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VOISEY'S BAY AND THE NICKEL POTENTIAL OF LABRADOR: A SUMMARY FOR THE NONSPECIALIST

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ABSTRACT

This article is a summary of Voisey's Bay and the nickel potential of Labrador, and is designed for the nonspecialist readers who have limited geological knowledge. The Voisey's Bay deposit was discovered in 1994, when drilling was completed at a site originally pinpointed in 1993 during an exploration program for diamonds. Voisey's Bay is a world-class nickel deposit, but it is not the largest or richest example of its type; based on its contained nickel metal, it is probably the seventh-largest in the world. However, it is probably the only place in today's world where high-grade nickel sulphide ores are known to sit close to deep-water access. There are three main nickel zones (or "sub-deposits") at Voisey's Bay, but one of these (the Ovoid) contains almost half the total metals. Due to its near-surface location, the Ovoid represents an even larger proportion of the total value of the find.

Large, high-grade nickel deposits are rare, because they are difficult exploration targets. The large exploration expenditures in Labrador in the post-Voisey's Bay years have still only scratched the surface of a remote and poorly explored region. Potential for further discoveries remains in the immediate Voisey's Bay area, but intense exploration coverage there indicates that these will likely be deep targets. Considerable potential for nickel deposits exists elsewhere in Labrador, but further discoveries can only come from sustained and systematic exploration programs, coupled with regional mapping. It is hoped that successful development of the Voisey's Bay deposits will result in renewed interest in the region's potential.

PREAMBLE

Since 1995, numerous technical publications have described and interpreted the geology of the Voisey's Bay deposit, whilst others have assessed the many other examples of nickel-bearing sulphide mineralization discovered in Labrador during the exploration boom of 1995 to 1998. However, there is a distinct lack of publications that explain facts about the deposits and discuss the nickel potential of Labrador in simpler language designed for the nonspecialist. This article is an attempt to fill that gap, and will hopefully prove useful to a wider audience with little or no geological knowledge, who are interested in finding out more about one of the province's most important mineral deposits and about its implications for the future.

This article is closely based upon the author's presentation and written summary from the 2001 "Voisey's Bay and Beyond" conference, held in Happy Valley - Goose Bay, June 25th to June 27th, 2001. The text has been updated to account for some post-2001 developments, and some simple illustrations used in the presentation have been included. Readers should note that the article is necessarily simplified for its target audience, and is not intended to be a full or exhaustive summary. For some intermediate-level geological information concerning nickel in Newfoundland and Labrador, readers are referred to the Commodity Series Report number 2, and references therein.

INTRODUCTION

The entire recorded nickel (Ni) production of Newfoundland and Labrador consists of about 100 tonnes, recovered from a small zone associated with the copper (Cu)–zinc (Zn) deposits at Tilt Cove, on the Baie Verte Peninsula, in the late 19th century. Although this seems trivial, it should be noted that the total *annual* world production of nickel in 1870 was a mere 500 tons, and Newfoundland thus represented a significant portion of this world supply. As we enter a new millenium, Newfoundland and Labrador is again poised to become a major supplier of nickel to the world, once the Voisey's Bay deposit is successfully brought into production.

This article has three main objectives. First, it provides a general overview of the Voisey's Bay deposit and places it in a wider global context. Second, it outlines the procedures employed in exploration for nickel, and discusses the special challenges that these deposits present. Third, it attempts to provide a general assessment of the potential for further discoveries of nickel in Labrador.

THE VOISEY'S BAY STORY

In 1993, Albert Chislett and Chris Verbiski of Archean Resources Ltd., discovered significant sulphide mineralization south of Nain, Labrador, whilst engaged in an exploration program for diamonds. They successfully persuaded a diamond exploration company to explore for nickel and copper, and drilling at the site now known as *Discovery Hill* commenced in late 1994. The second drillhole of the program returned a 41 m mineralized core intersection grading 2.96% Ni, 1.89% Cu and 0.16% (cobalt) Co, which awakened considerable interest in the mineral exploration community. Photographs of the early exploration work at Voisey's Bay (Plate 1) will eventually be an important part of the province's mining history. Three subsequent drillholes encountered similar mineralization, and geophysical surveys indicated a large *electromagnetic anomaly* (EM anomaly) nearby. An EM anomaly, as it is commonly termed, consists of measurements that indicate the presence of material that conducts electricity, which is unusual because most rocks are non-conductive. Sulphide minerals, however, conduct electricty extremely well, and this property is widely used in exploration. When this EM anomaly was drilled, the results made mining history; hole VB-95-07 returned 104 m of high-grade massive sulphide core grading 3.9% Ni, 2.8% Cu and 0.14% Co, and marked the discovery of the Ovoid zone, which is still the jewel in the Voisey's Bay crown. The Ovoid is a huge, bowl-shaped, accumulation of massive iron, nickel and copper sulphides that contains about 32 million tonnes of ore grading 2.83% Ni, 1.69% Cu and 0.12% Co. It is an extremely attractive sulphide accumulation from an economic perspective, because it sits just below the surface, and can therefore be mined very easily by open-pit methods.

