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Reconnaissance Geology of the Selway-Bitterroot Wilderness Area

by

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State of Idaho
DON SAMUELSON, Governor
Idaho Bureau of Mines and Geology
R. R. REID, Director

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RECONNAISSANCE GEOLOGY OF THE SELWAY-BITTERROOT WILDERNESS AREA

1965-1966

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ABSTRACT

The major geologic structure and rock types in 1200 square miles of the Selway-Bitterroot Wilderness Area have been mapped during 1965 and 1966. The largest rock unit, the Idaho batholith, is predominantly composed of coarse grained, directionless quartz monzonite containing phenocrysts of potassium feldspar and plagioclase. The batholith cuts metasediments of the Belt Supergroup and igneous bodies of several ages.

The metasediments were deformed by three regionally-penetrative fold events prior to intrusion by quartz monzonite of the batholith. Igneous intrusion preceded or accompanied each event of folding and metamorphism. Preliminary petrographic investigation indicates that at least two periods of prograde metamorphism occurred, both with a maximum in the sillimanite-almandine subfacies of the amphibolite facies. A third crystallization event, under retrograde conditions, has affected the higher grade mineral assemblages.

Small granite stocks cut the batholith and these stocks, and all other rock types, are cut by numerous dikes of varying composition.

Copper mineralization was detected near the abandoned Meadow Creek Lookout. Malachite and chrysocolla fill highly fractured white quartzite in a zone that may trend N-S. Assay of a selected sample indicates a copper content of 1%.

INTRODUCTION

General

This report presents the results of a reconnaissance geologic survey of 1200 square miles of the Selway-Bitterroot Wilderness Area. The survey covered by this report is part of a continuing program of geologic mapping, geochemical sampling and geophysical surveying designed to determine the economic mineral potential of the Wilderness Area. The mapping upon which this report is based was accomplished during July and August of 1965 and 1966. A total of 83 days were spent in the field.

Location

Approximately six 15 minute U. S. Forest Service quadrangles were mapped during 1965 and 1966. These quadrangles (see Fig. 1) are:

U. S. Forest Service Quadrangle Number	Coordinate of SE Corner	Area Mapped
615-4-2	N46°15' W115°15'	All
615-4-3	N46°00' W115°15'	All
615-4-4	N46°00' W115°00'	All
615-4-1	N46°15' W115°00'	All
614-3-2	N46°15' W114°45'	Northwest 1/4
514-2-2	N45°45' W114°45'	West 1/2
514-2-3	N45°30' W114°45'	Northwest 1/4
515-1-1	N45°45' W115°00'	South 1/2
515-1-4	N45°30' W115°00'	North 1/3

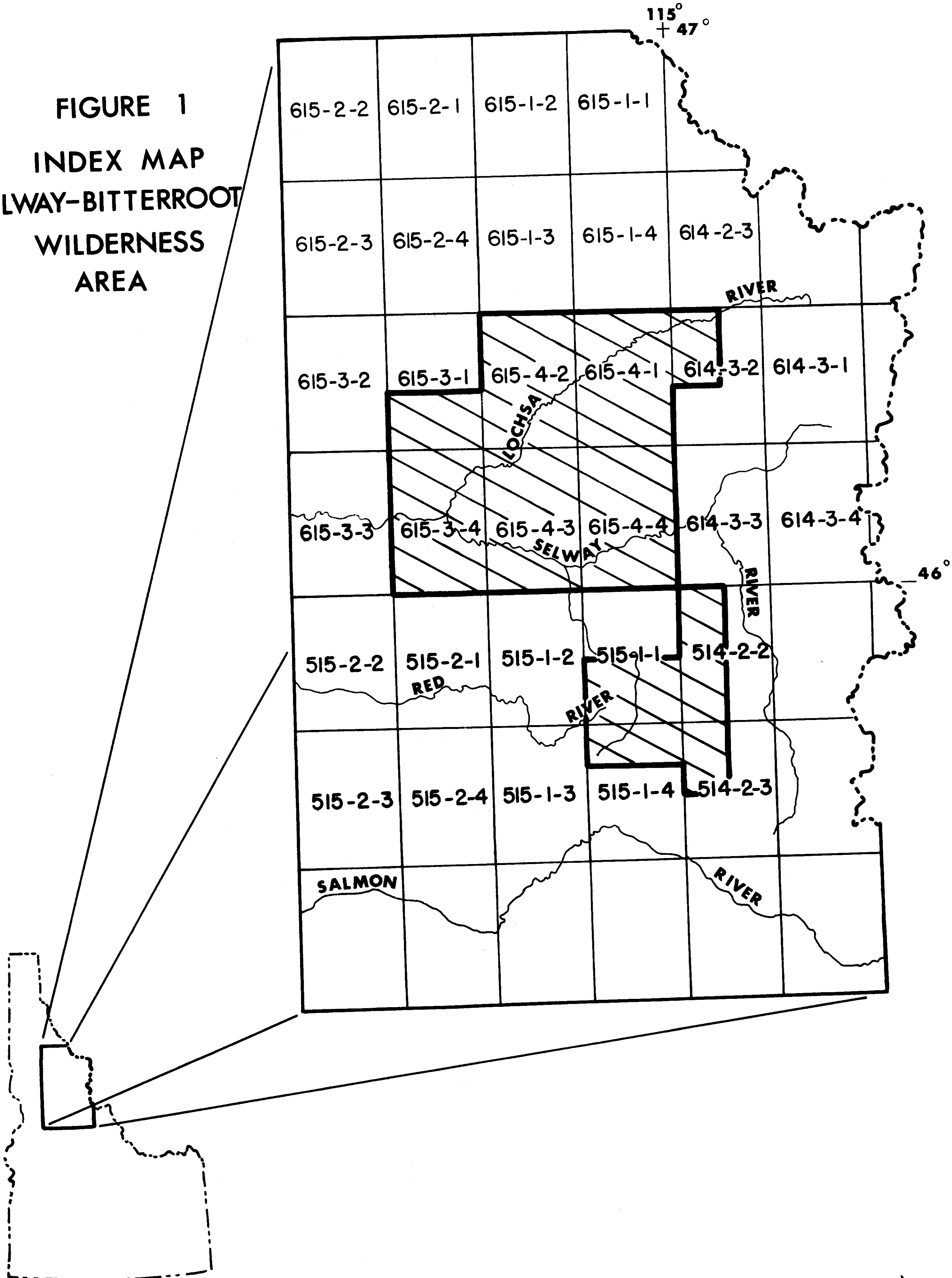
The area studied is drained by the Lochsa and Selway Rivers on the north and the Red River and Salmon River tributaries on the south. River elevations are from 1500 to 2000 feet above sea level on the Lochsa and Selway Rivers, a minimum of 4200 feet on the Red River, and a minimum of 4200 feet on Bargamin Creek, a tributary of the Salmon River.

