Monzonite

The long, irregular stock in the vicinity of Spiller and Babcock Peaks and Mount Moss (pl. 1) is composed chiefly of monzonite. This is a medium-fine equigranular rock of grayish to pinkish color. The feldspars, chiefly orthoclase and labradorite in nearly equal amount,[9] predominate over the ferromagnesian silicates, augite, hornblende, and biotite. A small amount of quartz is present in most places. The mass of monzonite is in general distinctly stocklike in character, but locally it spreads out in the form of sills, as in the rugged peaks immediately west of Babcock Peak where the monzonite is underlain by metamorphosed sedimentary rocks. Elsewhere the monzonite of the stock grades directly into monzonite porphyry sills and dikes. Thus there is no sharp boundary between the porphyry of the large dike that trends southeastward from Babcock Peak and the granular monzonite on the peak itself. Cross' map[10] shows several sills to the north of Mount Moss which bear similar relationships. Other sills of porphyry appear to be distinctly older than the monzonite.

The rocks on the eastern slope of Burwell Peak here mapped as the Cutler and Dolores formations, are traversed by a network of dikes and small irregular masses of monzonite, and in many places it is difficult to decide whether a given exposure is made up predominantly of sedimentary or of igneous rock.

Diorite

A comparatively large stocklike mass of diorite extends southward and eastward from Diorite Peak to the valleys of the La Plata River and Basin Creek. It is irregular in shape and cuts across several porphyry sills. A smaller and more irregular mass of diorite is exposed on and near Lewis Mountain. This is connected with a complicated

[9] Idem, p. 6.

[10] Idem, geologic map.

series of diorite dikes that extend northeastward for some distance past the area shown on plate 1. It appears probable that the masses on Diorite Peak and Lewis Mountain are closely related to these dikes, and the area between them is possibly underlain by diorite at no great depth. Another small diorite stock is poorly exposed near the end of the ridge just south of Bedrock Creek.

The typical diorite is somewhat darker gray than the monzonite, is finer-grained in most places, and contains a slightly larger amount of ferromagnesian minerals and more lime-soda feldspar. Augite is commonly more abundant than either hornblende or biotite, but locally, as near the border of the Lewis Mountain stock in the vicinity of the Columbus mine, the rock grades within a few feet from an augite-bearing rock to one in which hornblende is almost the only dark mineral. Small masses of granite, probably from the pre-Cambrian basement rocks, and a few rounded pebbles of quartz or quartzite occur as inclusions in places, but they are nowhere abundant.

The diorite is in most places distinctly younger than the porphyry sills, though locally the two rocks appear to be essentially contemporaneous. Thus, along the southern border of the Diorite Peak stock, near the Tomahawk mine, a pyritized breccia composed of a jumbled mass of fragments of sedimentary rock, diorite, and porphyry is exposed over a considerable area. As a rule porphyry forms the matrix of the rock fragments, but diorite occurs locally, and there appears to be a gradation from porphyry through the breccia mass to diorite.

As bodies of diorite and monzonite have not been found in contact, there is no means of discovering their relative age. Likewise, although it appears fairly certain that the stocks have played important parts in the metamorphism of the country rocks and the formation of ore deposits, the relative importance of the diorite and monzonite is unknown. Several productive veins have been discovered within or near the masses of diorite. Among them are the Columbus

