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U.S. GEOLOGICAL SURVEY CIRCULAR 920

The Conterminous United States Mineral Assessment Program: Background Information to Accompany Folio of Geologic, Geochemical, Geophysical, Remote Sensing, and Mineral Resource Maps of the Wallace $1^\circ \times 2^\circ$ Quadrangle, Montana and Idaho

Prepared in cooperation with
the Montana Bureau of Mines and Geology

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ABSTRACT

The Wallace 1°×2° quadrangle in Montana and Idaho was studied by an interdisciplinary research team that included geologists, geochemists, and geophysicists, as well as specialists in isotopic dating and remote sensing. The basic data resulting from these studies, as well as the final metallic mineral resource assessments, are published as a folio of maps, figures, tables, and accompanying discussions. This circular provides background information on the studies and lists the published components of the resource appraisal. An extensive bibliography lists both specific and general references that apply to this geoscience study of the quadrangle.

INTRODUCTION

This circular, as well as a folio of separately published maps, is part of a series of U.S. Geological Survey reports that contain information on the mineral resources and mineral resource potential of the conterminous United States. The studies described herein are for the Wallace 1°×2° quadrangle in Montana and Idaho (fig. 1). This circular and the folio maps were prepared under the Conterminous United States Mineral Assessment Program (CUSMAP). CUSMAP is intended to provide regional mineral appraisal information to assist in formulating a sound, long-range national minerals policy and to assist Federal, State, and local governments in making decisions that involve land-use policy. In addition, the products of CUSMAP are intended to increase geological, geochemical, and geophysical knowledge of the conterminous United States. In accomplishing these goals, the program provides a regional geologic and mineral resource framework for specific studies, such as the mineral appraisal of wilderness areas and guidance for mineral exploration.

LOCATION AND GEOGRAPHY

The Wallace 1°×2° quadrangle covers about 6,450 mi^2 in northwestern Montana and adjacent parts of Idaho between lat 47° and 48° N. and long 114° and 116° W. (fig. 1). The area includes part of the Cabinet Mountains, Bitterroot Range, and Salish Mountains, where major valleys are generally at elevations of 2,500 to 3,000 ft and mountain peaks at 5,000 to 7,000 ft. The crest of the Bitterroot Range in the western part of the area forms the State line between Montana and Idaho. The high point in the quadrangle is at about 8,000 ft on Squaw Peak in the southeastern part of the area. The quadrangle includes most of Flathead Lake, which is in the northeast corner of the area. Principal drainages are the Clark Fork, Flathead, Saint Regis, Coeur d'Alene, and St. Joe Rivers. Many small towns and communities are scattered across the area; the largest towns are Wallace, Idaho, near the west edge of the quadrangle, and Polson, Mont., in the northeast, at the south end of Flathead Lake. The Flathead Indian Reservation occupies most of the eastern third of the quadrangle. The Montana National Bison Range is in the south-central part of the reservation.

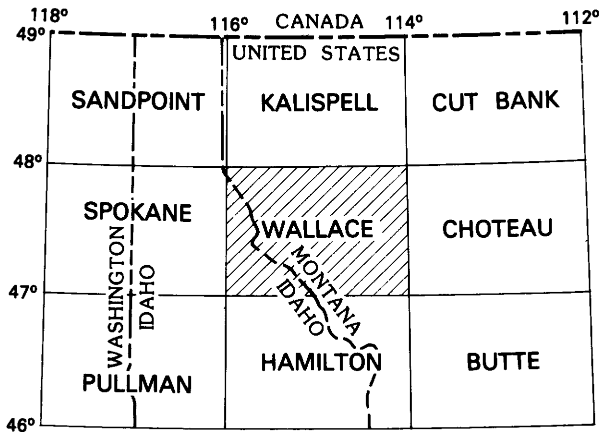

FIGURE 1.—Index map showing location of the Wallace and adjacent 1°×2° quadrangles, Montana, Idaho, and Washington.

