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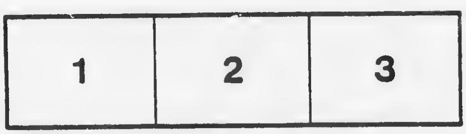

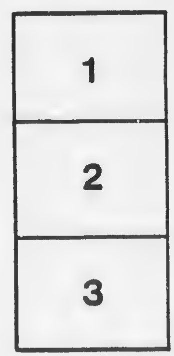

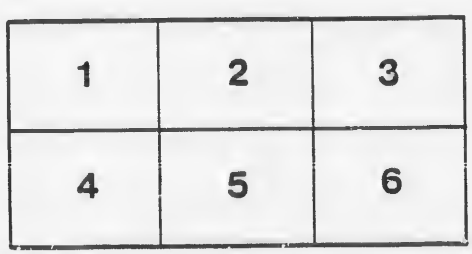

A GUIDE

INTERESTING

PHOSPHATE MINES

DESCRIPTION OF THE MINERALS

OF THE

LAURENTIAN FORMATION OF CANADA.

QUARTZ.—Quartz is the most common of all the materials of which rocks consist; it is one of the hardest minerals; does not melt in the hottest fire; is affected, but not dissolved, in the acids. A piece of quartz will write easily on glass. It is distinguished from any other mineral it resembles by breaking like glass as easily in one direction as another. It is of various colors, but mostly white, or some light shade of yellow, red or brown. Quartz is often found in six-sided colorless crystals. Sometimes one end of these crystals is attached to a surface of rock, forming brilliant groups. Purple-colored quartz crystals are the amethyst of jewellery; those of light yellow are the false topaz. The agate is another kind of quartz. The material of which quartz is made is called in chemistry Silica. Quartz, when pulverized and mixed with soda, potash, or some other minerals, melts easily and forms a glass. Common glass is made by melting together quartz, sand and soda. Hot water, containing soda or potash in solution, dissolves quartz, and deposits it again on its cooling. The water of hot springs often contain silica, which they have dissolved along with soda and potash; by deposits from such solutions fissures in the rock have been filled with quartz and the break mended. Sand and gravel beds have also, by these solutions, been cemented into the hardest of rocks. Quartz is very often found in the veins of the Laurentian formation; it also forms mountain masses, and then is called quartzite.

SILICATES.—A great number of minerals containing a large proportion of silica are called silicate. Of this the feldspar, orthoclase, oligoclase, labrodorite, etc., etc., are among the most important. Feldspar has generally a white or flesh-red color; resembles quartz, but is not quite as hard, though hard enough to scratch glass. It melts when highly heated, and breaks in one direction with a bright even surface; also in another direction nearly at right angles with the former. This kind of fracture is called cleavage. Quartz has no cleavage, while feldspar has cleavage in two directions. Wallastonite and seapolite are minerals resembling the spar.

MICA.—Mica, often called isinglass, is a soft silicate, does not scratch glass; is easily known by being easily cleavable into leaves thinner than the finest paper; the leaves are tough and elastic, and most frequently transparent; color white, grey, brown or black. White mica is very valuable, if cleavable in large smooth sheets. Clintonite resembles mica, but is harder. Mica is very common through the veins and disseminated through the rocks of the Laurentian formation, but is generally so dark of color as to be valueless.

TALC.—Talc is a mineral resembling mica, but the leaves are generally small and are not elastic. Massive varieties are called soap stone, steatite, etc., etc.

SERPENTINE.—This mineral is soft enough to be easily cut with a knife, and is generally of a green shade; it is distinguished by its compact structure, and a peculiar greasy feeling. A quarry where it could be got in good sized blocks would be of some value, if near railway or water communication. It is often used in paving the floors of public buildings, and many ornamental purposes.

PYRALLOLITE is a mineral somewhat resembling serpentine. Other soft silicate are gieseckite, volknerite and loganite.

HORNBLEND.—Hornblend is hard enough to scratch glass, and somewhat heavier than ordinary rocks; color, black or greenish black, rarely white; present in large quantities in the Laurentian and the phosphate band, as a vein stone and in beds. Asbestos, often called cotton stone, is a variety of hornblend.

PYROXENE.—Pyroxene is about the same weight and hardness as hornblend; color, various shades of green, occasionally greyish, white, brown, or black. It is an important rock in the Laurentian formation, and especially in the phosphate band, the latter being almost always followed by this mineral, and it is present in all the deposits that have yielded in any considerable output in Canada; it does not, however, follow that phosphate will be found where there is pyroxene. The Odegaarden mines, in Norway, are the richest phosphate mines in the world, but in these mines little or no pyroxene is found.

GARNET.—Garnet is very hard; color generally some shade of red; it is present in the phosphate bands in bunches of small red crystals disseminated through many strata of gneiss.

TOURMALINE is found scattered through most Laurentian strata in hard dark colored crystals; they often have only three sides; also six sided.

ZIRCON often found in the phosphate veins in beautiful four sided crystals of brownish red color; it is used in jewellery under the name of hyacinth, but is not very valuable.

SPHENE.—Like previously described silicates; crystals of this mineral are found interspersed through most Laurentian strata; the crystals are often wedge shaped and of a peculiar resinous lustre; its color is mostly a dark brown, grey or black. Willemite, Cryolite, Chondrodite, Tephroite and Idocrase are Laurentian silicates, and occur as crystal through the rocks and in veins.

CORUNDUM.—This is a very hard mineral and will scratch quartz or anything else, except diamond; color grey, brown or black; sapphire is a variety of corundum, and very valuable as gems; stones are called after their own colors, as follows:—Ruby, red; Topaz, yellow; Emerald, green; Amethyst, purple. Emery is another variety of corundum, and is extensively used for polishing and sharpening tools. Corundum consists chiefly of clay.

SPINEL.—Spinel is another Laurentian mineral resembling corundum.

CARBON AND CARBONATE.—Carbon is well known as common charcoal; the diamond is crystallized carbon, and can be burned like charcoal, but it takes a very strong heat to ignite it; carbon is present in the air, and in animal and vegetable substances; also, in many minerals; its compounds are called carbonates.

