

**2020 TECHNICAL REPORT
ON THE
PEBBLE PROJECT, SOUTHWEST ALASKA, USA**

NORTHERN DYNASTY MINERALS LTD.

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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
Alaska Peninsula Corporation	APC
Ampere	A
Annum (year)	a
Anadromous Waters Catalog	AWC
Acid Potential	AP
Acid Rock Drainage	ARD
Aqua Regia (HNO ₃ -HCl)	AR
Atomic absorption spectroscopy	AAS
Billion	B
Billion years ago	Ga
Brittle-ductile fault	BDF
Centimetre	cm
Carbon-In-Leach	CIL
Clean Water Act	CWA
Cominco Exploration Research Laboratory	CERL
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 cubic centimetre	g/cm ³
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

UNIT MEASURES AND ABBREVIATIONS	
Horsepower	hp
Hours	h
Hours per day	h/d
Hours per week	h/w
Hours per year	h/a
Iliamna Natives Limited	INL
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
Least Environmentally Destructive Practicable Alternative	LEDPA
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

UNIT MEASURES AND ABBREVIATIONS	
National Environmental Policy Act	NEPA
National Instrument 43-101	NI 43-101
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
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
Rivers and Harbors Act	RHA
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 kilometer	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
Vibrating wire piezometer	VWP
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.

Comprehensive deposit delineation, environmental, socioeconomic and engineering studies of the Pebble deposit began in 2004 and continued through 2013. A previous estimate of the mineral resources in the Pebble deposit was stated in a technical report completed in 2018.

Northern Dynasty completed a Preliminary Assessment on the Pebble Project in February 2011. Since that time, after considering stakeholder feedback, the Pebble Partnership developed a plan for the Pebble Project on the basis of a substantially smaller mine facility footprint, and with other material revisions. 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 and as noted in the Company's 2018 Technical Report, 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.

A smaller mine facility formed the basis of the permit application under Section 404 of the Clean Water Act (CWA) and Section 10 of the Rivers and Harbors Act (RHA) submitted to the US Army Corps of Engineers (USACE) by the Pebble Partnership on December 22, 2017. On January 8, 2018, USACE accepted the permitting documentation and confirmed that an Environmental Impact Statement (EIS) level of analysis was required to comply with its National Environmental Policy Act (NEPA) review of the Pebble Project. The EIS process progressed through the scoping phase in 2018. The USACE delivered the Draft EIS in the first quarter of 2019 and completed a public comment period from March to July 2019. In the latter part of 2019 and early 2020, the USACE and its consultants advanced toward a Final EIS. The preliminary Final EIS was circulated to co-operating agencies for review in February 2020. As part of the EIS preparation process, the USACE and its consultants had undertaken a comprehensive alternatives assessment to consider a broad range of development alternatives and announced the conclusions of the draft Least Environmentally Damaging Practicable Alternative (LEDPA) in May 2020. The USACE published the Final EIS on July 24, 2020.

As described in the 2018 and previous technical reports, the Pebble Deposit contains significant amounts of copper, gold, molybdenum and silver. The Pebble Deposit can also supply important products for alternative energy and other purposes of strategic national significance to the United States such as rhenium and palladium.

The purpose of this report is to document recent studies of the occurrence of rhenium and to estimate the rhenium mineral resources in the deposit. Previous work also determined significant amounts of palladium are present, at least in parts of the deposit; however, insufficient analysis has been completed to date to complete a resource estimate. The report also updates the proposed plan for the project as documented in the June 2020 Project Description and Final EIS.

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, 100 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 Pebble East Claims Corporation and Pebble West Claims Corporation, wholly-owned subsidiaries of the Pebble Partnership, a 100% interest in a contiguous block of 2,402 mining claims and lease hold locations covering approximately 417 square miles (which includes the Pebble Deposit).

1.4 GEOLOGICAL SETTING AND MINERALIZATION

Pebble is a porphyry-style copper-gold-molybdenum-silver-rhenium 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 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-rhenium mineralization is related to smaller granodiorite plutons and dykes that are similar in composition to, and emplaced near and above 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 plutons and dykes, and by 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 thin leached cap. Disseminated and vein-hosted copper-gold-molybdenum-silver-rhenium 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 Pebble West zone and deeper portions of the Pebble East zone. Rhenium occurs in molybdenite and high rhenium concentrations are present in molybdenite

concentrates. Elevated palladium concentrations occur in many parts of the deposit but are highest in rocks affected by advanced argillic alteration. 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 Table 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 and rhenium, neither were used as part of the copper equivalency calculation in order to facilitate comparison with previous estimates which did not consider the economic contribution of either of these metals. The highlighted 0.3% CuEq cut off is considered appropriate for deposits of this type in the Americas.

Table 1.5-1 Pebble Resource Estimate August 2020

Cutoff CuEq %	CuEq %	Metric Tonnes	Cu (%)	Au (g/t)	Mo (ppm)	Ag (g/t)	Re (ppm)	Cu Bib	Au Moz	Mo Bib	Ag Moz	Re Kkg
Measured												
0.3	0.65	527,000,000	0.33	0.35	178	1.7	0.32	3.83	5.93	0.21	28.1	167
0.4	0.66	508,000,000	0.34	0.36	180	1.7	0.32	3.81	5.88	0.20	27.4	163
0.6	0.77	279,000,000	0.40	0.42	203	1.8	0.36	2.46	3.77	0.12	16.5	100
1.0	1.16	28,000,000	0.62	0.62	302	2.3	0.52	0.38	0.56	0.02	2.0	14
Indicated												
0.3	0.77	5,929,000,000	0.41	0.34	246	1.7	0.41	53.58	64.81	3.21	316.4	2,443
0.4	0.82	5,185,000,000	0.45	0.35	261	1.8	0.44	51.42	58.35	2.98	291.7	2,271
0.6	0.99	3,455,000,000	0.55	0.41	299	2.0	0.51	41.88	45.54	2.27	221.1	1,748
1.0	1.29	1,412,000,000	0.77	0.51	343	2.4	0.60	23.96	23.15	1.07	109.9	853
Measured + Indicated												
0.3	0.76	6,456,000,000	0.40	0.34	240	1.7	0.41	56.92	70.57	3.42	344.6	2,615
0.4	0.81	5,693,000,000	0.44	0.35	253	1.8	0.43	55.21	64.06	3.18	320.3	2,431
0.6	0.97	3,734,000,000	0.54	0.41	291	2.0	0.50	44.44	49.22	2.40	237.7	1,848
1.0	1.29	1,440,000,000	0.76	0.51	342	2.4	0.60	24.12	23.61	1.08	112.0	867
Inferred												
0.3	0.55	4,454,000,000	0.25	0.25	226	1.2	0.36	24.54	35.80	2.22	170.4	1,603
0.4	0.68	2,646,000,000	0.33	0.30	269	1.4	0.44	19.24	25.52	1.57	119.1	1,154
0.6	0.89	1,314,000,000	0.48	0.37	292	1.8	0.51	13.90	15.63	0.85	75.6	673
1.0	1.20	361,000,000	0.68	0.45	377	2.3	0.69	5.41	5.22	0.30	26.3	251

Notes:

David Gaunt, P.Geo., a qualified person as defined under 43-101 who is not independent of Northern Dynasty, is responsible for the estimate.

Copper equivalent (CuEQ) calculations use metal prices: US\$1.85/lb for Cu, US\$902/oz for Au and US\$12.50/lb for Mo, and recoveries: 85% Cu, 69.6% Au, and 77.8% Mo (Pebble West zone) and 89.3% Cu, 76.8% Au, 83.7% Mo (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.

The mineral resource estimate is constrained by a conceptual pit shell that was developed using a Lerchs-Grossman algorithm and is based in the following parameters: 42 degree pit slope; metal prices and recoveries of US\$1,540.00/oz and 61% Au, US\$3.63/lb and 91% Cu, US\$20.00/oz and 67% Ag and US\$12.36/lb and 81% Mo, respectively; a mining cost of US\$1.01/ton with a US\$0.03/ton/bench increment and other costs (including processing, G&A and transport) of US\$6.74/ton.

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.

The terms "Measured Resources", "Indicated Resources" and "Inferred Resources" are recognized and required by Canadian regulations under 43-101. The SEC has adopted amendments to its disclosure rules to modernize the mineral property disclosure required for issuers whose securities are registered with the SEC under the US Securities Exchange Act of 1934, effective February 25, 2019, that adopt definitions of the terms and categories of resources which are "substantially similar" to the corresponding terms under Canadian Regulations in 43-101. Accordingly, there is no assurance any mineral resources that we may report as Measured Resources, Indicated Resources and Inferred Resources under 43-101 would be the same had we prepared the resource estimates under the standards adopted under the SEC Modernization Rules. Investors are cautioned not to assume that all or any part of mineral deposits in these categories will ever be converted into reserves. In addition, Inferred Resources have a great amount of uncertainty as to their economic and legal feasibility. Under Canadian rules, estimates of Inferred Resources may not form the basis of feasibility or pre-feasibility studies, or economic studies except for a Preliminary Economic Assessment as defined under 43-101.

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 at the Pebble deposit.

A conventional flotation process is proposed to produce copper concentrate and molybdenum concentrate. The flotation test results on variability samples derived from the 103 locked cycle flotation and the subsequent copper-molybdenum separation flotation tests indicate that marketable copper and molybdenum concentrates can be produced. The copper concentrate will also contain gold and silver contents that meet or exceed payable levels in representative smelter contracts; the molybdenum concentrate will contain significant rhenium (Re), with a reported grade range from 791 to 832 g/t Re observed in the locked cycle test (LCT) results of the copper-molybdenum separation.

A preliminary hydrometallurgical test program was performed on rougher and cleaner molybdenum concentrates to investigate the production of the marketable products of molybdenum trioxide (MoO_3) and ammonium perrhenate (NH_4ReO_4). The test program included pressure oxidation leach, a series of metal extractions/purifications from the pregnant leach solution, and a calcination process. The tested methods were found technically feasible. Satisfactory dissolution rates of molybdenum and rhenium were obtained from the rougher molybdenum concentrate samples. While additional alkaline leach is required on the pressure oxidation leach residues for the cleaner molybdenum concentrate samples.

In this technical report, the metal recovery projections of copper, gold, silver and molybdenum stay the same as those published in the 2018 technical report. A rhenium recovery estimate at a high level has been completed and included. Table 1.6-1 provides projected metals recoveries via flotation concentration for metals and a gravity circuit for gold. The recovery estimate bases are summarized as follows:

- The initial metal recovery projections of copper, gold, silver and molybdenum were published in 2014 based on a combined flotation and cyanide leach method. A total of 111 locked cycle tests on the 103 samples representing 8 metallurgical domains across the east and west of Pebble deposit were reviewed to establish the copper, gold and molybdenum distributions to the bulk copper-molybdenum concentrate. Ten of the 111 locked cycle flotation tests with silver assay results were utilized to estimate the silver recovery to the bulk flotation concentrate.
- The 2018 metal recoveries were updated to reflect the changes of the proposed processing methods, including the exclusion of the cyanide leach process and the implementation of a finer primary grind particle size. The flotation tests on composite samples indicate a general increase of metal recoveries with a decreasing primary grind size.
- The 2020 metal recovery projections were further updated to include the rhenium recovery to the molybdenum concentrate. The estimated rhenium recovery was 70.8%, based on the 10 LCT results of the rhenium recovery to the bulk concentrate, a one LCT stage recovery result in the subsequent separation of copper and molybdenum, as well as a recovery adjustment due to the reduction of primary grind size.

Table 1.6-1 Projected Metallurgical Recoveries – 2018, Tetra Tech

Domain	Flotation Recovery %				
	Cu Con, 26% Cu			Mo Con, 50% Mo	
	Cu	Au	Ag	Mo	Re
Supergene:					
Sodic Potassic	78.7	63.6	67.5	53.9	70.8
Illite Pyrite	72.1	46.5	67.8	66.3	70.8
Hypogene:					
Illite Pyrite	89.8	45.6	66.6	76.1	70.8
Sodic Potassic	90.1	63.2	67.0	80.1	70.8
Potassic	93.7	63.6	66.5	85.4	70.8
Quartz Pyrophyllite	94.7	65.2	64.4	80.4	70.8
Sericite	89.6	40.6	66.5	75.9	70.8
Quartz Sericite Pyrite	89.8	32.9	66.9	86.1	70.8

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.

Additional data collected from the 2009-2013 period was compiled into the Supplemental EBD (PLP, 2018) and transmitted to USACE. The full EBD, as well as all Supplemental EBD chapters that were substantively updated since the original EBD was published in 2012, are available on the USACE Pebble EIS website. In 2017, select environmental baseline studies were re-initiated and expanded. Monitoring data collected through 2019 has been provided to USACE.

The baseline study program includes:

surface water hydrology	wildlife
groundwater hydrology	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	

The Final EIS published by USACE on July 24, 2020 is the culmination of a 2 ½-year long, intensive review process under the National Environmental Policy Act (NEPA). Led by the USACE, the Pebble EIS also involved eight federal cooperating agencies (including the US Environmental Protection Agency and US Fish & Wildlife Service), three state cooperating agencies (including Alaska Department of Natural Resources and Alaska Department of Environmental Conservation), the Lake & Peninsula Borough and federally recognized tribes. Topline findings from the Final EIS Executive Summary include:

- On subsistence fish and wildlife resources: “Overall, impacts to fish and wildlife would not be expected to impact harvest levels. Resources would continue to be available because no population-level decrease in resources would be anticipated.” (ES-51)
- On commercial fishing: “There would be no measurable change in the number of returning salmon and the historical relationship between ex-vessel values and wholesale values. In addition, there would be no changes to wholesale values or processor operations expected.... Under normal operations, the Alternatives would not be expected to have a measurable effect on fish numbers and result in long-term changes to the health of the commercial fisheries in Bristol Bay.” (ES-87)
- On water quality: “An Alaska Pollutant Discharge Elimination System (APDES) permit stipulation requires treated water quality monitoring, to ensure discharged water meets applicable water quality criteria. Assuming these protections are adopted, direct and indirect impacts of treated contact waters to off-site surface water are not expected to occur.” (ES-70)
- On local communities and socioeconomic impacts: “The increase in job opportunities, year-round or seasonal employment, steady income, and lower cost of living described above would have beneficial impacts on the EIS analysis area, especially for communities in the LPB, during construction and operations of the project.” (ES-54)

“The project could reduce or eliminate the current local population decline because of the increase in employment opportunities and indirect effects on education and infrastructure; it could also lead some prior residents to return to communities.” (ES-48)

The next key step in the process with respect to several of Pebble’s key federal permits is the Record of Decision (ROD), which is expected to be issued by USACE during the fall of 2020. The Pebble Partnership must also secure a number of permits issued by the State of Alaska, a process expected to take 2 – 3 years.

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. Over the course of past two years, additional engineering work completed to support the environmental assessment process, as well as recommendations from USACE in the Final EIS, has resulted in some modifications to the plan and the Project Description has been updated accordingly. Project infrastructure includes:

- a 270 megawatt power plant located at the mine site;
- a 164 mile natural gas pipeline connecting existing supply on the Kenai Peninsula to the power plant at the mine site;
- an 82-mile transportation corridor from the mine site to a port site located north of Diamond Point in Iliamna Bay on Cook Inlet consisting of:
 - a private two-lane unpaved road that connects to the existing Iliamna/Newhalen road system;
 - the onland portion of the natural gas pipeline buried adjacent to the road; and
 - a concentrate pipeline to transport copper-gold concentrate from the mine site to the port with a return water pipeline to the mine site, both buried adjacent to the road; and
- a port facility incorporating:
 - concentrate dewatering, storage and handling;
 - fuel and supply storage;
 - local power supply; and
 - barge docks for supplies and to facilitate bulk lightering of concentrate between the Diamond Point Port and an offshore lightering location in Iniskin Bay for loading onto bulk carriers.

Following four years of construction activity, the proposed Pebble mine will operate for a period of 20 years using conventional drill-blast-shovel operations. The mining rate will average 70 million tons per year, with 66 million tons of mineralized material processed through the mill each year (180,000 tons per day), for an extremely low life-of-mine waste to mineralized material ratio of 0.12:1.

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;
- a comprehensive tailings and water management plan including a flow through design for the bulk tailings embankment;
- 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

The resource estimate documented herein confirms the presence of rhenium, a strategic metal, as a component of the Pebble deposit and demonstrates the Pebble Deposit is among the largest accumulations of rhenium in the world.

Products from mining this deposit, including rhenium, support development of alternative energy supply and other purposes of strategic national significance. The Pebble Deposit has significant regional economic importance for southwest Alaska and the entire state through the creation of high-wage jobs and training opportunities, supply and service contracts for local businesses, and government revenue.

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

This study assessed and estimated the amount of rhenium in the Pebble deposit. Elevated levels of palladium, vanadium, titanium and tellurium have been noted in raw analytical data and in metallurgical studies. A scoping level program is recommended to determine their potential for inclusion in future resource

estimates. Such a study would focus on these metals' deportment, distribution and the best approach to their quantification.

\$100,000

Review metallurgical testwork to date to identify opportunities to optimize treatment of supergene mineralization within the deposit, and provide recommendations on future sampling and testwork.

\$50,000

Complete an initial assessment of potential treatment methods of molybdenum concentrates to optimize the value of molybdenum and rhenium.

\$50,000

2.0 INTRODUCTION

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

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 Partnership¹ have conducted significant mineral exploration, environmental baseline data collection, and engineering work on the Pebble Project.

Northern Dynasty commissioned this technical report to document the results of a study of rhenium to include rhenium in the mineral resource estimate and to update status of the Pebble Project based on work since 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 main purpose of this technical report is to present the results of a study of the occurrence and amount rhenium – identified as a strategic metal by the US government – in the Pebble Deposit and to update the project's mineral resources to include an estimate of rhenium. The report will also document modifications to the proposed project reflected in the Pebble Partnership's June 2020 Project Description and the USACE Final EIS, dated July 24, 2020.

¹ Additional information on the history of the Pebble Partnership and Pebble Project is provided in Section 6.o.

2.2 SOURCES OF INFORMATION AND DATA

Information and studies obtained from Northern Dynasty and the Pebble Partnership for the 2020 Technical Report include:

- Information relating to permits, environmental studies, social or community impacts, surface rights, royalties, agreements and encumbrances relevant to this report;
- Information from geophysical, geochemical and geological surveys and drilling conducted by Northern Dynasty and the Pebble Partnership, and a previous operator;
- Information on metallurgical, geotechnical and other engineering studies, including the Project Description, by Northern Dynasty and the Pebble Partnership;
- Discussions with Northern Dynasty and Pebble Partnership personnel; and
- Inspection of the Pebble Project and surrounding area by QPs indicated in Section 2.3.

Information and studies from third-party sources used for this report are included in the references. The authors have reviewed and used information from the latter 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 visits² are tabulated below.

² All Qualified Persons are not independent of Northern Dynasty with the exception of Ting Lu.

Section	Report Section	Qualified Person & Professional Accreditation	Date of Last Site Visit
1.0	Summary	All; sign off by discipline	
2.0	Introduction	Stephen Hodgson, PEng	Oct 2019
3.0	Reliance on Other Experts	Stephen Hodgson, PEng	
4.0	Property Description and Location	Stephen Hodgson, PEng	
5.0	Accessibility, Climate, Local Resources, Infrastructure and Physiography	Stephen Hodgson, PEng	
6.0	History	Eric Tittley, PGeo/ David Gaunt, PGeo/James Lang, PGeo	
7.0	Geological Setting and Mineralization	James Lang, PGeo	July 2019
8.0	Deposit Types	James Lang, PGeo	
9.0	Exploration	James Lang, PGeo	
10.0	Drilling	Eric Tittley, PGeo/ James Lang, PGeo	
11.0	Sample Preparation, Analyses and Security	Eric Tittley, PGeo	Sept 2011
12.0	Data Verification	Eric Tittley, PGeo	
13.0	Mineral Processing and Metallurgical Testing	Ting Lu, PEng	
14.0	Mineral Resource Estimates	David Gaunt, PGeo	Sept 2010
15.0	Adjacent Properties	James Lang, PGeo	
16	Other Relevant Data and Information	Stephen Hodgson, PEng	
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		

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:

- Stephen Hodgson, PEng, relied on a letter from Trevor Thomas, Northern Dynasty's legal counsel, dated September 30, 2020, 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 September 30, 2020, 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, 100 miles northeast of Bristol Bay, and approximately 60 miles west of Cook Inlet (See Figure 4.2-1).

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.

4.2 DESCRIPTION

Northern Dynasty holds indirectly through Pebble East Claims Corporation and Pebble West Claims Corporation, wholly-owned subsidiaries of the wholly-owned Pebble Partnership, a 100% interest in a contiguous block of 2,402 administratively active mining claims and leasehold locations covering approximately 417 square miles (which includes the Pebble Deposit). 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 4.2-1 and further described in Section 6.0 History.

In June 2020, the Pebble Partnership established the Pebble Performance Dividend LLP to distribute a 3% Net Profits Royalty Interest in the Pebble Project to adult residents of Bristol Bay villages that have subscribed as participants. The Pebble Performance Dividend will distribute a guaranteed minimum annual payment of US \$3 million each year the Pebble mine operates beginning at the outset of project construction.

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 rental fees each year. Assessment work is due annually by noon of September 1. However, credit for excess assessment work can be banked for a maximum of four years after work is performed, and can be applied as necessary to continue to hold the claims in good standing. The Project claims have a variable amount of assessment 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 2020 are approximately US\$1,375,910 and are payable no later than 90 days after the assessment work is due (approximately December 1).

The details of the administratively active mining claims and leasehold locations are provided below in Figure 4.2-1 (ADL refers to the Alaska Department of Lands).

The claim boundaries have not been surveyed.

Figure 4.2-1 Mineral Claim Map with Exploration Lands and Resource Lands

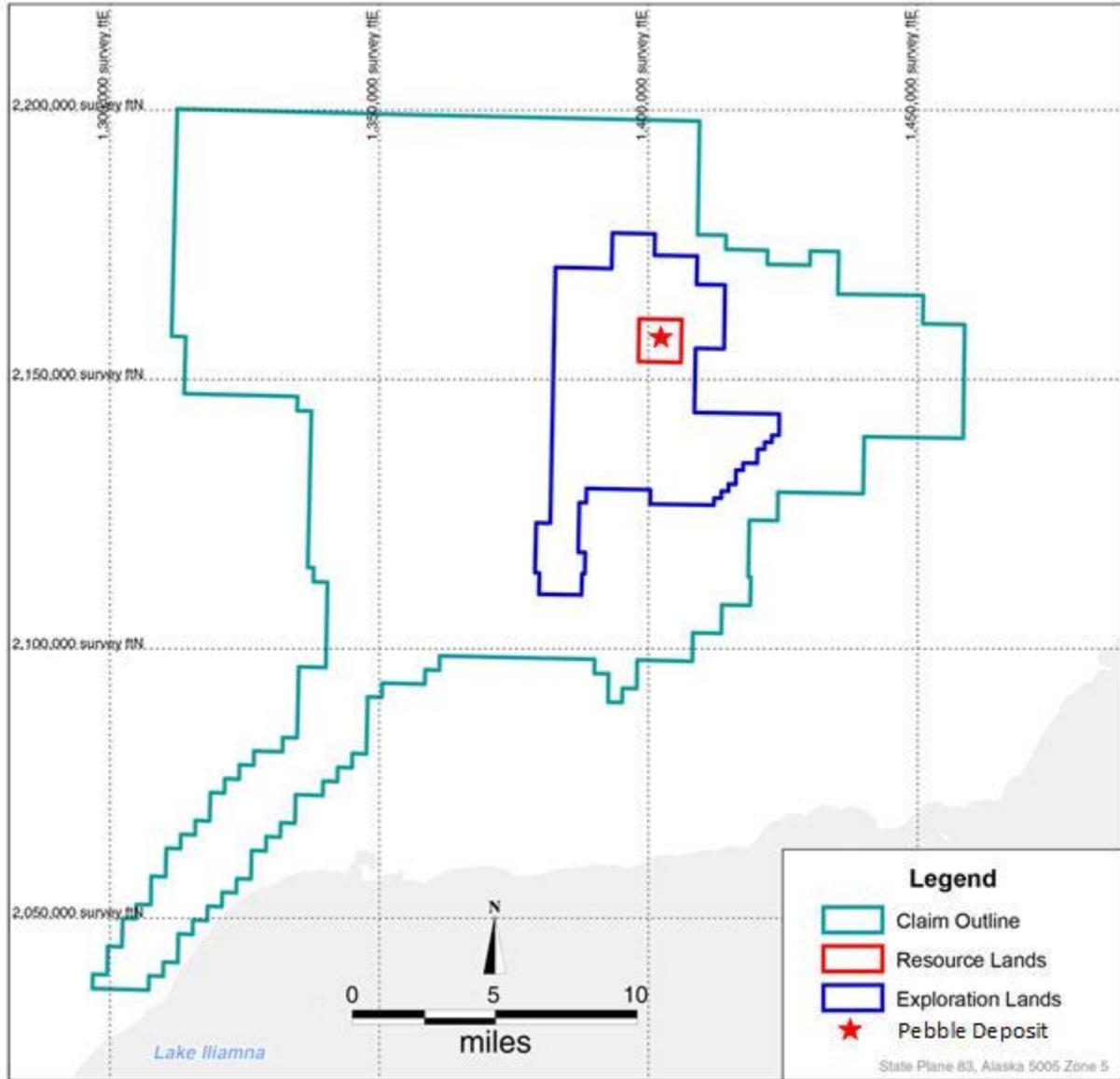


Table 4.2-1 Pebble Mineral Claims

ADL #	CLAIM NAME	ADL #	CLAIM NAME	ADL #	CLAIM NAME	ADL #	CLAIM NAME	ADL #	CLAIM NAME
644904	KAK 211	649710	KAK 266	657908	KAK 345	668742	KAS 2	669015	KAS 275
644905	KAK 212	649711	KAK 267	657909	KAK 346	668743	KAS 3	669038	KAS 298
644906	KAK 213	649712	KAK 268	657910	KAK 347	668744	KAS 4	669039	KAS 299
644907	KAK 214	649713	KAK 269	657911	KAK 348	668749	KAS 9	669040	KAS 300
644908	KAK 215	649714	KAK 270	657912	KAK 349	668750	KAS 10	669041	KAS 301
644909	KAK 216	649715	KAK 271	657913	KAK 350	668751	KAS 11	669042	KAS 302
644910	KAK 217	649716	KAK 272	657914	KAK 351	668752	KAS 12	669043	KAS 303
644911	KAK 218	649717	KAK 273	657915	KAK 352	668753	KAS 13	669060	KAS 324
644912	KAK 219	649718	KAK 274	657916	KAK 353	668758	KAS 18	669061	KAS 325
645600	SP 310	649719	KAK 275	657917	KAK 354	668759	KAS 19	669062	KAS 326
645601	SP 311	649720	KAK 276	657918	KAK 355	668760	KAS 20	669063	KAS 327
645606	SP 316	649721	KAK 277	657919	KAK 356	668761	KAS 21	669064	KAS 328
645607	SP 317	649722	KAK 278	657920	KAK 357	668762	KAS 22	669065	KAS 329
645608	SP 318	649723	KAK 279	657921	KAK 358	668769	KAS 29	669075	KAS 340
645609	SP 319	649724	KAK 280	657922	KAK 359	668770	KAS 30	669076	KAS 341
646604	PEBBLE BEACH 5942	649725	KAK 281	657923	KAK 360	668771	KAS 31	669077	KAS 342
646605	PEBBLE BEACH 5943	649726	KAK 282	657924	KAK 361	668772	KAS 32	669078	KAS 343
646606	PEB K 1	649727	KAK 283	657925	KAK 362	668773	KAS 33	669079	KAS 344
646607	PEB K 2	649728	KAK 284	657926	KAK 363	668784	KAS 44	669087	KAS 352
646608	PEB K 3	649729	KAK 285	657927	KAK 364	668785	KAS 45	669088	KAS 353
646609	PEB K 4	649730	KAK 286	657928	KAK 365	668786	KAS 46	669089	KAS 354
646610	PEB K 5	649731	KAK 287	657929	KAK 366	668787	KAS 47	669090	KAS 355
646611	PEB K 6	649732	KAK 288	657930	KAK 367	668788	KAS 48	669091	KAS 356
646612	PEB K 7	649733	KAK 289	657931	KAK 368	668801	KAS 61	669098	KAS 363
646613	PEB K 8	649734	KAK 290	657932	KAK 369	668802	KAS 62	669099	KAS 364
646614	PEB K 9	649735	KAK 291	657933	KAK 370	668803	KAS 63	669100	KAS 365
646615	PEB K 10	649736	KAK 292	657934	KAK 371	668804	KAS 64	669101	KAS 366
646616	PEB K 11	649737	KAK 293	657935	KAK 372	668805	KAS 65	669102	KAS 367
646617	PEB K 12	649738	KAK 294	657936	KAK 373	668806	KAS 66	669109	KAS 374
648906	PEB WB 64	649739	KAK 295	657937	KAK 374	668823	KAS 83	669110	KAS 375
648907	PEB WB 65	649740	KAK 296	657938	KAK 375	668824	KAS 84	669111	KAS 376
648908	PEB WB 66	649741	KAK 297	657939	KAK 376	668825	KAS 85	669112	KAS 377
648909	PEB WB 67	649742	KAK 298	657940	KAK 377	668826	KAS 86	669118	KAS 383
649664	KAK 220	649743	KAK 299	657941	KAK 378	668827	KAS 87	669119	KAS 384
649665	KAK 221	649744	KAK 300	657942	KAK 379	668828	KAS 88	669120	KAS 385
649666	KAK 222	649745	KAK 301	657943	KAK 380	668829	KAS 89	669121	KAS 386
649667	KAK 223	649746	KAK 302	657944	KAK 381	668849	KAS 109	669122	KAS 387
649668	KAK 224	649747	KAK 303	657945	KAK 382	668850	KAS 110	669127	KAS 392
649669	KAK 225	649748	KAK 304	657946	KAK 383	668851	KAS 111	669128	KAS 393
649670	KAK 226	649749	KAK 305	657947	KAK 384	668852	KAS 112	669129	KAS 394
649671	KAK 227	649750	KAK 306	657948	KAK 385	668853	KAS 113	669130	KAS 395
649672	KAK 228	649751	KAK 307	657949	KAK 386	668854	KAS 114	669135	KAS 400
649673	KAK 229	649752	KAK 308	657950	KAK 387	668855	KAS 115	669136	KAS 401
649674	KAK 230	649753	KAK 309	657951	KAK 388	668875	KAS 135	669137	KAS 402
649675	KAK 231	649754	KAK 310	657952	KAK 389	668876	KAS 136	669138	KAS 403
649676	KAK 232	649755	KAK 311	657953	KAK 390	668877	KAS 137		
649677	KAK 233	649756	KAK 312	657954	KAK 391	668878	KAS 138		
649678	KAK 234	649757	KAK 313	657955	KAK 392	668879	KAS 139		
649679	KAK 235	649758	KAK 314	657956	KAK 393	668880	KAS 140		
649680	KAK 236	649759	KAK 315	657959	KAK 396	668881	KAS 141		
649681	KAK 237	649760	KAK 316	657960	KAK 397	668901	KAS 161		
649682	KAK 238	649761	KAK 317	657961	KAK 398	668902	KAS 162		
649683	KAK 239	649762	KAK 318	657962	KAK 399	668903	KAS 163		
649684	KAK 240	649763	KAK 319	657963	KAK 400	668904	KAS 164		
649685	KAK 241	649764	KAK 320	657964	KAK 401	668905	KAS 165		
649686	KAK 242	649765	KAK 321	657965	KAK 402	668906	KAS 166		
649687	KAK 243	649766	KAK 322	663828	KAK 136A	668929	KAS 189		
649688	KAK 244	649767	KAK 323	663829	KAK 137A	668930	KAS 190		
649689	KAK 245	649768	KAK 324	663830	KAK 138A	668931	KAS 191		
649690	KAK 246	649769	KAK 325	663831	KAK 139A	668932	KAS 192		
649691	KAK 247	649770	KAK 326	663832	KAK 144A	668933	KAS 193		
649692	KAK 248	657890	KAK 327	663833	KAK 145A	668934	KAS 194	516806	PEBBLE BEACH 5448
649693	KAK 249	657891	KAK 328	663834	KAK 146A	668956	KAS 216	516807	PEBBLE BEACH 5449
649694	KAK 250	657892	KAK 329	663835	KAK 147A	668957	KAS 217	516808	PEBBLE BEACH 5450
649695	KAK 251	657893	KAK 330	663836	KAK 158A	668958	KAS 218	516809	PEBBLE BEACH 5451
649696	KAK 252	657894	KAK 331	663837	KAK 159A	668959	KAS 219	516810	PEBBLE BEACH 5452
649697	KAK 253	657895	KAK 332	663838	KAK 160A	668960	KAS 220	516811	PEBBLE BEACH 5453
649698	KAK 254	657896	KAK 333	663839	KAK 161A	668961	KAS 221	516812	PEBBLE BEACH 5454
649699	KAK 255	657897	KAK 334	663840	KAK 162A	668961	KAS 221	516813	PEBBLE BEACH 54548
649700	KAK 256	657898	KAK 335	663841	KAK 163A	668983	KAS 243	516814	PEBBLE BEACH 5549
649701	KAK 257	657899	KAK 336	663842	KAK 164A	668984	KAS 244	516815	PEBBLE BEACH 5550
649702	KAK 258	657900	KAK 337	663843	KAK 165A	668985	KAS 245	516816	PEBBLE BEACH 5551
649703	KAK 259	657901	KAK 338	663844	KAK 166A	668986	KAS 246	516817	PEBBLE BEACH 5552
649704	KAK 260	657902	KAK 339	663845	KAK 167A	668987	KAS 247	516818	PEBBLE BEACH 5553
649705	KAK 261	657903	KAK 340	663846	KAK 168A	668988	KAS 248	516819	PEBBLE BEACH 5554
649706	KAK 262	657904	KAK 341	663847	KAK 169A	669010	KAS 270	516820	PEBBLE BEACH 5651
649707	KAK 263	657905	KAK 342	663848	KAK 170A	669011	KAS 271	516821	PEBBLE BEACH 5652
649708	KAK 264	657906	KAK 343	663849	KAK 170A	669012	KAS 272	516822	PEBBLE BEACH 5653
649709	KAK 265	657907	KAK 344	668740	PEBA 113	669013	KAS 273	516823	PEBBLE BEACH 5654
				668741	KAS 1	669014	KAS 274	516824	PEBBLE BEACH 5751

ADL #	CLAIM NAME								
516825	PEBBLE BEACH 5752	516973	PEBBLE BEACH 4551	524776	PEBBLE BEACH 4053	524855	PEBBLE BEACH 6252	531423	PEBBLE BEACH 5146
516826	PEBBLE BEACH 5753	516974	PEBBLE BEACH 4552	524777	PEBBLE BEACH 4054	524856	PEBBLE BEACH 6253	531424	PEBBLE BEACH 5147
516827	PEBBLE BEACH 5754	516975	PEBBLE BEACH 4553	524778	PEBBLE BEACH 4055	524857	PEBBLE BEACH 6254	531425	PEBBLE BEACH 5244
516828	PEBBLE BEACH 5852	524511	SILL 5543	524779	PEBBLE BEACH 4148	524858	PEBBLE BEACH 6348	531426	PEBBLE BEACH 5245
516829	PEBBLE BEACH 5853	524512	SILL 5544	524780	PEBBLE BEACH 4149	524859	PEBBLE BEACH 6349	531427	PEBBLE BEACH 5246
516830	PEBBLE BEACH 5854	524515	SILL 5643	524781	PEBBLE BEACH 4153	524860	PEBBLE BEACH 6350	531428	PEBBLE BEACH 5247
516831	PEBBLE BEACH 5952	524516	SILL 5644	524782	PEBBLE BEACH 4154	524861	PEBBLE BEACH 6351	531429	PEBBLE BEACH 5344
516832	PEBBLE BEACH 5953	524519	SILL 5743	524783	PEBBLE BEACH 4155	524862	PEBBLE BEACH 6352	531430	PEBBLE BEACH 5345
516833	PEBBLE BEACH 5954	524520	SILL 5744	524784	PEBBLE BEACH 4248	524863	PEBBLE BEACH 6353	531431	PEBBLE BEACH 5346
516834	PEBBLE BEACH 6052	524523	SILL 5843	524785	PEBBLE BEACH 4249	524864	PEBBLE BEACH 6354	531432	PEBBLE BEACH 5347
516835	PEBBLE BEACH 6053	524524	SILL 5844	524786	PEBBLE BEACH 4255	525849	PEBBLE BEACH 6152	531433	PEBBLE BEACH 5444
516836	PEBBLE BEACH 6054	524527	SILL 5943	524787	PEBBLE BEACH 4348	531355	PEBBLE BEACH 3642	531434	PEBBLE BEACH 5445
516837	PEBBLE BEACH 6153	524528	SILL 5944	524788	PEBBLE BEACH 4349	531356	PEBBLE BEACH 3643	531435	PEBBLE BEACH 5446
516838	PEBBLE BEACH 6154	524531	SILL 6043	524789	PEBBLE BEACH 4355	531357	PEBBLE BEACH 3644	531436	PEBBLE BEACH 5447
516839	PEBBLE BEACH 4651	524532	SILL 6044	524790	PEBBLE BEACH 4448	531358	PEBBLE BEACH 3645	531437	PEBBLE BEACH 5544
516840	PEBBLE BEACH 4652	524535	SILL 6143	524791	PEBBLE BEACH 4449	531359	PEBBLE BEACH 3742	531438	PEBBLE BEACH 5545
516841	PEBBLE BEACH 4653	524536	SILL 6144	524792	PEBBLE BEACH 4450	531360	PEBBLE BEACH 3743	531439	PEBBLE BEACH 5546
516842	PEBBLE BEACH 4751	524539	SILL 6243	524793	PEBBLE BEACH 4454	531361	PEBBLE BEACH 3744	531440	PEBBLE BEACH 5547
516843	PEBBLE BEACH 4752	524540	SILL 6244	524794	PEBBLE BEACH 4455	531362	PEBBLE BEACH 3745	531441	PEBBLE BEACH 5644
516844	PEBBLE BEACH 4753	524541	SILL 6245	524795	PEBBLE BEACH 4548	531363	PEBBLE BEACH 3842	531442	PEBBLE BEACH 5645
516845	PEBBLE BEACH 4851	524542	SILL 6246	524796	PEBBLE BEACH 4549	531364	PEBBLE BEACH 3843	531443	PEBBLE BEACH 5646
516846	PEBBLE BEACH 4852	524543	SILL 6343	524797	PEBBLE BEACH 4550	531365	PEBBLE BEACH 3844	531444	PEBBLE BEACH 5647
516847	PEBBLE BEACH 4853	524544	SILL 6344	524798	PEBBLE BEACH 4554	531366	PEBBLE BEACH 3845	531445	PEBBLE BEACH 5744
516848	PEBBLE BEACH 4951	524550	SILL 6443	524799	PEBBLE BEACH 4555	531367	PEBBLE BEACH 3846	531446	PEBBLE BEACH 5745
516849	PEBBLE BEACH 4952	524551	SILL 6444	524800	PEBBLE BEACH 4648	531368	PEBBLE BEACH 3847	531447	PEBBLE BEACH 5746
516850	PEBBLE BEACH 4953	524557	SILL 6543	524801	PEBBLE BEACH 4649	531369	PEBBLE BEACH 3942	531448	PEBBLE BEACH 5747
516851	PEBBLE BEACH 5048	524558	SILL 6544	524802	PEBBLE BEACH 4650	531370	PEBBLE BEACH 3943	531449	PEBBLE BEACH 5844
516852	PEBBLE BEACH 5049	524568	SILL 6643	524803	PEBBLE BEACH 4654	531371	PEBBLE BEACH 3944	531450	PEBBLE BEACH 5845
516853	PEBBLE BEACH 5050	524569	SILL 6644	524804	PEBBLE BEACH 4655	531372	PEBBLE BEACH 3945	531451	PEBBLE BEACH 5846
516854	PEBBLE BEACH 5051	524579	SILL 6743	524805	PEBBLE BEACH 4748	531373	PEBBLE BEACH 3946	531452	PEBBLE BEACH 5847
516855	PEBBLE BEACH 5052	524580	SILL 6744	524806	PEBBLE BEACH 4749	531374	PEBBLE BEACH 3947	531453	PEBBLE BEACH 5944
516856	PEBBLE BEACH 5053	524595	SILL 6843	524807	PEBBLE BEACH 4750	531375	PEBBLE BEACH 4042	531454	PEBBLE BEACH 5945
516857	PEBBLE BEACH 5148	524596	SILL 6844	524808	PEBBLE BEACH 4754	531376	PEBBLE BEACH 4043	531455	PEBBLE BEACH 5946
516858	PEBBLE BEACH 5149	524611	SILL 6943	524809	PEBBLE BEACH 4755	531377	PEBBLE BEACH 4044	531456	PEBBLE BEACH 5947
516859	PEBBLE BEACH 5150	524612	SILL 6944	524810	PEBBLE BEACH 4848	531378	PEBBLE BEACH 4045	531457	PEBBLE BEACH 6044
516860	PEBBLE BEACH 5151	524630	SILL 7043	524811	PEBBLE BEACH 4849	531379	PEBBLE BEACH 4046	531458	PEBBLE BEACH 6045
516861	PEBBLE BEACH 5152	524631	SILL 7044	524812	PEBBLE BEACH 4850	531380	PEBBLE BEACH 4047	531459	PEBBLE BEACH 6046
516862	PEBBLE BEACH 5153	524649	SILL 7143	524813	PEBBLE BEACH 4854	531381	PEBBLE BEACH 4142	531460	PEBBLE BEACH 6047
516863	PEBBLE BEACH 5248	524650	SILL 7144	524814	PEBBLE BEACH 4855	531382	PEBBLE BEACH 4143	531461	PEBBLE BEACH 6144
516864	PEBBLE BEACH 5249	524668	SILL 7243	524815	PEBBLE BEACH 4948	531383	PEBBLE BEACH 4144	531462	PEBBLE BEACH 6145
516865	PEBBLE BEACH 5250	524669	SILL 7244	524816	PEBBLE BEACH 4949	531384	PEBBLE BEACH 4145	531463	PEBBLE BEACH 6146
516866	PEBBLE BEACH 5251	524684	SILL 7343	524817	PEBBLE BEACH 4950	531385	PEBBLE BEACH 4146	531464	PEBBLE BEACH 6147
516867	PEBBLE BEACH 5252	524685	SILL 7344	524818	PEBBLE BEACH 4954	531386	PEBBLE BEACH 4147	531465	PEBBLE BEACH 6148
516868	PEBBLE BEACH 5253	524698	SILL 7443	524819	PEBBLE BEACH 4955	531387	PEBBLE BEACH 4244	531469	PEBBLE BEACH 6149
516869	PEBBLE BEACH 5348	524699	SILL 7444	524820	PEBBLE BEACH 5054	531388	PEBBLE BEACH 4245	540399	PEBBLE BEACH 5555
516870	PEBBLE BEACH 5349	524712	SILL 7543	524821	PEBBLE BEACH 5055	531389	PEBBLE BEACH 4246	540400	PEBBLE BEACH 5655
516871	PEBBLE BEACH 5350	524713	SILL 7544	524822	PEBBLE BEACH 5154	531390	PEBBLE BEACH 4247	540401	PEBBLE BEACH 5755
516872	PEBBLE BEACH 5351	524714	SILL 7545	524823	PEBBLE BEACH 5155	531391	PEBBLE BEACH 4344	540402	PEBBLE BEACH 5855
516873	PEBBLE BEACH 5352	524715	SILL 7546	524824	PEBBLE BEACH 5254	531392	PEBBLE BEACH 4345	540403	PEBBLE BEACH 5955
516874	PEBBLE BEACH 5353	524716	SILL 7547	524825	PEBBLE BEACH 5255	531393	PEBBLE BEACH 4346	540404	PEBBLE BEACH 6055
516879	SILL 6351	524717	SILL 7548	524826	PEBBLE BEACH 5354	531394	PEBBLE BEACH 4347	540405	PEBBLE BEACH 6155
516880	SILL 6352	524748	PEBBLE BEACH 3452	524827	PEBBLE BEACH 5355	531395	PEBBLE BEACH 4444	540406	PEBBLE BEACH 6255
516888	SILL 6451	524749	PEBBLE BEACH 3453	524828	PEBBLE BEACH 5455	531396	PEBBLE BEACH 4445	540407	PEBBLE BEACH 6355
516889	SILL 6452	524750	PEBBLE BEACH 3454	524829	PEBBLE BEACH 5648	531397	PEBBLE BEACH 4446	540408	PEBBLE BEACH 6448
516948	PEBBLE BEACH 3850	524751	PEBBLE BEACH 3455	524830	PEBBLE BEACH 5649	531398	PEBBLE BEACH 4447	540409	PEBBLE BEACH 6449
516949	PEBBLE BEACH 3851	524752	PEBBLE BEACH 3552	524831	PEBBLE BEACH 5650	531399	PEBBLE BEACH 4544	540410	PEBBLE BEACH 6450
516950	PEBBLE BEACH 3852	524753	PEBBLE BEACH 3553	524832	PEBBLE BEACH 5748	531400	PEBBLE BEACH 4547	540411	PEBBLE BEACH 6451
516951	PEBBLE BEACH 3950	524754	PEBBLE BEACH 3554	524833	PEBBLE BEACH 5749	531401	PEBBLE BEACH 4644	540412	PEBBLE BEACH 6452
516952	PEBBLE BEACH 3951	524755	PEBBLE BEACH 3555	524834	PEBBLE BEACH 5750	531402	PEBBLE BEACH 4645	540413	PEBBLE BEACH 6453
516953	PEBBLE BEACH 3952	524756	PEBBLE BEACH 3652	524835	PEBBLE BEACH 5848	531403	PEBBLE BEACH 4646	540414	PEBBLE BEACH 6454
516954	PEBBLE BEACH 4050	524757	PEBBLE BEACH 3653	524836	PEBBLE BEACH 5849	531404	PEBBLE BEACH 4647	540415	PEBBLE BEACH 6455
516955	PEBBLE BEACH 4051	524758	PEBBLE BEACH 3654	524837	PEBBLE BEACH 5850	531405	PEBBLE BEACH 4744	540416	PEBBLE BEACH 6548
516956	PEBBLE BEACH 4052	524759	PEBBLE BEACH 3655	524838	PEBBLE BEACH 5851	531406	PEBBLE BEACH 4745	540417	PEBBLE BEACH 6549
516957	PEBBLE BEACH 4150	524760	PEBBLE BEACH 3752	524839	PEBBLE BEACH 5948	531407	PEBBLE BEACH 4746	540418	PEBBLE BEACH 6550
516958	PEBBLE BEACH 4151	524761	PEBBLE BEACH 3753	524840	PEBBLE BEACH 5949	531408	PEBBLE BEACH 4747	540419	PEBBLE BEACH 6551
516959	PEBBLE BEACH 4152	524762	PEBBLE BEACH 3754	524841	PEBBLE BEACH 5950	531409	PEBBLE BEACH 4844	540420	PEBBLE BEACH 6552
516960	PEBBLE BEACH 4250	524763	PEBBLE BEACH 3755	524842	PEBBLE BEACH 5951	531410	PEBBLE BEACH 4845	540421	PEBBLE BEACH 6553
516961	PEBBLE BEACH 4251	524764	PEBBLE BEACH 3848	524843	PEBBLE BEACH 6048	531411	PEBBLE BEACH 4846	540422	PEBBLE BEACH 6554
516962	PEBBLE BEACH 4252	524765	PEBBLE BEACH 3849	524844	PEBBLE BEACH 6049	531412	PEBBLE BEACH 4847	540423	PEBBLE BEACH 6555
516963	PEBBLE BEACH 4253	524766	PEBBLE BEACH 3853	524845	PEBBLE BEACH 6050	531413	PEBBLE BEACH 4944	540424	SILL 7643
516964	PEBBLE BEACH 4254	524767	PEBBLE BEACH 3854	524846	PEBBLE BEACH 6051	531414	PEBBLE BEACH 4945	540425	SILL 7644
516965	PEBBLE BEACH 4350	524768	PEBBLE BEACH 3855	524847	PEBBLE BEACH 6148	531415	PEBBLE BEACH 4946	540426	SILL 7645
516966	PEBBLE BEACH 4351	524769	PEBBLE BEACH 3948	524848	PEBBLE BEACH 6149	531416	PEBBLE BEACH 4947	540427	SILL 7646
516967	PEBBLE BEACH 4352	524770	PEBBLE BEACH 3949	524849	PEBBLE BEACH 6150	531417	PEBBLE BEACH 5044	540428	SILL 7647
516968	PEBBLE BEACH 4353	524771	PEBBLE BEACH 3953	524850	PEBBLE BEACH 6151	531418	PEBBLE BEACH 5045	540429	SILL 7648
516969	PEBBLE BEACH 4354	524772	PEBBLE BEACH 3954	524851	PEBBLE BEACH 6248	531419	PEBBLE BEACH 5046	540430	SILL 7743
516970	PEBBLE BEACH 4451	524773	PEBBLE BEACH 3955	524852	PEBBLE BEACH 6249	531420	PEBBLE BEACH 5047	540431	SILL 7744
516971	PEBBLE BEACH 4452	524774	PEBBLE BEACH 4048	524853	PEBBLE BEACH 6250	531421	PEBBLE BEACH 5144	540432	SILL 7745
516972	PEBBLE BEACH 4453	524775	PEBBLE BEACH 4049	524854	PEBBLE BEACH 6251	531422	PEBBLE BEACH 5145	540433	SILL 7746

