bedding planes allowed the solutions to permeate and replace the rock more thoroughly than elsewhere. All deposits so far discovered are small, and further prospecting is likely to result in the discovery of additional small shoots rather than of persistent ore bodies.

WEST TINTIC DISTRICT.

By G. F. Loughlin.

GEOGRAPHY.

Although the West Tintic district probably includes part of the West Tintic Range the few mines in the district that have produced ore lie to the west, in the low, southern part of the Sheeprock Mountains. The two ranges are separated by the two narrow valleys of Vernon and Cherry creeks. (See fig. 46, p. 424, and Pl. XXXVIII, *B*, p. 377.) Cherry Creek, which flows southward for 6 to 7 miles before disappearing at the northern end of Sevier Desert, is the principal stream and furnishes water for the towns of Mammoth and Robinson in the Tintic district 18 miles to the east, as well as for a few ranches in its valley. The mines of the West Tintic district, however, which are about 3 miles west of Cherry Creek, obtain their water from a well on Hassell's ranch about 1½ miles to the northeast.

The nearest towns to the West Tintic district are Eureka and Mammoth, in the Tintic district. From these towns the district is reached by a wagon road, for the most part of only moderate grade, that extends for 25 miles over a broad pass in the south-central part of the West Tintic Range. Ore may be hauled over this road to Tintic Junction or by a road to the south that extends from Cherry Creek valley to Jericho station on the Los Angeles & Salt Lake Railroad. The distance from the Scotia mine to Jericho is 16 to 17 miles.

GEOLOGY.

The formations in the West Tintic district include Paleozoic and probable pre-Paleozoic sedimentary rocks, and intrusive and effusive igneous rocks of probable Tertiary age. As a rule the sedimentary rocks form the more prominent summits and the igneous rocks the lower foothills, valleys, and some of the broader saddles. (See figs. 46, p. 424, and 47.)

SEDIMENTARY ROCKS.

PRE-CAMBRIAN (?) QUARTZITE.

The thick formation of quartzites, shales, and shaly conglomerates, which forms the bulk of the Sheeprock Range from the Columbia district southward, extends to the southern foothills of the range. In the West Tintic district its southern boundary is an irregular crescent, concave southward, and partly surrounding an area of limestone and dolomite that contains the productive mines and more promising prospects. The quartzite overlies the limestone but (see p. 438) is an overthrust.

The lithologic character of this formation in the West Tintic district is generally the same as in the districts to the northwest. The quartzite members, though much fractured, are the more resistant to erosion and form caps to many of the lower and higher summits, and the conglomerate and shale occupy the slopes and are in large part concealed beneath débris. The quartzite varies in composition from light colored and relatively pure to the dark-brown ferruginous variety so characteristic of the formation. The conglomerate members consist of angular to subangular cobbles or small boulders of older quartzite, schist, and slaty rocks, in a shaly to schistose matrix, and here as elsewhere bears a rather strong resemblance to glacial till. The shale mostly is gray to green, weathering to brown, and of typical structure.

The strike and dip of the formation vary and can be accurately determined at only a few places. The dips as a whole, however, are low to moderate to the north or northeast.

The formation is cut by many veins of white massive quartz, whose outcrops appear barren. They strike in many directions and none of them are traceable over considerable distances.

There is no local evidence to indicate the age of this formation, but as it is continuous northward to the Columbia district, where it underlies quartzite of Lower and Middle Cambrian age, there can be no reasonable doubt that it is either very early Lower Cambrian or pre-Cambrian.

PALEOZOIC LIMESTONE.

Dolomitic limestone, of uncertain age, occupies an area of a few square miles at the southern end of the range, and is surrounded by the quartzite series except on the south, where it is bordered by alluvium. Its northern boundary is about 1½ miles long and passes just north of the Walker shaft of the Scotia mine. From this northernmost and narrowest part it diverges southward. Its central part forms district to the east. A few bands are cherty. Optical and chemical study shows that much of the unmetamorphosed rock in the West Tintic district is very close to a pure dolomite in composition. The only impurities noted under the microscope are finely divided carbon,