Maximum elevation is 8200 feet on Burnt Knob. Maximum relief is approximately 5000 feet. The area is densely forested and/or brush covered, which combined with ubiquitous dead-fall timber makes off-trail travel extremely difficult and time consuming. Outcrops are nowhere abundant but are relatively more numerous on steep slopes, along rivers and in cirques on the highest peaks.

Access to the area from the north is by U. S. Highway 12 along the Lochsa River. Access from the south is by the Nez Perce Trail, an improved gravel road, which runs from Elk City, Idaho, to Darby, Montana. U. S. Forest Service jeep roads offer access to several points on the periphery of the Wilderness Area and are shown on Plate 1. Within the Wilderness Area, travel is entirely along U. S. Forest Service foot and horse trails. Trails shown on U. S. Geological Survey 7 1/2' topographic maps generally exist and are passable at least by foot. Trails shown on Forest Service planimetric sheets, may be good, passable, impassable, or in the planning stage. The only good trails are those used and cleared by local packers under contract to the Forest Service. Trail conditions should be determined by contacting local packers before any wilderness travel is attempted.

FIGURE 1

INDEX MAP
SELWAY-BITTERROOT
WILDERNESS
AREA



Method of Study

The mapping technique was determined by accessibility. Roads, trails, ridges and stream valleys were selected to provide a network of cross-strike traverses covering the area.

Geology was plotted directly on the U. S. Forest Service quadrangles. Location numbers and specimen numbers are keyed to initials of the observer. Specimens of representative and/or distinctive lithologies were collected.

Personnel

Geologists were:

1965

Earl M. P. Lovejoy, Chief geologist
Paul K. Krutak
Donald A. Morrison
Charles J. Waag

1966

Wm. Rucker Greenwood, Chief geologist
Russell E. Clemons
Richard V. McGehee
Donald A. Morrison

Field Assistants were:

1965

Richard Pfirman
David Hall
Russell Smith
Allan Holtzman

1966

David Huntsberger
Thomas Moore
Ronald Morton

STRUCTURE

The map pattern of the Wilderness Area is dominated by igneous intrusive rocks related to the Idaho batholith of Cretaceous age. However, the structural grain of the area is a product of complex folding which preceded emplacement of the batholith complex.

The dominant structural trend is determined by a set of large scale isoclinal folds (fold set 2) which locally plunge at high angles to the northwest or southeast. These folds overprint an earlier set of recumbent isoclinal folds (fold set 1) which apparently trended west-northwest before refolding. Culminations and depressions in the axial traces of set two folds define a third set of large scale open folds trending northeast. A fourth fold set, trending N-S, locally refolds earlier fold elements.

Similar structural histories have been recorded in the Elk City, Idaho, area, west of theWilderness Area (Reid, 1959), and in the St. Joe River basin (Reid, 1964; Greenwood, 1966), north of the Wilderness Area.

Numerous orthogneisses and unmetamorphosed intrusives were mapped. The several igneous intrusives can be arranged in chronological order by using the above deformational sequence as a timetable. That is, plutons are pretectonic or syntectonic to any folding that deforms them, and post-tectonic to any folds which they cross-cut. The Augen Gneiss of Blackhawk, Amphibolite of Green Mountain, and the biotite quartz dioritic orthogneisses of Coolwater Ridge are metamorphosed plutons that apparently were pretectonic or syntectonic to the first fold episode. Certain orthogneisses are syntectonic to the second period of folding. Orthoamphibolite in Canyon Creek cuts fold set 2 and apparently was sheared during the northeast folding. Quartz monzonite bodies of the Idaho batholith complex cross-cut the structures and plutons listed above and are in turn cross-cut by pink-granite stocks, thought to be of Tertiary age. Tertiary dike swarms cut all of the rock types. Some of these dikes are composed of partially devitrified glass, indicating a relatively shallow depth of intrusion. Hot sulfur-bearing springs indicate current thermal activity.

Radiometric mineral dates from Beltian rocks of the St. Joe River basin (Reid and Greenwood, 1967), of northern Idaho, suggest that the first period of folding and metamorphic recrystallization occurred in Precambrian time. Based on this correlation, the intrusive history of the Wilderness Area began in Precambrian time with the emplacement of the Amphibolite of Green Mountain and the Augen Gneiss of Blackhawk and the biotite quartz diorite of Coolwater Ridge. Repetitive intrusion of igneous material continued through the Tertiary.

Faults of regional magnitude have been mapped by ground traverse in areas of good exposure. Certain fracture systems may be related to ore genesis and are discussed under the heading of economic geology.

Airphoto linear features and dike set trends are strongly correlated. In most areas of the Wilderness, coverage and time limitations prevent accurate ground mapping of the dike sets, and trends and extensions of dikes were mapped from airphotos.

Analysis of airphoto linears is discussed under the heading of photogeology.