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540434	SILL 7747	542592	PEBBLE BEACH 5243	566568	PEBBLE BEACH 2737	566855	PEBBLE BEACH 3750	566966	PEBBLE BEACH 5539
540435	SILL 7748	542593	PEBBLE BEACH 5342	566569	PEBBLE BEACH 2738	566856	PEBBLE BEACH 3751	566967	PEBBLE BEACH 5540
540436	SILL 7843	542594	PEBBLE BEACH 5343	566570	PEBBLE BEACH 2739	566865	PEBBLE BEACH 3838	566968	PEBBLE BEACH 5541
540437	SILL 7844	542595	PEBBLE BEACH 5442	566571	PEBBLE BEACH 2740	566866	PEBBLE BEACH 3839	566969	PEBBLE BEACH 5638
540438	SILL 7845	542596	PEBBLE BEACH 5443	566572	PEBBLE BEACH 2741	566867	PEBBLE BEACH 3840	566970	PEBBLE BEACH 5639
540439	SILL 7846	542597	PEBBLE BEACH 5542	566607	PEBBLE BEACH 3138	566868	PEBBLE BEACH 3841	566971	PEBBLE BEACH 5640
540440	SILL 7847	542598	PEBBLE BEACH 5543	566608	PEBBLE BEACH 3139	566877	PEBBLE BEACH 3938	566972	PEBBLE BEACH 5641
540441	SILL 7848	542599	PEBBLE BEACH 5642	566609	PEBBLE BEACH 3140	566878	PEBBLE BEACH 3939	566973	PEBBLE BEACH 5738
540442	SILL 7943	542600	PEBBLE BEACH 5643	566610	PEBBLE BEACH 3141	566879	PEBBLE BEACH 3940	566974	PEBBLE BEACH 5739
540443	SILL 7944	542601	PEBBLE BEACH 5742	566637	PEBBLE BEACH 2938	566880	PEBBLE BEACH 3941	566975	PEBBLE BEACH 5740
540444	SILL 7945	542602	PEBBLE BEACH 5743	566638	PEBBLE BEACH 2939	566889	PEBBLE BEACH 4038	566976	PEBBLE BEACH 5741
540445	SILL 7946	542603	PEBBLE BEACH 5842	566639	PEBBLE BEACH 2940	566890	PEBBLE BEACH 4039	566977	PEBBLE BEACH 5838
540446	SILL 7947	542604	PEBBLE BEACH 5843	566640	PEBBLE BEACH 2941	566891	PEBBLE BEACH 4040	566978	PEBBLE BEACH 5839
540447	SILL 7948	552917	SOUTH PEBBLE 159	566655	PEBBLE BEACH 2836	566892	PEBBLE BEACH 4041	566979	PEBBLE BEACH 5840
540448	SILL 8043	552918	SOUTH PEBBLE 160	566656	PEBBLE BEACH 2837	566901	PEBBLE BEACH 4138	566980	PEBBLE BEACH 5841
540449	SILL 8044	552919	SOUTH PEBBLE 161	566657	PEBBLE BEACH 2838	566902	PEBBLE BEACH 4139	566981	PEBBLE BEACH 5938
540450	SILL 8045	552920	SOUTH PEBBLE 162	566658	PEBBLE BEACH 2839	566903	PEBBLE BEACH 4140	566982	PEBBLE BEACH 5939
540451	SILL 8046	552921	SOUTH PEBBLE 163	566659	PEBBLE BEACH 2840	566904	PEBBLE BEACH 4141	566983	PEBBLE BEACH 5940
540452	SILL 8047	552922	SOUTH PEBBLE 164	566660	PEBBLE BEACH 2841	566905	PEBBLE BEACH 4238	566984	PEBBLE BEACH 5941
540453	SILL 8048	552923	SOUTH PEBBLE 165	566697	PEBBLE BEACH 3238	566906	PEBBLE BEACH 4239	566985	PEBBLE BEACH 6038
540454	SILL 8143	552924	SOUTH PEBBLE 166	566698	PEBBLE BEACH 3239	566907	PEBBLE BEACH 4240	566986	PEBBLE BEACH 6039
540455	SILL 8144	552925	SOUTH PEBBLE 167	566699	PEBBLE BEACH 3240	566908	PEBBLE BEACH 4241	566987	PEBBLE BEACH 6040
540456	SILL 8145	552926	SOUTH PEBBLE 168	566700	PEBBLE BEACH 3241	566909	PEBBLE BEACH 4242	566988	PEBBLE BEACH 6041
540457	SILL 8146	552927	SOUTH PEBBLE 169	566701	PEBBLE BEACH 3242	566910	PEBBLE BEACH 4243	566989	PEBBLE BEACH 6042
540458	SILL 8147	552928	SOUTH PEBBLE 170	566737	PEBBLE BEACH 3038	566911	PEBBLE BEACH 4338	566990	PEBBLE BEACH 6043
540459	SILL 8148	552929	SOUTH PEBBLE 171	566738	PEBBLE BEACH 3039	566912	PEBBLE BEACH 4339	566991	PEBBLE BEACH 6138
540460	SILL 8243	552930	SOUTH PEBBLE 172	566739	PEBBLE BEACH 3040	566913	PEBBLE BEACH 4340	566992	PEBBLE BEACH 6139
540461	SILL 8244	566247	PEBBLE BEACH 1936	566740	PEBBLE BEACH 3041	566914	PEBBLE BEACH 4341	566993	PEBBLE BEACH 6140
540462	SILL 8245	566248	PEBBLE BEACH 1937	566751	PEBBLE BEACH 3252	566915	PEBBLE BEACH 4342	566994	PEBBLE BEACH 6141
540463	SILL 8246	566249	PEBBLE BEACH 1938	566752	PEBBLE BEACH 3253	566916	PEBBLE BEACH 4343	566995	PEBBLE BEACH 6142
540464	SILL 8247	566250	PEBBLE BEACH 1939	566753	PEBBLE BEACH 3254	566917	PEBBLE BEACH 4438	566996	PEBBLE BEACH 6143
540465	SILL 8248	566251	PEBBLE BEACH 1940	566754	PEBBLE BEACH 3255	566918	PEBBLE BEACH 4439	566997	PEBBLE BEACH 6238
540466	SILL 8343	566252	PEBBLE BEACH 1941	566767	PEBBLE BEACH 3338	566919	PEBBLE BEACH 4440	566998	PEBBLE BEACH 6239
540467	SILL 8344	566287	PEBBLE BEACH 2036	566768	PEBBLE BEACH 3339	566920	PEBBLE BEACH 4441	566999	PEBBLE BEACH 6240
540468	SILL 8443	566288	PEBBLE BEACH 2037	566769	PEBBLE BEACH 3340	566921	PEBBLE BEACH 4442	567000	PEBBLE BEACH 6241
540469	SILL 8444	566289	PEBBLE BEACH 2038	566770	PEBBLE BEACH 3341	566922	PEBBLE BEACH 4443	567001	PEBBLE BEACH 6242
540470	SILL 8543	566290	PEBBLE BEACH 2039	566771	PEBBLE BEACH 3342	566923	PEBBLE BEACH 4538	567002	PEBBLE BEACH 6243
540471	SILL 8544	566291	PEBBLE BEACH 2040	566781	PEBBLE BEACH 3352	566924	PEBBLE BEACH 4539	567003	PEBBLE BEACH 6244
540472	SILL 8643	566292	PEBBLE BEACH 2041	566782	PEBBLE BEACH 3353	566925	PEBBLE BEACH 4540	567004	PEBBLE BEACH 6245
540473	SILL 8644	566327	PEBBLE BEACH 2136	566783	PEBBLE BEACH 3354	566926	PEBBLE BEACH 4541	567005	PEBBLE BEACH 6246
541245	PB 113	566328	PEBBLE BEACH 2137	566784	PEBBLE BEACH 3355	566927	PEBBLE BEACH 4542	567006	PEBBLE BEACH 6247
541246	PB 114	566329	PEBBLE BEACH 2138	566793	PEBBLE BEACH 3438	566928	PEBBLE BEACH 4543	567007	PEBBLE BEACH 6338
541247	PB 115	566330	PEBBLE BEACH 2139	566794	PEBBLE BEACH 3439	566929	PEBBLE BEACH 4638	567008	PEBBLE BEACH 6339
541248	PB 116	566331	PEBBLE BEACH 2140	566795	PEBBLE BEACH 3440	566930	PEBBLE BEACH 4639	567009	PEBBLE BEACH 6340
541249	PB 117	566332	PEBBLE BEACH 2141	566796	PEBBLE BEACH 3441	566931	PEBBLE BEACH 4640	567010	PEBBLE BEACH 6341
541250	PB 118	566367	PEBBLE BEACH 2236	566797	PEBBLE BEACH 3446	566932	PEBBLE BEACH 4641	567011	PEBBLE BEACH 6342
541251	PB 119	566368	PEBBLE BEACH 2237	566798	PEBBLE BEACH 3447	566933	PEBBLE BEACH 4738	567012	PEBBLE BEACH 6343
541252	PB 120	566369	PEBBLE BEACH 2238	566799	PEBBLE BEACH 3448	566934	PEBBLE BEACH 4739	567013	PEBBLE BEACH 6344
542561	PEBBLE BEACH 4856	566370	PEBBLE BEACH 2239	566800	PEBBLE BEACH 3449	566935	PEBBLE BEACH 4740	567014	PEBBLE BEACH 6345
542562	PEBBLE BEACH 4956	566371	PEBBLE BEACH 2240	566801	PEBBLE BEACH 3450	566936	PEBBLE BEACH 4741	567015	PEBBLE BEACH 6346
542563	PEBBLE BEACH 5056	566372	PEBBLE BEACH 2241	566802	PEBBLE BEACH 3451	566937	PEBBLE BEACH 4838	567016	PEBBLE BEACH 6347
542564	PEBBLE BEACH 5156	566373	PEBBLE BEACH 2242	566811	PEBBLE BEACH 3538	566938	PEBBLE BEACH 4839	567017	PEBBLE BEACH 6438
542565	PEBBLE BEACH 5256	566407	PEBBLE BEACH 2336	566812	PEBBLE BEACH 3539	566939	PEBBLE BEACH 4840	567018	PEBBLE BEACH 6439
542566	PEBBLE BEACH 5356	566408	PEBBLE BEACH 2337	566813	PEBBLE BEACH 3540	566940	PEBBLE BEACH 4841	567019	PEBBLE BEACH 6440
542567	PEBBLE BEACH 5456	566409	PEBBLE BEACH 2338	566814	PEBBLE BEACH 3541	566941	PEBBLE BEACH 4938	567020	PEBBLE BEACH 6441
542568	PEBBLE BEACH 5556	566410	PEBBLE BEACH 2339	566815	PEBBLE BEACH 3546	566942	PEBBLE BEACH 4939	567021	PEBBLE BEACH 6442
542569	PEBBLE BEACH 5656	566411	PEBBLE BEACH 2340	566816	PEBBLE BEACH 3547	566943	PEBBLE BEACH 4940	567022	PEBBLE BEACH 6443
542570	PEBBLE BEACH 5756	566412	PEBBLE BEACH 2341	566817	PEBBLE BEACH 3548	566944	PEBBLE BEACH 4941	567023	PEBBLE BEACH 6444
542571	PEBBLE BEACH 5856	566413	PEBBLE BEACH 2342	566818	PEBBLE BEACH 3549	566945	PEBBLE BEACH 5038	567024	PEBBLE BEACH 6445
542572	PEBBLE BEACH 5956	566447	PEBBLE BEACH 2436	566819	PEBBLE BEACH 3550	566946	PEBBLE BEACH 5039	567025	PEBBLE BEACH 6446
542573	PEBBLE BEACH 6056	566448	PEBBLE BEACH 2437	566820	PEBBLE BEACH 3551	566947	PEBBLE BEACH 5040	567026	PEBBLE BEACH 6447
542574	PEBBLE BEACH 6156	566449	PEBBLE BEACH 2438	566829	PEBBLE BEACH 3638	566948	PEBBLE BEACH 5041	567035	PEBBLE BEACH 6546
542575	PEBBLE BEACH 6256	566450	PEBBLE BEACH 2439	566830	PEBBLE BEACH 3639	566949	PEBBLE BEACH 5138	567036	PEBBLE BEACH 6547
542576	PEBBLE BEACH 6356	566451	PEBBLE BEACH 2440	566831	PEBBLE BEACH 3640	566950	PEBBLE BEACH 5139	567045	PEBBLE BEACH 6646
542577	PEBBLE BEACH 6456	566452	PEBBLE BEACH 2441	566832	PEBBLE BEACH 3641	566951	PEBBLE BEACH 5140	567046	PEBBLE BEACH 6647
542578	PEBBLE BEACH 6556	566453	PEBBLE BEACH 2442	566833	PEBBLE BEACH 3646	566952	PEBBLE BEACH 5141	567047	PEBBLE BEACH 6648
542579	PEBBLE BEACH 6642	566487	PEBBLE BEACH 2536	566834	PEBBLE BEACH 3647	566953	PEBBLE BEACH 5238	567048	PEBBLE BEACH 6649
542580	PEBBLE BEACH 6643	566488	PEBBLE BEACH 2537	566835	PEBBLE BEACH 3648	566954	PEBBLE BEACH 5239	567049	PEBBLE BEACH 6650
542581	PEBBLE BEACH 6742	566489	PEBBLE BEACH 2538	566836	PEBBLE BEACH 3649	566955	PEBBLE BEACH 5240	567050	PEBBLE BEACH 6651
542582	PEBBLE BEACH 6743	566490	PEBBLE BEACH 2539	566837	PEBBLE BEACH 3650	566956	PEBBLE BEACH 5241	567051	PEBBLE BEACH 6652
542583	PEBBLE BEACH 6842	566491	PEBBLE BEACH 2540	566838	PEBBLE BEACH 3651	566957	PEBBLE BEACH 5338	567052	PEBBLE BEACH 6653
542584	PEBBLE BEACH 6843	566492	PEBBLE BEACH 2541	566847	PEBBLE BEACH 3738	566958	PEBBLE BEACH 5339	567053	PEBBLE BEACH 6654
542585	PEBBLE BEACH 6942	566527	PEBBLE BEACH 2636	566848	PEBBLE BEACH 3739	566959	PEBBLE BEACH 5340	567054	PEBBLE BEACH 6655
542586	PEBBLE BEACH 6943	566528	PEBBLE BEACH 2637	566849	PEBBLE BEACH 3740	566960	PEBBLE BEACH 5341	567055	PEBBLE BEACH 6656
542587	PEBBLE BEACH 5042	566529	PEBBLE BEACH 2638	566850	PEBBLE BEACH 3741	566961	PEBBLE BEACH 5438	567064	PEBBLE BEACH 6746
542588	PEBBLE BEACH 5043	566530	PEBBLE BEACH 2639	566851	PEBBLE BEACH 3746	566962	PEBBLE BEACH 5439	567065	PEBBLE BEACH 6747
542589	PEBBLE BEACH 5142	566531	PEBBLE BEACH 2640	566852	PEBBLE BEACH 3747	566963	PEBBLE BEACH 5440	567066	PEBBLE BEACH 6748
542590	PEBBLE BEACH 5143	566532	PEBBLE BEACH 2641	566853	PEBBLE BEACH 3748	566964	PEBBLE BEACH 5441	567067	PEBBLE BEACH 6749
542591	PEBBLE BEACH 5242	566567	PEBBLE BEACH 2736	566854	PEBBLE BEACH 3749	566965	PEBBLE BEACH 5538	567068	PEBBLE BEACH 6750

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567069	PEBBLE BEACH 6751	567957	SILL 6353	642824	BC 336	642927	BC 439	643441	BC 1010
567083	PEBBLE BEACH 6846	567958	SILL 6354	642825	BC 337	642928	BC 440	644284	SP 173
567084	PEBBLE BEACH 6847	567959	SILL 6355	642826	BC 338	642929	BC 441	644285	SP 174
567085	PEBBLE BEACH 6848	567960	SILL 6356	642827	BC 339	642930	BC 442	644286	SP 175
567086	PEBBLE BEACH 6849	567961	SILL 6445	642832	BC 344	642931	BC 443	644287	SP 176
567087	PEBBLE BEACH 6850	567962	SILL 6446	642833	BC 345	642932	BC 444	644288	SP 177
567088	PEBBLE BEACH 6851	567963	SILL 6447	642834	BC 346	642933	BC 445	644289	SP 178
567102	PEBBLE BEACH 6946	567964	SILL 6448	642835	BC 347	642934	BC 446	644290	SP 179
567103	PEBBLE BEACH 6947	567965	SILL 6449	642836	BC 348	642935	BC 447	644291	SP 180
567104	PEBBLE BEACH 6948	567966	SILL 6450	642837	BC 349	642936	BC 448	644292	SP 181
567105	PEBBLE BEACH 6949	567967	SILL 6453	642838	BC 350	642937	BC 449	644293	SP 182
567106	PEBBLE BEACH 6950	567968	SILL 6454	642839	BC 351	642938	BC 450	644294	SP 183
567107	PEBBLE BEACH 6951	567969	SILL 6455	642840	BC 352	642939	BC 451	644295	SP 184
567841	SILL 5343	567970	SILL 6456	642841	BC 353	642944	BC 456	644296	SP 185
567842	SILL 5344	567971	SILL 6545	642842	BC 354	642945	BC 457	644297	SP 186
567843	SILL 5345	567972	SILL 6546	642843	BC 355	642946	BC 458	644298	SP 187
567844	SILL 5346	567973	SILL 6547	642848	BC 360	642947	BC 459	644299	SP 188
567845	SILL 5347	567974	SILL 6548	642849	BC 361	642948	BC 460	644300	SP 189
567855	SILL 5443	567975	SILL 6549	642850	BC 362	642949	BC 461	644301	SP 190
567856	SILL 5444	567976	SILL 6550	642851	BC 363	642950	BC 462	644302	SP 191
567857	SILL 5445	567977	SILL 6551	642852	BC 364	642951	BC 463	644303	SP 192
567858	SILL 5446	567978	SILL 6552	642853	BC 365	642952	BC 464	644312	SP 201
567859	SILL 5447	567979	SILL 6553	642854	BC 366	642953	BC 465	644313	SP 202
567860	SILL 5448	567980	SILL 6554	642855	BC 367	642954	BC 466	644314	SP 203
567869	SILL 5545	567981	SILL 6555	642856	BC 368	642955	BC 467	644315	SP 204
567870	SILL 5546	567982	SILL 6556	642857	BC 369	642956	BC 468	644318	SP 207
567871	SILL 5547	568175	SILL 8345	642858	BC 370	642957	BC 469	644319	SP 208
567872	SILL 5548	568176	SILL 8346	642859	BC 371	642958	BC 470	644320	SP 209
567873	SILL 5549	568177	SILL 8347	642860	BC 372	642959	BC 471	644321	SP 210
567881	SILL 5645	568178	SILL 8348	642861	BC 373	642960	BC 472	644322	SP 216
567882	SILL 5646	568255	SILL 8743	642862	BC 374	642964	BC 476	644323	SP 225
567883	SILL 5647	568256	SILL 8744	642867	BC 379	642965	BC 477	644324	SP 226
567884	SILL 5648	642753	BC 265	642868	BC 380	642966	BC 478	644325	SP 227
567885	SILL 5649	642754	BC 266	642869	BC 381	642967	BC 479	644326	SP 228
567886	SILL 5650	642755	BC 267	642870	BC 382	642968	BC 480	644327	SP 229
567893	SILL 5745	642756	BC 268	642871	BC 383	642969	BC 481	644328	SP 230
567894	SILL 5746	642757	BC 269	642872	BC 384	642970	BC 482	644329	SP 231
567895	SILL 5747	642758	BC 270	642873	BC 385	642971	BC 483	644330	SP 232
567896	SILL 5748	642759	BC 271	642874	BC 386	642972	BC 484	644331	SP 235
567897	SILL 5749	642764	BC 276	642875	BC 387	642973	BC 485	644332	SP 236
567898	SILL 5750	642765	BC 277	642876	BC 388	642974	BC 486	644333	SP 237
567905	SILL 5845	642766	BC 278	642877	BC 389	642975	BC 487	644334	SP 238
567906	SILL 5846	642767	BC 279	642878	BC 390	642976	BC 488	644335	SP 239
567907	SILL 5847	642768	BC 280	642879	BC 391	642977	BC 489	644336	SP 245
567908	SILL 5848	642769	BC 281	642880	BC 392	642978	BC 490	644733	SOUTH PEBBLE 234
567909	SILL 5849	642770	BC 282	642881	BC 393	642979	BC 491	644734	SOUTH PEBBLE 240
567910	SILL 5850	642775	BC 287	642886	BC 398	642980	BC 492	644735	SOUTH PEBBLE 241
567911	SILL 5851	642776	BC 288	642887	BC 399	642981	BC 493	644736	SOUTH PEBBLE 242
567917	SILL 5945	642777	BC 289	642888	BC 400	642982	BC 494	644737	SOUTH PEBBLE 243
567918	SILL 5946	642778	BC 290	642889	BC 401	642983	BC 495	644738	SOUTH PEBBLE 244
567919	SILL 5947	642779	BC 291	642890	BC 402	642987	BC 499	645612	SP 322
567920	SILL 5948	642780	BC 292	642891	BC 403	642988	BC 500	645613	SP 323
567921	SILL 5949	642781	BC 293	642892	BC 404	642989	BC 501	645614	SP 324
567922	SILL 5950	642786	BC 298	642893	BC 405	642990	BC 502	645615	SP 325
567923	SILL 5953	642787	BC 299	642894	BC 406	642991	BC 503	645616	SP 326
567927	SILL 6045	642788	BC 300	642895	BC 407	642992	BC 504	645617	SP 327
567928	SILL 6046	642789	BC 301	642896	BC 408	642993	BC 505	645618	SP 328
567929	SILL 6047	642790	BC 302	642897	BC 409	642994	BC 506	645619	SP 329
567930	SILL 6048	642791	BC 303	642898	BC 410	642995	BC 507	645620	SP 330
567931	SILL 6049	642792	BC 304	642899	BC 411	642996	BC 508	645621	SP 331
567932	SILL 6050	642797	BC 309	642900	BC 412	642997	BC 509	645622	SP 332
567933	SILL 6053	642798	BC 310	642905	BC 417	642998	BC 510	645623	SP 333
567937	SILL 6145	642799	BC 311	642906	BC 418	642999	BC 511	645624	SP 334
567938	SILL 6146	642800	BC 312	642907	BC 419	643000	BC 512	645625	SP 335
567939	SILL 6147	642801	BC 313	642908	BC 420	643001	BC 513	645626	SP 336
567940	SILL 6148	642802	BC 314	642909	BC 421	643002	BC 514	645627	SP 337
567941	SILL 6149	642803	BC 315	642910	BC 422	643003	BC 515	645628	SP 338
567942	SILL 6150	642808	BC 320	642911	BC 423	643004	BC 516	645629	SP 339
567943	SILL 6153	642809	BC 321	642912	BC 424	643005	BC 517	645630	SP 340
567944	SILL 6154	642810	BC 322	642913	BC 425	643006	BC 518	645631	SP 341
567947	SILL 6253	642811	BC 323	642914	BC 426	643432	BC 1001	645632	SP 342
567948	SILL 6254	642812	BC 324	642915	BC 427	643433	BC 1002	645633	SP 343
567949	SILL 6255	642813	BC 325	642916	BC 428	643434	BC 1003	645634	SP 344
567951	SILL 6345	642814	BC 326	642917	BC 429	643435	BC 1004	645635	SP 345
567952	SILL 6346	642819	BC 331	642918	BC 430	643436	BC 1005	645636	SP 346
567953	SILL 6347	642820	BC 332	642919	BC 431	643437	BC 1006	645637	SP 347
567954	SILL 6348	642821	BC 333	642924	BC 436	643438	BC 1007	645638	SP 348
567955	SILL 6349	642822	BC 334	642925	BC 437	643439	BC 1008	645639	SP 349
567956	SILL 6350	642823	BC 335	642926	BC 438	643440	BC 1009	645640	SP 350

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645641	SP 351
645642	SP 352
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645644	SP 354
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645650	SP 360
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645658	SP 368
645659	SP 369
645660	SP 370
645661	SP 371
645662	SP 372
649923	BC 1171
649924	BC 1172
649925	BC 1173
649926	BC 1174
649927	BC 1175
649928	BC 1176
649929	BC 1177
649930	BC 1178
649931	BC1179
649932	BC1180
649939	BC1187
649940	BC1188
649948	BC1196
649949	BC1197

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 and equipment, closure of monitoring wells, and removal of piezometers. The State of Alaska holds a \$2 million reclamation security associated with removal and reclamation of these liabilities.

4.5 PERMITS

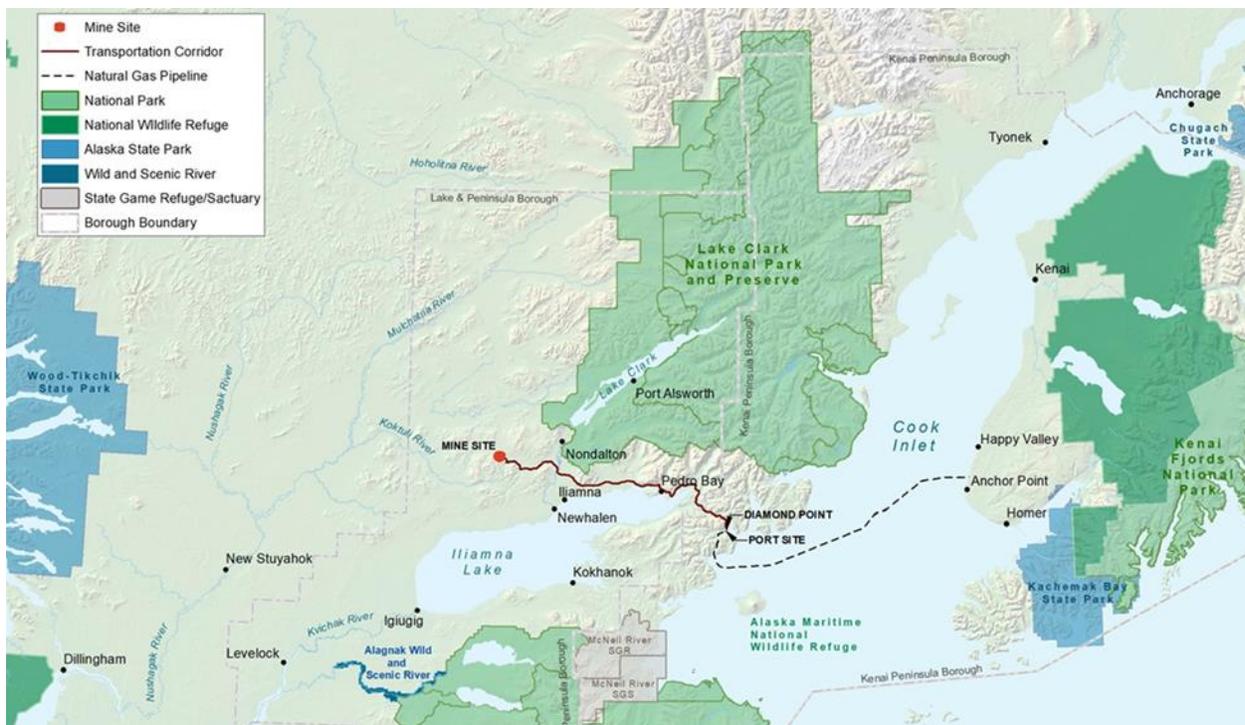
Permits necessary for exploration drilling and other field programs associated with pre-development assessment of the Pebble Project are obtained as required each year.

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

5.1 ACCESS

The Pebble property is located in southwest Alaska see Figure 5.1-1. The map shows a proposed infrastructure corridor for the project, as further described as the LEDPA in the Final EIS and in Section 16.5 of this report.

Figure 5.1-1 Property Location and Access 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 11.4 °F in January to 50.8 °F in July (at the Pebble 1 meteorological station). The mean annual precipitation in the deposit area is estimated to be 54.6 inches (at the Pebble 1 meteorological station). 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 for 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 have been 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 OVERVIEW

Cominco Alaska, a division of Cominco Ltd., now Teck Resources Limited (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 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, which was recognized as a precious-metal, epithermal-vein occurrence, and from outcrops over and surrounding what later became the Pebble area, but which at that time was of 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 (soil sampling, geological mapping, two diamond drill holes at the Pebble target) 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 Teck intersected significant intervals of porphyry-style gold, copper and molybdenum mineralization, validating this interpretation.

Table 6.1-1 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

Table 6.1-2 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

Exploration was accelerated when it became apparent that a significant copper-gold porphyry deposit had been discovered at Pebble. 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 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, Teck completed an IP survey, geochemical sampling, geological mapping and 20 diamond drillholes within and near the Pebble deposit).

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

Table 6.1-3 Total 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

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. Teck also completed 39 drill holes on the Sill prospect for a total of 10,445.5 ft in 1988 and 1989.

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 Surrey, BC, for long-term storage.

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.

6.2.2 Sample Analysis

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, 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 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.

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 (CERL) 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.

Teck analyzed a total of 6,987 core samples from 164 drill holes, including 676 samples analyzed from 39 drill holes on the Sill prospect.

6.3 HISTORICAL RESOURCE ESTIMATES

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 Table 6.3-1.

Table 6.3-1 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. Over the next 6 years, Anglo American spent US\$573 million on exploration, resource estimation, environmental data collection and technical studies, with a significant portion spent on engineering of possible mine development models, as well as related infrastructure, power and transportation systems prior to withdrawing from the 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 contemplated that an affiliate of First Quantum would subsequently execute an option agreement with Northern Dynasty (the "Option Agreement") with an option payment of US\$150 million staged over four years. This option would entitle First Quantum to acquire the right to earn a 50% interest in the Pebble Partnership for US\$1.35 billion. First Quantum made an early option payment of US\$37.5 million to Northern Dynasty, applied solely for the purposes of progressing the permitting of the Pebble Project but withdrew from the project in 2018.

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, and subsequently both the Purchased Claims and the Settlement Claims were transferred to an Northern Dynasty subsidiary and ultimately to Pebble West Claims Corporation, a subsidiary of the Pebble Partnership.

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, a subsidiary of the Pebble Partnership, which now holds title to these claims.

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) and its contained references.

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 an important syn-hydrothermal transpressional fault occurs in the eastern part of the deposit.

Since the early Late Cretaceous, deformation in southwest Alaska has occurred mostly on major dextral strike-slip faults that 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. Subparallel faults with less substantial displacement are located south of the Denali fault, and the Pebble district is located between what are probably terminal strands of the dextral 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 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; Olson et al., 2017, 2020). 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±Ag mineralization in the region 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) 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 (Figure 7.2-1) formed at the Whistler deposit (Hames and Roberts, 2020), located about 93.2 miles northeast of Pebble, at Kijik River (Kreiner et al., 2020), the Bonanza Hills (Anderson et al., 2013) and Shotgun (Rombach and Newberry, 2001). Late Cretaceous to intrusions are common in the Kahiltna terrane and widespread, voluminous Eocene 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

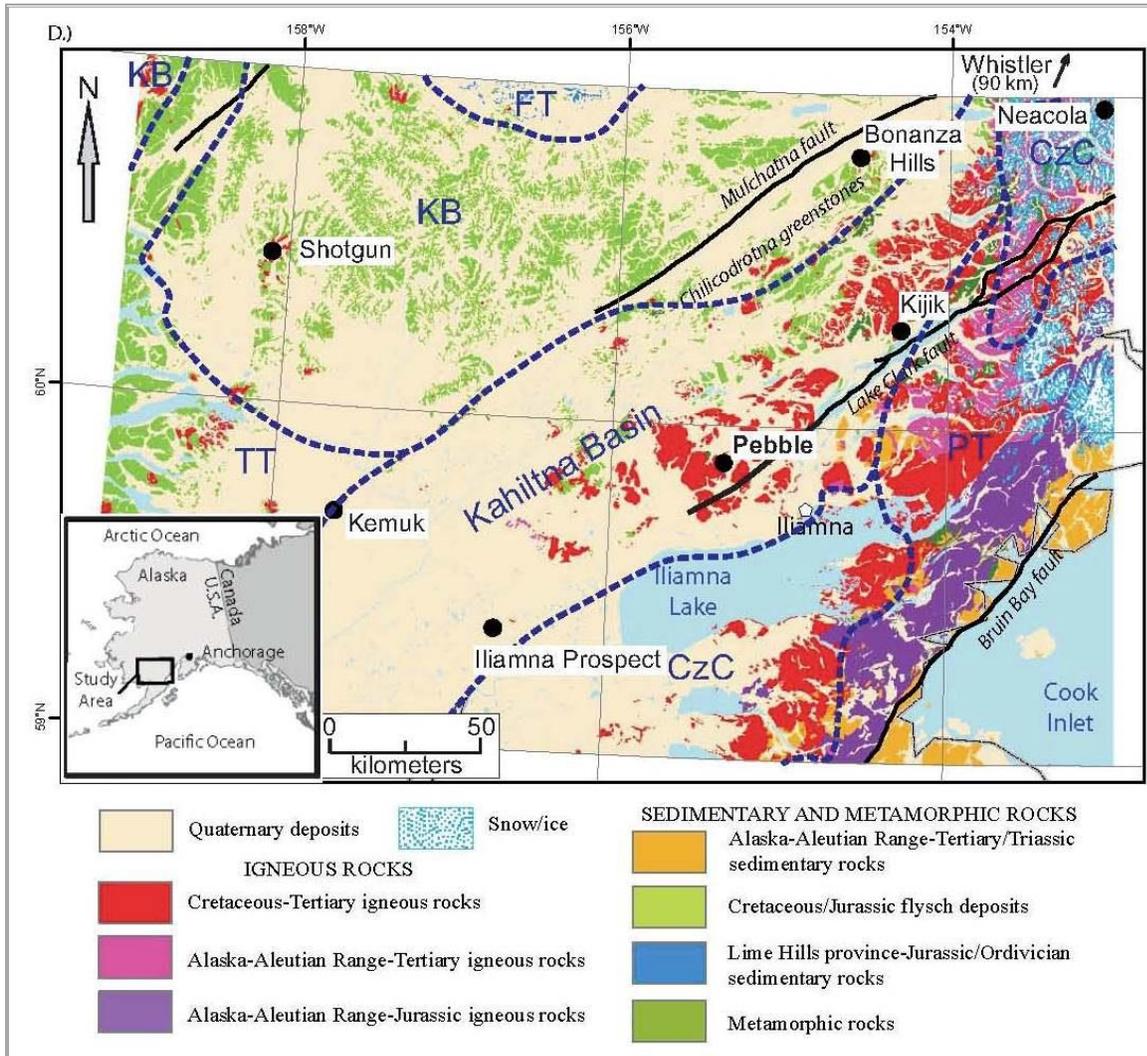
The oldest rock type in the Pebble district is the Kahiltna flysch, which comprises basal turbidites, interbedded basalt flows and lesser breccias, and minor gabbroid intrusions. The Kahiltna flysch forms a northeast-trending belt about 250 miles long, which has experienced multiple stages of igneous 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 7.2-1). 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 right-way-up.

The flysch locally contains thick layers of basalt flows, lesser breccias and minor mafic volcanoclastic 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 (Figure 7.2-2A) at approximately 96 Ma. 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, that ranges from biotite pyroxenite, monzodiorite, monzonite to syenomonzonite, monzonite and monzodiorite, and associated breccias extends occur in the southwest quadrant of the Pebble deposit and extend several miles to the south (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; Olson, 2015). Early intrusions are medium-grained, biotite monzonite porphyries (Figure 7.2-2D) that commonly contain scattered potassium feldspar megacrysts up to a few 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 laterally into breccias.

