WYOMING STATE GEOLOGICAL SURVEY

Gary B. Glass, State Geologist

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Open File Report 94-2

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STUDY OF METALS AND PRECIOUS STONES IN SOUTHERN WYOMING

by

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Laramie, Wyoming
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Abstract

This study identified several gold anomalies in placers and sand and gravel deposits along the northeastern flank of the Medicine Bow Mountains, suggesting a source terrane of scattered discrete gold occurrences or possibly a widespread gold source. In southwestern Wyoming, two silicified zones were identified that exhibit similarities to epithermal gold deposits reported elsewhere in the world. Additionally, sampling in the Kemmerer Coal Field revealed scattered weak gold anomalies including several high silver anomalies.

Several other deposits also investigated during this study included the Lake Owen layered mafic complex, the Broadway zinc-lead prospect, the Cockscomb copper deposit, the Leucite Hills lamproites, the Delaney Rim black cherts, and the Five Buttes and Ketchum Buttes uranium deposits.

Acknowledgments

The authors wish to thank Union Pacific Resources for financial support. Without the support from Union Pacific Resources this project would not have been possible.

Introduction

During 1991 and 1992, the Wyoming State Geological Survey investigated a number of areas in southern Wyoming for metals and precious stones. Coals, sands and gravels, paleoplacers, and silicified limestones and sandstones were examined for precious metals, and lamproites for diamond and peridot. This report is a summary of field research activities in 1992 and should be reviewed in conjunction with the first year of the project, as summarized by Hausel and others (1992).

Much of the area investigated did not include the classical terranes typically explored for precious metals and stones, and in many cases these areas were probably never seriously explored prior to this study. Several gold anomalies were discovered in areas thought to be barren of gold and silver. The anomalies suggest that detailed investigations could lead to the discovery of some commercial metal deposits in southern Wyoming in geological environments that have been avoided or overlooked by exploration groups in past years. Application of the same exploration concepts described here to similar environments in the remainder of the State could lead to the discovery of other potentially commercial metal deposits.

Sand, gravel, and related placer and lode deposits

Introduction

One of the high priority studies of 1992, as well as 1991, was the examination of sand and gravel resources and placers in southern Wyoming for gold (**Figure 1**). During 1991, several previously unknown gold anomalies were identified along the flanks of the Medicine Bow Mountains (Hausel and others, 1992). These preliminary results suggested that the gold anomalies may be relatively widespread, and this was confirmed in 1992 with the expansion of the 1991 project.

These widespread gold anomalies exist along the northeastern flank of the Medicine Bow Mountains. It is concluded that either: (1) several discrete sources are supplying gold to the surrounding streams, or (2) the gold is being supplied by one widespread source. The latter possibility points to the need for detailed geological and geochemical studies in this area.

Samples were collected along the flank of the Medicine Bow Mountains from as far west as Elk Mountain to as far east as the Little Laramie River near the northern flank of Sheep Mountain (**Plate 1**). Additionally, samples were collected in the Ft. Steele area about 20 miles northwest of the Medicine Bow Mountains and in the Laramie River about 30 miles east of the Medicine Bow Mountains.

The sampling techniques for the sand and gravel and placer deposits, however, were far from ideal. The samples were collected using only a shovel, followed by concentration in a gold pan. After the samples were collected, the recovered panned concentrates were examined for visible gold prior to assay. The better mineralized portions of the deposits were not accessible because heavy minerals tend to work their way from the surface to the base of the gravel deposits because of their high specific gravity. Pure gold, with a specific gravity of 19.3 (19.3 times heavier than water), will concentrate below the lighter minerals (e.g., quartz has a specific gravity of 2.87) and ultimately end up concentrated on bedrock or an impermeable clay layer within the gravels. In some drainages, this impermeable barrier may be only one or two feet deep. In other drainages, such as Rock Creek near Arlington, this could be several feet to tens of feet below the water surface. Thus, simply using a shovel will not allow access to the better portions of most gold placers.

The northern Medicine Bow Mountains are underlain by Proterozoic miogeoclinal metasedimentary rocks that include fluvial metaconglomerates similar to the Witwatersrand of South Africa and the Blind River of Canada (Hutchinson and Viljoen, 1988; Karlstrom and

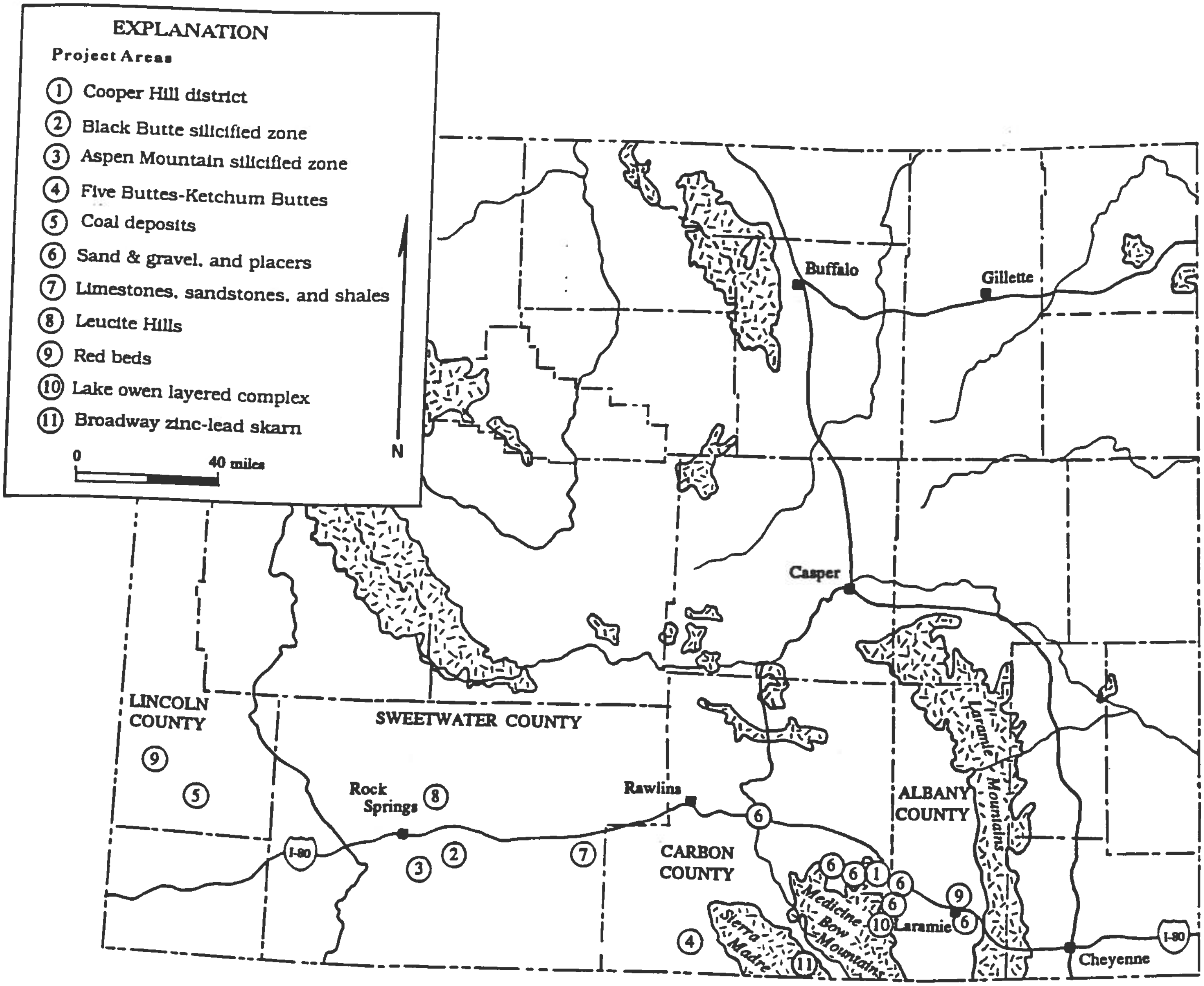

Figure 1. Areas examined for precious metals and stones in southern Wyoming in 1992.

others, 1981; Houston, 1992). It is tempting to suggest a possible relationship between the gold anomalies detected in the surrounding modern drainages and the quartz pebble metaconglomerates in the Proterozoic metasedimentary succession in the Medicine Bow Mountains. For example, in a study of the uranium and thorium resources in these metaconglomerates, Houston and others (1979) and Karlstrom and others (1981) tested a small number of radioactive metaconglomerates for gold. Samples from the basal conglomerate of the Magnolia Formation yielded several gold anomalies; the maximum detected gold (Au) value was 10 ppm in the Dexter Peak area of the Sierra Madre (west of the Medicine Bow Mountains).

There is a definite need for future studies of the metaconglomerates, particularly since paleoplacers in similar geological environments are known to be important sources for gold. The paleoplacers of the Witwatersrand, South Africa, for instance, have supplied 52 percent of all the gold mined in human history.

Sample results

In the region along Interstate 80 between Fort Steele and Laramie, a total of 54 samples were collected in the 1991 and 1992 field seasons (**Plate 1**). Twenty-four (or 44 percent) of these samples yielded visible gold! Thirty-seven samples were collected along the northern flank of the Medicine Bow Mountains, and only one did not contain anomalous concentrations of gold. The sample concentrates were chemically analyzed and yielded up to 256.0 ppm Au (**Plate 1** and **Table 1**).

Much of the visible gold occurred as colors (pinpoint- to pinhead-size gold), but flakes up to 3 mm in length were also recovered. Although primitive sampling techniques were used successfully to recover the gold, bulk sampling might be beneficial at some localities. In particular, it is strongly emphasized that any sand and gravel mining operation along the northern Medicine Bow Mountains should consider recovery of by-product gold.

Sample analyses from both the 1991 and 1992 field seasons suggest the presence of a widespread source terrane for gold in the Medicine Bow Mountains. However, because of the paucity of geochemical analyses of the gold itself, it is not possible to determine if the gold was derived from one widespread deposit or from several source areas. The source terrane problem is worthy of further research because of the potential economic benefits.

Table 1. Gold analyses of stream-sediment samples from southeastern Wyoming (nd=not detected, VG=visible gold identified in the sample, dashes=not analyzed). See **Plate 1** for sample locations. Samples ending in -91 were collected in 1991 and described by Hausel and others (1992). Samples ending in -92 were collected in 1992 and are described in the accompanying text. Analyses by Robert W. Gregory, Wyoming State Geological Survey laboratory.

Sample Number	Description	Au (ppm)
SG1-91	Grab sample concentrates, Dirt Bike pit.	1.7
SG2-91	Grab sample concentrate, Arlington pit.	4.7
SG2A-91	Panned concentrate, Arlington pit (VG).	>100.0
SG3-91	Panned concentrate, Western Mobile Pit, Laramie River (VG).	0.87
SG3A-91	Grab sample concentrate, Western Mobile, Laramie River.	1.2
SG4-91	Wash pit concentrates, Laramie River.	1.2
SG5-91	Grab sample concentrates, Laramie River (VG).	0.1
SG5A-91	Panned concentrates, Laramie River.	0.4
SG6-91	Grab sample concentrates, Laramie River.	0.1
SG6A-91	Panned concentrates, Laramie River.	0.2
SG7-91	Grab sample concentrates, Cooper Cove pit.	4.4
SG7A-91	Panned concentrates, Cooper Cove pit.	8.8
SG8-91	Grab sample concentrates, Cooper Creek.	>9.4
SG8A-91	Panned concentrates, Cooper Creek (VG).	30.2
SG9-91	Grab sample concentrate, North Fork Cooper Creek.	2.6
SG9A-91	Panned concentrate, North Fork Cooper Creek (VG).	>10.0
SG10-91	Grab sample concentrates, North Fork.	8.0
SG10A-91	Panned concentrates, North Fork placer (VG).	—
SG11-91	Grab sample concentrates, Cooper Creek placer.	>36.5
SG11A-91	Panned concentrates, Cooper Creek placer (VG).	—
SG12-91	Grab sample concentrates, Cooper Creek placer.	0.3
SG12A-91	Panned concentrates, Cooper Creek placer (VG).	24.0
SG13-91	Grab sample concentrate, Cooper Creek placer.	1.8
SG13A-91	Panned concentrate, Cooper Creek placer (VG).	35.9
SG14A-91	Panned concentrate, Rock Creek placer (VG).	>100.0
SG15-91	Grab sample concentrate, Ft. Steele pit.	0.3
SG15A-91	Panned concentrate, Ft. Steele pit.	2.2
SG16-91	Grab sample concentrate, North Platte River.	nd
SG16A-91	Panned concentrate, North Platte River.	2.7
SG16B-91	Panned concentrate, wash pit, North Platte River.	8.0
SG16W-91	Grab sample concentrates, wash pit, North Platte.	nd
SG17-91	Grab sample concentrates, Little Laramie River.	12.7
SG17A-91	Panned concentrates, Little Laramie River placer (VG).	—
SG1-92	North Platte River gravel (VG).	7.4
SG2-92	Elk Mountain gravel pit.	1.3
SG3-92	Permo-Triassic channel deposit, Laramie landfill (VG).	7.8
SG4-92	Permo-Triassic red bed clay, Laramie landfill.	nd
SG5-92	Dry wash in section 16, T16N, R77W (VG).	5.2
SG6-92	Gravel draw in Sections 4 and 5, T16N, R77W (VG).	23.9
SG7-92	Prospect pits, Mill Creek area.	66.8
SG8-92	West prospect pit, Middle Fork of Mill Creek (VG).	25.4
SG9-92	Gully in section 6, T16N, R77W (VG).	—
SG10-92	Gravel pit in section 13, T16N, R77W.	2.3
SG11-92	Emigrant Gulch hydralic placer (VG).	8.8
PL1-92	Wagonhound Creek placer (VG).	256.0
PL2-92	West Fork of Dutton Creek placer (VG).	113.0
PL3-92	Foote Creek placer (VG).	92.0
PL4-92	Onemile Creek placer (VG).	87.0
PL5-92	Fish Creek placer.	2.1
PL6-92	Sevenmile Creek placer (VG).	124.0
PL7-92	Rattlesnake Creek placer.	0.6
PL8-92	Dry channel on Threemile Creek.	nd
PL9-92	Threemile Creek placer.	4.6
PL10-92	Middle Fork Mill Creek placer (VG).	—

Elk Mountain area, Carbon County

Historical records indicate some argentiferous chalcocite was mined from the Elk Mountain area. To the south, in the Coad Mountain area, some copper was also recovered. Copper mineralization in the Coad Mountain area was reported in sheared schist; at Elk Mountain, copper was found as small replacement deposits in the Madison Limestone. There are no known gold production records for this area, although there is a brief historical reference to gold colors panned from the eastern drainages of Elk Mountain (Morrow, 1871).

During 1992, three samples were collected from the Elk Mountain area for this study (**Plate 1**). One was taken from the western flank, and two from the eastern flank. The concentrates from the three samples yielded only traces of gold.

Rattlesnake Creek placer

Sample PL7-92 (**Table 1**) was collected in the SW SW section 26, T20N, R82W, from a gravel bar along Rattlesnake Creek on the northwestern flank of Elk Mountain (**Plate 1**). The gravel was not extensive. The creek bed consisted mostly of mud with cobbles and a minor amount of gravel. Material dug from the site produced only a minor amount of black sand which assayed a trace of gold (0.60 ppm).

Gravel pit

Large gravel deposits occur on either side of the road along the north line of the NW section 1, T19N, R81W, in the east bank of Mill Creek. The gravels average more than 10 feet thick and cover several acres. One sample (SG2-92) was collected near the bottom of an embankment and contained fine sand, clay, and cobbles. The sample yielded a small amount of heavy black sand concentrates which assayed 1.3 ppm Au (**Table 1**).

About a mile west of the Mill Creek gravel deposit, another drainage known locally as UL Creek (NW SW section 35, T20N, R81W) was examined. Some sand was panned from this drainage but yielded no black sand concentrates. Because of the paucity of black sand and the lack of good placer traps, a sample was not collected for assay.

Fish Creek placer

A third sample was collected in S2 N2 section 14, T19N, R81W, from a small stream known as Fish Creek, which flows from the east flank of Elk Mountain. The sample (PL5-92) was panned from sand and gravel bars on the north edge of the creek about 50 feet upstream from a bridge. A small amount of black sand was recovered; the concentrate assayed 2.1 ppm Au (**Table 1**).

Herman mining district, Carbon County, Wyoming

Historical placer mining was reported on tributaries of the Medicine Bow River in what was then known as the Herman and Cooper Hill mining districts. These districts included Onemile, Threemile, Foote, and Rock Creeks, and the forks of Dutton, Cooper, and Wagonhound Creeks (Hausel, 1992b; 1993). Estimated value of the gravel (in 1896 prices) from some of the placers was 50 to 75 cents per cubic yard in gold (0.024 to 0.036 ounce per cubic yard).

The available historical data, the results of the 1991 study (Hausel and others, 1992), and the present study suggest that any sand and gravel operators in this region should consider potential recovery of by-product gold. Nearly every sand and gravel sample collected in this region yielded anomalous concentrations of gold.

Wagonhound Creek placer

Wagonhound Creek flows in a northerly direction from the northern end of the Medicine Bow Mountains (**Plate 1**). A sample (PL1-92) panned from bar deposits along the stream in the bottom of a steep-walled timbered canyon in the NW section 6, T18N, R79W (unsurveyed) (**Figure 2**), contained abundant cobbles and boulders; however, good gravel deposits were sparse. Several particles of gold were observed in the sample concentrates. The concentrates were highly anomalous and yielded 256 ppm Au.

Foote Creek placer

Foote Creek drains northeasterly from the northern flank of the Medicine Bow Mountains nearly parallel to Wagonhound Creek. A sample (PL3-92) was collected from the NE SE section 33, T19N, R79W (**Figure 2**), where the creek narrows into an area of many silted and grass-covered beaver ponds. At this locality, the stream cuts through the naturally reclaimed beaver ponds creating a small channel with some material ranging from boulders to sand and gravel. Due to the lack of heavy minerals in the gravels, only a very small amount of concentrate was recovered. The concentrates included a couple of very tiny gold colors. The concentrates assayed 92 ppm Au (**Table 1**).

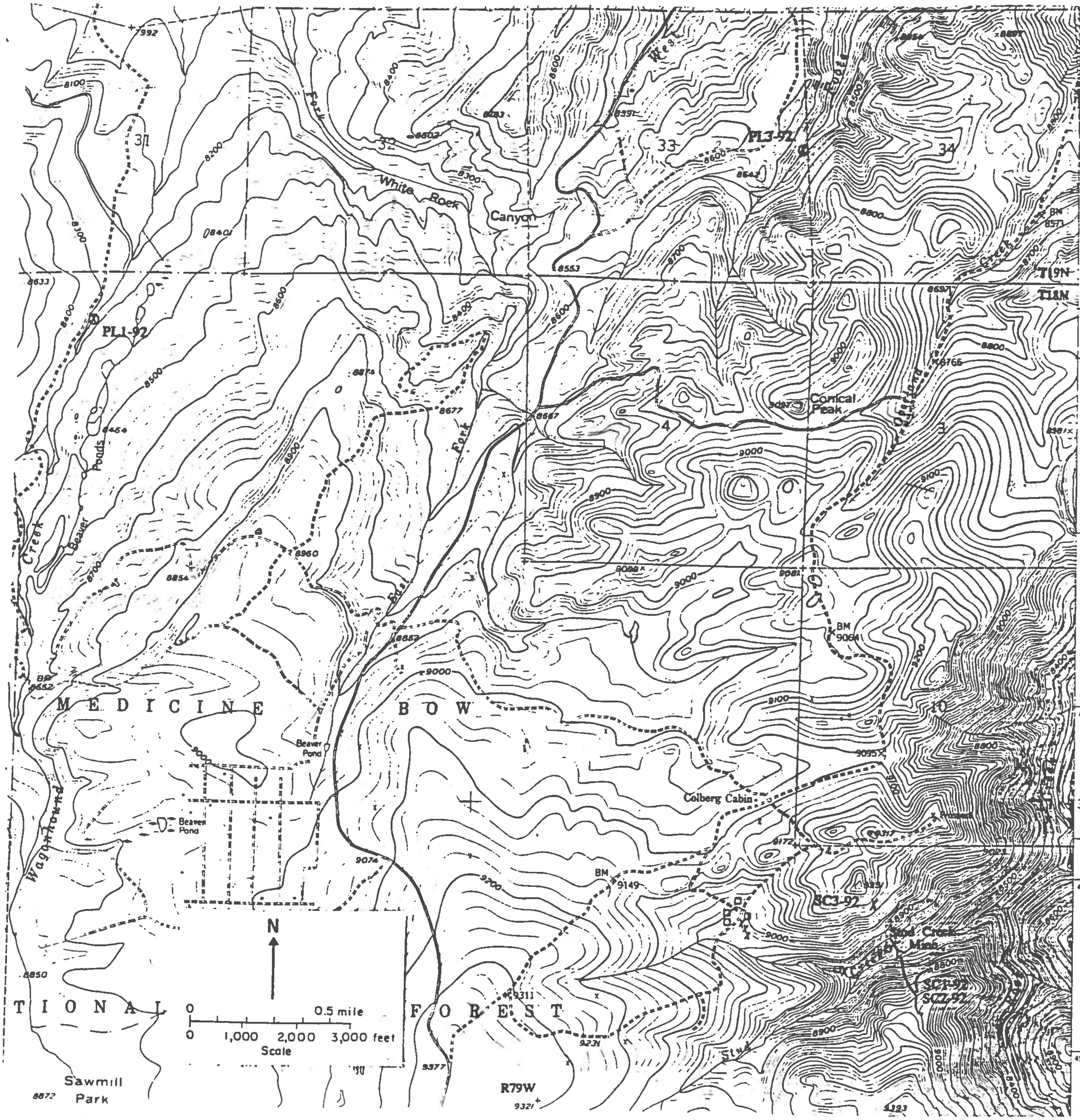

Figure 2. Sample location map for the Wagonhound Creek, Foote Creek, and Stud Creek areas of the northern Medicine Bow Mountains (portions of T18 and 19N, R79W of the White Rock Canyon 7.5-minute Quadrangle map).

