DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-1564-B
SHEET 2 OF 2

STUDIES RELATED TO WILDERNESS

The Wilderness Act (Public Law 88-577, September 3, 1964) and related acts require the U.S. Geological Survey and the U.S. Bureau of Mines to survey certain areas on Federal lands to determine their mineral resource potential. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a geochemical survey of the Kings River (B5198), Rancheria (C5198), Agnew (5199), and Oat Mountain (5197) Roadless Areas in the Sierra and Sequoia National Forests, Fresno County, California. These roadless areas were classified as further planning areas during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979.

INTRODUCTION

The Kings River, Rancheria, Agnew, and Oat Mountain Roadless Areas, together comprising the study area, lie between the crest of the Sierra Nevada and the east edge of the San Joaquin Valley, about 28 to 56 mi east of Fresno, Calif. (index map). These four roadless areas, which include approximately 145 sq mi (92,500 acres) in eastern Fresno County, Calif., are dominated by the extremely rugged Kings River Canyon, one of the deepest canyons in the nation. The Kings River and its tributaries flow westward from the Sierra Nevada crest to the San Joaquin Valley and form one of the larger drainage systems in the Sierra Nevada.

A combined geologic, geophysical, and geochemical investigation and a survey of the existing mines, prospects, and mineral occurrences were conducted to determine the mineral resource potential of the study area (Longwell, 1982; Spear, 1982a, 1982b; Nokleberg and others, 1983; Nokleberg and Longwell, 1984; Grimes and others, 1984). As part of this investigation, geochemical sampling was conducted during 1981 and 1982. A total of 388 rock samples, 127 minus-80-mesh stream-sediment samples, and bulk-sediment samples to produce 56 nonmagnetic heavy-mineral-concentrate samples were collected in and adjacent to the study area (Grimes and others, 1984). The two maps included in this report show the locations of all sites where rock samples were collected in this study and the distributions of anomalous concentrations for 15 elements (map A) and the locations of stream-sediment and (or) bulk-sediment sample sites (map B). Map B also shows the distributions of anomalous concentrations for as many as 12 elements in stream-sediment and nonmagnetic heavy-mineral-concentrate samples. The maps include outlines of those drainage basins with anomalous samples and shows weighted values for each basin based on the number of anomalous elements and their concentrations.

GENERAL GEOLOGY

Geologic maps of parts of the four roadless areas have been published by Krauskopf (1953), Matthews and Burnett (1965), Moore and Marks (1972), Moore (1978), Saleeby and others (1978), Moore and others (1979), and Nokleberg (1983). A detailed description of the geology of the study area, part of which is summarized here, is given in Nokleberg and others (1983); the geologic base for maps A and B is from that publication.

The study area is in the central part of the Sierra Nevada, a faulted and westward-tilted range that extends more than half the length of eastern California. The east slope of the range is a precipitous fault scarp; whereas, the west slope is moderately inclined, with deeply incised, major river systems, such as the Kings River, that create generally parallel east-west-trending deep canyons interspersed with areas of moderate relief. The part of the range in the study area is predominantly underlain by granitic, volcanic, and metamorphic rocks and locally covered with surficial deposits.

The Kings River Canyon exposes several Cretaceous granitic plutons of the Sierra Nevada batholith and less abundant, older metasedimentary and metavolcanic rocks. The metasedimentary rocks constitute the Kings terrane (Nokleberg, 1983), and are best exposed in the western part of the Boyden Cave roof pendant in the Agnew Roadless Area, in the Pine Ridge roof pendant in the Agnew Roadless Area, and in an unnamed roof pendant of metasedimentary rocks in the Oat Mountain Roadless Area. The metasedimentary rocks are of Late Triassic and Early Jurassic age (Moore and Dodge, 1962; Jones and Moore, 1973; Saleeby and others, 1978). The metavolcanic rocks are part of the Goddard terrane (Nokleberg, 1983) and are best exposed in the eastern part of the Boyden Cave roof pendant in the Agnew Roadless Area. The metavolcanic rocks are presumed to be of Jurassic age, by correlation with similar rocks in the Goddard roof pendant to the northeast (Nokleberg, 1983). A major fault, the Kings River suture, separates the Goddard and Kings terranes.

