	Presentation	material	English
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MOLYBDENUM

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FOREWORD

This essay has been written from knowledge gained from papers written on the subject and from data obtained in the field. The writer has been in the employ of the British Columbia Department of Mines for two years and has spent the greater part of the field seasons gathering various data on the war-minerals found in the Province. The deposits of molybdenum were outstanding amongst these minerals and the writer thought it appropriate to discuss this metal in an encompassing manner to gain practice in organizing data with which he was already familiar. The writer freely called upon, and copied numerous authors. Important information was obtained from Messrs. V. E. Eardley-Wilmot, T. L. Walker, L. Reinecke, F. L. Hess, M. E. Wilson and others. The length of this essay may be ascribed to the necessary detail which this topic demands.

a few leading references desirable

CHARACTERISTICS OF MOLYBDENUM AND MOLYBDENUM MINERALS.

Molybdenum

Pure molybdenum is a silvery white, malleable metal, softer than steel and capable of being filed and polished. Its specific gravity is about 10, not quite as heavy as lead. Its physical properties depend entirely upon the mode of production. If prepared by the reduction of molybdenum oxides with hydrogen it is a grey metallic powder, which may be compressed under heat into brittle bars. If the oxide is reduced by carbon an impure grey powder results, of which the specific gravity is about 8.75, due to the presence of carbon. Its hardness now is greater than that of quartz. Molybdenum is also manufactured by a chemical process, which gives a dark-blue metallic, crystalline powder.

The melting point of pure molybdenum is about 2500°C; even higher than that of platinum. Electrically, molybdenum is a good conductor and it is stronger and harder than copper. It is softer and more easily worked than tungsten. Alloyed with steel it behaves much as does tungsten, but is more potent. It is likewise very similar to chromium in the properties it imparts to steel, but much smaller quantities are required to produce the desired result.

Molybdenite

Molybdenite, the most widely distributed molybdenum mineral, has supplied by far the larger part of the world's production of molybdenum. It may easily be mistaken for graphite because of its appearance. Like graphite, it is a very soft gray mineral, with bright metallic luster and and sometimes occurring as hexagonal leaves. Its specific gravity is 4.7, more than twice that of graphite. There is a distinct blue tinge to the grey colour of the molybdenite leaves. It also has a grey-green streak which shows to best advantage on a porcelain streak plate, although the colour will streak on paper. When molybdenite MoS_2 is heated in the oxidizing flame on a charcoal block, pungent fumes of sulphur dioxide are given off and a white coating of molybdenum oxide is deposited on the charcoal.

Molybdenite is found under a variety of conditions which Hess classifies as follows:

1. In quartz veins, either as an original constituent or as a later filling of cracks;
2. in pegmatite;
3. in deposits formed by the replacement of granitoid rocks that resemble pegmatite and take the form of pipes or more tabular masses;
4. in greisen - a silicified granite rock containing more or less muscovite;
5. in granite;
6. in regionally metamorphosed rocks; and
7. in contact - metamorphic deposits.

Wulfenite

Wulfenite (lead molybdate, $PbMoO_4$) is an attractive reddish-yellow mineral which occurs in thin, square, tabular crystals. The red colour is attributed to vanadium, and the depth of colour is said to be proportional to the quantity of vanadium present. Wulfenite usually occurs in the oxidized parts of lead veins. The major source of wulfenite in the United States was from the old Mammoth mine, in Shultz, Arizona, but today this mine and adjacent ones lie idle, the production of this mineral having ceased. During the last war Germany mined wulfenite from a deposit within her borders and from several in Austria. Wulfenite is a source of molybdenum but does not rank with molybdenite when tonnages are considered.

Molybdite

Molybdite is an alteration product of molybdenite and is present in most molybdenite deposits. There has been considerable controversy about its composition but the formula proposed by Schaller that it is a hydrated iron molybdate ($Fe_2O_3 \cdot 3MoO_3 \cdot 7H_2O$) is most widely accepted. The characteristic canary-yellow of the molybdite draws the attention of the prospectors to outcroppings of rock mineralized with molybdenite. This property of molybdite makes the mineral of some value. Molybdite, however, is not an important ore of molybdenum, occurring only with deposits of molybdenite.