ROCK TYPES

Metasediments

The western part of the mapped area is underlain by a thick sequence of metasedimentary rocks which are tentatively correlated with rocks of the Belt Supergroup. Approximately 14 miles of vertically dipping Beltian metasediments are exposed along the Middle Fork of the Clearwater River, and along the Lochsa and Selway River. No gross stratigraphic repetition occurs in this area, i.e., no formational units are repeated. The sequence thus exposed is considerably thicker than previously described sequences of Belt rocks. It is probable that part or all of the disparity may be attributed to multiple folding, faulting, and volumetric increase through addition of igneous material now represented by orthogneisses. Alternatively, part or all of the rocks exposed may be Pre-Belt or possibly Triassic metasediments. This possibly is considered to be unlikely.

Correlation is based primarily on a comparison of the lithology and stratigraphic position of the rocks in the area mapped with the stratigraphy of Belt metasediments mapped by Hietanen (1963) in the vicinity of Pierce, Bungalow, and Elk River, plus published descriptions of Belt rocks mapped by Reid, 1964. Because of more complete exposure, correlation is considered to be more positive in the northern parts of the area along the Lochsa and Selway Rivers where rocks probably of the Prichard Formation, the Ravalli Group and the Wallace Formation occur. Correlation is less certain when extended southward to the vicinity of Elk City and Red River. Northwest-trending biotite gneisses and quartzites mapped by Reid near Elk City, however, resemble rocks of the Prichard Formation exposed to the north along the Middle Fork, (Shenon and Reed, 1934). Calc-silicate gneisses exposed northeast of Red River very likely are equivalent to Wallace rocks exposed along the Lochsa River. The calc-silicates northeast of Red River structurally overlie white quartzites which may be Missoula Group equivalents.

Although the regional correlation postulated may be incorrect, it is probable that the stratigraphy as established in the map area is consistent, i.e., rocks which are referred to as Prichard equivalents in the Lochsa region are identifiable as Prichard and are so designated where they occur to the south. This is particularly true of the Wallace gneiss (Pcwg) in which there occurs a high percentage of diopside-plagioclase gneisses, a readily identifiable rock.

The Prichard Formation

The Prichard Formation (Pcp) is intermittently exposed along the Middle Fork of the Clearwater River, and may extend southward to the Elk City area. Prichard rocks are in fault contact with quartz dioritic orthogneiss at their western limit on the Middle Fork. Biotite quartzite and biotite gneiss intercalations within the orthogneiss may represent migmatized Prichard metasediments.

At the fault contact, the Prichard is distinguished by garnetiferous mica schist, which is succeeded eastward by white, thick bedded biotite (± muscovite) quartzite (150 feet), siliceous garnetiferous mica schist (300 feet) and a layer of white to dark gray quartzite (300 feet). Thicknesses are approximate.

The remainder of the Prichard Formation is predominantly pelitic schist which may contain garnet and kyanite. Interlayered with the schist are relatively thin (10-50 feet) white to gray, muscovite and/or biotite quartzites. A 100 to 150 foot, thinly laminated, feldspathic biotite quartzite, with minor layers of hornblende-bearing gneiss, and a variegated, very massive and thick bedded white quartzite occur near the east limit of the formation. These rocks are succeeded on the east by garnetiferous mica schist, pelitic schist, and pelitic gneisses which apparently grade into garnetiferous biotite quartzite assigned to the Ravalli Group.

Ravalli Group

The contact between the Prichard Formation and the Ravalli Group is placed at the first appearance of garnetiferous biotite quartzite.

This boundary was chosen for mapping purposes and was not selected at the first appearance of a lithology which definitely could be correlated with published descriptions of Lower Ravalli units. The Ravalli Group, as designated in the Lochsa area, is a relatively homogeneous unit of garnetiferous biotite quartzite, pelitic schist and gneiss, minor micaceous white to gray quartzite, and very minor calc-silicate layers. No subdivision of the Ravalli Group into formational units was attempted.

The western Ravalli unit is a fine grained garnetiferous biotite feldspar quartzite which contains kyanite. The quartzite is succeeded eastward by garnet-free biotite quartzite which contains numerous granitic stringers and small bodies of leucocratic orthogneiss. This unit is succeeded on the east by pelitic rocks and garnet-mica-feldspar quartzite which forms the major portion of the rock exposed to the confluence of the Selway and Lochsa Rivers. At the confluence, the rock is a garnetiferous thick bedded quartzite containing minor hornblende-bearing gneiss layers. The uppermost units included within the Ravalli Group are exposed along the Coolwater Ridge road and the Big Hill road. At these locations pelitic schist, pelitic gneiss and pelitic quartzite are interlayered. Kyanite and garnet are common constituents. The upper boundary of the Ravalli Group was placed at the contact between a 50 foot layer of garnetiferous fine-grained, dark quartzite of remarkable toughness and the overlying quartz rich pelitic rocks of the Wallace Formation.

Wallace Formation

Metasediments which may be correlative with the Wallace Formation of the Belt Supergroup are well exposed along the Lochsa River from Pete King Creek east to Split Creek, and probable Wallace rocks occur as partially assimilated blocks within the batholith.

The Wallace Formation is divided into a lower unit composed of quartz-rich pelitic rocks, and an upper unit composed of diopside-plagioclase gneisses, quartzites and pelitic rocks. These subdivisions appear to correspond broadly to the Wallace Schist and Wallace Gneiss units in Clearwater County described by Hietanen, 1963.

The schist unit consists of quartz-plagioclase-biotite quartzites and gneisses, and quartz-biotite-plagioclase schists. These rocks differ only in relative abundance of common components and sequences are transitional. Garnet, kyanite and sillimanite occur sporadically. Alumino-silicates appear to be most abundant in the lower (western) part of the schist unit. In fresh exposures, the schist unit is relatively thick bedded and massive, but is more fissile and seemingly thin bedded where well weathered.

The gneiss unit consists of diopside - (∓ hornblende) - plagioclase gneisses interlayered with biotite quartzite, feldspathic quartzite, biotite-plagioclase gneiss and minor schist units. The diopside-plagioclase gneisses are gray green, and banded rocks. Thin laminae of quartz and feldspar separate layers of diopside and plagioclase. Hornblende may replace diopside where the gneisses are penetrated by quartzo-feldspathic stringers. Garnet is sparingly present in some layers. The diopside gneisses invariably are interlayered with quartzites and/or pelitic schists and gneisses and nowhere are there thick exposures (100-200 feet), composed exclusively of diopside-plagioclase gneisses. The diopside-plagioclase gneisses are most abundant in the eastern part of the gneiss unit.

