GEOLOGICAL SURVEY CIRCULAR 849

The Conterminous United States Mineral Appraisal Program: Background Information to Accompany Folio of Geologic, Geochemical, Geophysical, and Mineral Resource Maps of the Choteau 1° x 2° Quadrangle, Montana

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ABSTRACT

The Choteau 1°x 2° quadrangle in northwest Montana was studied by an interdisciplinary research team in order to appraise its mineral resource and hydrocarbon potential. The appraisal is based on field and laboratory investigations of the geology, geochemistry, and geophysics. The results of the investigations are published as a folio of maps, figures, tables, and accompanying discussions. This circular provides background information on the investigations and integrates the published components of the resource appraisal. A comprehensive bibliography cites both specific and general references to the geology, geochemistry, geophysics, and mineral deposits of the Choteau 1°x 2° 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 in this circular include the Choteau 1°x 2° quadrangle in Montana (fig. 1). This circular and the folio maps were compiled under the Conterminous United States Mineral Appraisal 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 planning. 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 Choteau 1°x 2° quadrangle covers approximately 16,600 km^2 in northwestern Montana between lat 47° and 48° N. and long 112° and 114° W. (fig. 1). The area straddles the front ranges of the northern Rocky Mountains; the eastern third is in the Great Plains physiographic province and the western two-thirds is in the Northern Rocky Mountains province. The Continental Divide trends northerly through the approximate center of the quadrangle. Principal drainages east of the Divide are the Dearborn, Sun, and Teton Rivers; west of the Divide they are the West Fork Flathead, Blackfoot, and Swan Rivers. Altitudes within the quadrangle range from about 2,700 m near the Continental Divide to about 1,100 m near the eastern boundary. The town of Choteau, the largest community in the quadrangle, is located on U.S. Highways 89 and 287 in the northeastern part.

The eastern third of the quadrangle is accessible by numerous paved and graveled roads and the western part is accessible by a highway that follows the broad,

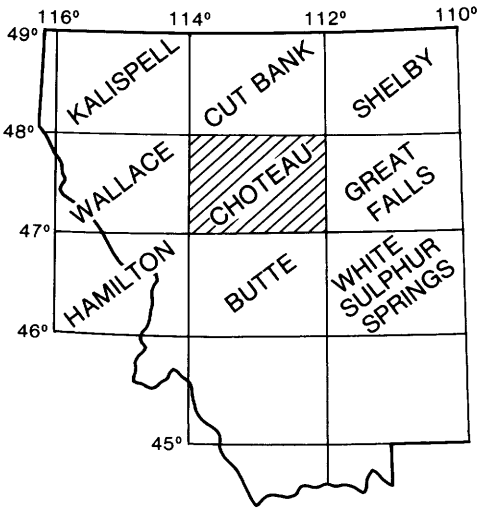

Figure 1.—Index showing location of the Choteau and adjacent 1°x 2° quadrangles, Montana.

northerly trending Swan River-Clearwater River valley between the Swan and Mission Ranges. About one-third of the Choteau quadrangle is included in the National Wilderness Preservation System. The central part contains the Great Bear, Bob Marshall, and Scapegoat Wilderness Areas, in which access is permitted only by foot or horseback. The Mission Range, along the western boundary, includes the Mission Wilderness Area where use of motorized vehicles is also restricted.

Sources of information

The maps and interpretations included in the CUSMAP folio of the Choteau 1^{o}x 2^{o} quadrangle (table 1) are a product of numerous multidisciplinary studies conducted between 1957 and 1979. Studies prior to this period provided invaluable background information, particularly the geological reconnaissance studies of Chapman (1900), Walcott (1906; 1908; 1915), and Stebinger (1918). Numerous workers contributed to an understanding of the stratigraphy of the Paleozoic and Mesozoic rocks prior to 1957. Studies of the metalliferous deposits in the quadrangle by Pardee and Schrader (1933) provided the basis for many subsequent economic geology studies, and the mine production records which they compiled have been used along with more modern data on the mineral resource map in the Choteau folio (Earhart and others, 1980).

Much of the information used in compiling the Choteau folio was generated from mineral resource studies by the U.S. Geological Survey and the U.S. Bureau of Mines of the wilderness and wilderness-candidate study areas. The wilderness studies began in 1968 and were completed in 1978.

Present investigations

The present investigations began in 1957 with the geologic mapping of six 7 1/2-minute quadrangles in the Sun River Canyon area by Mudge (1965; 1966a; 1966b; 1966c; 1967; 1968). The stratigraphy and structural geology of these quadrangles were discussd by Mudge (1972a; 1972b). Mudge (1968) conducted geological, geochemical, and geophysical studies in the southeastern part of the Lewis and Clark Range. Other mineral-resource studies from which much information is taken and incorporated in the CUSMAP studies include wilderness-related investigations (Mudge, Earhart, Watts and others, 1974; Mudge, Earhart, and Claypool, 1977; Mudge and Earhart, 1978; Mudge, Rice and others, 1978; Earhart and others, 1977). Studies of the stratigraphy and structure of the northern Disturbed Belt were used in compiling the geologic and structural maps included in the folio (Mudge, Earhart, and Rice, 1977a; 1977b). The above investigations were supplemented with geological, geochemical, and geophysical studies in 1977 and 1978 in order to provide complete coverage of the Choteau quadrangle.

