between the Straits and the fault, such boring operations will furnish the geologists with much data that are necessary and requisite in orde to be able to state with precision to what thickness the overlying strat cap the tilted and supposed coal-bearing beds beneath.

That there should be a possible coal-field beneath the newer over lying series and in the inclined beds below is a question of much inter est and worthy of more than cursory notice.

The prevalence of the coal basin depends upon the continuity of the unconformable contact between the two series of sediment, such as are exposed in Blackwood brook.

It may not be out of place here to state that far back an attemp was made to put down a bore hole with a view of obtaining coal, bu inasmuch as the hole was not carried down to a great depth, neith was a careful log preserved of the strata traversed during boring oper tions, the results were negative rather than positive, and whilst a Blackwood brook the underlying, tilted series of beds are near the su face of the ground, and a few hundred yards north of the brook, pr bably only a few hundred feet from the surface of the ground, the p cise thickness of the overlying strata can only be ascertained by bori or sinking a shaft.

It is to be hoped that before long the locality in question w receive a fair test—bore holes put down so as to traverse the newe overlying series—in order to ascertain the occurrence or non-occurrenc of the coal-bearing shales and strata of the Stellarton formation in th portion of Pictou county north of the "north fault."

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The Ore Deposits of the Boundary (Creek) District, B. C.

By R. W. Brock, B.A., Ottawa.

The district treated of in this paper is that lying along the International Boundary line, in the neighborhood of and between the valleys of the north fork of the Kettle river and Boundary Creek, B.C. Following upon the construction of the Columbia and Western railway, a little over two years ago, and the installation of smelters at Greenwood and Grand Forks a year and a half ago, the district at once took a foremost place in British Columbia lode mining and it now ranks as one of the most important factors in the production of copper in Canada.

While the mountains are not rugged and the western and southern slopes are often open, prospecting has not been easy, on account of the covering of drift which conceals the rocks over a considerable portion of the surface and on account of the complex geological structure of the district.

* Eruptive rocks, including granites, greenstones, lavas (and associated tuffs) and various intrusive dykes have the widest distribution. More or less altered sedimentary rocks (limestones, argillites, quartzites) together with more highly altered metamorphosed rocks, including serpentine, are met with in all parts of the district, but do not, as a rule, have large dimensions in any one place, being usually nothing more than inclusions of older formations caught up in the intrusive rocks.

The oldest rocks recognized in the district are the sedimentary and crystalline rocks. In the south-eastern part of the district just west of Grand Forks, some crystalline mica and hornblende schists and crystalline limestone occur, which resemble lithologically the rocks of the Shuswap series (Archean), but they may possibly merely represent in a more highly metamorphosed form the argillites and limestones found elsewhere in the district.

* The rocks have not been studied microscopically, and cannot therefore be named with strict scientific accuracy, but still closely enough for most practical purposes.

The argillites are normally dark or red, occasionally highly carbonaceous, but are often altered to gray knotted schist, or hornfels, or they may be largely silicified. The limestones are usually white and crystalline, but occasionally show an original black color. In places the lime is replaced by silica, forming cherty or quartz-like jasperoid rocks. True quartzite is only sparingly found. Closely associated with these is a serpentine, probably derived from a basic eruptive rock. It is frequently altered to a siliceous dolomite or magnesite. These rocks form a series closely resembling, and probably of the same age as, the Cache creek series described by Dr. Dawson, and ascribed by him to the carboniferous formation.

Somewhat younger than the sedimentary rocks is the greenstone, which has the greatest areal distribution of all the rocks of the district. Often it is altered, but where its structure is preserved it appears to be an augite-porphyrite, sometimes agglomeratic, similar to that rock found in many parts of West Kootenay, notably around Rossland. It cuts and holds inclusions of the older rocks. Indeed, in most of their occurrences, the latter appear simply as islands in the greenstone, varying in size from small fragments, closely packed and almost filling the greenstone matrix, to bands hundreds of meters long. Under pressure it becomes schistose and difficult to detect from some of the included argillites. Occurring with it are bands of tuff, filled with fragments of the older rocks, and interbanded with fine-grained ash-beds.

