Property Submission
094B/11

British Newfoundland Exploration Limited

Office Study, Robb Lake Project
Halfway River Area
Northeastern British Columbia

94B5,6

Nov. 13, 1972

Neil Campbell

BRITISH NEWFOUNDLAND EXPLORATION LIMITED

Subject: Office Study, Robb Lake Project

Location: Halfway River Area, Northeastern British Columbia

Date: November 13, 1972

By: Neil Campbell, Consultant

SUMMARY

A consortium of subsidiaries of Texas Gulf Sulphur, Inc., W. R. Grace and Co., together with Barrier Reef Resources Ltd., has discovered lead-zinc mineralization in dolomitic sediments near Robb Lake on Halfway River. The discovery (herein referred to as the Barrier prospect) is believed to be of a type designated as Mississippi Valley, alpine or telethermal and can be expected to share certain important characteristics of other examples of this type including the Pine Point and SE Missouri deposits. Twenty nine drill holes and numerous surface exposures on the Barrier prospect have indicated relatively high-grade mineralization over minable thicknesses. Insufficient information is available to determine whether the attitude and configuration of the individual mineralized zones lends itself to the extraction by low-cost mining methods, but a comparison of the preliminary exploration results with those at a similar stage at Pine Point and elsewhere suggests that eventual highly profitable production is a reasonable possibility.

Brinex has been fortunate in both promptly recognizing the substantial commercial potential of the area and securing large land holdings some of which are geologically very well situated vis-a-vis the Barrier discoveries. In addition, significant new discoveries have been made on lands so acquired.

As the writer has not visited the area and has only a superficial knowledge of data acquired there, detailed and specific recommendations are not possible. Rather, this report attempts to offer the applicable experience gained from exploration in similar conditions elsewhere. The high degree of significance attached to known mineralization, the application of "trend geology", the significance of sedimentary facies, modes of mineral deposition and the statistics of drilling results are stressed. Substantial drilling programs are warranted. It is emphasized, however, that owing to the high cost of drilling and the fact that an unusual range of information can be obtained from less costly surface work, exploration should proceed cautiously with full evaluation of surface data before extensive drilling is performed. When drilling is done, either for reconnaissance or ore development, geometric patterns should be followed in order that full use may be made of statistical analyses in interpreting the results. The land position should be kept to a manageable size, having due regard to the importance of proximity to known ore and favorable geologic conditions.

BACKGROUND GEOLOGY

At this early stage in the development of the Robb Lake discoveries, an evaluation of the Brinex properties must take into consideration the empirical characteristics common to most telethermal Pb-Zn deposits, the nature of the Pine Point Deposits and the known features of the Barrier Reef Resources Ltd. discovery. The relevant aspects of Pine Point geology will be described briefly and the known salient features of the Barrier deposits will be discussed. The way in which these features relate to Brinex holdings will then be described.

The successful phase of Pine Point exploration was based on evidence indicating that a linear array of ore bodies in the middle Devonian should overlie certain faults in the Precambrian basement. This did prove to be the case. Whether or not the origin of the ore relates closely to the faults continues to be a subject of academic debate but from a practical viewpoint, the demonstrable linearity of the distribution of both ore in the reef horizon and sub-ore in horizons both above and below is important. A similar linearity is clearly observed in the New Lead Belt of Missouri and elsewhere. Other controls such as ancient water tables presumably also existed and restricted ore deposition to limited portions along the favorable

structural trend. Nevertheless, because the Pine Point structure was known to project into northern British Columbia, the recurrence of ore in the middle Devonian there was considered a theoretical possibility. Moreover, through the same logic, it could be anticipated that the detailed characteristics of the B.C. ore would rather closely resemble those of the Pine Point deposits.