More than half the quadrangle is on national forests, which include parts of the Lolo, St. Joe, Coeur d'Alene, Kaniksu, Kootenai, and Flathead National Forests.

Most of the area is accessible by a network of State and Federal highways and then by county and forest roads. Permission from the Flathead Tribal Council is advisable for use of the back roads on the Indian reservation. A few parts of the area are accessible only by foot trail.

INDUSTRY

Principal industries in the area are logging and mining. Most of the timber is on national forests, although significant timber is also held on the Flathead Indian Reservation and by private companies. The largest sawmills in the quadrangle are at Thompson Falls, Superior, Polson, and Pablo, Mont. Many logs are hauled westward to Saint Maries, Idaho, and southeastward to Missoula, Mont. Mining activity has been scattered over much of the area. The quadrangle includes the eastern half of the world-famous Coeur d'Alene silver mining district, as well as many smaller districts such as those around Murray, Idaho, and Saint Regis and Superior, Mont.

PREVIOUS STUDIES

Geology and mineral resources in parts of the Wallace quadrangle have been studied in various degrees of detail since the turn of the century. Early interest was centered around the mining districts (MacDonald, 1906; Ransome and Calkins, 1908; Pardee, 1911; Calkins and Jones, 1914; Jones, 1919; Umpleby and Jones, 1923). Restudy of some of the same districts and new study of others occurred in the 1930's (Shenon and Taylor, 1936; Shenon, 1938) and again in the late 1940's and during the 1950's (Lyden, 1948; Cook, 1955; Hosterman, 1956; Sahinen, 1957; Weis and others, 1958; Campbell, 1960; Fryklund, 1964; Hobbs and others, 1965; Johns, 1970). Numerous specialized studies that include observations in the Wallace quadrangle have been done on such diverse topics as glacial geology (Pardee, 1910; Alden, 1953), geochronometry (McDowell, 1971; Armstrong, 1975; Armstrong and others, 1977), geochemistry (Wilson, 1963; Crosby, 1969; Gott and Cathrall, 1980), igneous petrology (Hietanen, 1963), paleontology (Keim and Rector, 1964), geophysics (LaPoint, 1971; Kleinkopf and others, 1972; Wold, 1982), and stratigraphy (Wagner, 1949; Wallace and Hosterman, 1956; Hietanen, 1968; Wells, 1974).

PRESENT INVESTIGATIONS

Systematic collection of data by the U.S. Geological Survey began in 1973 with geologic mapping at a 1:250,000 scale by A. B. Griggs and J. E. Harrison, who later were joined by J. D. Wells. All previous geologic mapping was checked and revised where necessary to meet the improved knowledge of stratigraphic units available in the 1970's. The geologic map was completed in 1981. A detailed stratigraphic study of the Prichard Formation near Plains, Mont., was done by E. R. Cressman in 1980–81. Aeromagnetic and gravity data were accumulated as time and money permitted through the 1970's, and a final effort was made by M. D. Kleinkopf to complete reconnaissance coverage by 1981. Audio-magnetotelluric surveys were conducted by C. L. Long in 1979–81. Background data on the geochemistry of rocks and stratabound mineral occurrences were collected along with the geologic mapping; systematic collection of samples of stream sediments and types of ore deposits was done under the direction of D. L. Leach and J. A. Domenico during the field seasons of 1979 through 1981. Chemical analyses were done by Domenico and D. M. Hopkins in the U.S. Geological Survey laboratories in Golden, Colo. Computer analyses and manipulation of the data were completed by Leach, H. E. Dawson, and R. J. Goldfarb in 1982. Isotopic dating of rocks and ores was done periodically by R. F. Marvin, R. E. Zartman, and J. D. Obradovich as the geologic mapping progressed. Remote sensing data from Landsat images and from side-looking radar were analyzed by L. C. Rowan and T. L. Purdy and field checked by Rowan in 1980. Data on mineral occurrences in the quadrangle were compiled from published and unpublished sources by Sharon Chesson and R. R. Wallace during 1979 and 1980, were put into the U.S. Geological Survey CRIB (changed to MRDS in 1983) file, and were manipulated by computer in 1981 by Thomas Griffith.