Younger than and cutting the greenstone is a gray hornblende biotite granite which is exposed near Greenwood, in Wellington camp and on Hardy mountain. Gray granite porphyry dykes from it cut the older formations a long way from the parent masses. The white altered porphyry on McCarren creek and at the City of Paris mine may belong to this series of dykes. This granite will probably prove to be the same rock as the Nelson granite, of West Kootenay, and about Jurassic in age.

Near Central Camp and northwest of it are bosses and dykes of gray diorite porphyrite, which microscopically closely resembles the Rossland monzonite, but until it has been carefully studied it is still uncertain that it is the same rock. Younger granites occur just outside the area described.

Beds of volcanic rocks are found at several points overlying the rocks already referred to. These are remnants of a sheet of volcanics which once covered the entire country but which, in this district, have been largely removed by erosion. The series consists of coarse and fine tuffs, ash-beds and shales (in which coal is sometimes found) with sheets of andesites, basalts, and other volcanic rocks. These latter are sometimes locally termed "bird's-eye porphyry." This series is probably of Tertiary age.

Dykes of a reddish or yellowish syenite-porphyry, having a fine-grained ground-mass, with conspicuous rosette-like phenocrysts of feldspar and some biotite, are common in the mineralized portions of the district, though wanting in the unmineralized. On the Carbonates claim, this reddish porphyry is seen as a contact facies of a coarse syenite-porphyry similar to those observed east of the North Fork and in the Rossland district, where such dykes are known to be from the Rossland granite. They would appear to have the same relationship here, but it is yet to be proved that they have no genetic connection with the volcanic flows as well. Dark lamprophyric dykes and some of a brownish basalt-like rock also occur.

The ore-bodies may for convenience be roughly divided into three classes: (1) The large low-grade copper-bearing sulphide deposits; (2) the oxydized copper veins, and (3) the small gold and silver-bearing quartz veins.

Undoubtedly the most striking characteristic of the deposits of the first class is their enormous size. In the Mother Lode mine development work so far has exposed an ore-body, for a length of 1180 feet, and a width of 140 feet, which is continuous to the bottom of the workings, at present 500 feet. The Knob Hill–Ironsides lead is of as yet unknown dimensions. It extends through the greater part of the length of both claims and probably into the **Gray Eagle**. The lowest stopes are 700 feet below the highest point of the vein, but diamond drilling has proven the vein for another 100 feet. Its proved width is said to be 400 feet. On the second level three ore shoots are said to occur, one of 150 feet, one of 100 feet, and a third of 200 feet in width. These with the poorly mineralized rock between, would give a total width to the vein at this point of approximately 800 feet. One stope, 100 by

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200 feet, is all in ore. While these figures are only approximate, they serve to illustrate the great size of the ore bodies and the extent of mineralization. These are of course the largest ore bodies yet disclosed, but some of the less developed properties have also very large deposits.

In structure these deposits belong to composite-vein type, formed by mineralizing solutions traversing the country rock, principally along fissures or zones of fissures in which they deposit the economic minerals and from which they replace with their mineral contents, particle by particle, sometimes only partially, sometimes completely, the original material of the country rock. On the outskirts of an ore body this substitution may be seen in all stages of development, the individual constituents of the country rock being one by one replaced Sometimes, as on the Emma claim, the replacement of the country rock has gone on so evenly that a completely banded ore has resulted. A banded structure cannot here be taken as a proof of open filling.