There are other minerals containing molybdenum which, as a source of molybdenum, are unimportant. The following table, showing the composition and characteristics

Mineral	Composition	Usual Color	Luster	Streak	Hardness	Specific Gravity	Percent Mo
Molybdenite	MoS_2	Lead - grey	Metallic	Blue-grey-green	1 - 1.5	4.7	59.95
Wulfenite	$PbMoO_4$	Orange - yellow	Resinous	White	2.75 - 3	6.7 - 7.0	26.15
Molybdite (Molybdic ochre)	$Fe_2O_3, 3MoO_3, 7H_2O$	Pale yellow	Earthy, silky	Straw yellow	1 - 2	4.5	39.63
Powellite	$CaMoO_4$	Dull grey	Resinous		3 - 5	4.25	47.98
Ilsemannite	MoO_2, $4MoO_3$	Blue - black					68.18
Belonesite	$MgMoO_4$	White	Transparent				52.08
Pateraite	$CoMoO_4$	Black					43.84
Achrematite	$3(3Pb_3As_2O_8, PbCl_2)$ $4(Pb_2MoO_5)$	Orange to brown	Resinous	Pale brown	3 - 4	6.0	3.40
Eosite	$Pb_3V_2MoO_{16}$	Deep red		Orange-yellow	3 - 4		variable
Koechlinite	$Bi_2O_3 MoO_3$	Green					18.60
Doubtful Minerals							
Molybdurane	$UO_2 UO_3 2MoO_4$						
Molybdoferrite	$FeMoO_4$	Apple green			3.0		
Knightite	Phosphate of Mo						
Chillagite	Molybdo-tungstate of lead	Yellow	Vitreous		3.5	7.5	10 to 14
Jordisite	MoS_2 (amorphous)	Lead-grey					59.95
Molybdosodalite	$Na_4(AlCl)Al_2Si_3O_{12}$, Mo						1.3

TABLE OF MOLYBDENUM MINERALS

of the known molybdenum minerals, is copied from Eardley-Wilmot's report on molybdenum.

HISTORY OF MOLYBDENUM

The metal, molybdenum, has been known for about a century and a half to chemists and mineralogists. The name "molybdaena" is derived from the Greek word meaning "lead", and it was referred to by Pliny in his extensive writings. The word was originally employed to designate a variety of substances containing lead. Later, the name was applied to galena, graphite and the mineral molybdenum sulphide, now called molybdenite. This classification of such a wide range of substances under the one name, molybdaena, was due to the similarity of the physical properties of each mineral. Galena was the first of these three substances to be differentiated, probably a result of its easy smelting properties. Graphite and molybdenite, on account of their great similarity, were not differentiated until the year 1778, when the great Swedish chemist, Karl Wilhelm Scheele, showed that, unlike graphite, this mineral forms a "peculiar white earth" which when treated with nitric acid and subjected to blow-pipe heat, sulphurous fumes are given off. From this powder he produced molybdic acid, which has become the chemist's most reliable agent for the determination of phosphorus in iron and steel.

The isolation of the metal was not obtained, however, until 1790, when P. J. Hjehn prepared it in the form of a metallic powder, and it was later proved to contain neither carbon nor lead.

A Japanese sword blade, made about 1330 A.D. by Masamune, was analyzed by a German steel expert and found to contain molybdenum.

For about a century no progress was made in the metallurgy and use of molybdenum, until the German Chemists, Sternberg and Deutsch, produced in 1893 a 96% pure molybdenum metal. They succeeded in reducing molybdate of lime with carbon and then separating the lime with hydrochloric acid. This impure metal found a ready market in Germany where its true value was recognized. The metal could replace tungsten satisfactorily in hard steel alloys favourable for armor plating, tungsten being a difficult metal for Germany to obtain in times of war.

Shortly after the German discovery, Henri Moissan, the French chemist, reduced the metal until it was 99.98% pure, by means of an electric furnace, and thereby succeeded in making the metal commercially important. This chemist also discovered several compounds of molybdenum, established several now recognized properties of the metal, and recorded accurately its atomic weight.

The first interest in the new metal in America manifested itself in 1898 when important lode discoveries were made in Arizona and New Mexico. The speed with which the United States now produced the metal at a time when few countries required it, caused a slump in the price and production practically ceased until 1914.