Breccias in the alkalic complex are complicated. Subordinate intrusion breccias have angular to subangular fragments in a cement of a relatively younger porphyritic biotite monzodiorite intrusion. Fragments of diorite sills, early alkalic biotite monzonite porphyry intrusions and flysch are most common xenoliths. In the common breccias, the matrices dominantly consist 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 and breccias within the deposit, the complex is modeled as a single unit, loosely interpreted as a megabreccia.

7.2.4 Hornblende Granodiorite 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 at least 6,400 ft thick within the East Graben. The sequence occurs mostly on, and thickens toward, the east side of the district, and is widespread to the southwest, south and north of Pebble. Sedimentary rock types are facing right-way-up but have been tilted about 20° east in the deposit area, 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. Lang et al., (2013) report that basalts in the East Graben are cut by 65 Ma hornblende monzonite porphyry intrusions, and Olson et al. (2017) assign sedimentary and volcanic rocks that overlie the eastern part of the deposit to the late Paleocene to Eocene Talarik Formation, which may correlate with the widespread Copper Lake Formation of Detterman and Reed (1980).

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 approximately 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 approximately 46 to 48 Ma (Bouley et al., 1995; Lang et al., 2013). These rocks are mostly exposed on Kaktuli Mountain east of the deposit and in the East Graben; reconnaissance drill intersections suggest they are also common in the southeast part of the district beneath 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 the valley floors and the flanks of the higher 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 approximately 11 Ka (Detterman and Reed, 1973; Hamilton and Klieforth, 2010).

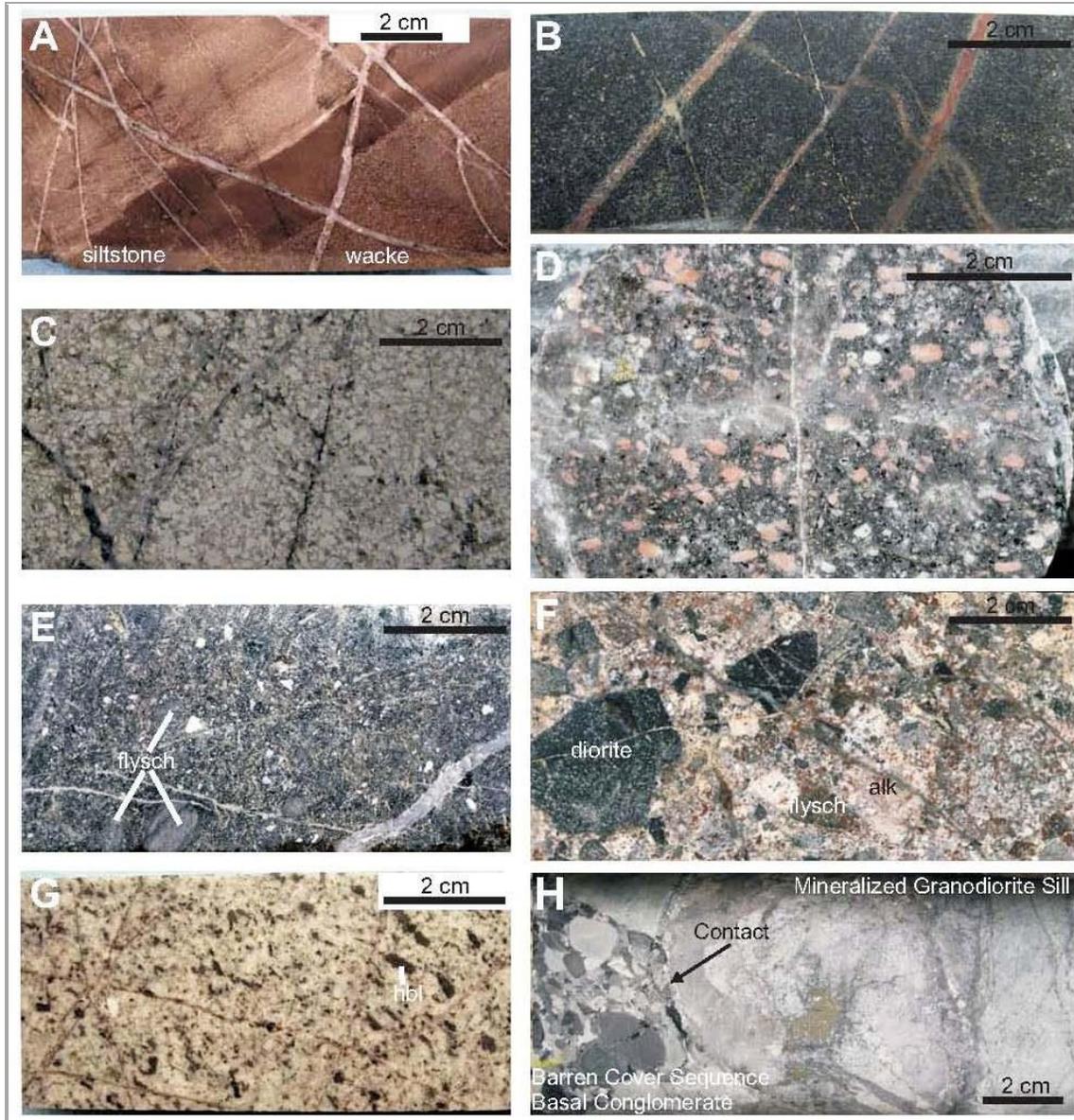
7.2.9 District Structure

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. A metallogenically-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 and displace 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 is believed to be a negative flower structure that 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 poly lithic 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. Greater detail on the geology of the Pebble deposit is available in Lang et al. (2013), Olson (2015), and Olson et al. (2017, 2020).

7.3.1 Rock Types

The deposit is hosted by Kahiltna flysch, diorite and granodiorite sills, alkalic intrusions and breccias, granodiorite stocks, and granodiorite to granite dykes 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 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 Kaskanak suite intrusions. Olson (2015) describes the sequence and composition of the intrusions within the Pebble deposit as: 1) earliest, voluminous equigranular granodiorite equivalent to the Kaskanak batholith; 2) transitionally porphyritic granodiorite stocks; 3) early-mineral granodiorite porphyry; 4) inter-mineral quartz granite porphyry; and 5) minor late-mineral high-silica quartz granite porphyry. Due to scale, the Kaskanak intrusions are simplified on Figure 7.3-1 and are shown as 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 normal fault. Contacts of stocks in the Pebble West zone dip steeply to moderately outward. Drill intersections of equigranular granodiorite at depths more than ~3,300 feet below the deposit support the hypothesis that the observed porphyry dikes and stocks in the upper part of the deposit emanate and were derived from a deeper reservoir of granodiorite at depth that is part of the main mass of the Kaskanak batholith.

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 and/or dykes.

The East Graben is filled by basalt flows and lesser sedimentary rocks that have an uncertain relationship to the cover sequence. The graben fill ranges from approximately 4,265 ft thick north of the ZE fault to a thickness of up to at least 6,400 ft to the south. Basalts in the lower half of the graben are cut by two ~65 Ma monzonite porphyry intrusions, which makes them older than the rocks that cover the Pebble East zone. The age of the upper part of the graben fill is unknown but similarities of the sedimentary layers to some rock types in the cover sequence suggests that they may be coeval.

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.

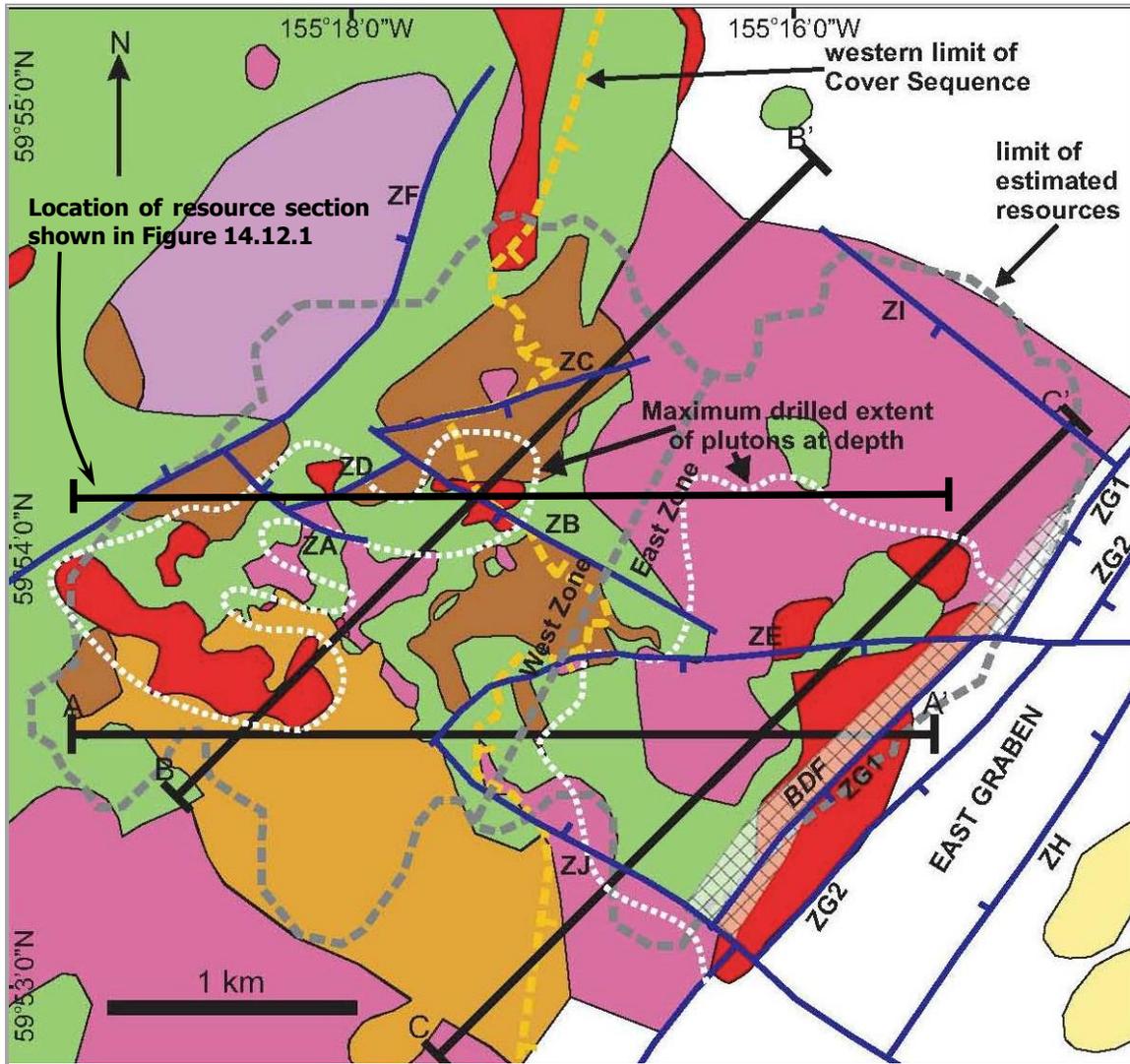
7.3.2 Structure

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). The folding predates intrusive activity at Pebble and diorite sills are commonly thicker where they exploited 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 affect the cover sequence. Displacement was 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 on the BDF.

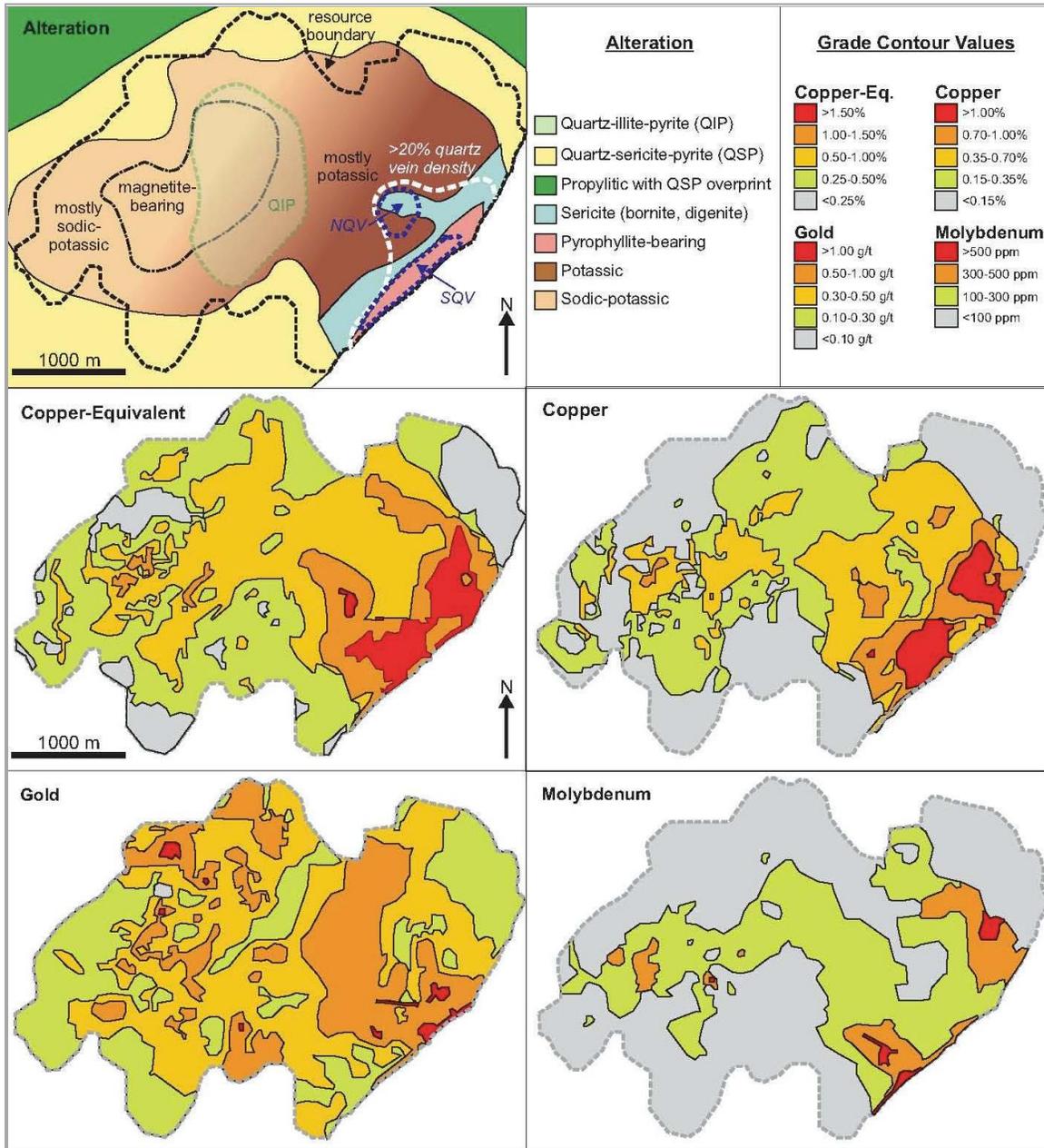
Brittle faults within the Pebble deposit conform to the district-scale patterns described above (Figure 7.3-1). The ZB, ZC and ZD faults occur in the Pebble West zone and exhibit normal offset of diorite and granodiorite sills of between 50 ft and 300 ft. Normal displacement on the ZJ and ZI faults is 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. Scissors-style, south-side-down normal 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 but remain undelineated. 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 were active at least from that time and likely continued at least until the Eocene (Olson, 2015).

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 7.3-2. White areas are either undrilled or rock types below cover sequence unknown. See Figure 7.2-1 for geology legend.

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



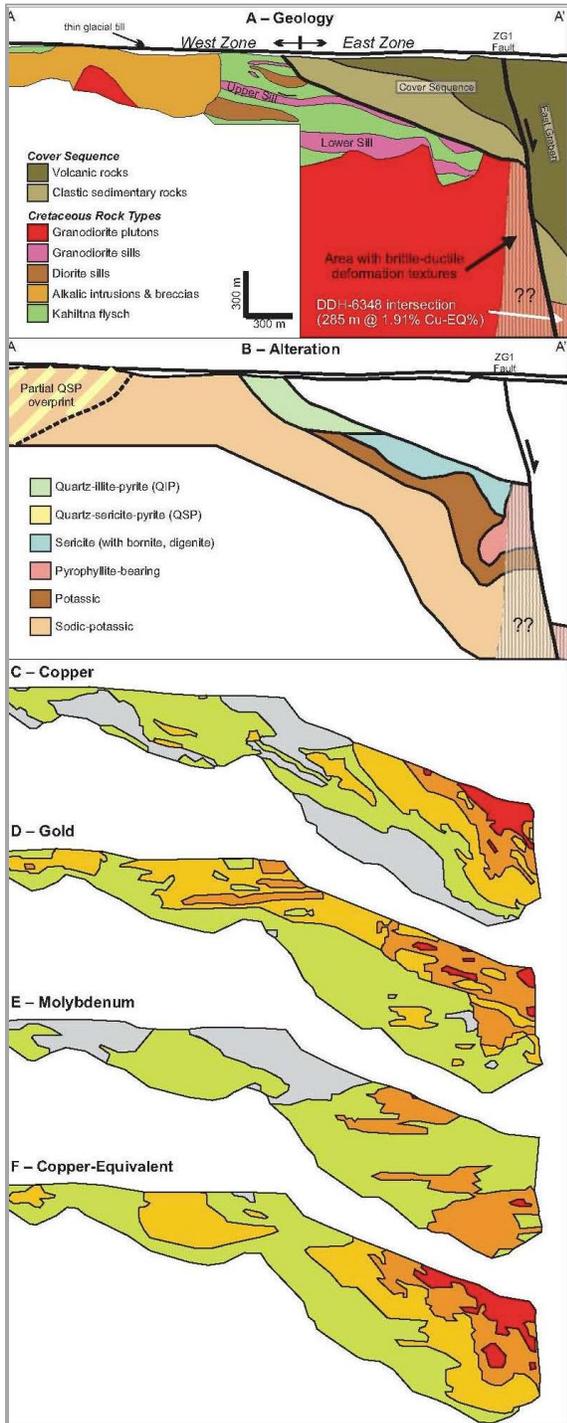
Note: Grades are shown as they appear in a previously completed resource block model (Gaunt et al., 2010), at the contact between the deposit and the overlying cover sequence, which has been removed. These grades are not derived from the current resource estimate.

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.

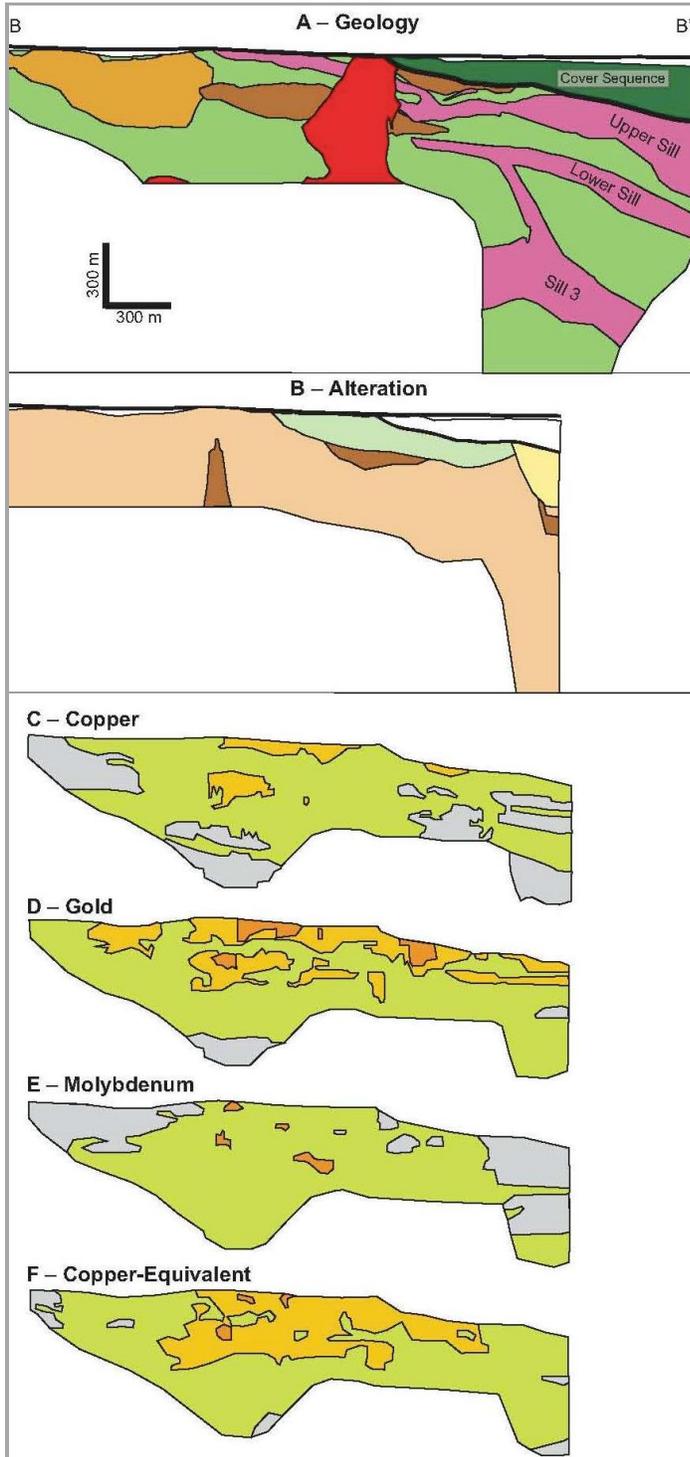
NQV and SQV are the northern and southern quartz vein domains (>50% quartz veins).

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



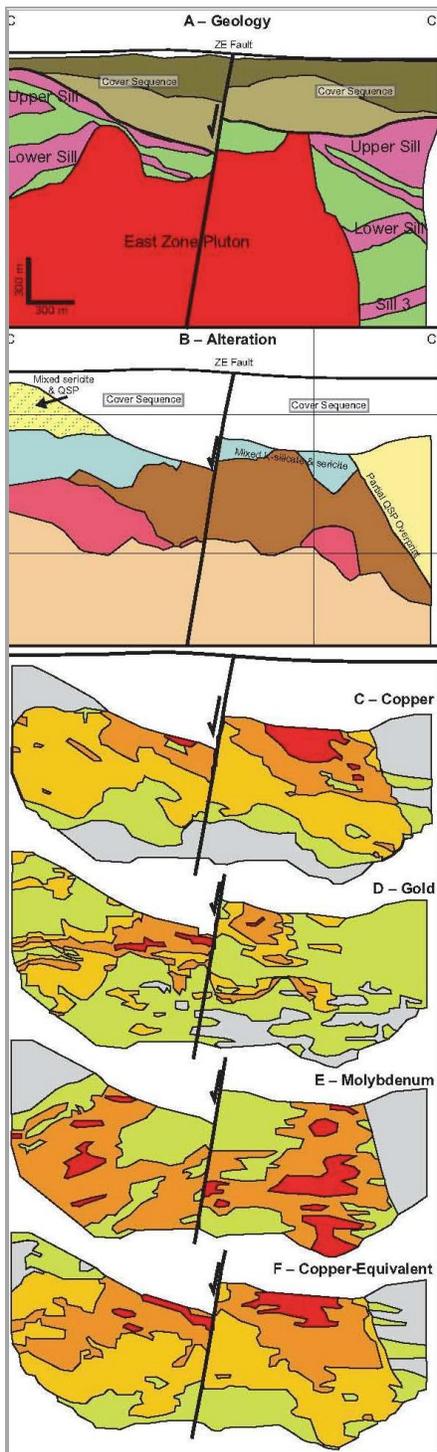
Note: Location of section is shown in Figure 7.3-1, and grade legends in Figure 7.3-2.

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 7.3-4, 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 and dykes. 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, a concept supported by magnetic data (Shah et al., 2009; Anderson et al., 2013). Hornfels-altered flysch is massive but highly susceptible to brittle fracture, although the narrow alteration envelopes around veins indicate that permeability between fractures 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 (also sometimes called K- or potassium-silicate alteration), sodic-potassic, illite±kaolinite, pyrophyllite and sericite advanced argillic, quartz-illite-pyrite, propylitic, and quartz-sericite-pyrite associations, 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-silver-rhenium 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; Gregory, 2017). 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 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 original Fe-Mg concentration of host rocks and, thus, is highest in flysch and diorite sills.

Intrusive rocks in the Pebble West zone are affected by early sodic-potassic alteration which comprises albite, biotite, potassium feldspar 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 both generally decrease in concentration with depth. Sodic-potassic alteration of sedimentary rocks is mineralogically similar to that in the intrusions and is typically pervasive.

In the Pebble East zone, sodic-potassic alteration occurs below potassic alteration and is distinguished from similar alteration in the Pebble West zone by the presence of epidote and calcite and by lower metal grades. 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 in this alteration and decreases with depth, and commonly comprises 2% pyrite and trace to minor chalcopyrite and molybdenite. This alteration is difficult to distinguish from peripheral propylitic alteration and its potential equivalence to well-mineralized sodic-potassic alteration in the Pebble West zone remains unclear.

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. The apparent relative timing is likely 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.

7.4.2.2. 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 common porphyry vein nomenclature, are not exact equivalents similarly named to vein types described from other deposits (e.g., Gustafson and Hunt, 1975; Clark, 1993; Gustafson and Quiroga, 1995). For clarity in the sections that follow, the term selvage is used to denote minerals lining the interior walls of a dilatant vein, whereas envelope refers to alteration in the host rock to a vein.

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 excluding 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, in most cases patterns extend smoothly across lithological contacts. Measurements in oriented drill core do not reveal any significant or consistent preferred vein orientations.

On the east side of the Pebble East zone there are two domains characterized by 50 to 90% quartz veins. These two zones are surrounded by and gradational with a larger zone that contains greater than 20% quartz veins of either the A₁ or B₁ vein subtypes (see below). These zones of high vein density probably reflect repeated refracturing and dilation that accommodated repeated vein precipitation events. The first domain 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 north-northeast-trending, nearly vertical, tabular zone that lies within the zone 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 during syn-hydrothermal deformation along the 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. The A₁ subtype is the most common 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.

The 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, 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 contain 2 to 5% of both pyrite and chalcopyrite with minor molybdenite and local bornite. Potassium feldspar (\pm biotite) alteration envelopes are ubiquitous, highly variable in width and contain disseminated chalcopyrite, pyrite and molybdenite.

B₂ veins occur below 2,600 ft depth 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 hydrothermal biotite and by minor calcite and epidote. The veins typically contain less than 2% pyrite, and minor chalcopyrite, and molybdenite.

B₃ veins are most common in the north-central and south-central part of the Pebble East zone, and below 5,600 ft depth 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, 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 inches 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 western half of the deposit. The 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.

7.4.2.3. 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 previously 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, but is likely a local reconstitution of older sulphides. Fracture or fault control is rarely apparent. Kaolinite accompanies illite in alteration of previously sodic-potassic altered areas where it replaces albite.

7.4.2.4. 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 occurs within and adjacent to the BDF. This alteration comprises a pyrophyllite-quartz-sericite-chalcopyrite-pyrite zone within the BDF that is bounded to the west 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 deep intersections in hole 6348 demonstrate that this alteration and its associated high grade mineralization continues eastward into the graben. Both the sericite and the pyrophyllite alteration types replace potassic and sodic alteration. The sericite alteration is locally replaced by younger quartz-sericite-pyrite alteration.

Pyrophyllite alteration is accompanied by quartz, sericite, pyrite and chalcopryrite. 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; quartz-sulphide veins within this zone are commonly deformed. Veins associated with pyrophyllite alteration are irregular, narrow, contain pyrite ± chalcopryrite in massive to semi-massive concentrations, contain variable quartz, and lack visible 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, tennantite-tetrahedrite, and locally trace enargite. These minerals commonly replace the rims of chalcopryrite 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.

7.4.2.5. 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 also 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 chalcopryrite. Sulphide concentration is less than 3% and is mostly pyrite.

Type H veins occur locally and at low vein density throughout propylitic alteration. They contain calcite, hematized magnetite, quartz, albite, epidote, pyrite and trace to minor chalcopryrite. H veins are planar, less than 0.4 in 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 alteration. Rarely, E veins cut sodic-potassic alteration in the Pebble West zone. The E veins are planar, can be up to two feet in width, have sharp contacts with host rocks and locally have weak sericite alteration envelopes. These veins contain various combinations of quartz, calcite, pyrite (locally arsenian), sericite, sphalerite, galena, minor chalcopryrite and trace arsenopyrite, tennantite-tetrahedrite, freibergite, argentite and native gold.

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

The QSP alteration occurs closer to the centre of the deposit than does the propylitic alteration, but where these two alteration types overlap the QSP alteration is younger. QSP alteration, which is equivalent to classic phyllic alteration, is commonly texture-destructive and forms a halo around the deposit with inner and outer alteration fronts that dip steeply away from the core of the deposit. 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 from potassic or advanced argillic alteration 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 outward 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 to moderate, grade-destructive QSP alteration, located at the transition between sodic-potassic and potassic alteration, that was later overprinted by low-temperature illite alteration as the hydrothermal system waned. QIP alteration is texturally and mineralogically similar to QSP alteration, except that illite is the main phyllosilicate phase rather than sericite (Harraden et al., 2012). The pyrite concentration in QIP alteration is typically 5 to 10%, which occurs mostly in type D veins and their alteration envelopes. Domains between the QIP alteration envelopes preserve relict sodic-potassic alteration that host most of the copper mineralization that remains in this zone.

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 underlying Cretaceous rocks. Young, brittle faults that cut the deposit, in particular the ZG₁ fault, host or are closely 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. An extremely small proportion of mineralization in the deposit is affected 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 overprint beneath a thin leached cap. Mineralization in the Pebble East zone is entirely hypogene with no preservation of leaching or paleo-supergene below the unconformity with 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 but is highly variable, and weak oxidation along fractures locally extends to depths of up to 500 ft along or near brittle faults. Hypogene pyrite is commonly preserved in the leached zone, 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. Similar to the overlying leached cap, the thickness of supergene mineralization is highly variable. It locally extends to a depth of 560 ft in strongly fractured zones, but on average is closer to 200 ft in average thickness and tapers toward the margins of the resource. In the supergene zone, pyrite is typically rimmed by chalcocite, covellite and minor bornite, and complete replacement of pyrite is rare (Gregory and Lang, 2009; Gregory et

al., 2012). The transition to hypogene mineralization with depth is gradational over vertical intervals of up to approximately 100 feet. Supergene processes increased copper grade up to approximately 50% across narrow intervals but the upgrading is typically much less.

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 preserved deposit has a flat 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 terminates over short distances due to the overprint by intense, grade-destructive 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 normal/oblique ZF fault, but drilling has been too shallow to determine if the deposit continues to the west at depth. On the east side, the deposit was down-dropped by the ZG1 fault and continuation of high-grade mineralization into the East Graben has been confirmed by drilling. Molybdenum exhibits a more diffuse pattern, is open at depth and, in some areas, domains with strongly elevated grade corresponds with higher densities of molybdenite-rich type B3 veins.

Mineralization was primarily introduced during early potassic and sodic-potassic alteration. Copper is hosted primarily by chalcopyrite (Figure 7.5-1) that is locally accompanied by minor bornite (Figure 7.3-2) 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 as intergrowths 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 newly formed 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 the sericite subtype of advanced argillic alteration.

The late QSP alteration is invariably destructive of both copper and molybdenum mineralization. Gold concentrations, however, remain consistent at 0.15 to 0.5 g/t, and locally exceed 1 g/t (Lang et al., 2008). The QIP alteration has a similar effect on copper, molybdenum and gold but is not completely pervasive, such that copper and molybdenum grades are reduced and some of the gold now occurs as high-fineness inclusions in pyrite formed by breakdown of older sulphides (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 highly reactive, 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.

Rhenium

The Pebble deposit is remarkable for its very large endowment in rhenium, for which a resource is estimated in Section 14 of this report that compares favourably with the largest known global resources of rhenium (Sinclair et al., 2009). Rhenium is one of the lesser known metals and is one of the rarest elements on earth, with a crustal abundance of less than one part per billion (John et al., 2017). The United States, under Executive Order 13817, has caused rhenium to be placed on its list of critical minerals, stating that it “is essential to the economic and national security of the United States that has a supply chain vulnerable to disruption.” (US Department of the Interior news release, May 18, 2018). Rhenium typically does not form discrete minerals in nature, but because of its valence and atomic radius instead almost exclusively substitutes for molybdenum in the lattice of molybdenite (e.g., McCandless et al., 1993; Barton et al., 2019). Globally most rhenium is recovered from flue dust created during the roasting of molybdenite concentrates, most of which come from porphyry style deposits like Pebble (John et al., 2017). Elevated concentrations of rhenium occur throughout the Pebble deposit and, as expected, the concentrations of rhenium and molybdenum are very closely correlated. Molybdenite concentrates produced during metallurgical testwork on the Pebble deposit, as described in Section 13 of this report, contain up to 960 ppm rhenium, which places Pebble in the upper echelon of porphyry deposits (e.g., McCandless et al., 1993; Barton et al., 2019). Detailed rhenium deportment studies have not yet been completed to determine if the concentration of rhenium in molybdenite varies spatially across the Pebble deposit or in paragenetically distinct stages of molybdenite precipitation, e.g., molybdenite in late B₃ veins compared to molybdenite in earlier potassic or sodic-potassic alteration. Visual inspection of the 3D distribution of molybdenum to rhenium ratios in assay results across the Pebble deposit, however, suggests a general consistency with limited variation.

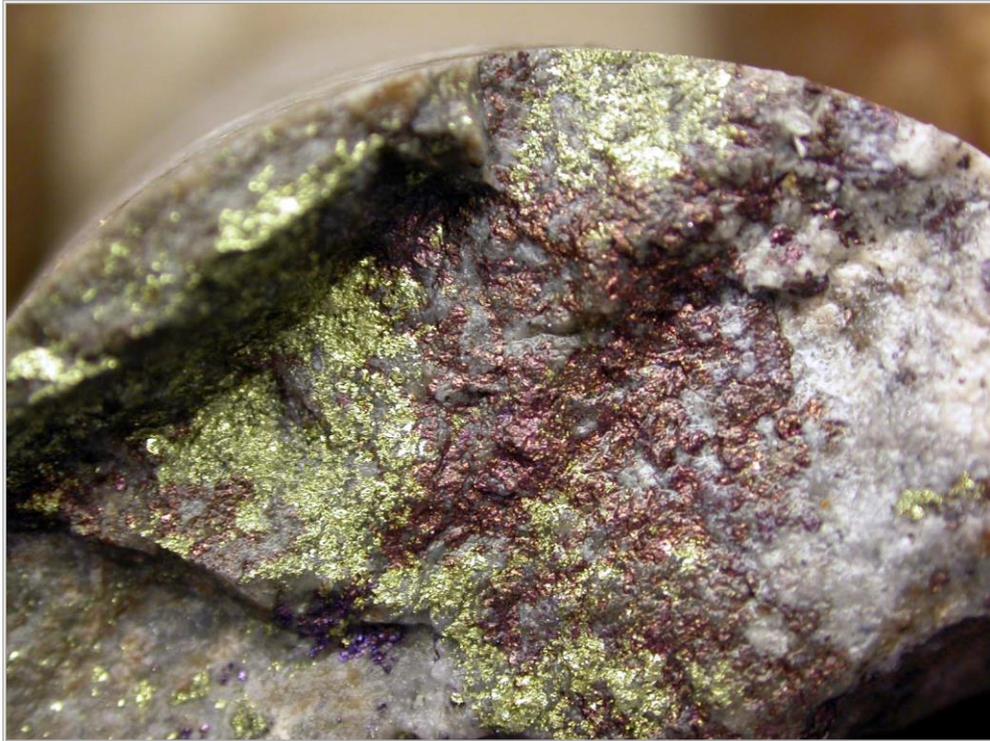
The Pebble deposit also contains elevated concentrations of the platinum group metal palladium, which is also considered a critical mineral by the Department of the Interior. This places Pebble among a very small minority of porphyry deposits known to contain significant palladium concentrations (e.g., McFall et al., 2018; Hanley et al., 2020). The highest concentrations of palladium at Pebble occur in or proximal to areas affected by advanced argillic alteration, but elevated palladium occurs in many parts of the deposit including within

the proposed open pit. The deportment of palladium remains essentially unstudied at Pebble. A single sample of pyrite from the pyrophyllite alteration zone was analyzed by in-situ laser ablation ICP-MS and found to contain elevated palladium in undetermined form (Gregory et al. (2013)). The deportment of palladium in porphyry deposits can be complex (e.g., Hanley et al., 2020) and a more detailed study of palladium deportment at Pebble is warranted to determine the degree to which this metal can be recovered to a chalcopyrite and/or pyrite concentrate.

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

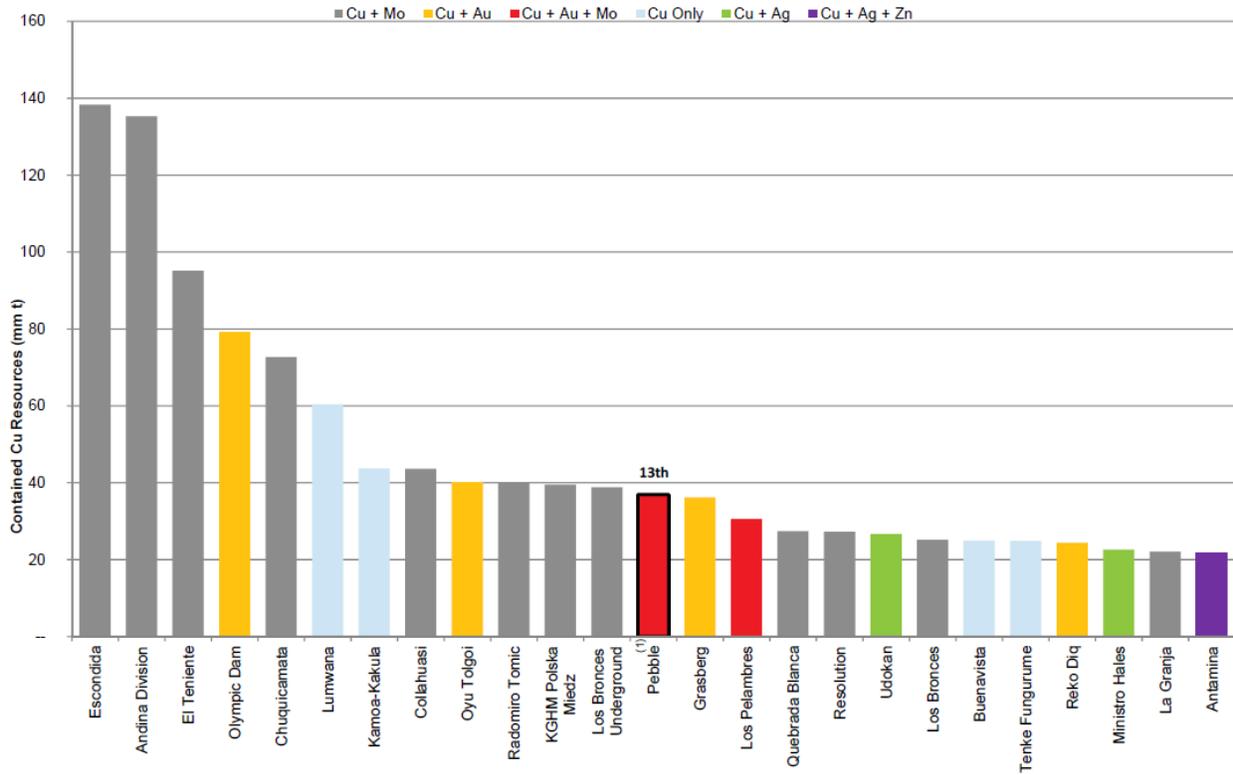
The Pebble deposit is classified as a copper-gold-molybdenum porphyry deposit. The principal features of porphyry copper deposits, as summarized recently by John et al. (2010), include:

- 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.

The Pebble deposit has many characteristics typical of porphyry deposits as a group, but it is unusual in terms of its sheer size and the variety and scale of its contained metal. 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 copper and precious metal deposits shows that it ranks at or near the top in terms of both contained copper (Figure 8.1-1) and contained precious metals (gold and silver; Figure 8.1-2). Pebble is both the largest known undeveloped copper resource and the largest known undeveloped gold resource in the world today. Pebble also has a very large endowment in both molybdenum and, as cited previously, in rhenium. The presence of palladium further highlights its unusual character. The bases for these estimations of metal endowment in the Pebble deposit are fully described in Section 14.0 of this report.

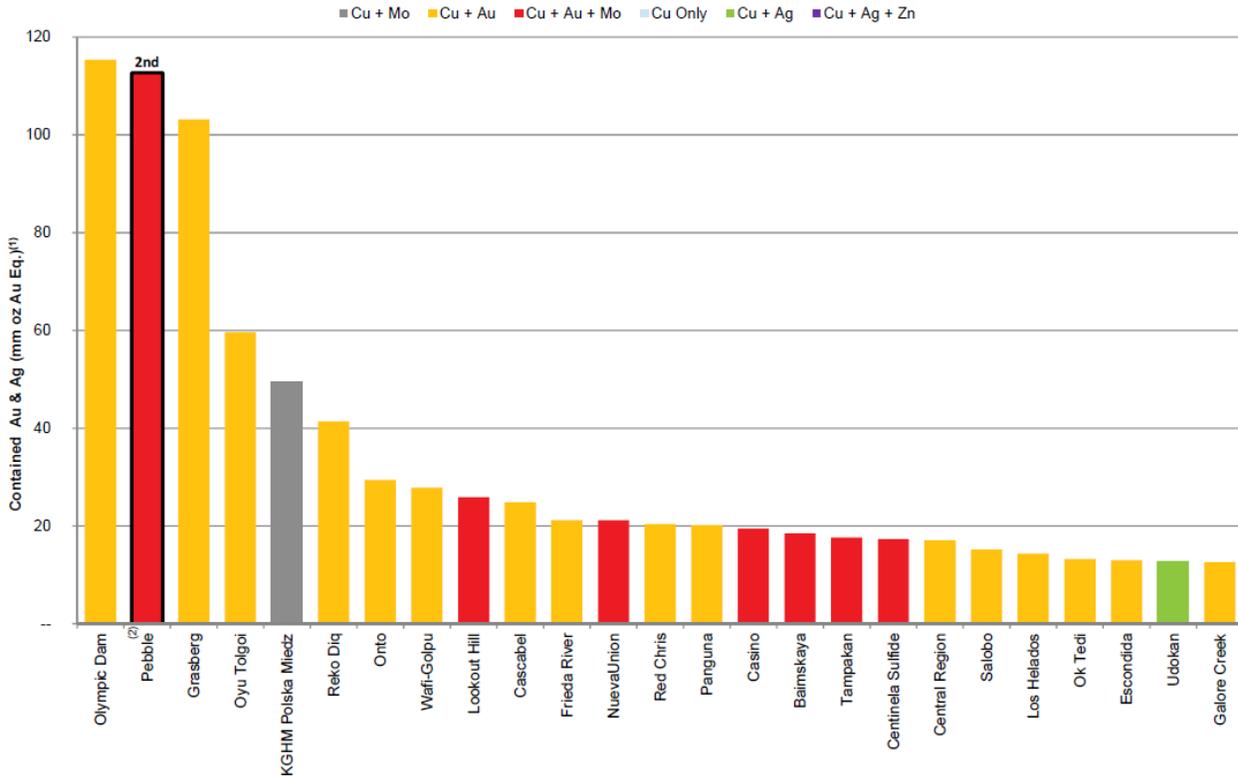
Figure 8.1-1 Pebble Deposit Rank by Contained Copper



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 Precious Metals



Source: Company filings, S&P Global Market Intelligence, street research; BMO Capital Markets

Note: Includes inferred resource.