Eastward, both units of the Wallace Formation become increasingly intermixed with primary gneisses of the Idaho batholith, and ultimately are supplanted by directionless igneous rock.

The northwest strike of rocks of the Wallace Formation indicates that they should crop out along the Selway River somewhat east of Selway Falls. No calc-silicates appear in this area, although small exposures of calc-silicates typical of the Wallace Gneiss occur near Otter Butte south of the river. Either the Wallace Formation is masked to the southeast by border zone rocks, (Pgn), of the batholith, or the disappearance of the Wallace rocks may be a function of structure, i.e., a fault exposing underlying pelitic rocks of the Ravalli Group, or a large northwest plunging fold producing the same effect.

Missoula Group

White to grayish-white quartzites crop out along the Elk Mtn. road, from Green Mtn. to Running Creek junction. The quartzite is massive and ranges in composition from a vitreous white quartzite to quartzites containing up to 40% feldspar. Mica is nowhere abundant, and generally forms less than 5% of the rock. Compositional layering generally is absent in the outcrops observed, and structural elements generally were not distinguished in outcrop..

The quartzite is thicker than any white quartzite mapped in lower Belt units, including the Prichard Formation, and it is in gradational contact with rocks assigned to the Wallace Formation. Therefore, the quartzite, tentatively, is assigned to the Missoula Group.

Biotite Gneiss

Biotite gneiss in the vicinity of Elk City was mapped by Reid in 1959, and by Greenwood in 1966. Reid described the biotite gneiss as a medium grained (1-2mm) rock containing 20-30% each of quartz, potassium feldspar, plagioclase and mica (including muscovite) which may contain garnet as small scattered grains. The biotite gneiss is strongly foliated and forms relatively massive outcrops. All gradations occur between biotite gneiss and biotite quartzite. This rock, shown as Pcbg on the geologic map, may be equivalent to the Prichard and/or the Ravalli Group as these units are defined along the Middle Fork of the Clearwater River.

Biotite Quartzite

Biotite quartzite is the predominant quartzite in the Elk City and Red River regions, but pure white quartzite, muscovite quartzite, and feldspathic quartzite transitional into biotite gneiss also occur (Reid,1959). The biotite quartzite is medium grained (1-2mm); biotite defines a schistosity. Plagioclase and potassium feldspar occur in subordinate amounts. Garnet apparently is absent.

The biotite quartzite unit, particularly the interlayered white quartzites, resembles the lower portion of the Prichard Formation exposed near the Middle Fork Guard Station on the Clearwater River, and is considered to be correlative with that unit.

Meta-igneous Rocks

Meta-igneous rocks, which vary greatly in composition and structural complexity, intrude the metasediments at several localities. These rocks, ranging in composition from ultramafic to granitic masses, have participated in one or more of the petrogenic cycles and indicate that igneous activity preceded or accompanied each of the regional metamorphisms.

Anthophyllite-Serpentine Masses

Small bodies composed of radiating clusters of anthophyllite, chlorite, tremolite and serpentine crop out in the Lochsa region. These bodies, which are resistant and stand above surrounding rocks, represent altered and/or metamorphosed ultramafic rocks.

None of the ultramafic masses mapped forms extensive exposures; it is probable that all are too small to be of commercial value. Fiber quality was not determined.

Augen Gneiss

A western extention of the Augen Gneiss of Blackhawk has been studied in thin-section by Reid (1959, p. 47-48); he states:

> Augen gneiss has a bulk composition like that of quartz monzonite, with an average grain size of one or two mm. except for augen, which occur either as lenticular grains from four to eight cm. across or as lenticular clusters of grains in which individual grains are one-half of one cm. in diameter. Quartz is irregular, xenoblastic, and has undulatory extinction in some rocks. Plagioclase, in the composition range An_{25} to An_{29}, has thin oligoclase rims against microcline. Also xenoblastic, plagioclase encloses small, oriented biotite grains and is myrmekitic against microcline.
> Microcline is non-microperthitic and enclosed small, strongly-altered, plagioclase grains, oriented biotite flakes, and quartz. Biotite exhibits a fair alignment parallel to s_2, although a few transverse (s_3?) grains were present.

The augen gneiss has a schistosity defined by biotite. Megacrysts of k-spar are lineated in the plane of schistosity. The augen gneiss probably is a metamorphosed igneous intrusive.

Hornblende-biotite Quartz Dioritic Orthogneiss

Rocks of the Prichard Formation are in fault contact with hornblende-biotite quartz dioritic orthogneiss near the Middle Fork Guard Station on the Clearwater River. The orthogneiss is coarse grained and has well developed schistosity. Epidote may be visible in hand specimen. Amounts of biotite and hornblende vary. Near Sutter Creek the orthogneiss is markedly more leucocratic and hornblende is absent. A small body of the orthogneiss which crops out north of Syringa is garnetiferous. Biotite quartzites and amphibilotites are intercalated within the orthogneiss, and may be either westward extensions of the Prichard Formation, or non-Belt rocks.

The age of the quartz dioritic orthogneiss is speculative. It very probably is older than the quartz diorite mapped to the north (see geologic map, and Hietanen, 1963) which is cataclastically sheared but not completely recrystallized. The relation between the quartz dioritic orthogneiss and the quartz diorite which crops out between Orofino and Kamiah is also unknown. Thin section examination of the latter indicates no recrystallization and little or no shearing, however, the quartz dioritic orthogneiss may be a sheared and recrystallized border phase of the Orofino-Kamiah quartz diorite. Further field work will ascertain this relationship.