Thus, the growth of a new industry, founded upon the expected use of ferro- molybdenum alloys, did not materialize. And this circumstance prevailed even in face of very successful results obtained in experiments performed by French chemists at the Creusot works in France.

The causes for the general inacceptability of the metal may be listed as: metallurgical difficulties in extracting the pure metal from its ores; uncertainty as to volume and quality of available ores; metallurgical difficulties in producing the steel alloys, together with their unreliability, which caused an unfavourable reaction against the metal; and the rapid advance of tungsten, due to its more plentiful ores, from which the metal could be extracted with less difficulty and expense than in the case of molybdenum. Today these difficulties have been overcome to a great extent. There are, today, no metallurgical difficulties of any significance; the quantity and quality can be assured owing to recent large discoveries such as the Climax, Colorado deposit; and the reputation of the metal in creating high tensile strength steels has been redeemed and greatly increased. It may be stated that molybdenum is as plentiful as tungsten and just as easy to handle, the unreliability of molybdenum in steel alloys being mainly due to the use of the impure metal and to the lack of knowledge of the proper heat treatment. The use of proper metallurgical methods in present times has vitiated any thought of unreliability upon the part of ferro-molybdenum alloys.

Shortly before the World War of 1914 there was a sudden demand for the metal caused mainly by Germany's demand for molybdenum. Apparently Germany anticipated a war and, realizing that it was impossible to lay up a sufficient stock of tengsten, was buying up large quantities of molybdenum to take its place. Although the market fluctuated abruptly, Great Britain did not realize the importance of the metal until war had commenced; it then sent out an urgent call for this vital metal.

The uses to which molybdenum was put during the war were varied, and so open to speculation that it was dubbed "the metallurgical mystery".

The molybdenum output today is carried almost entirely by the United States which produces from 80 to 90 per cent of the total supply. This market is available to the Allied Powers owing to the removal of the "Arms Embargo" by the United States Government just recently; consequently there should be no shortage of molybdenum experienced by these powers in the ensuing conflict. Germany will no doubt obtain some quantities from Russia and Norway, but at great cost for the deposits are uneconomical to mine.

USES OF MOLYBDENUM

The steel industry consumes most of the molybdenum produced today. Small amounts of sheet and wire molybdenum are employed as supporting filaments in incandescent lamps and radio tubes; and even smaller quantities, in the form of the oxide, are used by the chemical industry. Additional quantities are used in dyeing, woollens, silks, leather and rubber goods and this is one of the original uses of molybdenum compounds. They are, moreover, used in the preparation of blue colours, and for producing red and yellow pottery glazes, and sodium molybdate is an important ingredient of lithographic ink. The pottery industry has benefitted greatly from the expert use of molybdenum compounds in producing beautiful red and yellow glazes.

Alloy steels containing molybdenum are known in many fields; they are used extensively in aircraft and automobiles. Molybdenum is an invaluable aid in the nitriding of steels and may be substituted for tungsten in high-speed steels. It is present in rustless, heat-resisting and acid-resisting steels and is in alloy-steel guns and armour plate, saw steels, die steel, razor blades and many other products.

Aircraft and Automotive Industries

The use of aluminum-alloy beams for aeroplane wings is closely rivalled today by the production of chromium-molybdenum steel tubing. Heat treatment of the chromium-molybdenum tubing to a tensile strength of about 150,000 pounds per square inch permits the use of less material, so that the weight of the thin-walled tubing is equivalent to aluminum alloy beams of the same tensile strength. During the last World War it was suggested that all armour for tanks and aeroplanes be made of chromium-molybdemun steel and contracts were let with this idea in mind by the United States Government. The end of the war, however, prevented the fulfillment of these contracts.

Because of the hardness of chromium-molybdenum steel, it is used exclusively by some automobile factories in turning out axles, steering spindles and arms, bolts and similar articles. In tractor manufacture, chrominum-nickle-molybdenum steel is now made into rear-axle drive shafts, which are subjected to severe strain.

