2018 TECHNICAL REPORT
ON THE
PEBBLE PROJECT, SOUTHWEST ALASKA, USA

NORTHERN DYNASTY MINERALS LTD.

Effective Date – December 22, 2017

Issue date February 22, 2018

Qualified Persons
J. David Gaunt, PGeo.
James Lang, PGeo.
Eric Titley, PGeo.
Ting Lu, PEng.
Stephen Hodgson, PEng.

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UNIT MEASURES AND ABBREVIATIONS	
Above mean sea level	amsl
Acre	ac
Alaska Department of Environmental Conservation	DEC
Alaska Department of Fish and Game	ADFG
Alaska Department of Natural Resources	ADNR
Ampere	A
Annum (year)	a
Anadromous Waters Catalog	AWC
Acid Potential	AP
Acid Rock Drainage	ARD
Atomic absorption spectroscopy	AAS
Billion	B
Billion years ago	Ga
Brittle-ductile fault	BDF
Centimetre	cm
Carbon-In-Leach	CIL
Clean Water Act	CWA
Cubic centimetre	cm^3
Cubic feet per minute	cfm
Cubic feet per second	ft^3/s
Cubic foot	ft^3
Cubic inch	in^3
Cubic metre	m^3
Day	d
Days per week	d/wk
Days per year (annum)	d/a
Degree	°
Degrees Celsius	°C
Degrees Fahrenheit	°F
U.S. Environmental Protection Agency	EPA
Fire Assay	FA
Gram	g
Grams per litre	g/L
Grams per tonne	g/t
Gallons per minute	GPM
Greater than	>
Health, safety and environment	HSE
Hectare (10,000 m^2)	ha
Horsepower	hp
Hours	h
Hours per day	h/d
Hours per week	h/w

UNIT MEASURES AND ABBREVIATIONS	
Hours per year	h/a
Inch	in
Induced Polarization geophysics	IP
Inductively coupled plasma atomic emission spectroscopy	ICP-AES
Inductively coupled plasma mass spectrometry	ICP-MS
Kaskanak Creek	KC
Kilo (thousand)	k
Kilogram	kg
Kilograms per hour	kg/h
Kilograms per square metre	kg/m^2
Kilometre	km
Kilometres per hour	km/h
Kilopascal	kPa
Kilotonne	kt
Kilowatt	kW
Kilowatt hour	kWh
Kilowatt hours per tonne (metric ton)	kWh/t
Kilowatt hours per year	kWh/a
Less than	<
Litres	L
Litres per minute	L/m
Maximum potential acidity	MPA
Metal Leaching	ML
Metres	m
Metres above sea level	masl
Millions of years ago	Ma
Metric tonne	t
Microns	µm
Milligram	mg
Milligrams per litre	mg/l
Millilitre	mL
Millimetre	mm
Million	M
Million tonnes	Mt
Minute (plane angle)	‘
Minute (time)	min
Month	mo
National Environmental Policy Act	NEPA
Neutralizing Potential	NP
Neutralization potential ratio	NPR
North Fork Koktuli	NFK
Northern and Southern quartz vein domains	NQV and SQV
Ounce	oz
Parts per million	ppm
Parts per billion	ppb

UNIT MEASURES AND ABBREVIATIONS	
Potentially acid generating	PAG
Percent	%
Pounds	lb
Pounds per square inch	psi
Pounds per ton	lb/ton
Quality Control/Quality Assurance	QA/QC
Qualified Person	QP
Quartz Sericite Pyrite	QSP
Revolutions per minute	rpm
Semi-autogenous grinding	SAG
Sulphidize, acidify, recycle and thicken	SART
Second (plane angle)	"
Second (time)	s
Square	cm^2
Square foot	ft^2
Square inch	in^2
Square kilometre	km^2
Square metre	m^2
South Fork Koktuli	SFK
Three dimensional	3D
Three Dimensional Model	3DM
Tonnes	t
Thousand tonnes (1,000 kg)	kt
Tons (imperial)	tons
Total dissolved solids	TDS
Upper Talarik Creek	UTC
U.S. Army Corps of Engineers	USACE
Volt	V
Week	wk
Year (annum)	a

1.0 SUMMARY

1.1 INTRODUCTION

The Pebble deposit was originally discovered in 1989 and was acquired by Northern Dynasty Minerals Ltd. (Northern Dynasty) in 2001. Since that time, Northern Dynasty and subsequently the Pebble Limited Partnership (Pebble Partnership, in which Northern Dynasty currently owns a 100% interest) have conducted significant mineral exploration, environmental baseline data collection, and engineering studies to advance the Pebble Project.

Since the acquisition by Northern Dynasty, work at Pebble has led to an overall expansion of the Pebble deposit, as well as the discovery of several other mineralized occurrences along an extensive northeast-trending mineralized system underlying the property. Over 1 million feet of drilling has been completed on the property, a large proportion of which has been focused on the Pebble deposit. The previous estimate of the mineral resources in the Pebble deposit was stated in a technical report completed in 2014.

Comprehensive deposit delineation, environmental, socioeconomic and engineering studies of the Pebble deposit began in 2004 and continued through 2013.

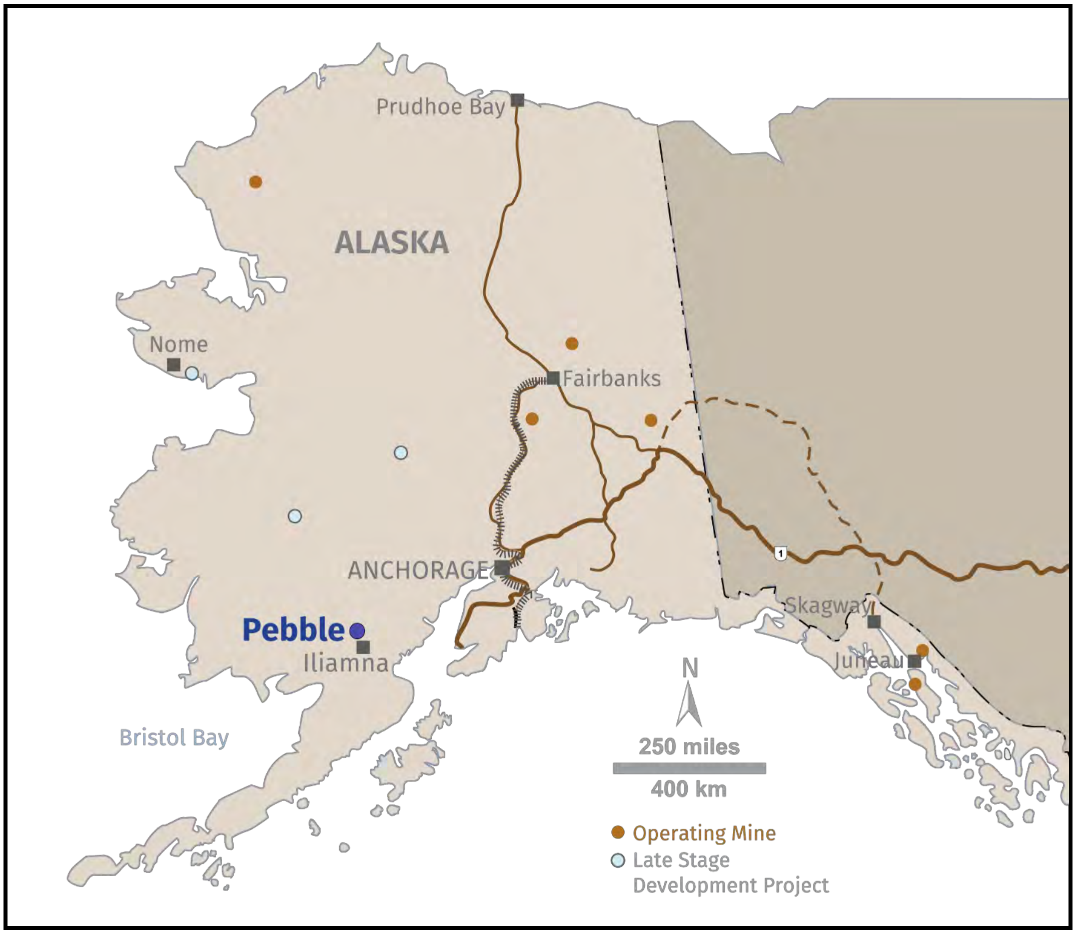
In February 2014, the US Environmental Protection Agency (EPA) announced a pre-emptive regulatory action under the Clean Water Act (CWA) to consider restriction or a prohibition of mining activities associated with the Pebble deposit. From 2014-2017, Northern Dynasty and the Pebble Partnership focused on a multi-dimensional strategy, including legal and other initiatives to ward off this action. On May 12, 2017, Northern Dynasty announced a settlement agreement with EPA, clearing the way for Pebble to apply for a CWA 404 permit with the US Army Corps of Engineers (USACE). Section 404 of the Clean Water Act (CWA) governs the discharge of dredged or fill materials into waters of the U.S., including wetlands. The U.S. Army Corps of Engineers (USACE) issues Section 404 permits with oversight by the U.S. Environmental Protection Agency (EPA). Also, in light of stakeholder and regulatory feedback, Northern Dynasty had initiated a broad review of the Pebble Project that took place in 2016 and 2017 to consider among other things, a smaller project footprint and improved environmental and safety enhancements, and has incorporated these and other improvements into a new proposed development project for Pebble. This proposal is outlined in a Project Description prepared by the Pebble Partnership and included as part of the Pebble Partnership's CWA 404 permit application filed with the USACE on December 22, 2017. On January 8, 2018, USACE accepted the permitting documentation and confirmed that an Environmental Impact Statement (EIS) level of analysis is required to comply with its National Environmental Policy Act (NEPA) review of the Pebble Project. Accordingly, in light of the foregoing Northern Dynasty has commissioned the current technical report to update information on the mineral resources and project status. This report incorporates a summary of the Project Description submitted with the CWA 404 permit application and an analysis of the revisions to the resource estimate based on process modifications reflected in the proposed project included in the Project Description.

Northern Dynasty completed a Preliminary Assessment on the Pebble Project in February 2011 and, as noted above, since that time after considering stakeholder feedback, the Pebble Partnership has submitted an application for a CWA 404 permit for the Pebble Project on the basis of a substantially smaller mine facility footprint and with other material revisions as are described in detail in Section 16.5 of this Report. As a result, the economic analysis included in the 2011 Preliminary Assessment is considered by Northern Dynasty to be out of date such that it can no longer be relied upon. In light of the foregoing, the Pebble Project is no longer an advanced property for the purposes of NI 43-101, as the potential economic viability of the Pebble Project is not currently supported by a preliminary economic assessment, pre-feasibility study or feasibility study. The EIS process currently underway by the USACE will consider alternative scenarios with respect to a number of aspects of the proposed project. Accordingly, the Company has not completed a current comprehensive economic analysis of the Pebble Project but anticipates that having a complete understanding of, and being able to properly assess all of the proposed alternatives that the USACE will be considering as part of the scoping process conducted during the initial phase of the EIS will provide additional clarity with respect to the project to be evaluated so that an economic analysis can be completed.

1.2 PROJECT LOCATION

The Pebble Project is located in southwest Alaska, approximately 200 miles southwest of Anchorage, 17 miles northwest of the village of Iliamna, 160 miles northeast of Bristol Bay, and approximately 60 miles west of Cook Inlet (Figure 1.2-1).

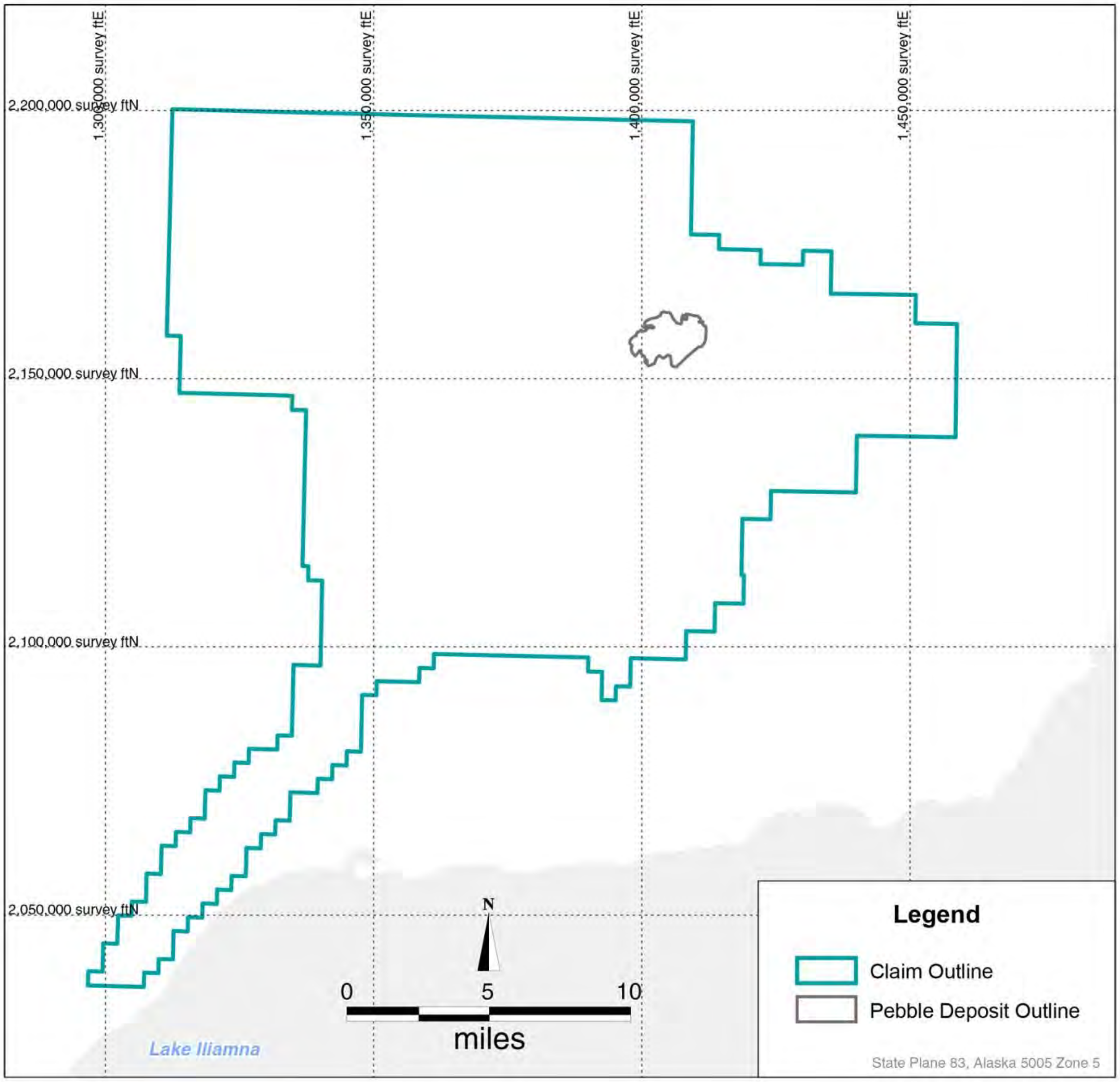
Figure 1.2-1 Property Location Map



1.3 PROPERTY DESCRIPTION

Northern Dynasty holds, indirectly through wholly-owned subsidiaries including Pebble Partnership, a 100% interest in a contiguous block of 2,402 mineral claims covering approximately 417 square miles (Figure 1.3-1). This includes 2,182 claims covering 364 square miles (including the Pebble deposit) held by Pebble Partnership subsidiaries Pebble East Claims Corporation and Pebble West Claims Corporation; and 220 claims covering 52.5 square miles held by Northern Dynasty subsidiary U5 Resources Inc.

Figure 1.3-1 Mineral Claim Map of the Pebble Project



1.4 GEOLOGICAL SETTING AND MINERALIZATION

Pebble is a porphyry-style copper-gold-molybdenum-silver deposit that comprises the Pebble East and Pebble West zones of approximately equal size, with slightly lower-grade mineralization in the center of the deposit where the two zones merge. The Pebble deposit is located at the intersection of crustal-scale structures that are oriented both parallel and obliquely to a magmatic arc which was active in the mid-Cretaceous age and which developed in response to the northward subduction of the Pacific Plate beneath the Wrangellia Superterrane.

The oldest rock within the Pebble district is the Jurassic-Cretaceous age Kahlitna flysch, composed of turbiditic clastic sedimentary rocks, interbedded basalt flows and associated gabbro intrusions. During the mid-Cretaceous (99 to 96 Ma), the Kahlitna assemblage was intruded first by approximately coeval granodiorite and diorite sills and slightly later by alkalic monzonite intrusions. At approximately 90 Ma, hornblende diorite porphyry plutons of the Kaskanak batholith were emplaced. Copper-gold-molybdenum-silver mineralization is related to smaller granodiorite plutons similar in composition to, and emplaced around the margins of, the Kaskanak batholith.

The Pebble East and Pebble West zones are coeval hydrothermal centers within a single magmatic-hydrothermal system. The movement of mineralizing fluids was constrained by a broadly vertical fracture system acting in conjunction with a hornfels aquitard that induced extensive lateral fluid migration. The large size of the deposit, as well as variations in metal grade and ratios, may be the result of multiple stages of metal introduction and redistribution.

Mineralization in the Pebble West zone extends from surface to approximately 3,000 ft depth and is centered on four small granodiorite plutons. Mineralization is hosted by flysch, diorite and granodiorite sills, and alkalic intrusions and breccias. The Pebble East zone is of higher grade and extends to a depth of at least 5,810 ft; mineralization on the eastern side of the zone was later dropped 1,970 to 2,950 ft by normal faults which bound the northeast-trending East Graben. East zone mineralization is hosted by a granodiorite pluton and adjacent granodiorite sills and flysch. The East and West zone granodiorite plutons merge with depth.

Mineralization at Pebble is predominantly hypogene, although the Pebble West zone contains a thin zone of variably developed supergene mineralization overlain by a leached cap. Disseminated and vein-hosted copper-gold-molybdenum-silver mineralization, dominated by chalcopyrite and locally accompanied by bornite, is associated with early potassic alteration in the shallow part of the Pebble East zone and with early sodic-potassic alteration in the West zone and deeper portions of the Pebble East zone. High-grade copper-gold mineralization is associated with younger advanced argillic alteration that overprinted potassic and sodic-potassic alteration and was controlled by a syn-hydrothermal, brittle-ductile fault zone located near the eastern margin of the Pebble East zone. Late quartz veins introduced additional molybdenum into several parts of the deposit.

1.5 MINERAL RESOURCE

The current resource estimate is based on approximately 59,000 assays obtained from 699 drill holes. The resource was estimated by ordinary kriging and is presented in Figure 1.5-1. The tabulation is based on copper equivalency (CuEq) that incorporates the contribution of copper, gold and molybdenum. Although the estimate includes silver, it was not used as part of the copper equivalency calculation in order to facilitate comparison with previous estimates which did not consider the silver content or its potential economic contribution. The highlighted 0.3% CuEq cut off is considered appropriate for deposits of this type in the Americas.

Figure 1.5-1 Pebble Resource Estimate December 2017

Threshold CuEq %	CuEq%	Tonnes	Cu (%)	Au (g/t)	Mo (ppm)	Ag (g/t)	Cu Blb	Au Moz	Mo Blb	Ag Moz
Measured										
0.3	**0.65**	**527,000,000**	**0.33**	**0.35**	**178**	**1.7**	**3.83**	**5.93**	**0.21**	**28.1**
0.4	0.66	508,000,000	0.34	0.36	180	1.7	3.81	5.88	0.20	27.4
0.6	0.77	279,000,000	0.40	0.42	203	1.8	2.46	3.77	0.12	16.5
1.0	1.16	28,000,000	0.62	0.62	302	2.3	0.38	0.56	0.02	2.0
Indicated										
0.3	**0.77**	**5,929,000,000**	**0.41**	**0.34**	**246**	**1.7**	**53.58**	**64.81**	**3.21**	**316.4**
0.4	0.82	5,185,000,000	0.45	0.35	261	1.8	51.42	58.35	2.98	291.7
0.6	0.99	3,455,000,000	0.55	0.41	299	2.0	41.88	45.54	2.27	221.1
1.0	1.29	1,412,000,000	0.77	0.51	343	2.4	23.96	23.15	1.07	109.9
Measured + Indicated										
0.3	**0.76**	**6,456,000,000**	**0.40**	**0.34**	**240**	**1.7**	**56.92**	**70.57**	**3.42**	**344.6**
0.4	0.81	5,693,000,000	0.44	0.35	253	1.8	55.21	64.06	3.18	320.3
0.6	0.97	3,734,000,000	0.54	0.41	291	2.0	44.44	49.22	2.40	237.7
1.0	1.29	1,440,000,000	0.76	0.51	342	2.4	24.12	23.61	1.08	112.0
Inferred										
0.3	**0.55**	**4,454,000,000**	**0.25**	**0.25**	**226**	**1.2**	**24.54**	**35.80**	**2.22**	**170.4**
0.4	0.68	2,646,000,000	0.33	0.30	269	1.4	19.24	25.52	1.57	119.1
0.6	0.89	1,314,000,000	0.48	0.37	292	1.8	13.90	15.63	0.85	75.6
1.0	1.20	361,000,000	0.68	0.45	377	2.3	5.41	5.22	0.30	26.3

Notes:

These resource estimates have been prepared in accordance with NI 43-101 and the CIM Definition Standards. Inferred Mineral Resources are considered to be too speculative to allow the application of technical and economic parameters to support mine planning and evaluation of the economic viability of the project. Northern Dynasty Minerals Ltd. advises investors that although these terms are recognized and required by Canadian regulations (under National Instrument 43-101 Standards of Disclosure for Mineral Projects), the U.S. Securities and Exchange Commission does not recognize them. Investors are cautioned not to assume that any part or all of the mineral deposits in these categories will ever be converted into reserves. In addition, "inferred resources" have a great amount of uncertainty as to their existence, and economic and legal feasibility. It cannot be assumed that all or any part of an Inferred Mineral Resource will ever be upgraded to a higher category. Under Canadian rules, estimates of Inferred Mineral Resources may not form the basis of feasibility or pre-feasibility studies, or economic studies except for Preliminary Economic Assessment as defined under 43-101. Investors are cautioned not to assume that part or all of an inferred resource exists, or is economically or legally mineable.

Copper equivalent calculations use metal prices of $1.85/lb for copper, $902/oz for gold and $12.50/lb for molybdenum, and recoveries of 85% for copper 69.6% for gold, and 77.8% for molybdenum in the Pebble West zone and 89.3% for copper, 76.8% for gold, 83.7% for molybdenum in the Pebble East zone.

Contained metal calculations are based on 100% recoveries.

A 0.30% CuEQ cut-off is considered to be appropriate for porphyry deposit open pit mining operations in the Americas.

All mineral resource estimates, cut-offs and metallurgical recoveries are subject to change as a consequence of more detailed analyses that would be required in pre-feasibility and feasibility studies.

1.6 MINERAL PROCESSING AND METALLURGICAL TESTING

Metallurgical testwork for the Pebble Project was initiated by Northern Dynasty in 2003 and continued under the direction of Northern Dynasty until 2008. From 2008 to 2013, metallurgical testwork progressed under the direction of the Pebble Partnership.

Geometallurgical studies were initiated by the Pebble Partnership in 2008, and continued through 2012. The principal objective of this work was to quantify significant differences in metal deportment that may result in variations in metal recoveries during mineral processing. The results of the geometallurgical studies indicate that the deposit comprises several geometallurgical (or material type) domains. These domains are defined by distinct, internally consistent copper and gold deportment characteristics that correspond spatially with changes in silicate alteration mineralogy.

Metallurgical testwork and associated analytical procedures were performed by recognized testing facilities with extensive experience with this analysis, with this type of deposit, and with the Pebble Project. The samples selected for the comminution, copper/gold/molybdenum bulk flotation, and copper molybdenum separation testing were representative of the various types and styles of mineralization present at the Pebble deposit.

The test results on variability samples derived from the 103 lock cycle flotation tests indicate that marketable copper and molybdenum concentrates can be produced with gold and silver contents that meet or exceed payable levels in representative smelter contracts.

Metal recoveries[1] projected in the 2014 technical report are based on the locked-cycle test (LCT) results of the variability samples, and associated gold leach testwork. This has been updated since secondary recovery using cyanide is not part of the project plan currently advancing through permitting. The flotation tests on composite samples indicate a general increase of metal recoveries when the primary grind size is reduced. Thus, a finer primary grind size P80 125µm was incorporated into the metal recovery projection model. Figure 1.6.1 provides projected metals recoveries via flotation concentration for metals and a gravity circuit for gold.

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[1] Silver recovery projection based on a dataset of 10 LCT samples

Figure 1.6-1 **Projected Metallurgical Recoveries**

Domain	Flotation Recovery %			
	Cu Con, 26% Cu			Mo Con
	Cu	Au	Ag	Mo
Supergene:				
Sodic Potassic	78.7	63.6	67.5	53.9
Illite Pyrite	72.1	46.5	67.8	66.3
Hypogene:				
Illite Pyrite	89.8	45.6	66.6	76.1
Sodic Potassic	90.1	63.2	67.0	80.1
K Silicate	93.7	63.6	66.5	85.4
QP	94.7	65.2	64.4	80.4
Sericite	89.6	40.6	66.5	75.9
QSP	89.8	32.9	66.9	86.1

1.7 ENVIRONMENTAL, PERMITTING AND SOCIAL CONDITIONS

The Pebble deposit is located on state land that has been specifically designated for mineral exploration and development. The project area has been the subject of two comprehensive land-use planning exercises conducted by the Alaska Department of Natural Resources (ADNR), the first in the 1980s and the second completed in 2005. ADNR identified five land parcels (including Pebble) within the Bristol Bay planning area as having "significant mineral potential," and where the planning intent is to accommodate mineral exploration and development. These parcels total 2.7% of the total planning area (ADNR, 2005).

Environmental standards and permitting requirements in Alaska are stable, objective, rigorous and science-driven. These features are an asset to projects like Pebble that are being designed to meet U.S. and international best practice standards of design and performance.

Northern Dynasty began an extensive field study program in 2004 to characterize the existing physical, chemical, biological, and social environments in the Bristol Bay and Cook Inlet areas where the Pebble Project might occur. The Pebble Partnership compiled the data for the 2004-2008 study period into a multi-volume Environmental Baseline Document (EBD, PLP, 2012). These studies have been designed to:

- Fully characterize the existing biophysical and socioeconomic environment;
- Support environmental analyses required for effective input into Project design;
- Provide a strong foundation for internal environmental and social impact assessment to support corporate decision-making;
- Provide the information required for stakeholder consultation and eventual mine permitting in Alaska; and,
- Provide a baseline for long-term monitoring of potential changes associated with mine development.

The baseline study program includes:

• surface water	• wildlife
• groundwater	• air quality
• surface and groundwater quality	• cultural resources
• geochemistry	• subsistence
• snow surveys	• land use
• fish and aquatic resources	• recreation
• noise	• socioeconomics
• wetlands	• visual aesthetics
• trace elements	• climate and meteorology
• fish habitat – stream flow modeling	• Iliamna Lake
• marine	

Additional environmental baseline studies were undertaken between 2009 and 2012. The results of these studies are being compiled into a supplemental EBD. In 2017, select environmental baseline studies were re-initiated and expanded.

1.8 PROJECT DESCRIPTION

On December 22, 2017, the Pebble Partnership submitted its CWA 404 permit application in which it is envisaged that the Pebble copper-gold-molybdenum porphyry deposit would be developed as an open pit mine, with associated on and off-site infrastructure, including:

- a 230 megawatt power plant located at the mine site;
- an 83-mile transportation corridor from the mine site to a port site on the west side of Cook Inlet;
- a permanent, year-round port facility near the mouth of Amakdedori Creek on Cook Inlet; and,
- a 188-mile natural gas pipeline from the Kenai Peninsula to the Pebble Project site.

Following four years of construction activity, the proposed Pebble mine will operate for a period of 20 years. This includes 14 years of mining using conventional drill-blast-shovel operations, followed by six years of milling material from a low-grade stockpile. The mining rate will average 90 million tons per year, with 58 million tons of mineralized material going through the mill each year (160,000 tons per day), for an extremely low life-of-mine waste to mineralized material ratio of 0.1:1.

The development proposed in Pebble's Project Description is substantially smaller than previous iterations, and presents significant new environmental safeguards, including:

- a development footprint less than half the size previously envisaged;
- the consolidation of most major site infrastructure in a single drainage (the North Fork Koktuli), and the absence of any primary mine operations in the Upper Talarik drainage;
- a more conservative Tailings Storage Facility (TSF) design, including enhanced buttresses, flatter slope angles and an improved factor of safety;
- separation of potentially acid generating (PAG) tailings from non-PAG bulk tailings for storage in a fully-lined TSF;
- no permanent waste rock piles; and
- no secondary gold recovery plant.

The project proposed in the Project Description uses a portion of the currently estimated Pebble mineral resources. This does not preclude development of additional resources in other phases of the project in the future, but such development would require additional evaluation and would be subject to separate permitting processes.

1.9 INTERPRETATION AND CONCLUSIONS

Based on the work carried out, this study should be followed by further technical and economic studies leading to an advancement of the project to the next level of development.

1.10 RECOMMENDATIONS

1.10.1 Recommended Program

The immediate priority is to maintain the project in good standing, continue environmental monitoring and complete engineering studies to support permiting.

Property maintenance (estimate) $1,030,000

- Annual state rentals are required to maintain the Pebble claims in good standing.

Environmental baseline data collection (estimate) $3,600,000

- An environmental baseline data collection program is planned for 2018.
- These activities include meteorology, wetlands, aquatic resources, marine studies, wildlife and stream flow monitoring, support at site, and staff to manage the work.

Site data collection to support permitting and engineering studies (estimated direct costs) $7,800,000

Total estimated cost **$12,430,000**

1.10.2 Additional Recommendations

As funding becomes available, the following additional recommendations are proposed in support of future technical studies.

Additional resource evaluation

- The deposit remains open in a number of locations, including adjacent to Hole 6348, which intersected high grade mineralization down-dropped on the east side of the ZG1 graben-bounding fault. Analysis should be undertaken to determine optimal methods for follow up drill testing of this area.
- A conditional simulation study should be completed in order to determine optimal drill spacings to move indicated and inferred resources to more confident classifications for a NI 43-101 compliant prefeasibility study.
- Supplemental geochemical analyses should be undertaken to incorporate rhenium in the block model estimation.

Additional metallurgical testwork

- Additional copper-molybdenum separation testwork is recommended to optimize metal grade and recovery to the molybdenum concentrate in support of a prefeasibility study.
- Ensuring sample numbers for comminution and flotation variability tests for each respective geometallurgical domain unit reflects the timing and expected proportions of each contained.

2.0 INTRODUCTION

The Pebble property hosts a globally significant deposit of copper, gold and molybdenum on state lands currently designated for mineral exploration and development in southwest Alaska.

Alaska was granted statehood in 1959 along with 28% of the state's land base for the explicit purpose of developing land and resources to support the state's government and citizenry. The Alaska State Constitution states: "It is the policy of the State of Alaska … to encourage the development of its resources by making them available for maximum use consistent with the public interest." The lands surrounding Pebble within the Bristol Bay Area Plan were received by the State from the U.S. government as part of the three-way Cook Inlet Land Exchange of 1976, and were recognized by the State at that time for their mineral prospectivity.

The Pebble deposit was originally discovered in 1989 and was acquired by Northern Dynasty in 2001. Since that time, Northern Dynasty and subsequently the Pebble Partnership[2] have conducted significant mineral exploration, environmental baseline data collection, and engineering work on the Pebble Project.

In 2018, Northern Dynasty commissioned a technical report to update the mineral resources and status of the Pebble Project based on work in 2016 and 2017.

Northern Dynasty is a mineral exploration and development company based in Vancouver, Canada, and publicly traded on the Toronto Stock Exchange under the symbol 'NDM' and on the NYSE American exchange under the symbol 'NAK'. Northern Dynasty is currently the sole owner of the Pebble Partnership which owns the Pebble Project.

2.1 TERMS OF REFERENCE AND PURPOSE

The authors have prepared this technical report for Northern Dynasty in general accordance with the guidelines provided in National Instrument (NI) 43-101 Standards of Disclosure for Mineral Projects.

The purpose of this technical report is to integrate a number of project changes since a 2014 technical report, in particular an updated resource estimate based on process modifications reflected in the proposed project which is the subject of a Project Description that formed part of the Pebble Partnership's Clean Water Act Section 404 permit application filed with the US Army Corps. of Engineers on December 22, 2017.

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[2] Additional information on the history of the Pebble Partnership and Pebble Project is provided in Section 6.0.

2.2 SOURCES OF INFORMATION AND DATA

Information and studies from third-party sources for the 2018 Technical Report are included in the references. The authors have reviewed and used information from these sources under the assumption that the information is accurate.

The principal units of measure used in this report are U.S. Standard Units. Exceptions are noted and include the mineral resource estimate, and other instances dictated by convention. Monetary amounts are in United States dollars, unless otherwise stated.

2.3 QUALIFIED PERSONS

The Qualified Persons (QPs) responsible for this technical report and the dates of their most recent site visits are[3]:

Section	Report Section	Qualified Person & Professional Accreditation	Date of Last Site Visit
1.0	Summary	All; sign off by discipline	
2.0	Introduction	David Gaunt, PGeo	Sept 2010
3.0	Reliance on Other Experts	David Gaunt, PGeo	
4.0	Property Description and Location	David Gaunt, PGeo	
5.0	Accessibility, Climate, Local Resources, Infrastructure and Physiography	David Gaunt, PGeo	
6.0	History	Eric Titley, PGeo/ David Gaunt, PGeo/James Lang, PGeo	
7.0	Geological Setting and Mineralization	James Lang, PGeo	Nov 2017
8.0	Deposit Types	James Lang, PGeo	
9.0	Exploration	James Lang, PGeo	
10.0	Drilling	Eric Titley, PGeo/ James Lang, PGeo	
11.0	Sample Preparation, Analyses and Security	Eric Titley, PGeo	Sept 2011
12.0	Data Verification	Eric Titley, PGeo	
13.0	Mineral Processing and Metallurgical Testing	Ting Lu, PEng	
14.0	Mineral Resource Estimates	David Gaunt, PGeo	
15.0	Adjacent Properties	James Lang, PGeo	
16	Other Relevant Data and Information	Stephen Hodgson, PEng	Oct 2017
17.0	Interpretation and Conclusions	All; sign off by discipline	
18.0	Recommendations	All; sign off by discipline	
19.0	References	All	
20.0	Certificates		

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[3] All Qualified Persons are not independent of Northern Dynasty with the exception of Ting Lu.

3.0 RELIANCE ON OTHER EXPERTS

Standard professional procedures were followed in preparing the contents of this report. Data used in this report has been verified where possible and the authors have no reason to believe that the data was not collected in a professional manner.

A QP has not independently verified the legal status or title of the claims or exploration permits, and has not investigated the legality of any of the underlying agreement(s) that may exist concerning the Pebble property, and has relied on legal counsel in terms of the confirmation of these matters.

In some cases, the QPs are relying on reports, opinions, and statements from experts who are not QPs for information concerning legal, environmental and socio-economic factors relevant to the technical report.

The following QPs who prepared this report relied on information provided by a number of experts who are not QPs:

- David Gaunt, PGeo., relied on a letter from Trevor Thomas, Northern Dynasty's legal counsel, dated February 22, 2018, confirming that title to the claims comprising the Pebble Project is held in the name of Pebble East Claims Corp. and Pebble West Claims Corp. (subsidiaries of the Pebble Partnership) and U5 Resources Inc. (a subsidiary of Northern Dynasty) and these are in good standing. The QP has also relied on Northern Dynasty for matters relating to permits, surface rights, royalties, agreements and encumbrances relevant to this report and discussed in Section 4;

- Stephen Hodgson, PEng., relied on a letter from Loretta Ford, M.Sc. P.Ag., Northern Dynasty's VP Environment and Sustainability and Sean Magee, BA, Northern Dynasty's VP Public Affairs, dated February 22, 2018, for matters relating to environmental studies and social or community impact discussed in Section 16.

4.0 PROPERTY DESCRIPTION AND LOCATION

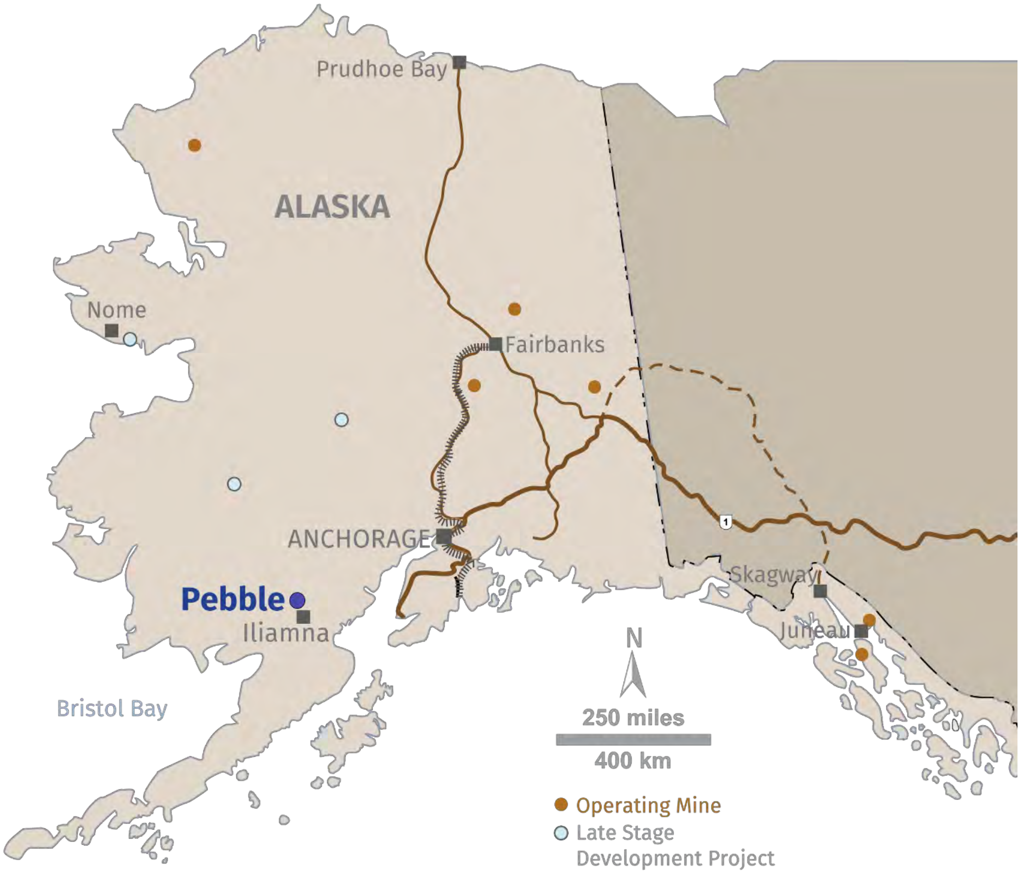
4.1 LOCATION

The Pebble property is located in southwest Alaska, approximately 200 miles southwest of Anchorage, 17 miles northwest of the village of Iliamna, 160 miles northeast of Bristol Bay, and approximately 60 miles west of Cook Inlet (Figure 4.1-1).

The property is centred, approximately, at latitude 59°53′54" N and longitude 155°17′44" W, and is located on the United States Geological Survey (USGS) topographic maps Iliamna D6 and D7, in Townships 2–5 South, Ranges 33–38 West, Seward Meridian.

The Pebble Partnership uses the U.S. State Plane Coordinate System (as Alaska 5005) as the preferred grid, measured in feet.

Figure 4.1-1 Pebble Project Location



4.2 DESCRIPTION

Indirectly through wholly-owned subsidiaries (including the Pebble Partnership), Northern Dynasty holds a 100% interest in a contiguous block of 2,402 mineral claims covering approximately 417 square miles, Figure 4.2-1 including:

- 2,182 claims covering 364 square miles (including the Pebble deposit) through its Pebble Partnership subsidiaries Pebble East Claims Corporation and Pebble West Claims Corporation; and
- 220 claims covering 52.5 square miles through Northern Dynasty's subsidiary U5 Resources Inc.

Teck Resources Limited (Teck) holds a 4% pre-payback net profits interest (after debt service), followed by a 5% after-payback net profits interest in any mine production from the Exploration Lands, which are shown in Figure 4.2.2 and further described in Section 6.0 History.

State mineral claims in Alaska are kept in good standing by performing annual assessment work or in lieu of assessment work by paying $100 per year per 40 acre (0.06 square mile) mineral claim, and by paying annual escalating state rentals. All of the claims come due annually on August 31. However, credit for excess work can be banked for a maximum of five years afterwards, and can be applied as necessary to continue to hold the claims in good standing. The Project claims have a variable amount of work credit available that can be applied in this way. Annual assessment work obligations for the property total some US$667,700 and annual state rentals for 2018 are US$$1,028,390.

The details of the mineral claims are provided below in Figure 4.2-3 (ADL refers to the Alaska Department of Lands).

The claim boundaries have not been surveyed.

Figure 4.2-1 Mineral Claim Map of the Pebble Project

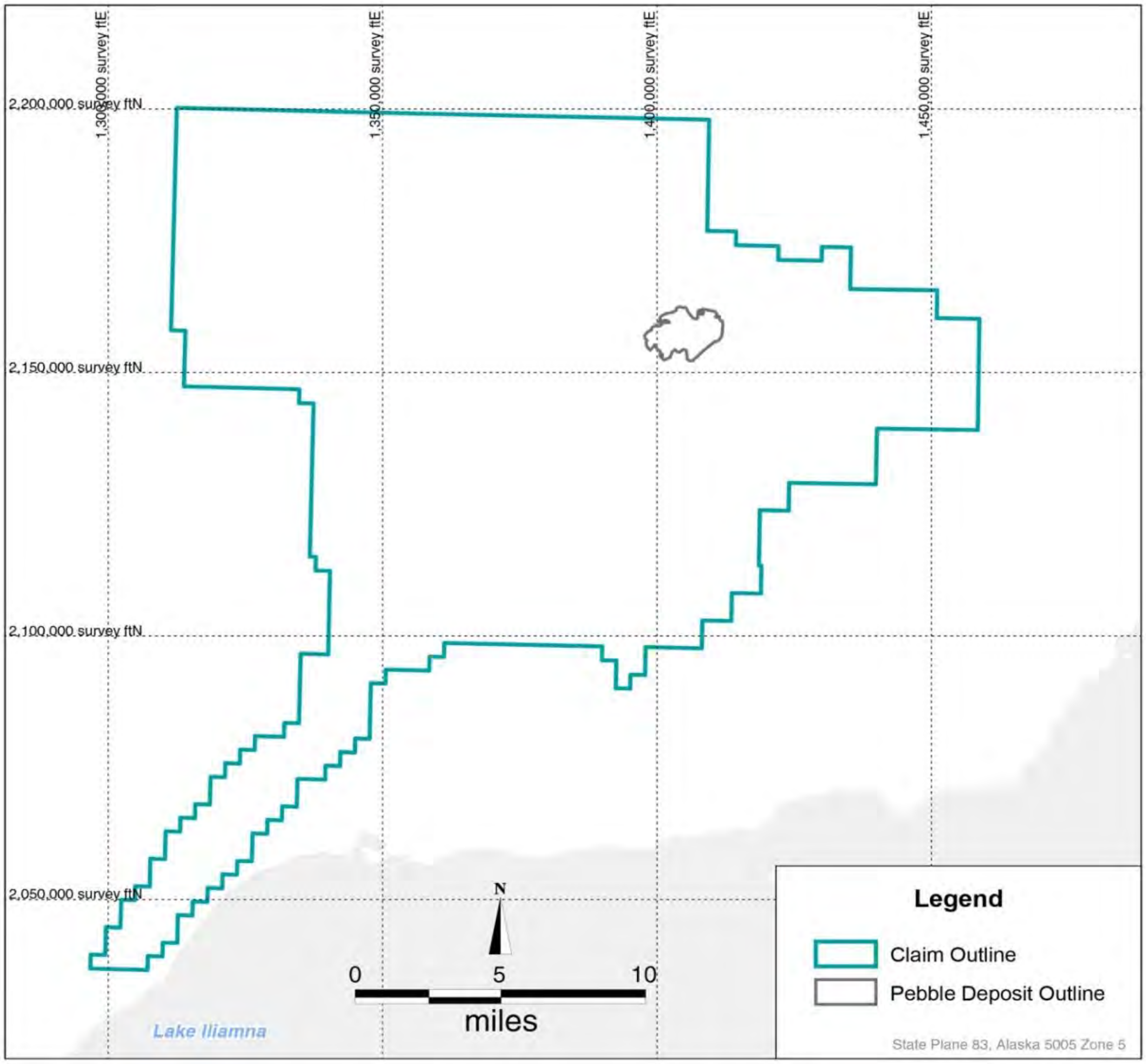


Figure 4.2-2 **Mineral Claim Map with Exploration Lands and Resource Lands**

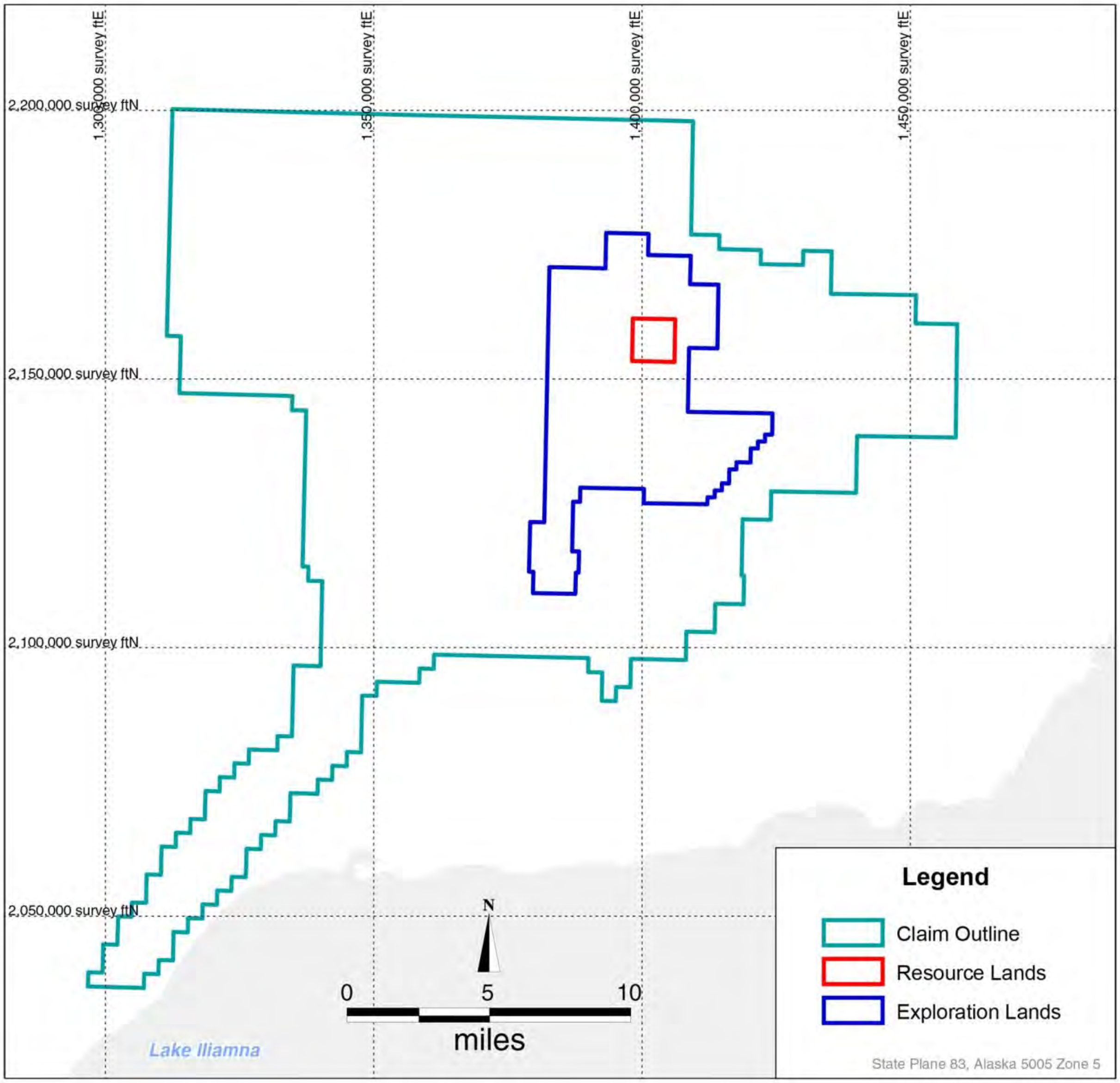
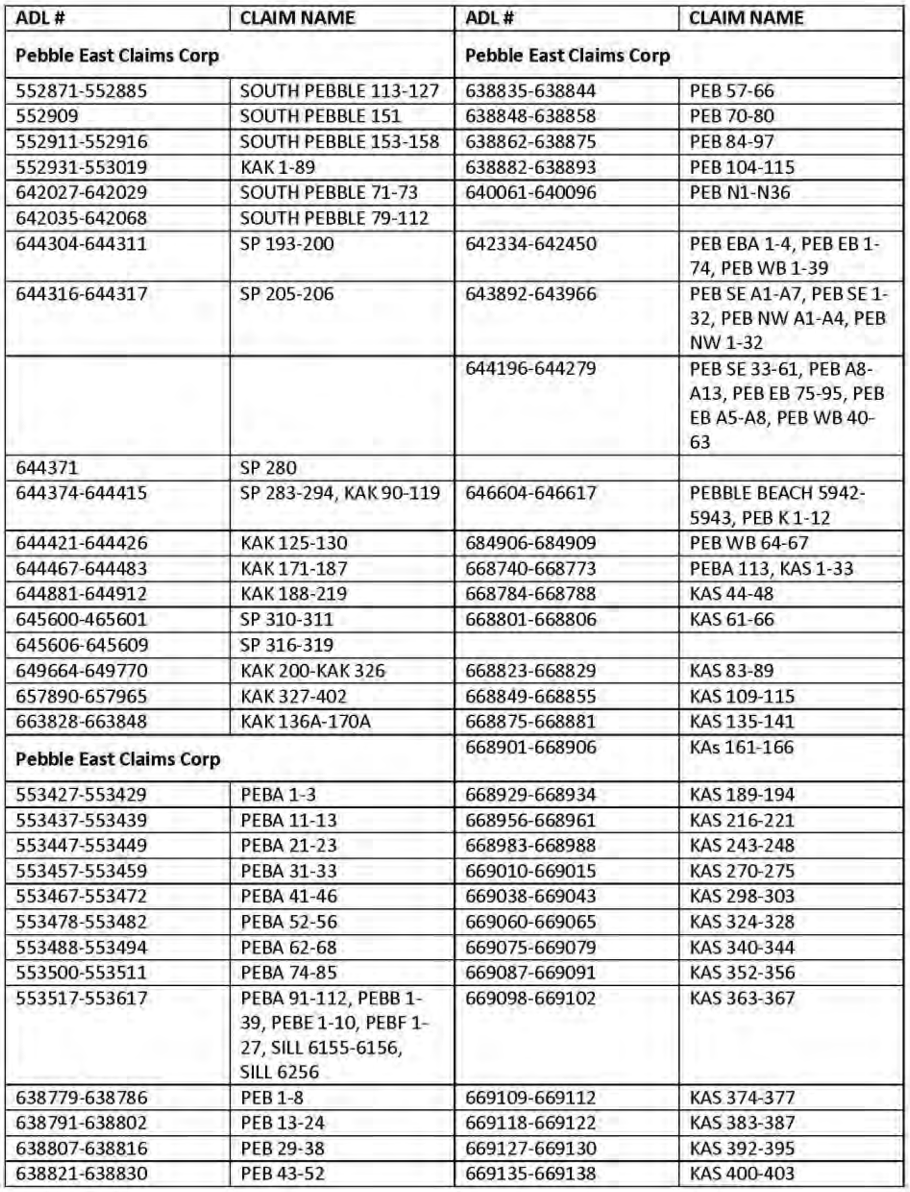
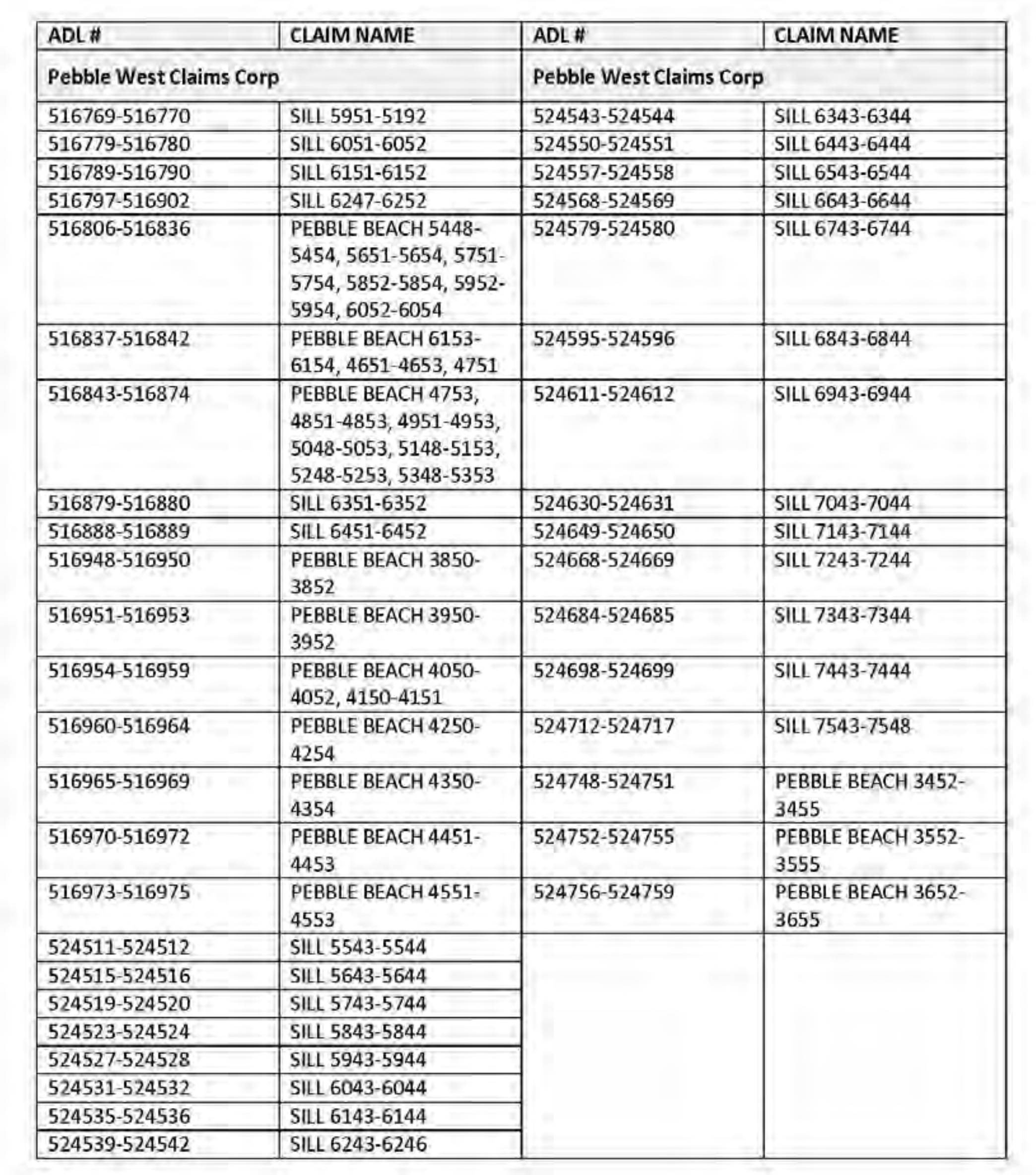


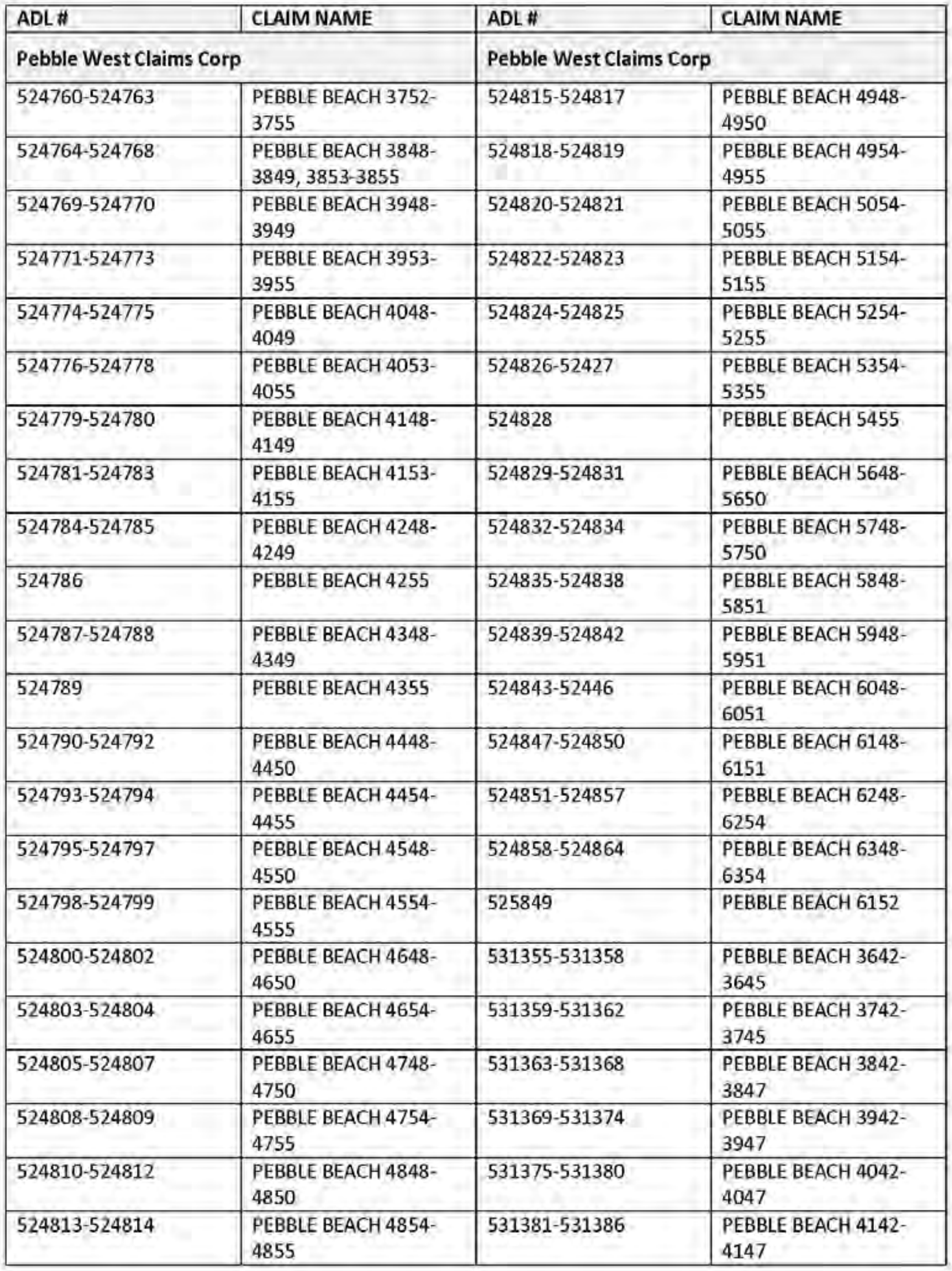
Figure 4.2-3 Pebble Mineral Claims



ADL #	CLAIM NAME	ADL #	CLAIM NAME
Pebble East Claims Corp		**Pebble East Claims Corp**	
552871-552885	SOUTH PEBBLE 113-127	638835-638844	PEB 57-66
552909	SOUTH PEBBLE 151	638848-638858	PEB 70-80
552911-552916	SOUTH PEBBLE 153-158	638862-638875	PEB 84-97
552931-553019	KAK 1-89	638882-638893	PEB 104-115
642027-642029	SOUTH PEBBLE 71-73	640061-640096	PEB N1-N36
642035-642068	SOUTH PEBBLE 79-112		
644304-644311	SP 193-200	642334-642450	PEB EBA 1-4, PEB EB 1-74, PEB WB 1-39
644316-644317	SP 205-206	643892-643966	PEB SE A1-A7, PEB SE 1-32, PEB NW A1-A4, PEB NW 1-32
		644196-644279	PEB SE 33-61, PEB A8-A13, PEB EB 75-95, PEB EB A5-A8, PEB WB 40-63
644371	SP 280		
644374-644415	SP 283-294, KAK 90-119	646604-646617	PEBBLE BEACH 5942-5943, PEB K 1-12
644421-644426	KAK 125-130	684906-684909	PEB WB 64-67
644467-644483	KAK 171-187	668740-668773	PEBA 113, KAS 1-33
644881-644912	KAK 188-219	668784-668788	KAS 44-48
645600-465601	SP 310-311	668801-668806	KAS 61-66
645606-645609	SP 316-319		
649664-649770	KAK 200-KAK 326	668823-668829	KAS 83-89
657890-657965	KAK 327-402	668849-668855	KAS 109-115
663828-663848	KAK 136A-170A	668875-668881	KAS 135-141
Pebble East Claims Corp		668901-668906	KAs 161-166
553427-553429	PEBA 1-3	668929-668934	KAS 189-194
553437-553439	PEBA 11-13	668956-668961	KAS 216-221
553447-553449	PEBA 21-23	668983-668988	KAS 243-248
553457-553459	PEBA 31-33	669010-669015	KAS 270-275
553467-553472	PEBA 41-46	669038-669043	KAS 298-303
553478-553482	PEBA 52-56	669060-669065	KAS 324-328
553488-553494	PEBA 62-68	669075-669079	KAS 340-344
553500-553511	PEBA 74-85	669087-669091	KAS 352-356
553517-553617	PEBA 91-112, PEBB 1-39, PEBE 1-10, PEBF 1-27, SILL 6155-6156, SILL 6256	669098-669102	KAS 363-367
638779-638786	PEB 1-8	669109-669112	KAS 374-377
638791-638802	PEB 13-24	669118-669122	KAS 383-387
638807-638816	PEB 29-38	669127-669130	KAS 392-395
638821-638830	PEB 43-52	669135-669138	KAS 400-403