Several major masses or plutons of quartz monzonite, granodiorite, and quartz diorite occur in the study area; numerous smaller bodies of gabbro and metagabbro crop out mainly in the western part of the study area. There is a general progression from more felsic plutons in the eastern part of the study area to more mafic plutons in the western part. Individual plutons are shown, but are not named on maps A and B. Three plutons dominate the study area: (1) a pluton of porphyritic biotite quartz monzonite (pqm) in the eastern part of the Kings River Roadless Area that is best exposed in the vicinity of Brush Canyon; (2) a pluton of fine-grained biotite quartz monzonite (fqm) in the western part of the Kings River Roadless Area, just east of the Garnet Dike mine; and (3) a pluton of hornblende quartz diorite (di) in the southern part of the Oat Mountain Roadless Area and in the southwestern part of the Kings River Roadless Area. This last pluton is best exposed in the White Deer Flat area south of Oat Mountain. These plutons have isotopic ages that range from 112 to 86 Ma, or Early to Late Cretaceous (Chen and Moore, 1982).

Numerous remnants of upper Tertiary olivine basalt lava flows are scattered over the upland parts of the study area. These flows, which belong to the San Joaquin and Kings volcanic fields, represent numerous small eruptions from scattered vents during the period from 4.5 to 3 Ma (Moore and Dodge, 1980, 1981). The largest area of Tertiary basalt exposures is found north of the north rim of the Kings River Canyon, in the Rancheria Roadless Area. On the south side of the Kings River Canyon, relatively large remnants of basalt flows are preserved northwest of Hume Lake, partly in the Kings River Roadless Area.

Deep erosion of the Tertiary volcanic rocks and underlying bedrock reflects (1) uplift of the Sierra Nevada during the late Tertiary and Quaternary and (2) dissection by streams and glaciers. The upper part of the Kings River Canyon has a broad U-shaped cross section, hanging tributaries, and other features typical of glaciated river valleys. The lower part of the canyon, which contain the majority of area included in the roadless areas, has a narrow V-shaped cross section, steep-walled narrow canyons, tributary streams with steep gradients, and other features typical of youthful topography that is being actively uplifted and eroded.

GEOCHEMICAL INVESTIGATIONS

Chemical analyses of 388 rock samples, 127 minus-80-mesh stream-sediment samples, and 56 nonmagnetic heavy-mineral-concentrate samples provided the basis for the geochemical assessment of the study area. Most rock samples were collected as composite chips from outcrops in the vicinity of the sample sites shown on map A. In a few instances only a single rock fragment was collected. Many samples were of fresh, unmineralized rock. The analyses of these samples provide background chemical information on elements in rocks that have not been affected by alteration or mineralization. Most rock samples were selected to characterize the chemistry of the rocks exposed in the vicinity of the sampling site; however, the actual areal extent of influence of the chemical information provided by each sample is not known. Thus, most of the rock samples only provide general information on the geochemical nature of the rock units present. Some altered and mineralized rocks were collected to provide information about specific elements present in mineralized areas and their relative abundances. Both the analyses of these samples and their rock names are listed in Grimes and others (1984).

The stream-sediment samples consisted of active alluvium collected primarily from first-order (unbranched) and second-order (below the junction of two first-order) streams as shown on U.S. Geological Survey 15-minute topographic maps. Each sample was a composite from several localities within an area that may extend as much as 100 ft from the center of each plotted site (map B). The samples were sieved, and the minus-80-mesh material was retained for analysis. The analyses of the stream-sediment samples reflect the chemistry of rock material eroded from the drainage basin upstream from each sampling site and may reveal unusually high concentrations of elements that may be related to mineral deposits.

Concentrate samples were processed from the same active alluvium used to make minus-80-mesh stream-sediment samples. The bulk sediment was panned and dried, and the resulting heavy-mineral fraction was treated with bromoform. The grains sinking in the bromoform were saved and separated into magnetic and relatively nonmagnetic fractions in a Frantz Isodynamic Separator[1]. The resulting nonmagnetic fraction was analyzed for this study. The analyses of the heavy-mineral-concentrate samples provide information about the chemistry of a limited number of minerals present in rock material eroded from the drainage basin upstream from each sampling site. The concentrating procedures may produce a sample rich in heavy minerals commonly associated with many types of mineral deposits. The selective concentration of ore-related minerals permits determination of some elements, such as Sn and W, that are not easily detected in stream-sediment samples. The chemical composition of a nonmagnetic heavy-mineral concentrate may also indicate specific minerals. For example, the Ba content in a stream-sediment sample may result from a number of different minerals, most of which normally have no relation to hydrothermal mineralization. Anomalous Ba values in a concentrate sample, however, often indicate the presence of only barite, a mineral that may be associated with mineralization.

