UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Selected analytical results, sample locality map, and discussion of trace-element anomalies for rock samples near Kings Canyon, Confusion Range, Millard County, west-central Utah

By

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This report is part of a series of data releases from on-going studies within the Delta 1° x 2 ° quadrangle, Utah prepared under the Conterminous United States Mineral Assessment Program (CUSMAP).

INTRODUCTION

In 1986, the U.S. Geological Survey began a reconnaissance geochemical survey of the Delta 1° x 2 ° quadrangle, west-central Utah. This geochemical survey is one of several geologic investigations of the quadrangle conducted as part of CUSMAP.

This report presents results of chemical analyses for selected elements, and a brief discussion of these results, for samples collected in the Confusion Range during 1989. Additional samples for geochemical and geologic studies were collected in conjunction with reconnaissance mapping of alteration and associated geologic features during 1988; results from analyses of these samples were presented in Zimbelman and others (1989).

GENERAL GEOLOGIC SETTING

The geology of the Delta quadrangle has recently been compiled by Morris (1987). He shows the southern part of the Confusion Range to consist almost entirely of Devonian carbonate rocks. Hintze (1974a,b) mapped the area of interest at a scale of 1:48,000. All of the samples discussed in this report were collected near the Devonian Simonson Dolostone and the Devonian Guilmette Formation contact. Hintze (1974a,b) described these units as follows. The Simonson consists of alternating light- and dark-brownish-gray dolostone forming low ledges. It is generally fine to coarsely crystalline and underlies the Guilmette Formation. The lowermost part of the Guilmette consists of dark-gray, finely crystalline, generally massive limestone that contains large amounts of breccia. This horizon weathers into a distinctly cavernous horizon, with individual caves varying from less than a meter wide to many tens of meters wide.

ALTERATION

Alteration in this area has received little study. Alteration generally consists of partial, selective silicification of either the uppermost Simonson Dolostone, the lowermost Guilmette Limestone, or both units. The alteration locally results in massive jasperoid bodies, but more commonly is selective, in many places comprising less than 10 percent of a 1-ton mass of rock; and only locally comprising more than 70 percent of a 1-ton mass of rock. The silicification typically occurs along bedding, and can be traced for many hundreds of meters along strike. However, silicification also cuts across bedding, most commonly along fault and fracture zones. The crosscutting silicification grades laterally into dominantly stratiform masses, and, at a distance from the fault or fracture, into delicate, stratiform layers of unaltered and altered zones. Locally, these stratiform layers are only a few millimeters apart and mimic the relict, thin bedding of the host rock. Gangue minerals in the silicified carbonate rock and (or) the jasperoid include quartz, calcite, barite, and fluorite. In addition to occurring as disseminations within the quartz, much of the barite and fluorite is distinctly coarser grained than the quartz, and occurs as veinlets or vug fillings within the jasperoid.

SAMPLING METHODS AND PREPARATION

Rock samples were collected at the sites shown on figure 1. Most of the samples represent chip samples composited from a single outcrop within a distance of approximately 50 m. However, where outcrops of different rock types were sampled from within a distance of approximately 50 m of one another, these samples were given the same sample site number, with a unique suffix (for example, 5700A, 5700B, 5700C, etc.). The sample sites were selected because they contain silicified rock, but samples that showed no visible signs of alteration were also sampled to provide background geochemical information. Silicification is quite varied, and where it comprises nearly 100 percent of the sample, the sample was termed jasperoid.

Rock samples were crushed and then pulverized to minus 0.15 mm with ceramic plates.

