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MAP SHOWING THE DISTRIBUTION, MINERALOGY, AND GEOCHEMISTRY OF HYDROTHERMALLY ALTERED ROCKS IN THE RENO 1°×2° QUADRANGLE, NEVADA AND CALIFORNIA

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INTRODUCTION

The Reno 1°×2° quadrangle, Nevada and California, is located along the western margin of the Great Basin and includes parts of Washoe, Storey, Churchill, Lyon, Douglas, Nye, Carson City, and Mineral Counties (fig. 1). The area has a rich mining history, especially the western part, which encompasses the Virginia Range. The purpose of this study was to compile a map showing the distribution and geochemistry of areas of hydrothermally altered rocks. This and related mineral appraisal studies (Greene and others, 1991; John and Sherlock, 1991; Hendricks, 1992) of the Reno quadrangle were funded by the Conterminous United States Mineral Assessment Program of the U.S. Geological Survey (USGS).

The following steps were used to generate this map: (1) Landsat Thematic Mapper (TM) images covering the quadrangle were acquired, (2) TM image data were digitally processed to display areas of potentially hydrothermally altered rocks, (3) these areas were compiled on 1:62,500-scale topographic maps, (4) these areas were evaluated in the field, and samples were collected, (5) the samples were mineralogically analyzed using visible and near-infrared (VNIR) wavelength reflectance spectroscopy and X-ray diffraction, (6) the samples were chemically analyzed, and (7) a 1:250,000-scale map was digitally compiled (see map). For each evaluated area, table 1 provides the sample number, the sample classification, latitude and longitude, a brief lithologic description, and the results of the mineralogic and geochemical analyses.

IMAGE PROCESSING

Acquisition of Landsat TM Images

The areal distribution of Landsat TM scenes covering the Reno quadrangle and their scene identification numbers and acquisition dates are shown on figure 1. These scenes are almost entirely free of clouds, and snow is present only in a few small areas in the mountains in the western part of the quadrangle. Although Landsat Multispectral Scanner (MSS) images are also available for the quadrangle, TM images have higher spatial resolution and superior spectral characteristics for mapping hydrothermally altered rocks (Goetz and others, 1983; Podwysocki and others, 1985). Airborne side-looking radar (SLAR) images were acquired for this quadrangle by the USGS. Although these images are not as useful as TM and MSS images for mapping hydrothermally altered rocks, they are useful for conducting structural studies (Rowan and others, 1991; Rowan and Bowers, in press).

Processing of Digital TM Image Data

Color-infrared composite (CIR) images and color-ratio composite (CRC) images were generated by digitally processing the TM data. The CIR images were used to assess the areal extent of vegetation cover and for logistical purposes. The CRC images provided the spectral and spatial information essential for delineating potential areas of hydrothermally altered rocks.

Podwysocki and others (1985), Huckerby and others (1986), and other authors discuss the reasons for using TM CRC images to map hydrothermally altered rocks. Briefly, the TM5 band/TM7 band ratio is used to display mineral absorption features that occur in the 2.0- to 2.4-micrometer (μm) region, while TM3/TM1 displays Fe^{3+} absorption. In spectra of hydrothermally altered rocks, absorption in the 2.0- to 2.4-μm region is caused by vibrational overtones and combination tones that occur in hydroxyl alteration minerals, such as alunite (fig. 2*A*), pyrophyllite (fig. 2*B*), illite/smectite (fig. 2*C–E*), and kaolinite (fig. 2*F*). Fe^{3+} absorption in the visible and ultraviolet wavelength regions is related to oxidation of pyrite and ferromagnesian minerals (fig. 2*G–I*). Because these absorption features are not unique to hydrothermally altered rocks, field and laboratory evaluation is required to assess what is truly altered. In addition, TM4/TM3 is used to distinguish between high TM5/TM7 values caused by vegetation and high values caused by alteration minerals.

In the color-ratio combination used in this study, TM5/TM7 = red, TM3/TM1 = green, TM4/TM3 = blue, limonitic hydrothermally altered rocks that contain hydroxyl-bearing minerals appear to be yellow, and bleached areas that lack intense Fe^{3+} absorption appear to be red to orange. Areas in the TM CRC images that have these colors are referred to as CRC image anomalies. Generally, propylitized rocks are not delineated in these images. Densely vegetated areas appear to be magenta due to the red and blue contributions of TM5/TM7 and TM4/TM3, respectively. Bedrock exposures in densely vegetated areas are not detectable in the TM images.

Compilation of the CRC anomalies on the 1:62,500-scale topographic maps of the quadrangle was accomplished by plotting the anomalous areas on color Versatec plots at this scale and then transferring them to the maps. Because of their color fidelity, the CRC images, reproduced on photographic film, were used to identify the anomalous areas to be compiled from the Versatec plots. Eight hundred and twenty-nine areas of varying size were delineated (see map).

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EVALUATION OF CRC IMAGE ANOMALIES

Field Evaluation

Approximately 77 percent of the CRC image anomalies were examined in the field using a four-wheel-drive vehicle and a helicopter; these areas constitute 95 percent of the total anomalous area mapped. Because of the large number of anomalies, most areas were examined only locally. In some large or lithologically complex areas, multiple samples were collected. Samples were not collected in some areas, including the areas evaluated during the final phase of fieldwork (table 1). The type of alteration present, if any, is determined by hand-specimen evaluation of the visible mineral grains, especially feldspars and ferromagnesian minerals, and the quartz content. The prealteration lithology was noted where it is still recognizable (table 1).

Laboratory Analyses

Visible and Near-Infrared Reflectance Spectra

Reflectance spectra were measured from 0.4 to 2.5 μm by using a Beckman UV5240 spectrometer equipped with an integrating sphere; halon was used as a reflectance standard (see Weidner and Hsia, 1981). For most samples, both freshly broken and weathered surfaces were analyzed.

The resulting spectra were analyzed by visually comparing the wavelength positions and spectral shapes of absorption features to reflectance spectra of individual minerals in our laboratory reference library and those published by Hunt and Salisbury (1970), Hunt and others (1971a,b, 1973), Hunt (1979), and Hunt and Ashley (1979). Some important products of hydrothermal alteration, such as quartz, microcline, and albite, lack absorption features in the 0.4- to 2.5-μm region, but OH, CO_3, and Fe^{3+} mineral spectra have multiple absorption features that are diagnostic of a particular mineral or mineral group. For example, alunite (fig. 2*A*), which is commonly found in advanced argillized rocks (Hemley and Jones, 1964; Hunt and Ashley, 1979), exhibits diagnostic absorption features at the intense 2.16- and weak 2.21-μm doublet; at 1.76 μm; at 2.32 μm; and at the 1.42- and 1.48-μm doublet. Ordered kaolinite also displays a doublet at 2.17 and 2.21 μm (fig. 2*F*), but the intensities are reversed relative to the alunite spectrum. In addition, the 1.76-μm feature is absent in kaolinite, and the doublet near 1.40 μm is at a shorter wavelength. Other hydrothermal alteration minerals that exhibit diagnostic absorption features in the 0.4- to 2.5-μm region include pyrophyllite, jarosite, dickite, tourmaline, zunyite, NH^{4+} minerals (for example, buddingtonite), talc, tremolite, muscovite, gypsum, and calcite (fig. 2*B*, *G*, *J–R*, respectively).

Some mineral groups are characterized spectrally by specific absorption features, but identification of individual minerals may be difficult. For example, chlorite and biotite spectra (fig. 2*S* and *T*, respectively) may have Mg-OH doublets between 2.30 and 2.40 μm, a narrow feature near 2.25 μm, and Fe^{2+} and Fe^{3+} absorption features at shorter wavelengths (Hunt and Salisbury, 1970; Hunt and others, 1973). In chlorite, a single feature located near 2.35 μm is observed more commonly than the doublet (McLeod and others, 1987) and was the basis for making the distinction between chlorite and biotite. Epidote has diagnostic features at shorter wavelengths (fig. 2*U*).

The distinction between hematite and goethite (fig. 2*H* and *I*, respectively) is based on the wavelength location of the Fe^{3+} absorption feature near 0.90 μm. The near-infrared minimum of the Fe^{3+} feature is located at a shorter wavelength in pure hematite spectra than in pure goethite spectra (Hunt and others, 1971a; Hunt and Ashley, 1979; Peters, 1983). This exact location, however, may be affected by Al^{3+} substitution for Fe^{3+} (Buckingham and Sommer, 1983). Most of the samples that contain substantial amounts of Fe^{3+} minerals probably consist of mixtures of goethite and hematite, as well as other Fe^{3+} minerals. Consequently, hematite and goethite in table 1 indicate which of these two Fe^{3+} minerals is spectrally dominant, but others, such as ferrihydrite, may be present. Pyrite does not have a diagnostic spectrum in this wavelength region and was identified visually.

Mixed-layer clay minerals can be separated into three categories on the basis of spectral reflectance differences that show variations in the proportion of illite and smectite (I/S) layers (Crowley and Vergo, 1988). In table 1, high I/S refers to samples that contain a high proportion of illite (fig. 2*C*); medium I/S refers to samples that contain approximately equal proportions of illite and smectite (fig. 2*D*), and low I/S refers to samples that contain a high proportion of smectite (fig. 2*E*). In general, with increasing proportions of smectite, the intensity of the HOH absorption feature near 1.9 μm increases, whereas the Al-OH features at 2.20 μm, 2.33 μm, and 2.38 μm decrease. Although these designations were not quantified, they are useful indicators of hydrothermal activity. High I/S is indicative of more intense alteration than low I/S (Duba and Williams-Jones, 1983; Horton, 1985). In some spectra, these distinctions were not possible because of the presence of other minerals that have intense 1.4- and 1.9-μm absorption features. In these cases, only I/S was used in table 1.

Some zeolite mineral spectra, such as those of clinoptilolite, commonly lack diagnostic absorption features (fig. 2*V*). Although these spectra are characterized by the presence of intense HOH absorption bands near 1.4 μm, 1.9 μm, and 2.74 μm (which is not seen on the figure, but which causes a steep slope between 2.2 and 2.5 μm), these features are also typical of low I/S spectra (figure 2*E*). Consequently, X-ray diffraction analysis was necessary to confirm the presence of zeolite minerals. X-ray diffraction analysis also was used to resolve uncertainties in some sample spectra because of mixing of minerals that have similar major spectral absorption features. Some identifications are uncertain and, therefore, are queried in table 1.

Halloysite and kaolinite/smectite reflectance spectra (fig. 2*W* and *X*, respectively) are somewhat similar to each other and to disordered kaolinite spectra (Crowley and Vergo, 1988). Halloysite and kaolinite/smectite differ, however, in the region near 1.4 μm and by the absence of the 2.17-μm shoulder in the kaolinite/smectite spectrum. The spectra of both of these minerals have a more intense 1.9-μm water absorption feature than ordered kaolinite (fig. 2*F*).

Diaspore and opal (fig. 2*Y* and *Z*, respectively) have broad features that may be masked by other mineral absorption features in polymineralic hydrothermally altered rocks. However, in samples in which they are abundant, these minerals can be easily identified spectrally.

Geochemical Analyses

Rock samples collected from field sites identified as CRC image anomalies were analyzed for 35 elements by a semiquantitative direct-current arc emission spectrographic method (Grimes and Marranzino, 1968) (see table 2 for a listing of the elements and their determination limits). In addition, more sensitive techniques (flame atomic absorption, cold-vapor atomic absorption, and inductively coupled plasma-atomic emission spectrometry) were used to analyze for several elements commonly used as indicators for base- and precious-metal mineralization (see table 3 for a listing of the elements and their lower determination limits).

