THE GEOLOGICAL SURVEY OF WYOMING

HORACE D. THOMAS, State Geologist

PRELIMINARY REPORT NO. 5

The Haystack Range
Goshen and Platte Counties

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Cover. Sunrise mine, Colorado Fuel and Iron Corporation. Photo by R. S. Houston.

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M. L. Millgate*

INTRODUCTION

The Haystack Range (index maps, Pl. 1) is located in parts of Ts. 27, 28, and 29 N., Rs. 64 and 65 W. in southeastern Wyoming. The Range is bounded mostly by lowland and is adjoined by the Chicago Mine Hill at the northwest end.

Several graded roads and numerous unimproved roads enable auto transport to within a few miles of any point in the area. In most years, field work may be conducted from late April to early November without serious inconvenience caused by weather.

The area was mapped on aerial photographs having a scale of about 1:12,000. Data were compiled on a base map taken from the U. S. Geological Survey topographic maps having a scale of 1:24,000. Topography and culture provided excellent control during data transfer.

TOPOGRAPHY AND VEGETATION

Relief is moderate, although much of the area is rough, broken, and can be traversed only on foot. Elevations range from about 4,500 to over 5,600 feet.

Vegetation consists of grasses, brush, evergreen trees, and some deciduous trees along drainageways. Northeast facing hillsides may be covered by a dense growth of evergreen trees or brush. Many of these hillsides are also covered by soil and scree; and are difficult to map. Elsewhere, rock exposures are good.

GENERAL GEOLOGY

Rocks in the mapped area (Pl. 1) include metamorphic, igneous, and other rocks of Precambrian age; sedimentary rocks of Paleozoic and Miocene ages; and unconsolidated, sedimentary rocks of Recent age.

Metasedimentary, pelitic and quartzo-feldspathic schist intruded by granite, pegmatite, silica veins, and cut by epidotized breccia zones make up much of the Haystack Range. Hornblende schist, probably originally an igneous rock, occurs mostly on the west flank of the Haystack Range. Granite is intruded by granite dikes, aplite, pegmatite, and crossed by epidotized breccia zones. Granite gneiss occurs in the north end of the Range. In the Chicago Mine Hill area west of Whalen Canyon metasedimentary rocks include dolomite, quartzite, phyllite, and ferruginous quartzites. Metamorphic rocks comprise the Whalen group of Smith (1903, p. 1).

Sandstone, dolomite, limestone, and shale beds of the Guernsey and Hartville formations of Paleozoic age overlie the Precambrian rocks with angular discordance. A karst plain forms the contact between the Guernsey formation and the overlying Hartville formation.

The tuffaceous clastic rocks of the Arikaree formation of Miocene age overlie all older rocks on an unconformable surface of great relief.

Unconsolidated detritus of Recent age is found chiefly along drainageways and on hillsides.

Metasedimentary Rocks of Precambrian Age

Schist. In the Haystack Range the metasedimentary rocks consist primarily of mica schist. Some schist is much intruded by granite and the complex schist-granite association could not be entirely shown at the map scale used. Outcrops of intermixed schist and granite are found north of McCann Pass, in the low hills east of

*Geologist, Geological Survey of Wyoming, Laramie, Wyoming.

the Haystack Range, and in the southern part of the Range. Outcrops consisting of more than 50 percent schist are classified as mica schist. This classification is workable in that outcrops are mostly granite or mostly schist.

Muscovite-quartz and biotite-quartz schist are the most common schist varieties. Locally, quartz is the dominant mineral. Small outcrops of hornblende-garnet and mica-garnet schist occur in the mica schist unit, mostly in the broad schist belt between McCann Pass and McGinnis Pass. A few, thin layers of graphite schist occur north of McCann Pass.

Schist layers of different lithology range from a fraction of an inch to about 50 feet in thickness. Persistent layers can be traced about 500 feet. Contacts between thin layers are fairly sharp, but thick layers show gradational contacts both along and across strike and commonly pass into different schist varieties 100 to 200 feet along strike.

