31 May 2001

Technical Report
Red Dog Mine Review, Alaska

Prepared for

Cominco Ltd.
Vancouver, Canada

by

Stephen Juras, PhD, P. Geo.
Vancouver, Canada

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IMPORTANT NOTICE

mrdi

01 June 2001

Mr. W. P. Armstrong
Cominco Ltd.
500-200 Burrard Street
Vancouver, BC V6T 3L7

Dear Bill

Re: Technical Report - Red Dog Mine Review, Alaska

Please find enclosed our independent Qualified Person's Technical Report on the Red Dog Mine Review, Alaska. We have issued 5 copies of the report – 3 for Cominco Ltd, 1 for the Red Dog Operation site, and 1 for submittal to the Ontario Securities Commission.

Work on this review was done on site at Red Dog Mine and in our Vancouver office. I was the Qualified Person responsible for the report's preparation and was assisted by Stephen Hodgson, P.Eng., for matters pertaining to mining and Robert Johnston, P.Eng, for assistance in reviewing metallurgy.

Yours sincerely,

Stephen J. Juras, Ph.D., P.Geo.
Chief Geologist

PROFESSIONAL PROVINCE S. J. JURAS BRITISH COLUMBIA GEOSCIENTIST

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01 June 2001

Ontario Securities Commission
Suite 1800
20 Queen Street West
Toronto, Ontario M5H 3S8

Attention: Corporate Finance

Dear Sirs

I refer to the Technical Report titled *Red Dog Mine Review, Alaska* dated 31 May 2001 prepared for Cominco Ltd. I hereby consent to the filing of my Technical Report by Cominco Ltd. I also consent to the filing of written disclosure of the Technical Report and of extracts from or a summary of the Technical Report in the written disclosure being filed.

Yours sincerely

PROFESSIONAL GEOSCIENTIST PROVINCE OF BRITISH COLUMBIA S. J. JURAS

Stephen J. Juras, Ph.D., P.Geo.
Chief Geologist

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I, Stephen J. Juras, P.Geo., am a Professional Geoscientist, Chief Geologist of MRDI Canada of 9030 161 Street in the City of Surrey in the Province of British Columbia.

I am a member of the Association of Professional Engineers and Geoscientists of British Columbia. I graduated from the University of Manitoba with a Bachelor of Science (Honours) degree in geology in 1978 and subsequently obtained a Master of Science degree in geology from the University of New Brunswick in 1981 and a Doctor of Philosophy degree in geology from the University of British Columbia in 1987, and I have practiced my profession continuously since 1987.

Since 1987 I have been involved in: mineral exploration for copper, zinc, gold and silver in Canada and United States, underground mine geology, ore control and resource modelling on copper, zinc, gold, silver and platinum/palladium properties in Canada, United States, Peru, Chile and Russia.

As a result of my experience and qualification I am a Qualified Person as defined in N.P. 43-101.

I am presently a Consulting Geologist and have been so since January 1998.

From May 15, 2001 until May 19, 2001 I visited Red Dog Operation in northern Alaska for the purposes of reviewing pertinent geological, mining and metallurgical data in sufficient detail to independently support the 2000 Red Dog Operation Mineral Reserve and Resource statement.

This report was prepared under my direct supervision in consultation with technical specialists, who are Qualified Persons in the fields of mine engineering and metallurgy.

One of the Qualified Persons is Stephen Hodgson, P.Eng., President of MRDI Canada, a member the Association of Professional Engineers and Geoscientists of British Columbia, who graduated with a Bachelor of Science in Mineral Engineering (Mining) from the University of Alberta. Mr. Hodgson has over 25 years of experience in various aspects of mining including operations management and engineering experience at open-pit and underground mines in Canada and Alaska.

The second Qualified Person is Robert Johnston, P.Eng., Senior Metallurgist of AMEC E&C, a member of the Association of Professional Engineers and Geoscientists of British Columbia, who graduated with a Mineral Technology Diploma from the Cambourne School of Mines, England. Mr. Johnston has over 40 years of experience in various aspects of engineering and operations including management of numerous mineral processing facilities.

I am not aware of any material fact or material change with respect to the subject matter of this technical report which is not reflected in this report, the omission to disclose which would make this report misleading.

I am independent of Cominco Ltd. in accordance with the application of Section 1.5 of National Instrument 43-101.

I have read National Instrument 43-101, Form 43-101FI and this report has been prepared in compliance with NI 43-101 and Form 43-101FI.

Dated at Vancouver, British Columbia, this 1st day of June, 2001.

PROFESSIONAL PROVINCE OF S. J. JURAS BRITISH COLUMBIA GEOSCIENTIST

Qualified Person

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1.0 SUMMARY

Cominco Ltd. has asked MRDI Canada, a division of AMEC E&C Services Limited (MRDI), to provide an independent Qualified Person's Review and Technical Report of the Red Dog Operation in Alaska. Stephen Juras, P. Geo., an employee of MRDI, served as the Qualified Person responsible for the preparation of the Technical Report as defined in National Instrument 43-101, *Standards of Disclosure for Mineral Projects*, and in compliance with Form 43-101F1 (the "Technical Reports"). The work entailed review of pertinent geological, mining and metallurgical data in sufficient detail to prepare the Technical Report, the purpose of which is to independently support the 2000 mineral resource and reserve statement.

The Aqqaluk, Main and Qanaiyaq deposits lie on ground held under an agreement with NANA. In 1982, Cominco American Inc. (a wholly-owned subsidiary of Cominco Ltd.) and NANA reached an agreement that led to the development of the Red Dog Mine. Under the agreement, Cominco Ltd. leases the property from NANA, operates the mine and markets the concentrate produced.

At this time, five deposits are defined at Red Dog: Main, Aqqaluk, Paalaaq, Qanaiyaq and Aŋarraaq. The Mineral Reserves are contained in the Main and Aqqaluk deposits. The remainder comprise Indicated and Inferred Mineral Resources. Production began from the Main deposit in 1989 and continues to be the sole location of mining.

Information and data for the review and report were obtained from Red Dog Operation during a site visit by MRDI on May 14 to 19, 2001. Background information for property description, land status, infrastructure, property history, geology and mineralization was obtained from existing company reports, papers and drawings and discussions with Cominco Ltd. personnel at the mine site. Detailed data on resource and reserve matters (database, resource modelling, production reconciliation, mine design, production costs, metallurgical data, process costs and site General and Administrative costs) were made available and examined during the site visit. Additional information concerning economic factors in support of the mineral reserve designation was obtained through discussions with Cominco Ltd. staff in Vancouver, B.C., Anchorage, Alaska, and Toronto, Ontario.

Red Dog is a sedimentary hosted exhalative (SEDEX) lead-zinc sulphide deposit. The orebodies are lens shaped and occur within structurally controlled (thrust faults) plates, are relatively flat lying and are hosted by marine clastic rocks (shales, siltstones, turbidites) and lesser chert and carbonate rocks. Barite rock is common in and above the sulphide units. Silicification is the dominant alteration type. Sulphide mineralization consists of semi-massive to massive sphalerite, pyrite, marcasite and galena.

Textures include massive, fragmental and veined types. Sedimentary layering within the sulphide zones is rare.

The database used to estimate the Mineral Reserve (Main and Aqqaluk deposits) consists of samples from drill core and reverse circulation holes (593 core holes and 161 reverse circulation holes). Samples were assayed for zinc, lead, silver, iron and barium. Data transfer was verified through a random 5 percent check of the resource database to original assay certificates. Quality assurance of the base metal analyses is supported by production history (reconciliation of model to blast holes and model to milled ore) for the Main deposit and by good control results from Quality Assurance and Control programs maintained during Aqqaluk drilling. The reverse circulation holes were drilled as 30 m fill-in holes in the Main deposit. Checks made in cross-section with the core holes and in plan with blast hole data showed no visual evidence of grade bias in the reverse circulation data.

Bulk density is calculated with a regression equation. The equation contains an assumed bulk density for unmineralized rock and is modified by contributions defined by amounts of barite (barium analysis), galena (lead analysis), sphalerite (zinc analysis) and pyrite/marcasite (iron analysis). Studies of measured bulk density compare favourably with the calculated values. Exceptions are for barium-rich units (the result of lower analytical quality in the barium analysis) and waste black shale units (due to lack of assay data in pyritic units that contain no appreciable sphalerite or galena). These exceptions mainly affect waste rock units at Red Dog and do not affect the estimated ore tonnage in the stated mineral resources and reserves.

The mineral resource and reserve estimates for the deposits at Red Dog Operation were calculated under the direction of Mr. William P. Armstrong, P.Eng., Cominco Ltd.'s Qualified Person for mineral resources and reserves. The estimates were made from 3-dimensional block models utilizing commercial mine planning software (MineSight®). The modelling procedure used industry-accepted methods in creating interpolation domains based on mineralized geology and grade estimation based on ordinary kriging or inverse distance weighting to the third power. Reasonableness of grade interpolation was reviewed by visual inspection of sections and plans displaying block model grades, drill hole composites and geology. Good agreement was observed.

The block model that was used in the estimation of the Mineral Reserve at Red Dog (Main and Aqqaluk deposits) was checked in more detail. Global and local bias checks in this block model, using nearest-neighbour estimated values versus the kriged values, found no evidence of bias. The model results were compared to blast hole and milled production data. Blast hole drill data over areas approximating a quarter of one year's production were compared to the block model blocks over the same areas: good agreement in average grade values was observed. Annual reconciliation comparison of milled production (mill measured grades and tonnage) to the block model (calculated from year-end topography and using the reserve cutoff value of U.S. $22.75 per ton) shows good agreement also. These validation criteria support a high degree of confidence in grade and tonnage prediction of the Red Dog Mineral Reserve block model for the Main and Aqqaluk deposits.

Classification of Mineral Resource and Reserve at Red Dog is based on a combination of drill data density, economic evaluation and production. The Main deposit contains a high density of drilling (30 m x 30 m), good validation results, especially to blast holes and milled production, and well-known economic and metallurgical performance (through mining history). This supports the category of Proven Mineral Reserve for all Main deposit mineralization above cutoff within the ultimate pit outline. Most of the mineralization above reserve cutoff value and within the ultimate pit at the Aqqaluk deposit is classified as Probable Mineral Reserve because, relative to the Main ore, the drill density is wider (60 m x 60 m). However, metallurgical testwork has been undertaken and an economic evaluation completed.

The remaining mineralization at Aqqaluk and the mineralization at Qanaiyaq, Paalaaq and Aηarraaq consists of Indicated and Inferred Mineral Resources. Aqqaluk mineralization within the ultimate pit outline and above cutoff value defined by greater than 60 m x 60 m drill spacing has been classified as Indicated Mineral Resource. Also within this pit outline is additional mineralized material that is as well or better defined as the Indicated Mineral Resource but whose metallurgy is uncertain. Expected metallurgical improvements based on improvements from the VIP project would allow this material to be processed economically. Because of this uncertainty, Cominco Ltd. has conservatively left this material as Inferred Mineral Resource until the VIP project has been completed and the expected metallurgical improvements are confirmed.

At Qanaiyaq the drill density of 60 to 120 m x 60 to 120 m, the presence of mineralized units similar to those in the Main deposit (for recovery confidence) and its unique position as a small klippe (defines extent of mineralization) supports its classification as Indicated Mineral Resource (at a 6% zinc grade cutoff). Mineralization at Paalaaq and Aηarraaq is defined by widely spaced drilling (100 m to 120 m). These are deep deposits and will be extracted by underground methods. These deposits are classified as Inferred Mineral Resource (at a 8% zinc grade cutoff) to reflect the lower drill hole density and resultant higher uncertainty in grade and geologic continuity.

The total Red Dog mineral reserves and resources are summarized in Table 1-1.

Table 1-1: 2000 Red Dog Mineral Reserves and Resources

Mineral Reserve/Resource	Tonnes (millions)	Zn (%)	Pb (%)	Ag (g/t)
Proven Mineral Reserve				
Main Deposit	41.9	19.2	5.2	100
Probable Mineral Reserve				
Aqqaluk Deposit	56.1	16.6	4.1	76
Total Mineral Reserve	**98.0**	**17.7**	**4.6**	**86**
Indicated Mineral Resource				
Aqqaluk Deposit	3.4	9.8	3.7	78
Qanaiyaq Deposit	9.6	17.8	5.5	117
Total Indicated Mineral Resource	**13.0**	**15.7**	**5.0**	**107**
Aqqaluk Deposit	6.8	6.5	3.6	59
Paalaaq Deposit	13.0	15.0	4.0	90
Aŋarraaq Deposit	17.2	15.8	4.8	71
Total Inferred Mineral Resource	**37.0**	**13.8**	**4.3**	**75**

Note: The cutoff for Main and Aqqaluk mineral reserves and resources is based on an NSR value of U.S. $22.75 per ton (U.S. $25.08 per tonne). The cutoffs used for Qanaiyaq, Paalaaq and Aŋarraaq are zinc grade values of 6% Zn for Qanaiyaq and 8% Zn for Paalaaq and Aŋarraaq

The reserve cutoff grade of U.S. $22.75 per ton (U.S. $25.08 per tonne) is based on a compilation of mining, milling and site General and Administrative costs during the three-year period from 1997 to 1999. The costs have been adjusted for the projected increase in production associated with the mill optimization project (VIP project) scheduled for completion in late 2001. Metallurgical studies show that, providing the present level of grade blending is maintained, the VIP predicted metallurgical results should be achievable.

The long-term production forecast was based on a mill throughput of 3.5 million tonnes of ore per year and approximate production of 1 million tonnes of zinc concentrate. The current long-range forecast based on proven and probable reserves envisions that the Main deposit and the Aqqaluk deposit will be completed in 2028. The forecast from 2001 to 2013 is for annual production of 3.5 million tonnes from the Main deposit at ore reserve grade and a 1:1 strip ratio. This is followed by production of 3.5 million tonnes annually from the Aqqaluk deposit at ore reserve grade and a 2:1 strip ratio from 2014 to 2028.

Operating costs have been forecast as a function of previous costs, the current (2001) budget and increased thoughput attributed to the VIP project. The operating costs have been adjusted post 2013 for the expected increase in strip ratio associated with the Aqqaluk pit.

Details of economic and sensitivity analyses, marketing and concentrate sales contracts, taxes, environmental and geotechnical considerations were reviewed. All were complete and fall within accepted industry standards.

The 2000 Red Dog Mineral Reserve and Mineral Resource statement is supported by this independent review.

2.0 INTRODUCTION AND TERMS OF REFERENCE

Cominco Ltd. has asked MRDI Canada, a division of AMEC E&C Services Limited (MRDI), to provide an independent Qualified Person's Review and Technical Report of the Red Dog Operation. Stephen Juras, P. Geo., an employee of MRDI, served as the Qualified Person responsible for the preparation of the Technical Report as defined in National Instrument 43-101, *Standards of Disclosure for Mineral Projects*, and in compliance with Form 43-101F1 (the "Technical Reports").

Information and data for the review and report were obtained from Red Dog Operation during a visit to site by MRDI on May 14 to 19, 2001. Additional information was obtained from Cominco Ltd. head office in Vancouver, B.C..

The work entailed review of pertinent geological, mining and metallurgical data in sufficient detail to prepare the Technical Report. Stephen Juras, P. Geo., in addition to supervising the preparation of the Technical Report, conducted and supervised the review on the geological data. Qualified Person assistance was provided by MRDI employees. Stephen Hodgson, P. Eng., supervised the investigation of mining issues, and Robert Johnson, P. Eng., conducted the review on metallurgical matters.

2.1 Terms of Reference

The Hilltop deposit is the former name for Qanaiyaq deposit. Some of the older maps and the geological report in Appendix B refer to Qanaiyaq as Hilltop.

Any reference to Anaaraq should be accepted as Aŋaaraq. The font necessary for the proper spelling was not always available in some software packages.

The red Dog mine is located in Alaska so all system of measurement use the imperial. Though most sections were made to conform to the metric system, some section were left using the imperial system.

3.0 DISCLAIMER

MRDI's review of Red Dog operation relied on referral to geotechnical work carried out by Mr. John F. Able, JR, Colorado P.E. 5642. MRDI used information from these reports under the assumption that it was prepared by a Qualified Person.

4.0 PROPERTY DESCRIPTION AND LOCATION

The Red Dog District is located in the De Long Mountains of the western Brooks Range of Alaska, approximately 135 km north of Kotzebue and 84 km inland from the coast of the Chukchi Sea. The Red Dog property is in the Noatak quadrangle of the Kotzebue Recreational District (see Figure 4-1).

There are five known deposits in the Red Dog District. Four (Main, Aqqaluk, Paalaaq and Qanaiyaq) occur in the immediate vicinity of the original discovery, while Aŋarraaq is approximately 8 km to the north (see Figure 4-2). Only the Main deposit is developed. The Red Dog property encompasses 373,369 acres (151,097 ha).