According to the most prominent mineral content, this class of deposits may be subdivided into a pyritic type, in which pyrrhotite, chalcopyrite, with some pyrite, are the chief minerals, and a magnetitic type in which magnetite, chalcopyrite with some pyrite, are chief minerals. Excepting that the pyrrhotite of the one is represented by magnetite in the other, these two types appear to be identical. Both the magnetite and the pyrrhotite replace the constituents of the country rock in the same way, both seem to have been formed, on the whole, a little prior to the other vein minerals, holding them in little veins or as points scattered through, yet sometimes interbanded with them; they are both accompanied by the same accessory and gangue minerals and the country rocks show the same alterations in both cases. Rarely do both the pyrrhotite and magnetite occur in the same deposit. In the Mother Lode a very little pyrrhotite is however reported, and in one or two small veins, as on the O. P. and Wolverine claims, both are found. The B. C., Maple Leaf, Winnipeg, Lake and Morrison, may be mentioned as representatives of the pyritic type, while the Knob Hill-Ironsides, Mother Lode, Brooklyn, Snowshoe, Oro Denoro, Emma and R. Bell belong to the magnetitic type.

Besides the metallic minerals already mentioned some marcasite appears to occasionally be present, and sometimes arsenopyrite, galena, zinc-blende, and molybdenite, but these are in all cases subordinate in quantity. Tetrahedrite has been found on the City of Paris. Specular iron is found somewhat sparingly in the Knob Hill, Brooklyn, Stemwinder, Snowshoe, B.C., and other mines; and bismuthinite occurs on the Bluebell claim, Summit Camp.

Calcite is a common gangue mineral, sometimes well crystallized, forming large masses, and also in the form of little seams through the ore and country rock. Seldom is it found in large quantities in those parts of a vein in which magnetite is heavily concentrated. Quartz is also an abundant gangue-stone, occurring in the same way as the calcite, though I have not observed it well crystallized. Silicification of the country rock to a cherty or quartz-like (jasperoid) mass, is a common, though not invariable phenomenon in the neighborhood of a vein. Red and green garnet (probably grossularite and almandine) and epidote are very abundant in and near the veins, both well crystallized and massive, often interbanded with the ores and forming a very large percentage of the vein material. The progress of their formation may be observed at many points in all stages, not only when limestone, but also when greenstone and granite form the country rock. In the Mother Lode, where limestone seems to be the country rock, while these minerals are developed the chief mass of the altered rock is made up of a felt-like aggregate of short green fibres, apparently of actinolite. A beautiful white radial tremolite occurs in the limestone at the Morrison mine. Kaolin, chlorite, and serpentine are probably among the alteration products, but until the microscopic examination of the rocks has been made an accurate account of the secondary minerals and their relative importance cannot be given.

The ores occur in all rocks except the most recent, the latter being the youngest granites, the porphyry and basic dykes and the Tertiary volcanics. In age, then, these deposits are probably early Tertiary. So far as yet found mineralization is confined to districts which show evidences of recent disturbance, more particularly where the older rocks are cut by the recent intrusives. Limestone in such a district seems favorable for the deposition of ores. In some cases the ore occurs in the limestone itself, but more frequently it is found in a rock along its contact with limestone. Thus in a greenstone where it holds inclu-

sions of limestone, the ore often occurs in the greenstone along its con
tact with the limestone, while the latter may show little or no mineral
ization. The lack of mineralization in the limestone in such cases may
be due to the fact that the limestone often flows and forms compac
lenticular masses, instead of fracturing, under pressure, and thus fu
nishes no channels for the mineralizing solutions. If attacked an
replaced by them, it must have been along the contacts and this mus
have taken place comparatively evenly, leaving a clean-cut unminera
ized wall. While this may have been the case in some of the larg
deposits, in many of the smaller veins occurring along such contac
the mineralization shows a distinct preference for the greenstone, th
limestone remaining unmineralized. That the contacts between lim
and other rocks should be favorable may have been due in part to th
chemical influence of the lime in precipitating the mineral contents
the solutions, but it was also due to the lack of firm cementing betwe
the limestone and the contact rock, which left free channels that th
solutions used as highways and bases for their operations. But whi
such contacts are favorable, mineralization is by no means confined
them. In fact in tne largest deposit yet found in the district (Kn
Hill–Ironsides), with the exception of an insignificant island of it, fou
on the intermediate level, limestone is conspicuously absent, althou
it occurs at numerous unmineralized points in the vicinity. Wh
most of the deposits are in greenstone, limestone or contacts betwe
these, they also occur in the serpentine, argillites and gray granite.

