



EXPLANATION

- Tertiary and younger rocks, undifferentiated**
  - QTu
  - mpu
- Paleozoic or Mesozoic rocks, undifferentiated**
  - SE
- Sherman granite**  
Pink or reddish gray and white, coarse-grained, locally porphyroblastic, massive to granitic, foliated and layered; trace to composition from granite to gneissoid; local fine-grained dikes.
- Gneisses and schists, undifferentiated**  
Foliated gneisses and schists of variable composition; characteristic coloration, garnet, and quartz; foliated and layered.
- Quartz monzonite gneiss**  
Pink and white, medium- to coarse-grained, principally plagioclase, quartz, and quartz with minor biotite; layered and foliated.
- Porphyroblastic granodiorite gneiss**  
Pink and white, coarse-grained, porphyroblastic, biotite, quartz, and quartz with minor biotite; irregular porphyroblasts 1/4 to 1/2 inch across; layered and foliated.
- Quartz diorite gneiss**  
Gray, medium- to coarse-grained, principally orthopyroxene, quartz, and quartz with minor biotite, hornblende, actinolite, and quartz; layered and foliated.
- Syenite-diorite gneiss**  
Intermediate between syenite and diorite gneiss; layered and foliated.
- Hornblende syenite**  
Gray, coarse-grained, massive, pyroxene, hornblende, quartz, and quartz with minor hornblende and quartz.
- Hypersyenite gneiss**  
Gray or green, coarse-grained, porphyroblastic, orthopyroxene, quartz, and quartz with minor quartz and pyroxene; foliation chiefly on rock in each outcrop.
- Norite and melanorite**  
Gray, fine- to medium-grained, contains plagioclase, orthopyroxene, and biotite with or without olivine; minor hornblende, actinolite, and quartz; layered and foliated; trace to composition from norite to melanorite in T. 17 N. and contains orthopyroxene, quartz, and quartz with minor quartz and pyroxene; layered and foliated; trace to composition from norite to melanorite in T. 17 N. mark positions of small orthopyroxene bodies.
- Fractured and altered anorthosite**  
Gray, medium-grained plagioclase with disseminated olivine and local magnetite-ilmenite; massive to foliated and layered, fractured and altered.
- Olivine anorthosite**  
Gray, medium-grained plagioclase with or without orthopyroxene; massive to foliated and layered.
- Noritic anorthosite**  
Gray, coarse-grained plagioclase with 10 to 40 percent orthopyroxene and magnetite-ilmenite; massive to foliated and layered. Locally contains 50 percent or more orthopyroxene.
- Granulated anorthosite**  
Light-gray, relatively fine-grained plagioclase with less than 10 percent orthopyroxene and magnetite-ilmenite; massive to poorly foliated and layered; granulated.
- Quartzite-anorthosite**  
Gray, fine- to medium-grained quartz with or without plagioclase and magnetite-ilmenite. Interspersed or scattered quartz with biotite and quartz. Interspersed or scattered quartz with biotite and quartz. Interspersed or scattered quartz with biotite and quartz.
- Anorthosite**  
Gray to blue-gray, medium- to coarse-grained plagioclase with less than 10 percent orthopyroxene and magnetite-ilmenite; massive to foliated and layered.
- Gray quartz monzonite gneiss**  
Gray to light-gray, medium- to coarse-grained, principally plagioclase, quartz, and quartz with minor biotite, hornblende, actinolite, and quartz; layered and foliated.
- White to light-gray or pink, coarse-grained, principally plagioclase, with minor quartz and minor hornblende and/or biotite; lineation of minerals and mineral aggregates.**
- Red quartz monzonite gneiss**  
Red, porphyroblastic to non-porphyroblastic, principally microcline and plagioclase with considerable quartz and some biotite; lineation of minerals and mineral aggregates.
- Biotite schist**  
Brown, fine-grained, contains biotite, quartz, plagioclase, and quartz with minor biotite, hornblende, actinolite, and quartz; layered and foliated.
- Hornblende schist**  
Black or gray, fine- to medium-grained, contains hornblende, orthopyroxene, and quartz with minor biotite, actinolite, and quartz; layered and foliated.
- Quartzite**  
White to gray, fine- to medium-grained, contains quartz, plagioclase, and quartz with minor biotite, hornblende, actinolite, and quartz; layered and foliated.
- Marble**  
White, gray, or light gray, fine- to medium-grained massive dolomite or limestone with local siliceous.

