.5	<0.1	0.2	0.03	9.3	9.4	0.07
99CH033	29	680	<2	35	68	8	11	16	<50	420	<40	23	<100	110	23	2	81	0.03	1.6	<0.2	<0.1	1.3	n.d.	n.d.	1.4	<0.05

[1] ICP-AES (inductively coupled plasma–atomic emission spectrometry).

[2] Hydride-generation atomic absorption spectrometry.

[3] Atomic absorption spectrophotometry after collection by fire assay.

[4] Cold-vapor analysis.

[5] Coulometric titration.

[6] Difference between carbonate carbon and total carbon concentrations.

[7] Automated carbon analyzer.

[8] Automated sulfur analyzer.

Table 1–9. Analyses of surface waters of the Stanley uranium district.

[Datum for all latitude and longitude values is WGS 1984. See appendix 1 for analytical procedures; table 1–10 for anion analyses; cfs, cubic feet per second; µS/cm, microsiemens per centimeter; ppm, parts per million; ppb, parts per billion; FTU, Formazine Turbidity Unit; n.d., not determined]

Sample no.	Site no.	Lab no.	Sample analyzed	Latitude (°N)	Longitude (°W)	Deposit name
99CH029RA	99CH029	C-137519	Raw water, not filtered; acidified with nitric acid	44.2972	114.8431	East Basin No. 1 mine
99CH029FA	99CH029	C-137566	Water, filtered @ 0.45 µm; acidified with nitric acid	44.2972	114.8431	East Basin No. 1 mine
00CH038RA	00CH038	C-176684	Raw water, not filtered; acidified with nitric acid	44.2971	114.8432	East Basin No. 1 mine
00CH038FA	00CH038	C-176740	Water, filtered @ 0.45 µm; acidified with nitric acid	44.2971	114.8432	East Basin No. 1 mine
00CH039RA	00CH039	C-176680	Raw water, not filtered; acidified with nitric acid	44.2981	114.8424	East Basin No. 1 mine (vicinity of mine)
00CH039FA	00CH039	C-176736	Water, filtered @ 0.45 µm; acidified with nitric acid	44.2981	114.8424	East Basin No. 1 mine (vicinity of mine)
00CH040RA	00CH040	C-176674	Raw water, not filtered; acidified with nitric acid	44.2956	114.8451	East Basin No. 1 mine (vicinity of mine)
00CH040FA	00CH040	C-176730	Water, filtered @ 0.45 µm; acidified with nitric acid	44.2956	114.8451	East Basin No. 1 mine (vicinity of mine)
99CH031RA	99CH031	C-137499	Raw water, not filtered; acidified with nitric acid	44.2862	114.8488	East Basin No. 1 mine (vicinity of mine)
99CH031FA	99CH031	C-137546	Water, filtered @ 0.45 µm; acidified with nitric acid	44.2862	114.8488	East Basin No. 1 mine (vicinity of mine)
99CH031DRA	99CH031D	C-137503	Raw water, not filtered; acidified with nitric acid	44.2862	114.8488	East Basin No. 1 mine (vicinity of mine)
99CH031DFA	99CH031D	C-137550	Water, filtered @ 0.45 µm; acidified with nitric acid	44.2862	114.8488	East Basin No. 1 mine (vicinity of mine)
99CH030RA	99CH030	C-137497	Raw water, not filtered; acidified with nitric acid	44.2981	114.8416	East Basin No. 1 mine (vicinity of mine)
99CH030FA	99CH030	C-137544	Water, filtered @ 0.45 µm; acidified with nitric acid	44.2981	114.8416	East Basin No. 1 mine (vicinity of mine)
00CH044RA	00CH044	C-176672	Raw water, not filtered; acidified with nitric acid	44.2753	114.8236	Coal Creek No. 1 mine and Deer Strike claims
00CH044FA	00CH044	C-176728	Water, filtered @ 0.45 µm; acidified with nitric acid	44.2753	114.8236	Coal Creek No. 1 mine and Deer Strike claims
00CH041RA	00CH041	C-176679	Raw water, not filtered; acidified with nitric acid	44.2778	114.8154	Deer Strike claims (vicinity of mine)
00CH041FA	00CH041	C-176735	Water, filtered @ 0.45 µm; acidified with nitric acid	44.2778	114.8154	Deer Strike claims (vicinity of mine)
00CH042RA	00CH042	C-176671	Raw water, not filtered; acidified with nitric acid	44.2798	114.8182	Deer Strike claims (vicinity of mine)
00CH042FA	00CH042	C-176727	Water, filtered @ 0.45 µm; acidified with nitric acid	44.2798	114.8182	Deer Strike claims (vicinity of mine)
00CH043RA	00CH043	C-176673	Raw water, not filtered; acidified with nitric acid	44.2836	114.8197	Little Joe claims
00CH043FA	00CH043	C-176729	Water, filtered @ 0.45 µm; acidified with nitric acid	44.2836	114.8197	Little Joe claims
01CH091RA	01CH091	C-192642	Raw water, not filtered; acidified with nitric acid	44.2834	114.8169	Little Joe claims
01CH091FA	01CH091	C-192700	Water, filtered @ 0.45 µm; acidified with nitric acid	44.2834	114.8169	Little Joe claims
99CH032RA	99CH032	C-137501	Raw water, not filtered; acidified with nitric acid	44.3139	114.8818	Lightning No. 2 adit
99CH032FA	99CH032	C-137548	Water, filtered @ 0.45 µm; acidified with nitric acid	44.3139	114.8818	Lightning No. 2 adit
99CH033RA	99CH033	C-137502	Raw water, not filtered; acidified with nitric acid	44.3141	114.8808	Lightning No. 2 adit (upstream of mine)
99CH033FA	99CH033	C-137549	Water, filtered @ 0.45 µm; acidified with nitric acid	44.3141	114.8808	Lightning No. 2 adit (upstream of mine)

Table 1–9. Analyses of surface waters of the Stanley uranium district.—Continued

[Datum for all latitude and longitude values is WGS 1984. See appendix 1 for analytical procedures; table 1–10 for anion analyses; cfs, cubic feet per second; µS/cm, microsiemens per centimeter; ppm, parts per million; ppb, parts per billion; FTU, Formazine Turbidity Unit; n.d., not determined]

Sample no.	Location information	Site description
99CH029RA	East Basin No. 1 mine, large open pit	Standing pond that fills abandoned open-pit mine; pond contains abundant vegetation
99CH029FA	East Basin No. 1 mine, large open pit	Standing pond that fills abandoned open-pit mine; pond contains abundant vegetation
00CH038RA	East Basin No. 1 mine, large open pit	Resample of pond water sample 99CH029, 1 year later (2000)
00CH038FA	East Basin No. 1 mine, large open pit	Resample of pond water sample 99CH029, 1 year later (2000)
00CH039RA	Small spring along old road about 380 ft north from East Basin No. 1 mine (approximately at mine level)	Small spring near and approximately at mine level; a background site adjacent to, but unaffected by, the mine
00CH039FA	Small spring along old road about 380 ft north from East Basin No. 1 mine (approximately at mine level)	Small spring near and approximately at mine level; a background site adjacent to, but unaffected by, the mine
00CH040RA	About 800 ft southwest of East Basin No. 1 mine, along road to mine	Spring in intermittent drainage just above road; a background site adjacent to, but unaffected by, the mine
00CH040FA	About 800 ft southwest of East Basin No. 1 mine, along road to mine	Spring in intermittent drainage just above road; a background site adjacent to, but unaffected by, the mine
99CH031RA	East Basin Creek about 0.75 mi downstream of the East Basin No. 1 mine	Flowing stream through mature forest; next to road
99CH031FA	East Basin Creek about 0.75 mi downstream of the East Basin No. 1 mine	Flowing stream through mature forest; next to road
99CH031DRA	Site duplicate of sample no. 99CH031	Site duplicate of 99CH031
99CH031DFA	Site duplicate of sample no. 99CH031	Site duplicate of 99CH031
99CH030RA	East Basin Creek, about 200 ft upstream of the East Basin No. 1 mine	Flowing stream through ponderosa forest; background site
99CH030FA	East Basin Creek, about 200 ft upstream of the East Basin No. 1 mine	Flowing stream through ponderosa forest; background site
00CH044RA	Coal Creek at 6,300 ft elevation, adjacent to road, and below junction with unnamed drainage below Deer Strike claims (0.5 mi downstream of mines)	Small flowing stream in fir forest
00CH044FA	Coal Creek at 6,300 ft elevation, adjacent to road, and below junction with unnamed drainage below Deer Strike claims (0.5 mi downstream of mines)	Small flowing stream in fir forest
00CH041RA	Unnamed tributary about 800 ft southeast of Deer Strike claims, at about same elevation as the mine	Spring in intermittent drainage; a background site adjacent to, but unaffected by, the mine
00CH041FA	Unnamed tributary about 800 ft southeast of Deer Strike claims, at about same elevation as the mine	Spring in intermittent drainage; a background site adjacent to, but unaffected by, the mine
00CH042RA	About 200 ft N40°W of collapsed and dry Deer Strike claims; at about the same elevation as the adit	Small seep in small boggy area along old road to mine
00CH042FA	About 200 ft N40°W of collapsed and dry adit of Deer Strike claims; at about the same elevation as the adit	Small seep in small boggy area along old road to mine
00CH043RA	Intermittent drainage about 600 ft downstream of Little Joe claims	Intermittent drainage
00CH043FA	Intermittent drainage about 600 ft downstream of Little Joe claims	Intermittent drainage
01CH091RA	Boggy area on old road within the Little Joe claims	Small pool in wet boggy depression in intermittent drainage
01CH091FA	Boggy area on old road within the Little Joe claims	Small pool in wet boggy depression in intermittent drainage
99CH032RA	Lightning No. 2 adit, lower pit wall; along Hay Creek about 0.1 mi east-northeast of confluence with Basin Creek	Mine drainage from a collapsed adit (evidence: timbers, rails) that was subsequently destroyed by "openpit" gouge in hillside; water flows from a low point on the slope
99CH032FA	Lightning No. 2 adit, lower pit wall; along Hay Creek about 0.1 mi east-northeast of confluence with Basin Creek	Mine drainage from a collapsed adit (evidence: timbers, rails) that was subsequently destroyed by "openpit" gouge in hillside; water flows from a low point on the slope
99CH033RA	Hay Creek, about 600 ft upstream of Lightning No. 2 adit	Stream flowing through a willow/tree thicket; a background site
99CH033FA	Hay Creek, about 600 ft upstream of Lightning No. 2 adit	Stream flowing through a willow/tree thicket; a background site