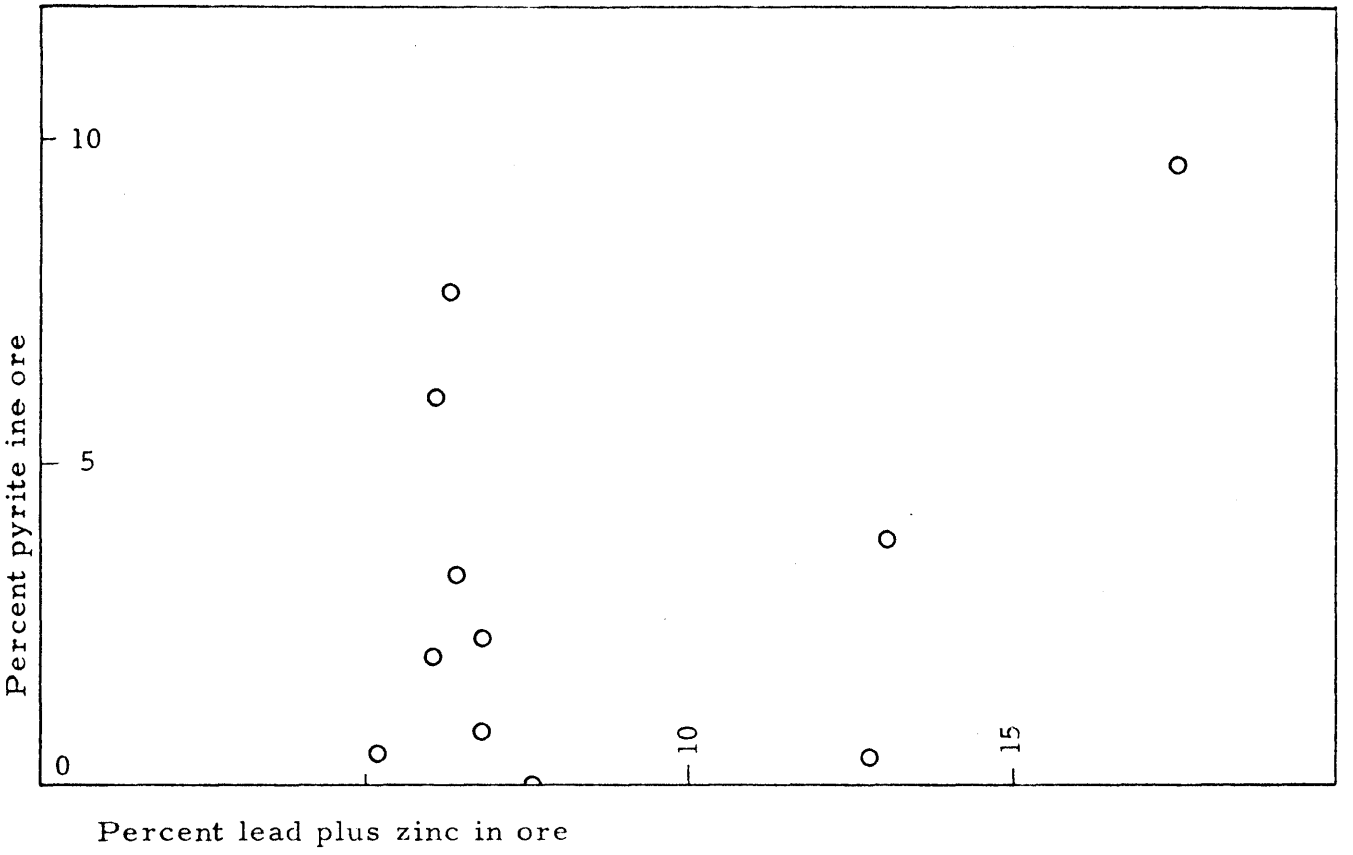
The host rock of most of the Pine Point ore is a faulted, coarsely recrystallized, vuggy dolomite generally co-extensive with a barrier reef. To the south of the reef, the beds pass into a fine-grained, hard, fossiliferous dolomite which still farther south contains salt and anhydrite beds of the Devonian evaporite basin. To the north, the reef interfingers with limestone and bituminous shales suggestive of deep water sedimentation. The beds overlying the reef are generally fine-textured limestones passing upward into shales. Below the reef are dolomite sandstones.

The ore bodies are of four general types. Those presently being mined by open pit methods are relatively rich, with maximum dimentions exceeding 100 feet in thickness and a few thousand feet in horizontal dimensions. They appear to be related to intersecting steeply-dipping fault systems accompanied by solution and collapse of the coarsely recrystallized dolomite reef rock. A second type (Pyramid) is similar but is situated mainly in the fine-grained

dolomite south of the reef body. A third type of ore body representing roughly half of the known reserves occurs within the reef but is relatively thin (average probably 10 to 20 ft.), and tabular with considerable lateral extent (up to 2000 ft.). The average grade is much lower (in the 5% Pb-Zn range) and the mineralization may be controlled by flat or gently-dipping faults or clay seams. The fourth type of mineralization consists of disseminated sphalerite and minor galena in the sub-reef dolomitic sands. These bodies are locally large but poorly defined, are generally low grade and may not be commercial at this time.

Diamond drilling has shown that galena and sphalerite is more abundant in ore bodies than pyrite/carcasite. There is no clear-cut relationship between the pyrite content and the presence of ore. In fact substantial bodies of heavy pyrite mineralization containing virtually no Pb-Zn are known. In some of the richer ore bodies of the first type, heavy pyrite forms a halo around the ore. In spite of the poor correlation between iron and ore, the pyrite is nevertheless useful in the application of geophysical techniques. The following chart shows typical relationships between pyrite content and metal values in ore bodies.

Distribution of pyrite with respect to values in ore



As has been mentioned, the ore in the Pine Point district occurs in numerous individual bodies and in this respect is similar to the ore in most telethermal Pb-Zn camps elsewhere. The ore bodies range in size from about 100,000 tons to slightly more than ten million tons. The following table illustrates approximately the district experience with respect to the statistical distribution.

Range in Tonnage	Number of bodies % of total	Tonnage % of total
Less than 150,000	17.14	20.53
150,000 to 500,000	28.57	
500,000 to 1,000,000	14.28	
1,000,000 to 2,000,000	28.57	32.48
2,000,000 to 5,000,000	5.73	9.34
5,000,000 to 10,000,000	5.71	37.65

Most, but not all, of the ore bodies lie within a rather regular belt thirty miles long and averaging slightly more than one mile wide. Within this belt, the ore bodies may fall along two or more fairly regular lines. The belt is parallel to the axis of the recrystallized reef but the reef itself is up to eight miles or more in width and has been traced for more than 100 miles. The lithology of the ore-bearing belt does not differ from that of adjacent barren rocks in any way that would be readily apparent.

The successful phase of the Pine Point exploration required pattern drilling over muskeg areas having very few outcrops. New discoveries were possible only because the operators had presumed precisely the correct trend of the ore belt. The drilling provided a good statistical picture of waste versus ore intercepts both as to the belt as a whole and within individual ore bodies. These figures are discussed later.

Other modes of exploration were attempted including soil geochemistry. The first geochemical surveys used cold extraction analyses and were totally ineffective even where traverses passed over extremely rich ore. The failure may have been due to a 40 ft. cover of glacial till reworked in part by lake waters. Electromagnetic surveys also proved ineffective even where substantial bodies of massive sulphides were known to exist. Gravity surveys gave weak responses over the largest ore bodies but were obviously useless as a reconnaissance tool. Time domain induced polarization surveys on the other hand proved to be highly effective and with their use, ore reserves were rapidly increased. It is noteworthy that frequency domain I.P. was generally much less effective. It should also be noted that spurious anomalies due to seasonal conditions were obtained. False leads were also obtained in other areas such as at Windy Point where the geology is similar but no ore is known to exist.