ADL #	CLAIM NAME	ADL #	CLAIM NAME
Pebble West Claims Corp		**Pebble West Claims Corp**	
516769-516770	SILL 5951-5192	524543-524544	SILL 6343-6344
516779-516780	SILL 6051-6052	524550-524551	SILL 6443-6444
516789-516790	SILL 6151-6152	524557-524558	SILL 6543-6544
516797-516902	SILL 6247-6252	524568-524569	SILL 6643-6644
516806-516836	PEBBLE BEACH 5448-5454, 5651-5654, 5751-5754, 5852-5854, 5952-5954, 6052-6054	524579-524580	SILL 6743-6744
516837-516842	PEBBLE BEACH 6153-6154, 4651-4653, 4751	524595-524596	SILL 6843-6844
516843-516874	PEBBLE BEACH 4753, 4851-4853, 4951-4953, 5048-5053, 5148-5153, 5248-5253, 5348-5353	524611-524612	SILL 6943-6944
516879-516880	SILL 6351-6352	524630-524631	SILL 7043-7044
516888-516889	SILL 6451-6452	524649-524650	SILL 7143-7144
516948-516950	PEBBLE BEACH 3850-3852	524668-524669	SILL 7243-7244
516951-516953	PEBBLE BEACH 3950-3952	524684-524685	SILL 7343-7344
516954-516959	PEBBLE BEACH 4050-4052, 4150-4151	524698-524699	SILL 7443-7444
516960-516964	PEBBLE BEACH 4250-4254	524712-524717	SILL 7543-7548
516965-516969	PEBBLE BEACH 4350-4354	524748-524751	PEBBLE BEACH 3452-3455
516970-516972	PEBBLE BEACH 4451-4453	524752-524755	PEBBLE BEACH 3552-3555
516973-516975	PEBBLE BEACH 4551-4553	524756-524759	PEBBLE BEACH 3652-3655
524511-524512	SILL 5543-5544		
524515-524516	SILL 5643-5644		
524519-524520	SILL 5743-5744		
524523-524524	SILL 5843-5844		
524527-524528	SILL 5943-5944		
524531-524532	SILL 6043-6044		
524535-524536	SILL 6143-6144		
524539-524542	SILL 6243-6246		



ADL #	CLAIM NAME	ADL #	CLAIM NAME
Pebble West Claims Corp		**Pebble West Claims Corp**	
524760-524763	PEBBLE BEACH 3752-3755	524815-524817	PEBBLE BEACH 4948-4950
524764-524768	PEBBLE BEACH 3848-3849, 3853-3855	524818-524819	PEBBLE BEACH 4954-4955
524769-524770	PEBBLE BEACH 3948-3949	524820-524821	PEBBLE BEACH 5054-5055
524771-524773	PEBBLE BEACH 3953-3955	524822-524823	PEBBLE BEACH 5154-5155
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524776-524778	PEBBLE BEACH 4053-4055	524826-52427	PEBBLE BEACH 5354-5355
524779-524780	PEBBLE BEACH 4148-4149	524828	PEBBLE BEACH 5455
524781-524783	PEBBLE BEACH 4153-4155	524829-524831	PEBBLE BEACH 5648-5650
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524787-524788	PEBBLE BEACH 4348-4349	524839-524842	PEBBLE BEACH 5948-5951
524789	PEBBLE BEACH 4355	524843-52446	PEBBLE BEACH 6048-6051
524790-524792	PEBBLE BEACH 4448-4450	524847-524850	PEBBLE BEACH 6148-6151
524793-524794	PEBBLE BEACH 4454-4455	524851-524857	PEBBLE BEACH 6248-6254
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524798-524799	PEBBLE BEACH 4554-4555	525849	PEBBLE BEACH 6152
524800-524802	PEBBLE BEACH 4648-4650	531355-531358	PEBBLE BEACH 3642-3645
524803-524804	PEBBLE BEACH 4654-4655	531359-531362	PEBBLE BEACH 3742-3745
524805-524807	PEBBLE BEACH 4748-4750	531363-531368	PEBBLE BEACH 3842-3847
524808-524809	PEBBLE BEACH 4754-4755	531369-531374	PEBBLE BEACH 3942-3947
524810-524812	PEBBLE BEACH 4848-4850	531375-531380	PEBBLE BEACH 4042-4047
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ADL #	CLAIM NAME	ADL #	CLAIM NAME
Pebble West Claims Corp		**Pebble West Claims Corp**	
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531391-531394	PEBBLE BEACH 4344-4347	540404	PEBBLE BEACH 6055
		540405	PEBBLE BEACH 6155
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531399	PEBBLE BEACH 4544	540407	PEBBLE BEACH 6355
531400	PEBBLE BEACH 4547	540408-540415	PEBBLE BEACH 6448-6455
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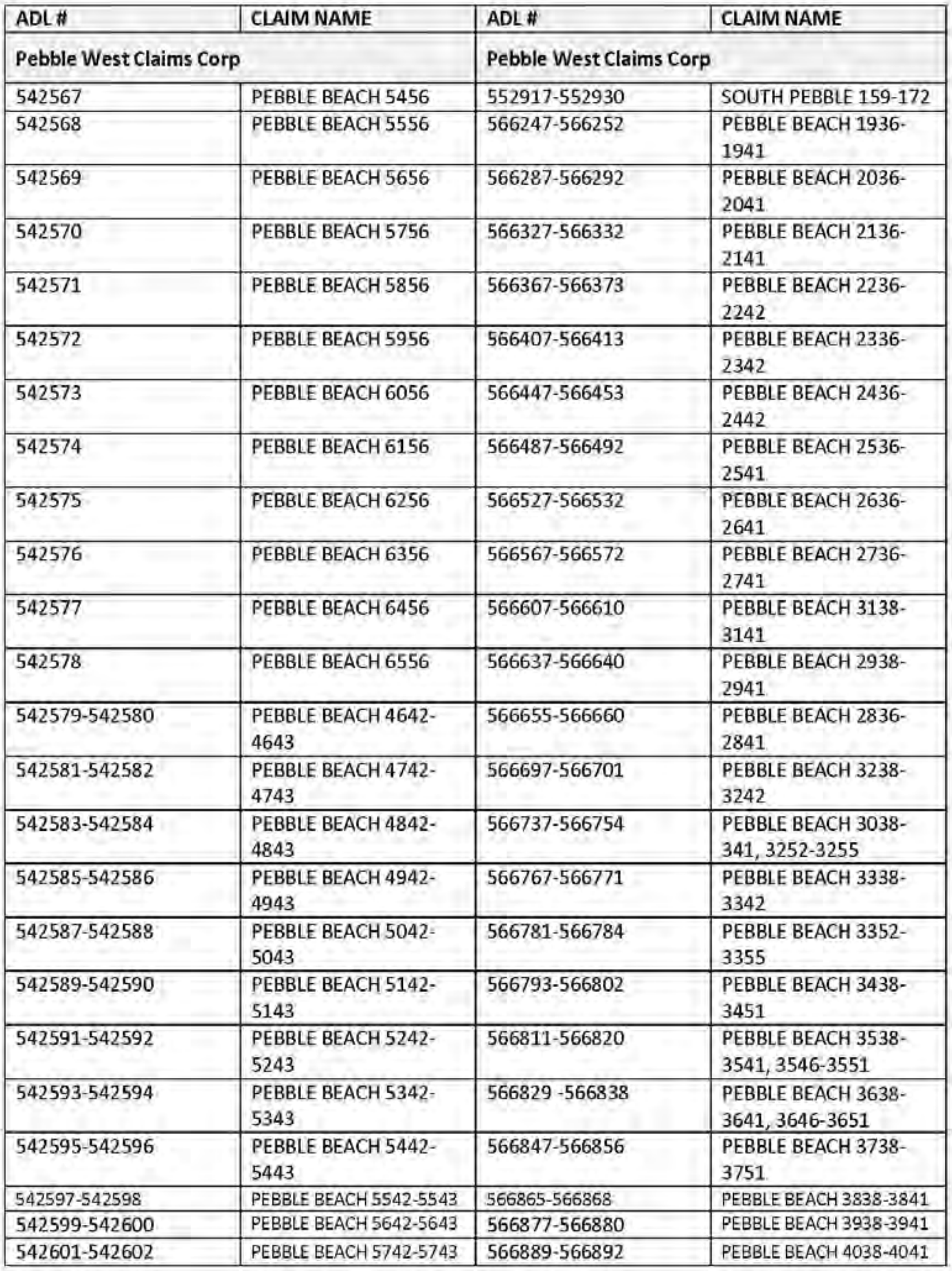
531405-531408	PEBBLE BEACH 4744-4747	540416-540423	PEBBLE BEACH 6548-6555
531409-531412	PEBBLE BEACH 4844-4847	540424-540435	SILL 7643-7648, SILL 7743-7748
531413-531416	PEBBLE BEACH 4944-4947	540436-540441	SILL 7843-7848
531417-53120	PEBBLE BEACH 5044-5047	540442-540447	SILL 7943-7948
531421-531424	PEBBLE BEACH 5144-5147	540448-540453	SILL 8043-8048
531425-531428	PEBBLE BEACH 5244-5247	540454-540459	SILL 8143-8148
531429-531432	PEBBLE BEACH 5344-5347	540460-540465	SILL 8243-8248
531433-531436	PEBBLE BEACH 5444-5447	540466-540467	SILL 8343-8344
531437-531440	PEBBLE BEACH 5544-5547	540468-540469	SILL 8443-8444
531441-531444	PEBBLE BEACH 5644-5647	540470-540471	SILL 8543-8544
531445-531448	PEBBLE BEACH 5744-5747	540472-540473	SILL 8643-8644
531449-531452	PEBBLE BEACH 5844-5847	541245-541252	PB 113-120
531453-531456	PEBBLE BEACH 5944-5947	542561	PEBBLE BEACH 4856
531457-531460	PEBBLE BEACH 6044-6047	542562	PEBBLE BEACH 4956
531461-531464	PEBBLE BEACH 6144-6147	542563	PEBBLE BEACH 5056
531648-531449	PEBBLE BEACH 4545-4546	542564	PEBBLE BEACH 5156
540399	PEBBLE BEACH 5555	542565	PEBBLE BEACH 5256
540400	PEBBLE BEACH 5655	542566	PEBBLE BEACH 5356
540401	PEBBLE BEACH 5755	542603-542604	PEBBLE BEACH 5842-5843
540402	PEBBLE BEACH 5855		



ADL #	CLAIM NAME	ADL #	CLAIM NAME
Pebble West Claims Corp		**Pebble West Claims Corp**	
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542568	PEBBLE BEACH 5556	566247-566252	PEBBLE BEACH 1936-1941
542569	PEBBLE BEACH 5656	566287-566292	PEBBLE BEACH 2036-2041
542570	PEBBLE BEACH 5756	566327-566332	PEBBLE BEACH 2136-2141
542571	PEBBLE BEACH 5856	566367-566373	PEBBLE BEACH 2236-2242
542572	PEBBLE BEACH 5956	566407-566413	PEBBLE BEACH 2336-2342
542573	PEBBLE BEACH 6056	566447-566453	PEBBLE BEACH 2436-2442
542574	PEBBLE BEACH 6156	566487-566492	PEBBLE BEACH 2536-2541
542575	PEBBLE BEACH 6256	566527-566532	PEBBLE BEACH 2636-2641
542576	PEBBLE BEACH 6356	566567-566572	PEBBLE BEACH 2736-2741
542577	PEBBLE BEACH 6456	566607-566610	PEBBLE BEACH 3138-3141
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542579-542580	PEBBLE BEACH 4642-4643	566655-566660	PEBBLE BEACH 2836-2841
542581-542582	PEBBLE BEACH 4742-4743	566697-566701	PEBBLE BEACH 3238-3242
542583-542584	PEBBLE BEACH 4842-4843	566737-566754	PEBBLE BEACH 3038-341, 3252-3255
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542591-542592	PEBBLE BEACH 5242-5243	566811-566820	PEBBLE BEACH 3538-3541, 3546-3551
542593-542594	PEBBLE BEACH 5342-5343	566829 -566838	PEBBLE BEACH 3638-3641, 3646-3651
542595-542596	PEBBLE BEACH 5442-5443	566847-566856	PEBBLE BEACH 3738-3751
542597-542598	PEBBLE BEACH 5542-5543	566865-566868	PEBBLE BEACH 3838-3841
542599-542600	PEBBLE BEACH 5642-5643	566877-566880	PEBBLE BEACH 3938-3941
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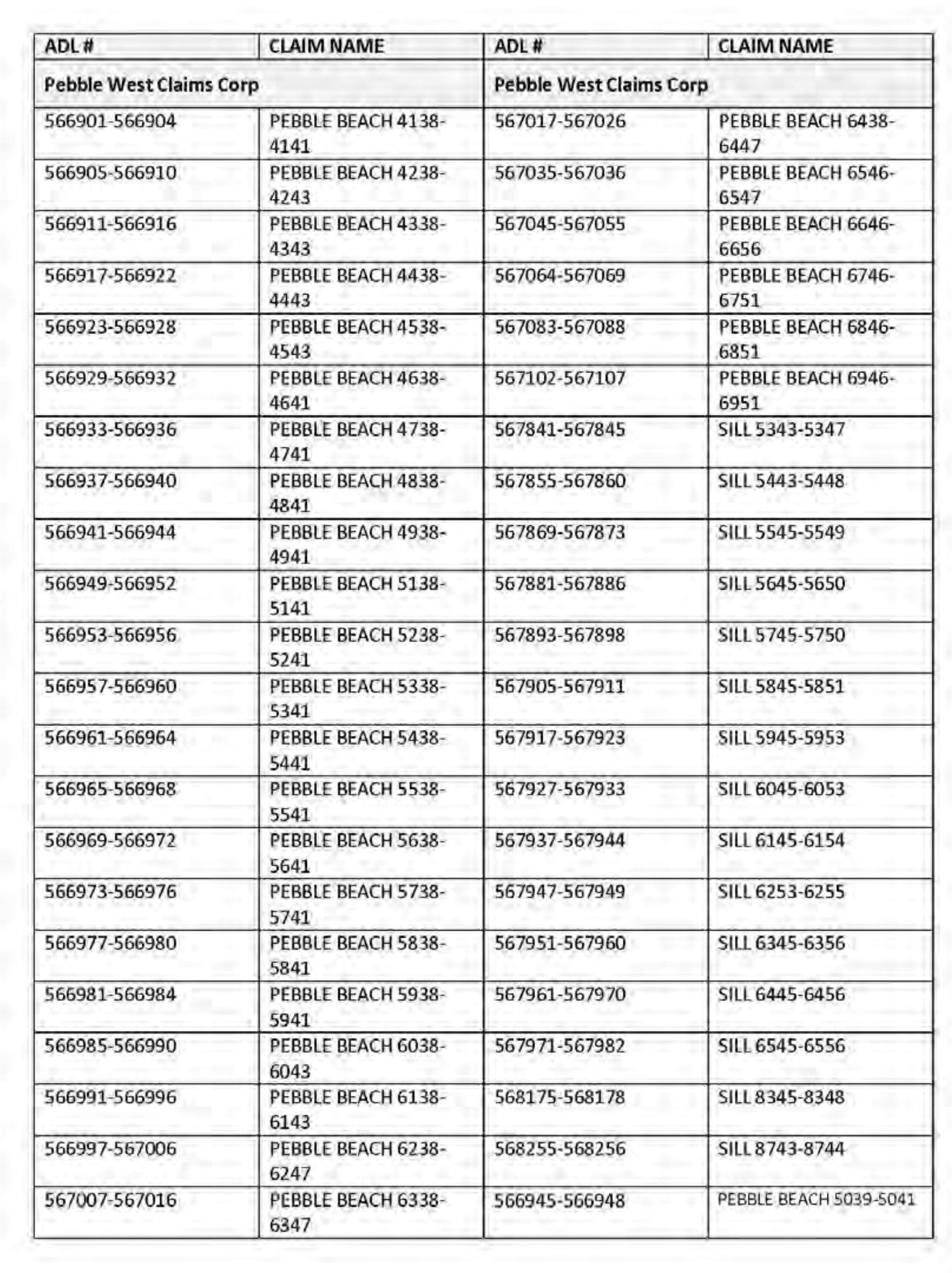

ADL #	CLAIM NAME	ADL #	CLAIM NAME
Pebble West Claims Corp		**Pebble West Claims Corp**	
566901-566904	PEBBLE BEACH 4138-4141	567017-567026	PEBBLE BEACH 6438-6447
566905-566910	PEBBLE BEACH 4238-4243	567035-567036	PEBBLE BEACH 6546-6547
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566917-566922	PEBBLE BEACH 4438-4443	567064-567069	PEBBLE BEACH 6746-6751
566923-566928	PEBBLE BEACH 4538-4543	567083-567088	PEBBLE BEACH 6846-6851
566929-566932	PEBBLE BEACH 4638-4641	567102-567107	PEBBLE BEACH 6946-6951
566933-566936	PEBBLE BEACH 4738-4741	567841-567845	SILL 5343-5347
566937-566940	PEBBLE BEACH 4838-4841	567855-567860	SILL 5443-5448
566941-566944	PEBBLE BEACH 4938-4941	567869-567873	SILL 5545-5549
566949-566952	PEBBLE BEACH 5138-5141	567881-567886	SILL 5645-5650
566953-566956	PEBBLE BEACH 5238-5241	567893-567898	SILL 5745-5750
566957-566960	PEBBLE BEACH 5338-5341	567905-567911	SILL 5845-5851
566961-566964	PEBBLE BEACH 5438-5441	567917-567923	SILL 5945-5953
566965-566968	PEBBLE BEACH 5538-5541	567927-567933	SILL 6045-6053
566969-566972	PEBBLE BEACH 5638-5641	567937-567944	SILL 6145-6154
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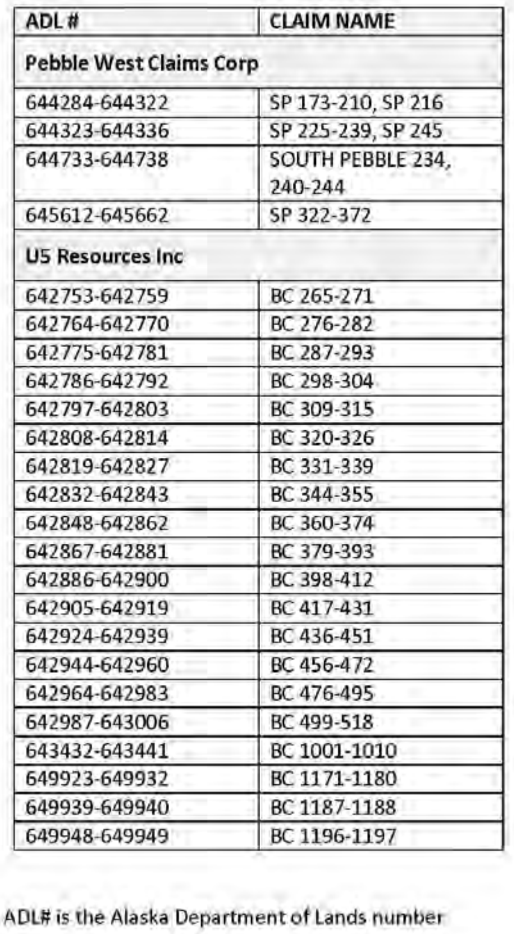
566977-566980	PEBBLE BEACH 5838-5841	567951-567960	SILL 6345-6356
566981-566984	PEBBLE BEACH 5938-5941	567961-567970	SILL 6445-6456
566985-566990	PEBBLE BEACH 6038-6043	567971-567982	SILL 6545-6556
566991-566996	PEBBLE BEACH 6138-6143	568175-568178	SILL 8345-8348
566997-567006	PEBBLE BEACH 6238-6247	568255-568256	SILL 8743-8744
567007-567016	PEBBLE BEACH 6338-6347	566945-566948	PEBBLE BEACH 5039-5041



ADL #	CLAIM NAME
Pebble West Claims Corp	
644284-644322	SP 173-210, SP 216
644323-644336	SP 225-239, SP 245
644733-644738	SOUTH PEBBLE 234, 240-244
645612-645662	SP 322-372
U5 Resources Inc	
642753-642759	BC 265-271
642764-642770	BC 276-282
642775-642781	BC 287-293
642786-642792	BC 298-304
642797-642803	BC 309-315
642808-642814	BC 320-326
642819-642827	BC 331-339
642832-642843	BC 344-355
642848-642862	BC 360-374
642867-642881	BC 379-393
642886-642900	BC 398-412
642905-642919	BC 417-431
642924-642939	BC 436-451
642944-642960	BC 456-472
642964-642983	BC 476-495
642987-643006	BC 499-518
643432-643441	BC 1001-1010
649923-649932	BC 1171-1180
649939-649940	BC 1187-1188
649948-649949	BC 1196-1197

ADL# is the Alaska Department of Lands number

4.3 SURFACE RIGHTS

Northern Dynasty currently does not own surface rights associated with the mineral claims that comprise the Pebble property. All lands are held by the State of Alaska, and surface rights may be acquired from the state government once areas required for mine development have been determined and permits awarded.

4.4 ENVIRONMENTAL LIABILITIES

Environmental liabilities associated with the Pebble Project include removal of structures, closing monitoring wells, and removal of piezometers. The State of Alaska holds a $2 million bond associated with removal and reclamation of these liabilities.

4.5 PERMITS

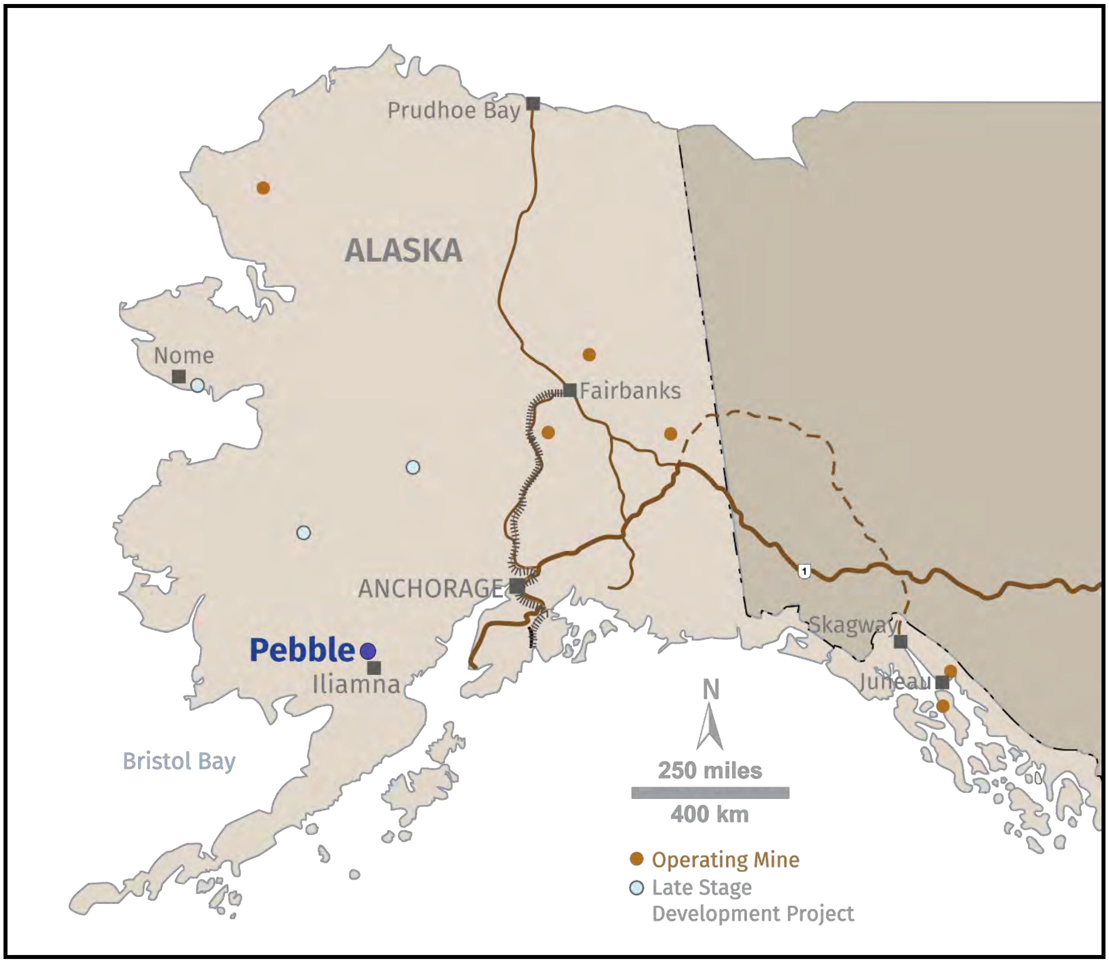
Permits necessary for exploration drilling and other field programs associated with pre-development assessment of the Pebble Project are obtained as required each year. Permitting is underway for the 2018 environmental programs.

5.0 ACCESSIBILITY, CLIMATE, LOCAL RESOURCES, INFRASTRUCTURE AND PHYSIOGRAPHY ACCESSIBILITY

5.1 ACCESS

The Pebble property is located in southwest Alaska Figure 5.1-1.

Figure 5.1-1 Property Location Map



Access to the property is typically via air travel from the city of Anchorage, which is situated at the northeastern end of Cook Inlet and is connected to the national road network via Interstate Highway 1 through Canada to the USA. Anchorage is serviced daily by several regularly scheduled flights to major airport hubs in the USA.

From Anchorage, there are regular flights to Iliamna through Iliamna Air Taxi. Charter flights may also be arranged from Anchorage. From Iliamna, access to the Pebble property is by helicopter.

5.2 CLIMATE

The climate of the Pebble Project area is transitional; it is more continental in winter because of frozen water bodies and more maritime in summer because of the influence of the open water of Iliamna Lake and, to a lesser extent, the Bering Sea and Cook Inlet. Mean monthly temperatures in the deposit area range from about 55°F in summer to 2°F in winter. Precipitation in the North Fork Koktuli River (NFK) drainage averages approximately 57.4 inches per year and in the South Fork Koktuli River (SFK) drainage averages approximately 50.8 inches per year. About one-third of this precipitation falls as snow. The wettest months are August through October.

The climate is sufficiently moderate to allow a well-planned mineral exploration program to be conducted year-round (Rebagliati, C.M., and Haslinger, R.J., 2003) at Pebble.

5.3 INFRASTRUCTURE

There is a modern airfield at Iliamna, with two paved 4,920 ft airstrips, that services the communities of Iliamna and Newhalen. The runways are suitable for DC-6 and Hercules cargo aircraft, and commercial jet aircraft.

There are paved roads that connect the villages of Iliamna and Newhalen to the airport and to each other, and a partly paved, partly gravel road that extends to a proposed Newhalen River crossing near Nondalton. The property is currently not connected to any of these local communities by road; a road would be planned as part of the project design.

There is no access road that connects the communities nearest the Pebble Project to the coast on Cook Inlet. From the coast, at Williamsport on Iniskin Bay, there is an 18.6 mile state-maintained road that terminates at the east end of Iliamna Lake, where watercraft and transport barges may be used to access Iliamna. The route from Williamsport, over land to Pile Bay on Iliamna Lake, is currently used to transport bulk fuel, equipment and supplies to communities around the lake during the summer months.

Also during summer, supplies are barged up the Kvichak River, approximately 43.4 miles southwest of Iliamna, from Kvichak Bay on the North Pacific Ocean.

A small run-of-river hydroelectric installation on the nearby Tazamina River provides power for the three communities in the summer months. Supplemental power generation using diesel generators is required during winter months.

5.4 LOCAL RESOURCES

Iliamna and surrounding communities have a combined population of just over 400 people. As such, there is limited local commercial infrastructure except that which services seasonal sports fishing and hunting.

5.5 PHYSIOGRAPHY

The property is situated at approximately 1,000 ft amsl in an area described as subarctic tundra. It is characterized by gently rolling hills and an absence of permafrost.

From Rebagliati, C.M., and Haslinger, J.M., 2003:

> *The Pebble property lies 80.5 km (50 miles) west of the Alaska Range in the Nushagak-Big River Hills, an area of rolling hills and low mountains separated by wide, shallow valleys blanketed with glacial deposits that contain numerous small, shallow lakes and are cut by several major meandering streams. The elevation ranges from 250 m (820 ft) amsl to 841 m (2,758 ft) amsl at Kaskanak Peak, the highest point on the property.*
>
> *Tundra plant communities (mixtures of shrub and herbaceous plants) cover the project area. Willow is common only along streams, and sparse patches of dense alder are confined to better drained areas where coarse soils have developed. Poorly drained regions underlain by fine soils support dwarf birch and grasses (Detterman and Reed, 1973).*

6.0 HISTORY

6.1 INTRODUCTION

Cominco Alaska, a division of Cominco Ltd. now Teck Resources Limited (Cominco (Teck)), began reconnaissance exploration in the Pebble region in the mid-1980s and in 1984 discovered the Sharp Mountain gold prospect near the southern margin of the current property. Gold was discovered in drusy quartz veins of probable Tertiary age near the peak of Sharp Mountain (anonymous Cominco (Teck) report, 1984). Grab samples of veins in talus ranged from 0.045 oz/ton Au to 9.32 oz/ton Au and 3.0 oz/ton Ag. No record of further work is available, but similar quartz veins were encountered in 2004 during surface mapping of the property conducted by Northern Dynasty. Most of these veins trend north-south and dip steeply.

In 1987, examination and sampling of several prominent limonitic and hematitic alteration zones yielded anomalous gold concentrations from the Sill prospect (recognized as a precious-metal, epithermal-vein occurrence), and the Pebble discovery outcrop (of then-uncertain affinity). These discoveries were followed by several years of exploration including soil sampling, geophysical surveys and diamond drilling.

Geophysical surveys were conducted on the property between 1988 and 1997. The surveys were dipole-dipole induced polarization (IP) surveys for a total of 122 line-km, and were completed by Zonge Geosciences. This work defined a chargeability anomaly about 31.1 square miles in extent within Cretaceous age rocks which surround the eastern to southern margins of the Kaskanak batholith. The anomaly measures about 13 miles north-south and up to 6.3 miles east-west; the western margin of the anomaly overlaps the contact of the Kaskanak batholith, whereas to the east the anomaly is masked by Late Cretaceous to Eocene cover sequences. The broader anomaly was found to contain 11 distinct centres with stronger chargeability, many of which were later demonstrated to be coincident with extensive copper, gold and molybdenum soil geochemical anomalies. All known zones of mineralization of Cretaceous age on the Pebble property occur within the broad IP anomaly.

Diamond drilling was first conducted on the property during the 1988 exploration program which included 24 diamond drill holes at the Sill epithermal gold prospect Figure 6.1-1 soil sampling, geological mapping, two diamond drill holes at the Pebble target (Figure 6.1-2) and three holes totalling 893 ft on a target (later named the 25 Gold Zone by Northern Dynasty) located 3.7 miles south of the Pebble deposit.

Drilling at the Sill prospect intersected mineralization with gold grades that justified further exploration, but the initial Pebble drill holes yielded only modest encouragement. In 1989, an expanded soil-sampling program, the initial stages of the induced polarization (IP) surveys described above and nine diamond drill holes were completed at the Pebble target, 15 diamond drill holes were completed at the Sill prospect and three diamond drill holes were completed elsewhere on the property. Although limited in scope, the IP survey at Pebble displayed response characteristics of a large porphyry-copper system. Subsequent drilling by Cominco (Teck) intersected significant intervals of porphyry-style gold, copper and molybdenum mineralization, validating this interpretation.

Figure 6.1-1 Cominco (Teck) Drilling on the Sill Prospect to the End of 1997

Year	No. of Drill Holes	Feet	Metres
1988	**24**	**7,048**	**2,148**
1989	**15**	**3,398**	**1,036**
Total	39	10,446	3,184

Figure 6.1-2 Cominco (Teck) Drilling on the Pebble Deposit to the End of 1997

Year	No. of Drill Holes	Feet	Metres
1988	**2**	**554**	**169**
1989	**9**	**3,131**	**954**
1990	**25**	**10,021**	**3,054**
1991	**48**	**28,129**	**8,574**
1992	**14**	**6,609**	**2,014**
1997	**20**	**14,696**	**4,479**
Total	118	63,140	19,245

When it became apparent that a significant copper-gold porphyry deposit had been discovered at Pebble, exploration was accelerated. In 1990 and 1991, 25 and 48 diamond drill holes, respectively, were completed. In 1991, baseline environmental and engineering studies were initiated and weather stations were established. A preliminary economic evaluation was undertaken by Cominco (Teck) in 1991, and was updated in 1992 on the basis of 14 new diamond drill holes. In 1993, an IP survey and a four-hole diamond-drill program were completed at the target that was later named the 25 Gold Zone. In 1997, Cominco (Teck) completed an IP survey, geochemical sampling, geological mapping and 20 diamond drillholes within and near the Pebble deposit (Figure 6.1-3).

From 1988 to 1995, Cominco (Teck) undertook several soil geochemical surveys on the property and collected a total of 7,337 samples (Bouley et al., 1995).

Figure 6.1-3 Total Cominco (Teck) Drilling on the Property to the End of 1997

Year	No. of Drill Holes	Feet	Metres
1988	26	7,602	2,317
1989	27	7,422	2,262
1990	25	10,021	3,054
1991	48	28,129	8,574
1992	14	6,609	2,014
1993	4	1,263	385
1997	20	14,696	4,479
Total	164	75,741	23,086

6.2 HISTORICAL SAMPLE PREPARATION AND ANALYSIS

6.2.1 Sample Preparation

Cominco (Teck) drilled 125 holes in the Pebble area between 1988 and 1997 for a total of 65,295.5 ft. These holes include 118 holes drilled in what later became known as Pebble West and seven holes drilled elsewhere on the property. Of the Pebble West holes, 94 were drilled vertically and 20 were inclined from −45° to −70° at various orientations. Cominco (Teck) also completed 39 drill holes on the Sill prospect for a total of 10,445.5 ft in 1988 and 1989.

Cominco (Teck) drill core was transported from the drill site by helicopter to a logging and sampling site in the village of Iliamna. The core from within the Pebble deposit was typically sampled on 10 ft intervals and most core from Cretaceous age units was sampled. Samples from the Sill and other areas were typically 5 ft in length, with shorter samples in areas of vein mineralization. Samples consisted of mechanically-split drill core. The samples were transported by air charter to Anchorage and by air freight to Vancouver, BC. All coarse rejects from 1988 through 1997 and all pulps from 1988 and most from 1989 have been discarded. The remaining pulps were later shipped by Northern Dynasty to a secure warehouse at Langley, BC, for long-term storage.

Cominco (Teck) systematically assayed for gold in the Cretaceous intersections from all drill holes completed on the property from 1988 through 1997. Copper analysis was added when the Pebble porphyry discovery hole was drilled in 1989, and single element copper analysis continued for all Cretaceous intersections in 1989. Selective single element molybdenum assays and single element silver analyses were added to some holes in 1989. In 1990, Cominco (Teck) added multi-element analysis to the analytical protocol, which included the determination of copper, molybdenum, silver and 29 additional elements. In 1991 and 1992, some sections of core were analyzed using the multi-element analysis and some were analyzed using single element copper analysis. Only four holes were drilled by Cominco (Teck) in 1993, on targets well south of the Pebble deposit, and these were only assayed for gold and copper. No drilling was completed from 1994 to 1996. Drill holes completed in 1997 were analyzed with a multi-element package.

6.2.2 Sample Analysis

Cominco (Teck) samples collected prior to the 1997 program were prepared and analyzed by ALS Minerals (ALS) Laboratories in North Vancouver, BC (formerly Chemex Labs Inc.). The core samples were processed by drying, weighing, crushing to 70% passing 10 mesh and then splitting to a 250 g sub-sample and a coarse reject; the 250 g sub-sample was pulverized to 85% passing 200 mesh.

During the 1997 program, drill core samples were prepared by ALS Laboratories in Anchorage. A 250 g pulp sample was then submitted to Cominco Exploration and Research Laboratory in Vancouver, BC, for copper analysis using an aqua regia (AR) digestion with inductively coupled plasma atomic emission spectroscopy (ICP-AES) finish. Gold was analyzed using fire assay (FA) on a one assay-ton sample with atomic absorption spectroscopy (AAS) finish. Trace elements also were analyzed by AR digestion and ICP-AES finish. One blind standard was inserted for every 20 samples analyzed. One duplicate sample was taken for every 10 samples analyzed.

Cominco (Teck) analyzed a total of 6,311 core samples from 125 drill holes on the property. On the Sill prospect, a total of 676 samples were analyzed from 39 drill holes.

6.3 HISTORICAL RESOURCE ESTIMATES

Cominco (Teck) prepared several resource estimates on the Pebble deposit during the 1990s, employing block models estimated with either kriging or inverse distance (ID) weighting. The cut-off grade used was 0.3% CuEq based on metal prices of $1.00/lb of copper and $375/oz of gold. These estimates are summarized in Figure 6.3-1.

Figure 6.3-1 Cominco (Teck) Resource Estimates

Year	Tonnage (million)	Cu (%)	Au (oz/ton)
1990	200	0.35	0.01
1991	500	0.35	0.01
1992	460	0.40	0.01
2000	1,000	0.30	0.01

These historical estimates are considered both relevant and reliable, as the methodology was consistent with industry standards at the time of estimation. The historical estimates are classified as Inferred. However, no QP has done sufficient work to evaluate these historical estimates and Northern Dynasty is not treating the historical estimates as current Mineral Resources. More recent estimates are described in Section 14.0.

6.4 OWNERSHIP HISTORY

The following summary of historical property agreements is taken from Rebagliati et al (2010).

> *In October 2001, Northern Dynasty acquired, through its Alaskan subsidiary, a two-part Pebble Property purchase option previously secured by Hunter Dickinson Group Inc. (HDGI) from an Alaskan subsidiary of Teck Cominco Limited, now Teck Resources Limited (Teck). In particular, HDGI assigned this two-part option (the Teck Option) as 80% to Northern Dynasty while retaining 20% thereof. The first part of the Teck Option permitted Northern Dynasty to purchase (through its Alaskan subsidiary) 80% of the previously drilled portions of the Pebble Property on which the majority of the then known copper mineralization occurred (the "Resource Lands Option"). Northern Dynasty could exercise the Resource Lands Option through the payment of cash and shares aggregating US$10 million prior to November 30, 2004. The second part of the Teck Option permitted Northern Dynasty to earn a 50% interest in the exploration area outside of the Resource Lands (the "Exploration Lands Option"). Northern Dynasty could exercise the Explorations Lands Option by doing some 18,288 m (60,000 ft) of exploration drilling by November 30, 2004, which it completed on time. The HDGI assignment of the Teck Option also allowed Northern Dynasty to purchase the other 20% of the Teck Option retained by HDGI for its fair value.*
>
> *In November 2004, Northern Dynasty exercised the Resource Lands Option and acquired 80% of the Resource Lands. In February 2005, Teck elected to sell its residual 50% interest in the Exploration Lands to Northern Dynasty for US$4 million. Teck still retains a 4% pre-payback advance net profits royalty interest (after debt service) and 5% after-payback net profits interest royalty in any mine production from the Exploration Lands portion of the Pebble property.*
>
> *In June 2006, Northern Dynasty acquired, through its Alaska subsidiaries, the remaining HDGI 20% interest in the Resource Lands and Exploration Lands by acquiring HDGI from its shareholders and through its various subsidiaries had thereby acquired an aggregate 100% interest in the Pebble Property, subject only to the Teck net-profits royalties on the Exploration Lands described above* [see Section 4. *At that time, Northern Dynasty operated the Pebble Property through a general Alaskan partnership with one of its subsidiaries.*

In July 2007, the Pebble Partnership was created and an indirect wholly-owned subsidiary of Anglo American plc (Anglo American) subscribed for 50% of the Pebble Partnership's equity effective July 31, 2007. Each of Northern Dynasty and Anglo American effectively had equal control and management rights in the Pebble Partnership and its general partner, Pebble Mines Corp. through respective wholly-owned affiliates. The Pebble Partnership's assets include the shares of two Alaskan subsidiaries, Pebble East Claims Corporation and Pebble West Claims Corporation, which hold registered title to the claims (see Section 4.0 for details). To maintain a 50% interest in the Pebble Partnership, Anglo American was required to make staged cash investments into the Pebble Partnership, aggregating $1.5 billion, towards comprehensive exploration, engineering, environmental and socioeconomic programs and, if warranted, development of the Pebble Project. On September 15, 2013, Anglo gave Northern Dynasty a 60-day notice of withdrawal from the Pebble Project. In December 2013, Northern Dynasty exercised its right to acquire Anglo American's interest in the Pebble Partnership and now holds a 100% interest in the Pebble Partnership.

On December 15, 2017 Northern Dynasty entered into a Framework Agreement ("Framework Agreement") with First Quantum Minerals Ltd. ("First Quantum") which contemplates that an affiliate of First Quantum will subsequently execute an option agreement with Northern Dynasty (the "Option Agreement"). The Option Agreement contemplates an option payment of US$150 million staged over four years, which will entitle First Quantum to acquire the right to earn a 50% interest in the Pebble Partnership for US$1.35 billion. The option period may be extended for up to two years by First Quantum making payments to be agreed upon which amounts will be offset against the US$1.35 billion additional investment amount. Under the terms of the Framework Agreement First Quantum has made an early option payment of US$37.5 million to Northern Dynasty, which will be applied solely for the purposes of progressing the permitting of the Pebble Project and will be set off and credited against the US$150 million option payment.

The entry by First Quantum into the Option Agreement is contingent upon, among other things, the completion of due diligence, necessary regulatory approvals being obtained and the successful negotiation of the final form of the Option Agreement and associated commercial agreements. Finalization and execution of the Option Agreement and associated commercial agreements is expected early in the second quarter of 2018[4].

On June 29, 2010, Northern Dynasty entered into an agreement with Liberty Star Uranium and Metals Corp. and its subsidiary, Big Chunk Corp. (together, "Liberty Star"), pursuant to which Liberty Star sold 23.8 square miles of claims (the 95 "Purchased Claims") to a U.S. subsidiary of Northern Dynasty in consideration for both a $1 million cash payment and a secured convertible loan from Northern Dynasty in the amount of $3 million. The parties agreed, through various amendments to the original agreement, to increase the principal amount of the Loan by $730,174. Northern Dynasty later agreed to accept transfer of 199 claims (the Settlement Claims) located north of the ground held 100% by the Pebble Partnership in settlement of the Loan. These claims are now held by Northern Dynasty's subsidiary U5 Resources Inc. The current size of this property is described in section 4.1. Northern Dynasty plans to effect the transfer of the Purchased Claims and the Settlement Claims from U5 Resources Inc. to the Pebble Partnership in the near future as contemplated under the Framework Agreement.

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[4] The likelihood of a partnering transaction is subject to risks related to the satisfactory completion of due diligence and negotiations, including finalization of definitive agreements and fulfilment of conditions precedent therein, including receipt of all necessary approvals. Such process may not be successfully completed or completed on terms satisfactory to Northern Dynasty.

On January 31, 2012, the Pebble Partnership entered into a Limited Liability Company Agreement with Full Metal Minerals (USA) Inc. (FMMUSA), a wholly-owned subsidiary of Full Metal Minerals Corp., to form Kaskanak Copper LLC (the LLC). Under the agreement, the Pebble Partnership could earn a 60% interest in the LLC, which indirectly owned 100% of the Kaskanak claims, by incurring exploration expenditures of at least US$3 million and making annual payments of $50,000 to FMMUSA over a period ending on December 31, 2013. On May 8, 2013, the Pebble Partnership purchased FMMUSA's entire ownership interest in the LLC for a cash consideration of $750,000. As a result, the Pebble Partnership gained a 100% ownership interest in the LLC, the indirect owner of a 100% interest in a group of 464 claims located south and west of other ground held by the Pebble Partnership. In 2014 the LLC was merged into Pebble East Claims Corporation, which now holds title to these claims. The current size of this property is described in Section 4.1.

7.0 GEOLOGICAL SETTING AND MINERALIZATION

7.1 REGIONAL GEOLOGY

The tectonic and magmatic history of southwest Alaska is complex (Decker et al., 1994; Plafker and Berg, 1994). It includes formation of foreland sedimentary basins between tectonostratigraphic terranes, amalgamation of these terranes and their translation along crustal-scale strike-slip faults, and episodic magmatism and formation of related mineral occurrences. The overview presented here is based largely on Goldfarb et al. (2013).

The allochthonous Wrangellia superterrane comprises the amalgamated Wrangellia, Alexander and Peninsular oceanic arc terranes that approached North America from the southwest in the early Mesozoic. West-dipping subduction beneath the superterrane formed the Late Triassic to Early Jurassic Talkeetna oceanic arc, which is now preserved in the Peninsular terrane east of Pebble (Figure 7.2-1). Several foreland sedimentary basins dominated by Jurassic to Cretaceous flysch, including the Kahiltna basin that hosts the Pebble deposit (Kalbas et al., 2007), formed between Wrangellia and pericratonic terranes and previously amalgamated allochthonous terranes of the Intermontane belt (Wallace et al., 1989; McClelland et al., 1992). Basin closure occurred as Wrangellia accreted to North America by the late Early Cretaceous (Detterman and Reed, 1980; Hampton et al., 2010). Between approximately 115 to 110 Ma and 97 to 90 Ma, the strata in the foreland basins were folded, complexly faulted and subjected to low-grade regional metamorphism (Bouley et al., 1995; Goldfarb et al., 2013). Intrusions at Pebble are undeformed (Goldfarb et al., 2013) and were probably emplaced during a period when at least local extension occurred across southwest Alaska in the mid-Cretaceous (e.g. Pavlis et al., 1993). The relative importance of extensional versus compressional structures to the formation of the Pebble deposit is not well constrained, although a syn-hydrothermal compressional fault has been recognized within the deposit.

Since the early Late Cretaceous, deformation in southwest Alaska has occurred mostly on major dextral strike-slip faults, broadly parallel to the continental margin (Figure 7.2-1). The major Denali fault in central Alaska forms the contact between the Intermontane Belt and the collapsed flysch basins. Smaller, subparallel faults are located south of the Denali fault, and the Pebble district is located between what are probably terminal strands of the Lake Clark fault zone (Figure 7.2-1; Shah et al., 2009). The Lake Clark fault zone marks the poorly defined boundary between the Peninsular terrane to the southeast and the Kahiltna terrane, which hosts Pebble, to the northwest (Figure 7.2-1). Haeussler and Saltus (2005) propose about 16.1 miles of dextral offset along the Lake Clark fault zone, most of which is interpreted to have occurred prior to approximately 38 to 36 million years ago. Recent field studies of geomorphology along the Lake Clark fault indicate that this structure has not experienced seismic activity for at least the last 10,000 years (Haeussler and Saltus, 2005, 2011; Koehler, 2010; Koehler and Reger, 2011). Other sub-parallel strike-slip faults also form terrane boundaries in the region, including the Mulchatna and Bruin Bay faults (Figure 7.2-1). Goldfarb et al. (2013) propose that most or all movement on these smaller structures occurred during oroclinal bending in the Tertiary, after formation of the Pebble deposit.

The initiation of magmatism and metallogenesis in the Pebble district approximately coincides with the onset of dextral transpression during basin collapse (Goldfarb et al., 2013). Alkalic to subalkalic intrusions were emplaced between approximately 100 and 88 Ma (Bouley et al., 1995; Amato et al., 2007; Hart et al., 2010; Lang et al., 2013). Alaska-type ultramafic complexes were emplaced at Kemuk, which is enriched in platinum group elements (Iriondo et al., 2003; Foley et al., 1997), and a mineralogically similar alkalic ultramafic body, albeit probably emplaced at shallow depths and without known enrichment in platinum group elements, occurs at Pebble (Bouley et al., 1995). Porphyry Cu-Mo±Au mineralization is associated dominantly with subalkalic, felsic to intermediate intrusions formed between 97 and 90 Ma, and includes deposits at Pebble, Neacola (Reed and Lanphere, 1973; Young et al., 1997; Figure 7.2-1) and possibly the undated Iliamna prospect (Figure 7.2-1). Late Cretaceous intermediate to felsic intrusions are subalkalic and were emplaced between 75 and 60 Ma (e.g., Couture and Siddorn, 2007; Goldfarb et al., 2013). Porphyry Cu-Au±Mo and/or reduced intrusion-related gold mineralization associated with these rocks formed at the Whistler deposit (reported in Couture and Siddorn, 2007), located about 93.2 miles northeast of Pebble, at Kijik River, the Bonanza Hills (Anderson et al., 2013) and Shotgun (Rombach and Newberry, 2001; Figure 7.2-1). Late Cretaceous to Tertiary intrusions and voluminous volcanic rocks cover much of the Kahiltna terrane and are associated with epithermal precious metal mineralization (Bundtzen and Miller, 1997). Igneous rocks of the mid-Cretaceous, Late Cretaceous, and Eocene magmatic suites are present within the Pebble district.

7.2 PROPERTY GEOLOGY

7.2.1 Kahiltna Flysch

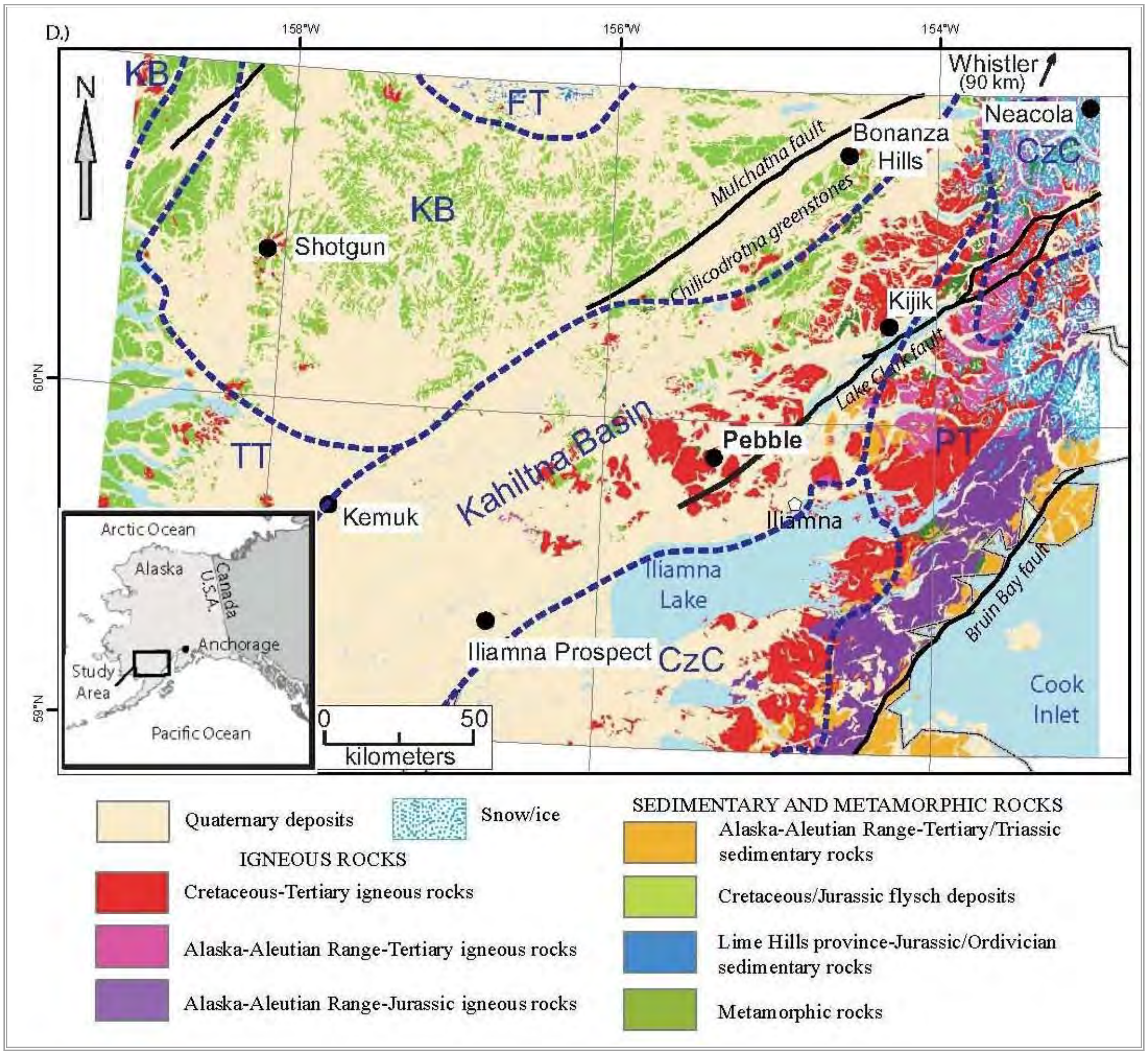
The oldest rock type in the Pebble district is the Kahiltna flysch, which comprises basinal turbidites, interbedded basalt flows and lesser breccias, and minor gabbroid intrusions. The Kahiltna flysch forms a northeast-trending belt about 250 miles long, which has experienced multiple stages of igneous and hydrothermal activity (Figure 7.2-1; Goldfarb, 1997; Young et al., 1997). The flysch in the vicinity of Pebble is at least 99 to 96 million years old, based on the maximum age of cross-cutting intrusions. Sediments were predominately derived from intermediate igneous source rocks and consist of siltstone, mudstone, subordinate wacke and rare, thin, lensoidal beds of matrix-supported pebble conglomerate (Figure 7.2-2A). Bedding ranges from laminar to thick and is commonly poorly defined. Bouma sequences (Bouley et al., 1995), graded beds and load casts demonstrate that the stratigraphy is normal-facing.

The flysch locally contains thick layers of basalt flows, lesser breccias and minor mafic volcaniclastic rocks located mostly in the southwest and northern parts of the district. Undated gabbros cut the flysch and volcanic rocks in several areas and are interpreted to be related either to the basaltic volcanic rocks within the flysch or to younger diorite sills.

7.2.2 Diorite and Granodiorite Sills

Diorite and granodiorite sills intruded the Kahiltna flysch at about 96 Ma (Figure 7.2-1). These two rock types are interpreted to be approximately coeval, based on the similarity in their distribution and style of occurrence; they are only well documented within the Pebble deposit.

Figure 7.2-1 **Location of the Pebble Deposit & Regional Geological Setting of Southwest Alaska**



Note: Modified slightly from Anderson et al., 2013. Dashed lines separate terranes: KB=Kuskokwim Basin; TT=Togiak Terrane; PT=Peninsular Terrane; FT=Farewell Terrane; CzC=Cenozoic cover. Filled circles are the locations of mineral deposits discussed in this text. Major dextral strike-slip faults are indicated by solid lines.

Diorite sills are laterally extensive and range from less than 10 ft to greater than 300 ft in thickness. They are most common as stacked sheets in the western part of the Pebble deposit. The sills are medium-grained and weakly porphyritic, with common plagioclase and hornblende and minor pyroxene set in a very fine-grained groundmass of plagioclase and hornblende (Figure 7.2-2B).

Three laterally continuous granodiorite sills occur within the Pebble deposit. They are up to 1,000 ft thick, with the thickest portions in the northeast part of the deposit. The sills range from fine- to medium-grained, with common plagioclase and hornblende as well as minor amounts of apatite, in a very fine-grained groundmass of potassium feldspar and quartz with minor to accessory magnetite, apatite and zircon (Figure 7.2-2C).

7.2.3 Alkalic Intrusions and Associated Breccias

A complex suite of alkalic porphyry intrusions (including quartz-free biotite pyroxenite, syenomonzonite, monzonite and monzodiorite) and associated breccias extends south from the southwest quadrant of the Pebble deposit (Schrader, 2001; Hart et al., 2010; Goldfarb et al., 2013). Isotopic dates on diorite and granodiorite sills, biotite pyroxenite and alkalic intrusions indicate that they are approximately coeval and were emplaced between 99 and 96 Ma (Schrader, 2001). Early intrusions are medium-grained, biotite monzonite porphyries (Figure 7.2-2D) that commonly contain scattered potassium feldspar megacrysts up to several centimetres in size. Later intrusions are fine-grained porphyritic biotite monzodiorite (Figure 7.2-2E). All intrusive phases contain angular to subrounded xenoliths of flysch, diorite and, in the younger monzodiorite phase, xenoliths of older alkalic intrusions. Many of the intrusions grade into breccias.

Breccias in the alkalic complex are complicated. Subordinate intrusion breccias have angular to subangular fragments in a cement of the later porphyritic biotite monzodiorite intrusion. Fragments of diorite sills, early alkalic biotite monzonite porphyry intrusions and flysch are most common. The breccia matrix dominantly consists of a rock flour composed of subangular to subrounded fragments of these same rock types (Figure 7.2-2F). Hydrothermal cement is absent, and fragments range from a few millimetres to tens of metres in size. Locally, intersections of diorite and granodiorite sills within the breccia bodies may correlate laterally with undisturbed sills. Due to the internal complexity of the alkalic rocks within the deposit, the complex is modeled as a single unit, loosely interpreted as a megabreccia.

7.2.4 Hornblende Granodiorite Porphyry Intrusions

Granodiorite intrusions include the Kaskanak batholith and numerous smaller bodies, mostly within or proximal to zones of porphyry-style mineralization around the margins of the batholith. All isotopic dates on these rocks are approximately 90 Ma (Bouley et al., 1995; Lang et al., 2013). The Kaskanak batholith is dominantly a medium-grained hornblende granodiorite porphyry, with minor equigranular hornblende quartz monzonite. Granodiorite intrusions spatially associated with porphyry-style mineralization throughout the Pebble district are all mineralogically and texturally similar to the main phase of the Kaskanak batholith (Figure 7.2-2G). All of these intrusions are characterized by common hornblende, plagioclase and minor quartz and titanite, set in a fine-grained groundmass of quartz, plagioclase, potassium feldspar, apatite, zircon and magnetite. Megacrysts of potassium feldspar are up to 0.6 in in size, increase in both size and concentration with depth (from less than 2% to greater than 5%) and poikilitically enclose plagioclase and hornblende phenocrysts.

7.2.5 Volcanic-Sedimentary cover sequence

Cretaceous rock types 90 Ma or older are unconformably overlain by well-bedded sedimentary and volcanic rocks (Figure 7.2-2H), informally called the cover sequence. The cover sequence is up to 2,200 ft thick over the eastern edge of the Pebble deposit, and basalt flows with lesser interbeds of clastic sedimentary rocks are up to 6,400 ft thick within the East Graben. The sequence occurs mostly on, and thickens toward, the east side of the district, with additional exposures overlying and to the west and south of the Kaskanak batholith. Sedimentary rock types are normal-facing but have been tilted about 20° east, and include pebble to boulder conglomerate, wacke, siltstone and mudstone. Plant fossils are common in wacke, and coal-bearing seams up to approximately 1.5 ft thick have been intersected by drilling. Volcanic to sub-volcanic rocks include basalt flows and mafic dykes and sills. Volcaniclastic rocks are abundant and contain angular fragments ranging from basalt to rhyolite within a matrix of comminuted volcanic material. The cover sequence is cut by minor narrow, dykes and sills of felsic to intermediate composition, as well as by 65 Ma hornblende monzonite porphyry intrusions (Lang et al., 2013).

7.2.6 Hornblende Monzonite Porphyry Intrusions

Two porphyry intrusions of hornblende monzonite, up to 820 ft thick, cut basalts within the East Graben and have been dated at 65 Ma (Lang et al., 2013). They are medium-grained and porphyritic, with common plagioclase and lesser hornblende set in a fine-grained groundmass of potassium feldspar, plagioclase and minor magnetite. These intrusions are not hydrothermally altered.