Hornblende schist occurs within the mica schist unit. The rock is composed mostly of subhedral hornblende crystals. Biotite, hematite, plagioclase feldspar, quartz and limonite occur in most places. In one place, the hornblende schist crosscuts the mica schist. Thus, hornblende schist may represent basic intrusives emplaced prior to metamorphism. Elsewhere, hornblende schist is conformable with surrounding rocks. Small outcrops of hornblende schist occur at Round Top and near the Old Government Farm.

Hematitic mica schist occurs along the McCann fault. Hematite is found in small pods, along fractures, and disseminated in the schist.

Dolomite. Dolomite and sandy dolomite containing phyllite and quartzite layers occur in the Chicago Mine Hill escarpment west of Whalen Canyon. This unit probably overlies the mica schist, but nowhere in the area are the two units visibly in contact. Several phyllite and quartzite layers are known to occur near the top of the dolomite unit (Ebbett, 1956, p. 11-20). Phyllite and quartzite layers in dolomite are common north of Kimble Ranch. This sequence may represent the basal layers of the dolomite unit, but the sequence is in contact with overlying rock along the Sunrise fault and therefore its stratigraphic position is not definitely known.

Quartzite layers are mostly discontinuous, fine-grained, platy, and thus do not indicate normal or overturned layers.

In most places, chlorite is the dominant mineral in phyllite. Locally, biotite is most abundant. Phyllite in dolomite commonly exhibits variations in thickness and lithology, may be discontinuous, and cannot be definitely correlated from place to place except where continuous at the ground surface.

Ferruginous quartzite. Ferruginous quartzite (jasper of Ball, 1906b, p. 194) occurs in the SE 1/4 Sec. 5, T. 27 N., R. 65 W., and crops out to the southwest beyond the map area (Ebbett, 1956, p. 36). Similar rock is not found elsewhere in the area. This rock consists mostly of multicolored, ferruginous, microcrystalline quartzite and is the "iron formation" of some authors. Ferruginous quartzite is closely associated with some iron-ore bodies located just above the dolomite unit (Ebbett, 1956, p. 86). Thus, the ferruginous quartzite, although not continuous in the map area, occupies a stratigraphic zone between the underlying dolomite and the overlying phyllite.

Phyllite. A thick phyllite sequence occurs above the dolomite throughout the Chicago Mine Hill area. The top of this unit is not exposed. The unit consists mostly of dark, very fine-grained, chlorite phyllite. Northwest of Frederick Ranch the phyllite is red as a result of iron-oxide content. The contact between the red and green varieties is poorly exposed. Red phyllite may be an oxidation product of green phyllite.

Igneous Rocks of Precambrian Age

Granite. Granite occurs as stocks, irregular masses, dikes, and sills in schist east of Whalen Canyon. In much of the area the granite contains schist inclusions or has a poorly developed planar structure caused by minor textural differences and enhanced by fracturing. The planar structure is commonly parallel to the attitude of adjoining or included schist.

Relatively massive granite without schist inclusions forms the stock in the McGinnis Pass area, comprises most dikes and sills, and forms the central parts of the irregular granite masses north of McCann Pass.

Locally, porphyritic granite contains phenocrysts of microcline nearly one inch long. In places, granite passes to quartz monzonite and Carl (1962, p. 1112) found granodiorite in the southwestern part of the Haystack Range. The granitic rocks are thought to be part of one intrusive phase because compositional differences are broadly gradational.

The conformable contact of the granite stock with schist is everywhere well defined. Contacts of granitic rock with schist septa and inclusions are well defined along foliate directions, but are indefinite and gradational where granite crosscuts schist foliation.

Aplite. Aplite dikes occur in granite in the southwestern extremity of the Haystack Range. The dikes are 1/2 to 25 feet thick and the largest is over 500 feet long. Contacts with granite and pegmatite are sharp and in one place a pegmatite dike clearly crosses aplite.

Granite pegmatite. Granite pegmatite dikes and sills occur in mica schist and granitic rocks. The largest and most numerous outcrops are sills in the mica schist belt north of McGinnis Pass. Other pegmatite occurs as sills in schist near the Twin Hills, as dikes in granite in the southwestern extremity of the Range, and a small dike swarm occurs in granite south of Seward Pass.

Most pegmatites are unzoned or poorly zoned; the intermediate and wall zones are not separable in most bodies. Border zones and cores are well defined in a few bodies, but border zones are discontinuous.