1. Converted to Au Eq. at street consensus Au price of US\$1,500/oz and Ag price of US\$18.00/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 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 2,344 line-km (1,456.5 line-mi) were flown at 200 m (656 ft) line spacing, covering an area of 425 square km (164.5 square miles). The survey lines were flown at a mean terrain clearance of 60 m (196.8 ft) along flight lines oriented 135° at a line spacing of 200 m (656 ft), with tie lines oriented 045° at a spacing of 2 km (1.24 miles). Immediately over the Pebble deposit, an area of 23 square km (14.4 square miles) was surveyed at a 100 m (328 ft line) spacing for a total of 342 line-km (212.5 line-mi km), 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 was 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 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

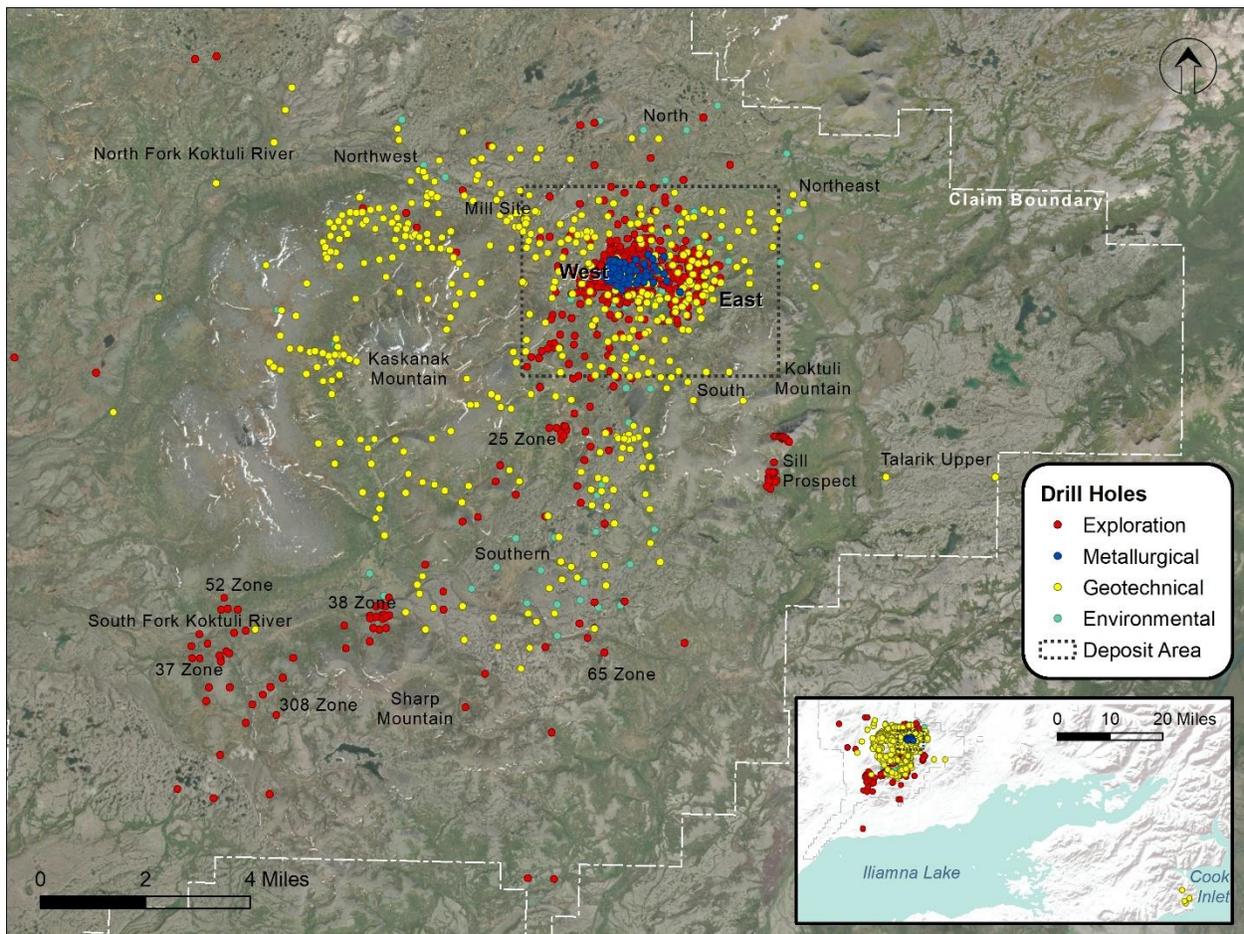
analyses of glacial till; and (4) orientation surveys which utilized a variety of weak extraction geochemical techniques. The results of these surveys were largely consistent with the results obtained by earlier soil sampling programs.

10.0 DRILLING

10.1 LOCATION OF ALL DRILL HOLES

Extensive drilling totaling 1,048,509.8 ft has been completed in 1,389 holes on the Pebble Project. These drill campaigns took place during 19 of the 26 years between 1988 and 2013, and in 2018 and 2019. The spatial distribution and type of holes drilled is illustrated in Figure 10.1-1. A detail of the drilling in the “Deposit Area” is shown in Figure 10.2-1.

Figure 10.1-1 Location of all Drill Holes



Drilling completed by 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). All holes were resurveyed in 2008 and 2009, with the exception of the Sill holes. A digital terrain model for the site was generated by photogrammetric methods in 2004. All post- 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 Table 10.2-1. 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). Detailed information on the 2010 through 2013 drill programs may be found in technical reports by Gaunt et al. (2014 and 2018).

Most of the footage on the Pebble Project was drilled using diamond core drills. Only 18,716 ft was percussion-drilled from 229 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.

From early 2004 through 2013, all Pebble drill core was geotechnically logged on a drill run basis. Almost 70,000 measurements were made for a variety of geotechnical parameters on 737,000 ft of core drilling. Recovery is generally very good and averages 98.2% overall; two-thirds of all measured intervals have 100% core recovery. Detailed (domain-based) geotechnical logging and downhole surveys were also conducted between 2007 and 2012. Proper domain selection is the basis for rock mass classification and domain-based data is used extensively in open pit and underground mine design. In order to maximize the information from the 2007-2012 drill programs, several tools and techniques were added to a number of holes including: triple tube drilling, core orientation, acoustic televiewer probe and comprehensive point load testing complemented by laboratory UCS testing. Additionally, all Pebble drill core from the 2002 through 2013, 2018 and 2019 drill programs was photographed in a digital format.

Figure 10.2-1 Location of Drill Holes – Pebble Deposit Area

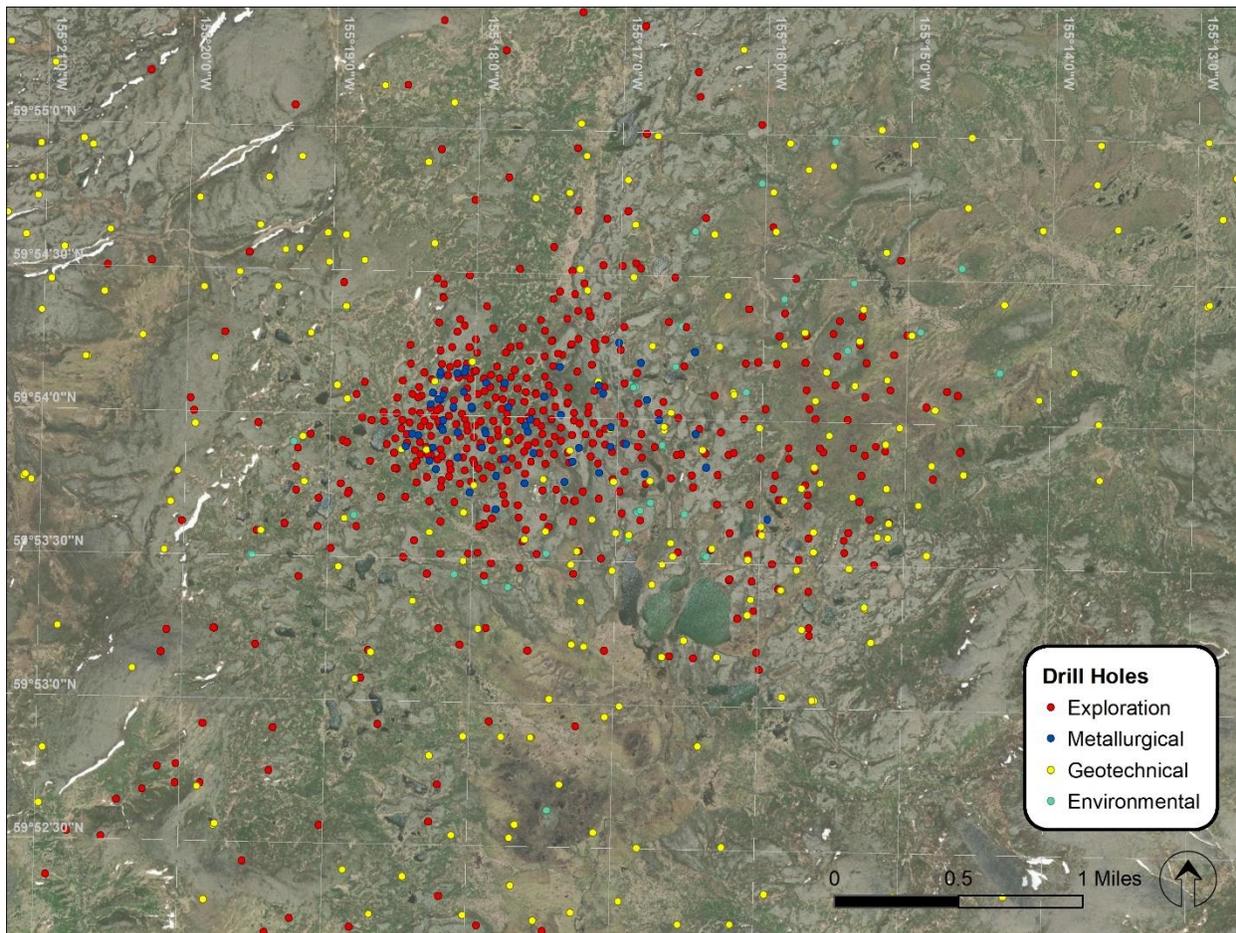


Table 10.2-1 Summary of Drilling to December 2019

	No. of Holes	Feet	Metres
By Operator			
Teck ¹	164	75,741.0	23,086
Northern Dynasty	578	495,069.5	150,897
Pebble Partnership ²	640	472,249.3	143,942
FMMUSA	7	5,450.0	1,661
Total	1,389	1,048,509.8	319,586
By Type			
Core ^{1,5}	1,160	1,027,671.9	313,234
Percussion ⁶	229	20,838.0	6,351
Total	1,389	1,048,509.8	319,586
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
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
2018	28	4,374.2	1,333
2019	6	1,917.4	584
Total	1,389	1,048,509.8	319,586
By Area			
East	149	450,047.3	137,174
West	447	349,128.7	106,414
Main ⁷	83	9,629.8	2,935
NW	215	49,951.1	15,225
North	84	30,927.0	9,427
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	19,621
SW	39	6,658.8	2,030
Sill	39	10,445.5	3,184
Cook Inlet	8	909.5	277

Total	1,389	1,048,509.8	319,586
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Notes to table:

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. Drill holes 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 drill holes; data acquired in 2010.
 6. Percussion holes were drilled for engineering and environmental purposes. 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 2019; the drilling completed after 2012 is outside the area of the resource estimate. Highlights of drilling completed by Northern Dynasty and the Pebble Partnership between 2001 and 2019 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 0 ft 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 184,726 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 holes totaling 3,133 ft were drilled in the Pebble West zone. Geotechnical drilling elsewhere on the property included 103 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.
- The Pebble Partnership drilled 4,374.2 feet in 28 core holes for geotechnical purposes in 2018 to test tailings and water storage facilities in areas remote from the Pebble deposit.
- The Pebble Partnership drilled 1,917.4 feet in six percussion holes adjacent to the Pebble deposit to enable hydrological testing in 2019.
- 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 Table 10.3-1 and Table 10.3-2 shows a summary of bulk density drill holes used in the current mineral resource estimate.

Table 10.3-1 Summary of All Bulk Density (g/cm³) 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

Table 10.3-2 Summary of Bulk Density (g/cm³) 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 81,188 samples taken from drill core 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 Tertiary³ 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 229 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 sampling methods and procedures are 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 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 and the 2018 analytical programs are stored in locked containers at Delta Junction, AK. Drill core assay pulps from the 1989 through 2013 and the 2018 programs are stored at a secure warehouse in Surrey, 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

³Tertiary 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 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.

11.1.14 Pebble Partnership 2018 Drilling

In 2018, 28 vertical geotechnical holes were drilled to test tailings and water storage facilities.

11.1.15 Pebble Partnership 2019 Drilling

Six reverse circulation (RC) percussion holes were drilled by T&J Enterprises for hydrogeological site investigation in 2019 in support of the ongoing EIS process. The work consisted of drilling vertically through overburden and bedrock, followed by the installation of pumping wells, monitoring wells, and grouted-in vibrating wire piezometers (VWPs). These holes were not sampled for assay.

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. In 2002, 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 Surrey, BC 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 pulps were shipped by commercial airfreight to the SGS laboratories in either Toronto, ON, or Rouyn, QC. The assay pulps were returned for storage at the Surrey 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 and 2018 Sample Preparation

For the 2004 through 2013 and 2018 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 and 2018. Assay pulps were returned for long-term storage at the Surrey warehouse. Crushed reject samples from the 2006 through 2013 and 2018 analytical programs are stored in locked containers at Delta Junction, AK.

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 for copper, molybdenum, silver and additional elements by multi-element analysis and for gold by fire assay.

Multi-element analysis for 34 elements, including copper, molybdenum and silver, was by AR digestion of an 0.5 g sample with an ICP-AES finish (ALS code ME-ICP41 shown in Table 11.3-1).

Table 11.3-1 ALS Aqua Regia Digestion Multi-Element Analytical Method ME-ICP₄₁

Element	Symbol	Units	Lower Limit	Upper Limit
Silver	Ag	ppm	0.2	100
Aluminum	Al	%	0.01	15
Arsenic	As	ppm	2	10,000
Boron	B	ppm	10	10,000
Barium	Ba	ppm	10	10,000
Beryllium	Be	ppm	0.5	100
Bismuth	Bi	ppm	2	10,000
Calcium	Ca	%	0.01	15
Cadmium	Cd	ppm	0.5	500
Cobalt	Co	ppm	1	10,000
Chromium	Cr	ppm	1	10,000
Copper	Cu	ppm	1	10,000
Iron	Fe	%	0.01	15
Gallium	Ga	ppm	10	10,000
Mercury	Hg	ppm	1	10,000
Potassium	K	%	0.01	10
Lanthanum	La	ppm	10	10,000

Element	Symbol	Units	Lower Limit	Upper Limit
Magnesium	Mg	%	0.01	15
Manganese	Mn	ppm	5	10,000
Molybdenum	Mo	ppm	1	10,000
Sodium	Na	%	0.01	10%
Nickel	Ni	ppm	1	10,000
Phosphorus	P	ppm	10	10,000
Lead	Pb	ppm	2	10,000
Sulfur	S	%	0.01	10
Antimony	Sb	ppm	2	10,000
Scandium	Sc	ppm	1	10,000
Strontium	Sr	ppm	1	10,000
Titanium	Ti	%	0.01	10
Thallium	Tl	ppm	10	10,000
Uranium	U	ppm	10	10,000
Vanadium	V	ppm	1	10,000
Tungsten	W	ppm	10	10,000
Zinc	Zn	ppm	2	10,000

A total of 1,715 samples from 26 drill holes exhibiting porphyry style copper-gold mineralization were assayed for copper by AR digestion with an AAS finish to the ppm level (ALS code Cu-AA46 shown in Table 11.3-2). Five copper assays greater than 10,000 ppm in hole 2037 were also assayed by this method. A further 271 samples from 5 drill holes were assayed for copper by four-acid (HNO₃-HClO₄-HF-HCl) digestion AAS (ALS code Cu-AA61 in Table 11.3-2) and 62 samples from drill hole 2034 were assayed for molybdenum by four-acid digestion with an AAS finish (ALS code Mo-AA61 shown in Table 11.3-2). Two samples with Pb and Zn concentrations >10,000 ppm by method ME-ICP₄₁ were reanalyzed by four-acid digestion AAS (ALS codes Pb-AA46 and Zn-AA46 respectively, these methods also shown in Table 11.3-2).

Table 11.3-2 ALS Additional Analytical Procedures

Element	Symbol	Method Code	Digestion	Instrument	Sample Mass (g)	Units	Lower Limit	Upper Limit
Copper	Cu	Cu-AA46	Aqua regia	AAS	0.4	%	0.01	50
Lead	Pb	Pb-AA46	Aqua regia	AAS	0.4	%	0.01	50
Zinc	Zn	Zn-AA46	Aqua regia	AAS	0.4	%	0.01	50
Copper	Cu	Cu-AA61	Four-acid	AAS	0.4	ppm	1	10000
Copper	Cu	Cu-AA62	Four-acid	AAS	0.4	%	0.01	50
Copper	Cu	Cu-OG62	Four-acid	ICP-AES	0.4	%	0.01	40

Gold concentrations were determined by 30 g FA fusion with lead as a collector and an AAS finish (ALS code Au-AA23 in Table 11.3-3). 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 (ALS code Au-GRAV21 in Table 11.3-3). Seven samples from hole 2013 were analyzed for gold, platinum and palladium by 30 g FA fusion with ICP finish (ALS code PGM-ICP23 in Table 11.3-3). In 2007, and additional 459 samples from 11 other 2002 holes were analyzed by this method.

Table 11.3-3 ALS Precious Metal Fire Assay Analytical Methods

Element	Symbol	Method Code	Instrument	Sample Mass (g)	Units	Lower Limit	Upper Limit
Gold	Au	Au-AA23	AAS	30	ppm	0.005	10
Gold	Au	Au-GRA21	Gravimetric	30	ppm	0.05	1000
Gold	Au	PGM-ICP23	ICP-AES	30	ppm	0.001	10
Platinum	Pt	PGM-ICP23	ICP-AES	30	ppm	0.005	10
Palladium	Pd	PGM-ICP23	ICP-AES	30	ppm	0.001	10

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 assayed for copper by a total digestion ICP-AES method and for gold by FA. An AR digestion multi-element geochemical package was used for 33 additional elements including copper, molybdenum and silver.

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 in percent on SGS method ICAY50 as detailed in Table 11.3-4.

Table 11.3-4 SGS Copper Analytical Method ICAY50

Element	Symbol	Digestion	Instrument	Sample Mass (g)	Units	Lower Limit	Upper Limit
Copper	Cu	Sodium Peroxide Fusion	ICP-AES	0.2	%	0.01	10

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 g/t. The SGS analytical methods for gold are listed in Table 11.3-5.

Table 11.3-5 SGS Gold Fire Assay Analytical Methods

Element	Symbol	Method Code	Instrument	Sample Mass (g)	Units	Lower Limit	Upper Limit
Gold	Au	FA305	AAS	30	ppb	5	2000
Gold	Au	FA30G	Gravimetric	30	g/t	0.03	1000

All samples were subject to multi-element analysis for 33 elements including copper, molybdenum and sulphur by AR digestion with an ICP-AES finish at SGS Toronto by SGS method ICP70. The elements reported, units and detection limits are listed in Table 11.3-6.

Table 11.3-6 SGS Aqua Regia Digestion Multi-Element Analytical Method ICP70

Element	Symbol	Units	Lower Limit	Upper Limit
Silver	Ag	ppm	0.2	10
Aluminum	Al	%	0.01	15
Arsenic	As	ppm	3	10000
Barium	Ba	ppm	1	10000
Beryllium	Be	ppm	0.5	2500
Bismuth	Bi	ppm	5	10000
Calcium	Ca	%	0.01	15
Cadmium	Cd	ppm	1	10000
Cobalt	Co	ppm	1	10000
Chromium	Cr	ppm	1	10000
Copper	Cu	ppm	0.5	10000
Iron	Fe	%	0.01	15
Potassium	K	%	0.01	15
Lanthanum	La	ppm	0.5	10000
Lithium	Li	ppm	1	10000
Magnesium	Mg	%	0.01	15
Manganese	Mn	ppm	2	10000

Element	Symbol	Units	Lower Limit	Upper Limit
Molybdenum	Mo	ppm	1	10000
Sodium	Na	%	0.01	15
Nickel	Ni	ppm	1	10000
Phosphorus	P	%	0.01	1
Lead	Pb	ppm	2	10000
Sulphur	S	%	0.01	10
Antimony	Sb	ppm	5	10000
Scandium	Sc	ppm	0.5	10000
Tin	Sn	ppm	10	10000
Strontium	Sr	ppm	0.5	5000
Titanium	Ti	%	0.01	15
Vanadium	V	ppm	2	10000
Tungsten	W	ppm	10	10000
Yttrium	Y	ppm	0.5	10000
Zinc	Zn	ppm	0.5	10000
Zirconium	Zr	ppm	0.5	10000

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 2002, 2004-2013 and 2018 Sample Analysis

Analytical work in 2002, from 2004 to 2013 and 2018 was completed by ALS of North Vancouver. Total copper and molybdenum concentrations were determined by an intermediate-grade multi-element analytical method. A four-acid digestion was followed by ICP-AES finish (ALS code ME-ICP61a). This multi-element method was also used to determine 31 additional elements including sulphur. The elements reported, units and detection limits are listed in Table 11.3-7.

Table 11.3-7 ALS Four Acid Digestion Multi-Element Analytical Method ME-ICP61a

Element	Symbol	Units	Lower Limit	Upper Limit
Silver	Ag	ppm	1	200
Aluminum	Al	%	0.05	50
Arsenic	As	ppm	50	100000
Barium	Ba	ppm	50	50000
Beryllium	Be	ppm	10	10000
Bismuth	Bi	ppm	20	50000
Calcium	Ca	%	0.05	50
Cadmium	Cd	ppm	10	10000
Cobalt	Co	ppm	10	50000
Chromium	Cr	ppm	10	100000
Copper	Cu	ppm	10	100000
Iron	Fe	%	0.05	50
Gallium	Ga	ppm	50	50000
Potassium	K	%	0.1	30
Lanthanum	La	ppm	50	50000
Magnesium	Mg	%	0.05	50
Manganese	Mn	ppm	10	100000
Molybdenum	Mo	ppm	10	50000
Sodium	Na	%	0.05	30
Nickel	Ni	ppm	10	100000
Phosphorus	P	ppm	50	100000
Lead	Pb	ppm	20	100000
Sulphur	S	%	0.05	10
Antimony	Sb	ppm	50	50000
Scandium	Sc	ppm	50	50000
Strontium	Sr	ppm	10	100000
Thorium	Th	ppm	50	50000
Titanium	Ti	%	0.05	30
Thallium	Tl	ppm	50	50000
Uranium	U	ppm	50	50000
Vanadium	V	ppm	10	100000
Tungsten	W	ppm	50	50000
Zinc	Zn	ppm	20	100000

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). Details on this and other copper check assay and overlimit methods employed are in Table 11.3-2.

Gold content was determined by 30 g lead collection FA fusion with AAS finish (ALS code Au-AA23). A total of 14 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). In 2002, 464 samples from 12 holes in the 25 Zone, 37 Zone and nearby were also analyzed by method PGM-ICP23. Table 11.3-3 provides further details on the sample size and detection limits of the ALS precious metal fire assay methods used. A single silver value >200 ppm was re-analyzed by AR digestion AAS (Method Ag-AA62 on Table 11.3-2). Beginning in 2004 for Tertiary rocks and 2007 for Cretaceous rocks, samples were analyzed for 48 elements including copper, molybdenum, silver and rhenium

by four-acid digestion followed by ICP-AES and inductively coupled plasma–mass spectroscopy finish (ICP-MS). Information on this method (ALS code ME-MS61) is listed in Table 11.3-8.

Table 11.3-8 ALS Four Acid Digestion Multi-Element Analytical Method ME-MS61

Element	Symbol	Unit	Lower Limit	Upper Limit
Silver	Ag	ppm	0.01	100
Aluminum	Al	%	0.01	50
Arsenic	As	ppm	0.2	10000
Barium	Ba	ppm	10	10000
Beryllium	Be	ppm	0.05	1000
Bismuth	Bi	ppm	0.01	10000
Calcium	Ca	%	0.01	50
Cadmium	Cd	ppm	0.02	500
Cerium	Ce	ppm	0.01	500
Cobalt	Co	ppm	0.1	10000
Chromium	Cr	ppm	1	10000
Cesium	Cs	ppm	0.05	500
Copper	Cu	ppm	0.2	10000
Iron	Fe	%	0.01	50
Gallium	Ga	ppm	0.05	500
Germanium	Ge	ppm	0.05	500
Hafnium	Hf	ppm	0.1	500
Indium	In	ppm	0.005	500
Potassium	K	%	0.01	10
Lanthanum	La	ppm	0.5	500
Lithium	Li	ppm	0.2	500
Magnesium	Mg	%	0.01	50
Manganese	Mn	ppm	5	100000
Molybdenum	Mo	ppm	0.05	10000

Element	Symbol	Units	Lower Limit	Upper Limit
Sodium	Na	%	0.01	10
Niobium	Nb	ppm	0.1	500
Nickel	Ni	ppm	0.2	10000
Phosphorous	P	ppm	10	10000
Lead	Pb	ppm	0.5	10000
Rubidium	Rb	ppm	0.1	500
Rhenium	Re	ppm	0.002	50
Sulphur	S	%	0.01	10
Antimony	Sb	ppm	0.05	1000
Scandium	Sc	ppm	0.1	250
Selenium	Se	ppm	1	1000
Tin	Sn	ppm	0.2	500
Strontium	Sr	ppm	0.2	10000
Tantalum	Ta	ppm	0.05	100
Tellurium	Te	ppm	0.05	500
Thorium	Th	ppm	0.01	500
Titanium	Ti	%	0.005	10
Thallium	Tl	ppm	0.02	500
Uranium	U	ppm	0.1	500
Vanadium	V	ppm	1	10000
Tungsten	W	ppm	0.1	10000
Yttrium	Y	ppm	0.1	500
Zinc	Zn	ppm	2	10000
Zirconium	Zr	ppm	0.5	500

As adjuncts to ALS methods ME-ICP61 and ME-MS61, mercury was determined by aqua regia digestion with cold vapour AAS finish (ALS method Hg-CV41) and aqua regia digestion ICP-MS (ALS method Hg-MS42) on samples where method ME-ICP61a is not performed. Table 11.3-9 provides further details on these methods.

Table 11.3-9 ALS Mercury Aqua Regia Digestion Analytical Methods

Element	Symbol	Method Code	Sample Mass (g)	Units	Lower Limit	Upper Limit
Mercury	Hg	Hg-CV41	0.5	ppm	0.01	100
Mercury	Hg	Hg-MS42	0.5	ppm	0.005	100

A total of 13,371 samples were subject to sequential copper speciation analyses that included: oxide copper analysis by citric acid leach AAS finish; non-sulphide copper analysis by 5% 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). These methods and the database codes associated with them are outlined in Table 11.3-10.

Table 11.3-10 ALS Copper Speciation Analytical Methods

Database Code	Method Code	Leach	Sample Mass (g)	Units	Lower Limit	Upper Limit
CuOx	Cu-AA04	Citric acid	0.25	%	0.01	10
CuS	Cu-AA05	5% Sulphuric acid	0.5	%	0.01	10
CuCN	Cu-AA17	Cyanide	2	%	0.01	10

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 MA270, a four-acid digestion with ICP-AES finish, was used to determine total concentrations for copper, molybdenum and 38 additional elements. Table 11.3-11 lists the elements analyzed and the detection limits of this method.

Table 11.3-11 BVCCL Four Acid Digestion Multi-Element Analytical Method MA270

Element	Symbol	Units	Lower Limit	Element	Symbol	Units	Lower Limit
Silver	Ag	ppm	0.5	Sodium	Na	%	0.01
Aluminum	Al	%	0.01	Niobium	Nb	ppm	0.5
Arsenic	As	ppm	5	Nickel	Ni	ppm	0.5
Barium	Ba	ppm	5	Phosphorus	P	%	0.01
Beryllium	Be	ppm	5	Lead	Pb	ppm	0.5
Bismuth	Bi	ppm	0.5	Rubidium	Rb	ppm	0.5
Calcium	Ca	%	0.01	Sulphur	S	%	0.05
Cadmium	Cd	ppm	0.5	Antimony	Sb	ppm	0.5
Cerium	Ce	ppm	5	Scandium	Sc	ppm	1
Cobalt	Co	ppm	1	Tin	Sn	ppm	0.5
Chromium	Cr	ppm	1	Strontium	Sr	ppm	5
Copper	Cu	ppm	0.5	Tantalum	Ta	ppm	0.5
Iron	Fe	%	0.01	Thorium	Th	ppm	0.5
Hafnium	Hf	ppm	0.5	Titanium	Ti	%	0.001
Potassium	K	%	0.01	Uranium	U	ppm	0.5
Lanthanum	La	ppm	0.5	Vanadium	V	ppm	10
Lithium	Li	ppm	0.5	Tungsten	W	ppm	0.5
Magnesium	Mg	%	0.01	Yttrium	Y	ppm	0.5
Manganese	Mn	ppm	5	Zinc	Zn	ppm	5
Molybdenum	Mo	ppm	0.5	Zirconium	Zr	ppm	0.5

Check assays for gold were determined by Acme (BVCCL) code FA330, a 30 g FA fusion with ICP-AES finish. Table 11.3-12 lists the details for this method.

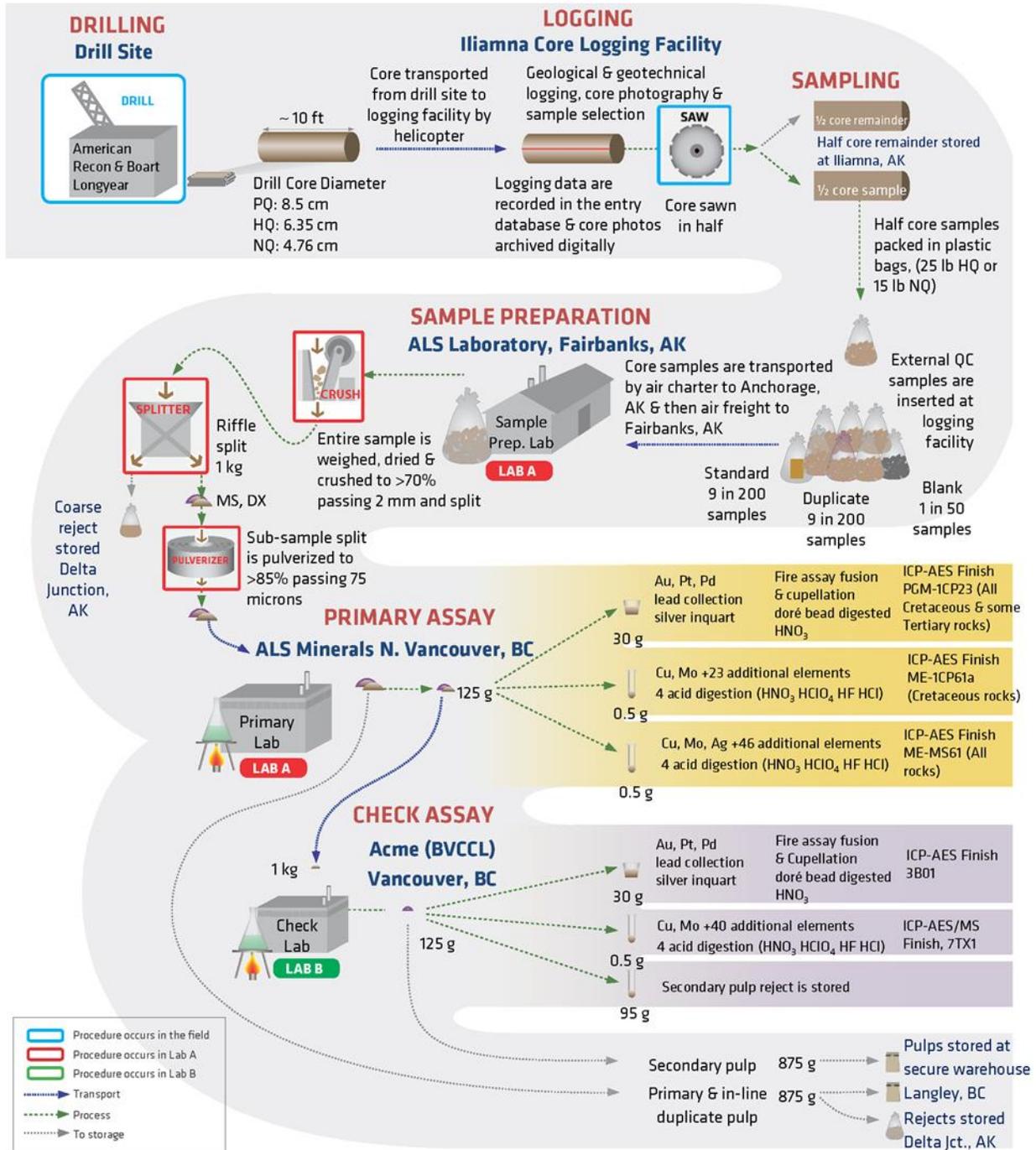
Table 11.3-12 BVCCL Precious Metal Fire Assay Analytical Method

Element	Symbol	Method Code	Instrument	Units	Sample Mass (g)	Lower Limit
Gold	Au	FA330	ICP-AES	ppb	30	2

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).

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

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

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:

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

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.

11.4 QUALITY CONTROL/QUALITY ASSURANCE

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

11.4.1 Quality Assurance and Quality Control

Northern Dynasty maintained an effective QA/QC program consistent with industry best practices, which was 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.

Table 11.4-1 describes the QA/QC sample types used in the program. The performance of the copper-gold standard CGS-16 is illustrated in Figure 11.4-1 and Figure 11.4-2. A comparison of the matched-pair duplicate assay results of ALS and Acme (BVCCCL) for 2004 through 2010 is provided in Figure 11.4-3 and Figure 11.4-4.

Table 11.4-1 QA/QC Sample Types Used

QC Code	Sample Type	Description	Percent of Total
MS	Regular Mainstream	<ul style="list-style-type: none"> Regular samples submitted for preparation and analysis at the primary laboratory. 	89%
ST	Standard (Certified Reference Material)	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> Standard reference sample submitted with duplicates and replicates to the check laboratory. 	<1%
BL	Blank	<ul style="list-style-type: none"> Sample containing negligible or background amounts of elements of interest, to test for contamination. 	2% 1 in 50

Figure 11.4-1 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.)

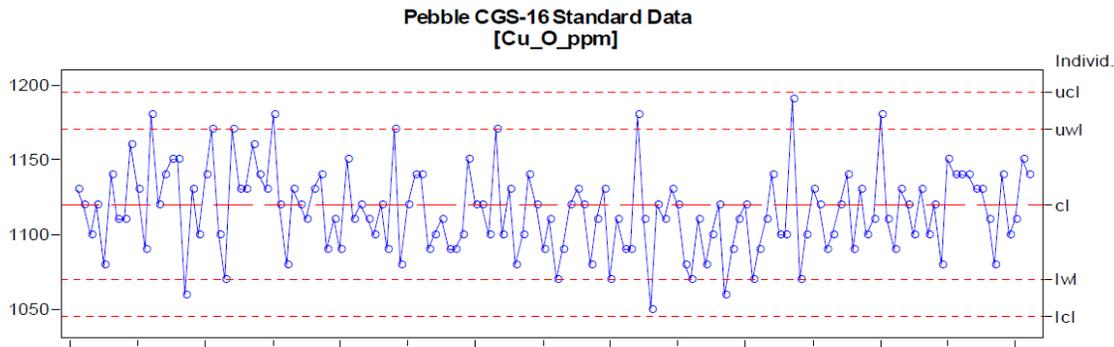
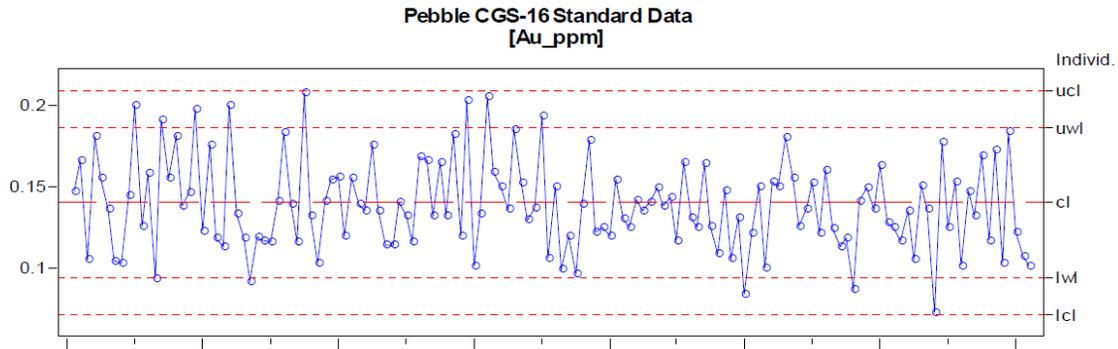


Figure 11.4-2 Performance of the Gold Standard CGS-16 in 2008

Limits:	Overall Bias
Target: 0.14 g/t	-0.001 g/t (-0.99% rel.)
2SD: ± 0.046 g/t	
3SD: ± 0.069 g/t	



11.4.2 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 tag 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 2018 and 2020 rhenium analysis programs. Copper and gold standards were inserted during the 1997 through 2020 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 mineralized Cretaceous rocks are certified for gold, copper, molybdenum, silver and arsenic. One low-grade 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.

11.4.3 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 11.4-3 and Figure 11.4-4 provide a comparison of the matched-pair duplicate assay results of ALS and Acme (BVCCL) for 2004 through 2010.

Figure 11.4-3 Comparison of Gold Duplicate Assay Results for 2004 to 2010

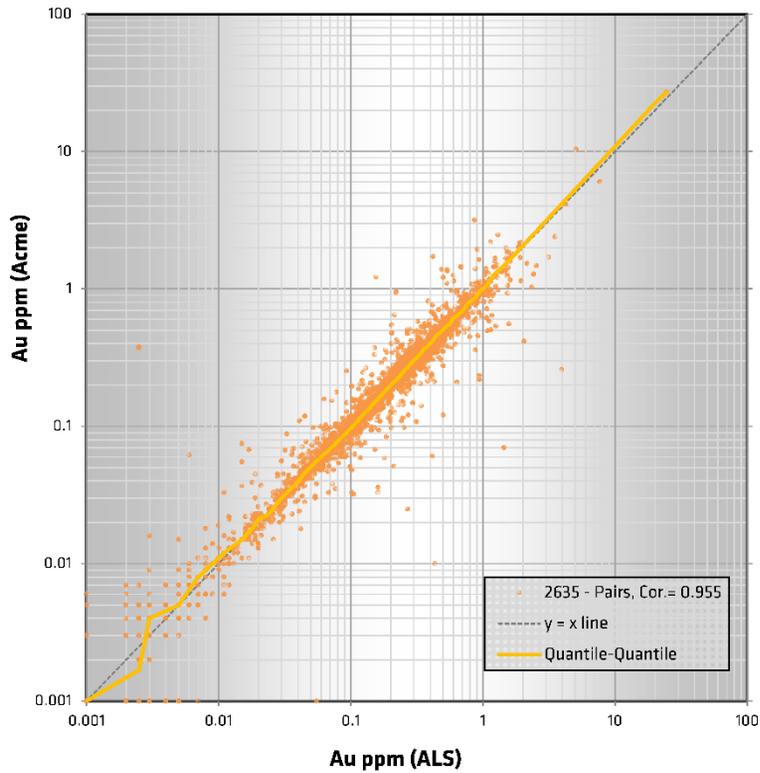
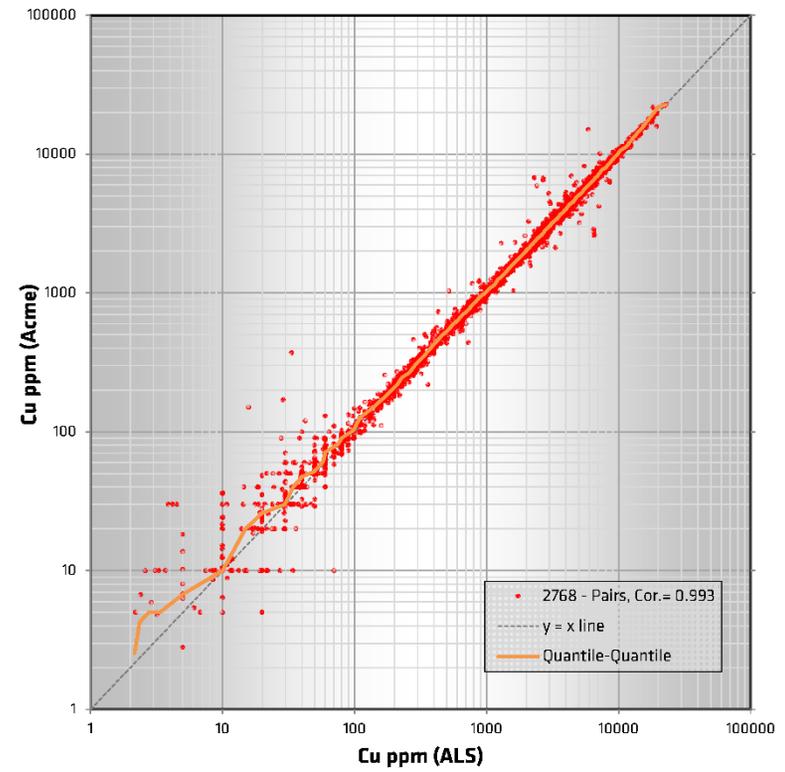


Figure 11.4-4 Comparison of Copper Duplicate Assay Results for 2004 to 2010



11.4.4 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 low grade 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, possibly due to cross-sample mixing errors during crushing.