SAMPLE ANALYSIS

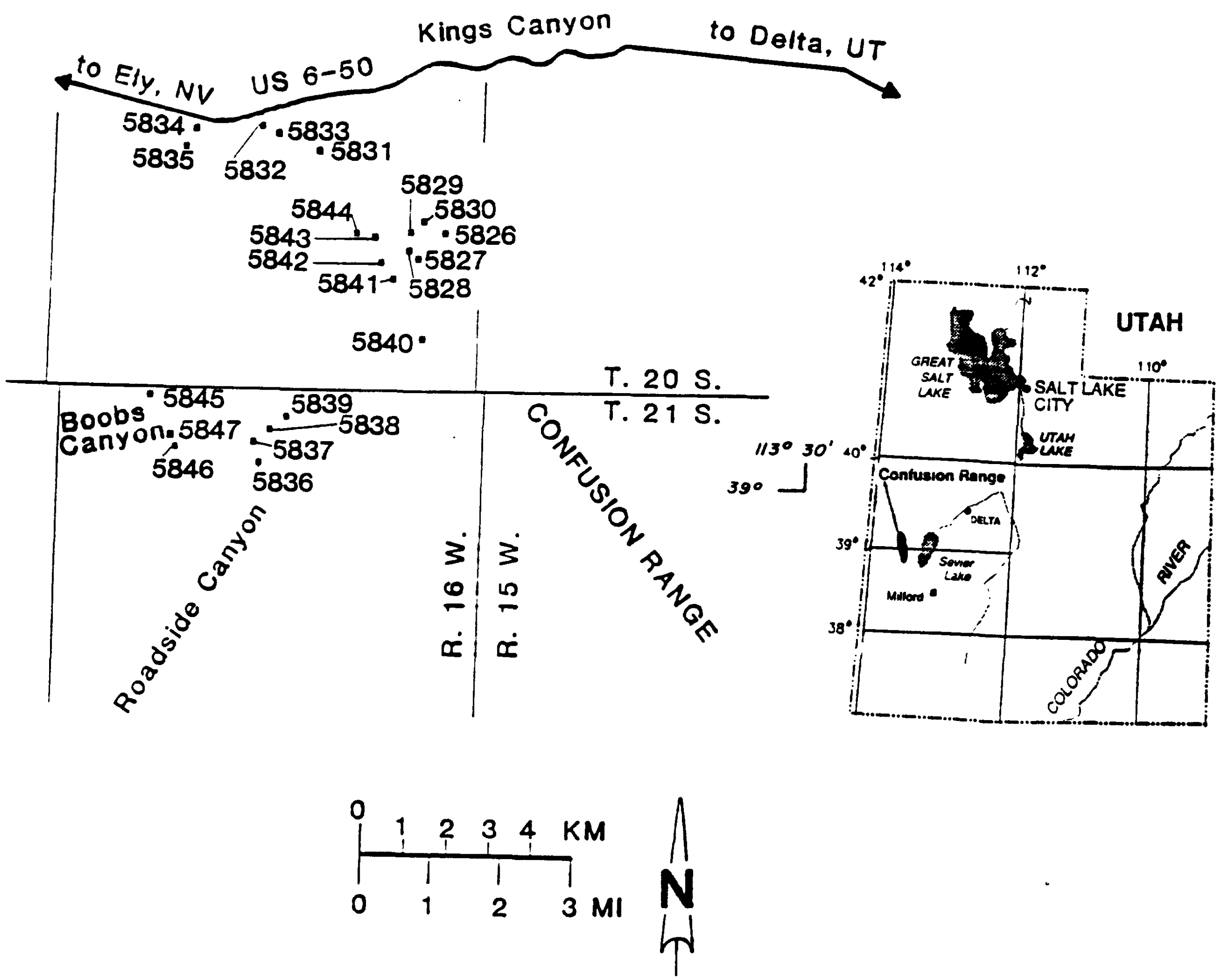
Spectrographic method

The samples were analyzed for 35 elements using a semiquantitative, direct-current arc emission spectrographic method (Grimes and Marranzino, 1968). Elements analyzed by this method that are discussed in this report, and their lower limits of determination, are listed in table 1. Spectrographic results were obtained by visual comparison of spectra derived from the sample against spectra obtained from standards made from pure oxides and carbonates. Standard concentrations are geometrically spaced over any given order of magnitude of concentrations as follows: 100, 50, 20, 10, and so forth. Samples whose concentrations are estimated to fall between those values are assigned values of 70, 30, 15, and so forth. The precision of the analytical method is approximately plus or minus one reporting interval at the 83 percent confidence level and plus or minus two reporting intervals at the 96 percent confidence level (Motooka and Grimes, 1976).

Selected analytical data from the spectrographic analyses are listed in table 3. The emission spectrographic data also include analyses for boron, beryllium, bismuth, cadmium, cobalt, chromium, gallium, germanium, lanthanum, manganese, molybdenum,

Figure 1--Sample location map.