All of the samples were analyzed for 31 elements (Ag, As, Au, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, La, Mg, Mn, Mo, Nb, Ni, Pb, Sb, Sc, Sn, Sr, Th, Ti, V, W, Y, Zn, and Zr) by six-step semiquantitative emission spectroscopy. Any rock samples in which either As or Ag was detected in the spectrographic analysis were also analyzed by atomic-absorption spectrometry for Au. Sixty-nine of the 127 stream-sediment samples were also analyzed for Zn by atomic-absorption spectrometry. Further details concerning the collection, preparation, and analysis of the samples, as well as a tabulation of the analyses have been published by Grimes and others (1984).

EVALUATION OF THE ANALYSES

On the basis of analyses of samples collected in both mineralized and unmineralized localities in this and other roadless areas and wildernesses in the Sierra Nevada region, a suite of 17 elements (Ag, As, Au, B, Ba, Bi, Cd, Co, Cu, Fe, Mn, Mo, Pb, Sb, Sn, W, and Zn) was selected as possibly being associated with mineral deposits that might be expected to be present in the vicinity of the study area. Some of these selected elements contained no anomalous values in a given sample medium. Of the 17 elements, 15 were found to be anomalous in the rock samples (table 1). In a similar manner, 6 elements were found to be anomalous in the stream-sediment samples (table 2) and 12 elements were found to be anomalous in the concentrate samples (table 3). In the study area, Ag, Au, Ba, Cu, Mo, Pb, Sn, W, and Zn are most commonly associated with the ore or ore-related minerals argentite-acanthite, native gold, barite, chalcopyrite, molybdenite, galena, cassiterite, scheelite, and sphalerite (or their oxidation products), respectively. The most important mineral residences of the other selected elements are not known. Arsenic is commonly found as arsenopyrite or in arsenic-rich sulfosalts; Bi, in bismuthinite or in Pb or rare-earth minerals; B, in accessory minerals such as biotite or tourmaline; Mn, in calcite, mafic accessory minerals, or various manganese oxides; and Sb, in stibnite or sulfosalts. Cadmium commonly substitutes for Zn in Zn-rich minerals such as sphalerite. Iron in a nonmagnetic heavy-mineral-concentrate sample commonly indicates pyrite or arsenopyrite, or oxidized products of these minerals.

Cobalt can substitute for Fe^{2+} in Fe-rich minerals. In the concentrate samples, anomalous Co concentrations are thought to represent primarily the mineral pyrite--and thus considered to be associated with mineralization--when Ni concentrations are not anomalous. When both Co and Ni are anomalous in a sample, it is probable that Co is present in a mafic rock-forming accessory mineral, such as biotite or hornblende, that most likely is not related to any mineralization.

The ranges of background and anomalous concentrations for each selected element in each of the three types of samples were determined after studying percent-frequency distribution histograms for these elements, the distributions of the anomalous elements relative to known rock types in the field area, and information on other areas in the Sierra Nevada which have had mineral assessments. (See, for example, Brem and others, 1984; Chaffee, Banister, and others, 1980; Chaffee, Hill, and others, 1980; Chaffee and others, 1981; Chaffee and others, 1983a, 1983b, 1983c; John, Armin, Plouff, Chaffee, Federspiel, and others, 1983; John, Armin, Plouff, Chaffee, Peters, and others, 1983; Keith and others, 1983; McKee and others, 1982; Sutley and others, 1982; Sutley, Chaffee, Brem, and others, 1983; Sutley, Chaffee, Fey, and others, 1983a, 1983b, 1983c).

DISCUSSION OF MAP A

Anomalous concentrations of the selected elements in rock samples are shown on map A for each sample containing anomalous elements. In several instances more than one sample was collected at a given site (Grimes and others, 1984). For such sites all anomalous values are shown on map A without regard to any particular sample. If an element was anomalous in more than one sample at a site, then all anomalous values are shown. Some of the anomalous concentrations are thought to be related only to the normal but varying chemistry of different rock types. Other anomalies may be related to the effects of known or suspected hydrothermal mineralization; these anomalies are described below.