11.4.5 QA/QC on Other Elements

The four-acid digestion ICP-AES 33 multi-element analytical method employed from 2004 through 2013 (ALS method ME-ICP61) is optimized for copper and molybdenum analysis. The copper and molybdenum assays were monitored by internal laboratory and external standards.

Parallel to this method (as described in Section 11.0), an ICP-MS 48 multi-element method (ALS Method ME-MS61) 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.

11.4.6 Rhenium Study

In July 2020, the original assay pulps from 938 sample intervals cored in years 1991, 2003, 2004 and 2005 Pebble deposit drilling were retrieved from a company warehouse for a study on the relationship between rhenium and molybdenum concentrations. The selected samples were originally analyzed for copper, molybdenum and other elements, but had not been analyzed for rhenium. Samples were submitted to ALS laboratory in North Vancouver for multi-element analysis by four acid digestion ICP-MS finish (ALS method ME-MS61), along with 52 Pebble project-based standards, 17 nominal blanks and 48 duplicates. In addition to rhenium and molybdenum, the concentrations of copper, silver and 44 other elements were also determined in this study. The performance of standard PLP-1 for rhenium is illustrated in Figure 11.4-5. The pre-2020 results and year 2020 results from ALS are highlighted by lighter and darker shaded lines respectively. The performance of the nominal (low element concentration)

blank PLP-2 for rhenium is similarly presented in Figure 11.4-6. As the control samples used had not originally been subject to round-robin analysis for rhenium, results of several hundred analyses at ALS laboratory were used to establish reasonable concentration levels for them. These levels were corroborated with results obtained by other analytical laboratories using similar analytical methods.

Figure 11.4-5 Performance of Standard PLP-1 for Rhenium

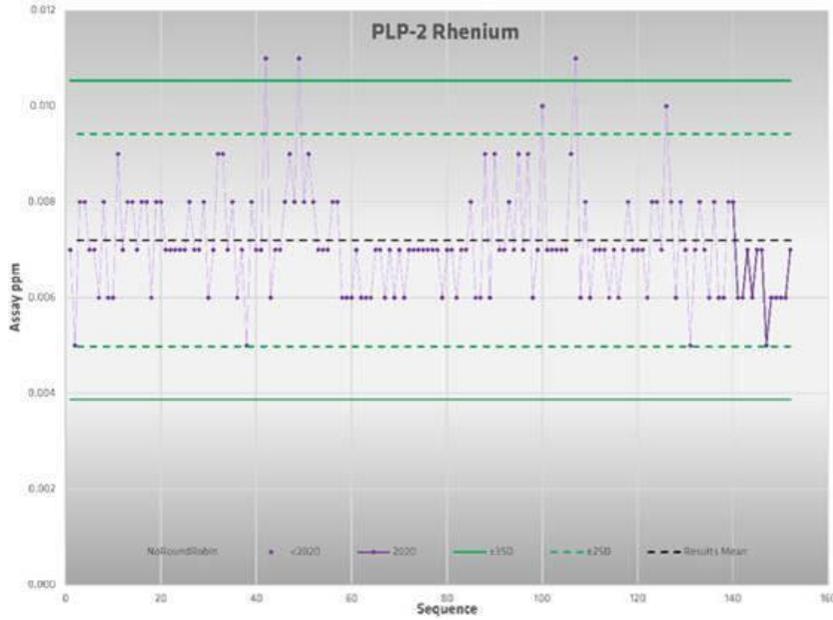
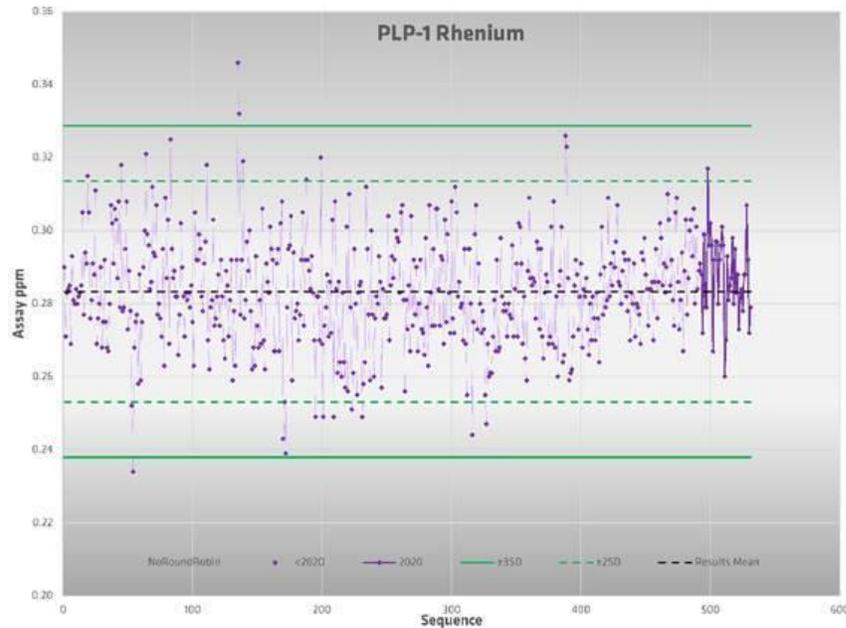


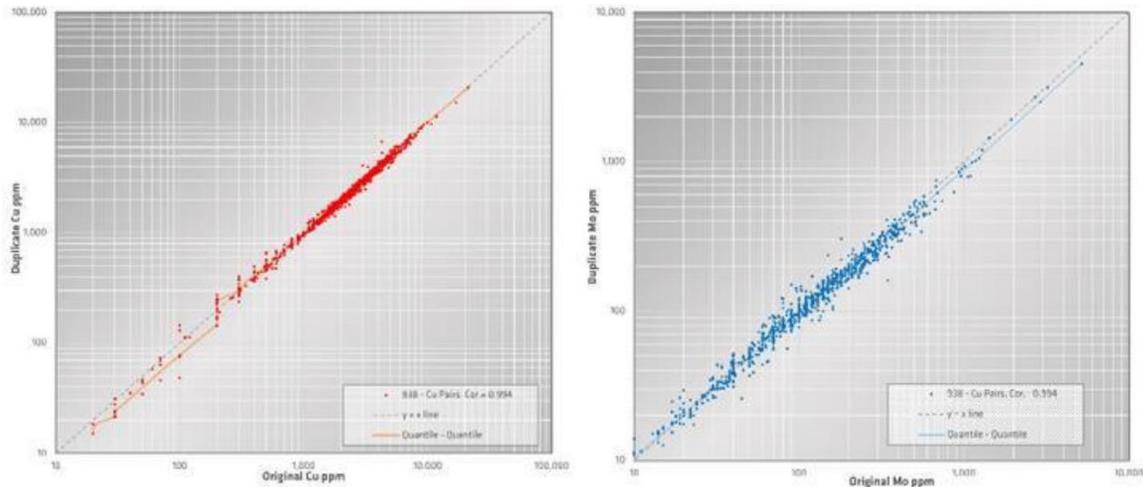
Figure 11.4-6 Performance of Control Sample PLP-2 for Rhenium



Based on the results of this study, the QP is of the opinion that the rhenium results obtained are suitable for use in this technical report.

As part of the 2020 rhenium study, additional elements including copper and molybdenum were analyzed by the multi-element method employed. The copper and molybdenum results obtained in 2020 were compared with the original assay results. These comparisons are presented in Figure 11.4-7 as scatterplots in log format of the original results versus the new results. A reasonable level of correspondence in concentrations of the matched pairs was obtained for each element.

Figure 11.4-7 Scatterplots in Log Format of Original vs 2020 Re-analysis for Copper and Molybdenum



In the opinion of the QP, the reanalysis of these samples for copper and molybdenum lends further credence to the veracity of the assay results for these elements and the appropriateness of their use in this technical report.

11.5 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.

11.6 SURVEY VALIDATION

In 1988, 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 Kaktuli, 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 Teck holes were surveyed by single shot magnetic methods. In 2008, several angle holes were also surveyed by a non-magnetic gyroscopic tool.

11.7 DATA ENVIRONMENT

All drill logs collected on the Pebble Project have been compiled in a SQL Server database. Drill hole logs have been entered into notebook computers running a digital data entry module for the Pebble

Project at the core shack in Iliamna prior to 2018. During the pre-2018 drilling programs, the core logging computers were synchronized on a daily basis with the site master database on the file server in the Iliamna geology office. Since 2018 data entry is to a cloud-based server. 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 reviewed and validated, and initial corrections made.

Prior to 2018, site data was 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. Since 2018, a cloud-based application has been used. 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, an independent QA/QC consultant compiled the sample log data from the site with assay data received directly from the laboratories for the 2004 through 2012 programs as part of an ongoing monitoring process. Compiled data are exported to the site database, to resource estimators, and to other users as required.

11.7.1 Error Detection Processes

Error detection within the data entry modules 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 printed.

Site data are transmitted to the Pebble database compilation group on a regular basis. 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 site sampling data, 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.

11.7.2 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 (ALS method ME-ICP61) supersedes copper by low grade multi-element method (ALS method ME-MS61).

In the case of all other elements, including molybdenum, silver and sulphur analyses from 2007 through 2013, the multi-element method (ALS method ME-MS61) supersedes the intermediate grade multi-element method (ALS method ME-ICP61), unless the low-grade method results are greater than the upper detection limit. In that case, the intermediate grade method result prevails. All rhenium results are by ALS method ME-MS61. Infrequent extremely high results for Cu, Mo, Ag, Pb or Zn were reanalyzed by single element over limit analytical methods that supersede the original result.

11.7.3 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.

11.7.4 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.

11.8 VERIFICATION OF DRILLING DATA

The 1997 and prior 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 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. A complete set of original information, including original drill logs, does not exist for all historical holes, particularly for those drilled in the Sill zone in 1988 and 1989. Assay data for the 1988 and 1989 holes drilled in Pebble West and 25 zone is from a combination of CERL assay certificates, the Teck digital compilation file and the original drill logs. The data compiled by Teck appears to be of good quality and matches the digital analytical data received directly from the CERL and ALS 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 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 2019 is described in Section 11.4. Typically, validation and verification work was completed within a few months of completion of a drill hole, 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 prior to 2009 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.

12.0 DATA VERIFICATION

QP David Gaunt was involved in the due diligence program and conducted the original modelling of the deposit prior to its acquisition by Northern Dynasty in 2001. He has been directly involved in resource estimation of the project continuously since that time. In this capacity he has worked directly with site personnel including QA/QC supervisors, project geologists, engineering personnel, data loggers, and other management personnel. QP David Gaunt either authored or supervised all resource estimates completed on the project from 2003 through to 2018 and has extensive knowledge of this work. QP David Gaunt has conducted numerous site visits to review aspects of the program such as drilling, sample procedures, geological interpretation, and QA/QC status. The most recent visit to site was conducted in 2010. All aspects of the project pertinent to resource estimation were deemed to be of suitable standard.

In the months immediately prior to the completion of this technical report, QP David Gaunt extensively reviewed all aspects of the resource estimate including analytical QA/QC, statistical performance, domaining, variography and estimation parameters of rhenium. Analytical data and estimation procedures developed were deemed to be appropriate for estimation of rhenium.

Subsequent verification analyses on estimated grades lends credence to their accuracy, spatial distribution and correspondence with informing drill data.

QP James Lang has been directly involved in the acquisition of geological, exploration, drilling, and other related types of data on the Pebble Project since 2003. He has been physically on the Project site every year through 2019 for a total of over 650 days. Prior to 2007, QP Lang undertook a variety of specialized geological studies of both the Pebble deposit and the surrounding environs for Northern Dynasty, including examination of outcrops, extensive examination, review, and sampling of diamond drill core, review and reconciliation of drill logs, review of geochemical results in respect of geological controls, the acquisition of geotechnical data from drill core, and other similar activities, and he also participated in QA/QC oversight of many types of geological data acquisition. From 2007-2010, QP Lang was on-site Chief Geologist for the Project on behalf of Northern Dynasty and the Pebble Partnership, supervising the geology team and their activities, including QA/QC oversight of their data collection methods, supervision of geometallurgical and metal deportment studies, modeling in support of deposit delineation and exploration, and characterization of the physical and mineralogical properties of the deposit. He also served as geological liaison to the metallurgical and geotechnical engineering and environmental disciplines. QP Lang was a member of the Geology and Exploration Technical Committee of the Pebble Partnership from 2007-2013, the duties of which included review of data collection methods, review of the results of drilling, and geochemical and geophysical surveys, and the planning of all exploration and geology activities on the Project. Since 2013, QP Lang has remained responsible for the limited geological activities that have occurred on the Project and the curation of geological data.

Verification of the geological data presented in the present report was achieved by two primary means. Firstly, by the direct participation of QP Lang in the acquisition of much of the data utilized in this report, and secondly by his historical and ongoing custodianship of the geological data and its review in

the context of newly acquired analytical data presented and regional context provided by third party studies referenced in this report. As mentioned above, QP Lang also conducted site visits to observe and oversee collection of the data. During the period from 2003 until present, there have been no limitations placed on the ability of QP Lang to verify the data used herein, and there have been no material failures in the verification of said data. QP Lang deems these data to be appropriate to and adequate for the purposes of this technical report.

QP Eric Titley was involved in the due diligence program on exploration conducted by Teck that ultimately resulted in the acquisition of the Pebble Project by Northern Dynasty in 2001. He has been directly involved in the exploration, drilling, sampling, analytical, QA/QC and data management programs of the Pebble Project on behalf of Northern Dynasty and Pebble Partnership continuously since then. Northern Dynasty and Pebble Partnership systematically validated and verified results from its exploration programs on the Pebble Project as they progressed between May 2002 and October 2019. QP Eric Titley supervised the analytical, QA/QC and data management aspects of these programs on behalf of Northern Dynasty and Pebble Partnership and has extensive knowledge of this work. QP Eric Titley conducted site visits, most recently in September 2011, to review the ongoing drilling, sampling, and analytical QA/QC operations. All aspects of these programs were deemed to be of a suitable standard.

In the months immediately prior to completion of this technical report, QP Eric Titley extensively reviewed and re-assessed the drill hole database used in the current resource estimate. This involved detailed comparison of the resource database with original source records that support it, including a number of original laboratory assay certificates. A high level of concordance between the resource database and the original source records was indicated by this study. In addition, over 900 original assay pulps from the 1991 through 2005 drill programs within the current resource area were retrieved and subject to multi-element analysis. Re-analysis results included copper, molybdenum, silver and rhenium. The new copper, molybdenum and silver analyses compare with the original assays to an acceptable level. The 900 plus new rhenium analyses were used to upgrade the data support for this element in the resource database.

The verification work conducted lends credence to the veracity of the resource database. In the QP's opinion the data is adequate for the purposes used in this technical report.

QP Ting Lu was involved in the metallurgical testwork review, metal recovery projections, and processing design since 2012 when Tetra Tech was retained by Northern Dynasty to conduct an internal engineering study for the Pebble Project. She was also the QP for the preparation of Section 13, Mineral Processing and Metallurgical Testing, of the 2014 and 2018 technical reports for Northern Dynasty.

In her QP's capacity, QP Ting Lu has reviewed the relevant mineral processing and metallurgical test reports that were completed by reputational commercial laboratories and leading processing equipment manufacturers. QP Ting Lu has conducted her due diligence by reviewing the background, procedures and results of the testing programs. She also analyzed original test data and communication documents to verify the test results for metal recovery projections. All aspects of these programs were deemed to be of suitable standard.

In the months immediately prior to the completion of this technical report, QP Ting Lu extensively reviewed all aspects of the test results regarding rhenium distributions and recovery methods. She has projected the rhenium recovery based on the results of the conventional flotation tests.

In the QP Ting Lu's opinion, the verification work conducted for the testwork review and metal projections is adequate for the purposes used in this technical report.

QP Stephen Hodgson has served many years in engineering leadership positions for the Pebble Project, including studies of the project in 1991 and 1992 for a previous owner. He joined Northern Dynasty as Vice President Engineering in 2005 and has been engaged in the project since that time, managed engineering studies. With the creation of the Pebble Partnership in 2007, he was Director of Engineering until 2011. Between 2011 and 2013, he served as a member of the project's Steering Committee and resumed the engineering leadership role in 2013. In 2017, he was named Senior Vice President Engineering and Project Director for the Pebble Partnership with responsibility for the technical aspects of the project, including oversight of the development of the Project Description.

QP Hodgson has visited the Pebble site many times, the most recent occasion in October 2019 to observe and oversee the collection of engineering and other data for project design for the environmental assessment process. He has interacted continuously with the Geological team during his tenure with Northern Dynasty and Pebble Partnership, including collaborating in the development of enclosing pits to define resources. QP Hodgson has reviewed all sections of this report and discussed the information presented by each of the authors.

QP Hodgson's opinion is, given his tenure on and in-depth knowledge of the Pebble Project and his interaction with the geological and resource teams, these data are appropriate and adequate for the purposes of this technical report.

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 2014, geometallurgical studies, and an updated metal recovery projection. For a review of previous testwork, refer to the 2011 Technical Report completed by Wardrop (Tetra Tech).

13.1 TEST PROGRAMS SUMMARY

Metallurgical testwork between 2005 and 2012 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 from 2011 to 2014 was focused on metallurgical verification tests on samples representing each metallurgical domain at the property in batch, pilot, and locked cycle tests. Additional testwork conducted at this stage included evaluations of the performance of a secondary gold recovery plant, which has now been removed from the proposed process plant, and pressure oxidation of molybdenum concentrates to recover molybdenum and rhenium, and the subsequent metal extractions.

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 Table

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.

Table 13.1-1 Testwork Programs and Reports 2006 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 Mill 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 Moulton 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

Test Program	Laboratory	Report Date
Copper Sulphide Jar Mill Testing Test Plant Report #20002007	Metso	Apr 12, 2010
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, obtained from the last cleaner stage of the open circuit tests, was found to contain significant rhenium, with grades ranging up to 960 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 previous 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 2011 to 2013 Testwork

The Pebble Partnership continued metallurgical testwork during 2011 and 2013. The major goals of the 2011 and 2013 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;
- 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; and
- Perform an initial program to test a Molybdenum Autoclave Process (MAP) on Pebble concentrates for molybdenum and rhenium recovery.

Table 13.1-2 Subsequent Testwork Programs and Reports, 2011 to 2014

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 Department 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
An Investigation into the Recovery of Copper, Gold, and Molybdenum from the Pebble Deposit; Incomplete; Final Report, Project 12072-003 and -007	SGS Lakefield	Sep 24, 2014

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 Table 13.2-1 and, Table 13.2-3, respectively.

Table 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.

Table 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 Table 13.2-3 through Table 13.2-6. The testwork completed is considered to be representative of the deposit.

Table 13.2-3 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.

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

	CWi (kWh/t)			Rock Density g/cm ³
	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

The SAG Mill Comminution (SMC) test is to provide impact breakage parameters in a cost-effective means when a full drop weight test JK Drop-Weight test is not available due to the limited sample quantities. Additional SMC tests were conducted on Pebble West and Pebble East drill core samples in 2012. The major test results including the direct measurements of sample densities and JK Drop-Weight index (DWi), the calculated JK rock breakage parameters A x b, and the t₁₀ values are summarized in Table 13.2-4 for Pebble West zone and Table 13.2-5 for Pebble East samples. Test results since 2004 are also presented.

Table 13.2-4 Major SMC Data Comparison on Pebble West Samples-SGS Test Report Sept.2014

	DWi kWh/m ³			A x b			t ₁₀ @1kWh/t			Density (g/cm ³)				
	2005, 2006	2008	2011	2004	2005, 2006	2008	2011	2005, 2006	2008	2011	2004	2005, 2006	2008	2011
Core Years	2005, 2006	2008	2011	2004	2005, 2006	2008	2011	2005, 2006	2008	2011	2004	2005, 2006	2008	2011
Comp	W1 to W177	W178 to W394	W395 to W445	-	W1 to W177	W178 to W394	W395 to W445	W1 to W177	W178 to W394	W395 to W445	-	W1 to W177	W178 to W394	W395 to W445
Years Tested	2008, 2010, 2011	2009, 2010, 2011	2011	2005	2008, 2010, 2011	2009, 2010, 2011	2011	2008, 2010, 2011	2009, 2010, 2011	2011	2005	2008, 2010, 2011	2009, 2010, 2011	2011
Results Available	53	64	15	47	53	64	15	53	64	15	47	53	64	15
Average	6.46	6.12	6.94	45.7	44.0	50.1	43.6	31.8	34.8	31.3	2.59	2.60	2.60	2.62
Minimum*	2.74	1.79	2.61	98.3	89.4	135.2	98.9	46.5	62.3	48.1	2.49	2.43	2.38	2.44
Median	5.93	5.78	7.47	43.1	43.2	45.6	35.9	31.7	33.6	29.7	2.59	2.62	2.59	2.64
Maximum*	11.5	10.9	11.1	26.0	24.0	26.1	24.5	21.3	22.8	21.5	2.89	2.76	2.90	2.74

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

Table 13.2-5 Major SMC Data Comparison on Pebble East Samples - SGS Summary Report Sept. 2014

Phase	DWi kWh/m ³			A x b			t ₁₀ @1kWh/t			Density (g/cm ³)		
	I	II	III	I	II	III	I	II	III	I	II	III
Results Available	134	182	44	134	182	44	134	182	44	134	182	44
Average	4.93	6.16	3.88	57.9	45.7	75.3	40.1	33.1	46.2	2.61	2.59	2.59
Minimum*	1.69	2.59	1.61	150	98.3	158.8	68.8	51.2	70.6	2.50	2.49	2.53
Median	4.85	6.04	3.79	54.3	43.1	68.1	39.5	32.3	45.0	2.61	2.59	2.58
Maximum*	8.81	10.3	6.3	30.0	26.0	41.5	25.9	22.7	31.6	2.87	2.89	2.69

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

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 Table 13.2-6. 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.

Table 13.2-6 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 FLOTATION CONCENTRATION TESTS

Focusing on the on-site production of three final products, namely copper concentrate, molybdenum concentrate and gold gravity concentrate, flotation tests conducted on Pebble since 2011 primarily consisted of:

- bulk flotation to produce a copper-molybdenum flotation concentrate with associated gold and rhenium;
- molybdenum flotation to produce the final copper concentrate and molybdenum concentrate; and,
- pyrite flotation with the concentrate being subjected to cyanide leaching; however, cyanide leaching has been removed from the proposed processing method for the Pebble deposit.

Other separation techniques were also tested at a preliminary level to optimize metal recoveries and concentrate grades, including:

- gravity recoverable gold (GRG) tests (section 13.4);
- 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; and
- pressure oxidation tests conducted on molybdenum flotation concentrates and metal extractions to recover molybdenum and rhenium (Section 13.5).

13.3.1 Recovery of Bulk Flotation Concentrate

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.

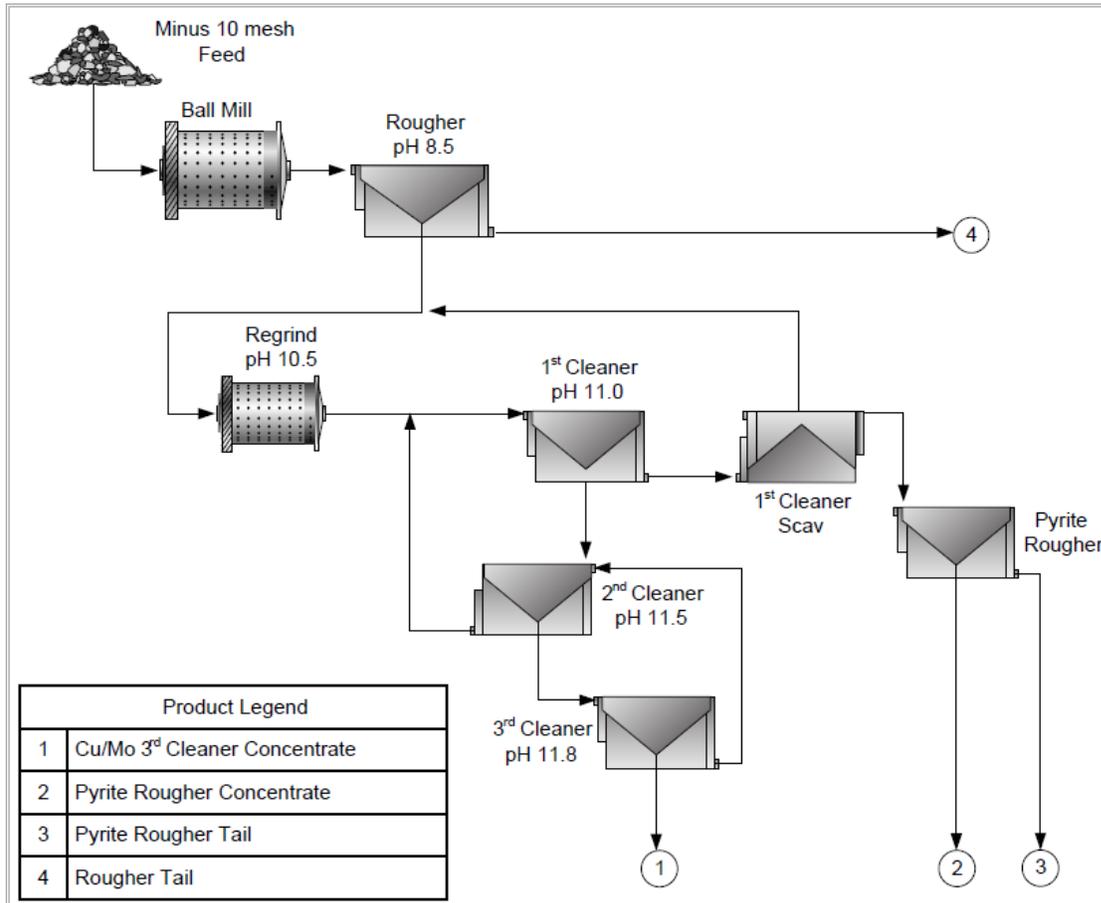
- Rougher Pulp Density (SGS 2012)
 - Tests on one composite sample indicated that reducing pulp density from 30 to 25% improved gold and molybdenum recovery significantly, while copper recovery was unaffected.
- Flotation Rate (SGS 2011/2012)
 - The supergene sample was found to be the slowest to recover 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. 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 Table 13.3-1. The average metal recoveries were higher than with the batch tests, while the metal grades of the concentrates 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

Table 13.3-1 Summary of Locked-Cycle Test Variability Test Results

Domain	Feed Properties						3rd CI Average Grade			3rd CI 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 (CI), pyrite (Py), chalcopyrite (Cpy), pyrite to chalcopyrite ratio (Py:Cpy), Recovery (Rec)

Samples from ten LCT tests were submitted for rhenium and silver assays to complete a mass balance. The recoveries of rhenium and silver to the 3rd cleaner concentrate was calculated as 73.4% and 62.7%, respectively, as shown in Table 13.3-2. A linear relationship between the recovery of molybdenum and

rhenium can be observed on the ten sets of data. This can be attributed to the rhenium occurrence as a solid substitution for molybdenite atoms on the molybdenite lattice structure (SME, 2018).

Table 13.3-2 Locked-Cycle Test Results on Pebble Variability Samples, SGS 2014

Test #/Composite	Cu/Mo Concentrate Grade, %, g/t					Cu/Mo Concentrate Recovery %				
	Cu	Au	Mo	Ag	Re	Cu	Au	Mo	Ag	Re
LCT1/W182	28.8	12.3	0.38	69	9.7	67.2	41.4	43.8	29.6	42.0
LCT4/W265	30.5	33.9	0.67	76	10.0	82.2	68.6	68.6	48.9	58.5
LCT7/W223	27.3	21.7	0.7	60	18.4	72.7	67.8	74.7	62.9	76.3
LCT41/W181	31.9	24.6	0.31	90	6.0	73.0	56.5	51.5	62.9	45.9
LCT62/V101	31.2	11.4	0.45	74	5.3	93.0	64.9	82.2	80.8	83.2
LCT63/V102	29.5	10.6	0.51	81	8.2	94.2	56.9	86.7	81.4	87.8
LCT64/V130	24.2	18.0	1.80	104	32.8	89.3	61.1	96.4	74.7	96.3
LCT66/V222	24.8	3.8	2.07	82	33.1	83.9	29.1	89.9	73.0	91.0
LCT69/V263	24.3	6.0	1.40	65	26.3	84.2	35.7	67.0	63.1	71.0
LCT89/W312	18.0	11.6	1.05	99	22.1	56.2	37.7	77.5	49.6	82.4

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 P₈₀ 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 Table 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.

Table 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 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. 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. Any further continuous testwork would ideally be completed on a higher feed rate and a sufficient amount of operation time reserved for reagent optimization. The continuous flotation results for the K-Silicate composite were close to the locked cycle test results, with the exception that molybdenum recoveries were slightly lower. The continuous flotation copper recovery for the supergene composite was higher compared to the locked cycle test result. For the remaining three composites, copper and gold recoveries were 7% lower, on average. Except for the supergene composite, molybdenum losses to the rougher tail were almost twice as high as in the locked cycle test. Final concentrate molybdenum recoveries were almost half the LCT recoveries. The molybdenum 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 gold 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 gold 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% copper concentrate.

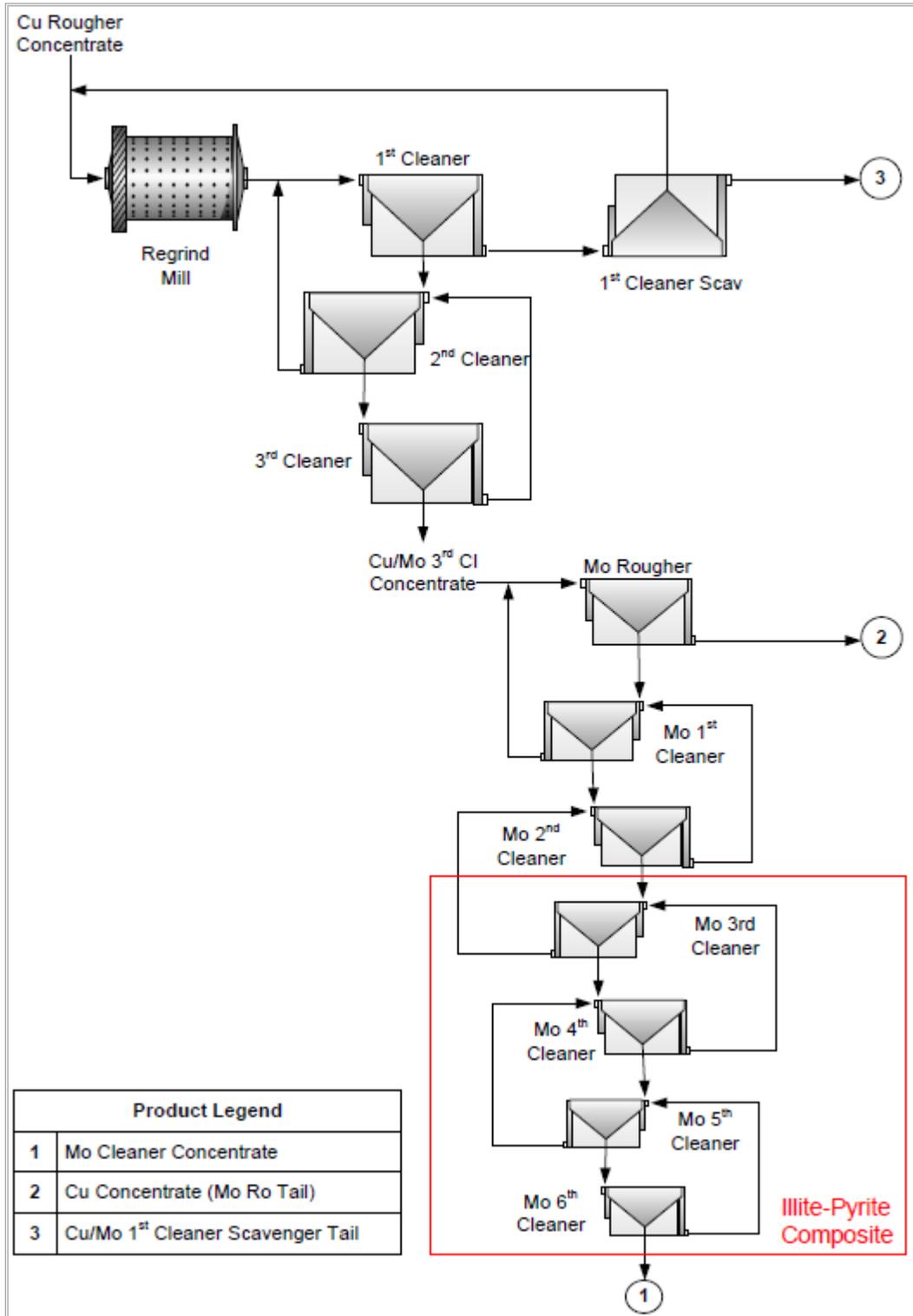
13.3.2 Separation of Molybdenum and Copper

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 in 2011.

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 13.3-2. The cycle numbers were varied in order to achieve the target grade of a final molybdenum concentrate.

Figure 13.3-2 Basic Testwork Flowsheet, SGS 2011



The 2011 program results outlined in Table 13.3-4 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 also in Table 13.3-4.

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 Sodium Hydrosulfide (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.

Table 13.3-4 Locked-Cycle Test Results of Molybdenum Flotation, SGS 2011-2012

Composite	Regrind Size P ₈₀ µm	Mo Concentrate							Cu Concentrate						
		Grade				Recovery %			Grade				Recovery %		
		Cu %	Au		Mo %	Cu	Au	Mo	Cu %	Au		Mo %	Cu	Au	Mo
			g/t	oz/ton						g/t	oz/ton				
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	0.062	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

Notes: SGS 2011 recovery is based on the overall feed; SGS 2012 recovery is based on the circuit feed to the copper-molybdenum separation flotation.

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 Table 13.3-5.

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.

Table 13.3-5 Molybdenum Recovery, G&T 2011

	Regrind Size P ₈₀ μm	Grade				Recovery %		
		Cu %	Au		Mo %	Cu	Au	Mo
			g/t	oz/ton				
Test 1	33	-	-	-	-	-	-	-
Molybdenum Concentrate	-	1.45	2.36	0.0689	50.6	0.1	0.2	76.2
Molybdenum 3 rd CI Tail	-	12.9	18.9	0.552	12.1	0.1	0.2	3.0
Molybdenum 2 nd CI Tail	-	24.2	35.4	1.034	3.89	1.2	3.1	6.9
Molybdenum 1 st CI 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 3 rd CI Tail	-	14.8	21.2	0.619	8.18	0.1	0.2	1.4
Molybdenum 2 nd CI Tail	-	21.3	38.4	1.12	5.51	0.5	1.5	4.3
Molybdenum 1 st CI 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

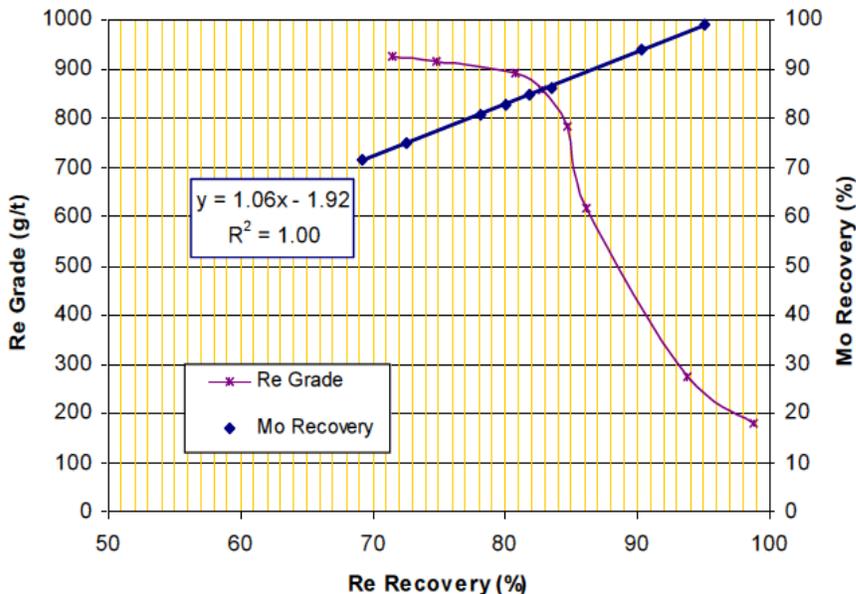
Ro – rougher; CI - cleaner

13.3.3 Rhenium Recovery into Molybdenum Concentrate

Rhenium will report to the molybdenum concentrate in molybdenum flotation process. A rhenium mass balance was reported by SGS in 2012 with the test results of an open circuit batch molybdenum cleaner flotation test (Table 13.3-6, Mo-F13). Figure 13.3-3 presents the rhenium recovery and grade data. Rhenium grade of over 900 g/t was observed in the 5th and 6th cleaner molybdenum concentrates. A linear relationship is also noticed between molybdenum recovery and rhenium recovery.

Table 13.3-6 Molybdenum Open Cycle Cleaner Flotation Test Results (Mo-F13, SGS 2012)

Products	Weight		Assays				Distributions			
	g	%	Cu %	Mo %	Au g/t	Re g/t	Cu %	Mo %	Au %	Re %
Mo 6th CI Conc	42.9	1.21	1.59	49.0	1.75	926	0.1	69.2	0.2	71.4
Mo 6th CI Tail	2.5	0.07	3.69	40.8	2.17	759	0	3.4	0	3.4
Mo 5th CI Tail	5.1	0.14	5.76	33.9	3.79	651	0	5.7	0.1	6
Mo 4th CI Tail	3.2	0.09	11	18.1	7.82	341	0	1.9	0.1	2
Mo 3rd CI Tail	6.5	0.18	18.6	8.29	14.3	163	0.2	1.8	0.2	1.9
Mo 2nd CI Tail	17.4	0.49	30.1	2.85	17.6	47.6	0.7	1.6	0.8	1.5
Mo 1st CI Scav Conc	7.9	0.22	14.7	18.6	12.9	364	0.2	4.8	0.3	5.2
Mo 1st CI Scav Tail	104.3	2.94	25	0.58	15.2	13.1	3.6	2	4.2	2.5
Rougher Sc Conc	116.9	3.3	23.8	1.24	13.3	24	3.9	4.8	4.2	5
Rougher Scav Tail	3235.5	91.3	20.2	0.046	10.4	<0.2	91.2	4.9	89.9	1.2
Head (calc.)	3542.2	100	20.2	0.86	10.6	15.7	100	100	100	100

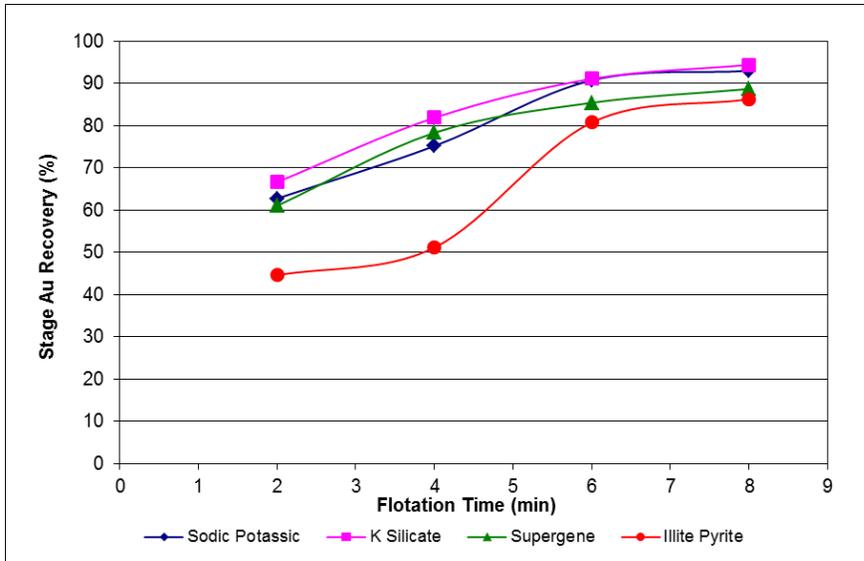
Figure 13.3-3 Rhenium Grade and Recovery Relationship (SGS 2012)


13.3.4 Pyrite Flotation

The purpose of a pyrite flotation is to concentrate gold bearing sulphide minerals prior to a subsequent cyanide leach process. This pyrite flotation stage will be unlikely implemented as the cyanide leach circuit has been excluded from the processing methods for Pebble deposit. Nonetheless, the following is a brief summary of the testwork related to pyrite flotation.

A pyrite flotation step was included as part of the locked cycle variability tests. The pyrite flotation stage gold recoveries from the initial samples were found to be highly variable in a four-minute laboratory flotation process. In order to optimize the pyrite flotation metallurgy, SGS performed a series of kinetics tests on the first scavenger tailings samples generated from four domain composite samples. Results of the tests are summarized in Figure 13.3-4 which shows the optimum laboratory flotation time occurs at approximately eight minutes.

Figure 13.3-4 Pyrite Flotation Kinetics Test Results



13.4 GOLD RECOVERY TESTS

Both gravity concentration 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. 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 MAP TESTS FOR MOLYBDENUM AND RHENIUM RECOVERY

SGS conducted a preliminary pressure oxidation testing program on molybdenum concentrates to establish a conceptual hydrometallurgical process flowsheet for molybdenum and rhenium recovery. The testwork is named as Molybdenum Autoclave Process (MAP) testwork. The MAP testwork provides a potential processing method to recover molybdenum and rhenium utilising a hydrometallurgical method. The MAP testwork includes initial leaching tests to establish test conditions, subsequent confirmation leaching tests and metal extraction tests from pregnant leach solutions.

13.5.1 Preliminary Leaching Tests

Preliminary leaching tests were conducted in one-stage pressure oxidation (POX) leach with a Hot Cure process and in the two-stage leach including the POX/Hot Cure process plus an alkaline leach on the POX residues. The tested concentrate samples ranged from 11.6 to 47.2% Mo representing rougher to cleaner grades of the molybdenum concentrates that were composited from varied flotation tests.

A total of 21 pressure oxidation leach tests were conducted at 230 °C and 100 psi O₂ for 2 hours with additional hot cure process in 14 tests, that is, to continue the leaching process at 95 °C and a normal pressure for varied time. Alkaline leaching tests were performed in the six leaching tests. Major observation from the preliminary tests are:

- The extraction of molybdenum is inferior to copper and rhenium, it also decreases with the increasing molybdenum head grade. This indicates that one-stage leaching is only applicable for low grade molybdenum concentrate (rougher concentrate). Leach on the residues seems to be required for the higher-molybdenum grade concentrates.
- Hot Cure process and the addition of magnesium can improve the molybdenum extraction; however, leaching at a lower pulp density of 4.0% reduced from 7.5%, and the addition of copper do not help the molybdenum dissolution.
- MoS₂ and MoO₃ are major molybdenum species with small amounts of FeMoO₄ in hot cure residues that is the feed to the alkaline leach; MoS₂ is the only molybdenum components in the alkaline residues.