Porphyry dykes are usually to be found in close proximity to
ores, sometimes as at the No. 7 mine the ore lies parallel to a d
along its contact or in the immediate neighborhood. At the B.
Mother Lode and other mines dykes lie almost horizontal, runn
through the ore-bodies at approximately right angles. The ore is co
tinuous on borh sides of the dykes, little or not at all faulted or oth
wise altered by them. The dykes, while containing traces of metal
minerals, show no signs of mineralization. In age they are about t
same or a little younger than the ore deposits, showing the deposits
have been formed during or before the close of the cooling of the er
tive magmas.

While the deposition of the mineral contents of the veins is

dently largely hydrothermal, many of the minerals formed are characteristic of contact zones and there seems to be strong reasons for supposing the deposits to be connected with eruptive after-actions. The reasons for this belief cannot be discussed at length in the limits of a short paper. The magnetite appears to have been formed in the same way and under the same conditions as the pyrrhotite. It appears to be a primary constituent of the ore. Its formation seems to have depended upon a deficiency in sulphur, the available sulphur being siezed upon by the copper and going to form chalcopyrite. On account of the variety of rocks in which the ores are found it is evident that the source of the material of the veins cannot have been local. From the fact that the mineralized districts are much cut up by eruptive dykes, that areas of recent eruptions are close at hand and vents from which the volcanic series was ejected are probably near by, and that magnetite has so far seldom or never been found to have resulted from the deposition of ordinary mineral-bearing underground solutions, while common in contact metamorphism and as the result of solfataric action, it seems fair to conclude that the deposits have a connection with the recent eruptive rocks and that at least some of the material was derived from the magma of the eruptives brought up by the after-actions characteristic of vulcanism. This view is supported by the independence of the deposits with regard to the country rocks, the resemblance of some of their materials to that of nickel-pyrrhotite and other deposits considered to be the products of magmatic secretion and others to the products of volcanic after-action. At the same time it is not claimed that deep-seated underground circulating waters have had no share in the mineralization. Indeed the mingling of solutions from the two sources may have had a marked influence in the precipitation of their mineral contents.

Somewhat similar deposits, though on a much smaller scale, of magnetite and chalcopyrite occur at * Cherry Bluff, Kamloops lake, near what Dr. Dawson considered a volcanic vent. These have no doubt been formed by volcanic after-actions.

† In the Kristiana district, Norway, magnetite and specular iron,

* Geological Survey of Canada, N.S., Vol. 7, 1894, p. 341B.
† Zeitsch. für Praclt. Geology, 1894, pp. 177, 464; 1895, p. 154.

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together with the sulphides of copper, zinc, lead, etc., occur within the metamorphosed zone of eruptions, especially granite, though as far as 2 kilometers from the actual contact. In association with them are contact minerals similar to many in the Boundary District. These deposits are explained by Vogt and others as the result of contact metamorphism and after-actions.

Similarly the Norwegian pyrite deposits have been shown by the same authority to be connected with contact metamorphism due to gabbro and granite.

‡ The pyrrhotitic deposits of Rossland, B.C., have many points of resemblance to the Boundary deposits, although differing somewhat in the accompanying minerals.

In ore-bodies formed by the replacement of the country rock along and from fissures, it is to be expected that mineralization should often be irregular and the ore-bodies should show correspondingly irregular forms. This is here the case. Often the deposits have no definite walls, the country rock in the neighborhood being mineralized to a greater or less distance from the main deposit, the line between the two bhing often merely a commercial wall. Unmineralized portions of the country rock are apt to be found as remnants in the vein and bunches or masses of ore may wander into the country rock. The ore is usually found in the veins in the form of shoots of various outlines. Sometimes several of these occur, often rudely parallel. In some places veins with similar filling intersect at various angles. Small stringers leading from the main veins are not uncommon. Most of the larger veins have a northerly strike with a high dip to the east. In the case of the Knob Hill–Ironsides the dip is as low as 45 or 50 degrees. Not enough development work has been done to generalize on the forms and pitches of the shoots. That of the Mother Lode pitches south. In the B. C. mine, a horizontal plating of the ore is quite pronounced.