SAMPLE SITE	LATITUDE	LONGTITUDE
5826	39 03 17	113 35 22
5827	39 03 01	113 36 5
5828	39 03 04	113 36 8
5829	39 03 11	113 36 5
5830	39 03 17	113 35 52
5831	39 03 53	113 37 32
5832	39 04 16	113 38 24
5833	39 04 07	113 38 3
5834	39 04 05	113 39 31
5835	39 03 44	113 39 45
5836	38 59 56	113 38 45
5837	39 00 03	113 38 25
5838	39 00 35	113 38 7
5839	39 00 44	113 37 50
5840	39 02 45	113 36 24
5841	39 02 51	113 36 28
5842	39 03 01	113 36 34
5843	39 03 13	113 36 40
5844	39 01 31	113 35 43
5845	39 01 05	113 40 15
5846	39 00 31	113 40 2
5847	39 00 32	113 40 9



niobium, nickel, scandium, tin, strontium, thorium, vanadium, tungsten, yttrium, and zirconium; preliminary interpretation of these data suggest that none of the samples discussed in this report contained anomalous amounts for any of these elements.

Chemical methods

Other methods of analysis used on the rock samples are summarized in table 2. In addition to the spectrographic analyses, the samples were analyzed for gold, mercury, arsenic, antimony, bismuth, cadmium, zinc, and fluorine by other methods. Gold analyses were done using an atomic absorption spectroscopy method described by Thompson and others (1968). Mercury was analyzed by a modification of the atomic absorption method described by Crock and others (1987). Arsenic, antimony, bismuth, cadmium, and zinc were analyzed by an inductively coupled plasma-atomic emission spectrometric method described by Crock and others (1987). Fluorine was analyzed by an ion selective electrode method described by Hopkins (1977). Preliminary interpretation of the cadmium and bismuth data suggest that none of the samples discussed in this report contained anomalous amounts for these elements, and these data are not discussed further.

Selected analytical data obtained from these methods are listed in table 3.

ROCK ANALYSIS STORAGE SYSTEM

Upon completion of all analytical work, the analytical results were entered into a computer-based file called Rock Analysis Storage System (RASS). This data base contains both descriptive geological information and analytical data. Any or all of this information may be retrieved and converted to a binary form (STATPAC) for computerized statistical analysis or publication (VanTrump and Miesch, 1977).

DESCRIPTION OF DATA TABLE

Table 3 lists selected results of analyses for the rock samples. For the table, the data are arranged so that column 1 contains the field numbers, corresponding to the numbers shown on the site location map (figure 1). Columns in which the element headings show the letter "s" below the element symbol are emission spectrographic analyses; "aa" indicates atomic absorption analyses; "icp" indicates inductively coupled plasma-atomic emission spectroscopy; and "ise" indicates ion selective electrode method. A letter "N" in table 3 indicates that a given element was looked for but not detected at the lower limit of determination shown for that element in tables 1 or 2. If an element was observed but was below the lowest reporting interval, an "<" was entered in table 3 in front of the lower limit of determination. If an element was observed but was above the highest reporting value, an ">" was entered in table 3 in front of the upper limit of determination. Table 4 is a brief description of the macroscopic characteristics of the rock samples.

GEOCHEMICAL OBSERVATIONS

Although it is too early to fully evaluate the significance of the data presented here, it is fair to state that these samples are highly anomalous in several elements, including gold, silver, mercury, arsenic, antimony, fluorine, and barium, and, locally, copper, lead, and zinc. This suite of elements commonly occurs in many types of epithermal mineral deposits (Silberman and Berger, 1985). All of the sites shown on figure 1 contain rocks with anomalous amounts of one or more of the elements shown in table 1; figure 2 summarizes the elements that are anomalous at each site, as well as providing a listing of corresponding minimum values considered anomalous for the elements discussed in this report. Figure 2 demonstrates the widespread nature of the anomalous trace-elements, especially gold, in this area. The diversity of anomalous trace-element suites suggests that more work on this area is needed.

SUMMARY

Although the amount of alteration visible at the surface in this area is not extensive, the persistence and wide distribution of the geochemical anomalies suggest they are of considerable importance. The wide distribution of the geochemical anomalies, typically within one or more (stacked) stratiform horizon(s), suggests the existence of a large hydrothermal system that affected an area of several tens of kilometers. Because the geochemically anomalous rocks are inconspicuous in outcrop, there could be a larger volume of similarly altered or mineralized rock in the subsurface or in adjacent areas.

Anomalies of the type described would probably be difficult to identify in many regional-scale geologic investigations. Additional occurrences of altered and (or) mineralized rock would probably only be discovered through detailed geologic studies.