Stud Creek

This area has a number of prospects, a mine, and the remains of some old abandoned cabins (**Figure 2**). In section 15, T18N, R79W, a mine tunnel was located on Stud Creek. The tunnel is about 400 feet long and driven in a north-northwesterly direction. At about 150 feet from the portal, the tunnel cut a narrow 2- to 4-inch-wide, near horizontal, poorly mineralized vein in amphibolite. Other than this vein, there was little evidence of any other mineralization in the mine workings. It appears the tunnel was driven to test a limonite-stained chlorite schist and quartzite exposed on the hillside to the north above the tunnel, but stopped short of this target.

Two samples collected from the mine dump at the tunnel on Stud Creek included SC1-92, a silicified quartz-chlorite schist with disseminated and fracture-filling pyrite, and SC2-92, an altered schist which produced a strong sulfur odor when struck by a hammer. A third sample, SC3-92, was collected from a pit to the north. This sample consisted of quartzite with bands of limonite. All three samples were poorly mineralized and were not assayed.

Emigrant Gulch placer mine

Emigrant Gulch, an unnamed tributary on the Arlington 7.5-minute Quadrangle, converges downstream with the West Fork of Foote Creek. Interest in this area was noted in 1876 following reports that gold had been found in dirt on the Overland Trail, which passes through the gulch.

The first placer gold mine began operating in 1877. In 1897, mining operations were reported by the Overland Gold Mining Company. The historical reports indicated at least three miles of ditches were constructed from Foote and Wagonhound Creeks to supply water to giants used to wash gravel into 1,300 feet of flumes and riffles in Rock Creek and Emigrant Gulch. Gravels at Emigrant Gulch were reported to average 0.036 oz/yd^3; however, no production records were kept for the mine. No evidence of hydraulic mining operations was found along Rock Creek, although extensive surface disturbance in this area may have destroyed any evidence of the old workings.

The exact location of the historical Emigrant Gulch mine remained unknown despite a recent literature search that only found information that alluded to its existence. However, during the 1992 field studies, Eric Nielsen of the Wyoming State Geological Survey interviewed several ranchers and individuals in the Rock Creek area and found a Mr. Chet Pitcher, an Arlington resident, who had some knowledge of the old placer mine. He identified the exact location of the Emigrant Gulch placer site. Mr. Pitcher at one time accumulated some of the old monitor (giant) nozzle parts.

According to Mr. Pitcher, the Emigrant Gulch hydraulic mine was located in the NW section 24, T19N, R79W, and in the SW section 13, T19N, R79W, less than 100 yards north of the present Interstate 80 (**Figure 3**). The historical workings are well hidden by willow trees, but the site is marked by gravel tailings and naturally reclaimed scars along the stream banks for a length of about 2,500 feet. The site lies adjacent to the Overland Trail.

The majority of the fluvial material from the gulch consists of sandy soil with some gravel. Only small amounts of undisturbed gravel remain in the gulch and the property appears to be essentially mined out. During the 1992 field season, the gulch was dry and samples were collected in five-gallon buckets along the east bank of the gulch, transported to water, and panned. Upon panning, the samples produced some visible gold colors and a small amount of black sand. The panned concentrates were assayed and yielded 8.8 ppm Au (sample SG11-92, **Table 1**). Samples SG2-91, SG2A-91, and SG14A-91 (**Table 1** and **Plate 1**) collected in the Rock Creek drainage to the east in 1991 also contained anomalous gold concentrations (Hausel and others, 1992).

Onemile Creek placer

Onemile Creek flows north parallel to Rock Creek approximately one mile east of Arlington (**Plate 1**). Sample PL4-92 (**Table 1**) was collected and panned in the SW SE section 31, T19N, R78W, where the creek narrows in the bottom of a canyon approximately 1.5 miles south of Interstate 80. The concentrates from several sand bars were combined for analysis since very little black sand was present. The concentrates contained tiny particles of gold and assayed 87.0 ppm Au.

Threemile Creek placer

Threemile Creek drains the northern flank of the Medicine Bow Mountains and lies between Onemile Creek and the West Fork of Dutton Creek (Arlington 7.5-minute Quadrangle). The creek flows under Interstate 80 nearly three miles east of Arlington where it is crossed by the historical Overland Trail.

During this investigation, the stream bed carried only a small flow of water in the upper reaches of the drainage. Downstream in the SE section 8, T18N, R78W, the water disappeared underground leaving the surface channel dry. Good natural traps in this region

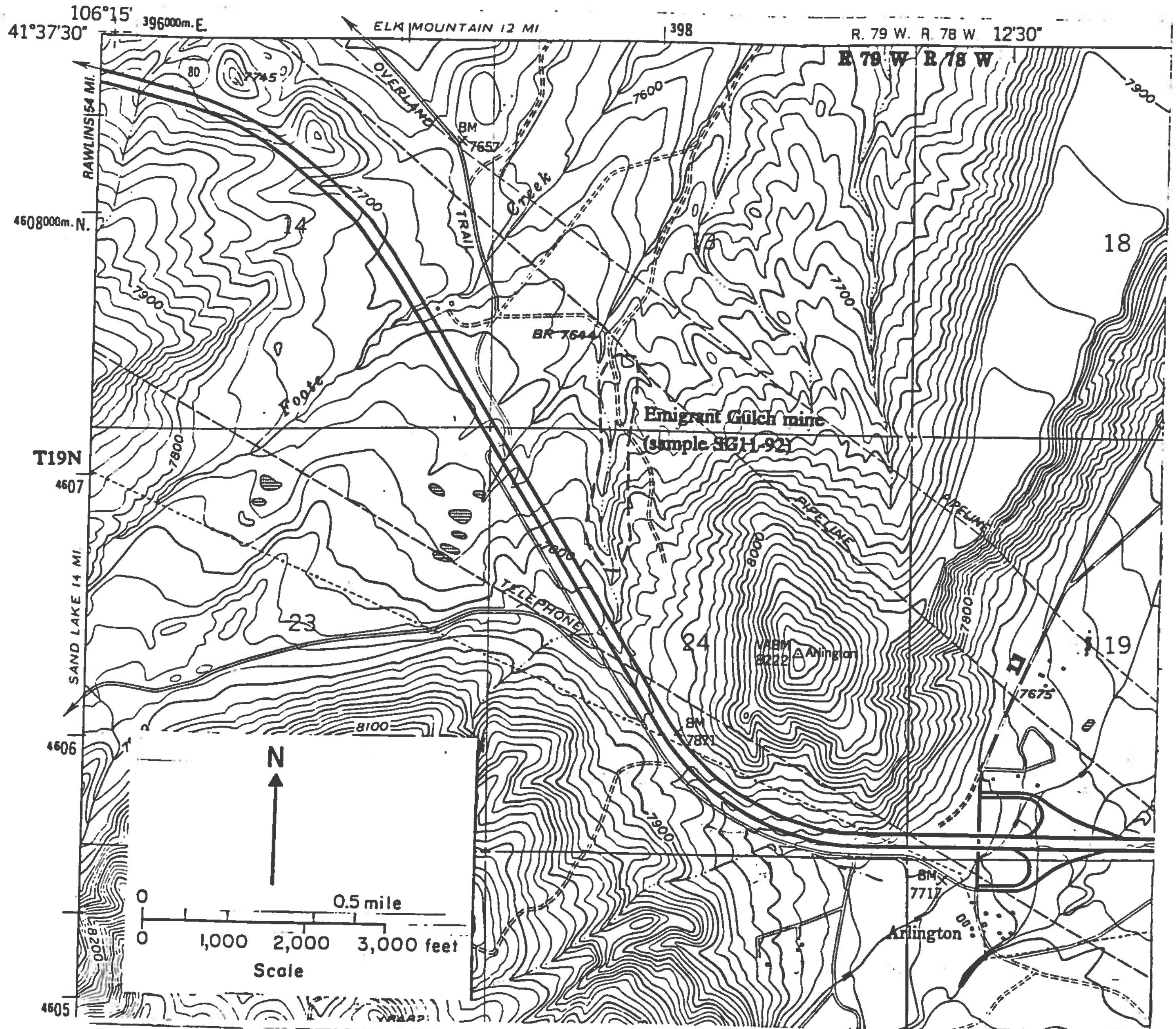

Figure 3. Location of the Emigrant Gulch placer mine near Arlington, Wyoming (Arlington 7.5-minute Quadrangle map).

are almost nonexistent and the area appeared to be a poor placer gold trap. However, five-gallon buckets of sand and gravel were collected from various places along the dry stream bed and transported to a pond downstream where the water flow returned to the surface. The material was panned and only a small amount of black sand was recovered. These concentrates were assayed yielding no detectable gold (Sample PL8-92, **Table 1**). About half a mile downstream near the White Ranch, a mine dump was found and samples were collected from the dump. The samples were weakly mineralized and were not analyzed.

A mile farther downstream from Sample PL8-92, Sample PL9-92 (**Table 1**) was collected in the N2 SW section 4, T18N, R78W, and panned from a large bar deposit about 75 feet south from where the jeep trail fords the creek. This bar contained particle sizes from sand to gravel to small boulders and yielded a very small amount of black sand concentrate. The concentrates assayed 4.6 ppm Au.

Cooper Hill mining district, Carbon County

The Cooper Hill district was mapped at a 1:12,000 scale and several of the district's mines were sampled in 1991 (Hausel and others, 1992). Stream-sediment samples were collected in 1991 from Cooper Creek and North Fork Cooper Creek on the eastern flank of the district. Anomalous concentrations of gold were found in all of the samples taken between the village of Morgan and Interstate 80. Samples SG7-91 to SG13A-91 (**Table 1**) assayed from 0.3 ppm to >36.5 ppm Au. Visible gold was recovered from six of the panned samples (Hausel and others, 1992).

West Fork of Dutton Creek

The West Fork of Dutton Creek flows to the northeast from a canyon about a mile west of Cooper Hill. The stream continues to the north around the northern edge of Deer Mountain where it converges with the East Fork of Dutton Creek. Gravel deposits on each side of a fence located on the section line between section 9 and section 10, T18N, R78W, (Arlington 7.5-minute Quadrangle) were sampled in 1992 (Sample PL2-92, **Table 1**) in the West Fork. The sample concentrates yielded several particles of gold and assayed 113.0 ppm Au.

Cooper Creek adit

A mine hidden in the trees was located on Cooper Creek south of Cooper Hill in 1992 (SW section 3, T17N, R78W). The adit was driven on a 5- to 6-foot-wide quartz vein in chlorite schist (**Figure 4**). The tunnel followed the vein for 140 feet to the southeast and terminated in quartz. A select sample (Sample CH2-92) from the mine dump yielded neither gold nor silver. Sample CH1-92, collected from the eastern mine rib in an open fold, also yielded no detectable gold or silver. A third sample (CH5-92), consisting of boxwork quartz containing some chalcopyrite, was collected 20 feet from the mine face and yielded >2.0 percent Cu, 0.071 ppm Au, 1.9 ppm Ag, and 128 ppm Pb.

Mill Creek mining district, Carbon County

The historical literature indicates some gold was recovered south of Cooper Hill in what was known as the Mill Creek district (Hausel, 1992b). Only a few prospects occur in this district.

Sevenmile Creek

Sevenmile Creek drains the northeastern flank of the Medicine Bow Mountains and flows in an easterly direction to James Lake, several miles east of the Medicine Bow uplift. Access to the drainage was limited due to private ownership.

One sample was obtained from a small sand bar about 100 feet west of a fence on the section line between the SE section 24, T17N, R78W, and the SW section 19, T17N, R77W (Sample PL6-92, **Figure 5**). The creek bed is composed of boulders and large cobbles with very little sand and gravel. Even though panned samples yielded very little black sand, gold colors, including one gold flake nearly 1 mm across, were recovered. The concentrates assayed 124 ppm Au (**Table 1** and **Plate 1**).

Middle Fork of Mill Creek

The Middle Fork (**Figure 5**) is one of three forks converging downstream from the northeastern flank of the Medicine Bow Mountains to form Mill Creek. Mill Creek then converges with the Little Laramie River a few miles to the east.

The first historical reference to gold on Mill Creek was in 1864, when a man and his son reportedly panned $2 to $3 per day in gold (about 0.1 to 0.15 ounce per day). Before the end of the summer, the father was killed by Indians and the son left the area. Ten years later, the area was again prospected without any significant discoveries (Anonymous, 1907). In June, 1905, two prospectors named George Mugler and John McClure were reportedly working 1,260 acres of placer claims on Mill Creek and making about $1.50 per day (about 0.075 ounce of gold per day). They also recovered several nuggets worth $2 (0.1 ounce) and a few worth as much as $5 (0.25 ounce) (Anonymous, 1905). Tage Benson of Laramie also reported that

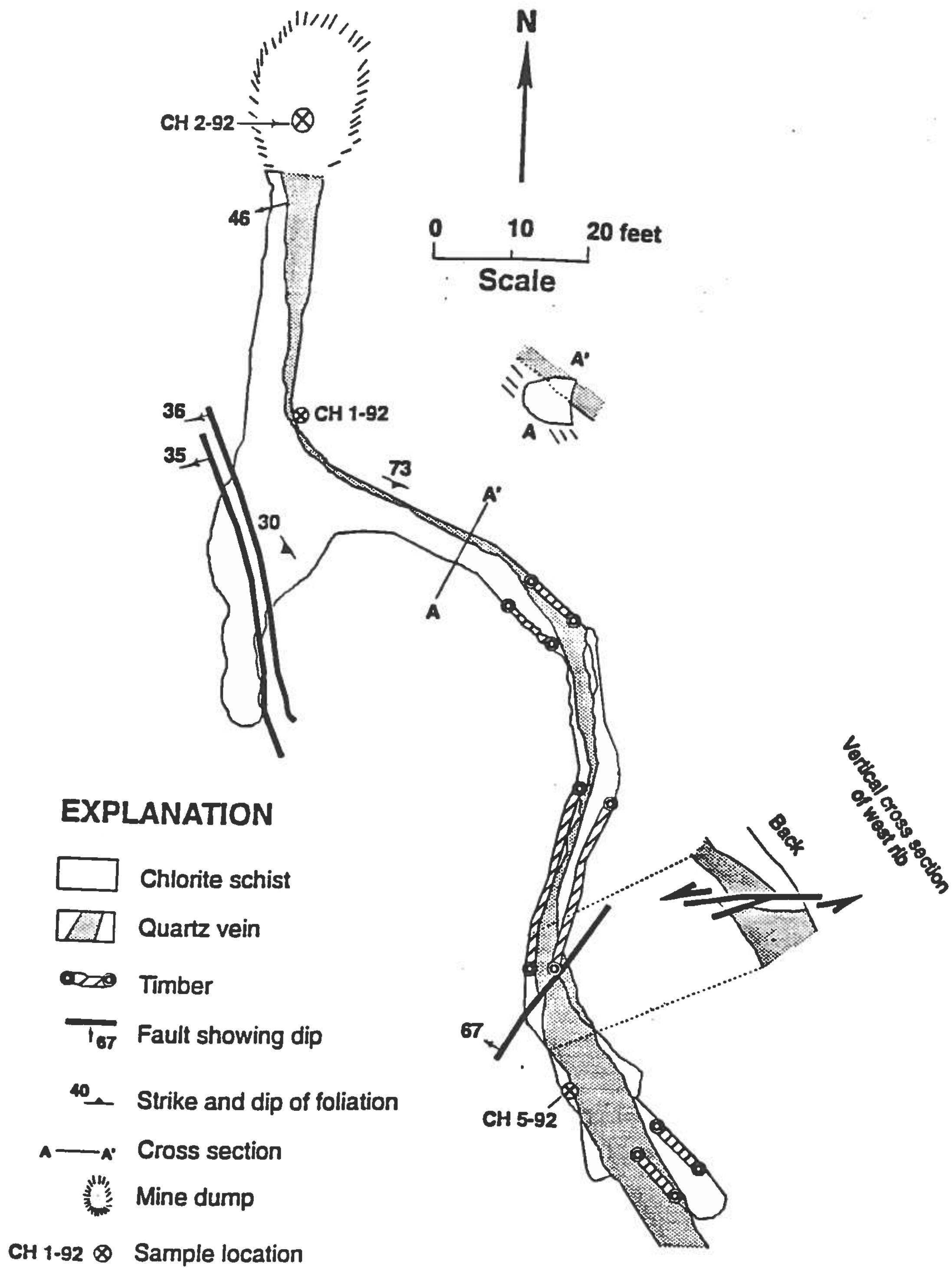

Figure 4. Cooper Creek mine adit, Cooper Hill mining district, Medicine Bow Mountains. (Geology by W. Dan Hausel and Jamie Clemons, 1992.)

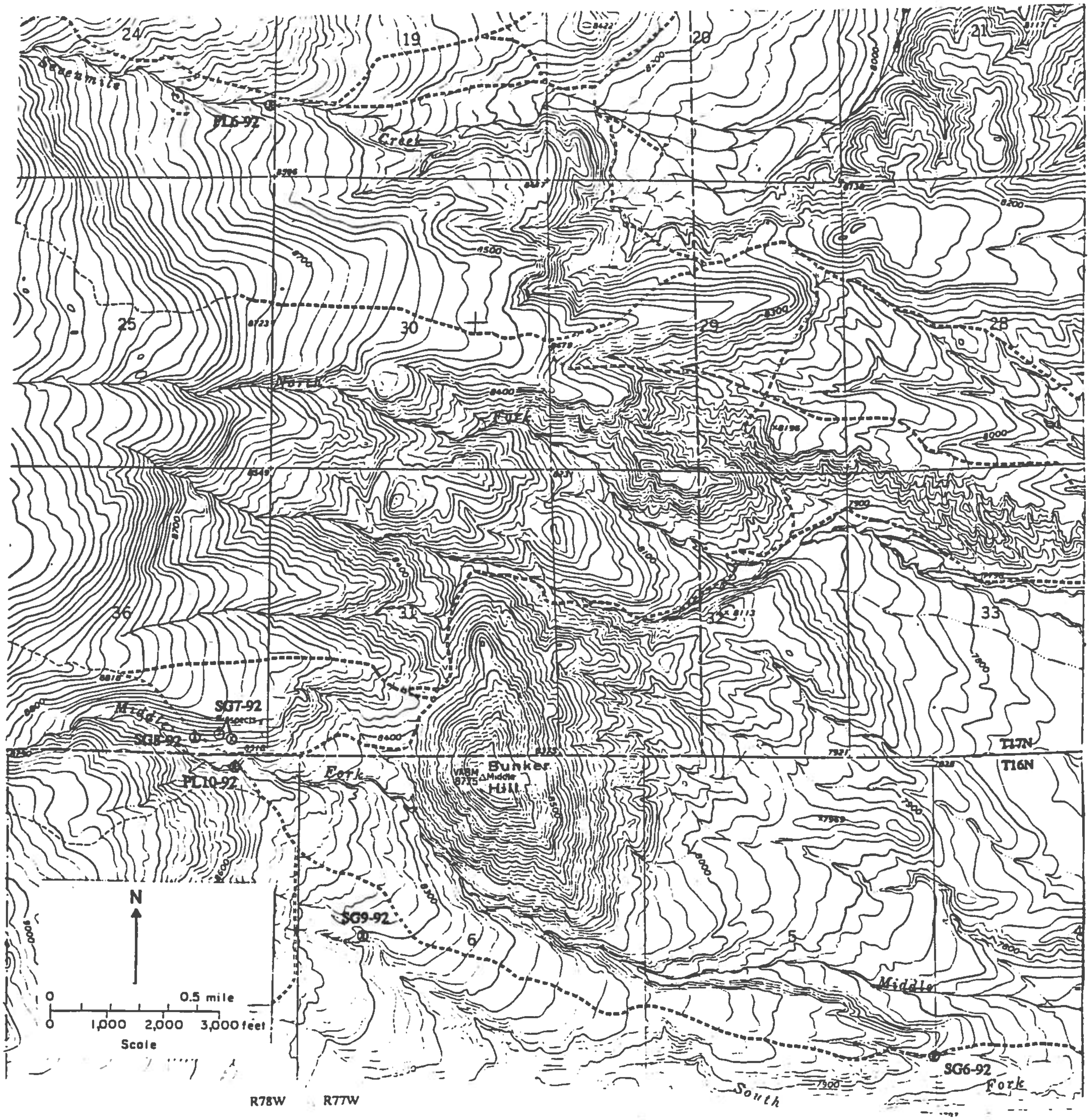

Figure 5. Sample locations in the Mill Creek district, Medicine Bow Mountains (Strouss Hill 7.5-minute Quadrangle map). See **Table 1** for analytical data.

his grandfather recovered some gold from the Middle Fork of Mill Creek during the 1930s (verbal communication to Eric Nielsen, 1992).

Evidence of early placer mining can still be found at several locations along the Middle Fork in section 36, T17N, R78W. Old mining equipment, tailings, and several prospect pits were found along the south slope of a hill immediately north of the creek (**Figure 5**).

A sample site (PL10-92) was selected on the south bank of the Middle Fork a few feet west of the jeep trail fording the stream in the NE NE section 1, T16N, R78W (**Figure 5**). Samples from this site contained a fair amount of black sand, and the concentrates from several pans contained visible flakes of gold up to 1 mm in length. All visible gold was removed from the concentrates and the gold was examined microscopically. The remaining concentrates were not assayed as it was obvious the sample contained anomalous amounts of gold. The boulders in the channel bottom did not seem to have been disturbed to any great extent; some coarse gold may lie beneath the boulders.