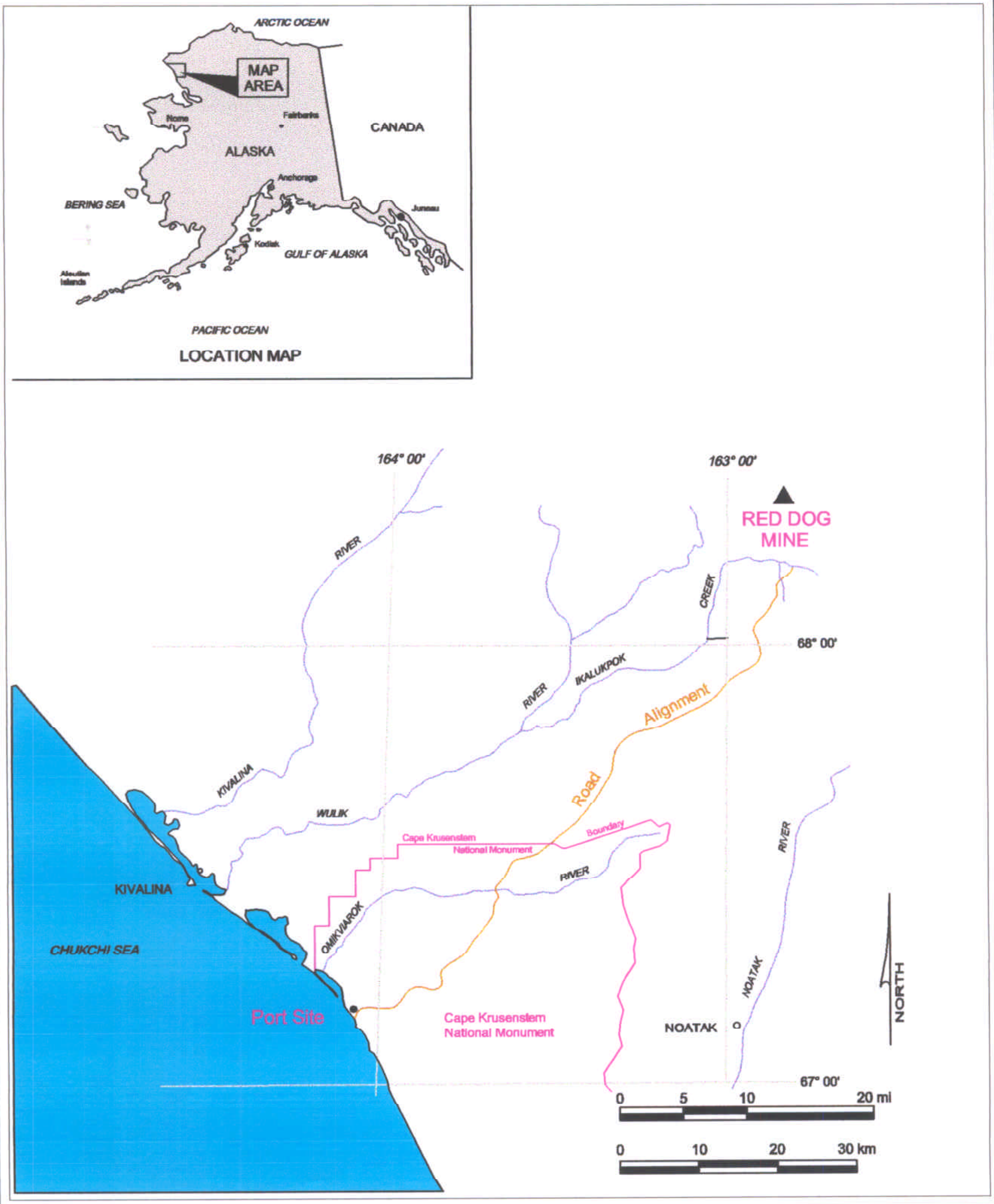
Table 4-1: Deposit Locations

Deposit	Longitude	Latitude
Main	162° 49' 30" W	68° 04' 15" N
Aqqaluk	162° 49' 47" W	68° 04' 34" N
Paalaaq	162° 49' 38" W	68° 04' 54" N
Qanaiyaq	162° 50' 09" W	68° 03' 28" N
Aŋarraaq	162° 57' 44" W	68° 09' 41" W

The Aqqaluk, Main and Qanaiyaq deposits lie on ground held under an agreement with NANA. In 1982, Cominco American Inc. (a wholly-owned subsidiary of Cominco Ltd.) and NANA reached an agreement that led to the development of the Red Dog Mine. Under the agreement, Cominco Ltd. leases the property from NANA, operates the mine and markets the concentrate produced. The deal involved an initial royalty payment of U.S. $1.5 million and provides for annual royalty payments of U.S. $1 million; an NSR of 4.5% (paid quarterly); and an NPR of 25% for Years 1 to 5, 30% for Years 6 to 10 and increasing to 50% by Year 26. The same agreement includes an additional lease rental payment of U.S. $1 per acre on initial signing of the agreement and an annual payment of U.S. $1 per acre on undisturbed land and U.S. $100 per acre of disturbed land. The agreement provided the means to develop one of the richest zinc deposits in the world, give employment opportunities and protect the subsistence lifestyle of the people in the region.

The rest of the property is held under two claim groups known as the Noatak and Noatak-Road Groups, which consist of 7979 unpatented claims. The Aŋarraaq Deposit is located on unpatented claims of the Noatak Group that are held through normal claim rental payments to the state government of Alaska.

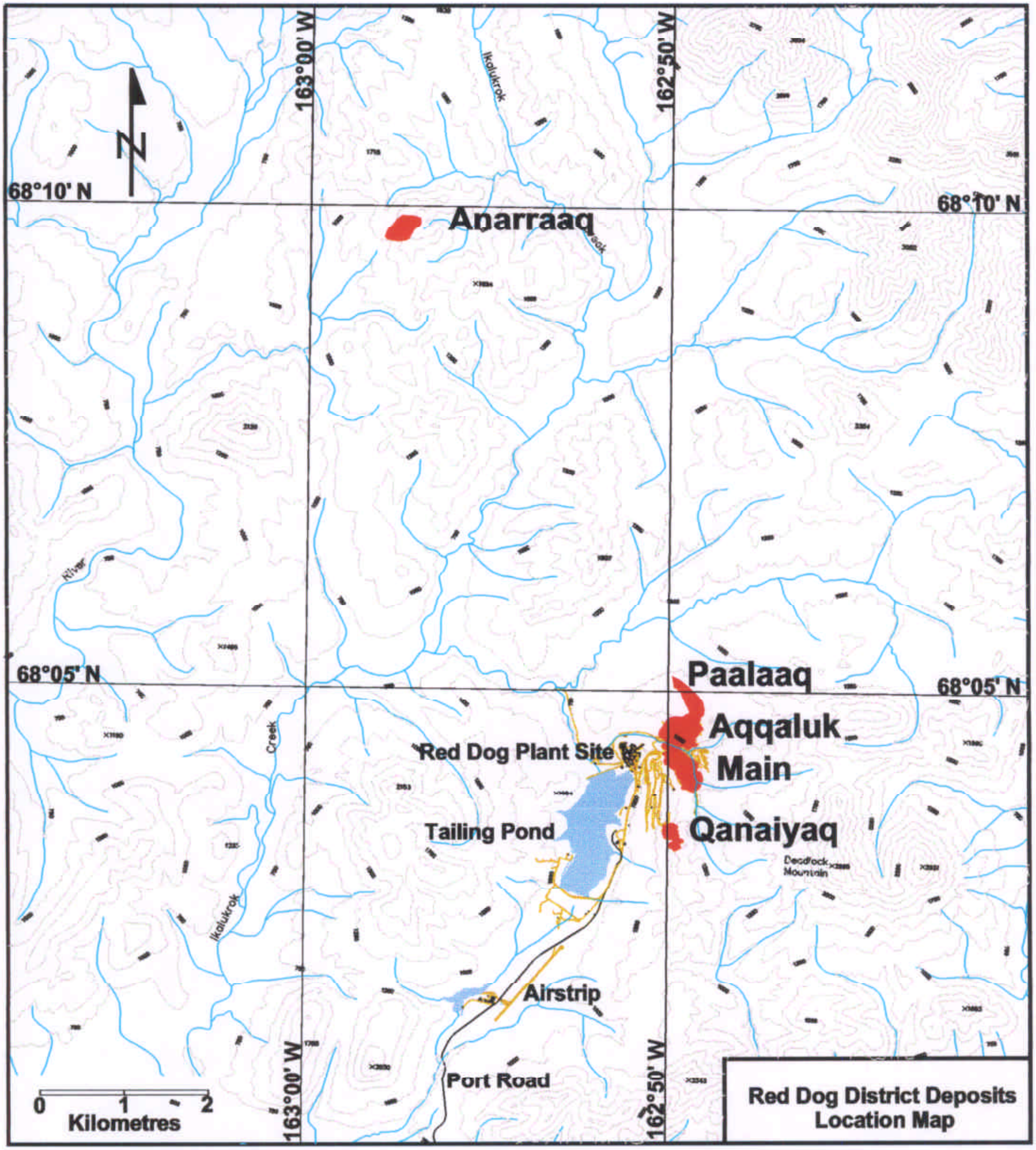
Figure 4-1: Red Dog District Location Map



Approved By:	.		RED DOG PROJECT Cominco Alaska	Title: RED DOG MINE AND PORT PROJECT LOCATION MAP .
Checked By:	.			
Drawn By:	SOH			
Designed By:	.		MWO or Job No. .	Drawing No. / Rev.
Engineering Review				

Computer File No. Y:\MINETECH INTER\MAPS\ENVIRONMENTAL\99_REC_PLAN\99_RECPLN_LOCATION.DWG

Figure 4-2: **Deposit Locations**


68°10' N
163°00' W
162°50' W
68°10' N
Anarraaq
68°05' N
Paalaaq
68°05' N
Aqqaluk
Red Dog Plant Site
Main
Tailing Pond
Qanaiyaq
Deadlock Mountain
Ikalukrok
River
Creek
Airstrip
Port Road
163°00' W
162°50' W
0 1 2
Kilometres
Red Dog District Deposits
Location Map

A copy of the requirements for claims holding in Alaska and a list of the claims and their status can be found in Appendix A. A claims map has been included as Figure 4-3. This plan shows the location of the Red Dog and Aŋarraaq deposits in relation to the claims and the property outlines. Two infrastructure maps showing the locations of buildings and the open pits are included as Figures 4-4 and 4-5.

An important provision of the agreement deals with employment. First preferences on all Red Dog projects go to qualified native people in the NANA region. The objective is to eventually have 100% native employment at the mine site.

A discussion on the environmental liabilities and procedures for the Red Dog Operation is included in Section 19.5 of this report under the subheading "Environmental Considerations."

The permitting process for the Red Dog Mine has been completed. The permits currently in place are listed in Table 4-2.

Table 4-2: Current Permits for the Red Dog Mine

Permit	Concerning
NEPA	National Environmental Act
ADNR	Land Use
ADNR	Underground Exploration
ADNR	Water Withdrawal
EPA NPDES	Discharge
ADEC 401	Certification of the NPDES Permit
ADEC	Construction Air
ADEC Title V	Operating Air Permit
COE	Wetlands
ADF&G	Habitat
ADGC	Coastal Projects Questionnaire
NW Arctic Borough Permit	Land Use
Material Sites Permitting	
ADF&G	Stream Crossing
Solid Waste Permit	Landfill and Waste Rock/Tailings
ADNR	Drinking Water, STP System Approval, Food Services
C-Plan	Revision for On-site Fuel Storage
Reclamation Plan	
USF&W	Endangered Species Clearance, Habitat Services
SHPO	Archaeological Clearances

Figure 4-3: Claim Map

Figure 4-4: Infrastructure Map

Figure 4-5: Air Photo Infrastructure Map

5.0 ACCESSIBILITY, CLIMATE, LOCAL RESOURCES, INFRASTRUCTURE AND PHYSIOGRAPHY

The Red Dog Operation lies within a series of moderately sloping hills ranging in elevation from 260 m to 1,200 m above sea level. To the south and southwest, the hills drop off abruptly to a gentle coastal upland, which continues to the Chukchi Sea.

This is an area of continuous permafrost where most outcrops consist of rubble material. Vegetation in the area of the deposits is mainly low brush and muskeg.

There was no development in this remote area before the inception of the project. Now a gravel airstrip, 5 km southwest of the mine, allows jet access from Anchorage and Kotzebue. Smaller planes provide service to other native communities in the region. An 84 km gravel road connects the mine to a port facility on the Chukchi Sea. Because of its northerly location, this port is seasonal, operating from early July to early October. Concentrates are stored at a large facility at the port during the winter months.

6.0 HISTORY

For the Main deposit the initial Pb-Zn-Ag showings along Red Dog Creek were noted by the USGS in the early 1970s. Cominco Ltd. staked the area in late 1978, conducted geological mapping, geophysical surveys and geochemical sampling in 1979 and commenced drilling in 1980.

Mineralization was reported in the Red Dog area in 1953 when geologists noted mineral staining. The deposit was later documented in the U.S. Geological Survey of 1970 after it was brought to the attention of the Survey by the late Bob Baker of Kotzebue, a bush pilot and prospector who noticed a rusty alteration zone in Red Dog Creek while flying over the area. Mr. Irving Tailleur of the U.S. Geological Survey coined the name “Red Dog Creek” after Bob Baker’s prospecting company, the Red Dog Mining Company, which was named after his pet dog who frequently flew with him.

With the passage of the Alaska Native Claims Settlement Act in 1971, certain lands in Alaska were withdrawn from staking and selection. This included the land at Red Dog. In 1975, the U.S. Bureau of Mines was directed to conduct a mineral assessment survey in Northwest Alaska, and Red Dog was “discovered” again. In the fall of 1975, the U.S. Bureau of Mines issued a press release announcing the significance of the deposit at Red Dog. Mining companies working in the area at the time proceeded to stake hundreds of thousands of mining claims in the De Long Mountains. The Red Dog deposit was not staked at this time because it lay on withdrawn land.

The NANA Regional Council became interested in selecting the land at Red Dog in 1976. Since the area was withdrawn from selection, NANA approached Congress about obtaining the rights to the area. On December 18, 1978, the land withdrawal expired and Cominco Ltd. staked the area over the Red Dog deposit. Geological mapping, geochemistry and geophysics were carried out in 1978 and 1979, and the first seven holes were drilled in 1980.

With the passage of the 1980 Alaska National Interest Lands Conservation Act, the land around and including Red Dog were available for selection by NANA. NANA made this selection, and negotiations over development and ownership between Cominco Ltd. and NANA began. Drilling continued, and another 24 holes were completed in 1981. In 1982, an agreement was signed between NANA and Cominco Ltd. regarding the development of the deposit.

With the agreement signed, a number of projects had to be completed before construction could begin. These included developing design concepts, performing feasibility studies, completing environmental reports and permitting and starting detail engineering. Additionally, two other major hurdles had to be overcome: obtaining Congressional approval to build a road through Cape Krusnestern National Monument and State of Alaska financing for the transportation system.

Cominco Ltd. awarded an EPCM contract for the Red Dog project to the Ralph M. Parsons Corporation of Pasadena, California. Initial development of the project began in 1986 with the installation of a shallow water dock and small staging area at the port site. With these facilities in place, major construction on the road and the mine site started in July 1987. The major process facilities were designed as large modules that were built in the Philippines, transported to the Red Dog port site by barge and carried to the mine site by specially designed heavy equipment movers. By November 1989, construction was complete and the mine started operation.

During the initial years 1989 to 1992, the tonnage of ore processed increased to 1.4 million tonnes per year. Between 1992 and 1995 the addition of grinding capacity (two ball mills), flotation capacity (two column cells), a water treatment plant and several smaller projects aimed at improving recovery increased capacity to 2.2 million tonnes per year.

In December 1995, a mine expansion project known as the Production Rate Increase (PRI) was initiated. The PRI project was designed to increase the mine and mill production capacity to 3.2 million tonnes per year and the zinc concentrate production from 590,000 tonnes per year to 907,000 tonnes per year. The design was based on an average head grade of 19.5% zinc and producing a 55% zinc concentrate at 85% recovery. The process additions during PRI included a new gyratory crusher, an additional SAG mill, an additional ball mill, increases to zinc and lead flotation capacity and a zinc filtration press. The project also included additional concentrate storage at the port and expansion of the accommodation complex.

In the summer of 1999, Cominco Ltd. initiated a property-wide initiative to optimize the economic value of the Red Dog Operation. This program, known as the Value Improvement Project (VIP), encompassed a broad range of initiatives including expansion of capacity for power generation, concentrate thickening, water treatment and flotation. On completion of the mill optimization, production capacity will be 3.5 million tonnes per year.

The VIP program also included fill-in drilling at Aqqaluk to better definite reserves, obtain metallurgical samples of the various ore types and provide sufficient detail for open pit modelling to determine the mining sequence.

7.0 GEOLOGICAL SETTING

The following geological descriptions have been summarized from a geological paper available in Appendix B. The paper is *Geologic Setting and Genesis of the Red Dog Zinc-Lead-Silver Deposit, Western Brooks Range, Alaska*, by D.W. Moore, L.E. Young, J.S. Modene and J.T. Plahuta, Economic Geology, Volume 81, 1986, pages 1696 to 1727.

The Red Dog deposits are SEDEX, zinc-lead-silver deposits hosted in Mississippian- to Pennsylvanian-age black shale.

The deposits are found in the De Long Mountains, which are made up of eight stacked and folded allochthons. The six structurally lowest allochthons are composed of Devonian through to Cretaceous clastic and chemical sedimentary rocks, while the two upper allochthons are of Jurassic and older age and are made of mafic to ultramafic igneous sequences (see Figure 7-1).

The Red Dog deposits are found in the second lowest allochthon hosted by black silicious shale and chert of the Kuna Formation. The stratigraphic footwall to the mineralization is an interbedded, light gray, calcarenite and dark gray calcareous shale, the Kivalina unit. The deposits themselves are a strata-bound accumulation of silicious rock, barite and sulphides. The hanging wall unit to the mineralization is a silica- and sulphide-poor barite of the lower Siksikpuk Formation of Pennsylvanian to Permian age (see Figures 7-2 and 7-3).

Figure 7.1: Allochthons of the Red Dog Region (Moore, 1986)

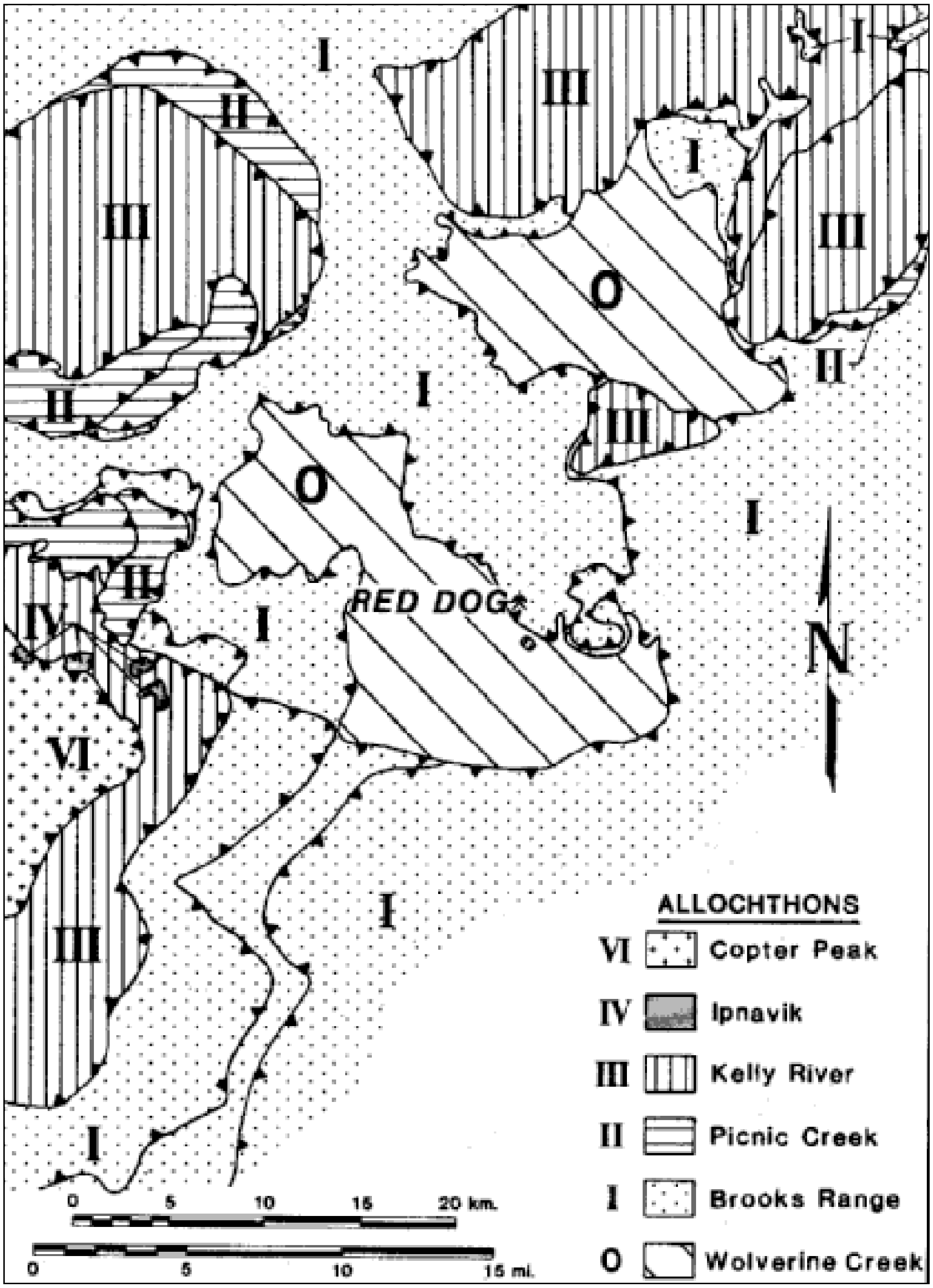


Figure 7-2: Stratigraphic Section of the Red Dog Sequence (Moore, 1986)