Carl (1962), Ball (1906c), and Hanley and others (1950) have studied and described the pegmatites and prospects of the Haystack Range. The pegmatites are fine- to medium-grained, mostly medium-grained and composed of quartz, microcline, microcline perthite, plagioclase, muscovite, tourmaline, biotite, garnet, apatite, and beryl; in order of relative abundance. Discontinuous, plagioclase-rich border zones are about two inches thick. Pegmatite cores consist of quartz, microcline perthite, or microcline which may be coarse-grained. Tourmaline is the black, iron-rich variety and commonly forms euhedral crystals. Beryl occurs mostly in euhedral, prismatic crystals 2 to 6 inches long. Muscovite occurs as books and flakes of various sizes.

There are mineralogic and textural variations from place to place in pegmatite. For example, most medium-grained, beryl-bearing, muscovite-rich pegmatite occurs in the N 1/2, N 1/2, sec. 36 and secs. 25, 26, and 35, T.28 N., R.65 W. Here, pegmatites which have plagioclase as the dominant feldspar are more likely to contain abundant beryl and muscovite (Hanley and others, 1950, p.114.) Elsewhere in the schist belt pegmatites are fine-grained; poor in plagioclase, muscovite, and garnet; and no beryl has been observed. At other places in the area, pegmatites may be medium-grained but are poor in muscovite and beryl.

Other Rocks of Precambrian Age

Granite gneiss. Granite gneiss crops out in the northern end of the Haystack Range. The foliate character of the rock is visible from a distance because many, closely spaced joints parallel the foliation. The rock weathers into angular blocks. The rounded, exfoliate weathering forms characteristic of granite are lacking.

Granitic layers consist mostly of quartz, microcline, sodic feldspar, biotite, and some muscovite. Microcline and biotite are poorly aligned, but do contribute to the foliation of the rock. Most foliation is a result of discontinuous, closely spaced, thin layers of fine-grained quartz aggregates.

Granite gneiss is in sharp contact with chlorite phyllite to the west. To the east and south the pronounced foliate character of the gneiss gives way gradationally over distances of 100 to 200 feet to the poorly defined, nonpersistent foliation in granite. Contact relations are unknown to the north because of intervening cover.

The attitude of granite gneiss is conformable to that of metasedimentary rocks to the west and granite to the east. Except for a single, simple, small pegmatite dike contained in the granite gneiss, clear evidence of cross-cutting relationships and diverse structures with neighboring rocks is lacking. Thus the significance of granite gneiss is not entirely understood. Absolute age determinations of gneiss and granitic rocks of the area would help place the granite gneiss in proper perspective.

Epidotized breccia zones. Epidotized breccia zones, linear in outcrop, occur in the Twin Hills and in the southwestern end of the Haystack Range. These zones are probably fault zones, but other than brecciation and rare slickensiding on epidote-coated surfaces, evidences of faulting are lacking. In the Twin Hills, breccia zones consist of shattered granite welded to coherence by epidote and quartz. Contacts with granite are both sharp and gradational. The zones in the southwest are smaller and less well defined. Here, epidote commonly coats fracture surfaces and does not impart a great degree of coherence to the rock. Epidotized breccia zones are thought to be younger than pegmatite, because pegmatite bodies in the Twin Hills and near the Old Government Farm show epidote on fracture surfaces.

Silica veins. Veins of multicolored, cryptocrystalline silica, mostly jasper, are associated with fault and fracture zones. Veins occur in sec. 14, T.28 N., R.65 W. and with faulting in NE 1/4, sec. 26, T.28 N., R.65 W., and in sec. 6, T.27 N., R.64 W. These veins both conform with and cross cut the attitude of rocks in which they occur. Veins are commonly 3 to 5 feet wide and up to about 850 feet long. Jasper masses are porous, and in the southeastern exposures a very few small flakes of molybdenite can be found in the jasper. Silica veins are thought to have formed after the epidotized breccia zones because no epidote was found in the veins. The veins are not associated with other dikes or sills, so their time of formation is not definitely known.