Threshold values for selected elements in rock samples collected for this study are shown in table 4. A threshold value is defined as the concentration of an indicator element above which a sample is considered to be anomalous (Rose and others, 1979). It is usually the upper limit of normal background fluctuations. In this study, there is an inadequate background population because most of the rock samples were collected because they exhibited some type of alteration. Such alteration is usually accompanied by elevated concentrations of one or more indicator elements. For this reason, the thresholds given in table 4 were determined from compiled values for average rock compositions (Wedepohl, 1969–1978; Turekian, 1977). These threshold values are only intended to give a general indication of regional background for the study area and should not be interpreted as definitive for local background. Elements that have concentrations above these threshold values are considered to be anomalous and are used to define the geochemically anomalous samples shown in table 1 and the geochemically anomalous areas shown on the map.

RESULTS

The 829 CRC image anomalies shown on the map can be separated into four categories or units: (1) verified hydrothermally altered rocks (red), (2) probable hydrothermally altered rocks (green), (3) unaltered rocks (blue), and (4) unevaluated areas (black).

Areas of verified hydrothermally altered rocks that contain anomalous amounts of the elements listed in table 4 are shown in red on the map. Hydrothermally altered areas that are not geochemically anomalous (<50 percent of samples yielded anomalous values) and areas that lack geochemical analyses are only outlined in red. Mines and prospects also are shown.

Verified Hydrothermally Altered Rocks

The presence of hydrothermal alteration was verified by evaluation of field relations, with particular attention to mineralogical and textural modifications of prealteration lithologies, and by subsequent laboratory mineralogic determinations by using VNIR spectroscopy and X-ray diffraction. These areas constitute approximately 52 percent of the 829 CRC image anomalies and are indicated in table 1 by the letter A. Sample numbers also are shown on the map. These altered areas constitute approximately 85 percent of the area encompassed by the 829 CRC anomalies.

The largest area of hydrothermally altered rocks encompasses the Peavine and Wedekind mining districts near the western margin of the quadrangle (map, area A). The distribution of altered rocks within these districts is similar to that shown by Bonham (1969). The rocks are mainly Mesozoic metavolcanic rocks and bleached, limonitic, argillized, Tertiary andesitic rocks and granodiorite porphyry (Bonham, 1969; Hudson, 1977). Locally, silicified rocks form resistant outcrops within broad areas of soft, argillized rocks. Alteration minerals include pyrophyllite, alunite, gypsum, zunyite, kaolinite, opal, hematite, jarosite, goethite, and high I/S (table 1 and map, area A). Large parts of the altered area contain anomalous amounts of Ag, As, Pb, Hg, Te, and Tl (table 1 and map, area A).

Hydrothermally altered rocks are widespread in the Virginia Range (Thompson, 1956; Whitebread, 1976; Ashley and others, 1979). The largest areas are located near Washington Hill (map, area B), the Geiger Grade area (map, area C), and the Ramsey mining district (map, area D). The predominant rock type in all three areas is bleached, argillized, Tertiary volcanic rocks, but silicified rocks+adularia are common locally in the Ramsey district (David John, USGS, oral commun., 1991). Andesitic lavas and pyroclastic rocks of the Alta Formation are widespread in the Geiger Grade area, whereas andesitic lavas, pyroclastic rocks, and andesite porphyry of the Kate Peak Formation underlie the other two areas. Although the alteration mineralogy is similar to that in the Peavine-Wedekind area (map, area A), more elements are anomalously concentrated in the Virginia Range (table 1 and map, areas B–D). However, the number of samples analyzed in this study is too small to be considered comprehensive.

Vegetation cover affects the distribution of hydrothermally altered rocks shown on the map. Juniper (*Juniperus* sp.) and sagebrush (*Artemisia* sp.) obscure substantial areas of altered rocks near Virginia City, Nev. (Ashley and others, 1979). On the other hand, clays resulting from intense argillization in the Geiger Grade area (map, area C) are responsible for the sparse ponderosa pine (*Pinus ponderosa*) cover and the lack of normal understory vegetation (Billings, 1950). Consequently, mapping of the altered rocks is more complete here than in areas around Virginia City.

The area of hydrothermally altered rocks located southeast of the Virginia Range at the southern margin of the quadrangle (map, area E) occurs in Mesozoic granodiorite porphyry in the Singatse Range and Mesozoic metavolcanic rocks and Tertiary tuff in the Buckskin Range (Moore, 1969). A large number of alteration minerals were identified in samples from this area, including muscovite; high, medium, and low I/S; alunite; jarosite; goethite; hematite; chlorite; epidote; talc; tremolite; kaolinite/smectite; amorphous silica; and halloysite (table 1). Limonitic andesite (sample nos. 241 and 252; table 1 and map, area E) and dolomite with calcite veins (sample no. 247; table 1 and map, area E) do not appear to be hydrothermally altered, but they are geochemically anomalous.

In the Olinghouse area (map, area F), hydrothermal alteration affected Tertiary volcanic rocks and granodiorite. In the altered volcanic rocks (sample nos. 437–452), the dominant alteration minerals are high, medium, and low I/S; kaolinite; goethite; hematite; and jarosite (table 1 and map, area F). In some areas, the volcanic rocks are only weakly argillized. Locally, epidote and chlorite are abundant, especially along fractures in the granodiorite (sample nos. 460 and 461). The number of samples that are geochemically anomalous and the number of anomalous elements are lower here than in the areas described above. The elements that exceeded the threshold values (table 4) are Au, Ag, Hg, Pb, Ni, Mo, Te, and Tl (table 1 and map, area F).

In the Pyramid district (map, area G), Tertiary volcanic rocks, mainly tuffs, are altered along generally northwest-oriented zones. The zones appear to correspond roughly to the trend of mineralized veins (Bonham, 1969; Wallace, 1975, 1979). Alteration minerals include I/S, kaolinite, pyrophyllite, dickite, diaspore, jarosite, chlorite, hematite, and goethite (table 1 and map, area G). The diversity of anomalous elements, including Ag, As, Au, Bi, Cu, Hg, Pb, Sb, Sn, Te, and Tl (table 1 and map, area G), is consistent with the presence of both precious- and base-metal mineralization (Bonham, 1969).

Approximately 10 km east of the Pyramid district, Tertiary tuffs are hydrothermally altered in the Guanomi mine area (map, area H). According to Bonham (1969), the alteration is related to intrusion of a quartz monzonite porphyry, which also is altered. Samples collected in this area commonly contain high, medium, and low I/S; pyrophyllite; jarosite; hematite; and goethite. Kaolinite, alunite, halloysite, muscovite, dickite, I/S, diaspore, and gypsum occur less commonly (table 1 and map, area H). The area has been explored for both Ag-Au and Cu-Mo mineralizations (Bonham, 1969). Indeed, the geochemical analyses of our samples indicate a wide range of both precious- and base-metal elements, such as Ag, As, Au, Bi, Cu, Hg, Mo, Pb, Sn, Te, Tl, and Zn (table 1 and map, area H).

In general, areas of hydrothermally altered rocks are smaller in the eastern part of the quadrangle than in the western part. One of the largest altered areas in the east is located on the western slope of the southern Stillwater Range south of Cox Canyon (map, area I). According to David John (USGS, oral commun., 1991) most of the area is underlain by a Miocene rhyolite dome that is generally unaltered. However, the samples that we analyzed are hydrothermally altered tuffs (table 1 and map, area I). The most common alteration minerals are kaolinite; high and medium I/S; hematite; goethite; and jarosite (table 1). Mercury, tellurium, and thallium are anomalously high in several samples, and one sample (no. 102) also contains anomalous amounts of arsenic, molybdenum, and boron.

The moderately large area of altered rocks in the Sand Springs Range (map, area J) is located entirely within Cretaceous granite. The alteration mineralogy is simple and consists of I/S, muscovite, and hematite; pyrite was observed in some samples (table 1 and map, area J). Only thallium has anomalously high values, except for sample no. 149, which has anomalously high values of molybdenum.

Other moderately large areas of hydrothermally altered rocks in the southeastern part of the quadrangle are present in the Rawhide-Regent area (sample nos. 18 and 19), in the southern part of the Sand Springs Range (sample nos. 171–176), north of Fairview Peak (sample nos. 150–157), and in the Westgate area (map, area K). At Rawhide, alteration minerals include kaolinite, high I/S, low to moderate I/S, alunite, hematite, and jarosite; and Ag, Hg, Mo, Pb, and Tl are present in anomalously high amounts. In the southern Sand Springs Range and Fairview Peak areas, the alteration minerals are similar to those in the Rawhide-Regent area, except that alunite and jarosite were not detected, and chlorite and kaolinite/smecite were noted. Kaolinite was not noted in the Fairview Peak samples. Alteration minerals in the Westgate area are limited to I/S, chlorite, goethite, hematite, and jarosite; anomalously high levels of silver, mercury, and thallium were detected.

In the northeastern corner of the quadrangle, a cluster of small- to moderate-size areas of altered rocks occurs in the Dixie Valley mining district (map, area L). Altered volcanic rocks contain kaolinite; high, medium, and low I/S; chlorite; dickite; hematite; jarosite; and goethite. Although the area was explored mainly for precious metals (Willden and Speed, 1974), anomalously high levels of Mo, Pb, and Cu, as well as Ag, Hg, Sb, B, and Tl, were noted in our samples (table 1).

Several clusters of small areas of hydrothermally altered rocks, including those near Virginia City, are caused by extensive vegetation that obscures much of the altered ground. A similar explanation applies to the cluster of small altered areas in the Como mining district (map, area M), although the alteration is much less extensive than that in the Virginia City area (Russell, 1981). Vegetation also obscures altered rocks in the northern Carson Range (Hudson, 1983) (map, area N).

In the Jessup mining district (map, area O), the scattered map pattern of hydrothermally altered rocks is related to pre-Tertiary metasedimentary and metavolcanic rocks that have been locally silicified and locally argillized, particularly adjacent to rhyolitic intrusive bodies; locally, the rhyolitic rocks are also hydrothermally altered. The dominant alteration minerals are high, medium, and low I/S; kaolinite/smectite; chlorite; jarosite; and goethite. Geochemical analyses show that Au, Ag, Hg, Mo, Zn, and Tl exceed the threshold values (table 4) in samples from this area (table 1).

Probable Hydrothermally Altered Rocks

The cluster of small hydrothermally altered areas in the central part of the quadrangle are silicified and argillized Tertiary tuffs and narrow breccia zones along northeast-trending faults (map, area P) (Quade and Tingley, 1987). The distribution of the altered rocks appears to be more extensive than that shown on the map, because quartz-adularia alteration has affected the Tertiary basalt and tuff (David John, USGS, written commun., 1991). Neither quartz nor adularia has distinctive absorption features in the VNIR wavelength region and, therefore, this type of altered rock does not produce CRC image anomalies. Areas labeled 590 represent locations that have not been evaluated by the authors, but generally correspond to altered areas mapped by John (written commun., 1991). The samples that we collected and analyzed (nos. 50, 54, and 55) are argillized tuffs that have anomalously high amounts of As, Hg, Sb, Ag, and Tl, as well as Mo, Ni, and W (table 1 and map, area P).