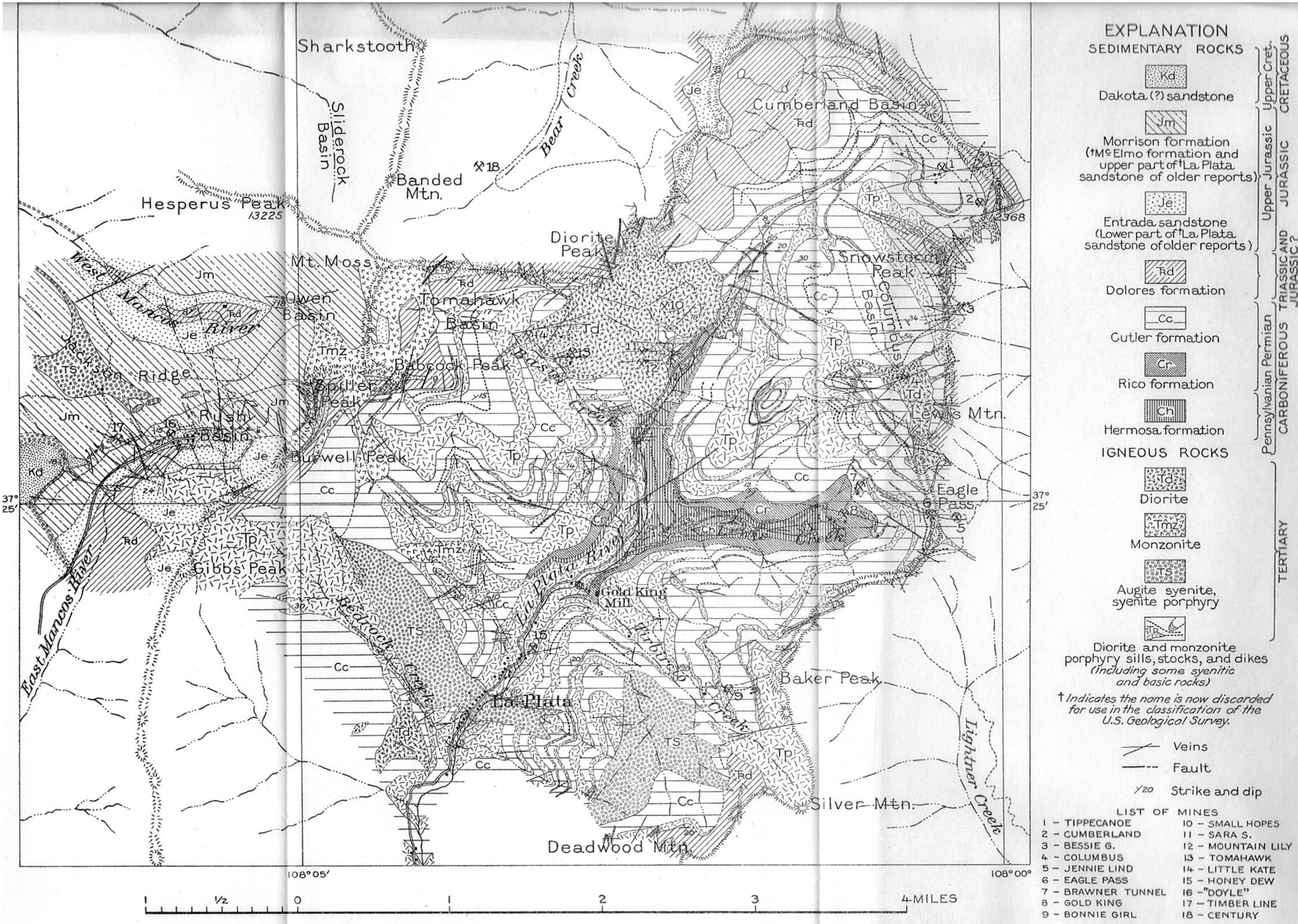

PLATE 1—GEOLOGIC MAP OF PART OF THE LA PLATA MOUNTAINS, COLORADO.

Geology by Edwin B. Eckel, assisted by F. W. Galbraith and R. S. Moehlman.

Base from topographic map of the La Plata quadrangle, U. S. Geological Survey, 1895, with corrections by Edwin B. Eckel vein system, which traverses the Lewis Mountain stock, and the Small Hopes, Sara S., Mountain Lily, Tomahawk, and Little Kate veins, on the slopes of Diorite Peak.

The monzonite and diorite stocks cut through the sedimentary strata without visibly disturbing them. In general, the intrusive masses swell out in shaly beds, such as those of the Dolores and Cutler formations, but narrow markedly in siliceous beds, such as the Entrada sandstone.

Basic Rocks

A series of dark fine-grained basic rocks appear to represent the last stage of igneous intrusion in the La Plata Mountains. They occur in large part as short discontinuous dikes, but some occur as thin sills. These rocks, which have not been differentiated from the porphyritic rocks on plate 1, appear to be younger than all other igneous rocks. They have not been studied in detail during the present investigation, but Cross discusses them at some length.[11]

STRUCTURE

Folds.—The most pronounced structural feature of the La Plata Mountains is a domical uplift of the sedimentary beds, which blends somewhat into the southwestern flank of the much broader San Juan uplift. The beds dip away in all directions from a center that appears to lie in the vicinity of Diorite Peak and Lewis Mountain. Dips of 5° to 20° are most common, though local dips as high as 60° have been observed. Beyond the limits of the dome, which is about 15 miles in diameter, the strata are nearly flat.

Local folds of comparatively small magnitude are superimposed on the regional dome. Some of these folds are unquestionably due to the intrusion of thick porphyry sills, but the origin of others is problematic. The stocks of igneous rock cut across the sedimentary rocks without visibly disturbing the structure and hence appear to have had

[11]Cross, Whitman, op. cit. (La Plata folio), p. 7.

little direct influence on the shape of the La Plata dome. The introduction of great quantities of porphyry, however, in the form of sills between the sedimentary strata, must certainly have caused a large part of the doming, even though other factors determined the site of the intrusions and of the consequent folding.

Faults.—Faults are comparatively rare in the La Plata Mountains. Only a few are shown on plate 1, but many of the veins in the central part of the district follow minor breaks that have displaced the strata from 1 or 2 feet up to 20 or 30 feet. These faults radiate in general from the center of the La Plata uplift and probably developed in response to tensional stresses set up during the formation of the dome.