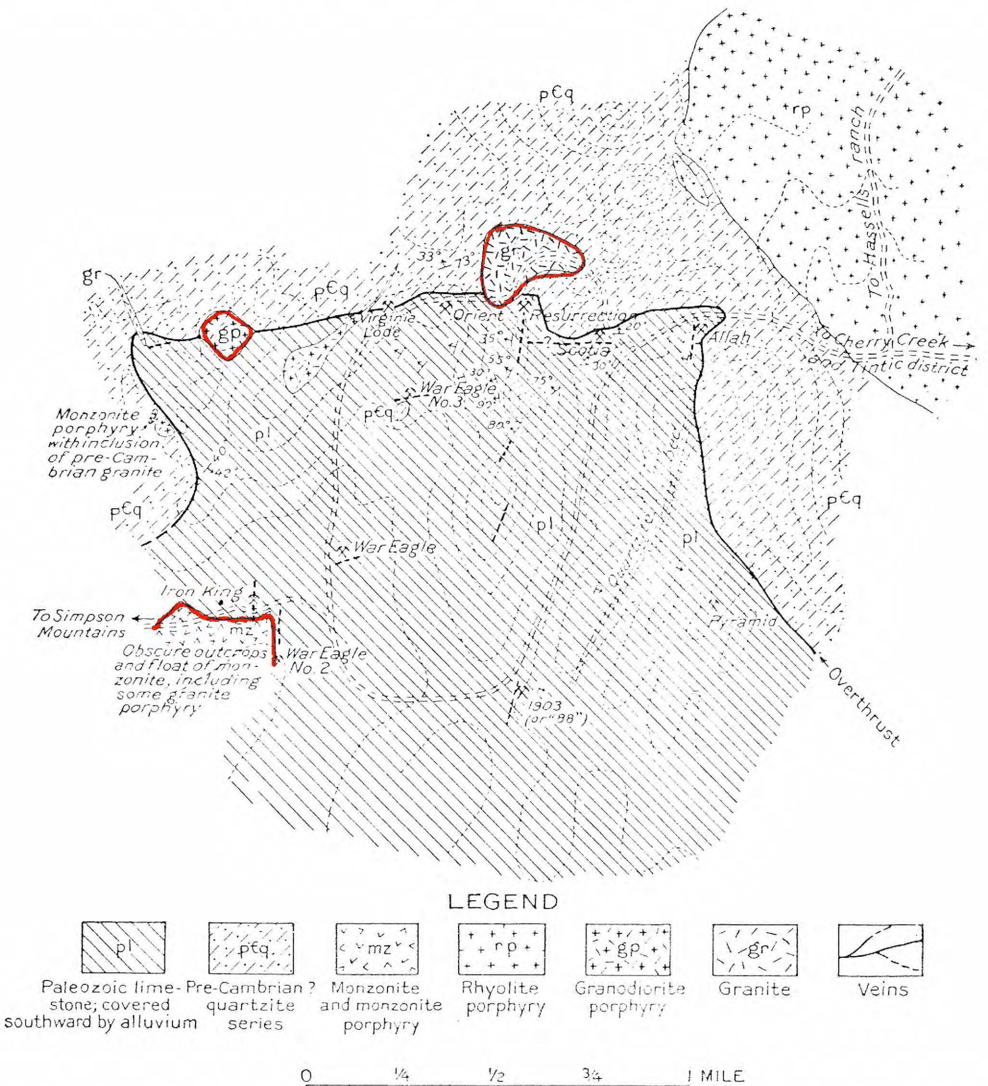

FIGURE 47.—Sketch map showing main geologic features and the locations of mines and prospects in the West Tintic district.

the high north-south ridge southwest of the Scotia mine and also comprises the lower ridges to the east and west.

Where not affected by contact metamorphism it is prevailingly of dark bluish gray and fine grained. Some beds are of very even texture, others are finely banded with lighter gray streaks, and others are spangled with short white markings characteristic of certain Middle and Upper Cambrian dolomites in the Tintic

which colors the rock, and a few minute but well-formed quartz crystals.

Where affected by incipient metamorphism the rock is partly or completely bleached to very light gray or white by the elimination of carbon, but the composition is not appreciably affected. Tremolite is the only silicate mineral noted in this phase of the rock. Although it is more abundant in bleached rock it has been noted forming radiating aggregates in unbleached dolomite. More intense metamorphism nearer the intrusive igneous contacts has developed a number of typical silicate minerals, the most conspicuous of which are garnet and epidote; diopside, tremolite, hornblende, actinolite, phlogopite, titanite, and chlorite are present in fine to microscopic gray to green aggregates, some of which resemble chert in appearance. These metamorphic minerals tend to form abundantly in certain layers and to be bounded by layers of granular calcite. The presence of calcite as the prevailing carbonate in the thoroughly metamorphosed rock is in marked contrast to the prevailing dolomitic character of the unmetamorphosed rock.

A bed of shaly limestone, which marks approximately the upper limit of the ore horizon in the Scotia mine, deserves special mention. At one place along its outcrop, southeast of the Walker shaft, it forms the hanging wall of an old open-cut stope which yielded bonanza ore in the early days and for this reason has been locally called the "bonanza shale." The rock is bluish gray, lighter than the dolomitic rock, microgranular, and very thin bedded to shaly. The thin beds of limestone are separated by shaly partings. Immersion in dilute hydrochloric acid yields brisk effervescence, proving a general absence of dolomite, and the abundant residue after solution consists chiefly of fine quartz grains and sericite flakes.

Cherty beds have been noted in the eastern and northwestern parts of the limestone area. A few thin intercalated beds of quartzite in the vicinity of the eastern beds are much fractured and filled with comby quartz veins. The most prominent of these extends northward with approximately vertical dip, along the top of the low ridge east of the road between the "1903" and the Scotia mines (fig. 47) to the saddle southeast of the Scotia mine, where it passes beneath the contact of the limestone and pre-Cambrian (?) quartzite series. A few sandy beds were noted between the south end of the high limestone ridge and the road junction to the west.

No determinable fossils have been found in the limestone area. The only characteristic markings in the central and eastern parts of the area are the short white spangles, similar to those in the Middle and Upper Cambrian limestone of the Tintic district, which appears in a few beds. These with the prevailing dolomitic character suggest correlation with Cambrian; but as later Paleozoic limestones, including those of Mississippian age, are also conspicuously dolomitic, no definite age is assigned to the rock. The black chert nodules near the northwest corner of the limestone area strongly suggest lower Mississippian age.

IGNEOUS ROCKS.

GENERAL CHARACTER.

The igneous rocks of the West Tintic district consist of stocks and dikes of granitic and monzonitic rocks, extensive bodies of extrusive rhyolite, and doubtless latite, the extrusive equivalent of monzonite, though no well-defined outcrops of this were recognized. The granitic rocks comprise one inclusion of pre-Cambrian granite and stocks, dikes, and sills presumably of Tertiary age. The monzonitic rocks are also assigned to the Tertiary. No contacts between the Tertiary granitic and monzonitic rocks have been found.

PRE-CAMBRIAN GRANITE.

Pre-Cambrian granite is represented by an inclusion 3 or 4 feet in diameter in a monzonite porphyry dike, which cuts the quartzite series near the western boundary of the limestone area. (See fig. 47.) The granite is pink, rather coarse grained, and somewhat gneissoid. It consists of pink alkalic feldspar, white plagioclase, and quartz, the last two obscured by fine granulation. A small quantity of chlorite after biotite is also present. As seen in thin section the principal minerals are microperthite, calcic oligoclase, quartz, and chlorite. The usual minor constituents are present, and one allanite crystal associated with epidote was noted. The section is traversed by several microscopic crushed zones, and in this respect is markedly different from the intrusive granite of the district. The presence of this inclusion suggests that a portion of the granite which is known to underlie the quartzite series in some parts of the State is present in the segment overthrust upon the limestone, though not exposed at the surface.

TERTIARY INTRUSIVE ROCKS.

Character and distribution.—The intrusive rocks of the district vary in appearance but are for the most part very similar in chemical composition and fall in the granodiorite or quartz monzonite groups. The most alkalic (salic) variety noted is a muscovite granite, and the most ferromagnesian (mafic) variety is a dioritic phase of monzonite.

The intrusive bodies are for the most part small, and most of them are grouped in an east-northeast zone near the northern boundary of the limestone area. A small complicated stock, much obscured by débris covering, is present in the southwest part of the area, and dikes of granite porphyry and monzonite porphyry are very abundant, most of those noted trending a little east of north or a little north of east. No distinct age relations have been found.