Figure 2--Geochemical anomalies map. Minimum values considered anomalous, in parts per million: Au, 0.05; Ag, 5; Hg, 0.5; As, 100; Sb, 90; Ba, >5000; Cu, 500; Pb, 500; Zn, 500; F, 5000. Sample sites without geochemical anomalies are marked ⊸ .

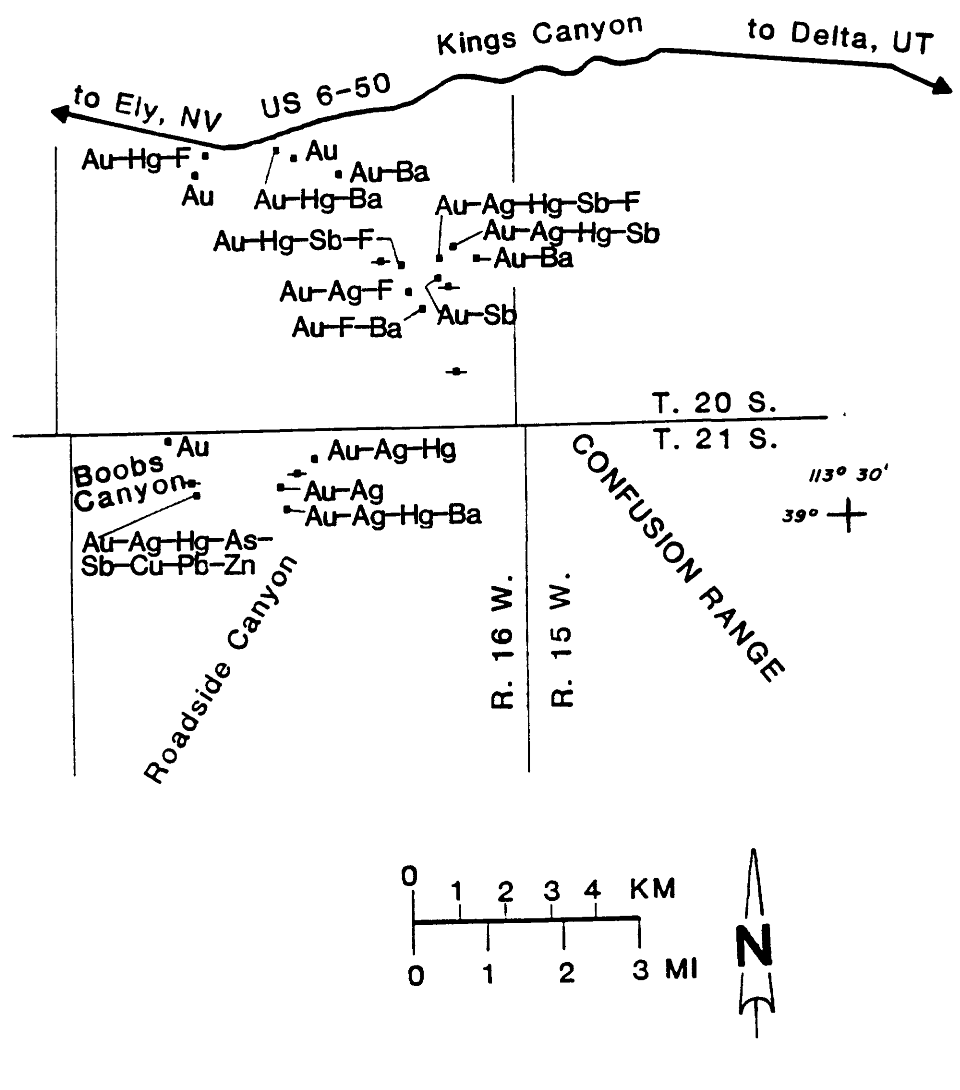


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TABLE 1.--Limits of determination for the spectrographic analysis of rock samples, based on a 10-mg sample; all values in parts per million.

Element	Lower limit of determination (ppm)	Upper limit of determination (ppm)
Silver (Ag)	0.5	5000
Barium (Ba)	20	5000
Copper (Cu)	5	20,000
Lead (Pb)	10	20,000

TABLE 2.--Chemical methods and lower limits of determination

[AA, atomic absorption; AACV, atomic absorption cold vapor; ICP, inductively coupled argon plasma-atomic emission spectrographic; ISE, ion selective electrode]; all values in parts per million.