Near the northern limit of the uplift Cross' map[12] shows a series of faults that trend toward the northeast and extend for several miles. The displacement along these faults, which are, in general, downthrown away from the center of the dome, ranges from a few feet to 500 feet or more. The only other conspicuous faults mapped by Cross are the Menefee fault, west of the East Mancos River, and the Parrott fault, which crosses the saddle between Parrott and Madden Peaks just south of the southwest corner of the area shown on plate 1. The two faults, which trend nearly due east, are almost in a direct line, and each can be traced for several miles. The rocks on the south side of the Parrott fault have been dropped about 1,000 feet. Another system of strong east-west faults is known to exist in the vicinity of the May Day and Idaho mines. These faults have also displaced the strata downward on the south side, or away from the center of the dome.

None of the fault fractures just described are known to contain ore deposits. There are indications that the May Day and Idaho faults, at least, were formed prior to ore deposition and that the gouge along them played an important part in the localization of ore deposits.

[12]Cross, Whitman, op. cit., geologic maps and structure—section sheet.

The general structural picture of the La Plata Mountains is that of a relatively sharp dome in the sedimentary and igneous rocks. On the outskirts of the dome there is a series of faults of large displacement, which are nearly or quite barren of ore deposits and which offer a slight suggestion of concentric arrangement about the uplift. Another series of short, discontinuous faults of small displacement radiate from the center of the dome and contain ore deposits in many places.

ORE DEPOSTIS

History and Production

Gold and silver were first discovered in the La Plata mining district in 1878, when the Comstock mine was opened near the town of La Plata and work was begun on the Cumberland and Snowstorm properties. Many locations were made in the next 3 years, but the output was small until 1902, when the Neglected mine came into production. The Valley View claim, now part of the Idaho mine group, was located the same year and was followed by discovery of the May Day deposit in 1903. These mines began production in 1904, reached a peak about 1907, and in spite of many legal and other difficulties remained the leading mines for many years.

From 1878 through 1934 the mines of the La Plata district have produced $4,052,075 in gold and $1,238,977 in silver.[13] From 1902 to 1914 more than $3,500,000 was produced in the district, largely from the Neglected, Idaho, and May Day mines. In 1914 production dropped below $100,000 for the first time in 12 years and thereafter remained comparatively low until 1929, when it suddenly jumped to more than $165,000, largely owing to production from the Gold King mine. It dropped sharply during the next 3 years but again exceeded $100,000 in 1934, in part owing to the higher price for gold and in part to discovery and exploitation of

[13]Henderson, C. W., Supervising Engineer, U. S. Bureau of Mines, Denver, personal communication.

the Red Arrow mine, which led to renewed activity in a number of other mines. Exclusive of the year 1894, when a production of more than 417,000 ounces of silver is reported, apparently erroneously,[14] the ratio of gold to silver in the ores appears to have been about 1 to 8 by weight.

The record of nearly continuous production ever since the discovery of gold in the district is of interest in view of the notably irregular and pockety occurrence of the telluride ore deposits that have yielded most of the gold and silver.

Minerals of the Deposits

The chief ore minerals of the La Plata district are the tellurides of gold and silver (sylvanite, petzite, hessite, and calaverite) and free gold. Among other metallic minerals that are known or have been reliably reported to occur are argentiferous tetrahedrite, tennantite, stephanite, and other sulphantimonides and sulpharsenides of silver, pyrite, marcasite, chalcopyrite, galena, sphalerite, stibnite, magnetite, and hematite. Native tellurium, the lead and mercury tellurides (altaite and coloradoite), cinnabar, native mercury, and native amalgam are very probably present in small quantities in some of the ores.

Quartz and chalcedony are the chief gangue minerals in most of the deposits, but calcite and other carbonates, barite, fluorite, chlorite, sericite, kaolin, and other minerals are locally present in considerable amounts. The tellurides commonly occur as flakes or tiny veinlets in dark greenish to grayish quartz. The green color of the quartz appears to be due to finely divided chlorite, or possibly to the presence of the vanadium mica, roscoelite, and even where no metallic minerals are visible under the hand lens, quartz of this type is almost invariably an indication of high-grade shipping ore.

[14]Henderson, C. W., U. S. Geol. Survey Prof. Paper 138, p. 177, 1926.

Classification and Character of the Ore Deposits

Most of the ore deposits fall into two mineralogic classes—the telluride ores and the gold-bearing pyrite ores. The telluride ores are commonly of much higher grade than the others and have yielded the bulk of the production from the district. A few deposits, such as the silver-bearing veins of the Cumberland and nearby mines and the lead-copper deposits in the vicinity of the Honey Dew mine, do not fall into either of the two classes. Further work is necessary to clarify the relations between the various types of deposits. There are some indications that the auriferous pyrite and the base-metal deposits were formed closer to the source of the ore-bearing solutions and at somewhat higher temperatures than the telluride deposits.

The ore deposits may be further subdivided into those that occur as veins and those that have been developed by partial or complete replacement of certain strata. Other classes, such as the low-grade pyritiferous bodies in breccia zones, the placers, and the gold-bearing bog-iron deposits in Rush Basin and elsewhere, will not be considered here. Their general features are described by Purington.[15]

The general features of ore occurrence are brought out in the following descriptions of four typical deposits.

Telluride veins associated with porphyry dike: the Neglected mine.