The data and the maps prepared for the Wallace 1°×2° quadrangle folio are being released in a series of USGS formal reports and open files (tables 1 and 2).

DESCRIPTIONS OF MAPS OF THE WALLACE 1°×2° FOLIO

GEOLOGIC MAPS (MF–1354–A, I–1509–A)

A colored geologic map and a structure map of the quadrangle are published at a scale of 1:250,000 as I–1509–A. These maps are accompanied by detailed map explanations, cross sections, stratigraphic columns, and some explanatory and interpretative text. An uncolored, generalized map at the same scale has only a simple explanation and is published as MF–1354–A. This simplified map is used as an underlay for other maps of the Wallace CUSMAP folio that show geochemical, geophysical, and mineral resource data.

Bedrock in the Wallace quadrangle consists dominantly of metasedimentary rocks of the Middle Proterozoic Belt Supergroup. About 60,000 ft of Belt rocks are exposed on a single thrust plate. The rocks are mostly fine grained clastics and carbonates that show a variety of bedding characteristics and sedimentary structures. Regional metamorphism increases from diagenetic mineral assemblages at the top of the section downward through a chlorite-sericite zone into a garnet zone of the greenschist facies in the lowest exposed rocks. Metamorphism also increases near intrusive rocks and is as high as the amphibolite facies in the southwestern part of the quadrangle, where metamorphic isograds related to the Idaho batholith have been mapped by Hietanen (1963, 1968) and Lang (Lang and Rice, 1982).

Precambrian sills and dikes of dioritic to gabbroic composition have been intruded into Belt rocks. Most occur in the lower part of the Prichard Formation, but a few are found in the Burke, Wallace, Helena, Mount Shields, and Garnet Range Formations. The dikes and sills represent more than one episode of intrusion (Harrison, 1972).

Cambrian sedimentary rocks unconformably overlie Belt rocks in the southeastern and north-central parts of the quadrangle. The rocks consist of a lower quartzite overlain by shale, limestone, and dolomite.

Stocks and dikes ranging in composition from diorite to granite are exposed in many parts of the quadrangle. In a regional sense, these intrusive rocks are outliers of the Idaho batholith, which is about 40 mi south of the quadrangle, and of the batholithic terrane of eastern Washington and northern Idaho, an area about 70 mi northwest of the quadrangle. Ages of these intrusions within the Wallace quadrangle range from about 120 million years (m.y.) to about 35 m.y. (Marvin and others, 1984) or Cretaceous to Oligocene. Many of the plutons are along or near high-angle faults, and where they encounter thrust faults, most appear to intrude through or at least into the thrusts. A zone of intrusions extends north-northeast from the St. Joe fault at the west edge of the quadrangle through the Coeur d'Alene mining district near Wallace, Idaho, to the northeast side of the Clark Fork valley near Trout Creek, Mont. Many geologists have considered this zone to reflect some deep crustal flaw whose intersection with a zone of west-northwest-trending fractures (the Lewis and Clark line) near Wallace may control the location of the Coeur d'Alene mining district.

Tertiary sedimentary and volcanic rocks underlie small parts of the quadrangle and are most abundant in the valley of Ninemile Creek near the southeast corner of the area. The sedimentary rocks include conglomerate, shale, coal, and volcanic ash. A small volcanic field in the northeast part of the quadrangle contains mostly volcanic agglomerate, conglomerate, and breccia, plus dacite tuff.

Unconsolidated deposits in the quadrangle include widespread occurrences of Pleistocene glacial debris from both continental and mountain glaciers, as well as lake silt from glacial Lake Missoula. Alluvial deposits occur along most stream courses.