Prospect pits a short distance north of sample site PL10-92 along the north bank of the Middle Fork (S2 SE section 36, T17N, R78W) were also examined (**Figure 5**). Some five-gallon buckets of mixed soil and gravel were collected from various places along the banks of a prospect at the south end of a small grove of trees (Sample SG7-92). Gravel mixed with soil containing clay was also collected from the next pit west and a few feet higher on the hill and combined with the first sample. The horizon containing the gravel occurred in the top six inches of the pit. Panning produced very small amounts of black sand and the combined samples from the two pits were assayed yielding 66.8 ppm Au (**Table 1**).

West of these prospects at the base of the hill are a number of prospect pits with a greater amount of gravel. The gravel is dispersed through the soil and is generally within the top 1.5 feet or less of the surface. Several five-gallon buckets of gravel and soil were collected from various placers in the pits and piles (Sample SG8-92). Panning produced a small amount of black sand with one visible gold color. The concentrates assayed 25.4 ppm Au (**Table 1**).

South Fork Mill Creek gully

A gully located a quarter mile south of the Middle Fork runs parallel to the Middle Fork and converges with the South Fork of Mill Creek in section 6, T16N, R77W. Sample SG9-92 (**Figure 5**) was collected in the upper reaches of the gully to the southwest of Bunker Hill because the drainage cut through a thick horizon with abundant sand and gravel to boulder-size material (**Figure 5**). Several five-gallon buckets of the material from small gravel deposits in the bottom of the gully were collected and transported to water for panning. The concentrates contained a fair amount of black sand and several flakes of gold up to 1 mm in length were recovered. No assay was performed since it was obvious that gold was present.

Gully between the Middle and South Forks of Mill Creek

Another gully lies parallel to both the Middle Fork and the South Fork of Mill Creek in the S2 of sections 4 and 5, T16N, R77W (**Figure 5**). A dirt road runs along the northern flank of the draw.

The draw cuts through localized gravel deposits. Samples of gravel from the draw were collected in five-gallon buckets from various places along the gully in the vicinity of the section line between sections 4 and 5 and transported to water for panning. Several small particles of gold and one flake measuring 3 mm across by 0.5 mm thick and weighing 0.2 grain (480 grains = 1 ounce) were recovered. The flake was removed and the remaining black sands were assayed yielding 23.9 ppm Au (Sample SG6-92, **Table 1**, **Plate 1**).

Gravel pit, NE section 13, T16N, R77W

A small excavation exposed gravel with soil south of a dirt road that runs through the NE section 13, T16N, R77W. The excavation lies a short distance north of Webb Lake and south of Mill Creek. A fair amount of black sand concentrates was recovered from panning and the concentrates assayed 2.3 ppm Au (Sample SG10-92, **Table 1** and **Plate 1**).

Nellis Creek

Nellis Creek lies south of Mill Creek. A dry tributary of Nellis Creek located in the NW section 16, T16N, R77W, forms a deep wash with abundant sand and gravel extending north from the center of the N2 N2 of section 16 into the center of the S2 S2 section 9, T16N, R77W. Sample SG5-92 was collected from the center of the N2 N2 of section 16, T16N, R77W, in five-gallon buckets from this large sand and gravel deposit. The sample was collected a few feet north of a fence that crosses the wash. This material was transported to water and panned. The concentrates included a large amount of black sand and some tiny gold colors. The concentrates assayed 5.2 ppm Au (**Table 1** and **Plate 1**).

Little Laramie River

Samples panned from the Little Laramie River to the south of Nellis Creek also yielded anomalous gold (Hausel and others, 1992). Sample sites SG17-91 and SG17A-91 (**Table 1** and **Plate 1**) lie downstream from the historical Centennial Ridge mining district.

Laramie area, Albany County

Laramie River

During 1991, several samples were collected from sand and gravel deposits along the banks of the Laramie River both north and south of the Laramie city limits. All of the sample concentrates were weakly anomalous in gold (**Plate 1**), and Sample SG3-91 contained minor visible gold.

Red beds at Laramie's landfill

During the 1992 field season, two samples were collected in the Laramie area. Based on reports of gold in the Laramie city landfill (Bob Jones and Dean Farris, verbal communication to Hausel), samples were collected in the landfill to test for gold.

North of Laramie, deeply trenched excavations within Laramie's landfill expose cross-bedded conglomerates in paleochannels of the Permian-Triassic Chugwater Formation. Several five-gallon buckets of sand and gravel were collected from various places in the exposed channels in the sides of the recently excavated northernmost trench in the NW NW section 22, T16N, R73W. The material in the channel was consolidated but poorly cemented and relatively easy to dislodge with a spade. A sample of the red bed clay was also collected from the landfill. These were transported to a water source and panned. The sand and gravel from the paleochannel provided a fair amount of black sand concentrate including a few particles of visible gold. The concentrates yielded 7.8 ppm Au (Sample SG3-92, **Table 1** and **Plate 1**). The clay sample (SG4-92) yielded no black sand and contained no detectable gold.

North Platte River, Carbon County

The North Platte River contains extensive sand and gravel resources within its banks and in the adjacent sand bars, and gold has been reported in the river as far downstream as western Nebraska. There are no known records of commercial gold production from the North Platte River in Wyoming, although Thomas (1947) reported a placer mining venture had been scheduled near Alcova, Wyoming. It is not known if this venture ever began.

In southern Wyoming, tributaries draining both the Medicine Bow Mountains and Sierra Madre feed the North Platte River. These tributaries include Douglas Creek, which yielded at least 4,000 ounces of gold to placer miners in the historical past, and the Encampment River and other tributaries that cut across known gold-bearing terranes (Hausel, 1989). Farther north, the North Platte River cuts through the Seminoe Mountains several miles upstream from Alcova. The Seminoe Mountains host narrow, but rich, auriferous gold veins and include some placers and paleoplacers (Hausel, 1992a) which could have provided some of the Alcova gold reported by Thomas (1947).

Where the North Platte River flows under Interstate 80 at Ft. Steele, several pits are periodically operated to supply sand and gravel for reconstruction of the Interstate and for the needs of the nearby communities. Samples were collected from various pits at Ft. Steele in 1991 and 1992 to determine if there is any potential for by-product gold. In 1991, sample concentrates obtained from panning the sand and gravel produced some geochemical anomalies and yielded values from none (not detected) to 8.0 ppm Au (Samples SG15-91 to SG16W-91, **Table 1**) (Hausel and others, 1992).

In 1992, sand and gravel was panned from a previously unsampled pit on the north side of Interstate 80 (Sample SG1-92, **Table 1**) and along the east bank of the North Platte River (SW SW section 25, T21N, R85W) (**Plate 1**). The sample was from an abandoned and reclaimed gravel pit near Ft. Steele about 20 miles northwest of the Medicine Bow Mountains. Material was collected from the bottom of an existing 10-foot-deep hole in the pit. The material consisted of sand, gravel, and cobbles. Panned concentrates produced from this material yielded black sands and a few, tiny, visible, gold colors. The concentrates were assayed and yielded 7.4 ppm Au (**Table 1**).

Silicified zones south of Rock Springs

Two prominent, structurally controlled, silicified zones south of Rock Springs were identified and sampled for gold and other trace metals in 1991 and 1992. Both deposits have some characteristics of epithermal gold deposits and possibly originated from thermal waters with high silica concentrations.

The Quaking Asp Mountain deposit located south of Rock Springs forms an enormous silicified zone covering 20 to 30 square miles and has associated travertine, alunite, kaolinite, free sulfur, and minor banded chert (jasperoid?). This deposit was sampled in 1991 and yielded some weak gold anomalies (Hausel and others, 1992). A similar silicified zone was sampled 15 miles east at Black Butte (see following section on Black Butte) (**Figure 1**). The

Black Butte deposit located east of Rock Springs and south of Point of the Rocks forms a small, one-square-mile, silicified zone. Some kaolinite and minor chert has been recognized at Black Butte. These two structurally-controlled, parallel, silicified zones suggest that other undiscovered zones of silicification may occur in this region.

Quaking Asp (Aspen) Mountain, Sweetwater County

An extensive, structurally-controlled, silicified zone was mapped during the 1991 and 1992 field seasons at Quaking Asp Mountain (also known as Aspen Mountain) 10 miles south of Rock Springs (**Figure 1**). This enigmatic zone exhibits not only a well-defined silicified zone but also kaolinite and alunite alteration with banded cherts and jasperoid, travertine, and free sulfur similar to some disseminated epithermal gold deposits (Hausel and others, 1992). The deposit was sampled for gold and some minor precious metal anomalies were detected during the 1991 field project. During the 1992 field study, additional samples were collected and analyzed for a suite of trace metals including gold.

Quaking Asp Mountain is a northeasterly-trending hill rising 1,700 to 1,800 feet above the surrounding basin. The hill stands as positive relief due to intense and widespread silicification which has made it relatively resistant to erosion. In addition to being silicified over a 20- to 30-square-mile region, several other anomalies have been recognized. These include a zone of alunite discovered by drilling along the southeastern margin of the hill (Love and Blackmon, 1962), travertine on the western edge of the hill (Kirschbaum, 1986), free sulfur (Tom Sharps, Rocky Mountain Energy Company, personal communication to W.D. Hausel), a breccia along the southeastern flank of the hill, kaolinite alteration, gray banded chert and russet banded chert (jasperoid ?) with crosscutting (?) quartz veinlets closely associated with a projected northeasterly-trending fault, an H_2S-spring on the southern flank of the hill (Hausel and others, 1992), and a seismic profile that suggests the presence of a shallow intrusive beneath Quaking Asp Mountain (Ron Cramer, Union Pacific Resources, verbal communication, 1992).

The occurrence of alunite at Quaking Asp Mountain is quite intriguing, in that alunite is commonly associated with epithermal gold deposits (Hausel and others, 1992). The only other alunite deposits reported in Wyoming are found in association with solfatara and hot springs deposits in Yellowstone National Park.

Background

An eight-foot bed of alunite claystone was identified in drill cuttings from an oil and gas exploration hole on the south flank of Aspen Mountain in 1957 by geologist E. R. Keller with

Mountain Fuel Supply Company. This zone was later trenched and investigated by the U.S. Geological Survey (Love and Blackmon, 1962). The claystone was intersected within 30 feet of the surface. About a mile southwest of the trench, a core hole was drilled that penetrated 6 feet of white claystone at 145 feet deep suggesting the alunite may be relatively widespread. About 200 feet southeast of this core hole, a gas well was drilled (NE section 34, T17N, R104W) which cut through 3,704 feet of hard, silicified, Cretaceous sandstone and shale (Love and Blackmon, 1962).

This current study was undertaken as the second year of a reconnaissance project recommended by geologists from Union Pacific Resources and the Wyoming State Geological Survey to determine a source for the silicification and clay alteration on Aspen Mountain. This reconnaissance indicates that Aspen Mountain may represent a paleo-epithermal system. Whether or not this system carries gold was also answered during initial phases of the project. Sixteen samples collected during the 1992 investigation were weakly anomalous in gold (**Table 2**).

Geology

Aspen Mountain is formed of highly silicified Cretaceous shales and sandstones. The hill is capped by highly silicified, fine- to medium-grained sandstone and quartzite of the Rock Springs Formation (Upper Cretaceous), which is underlain by highly silicified, gray silty and sandy shale interbedded with gray siltstone and fine-grained sandstone of the Blair Formation (Upper Cretaceous) (Kirschbaum, 1986).

Locally, both of these formations are unconformably overlain by sandstone facies of the Bishop Conglomerate (?) (Oligocene). The Bishop Conglomerate (?) forms a gray, yellow-green and white, subrounded to well-rounded, fine- to coarse-grained tuffaceous to limy sandstone, yellowish-green mudstone, white, silty to sandy tuff, and tuffaceous conglomerate containing some angular gray siltstone, sandstone, and quartzite rock fragments. Both Kirschbaum (1986) and Love and Blackmon (1962) place the alunite-bearing claystone within the Bishop Conglomerate. The lower part of this unit includes gray silicified sandstone with some secondary chert. The alunite-bearing claystone appears to be stratified (Love and Blackmon, 1962).

The source of the alunite at Aspen Mountain is unknown. But because of the potential for extending the known occurrence of alunite mineralization and the possibility of finding associated gold mineralization, a study of the economic geology of this deposit is considered high priority. For discussion on alunite alteration and genesis, see Hausel and others (1992).

Table 2. Geochemical analyses of samples from the Aspen Mountain area, southwestern Wyoming (n.d. = not detected; tr = trace; dash = not tested). With the exception of the NURE (National Uranium Resource Evaluation) samples, all 1991 samples were analyzed by Gordon Marlatt, and all 1992 samples were analyzed by Bondar-Clegg. See **Plate 2** for sample locations.

Sample Number	Description	Ag (ppm)	As (ppm)	Au (ppm)	Ba (ppm)	Cu (ppm)	Hg (ppm)	Mo (ppm)	Pb (ppm)	Sb (ppm)	W (ppm)	Zn (ppm)
	1992 samples											
AM1-92	Brecciated limestone (travertine).	nd	218	0.015	—	12	0.022	1	14	4.2	—	53
AM2-92	Brecciated limestone (travertine).	nd	85	nd	—	8	0.054	7	12	3.9	—	62
AM3-92	Travertine (?).	0.4	11	nd	—	4	nd	nd	2	nd	—	6
AM4-92	Travertine (?).	0.4	5.5	nd	—	5	nd	nd	4	nd	—	6
AM5-92	Gray banded chert from Chert Hill.	nd	197	nd	—	45	0.168	7	22	12	—	18
AM6-92	Red-yellow-gray banded chert from Chert Hill.	nd	187	nd	—	65	0.106	7	22	16	—	24
AM7-92	Gray carbonate with chert clasts.	nd	6.9	0.009	—	6	0.056	1	49	7.3	—	9
AM8-92	Limonite-stained sandstone with minor gray chert.	nd	708	nd	—	21	0.709	4	51	15	—	51
AM9-92	Light-gray kaolinitic siltstone.	nd	662	nd	—	17	0.601	6	30	18	—	36
AM10-92	Weakly silicified kaolinitic sandstone.	nd	281	nd	—	21	0.034	3	17	8.9	—	123
AM11-92	Limonite-kaolinite-cemented sandstone.	nd	113	nd	—	11	0.026	2	20	2	—	30
AM12-92	Limonite-kaolinite-carbonate-cemented sandstone with minor epidote.	nd	102	nd	—	13	0.092	4	16	4.3	—	9
AM13-92	Carbonate-cemented sandstone.	nd	26	nd	—	5	0.014	9	18	1.7	—	6
AM14-92	Limonite-cemented sandstone breccia.	nd	1,430	nd	—	19	0.023	29	32	3.2	—	690
AM15-92	Carbonate-cemented siltstone with minor chert.	nd	177	nd	—	18	0.416	9	26	5.8	—	10
AM16-92	Chert breccia. Matrix and clasts replaced by silica.	nd	107	nd	—	19	0.351	9	14	2.9	—	5
	1991 samples											
AM1-91	Clay-cemented sandstone from west wall of trench.	—	—	nd	—	—	—	—	—	—	—	—
AM2-91	Alunite-cemented sandstone breccia from trench floor.	—	—	nd	—	—	—	—	—	—	—	—
AM3-91	Limonite-stained, silicified sandstone from trench floor.	—	—	nd	—	—	—	—	—	—	—	—
AM4-91	Alunite(?)-kaolinite-cemented sandstone.	—	—	nd	—	—	—	—	—	—	—	—
AM5-91	Silicified sandstone.	—	—	nd	—	—	—	—	—	—	—	—
AM6-91	Kaolinite-cemented sandstone.	—	—	nd	—	—	—	—	—	—	—	—
AM7-91	Highly silicified sandstone.	—	—	nd	—	—	—	—	—	—	—	—

Table 2 continued.

Sample Number	Description	Ag (ppm)	As (ppm)	Au (ppm)	Ba (ppm)	Cu (ppm)	Hg (ppm)	Mo (ppm)	Pb (ppm)	Sb (ppm)	W (ppm)	Zn (ppm)
AM8-91	Weakly silicified and iron-stained sandstone.	—	—	nd	—	—	—	—	—	—	—	
AM9-91	Highly silicified sandstone.	—	—	nd	—	—	—	—	—	—	—	—
AM10-91	Limonite-hematite-stained banded jasperoid (?) with secondary, cross-cutting quartz veinlets.	—	—	nd	—	—	—	—	—	—	—	—
RS-13	Kaolinized sandstone.	—	—	tr	—	—	—	—	—	—	—	—
RS-14	Hard, silicic sandstone with disseminated limonite after pyrite.	—	—	0.1	—	—	—	—	—	—	—	—
RS-15	Silicified sandstone.	—	—	nd	—	—	—	—	—	—	—	—
RS-16	Silicified sandstone with some limonite after pyrite.	—	—	nd	—	—	—	—	—	—	—	—
RS-17	Silicified, kaolinized sandstone.	—	—	nd	—	—	—	—	—	—	—	—
RS-18	Silicified sandstone.	—	—	0.08	—	—	—	—	—	—	—	—
RS-19	Soil sample.	—	—	nd	—	—	—	—	—	—	—	—
RS-20	Yellow clay from trench.	—	—	nd	—	—	—	—	—	—	—	—
RS-21	White clay.	—	—	nd	—	—	—	—	—	—	—	—
RS-22	Alunitic (?) shale.	—	—	tr	—	—	—	—	—	—	—	—
RS-23	Grey silty sandstone.	—	—	nd	—	—	—	—	—	—	—	—
RS-24	Grey silty sandstone.	—	—	tr	—	—	—	—	—	—	—	—
RS-25	Permeable sandstone with limonite in streaks.	—	—	nd	—	—	—	—	—	—	—	—
RS-26	Permeable sandstone with some kaolinite and limonite.	—	—	nd	—	—	—	—	—	—	—	—
RS-27	Iron-stained sandstone.	—	—	nd	—	—	—	—	—	—	—	—
RS-28	Carbonaceous shale.	—	—	nd	—	—	—	—	—	—	—	—
RS-29	Carbonaceous shale (hydrocarbon-rich).	—	—	nd	—	—	—	—	—	—	—	—
RS-30	Well-sorted sandstone.	—	—	nd	—	—	—	—	—	—	—	—
RS-31	Well-sorted sandstone.	—	—	tr	—	—	—	—	—	—	—	—
RS-32	Shale at base of sandstone.	—	—	nd	—	—	—	—	—	—	—	—
RS-33	Sandstone.	—	—	nd	—	—	—	—	—	—	—	—
RS-34	Sandstone.	—	—	nd	—	—	—	—	—	—	—	—
RS-35	Gypsum-rich sandstone.	—	—	nd	—	—	—	—	—	—	—	—
RS-36	Coal (6" seam).	—	—	nd	—	—	—	—	—	—	—	—
RS-37	Tar sand above coal.	—	—	nd	—	—	—	—	—	—	—	—
RS-38	Coal (top of seam) with about 5% pyrite.	—	—	nd	—	—	—	—	—	—	—	—
RS-39	Coal (middle of seam) with about 2% pyrite.	—	—	0.08	—	—	—	—	—	—	—	—
RS-40	Coal (bottom of seam) with about 8% pyrite.	—	—	nd	—	—	—	—	—	—	—	—
RS-41	Clinker.	—	—	nd	—	—	—	—	—	—	—	—
RS-42	Clinker.	—	—	nd	—	—	—	—	—	—	—	—
RS-43	Thin-bedded sandstone (limonite after pyrite).	—	—	nd	—	—	—	—	—	—	—	—

Table 2 continued.

Sample Number	Description	Ag (ppm)	As (ppm)	Au (ppm)	Ba (ppm)	Cu (ppm)	Hg (ppm)	Mo (ppm)	Pb (ppm)	Sb (ppm)	W (ppm)	Zn (ppm)
RS-44	Extremely hard, silicified sandstone.	—	—	nd	—	—	—	—	—	—	—	—
RS-45	Quartzite.	—	—	nd	—	—	—	—	—	—	—	—
RS-46	Quartzite.	—	—	nd	—	—	—	—	—	—	—	—
RS-47	Partially silicified sandstone with abundant	—	—	tr	—	—	—	—	—	—	—	—
	kaolinite and chert.	—	—									
RS-48	Claystone with bedded chert.	—	—	nd	—	—	—	—	—	—	—	—
RS-49	Sub-silicified sandstone.	—	—	0.115	—	—	—	—	—	—	—	—
RS-50	Sandstone with manganese (?) veins.	—	—	nd	—	—	—	—	—	—	—	—
RS-51	Kaolinitic sandstone.	—	—	nd	—	—	—	—	—	—	—	—
RS-52	Silicified sandstone.	—	—	nd	—	—	—	—	—	—	—	—
RS-53	Clay.	—	—	nd	—	—	—	—	—	—	—	—
RS-54	Soil sample on top of travertine.	—	—	nd	—	—	—	—	—	—	—	—
RS-55	Soil sample on top of travertine (magnetic	—	—	nd	—	—	—	—	—	—	—	—
	deflection of compass needle).	—	—									
RS-56	Soil sample from base of travertine.	—	—	nd	—	—	—	—	—	—	—	—
RS-57	Calcite-cemented breccia.	—	—	0.06	—	—	—	—	—	—	—	—
RS-58	Tuffa (evaporite calcite).	—	—	tr	—	—	—	—	—	—	—	—
RS-59	Soil sample on limestone (?) (travertine?).	—	—	nd	—	—	—	—	—	—	—	—
RS-60	Kaolinite-cemented sandstone.	—	—	tr	—	—	—	—	—	—	—	—
RS-61	Soil sample.	—	—	nd	—	—	—	—	—	—	—	—
RS-62	Hard, silicified sandstone.	—	—	nd	—	—	—	—	—	—	—	—
RS-63	Soil sample.	—	—	nd	—	—	—	—	—	—	—	—
RS-64	Soil sample.	—	—	nd	—	—	—	—	—	—	—	—
RS-65	Soil sample.	—	—	nd	—	—	—	—	—	—	—	—
RS-66	Limonite-stained, silicified sandstone.	—	—	nd	—	—	—	—	—	—	—	—
RS-67	Soil sample.	—	—	nd	—	—	—	—	—	—	—	—
RS-68	Soil Sample.	—	—	nd	—	—	—	—	—	—	—	—
RS-69	Silicified sandstone with minor kaolinite.	—	—	nd	—	—	—	—	—	—	—	—
RS-70	Extremely hard silicified sandstone with kaolinite.	—	—	nd	—	—	—	—	—	—	—	—
RS-71	Silicified sandstone.	—	—	nd	—	—	—	—	—	—	—	—
RS-72	Silicified sandstone.	—	—	nd	—	—	—	—	—	—	—	—
RS-73	Soil sample.	—	—	nd	—	—	—	—	—	—	—	—
RS-74	Stream-sediment sample.	—	—	nd	—	—	—	—	—	—	—	—
RS-75	Stream-sediment sample.	—	—	nd	—	—	—	—	—	—	—	—
RS-76	Stream-sediment sample.	—	—	nd	—	—	—	—	—	—	—	—
RS-77	Stream-sediment sample.	—	—	nd	—	—	—	—	—	—	—	—
RS-78	Stream-sediment sample.	—	—	nd	—	—	—	—	—	—	—	—

Table 2 continued.