Anomalous concentrations of 15 elements (Ag, As, Au, Ba, Bi, Cd, Cu, Fe, Mn, Mo, Pb, Sb, Sn, W, and Zn) were identified in rock samples (map A; table 1). Most of these elements occur in weakly anomalous concentrations, and represent slightly above normal enrichment in rocks common in the study area. The moderately to strongly anomalous concentrations represent various known or possible types of mineral occurrences, as discussed below. For simplicity, areas with similar rock chemistry and geologic environment are discussed together. Areas are lettered from west to east on map A. For each sample with anomalous concentrations of one or more elements, the obvious ore minerals or type of alteration are described. Generally, ore minerals could not be identified in either hand sample or thin section to account for most of the strongly anomalous concentrations, indicating that most of these anomalous concentrations are caused by extremely rare amounts of ore minerals.

Areas A, C, D, E, F, and H: Area A is in the southern part of the Oat Mountain Roadless Area, and areas C, D, E, F, and H are in, or adjacent to, the western and southern parts of the Kings River Roadless Area. Rock samples from these areas locally contain strongly anomalous concentrations of Mn and Mo, and (or) moderately anomalous concentrations of Ag, Ba, Bi, Cu, Mo, Pb, Sb, Sn, and Zn, mainly in biotite-muscovite-quartz schist, quartz schist, and to a lesser extent in calc-schist and marble, all of which are commonly iron stained or contain accessory pyrite, local quartz veins, or granitic dikes. Manganese is thought to occur in biotite; areas containing pyrite, and iron oxides most likely derived from pyrite, are the only obvious sources observed in hand specimen or thin section for the other anomalous concentrations.

Area A consists of a highly fractured, limonite-stained, 3-ft-wide quartz vein exposed in a small pit in biotite-quartz schist. The vein contains traces of precious and base metals (Nokleberg and others, 1983). Part of area F includes the Southerland tungsten prospect, which consists of a shear zone with two quartz veins, 10 to 12 in. thick that are exposed on the bank of the Kings River in a 20-ft-wide open cut in diorite (Nokleberg and others, 1983). Samples of the vein collected and analyzed by the U.S. Bureau of Mines contained as much as 0.89 troy oz Au per ton and 0.2 troy oz Ag per ton, and samples of wallrock contain as much as 0.18 troy oz Au per ton and 0.4 troy oz Ag per ton (Nokleberg and others, 1983). Areas C, D, E, and H probably represent widely scattered and minor occurrences of base-metal sulfides occurring either in schist near quartz veins, or less likely, in stratabound lenses.

Areas B and M: Area B is adjacent to the northwest corner of the Kings River Roadless Area, and area M is about 3.2 mi east of the eastern part of the Kings River Roadless Area. Single rock samples from each of these areas contain weakly to moderately anomalous Ag, Mo, and Pb in biotite-muscovite quartz monzonite in area B, and Mo and Zn in porphyritic biotite quartz monzonite in area M. No obvious source for the Ag or Mo was seen in hand specimen or thin section. These concentrations of Ag and Mo probably represent scattered and insignificant amounts of accessory sulfides in unaltered granitic plutons.

Areas G, J, and N: Area G is in the east-central part of the Kings River Roadless Area, area J is in the southern part of the Rancheria Roadless Area, and area N is in the western part of the Agnew Roadless Area. Certain rock samples from these areas contain strongly anomalous concentrations of Fe, Mn, Sb, and (or) W, and (or) moderately anomalous concentrations of Ag, Au, Ba, Bi, Cu, Fe, Mo, Sn, and (or) W, mainly in contact-metasomatic skarn (tactite), marble, and calc-schist, but also locally in hornblende diorite, hornblende-biotite granodiorite, and biotite quartz monzonite adjacent to tactite or calcareous wall rocks. Pyrite and Fe-staining are locally abundant in both the tactite and granitic rocks in these areas.

Area G is near the Marble Contact and Big Buck tungsten prospects, both part of the "Kings River tungsten district" (Nokleberg and others, 1983). At the northern end of area N is the Tehipite tungsten prospect, which consists of discontinuous tactite masses in diorite. One sample of tactite collected by the U.S. Bureau of Mines was found to contain 0.1 weight percent WO_3 (Nokleberg and others, 1983). The anomalous Fe in areas G and N is thought to occur mainly in pyrite, and the anomalous Mn is thought to occur in clinopyroxene in tactite. The other anomalous element concentrations are probably present in scheelite, pyrite, Fe-oxides derived from pyrite, or in sulfide minerals. These anomalies are thought to result from element enrichment in widely scattered and minor occurrences of either tungsten-bearing tactite or granitic plutons adjacent to these W occurrences. The southern part of area G extends into the steep, brushy, inaccessible south side of the Kings River Canyon, where abundant marble is intruded by granitic rocks. The geologic environment is thus favorable for tactite W deposits; however, no such deposits have as yet been identified (Nokleberg and others, 1983).