Turning now to a statistical treatment of drilling results, telethermal Pb-Zn deposits in carbonate rocks tend to offer few definitive guides to the explorationist. Stratigraphy and facies changes are commonly critically important but these features can rarely be observed on the surface. Structures such as shear zones and definitive wall-rock alteration offer little assistance. Historically, however, great im-

portance has been attached to the presence or absence of galena and sphalerite intersected by drill holes, even where the metallic content is far below the commercial level. In a given mining camp where the ore characteristics are well known, a given level of mineralization intensity can be assessed fairly accurately in terms of the probability of finding ore in the proximity of the drill hole. The appropriate future course of exploration can be determined. In new areas where it is not yet known whether the "habit" of the mineralization tends toward bodies of commercial size, such data can be used with much less confidence. (In the Robb Lake area, where no ore has been developed by detailed drilling, the experience from Pine Point may be applied with appropriate caution and reservations).

It is a widely accepted practice in exploration for telethermal ore deposits to classify mineralized drill hole intercepts with respect to both the grade and thickness of the mineralization. That is to say, the core assay is multiplied by the true thickness to give a figure in terms of feet per cent lead plus zinc. Formerly, a minimum thickness of eight feet was used but in many camps, 12 feet is now used. One might imagine that very low grade mineralization distributed over a very great thickness might give a misleading ft.-per cent reading but this appears rarely to be a problem. Drill intercepts are classified as to metal content as follows:

Intercept Category	Pine Point ft. /%	S.E. Missouri ft. /%
Shines	Nil	Nil
Trace	1-15.9	1- 7.9
Indicative	16-39.9	8-19.9
Ore	40 or more	20 or more

By "Shines" is meant a few widely-spaced crystals of sphalerite or galena in drill core, quantitatively insufficient to be detected in conventional assaying. Where the stratigraphic position and litho-facies are appropriate in Missouri, the occurrence of shines is considered by many as being indicative of the "right ball park" and justifies reconnaissance drilling on a spacing (in horizontal beds) of approximately one square mile per drill hole. In S.E. Missouri, the ratio between the number of trace holes and ore bodies found in reconnaissance drilling is not known precisely but probably lies in the range of 10 to 20 trace holes per ore body found. In the same region, "indicative" holes have considerable statistical importance. That is to say, approximately five indicative intercepts are encountered for every ore body found. Drilling on an open (1000 ft.) pattern is justified by such a discovery in an appropriate geologic environment. An "ore" intercept found in reconnaissance drilling is extremely significant. In one program of 65 holes, one ore body was developed around one of the three "ore" intercepts. In other programs, the

ratio of ore intercepts to ore bodies was much higher. An ore intercept justifies close-pattern (200 ft. grid) development drilling.

The statistical experience at Pine Point was generally similar to that in S.E. Missouri except that an ore intercept was statistically more likely to indicate an ore body. That is to say, between six and seven ore bodies were found for every ten ore intercepts obtained in reconnaissance drilling.

It should be emphasized that a so-called "ore intercept" does not necessarily mean that the intercept is of commercial grade and thickness. Rather, the classification of intercepts should be regarded as a way of presenting a certain kind of purely geologic data that has been found through long experience to have relevance in evaluating the results of reconnaissance drilling and planning further work. It should also be stressed that the statistical experience is most useful in places where it is already known that the general geological environment does produce bodies of commercial size and grade. Where it is known that the environment does not produce such bodies, the statistics have much less relevance. For example, recrystallized dolomite in S.E. Missouri (called "white rock") is known to contain mineralization which tends to be erratic and forms only small deposits. Ore intercepts in this facies have comparatively little commercial significance. At Robb Lake, one cannot yet be

sure that the geological environment does produce commercial concentrations of ore as no detailed drilling nor production has been done. At this point in time, however, it would be reasonable to assume (in spite of the absence of proof) that conditions there are similar to those at Pine Point and that the statistical experience is transferable with caution. This is discussed later in more detail.

The foregoing relates to reconnaissance drilling. A statistical evaluation is also necessary in the detailed drilling of an established ore body. In most American camps, the distribution of ore-grade mineralization within an ore body capable of being mined profitably is erratic and follows a "swiss cheese" or "moth eaten" pattern. In close-pattern drilling of such an ore body, a certain percentage of the holes will report as sub-ore or waste. The ratio of ore to waste holes is very commonly as high as 50%. In a typical but not representative ore body in the Pine Point region, close pattern drilling yielded the following distribution:

Trace or blank	8%
Indicative	16%
Ore	76%

Generally, the margins of the ore bodies here are defined by sharp "drop-offs" in ore intercepts. Both here and elsewhere, the ratio of ore to sub-ore intercepts is important in evaluating the degree of certainty that the estimated tonnage and grades will actually be realized in mining. Where the ratio is 80% or better, there is a

high level of certainty that the estimated tonnage and the estimated grade (or better) will be recovered in mining. Where the ratio is low, some of the ore grade material may be discovered to be in the form of small runs and unminable pods.

BARRIER REEF RESOURCES DISCOVERY

The writer has not visited the Robb Lake area and is therefore not qualified to comment on many significant features of the local geology. However, Mr. Westoll has described the excellent field observations made by the Brinex staff and consultants G. J. Dickie and C. R. Stelck. The geology of the Barrier discovery was also discussed with Mr. A. F. Reeve, President.