Element determined	Method	Lower limit of determination	Reference
Gold (Au)	AA	0.05	Thompson and others, 1968
Mercury (Hg)	AACV	0.02	Crock and others, 1987
Arsenic (As)	ICP	5	Crock and others, 1987
Antimony (Sb)	ICP	2	Crock and others, 1987
Zinc (Zn)	ICP	2	Crock and others, 1987
Fluorine (F)	ISE	0.01	Hopkins, 1977

TABLE 3.--Selected results of analyses of rock samples, Kings Canyon area, Confusion Range, west-central Utah. Analytical methods discussed in text and tables 1 and 2. Starred samples (*) collected for background geochemical information. (**N**, not detected; <, detected but below the limit of determination shown; >, determined to be greater than the value shown; values shown in parts-per-million except fluoride in percent)

SAMPLE	Au	Ag	Hg	As	Sb	F	Ba	Cu	Pb	Zn
5826A	.10	<0.5	.12	6	3	.01	>5000	<5	N	31
5826B*	N	N	.02	<5	<2	.04	20	5	<10	<2
5827A*	N	N	.02	<5	<2	.18	70	N	N	<2
5828A	.05	2	.12	7	68	.06	200	<5	<10	6
5828B	.15	5	.24	8	128	.10	500	7	<10	57
5828C*	<.05	3	.20	<5	3	.04	<20	<5	<10	8
5829A	.60	7	.80	18	2340	2.26	5000	5	<10	55
5930A	1.00	20	1.1	17	188	.04	5000	20	10	169
5831A	.05	<.5	.14	21	12	.02	300	20	<10	62
5831B	.10	N	.20	12	5	.02	100	<5	N	38
5831C*	N	N	.04	<5	<2	.02	<20	7	N	<2
5831D	.90	<.5	.34	14	7	.01	>5000	10	<10	77
5832A	1.00	1	.70	16	15	.01	>5000	10	50	60
5832B	.65	2	.88	22	22	.02	>5000	15	300	241
5832C	N	<.5	.26	<5	3	<.01	200	<5	<10	3
5832D*	.05	N	.14	<5	<2	.02	50	<5	10	<2
5832E	.40	N	.40	8	5	.01	>5000	5	15	27
5833A	N	N	.04	<5	<2	<.01	500	<5	N	<2
5833B	.15	N	.12	<5	<2	.04	200	<5	<10	3
5834A	.05	N	.32	6	4	.01	150	7	<10	<2
5834B	N	N	.74	<5	3	.85	100	<5	N	<2
5835A	.15	N	.10	<5	2	.02	200	<5	<10	3
5835B	N	N	.04	<5	<2	.02	150	<5	<10	3
5835C*	N	N	.06	<5	<2	<.01	<20	N	N	<2

TABLE 3--continued

SAMPLE	Au	Ag	Hg	As	Sb	F	Ba	Cu	Pb	Zn
5836A	.50	20	.64	6	23	<.01	150	10	<10	15
5836B	.45	30	.34	22	41	.02	200	20	50	38
5836C*	.10	20	1.6	<5	2	.01	20	10	150	16
5836D*	.10	10	.40	5	5	.01	70	5	20	25
5836E*	.05	3	.16	12	14	<.01	20	7	10	56
5836F	.30	5	.06	<5	3	<.01	70	<5	<10	3
5836G	.45	7	.14	<5	7	<.01	>5000	5	<10	6
5836H*	N		.10	<5	4	.02	30	<5	<10	20
5837A	N	10	.48	<5	3	.02	300	7	N	22
5837B	N	20	.38	6	4	<.01	2000	10	<10	28
5837C	.30	10	.34	8	4	.02	300	10	<10	76
5838A	N	N	.04	<5	<2	.02	150	<5	<10	<2
5838B*	N	N	N	<5	<2	<.01	<20	N	N	<2
5839A	N	N	.10	<5	<2	.02	50	<5	<10	<2
5839B	.60	100	5.8	10	44	<.01	2000	30	200	125
5839C*	.05	2	.36	<5	6	.02	20	5	100	148
5840A	N	.5	.04	22	<2	.10	20	<5	<10	7
5840B	N	N	.04	<5	3	.01	100	<5	<10	4
5840C*	N	N	N	6	<2	.04	20	N	N	<2
5841A	.85	7	.30	10	27	5.02	>5000	5	<10	35
5841B*	N	N	N	<5	<2	.01	<20	N	N	<2
5842A	.15	10	.04	<5	5	6.74	300	<5	N	4
5842B*	N	N	.04	<5	2	.01	20	<5	N	5
5843A	N	2	.32	<5	32	1.28	500	5	N	2
5843B	.15	1	.24	9	529	.94	1000	5	<10	8
5843C*	.05	.5	.82	<5	3	.13	50	<5	N	<2
5844A*	N	N	N	<5	<2	.01	<20	N	N	<2
5845A	.20	<.5	.16	<5	9	.01	200	<5	<10	4
5845B*	.05	N	.08	<5	4	.01	<20	<5	<10	3