GRAPHITE OR PLUMBAGO.—Graphite (erroneously called black lead), is, when unmixed, pure carbon; it is familiar to all as the material from which lead-pencils are made, and as stove-blacking; it is one of the commonest of the Laurentian minerals and is found disseminated in most of the rocks; also, in an impure state in beds; the most valuable deposits are veins; it is found in the phosphate band, but only in small quantities; the graphite band underlies the phosphate band, and where one of these two minerals is found, there is but small hopes of finding the other in any considerable quantity.

CALCITE OR CARBONATE OF LIME.—Calcite often resembles feldspar, but is cleavable in three directions, and soft enough to be cut with a knife; coloress crystals sometimes resemble those of quartz, but are distinguished by their softness; in a rock form it is the common limestone; white or grey crystalline limestone is one of the most common rocks in the Laurentian formation, but is generally scarce near valuable phosphate deposits; all limestones dissolve with brisk effervesence in cold nitric or hydrocholoric acids. Veins of calcite or calcareous spar sometimes carry copper ore.

DOLOMITE.—Dolomite is distinguished from limestone, which it much resembles by not dissolving so readily in acids, except the solution is heated; it is an impure limestone containing magnesium.

HEAVY SPAR, OR BARYTES, is a very heavy mineral, generally white and much resembles feldspar in appearance, from which it is, however, easily distinguished, owing to its being heavier and softer; it is largely used in manufacturing white paint, and was at one time of considerable value, but has lately so much depreciated in price that it could hardly be mined with profit; it is often found in the veins of the Laurentian formation, sometimes carrying lead ore.

FLUOR SPAR, considerably harder and heavier than calcite, but does not scratch glass; color generally green and sometimes yellow, rarely red; it is of some value for manufacturing purposes.

PHOSPHATE OR PHOSPHATE OF LIME.—This mineral is never hard enough to scratch glass, and is considerably heavier than limestone; the color is generally sea green or bluish green, sometimes violet, blue or white, also yellow, grey, red and brown; its colors are not very bright, and it is often translucent; the powder of the mineral is always white, no matter what its color may be; it is composed of phosphate of lime with fluoride or chloride of lime, or both; the presence of fluorine or chlorine is variable; the one in many cases nearly or wholly replacing the other; in most kinds both fluorine and chlorine are present. The following is an analysis from the principal phosphate countries, taken from Danas' system of mineralogy; the one from Canada is by Dr. T. Sterry Hunt :—

	Murcia. Spain.	Arudal. Norway.	Suarmer. Norway.	Burges. Canada.	Greiner. Tyrol.
Phosphate of Lime...	92.066	92.189	91.13	91.20	92.16
Chloride of Calcium..	0.885	.801	4.28	.78	traces.
Fluoide of Lime	7.049	7.010	4.59	7.60	7.79

Apatite was named by Werner, a German mineralogist, from a Greek word meaning to deceive; older mineralogists having referred it to different other species. It is distinguished from other minerals by its crystals always being six sided, and is never hard enough to scratch glass, nor does it effervesce when heated with acids; but, if powdered and heated in nitric or hydrochloric acids, it dissolves readily without effervescence; if a small quantity of sulphuric acid or ammonia is poured into the solution, a white precipitate is formed; the nitric acid solution also gives a white precipitate, with acitate of lead; these tests can be performed by anyone. The acids, acitate of lead or ammonia can be had at any drug-store, also test tubes, in which to perform the operation; chemicals, enough to perform a hundred tests with, say, half a dozen test tubes, can be procured at no greater outlay than one dollar. The nitric acid should be a little mixed with water. The following is the process :—Take about a thimble full of acid in a test tube, add about as much of the finely powdered mineral as will lay on the point of a penknife, hold the test tube over the flame of a candle and let the acid boil for a few minutes; should the mineral be pure phosphate, the result will be that it will all dissolve, any residue is impurity; after the solution, cools pour in sulphuric acid or ammonia slowly, and it will sometimes be found necessary to stir the solution; if it contains phosphate it will turn milk-white, and if the tube is left standing some time a white precipitate will be formed; those who have the opportunity, should try the experiment with a known specimen of phosphate first, and they will afterwards have no difficulty of recognising the re-action of the mineral. Phosphate is one of the most abundant minerals in the Laurentian vein stones, of which it often constitutes the entire mass; it then appears as a crystalline rock of uneven fracture, and sea green color, passing into greyish or redish, sometimes intermixed with scales of black mica; in some instances, it forms a coarse crystalline mass, in which distinct prisms of apatite are observed penetrating the confused crystalline mass of the same mineral, which has apparently been deposited round them; it is most frequently associated with pyroxene and mica; also, calcite, generally of a pink color, hornblend, granite, and nearly all species contained in the Laurentian strata; the most characteristic are, however, pyroxene, calcite and mica. In most of the rich deposits, the pyroxene prevails largely, calcite and mica; being present in very small quantities; the pyroxene generally occupies the sides of the veins; the phosphate, which is often intermixed with small pieces of calcite and a few scales of mica, fills the central part. The apatite seldom forms a continuous belt of any considerable extent, but is cut off by pyroxene; many rich veins are filled with alternating irregular masses of apatite and pyroxene; some of these masses of apatite are very large, in a few instances five or six hundr . tons have been found in a body; these deposits often terminate abruptly, but are generally connected by strings. In a great number of veins, they are, however, entirely separated by the pyroxene vein stone, in which they are imbedded; but, in most of these cases, a crack or joint in the pyroxene will lead to the next mass of phosphate; this irregularity will be better explained farther on.

PART II.

Rocks of the Laurentian Formation.

Granites.—Granite is one of the crystalline rocks, and is a mixture of quartz, feldspar and mica; it is a hard and compact rock of red color, and is a valuable building stone.

Gneiss.—Gneiss consists of the same material as granite, but is divided into beds or layers of more or less thickness or regularity. It is sometimes difficult to say if a rock should be considered gneiss or granite, as there are all grades from genuine granite to gneiss; when other minerals than quartz, mica, or feldspar are present in gneiss, it is often named after these minerals, as for instance, when pyroxene or garnet are one of the constituents: pyroxenic gneiss, or garnetiferous gneiss. So also rocks resembling granite in structure are said to be granitoid; for example, some pyroxenic rocks are called granitoid pyroxene.