Uncertainty about the presence of hydrothermal alteration arises for several reasons. For instance, weak alteration is sometimes difficult to validate either in the field or by using reflectance spectroscopy and X-ray diffraction (sample nos. 225, 226, 274, 275, 279, 467, 468, and 579). In most of these areas, alteration is suggested by the probable presence of alteration minerals or by field relations, such as bleaching of localized bedrock areas. Another problematic situation involves the presence of a mixture of hydrothermally altered and unaltered rocks where the altered rocks may not be in place (sample nos. 29, 126, 542, and 572). Additionally, sedimentary and metasedimentary rocks that contain limonitic and hydroxyl minerals are commonly problematic because these minerals may be present due to regional or contact metamorphism, instead of hydrothermal alteration (sample nos. 21, 100, 104, 310, and 556). These areas of probable hydrothermally altered rocks constitute 8 percent of the total number of CRC image anomalies, which is equivalent to about 3 percent of the area of anomalies.

Unaltered Rocks

Approximately 16 percent of the 829 CRC image anomalies, or about 6 percent of the area covered by these anomalies, proved to consist of unaltered rocks. These areas may be placed in one of the following categories, which are listed in order of decreasing frequency of occurrence: (1) tuffaceous rocks, (2) argillic sedimentary and metasedimentary rocks, (3) volcanic rocks, (4) dry grass+soil, (5) carbonate rocks, and (6) intrusive rocks.

Tuffaceous rocks that contain zeolite minerals (for example, clinoptilotite and heulandite) and, less commonly, opal have low reflectance in TM band 7 (fig. 2*V* and *Z*, respectively) and yield high TM5/TM7 values that make them indistinguishable from hydrothermally altered rocks in TM CRC images. X-ray diffraction is typically necessary for identifying zeolite minerals, as some lack diagnostic VNIR absorption features. Several samples that contain zeolites and appear to be unaltered are geochemically anomalous with respect to thallium (sample nos. 68, 92, 96, 114, 180, 213, 214, 404, and 426).

Sedimentary and metasedimentary rocks that contain argillic (such as kaolinite, fig. 2*F*) and phyllic (such as muscovite, fig. 2*P*) alteration minerals also exhibit high TM5/TM7 values because of the Al-OH absorption features that occur in the TM7 band. In some areas, these rocks are also limonitic due to weathering of ferromagnesian and opaque minerals that do not reflect hydrothermal alteration.

Most of the unaltered volcanic rocks that appear as anomalies in the CRC images are flow rock that range in composition from rhyolite to basalt. Amorphous silica, which has broad absorption features within TM band 7 (fig. 2*Z*), is present in many of these rocks. In others, the moderately high TM5/TM7 values evident in the CRC images are related to the presence of I/S that may be due to weathering. In a few areas, the CRC image anomaly appears to be caused by a mixture of basalt boulder, soil, and vegetation (sample no. 562).

Dry vegetation, such as cheat grass, is characterized by water absorption and, hence, a high TM5/TM7 range of values (Rowan and others, 1987). In addition, the lack of chlorophyll results in high TM3/TM1 values that are similar to Fe^{3+} minerals. In some areas of sparse grass, tan soil contributes to the high TM5/TM7 values due to its kaolinite and (or) I/S content.

Carbonate rocks commonly have an intense CO_3 absorption feature centered near 2.30 μm (fig. 2*R*). Although this feature occurs on the long-wavelength edge of TM band 7, high TM5/TM7 values result where the feature is intense. This feature is absent or weak in carbonate rocks that contain even moderate amounts of organic matter and have been subjected to high temperatures (Crowley, 1986; Rowan and others, 1992).

Where intrusive rocks appear as CRC image anomalies, chlorite±I/S is present and accounts for the high TM5/TM7 values (see fig. 2*S*, *C–E*, respectively). Although these minerals may be caused by propylitic alteration, we have not attempted to map this type of alteration.

Unevaluated Areas

As mentioned previously, most of the unevaluated areas, which constitute approximately 28 percent of the CRC image anomalies, are small (about 5 percent of anomalous areas). However, some of these areas may be especially important because of their moderate size and (or) proximity to extensive altered areas. The areas near samples 175, 233, 249, 251, and 463 are notable in this respect.

SUMMARY

Field and laboratory evaluations of 642 of the 829 areas delineated in Landsat TM CRC images indicate that approximately 88 percent of the area encompassed by the anomalies is either definitely hydrothermally altered or probably hydrothermally altered. Geochemical analyses indicate that about 19 percent of the altered areas have at least one of the anomalous elements listed in table 4.

In the western part of the quadrangle, the largest areas of hydrothermally altered rocks are located in the Peavine-Wedekind, Olinghouse, and Pyramid mining districts. In the eastern part of the quadrangle, the largest areas are located in the southern Stillwater Range, northern and southern Sand Springs Range, near Fairview Peak, and in the Westgate area.

Determinations of the alteration mineralogy resulted in the identification of 24 minerals. In general, the dominant minerals are hematite, goethite, jarosite, kaolinite, pyrophyllite, alunite, chlorite, and varying proportions of I/S. Most of the geochemically anomalous samples are located in mining areas. However, some anomalies, including anomalously high gold values, occur where no mines or prospects are documented. Unaltered CRC anomalies consist of zeolitic tuffs, sedimentary and metasedimentary rocks containing phyllosilicate and (or) carbonate minerals, glassy volcanic rocks, and dry grass±soil. Slightly altered intrusive rocks constitute a minor category. Most of the unevaluated CRC anomalies are small (5 percent of areas of anomalies). However, some are located near geochemically anomalous hydrothermally altered rocks and, therefore, warrant evaluation.

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Table 1.—Description of CRC image anomalies evaluated through laboratory and field studies

[Sample numbers and locations refer to the map. The following designations are listed as prefixes to the sample numbers: A, verified hydrothermally altered rocks; A?, probable altered rocks; U, unaltered rocks. Mineralogical determinations were made by analyzing visible and near-infrared reflectance spectra and X-ray diffraction patterns of selected samples. The distinction among high, medium, and low illite/smectite (I/S) is discussed in the section on Laboratory Analyses. Geochemical anomalies are noted for elements in samples that exceed the threshold values listed in table 4]

Map area	Sample no.	Latitude	Longitude	Field description	Mineralogy	Geochemical anomalies
	U10	39°45′25″	119°40′41″	Hematitic, rhyolitic flow rock—not sampled.	No analysis	No analysis.
	A11	39°16′09″	118°19′08″	Moderately argillized tuff	Kaolinite, goethite	None.
	A12	39°15′45″	118°18′56″	Diorite with pyrite	High I/S, goethite, chlorite(?)	Do.
	A13	39°14′26″	118°23′40″	Altered, fine-grained air-fall tuff	High I/S	Tl.
	A16	39°02′35″	118°17′44″	Epidotized lithic tuff and limestone	Epidote, calcite, I/S	None.
J	U17	39°01′31″	118°18′08″	Granodiorite	Chlorite, medium I/S	Do.
	A18	39°00′56″	118°23′40″	Highly altered volcanic rock	Kaolinite, high I/S, hematite, jarosite	No analysis.
	A19	39°00′50″	118°26′07″	Brecciated, silicified rock	Hematite, alunite, kaolinite, low to medium I/S.	Ag, Hg, Mo, Pb, Tl.
O	A20	39°56′53″	118°52′51″	Fresh, pyritic, silicified rock	Medium to high I/S, goethite	Tl.
	A?21	39°15′43″	118°21′31″	Limestone and hornfels	None	Ag, Cu.
	A22	39°03′06″	118°01′55″	Argillized lithic tuff	High I/S, goethite	Tl.
	A23	39°02′39″	118°00′53″	Bleached, argillized, pyritic rock	Medium to high I/S, kaolinite/smectite, goethite, jarosite, chlorite.	Hg, Tl.
	A24	39°03′01″	118°05′44″	Weakly altered volcanic rocks	Opal	None.
	A25	39°01′46″	118°07′25″	Argillized lithic tuff	Kaolinite	Do.
	A26	39°03′21″	118°02′25″	Argillized volcanic rock	Medium I/S	Do.
	A27	39°06′36″	118°05′57″	Argillized lithic tuff	Kaolinite, goethite	Do.
	A28	39°06′08″	118°11′10″	Limonitic, argillized tuff and quartzite	Jarosite, goethite/hematite, medium to high I/S.	Cu, Te, Tl.
	A?29	39°06′21″	118°11′29″	Unaltered andesite and pyritic lithic tuff.	High I/S, biotite	No analysis.
	U30	39°12′14″	118°08′49″	Cheat grass—not sampled	No analysis	Do.
	A31a	39°19′56″	118°06′45″	White marble with gypsum	Calcite, gypsum	None.
	A31b	39°19′56″	118°06′45″	Limonitic granodiorite	Chlorite, I/S	No analysis.
	A32	39°26′59″	118°03′01″	Weakly altered latite	High I/S	Hg, Tl.
	A33	39°22′21″	118°05′40″	Fine-grained, pyritic rhyolite	Halloysite, goethite, jarosite, low I/S	None.
K	A34	39°17′38″	118°02′08″	Weakly argillized tuff	High I/S	Ag.
K	A35	39°17′03″	118°02′38″	Limonitic, argillized, andesitic tuff	Goethite, medium I/S, chlorite	Tl.
K	A36	39°17′18″	118°03′07″	Medium-gray limestone	Tremolite	None.
	A39	39°23′52″	118°08′24″	Highly altered, pyritic rhyolite	Jarosite, medium to high I/S, NH^{4+}-bearing mineral.	Tl.
K	A40	39°20′09″	118°03′48″	Limonitic siltite and shale	Medium I/S, goethite	Hg, Tl.
	A41	39°18′40″	118°07′07″	Argillized granodiorite	Kaolinite/smectite(?), goethite	None.
A	A42	39°34′48″	119°44′39″	Highly argillized, limonitic rock	Alunite, hematite	Do.
P	A50	39°25′36″	119°04′45″	Banded, limonitic, argillized tuff	Kaolinite, jarosite, goethite, low I/S	As, Sb, Hg, Mo, Tl.
P	A51	39°25′23″	119°04′43″	Limonitic, argillized tuff—not sampled	No analysis	No analysis.
P	A52	39°25′17″	119°04′24″	Limonitic soil—not sampled	do.	Do.
P	A53	39°25′19″	119°04′31″	Limonitic soil—not sampled	do.	Do.
P	A54	39°24′44″	119°03′45″	Limonitic, altered lithic tuff	Goethite, jarosite, low I/S	Ag, Hg, As, Ni, W, Tl.
P	A55	39°24′58″	119°03′22″	Limonitic, argillized tuff with boxwork	Low I/S, hematite/goethite	Ag, Hg, Tl.
P	U56	39°25′45″	119°01′28″	Cheat grass—not sampled	No analysis	No analysis.
	U57	39°26′57″	119°13′22″	White, pink, dark-gray volcanic rock and sedimentary rocks.	Zeolite, muscovite	None.
	A58	39°15′46″	119°14′49″	Limonitic, argillized tuff	Jarosite, low I/S	Do.
	A59	39°26′03″	118°33′02″	Bleached, friable, diatomaceous rock	I/S, amorphous silica	Do.
	U60	39°14′21″	118°46′52″	Gray, glassy, fractured volcanic rock	Opal	Do.
	U61	39°12′14″	118°47′23″	Limonite-stained basalt	None	Do.
	A62	39°14′29″	118°43′42″	Altered tuff	Opal	Do.
	A63	39°52′28″	118°42′48″	Limonitic, fractured, silicified rock	Jarosite, high I/S	Tl.
	A?64	39°52′39″	118°42′23″	Limonitic breccia—not sampled	No analysis	No analysis.
	A65	39°53′11″	118°41′57″	Bleached, highly altered rock	Gypsum, jarosite	Hg, Tl, Sb.
	A?66	39°52′50″	118°43′07″	Limonitic rock and bleached, altered rock—not sampled.	No analysis	No analysis.
	U67	39°59′13″	118°47′21″	Zeolitized rock	Zeolite	None.

