Surface zone .....50 to 200 feet deep from the croppings; contains oxidized copper minerals or is barren.
Chalcocite zone...100 to 400 feet in vertical extent; possibly more in places; contains chalcocite and pyrite.
Pyritic zone......Begins 200 to 600 feet below the surface; contains pyrite, chalcopyrite, zinc blende, and molybdenite.

The minerals of the upper two zones have been derived from those of the pyritic zone by processes of direct and indirect oxidation; the chalcocite is derived from replacement of pyrite and sphalerite probably by aid of cupric-sulphate solutions. The surface zone has been derived from the chalcocite zone by its gradual and direct oxidation. The pyritic zone has thus far been found to be poor in copper and rarely makes commercial copper ore; the chalcocite zone produces the richest ore and the richest part of it is near its upper limit; the leached zone is usually poor and sometimes practically barren. These changes with depth may be observed also in the contact-metamorphic ores, but these ores as a rule are not altered to depths so great.

The Coronado vein, which occupies a fault fissure between pre-Cambrian granite and quartzite, differs in many respects from the deposits in the porphyry, and it is suggested by Lindgren [1] that it probably had a different origin. The ore minerals include pyrite, chalcopyrite, and chalcocite. Sphalerite is not mentioned by Wendt [2] or by Lindgren as a vein constituent, although it appears in appreciable quantities in other ores in this district. Lindgren notes that chalcocite ore is found in this vein as deep as 500 or 600 feet below the surface. More recently, according to Tolman,[3] a chalcocite zone has been found in the Coronado mine considerably deeper than in any other mine in the district.

ELY, NEVADA.

By A. C. Spencer.

The Ely district, Nevada,[4] is an area of folded and faulted Paleozoic limestones and shales ranging in age from Silurian to Carboniferous. These formations are intruded by monzonite porphyry along an east-west zone about 9 miles long and from one-half to 1 mile wide. These older formations are locally overlain by rhyolite flows of Tertiary age. The sedimentary rocks adjacent to the porphyry intrusions are greatly altered, being locally garnetized or changed to jasperoid and commonly charged with great quantities of pyrite. In places near the igneous masses considerable amounts of chalcopyrite occur with the

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[1] Lindgren, Waldemar, op. cit., p. 344.
[2] Wendt, A. F., The copper ores of the Southwest: Trans. Am. Inst. Min. Eng., vol. 15, 1887, pp. 28-52.
[3] Tolman, C. F., The southern Arizona copper fields: Min. and Sci. Press, vol. 99, 1909, p. 390.
[4] Lawson, A. C., The copper deposits of the Robinson mining district, Nevada: Bull. Dept. Geology Univ. California, vol. 4, No. 14, 1906, pp. 287-357. Spencer, A. C., Preliminary geologic map of the vicinity of Ely, Nev., U. S. Geol. Survey, 1912.

pyrite, and rarely zinc blende and pyrrhotite accompany these sulphides. Galena and its oxidation products occur in irregular lodes within the metamorphic area, principally at some distance from the porphyry masses. Gold ores, formerly exploited, occur mainly in the form of blanket lodes, the gold being associated with lead carbonate.

Of many superficial showings of copper carbonates none has been developed profitably, but oxidized ores of relatively high grade have been discovered in the Alpha mine of the Giroux Co., at considerable depth. This ore body is inclosed by metamorphosed and thoroughly oxidized sedimentary rocks that lie several hundred feet from the nearest mass of porphyry.

The present importance of the district centers in the low-grade disseminated ores in porphyry. The igneous rock was locally fractured after its intrusion, and great masses of it became infilled with veinlets of quartz carrying pyrite and chalcopyrite. Even away from the fractures the porphyry was charged with sulphides and the rock was greatly altered, with abstraction of lime, magnesia, soda, and iron and with noteworthy addition of potash. These losses and gains involved the destruction of hornblende and lime-soda feldspar and the formation of mica, including brown mica and sericite. The outcrops of the ore masses are yellowish or less commonly red and are said to carry not over 0.5 per cent of copper. There is an abrupt change from this capping to soft bluish-white porphyry ore, which carries disseminated sulphide minerals, including copper glance, as films coating grains of pyrite and chalcopyrite or, less commonly, completely replacing such grains.

One company, the Nevada Consolidated, has developed about 49,000,000 tons of disseminated ore, the average being 1.7 per cent copper. The variations in depth are indicated in three sections as follows:[1]

Thickness, in feet, of capping and of ore in workings of the Nevada Consolidated Co., Ely, Nev.

Section.	Average thickness of direct capping.	Average thickness of profitable ore.
Eureka	87.1	190
Hecla	101.4	280.3
Liberty	154.7	193.3
Average	102.5	217.9

The profitable ore is known to extend locally to depths about 600 feet below the surface. In one place a hole was put down nearly 400 feet below the ore body in material which carried less than 0.4 per cent of copper.

[1] Fifth Ann. Rept. Nevada Consolidated Copper Co., for 15 months ended Dec. 31, 1911, p. 8.

The gold and silver content of the disseminated ores is considerable. In 1911 the average per ton was 0.013 ounce gold and 0.079 ounce silver. Although less than 60 per cent of the precious metals was saved, their value recovered was 17.35 cents a ton.

A composite analysis of 1,000 samples of ore from the Ruth mine shows, as stated by Lawson, sulphur, 6 per cent; iron, 5.3 per cent; and copper, 2.61 per cent, which may be calculated as equivalent to pyrite, 10 per cent; chalcopyrite, 1.8 per cent; and chalcocite, 2 per cent.

It may be stated as a general truth that any porphyry carrying more than 1 per cent of copper owes its grade to the presence of chalcocite, the enrichment having resulted from precipitation of this mineral out of solutions derived from overlying material.

In the porphyry mines the lower limit of complete oxidation is everywhere considerably above the water level, the difference in elevation being about 250 feet in the Ruth mine. While most of the material carrying chalcocite lies above standing water, the bottom of the ore seems to bear no definite relation to the water table. The greatest depth of porphyry ore is about 600 feet, but in the Alpha mine, which lies outside of the porphyry ore, enriched ore was found between the 700 and 1,200 foot levels. Here the water stands somewhat more than 1,000 feet below the surface and most of the lode material is fully oxidized and leached to this depth.

SANTA RITA AND HANOVER DISTRICTS, NEW MEXICO.

The Santa Rita and Hanover districts, New Mexico,[1] are adjacent and show similar geologic features. The country is an area of Carboniferous and older sedimentary rocks, consisting of limestone, quartzite, and shale. These are intruded by granodiorite, quartz monzonite porphyry, and related igneous rocks, and along the intrusive contacts garnet zones have developed. Considerable masses of magnetite, pyrite, and zinc blende are present. Pyrrhotite[2] is found in the Hanover district, and sphalerite has been mined to some extent for zinc.[3]

At Santa Rita most of the copper occurs as native metal, oxide, or sulphide in altered porphyry. Chalcocite with kernels of pyrite is present both in the quartzite and the porphyry.[4]

As stated by Graton, it is certain that much of the copper that now exists as native metal or oxide was not precipitated on pyrite but must have been deposited from solution in open spaces and in porphyry as replacement along fissures.

[1] Lindgren, Waldemar, Graton, L. C., and Gordon, C. H., The ore deposits of New Mexico: Prof. Paper U. S. Geol. Survey No. 68, 1910, p. 305.
[2] Idem, pp. 53, 58, 81.
[3] Idem, p. 309.
[4] Idem, p. 62.