Table 1–9. Analyses of surface waters of the Stanley uranium district.—Continued

[Datum for all latitude and longitude values is WGS 1984. See appendix 1 for analytical procedures; table 1–10 for anion analyses; cfs, cubic feet per second; µS/cm, microsiemens per centimeter; ppm, parts per million; ppb, parts per billion; FTU, Formazine Turbidity Unit; n.d., not determined]

Sample no.	Temp.	Flow rate	pH	Conductivity	Turbidity	Dissolved O_2	Alkalinity field	Acidity	Fe^{2+}	Fe^{2+}(1)	Water source
	(°C)	(cfs)		(µS/cm)	(FTU)	(ppm)					
99CH029RA	15.0	0(5)	7.2	360	0.98	7	150	<20			Open-pit pool
99CH029FA	15.0	0(5)								0.03	Open-pit pool
00CH038RA	16.0	0(5)	7.7	360	1	7	100		<0.1		Open-pit pool
00CH038FA	16.0	0(5)									Open-pit pool
00CH039RA	12.0	0.002(6)	8.2	230	0.53	7	100		<0.1		Spring in vicinity of mine
00CH039FA	12.0	0.002(6)									Spring in vicinity of mine
00CH040RA	14.0	0.05(6)	8	180	1.4	7	70		<0.1		Spring in vicinity of mine
00CH040FA	14.0	0.05(6)									Spring in vicinity of mine
99CH031RA	9.9	15(5)	7	99	0	7	51	<20			Creek
99CH031FA	9.9	15(5)								0.01	Creek
99CH031DRA	9.9	15(5)	7	99	0	7	54	<20			Creek
99CH031DFA	9.9	15(5)								0.01	Creek
99CH030RA	8.2	15(5)	7.2	91	0	7	52	<20			Creek
99CH030FA	8.2	15(5)								0.01	Creek
00CH044RA	13.0	0.11(5)	8.4	150	0.1	7	50		<0.1		Small stream
00CH044FA	13.0	0.11(5)									Small stream
00CH041RA	10.0	0.003(6)	8.3	220	3.5	7	100		<0.1		Spring
00CH041FA	10.0	0.003(6)									Spring
00CH042RA	18.0	0.0003(5)	7.5	150	5.5	5	70		0.2		Seep
00CH042FA	18.0	0.0003(5)									Seep
00CH043RA	9.0	0.01(6)	8.3	170	8.3	7	70		<0.1		Stream
00CH043FA	9.0	0.01(6)									Stream
01CH091RA	8.8	0.001(5)	7.6	150	3.5	8	70		<0.1		Spring
01CH091FA	8.8	0.001(5)									Spring
99CH032RA	8.6	0.0045(5)	6.9	110	0	7	58	<20			Adit drainage
99CH032FA	8.6	0.0045(5)								0.01	Adit drainage
99CH033RA	9.5	0.45(5)	7.6	110	0	7	50	<20			Stream
99CH033FA	9.5	0.45(5)								0.01	Stream

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[1] CO, colorimetry.

[2] AF, atomic fluorescence spectrometry.

[3] ICP-MS, inductively coupled plasma–mass spectrometry.

[4] ICP-AES, inductively coupled plasma–atomic emission spectrometry.

[5] Estimated.

[6] Calculated.

Table 1–9. Analyses of surface waters of the Stanley uranium district.—Continued

[Datum for all latitude and longitude values is WGS 1984. See appendix 1 for analytical procedures; table 1–10 for anion analyses; cfs, cubic feet per second; µS/cm, microsiemens per centimeter; ppm, parts per million; ppb, parts per billion; FTU, Formazine Turbidity Unit; n.d., not determined]

Sample no.	Type of site	Water color, odor, or turbidity	Channel-bed description
99CH029RA	Standing water in open sunny pit	None	Mud and reed(?)–filled pond; a lot of algae and water bugs
99CH029FA	Standing water in open sunny pit	None	Mud and reed(?)–filled pond; a lot of algae and water bugs
00CH038RA	Standing water in open sunny pit	None	Muddy bottomed, reed-filled pond; abundant water bugs, egg masses, and gilled amphibians (?)
00CH038FA	Standing water in open sunny pit	None	Muddy bottomed, reed-filled pond; abundant water bugs, egg masses, and gilled amphibians (?)
00CH039RA	Flowing water in topographic depression, sun/shade	None	Fine gray sediment and dark organic-rich mud, well-vegetated banks
00CH039FA	Flowing water in topographic depression, sun/shade	None	Fine gray sediment and dark organic-rich mud, well-vegetated banks
00CH040RA	Flowing water in intermittent drainage; sun/shade	None	Heavy moss, grass, and willow on granitic, medium-sized gravel alluvium; no iron or manganese oxides or salts observed
00CH040FA	Flowing water in intermittent drainage; sun/shade	None	Heavy moss, grass, and willow on granitic, medium-sized gravel alluvium; no iron or manganese oxides or salts observed
99CH031RA	Creek flowing through sunny open area	None	Minor iron and manganese oxides; algae makes alluvium slippery; willow, wildflowers, bushes, and grass banks
99CH031FA	Creek flowing through sunny open area	None	Minor iron and manganese oxides; algae makes alluvium slippery; willow, wildflowers, bushes, and grass banks
99CH031DRA	Site duplicate of sample no. 99CH031	None	See sample no. 99CH031
99CH031DFA	Site duplicate of sample no. 99CH031	None	See sample no. 99CH031
99CH030RA	Creek flowing through sunny open area	None	Slippery rocks owing to algae on alluvium, minor iron oxides, moderate manganese oxides on alluvium, low organic content in sediment
99CH030FA	Creek flowing through sunny open area	None	Slippery rocks owing to algae on alluvium, minor iron oxides, moderate manganese oxides on alluvium, low organic content in sediment
00CH044RA	Flowing water in sun/shade	None	Iron and manganese oxide–stained cobbles and boulders; mossy, grass-covered banks
00CH044FA	Flowing water in sun/shade	None	Iron and manganese oxide–stained cobbles and boulders; mossy, grass-covered banks
00CH041RA	Flowing seep that coalesces into small brook for short distance, then disappears; sun/shade	None	Organic debris (sticks, logs, etc.) covering granitic alluvium; no iron or manganese oxides or salts observed
00CH041FA	Flowing seep that coalesces into small brook for short distance, then disappears; sun/shade	None	Organic debris (sticks, logs, etc.) covering granitic alluvium; no iron or manganese oxides or salts observed
00CH042RA	Barely flowing seep in sun	None	Moss, grass, and sedge on mud with granitic pebbles; no iron or manganese oxides or salts observed
00CH042FA	Barely flowing seep in sun	None	Moss, grass, and sedge on mud with granitic pebbles; no iron or manganese oxides or salts observed
00CH043RA	Flowing water in sun/shade	None	Moss-covered alluvium; slight iron oxide staining; grass, monkeyflower, and bushes covering banks
00CH043FA	Flowing water in sun/shade	None	Moss-covered alluvium; slight iron oxide staining; grass, monkeyflower, and bushes covering banks
01CH091RA	Barely flowing water in sun/shade	Slight turbidity	Pool 2 ft × 4 ft × 2 in. deep dammed by fallen log; in intermittent drainage depression; abundant organic debris; healthy-looking vegetation
01CH091FA	Barely flowing water in sun/shade	Slight turbidity	Pool 2 ft × 4 ft × 2 in. deep dammed by fallen log; in intermittent drainage depression; abundant organic debris; healthy-looking vegetation
99CH032RA	Water flowing from adit into sunny area	None	Algae and moss on mud and rocks, manganese oxides; flows through willow, grass, and moss
99CH032FA	Water flowing from adit into sunny area	None	Algae and moss on mud and rocks, manganese oxides; flows through willow, grass, and moss
99CH033RA	Stream flowing through sun/shade	None	Minor iron oxides on alluvium; rocks slippery owing to abundant algae; flows through willow thicket
99CH033FA	Stream flowing through sun/shade	None	Minor iron oxides on alluvium; rocks slippery owing to abundant algae; flows through willow thicket