Rocks of Paleozoic and Later Ages

Rocks of Paleozoic and later ages are well mapped and described by Smith (1903), Condra and Reed (1935), Denson and Botinelly (1949), Love and others (1953), Rapp and others (1957), and McGrew (1963). The reader is referred to these publications for details.

The oldest Paleozoic rocks in the area are the beds of the Guernsey formation of Devonian (?) and Mississippian ages. The lower beds of the Hartville formation of Pennsylvanian age crop out extensively. The Guernsey and Hartville formations form most of the Chicago Mine Hill and cap the Haystack Range and hills east of the Range.

The Arikaree formation of Miocene age crops out in the lowlands around the Haystack Range and occurs as valley fill on the Chicago Mine Hill.

Alluvium of Recent age occurs mostly along the bottoms of Whalen Canyon and Cottonwood Draw. Colluvium is found mostly on steep hillsides of the Haystack Range and Chicago Mine Hill.

Structure

Structural features of two ages are recognized in the Haystack Range. The older features defined in rocks of Precambrian age, are everywhere transected by the unconformity at the base of the Guernsey formation. The younger feature defined in rocks of Paleozoic age, probably formed during Laramide time and are partially concealed by rocks of Miocene and later ages. In the area, no deformation is recognized in rocks of Miocene and later ages.

Structure in Precambrian rocks. The main structural feature of the Haystack Range is the large, northward plunging antiform south of McCann Pass. This fold is best delineated by the mica schist-granite contact in the southern part of the Range. The many pegmatite sills show the structural form in the mica schist belt and in places show the character of minor folding. The east limb of the fold is contorted and pegmatite sills delineate subsidiary folds. Axes of subsidiary folds are convergent with respect to the axis of the major fold. North of McCann Pass, schist intruded by granite poorly delineates several folds, one of which is probably an extension of the antiform across the McCann fault.

West of the map area in the vicinity of Sunrise, fold axes and rock attitudes strike nearly east-west (Ball, 1906b, p. 195) and to the north, turn northerly until rock attitudes strike nearly north; parallel to the dominant fold of the Haystack Range. West of Whalen Canyon, axes of major folds are probably concealed beneath rocks of Paleozoic and later ages.

Most deformational and metamorphic features of Precambrian rocks are apparently related to events during and after intrusion of granite and related rocks. The possible exception is lineation as a result of mineral parallelism which occurs mostly in mica schist. The linear feature seems to be folded with the schist and may be relict from an earlier period of deformation and metamorphism. Foliation of metasedimentary rocks is definitely relict bedding in most places and is of the same age as the metasedimentary rocks.

The major fault of demonstrably pre-Devonian (?) age is the McCann fault. This fault transects the major antiform of the Haystack Range and can be traced by discontinuous outcrop across Whalen Canyon and into the Chicago Mine Hill escarpment, where it is concealed beneath the Guernsey formation. The fault strikes northwest, but the dip of the fault is not known. The upthrown side of the fault is probably the northern side because the dolomite outcrop west of Whalen Canyon is apparently shifted westward north of the fault. Minor faults of probable Precambrian age are those associated with epidotized zones and silica veins. Along most minor faults there is no evidence to indicate direction of relative movement.

Structural features of Laramide age. The broad, easterly arcuate Haystack dome, defined in rocks of Paleozoic age, is the only fold of Laramide age recognized in the area. In previous work, Denson and Botinelly (1949) mapped the domal axis to about the south limit of T. 28 N. The writer has extended the axis about three miles southwest. The axis probably continues further south, but is poorly delineated because outcrops of Paleozoic rocks are widely separated. The dome is broadly coincident with the major antiform in Precambrian rocks and also with outcrops of granitic rocks.

The major fault of Laramide age is the Sunrise fault which strikes north-south and is nearly vertical. Vertical displacement along the fault is at least 300 feet (Denson and Botinelly, 1949, sheet 2) and is downthrown on the west. The fault cannot be followed northward much beyond the map area. It probably extends south down Whalen Canyon, but is concealed by rocks of Tertiary age. One lesser fault occurs in the southernmost of the Twin Hills. Here the Guernsey formation shows displacement of a few tens of feet.