Following the discovery of the Ovoid zone, it was clear that this was a find of major significance, and perhaps amongst the select group of discoveries that geologists call *World Class Deposits* (i.e., of a size and grade matched only by a few other examples worldwide). The discovery of the Ovoid also provided the impetus and financial resources to expand a high-cost exploration program in a remote environment. Within a year, deep drilling east of the Ovoid had discovered a second nearby sulphide zone, known as the Eastern Deeps, located 250 to 800 m below surface. The Eastern Deeps is an example of what geologists term a *blind ore body*, i.e., it does not intersect the surface. Although the Eastern Deeps is larger than the Ovoid in terms of overall tonnage, the sulphide minerals are associated with larger

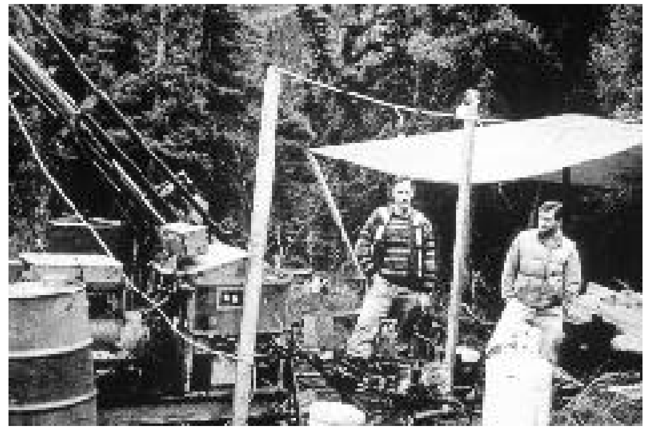

Plate 1. *Albert Chislett and Chris Verbiski at a drilling site near Discovery Hill in the early days of exploration at Voisey's Bay.*

amounts of nickel-poor silicate minerals, and the overall average grade is thus significantly lower. A third discovery was subsequently made just to the west of the Ovoid (by Inco, who took over Diamond Fields Resources in 1996). This discovery, known as the Reid Brook Zone, is also a blind deposit, located up to 1000 m below the surface. It has an extremely complex shape and is not as physically continuous as either the Ovoid or the Eastern Deeps. This, coupled with slightly lower metal contents in the sulphide ore minerals, also reduces its average grade to less than half that of the Ovoid. Although current reserve and resource estimates for the whole Voisey's Bay deposit include some smaller zones not listed individually above (e.g., the Discovery Hill and Northeastern Deeps zones), the bulk of the defined and indicated tonnage remains within the Ovoid, Eastern Deeps and Reid Brook zones.

The Voisey's Bay discovery had a significant impact on mineral exploration in Canada, and a tremendous impact in Labrador. It demonstrated that world-class, near-surface ore deposits remain to be discovered in Canada's hinterland. It also focused attention on the specific geological environment of northern Labrador, which had previously been regarded as having only limited potential for nickel mineralization. These factors combined to create a staking and exploration rush of unprecedented scale (Figure 1). Prior to 1995, annual exploration expenditures in Labrador were generally less than $1 million. The total exploration spending in Labrador from 1995 to 1997 was over $220 million, with $80 million spent in 1996 alone. However, 1998 and 1999 saw a progressive reduction in spending outside Voisey's Bay itself. This reflects many factors, but the most important were the lack of any new economic discoveries in Labrador, and the problems experienced by junior mining companies in the wake of the Bre-X stock collapse.

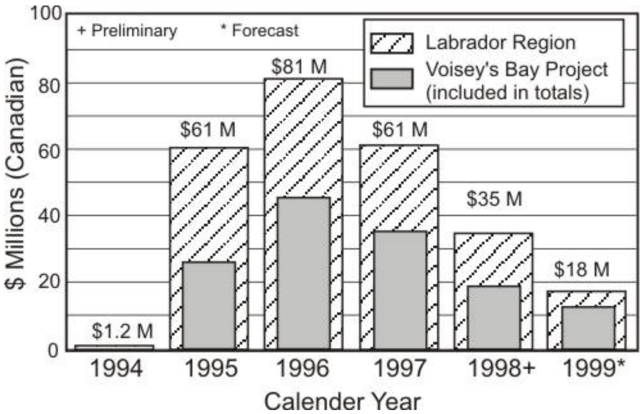

Figure 1. *Total exploration spending in Labrador from 1994 to 1999, showing the huge impact of the discovery of the Voisey's Bay deposit. The spending at the Voisey's Bay project itself is also indicated; note that this amounted to close to half the total expenditure. (From Newfoundland and Labrador Department of Mines and Energy statistics.)*