No attempt will be made to paraphrase the geological information already compiled. Briefly, however, the Robb Lake area is situated on the approximate projection of the basement structures underlying the Pine Point area. The continuity of this structure into northern British Columbia has been indicated by many lines of evidence best developed by Alberta petroleum companies. As at Pine Point, the mineralized horizon is in the middle Devonian. As stated by Dickie, the middle Devonian includes dark shaly limestones in which dark gray fossiliferous reefal dolomites are developed at various stratigraphic levels. In some places as in the Mt. Bertha

area, the reefs are small, about 50 feet thick and overlain by shaly limestone. In the Reef Mountain and Westoll areas, the reef build-up is about 200 ft. thick. The reef material is strongly recrystallized in places and shows the significant "zebra" structure in many places. A similar reef build-up is understood to comprise the host rock of the Barrier discoveries.

It might be noted here that none of the Brinex specimens available at Vancouver showed the coarse recrystallization observed at Pine Point. Some of the Barrier specimens do show this feature. No great significance is presently attached to this. It should also be noted that a reef is a relatively rigid organic body which yields less to compaction than do correlative sediments and is recognized not so much by the presence of fossils as by its form and relation to off-reef facies. This is mentioned because of the hazard in identifying a particular bed as reefal where its relation to other facies is not definitely known.

A black, non-calcareous shale (Besa River formation) is reported to overlie the middle Devonian shaly limestones and reefal dolomites. The shales tend to be expressed on the surface by broad, flat knolls and it outcrops only along creeks.

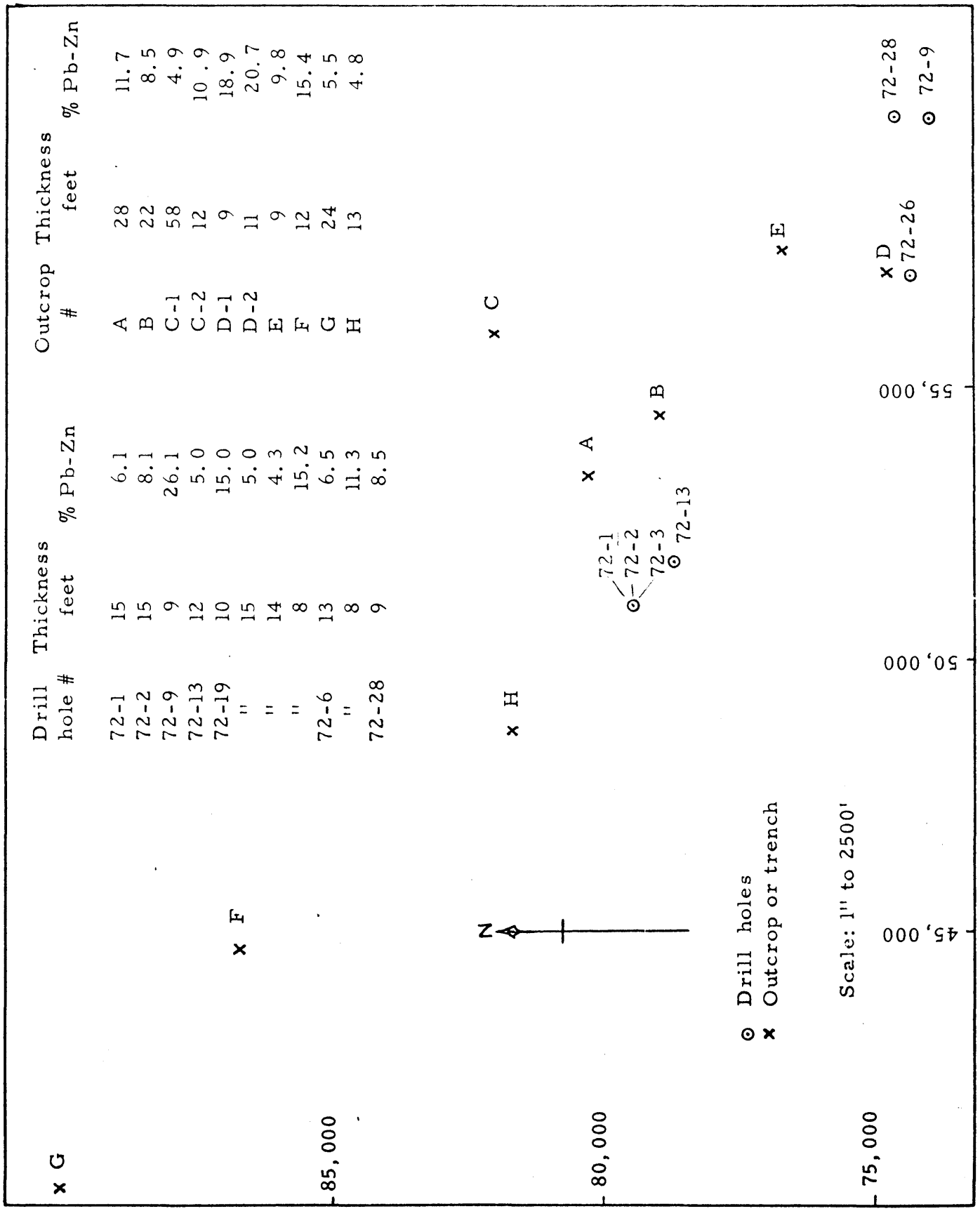
The structure is characterized by a series of NNW-trending gently-

pitching folds and strong WNN thrust faults. Exposures of the host rocks are determined by the local structural conditions and the mountainous topography.