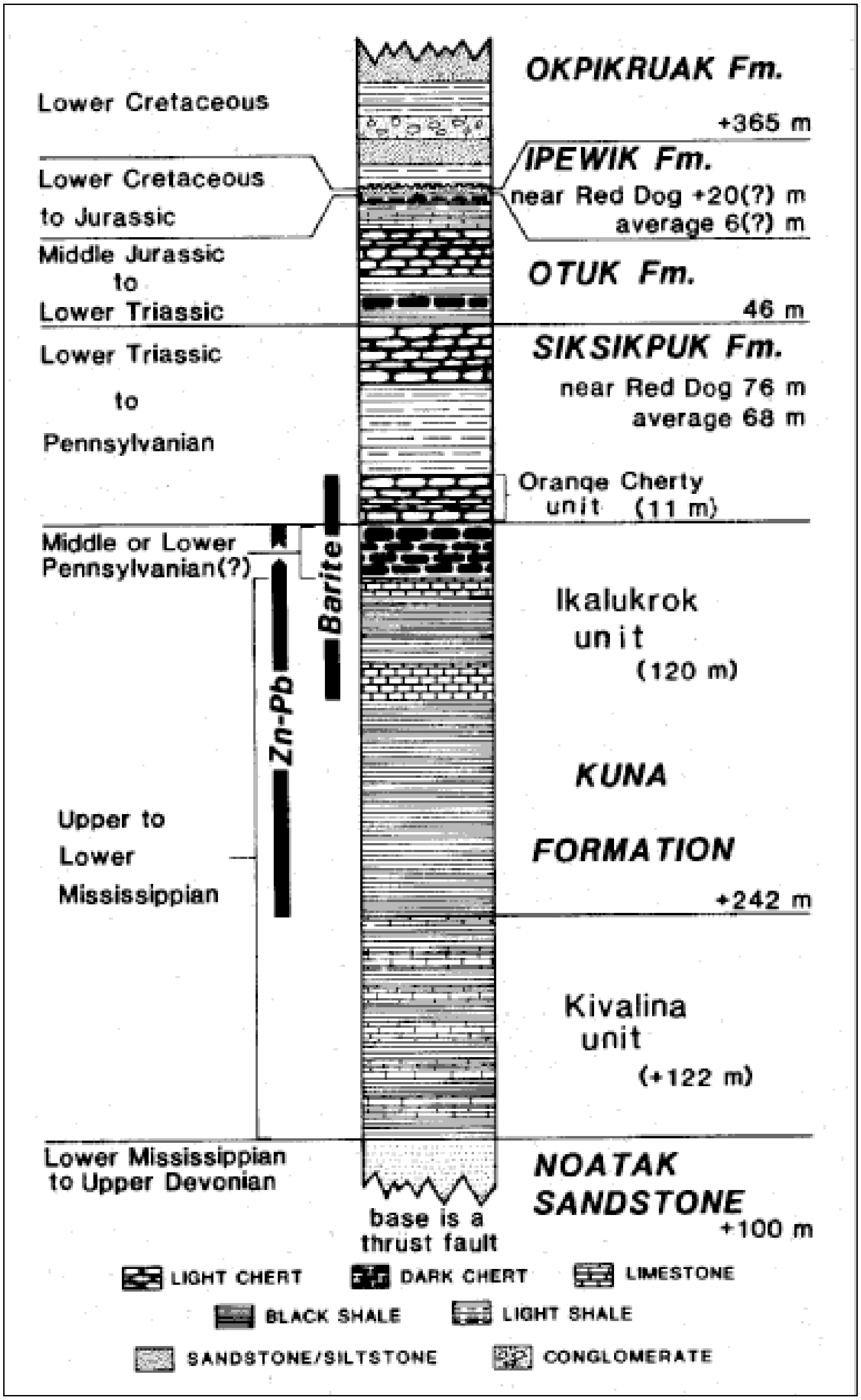
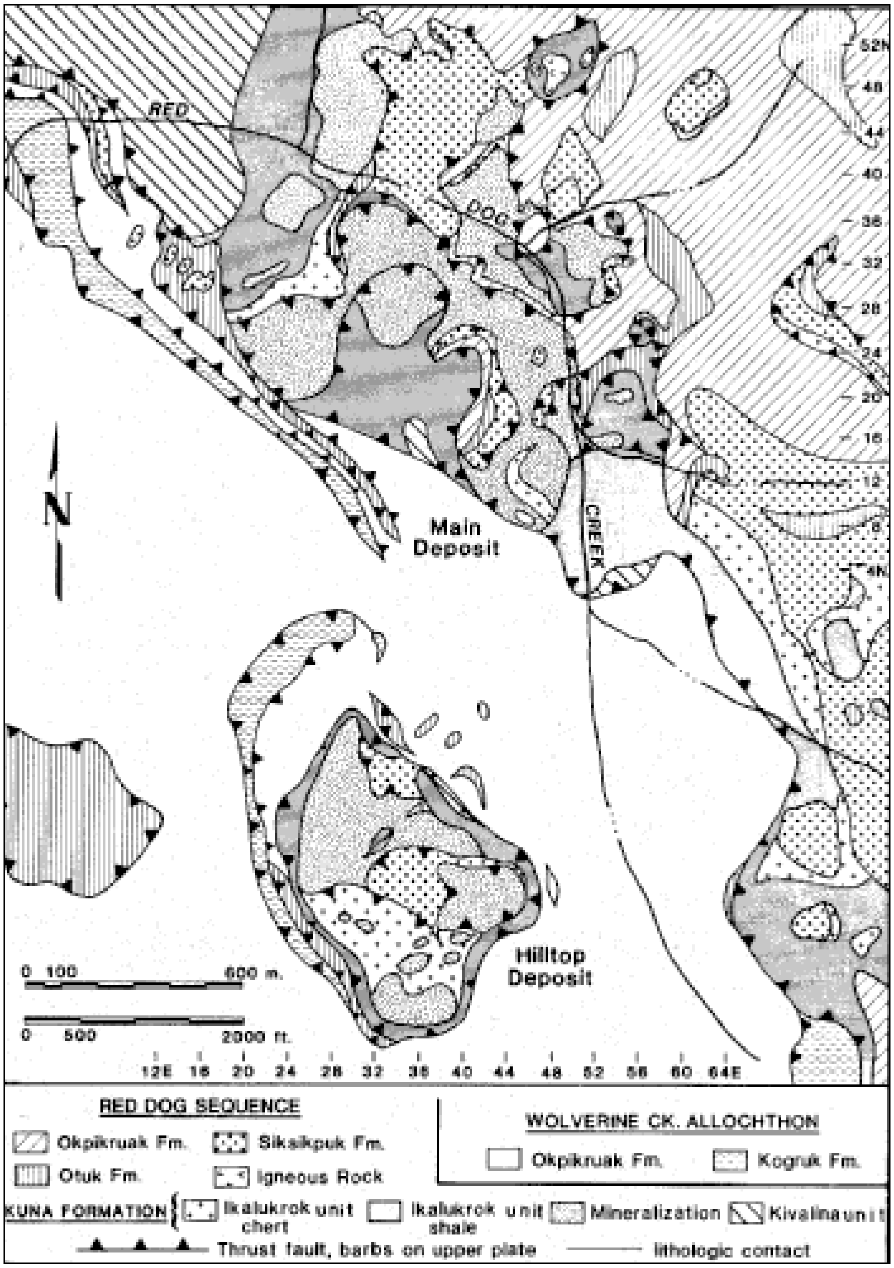


Figure 7-3: Bedrock Geology for the Main and Qanaiyaq (Hilltop) Deposits (Moore, 1986)



7.1 Main Deposit

The Main deposit, as known from drilling and pit mapping, is a nearly flat, elongate stack of mineralized lenses. It extends 1,600 m in a northwest direction, varies in width from 150 m to 975 m and is up to 135 m thick. The erosion contact of the structural footwall tectonic melange zone and underlying Okpikruak formation of the Wolverine Creek allochthon forms the western and southwestern edge of the deposit.

To the north and northeast, the Main merges with the Aqqaluk deposit. Main and Aqqaluk are actually one deposit separated for convenience along a line defined by Red Dog and Shelly creeks.

The Main deposit consists of two major and one minor mineralized plates and their associated cap rocks. The upper plate is a flat-lying sheet of Kivalina unit limestone and shale, Ikalukrok unit siliceous shale and sulphide-bearing barite rock. The median plate contains most of the reserves in the Main zone and consists of a sequence of massive to semi-massive sulphide rock, sulphide-bearing silica rock and sulphide-bearing barite rock. The mineralized portion of the median plate is capped with a sequence of shale and chert of Sihsikpuk, Otuk and Okpikruak units. The lower plate mineralization in the Main deposit consists of sulphide-veined, silicified, Ikalukrok shale and sulphide-bearing barite rock. An idealized section through the Main and Aqqaluk deposits is shown in Figure 7-4.

7.2 Aqqaluk

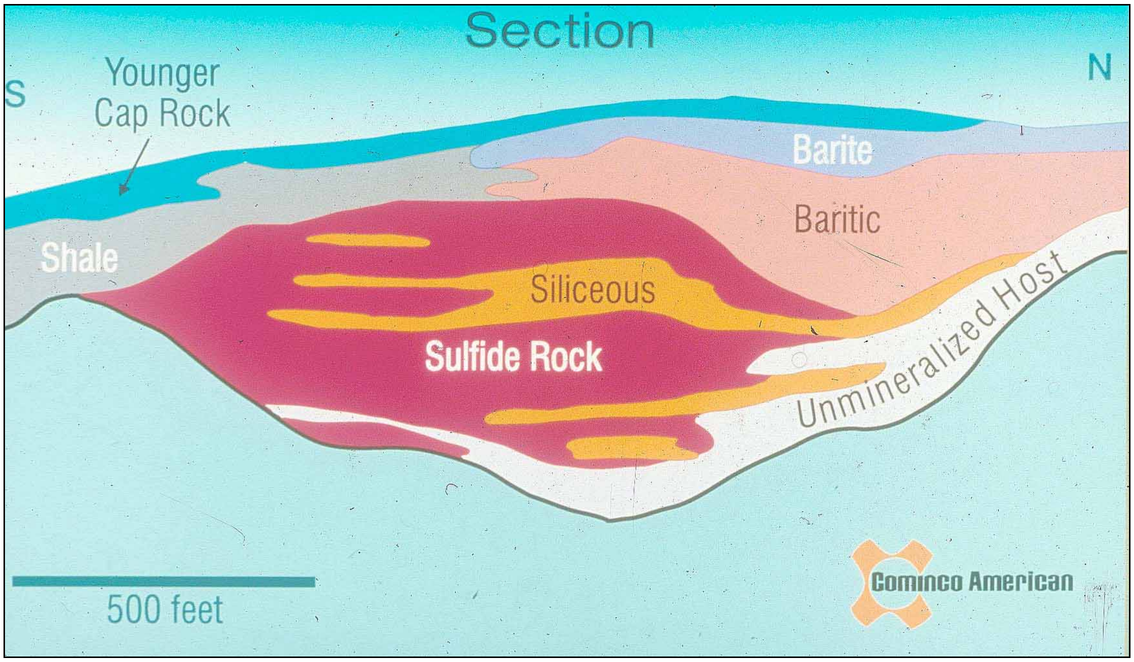
The Aqqaluk deposit lies directly to the north of the Main deposit. The Aqqaluk deposit is defined as any open pittable ore north of the roughly east-west line made by Shelly Creek and Red Dog Creek, downstream of the Shelly Creek intersection. Any Paalaaq (sub-lower plate) ore mined in an open pit would also be considered Aqqaluk. Lower plate mineralization forms the largest component (70% to 80%) of the Aqqaluk reserves and resources. The dimensions of the mineralization at the Aqqaluk deposit are 700 m east-west, 600 m north-south and up to 150 m thick.

In general the base of the Aqqaluk deposit is defined as a melange unit that corresponds to Lower Plate thrust. In contact with the melange is a mineralized sequence of veined Ikalukrok shale, followed by semi-massive to massive sulphide rock interfingered with mineralized silica exhalite. Capping this sulphide-rich package is weakly mineralized to barren barite cap.

Thickness of the veined unit varies from 3 m to 30 m, sulphide and the silicic exhalite varies from 3 m to 80 m and from barite cap varies from 1 m to 80 m.

To the south of Red Dog Creek, Aqqaluk is over thrust by the median plate of the Main deposit. To the north, east and west it is either bounded by the Lower Plate thrust or grades into unmineralized silicified Ikalukrok shale.

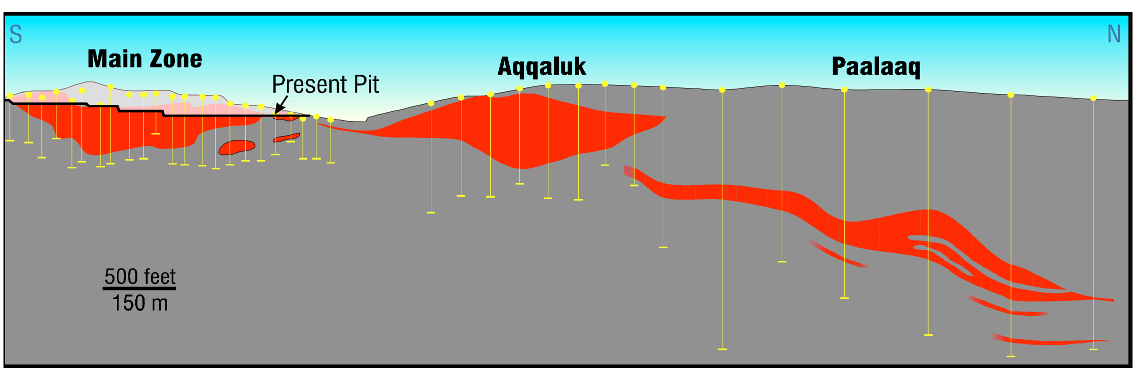
Figure 7-4: Aqqaluk Deposits, Idealized Section



7.3 Paalaaq

The Paalaaq deposit is an arcuate shaped mineralized zone lying to the north of the Aqqaluk deposit. The deposit is approximately 1,200 m north-south, 100 m to 200 m east-west and up to 60 m thick. The wide-spaced drilling has not allowed a detailed geological breakdown of ore types; however, they are similar to those found in the Main and Aqqaluk zones. The zone is contained within a thrust sheet below the Aqqaluk deposit, referred to as the sub-lower plate. Drilling has shown the eastern and western margins to be structurally defined. The zone is open to the north and appears to be truncated by the Lower Plate thrust to the south (Figure 7-5).

Figure 7-5: Main, Aqqaluk and Paalaaq Zones



7.4 Qanaiyaq

The Qanaiyaq deposit (formerly referred to as the Hilltop deposit) lies approximately 600 m to the south of the Main deposit. It is contained in a flat-lying klippe 850 m long by 600 m wide. The klippe forms the crest of a hill, thus the limits of mineralization are well defined. The mineral assemblage and internal structure of Qanaiyaq is similar to that observed in the Main deposit.

7.5 Aŋarraaq

The Aŋarraaq zone occurs at the base of a large thrust sheet at a depth of approximately 640 m. As at Red Dog, the mineralization is hosted within a large lens of silicified and pyritic shale within the Ikalukrok sequence of black shale, chert, turbidite and barite. Younger units of Siksikpuk shale, siltstone and chert overlie the Ikalukrok and are in turn overlain by Otuk chert. These units are unconformably overlain by a sequence of Cretaceous shale, siltstone and interbedded greywacke.

The host units are part of a thrust sheet, which has moved from south to north. The mineralized zone occurs between the basal thrust of the sheet and an overlying thrust that is one of several internal to the thrust sheet. The overlying thrust merges with the basal thrust to form the southeast margin of the mineralized zone. This structural bounding is analogous to the Red Dog Main and Aqqaluk deposits, where basal and overlying thrusts merge to contain the mineralization in discrete lens-shaped bodies.

The Aŋarraaq mineralization consists of strata-bound, banded-to-massive sphalerite, galena and pyrite bodies. This mineralization, as defined by current drilling, occurs in a lenticular zone 480 m in length, 430 m in width and up to 73 m thick. The mineralized zone is contained within a larger lens of silicified and pyritic shale 825 m long, 600 m wide and 122 m thick.

A large barite body 60 m to 100 m thick and containing a possible 1 billion tonnes lies above the sulphides. A thrust fault and 91 m of barren shale separate the barite body and the sulphides.