The Neglected mine, one of the largest producers in the district, is an excellent example of the type of telluride veins that are closely associated with dikelike bodies of intrusive igneous rock. The mine is situated in the eastern part of the district (fig. 1) on a tributary of Junction Creek, at an altitude of about 10,300 feet. The deposit was first discovered about 1895 and has since produced considerably more than $500,000, largely during the years 1902-5. Em-

[15]Purington, C. W., U. S. Geol. Survey Geol. Atlas, La Plata folio (No. 60), pp. 12-14, 1899 [1901].

mons[16] described the deposit after a visit to the mine in 1904. Development work completed since his visit has served to throw much new light on the mode of ore occurrence.

The mine was originally worked through a vertical shaft from which levels running east and west were opened at depths of 35, 85, 125, and 175 feet. More recently a short adit was opened 65 feet below the collar of the shaft and an 1100-foot drainage adit was driven to connect the 175-foot level with the surface. There are now more than 5,000 feet of workings in the mine.

Geology.—The mine is located in generally unaltered red shales and arkosic sandstones of the Cutler formation about 4 to 5 miles from the center of the La Plata uplift. The sedimentary rocks dip in general toward the east and southeast at angles of 5° to 10°, and are cut by a tabular body of monzonite porphyry which trends nearly due east and dips from 50° S. to vertical. This body was formerly thought to be a typical dike, with comparatively great lateral and vertical extent,[17] but detailed geologic mapping of all accessible mine workings indicates that it is an eastward-pitching tabular mass, about 50 feet in thickness, 200 to 300 feet in height, and of unknown extent along the pitch. The angle of pitch ranges from 10° to 40° but averages about 20°.

Porphyry sills, which range from 1 or 2 feet to 50 feet or more in thickness, occur at several horizons in the surrounding sedimentary strata. They all appear to connect with the dike, which probably represents the channel through which the porphyry magma rose. One of the thickest sills crops out near the mine shaft and can be seen underground on the 35- and 65-foot levels.

A strong fault zone, parallel to the tabular porphyry body, has been traced on the surface for a distance of about

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[16]Emmons, W. H., The Neglected mine and nearby properties, Durango quadrangle, Colorado: U. S. Geol. Survey Bull. 260, pp. 121-127, 1905.

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[17]Emmons, W. H., op. cit., p. 125.

2 miles. In places it occurs within the dike; elsewhere it follows either the hanging wall or the footwall contact with the sedimentary beds. Like the dike, it dips steeply toward the south. The amount of displacement along the fault is unknown because of the lenticular character of the sedimentary strata and the absence of recognizable marker beds, but slickensided surfaces indicate that the south or hanging-wall side has moved downward toward the west at a steep angle.

In the vicinity of the porphyry dike on the 125- and 175-foot levels the fault zone is split into two branches for a horizontal distance of 600 to 700 feet. The wedge of rock between these splits, from 10 to 30 feet wide, is somewhat broken and shattered throughout. The fractured zones along the two branches themselves range from 1 to 16 feet in width and consist of sheared and brecciated wall rocks which are more or less thoroughly silicified and are traversed by numerous veinlets of white to gray fine-grained quartz. Both east and west of the limits of the porphyry dike the fault zone is weak and ranges in general from 6 inches to about 18 inches in width.

Along the length of the dike the wall rocks are strongly altered for distances of 2 to 10 feet away from the fracture zones. The shales and the groundmass of the porphyry have been bleached and silicified. The feldspars of the porphyry and of the arkosic sandstones have been altered to a soft white claylike mineral, probably in large part koalin.[18] Considerable quantities of pyrite also occur in the wall rocks. Beyond the limits of the dike the sedimentary rocks are much fresher and the altered zone next to the fault is only a few inches thick at most.

There have probably been at least two periods of movement along the Neglected fault zone since the intrusion of the porphyry. During the first period fractures were opened in and near the porphyry body. Solutions that probably

[18]Emmons, W. H., op. cit., p. 125.

rose along the same channel as that originally followed by the porphyry magma caused silicification of the wall rocks. These rocks were thus rendered more competent and during a later period of movement were sheared and brecciated. The breccia was later cemented by further addition of quartz.

Ore deposits.—The principal ore minerals of the mine are the tellurides of gold and silver, of which sylvanite is probably most abundant. Free gold was common in the early near-surface workings but is rarely present in the deeper ores. Pyrite is relatively plentiful, and some chalcopyrite is present on the lower levels. Emmons reports the presence of amalgam.[19]

The ore occurs as small veins and stringers of quartz containing the telluride minerals and in places is remarkably rich. Some of the stringers occur in the fractured wall rock, particularly in the wedge between the two branches of the main fault. Locally they occur in such abundance as to render the whole mass of rock a low-grade milling ore. Most of the ore, however, occurs in the silicified fault zones. The richest ores in these zones have been found at the contact between silicified shales and porphyry, but much shipping ore has been obtained from those parts of the zones within the dike. The arkosic sandstones appear to be very unfavorable wall rocks, doubtless because the alteration processes have kaolinized the contained feldspars and rendered the rock soft and crumbly rather than hard and competent like the interbedded shales.