Granodiorite group.—A stock of roughly triangular outline is exposed along the curving ridge northwest of the Scotia mine. It consists mostly of light-gray coarse-grained, considerably disintegrated rock, with minor varieties of aplite and granite porphyry along the border. Contact metamorphism along its border is expressed by induration of shale beds in the quartzite and by slight alteration in the adjacent part of the limestone. The mineral composition and textûre of the coarse-grained rock is essentially similar to that of the larger granodiorite in the Columbia-Erickson district to the northwest and on Desert Mountain to the southwest.

The border porphyry phase is of interest for comparison with the variations in the other stocks. It consists of a very fine grained groundmass with prominent rounded grains of quartz, the largest of which are 3 millimeters in diameter, white crystals of altered feldspar, and a few weathered scales of biotite. It differs from the main body of the stock merely in the smaller size of most of its components. In thin section the quartz phenocrysts show some resorption, and their corroded edges are fringed with secondary quartz, which is accompanied by a little calcite and sericite. The plagioclase crystals (An_{35-45}) are considerably altered. Biotite phenocrysts are altered to a mixture of chlorite and calcite, with or without sericite. The groundmass consists of fine graphic intergrowths of quartz and alkalic feldspar inclosing some short laths of plagioclase (oligoclase-andesine). A few spherulites consisting largely of quartz are associated with the graphic intergrowths.

The narrow wedge-shaped stock to the west crosses the overthrust without displacement and ends northwestward as a sill in the quartzite series. Another small stock just west of this one also cuts the overthrust. These two stocks consist of granodiorite porphyry, with prominent phenocrysts of feldspar but none of quartz in an aplitic groundmass. A small amount of altered biotite and 3 or 4 per cent of oxidized pyrite grains are also present. In thin section most of the plagioclase is too much sericitized to be identified, but a few grains indicate calcic andesine. Biotite is altered to chlorite. The groundmass consists of quartz and feldspar, mostly in graphic intergrowth. The feldspar is much kaolinized but appears to include both alkalic and plagioclase varieties, the latter less calcic than the plagioclase phenocrysts. The pyrite is associated with sericite, secondary quartz, and chlorite, and is clearly an alteration product. This rock differs from that first described mainly in the absence of quartz phenocrysts, though it contains a large amount of quartz in the groundmass.

Another small stock (not accurately outlined in fig. 47) outcrops to the southeast just west of the overthrust contact. This rock is light pink and composed of plagioclase, biotite, and a few hornblende crystals with scattered fine grains of magnetite and titanite in an extremely fine grained groundmass. In thin section the feldspar phenocrysts prove to be mostly plagioclase with a few of microperthite ($Or_{80}Ab_{20}$). The plagioclase includes two varieties; large crystals of labradorite (An_{60}) partly resorbed, and oligoclase (An_{25}) in relatively small grains and in one place forming a rim around an older labradorite. Biotite and common hornblende are typical and considerably chloritized. The groundmass consists of abundant quartz and alkalic feldspar (microcline microperthite), with a less amount of sodic plagioclase. Minor constituents include magnetite, titanite, apatite, and zircon.

A dike of muscovite granite, which trends N. 25° W. across the overthrust contact in the extreme northwest corner of the limestone area, is nearly white, fine, even grained, and composed of white feldspar, colorless quartz, thinly scattered muscovite, and some flakes of biotite. As estimated in thin section, the feldspars comprise about 55 per cent, quartz 40 per cent, and muscovite and minor accessories 5 per cent. Four-fifths of the feldspar is perthitic microcline with small unoriented inclusions of plagioclase. The remainder is plagioclase—oligoclase-andesine (An_{30}) with more sodic outer zones. The muscovite tends to form poikilitic crystals inclosing small well-crystallized grains of quartz, and appears to have been on the whole the latest important mineral to crystallize. The minor constituents noted are biotite, separate or intergrown with muscovite, magnetite, and zircon.

The composition of this rock is very similar to that of the groundmass of the rocks previously described (p. 435). Those rocks contained no primary muscovite, but the presence of muscovite in this rock may well be attributed to a greater concentration of water and fluorine in a salic portion of magma and does not necessarily indicate the intrusion of a distinct magma. In other words, the muscovite granite is regarded as a salic differentiate from the granodioritic magma.

The large area of granite porphyry and rhyolite porphyry northeast of the limestone area has the same general composition as the granodioritic rocks, but part of it differs in possessing textures characteristic of effusive rocks. In spite of these textures all the contacts with the quartzite series on the west are nearly vertical and intrusive. To the east, however, the rocks are in part clearly extrusive, and it is concluded that the main vent through which the lavas of the region were erupted is in the western part of this area.

The greater part of the rock in this vent varies in texture from very fine grained porphyry to rhyolite porphyry, although several eruptions are represented. Much of it is light gray, dense porphyritic, and contains abundant phenocrysts of quartz and feldspar, with a little biotite and magnetite. In thin section the quartz phenocrysts show resorption and many of them are cracked or even "faulted," the groundmass filling the fractures. The feldspar forms roughly rectangular grains, some of them with resorbed rims. Plagioclase (andesine) is somewhat more abundant than alkalic feldspar, a few grains of which have a poorly defined structure suggesting microcline. Biotite and minor accessories are typical.

Another rock in the vent, intrusive into the one just described, is of dark-purplish color and somewhat denser texture but is essentially identical in mineral composition. The appearance of this rock is also characterized on the surface by the pink color of the alkalic feldspar. This color disappears a fraction of an inch away from the surface or from fracture lines, and is clearly the result of weathering.

Several dikelike intrusions of rhyolitic rock in this area were noted along the road that extends northward and eastward by Hassell's ranch to the divide between Vernon and Cherry creeks, but none were studied in detail. A special variation, however, is represented by the narrow body of rhyolite breccia that cuts the quartzite series vertically just west of the main area. (See fig. 47.) This rock is purple to gray, finely fragmental, and consists of banded to massive fragments of rhyolite in a fine matrix of the same material. Its chemical and mineral composition is shown by the microscope to be similar to the rocks of the main area, from which it differs only in texture.