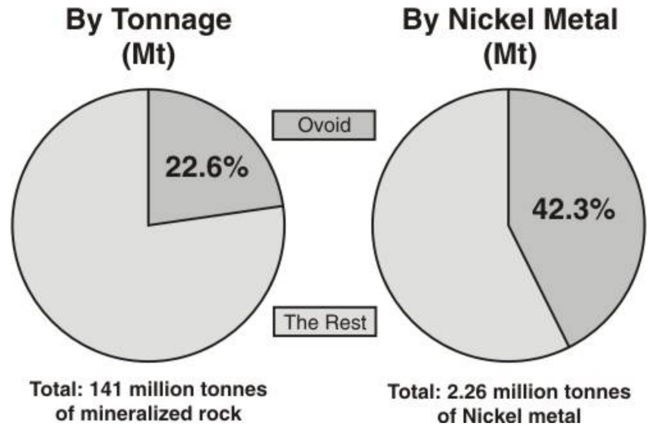

Figure 2. *The proportion of total resource tonnage at Voisey's Bay represented by the Ovoid zone versus the proportion of contained nickel metal that it represents. Given the relative ease of open-pit mining compared to underground development, it is clear that the Ovoid zone represents a very important part of the total "value" of the deposits.*

VOISEY'S BAY TODAY, AND IN A GLOBAL CONTEXT

The most recent total reserve plus resource estimate for Voisey's Bay by Inco is about 141 million tonnes at an average grade of 1.63% Ni, 0.85% Cu and 0.09% Co. As outlined above, most of this is contained within the three main zones, i.e., the Ovoid, Eastern Deeps and Reid Brook. Although the Ovoid represents less than 25% of the total tonnage, it contains more than 40% of the metals; given that it is also the easiest part to mine, and therefore potentially the most profitable, it represents an even larger proportion of the overall value of the Voisey's Bay project (Figure 2). The Ovoid is also the only part of Voisey's Bay that is presently considered to represent *reserves*, i.e., quantities of material that are precisely defined, and for which mining is considered economically feasible. The term *resource*, as generally used, is a more general estimate of the total amount of mineralized rocks, but it does not imply that all of this can actually be mined.

There is no doubt that Voisey's Bay is a world-class deposit, but it is a long way from being the largest or the richest deposit of its type in the world, as illustrated by Figure 3 (top). The deposits of Nor'ilsk in Siberia and Sudbury in Ontario each contain over 20 million tonnes of nickel metal, as opposed to about 2 million tonnes at Voisey's Bay, and the world's third largest nickel deposit, at Jinchuan in China, is still almost three times larger than Voisey's Bay. However, the inventory of nickel metal at Voisey's compares favourably with that of several other prominent nickel (sulphide ore) mining districts, such as Kambalda (Australia), Thompson (Manitoba, Canada) and Pechenga (Russia). In a generalized ranking of major sulphide deposits on the basis of contained nickel metal, Voisey's Bay is currently in seventh place, but it should be noted that this relative position depends on the reliability of reserve and resource figures from elsewhere, and how they are calculated – this is not an exact science.

Sulphide deposits are, however, only one of two types of nickel deposits in the world. The other type, known as *laterite* deposits, are developed through the intense tropical weathering and enrichment of rocks with originally modest Ni contents (<0.5%); needless to say, there is no potential for laterites in Labrador! Many individual laterite deposits, such as those of the French territory of New Caledonia (currently the world's largest producer of nickel) are equivalent to or larger than Voisey's Bay in terms of contained metal, as illustrated by Figure 3 (bottom). For example, the undeveloped Koniambo (Falconbridge) and Goro (Inco) deposits in New Caledonia collectively contain at least twice as much nickel as Voisey's Bay. In general, sulphide-type nickel deposits tend to have higher values per tonne, because they also contain valuable byproducts, notably copper, cobalt and the platinum-group-elements (PGE). The latter have become very important in recent years due to sharp increases in their prices. Although copper and cobalt make a valuable contribution to the value of Voisey's Bay, the deposit is in general very poor in PGEs, typically containing less than 0.5 grams total PGEs per tonne in the most massive sulphide ore.