Aeromagnetic data were obtained by the U.S. Geological Survey in conjunction with regional studies in northwestern Montana (Mudge and others, 1968; Harrison and others, 1969; and Kleinkopf and Mudge, 1972). These data were supplemented by aeromagnetic surveys flown in the southeastern part of the quadrangle in 1978 (U.S. Geological Survey, 1980a).

Gravity data were generated as a part of the mineral resource studies of wilderness areas (Mudge and others, 1975; Kleinkopf and others, 1978). These data were supplemented by the results of unpublished gravity surveys by D. M. Wilson throughout the remainder of the Choteau quadrangle. Although the gravity data are not included in the folio, unpublished interpretations of the gravity data were utilized in the preparation of the mineral resource map.

DESCRIPTIONS OF MAPS OF THE CHOTEAU 1^{o}x 2^{o} FOLIO

Geologic maps—(OF-79-280, 79-863, and 79-719)

The rocks in the Choteau quadrangle range from Proterozoic to Quaternary in age. Most of the rocks are of sedimentary origin. Locally the sedimentary rocks are intruded by stocks, dikes, and sills that range from Proterozoic to Tertiary in age. Glacial deposits of Pleistocene age cover large areas in the eastern part and occupy the major valleys elsewhere in the quadrangle. The western two-thirds of the quadrangle is structurally complex and contains numerous thrust faults, normal faults, and folds.

The oldest rocks exposed are clastic and carbonate rocks assigned to the Belt Supergroup of Proterozoic age. The Belt rocks are regionally metamorphosed to the chlorite subfacies and are widely distributed throughout the western two-thirds of the quadrangle.

The Belt rocks are overlain by Paleozoic rocks that are predominantly limestone and dolomite. The Paleozoic rocks are best exposed along the Sawtooth Range which forms the mountain front in the east-central part of the quadrangle. They are also exposed at many places on and near the Continental Divide and along down-faulted blocks to the west of the Divide.

Most of the eastern third of the quadrangle is underlain by Mesozoic rocks that consist mostly of mudstone, shale, and sandstone. The Mesozoic rocks are also exposed in north-trending narrow belts along the front range to as far west as the North Fork Sun River.

Tertiary sedimentary rocks underlie small areas in the southern and western parts of the quadrangle and mostly consist of mudstone, shale, and conglomerate. Widespread glacial deposits of Pleistocene age are derived from continental glaciers in the eastern third of the area and from mountain glaciers to the west. Quaternary unconsolidated alluvial and colluvial deposits are widely distributed throughout the quadrangle.

Igneous rocks occur locally throughout the quadrangle, but are most abundant in the southeastern part. Andesite and diorite sills of Proterozoic age locally crop out in the western two-thirds of the quadrangle and are the oldest igneous rocks exposed in the area. Trachyandesite sills of Cretaceous age crop out in the central and north-central parts of the area, and Tertiary stocks, dikes, and sills, mostly of monzonitic to rhyolitic composition, crop out in the southeastern part. Volcanic and volcanic-sedimentary rocks of Cretaceous and Tertiary ages are also present in the southeast part.

The dominant structural features in the Choteau quadangle are thrust faults, normal faults, and folds which are a part of the Northern Disturbed Belt—a

north to northwesterly striking belt of highly deformed rocks that extends from the southeastern corner of the quadrangle through the east-central part to the north boundary. The rocks to the west of the Disturbed Belt contain broad, open folds and numerous normal faults. To the east, the rocks dip gently easterly.

Hydrocarbon Potential Map (OF-80-24)

Oil and gas are produced from wells to the north and east of the quadrangle. Gas has been located in the Northern Disturbed Belt in the north part of the quadrangle, and the results of present studies indicate a high potential for additional discoveries.

Mineral Resources Map (MF-858A)

Past mineral production in the Choteau quadrangle mostly consisted of base and precious metals and totaled about $25 million, all from the southeastern part. As of 1980, there were no producing mines in the quadrangle. A copper-molybdenum porphyry-type deposit in the southeastern part of the quadrangle is reported to be of economic size and grade (Miller and others, 1973), and the surrounding area has a high potential for the discovery of similar deposits. Occurrences of stratabound copper and silver are widespread in the Proterozoic rocks in the western two-thirds of the quadrangle. Silver-copper ore was produced from one stratabound deposit in the southern part, but the other known occurrences are of submarginal grade. Other mineral occurrences in the quadrangle include stratabound and replacement deposits of lead and zinc, base and precious metals in vein deposits, and stratiform titaniferous magnetite deposits.