Sample Number	Description	Ag (ppm)	As (ppm)	Au (ppm)	Ba (ppm)	Cu (ppm)	Hg (ppm)	Mo (ppm)	Pb (ppm)	Sb (ppm)	W (ppm)	Zn (ppm)
RS-79	Stream-sediment sample from	—	—	nd	—	—	—	—	—	—	—	—
	mouth of H_2S-spring.		—									
RS-80	Stream-sediment sample.	—	—	nd	—	—	—	—	—	—	—	—
RS-81	Stream-sediment sample.	—	—	nd	—	—	—	—	—	—	—	—
RS-82	Stream-sediment sample.	—	—	nd	—	—	—	—	—	—	—	—
RS-83	Stream-sediment sample.	—	—	nd	—	—	—	—	—	—	—	—
RS-84	Stream-sediment sample.	—	—	nd	—	—	—	—	—	—	—	—
RS85	Soil sample.	—	—	nd	—	—	—	—	—	—	—	—
RS-86	Soil sample.	—	—	nd	—	—	—	—	—	—	—	—
RS-87	Silicified sandstone, some kaolinite.	—	—	0.08	—	—	—	—	—	—	—	—
RS-88	Nonsilicified shale.	—	—	nd	—	—	—	—	—	—	—	—
RS-89	Stream-sediment sample.	—	—	tr	—	—	—	—	—	—	—	—
RS-90	Silicified sandstone.	—	—	0.08	—	—	—	—	—	—	—	—
RS-91	Nonsilicified sandstone.	—	—	nd	—	—	—	—	—	—	—	—
RS-92	Calcite-cemented sandstone breccia.	—	—	nd	—	—	—	—	—	—	—	—
RS-93	Calcite-cemented sandstone breccia.	—	—	nd	—	—	—	—	—	—	—	—
RS-94	Subsilicified sandstone.	—	—	tr	—	—	—	—	—	—	—	—
RS-95	Nonsilicified sandstone.	—	—	nd	—	—	—	—	—	—	—	—
RS-96	Nonsilicified sandstone.	—	—	nd	—	—	—	—	—	—	—	—
	Department of Energy samples											
NURE 8519	Stream sediment.	—	—	nd	606	13	—	—	24	—	—	—
NURE 8520	Stream sediment.	—	—	nd	—	13	—	—	8	—	—	90
NURE 8526	Stream sediment.	—	—	—	—	14	—	—	12	—	—	136
NURE 8527	Stream sediment.	—	—	—	—	—	—	—	13	—	—	—
NURE 8532	Stream sediment.	—	—	nd	—	—	—	—	—	—	—	—
NURE 8533	Stream sediment.	—	—	nd	—	—	—	—	—	—	—	—
NURE 8534	Stream sediment.	—	—	nd	—	—	—	—	—	—	—	—
NURE 8535	Stream sediment.	—	—	nd	—	17	—	—	10	—	18	100
NURE 8536	Stream sediment.	—	—	nd	—	—	—	—	—	—	—	—
NURE 8537	Stream sediment.	—	—	nd	—	11	—	—	14	—	23	—
NURE 8538	Stream sediment.	—	—	nd	—	16	—	—	—	—	—	44
NURE 8539	Stream sediment.	—	—	nd	—	20	—	—	46	—	—	115
NURE 8556	Stream sediment.	—	—	nd	—	26	—	—	8	—	—	131
NURE 8555	Stream sediment.	—	—	nd	—	—	—	—	—	—	—	—
NURE 8554	Stream sediment.	—	—	nd	—	—	—	—	13	—	25	90

Hydrothermal alteration in epithermal gold deposits is typically accompanied by sulfides and enrichment in several metals. In the sedimentary-hosted, Carlin-type gold deposits of Nevada for example, the ore zones exhibit metal enrichments of Au (11 ppm), Ag (0.4 ppm), Cu (35 ppm), Zn (185 ppm), Pb (30 ppm), Mo (7 ppm), Sb (130 ppm), Hg (25 ppm), As (480 ppm), Ba (2200 ppm), B (70 ppm), La (30 ppm), W (18 ppm), and Se (2 ppm?) compared to the host rock (Boyle, 1979). The mineralization is also closely associated with near-vertical normal faulting, and carbonaceous carbonates. A general ore-stage alteration zonation pattern recognized at Carlin has dickite and kaolinite near the now-silicified areas. In some deposits, the occurrence of fault-controlled, intensely silicified tabular zones referred to as jasperoids has been recognized as an important characteristic of Carlin-type deposits. A later episode of silicification typically results in crosscutting quartz veins and additional silicification of the jasperoids (Berger and Henley, 1989).

A total of 112 chip samples collected at Quaking Asp Mountain yielded 0.0 to 0.115 ppm Au. Sixteen chip samples collected in 1992 yielded 0.0 to 0.4 ppm Ag, 4.0 to 65.0 ppm (an average of 18 ppm) Cu, 5.0 to 690.0 ppm (an average of 71.0 ppm) Zn, 2.0 to 51.0 ppm (an average of 20.0 ppm) Pb, 0.0 to 29.0 ppm (an average of 6.0 ppm) Mo, 0.0 to 18 ppm (an average of 6.6 ppm) Sb, 0.0 to 0.709 ppm (an average of 0.167 ppm) Hg, and 5.5 to 1,430 ppm (an average of 270.0 ppm) As (**Table 2** and **Plate 2**). These samples show enrichment in silver, copper, zinc, lead, molybdenum, and arsenic that are comparable to the Carlin-type ore zones reported by Boyle (1979). The antimony, mercury, and gold contents of the samples collected at Quaking Asp Mountain are comparatively low. Gold was detected in 18 (or 16 percent) of 110 samples from the Aspen Mountain silicified zone in considerably lower quantities than reported for the Carlin-type ore. However, disseminated gold deposits are very difficult to sample and typically require bulk sampling to identify gold anomalies and ore zones. All samples collected to date have been chip samples.

During sampling of the Aspen Mountain area in 1991, Gordon Marlatt noted a slight magnetic deflection of his compass needle along the western edge of the silicified zone. Consequently, a proton precession ground magnetic survey was conducted across Aspen Mountain (**Figure 6**). The profile was run east of the site observed by Marlatt. No unusual magnetic anomalies were detected.

During field studies, it was noted that the vegetative cover on the Aspen Mountain silicified zone was different from the surrounding nonsilicified areas. The silicified zone covers an area of 20 to 30 square miles and transcends the contacts of the Rock Springs Formation, the Blair Formation, and the Bishop Conglomerate. The silicified zone is covered with grass, but lacks

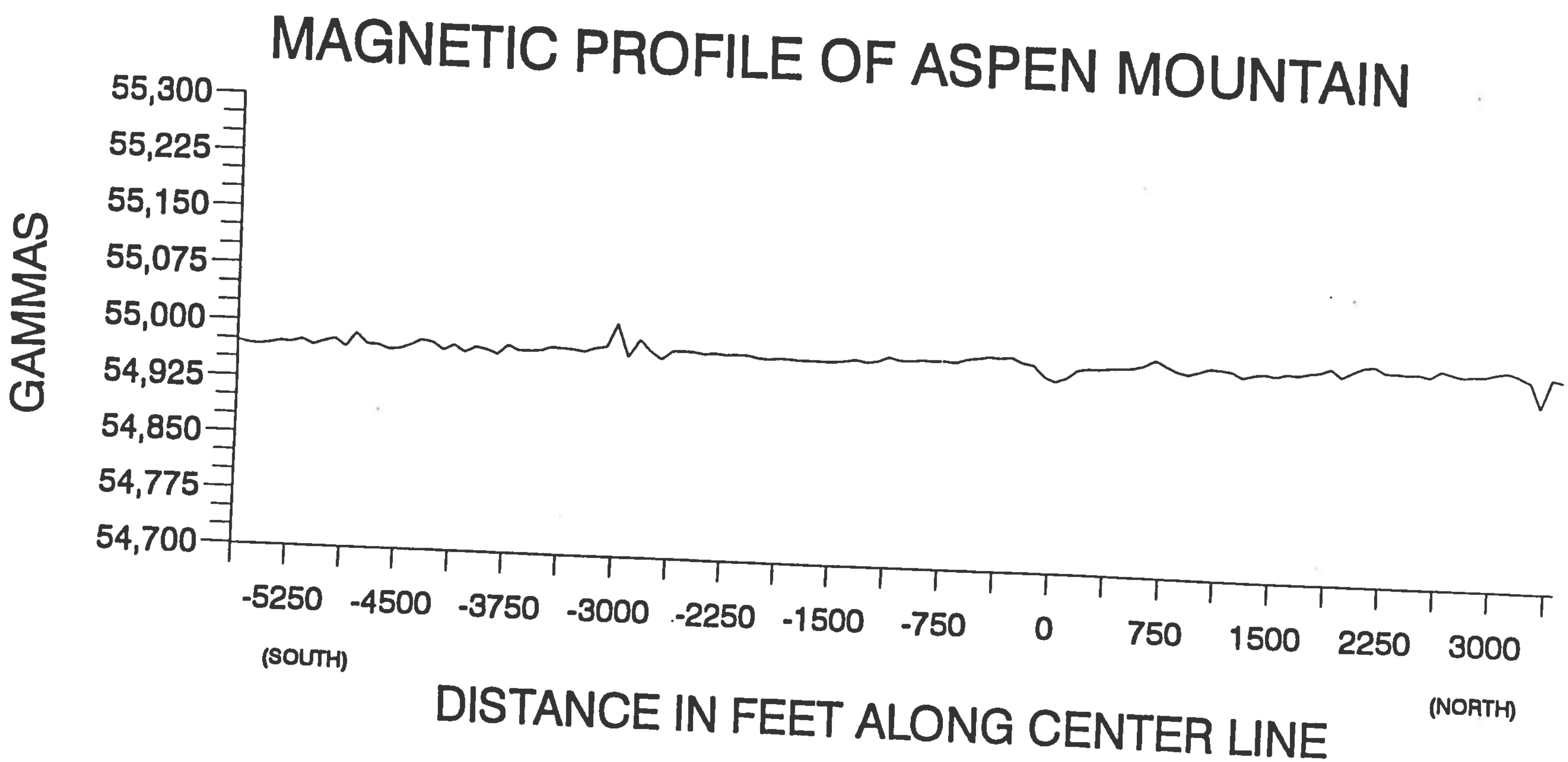

Figure 6. Magnetic profile across Quaking Asp Mountain. See **Plate 2** for location of the profile.

the brush present over the nonsilicified rocks. This vegetative difference was favorable for mapping the extent of alteration with remote sensing imagery.

In many volcanic-hosted epithermal gold deposits, the vent of the epithermal system seems to have been a large fracture or fault, so that the alteration pattern is elongated with strongly silicified rock along a main axis flanked successively by alunitic, argillic, and finally propylitic zones on each side of the siliceous axial zone. A similar zone of alteration was recognized at Aspen Mountain. The elongated zone of silicification appears to be controlled by a northeasterly fault. Sampling is insufficient to determine the extent of other alteration zones, however.

The cap of many epithermal deposits is highly siliceous and may resemble chert or opalite, and if formed at or near the surface, it may be porous like siliceous sinter. Native sulfur commonly is present in pores and cavities. The siliceous zone grades outward to a zone of highly altered rock composed mainly of microcrystalline quartz and alunite. Kaolinite (or its polymorph, dickite) as well as opaline cristobalite, are common in the argillic zone. Pyrite may be found in quartz-alunite rock, particularly at depth. Characteristic minerals of the propylitic zone include epidote, chlorite, zeolites, pyrite, and calcite (Hall and Bauer, 1983).

Black Butte, Sweetwater County

Black Butte was investigated following the recommendation of Dr. J.D. Love of the U.S. Geological Survey. The butte stands out as a prominent mesa south of Interstate 80 and south of Point of the Rocks (**Figure 1**). The mesa is capped by coarse-grained, cross-bedded sandstone of the Canyon Creek zone of the Ericson Sandstone (Upper Cretaceous) (Roehler, 1979). Where exposed at the top of the butte, portions of the Ericson have been silicified, producing resistant quartzite and minor chert similar to Aspen Mountain to the west. An east-northeast trending fault appears to have acted as a conduit for siliceous solutions. The fault was traced on the surface for 15 miles, and the one-square-mile silicified zone was outlined using remote sensing imagery (**Figure 7**).

Locally, the silicification of the sandstone was so intense that it completely replaced the sand grains with microcrystalline chert. Nearby, limonite gossans have developed in what appears to be coal. Some of the coal (?) carries anomalous gold, and in places the coals have apparently been altered to pure carbon, a process requiring considerable heat. Some local kaolinization of the sandstones was also recognized.

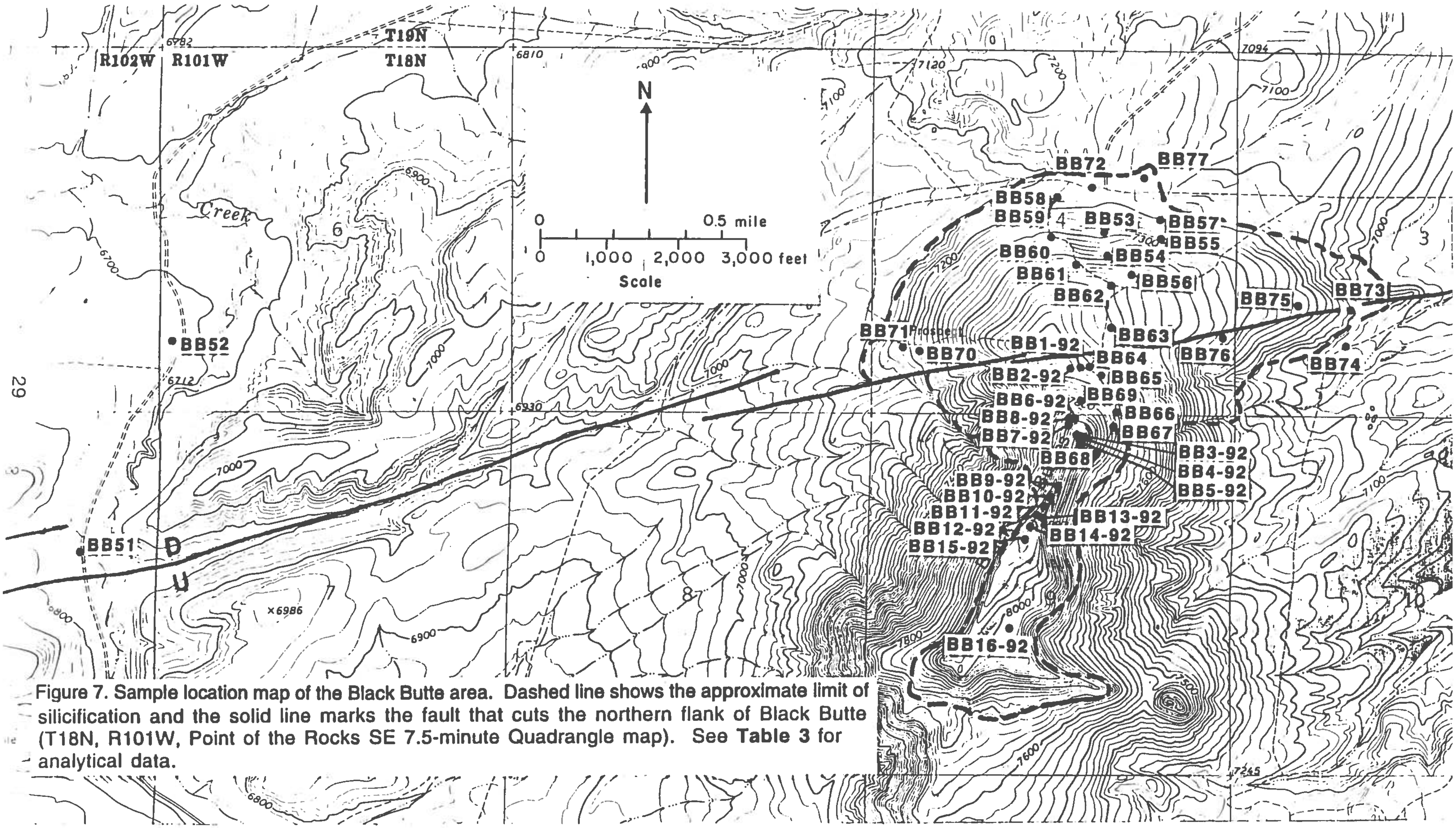

Figure 7. Sample location map of the Black Butte area. Dashed line shows the approximate limit of silicification and the solid line marks the fault that cuts the northern flank of Black Butte (T18N, R101W, Point of the Rocks SE 7.5-minute Quadrangle map). See **Table 3** for analytical data.

Forty-one chip samples were taken along Black Butte to test for gold (**Figure 7**). Additionally, Sample BB7-92 of white clay was collected for X-ray diffraction (XRD) analyses. The x-ray pattern was typical of kaolinite.

Of the 41 samples collected for gold analyses (**Table 3**), seven yielded trace gold. The highest value was only 40 ppb Au (Sample BB59). Fourteen of the samples were also analyzed for other trace metals. Two samples (BB6-92 and BB11-92) yielded weak arsenic anomalies of 220 ppm and 170 ppm, respectively. One sample (BB8-92) produced a weak mercury anomaly (0.279 ppm). The results suggest that a paleo-thermal spring was responsible for the silicification at Black Butte. This deposit, like Quaking Asp Mountain, should be bulk sampled for gold.

Cockscomb copper deposit, Lincoln County

The Cockscomb copper deposit in Lincoln County of western Wyoming was examined during this study because of the similarity to the Lake Alice red bed copper deposits to the north near Cokeville. The Cockscomb deposit lies in Watercress Canyon on Rock Creek Ridge about 15 miles west-northwest of Kemmerer (**Figure 1**). The deposit was described by Veatch (1907) as occurring in an overturned anticline in red beds of the Beckwith Formation. According to later work and mapping by Rubey and others (1975), the Cockscomb is located in the SE NW section 4, T22N, R118W, and hosted by quartzite in the Permian-Pennsylvanian Wells Formation which is 20 to 30 feet stratigraphically below the Grandeur Member of the Park City Formation.

The Cockscomb deposit crops out near the top of the ridge on the north flank of Watercress Canyon and was traced over a distance of about 1,000 feet. Samples collected by Rubey and others (1975) from the mineralized zone yielded from 0.1 percent to 7.5 percent Cu, 0.6 to 2.7 ppm Ag, <0.02 to 0.03 ppm Au, 30 to 700 ppm Pb, 70 to 360 ppm Zn, 200 to 700 ppm As, 30 to 50 ppm Mn, 8 to 150 ppm Mo, 10 to 20 ppm V, and 5 to 50 ppm Ni. Samples collected in 1992 included cupriferous sandstone, quartzite, limestone, and limestone breccia (**Table 4**). These samples yielded anomalous copper (0.02 to 3.35 percent), zinc (0.01 to 1.38 percent), silver (0.24 to 15.1 ppm), and lead (12 ppm to 0.12 percent). One sample (Sample WC7-92) produced a gold anomaly of 300 ppb (0.3 ppm). The samples were collected from outcrop, within prospect pits, and in two short adits over a distance of about 1,000 feet (**Figure 8**).

Similar red bed copper-silver-zinc deposits have been reported elsewhere in the Overthrust Belt. These occur primarily in the Nugget Sandstone and the Twin Creek Limestone (Love and Antweiler, 1973; Hausel and Harris, 1983). The potential widespread occurrence of such

Table 3. Geochemical analyses of rocks from the Black Butte silicified zone, Sweetwater County, Wyoming (nd=not detected, tr=trace, dashed=not analyzed, ppb=parts per billion, ppm=parts per million). Analyses by Bondar-Clegg and Gordon Marlatt.