Although these comparisons may at first seem rather discouraging for Voisey's Bay, some important factors must be kept in mind. First, comparisons of operating deposits

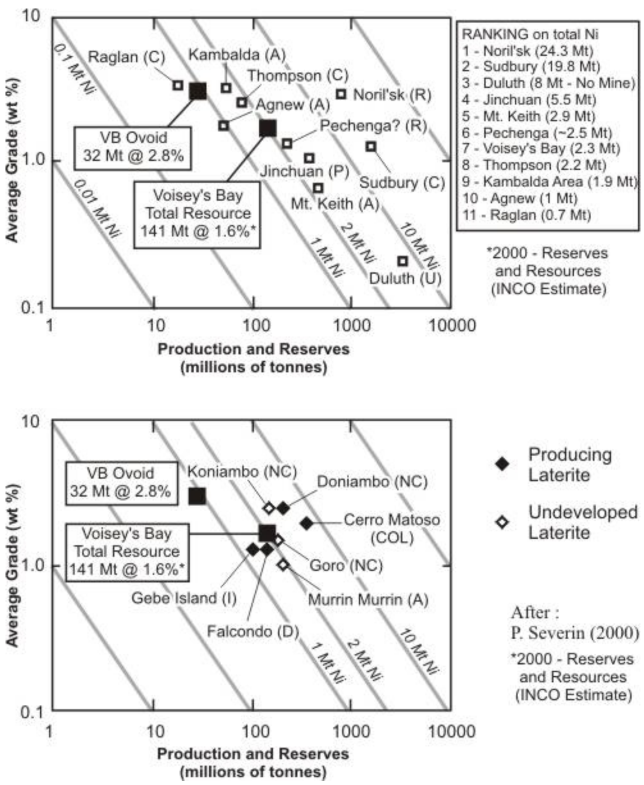

Figure 3. *(top) The major sulphide-type nickel deposits of the world, using figures from articles by A.J. Naldrett, with modifications. The axes of the diagram are logarithmic; thus, the diagonal lines in the chart indicate the amount of contained nickel metal. (bottom) Selected major laterite-type nickel deposits of the world, using figures from an article by Paul Severin, displayed on the same type of chart. C - Canada; A - Australia; R - Russia; P - People's Republic of China; D - Dominican Republic; NC - New Caledonia; I - Indonesia; COL - Columbia.*

from which large amounts of ore have *already* been removed, with newly discovered, unexploited deposits are essentially comparisons between apples and oranges. Although vast resources do remain in established districts such as Sudbury, they are increasingly expensive to mine, as the near-surface concentrations have long been exhausted. Second, the reserves of underground mining operations commonly grow through time, because detailed exploration at great depth only becomes practical once mining is underway. If one were to survey *today's* world for large, high-grade, near-surface nickel sulphide deposits located near deep-water access, Voisey's Bay (and specifically the Ovoid) stands out from all others. Third, it may appear that there is an abundance of large laterite-type deposits, but ore-treatment problems continue to impede the development of many and, to quote Paul Severin (vice-president of exploration for Falconbridge in 2001) *"Large, high-grade nickel sulphide deposits are rare, as are significant new discoveries"*.

To summarize, although Voisey's Bay is not the richest nickel deposit in the world, it is without question the most significant new *greenfield nickel* find (i.e., a discovery that focused attention upon a largely unexplored area) since the western Australian discoveries about 30 years ago.

EXPLORATION FOR NICKEL IN TODAY'S WORLD

There is a good reason why large, high-grade nickel sulphide deposits are rare – this type of deposit presents a very difficult exploration target. If mineral exploration is akin to seeking a needle in a haystack, exploring for a nickel deposit is like trying to thread the eye of that needle.

The majority of the world's metallic ore deposits are of a type termed *hydrothermal*, and are produced by the actions of fluids (typically superheated aqueous solutions) that move and circulate through the Earth's crust. In this process, metals are dissolved in the hot deeper regions of the Earth's crust and then redeposited at shallower, cooler levels. The passage of huge volumes of fluids through rocks produces what geologists call *alteration*, in which the original component minerals and chemical compositions of rocks are drastically altered. Nickel deposits, on the other hand, belong to a much rarer type of deposit termed *magmatic*. Deposits of this type form from bodies of molten rock (or *magma*) within the crust, and thus develop at very high temperatures (> 1000°C), in the absence of fluids such as water. Some magmatic deposits also form at far greater depths than hydrothermal deposits, and thus require far greater amounts of erosion to be accessible from surface. Nickel deposits form when liquid sulphur-rich droplets develop within a magma that contains minor amounts of nickel (<0.05%); the nickel is strongly attracted to the sulphur-rich liquid, which essentially scavenges nickel from huge volumes of the surrounding magma. If this nickel-rich liquid can then be physically concentrated (commonly by density segregation or fluid dynamic effects), and allowed to cool and solidify, an economic nickel deposit may result.