7.2.7 Eocene Volcanic Rocks and Intrusions

Volcanic and sub-volcanic intrusive rocks on the east side of the district are dated at 46 to 48 Ma (Bouley et al., 1995; Lang et al., 2013). These rocks are mostly exposed on Koktuli Mountain east of the deposit, and limited drill intersections suggest they may be common in the southeast part of the district below glacial cover. Rock types include felsic dykes, brecciated rhyolite flows, fine-grained, equigranular to porphyritic biotite-bearing hornblende latite intrusions and coarse-grained hornblende monzonite porphyry.

7.2.8 Glacial Sediments

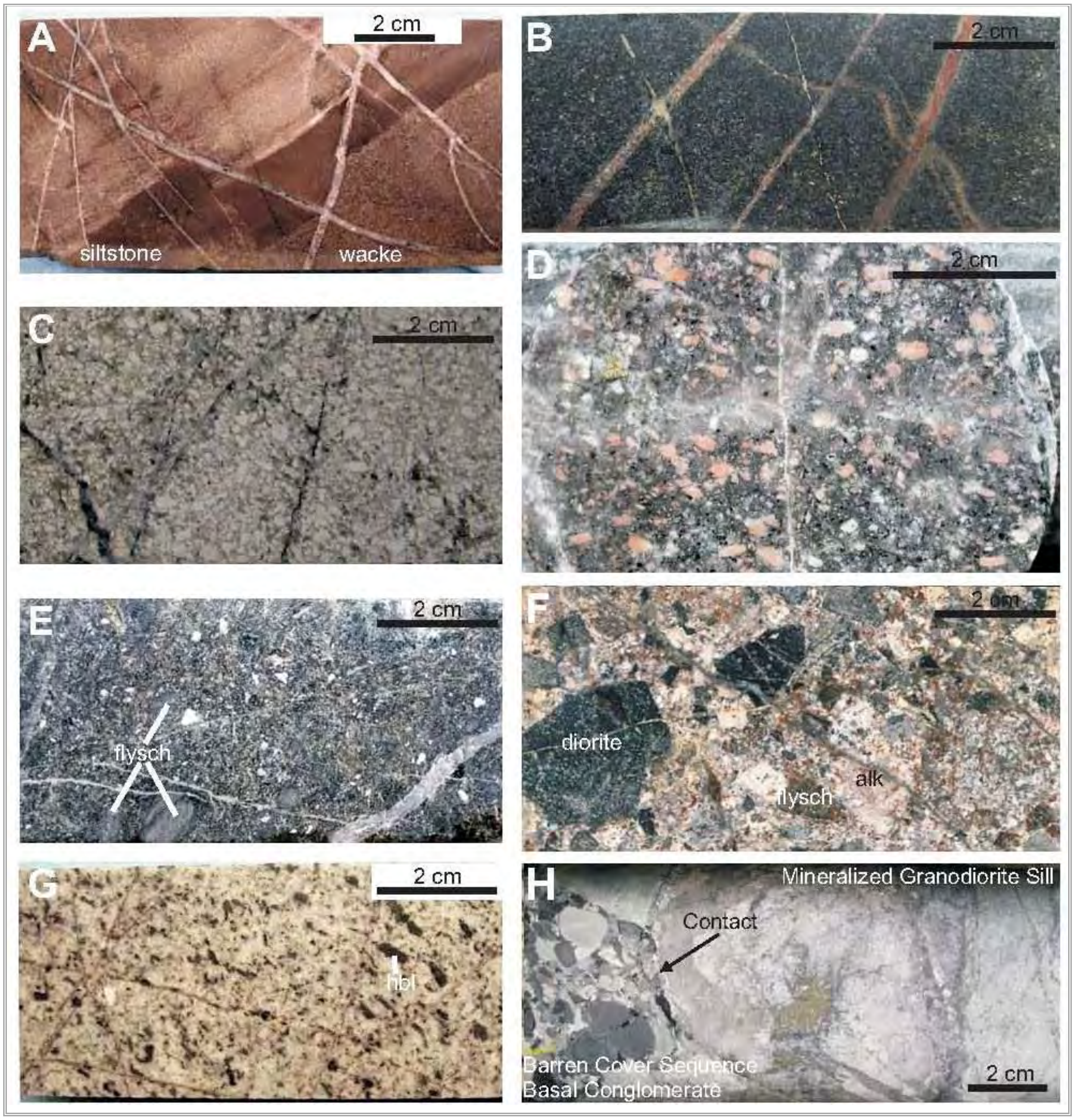
Unconsolidated glacial sediments of Pleistocene to recent age cover all but the tops of the highest hills (Detterman and Reed, 1973; Hamilton and Klieforth, 2010). The sediments are typically less than 100 ft thick, but drill intersections range up to 525 ft in the wide valley in the southeast part of the district. Ice flow directions over the deposit were to the south-southwest, and the glaciers had retreated by about 11 Ka (Detterman and Reed, 1973; Hamilton and Klieforth, 2010).

7.2.9 District Structure

The structural history of the district outside of the Pebble deposit is poorly understood due to a paucity of outcrop and marker horizons. The Kahiltna flysch exhibits shallow to moderate dips to the east, south and southeast, which may reflect doming around the margins of the Kaskanak batholith. Folds in the flysch are open, and most inter-limb angles are less than 20°. Folding and related deformation predate hydrothermal activity at Pebble (Bouley et al., 1995; Goldfarb et al., 2013).

Faults are abundant throughout the Pebble district. The significant northeast-trending, syn-hydrothermal brittle-ductile fault zone (BDF) is described later in this section. Most faults are brittle normal or normal-oblique structures that cut all rock types in the district and, in many cases, have been inferred from discontinuities in airborne magnetic and electromagnetic data. The most prominent faults strike north-northeast and northwest, with fewer striking east. The most important of these faults bound the northeast-trending East Graben, which down-drops high-grade mineralization on the east side of the Pebble deposit. Brittle faults cut Eocene rock types, but precursor structures may have been periodically active since the mid-Cretaceous (L. Rankin, pers. comm., 2011). There is no geological evidence to suggest that these faults have been recently active.

Figure 7.2-2 Rock Types in the Pebble District



Notes:
A: Kahiltna flysch with interbedded siltstone and wacke affected by biotite-rich potassic alteration.
B: Diorite sill cut by magnetite-rich veins with intense biotite-rich potassic alteration.
C: Granodiorite sill with crowded porphyritic texture and pervasive potassic alteration.
D: Biotite monzonite porphyry member of the alkalic suite.
E: Late biotite monzodiorite porphyry member of the alkalic suite with angular xenoliths of flysch.
F: Diatreme breccia from the alkalic suite with polylithic fragments in a matrix of rock flour.
G: Pebble East zone granodiorite porphyry pluton with relict hornblende phenocrysts selectively altered to biotite.
H: Sharp contact between mineralized granodiorite sill and overlying basal conglomerate of the cover sequence at the top of the Pebble East zone.

7.3 DEPOSIT GEOLOGY

The characteristics of the Pebble deposit are shown in plan view in Figure 7.3-1 and Figure 7.3-2, and in cross-section in Figure 7.3-3 to Figure 7.3-5. Geological interpretation of the Pebble deposit is based almost entirely on diamond drill intersections.

7.3.1 Rock Types

The deposit is hosted by Kahiltna flysch, diorite and granodiorite sills, alkalic intrusions and breccias, and granodiorite stocks (Figure 7.3-1 and Figure 7.3-3). Within the deposit, the Kahiltna flysch is a well-bedded siltstone with less than 10% coarser-grained, more massive wacke interbeds; basalt and gabbro are absent. Bedding within the flysch typically dips less than 25° to the east. The flysch was intruded by diorite sills, granodiorite sills and rocks of the alkalic suite prior to hydrothermal activity. The diorite sills are found only in the western half of the deposit (Figure 7.3-3), whereas some granodiorite sills extend across the entire deposit. Intrusions and breccias of the alkalic suite occupy the southwest quadrant of the deposit (Figure 7.3-1).

The deposit is centered on a group of five hornblende granodiorite porphyry intrusions, including the larger Pebble East zone pluton and four smaller bodies in the Pebble West zone. The north contact of the Pebble East zone pluton is close to vertical, and its upper contact dips shallowly to the west; it remains undelineated to the south, and has been dropped into the East Graben by the ZG1 fault. Contacts of stocks in the Pebble West zone dip steeply to moderately outward. Recent deep drilling suggests that the granodiorite intrusions coalesce at depths greater than 3,280 ft. Dykes and sills of hornblende granodiorite porphyry are uncommon and are found mostly in host rocks above and adjacent to the Pebble East zone pluton.

The Pebble East zone is entirely concealed by the east-thickening cover sequence. The contact between the flysch and the cover sequence ranges from sharp and undisturbed to structurally disrupted with slippage along the contact. The lower half of the sequence comprises a thick basal conglomerate with well-rounded cobbles and boulders of intrusive and volcanic rock types of unknown provenance, overlain by complex, interlayered, discontinuous lenses of pebble conglomerate, wacke, siltstone, and mudstone. The upper half of the sequence comprises volcanic and volcaniclastic rocks (Figure 7.3-3) dominated by basalt or andesite and intruded by minor felsic to intermediate sills. The cover sequence within the East Graben ranges from approximately 4,265 ft thick north of the ZE fault to a thickness of up to 6,400 ft to the south. The graben is filled by basalt flows and lesser sedimentary rocks.

Eocene rocks are rare within and proximal to the Pebble deposit. Where thus far encountered, they comprise narrow felsic dykes, a pink hornblende monzonite intrusion intersected at depth in the central part of the East Graben, and a rhyolite flow breccia at the top of the East Graben, south of the ZE fault.

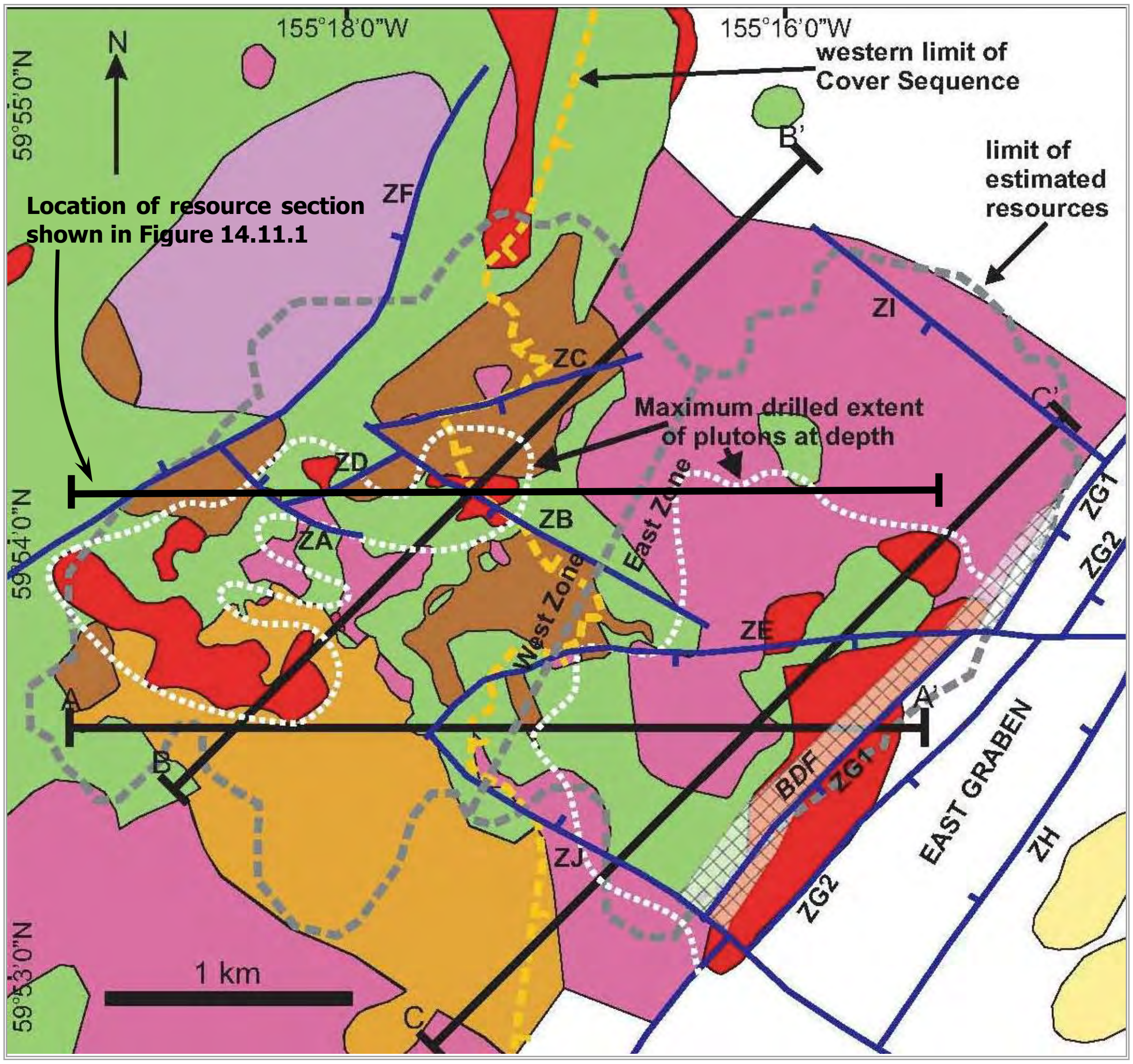
7.3.2 Structure

Within the western part of the Pebble deposit, the Kahiltna flysch occurs as an open, M-shaped anticline with axes that plunge shallowly to the east-southeast (Rebagliati and Payne, 2006). Diorite sills are commonly thicker near the hinges of the folds. Folding did not affect the cover sequence.

A brittle-ductile fault zone (BDF) has been identified on the east side of the Pebble deposit (Figure 7.3-1) where it manifests a zone of deformation defined by distributed cataclastic seams and healed breccias. It strikes north-northeast, extends at least 1.86 miles along strike, is up to 650 ft wide and is vertical to steeply west-dipping. The BDF is truncated on the east by the ZG1 fault (Figure 7.3-3) and does not penetrate the cover sequence. Displacement appears to have been dextral-oblique/reverse (S. Goodman, pers. comm., 2008), and correlation of alteration domains across the fault limits post-hydrothermal lateral displacement to less than 1,310 ft. The BDF was active before, during and after hydrothermal activity. Deformation is most intense in flysch north of the Pebble East Zone pluton but is weaker within the intrusion, suggesting that the BDF was more active before or during emplacement of the stock. Syn-hydrothermal control on mineralization by the BDF is indicated by the much higher grades of copper and gold and higher vein density within the structural zone compared to adjacent, undeformed host rocks. The characteristics of deformation along the BDF, and its timing relative to hydrothermal activity at Pebble, support at least a local compressional to transpressional environment during the formation of the deposit. Local deformation of veins indicates some post-hydrothermal movement.

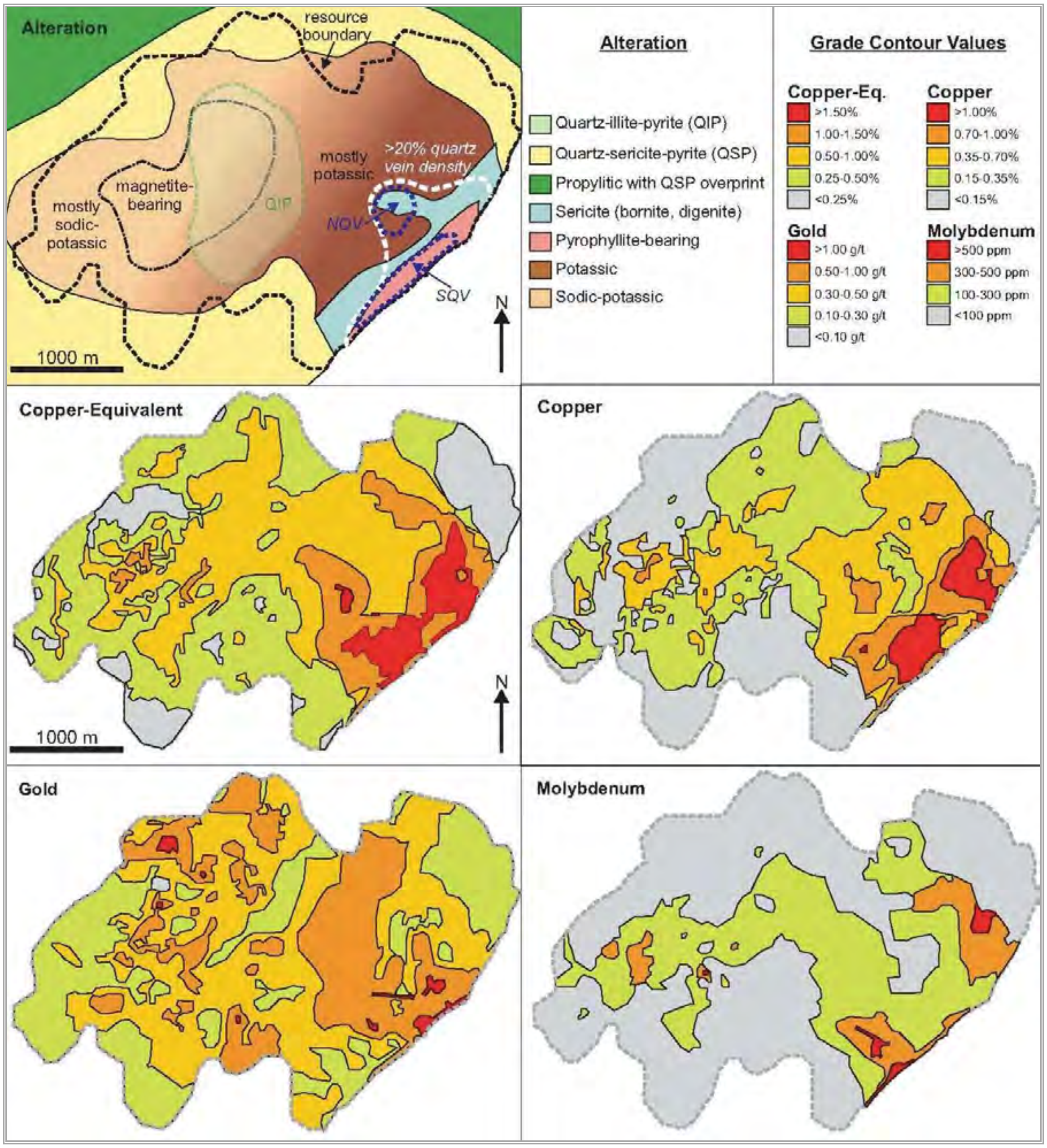
Brittle faults within the Pebble deposit conform to the district-scale patterns described above (Figure 7.3-1). The ZB, ZC and ZD faults occur in the Pebble West zone and exhibit normal offset of diorite and granodiorite sills of between 50 ft and 300 ft. Normal displacement on the ZJ and ZI faults is not well constrained. The ZA fault has about 100 ft of apparent reverse movement. A minimum of 820 ft of normal displacement occurred across the steeply west-dipping ZF fault, juxtaposing mineralized sodic-potassic alteration in the east against poorly mineralized, propylitic and quartz-sericite-pyrite alteration to the west. Displacement on the ZE fault increases from around 100 ft on its western end to about 980 ft on the east side of the deposit. The ZG1 fault forms the western boundary of the East Graben and has well-defined normal displacement of approximately 2,100 ft in the north and 2,900 ft in the south, based on offset of the contact between the deposit and the cover sequence (Figure 7.3-3). The ZG2 fault, which is parallel to the ZG1 fault, has between 880 ft and 1,800 ft of normal displacement. The ZH fault and possible parallel structures farther east mark the eastern margin of the East Graben. Many of these brittle faults localized intermediate to mafic dykes and a date of 84 Ma for an andesite dyke by Schrader (2001) indicates that brittle faults remained active until at least that time.

Figure 7.3-1 Geology of the Pebble Deposit Showing Section Locations



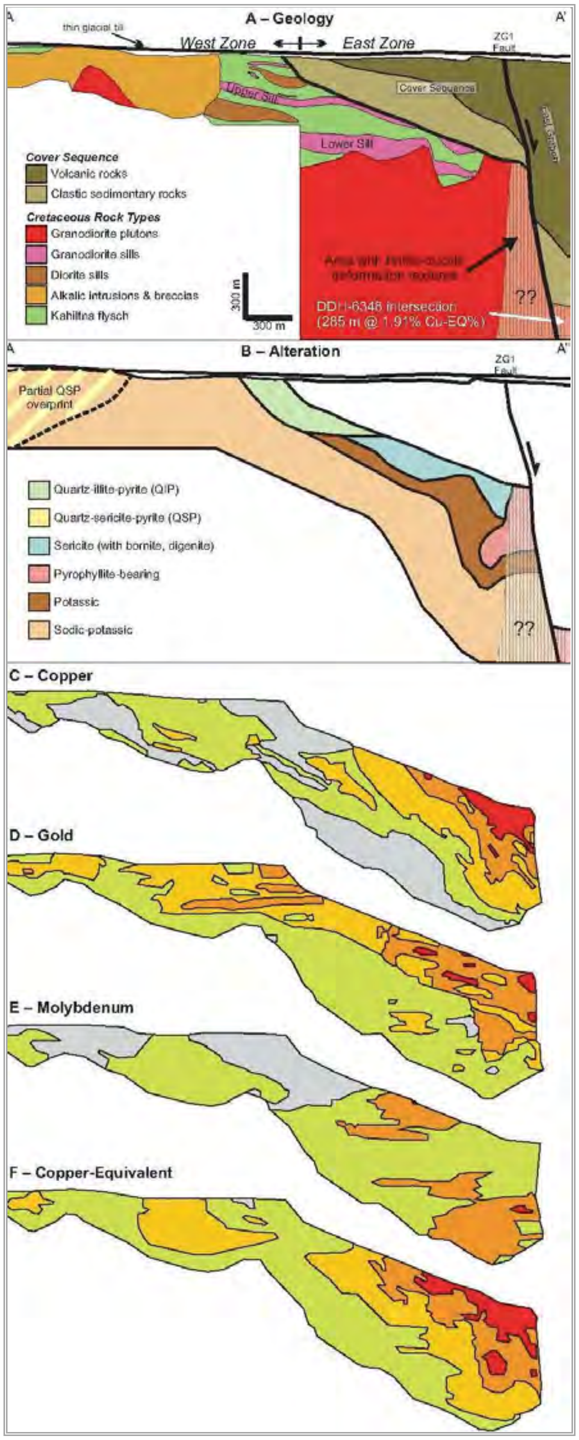
Note: The late Cretaceous cover sequence occurs to the east of the dark yellow line and has been removed for clarity.
Cross-sections A-A’, B-B’ and C-C’ are shown in Figure 7.3-3, Figure 7.3-4 and Figure 7.3-5, respectively.
The brittle-ductile fault zone (BDF) is indicated by the cross-hatched pattern.
The dashed outline of the estimated resources at a 0.3% CuEq cut-off is used as a reference point for alteration and grade distribution in Figure 7.3-5.
White areas are either undrilled or rock types below cover sequence unknown.
See Figure 7.3.3 for geology legend.

Figure 7.3-2 **Plan View of Alteration and Metal Distribution in the Pebble Deposit**



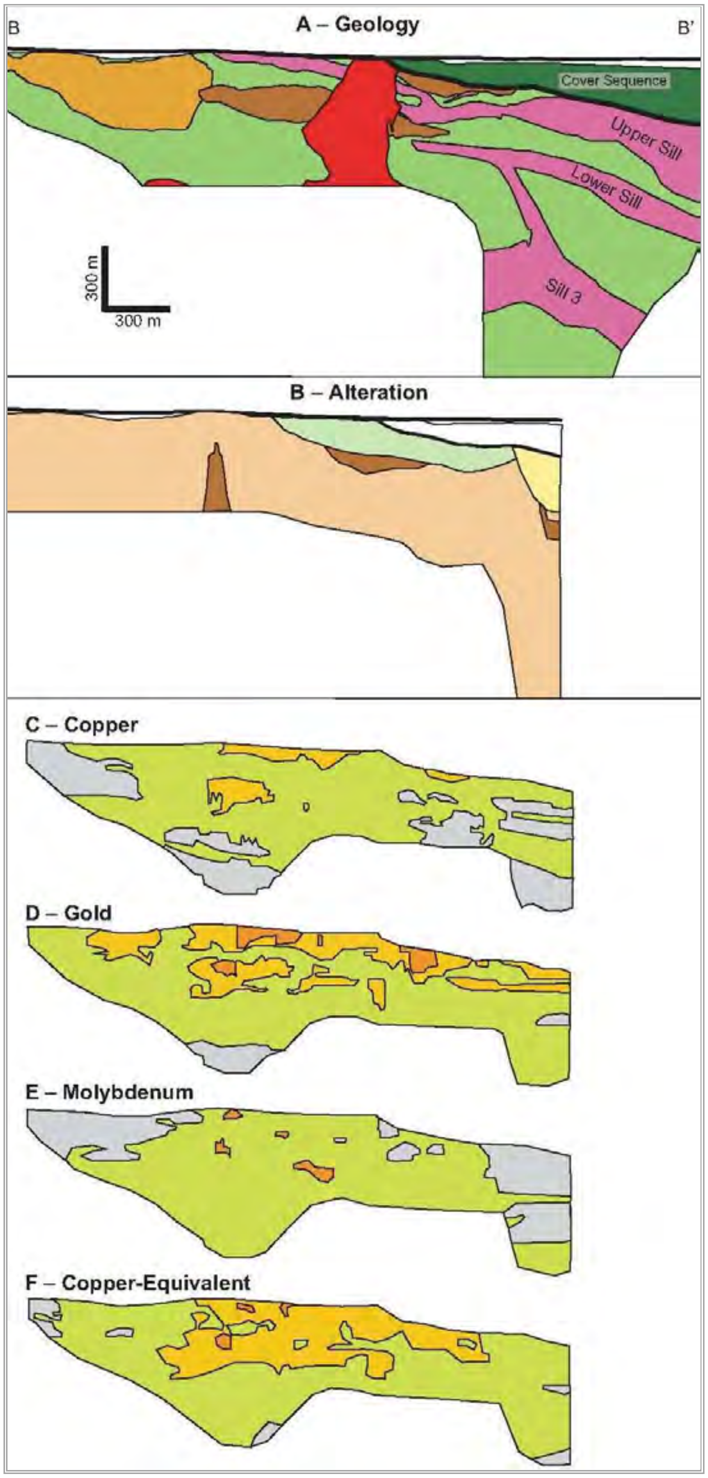
Note: Grades are shown as they appear in a previously completed resource block model (Gaunt et al., 2010), at the contact between the deposit and the overlying cover sequence, which has been removed. These grades are not derived from the current resource estimate.
For geological reference, the resource outline matches that shown in Figure 7.3-1.
A simplified distribution of alteration types is shown on the map at upper left.
NQV and SQV are the northern and southern quartz vein domains (>50% quartz veins).

Figure 7.3-3 Geology, Alteration and Distribution of Metals on Section A-A’



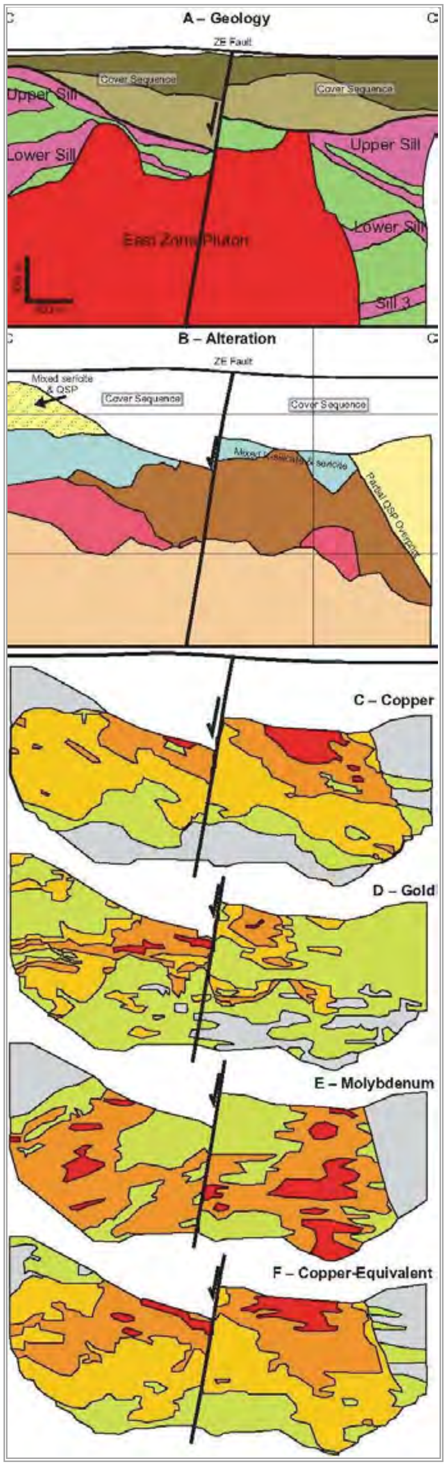
Note: Location of section is shown in Figure 7.3-1, and grade legends in Figure 7.3-2.

Figure 7.3-4 Geology, Alteration and Metal Distribution on Section B-B’



Note: Location of section is shown in Figure 7.3-1, and legend for grade ranges and alteration in Figure 7.3-2.

Figure 7.3-5 Geology, Alteration and Metal Distribution on Section C-C’



Note: Location of section is shown in Figure 7.3-1, and legend for grade ranges and alteration in Figure 7.3-2.

7.4 DEPOSIT ALTERATION STYLES

Alteration styles are summarized below in the order of their interpreted relative ages.

7.4.1 Pre-hydrothermal Hornfels

Hornfels related to intrusion of the Kaskanak batholith pre-dates hydrothermal activity and is found in all Cretaceous rock types, except granodiorite plutons. The hornfels aureole to the batholith is narrow south of Pebble but extends well east of the batholith in the vicinity of the deposit, which suggests that the batholith underlies the deposit (which is supported by magnetic data; Shah et al., 2009; Anderson et al, 2013). Hornfels-altered rocks are massive and susceptible to brittle fracture, although the narrow alteration envelopes around veins indicate that permeability was low. Hornfels in flysch outside the deposit comprises biotite, K-feldspar, albite, plagioclase and quartz with minor pyrite and other accessory minerals.

7.4.2 Hydrothermal Alteration

Numerous stages of hydrothermal alteration are present, including: potassic, sodic-potassic, illite±kaolinite, pyrophyllite and sericite advanced argillic, quartz-illite-pyrite, propylitic, and quartz-sericite-pyrite assemblages, as well as a variety of vein types. Sericite is defined herein as fine-grained, crystalline white mica, whereas illite is very fine-grained, non-crystalline white mica (Harraden et al., 2013). Advanced argillic alteration follows the naming convention of Meyer and Hemley (1967), although there are some differences noted in Pebble alteration. Most metals were introduced during early potassic and sodic-potassic alteration, with significant enhancement of grade in areas overprinted by younger advanced argillic alteration.

7.4.2.1. EARLY POTASSIC AND SODIC-POTASSIC ALTERATION

Most copper-gold-molybdenum mineralization coincides with early potassic and sodic-potassic alteration. Potassic alteration occurs mostly in the upper part of the Pebble East zone, whereas sodic-potassic alteration occurs in the Pebble West zone and below potassic alteration in the Pebble East zone. Sodic-potassic alteration is distinguished from potassic primarily by the presence of albite and a higher concentration of carbonate minerals (Gregory and Lang, 2011, 2012). Associated vein types are described below.

Potassic alteration occurs in all rock types and is most intense in flysch and granodiorite sills near the Pebble East zone pluton, within the Pebble East zone pluton and in small areas of the Pebble West zone (Gregory and Lang, 2009). It is weakest in the area between the Pebble East and Pebble West zone centers. The assemblage includes potassium feldspar, quartz (both replacing igneous groundmass and locally plagioclase phenocrysts), and biotite (replacing igneous hornblende and biotite) with trace to minor ankerite or ferroan dolomite, apatite and rutile. Sulphides include disseminated chalcopyrite and pyrite with minor molybdenite and bornite (Gregory and Lang, 2009). The proportion of biotite to potassium feldspar correlates with the Fe-Mg concentration of host rocks and is highest in flysch and diorite sills.

Intrusive rocks in the Pebble West zone are affected by early sodic-potassic alteration which comprises albite (replacing plagioclase phenocrysts), biotite (replacing igneous biotite and hornblende), potassium feldspar (replacing groundmass feldspars) and quartz, accompanied by ankerite, ferroan dolomite, trace apatite, magnetite and, locally, siderite. The concentration of carbonate minerals increases with depth. Sulphides include pyrite and chalcopyrite that decrease in concentration with depth. Sodic-potassic alteration of sedimentary rocks is pervasive and characterized by fine-grained potassium feldspar accompanied by minor biotite or by fine-grained potassium feldspar and albite.

In the Pebble East zone, sodic-potassic alteration occurs below potassic alteration and is distinguished from similar alteration of the Pebble West zone by the presence of epidote and calcite. The potassic to sodic-potassic transition occurs over vertical distances of less than 330 ft. In the Pebble East zone pluton, cores and rims of zoned plagioclase phenocrysts are replaced by calcite-epidote and albite, respectively. Hornblende phenocrysts were replaced by biotite and then by chlorite. Hematitized igneous magnetite is also present. The igneous groundmass was replaced by fine-grained quartz, potassium feldspar, and variable albite. Mineralization is weak and decreases with depth, and includes 2% pyrite and trace to minor chalcopyrite and molybdenite. This alteration is pervasive in flysch, is absent in granodiorite sills and is difficult to distinguish from peripheral propylitic alteration.

Potassic alteration overprints sodic-potassic alteration but the two alteration types are interpreted to be coeval and therefore are treated as a single alteration event, with the apparent relative timing a consequence of telescoping and/or changing fluid chemistry during cooling. The paragenetic and spatial relationship between sodic-potassic alteration in the Pebble East and Pebble West zones and peripheral propylitic alteration is not established.

7.4.2.1.1. Vein Types Associated with Early Potassic and Sodic-Potassic Alteration

Four major quartz-sulphide vein types, comprising 80% of all veins in the deposit, are associated with early potassic and sodic-potassic alteration and are classified as types A, B, M and C. Each type includes varieties that broadly correlate with lateral and/or vertical position in the deposit. The naming conventions, while similar to standard porphyry vein nomenclature, are not exact equivalents to vein types described from other deposits (e.g., Gustafson and Hunt, 1975; Clark, 1993; Gustafson and Quiroga, 1995).

Total density of vein types A, B and C across most of the Pebble deposit is between 5 and 15 vol % (using the criteria of Haynes and Titley (1980) and not including alteration envelopes). Lower concentrations occur near the margins of the deposit and at depth below the 0.3% CuEq resource boundary. Higher concentrations occur within or proximal to the Pebble East zone pluton and locally proximal to the smaller granodiorite plutons in the Pebble West zone. Vein density does not correlate consistently with rock type and patterns extend smoothly across geologic contacts. Measurements in oriented drill core do not reveal any preferred vein orientations.

On the east side of the Pebble East zone there are two areas with 50 to 90% quartz veins within a broader zone with greater than 20% quartz veins. These veins are interpreted to belong to the A1 or B1 vein types. These high vein density areas probably reflect repeated refracturing and dilation. The first area is located north of the ZE fault in a broadly cylindrical zone 330 to 1,640 ft wide and extending up to 1,970 ft below the cover sequence. Veins in this first zone are not deformed and controlling faults have not been identified. The second area forms a northeast-trending, nearly vertical, tabular zone that coincides with the extent of brittle-ductile deformation (described above). This second area is truncated to the east by the ZG1 fault, continues into the East Graben and is open below depths of 4,920 ft. Veins in this zone are commonly deformed and locally brecciated and formed along the active BDF or a precursor structure.

Type A Veins

Type A veins are the oldest of the four types and include subtypes A1, A2 and A3. A1 is the most common type and occurs mostly within the upper 2,300 ft of the Pebble East zone pluton. These veins are sinuous to anastomosing, discontinuous, and typically have diffuse contacts. They contain quartz, trace to minor potassium feldspar, less than 1 to 2% pyrite, lesser chalcopyrite, and rare molybdenite. Potassium feldspar alteration envelopes are commonly narrow, diffuse, and a few millimetres wide. They occur within zones of pervasive, weakly mineralized potassic alteration.

A2 veins occur below approximately 3,300 ft in the Pebble East zone pluton and have characteristics transitional between quartz veins and pegmatites. They are characterized by potassium feldspar selvages and coarse-grained cores of euhedral to subhedral quartz. Coarse clots of biotite are locally present along with trace chalcopyrite, molybdenite and/or pyrite. The A2 veins are sinuous, discontinuous, irregular, have diffuse contacts and lack alteration envelopes.

A3 veins are transitional between vein types A1 and B1 and are most common below 2,500 ft in the Pebble East zone pluton. The A3 veins are typically anastomosing, less than 0.4 in wide, sinuous to irregular and have diffuse contacts with prominent potassium feldspar envelopes. They contain quartz with trace to minor potassium feldspar and biotite, and locally contain up to 3% pyrite, minor chalcopyrite and rare molybdenite.

Type B Veins

Type B veins cut type A veins and include subtypes B1, B2 and B3. These are spatially coincident with potassic and sodic-potassic alteration, are the most widespread veins at Pebble and are most abundant within and proximal to the Pebble East zone pluton.

B1 veins are the most common subtype and are planar, continuous, have sharp contacts, and are typically 0.1 to 1.2 in wide. They are dominated by quartz with trace to minor biotite, potassium feldspar, apatite and/or rutile. The veins typically comprise 2 to 5% pyrite and chalcopyrite with minor molybdenite and local bornite. Potassium feldspar (±biotite) alteration envelopes are ubiquitous, highly variable in width and contain disseminated chalcopyrite, pyrite and molybdenite.

B2 veins occur below 2,600 ft in the Pebble East zone and broadly coincide with sodic-potassic alteration. They contain quartz and minor K-feldspar and have narrow, weak potassium feldspar or biotite alteration envelopes. B2 veins transition upward into B1 veins and are distinguished from B1 veins by green chlorite pseudomorphs after coarse aggregates of locally preserved biotite and by minor calcite and epidote. The veins typically contain less than 2% pyrite, minor chalcopyrite, and minor molybdenite.

B3 veins are most common in the north-central and south-central part of the Pebble East zone as well as at depths below 5,600 ft in the lower grade domain between the Pebble East and Pebble West zones. These veins are similar to B1 veins but contain molybdenite as the dominant sulphide and have only sporadic, weak, potassium feldspar alteration envelopes. B3 veins are planar and can be greater than 3.3 ft in width. B3 veins cut vein types A, B1 and B2 and, locally, C veins; B3 veins are interpreted to represent a late substage of early alteration which locally introduced significant molybdenum to the Pebble deposit.

Type M Veins

Type M veins are associated with magnetite-bearing sodic-potassic alteration within and proximal to diorite sills in the Pebble West zone. Paragenetically they formed between vein types B1 and C. They are planar to irregular and are typically 0.4 to 2 in wide. These veins comprise mostly magnetite and quartz with lesser ankerite and potassium feldspar as well as greater than 10% chalcopyrite and pyrite with minor molybdenite. The M veins have narrow potassium feldspar alteration envelopes.

Type C Veins

Type C veins are the most abundant veins in the deposit, with the exception of the Pebble East zone pluton. C veins cut A and B veins (except possibly the B3 subtype), and are contemporaneous with or slightly younger than M veins. C veins at Pebble are defined according to their relative timing and do not resemble the C veins defined by Gustafson and Quiroga (1995). The veins contain mostly quartz, locally abundant ankerite or ferroan dolomite, minor to trace potassium feldspar, magnetite and biotite, and 10% (locally up to 50%) sulphides. Sulphides include pyrite and chalcopyrite, variable molybdenite, trace arsenopyrite and rare bornite. The veins are planar, have sharp contacts, range from less than 0.4 in to approximately 2 in wide and commonly contain vugs along their central axis. Alteration envelopes are prominent with similar mineralogy to the veins and can be up to 10 times the width of the vein in the more permeable intrusive host rocks. Where the alteration envelopes to several C veins overlap, drill intersections up to approximately 15 ft in length can grade up to several percent copper.

7.4.2.2. INTERMEDIATE ILLITE ± KAOLINITE ALTERATION

Illite ± kaolinite alteration is coincident with and overprints early potassic and sodic-potassic alteration. Alteration intensity is highest at moderate depths within the Pebble East zone pluton. In these rocks, illite replaces phenocrysts of plagioclase altered to potassium feldspar and locally replaces the potassically-altered igneous matrix. This alteration style is weakest in flysch in the Pebble West zone. Minor pyrite co-precipitated with illite. Fracture or fault control is rarely apparent. Kaolinite accompanies illite in alteration of previously sodic-potassic altered areas where it replaces albite.

7.4.2.3. LATE ADVANCED ARGILLIC ALTERATION

Advanced argillic alteration occurs only in the East Zone, where it is associated with the highest grades of copper and gold in the deposit. Advanced argillic alteration is focused along and adjacent to the BDF. This alteration comprises a pyrophyllite-quartz-sericite-chalcopyrite-pyrite zone along the BDF bounded by an upwardly-flaring envelope of sericite-quartz-pyrite-bornite-digenite-chalcopyrite alteration to the west (cf., Khashgerel et al., 2009). Advanced argillic alteration is truncated on the east by the ZG1 fault but continues into the graben. Both sericite and pyrophyllite-bearing alteration replace previous alteration type; the sericite alteration is locally replaced by younger quartz-sericite-pyrite alteration.

Pyrophyllite alteration is accompanied by quartz, sericite, pyrite and chalcopyrite. Pyrite concentration is commonly greater than 5% and is much higher than in adjacent early potassic alteration. Pyrophyllite alteration is coincident with but overprints the southern zone of high quartz vein density, where quartz-sulphide veins within the BDF are commonly deformed. Veins associated with pyrophyllite alteration are irregular, narrow, massive to semi-massive, contain pyrite ± chalcopyrite with variable quartz, and lack alteration envelopes. Pyrophyllite alteration has not been identified in the northern zone of high quartz vein density.

Pervasive sericite alteration forms an upward-flaring envelope west of the pyrophyllite alteration. Sericite alteration occurs in the upper 1,000 ft of the deposit on the downthrown southern side of the ZE fault. This alteration is pervasive and dominated by white sericite that replaces feldspars previously affected by potassic and illite alteration. Pyrite concentration is intermediate between pyrophyllite alteration and early potassic alteration and decreases with depth. Sericite alteration is distinguished by high-sulphidation hypogene copper minerals represented by various combinations of bornite, covellite, digenite, tennanite-tetrahedrite, and locally trace enargite. These minerals commonly replace the rims of chalcopyrite and pyrite precipitated during early potassic alteration. Minor quartz-rich veins with pyrite are related to this alteration, are narrow and irregular, and locally have well-developed envelopes with quartz, sericite, pyrite and high sulphidation copper minerals.

7.4.2.4. PROPYLITIC ALTERATION

Propylitic alteration extends at least 3 miles south of the deposit and to the limit of drilling 1.4 miles to the north. Weak propylitic alteration occurs throughout the eastern half of the Kaskanak batholith. This alteration comprises chlorite, epidote, calcite, quartz, magnetite and pyrite, minor albite and hematite, and trace chalcopyrite. Sulphide concentration is less than 3% and is mostly pyrite.

Type H veins occur locally, in low density, throughout propylitic alteration and contain calcite, hematized magnetite, quartz, albite, epidote, pyrite and trace to minor chalcopyrite. H veins are planar, less than 0.4 in (1 cm) wide and have alteration envelopes similar in mineralogy and width to the veins.

Polymetallic type E veins occur locally south of the deposit, in areas of propylitic and quartz-sericite-pyrite (QSP) alteration. Rarely, E veins cut sodic-potassic alteration in the Pebble West zone. E veins are planar, up to tens of centimetres in width, have sharp contacts with host rocks and locally have weak sericite alteration envelopes. These veins contain quartz, calcite, pyrite (locally arsenian), sericite, sphalerite, galena, minor chalcopyrite and trace arsenopyrite, tennantite-tetrahedrite, freibergite, argentite and native gold.

7.4.2.5. QUARTZ-SERICITE-PYRITE AND QUARTZ-ILLITE-PYRITE ALTERATION

Although QSP alteration occurs closer to the centre of the deposit than propylitic alteration, where these alteration styles overlap QSP overprints propylitic alteration. QSP alteration (equivalent to classic 'phyllic' alteration) is texture-destructive and forms a halo around the deposit with alteration fronts that dip steeply outward. This halo extends at least 2.6 miles south of the deposit and 0.9 miles north; it is weakly developed west of the ZF fault where it partially overprints propylitic alteration. It occurs at depth in the north part of the East Graben but its full distribution east of the ZG1 fault is not established. In the Pebble East zone, the transition to intense, pervasive QSP alteration typically occurs over 50 to 60 ft. Weak QSP alteration occurs sporadically throughout the Pebble West zone with a more gradual transition than in the Pebble East zone.

Mineralogy of QSP alteration includes quartz, sericite, 8 to 20% pyrite, minor to trace ankerite, rutile and apatite, and rare pyrrhotite. Zones are cut by up to 10% pyrite-rich type D veins (Gustafson and Hunt, 1975) with variable amounts of quartz and trace rutile, chalcopyrite and ankerite. D veins are planar, have sharp contacts with host rocks and range from less than 1 in to 5 ft in width. Alteration envelopes are typically wider than the veins and form intense pervasive QSP alteration where they coalesce.

Quartz-illite-pyrite (QIP) alteration partially replaces potassic and/or sodic-potassic alteration in the upper, central part of the deposit. QIP alteration is interpreted as a zone of former weak QSP alteration at the transition between potassic/sodic and potassic alteration, which was later overprinted by low-temperature illite alteration as the hydrothermal system waned. QIP alteration is similar to QSP alteration, with illite as the main phyllosilicate phase (Harraden et al., 2012). Pyrite abundance is typically 5 to 10% in type D veins and associated QIP alteration envelopes. Domains between alteration envelopes are marked by a decrease in the density of D veins and their alteration envelopes.

7.4.3 Post-Hydrothermal Alteration

The youngest alteration at Pebble is clay alteration, which is common within 50 ft of the contact between the cover sequence and Cretaceous rocks. Young, brittle faults cut the deposit (in particular the ZG1 fault) and contain or are associated with basalt dikes related to volcanic rocks in the cover sequence. The faults and dikes are surrounded by narrow alteration zones of epidote, calcite, chlorite, and pyrite. A very small proportion of mineralization is disrupted by this alteration.

7.5 DEPOSIT MINERALIZATION STYLES

Mineralization in the Pebble West zone is mostly hypogene, with a thin zone of mostly weak supergene mineralization beneath a thin leached cap. Mineralization in the Pebble East zone is entirely hypogene with no preservation of leaching or paleo-supergene below the cover sequence.

7.5.1 Supergene Mineralization and Leached Cap

A thin leached cap occurs at the top of the Pebble West zone; strong leaching is rarely more than 33 ft thick although weak oxidation locally extends to depths of up to 500 ft along faults. Hypogene pyrite is common and minor malachite, chrysocolla and native copper are present locally.

Supergene mineralization occurs only in the Pebble West zone where the cover sequence is absent. Supergene mineralization has an average thickness of 72 ft but at least traces of supergene minerals locally extend to depths of 560 ft in strongly fractured zones. In the supergene zone, pyrite is typically rimmed by chalcocite, covellite and minor bornite; complete replacement is rare (Gregory and Lang, 2009; Gregory et al., 2012). The transition to hypogene mineralization is gradational over distances of up to approximately 100 feet. Supergene processes increased copper grade up to approximately 50% across narrow intervals.

7.5.2 Hypogene Mineralization

Patterns of metal grades and ratios at Pebble correspond closely to alteration styles, with only weak or local relationships to host rock. The deposit has a tabular geometry when the 20° post-hydrothermal tilt is removed. Copper and gold grades diminish below approximately 1,300 ft depth in the Pebble West zone but extend much deeper in the Pebble East zone, particularly within and proximal to the BDF. Laterally, grades decrease gradually toward the north and south margins of the deposit, where mineralization is abruptly terminated where overprinted by poorly-mineralized QSP alteration. Moderate grades with the shortest vertical extent are observed in the middle of the deposit between the Pebble East and Pebble West zones. There is a general correspondence between copper and gold grades outside of the Pebble East zone pluton;

within the Pebble East zone pluton, there is a closer correspondence between copper and molybdenum at low grades of gold, except where gold-rich advanced argillic alteration is present. On the west side of the deposit, mineralization extends to the ZF fault, whereas on the east side it was down-dropped into the East Graben by the ZG1 fault. Molybdenum exhibits a more diffuse pattern, is open at depth and, in some areas, elevated grade corresponds with more abundant type B3 veins.

Mineralization was primarily introduced during early potassic and sodic-potassic alteration. Copper is hosted primarily by chalcopyrite (Figure 7.5-1), locally co-precipitated with bornite (Figure 7.5-2) and trace tennantite-tetrahedrite. The pyrite to chalcopyrite ratio is typically close to one in potassic alteration in the Pebble East zone but is commonly much higher in the Pebble West zone where sulphide-rich type C and, locally, type D veins are present. Gold occurs primarily as electrum inclusions in chalcopyrite with minor amounts hosted by silicate alteration minerals and pyrite, and rarely as gold telluride inclusions in pyrite (Gregory et al., 2013). Diorite sills with magnetite-rich alteration and type M veins have relatively high gold concentrations. Molybdenite occurs in quartz veins and intergrown with disseminated chalcopyrite.

Incipient to weak illite±kaolinite alteration had little effect on grade, whereas strong alteration reduced the grade of copper and gold but left molybdenum largely undisturbed. Gold liberated during illite±kaolinite alteration was reconstituted as high-fineness inclusions (gold grains with less than 10 wt% Ag) in pyrite (Gregory and Lang 2009; Gregory et al., 2013). These patterns are consistent with the effects of illite alteration on grade in many porphyry deposits (e.g., Seedorf et al., 2005; Sillitoe, 2010).

Advanced argillic alteration zones have much higher grades of copper and gold but similar molybdenum compared to adjacent early potassic alteration. Pyrophyllite alteration precipitated high concentrations of pyrite and chalcopyrite and both minerals contain inclusions of high-fineness gold (Gregory et al., 2013). During sericite alteration, bornite, covellite, digenite and trace enargite or tennantite replaced chalcopyrite formed during early potassic alteration and also precipitated minor additional pyrite (Gregory and Lang, 2009). In general, gold occurs as high-fineness inclusions in later pyrite and high-sulphidation copper minerals, whereas electrum predominates in relict early chalcopyrite (Gregory et al., 2013).

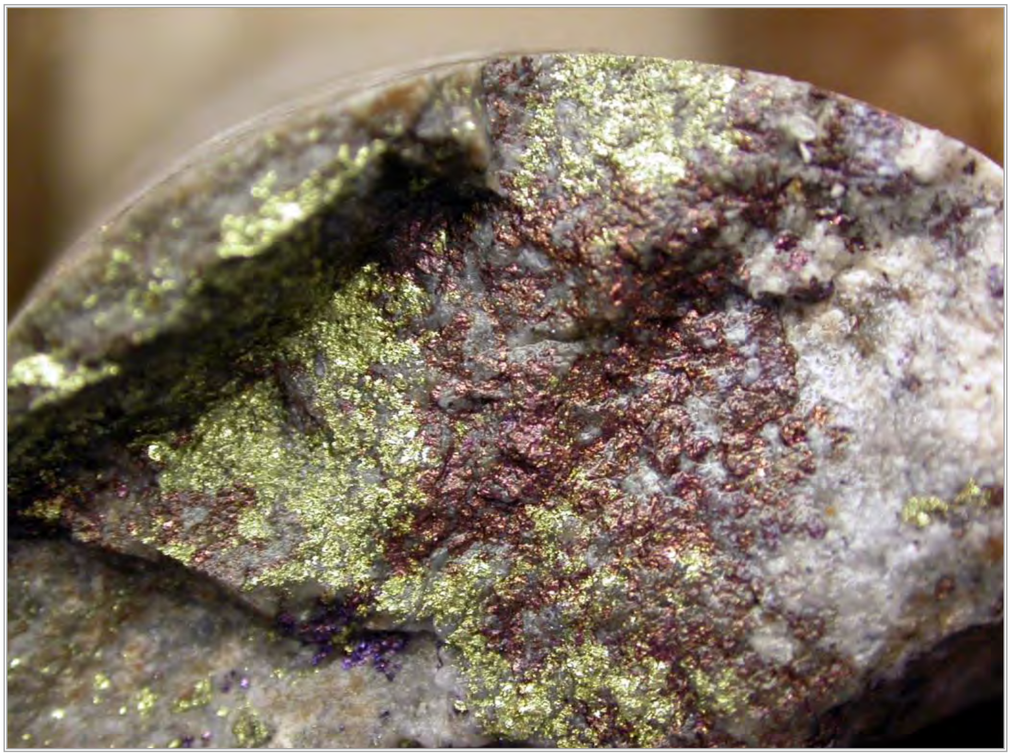
The zone of high quartz vein density along the BDF is typically well-mineralized where it has been overprinted by pyrophyllite alteration. The northern zone of high quartz vein density has average to low grades of copper and gold except in small areas where higher grades reflect the presence of sericite alteration.

Copper and molybdenum mineralization was largely removed by late QSP alteration. Gold concentrations remain consistent at 0.15 to 0.5 g/t, and locally exceed 1 g/t (Lang et al., 2008). The QIP alteration partially overprints early alteration types and affected areas retain low copper and molybdenum grades with gold occurring as inclusions in younger stages of pyrite (Gregory et al., 2013).

Grade variation within the cores of the Pebble East and Pebble West zones shows a weak, local relationship to rock type. Higher than average copper and gold grades are spatially related to iron-rich diorite sills, a relationship common in porphyry deposits (e.g., Ray, Arizona; Phillips et al., 1974). On the margins of the deposit and in the lower grade area between the Pebble East and Pebble West Zones, relatively impermeable flysch affected by pre-hydrothermal hornfels has lower grades than adjacent, more permeable granodiorite sills.

Figure 7.5-1 Drill Core Photograph Showing Chalcopyrite Mineralization

Figure 7.5-2 Drill Core Photograph Showing Chalcopyrite and Bornite Mineralization



8.0 DEPOSIT TYPES

8.1 DEPOSIT TYPES

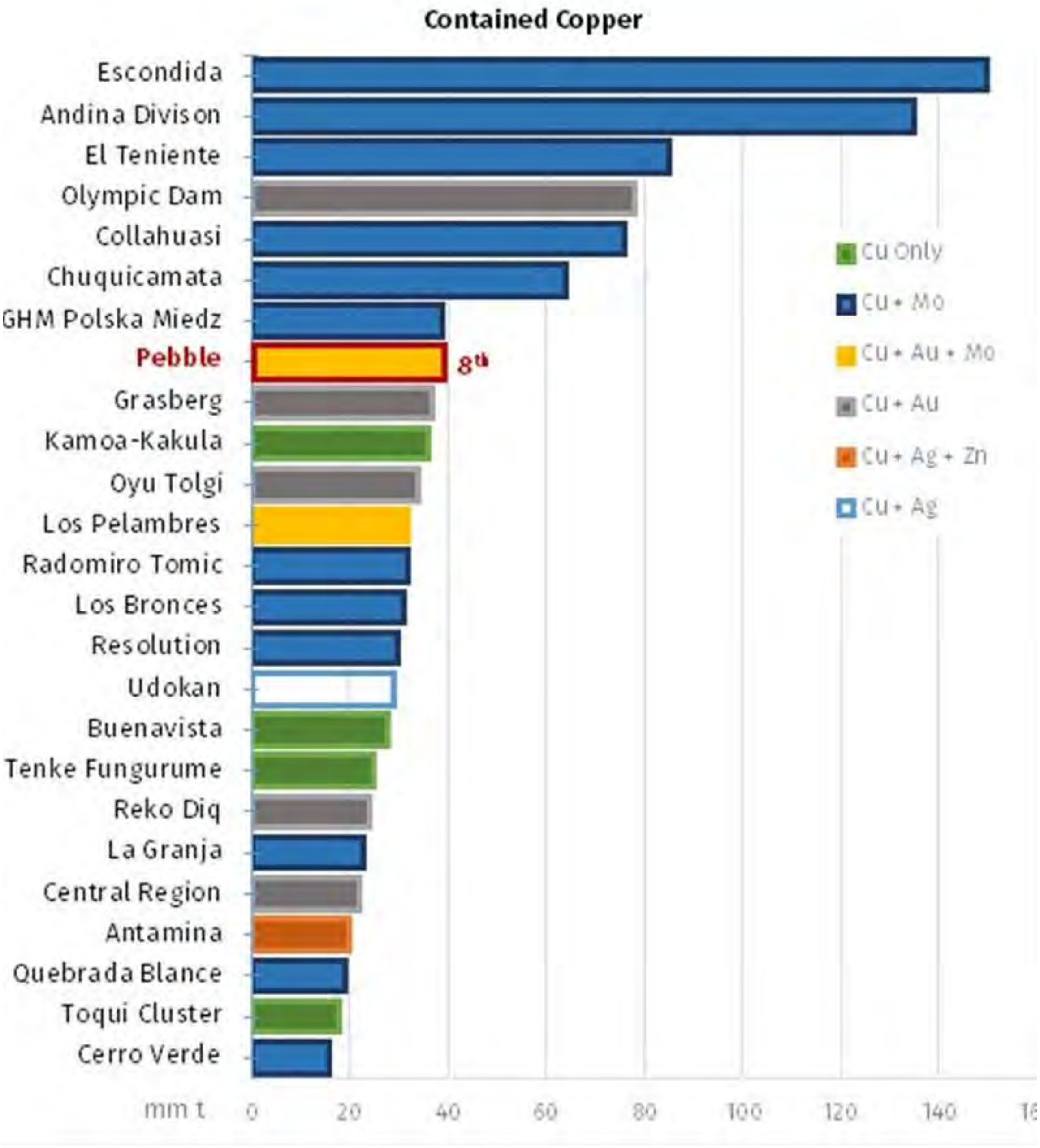
The Pebble deposit is classified as a copper-gold-molybdenum porphyry deposit. The principal features of porphyry copper deposits, as summarized recently by John et al. (2010), include:

- Mineralization defined by copper and other minerals which occur as disseminations and in veins and breccias which are relatively evenly distributed throughout their host rocks;
- Large tonnage amenable to bulk mining methods;
- Low to moderate copper grades, typically between 0.3% and 2.0%;
- A genetic relationship to porphyritic intrusions of intermediate composition that typically formed in convergent-margin tectonic settings;
- A metal assemblage dominated by various combinations of copper, gold, molybdenum and silver, but commonly with other associated metals of low concentration; and,
- A spatial association with other styles of intrusion-related mineralization, including skarns, polymetallic replacements and veins, distal disseminated gold-silver deposits, and intermediate to high-sulphidation epithermal deposits.

These characteristics correspond closely to the principal features of the Pebble deposit as described in Section 7.0 of this report. This report focuses exclusively on the Pebble porphyry deposit; other deposits of intrusion-related skarn, vein and porphyry style mineralization have been encountered elsewhere on the Pebble property but have not been the subject of detailed exploration or delineation.

Pebble has one of the largest metal endowments of any gold-bearing porphyry deposit currently known. Comparison of the current Pebble resource to other major gold-bearing porphyry deposits shows that it ranks at or near the top in terms of both contained copper (Figure 8.1-1) and gold (Figure 8.1-2). In fact, Pebble is both the largest known undeveloped copper resource and the largest known undeveloped gold resource in the world today. The basis of this estimation of metal endowment in the Pebble deposit is fully described in Section 14.0 of this report.