ECONOMIC GEOLOGY

Mineral commodities produced or studied in the area include iron, copper, mica, beryl, and graphite. Iron ore, crushed rock, and limestone have been produced in quantity from mines and quarries in areas near Guernsey and Hartville.

Iron

Iron ore has been mined from hematite ore bodies which occur mostly in phyllite of Precambrian age above the predominantly carbonate rocks (Ball, 1906b, p.196; Ebbett, 1956, p.86; Osterwald and others, 1959, p.105). No hematite of economic significance was found north of Chicago mine, a former iron ore deposit, so the ore-bearing zones are absent or concealed by rocks of Paleozoic age to the west of the Chicago Mine Hill escarpment.

Hematite occurs in mica schist along the McCann fault in the vicinity of McCann Pass. Small quantities of this rock contain much iron and some may be amenable to concentration. On the west side of McCann Pass, hematite content of mica schist south of the McCann fault is probably not of economic importance. Elsewhere along the fault zone, hematite content of the rock is greater but information upon which to base estimates of tonnage and grade is lacking.

Two unmapped outcrops of hematitic schist occur. One is located in the SE 1/4, sec. 28, T.27 N., R.65 W. on the south side of a small hill and is partially concealed by the Guernsey formation. This occurrence is apparently a small pod of hematitic schist in mica schist because it terminates laterally at the surface. The other is located in the SE 1/4 SE 1/4, sec. 12, T.27 N., R.65 W. at the southern end of an outcrop of mica schist. Here, an east-west trending belt of hematitic schist about 50 to 75 feet wide transects the mica schist outcrop. The hematitic schist is concealed on the south, east, and west by overlying rocks. Both areas should be examined for possible extensions of hematitic schist and the material examined for amenability to concentration.

Copper

Copper has been mined in nearby areas, mostly in conjunction with iron ore production (Ball, 1906a, p.94; Osterwald and others, 1959, p.49-50, 55). There are no active copper mines. A few adits and shafts were completed prior to 1906 in areas showing copper mineralization; mostly in the Haystack Range along the south edge of the McCann fault and along the two smaller faults to the north. These old workings are without exception extremely dangerous and should not be entered.

Copper-bearing minerals are widely distributed in small amounts throughout rocks of Precambrian age. The basal arkose of the Guernsey formation locally contains abundant copper minerals. Chrysocolla, malachite, and azurite are found west of Whalen Canyon, commonly in faulted and fractured zones and rarely on weathered rock surfaces. In the Haystack Range, secondary malachite and chrysocolla commonly occur along the McCann fault, less commonly north of the fault, and in sparse amounts in schist and pegmatite south of the fault. Copper deposits previously mined consisted largely of chrysocolla, malachite, and chalcocite with lesser amounts of tennantite (?), native copper, azurite, bornite, covellite, cuprite, and chalcopyrite (Ball, 1906a, p.95). Copper deposits occur mostly as small lenses in the basal arkose of the Guernsey formation and in underlying rocks of Precambrian age. These lenses rarely extend more than 50 feet below the Guernsey formation and in places less than 20 feet (Ball, 1906a, p.98). The weakly mineralized area along the McCann fault may consist of fissure veins in part and may be the source of the widely distributed copper mineralization. Much exploratory work would be necessary to establish the economic potential of this area.

Initial copper mineralization probably occurred in Precambrian time, because subrounded chrysocolla fragments occur in places in the basal arkose of the Guernsey formation. Most copper-bearing minerals are secondary minerals indicative of supergene enrichment and oxidation. Mineralized areas may represent copper concentrated downward by waters of meteoric origin from a great volume of weakly mineralized, overlying rock.

Results of previous copper mining in nearby areas (Ball, 1906a, p.93-107) are not encouraging. Deposits mined were not large and had no appreciable vertical extension. When secondary copper minerals near the surface were exhausted, mines consistently failed for want of ore. However, there apparently has been no sustained exploration program utilizing modern methods in search of copper.

Minerals in Pegmatite

Minerals of greatest economic interest which occur in the granite pegmatite are muscovite, beryl, quartz, and microcline. Small amounts of muscovite and beryl have been produced commercially. Total production is not known, but cannot be great. All production is obtained by hand cobbing pegmatite rock mined from surface workings. Some dry ground, scrap muscovite was produced at the Crystal Palace and Haystack No. 2 mines (Hanley and others, 1950, p.116, 119). Quartz and feldspar have not been produced, but may be produced in the future for use in ceramics and building construction.