- Contact**  
Dashed where approximately located.
- Fault**  
Dashed where approximately located. Arrows show relative movement; U, upthrown side; D, downthrown side.
- Thrust fault**  
Dashed where approximately located. T on overriding block.
- Axis of anticline, showing plunge of axis**
- Strike and dip of layering**
- Strike of vertical layering**
- Strike of vertical layering and plunge of lineation**
- Horizontal layering**
- Horizontal layering, showing horizontal lineation**
- Strike and dip of layering and plunge of lineation**
- Strike and dip of layering, showing horizontal lineation**
- Mine or quarry**
- Titaniferous iron**

GEOLOGIC MAP OF ANORTHOSITE AREAS  
SOUTHERN PART OF LARAMIE RANGE, WYOMING

By  
W. H. Newhouse and A. F. Hagner

INTRODUCTION

The anorthosite areas of the southern part of the Laramie Range are in the southeastern part of Wyoming, Tps. 16 to 21 N., Rs. 71 and 72 W., and extend about 30 miles in a northerly direction and 6 to 11 miles easterly. The area is readily accessible by State Highway 34, two county roads, and numerous ranch roads. The Union Pacific Railroad to the west and the Colorado & Southern Railroad to the east may be reached by State county and ranch roads. Laramie, the nearest city, is about eight miles west of the southwestern part of the map.

Field work on the anorthosite areas was begun in the summer of 1944 and was continued during the summer of 1945. Minor amounts of work were done in later summers up to and including 1951. The study was a joint project of the U. S. Geological Survey and the Geological Survey of Wyoming.

The purpose of the work was to gain a better knowledge of the relations of the different iron deposits to the different varieties of anorthosite, and to study the relations of the different varieties of anorthosite to the structure of the anorthosite masses. Because anorthosite is a possible future source of aluminum, the knowledge of its variations in composition may be useful.

Some data on the marginal relations and faulting of the Precambrian rocks was taken from maps prepared by graduate students of the Geology Department of the University of Wyoming including L. O. Gray, Jr., J. D. Hahn, C. R. Hammond, and M. S. Tudor. J. E. Harrison mapped the Sherman granite as a part of his doctoral dissertation at the Geology Department, University of Illinois, Urbana, Ill., U. S. Bur. Mines Rept. Inv. 3818, 1941. W. DeVore was responsible for the mapping of the hornblende schist and the syenite on the northern part of the map. Many ranchers gave helpful information and assistance.

ANORTHOSITIC ROCKS

There are two large anorthosite masses within the region mapped. The northern one extends from the center of T. 17 N. to the northern part of T. 21 N., and the southern one about 40 square miles in area, is 2 to 3 miles south of the northern one. Numerous small masses are present, particularly in the southern part.

The most characteristic features of the anorthositic rocks are their simple mineralogy and relatively simple structure. The predominant mineral is plagioclase with appreciable amounts of orthopyroxene in the noritic varieties; considerable olivine occurs locally. Magnetite and ilmenite are the principal accessory minerals. The rocks have the form of a folded lens or a tabular-shaped mass consisting of several thick layers of anorthosite and noritic anorthosite. The major structure of the northern and southern masses is anticlinal. The rocks exhibit a tabular structure of plagioclase crystals called platy crystal structures.

Rocks of the anorthosite series have been divided into five map units on the basis of percentage and kind of minerals, and on granulation and alteration. These three major units include anorthosite with less than 10 percent dark minerals, noritic anorthosite with 10 to 20 percent dark minerals, and olivine anorthosite.

NORTHERN ANORTHOSITE MASS

The anorthosite and noritic anorthosite of the northern mass form four major layers, each several thousand feet thick. Within most of these major layers are smaller layers of the other anorthositic rocks that are from one to several tens of feet thick. Olivine anorthosite is restricted to the northern mass, where it forms lenses and layers that vary considerably in size and shape.