MICA SCHIST AND MICA SLATE.--When mica is the predominating mineral in gneiss, it is called micaous gneiss, or if in thin beds, mica schist, or mica slate.

SYENITE.—This rock much resembles granite in hardness and color; it consists of nearly the same minerals, the mica in granite being replaced in syenite by hornblend; while granite consists of quartz, feldspar and mica, syenite is a mixture of quartz, feldspar and hornblend. The Scotch, and many of the so-called statuary granites, are really syenites.

SYENITE GNEISS.—Gneiss consisting of the same material as syenite, is called syenite gneiss; or if hornblend predominates, hornblend, gneiss, schist, or slate.

TRAP.--This mineral has come to the surface in a molten state, it has flowed through fissures in the rocks, and has often overflowed the surrounding country; the part filling the fissure is called a dyke; it is a hard, tough, close-grained rock, of dark color, and more or less crystalline. Sometimes it forms a mass of prisms. Trap dykes are of frequent occurrence in the Laurentian districts.

PART III.

METALLIC ORES.

The majority of metallic ores can be distinguished from most other minerals by their metallic lustre; most of them are also very heavy, and as a rule not hard.

MAGNATITE,—An iron ore of black color; it contains 70 per cent. of iron, and is very heavy. It is known by being attractable by the magnetic. This very important ore is found in large quantities through the Laurentian formation of Canada; valuable deposits are generally beds.

HEMATITE.—A steel grey ore of iron, often also of a red color, the powder always being red; red ohre is an earthen hematite; it contains, when pure, about 70 per cent. of iron.

IRON PYRITES.—Cubic pyrites is of frequent occurrence in the Laurentian range, sometimes in crystals imbedded in other minerals, and, other times filling considerable portions of the veins, associated with apatite, pyroxene or mica; it is of a brass color, worthless as an iron ore, but of some value for the manufacture of sulphuric acid, if found near a railway or navigation. It occasionally contains nickel and cobalt.

MAGNETIC PYRITES resemble the cubic pyrites, but is attractable by the magnet and softer.

COPPER PYRITES.—This very important copper ore resembles magnetic pyrites, but is not magnetic; it occurs often in the Laurentian veins often associated with calcite, sometimes with iron pyrites, contains, when pure, 34 per cent. of copper.

MISPICKEL.—Mispickel, or arsenical pyrites, is of silver white color, hard enough to scratch glass, and extraordinarily heavy; it has been found in several places, through the Laurentian range, but sc far only in small quantities, contains about 46 per cent. of arsenic.

ANTIMONY.—Sulphuret of antimony is a soft but heavy mineral, of a lead grey color, but tarnishes black; can be cut in slices with a knife, and is easily melted; contains 70 per cent. of antimony; has been found in small quantities in Canada.

MOLYBDENITE.—Molybdenite, or sulphuret of molybdenum, is a soft and heavy mineral of a lead grey color; it much resembles plumbago, but is decomposed by nitric acid while plumbago is insoluble. It is a valuable mineral mostly found in quartz veins.

GALLNA.—One of the most valuable of minerals. All the lead and a large portion of the silver of commerce are obtained from this ore; it is soft, lead grey in color, very heavy, and contains over 86 per cent. of lead; can be melted in a common forge with charcoal; found with quartz, feldspar and pyrites in the Laurentian veins.

PART IV.

GEOLOGY.

GEOLOGY derives its name from the Greek, *ge* the earth and *logos* a discourse. It is a science of the greatest importance to the miner, especially to the Canadian phosphate miner. Engaged in what may be called a new enterprise, he cannot learn as much from the experience of others, as he could, if engaged in the mining of other minerals, but must, observe for himself, and note the facts which are likely to help him in explaining the nature of the phosphate deposits, and thus enable him to decide which deposits are valuable and which are worthless. Without some knowledge of geology, he is poorly qualified to make these observations. We will, therefore, for the benefit of those who have not had the advantage of a liberal education, endeavor to explain a few of the leading facts necessary to become familiar with.

All are aware that the solid parts of the earth consists of distinct substances, such as clay, chalk, sand, limestone, coal, slate, these, with a number of other substances, forms what is called the crust of the earth, or that part of our globe which is open to our observation; this is, of course, but a small part of the earth. Many would think only the surface, but the geologist is often, by reasoning from what he can observe, able to predict what will be found at great depth. This is plainly proved in digging artesian wells, water being invariably found as predicted by them. The rocks, forming this crust, are arranged in a certain order, and it is found convenient to divide them into four great classes, viz.: 1st. Aqueous rocks; 2nd. Volcanic rocks; 3rd. Plutonic rocks; and 4th, Metamorphic rocks. With reference to the different circumstances and causes by which they were produced.

AQUEOUS ROCKS.—These rocks are also called sedimentary or fossiliferous, and cover a greater part of the earth's surface than any other; they are stratified or divided into distinct layers; the term strata means a bed or anything spread out. It is plain, judging from the appearance of these strata, that they have been spread out by the action of water; we see the same thing going on every day at the mouth of rivers, and on river flats during freshets or high water; running water is always charged, more or less, with mud or sand, especially if the current is strong;

where the current stops, as at the mouth of rivers, or where river flats are overflowed, the mud or sand sinks to the bottom and forms strata or beds. In these beds we find pieces of wood, shells, the teeth and bones of fish, etc., etc. The same are found in the aqueous rocks, all the difference is, that they are petrified or turned into stone like the sand and mud; these petrified remains of animals and plants are called fossils; they are of great importance to the geologist and miner; for example it can be often told with certainty, if a coal deposit is valuable or not, from the fossils found in the coal. Aqueous rocks vary as to the mineral composition, color, grain and hardness, but they are properly classed together as having a common origin; they are all formed under water as mud and sand banks are at present; all the difference is, that rocks have had time to settle and solidify.