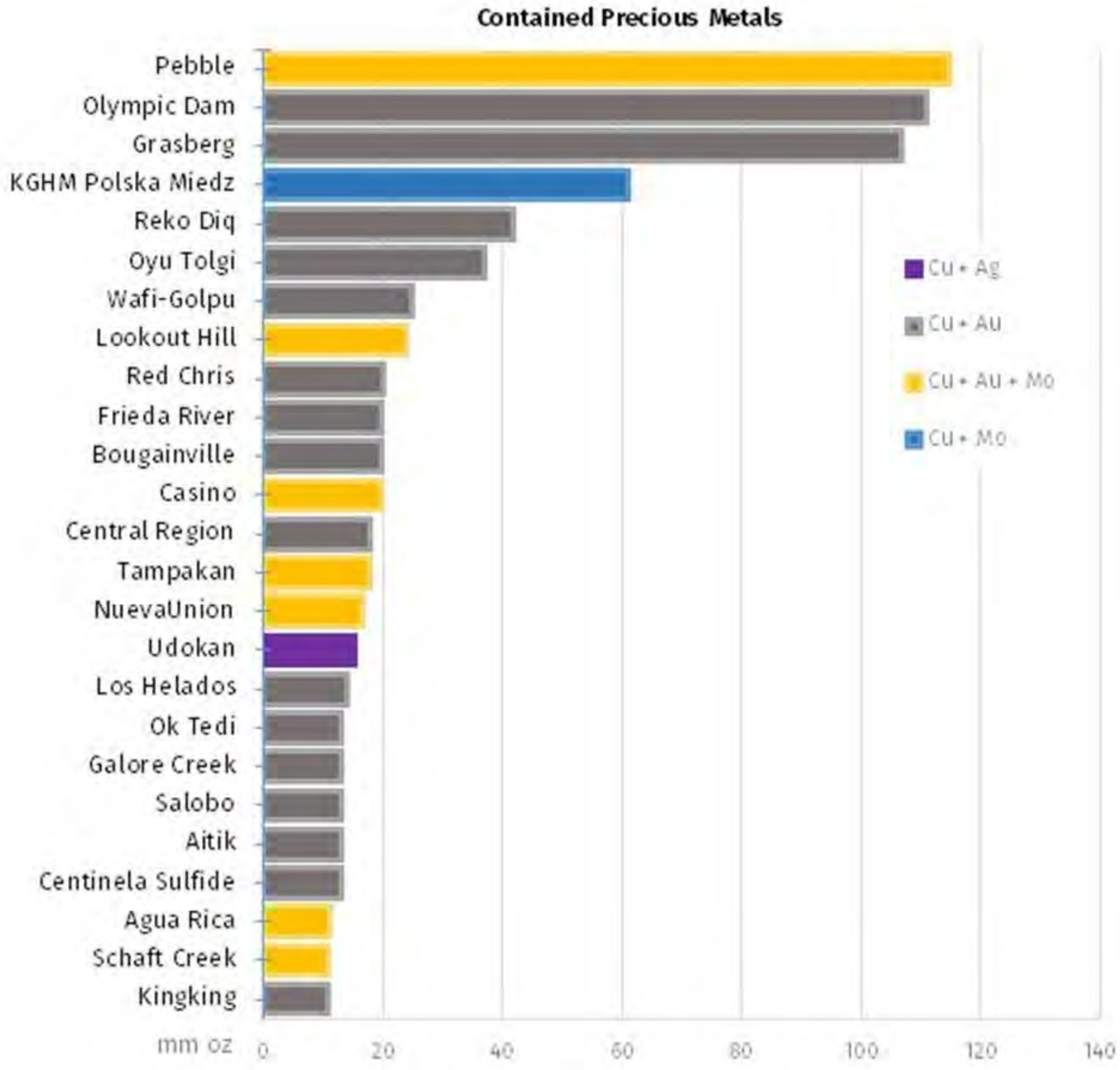
Figure 8.1-1 **Pebble Deposit Rank by Contained Copper**



Source: Company filings, Metals Economics Group; BMO Capital Markets

1. Note: Includes inferred resource.
2. At 0.30% Cu Eq. cut-off.

Figure 8.1-2 Pebble Deposit Rank by Contained Gold



Source: Company filings, Metals Economics Group, street research; BMO Capital Markets

Note: Includes inferred resource.

1. Converted to Au Eq. at street consensus Au price of US$1,300/oz and Ag price of US$19.25/oz
2. At 0.30% Cu Eq. cut-off.
3. Source: World Gold Council (https://www.gold.org/about-gold/facts-about-gold) says that about 187,000 tonnes of gold have been mined since the beginning of civilization. Pebble resource represents 3,340 T (10,776,800,344 tonnes x 0.31 g/t = 3,340 T).

9.0 EXPLORATION

9.1 OVERVIEW

Geological, geochemical and geophysical surveys were conducted in the Pebble Project area from 2001 to 2007 by Northern Dynasty and since mid-2007 by the Pebble Partnership. The types of historical surveys and their results are summarized below. More detailed descriptions of historical exploration programs and results may be found in Rebagliati and Haslinger (2003), Haslinger et al. (2004), Rebagliati and Payne (2006 and 2007), Rebagliati and Lang (2009) and Rebagliati et al. (2005, 2008, 2009 and 2010).

9.1.1 Geological Mapping

Between 2001 and 2006, the entire Pebble property was mapped for rock type, structure and alteration at a scale of 1:10,000. This work provided an important geological framework for interpretation of other exploration data and drilling programs. A geological map of the Pebble deposit was also constructed but, due to a paucity of outcrop, was based solely on drillhole information. The content and interpretation of district and deposit scale geological maps have not changed materially from the information presented by Rebagliati et al. (2009 and 2010).

9.1.2 Geophysical Surveys

In 2001, dipole-dipole IP surveys totalling 19.3 line-mi were completed by Zonge Geosciences for Northern Dynasty, following up on and augmenting similar surveys completed by Cominco (Teck).

During 2002, a ground magnetometer survey totalling 11.6 line-mi was completed at Pebble. The survey was conducted by MPX Geophysics Ltd., based in Richmond Hill, Ontario. The principal objective of this survey was to obtain a higher resolution map of magnetic patterns than was available from existing regional government magnetic maps. The focus of this work was the area surrounding mineralization in the 37 Skarn zone in the southern part of the Pebble district. A helicopter-based airborne magnetic survey was flown over the entire Pebble property in 2007. A total of 1,456.5 line-mi were flown at 656 ft line spacing, covering an area of 164.5 square miles. The survey lines were flown at a nominal mean terrain clearance of 196.8 ft along flight lines oriented 135° at a line spacing of 656 ft, with tie lines oriented 045° at a spacing of 1.24 miles. Immediately over the Pebble deposit, an area of 14.4 square miles was surveyed at a 328 ft line spacing for a total of 212.5 line-mi, without additional tie lines.

During 2007, a limited magnetotelluric survey was completed by GSY-USA Inc., the U.S. subsidiary of Geosystem SRL of Milan, Italy, under the supervision of Northern Dynasty geologists. The survey focused on the area of drilling in the Pebble East zone and comprised 196 stations on nine east-west lines and one north-south line, at a nominal station spacing of 656 ft. Interpretation, including 3D inversion, was completed by Mr. Donald Hinks of Rio Tinto Zinc.

In July 2009, Spectrem Air Limited, an Anglo American-affiliated company based in South Africa, completed an airborne electromagnetic, magnetic and radiometric survey over the Pebble area. A total of 2,386 line-mi were surveyed in two flight block configurations:

- a regional block covering an area of about 18.6 x 7.5 miles at a line spacing of 0.95 miles; and,
- a more detailed block which covered the Pebble property using a line spacing of 820 ft.

The orientation of flight lines was 135° for both surveys, with additional tie-lines flown orthogonally. The objectives of this work included provision of geophysical constraints for structural and geological interpretation in areas with significant glacial cover.

Between the second half of 2009 and mid-2010, a total of 120.5 line-mi of IP chargeability and resistivity data were collected by Zonge Engineering and Research Organization Inc. (Zonge Engineering) for the Pebble Partnership. This survey was conducted in the southern and northern parts of the property and used a line spacing of about 0.5 miles; the objective of this survey was to extend the area of IP coverage completed prior to 2001 by Cominco (Teck) and during 2001 by Northern Dynasty.

During 2010, an airborne electromagnetic (EM) and magnetometer geophysical survey was completed on the Pebble property totalling 4,009 line-mi. This survey was conducted by Geotech Ltd. of Aurora, Ontario.

The USGS collected gravity data from 136 stations distributed over an area of approximately 2,317 square miles during 2008 and 2009.

9.1.3 Geochemical Surveys

Between 2001 and 2003, Northern Dynasty collected 1,026 soil samples (Rebagliati and Lang, 2009). Typical sample spacing in the central part of the large geochemical grid was 100 ft to 250 ft along lines spaced 122 to 400 ft to 750 ft apart; samples were more widely spaced near the north, west and southwest margins of the grid.

These sampling programs outlined high-contrast, coincident anomalies in gold, copper, molybdenum and other metals in an area that measures at least 5.6 miles north-south by up to 2.5 miles east-west, with strong but smaller anomalies in several outlying zones. All soil geochemical anomalies lie within the IP chargeability anomaly described above. Three very limited surficial geochemical surveys were completed by the Pebble Partnership in 2010 and 2011; no significant geochemical anomalies were identified. A total of 126 samples, comprising 113 till and 13 soil samples, were collected on the KAS claims located in the southern end of the property; samples were on lines spaced approximately 8,000 ft apart with a sample spacing of approximately 1,300 ft. A total of 109 soil samples were collected from two small areas located approximately 11 miles to the west-northwest and 15 miles west of the Pebble deposit; samples were spaced approximately 330 ft apart on lines that were irregularly spaced to accommodate terrain features.

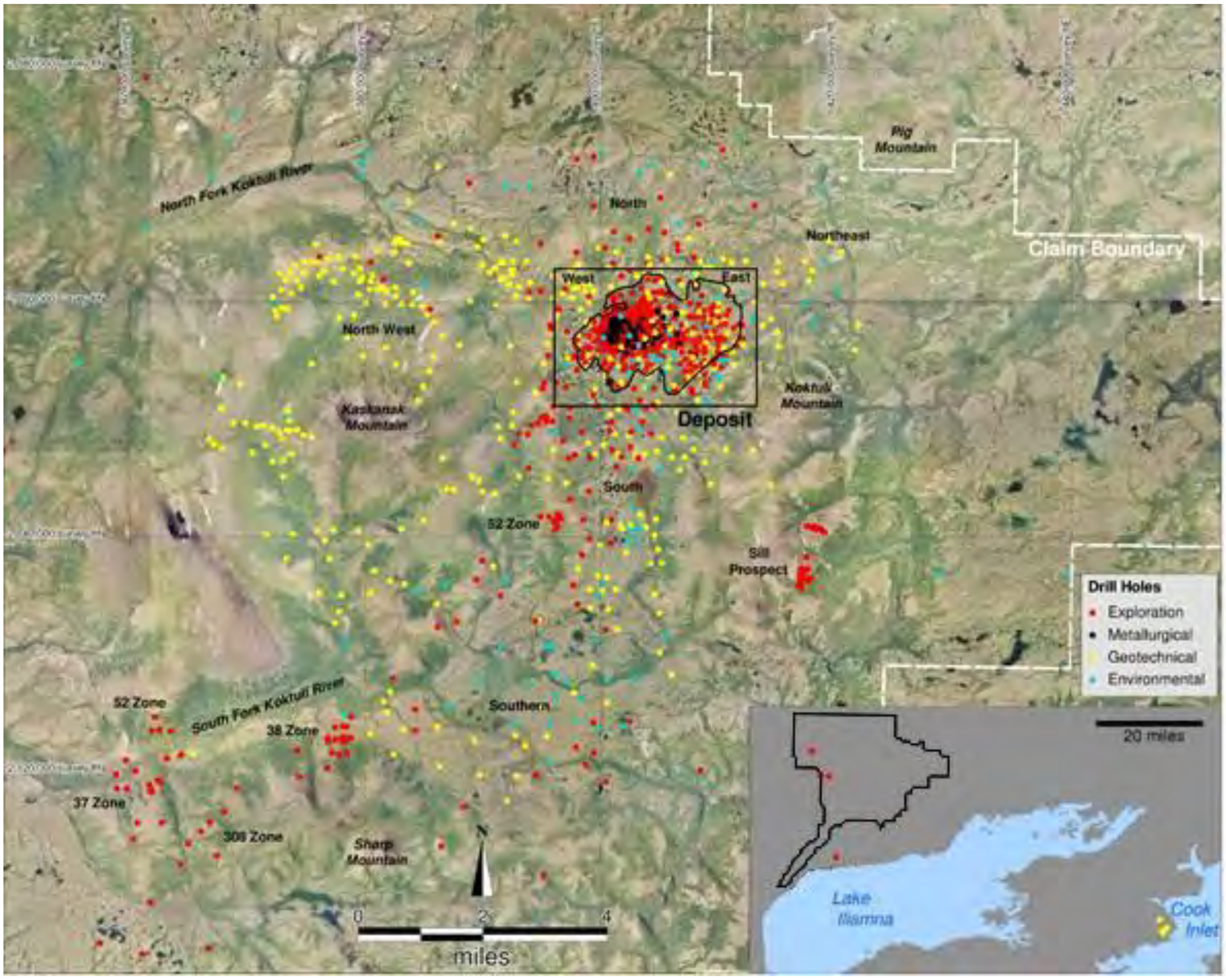
Additional surveys were completed between 2007 and 2012 by researchers from the USGS and the University of Alaska Anchorage (see summary in Kelley et al., 2013 and contained references). The types of surveys that were completed by these groups include: (1) hydrogeochemical surveys in several parts of the Pebble property which obtained multi-element inductively coupled plasma mass spectrometry (ICP-MS) data from samples of surface waters; (2) determination of copper isotope ratios in surface waters; (4) heavy indicator mineral analyses of glacial till; and (4) orientation surveys which utilized a variety of weak extraction geochemical techniques. The results of these surveys were largely consistent with the results obtained by earlier soil sampling programs.

10.0 DRILLING

10.1 LOCATION OF ALL DRILL HOLES

Extensive drilling totaling **1,042,218** ft has been completed in 1,355 holes on the Pebble Project. These drill campaigns took place during 19 of the 26 years between 1988 and 2013. The spatial distribution and type of holes drilled is illustrated in Figure 10.1-1.

Figure 10.1-1 Location of all Drill Holes



Drilling completed by Cominco (Teck) (1988 to 1997) is described briefly in Section 6.0 and will not be discussed further here.

All drill hole collars have been surveyed using a differential global positioning system (GPS). A digital terrain model for the site was generated by photogrammetric methods in 2004. All post-Cominco (Teck) drill holes have been surveyed downhole, typically using a single shot magnetic gravimetric tool. A total of 989 holes were drilled vertically (-90°) and 192 were inclined from -42° to -85° at various azimuths.

10.2 SUMMARY OF DRILLING 2001 TO 2013

The Pebble deposit has been drilled extensively (Figure 10.2-1). Drilling statistics and a summary of drilling by various categories to the end of the 2013 exploration program are compiled in Figure 10.2-2. This includes seven drill holes completed by FMMUSA, drilled by Peak Exploration (USA) Corp. in the area in 2008; these holes were drilled on claims that are now part of the Pebble property and have been added to the Pebble dataset. Detailed descriptions of the programs and results for 2009 and preceding years may be found in technical reports by Rebagliati and Haslinger (2003 and 2004), Haslinger et al. (2004), Rebagliati and Payne (2005, 2006 and 2007), and Rebagliati et al. (2008, 2009 and 2010).

Most of the footage on the Pebble Project was drilled using diamond core drills. Only 18,716 ft was percussion-drilled from 222 rotary drill holes. Many of the cored holes were advanced through overburden, using a tricone bit with no core recovery. These overburden lengths are included in the core drilling total.

Since early 2004, all Pebble drill core has been geotechnically logged on a drill run basis. Over 69,000 measurements were made for a variety of geotechnical parameters on 735,000 ft of core drilling. Recovery is generally very good and averages 98.5% overall; two-thirds of all measured intervals have 100% core recovery. Additionally, all Pebble drill core from the 2001 through 2013 drill programs was photographed in a digital format.

Figure 10.2-1 Location of Drill holes – Pebble Deposit

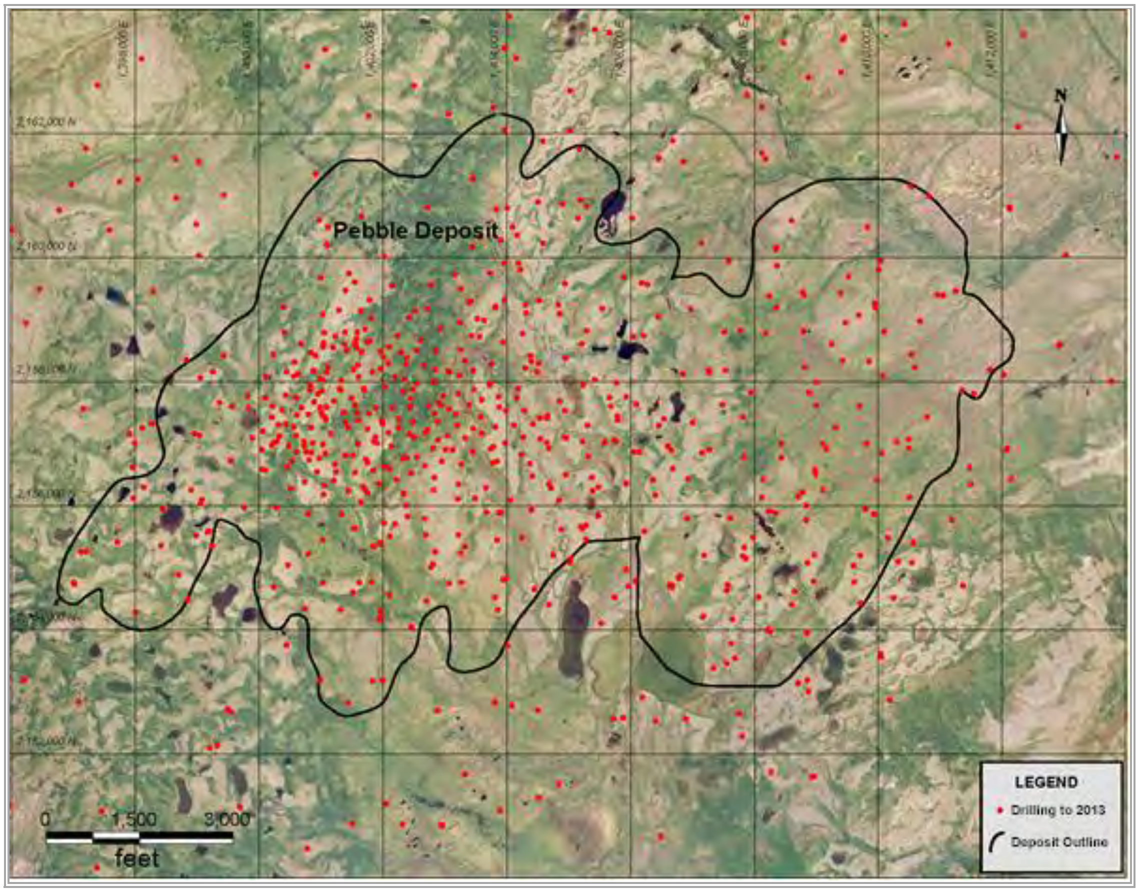


Figure 10.2-2 Summary of Drilling to December 2013

	No. of Holes	Feet	Metres
By Operator			
Cominco (Teck)[1]	164	75,741.0	23,086
Northern Dynasty	578	495,069.5	150,897
Pebble Partnership[2]	606	465,957.7	142,024
FMMUSA	7	5,450.0	1,661
Total	1,355	1,042,218.2	317,668
By Type			
Core[1,5]	1,132	1,023,297.6	311,901
Percussion[6]	223	18,920.6	5,767
Total	1,355	1,042,218.2	317,668
By Year			
1988[1]	26	7,601.5	2,317
1989[1]	27	7,422.0	2,262
1990	25	10,021.0	3,054
1991	48	28,129.0	8,574
1992	14	6,609.0	2,014

	No. of Holes	Feet	Metres
1993	4	1,263.0	385
1997	20	14,695.5	4,479
2002	68	37,236.8	11,350
2003	67	71,226.6	21,710
2004	267	165,567.7	50,465
2005	114	81,978.5	24,987
2006[3]	48	72,826.9	22,198
2007[4]	92	167,666.9	51,105
2008[5]	241	184,726.4	56,305
2009	33	34,947.5	10,652
2010	66	57,582.0	17,551
2011	85	50,767.7	15,474
2012	81	35,760.2	10,900
2013	29	6,190.0	1,887
Total	1,355	1,042,218.2	317,668
By Area			
East	149	450,047.3	137,174
West	447	349,128.7	106,414
Main[7]	77	7,712.4	2,351
NW	195	46,663.9	14,223
North	76	29,840.0	9,095
NE	15	1,495.0	456
South	117	48,387.8	14,749
25 Zone	8	4,047.0	1,234
37 Zone	7	4,252.0	1,296
38 Zone	20	14,221.5	4,335
52 Zone	5	2,534.0	772
308 Zone	1	879.0	268
Eastern	5	621.5	189
Southern	147	64,374.4	19621
SW	39	6,658.8	2030
Sill	39	10,445.5	3,184
Cook Inlet	8	909.5	277
Total	1,355	1,042,218.2	317,668

Notes:

1. Includes holes drilled on the Sill prospect.
2. Holes started by Northern Dynasty and finished by the Pebble Partnership are included as the Pebble Partnership.
3. Drillholes counted in the year in which they were completed.
4. Wedged holes are counted as a single hole including full length of all wedges drilled.
5. Includes FMMUSA drillholes; data acquired in 2010.
6. Shallow (<15 ft) auger holes not included.
7. Comprises holes drilled entirely in Tertiary cover rocks within the Pebble West and Pebble East areas.
   Some numbers may not sum exactly due to rounding.

The drill hole database includes drill holes completed up until 2013; the drilling completed in 2013 is outside the area of the resource estimate. Highlights of drilling completed by Northern Dynasty and the Pebble Partnership between 2001 and 2013 include:

- Northern Dynasty drilled 68 holes for a total of 37,237 ft during 2002. The objective of this work was to test the strongest IP chargeability and multi-element geochemical anomalies outside of the Pebble deposit, as known at that time, but within the larger and broader IP chargeability anomaly described above. This program discovered the 38 Zone porphyry copper-gold-molybdenum deposit, the 52 Zone porphyry copper occurrence, the 37 Zone gold-copper skarn deposit, the 25 Zone gold deposit, and several small occurrences in which gold values exceeded 3.0 g/t.
- In 2003, Northern Dynasty drilled 67 holes for a total of 71,227 ft, mainly within and adjacent to the Pebble West zone to determine continuity of mineralization and to identify and extend higher grade zones. Most holes were drilled to the zero meter elevation above mean sea level and were 900 to 1,200 ft in length. Eight holes for a total of 5,804 ft were drilled outside the Pebble deposit to test for extensions and new mineralization at four other zones on the property, including the 38 Zone porphyry copper-gold-molybdenum deposit and the 37 Zone gold-copper skarn deposit.
- Drilling by Northern Dynasty in 2004 totalled 165,481 ft in 266 holes. Of this total, 131,211 ft were drilled in 147 exploration holes in the Pebble deposit; one exploration hole 879 ft in length was completed in the southern part of the property that discovered the 308 Zone porphyry copper-gold-molybdenum deposit. Additional drilling included 21,335 ft in 26 metallurgical holes in Pebble West zone, 9,127 ft in 54 geotechnical holes and 3,334 ft in 39 water monitoring holes, of which 33 holes for a total of 2,638 ft were percussion holes. During the 2004 drilling program, Northern Dynasty identified a significant new porphyry centre on the eastern side of the Pebble deposit (the Pebble East zone) beneath the cover sequence (as described in Section 7).
- In 2005, Northern Dynasty drilled 81,979 ft in 114 holes. Of these drill holes, 13 for a total of 12,198 ft were drilled mainly for engineering and metallurgical purposes in the Pebble West zone. Seventeen drill holes for a total of 60,696 ft were drilled in the Pebble East zone. The results confirmed the presence of the Pebble East zone and further demonstrated that it was of large size and contained higher grades of copper, gold and molybdenum than the Pebble West zone. The Pebble East zone remained completely open at the end of 2005. A further 13 holes for a total of 2,986 ft were cored for engineering purposes outside the Pebble deposit area. An additional 6,099 ft of drilling was completed in 71 non-core water monitoring wells.
- Drilling during 2006 focused on further expansion of the Pebble East zone. Drilling comprised 72,827 ft in 48 holes. Twenty of these holes were drilled in the Pebble East zone, including 17 exploration holes and three engineering holes for a total of 68,504 ft. The Pebble East zone again remained fully open at the conclusion of the 2006 drilling program. In addition, 2,710 ft were drilled in 14 engineering core holes and 1,612 ft were drilled in 14 monitoring well percussion holes elsewhere on the property.
- Drilling in 2007 continued to focus on the Pebble East zone. A total of 151,306 ft of delineation drilling in 34 holes extended Pebble East to the northeast, northwest, south and southeast; the zone nonetheless remained open in these directions, as well as to the east in the East Graben. Additional drilling included 10,167 ft in nine metallurgical holes in Pebble West, along with 4,367 ft in 26 engineering holes and 1,824 ft in 23 percussion holes for monitoring wells across the property.
- In 2008, 234 holes were drilled totalling 179,275 ft, the most extensive drilling on the project in any year to date. A total of 136,266 ft of delineation and infill drilling, including six oriented holes, was completed in 31 holes in Pebble East. This drilling further expanded the Pebble East zone. Fifteen metallurgical holes for a total of 14,511 ft were drilled in the Pebble West zone. One 2,949 ft

infill/geotechnical hole was drilled in the Pebble West zone. Geotechnical drilling elsewhere on the property included 105 core holes for a total of 18,806 ft. Hydrogeology and geotechnical drilling outside of the Pebble deposit accounted for 82 percussion holes for a total of 6,745 ft. In 2010, the Pebble Partnership acquired the data for seven holes totalling 5,450 ft drilled by FMMUSA in 2008. These drill holes are located near the Property on land that is now controlled by the Pebble Partnership and provided information on the regional geology.

- The Pebble Partnership drilled 34,948 ft in 33 core drill holes in 2009. Five delineation holes were completed for 6,076 ft around the margins of Pebble West and 21 exploration holes for a total of 22,018 ft were drilled elsewhere on the property. In addition, seven geotechnical core holes were drilled for a total of 6,854 ft.
- In 2010, the Pebble Partnership drilled 57,582 ft in 66 core holes. Forty-eight exploration holes totalling 54,208 ft were drilled over a broad area of the property outside the Pebble deposit. An additional 3,374 ft were drilled in 18 geotechnical holes within the deposit area and to the west.
- In 2011, the Pebble Partnership drilled 50,768 ft in 85 core holes. Eleven holes were drilled in the deposit area totalling 33,978 ft. Of these, two holes were drilled in Pebble East for metallurgical and hydrogeological purposes. The other nine holes in the deposit area were drilled for further delineation of Pebble West and the area immediately to the south. These results indicated the potential for resource expansion to depth in the Pebble West zone. Six holes totalling 8,780 ft were also drilled outside the Pebble deposit area to the west and south. In addition, 8,010.2 ft was drilled in 68 geotechnical holes within and to the north, west and south of the deposit.
- The Pebble Partnership drilled 35,760 ft in 81 core holes in 2012. Eleven holes totalling 13,754 ft were drilled in the southern and western parts of the Pebble West zone. The results show potential for lateral resource expansion in this area and further delineation drilling is warranted. Six holes totalling 6,585 ft. were drilled to test exploration targets to the south on the Kaskanak claim block, to the northwest and south of Pebble, and on the KAS claim block further south. An additional 64 geotechnical and hydrogeological holes were drilled totalling 15,422 ft. Of this drilling, 41 holes were within the deposit area and 15 geotechnical holes were drilled at sites near the deposit, and eight geotechnical holes were completed near Cook Inlet.
- The Pebble Partnership drilled 6,190 ft in 29 core holes for geotechnical purposes in 2013 at sites west, south and southwest of the deposit area.
- No holes were drilled in 2014, 2015, 2016 or 2017.

A re-survey program of holes drilled at Pebble from 1988 to 2009 was conducted during the 2008 and 2009 field seasons. For consistency throughout the project, the resurvey program referenced the control network established by R&M Consultants in the U.S. State Plane Coordinate System Alaska Zone 5 NAVD88 Geoid99. The resurvey information was applied to the drill collar coordinates in the database in late 2009.

In 2009 and 2013, the survey locations, hole lengths, naming conventions and numbering designations of the Pebble drill holes were reviewed. This exercise confirmed that several shallow, non-cored, overburden drill holes described in some engineering and environmental reports were essentially the near-surface pre-collars of existing bedrock diamond drill holes. As these pre-collar and bedrock holes have redundant traces, the geologic information was combined into a single trace in the same manner as the wedged holes. In addition, a number of very shallow (less than 15 ft), small diameter, water-monitoring auger holes were removed from the exploration drill hole database, as they did not provide any geological or geochemical information.

10.3 BULK DENSITY RESULTS

Bulk density measurements were collected from drill core samples, as described in Section 11.4. A summary of all bulk density results is provided in Figure 10.3-1.

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Figure 10.3-2 shows a summary of bulk density drill holes used in the current mineral resource estimate.

Figure 10.3-1 Summary of All Bulk Density Results

Age	No. of Measurements	Density Mean	Density Median
Quaternary	34	2.60	2.61
Tertiary	2,703	2.57	2.57
Cretaceous	8,671	2.66	2.64
All	11,775	2.63	2.62

Figure 10.3-2 Summary of Bulk Density Results Used for Resource Estimation

Age	No. of Measurements	Density Mean	Density Median
Tertiary	3,026	2.56	2.57
Cretaceous	8,130	2.64	2.62
All	11,185	2.62	2.61

11.0 SAMPLE PREPARATION, ANALYSES, AND SECURITY

11.1 SAMPLING METHOD AND APPROACH

The Pebble deposit has been explored by extensive core drilling, with 80,859 samples taken from drillcore for assay analysis. Nearly all potentially mineralized Cretaceous core drilled and recovered has been sampled by halving in 10 ft lengths. Similarly, all core recovered from the Late Cretaceous to Early Tertiary cover sequence (referred to as Tertiary[5] here and in Sections 12.0 and 13.0) has also been sampled, typically on 20 ft sample lengths, with some shorter sample intervals in areas of geologic interest. Unconsolidated overburden material, where it exists, is generally not recovered by core drilling and therefore not usually sampled.

Rock chips from the 222 rotary percussion holes were generally not sampled for assay analysis, as the holes were drilled for monitoring wells and environmental purposes. Only 35 samples were taken from the drill chips of 26 rotary percussion holes outside the Pebble deposit area, which were drilled for condemnation purposes.

For details of the main rock units in the Pebble deposit and mineralization, see Section 7.0. Summaries of relevant sample composites are obtained in technical reports by Rebagliati and Haslinger (2003 and 2004), Haslinger et al. (2004), Rebagliati and Payne (2005, 2006 and 2007), and Rebagliati et al. (2008). Sampling methods and procedures for drill holes completed by Cominco (Teck) are described in these earlier reports, and will not be discussed further here.

Half cores remaining after sampling were replaced in the original core boxes and stored at Iliamna, AK in a secure compound. Later geological, metallurgical and environmental sampling took place on a small portion of this remaining core. Crushed reject samples from the 2006 through 2013 analytical programs are stored in locked containers at Delta Junction, AK. Drill core assay pulps from the 1989 through 2013 programs are stored at a secure warehouse in Langley, BC.

11.1.1 Northern Dynasty 2002 Drilling

In 2002, 68 drill holes were completed by Quest America Drilling Inc. (Quest). All holes were NQ2 diameter (2 inches/5.08 cm). The core was boxed at the rig and transported daily by helicopter to the secure logging facility in Iliamna. A total of 2,467 core samples, averaging 10 ft long, were collected by Northern Dynasty personnel. Sampling was performed by mechanically splitting the core in half lengthwise.

11.1.2 Northern Dynasty 2003 Drilling

In 2003, drilling was completed by contractor Quest. All core was NQ2 diameter. The core was boxed at the rig and transported daily by helicopter to the secure logging facility at the village of Iliamna. Samples averaged

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[5] Tertiary in usage throughout this section is a collective reference to all unmineralized rocks of the cover sequence that directly overlies the Pebble deposit.

10 ft long. Sampling was performed by mechanically splitting the core in half lengthwise. Coarse rejects were stored at SGS Mineral Services in Fairbanks, Alaska, until early 2005, and then discarded.

11.1.3 Northern Dynasty 2004 Drilling

Most of the 2004 drilling was also completed by Quest, with some footage drilled by Boart Longyear Company (Boart Longyear) and Midnight Sun Drilling Co. Ltd. Core diameters included NQ2, HQ (2.5 in/6.35 cm diameter) and PQ (3.3 in/8.31 cm diameter). Thirty-three rotary percussion water well, engineering and environmental holes were also completed. The 2004 drilling program included 26 larger diameter (PQ and HQ) holes for metallurgical testing. The core was boxed at the rig and transported daily by helicopter to the secure logging facility in the village of Iliamna. A total of 12,865 Cretaceous (syn-mineralization) samples averaging 10 ft long were taken in 2004; 10,893 samples were mechanically split half-core samples and 1,972 samples were of the metallurgical type. The metallurgical samples were taken by sawing an off-centre slice representing 20% of the core volume, which was submitted for assay analysis. The remaining 80% was used for metallurgical purposes. No intact drill core remains after this type of metallurgical sampling, only assay reject and pulp samples. In addition, 904 Tertiary (post-mineralization) samples averaging 15 ft long were taken for trace element analysis. Tertiary samples were collected by mechanically splitting the core in half lengthwise. The average core recovery for all samples taken in 2004 was 97.6%.

11.1.4 Northern Dynasty 2005 Drilling

In 2005, drilling was again completed by contractor Quest. Core diameters included NQ2, HQ and PQ core. The core was boxed at the rig and transported daily by helicopter to the secure logging facility in the village of Iliamna. A total of 4,378 Cretaceous samples and 1,435 Tertiary samples were collected. Of the Cretaceous samples, 3,541 were taken by sawing the core in half lengthwise. The remaining 837 Cretaceous samples and all Tertiary samples were from metallurgical holes, and were sampled using the 20% off-centre saw method described in Section 11.1.3. Cretaceous samples averaged 10 ft long and Tertiary samples averaged 20 ft long. The average core recovery for all 2005 core holes was 98.4%. In addition to the core drilling, a total of 6,100 ft was drilled in 71 rotary percussion holes by Foundex Pacific Inc. (Foundex) for water monitoring purposes. No samples were collected or analyzed from these holes.

11.1.5 Northern Dynasty 2006 Drilling

The drilling contractors in 2006 were American Recon Inc. (American Recon) and Boart Longyear. Drill holes were NQ2 and HQ in diameter. A total of 13 shallow rotary percussion holes were also completed for environmental purposes by Foundex. The core was boxed at the rig and transported daily by helicopter to the secure logging facility at Iliamna. The 2,759 Cretaceous samples collected averaged 10 ft long and the 1,847 Tertiary samples averaged 20 ft long. The Cretaceous samples were collected by sawing the core in half lengthwise, and the Tertiary samples were collected by the 20% off-centre saw method described in Section 11.1.3. Average core recovery in 2006 was 98.7%.

11.1.6 Northern Dynasty and Pebble Partnership 2007 Drilling

The drilling contractors used in 2007 were American Recon, Quest and Boart Longyear. Drill holes were NQ2 and HQ in diameter, and were drilled for geological and metallurgical purposes. Additional drilling was completed by Foundex to establish monitoring wells, but core was not recovered from these holes. Several holes included wedges; in cases where the wedged hole successfully extended beyond the total depth of the parent hole, they were treated as extensions of their parent holes and overlapping information was ignored. The core was boxed at the rig and transported daily by helicopter to the secure logging facility at Iliamna. A total of 12,664 samples were taken from the 72 drill holes. The 9,485 Cretaceous samples averaged 10 ft long, and the 3,179 Tertiary samples averaged 20 ft long. The Cretaceous samples were collected by sawing the core in half lengthwise, and the Tertiary samples were collected by the 20% off-centre saw method described in Section 11.1.3. The average core recovery for 2007 drill holes was 99.7%.

11.1.7 Pebble Partnership 2008 Drilling

The drilling contractors used in 2008 were American Recon, Boart Longyear and Foundex. Drill holes were NQ, HQ and PQ in diameter, and were drilled for delineation, geotechnical and metallurgical purposes. The core was boxed at the rig and transported daily by helicopter to the secure logging facility at Iliamna. The large 1.7 to 2.2 lb Cretaceous rock assay pulps and the 0.5 lb Tertiary waste rock pulps from these years are stored in a secure warehouse at Langley, BC. A total of 12,701 samples were taken in 2008 by the Pebble Partnership. The 9,312 Cretaceous samples averaged 10 ft long and the 3,389 Tertiary samples averaged 20 ft long. The Cretaceous samples were collected by sawing the core in half lengthwise. The Tertiary samples and assay samples from metallurgical holes were collected using the 20% off-centre saw method described in Section 11.1.3. The remaining 80% of the core from the Cretaceous portions of the metallurgical holes were used for metallurgical testing.

11.1.8 FMMUSA 2008 Drilling

In 2010, the Pebble Partnership acquired the data for seven holes with 414 samples drilled by FMMUSA in 2008. These drill holes are located near the Property on land that is now controlled by the Pebble Partnership, and provided information on the regional geology.

11.1.9 Pebble Partnership 2009 Drilling

The drilling contractor used for 2009 drilling was American Recon. Drill holes were NQ, HQ and PQ in diameter. The core was boxed at the rig and transported daily by helicopter to the secure logging facility at Iliamna. A total of 2,835 mainstream samples (including duplicate samples) were collected in 2009. The 2,555 Cretaceous samples averaged 10 ft long and the 280 Tertiary samples averaged 20 ft long. The Cretaceous samples were collected by sawing the core in half lengthwise. Tertiary samples were collected using the 20% off-centre saw method described in Section 11.1.3.

11.1.10 Pebble Partnership 2010 Drilling

Drilling contractors used for 2010 drilling were American Recon and Foundex. Drill holes were NQ and HQ in diameter. The core was boxed at the rig and transported daily by helicopter to the secure logging facility at Iliamna. A total of 4,714 mainstream samples were taken in 2010. The 4,463 Cretaceous samples and the 251 Tertiary samples averaged 10 ft long. All samples were taken by sawing the core in half lengthwise.

11.1.11 Pebble Partnership 2011 Drilling

Drill contractors American Recon, Quest and Foundex completed 85 holes in 2011. The hole numbering sequences are 11526 through 11542 for 17 district exploration holes and GH11-229 through GH11-296 for 68 geotechnical holes. Most of these holes were drilled vertically except for 11526, 11528, 11530, 11532, 11533 and

11539, which were inclined at -80°, and 11529, drilled at -75°. Among 68 geotechnical holes, 43 were sonic drilling. A total of 4,281 mainstream samples were taken. The 3,674 Cretaceous samples averaged 10 ft in length and the 607 Tertiary samples averaged 20 ft in length. Cretaceous samples were taken by sawing the core in half lengthwise. Tertiary samples were taken by the 20% off-centre saw-cut method described above.

11.1.12 Pebble Partnership 2012 Drilling

Drill contractors Quest and Foundex completed 81 holes in 2012. The hole numbering sequences are 12543 through 12562 for 20 exploration, delineation and hydrological holes, and GH12-297 through GH12-357S for 61 geotechnical holes. Most of 12-series holes were drilled with dips of -65° to -80°, and azimuths of 90° to 270° except for 12546, 12554, 12558, 12559, 12561 and 12562, which were drilled vertically. All GH-series holes were drilled vertically. Among 61 geotechnical holes, 31 were completed by sonic drilling. Of the 81 holes, 14 holes were drilled in the southern and western parts of the Pebble West zone; 6 holes were drilled in the broader claim area to test exploration targets to the south on the Kaskanak claim block to the northwest and south and the KAS claim block further south; and the 61 geotechnical and hydrogeological holes were drilled in the deposit area (45 holes), in Site A (8 holes) and in the area 50 miles to the southeast near Cook Inlet (8 holes). A total of 2,681 core samples (2,537 Cretaceous samples and the 144 Tertiary samples) were taken in 2012. The Cretaceous samples averaged 10 feet in length and were taken by sawing the core in half lengthwise. Tertiary samples averaged 20 ft in length and were taken by the 20% off-centre cut method.

11.1.13 Pebble Partnership 2013 Drilling

Drill contractor Foundex completed vertical drilling in 37 holes at sites near the deposit in 2013. These holes numbered GH13-358 through GH13-383 were drilled PQ and HQ size for geotechnical and hydrogeological purposes. A total of 523 samples were taken: 1 from Quaternary, 124 from Tertiary and 398 from Cretaceous strata. The Cretaceous and Quaternary samples average 10 feet in length and were taken by sawing the core in half lengthwise. The Tertiary samples average 15 feet in length and were taken by the 20% off-centre cut method.

Essentially, all of the potentially mineralized Cretaceous rock recovered by drilling on the Pebble Project is subject to sample preparation and assay analysis for copper, gold, molybdenum and a number of other elements. Similarly, all Late Cretaceous to Early Tertiary cover sequence (Tertiary) rock cored and recovered during the drill program is also subject to sample preparation and geochemical analysis by multi-element methods. Since 2007, all sampling at Pebble has been undertaken by employees or contractors under the supervision of a QP. The QP believes these processes are acceptable for use in geological and resource modelling for the Pebble deposit.

11.2 SAMPLE PREPARATION

11.2.1 2002 Sample Preparation

In 2002, the samples were prepared at the Fairbanks laboratory of ALS, which has been certified under an International Organization for Standardization (ISO) 9001 since 1999. The sample bags were verified against the numbers listed on the shipment notice. The entire sample of half-core was dried, weighed and crushed to 70% passing 10 mesh (2 mm), then a 250 g split was taken and pulverized to 85% passing 200 mesh (75 µm).

The pulp was split, and approximately 125 g were shipped by commercial airfreight for analysis at the ALS laboratory in North Vancouver. The remaining pulps were shipped to a secure warehouse at Langley for long-term storage. The coarse rejects were held for several months at the Fairbanks laboratory until all quality assurance/quality control (QA/QC) measures were completed and were then discarded.

11.2.2 2003 Sample Preparation

The 2003 samples were prepared at the SGS Mineral Services (SGS) sample preparation laboratory in Fairbanks. After verification of the sample bag numbers against the shipment notice, the entire sample of half-core was dried, weighed and crushed to 75% passing 10 mesh (2 mm). A 400 g split was taken and pulverized to 95% passing 200 mesh (75 µm), and the pulp was shipped by commercial airfreight to the SGS laboratories in either Toronto, ON, or Rouyn, QC. The assay pulps were returned for storage at the Langley warehouse. Coarse rejects were held for several months at the Fairbanks laboratory until all QA/QC measures were completed and were then discarded.

11.2.3 2004-2013 Sample Preparation

For the 2004 through 2013 drill programs, the ALS sample preparation laboratory in Fairbanks performed the sample preparation work. The laboratory received the half-core Cretaceous samples and the off-centre saw splits from the Tertiary samples and metallurgical holes, verified the sample numbers against the sample shipment notice and performed the sample drying, weighing, crushing and splitting. ALS of North Vancouver pulverized the samples from 2004 through 2006 (as described for 2002 samples), and ALS Fairbanks pulverized the samples from 2007 through 2013.

11.3 SAMPLE ANALYSIS

11.3.1 2002 Sample Analysis

Analytical work for the 2002 drilling program was completed by ALS of North Vancouver, BC, an ISO 9002 certified laboratory. All samples were analyzed by fire assay (FA) for gold, and a standard multi-element geochemical package was used for additional elements including copper and molybdenum. In addition, several drill holes exhibiting copper-gold porphyry-style mineralization were subjected to copper assay level determinations. A few molybdenum assay level determinations were also performed. Gold concentration was determined by 30 g FA fusion with lead as a collector and an atomic absorption spectrometry (AAS) finish. The four samples that returned gold results greater than 10,000 ppb (10 g/t), were re-analyzed by one assay ton FA fusion with a gravimetric finish.

All samples were subject to multi-element analysis for 34 elements, including copper and molybdenum, by aqua regia digestion with an ICP-AES finish. A total of 1,822 samples from 31 drill holes exhibiting porphyry style copper-gold mineralization were assayed for copper by aqua regia digestion with an AAS finish to the ppm level. For copper assays greater than 10,000 ppm, another total digestion with an AAS finish analysis was performed to the percent level. A further 61 samples from one drill hole were assayed for molybdenum by four-acid digestion with an AAS finish to the ppm level.

11.3.2 2003 Sample Analysis

Analytical work for the 2003 drilling program was completed by SGS Canada Inc. of Toronto, ON, an ISO 9002 registered, ISO 17025 accredited laboratory. All samples were analyzed by FA for gold, and a standard multi-element geochemical package was used for additional elements including copper and molybdenum. Gold analyses were completed at SGS Rouyn, QC, by one assay ton (30 g) lead-collection FA fusion with AAS finish, with results reported in ppb. Ten samples that returned gold results greater than 2,000 ppb (2 g/t) were re-analyzed by 30 g FA fusion with a gravimetric finish, with results reported in grams per tonne. Copper assays were completed at SGS Toronto, ON. Samples were fused with sodium peroxide, digested in dilute nitric acid and the solution analyzed by ICP-AES, with results reported to the percent level.

All samples were subject to multi-element analysis for 33 elements including copper, molybdenum and sulphur by aqua regia digestion with an ICP-AES finish at SGS Toronto. In addition, 30 samples were analyzed for whole-rock geochemical analysis by lithium metaborate fusion with an x-ray fluorescence (XRF) finish. All duplicates were analyzed at ALS laboratory in North Vancouver, BC.

11.3.3 2004-2013 Sample Analysis

Analytical work in 2002, and from 2004 to 2013 was completed by ALS of North Vancouver. Total copper and molybdenum concentration was determined by an intermediate-grade multi-element analytical method. A four-acid digestion was followed by ICP-AES finish (ALS code ME-ICP61a). The same multi-element method was used to determine 31 additional elements including sulphur. In 2004 and 2005, approximately one sample in 10 was also analyzed for copper by a high-grade, four-acid digestion method with AAS finish (ALS code Cu-AA62).

Beginning in 2004 for Tertiary rocks and 2007 for Cretaceous rocks, samples were analyzed for 47 elements by four-acid digestion followed by ICP-AES and inductively coupled plasma–mass spectroscopy finish (ICP-MS) and for mercury by aqua regia digestion cold vapour AAS (ALS code ME-MS61m). Gold content was determined by 30 g lead collection FA fusion with AAS finish (ALS code Au-AA23). A total of 10 samples from this period returned gold values greater than 10 ppm; they were re-analyzed by 30 g FA fusion with a gravimetric finish (ALS code Au-GRA21), with results reported in ppm. From drill hole number 7371 onward, gold, platinum and palladium concentrations were determined by 30 g FA fusion with ICP-AES finish (ALS code PGM-ICP23).

A total of 13,371 samples were subject to copper speciation analyses that included: oxide copper analysis by citric acid leach AAS finish; non-sulphide copper analysis by 10% sulphuric acid leach AAS finish and cyanide leachable copper on the sample residue of the sulphuric acid leach by cyanide leach AAS finish (ALS codes Cu-AA04, Cu-AA05 and Cu-AA17). A total of 222 samples from a drill hole in Pebble East were analyzed for precious metals (ALS code Au-SCR21 modified to include platinum and palladium). A 1,000 g pulp sample was screened at 100 µm (Tyler 150 mesh) and the entire plus fraction was weighed and analyzed by FA ICP finish and two 30 g minus fractions.

All duplicates since 2004 have been analyzed at Acme Analytical Laboratories (Acme), now Bureau Veritas Commodities Canada Ltd. (BVCCL) in Vancouver, BC, using similar methods to those at ALS. Acme (BVCCL) code Group 7TD, a four-acid digestion with ICP-AES finish, was used to determine total concentrations for copper, molybdenum and 20 additional elements. In 2010, 115 till samples were also analyzed at Acme

(BVCCL) in Vancouver. The samples were dried and sieved to 230 mesh (63 µm), and a 15 g sub-sample was digested in aqua regia and analyzed by ICP-MS (Acme (BVCCL) code 1F05).

Check assays for gold were determined by Acme (BVCCL) code Group 3B, a 30 g FA fusion with ICP-AES finish.

Figure 11.3-1 illustrates the sampling and analytical flowchart for the 2010 through 2013 drill programs.

11.3.4 Bulk Density Determinations

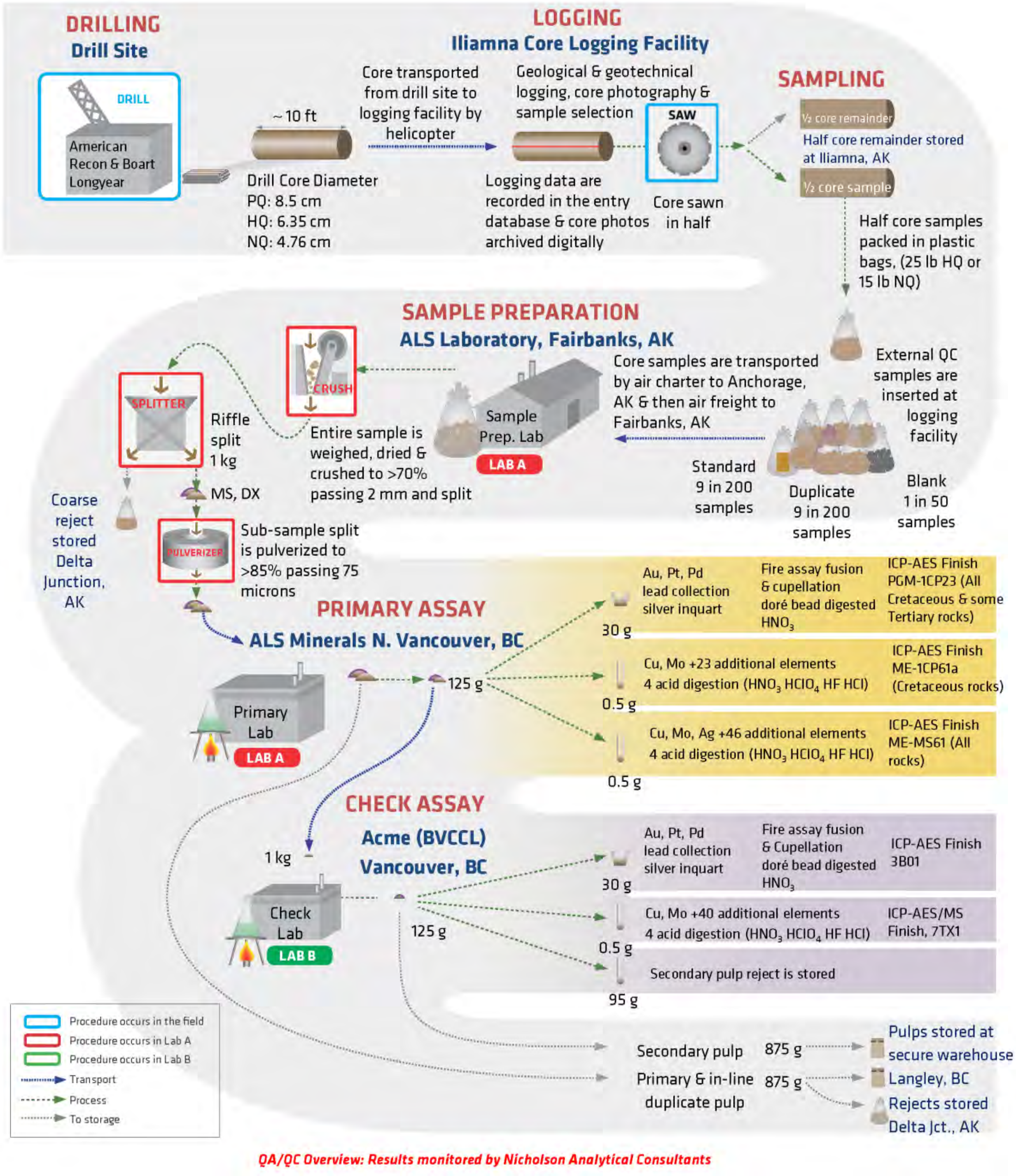
Density measurements were made at 100 ft intervals within continuous rock units, and at least once in each rock unit less than 100 ft wide. Rocks chosen for analysis were typical of the surrounding rock. Where the sample interval occurred in a section of missing core, or poorly consolidated material unsuitable for measurement, the nearest intact piece of core was measured instead.

Core samples free of visible moisture were selected; they ranged from 3 to 12 in long, and averaged 11.8 in. The samples were dried, weighed in air on a digital scale (capacity 4.4 lb) and the mass in air (MA) recorded to the nearest 0.1 g. Then, the sample was suspended in water below the scale and its weight in water (Mw) entered into the same table. Calculation of the density was conducted using the following formula:

$$\textbf{Density} = \mathbf{MA/(MA - Mw)}$$

Core-sized pieces of aluminum were used as density standards at site starting in 2008. A total of 9,951 density measurements of Tertiary and Cretaceous rocks were taken using a water immersion method on whole and half drill core samples at the Iliamna core logging facility.

Figure 11.3-1 Pebble Project 2010 to 2013 Drill Core Sampling and Analytical Flow Chart



QA/QC Overview: Results monitored by Nicholson Analytical Consultants

12.0 DATA VERIFICATION

The QP has reviewed the data verification procedures followed by the Pebble Partnership and by third parties on behalf of the Pebble Partnership, and believes these procedures are consistent with industry best practices and acceptable for use in geological and resource modelling.

12.1 QUALITY ASSURANCE AND QUALITY CONTROL

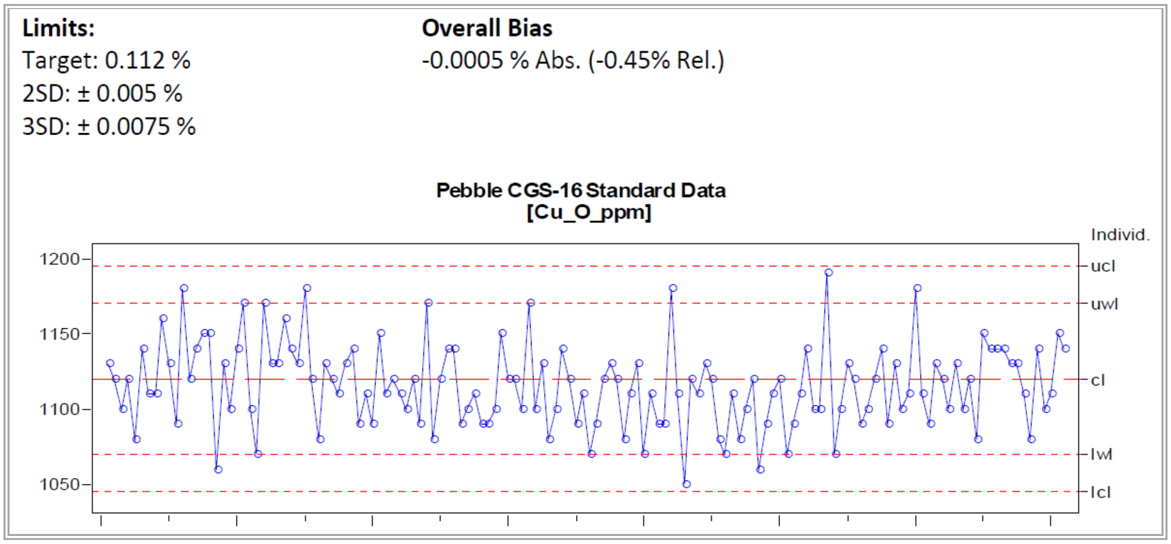
Northern Dynasty maintained an effective QA/QC program consistent with industry best practices, which has continued from 2007 to 2013 under the Pebble Partnership. This program is in addition to the QA/QC procedures used internally by the analytical laboratories. The QA/QC program has also been subject to independent review by Analytical Laboratory Consultants Ltd (ALC, 2004 to 2007) and Nicholson Analytical Consulting (NAC, 2008 to 2012). The analytical consultants provide ongoing monitoring, including facility inspection and timely reporting of the performance of standards, blanks and duplicates in the sampling and analytical program. The results of this program indicate that analytical results are of a high quality, suitable for use in detailed modelling and resource evaluation studies.

Figure 12.1-1 describes the QA/QC sample types used in the program. The performance of the copper-gold standard CGS-16 is illustrated in and Figure 12.1-3. A comparison of the matched-pair duplicate assay results of ALS and Acme (BVCCL) for 2004 through 2010 is provided in Figure 12.1-4 and Figure 12.1-5.

Figure 12.1-1 QA/QC Sample Types Used

QC Code	Sample Type	Description	Percent of Total
MS	Regular Mainstream	• Regular samples submitted for preparation and analysis at the primary laboratory.	89%
ST	Standard (Certified Reference Material)	• Mineralized material in pulverized form with a known concentration and distribution of element(s) of interest. • Randomly inserted using pre-numbered sample tags.	4.5% or 9 in 200
DP	Duplicate or Replicate	• An additional split taken from the remaining pulp reject, coarse reject, ¼ core or ½ core remainder. • Random selection using pre-numbered sample tags.	4.5% or 9 in 200
SD	Standard Duplicate	• Standard reference sample submitted with duplicates and replicates to the check laboratory.	<1%
BL	Blank	• Sample containing negligible or background amounts of elements of interest, to test for contamination.	2% 1 in 50

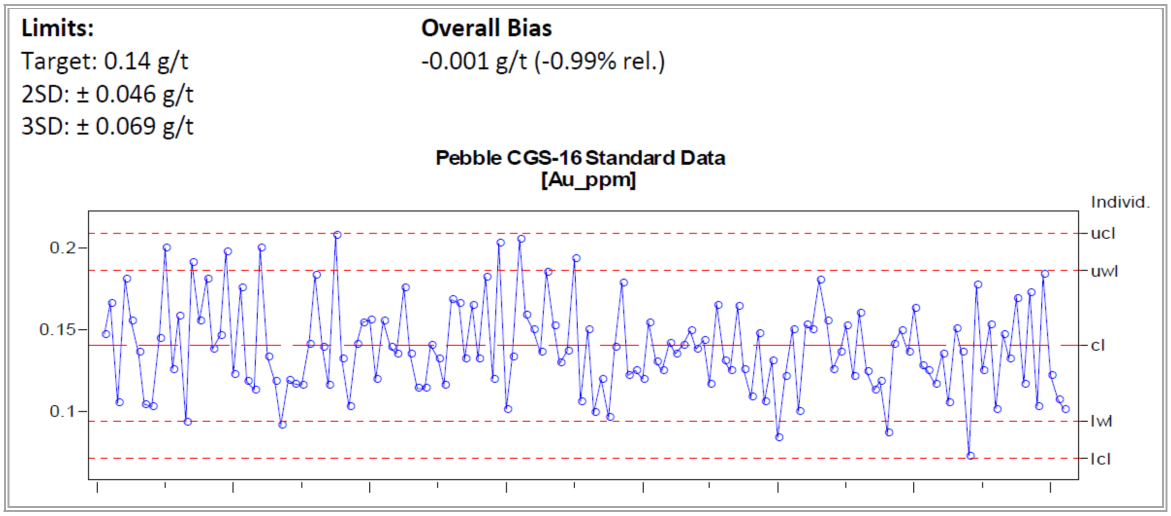
Figure 12.1-2 Performance of the Copper Standard CGS-16 in 2008



Limits:
Target: 0.112 %
2SD: ± 0.005 %
3SD: ± 0.0075 %

Overall Bias
-0.0005 % Abs. (-0.45% Rel.)

Figure 12.1-3 Performance of the Gold Standard CGS-16 in 2008



12.1.1 Standards

Standard reference materials were inserted into the Cretaceous sample stream (approximately 9 samples for every 200 samples) after sample preparation as anonymous (blind), consecutively-numbered pulps. These standards are in addition to internal standards routinely analyzed by the analytical laboratories. Standards were inserted in the field by the use of sample tags, on which the "ST" designation for "Standard" was pre-marked. For the Tertiary waste rock analytical program, coarse blanks were inserted at the sample tags positions marked as ST until late 2008 and, since then a commercial pulp blank has been used.

Standard performance was monitored by charting the analytical results over time against the concentration of the control elements. The results are compared with the expected value and range, as determined by round-robin analysis. A total of 32 different standard reference materials were used to monitor the assay results from 1997 through 2013. Copper and gold standards were inserted during the 2002 through 2013 programs. Molybdenum standards were added in September 2008.

In December 2007, several tons of coarse reject samples from Pebble East and Pebble West were pulled from storage and shipped to Ore Research & Exploration Pty Ltd in Melbourne, Australia, for the production of ten matrix-matched certified reference materials. These standards (PLP-1 through PLP-10) became available in late 2009 and have been used to monitor the Pebble analytical results since that time. Nine of the standards from Cretaceous rock are certified for gold, copper, molybdenum, silver and arsenic. One standard (PLP-2) is from Tertiary rock and is certified for copper, molybdenum, arsenic, silver and mercury.

A standard determination outside the control limits indicates a control failure. The control limits used are as follows:

- warning limits: ±2 standard deviations; and,
- control limits: ±3 standard deviations.

When a control failure occurred, the laboratory was notified and the affected range of samples re-analyzed. By the end of the program, no sample intervals had outstanding QA/QC issues. The standard monitoring program provides a good indication of the overall accuracy of the analytical results.

12.1.2 Duplicates

Random duplicate samples were selected and tagged in the field by the use of sample tags on which the “DP” designation for “duplicate” was pre-marked. From 2004 onward, samples to be duplicated were split by ALS at Fairbanks and submitted to Acme (BVCCL) in Vancouver for pulverization.

The original samples were assayed by ALS of North Vancouver and the corresponding duplicate samples were assayed by Acme (BVCCL) of Vancouver. The approximately 2,000 coarse reject, inter-laboratory duplicate assay results from 2004 to 2010 match well; the correlation coefficients are 0.96 for gold, 0.98 for copper and 0.98 for molybdenum. In 2011 and 2013, the duplicate analyses rate of 9 in 200 samples was continued and the number of duplicate samples analyzed was doubled. The protocol was modified so that after every 20th mainstream sample analyzed within the regular sample stream an in-line, intra-laboratory coarse reject duplicate (a “prep-rep” duplicate) was analyzed. In addition to this, the original pulp of this sample was sent to Acme (BVCCL)in Vancouver for inter-laboratory check assaying when final QA/QC on the original samples was completed.