Essentially all the ore from the Neglected mine has been taken from a single ore shoot, which is closely associated with the porphyry dike and like it pitches to the east at angles of 15° to 20°. No stoping of importance has been done to the east of (above) the dike, and stoping to the west of (below) the tabular body has extended less than 200 feet horizontally from the porphyry on both the 125- and

[19]Emmons, W. H., op. cit., p. 125.

175-foot levels. The most profitable zone has been that between the 85- and 175-foot levels.

Most of the ore within 50 feet of the surface was oxidized and contained much free gold. Below the oxidized zone, however, there is no (notable) change in the character or grade of the ore down to the lowest level. The porphyry dike, which appears to control the occurrence of the ore, is known to extend downward below the 175-foot level. Whether more ore would be found in depth at favorable horizons is open to speculation.

Telluride veins in altered red beds: the Gold King mine

The Gold King mine, which did not begin production until 1927, presents a good example of a telluride vein in altered red beds and illustrates the relation of the ore deposits to the degree of silicification of the wall rocks, to porphyry sills, and to vein structure. The mine is situated on the north bank of Lewis Creek, at an altitude of about 10,800 feet. Since 1927 it has produced about $400,000 in gold, silver, and lead.

The mine is worked through a 600-foot adit, which connects with the east-west main level about 350 feet below the surface. There are two long drifts above the main level, known as the intermediate and second levels. Four shorter drifts below the main level were worked through a 400-foot winze near the junction of the main adit and the main level. There are about 6,000 feet of workings in the mine, but at the time of examination all those below the main level were under water.

Geology.—Most of the rocks in the vicinity of the Gold King mine are relatively fresh, a fact which is not in accord with their proximity to the diorite stock on Lewis Mountain but for which no explanation is available at present. As shown on plate 1, the main adit of the mine is just above the base of the Rico formation.

The contact of the Rico and Hermosa formations must be not far below the main level in the mine, but it was not recognized in the winze, and little information is available as to the character of the beds in the lower workings. One small exposure of red sandy and shaly limestone containing probable Rico fossils was found in the mine on the second level, but the top of the Rico formation could not be identified accurately. All the available evidence points to the fact that the bulk of the ore produced has come from the Rico formation, though some was found in the Cutler and some almost certainly in the uppermost Hermosa beds.

The rocks exposed in the mine are interbedded shales, mudstones, sandstones, and grits. The beds dip 2°-20° W. Several porphyry sills, which range from 1 foot to nearly 200 feet in thickness, are exposed. Most of them are very irregular in shape and swell out or cut across the sedimentary strata in many places.

A body of breccia, the shape and character of which are not entirely clear, is exposed on the main level just east of its junction with the main adit. It does not appear on the intermediate level but reappears in the stopes above that level and has also been cut on the second level. The breccia is composed of angular fragments of sedimentary rocks. The mass is thoroughly silicified throughout and contains abundant pyrite between the interstices of the breccia fragments. Its contacts with the adjacent sedimentary strata are in places gradational, and elsewhere are marked by fairly well defined fractures. The breccia mass is 100 to 200 feet wide and as seen in the mine appears to trend north, or at right angles to the course of the Gold King vein. Its walls are nearly vertical, but its downward extent is not known. Whether it is a pipelike body or represents a northward-trending crushed zone is also unknown.

The porphyry sills appear to be later than the breccia and to cut through it. This explains the absence of the breccia on the intermediate level, which is driven in a thick body of porphyry at the place where the breccia should appear.

The Gold King vein follows a fault that trends nearly due east and dips 35°-85° N., with an average dip of about 60°. The direction and amount of displacement along the fault are not known. In and near the breccia mass the fracture zone takes an irregular course and is much split up; elsewhere its course is regular, and only a few minor fractures split off into the walls.

The main fracture consists of a zone of crushed and brecciated country rock, which is thoroughly cemented and more or less completely replaced by silica in the form of dense to finely crystalline quartz. Within and near the breccia mass the fracture zone is from about 2 inches to 10 feet or more wide, but elsewhere it is in few places more than 6 inches wide.

On each side of the breccia mass the wall rocks along the fault are silicified for 2 to 10 feet away from the fault plane. Elsewhere the silicified zone is less than 1 foot thick or is entirely absent.

Ore deposits.—The principal ore minerals of the Gold King mine are tellurides of gold and silver. Petzite and sylvanite are probably most abundant, but calaverite, altaite, and other tellurides appear to be present in some specimens. Small veinlets and irregular masses of free gold have been found even on the lower levels and are commonly intimately associated with the telluride minerals. Galena occurs in considerable abundance in some of the ores, particularly in those from the upper levels. White to dark-green or gray quartz is the most abundant gangue mineral, but light-lavender fluorite is locally somewhat abundant, and some barite is present in much of the ore, particularly in that which is rich in galena.

The telluride ore occurs as veins or lenticular masses of dark-colored quartz which is shot through with irregular masses of the telluride minerals. Some of the quartz is vuggy, and the vugs are lined with crystals of tellurides, fluorite, and barite.