Structure in the area is complex, and many features are strikingly displayed on the maps. A southeast-trending zone of strike-slip and high-angle faults transects the quadrangle from the center of the west edge to the southeast corner; this zone is part of the Lewis and Clark line (Billingsley and Locke, 1939). The large intermontane valley at the east edge of the quadrangle occurs along multiple high-angle faults in the Rocky Mountain trench. A major strike-slip fault (the Hope) extends from near the center of the quadrangle northwest along the valley of the Clark Fork; another (the St. Marys) extends from about the same point near the center of the quadrangle eastward along the valley of the Flathead River. Numerous thrust faults are scattered over the quadrangle; these are commonly cut by the abundant high-angle faults that occur in most of the area. The most common folds are broad open structures that are outlined by the patterns of lithologic units; a few tight folds or folds that have one vertical to overturned limb are present locally.

GEOCHEMICAL MAPS (MF–1354–C, D; I–1509–B, C, D)

The geochemical maps contain data from a geochemical survey conducted in the Wallace quadrangle from 1978 to 1981. These data show the distribution and abundance of selected elements and were used to delineate areas having anomalous concentrations of those elements. The geochemical survey consisted of the collection and analysis of samples of stream sediments and nonmagnetic heavy-mineral concentrations from 1,229 locations. An unbalanced, four-level, nested sampling procedure was used to partition the total variability of the data among four major sources of variability.

All samples were prepared and analyzed by the U.S. Geological Survey laboratories in Golden, Colo. The stream sediments were air dried and then sieved using an 80–mesh sieve. The material passing through the 80–mesh sieve was pulverized to less than 100 mesh for analysis. Heavy-mineral concentrates were collected using a standard gold pan. Commonly, 3–4 kilograms of composited sediment were collected to yield the desired 30–60 grams of concentrate. These samples were air dried, and the highly magnetic material was removed by an electromagnet. Any low-density material remaining in the concentrate was separated by allowing the heavier fraction to settle through bromoform (specific gravity of 2.8). The resulting heavy-mineral fraction was then separated into a nonmagnetic and a magnetic fraction using a Frantz Isodynamic separator[1] at a setting of 0.6 ampere with 15° forward and 15° side settings. The nonmagnetic fraction was pulverized in an agate mortar before analysis.

Each stream-sediment and nonmagnetic heavy-mineral sample was analyzed semiquantitatively for 31 elements using an optical emission spectrograph. Each stream-sediment sample was also analyzed by atomic absorption spectrometry for total-metal concentrations of silver, bismuth, cadmium, copper, lead, antimony, and zinc, because this method has lower detection limits than possible by emission spectrography. These elements were selected because they are important constituents of most of the mineral deposits in the quadrangle. Atomic absorption spectrometry was also used to determine concentrations of this same suite of elements (except for cadmium) that were partially extractable in weak hydrochloric acid. All the data for the geochemical survey are available on computer tape from the National Technical Information Service (McDanal and others, 1982) and in U.S. Geological Survey Open-File Report 82–494 (Leach and others, 1982). The latter report describes in detail the procedure used in the survey, as well as provides a variety of statistical summaries and estimates based on the data sets.

Results have been released as U.S. Geological Survey Open-File Reports that include maps at a scale of 1:250,000, which show distribution and abundance of antimony, cadmium, copper, lead, silver, and zinc in nonmagnetic heavy-mineral concentrates and in stream sediments for both total and partially extractable metals. Included in the reports are contour maps for each of the elements used in identifying broad regional geochemical trends. One map (Open-File Report 84–700) shows

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

the distribution and abundance of bismuth, molybdenum, tin, and tungsten in nonmagnetic heavy-mineral concentrates; these data were used to help develop the resource map for porphyry molybdenum-tungsten deposits.

For each of the three data sets—nonmagnetic heavy minerals, total metals in stream sediments, and partially extractable metals in stream sediments—maps were compiled to show the suite of elements that may be present in anomalous concentrations at each sample location in the quadrangle. These maps (I–1509–B, C, and D) were used to help derive several of the mineral-resource appraisal maps.