Monzonite.—The only stocklike body of monzonite in the immediate vicinity of the mines is in the southwest part of the limestone area and is so obscured by débris of rhyolitic or granodiolitic porphyry that its exact outline and structural relations are not easily determined. Dikes and sills of monzonite porphyry have been noted at several places throughout the limestone area. The typical monzonite is gray, medium, and even grained, and consists chiefly of gray translucent feldspars, biotite and augite, the augite being more or less altered to hornblende. Both feldspars are recognizable megascopically, plagioclase as a rule forming gray or white lath-shaped twinned crystals which are surrounded by alkalic feldspar of slightly different color and with no definite crystallographic outline. Pyrite is present as small grains scattered through the rock and also as thin films or sheets along fracture planes. In thin section the plagioclase presents a marked zonal growth, the zones ranging in composition from An_{50} to An_{25} or being even somewhat more sodic. They average about An_{35}. The alkalic feldspar, which has a very fine perthitic structure, forms irregular grains of various sizes. Some of the smaller form partial rims around plagioclase, and the larger ones have a poikilitic character, inclosing crystals of all the other primary minerals except quartz. Quartz forms irregular grains, some of which are a millimeter in diameter, mostly interstitial to the other minerals but in part forming micrographic intergrowths with alkalic feldspar. The microscopic quartz amounts to nearly 10 per cent of the rock. Biotite forms typical grains, some with resorbed margins. Augite forms prismatic grains averaging about a millimeter in length and showing all stages of the transition from fresh augite into compact green hornblende with typical cleavage and pleochroism. Some of the augite (or hornblende) grains are intergrown with biotite. Minor accessories include rather abundant titanite and magnetite in irregular to hypautomorphic grains, apatite in typical well-formed prisms, and rarely zircon.

Besides the typical rock variations of dioritic character are present in the monzonite stock. Some are feldspathic; others have a preponderance of black minerals. In the feldspathic variety the plagioclase has about the same composition as in the typical monzonite, but alkalic feldspar and quartz are very scarce. Biotite is the principal accessory and is accompanied by a little uralitic hornblende (after augite?). The darker variety consists of zonal plagioclase, averaging near An_{50} in composition, and primary hornblende accompanied by a little biotite. No augite is present. Alkalic feldspar and quartz form fine interstitial aggregates among the predominant minerals. Magnetite, titanite, and apatite, the first two frequently of megascopic size, are conspicuous minor constituents in both varieties.

Alteration.—Alteration has affected all the igneous rocks of the district to a greater or less extent, but the kind of alteration is the same in all of them and is of the propylitic type. The common alteration minerals are sericite, chlorite, epidote, calcite, quartz, and pyrite, and these are accompanied in some of the rocks by uralitic hornblende, secondary titanite, and magnetite. The relations of these minerals to one another show that they were formed at the same time, and they are attributed to the action of heated waters that permeated the rocks during ore deposition. Kaolin and limonite are the principal minerals formed since that time by surface weathering.

Paragenesis.—The different intrusive rocks of the district are closely related. In some the more calcic plagioclase and the black silicates are concentrated in relatively large proportions; and in one, the muscovite granite, the quartz and alkalic feldspars are especially concentrated. The plagioclase is contained mainly in the phenocrysts or earlier-formed minerals and the alkalic feldspars mainly in the groundmass or later-formed minerals of the intermediate (granodioritic) rocks of the district. Sufficient time to allow certain degrees of concentration of the earlier groups of minerals before the later groups began to crystallize accounts for the variations in composition and for the different textural characteristics of the rocks.

TERTIARY EXTRUSIVE ROCKS.

The principal area of extrusive volcanic rocks extends eastward from the vent already described across Cherry Creek valley, 3 miles distant, and partly up the west slope of the West Tintic Range. Small isolated areas lie on the east slope of the range. The rocks, so far as noted, are prevailingly rhyolitic and include flows and breccias, but as they are some distance from the mining district proper they have not been studied in detail.

STRUCTURE.

FOLDING.

The exact structure of the limestone has not been determined. The strata at the Scotia mine dip 20°–25° N. and appear to lie conformably beneath the quartzite series. South of the Scotia mine, along the high limestone ridge, they strike north-northeast and dip very steeply west. On the low ridge to the east they strike similarly but dip from vertical to steeply east. These relations, together with the distribution of the cherty zone, suggest a sharp anticline with a north-pitching axis approximately along the road between the "1903" and the Scotia mines and through the Scotia property. In the limestone area west of the high ridge débris coverings and metamorphism greatly conceal the structure. Near the west contact, across the ridge southwest of the Orient shaft, there is some indication of a local pinched syncline, but the attitude of the beds as a whole is the same as those on the high ridge. The available data suggest a major anticline with nearly vertical limbs, whose axis is about halfway between the middle of the limestone area and its eastern contact with the quartzite series.

OVERTHRUST.

The structure of the limestone is thus unsymmetrical with respect to the quartzite series, and other discordances in position exist between the two rocks along the contact. The disappearance of the thin quartzite bed in the eastern limestone area beneath the great quartzite series has already been mentioned. This structure either implies the very rapid pinching out of some hundreds of feet of limestone and their equally sudden reappearance just to the north, or is due to an overthrust. The attitude of the beds is apparently conformable at the Scotia mine, but a shale member, which immediately overlies the limestone, is beveled off both to the east and west. At the saddle between the Scotia and Orient mines a small mass of quartzite rests on limestone, the contact dipping northeast at a low angle. Just south of this point, on the high limestone ridge, the limestone strata strike a little east of north, but the limestone-quartzite contact continues westward across the Orient and Virginia Lode claims without regard to the strike and dip of the limestone. At the Virginia Lode prospect the limestone is separated from a shale member of the quartzite by a nearly vertical east-west fault. From this point westward the contact is complicated by two small stocks and a few dikes of granitic and monzonitic rock.