Figure 12.1-4 and Figure 12.1-5 provide a comparison of the matched-pair duplicate assay results of ALS and Acme (BVCCL) for 2004 through 2010.

Figure 12.1-4 **Comparison of Gold Duplicate Assay Results for 2004 to 2010**

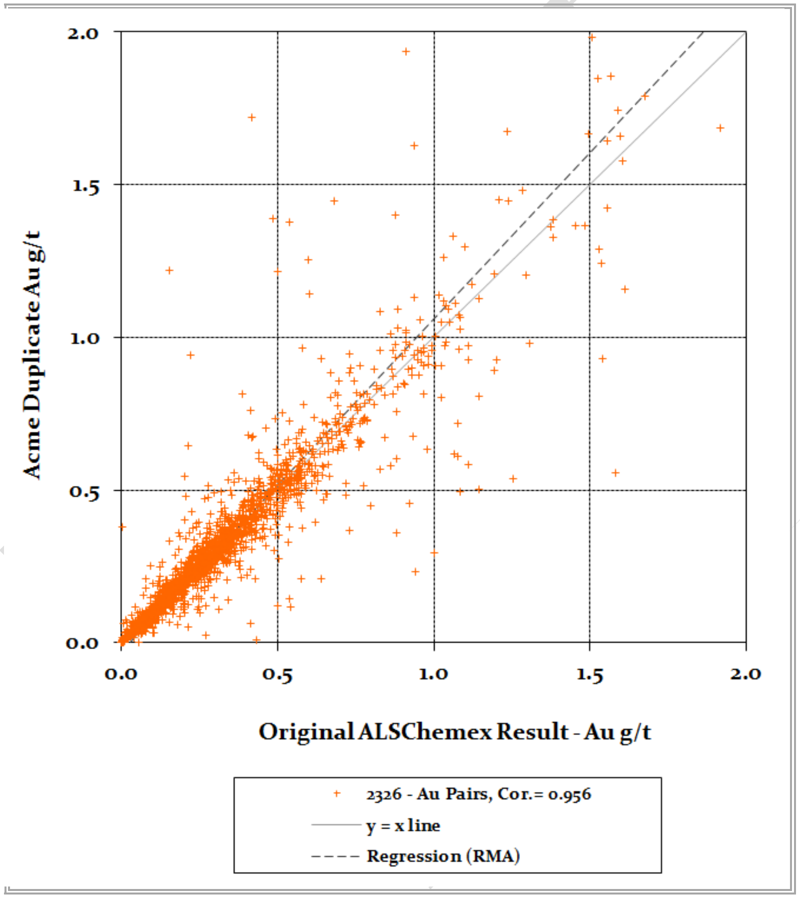
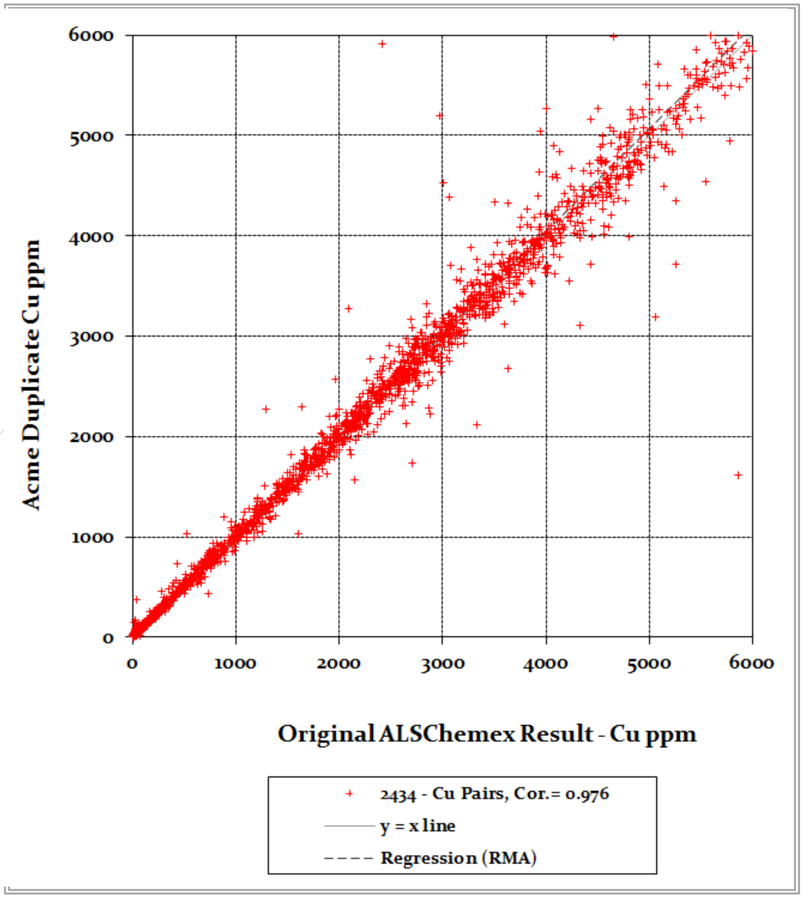


Figure 12.1-5 **Comparison of Copper Duplicate Assay Results for 2004 to 2010**



12.1.3 Blanks

A total of 1,362 field blanks have been inserted since 2004 to test for contamination. This is in addition to the analytical blanks routinely inserted with the samples by the assay laboratories as a part of their internal quality control procedures. In 2004, coarse landscape dolomite was inserted as a blank material. This material was replaced by gravel landscape material between 2005 and late 2008. In late 2008, the gravel blank was replaced by a quarried grey granitic landscape rock. This material has a lithological matrix similar to the Pebble Cretaceous host rocks.

About 1 lb of the blank was placed in a sample bag, given a sequential sample number in the sequence and randomly inserted one to six times per drill hole after the regular core samples were split at Iliamna. These blank samples were processed in sample number order along with the regular samples.

Of the blanks inserted, 444 were included in the Tertiary waste rock sample program in the position marked for the standard. In late 2008, a commercial precious metals pulp blank was inserted with the Tertiary waste rock samples. In late 2009, the use of matrix-matched Tertiary standard PLP-2 was initiated.

The majority of assay results for the blanks report at or below the detection limit. The maximum values reported in the current results are gold (0.028 g/t) and copper (0.057%). No significant contamination occurred during sample preparation, with a few minor exceptions, likely due to cross-sample mixing errors during crushing.

12.1.4 QA/QC on Other Elements

The four-acid digestion ICP-AES 33 multi-element analytical method employed from 2004 through 2013 is optimized for copper and molybdenum analysis. The copper and molybdenum assays were monitored by internal laboratory and external standards.

The lower detection limits of the suite of elements analyzed are as follows: copper (10 ppm), gold (0.001 ppm), molybdenum (0.05 ppm), silver (0.01 ppm), aluminum (0.01%), arsenic (0.2 ppm), barium (10 ppm), beryllium (0.05 ppm), bismuth (0.01 ppm), calcium (0.01%), cadmium (0.02 ppm), cerium (0.01 ppm) cobalt (0.1 ppm), chromium (1 ppm), cesium (0.05 ppm), iron (0.01%), gallium (0.05 ppm), germanium (0.05 ppm), hafnium (0.1 ppm), mercury (0.01 ppm), indium (0.005 ppm), potassium (0.01%), lanthanum (0.5 ppm), lithium (0.2 ppm), magnesium (0.01%), manganese (5 ppm), sodium (0.01%), niobium (0.1 ppm), nickel (0.2 ppm), phosphorus (10 ppm), lead (0.5 ppm), palladium (0.001 ppm), platinum (0.005 ppm), rubidium (0.1 ppm), rhenium (0.002 ppm), sulphur (0.01%), antimony (0.05 ppm), scandium (0.1 ppm), selenium (1 ppm), tin (0.2 ppm), strontium (0.2 ppm), tantalum (0.05 ppm), tellurium (0.05 ppm), thorium (0.2 ppm), titanium (0.005%), thallium (0.02 ppm), uranium (0.1 ppm), vanadium (1 ppm), tungsten (0.1 ppm), yttrium (0.1 ppm), zinc (2 ppm) and zirconium (0.5 ppm).

Parallel to this method (as described in Section 11.0), an ICP-MS 48 multi-element method was also used to determine the same 25 elements above and 23 additional elements. The ICP-MS method gives lower detection limits for most of the elements.

12.2 BULK DENSITY VALIDATION

The bulk density data were reviewed prior to the July 2008 resource estimation. The following types of errors were noted: entry errors, standards labelled as regular samples, incorrectly calculated density values based on the mass in air and mass in water values entered and extremely high or low-density values without appropriate explanation. These errors were investigated and corrected prior to including the data for resource estimation.

Two other possible sources of error in the measurements were identified: the presence of moisture in the mass in air measurement for some samples, and the presence of porosity and permeability of the bulk rock mass not determinable by the method. The former will result in measurements that are somewhat overstated, and the latter in measurements that are understated in terms of the dry in situ bulk density.

It is recommended that additional drying and wax coating tests be performed by an external laboratory under controlled conditions on a variety of samples already tested by the water immersion method. In addition, several samples of cut cylinders of core should be included with these tests, the dimensions of which can be accurately measured so that their volumes can be calculated directly. It is also recommended that the bulk in situ porosity and permeability of the rock mass be determined by geotechnical testing.

12.3 SURVEY VALIDATION

In 1988, Cominco (Teck) established a survey control network including the *Pebble Beach* base monument in the deposit area using U.S. State Plane Coordinate System Alaska Zone 5. This monument was tied to the NGS State Monuments Koktuli, PIG and RAP at Iliamna and formed the base for subsequent drill collar surveys. In 2004, air photo panels and a control network were established using NAD 83 US State Plane Coordinate System Alaska Zone 5 with elevations corrected to NAVD88 based on Geoid99.

In 2005, differences between the elevations of surveyed drill collars in the deposit area and the digital elevation model (DEM) topography were observed. In early 2008, a re-survey program was initiated to investigate and resolve these discrepancies. A consistent error was identified in the collar coordinates from some years, and questions arose as to whether drill collars had been surveyed to the top of the drill casing or to ground level. In September 2008, two new control points - Pebble 1 and Pebble 2 - were established by R&M Consultants Inc. of Anchorage in the deposit area; they tied these two points and the Pebble Beach monument into the 2004 control network and an x, y, z linear coordinate correction was applied to resolve previously observed drill hole elevation discrepancies.

Subsequently, during the 2008 and 2009 field seasons, all holes drilled at the Pebble Project since inception in 1988 were re-surveyed using a real time kinematic (RTK) GPS, referencing the coordinates of the *Pebble Beach* monument as established by the 2008 re-survey to gain a complete set of consistently acquired collar survey data. The majority of the drill holes were marked with a wooden post and an aluminum tag. In cases where the post was missing, the original coordinates were used to find evidence of the drill hole. Any hole missing a drill post was re-marked, and this was noted in the database. The resurveys were taken to the top of tundra over the centre of the drill hole. Where a drill hole could not be located, the resurveyed coordinate was taken at the original drill collar coordinates and the elevation re-established in the new system.

All post Cominco (Teck) holes were surveyed by single shot magnetic methods. In 2008, several angle holes were also surveyed by a non-magnetic gyroscopic tool.

12.4 DATA ENVIRONMENT

All drill logs collected on the Pebble Project have been compiled in a Microsoft® SQL Server database. Drill hole logs have been entered into notebook computers running the Microsoft® Access data entry module for the Pebble Project at the core shack in Iliamna. During drilling programs, the core logging computers are synchronized on a daily basis with the site master database on the file server in the Iliamna geology office. Core photographs are also transferred to the file server in the Iliamna geology office on a daily basis. In the geology office, the logs are printed, reviewed and validated, and initial corrections made.

The site data is transmitted on a weekly basis to the Vancouver office, where the logging data are imported into the Project master database and merged with digital assay results provided by the analytical laboratories. After importing, a further printing, validation and verification step follows. Any errors noted are submitted to the Iliamna office for correction. If analytical re-runs are required, the relevant laboratories are notified and corrections are made to the corresponding results within the project master database. Parallel to this, the independent QA/QC consultant compiles sample log data from the site with assay data received directly from the laboratories as part of the ongoing monitoring process. Compiled data are exported to the site entry database, to resource estimators, and to other users as required.

12.4.1 Error Detection Processes

Error detection within the data entry module is used in the core shack and the Iliamna geology office as part of the data verification process. This process standardizes and documents the data entry, restricts data which can be entered and processed, and enables corrections to be made at an early stage. Users are prompted to make selections from ‘pick-lists’, when appropriate, and other entries are restricted to reasonable ranges of input. In other instances, information must be entered and certain steps completed prior to advancing to the next step. After the logs have been entered, they are reviewed and validated by the logger and a copy printed out for the site files.

Site data are transmitted to the Pebble database compilation group on a weekly basis. Software validation routines are run to identify several types of errors. The compiled data from the header, survey, assay, geology and geotechnical tables are validated for missing, overlapping or duplicated intervals or sample numbers, and for matching drill hole lengths in each table. Drill hole collars and traces are viewed on plan view and in section by a geologist as a visual check on the validity of the collar and survey information.

As the analytical data are returned from the laboratory, they are merged with the sample logs and then printed out, and the gold, copper, molybdenum and silver values of the regular samples and QA/QC samples are reviewed. Particular attention is paid to standards that have failed QA/QC as they are targeted for immediate review; re-runs are requested from the analytical laboratory if necessary.

12.4.2 Analysis Hierarchies

The first valid QA/QC-passed analytical result received from the primary laboratory has the highest priority in the analytical hierarchy. If the same analytical method is used more than once, no averaging is done. If different analytical methods are employed on the same sample, the most appropriate combination of digestion and analytical method is selected and used.

For gold analysis, FA determined by gravimetric finish supersedes results by AAS or ICP finish, particularly where the AAS or ICP results are designated as over limits. For copper analysis done on Cretaceous rocks after 2004, ALS intermediate grade multi-element analytical method (code ME-ICP61a) supersedes copper by low grade multi-element method (code ME-MS61m).

In the case of all other elements, including molybdenum, silver and sulphur analyses from 2007 through 2013, the low grade multi-element method (code ME-MS61m) supersedes the intermediate grade multi-element method (code ME-ICP61a), unless the low grade method results are greater than the upper detection limit. In that case, the intermediate grade method result prevails.

12.4.3 Wedges

Some long holes, particularly in Pebble East, were intentionally wedged. This was undertaken when drilling conditions in the parent hole deteriorated to such an extent that continuation to target depth was impractical. For consistency of sample support for geological and resource modelling, mother hole/wedge hole combinations are represented by singular linear traces in the database. In treating the wedged portion of a hole that successfully extends beyond its parent hole, the following approach was used. The wedged portion of the hole was treated as a continuation of the mother hole from the point where the wedge starts. The information from the mother hole and the wedge was blended onto a string that follows the mother hole to the wedge point, and then follows the wedge (and the wedge surveys) to the end of the hole. The ‘best available’ information from the two hole strings was combined to produce one linear drill hole trace.

12.4.4 Control of QA/QC

Data are made available to the technical team for immediate use after the error trapping and initial review process is complete. However, at the time the data is made available, validation, verification and analytical QA/QC may still be in progress on recently-generated information. At the time the drill data was exported from the primary database for use in the current resource estimate, the results had been validated and all assay results had passed analytical QA/QC.

12.5 VERIFICATION OF DRILLING DATA

The 1997 and prior Cominco (Teck) data were validated by Northern Dynasty in 2003 using:

- the digital data and printed information;
- digital assay results obtained directly from ALS and Cominco Exploration Research laboratories, where available; and
- selected re-analysis of the original assay pulps.

Most of the pre-2002 data in the current database is derived from a digital compilation created by Cominco (Teck) in 1999. Twenty-eight gold results from 1988 and 1989 holes, which existed only on hand-written drill logs, were added to the database. Although a complete set of original information does not exist for all the historical holes and, in particular, the printed assay certificates were not found, the digital data appear to be of good quality. The data compiled by Cominco (Teck) matches the digital analytical data received directly from the laboratories, with few exceptions. Most differences appear to be due to separately reported over-limits and re-runs. The small number of errors identified in the Cominco (Teck) data, including mismatched assay data, conversion errors, unapplied over-limits and typographical errors were corrected.

The 2002 analytical data were also verified and validated. A few errors were identified and corrected. When the 2003 digital data were verified against the assay certificates, some differences with the printed certificates were identified. In 2003, the analytical results were provided by SGS in a digital format that included SGS internal standards, duplicates and blanks. These digital results differed from the values on the corresponding printed certificates in two ways: digits in excess of three significant figures were recorded, and results were not trimmed to the upper detection limit value. As a result, sixteen 2003 gold assays over 2,000 ppb had incorrect values assigned to them in the database. This was corrected by applying the correct FA over-limit re-run result to these samples in the database. No over-limits existed in the 2003 copper results so there were no errors with this element. The lone over-limit molybdenum value was left untrimmed, because this result was substantiated by an ALS check assay. Results from 2003 for elements other than gold, copper and molybdenum were left untrimmed in the database.

Norwest Corporation reported on additional data verification done in conjunction with the resource estimate in a technical report dated the February 20, 2004. "*Norwest received, from Northern Dynasty, the initial Pebble drill hole database in the form of an assay, collar, downhole survey and geology file. An audit was undertaken of 5% of the data within these files. Digital files were compared to original assay certificates and survey records. It was determined that the downhole survey file had an unacceptable number of errors. The assay file had an error rate of approximately 1.2%. This was considered acceptable for this level of study.*" These errors were investigated and subsequently corrected by Northern Dynasty.

The ongoing error-trapping and verification process for drill hole data collected from 2004 to 2013 is described in Section 12.4. Typically, validation and verification work for each year was completed by January of the following year, although some QA/QC issues took longer to resolve. Work at the Iliamna office consisted mostly of validating the site data entry and resolving errors that were identified.

Additional validation and verification work was performed in the Vancouver office. This consisted of checking the site data tables for missing, overlapping, unacceptable and mismatching entries, and reviewing the analytical QA/QC results. During verification of the data, a low number of errors were recorded. Erroneously labelled standards in the sample log were the main source of error. Digital values not matching the analytical certificates were the next area of concern. In this case, the digital data were usually correct, as the certificates had been superseded by new results from QA/QC re-runs.

In addition to typical database validation procedures, the copper, gold and molybdenum data included in Northern Dynasty news releases were manually verified against the results on the ALS analytical certificates.

A significant amount of due diligence and analytical QA/QC for copper, gold and molybdenum has been completed on the samples that were used in the current mineral resource estimate. This verification and validation work performed on the digital database provides confidence that it is of good quality and acceptable for use in geological and resource modelling of the Pebble deposit.

13.0 MINERAL PROCESSING AND METALLURGICAL TESTING

Metallurgical testwork for the Pebble Project was initiated by Northern Dynasty in 2003, and continued under the direction of Northern Dynasty until 2008. From 2008 to 2013, metallurgical testwork progressed under the direction of the Pebble Limited Partnership (PLP). During the same period, geometallurgy studies were conducted by PLP and continued until 2012. This section includes testwork review with a focus on tests completed from 2011 to 2013, geometallurgical studies, and an updated metal recovery projection.

13.1 TEST PROGRAMS SUMMARY

Metallurgical testwork for the Pebble Project can be divided into three stages. The first stage testwork was conducted from 2003 to 2005 to understand the metallurgical response of the mineralized materials and to develop a baseline process flowsheet. The second stage testwork, conducted between 2006 and 2010, was performed to optimize the baseline flowsheet on variability samples and to investigate appropriate processing methods to improve metal recoveries. The third stage testwork was focused on metallurgical verification tests on samples representing each metallurgical domain at the property in batch, pilot, and locked cycle tests. Testwork conducted during this period included evaluations of the performance of a secondary gold recovery plant. Such a plant has now been removed from the proposed process plant.

13.1.1 2003 to 2005 Testwork

The first stage metallurgical testwork was performed by different laboratories. Vancouver based Process Research Associates Ltd (PRA) testwork was preliminary in nature, which was followed by testwork completed by G&T Metallurgical Services Ltd. (G&T) in Kamloops, BC. Based on their test results, a comprehensive metallurgy test program was carried out at SGS Lakefield (SGS) laboratories located in Lakefield, ON. The basic flowsheet from PRA was optimized by testing on primary grind size, regrind size, flotation and gold leaching. In addition, comminution data were obtained from samples covering all of the lithology and alteration combinations in the mineral resource. A few miscellaneous tests were also performed including settling and filtration and concentrates properties. The SGS test results demonstrated that marketable concentrate over 26% copper could be obtained and production of molybdenum as a separate concentrate and gold doré by leaching were viable.

13.1.2 2006 to 2010 Testwork

The second stage metallurgical testwork, conducted between 2006 and 2010, covered comminution, gravity separation, flotation, leaching, settling tests and other miscellaneous testwork as listed in Figure 13.1-1. The main purpose of the testwork was to optimize the process flowsheet to incorporate supergene mineralization from the western portion of the Pebble deposit, and to explore the performance variability of composite samples from Pebble West zone and Pebble East zone mineralization.

Figure 13.1-1 Testwork Programs and Reports 2008 to 2010

Test Program	Laboratory	Report Date
Metal Recoveries Related Programs: Comminution/Flotation/Leaching Tests		
Screen Analysis Data on Rod Mill Feed	Phillips Enterprises, LLC	Apr 17, 2008
Rod Mill Grindability Test Data	Phillips Enterprises, LLC	Apr 18, 2008
Screen Analysis Data on Rod Mill Product	Phillips Enterprises, LLC	May 13, 2008
Bond Abrasion Test Data	Phillips Enterprises, LLC	Apr 22, 2008
Ball Mill Grindability Test Data	Phillips Enterprises, LLC	Jun 6, 2008
Screen Analysis Data on Ball Mill Feed	Phillips Enterprises, LLC	Jun 10, 2008
Screen Analysis Data on Ball Mil Product	Phillips Enterprises, LLC	Jun 24, 2008
Mail to the Pebble Partnership c/o Mr. Alex Doll, Final Report of Comminution QA/QC Testing	Phillips Enterprises, LLC	Jul 18, 2008
Technical Memorandum to Steve Moult of Pebble Partnership, Grinding Throughput Calculation Procedure for Mine Production Schedules	DJB Consultants Inc (DJB)	Sep 30, 2008
E-Mail Transmission, Compare JK SimMet SABC-A and SABC-B Throughput Prediction to Morrell Total Power Calculation for Selected 2010 SMC Samples; Also Morrell HPGR Predictions	Contract Support Services	Jan 21, 2010
E-Mail Transmission, Final Report, Pebble LOM Simulations, Years 1 to 13: SABC-A vs. SABC-B Circuit Options	Contract Support Services	Apr 7, 2010
E-Mail Transmission, Final Report, Pebble LOM Simulations, Years 1 to 25: SABC-A vs. SABC-B Circuit Options	Contract Support Services	Apr 29, 2010
E-Mail Transmission, Summary of Results, Pebble LOM Simulations: Years 1–45: SABC-A Revision B, Correct Year 8 Throughput	Contract Support Services	Dec 30, 2010
E-Mail Transmission, Summary of Results, Pebble LOM Simulations, Years 1–45: SABC-B Circuit Option, Comparison with SABC-A	Contract Support Services	Dec 30, 2010
An Investigation into the Recovery of Copper, Gold, and Molybdenum by Laboratory Flotation from Pebble Samples. Project 10926-008 Report #1	SGS Lakefield	Jul 6, 2006
An Investigation into Copper, Gold, and Molybdenum Recovery from Pebble East Phase I Composites. Project 11486-003 Report #1	SGS Lakefield	Jun 30, 2009
An Investigation into Bulk Flotation of Pebble East and West Composites, Project 11486-003 Report #2	SGS Lakefield	Jun 26, 2009
An Investigation into Aging of Pebble East Phase I Samples. Project 11486-003 Report #3	SGS Lakefield	Jun 30, 2009
Tank Cell e500 Mechanical Testwork	Outotec	Mar 11, 2010
Copper Sulphide Jar Mill Testing Test Plant Report #20002007	Metso	Apr 12, 2010

Test Program	Laboratory	Report Date
An Investigation into the Recovery of Copper, Gold, and Moly from Pebble East and West zones. Project 12072-002 Report #2	SGS Lakefield	Dec 21, 2009, Jan 24, 2010
Determination of GRG Content Final Report Revised # T1144	COREM	May 27, 2010
Gravity Modelling Report Project # KRTS 20587	Knelson Research & Technology Centre	Aug 17, 2010
Settling Tests		
Summary of High Rate Thickening Test Results Tailings Samples	Outotec	Apr 2, 2010
Outotec Thickener Interpretation and Recommendations for Test Data Report TH-0493	Outotec	Apr 9, 2010
Thickener Test Data Report # TH-0493	Outotec	Apr 9, 2010
Thickener Test Data Report # TH-0493_R1	Outotec	Apr 16, 2010
Thickener Test Data Report # TH-0497	Outotec	Jun 2, 2010
Outotec Thickener Interpretation and Recommendations for Test Data Report TH-0497	Outotec	Jun 17, 2010
Filtration Tests		
Test Report 12875T1 Pebble Partnership	Larox	Mar 8, 2010, Apr 7, 2010
Rheology Tests		
Report of Investigation into The Response of the Pebble Project Rougher Tailings to Sedimentation and Rheology Testing	FL Smith	Mar 2010

The major observations from the second testwork campaign are summarized as follows:

- Bulk flotation testwork was intended to optimize the flowsheet to treat the supergene and transition zones in Pebble West. Most samples achieved the 26% copper concentrate target, in the variability tests and the locked cycle tests.
- Copper-molybdenum locked cycle separation tests demonstrated, of the circuit feed, more than 99% of the copper was recovered to copper concentrate and 92.6 to 98.4% of the molybdenum was recovered to molybdenum concentrate.
- The molybdenum concentrate was found to contain significant rhenium, with grades ranging from 960 to 1,100 g/t, and the copper content observed was between 1.8% and 5.9%.
- Gravity recoverable gold (GRG) was determined to optimize gravity gold recovery. The obtained recovery was similar to 2008 testwork.
- Pyrite flotation was conducted with pyrite concentrate subjected to gold leaching tests. The average gold extraction was 55% by leaching for 48 hours.
- Other metallurgical testwork conducted in this period included tailings thickening, regrinding jar tests, and copper concentrate thickening and filtration.

13.1.3 Testwork Programs 2011 to 2013

The Pebble Partnership continued metallurgical testwork in 2011 and 2012 (Figure 13.1-2). The major goals of the 2011 and 2012 testwork program were as follows:

- Complete QEMSCAN (Quantitative Evaluation of Materials by Scanning Electron Microscopy) analysis of the variability sample inventory to support geometallurgical studies;
- Conduct additional flotation variability tests to ensure samples of each metallurgical domain type are represented; and,
- Conduct continuous flotation testwork to generate product for downstream testwork
- Conduct testwork related with the design of the secondary recovery gold plant, which has subsequently been removed from the process design and will not be discussed in detail herein.

Figure 13.1-2 Subsequent Testwork Programs and Reports, 2011 to 2013

Test Program	Laboratory	Report Date
Metal Recoveries – Comminution/Flotation/Leaching		
An Investigation into Ultrafine Grinding of Pilot Plant Concentrates from the Pebble Deposit	SGS Lakefield	Feb 9, 2011
An Investigation into the Grindability Characteristics of a Single Sample W-214-215 from the Pebble West zone	SGS Lakefield	Apr 6, 2011
Continuous Flotation of Five Composites from the Pebble Deposit	SGS Lakefield	Jun 21, 2011
Copper Molybdenum Separation Testing on a Pebble Bulk Concentrate	G&T Metallurgical Services Ltd.	Sep 22, 2011
An Investigation into the Recovery of Copper, Gold, and Molybdenum from the Pebble Deposit; Incomplete; Progress Report, Project 12072-003 and -007	SGS Lakefield	Jan 24, 2012
Concentrate Quality		
An Investigation by High Definition Mineralogy into the Mineralogy Characteristics of Five Concentrate Samples from Five Different Composites	SGS Lakefield	Mar 23, 2011
An Investigation into a Deportment Study of Gold in Eight Samples from the Pebble Gold zone	SGS Lakefield	Jun 17, 2011
An Investigation by High Definition Mineralogy into the Mineralogy Characteristics of Eight Products of Three Pilot Plant Samples	SGS Lakefield	Jun 23, 2011
Filtration		
Filtration Test Report	Outotec	Jun 17, 2011
Rheology Tests		
Grinding Transfer Stream Rheology Testwork Report, Report # PBL-5172 R02 Rev 0 & Rev 1	Paterson & Cooke	Sep 2011, Oct 2011
Bulk Tailings Rheology Testwork Report. Report # 4303207-25-RP-002	Paterson & Cooke	Nov 2011

13.2 COMMINUTION TESTS

13.2.1 Bond Grindability Tests

The Bond rod mill index (RWi) and Bond ball mill work index (BWi) are listed in Figure 13.2-1 and, Figure 13.2-2, respectively.

Figure 13.2-1 Pebble West Rod Mill Data Comparison, SGS January 2012**

	RWi (kWh/t)			
Core Year	2004	2005, 2006	2008	2011
Composites	-	W1 to W177	W178 to W394	W395 to W445
Year Tested	2005	2008, 2010, 2011	2009, 2010, 2011	2011
Results Available	295	47	19	3
Average	15.6	14.4	13.0	15.3
Minimum*	9.7	10.1	11.0	11.6
Median	15.3	14.0	12.8	12.6
Maximum*	24.3	20.4	19.5	21.7

Notes: *Minimum and maximum refer to softest and hardest values for the grindability test.
**Drilled samples are from the Pebble West zone at a grind particle size of 1.4 mm or 14 mesh.

Figure 13.2-2 Pebble West Ball Mill Data Comparison, SGS January 2012**

	BWi (kWh/t)			
Core Year	2004	2005, 2006	2008	2011
Composites	-	W1 to W177	W178 to W394	W395 to W445
Year Tested	2005	2008, 2010, 2011	2009, 2010, 2011	2011
Results Available	295	57	72	2
Average	14.2	14.0	13.4	11.7
Minimum*	7.7	8.4	8.0	11.4
Median	14.0	13.7	12.7	11.7
Maximum*	22.1	21.7	20.4	12.1

Notes: *Minimum and maximum refer to softest and hardest values for the grindability test.
**Drilled samples are from the Pebble West zone, at a grind particle size of 0.147 mm or 100 mesh for the 2005 tests, and 0.204 mm/65 mesh for the remaining tests.

13.2.2 Bond Low Energy Impact Tests

Comminution testwork was carried out on samples collected between 2004 and 2010, and summarized in the January 2012 SGS report. These data are reproduced in Figure 13.2-1 through 4. The testwork completed is considered to be representative of the deposit. Figure 13.2-1 shows the Bond low-energy impact test results on Pebble West zone samples. The tests were completed by Philips Enterprises, LLC under the supervision of SGS.

Figure 13.2-3 Bond Low-Energy Impact Test Results, SGS January 2012

	CWi (kWh/t)			Rock Density
	Average	Minimum	Maximum	
Average*	9.9	5.3	17.8	2.52
Minimum	3.7	1.6	8.1	2.38
Median	10.0	5.3	17.7	2.54
Maximum	15.6	10.5	33.9	2.68

Note: *Average of 22 drilling samples from Pebble West zone.

13.2.3 SMC Tests

Figure 13.2-4 compares the SAG mill comminution (SMC) test results, all of which were conducted on Pebble West zone samples.

Figure 13.2-4 JK Tech/SMC Data Comparison SGS January 2012**

	A x b			Mineralized Material Densities		
Core Years	2004	2005, 2006	2008	2004	2005, 2006	2008
Composites	-	W1 to W177	W178 to W394	-	W1 to W177	W178 to W394
Years Tested	2005	2008, 2010, 2011	2009, 2010, 2011	2005	2008, 2010, 2011	2009, 2010, 2011
Results Available	47	53	64	47	53	64
Average	43.5	44.0	50.1	2.59	2.60	2.60
Minimum*	89.4	89.4	135.2	2.43	2.43	2.38
Median	42.6	43.2	45.6	2.61	2.62	2.59
Maximum*	24.0	24.0	26.1	2.76	2.76	2.90

Notes: * Minimum and maximum refer to softest and hardest values for the grindability test.

** Drilled samples are all from the Pebble West zone.

13.2.4 MacPherson Autogenous Grindability Tests

Two variable samples from the Pebble West zone were blended and sent to SGS Lakefield for MacPherson autogenous grindability tests. The test results are shown in Figure 13.2-5. The composite sample was categorized as medium with respect to the throughput rate, the specific energy input, and the final grind. The composite sample is near the median of the Pebble West distribution for A x b, drop weight index (DWI) and BWi.

Figure 13.2-5 MacPherson Autogenous Grindability Test Results, SGS January 2012

Sample	Feed Rate (kg/h)	F_{80} (µm)	P_{80} (µm)	Gross Work Index (kWh/t)	Correlated Work Index (kWh/t)	Gross Energy Input (kWh/t)	Hardness Percentile
W214/215	12.4	22,176	331	13.6	12.6	6.5	31

13.3 METALLURGICAL TESTS

Focusing on the on-site production of three final products (copper concentrate, molybdenum concentrate and gold doré), flotation tests primarily consisted of:

- flotation tests to produce a bulk flotation concentrate containing copper, gold and molybdenum;
- further separation of copper from molybdenum; and,
- pyrite flotation tests with the concentrate to be further treated by cyanide leaching method in a carbon-in-leach (CIL) circuit. This will not be discussed in detail herein as cyanide leaching has been removed from the process design.

Some other tests were also carried out at a preliminary level to optimize metal recoveries, including gravity recoverable gold (GRG) tests and sulphidization, acidification, recycling, and thickening (SART) process tests to recover copper from leaching circuit residue. SART test results are not included due to removing cyanide applications in the process design.

13.3.1 Recovery of Bulk Flotation Concentrate Cu/Au/Mo

13.3.1.1. FLOTATION KINETICS AND PRELIMINARY OPTIMIZATION

In 2011 and 2012 test programs, SGS investigated flotation kinetic properties. Both rougher flotation and first cleaner flotation were tested on various samples; pH value, reagent type/dosage/addition points and pulp density factors were varied in order to determine optimized conditions for subsequent batch cleaner and locked-cycle tests.

The 2011 program focused on bulk rougher kinetics tests on composite samples representing supergene and hypogene rock types. The 2012 program included rougher flotation kinetics on the individual variability sample W182, representing supergene, and four domain composite samples, namely K-silicate, supergene, sodic potassic and illite-pyrite. Additional first cleaner kinetics was also investigated on the four domain samples.

The observations from the two programs are summarized as follows:

- Rougher pH Level (SGS 2011)
  - By increasing pH values of the rougher flotation stage to about 8.5, metal recoveries to rougher concentrate can be significantly increased. This was attributed to the low average natural pH value of the four sample types (i.e., 5.8, 5.7, 7.2 and 6.2).
- Rougher Reagent Dosage and Addition Points (SGS 2011)
  - A rougher flotation collector comparison was made between using only potassium ethyl xanthate (PEX) as the collector versus PEX with the promoter (AERO 3894) added. It was observed that metal recoveries increased for supergene with the addition of AERO 3894; however, metal recovery increases were not demonstrated for other samples.
  - Collector dosages for PEX and AERO 3894 were tested at 27.5 g/t and 45 g/t, respectively. The results indicated that adding 27.5 g/t PEX was sufficient for the first two rougher stages. The optimized retention time is about 12 minutes for the rougher stage.

- Rougher Sulphidization (SGS 2012)
  - Tests on sample W182 were performed to investigate the effect in the rougher stage of using sodium hydrosulphide (NaHS) to achieve a target of a reduction potential (-140 mV measured with silver/silver cleaner) electrode. There were no observed effects on metal recoveries to the rougher concentrate.
- Rougher Pulp Density (SGS 2012)
  - Tests on one composite sample indicated that reducing pulp density from 30 to 25% improved gold and molybdenum recovery significantly, while copper recovery was unaffected.
- Flotation Rate (SGS 2011/2012)
  - The supergene sample was found to be the slowest to recover copper, gold and molybdenum in the rougher flotation stage and the K-silicate sample the fastest. The indicated retention time for rougher flotation is approximately 12 minutes. At the first cleaner stage, all samples presented similar flotation rates in terms of copper recovery, with the molybdenum recovery rate being the slowest. The retention time indicated by the tests for first cleaner flotation is six minutes.

13.3.1.2. FLOTATION TESTS ON VARIABILITY SAMPLES

SGS has conducted significant flotation testwork since mid-2009 on both the Pebble West and Pebble East zones. The baseline flowsheet is shown in Figure 13.3-1**Error! Reference source not found.**. The target pH value for the rougher flotation stage was set at 8.5, and the P_{80} feed particle size was about 200 µm. The regrind size, reagent dosage and types and pH levels in the cleaner flotation stage were varied across the testwork in order to determine the optimal copper grade of the bulk concentrate.

SGS conducted batch cleaner tests on 146 variability samples from the Pebble West and Pebble East zones. The variability samples represented the flotation domains as described in Section 13.3.1, and should be considered representative of the mineralized material. Five of the variable batch cleaner tests were performed on the low copper grade samples. At an average feed grade of 0.16% copper, a bulk concentrate containing about 29.3% copper can be recovered at a 68.1% recovery. This indicates that a saleable concentrate can be produced from low-grade mineralized material.

SGS also performed locked-cycle tests on 107 variability samples from the Pebble West and Pebble East zones, the results of which are summarized in

Figure 13.3-2. The average metal recoveries were higher than with the batch tests, while the metal grades were slightly lower. Three duplicate locked-cycle tests were performed, with results in a similar range to those obtained from the variable locked-cycle tests.

Figure 13.3-1 Basic Testwork Flowsheet, SGS 2011

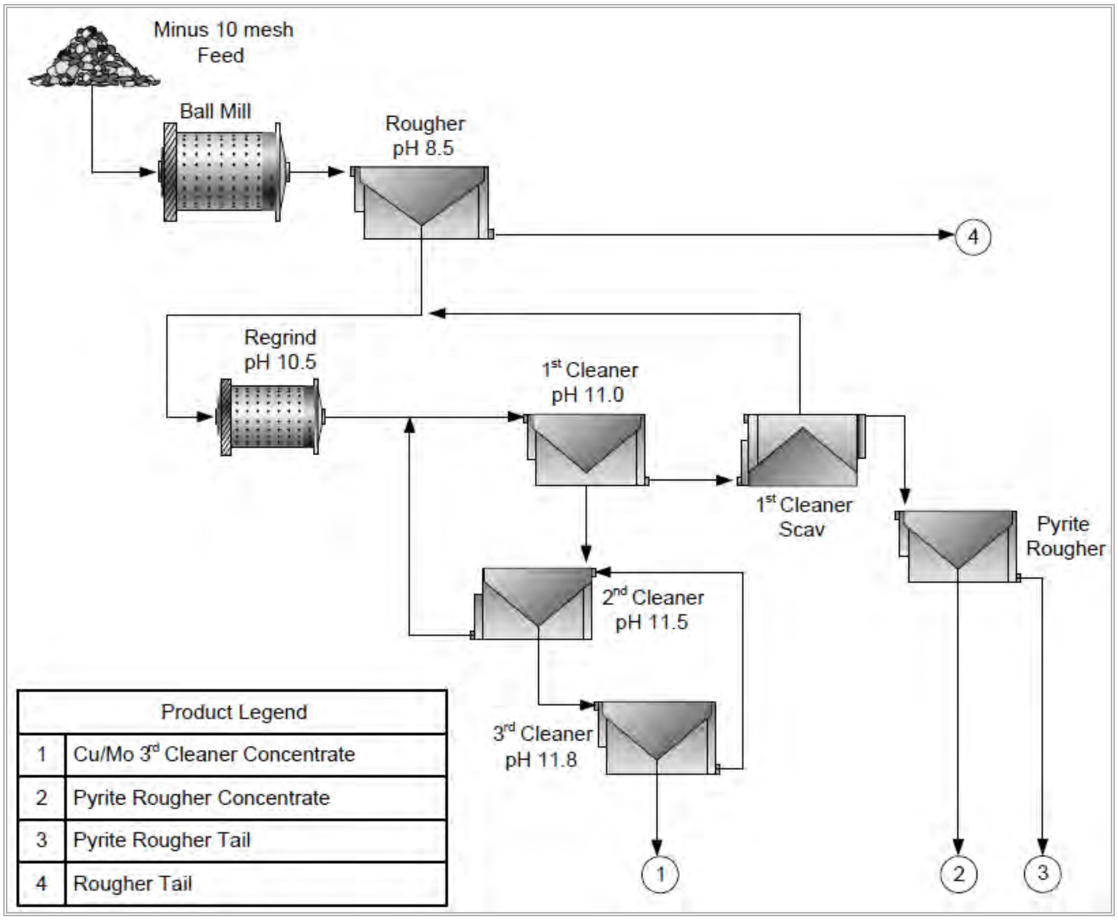


Figure 13.3-2 Summary of Locked-Cycle Test Variability Test Results

Domain	Feed Properties						3rd Cl Average Grade			3rd Cl Average Rec		
	Py	Cpy	Py:Cpy	Cu	Au	Mo	Cu	Au	Mo	Cu	Au	Mo
	%	%		%	gpt	%	%	gpt	%	%	%	%
Supergene Illite Pyrite	6.8	0.8	7.0	0.33	0.4	0.011	24.1	37.7	0.8	64.3	36.0	61.0
Supergene Sodic Potassic	3.3	1.0	4.0	0.48	0.42	0.016	30.7	19.6	0.8	75.4	53.8	54.7
Hypogene Illite Pyrite	6.4	1.0	6.3	0.36	0.43	0.015	27.2	18.3	1.1	83.8	44.2	77.3
Hypogene Sodic Potassic	3.7	1.0	4.8	0.35	0.38	0.024	27.5	19.5	1.8	84.6	55.6	79.8
Hypogene K-Silicate	3.1	2.3	1.9	0.63	0.62	0.024	27.6	21.4	1.2	90.8	59.6	88.4
Hypogene Sericite	8.3	1.9	6.1	0.66	0.36	0.031	25.1	7.6	1.3	82.5	41.9	82.0
Hypogene Quartz-sericite-pyrite	11.8	2.2	6.9	0.58	0.33	0.036	25.7	5.7	1.6	86.0	33.0	85.6
Hypogene Quartz Pyrophyllite	18.1	5.0	3.7	1.51	0.83	0.027	30.5	11	0.5	93.6	60.9	84.5

Definitions: cleaner (Cl), pyrite (Py), chalcopyrite (Cpy), pyrite to chalcopyrite ratio (Py:Cpy), Recovery (Rec)

13.3.1.3. FLOTATION TESTS OPTIMIZATION

SGS made a few attempts to improve the copper grade in the obtained bulk concentrate for samples with high clay and/or pyrite/chalcopyrite content. SGS observed that:

- Adding sodium silicate did not appear to have a beneficial impact on the selectivity of metal recovered to rougher flotation concentrate;
- Reducing pulp density from 35% to 28% solids improved metal recoveries, especially with molybdenum;
- For samples high in pyrite, adding dextrin helped to achieve the desired 26% copper of bulk concentrate copper/gold/molybdenum; however, it was also noted that extra fuel oil will be required when adding dextrin. SGS also recommend considering a ratio of sulphur to copper of 10.0 to identify if dextrin addition is required;
- The effects of regrind size, and pulp temperature were further investigated in batch cleaner flotation tests and in the locked-cycle tests. The testwork was performed by SGS in both 2011 and 2012, resulting in the following major conclusions: the investigated regrind size P_{80} of 15 to 58 µm had little impact on copper recovery or grades, while a finer regrind size benefitted both gold and molybdenum recovery; and,
- There was no observed impact from changing the pulp temperature from 5°C to 25°C on metal metallurgical performance.

SGS also compared two other frothers (HP700 and W22 C) with the primary frother, methyl isobutyl carbinol (MIBC). SGS found that the HP700 froth bed was less stable than that of the MIBC; W22 C showed better molybdenum recovery, and a lower dosage produced similar metal recoveries. SGS also compared the lower cost collector sodium ethyl xanthate (SEX) with PEX, and concluded that interchanging SEX and PEX had no effect on metal recoveries.

13.3.1.4. FLOTATION TESTS ON BULK COMPOSITES

As part of SGS's 2011 test program, bulk flotation tests on a locked-cycle scale were conducted on illite-pyrite, carbonate and supergene composites. The purpose of this testwork was to produce large quantities of products that could be used for vendor testwork. It should be noted that the carbonate composite sample was an early geometallurgical domain type classification, and was redefined as sodic potassic in later geometallurgical studies. The locked-cycle test results are shown below in Figure 13.3-3. SGS observed that the illite-pyrite composite did not reach the target copper grade of 26%. SGS suspected this may be caused by a low head grade and the presence of high levels of pyrite and clay minerals.

Figure 13.3-3 Locked-Cycle Test Results of Bulk Samples, SGS 2012

Composite	Regrind Size P_{80} µm	Cu/Mo Concentrate Grade				Cu/Mo Concentrate Recovery %		
		Cu %	Au		Mo %	Cu	Au	Mo
			g/t	oz/ton				
Illite-Pyrite	28	10.4	11.2	0.327	0.20	77.0	40.3	34.9
Carbonate	37	28.4	10.7	0.312	1.25	79.4	43.5	59.8
Supergene	38	27.1	16.0	0.467	1.64	70.6	47.3	70.0

13.3.1.5. Flotation Tests on continuous Composites

A small scale continuous flotation plant was utilized on five composite samples from the Pebble deposit to generate additional quantities of sample for vendor testwork. The five composites ranged in head grade from 0.28 to 0.57% Cu, from 0.30 to 0.46 g/t Au, and from 0.010 to 0.028% Mo. The main purpose of this continuous flotation testwork was to generate product for downstream testwork and to evaluate the implementation of a gravity circuit on a portion of the feed to the regrind mill.

The pilot plant was completed over a series of day shifts and continuous runs. Overall, 28 runs were completed: 17 on the commissioning, 3 on the sodic potassic, 2 on the K-silicate, 3 on the supergene, and 3 on the illite pyrite composites.

Any further continuous testwork would ideally be completed on a higher feed rate and a sufficient amount of operation time would be reserved for reagent optimization. Future testwork should include adequate sample to optimize Mo recovery by (1) increasing the cleaning circuit retention time and (2) optimizing reagent dosages. The addition of a Knelson concentrator in the regrind circuit of a pilot plant was challenging due to the amount of water generated by the Knelson circuit. The additional water generated was finally managed by using a thickener to treat the Knelson tailings stream.

The continuous flotation results for the K-Silicate composite were close to the locked cycle test results, with the exception that Mo recoveries were slightly lower. The continuous flotation Cu recovery for the supergene composite was higher compared to the locked cycle test result. For the remaining three composites, Cu and gold recoveries were 7% lower, on average. Except for the supergene composite, Mo losses to the rougher tail were almost twice as high as in the locked cycle test. Final concentrate Mo recoveries were almost half the LCT recoveries. The Mo recovery to the final concentrate would likely improve with longer retention times in the 2nd and 3rd cleaning stages.

One of the main purposes of the pilot plant was to determine the amount of Au that could be recovered by adding a Knelson concentrator in the regrind circuit. The Knelson concentrator treated a 33% bleed stream from the regrind cyclone underflow. The average Au recovery to the Knelson concentrate ranged from 2.6% for the Supergene composite to 7.5% for the K-silicate composite. A comparison of metallurgical performance with and without the Knelson concentrator indicated similar overall Au recoveries to a 26% Cu concentrate.

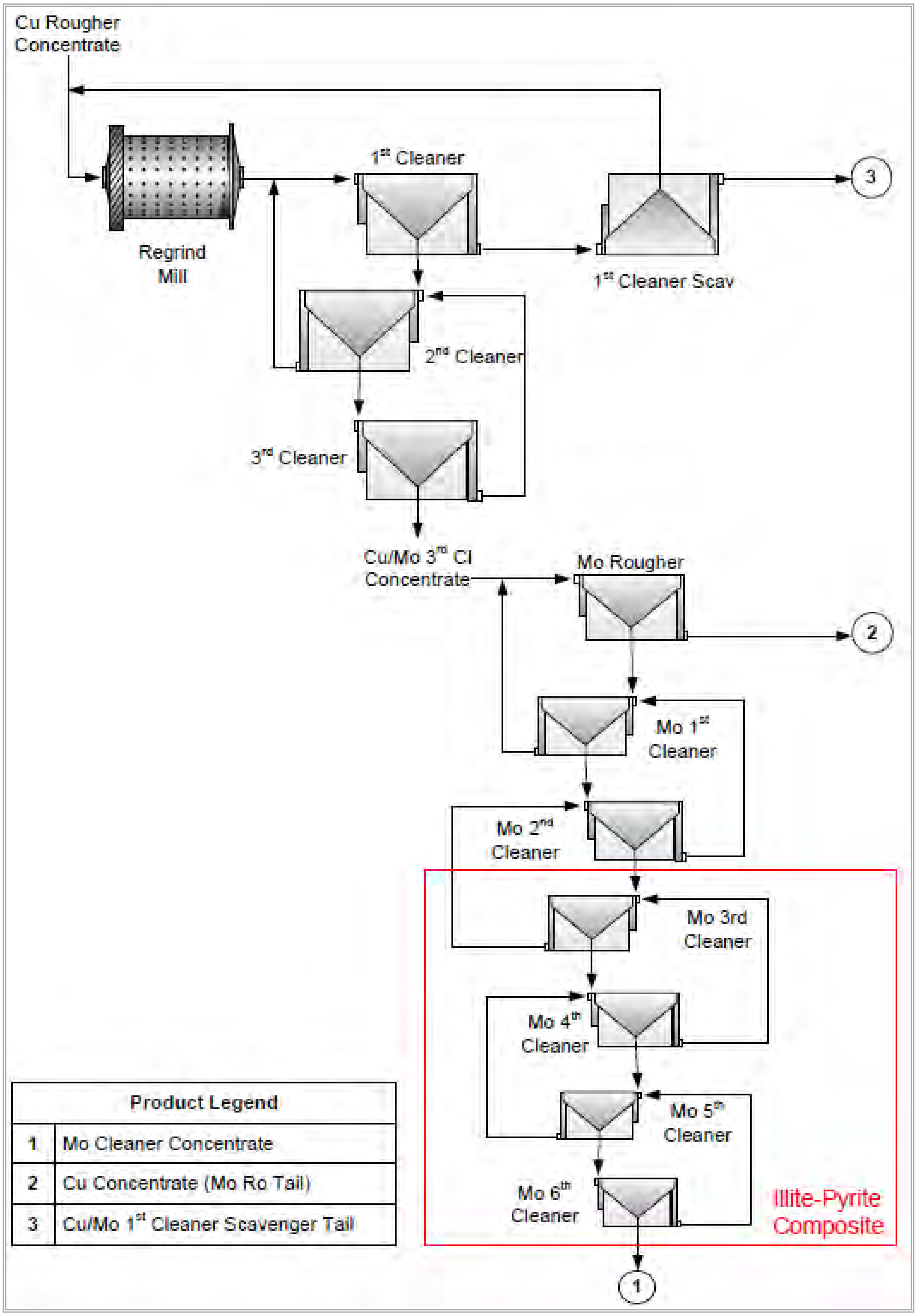
13.3.2 Separation of Molybdenum and Copper

Separation of molybdenum from copper in the bulk flotation concentrate was tested by SGS in the 2011 and 2012 programs. In addition, G&T also performed separation tests on one sample.

13.3.2.1. SGS SEPARATION WORK, 2011 AND 2012

Preliminary separation tests for molybdenum and copper were performed on three composite samples, including illite-pyrite, carbonate and supergene (SGS 2011). The locked-cycle tests in the 2011 program employed a basic flowsheet, as shown in Figure 13.4.4. The cycle numbers were varied in order to achieve the target grade of a final molybdenum concentrate.

Figure 13.3-4 Basic Testwork Flowsheet, SGS 2011



Product Legend	
1	Mo Cleaner Concentrate
2	Cu Concentrate (Mo Ro Tail)
3	Cu/Mo 1st Cleaner Scavenger Tail

The 2011 program results outlined in Figure 13.3-5 show that only the carbonate composite achieved a molybdenum grade of 50%, while the other two composite samples were unable to produce a marketable molybdenum product. Increasing the locked cycles from 3 to 6 for the illite-pyrite composite produced only a marginal increase in molybdenum grade.

As part of the 2012 testing program, further tests to improve the molybdenum separation were conducted on four domain samples. The commissioning sample, which represented the sodic potassic domain, was used to optimize the flotation conditions required for copper-molybdenum separation. A series of open cycle and kinetic tests were conducted to establish the conditions for the commissioning composite locked cycle test. Results of the locked cycle tests are provided in Figure 13.3-5.

Locked cycle test results for the latter three composites were found to be below expectation. It should be noted that the locked cycle tests conducted on the illite pyrite, sodic potassic and supergene composites were carried out without the open cycle tests to confirm conditions (due to their smaller mass compared to the commissioning composite), and by a different flotation operator than previous. Molybdenum head grades of the bulk cleaner concentrates from the three problematic domain samples were also below typical values achieved in locked cycle tests which may have contributed to the poor results. Further investigation confirmed that major molybdenum loss occurred in the rougher circuit.

Addition of the flotation reagent NaSH in the rougher state was found to be too high, resulting in unacceptable molybdenum depression. Adding a scavenger stage to the rougher flotation resulted in significant improvements in molybdenum recovery of approximately 15% for the sodic potassic composite, and over 30% for the illite pyrite composite. The scavenger tests were not conducted for the supergene composite due to lack of sample.

Figure 13.3-5 Locked-Cycle Test Results of Molybdenum Flotation, SGS 2011-2012

Composite	Regrind Size P_{80} µm	Mo Concentrate							Cu Concentrate						
		Grade				Recovery %			Grade				Recovery %		
			Au							Au					
		Cu %	g/t	oz/ton	Mo %	Cu	Au	Mo	Cu %	g/t	oz/ton	Mo %	Cu	Au	Mo
SGS 2011															
Illite-Pyrite	28	5.93	15.4	0.500	11.6	0.7	0.9	32.3	10.5	11.1	0.324	0.015	76.3	39.4	2.6
Carbonate	37	1.81	3.96	0.116	49.7	0.1	0.4	55.5	29.0	10.9	0.318	0.091	79.3	43.1	4.2
Supergene	38	3.46	3.84	0.112	38.7	0.4	0.5	68.9	28.1	16.5	0.482	0.027	70.2	46.8	1.1
SGS 2012															
Commission	-	1.86	2.12	0.0619	48.2	0.2	0.3	92.7	21.8	11.2	0.327	0.068	99.8	99.7	7.3
Sodic Potassic	-	3.01	N/A	N/A	41.1	0.1	N/A	83.6	23.3	N/A	N/A	0.074	99.9	N/A	16.4
Illite-Pyrite	-	3.19	N/A	N/A	43.5	0.02	N/A	79.8	23.8	N/A	N/A	0.14	99.8	N/A	20.2
Supergene	-	2.42	N/A	N/A	43.8	0.1	N/A	86.9	29.8	N/A	N/A	0.078	99.9	N/A	13.1

13.3.2.2. G&T SEPARATION WORK

G&T tested molybdenum recovery from bulk flotation concentrate, using one sample of copper-molybdenum bulk concentrate (G&T 2011). The head analysis indicated that the bulk concentrate had high levels of pyrite (about 13.2%) and galena (about 0.5%). Due to the limited sample size, only two batch cleaner tests were performed on the bulk concentrate sample. A regrind stage was used in Test 1, while no regrinding was performed in Test 2. The test results are summarized in Figure 13.4.6.

Test 1 and Test 2 results were 50.6% and 47.6% for molybdenum grades in the final molybdenum concentrates, and recoveries were 76.2% and 74.7% molybdenum, respectively. G&T recommended further testing be considered, including locked-cycle tests and other potential reagent schedules.

Figure 13.3-6 Molybdenum Recovery, G&T 2011

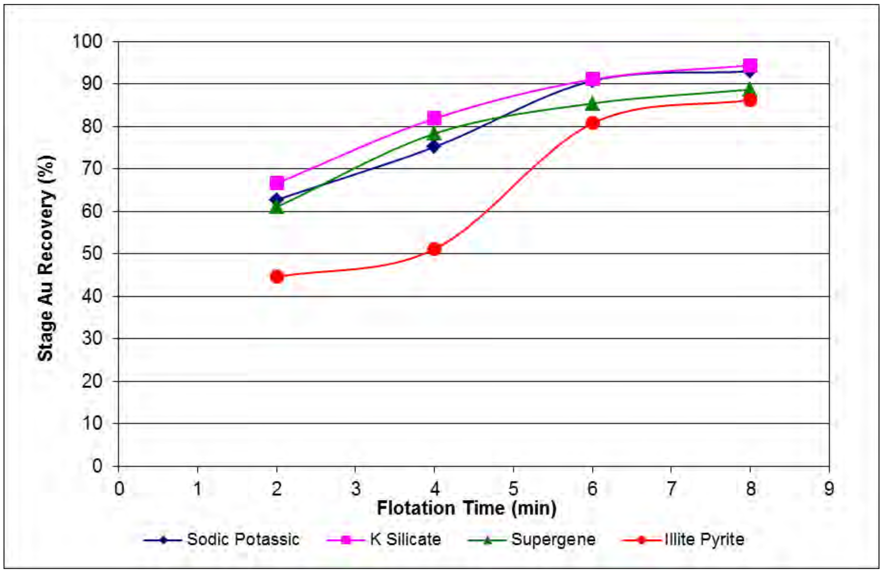
	Regrind Size P_{80} µm	Grade				Recovery %		
			Au					
		Cu %	g/t	oz/ton	Mo %	Cu	Au	Mo
Test 1	33	-	-	-	-	-	-	-
Molybdenum Concentrate	-	1.45	2.36	0.0689	50.6	0.1	0.2	76.2
Molybdenum 3rd Cl Tail	-	12.9	18.9	0.552	12.1	0.1	0.2	3.0
Molybdenum 2nd Cl Tail	-	24.2	35.4	1.034	3.89	1.2	3.1	6.9
Molybdenum 1st Cl Tail	-	24.3	27.7	0.809	1.47	5.3	10.4	11.3
Molybdenum Ro Tail	-	26.3	14.2	0.415	0.02	93.3	86.2	2.6
Test 2	49	-	-	-	-	-	-	-
Molybdenum Concentrate	-	2.74	3.92	0.114	47.6	0.1	0.3	74.7
Molybdenum 3rd Cl Tail	-	14.8	21.2	0.619	8.18	0.1	0.2	1.4
Molybdenum 2nd Cl Tail	-	21.3	38.4	1.12	5.51	0.5	1.5	4.3
Molybdenum 1st Cl Tail	-	27.9	28.4	0.829	0.80	3.6	6.5	3.6
Molybdenum Ro Tail	-	26.0	13.9	0.406	0.12	95.8	91.5	16.0

Ro – rougher; Cl - cleaner

13.3.3 Pyrite Flotation

A pyrite flotation step was included as part of the locked cycle variability tests described in Section 13.5.1.2. Pyrite flotation stage gold recoveries from the initial samples tested were found to be highly variable, using a four minute laboratory flotation time. In order to optimize the pyrite flotation metallurgy, SGS performed a series of kinetics tests using first scavenger tailings generated from four domain composite samples. Results of the tests are summarized in Figure 13.3-7 which shows the optimum laboratory flotation time occurs at approximately six minutes.

Figure 13.3-7 Pyrite Flotation Kinetics Test Results



13.4 GOLD RECOVERY TESTS

Both gravity concentration method and cyanide leaching methods were investigated as part of metallurgical test program to recover gold from the mineralized samples. Secondary gold recovery using cyanide is not part of the project plan currently advancing through permitting, so is not included in this section.

13.4.1 Gravity Recoverable Gold Tests

Three composite samples, representing illite-pyrite, carbonate and supergene mineralization types, were tested for gravity recoverable gold potential in COREM's facility (COREM, 2010). GRG tests were carried out on the variable samples reground to a target particle size P_{80} of 25 µm. Using a modified GRG test, the supergene sample had the highest GRG content of 33%, followed by illite-pyrite with 29% GRG and carbonate at 23%.

In 2011, four composite samples from the continuous testwork program were tested for gravity recoverable gold. The K-silicate sample had the highest GRG potential at 49%, followed by sodic potassic (41%), supergene (33%), commissioning (26%), and illite pyrite (25%).