In addition to these data maps, an interpretative geochemical map (MF–1354–C) includes a text that describes the steps used to determine the geochemical favorability for mesothermal base- and precious-metal vein deposits in the Wallace quadrangle.

AEROMAGNETIC, GRAVITY, AND METALLIC MINERAL FAVORABILITY MAPS (MF–1354–E)

The aeromagnetic and gravity maps of the Wallace quadrangle were prepared from four separate aeromagnetic surveys totaling about 16,000 line miles and from nearly 2,100 gravity stations spaced about 5 mi apart (Bankey and Kleinkopf, 1982; Bankey and others, 1982; Wold, 1982; U.S. Geological Survey, 1978, 1979; Wilson, 1979; Kleinkopf and others, 1972; Douglas, 1972; LaPoint, 1971). Total intensity magnetic, Bouguer gravity, and magnetic and gravity residual maps were used to locate and outline the configuration of buried intrusions and to delineate major faults and shear zones in the subsurface.

The aeromagnetic and gravity anomaly data were used to help evaluate the quadrangle for porphyry molybdenum-tungsten, mesothermal base- and precious-metal veins, and epithermal silver deposits. These types of hydrothermal deposits are assumed to be related to granitic intrusions, and the magnetic anomaly data provide the most diagnostic criteria for locating buried plutons and for defining the subsurface configuration of exposed plutons. Gravity information helps outline major structural trends, and upward continuation of anomalies helps to define areas that may contain blind intrusions.

The results of the magnetic and gravity study are summarized on a map that shows geophysical favorability for metallic-mineral-bearing hydrothermal veins. An arbitrary system of favorability was used to rank areas from most favorable (3 points) to unfavorable (–1 point). The results of this favorability ranking are integrated with audio-magnetotelluric, geochemical, geological, and mineral occurrence data as part of the metallic mineral resource appraisal of the quadrangle (Harrison, Leach, Kleinkopf, Cressman, and others, in press; Long, 1983).

AUDIO-MAGNETOTELLURIC STUDIES (MF–1354–B)

The regional subsurface resistivity in terrane of the Belt Supergroup was studied using natural source audio-magnetotelluric (AMT) currents. The data were plotted on a 7.5-Hertz map, two 27-Hertz maps, and six resistivity cross sections (Long and others, 1981; Long, 1982; Long, 1983). The AMT data identified conductive zones that are inferred to be related to sulfide minerals in certain beds of the Prichard Formation, an altered zone associated with a buried porphyry molybdenum stock, and subsurface extensions of geologic units and structures. This study has demonstrated an effective reconnaissance geophysical method for outlining sulfide-bearing strata that may be within suitably shallow depths for future mineral exploration.

ISOTOPE DATA MAP (MF–1354–G)

The isotope data map of the Wallace quadrangle shows (1) the sample localities and radiometric ages for 15 samples, as well as sample localities for 20 other samples that gave hybrid or spurious ages, and (2) the location of 36 mines or prospects from which galena was collected for lead isotope analysis. The isotopic ratios of lead indicate that some lead is Precambrian and some is Mesozoic-Cenozoic.

Rocks and minerals from metamorphic and igneous bodies were also dated. The pre-Belt basement gneiss is about 1,665 m.y. old according to uranium-lead (U-Pb) determinations on zircon. Radiometric dates for rocks of the Belt Supergroup are mostly hybrid (secondary) ages, reflecting the effects of metamorphic, plutonic, thermal, and tectonic events on Belt strata. Several potassium-argon (K-Ar) mineral ages and U-Pb zircon ages indicate that plutonic activity within the quadrangle occurred at about 100 m.y. and 50 m.y. ago. The most recent igneous activity, as dated by the K-Ar method, occurred about 30 m.y. ago (mid-Oligocene) and resulted in the formation of the small Hog Heaven volcanic field in the northeastern quadrant of the quadrangle.