Nitriding Steels

This process consists, mainly, of case-hardening the finished product of steel by heating it in an atmosphere of nitrogen at fairly high temperatures, usually 900°F to 1000°F. The nitrogen combines with the elements present in the surface of the steel, and subsequently forms an extremely hard outer casing. Molybdenum nitride is one of the most readily formed nitrides with high nitrogen content, being superceded only by aluminum, and closely followed by chromium. Consequently, it is not surprising that an aluminum-molybdenum-chromium steel alloy should be one that is most frequently nitrided.

Molybdenum-nitriding steels are used extensively for pump shafts, steering gear sectors, valve guides, oil-pressure regulators, and many small parts for automobiles; in aircraft they are used for camshaft gears and, for control bushings, pins and bolts in which resistance to wear is essential.

CHARACTERISTICS OF MOLYBDENUM DEPOSITS

The characteristics of the mineral deposits of molybdenum are best described in relation to the ores, molybdenite and wulfenite. The molybdenite deposits are by far the most prolific of molybdenum deposits and generally, though not exclusively, are found associated with silicious igneous rocks. Quartz veins ~~carrying~~ with contemporaneous molybdenite ~~that has been deposited with it,~~ often have muscovite or biotite flakes along the borders and standing normal to the vein. The quartz is usually of the glassy, easily splintered variety. In other quartz veins the molybdenite may be deposited partly with the quartz, & partly in cracks in it, either as finely disseminated flakes or in large well formed crystals. A later movement often grinds the molybdenite that has filled the cracks into a "paint" which smears the quartz. Often the siliceous solutions that form the simple quartz veins, replace the country rock on either side of the vein, the molybdenite (being carried by these solutions) also replacing this rock.

Molybdenite, when it occurs in pegmatite, has been brought in after the solidification of the dyke and is a replacement mineral. The ore-bearing solutions moved along tiny cracks which subsequently have healed so well, as to be almost invisible to the naked eye. The molecules of molybdenite replaced the pegmatite minerals slowly, and to such an extent that it appears as one of the original minerals. This form of replacement occurs in granite. It is well to note that a tiny crack often leads to a large mass of mineral in apparently solid rock. This method is actually the true form of deposition of all the supposedly original molybdenite in granite, according to Hess.

Molybdenite is present in many contact metamorphic deposits, although these deposits are not very extensive. The minerals accompanying the molybdenite are those usually found in rock formed by contact metamorphism, such as garnet, epidote, hornblende, pyroxenes, scheelite, zeolites and sulphides of iron, copper, and zinc. The molybdenite may occur as mere flakes or in large crystals.

Molybdenite occurs in gneiss along the gliding planes. Apparently the solutions carrying the mineral were introduced while the rock, buried at great depth, was subjected to heat and pressure. But this must not be taken as final because the molybdenite is usually associated with glassy quartz, in which cracks heal very easily.

Wulfenite occurs only in the oxidized parts of lead veins, these veins not being very abundant. It is remarkable that the large lead producers in the world carry none, or almost none, of this mineral in their oxidized zones. Wulfenite undoubtedly formed from molybdenum original in the vein though the primary mineral has never been identified. It is possible that molybdenum may take the place of a small portion of the lead in galena, and finally the wulfenite is formed by the oxidation of the galena. Naturally, wulfenite deposits cannot be expected to extend much below the groundwater level.

OCCURRENCE OF MOLYBDENUM DEPOSITS

The largest molybdenum deposit in the world is found at Climax, Colorado. It is a molybdenite producer, the mineral occurring in a tremendous, silicified, brecciated zone. This siliceous zone has been cut by a large cirque in the west side of a north-south mountain ridge at an elevation of 12,000 feet. As might be expected, the topography is extremely rugged and climatic conditions are exceedingly severe. The developed ore body lies in a brecciated porphyry with granitoid rocks which are, in general, rather quartzose. The extent of the deposition of the molybdenite is amazing. The entire siliceous body has been thoroughly shattered though not crushed, to the extent that uncracked pieces exceeding two cubic inches in size are often found. Hot solutions from the magma passed through every crack and deposited sericite and silica in tremendous quantities. As this siliceous flow continued, thin films of molybdenite were precipitated in most of the veinlets and the entire mass sealed with silica. The ore being mined today averages much less than 1% and recently the production in this camp has been increased from 10,000 to 15,000 tons per day, according to Warren.