A granulated zone and two fractured and altered zones were mapped in the northern anorthosite mass. The granulated anorthosite zone, about 9 miles long and 1,000 to 3,000 feet wide, occurs along or near the anticlinal crest in T. 20 N., R. 71 W. This zone continues southward as a fractured and altered zone about 8 miles long. It begins northeast of Iron Mountain near the anticlinal crest and trends southeast across the eastern limb of the fold. Another, more irregular, fractured and altered zone extends west and south of Iron Mountain for about 4 miles along the anticlinal crest.

**Anorthosite.**—Anorthosite is the principal rock in the eastern part of the northern mass. It also is present as a thin layer on the southwest margin of this mass.

The anorthosite is light to medium gray or blue gray, medium to coarse grained, and has a tabular structure of plagioclase with or without hornblende, actinolite, and quartz. The mineralogy is simple. Much of the anorthosite is composed almost entirely of plagioclase with only 1 or 2 percent of orthopyroxene and magnetite-ilmenite. The anorthosite content of the plagioclase in the anorthosite ranges from about 60 to 85 percent. Most of the plagioclase is fresh, but some shows incipient alteration, particularly along fractures and twin lamellae, to sericite, carbonate minerals, and clay. Grain size of the plagioclase ranges from a small fraction of an inch across to crystals that are 10 inches long and 2 inches wide; most of the grains would fall between the limits of one-eighth to one-half inch wide and three-sixteenths to 1 inch long. The unaltered orthopyroxene ranges in composition from 17 to 54 percent orthoferrosilite. It is generally altered to one or more of the following minerals: hornblende, actinolite, biotite, epidote, and chlorite. Magnetite-ilmenite may make up several percent of the rock and in places is partly altered to hematite, limonite, and titanite. Locally the pyroxene and magnetite-ilmenite are concentrated in patches or clusters; these are occasionally arranged in bands or layers. Minute inclusions of rod-shaped and prismatic minerals are found in the plagioclase.

Anorthosite commonly exhibits a well-developed parallelism of plagioclase crystals; 800 fss are subparallel to parallel. Layering and foliation due to platy plagioclase crystals are parallel as observed in outcrops. The ratio of length to width of plagioclase crystals ranges from about 2:1 to as much as 10:1. This ratio also varies with composition, being less in the more calcic varieties. As seen under the microscope, many of the large crystals are bent and some are microfractured. These are believed to be protoclinal effects; cataclastic effects are minor and local. Most of the plagioclase exhibits slight twinning, frequently accompanied by perthite twinning. Carlsbad twinning is commoner in the large crystals than in the small crystals. In places the anorthosite consists of relatively large crystals in a fine-grained matrix.

**Noritic anorthosite.**—Noritic anorthosite is the dominant rock in the western part of the northern anorthosite mass. A narrow layer is present in the southeastern portion of this mass; a less extensive, narrower one occurs about 3 miles east of the Berner ranch just west of the anticlinal axis.

**Noritic anorthosite.**—Noritic anorthosite is darker gray than anorthosite and in general is coarser grained. Orthopyroxene in the noritic anorthosite is coarse grained and occurs with some clinopyroxene as grains which are interstitial to the plagioclase. The pyroxene is not as completely altered as that in anorthosite. In places pyroxene forms 20 to 40 percent of the rock; these varieties should then be classed as feldspathic noritic and noritic. Magnetite-ilmenite is a minor constituent that occasionally occurs as coarse-grained interstitial groups of grains. Where the percentage of pyroxene is high, platy crystal structure may be lacking except locally.

In places, noritic anorthosite is present in anorthosite as transgressive veins, pegmatites, layers, and as interstitial material in anorthosite breccia or rubble. Anorthosite breccia with a cement of noritic anorthosite grades into large zones of breccia that are almost completely replaced by the noritic anorthosite. This is a characteristic feature of large portions of the northern anorthosite mass, particularly north of the Berner ranch. In the pegmatite, plagioclase and orthopyroxene crystals as much as several inches across are found; coarse-grained olivine locally accompanies the pyroxene in this rock.