VOLCANIC ROCKS.—This division of rocks are such as have been produced near the surface, not by water, but by fire or subterraneous heat; they are not stratified, and carry no fossils; they consist of different sorts of lava, *i.e.*, a rock that has been ejected in a liquid or molten state by volcanos, and has cooled and solidified in the air or under water. We find volcanic rocks in many places where no volcanos exist at the present, from this we come to the conclusion, that volcanos have, at some day or other, existed in nearly every country.

PLUTONIC ROCKS.—These include all the granites and some other important rocks; they are supposed to be of igneous origin, but to have been formed under great pressure at a considerable depth in the earth; like the lava, they have been melted and have afterwards cooled and crystallized, but very slowly, and under very different conditions to bodies cooling in the open air; as a consequence they are more crystalline and more solid than the lavas. It would take too long to explain the long chain of facts and reasonings, by which this theory (the Plutonic theory) is established; suffice it to say, it is well established by facts and accepted by all geologists. Plutonic rocks have neither stratafication, nor fossils; they have often pushed through other strata, but rarely, if ever rests on them; some of the pyroxenes in the Canadian phosphate regions belong to this class.

METAMORPHIC OR STRATIFIED CRYSTALLINE ROCKS.—This great division of rocks is the crystalline strata and slates, called gneiss, mica, schist, clay, slate, etc., etc. They are often as crystalline as granite, yet are divided into beds; the beds are generally an alternation of substances, varying in composition, color and thickness, precisely as we see in the aqueous rocks.

According to the Huttonian theory, which is universally adopted, these strata were originally deposited by water in the usual form of sediment, but they were afterwards so altered by subterranean heat as to assume a new texture, having been heated to a semi-fluid state, and have afterwards slowly cooled and crystallized in a manner similar to granite. The animal and vegetable remains have mostly been destroyed by the great heat, still the remains of some shells are still found, some of them in Canada. The Canadian phosphate rocks belong chiefly to the metamorphic rocks.

LIMESTONES.—The limestones are deposited in a manner different to the other sedimentary rocks, and are chiefly made up of animal remains; they are at present being deposited on a grand scale in our tropical oceans, where coral reefs exist. Where limestones have not been subject to subterranean heat, we find the remains of corals and kindred animals. Limestones exist in most parts of the earth; thus, it is plain to us that where we now find mountainous countries, or where the eternal ice of the poles cover the ground, there once existed oceans of tropical temperature, in which coral reefs grew, as they are growing to-day in the Indian or Pacific oceans.

INCLINED STRATIFICATION.

We have seen that stratified rocks have been deposited by water. If we examine the ocean at the mouth of a large stream, as, for example, the Mississippi, it is found that the bottom of it is a plain of considerable extent, all hills and gullies having been levelled by mud and sand deposited by the river water. On this plain regular strata are deposited, the strong current of high water carrying coarse sand and pebbles, while the slow current of low water deposits mud and clay; from this it is apparent that stratified rocks were originally level or nearly so. If, however, we examine a mountainous country, it is found that the strata is frequently inclined at all angles, from level to vertical; from this we conclude that changes of level have taken place, and by closer examination we find that the strata has often been bent, something in the same way, as if we were to try to imitate mountains and gullies by bending the leaves of a book, or, in other words, the bent strata somewhat resemble, on a large scale, the face of a washboard. If a line is drawn along what would represent the bottoms of the gullies, it is called a synclinal line; one following what would represent the tops of the mountains is called an anticlinal; the curves of the strata are generally shortest at the anticlinals and synclinals, and the strata is often broken on both of these lines; the strain having been too great. It is quite apparent that a crack or vein on a synclinal would be narrow on the surface, and wide in going downwards; while one on an anticlinal would be wide at the surface, and narrow down like a wedge; it is evident, from this, that miners will profit from knowing or being able to recognize the one line from the other.

Dip and Strike.—If a bed or stratum is inclined to one side, it is said to dip, and the point of the compass to which it is inclined, is called the "point of dip," the deviation from a level line is called the "angle of dip." The strike or bearing of the strata is represented by a line drawn at right angles to the dip.

Fault.—Rents or cracks are often seen in rocks which appear to be simply broken, the separate parts remaining stationary, but a fissure is sometimes found several inches or yards wide intervening between the disjointed portions; these fissures are usually filled with loose earth, sand, rock or valuable minerals. It is not unusual to find that the rock, on one side of a fissure, has been thrown above or below the strata on the other side, with which it was at one time united; this displacement is called a shift, slip, or fault; sometimes they retain their parallelism in this motion so that the strata on each side of the fault remain parallel to one another; at other times they inclined one from another, but can still be easily identified; the different strata having the same thickness, and would fit as nicely as a broken piece of crockery, if they could be moved back to their original position. The difference in the level of the strata on the opposite sides of the fissures varys from a few inches to thousands of feet. A number of examples of faults can be seen on the south bank of the Ottawa River near the city of Ottawa. The shift in some of them is quite considerable. The miner is often perplexed by the faults he finds the lines and bearings which guide him cut off by the fissure, and the remainder of his deposit slipped away from him, and again it is often very difficult to find the extent and direction of the dislocation. In a number of faults the walls have rubbed against one another, and the surfaces are smoothed and polished; these polished surfaces are called "slicken sides." If the miner finds slicken sides on the walls of the vein in which he is working, he knows that it is of considerable length and depth, or, in other words, he is not working in a pocket or crevice. If, however, a fissure with slicken side crosses his vein, his deposit has moved in some direction or other. Faults or dislocations are very frequent in the Canadian phosphate districts, and it is of the utmost importance that they should be closely observed and understood.

DENUDATION.—As before stated, the dislocation in some faults amount to thousands of feet; in such cases we should expect to find one wall thousands of feet higher at the surface of the earth than the other, or, in other words, one wall should form a precipice above the other. This, however, is not the case, but the surface is generally as smooth and level as if no dislocation had taken place; this proves to us that the surface of our earth is continually wearing away. Large quantities of rocks have by water been removed to gullies, lakes and oceans, where it is found in the shape of boulders, pebbles and sediment, building up new stratafied rocks; this levelling process is called "denudation," by this denuding action of water, mountains are smoothened down, while holes and low places are filled up forming river flats and plains, fit for cultivation.