Other United States Deposits

In Colorado, there is also the deposit at Camp Urad owned by the Vanadium Corporation of America. It has been one of the largest producers of molybdenite to date. Wulfenite was mined extensively from the old Mammoth mine in Shultz, Arizona, during the last war and it occurs in moderate amounts in the nearby Collins mine. The occurrences of molybdenite in the United States are many, and attempts to mine the mineral have been made in California, Idaho, Maine, Montana, Nevada, Oregon, Texas, and Washington.

Australian Deposits

Australia has been for many years a producer of molybenite, and, though it has been found in all the states except Tasmania, the majority of the production has been in the eastern coastal region. Queensland has numerous deposits of molybdenite either in intrusive granite or in the adjacent country rock. The mineral when it occurs in commercial quantities, is found in pipes, in veins or in altered granitic rocks called "greisen". The largest producer in Queensland is the Wonbah Mine. The geological feature of the mine is the occurrence of molybdenite in a large quartz pipe. The position of a pipe is usually controlled by a system of cross-jointing in the granitic rocks producing a zone favourable to quartz deposition at the intersection of the cracks. The rock around the pipe is usually altered and the resulting structure is roughly tube-like, dipping at a slight angle from the vertical. A pipe is by no means a smooth and symmetrical structure but often follows an irregular path. In the deposit at Wonbah ~~there is a form of~~ some segregation of the minerals is apparent in the quartz pipe. The majority of the molybdenite mined is in the outer periphery of the pipe while numerous sulphides such as chalcopyrite, galena, and sphalerite, occur in the inner core. This obviates the necessary separation of the molybdenite from these minerals and since the gangue is clean, white quartz, metallurgical difficulties do not exist.

Other principal molybdenite-bearing districts in Queensland are those of Wolfram, Bamford and Khartoum. The structure of the ore deposit at Wolfram is represented by numerous pipes cutting a granodiorite mass; that at Khartoum is a mica-bearing, quartz-vein cutting granite. The mine at Wolfram yielded a greater quantity of wolframite but carried good quantities of molybdenite; the deposit at Khartoum carried only molybdenite. These deposits were worked from 1902 until 1920 when the British Government's war control ceased, as did the demand, causing the bottom to fall out of the market price of molybdenum.

There is an enormous contact metamorphic deposit of molybdenite in New South Wales comparable in size with that of Climax, Colorado. It is known as the Yetholme deposit, deriving the name from the near by town of Yetholme, and is situated on Mount Tennyson. The deposit is, however, of low grade and there must be a substantial rise in price before the mills already on the property will be able to operate. Here, granite masses have intruded Palaeozoic beds containing limestone and masses of garnet - wollastonite tactite carrying molybdenite have been formed. Numerous deposits, the majority of which are pipe-like, occur in New South Wales and Victoria and produced more or less molybdenite during the War, 1914-1918, and will be able to do so again, if necessary.

Norwegian Deposits

The Norwegian deposits are numerous, some being rich enough to be worked profitably under normal conditions. In the last war the miners found themselves ~~in the position~~ to sell to both groups of contenders; Germany was willing to offer a high price for the valuable mineral and Britain was willing to pay a higher price to prevent shipments to the enemy.

The most important discoveries in Norway are at Knabeheiem, North of Flekkefjord. The deposits can be divided into the following ~~classification~~:

(1) Quartz lodes;

(2) fissured granite, more or less decomposed, carrying molybdenite with little quartz;

(3) impregnated granite or norite.

Numerous minerals including pyrite, chalcopyrite, a little pyrrhotite, feldspar, mica and hornblende, are found in these deposits. The ore in many properties ~~carries~~ for a little depth and then pinches out; this may be a characteristic of the lode deposits in this sector. In the Knaben mine, the ore is in a finely disseminated mass occurring in wide bands with occasional pockets (of rich masses) of molybdenite.

It is of interest to note that during the last war rocks containing molybdenite became a form of currency in Norway. It was not uncommon for a shepherd to exchange a pound of molybdenite ore that he had obtained from the hills, for a pound of butter.

Although the deposits at Knabenheiem cover a great area, and,even with the multiplicity of deposits in the country, production in Norway is carried on by a few mines, the others being only of mineralogical interest.

There are molybdenum deposits in other countries: Sweden, Germany, Austria, Spain and China, but their importance does not compare with that of the United States, Australia, Norway and Canada.