Table 1–9. Analyses of surface waters of the Stanley uranium district.—Continued

[Datum for all latitude and longitude values is WGS 1984. See appendix 1 for analytical procedures; table 1–10 for anion analyses; cfs, cubic feet per second; µS/cm, microsiemens per centimeter; ppm, parts per million; ppb, parts per billion; FTU, Formazine Turbidity Unit; n.d., not determined]

Sample no.	Hg[2]	Ag[3]	Ag[4]	Al[3]	Al[4]	As[3]	As[4]	Au[3]	B[4]	Ba[3]	Ba[4]	Be[3]	Be[4]	Bi[3]	Ca[3]	Ca[4]	Cd[3]	Cd[4]	Ce[3]	Co[3]	Co[4]
	(ppb)														(ppm)		(ppb)				
99CH029RA		<0.01	<10	8.7	17	200	180	<0.01	<5	130	120	<0.05	<5	<0.01	56	59	<0.02	<5	0.05	0.09	<10
99CH029FA	<0.005	<0.01	<10	<1	<10	190	260	<0.01	<5	130	120	<0.05	<5	<0.01	55	57	<0.02	<5	0.01	<0.02	<10
00CH038RA		<0.01	<10		42	150	200	<0.01	<10	97	97	<0.05	<10	<0.01	55	61	<0.02	<10	0.1	<0.02	<10
00CH038FA	<0.005	<0.01	<10	<0.4	<10	150	210	<0.01	<10	96	98	<0.05	<10	<0.01	55	61	<0.02	<10	0.03	0.03	<10
00CH039RA		0.02	<10	18	15	0.5	<100	<0.01	<10	110	110	<0.05	<10	<0.01	38	41	<0.02	<10	0.06	<0.02	<10
00CH039FA	<0.005	<0.01	<10	<0.4	<10	0.5	<100	<0.01	<10	110	110	<0.05	<10	<0.01	35	40	<0.02	<10	<0.01	<0.02	<10
00CH040RA		<0.01	<10	12	13	0.9	<100	<0.01	<10	8.7	8.2	<0.05	<10	<0.01	18	17	<0.02	<10	0.03	<0.02	<10
00CH040FA	<0.005	<0.01	<10	<0.4	<10	2	<100	<0.01	<10	15	14	<0.05	<10	<0.01	28	32	<0.02	<10	<0.01	<0.02	<10
99CH031RA		<0.01	<10	11	13	1	<100	<0.01	<5	5.9	6.2	<0.05	<5	<0.01	11	13	<0.02	<5	0.04	<0.02	<10
99CH031FA	<0.005	<0.01	<10	<1	<10	1	<100	<0.01	<5	5.5	5.8	<0.05	<5	<0.01	12	13	<0.02	<5	0.02	<0.02	<10
99CH031DRA		<0.01	<10	9.2	12	1	<100	<0.01	<5	5.6	5.7	<0.05	<5	<0.01	12	13	<0.02	<5	0.03	<0.02	<10
99CH031DFA	<0.005	<0.01	<10	<1	<10	1	<100	<0.01	<5	5.6	5.6	<0.05	<5	<0.01	12	12	<0.02	<5	<0.01	<0.02	<10
99CH030RA		<0.01	<10	11	13	1	<100	<0.01	<5	4.9	6.1	<0.05	<5	<0.01	11	12	<0.02	<5	0.02	0.02	<10
99CH030FA	<0.005	<0.01	<10	<1	<10	1	<100	<0.01	<5	5	5.4	<0.05	<5	<0.01	11	12	<0.02	<5	<0.01	<0.02	<10
00CH044RA		<0.01	<10	12	15	2	<100	<0.01	<10	4	3.9	<0.05	<10	<0.01	15	14	<0.02	<10	0.04	<0.02	<10
00CH044FA	<0.005	<0.01	<10	1	<10	2	<100	<0.01	<10	4	3.8	<0.05	<10	<0.01	13	13	<0.02	<10	0.02	<0.02	<10
00CH041RA		0.03	<10	17	19	<0.2	<100	<0.01	<10	5.2	4.9	<0.05	<10	<0.01	15	15	<0.02	<10	0.1	<0.02	<10
00CH041FA	<0.005	<0.01	<10	<0.4	<10	<0.2	<100	<0.01	<10	4	4.3	<0.05	<10	<0.01	13	14	<0.02	<10	<0.01	<0.02	<10
00CH042RA		<0.01	<10	540	770	3.9	<100	<0.01	<10	21	21	<0.05	<10	<0.01	35	36	0.03	<10	2.4	0.6	<10
00CH042FA	<0.005	<0.01	<10	0.6	<10	2	<100	<0.01	<10	14	14	<0.05	<10	<0.01	32	35	<0.02	<10	0.06	0.3	<10
00CH043RA		<0.01	<10	22	24	3.1	<100	<0.01	<10	6.4	6	<0.05	<10	<0.01	14	14	<0.02	<10	0.06	<0.02	<10
00CH043FA	<0.005	<0.01	<10	<0.4	<10	7.6	<100	<0.01	<10	15	14	<0.05	<10	<0.01	32	35	<0.02	<10	<0.01	<0.02	<10
01CH091RA		0.1	<1	38	33	11	<100	<0.01	<5	12	12	<0.05	<10	<0.01	32	33	<0.02	<5	0.4	<0.02	<10
01CH091FA	<0.005	0.1	<1	1.6	<10	7.2	<100	<0.01	<5	11	9.7	<0.05	<10	<0.01	31	31	<0.02	<5	0.03	<0.02	<10
99CH032RA		<0.01	<10	44	50	1	<100	<0.01	<5	15	15	<0.05	<5	<0.01	14	16	0.2	<5	0.68	0.08	<10
99CH032FA	<0.005	<0.01	<10	<1	<10	0.9	<100	<0.01	<5	14	14	<0.05	<5	<0.01	14	15	0.1	<5	0.06	<0.02	<10
99CH033RA		<0.01	<10	14	17	0.6	<100	<0.01	<5	3.8	4.1	<0.05	<5	<0.01	14	15	<0.02	<5	0.04	<0.02	<10
99CH033FA	<0.005	<0.01	<10	1	<10	0.6	<100	<0.01	<5	3.8	3.9	<0.05	<5	<0.01	14	15	<0.02	<5	<0.01	<0.02	<10

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[1] CO, colorimetry.

[2] AF, atomic fluorescence spectrometry.

[3] ICP-MS, inductively coupled plasma–mass spectrometry.

[4] ICP-AES, inductively coupled plasma–atomic emission spectrometry.

[5] Estimated.

[6] Calculated.

Table 1–9. Analyses of surface waters of the Stanley uranium district.—Continued

[Datum for all latitude and longitude values is WGS 1984. See appendix 1 for analytical procedures; table 1–10 for anion analyses; cfs, cubic feet per second; µS/cm, microsiemens per centimeter; ppm, parts per million; ppb, parts per billion; FTU, Formazine Turbidity Unit; n.d., not determined]