Figure 7-7: Aŋarraaq Section

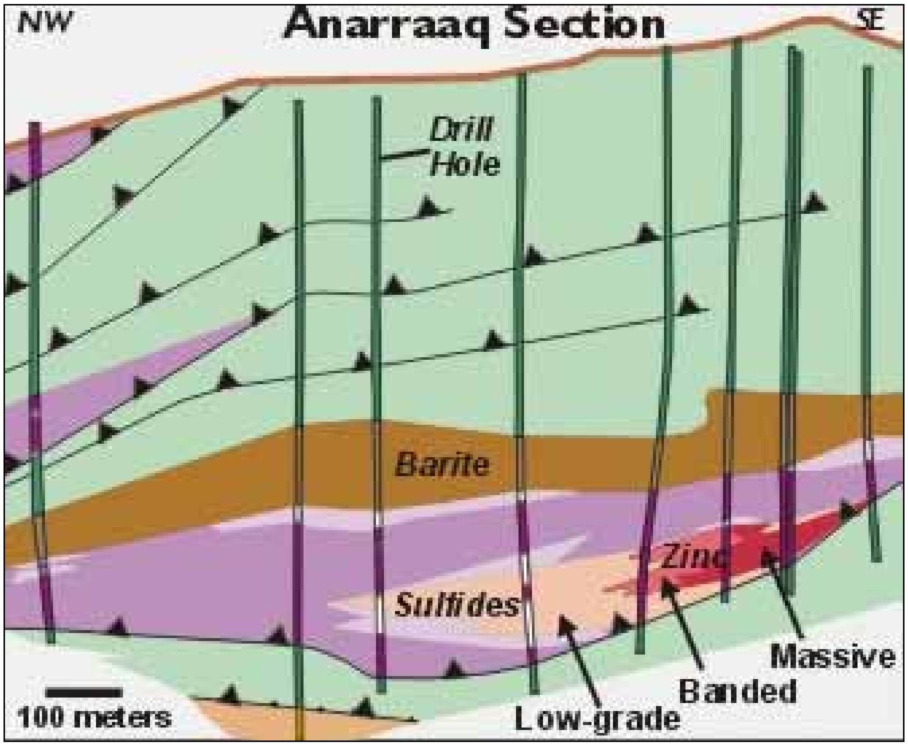
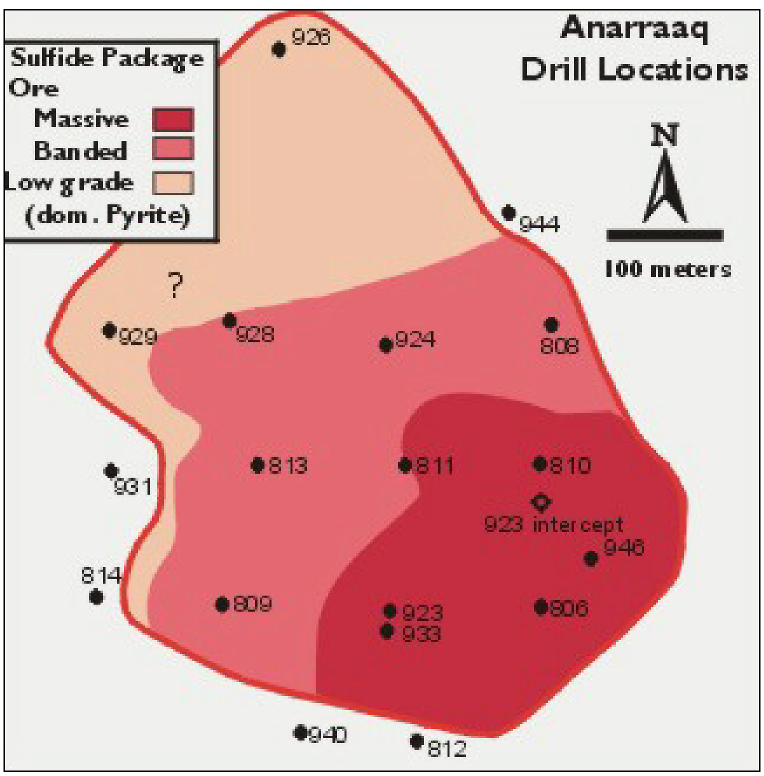


Figure 7-8: Aŋarraaq Plan



8.0 DEPOSIT TYPES

The Red Dog deposits are examples of a sedimentary-hosted exhalite (SEDEX) lead-zinc sulphide deposit. These deposits occur within tectonically (growth fault) controlled sedimentary basins situated in a continental rise, continental shelf or intracontinental marine basin. The host rocks are deep marine clastic sedimentary rocks (shales, siltstones, fine- to coarse-grained turbidites), starved basin lithofacies (carbonaceous to siliceous shales, chert) and shallow marine lithofacies (calcareous shales, carbonates). The deposit form is typically layered to lensoidal, concordant to the host sedimentary layers. Lateral extents vary from 10s to 100s times the lens thickness.

Principal sulphide minerals are sphalerite, galena and pyrite. Barite is commonly present.

Alteration is common and comprises silicification, albitization, chloritization or dolomitization. These zones can commonly contain stockwork and disseminated sulphide mineralization (Eckstrand, 1984).

A genetic model developed for the Red Dog deposits combines a sedimentary exhalite (SEDEX) and replacement origin. Reduced black shale of the Kuna Formation was deposited in a restricted sub-basin developed during rifting in early Mississippian time. Block faulting associated with rifting tapped the regionally extensive Noatak sandstone and provided a pathway for fluid flow to the sea floor. Syngenetic barite rock and subordinate amounts of low-grade sulphide rock and silica rock were deposited as sediments. The barite rock formed a cap, which restricted and localized fluid flow. Replacement by silica and sulphides continued under this cap. Upward migration of the vein system, through the exhalite, further upgraded the deposit. Thrusting related to a Cretaceous-aged compressional event fragmented and structurally repeated the ore body.

9.0 MINERALIZATION

The Main, Aqqaluk, Paalaaq and Qanaiyaq deposits consist of a strata-bound accumulation of silica rock, baritic rock and sulphide rock, hosted for the most part within Ikalukrok siliceous shale and chert. Texturally the ore can range from massive to fragmental to poorly bedded over short distances.

Within each thrust plate, high sulphides dominate in the centre of the deposit, baritic facies tend to cap sulphide-rich zones and silica rock occurs both within and along the margins of the main mass of the deposit. The Ikalukrok shale at the base or on the peripheries of the deposit is generally silicified and often contains numerous 1 cm to 10 cm veins of coarser sphalerite, galena and silica.

Five basic mineralogical ore types are recognized at the Red Dog deposits: silica rock, baritic rock, massive sulphide, semi-massive sulphide and sulphide veins.

The silica rock is milky to translucent grey rock, consisting of fine- to medium-grained quartz, cryptocrystalline chert and subordinate radial chalcedony. The quartz characteristically forms growth-zoned mosaic aggregates or single crystals up to 2 mm long. Clusters of fine barite and sphalerite grains are common at the cores of the quartz crystals. Chert forms blobby or nebulous patches, which coalesce to form more or less compact masses of cryptocrystalline quartz. Silica rock often contains an indistinct quartz-barite vein network and quartz crystal-lined vugs. Worm burrows or tubes are common within the silica rock. These tubes are generally 0.5 to 1 cm in diameter and up to 10 cm in length. Sulphides are a common accessory to the silica rock and where sufficiently abundant constitute an ore type. Sphalerite and lesser amounts of pyrite, marcasite and galena are present as very fine 10 to 50 µm dustings in chert-bearing portions. Coarse-grained sulphides also occur in the growth-zoned quartz. Varying proportions of sulphide commonly result in the development of poorly developed layering in the silica rock.

Baritic rock forms a mineralogical continuum with the silica rock. Sphalerite, pyrite and galena are common constituents of the baritic rocks. Galena is more abundant in this unit than in the deposit as a whole. Sphalerite is commonly crustiform and growth zoned. Calcite and gypsum are minor constituents. Barite typically occurs as coarse-grained non-oriented aggregates of prismatic crystals up to several millimetres in size. Sulphides occur as coarse granules along crystal boundaries or as fine-grained disseminations associated with quartz.

Sulphide rocks have been arbitrarily subdivided into two categories based on total sulphide content: massive sulphide contains greater than 70% sulphide, and semi-massive sulphide contains between 40 and 70% sulphide. A third category, sulphide bearing, contains 1 to 40% sulphide and is used to describe mineralized barite, silica rock or shale. Sulphide rocks are generally massive to poorly bedded. Fine-grained fragmental textures are common in massive sulphide. Coarse angular breccias occur throughout the deposit but are best developed near the base where fragments of silicified shale, crustiform-banded sphalerite and a variety of other minerals including barite and sulphide breccia occur in a fine-grained sulphide matrix. Sulphide mineralogy, in decreasing order of abundance, is sphalerite, pyrite, marcasite and galena. Minor chalcopyrite and pyrrhotite occur as minute blebs in the sphalerite. Silica is the common gangue constituent in the sulphide facies. It commonly occurs as mosaics of strongly growth-zoned quartz crystals. Barite is also common as veinlets and pockets within the gangue. Shale fragments are common constituents of the sulphide fragmental rock.

Sphalerite occurs as massive monomineralic accumulations, as fine dispersions throughout compact cherty silica or as bladed growth-zoned intergrowths with growth-zoned subhedral quartz. Sulphide breccias containing broken shards and crusts of banded or colloform sphalerite are relatively common. Galena, the least common major sulphide, generally occurs as coarse-grained aggregates in sphalerite, less commonly as sulphide veins and rarely as monomineralic layers in massive sulphide. Pyrite occurs as brecciated to massive material, aggregates of euhedral to subhedral grains, fine-grained disseminations in chert or shale, colloform bands, spherulites and framboids. Pyrite occurs intergrown with sphalerite and galena down to a range of a few µm. Marcasite is relatively common as patchy or banded intergrowths with pyrite or as independent colloform masses.

Sulphide vein mineralization is found within the hosting Ikalukrok shale near the base or margins of the sulphide-rich areas. In many places, concentrations of veins within the shale constitute ore. Veins also cross-cut silica and sulphide rock, suggesting multiple pulses of mineralization. Veins vary in width from hairline fracture fillings to nearly a metre. Wall rock fragments are commonly included in the veins. Banding, crustiform and comb textures indicate open space filling. Sulphides are generally coarse grained within the veins. Light and dark bands of sphalerite parallel to the walls of veins are attributed to varying iron content. Pyrite and galena are subordinate to sphalerite and commonly form monomineralic bands parallel to the vein walls. Drusy quartz and lesser barite are common as infillings at the centre of the veins but also may occur at the vein margins.

At the Aŋarraaq deposit two dominant geological ore types have been identified (Type A and Type B). Type A is massive sulphide and accounts for the bulk of the Aŋarraaq mineralization at this time. It consists of medium-coarse red-brown sphalerite with approximately equal amounts of pyrite. Galena is a minor component and occurs in late veins, disseminations and vugs. Gangue consists of buff-coloured calcite and minor remnant silicified shale. Veins of sphalerite, pyrite and galena are sometimes present, cross-cutting the massive sulphide host rock or parallel to the bedding.

Type B consists of interlayered sulphide and shale and is usually semi-massive with fines to medium-grained, tan to light-grey sphalerite. It has twice as much pyrite (± marcasite) as type A. Minor galena is present and occurs as disseminations and lesser veins. Gangue consists of remnant silicified and unsilicified shale and minor buff-coloured calcite veins. The original texture of the host rock is preserved.

10.0 EXPLORATION

Exploration work in the Red Dog District started in 1978 and with the exception of a hiatus between 1990 and 1994 has been nearly continuous. Exploration has included geological mapping, geochemistry, geophysical surveys and drilling.

Geophysical methods included Airborne EM, IP, CSAMT, TEM, UTEM and gravity. The original gravity and IP surveys were generally small surveys of specific claims or geological targets. More recent gravity surveys have been completed on a regional scale. Gravity is partially credited with the discovery of the Aŋarraaq deposit. Down-hole IP has also proved effective at Aŋarraaq.

11.0 DRILLING

Since 1978, Cominco Ltd. has drilled 192,836 m in 1,075 holes in the district (see Table 11-1). This drilling consists of 38,845 m (170 holes) of exploration and 153,990 m (905 holes) of ore definition drilling. A map showing the locations of all drill holes for the Paalaaq, Aqqaluk, Main and Qanaiyaq deposits is provided in Appendix C.

The ore definition drilling is distributed between the Main, Aqqaluk, Aŋarraaq, Paalaaq and Qanaiyaq deposits. In the case of the Main deposit, 25% of the definition drilling was reverse circulation (RC) drilling, and at Qanaiyaq 55% of the holes were RC. All other ore definition drilling has been diamond drilling.

The collars of ore definition holes and exploration holes close to the deposits are initially located by the mine surveyors and surveyed again after completion of the hole. The surveyors, with the exception of some of the more remote and pre-1985 holes, have picked up most of the exploration holes on the property.

Since 1997, all holes in excess of 150 m (500 feet) have been surveyed with a down-hole instrument. These longer holes are surveyed at 150 m intervals and at the final hole depth using a single-shot Sperry Sun instrument. All holes are vertical, and experience has indicated that there is very little deviation in holes less than 150 m. Before 1997, the only holes with down-hole surveys were from 1982-83.

Table 11-1: Red Dog District Drilling History

Year	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**
Exploration													
Holes	6	3	22	18	21	22	13	8	7	7	3	2	2
Metres	610	574	5,587	3,243	3,068	3,903	1,869	1,201	1,343	789	434	677	331
Ore Definition													
Holes				8	30	33	34	6	2				15
Metres				979	3,522	4,617	2,176	335	156				1,253
Total Holes	**6**	**3**	**22**	**26**	**51**	**55**	**47**	**14**	**9**	**7**	**3**	**2**	**17**
Total Metres	**610**	**574**	**5,587**	**4,222**	**6,590**	**8,521**	**4,045**	**1,536**	**1,499**	**789**	**434**	**677**	**1,584**

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**Total**
Exploration												
Holes						5	3	1		21	6	170
Metres						723	978	762		8,332	4,421	38,845
Ore Definition												
Holes	46	69	98	67	33	119	60	74	9	95	107	905
Metres	5,899	7,553	10,230	9,853	4,339	16,521	11,233	17,175	3,542	26,433	28,172	153,990
Total Holes	**46**	**69**	**98**	**67**	**33**	**124**	**63**	**75**	**9**	**116**	**113**	**1,075**
Total Metres	**5,899**	**7,553**	**10,230**	**9,853**	**4,339**	**17,245**	**12,211**	**17,936**	**3,542**	**34,765**	**32,593**	**192,836**

11.1 Main

Since 1980, 57,570 m in 467 diamond drill holes and 19,635 m in 160 RC holes have been completed at the Main deposit (Table 11-2). Figure 11-1 is a location map showing drill hole locations relative to the pit location at the Main deposit. The drill spacing in the pit is nominally 30 m x 30 m.

Table 11-2: Main Deposit Drilling History

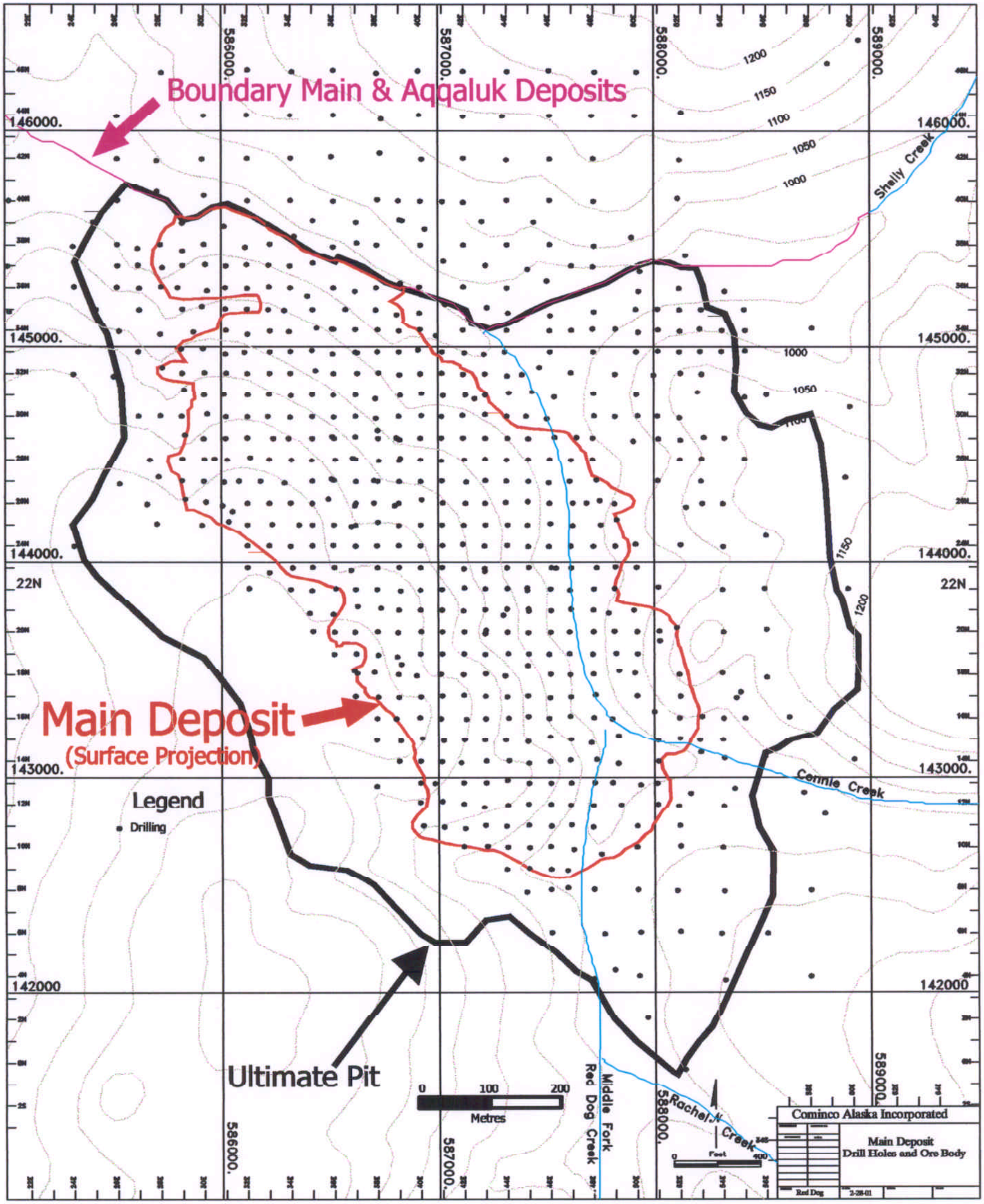
Year	1980	1981	1982	1983	1984	1985-88	1989	1990	1991	1992
DDH	7	24	33	28	6		3	46	34	34
Metres	829	2,768	4,617	1,790	335		471	5,899	3,685	3,814
RC Holes									28	44
Metres									2,787	4,756
Total Holes	**7**	**24**	**33**	**28**	**6**	**0**	**3**	**46**	**62**	**78**
Total Metres	**829**	**2,768**	**4,617**	**1,790**	**335**	**0**	**471**	**5,899**	**6,472**	**8,571**

Year	1993	1994	1995	1996	1997	1998	1999	2000	Total
DDH	35	18	20	38	34	4	44	59	467
Metres	5,062	2,520	2,468	5,250	5,033	388	5,152	7,489	57,570
RC Holes	32	15	21	13	7				160
Metres	4,791	1,819	2,685	1,751	1,044				19,634
Total Holes	**67**	**33**	**41**	**51**	**41**	**4**	**44**	**59**	**627**
Total Metres	**9,853**	**4,339**	**5,154**	**7,001**	**6,077**	**388**	**5,152**	**7,489**	**77,205**