Biotite-Plagioclase Quartz Dioritic Orthogneiss

Biotite-plagioclase quartz dioritic orthogneiss forms a relatively large body near the crest of Coolwater Ridge south of the Lochsa River. The orthogneiss is compositionally similar to pelitic rocks of the Wallace schist with which it is in contact. Biotite (15-25%) with quartz (15-30%) and plagioclase (45-60%) are the dominant minerals. Schistosity is defined by planar parallelism of biotite, but the schistosity is more imperfect than that of the pelitic rocks which form the Wallace schist.

The orthogneiss contains biotite rich clots which resemble mafic cognate inclusions common in igneous rocks, and quartz rich paragneiss (?) lenses which may represent xenoliths incorporated in the orthogneiss prior to metamorphism.

The orthogneiss is folded. Minor folds have a well developed axial plane schistosity, and knife sharp fold crests. These characteristics are typical of the first fold event and suggest that the parent quartz diorite was intruded prior to the first deformation.

Orthoamphibolites

Orthoamphibolites representing metamorphosed mafic dikes and sills occur at numerous localities. Most such masses are too small to be shown on the geologic map. The orthoamphibolites are composed predominantly of plagioclase and hornblende and, characteristically, have a well developed lineation defined by prismatic hornblende. Schistosity may be indiscernible. Quartz-feldspathic layers in some orthoamphibolites form well defined folds.

The Green Mountain amphibolite is composed of roughly equal amounts of hornblende and plagioclase. A small amount of the rock mapped as amphibolite is composed predominantly of hornblende and may be called a hornblendite. A schistosity is well to poorly defined by parallelism of tabular hornblende and/or plagioclase crystals. Grain size of the plagioclase and hornblende is roughly equal and ranges from 2mm. to 10mm. Deformation appears not to have been penetrative in the amphibolite body at Green Mtn. Strongly developed schistosity has been observed to grade to a barely discernable schistosity in a few inches across strike.

The orthoamphibolites represent several generations of intrusion of mafic rocks. Several small orthoamphbolite masses exposed along the Lochsa River were deformed by the second fold event. An orthoamphibolite in Canyon Creek apparently is not deformed by the second fold event but has a lineation parallel to the northeast event, suggesting intrusion later than second fold event but prior to the third.

Igneous Rocks

Igneous rocks include the following types:

1. Porphyritic quartz monzonite which forms most of the batholith in the area mapped.
2. Porphyritic to non-porphyritic quartz monzonitic to quartz dioritic primary gneisses which are compositional and textural variations of the above.
3. Biotite ($\mp$) hornblende quartz diorites which apparently represent pre-Idaho batholith but post-metamorphism igneous events.
4. Porphyritic to non-porphyritic granites which are either late stage batholithic rocks or post-batholithic (Tertiary ?) rocks.
5. Dikes of varying composition, ranging from dolerite to aplite.

Quartz Monzonite

Porphyritic quartz monzonite is the typical batholithic rock. Quartz, potassium feldspar, plagioclase, biotite and muscovite are the dominant minerals. Potassium feldspar forms phenocrysts which may be 5 cm in the long direction. Plagioclase occurs less frequently as phenocrysts. The fabric is coarse grained and directionless. Color index varies from 10 to 20.

The quartz monzonite weathers to spherical boulders and produces a light colored, granular, feldspar-rich soil which is well drained and which supports less dense vegetation than that characteristic of the metasediments.

Quartz monzonitic to quartz dioritic primary gneisses are textural and compositional variations of the porphyritic quartz monzonite. These rocks are common near contacts and represent border phases of the quartz monzonite. A schistosity is defined by parallel orientation of biotite and a lineation is defined by preferred orientation of phenocrysts. Compositional layering defined by poorly developed segregation of biotite is not uncommon. The primary gneiss is finer grained than the porphyritic quartz monzonite.

The width of the zone of primary gneiss (and migmatite) development varies greatly. In the Red River area where igneous rock of the batholith is in contact with rocks of the Missoula Group and the Wallace Formation, primary gneisses are essentially absent and the metasediments directly contact the porphyritic quartz monzonite. In the vicinity of the Selway River, however, an extensive zone of approximately nine miles consisting of an intermixture of primary gneiss, paragneisses, and orthogneisses (?) (i.e. a migmatite zone) is interposed between dominantly metasedimentary terrane and the porphyritic quartz monzonite. A less extensive zone (one mile) is exposed along the Lochsa River.

Quartz Diorites

Quartz diorite bodies, which are distinct from the quartz dioritic primary gneisses discussed in the previous section, apparently represent pre-Idaho batholith igneous events, although the difference in age between the quartz monzonite of the batholith and the quartz diorite bodies may be relatively slight. A large mass of quartz diorite (which is discordantly intersected by rocks of the batholith) crops out north of the Lochsa River. This mass probably is equivalent to the quartz diorite mapped near Pierce, (Kgd) of Hietanen, 1963). A second small quartz diorite (Hgd) occurs south of the Lochsa River near the crest of Coolwater Ridge (Louse Point Pluton, Krutak, et. al., 1965). The relative age of the Louse Point Pluton remains somewhat speculative, however, it is assumed to be approximately the same age as the larger mass to the north (Kgd) above.

The quartz diorites typically contain hornblende, biotite, plagioclase and quartz. Hornblende, generally, is subordinate to biotite, and may be minor in some varieties. Biotite is black and in hand specimen may easily be mistaken for fine grained hornblende. These rocks are coarse grained but nonporphyritic in contrast to the quartz monzonite of the batholith. The quartz diorites have a well defined schistosity formed by parallel orientation of biotite. The definition of the schistosity is partly the result of cataclastic shear. Where hornblende is prominent, prismatic hornblende grains show a preferred orientation. Lineation in the Louse Point Pluton is particularly well formed.

Granites

Numerous stocks of granitic composition crop out in the mapped area. On the geologic map, rocks identified by the symbol Tg include a coarsely crystalline granite at Running Creek northeast of Red River, and stocks of microgranite prophyry. The microgranite-porphyry stocks are hypabyssal bodies containing phenocrysts of potassium feldspar and quartz in a fine grained groundmass. The granite and microgranite stocks cut the quartz monzonite and have been assigned to the Tertiary by previous workers (Ross and Forrester, 1958, p. 25).