Sample Number	Description	Ag (ppm)	As (ppm)	Au (ppb)	Cu (ppm)	Hg (ppm)	Mo (ppm)	Pb (ppm)	Sb (ppm)	Zn (ppm)
BB1-92	Quartzite with chert from prospect pit.	<0.2	12	<5	5	<0.010	4	5	0.5	4
BB2-92	Banded chert with disseminated limonite.	<0.2	24	<5	6	<0.010	43	7	1	3
BB3-92	Quartzite with jasper fragments.	<0.2	16	<5	4	<0.010	6	9	0.6	3
BB4-92	Nonsilicified sandstone w/ green chrome mica(?).	<0.2	14	<5	3	<0.010	5	6	0.3	4
BB5-92	Quartzite.	<0.2	5.7	<5	6	<0.010	4	4	0.4	2
BB6-92	Quartzite with minor limonite.	<0.2	220	12	16	0.016	52	14	6.2	6
BB8-92	Quartzite.	<0.2	69	6	11	0.279	23	5	13	3
BB9-92	Iron-stained quartzite.	<0.2	34	<5	5	0.011	8	8	1	6
BB10-92	Hard, cross-bedded quartzite.	<0.2	26	<5	5	0.017	2	11	1	14
BB11-92	Quartzite with small pebbles & minor limonite pits.	<0.2	170	13	8	0.047	24	87	11	3
BB12-92	Quartzite.	<0.2	6.7	<5	3	<0.010	2	7	0.3	<1
BB13-92	Quartzite breccia with clasts of friable sandstone.	<0.2	24	<5	4	0.021	11	8	1.5	3
BB14-92	Quartzite.	<0.2	2.7	<5	2	<0.010	<1	4	<0.2	3
BB15-92	Quartzite.	<0.2	42	<5	5	0.017	7	8	0.5	8
BB-51	Quartzite.	nd	—	nd	—	—	—	—	—	—
BB-52	Quartzite float.	nd	—	nd	—	—	—	—	—	—
BB-53	Quartzite.	nd	—	nd	—	—	—	—	—	—
BB-54	Limonite-stained sandstone.	nd	—	nd	—	—	—	—	—	—
BB-55	Sandstone with minor kaolinite.	nd	—	nd	—	—	—	—	—	—
BB-56	Silicified sandstone with minor iron stains.	nd	—	nd	—	—	—	—	—	—
BB-57	Banded grey chert.	nd	—	tr	—	—	—	—	—	—
BB-58	Vuggy gossan after coal (?).	nd	—	nd	—	—	—	—	—	—
BB-59	Gossan.	nd	—	tr	—	—	—	—	—	—
BB-60	Cherty quartzite.	nd	—	40	—	—	—	—	—	—
BB-61	Iron-stained cherty quartzite.	nd	—	nd	—	—	—	—	—	—
BB-62	Orange friable sandstone.	nd	—	nd	—	—	—	—	—	—
BB-63	Orange friable sandstone.	nd	—	nd	—	—	—	—	—	—
BB-64	Orange friable sandstone.	nd	—	nd	—	—	—	—	—	—
BB-65	Black carbonaceous sandstone.	nd	—	nd	—	—	—	—	—	—
BB-66	Iron-stained sandstone.	nd	—	nd	—	—	—	—	—	—
BB-67	White, kaolinitic sandstone.	nd	—	nd	—	—	—	—	—	—
BB-68	Banded quartzite.	nd	—	nd	—	—	—	—	—	—
BB-69	Kaolinitic, carbonaceous shale.	nd	—	nd	—	—	—	—	—	—
BB-70	Altered coal.	nd	—	nd	—	—	—	—	—	—
BB-71	Partially silcified sandstone.	nd	—	nd	—	—	—	—	—	—
BB-72	Weathered coal.	nd	—	6	—	—	—	—	—	—
BB-73	Grey-brown quartzite with limonite pits.	nd	—	nd	—	—	—	—	—	—
BB-74	Cherty quartzite.	nd	—	nd	—	—	—	—	—	—
BB-75	Quartzite with minor iron stains.	nd	—	nd	—	—	—	—	—	—
BB-76	Quartzite.	nd	—	nd	—	—	—	—	—	—
BB-77	Quartzite.	nd	—	nd	—	—	—	—	—	—

Table 4. Geochemical analyses of gossaniferous lim ne, quartzite, and sandstone from the Cockscomb copper deposit, Watercress Canyon, Lincoln County, Wyoming (ppb=parts per billion, ppm parts per million, %=weight percent, nd=not detected, dashed=not analyzed). Analyses by Bondar-Clegg. See **Figure 8** for sample locations.

Sample Number	Description	Ag (ppm)	(ppb)	Co (ppm)	Cu (%)	Ga (ppm)	Pb (ppm)	V (ppm)	Zn (%)
WC1-92	Limonite-stained limestone.	0.24	nd	—	0.12	—	19	—	0.03
WC2-92	Cupriferous sandy limestone.	2.9	<5	—	3.35	—	12	51	0.32
WC4-92	Gossaniferous limy sandstone.	7.3	<5	3	3.02	52	115	—	0.09
WC5-92	Limonite-stained sandy limestone breccia.	10.9	<5	10	0.02	17	1213	—	0. 20
WC6-92	Brecciated limestone with malachite stains.	15.1	<5	11	1.84	36	807	—	1.38
WC7-92	Malachite-limonite-stained limestone.	1.57	300	—	0.61	—	163	—	0.05
WC8-92	Malachite-stained silicified limestone.	0.9	5	4	0.79	—	53	—	0.01
WC10-92	Limonite-malachite-stained quartzite.	1.17	nd	—	1.91	—	77	—	0.13
WC11-92	Limonite-stained quartzite breccia.	0.24	nd	—	0.10	—	42	—	0.03

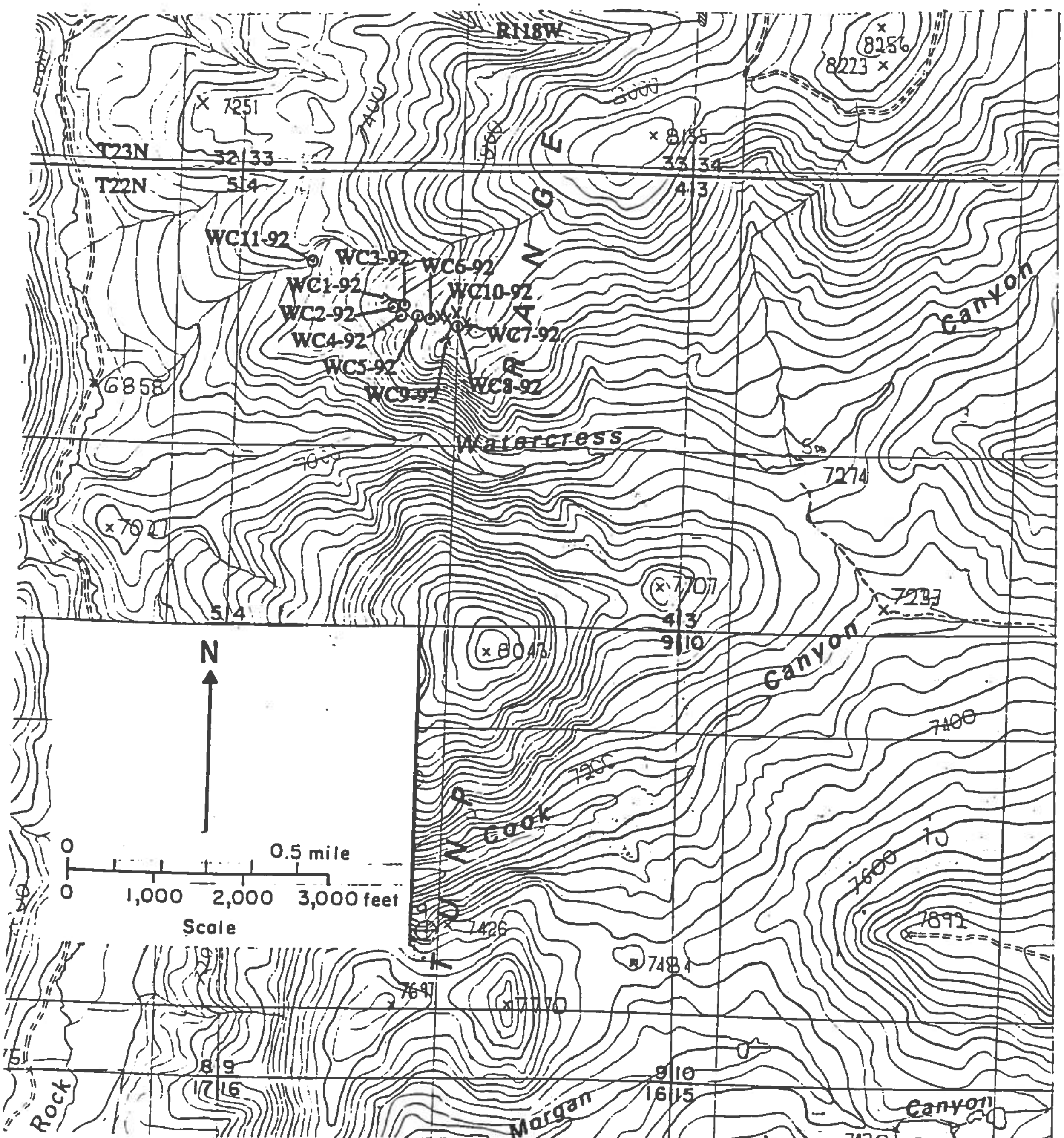

Figure 8. Sample location map of the Cockscomb copper-zinc-silver deposit (The Rock Slide 7.5-minute Quadrangle map). See **Table 4** for analytical data.

deposits suggests that further exploration of red bed mineralization is warranted in western Wyoming.

Black cherts of Delaney Rim, Sweetwater County

During 1991, a gold anomaly was outlined along Delaney Rim southwest of Wamsutter following reports by Dean Farris of Laramie (personal communication to Hausel, 1991) that gold was associated with fossiliferous limestones of the Tipton Shale Member of the Green River Formation. The reconnaissance study identified weak gold anomalies over a relatively widespread area on the north and northwest flanks of the Washakie Basin (Hausel and others, 1992).

Delaney Rim is capped by a basinward-dipping black chert that carries low levels of gold. The chert typically replaces *Goniobasis* "*Turritella*" gastropod fossils and oolitic limestones that have attracted much lapidary interest. The limestones are relatively thin, typically only one to two feet in thickness, but are widespread, covering a large area of the Washakie Basin north of Barrel Springs Draw (**Figure 9**). The limestones are underlain and overlain by oil shale beds also in the Tipton.

Three separate limestone beds at Delaney Rim are locally replaced by silica. The uppermost unit consists of *Goniobasis* chert (deeper-water facies). The middle unit is mostly silicified algal heads (offshore facies), while the lower unit is primarily oolitic limestone (shore facies). These limestones occur within a section about 150 to 200 feet thick. Most of the cherts contain hydrocarbons, necessitating roasting of the samples prior to analysis. The hydrocarbons impart a brown color to the cherts, although some cherts are black. The black is due to the presence of finely divided magnetite inclusions.

The results of sampling identified two anomalous regions along Delaney Rim. One area was on the eastern flank of Delaney Rim southwest of Wamsutter, and another area was along the western margin of the rim southwest of the Tipton railroad siding. The anomaly along the eastern flank of Delaney Rim covers a widespread area of about 50 square miles. Of 65 samples collected in the eastern region, trace to anomalous gold or silver was detected in 20 samples. The gold values ranged from trace gold to 0.100 ppm Au (**Table 5**).

Samples collected farther to the west along the northwestern flank of Delaney Rim south and southwest of Tipton also produced gold anomalies. These were collected over a distance of about 9 miles along the rim west from Tipton. The samples yielded weak gold anomalies

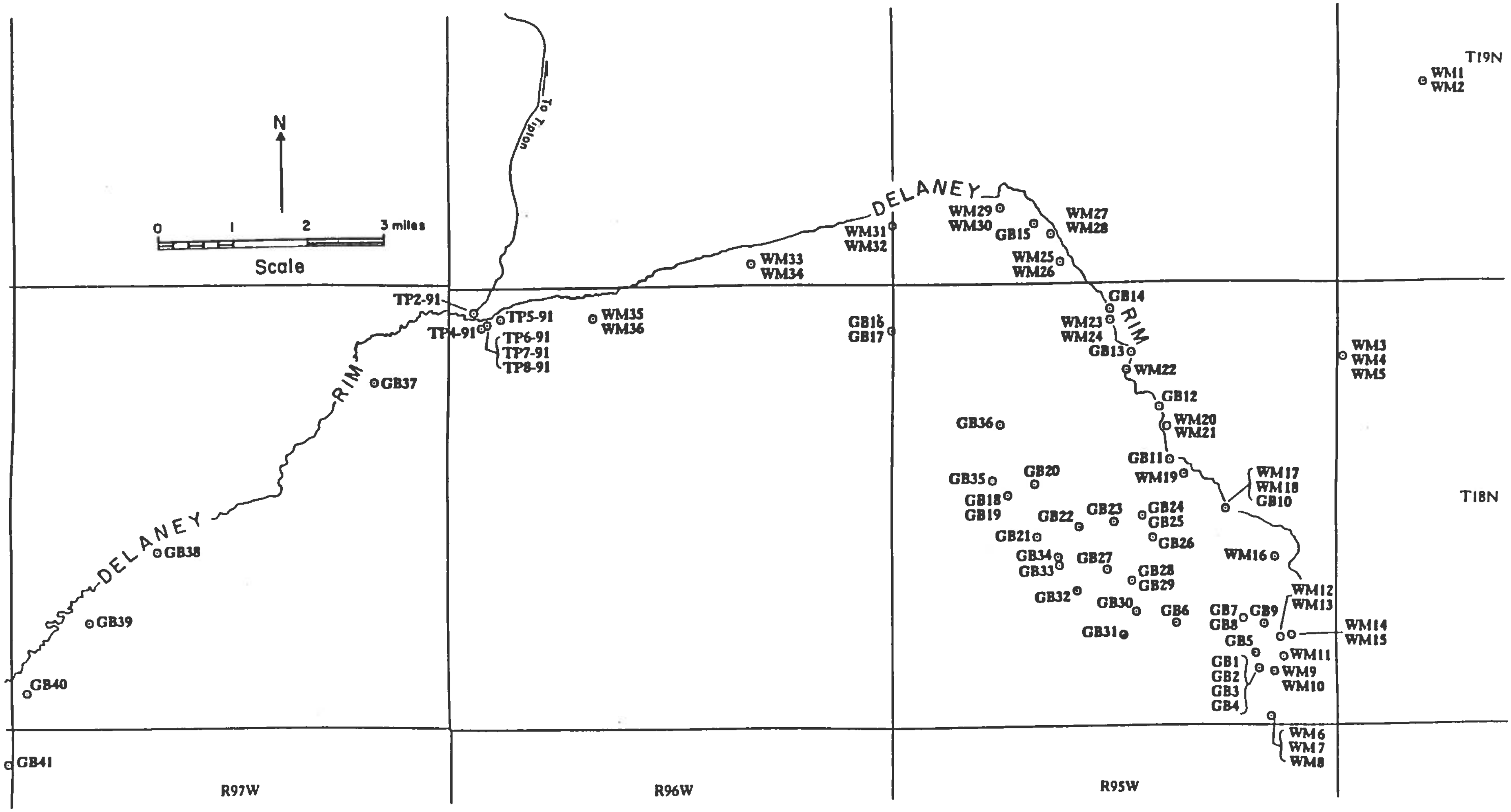

Figure 9. Sample sites along Delaney Rim (1:100,000-scale metric topographic maps of the Red Desert Basin and Kinney Rim 30" x 60" Quadrangles). Samples with prefix TP and WM were collected in 1991 and described by Hausel and others, 1992. Samples with the prefix GB were collected in 1992 and described in **Table 5**.

Table 5. Gold and silver analyses of black chert deposits of the Delaney Rim near Wamsutter, Sweetwater County, Wyoming (nd=not detected, tr=trace, dash=not analyzed, ppb=parts per billion, ppm=parts per million). Includes sample groups from 1992 (GB prefix) and from1991(WM and TP prefix). Sample locations shown on **Figure 9**. Analyses by Gordon Marlatt.

Sample Number	Description	Ag (ppm)	Au (ppb)
	Eastern Area		
GB1	Chert.	nd	nd
GB2	*Goniobasis*-limestone.	nd	nd
GB3	Cherty-limestone with *Goniobasis* layer.	nd	nd
GB4	Chert, entirely replaced by black silica.	nd	nd
GB5	Fossiliferous limestone replaced by chert.	nd	nd
GB6	Chert.	nd	nd
GB7	Chert replacing limestone.	nd	nd
GB8	Chert.	nd	nd
GB9	Siltstone, silicification on partings.	nd	nd
GB10	Chert, replacing interbedded coral and oolites.	nd	nd
GB11	Chert, replacing oolitic limestone.	nd	nd
GB12	Chert.	nd	nd
GB13	Chert, replacing coral and oolites.	nd	50
GB14	Chert, replacing oolitic limestone.	nd	tr
GB15	Chert, massive silicification.	1.3	nd
GB16	Partially silicified shale, some jasper.	1.3	nd
GB17	Shale.	tr	nd
GB18	Chert.	nd	nd
GB19	Chert.	nd	nd
GB20	Chert float.	nd	nd
GB21	Chert.	nd	nd
GB22	Chert along fault trace.	nd	40
GB23	Chert, non-fossiliferous.	nd	60
GB24	Chert.	nd	nd
GB25	Chert, fossiliferous.	—	nd
GB26	Chert, non-fossiliferous.	—	nd
GB27	Sandstone, silicified.	—	40
GB28	Sandstone, silcified, hydrocarbon-bearing.	—	50
GB29	Sandstone, silicified.	—	tr
GB30	*Goniobasis*, cherty limestone.	—	nd
GB31	*Goniobasis* chert.	—	50
GB32	Silicified tuffa.	—	nd
GB33	Non-fossiliferous chert.	—	80
GB34	Oolitic limestone replaced by chert.	—	50
GB35	Bedded sandstone.	—	tr
GB36	Chert replacing coral-bearing limestone.	—	nd
WM6	Grey-green sandstone.	—	80
WM7	*Goniobasis* chert float.	—	tr
WM8	Fossiliferous claystone.	—	nd
WM9	Brown, silicified sandstone.	—	nd
WM10	*Goniobasis* chert float.	—	tr
WM11	*Goniobasis* chert.	—	nd
WM12	Black, *Goniobasis* chert float.	—	100
WM13	Soil sample.	—	nd
WM14	Tuffaceous claystone.	—	nd
WM15	Black *Goniobasis* chert.	—	nd

Table 5 continued.

Sample Number	Description	Ag (ppm)	Au (ppb)
	Eastern Area		
WM16	Olive-green siltstone.	—	nd
WM17	*Goniobasis* chert.	—	nd
WM18	Soil sample.	—	nd
WM19	*Goniobasis* and stromatolitic chert.	—	nd
WM20	Hard, silicified, oolitic chert.	—	nd
WM21	Soil sample.	—	nd
WM22	Fossiliferous chert.	—	nd
WM23	Fossiliferous chert.	—	nd
WM24	Soil sample.	—	nd
WM25	Brown chert.	—	tr
WM26	Soil sample at WM25.	—	nd
WM27	Oolitic limestone.	—	nd
WM28	Oolitic limestone.	—	60
WM29	Black chert replacing oolitic limestone.	—	nd
WM30	Soil sample at WM29.	—	nd
WM31	Fossiliferous chert.	—	nd
WM32	Soil sample at WM31.	—	nd
WM33	Black, fossiliferous chert.	—	nd
WM34	Soil sample at WM33.	—	nd
	Western Area		
GB37	Chert replacing *Goniobasis* limestone.	nd	tr
GB38	Chert replacing oolitic limestone.	nd	tr
GB39	Chert replacing oolitic limestone.	nd	tr
GB40	Chert replacing oolitic limestone.	nd	90
GB41	Chert replacing oolitic limestone.	nd	tr
WM35	Brown, glassy fossiliferous chert.	—	nd
WM36	Soil sample at WM35.	—	nd
TP2-91	*Goniobasis* limestone.	—	nd
TP4-91	*Goniobasis* limestone.	—	nd
TP5-91	*Goniobasis* limestone.	—	180
TP6-91	*Goniobasis* limestone.	—	nd
TP7-91	*Goniobasis* limestone.	—	nd
TP8-91	*Goniobasis* limestone.	—	nd
	Other areas		
WM1	Stromatolitic limestone.	—	nd
WM2	Limestone.	—	70
WM3	*Goniobasis* chert.	—	100
WM4	Conglomeratic sandstone.	—	100
WM5	Olive-green sandstone.	—	70

that ranged from a trace to 0.180 ppm Au (Samples GB37-GB41, and Sample TP5-91, **Table 5**).

About a mile and a half south of the northern edge of Delaney Rim, jasper was found replacing oil shale at Sample Sites GB16 and GB17 (**Figure 9**). Because outcrops of this silicified shale are limited, no estimate of the extent of replacement could be made. Neither of these samples yielded gold values; however, a trace and 1.3 ppm of silver, respectively, were detected. Silver (1.3 ppm) was also detected in one other sample (GB15) two miles to the northeast.

Five Buttes, Ketchum Buttes, and Savery Creek prospects, Carbon County

Five Buttes, Ketchum Buttes, and Savery Creek prospect areas are located about 15 to 18 miles northeast of Baggs, Wyoming, in Carbon County (**Figure 1**). All three areas lie along fracture systems that appear to converge on Battle Mountain 16 miles to the south (**Figure 10**). Battle Mountain is a butte formed of Tertiary basalt near the Colorado-Wyoming border.