Sample no.	Cr[3]	Cr[4]	Cs[3]	Cu[3]	Cu[4]	Dy[3]	Er[3]	Eu[3]	Fe[3]	Fe[4]	Ga[3]	Gd[3]	Ge[3]	Ho[3]	In[3]	K[3]	K[4]	La[3]	Li[3]	Li[4]
	(ppb)															(ppm)		(ppb)		
99CH029RA	<1	<10	<0.02	0.6	<10	<0.005	<0.005	<0.005	65	60	<0.03	0.01	<0.09	<0.005	<0.01	1.1	1.1	0.02	8.3	<10
99CH029FA	<1	<10	<0.02	0.7	<10	<0.005	<0.005	<0.005	n.d.	<20	<0.03	<0.005	<0.09	<0.005	<0.01	0.96	1	<0.01	8.2	<10
00CH038RA	<1	<10	0.02	0.5	<10	0.01	0.006	<0.005	160	180	<0.02	0.02	<0.02	<0.005	<0.01	1.2	1.4	0.06	8.3	10
00CH038FA	<1	<10	<0.01	<0.5	<10	<0.005	<0.005	<0.005	n.d.	<50	<0.02	<0.005	<0.02	<0.005	<0.01	1.1	1.4	0.02	7.7	11
00CH039RA	<1	<10	0.06	<0.5	<10	<0.005	<0.005	<0.005	34	<50	<0.02	0.007	<0.02	<0.005	<0.01	0.48	0.48	0.03	<0.5	<10
00CH039FA	<1	<10	0.03	<0.5	<10	<0.005	<0.005	<0.005	28	<50	<0.02	<0.005	<0.02	<0.005	<0.01	0.4	0.48	<0.01	<0.5	<10
00CH040RA	<1	<10	<0.01	<0.5	<10	<0.005	<0.005	<0.005	22	<50	<0.02	<0.005	<0.02	<0.005	<0.01	0.1	0.1	0.02	<0.5	<10
00CH040FA	<1	<10	<0.01	<0.5	<10	<0.005	<0.005	<0.005	18	<50	<0.02	<0.005	<0.02	<0.005	<0.01	0.16	0.18	0.01	<0.5	<10
99CH031RA	<1	<10	<0.02	<0.5	<10	0.02	<0.005	<0.005	<30	<20	0.03	<0.005	<0.09	<0.005	<0.01	0.33	0.37	0.02	<0.5	<10
99CH031FA	<1	<10	<0.02	<0.5	<10	<0.005	<0.005	<0.005	n.d.	<20	<0.03	<0.005	<0.09	<0.005	<0.01	0.36	0.39	0.01	<0.5	<10
99CH031DRA	<1	<10	<0.02	<0.5	<10	<0.005	<0.005	<0.005	<30	<20	0.05	0.006	<0.09	<0.005	<0.01	0.34	0.39	0.02	<0.5	<10
99CH031DFA	<1	<10	<0.02	<0.5	<10	<0.005	<0.005	<0.005	n.d.	<20	<0.03	<0.005	<0.09	<0.005	<0.01	0.36	0.37	0.01	0.6	<10
99CH030RA	<1	<10	<0.02	<0.5	<10	<0.005	<0.005	<0.005	<30	<20	0.04	0.005	<0.09	<0.005	<0.01	0.3	0.36	0.02	<0.5	<10
99CH030FA	<1	<10	<0.02	<0.5	<10	<0.005	<0.005	<0.005	n.d.	<20	<0.03	<0.005	<0.09	<0.005	<0.01	0.34	0.34	<0.01	0.5	<10
00CH044RA	<1	<10	0.04	<0.5	<10	<0.005	<0.005	<0.005	13	<50	<0.02	<0.005	<0.02	<0.005	<0.01	0.42	0.42	0.02	<0.5	<10
00CH044FA	<1	<10	0.02	<0.5	<10	<0.005	<0.005	<0.005	12	<50	<0.02	<0.005	<0.02	<0.005	<0.01	0.34	0.38	0.01	<0.5	<10
00CH041RA	<1	<10	<0.01	<0.5	<10	0.006	<0.005	<0.005	49	50	<0.02	0.01	<0.02	<0.005	<0.01	0.58	0.63	0.1	2.4	<10
00CH041FA	<1	<10	<0.01	<0.5	<10	<0.005	<0.005	<0.005	8.4	<50	<0.02	<0.005	<0.02	<0.005	<0.01	0.45	0.57	<0.01	1	<10
00CH042RA	<1	<10	0.2	0.7	<10	0.13	0.055	0.03	920	1,200	0.2	0.15	<0.02	0.02	<0.01	1.6	1.7	1.1	5.4	<10
00CH042FA	<1	<10	<0.01	<0.5	<10	0.006	<0.005	<0.005	83	66	<0.02	0.005	<0.02	<0.005	<0.01	1.2	1.5	0.03	3.7	<10
00CH043RA	<1	<10	0.02	<0.5	<10	<0.005	<0.005	<0.005	28	<50	<0.02	0.006	<0.02	<0.005	<0.01	0.53	0.51	0.04	<0.5	<10
00CH043FA	<1	<10	0.02	<0.5	<10	<0.005	<0.005	<0.005	27	<50	<0.02	<0.005	<0.02	<0.005	<0.01	1.1	1.3	<0.01	1	<10
01CH091RA	<1	<10	0.01	0.9	<10	0.01	<0.005	0.005	320	400	0.02	0.02	<0.02	<0.005	<0.01	1.6	1.7	0.2	3.6	3.7
01CH091FA	<1	<10	<0.01	0.7	<10	<0.005	<0.005	<0.005	n.d.	<20	<0.02	<0.005	<0.02	<0.005	<0.01	1.6	1.7	<0.01	3.4	3.5
99CH032RA	<1	<10	0.1	<0.5	<10	0.059	0.02	0.054	56	64	<0.03	0.12	<0.09	0.008	<0.01	0.5	0.57	1.6	0.9	<10
99CH032FA	<1	<10	0.05	<0.5	<10	0.02	0.01	0.01	n.d.	<20	<0.03	0.055	<0.09	<0.005	<0.01	0.55	0.54	0.53	0.5	<10
99CH033RA	<1	<10	<0.02	<0.5	<10	<0.005	<0.005	<0.005	<30	<20	<0.03	<0.005	<0.09	<0.005	<0.01	0.32	0.39	0.03	1	<10
99CH033FA	<1	<10	<0.02	<0.5	<10	<0.005	<0.005	<0.005	n.d.	<20	<0.03	<0.005	<0.09	<0.005	<0.01	0.34	0.34	<0.01	1	<10

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[1] CO, colorimetry.

[2] AF, atomic fluorescence spectrometry.

[3] ICP-MS, inductively coupled plasma–mass spectrometry.

[4] ICP-AES, inductively coupled plasma–atomic emission spectrometry.

[5] Estimated.

[6] Calculated.

Table 1–9. Analyses of surface waters of the Stanley uranium district.—Continued

[Datum for all latitude and longitude values is WGS 1984. See appendix 1 for analytical procedures; table 1–10 for anion analyses; cfs, cubic feet per second; µS/cm, microsiemens per centimeter; ppm, parts per million; ppb, parts per billion; FTU, Formazine Turbidity Unit; n.d., not determined]

Sample no.	Mg[3]	Mg[4]	Mn[3]	Mn[4]	Mo[3]	Mo[4]	Na[3]	Na[4]	Nd[3]	Ni[3]	Ni[4]	P[3]	P[4]	Pb[3]	Pb[4]	Pr[3]	Rb[3]	Re[3]	Sb[3]	Sb[4]	Se[3]
	(ppm)		(ppb)				(ppm)		(ppb)												
99CH029RA	5.3	5.3	18	19	4.7	<20	7.6	7.7	0.02	<0.1	<10	3	<100	0.06	<50	<0.01	0.35	<0.02	0.29	<50	<0.8
99CH029FA	5.3	5.3	13	14	4.9	<20	7.8	7	<0.01	<0.1	<10	<2	<100	<0.05	<50	<0.01	0.33	<0.02	0.34	<50	<0.8
00CH038RA	5.7	5.7	28	29	4.1	<20	6.7	7.5	0.06	<0.1	<10	<3	<100	0.2	<100	0.01	0.4	<0.02	0.5	<100	<0.4
00CH038FA	5.6	5.8	19	20	4.1	<20	6.1	8	0.02	<0.1	<10	<3	<100	0.09	<100	<0.01	0.4	<0.02	0.5	<100	<0.4
00CH039RA	7	6.4	1.2	<10	1.2	<20	10	11	0.03	<0.1	<10	<3	<100	0.07	<100	<0.01	0.79	<0.02	0.02	<100	<0.4
00CH039FA	5.8	6.4	0.03	<10	1.2	<20	8.8	11	<0.01	<0.1	<10	<3	<100	<0.05	<100	<0.01	0.73	<0.02	0.03	<100	<0.4
00CH040RA	2.8	2.4	1.7	<10	0.3	<20	3.4	3.6	0.01	<0.1	<10	<3	<100	<0.05	<100	<0.01	0.2	<0.02	<0.02	<100	<0.4
00CH040FA	4.2	4.3	0.35	<10	0.6	<20	5.2	6.5	<0.01	<0.1	<10	<3	<100	<0.05	<100	<0.01	0.2	<0.02	0.02	<100	<0.4
99CH031RA	1.7	1.7	0.85	<10	0.4	<20	6	5.9	0.01	<0.1	<10	9.2	<100	0.2	<50	<0.01	0.44	<0.02	0.1	<50	<0.8
99CH031FA	1.7	1.7	0.36	<10	0.4	<20	6.1	5.6	<0.01	<0.1	<10	4	<100	<0.05	<50	<0.01	0.44	<0.02	0.09	<50	<0.8
99CH031DRA	1.7	1.7	0.65	<10	0.4	<20	6.1	5.9	0.02	<0.1	<10	9.3	<100	<0.05	<50	<0.01	0.48	<0.02	0.1	<50	<0.8
99CH031DFA	1.7	1.6	0.33	<10	0.4	<20	6.3	5.5	0.03	<0.1	<10	4	<100	<0.05	<50	<0.01	0.47	<0.02	0.1	<50	<0.8
99CH030RA	1.5	1.6	0.49	<10	0.4	<20	5.9	5.8	0.03	<0.1	<10	8.5	<100	<0.05	<50	<0.01	0.38	<0.02	0.09	<50	<0.8
99CH030FA	1.6	1.5	0.17	<10	0.4	<20	6.1	5.6	<0.01	<0.1	<10	5	<100	<0.05	<50	<0.01	0.46	<0.02	0.1	<50	<0.8
00CH044RA	2.1	1.8	0.67	<10	0.79	<20	5.3	5.5	0.02	<0.1	<10	<3	<100	<0.05	<100	<0.01	0.4	<0.02	0.2	<100	<0.4
00CH044FA	1.8	1.8	0.38	<10	0.73	<20	4.4	5.1	<0.01	<0.1	<10	<3	<100	0.09	<100	<0.01	0.3	<0.02	0.2	<100	<0.4
00CH041RA	0.9	0.84	6.6	<10	0.1	<20	2.1	2.2	0.06	<0.1	<10	<3	<100	0.09	<100	0.02	0.2	<0.02	0.06	<100	<0.4
00CH041FA	0.8	0.81	<0.02	<10	0.1	<20	1.6	2.2	<0.01	<0.1	<10	<3	<100	0.06	<100	<0.01	0.2	<0.02	0.04	<100	<0.4
00CH042RA	2.2	2	130	140	0.06	<20	4.9	5.5	0.86	<0.1	<10	14	<100	0.83	<100	0.21	3	<0.02	0.05	<100	<0.4
00CH042FA	1.9	1.9	100	100	0.1	<20	4.4	5.5	0.03	<0.1	<10	<3	<100	<0.05	<100	<0.01	0.4	<0.02	0.05	<100	<0.4
00CH043RA	1.3	1.1	2.3	<10	0.2	<20	2.3	2.4	0.02	<0.1	<10	<3	<100	<0.05	<100	<0.01	0.2	<0.02	0.05	<100	<0.4
00CH043FA	2.7	2.6	0.17	<10	0.59	<20	4.8	6	<0.01	<0.1	<10	<3	<100	<0.05	<100	<0.01	0.3	<0.02	0.2	<100	<0.4
01CH091RA	1.4	1.5	28	33	0.4	<20	4	4.6	0.2	<0.1	<10	5	<100	0.1	<50	0.05	0.4	<0.02	0.04	<50	<0.2
01CH091FA	1.4	1.4	4.1	<10	0.5	<20	4	4.1	<0.01	0.1	<10	<2	<100	<0.05	<50	<0.01	0.3	<0.02	0.04	<50	<0.2
99CH032RA	1.6	1.5	3.9	<10	3.7	<20	7.2	6.8	1.5	<0.1	<10	16	<100	1.2	<50	0.42	0.64	<0.02	1.3	<50	<0.8
99CH032FA	1.6	1.5	0.85	<10	4.2	<20	7.2	6.5	0.5	<0.1	<10	12	<100	0.08	<50	0.1	0.6	<0.02	1.1	<50	<0.8
99CH033RA	1.6	1.6	0.69	<10	0.59	<20	7.8	7.6	0.01	<0.1	<10	12	<100	0.07	<50	<0.01	0.27	<0.02	0.07	<50	<0.8
99CH033FA	1.6	1.6	0.36	<10	0.62	<20	7.8	7.2	<0.01	<0.1	<10	10	<100	<0.05	<50	<0.01	0.25	<0.02	0.08	<50	<0.8