ECONOMIC GEOLOGY

General

The land contained in the Selway-Bitterroot Wilderness Area is undeveloped for two obvious reasons: (1) rugged topography, and, more importantly, (2) the failure of early prospectors to locate payable mineral deposits. Both of these factors are important in designing present day search programs in this area. Relative inaccessibility influences the ore body size and grade required for profitable mining, and the likelihood of encountering a major deposit by using techniques of the original prospectors is low.

In the present search program, ground traverses are used to prepare a geologic framework for the interpretation of geophysical and geochemical anomalies. Where mineralization is detected by ground traverse, structure and wall rock control are studied. Likely off-trail targets are outlined for geochemical and/or geophysical prospecting based on studies of the airphoto tectonic map and knowledge of the inspected mineralized areas.

Mineralization

Meadow Creek Lookout

Near the abandoned U. S. Forest Service Meadow Creek Lookout (see Plate 1) copper mineralization has been detected by ground traverse. Several prospect pits show malachite and chrysocolla in highly fractured white quartzite. There is an abundance of fine disseminated pyrite, now altered to limonite, in the quartzite. Cobalt bloom and nickel stain are found on some joint faces. Spectrochemical analysis, by Earth Sciences, Inc. of Golden, Colorado, of a selected sample indicates 1% copper with 10 ppm nickel and 9 ppm silver. Soil cover is deep in the area of Meadow Creek Lookout and the only rock observed in place was in a partially slumped prospect pit. Based on this small exposure and the distribution of malachite-bearing float, mineralization appears to be related to N-S to NNE bearing fractures in the quartzite. Spottily developed copper mineralization has been observed for more than a mile down the ridge which leads west of the abandoned lookout. This distance appears to be the exposed cross-strike width of the N-S to NNE trending mineralized zone. Quartz monzonite of the Idaho batholith complex cuts off the quartzite north and south of Meadow Creek Lookout (see Plate 1), giving a maximum possible mineralized strike length of about 6 miles. Geochemical sampling and more detailed field mapping in the Meadow Creek Lookout area are planned for the 1967 field season. It is hoped that detailed study of this area will provide clues for the location of other copper deposits in the Wilderness Area.

PHOTOGEOLOGIC ANALYSIS

Coverage

Air photos are available for the major part of the report area. These are standard 9 x 9" overlapping vertical black and white photographs. Scale is approximately 1:60,000 for the entire area.

Procedures

Overlapping vertical airphotos allow stereo viewing of all but the terminal parts of each flight strip. Each set of airphotos was studied at least twice in 3-dimensional view. Each set was first examined with no magnification, and with the entire overlap area of one pair of photos in stereo view at one time. This method reduces the chances of major features escaping notice. All supposed rock contacts, linear elements, and determined attitudes were marked on the prints with colored pencils. In subsequent examinations a magnifying stereoscope was used and additional features plotted as before.

After the airphotos had been annotated they were projected at correct scale onto a Forest Service planimetric base-map, and the information traced to the base-map.

Limitations

Successful photogeologic evaluation depends upon many factors in addition to the experience of the interpreter. When a large number of the "external variables" are favorable a reliable and informative interpretation is possible. As the number of unfavorable variables increases, the photogeologic interpretation becomes more and more difficult, and hence less reliable.

In the present case, many factors combine to make this region far from ideal for rewarding photogeology. Limiting factors include the following:

1. Generally inferior print quality. All interpretation depends upon tonal variations - some very subtle - to convey the information. The prints available to us were virtually lacking in contrast, possibly due to blind use of electronic dodging in the printing.
2. Scale of the photos was about 1:60,000. This is a fine scale for gross fracture and stream pattern analysis, and for general structure of moderately deformed stratified units. However, it is far too small for use in determination of structure in regions of isoclinal folding and polydeformation in metamorphic rocks.
3. Dense vegetation cover is present over much of the study area, and this greatly reduces the geologic detail shown on the airphotos.
4. Metamorphic rocks and plutonic masses are known to be the least satisfactory types for airphoto evaluation. When mixed, as they are in this region, they are quite challenging to map on the ground, and even more enigmatic on airphotos.
5. Complex structural relationships are quite naturally more difficult to handle than the simpler patterns. In the study area the rocks have been subjected to at least three distinct deformational events, and major faulting.

Objectives of the Photogeologic Experiment

Because of the unfavorable condition for photogeologic mapping, we decided to plot photogeologic linears and anomalies and see if the airphoto data could be of assistance to the mapping program.

Preliminary inspection of the photos revealed that the obvious features were consistently linear traces over large tracts, and some sharp changes in terrain morphology. Therefore, we decided to map possible rock-type contacts, and all airphoto linears (except for very minor ones). Linears, as thus determined, included such features as exceptionally straight stream canyons, joints, faults and shear zones, dikes, primary foliation, and secondary foliation. It was assumed that ground mapping would relate certain directions of linears to certain geologic conditions. All anomalies on the photos were plotted.

The linears became by far the most abundant features noted, and an attempt was made to plot all linears according to the same standards. When the linears were too closely spaced to show all of them at the scale of the compilation, a smaller number were shown, but the plot density is proportionate to the apparent density of linears on the photo.

The relatively "small" scale of the photos automatically eliminates minor linears and small details of fabric. Within the resolution limits of the airphoto there is a great wealth of data, and this study should allow a suitable basis for statistical analysis.

Results

The photogeologic analysis covers an area of approximately 3200 square miles. All of the photo linears determined are plotted on a single base-map, Plate I, at a scale of 1:125,000. This map and the subjective conclusions drawn from it comprise the results of the study to this date. The geologic ;information gathered by ground teams has been added to the same map. Study of the map indicates the following:

1. The most prominent linear trend is to the northeast, the second is to the northwest.
2. All of the (major) faults or shear zones determined by the several ground parties are coincident with photo linears plotted independently from airphotos alone.
3. Some of the linears, after the completion of the map, were found to persist for very great distances. A few of the northeasterly linears are nearly 50 miles long as plotted, and extend an unknown distance beyond the limits of the study area.
4. Some of the ground-determined lithologic contacts are coincident with mapped photo-linears, but others were not.