Area I: This area is in the southeastern part of the Kings River Roadless Area. Strongly anomalous concentrations of Fe, Mn, Sn, and Zn, and moderately anomalous concentrations of Ag and Mo occur in an isolated, small magnetite-quartz-biotite gossan occurring between marble and a large pluton of porphyritic biotite quartz monzonite, about 1 mi east of Cabin Creek. The gossan occurs on the eastern side of the marble lens, adjacent to the quartz monzonite, and varies from 8 to 150 ft thick. Heavy brush cover precluded determining the extent of this gossan. The marble is about 50 ft thick. The anomalous concentrations of Fe probably represent magnetite. No source is known for the anomalous Mn. The other element anomalies are probably related to sulfide minerals present in the gossan. This area may represent a contact-metasomatic or oxidized quartz vein occurrence.

Area K: This area is adjacent to the southeast corner of the Rancheria Roadless Area. Moderately to strongly anomalous concentrations of Ag, As, Au, Bi, Cd, Cu, Fe, Mn, Pb, Sb, Sn, and Zn occur in pods of tactite, locally with massive pyrite and lesser magnetite, in calcite marble at the Geraldine Lakes prospect (Nokleberg and others, 1983). Within a few hundred feet of the tactite body, the marble is intruded by hornblende-biotite granodiorite. Samples of tactite at the prospect collected and analyzed by the U.S. Bureau of Mines contain as much as 0.59 weight percent WO_3 and 300 ppm Ag (Nokleberg and others, 1983). The anomalous concentrations of Fe probably indicate pyrite; anomalous Mn may be present in clinopyroxene in the tactite. The other element anomalies are anomalous concentrations probably related to scattered sulfide minerals associated with the tactite and massive pyrite. This area represents a minor, contact-metasomatic tactite and base-metal sulfide occurrence.

Area L: Area L is located about 1.4 mi east of the southeast corner of the Rancheria Roadless Area. A single rock sample contains moderately anomalous concentrations of Ag, Pb, and Zn in an erosional remnant of Tertiary porphyritic olivine-augite basalt. No obvious source for Ag, Pb, or Zn was found in hand sample or thin section. Anomalies of these elements are probably associated with insignificant amounts of accessory sulfides in the unaltered olivine basalt.

Area O: This area extends from north of the south fork of the Kings River in the southeast corner of the Kings River Roadless Area to the north-central part of the Agnew Roadless Area. Moderately to strongly anomalous concentrations of Ag, As, Au, Cd, Cu, Mo, and Zn occur in biotite-quartz schist, pelitic schist, calc-schist, marble, and tactite that locally contain extensive dikes of hornblende diorite and porphyritic biotite quartz monzonite and Au- or Ag-bearing quartz veins. Disseminated pyrite and Fe-staining are locally abundant. The Sierra Scientific gold prospect occurs at the west end of the area, and consists of a shear zone, as wide as 10 in. with brecciated vein quartz and sulfide (mostly pyrite) minerals (Nokleberg and others, 1983). The quartz vein, hosted in quartzite, was found by the U.S. Bureau of Mines to contain as much as 0.4 troy oz Ag per ton (Nokleberg and others, 1983). The anomalous values in area O are related to sulfide minerals that are either sporadically distributed or associated with tactite or quartz veins. This area probably represents minor, small occurrences of contact-metasomatic tactite or base-metal sulfides in quartz veins.

DISCUSSION OF MAP B

Sample localities where anomalous concentrations of the selected elements were detected in stream-sediment and concentrate samples are shown on map B. Drainage basins associated with each anomalous sample are also shown to indicate the possible extent of the source area for each of those samples. Very few of the stream-sediment samples contained anomalous concentrations of the selected elements used in this study (table 2). The few such anomalies shown on map B are all weak and may represent the high end of normal concentration distributions for these elements in the rock types present. In contrast to the stream-sediment samples, many of the concentrate samples were found to contain anomalous amounts of the selected elements (table 3). To summarize the relative importance of the concentrate anomalies for each sample, the anomalous concentrations were evaluated using a technique called SCORESUM (Chaffee, 1983).