These prospects were all explored for uranium in the 1950s. According to Osterwald and others (1966), uranophane was found in the lower part of the North Park Formation (?) of Miocene age at Ketchum Buttes. The uranophane occurred as disseminated grains in sandstone. A grab sample of radioactive sandstone was reported by Osterwald and others (1966) to have assayed 0.031 percent U_3O_8. A channel sample taken in limonite-stained claystone near the top of the westernmost butte reportedly assayed 0.32 percent U_3O_8.

Reconnaissance of these buttes by Gordon Marlatt suggested that they may represent post-Miocene paleo-hot springs. The surface formations are sandstones, siltstones, and limestones of the Miocene Browns Park Formation which are underlain with angular unconformity by Cretaceous sandstones.

The buttes are expressed at the surface as long, linear, ridges. Ketchum Buttes and the surrounding buttes are topped by travertine (?). The easternmost butte at Ketchum Buttes contains silica bands in the form of red jasper that partially replaces sandstone and limestone. An old, abandoned excavation for uranium shows stockwork-like breccia in the sedimentary rocks.

A similar situation occurs about five miles east of Ketchum Buttes at the Savery Creek prospect, although the rocks here are much higher in silica and limonite and contain layers of

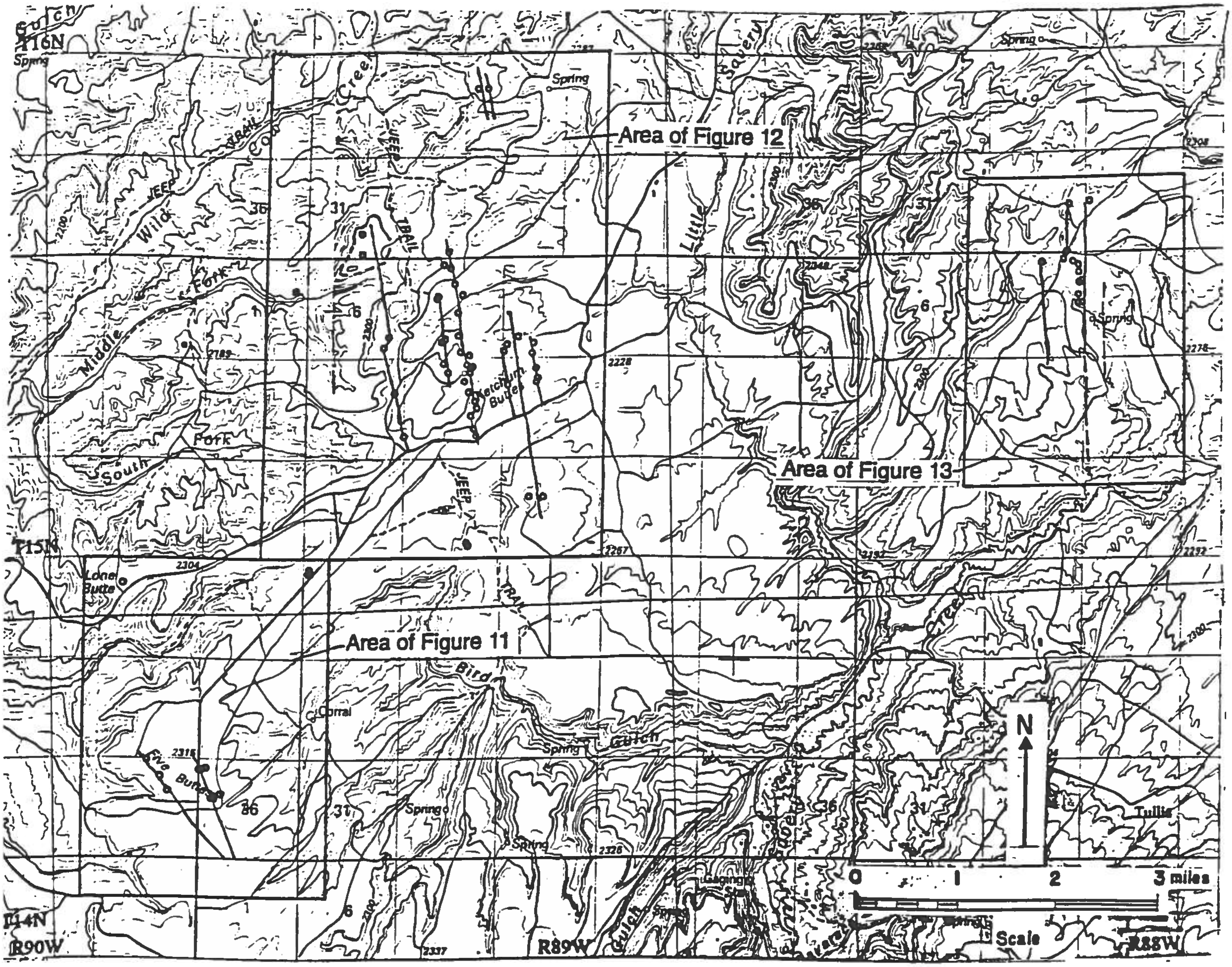

Figure 10. Sample location sites, locations of detailed maps, and projected fracture systems of Five Buttes, Ketchum Buttes, and the Savery Creek prospects, Carbon County, Wyoming (1:100,000-scale metric topographic map of the Baggs 30" x 60" Quadrangle. These fracture systems projects southward to the Battle Mountain volcanic center.

completely silicified limestone. Some limonite at this locality appears to be crystallized after pyrite.

Samples collected from Five Buttes (Samples FB1-92 to FB5-92 and KB1 to KB7) show a few minor geochemical anomalies (**Figure 11** and **Table 6**). Samples of calcite-cemented sandstone (Samples KB1 and KB2) yielded 60 ppb and a trace of gold, respectively. Sample FB3-92, also a calcite-cemented sandstone, yielded a weak mercury anomaly of 0.526 ppm.

Samples collected from Ketchum Buttes (Samples KB1-92 to KB4-92, and KB11 to KB61, **Figure 12**) northeast of Five Buttes show a few minor scattered gold anomalies ranging from a trace to 70 ppb (**Table 6**). Four weakly radioactive samples (KB1-92 to KB4-92) yielded weak molybdenum (150 ppm to 2,286 ppm) and arsenic (86 ppm to 565 ppm) anomalies. Sample KB2-92 was also weakly anomalous in mercury (0.226 ppm). None of these four samples contained any significant precious metal anomalies. A small silicified zone was mapped at the northern extent of the westernmost fracture zone. Samples KB39 and KB40 collected from this zone were unmineralized.

At the Savery Creek prospect, samples were also collected along north-south trending fractures (**Figure 13**). This area yielded a small concentration of samples with weak gold anomalies (Samples KB62 to KB75). Gold values ranged from not detected to 60 ppb (**Table 6**).

All of the samples collected from the three areas in this region were chip samples. Bulk samples were not collected.

Kemmerer coal mining district

The Kemmerer coal mining district of the Hams Fork Coal Field is centered on the town of Kemmerer in Lincoln County of western Wyoming (**Figure 1**). Gold anomalies were reported by the U.S. Geological Survey (1968) in the Kemmerer district. According to that study, maximum values of 1 ppm were detected. As a follow-up to the U.S. Geological Survey study, a total of 91 samples were collected from the Kemmerer district in an attempt to reproduce the earlier results reported by the U.S. Geological Survey, and to determine if the metal was widespread or localized. The samples collected during this study were mostly coal; however, a few samples of clinker, sandstone, or shale closely associated with coal were also collected. The highest gold value detected from the 91 samples during this project was only 90 ppb Au, an order of magnitude lower than reported by the U.S. Geological Survey (1968).

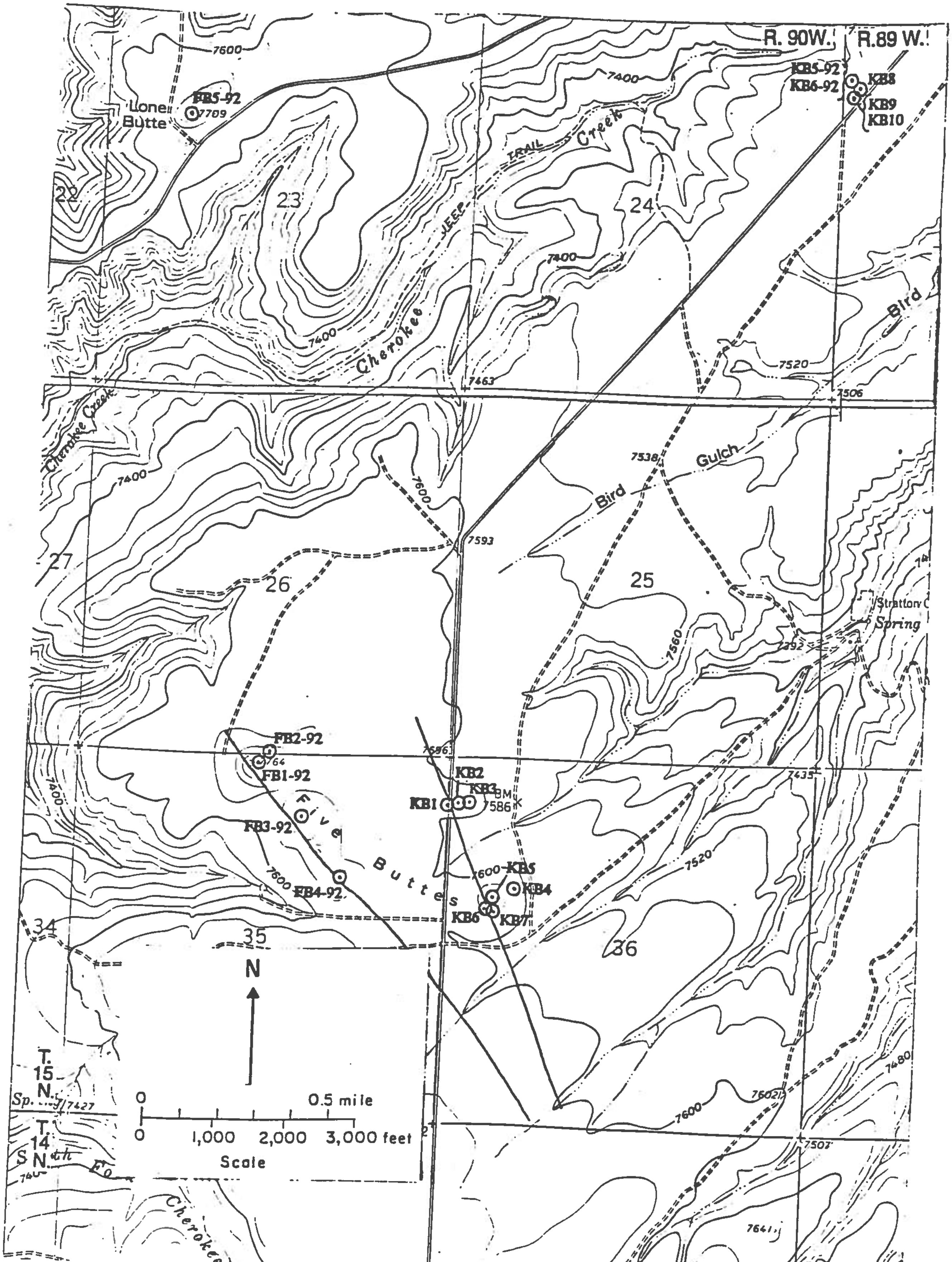

Figure 11. Sample locality map for the Five Buttes area (Ketchum Buttes and Browns Hill 7.5- minute Quadrangle maps). See **Table 6** for analytical data.

Table 6. Geochemical analyses of samples from Five Buttes, Ketchum Buttes, and the Savery Creek prospects (nd=not detected, tr=trace, dash=not analyzed, ppb=parts per billion, ppm=parts per million). Refer to **Figures 10, 11, 12,** and **13** for sample locations. Analyses by Bondar-Clegg and Gordon Marlatt.

Sample Number	Description	Ag (ppm)	As (ppm)	Au (ppb)	Ba (ppm)	Cu (ppm)	Hg (ppm)	Mo (ppm)	Pb (ppm)	Sb (ppm)	U (ppm)	V (ppm)	Zn (ppm)
	Five Buttes												
FB1-92	Limonite-stained sandstone.	<0.2	25	<5	—	4	0.012	37	5	<0.2	—	—	41
FB2-92	Iron-stained limestone w/ limonite veinlets.	<0.2	176	<5	—	8	<0.010	195	7	<0.2	—	—	43
FB3-92	Iron-rich, calcite-cemented sandstone.	<0.2	180	<5	—	6	0.526	305	4	<0.2	—	—	54
FB4-92	Iron-rich limestone.	<0.2	25	<5	—	9	<0.010	20	7	<0.2	—	—	27
FB5-92	Calcite-limonite-cemented sandstone.	<0.2	44	<5	—	3	<0.010	32	4	1.3	—	—	19
KB1	Calcite-cemented sandstone.	nd	—	60	—	—	—	—	—	—	—	—	—
KB2	Iron-calcite-cemented sandstone.	nd	—	tr	—	—	—	—	—	—	—	—	—
KB3	Calcite-cemented sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB4	Calcite-cemented sandstone w/ Fe-Mn-stains.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB5	Thin bedded limestone, minor silicification.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB6	Limestone breccia.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB7	Limestone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB5-92	Massive calcite cemented sandstone.	<0.2	2.9	<5	—	3	<0.010	3	5	0.4	—	—	16
KB6-92	Soft, unconsolidated, fracture-filling dirt.	<0.2	6.4	<5	—	5	0.025	2	8	0.9	—	—	30
KB8	Calcite-cemented sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB9	Friable sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB10	Friable sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
	Ketchum Buttes												
KB1-92	Weakly radioactive travertine (?).	<0.2	565	<5	80	3	0.053	2286	4	<0.2	134	12	10
KB2-92	Weakly radioactive limestone.	<0.2	259	<5	—	50	0.226	182	10	2.1	1440	124	151
KB3-92	Limonite-stained radioactive limestone.	0.6	433	<5	—	3	0.032	1040	6	<0.2	75	22	14
KB4-92	Weakly radioactive sinter.	<0.2	86	<5	—	6	<0.010	150	2	<0.2	29.2	33	32
KB11	Calcite-cemented sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB12	Calcite-cemented sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB13	Calcite-cemented sandstone.	nd	—	50	—	—	—	—	—	—	—	—	—
KB14	Calcite-cemented sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB15	Calcite-cemented sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB16	Calcite-cemented sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB17	Calcite-cemented sandstone-siltstone.	nd	—	nd	—	—	—	—	—	—	—	—	—

Table 6 continued.

Sample Number	Description	Ag (ppm)	As (ppm)	Au (ppb)	Ba (ppm)	Cu (ppm)	Hg (ppm)	Mo (ppm)	Pb (ppm)	Sb (ppm)	U (ppm)	V (ppm)	Zn (ppm)
	Ketchum Buttes												
KB18	Iron-stained calcite-cemented sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB19	Iron-stained calcite-cemented sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB20	Iron-stained calcite-cemented sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB21	Clay.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB22	Sandstone.	tr	—	tr	—	—	—	—	—	—	—	—	—
KB23	Sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB24	Sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB25	Black, banded chert.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB26	Quartz vein (?), minor pyrite.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB27	Sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB28	Sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB29	Sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB30	Sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB31	Sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB32	Sandstone interbedded with limestone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB33	Sandstone interbedded with limestone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB34	Sandstone interbedded with limestone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB35	Sandstone interbedded with limestone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB36	Sandstone interbedded with limestone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB37	Sandstone interbedded with limestone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB38	Sandstone.	nd	—	tr	—	—	—	—	—	—	—	—	—
KB39	Chert.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB40	Quartzite.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB41	Friable sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB42	Friable sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB43	Friable sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB44	Friable sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB45	Calcite-cemented sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB46	Calcite-cemented sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB47	Calcite-cemented sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB48	Hard sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB49	Hard sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB50	Hard sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—

Table 6 continued.

Sample Number	Description	Ag (ppm)	As (ppm)	Au (ppb)	Ba (ppm)	Cu (ppm)	Hg (ppm)	Mo (ppm)	Pb (ppm)	Sb (ppm)	U (ppm)	V (ppm)	Zn (ppm)
	Ketchum Buttes												
KB51	Gossaniferous material.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB52	Hard sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB53	Hard sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB54	Hard sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB55	Green, hard sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB56	Gossan.	nd	—	70	—	—	—	—	—	—	—	—	—
KB57	Russet chert.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB58	Sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB59	Sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB60	Sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB61	Sandstone.	2.5	—	50	—	—	—	—	—	—	—	—	—
	Savery Creek												
KB62	Partially silicified travertine.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB63	Sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB64	Sandstone.	nd	—	tr	—	—	—	—	—	—	—	—	—
KB65	Sandstone-siliceous sinter.	nd	—	40	—	—	—	—	—	—	—	—	—
KB66	Sandstone-siliceous sinter.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB67	Sandstone.	nd	—	50	—	—	—	—	—	—	—	—	—
KB68	Iron-stained sandstone.	nd	—	tr	—	—	—	—	—	—	—	—	—
KB69	Sandstone with boxworks.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB70	Friable sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB71	Limestone w/ chert replacements & veins.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB72	Calcite-cemented sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB73	Silcified limestone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB74	Sandstone.	nd	—	nd	—	—	—	—	—	—	—	—	—
KB75	Earthy limonite.	nd	—	60	—	—	—	—	—	—	—	—	—

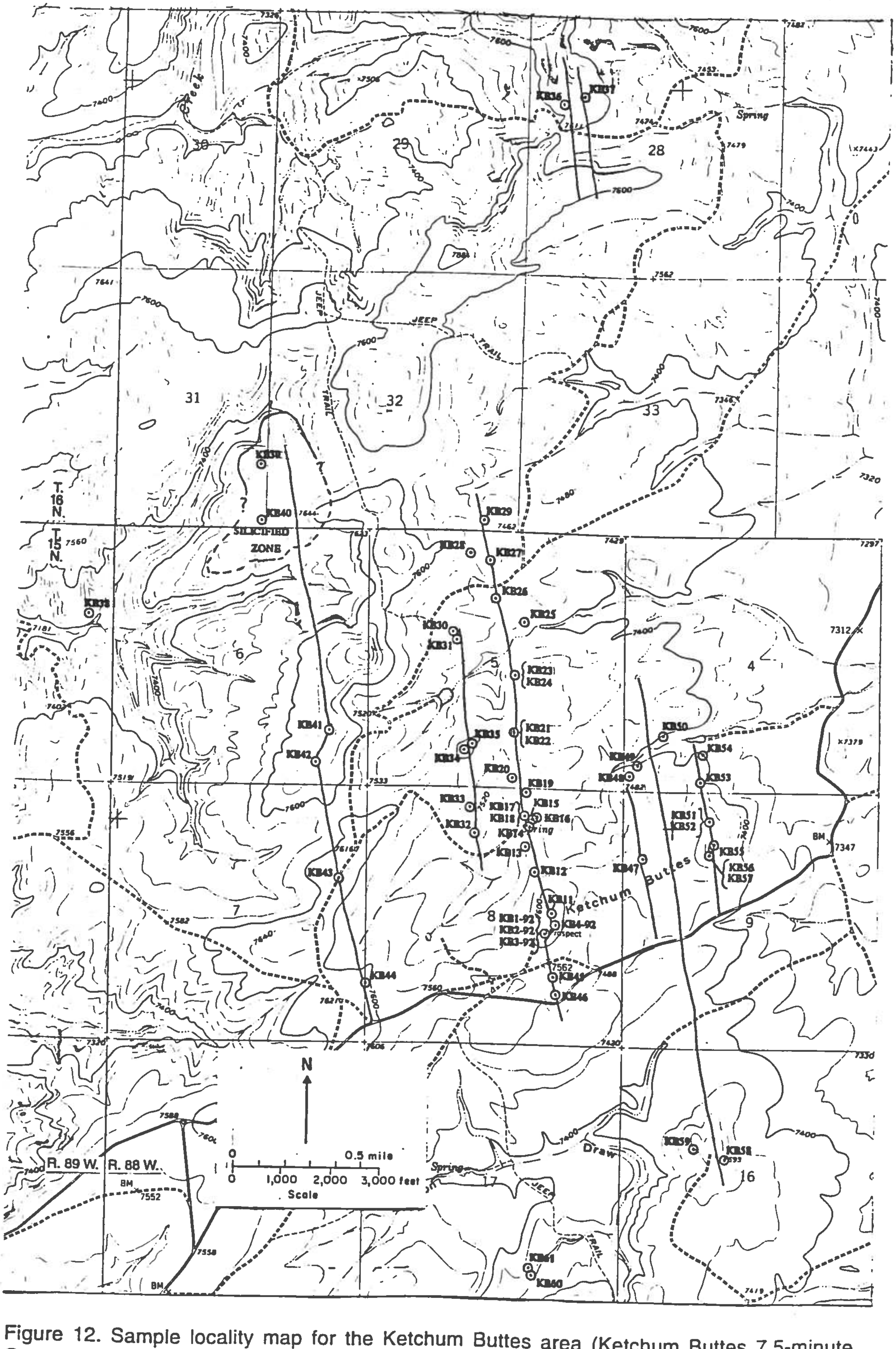

Figure 12. Sample locality map for the Ketchum Buttes area (Ketchum Buttes 7.5-minute Quadrangle map). See **Table 6** for analytical data.