FORMATION.—The rocks resembling one another in one or more respects, are classed under the name of formation; for instance, a series of rocks in which we find the remains of fresh water shells and fishes, are termed a fresh water formation, those carrying salt water shells are said to be a salt water formation. The rocks of our phosphate region may, in the same manner, be termed the phosphate formation.

The rocks forming the earth's crust are divided into a great number of formations, according to their different ages. They are distinguished by the fossils found in them. The oldest of these formations is the Laurentian, and derives its name from the St. Lawrence River. The rocks of eastern and northern Canada belong to this series, and the phosphate band is the latest or the top of it.

MINERAL VEINS AND HOW THEY ARE FORMED.—Mineral veins are rents in the earth's crust caused by earthquakes or by shrinkage of the rocks passing from a higher to a lower temperature; they are generally filled with quartz or some sort of limestone. Sometimes metallic or other valuable mineral matters have found their way into such open fissures by infiltration from the surrounding strata, or by segregation as it is termed. Water, especially when heated under pressure, is a strong solvent, and springs are found which contain many different mineral substances, as, for instance, iron, quartz, sulphur, lime and others. The fissures termed veins extend downwards to indefinite or unknown depths; the water finds its way through them down, to strongly heated subterranean regions; is heated and dissolves the different minerals; it is afterwards ejected through the same or other veins by the pressure of steam or other causes; as it approaches the surface it is cooled, and the mineral substances are crystallized and adhere to the walls of the veins; in this manner the fissure is filled.

The valuable minerals would be of no use to us, if they were left scattered at random through the rocks; it would not pay to extract them, but nature does the greatest part of the work for us, sorting the minerals and storing them in the veins where they can be profitably mined.

Slickensides are found in a number of minerals veins, showing that dislocation has taken place, or that the vein is coincident with a fault. This fact helps to explain why veins are filled with a great variety of minerals.

It is a well-known fact that different minerals may crystallize out of the same solution, each as pure as if crystallized from a solution of its own, or, in other words, water charged with different minerals at the same time in the same vein; this explanation will not, however, do in all cases.

In our phosphate country we find the veins filled with phosphate of lime, pyroxene and many other minerals; most pyroxenes contain more or less magnesium, and phosphorous is more strongly attracted by magnesium than by calcium (lime);

if, then, a mineral spring charged with all the elements contained in the phosphate of lime and pyroxene, would discharge into a fissure, the result would be phosphate of magnesium and not phosphate of lime. Pyroxene and phosphate of lime can consequently not have been deposited from the same solution, unless causes, which we do not understand, have been in operation; the dislocations will, we think, give a key to the difficulty. Supposing a fissure is formed by an upheaval, settlement or earthquake, it passes through rocks of different hardness and of different mineral characters, it is consequently crooked, both in horizontal and vertical directions. A dislocation takes place after which the crooked walls will not fit one another closely, but a series of cavities are formed; the fissure cuts a spring charged with phosphate of lime, and the cavities are filled with this material; after this still another dislocation takes place, the spring carrying phosphate of lime is closed, while one charged with pyroxene and other minerals is opened, the new cavities formed are filled with these materials, and so on, dislocation after dislocation takes place; different springs are opened and cavities formed and filled with different minerals in the most irregular forms, and in a way that, at first sight, seems unexplainable and entirely at random, while it is really done by nature in a most systematic manner; if the fissure is straight and the walls perfect plains, the vein will be banded, *i.e.*, the different minerals will be found in regular beds; for example, first a bed of phosphate, then pyroxene, then mica, next iron pyrites, etc., etc.

Phosphate miners in this country are in the habit of saying that the place is "run out," when they have exhausted the mass of mineral, at which they have been working, but by closely observing what has been said above, it will be seen that where one mass of phosphate is found, other masses are very likely to exist close at hand, especially, if any slickensides are to be seen, and in many cases the searches will be successful. In the Laurentian formation in Canada, two classes of mineral veins are found, as follows :—Those filled chiefly with calcareous spar and sometimes with pyrites or fluor spar, often carrying galena, also sulphurets of iron, zinc, or copper; these veins are found to traverse strata of later formations, and are consequently of far later date than the Laurentian period, they carry no phosphate and are nearly always vertical and regular.

The second class are filled with quartz, feldspar, calcite, pyroxene, phosphate of lime, granite and graphite, of which one or more will be found to prevail, but they may contain besides, numerous other species, including, nearly every one to be met with in the Laurentian limestones, and their accompanying pyroxene and gneissic rocks; they exhibit great difference in mineralogical character, not alone in different veins, but in different parts of the same vein. When these veins occur in the phosphate bands, they are very frequently filled with pyroxene, associated with phosphate of lime, mica and calcite; it is in these veins that the greater number of valuable phosphate deposits are found; they are very irregular and found to vary in width from a few inches to twenty or thirty feet in a short distance; this irregularity will be easily explained by referring to what has been said on dislocations. In many of them, limestone is the predominant mineral, where this is the case, phosphate is not likely to be present in large quantities; veins containing large quantities of mica also as a rule prove failures.

DYKES.—Rents in the rocks, into which has been injected molten masses of rocks, as granite or trap, are called dykes; they are often of great width, and frequently traverse the different strata for miles.

Some ot the phosphate deposits have the appearance of being dykes filled chiefly with pyroxene, phosphate and sometimes granite. Many geologists are of the opinion that granite does not exist as a vein stone. If they are correct, we may feel certain that some of our phosphate deposit will not be exhausted for generations; there are, however, different opinions respecting this. Dr. Sterry T. Hunt, who has had large experience in Canada, thinks that all these deposits are veins. It will be found that many of them are dykes, while others are veins; this conclusion has been arrived at from close observation of the developments in the County of Ottawa. Dykes, it is known, are connected with the molten interior of our globe, and if they carry phosphate at or near the surface, it is difficult to see any reason why it should not be found at as a great a depth as has ever been penetrated to.

ROCKS OF THE PHOSPHATE BAND.—As before stated, the phosphate band is the the last of the Laurentian formation. The rocks of which its strata is built up, much resembles those of the lower part of this great series; there is, however, an easily observed difference, but it is, perhaps, impossible to describe them in such a way as to make them recognizable.