Table 1.—Description of CRC image anomalies evaluated through laboratory and field studies—Continued

Map area	Sample no.	Latitude	Longitude	Field description	Mineralogy	Geochemical anomalies
	U68	39°59′33″	118°47′41″	Zeolitized soil and rock	Zeolite(?)	Tl.
	U69	39°59′39″	118°47′58″	Zeolitized soil and rock—not sampled	No analysis	No analysis.
O	A70	39°56′52″	118°52′49″	Limonitic tuff	Goethite, high I/S	Zn, Tl.
O	A71	39°56′40″	118°52′18″	Limonitic tuff and bleached tuff—not sampled.	No analysis	No analysis.
O	A72	39°56′25″	118°51′45″	Highly argillized, fractured zone of volcanic rock.	Halloysite, hematite	Hg, Ag, Tl.
C	A73	39°23′08″	119°42′34″	Limonitic, altered tuff	Medium I/S, jarosite, chlorite, hematite, pyrophyllite, alunite.	Te.
C	A74	39°23′03″	119°42′07″	Altered volcanic rock	Hematite, pyrophyllite	Te, Tl.
C	A75	39°22′32″	119°40′30″	Altered lithic tuff	Low I/S, pyrophyllite	None.
	U76	39°20′51″	119°38′18″	Unaltered, dacitic flow rock	I/S, biotite	Do.
	A77	39°19′54″	119°38′43″	Propylitized andesite	Chlorite, I/S	Cu.
	A78	39°18′53″	119°38′21″	Altered volcanic rock	Medium I/S, hematite	Te.
	A79	39°19′08″	119°38′11″	Intensely argillized andesite	Alunite	Hg, Te.
	A80	39°17′55″	119°38′36″	Argillized andesite	Dickite, hematite	Pb, Bi, Te.
	A81	39°19′13″	119°38′41″	Phyllically altered volcanic rock	High I/S, hematite	Ag, Cu, Pb, Zn, Te.
C	A82	39°23′00″	119°38′14″	Limonitic, intensely argillized volcanic rock.	Alunite, hematite	Hg, Te.
C	A83	39°23′43″	119°38′33″	Argillized tuff	Alunite, hematite, kaolinite	Do.
B	A84	39°27′25″	119°38′30″	Argillized tuff	Alunite	Pb, Hg, Te.
B	A85	39°27′34″	119°38′26″	Limonitic, altered tuff	Alunite, hematite	As, Bi, Sb, Hg, Ag, Pb, Te.
B	A86	39°27′42″	119°38′21″	Argillized, limonitic rock	do.	Hg, Pb, Te, Tl.
B	A87	39°27′45″	119°37′54″	Lithic tuff with opaline fragments and pyrite.	Low I/S	Hg, Te.
	U88	39°26′26″	119°07′54″	Clayey, tan soil	do.	None.
F	A88a	39°39′54″	119°22′35″	Argillized tuff with boxwork—not sampled.	No analysis	No analysis.
F	A88b	39°40′05″	119°22′27″	Intensely fractured, argillized tuff—not sampled.	do.	Do.
F	A88c	39°40′42″	119°22′06″	Argillized tuff and silicified tuff with pyrite—not sampled.	do.	Do.
F	A88d	39°41′30″	119°21′39″	Silicified, bleached lithic tuff with pyrite—not sampled.	do.	Do.
F	A88e	39°41′33″	119°21′44″	Slightly argillized, andesitic flow rock—not sampled.	do.	Do.
F	A88f	39°41′25″	119°21′45″	Silicified lithic tuff and argillized lithic tuff—not sampled.	do.	Do.
	U88h	39°31′21″	119°17′34″	Light-tan soil and blocks of basaltic rocks—not sampled.	do.	Do.
	A89	39°48′28″	118°52′49″	Limonitic, fractured siltstone	Muscovite, goethite	Hg, As, Sb, Tl.
K	A90	39°18′34″	118°04′08″	Limestone and mica schist with pyrite	Calcite	None.
K	A91	39°18′15″	118°03′49″	Limonitic, altered tuff	Hematite, goethite, medium I/S	Ag, Hg, Tl.
	U92	39°07′49″	118°01′18″	Green and white tuff	Zeolite, muscovite	Tl.
	A93	39°03′49″	118°05′54″	Limonitic, altered tuff	High I/S, hematite	Tl.
	A94	39°03′51″	118°07′18″	Pyritic phyllite and vein quartz	High I/S, chlorite	Hg, Bi, B.
	A95	39°26′21″	118°15′09″	Altered tuff	High I/S	None.
	U96	39°35′20″	118°16′55″	Fresh, unaltered tuff	Medium I/S, zeolite	Tl.
	A97	39°37′20″	118°17′17″	Altered tuff	Medium I/S	Hg, Tl.
	A98	39°37′32″	118°16′37″	Argillized rock	Jarosite, high I/S	Te.
	A99	39°37′25″	118°16′27″	Limonitic, clayey rock	Hematite, medium I/S, jarosite(?)	Do.
	A?100	39°37′21″	118°16′03″	Limonitic, clayey rock—not sampled	No analysis	No analysis.
I	A101	39°40′32″	118°18′10″	Limonitic, altered tuff	Hematite, calcite, kaolinite, high I/S	Hg.
I	A102	39°40′27″	118°17′07″	Limonitic, silicified tuff	Kaolinite, hematite, goethite, medium to high I/S.	As, Hg, Mo, B, Tl.
I	A103	39°40′19″	118°16′54″	Silicified rock	Hematite, high I/S	Tl.
	A?104	39°48′25″	118°12′32″	Siltstone with limestone and shale	None	Ni.
	U105	39°52′05″	118°10′35″	Dark-gray limestone	Calcite	None.
	A106	39°58′17″	118°03′40″	Silicified rock	Dickite, hematite	Hg.
	A107	39°55′33″	118°03′32″	Argillized tuff	Zeolite(?)	None.
	A108	39°56′06″	118°00′29″	Green, argillized tuff	Tourmaline, chlorite	Hg, Tl.
L	A109	39°51′26″	118°03′01″	Limonitic, argillized, silicified rock	Goethite	Cu.

Table 1.—Description of CRC image anomalies evaluated through laboratory and field studies—Continued

Map area	Sample no.	Latitude	Longitude	Field description	Mineralogy	Geochemical anomalies
L	A110	39°50′55″	118°03′52″	Pyritic granodiorite	Low I/S, chlorite, hematite	None.
L	U111	39°50′42″	118°04′51″	Olive-drab soil and lithic-tuff fragments—not sampled.	No analysis	No analysis.
L	U112	39°50′05″	119°04′09″	Granodiorite—not sampled	do.	Do.
L	A113	39°50′11″	118°03′00″	Argillized granodiorite	Kaolinite, goethite	Hg.
	U114	39°37′52″	118°17′02″	Unaltered tuff	Zeolite	Tl.
	A115	39°37′41″	118°16′10″	Argillized tuff	High I/S	Te.
I	A116	39°38′56″	118°16′17″	Argillized tuff	Kaolinite, hematite	None.
I	A117	39°39′31″	118°16′46″	Slightly argillized tuff	Medium I/S, goethite	Hg, Tl.
I	A118	39°39′14″	118°16′07″	Argillized rock	Kaolinite, goethite	Hg.
I	A119	39°40′04″	118°16′38″	Silicified rock	Kaolinite	None.
	U120	39°46′17″	118°15′09″	Dark-gray siltstone	None	Do.
L	A121	39°50′57″	118°01′28″	Limonitic, silicified rock	Medium I/S, hematite, jarosite(?)	Sb, Hg, Ag, Cu, Mo, Pb.
L	A122	39°51′01″	118°01′54″	Altered granite breccia	Kaolinite, high I/S	None.
L	A123	39°50′17″	118°02′02″	Argillized rhyolite and granite	High I/S, kaolinite	Hg, Ag.
L	A124	39°50′39″	118°01′42″	Argillized volcanic rock	I/S, goethite	Hg.
L	A125	39°49′52″	118°01′49″	Argillized volcanic rock	Kaolinite, hematite	None.
L	A?126	39°50′12″	118°02′33″	Argillized tuff and unaltered tuff—not sampled.	No analysis	No analysis.
	A127	39°49′20″	118°04′14″	Pyritic granodiorite	Hematite, jarosite, medium I/S	None.
L	A128	39°49′14″	118°04′55″	Argillized rhyolite	Hematite, dickite, chlorite(?)	B.
L	U129	39°49′09″	118°04′36″	Coarse-grained, unaltered granite	Chlorite(?), I/S(?)	None.
L	A130	39°48′51″	118°04′26″	Limonitic, pyritic quartzite	Chlorite, medium I/S, hematite	Do.
L	U131	39°48′37″	118°04′50″	Coarse ultramafic rock	High I/S, chlorite	Do.
L	A132	39°47′43″	118°05′08″	Argillized volcanic rock	Kaolinite, jarosite	Hg, Tl.
	U133	39°36′59″	118°13′42″	Limonitic granodiorite—not sampled	No analysis	No analysis.
	A134	39°36′06″	118°13′19″	Argillized volcanic rock	Chlorite(?)	Tl.
	A135	39°35′49″	118°13′24″	Argillized volcanic rock	Medium I/S	Do.
	A136	39°35′34″	118°13′40″	Propylitized volcanic rock	Chlorite	None.
	A137	39°33′47″	118°12′06″	Silicified rock	High I/S, goethite, hematite	Tl.
	A138	39°33′37″	118°11′59″	Silicified rock	Medium I/S, jarosite	Do.
	A139	39°21′15″	118°21′10″	Argillized volcanic rock	Kaolinite	Hg.
K	A140	39°19′13″	118°03′00″	Argillized, silicified rock	Medium I/S	Do.
K	A141	39°18′54″	118°02′59″	Limonitic, argillized volcanic rock	Medium I/S, jarosite	Ag, Hg, Tl.
	U142	39°20′04″	118°27′17″	Tan, unaltered sediments	Calcite	None.
	U143	39°19′55″	118°27′05″	Tan, unaltered sediments	do.	Do.
	U144	39°19′51″	118°26′51″	Tan sediments—not sampled	No analysis	No analysis.
	A?145	39°16′55″	118°22′41″	Limonitic sedimentary rock	Chlorite, hematite	As.
J	A146	39°13′32″	118°21′37″	Pyritic, argillized granodiorite	Hematite, medium I/S	Tl.
J	A147	39°13′55″	118°22′17″	Argillized granodiorite	Hematite, low I/S	None.
J	A148	39°12′46″	118°21′04″	Argillized granodiorite	Hematite, muscovite	Do.
J	A149	39°13′20″	118°20′19″	Pyritic, argillized granodiorite	Low I/S	Mo.
	A150	39°15′11″	118°11′32″	Limonitic, silicified volcanic rock	Medium I/S, hematite	Ag, Tl.
	A151	39°15′09″	118°10′02″	Argillized rock and silicified rock—not sampled.	No analysis	No analysis.
	A152	39°15′43″	118°08′35″	Argillized lithic tuff	I/S	None.
	A153	39°16′31″	118°08′31″	Argillized, silicified rock	High I/S	Ag, Tl.
	A154	39°16′30″	118°08′40″	Argillized volcanic rock	High I/S, hematite	Tl.
	A155	39°16′43″	118°08′22″	Argillized, pyritic volcanic rock—not sampled.	No analysis	No analysis.
	A156	39°15′02″	118°08′14″	Argillized crystal tuff	Low I/S	None.
	A157	39°14′09″	118°11′31″	Argillized tuff	Hematite, low I/S, chlorite	Ag, Tl.
	A158	39°10′41″	118°12′52″	Argillized crystal tuff	Hematite, high I/S	None.
	A159	39°04′22″	118°07′03″	Argillized lithic tuff—not sampled	No analysis	No analysis.
	A160	39°02′13″	118°00′19″	Argillized crystal tuff	Hematite, kaolinite	Ag.
	A162	39°00′47″	118°09′07″	Limonitic, pyritic sediments	do.	Te.
	A163	39°07′09″	118°11′05″	Limonitic quartzite	Jarosite, high I/S	Au, Mo, Te.
	A164	39°06′59″	118°13′36″	Argillized lithic tuff	Kaolinite	Hg.
	A165	39°06′50″	118°13′36″	Argillized lithic tuff	Low I/S, hematite	Do.
	U166	39°06′59″	118°14′08″	Limonitic biotite-granite—not sampled	No analysis	No analysis.
	A167	39°04′00″	118°16′25″	Slightly argillized lithic tuff	Zeolite	Tl.