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[1] CO, colorimetry.

[2] AF, atomic fluorescence spectrometry.

[3] ICP-MS, inductively coupled plasma–mass spectrometry.

[4] ICP-AES, inductively coupled plasma–atomic emission spectrometry.

[5] Estimated.

[6] Calculated.

Table 1–9. Analyses of surface waters of the Stanley uranium district.—Continued

[Datum for all latitude and longitude values is WGS 1984. See appendix 1 for analytical procedures; table 1–10 for anion analyses; cfs, cubic feet per second; µS/cm, microsiemens per centimeter; ppm, parts per million; ppb, parts per billion; FTU, Formazine Turbidity Unit; n.d., not determined]

Sample no.	Si[3]	Si[4]	Sm[3]	Sr[3]	Sr[4]	Tb[3]	Th[3]	Ti[3]	Ti[4]	Tl[3]	Tm[3]	U[3]	V[3]	V[4]	W[3]	Y[3]	Yb[3]	Zn[3]	Zn[4]
	(ppm)		(ppb)																
99CH029RA	n.d.	4.1	0.01	1900	1500	<0.005	<0.03	<0.05	<50	<0.05	<0.005	49	0.1	<10	0.03	0.2	<0.01	0.7	<10
99CH029FA	n.d.	3.9	<0.01	1800	1400	<0.005	<0.03	<0.05	<50	<0.05	<0.005	48	<0.1	<10	<0.02	0.3	<0.01	0.5	<10
00CH038RA	0.93	1.4	<0.01	1600	1600	<0.005	<0.007	n.d.	<50	<0.05	<0.005	61	<0.2	<10	<0.02	0.2	<0.01	0.7	<10
00CH038FA	0.93	1.4	<0.01	1400	1600	<0.005	<0.007	n.d.	<50	<0.05	<0.005	61	<0.2	<10	<0.02	0.2	<0.01	1	<10
00CH039RA	5.6	5	<0.01	830	870	<0.005	<0.007	n.d.	<50	<0.05	<0.005	0.17	0.3	<10	<0.02	0.2	<0.01	<0.5	<10
00CH039FA	5.1	5.1	<0.01	710	850	<0.005	<0.007	n.d.	<50	<0.05	<0.005	0.17	<0.2	<10	<0.02	0.2	<0.01	1	<10
00CH040RA	4.6	4	<0.01	170	180	<0.005	<0.007	n.d.	<50	<0.05	<0.005	0.12	1.7	<10	<0.02	0.02	<0.01	<0.5	<10
00CH040FA	7.5	7.3	<0.01	260	310	<0.005	<0.007	n.d.	<50	<0.05	<0.005	0.22	2.6	<10	<0.02	0.01	<0.01	0.5	<10
99CH031RA	n.d.	6.6	<0.01	120	120	<0.005	<0.03	<0.05	<50	<0.05	<0.005	0.44	2	<10	0.04	0.02	<0.01	<0.5	<10
99CH031FA	n.d.	6.6	<0.01	120	120	<0.005	<0.03	<0.05	<50	<0.05	<0.005	0.43	2	<10	<0.02	0.01	<0.01	<0.5	<10
99CH031DRA	n.d.	6.5	<0.01	120	130	<0.005	<0.03	<0.05	<50	<0.05	<0.005	0.45	2	<10	0.05	0.02	<0.01	<0.5	<10
99CH031DFA	n.d.	6.6	<0.01	120	120	<0.005	<0.03	<0.05	<50	<0.05	<0.005	0.42	2	<10	<0.02	0.02	<0.01	<0.5	<10
99CH030RA	n.d.	6.6	<0.01	100	110	<0.005	<0.03	<0.05	<50	<0.05	<0.005	0.25	2	<10	0.03	0.02	<0.01	<0.5	<10
99CH030FA	n.d.	6.8	<0.01	100	110	<0.005	<0.03	<0.05	<50	<0.05	<0.005	0.24	2	<10	<0.02	0.01	<0.01	<0.5	<10
00CH044RA	4.7	4.4	<0.01	170	170	<0.005	<0.007	n.d.	<50	<0.05	<0.005	0.8	0.79	<10	<0.02	0.02	<0.01	<0.5	<10
00CH044FA	4.3	4.3	<0.01	150	160	<0.005	<0.007	n.d.	<50	<0.05	<0.005	0.74	0.61	<10	<0.02	0.01	<0.01	1	<10
00CH041RA	2.8	2.6	0.02	170	180	<0.005	<0.007	n.d.	<50	<0.05	<0.005	2.6	<0.2	<10	<0.02	0.04	<0.01	<0.5	<10
00CH041FA	2.3	2.5	<0.01	150	170	<0.005	<0.007	n.d.	<50	<0.05	<0.005	2.4	<0.2	<10	<0.02	0.01	<0.01	<0.5	<10
00CH042RA	9.4	8.8	0.2	390	410	0.02	0.047	n.d.	<50	<0.05	0.008	1.8	0.87	<10	<0.02	0.92	0.06	6	<10
00CH042FA	7.9	7.8	<0.01	340	400	<0.005	<0.007	n.d.	<50	<0.05	<0.005	1.4	<0.2	<10	<0.02	0.05	<0.01	0.8	<10
00CH043RA	2.5	2.3	<0.01	160	170	<0.005	<0.007	n.d.	<50	<0.05	<0.005	1.7	<0.2	<10	<0.02	0.03	<0.01	<0.5	<10
00CH043FA	5.6	5.7	<0.01	340	410	<0.005	<0.007	n.d.	<50	<0.05	<0.005	4.2	<0.2	<10	<0.02	0.01	<0.01	<0.5	<10
01CH091RA	5.6	6.3	0.02	370	410	<0.005	<0.03	n.d.	<50	<0.05	<0.005	4.4	0.5	<10	0.02	0.1	<0.01	2	<10
01CH091FA	5.1	5.7	<0.01	380	340	<0.005	<0.03	n.d.	<50	<0.05	<0.005	4	0.2	<10	0.02	0.03	<0.01	1	<10
99CH032RA	n.d.	7.6	0.23	130	140	0.008	<0.03	0.09	<50	0.09	<0.005	19	1	<10	0.03	0.3	0.01	9	<10
99CH032FA	n.d.	7.5	0.06	140	140	0.005	<0.03	0.06	<50	0.06	<0.005	16	1	<10	<0.02	0.1	0.02	6	<10
99CH033RA	n.d.	7.6	0.02	94	98	<0.005	<0.03	<0.05	<50	<0.05	<0.005	0.53	2	<10	0.03	0.02	<0.01	<0.5	<10
99CH033FA	n.d.	7.4	<0.01	98	96	<0.005	<0.03	<0.05	<50	<0.05	<0.005	0.52	2	<10	<0.02	0.02	<0.01	<0.5	<10

[1] CO, colorimetry.