11.2 Aqqaluk

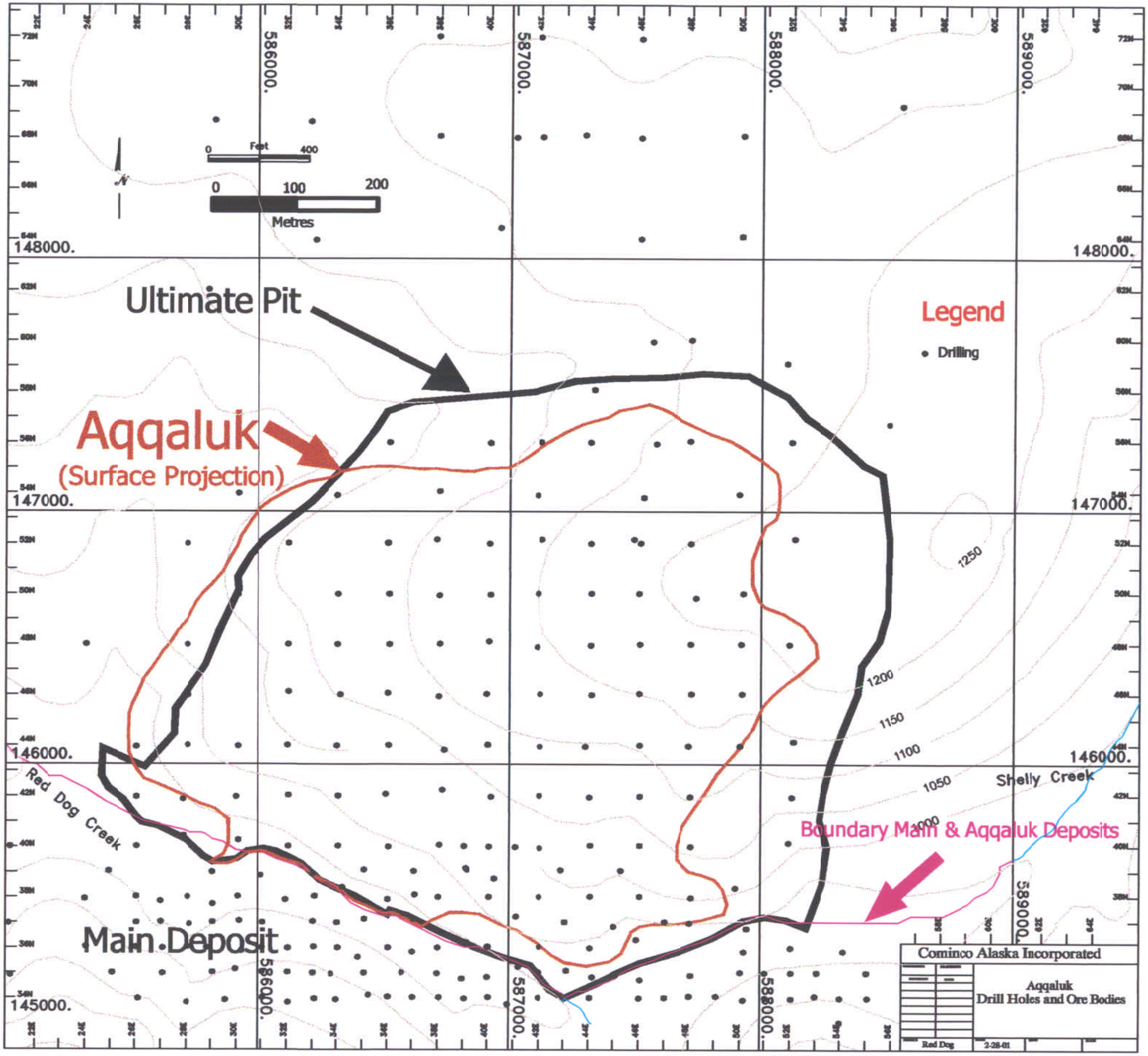
Since 1980, 127 core holes have been drilled in Aqqaluk, for 24,515 m of core (Table 11-3). Drill spacing is nominally 30 m x 60 m in the southern end, along the common boundary with the Main Deposit. Coverage decreases to 60 m x 60 m over the middle of the deposit where the majority of reserve and resource tonnes are currently defined. Along the northern and western edges, the coverage falls to 120 m x 60 m. Figure 11-2 shows the locations of the drill collars in relation to the boundaries of the mineralization and the proposed pit outline.

Figure 11-1: Drill Hole Location – Main Deposit



Boundary Main & Aqqaluk Deposits
Main Deposit
(Surface Projection)
Ultimate Pit
Legend
Drilling
585000.
586000.
587000.
588000.
589000.
146000.
145000.
144000.
143000.
142000
22N
Shelly Creek
Connie Creek
Middle Fork
Red Dog Creek
Rachel Creek
1200
1150
1100
1050
1000
0
100
200
Metres
Cominco Alaska Incorporated
Main Deposit
Drill Holes and Ore Body
Red Dog

Figure 11-2: Drill Hole Location – Aqqaluk Deposit



Ultimate Pit
Aqqaluk
(Surface Projection)
Legend
Drilling
Main Deposit
Red Dog Creek
Shelly Creek
Boundary Main & Aqqaluk Deposits
Feet
0
400
0
100
200
Metres
148000.
147000.
146000.
145000.
586000.
587000.
588000.
589000.
1250
1200
1150
1100
1050
1000
Cominco Alaska Incorporated
Aqqaluk
Drill Holes and Ore Bodies
Red Dog
2-28-01

Table 11-3: Aqqaluk Drilling

Aqqaluk	1980	1981	1985	1991	1995	1996	1997	1999	2000	Total
DDH	1	4	2	6	39	1	16	28	29	126
Metres	150	551	156	989	7,084	328	2,930	6,493	5,743	24,424
RC Holes				1						1
Metres				91						91
Total Holes	**1**	**4**	**2**	**7**	**39**	**1**	**16**	**28**	**29**	**127**
Total Metres	**150**	**551**	**156**	**1,081**	**7,084**	**328**	**2,930**	**6,493**	**5,743**	**24,515**

11.3 Paalaaq

Since 1995, 39 diamond drill holes have been drilled for a total of 17,270 m in the Paalaaq deposit (Table 11-4). Drill spacing in this area is nominally 120 m x 120 m. Drill collar locations in relation to the mineralization are shown in Figure 11-3.

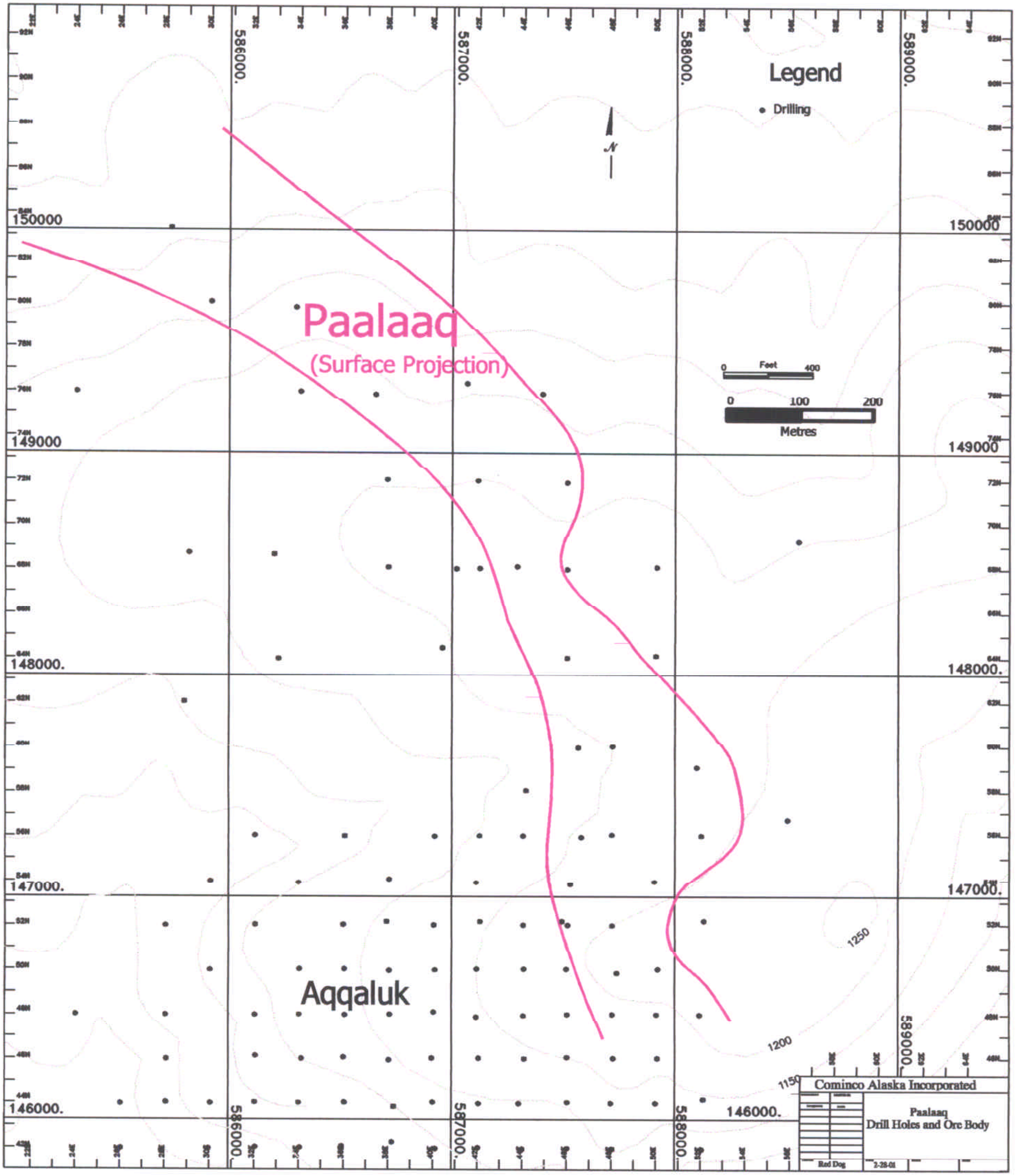
Table 11-4: Paalaaq Drilling

Paalaaq	1995	1996	1997	1998	1999	2000	Total
DDH	9	8	17	5			39
Metres	2,044	3,905	8,167	3,154			17,270
RC							0
Metres							0.0
Total Holes	**9**	**8**	**17**	**5**			**39**
Total Metres	**2,044**	**3,905**	**8,167**	**3,154**			**17,270**

11.4 Qanaiyaq

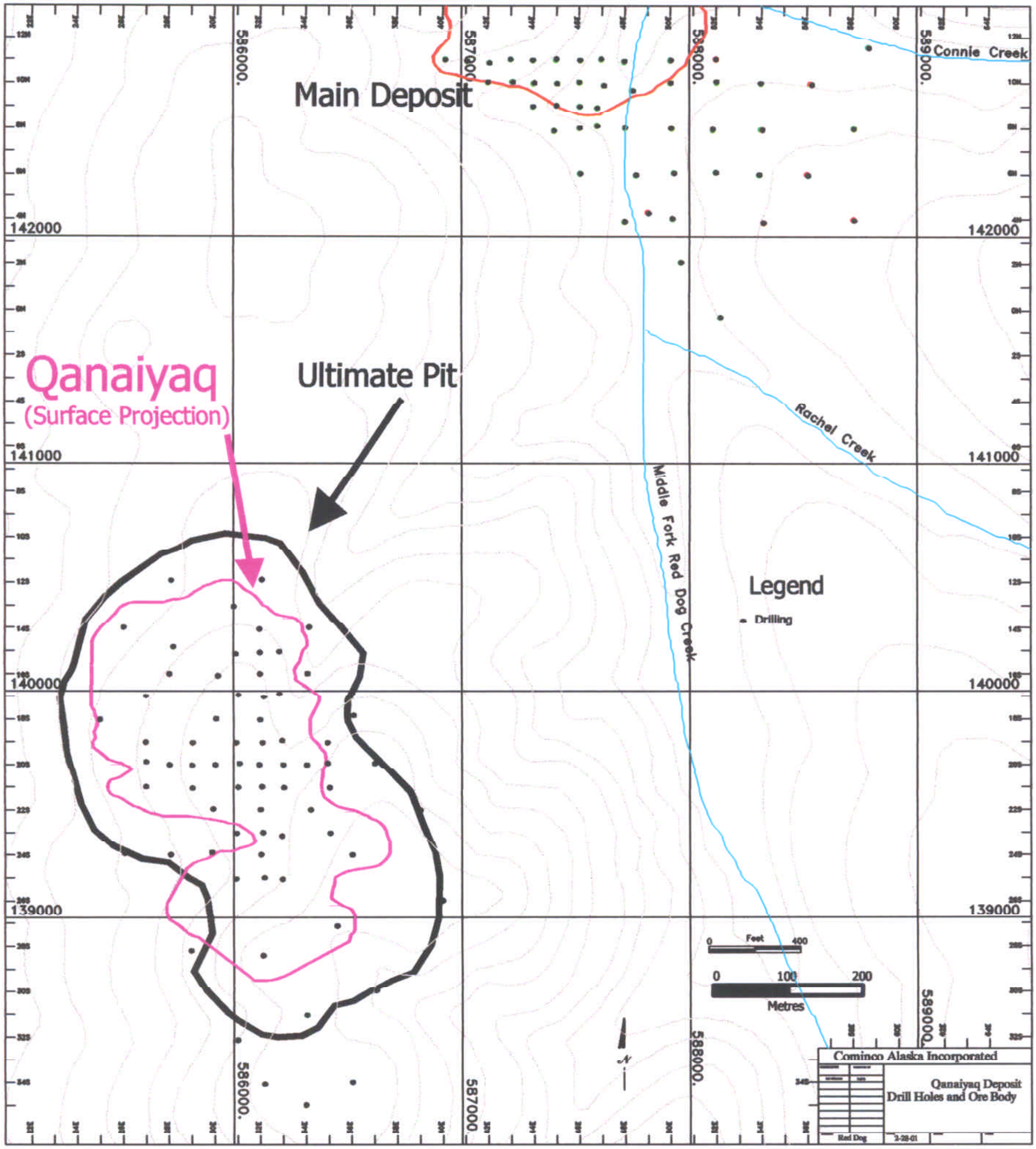
The Qanaiyaq deposit is defined by 70 holes. Parts of the middle of the resource are drilled out at 30 m x 30 m, while other parts of the currently outlined >6% zinc zone are 120 m x 60 m. Figure 11-4 shows the drill hole collars in relation to the surface projection of the mineralization and the pit outline.

Figure 11-3: Drill Hole Location – Paalaaq Deposit



Legend
Drilling
Paalaaq
(Surface Projection)
Aqqaluk
Feet
0
400
0
100
200
Metres
586000.
587000.
588000.
589000.
150000
149000
148000.
147000.
146000.
1250
1200
1150
Cominco Alaska Incorporated
Paalaaq
Drill Holes and Ore Body
Red Dog

Figure 11-4: Drill Hole Location – Qanaiyaq Deposit



Main Deposit
Connie Creek
Qanaiyaq
(Surface Projection)
Ultimate Pit
Rachel Creek
Middle Fork Red Dog Creek
Legend
Drilling
586000.
587000.
588000.
589000.
142000
141000
140000
139000
Feet
0
400
0
100
200
Metres
N
Cominco Alaska Incorporated
Qanaiyaq Deposit
Drill Holes and Ore Body
Red Dog
2-28-01

Table 11-5: Qanaiyaq Drilling

Qanaiyaq	1981	1983	1989	1992	1995	Total
DDH	2	6	12		15	35
Metres	203	386	782		999	7,778
RC				20	15	35
Metres				1,660	1,240	9,515
Total Holes	**2**	**6**	**12**	**20**	**30**	**70**
Total Metres	**203**	**386**	**782**	**1,660**	**2,240**	**17,293**

11.5 Aŋarraaq

Forty-two drill holes have been completed on the Aŋarraaq deposit to date, for a total of 29,730 m of core (Table 11-6). Drill spacing at this deposit is nominally 120 m x 120 m. A collar location plan is included as Figure 11-5.

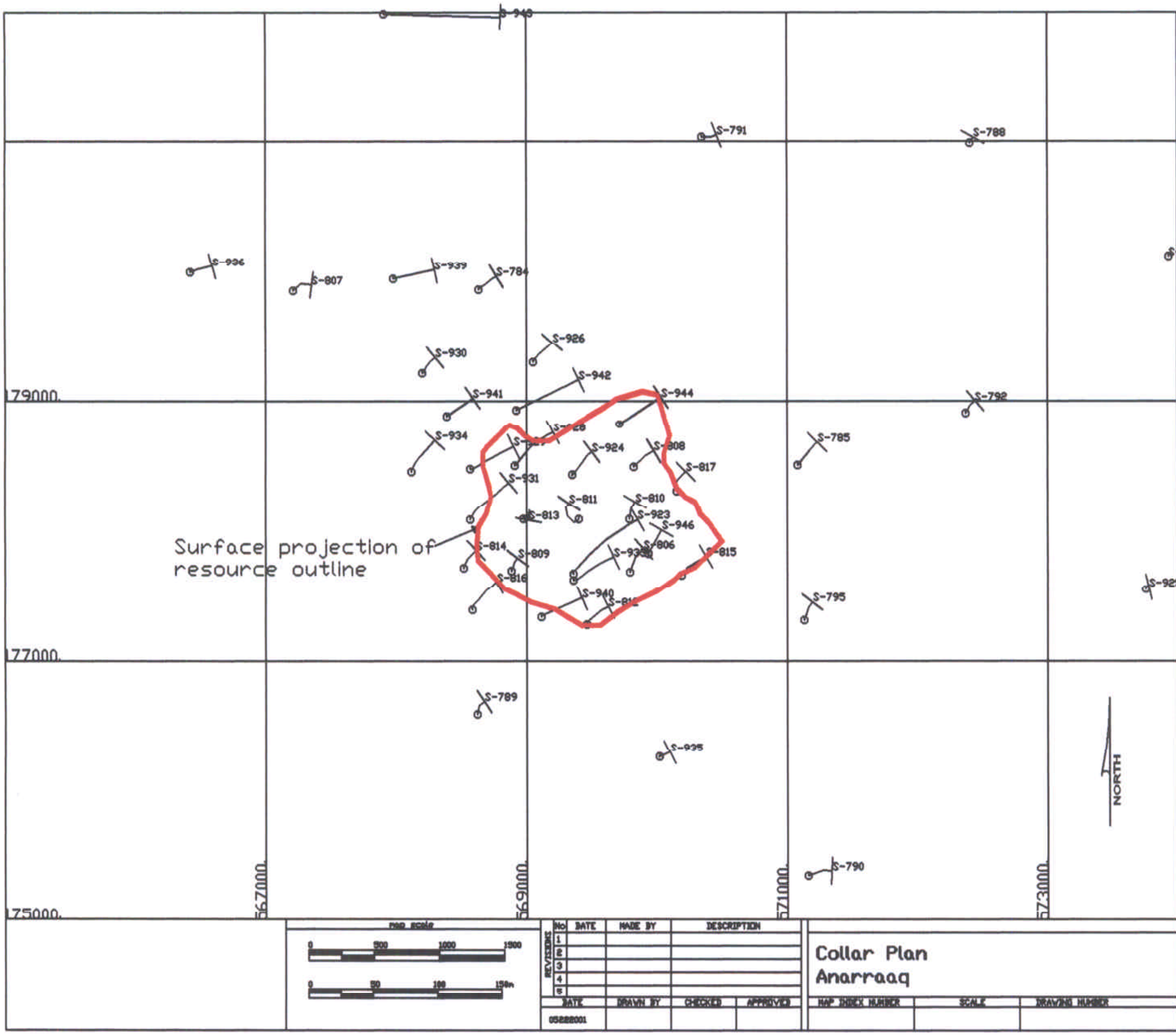
Table 11-6: Aŋarraaq Drilling

Aŋarraaq	1999	2000	Total
DDH	23	19	42
Metres	14,789	14,941	29,730
RC Holes			0
Metres			0
Total Holes	**23**	**19**	**42**
Total Metres	**14,789**	**14,941**	**29,730**

11.6 Core Logging Procedures

Core is delivered to the core logging building at the mine complex. A geologist makes a written log for the hole, which includes geological and geotechnical information. All drilling, logging and sampling at the Red Dog mine is in the imperial system of measurement (feet and inches).