The mode of formation of nickel deposits affects a parameter that geologists call *target size*. Hydrothermal ore deposits are commonly associated with huge zones of alteration, which are many times larger than the actual orebodies. This means that the target is easier to find and, thanks to changes in the type of and intensity of alteration, geologists can develop directional indicators to guide the course of exploration. In contrast, the target size for a nickel deposit is only slightly larger than the ore zones themselves. A typical nickel sulphide deposit presents a target that is 100 to 1000 times smaller than a hydrothermal ore deposit of broadly comparable in-situ value. For example, a hole drilled in early 1995, just before the remarkable discovery hole VB-95-07, actually passed within a few tens of metres of the

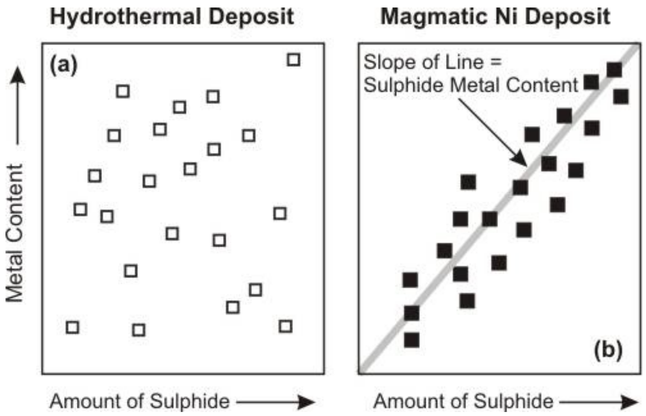

Figure 4. *Schematic illustration of the differing "grade spectra" of hydrothermal and magmatic sulphide deposits. (a) In hydrothermal deposits, there is commonly no well-defined correlation between the sulphide content and the metal content, and barren sulphides may coexist with high-grade material. (b) In magmatic sulphide deposits, the metal content of ores is commonly a simple function of the amount of sulphides that they contain. Thus, the sulphide metal content provides a fairly reliable indication of grade potential.*

Ovoid zone, but returned essentially no indications of nickel mineralization. A result such as this would be extremely rare in the case of a hydrothermal deposit.

A second important difference between magmatic nickel deposits and hydrothermal deposits lies in their *grade spectra*, or the range of metal contents observed in sulphide-bearing rocks (Figure 4). In many hydrothermal deposits large amounts of essentially barren sulphides coexist with smaller concentrations of ore-grade material, and the metal content of the "ores" is *not correlated* with the amount of sulphides that they contain. The situation in nickel deposits is very different, because the Ni content of "ores" is generally related closely to the proportion of sulphides that they contain. Using a simple mathematical procedure involving the analyses for Ni, Cu and sulphur, geologists can calculate the *sulphide metal content*, which normally remains fairly constant within a given deposit. For example, at Voisey's Bay the rocks show a range of Ni contents, because the amount of sulphide varies, but the sulphide metal content falls within a very narrow range (3 to 5% Ni). The same is true for many other major nickel deposits in the world, although the actual sulphide metal content varies; for example, at the Raglan deposit in Québec, sulphides commonly contain more than 10% Ni. Thus, in evaluating nickel sulphide mineralization, the sulphide metal content, or *tenor* is of critical importance, because it provides the upper limit for the grade of massive sulphide accumulations, should they exist on the property. In the nickel exploration business, the expression *"tenor is everything"* is commonly heard, and it

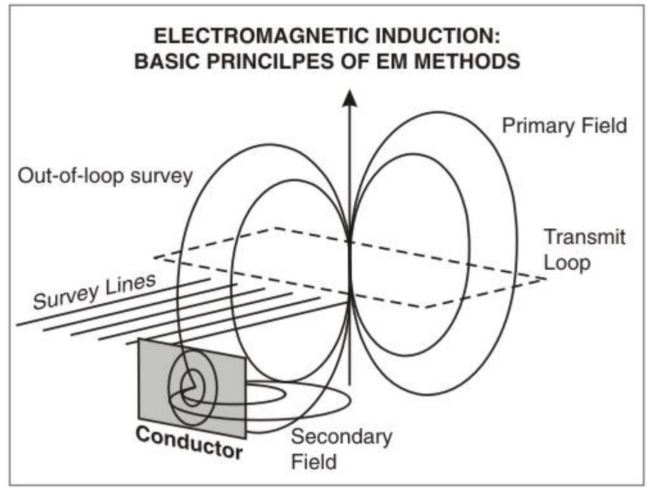

Figure 5. *A simple illustration of geophysical prospecting using electromagnetic (EM) techniques. A strong "primary" magnetic field is generated by a transmitter, which causes the development of a weak "secondary" field in a buried conductive zone. A receiver instrument is then used to look for the very subtle secondary field. EM surveys are by far the most common exploration method for nickel deposits.*

is a truism – this property will commonly determine if continued exploration is warranted. This characteristic of nickel deposits acts to further reduce the target size, but it does help in making decisions about continued exploration at a given prospect.