Geochemical Maps (MF-858B, C, D, E, F)

The geochemical maps contain data from geochemical surveys conducted by the U.S. Geological Survey in the Choteau quadrangle from 1968-1979. These data show the distribution and abundance of selected elements and delineate areas with anomalous concentrations.

The geochemical studies consisted of the collection and analyses of 3,329 rock and 2,235 stream-sediment samples and of the compilation and interpretation of the analytical data. All of the major rock types that crop out in the quadrangle were sampled. They include fresh unaltered rocks, which were analyzed in order to determine normal trace-element populations, and mineralized and altered rocks. Stream sediments were collected from most of the streams in the quadrangle from the finest-grained sediment available; where possible, they were taken from the most active part of the stream.

All samples were prepared and analyzed by the U.S. Geological Survey in mobile laboratories at field camps or in laboratories in Golden, Colo. The rock samples were crushed, split, and ground to 0.1 mm in a pulverizer equipped with ceramic plates. The stream sediments were air dried and sieved to minus 0.18 mm in stainless-steel sieves. Most samples were analyzed for 30 elements by an optical emission-spectrographic method, for gold by an atomic absorption method, and for mercury by a vapor detector technique.

Geochemical data sets were merged and manipulated by a computer located at the U.S. Geological Survey Computer Center in Denver, Colo. The combined data set contains multi-element analyses and locations of all samples (Grimes and others, 1980), and is available on computer tape from the National Technical Information Service (McDanal and others, 1980). Data reduction, which eliminated duplicate sample sites and samples that were collected too close together to plot at a 1:250,000-map scale, was accomplished by dividing the quadrangle into a grid with 0.5-km-square cells and selecting the maximum value for each chemical element and sample location within the cell. The resultant minor deviations in some of the sample locations are considered insignificant at the scale of the folio maps and have negligible effect on the delineation of anomaly patterns in the quadrangle. All of the geochemical distribution and abundance plots were produced on a flatbed plotter from the condensed rock and stream-sediment data sets and were plotted on a screened topographic and generalized geologic base map. The elements shown on these maps were selected on the basis of their associations with the types of mineral deposits that may occur in the quadrangle as suggested by the geology, and on the availability of analytical data from previous geochemical studies.

Aeromagnetic Map (MF-858G)

The aeromagnetic map of the Choteau quadrangle is a mosaic of six separate surveys flown by the U.S. Geological Survey to study regional structure and the magnetic character of the rocks in the upper part of the Earth's crust (Kleinkopf and Mudge, 1972; U.S. Geological Survey, 1969; 1979; 1980a; 1980b). Aeromagnetic data support geologic mapping, and they provide a basis for the assessment of mineral resource potential in the subsurface. The configuration and location of buried intrusive bodies and the delineation of major faults and shear zones in the subsurface are interpreted from the magnetic data. Some of these features are reflected by magnetic trends associated with known mineralized localities. In the southeastern part of the quadrangle magnetic data are interpreted to reflect near-surface apophyses of buried intrusions that may contain porphyry-type, copper-molybdenum deposits.

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Table 1.—Maps of the Choteau 1°x 2° quadrangle folio

[MF, U.S. Geological Survey Miscellaneous Field Studies Map; OF, Open-File Report]

Series No.	Author	Subject
MF-858A	Earhart, Mudge, Whipple, and Connor (1980) ...	Mineral resources.
MF-858B	Grimes and Leinz (1980a).....	Geochemical distribution and abundance of copper.
MF-858C	Grimes and Leinz (1980b).....	Geochemical distribution and abundance of silver.
OF 80-1258	Grimes, Leinz, and Hopkins (1980)	Spectrographic and chemical analyses, and sample-location maps.
MF-858D	Leinz and Grimes (1980a).....	Geochemical distribution and abundance of lead.
MF-858E	Leinz and Grimes (1980b).....	Geochemical distribution and abundance of zinc.
MF-858F	Leinz and Grimes (1980c).....	Geochemical distribution and abundance of mercury, arsenic, and molybdenum.
MF-858G	Kleinkopf (1980)	Aeromagnetic map and interpretation.
OF 80-24	Mudge, Clayton, and McNichols (1980)	Hydrocarbons.
OF 79-280	Mudge, Earhart, Whipple, and Harrison (1979a)[1]	Geology.
OF 79-863	Mudge, Earhart, Whipple, and Harrison (1979b)[1]	Structure.
OF 79-719	Whipple (1979)	Geologic map of southwestern part of quadrangle.

[1]U.S. Geological Survey Open-File Reports are preliminary and printed in black and white; a final version will be published in color in the Miscellaneous Investigations series (Mudge, Earhart, Whipple, and Harrison, in press).

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