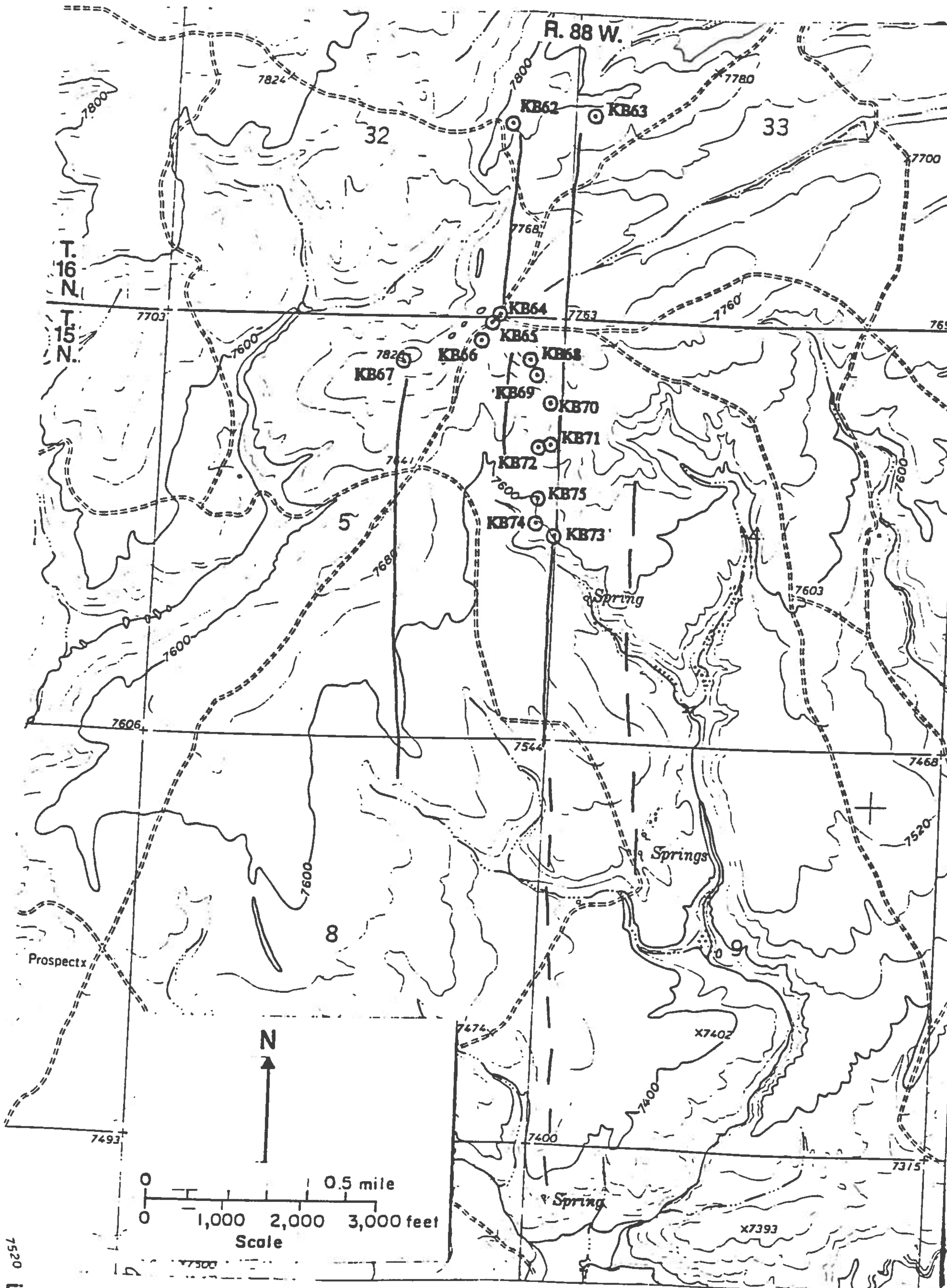

Figure 13. Savery Creek prospect area (McCarty Ranch 7.5-minute Quadrangle map). See **Table 6** for analytical data.

A few samples yielded relatively high silver contents. This was an unexpected discovery since no silver values had been reported in this area prior to this study. Twenty-nine samples yielded anomalous silver with values ranging from a trace to 13.0 ppm (0.38 ounce per ton) (**Table 7**). In total, 52 of the 91 samples yielded trace to anomalous amounts of gold and/or silver. In other words, 57 percent of the analyzed samples contained detectable precious metals.

Coal mining in the Kemmerer district has been along two parallel ridges lying east and west of the town of Kemmerer (**Figure 14**). The easternmost ridge immediately east of Kemmerer is known as Oyster Ridge. The second coal-producing ridge is west of Kemmerer where the Kemmerer (Elkol) and Skull Point open pit mines are located. This ridge is referred to here as the Adaville ridge (**Figure 14**).

Oyster Ridge is the middle part of the Upper Cretaceous Frontier Formation. At this location, the Cretaceous sandstone beds dip about 20°W. The entire Frontier Formation is about 2,500 feet thick and includes minable coals throughout the formation and coals as much as 24 feet thick. Prior to 1960, underground coal mining in the Kemmerer district was confined principally to this ridge.

Adaville ridge is composed of the Upper Cretaceous Adaville Formation. The coal-bearing part of this formation lies stratigraphically above the Lazeart Sandstone Member of the Adaville Formation (about 400 feet thick), the Shurtliff Sandstone Member of the Hillard Shale (about 500 feet thick), and the lower part of the Hilliard Shale (about 6,500 feet thick). The Hilliard Shale lies stratigraphically above the Frontier Formation. Shales and sandstones of the Hilliard Shale are less resistant than the coal-bearing units both stratigraphically above (west) and stratigraphically below (east) and form an erosional strike valley. The Adaville Formation is about 2,900 feet thick, of which at least 250 feet is coal. While some early underground coal mines were developed on the Adaville coals, these coals were not developed in earnest until after 1960, when large open pit mines were opened to supply coal for the nearby Naughton power plant.

Most of the samples collected during this study were from mine dumps on Oyster Ridge, since it was assumed that the gold-bearing coal reported by the U.S. Geological Survey (1968) came from this area. The samples collected from Oyster Ridge (Samples D1 to D45, and D67 to D76) yielded some weak gold anomalies that ranged from a trace to 90 ppb. The silver values ranged from a trace to 13.0 ppm (**Table 7**).

Table 7. Precious metal analyses of coal samples from the Kemmerer coal mining district (nd=not detected, tr=trace, ppb=parts per billion, ppm=parts per million). Sample locations are in **Figure 14**. Analyses by Gordon Marlatt.

Sample Number	Description	Ag (ppm)	Au (ppb)
	Frontier Formation		
D1	Coal, weathered, 2.5% clay component.	nd	nd
D2	Coal, weathered, from mine dump.	nd	tr
D3	Coal, weathered, from outcrop, 30% clay.	2.5	50
D4	Coal, partially weathered, abundant sulfides.	nd	nd
D5	Coal, weathered, minor sulfides.	nd	nd
D6	Clinker, from dump.	nd	nd
D7	Coal, sub-weathered, minor sulfides.	nd	70
D8	Sandstone-claystone, limonite after pyrite on partings.	nd	50
D9	Coal, weathered, minor pyrite.	2.5	90
D10	Coal, weathered, minor pyrite.	nd	nd
D11	Coal, weathered, minor pyrite, from dump.	nd	nd
D12	Coal, no sulfides, located below sandstone.	nd	nd
D13	Coal, sub-weathered, clay partings, from dump.	12.5	nd
D14	Coal, sub-weathered, clay partings, from dump.	2.5	50
D15	Coal, abundant partings, with oxidized pyrite.	2.5	nd
D16	Coal, abundant pyrite on partings, from dump.	nd	tr
D17	Coal, weathered, no pyrite, from dump.	tr	nd
D18	Coal, black and shiny.	nd	70
D19	Coal, sub-weathered, abundant altered pyrite, from dump.	nd	nd
D20	Coal with sandstone, abundant limonite after pyrite, dump.	tr	nd
D21	Coal, abundant altered pyrite on partings.	3	nd
D22	Coal, from dump.	2.5	nd
D23	Coal/shale, thinly laminated, altered pyrite on partings.	3	nd
D24	Coal, some altered pyrite, from dump.	2.5	nd
D25	Coal, from dump.	13	nd
D26	Coal, massive, mine dump no. 6.	2.5	nd
D27	Coal, grab sample from mine dump d-1.	nd	nd
D28	Coal, grab sample from mine dump d-1.	nd	70
D29	Coal, grab sample from mine dump d-1.	nd	nd
D30	Coal, grab sample from mine dump d-1.	nd	tr
D31	Coal, grab sample from mine dump d-1.	nd	40
D32	Coal, bedded, massive, grab sample from dump d-2.	nd	nd
D33	Coal, grab sample from mine dump d-2.	nd	nd
D34	Coal, grab sample from mine dump d-2.	nd	nd
D35	Coal, grab sample from mine dump d-2.	nd	nd
D36	Coal, grab sample from mine dump d-2.	nd	nd
D37	Coal, grab sample from dump d-3, Sublette townsite.	13	60
D38	Coal, grab sample from dump d-3, Sublette townsite.	5	nd
D39	Clinker with some unburned coal, from boiler waste pile.	2.5	tr
D40	Clinker, grab sample from boiler waste pile, Sublette townsite.	nd	nd
D41	Coal, sub-weathered, from outcrop.	nd	nd
D42	Carbonaceous shale, fissile zone.	nd	nd
D43	Coal, altered pyrite on partings, from dump.	nd	70
D44	Coal, parting with some pyrite, from dump.	nd	nd
D45	Coal, from dump.	nd	nd
D67	Coal, from dump, some altered pyrite.	nd	nd

Table 7 continued.

Sample Number	Description	Ag (ppm)	Au (ppb)
D68	Coal, grab sample from dump, altered pyrite.	nd	60
D69	Shaly coal, from dump.	nd	nd
D70	Coal, grab sample from dump.	tr	60
D71	Coal, grab sample from dump.	nd	tr
D72	Coal, grab sample from dump.	nd	nd
D73	Coal, grab sample from dump.	10	50
D74	Coal, weathered with some kaolinite, from outcrop.	5	nd
D75	Coal, weathered with some kaolinite, from outcrop.	nd	tr
D76	Coal, grab sample from dump of the Radiant mine.	nd	nd
	Adaville Formation, outcrops north of Hams Fork		
D46	Coal, weathered, from outcrop.	nd	tr
D47	Coal, weathered, from outcrop, below sandstone.	nd	80
D48	Coal, weathered, with clay component.	nd	nd
D49	Coal, weathered, with clay component.	7.5	nd
D50	Coal, weathered, with clay component.	5	tr
D51	Coal, weathered, with clay component, above sandstone.	5	tr
D52	Coal with 50% clay component.	6	nd
D53	Coal, weathered, with minor clay.	nd	nd
D54	Coal, weathered, with minor clay.	nd	60
D55	Coal, weathered, with minor clay.	nd	nd
D56	Coal with 50% clay component.	nd	nd
D57	Coal, in subcrop, 30 cm above sandstone.	nd	nd
D58	Coal, weathered in subcrop, 20 cm above sandstone.	nd	nd
D59	Coal, weathered, in subcrop.	nd	nd
D60	Coal, weathered, in subcrop.	nd	nd
D61	Coal mixed with shale.	8	60
D62	Coal, weathered.	nd	70
D63	Coal.	2.5	nd
D64	Coal, weathered, in subcrop.	nd	nd
D65	Coal, pristine, grab sample from dump.	nd	nd
D66	Coal with abundant altered pyrite, from outrcop.	tr	nd
	Adaville Formation, outcrops south and west of Skull Point		
D77	Coal, top of #3 seam.	nd	nd
D78	Coal, middle of #3 seam.	nd	nd
D79	Coal, bottom of #3 seam, some pyrite.	nd	50
D80	Coal, top of D1-L seam.	nd	nd
D81	Coal,1/4 down from top of face.	nd	tr
D82	Coal, 3/4 down from top of face.	nd	50
D83	Coal, second seam from top.	nd	40
D84	Coal, second seam from the bottom.	nd	nd
D85	Coal, third seam from bottom.	7.5	tr
D86	Shale, below third seam.	2.5	50
D87	Sandstone, pyritic, below seam.	nd	nd
D88	Coal, pyritic.	2	tr
D89	Coal, top of seam.	nd	50
D90	Coal, base of seam.	nd	tr
D91	Coal.	nd	50

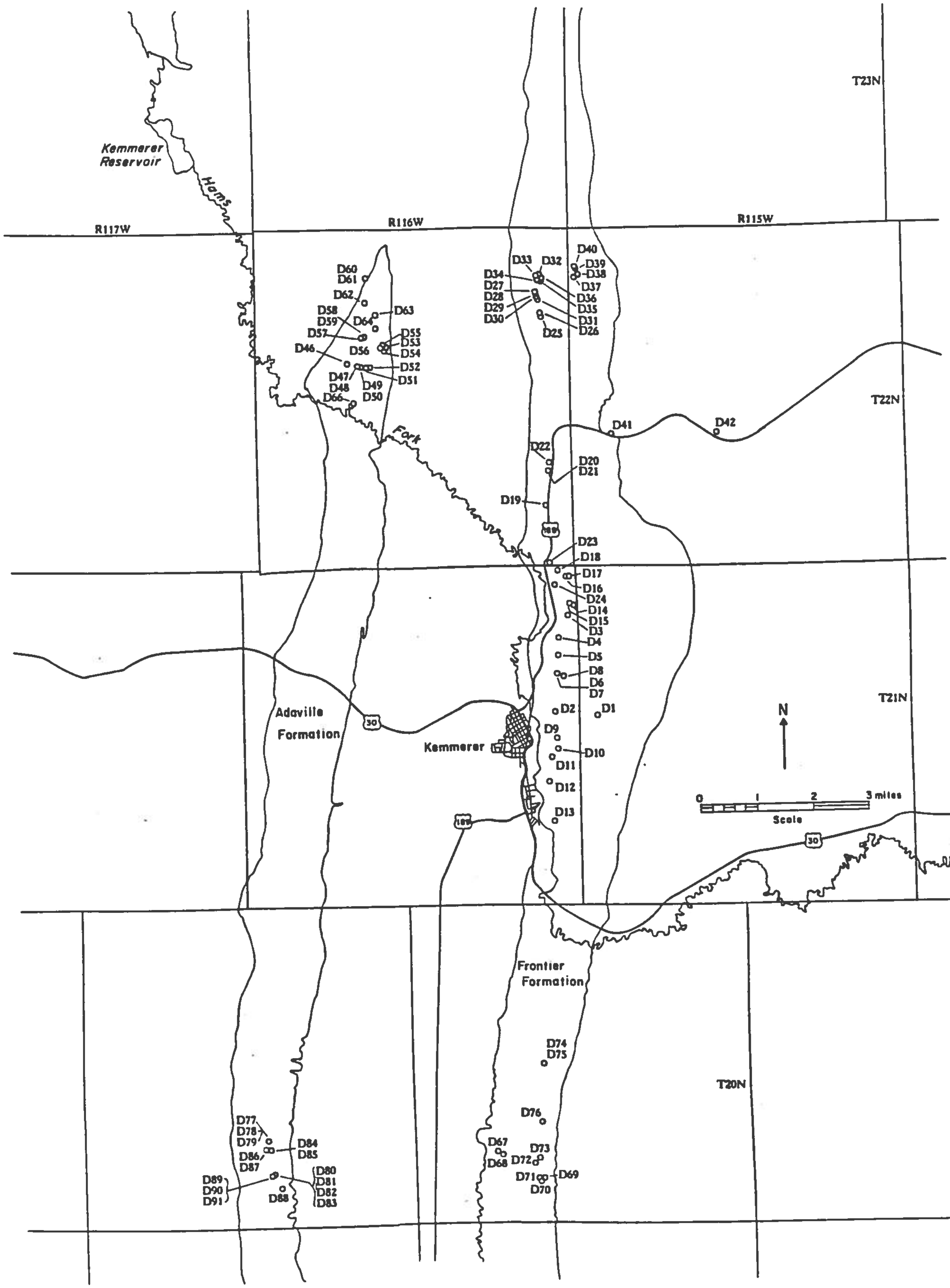

Figure 14. Sample location map of the Kemmerer coal mining district (1:100,000 metric topographic map of the Kemmerer 30" x 60" Quadrangle). Analyses for gold and silver shown on **Table 7**.

A total of 36 samples were taken from the Adaville ridge to the west. Of these, 15 were from an operating mine and 21 were from poor outcrops on the ridge north of the Ham's Fork River. The northern area is due for development as a coal mine, although construction has not yet begun. Samples collected from Adaville ridge (Samples D46 to D66, and D77 to D91) yielded none to 80 ppb Au and none to 8.0 ppm Ag (**Table 7**).

Samples taken from the mine dumps were usually grab samples of coal, although pyritic material was sampled if available. In some cases, the dump samples were weathered. The effects of weathering on the original metal content of the coal are unknown.

The assay results were mixed. Gold was detected in lower concentrations than reported by the U.S. Geological Survey (1968). This may be a function of sampling, as there was no access to mine faces during this study. Most samples were from dumps.

The silver concentrations in the area are somewhat surprising. Grab samples yielded silver concentrations from a trace to 13 ppm, which are extremely high for coal. There is also empirical evidence (Gordon Marlatt, personal communication, 1992) that the coals may contain anomalous arsenic, cobalt, nickel, and copper. The presence of these and other trace metals needs to be addressed in future studies.

The process to recover silver and the other metals from coal requires that the coal first be oxidized, i.e., burned. Burning will tend to concentrate metals in the coal by about an order of magnitude (Marlatt and Spatz, 1991). This could produce a silver content in some of the ash of about 130 ppm (about 4 ounces per ton) and a gold content of about 0.5 ppm (0.015 ounce per ton), thus making the ash a potential source of precious metals.

Lake Owen layered complex, Carbon County

The Lake Owen mafic complex in the Medicine Bow Mountains of southeastern Wyoming (**Figure 1**) was briefly examined during this study. This is a layered mafic complex that is virtually unaffected by deformation and metamorphism. The complex forms a 20- to 25-square mile, funnel-shaped mafic intrusion tilted 75° on its side, exposing a cross-section of at least 16 cyclic units. Vanadiferous titanomagnetite cumulates are persistent in gabbro-norite near the tops of some cyclic units (Loucks, 1991). Some of these cyclic units may contain near-commercial values of vanadium.

Cumulus sulfides occur in at least 12 stratigraphic horizons in the complex. Some of these zones contain elevated gold and platinum ± palladium. Four of the horizons reportedly have laterally persistent precious metal anomalies of a few hundred to a few thousand parts per billion, and contain Au-Ag alloys, Pt-arsenides, Pt-Pd-tellurides and sulfides associated with disseminated chalcopyrite, pentlandite, pyrrhotite, pyrite, gersdorffite, bornite, millerite, and PGE (platinum group elements)-bearing carrollite (Loucks, 1991). The mineralized zones are generally lenticular and spotty and include zones up to 15 feet thick with strike lengths of more than 1 mile.

A few samples were collected in the complex during this project as initial reconnaissance of the region. The samples were collected in Louck's (1991) zones of interest (ZOI) where anomalous precious metals had been detected (**Figure 15**). The samples (**Table 8**) yielded weak precious metal anomalies that ranged from 6 ppb to 14 ppb Au, 18 ppb to 75 ppb Pt, and 5 ppb to 50 ppb Pd. A sample of magnetite cumulate (LO5-92) collected from a prospect pit in the SE section 2, T13N, R78W, yielded 73.66 percent Fe_2O_3, 7.79 percent TiO_2, 900 ppm Cr_2O_3, 0.21percent V, 47 ppm Ni, and 139 ppb Au+Pt+Pd (**Table 8**). These values are considered anomalous and further studies of this area are recommended.

Broadway mine, Carbon County

The Broadway property in the southeastern Sierra Madre of southern Wyoming (**Figure 1**) was briefly examined for base and precious metal values in 1992. The property is one of several potentially commercial base and precious metal properties in the historic Encampment district. It is located on the East Fork Creek in the SW section 32, T14N, R83W, of the Dudley Creek 7.5-minute Quadrangle, and is accessible by the Blackhall Mountain forest road, 19 miles south of Encampment. The last 2.5 miles are on a rough jeep trail. Reclamation has destroyed all field relationships on the property; the old shafts, trenches, and outcrops have all been buried and ore samples are scattered throughout the mineralized area.

The available records indicate a long period of exploration activity on the Broadway property. The property was initially staked in 1904 and a 20-foot-deep shaft was sunk in search of gold. In 1927, three additional shafts of about the same depth were sunk.

According to Osterwald (1947), the U.S. Bureau of Mines collected five character samples and one channel sample from the area in 1942. These samples assayed 0.0 to 12.5 percent Zn, and 0.5 to 1.9 percent Pb. A platinum group metal was also identified by spectrograph at that time.