The Barrier (or "Robb Lake") discoveries are said to be situated in a northwesterly-trending anticline (or pericline) whose flanks dip to to 50° at one end and up to 20° at the other end. The significant mineralization so far found is said to lie within a ten square mile area roughly five miles long and two miles wide. Actually, all occurrences of ore-grade localities but one reported to Barrier shareholders lie within a belt five miles long, 2000 ft. wide and trending N 50° W in relation to the Barrier coordinate system. (See plate 1). Twenty-nine holes totalling 14,910 feet have been drilled. Seven of these intersected values well above the 40 feet per cent Pb-Zn level used to classify Pine Point ore intercepts. Six of these cut lower grade mineralization over 65 to 300 feet in length. The drill holes were grouped in three areas and therefore do not in themselves give a reliable indication of the total potential. However, significant mineralized outcrops have been found in various places (probably including a few that were drilled). Assays are reported from ten such localities and these are generally richer and thicker than the drill intercepts.

The mineralization is said to be in a recrystallized reef dolomite.

Fig. 1: Distribution of Barrier mineralization
As reported by A. F. Reeve, Oct. 2, 1972



Some of the mineraled specimens displayed by Reeve are coarsely recrystallized but others consisted of finely crystalline dolomite. Reeve believes the ores resemble those of central Tennessee. By way of explanation, the latter are generally believed to be located at a horizon where ancient, descending surface waters leached carbonate material near the then existing water table where circulation was facilitated by faulting. Collapse then occurred and ore was deposited in the breccias so developed. The resulting ore bodies formed highly irregular, linear "runs". The mining of this type of deposit is more costly than in the more "blanket" like deposits found at Pine Point and S.E. Missouri. The difficulty could be expected to be substantially increased if the beds were inclined rather than flat as in Tennessee and the profitability of the deposits correspondingly decreased. In the absence of any detailed drilling, much less actual production experience at Robb Lake, the writer can see no source of evidence on which such a comparison can be made safely. Accordingly, it seems reasonable to suppose that there is a strong possibility that the shapes of the individual mineralized zones are more like those found in the otherwise similar deposits at Pine Point. The few Robb Lake mineralized specimens seen by the writer are highly brecciated, infilled and partially replaced by secondary dolomite and sphalerite with minor galena. Pyrite is scant or absent in the specimens. Nevertheless some iron oxides are seen.

The justification for Brinex exploration in the Robb Lake relates to the quantity and grade of ore which may have already been encountered by Barrier. Some estimate of the success of Barrier is therefore necessary however weakly based and uncertain such an estimate may be. It is not presently known whether the mineralization encountered by Barrier is in small pods or bodies large enough to mine. Nor is it known whether the configuration of the shoots lends itself to low-cost mining. If it be assumed, however, that the bodies are minable by low-cost methods and that individual shoots are of a size normal for telethermal Pb-Zn deposits or averaging about one million tons, then it can be said that general experience suggests that approximately ten million tons averaging 8% Pb plus Zn may have already been tapped by drill holes and surface exposures. It is not known how much of the mineralized belt has been removed by erosion nor how much farther it extends but the "potential" ore not yet found could be a multiple of this figure. (This compares with 1971 Pine Point reserves of 43.5 million tons averaging 2.5% Pb and 6.0% Zn). In summary, if the statistical experience described is applied and the geologic assumptions are correct, the Barrier discoveries represent a zinc resource of substantial volume and grades well above those of most of the producing North American mines of the same type. Again, the conjectural nature of this estimate is emphasized.

No attempt will be made here to estimate the profitability of mining Robb Lake ore as defined above. It may be noted parenthetically that 1971 Pine Point net profits were $3.08 per ton after taxes $0.57/T, depreciation etc $1.63/T and operating costs $4.02/T. It might also be noted, that although a railway was built to Pine Point, early studies showed that operation with truck haulage was feasible.

BRINEX DISCOVERIES

The foregoing descriptive material is offered as a basis in experience for evaluating the new discoveries where the "habit" of the mineralization has not yet been established by development operations. Within this context, the following "ground rules" appear to be applicable:

(1) The existence of galena and sphalerite in place is regarded as the most important kind of evidence with respect to possible ore, even where the grade of the mineralization is well below ore levels. Where these sulphides are found in the formation known to be the host rock of ore elsewhere, the degree of significance is greatest. Where the mineralization is found in other formations such as shale, sandstone and limestone (as opposed to dolomite) the degree of significance is much weaker.

(2) The ore reserves eventually developed may be comprised of numerous isolated bodies averaging around one to two million tons. Although the reason may be conjectural and the actual effect masked by a broader distribution of poorer mineralization or confused by thrust faulting, there is a strong possibility that the more profitable ore bodies are distributed in a linear array. Early recognition of this tendency may have a considerable influence on the eventual profitability of the exploration venture.

(3) The mineralization will almost certainly be found at several stratigraphic horizons. However, the most commercially valuable ore bodies may be expected to exist only in the most favorable host rock. Specifically, they may be expected to occur in or closely associated with thicker reef developments.

Metallic content of rocks:

It has been mentioned that in early exploration at least, soil geochemistry at Pine Point was totally ineffective. In the Mississippi Valley area generally, the experience has not been much better. In the Appalachian camps where considerable thickness of residual soil overlies orebodies, some success was achieved. In the Kootenay Arc area, explanations for numerous geochemical anomalies have been found by drilling but success in finding ore bodies by this means is questionable. In the Robb Lake area where rapid erosion may have truncated concealed ore bodies, a higher expectation of success would be reasonable. The discovery of mineralized float is probably a better guide to ore although here again, a search for the origin of such float may prove surprisingly frustrating. The discovery of sulphides in place (even where not of ore grade) is regarded as highly significant. In spite of the fact that ore may contain very little pyrite and heavy pyrite concentrations may contain no ore, the existence of gossans, however weakly developed, must be regarded as worthy of investigation.