[2] AF, atomic fluorescence spectrometry.

[3] ICP-MS, inductively coupled plasma–mass spectrometry.

[4] ICP-AES, inductively coupled plasma–atomic emission spectrometry.

[5] Estimated.

[6] Calculated.

Table 1–10. Anion analyses of surface waters by ion chromatography, Stanley uranium district.

[Datum for all latitude and longitude values is WGS 1984. See appendix 1 for analytical procedures; cfs, cubic feet per second; ppm, parts per million]

Sample no.	Site no.	Laboratory no.	Sample analyzed	Latitude (°N)	Longitude (°W)	Deposit name
99CH029FU	99CH029	C-137420	Water, filtered @ 0.45 µm; not acidified	44.2972	114.8431	East Basin No. 1 mine
00CH038FU	00CH038	C-176954	Water, filtered @ 0.45 µm; not acidified	44.2971	114.8432	East Basin No. 1 mine
00CH039FU	00CH039	C-176950	Water, filtered @ 0.45 µm; not acidified	44.2981	114.8424	East Basin No. 1 mine (vicinity of mine)
00CH040FU	00CH040	C-176944	Water, filtered @ 0.45 µm; not acidified	44.2956	114.8451	East Basin No. 1 mine (vicinity of mine)
99CH031FU	99CH031	C-137400	Water, filtered @ 0.45 µm; not acidified	44.2862	114.8488	East Basin No. 1 mine (vicinity of mine)
99CH031DFU	99CH031D	C-137404	Water, filtered @ 0.45 µm; not acidified	44.2862	114.8488	East Basin No. 1 mine (vicinity of mine)
99CH030FU	99CH030	C-137398	Water, filtered @ 0.45 µm; not acidified	44.2981	114.8416	East Basin No. 1 mine (vicinity of mine)
00CH044FU	00CH044	C-176942	Water, filtered @ 0.45 µm; not acidified	44.2753	114.8236	Coal Creek No. 1 and Deer Strike claims
00CH041FU	00CH041	C-176949	Water, filtered @ 0.45 µm; not acidified	44.2778	114.8154	Deer Strike claims (vicinity of mine)
00CH042FU	00CH042	C-176941	Water, filtered @ 0.45 µm; not acidified	44.2798	114.8182	Deer Strike claims (vicinity of mine)
00CH043FU	00CH043	C-176943	Water, filtered @ 0.45 µm; not acidified	44.2836	114.8197	Little Joe claims
01CH091FU	01CH091	C-192732	Water, filtered @ 0.45 µm; not acidified	44.2834	114.8169	Little Joe claims
99CH032FU	99CH032	C-137402	Water, filtered @ 0.45 µm; not acidified	44.3139	114.8818	Lightning No. 2 adit
99CH033FU	99CH033	C-137403	Water, filtered @ 0.45 µm; not acidified	44.3141	114.8808	Lightning No. 2 adit (upstream of mine)

Sample no.	Location information	Site description
99CH029FU	East Basin No. 1 mine, large open pit	Standing pond that fills abandoned open-pit mine; pond contains abundant vegetation
00CH038FU	East Basin No. 1 mine, large open pit	Resample of pond-water sample no. 99CH029, 1 yr later
00CH039FU	Small spring along old road about 380 ft north from East Basin No. 1 mine (approximately at mine level)	Small spring near and approximately at mine level; a background site adjacent to, but unaffected by, the mine
00CH040FU	About 800 ft southwest of East Basin No. 1 mine, along road to mine	Spring in intermittent drainage just above road; a background site adjacent to, but unaffected by, the mine
99CH031FU	East Basin Creek about 0.75 mi downstream of the East Basin No. 1 mine	Flowing stream through mature forest; next to road
99CH031DFU	Site duplicate of sample no. 99CH031	Site duplicate of sample no. 99CH031
99CH030FU	East Basin Creek, about 200 ft upstream of the East Basin No. 1 mine	Flowing stream through ponderosa forest; background site
00CH044FU	Coal Creek at 6,300 ft elevation, next to road and below junction with unnamed drainage below Deer Strike claims (0.5 mi downstream of mines)	Small flowing stream in fir forest
00CH041FU	Unnamed tributary about 800 ft southeast of Deer Strike claims, at about same elevation as the mine	Spring in intermittent drainage; a background site adjacent to, but unaffected by, the mine
00CH042FU	About 200 ft N40°W of collapsed and dry Deer Strike claims; at approximately the same elevation as the adit	Small seep in small boggy area along old road to mine
00CH043FU	Intermittent drainage about 600 ft downstream of Little Joe claims	Intermittent drainage
01CH091FU	Boggy area on old road within the Little Joe claims	Small pool in wet boggy depression in intermittent drainage
99CH032FU	Lightning No. 2 adit, lower pit wall; along Hay Creek about 0.1 mi east-northeast of confluence with Basin Creek; water flows from low point on slope	Mine drainage from collapsed adit (evidence: timbers, rails) that was later destroyed by "open-pit" gouge in hillside
99CH033FU	Hay Creek, about 600 ft upstream of Lightning No. 2 adit	Stream flowing through a willow-tree thicket; a background site

Table 1–10. Anion analyses of surface waters by ion chromatography, Stanley uranium district.—Continued

[Datum for all latitude and longitude values is WGS 1984. See appendix 1 for analytical procedures; cfs, cubic feet per second; ppm, parts per million]

Sample	Temperature	Flow rate		Water source	Type of site	Water	Water	Turbidity
no.	(°C)	(cfs)	Method			color	odor	noted
99CH029FU	15.0	0	Estimated	Open-pit pool	Standing water in open sunny pit	Colorless	None	None
00CH038FU	16.0	0	Estimated	Open-pit pool	Standing water in open sunny pit	Colorless	None	None
00CH039FU	12.0	0.002	Calculated	Spring in vicinity of mine	Flowing water in topographic depression, sun/shade	Colorless	None	None
00CH040FU	14.0	0.05	Calculated	Spring in vicinity of mine	Flowing water intermittent drainage; sun/shade	Colorless	None	None
99CH031FU	9.9	15	Estimated	Creek	Creek flowing through sunny open area	Colorless	None	None
99CH031DFU	9.9	15	Estimated	Creek	Site duplicate of 99CH031	Colorless	None	None
99CH030FU	8.2	15	Estimated	Creek	Creek flowing through sunny open area	Colorless	None	None
00CH044FU	13.0	0.11	Estimated	Small stream	Flowing water in sun/shade	Colorless	None	None
00CH041FU	10.0	0.003	Calculated	Spring	Flowing seep that coalesces into small brook that then disappears; sun/shade	Colorless	None	None
00CH042FU	18.0	0.0003	Estimated	Seep	Barely flowing seep in sun	Colorless	None	None
00CH043FU	9.0	0.01	Calculated	Stream	Flowing water in sun/shade	Colorless	None	None
01CH091FU	8.8	0.001	Estimated	Spring	Barely flowing water in sun/shade	Colorless	None	Slight
99CH032FU	8.6	0.0045	Estimated	Adit drainage	Water flowing from adit into sunny area	Colorless	None	None
99CH033FU	9.5	0.45	Estimated	Stream	Stream flowing through sun/shade	Colorless	None	None

Sample	Channel-bed description	F^{1-}	Cl^{1-}	SO_4^{2-}	NO_3^{1-}
no.		(ppm)			
99CH029FU	Mud and reed(?)–filled pond; a lot of algae and water bugs	0.1	0.4	31	<0.1
00CH038FU	Muddy bottomed, reed-filled pond; abundant water bugs, egg masses, and gilled amphibians(?)	0.2	0.2	43	<0.08
00CH039FU	Fine gray sediment and dark organic-rich mud, well-vegetated banks	0.1	0.8	6.8	<0.08
00CH040FU	Heavy moss, grass, and willow on granitic medium-sized gravel alluvium; no iron or manganese oxides or salts observed	0.1	0.5	2.5	<0.08
99CH031FU	Minor iron and manganese oxides; algae makes alluvium slippery; willow, wildflowers, bushes, and grass banks	0.1	0.3	2.9	<0.1
99CH031DFU	See sample no. 99CH031	<0.1	0.2	3	<0.1
99CH030FU	Slippery rocks owing to algae on alluvium, minor iron oxides, moderate manganese oxides on alluvium, low organic content in sediment	0.1	0.3	2.8	<0.1
00CH044FU	Iron and manganese oxide–stained cobbles and boulders; mossy, grass-covered banks	0.1	0.3	1.6	<0.08
00CH041FU	Organic debris (sticks, logs, etc.) covering granitic alluvium; no iron or manganese oxides or salts observed	0.2	0.7	<0.5	<0.08
00CH042FU	Moss, grass, and sedge on mud with granitic pebbles; no iron or manganese oxides or salts observed	0.1	0.3	<0.5	<0.08
00CH043FU	Moss-covered alluvium; slight iron oxide staining; grass, monkeyflower, and bushes covering banks	0.2	0.6	1.6	<0.08
01CH091FU	Pool 2 ft × 4 ft × 2 in. deep dammed by fallen log; in intermittent drainage depression; abundant organic debris; healthy-looking vegetation	0.2	0.6	<0.5	0.09
99CH032FU	Algae and moss on mud and rocks, manganese oxides; flows through willow, grass, and moss	0.2	0.3	3	<0.1
99CH033FU	Minor iron oxides on alluvium; slippery rocks owing to abundant algae; flows through willow thicket	0.1	0.3	2.8	<0.1

Table 1–11. Analyses of solutions from leaching of composite mine-waste samples in the Stanley uranium district.