TABLE 3--continued

SAMPLE	Au	Ag	Hg	As	Sb	F	Ba	Cu	Pb	Zn
5846A	.95	70	1.5	28	78	<.01	70	10	30	130
5846B	.40	2000	5.7	714	843	<.01	2000	500	2000	1060
5846C*	.15	20	.40	15	6	.03	<20	N	15	158
5846D	.30	100	16.0	117	142	.01	100	500	1000	10,200
5847A*	N	.5	.02	<5	<2	.01	<20	N	N	<2

TABLE 4.--Rock sample descriptions, formatted as follows: color of fresh rock; texture; mineralogy as estimated in the field; degree of silicification in a 1-ton sample, where appropriate; host rock as estimated in the field and as described and mapped by Hintze (1974a,b). NOTE: all percentages are estimates from field examination. Abbreviations: **Dg**-Devonian Guilmette Limestone, **Dsi**-Devonian Simonson Dolostone, **qz**-quartz, **cc**-calcite, **do**-dolomite, **ba**-barite, **fl**-fluorite, **ix**-iron-oxide minerals.

5826A	**Jasperoid**--brownish-grey; very-fine-grained to aphinitic, brecciated; qz, ba, cc, ix; silicification up to 90%; Dsi.
5826B	**Dolostone**--medium grey; silt-sized to finer-grained, crystalline; 98% do, 2% secondary cc along fractures; Dsi.
5827A	**Limestone**--medium grey; finely crystalline; cc; no visible alteration; Dg.
5828A,B	**Jasperoid**--grey and brown; brecciated to network veined; cc, qz, ix; partially silicifed (to 10%) limestone; Dg.
5828C	**Limestone**--medium grey; finely crystalline; cc; no visible alteration; Dg.
5829A	**Jasperoid**--brown, purple, white; massive carbonate with fine- to medium-grained secondary minerals; qz, fl, cc, ba; up to 15% silicification in limestone accompanied by fl and ba; Dg.
5830A	**Jasperoid**--grey, brown; very-fine grained; qz, cc; lacey, selective (to 10%) silicification of limestone; Dg.
5831A,B	**Jasperoid**--rusty brown; very-fine to very-coarse grained; qz, do, ix; selective silicification (to 5%) of dolostone; Dsi.
5831C	**Dolostone**--medium grey; fine grained, crystalline; do; no visible alteration; Dsi.
5831D	**Jasperoid**--rusty brown; fine to very-coarse grained; qz, do, ba, ix; up to 5% silicification of dolostone accompanied by very-coarse grained ba; Dsi.
5832A,B,E	**Jasperoid**--greyish-brown; very-fine to very-coarse grained, brecciated; qz, ix, ba; up to 100% silicification of dolostone; Dsi.
5832C	**Jasperoid**--as above, only 50% silicification.
5832D	**Dolostone**--brownish-grey; very-fine grained, crystalline; do; contains less than 5% secondary silica; Dsi.