Table 1.—Description of CRC image anomalies evaluated through laboratory and field studies—Continued

Map area	Sample no.	Latitude	Longitude	Field description	Mineralogy	Geochemical anomalies
	A168	39°01′35″	118°16′37″	Very limonitic, intensely altered rock	Low I/S, goethite	Te.
	A169	39°01′04″	118°15′58″	Argillized volcanic rock	High I/S, hematite	Te, Tl.
	A170	39°01′20″	118°15′26″	Argillized, silicified volcanic breccia	High I/S	Do.
	A171	39°02′01″	118°19′19″	Limonitic, argillized volcanic breccia and silicified volcanic breccia.	Hematite, high I/S	Tl.
	A172	39°01′36″	118°19′22″	Limonitic, argillized volcanic rock and silicified volcanic rock.	Hematite, kaolinite/smectite	Te.
	A173	39°01′28″	118°19′58″	Pyritic quartzite	Chlorite(?)	None.
	A?174	39°01′36″	118°20′44″	Fine-grained, iron-rich rock	High I/S, hematite	Hg, Ag, Tl.
	A175	39°02′54″	118°21′55″	Limonitic, silicified rock	Hematite, high I/S	Hg, Te.
	A176	39°05′41″	118°23′35″	Argillized volcanic rock	Kaolinite, hematite	Hg.
	A177	39°08′10″	118°23′52″	Sheared, altered porphyry	Hematite, muscovite	None.
	U178	39°15′16″	118°42′09″	Volcanic glass	Amorphous silica	Do.
	U179	39°18′10″	119°24′34″	Hematitic-weathering basalt—not sampled.	No analysis	No analysis.
	U180	39°12′09″	119°34′59″	Unaltered crystal tuff	Zeolite	Tl.
	U181	39°10′42″	119°33′12″	Soil, tuff, and andesite boulders—not sampled.	No analysis	No analysis.
	U182	39°12′07″	119°37′57″	Unaltered tuff	Zeolite	None.
	U183	39°01′29″	119°41′34″	Sand and gravel—not sampled	No analysis	No analysis.
	U184	39°05′02″	119°38′55″	Marble	Calcite	None.
	A185	39°04′52″	119°38′58″	Altered leucocratic granite	High I/S	Do.
	U186	39°02′38″	118°34′11″	Cheat grass—not sampled	No analysis	No analysis.
	A187	39°03′51″	119°32′57″	Argillized granite	High I/S, chlorite	Ag, Cu.
	A188	39°04′22″	119°39′21″	Silicified rock	Kaolinite/smectite, hematite	None.
E	A190	39°02′12″	119°20′25″	Weakly argillized volcanic rock	High I/S	Do.
E	A191	39°01′37″	119°20′50″	Silicified volcanic rock	do.	Te, Tl.
E	A192	39°01′38″	119°21′25″	Argillized volcanic rock	High I/S, alunite, jarosite(?)	Hg, Pb, Tl, Te.
E	A193	39°00′25″	119°21′13″	Limonitic, silicified rock	Hematite, high I/S, tremolite	Cu.
E	A194	39°00′13″	119°20′55″	Limonitic, weakly argillized tuff	High I/S, goethite	Ag, Te, Tl.
M	A195	39°11′38″	119°28′54″	Argillized andesite	Kaolinite, hematite	Hg.
M	A196	39°12′26″	119°27′26″	Limonitic, argillized andesite and silicified andesite.	Medium I/S, goethite	Ag, Tl.
M	A197	39°09′52″	119°27′35″	Argillized, silicified volcanic rock	Jarosite(?), I/S	Te.
M	U198	39°10′13″	119°26′30″	Unaltered basalt	Goethite	None.
M	U199	39°10′29″	119°25′17″	Basalt and colluvium—not sampled	No analysis	No analysis.
M	A200	39°11′09″	119°26′57″	Argillized volcanic rocks—not sampled	do.	Do.
F	A201	39°01′33″	119°22′12″	Limonitic, argillized tuff	High I/S	Ag, Hg, Tl, Mo.
	A202	39°52′22″	119°04′52″	Slightly altered diorite and silicified rock.	Epidote, high I/S, hematite	Hg, Tl.
	A203	39°52′56″	119°05′30″	Gossan	Hematite	Ag, B, Te, Tl.
	A204	39°52′50″	119°06′28″	Limonitic, silicified rock—not sampled	No analysis	No analysis.
	A205	39°54′04″	119°01′23″	Argillized volcanic rock	High I/S	Tl.
	A?206	39°55′41″	118°59′25″	Hematitic, altered volcanic rock—not sampled.	No analysis	No analysis.
	A207	39°57′56″	119°04′02″	Silicified volcanic rock	Jarosite, low I/S	None.
	U208	39°02′43″	118°47′24″	Red, green, white crystal tuff	Low I/S	Tl.
	A?209	39°02′25″	118°47′11″	Breccia	Zeolite	Do.
	U210	39°05′21″	118°45′58″	Clayey soil	do.	None.
	U211	39°07′36″	118°44′30″	Soil	Low I/S	Do.
	U212	39°07′41″	118°44′37″	Bright-green tuff	Medium I/S	Te, Tl.
	U213	39°06′07″	118°43′27″	White-green lithic tuff	Zeolite	Pb, Te, Tl.
	U214	39°05′53″	118°43′19″	Red lithic tuff	Low I/S, hematite, zeolite	Tl.
	A216	39°14′52″	118°42′15″	Silicified lithic tuff	Low I/S, jarosite	Do.
	A217	39°09′47″	118°34′53″	Limonitic, altered tuff	Kaolinite, goethite, hematite	Hg, As, Sb, Te, Tl.
	A218	39°10′24″	118°35′15″	Slightly argillized, white to gray tuff	Alunite, jarosite, high I/S	Hg.
	A219	39°09′56″	118°35′41″	Limonitic, weakly argillized tuff	High I/S, jarosite	Hg, Mo, Te, Tl.
	U220	39°09′47″	118°35′22″	Soil with tuff fragments—not sampled	No analysis	No analysis.
	U221	39°07′06″	118°32′06″	Soil; white, pink, and purple lithic tuff	Zeolite	None.
	A222	39°07′01″	118°32′11″	Moderately argillized lithic tuff	Kaolinite/smectite, hematite	Mo.
	A?223	39°07′06″	118°32′19″	Limonitic, argillized tuff	Kaolinite, low I/S	Tl.

Table 1.—Description of CRC image anomalies evaluated through laboratory and field studies—Continued