There have been considerable movements since the ore was deposited; numerous slips, some with gouge or secondary filling, traverse the ore bodies. This broken nature of the ground, coupled with the original irregularity in the form of the ore body makes the exploitation

‡ Trans. Canadian Institute of Mining Engineers, Vol. 2, 1899, p. 72.

of the smaller deposits sometimes difficult and precarious. The slips so far encountered have not been sufficiently large to have seriously affected the larger deposits. The serpentine is particularly full of slips, some prior but many subsequent to the formation of the ores, which make it probably the least satisfactory country rock in the district.

The values in the ores are principally in copper and gold, sometimes with accessory silver. Further study is required to formulate the laws governing the distribution of gold values. Generally magnetite and pyrrhotite when occurring alone are almost barren, yet this is not always the case. In the Knob Hill–Ironsides the massive magnetite is said to have a gold value. This is said to be the case on the Seattle claim, but in an assay of this magnetite made for the writer no gold was found, though the accompanying chalcopyrite was auriferous. In the Winnipeg mine pure pyrrhotite carries as high gold values as have been found in the mine, but at other points in the same mine barren pyrrhotite is found. Chalcopyrite occurring in magnetite and pyrrhotite is generally a gold carrier, but the gold value of an ore does not always increase with the copper percentage. Thus in the Mother Lode the best gold values are said to be found where the ore runs about 2 per cent. in copper. In the B. C. mine the gold is said to be confined to the chalcopyrite—pyrite and pyrrhotite being barren. On the other hand, in the Brooklyn, Stemwinder and Rawhide the best gold values are reported from the pyrite and ore-carrying specularite. So far as could be superficially observed, the local opinion that the intersection of veins or stringers with the main bodies does not cause an enrichment, seems to be supported by the facts. It may be noted that where dykes cross the ore bodies there appears in some cases to be an enrichment of the ore. Possibly there may prove to be a relationship between the quartz and the tenor of the ore. Though segregated in places, the chalcopyrite is on the whole remarkably evenly distributed through even the immense deposits. Away from the chief centres of mineralization while magnetite and pyrite are still sometimes found, the copper and gold are only sparingly present. The actual values of the ores per ton and the cost of mining and treatment have not been made public. The ores, as a rule, are certainly very low-grade, lower than was at first hoped. This has been partly counterbalanced by the size the bodies have shown on development and the remarkable adaptability of the ores to smelting. The magnetite, quartz and calcite are present in the required proportions so that no fluxing or roasting is necessary, so that the cost of smelting, as well as the cost of mining these ores, is exceptionally low. It is generally admitted that many of the properties can only be successfully operated by doing their own smelting; for this reason a union of the smaller mines or the building of a union smelter has been suggested.

A member of the Dominion Copper Company kindly furnished permission to publish the following figures regarding the contents of the ores of this company, which are more or less representative of the ores of Greenwood Camp.

GROSS RETURNS.

Si O	39.00 per cent.		
Ca O	17.00 "		
Fe O	14.00 "		
Cu	1.95 "	= 39 lbs. Cu (at 10c. per lb.)	$3.90
AU	.119 oz		2.40
Ag	.44 oz.		0.22

NET RETURNS.

Cu	$3.10
Au	2.40
Ag	.22
	$5.72

Values as high as $30 per ton are reported on car lots of ore from the Winnipeg mine, but such returns are exceptional, for the ores of the district as a whole.

The method of mining adopted in the large mines is to be presented in another paper and need not be referred to here.

A striking feature in the deposits is the lack of surface oxydation or alteration. At most, a few feet below the surface of the ground the ore exhibits the same characters as are found in depth. The soil overlaying a deposit is often quite unstained, offering no indication of the underlying ore, and consequently adding to the difficulties of prospecting; sometimes the surface of the ore even retaining the glacial polishing. The explanation of this feature is probably to be found in the

heavy glaciation to which this region has been subjected. The old oxydized, and perhaps enriched, upper portions of the veins have been cut away by the Cordilleran glacier and since then the surface has been often more or less protected.