In Brinex claim block 5 (Nabesche area) rocks of the favorable horizon are understood to be relatively well-exposed although the kind of lithology found at the Barrier discoveries may not be well developed. Geochemical work has been done but the results (which are presumably not very encouraging) have not been studied by the writer. It may be significant that substantial quantities of sphalerite in outcrop are said to occur in a thrust block roughly five miles to the southeast. This means that some 40 miles south of the Barrier discoveries, the mineral belt may still contain ore.

The Brinex block 2 and adjoining Marini option (Perkins property) is reported to be underlain by a thick development of reefal dolomite with widespread recrystallization. A comprehensive overview of the soil geochemistry is not available at this writing although a lead background of 80 PPM is mentioned and local anomalies up to 200 PPM have been obtained. Undoubtedly the most important "bit" of geochemical information is the result of pattern rock sampling where samples over 50 foot squares gave values averaging 1.2% Zn in one instance and 1.8% Zn in another. As the beds dip 50^{o}, this may represent a true thickness of up to 40 feet. Because bedrock sampling offers a degree of material selection not possible in a drill core, the results cannot always be equated. Nevertheless the results obtained at this locality correspond to drill intercepts of 48 and 72 feet per cent

respectively. Referring to the earlier remarks on the classification of mineralized intercepts, these results are seen to be in the highly significant range. The picture is further enhanced by the presence of breccia. Briefly, the existence of ore at or near this locality is not assured but the results definitely provide justification for testing by pattern drilling.

Cusker - Bertha:

Brinex claim blocks 1, 3 and 4, the Southwest Bertha Block and the Dodson submittal:

The writer's information on anomalous mineralization in this important area is superficial and judgements must be weighted accordingly. Briefly, it is understood that rich float was obtained in the Southwest Bertha block. Two geochemical anomalies with zinc values exceeding 1000 PPM were found. Copper was also found in some places. It was observed that sphalerite occurs in dolomite veinlets and copper in siliceous veinlets, neither in abundance. It is not entirely clear whether the geochemical anomalies relate to metals derived from shales or from dolomites. This is important in evaluating the anomalies owing to the fact that on average, argillaceous sediments contain 20 PPM Pb, 200 PPM Zn whereas carbonate sediments contain only 7 PPM Pb and 12 PPM Zn. The occurrence of copper (absent at Pine Point) is

interesting and of possible commercial importance. Copper, zoned in S.E. Missouri deposits, is a valuable by product. The mode of occurrence i.e. in veinlets is not regarded as encouraging. It may represent re-mobilization of values derived from ore bodies elsewhere. The occurrence of sub-commercial vein sulphides remote from ore bodies is not uncommon in other camps.

A small amount of prospecting on the Dodson submittal is said to have resulted in the discovery of well mineralized dolomite fragments in a shale scree slope over a strike length of 3000 feet. This alone justifies intensive prospecting.

In summary, the geochemical anomalies and float discoveries in these blocks of claims might be compared to exploration in flat-lying beds where trace intercepts have been obtained in several widely spaced holes. (The latter situation would provide justification for drilling on a 1000 ft. pattern in selected areas.) The amount and wide distribution of mineralization found, coupled with the close proximity to probable rich ore bodies of the Barrier property makes the Brinex land holdings in this area highly attractive from an exploration viewpoint.

Distribution of mineralization:

The importance of early recognition of ore "trends" has been stressed both at Pine Point where an underlying structural control is apparent

and in the new lead belt of SE Missouri where the cause is not apparent. That is to say, strongly linear trends commonly do exist and may be of considerable empirical value in telethermal exploration even where the reason for this phenomenon is unknown or conjectural. More than one trend may exist, commonly, but not always, parallel. Where the beds are folded and faulted as they are at Robb Lake, the location and strike of these linear arrays of ore bodies may be hard to decipher and they need not follow the grain of the country. The limited information from the Barrier discoveries suggests that a linear array striking N 50° W does exist here. Until the folding is better understood and the amount of movement on the many thrust faults has been estimated, one can scarcely do better than simply project the Barrier trend in both directions.

It also appears to be true in some camps that a central portion of a given linear array contains the larger and richer ore bodies. Other ore bodies occur along extensions of the trend but they are smaller and leaner. To the extent that this may be true, proximity to known better ore bodies is an important consideration in evaluating the exploration potential of new properties. In this connection, the properties in the McCusker-Bertha area are very well situated. Although very little is known about the Dodson submittal, it may be regarded as attractive in this regard. The properties in the Laurier area are

somewhat more remote and they lie several miles southwest of the straight-line projection of the Barrier trend. In this respect, they may be considered less attractive. The Nabesche block, situated 40 miles from the Barrier discoveries and well off the projected trend would be considered least attractive within the context of "trend" logic.

Stratigraphy and lithology:

As a general observation, where the host horizon is reefal, as at Pine Point, SE Missouri, Ireland and elsewhere, ore bodies tend to be in or closely associated with reefs or off-reef detritus. This may be due to the inherently greater porosity and permeability of such structures. Hydrocarbons also trapped there are often considered to be effective reductants to ore bearing solutions. The conclusion that ore is associated with reef development in the Robb Lake area therefore seems well founded.