MOLYBDENUM IN EASTERN CANADA

The production of molybdenum ores has been restricted to a zone of Precambrian rocks bounded on the south in Quebec by the lower Ottawa Valley and passing southwest through Renfrew county to southern Haliburton county in Ontario.

The classification of the various molybdenite deposits in this area, according to Wilson, is as follows:

(1) Segregations of pyrite, pyrrhotite, fluorite, quartz, and orthoclase in quartz syenite;

(2) Veins of pyrite, pyrrhotite, and quartz in granite gneiss;

(3) Pegmatite dykes, and felspathic quartz veins;

(4) and contact metamorphic deposits.

The largest molybdenite producing mine in Canada is representative of the first type of deposit. The molybdenite is disseminated in small flakes throughout the rich zone which is comparatively small. This property is worked by the Dominion Molybdenite Company and is near Quyon, Pontiac district, Quebec.

The second type of deposit is very similar to the first except that the flakes are much larger and occur more irregularly disseminated throughout the mass. The ore found in the mines of the International Molybdenum Company, on Mount St. Patrick, Renfrew county, Ontario, is typical of this second type. Apparently, the deposits do not go deep and the molybdenite is largely scattered, so it is not surprising that this kind of deposit has not proved very fruitful.

Occurrences of the pegmatite type are very common. Invariably they are irregular and the mineral content is inconsistent but often the mineralized areas are exceedingly rich. Since the molybdenite generally occurs in pockets, or as large flakes within the pegmatite zones, it can often be concentrated profitably on a small scale, by hand-cobbing. The total output of the Spain Mine in Griffith township, Ontario, was in the form of hand-picked flake, and the mine has been the most spectacular in the Dominion, having in places, solid lumps of molybdenite weighing twenty pounds.

In the fourth type, molybdenite is intimately associated with green pyroxene in the contact-pyroxenite of the Grenville Series. This kind of deposit is very prevalent in Southeastern Pontiac, Quebec; an example of which is the Squaw Lake deposit in Huddersfield township, Quebec. In many of these deposits, masses and also large well-formed crystals of molybdenite occur in a massive, green pyroxenite-rock, which is quite free from other metallic sulphides. They are spectacular in appearance, but are on the whole of doubtful commercial value.

The Moss Mine, near Quyon, Quebec, now owned by the Dominion Molybdenite Company, has had the best production record by far in Canada. Intermittently since 1916 it has mined 61,000 tons of ore and 58,000 tons have been milled, from which about 383 tons of pure molybdenite was recovered and shipped.

This production forms approximately 81 per cent of the total production in Canada since 1916.

MOLYBDENITE IN BRITISH COLUMBIA

The occurrences of molybdenite in the Province are manifold and have the distinction of being the richest in Canada. The ores, however, are difficult to handle owing to their complexity and association with deleterious minerals, namely, copper and arsenic. By taking full advantage of modern methods of separation it is, nevertheless, possible to obtain a fairly pure concentrate. The small quantities of copper present, if not in excess of half of one per cent, probably will not affect the strength of low molybdenum steels, and as for the arsenic, it should be possible to roast it out satisfactorily.

The molybdenite is associated with granitic rocks in most of the occurrences. The deposits often occur as a mineralization of quartz veins; as a dissemination of the mineral into granite or pegmatite, or as a impregnation of limestones by an engulfing granite. From this variety of conditions,

COMPANY OR MINE	LOCALITY	QUANTITY	APPROX. PER CENT	APPROX. MoS_2 CONTENT
		Tons	MoS_2	Pounds
Molybdenum Mining and Reduction Co.	Alice Arm	383.0	2.00	15,320
International Molybdenum Co., "Molly."	Lost Creek	202.5	5.89	23,840
New Hazelton Gold Cobalt Mines, Ltd.	New Hazelton	27.1	1.42	765
Index mine	Texas creek	8.0	15.70	2,512
Coxey mine	Rossland	2.7	14.00	756
Golconda	Ollala	2.2	17.11	753
Timothy mountain	Lac la Hache	0.4	30.00	240
	TOTALS	625.9	av. 3.68	44,186

TABLE OF PRODUCERS WITH SHIPMENTS IN EXCESS OF 500 POUNDS — BRITISH COLUMBIA

From Eardley Wilmott, 1925 p 31.

there have been but very few producers though the grade of the shipments has been high. A table of the producers is given, setting forth the record of shipments from this Province, in excess of 500 pounds, to concentrators. The list emphasizes the relatively high grade of ore shipments from the Province. It must be remembered an ore which continually runs one per cent is beyond the hopes of the most optimistic mine manager.