Frank W. Osterwald with the Wyoming State Geological Survey examined the Broadway mine in 1947. Osterwald noted that the property had been previously examined by geologists

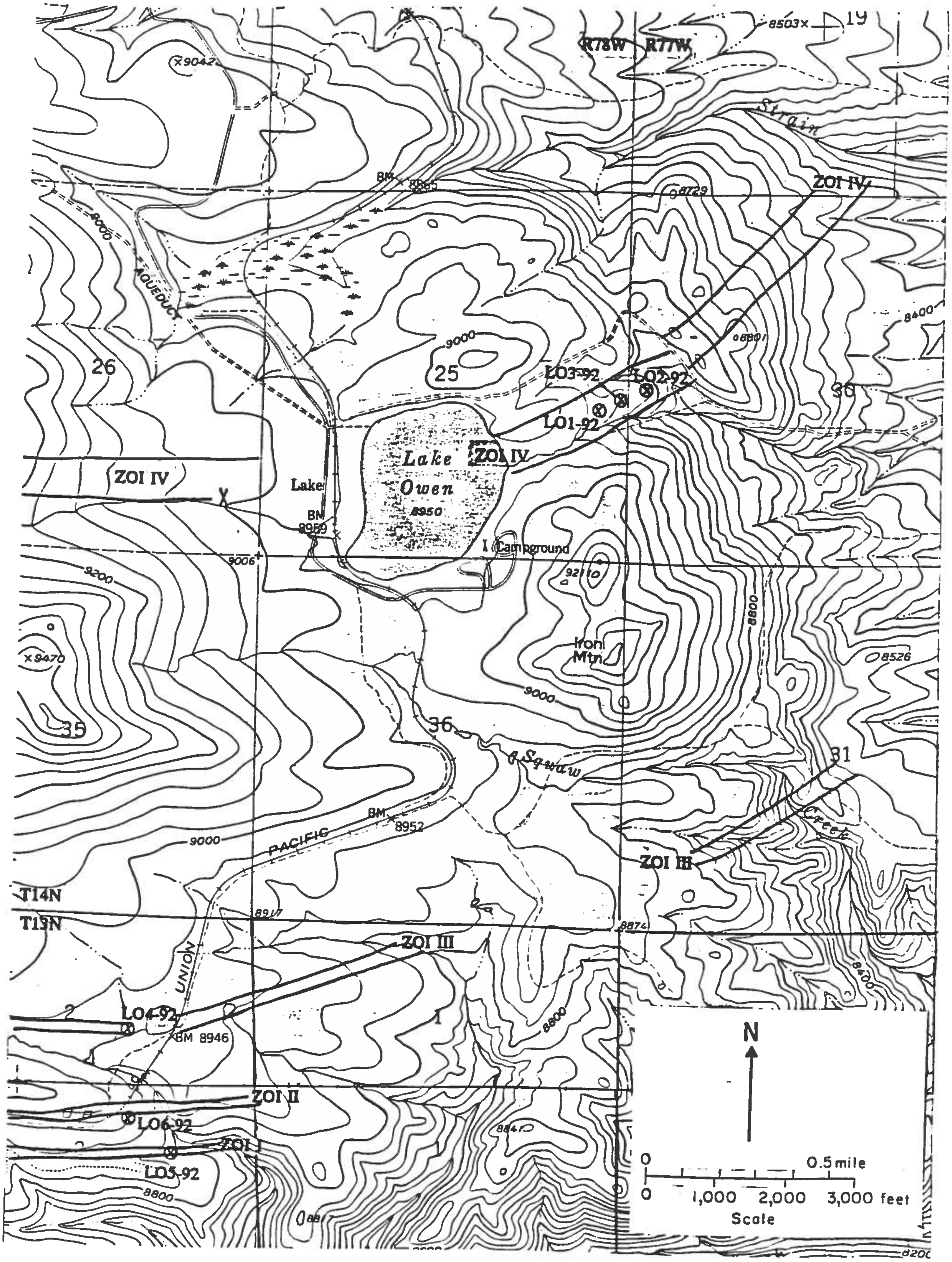

Figure 15. Sample location map of the Lake Owen layered mafic complex showing Louck's (1991) zones of interest (ZOI). Lake Owen 7.5-minute Quadrangle map. See **Table 8** for analytical data.

Table 8. Geochemical analyses of mafic rocks from the Lake Owen layered complex (dash=not analyzed, ZOI=zone of interest, ppb=parts per billion, ppm=parts per million, %=weight percent). Location of samples shown on **Figure 15**. Analyses by Bondar-Clegg.

Sample Number		Fe_2O_3 (%)	TiO_2 (%)	Cr_2O_3 (%)	Ag (ppm)	Au (ppb)	Ni (ppm)	Pd (ppb)	Pt (ppb)	V (ppm)
LO1-92	Norite (ZOI 4).	—	—	0.02	<0.2	6	14	5	18	—
LO2-92	Gabbronorite (ZOI 4).	—	—	0.05	<0.2	8	18	5	20	—
LO3-92	Gabbronorite.	—	—	0.03	<0.2	6	22	9	22	—
LO4-92	Norite (ZOI 3).	—	—	0.02	<0.2	11	13	6	33	—
LO5-92	Magnetite-plagioclase cumulate.	73.66	7.79	0.09	—	14	47	50	75	2139
LO6-92	Magnitite cumulate (ZOI 2).	17.09	0.63	0.05	—	6	16	11	28	101

from New Jersey Zinc. At this time, Osterwald (1947) described the ore zone as 1,000 feet long and about 50 feet wide, continuing under a heavily wooded area for an unknown distance. The ore mineralogy included massive sphalerite and minor galena with local disseminated chalcopyrite, chalcocite, and covellite. Small amounts of secondary malachite and chrysocolla were observed. The ore content was described to range from 3 to 35 percent throughout the property. Near one of the shafts, a gray and white gneissic rock hosting 1 to 5 percent disseminated chalcocite, chalcopyrite, and bornite was sampled.

The ore was localized along the contact of a granite and a complex of gneiss, amphibolite, gabbro, and diorite. The dip of the ore body varied from 50°SE to 50°NW, and the ore reportedly replaced amphibolite host rock where the amphibolite was sheared. The replacement was controlled by a set of northwest-trending cross-fractures. The deposit appeared to be zoned with a copper-rich zone and a zinc-rich zone. Analyses of grab sample material yielded 0.003 percent to 0.82 percent Cu, 0.52 to 1.2 percent Pb, 0.031 percent to 6.9 percent Zn, 0.11 opt to 9.1 opt Ag, and 0.1 to 0.5 ppm Au (Forrest Root, Wyoming State Geological Survey, unpublished file data).

Bunker Hill Mining Company explored the property during 1966 and 1967. Their work consisted of mapping, sampling, trenching, and drilling. Nine shallow drill holes totaling 850 feet were completed, two of which intersected significant mineralization. The best drilled intercept was near the No. 2 shaft, where 20.5 feet of 8 percent Zn was encountered. Based on a small amount of data, it was estimated that ore in sight, in a small area 150 feet by 8 feet by 100 feet deep, amounted to 12,000 tons of 10 percent Zn.

At about this same time, DeNault (1967) conducted a thesis project of the Broadway property. He mapped the area surrounding the property and collected a series of stream-sediment samples. A soil geochemical survey completed by DeNault (1967) indicated the property was anomalous in lead and zinc. Petrographic analysis identified the host rock pyroxenite to typically consist of diopside with minor enstatite replaced entirely or partially by spessartine. One sample examined by DeNault contained considerable olivine.

Amselco examined the Broadway property in 1976, and in 1977, the company drilled the deposit and completed zinc, lead, and copper soil geochemical surveys over a relatively large area. The surveys identified a 3,000-foot-long copper soil geochemical anomaly, a 2,200-foot-long, 100- to 1,000-foot-wide zinc soil geochemical anomaly, and a 1,500-foot-long lead soil geochemical anomaly. Mineralization was recognized as massive zinc, lead, and copper sulfide associated with a lens of tightly folded pyroxene-garnet rock. The pyroxenite was traced for nearly 1,400 feet on the surface.

The Broadway property was briefly examined by the Wyoming State Geological Survey in the 1992 field season, and a suite of samples were collected from the property for geochemical analyses (Hausel, 1992c). Ore sample specimens collected during this investigation consisted of banded massive sphalerite with lesser galena in a matrix of tremolite and spessartine, and granodiorite with disseminated chalcopyrite and chalcocite. The host rock of the massive sulfide is a pyroxene-spessartine hornfels skarn.

Five samples collected for assay included: (1) BW1-92, a limonite-stained felsite; (2) BW2-92, granodiorite with disseminated chalcopyrite and chalcocite; (3) BW3-92, sphalerite-galena-bearing pyroxenite hornfels; (4) BW5-92, spessartine-calcite-quartz-pyroxene-actinolite hornfels with massive sphalerite and minor galena; and (5) BW6-92, spessartine-calcite-diopside-actinolite hornfels with massive sphalerite and a trace of galena. These samples yielded 0.02 to 8.17 percent Zn, 0.30 to 5.66 percent Pb, 0.05 to 1.82 percent Cu, 0.1 ppm to 3.3 ppm Au, and 0.2 opt to 12.18 Ag (**Table 9**).

Leucite Hills, Sweetwater County

The Leucite Hills north of Rock Springs consists of a unique group of rocks called lamproites found only at a few other localities in the world. These rocks occur in only 25 provinces or fields in the world, making them some of the world's rarest rocks. Hausel and others (1992) discussed the mineralogy, geochemistry, and origin of lamproites in general and the Leucite Hills lamproites specifically.

In 1991, samples of lamproite were collected from South Table Mountain and Endlich Hill (Hausel and others, 1992). In 1992, Samples LH1-92 and LH2-92, consisting of fragmental olivine-bearing lamproite, were taken from Endlich Hill in section 8, T22N, R102W; Sample LH3-92 was taken from Wortman dike; and Sample LH4-92 of olivine-bearing magma was collected from Black Rock in section 13, T22N, R101W. The total weight of the collected samples was between 100 to 200 pounds. These samples were concentrated, followed by processing across a grease table. No diamonds were recovered.

Because of the small sample volume, our results are not yet considered diagnostic. Detailed petrographic and geochemical analyses or larger sample volumes are necessary to diagnose the potential of these rocks to contain diamond. Further research is highly recommended due to the similarities of these rocks to the diamondiferous lamproites in the Kimberley region of northwestern Australia.

Table 9. Geochemical analyses of sulfide-rich samples from the Broadway property, Encampment district, Sierra Madre (dash=not determined, %=weight percent, ppb=parts per billion, opt=ounces per ton). Analyses by Bondar-Clegg.

Sample Number	Ag (opt)	Au (ppb)	Cu (%)	Pb (%)	Pd (ppb)	Pt (ppb)	Zn (%)
BW1-92	2.0	3,278	0.77	0.30	—	—	0.31
BW2-92	12.18	1,604	1.82	0.75	—	—	0.02
BW3-92	1.37	156	0.18	5.66	—	—	4.34
BW5-92	0.2	104	0.05	0.69	2	<5	7.66
BW6-92	0.29	215	—	0.62	—	—	8.17

Suggestions for future studies

The results of this and the previous study (Hausel and others, 1992) have shown southern Wyoming to include numerous metal anomalies that have either been undetected or ignored by earlier studies. Any future studies in this region should consider a possible widespread gold deposit in the northern Medicine Bow Mountains. The source of the gold detected in stream-sediment concentrates in this region needs to be addressed. All drainages in this region should be sampled and research efforts should concentrate on locating the source terrane. Sampling of the Proterozoic metaconglomerates in the northern Medicine Bow Mountains for gold would be recommended next, in that the metaconglomerates are a likely source rock for some of the precious metals in this region.

The Medicine Bow Mountains also include a layered mafic complex that has yielded gold, platinum, palladium, titanium, and vanadium anomalies. This relatively undisturbed complex should be sampled in detail for stratiform precious metal and strategic metal deposits. A systematic search of gossans in the layered cumulate zones is recommended, along with magnetic surveys to map the extent of the magnetite cumulates.

The nearby Sierra Madre includes similar geologic environments as the Medicine Bow Mountains. The Sierra Madre encloses dozens of base metal deposits with associated precious metal values that have not been examined in modern times. Historical base and precious metal production from this region has been moderate and the geological environment is favorable for the discovery of significant metal deposits. Future projects should consider this region as high priority. Drainages exiting the Sierra Madre need to be systematically sampled, as they have in the northern Medicine Bow Mountains, and historical mineral deposits in the Sierra Madre should be examined in light of modern theories of ore genesis.

Quaking Asp Mountain and Black Butte in the Green River Basin exhibit similarities to large-tonnage, epithermal gold deposits. These two silicified zones have yielded some interesting geochemical anomalies and need to be bulk sampled. The presence of these two silicified zones suggest the possibility of additional unrecognized zones in the basin. Numerous parallel faults associated with the Rock Springs uplift should be examined and explored for similar silicification.

Coal deposits in the Green River Basin and the Hams Fork Coal Field have yielded some precious-metal anomalies. Detailed studies are needed to determine in what form the metal anomalies occur, and in particular, to determine where and how the metal is concentrated in the coal ash. Some ash may contain possible low-grade, but commercially recoverable precious metals.

Finally, the Leucite Hills represent one of the largest lamproite volcanic fields in the world. These Quaternary volcanic rocks erupted through the Wyoming Archean craton about 1.0 million years ago. The rocks are chemically similar to the diamondiferous lamproites in the Kimberley region of northwestern Australia and in the Murfreesboro district of Arkansas. Samples collected to date have been small and total only a few hundred pounds. To test for diamonds, much larger samples are needed.

Future studies should concentrate on sampling drainages exiting the olivine-bearing lamproites as well as comparative petrographic and geochemical analyses with the diamondiferous lamproites of the Kimberley region of Western Australia. The world-class diamond deposit, the Argyle, was discovered by sampling nearby stream-sediments. Because sampling in the volcanic field has been exclusively confined to the rock, future studies should concentrate on the stream sediments.

Conclusions

The results of this two-year study have shown that southern Wyoming contains many previously unrecognized precious metal and base metal anomalies. Some of these deposits are quite intriguing, especially the Black Butte and Quaking Asp Mountain silicified zones which show similarities to disseminated epithermal gold deposits.

The coal deposits in the Kemmerer region are also of interest. Based on the high silver values identified in this study, and the relatively high gold contents reported by earlier studies, future research is warranted to identify how the precious metals occur and where they end up after the coal is burned.

The results of stream-sediment sampling in the northern Medicine Bow Mountains have been very encouraging. Gold anomalies have been recognized all along the northeastern flank of the range and suggest the presence of a widespread gold source terrane.

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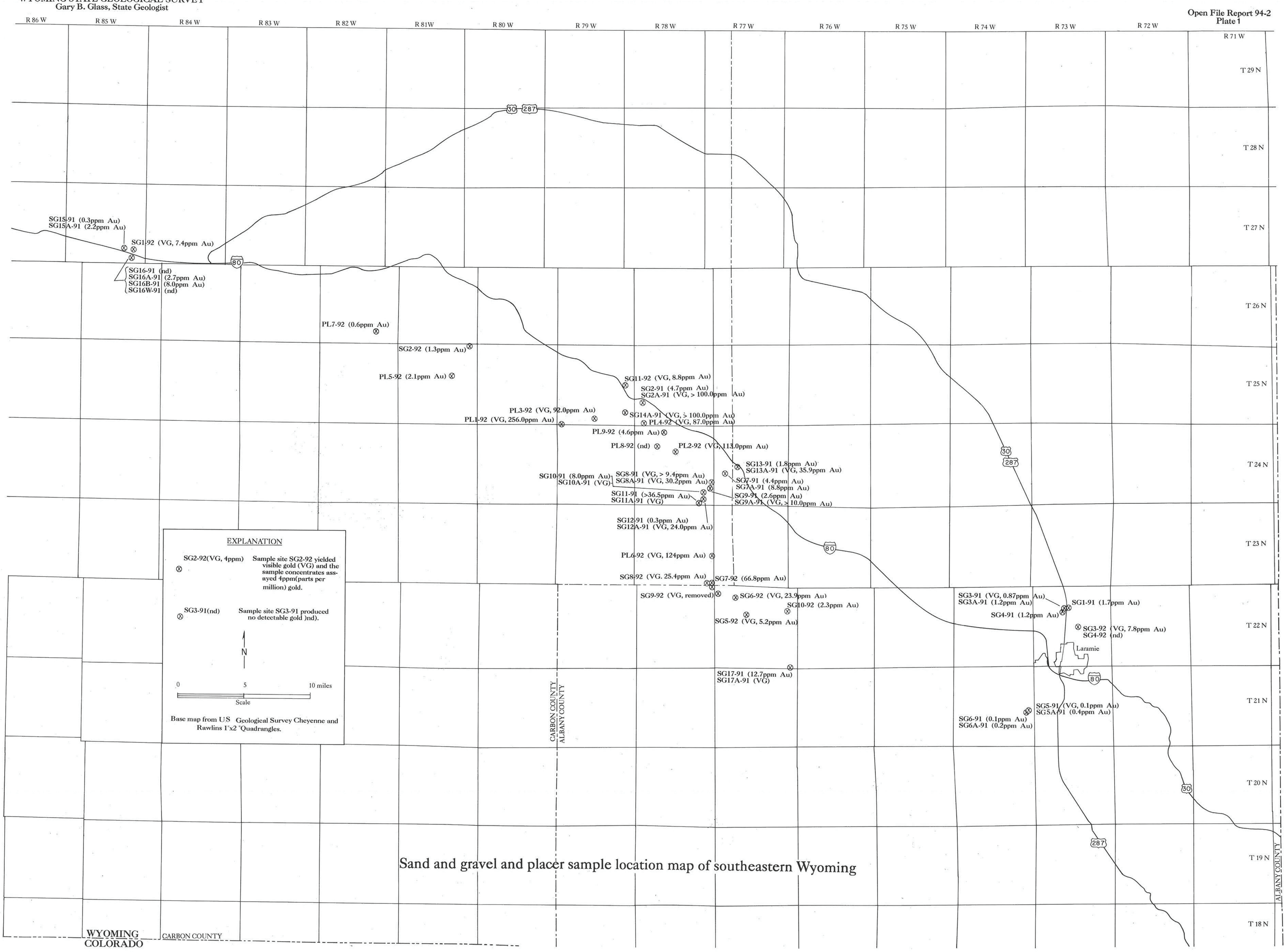
WYOMING STATE GEOLOGICAL SURVEY
Gary B. Glass, State Geologist

Open File Report 94-2
Plate 1



Sand and gravel and placer sample location map of southeastern Wyoming

WYOMING STATE GEOLOGICAL SURVEY
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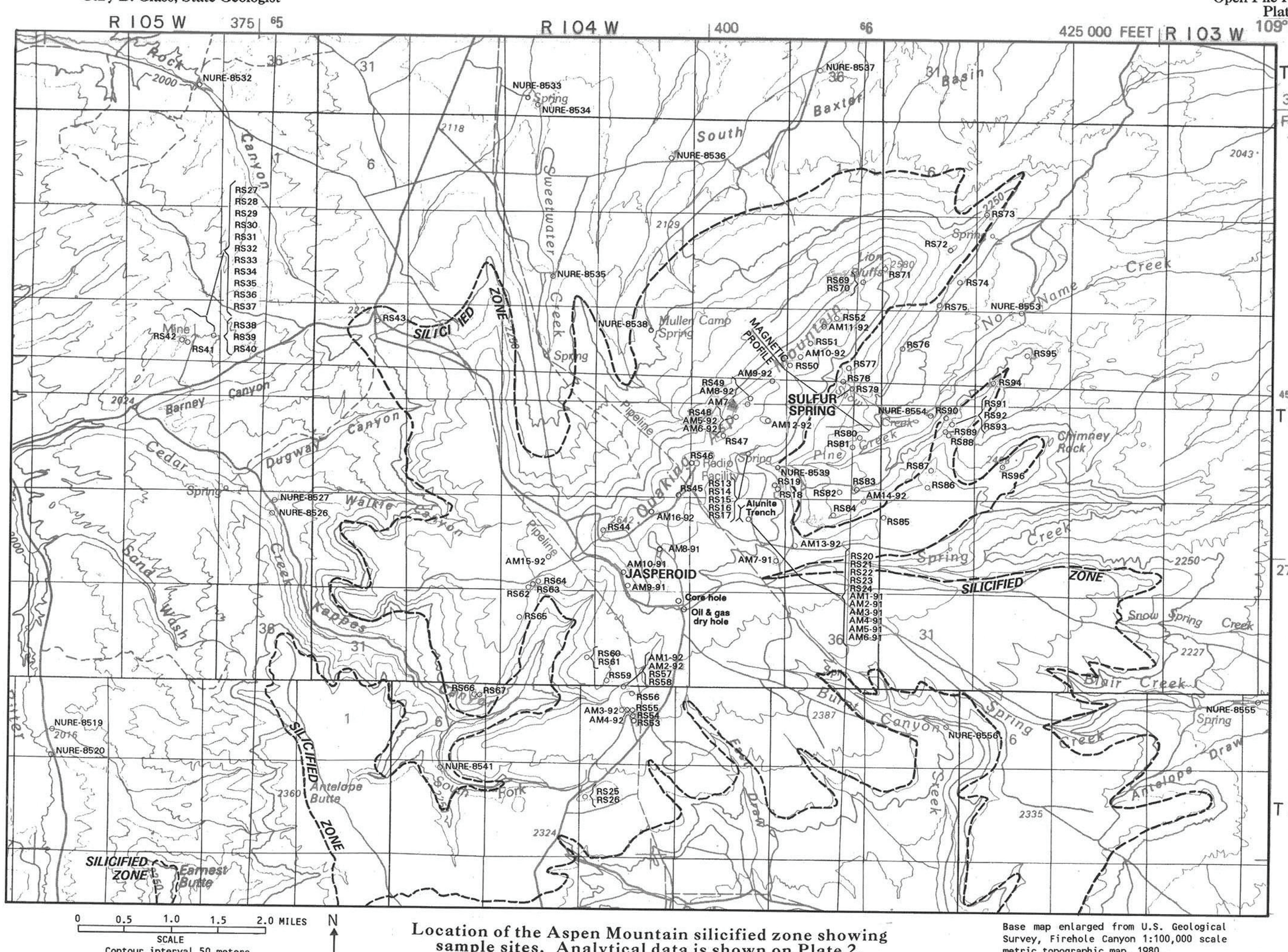
Plate 2



0 0.5 1.0 1.5 2.0 MILES
SCALE
Contour interval 50 meters

Location of the Aspen Mountain silicified zone showing sample sites. Analytical data is shown on Plate 2.

Base map enlarged from U.S. Geological Survey, Firehole Canyon 1:100,000 scale metric topographic map, 1980.