Map area	Sample no.	Latitude	Longitude	Field description	Mineralogy	Geochemical anomalies
	A224	39°03′48″	119°39′15″	Limonitic, weakly argillized tuff	do.	Hg, Tl.
	A?225	39°03′25″	118°39′07″	Weakly altered tuff	Opal(?)	None.
	A?226	39°03′10″	118°38′50″	Bleached, argillized tuff and flow rock	Low I/S	Te.
	A227	39°00′42″	118°54′15″	Limonitic, altered rock	Jarosite, high I/S	Ag, Hg, Mo, Pb, Te, Tl.
	A228	39°00′52″	118°54′29″	Limonitic, weakly argillized tuff	Chlorite(?)	Tl.
	A229	39°00′46″	118°54′34″	Altered tuff	Jarosite, high I/S	Ag.
	A230	39°09′42″	118°35′40″	Tan to pink, weakly argillized tuff	Low I/S	Tl.
	A231	39°02′35″	118°58′42″	Limonitic, silicified metavolcanic rock	Muscovite, chlorite(?)	Do.
	A232	39°02′58″	118°59′15″	Pink, silicified metavolcanic rock	Muscovite	Do.
	A233	39°03′22″	118°59′52″	Limonitic, altered breccia with gypsum veins.	Jarosite, high I/S, gypsum, goethite, muscovite.	Mo, Ni, Tl.
E	A234	39°03′06″	119°14′20″	Epidotized quartz monzonite	Medium I/S, epidote, chlorite	Cu.
E	A235	39°02′50″	119°15′56″	Limonitic, silicified tuff	Muscovite, hematite, kaolinite/smectite	Au, Ag, Cu, Mo, Bi, Te, Tl.
E	A236	39°01′42″	119°15′56″	Limonitic, silicified tuff with talc	Talc, high I/S	Te, Tl.
E	A237	39°00′53″	119°17′01″	White, light-green, pyritic quartz monzonite.	Low to medium I/S, chlorite(?), epidote	Hg, Ag, Cu, Te.
E	A238	39°00′10″	119°17′31″	Limonitic, pyritic, epidotized quartz monzonite with talc veins.	Halloysite, talc, epidote, muscovite, chlorite, medium I/S.	Hg, Cu, Mo, B, Te, Tl.
E	U239	39°02′19″	119°17′32″	Limonitic gravel	Medium I/S, goethite	None.
E	U240a	39°02′17″	119°17′25″	Bright tuff gravel	Amorphous silica	Do.
E	U240b	39°02′17″	119°17′25″	Bright tuff, unaltered	Low I/S, goethite	Do.
E	U241	39°02′50″	119°20′13″	Limonitic andesite and soil	Medium I/S	Ag.
E	U242	39°03′12″	119°19′47″	Soil and dry grass—not sampled	No analysis	No analysis.
E	A243	39°04′50″	119°20′13″	Argillized lithic tuff	Chlorite, epidote, high I/S	Hg, Te, Tl.
E	U244	39°04′32″	119°21′00″	Limonitic volcanic rock	High I/S	None.
E	A245	39°03′50″	119°21′03″	Limonitic, argillized andesite	Muscovite	Do.
E	U246	39°07′20″	119°19′37″	Limonitic tuff	None	Do.
E	U247	39°05′40″	119°22′43″	Dolomite with calcite veins	Calcite	Ag.
E	U248	39°05′29″	119°22′20″	Dolomite boulders—not sampled	No analysis	No analysis.
E	A249	39°05′29″	119°22′51″	Pyritic andesite	Low I/S, chlorite, goethite	Cu.
E	A250	39°04′57″	119°21′59″	Greenish andesite	Goethite, jarosite, high I/S	Ag, Te, Tl.
E	A251	39°04′57″	119°22′26″	White, silicified rock	Epidote, zeolite(?)	Ni, Te.
E	U252	39°05′40″	119°23′48″	Limonitic andesite	High I/S	Te, Tl.
E	A253	39°06′34″	119°18′12″	Limonitic, altered tuff	Low I/S	Te.
E	A254	39°08′18″	119°20′50″	Limonitic, altered tuff	Low to high I/S, hematite, muscovite, jarosite.	None.
G	A255	39°51′43″	119°36′58″	Limonitic, argillized lithic tuff	High I/S, hematite, kaolinite	Au, Ag, As, Sb, Hg, Bi, Cu, Pb, Sn, Te, Tl.
G	A256	39°51′24″	119°36′53″	Propylitized, welded lithic tuff and argillized, welded lithic tuff.	Medium I/S, dickite, pyrophyllite, chlorite.	Ag, Hg, As, Pb, Zn, Te, Tl.
G	A257	39°50′58″	119°36′07″	Limonitic, silicified breccia	Hematite, jarosite, I/S	Sb, Hg, Ag, Cu, Pb, Te, Tl.
G	A258	39°50′40″	119°36′04″	Propylitized ash-flow tuff and weakly argillized ash-flow tuff.	High I/S, chlorite, goethite, hematite	Hg, Ag, Te, Tl.
G	A259	39°52′07″	119°35′13″	Weakly argillized dike and silicified volcanic rock.	Medium I/S, goethite, diaspore, hematite.	Ag, Pb, Te.
H	A260	39°50′49″	119°28′27″	Limonitic, argillized tuff	High I/S, jarosite, hematite	As, Ag, Mo, Pb, Tl.
H	A261	39°50′50″	119°28′34″	Bleached, argillized tuff	High I/S, gypsum, jarosite(?), kaolinite	As, Tl.
H	A262	39°50′35″	119°28′19″	Intense limonitic stain, weakly to moderately argillized rock.	Jarosite, medium to high I/S, hematite, goethite.	As, Ag, Pb, Te, Tl.
H	A263	39°50′01″	119°28′03″	Altered, limonitic granodiorite and intensely altered rhyolite.	High I/S	As, Hg, Ag, Bi, Mo, Pb, Sn, Zn, Te, Tl.
H	A264	39°49′58″	119°29′08″	Intense hematitic stain on altered tuff	Diaspore, pyrophyllite, muscovite, kaolinite(?).	As, Cu, Mo, Pb, Sn, Te, Tl.
H	A265	39°49′58″	119°29′20″	Vuggy, silicified rock	Alunite, pyrophyllite	As, Bi, Mo, Pb, Te, Tl.
H	A266	39°50′07″	119°29′20″	Limonitic, argillized andesite/rhyolite	Pyrophyllite, halloysite, low I/S, hematite	Au, As, Pb, Mo, Te, Tl.
H	A267	39°50′42″	119°27′15″	Argillized rock and siliceous rock with pyrite.	Kaolinite, jarosite, pyrophyllite	Tl.
	A268	39°56′25″	119°17′04″	Pyrite-rich metasedimentary rocks	No analysis	Te, Tl.
	A269	39°56′26″	119°16′52″	Altered volcanic rock	Medium I/S, jarosite	As, Te.
	A270	39°56′22″	119°16′40″	Limonitic, fractured, silicified rock	Alunite, jarosite, goethite, hematite, gypsum, I/S.	As, Hg, Mo, Te.

Table 1.—Description of CRC image anomalies evaluated through laboratory and field studies—Continued

Map area	Sample no.	Latitude	Longitude	Field description	Mineralogy	Geochemical anomalies
	A271	39°56′07″	119°16′50″	Limonitic, quartz-pyrite-sericite rock	Muscovite, goethite, hematite, jarosite	None.
	A272	39°55′55″	119°16′49″	Limonitic, quartz-pyrite-sericite, altered rock.	High I/S, goethite	Ag.
	A?273	39°54′39″	119°37′56″	Tan soil	Low I/S	None.
	A?274	39°55′08″	119°38′01″	Orange-tan, limonitic lithic tuff	None	Hg.
	A?275	39°55′05″	119°37′56″	Green-gray lithic tuff	do.	Tl.
	A?279	39°55′02″	119°37′56″	Lithic tuff	Zeolite, hematite	Hg, Tl.
	A280	39°54′31″	119°36′14″	Iron-stained, purple rhyolite, slightly argillized.	None	Do.
	U282	39°52′48″	119°33′26″	Dry grass—not sampled	No analysis	No analysis.
H	A293	39°50′22″	119°27′42″	Argillized tuff and iron-stained, silicified rock.	Diaspore, jarosite, muscovite, dickite	Bi, Pb, Sn, Tl.
H	A294	39°50′20″	119°27′37″	Argillized tuff and iron-stained, silicified rock.	Pyrophyllite, I/S, diaspore, kaolinite	Pb, Tl.
H	A295	39°50′16″	119°27′46″	Fine-grained, silicified rock	Pyrophyllite, jarosite	Bi, Mo, Pb, Tl.
H	A296	39°49′54″	119°28′14″	Fine-grained, silicified rock—not sampled.	No analysis	No analysis.
H	A297	39°49′30″	119°28′18″	Fine-grained, silicified rock—not sampled.	do.	Do.
H	A298	39°50′16″	119°27′28″	Fine-grained, silicified rock	Pyrophyllite, I/S, hematite	Pb, Te, Tl.
H	A299	39°48′29″	119°25′57″	Silicified lithic tuff with pyrite	Medium I/S, hematite, chlorite	Ag, Tl, Te.
	A300	39°46′50″	119°25′18″	Limonitic, silicified lithic tuff and argillized lithic tuff.	Kaolinite, hematite, medium to high I/S, jarosite(?).	Hg, Tl.
	A301	39°46′50″	119°25′30″	Limonitic, silicified lithic tuff and argillized lithic tuff—not sampled.	No analysis	No analysis.
	A302	39°46′41″	119°25′23″	Green, silicified andesite with pyrite	High I/S	Ag.
	A303	39°46′42″	119°25′38″	Moderately to intensely argillized lithic tuff.	Jarosite, high I/S	Hg.
A	A306	39°34′26″	119°51′43″	Limonitic, intensely silicified rock	Alunite, goethite, high I/S	Ag, Pb, Hg, Te, Tl.
A	A307	39°34′27″	119°51′53″	Hematitic, argillized breccia	Hematite, I/S(?)	Ag, Pb, Hg, Te.
	A308	39°38′35″	119°55′47″	Epidotized granodiorite	Tourmaline, epidote	None.
	U309	39°41′22″	119°53′53″	Soil from area of cheat grass	Medium I/S	No analysis.
	A?310	39°41′40″	119°58′56″	Limonitic quartz-muscovite schist	Muscovite, chlorite(?), goethite, hematite	Ag, Zn, Te.
A	A311	39°34′32″	119°48′08″	Limonitic, silicified andesite	High I/S	Hg.
A	A312	39°34′48″	119°48′03″	Limonitic, argillized andesite	High I/S, hematite, goethite	Te, Tl.
A	A313a	39°34′59″	119°47′50″	Red, altered andesite	Kaolinite, goethite, alunite, hematite	None.
A	A313c	39°34′59″	119°47′50″	Red, altered tuff and sediments	Alunite, I/S	Hg, Te, Tl.
A	A314	39°34′40″	119°45′56″	Silicified breccia	Pyrophyllite, hematite, I/S, zunyite, gypsum.	As, Pb.
A	A315	39°34′27″	119°45′23″	Silicified breccia—not sampled	No analysis	No analysis.
A	A316	39°35′31″	119°44′40″	Altered tuff and sediments	Low I/S, alunite, jarosite, goethite, hematite.	None.
A	A317	39°34′14″	119°43′21″	Tan, quartzose rock	Kaolinite, hematite, medium I/S, opal	Te.
	U318	39°32′37″	119°36′15″	Soil with cheat grass	Low I/S	None.
B	U319	39°30′09″	119°37′57″	Soil and quartz fragments	do.	Do.
	U320	39°44′41″	119°44′08″	Soil with quartz and feldspar fragments	do.	Do.
	U321	39°41′34″	119°44′50″	Soil with cheat grass	None	Do.
	A322	39°41′29″	119°44′01″	Limonitic rhyolite	Goethite, amorphous silica(?), I/S, hematite.	Mo.
	U323	39°41′34″	119°43′59″	Soil and diorite	Low I/S, hematite	None.
	U324	39°41′39″	119°43′56″	Cheat grass—not sampled	No analysis	No analysis.
	A400	39°22′47″	118°05′09″	Limonitic, argillized tuff	Kaolinite, low I/S, goethite	Tl.
	A401	39°27′52″	118°06′45″	Argillized, silicified tuff	Medium I/S, jarosite	Do.
	A402	39°28′18″	118°06′39″	Argillized, silicified crystal tuff	Medium to high I/S, goethite	Tl, Te.
	A403	39°28′23″	118°07′09″	Argillized to silicified crystal tuff	Medium I/S, goethite	Ag, Tl.
	U404	39°04′58″	118°47′25″	Unaltered crystal tuff and white to pink lithic tuff.	Low I/S, chlorite(?), zeolite	Tl.
E	A405	39°03′02″	119°15′11″	Limonitic, silicified rock	Goethite, high I/S, jarosite	No analysis.
E	A406	39°01′03″	119°17′35″	Limonitic, argillized, fractured granodiorite.	Chlorite, low and high I/S, goethite	Cu, B.
E	A407a	39°00′36″	119°18′01″	Limonitic, argillized granodiorite	Kaolinite(?), goethite, medium I/S	None.
E	A407b	39°03′26″	119°17′51″	Limonitic, argillized rock and silicified rock with pyrite.	Low I/S, hematite	Te.