13.5 AUXILIARY TESTS

13.5.1 Concentrate Filtration

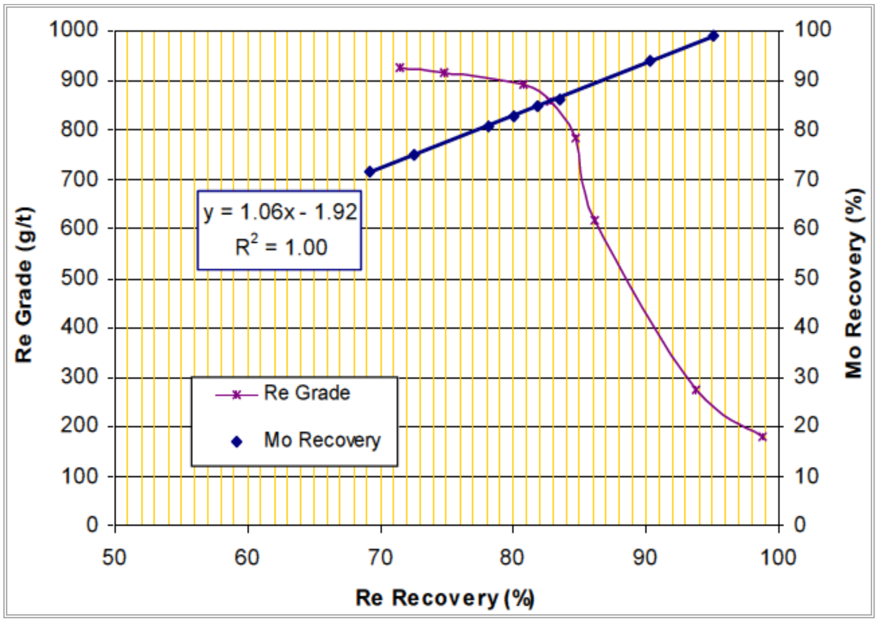
Outotec tested the filtration rates and cake moisture on a copper concentrate sample (Outotec June 2011). Three tests with varied pumping times were performed at Outotec's laboratory. With a feed solids density of 58 to 60% by weight, the cake moisture for all three tests was less than 9%. The measured filtration rate was between 569 and 663 kg/m²/h.

13.6 QUALITY OF CONCENTRATES

The results of assays obtained on locked cycle test Cu/Mo 3rd cleaner concentrates indicate that Pebble concentrates will not be problematic in terms deleterious elements. The assays showed deleterious elements to be below the penalty trigger for almost all of the 75 samples tested, with the exception of two supergene samples that exceeded for arsenic, one sodic potassic sample for antimony, one illite pyrite sample for zinc, and two illite pyrite and one sodic potassic samples for mercury.

In addition to copper, molybdenum, gold and silver, rhenium was also identified in the bulk flotation concentrates (SGS, 2012). The rhenium concentration measured between 0.082 g/t to a high of 3.56 g/t. Rhenium can be recovered in the molybdenum flotation tests. In test Mo-F13, the rhenium grade was increased to 26.3 g/t in the molybdenum concentrate. Figure 13.6-1 shows the rhenium grade and recovery relationship from test Mo-F13.

Figure 13.6-1 Rhenium Grade and Recovery Relationship SGS 2012



13.7 GEOMETALLURGY

13.7.1 Introduction

Geometallurgical studies were initiated by the Pebble Partnership in 2008, and continued through 2012. The studies were conducted in partnership between the Geology and Metallurgy Departments. The principal objective of this work was to quantify significant differences in metal deportment that may result in variations in metal recoveries during mineral processing.

Characterization of the respective geometallurgical domains within the deposit was based on the acquisition of detailed mineralogical data determined using QEMSCAN mineral mapping technology. QEMSCAN was used to form the basis for definition of the geometallurgical domains as follows:

- To determine the mineralogy of samples;
- To classify them by alteration assemblage;
- To assess variations in copper mineral speciation; and,
- To locate gold inclusions down to 1 µm in diameter and characterize their size, shape, composition and host mineralogy.

The results of the geometallurgical studies indicate that the deposit comprises numerous geometallurgical (or material type) domains. These domains are defined by distinct, internally consistent copper and gold deportment characteristics that correspond spatially with changes in silicate alteration mineralogy. Overall metal deportment reflects characteristics developed during both initial metal introduction during mineralizing alteration stages and subsequent redistribution by overprinting alteration types.

Chalcopyrite is the dominant copper mineral in most of the deposit. Bornite is an important component of advanced argillic alteration. Supergene enrichment, in the form of chalcocite rims on chalcopyrite occurs in the near surface portion of the deposit. Molybdenum deportment does not vary appreciably across the deposit, and occurs as molybdenite associated with both chalcopyrite and pyrite.

Gold has the most variable deportment characteristics and these can be related directly to variations in predicted gold recoveries as determined by metallurgical testwork. Gold occurs mostly as inclusions in chalcopyrite, pyrite and silicate alteration minerals. The proportion of gold inclusions in chalcopyrite and silicate alteration minerals relative to inclusions in pyrite has a positive correlation with higher gold recoveries obtained during flotation-based mineral process testing.

13.7.2 Description of Geometallurgical Domains

Hypogene mineralization in the Pebble deposit has been divided into seven geometallurgical domains that correspond to the seven zones in the three dimensional alteration model. The most volumetrically significant are the K-silicate and sodic-potassic domains. The other domains are illite-pyrite, QSP (quartz-sericite-pyrite), quartz-pyrophyllite, sericite and 8431M domains.

K-silicate

The K-silicate domain is concentrated near the top of the main granodiorite pluton and its immediate host rocks in the eastern part of the deposit. Material in this domain is dominated by K-feldspar, quartz and illite with minor biotite and a chalcopyrite-rich sulphide assemblage (average 2.5 wt%) accompanied by pyrite (average 3.6 wt%). Sphalerite is a trace component of the sulphide assemblage in this domain.

Gold occurs dominantly as inclusions in chalcopyrite. This material type is volumetrically most important in the Pebble East zone and is predicted to have the best metallurgical response due to low clay and pyrite concentrations and a close association of gold with chalcopyrite.

NK - sodic-potassic

Material in the NK domain is dominated by K-feldspar, quartz, albite and biotite with low clay contents that include both illite and kaolinite, typically in equal amounts. Pyrite (average 3.4 wt%) and chalcopyrite (average 1.3 wt%) dominate the sulphide assemblage. Siderite (Fe carbonate) is a component of some material in the southern area of the Pebble West zone. The NK domain is restricted to the shallow western portion of the Pebble West zone, of which the upper part contains secondary sulphides, dominantly chalcocite that rims chalcopyrite.

This domain has a moderate chalcopyrite to pyrite ratio and gold occurs as inclusions in chalcopyrite and pyrite.

Illite-pyrite

Samples representing illite-pyrite altered material are dominated by a silicate mineral assemblage of K-feldspar, quartz, illite and biotite. The amount of K-feldspar preserved in the samples varies, and intense illite alteration and pyrite development are prominent in all samples from this domain. The illite-pyrite domain is high in pyrite (average 9.2 wt%) and low in chalcopyrite (average 1.0 wt%). This assemblage occurs in the eastern part of the Pebble West zone mainly at shallow levels. Secondary chalcocite occurs in shallow samples on the western edge of the illite-pyrite domain but this effect is not present in the eastern portion of the domain.

Illite-pyrite material has a very high concentration of pyrite and minor chalcopyrite. Gold occurs as inclusions within pyrite. The high clay (illite) and pyrite concentrations and the close gold-pyrite association may lead to mineral processing challenges.

QSP - quartz-sericite-pyrite

The QSP domain occurs on the far north and south extents of the alteration model, mainly on the eastern side of the deposit. This material is dominated by K-feldspar, quartz and sericite with minor biotite and very high pyrite (average 9.5 wt%) and lower chalcopyrite (average 1.85 wt%) contents. This material is very similar to the material in the illite-pyrite domain.

Quartz-pyrophyllite

Quartz-pyrophyllite alteration, which occurs in the Pebble East zone is related to a zone of intense quartz veining. The mineralogy of this material is characterized by a quartz-sericite-pyrophyllite assemblage. This domain has the highest pyrite (average 9.7 wt%) and chalcopyrite (average 3.8 wt%) contents of all the domains. Trace bornite is also present.

Both pyrite and chalcopyrite concentrations are high in this domain, and gold occurs as inclusions in chalcopyrite, pyrite and silicate minerals. This is the highest grade material, but has higher clay (pyrophyllite and sericite) and pyrite concentrations, along with a more variable gold deportment.

Sericite

Sericite alteration is characterized by quartz and sericite with minor pyrophyllite and variable amounts of K-feldspar. This material occurs in two areas within the Pebble East zone. The main and most intense domain of sericite alteration occurs in the south, adjacent to the quartz-pyrophyllite domain. A second, weaker domain of sericite alteration occurs in the northern part of the Pebble East Zone in the shallowest part of the zone, below the TK contact. The northern sericite domain has much higher K-feldspar and lower sericite contents in comparison to the southern sericite domain, which is very sericite-rich. The sulphide assemblage is dominated by pyrite (average 7 to 8 wt%) and chalcopyrite (average 1.5 to 2.9 wt%). Bornite (accompanied by minor digenite/covellite) content is variable, ranging from absent or trace intergrowths with chalcopyrite to full scale replacement of chalcopyrite by bornite and pyrite. The arsenic sulphides enargite and tennantite are a trace component of the sulphide assemblage, as is sphalerite. Gold occurs as inclusions in pyrite and chalcopyrite and also in solid solution in bornite and digenite. Some of the highest molybdenite contents are in this domain.

High clay (sericite) and pyrite concentrations and variable gold deportment may have implications for mineral processing but the high-tenor copper sulphides may yield a higher concentrate grade.

8431M

Drill holes 8431M and 11527 cut across the NK domain in the center of the Pebble West zone. Samples from these drill holes, however, are more typical of the core of the K-silicate mineralized system in the Pebble East zone and are characterized by a K-feldspar-biotite assemblage with minor quartz and illite. Large zones of K-feldspar-magnetite-pyrite-chalcopyrite-cemented breccia were encountered in the drill holes. This material, which is limited to these drill holes, dominantly occurs within a diorite sill and is very high grade with chalcopyrite content averaging 2.7 wt%, well in excess of other domains within the Pebble West zone. High molybdenite contents are also observed in this domain.

Samples from drill hole 8431M have the highest gold recoveries in the Pebble West zone. The samples are anomalously high in both copper and gold grade; however, the gold deportment is dominated by pyrite-hosted gold grains. High gold recovery may be related to the larger than average gold grain size which may result in liberation during grinding and therefore improved recovery to the copper concentrate.

Supergene mineralization

A thin, irregular zone of supergene mineralization of variable thickness covers extensive parts of the Pebble West zone. The zone is characterized by weak enrichment of chalcocite and covellite that rims primary chalcopyrite. Supergene mineralization is defined as all material with cyanide soluble copper above 20%. Two supergene mineralization domains are defined by the silicate alteration assemblage that has undergone secondary enrichment. These domains are denoted supergene illite-pyrite and supergene sodic potassic.

Geometallurgy and the resource model

The geometallurgical domains described above correspond directly with specific domains in the 3D alteration model and are being used to constrain the geometallurgical parameters in the resource model. Specific metallurgical recoveries were applied to each geometallurgical domain type, which is described in section 13.11.2.

13.8 METAL RECOVERY PROJECTION

In the 2014 technical report on the Pebble project, a metal recovery projection was completed based on the variability locked-cycle flotation tests, variability cyanidation tests, and cyanide recovery (SART) tests on two commissioning samples. The overall metal recoveries of copper, gold, and silver consist of two parts with the majority via flotation concentration and a small portion from the gold plant, i.e., the cyanide leaching and SART processes. Secondary gold recovery using cyanide is not part of the project plan currently advancing through permitting. As a result, the 2014 metal recovery projections are adjusted accordingly.

13.8.1 Metal Recovery Projection Basis

The adjusted analysis made to predict metal recoveries can be summarized as follows, starting from the new changes made in the analysis followed by the original analysis basis that are still applicable.

Adjusted Analysis Basis

The following considerations were made in adjusting the metal recoveries:

- Removing recoveries of copper, gold, and silver from the gold and SART plants;
- Reducing the primary grind size P_{80} from about 200 µm to 125 µm with corresponding improved metal recoveries;
- Adjusting the copper recovery by applying an average recovery increase of 0.5% per 10 µm reduction of primary grind size; and
- Applying a similar same recovery change factor for gold, silver, and molybdenum.

Valid Considerations from the Original Analysis

The following considerations were utilized in the original analysis and are still valid:

- A review of the 103 available samples, eight were excluded from the analysis – 5 of 8 because they were below the 0.20% Cu cut-off grade, and 3 of 8 because they were contaminated by drilling fluid;
- The remaining 95 samples were used to determine copper, gold and molybdenum recoveries;
- Silver recovery was based on a dataset of 10 samples due to incomplete silver assay data for the testwork;
- Locked cycle test recovery distributions were reviewed for each geometallurgical domain type to determine if domains could be grouped into similar recovery domains;
- The outcome of this analysis established seven recovery domains for copper, six for gold, and seven for molybdenum;
- Recoveries were determined using the median value of each dataset;
- Copper-molybdenum separation efficiency was assumed to be 92.7% molybdenum recovery to the molybdenum concentrate; and
- Gold recovery included an incremental 1.0% for the gravity circuit.

13.8.2 Effects of Primary Grind Size on Samples

Four testwork programs were conducted in 2005 and 2006 by SGS to investigate the impacts of the primary grind size on metal recoveries with different composite samples in rougher flotation, batch cleaner flotation and locked-cycle flotation tests. A general observation was made that higher metal recoveries can be obtained with a finer primary grinding size, with just a few exceptions that mainly resulted from the inconsistent test conditions. The primary size effect testing results are plotted and connected with trendline by SGS as presented in Figure 13.9-1 to 13.9-3.

Figure 13.8-1 The Effect of Primary Grind Fineness of Copper Recovery to Rougher Concentrate

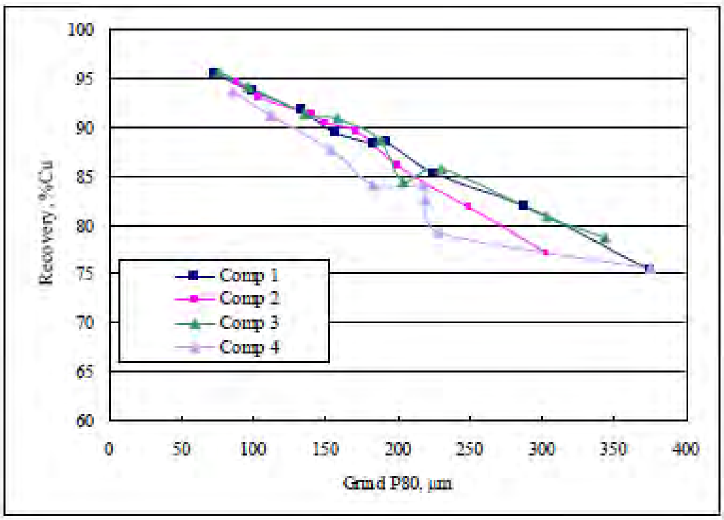


Figure 13.8-2 Effect of Primary Grind Size on Cu, Au and Mo Recovery to Batch Copper Concentrate

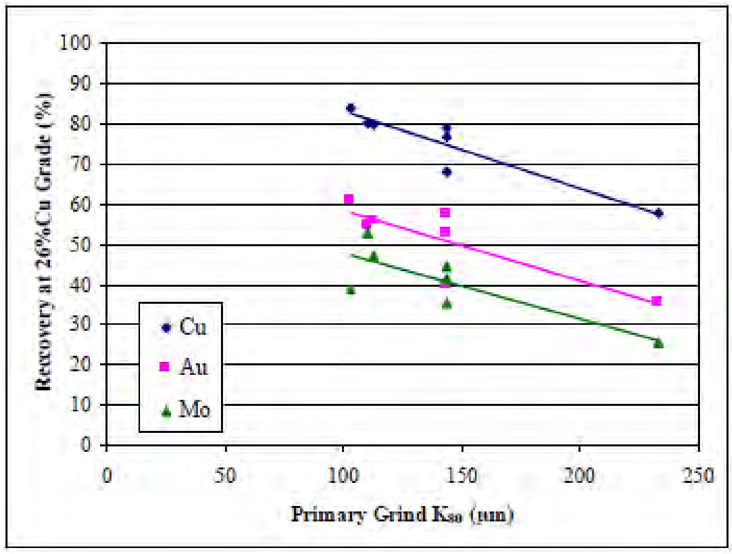
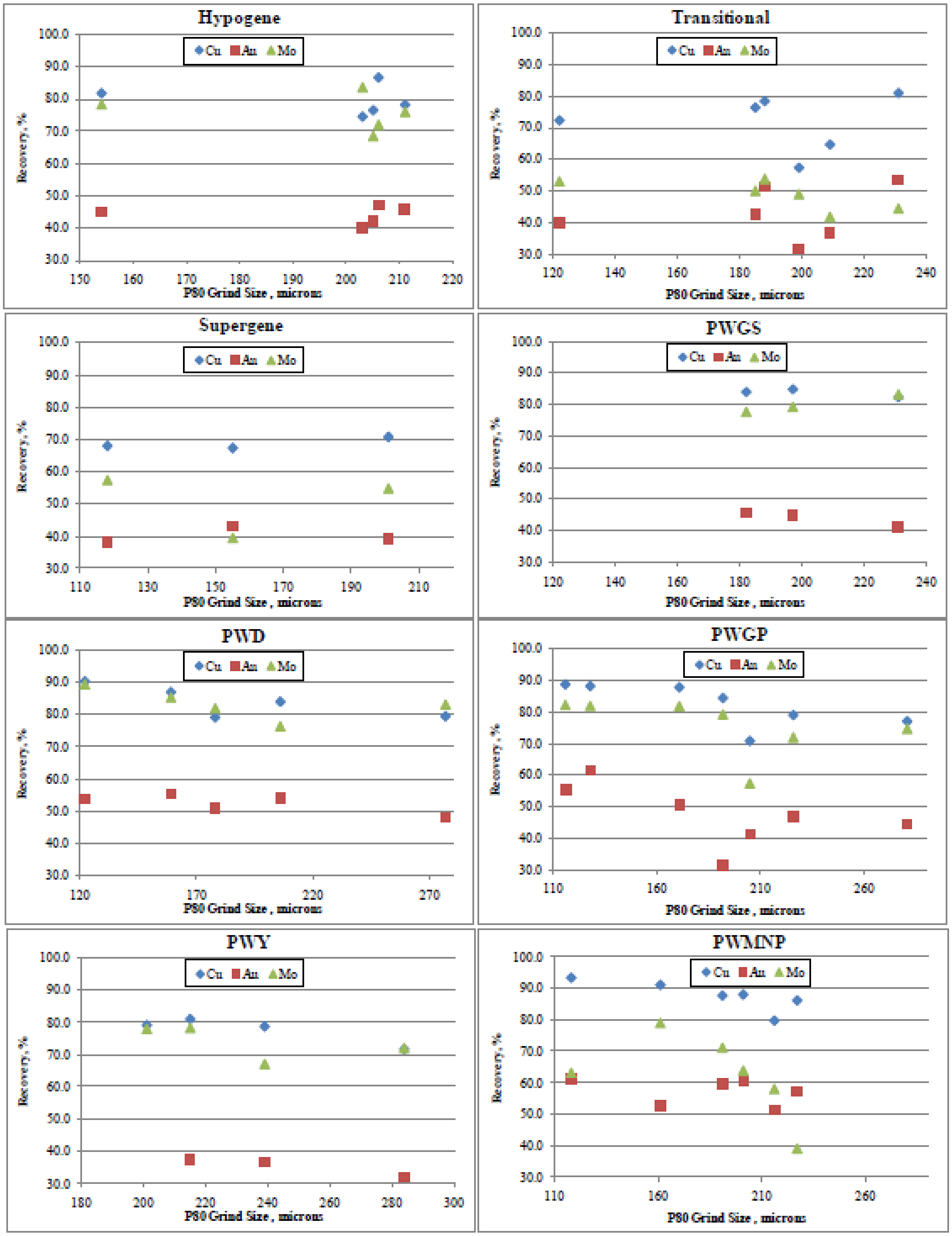


Figure 13.8-3 Cu, Au, and Mo Recovery into a 26% Batch Cu Concentrate



The observed linear relationship between the primary grind size and metal recovery change was mathematically summarized by SGS as follows:

"Linear trendlines that were fitted to the data sets suggested that in only 4 cases the metal recovery improved with coarser grinds compared with 20 cases that produced inferior recoveries at a coarse grind. Metal losses of Cu, Au, and Mo typically ranged between 0.5% to 1.0% per 10 microns increase in grind size."

Similar observations were obtained from the batch cleaner and locked cycle flotation tests as shown in the Figure 13.9.4 to Figure 13.9.6. It can be noted that the metal recovery increase in the locked cycle flotation tests is lower as compared with the batch cleaner flotation tests. The average metal increase per 10 µm reduction of primary grind size from the locked cycle tests are 0.48% for copper, 0.15% for gold, and 0.34% for molybdenum.

Figure 13.8-4 Summary of Batch Recovery Change per 10µm Primary Grind Size Reduction

Composite	Product	Change per 10 µm Size Reduction (% Recovery)		
		Cu	Au	Mo
2005G	Ro+Scav Concentrate	0.62	0.24	0.53
2005Y	Ro+Scav Concentrate	0.70	0.37	0.53
2006G	Ro+Scav Concentrate	0.28	0.23	0.24
2006Y	Ro+Scav Concentrate	0.50	0.22	0.40
2005G	Cu/Mo Concentrate	0.62	NA	0.44
2005Y	Cu/Mo Concentrate	0.86	NA	0.59
2006G	Cu/Mo Concentrate	0.33	NA	0.51
2006Y	Cu/Mo Concentrate	0.49	NA	0.44

Figure 13.8-5 Summary of LCT Recovery Change per 10µm Primary Grind Size Reduction

Composite	Product	Change per 10 µm Size Reduction (% Recovery)		
		Cu	Au	Mo
2005G	Ro+Scav Concentrate	0.32	0.19	0.28
2005Y	Ro+Scav Concentrate	0.66	0.14	0.52
2006G	Ro+Scav Concentrate	0.20	0.16	0.22
2006Y	Ro+Scav Concentrate	0.48	0.19	0.38
2005G	Cu/Mo Concentrate	0.34	0.24	0.16
2005Y	Cu/Mo Concentrate	0.76	0.01	0.67
2006G	Cu/Mo Concentrate	0.18	0.13	0.12
2006Y	Cu/Mo Concentrate	0.65	0.25	0.40

Figure 13.8-6 Change in Metal Recovery for 10µm Primary Grind Size Reduction, P80 150µm to 300µm

Composite	Product	Cu %	Au %	Mo %
PBA	Cu/Mo Concentrate	0.38	-0.46	0.59
PBB	Cu/Mo Concentrate	0.57	0.15	1.46
PBC	Cu/Mo Concentrate	0.54	0.68	0.31
PBD	Cu/Mo Concentrate	0.45	-0.43	0.58
PBE	Cu/Mo Concentrate	0.34	0.01	-0.1
PBF	Cu/Mo Concentrate	0.54	0.38	0.57
PBA	Ro+Scav Concentrate	0.84	-1.05	0.84
PBB	Ro+Scav Concentrate	0.29	0.50	1.61
PBC	Ro+Scav Concentrate	0.41	0.34	-0.01
PBD	Ro+Scav Concentrate	0.40	0.01	0.72
PBE	Ro+Scav Concentrate	0.79	0.31	0.70
PBF	Ro+Scav Concentrate	0.51	0.46	0.64

13.8.3 Metal Recovery Projection Results

The adjusted metal recoveries are presented in Figure 13.9.7, excluding the recovery of gold, silver and copper from the leaching circuit and SART process. The flotation recoveries are adjusted based on the previous projection but at a finer primary grind P_{80} of 125 µm.

Figure 13.8-7 Projected Metallurgical Recoveries, P80 of 125µm without cynaide leaching & SART

Domain	Flotation Recovery %			
	Cu Con, 26% Cu			Mo Con
	Cu	Au	Ag	Mo
Supergene:				
Sodic Potassic	78.7	63.6	67.5	53.9
Illite Pyrite	72.1	46.5	67.8	66.3
Hypogene:				
Illite Pyrite	89.8	45.6	66.6	76.1
Sodic Potassic	90.1	63.2	67.0	80.1
K Silicate	93.7	63.6	66.5	85.4
QP	94.7	65.2	64.4	80.4
Sericite	89.6	40.6	66.5	75.9
QSP	89.8	32.9	66.9	86.1

14.0 MINERAL RESOURCE ESTIMATES

14.1 SUMMARY

The current Pebble mineral resource estimate is based on all core holes in the vicinity of the block model extents, completed to the end of 2013. Based on descriptive statistics, 3D surfaces and wireframe models of domains for each of the four metals, as well as bulk density were interpreted and used in the development of search strategies and geostatistical parameters for block interpolation and resource classification.

The updated Pebble resource estimate is presented in Figure 14.1.1. Tonnes have been rounded to the nearest million. The highlighted 0.3% CuEq cut off is considered appropriate for deposits of this type in the Americas.Of the total resource, the Measured category represents approximately 5%, the Indicated category represents 54%, and the Inferred category represents approximately 41%.

Figure 14.1-1 Pebble Deposit Mineral Resource Estimate December 2017

Threshold CuEq %	CuEq	Tonnes	Cu (%)	Au (g/t)	Mo (ppm)	Ag (g/t)	Cu Blb	Au Moz	Mo Blb	Ag Moz
Measured										
0.3	**0.65**	**527,000,000**	**0.33**	**0.35**	**178**	**1.7**	**3.83**	**5.93**	**0.21**	**28.1**
0.4	0.66	508,000,000	0.34	0.36	180	1.7	3.81	5.88	0.20	27.4
0.6	0.77	279,000,000	0.40	0.42	203	1.8	2.46	3.77	0.12	16.5
1.0	1.16	28,000,000	0.62	0.62	302	2.3	0.38	0.56	0.02	2.0
Indicated										
0.3	**0.77**	**5,929,000,000**	**0.41**	**0.34**	**246**	**1.7**	**53.58**	**64.81**	**3.21**	**316.4**
0.4	0.82	5,185,000,000	0.45	0.35	261	1.8	51.42	58.35	2.98	291.7
0.6	0.99	3,455,000,000	0.55	0.41	299	2.0	41.88	45.54	2.27	221.1
1.0	1.29	1,412,000,000	0.77	0.51	343	2.4	23.96	23.15	1.07	109.9
Measured + Indicated										
0.3	**0.76**	**6,456,000,000**	**0.40**	**0.34**	**240**	**1.7**	**56.92**	**70.57**	**3.42**	**344.6**
0.4	0.81	5,693,000,000	0.44	0.35	253	1.8	55.21	64.06	3.18	320.3
0.6	0.97	3,734,000,000	0.54	0.41	291	2.0	44.44	49.22	2.40	237.7
1.0	1.29	1,440,000,000	0.76	0.51	342	2.4	24.12	23.61	1.08	112.0
Inferred										
0.3	**0.55**	**4,454,000,000**	**0.25**	**0.25**	**226**	**1.2**	**24.54**	**35.80**	**2.22**	**170.4**
0.4	0.68	2,646,000,000	0.33	0.30	269	1.4	19.24	25.52	1.57	119.1
0.6	0.89	1,314,000,000	0.48	0.37	292	1.8	13.90	15.63	0.85	75.6
1.0	1.20	361,000,000	0.68	0.45	377	2.3	5.41	5.22	0.30	26.3

Notes:

These resource estimates have been prepared in accordance with NI 43-101 and the CIM Definition Standards. Inferred mineral Resources are considered to be too speculative to allow the application of technical and economic parameters to support mine planning and evaluation of the economic viability of the project.

Northern Dynasty Minerals Ltd. advises investors that although these terms are recognized and required by Canadian regulations (under National Instrument 43-101 Standards of Disclosure for Mineral Projects), the U.S. Securities and Exchange Commission does not recognize them. Investors are cautioned not to assume that any part or all of the mineral deposits in these categories will ever be converted into reserves. In addition, "inferred resources" have a great amount of uncertainty as to their existence, and economic and legal feasibility. It cannot be assumed that all or any part of an Inferred Mineral Resource will ever be upgraded to a higher category. Under Canadian rules, estimates of Inferred Mineral Resources may not form the basis of feasibility or pre-feasibility studies, or economic studies except for Preliminary Economic Assessment as defined under 43-101. Investors are cautioned not to assume that part or all of an inferred resource exists, or is economically or legally mineable.

Copper equivalent calculations use metal prices of $1.85/lb for copper, $902/oz for gold and $12.50/lb for molybdenum, and recoveries of 85% for copper 69.6% for gold, and 77.8% for molybdenum in the Pebble West zone and 89.3% for copper, 76.8% for gold, 83.7% for molybdenum in the Pebble East zone.

Contained metal calculations are based on 100% recoveries.

A 0.30% CuEQ cut-off is considered to be appropriate for porphyry deposit open pit mining operations in the Americas.

All mineral resource estimates, cut-offs and metallurgical recoveries are subject to change as a consequence of more detailed analyses that would be required in pre-feasibility and feasibility studies.

14.2 EXPLORATORY DATA ANALYSIS

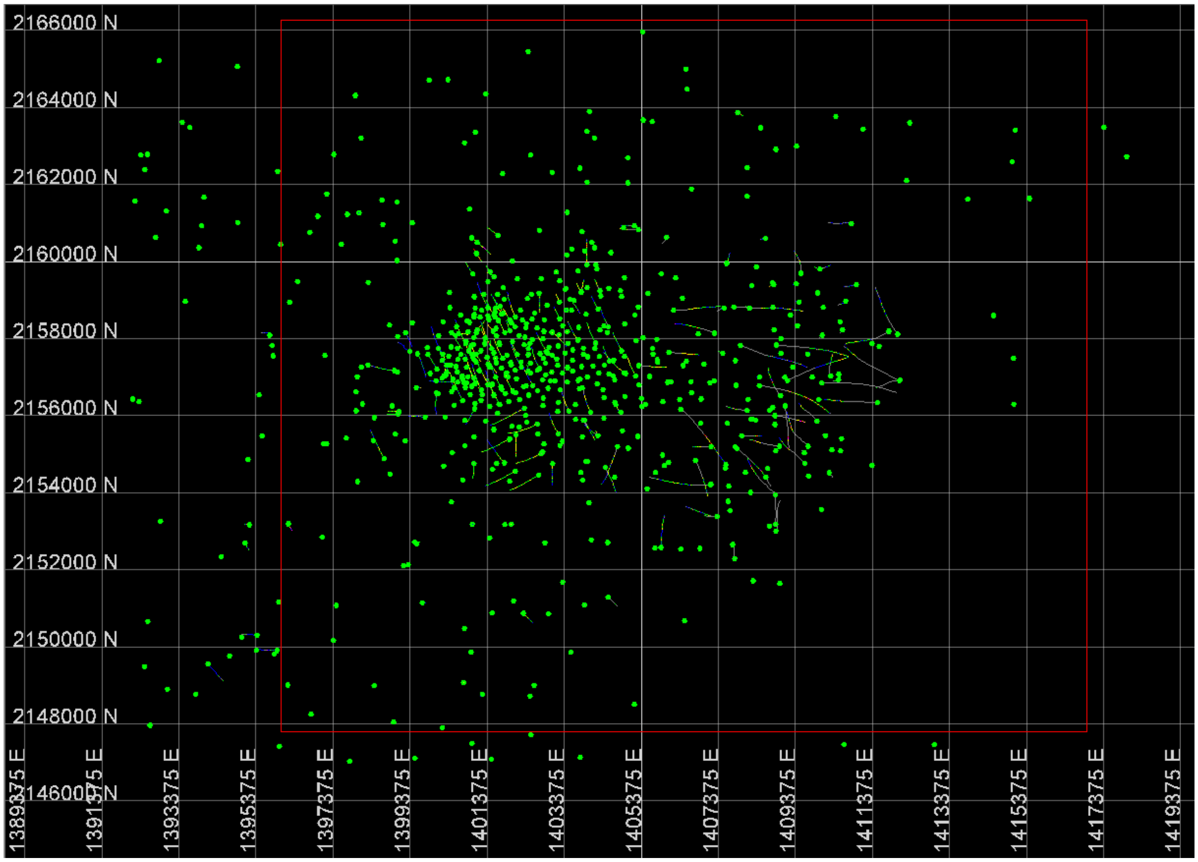
14.2.1 Assays

Descriptive global statistics for all non-zero copper, gold, silver, and molybdenum assays are presented in Figure 14.2-1. The distribution of drill holes relative to the extent of the block model is shown in Figure 14.2.2.

Figure 14.2-1 Pebble Deposit Assay Database Descriptive Global Statistics

Statistic (Non-zero)	Length (ft)	Ag (ppm)	Au (g/t)	Cu (%)	Mo (ppm)
Mean	9.97	1.57	0.32	0.33	191.3
Median	10.00	1.00	0.23	0.26	130
Standard Deviation	1.86	5.02	1.50	0.31	298.26
Coefficient of Variation	0.19	3.20	4.63	0.94	1.56
Kurtosis	23.31	30529	41613	28.36	2,455
Skewness	2.1	155.3	189.9	2.9	29.00
Minimum	0.001	0.1	0.001	0.001	0.20
Maximum	55	1030	334.8	9.29	32200
Count	59105	58876	59114	58912	59114

Figure 14.2-2 Pebble Deposit Plan View of Drill Holes and Block Model Extent (red rectangle)



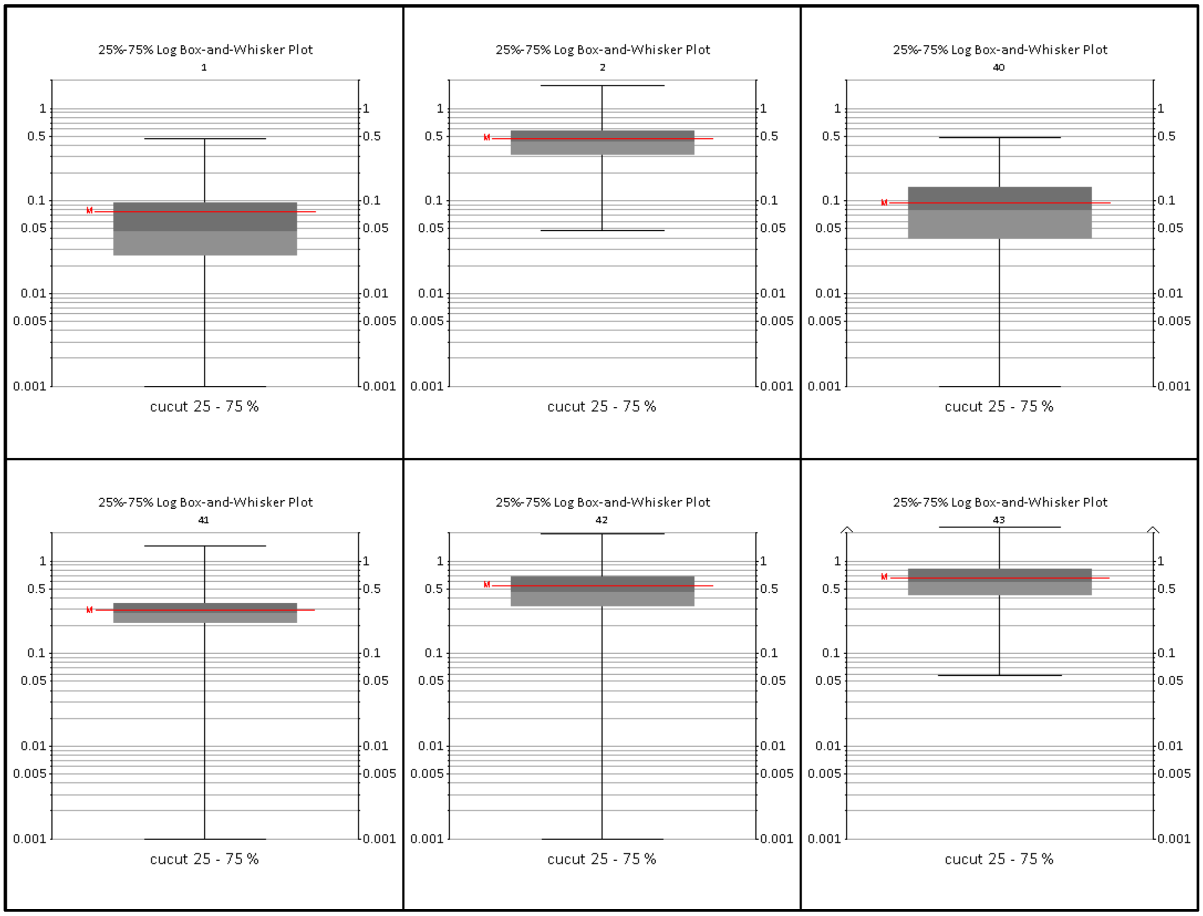
Metal distribution within the Pebble deposit is affected by lithology, alteration, weathering and structure such that the distribution cannot be constrained on the basis of a single attribute. Further, the distribution of each of the metals differs in accordance with the differing response of those metals to the thermal and chemical environments prevailing at the time of deposition. Therefore, different domains were used for each of the four metals. These domains are tabulated in Figure 14.2-3; the domains for copper are shown in section view in Figure 14.2-8.

Descriptive statistics were generated for each of the metal domains; these are summarized graphically as box-and-whisker plots in Figure 14.2-4 to Figure 14.2-7.

Figure 14.2-3 Pebble Deposit Metal Domains

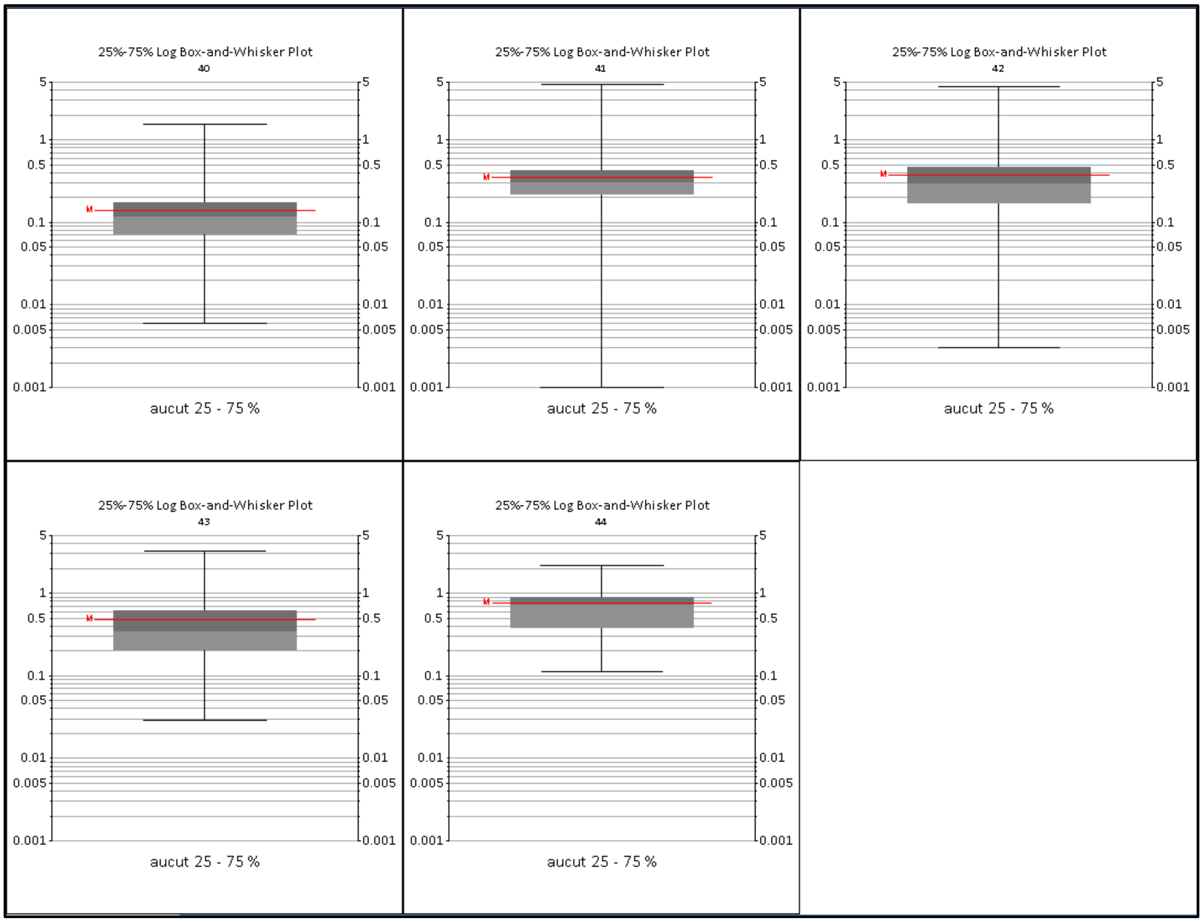
Domain	Code	Explanation
Ag low grade	40	Hypogene at depth
Ag moderate grade	41	West part near surface
Ag Northeast	42	East part, North of ZE fault
Ag Southeast	43	East part, South of ZE fault
Au low grade	40	Hypogene at depth
Au moderate grade	41	West part near surface
Au Northeast	42	East part north of ZE fault
Au Southeast	43	East Part south of ZE fault
Cu Leach	1	Cu/Leach
Cu Supergene	2	Cu/Supergene
Cu low grade	40	Hypogene at depth
Cu moderate grade	41	Hypogene West near surface
Cu Hypogene Northeast	42	East part north of ZE fault
Cu Hypogene Southeast	43	East part south of ZE fault
Mo low grade	40	Below 70ppm cap
Mo high grade	41	Above 70ppm cap west
Mo high grade Northeast	42	Above 70ppm cap, east part north of ZE fault
Mo high grade Southeast	43	Above 70ppm cap, east part south of ZE fault
Mo low grade	45	Below base cap

Figure 14.2-4 Pebble Deposit Copper Assay Domain Box-and-Whisker Plots



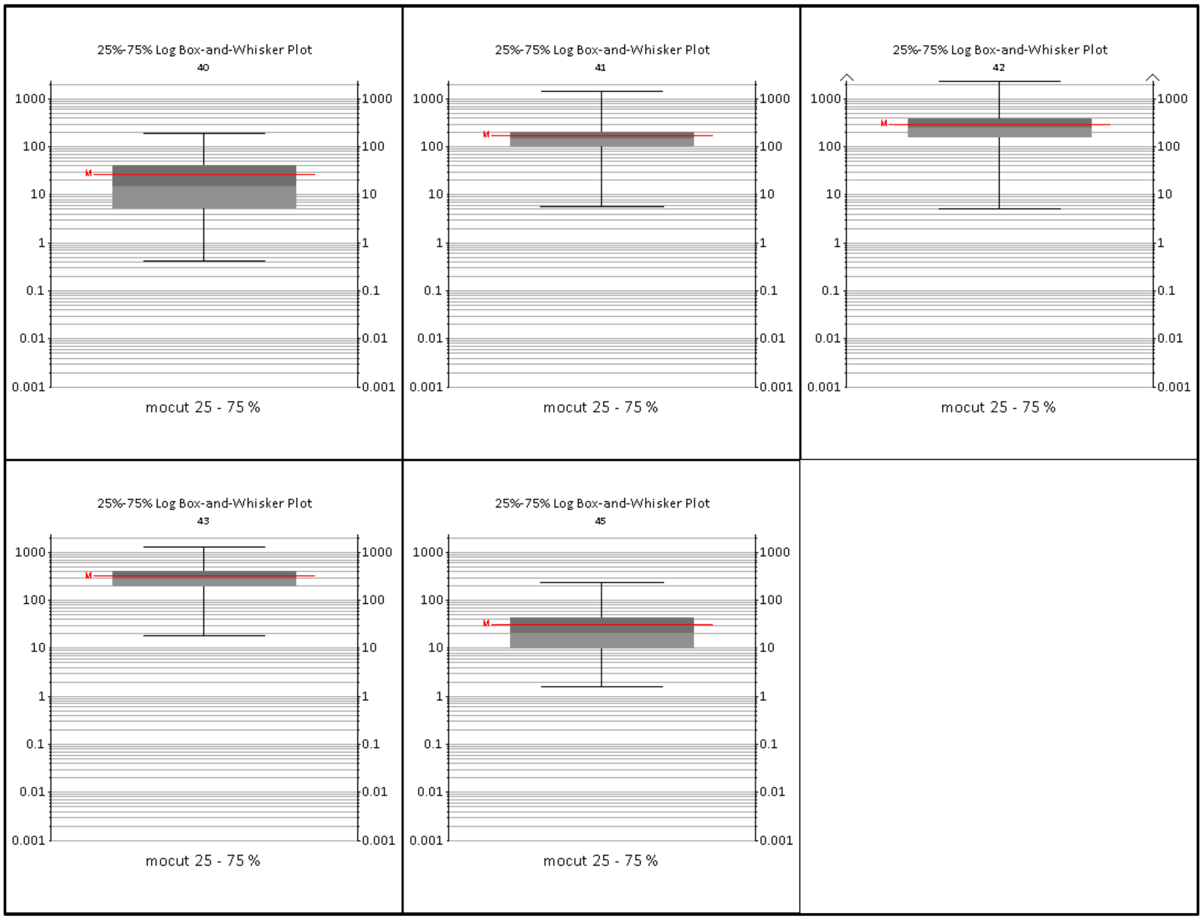
Note: M = arithmetic mean

Figure 14.2-5 **Pebble Deposit Gold Assay Domain Box-and-Whisker Plots**



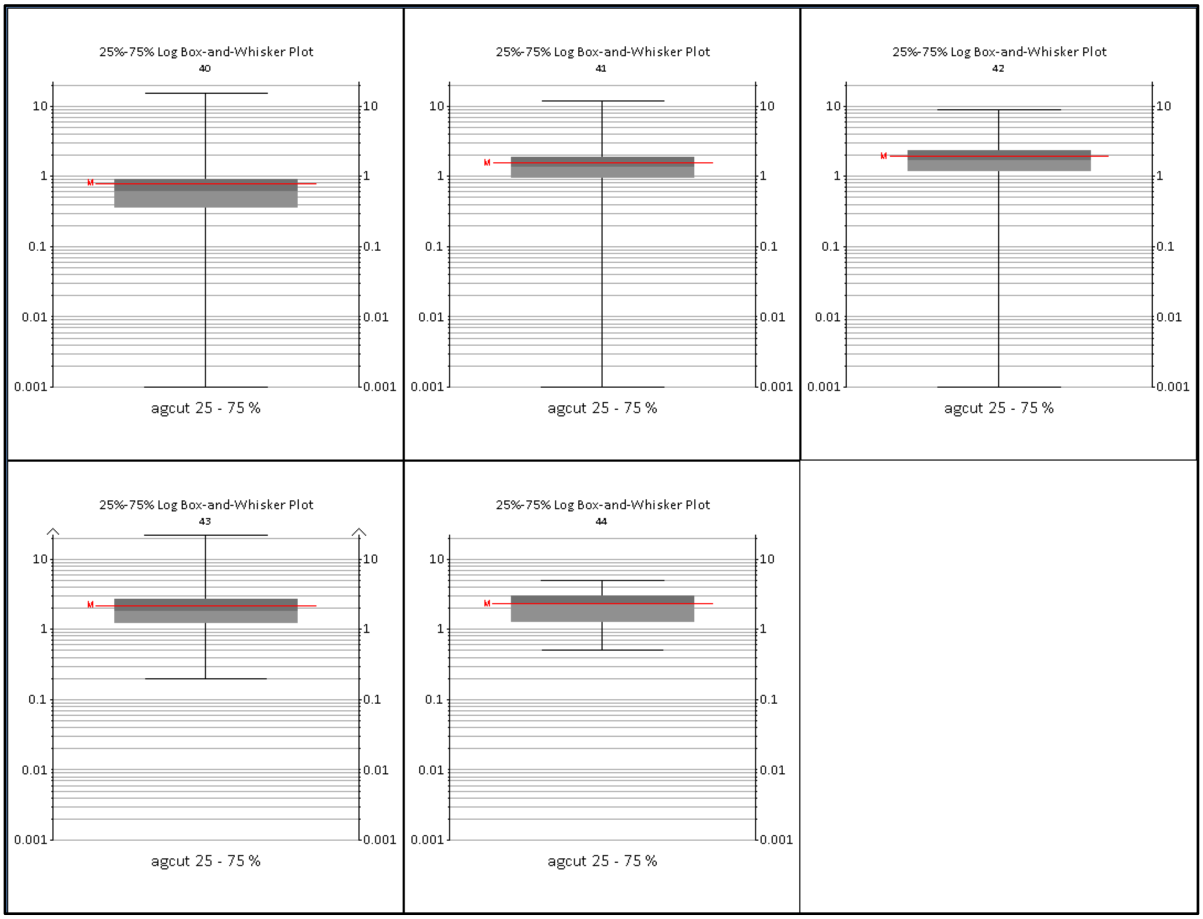
Note: M = arithmetic mean

Figure 14.2-6 Pebble Deposit Molybdenum Assay Box-and-Whisker Plots



Note: M = arithmetic mean

Figure 14.2-7 Pebble Deposit Silver Assay Box-and-Whisker Plots

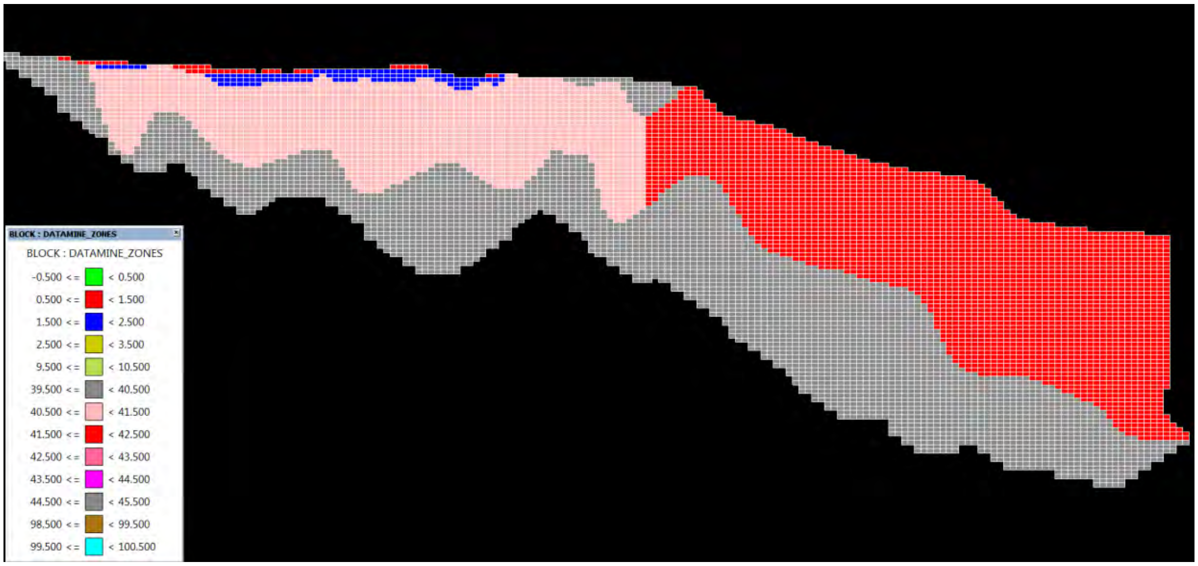


Note: M = arithmetic mean

There are four basic domains for copper, gold, molybdenum and silver, plus additional leach and supergene domains for copper. A north-south boundary separates the flat-lying western portion of the deposit from the east-dipping eastern portion of the deposit and an east-west fault (the ZE fault) divides the eastern portion of the deposit into northeast and southeast quadrants. The west half of the deposit has high-grade and low-grade domains that are separated by a planar, gently east-dipping interface that extends into the eastern portion of the deposit beneath the northeast and southeast hypogene domains.

As can be seen from the box-and-whisker plots, the fault-bounded domains (42, 43) have similar average grades for all metals however their separation into domains is required due the displacement along the ZE fault plane. The low-grade domain is, for all metals, clearly dissimilar from the others despite physical continuity and therefore requires domain status. The copper leach zone is also clearly distinguishable although the supergene zone is not markedly different from the other high-grade domains. Five of the six domains are shown in Figure 14.2-8. This east-west section is located north of the east west trending ZE fault so zone 43 is not visible. The east-west divide is clearly visible between zones 41 in the west and 42 in the east.

Figure 14.2-8 Pebble Deposit Copper Grade Domains



14.2.2 Capping

Capping is the process of reducing statistically anomalous high values (outliers) within a sample population in order to avoid the disproportionate influence these values could have on block estimation. The determination of appropriate capping levels is subjective but is commonly established by reference to cumulative frequency plots of the metal assays. Prominent breaks in the plot line, particularly at the upper end, infer a sub-population of values separate from the main population. The break in the trend defines the capping value and all assays above that point are reduced to the capping value.

Capping values applied to the Pebble assays were determined for each domain and are shown in Figure 14.2-9.

Figure 14.2-9 Pebble Deposit Capping Values

Code	Explanation	Units	Cap
40	Ag - Hypogene at depth	g/t	35
41	Ag - Hypogene West near surface	g/t	19
42	Ag - North of ZE fault	g/t	13
43	Ag - South of ZE fault	g/t	70
40	Au - Hypogene at depth	g/t	2.8
41	Au - Hypogene West near surface	g/t	7.0
42	Au - North of ZE fault	g/t	7.7
43	Au - South of ZE fault	g/t	4.3
1	Cu - Leach	%	0.25
2	Cu - Supergene	%	2.2
40	Cu - Hypogene at depth	%	0.8
41	Cu - Hypogene West near surface	%	2.0
42	Cu - North of ZE fault	%	2.4
43	Cu - South of ZE fault	%	2.4
40	Mo - Below 70ppm cap	ppm	300
41	Mo - Above 70ppm cap west	ppm	2100
42	Mo - Above 70ppm cap, north of ZE fault	ppm	2800
43	Mo - Above 70ppm cap, south of ZE fault	ppm	2800

14.2.3 Composites

Compositing to a common length overcomes the influence of sample length on grades within the resource estimate. Samples were composited to 50 ft lengths to match the anticipated bench height. Although the compositing is not intended to ensure the composite intervals will coincide with the benches, the composite length results in grades that match the resolution of those that can be expected from bench-scale sampling. The number of composites and their mean values, are given in Figure 14.2-10.

Figure 14.2-10 Pebble Deposit Composite Mean Values

Metal	Composites	Mean
Ag (g/t)	16,210	1.17
Au (g/t)	12,254	0.31
Cu (%)	16,184	0.24
Mo (ppm)	16,170	140
Bulk Density	9,830	2.62

14.3 BULK DENSITY

The database contains values for 9,830 bulk density measurements. These measurements were made on 0.1-m samples of drill core selected from locations throughout the Pebble deposit so as to reasonably reflect deposit-wide variations in rock mass. These values were not composited because they are spatially isolated and not appropriate for compositing, but were imported directly into the composite table. Five separate bulk density domains were identified:

1. Pyrite cap within the western portion of the deposit (SGZ1);
2. Pyrite cap within the eastern portion of the deposit (SGZ2);
3. Cretaceous hanging wall (SGZ3);
4. Tertiary unmineralized rock east of the ZG1 Fault (SGZ10); and,
5. Tertiary unmineralized rock west of the ZG1 Fault (SGZ11).

The kriged bulk density measurements within these domains were used to calculate tonnages.

14.4 GEOLOGICAL INTERPRETATION

The Pebble deposit extends for a strike length of approximately 13,000 ft, a width of 7,700 ft, and to a depth of at least 5,810 ft. As mentioned in Sections 14.1 and 14.2, for the purpose of resource estimation, the Pebble deposit has been partitioned into metal domains. These domains are defined by deposit orientation, structure and grade. Three boundaries are common to all metals: 1) the north-south divide that separates the deposit into east and west portions and marks a change in the dip of the stratigraphy from flat lying to gently east dipping, 2) the east-trending fault (ZE Fault) that divides the eastern portion of the deposit into two zones, and 3) the north-northeast trending ZG Fault which constrains the deposit to the east. The shape and location of the domain boundary differs among the metals but in general is gently east-dipping and separates an upper higher-grade zone (copper, gold and silver) from a lower grade zone. East of the east-west divide the higher-grade zone is divided into a north and a south domain by the ZE Fault; the lower-grade zone underlies both western and eastern parts of the deposit. In the case of molybdenum, in contrast to the other metals, the upper, western zone is lower-grade and the underlying zone is higher grade. There are two additional domains for copper: leached and supergene; both are located in the near-surface western portion of the deposit and both have been interpreted based on copper speciation data. Copper grade distribution is further constrained by two lower-grade domains that overlie portions of the east and west halves of the deposit. The gold domains also contain a very small low-grade domain immediately above the western higher-grade domain.

The bulk density domains are described in Section 14.3.

Separate variables were set up in the block model for each of the metals, each metal domain and for bulk density (noted as SG0 to SG3 and SG10 in Figures 14.5.1 and Figure 14.5.2). This approach allowed for the application of a unique suite of search strategies and kriging parameters to each metal domain based on its geostatistical characteristics.

14.5 SPATIAL ANALYSIS

The Pebble variography and search ellipse parameters are presented in Figure 14.5-1 and Figure 14.5-2, respectively.

Figure 14.5-1 Pebble Deposit Variogram Parameters

Domain	Variogram Weights			S1 Axis Range (ft)			S2 Axis Range (ft)		
	S0	S1	S2	Major	Semi-major	Minor	Major	Semi-major	Minor
Ag40	0.52	0.41	0.00	750	475	1,500	0	0	0
Ag41	0.30	0.33	0.00	450	360	475	0	0	0
Ag42	0.08	0.34	0.26	600	600	600	700	2,250	1,500
Ag43	0.13	0.49	0.00	1,300	800	1,200	0	0	0
Au40	0.46	0.54	0.00	700	700	350	0	0	0
Au41	0.16	0.26	0.29	250	250	200	1,200	850	800
Au42	0.43	0.57	0.00	1,100	1,500	800	0	0	0
Au43	0.20	0.70	0.00	900	600	450	0	0	0
Cu1	0.31	0.48	0.21	700	700	350	700	700	350
Cu2	0.40	0.60	0.00	900	520	520	0	0	0
Cu40	0.15	0.60	0.00	1,400	1,300	550	0	0	0
Cu41	0.11	0.25	0.30	450	700	450	4,000	1,300	1,300
Cu42	0.13	0.12	0.30	370	500	700	1,400	1,100	700
Cu43	0.12	0.49	0.00	1,500	1,300	500	0	0	0
Mo40	0.28	0.72	0.00	900	200	450	0	0	0
Mo41	0.19	0.16	0.30	600	1,000	500	1,700	1,000	1,600
Mo42	0.38	0.19	0.35	1,200	1,200	1,200	1,200	1,200	1,200
Mo43	0.47	0.23	0.30	1,300	1,900	900	1,900	2,000	1,000
SG0	0.44	0.56	0.00	1,350	1,350	800	0	0	0
SG10	0.34	0.41	0.00	1,350	850	950	0	0	0
SG1	0.46	0.54	0.00	640	485	450	0	0	0
SG2	0.37	0.63	0.00	1,700	1,280	500	0	0	0
SG3	0.42	0.40	0.00	1,825	1,610	900	0	0	0

Figure 14.5-2 Pebble Deposit Search Ellipse Parameters

Domain	Ellipse Orientation (°)			Ellipse Dimensions (ft)		
	Bearing	Plunge	Dip	Major	Semi-major	Minor
Ag40	120.0	0.0	60.0	565	355	1,125
Ag41	180.0	0.0	0.0	340	270	355
Ag42	130.0	0.0	-60.0	525	1,690	1,125
Ag43	20.0	40.0	0.0	975	600	900
Au40	0.0	-0.5	0.0	510	510	260
Au41	70.0	0.0	-0.5	800	600	560
Au42	290.0	20.0	0.0	825	1,110	600
Au43	79.0	-17.0	-10.0	715	460	350
Cu1	40.0	0.0	0.0	550	530	270
Cu2	30.0	0.0	-0.5	675	390	400
Cu40	72.0	-30.0	-28.0	1,100	1,020	425
Cu41	53.0	-20.0	-79.0	2,900	950	950
Cu42	290.0	40.0	-0.5	1,023	830	540
Cu43	310.0	58.0	-17.0	1,180	1,030	400
Mo40	160.0	0.0	90.0	720	155	350
Mo41	180.0	0.0	-90.0	1,200	800	1,200
Mo42	130.0	0.5	-90.0	900	890	900
Mo43	143.0	-68.0	-26.0	1,230	1,430	710
SG0	30.0	0.0	0.0	1,000	1,000	600
SG10	40.0	0.0	-90.0	1,050	450	550
SG1	88.0	6.0	40.0	450	350	325
SG2	117.0	-34.0	22.0	1,300	1,000	370
SG3	80.0	0.0	0.0	1,300	1,200	660

14.6 Resource Block Model

The block model parameters are set out in Figure 14.6-1.

Figure 14.6-1 Pebble Deposit 2017 Block Model Parameters

Origin*	Coordinates	Dimensions	Number	Size (ft)	Rotation (°)
X	1396025	Columns	279	75	0
Y	2147800	Rows	246	75	-
Z	-5500	Levels	150	50	-

Note: *Denotes lowermost left-hand corner of the block model.