Figure 11-5: Drill Hole Location – Aŋarraaq Deposit


Surface projection of resource outline
179000.
177000.
175000.
567000.
569000.
571000.
573000.
NORTH
S-936
S-807
S-784
S-930
S-926
S-942
S-941
S-944
S-934
S-924
S-808
S-817
S-931
S-811
S-810
S-813
S-923
S-946
S-814
S-809
S-806
S-815
S-816
S-791
S-788
S-781
S-792
S-785
S-795
S-789
S-790
map scale
0
500
1000
1500
50
100
150m
No
DATE
MADE BY
DESCRIPTION
REVISIONS
1
2
3
4
5
DATE
DRAWN BY
CHECKED
APPROVED
05222001
Collar Plan
Anarraaq
MAP INDEX NUMBER
SCALE
DRAWING NUMBER

The geological data captured include identification of specific geological formations, colour, measurements of structural features relative to the core axis (bedding, foliation, cleavage), any inclusions of bitumen, nature of fracture filling and a geological description. This geological section of the log encompasses as complete a visual description of the core as possible and includes such items as hardness, grain/crystal sizes, textures, lithological characteristics, deformation styles, sedimentary features, spatial relations, contact styles, metallurgical concerns and complete description of the mineralization.

The geologist is also required to make visual estimates of the percentage content of lead, zinc, iron and barium. These estimates are to be of the percentage content of the elements and not the mineral content of galena, sphalerite, pyrite and barite. The geologist is instructed to visualize the percentage mineral content for the specified element and then multiply it by the fraction of the molecular weight accounted for by the metallic cation. The fractions for the specified minerals are as follows:

- Weight percent Zn in sphalerite 67%
- Weight percent Pb in galena 86%
- Weight percent Fe in pyrite 47%
- Weight percent Ba in barite 58%

The geotechnical data captured include core loss, RQD, open fracture intensity, closed fracture intensity and occasionally some point load tests as requested by the engineering department. Core loss is captured by cumulatively measuring the pieces of core between two footage markers in the core box. This measured length is then subtracted from the actual length (as indicated by the footage markers) of the interval, and the amount of missing core is recorded. RQD measurements are captured as the pieces of core that are greater than twice the core diameter. Different sizes of core are drilled on the property, and so different criteria are used, as follows. For HQ drilling the core pieces must be greater than 7.6 cm long and for NQ drilling, 10.2 cm. Therefore, the RQD is measured by cumulatively adding the length of all core pieces greater than the required minimum core length in a 3 m intervals. A percentage of all core pieces greater in length than the minimum requirement is calculated for each 3 m length of the drill hole. Fracture intensity is measured by counting the number of open fracturing (actual breaks in core competency) for every 30.5 cm of core.

When the core logging process has been completed, the geologist then marks and tags the core for sampling and includes locations for insertion of standards and duplicates.

After splitting, the remaining half core is put into wax core trays and stored on shelves inside large metal shipping containers at the mine. In some cases this stored core has been used for metallurgical testwork.

Within mineralized sections, at approximately 6 to 8 m intervals, a 1.5 m sample interval is selected, measured and weighed to provide a specific gravity calculation. There is no need to dry the core in an oven because there is very limited porosity and the core is solid; air-drying is sufficient. These physical specific gravity measurements are used to confirm and modify if necessary the density algorithm used in the mine model.

12.0 SAMPLING METHOD AND APPROACH

At the Red Dog mine the core is systematically sampled in 1.5 m or 3 m intervals. When a particularly thick section of high-grade mineralization more than 10 m wide is encountered, the sample length is extended to 3 m samples; otherwise the core is sampled in 1.5 m increments. Sampling is bracketed by no less than 7.6 m of sampled core on either side of visible mineralization. Geologists are encouraged to over-sample as opposed to leaving the core under-sampled.

One duplicate and one standard are marked up and inserted into the sample stream for every 10 samples submitted to the lab. No blanks are used to assess the sample preparation.

13.0 SAMPLE PREPARATION, ANALYSES AND SECURITY

Both the RC and diamond drill core are sampled in either 1.5 m (5 foot) or, less frequently 3 m (10 foot) intervals. Core is split in half using a pneumatic splitter. One of the splits is crushed to ¼ in and then pulverized in a ring and puck mill. When an RC hole is assayed, the chips are crushed and pulverized in the same manner. A 250 gram aliquot of the pulp is submitted for assay.

Prior to the mine start-up in 1990, all analysis was done at Cominco Ltd.'s Exploration Research Laboratory (ERL) in Vancouver, B.C., since 1990 all analytical work has been done on site at the Red Dog mine laboratory. Table 13 outlines the analytical methods currently in use at the mine.

Table 13-1: Red Dog Analytical Analysis on Drill core and RC Cuttings

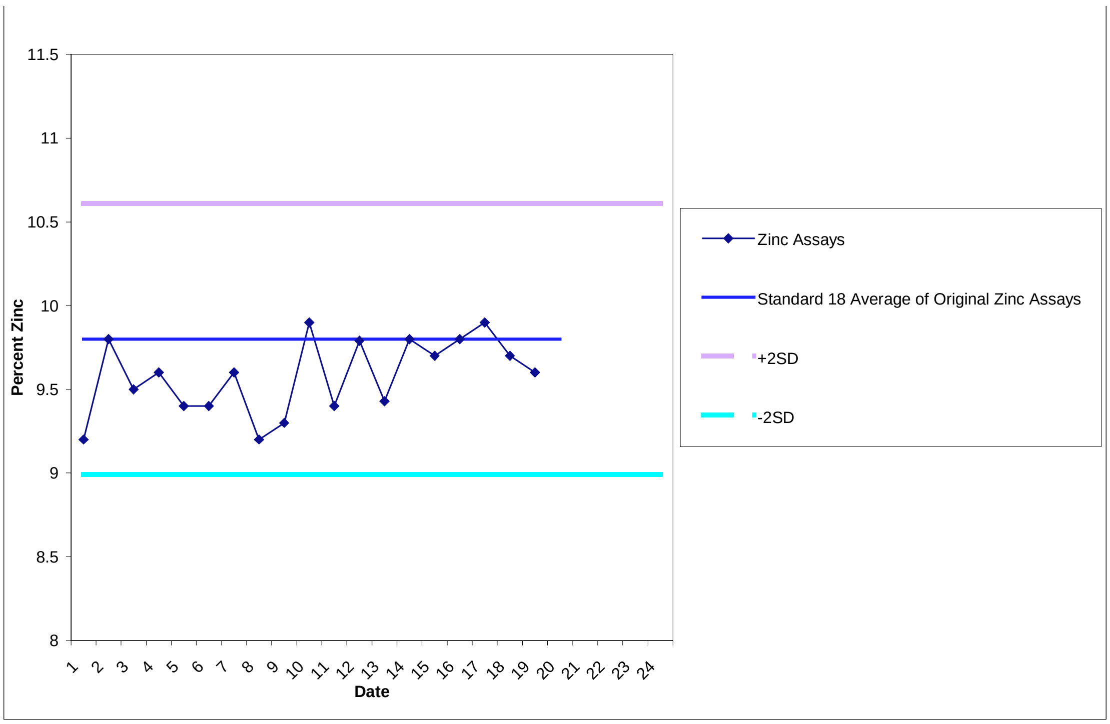
Element		Analytical Method	Detection Limit
Lead	Pb	Acid digestion/ICP	0.022 ppm
Zinc	Zn	Acid digestion/ICP	0.008 ppm
Iron	Fe	Acid digestion/ICP	0.011 ppm
Barium	Ba	XRF/ Powder	not established
Soluble Lead	sPb	Weak acid leach/AA	0.04 ppm
Soluble Zinc	sZn	Weak acid leach/AA	0.002 ppm
Silver	Ag	Nitric acid/ AA	0.007 ppm
Copper	Cu	Nitric acid/ AA	0.007 ppm
Sulphur (elemental)	S	Solvent leach/ gravimetric	not established
Total Organic Carbon	TOC	Leco	not established

Note: No trace metals run on ICP

Originally, all coarse rejects were stored at the mine; however, the volume of the material and degradation due to oxidation made this impractical. When a drill program is planned, it is decided what if any reject material will be required for metallurgical work. If coarse rejects are required, they are stored in plastic bags that are vacuum sealed and flooded with nitrogen to prevent oxidation. Only those rejects over 6% Zn are retained. Upon completion of the drill program the appropriate rejects are selected for compositing and metallurgical testwork. Once samples are no longer needed for testwork, they are discarded.

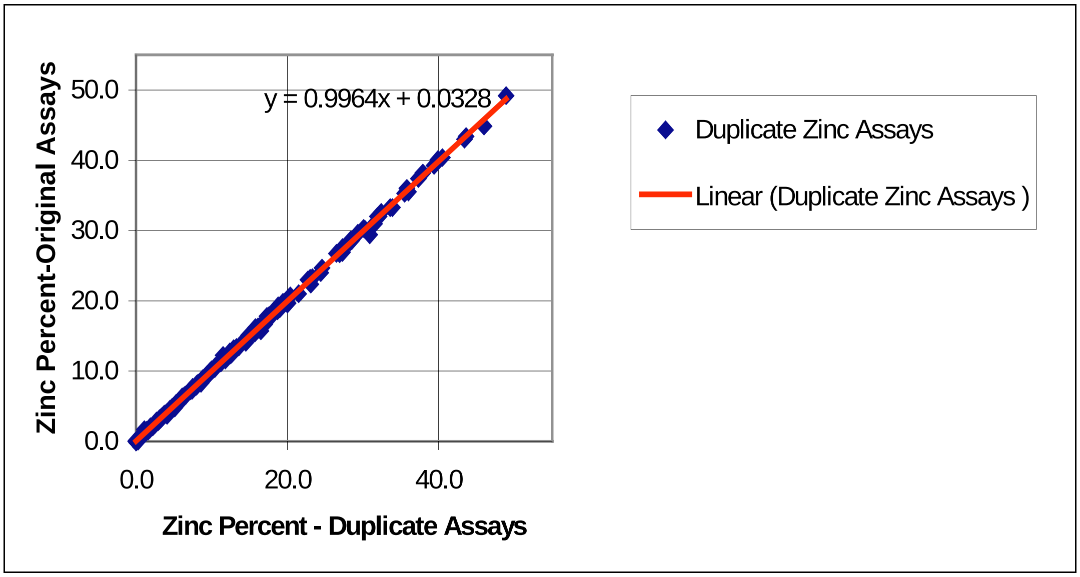
The mine has a two-part quality control program. The geology department submits duplicates and standards within each batch of 10 to 15 samples. The department maintains an inventory of 5 to 10 standards of varying grade ranges and ore types that are custom made on site from ore in the pit. Standards selected for insertion are similar in grade and mineralogy to the accompanying sample batch. To determine the average grades of the standards, five samples from each standard are analyzed at the Red Dog laboratory and four outside laboratories. Figure 13-1 illustrates the performance of Standard 18 over time. The assay results for this standard show that it is returning values a little below the average for the standard but well within the two standard deviation limits.

Figure 13-1: Aqqaluk – 1999-2000 Drilling Program results for Standard 18



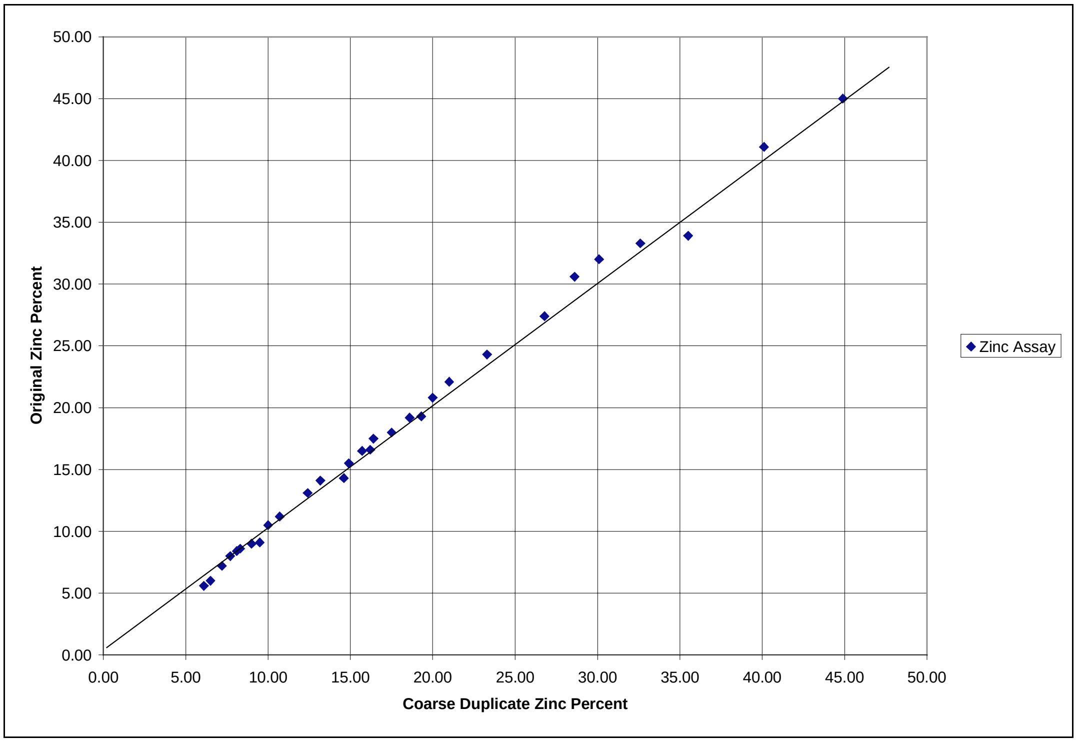
The geologist marks up the core to indicate which samples are to be duplicated, and during sample preparation a pulp duplicate is made from the sample. Figure 13-2 illustrates the performance of the pulp duplicates from the 1999-2000 drill program at the Aqqaluk deposit. There is very little variance in these pulp duplicates as seen in the chart below that illustrate very good reproducibility of the zinc assays.

Figure 13-2: Aqqaluk 1999 – 2000 Drill Program - Pulp Sample Duplicates



In 2000, Cominco Ltd. conducted a study to test for any increase in variability of the duplicate samples if coarse reject was used instead of pulp material. Figure 13-3 represents the results of this study. As seen in the graph, the coarse reject duplicates have performed very well and indicate good reproducibility of the zinc values.

Figure 13-3: Aqqaluk – 1999-2000 Drill Program - Coarse Reject Sample Duplicates



In addition to the duplicate and standard samples submitted by the geology department, the laboratory also has an internal procedure of standards, duplicates and blanks.

MRDI reviewed the QAQC data from the 1999-2000 drill program at the Aqqaluk deposit and found them to be well within acceptable limits.

14.0 DATA VERIFICATION

The mine site database received from the Red Dog Mine contained locations, assays and geotechnical data for drilling results from the property. Many fields in the database were calculated fields, but raw assay data for zinc, lead, silver, iron and barite were checked along with downhole surveys and collar locations.

MRDI conducted a standard 5% check of the database to verify all drill hole data that influence the reserves. Drill holes were chosen at random, but preference was given to drill holes that still had an influence on the reserve as opposed to those drilled into areas of the pit that have already been mined. Twenty-five holes were chosen from the Main deposit and eight holes from the Aqqaluk deposit.

The Red Dog Mine database passed this examination with an error rate of only 1.2% for the Main database (Table 14-1) and 0.9% for the Aqqaluk database (Table 14-2) after examining 14,170 assay results.

Table 14-1: Main Deposit Data Check Results

	Results			
Hole#	**Incorrect**	**Checked**	**Available**	**Comments**
15A		0	96	backup material unavailable
33	2	68	68	44.3 to 46.2 entered as 44.3 to 46.1
33				46.2 to 51 entered as 46.1 to 51
63	8	101	101	Log says 0 to 31 is overburden but database contains 5 ft sampling from 0 to 34
63				29 to 31 entered as 29 to 34
63				31 to 37 entered as 34 to 37
63				81 to 86.5 entered as 81 to 85.5
63				86.5 to 90 entered as 85.5 to 90
63				288.8 to 294.8 entered as 288.8 to 294.3
63				294.8 to 300 entered as 294.3 to 300
63				334 to 339, Zn entered as 26.78 instead of 29.78
64	0	33	61	backup material available for only 33 samples
77	2	15	78	102.5 to 107 entered as 102.5 to 107.5
77				107 to 110 entered as 107.5 to 110
106	0	7	83	backup available for only 7 samples
158	0	90	90	
221	0	99	99	
270	3	52	52	200 to 205, Zn entered as -1 instead of 2.9, Pb -1 instead of 1.2, Fe as -1 instead of 1.1
270				
270				
273	0	65	65	
287	0	60	60	
301	0	63	63	

Table 14-1 continued

	Results			
Hole#	**Incorrect**	**Checked**	**Available**	**Comments**
308	0	53	53	
353	0	50	50	
355	1	86	86	142 to 147, Zn entered as -1 instead of 1.0
357	0	34	34	
363	0	62	62	
365	0	71	71	
366	2	71	71	37 to 42, Zn entered as 25.14 insteadn of 25.1
366				62 to 67, Zn entered as 3.14 instead of 3.1
396	0	84	84	
443	0	26	26	
447	1	102	102	265 to 270, Zn entered as 0.1 instead of 2.5
477	1	41	41	0 to 15 Zn entered as 30.6 instead of 30.7
480	0	49	49	
487	1	93	93	390 to 395, Ba entered as 0.5 instead of 0.6
611		0	71	No backup available
618	0	29	29	
624	0	70	70	
877	0	83	83	
894	0	78	78	
Totals	**21**	**1735**	**2069**	
		1.2	**Error Rate**	
		84	**Assays unavailable for checking**	

Table 14-2: Aqqaluk Database Check Results

Hole#	Results Incorrect	Checked	Available	Comments
216	0	52	52	
501	0	44	44	
552	5	133	133	40 to 45, Ba reported as 41.2 instead of 41.4
				260 to 265, Ag reported as 0.71 instead of 0.77
				440 to 445, Ag reported as 0.57 instead of 0.51
				545 to 550, Pb reported as 4.7 instead of 9.7
				605 to 610, Zn reported as -1 instead of 0.2
554	0	108	108	
565	2	73	73	110 to 120, Ba reported as 34.6 instead of 39.6
				210 to 215, Zn reported as 43.3 instead of 43.4
820	0	135	135	
823	0	111	111	
845	0	108	108	
	7	**764**	**764**	
		0.9	**% Error in database**	

15.0 ADJACENT PROPERTIES

Adjacent properties are not relevant for this review of Red Dog Operations.

16.0 MINERAL PROCESSING AND METALLURGICAL TESTING

Metallurgy has been developed for the two deposits at Red Dog that have been classified as Mineral Reserve – Main and Aqqaluk. The metallurgical characteristics of the various ore types in the Main deposit have been developed through mill experience and extensive testwork at Cominco Ltd. Research and other laboratories and is well understood. MRDI has examined the predictions for metallurgy form the Main deposit and found them to be consistent with actual plant results (Section 19).

MRDI reviewed reports on metallurgical testwork done to support the Mineral Reserve classification of Aqqaluk. Testwork has been carried out on drill core composites from the Aqqaluk deposit. The samples were selected according to the five ore types identified by the Red Dog geological department:

- Low iron siliceous
- High iron siliceous
- Vein
- Baritic
- Median plate.