It is tempting to believe that the ore is most likely to be associated with intense recrystallization. Most of the ore at Pine Point does indeed have this association but the largest and richest ore body is situated off the flank of the coarsely recrystallized dolomite, in fine grained dolomites. The recent major discoveries in central Tennessee are associated with recrystallization of collapse breccia but commonly occur on the margins of the recrystallized zones rather than within

them. In SE Missouri, the ore bodies are distributed mainly in reef environments but definitely beyond the margin of a large area of "white rock". In the Robb Lake area, then, one might reasonably expect ore where thick reef build-ups have occurred. However, adjacent facies where there is only off-reef detritus and little recrystallization should also be considered attractive at this time. The writer is not sufficiently well-informed to be able to point to specific places where the more favorable lithology exists.

It is well known that with few exceptions, the host rock of telethermal deposits is dolomitic rather than limey although limestone beds are commonly nearby. The mining camps commonly exist where (on a regional scale) limestone beds pass into a dolomitic facies. In many camps, particularly in continental Europe, a shale capping over the host rock is present. Domal structures appear favorable. For these reasons, the area SSE from the Barrier discovery where gently-dipping favorable host rocks are overlain by shale (according to E. J. Irish) is considered promising for mineralization. The depth of the favorable horizon and higher cost of drilling may preclude exploration here at this time.

Detailed structures and textures too numerous to discuss here seem to be a common denominator to the host rock of ore in many telethermal mining camps. The same is true of the metallic mineralization and

recognition of these features is sometimes useful in discriminating between potentially valuable mineralization and mineralization which rarely develops into ore bodies.

EXPLORATION PROCEDURE

The well established conventional procedure for exploring for flat or gently-dipping telethermal deposits involves an enormous amount of drilling made possible by relatively low unit drilling costs. Drilling is still essential in alpine-type deposits although here the fact that both mineralization and changing sedimentary facies can be recognized in surface outcrop facilitates exploration and reduces the amount of reconnaissance drilling required. (For example as much has been accomplished at Robb Lake with 29 holes and a few trenches in one year as was accomplished at Pine Point with 150 holes over 50 years.) On the other hand, the configuration of the alpine type ores, the dip of the beds and faulting coupled with difficult topographic and geographic conditions may make mining unprofitable in spite of better-than-normal grades. There is no firm evidence presently pointing in this direction at Robb Lake.

As mentioned, extensive drilling is necessary to find and outline ore bodies but because of the currently extremely high costs of drilling in the Robb Lake area, all of the effective but less expensive approaches

to exploration should be fully used in order to minimize the amount of drilling necessary. These preliminary techniques can be reviewed briefly as follows:

1. Geological mapping: Reference has been made to the excellent work done by Dickie. It would be useful to compile further data relating to the thickness of reef development, distribution of various off-reef facies, the precise kind of lithology and (most important) the areal distribution of precise stratigraphic intervals favorable to ore deposition. As much of this kind of information as the Barrier group are prepared to release should be assembled and applied in the discrimination between other sites available for exploration.

2. Geochemistry: In spite of the unimpressive performance of soil geochemical methods generally, it has been used with some good results in Ireland and elsewhere and it probably has application in the Robb Lake area. Care obviously must be used in interpreting geochemical results with respect to the source of anomalous metal concentrations. Pathfinder elements are beginning to appear significant in older districts but their use at Robb Lake may be impractical at this time.

Simple, conventional prospecting for mineralized float and values in situ probably will be the most effective approach in relation to costs.

Ground coverage must be thorough and the prospectors must be equipped to recognize sphalerite which can often be distinguished only with difficulty from dolomite. Attention should be paid to iron oxide zones, brecciation, collapse features etc. The areal scope of both geochemical surveys and prospecting can reasonably be confined to places where the favorable horizon outcrops or is near surface.

3. Geophysics: Induced polarization has been used successfully at Pine Point, Ireland and to a limited degree in SW Wisconsin. In most other camps, it has been of questionable utility. It remains to be seen whether the pyrite content and other features of Robb Lake ore lend themselves to successful IP surveys. It seems likely that where ore is overlain by black (and presumably carbon/pyrite-bearing shales) such surveys will not be applicable. Induced polarization seems likely to be of value, not as a reconnaissance tool, but as a technique applicable where an ore trend has been established and selection of drill sites has become necessary.

4. Trenching: Early trenching at Pine Point aided in providing information as to the character of the mineralization but was of little help in determining the grade and quantity of the ore. This is done much better by drill holes. The reason may be the irregular distribution of sulphides. Similar results have been experienced elsewhere.

5. Drilling: As mentioned earlier, much drilling is necessary both in reconnaissance exploration and detailed ore development. The spotting of drill sites should follow a reasonably regular pattern in both situations partly because the objective is to develop a picture of planar geologic controls and partly as the results in terms of mineralization must be interpreted on a statistical basis owing to the fact that a blank hole may not confirm the absence of ore nor vice versa.

6. Funding: The maximum amount of money which can reasonably be spent on exploration must not exceed the arithmetic product of net profits expected and the probability of success. For example, the successful phase of exploration at Pine Point requiring a firm expenditure of $80,000 was justified on the grounds that a careful analysis indicated a 1/80 probability of eventually developing ores which would net $50 million. No attempt to develop such a rationale for Robb Lake will be made here although the situations presently appear roughly comparable on the basis of scant available information.

7. Timing: Exploration for telethermal ores is relatively highly time-consuming and not suited to crash programs. A knowledge of the geologic controls tends to develop slowly. Fortuitous surface exposure of mineralization as on the Barrier properties may accelerate the process but in general, one should not expect to be able to determine the presence or absence of ore in any sizeable block of well-situated land in a

single season. Rather, the work should progress methodically rather cautiously, making full use of new information in planning or revising plans for future work.