LINEAMENT ANALYSIS MAPS (MF–1354–H)

Linear and arcuate features were mapped on Landsat images and image mosaics to examine possible relations between fracture zones, intrusive bodies, and mineral deposits in the quadrangle. Landsat band 5 and band 7 image mosaics were used for mapping these features in the quadrangle, as well as in the region adjacent to the quadrangle, and digitally processed color-infrared composite images were used for detailed studies in the quadrangle and bordering areas. The linear features mapped on the color-infrared images were digitized to facilitate statistical analysis. Lineaments identified using this approach were compared with mapped fault and fracture zones, aeromagnetic and Bouguer gravity anomalies, and geochemical anomalies, as well as with the distributions of different types of metal deposits. Most of the Cretaceous and Tertiary intrusive bodies are along northeast-trending lineaments, and many are marked by arcuate features.

METALLIC MINERAL OCCURRENCE MAP (MF–1354–F)

The mineral occurrence map shows the location of about 550 mines and prospects and the kinds of metals found in them. About a third of the mines and prospects are in the Coeur d'Alene mining district in the west-central part of the quadrangle; another third are along the Lewis and Clark line southeast of that district; and the remainder are scattered over the quadrangle. Principal products from the mines have been gold, silver, lead, zinc, cadmium, copper, and bismuth. Other commodities that have been produced or are known in the area include molybdenum, tungsten, antimony, nickel, platinum-group metals, and uranium. Symbols on the map identify each known property and show each classified into one of several categories consisting of individual metals or groups of metals. A table lists property name, location, metals known or produced, and references used to characterize the mine or prospect.

RESOURCE APPRAISAL MAPS (I–1509–E, F, G, H, I, AND J)

Resource appraisal maps have been prepared for placer gold (I–1509–E), stratabound copper-silver (I–1509–F), Sullivan-type stratabound lead-zinc-silver (I–1509–G), porphyry molybdenum-tungsten, platinum-group metals, and epithermal silver (I–1509–H), and mesothermal base- and precious-metal veins (I–1509–I). In addition, a summary map has been prepared showing all metallic mineral resources (I–1509–J). Each of these maps is accompanied by a pamphlet that explains the resource appraisal system used for all appraisals. In addition, each individual map includes a written description of the occurrence model used for the type of ore deposit being appraised, the criteria for determining various levels of favorability within a subarea of the quadrangle, and numerical values assigned to those levels of favorability. Subareas identified within the quadrangle have been classified into six levels of decreasing favorability and one level of unfavorablility for the type of deposit being evaluated. The numerical scores assigned by the appraisal team are shown for each subarea. Data supporting the scores are shown on the maps; where the data are necessarily generalized, the detailed data can be found in other maps and reports of the Wallace CUSMAP folio.

TABLE 1.—*Principal maps of the Wallace 1°×2° quadrangle folio*

[MF, U.S. Geological Survey Miscellaneous Field Studies Map; I, U.S. Geological Survey Miscellaneous Investigations Series]