The next phase of study is the development of appropriate methodology for statistical analysis of the photo linears in order to determine their relationship to factors of geologic or geographic importance. Possible examples would be:

1. Testing for correlation between drainage density and photo linear density.
2. Testing for correlation between different rock types and variations in linear density.

3. Testing for correlation between trends of linears and trends of stream channels in areas of the linears.

Importance of this Study

Even without the results of statistical analysis, the map of the photo linears suggests that the photogeologic study is an extremely useful approach and that it can add significant information for a relatively small investment of funds.

SUMMARY

Reconnaissance mapping of approximately 1200 square miles of the Selway-Bitterroot Wilderness Area has been accomplished during 1965 and 1966.

Preliminary mapping has defined a belt of north to northwest trending polymetamorphic metasedimentary rocks which border the west margin of the Idaho batholith, and has delineated part of the border of the batholith and several smaller plutons. One area of possible economic potential has been mapped in the southern part of the area.

The metasedimentary rocks are tentatively correlated with rocks of the Belt Supergroup as suggested by a comparison of lithology and stratigraphic position with Beltian Rocks in northern Idaho. Three periods of penetrative and regional deformation are recorded in the metasediments, and two local, non-penetrative deformations have been distinguished. The first period of regional deformation produced west-northwest trending isoclinal recumbent folds and was accompanied by complete recrystallization of the original sedimentary pile, probably in the sillimanite-almandine subfacies of the amphibolite facies. The second episode of regional deformation produced northwest trending isoclinal folds with an incipient axial plane schistosity, and was accompanied by partial recrystallization. Culminations and depressions in the axes of the first and second generation folds, plus minor folds and lineation data indicate that the metasediments were deformed on a regional basis a third time producing relatively open to sub-isoclinal folds oriented northeast. Minor recrystallization accompanied this event. North-south folds, mainly concentric in style, and kink folds, both only locally expressed, overprint the earlier regional structures. The first fold event may have occurred in the Precambrian as suggested by radiometric data and the geologic history of adjacent areas. The age of later events remains speculative, although there is some suggestion that they may be assigned to the Mesozoic.

Orthogneisses of varying ages are intercalated within the metasediments. The orthogneisses represent metamorphosed igneous masses which were emplaced syntectonically or pretectonically to one or more of the regional deformations. An augen gneiss body of batholithic dimensions in the southern part of the area, and a quartz dioritic orthogneiss gneiss to the north, apparently were deformed by the first and all later fold events, indicating intrusive igneous activity prior to the first deformation. Other orthogneisses, including orthoamphibolites, may be assigned to later events. A hornblende-biotite quartz dioritic orthogneiss bounds the map area on the west in the Lochsa region. The age of the orthogneiss remains uncertain, however, it is pre-Idaho batholith, and may be either a sheared and recrystallized border phase of igneous masses which crop out along the Clearwater River, or it may represent an intrusive and metamorphic event which occurred prior to the emplacement of the Middle Fork rocks.

The orthogneisses have served to swell the volume of the metasedimentary pile, and partially explain the disparity in thickness of the sequence of Belt rocks exposed in the map area with sequences mapped to the north in the St. Joe and Coeur d'Alene areas.

The Idaho batholith underlies much of the Wilderness Area. The batholith typically is composed of coarse grained, directionless prophyritic quartz monzonite containing phenocrysts of potassium feldspar and plagioclase, in order of respective abundance. The batholith is margined by a border phase consisting of primary gneisses, ranging from quartz diorite to quartz monzonite in composition, which are intercalated within paragneisses and orthogneisses. Thickness of the border zone so defined varies from approximately 14 miles along the Selway River to a negligible

width in the Red River area.

The batholith is cut by small granitic stocks and numerous dikes of varying composition. Most granitic stocks are micro-granite porphyries, although a coarse grained pink granite occurs east of Red River. These rocks are post-batholith and probably are Tertiary in age. Possibly more than one episode of granite intrusion is represented.

Copper minerlization was detected by ground traverse near the abandoned Forest Service Meadow Creek Lookout (See plate I) where several prospect pits show malachite and chrysocolla in highly fractured white quartzite. Mineralization apparently is related to N-S to NNE fractures in the quartzite. Preliminary mapping suggests a maximum possible strike length of 6 miles with a possible cross-strike width of 1 mile. An assay of mineralized quartzite indicates a copper content of 1%, a potentially valuable percentage if persistent throughout the mineralized zone.

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Elk City and Vicinity mapped by R. R. Reid, 1959