Most of the ore so far produced was found in an ore shoot that is closely associated with the breccia mass. Above the main level the shoot was 250 to 350 feet long and at least 200 feet high. Stope and assay maps suggest that it pitches toward the east below the main level, but its downward extent is not known. No certain guide has been discovered to govern predictions as to the occurrence of ore within the shoot. Wide places in the vein appear to be more favorable than narrow ones. In several places the vein splits and encloses large wedges or horses of wall rock. Minable ore has been found to occur along only one of these splits at any one place, but it displays no general preference for either the footwall or hanging-wall splits.

A smaller ore shoot, which has yielded ore of somewhat lower grade than the one described above, has been exploited above the second level, east of the breccia mass. The stopes and assay maps indicate that this shoot is only about 60 feet high and 300 feet long. Within and near this shoot the vein is narrower than in the larger shoot, and the wall rocks, which include shale, sandstone, and porphyry, are only slightly silicified. The available evidence indicates that a sharp steepening of the dip of the vein has been a controlling factor in causing the localization of ore. Below the second level the dip ranges from 50° to 60°; above it the dip is 65° to 80°.

Breccia bodies similar to that described above have not been observed in other parts of the district, but the close relationship of the ore deposits to silicification of the wall rocks and to changes in dip or strike of the veins are common features in many deposits.

Pyritic Gold Veins and Replacement Bodies: The "Doyle" (Hesperus) Mine

The "Doyle" or Hesperus mine, which comprises a large group of claims and mine workings on both sides of Jackson Ridge (pl. 1), is typical of those deposits which consist of gold-bearing pyrite in veins and replacement bodies. The "Doyle" deposits have been known for many years, and several attempts have been made to exploit them. Most of these attempts have been relatively unsuccessful, chiefly because of the metallurgical difficulties that have been encountered. In 1934 the properties were taken over by the Hesperus Mining Co., which began development on a large scale. Most of the buildings and equipment erected by this company were carried away by snowslides early in 1936, but it is understood that plans are now under way to resume development.

The principal mine workings consist of a great number of tunnels ranging from a few feet to several hundred feet in length. A few shafts, from 10 to 80 feet deep, have also been sunk.

Geology.—As shown on plate 1, the sedimentary rocks exposed on Jackson Ridge range from the Dolores formation to the Dakota (?) sandstone. They dip 5° to 15° toward the west and northwest. All the rocks are rather thoroughly metamorphosed, doubtless because of their proximity to the large monzonite stock exposed on Spiller and Babcock Peaks. The "Upper" and "Lower" La Plata sandstones have been converted to hard, relatively coarse-grained quartzites in most places; the Dolores, "Middle La Plata shale," and "McElmo" beds are largely dense light-colored fine-grained quartzites or hornfels which locally contain small masses of garnet, epidote, and other "contact-metamorphic" minerals. The "La Plata limestone," which ranges from less than 6 inches to 6 feet or more in thickness, is almost completely replaced by granular pyrite, which locally contains considerable quartz. No traces of the original limestone character of the bed are visible in any of the exposures on Jackson Ridge. Where it is exposed on the northwest side of the ridge, along the West Mancos River, the bed appears to be much thinner than it is along the East Mancos.

A few northwestward trending porphyry dikes are shown on plate 1. Most of them appear to be offshoots of the large stocklike mass of porphyry in the vicinity of Gibbs Peak. A sheet of syenite porphyry is extensively exposed on the northwestern slope of Jackson Ridge.

A great number of steeply dipping faults, which range in trend from north to nearly due east, cross the ridge. Most of them can be traced only for a few hundred feet, but several appear to be continuous for a mile or more. The displacements along the faults range from a few inches to about 30 feet.

Ore deposits.—The primary ore in the various deposits that have been explored on Jackson Ridge is composed of fine to coarsely granular pyrite that contains gold and a little copper. The gold probably occurs in large part as very fine particles of free gold disseminated through the pyrite, although some of it possibly occurs in the form of tellurides. Locally the ore contains a considerable amount of fine-grained white quartz. Near the surface much of the pyrite has been oxidized to limonite, but no ore was seen that did not contain some residual pyrite.

Most of the development work to date has been done on the so-called "flat vein" or pyritic replacement body at the "La Plata limestone" horizon, and comparatively large flat stopes have been opened on several claims. The highest gold content in the pyrite occurs in close proximity to cross-cutting veins, where representative samples are authoritatively reported to contain several ounces of gold to the ton. The whole bed of ore is reported to show an average gold content of 0.20 to 0.35 ounce to the ton.

Only a few of the vertical veins have been explored to any considerable extent, although the future of the mine would appear to depend somewhat on the development of these ore bodies. The pyritic vein matter is similar to that in the limestone replacement body and appears to contain at least as much gold to the ton.

The Timberline vein has been opened for short distances on two levels, both of which are in the silicified "McElmo" shales. The vein ranges from about 3 inches to several feet in thickness and consists of auriferous pyrite and quartz. Little is known of the character of this and other veins in the underlying "La Plata sandstones".