The SCORESUM values, which are shown on map B in a circle in each drainage basin containing an anomalous sample, were created in the following manner: First, the full range of reported analyses for each element of interest was divided into four categories, as shown in table 4. Anomaly scores--values of 0 (background), 1 (weakly anomalous), 2 (moderately anomalous), or 3 (strongly anomalous)--were substituted for all of the analyses falling into each of the four categories. For a given element, the range of reported analyses falling into each of the three anomaly categories was somewhat arbitrarily selected. As a rough guide, the concentrations assigned to the weakly anomalous category generally (but not always) included those values between the threshold value and the 95th percentile value for the each of the three subsets. Those concentrations considered to be moderately anomalous generally fell between the 95th and 98th percentiles, and those concentrations considered to be strongly anomalous were generally restricted to the upper 2 percent of the samples. After the anomaly scores were assigned to all of the selected elements, the scores for this group of elements were summed for each sample site (SCORESUM) and then plotted on the map. If the SCORESUM for a given sample was zero, then the associated drainage basin was not outlined on map B.

All of the elements were evaluated as a single suite representing either a contact-metasomatic-deposit environment or a quartz-vein environment, either of which may contain base- or precious-metal sulfide minerals, tungsten-related minerals, or both. Those drainage basins whose samples have SCORESUM values ≥4 were deemed to be the most significant in terms of mineral potential. These areas are labelled on map B and described below.

Area A: This area is in the center of the Oat Mountain Roadless Area. The concentrate samples from this area contain anomalous B and W. The outcrops in the basins in this area are predominantly biotite-quartz-muscovite schist, with lesser biotite quartz monzonite and sparse marble. This area might contain contact-metasomatic (tactite) W occurrences. No prospects are known in this area.

Area B: This area is in the eastern part of the Oat Mountain Roadless Area. The concentrate sample from this area contains 10,000 ppm Ba as well as anomalous B. The rocks in the basin include biotite-quartz-muscovite schist, hornblende diorite, and smaller amounts of marble. Vein or stratiform barite might be present in the area. The anomaly may also reflect unusually high concentrations of these two elements in the protoliths for the metasedimentary rocks in this part of the study area. No mineral occurrences are known in this area.

Area C: This area is in the northwestern part of the Kings River Roadless Area. The concentrate sample from this area contains anomalous concentrations of B, Sn, and W. The rocks in this area are predominantly hornblende diorite and calc-schist. The rock types and the suite of anomalous elements suggest that contact-metasomatic (tactite) W occurrences may be present near this area; however, none is known in this particular drainage basin.

Area D: This area includes the Fox Canyon drainage basin in the north-central part of the Kings River Roadless Area. The stream-sediment sample from this area contains weakly anomalous Sn and W. The concentrate sample contains strongly anomalous Bi, Mo, and W. Rock types in the area include marble, calc-schist, tactite, hornblende diorite, and fine-grained biotite quartz monzonite. These anomalies probably reflect contamination from the dumps of Garnet Dike tungsten mine, which is upstream from the sample site (Nokleberg and others, 1983).

Area E: This area includes several drainages in the south-central part of the Kings River Roadless Area. The concentrate samples from the drainage basins comprising this area are strongly anomalous for some or all of the elements Ag, As, Bi, Cu, Pb, Sb, Sn, and W. The area contains outcrops of hornblende diorite and biotite quartz monzonite intruding predominantly biotite-muscovite-quartz schist, calc-schist, and marble. The suite of anomalous elements, taken in combination with the rock types present, indicates the presence of contact metasomatic base- and precious-metal sulfide occurrences and W occurrences. Immediately north of area E are the Marble Contact tungsten prospect and the Big Buck tungsten deposit, both consisting of marble with tactite stringers and pods near outcrops of hornblende diorite (Nokleberg and others, 1983). No known W prospects exist in area E (Nokleberg and others, 1983).

Area F: This area includes drainage basins on the north side of the Kings River in the northeastern part of the Kings River Roadless Area and in the large drainage basin just east of that roadless area. The samples from the drainage basins included in area F are anomalous for one or more of the elements As, Bi, Co, Cu, Mo, Sn, and W. The associated drainage basins contain outcrops of quartz monzonite, with lesser amounts of diorite and gabbro. The geologic units and the suite of anomalous elements suggest that W-rich quartz veins may occur in the area. No confirmed mineral occurrences were identified in the area.