Exploration for nickel is, to a large extent, focussed around *geophysics*, which is essentially a method that investigates the physical properties of rocks and minerals, looking for unusual properties, or *anomalies*. The importance of geophysics reflects the small target size, and also the anomalous physical properties of sulphide minerals, notably the iron sulphide pyrrhotite, which is a good conductor of electricty and also variably magnetic. The dominant geophysical techniques in nickel exploration are *electromagnetic surveys*, commonly abbreviated to *EM*. These techniques all have a common methodology – a primary electromagnetic field is generated, which penetrates into the subsurface, where it generates a much weaker secondary field around any conductive rocks in the area. Sensitive detectors search for this secondary field, and repeated measurements attempt to position the source (Figure 5). Although geophysicists would cringe at the analogy, it resembles looking for a small mirror at the bottom of a deep hole with a flashlight. As the hole gets deeper, you need a more powerful flashlight to search, and you are less likely to spot a small mirror. In exploring for nickel, EM surveys become more expensive and less reliable when targets are buried hundreds of metres below the surface.

EM techniques are powerful, but have inherent limitations. First, sulphides are not the only conductive minerals; for example, the generally worthless mineral graphite produces equally strong anomalies, and is particularly common in Labrador. Under some circumstances, wet clays near the surface – or zones containing salt water – also produce spurious results. Second, EM cannot distinguish easily between dispersed and massive sulphides, nor can it provide any information about metal contents. Most importantly, EM techniques have finite depth penetration – in general, deeper targets require much stronger primary fields, and produce far more subtle secondary signals, which are harder to detect. There are many different EM techniques, but as a general rule the most cost-effective and rapid techniques (helicopter-borne systems) have the most limited penetration (<100 m). Detecting deeper targets generally requires more complex and costly ground surveys, which are effective to 250 to 300 m depth under most conditions. The responses of the Voisey's Bay deposits to various geophysical surveys illustrate these effects well; near-surface regions (e.g., the Ovoid and Discovery Hill zones) have clear and unambiguous responses, but deeply buried sections of the Eastern Deeps and Reid Brook Zones have very subtle geophysical signatures. Although there are exceptions, the general concensus is that interpretation of EM results becomes very problematic below about 400 m depth. A specialized technique known as *audio-magnetotellurics* or *AMT* has been employed at Voisey's Bay, and successfully images the deeply buried mineralization, but only in the most general, unfocused sense. To penetrate effectively beyond 400 to 500 m requires the use of *downhole EM*, where drillholes are used to place receivers closer to potential deep conductive sources. Needless to say, this is vastly more expensive than surface-based geophysical surveys. Other techniques such as seismic reflection (similar to methods used in petroleum exploration) have the potential to extend detection closer to mining depth limitations (i.e., 2000 to 3000 m), and have been tested successfully at Sudbury. However, their practical application in terms of mineral exploration (particularly in remote regions) lies many years in the future.

THE NICKEL POTENTIAL OF LABRADOR

The fact that over $250 million was spent in exploration of Labrador following the Voisey's Bay discovery has led some to conclude that Labrador has been thoroughly investigated, but this is not the case. Although this seems like a vast amount, it must be remembered that the Voisey's Bay project itself accounts for about half of this total (Figure 1), and most of this money was spent within a few kilometres of Discovery Hill. Exploration budgets elsewhere in Labrador typically allocated about half the total spending to air support services, notably helicopters; thus, the amount of money actually spent *on the ground* in exploration work is smaller than it first appears. Finally, many junior companies (some of which had existed for only a few months previously) were attempting ambitious programs with essentially no experience in either nickel exploration or the hostile, remote environment of Labrador. Many such programs were well-managed and systematic, but the results of others cannot be considered conclusive or exhaustive. In some areas, assessment reports were never submitted to government, and the exploration results cannot even be evaluated. The post-Voisey's Bay exploration boom did not locate a second deposit of comparable value, but it did result in the discovery of numerous new examples of magmatic sulphide mineralization, many of which merit further attention (Figure 6).

A well-known exploration proverb states that "*the best place to find a new mine is next door to an old mine*". Although the Voisey's Bay deposit is not yet a mine, this area remains highly favourable for future exploration. However, five years of intense exploration around the main deposits must constrain our expectations. As outlined above, large sulphide deposits less than 400 m below the surface should respond well to EM surveys, and this area has now been well covered by several such techniques. These results appear to rule out the presence of another near-surface orebody akin to the Ovoid, and suggest that any future discoveries around Voisey's Bay will be deeper, blind deposits, more akin to the Eastern Deeps. Deep-penetrating AMT surveys have also been conducted over much of the immediate Voisey's Bay area, but the results of these remain undisclosed. Recent results from deep drilling in an area known as Ryan's Pond suggest that a geological environment akin to the Eastern Deeps may exist here, with interesting grades (the sulphide metal contents here are up to 6% Ni). However, only dispersed sulphide mineralization has been found to date, and the great depth (> 1400 m below surface) limits the practicality of detailed exploration from surface. Regions such as this will be more easily explored following the establishment of underground mining.