[In each horizontal panel the top seven samples are from strata-bound, sedimentary rock–hosted deposits, and the bottom four samples are from granite-hosted vein-type deposits. Datum for all latitude and longitude values is WGS 1984. For all samples, the pH of the extractant was 5.6. See appendix 1 for analytical procedures. Temp., final temperature; μS/cm, microsiemens per centimeter; n.d., no data; ppm, parts per million; ppb, parts per billion]

Sample	Site name	Laboratory	Sample description	Latitude	Longitude
no.		no.		(°N)	(°W)
24JH99	East Basin No. 1 mine	C-153078	<2-mm-diameter material on surfaces of pit wall, floor, and embankment	44.2970	114.8435
05JH00	East Basin No. 1 mine	C-176795	<2-mm-diameter material on surfaces of pit wall, floor, and embankment	44.2970	114.8435
13JH00	Coal Creek No. 1 mine	C-176789	<2-mm-diameter material of surfaces of open-pit wall, floor, and dumps	44.2849	114.8255
13JH00D	Coal Creek No. 1 mine	C-176786	Duplicate field sample of sample 13JH00	44.2849	114.8255
10JH00	Deer Strike claims	C-176808	<2-mm-diameter material on surface of upper mine-waste dump	44.2793	114.8176
11JH00	Deer Strike claims	C-176792	<2-mm-diameter material on surface of lower mine-waste dump	44.2793	114.8176
07JH00	Shorty pit	C-176791	<2-mm-diameter material on surfaces of open-pit mine-waste dumps	44.2993	114.8562
20JH00	Alta adit	C-176798	<2-mm-diameter rock from slumped material on floor inside of adit	44.2873	114.7886
21JH00	Alta adit	C-176788	<2-mm-diameter material from surfaces of mine-waste dumps	44.2873	114.7886
17BV01	Baker & Potato Hill claims	C-197337	<2-mm-diameter material in weathered face of prospect trench	44.3194	114.8980
30JH99	Lightning No. 2 adit	C-153075	<2-mm-diameter material from surfaces of mine-waste dumps	44.3136	114.8819

Sample	Sample	Sample area	Minerals determined by X-ray diffraction analysis	
no.	increments*	(ft^2)	Major	Minor
24JH99	30		Quartz	Albite, kaolinite
05JH00	30		Quartz	K-feldspar, plagioclase, kaolinite
13JH00	30		Quartz	K-feldspar, kaolinite
13JH00D	30		Quartz	K-feldspar, kaolinite
10JH00	40	400	Quartz	K-feldspar, kaolinite, plagioclase
11JH00	30	600	Quartz	K-feldspar, kaolinite, plagioclase
07JH00	30		Quartz	K-feldspar, kaolinite
20JH00	30		Quartz, plagioclase	Kaolinite
21JH00	30		Plagioclase	Quartz
17BV01	34	400	Quartz, plagioclase	Muscovite, kaolinite, montmorillonite
30JH99	30		Quartz	Albite, orthoclase

Sample	Minerals determined by X-ray diffraction analysis (continued)	Final	Temp.	Conductivity	Final acidity	Final titration alkalinity
no.	Trace	pH	(°C)	(μS/cm)	(ppm)	(ppm)
24JH99	Orthoclase, muscovite	6.5	25	19	<20	4.1
05JH00	Montmorillonite, muscovite	6.7	25	9.8	<20	5.9
13JH00	Muscovite	5.7	25	3.6	<20	2.2
13JH00D	Muscovite, plagioclase, jarosite?	5.3	25	2.6	<20	2.7
10JH00	Muscovite, pyrite?	6.3	25	27	<20	4.1
11JH00	Muscovite	6	25	5.7	<20	4.9
07JH00	Muscovite	5.3	25	5	<20	2.3
20JH00	Pyrite, muscovite, poorly crystalline mixed-layer clay	7.1	25	11	<20	2
21JH00	Kaolinite, pyrite, muscovite, poorly crystalline mixed-layer clay, anhydrite?, vermiculite?	6.7	25	3	<20	3.1
17BV01	Hydronium jarosite, magnesiohornblende	6.3	23	2.7	<20	2.5
30JH99	Muscovite, kaolinite	6.4	25	6	<20	3.9

Sample	F^{1-}(1)	Cl^{1-}(1)	SO_4^{2-}(1)	NO_3^{1-}(1)	Hg[2]	Ag[3]	Ag[4]	Al[4]	As[3]	As[4]	Au[3]	B[4]	Ba[3]	Ba[4]	Be[3]	Be[4]	Bi[3]
no.	(ppm)				(ppb)												
24JH99	<0.08	<0.08	6.1	0.1	n.d.	<0.2	<10	42	45	<100	<0.01	<5	33	32	0.06	<5	<0.1
05JH00	0.1	0.1	1.8	0.2	<0.005	0.06	<10	180	50	<100	<0.01	<10	4	4.2	<0.05	<5	<0.01
13JH00	<0.08	<0.08	<0.5	0.1	<0.005	0.04	<10	16	230	220	<0.01	<10	0.1	<1	<0.05	<5	<0.01
13JH00D	<0.08	<0.08	<0.5	<0.08	<0.005	<0.01	<10	15	210	150	<0.01	<10	0.1	<1	<0.05	<5	<0.01
10JH00	<0.08	0.08	8.2	0.1	<0.005	0.02	<10	140	24	<100	<0.01	<10	5.5	5.6	<0.05	<5	<0.01
11JH00	<0.08	0.09	0.8	<0.08	<0.005	0.04	<10	91	47	<100	<0.01	<10	1	1.3	<0.05	<5	<0.01
07JH00	0.1	0.08	1	0.1	<0.005	0.09	<10	150	25	<100	<0.01	<10	1	<1	0.06	<5	<0.01
20JH00	0.1	0.1	0.7	3	0.02	0.03	<10	45	0.4	<100	<0.01	<10	3	2.7	<0.05	<5	<0.01
21JH00	<0.08	<0.08	<0.5	0.1	<0.005	0.1	<10	25	0.5	<100	<0.01	<10	0.5	<1	<0.05	<5	<0.01
17BV01	<0.08	<0.08	<0.5	<0.08	<0.005	0.02	<10	<10	1	<100	<0.01	<10	0.2	<1	<0.05	<5	<0.01
30JH99	0.09	<0.08	<1	0.9	n.d.	<0.2	<10	46	3.5	<100	<0.01	<5	3	3.1	<0.05	<5	<0.1

[1] IC, ion chromatography.

[2] AF, atomic fluorescence spectrometry.

[3] ICP-MS, inductively coupled plasma–mass spectrometry.

[4] ICP-AES, inductively coupled plasma–atomic emission spectrometry.

* Scoops of a trowel.

Table 1–11. Analyses of solutions from leaching of composite mine-waste samples in the Stanley uranium district.—Continued

[In each horizontal panel the top seven samples are from strata-bound, sedimentary rock–hosted deposits, and the bottom four samples are from granite-hosted vein-type deposits. Datum for all latitude and longitude values is WGS 1984. For all samples, the pH of the extractant was 5.6. See appendix 1 for analytical procedures. Temp., final temperature; µS/cm, microsiemens per centimeter; n.d., no data; ppm, parts per million; ppb, parts per billion]

Sample	Ca[3]	Ca[4]	Cd[3]	Cd[4]	Ce[3]	Co[3]	Co[4]	Cr[3]	Cr[4]	Cs[3]	Cu[3]	Cu[4]	Dy[3]	Er[3]	Eu[3]	Fe[3]	Fe[4]
no.	(ppm)		(ppb)														
24JH99	2.1	2.3	0.04	<5	0.2	0.04	<10	<1	<10	0.01	0.5	<10	0.008	<0.005	<0.005	n.d.	26
05JH00	0.74	0.87	0.03	<10	0.2	0.1	<10	<1	<10	0.03	1	<10	0.02	0.006	<0.005	n.d.	75
13JH00	<0.05	<0.1	0.02	<10	0.09	0.04	<10	<1	<10	0.01	<0.5	<10	0.008	<0.005	<0.005	7.7	<50
13JH00D	<0.05	<0.1	<0.02	<10	0.09	0.04	<10	<1	<10	0.01	<0.5	<10	0.01	<0.005	<0.005	7.6	<50
10JH00	3.3	3.3	0.2	<10	0.99	0.2	<10	<1	<10	0.01	1	<10	0.073	0.04	0.02	n.d.	54
11JH00	0.4	0.51	0.1	<10	0.5	0.2	<10	<1	<10	<0.01	<0.5	<10	0.069	0.04	0.01	12	<50
07JH00	n.d.	0.16	0.03	<10	0.2	0.1	<10	<1	<10	0.02	0.5	<10	0.01	<0.005	<0.005	19	<50
20JH00	0.4	0.42	0.3	<10	0.74	<0.02	<10	<1	<10	0.05	<0.5	<10	0.05	0.02	0.02	n.d.	50
21JH00	<0.05	<0.1	0.04	<10	0.62	<0.02	<10	<1	<10	<0.01	<0.5	<10	0.02	0.008	<0.005	12	<50
17BV01	0.1	0.12	<0.02	<10	0.89	<0.02	<10	<1	<10	<0.01	<0.5	<10	0.14	0.099	0.05	<1	<50
30JH99	0.51	0.57	0.3	<5	2.1	0.04	<10	<1	<10	0.09	<0.5	<10	0.072	0.04	0.05	n.d.	48