Area G: This area is in the central part of the Agnew Roadless Area. The concentrate samples from these drainage basins are anomalous for one or more of the elements As, Bi, Co, Sn, and W. Rocks in this area include quartz veins, biotite quartz monzonite, hornblende granodiorite, and hornblende diorite plutons that intrude biotite-quartz schist, biotite-muscovite schist, quartzite, marble, and calc-schist. The geologic units and anomalous elements suggest a contact-metasomatic environment that may contain W deposits as well as minor base- and precious-metal sulfide occurrences. The Sierra Scientific gold quartz-vein prospect and the Tehipite tungsten tactite prospect occur near this area (Nokleberg and others, 1983).

Area H: This area includes several drainage basins in the northeastern part of the Kings River Roadless Area and the extreme southern part of the Rancheria Roadless Area. The samples from the drainage basins are anomalous for one or more of the elements Bi, Co, Cu, Mo, Sn, and W. The rocks in these basins are predominantly biotite quartz monzonite, but also contain hornblende diorite, pelitic schist, calc-schist, marble, and quartzite. The rock types and the suite of anomalous elements suggest that occurrences of vein-type, as well as contact metasomatic W, accompanied by base- and precious-metal sulfide occurrences, may be present particularly in the northern part of area H. The Garlic Meadow gold prospect, without confirmed Au, occurs in the northern part of the area (Nokleberg and others, 1983). The Lodge Pole and Ground Hog tungsten prospects, both consisting of discontinuous, irregular tactite bodies adjacent to or near granitic plutons, occur just north of the area (Nokleberg and others, 1983).

Area I: This area is in the Cabin Creek drainage basin in the northeastern part of the Rancheria Roadless Area. The concentrate sample from this drainage basin contains strongly anomalous Bi and W. Outcrops in the area contain biotite quartz monzonite, hornblende granodiorite, and Tertiary olivine basalt. Much of this area is covered by alluvium and glacial deposits; thus, the actual source of the material in the analyzed sample cannot be accurately determined. The rock types and the suite of anomalous elements suggest that W-rich quartz veins or tactite pods in the granitic rocks might be the source of the anomaly. No mineral occurrences are known in the area.

SUMMARY AND CONCLUSIONS

Several areas that have rock, stream-sediment, and heavy-mineral-concentrate samples with anomalous concentrations were identified in this study. These areas, shown on maps A and B, may be related to known or undiscovered mineral occurrences. The types of mineralization that may occur in each area are summarized in table 5 for all 3 sample media. Those areas with anomalous values deemed not to be related to possible mineralization have been omitted from table 5.

The analytical results of the heavy-mineral-concentrate samples generally provide more useful information than those from the stream-sediment samples for identifying potentially mineralized areas. The number and sample density of the concentrate samples, and thus the total area evaluated by these samples, are significantly less than the number and sample density of the stream-sediment samples. Additional, more detailed sampling using concentrate samples might identify additional anomalous areas related to mineralization.

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Table 1.--Summary of statistical information for 388 rock samples, Kings River, Rancheria, Agnew, and Oat Mountain Roadless Areas, California

[All values are in parts per million except those for Fe, which are in percent. N, not detected at the lower limit of determination, shown in parentheses. Leaders (--) indicate no data]

Element	Value or range of values		Percentiles				
	Background	Anomalous	50	75	90	95	98
Ag	N(0.5)-0.5	0.7-300	N(0.5)	N(0.5)	<0.5	0.5	2.0
As	N(200)-<200	200-1,000	N(200)	N(200)	N(200)	N(200)	N(200)
[1]Au	N(0.05)-0.05	0.064-0.38	--	--	--	--	--
Ba	N(20)-2,000	3,000->5,000	500	1,000	1,500	2,000	3,000
Bi	N(10)-<10	10-100	N(10)	N(10)	N(10)	N(10)	N(10)
Cd	N(20)	<20->500	N(20)	N(20)	N(20)	N(20)	N(20)
Cu	N(5)-100	150-500	7	20	70	100	150
Fe	N(0.05)-7	10->20	3	5	7	7	10
Mn	N(10)-2,000	3,000->5,000	500	1,000	1,500	2,000	5,000
Mo	N(5)-10	15-50	N(5)	N(5)	5	10	20
Pb	N(10)-70	100->20,000	20	30	50	50	70
Sb	N(100)-100	150-1,500	N(100)	N(100)	N(100)	N(100)	N(100)
Sn	N(10)-<10	10-1,000	N(10)	N(10)	N(10)	N(10)	N(10)
W	N(50)	<50-1,000	N(50)	N(50)	N(50)	N(50)	N(50)
Zn	N(200)-<200	200-10,000	N(200)	N(200)	<200	<200	300

[1] No valid summary data; only 35 samples analyzed.