EXPLORATION PROPOSALS

As the writer has not visited the Robb Lake area, and has at best only a superficial knowledge of the local geology, reliable specific recommendations are difficult and should be regarded as a minority opinion.

1. Objective: Ore bodies grouped within 5 to 10 miles of each other, having an aggregate volume of 10 million tons and grading about twice the normal figure for deposits of this type or about 8% combined Pb-Zn probably would be the minimum basis for a viable mining operation in this locality provided low-cost mining methods prove to be applicable. The attainment of such an object does not appear unreasonable.

2. Land: The 1100 claims now held by Brinex in an area 70 miles long may prove to be of unmanageable size without a large and diversified staff. Additional ground, if well situated, should be secured but a strong effort should be made to selectively drop claims where positive encouragement seems unlikely.

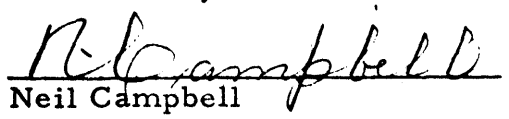
3. Geo-surveys: Simple intensive prospecting of selected areas is strongly recommended. Approximately two man-days per claim should

be allowed. Reconnaissance soil geochemistry in selected areas and stream sediment sampling appears justified. Where encouragement has been obtained already, IP surveys should follow.

4. Drilling: Holes spaced on a 400 foot grid pattern in the plane of the mineralized bed at the Laurier discovery is warranted. Positive ore intercepts should be expected within a 6-hole program as a basis for continued drilling. Elsewhere, wide-spaced drilling would be consistent with a normal practice. Where a definite ore trend is believed to exist, 1000 ft. pattern drilling will be in order. Elsewhere, hole density of one per square mile would be appropriate. The drilling experience at Robb Lake is not known, but poor core recovery and selective loss of values is ordinarily a serious problem. Accordingly, N-X size bits should be used if possible. Solid or rotary bits are commonly used to penetrate sections where no ore can be expected.

5. Financial: Probably most reconnaissance programs conducted by substantial companies fall in the range of $100,000 to $200,000 per year over several years. Where ore is encountered, the program commonly increases to the $500,000 per year level in order to block out reserves and provide data for feasibility studies. A reasonable figure for the cost of finding ore is 65¢ per ton.

Submitted by:



Neil Campbell
607 Northtown Office Building
Spokane, Washington 99207
November 13, 1972

NC:pn

APPENDIX I

The following is a statistical representation of drill intercepts on a typical but not necessarily representative Pine Point ore body developed by one of several companies active there.

Horizontal dimensions: 2,000 ft. by 760 ft.

Reserves: 2.34 million tons averaging 0.9% Pb, 4.9% Zn.

Intercept categories in terms of feet x per cent Zn plus Pb.

"Ore"	40
"Indicative"	16-40
"Trace"	1-16
"Blank"	0

Within minable ore outline

Ore	19 holes or 76% of total
Indicative	4 holes or 16% of total
Trace	2 holes or 8% of total
Blank	0 holes or 0% of total

In a belt 300 feet wide around ore body

Ore	0 holes or 0% of total
Indicative	3 holes or 16% of total
Trace	14 holes or 74% of total
Blank	2 holes or 10% of total

In a belt 1,000 feet wide around ore body

Ore	0 holes or 0% of total
Indicative	3 holes or 11% of total
Trace	14 holes or 52% of total
Blank	8 holes or 37% of total

APPENDIX II

Typical production figures from telethermal deposits:

Mine	Company	Data Year	T/Day	%Pb	%Zn	
Austinville, Va.	N. J. Zinc Co.	1968	1785	0.7	4.0	
Jeff. City, Tenn.	"	"	1279	--	3.8	
Friedensville, Tenn.	"	"	1730	--	6.4	x
Flat Gap, Tenn.	"	"	1400	--	3.2	
New Market, Tenn.	Amer. Zinc Co.	"	2059	--	2.88	
Blackstone, Wis.	"	"	22	.28	3.24	
Champion, Wis.	"	"	370	.03	3.94	
Thompson, Wis.	"	"	230	.03	3.36	
Mascot #2, Tenn.	"	"	1436	--	2.45	
Young, Tenn.	"	"	2867	--	2.98	
N. Friends, Tenn.	"	"	291	--	2.98	
Coy, Tenn.	"	"	417	--	4.50	
Ozark, Mo.	Kennecott	"	6000	5.51	1.07	x
Viburnum, Mo.	St. Joe	1964	5000	3.	--	
Indian Creek, Mo.	St. Joe	1957	1584	2.52	.22	
Tri State, Mo.	Mining Dist.	1948	--	.38	2.18	
Upper Miss. Val.	Mining Dist.	1968	--	.26	3.15	
East Tenn.	Mining Dist.	1948	--	--	3.2	
Southeast, Mo.	Mining Dist.	1948	--	2.7	--	
Jersey, B.C.	Can. Expln.	1968	1400	1.4	3.2	
Reeves, B. C.	Reeves Mac.	1971	580	.8	7.6	x
Pine Point	Cominco	1971	11800	2.3	6.4	x
Malines, France	Pennarroya	1971	1000	1.25	4.21	x
Peyrebrune, France	"	"	300	1.0	3.5	
Largentiere, France	"	"	2000	3.74	0.6	
Plaque, France	"	"	600	3.74	--	
Masua, Sardinia	AMMI	1972	1500	1.0	7.0	x
Midbladen, Morocco	-----	1970	190	8.0	--	x
Bastenberg, Germany	Stolberg	1968	1300	1.67	3.14	
Pend O'reille	Pend O'reille	1972	600	.92	3.55	

NOTE: Higher grade, complex ores produced in Ireland are not shown although classified as telethermal.