QUARTZITE, in which stratification is observable, is often met with ; it is generally covered with red-colored patches and streaks.

The granitoid rocks are generally coarse, and graduate into different varieties of gneiss, in which clusters of small red-colored garnet crystals are very frequent.

The pyroxene gneiss, in which important deposits are found, is sometimes coarse and granitoid ; at other times, thinly bedded and schistose, holding a number of garnets and often cut by fine grained granite veins. Fine-grained thinly bedded micaous gneiss traversed by thread-like veins of quartz are also of frequent occurrence.

The limestones are generally white, granular and highly crystalline, in bands seldom measuring twenty feet across, often holding crystals and grains of phosphate, sometimes amounting to twenty per cent. of its volume.

Pyroxene occurs in granitoid masses of different sizes and often forms whole mountains ; it has a variety of colors, but is generally of some greenish shade ; near the most of the valuable phosphate deposits, it is of a particular dark bluish green color. Crystals and particles of phosphate are nearly always found through it, and the veins, by which it is traversed, are generally filled with crystals of phosphate and mica, with more or less pyroxene as a vein stone.

APATITE OR PHOSPHATE OF LIME OF CANADA.—The existence of this mineral in Canada has been known for a considerable length of time, say, from the early days of the geological survey ; mining operations, also to some extent, have been carried on in the Rideau regions, but in most cases without any marked success, though this should often be attributed to want of perseverance and ability to conduct the work in an economic manner. On the whole, however, experience does not show favorably for the Rideau district.

In the County of Ottawa, a very little was done in mining until about eighteen months ago, but for the last twelve months a genuine phosphate fever has existed. Hundred of openings have been made with more or less success, but they were generally made in places where the prospects of a profit were slim.

Every farmer in the county, on whose farm there is any rocks, of course forces on his imagination that he must have a mine on his land; the farmers ask prices at, and speculators have been buying lands altogether at random, often paying considerable sums for worthless locations; the work has, in most cases, been in charge of men, who are not alone entirely void of scientific knowledge, but who had not a day's experience in mining in any of its branches; how sensible business men can expect success when their interests are in charge of men of this class is difficult to understand. Phosphate must have been too much for some of them.

Mining is the most difficult branch of engineering, and the mining engineer has the most extensive study of all professional men; how, then, is he to be successfully replaced by men, having neither theoretical nor practical knowledge of the subject?

Where the operations have been conducted by men in possession of the necessary knowledge, they have so far proved successful in the Ottawa district. Cases could be mentioned where large sums have been realized, and a number of persons have, by a trifling outlay, acquired lands that will before long prove very valuable; and even, at the present day, lots of one hundred acres that were purchased for from fifty to one hundred dollars with a royalty, a few months ago, cannot be purchased under five to ten thousand dollars, and even far higher amounts than these have been paid.

Of course, a number of losses have been incurred, but none of any great importance, but this we would mainly attribute to what has already been described as want of experience.

Men who have a few hundred dollars to invest, desire to make a fortune in a month or two; they buy at random a phosphate location for a large part of their capital, and then "go it blind;" in some but very few cases has success been met with, and they are owing to good luck more than judgment. Considerable capital is required in this as well as any other sort of mining to start with, although, in some instances, it may not be required, as, in many cases, not only expenses have been paid, but a profit has been made from the day work commences; nevertheless, it should be considered imprudent, as it is in all mining, to undertake work without a liberal margin to enable preservance, should success not be met with as soon as expected. We have no doubt but that many places that have been abandoned for the want of funds will prove very valuable, and in most worthless locations there never existed indications warranting any considerable expenditure.

The experience gained from the work done in the County of Ottawa goes far to prove that phosphate exists in inexhaustible quantities, and that it will soon become one of the staple productions of Canada. At McLaurin & Co.'s mine, in Templeton township, over ten thousand tons of mineral has been taken out in less than a year, without going more than twenty feet below the surface; a profit of not less than twelve dollars per ton must have been realized on this; it is stated that the location with some land attached has lately been disposed of for forty-five thousand dollars to English capitalists.

Mr. McLaurin is at present said to be working a mine even more promising than the one sold.

At Mr. Main's mine, in township of Hull, six to eight men have been employed for about ten months; the production has been about one hundred tons per month, the profits for the amount invested here must be large, owing to the short distance the mineral has to be drawn.

Mr. Walter Brown, now of Buckingham, who may be considered one of the pioneer phosphate men, has been remarkably successful in purchasing and selling lands; his former experience having stood well to him, and enabled him to secure rich locations. In some of the deposits discovered on the land owned by him, the production averaged one hundred tons per month, and where only two men were employed.

There are many other individuals and a few companies doing a prosperous and largely paying business, whose names are too numerous to mention, but we might state that the Buckingham

Mining Company, formed principally of Montreal gentleman, is considered one of the bonanzas of the country.

Shipments this year will aggregate about seven thousand tons from the County of Ottawa. The fact we consider significant. It should be remembered that the so-called mines, with one exception, are surface digging, and the only machinery used a common derrick; many of them have not even got this commodity, but the minerals and rocks are carried out of the holes by hand. In nearly all cases where water accumulates it is dipped out with pails.

PHOSPHATE IN NORWAY.

Norway is a country which, in geological and mineralogical character, very much resembles Canada. In that country phosphate has been mined to considerable extent for the last twenty-five or thirty years, as at Kragero, Skuttorud, etc., etc., and during the last six years the business has increased to something enormous, in some of the mines the yield exceeding one thousand tons per month.

In 1872, the Odegaarden mine was discovered, and many more have since been found in the same district, which seems to be the richest yet discovered. The phosphate occurs in a manner quite different to most Canadian locations; the immediate vicinity of the vein is occupied by spotted gabro, a sort of granitoid rock, composed of hornblend and labrodorite; the veins are mica veins carrying phosphate enstatite (a silicate resembling pyroxene in composition but containing more magnesia), and rutile (a dark-colored very hard and heavy mineral). The veins are not as irregular as most Canadian deposits, the mica is black and occupies the sides of the veins, in the richest deposit the quantity being small, merely a lining between the wall rock and the phosphate, which, in some cases, forms a continuous mass for the length of two hundred feet; the greatest width of pure mineral is of seven or eight feet. Sometimes the veins are filled with irregular masses and crystals of hornblend and phosphate; in some cases, the hornblend is replaced by enstatine, seldom by rutile. The country rocks are ordinary violet gabro (not the spotted variety), hornblend, gneiss, granite, ordinary gneiss and quartzite Limestone is not found in the vicinity of valuable deposits, and little or no pyroxene. Phosphate is not scattered in small pieces and crystals through the country rock as in Canada, but is found in the veins only.