Alice Arm Molybdenum Mining and Reduction Co.

The Molybdenum Mining and Reduction Co. own numerous claims on the northeast end of Alice Arm. The formation, as a whole, is sedimentary consisting of slates or argillites which have many dykes and faults. It is not far from the intrusive granite masses which appear farther up the mountain-side. The ore occurs in a series of irregular quartz veins of the contact fissure type which are dislocated in places by shearing and by dykes ~~formations~~. The mineralization consists mostly of amorphous molybdenite, sometimes called jordanite, in the form of thin seams parallel to the walls, and in places where the seams have been crumpled and curved by pressure they attain a thickness up to one-fourth of an inch. Small quantities of pyrite are present but there are no other associated minerals. The ore deposit is fairly extensive and with a favourable price the company should be able to mine a large portion of the mineralized zone.

Lost Creek "Molly" Mine

The "Molly" mine is situated to the south of Lost Creek, on the old Dewdney Trail, about 15 miles by wagon road south of Salmo. The mine was operated in 1916 by the International Molybdenum Company but it has been turned back to the original owners at present.

The ore body is associated with the upper border of a large intrusive mass of granitic rocks that have been laid bare by erosion. The country rock consists of slate and shale, intruded by a granite mass which has been cut by pegmatite dykes, and along which the ore occurs. At certain areas, near the contact of the shale and granite, the rock has been altered to schist, and the granite contact with the sedimentaries is irregularly circular in shape. The chilled border of the granite forms a hard fine-grained shell, through which a few grains of molybdenite are scattered. This capping overlies the molybdenite ore zone, which is characterized by platy, or sheeted jointing of the granite. The jointing gives it an almost sedimentary appearance and it is chiefly in these jointing planes that the molybdenite occurs. In places where the granite is not so sheeted, but more blocky, the deposit is leaner or even barren.

During the last war two carloads of ore were shipped and since it is a low copper molybdenite, it may again produce when the value of molybdenite increases.

New Hazelton Gold-Cobalt Mines, Ltd.

The workings are located about 11 miles west of New Hazelton. The geology is straightforward, consisting of six well-defined veins, three of which are gold-cobalt and three copper-gold. The molybdenite is apparently confined to the gold-cobalt veins which are between granodiorite walls. The vein filling consists of hornblende, quartz, altered wall-rock and, in places, metallic sulphides. Arsenopyrite is the most abundant sulphide and carries almost all of the gold, cobalt and silver values. In places, considerable amounts of molybdenite are found in rich pockets. A considerable tonnage of molybdenite could be obtained from this property were it not for the difficulty of concentration which involves the economic separation and saving of the other valuable minerals present in the ore.

Index Mine

The property is about fifteen miles southwest of the town of Lillooet. The mine is located on what now forms the apex of an intrusive quartzose granite mass, which forms an elongated, irregular, oval-shaped mountain extending for a mile in a northeast and southwest direction. The granite is intrusive into schists and limestones that form outcrops encircling the ore-bearing granite mass, the schists being cut by numerous porphyry dykes.

The main ore-body is confined to a fracture, about two feet wide, running along the course of the granite. This fracture is richly mineralized, the ore in some places carrying 76 per cent molybdenite. The ore also occurs along closely spaced joint-planes in the fine grained quartzose members, as well as impregnations in the granite. The main exposure is about 300 feet along the apex of the mountain though the ore can be traced for several thousand feet. The mineral zone, in places, is at least 200 feet wide and is full of small, platy joint-planes carrying molybdenite. The zone probably averages from four to eight per cent. The ore has been found in numerous outcrops down the side of the mountain and it has been followed for 1,200 feet vertically. The molybdenite often occurs in vitreous quartz veins and a number of them is considered an indication of an ore zone. Although the quantity of high-grade ore is probably limited, there is undoubtedly a large tonnage of lower grade ore, free of deleterious minerals, which could be concentrated by a small mill.