Muscovite and beryl of greatest concentration and grade occur in the central Haystack Range. Beryl is evenly distributed through some of the pegmatites, and occurs mostly in poorly defined intermediate and border zones of others. Some beryl probably occurs in most of the pegmatites in the central part of the Haystack Range. Muscovite seems to occur mostly in intermediate and wall zones. According to visual estimates of Hanley and others (1950) the better muscovite- and beryl-bearing zones of pegmatites generally contain less than 20% muscovite and less than 2% beryl by volume. Assuming all muscovite is mined, not more than about five percent will be of first grade, the remaining will consist of lower grades and scrap. These visual estimates represent about the upper limit of muscovite and beryl concentration which may be found in some pegmatites of the area and do not completely account for the fact that ease of mining and value of the commodity produced is a function of grain size of the minerals.

Beryl in two pegmatites south of McGinnis Pass occurs as beryl aggregates in coarse-grained quartz cores. In both places, beryl comprises considerably less than one percent of the pegmatite mass. In one pegmatite (NW 1/4, sec. 14, T.27 N., R.65 W.) about 150 pounds of beryl was recovered at the surface, but the downward extension of the aggregate was not exploited.

Quartz and microcline occur in all pegmatites in varying amounts. The larger grain sizes of these minerals, most amenable to hand cobbing, occur in cores of pegmatites. The large pegmatite masses northwest of Woodworth Spring consist mostly of quartz and microcline, but here, grain size is smaller and separation of minerals would be more difficult. At the present time, the Haystack Range is relatively far removed from industrial and urban centers. Thus, low value commodities of the area, such as quartz and feldspar for industrial and ceramic use probably cannot compete with existing sources of supply. However, small tonnages of rock for specialized use, such as ornamental aggregate, might be marketed successfully.

Limestone

A massive limestone bed of the lower Guernsey formation has been quarried near Hartville (Osterwald and others, 1959, p.165) and the limestone used in sugar refining. This bed crops out in the Chicago Mine Hill escarpment and in the hills east of the Haystack Range. The bed does not crop out over large areas nor has the limestone been tested for purity. Overlying rock must be stripped from the bed before large quantities of limestone can be quarried. In most places, hillsides above the limestone are steep and overlying rock thickens rapidly with distance behind the outcrop.

Graphite

The richest graphite-bearing layers of mica schist occur on the north side of McCann Pass between McCann fault and the mica schist-granite contact. Here, a graphitic layer 2 to 10 feet wide can be traced for about 1000 feet on the east side of McCann Pass. Similar layers, about 2 feet thick, occur in discontinuous outcrop on the west side. The thicker layer dips 60 to 80 degrees northwest into the hillside. According to Ball, (1906d, p.427) a specimen of better grade rock assayed 13 percent carbonaceous matter and 5 percent graphite. The graphite grains and flakes are 0.15 to 0.04 millimeter in average diameter from place to place (Ball, 1906d, p.428).

The graphitic mica schist would probably have to be mined by underground methods and fine grinding would be necessary to liberate the graphite grains. These layers probably cannot be economically exploited at present.

Other carbonaceous schist occurs further north of McCann Pass and in the schist belt south of the Pass. These layers are mostly less than two feet in thickness, very fine-grained, and carbon content is not great. Most of the carbonaceous matter may be amorphous carbon and not graphite.

Crushed Rock

Southwest of the map area, about one mile northeast of Guernsey in S 1/2, sec. 25, T.27 N., R.66 W., the Guernsey Stone Company produces crushed rock for use largely as track ballast for railroads. Over 250,000 tons per year are produced (State Inspector of Mines of Wyoming, 1963). The rock quarried is siliceous dolomite and diabase of Precambrian age.

South of the map area in SW 1/4, sec. 32, T.27 N., R.65 W. a similar rock has been produced in the past.

Much of the rock in the map area, especially granite and granite gneiss, is suitable for use as crushed rock, but is unfavorably situated with respect to railroad transportation.

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