**Outcrops of noritic anorthosite** are subrounded to round and brown; they weather to a coarse arkosic soil.

**Olivine anorthosite.**—About 30 of the olivine anorthosite bodies mapped are concentrated in the southern part of the northern anorthosite mass and 6 near the northern extremity of the mass. The olivine anorthosite bodies range from 300 feet long and 100 feet wide to one 2 1/4 miles long and a mile wide. These bodies vary greatly in shape but in general are elongate parallel to the strike of the anorthosite, with only local divergence of structure. The two largest masses or layers narrow or finger out along the strike. All but three occur within the feldspathic variety of anorthosite. All but a few small bodies are on the west flank of the anticline or near the crest; only two are more than 2 miles from the crest.

The olivine in this rock ranges in amount from a few percent to more than 50 percent. Orthopyroxene is commonly, but not always, present. Thus the rock is an olivine anorthosite, troctolite, or olivine norite depending upon variations in the percentage of olivine and pyroxene.

**Granulated anorthosite.**—The granulated anorthosite along or near the anticlinal crest in the northern mass occupies a zone approximately 9 miles long and 1,000 to 3,000 feet wide. The rock in this zone is blue gray and white, fine grained, and granular. Much of the original plagioclase has been crushed or granulated and then recrystallized. This crushing and recrystallization has resulted in the formation of a uniform fine-grained rock wherever all the plagioclase was granulated, or in a rock consisting of larger crystals in a fine groundmass wherever all the plagioclase was not granulated. In the incompletely granulated rock the large crystals range in size from one-eighth to 1 inch across; the average size is about one-fourth inch across. These crystals are darker gray than the groundmass and may form 10 to 20 percent of the rock. The groundmass is white or light gray and saccharoidal. Uniform fine-grained rock grades into rock with relatively large plagioclase crystals in a fine-grained matrix. This gradation results, locally, in a patchy, mottled, or veined appearance. In addition to being granulated, the anorthosite is fractured and sheared. Locally, shear planes have developed parallel to and across the platy crystal structure and have obliterated this structure in large part. Plagioclase crystals in many outcrops are either not aligned, or are aligned in only a small part of the outcrop.

**Fractured and altered anorthosite.**—Two fractured and altered zones are present in the northern anorthosite mass. One is a southward extension of the granulated anorthosite zone and is approximately 8 miles long. This fractured and altered zone trends southeast across the eastern flank of the anticline. From a mile northeast of Iron Mountain the zone trends southeast across the eastern flank of the anticline. A second fractured and altered zone extends southwest along the anticlinal crest for about 4 miles. This second zone is highly irregular and may be traced from a mile north of Iron Mountain as a narrow band that widens to about 2 miles and then narrows again to the southwest.

The fractured and altered zones localized an early period of mineralization when widely disseminated olivine and local magnetite-ilmenite were deposited. Later the zones were intruded by small granitic dikes, which produced widespread alteration in the broken and mineralized anorthosite. Sericite and chlorite were the alteration products commonly formed.

SOUTHERN ANORTHOSITE MASS

The southern anorthosite mass appears to be one major layer of anorthosite. It does not contain any noritic anorthosite or olivine anorthosite layers, nor any associated syenite or norite. Granitic dikes are numerous in the southern anorthosite mass and form as much as 20 percent of the volume of the rock. Most of the dikes range from a few inches to several feet thick and have a gneissic structure. They transect the platy crystal structures of the anorthosite at various angles. Titaniferous iron deposits have not been found in this mass.

**Anorthosite.**—The anorthosite is light gray, medium grained, and contains plagioclase crystals, which in much of the area are almost equidimensional. That is, the crystals in hand specimens are only slightly elongated. Platy crystal structure of the plagioclase is fair to good and consists of a parallel alignment of plagioclase with or without hornblende. The anorthosite content of the plagioclase in the anorthosite ranges from about 50 to 65 percent. Locally the anorthosite contains considerable hornblende and biotite—as much as 25 percent. Minor amounts of actinolite, chlorite, and epidote or calcite may accompany the hornblende and biotite. These minerals commonly occur as spots, blotches, or streaks and appear to be alteration products of pyroxene developed by the action of granitic dikes on the anorthosite.

**Quartzite-anorthosite.**—A rock that has the appearance of quartzite is intimately interlayered with anorthosite in the southeastern portion of the southern anorthosite mass.