Photogeology by William B. Hall and
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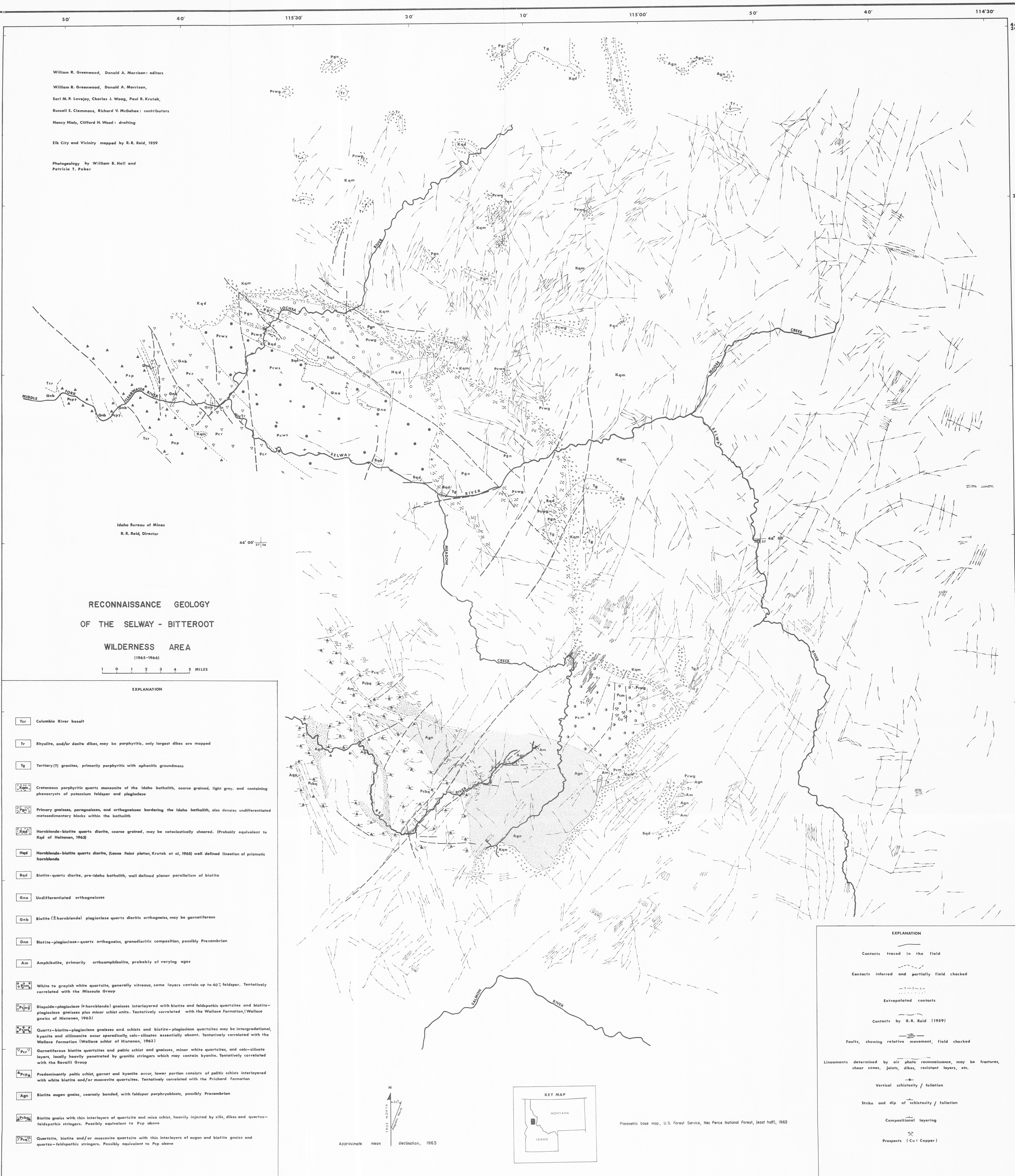
RECONNAISSANCE GEOLOGY OF THE SELWAY - BITTEROOT WILDERNESS AREA

(1965-1966)



EXPLANATION

Tcr	Columbia River basalt
Tr	Rhyolite, and/or dacite dikes, may be porphyritic, only largest dikes are mapped
Tg	Tertiary (?) granites, primarily porphyritic with aphanitic groundmass
Kqm	Cretaceous porphyritic quartz monzonite of the Idaho batholith, coarse grained, light grey, and containing phenocrysts of potassium feldspar and plagioclase
Pgn	Primary gneisses, paragneisses, and orthogneisses bordering the Idaho batholith, also denotes undifferentiated metasedimentary blocks within the batholith
Kqd	Hornblende-biotite quartz diorite, coarse grained, may be cataclastically sheared. (Probably equivalent to Kqd of Heitanen, 1963)
Hqd	Hornblende-biotite quartz diorite, (Louse Point pluton, Krutak et al, 1965) well defined lineation of prismatic hornblende
Bqd	Biotite-quartz diorite, pre-Idaho batholith, well defined planar parallelism of biotite
Gno	Undifferentiated orthogneisses
Gnb	Biotite (± hornblende) plagioclase quartz dioritic orthogneiss, may be garnetiferous
Gna	Biotite-plagioclase-quartz orthogneiss, granodioritic composition, possibly Precambrian
Am	Amphibolite, primarily orthoamphibolite, probably of varying ages
Pcm	White to grayish white quartzite, generally vitreous, some layers contain up to 40% feldspar. Tentatively correlated with the Missoula Group
Pcwg	Diopside-plagioclase (+ hornblende) gneisses interlayered with biotite and feldspathic quartzites and biotite-plagioclase gneisses plus minor schist units. Tentatively correlated with the Wallace Formation, (Wallace gneiss of Hietanen, 1963)
Pcws	Quartz-biotite-plagioclase gneisses and schists and biotite-plagioclase quartzites may be intergradational, kyanite and sillimanite occur sporadically, calc-silicates essentially absent. Tentatively correlated with the Wallace Formation (Wallace schist of Hietanen, 1963)
Pcr	Garnetiferous biotite quartzites and pelitic schist and gneisses, minor white quartzites, and calc-silicate layers, locally heavily penetrated by granitic stringers which may contain kyanite. Tentatively correlated with the Ravalli Group
Pcp	Predominantly peltic schist, garnet and kyanite occur, lower portion consists of pelitic schists interlayered with white biotite and/or muscovite quartzites. Tentatively correlated with the Prichard Formation
Agn	Biotite augen gneiss, coarsely banded, with feldspar porphyroblasts, possibly Precambrian
Pcbq	Biotite gneiss with thin interlayers of quartzite and mica schist, heavily injected by sills, dikes and quartzo-feldspathic stringers. Possibly equivalent to Pcp above
Pcq	Quartzite, biotite and/or muscovite quartzite with thin interlayers of augen and biotite gneiss and quartzo-feldspathic stringers. Possibly equivalent to Pcp above

EXPLANATION

Contacts traced in the field

Contacts inferred and partially field checked

Extrapolated contacts

Contacts by R.R. Reid (1959)

Faults, showing relative movement, field checked

Lineaments determined by air photo reconnaissance, may be fractures, shear zones, joints, dikes, resistant layers, etc.

Vertical schistosity / foliation

Strike and dip of schistosity / foliation

Compositional layering

Prospects (Cu = Copper)