Table 2.--Summary of statistical information for 127 stream-sediment samples, Kings River, Rancheria, Agnew, and Oat Mountain Roadless Areas, California

[All values are in parts per million. N, not detected at the lower limit of determination shown in parentheses]

Element	Values or range of values		Percentiles				
	Background	Anomalous	50	75	90	95	98
Bi	N(20)	<20-20	N(20)	N(20)	N(20)	N(20)	N(20)
Cu	N(5)-50	70-100	15	50	50	70	70
Mo	N(5)	<5-5	N(5)	N(5)	N(5)	N(5)	N(5)
Pb	10-50	70-100	20	20	30	30	50
Sn	N(10)	<10-20	N(10)	N(10)	N(10)	N(10)	N(10)
W	N(50)	<50-50	N(50)	N(50)	N(50)	N(50)	N(50)

Table 3.--Summary of statistical information for 56 concentrate samples, Kings River, Rancheria, Agnew, and Oat Mountain Roadless Areas, California

[All values in parts per million. N, not detected at the lower limit of determination, shown in parentheses]

Element	Value or range of values		Percentiles				
	Background	Anomalous	50	75	90	95	98
Ag	N(1)	100	N(1)	N(1)	N(1)	N(1)	100
As	N(500)	500-5,000	N(500)	N(500)	500	700	2,000
B	N(20)-150	200-1,500	<20	50	200	300	700
Ba	<50-700	5,000-10,000	300	500	700	700	5,000
Bi	N(20)-100	150-2,000	<20	150	1,000	2,000	2,000
[1]Co	<10-20	30-100	15	20	70	70	100
Cu	N(10)-50	70-2,000	<10	15	20	100	100
Mo	N(10)-50	70-700	<10	20	70	150	200
Pb	N(10)-100	150-1,500	20	30	70	150	1,000
Sb	N(500)	1,000-2,000	N(500)	N(500)	N(500)	N(500)	1,000
Sn	N(20)-70	100->2,000	50	70	150	500	2,000
W	N(100)-150	200-20,000	150	500	700	1,500	1,500

[1] Only those samples with a combination of cobalt values ≥30 ppm and nickel values <100 ppm are considered significant.

Table 4.--Anomaly scores for concentrate samples, Kings River, Rancheria, Agnew, and Oat Mountain Roadless Areas, California

[All values in parts per million. N, not detected at the lower limit of determination, shown in parentheses. Leaders (--) indicate no values reported]

Element	Anomaly scores and values or ranges of values			
	0 (background)	1 (weak)	2 (moderate)	3 (strong)
Ag	N(1)	--	--	100
As	N(500)	--	500	700-5,000
B	N(20)-150	200	300	700-1,500
Ba	<50-700	--	--	5,000-10,000
Bi	N(20)-100	150	200	300->2,000
[1]Co	<10-20	30-50	70	100
Cu	N(10)-50	70	100	150-2,000
Mo	N(10)-50	70-100	150	200-700
Pb	N(10)-100	150	--	1,000-1,500
Sb	N(500)	--	--	1,000-2,000
Sn	N(20)-70	100	150-200	500->2,000
W	N(100)-150	200	300-500	700->20,000

[1] Only those samples with a combination of cobalt values ≥30 ppm and nickel values <100 ppm are considered significant.

Table 5.--Summary classification of anomalous areas, by sample type, Kings River, Rancheria, Agnew, and Oat Mountain Roadless Areas, California

[Areas not listed contain anomalies not thought to be related to mineral occurrences]

Sample media	Areas designated on maps A and B with known or suspected mineral occurrence	
	Contact metasomatic tactite (W and (or) base and precious metal)	Quartz vein (W and (or) base and precious metal)
Rock samples (Map A)	G, I, J, K, N, O	A, C, D, E, F, H, I, O
Stream-sediment and concentrate samples (Map B)	A, C, D, E, G, N, I	F, H, I

SUMMARY GEOCHEMICAL MAPS FOR SAMPLES OF ROCK, MINUS-80-MESH STREAM SEDIMENT, AND NONMAGNETIC HEAVY-MINERAL CONCENTRATE, KINGS RIVER, RANCHERIA, AGNEW, AND OAT MOUNTAIN ROADLESS AREAS, FRESNO COUNTY, CALIFORNIA

By

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1988

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[1] Any use of trade names is for descriptive purposes only and does not imply endorsement by the U.S. Geological Survey.

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