Sample	Ga[3]	Gd[3]	Ge[3]	Ho[3]	In[3]	K[3]	K[4]	La[3]	Li[3]	Li[4]	Mg[3]	Mg[4]	Mn[3]	Mn[4]	Mo[3]	Mo[4]
no.	(ppb)					(ppm)		(ppb)			(ppm)		(ppb)			
24JH99	<0.02	0.01	<0.02	<0.005	<0.01	0.7	0.73	0.08	0.87	<10	0.13	0.15	12	12	<1	<20
05JH00	<0.02	0.02	<0.02	<0.005	<0.01	0.36	0.36	0.2	<0.5	<10	0.1	<0.1	3.3	<10	0.2	<20
13JH00	<0.02	0.01	<0.02	<0.005	<0.01	0.38	0.4	0.04	<0.5	<10	0.01	<0.1	0.72	<10	0.1	<20
13JH00D	<0.02	0.007	<0.02	<0.005	<0.01	0.35	0.38	0.05	<0.5	<10	<0.01	<0.1	0.28	<10	0.1	<20
10JH00	<0.02	0.06	<0.02	0.01	<0.01	0.91	0.99	0.56	<0.5	<10	0.13	0.12	11	11	0.78	<20
11JH00	<0.02	0.069	<0.02	0.01	<0.01	0.34	0.34	0.2	<0.5	<10	0.02	<0.1	2.1	<10	0.3	<20
07JH00	0.02	0.008	<0.02	<0.005	<0.01	0.46	0.48	0.1	1	<10	0.03	<0.1	1.9	<10	0.2	<20
20JH00	<0.02	0.09	<0.02	0.005	<0.01	0.89	0.9	1.1	<0.5	<10	0.09	<0.1	6.7	<10	0.68	<20
21JH00	<0.02	0.03	<0.02	<0.005	<0.01	0.42	0.44	0.4	<0.5	<10	0.02	<0.1	2.9	<10	0.1	<20
17BV01	<0.02	0.17	<0.03	0.03	<0.01	0.39	0.38	0.4	0.57	<10	0.02	<0.1	4	<10	0.4	<20
30JH99	<0.02	0.12	<0.02	0.01	<0.01	0.5	0.53	1.6	<0.1	<10	0.04	<0.1	6.5	<10	22	<20

Sample	Na[3]	Na[4]	Nd[3]	Ni[3]	Ni[4]	P[3]	P[4]	Pb[3]	Pb[4]	Pr[3]	Rb[3]	Re[3]	Sb[3]	Sb[4]	Se[3]
no.	(ppm)		(ppb)												
24JH99	0.11	0.12	0.07	0.1	<10	14	<100	0.08	<50	0.02	0.2	<0.02	<0.2	<50	<0.5
05JH00	0.61	0.64	0.1	0.2	<10	23	<100	0.2	<100	0.03	0.2	<0.02	4.4	<100	<0.4
13JH00	0.16	0.17	0.04	<0.1	<10	46	<100	<0.05	<100	<0.01	0.4	<0.02	2	<100	<0.4
13JH00D	0.18	0.2	0.05	<0.1	<10	41	<100	<0.05	<100	0.01	0.4	<0.02	2	<100	<0.4
10JH00	0.5	0.55	0.44	0.3	<10	17	<100	0.2	<100	0.1	0.54	<0.02	3.1	<100	<0.4
11JH00	0.38	0.41	0.26	<0.1	<10	11	<100	0.2	<100	0.06	0.2	<0.02	2.4	<100	<0.4
07JH00	0.71	0.77	0.09	0.2	<10	35	<100	0.2	<100	0.02	0.68	<0.02	7	<100	<0.4
20JH00	0.33	0.33	0.81	<0.1	<10	11	<100	0.1	<100	0.2	2.7	<0.02	1.3	<100	<0.4
21JH00	0.1	0.1	0.25	<0.1	<10	66	<100	0.06	<100	0.07	0.3	<0.02	1.4	<100	<0.4
17BV01	0.08	<0.1	0.49	<0.1	<10	n.d.	<100	0.1	<100	0.1	0.3	<0.02	0.1	<100	<0.2
30JH99	0.09	0.1	1.3	0.1	<10	43	<100	4.1	<50	0.38	0.99	<0.02	9.4	<50	<0.5

Sample	Si[4]	Sm[3]	Sr[3]	Sr[4]	Tb[3]	Th[3]	Ti[4]	Tl[3]	Tm[3]	U[3]	V[3]	V[4]	W[3]	Y[3]	Yb[3]	Zn[3]	Zn[4]
no.	(ppm)	(ppb)															
24JH99	0.3	0.01	30	28	<0.005	0.008	<50	<0.2	<0.005	2.6	<0.3	<10	<0.2	0.05	<0.01	0.9	<10
05JH00	0.56	0.02	8.4	8.5	<0.005	0.039	<50	<0.05	<0.005	3.4	<0.2	<10	<0.02	0.1	<0.01	1	<10
13JH00	0.1	0.01	0.45	<1	<0.005	<0.007	<50	<0.05	<0.005	6.3	<0.2	<10	<0.02	0.02	<0.01	<0.5	<10
13JH00D	0.1	0.01	0.29	<1	<0.005	<0.007	<50	<0.05	<0.005	7.3	<0.2	<10	<0.02	0.04	<0.01	<0.5	<10
10JH00	0.33	0.08	77	83	0.01	0.03	<50	<0.05	0.006	17	<0.2	<10	0.04	0.72	0.04	2	<10
11JH00	0.28	0.04	16	16	0.008	0.01	<50	<0.05	0.007	21	0.4	<10	0.06	0.83	0.05	0.9	<10
07JH00	0.39	0.02	1.5	1.5	<0.005	0.034	<50	<0.05	<0.005	12	<0.2	<10	<0.02	0.05	<0.01	2	<10
20JH00	0.14	0.1	7	6.8	0.006	0.023	<50	0.66	<0.005	1.6	<0.2	<10	<0.02	0.3	0.02	0.8	<10
21JH00	<0.1	0.04	1	1	<0.005	0.01	<50	<0.05	<0.005	0.28	<0.2	<10	<0.02	0.08	<0.01	<0.5	<10
17BV01	0.11	0.17	2.5	2.7	0.03	0.07	<50	0.2	0.01	14	0.2	<10	0.24	0.8	0.1	<0.5	<10
30JH99	0.23	0.2	7.1	6.9	0.02	0.09	<50	1.2	0.01	9.7	<0.3	<10	<0.2	0.51	0.04	20	14

[1] IC, ion chromatography.

[2] AF, atomic fluorescence spectrometry.

[3] ICP-MS, inductively coupled plasma–mass spectrometry.

[4] ICP-AES, inductively coupled plasma–atomic emission spectrometry.

Appendix 2. Photographs of Sample Sites

The photographs (figs. 2–1 to 2–9) presented here indicate the types of sites at which stream sediment and (or) water were collected in the Stanley uranium district.

Figure 2–1. Site 99CH030: East Basin Creek, about 200 ft upstream of the East Basin No. 1 mine.

Figure 2–2. Site 99CH031: East Basin Creek, about 0.75 mi downstream of the East Basin No. 1 mine.

Figure 2–3. Site 00CH039: Spring, 380 ft north of the East Basin No. 1 mine. The spring is upstream of the mine and at a slightly higher elevation.

Figure 2–4. Site 00CH040: Spring, 800 ft southwest of the East Basin No. 1 mine. The spring is downstream of the mine and at a slightly lower elevation.

Figure 2–5. Site 00CH042: Small seep in boggy area, about 200 ft northwest of the Deer Strike claims and slightly higher in elevation.

Figure 2–6. Site 00CH043: Intermittent creek, about 600 ft downstream of the Little Joe claims.

Figure 2–7. Site 00CH044: Coal Creek, about 0.5 mi downstream of the Deer Strike claims and Coal Creek claims.

Figure 2–8. Site 01CH091: Small pool in boggy depression along old road within the Little Joe claims.

Figure 2–9. Site 99CH033: Hay Creek, about 600 ft upstream of the Lightning No. 2 adit.