The Voisey's Bay deposit is associated with a geological feature known as the Voisey's Bay Intrusion, which is a body of igneous rock, i.e., a rock crystallized from a magma that rose in the Earth's crust over a billion years ago. The Voisey's Bay Intrusion is dominated by rocks termed *gabbro* and *troctolite*, which themselves have higher nickel contents than most other common rock types. Moving farther afield, all areas known or suspected to be underlain by similar gabbroic and troctolitic rocks are prime exploration targets. At Voisey's Bay, these locally occur beneath a thin screen of younger granite, and do not form surface outcrops. The same situation may exist immediately south of Voisey's Bay, where existing mapping shows mostly granite and anorthosite. Inco has acquired the mineral rights to a large

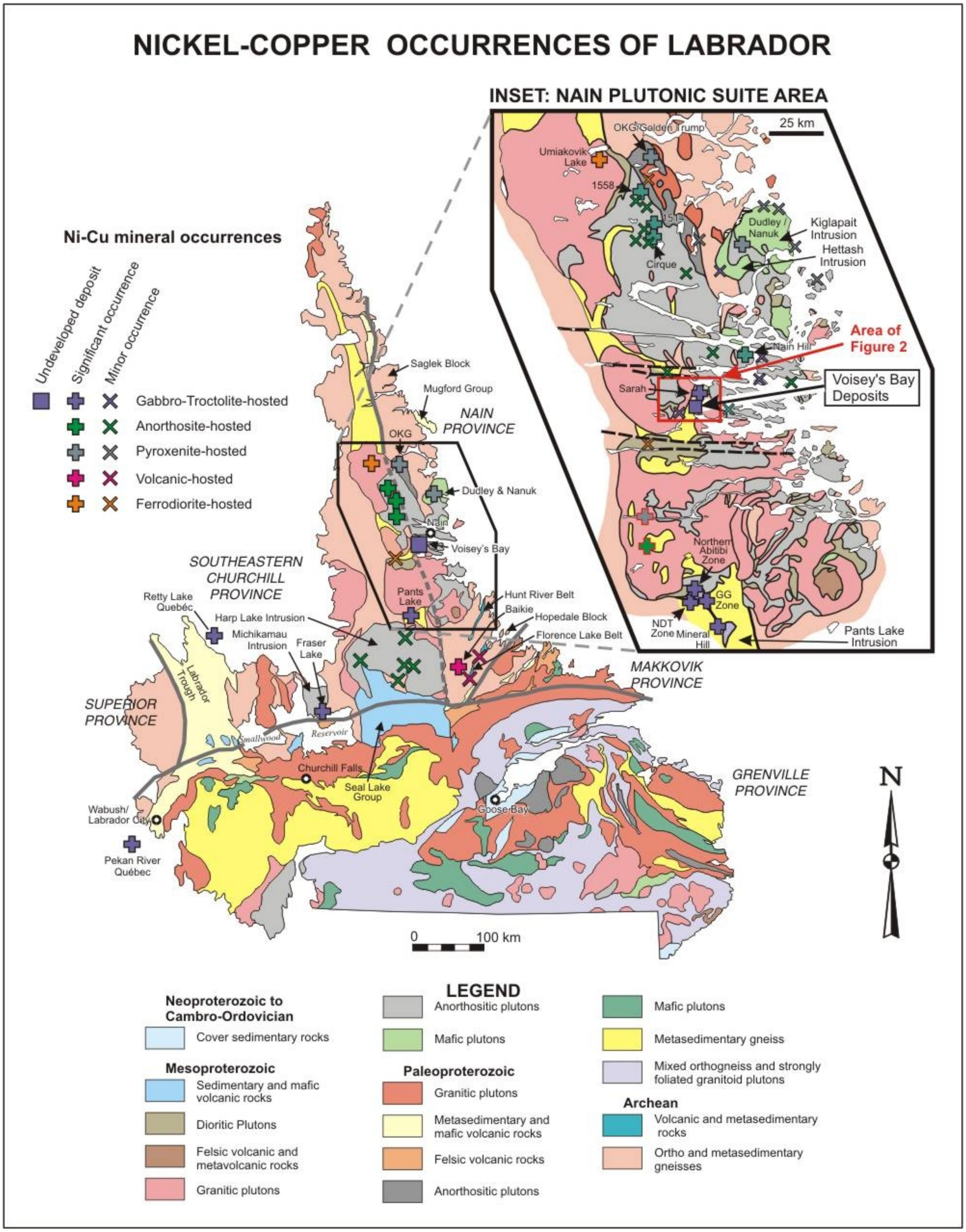

Figure 6. *A simplified geological map of Labrador, showing the locations of the Voisey's Bay deposit and many other examples of magmatic sulphide mineralization discovered during the exploration boom that followed the Voisey's Bay discovery. This map is reproduced from the commodity series on Nickel (#2), which should be consulted for further details concerning sites and mineralization types.*