Golconda Mine

This property lies one mile west of Ollala and 1,100 feet above it. At the outcrop, which is a few feet wide, a mass of decayed pyroxenite shows yellow molybdic ochre. The molybdenite, which carries copper sulphate, is slickensided and amorphous, but possesses a bright luster. The ore-shoot is lying against a steep fault plane or slip, running almost at right angles to the surface outcrop. The ore-body is wedge-shaped and tapers to a few inches in width down about 30 feet. This property, if exploited properly, may be a possible producer.

Timothy Mountain

This deposit is situated about 35 miles northeast of Lac La Hache (115 mile house) on the Cariboo Highway. The country rock is a grey, granitoid quartz-diorite made up mainly of hornblende and labradorite. The veins are banded fissure fillings, orthoclase and pyrite lying on the outside, with molybdenite and quartz in the centre. Bands of almost pure molybdenite, nearly an inch across, are not uncommon, the mineral being found entirely inside the veins which vary in width from one inch to three feet. Outcrops have been uncovered over a horizontal distance of 1,900 feet, and the greatest proved distance between veins across the strike is 75 feet. If this property were connected by a hauling road it would undoubtedly be possible to produce molybdenite profitably, especially in time of war, owing to the quantity and quality of the ore.

Mt. Olie

A recent discovery of molybdenite has opened up a property about 17 miles west of Mt. Olie on the North Thompson River. The greenstone lavas and intrusives of the area have been broken through in one vicinity by a stock of quartz-porphyry. The molybdenite occurs as filling in tension cracks developed in the outer periphery of the porphyry. The country rock is invaded with irregular aplite bodies and well-defined quartz veins, both of which carry the molybdenum sulphide. In at least one of the quartz veins, fluorite occurs with the molybdenite and thus creates an interesting association, mineralogically. The molybdenite has been found lying as an amorphous blue-grey mud in the lenticular tension cracks and also, as bright crystals impregnated into the quartz porphyry. This deposit is exceedingly rich in spots and if the prerequisite development is done, it may become a producer.

Westwold

The Grand Prairie Mine is situated three miles southwest of Westwold and approximately 500 feet higher. The deposit is typical of the type produced by intense metamorphism. The ore-bearing material is a two foot band of hard, greenish siliceous rock, with much garnetite. The ore-zone is quite extensive running roughly north and south and for approximately 1000 feet. The grade, unfortunately, is not high, ~~and the reason it was~~ discussed here, ~~is that~~ it is one of the best examples of contact-metamorphism ~~in~~ molybdenite deposits known in the Province.

The number of deposits that have been located to date in the Province may well exceed one hundred, but the majority of them are in the embryonic stage and cannot be pronounced upon and the others are too small for recognition. The conditions, however, are favorable for ore deposits of some magnitude and the number of properties recorded so far are indicative of a wide-spread occurrence of the mineral. Undoubtly, British Columbia could produce more than her share of this necessary mineral if called upon to do so.

SUMMARY

The world contains innumerable molybdenum deposits, all of which, except in the oxidized parts, carry the metal, so far as is known, in the form of molybdenite. Some of the molybdenite deposits, however, are extensive and contain large quantities of the metal. Wulfenite is of much less common occurrence, and the deposits are smaller, extending only as deep as the zone of oxidation. The form of molybdenum below the oxidized zone is unknown. Compared with tungsten deposits there are many more occurrences of molybdenite and the largest deposits are much larger than those of tungsten. A few, like those at Climax, Colorado, and Yetholme, New South Wales, are very large, though of comparatively low grade, carrying only about one per cent or less of MoS_2, and it is likely that under the stimulus of a continuous demand a large number of such deposits might be found. There are numerous areas where such deposits may be expected such as the mountain region extending from Mexico to Alaska; eastern Canada; Scandinavia; Siberia; the mountain region extending along the west coast of the Pacific from Tasmania to Siberia, - anywhere, in fact, where large areas of granite exist whose upper parts have not been deeply and generally eroded. In other words, the newly exposed granitic areas of the world. The scarcity which may result from an intensely absorbent market, if one should so develop during the next war, would give an added impetus in the search for this mineral. molybdenum.