5833A	**Jasperoid**--white to light-grey; very-fine grained, brecciated; qz, cc; selective replacement of limestone; Dg.
5833B	**Jasperoid**--rusty-brown; very-fine grained; qz, ix, do; selective replacement of dolostone; Dsi.
5834A	**Jasperoid**--rusty-brown; very-fine grained; qz, ix, do; partial replacement of dolostone, maximum secondary silica 5%; Dsi.
5834B	**Jasperoid**--rusty-brown; very-fine grained; qz, ix, do; partial replacement of dolostone, maximum secondary silica 20%; Dsi.
5835A,B	**Jasperoid**--medium grey; very-fine grained, brecciated; qz, ix, cc; highly irregular, partial replacement to 2% introduced silica; Dg.
5835C	**Limestone**--medium grey; very-fine grained, brecciated; cc; laced with cc veinlets (up to 2 volume percent); Dg.
5836A,B,F,G	**Jasperoid**--brownish-grey, light grey, medium grey; very-fine grained, brecciated; qz, ix, ba, cc; intensely brecciated, variably silicified (up to 95%) limestone breccia, includes local areas of cc and ba veining cutting jasperoid; Dg.
5836C,D,H	**Limestone Breccia**--medium to dark grey; brecciated, with angular limestone clasts of various colors; cc; selected clasts are cut by cc veinlets, but the matrix is not, no other visible alteration; Dg.
5836E	**Limestone**--medium grey; very-fine grained; cc, minor ix; no visible alteration; Dg.
5837A,B,C	**Jasperoid**--medium to dark grey; very-fine grained, brecciated; qz, do, ix; variably silicifed (to 10%) dolostone; Dsi.
5838A	**Jasperoid**--medium grey; very-fine grained, brecciated; qz, ix, cc; partially silicified (to 5%) limestone; Dg.
5838B	**Limestone**--light to medium grey; very-fine grained, brecciated; cc; no visible alteration; Dg.
5839A,B	**Jasperoid**--medium grey; very-fine grained, brecciated; qz, cc, ix; variably replaced limestone by lacey to brecciated, iron-stained qz with 50% maximum introduced silica; Dg.
5839C	**Limestone**--medium grey; very-fine grained, crystalline cc; no visible alteration; Dg.
5840A	**Limestone**--medium grey, yellow, red, brown;

grungy, brecciated; cc, clays, ix; no apparent silicification, oxidized fault or fracture zone; Dg.

5840B **Jasperoid**--medium grey; fine-grained, crystalline; cc, qu, ix; selectively silicified (up to 2%) limestone; Dg.

5840C **Limestone**--medium grey and white; very-fine grained, crystalline, brecciated; cc, cc veinlets; laced with cc veinlets, no other alteration visible; Dg.

5841A **Jasperoid**--medium grey; very-fine to very-coarse grained; qz, ba, fl, ix, cc; finely-laminated to massive silicification of limestone varying along strike; Dg.

5841B **Limestone**--medium grey and white; very-fine grained, crystalline, brecciated; cc, cc veinlets; laced with cc veinlets, no other alteration visible; Dg, collected about 20-50 feet stratigraphically above 5841A.

5842A **Jasperoid**--purplish-grey; very-fine to very-coarse grained; fl, qz, cc, ba, ix; partial replacement of limestone along stratiform horizon, about 25-45 feet thick; Dg.

5842B **Limestone**--medium grey and white; very-fine grained, crystalline, brecciated; cc, cc veinlets; laced with cc veinlets, no other alteration visible; Dg.

5843A **Jasperoid**--medium grey, white, purple; very-fine to medium grained; qz, cc, fl, ix; partial replacement (to 15%) of limestone; Dg.

5843B **Jasperoid**--medium-brown; very-fine to medium grained; qz, fl, ix, ba; near total replacement of limestone by secondary minerals, which are, in turn, cut by neworking fl veinlets; Dg.

5843C **Limestone**--medium grey and white; very-fine grained, crystalline, brecciated; cc, cc veinlets; laced with cc veinlets, no other alteration visible; Dg.

5844A **Limestone**--medium grey; very-fine to fine grained, crystalline, brecciated; cc; no visible alteration; Dg.

5845A **Jasperoid**--light to medium brown; very-fine grained; qz, ix; silicified (to 10%) limestone at base of massive cliff; near Dsi, Dg contact.

5845B **Limestone**--medium grey; very-fine grained, crystalline, brecciated; cc; contains minor cc veinlets; near Dsi, Dg contact.

5846A,B	**Jasperoid**--brown to purplish black; very-fine grained, brecciated; qz, ix, cerargyrite; near totally replaced dolostone that is intensely oxidized and iron-stained; Dsi.
5846C	**Dolostone**--brownish-grey; fine to medium grained, crystalline; do; no visible alteration; Dsi.
5846D	**Jasperoid**--varied colored, including brown, grey, yellow, black; medium to coarse grained, "sanded"; qz, ix; near total replacement of dolostone; Dsi.
5847A	**Dolostone**--medium grey; very-fine to fine grained, crystalline; do; no visible alteration; Dsi.