It is the opinion of Norwegian geologists that all their phosphate deposits are irruptive veins or dykes. Mr W. C. Brogger and H. H. Reuch, in a report to the Norwegian Government, express this opinion; practical results prove them to be correct.

Mr. Dahll, who has had an almost life-long experience in phosphate mining at Kragero, has come to the same conclusion.

The gabro is considered in some way connected with the phosphate, and the eruption of the phosphate to have taken place simultaneously with, or immediately after the eruption of the gabro, before it was solidified. In some instances the gabro is intersected by a net-work of paying veins. Messrs. Brogger and Reuch report the following:—"The practical result of experience in our phosphate mines is, that we can reasonably expect to find apatite in gabro, especially if one or more of its characteristic associates, as enstatine or rutile, is found; only deposits in or in the vicinity of gabro have yielded any considerable out-put."

Are our Phosphate Mines Permanent?

This is a question in which much interest is taken at the present. In Norway these mines have proved as permanent as any others, and it is more than probable that the same will be the case in Canada.

We have here four classes of deposits:

1st. Grains and crystals of the mineral scattered through the different stratified rocks;

2nd. Crystals and irregular masses generally of a small size in pockets and crevices, or scattered at random through large masses of granitoid pyroxene;

3rd. Phosphate associated with various other minerals in veins filled by infiltration from the surrounding strata;

4th. Phosphate associated with other minerals in irruptive veins or dykes.

The first class is not likely ever to prove of any value; the rocks containing the phosphate could be crushed, and the mineral, being heavier than ordinary rock, washed out. Under this process it would be necessary that 40 per cent. of the mineral should exist in the rock to ensure a profit. No stratified rock has as yet been as rich as this; the richest that has come under our observation has been a band of magnesian limestone, containing about twenty per cent. Considerable work has been done in deposits of this nature, but not with the object of crushing the rock; the result has, of course, been unfavorable.

Deposits of the second class have proved most disastrous to our miners. It is the general opinion that where the mineral is scattered profusely over several acres of ground, some rich deposit must exist; this opinion has proved erroneous. It is surprising what a quantity of floating specimens will be thrown off by a small crevice or pocket; a great number of these locations have been tested and have proved failures, and probably always will. Experience tends to show us that phosphate does not exist in large irregular masses, except as a vein stone, and it is certainly most imprudent to attempt to work this class of deposit.

The third class of deposits have often proved very satisfactory. It has already been stated that two classes of veins are found in the Laurentian range of Canada, and that many of the valuable phosphate deposits are found in the second; also, that many of these deposits may be expected to extend down to great depth, and to be as rich as at the surface.

Norwegian geologists have proved that the phosphate deposits of that country are of Laurentian age, and there is good reason to suppose that the age of Canadian deposits is, at least, equal to that of those in Norway. It is admitted that the earth's surface has been worn down or denuded many thousand feet during comparatively short geological periods. If, then, our phosphate deposits are of Laurentian date, they have existed through countless ages, and the denuding action has, in all probability, been as intense in Canada as in other countries. These facts convey to us the conclusion that the deposits in times past extended to a level thousands of feet higher than the present surface. That the denudation at this time has reached to within a few feet of the bottom of all these deposits, seems unreasonable to suppose.

The greatest depth yet reached in any of the mines in Ottawa County is about one hundred and twenty (120) feet, and only in one case; at that depth the vein is fifteen (15) feet wide, and filled with pure phosphate.

The fourth class are irruptive veins or dykes, and are the only deposits found in Norway. They have there been worked with great success, and some of them have been profitably worked in Canada. In the locations considered, dykes or irruptive veins, many, but not all the characteristics of Norwegian mines, are present; that mines, quite similar to those existing in Norway, will be found in Canada, is almost without a doubt.

The writer has long wished to examine closely, certain districts in which he has good reason to think that such will be found. This being the only class found in Norway, explains why failures there have been less frequent than in Canada. The chances are, however, greatly in favor of the Norwegian miner, he having not only this class of deposits to deal with, which are most likely to prove valuable, and is not misled by the two worthless classes found in Canada.

Mining operations in Norway are always conducted by mining engineers of the highest scientific and practical knowledge, and the work done by old and experienced hands. Men of this class are, as yet, unknown in Canada. Norwegians are used to mining, and not likely to commence without the necessary capital. In this country the phosphate miner, in the majority of cases, commences with a few hundred dollars, and to this limited amount of capital may be attributed, in many cases, their want of success. Notwithstanding this, the production in some of the Canadian locations will compare favorably with the best results obtained in Norway.

At the Odegaarden mine, the production was three thousand two hundred tons during the two first years' work; the operations were on a large scale, a number of veins worked and the greatest depth reached one hundred and twenty feet. At the McLaren mine, in Templeton township, a thousand tons have been shipped in less than a year, without excavating twenty feet below the surface. Mr. McLaren, who has himself superintended the work, is a mill owner, and has spent his lifetime in the lumbering business; his employees are his old mill hands, the average number of them employed being about fifteen. Judging from the amount of work done at Odegaarden mine, the number employed there must have been about fifty. This comparison shows very favorably for Canada, and this success can only be explained by the unparalleled richness of Canadian locations. Cases could be multiplied were it necessary; but what has been said must (if experience be considered a guide) force the conclusion that Canada will, before long, become one of the greatest, if not the greatest, phosphate producing countries in the world.

EXPLORATIONS.—It is not the intention to say anything on mining proper; to do so, would swell these few pages into a large volume.