Available data indicate the existence of a large aggregate tonnage of low- to medium-grade ore in the "Doyle" properties. Extraction of ore will be relatively difficult and expensive, however, on account of variations in thickness of the main ore bed. Metallurgical difficulties incident to the character of the pyritic ore must also be overcome.

Telluride Veins and Replacement Deposits in the †La Plata Sandstone: May Day and Idaho Mines

The May Day and Idaho mines, near the mouth of La Plata Canyon, which have together yielded a very large share of the total production from the La Plata district, are the best examples of telluride deposits in the †La Plata sandstone. The Idaho deposits were discovered in 1902; those of the May Day in 1903. Since that time production of ore from the group has been almost continuous, although it has fallen off markedly since 1914.

There are well over 5 miles of workings in the two mines, most of which were accessible in 1935. The principal workings are shown on the block diagram (pl. 2).

Geology.—The rocks exposed in and near the May Day and Idaho mine workings range from the Dolores formation through the †McElmo formation (pl.2). All the formations occur in normal development and show no unusual features.

The beds are relatively fresh in most places, but in the vicinity of porphyry dikes or close to the walls of some of the veins and faults the sandstones and shales are altered to quartzite and hornfels.

Several irregular dikelike bodies of porphyry, which are not shown on plate 2, have been exposed in the mine workings. The most continuous of these follows the Idaho fault for almost its entire length. The porphyries are very irregular in form and in general are much sheared and

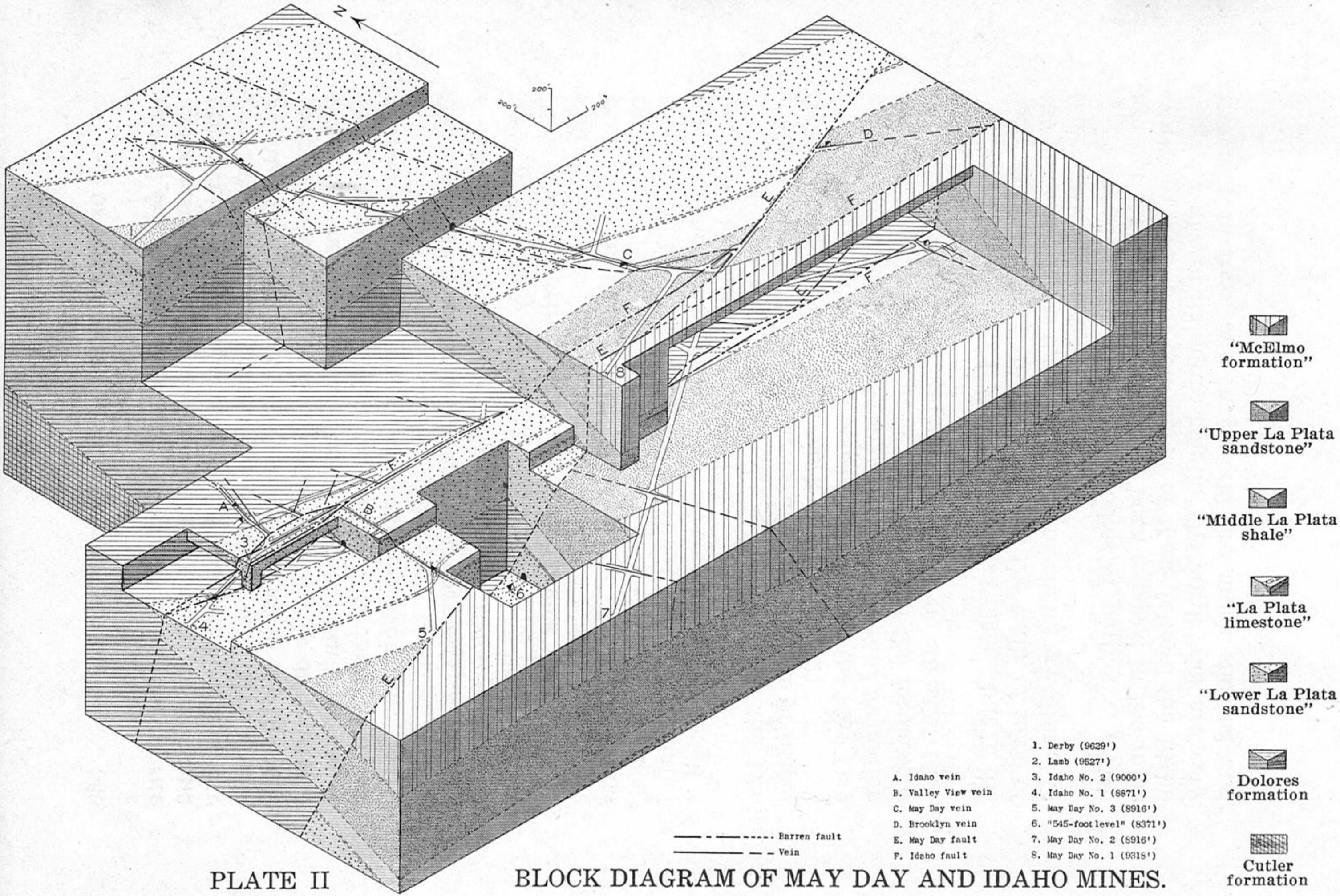

PLATE II BLOCK DIAGRAM OF MAY DAY AND IDAHO MINES.

altered. Most of the contacts seen are fault contacts. There is some evidence to indicate that the formation of the strong east-west faults and the intrusion of the porphyries were essentially contemporaneous.