The rocks mapped as quartzite-anorthosite vary greatly in mineralogy, texture, and structure. The oldest is a rock that ranges in composition from a gray, medium-grained rock consisting entirely of quartz to one that is largely plagioclase or plagioclase and monoclinc pyroxene, minor garnet, and magnetite-ilmenite, with or without syenite. The pyroxene is commonly altered in part to hornblende and biotite. The quartzite shows various stages of replacement first by fine-grained white plagioclase, and finally by the typical gray, granular anorthosite of the area.

All the rocks show mineral layering, and this is particularly apparent where both dark and light minerals are present. Occasionally veins or zones of white plagioclase parallel to the quartzite layering bring out the planar structure. Locally the planar structure resembles gneissic structure and is formed by elongated masses of quartz grains, pyroxene, and plagioclase. In other places the planar structure is formed by quartzite breccia, domo-sized and smaller, with pyroxene and plagioclase cementing and replacing the matrix. There is a lineation of mineral grains and of aggregates of grains, and in all observations this lineation lies within the planar structure.

STRUCTURE

A complete section of the anorthosite series is not exposed. The part that is exposed has the form of a folded lens or tabular-shaped mass. This mass consists of four major compositional layers, each several thousand feet thick, in the northern mass. Structural features are relatively simple and are outlined by compositional layering and platy crystal structure.

The major structure of the anorthosite is a sharply defined anticline in the east, which trends north for 26 miles. The anticline in the southern mass trends north for 10 to 12 miles long. In the northern area the anorthositic rocks dip, in general, to the west except where modified by the major anticline. Dips of platy crystal structure and layering on the northern anticline range from 20° to 60°, the majority being from 40° to 60°. The dip in the south is in T. 20 N., R. 71 W., and the anticline plunges south from this point for 17 miles and then for 8 miles. This structure is modified by minor folds.

Many of the outcrops of anorthositic rocks contain evidence of shearing. Narrow zones as wide as several inches are common. These zones may be parallel to the platy crystal structure and compositional layering of the anorthosite, or they may transect these features at various angles. Locally, there is an alignment of minerals along the shear planes. In such places the anorthosite has recrystallized during shearing to produce the parallelism of minerals.

The lowermost of the four major compositional layers consists of anorthosite. It is exposed on the eastern flank of the anticline and extends north and south along the crest of this structure. Above this major horizon is a layer of noritic anorthosite, which is very thick on the western flank of the anticline, but which thins and becomes less rich in dark minerals as it approaches the eastern extremity of the anticline. In these portions, platy crystal structure outcrops across the fold axis, but the dark minerals disappear. The rock with a low percentage of dark minerals extends around the flank of the fold for several miles.

The location of olivine anorthosite and its thickness from one horizon to the next appears to be determined, in part at least, by structural features of the northern anorthosite mass. The olivine anorthosite in the southern half of this mass occurs in folds or warps along the flank of the major anticline. Nearly all the magnetite-ilmenite on bodies of the Laramie Range are within a short distance of the major anticlinal axis in the northern anorthosite mass. The deposits and accompanying mineralization are, for the most part, at places where the anticline changes direction.

SELECTED BIBLIOGRAPHY

- Darton, N. H., Shickovler, Elliot, and Siebenlist, E. E., 1910, Description of the Laramie-Sherman quadrangle, Wyoming; U. S. Geol. Survey Geol. Atlas, 200, 100 p.
- Diemer, R. A., 1941, Titaniferous magnetite deposits of the Laramie Range, Wyo.; Wyo. Geol. Survey Bull. 21, 29 p.
- Fowler, K. S., 1930, The anorthosite area of the Laramie Mountains, Wyo.; Am. Jour. Sci., v. 19, p. 305-315, 373-403.
- Frey, Eugene, 1946a, Exploration of Iron Mountain titaniferous magnetite deposits, Albany County, Wyo.; U. S. Bur. Mines Rept. Inv. 3988.
- Frey, Eugene, 1946b, Exploration of the Shanton iron-ore property, Albany County, Wyo.; U. S. Bur. Mines Rept. Inv. 3918.
- Singewald, J. T., Jr., 1938, The titaniferous iron ore in the United States; U. S. Bur. Mines Bull. 64.