The grades of the various samples collected were in reasonable agreement with the preliminary block model grade estimates of the Aqqaluk deposit.

Modal analysis and open-circuit and locked-cycle flotation testwork were conducted on the first four ore types. This allowed a reasonable estimate to be made of the likely metallurgical performance. Work on the Median plate ore type consisted of modal and two open-circuit flotation tests, which makes projecting the metallurgical performance less reliable. This ore type does not represent a large part of the Aqqaluk mineralization. The projected metallurgy for Aqqaluk ores is consistent with the testwork done and assumptions regarding mill feed grade and tonnage estimates as of 1999.

The 2000 Aqqaluk Mineral Reserve estimate contains the results of significant drilling during the year 2000. MRDI recast Cominco Ltd.'s projected metallurgy for Aqqaluk with 2000 ore type breakdown and grade estimates. The key difference was a 15% increase in mill feed zinc grade. The results are shown in Table 16-1. The predictions concerning product amount, grade and relative distribution are in good agreement to the original projections.

Table 16-1: Projected Aqqaluk Metallurgy using 2000 Mineral Reserve Grade Estimates

		Assay %		Distribution %	
Product	**Weight %**	**Lead**	**Zinc**	**Lead**	**Zinc**
Mill Feed	100.0	4.1	16.6	100.0	100.0
Lead Conc.	4.1	59.1	12.6	59.1	3.1
Zinc Conc.	25.2	3.3	54.5	20.3	82.6

17.0 MINERAL RESOURCE AND MINERAL RESERVE ESTIMATES

The mineral resource and reserve estimates for the deposits at Red Dog Operations were calculated under the direction of Mr. William P. Armstrong, P.Eng., Cominco Ltd.'s Qualified Person for mineral resources and reserves. The estimates were made from 3-dimensional block models untilizing commercial mine planning software (MineSight®). As part of MRDI's independent review, grade interpolation parameters were examined for suitability and the models checked for validity. The resource and reserve calculation method and appropriateness of resource and reserve classification categories used were also examined.

17.1 Geologic Models

The Red Dog deposits exist in three geologic block models: Main+Aqqaluk, Qanaiyaq and Aŋarraaq. No model has been made for Paalaaq at this time. Project limits and cell block sizes for each MineSight® project are shown in Table 17-1.

Table 17-1: Project Limits and Model Cell Block Sizes

Deposit	Axis	Minimum (ft)	Maximum (ft)	Block Size (ft)
	X (east)	585,000	589,500	25
Main and Aqqaluk	Y (north)	141,500	148,500	25
	Z	400	1,350	25
	X (east)	584,500	588,000	25
Qanaiyaq	Y (north)	137,000	142,000	25
	Z	1,000	1,600	25
Paalaaq	(Sectional Resource)			
	X (east)	560,000	595,000	100
Aŋarraaq	Y (north)	170,000	199,000	100
	Z	-2000	2000	25

Modelling philosophy was similar for all models, with geologic features being important in controlling the extent of interpolation. The geologic features are best known for the Main, Aqqaluk and Qanaiyaq deposits. In the area containing these deposits, 25 units are recognized. These comprise sedimentary, exhalative and structural units that are unmineralized to strongly sulphide mineralized. Units used in grade interpolation are listed in Table 17-2. Not all units occur in each deposit. Many units are defined by structural location and lithology (e.g., barite-rich exhalitive units, shale types). A key discriminant between the strongly and weakly sulphide mineralized units is a 15% zinc grade boundary.

MRDI examined zinc assay values within the sulphide mineralized units using histograms, probability plots and contact profiles. Results confirmed that boundaries between weakly and strongly mineralized exhalitive units are lithologically and structurally distinct. For the most part, the two occur as sedimentary layers in sharp contact with one another. The weakly mineralized unit has a higher silica exhalite component, whereas the strongly mineralized unit contains higher sulphide (usually sphalerite) levels. Aŋarraaq sulphide mineralization comprises two types for modelling purposes: massive, relatively silver-rich sulphides and semi-massive to massive iron-sulphide-richer, silver-poorer sulphides. Examples of representative Main, Aqqaluk and Qanaiyaq sections and plans, containing drill hole zinc assays and composites, and sulphide mineralized geologic units are included in Appendix C. Sectional examples for Paalaaq and Aŋarraaq are also included in Appendix C.

Table 17-2: Mineralized Geology Unit Names and Block Model Codes – Main, Aqqaluk, Qanaiyaq Deposits

Code	Mineralized Geology Unit
1	Median plate lower-grade (<15% Zn) exhalite
2	Lower-grade (<15% Zn) weathered exhalite, any plate
6	Median plate Ikalukrok vein unit
7	Sub-lower plate barite
8	Lower plate, lower-grade (<15% Zn) exhalite
9	Upper plate, lower-grade (<15% Zn) exhalite
10	Sub-lower plate vein unit
11	Median plate higher-grade (>15% Zn) exhalite
12	Higher-grade (>15% Zn) weathered exhalite, any plate
13	Lower plate Ikalukrok vein unit
15	Median plate Ikalukrok barite
16	Lower plate Ikalukrok barite
17	Upper plate Ikalukrok barite
18	Lower plate higher-grade (>15% Zn) exhalite
21	Sub-lower plate, lower-grade (<15% Zn) exhalite

Mine staff initially interpreted the Main, Aqqaluk and Qanaiyaq deposits on section (east-west and north-south) then balanced this interpretation in plan view. MRDI reviewed sectional and plan views for internal consistency in the geologic interpretation and found them to be well done. Paalaaq and Aŋarraaq interpretations were only made in east-west sections. The sectional geological outlines for all deposits were used for tagging geology codes in the drill hole assay database. The plan geology outlines were used to tag the geology codes into the block models (on a majority rule basis). MRDI checked the results of the geology tagging and found it to have been done properly.

The assays were composited into 25 foot bench composites, honouring geology units. This process resulted in as many as five bench composites at a particular bench composite x-y-z location because of the splitting by geology. MRDI reviewed the results of the compositing process and found it to have been done correctly. However, because of the way MineSight® electronically stores this type of data, the resulting composite database is sensitive to selection protocols. As long as the composites are selected by geology codes, the proper composites are chosen in grade interpolation (Section 17.2).

Mine staff conducted spatial analyses of composites from the Main, Aqqaluk and Qanaiyaq drill hole data using multi-directional variograms. MRDI reviewed this work and found that the interpreted models were reasonable. Variogram parameters for zinc, lead and silver are shown in Table 17-3.

Table 17-3: Variogram Parameters – Main, Aqqaluk and Qanaiyaq Deposits

Geology Codes	Type	Nugget	Sill Difference	Range Y (ft)	Range X (ft)	Range Z (ft)	Rotation Z Left Hand
Zinc – Main, Aqqaluk							
1, 2	Exp	0.143	0.857	70	60	40	90
6, 8, 13	Exp	0.120	0.880	80	70	50	90
7, 9, 15, 16, 17, 21	Exp	0.199	0.801	100	80	65	150
10, 11, 12, 18	Exp	0.165	0.835	80	65	40	135
Lead, Silver – Main, Aqqaluk							
1, 2, 6, 8	Exp	0.165	0.835	95	75	60	110
7, 9, 21	Exp	0.210	0.790	78	68	68	135
10, 11, 12, 18	Exp	0.158	0.842	80	65	50	90
13	Exp	0.226	0.774	80	70	55	110
15, 16, 17	Exp	0.191	0.809	60	55	40	135
Zinc, Lead, Silver - Qanaiyaq							
All codes	Sph	0.02	0.13	275	350	275	0

Note: Exp = exponential model; Sph = spherical model. Exponential ranges are 1/3 the practical range.

Red Dog staff calculate bulk density with a regression equation. The logic used is similar to other massive sulphide operations. The equation begins with a general value for unmineralized rock and is modified by contributions defined by amounts of barite (barium analysis), galena (lead analysis), sphalerite (zinc analysis) and pyrite/marcasite (iron analysis). The result is a tonnage factor.

The mine staff regularly conduct programs to check the calculated bulk density numbers, and for the most part the results of these checks support the values calculated by the regression equation. MRDI reviewed the data from these programs and supports the conclusions reached by Red Dog staff. Barite-rich units give the poorest comparisons, with the calculated values being low relative to the measured ones. This is directly related to the quality of the barium analyses, which is limited by the analytical method employed at the Red Dog laboratory. Waste black shale units also give poor results because of the variable iron sulphide contents. With no appreciable zinc or lead sulphides, samples from these shale units are not routinely assayed and are thus assigned the default bulk density value in the regression formula.

The calculated bulk density values that correlate poorly relative to measured values affect waste rock units at Red Dog but not the estimated tonnage in the stated mineral resources and reserves. The likely impact would be an understatement of calculated waste rock tonnage. This, however, should not materially affect any of the assumptions made in the long-term production forecasts (see Section 19).

17.2 Interpolation Plans

Values for zinc, lead, silver, iron and organic carbon were interpolated by ordinary kriging, while the barium and soluble lead values were interpolated by inverse distance weighting to the third power. A two-pass procedure was used, with the first pass set at a wider search distance and selected on ore type groupings. The second pass used smaller search distances and selected on geology codes. All domains were treated as hard boundaries, which means that only composite values of the same ore type or geology code as the model block could be used to interpolate that block’s grades. Essentially all Main and Aqqaluk model block grades were reset by the second pass interpolation. The interpolation parameters for the second-pass method are the same for all Main, Aqqaluk and Qanaiyaq interpolation runs:

- Minimum composites to interpolate a model block = 2
- Maximum composites to interpolate a model block = 15
- Maximum X (east) search = 300 ft
- Maximum Y (north) search = 300 ft
- Maximum Z (elevation) search = 30 ft
- Maximum distance to project composite = 300 ft.

Qanaiyaq used a three-pass method, where – the first two were identical to those used in the Main and Aqqaluk model and the third had a more tightly constrained search distance and used ore type grouping as a filter. By not using the geology codes as a filter for the final pass, portions of the Qanaiyaq model were interpolated using sets of incorrectly chosen composites. Effects on this model are discussed in Section 17.3.

17.3 Model Validation

MRDI completed a reasonableness review of the Red Dog block models, looking primarily at the grade interpolation relative to drill hole composite values. This was done primarily by inspection of sections and plans and focussed on zinc – the most important economic element at Red Dog. Information on the sections and plans included kriged model zinc grades, mineralized geology unit boundaries, ultimate pit outlines, topography as of December 31, 2000, and drill hole zinc composite values. Overall good agreement exists between the composite and model block zinc values. Examples of representative Main, Aqqaluk and Qanaiyaq sections and plans, containing block model zinc grades, drill hole composite zinc values, geology unit outlines and ultimate pit traces, are included in Appendix C.

MRDI also checked the block model estimates for global bias by comparing the average values (with no cutoff) from the model (ordinary kriging) with the means from nearest-neighbour estimates (the nearest-neighbour estimator produces a theoretically unbiased estimate of the average value when no cutoff grade is imposed and is a good basis for checking the performance of different estimation methods). To conduct this check, nearest-neighbour zinc grades were estimated for the Main+Aqqaluk model and compared to the existing model kriged zinc grade. Mean and standard deviation values from ordinary kriging and nearest-neighbour zinc estimates (at zero zinc cutoff grade) are tabulated in Table 17-4. Results show no evidence of bias in the estimates.

Table 17-4: Zinc Mean and Standard Deviation (s.d.) Values from Ordinary Kriging and Nearest-Neighbour Estimates

Geology Codes	Type	Mean %	s.d	Mean %	s.d.
		Main Deposit		Aqqaluk Deposit	
1, 2	Krige	5.71	5.39	5.22	4.38
	NN	5.71	7.00	5.05	5.74
11, 12, 18	Krige	25.5	4.33	27.2	5.46
	NN	24.7	7.57	26.7	8.37
7, 15, 16, 17	Krige	4.32	2.13	2.67	2.51
	NN	4.22	2.88	2.64	3.53
6, 13	Krige	7.31	4.34	8.44	6.12
	NN	7.07	6.11	8.14	7.79
		Qanaiyaq Deposit			
1, 2	Krige 3	2.74	3.81		
	Krige 2	2.45	3.36		
	NN	2.56	4.58		
11, 12, 18	Krige 3	24.5	6.48		
	Krige 2	25.6	5.13		
	NN	25.5	7.91		
7, 15, 16, 17	Krige 3	1.07	1.07		
	Krige 2	1.00	0.66		
	NN	0.98	1.03		

Note: Krige 3 = third pass Qanaiyaq value, krige 2 = second pass Qanaiyaq value.

MRDI also checked for local trends in the grade estimates in the Main+Aqqaluk block model. This was done for zinc grade by plotting the results from the nearest-neighbour estimate versus the ordinary kriging results bench by bench in the major geology domain. The ordinary kriging should be smoother than the nearest-neighbour estimate, thus the nearest-neighbour estimate should fluctuate around the ordinary kriging estimate on the plot. Results show a close tracking between the two estimates and do not show local trends in the estimate.

MRDI reviewed the Qanaiyaq model, which was last updated by Red Dog Operations in 1995, by comparing values in the existing three-pass model to those estimated by using the geology code filter second-pass parameters and the nearest-neighbour zinc grade (note that the three-pass method is not used by Red Dog Operations for any current model work). At zero cutoff grade, the second-pass kriged zinc and nearest-neighbour zinc mean values show excellent agreement, whereas the third-pass kriged zinc and nearest-neighbour zinc mean values show fair agreement (see Table 17-4).

At the cutoff zinc grade used to categorize the resource (6%) comparisons of the two zinc grades indicate that the current Qanaiyaq model likely understates the resource zinc grade and overstates the resource tonnage by about 5%. This should not have any noticeable impact on the long-term production forecast.

MRDI also checked the Main deposit portion of the Main+Aqqaluk block model against blast hole results and tabulated mill production statistics. The blast hole checks were done visually in plan and by comparison with average zinc grades in common areas equal to quarterly production (see Section 18). Good agreement exists between the zinc grade estimates and blast hole values. Comparisons made to material received at the mill (Section 18) showed that good agreement exists between the zinc grades on an annual basis.

17.4 Resource Classification and Summaries

The mineralization at Red Dog Operations as of December 31, 2000, is classified into Mineral Reserves and Resources and is shown in Table 17-5.

Table 17-5: 2000 Red Dog Mineral Reserves and Resources

Mineral Reserve/Resource	Tonnes (millions)	Zn (%)	Pb (%)	Ag (g/t)
Proven Mineral Reserve				
Main Deposit	41.9	19.2	5.2	100
Probable Mineral Reserve				
Aqqaluk Deposit	56.1	16.6	4.1	76
Total Mineral Reserve	**98.0**	**17.7**	**4.6**	**86**
Indicated Mineral Resource				
Aqqaluk Deposit	3.4	9.8	3.7	78
Qanaiyaq Deposit	9.6	17.8	5.5	117
Total Indicated Mineral Resource	**13.0**	**15.7**	**5.0**	**107**
Inferred Mineral Resource				
Aqqaluk Deposit	6.8	6.5	3.6	59
Paalaaq Deposit	13.0	15.0	4.0	90
Aŋarraaq Deposit	17.2	15.8	4.8	71
Total Inferred Mineral Resource	**37.0**	**13.8**	**4.3**	**75**

Note: The cutoff for Main and Aqqaluk mineral reserves and resources is based on an NSR value of U.S. $22.75 per ton (U.S. $25.08 per tonne). The cutoffs for Qanaiyaq, Paalaaq and Aŋarraaq are zinc grade values 6% Zn for Qanaiyaq and 8% Zn for Paalaaq and Aŋarraaq.

The entire Main deposit within its ultimate pit outline is classified as Proven Mineral Reserve. This level of reserve category is supported by good mill-blast hole-model reconciliation and a dense drill pattern (100 x 100 feet). Economic parameters are also well established and supported by current production.

Most of the Aqqaluk deposit within its ultimate pit outline is classified as Probable Mineral Reserve. The reserve category is used here because the drill spacing varies from 100 x 100 feet to 200 x 200 feet and no production history yet exists. However, metallurgical testwork has been undertaken (see Section 16) and an economic evaluation completed. Aqqaluk also contains a small tonnage of Mineral Resource material within the ultimate pit outline. The Indicated Mineral Resource portion is defined as material within the ultimate pit outline but at a drill spacing greater than 200 x 200 feet. The economic evaluation and long-term forecast does not use the Indicated Resource material.

Additional mineralized material also exists within the Aqqaluk ultimate pit outline that is as well or better defined as the Indicated Mineral Resource but whose metallurgy is uncertain. A major project is currently underway at Red Dog (Value Improvement Project, or VIP) to enhance the mill performance (Section 19). The expected metallurgical improvements that should be realized from the VIP project would allow this material to be processed economically. Because of this uncertainty, Cominco Ltd. has conservatively left this material as Inferred Mineral Resource until the VIP project has been completed and the expected metallurgical improvements are confirmed. The economic evaluation for Aqqaluk and long-term plan forecasts that include Aqqaluk do not use any of the Inferred Resource material.

Qanaiyaq is all classified as Indicated Mineral Resource within its ultimate pit outline. Its drill spacing is generally 200 x 200 feet to 400 x 400 feet. Qanaiyaq is a klippe located near the Main deposit, and as such the location and extent of mineralization is well known. Altogether, confidence exists to support its classification category.

The remaining two deposits, Paalaaq and Aŋarraaq, are underground mining prospects with around 300 to 400 foot spaced drilling. These deposits are classified as Inferred Mineral Resources to reflect the lower drill hole density and resultant higher uncertainty in grade and geologic continuity.

The calculation of the mineral reserve cutoff is based on a Net Smelter Return value. This value combines the zinc and lead concentrate streams with the associated silver credits. The following factors have been utilized in the creation of the NSR model:

Table 17-6: Price, Recovery and Concentrate Grade, Red Dog Main Deposit

Commodity	Price (U.S.$)	Recovery	Concentrate Grade
Zinc	0.55 /lb.	90.196-0.4205(*)%Fe	59.075-0.531(*)% Fe
		max 87% Zn	max 56% Zn
Lead	0.25 /lb.	57.5%	55.0%
Silver	5.00 /oz	66.4%	Into Pb and Zn Conc.

(*) Recoveries are related to iron content of the material processed.

Table 17-7: Price, Recovery and Concentrate Grade, Aqqaluk Deposit

Commodity	Price (U.S.$)	Recovery (%)	Concentrate Grade
Zinc	0.55 /lb.	82	55%
Lead	0.25 /lb.	60	59%
Silver	5.00 /oz	66.4	Into Pb and Zn Conc.

Metal prices have been based on Cominco Ltd. long-term price projections, and are reasonable and within market parameters (see Section 19).

Additional parameters considered in calculating the NSR value are based on actual concentrate distributions and costs; these are the trucking, port handling, shipping and AIDEA (Alaska Industrial Development and Export Authority) payments. Distribution of concentrate production is shown in Table 17-8.

Table 17-8: Distribution of Concentrate Production

Location	Zinc Concentrate (%)	Lead Concentrate (%)
North America	30	10
Far East	25	35
Europe	45	55
Total	**100**	**100**

Smelting and refining charges have been based upon the project evaluation costs.