In Copper Camp oxydized copper-bearing veins occur, forming at first sight a totally different type of deposit. A short description of the King Solomon claim will illustrate this type. This deposit is found at a contact between a dyke of porphyry and crystalline limestone. Wedge-shaped tongues of the porphyry extend from the main dyke into the limestone. Both the limestone and the dyke are much fractured and traversed by little slips. These fractures cut the limestone into small blocks. In the limestone, and to a less extent in the fractures in the porphyry, along the contact, are deposited various oxydation minerals of iron and copper, including native copper. These embrace red massive and earthy hematite and yellow limonite, crystallized and massive malachite and azurite, a black amorphous substance, a mixture containing copper oxide (melaconite, lampadite and chalcocite), cuprite, often in transparent crystals, native copper, chrysocolla and probably copper-pitchblende. The edges of the small limestone blocks have often been dissolved and the copper ores then occur as encrustations surrounding a core of lime. The main fissures are filled with the iron and copper minerals, the smaller principally with the copper. In the porphyry it is only the fractures near the contact which contain a thin film of copper ore, the rock itself remaining fresh and unaltered. About 650 feet from the main working on the King Solomon is a small vein. The rock is here not so badly shattered. On the suface carbonates and other copper minerals with iron oxides are found; a little below the surface the sulphates of these metals occur, and below these unoxydized pyrite and chalcopyrite begin to appear. What can be seen to be taking place here on a small scale is probably what occurred on the King Solomon ledge proper on a much larger scale, so that this type of deposit is probably an oxydized and secondarily enriched form of a sulphide deposit, similar to the first type of Boundary deposits and produced by the action of surface waters. The iron of the sulphides has been removed or redeposited as hematite and limonite; the copper has been more or less concentrated in the form of various oxydized minerals. At greater depth the unaltered iron and copper sulphides will presumably be found, although between the oxydized minerals and the unaltered sulphides it is quite possible that a zone of enriched sulphides will be found. That a zone of oxydation and enrichment should be found in the veins of Copper Camp and not elsewhere in the district may in part be explained by the local topography, and the broken nature of the country rock, but the chief factor, in all probability, has been the capping of volvanic rocks which covers the hill-tops all around and extends almost to the King Solomon and other of these deposits. In glacial times these rocks are likely to have extended a little farther, in which case they would have protected the deposits from the scouring effects of the ice-sheet. In addition, the contact between the volcanic and older rocks is likely to be a natural waterway.

The quartz veins, constituting the third type of deposit, are found in the neighborhood of the first type, but seem more abundant on the outskirts of the areas of chief mineralization. They are sometimes parallel to the large sulphide bodies, but do not, as a rule, show the same regularity in their strike. In form they are more regular and they are usually enclosed between well-defined walls. Chalcopyrite, pyrite, arsenopyrite, galena and zinc-blende are the chief metallic minerals. Tetrahedrite and some rich silver minerals are said to have been found in some of these veins. The principal values are in silver and gold. High assays are reported to have been obtained from a number of these veins, but the only one at present being worked in the district embraced in this paper is the No. 7 mine. In age and mode of formation there have been little difference between these and the previous deposits, though in that case they would probably represent the closing stage of mineralization.

Some of the practical deductions from an examination of the ore deposits may be summarized as follows:—

Ores may be found in any of the older rocks where the other conditions for mineralization were favorable.

Districts which show evidences of late disturbances through vulcanism, manifested by intrusions of recent eruptives and heavy dyking, are promising fields for prospecting.

Limestone contacts in such areas should, in particular, be carefully prospected.

Since, with the exception of certain deposits in Copper Camp, there is no zone of oxydation and secondary enrichment in the main deposits, while the general conditions remain unchanged, no loss of values is to be expected in depth.