At the northwest corner of the limestone area the limestone strikes N. 25° W. and dips nearly vertically, but the quartzite contact curves from east to west through an angle of about 115° to a trend paralleling the limestone bedding. Southward along the west contact the attitude of the limestone beds varies. At one place, at the head of a small branch gulch in a southwest direction from the Virginia Lode prospect, the limestone close to the contact strikes N. 40° E. and dips 42° SE., whereas the contact strikes about north. The limestone is much contorted and somewhat metamorphosed. From this point southward the contact extends along the crest of a low south-sloping ridge, until the ridge surface sinks below it, leaving only limestone, and thus proving that the plane of contact along this ridge dips west at a low angle, away from the dip of the limestone. The limestone at some places along the contact is overlain by quartzite and at others by shale. Both the limestone and quartzite are scattered at several places along the contact.

Within the limestone area a low ridge south of the War Eagle No. 3 open cut is capped by quartzite but consists otherwise of steeply dipping limestone whose exposures surround the quartzite. The quartzite is not intercalated in the limestone and is regarded as a remnant of the great quartzite series which once overlay the limestone.

The evidence, although obscured along much of the contact by débris, all points to discordant relations between the limestone and quartzite, which, coupled with the stratigraphic evidence already given, indicates an overthrust fault of undulating character. The limestone area was completely covered by the quartzite at one time, the fault contact arching over it. To regard the contact as an unconformity would necessarily imply an immense thickness of pre-Cambrian limestone in the West Tintic district and nowhere else in the Great Basin region. Furthermore, no fragments of the limestone and only pebbles and cobbles of siliceous sediments have been found in the overlying quartzite, whereas the structural details of the contact are indicative of disturbance.

Results of a brief reconnaissance in the West Tintic Range along the Tintic Road lend support to the foregoing interpretation. Along the road the sedimentary rocks consist of quartzite with intercalated beds of shale and limestone dipping westward at a low angle. Fossils collected from two limestone beds were determined by G. H. Girty, as follows:

Bed southwest of Summer ranch: Sponge?, *Zaphrentis?* sp., *Bellerophon* sp.

Bed 100 yards north of the Mammoth reservoir: *Zaphrentis* sp. and *Lithostrotion whitneyi*.

Mr. Girty states that these faunas are too scant and too poorly preserved to be assigned to any definite horizon, but he regards them as probably upper Mississippian.

Along the crest of the range north of the road and on its west slope down to the divide between Cherry and Vernon creeks lie coarse conglomerate and quartzite of pre-Cambrian (?) age, whose western dip suggest that they formerly extended over the upper Mississippian quartzite and that the overthrust extends as far eastward as the crest of the West Tintic Range. Their exact trend in the West Tintic Range, however, can be determined by detailed work alone, much of their surface being covered by disintegrated volcanic rocks and care being necessary to distinguish the light-colored quartzite members in the pre-Cambrian (?) from beds of similar appearance in the upper Mississippian (?) formation. The stratigraphic and structural relations of the rocks in the West Tintic Range and the West Tintic mining district are shown in figures 46 (p. 424) and 47 (p. 433).

The age of the overthrust is clearly greater than that of the Tertiary igneous rocks but can not be definitely determined on local evidence. It may be contemporaneous with the overthrusts in the Wasatch Range, which are of Cretaceous age.

FAULTING AND FISSURING.

With the exception of the overthrust already described, faults of considerable displacement are not conspicuous. Those actually exposed and also those strongly suggested in the field lie in two systems that trend nearly north and nearly east. A porphyry sill at the small iron-ore prospect on the Virginia Lode claim is displaced 3 feet by a north-south fault with a 60° dip, and a well-defined east-west fault with nearly vertical dip is exposed just to the west. Its strike coincides with the limestone-quartzite contact, but its vertical dip suggests that it may cut the plane of the overthrust at this place. Another fault, which trends nearly north, is suggested by a deflection of the overthrust contact east of the Resurrection (Prairie Bell) prospect but has not been traced northward or southward. Other faults of similar trends are suggested at a few places by apparently discordant relations of the strata. None of them are closely connected with ore deposits.

Mineralized fissures also follow two prevailing directions: N. 15°–20° E. with vertical dip and N. 70° E. with steep southerly dip.

HISTORY AND PRODUCTION.

No satisfactory account of the production of the West Tintic district can be given, for in the earlier years its output was included by the Director of the Mint with the Tintic district. The Scotia mine has been undoubtedly the largest producer, but accurate data of its output are not available. According to W. W. Riter, of Salt Lake City, who was one of its original owners, the first pocket of ore, found about 1870, amounted to about 250 tons of 65 per cent lead ore containing a moderate proportion of silver. This ore was shipped to Swansea, Wales, and to smelters south of Salt Lake City. In 1871 the property was sold to Joab Lawrence and associates, who joined in building the Homansville smelter in the Tintic district. This enterprise failed, and the smelter was moved away in 1872. The mine later passed into the hands of the Boston-Tintic Mining Co., by whom it has been worked or leased intermittently. The production of the Scotia mine since 1880 has probably amounted to somewhat more than 3,000 tons, valued at about $150,000.

From 1902 to 1913 only two mines shipped ore, both in small amounts.

ORE DEPOSITS.

GENERAL CHARACTER.

The ore deposits of the district comprise several types, transitional into one another, which indicate deposition at temperatures ranging from those existing along the margins of crystallizing intrusive rocks down to moderate and even low. All the types are in limestone, in or closely associated with fissures, some of which coincide with the bedding of the rock.

The deposits formed at highest temperatures are of the contact-metamorphic type. More or less contact metamorphism has been produced around all the larger ore bodies of granodioritic and monzonitic rocks and also along some of the dikes and sills. The most intense metamorphic effect is just north of the monzonite stock in the southwest part of the limestone area, and the only contact-metamorphic ore body of much promise—that of the Iron King mine—is in this place.

MINES.

IRON KING MINE.

The workings of the Iron King mine are in both metamorphic limestone and monzonite and cut dikes of granite porphyry. The mine in 1913 was opened by a shaft 200 feet deep and by 200 feet of drifts, but the underground workings were not accessible when visited. A part of the ore body, however, was exposed along a narrow deep open cut. The ore body forms a vertical band a few feet thick, parallel to the vertical north-south bedding.

The most conspicuous ore minerals are magnetite and specularite, which form an apparently solid mass, colored in places by green copper stains. Some specimens are of magnetite, others of hematite, and both varieties contain disseminated grains and well-defined veinlets of pyrite. No chalcopyrite was recognized, and the green copper stains may have been derived from copper in the pyrite. A small shipment in 1913 contained two classes of ore, one carrying 0.282 ounce of gold and 2.6 ounces of silver to the ton, 6.2 per cent copper and 40.9 per cent iron; and the other carrying 0.15 ounce of gold and 1.55 ounces of silver to the ton, 3.15 per cent copper and 48.8 per cent iron.