14.7 INTERPOLATION PLAN

Grade interpolation was carried out in three passes: the search ellipse used for the first pass had axes that measured 95% of the variographic range (those shown in Figure 14.5-2), the second pass used search ellipse axes equal to 150% of the range and the third pass used search ellipse dimensions equal to 300% of the range.

The first and second passes were limited to a minimum of eight and a maximum of 24 composites, with a maximum of three composites from any one drill hole. For the third pass the minimum number of composites was set to five.

Domain boundaries were 'hard' (interpolation using composites only from within a given domain) with the exception of the east-west divide. The boundary restrictions are set out in Figure 14.7-1.

Figure 14.7-1 Pebble Deposit Interpolation Domain Boundaries

Domain Estimated	Domains Sourced
Ag40	Ag zone 40
Ag41	Ag zone 41, 42, 43
Ag42	Ag zone 42, 41
Ag43	Ag zone 43, 41
Au40	Ag zone 40
Au41	Au zone 41, 42, 43
Au42	Au zone4 2, 41
Au43	Au zone 43, 41
Cu1	Cu zone 1
Cu2	Cu zone 2
Cu40	Cu zone 40
Cu41	Cu zone 41, 42, 43
Cu42	Cu zone4 2, 41
Cu43	Cu zone 43, 41
Mo40	Mo zone 40
Mo41	Mo zone 41, 42, 43
Mo42	Mo zone 42, 41
Mo43	Mo zone 43, 41

14.8 REASONABLE PROSPECTS OF ECONOMIC EXTRACTION

The resource estimate is constrained by a conceptual pit that was developed using a Lerchs-Grossman algorithm and is based on the parameters set out in Figure 14.8-1.

Figure 14.8-1 Pebble Deposit Conceptual Pit Parameters

Parameter		Units	Cost ($)	Value
Metal Price	Gold	$/oz	-	1540.00
	Copper	$/lb	-	3.63
	Molybdenum	$/lb	-	12.36
	Silver	$/oz		20.00
Metal Recovery	Copper	%	-	91
	Gold	%	-	61
	Molybdenum	%	-	81
	Silver	%	-	67
Operating Cost	Mining (mineralized material or waste)	$/ton mined	1.01	-
	Added haul lift from depth	$/ton/bench	0.03	-
	Process			
	-Process cost adjusted by total crushing energy	$/ton milled	4.40	-
	-Transportation	$/ton milled	0.46	-
	-Environmental	$/ton milled	0.70	-
	-G&A	$/ton milled	1.18	-
Block Model	Current block model	ft	-	75 x 75 x 50
Density	Mineralized material and waste rock	-	-	Block model
Pit Slope Angles	-	degrees	-	42

14.9 MINERAL RESOURCE CLASSIFICATION

Resources are classified as Measured, Indicated and Inferred. For a block to qualify as Measured, the average distance to the nearest three drill holes must be 250 ft or less of the block centroid. For a block to qualify as Indicated, the average distance from the block centroid to the nearest three holes must be 500 ft or less. For a block to qualify as Inferred it will generally be within 600 ft laterally and 300 ft vertically of a single drill hole. Blocks were plotted according to the above criteria and then individual 3D solids were created encompassing the block extents while eliminating outliers. These solids were then used to assign the final block classification.

14.10 COPPER EQUIVALENCY

The resource has been tabulated on the basis of copper equivalency (CuEq); gold and molybdenum are converted to equivalent copper grade and those equivalencies are added to the copper grade. Silver grades were not estimated in 2011; therefore, to permit a direct comparison between the 2011 and 2014 resource estimates, silver was not included in the 2014 CuEq calculation. To further maintain the comparison between the previous and current estimates, the CuEq formula is predicated upon the metal prices and metal recoveries used in the 2011 estimate. This does not affect the actual metal grades reported, only their equivalent copper grades when calculating the copper equivalent value.

Metallurgical testing has determined that metal recoveries in the eastern portion of the deposit (west of State plane easting 1405600) can be expected to be higher than those for the western portion of the deposit. Therefore, separate equivalency estimates were made for the western and eastern portions of the deposit. The formulae used for the conversion are given as follows:

$$\text{CuEq General Equation} = \text{Cu\%} + ((\text{Au g/t} * (\text{Au recovery} / \text{Cu recovery}) * (\text{Au \$ per gram} / \text{Cu \$ per \%})) + ((\text{Mo ppm} * (\text{Mo recovery} / \text{Cu recovery}) * ((\text{Mo \$ per \%}) / \text{Cu \$ per \%}))$$

$$\text{CuEq (Pebble West)} = \text{Cu\%} + ((\text{Au g/t} * (0.696/0.85) * (29.00/40.75)) + ((\text{Mo ppm} * (0.778/0.85) * (275.58/40.79))$$

$$\text{CuEq (Pebble East)} = \text{Cu\%} + ((\text{Au g/t} * (0.768/0.893) * (29.00/40.79)) + ((\text{Mo ppm} * (0.837/0.893) * (275.58/40.79))$$

Where:

- Pebble West Au recovery = 69.6%;
- Pebble East Au recovery = 76.8%;
- Pebble West Cu recovery = 85%;
- Pebble East Cu recovery = 89.3%;
- Pebble West Mo recovery = 77.8%;
- Pebble East Mo recovery = 83.7%;
- Cu price = $1.85/lb;
- Au price = $902/oz;
- Mo price = $12.50/lb;
- all metal prices are based on the estimate in the 2011 technical report;
- g/oz = 31.10348; and,
- lb/% = 22.046.

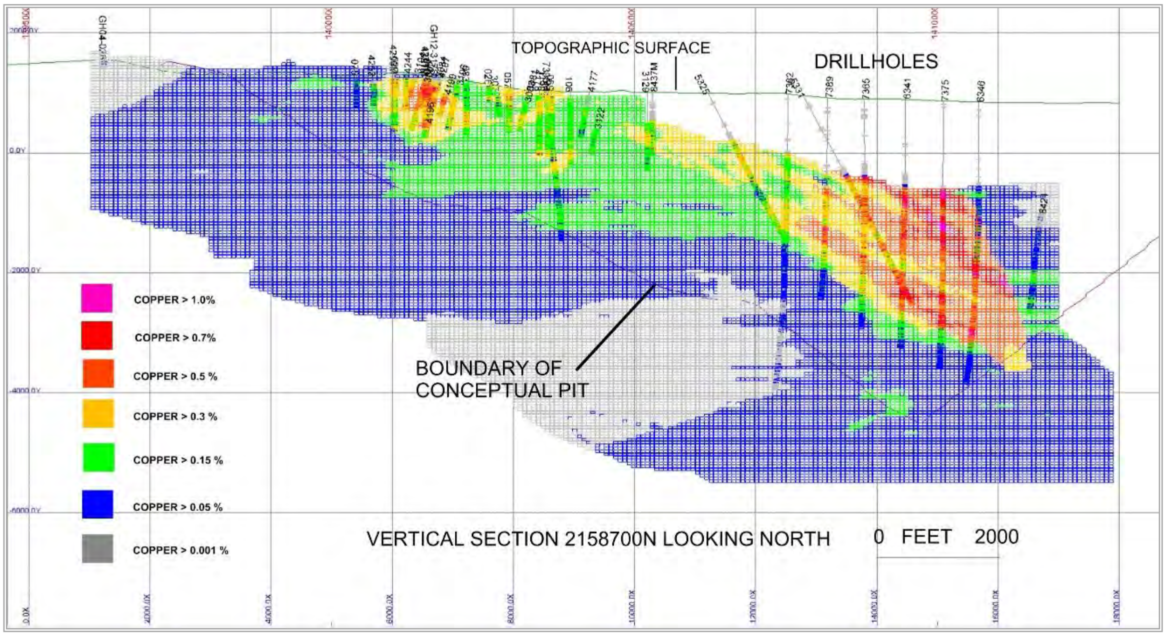
14.11 BLOCK MODEL VALIDATION

The resource estimate was validated in two ways.

The block model was inspected visually for correspondence between composite grades and block grades. This inspection was carried out on vertical sections at 100-foot intervals both east-west and north-south.

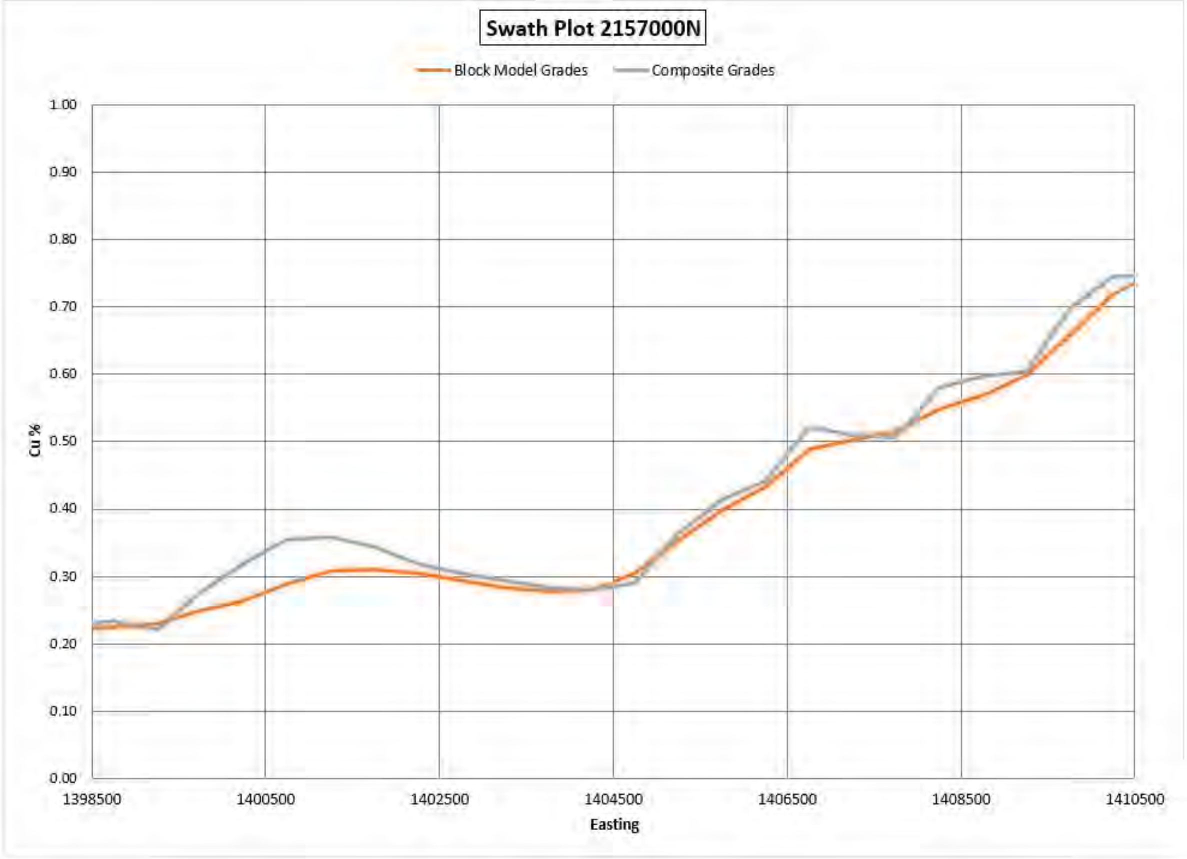
There is close agreement between composite and block grades. By way of example, Figure 14.11.1 shows the correlation between block and composite copper grades for vertical section 2158700 N.

Figure 14.11-1 **Pebble Deposit Vertical Section 2158700N Block and Composite Copper Grades; Section Line Location Shown in Figure 7.3.1**



The second type of validation consisted of the production of a series of swath plots in which the variation in metal grade for both estimated blocks and informing samples is compared along a nominated section. The comparison for copper, presented in Figure 14.11.2 shows that there is reasonable agreement between the two.

Figure 14.11-2 Pebble Deposit Block Copper Grades Versus Composite Copper Grades



14.12 COMPARISON WITH PREVIOUS ESTIMATE

Figure 14.12-1 shows the percent difference between tonnages and metal grades for the 2014 and 2017 Pebble resource estimates. Although the 2017 estimate incorporated a new pit shell to test for reasonable prospects for economic extraction which is based on updated metal recoveries, the differences between the two estimates are negligible.

Figure 14.12-1 Pebble Deposit Comparison between 2014 and 2017 Resource Estimates

Pebble Deposit Resource Estimate 2017							Pebble Resource Estimate 2014						Percent Change (2017-2014)					
Threshold CuEq%	CuEq%	Tonnes	Cu (%)	Au (g/t)	Mo (ppm)	Ag (g/t)	CuEq%	Tonnes	Cu (%)	Au (g/t)	Mo (ppm)	Ag (g/t)	CuEq%	Tonnes	Cu (%)	Au (g/t)	Mo (ppm)	Ag (g/t)
Measured																		
0.3	**0.65**	**527,000,000**	**0.33**	**0.35**	**178**	**1.7**	**0.65**	**527,000,000**	**0.33**	**0.35**	**178**	**1.7**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
0.4	0.66	508,000,000	0.34	0.36	180	1.7	0.66	508,000,000	0.34	0.36	180	1.7	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
0.6	0.77	279,000,000	0.40	0.42	203	1.8	0.77	279,000,000	0.40	0.42	203	1.8	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1.0	1.16	28,000,000	0.62	0.62	302	2.3	1.16	28,000,000	0.62	0.62	302	2.3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Indicated																		
0.3	**0.77**	**5,929,000,000**	**0.41**	**0.34**	**246**	**1.7**	**0.77**	**5,912,000,000**	**0.41**	**0.34**	**245**	**1.7**	**0.0%**	**0.3%**	**0.0%**	**0.0%**	**0.4%**	**0.0%**
0.4	0.82	5,185,000,000	0.45	0.35	261	1.8	0.82	5,173,000,000	0.45	0.35	260	1.8	0.0%	0.2%	0.0%	0.0%	0.4%	0.0%
0.6	0.99	3,455,000,000	0.55	0.41	299	2.0	0.99	3,450,000,000	0.55	0.41	299	2.0	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
1.0	1.29	1,412,000,000	0.77	0.51	343	2.4	1.29	1,411,000,000	0.77	0.51	343	2.4	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
Measured + Indicated																		
0.3	**0.76**	**6,456,000,000**	**0.40**	**0.34**	**240**	**1.7**	**0.76**	**6,439,000,000**	**0.40**	**0.34**	**240**	**1.7**	**0.0%**	**0.3%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
0.4	0.81	5,693,000,000	0.44	0.35	253	1.8	0.81	5,681,000,000	0.44	0.35	253	1.8	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%
0.6	0.97	3,734,000,000	0.54	0.41	291	2.0	0.97	3,729,000,000	0.54	0.41	291	2.0	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
1.0	1.29	1,440,000,000	0.76	0.51	342	2.4	1.29	1,439,000,000	0.76	0.51	342	2.4	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
Inferred																		
0.3	**0.55**	**4,454,000,000**	**0.25**	**0.25**	**226**	**1.2**	**0.54**	**4,460,000,000**	**0.25**	**0.26**	**222**	**1.2**	**1.9%**	**-0.1%**	**0.0%**	**-3.8%**	**1.8%**	**0.0%**
0.4	0.68	2,646,000,000	0.33	0.30	269	1.4	0.68	2,630,000,000	0.33	0.30	266	1.4	0.0%	0.6%	0.0%	0.0%	1.1%	0.0%
0.6	0.89	1,314,000,000	0.48	0.37	292	1.8	0.89	1,290,000,000	0.48	0.37	291	1.8	0.0%	1.9%	0.0%	0.0%	0.3%	0.0%
1.0	1.20	361,000,000	0.68	0.45	377	2.3	1.20	360,000,000	0.69	0.45	377	2.3	0.0%	0.3%	-1.4%	0.0%	0.0%	0.0%

14.13 FACTORS THAT MAY AFFECT THE RESOURCE ESTIMATES

These mineral resource estimates may ultimately be affected by a broad range of environmental, permitting, legal, title, socio-economic, marketing and political factors pertaining to the specific characteristics of the Pebble deposit (including its scale, location, orientation and polymetallic nature) as well as its setting (from a natural, social, jurisdictional and political perspective).

Other relevant factors which may affect the Mineral Resource estimate include changes to the geological, geotechnical and geometallurgical models, infill drilling to convert mineral resources to a higher classification, drilling to test for extensions to known resources, collection of additional bulk density data and significant changes to commodity prices. It should be noted that all factors pose potential risks and opportunities, of greater or lesser degree, to the current mineral resource.

15.0 ADJACENT PROPERTIES

There are no properties adjacent to the Pebble Project relevant to this report.

16.0 OTHER RELEVANT DATA AND INFORMATION

16.1 PROJECT SETTING

16.1.1 Jurisdictional Setting

The Pebble Project is located in Alaska, a state with a constitution that encourages resource development and a citizenry that broadly supports such development. Alaska has a strong tradition of mineral development and hard-rock mining.

Environmental standards and permitting requirements in Alaska are stable, objective, rigorous and science-driven. These features are an asset to projects like Pebble that are being designed to meet U.S. and international best practice standards of design and performance. Alaska has an experienced Large Mine Permitting Team (LMPT) to facilitate the permitting process and ensure an integrated strategy for federal and state permitting.

The Pebble deposit is located on state land that has been specifically designated for mineral exploration and development. The Pebble Project area has been the subject of two comprehensive land-use planning exercises conducted by the Alaska Department of Natural Resources (ADNR); the first in the 1980s and the second completed in 2005. ADNR identified five land parcels (including Pebble) within the Bristol Bay planning area as having “significant mineral potential,” and where the planning intent is to accommodate mineral exploration and development. These parcels total 2.7% of the total planning area (ADNR, 2005).

16.1.2 Environmental and Social Setting

The Pebble deposit is located under rolling, permafrost-free terrain in the Iliamna region of southwest Alaska, approximately 200 miles southwest of Anchorage and 60 miles west of Cook Inlet. The surface elevation over the deposit ranges from approximately 800 to 1,200 ft amsl, although mountains in the region reach 3,000 to 4,000 ft amsl. Vegetation generally consists of wetland and scrub communities with some coniferous and deciduous forested areas that become more common eastward toward the Aleutian Range.

The deposit area lies within the upper reaches of the Koktuli River and Upper Talarik Creek (UTC) drainages. Approximately 17 miles from the deposit area, the North Fork (NFK) and South Fork (SFK) streams merge to form the main Koktuli River. The Koktuli River is tributary to the lower Mulchatna River, which drains via the lower Nushagak River to Bristol Bay at Dillingham, some 220 river miles southwest of the deposit area. The UTC flows into Iliamna Lake, which in turn drains into Bristol Bay via the Kvichak River some 140 river/lake miles to the southwest (Figure 16.1-1).

Figure 16.1-1 Bristol Bay Watersheds

The Kvichak and Nushagak river systems are two of nine major systems that drain to Bristol Bay and support important Pacific salmon runs, most notably sockeye salmon (Jones et al., 2013). The Kvichak and Nushagak watersheds total some 23,567 square miles, of which the NFK, SFK and UTC Project watersheds comprise only 355 square miles, or approximately 1.5% of the total Bristol Bay watershed. Government data indicate that, over the past decades, the combined Kvichak and Nushagak river systems have contributed about 20 to 30% of total Bristol Bay sockeye salmon escapement. Thus, some 70 to 80% of Bristol Bay sockeye production is hydrologically isolated from any potential effects of the Pebble Project.

Based on field studies conducted by the Pebble Partnership over ten years, along with other government studies, e.g. Alaska Department of Fish and Game (ADFG) 2009, independent consultants estimated that, at 400 square miles, the three watersheds surrounding Pebble (NFK, SFK and UTC) generally produce less than 0.5% of the total Bristol Bay sockeye run (harvest plus escapement).

Wildlife using the deposit area includes various species of raptors and upland birds, brown bear, caribou and moose. Although no listed species are known to use the deposit area, several species listed under the Endangered Species Act—Steller's Eider, Sea Otter, Steller's Sea Lion, and the Cook Inlet Beluga Whale—as well as harbour seals protected under the Marine Mammal Protection Act, are known to be present in Cook Inlet and some western Cook Inlet shoreline communities. As the Pebble Project moves forward, the Pebble Partnership will conduct wildlife surveys of potential port sites at Cook Inlet to more fully characterize wildlife conditions.

The deposit area and areas of potential transportation corridors are isolated and sparsely populated. The Pebble deposit is located primarily within the Lake and Peninsula Borough, which has a population of about 1,600 persons in 18 communities. In the deposit area, the closest communities comprise three villages—Iliamna, Newhalen and Nondalton—about 17-19 miles from the deposit site. The largest village population size is about 250 full-time residents. There are local roads in the village areas and summer barges up the Kvichak River and on Iliamna Lake. The airport at Iliamna provides the only year-round access to and from the area.

The total population within the Bristol Bay region is approximately 7,500. The main population center of the region is Dillingham, located on Bristol Bay approximately 130 miles southwest of the deposit. It has a population size of about 2,300, or 30% of the region.

16.2 BASELINE STUDIES – EXISTING ENVIRONMENT

Northern Dynasty began an extensive field study program in 2004 to characterize the existing physical, chemical, biological and social environments in the Bristol Bay and Cook Inlet areas where the Pebble Project might occur. The Pebble Partnership compiled the data for the 2004 to 2008 study period into a multi-volume Environmental Baseline Document (PLP, 2012). As well, supplemental environmental reports that incorporate data from the period 2009 to 2012 are in preparation. The EBD is publicly available at http://pebbleresearch.com/. These studies have been designed to:

- Fully characterize the existing biophysical and socioeconomic environment;
- Support environmental analyses required for effective input into the Pebble Project design;
- Provide a strong foundation for internal environmental and social impact assessment to support corporate decision-making;
- Provide the information required for stakeholder consultation and eventual mine permitting in Alaska; and,

- Establish a baseline for long term monitoring to assess potential changes associated with future mine development.

The baseline study program includes:

• surface water	• wildlife
• groundwater	• air quality
• surface and groundwater quality	• cultural resources
• geochemistry	• subsistence
• snow surveys	• land use
• fish and aquatic resources	• recreation
• noise	• socioeconomics
• wetlands	• visual aesthetics
• trace elements	• climate and meteorology
• fish habitat – stream flow modeling	• Iliamna Lake
• marine	

Additional environmental baseline studies were undertaken between 2009 and 2012. The results of these studies are being compiled into a supplemental EBD. In 2017, select environmental baseline studies were re-initiated and expanded.

The following sections highlight key environmental topics; more detail is provided in the EBD (2012).

16.2.1 Climate and Meteorology

Meteorological monitoring consists of six meteorological stations located in the mine (Bristol Bay drainage) study area and three stations located in the Cook Inlet study area near Iliamna Bay (PLP, 2012). Meteorological monitoring in the area near the deposit occurs at an elevation between 800 to 2,300 ft amsl. Monitoring in the Cook Inlet study area occurs near sea level.

Data collected at all stations has included wind speed and direction, wind direction standard deviation and air temperature. Collected data at stations where instrumentation has been installed include differential temperature, solar radiation, barometric pressure, relative humidity, precipitation and, in summer, evaporation. Meterological monitoring was suspended at the Pebble 1 station in 2014 and restarted in 2017. A new monitoring station was installed near the proposed Amakdedori Port site in 2017. Monitoring at the remaining stations was suspended in 2013 after sufficient baseline data was collected.

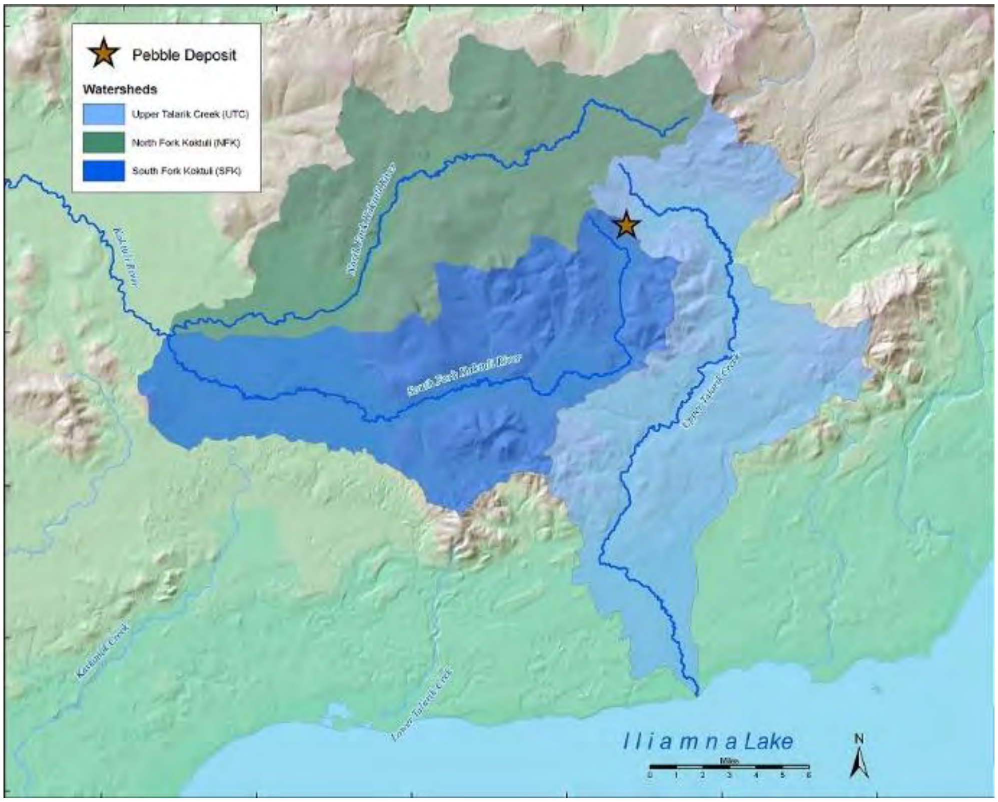
Mean monthly temperatures in the deposit area range from about 55°F in summer to 2°F in winter. Precipitation averages approximately 54 inches per year, about one-third of which falls as snow. The wettest months are August through October.

16.2.2 Surface Water Hydrology and Quality

16.2.2.1 SURFACE WATER HYDROLOGY

The Bristol Bay drainage basin encompasses 41,900 square miles in southwest Alaska (Figure 16.2-1). This map shows the study area, which is principally defined as the 400 square miles within the SFK, NFK and UTC drainages. The Nushagak and Kvichak watersheds constitute 49% of the Bristol Bay basin area. The deposit location straddles the watershed boundary between the SFK and UTC and lies close to the headwaters of the NFK. The area studied near the deposit encompasses the drainages of these three watercourses as well as the headwaters of Kaskanak Creek (KC). While the deposit area and potential mine footprint does not affect the Kaskanak Creek headwaters, it was included in the study design to allow for comprehensive long term monitoring of mine operations.

Figure 16.2-1 Local Watershed Boundaries



Annual stream flow patterns in the mine study area are generally characterized by a bi-modal hydrograph with high flows in spring resulting from snowmelt and low flows in early to mid-summer resulting from dry conditions and depleting snow packs. Frequent rainstorms in late summer and early autumn contribute to another high-flow period. The lowest flows occur in winter when most precipitation falls as snow and remains frozen until spring. Loss and gain of surface flow to groundwater plays a prominent role in the flow patterns of all study area creeks and rivers, causing some upstream sites to run dry seasonally while causing others to be dominated by baseflow due to gains.

During winter and summer low-flow periods, stream flows are primarily fed by groundwater discharge. Observed baseflows were higher during summers than winters due to snowmelt recharge of aquifers and intermittent rainstorms. Baseflows were lowest in late winter after several months without surface runoff. Low-flow conditions are also influenced by fluctuations in surface storage features such as lakes, ponds and wetlands; however, changes in surface storage are minimized during the late winter freeze.

16.2.2.2 Surface Water Quality

Surface water quality sampling within the study area occurred between 2004 and 2008 at numerous locations in the NFK, SFK, UTC and KC drainages. Stream samples were collected from 44 locations during 50 sampling events from April 2004 through December 2008. Lake and pond samples were collected from 19 lakes once or twice per year during 2006 and 2007. Seep samples were collected from 11 to 127 sample locations, depending on the year, two to five times per year. Altogether, over 1,000 samples were collected from streams, more than 600 samples from seeps, and approximately 50 samples from lakes.

Surface water in the study area is characterized by cool, clear waters with near-neutral pH that are well-oxygenated, low in alkalinity, and generally low in nutrients and other trace elements. Water types ranged from calcium-magnesium-sodium-bicarbonate to calcium-magnesium-sodium-sulphate. Water quality occasionally exceeded the maximum criteria for concentrations for various trace elements. Additionally, cyanide was present in detectable concentrations; there were consistently detectable concentrations of dissolved organic carbon; and no detectable concentrations of petroleum hydrocarbons, polychlorinated biphenyls (PCBs), or pesticides found.

16.2.3 Groundwater Hydrology and Quality

16.2.3.1 Groundwater Hydrology

Beginning in 2004, Northern Dynasty established an extensive groundwater monitoring network across the study area. Initially the groundwater quality monitoring network consisted of 21 wells at 10 locations. The Pebble Partnership expanded the monitoring network throughout the study period as the understanding of the groundwater flow regime and chemistry was refined. By 2008, the monitoring network consisted of 39 wells at 20 locations. More than 200 response tests have been conducted in shallow wells that have been installed throughout the study area for the baseline assessment. In general, a greater proportion of response tests in the overburden materials indicated higher hydraulic conductivity estimates for the overburden than for the shallow bedrock (PLP, 2012).

Generally, there is a strong correlation between groundwater levels and stream flows in the study area; the highest groundwater levels were recorded during spring runoff and/or during fall rains and the lowest groundwater levels were recorded just before spring runoff. The potential for baseflow to sustain stream flows at the upper reaches of tributaries is limited, given the limited groundwater storage capacity of the overburden and upper bedrock aquifers. Where substantial thicknesses of permeable alluvium are present downstream, the sustained baseflow in the main streams during winter indicates considerable storage in the overburden aquifer.

EBD 2012 identified three groundwater divides within the study area, generally reflecting the three surface water drainage basins (NFK, SFK and UTC). Based on the water balance model prepared by Schlumberger (PLP, 2012), it has been estimated that more than 95% of the water that recharges groundwater within the three surface water drainages also discharges within the same drainage basin. Although some cross-basin transfer occurs, it is well understood.

16.2.3.2 GROUNDWATER QUALITY

Groundwater wells were located within the Pebble deposit resource area (10 wells at seven locations), and along the three surface water drainage basins identified as reflective of groundwater flow from the Pebble deposit resource area. The EBD 2012 compared the results of groundwater quality sampling with the most stringent benchmark water quality criteria derived from Title 18 of the Alaska Administrative Code, Chapter 75 (18AAC75), and Alaska Water Quality Criteria (ADEC, 2008).

16.2.4 Geochemical Characterization

Northern Dynasty and the Pebble Partnership conducted a comprehensive geochemical characterization program to understand the metal leaching (ML) and acid rock drainage (ARD) potential associated with the rock types present in the general deposit area within the Pebble Project study area. The ML/ARD study was designed to characterize the materials that could be produced from the mining and milling process at the Pebble deposit, including both waste rock and tailings material (PLP, 2012). Classification of acid generating potential is based on Mine Environment Neutral Drainage (MEND, 1991) guidelines that classify rock as potentially acid generating (PAG), uncertain or non-PAG based on the neutralization potential ratio (NPR), defined as the neutralization potential (NP) divided by maximum potential acidity (MPA). Detailed characterization and classification of PAG and non-PAG materials enable engineers to design appropriate materials handling, sorting and storage strategies to ensure the long-term protection of water quality.

Acid-base accounting results indicate that the Tertiary units are dominantly non-PAG. No samples of Tertiary rock generated acidic conditions under field or laboratory conditions. Minor components of the Tertiary volcanic rocks (less than 1% based on testing) contain pyrite mineralization and have been found to be PAG. The pre-Tertiary samples from the porphyry-mineralized rock from the deposit area have variable acid generation potential. Pre-Tertiary rock was found to be dominantly PAG due to elevated acid potential (AP) values resulting from increased sulphur concentrations and limited NP resulting from lack of carbonate minerals. In the pre-Tertiary samples, acidic conditions occur quickly in core with low NP. Field data suggest that the onset to acidic conditions is about 20 years, while laboratory kinetic tests show that the delay to the onset of acidic conditions is expected to be between a decade and several decades for PAG rock.

The majority of the overburden samples analyzed have been classified as non-PAG, with very low total sulphur content dominated by sulphide. For pre-Tertiary material, metal mobility tests identified copper as the main contaminant in the leachate. Subaqueous conditions also produced the dissolution of gypsum and iron carbonate, as well as arsenic leaching. Weathering of the mineralized pre-Tertiary material under oxidizing conditions produced an acidic leachate dominated by sulphate and calcium. Non-PAG tests indicated that the oxidation of pyrite resulted in low pH conditions, which increased metal mobility.

16.2.5 Wetlands

Section 404 of the *Clean Water Act* (CWA) governs the discharge of dredged or fill materials into waters of the U.S., including wetlands. The U.S. Army Corps of Engineers (USACE) issues Section 404 permits with oversight by the U.S. Environmental Protection Agency (EPA). Given the Pebble Project's location and scope, the information required to support the Pebble Partnership's eventual Section 404 permit application is significant. Accordingly, Northern Dynasty and the Pebble Partnership conducted an extensive, multi-year wetlands study program at Pebble in both the Bristol Bay and Cook Inlet drainages.

The study area is much larger than the deposit area. This entire study area has been mapped to determine the occurrence of wetlands and to characterize baseline conditions. Overall, water bodies, wetlands and transitional wetlands represent 9,826 acres, or 33.4%, of the study area. Of the 375 water features evaluated in the overall study area, 308 (82.1%) were classified as lakes or perennial ponds, the vast majority of which were open water. The remaining 67 water features (17.9%) were classified as seasonal ponds or the drawdown areas of perennial ponds, which were roughly evenly encountered as open water or partially vegetated/barren ground.

A preliminary wetlands delineation in the field has been conducted, along potential transportation corridors from the deposit area to potential port sites on Cook Inlet. The Pebble Partnership will continue mapping wetlands and vegetation along potential transportation corridors.

16.2.6 Fish, Fish Habitat and Aquatic Invertebrates

Extensive aquatic habitat studies, initiated in 2004, were conducted from 2004 to 2008. They have varied in scope, study area and level of effort, as the information base has grown and specific data needs have become more defined. The aquatic habitat study program encompassed the three main deposit area drainages (NFK, SFK and UTC) and the Koktuli River, and in and around Iliamna Lake. Completed studies include:

- Fish population and density estimates using various field methods (dip netting, electro-fishing, snorkeling and aerial surveys);
- Fish habitat studies (main-channel and off-channel transects and habitat preferences);
- Fish habitats/assemblages above Frying Pan Lake;

- Salmon escapement estimates;
- Spring spawning counts and radio telemetry for rainbow trout;
- Radio telemetry of arctic grayling to assess stream fidelity;
- Overwintering studies for salmon, trout and grayling;
- Frying Pan Lake northern pike population estimate;
- Geo-referenced video aquatic habitat mapping;
- Intermittent flow reach, habitat and fish use; and,
- Fish tissue measurements for trace metals.

16.2.6.1. FISH AND FISH HABITAT

Project Site

The Kvichak and Nushagak river systems are two of the nine major systems that drain into Bristol Bay and support important runs of sockeye salmon, as well as other salmon species. This sockeye population supports valued commercial, subsistence and sport fisheries. Government studies, e.g. ADFG, 2009, indicate that, over the past decades, the combined Kvichak and Nushagak-Mulchatna river systems have contributed about 20 to 30% of total Bristol Bay sockeye salmon production.

Thus, some 70 to 80% of Bristol Bay sockeye production is hydrologically isolated from any potential effects of the Pebble Project. The total area of the Kvichak and Nushagak-Mulchatna river systems is some 23,567 square miles, of which the NFK, SFK and UTC watersheds near the deposit site account for only about 355 square miles, or about 1.5%. Based on the Pebble Partnership's extensive field studies and other government studies, independent consultants estimated that these three watersheds generally produce less than 0.5% of the total Bristol Bay sockeye run (i.e. harvest plus escapement).

The deposit area is characterized by small headwater streams of poor habitat quality and low fish density. Fish production is naturally limited by physical and chemical factors in these reaches, most notably intermittent flow with extreme low flow hydrology and oligotrophic conditions that constrain aquatic productivity. The lowest reaches of the three study area streams outside the deposit area have more stable hydrologic conditions and support numerous salmon and resident species.

The macro-invertebrate and periphyton studies near the Pebble deposit are part of the overall program of baseline investigations to describe the current aquatic conditions in the study area. Baseline information on macro-invertebrate and periphyton community assemblages is valued because the biota are essential components of the aquatic food web, and their community structure, particularly with respect to the more sensitive taxa, are an indicator of habitat and water quality.

The main objective of the macro-invertebrate and periphyton field and laboratory program was to characterize the diversity, abundance and density of macro-invertebrates and periphyton within freshwater habitats in the study area. Macro-invertebrates and periphyton were sampled in the study area in 2004, 2005 and 2007 as part of the environmental baseline studies for the Pebble Project. In 2004, 20 sites in the study area were sampled and of these, eight sites (five in the immediate vicinity of the deposit) were selected for continued sampling in 2005, and 10 were sampled in 2007.

Potential Transportation Corridor

Transportation corridor options consist of the main access route between the deposit area and potential port sites on Cook Inlet, as well as any shorter spurs that would be used to link a mine site with Iliamna Village.

Data from the AWC and field observations by independent experts indicate that many, but not all, waters in the area support anadromous fish populations, including all five Pacific salmon species (Chinook, sockeye, coho, pink, and chum) plus steelhead and rainbow trout, Dolly Varden, and arctic char. Population densities vary based on stream size and morphology, which can restrict population sizes or limit access to upstream habitats. The Pebble Partnership will conduct additional fish habitat surveys along corridor routes, including Cook Inlet locations, during a later phase of the Pebble Project's development.

16.2.7 Marine Habitats

16.2.7.1. MARINE NEARSHORE HABITATS

The nearshore marine habitat study area focused on areas in the lower Cook Inlet region. The western shorelines from Kameshak Bay north to Knoll Head are composed of a diversity of habitats, including steep rocky cliffs, cobble or pebble beaches and extensive sand/mud flats. Eelgrass is found at a number of locations and habitats; eelgrass, along with macro-algae, is an important substrate for spawning Pacific herring. Overall, the habitats in the study area provide a wide range of habitat types, resulting in a wide range of biological assemblages.

Preliminary data gathered at Amakdedori beach in 2013 indicate that Pacific herring are the predominant species present in the nearshore environment, with smaller populations of Dolly Varden and pink salmon.

16.2.7.2. MARINE BENTHOS

The littoral and subtidal habitats in lower Cook Inlet support diverse communities of marine and anadromous species of ecological and economic importance. The marine benthos study's intent was to characterize benthic assemblages in marine habitats in the lower Cook Inlet region.

The marine investigations were undertaken over a five-year period from 2004 to 2008, and included several habitat sampling events, mostly in mid to late summer. Each intertidal habitat type provides feeding areas for different pelagic and demersal fish and invertebrates that forage over the intertidal zone during high tides. The estuarine and nearshore rearing habitats of juvenile salmonids are an important component of the intertidal zone, especially for pink and chum salmon that out-migrate from streams along the shoreline and elsewhere in Cook Inlet. Another important component of the intertidal zone is the substrate used for spawning by Pacific herring.

16.2.7.3. NEARSHORE FISH AND INVERTEBRATES

The study of nearshore fish and macroinvertebrates has been undertaken to collect baseline data on the abundance, distribution and seasonality of major aquatic species on the western side of Cook Inlet (PLP, 2012). These marine investigations were undertaken between 2004 and 2008. The study area is a complex marine ecosystem with numerous fish and macro-invertebrate species that use the area for juvenile rearing, refuge, adult residence, migration, foraging, staging and reproduction.

The study area also functions as a rearing area for juvenile Pacific herring. Herring was the dominant fish species, and young-of-the-year and one-year-olds were the dominant life stages found from March through November in the several sampling years, with peak occurrences noted during the summer (PLP, 2012).

The nearshore area is also a rearing area for juvenile salmon, which, as a group, were second to herring in abundance. Juvenile pink and chum salmon were the most abundant salmonid species, and showed a typical spring and summer outmigration as young-of-the-year fish. Juvenile chum displayed a short outmigration period during May and June, while juvenile pink salmon remained in the area into August. Both species were largely gone by September.

The Pebble Partnership will conduct additional surveys if necessary as the Pebble Project moves forward.

16.3 POTENTIAL ENVIRONMENTAL EFFECTS AND PROPOSED MITIGATION MEASURES

The application of sound engineering, environmental planning and best management practices, including compliance with existing U.S. federal and state environmental laws, regulations and guidelines, will ensure that all of the environmental issues associated with the development and operation of the Pebble Project can be effectively addressed and managed.

The major environmental pathways include air, water and terrestrial resources. During the preliminary stages of the Pebble Project, Northern Dynasty identified key environmental issues and design drivers that have formed the basis of baseline data collection, environmental and social analysis and continuing stakeholder consultations influencing the Pebble Project design. The effects assessment has confirmed these as important issues and design drivers, and has identified mitigation measures for each. The key mitigation strategies for these drivers include:

- Water: development of a water management plan that maximizes the collection and diversion of groundwater, snowmelt and direct precipitation away from the mine site;
- Wetlands: implementation of a water management plan (in accordance with USACE guidelines and regulations) to reduce wetland impacts;
- Aquatic habitats: development of a water management plan and habitat mitigation measures that includes strategies to effectively manage the release of treated water in compliance with

anticipated regulatory requirements to maintain downstream flows and to protect downstream fish habitat and aquatic environments;

- Air quality: implementation of air emissions and dust suppression strategies; and,
- Marine environment: minimize the port facility's footprint in the intertidal zone, particularly in soft sediment intertidal areas.

Direct integration of these and other appropriate measures into the Pebble Project design and operational strategies are expected to effectively mitigate possible environmental effects and minimize residual environmental effects associated with the construction, operation and eventual closure of any proposed mine at the Pebble Project.

16.4 ECONOMY AND SOCIAL CONDITIONS

The Alaska economy is dependent on natural resources for both employment and government revenue. Oil and natural gas, mining, transportation, forestry, fishing and seafood processing, as well as tourism, represent a significant proportion of the overall private sector economy, with oil and gas contributing some 90% of state government revenues on an annual basis. Recent declines in resource commodity prices, notably for oil, have substantially reduced state government revenues and triggered a fiscal crisis for the Alaska State Legislature. At 7.3% in 2017, the seasonally adjusted unemployment rate in Alaska is highest among the 50 US states.

Of the nearly 740,000 people living in Alaska on a full-time basis, approximately half live in the greater Anchorage area. Approximately 15% of Alaska's population is of Native ancestry.

The Pebble Deposit is located in southwest Alaska's Lake and Peninsula Borough, home to an estimated 1,600 people in 18 local villages. At more 30,000 sq. miles, the Lake and Peninsula Borough is among the least densely populated boroughs or counties in the country. There are no roads into the borough, and few roads within it, contributing to an extremely high-cost of living and limited job and other economic opportunities for local residents.

The communities in closest proximity to Pebble are Nondalton, Iliamna and Newhalen. Pedro Bay lies on the northern shore of Iliamna Lake, some distance and isolated from these three closest communities. Igiugig and Kokhanok, on the southern shore of Iliamna Lake, are also proximal to transportation infrastructure proposed for the project. While the Pebble Partnership has generated employment for residents of villages through the Lake and Peninsula Borough and broader Bristol Bay region over the past decade, those communities surrounding Iliamna Lake have provided the greatest proportion of the local workforce.

With project infrastructure planned to connect the proposed mine site to the villages of Iliamna, Newhalen and Kokhanok, these and other communities are expected to continue to be important sources of project labour in future.

The Bristol Bay Borough is the only other organized borough in the Bristol Bay region, with some 900 full-time residents in three villages. A significant portion of the Bristol Bay region is not contained within an organized borough; the Dillingham Census Area comprises 11 different communities. A total of about 7,500 people call the Bristol Bay region home, with the largest population centers in Dillingham, King Salmon and Naknek.

Most Bristol Bay villages have fewer than 150 - 200 full-time residents. A majority of the population is of Alaska Native descent and Yup'ik or Denai'ina heritage. Virtually all the region's residents participate to some degree in subsistence fishing, hunting and gathering activities. Subsistence is considered to be central to Alaska Native culture, and provides an important food source for local residents.

There are 13 incorporated first- and second class cities in the Bristol Bay region, and 31 tribal entities as recognized by the US Bureau of Indian Affairs. There are also 24 Alaska Native Village Corporations created under the Alaska Native Claims Settlement Act, two of which – Alaska Peninsula Corporation and Iliamna Natives Limited – hold surface rights for significant areas of land near the Pebble Project and along its proposed transportation infrastructure corridors.

The private sector economy of the Bristol Bay region is dominated by commercial salmon fishing. Although the resource upon which the industry is based remains healthy, the economics of the fishery have declined significantly over the past several decades due to the rise of global salmon aquaculture and various domestic policy and market factors. Ex-vessel prices for sockeye salmon, the dominant species in the Bristol Bay fishery, have fallen from an inflation-adjusted peak of $3.75/lb in 1988 to a 10-year average of just under $1.00/lb in the 1990s and $0.60/lb in the 2000s. In recent years, ex-vessel prices have exceeded $1.00/lb.

As a result of these declines, the percentage of Bristol Bay fishing licenses and related employment held by residents of the region has fallen precipitously over the past 20 years, as has the region's overall economic health. Bristol Bay's economy today is characterized by a high proportion of non-resident labour and business ownership. Key private-sector industries are highly seasonal, such that unemployment among year-round residents is particularly high.

Bristol Bay communities also face among the highest costs of living in the U.S., due to the requirement to fly in many of the goods and commodities required for daily life, including fuel for heating homes and operating vehicles. Energy costs, in particular, are a significant deterrent to economic development.

As a result of a lack of jobs and economic opportunity in the region, Bristol Bay communities are slowly losing population as residents seek opportunities in other parts of the state. For example, the population of the Lake and Peninsula Borough declined 17% between 2000 and 2010, while the Bristol Bay Borough lost more than 23% of its population. In several communities, schools have closed or are threatened with closure as a result of diminishing enrolment.

A subsistence lifestyle is practiced by the vast majority of residents of Bristol Bay communities, including fishing for salmon and other species, hunting of terrestrial mammals and birds, and gathering berries. Salmon, in particular, are considered a critically important resource for the region, from a cultural, economic and environmental perspective.

16.4.1 Community Consultation and Stakeholder Relations

Since 2004, the Pebble Partnership and its predecessor Northern Dynasty have undertaken a comprehensive stakeholder relations and community outreach program. In addition to ensuring that relevant stakeholder groups and individuals receive early notification of all work programs, the objectives of the Pebble Partnership's stakeholder and community relations program are:

- To provide regular progress updates on project-related activities, opportunities and planning;
- To seek input on stakeholder priorities, issues and concerns, and provide feedback on how they are being addressed;
- To educate stakeholders on responsible resource development and modern mining principles and practices;
- To maximize economic and community benefits associated with the Pebble Project, both in the exploration and development phase and during mine operations; and,
- To provide opportunities for two-way dialogue and the development of long-term, respectful and mutually beneficial relationships.

The Pebble Partnership has developed a dedicated and knowledgeable stakeholder relations team to implement this program.

16.5 PROJECT DESCRIPTION AND PERMITTING

Forward Looking Information and Other Cautionary Factors

This section includes certain statements that may be deemed "forward-looking statements". Although Northern Dynasty believes the expectations expressed in its forward-looking statements are based on reasonable assumptions, such statements should not be in any way construed as guarantees of the ultimate size, quality or commercial feasibility of the Pebble Project or of Northern Dynasty's future performance. Assumptions used by Northern Dynasty to develop forward-looking statements include the following: the Pebble Project will obtain all required environmental and other permits and all land use and other licenses, studies and development of the Pebble Project will continue to be positive, and no geological or technical problems will occur. The likelihood of a partnering transaction is subject to risks related to the satisfactory completion of due diligence and negotiations, including finalization of definitive agreements and fulfilment of conditions precedent therein, including receipt of all necessary approvals. Such process may not be successfully completed or completed on terms satisfactory to Northern Dynasty. The likelihood of future mining at the Pebble Project is subject to a large number of risks and will require achievement of a number of technical, economic and legal objectives, including obtaining necessary mining and construction permits, approvals, licenses and title on a timely basis and delays due to third party opposition, changes in government policies regarding mining and natural resource exploration and exploitation, the final outcome of any litigation, completion of pre-feasibility and final feasibility studies, preparation of all necessary engineering for open pit and underground workings and processing facilities as well as receipt of significant additional financing to fund these objectives as well as funding mine construction. Such funding may not be available to Northern Dynasty on acceptable terms or on any terms at all. There is no known ore at the Pebble Project and there is no assurance that the mineralization at the Pebble Project will ever be classified as ore. The need for compliance with extensive environmental and socio-economic rules and practices and the requirement for the Company to obtain government permitting can cause a delay or even abandonment of a mineral project. Northern Dynasty is also subject to the specific risks inherent in the mining business as well as general economic and business conditions. For more information on the Company, Investors should review Northern Dynasty's annual Form 40-F filing with the United States Securities and Exchange Commission and its home jurisdiction filings that are available at www.sedar.com.

This section is presented in US Standard units as used in the permitting application and Project Description submitted to the US Army Corps of Engineers (USACE) in December 2017.

Pebble Partnership filed a CWA 404 permitting application with USACE. USACE confirmed that Pebble's permitting application was complete in January 2018 and an Environmental Impact Statement (EIS) is required to comply with its National Environmental Policy Act (NEPA) review of the Pebble Project. As the NEPA EIS process requires a comprehensive 'alternatives assessment' be undertaken to consider a broad range of development alternatives, the final project design and operating parameters for the Pebble Project and associated infrastructure may vary from that set out in the following.

This section describes the various project components and the operations associated with those components through the active life of the project proposed for assessment under the NEPA process at this time. It does not preclude changes that may occur from the current process nor that the project may be subject to other permitting processes over time.

Northern Dynasty completed a Preliminary Assessment on the Pebble Project in February 2011 and, as noted above, since that time after considering stakeholder and regulatory feedback, Northern Dynasty has submitted for federal permitting a proposed project with a substantially smaller mine facility footprint and with other material revisions as are described in detail in this Section 16.5. As a result, the economic analysis included in the 2011 Preliminary Assessment is considered by Northern Dynasty to be out of date such that it can no longer be relied upon. In light of the foregoing, the Pebble Project is no longer an advanced property for the purposes of NI 43-101, as the potential economic viability of the Pebble Project is not currently supported by a preliminary economic assessment, pre-feasibility study or feasibility study. The EIS process currently underway by the USACE will consider alternative scenarios with respect to a number of aspects of the proposed project. Accordingly, the Company has not completed a current comprehensive economic analysis of the Pebble Project but anticipates that having a complete understanding of, and being able to properly assess all of the proposed alternatives that the USACE will be considering as part of the scoping process conducted during the initial phase of the EIS will provide additional clarity with respect to the project to be evaluated so that an economic analysis can be completed.

The Pebble Partnership's permit application envisages the Pebble Project being developed as an open pit mine with associated on and off-site infrastructure described in this section. Construction will last for approximately four years, followed by a commissioning period and 20 years of mineral processing. Mining pre-production will start during construction, and active mining from the pit will continue through the first 14 years of mineral processing. For the last six years of mineral processing, the mill will be fed from the low grade (LG) stockpile.

Figure 16-5.1 shows the layout of the mine site, including the major facilities and site infrastructure. Figure 16.5.2 summarizes general operating information for the proposed project.

Figure 16.5-1 Potential Mine Site Layout

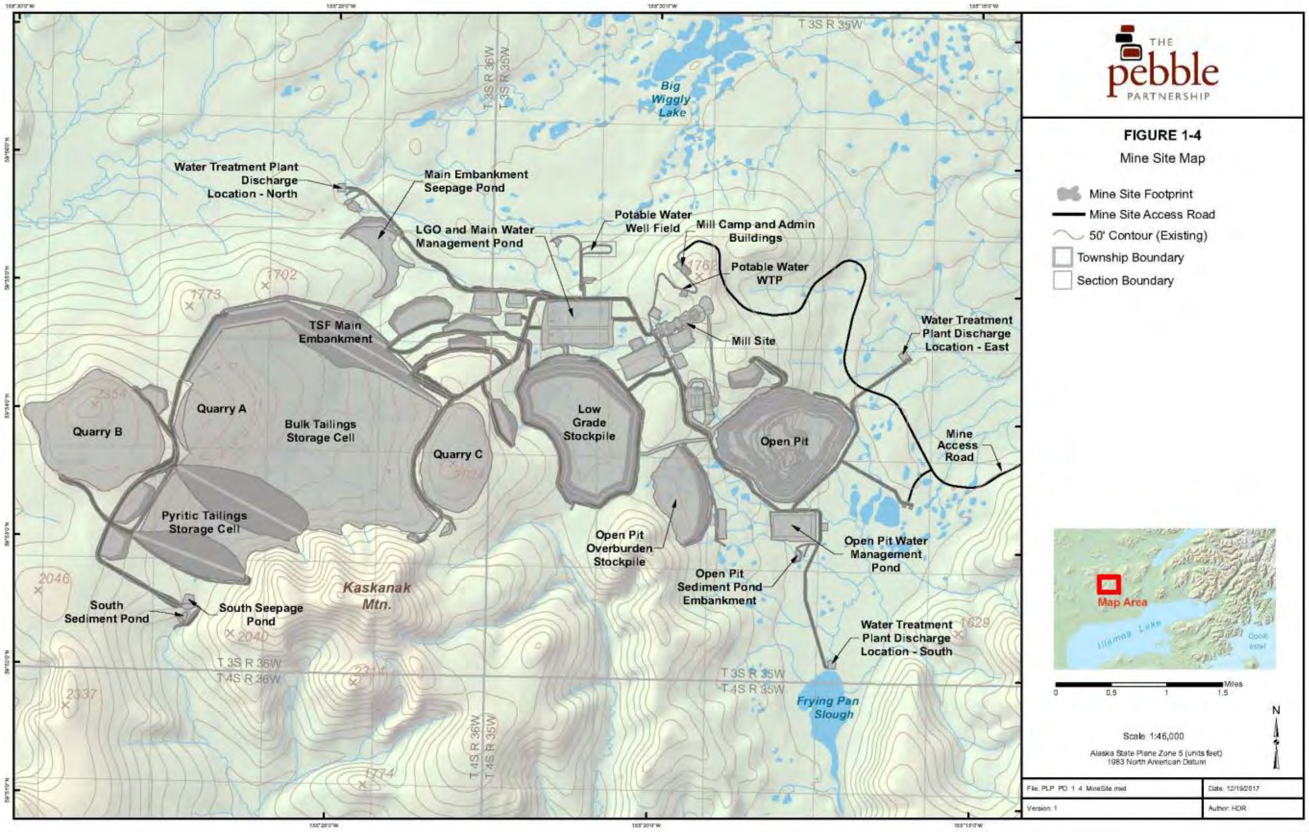


Figure 16.5-2 Summary Project Information

Item	Value
General Operation	
Construction	4 years
Open pit mining	14 years
LG stockpile processing	6 years
Total project operations	20 years
Daily schedule	24 hours
Annual schedule	365 days
Mine Operation	
Pre-production mined volume	30 million tons
Annual mining rate	90 million tons
Operations mined volume	1,200 million tons
Mine life strip ratio	0.1:1 (waste:mineralized material)
Open pit dimensions	6,500 x 5,500 ft, 1,330–1,750 ft deep
Process Operation	
Daily process rate	160,000 tons
Annual process volume	58 million tons
Copper-gold concentrate	600,000 tons per year
Molybdenum concentrate	15,000 tons per year

Design criteria as presented are approximate and have been averaged and rounded as appropriate for ease of reference.

16.5.1 Mining

16.5.1.1 METHODS AND PHASING

The proposed Pebble Mine will be a conventional drill, blast, truck, and shovel operation with a mining rate peaking at 90 million tons per year and an overall stripping ratio of 0.1 ton of waste per ton of mineralized material.

The open pit will be developed in stages, with each stage expanding the area and deepening the previous stage. The final dimensions of the open pit will be approximately 6,500 feet long and 5,500 feet wide, with depths between 1,330 and 1,750 feet.

Mining will occur in three phases: Preproduction, Production, and Stockpile Reclaim.

The mine operation will commence during the last year of the Preproduction Phase and extend for 14 years during the Production Phase. During this period, 1,100 million tons of mineralized rock and 100 million tons of waste rock will be mined. After the open pit is depleted, the process plant will be fed with mineralized material reclaimed from the LG stockpile. Non-potentially acid generating (NPAG) waste rock will be used in construction of the tailings embankments or mine site roads. The potentially acid generating (PAG) waste rock will be stored in the LG stockpile until closure, when it will be back-hauled into the open pit. Fine- and coarse-grained soils will be stored southwest of the pit and north of the main tailings storage facility (TSF) embankment and will be used for reclamation during mine closure.

The Preproduction Phase consists of dewatering the pit area and mining of non-economic materials overlying the mineralized material, to be stockpiled for initial process plant feed, from the initial stage of the open pit. Dewatering will begin approximately one year before the start of preproduction mining, which will last for one year. Approximately 30 million tons of material will be mined during this phase (Figure 16.5-3).

Figure 16.5-3 Mined Material - Preproduction Phase

Material Type	Quantity
Overburden	8 million tons
Mineralized material process plant feed	19 million tons
NPAG waste rock	2 million tons
PAG waste rock	1 million tons

The Production Phase encompasses the period during which economic-grade mineralized material will be fed to the metallurgical process plant that produces concentrates for shipment and sale. The Production Phase is planned to last for 20 years. Mineralized material will be mined for 14 years and be fed through the process plant at a rate of 160,000 tons/day. The open pit will be mined in a sequence of increasingly larger and deeper stages. As the mining rate will exceed the processing rate, surplus mineralized material, selected based on its relative value, will be stored on the LG stockpile and later processed during the Stockpile Reclaim Phase. Approximately 1.2 billion tons of material are planned to be mined during the Production Phase (Table 16.5.4).

Figure 16.5-4 Mines Material - Production Phase

Material Type	Quantity
Overburden	63 million tons
Mineralized material process plant feed	1,098 million tons
NPAG waste rock	15 million tons
PAG waste rock	27 million tons

The Stockpile Reclaim Phase will commence during the last year of the Production Phase and extend for an additional six years. During this phase, mining activity will be limited to reclaiming material from the LG stockpile to feed through the process plant. The process rate will continue at 160,000 tons/day. At the end of this phase, the LG stockpile will be depleted.

16.5.1.2 BLASTING

Most open pit blasting will be conducted using emulsion blasting agents manufactured on site. In dry conditions, a blend of ammonium nitrate and fuel oil (ANFO) can be used as the blasting agent. However, most ammonium nitrate will be converted to an emulsion blasting agent because of its higher density and superior water resistance.

Based on knowledge of the rock types in the Pebble Deposit, blasting will require an average powder factor of approximately 0.5 pound per ton of rock. Blasting events during the Preproduction Phase will occur approximately once per day. The frequency will increase during the Production Phase, with events occurring as often as twice per day.

16.5.1.3 WASTE ROCK AND OVERBURDEN STORAGE

Waste rock is material with a mineral content below an economically recoverable level that is removed from the open pit, exposing the higher grade production material. Waste rock will be segregated by its potential to generate acid. NPAG waste rock will be used to construct various mine site structures, including TSF embankments, water management pond (WMP) embankments, and mine site roads. Waste rock that is potentially acid generating will be stored within the LG stockpile until mine closure, when it will be back hauled into the open pit. Quantities of material mined are outlined in Table 16.5.3 and Table 16.5.4 above.

During the Preproduction Phase, approximately 19 million tons of mineralized material will be removed from the open pit and stockpiled within the LG stockpile. This material will be processed once the mill starts up.

Overburden is the unconsolidated material lying at the surface. At the Pebble Deposit, the overburden depth ranges from 0 to 140 feet. Overburden removal will commence during the Preproduction Phase and will recur periodically during the Production Phase at the start of each pit stage. The overburden will be segregated and stockpiled in a dedicated location southwest of the open pit. A berm built of non-mineralized rock will surround the overburden to contain the material and increase stability. Overburden materials deemed suitable will be used for construction. Fine- and coarse-grained soils suitable for plant growth will be stockpiled for later use as growth medium during reclamation. Growth medium stockpiles will be stored at various locations around the mine site and stabilized to minimize erosion potential.

16.5.1.4 LOW GRADE STOCKPILE

The LG stockpile will be used during the Preproduction and Production phases to store mineralized material, segregated on the basis of its relative value, and PAG waste rock mined from the open pit. The LG stockpile will be placed on an engineered liner to control seepage losses through the stockpile.