The presence of the non-dissolved molybdenum sulphide explains the low molybdenum extraction when treating high grade molybdenum concentrates. Low iron content in the cleaner molybdenum concentrates may be one of the major reasons for the incomplete oxidation of the molybdenum sulphide.

13.5.2 POX and Hot Cure Leaching Confirmation Tests

Five additional molybdenum concentrate samples were prepared from various flotation tests to confirm the leaching observations in the previous one-stage leaching tests. The solids concentration of the leaching tests was increased to about 10% by weight; while other test conditions such as leach

temperature, pressure, and time are the same as POX 7 that is conducted at 230 °C and 100 psi O₂ for 2 hours POX leach and 4 hours of hot cure.

The molybdenum concentration of the tested concentrate samples ranged from 12.2 to 48.1% Mo, which is similar to the previous samples in the previous tests. The concentrations of copper, iron, rhenium of the tested samples are listed in Table 13.5-1.

Table 13.5-1 MAP Test Samples Assay Results

MAP Samples	Cu %	Mo %	Re g/t	Fe%	S ²⁻ %
S-1	3.15	48.1	356	2.41	35.2
S-2	10.7	28.9	239	10.2	31.3
S-3	20.9	12.2	119	20.8	31.9
S-4	12.8	26.3	258	13.0	31.9
S-5	4.73	42.1	410	4.94	33.0

Ten POX and Hot Cure leach tests were completed on the different molybdenum concentrates with the results listed in Table 13.5-2 POX and Alkaline Leach Test Results Table 13.5-2. Similarly, Mo recoveries were high with low molybdenum head grades and low for the high-grade molybdenum concentrate samples. Adding Fe³⁺, Mg and NH₄ to the POX and Hot Cure leach process of the final molybdenum concentrate samples, the dissolution rates were improved to 33 to 45% from 7 to 15%. The result confirmed the possibility of using one-stage POX/hot cure leach for rougher molybdenum concentrates, and the requirement of the two-stage leaching for the high-grade molybdenum concentrates.

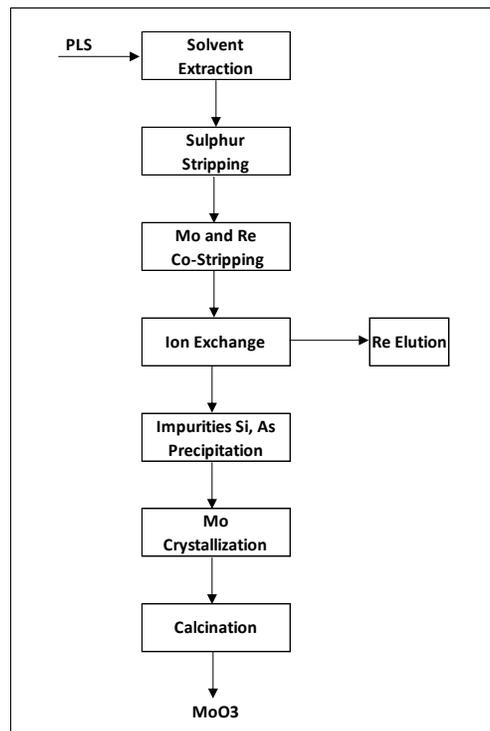
Table 13.5-2 POX and Alkaline Leach Test Results

Test #	Sample #	Head (calc)	POX Diss	Head (calc)	POX Diss	Head (calc)	POX Diss	POX Diss
		Mo%	Mo%	Cu%	Cu%	Re g/t	Re%	Fe%
Ro Conc								
POX24	S-3	10.7	90.9	19.0	99.7	n/a	n/a	26.1
Mo 1st Cl + Scav Conc								
POX23	S-2	27.3	79.9	10.6	99.9	n/a	n/a	89.4
POX25	S-4	24.9	99.2	13.1	100.0	259	99.9	87.3
Final Mo Con								
POX22	S-1	47.1	7.6	3.2	99.6	310	98.3	83.6
POX27	S-1	46.7	15.1	5.9	99.7	319	93.3	91.9
POX28	S-1	46.6	12.4	3.0	99.5	306	n/a	83.2
POX31	S-1	46.0	7.1	2.9	99.6	387	100.0	84.7
POX26	S-5	28.7	45.1	5.9	99.7	354	93.3	91.9
POX29	S-5	38.2	42.1	4.7	99.8	400	99.6	86.1
POX30	S-5	40.0	33.1	3.9	99.7	392	n/a	94.4

13.5.3 Metal Extractions from Pregnant Leach Solution Tests

A series of the major metal extraction steps from the pregnant leach solution (PLS) were tested on a batch scale level by SGS that involve the bulk loading of molybdenum and rhenium via Solvent Extraction (SX), sulphur stripping, bulk stripping of molybdenum and rhenium, rhenium recovery tests of Ion Exchange (IX) and elution, precipitation of silica and arsenic, molybdenum crystallization and calcination to produce MoO_3 . The extraction tests are plotted on Figure 13.5-1 with the major results and observations are summarized as follows.

Figure 13.5-1 Metal Extraction Steps Tested by SGS



After the removal of rhenium and impurities of silica and arsenic, the molybdenum strip liquor was evaporated by boiling off water to crystallize ammonium molybdate $((\text{NH}_4)_2\text{MoO}_4)$. SGS conducted such tests at 75% and 87.5% evaporation rate. The solubility of Mo in this solution at room temperature was found to be about 130 g/L. Two calcinations tests were further conducted to produce molybdenum trioxide (MoO_3) from the ammonium molybdate using a tube furnace by SGS. Table 13.5-3 presents the quality of $(\text{NH}_4)_2\text{MoO}_4$ and MoO_3 .

Table 13.5-3 (NH₄)₂MoO₄ and MoO₃ Analysis Results

Products	Mo %	As %	Si%		Al %	SO ₄ %
75% Evaporation						
(NH ₄) ₂ MoO ₄ Product	57.8	<0.001	<0.07		0.07	0.8
MoO ₃ Product	67.3	<0.001	<0.07		1.59	0.2
87.5% Evaporation						
(NH ₄) ₂ MoO ₄ Product	58.2	<0.001	<0.07		<0.02	0.9
MoO ₃ Product	66.6	<0.001	<0.07		1.45	0.3

13.6 AUXILIARY TESTS

13.6.1 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.

13.7 QUALITY OF CONCENTRATES

The results of the detailed assays obtained on all the variability locked cycle test copper/molybdenum 3rd cleaner concentrates were completed and reported in the 2014 SGS report. Table 13.7-1 shows the major elements distributions. The median concentrations of the potentially payable elements in the final copper/molybdenum concentrates are 27.5% Cu, 15.5 g/t Au, 1.07% Mo, 20.2 g/t Re and 71 g/t Ag.

Table 13.7-1 LCT Cu-Mo Concentrate Major Elements Analysis Results – SGS 2014

Variability Samples	Cu %	Au g/t	Mo %	S %	Fe %	Re g/t	Ag g/t
Average	27.1	16.9	1.26	34.6	29.9	23.7	75
Min	17.6	1.2	0.07	23.5	23.5	1.3	20
Median	27.5	15.5	1.07	34.4	29.9	20.2	71
Max	39.0	52.7	4.82	40.7	34.5	122.0	151

The detailed elemental analysis was also completed on the copper-molybdenum concentrate samples of the variability LCT as reported in the 2014 SGS report. The results indicate that Pebble bulk concentrate will not be problematic in terms of deleterious elements. The assays showed that more than 90% of the 103 variability samples were below the penalty triggers for mercury (Hg), antimony (Sb), arsenic (As), and zinc (Zn), with the exception of 10 samples from illite pyrite and sodic potassic zones.

The elemental analysis of copper concentrates and molybdenum concentrates from the copper/molybdenum separation testwork are listed in Table 13.7-2 and Table 13.7-3. The reported rhenium grade in the LCT molybdenum concentrate ranged from 791 to 832 g/t Re.

Table 13.7-2 LCT Cu Concentrate Major Elements Analysis Results – SGS 2014

	Cu %	Au g/t	Mo %	S%	Fe %	Re g/t	Ag g/t
Illite Pyrite	23.0	10.2	0.026	36.1	31.8	0.4	91
Supergene	29.3	11.4	0.065	33.0	28.9	1.5	104
Sodic Potassic	24.0	8.54	0.011	36.2	33.1	<0.2	37
K-Silicate	24.0	8.41	0.021	36.6	32.9	0.3	39
Commission	21.2	10.6	0.032	35.0	32.1	0.5	80

Table 13.7-3 LCT Mo Concentrate Major Elements Analysis Results – SGS 2014

	Cu %	Au g/t	Mo %	S%	Fe %	Re g/t	Ag g/t
Illite Pyrite	3.94	3.42	42.6	38.5	5.33	791	31.6
Supergene	2.45	3.87	43.7	34.0	3.84	832	23.2
Sodic Potassic	3.71	3.60	43.0	34.9	5.31	830	22.9
K-Silicate	2.53	1.34	50.9	36.7	3.34	n/a	11.1
Commission	1.94	2.12	47.8	35.9	3.37	812	<40

13.8 GEOMETALLURGY

13.8.1 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 department, meaning the mineralogical association of a given metal 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 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 the initial stage of metal introduction that occurred during specific stages of alteration and subsequent redistribution by overprinting alteration types.

Chalcopyrite is the dominant copper mineral in most of the deposit. Bornite is a greatly subordinate component that is most abundant in advanced argillic alteration. Supergene mineralization, in the form of chalcocite and lesser bornite and covellite, forms rims on and partially replaces hypogene chalcopyrite in the near surface portion of the western half of the deposit, where mineralization was exposed subsequent to glaciation (there is no evidence for paleo-supergene effects in the eastern part of the deposit that is located beneath the post-hypogene rocks of the cover sequence). Hypogene pyrite is present in much of the supergene zone where it typically has been partially replaced by the supergene copper minerals. Molybdenum deportment does not vary appreciably across the deposit, and this metal occurs exclusively in the mineral molybdenite. The deportment of silver and palladium has not been studied in detail. Rhenium, as discussed in the Mineralization section above, occurs as a substitution for molybdenum in the matrix of molybdenite, but the potential for spatial and temporal variations in the degree of substitution has not been studied.

Gold has a more variable deportment across the deposit than the other primary metals of economic interest, and this behaviour can be related directly to variations in predicted gold recoveries to different metallurgical products, as determined by metallurgical testwork. Gold occurs mostly as inclusions in chalcopyrite, pyrite, and to a much lesser extent, in silicate alteration minerals. The proportion of gold hosted by chalcopyrite, pyrite, and the silicate alteration minerals varies significantly between volumetric domains that were affected by different types or combinations of hydrothermal alteration (see Gregory et al., 2013, for additional details). The consequence of these differences in gold deportment is that different alteration domains exhibit different degrees of recovery to different processing materials, such as copper concentrates versus pyrite concentrates versus silicate tailings. It is this knowledge of the relationship between hydrothermal alteration, as defined in a three dimensional alteration model for the Pebble deposit, and the specific deportment of gold micro-inclusions that allows the spatial variations in gold recovery across the deposit to be modelled.

13.8.2 Description of Geometallurgical Domains

Hypogene mineralization in the Pebble deposit has been divided into seven geometallurgical domains, the boundaries of which correspond to the distribution of specific alteration types and their combination within the three-dimensional alteration model. The most volumetrically significant geometallurgical domains are the potassic (in some places referred to as K-silicate or potassium silicate) and sodic-potassic domains, whereas the illite-pyrite, QSP (quartz-sericite-pyrite), quartz-pyrophyllite, sericite, and 8431M domains are smaller. Two additional domains occur in the western part of the Pebble deposit

where the sodic-potassic and illite-pyrite domains are overprinted by supergene alteration. These domains are being used to constrain the geometallurgical parameters in the resource block model. Specific metallurgical recoveries have been applied to each geometallurgical domain, as further described below in Section 13.11.2.

Potassic Domain

The potassic 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 minor biotite, and has been variably overprinted by illite. The copper sulphide minerals are dominated by chalcopyrite, accompanied by a subequal concentration of pyrite and, more rarely, traces of sphalerite. 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.

Sodic-Potassic Domain

Material in the sodic-potassic domain is dominated by K-feldspar, quartz, albite and biotite, accompanied by low concentrations of subequal illite and kaolinite. Chalcopyrite is the main copper sulphide mineral and the ratio of pyrite to chalcopyrite is moderate and a bit higher than in the potassic domain. The carbonates siderite and ferroan dolomite are also commonly present. Gold occurs as inclusions in both chalcopyrite and pyrite. It is the dominant geometallurgical domain in the western part of the deposit and extends to depth to the east, below the potassic domain. Supergene mineralization is present in the uppermost part of this domain in the western part of the deposit (see below).

Illite-Pyrite Domain

The mineralogical characteristics of the illite-pyrite domain reflect successive, partial overprints of quartz-sericite-pyrite and later illite alteration on an early stage of well-mineralized sodic-potassic and/or potassic alteration. Illite-pyrite material is dominated by K-feldspar, quartz, illite and biotite. The illite-pyrite domain has a high concentration of pyrite and a high ratio of pyrite to chalcopyrite. This assemblage occurs in the shallow part of the eastern portion of the Pebble West zone and also extends to the east where it replaces potassic alteration below the cover sequence. Supergene mineralization affects the upper part of the illite-pyrite domain in the western part of the deposit that is not concealed by the younger cover sequence (see below). Gold deports as inclusions both within early chalcopyrite that is part of the early sodic-potassic and potassic alteration, and to a greater extent in pyrite that formed during the later alteration overprints. The high clay and pyrite concentrations are expected to lead to processing challenges that could include the increase of reagent consumptions and/or the decrease of a flotation selectivity between copper minerals and pyrite. Additionally, the gold-pyrite association will result in a lower gold recovery to the final copper flotation concentrate compared to the sodic-potassic and potassic geometallurgical domains.

Quartz-Sericite-Pyrite (QSP) Domain

The quartz-sericite-pyrite domain occurs on the north and south margins of the alteration model. This alteration is a late stage overprint around the margins of the deposit and is strongly grade destructive for copper, molybdenum, and gold that originally formed during earlier alteration types. This material is dominated by quartz and sericite, has a very high pyrite concentration, and contains very little chalcopyrite. As a consequence, both grade and recovery of this domain are very low and it would form a part of the normal processing stream.

Quartz-Pyrophyllite Domain

The quartz-pyrophyllite domain is coincident with the distribution of quartz pyrophyllite alteration. It occurs in the easternmost part of the deposit where it has typically overprinted an older zone of potassic alteration with a very high concentration of quartz veins. This material is composed mostly of quartz, sericite, and pyrophyllite. -pyrophyllite assemblage. This domain has high concentrations of both pyrite (average 9.7 wt%) and chalcopyrite (average 3.8 wt%), along with very low concentrations of bornite. Gold mostly occurs as inclusions in chalcopyrite, with lesser amounts in pyrite and silicate alteration minerals. This is the highest grade material in the deposit and has favourable gold deportment, but also has higher clay and pyrite concentrations.

Sericite Domain

The high-grade sericite domain is not to be confused with the very low grade quartz-sericite-pyrite domain. The sericite domain is characterized by quartz, sericite, minor pyrophyllite, and variable concentrations of K-feldspar. This material occurs in two areas within the Pebble East zone. The main and most intense volume of sericite domain occurs south of the ZE fault and forms an envelope to the western side of the quartz-pyrophyllite domain. A second, much weaker and smaller area of sericite domains occurs in the Pebble East zone, just north of the ZE fault. The copper minerals are dominated by chalcopyrite accompanied by trace to minor bornite, digenite and covellite, traces of the arsenic-bearing sulphosalts enargite and tennantite, and trace sphalerite. The pyrite concentration is high but the pyrite to chalcopyrite ratio is moderate due to high copper grade. Gold inclusions occur in both chalcopyrite and pyrite, and to a much lesser extent in bornite and digenite. The domain has high concentrations of both clay and pyrite and variable gold deportment; this may have implications for mineral processing but the high-tenor copper sulphides may yield a higher concentrate grade.

8431M Domain

The 8431M domain is a variant on the potassic domain. It occurs as a small volume of rock in the vicinity of drill holes 8431M and 11527 in the western part of the deposit and is surrounded by the sodic-potassic domain. The material contains abundant biotite and K-feldspar, lesser quartz and illite, and also contains a relatively higher concentration of magnetite similar to that found in altered diorite sills (see above). The copper minerals are dominated by chalcopyrite and the concentration of pyrite is relatively low, yielding a lower than average pyrite to chalcopyrite ratio. The concentration of molybdenite is also very high. Metallurgical tests from hole 8431M have the highest gold recoveries in the western part of the deposit. This is unusual because most of the gold occurs as inclusions in pyrite, but it is believed

that the larger grain size of the gold inclusions results in liberation and therefore higher than expected recovery. Because the 8431M geometallurgical domain is so small, it has been included with the surrounding sodic-potassic geometallurgical domain for modeling purposes.

Supergene Domains

A thin, irregular zone of supergene mineralization of variable thickness extends across the near-surface part of much of the western part of the deposit. The zone is characterized by weak enrichment of copper that manifests partial replacement of hypogene chalcopryrite and rimming of hypogene pyrite by supergene chalcocite and lesser bornite and covellite. Geometallurgically, supergene mineralization is defined as all material with cyanide soluble copper above 20%. Supergene effects overprint the near surface parts of the sodic-potassic and illite-pyrite domains in the western part of the deposit and require consideration as two additional geometallurgical domains.

13.9 METAL RECOVERY PROJECTION

Metal recovery projections of copper, gold, silver and molybdenum were published in 2014 based on the review of 111 variability locked cycle flotation test results on 103 samples. The projections were updated in 2018 to reflect the changes of the proposed processing methods for Pebble deposit, including the exclusion of a cyanide leach process and the implementation of a finer primary grind particle size to improve metal recoveries. The 2018 projections remain the same in this technical report, while a high-level recovery estimate of rhenium has been completed and included.

13.9.1 Metal Projections of Copper, Gold, Silver and Molybdenum – 2014/2018, Tetra Tech

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. In 2018, as secondary gold recovery using cyanide was excluded from the proposed processing methods, the 2014 metal recovery projections were adjusted accordingly.

13.9.1.1 Metal Recovery Projection Basis – 2014/2018, Tetra Tech

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 P₈₀ 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 in 2014

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.

13.9.1.2 Effects of Primary Grind Size on Metal Recoveries

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 Figure 13.9-3.

Figure 13.9-1 The Effect of Primary Grind Fineness of Copper Recovery to Rougher Concentrate

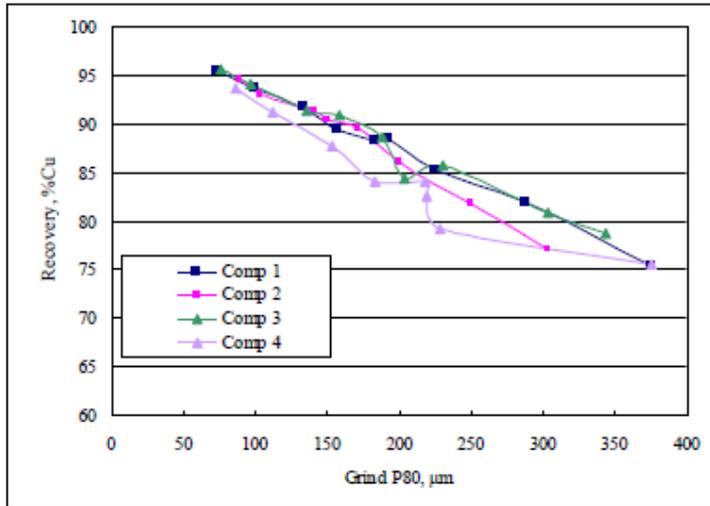


Figure 13.9-2 Effect of Primary Grind Size on Cu, Au and Mo Recovery to Batch Copper Concentrate

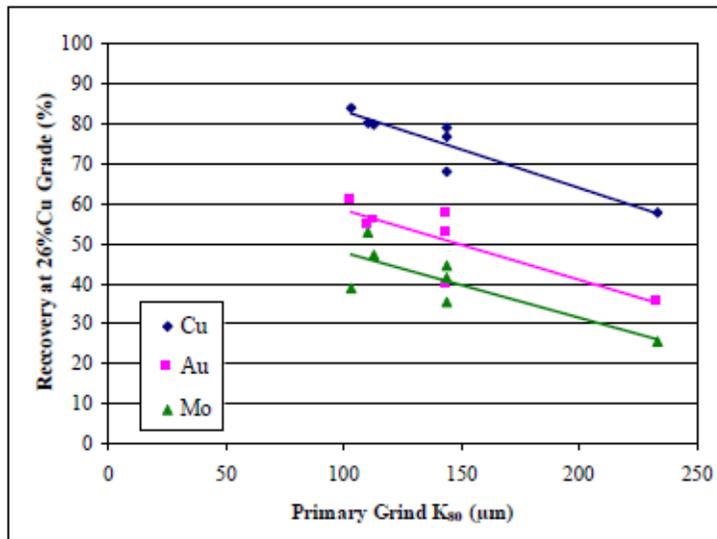
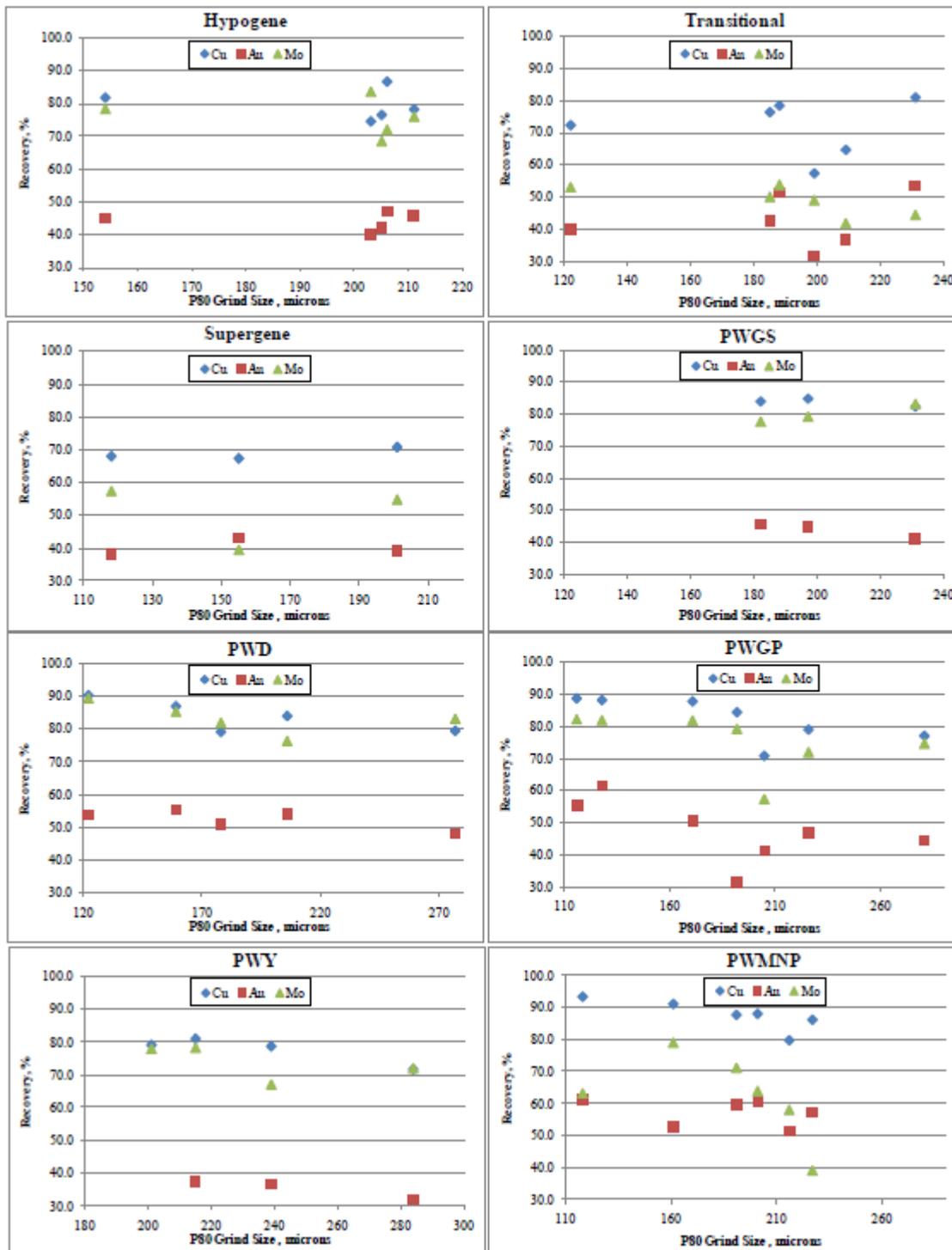


Figure 13.9-3 Cu, Au, and Mo Recovery into a 26% Batch Cu Concentrate



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 Table 13.9-1 to Table 13.9-3. 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.

Table 13.9-1 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

Table 13.9-2 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

Table 13.9-3 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

13.9.2 Metal Recovery Projection Results

The adjusted metal recoveries are presented in Table 13.9-4, 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 P₈₀ of 125 µm.

Table 13.9-4 Projected Metallurgical Recoveries – 2018 Tetra Tech

Domain	Flotation Recovery %			
	Cu Con, 26% Cu			Mo Con, 50% Mo
	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
Potassic	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

13.9.3 Rhenium Recovery Estimate – 2020

Copper-molybdenum porphyry deposits are the world's primary source of rhenium (SME, 2018). The metallurgical test work from 2011 to 2013 on Pebble deposit indicates that significant rhenium can be recovered to the bulk Cu-Mo flotation concentrate and further concentrated into the final molybdenum flotation concentrate. The overall rhenium recovery is determined by the rhenium recovery to the bulk copper-molybdenum concentrate and the separation efficiency of the rhenium into the molybdenum concentrate in the subsequent copper-molybdenum separation stage. The estimated rhenium recovery is about 70.8% on average for all the domains based on the following considerations:

- The available rhenium distributions to the bulk copper/molybdenum concentrates are based on the 10 of the 111 LCT tests on variability samples. The average recovery was calculated as 73.4% representing five of the eight geometallurgical domains.
- The application of a similar separation efficiency of molybdenum as of 92.7% in the copper-molybdenum separation to estimate the rhenium stage recovery, considering the significant linear relationship between the molybdenum and rhenium bulk and circuit recovery test data (Section 13.3.1.2 and 13.3.3).
- The adjustment of the overall rhenium recovery by applying a similar factor for an average recovery increase of 0.5% per 10 µm reduction of primary grind size.

14.0 MINERAL RESOURCE ESTIMATES

14.1 SUMMARY

The Pebble mineral resource estimate presented herein represents an update to the resource estimate completed in 2017 (Gaunt et al, 2018). Additional analyses from stored pulps and from regression analysis have been added to the Pebble drill database for rhenium, so this element is now included the Pebble resource table. No additional drilling has taken place in the vicinity of the resource area since 2013, nor have any additional analyses have been obtained since that time for copper, gold, molybdenum, or silver so the resource grades for these elements and the overall resource tonnage has remained the same.

The current estimate is based on all core holes in the vicinity of the block model extents, completed to the end of 2013. Wireframe domains for the metals, as well as bulk density, were interpreted using geological, structural and alteration data. Descriptive statistics, unique search strategies and geostatistical parameters for block interpolation and resource classification were then developed for each of the modeled domains.

The updated Pebble resource estimate is presented in Table 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%.

Table 14.1-1 Pebble Deposit Mineral Resource Estimate August 2020

Cutoff CuEq %	CuEq	Tonnes	Cu (%)	Au (g/t)	Mo (ppm)	Ag (g/t)	Re (ppm)	Cu Blb	Au Moz	Mo Blb	Ag Moz	Re (Kkg)
Measured												
0.3	0.65	527,000,000	0.33	0.35	178	1.7	0.32	3.83	5.93	0.21	28.1	167
0.4	0.66	508,000,000	0.34	0.36	180	1.7	0.32	3.81	5.88	0.20	27.4	163
0.6	0.77	279,000,000	0.40	0.42	203	1.8	0.36	2.46	3.77	0.12	16.5	100
1.0	1.16	28,000,000	0.62	0.62	302	2.3	0.52	0.38	0.56	0.02	2.0	14
Indicated												
0.3	0.77	5,929,000,000	0.41	0.34	246	1.7	0.41	53.58	64.81	3.21	316.4	2,443
0.4	0.82	5,185,000,000	0.45	0.35	261	1.8	0.44	51.42	58.35	2.98	291.7	2271
0.6	0.99	3,455,000,000	0.55	0.41	299	2.0	0.51	41.88	45.54	2.27	221.1	1748
1.0	1.29	1,412,000,000	0.77	0.51	343	2.4	0.60	23.96	23.15	1.07	109.9	853
Measured + Indicated												
0.3	0.76	6,456,000,000	0.40	0.34	240	1.7	0.41	56.92	70.57	3.42	344.6	2,615
0.4	0.81	5,693,000,000	0.44	0.35	253	1.8	0.43	55.21	64.06	3.18	320.3	2,431
0.6	0.97	3,734,000,000	0.54	0.41	291	2.0	0.50	44.44	49.22	2.40	237.7	1,848
1.0	1.29	1,440,000,000	0.76	0.51	342	2.4	0.60	24.12	23.61	1.08	112.0	867
Inferred												
0.3	0.55	4,454,000,000	0.25	0.25	226	1.2	0.36	24.54	35.80	2.22	170.4	1,603
0.4	0.68	2,646,000,000	0.33	0.30	269	1.4	0.44	19.24	25.52	1.57	119.1	1,154
0.6	0.89	1,314,000,000	0.48	0.37	292	1.8	0.51	13.90	15.63	0.85	75.6	673
1.0	1.20	361,000,000	0.68	0.45	377	2.3	0.69	5.41	5.22	0.30	26.3	251

Notes:

David Gaunt, P.Geol., a qualified person who is not independent of Northern Dynasty is responsible for the estimate.

Copper equivalent (CuEQ) calculations use metal prices: US\$1.85 /lb for Cu, US\$902 /oz for Au and US\$12.50 /lb for Mo, and recoveries: 85% Cu, 69.6% Au, and 77.8% Mo (Pebble West zone) and 89.3% Cu, 76.8% Au, 83.7% Mo (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.

The mineral resource estimate is constrained by a conceptual pit shell that was developed using a Lerchs-Grossman algorithm and is based in the following parameters: 42 degree pit slope; metal prices and recoveries of US\$1,540.00 /oz and 61% Au, US\$3.63 /lb and 91% Cu, US\$20.00 /oz and 67% Ag and US\$12.36 /lb and 81% Mo, respectively; a mining cost of US\$1.01/ ton with a US\$0.03 /ton/bench increment and other costs (including processing, G&A and transport) of US\$6.74 /ton.

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.

The terms "Measured Resources", "Indicated Resources" and "Inferred Resources" are recognized and required by Canadian regulations under 43-101. The SEC has adopted amendments to its disclosure rules to modernize the mineral property disclosure required for issuers whose securities are registered with the SEC under the US Securities Exchange Act of 1934, effective February 25, 2019, that adopt definitions of

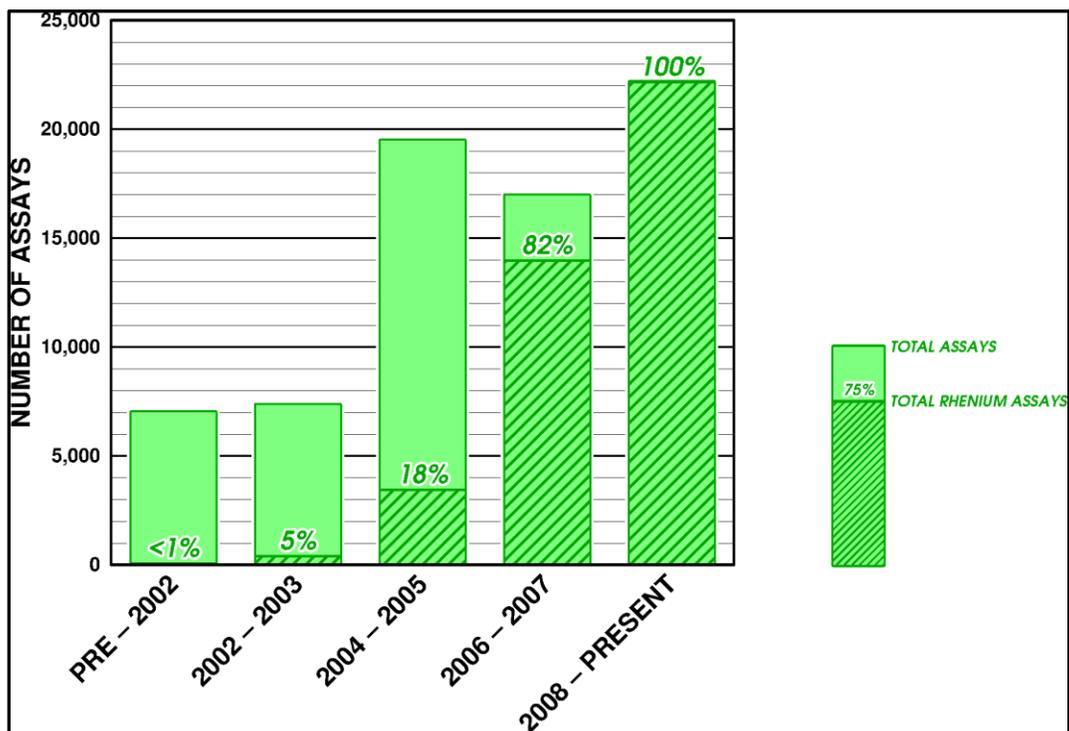
the terms and categories of resources which are "substantially similar" to the corresponding terms under Canadian Regulations in 43-101. Accordingly, there is no assurance any mineral resources that we may report as Measured Resources, Indicated Resources and Inferred Resources under 43-101 would be the same had we prepared the resource estimates under the standards adopted under the SEC Modernization Rules. Investors are cautioned not to assume that all or any part of mineral deposits in these categories will ever be converted into reserves. In addition, Inferred Resources have a great amount of uncertainty as to their economic and legal feasibility. Under Canadian rules, estimates of Inferred Resources may not form the basis of feasibility or pre-feasibility studies, or economic studies except for a Preliminary Economic Assessment as defined under 43-101.

14.2 DEVELOPMENT OF RHENIUM DATABASE FOR ESTIMATION

14.2.1 Introduction

As shown in Figure 14.2-1, rhenium assays did not become a standard part of the drill hole assay program until 2008. This leaves slightly less than half (45%) of the drill-hole data base with no direct measurement of rhenium in the Pebble Project area. Spatially, the area deficient in rhenium analyses is located primarily in the western portion of the Pebble deposit.

Figure 14.2-1 Growth in the percentage of drill-hole sample intervals with rhenium assays.



With rhenium now recognized as a strategic commodity that should be included in the inventory of revenue-producing metals produced as by-products during copper-molybdenum extraction, it is important that the resource block model incorporates a reliable prediction of rhenium grade for every potential ore block.

The problem of missing rhenium analyses can be overcome by assigning reliable predictions of grades to any drill-hole interval that is missing a direct measurement of rhenium. Such predictions can be made by developing a regression equation based on a correlated variable. In the case of Pebble this approach is viable due to the extraordinarily strong correlation between rhenium and molybdenum, with the latter having been assayed in 99% of the drill-hole sample intervals. This approach is not new, in the mining industry there are numerous examples of grade prediction by regression for base metals, and it is also very often employed to predict uranium grades from gamma logs, as described in the CIM's Best Practice Guideline (CIM, 2003).

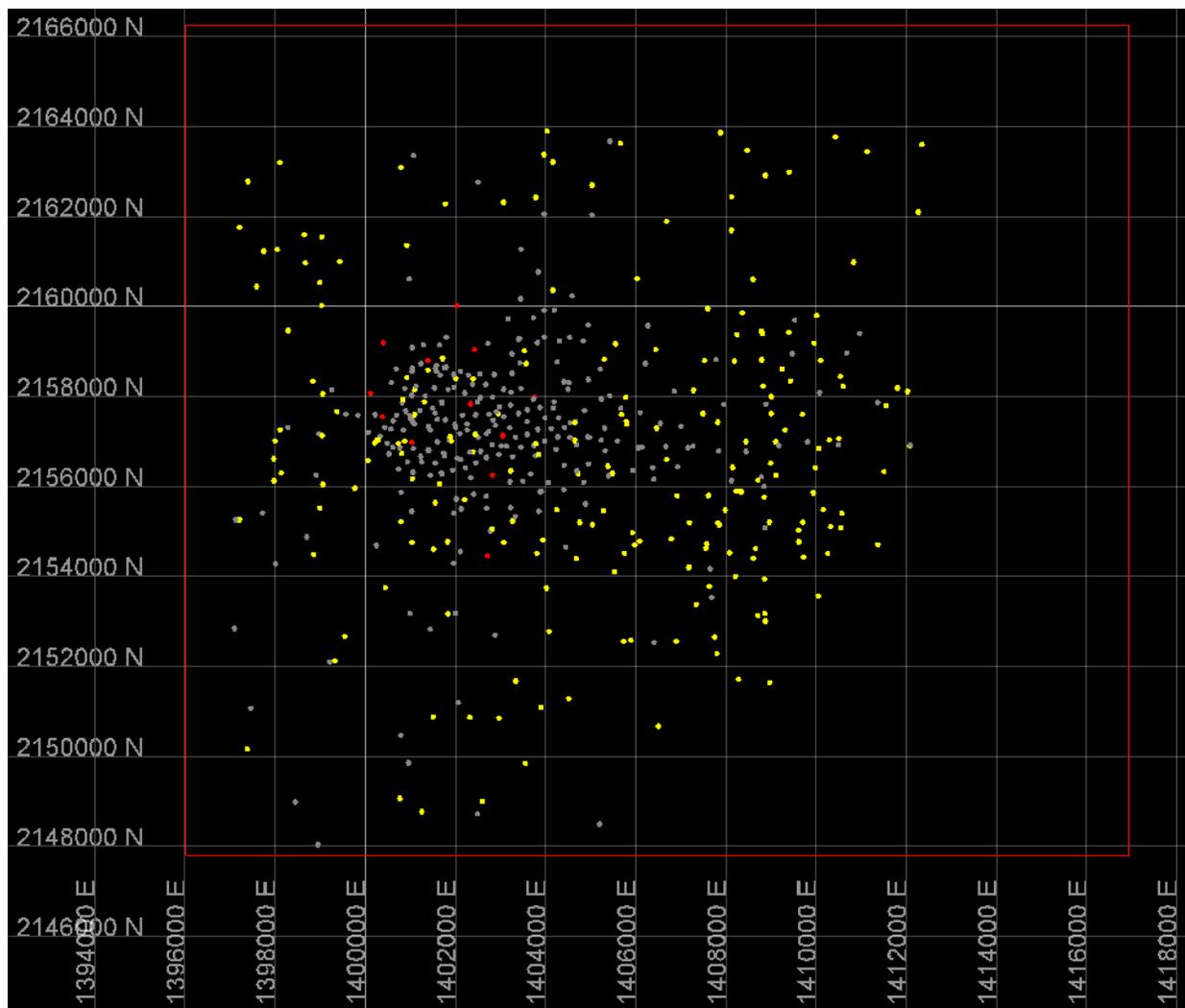
14.2.2 Data Used to Develop the Regression Equation

The data base used for this study includes assays for 72,873 drill-hole sample intervals from the Pebble Project, dating back to 1988, 39,936 of which have rhenium assays. To ensure that the rhenium predictions are most accurate for material above the resource threshold of 0.3% CuEq, the data used for the regression study did not include any drill-hole sample intervals where $\text{CuEq} < 0.3\%$. This reduces the number of sample intervals to 18,554.

A few of the multi-element ICP assays were done using an aqua regia digestion to put the metals into solution. For some elements, aqua regia results in only a partial digestion. A four-acid digestion with nitric, perchloric, hydrofluoric and hydrochloric acids breaks down most silicate and oxide minerals, allowing for near-total analyses of most elements. Since over 99.9% of the $\text{CuEq} > 0.3\%$ intervals were analyzed use a four-acid digestion, the very few that were done with an aqua regia digestion were dropped, leaving 18,536 sample intervals for the regression study.

In 2020, to better inform the regression analysis, approximately 1000 additional sample pulps were retrieved and analysed for rhenium. These additional samples were selected based on a range of molybdenum grades and to provide spatial coverage in areas lacking rhenium data, specifically in the western part of the Pebble deposit area (Figure 14.2-2). Of the 1000 additional rhenium analyses, 50 were intentionally excluded from the data base so that they could be used to check the reliability of the regression equation after it had been developed (Srivastava, 2020).

Figure 14.2-2 Block Model (red line); DDH Collars and Re analyses: Lacking (grey), Existing (yellow), 2020 Pulps (red)



14.2.3 Data Analysis

Table 14.2-1 shows the correlation coefficients between Re and each of 21 possible predictors. The only strong correlation is with molybdenum: +0.87. The correlations between Re and several of the other elements (barium, potassium, lead, strontium, zinc) are not significantly different from zero; and for the others, their correlations with rhenium are very weak at best.