On account of the irregular form which the ore bodies may possess and the complex nature of the rock formations, a careful and detailed study of the surface of the ground in the neighborhood of the mines would be of great practical assistance in the exploitation of the ore bodies. For the same reason development work must always be kept well ahead of the actual mining. Cross-cutting must frequently be resorted to, to determine the actual limits of the deposit, and to prove the existence or non-existence of parallel ore shoots. The limits of mineralization must be actually proved, and similarly only that ore can be with certainty reckoned on which has been actually blocked out.

In this connection diamond drilling can be used with advantage. Careful magnetic surveys would also be of great value in locating ore-bodies under the covering of drift, and also in testing for ore in the mines themselves. Especially good results should be obtainable by this method in the magnetitic type of deposit, but it should also prove successful in the pyrrhotitic deposits. It has proved successful in such deposits in Scandinavia, and I am informed that experiments made with it on the Sudbury pyrrhotite deposits, last summer, have yielded good results.

Where the ore occurs at a limestone contact the limestone wall may often be used for following the ore, it being kept in mind that the ore does not always follow strictly along the contact, and that the limestone may pinch out without causing the ore to likewise give out. The dykes in some cases may be used in the same way.

The pyrrhotite and magnetite should always be assayed, as barren-looking material may carry good pay values. The minerals in the ore and the conditions where pay values occur should be carefully studied with a view to ascertaining which carry the values, and what were the causes which produced the concentration of values. The porphyry dykes themselves, while not mineralized in the same way as the country rock, may in places prove auriferous. In a specimen from a similar porphyry dyke, from the Valkyr mountains, east of Lower Arrow lake, examined last winter, free gold was plainly visible, even with the naked eye.

In prospecting it is to be remembered that float may have been carried a considerable distance, even across valleys, by the former glacier. The general course of the latter was about S. 30 E., but it was influenced by the local topography.

In a promising deposit of the oxydized copper type, one would be warrented in testing the deposit to a sufficient depth to ascertain if a zone of enriched sulphides exists between the oxydized zone and that of the unaltered sulphides. As *Emmons and Weed have pointed out, the bonanzas of high-grade ore in Butte, in Arizona, and other points, are situated between the zones of oxydation and unaltered sulphides. Below the limits of alteration the deposit may or may not be rich enough to work.

Safety Lamps and Colliery Explosions.

By JAMES ASHWORTH, M.E., Mount Chaddesden, England.

The fearful explosions which are continually occurring in various parts of the world, notably that of the Universal Colliery in South Wales, the Fraterville coal-mine in Tennessee on the 19th of last May, and lastly the one at the Fernie No. 2 tunnel workings of the Crow's Nest coal field, on the 22nd of May, about 7.30 p.m., are sufficient in themselves to cause those who have the charge of mines which give out firedamp, as well as those who have money invested in them, to seriously consider in what way this risk may be lessened, if not almost totally prevented.

It is suggested by the newspaper reports on the Fernie disaster, that the explosion originated from blasting in the coal. Similarly it was also suggested that the explosion at the Universal Colliery, Senghenydd, was caused in a similar way, but in the latter case only one witness could be found to suggest that an explosive had originated the disaster, though many witnesses proved that it could not have thus originated, and that it was in all probability caused by a totally different cause, and in a totally different part of the mine. The other cause and in all probability tbe true one, was the failure of a safety lamp to prevent the flame inside the lamp igniting the firedamp outside.

Under the Mines Regulation Acts of Parliament which regulate the management of coal-mines in Great Britain, all the lamps in use must be bonneted, that is to say, the gauze part of the lamp must be protected by a shield, so that an explosive air current cannot impinge directly on the naked gauze and cause it to become so quickly overheated as to destroy its protective value. Experiments have proved most conclusively that gauze lamps of the Davy type, such as the old Scotch gauze lamp, cannot withstand an explosive current of the lowest velocity on account of their large cubic contents, because the ignition of a large volume of firedamp exerts such a high velocity that the flame is forced through the mesh of the wire almost instantaneously, and without waiting to