As shown in plate 2 ,the rocks dip in general toward the south at angles ranging from 15° to 35°. There are two distinct sets of fractures. One of these trends nearly due east and consists of several faults with large vertical and possibly large horizontal displacement. The two main faults of this set are known as the Idaho and May Day faults. These faults are marked in most places by a crushed zone ranging from about 2 to 20 feet in width and by abundant gouge, which is present regardless of the character of the immediate wall rocks. So far as known, these faults are essentially barren of ore deposits, though in some places barite, calcite, and a little pyrite occur along the fault planes.

In addition to the strong east-west faults there is a series of veins that trend nearly due north and follow faults of comparatively small displacement. These faults appear to be older than the east-west faults and to be displaced by them. Whether what appear to be different veins are actualy faulted segments of the same original veins is open to question.

Ore deposits.—Base metals are almost entirely lacking in the May Day and Idaho mines, though in places very small amounts of galena, sphalerite, and pyrite occur. The gold and silver occur largely in the form of tellurides. Locally, particularly in the "La Plata limestone," the ore occurred as solid masses of mixed tellurides several feet in diameter. Much of the ore, however, consists of white sandstone that contains minute dark specks of the telluride minerals. Some high-grade free gold ore was mined near the surface during the early history of the mines.

Quartz is by far the most abundant gangue mineral, but some calcite and barite occur in places, particularly in deposits in the "La Plata limestone".

The vein ores occur within well-defined walls, which are from a few inches to about 8 feet apart. The common stoping width in both the May Day and Idaho mines ranges from 2 to 4 feet. The ore streaks range from small seams to veins of solid ore several feet in width separated by horses of nearly barren country rock. Some of the best ore in the district has been taken from stopes in the "La Plata limestone" close to ore-bearing veins. The metal content in the limestone decreases rapidly away from the veins, and the stopes rarely extend more than 50 feet from them.

Most of the production from the May Day and Idaho mines has come from the Idaho vein north of the Idaho fault, from the Valley View vein between the two main faults, and from the May Day vein north of the May Day fault. In addition, some ore has been taken from the Brooklyn, Gertrude, and other veins.

The veins are strong and wide in the "Upper" and "Lower" La Plata sandstones and in the limestone, and most of the ore produced has come from these strata. The veins in general pinch to mere cracks in the shaly beds, and except for one stope in the Idaho mine little ore has been found in the Dolores, the "Middle La Plata shale," or the "McElmo" shales.

Most of the ore so far extracted has been found relatively close to the intersections of the veins with the barren faults. There appears to be sufficient evidence to prove that the east-west faults were in existence before the period of ore deposition and that the strong gouge zones acted as dams and in large part guided the ascending ore-bearing solutions. Subsequent movements along the east-west faults have obscured this relation and led to the belief held by many local geologists and engineers that the May Day and Idaho faults are later than the ore and that they displaced the ore-bearing veins.

Other deposits in the †La Plata sandstone, none of which have approached the production of the May Day and Idaho mines, are the Incas, Jumbo, Lucky Discovery, and the widely publicized Red Arrow.

Suggestions for Prospecting

Specific suggestions for prospecting must await completion of the study of the district, but the following generalizations may be of some value in guiding further search for ore.

The highly metamorphosed rocks in the central part of the La Plata dome do not appear to be as favorable for productive ore deposits as the generally unaltered beds farther from the center. All the large producing mines, such as the Gold King, Neglected, May Day, and Idaho, are situated in areas where the rocks are comparatively fresh. With the exception of the Gold King, which is in a reentrant in the metamorphosed area, all the large productive mines are 4 to 6 miles from the center of the dome.

Several smaller deposits occur within the metamorphosed area. Some of them, such as those of the Small Hopes, Mountain Lily, and Tomahawk mines, occur as veins in diorite, and others are in metamorphosed sediments. The outlook for discovery of large deposits in the metamorphosed area is decidedly less encouraging, however, than that for the outlying parts of the district.

Veins along which there has been local silicification of the wall rocks are commonly much more promising than those that traverse entirely unaltered red beds. Any fissure that occurs in red beds should commonly prove stronger and more productive in its extensions into limy zones or into the †La Plata sandstone beds. Intersections of two veins, of a vein and a dike, or of a vein and a barren fault should be worthy of prospecting.

Consideration of the geologic conditions, of the heavy cover over much of the district, and of the fact that at least two rich deposits, the Gold King and the Red Arrow, have been discovered within the past decade, leads the writer to believe that further intelligently directed prospecting is justified.