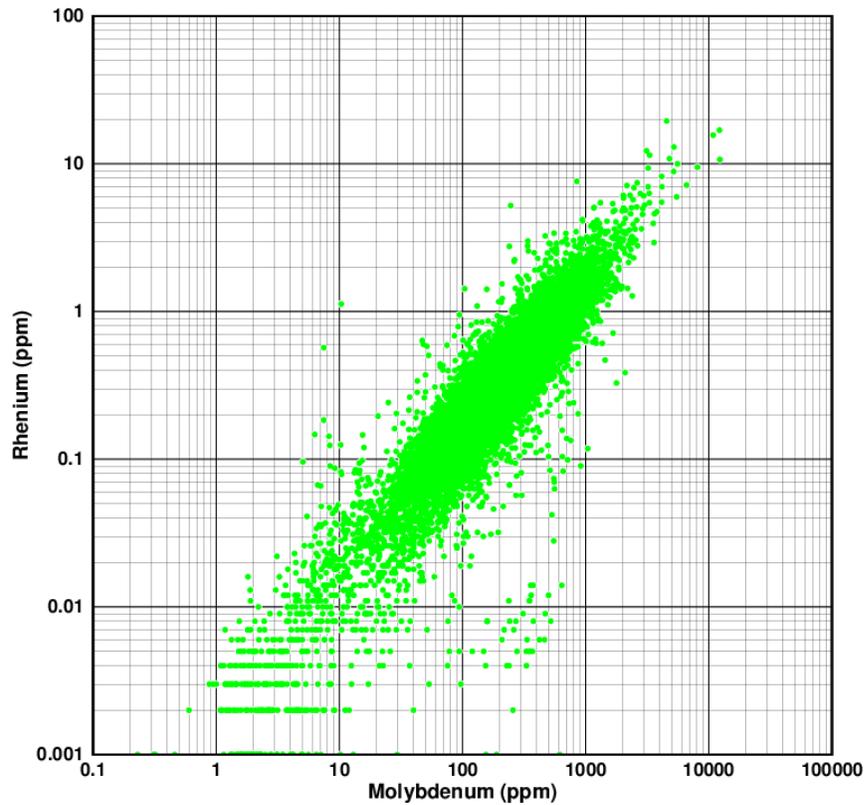
Table 14.2-1 Correlation coefficients between rhenium and other elements

Ag	Al	As	Ba	Ca	Cd	Co
+0.02	+0.02	+0.02	0.00	-0.09	-0.02	-0.07
Cr	Cu	Fe	K	Mg	Mn	Mo
-0.04	+0.16	-0.14	0.00	-0.12	-0.13	+0.87
Na	Ni	Pb	Sb	Sr	V	Zn
-0.08	-0.07	-0.01	-0.02	0.00	-0.10	0.00

Figure 14.2-3 shows a scatterplot of rhenium versus molybdenum on a log-log scale. The linear relationship between the logarithms of the two elements results in the regression equation having the following form when expressed in terms of the raw, untransformed variables (with both measured in units of parts-per-million):

$$Re = 0.002269 \cdot Mo^{0.951}$$

Figure 14.2-3 Rhenium Versus Molybdenum

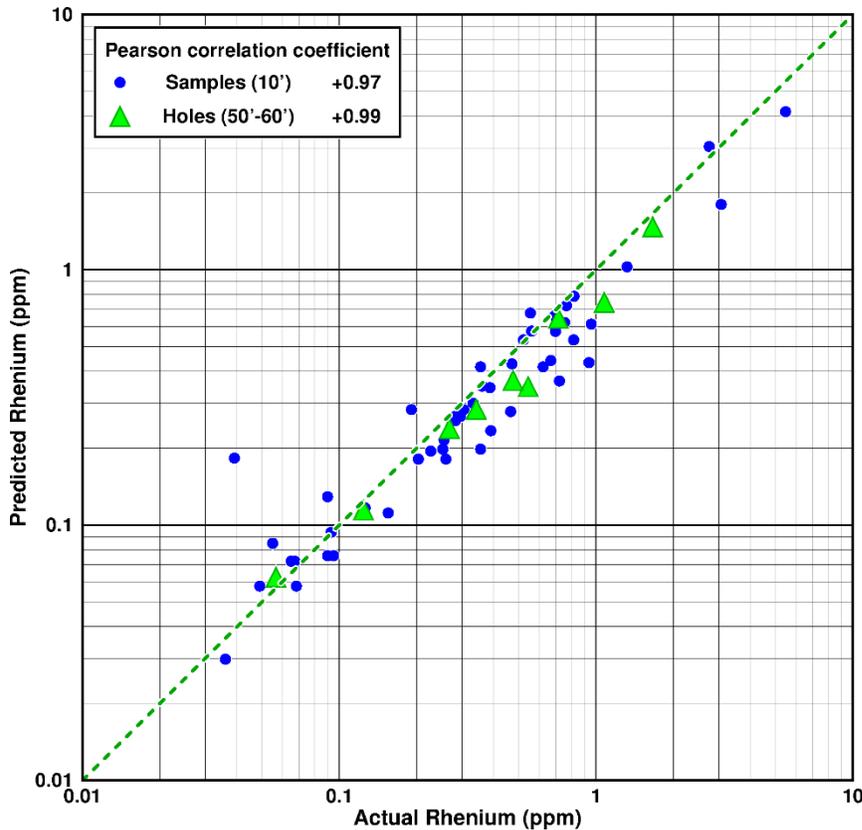


14.2.4 Validation

Subsequent to the development of the regression formula, rhenium assays for the 50 withheld samples were provided so that the reliability of the prediction could be assessed using data that had not played any role in the development of the regression equation (Srivastava, 2020).

Figure 14.2-4 shows the rhenium grades predicted by the regression equation versus the rhenium assays actually reported by the lab.

Figure 14.2-4 Rhenium predictions versus actual rhenium assays for withheld validation samples



The blue dots in Figure 14.2-4 are the 50 withheld validation sample assays from the initial data base. For these 50 samples, there is a small bias, with the predicted rhenium values being slightly conservative at about 15% lower than the actual assays. The correlation between the actual assays and the predictions is an excellent +0.97.

For the purpose of grade estimation into the block model, the reliability of the rhenium predictions is actually better than the blue dots in Figure 14.2-4 suggest. Each of the blue dots corresponds to an assay from a 10' interval in a drill-hole, a volume much smaller than the 75 ft x 75 ft x 50 ft blocks used in the resource block model. Predictions for small volumes are always more uncertain than predictions made for larger volumes. In order to test the reliability of the rhenium predictions for larger volumes, the 50 validation samples were intentionally chosen in consecutive runs that were 50 ft to 60 ft in length.

Table 14.2-2 shows the 50 validation samples and their grouping into nine consecutive runs. The green triangles on Figure 14.2-4 show the comparison between predicted and actual rhenium at the 50 ft to 60 ft scale, approximately the height of resource blocks. The correlation coefficient, which was excellent at the 10 ft scale, is an even stronger +0.99 at the scale closer to the size of resource blocks.

Table 14.2-2 Predicted and actual rhenium for 50 withheld validation samples, at 10 ft scale and at 50 ft-

Hole ID	From (feet)	To (feet)	Length (feet)	Re-actual (ppm)	Re-predicted (ppm)	Re-actual (ppm)	Re-predicted (ppm)
5319M	312	322	10	0.253	0.198	0.124	0.114
5319M	322	332	10	0.093	0.094		
5319M	332	342	10	0.095	0.076		
5319M	342	352	10	0.090	0.076		
5319M	352	362	10	0.090	0.129		
4257	299	309	10	0.355	0.198	0.341	0.283
4257	309	319	10	0.260	0.181		
4257	319	329	10	0.691	0.661		
4257	329	339	10	0.305	0.283		
4257	339	349	10	0.155	0.111		
4257	349	359	10	0.282	0.266		
4217	199	209	10	0.958	0.612	0.475	0.368
4217	209	219	10	0.256	0.215		
4217	219	229	10	0.191	0.283		
4217	229	239	10	0.332	0.300		
4217	239	249	10	0.818	0.531		
4217	249	259	10	0.296	0.266		
4203	268	278	10	0.360	0.350	1.662	1.470
4203	278	288	10	5.470	4.160		
4203	288	298	10	0.555	0.677		
4203	298	308	10	0.203	0.181		
4203	308	318	10	0.622	0.416		
4203	318	328	10	2.760	3.038		
4195	99	117	18	0.720	0.367	1.076	0.745
4195	117	129	12	3.070	1.802		
4195	129	139	10	1.320	1.027		
4195	139	149	10	0.521	0.531		
4195	149	169	20	0.355	0.416		
3135	448	458	10	0.065	0.072	0.057	0.062
3135	458	468	10	0.068	0.058		
3135	468	478	10	0.049	0.058		
3135	478	488	10	0.067	0.072		
3135	488	498	10	0.036	0.030		
3135	498	508	10	0.055	0.085		
3104	128	138	10	0.039	0.183	0.268	0.238
3104	138	148	10	0.227	0.195		
3104	148	158	10	0.283	0.256		
3104	158	168	10	0.126	0.117		
3104	168	178	10	0.667	0.441		
3104	468	479.5	11.5	0.938	0.433	0.544	0.348
3104	479.5	488	8.5	0.465	0.278		
3104	488	498	10	0.389	0.234		
3104	498	508	10	0.470	0.428		
3104	508	518	10	0.386	0.345		
3082	349	359	10	0.821	0.787	0.714	0.644
3082	359	369	10	0.561	0.575		
3082	369	379	10	0.703	0.638		
3082	379	389	10	0.695	0.573		
3082	389	401.9	12.9	0.754	0.622		

The results of the blind, hindsight validation study confirm that the following regression equation:

$$Re=0.002269 \cdot Mo^{0.951}$$

produces excellent predictions of rhenium at the scale of the sample interval and even better predictions at the scale of the resource blocks. Even though there is a small bias in the predictions for the 50 samples chosen for the validation study, it is slight and it is on the conservative side.

The regression equation was used to populate missing rhenium analyses into the drill database and these values along with the existing rhenium results were used to estimate rhenium into the Pebble block model.

14.3 GEOLOGICAL INTERPRETATION FOR ESTIMATION

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. 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, for the purpose of resource estimation domains were developed for each of the five metals.

These domains are defined by deposit orientation, geology 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; this lower-grade zone underlies both western and eastern parts of the deposit. East of the east-west divide the higher-grade zone is divided into a north and a south domain by the ZE Fault. 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. The domaining developed for molybdenum was used for rhenium estimation given the very high statistical and spatial correlation between these two metals.

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 14.5.

The above described domains are tabulated in Table 14.3-1.

As a general statement domain code 40 will identify lower grade portions of the deposit, domain code 41 will identify upper, higher grade portions in the western half of the deposit, whereas domain codes 42 and 43 will identify northern and southern quadrants respectively in the eastern half of the deposit.

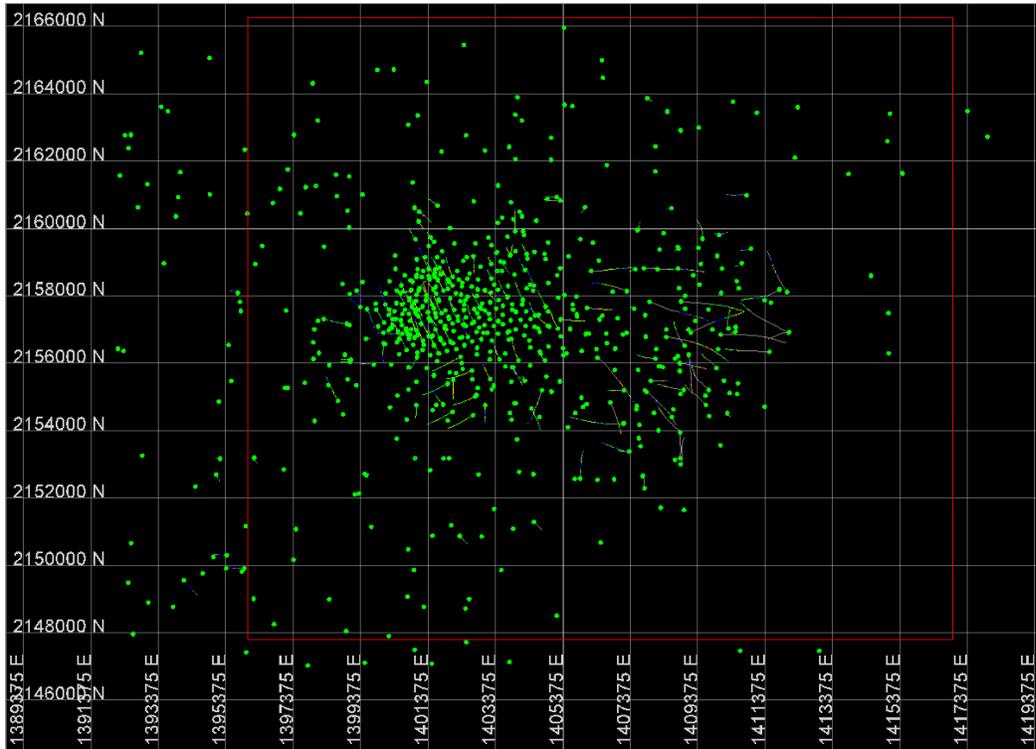
Table 14.3-1 Pebble Deposit Metal Domains

Domain	Code	Description
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/Re low grade	40	Above 70ppm cap
Mo/Re high grade	41	Below 70ppm cap west
Mo/Re high grade Northeast	42	Above 70ppm cap, east part north of ZE fault
Mo/Re high grade Southeast	43	Above 70ppm cap, east part south of ZE fault

Separate variables were set up in the block model for each of the metals, each metal domain and for bulk density (noted as SGo to SG₃ and SG₁₀ in Section 14.5). 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.

The distribution of drill holes relative to the extent of the block model is shown in Figure 14.3-1.

Figure 14.3-1 Pebble Deposit Plan View of Drill Holes and Block Model Extent (red rectangle)



14.4 EXPLORATORY DATA ANALYSIS

14.4.1 Assays

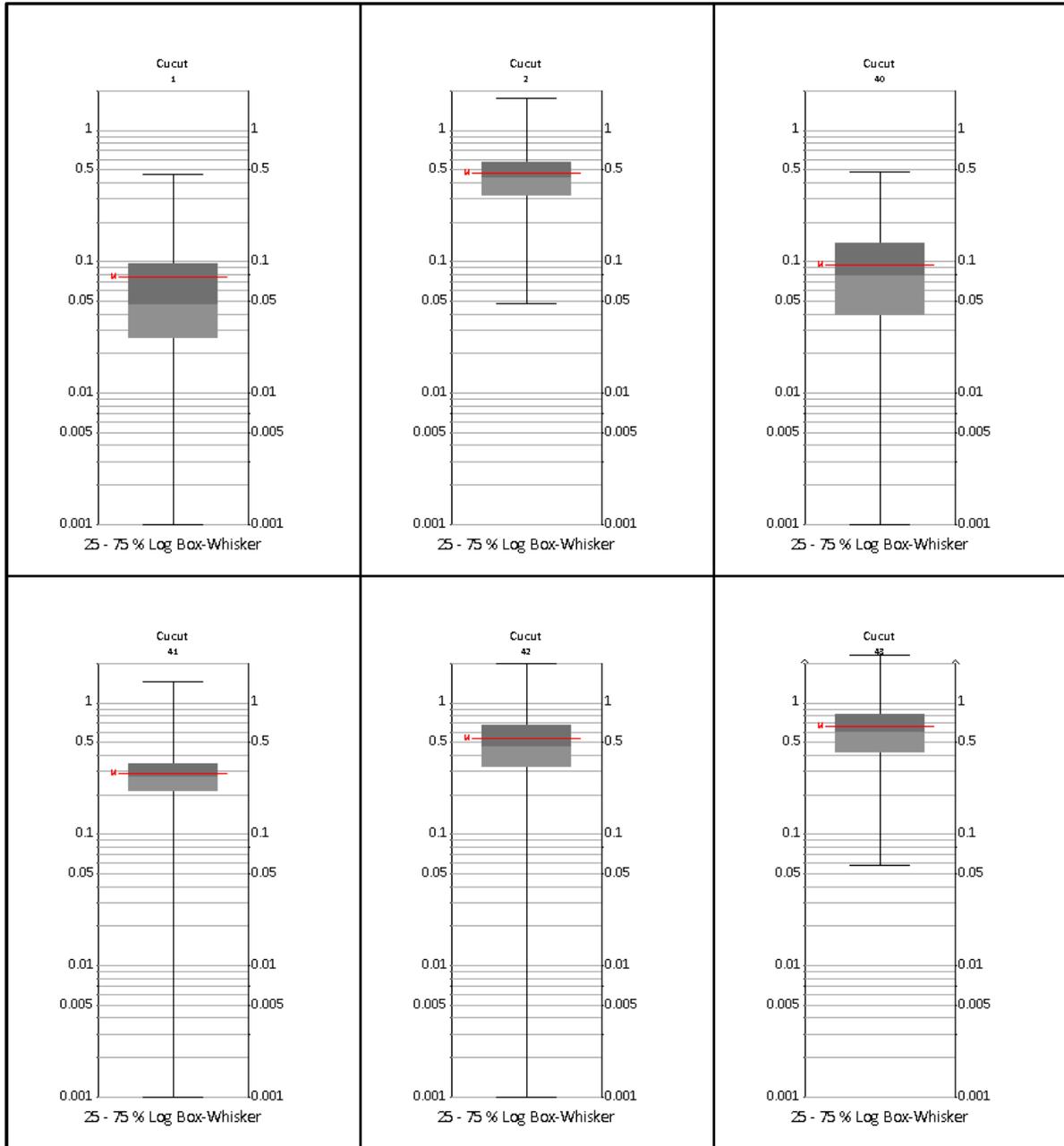
Global descriptive statistics for all non-zero copper, gold, silver, molybdenum, and rhenium assays are presented in Table 14.4-1.

Table 14.4-1 Pebble Deposit assay Database Descriptive Global Statistics

Statistic (Non-zero)	Length (ft)	Ag (ppm)	Au (g/t)	Cu (%)	Mo (ppm)	Re (ppm)
Mean	9.97	1.57	0.32	0.33	191.3	0.33
Median	10.00	1.00	0.23	0.26	130	0.22
Standard Deviation	1.86	5.02	1.50	0.31	298.26	0.49
Coefficient of Variation	0.19	3.20	4.63	0.94	1.56	1.49
Kurtosis	23.31	30529	41613	28.36	2,455	1285
Skewness	2.1	155.3	189.9	2.9	29.00	20.26
Minimum	0.001	0.1	0.001	0.001	0.20	0.001
Maximum	55	1030	334.8	9.29	32200	43.93
Count	59105	58876	59114	58912	59114	58093

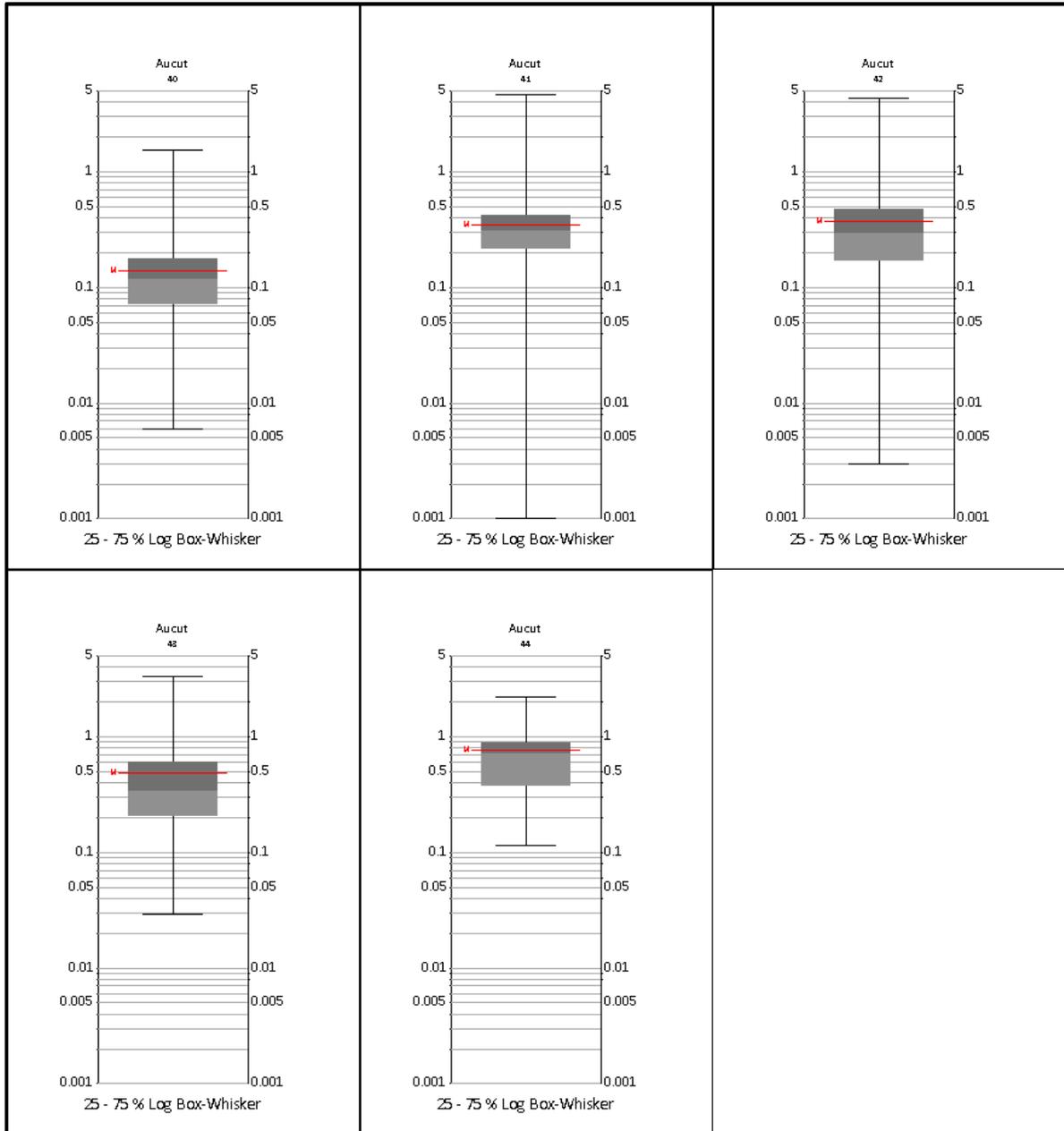
Descriptive statistics were generated for each of the metal domains and these are summarized graphically as box-and-whisker plots in Figure 14.4-1 to Figure 14.4-5.

Figure 14.4-1 Pebble Deposit Copper Assay Domain Box-and-Whisker Plots



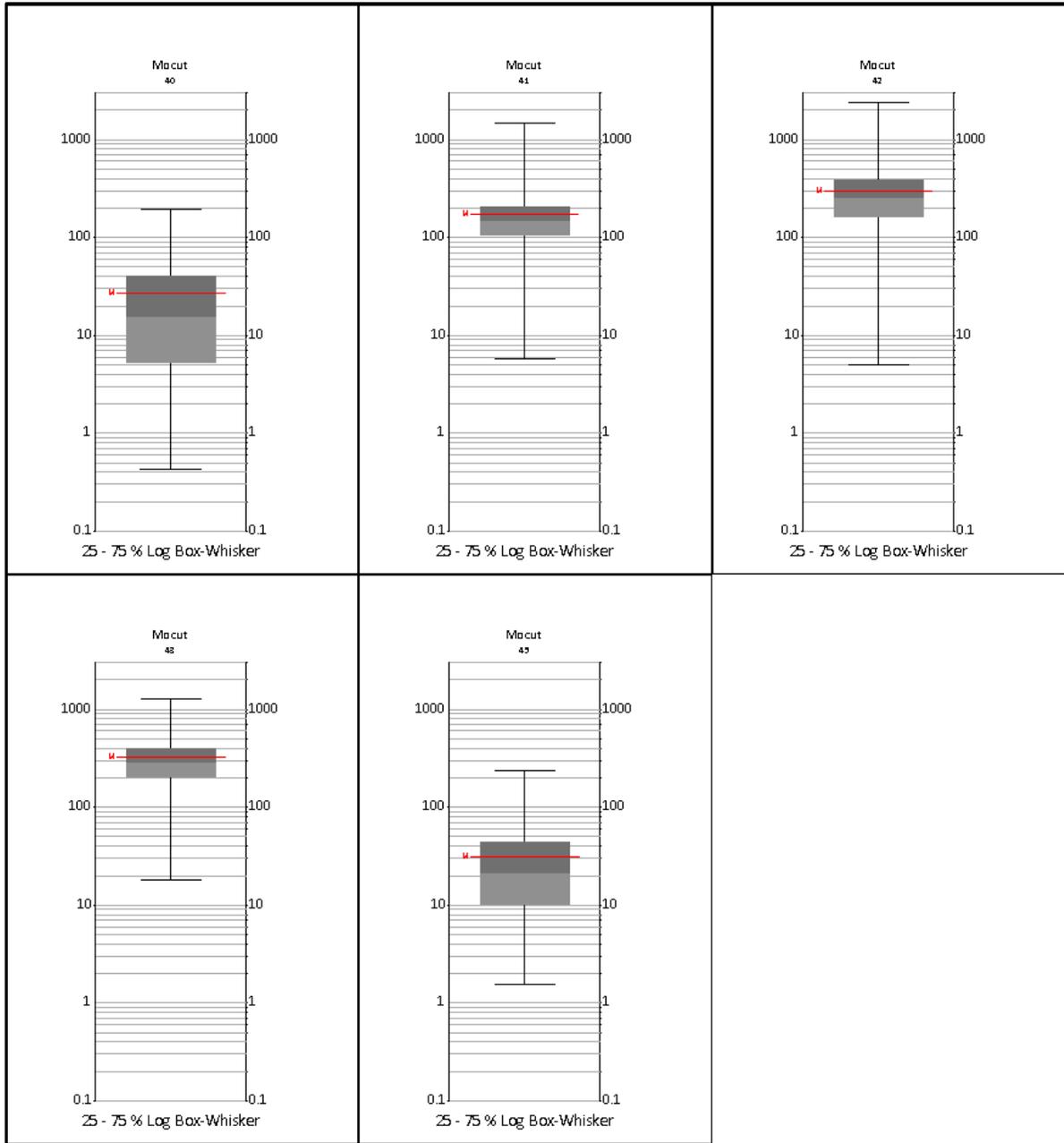
Note: M = arithmetic mean

Figure 14.4-2 Pebble Deposit Gold Assay Domain Box-and-Whisker Plots



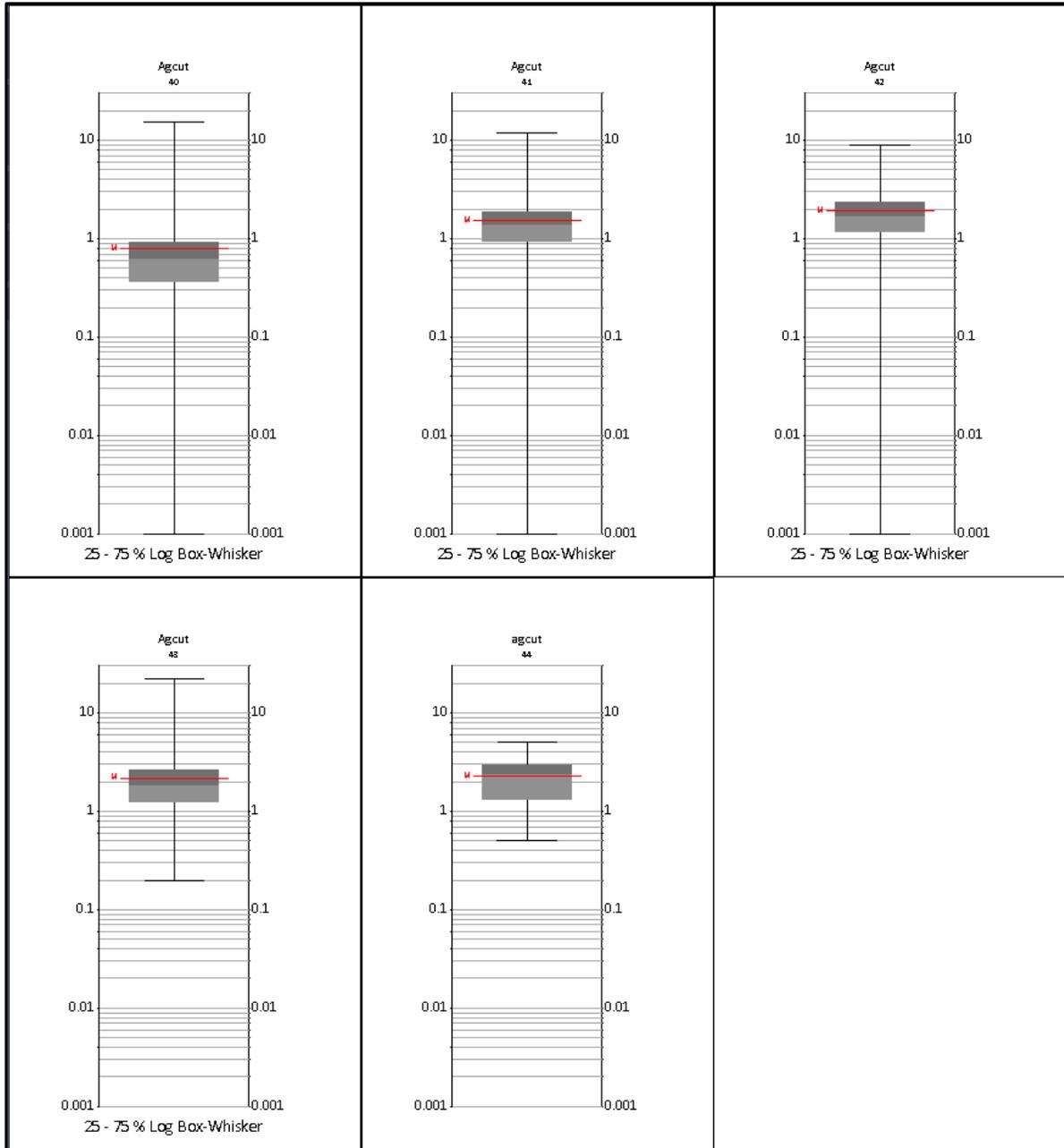
Note: M = arithmetic mean

Figure 14.4-3 Pebble Deposit Molybdenum Assay Box-and-Whisker Plots



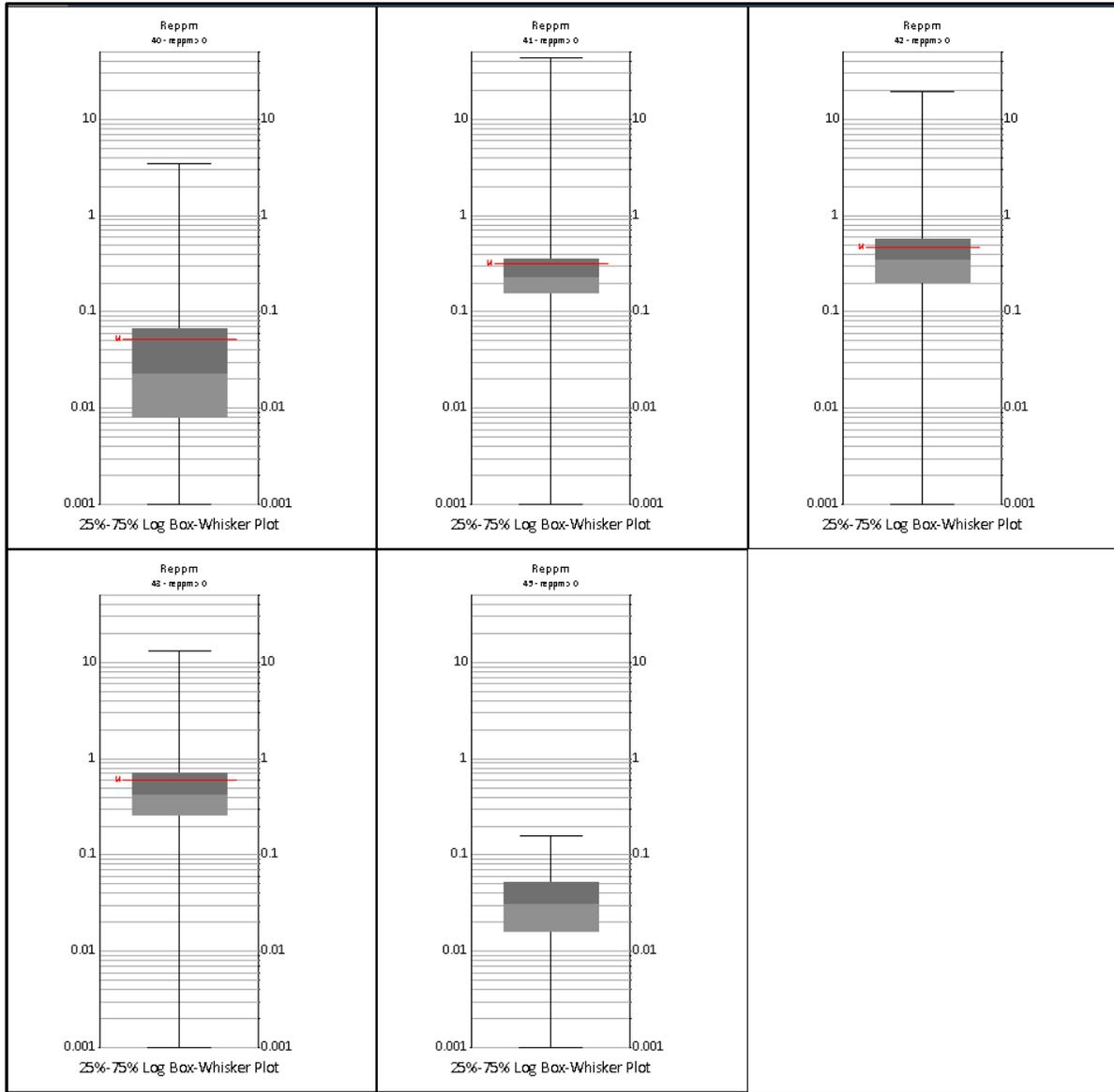
Note: M = arithmetic mean

Figure 14.4-4 Pebble Deposit Silver Assay Box-and-Whisker Plots



Note: M = arithmetic mean

Figure 14.4-5 Pebble Deposit Rhenium Assay Box-and-Whisker Plots



As described in Section 14.3 there are four basic domains for copper, gold, molybdenum, silver and rhenium, plus additional leach and supergene domains for copper. A north-south *soft* boundary separates the flat-lying western portion of the deposit from the gently east-dipping eastern portion of the deposit and it is for this reason that the deposit is broadly divided into east and west halves despite physical continuity. The eastern portion of the deposit is divided into northern and southern quadrants by an east-west fault (the ZE fault) which always defines a *hard* boundary between these two zones.

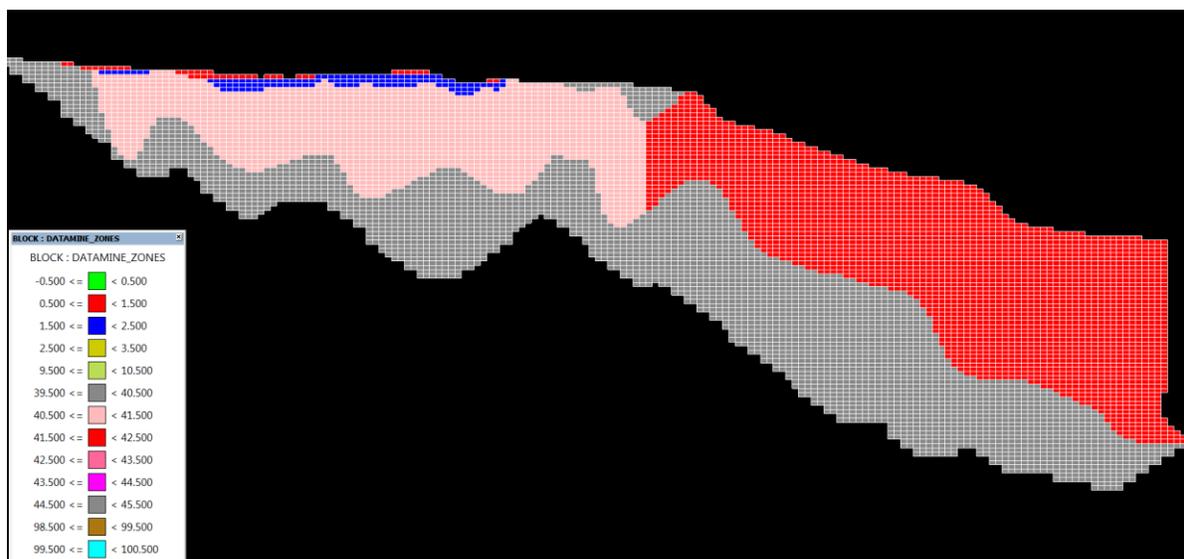
For copper, gold, and silver the west half of the deposit has a flat lying, near surface high-grade domain (4₁) which is underlain by a low-grade domain (4₀). As indicated on the box-and-whisker plots (Figure

14.4-1, Figure 14.4-2, Figure 14.4-4) there is a marked difference in mean grades for these zones and, as such, these domains are separated by a planar, gently east-dipping *hard* boundary that extends into the eastern portion of the deposit beneath the northeast and southeast hypogene domains.

For molybdenum and rhenium the west half of the deposit has a thin, flat lying near surface low grade domain (40) which is underlain by a higher-grade domain (41) as shown by the grades in the box-and-whisker plots (Figure 14.4-3 and Figure 14.4-5). These domains are separated by a planar, flat lying *hard* boundary that extends into the eastern portion of the deposit into the upper reaches of the northeast and southeast hypogene domains.

The box-and-whisker plots also indicate that the fault-bounded domains (42, 43) have similar average grades for all metals however their separation into domains by a *hard* boundary is required due the displacement along the ZE fault plane. 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 14.4-6. 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 14.4-6 Pebble Deposit Copper Grade Domains



14.4.2 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 Table 14.4-2.

Table 14.4-2 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
40	Re - Below 70ppm cap	ppm	0.7
41	Re - Above 70ppm cap west	ppm	3.0
42	Re - Above 70ppm cap, north of ZE fault	ppm	3.9
43	Re - Above 70ppm cap, south of ZE fault	ppm	5.8

14.4.3 Composites

Compositing to a common length overcomes the influence of sample length on grade weighting 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 Table 14.4-3.

Table 14.4-3 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
Re (ppm)	11,914	0.32
Bulk Density (g/cm ³)	9,830	2.62

14.5 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; hence were employed directly in the interpolation process. 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.

14.6 SPATIAL ANALYSIS

The Pebble variography and search ellipse parameters are presented in Table 14.6-1 and Table 14.6-2, respectively.

Table 14.6-1 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
Re40	0.20	0.07	0.73	150	150	120	1500	900	700
Re41	0.27	0.31	0.42	160	260	325	900	700	575
Re42	0.29	0.20	0.51	400	400	400	1200	1200	1100
Re43	0.38	0.05	0.57	300	300	300	1700	1700	850
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

Table 14.6-2 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
Re40	79.0	-7.0	-19	1500	900	700
Re41	340	0	0	900	700	575
Re42	324	29	-78	1200	1200	1100
Re43	60	0	-80	1700	1700	850
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

14.7 RESOURCE BLOCK MODEL

The block model parameters are set out in Table 14.7-1.

Table 14.7-1 Pebble Deposit 2020 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.

14.8 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 Table 14.6-1), 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 Table 14.8-1.

Table 14.8-1 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 zone 42, 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 zone 42, 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
Re40	Mo zone 40
Re41	Mo zone 41, 42, 43
Re42	Mo zone 42, 41
Re43	Mo zone 43, 41

14.9 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 Table 14.9-1.

Table 14.9-1 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	

14.10 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.

14.11 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. Neither silver nor rhenium grades were estimated prior to 2014 and 2020 respectively; therefore, to permit a direct comparison between previous resource estimates, neither metal was included in the current 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:

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

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

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

Where:

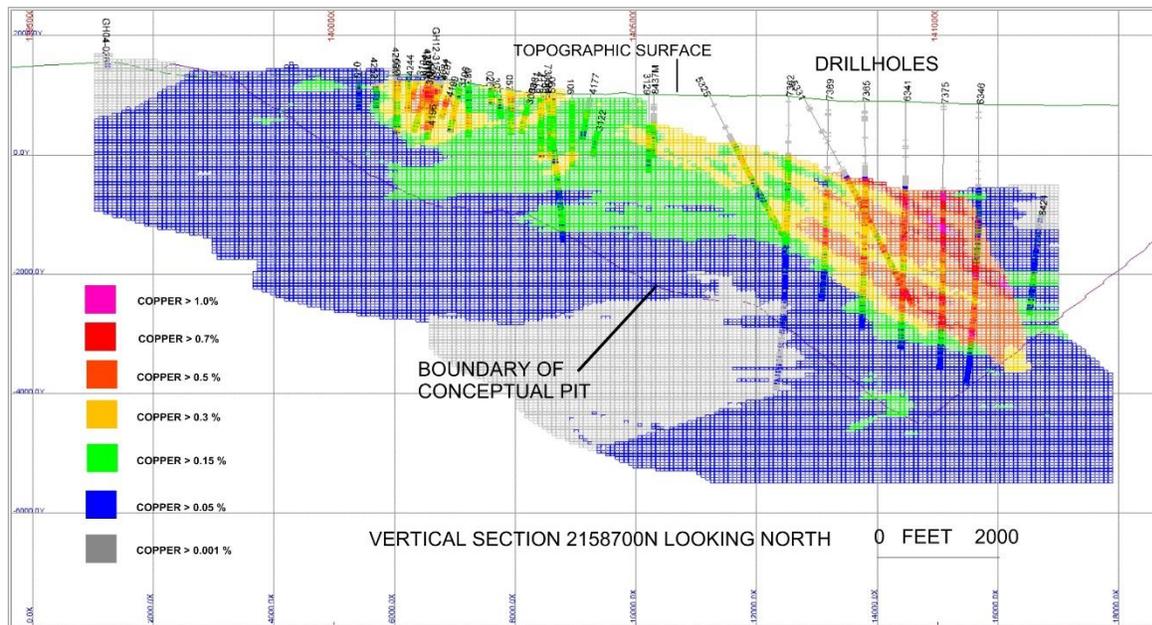
- Pebble West Au recovery = 69.6%;
- Pebble East Au recovery = 76.8%;
- Pebble West Cu recovery = 85%;
- Pebble East Cu recovery = 89.3%;
- Pebble West Mo recovery = 77.8%;
- Pebble East Mo recovery = 83.7%;
- Cu price = \$1.85/lb;
- Au price = \$902/oz;
- Mo price = \$12.50/lb;
- all metal prices are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

14.12 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 14.12-1 shows the correlation between block and composite copper grades for vertical section 2158700 N.

Figure 14.12-1 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 swath plot analysis in which the variation in metal grade for both estimated blocks and informing samples is compared along a nominated section. The comparison for copper, gold, molybdenum and rhenium presented in Figure 14.12-2 to Figure 14.12-5 shows that there is reasonable agreement between the two.