Table 1.—Description of CRC image anomalies evaluated through laboratory and field studies—Continued

Map area	Sample no.	Latitude	Longitude	Field description	Mineralogy	Geochemical anomalies
E	A408	39°00′34″	119°19′26″	White, argillized tuff	Low I/S	Tl.
E	A409	39°03′46″	119°20′39″	Limonitic, sericitic rock	High I/S, hematite, goethite	Te, Tl.
	A410	39°21′58″	119°26′54″	Limonitic, silicified rock	Hematite, low I/S	Hg, Te.
	U411	39°20′17″	119°31′10″	Glassy tuff	Low I/S	Te.
A	A412	39°33′10″	119°54′25″	Limonitic, argillized rock	High I/S, goethite	Do.
A	A413	39°33′30″	119°54′24″	Limonitic, altered, andesitic tuff	Goethite, I/S	Do.
O	A414	39°56′44″	118°52′42″	Tan, argillized, silicified, laminated sedimentary rock.	Medium to high I/S	Ag.
O	A415	39°56′30″	118°52′59″	Light-colored, altered lithic tuff	Jarosite, medium I/S	Au, Ag, Tl.
O	A416	39°57′21″	118°52′45″	Tan, fractured, silicified rock with boxwork.	Kaolinite/smectite(?)	Ag, Hg, Tl.
O	A417	39°57′21″	118°52′46″	Tan, fine-grained, argillized rock	Kaolinite, jarosite	Ag, Mo, Tl.
O	A418	39°57′56″	118°52′49″	Green, fine-grained, altered rock	Goethite, low to medium I/S, chlorite	None.
O	A419	39°57′03″	118°51′31″	Tan, laminated, silicified rock	High I/S	Tl.
O	A420	39°57′30″	118°51′39″	White, silicified rock	Medium I/S	Ag.
O	A421	39°57′25″	118°51′33″	White, silicified rock	High I/S	As, Hg, Ag, Tl.
	U422	39°58′59″	118°49′33″	Dark-red rhyolite	None	None.
	U423	39°58′41″	118°49′09″	Pink, white rhyolite—not sampled	No analysis	No analysis.
	U424	39°58′45″	118°48′42″	Yellow, tuffaceous sediment	Zeolite(?)	None.
	U425	39°59′48″	118°46′30″	Yellow, tuffaceous sediment	Zeolite	Do.
	U426	39°59′21″	118°46′06″	Yellow, tuffaceous sediment	do.	Tl.
	A427	39°59′28″	118°45′53″	Bright-green soil	Gypsum, muscovite	No analysis.
G	A428	39°50′53″	119°35′00″	Argillized crystal tuff	High I/S, goethite	Pb, Tl.
G	A429	39°50′42″	119°34′55″	Silicified rock	I/S, hematite	None.
G	A430	39°50′46″	119°35′51″	Argillized volcanic rock	Medium I/S, kaolinite, goethite	Ag, Cu, Pb, Te, Tl.
G	A431	39°50′47″	119°35′16″	Argillized volcanic rock	Pyrophyllite, I/S	Pb, Sn, Tl.
G	A432	39°50′43″	119°35′20″	Argillized volcanic rock	High I/S, jarosite	Ag, Pb, Tl.
G	A433	39°50′39″	119°36′55″	Argillized crystal tuff	Halloysite	Mo, Tl.
H	A434	39°49′45″	119°27′01″	Limonitic, argillized crystal tuff	Jarosite, hematite, high I/S	Pb, Tl.
H	A435	39°50′03″	119°27′16″	Limonitic, argillized crystal tuff	Goethite, pyrophyllite	Pb, Te.
H	A436	39°49′48″	119°28′13″	Colluvium of altered rock—not sampled.	No analysis	No analysis.
F	A437	39°41′25″	119°21′47″	Propylitically altered volcanic rock	High I/S, jarosite	Tl.
F	A438	39°41′25″	119°21′49″	Altered, pyritic volcanic rock	Medium to high I/S, hematite	Hg, Ag, Tl.
F	A439	39°41′25″	119°21′52″	Limonitic, argillized volcanic rock	High I/S, goethite, jarosite	Hg, Tl.
F	A440	39°41′26″	119°21′57″	Argillized tuff and silicified tuff	High I/S, goethite, jarosite, muscovite, hematite.	Hg, Ag, Te, Tl.
F	A441	39°41′33″	119°21′57″	Slightly to moderately argillized rock	High I/S, chlorite(?), jarosite	Pb, Tl.
F	A442	39°41′33″	119°21′50″	Propylitic, green andesite	High I/S	Tl.
F	A443	39°41′35″	119°21′43″	Limonitic, argillized volcanic rock	Kaolinite, goethite, high I/S, hematite	Mo.
F	A444	39°42′00″	119°22′39″	Slightly argillized tuff	High I/S	Hg.
F	A445	39°42′07″	119°23′03″	Limonitic, weakly argillized tuff—not sampled.	No analysis	No analysis.
F	A446	39°41′26″	119°23′22″	Weakly argillized tuff with quartz veins—not sampled.	do.	Do.
F	A447	39°42′04″	119°22′24″	Limonitic crystal tuff	Chlorite, medium I/S, epidote, hematite	None.
F	A448	39°44′12″	119°23′40″	Argillized crystal tuff	High I/S, chlorite, goethite, jarosite	Do.
F	A449	39°42′58″	119°23′05″	Limonitic, argillized crystal tuff	Kaolinite, goethite, high I/S, jarosite	Tl, Hg.
F	A450	39°42′32″	119°22′36″	Limonitic, argillized lithic tuff and crystal tuff.	Kaolinite, goethite	Te.
F	A451	39°42′24″	119°22′18″	Dark-green, epidotized crystal tuff	Epidote	None.
F	A452	39°42′15″	119°22′22″	Limonitic, weakly argillized crystal tuff	Jarosite, I/S, goethite	Do.
N	A454	39°28′04″	119°52′24″	Limonitic, argillized tuff	Kaolinite, jarosite(?), alunite, goethite, hematite, chlorite(?).	Hg, Te.
N	A455	39°27′46″	119°51′24″	Intensely argillized, limonitic tuff	Medium I/S, hematite, goethite	Te, Tl.
N	A456	39°27′11″	119°53′06″	Argillized volcanic rock	do.	Te.
N	A457	39°27′32″	119°54′06″	Limonitic, argillized tuff	Hematite, halloysite	Do.
F	A458	39°39′47″	119°25′03″	Altered andesite	Chlorite, I/S	None.
F	A459	39°39′52″	119°24′47″	Weakly argillized, limonitic, intrusive rock.	High I/S	Hg.
F	A460	39°40′13″	119°24′02″	Limonitic granodiorite	Low and high I/S, chlorite, hematite	Au, Te, Tl.
F	A461	39°40′26″	119°24′25″	Limonitic, slightly argillized granodiorite.	High I/S, chlorite	Ni.

Table 1.—Description of CRC image anomalies evaluated through laboratory and field studies—Continued

Map area	Sample no.	Latitude	Longitude	Field description	Mineralogy	Geochemical anomalies
F	A462	39°40′56″	119°23′18″	Limonitic, altered, intrusive rock	High I/S, goethite	Au, Tl.
F	U463	39°39′10″	119°25′55″	White, tuffaceous sediments	Zeolite	None.
F	A464	39°38′42″	119°23′57″	Bright, slightly altered, intrusive rock	I/S	Do.
F	U465	39°37′25″	119°26′03″	Limonitic ash-flow tuff and rhyolite	do.	Do.
	U466	39°35′43″	119°23′09″	Limonitic, arkosic sedimentary rocks—not sampled.	No analysis	No analysis.
	A?467	39°14′13″	119°44′20″	Weakly argillized volcanic rock	I/S, hematite	Hg.
	A?468	39°14′08″	119°44′43″	Weakly argillized volcanic rock	Low I/S, hematite, goethite, chlorite(?)	Tl.
	A469	39°15′12″	119°37′56″	Argillized volcanic rock	Low I/S	Ag, Hg, Tl.
C	A470	39°23′13″	119°44′27″	Siliceous sinter	Low I/S, opal	None.
D	A471	39°26′14″	119°22′17″	Limonitic, argillized rock and silicified rock—not sampled.	No analysis	No analysis.
D	A472	39°27′44″	119°23′22″	Limonitic, argillized rock and silicified rock—not sampled.	do.	Do.
D	A473	39°28′09″	119°28′02″	Argillized, rhyodacitic flow rock—not sampled.	do.	Do.
	A474	39°19′02″	119°34′53″	Limonitic, argillized rock and propylitized rocks—not sampled.	do.	Do.
	A475	39°19′45″	119°33′01″	Argillized volcanic rock—not sampled	do.	Do.
	A476	39°16′57″	119°35′21″	Argillized volcanic rock—not sampled	do.	Do.
B	A477	39°28′54″	119°41′43″	Bleached, silicified rhyodacite and argillized rhyodacite—not sampled.	do.	Do.
B	A478	39°29′44″	119°36′41″	Bleached, argillized rhyodacite and silicified rhyodacite—not sampled.	do.	Do.
C	A479	39°24′51″	119°38′46″	Limonitic, argillized volcanic rock—not sampled.	do.	Do.
C	A480	39°21′38″	119°39′08″	Bleached volcanic rock and limonitic, argillized volcanic rock—not sampled.	do.	Do.
	A481	39°18′57″	119°40′40″	Bleached, argillized volcanic rock—not sampled.	do.	Do.
	A482	39°17′27″	119°38′27″	Argillized andesite—not sampled	do.	Do.
	A483	39°17′24″	119°43′28″	Argillized ash-flow tuff and granodiorite—not sampled.	do.	Do.
A	A484	39°33′41″	119°48′03″	Argillized volcanic rock—not sampled	do.	Do.
	A485	39°27′16″	119°16′28″	Argillized rhyodacite and limonitic, propylitized rhyodacite—not sampled.	do.	Do.
	A500	39°13′58″	119°39′22″	Argillized, pyritic tuff—not sampled	do.	Do.
	A502	39°13′29″	119°40′48″	Argillized rock in mine dump—not sampled.	do.	Do.
	A503	39°13′42″	119°41′33″	Gypsum and marble—not sampled	do.	Do.
	U504	39°13′15″	119°39′49″	Marl and gypsiferous sediments—not sampled.	do.	Do.
	A505	39°14′48″	119°38′58″	Argillized volcanic rock—not sampled	do.	Do.
K	A506	39°17′38″	118°02′37″	Limonitic, argillized tuff—not sampled	do.	Do.
K	A507	39°18′16″	118°02′13″	Limonitic, bleached, argillized rock—not sampled.	do.	Do.
K	A508	39°20′08″	118°04′43″	Limonitic, argillized rock and silicified rock—not sampled.	do.	Do.
K	A509	39°16′16″	118°03′13″	Limonitic, argillized rock and locally silicified rock—not sampled.	do.	Do.
A	U510	39°35′11″	119°54′24″	Basalt and silicified rock colluvium and grass—not sampled.	do.	Do.
A	A511	39°34′42″	119°55′34″	Limonitic, brecciated, silicified tuff	Muscovite	Do.
N	A512	39°28′29″	119°51′01″	Argillized, hematitic, welded tuff—not sampled.	No analysis	Do.
N	A513	39°28′21″	119°50′54″	Sericitic, limonitic tuff—not sampled	do.	Do.
N	A?514	39°28′17″	119°50′43″	Silicified(?) tuff—not sampled	do.	Do.
N	A515	39°28′08″	119°50′42″	Limonitic, argillized tuff—not sampled	do.	Do.
N	A516	39°27′36″	119°51′30″	Bleached, limonitic tuff—not sampled	do.	Do.
N	A517	39°27′31″	119°51′22″	Limonitic, argillized rock—not sampled	do.	Do.
N	A518	39°27′29″	119°54′00″	Very limonitic, argillized tuff—not sampled.	do.	Do.
N	A519	39°27′43″	119°54′19″	Argillized tuff—not sampled	do.	Do.