Map No.	Author(s) (year of publication)	Subject
MF-1354-A	Harrison, Griggs, and Wells (1981)	Generalized geology.
MF-1354-B	Long (1983)	Audio-magnetotelluric studies.
MF-1354-C	Leach (in press)	Geochemical favorability for mesothermal base- and precious-metal veins.
MF-1354-D	Leach and Goldfarb (in press)	Geochemical distribution of lead, zinc, copper, and silver; also geochemical distribution of lead and zinc.
MF-1354-E	Kleinkopf, Harrison, and Bankey (in press).	Aeromagnetic, gravity, and metallic mineral favorability maps.
MF-1354-F	Chesson, Wallace, and Griffith (1984).	Metallic mineral occurrences.
MF-1354-G	Marvin, Zartman, Obradovich, and Harrison (1984).	Geochronometric and isotope data.
MF-1354-H	Rowan and Purdy (in press)	Lineament analysis.
I-1509-A	Harrison, Griggs, and Wells (in press).	Geology and structure.
I-1509-B	Leach and Domenico (in press)	Distribution of samples of heavy-mineral concentrates containing anomalous antimony, arsenic, copper, lead, silver, and zinc.
I-1509-C	Leach and Hopkins (in press)	Distribution of stream sediments containing anomalous antimony, bismuth, cadmium, copper, lead, silver, and zinc.
I-1509-D	Leach and Hopkins (in press)	Distribution of stream sediments containing anomalous partially extractable antimony, bismuth, copper, lead, silver, and zinc.
I-1509-E	Harrison, Domenico, and Leach (in press).	Resource appraisal for placer gold.
I-1509-F	Harrison, Domenico, and Leach (in press).	Resource appraisal for stratabound copper-silver.
I-1509-G	Harrison, Cressman, Long, Leach, and Domenico (in press).	Resource appraisal for stratabound lead-zinc-silver.
I-1509-H	Harrison, Leach, Kleinkopf, and Long (in press).	Resource appraisal for porphyry molybdenum-tungsten, platinum-group metals, and epithermal silver.
I-1509-I	Harrison, Leach, and Kleinkopf (in press).	Resource appraisal for mesothermal base- and precious-metal veins.
I-1509-J	Harrison, Leach, Kleinkopf, Cressman, Long, and Domenico (in press).	Summary of resource potential for metallic minerals.

TABLE 2.—*Supplemental Open-file reports and maps of the Wallace 1°×2° quadrangle folio*[1]

[OF, U.S. Geological Survey Open-File Report]

Report No.	Author(s) (year of release)	Subject
OF-81-785	Cressman (1981)	Geologic map of the Plains-Perma area.
OF-81-1153	Long, Tippens, and Lewis (1981)	Audio-magnetotelluric data.
OF-82-132	Bankey, Brickey, and Kleinkopf (1982).	Principal facts for 1980 gravity stations.
OF-82-494	Leach, Domenico, Hopkins, Dawson, and Goldfarb (1982).	Geochemical data and statistical summaries for stream sediments and nonmagnetic heavy-mineral concentrates.
OF-82-495	Cressman (1982)	Stratigraphic section of Prichard Formation.
OF-82-577	Leach (1982)	Geochemical favorability for mesothermal veins (one 35-mm colored slide).
OF-82-581	Harrison, Leach, Kleinkopf, Cressman, Long, and Domenico (1982).	Metallic mineral resource appraisal (nine 35-mm colored slides).
OF-82-671	Long (1982)	Audio-magnetotelluric surveys (four 35-mm colored slides).
OF-82-709	Kleinkopf, Harrison, and Bankey (1982).	Aeromagnetic, gravity, and metallic mineral resource favorability (three 35-mm colored slides).
OF-82-883	Bankey and Kleinkopf (1982)	Principal facts for Bouguer gravity map.
OF-83-304	Leach, Hopkins, Domenico, and Dawson (1984a).	Geochemical distribution and abundance of lead.
OF-83-305	Leach, Hopkins, Domenico, and Dawson (1984b).	Geochemical distribution and abundance of cadmium.
OF-83-306	Leach, Hopkins, Domenico, and Dawson (1984c).	Geochemical distribution and abundance of antimony.
OF-83-307	Leach, Hopkins, Domenico, and Dawson (1984d).	Geochemical distribution and abundance of copper.
OF-83-308	Leach, Hopkins, Domenico, and Goldfarb (1984a).	Geochemical distribution and abundance of zinc.
OF-83-309	Leach, Hopkins, Domenico, and Goldfarb (1984b).	Geochemical distribution and abundance of silver.
OF-84-700	Leach and Domenico (1985)	Geochemical distribution and abundance of bismuth, molybdenum, tin, and tungsten.

[1]Open-file reports for the Wallace quadrangle include basic geochemical and geophysical data, 35-mm slides of preliminary maps that are or will be superseded by maps of the I or MF series (see table 1), and black and white maps of selected data that are shown only in combined forms on other maps of the folio.

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