The reserve cutoff has been based upon the previous three-year period (1997 to 1999) compilation of ore mining, milling and site general and administrative costs. The costs for 1997 and 1998 have been adjusted to 1999 dollars using a 2% inflation factor. These costs have then been adjusted for the increase in production associated with the mill VIP project scheduled to be complete in late 2001. This has resulted in a cutoff NSR of $25.08 per tonne of ore ($22.75 per ton)

The pit design is based on a Lerchs-Grossmann algorithm run utilizing a complex slope option. The slope designs incorporate work carried out by John F. Abel, JR, Colorado P.E. 5642. MRDI has used this information, under the assumption that he is a qualified person. The Red Dog Main pit has been subdivided into 12 quadrants, with each quadrant subdivided into six elevation changes. Inter-ramp angles for the pit range from a low of 30° to a high of 63° (Appendix D, sector map and table).

The wall angles used for the design of the Aqqaluk pit are based on a 41° inter-ramp angle. This represents a 1° drop in the median value for the middle formation from the Main deposit. Although no geotechnical data currently exist for the Aqqaluk deposit, the lithologies are the same as the Main deposit, and the design is less aggressive than the Main pit. Given that Aqqaluk is not forecast to be mined until 2013, ample time exists to define the overall geotechnical parameters for the pit.

18.0 OTHER DATA AND INFORMATION

18.1 Reconciliation

Reconciliation of block model estimates to production at operating mines is an important measure of the predictive nature of the block model for future production. Two sets of data are available from the Main deposit to compare with the block model estimates: blast hole data and milled production data. MRDI evaluated these data to obtain a level of confidence in block model performance to actual production.

Blast hole data provide a measure of how well the block model estimates locally. MRDI compared blast hole values averaged over a known area (called blast blocks) against the average block model values from the same area. The areas were outlined in recently mined benches and made equal to approximately one-quarter of annual production (currently around 850,000 tons). Both sets of averages were weighted by bulk density. Results of this analysis are shown in Table 18-1. Good agreement is demonstrated.

Table 18-1: Blast Block versus Block Model Zinc grade – mean (m) grades and c.v. (coefficient of variation = standard deviation / mean)

		Blast Block		Block Model		% Difference
Bench	**Area**	**m**	**c.v.**	**m**	**c.v.**	**Δ m**
950	A	23.0	0.48	22.6	0.41	-2%
	B	19.3	0.43	19.3	0.39	0%
	C	16.9	0.49	17.3	0.46	2%
900	A	19.5	0.30	21.6	0.21	10%
	B	24.8	0.38	24.6	0.24	0%
	C	22.9	0.39	21.3	0.35	-8%
875	A	28.2	0.37	27.0	0.30	-4%
	B	20.4	0.33	21.7	0.28	6%

Note: Area denotes regions outlined on a bench that approximately equal one quarter's production.

MRDI also reviewed bench plans of the blast hole data overlain by the drill hole composite data. Good agreement was seen between the drill hole composite zinc grades and surrounding blast hole zinc grades (i.e., high-grade composites were surrounded by high grade blast holes values). Agreement was best in the semi-massive to massive sulphide ore types. MRDI did not observe any bias in drill hole type (reverse circulation or core) relative to surrounding blast hole data.

MRDI reviewed 1998, 1999 and 2000 annual mill reconciliation data relative to the block model from the Main deposit. The block model annual estimates were calculated by mine staff and used year-end topographic surfaces. Mined ore was estimated using 6% Zn – the grade control cutoff at Red Dog. The milled material figures contain the year-end tonnage and grade (to dry weight). The ratio of milled material to block model is then a measure of how well the milled ore tonnage and grade reconciles to predictions made by the block model. The results, shown in Table 18-2, demonstrate that the block model does an adequate job predicting grade. Ore tonnage is slightly over-predicted and may reflect assumptions made in the bulk density calculation. Overall mill to block model performance, however, is still good.

Table 18-2: Milled Material to Block Model Reconciliation – 1998, 1999 and 2000

Year	Tonnage (t)	Zn %	Pb %	Zn Metal (t)	Pb Metal (t)
Milled Production					
1998	2,753,000	21.4	5.2	586,000	143,000
1999	3,283,000	21.3	5.2	699,000	171,000
2000	3,366,000	21.0	4.7	707,000	158,000
Block Model					
1998	2,653,000	21.6	5.1	573,000	135,000
1999	3,519,000	20.5	5.0	721,000	176,000
2000	3,532,000	20.9	4.8	738,000	170,000
Mill / Model Ratio					
1998	1.04	0.99	1.02	1.03	1.06
1999	0.93	1.04	1.04	0.97	0.97
2000	0.95	1.00	0.98	0.96	0.93

19.0 REQUIREMENTS FOR TECHNICAL REPORTS ON PRODUCTION PROPERTIES

19.1 Mining Operations

The Red Dog mine currently operates as a conventional open pit approximately 900 m long in the north-south direction and 600 m wide east-west. The pit is mined on 7.6 m (25 foot) benches, and a single bench configuration is used for the final high wall. The overall inter-ramp wall slopes are based on the parameters discussed in Section 18. The bench face angle is designed for 67°, and the safety benches are calculated as the difference between the overall inter-ramp slope and the face angle. Road widths are 27 m for two-lane traffic and 18 m for single-lane traffic. All roads have been designed for a maximum grade of between 8% and 10%.

Major equipment for the mine includes:

- 3 Caterpillar 777B haulage trucks
- 3 Caterpillar 777D haulage trucks
- 3 Caterpillar 992 front-end loaders
- 2 Ingersoll Rand DML45 blast hole drills
- 3 Caterpillar 988 front-end loaders
- 3 Caterpillar 16G graders
- 1 Caterpillar 14G grader
- 2 backhoes (Caterpillar 235, Hitachi EX270)
- 2 Caterpillar D9R tracked dozers
- 1 Komatsu D275 tracked dozer.

The ore from the pit is placed on a blending stockpile adjacent to the crushing facilities, then reclaimed by wheel loader and fed to the primary crusher. The crushed ore is placed on a coarse ore stockpile, from which it is reclaimed and fed to semi-autogenous (SAG) mills followed by flotation circuits that produce zinc and lead concentrates. Concentrate is stored on site then hauled by truck to the port site facility on the Chukchi Sea. The concentrates are stored at the port and then shipped to the contracted smelting facilities during the shipping season between early July and early October.

The current production forecast is based on producing approximately 1 million tonnes of zinc concentrate with a head grade that approximates the reserve grade for the Red Dog main deposit. The production forecast has been generated in support of the VIP Project, which de-bottlenecks the flotation circuits. The long-term production forecast has been based on an annual mill throughput of 3.5 million tonnes and production of approximately 1 million tonnes of zinc concentrate. The current long-range forecast using proven and probable reserves envisions that the Red Dog deposit and the Aqqaluk deposit will be completed in 2028. The forecast from 2001 to 2013 is for annual production of 3.5 million tonnes at reserve grade and a 1:1 strip ratio from the Main deposit. This is followed by production at 3.5 million tonnes annually at reserve grade and a 2:1 strip ratio from the Aqqaluk deposit from 2014 to 2028.

Total personnel directly employed by Cominco Ltd. to operate the Red Dog Mine currently stands at 425 employees

19.2 Recoverability

The previous three years' recoveries and concentrate grades are compared to the expected recoveries and concentrate grades expected from the VIP expansion in Table 19-1.

Table 19-1: Actual and Projected Recoveries and Concentrate Grades

Year	Zinc %		Lead %	
	Recovery	Concentrate Grade	Recovery	Concentrate Grade
1998 to 2000	82.7	55.4	56.2	58.1
VIP	87	56	58	55

The projected increase in metallurgical response is based on a simulation study carried out by Cominco Ltd. Research. Data for the study were provided from flotation circuit surveys carried out between January 1997 and December 1999. The results appear to be reasonable, although no checks were carried out on the data or methodology. A current schematic process flow chart for the Red Dog mill is provided in Appendix E.

One of the keys to the relatively stable metallurgy during the period 1998 to 2000 was the consistent feed grade, as indicated in Table 19-2.

Table 19-2: Zinc and Lead Historical Mill Head Grades and Monthly Variations

	Lead %		Zinc %	
Year	**Annual Average**	**Monthly Range**	**Annual Average**	**Monthly Range**
1998	5.2	4.6 – 6.1	21.4	19.8 – 23.0
1999	5.2	4.3 – 6.3	21.3	19.7 – 22.4
2000	4.7	4.3 – 5.4	21.0	20.4 – 22.3

Provided that the level of grade blending is continued once the VIP project expansion comes on-line, the predicted metallurgical results should be achievable.

The additional retention time particularly in the zinc flotation circuit, should allow for improved recovery and result in lower silica content in the zinc concentrate, making it more readily marketable.

Based on the model to mill reconciliation data, dilution has been set at zero and mining recovery at 100%. MRDI is in agreement with this assessment.

19.3 Markets

The concentrates are shipped from the port to smelters in North America, Europe and the Far East. By-product credits are obtained for the silver contained in both concentrates.

19.4 Contracts

The mining and concentrating of the Red Dog ores are done directly by Cominco Alaska Incorporated, a wholly-owned subsidiary of Cominco Ltd.. The sales contracts and marketing of the concentrate are handled by a management contract with Cominco Ltd. as laid out under the Cominco Ltd.-NANA agreement. Currently 90% of the concentrates are under long-term contracts, with the remaining 10% under annual contracts. The long-term contracts generally require a 12-month notification for cancellation. Provisions exist within the smelter contracts for silica and cadmium penalties if these concentrations exceed the negotiated grade in the concentrates. At present only a small penalty is being paid on the cadmium.

Transportation of concentrates between the mine site and the port are carried out through existing contracts with NANA-Lynden, a joint venture between NANA and Lynden. Concentrate is lightered to the ocean freighters under contract to the Foss Corporation. Ocean shipping is arranged through Cominco Ltd.'s traffic group for transport through to the smelting complexes.

19.5 Environmental Considerations

As per existing Alaskan legislation, reclamation bonding is set at U.S. $303 /ha (U.S. $750 per acre) of disturbance. This is reviewed every five years and re-negotiated based on new usage. Based on the existing NANA agreement, efforts have been made to strip and use the topsoil for reclamation purposes. To date 65 ha at the mine site and 20 ha at the port have been reclaimed. Included within the current long-range economic forecast are provisions of U.S. $53 million for the reclamation of the Red Dog main pit area in the year 2013.

19.6 Taxes

The Red Dog Mine, and surrounding areas are bound by the Cominco Ltd.-NANA Agreement of 1982. This Agreement forms the basis for the working agreement between the two parties, and provides a 4.5% net smelter return and, depending upon profitability and the recovery of capital expenditures plus interest, a sliding net proceeds royalty that starts at 25% and rises over time to 50%. The mine is subject to the Alaska State Tax, a U.S. Federal Tax, PILOT (payment in lieu of taxes) and the Alaska State Mining Tax. The royalties and taxes have all been included within the economic model.

19.7 Capital and Operating Cost Estimates

Given the location of the mine site, the fixed component of the operating cost estimate accounts for more than 90% of the operating costs. This being the case, the mine operating costs have been derived from past operating costs, factored by the strip ratio to arrive at a final mining cost. The Mill and General and Administrative costs have been held current from the projections made from the VIP project analysis. Operating costs used for the long range-forecast are shown in Table 19-3.

Table 19-3: Forecast Operating Costs (U.S.$/tonne Milled)

	Year 2002 to Year 2013 Red Dog Main	Year 2013 to Year 2028 Aqqaluk
Mining	5.20	6.81
Milling	11.01	11.01
General and Administrative	19.32	19.32
Total	**35.53**	**37.14**

The operating cost estimate has been reviewed and compared with the 2000 actual costs and 2001 budget costs in Table 19-4.

Table 19-4: Year 2000 Actual and Year 2001 Budget Operating Costs

	Year 2000 Actual (U.S.$/t Milled)	Year 2001 Budget (U.S.$/t Milled)
Mining	4.21	4.76
Milling	9.70	11.04
General and Administrative	19.94	20.34
Total	**33.85**	**36.15**

The operating cost forecast has been adjusted by the increase in throughput on a constant dollar basis. Given that more than 90% of the costs are fixed, this is seen as a reasonable assumption. The projected increase in the operating costs for the Aqqaluk deposit is based on the higher strip ratio associated with the pit.

Capital cost estimates are broken down into three main groupings, sustaining capital, pre-production capital and VIP capital. Sustaining capital has been estimated at U.S. $9 million per year from years 2002 through 2028. The pre-production capital is utilized for the pre-stripping requirements for the Aqqaluk pit, estimated at U.S. $30 million in year 2012 and U.S. $30 million in year 2013. The major current capital expenditure, the VIP project, is currently in progress and is expected to be complete in late 2001.

The capital expenditure schedule has been estimated in detail through 2003 based on equipment replacement and operations and from that point on based on an equipment replacement schedule as follows:

- Loader replacement every 7 years
- Truck replacement every 10 years
- Drill replacement every 6 years
- Tracked dozer replacement every 5 years.

This schedule runs the equipment out to the end of its projected life and given the utilization of the equipment on-site is a reasonable assumption. The capital schedule within the economic model will certainly be able to cover the equipment replacement schedule that has been proposed.

19.8 Economic Analysis

An after-tax economic analysis for the Main and Aqqaluk deposits has been completed on the proven and probable reserves. The forecast starts in year 2001 and runs through 2028. The assumptions used within the model are as follows:

Interest Rates and Inflation

- Prime rate 8.0%
- LIBOR rate 5.5% (London Inter-bank Offering Rate)
- Inflation constant dollars

Metal Prices (U.S. $)

- Zinc $0.48/lb until 2002, then $0.50/lb for 2002 until 2028
- Lead $0.22/lb for 2001, $0.24/lb for 2002, then $0.25/lb until 2028
- Silver $4.70/oz for 2001, then $5.00 until 2028
- Cadmium $0.25/lb through the life of the plan

Recoveries

- Based on VIP metallurgy

After-tax cash flows for the mine have been calculated based on the data and assumptions above. The cash flow is positive, indicating that the proven and probable reserves can be mined at a profit.

Sensitivities to the current long-range forecast have been run against the following:

- Zinc recovery
- Zinc grade
- Zinc metal price
- Operating costs.

A review of the data assumptions indicates that they are within market parameters and are reasonable.

The details of the economic and sensitivity analysis are regarded by Cominco Ltd. as confidential. MRDI reviewed the economic model and sensitivities in detail and believes that they are complete, reasonable and meet industry standards.

19.9 Payback

Currently the Red Dog Mine is carrying no operational debt. Justification for the VIP project was based on the above economic analysis. The payback associated with the U.S. $105 million expansion project has been estimated to be 3.6 years.

19.10 Mine Life

The current long-range forecast used for the justification of the VIP project mines the Main and Aqqaluk deposits at a rate of 3.5 million tonnes of ore feed per year. The completion date for this current plan is 2028. Depending on the results of additional drilling, the Paalaaq deposit, the Qanaiyaq deposit and the Aŋarraaq deposit have the potential to extend the mine life.

20.0 INTERPRETATION AND CONCLUSIONS

MRDI reviewed pertinent geological, mining and metallurgical data from the Red Dog Operation to obtain a sufficient level of understanding to assess the Red Dog 2000 Mineral Reserve and Resource statement. The following is a list of general conclusions made by MRDI during its review:

- The geology of the Red Dog lead-zinc sedimentary hosted exhalative massive sulphide deposits is well understood. The mineralization types (veined, semi-massive to massive, sphalerite rich) and extents are well defined. That knowledge has been integrated into the geologic block models, mining practice and metallurgy.

- The database to support the Mineral Reserve and Mineral Resource comprises 1,075 drill holes. The high quality of the assay data used to estimate the Mineral Reserve at Red Dog (Main and Aqqaluk deposits) is supported by good reconciliation of material milled to block model grades and tonnages (Main) and a well-run quality assurance and control program (Aqqaluk). MRDI verified the database used for the block model estimates for the Mineral Reserve by a 5% check to original assay and survey data.

- The 2000 block model was developed using industry-accepted methods. MRDI validated the model estimates and found them to reasonably estimate grade and tonnage for the Main and Aqqaluk deposits. The resource estimated for Qanaiyaq may have understated the grade by approximately 5%, but this will have no impact on the long-term production forecast.

- The Mineral Reserve and Mineral Resource at Red Dog is classified into Proven Reserve (Main deposit), Probable Reserve (Aqqaluk), Indicated Resource (Aqqaluk, Qaniayaq) and Inferred Resource (Paalaaq and Aŋarraaq). MRDI assessed the criteria used by Cominco Ltd. for this classification and agrees with them.

- The cutoff grade strategy employed by Red Dog is sound. MRDI reviewed the various assumptions that made up the basis for the cutoff value and found them to be sound and based on industry-accepted parameters.

- MRDI found that Red Dog metallurgical expectations are reasonable and based on stable metallurgical results during recent production. MRDI also found reasonable the expectations made by Red Dog staff regarding the projected metallurgy for the VIP project (for the Main deposit) and the proposed metallurgy for Aqqaluk mineralization.

- MRDI found the operating cost estimate to be reasonable and to have been calculated using sound industry-accepted practices.
- MRDI found the assumptions used for the economic forecast to be within market parameters and to be valid assumptions for an economic forecast.

This independent review by MRDI supports the 2000 Red Dog Operation Mineral Reserve and Mineral Resource statement.

21.0 REFERENCES

Geologic Setting and Genesis of the Red Dog Zinc-Lead-Silver Deposit, Western Brooks Range, Alaska, D.W. Moore, L.E. Young, J.S. Modene and J.T. Plahuta, Economic Geology, Volume 81, 1986, pages 1696 to 1727.

Canadian Mineral Deposit Types: A Geological Synopsis, O.R. Eckstrand, Geological Survey of Canada, Economic Geology Report 36, 1984.

APPENDIX A PROPERTY DESCRIPTION

Alaska State Claims Holding
Costs – General Requirements

Cominco American Noatak
Tenure 2001

APPENDIX B GEOLOGICAL PAPER

***Geologic Setting and Genesis of the Red Dog Zinc-Lead-Silver Deposit, Western Brooks Range, Alaska*, D.W. Moore, L.E. Young, J.S. Modene and J.T. Plahuta, Economic Geology, Volume 81, 1986, pages 1696 to 1727.**

APPENDIX C SECTIONS AND PLANS

Red Dog Drill Holes and Ore Bodies

Red Dog Operations Main Zone
Composites, Geology and Zn Blocks
- Section 38E
- Section 42E
- Section 46E

Red Dog Operations Aqqaluk
Composites, Geology and Zn Blocks
- Section 38E
- Section 42E
- Section 46E

Red Dog Operations Block Model
Bench Plans Main and Aqqaluk
- Bench 700
- Bench 800
- Bench 900
- Bench 1000
- Section 100

APPENDIX D GEOTECHNICAL DATA

Main and Aqqaluk Ultimate Pit
Slope Sectors and Quadrants – Geotech Sectors

For Pit Slope Design, April 2001 Design

Angle and Sector Table

Appendix E Metallurgical Flowsheet

Appendix F Photographs

Red Dog Main
Red Dog Main and Aqqaluk
Red Dog Operations
Port