The LG stockpile will be progressively developed through the Production Phase, during which some stockpiled material will be reclaimed for feed to the process plant. At its peak, the LG stockpile will contain approximately 330 million tons of mineralized material.

16.5.1.5 EQUIPMENT

The proposed Project will use the most efficient mining equipment available in the production fleet to minimize fuel consumption per ton of rock moved. Most mining equipment will be diesel-powered. This production fleet will be supported by a fleet of smaller equipment for overburden removal and other specific tasks for which the larger units are not well-suited. Equipment requirements will increase over the life of the mine to reflect increased production volumes and longer cycle times for haul trucks as the pit is lowered. All fleet equipment will be routinely maintained to ensure optimal performance and minimize the potential for spills and failures. Mobile equipment (haul trucks and wheel loaders) will be serviced in the truck shop; track-bound equipment (shovels, excavators, drills, and dozers) will be serviced in the field under appropriate spill prevention protocols.

Electric shovels, each mounted on a base platform equipped with tracks, will be the primary equipment unit used to load blasted rock into haul trucks. Each electric shovel is capable of mining at a sustained rate of approximately 30 million tons per year. Diesel hydraulic shovels, due to their greater flexibility, will be used to augment excavation capacity, depending on the mining application.

Wheel loaders are highly mobile, can be rapidly deployed to specific mining conditions, and are highly flexible in their application. Diesel off-highway haul trucks will be used to transport the fragmented mineralized material to the crusher.

Track-mounted drill rigs are used to drill blast holes into the waste rock and mineralized material prior to blasting. Hole diameters will vary between 6 and 12 inches. Drill rigs may be either electrically powered, as is the case for the larger units, or diesel powered.

This equipment will be supported by a large fleet of ancillary equipment, including track and wheel dozers for surface preparation, graders for construction and road maintenance, water trucks for dust suppression, maintenance equipment, and light vehicles for personnel transport. Other equipment, such as lighting plants, will be used to improve operational safety and efficiency.

16.5.2 Mineral Processing

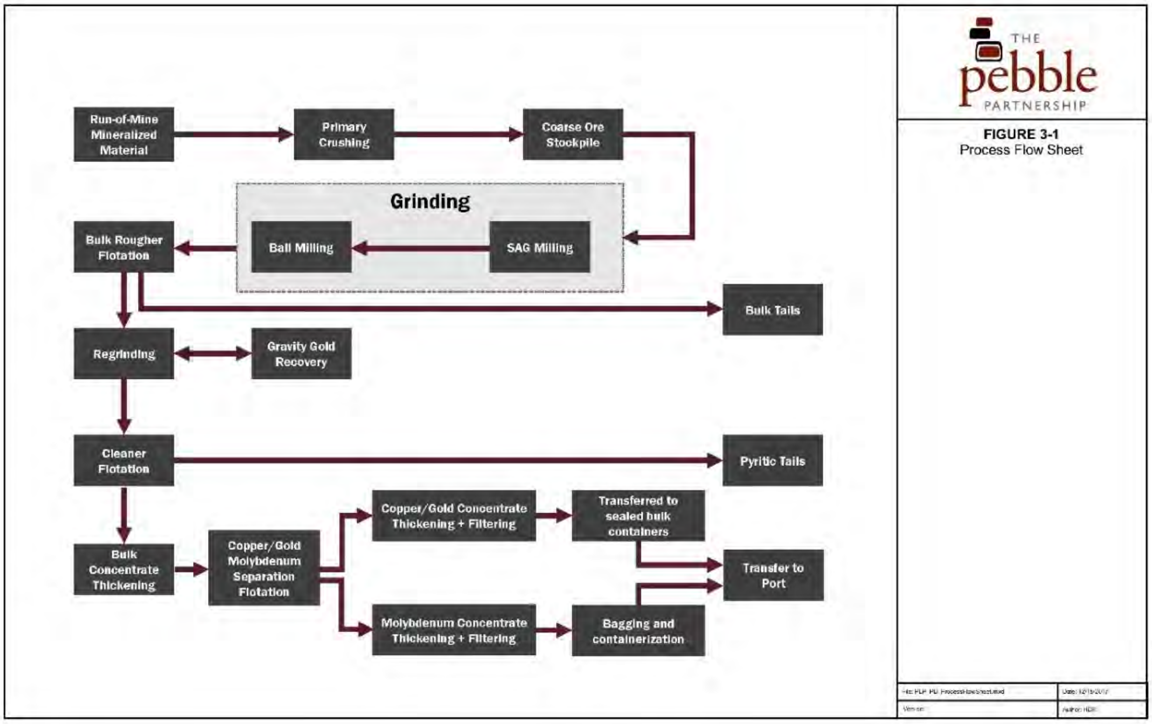
In the proposed plan, mineral processing facilities will be located at the mine site. Blasted mineralized material from the open pit will be fed to a crushing plant to reduce the maximum particle size to approximately six inches. This crushed material will be conveyed to a coarse ore stockpile, which in turn feeds a grinding plant within the process plant. In the grinding plant, semi-autogenous grinding (SAG) mills and ball mills further reduce the plant feed to the consistency of very fine sand. The next step is froth flotation, in which the copper and molybdenum minerals are separated from the remaining material to produce concentrates. The concentrates are then filtered for shipment. Gravity concentrators will be placed at strategic locations to recover free gold, which will be shipped off site for refining.

The copper-gold concentrate will be loaded into covered bulk shipping containers; the molybdenum concentrate will be packaged in bulk bags and loaded into shipping containers. Other economically valuable minerals—palladium and rhenium—will be present in the concentrates and may be recovered at the refineries. Figure 16.5-5 shows the process flowsheet.

The concentrate containers will be transported by truck to the Amakdedori Port on Cook Inlet. The contents of the copper-gold concentrate containers will be directly unloaded into the holds of Handysize bulk carriers for shipment, while the molybdenum containers will be loaded onto barges or other ships.

Over the life of the Project, approximately 1.1 billion tons of mineralized material will be fed to the process plant at a rate of 160,000 tons/day. On average, the process plant will produce approximately 600,000 tons of copper-gold concentrate per year, containing approximately 287 million pounds of copper, 321,000 ounces of gold and 1.6 million ounces of silver, and approximately 15,000 tons of molybdenum concentrate, containing about 13 million pounds of molybdenum.

Figure 16.5-5 Process Flow Sheet



16.5.2.1 CRUSHING AND GRINDING

Mineralized material from the open pit or LG stockpile will be delivered by 400-ton haul trucks to primary gyratory crushers located adjacent to the rim of the open pit. The crushers will reduce the mineralized material to a maximum size of six inches. The crushed mineralized material from both crushers is delivered via a single, covered, overland conveyor to the coarse ore stockpile.

The coarse ore stockpile is contained within a covered steel frame building to minimize fugitive dust emissions and control mineralized material exposure to precipitation. The stockpile provides surge capacity between the crushers and the process plant, improving the efficiency of the latter and enabling it to operate if the feed from the crushers is not available.

The stockpiled material will be reclaimed by apron feeders mounted below the pile that deliver it onto two conveyor belts feeding the SAG mills. Baghouse-type dust collectors will be provided at each transfer point to control fugitive dust emissions. Water will be added to the process at the SAG mill, thereby eliminating the need for additional baghouses. A sump will be located in each reclaim tunnel to collect any excess water; however, such drainage is likely to be minimal.

The primary grinding circuit will use two parallel, 40-foot-diameter SAG mills and associated ball mills to grind mineralized material to the finer consistency necessary to separate the valuable minerals. Steel balls are added to the SAG mill to aid in grinding the mineralized material. Coarse mineralized material, water, and lime are fed into the SAG mills and the mineralized material is retained within the SAG mills by grates until the particles reach a maximum size of one to two inches.

Discharge from each SAG mill will be screened to remove larger particles ranging from one to two inches ("pebbles") and sent to the ball mills. The large particles will be conveyed to the pebble-crushing facility where they will be crushed and re-introduced to the SAG mill.

The next grinding step is ball milling. Ball mills have a lower diameter-to-length ratio than SAG mills and use a higher percentage of smaller steel balls compared to SAG mills, allowing them to grind the feed to a finer size. Two ball mills will be matched with each SAG mill.

The slurry from the ball mills will be pumped into the hydro-cyclones, which separate the finer material from the larger material through centrifugal force. The slurry with the coarser material will be recycled back to the ball mills for additional grinding. The slurry containing the finer material will be pumped to the flotation cells. Grinding circuit slurry pH levels will be adjusted to 8.5 by adding lime slurry to minimize corrosion on the mill liners and promote efficient mixing prior to flotation.

16.5.2.2 CONCENTRATE PRODUCTION

Copper-gold and molybdenum concentrates will be produced via flotation, which will separate the metal sulfides from pyrite and non-economic minerals. Two tailings streams will be produced: bulk tailings and pyritic tailings.

The rougher flotation circuit is designed to separate the sulfide minerals, predominantly copper, molybdenum, and iron sulfides (pyrite) within the process plant feed from the non-sulfide minerals. Slurry from the ball mills is split between two banks of bulk rougher flotation cells. Reagents added to the slurry promote mineral separation by inducing mineral particles to attach to air bubbles created by blowing air through the flotation cells. Additional reagents are added to promote froth bubble stability. This froth, with the mineral particles attached, rises to the surface and is collected as a bulk rougher concentrate for the next phase of flotation.

Bulk rougher concentrate slurry is then routed to the regrind circuit. Material that does not float – the bulk flotation tailings from which most of the sulfide minerals have been removed – will be pumped to two tailings thickeners.

The bulk rougher concentrate is reground to sufficiently liberate minerals and enable the separation of the copper-molybdenum sulfide minerals from iron and other sulfides, thus producing concentrates with commercially acceptable grades. A gravity gold recovery circuit is attached to the regrind circuit to recover free gold that might otherwise be lost.

Reground bulk rougher concentrates will be upgraded through a two-stage cleaning process. The concentrate from the cleaning process will report to copper-molybdenum separation, while the tailings will report to the pyritic tailings thickener for thickening prior to pumping to the pyritic tailings storage cell in the TSF. The same reagents used in the rougher flotation circuit will be used in the cleaning circuit, with additional reagents used to aid in the suppression of gangue minerals. The cleaning stage is operated at an elevated pH—through lime addition—to suppress pyritic minerals, which would lower the grade of final concentrates.

Water will be removed from the bulk concentrate in a conventional thickener. This will remove as much of the bulk flotation reagents as possible before the slurry enters the copper-gold/molybdenum separation circuit, thus increasing separation process efficiency. Reagents will be recycled to the rougher process with the thickener overflow. The resulting slurry will contain 50 percent solids by weight and will go forward to copper-gold/molybdenum separation.

The final flotation process is designed to separate copper-gold and molybdenum concentrates by adding reagents. The concentrate from the separation stage is the molybdenum concentrate, while the tailings comprise the final copper-gold concentrate.

The upgraded copper-gold concentrate will be thickened to 55 percent solids by weight in a high-rate thickener. The thickener overflow will return to various circuits for use as process water. The thickener underflow will be fed to a pressure filter to reduce the moisture to approximately eight percent. The filter product will be conveyed to specialized bulk cargo containers with removable locking lids that prevent dust emissions and incidental spills while maintaining product quality through the logistics chain.

The molybdenum concentrate will be thickened in a high-rate thickener to 55 percent solids by weight. The thickener underflow will be pumped to the molybdenum concentrate filter press, where the moisture content will be reduced to 12 percent. The filtered concentrate will be further dewatered by a dryer to five percent moisture before being bagged, containerized, and shipped offshore.

16.5.2.3 OTHER

Process water will be drawn from the main water management pond (WMP) and the tailings thickener overflow streams. The primary process water source is the bulk tailings thickener overflow. Precipitation, runoff, and diverted water will be directed to runoff water ponds, and then to the mill site WMP. Some treated water will be diverted to the process for pump glands and other similar applications.

Processing mineralized material to recover copper, gold, and molybdenum will produce two types of tailings: bulk flotation and pyritic. Bulk flotation tailings will be pumped to the bulk tailings thickener, where flocculant will be added as necessary to help the settling process. Tailings thickener underflow, at approximately 55 percent solids, will be pumped to the bulk tailings storage cell. The pyritic tailings will be thickened, mixed with water treatment plant (WTP) sludge, and pumped to the pyritic tailings storage cell. The overflow streams from each thickener will be returned to the process. Supernatant water in the pyritic tailings storage cell and bulk tailings storage cell will be reclaimed to the mill site WMP. Some of this water will be pumped to the process water tank for re-use in the process plant. The remaining water will be treated in the WTP and discharged.

16.5.3 Tailings Storage Facility (TSF)

16.5.3.1 SITING AND DESIGN CRITERIA

Pebble Partnership conducted a multi-year, multi-disciplinary evaluation to select a TSF location that meets all engineering and environmental goals while allowing for cost-effective integration into the site waste and water management plans. During this evaluation, more than 35 tailings disposal options were tested against a range of siting criteria.

The final TSF design will incorporate the following:

- Permanent, secure, and total confinement of tailings solids within an engineered disposal facility;
- Control, collection, and recovery of tailings water from within the tailings impoundments for recycling to the process plant operations as process water, or treatment prior to discharge to the environment;
- Providing seepage collection systems below the impoundment structures to prevent adverse downstream water quality impacts;
- The inclusion of freeboard to contain the entire volume of the Inflow Design Flood (IDF) above the tailings beach. The maximum operating pond will not flood the entire tailings beach;
- Limiting the volume of stored water within the bulk tailings cell and keeping the operating pond away from the dam face;
- The consideration of long-term closure management at all stages of the TSF design;
- The inclusion of monitoring instrumentation for all aspects of the facility during operations and after closure; and
- The design includes flattened slopes to increase the static factor of safety.

16.5.3.2 TAILINGS DEPOSITION

The bulk flotation and pyritic tailings streams will be delivered to the TSF using two pump stations, one located in the process plant and one booster station positioned approximately mid-way along the pipeline route. The bulk tailings will be discharged via spigots spaced at regular intervals along the interior perimeter of the bulk tailings cell to promote beach development, which will allow the supernatant pond to be maintained away from the main embankment.

Pyritic tailings from the cleaner scavenger flotation circuit will be discharged into the pyritic tailings cell at sub-aqueous discharge points. The sub-aqueous discharge is necessary to prevent oxidation and potential acid generation.

16.5.3.3 PROPOSED FACILITY

The TSF will be located within the NFK watershed. Total TSF capacity will be sufficient to store the 20-year mine life tailings volume (1.1 billion tons). Approximately 88 percent (950 million tons) of the tailings will be bulk tailings, and approximately 12 percent (135 million tons) will be pyritic tailings.

The TSF has separate cells for bulk and pyritic tailings and has four embankments: main, south, and east perimeter embankments and an internal embankment separating the bulk and pyritic tailings cells. The pyritic tailings will be stored in a lined cell between the internal and south embankments, and bulk tailings will be stored between the main, internal, and east embankments.

Starter embankments for the main, south and internal embankments will be constructed as part of initial TSF construction; east embankment construction will begin in year ten of operations. The main embankment will function as a permeable structure to maintain a depressed phreatic surface in the embankment and in the tailings mass in proximity to the embankment. A basin underdrain system will be constructed at various locations throughout the bulk cell basin to provide preferred drainage paths for seepage flows. The pyritic tailings cell will be a fully lined facility with subsurface drains to convey seepage to the north and south based on the topography.

The pyritic tailings cell will have a full water cover during operations, while the bulk tailings cell will have a relatively small supernatant pond, located away from the main embankment, to promote large tailings beach development upstream of the main embankment.

The TSF downstream embankment slopes will be maintained at approximately 2.6H:1V (horizontal:vertical), including buttresses established at the downstream toe of the main embankment. The final embankment crest elevation will be approximately 1,770 feet above sea level for the main, east, and internal embankments. The south embankment final crest elevation will be a minimum of five feet higher (1,775 feet above sea level) than the internal embankment. This safety precaution will ensure that any potential overflow would be directed to the much larger bulk tailings cell. Embankment heights, as measured from lowest downstream slope elevation, will be approximately 600 feet (main), 350 feet (south), 420 feet (internal), and 60 feet (east).

The TSF embankments will be constructed using earth- and rockfill materials, including NPAG waste rock excavated from the open pit. The material for the starter embankments will be sourced from excavations required at the embankment locations and from a quarry located within the impoundment area. The embankments will be raised progressively during the mine life. After the quarry within the impoundment is inundated with tailings, material will be sourced from two quarries immediately west and east of the impoundment. Embankments will be constructed in stages throughout the life of the Project, with each stage providing the required capacity until the next stage is completed. Planned embankment raises will be evaluated each year and sized according to a review of the process plant throughput, actual tailings settled densities, and water storage requirements.

All stages of embankment design include a freeboard allowance above the maximum operating TSF pond level and tailings beach. The freeboard allowance includes containment of the IDF and wave run-up protection, as well as an allowance for post-seismic embankment settlement. The IDF for the facility has been selected as the Probable Maximum Flood (PMF). The embankment freeboard requirements will be reviewed as part of each dam lift and dam safety review, and will be adjusted, as required to reflect actual mine water management conditions. The design PMF volume is based on the 72-hour Probable Maximum Precipitation (PMP) event, plus the snow water equivalent from a 1-in-10-year snowpack.

The seepage management system will also include seepage control measures downstream of the TSF embankments. These include seepage recycle ponds with grout curtains and low-permeability core zones, and downstream monitoring wells. Embankment runoff and TSF seepage collecting in the downstream seepage recycle ponds will ultimately be transferred to a WMP to be used in mining operations. Surplus water from the WMPs will be treated to achieve discharge standards and then released to the environment.

16.5.4 Infrastructure

Due to the remote location and the absence of existing infrastructure, the Project will be required to provide basic infrastructure, as well as the support facilities typically associated with mining operations. These facilities require reasonable access from the Pebble Deposit, and would be situated foremost for stability and safety. Figure 16.5.1 shows the mine site layout.

16.5.4.1 ON-SITE

Power Generation and Distribution

There is no existing power infrastructure in the Project vicinity. All required generating capacity, distribution infrastructure, and backup power will be developed by the Project.

To meet the projected power requirement while providing sufficient peaking capacity and N+1 redundancy (one generating unit held in reserve for maintenance or emergency use) will require a plant with an installed nameplate capacity of 230 MW. The plant will use high-efficiency combustion turbine or reciprocating engine generators operating in a combined-cycle configuration. The units would be fired by natural gas provided to the site via pipeline. Design-appropriate controls will be used to manage airborne emissions and meet Alaska Department of Environmental Conservation (ADEC) air quality criteria and best management practices (BMPs). Unused waste heat will be rejected through a closed-loop, water cooled system.

The various mine load centers would be serviced by a 69-kilovolt distribution system using a gas-insulated switchgear system located at the power plant.

Emergency backup power for the mine site will be provided by both standby and prime-rated diesel generators connected into electrical equipment at areas where power is required to ensure personnel safety, avoid the release of contaminants to the environment, and allow for the managed shutdown and/or ongoing operation of process-related equipment.

Heating

Waste heat from the power plant will be used to heat mine site buildings and supply process heating to the water treatment plant. Low-pressure steam, via heat exchangers, will heat a closed-loop glycol system that distributes heat to various buildings. Warm water from the steam condenser discharge will be routed to the water treatment plant to provide process heating.

Shops

The truck shop complex will house a light-vehicle maintenance garage, a heavy-duty shop that can accommodate 400-ton trucks, a truck wash building, a tire shop and a fabrication and welding shop. The layout is designed to maintain optimal traffic flow and minimize the overall complex footprint. An oil-water separation system will be designed for water collected from the wash facility and floor drains.

On-site Access Roads

There will be several access roads within the mine site area, including a road from the gatehouse to the mine site and secondary roads linking with the various facilities around the mine. Roads will be sized according to the operating requirements and the types of equipment using them.

Personnel Camps

The first camp to be constructed at the mine site will be a 250-person fabric-type camp to support early site construction activities and throughout the Preproduction Phase as required for seasonal peak overflows. The main construction camp will be built in a double-occupancy configuration to accommodate 1,700 workers. This facility will later be refurbished for 850 permanent single-occupancy rooms for the operations phase. The camp will include dormitories, kitchen and dining facilities, incinerator, recreation facilities, check-in/check-out areas, administrative offices and first aid facilities.

The mine will operate on a fly-in, fly-out basis, except for those personnel residing in the communities connected to the access road corridor.

Potable Water Supply

A series of groundwater wells located north of the mine site will supply potable water to the mine site. Preliminary tests indicate that minimal water treatment will be required. Treatment will likely include multimedia filtration, chlorination with sodium hypochlorite, and pH adjustment with sodium hydroxide. The treatment plants will be designed to meet federal and state drinking water quality standards.

Potable water will be distributed through a pump and piping network to supply fresh water to holding tanks at the personnel camp and process plant. Holding tank capacity will be sufficient for a 24-hour supply. Diesel-fired backup pumps will be installed to provide potable water during an electrical outage.

Communications

Communications to site will be via fiber optic cable with satellite backup for critical systems. The fiber optic cable will connect to existing fiber optic infrastructure in the region or a dedicated fiber optic cable laid in conjunction with the gas pipeline.

The process plant communications system will use a dedicated ethernet network to support mine process control system communications. A separate network will connect various main components of the fire-detection and alarming system. Closed-circuit television, access control, and voice over internet protocol telephone systems will be integrated with the local area network. Mine operations will use two-way radios, cell phones, and similar equipment for communications.

Laboratories

Two laboratories – a metallurgical lab and an assay lab - will operate at the mine site during the Production Phase. The laboratories will use state-of-the-art equipment and be fully equipped sample receiving and storage, sample preparation, and requisite testing. Chemical wastes will be disposed of in accordance with all applicable laws and regulations.

Materials Supply and Management

General supplies and bulk reagents will typically be stored in, or adjacent to the area of use. The location of the explosives storage and emulsion manufacturing plant is based on the need to minimize transfer distances and to provide a safety buffer between the explosives plant and other facilities.

Diesel Fuel

Diesel fuel to support the mining operation, as well as the trucking and ferry logistics systems, will be imported to the Amakdedori Port using coastal tanker vessels or barges. The expected maximum parcel size for delivery is four million gallons, which will allow for extended periods between shipments in winter months. The Amakdedori Port will accommodate sufficient bulk fuel storage to provide one month of buffer and allow for the offloading of bulk fuel carriers.

Diesel fuel will be transferred from the Amakdedori Port to the mine site using ISO tank-container units, which have a capacity of 6,350 gallons. These units will be loaded at the port and transported by truck and ferry to the mine site. The main mine site fuel storage area will contain fuel tanks in a dual-lined and bermed area designed to meet regulatory requirements. Sump and truck pump-out facilities will be installed to handle any spills. There will also be pump systems for delivering fuel to the rest of the mine site. Dispensing lines will have automatic shutoff devices, and spill response supplies.

Fuel will be dispensed to a pump house located in a fuel storage area for fueling light vehicles, and to fuel tanks in the truck shop complex for fueling mining equipment. These tanks will also be in a lined and bermed secondary containment area.

Lubricants

Lubricants will be packaged in drums and/or totes and stored on site within a secondary containment area.

Explosives

The materials used to manufacture blasting agents include ammonium nitrate prill, fuel oil, emulsifying agents, and sensitizing agents (gaseous). The containers used to transport the prill will be offloaded, using a container tilter, to a bucket elevator, which will unload the prill to three silos, each sized for 150,000 pounds. As a safety precaution, ammonium nitrate prill will be stored and prepared for use at a location approximately 0.75 mile southeast of the final pit rim. Electrical delay detonators and primers will be stored in the same general area, but in a separate magazine located apart from each other and separate from the prill. All facilities will be constructed and operated to meet mine safety and health regulations.

Reagents

Reagents will arrive at the mine site by truck in 20- or 40-ton containers, and stored in a secure bulk reagent storage area, segregated according to compatible characteristics. The reagent storage area will be sufficient to maintain a two-month supply at the mine site.

Reagents will be used in very low concentrations throughout the mineral processing plant and are primarily consumed in the process; low residual reagent quantities remain in the tailings stream and will be disposed in the TSF where they will be diluted and decompose. The metallurgical and assay laboratories will also use small amounts of reagents. Any hazardous reagents imported for testing will be transported, handled, stored, reported, and disposed of as required by law, in accordance with manufacturers' instructions, and consistent with industry best practices.

Waste Management and Disposal

Mine Waste

Used tires and rubber products will be reused to the extent practicable. Additional used tires, along with other damaged parts, worn pipes and scrap steel, will be packaged as necessary and back-loaded into empty containers for shipment and disposal off site. Other materials, such as reagent packaging will be evaluated against applicable regulations, permits and health and safety plans for possible incineration in the on-site incinerator or packed for removal and disposal off site.

Most inorganic aqueous wastes from the metallurgical and assay laboratories will be collected in a sump, with the remainder routed to the domestic sewage treatment plant. Fugitive organics will be skimmed from the surface of the sump prior to discharging the aqueous portion to the LG and main WMP. Waste oil will be reused as fuel in used oil heaters to augment heating in the truck shop and/or other buildings on site. Waste oils not suitable for burning, as well as lubricants and any hazardous materials will be managed and shipped to approved off-site facilities according to applicable BMPs and regulations.

Water from the truck wash will be routed to the TSF. Water in the TSF will be either recycled within the mill and processing plant or treated and discharged.

Domestic Waste

Domestic refuse from the camp kitchen, living quarters, and administration block will be disposed of on site in a permitted landfill, or shipped off-site to appropriate disposal sites. Some wastes, including putrescible wastes, will be incinerated on site, and the remaining ashes will be disposed of in accordance with applicable BMPs and regulations. Separate sewage treatment plants will be located at the camp and the process plant.

Grey water from the kitchen, showers, and laundry facilities will be treated to remove biological oxygen demand, total suspended solids (TSS), total phosphate, total nitrogen, and ammonia to meet ADEC domestic waste-discharge criteria. The process plant sewage treatment plant will receive effluent that may have metallic residues from the workers' change house and associated laundry. This sewage treatment plant will be designed for metals removal in addition to the above-mentioned ADEC domestic waste-discharge criteria. Treated water will be discharged to the TSF.

Water Management and Water Treatment Plants

The main objective of water management at the mine site is to manage, in an environmentally responsible manner, water that originates within the project area while providing an adequate water supply for operations. A primary design consideration is to ensure that all contact water that requires treatment prior to release to the environment will be effectively managed. This includes carefully assessing the Project facility layout, process requirements, area topography, hydrometeorology, aquatic habitat/resources, and regulatory discharge requirements for managing surplus water

All runoff water contacting the facilities at the mine site and water pumped from the open pit will be captured to protect the overall downstream water quality. The ultimate Project design will incorporate a detailed analysis of water collection and management, including quantity and quality estimates, water treatment options, water management facility design, and strategic discharge of treated water. The water management plan will enable the plant to operate without requiring additional water from off-site sources. Mine site water management systems will be designed for the entire life cycle of the Project, from initial construction through the preproduction phase, operation, and closure.

Water collected around the mine area and Amakdedori Port site will require treatment prior to discharge to the environment. Treatment methods will include a mixture of settling for sediment removal, chemical additions to precipitate trace elements, filtration, reverse osmosis, and evaporation to meet final discharge criteria.

The mine area will have two water treatment plants (WTP) constructed with multiple, independent treatment trains, which will enable ongoing water treatment during mechanical interruption of any one train. The main WTP will treat water from the main embankment seepage pond and the LG stockpile WMP. The open pit WTP will treat water from the open pit WMP with treatment plant processes commonly used in the mining industry around the world.

16.5.4.2 OFF-SITE

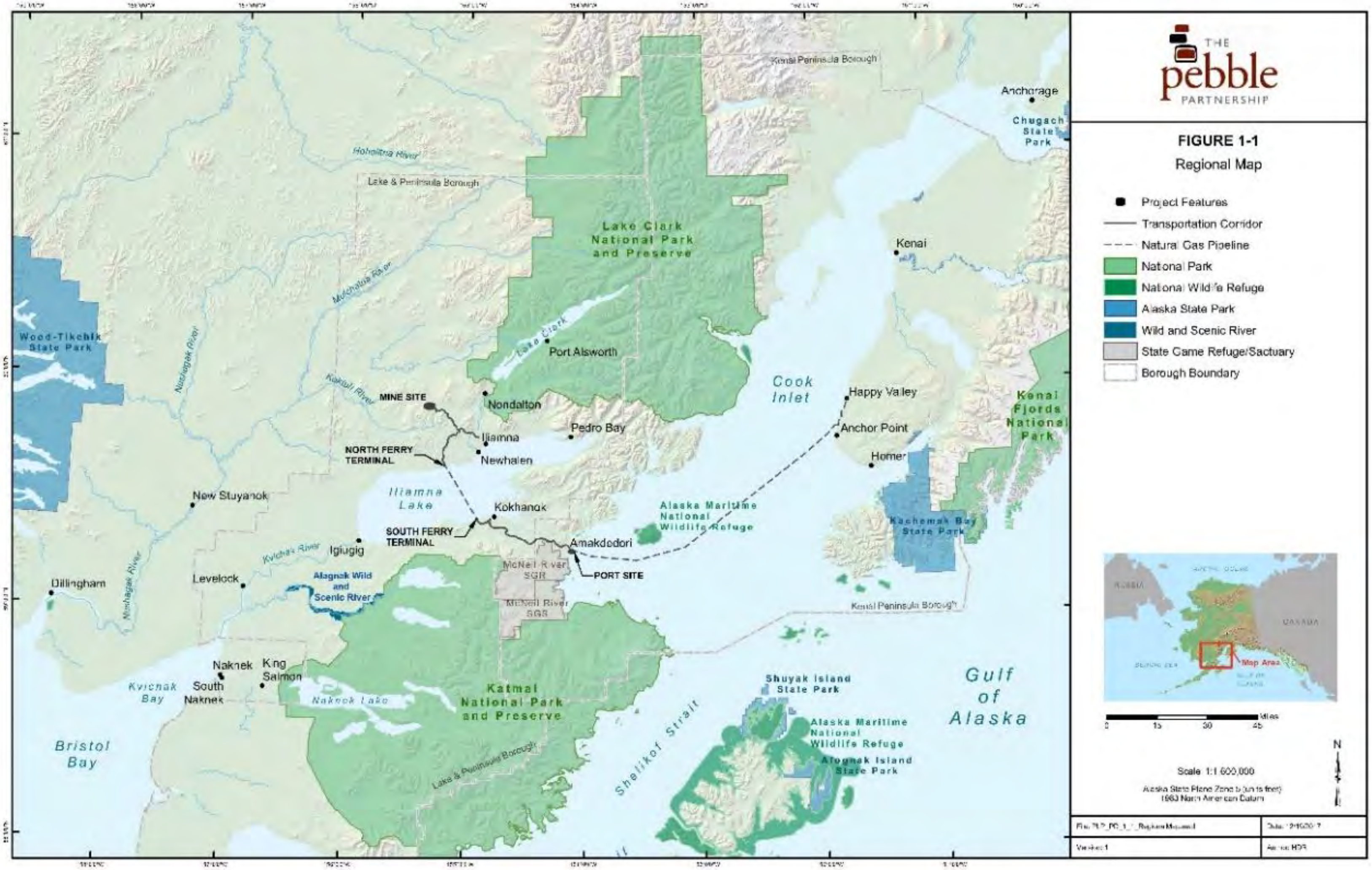
Transportation Corridor

The location of the Pebble Project mine site is physically separated from the marine terminal location by Iliamna Lake, which is roughly 75 miles long and up to 20 miles across, with no existing roadway networks around it. To avoid the environmental impact of constructing new roads around the lake, an all-season ice-breaking ferry will be used to cross the lake between ferry landings on each shore, which are connected to the mine site and Amakdedori Port by access roads.

The transportation corridor was designed to avoid wetlands where feasible, minimize disturbance area, minimize stream crossings, avoid geological and avalanche hazards, avoid culturally significant sites, minimize effects on subsistence hunting and gathering, optimize the alignment for the best soil and geotechnical conditions, and minimize road grades.

The main access road will run southward from the mine site to the north shore of Iliamna Lake. Ferry terminals will be located on the north and south shores. From the south shore of the lake, the access road will run to the marine port site on Cook Inlet at Amakdedori. Spur roads will connect to the villages of Iliamna, Newhalen, and Kokhanok Figure 16.5-6.

Figure 16.5-6 Infrastructure



Road

The main access road will be a private 30-foot-wide gravel road, which will enable two-way traffic, and will be capable of supporting anticipated development and operational activities during construction and truck haulage of concentrate from the mine to the port.

The access roads will include eight bridges, six of which will be single-span, two-lane bridges that range in length from approximately 90 to 170 feet. There will be one large (550 feet) multi-span, two-lane bridge across the Newhalen River and one large (455 feet) multi-span, two-lane bridge across the Gibraltar River. Road culverts at stream crossings are divided into categories based on whether the streams are fish bearing. Culverts at streams without fish will be designed and sized for drainage only, in accordance with ADOT&PF standards. Culverts at streams with fish will be designed and sized for fish passage in accordance with ADOT&PF and Alaska Department of Fish and Game (ADF&G) standards.

A natural gas pipeline and fiber optic cable will be buried adjacent to the main access road. For river crossings, the gas pipeline will either use horizontal directional drilling or be attached to the bridge structures.

Iliamna Lake Ferry

A custom designed ferry will transit Iliamna Lake between the North and South Ferry Terminals, carrying inbound supplies from the Amakdedori Port to the mine site and returning with copper-gold and molybdenum concentrates, backhauled waste, and empty containers.

The one-way ferry trip is about 18 miles and will take approximately 3 hours to complete in ice conditions, or 1.5 hours in open water. On average, one round trip per day across the lake will be required.

The vessel is designed to operate year-round, in all ice conditions. Cargo will be carried on the vessel deck. The vessel is symmetrical forward and aft with two icebreaking bows, allowing operation in open water or ice in either direction without the need to turn the vessel around at each terminal. Each bow will be fitted with a ramp that provides access to shore. The diesel-electric propulsion system has four azimuthing propellers providing 100 percent thrust over a full 360 degrees, which will provide propulsion, station keeping in all wind conditions, and ice management (clearing ice away from the hull) when needed. Accommodation for 12 crew members is included on the vessel.

The ferry terminals will initially serve as trans-shipment points for construction barge traffic across Iliamna Lake, using small temporary barges until the ferry is assembled. The south ferry terminal site includes the ferry assembly site where the ferry will be assembled from pre-fabricated components.

The permanent facilities at the ferry terminals include container handling and storage facilities, office and maintenance buildings, and local power supply. Each ferry terminal facility will have space for a minimum of two days of storage of the average concentrate container traffic. The patio surface will be finished as semi-permeable gravel. An access ramp will be built out from shore as a rock and aggregate causeway structure to provide approximately 40 feet of roadway surface for trucks and forklifts to access the ferry.

Transportation Corridor Traffic

To facilitate efficient cargo movement and optimize ferry space, most material will be transported in shipping containers. At each ferry terminal, a container yard with forklift trucks will be provided to stage empty and loaded containers for loading on/off the ferry, and truck transfer. Some cargo will be handled as break-bulk if it does not fit into containers.

Inbound Project cargo and consumables will be transported using standard ISO containers for ocean freight (either 20- or 40-foot size). Diesel fuel will be transferred from the Amakdedori Port to the mine site using ISO tank-container units, which have a capacity of 6,350 gallons. Copper-gold concentrate will be loaded into specialized bulk cargo containers, each containing about 38 tons of concentrate, with removable locking lids. Truck/trailer units will be designed to haul up to three loaded containers per trip.

Daily transportation of concentrate, fuel, reagents and consumables will require up to 35 round trips per day for each leg of the road, including three loads of fuel per day.

Amakdedori Port

Incoming supplies such as equipment, reagents, and fuel will be barged to the Amakdedori Port and then transported by truck to the mine site. To a lesser extent, some supplies, such as perishable food, may be transported by air to the Iliamna Airport and trucked to the mine site.

The Amakdedori Port will be constructed to enable direct loading of the concentrate to Handysize bulk carriers. The Amakdedori Port will include shore-based facilities to receive and store containers and fuel, as well as two, 2-MW natural gas power generators with an emergency diesel generator, a natural gas compressor station, maintenance facilities, employee accommodations, and offices. The shore-based complex will be constructed on an engineered fill patio, with the elevation set to address tidal surge from major storms and potential tsunamis.

The marine component includes an earthen access causeway extending out to a marine jetty located in 15 feet of natural water depth. On one side will be a roll-on/roll-off barge access berth and a separate berth on the opposite side for Handysize bulk carriers. The jetty is expected to be constructed as a sheet pile cell structure filled with granular material. The main jetty for ships up to 40,000 dead weight tons in size will be 700 feet in length and equipped with marine fenders and mooring bollards to secure the vessel alongside. The opposite side of the jetty will have a roll-on/roll-off barge berth and floating access ramp to accommodate barges up to 400 by 100 feet for container service. A floating dock, on the jetty but separate from the cargo handling berths, will be provided for ice-breaking tug moorage.

A dredged channel is required to access the berth for Handysize ships. The channel will be dredged to 50 feet below the low-low water line to allow for the required under-keel clearance for the design ship and will be 400 feet wide at the bottom. In the area near the berth, a 1,200-foot diameter (minimum) turning basin will be provided for ships to safely navigate in and out of the berth. The dredged material will be used to construct the jetty, causeway, and/or the main terminal patio area, if suitable. Excess dredgeate will be stored in an impoundment adjacent to the port facilities. Annual maintenance dredging will be required through the life of the port facility.

Copper-gold concentrates will be transported from the mine site to the Amakdedori Port by truck in covered bulk cargo containers and stored between vessel sailings on a dedicated laydown pad adjacent to the jetty. The bulk carrier ships will transport the concentrate to out of state smelters. This containerized bulk handling system minimizes dust emissions and the risk of spills. The empty containers will be cleaned of any residue on the outside while at the port, returned to the mine site and reused for transporting concentrate.

Up to 25 Handysize ships will be required annually to transport concentrate. Up to 30 marine line-haul barge loads of supplies and consumables will be required annually. Two ice-breaking tug boats will be used to support marine facility operations.

Natural Gas Pipeline

Natural gas will be supplied to the Amakdedori Port and the mine site by pipeline (Figure 16.5.6). The pipeline will connect to the existing gas pipeline infrastructure near Happy Valley on the Kenai Peninsula and will be designed to provide a gross flow rate of 50 million standard cubic feet per day. A fiber optic cable will be ploughed in, or buried in a shallow trench, adjacent to the pipeline.

A metering station will be constructed at the offtake point and the pipeline will then follow the ADOT&PF ROW south along the Sterling Highway for nine miles to a gas-fired compressor station located on State of Alaska lands north of Anchor Point.

The compressor station will feed a 94-mile subsea pipeline that will be constructed using heavy wall nominal 12-inch-diameter pipe designed to have negative buoyancy and provide erosion protection against tidal currents.

The pipeline will come ashore at the Amakdedori Port, where natural gas will be fed to the port site power station and used for site heating. A second gas-fired compressor station will be located at the port site. The distance from the Amakdedori Port to the mine site is approximately 81 miles and will consist of three sections. The first section will follow the access road to the South Ferry Terminal, and be buried in a trench adjacent to the road prism, similar to a line that currently exists between Happy Valley and Anchor Point. At the South Ferry Terminal, gas will be fed from the pipeline to the facilities for power supply and facility heat. At this point, the pipeline will enter Iliamna Lake for the next section, an approximate 18-mile lake crossing. The design of this section of the pipe, transitions, and burial will be similar to the Cook Inlet crossing. The pipeline will come ashore at the North Ferry Terminal. Natural gas will be used to provide power and heat at ferry terminal facilities. From this point, the pipeline will follow the road route 28 miles to the mine site, with a design like the section south of Iliamna Lake.

16.5.5 Permitting

On December 22, 2017, the Pebble Partnership submitted a Department of the Army permit application to the US Army Corps of Engineers (USACE) for authorization to discharge fill material and conduct work in navigable waters, which requires approval under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbor Act. Based on the information provided, USACE made a determination that the proposed project would require an Environmental Impact Statement (EIS) level of analysis to comply with the National Environmental Policy Act (NEPA). USACE will be the Lead Federal Agency for the development of the EIS document.

USACE is now in the process of consulting with other Federal agencies to determine what additional Federal authorizations will be required and how those agencies will participate in the EIS process.

Federal, State, and Tribal entities with special expertise on the project may also request to be cooperating agencies even though they do not issue any Federal permits for the project.

The EIS process will begin with public scoping, where the proposed project is presented to the public and the public has the opportunity to comment on the project, outlining any concerns or questions they may have and proposing any alternatives they believe should be evaluated in the EIS. Following scoping, USACE and the cooperating agencies will evaluate the comments received and identify a set of alternatives, including a “no action” alternative, to be evaluated in the EIS together with the proposed project. Following this a Draft EIS (DEIS) will be developed with the assistance of an independent team of technical experts, known as the third party consultant, that evaluates the impacts of the proposed project and the alternatives. The DEIS will be made available for public review and comment and any additional issues identified through the public comment process will be addressed in the Final EIS (FEIS) document. A minimum of thirty days after the release of the FEIS the USACE and other Federal agencies that may be issuing a permit for the project will each produce their own Record of Decision that will explain their decision to either issue the permits as requested, issue the permits with modifications, or deny the permits. In addition to the USACE permits, the project may require Federal permits from the US Coast Guard, the Bureau of Environmental Enforcement, the National Marine Fisheries Service, and the US Fish and Wildlife Service, in addition to many other Federal, State, and local authorizations.

17.0 INTERPRETATION AND CONCLUSIONS

17.1 GENERAL

The 2018 Technical Report for the Pebble Project has been completed in accordance with NI 43-101. The report describes the results of a December 2017 resource estimate for the Pebble Project and updates the status of the project. These programs suggest that the project merits follow up with further technical and economic studies leading to an advancement of the project to the next level of development.

17.2 GEOLOGY AND MINERAL RESOURCE ESTIMATE

The Pebble property hosts a globally significant copper-gold-molybdenum-silver deposit. The exploration and drilling programs completed thus far are appropriate to the type of the deposit. The exploration, drilling, geological modelling and research work support the interpreted genesis of the mineralization.

It is the opinion of the relevant QPs of this report that the drill database for the Pebble deposit is reliable and sufficient to support the purpose of this technical report and a current mineral resource estimate.

Estimations of mineral resources for the Pebble Project conform to industry best practices and meet requirements of the Canadian Institute of Mining and Metallurgy.

Factors which may affect the Mineral Resource estimate include changes to the geological, geotechnical and geometallurgical models, infill drilling to convert mineral resources to a higher classification, drilling to test for extensions to known resources, collection of additional bulk density data and significant changes to commodity prices. It should be noted that all factors pose potential risks and opportunities, of greater or lesser degree, to the current mineral resource.

The very minor differences between the 2014 Pebble resources and the current 2017 resource estimate are due primarily to changes in resource pit configuration resulting from the application of updated metal recoveries.

Mineralization at Pebble is open in several directions and offers the opportunity, with additional drilling, to expand the resource base.

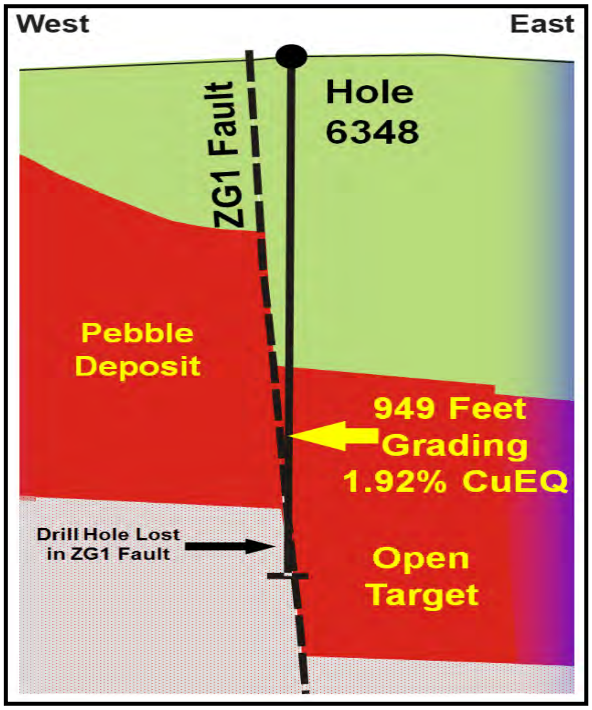
17.2.1 Updating of Inferred Resource

Approximately 41% of the currently estimated resource is classified as Inferred. The resource used as the basis for a prefeasibility or feasibility study, as defined by NI 43-101, must be classified as Measured or Indicated. There may be a future requirement to upgrade some portion of the Inferred resource to Measured or Indicated categories through additional drilling. It is likely not necessary or desirable to upgrade all of the Inferred Resource in the immediate future, but the prioritization of areas to be upgraded should involve an integrated study of future mining and metallurgical objectives.

17.2.2 Eastern Extension

Drill hole 6348 is perhaps the most significant drill intersection in the Pebble deposit. It intersected 949 ft of mineralization with an average grade of 1.24% copper, 0.74 g/t gold and 0.042% molybdenum, or 1.92% CuEq (using 2011 metal prices and recovery assumptions), before the hole was lost at a depth of 5,663 ft in the ZG1 Fault (Figure 17.2.1). This drill hole lies east of the ZG1 Fault and follow up drilling of the Cretaceous host rocks to this mineralization has not yet been completed, thereby leaving the extent of this high-grade mineralization unknown. This area represents a significant exploration target. Given the depth of this target and the expense of drilling at the Pebble Project, it is recommended that a study be undertaken to determine the best approach to exploring it. Such a study would determine the best drill pattern to be employed, outline any potential issues and determine the type of equipment which will optimize the chances of successful completion of follow-up holes.

Figure 17.2-1 Untested Exploration Potential East of Drillhole 6348



17.2.3 Block Model Update

The extensive metallurgical testwork conducted on the Pebble deposit demonstrates the deposit contains significant amounts of rhenium. Initial analysis suggests recovery of rhenium from molybdenum concentrate could have a positive impact on project economics. Additional studies of this opportunity should be conducted, including metallurgical testwork, market assessment and update of the project geological block model. Since assays for rhenium only date from 2007, a number of pulps from earlier drilling would require re-assaying.

17.3 METALLURGICAL TESTWORK AND PROCESS DESIGN

Metallurgical testwork and associated analytical procedures were performed by recognized testing facilities with extensive experience with this analysis, with this type of deposit, and with the Pebble Project. The samples selected for the comminution, copper/gold/molybdenum bulk flotation, and copper molybdenum separation testing were representative of the various types and styles of mineralization present at the Pebble deposit.

The test results on variability samples derived from the 103 lock cycle flotation tests indicate that marketable copper and molybdenum concentrates can be produced with gold and silver contents that meet or exceed payable levels in representative smelter contracts.

A finer primary grind size P_{80} of 125 µm was incorporated into the metal recovery projection. The adjustment was based on the average recovery increase of copper per each 10µm size reduction obtained from the flotation tests on composite samples and at various test conditions.

As the project advances, the following testwork should be considered:

- Additional copper molybdenum separation testwork in order to optimize molybdenum and rhenium grade and recovery to the molybdenum concentrate, and reduce levels of copper reporting to the molybdenum concentrate;
- Include silver assays in all product streams for future locked cycle tests in order to improve the confidence level of the silver mass balance, and potentially optimize silver recovery. At present, only 10 locked cycle tests were assayed for silver in all product streams, while the remainder of tests contained silver assays for the bulk concentrate only;
- Ensure that the number of comminution and flotation variability samples tested for each respective geometallurgical domain unit reflects the timing and expected proportions of each contained within future engineering mine plans;
- Conduct rougher flotation tests at varied grind size on each geometallurgical domain sample to confirm the size impacts on metal recoveries especially for gold, silver, and molybdenum; and Conduct locked cycle tests to verify the rougher flotation test results; the locked cycle test results, together with the cost considerations, will help to confirm the primary size selection and comminution circuit design in the next phase of work.

17.4 ENVIRONMENTAL

The Pebble Project is currently subject to a CWA 404 permitting process in Alaska. Exploration activities completed to date have been conducted under the relevant permits.

The following mitigation strategies have been identified for key environmental drivers:

- Water: development of a water management plan that maximizes the collection and diversion of groundwater, snowmelt, and direct precipitation away from the mine site;
- Wetlands: implementation of a water management plan (in accordance with USACE guidelines and regulations) to reduce wetland impacts;
- Aquatic Habitats: development of a water management plan that includes strategies to effectively manage the release of treated water in compliance with anticipated regulatory requirements to maintain downstream flows and to protect downstream fish habitat and aquatic environments;
- Air Quality: implementation of air emissions and dust suppression strategies; and,
- Marine Environment: minimize the port facility's footprint in the intertidal zone, particularly in soft sediment intertidal areas.

Direct integration of these measures into project design and operational strategies are expected to effectively mitigate possible environmental effects and minimize residual environmental effects associated with the construction, operation, and eventual closure of any proposed mine at the Pebble Project.

18.0 RECOMMENDATIONS

18.1 RECOMMENDED PROGRAM

18.1.1 Recommended Program

The immediate priority is to maintain the project in good standing, continue environmental monitoring and complete engineering studies to support permiting.

Property maintenance (estimate)	$1,030,000

- Annual state rentals are required to maintain the Pebble claims in good standing.

Environmental baseline data collection (estimate)	$3,600,000

- An environmental baseline data collection program is planned for 2018.
- These activities include meteorology, wetlands, aquatic resources, marine studies, wildlife and stream flow monitoring, support at site, and staff to manage the work.

Site data collection to support permitting and engineering studies (estimated direct costs)	$7,800,000
Total estimated cost	**$12,430,000**

18.2 ADDITIONAL RECOMMENDATIONS

As funding becomes available, the following additional recommendations are proposed in support of future technical studies Additional resource evaluation

- The deposit remains open in a number of locations, including adjacent to Hole 6348, which identified high grade mineralization down-dropped on the east side of the ZG1 graben-bounding fault. Analysis should be undertaken to determine optimal methods for follow up drill testing of this area.
- A conditional simulation study should be completed in order to determine the optimal drill spacing to move inferred resources to more confident classifications for a NI 43-101 compliant prefeasibility study.
- Supplemental geochemical analyses should be undertaken to incorporate rhenium in the block model estimation.

Additional metallurgical testwork

- Additional copper-molybdenum separation testwork is recommended to optimize metal grade and recovery to the molybdenum concentrate in support of a prefeasibility study.
- Ensuring sample numbers for comminution and flotation variability tests for each respective geometallurgical domain unit reflects the timing and expected proportions of each contained.
- Conduct flotation tests at varied grind size on each geometallurgical domain sample to confirm the size impacts on metal recoveries especially for gold, silver, and molybdenum.

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20.0 Certificates

J. David Gaunt, P.Geo.
15TH FLOOR, 1040 WEST GEORGIA ST.
VANCOUVER, BRITISH COLUMBIA
Telephone: 604-684-6365 Fax: 604-662-8956
davidg@hdgold.com

I, J. David Gaunt, P.Geo., am a Professional Geologist in the City of Vancouver, in the Province of British Columbia.

1. I am co-author of this report entitled "2018 Technical Report on the Pebble Project, Southwest Alaska, USA", effective date December 22, 2017. I am responsible for sections 2 through 5, 6.3, 6.4, 14, and 19.3, and jointly responsible for sections 1, 17 and 18 of this report.
2. I have been involved with the project since 2001, and co-authored technical reports in 2008, 2009 and 2014.
3. I am a member in good standing of: The Association of Professional Engineers and Geoscientists of British Columbia, registration No.20050, and The Prospectors and Developers Association of Canada.
4. I am a graduate of Acadia University, Nova Scotia (B.Sc., Geology, 1985).
5. I have practiced my profession continuously since graduation and have been involved in mineral exploration and resource estimation for precious and base metals in Canada, USA, Mexico, Argentina, Chile, Australia, Spain, Hungary, Afghanistan, China, and South Africa. I have previous experience with intrusion related copper gold deposits, notably Veladero, and Pebble.
6. As a result of my qualifications and experience I am a Qualified Person as defined in National Instrument 43–101.
7. I am not independent of the issuer, Northern Dynasty Minerals Ltd.
8. I have visited the Pebble Project several times, most recently on September 1st and 2nd, 2010, and have been involved in the resource estimates relating to Pebble since 2001.
9. 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.
10. I am not aware or any material fact or material change with respect to the subject matter of this technical report, which is not reflected in the report, the omission of which to disclose would make this report misleading.

Dated in Vancouver on this 22nd day of February, 2018.

J. David Gaunt

J. David Gaunt, P.Geo.

James R. Lang Ph.D, P.Geo
15TH Floor, 1040 W. Georgia St.
Vancouver, British Columbia V6E 4H1
Ph: 604-684-6365; e-mail: jimlang@hdimining.com

I, James R. Lang Ph.D, P.Geo., of Surrey, British Columbia, Canada, do hereby certify that:

1) I am Senior Vice President Geology at Hunter Dickinson Inc., with offices located at the address shown above.
2) I graduated with a B.Sc. in geology from Michigan State University, East Lansing, Michigan, USA in 1983, and received M.Sc. and PhD degrees in economic geology from the University of Arizona, Tucson, Arizona, USA in 1986 and 1991, respectively.
3) I am a registered member of the Association of Professional Engineers and Geoscientists of British Columbia, Registration Number 25376.
4) I have worked as an economic geologist for 28 consecutive years.
5) I have read the definition of "qualified person" set out in National Instrument 43-101 ("NI 43-101") and certify that by reason of my education, affiliation with a professional association (as defined by NI 43-101) and past relevant work experience, I fulfill the requirements to be a "qualified person" for the purposes of NI 43-101.
6) I am co-author of this Technical Report titled "2018 Technical Report on the Pebble Project, Southwest Alaska, USA", effective date December 22, 2017. I am solely responsible for sections 1.4, 6.1, 7.0, 8.0, 9.0, 15.0 and 19.1 and am jointly responsible for sections 10.0 and 17.2 of this report.
7) I have been physically present at the project area every year since 2003 for a total of over 625 days. From 2007 through 2010 I acted as Chief Geologist for the project. My most recent visit was in November 2017. I am familiar with the geology, topography, physical features, access, location and infrastructure.
8) I am not aware of any material fact or material change with respect to the subject matter of the Technical Report that is not reflected in the Technical Report, the omission to disclose which might make the Technical Report misleading.
9) I am NOT independent of the issuer, Northern Dynasty Minerals Ltd., applying all tests in Section 1.5 of National Instrument 43-101.
10) I have read National Instrument 43-101 and Form 43-101F1, and the Technical Report has been prepared in compliance with that instrument and form.
11) As of the date of the certificate, to the best of my knowledge, information and belief, the technical report contains all scientific and technical information that is required to be disclosed to make the technical report not misleading.

Dated this 22 day of February, 2018.
James R. Lang

James R. Lang, Ph.D., P.Geo.

Eric D. Titley
15th Floor – 1040 West Georgia Street,
Vancouver, British Columbia, Canada, V6E 4H1
Tel. 604-684-6365, Email: EricTitley@hdimining.com

I, Eric D. Titley, P.Geo. do hereby certify that:

I am Senior Manager | Resource Geology, at the above address.

1. I am a graduate of the University of Waterloo, Waterloo, Ontario with a Bachelor of Science degree in Earth Sciences (geography minor) in 1980.
2. I have practiced my profession continuously since 1980.
3. I am a Professional Geoscientist registered with the Association of Professional Engineers and Geoscientists in the province of British Columbia, Canada.
4. I have read the definition of "qualified person" set out in National Instrument 43-101 ("NI 43101") and certify that by reason of my education, affiliation with a professional association (as defined in NI 43-101) and past relevant work experience, I fulfill the requirements to be a "qualified person" for the purposes of NI 43-101.
5. I am the author of sections 6.2, 11, and 12 and jointly responsible for section 10 of the report entitled "2018 Technical Report on the Pebble Project, Southwest Alaska, USA" (the "Technical Report"). The Technical Report has an effective date of December 22, 2017. The Technical Report is based on my knowledge of the project area and drilling database included in the Technical Report, and on review of published and unpublished information on the property and surrounding areas. I conducted a site visit of the Pebble Project on the 20th of September, 2011.
6. At the effective date of the Technical Report, to the best of my knowledge, information and belief, the part of the Technical Report for which I am responsible, contains all the scientific and technical information that is required to be disclosed to make the technical report not misleading.
7. I am not independent of Northern Dynasty and affiliated companies applying the tests in section 1.5 of National Instrument 43-101.
8. I have had prior involvement with the property as an author of technical reports in 2010, 2009 and 2008 and ongoing review of the drilling database.
9. I have read National Instrument 43-101 and Form 43-101F1, and the Technical Report has been prepared in compliance with that Instrument and Form.

Dated this 22nd day of February, 2018

Eric D. Titley

Eric D. Titley, P.Geo

Ting Lu, P. Eng., M.Sc.

I, Ting Lu, P. Eng., M.Sc., of Vancouver, British Columbia, do hereby certify:

I am a Senior Metallurgical Engineer with Tetra Tech Canada Inc. with a business address at 1000 - 885 Dunsmuir Street, Vancouver, British Columbia, V6C 1N5.

This certificate applies to the technical report entitled "2018 Technical Report on the Pebble Project, Southwest Alaska, USA", effective date December 22, 2017 (the "Technical Report").

I am a graduate of Queen's University, Kingston, Ontario, Canada (M.Sc., 2006) and Taiyuan University of Technology, Taiyuan, Shanxi, P.R. China (H.B. Sc., 1996). I am a member in good standing of the Association of Professional Engineers and Geoscientists of British Columbia (#32897). My relevant experience includes 15 years of experience in the mineral processing industry. I worked on the Mt. Milligan Copper-Gold Feasibility Study Project with Terrane Metals Corp., the Kerr-Sulphurets-Mitchell (KSM) Copper-Gold-Molybdenum Prefeasibility Study Project with Seabridge Gold Inc. and the La Joya Silver-Copper-Gold-Lead-Zinc Preliminary Economic Assessment Project with Silvercrest Mines Inc., Chile. I am a "Qualified Person" for the purposes of National Instrument 43-101 (the "Instrument").

I did not complete a personal inspection of the Property.

I am responsible for Sections 1.6, 13.0, 17.3 and 19.2 and jointly responsible for section 18.2 of the Technical Report.

I am independent of North Dynasty Minerals Ltd. as defined by Section 1.5 of the Instrument.

I co-authored a Technical Report on the Pebble Project in 2014.

I have read the Instrument and the sections of the Technical Report that I am responsible for have been prepared in compliance with the Instrument.

As of the date of this certificate, to the best of my knowledge, information and belief, the sections of the Technical Report that I am responsible for contain all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Signed and dated this 22nd day of February, 2018 at Vancouver, British Columbia.

Ting Lu

Ting Lu, P. Eng., M.Sc.
Senior Metallurgical Engineer
Tetra Tech Canada Inc.

Stephen Hodgson, P.Eng.
202 – 1099 Marinaside Crescent,
Vancouver, British Columbia V6Z 2Z3
stephenhodgson@hdimining.com

I, Stephen Hodgson, P.Eng., do hereby certify that:

1. I am an employee of Northern Dynasty Minerals Ltd., with a business office at Suite 1500-1040 West Georgia Street, Vancouver, British Columbia.

2. I am a graduate of the University of Alberta (B.Sc, Mineral Engineering, Mining, 1976).

3. I am a member in good standing of the Association of Professional Engineers and Geoscientists of British Columbia, License number 18501.

4. I have practiced my profession continuously since graduation in mine operations in Canada and the United States, as a consulting mining engineer in Canada, the United States, Peru, Chile, Vietnam, Venezuela, Kyrgyzstan, Australia, New Caledonia, South Africa, Russia, and Mongolia, and as a Vice President of Engineering in the United States.

5. I have read the definition of "qualified person" set out in National Instrument 43-101 and certify that by reason of my education, affiliation with a professional association, as defined by NI 43-101, and past relevant work experience, I fulfill the requirements to be a "qualified person" for the purpose of NI 43-101.

6. I am a co-author of the technical report entitled, "2018 Technical Report on the Pebble Project, Alaska, USA", effective date December 22, 2017, which relates to the Pebble Project, Alaska, United States. I am responsible for Section 16 and co-responsible for Sections 1 and 18 of the report. I have provided engineering and management services for Northern Dynasty on the project since 2005.

7. I have considerable experience related to project development and operations, including porphyry copper deposits such as Pebble.

8. I visited the Pebble Project numerous times, most recently in October 2017. I am familiar with the geology, topography, and physical features of the property.

9. I am not independent of the issuer, Northern Dynasty Minerals Ltd.

10. I have had prior involvement with the property as an author of technical reports in 2010, 2009 and 2008 and ongoing review of engineering work related to Pebble.

10. I have read the Instrument and the sections of the Technical Report that I am responsible for have been prepared in compliance with the Instrument.

11. As of the date of this certificate, to the best of my knowledge, information and belief, the sections of the Technical Report that I am responsible for contain all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Signed on this 22 day of February, 2018.

Stephen Hodgson

Stephen Hodgson, P.Eng.