The margins of the ore show replacement of an epidotic phase of the metamorphic limestone, a relation which indicates that the ore was formed at a later stage of contact metamorphism than were the silicate gangue minerals. The silicate rock, as shown by specimens on the dump, is also cut and replaced to some extent by vein quartz and calcite, which imply that mineralization continued after the temperature had fallen below the range at which the silicates had formed.

VIRGINIA LODE.

Another type of contact-metamorphic ore that has been prospected on the Virginia Lode claim is pyritized shale along the hanging wall of a porphyry dike. Oxidation has decomposed the pyrite and concentrated the iron along the margin of the dike in the form of limonite in a layer ranging from a thin film to 6 feet thick. A similar deposit of limonite has been opened in a prospect tunnel on the Allah property east of the shaft. No assays of either ore were obtained. Deposits of this type may be mistaken for the weathered outcrops of a silver-lead deposit, but it is improbable that valuable silver-lead deposits will be found in either shale or quartzite.

WAR EAGLE CLAIMS.

Closely related to the magnetic ore of the Iron King mine is that of the War Eagle No. 2, which forms a north-south vein a short distance to the east. The vein is opened by a shaft 70 feet deep, with short drifts on the 25 and 70 foot levels. The vein sends short tongues into the wall rock, which includes both metamorphic limestone and silicified granodiorite porphyry. Monzonite is exposed in surface workings near the vein. The ore thus far found occurs in small bodies, from one to a few tons in weight, of barren or low-grade massive quartz associated with branch fissures at their junction with the main vein, between stretches. The primary ore mineral is chalcopyrite in irregular patches, usually in a matrix of fine-grained specularite. The gangue mineral is quartz, with local developments of barite and calcite. Chalcopyrite also forms scattered grains or bunches in milky quartz and occurs as narrow bands alternating with cherty replacement quartz. Some bunches of lead ore are present, but no primary lead minerals have been found. The chalcopyrite is largely oxidized to a dark resinous or pitchy form of limonite and to malachite and chrysocolla. The oxidized lead ore, with which some copper minerals are mixed, consists of cerusite and bindheimite (hydrous antimonate of lead) and probably a little anglesite, accompanied by small amounts of the zinc minerals, most conspicuous of which is aurichalcite. This ore, which is characterized by the yellow color of the earthy bindheimite and is locally called "chlorides," is rich in silver, and one small sample is said to have assayed 821 ounces to the ton. Both lead and copper ores contain more or less black manganese oxide. Secondary gangue minerals are finely crystalline to chalcedonic quartz and calcite.

The War Eagle claim, a short distance northeast of the War Eagle No. 2, contains copper ore similar to that just described except that it lacks specularite. The workings are opened by an inclined shaft 200 feet deep sunk along the hanging wall of a granite porphyry dike, along which bunches of ore were found. A drift on the 200-foot level follows a vein trending S. 70° W., which also follows a dike hanging wall. A winze from this level follows the dip of the vein, which is said to expand downward to a width of 4 feet and to contain rich ore some of which assays 13 per cent copper and 200 ounces of silver to the ton. The average content is said to be about 4 per cent copper and 16 ounces of silver to the ton.

On the War Eagle No. 3 prospect, considerably farther north, a vein trending N. 75° E. and dipping from vertical to steeply north has been mined from the surface for lead ore, but the workings were not accessible when visited. Ore seen on the surface consists of galena partly oxidized to cerusite, accompanied by white patches of calamine, a little microscopic smithsonite, and brown and black stains of limonite and wad. The principal gangue at the surface is calcite in banded columnar masses (travertine), which extend in places 2 feet into the footwall of the open cut. The general run of ore is said to have been accompanied by soft red iron oxide. Its silver content is not stated, but gold to the value of $5 a ton has been reported.

The relations of the three War Eagle prospects indicate that the temperature of ore deposition decreased northward. Though not along a single vein, it seems probable that the three prospects are connected by a system of intersecting approximately north-south and east-west fissures. The mineral composition of the War Eagle No. 2 ore indicates a high temperature, though not so high as that required for contact-metamorphic ore; the nonsiliceous type of lead-zinc ore at the War Eagle No. 3 is characteristic of deposition at relatively low temperatures.

ORIENT WORKINGS.

The Orient workings, north of the War Eagle No. 3, were inaccessible. On the dump was a small pile of oxidized copper-iron ore and some metamorphic limestone with a few green copper stains. No primary ore was found.

"1903" OR "1888" MINE.

The "1903," formerly the "1888," mine, near the southeast base of the high limestone ridge, is of particular interest because of its varied character. It is opened by an inclined shaft 140 feet deep and by 150 feet or more of drifting on the 45-foot level, mostly east of the shaft. The country rock is dolomitic limestone, partly metamorphosed, with steep eastward dip. Quartzite, which outcrops west of the shaft, is said to be cut by a short winze from the west end of the 45-foot level.

The deposit consists of a N. 15° E. quartz vein, parallel to the bedding, intersected at the shaft by an east-west mineralized fissure with southerly dip. The quartz in the main vein is mostly dense and cherty but is well crystallized around cavities. In a shallow pit 200 feet north of the shaft the vein consists of quartz, barite, and galena. The barite forms a network of platy crystals, and the quartz and galena fill the interstices, impregnate the barite crystals, and fill cracks in them. Pyrite and a few specks of zinc blende are minor constituents. A little cerusite and secondary quartz are also present.

The material in and close by the cross fissure, which is followed by the shaft, is mainly quartz-fluorite-galena ore, accompanied in places by quartz-chalcopyrite-galena ore. The variety containing chalcopyrite resembles that from the War Eagle vein, but its galena is more conspicuous. The chalcopyrite forms relatively pure large grains or masses some of which are 2 inches in diameter; and the galena forms fine-grained aggregates inclosing a few small grains of chalcopyrite. The quartz is fine grained and resembles quartzite and chert. The fluorite variety consists of rather coarse-grained fluorite and galena in a matrix of cherty quartz, which in places is apparently absent. The ore cut in the shaft and along the drift to the east was 1 to 4 feet thick and contained an average of 22 per cent lead. The principal shoot is a heavy galena ore of this general type on the east or hanging side of the main vein, about 30 feet north of the drift along the cross break. It lies between two bands of chert-tremolite rock and extends upward from the level at 45° N. 5° E. The walls of the stope are of low-grade fluorite-galena ore with varying amounts of quartz.