part of this area, and perhaps intends eventually to test this hypothesis through geophysics and drilling. East of Voisey's Bay, International Canalaska Resources (in conjunction with Falconbridge Canada) failed to find the buried extension of the Voisey's Bay Intrusion by deep drilling in 1997. Although this does not rule out the existence of the favourable host rocks, it means that they would have to be beyond 1600 m depth, and thus cannot be explored effectively from surface. To the west of Voisey's Bay, deep drilling indicates a large body of potentially favourable troctolite, and the geology of this troctolite area remains very poorly known. Exploration by NDT Ventures in this area in 1996 and 1997 detected minor sulphide mineralization with sulphide metal contents akin to those of the Voisey's Bay deposit. However, geophysical coverage and regional geology imply that any potential targets must lie at significant (>500 m) depths. North of Voisey's Bay, favourable troctolite host rocks are also extensive within an area known as the Mushuau Intrusion, which locally hosts sulphide mineralization similar to that at Voisey's Bay. Although the Mushuau Intrusion is not exactly the same composition or age as the Voisey's Bay Intrusion, it has not been assessed in detail, and has recently been shown to be very extensive in the subsurface.

Regional exploration by junior mining companies throughout northern Labrador from 1995 to 1998 demonstrated that sulphide mineralization is relatively abundant in a variety of rock types (Figure 6). The most common type of mineralization is hosted by a rock type termed *anorthosite*, which is also the most abundant rock type in this part of Labrador. Many of these prospects were initially located by airborne geophysical surveys and later tested by drilling. Most analyses of core samples indicate that the sulphide metal contents are less than 1% Ni. Given the general consistency of sulphide metal contents in magmatic sulphide deposits (*see above*), the probability of intersecting higher grade sulphides at these occurrences is not high, although the surrounding areas may still hold potential. However, a few sites, notably north of Nain, returned higher sulphide metal contents (up to 1.5 to 2% Ni), and may thus merit a second round of exploration. Many other exploration projects were focused on rocks called *ferrodiorites*, which commonly show excellent geophysical responses because they contain abundant magnetite, which is a magnetic, but generally worthless, mineral. Disseminated sulphides are locally present in these rocks, but these generally also show inadequate tenor – sulphide metal contents are generally less than 0.5% Ni. The sulphides in these are more enriched in copper (up to 4% Cu), but copper-rich massive sulphide deposits of magmatic type are extremely rare on a worldwide scale, and there is no clear exploration model. However, geologists have been surprised by prospectors before!

Anorthosite- and ferrodiorite-hosted sulphide mineralization was extensively tested throughout the region from 1995 to 1998, largely because it provided the most obvious geophysical targets. However, many more subtle geophysical targets may have been overlooked, because the unusual conditions of the post-Voisey's Bay rush demanded the rapid establishment of drilling programs.

The best potential for nickel discoveries outside the Voisey's Bay region lies within rocks of similar composition to the Voisey's Bay Intrusion, which make up only a small proportion (10% or less) of the surface geology. The most prominent example is the Pants Lake Intrusion, a large body that formed the centre of the *South Voisey's Bay Project* of Donner Minerals and numerous partners. This area became the site of the second largest exploration program in Labrador from 1996 to 1998, and is now under active exploration by Falconbridge Canada. The Pants Lake Intrusion has many similarities to the host rocks at Voisey's Bay, is of similar age, and contains strikingly similar mineralization. To date, most of the mineralization has proved to be disseminated in nature, and the average sulphide metal contents are also lower than at Voisey's Bay (1.5 to 3% Ni versus 3 to 5% Ni). However, there are indications of higher grade sulphides in several areas. The areal extent of the Pants Lake Intrusion is huge compared to that of the Voisey's Bay Intrusion, and there remains much room for continued exploration here. Other examples of gabbro- and troctolite-hosted mineralization are present in the Nain area, and also merit continued exploration. Unrecognized potential host rocks of this type may be present in many other parts of northern Labrador, particularly in poorly exposed inland areas toward the Québec border, which still remain largely unmapped and unexplored. The 1995-1997 exploration effort was very much focussed on well-exposed regions dominated by anorthosites, and dominated by shallow-level EM targets. Thus, over much of this vast region, we have literally only scratched the surface. Geological mapping coverage in Labrador is far from complete, let alone its systematic exploration.

More than 80% of the exploration expenditures in Labrador shown in Figure 1 were within a 150 km radius of Voisey's Bay, and other parts of Labrador received far less attention. Many of these regions retain potential for nickel mineralization and some (e.g., the Hopedale area) are known to host prospects with interesting grades. Potential host rocks for nickel mineralization occur throughout Labrador, and many have not received even the most cursory examination. Successful development of the Voisey's Bay deposit in the years to come will inevitably reawaken interest in this vast region, and hopefully a second wave of more systematic and focused exploration will be the result. Continued geological mapping and research in Labrador will also play a key role in facilitating such activities.

ACKNOWLEDGMENTS

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