Table 1.—Description of CRC image anomalies evaluated through laboratory and field studies—Continued

Map area	Sample no.	Latitude	Longitude	Field description	Mineralogy	Geochemical anomalies
	U520	39°19′13″	119°43′18″	Unaltered granodiorite—not sampled	do.	Do.
	A521	39°16′21″	119°41′43″	Limonitic, argillized crystal tuff—not sampled.	do.	Do.
	A522	39°17′28″	119°40′52″	Bleached, argillized rock—not sampled	do.	Do.
	A523	39°17′24″	119°37′39″	Argillized volcanic rock and silicified volcanic rock—not sampled.	do.	Do.
	A524	39°17′47″	119°37′26″	Limonitic, argillized rock—not sampled	do.	Do.
	A525	39°18′01″	119°37′32″	Very limonitic, silicified rock—not sampled.	do.	Do.
	A526	39°18′17″	119°37′11″	Limonitic, argillized rock—not sampled	do.	Do.
	A527	39°16′21″	119°39′50″	Tan alluvium	do.	Do.
	A528	39°18′26″	119°39′04″	Limonitic, argillized rocks and quartz veins—not sampled.	do.	Do.
	U529	39°36′48″	119°57′03″	Unaltered, glassy volcanic rock—not sampled.	do.	Do.
	U530	39°36′31″	119°56′58″	Quartzite with epidote on fracture surfaces—not sampled.	do.	Do.
	U531	39°36′57″	119°56′37″	Dry grass—not sampled	do.	Do.
	U532	39°37′28″	119°57′44″	Dry grass and brown soil—not sampled	do.	Do.
A	U533	39°35′09″	119°53′12″	Vegetation—not sampled	do.	Do.
A	A534	39°35′02″	119°52′48″	Very limonitic breccia with vuggy silica—not sampled.	do.	Do.
A	A535	39°35′27″	119°53′26″	Slightly altered volcanic rock	High I/S	Do.
A	A536	39°35′27″	119°53′48″	Weakly argillized tuff—not sampled	No analysis	Do.
A	A537	39°35′39″	119°53′47″	Limonitic, silicified breccia—not sampled.	do.	Do.
A	A538	39°34′07″	119°54′07″	Limonitic, bleached, silicified volcanic rock and argillized volcanic rock—not sampled.	do.	Do.
A	A539	39°34′00″	119°53′38″	Silicified, argillized, iron-rich breccia—not sampled.	do.	Do.
A	A540	39°33′26″	119°53′06″	Limonitic, altered rock with 0.5-cm quartz phenocrysts—not sampled.	do.	Do.
	U541	39°20′20″	119°31′19″	Pumice in quarry—not sampled	do.	Do.
	A?542	39°18′33″	119°33′22″	Mixture of argillized volcanic rock and unaltered colluvium—not sampled.	do.	Do.
	U543	39°19′46″	119°37′07″	Unaltered, limonitic tuff—not sampled	do.	Do.
	U544	39°23′15″	119°33′27″	Ash-flow tuff with kaolinite in weathered rock—not sampled.	do.	Do.
	U545	39°23′07″	119°33′59″	Iron-stained ash-flow tuff—not sampled	do.	Do.
O	A546	39°56′23″	118°51′09″	Limonitic, silicified rock and argillized rock—not sampled.	do.	Do.
O	A547	39°56′32″	118°53′16″	Argillized volcanic rock—not sampled	do.	Do.
O	A548	39°56′24″	118°53′50″	Weakly argillized volcanic rock—not sampled.	do.	Do.
O	U549	39°56′19″	118°54′08″	Sheared metagraywacke—not sampled	do.	Do.
O	U550	39°56′14″	118°55′04″	Soil—not sampled	do.	Do.
O	U551	39°56′22″	118°55′33″	Soil and unaltered basalt boulders—not sampled.	do.	Do.
	U552	39°57′29″	118°58′02″	Scoria and vesicular basalt boulders—not sampled.	do.	Do.
	U553	39°57′22″	118°58′36″	Soil and scoria—not sampled	do.	Do.
	U554	39°56′47″	118°58′40″	Gabbro—not sampled	do.	Do.
	U555	39°56′36″	118°59′02″	Iron-stained scoria and green phyllite—not sampled.	do.	Do.
	A?556	39°56′37″	118°59′21″	Iron-rich phyllite—not sampled	do.	Do.
	U557	39°52′38″	118°53″41″	Tufa deposit—not sampled	do.	Do.
	U558	39°31′34″	119°15′51″	Scoriaceous basalt—not sampled	do.	Do.
	U559	39°30′39″	119°17′37″	Basalt boulders—not sampled	do.	Do.
	U560	39°30′10″	119°16′38″	Scoriaceous basalt boulders—not sampled.	do.	Do.
	U561	39°31′04″	119°17′03″	Scoriaceous basalt boulders—not sampled.	do.	Do.

Table 1.—Description of CRC image anomalies evaluated through laboratory and field studies—Continued

Map area	Sample no.	Latitude	Longitude	Field description	Mineralogy	Geochemical anomalies
	U562	39°32'42"	119°16'52"	Clayey lake-bed sediments and basalt boulders—not sampled.	do.	Do.
	U563	39°34'14"	119°16'50"	Clayey lake-bed deposit—not sampled	do.	Do.
	U564	39°34'21"	119°16'59"	White, lake-bed deposit—not sampled	do.	Do.
	U565	39°34'13"	119°19'24"	Grass with basalt boulders—not sampled.	do.	Do.
	A?566	39°34'23"	119°18'33"	Strongly propylitized volcanic rock	Chlorite	Do.
	U567	39°34'18"	119°18'44"	Unaltered volcanic rock—not sampled	No analysis	Do.
	A?568	39°52'26"	118°58'54"	Gypsiferous, bleached rock	Low to medium I/S, gypsum, zeolite(?)	Do.
	U569	39°52'16"	118°58'01"	Clayey lake-bed deposit—not sampled	No analysis	Do.
	U570	39°48'24"	118°53'14"	Unaltered conglomerate and intrusive rock—not sampled.	do.	Do.
	U571	39°48'11"	118°52'58"	Unaltered conglomerate—not sampled	do.	Do.
	A?572	39°48'20"	118°52'54"	Limonitic, silicified breccia and unaltered conglomerate—not sampled.	do.	Do.
	U573	39°49'01"	118°52'56"	Tufa deposit—not sampled	do.	Do.
	U574	39°49'44"	118°53'07"	Limestone—not sampled	do.	Do.
O	A575	39°56'21"	118°52'04"	Weakly argillized, silicified volcanic rock.	Medium I/S	Do.
O	A576	39°55'59"	118°55'37"	Limonitic, argillized, silicified volcanic rock—not sampled.	No analysis	Do.
O	U577	39°55'56"	118°56'00"	Unaltered phyllite	Chlorite	Do.
O	U578	39°56'10"	118°55'49"	Soil—not sampled	No analysis	Do.
O	A?579	39°56'04"	118°54'53"	Argillized volcanic rock and propylitized volcanic rock—not sampled.	do.	Do.
O	A580	39°56'35"	118°54'28"	Weakly argillized volcanic rock—not sampled.	do.	Do.
O	A?581	39°56'29"	118°54'22"	Argillized crystal tuff and unaltered volcanic rock—not sampled.	do.	Do.
	U582	39°54'16"	119°05'15"	Carbonate rocks and caliche—not sampled.	do.	Do.
	A583	39°53'42"	119°05'47"	Argillized volcanic rock	Low I/S, jarosite	Do.
A	A584	39°34'01"	119°53'03"	Limonitic, argillized volcanic rock and silicified volcanic rock—not sampled.	No analysis	Do.
A	A585	39°33'18"	119°53'11"	Intensely argillized, silicified volcanic rock—not sampled.	do.	Do.
	U586	39°30'51"	119°55'21"	Dry grass—not sampled	do.	Do.
	U587	39°30'29"	119°54'24"	Dry grass—not sampled	do.	Do.
	U588	39°16'27"	119°45'50"	Dry grass and soil—not sampled	do.	Do.
	A589	39°13'49"	119°44'53"	Limonitic rhyolite with thin veins	Low I/S	Do.
P	A?590	39°23'09" [1]	118°59'29" [1]	Limonitic, argillized volcanic rock and breccia—not sampled.	No analysis	Do.

[1]Approximate center of areas designated A?590.

Table 2.—Elements and limits of determination (based on a 10-mg sample) for the direct-current arc emission spectrographic analysis of rocks collected from areas of CRC image anomalies in the Reno 1°×2° quadrangle

[The geochemical results reported here were provided by analytical laboratories of the U.S. Geological Survey. Analysts were J.M. Motooka, R.T. Hopkins, R.M. O'Leary, T.A. Roemer, P.L. Hageman, D.L. Fey, R.H. Hill, and F.W. Tippitt]

Element	Lower determination limit	Upper determination limit
	Percent	Percent
Calcium (Ca)	0.05	20
Iron (Fe)	.05	20
Magnesium (Mg)	.02	10
Phosphorus (P)	.2	10
Sodium (Na)	.2	5
Titanium (Ti)	.002	1
	Parts per million	Parts per million
Antimony (Sb)	100	10,000
Arsenic (As)	200	10,000
Barium (Ba)	20	5,000
Beryllium (Be)	1	1,000
Bismuth (Bi)	10	1,000
Boron (B)	10	2,000
Cadmium (Cd)	20	500
Chromium (Cr)	10	5,000
Cobalt (Co)	10	2,000
Copper (Cu)	5	20,000
Gallium (Ga)	5	500
Germanium (Ge)	10	100
Gold (Au)	10	500
Lanthanum (La)	50	1,000
Lead (Pb)	10	20,000
Manganese (Mn)	10	5,000
Molybdenum (Mo)	5	2,000
Nickel (Ni)	5	5,000
Niobium (Nb)	20	2,000
Scandium (Sc)	5	100
Silver (Ag)	.5	5,000
Strontium (Sr)	100	5,000
Thorium (Th)	100	2,000
Tin (Sn)	10	1,000
Tungsten (W)	20	10,000
Vanadium (V)	10	10,000
Yttrium (Y)	10	2,000
Zinc (Zn)	200	10,000
Zirconium (Zr)	10	1,000

Table 3.—Chemical methods used for the analysis of rocks collected from areas of color-ratio composite image anomalies in the Reno 1°×2° quadrangle

[AA = atomic absorption; ICP-AES = inductively coupled plasma-atomic emission spectrometry]

Element determined	Method	Lower determination limit (parts per million)	Reference
Gold (Au)	Flame AA	0.05	O'Leary and Chao, 1990.
Tellurium (Te)	do.	.05	Do.
Thallium (Tl)	do.	.05	Do.
Mercury (Hg)	Cold-vapor AA	.02	O'Leary and others, 1990.
Antimony (Sb)	ICP-AES	.600	Motooka, 1988.
Arsenic (As)	do.	.600	Do.
Bismuth (Bi)	do.	.600	Do.
Cadmium (Cd)	do.	.050	Do.
Copper (Cu)	do.	.050	Do.
Gold (Au)	do.	.150	Do.
Lead (Pb)	do.	.600	Do.
Molybdenum (Mo)	do.	.090	Do.
Silver (Ag)	do.	.045	Do.
Zinc (Zn)	do.	.050	Do.

Table 4.—Threshold values for selected elements analyzed in rock samples collected from areas of color-ratio composite image anomalies in the Reno 1°×2° quadrangle

Element	Threshold value (parts per million)
Antimony (Sb)	4
Arsenic (As)	20
Bismuth (Bi)	2
Boron (B)	1000
Copper (Cu)	70
Gold (Au)	.05
Lead (Pb)	100
Mercury (Hg)	.15
Molybdenum (Mo)	10
Nickel (Ni)	50
Silver (Ag)	.5
Tellurium (Te)	.05
Thallium (Tl)	.7
Thorium (Th)	100
Tin (Sn)	10
Tungsten (W)	20
Zinc (Zn)	130

*U.S. G.P.O.:1995-387-030:90