The composition of the ore mined is as follows: Gold (trace), silver 1.3 ounces to the ton, lead 46.8 per cent, copper 0.2 per cent, insoluble 17.1 per cent, sulphur 5.1 per cent, iron 1.2 per cent, lime 26.1 per cent. The ratio of lead to sulphur indicates that four-fifths of the lead was present as galena. The low silver content of this slightly oxidized ore is in striking contrast to the high content in the thoroughly oxidized antimonial lead ores of the War Eagle No. 2 and Scotia mines.

A variety of ore containing barite, carbonate, and galena, noted only on the dump of the "1903" mine, forms bands in and contains inclusions of the quartz-galena ore. The barite forms a typical network of plates, and the other minerals fill the interstices. The carbonate is mostly calcite, which incloses small rhombs of ferruginous dolomite.

Secondary ore minerals are limonite, malachite, chrysocolla, cerusite, and calamine, the calamine indicating the former presence of a considerable though minor amount of zinc blende. The secondary gangue minerals are drusy quartz, calcite, and aragonite in the form of tufts of needles on the secondary calcite.

The different types of primary ore in the "1903" mine include most of those found in the entire district. The chalcopyrite-galena type represents a transition from deposition at rather high to moderate temperatures; the fluorite and the barite-quartz types are believed to represent deposition at moderate temperatures, and the barite-carbonate type represents a still lower temperature, and, from its structural relations, appears to mark the last stage of deposition. Failure to find the fluorite and barite-quartz types in contact prevents a statement as to their relative ages. The fluorite type has not been found in any other mine in the district.

ALLAH PROSPECT.

The quartz-barite-galena type of ore is also represented a mile north of the "1903" mine by the veins on the Allah property. One vein, 4 or 5 feet wide, strikes N. 10° E. and dips 80° W. and is associated with two east-west veins traceable for considerable distance by float. Very little prospecting has been done on these veins. Besides the well-defined veins several small bunches of similar composition are exposed on the surface and in the 198-foot shaft and appear to be local enlargements of tight fissures or at the intersections of fissures. No ore has been mined on this property, but the well-defined veins merit more attention than they have received. The presence of limonite similar to that in the Virginia lode was mentioned on page 440.

SCOTIA MINE.

The deposits in the Scotia mine, at the northeast base of the high limestone ridge, are associated with a strong quartz vein that trends S. 65° W. to the south of the Walker shaft and with north-south fissures that have been followed from the shaft northward. The vein has been developed by a few shallow inclined shafts and by about 450 feet of drifts, inaccessible when visited; and the north-south fissures have been opened by a 150-foot vertical shaft and by drifts and inclines on the 50, 86, and 150 foot levels.

The quartz vein, called the "Blue Jay" vein, trends S. 65° W. closely parallel to a monzonite porphyry sill, and probably connects with a N. 15° E. vein which extends along the east slope of the high limestone ridge and on which the Resurrection (Prairie Bell) prospect is located. The Blue Jay vein dips 70°–80° N., but its vertical extent is not known. Workings beneath it on the 50-foot level were inaccessible, and those on the 150-foot level have not exposed any prominent quartz veins. The quartz of the vein varies from the fine-grained replacement type to milky and well-crystallized varieties. It contains fine grains of pyrite, and much of it is stained with malachite, azurite, light-green copper arsenates, and an unnamed hydrous lead arsenate, perhaps the equivalent of the antimonate, bindheimite. It is, so far as seen, of low grade but has yielded some very rich ore from its hanging-wall side. The principal ore shoot is now represented by the "Bonanza" open cut, which extends downward across the bedding of a shaly limestone, known as the "bonanza shale," into the underlying limestone. This rock, at the open cut, dips 40°–45° N., steeper than elsewhere on the property and, together with the shattered character of the rock, indicates considerable disturbance along the vein fissure. The ore impregnated the laminae of the shaly rock and evidently replaced the limestone below. The shaly character of the rock may have had some influence on the gold content. (See p. 394.) Oxidation, however, further concentrated the metal contents, which ran well in gold, silver, and lead. A short distance west of the "Bonanza" open cut the shaly horizon has been explored by inclined shafts and drifts, and considerable silver-lead ore containing some copper and up to $33 to the ton in gold is said to have been mined from them. These old workings were inaccessible in 1913.

The ore associated with the fissures trending N. 15° E. has been followed from the 86-foot level, west of the Walker shaft, northward and downward below the 150-foot level. The ore horizon, 70 to 80 feet thick, is in the limestone below the "bonanza shale" and above a fine-grained granite porphyry sill. The primary ore minerals are galena, jamesonite, pyrite, arsenopyrite, and a little chalcopyrite and zinc blende; the secondary minerals are cerusite, anglesite, bindheimite, a hydrous lead arsenate, limonite, and hematite, pharmacosiderite and scorodite. The primary gangue minerals are replacement quartz, which has replaced limestone, and scalenohedral calcite; the principal secondary mineral is calcite in crusts and flat rhombohedrons.

The main ore body begins opposite the shaft on the 86-foot level, where it consists of a little galena and black replacement quartz in a mass of soft hematite. Mineralized ground was worked from this point northward for 170 feet to a cave which contained several loose boulders of high-grade ore. A small stope extends from the west end of the cave, following a northerly fissure down to the 150-foot level, below which small amounts of ore have been found close to the fissure. A short distance north of the cave, at the top of No. 6 raise, a remnant of ore consists of lenses of galena and jamesonite, partly oxidized, along a silicified bed. Considerable arsenopyrite and pyrite ("sulphides"), said to have formed a casing around the galena-jamesonite ore, have been mined in this vicinity, but little of them was in sight in 1913. The arsenopyrite is partly oxidized to the hydrous arsenates, pharmacosiderite and scorodite, and to earthy hematite and limonite.