Most deposits are covered with clay or dirt; this should be removed for a considerable space, and the surface of the rock exposed to view; a careful examination of it should be made, so as to discover, if possible, the nature of the deposit; too little of this work has been done in nearly all the locations which have come under our observation; had this been better attended to, a large amount of fruitless expense might have been obviated.

It does not cost much to do a considerable amount of stripping, and miners should be patient and not spare a few dollars at this. After the stripping has been duly attended to, and the rocks properly examined, it will, in many cases, be possible to determine the nature of the deposit; if it belongs to the first or second class formerly described, no further work should be done, unless mineral enough is taken to pay expenses; it is, however, very unlikely that such will ever be the case.

Large masses of phosphate embedded in granitoid pyroxene may, possibly, yet be found, but must be very rare, none yet having been observed; in consequence, it would be considered imprudent to go to any expense in looking for such deposits.

Should anything be found, indicating that the deposit belonged to Class Nos. 3 or 4, stripping, in the direction of the vein, should be continued, and everything closely observed, bearing in mind, and remembering what has been said on dislocations, dykes and mineral veins ; this done, blasting may be resorted to if the place appears promising, but should not be long continued, unless enough mineral is taken out to pay expenses. If, this is not the case, it will be found cheaper to resort to boring; this operation is very simple, and the tools necessary can be made by any blacksmith, and can be had at a small outlay ; the principal tool is an ordinary drill of two inches in diameter and seven or eight feet long, to the upper end of which is attached a strong swivel, made so as to turn easily, but with a middling close fit. The hole is started in the same manner, as with an ordinary churn drill, but great care must be taken to go down perpendicularly from the commencement, the point of the drill should be nearly square, and of such a size as to make a hole large enough to allow of its turning with perfect ease, and the turning should be well attended to from the beginning, so as to make the hole as nearly circular as possible. When it is about five feet deep, the drill will be too short to work any longer by hand, a manilla rope of an inch diameter is then attached to the swivel (hemp rope will not do), and the drill suspended from the end of a spring-pole, 15 or 20 feet long, the large end of which is firmly secured to the ground in such a position as to leave six or seven feet of rope between the top of the pole and the drill, when the bitt or point is elevated about two feet from the bottom of the hole. After this, the drilling may be recommenced; some contrivance is arranged for two laborers to stand on, who, by depressing the pole, allow the drill to descend to the bottom of the hole, when the strength of the pole raises it again; the weight of the drill, when suspended, stretches the rope, and it untwists, thereby turning the drill; when the drill strikes the rock the weight is suddenly taken off and the rope twists back to its original position, moving the swivel to which it is attached; in this manner the drill is turned more perfectly than could be done by hand ; the hole is kept wet, as in ordinary drilling, and is cleaned out with a sand pump ; this is a sheet iron tube, small enough to be inserted into the hole, and fifteen to eighteen inches long, the bottom of which is a leather valve covered with a circular piece of sheet iron; the upper end has some contrivance by means of which a cord can be attached; when the hole is to be cleaned out, the pump is let down, and when the lower end touches the mud, the valve opens and the tube is filled; on raising the pump, the valve closes, and the contents are brought to the surface; to raise the sand from the bottom of the hole, it is necessary to give the pump a few quick jerks, so as to stir the sand up; pieces of steel as large as the top of one's finger have been taken up by means of this simple contrivance. From every foot as the drill goes down, some of the mud should be saved, dried, and tested for phosphate, as before directed. Two drills should be kept on hand so as to sharpen one while the other is in use, and when the hole becomes deep it will be found convenient to put up an ordinary wench, wherewith to raise the drill, when the mud is to be pumped out.

Cavities in the rock are sometimes struck, and the drill jammed in by pieces of rock, and it is sometimes difficult to get it loose; tongs and other contrivances are used, and it can always be taken out, but it will, in most cases, be cheaper to leave it, and bore somewhere else, unless it can be pulled out with the rope. When the drill is taken out after being thus stuck, the cavity should be filled with cement, which will set in a short time, after which drilling can be continued. The cost of the tools described should not exceed ten dollars, and two men will, under ordinary circumstances, bore ten feet per day; the cost is, consequently, about twenty-five cents per foot, exclusive of superintendence, or a hole, a hundred feet, can be bored for from twenty-five to forty dollars, while a shaft of that depth would cost, at least, one thousand dollars, and the information obtained by boring is about equal to that obtained by digging shafts.

Locations of great promise should be explored by boring only; to do so will, of course, require some capital, while by blasting a profit might be made from the outset; but this will, in many cases, impair the value of the mine. Systematic underground work will, undoubtedly, be found necessary in many of our mines. Where such operations are to be carried on, not a sod should be moved, or a blast fired unnecessarily, as, by so doing, the surface water is admitted, which will afterwards have to be pumped out at a great expense; in such cases the deposits should be explored, and the mine planned on paper by a competent engineer before blasting is commenced.

Where any large quantity is to be removed, this is by far the cheapest way. An idea is given of how cheap underground mining can be done, when we see coal miners, in Pennsylvania, raising coal from mines hundreds of feet deep, ship it to Ottawa, and sell it for six to seven dollars per ton.

Open diggings can hardly be worked with profit to a greater depth than fifty feet, be the vein ever so rich, while in extensive underground works, a depth of several hundred feet make little or no difference in the cost of the mineral.

It is often asserted that phosphate mining is very risky and uncertain the same might, with equal justice, be said of any business, if entered into by men wanting the required knowledge. Had our mining operations been conducted by competent men, they would likely have been as successful as operations of this nature ever are; but exploring can seldom be done without cost, and is not likely to lead to valuable discoveries if not properly conducted.

In purchasing and exploring phosphate lands, it should always be remembered that deposits Nos. 1 and 2 are worthless, the mineral being profusely scattered through nearly all kinds of rocks in districts where no valuable discoveries have yet been made.

Nothing should be paid for any location unless it is evident that it belongs to Class Nos. 3 or 4, in this case it may be valuable, but it may also be valueless, as veins are exceedingly numerous, and it is only exceptional cases in which they carry phosphate in paying quantities; however, with proper precaution and judgment, there is no reason to consider but that phosphate mining is as safe as most investments, and with the chances of its being far more remunerative.