On the 150-foot level two northerly fissures, one on either side of the shoot just described, have been followed along inclined winzes. Both are accompanied by small bunches of rather fine grained galena with a little pyrite and zinc blende and some copper stains. Quartz is inconspicuous, and calcite is the principal visible gangue mineral. These bunches are formed mostly along bedding planes close to the fissure and just above the porphyry sill. The eastern fissure lies about 80 feet from the main stope, and the bedding planes of the intervening ground contain small amounts of sulphides, especially pyrite. The western fissure, 90 feet from the main stope, is not so clearly related to it.

The ore content north of the shaft has in general ranged as follows according to smelter returns: Gold 0.19 to 0.35 ounce and silver 16.85 to 34.65 ounces to the ton, lead 26.7 to 54.75 per cent, iron 5.45 to 15.55 per cent, insoluble 2.45 to 9 per cent, zinc 1.4 to 3.3 per cent, sulphur 0.7 to 3.8 per cent, and speiss[1] 26 to 41 per cent. The percentages of sulphur show that most of the ore was oxidized. Some "boulder" ore from the cave is said to have contained 60 per cent lead and 200 ounces of silver to the ton, and the oxidized arsenopyrite ore from $10 to $15 of gold to the ton.

The changes in mineral composition of the ore imply that the northern part is farthest from the source and that the metal contents of the ore decrease in value northward, especially as very little oxidation has taken place below the 150-foot level. From this it may be inferred that the ore solutions came from the south, possibly from the "Blue Jay" vein; but no connection with this vein has been established, and the fact that other low-grade quartz bodies have been found but not explored suggests that the ore was introduced through some nearer channel.

CONCLUSIONS.

The ores of the West Tintic district include several varieties which grade into one another. They were introduced through two intersecting systems of fissures, one trending N. 65°–75° E. and the other N. 15°–20° E. They doubtless followed the more open courses along these fissures, and formed deposits only in those that varied in dimensions. The deposits as a rule are small bodies formed where conditions were especially favorable to replacement of limestone. It is a striking fact that the largest deposits studied are not in the vein proper but are adjacent to it in easily replaceable rock, shattered zones, or along branch fissures. This relation is illustrated in the War Eagle No. 2 by the small shoots of high-grade ore, in the "1903" mine by the galena shoot, and in the Scotia mine by the "bonanza" open cut and perhaps by the ore body north of the Walker shaft. The fact that the Scotia ore body is larger than the others is attributed to the unmetamorphosed state of the limestone and to the introduction of the ore between an impervious roof and floor. The size of this ore body, however, is small when compared to those in the average mines of the leading districts, and it must be concluded that ore deposition in the West Tintic district has taken place

[1] See footnote, p. 412.

on a correspondingly small scale, and under conditions that did not favor the concentration of deposition in a few main channels.

The work done justifies the conclusion that with more favorable transportation facilities the district could maintain a small steady output, but that under present conditions there is little hope of steady production.

DESERT MOUNTAIN.

By G. F. Loughlin.

Desert Mountain, or, more appropriately, the Desert Hills, include a cluster of low bare peaks which lie about 12 miles southwest of the West Tintic mining district. The nearest railroad station is Jericho, about 20 miles to the east. (See fig. 46.) There is no water at Desert Mountain; the nearest supplies are at Judd Creek, 8 miles north-northwest, on the road to Simpson Mountains, and at Cherry Creek in the West Tintic district, 12 miles east.

GEOLOGY.

Only the western face of the mountain was visited. The rock here is mostly a light-gray granite cut by a few diabase dikes. Apophyses from the granite are intrusive into a dark quartzite which has not been studied closely, but which presents the same dark colors on weathered surfaces as does the pre-Cambrian(?) quartzite series of the Sheeprock Mountains and the southern Simpson Mountains. The quartzite is exposed at the southern and northern end of the mountain and in low knolls which extend to the northeast. Detritus from the principal valley which drains the southern part of the mountain area contains a large number of pebbles of volcanic rocks (mostly rhyolitic), but no extrusive rocks were seen in place.

The granite is light gray and ranges in texture from even grained to porphyritic. The main body is much crumbled on the surface, is medium grained, and in places contains phenocrysts of alkalic feldspar (microcline) and of quartz half an inch in diameter. Its principal minerals are white feldspar (both plagioclase and microcline), gray glassy quartz, and black to brownish flakes of biotite. Another type is an aplite which forms dikelike and irregular masses in the main body, to which it is similar in color but is much finer grained. It is fresh even close to the surface and in addition to the above minerals contains a small percentage of muscovite. It also contains phenocrysts of feldspar and quartz, few of which are conspicuous. Many of the aplitic dikes have coarse-grained pegmatitic variations which grade into massive quartz veins. Several such quartz occurrences outcrop along the road among the low hills just north and northeast of the Rockwell shaft, but none are large enough to be of any economic interest or to show any promising indications of metal contents.

The diabase is dark greenish gray and has a fine-grained ophitic texture, except along the dike margins and narrow offshoots, where it is black and dense. The visible minerals are white feldspar in short rodlike grains, in a soft dark-green chloritic material. There is a suggestion of porphyritic texture in places, a chloritized dark material (presumably augite) forming small phenocrysts. Microscopic study shows the feldspar to be principally plagioclase (An_{35}) accompanied by a little orthoclase. The composition of the former, more sodic than in the average diabase, and the presence of the latter are characters tending toward those of monzonite.

Both the topography and distribution of the quartzite and granite suggest faulting, especially around the valley just mentioned, but no faults were proved. The granite is thoroughly fissured in several directions, the principal systems trending north-south (dipping 45°–60° W.) and east-west (dipping 60°–65° N.). In both of these systems sheet jointing is very conspicuous. Another strong system has gentle dip and near the quartzite approximately parallels the intrusive contact.

ORE DEPOSITS.

The only known important ore deposit in Desert Mountain is the vein followed by the Rockwell inclined shaft, near the northwest end of the mountain, south of a group of low foothills. There are a few other prospects in the vicinity, but only a little work has been done on them. The vein follows a north-south sheeted fissure zone, which dips 60° W. The outcrop of copper-stained rock is 6 to 8 feet wide. It is partly covered by dump débris but is exposed for at least 50 feet south of the shaft, which begins in ore. The cliffs, however, on the spur just north of the shaft, although they