Figure 14.12-2 Copper Swath Plot at 2157000N

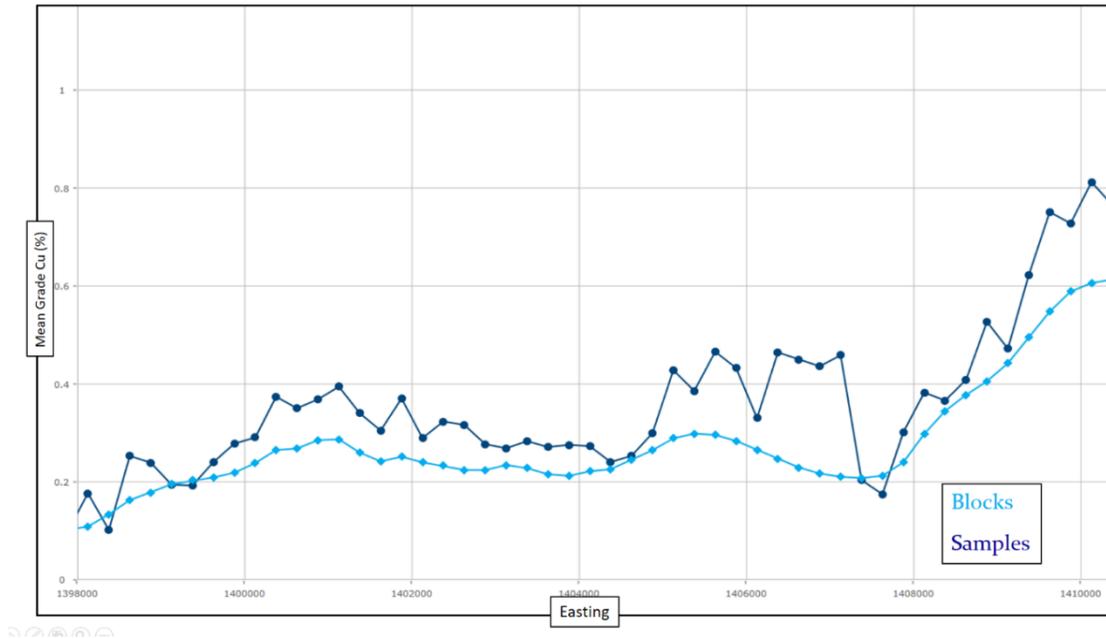


Figure 14.12-3 Gold Swath Plot at 2157000N

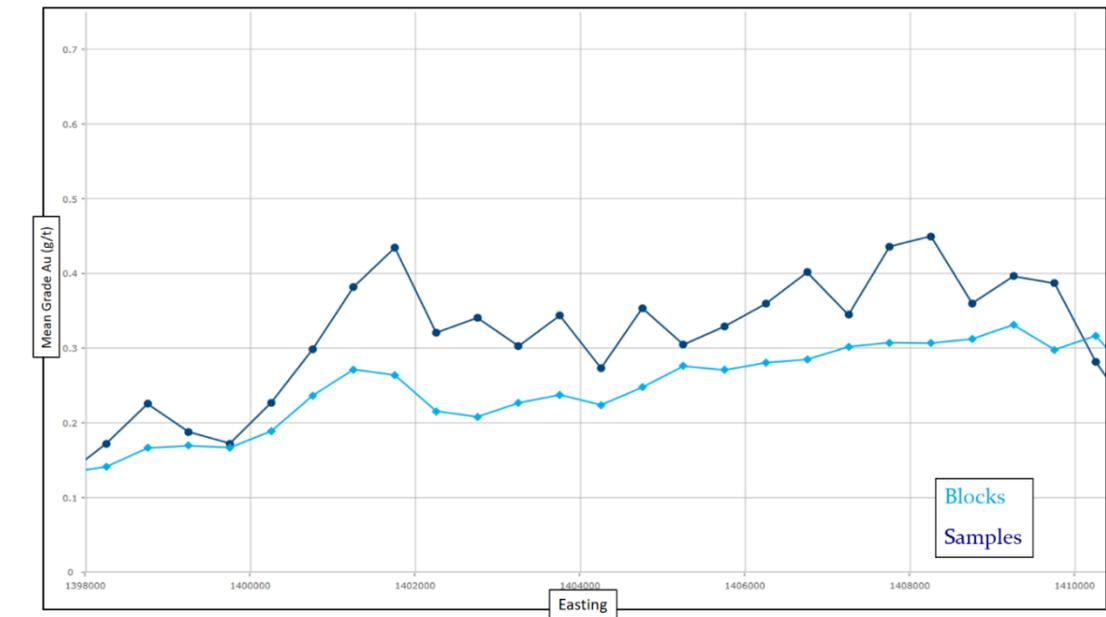


Figure 14.12-4 Molybdenum Swath Plot at 2157000N

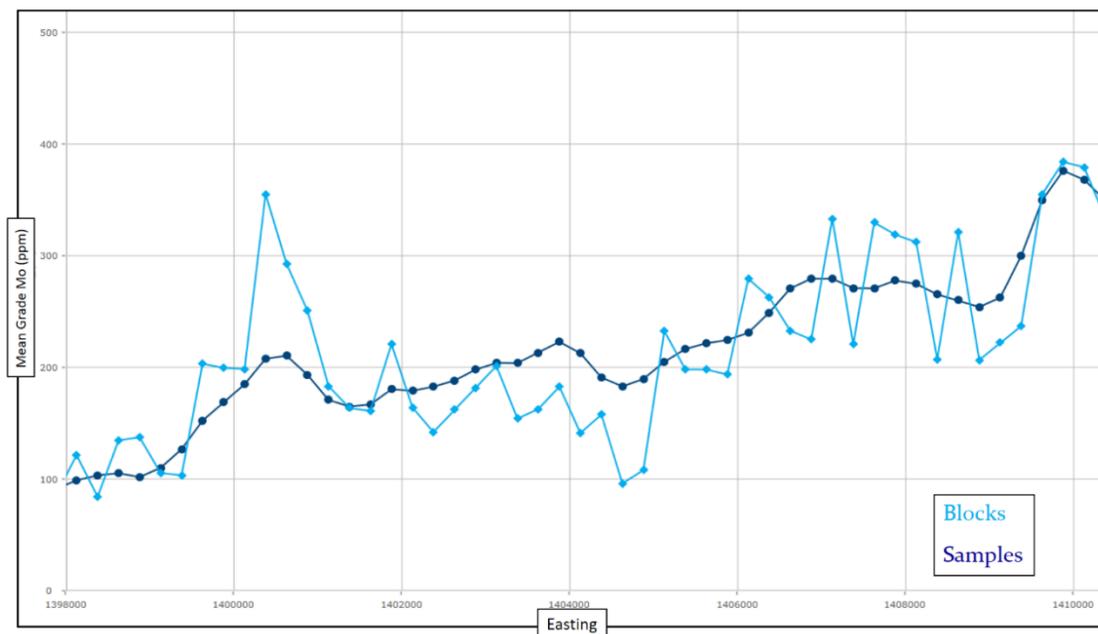
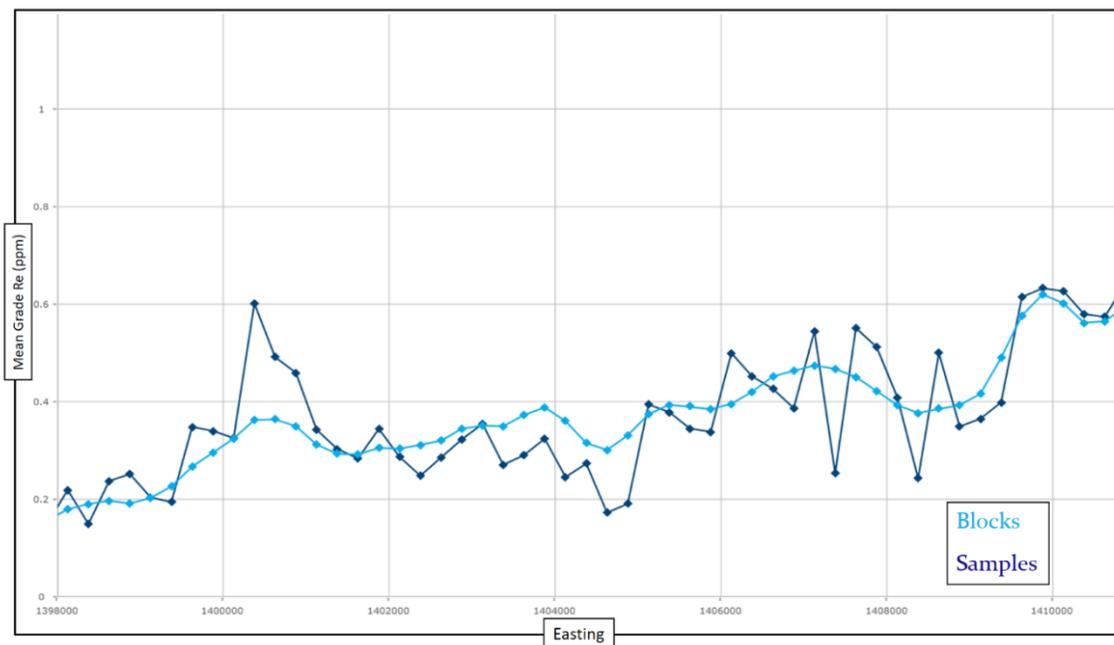


Figure 14.12-5 Rhenium Swath Plot at 2157000N



14.13 COMPARISON WITH PREVIOUS ESTIMATE

This resource estimate represents an update to the previous Pebble resource estimate only in the sense that rhenium has been added to the resource table. No other work or additional information has been added to the previously estimated metal grades (copper, gold, molybdenum, silver) so they have not changed from the December 2017 43-101 estimate, nor has the deposit's overall tonnage.

14.14 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

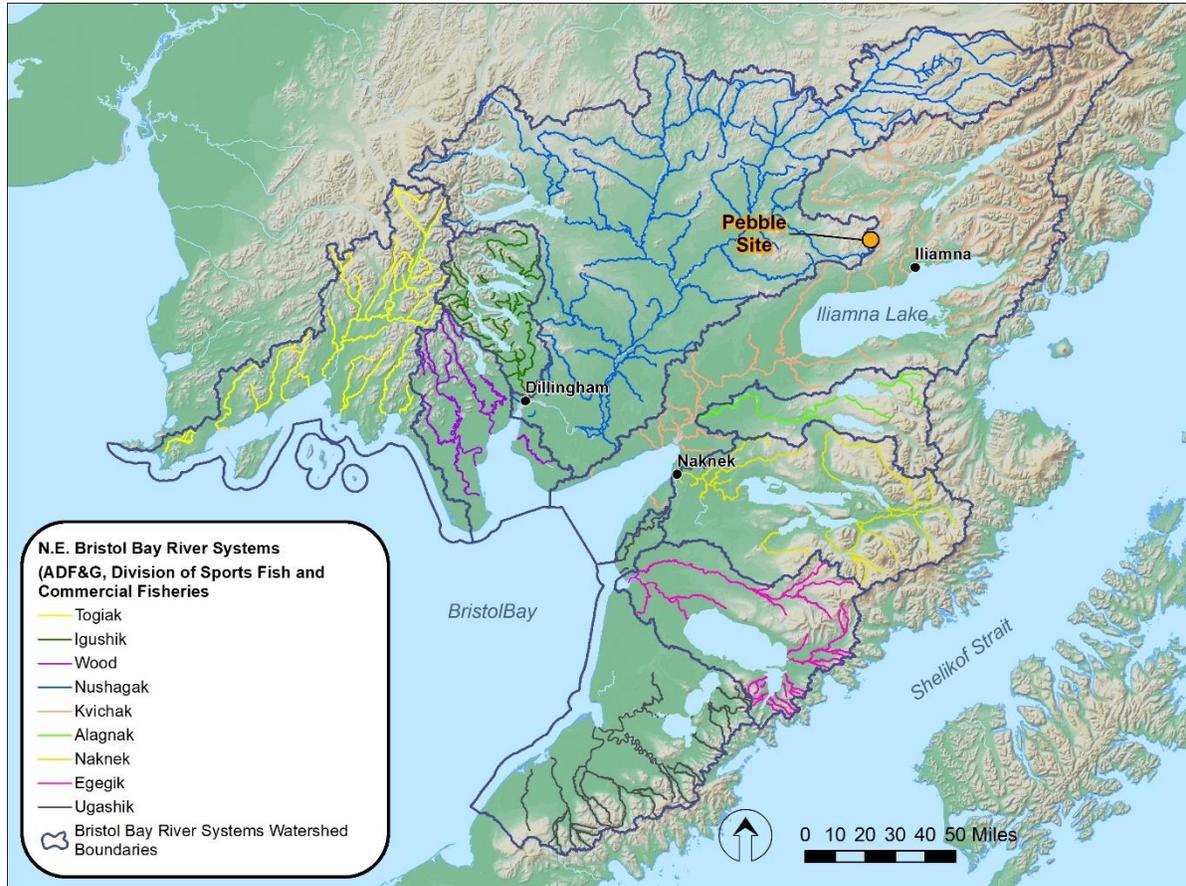
The Pebble deposit is located under rolling, permafrost-free terrain in the Iliamna region of southwest Alaska, approximately 200 miles southwest of Anchorage and 60 miles west of Cook Inlet. The surface elevation over the deposit ranges from approximately 800 to 1,200 ft amsl, although mountains in 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 at a drainage divide between the Nushagak River and Kvichak River systems (Figure 16.1-1). The Nushagak River system drains to Bristol Bay at Dillingham, 220 river miles southwest of the deposit area. The Kvichak River system covers drains into Bristol Bay via the Kvichak River 140 river/lake miles to the southwest.

In the deposit area, the tributaries of the Nushagak River in the deposit area are the North Fork Koktuli (NFK), South Fork Koktuli (SFK), while the tributary of the Kvichak River is Upper Talarik Creek (UTC). The deposit area is within the uppermost reaches of these streams and their flow is small within the project footprint. Approximately 17 miles from the deposit area, the NFK and SFK streams merge to form the main Koktuli River. The Koktuli River is tributary to the lower Mulchatna River, which drains

Figure 16.1-1 via the lower Nushagak River to Bristol Bay at Dillingham, 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 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 22,965 square miles, of which the NFK, SFK and UTC watersheds comprise only 355 square miles, or approximately 0.8% of the total Bristol Bay watershed of 45,246 square miles (USGS 2013). 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. In 2019, these systems accounted for 23% of sockeye returns (ADFG 2020). 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 the NFK, SFK and UTC watersheds generally produce less than 0.5% of the total Bristol Bay sockeye run

(harvest plus escapement). The NFK and SFK watersheds, within which all major mine site infrastructure is located, produces less than 1/10th of 1% (or <0.01%) of all Bristol Bay sockeye.

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, northern sea otter, Steller sea lion, humpback whale, 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.

The deposit area and areas of potential transportation corridors are isolated and sparsely populated. The Pebble deposit is located within the Lake and Peninsula Borough, which has a population of about 1,600 persons in 18 communities. The closest villages – Iliamna, Newhalen and Nondalton – lie approximately 17-19 miles from the deposit site. Pedro Bay, a small village 43 miles from the deposit, sits adjacent to the proposed transportation corridor. The population of Newhalen, the largest village, is about 215 full-time residents. A road connects the villages of Newhalen and Iliamna and extends to a proposed crossing of the Newhalen River just south of Nondalton. Otherwise there are only local roads in the villages. Another road connects Williamsport on Iliamna Bay in Cook Inlet with Pile Bay at the east end of Iliamna Lake. Summer barges up the Kvichak River and on Iliamna Lake provide some freight service into the communities on Iliamna Lake. All of the communities are serviced by an airport or airstrip to provide year-round access. The airport serving Iliamna and Newhalen is a substantial facility that is available to a wide range of aircraft.

The total population within the Bristol Bay region is approximately 7,000. The largest population center of the region is Dillingham, located on Bristol Bay approximately 125 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 (EBD) (PLP, 2012). Supplemental environmental reports (SEBD) incorporated data collected from the period 2009 to 2012. Monitoring data collected through 2019 has been provided to USACE. The EBD and SEBD are publicly available at <https://www.pebbleprojecteis.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 hydrology	• wildlife
• groundwater hydrology	• 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	

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

16.2.1 Climate and Meteorology

Meteorological monitoring data were collected from 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 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. Meteorological monitoring was suspended at the Pebble 1 station in 2014 and restarted in 2017. A new monitoring station was installed near the then proposed Amakdedori Port site in 2017. Monitoring at the remaining stations was suspended in 2013 after sufficient baseline data was collected.

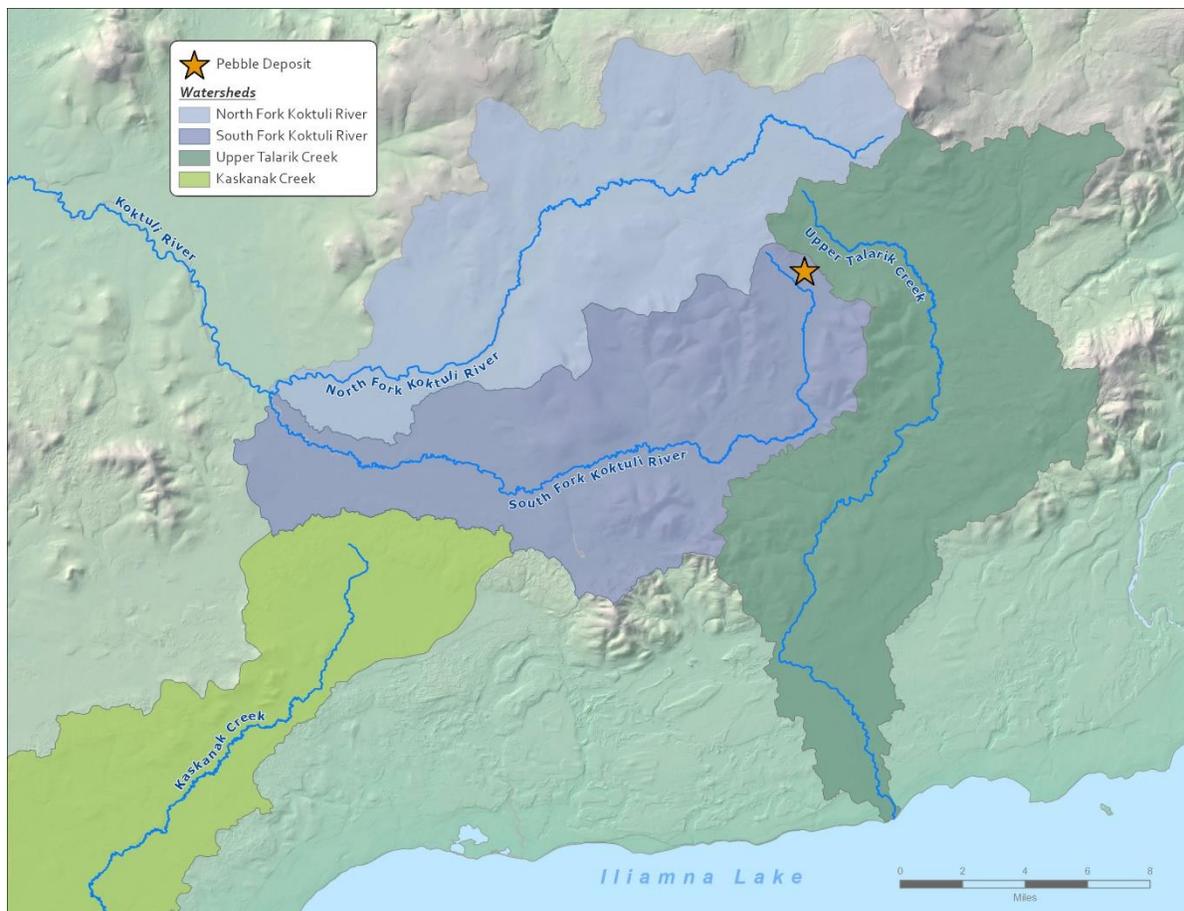
Mean monthly temperatures in the deposit area range from about 50.8°F in July to 11.4°F in January. The mean annual precipitation is estimated to be 54.6 inches per year, about one-third of which falls as snow. The wettest months are August through October.

16.2.2 Surface Water Hydrology and Quality

16.2.2.1 SURFACE WATER HYDROLOGY

The Bristol Bay drainage basin encompasses 45,246 square miles in southwest Alaska. The map in Figure 16.2-1 shows the study area, which is principally defined as the 355 square miles within the SFK, NFK and UTC drainages. The Nushagak and Kvichak watersheds constitute 51% of the Bristol Bay basin area (USGS 2013). 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 snowpacks. 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 2014 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 Alaska water quality criteria for trace elements such as copper and iron, likely due to mineralized rock in the area. 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. The Pebble Partnership expanded the monitoring network to refine the understanding of the groundwater flow regime; between 2004 and 2019 groundwater monitoring data were collected over variable periods of time at more than 500 monitoring locations.

The hydrostratigraphy of the Project area includes three main units: unconsolidated sediments, weathered bedrock, and competent bedrock. The unconsolidated sediments, deposited during multiple episodes of glaciation, have variable hydrogeologic properties ranging from highly permeable sands and gravels to very low permeability clays. The weathered bedrock unit, which outcrops along ridges and hilltops, tends to be more permeable than the underlying competent bedrock. No permafrost has been identified in the study area.

In 2019 six boreholes were drilled and instrumented to the northeast of the proposed open pit. The stratigraphy encountered in these holes was broadly similar, consisting of 90 to 100 ft of Quaternary glacial sediments overlying Tertiary conglomerate and Cretaceous granodiorite. Two 6 in. nominal diameter pumping wells were installed to target zones interpreted to be more permeable (ie weathered bedrock and Tertiary-Cretaceous contact). Monitoring wells were installed in the weathered bedrock and vibrating wire piezometers were installed in both bedrock units and unconsolidated sediments. Slug tests conducted in the two monitoring wells yielded hydraulic conductivity estimates for the weathered bedrock at this location ranging from the order of 10^{-3} to 10^{-5} ft/s.

In addition, a 72-hour pumping test was conducted in a previously installed pumping well in the Bulk Tailings Storage Facility Seepage Collection Pond area. The pumping test was conducted at a rate of approximately 4 gpm, and drawdown was observed in the pumping well and at instruments located approximately 30 ft away. Hydraulic conductivity estimates from this test for the interpreted bedrock aquifer were on the order of 10^{-6} ft/s, comparable to values for weathered bedrock from previous studies at the site.

Throughout the study area the water table mimics surface topography in a subdued fashion; it is generally located near or at ground surface in low-lying areas, and at greater depths near ridges and ridge tops. Flowing artesian conditions, where groundwater levels are above ground surface, are observed in some low-lying discharge areas. Groundwater elevations are typically observed to be lowest during the spring prior to snowmelt, and highest immediately following freshet and/or autumn rains. Groundwater-surface water interactions within the study area are complex due to the heterogeneous nature of the surficial geology and variable topography.

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. Sample analysis shows high dissolved oxygen levels at most locations, with most median pH values ranging from 5.3 to 8.5. Sites with elevated trace metal concentrations were generally in the vicinity of the deposit. The EBD and SEBD 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. Minor components of the Tertiary volcanic rocks (less than 1% based on testing) contain pyrite mineralization and have been found to be PAG and some generated acid in laboratory tests. 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 the low levels 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.

All wetlands delineation in the field for the northern route identified in the project description has been completed.

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 Kaktuli 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 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

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 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.

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.

Data collected in Iliamna and Iniskin bays in 2010 and 2011 indicate that Pacific herring are the predominant species present in the nearshore environment, primarily in Iniskin Bay. Chum and pink salmon are the predominant salmonids found in the bays, with smaller populations of coho and sockeye also present.

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.

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 a significant majority 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. The COVID 19 pandemic's effect on oil prices and other Alaska industries has steepened the state's economic and fiscal decline, while also contributing to significant job losses.

Of the nearly 730,000 people living in Alaska on a full-time basis, more than 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, approximately 43 miles east of Iliamna and adjacent to the proposed transportation corridor. Igiugig and Kokhanok are the other two villages located on Iliamna Lake. 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 fifteen years, 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 Pedro Bay, 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 about 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. About 7,000 people call the Bristol Bay region home, with the largest population center in Dillingham.

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, three of which – Alaska Peninsula Corporation, Iliamna Natives Limited, and Pedro Bay Corporation – hold surface rights for significant areas of land near the Pebble Project and along its proposed transportation infrastructure corridor. Separate Native Village Corporations are also centered in Igiugig (Igiugig Native Corporation) and Nondalton (Kijik Corporation).

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; the 2020 price was approximately \$0.70/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, 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

Pebble Project technical programs are supported by stakeholder engagement activities in Alaska. The objective of stakeholder outreach programs undertaken by the Pebble Partnership are to:

- advise residents of nearby communities and other regional interests about Pebble work programs and other activities being undertaken in the field;

- provide information about the proposed development plan for the Pebble Project, including potential environmental, social and operational effects, proposed mitigation and environmental safeguards;
- allow the Pebble Partnership to better understand and address stakeholder priorities and concerns with respect to development of the Pebble Project;
- encourage stakeholder and public participation in the USACE-led EIS permitting process for Pebble; and
- facilitate economic and other opportunities associated with advancement and development of the Pebble Project for local residents, communities and companies.

In addition to meeting with stakeholder groups and individuals, and providing project briefings in communities throughout Bristol Bay and the State of Alaska, the Pebble Partnership's outreach and engagement program includes:

- workforce and business development initiatives intended to enhance economic opportunities for regional residents and Alaska Native corporations;
- initiatives to develop partnerships with Alaska Native corporations, commercial fishing interests and other in-region groups and individuals;
- outreach to elected officials and political staff at the national, state and local levels; and
- outreach to third-party organizations and special interest groups with an interest in the Pebble Project, including business organizations, community groups, outdoor recreation interests, Alaska Native entities, commercial and sport fishery interests, conservation organizations, among others.

Through these various stakeholder initiatives, the Company seeks to advance a science-based project design that is responsive to stakeholder priorities and concerns, provides meaningful benefits and opportunities to local residents, businesses and Alaska Native corporations, and energizes the economy of Southwest Alaska.

Right-of-Way Agreements

The Pebble Partnership carries out an active program of engagement and consultation with stakeholders in the area of the Pebble Project in parallel with its technical work, and includes discussions to secure stakeholder agreements to support the project's development. Right-of-way agreements established to date are described below. These agreements cover land access routes for infrastructure alternatives proposed in the EIS documents.

Agreements with Alaska Native Village Corporations

In November 2018 and May 2019, the Pebble Partnership finalized Right-of-Way Agreements with Alaska Peninsula Corporation ("APC") and Iliamna Natives Limited ("INL") respectively, securing the right to

use defined portions of each Alaska Native village corporations' lands for the construction and operation of transportation infrastructure associated with the Pebble Project.

The Right-of-Way Agreements secure access to portions of several proposed transportation and infrastructure routes to the Pebble Project site for construction and operation of the proposed mine, and represent a significant milestone in the developing relationship between Pebble and the Alaska Native people of the region.

The agreements with APC and INL include the following provisions:

- The Pebble Partnership will make annual toll payments to Alaska Native village corporations upon whose lands Pebble-related transportation infrastructure is built and operated, and pay other fees prior to and during project construction and operation;
- INL and APC will be granted 'Preferred Contractor' status at Pebble, which provides a preferential opportunity to bid on Pebble-related contracts located on their lands; and
- PLP and the two Alaska Native village corporation parties have agreed to negotiate a profit sharing agreement that will ensure APC, INL and their shareholders benefit directly from the profits generated by mining activity in the region.

Additionally, transportation and other infrastructure for a mine at Pebble is expected to benefit APC, INL, their shareholders and villages through access to lower cost power, equipment and supplies, as well as enhanced economic activity in the region. Spur roads connecting to local villages will allow local residents to access jobs at the Pebble mine site, port site and ferry landing sites.

The USACE's identification of the Northern Transportation Route as the draft LEDPA for the Pebble Project requires that the Pebble Partnership secure additional Right-of-Way Agreements ("ROW") with Alaska Native village corporations and other private landowners with land holdings along the northern route. The Pebble Partnership is in the process of securing these additional ROW agreements, and is confident it will ultimately achieve the access rights required to build and operate transportation and related infrastructure along the Northern Transportation Route.

Bristol Bay Revenue Sharing Program

On June 16, 2020, Northern Dynasty announced that the Pebble Partnership has established the Pebble Performance Dividend LLP to provide for a local revenue sharing program with the objective of ensuring that full-time residents of communities in southwest Alaska will benefit directly from the future operation of the proposed Pebble Project. The intention is for the Pebble Performance Dividend LLP to distribute cash generated from a 3% net profits royalty interest in the Pebble Project to adult residents of Bristol Bay villages that have subscribed as participants, with a guaranteed minimum aggregate annual payment of US\$3 million each year the Pebble mine operates beginning at the outset of project construction and with future payments following capital payback expected to increase beyond this initial amount.

Logistics MOU with Alaska Peninsula Corporation

The Company announced on July 6, 2020 that the Pebble Partnership entered into a memorandum of understanding (the “MOU”) with the APC which envisages that APC will lead the development of a consortium of Alaska Native village corporations to provide logistics services to the project. It is contemplated that the final agreement will include access road maintenance, truck transport, port operations and other logistical services should the development of the mine proceed. The MOU is consistent with the Company’s strategy of ensuring the development of the Pebble Project will benefit local Alaska communities and people. The MOU is not a binding final contract which will require further negotiation of definitive contracts. There is no assurance that these contracts will be concluded.

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”. All statements in this section, other than statements of historical facts, that address exploration drilling, exploitation activities and events or developments that the Company expects are forward-looking statements. Although the Company 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, that the Pebble Project will secure all required government permits, or of the Company’s future performance.

Assumptions used by NDM to develop forward-looking statements include the assumptions that (i) the Pebble Project will obtain all required environmental and other permits and all land use and other licenses without undue delay, (ii) studies for the development of the Pebble Project will be positive, (iii) NDM will be able to establish the commercial feasibility of the Pebble Project, and (iv) NDM will be able to secure the financing required to develop the Pebble Project. 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 (i) obtaining necessary mining and construction permits, licenses and approvals without undue delay, including without delay due to third party opposition or changes in government policies, (ii) the completion of feasibility studies demonstrating the Pebble Project mineral reserves that can be economically mined, (iii) completion of all necessary engineering for mining and processing facilities, and (iv) receipt by NDM of significant additional financing to fund these objectives as well as funding mine construction, which financing may not be available to NDM on acceptable terms or on any terms at all. The Company is also subject to the specific risks inherent in the mining business as well as general economic and business conditions, as well as risks relating to the uncertainties with respect to the effects of COVID-19. For more information on the Company, Investors should review the Company’s filings with the United States Securities and Exchange Commission and its home jurisdiction filings that are available at www.sedar.com.

The National Environment Policy Act Environmental Impact Statement 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 significantly from that contemplated in this presentation. As a result, the Company will continue to consider various development options and no final project design has been selected at this time.

This section is presented in US Standard units as used in the permitting application and Project Description submitted to the USACE in June 2020.

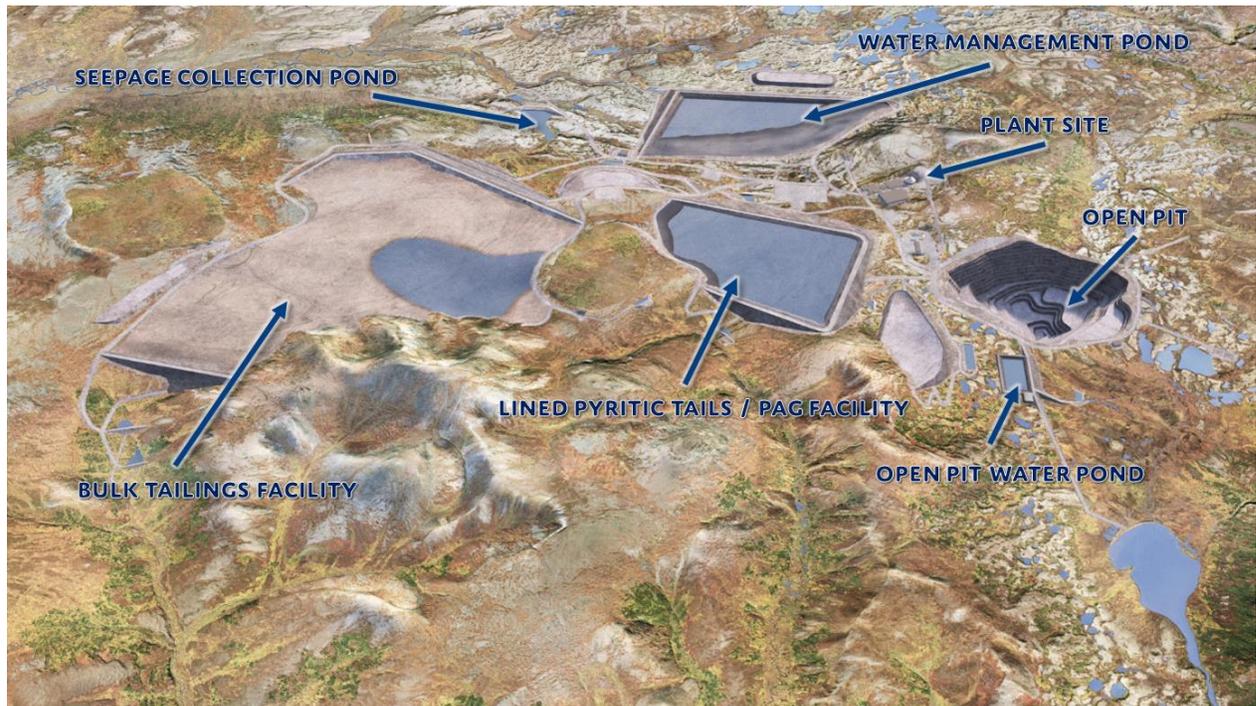
Pebble Partnership filed a CWA 404 permitting application with USACE on December 22, 2017. USACE confirmed that Pebble's permitting application was complete in January 2018 and an Environmental Impact Statement (EIS) is required to comply with its National Environmental Policy Act (NEPA) review of the Pebble Project. The NEPA EIS process included a comprehensive 'alternatives assessment' that considered a broad range of development alternatives. The project design and operating parameters for the Pebble Project and associated infrastructure described below reflects the LEDPA in the Final EIS published by USACE in July 2020. As USACE is completing its Record of Decision, the final design 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 assessed under the NEPA process at this time and is derived from the Project Description incorporated in the Final EIS. 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 published a Preliminary Economic Assessment (PEA) on the Pebble Project in February 2011 and, as noted above, since that time after considering stakeholder and regulatory feedback, Pebble Partnership submitted for federal permitting a proposed project with a substantially smaller mine facility footprint and with other material revisions as are described in this Section 16.5. As a result, the economic analysis included in the 2011 PEA 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. As the Final EIS has only recently been published by the USACE, the Company has not completed a current comprehensive economic analysis of the Pebble Project.

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.

Figure 16.5-1 shows the layout of the mine site, including the major facilities and site infrastructure. Table 16.5-1 summarizes general operating information for the proposed project.

Figure 16.5-1 Potential Mine Site Layout

Table 16.5-1 Summary Project Information

Item	Value
General Operation	
Construction	4 years
Total project operations	20 years
Daily schedule	24 hours
Annual schedule	365 days
Mine Operation	
Preproduction mined tonnage	33 million tons
Average annual mining rate	70 million tons
Operations mined tonnage	1,440 million tons
Mine life strip ratio	0.12:1 (waste: mineralized material)
Open pit dimensions	6,800 ft x 5,600 ft, 1,950 ft deep
Process Operation	
Daily process rate	180,000 tons
Annual process volume	66 million tons
Copper-gold concentrate	613,000 tons per year (average)
Molybdenum concentrate	15,000 tons per year (average)
Pyritic Tailings Storage Facility	
Approximate capacity (tailings)	155 million tons
Approximate capacity (PAG waste)	93 million tons
South embankment (height)	215 feet
North embankment (height)	335 feet
East embankment	225 feet
Bulk Tailings Storage Facility	

Item	Value
Approximate capacity	1,140 million tons
Main embankment (height)	545 feet
South embankment (height)	300 feet
Main Water Management Pond	
Approximate capacity	2,450 million cubic feet (56,000 ac-ft)
Embankment height	190 feet
Concentrate Pipeline	
Diameter	6.25 inches
^a 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 Pebble Mine will be a conventional drill, blast, truck, and shovel operation with an average mining rate of 70 million tons per year and an overall stripping ratio of 0.12 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 6,800 feet long and 5,600 feet wide, with depths to 1,950 feet.

Mining will occur in two phases – Preproduction and Production.

The mine operation will commence during the last year of the Preproduction Phase and extend for 20 years during the Production Phase. Approximately 1.3 billion tons of process plant feed and 150 million tons of waste rock and overburden will be mined. Non-potentially acid generating (NPAG) and non-ML waste will be used in construction of the tailings embankments. The PAG and ML waste rock will be stored in the pyritic TSF 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 TSF embankments 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 from the initial stage of the open pit. Dewatering will begin approximately one year before the start of Preproduction mining. Approximately 33 million tons of material will be mined during this phase (Table 16.5-2).

Table 16.5-2 Mined Material Preproduction Phase

Material Type	Quantity
Overburden	22 million tons
Waste rock	11 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 and be fed through the process plant at a rate of 180,000 tons/day. The open pit will be mined in a sequence of increasingly larger and deeper stages. Approximately 1.4 billion tons of material are planned to be mined during the Production Phase (Table 16.5-3).

Table 16.5-3 Mines Material - Production Phase

Material Type	Quantity
Overburden	38 million tons
Mineralized material process plant feed	1,291 million tons
Waste rock	82 million tons

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. Initial operations during the Preproduction Phase may use pre-packed emulsion blasting agents or a mobile bulk emulsion manufacturing plant. After the explosives plant is completed, the emulsion-based ANFO explosive will be used as the primary blasting agent.

The ANFO will be stored separately as a safety precaution. All explosive magazines will be constructed and operated to meet mine safety and health regulations. The ammonium nitrate solution will be mixed with diesel fuel and emulsifying agents in a mobile mixing unit on the mining bench where blasting is to take place. The emulsion will become a blasting agent only once it is sensitized using the sensitizing agent while in the drill hole.

Based on knowledge of the rock types in the Pebble Deposit, blasting will require an average powder factor of approximately 0.5 pounds 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 mined 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 and non-ML waste rock may be used for embankment construction. PAG and ML waste rock will be stored in the pyritic TSF 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 33 million tons of non-mineralized and mineralized material will be removed from the open pit. Non-mineralized waste and overburden will be stockpiled or used in construction, mineralized waste will be stockpiled and relocated to the pyritic TSF once

complete, or if grades are sufficient, stockpiled for milling once the mill is complete. Material will be stockpiled within the pit footprint, or in designated stockpiles as appropriate.

Overburden is the unconsolidated material lying at the surface. At the Pebble Deposit, the overburden depth ranges from 0 to 140 ft. 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.

16.5.1.5 EQUIPMENT

The Project production fleet will use the most efficient mining equipment available 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. Track-mounted electric shovels 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 in. 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.

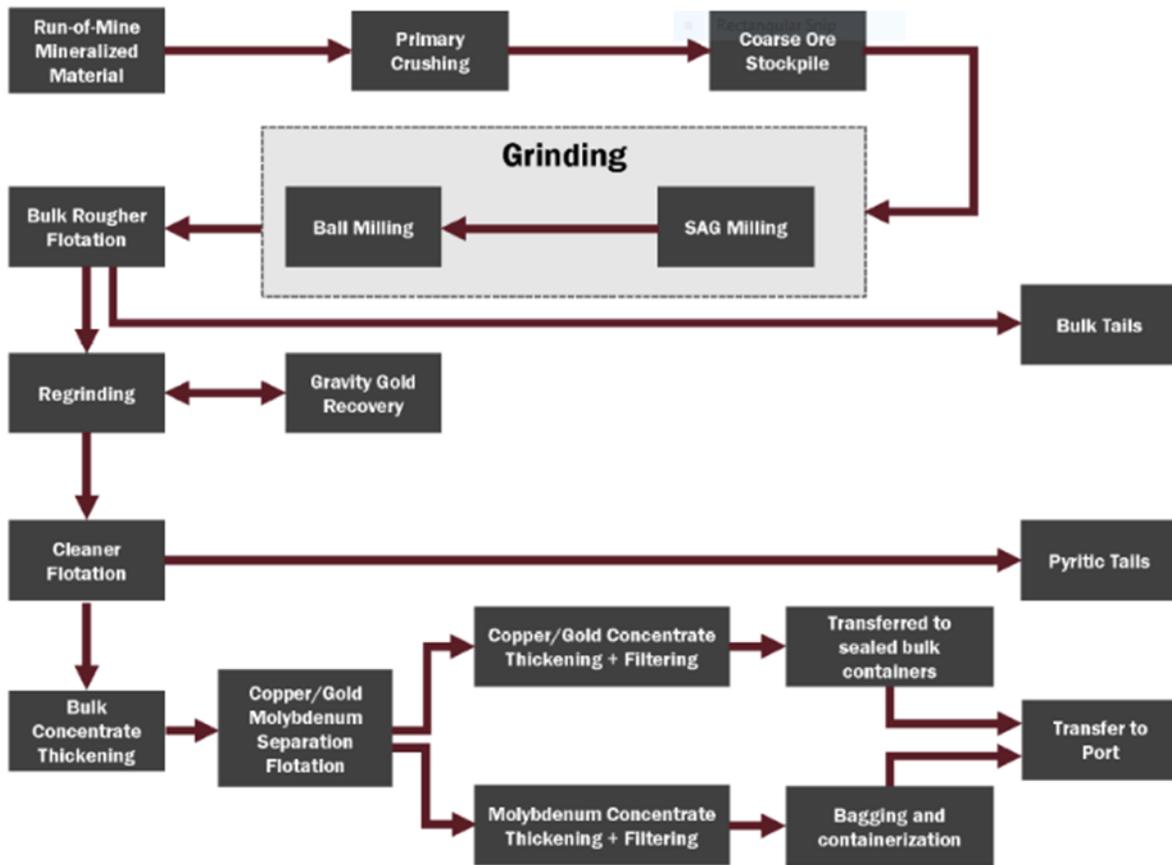
16.5.2 Mineral Processing

Blasted mineralized material from the open pit will be fed to the mineral processing facilities will be located at the mine site. Within the process plant, the copper and molybdenum minerals are separated from the remaining material to produce copper-gold and molybdenum concentrates. Gravity concentrators will be placed at strategic locations to recover free gold, which will be shipped off site for refining. Other economically valuable minerals (gold, silver and palladium in the copper-gold

concentrate and rhenium in the molybdenum concentrate) will be present in the concentrates. Figure 16.5-2 shows the process flowsheet.

Over the life of the Project, approximately 1.3 billion tons of mineralized material will be fed to the process plant at a rate of 180,000 tons/day. On average, the process plant will produce approximately 613,000 tons of copper-gold concentrate per year, containing approximately 318 million pounds of copper, 362,000 ounces of gold and 1.8 million ounces of silver, and approximately 15,000 tons of molybdenum concentrate, containing about 14 million pounds of molybdenum.

Figure 16.5-2 Process Flow Sheet



16.5.2.1 CRUSHING AND GRINDING

The separation of the copper and molybdenum minerals from the gangue minerals requires to mineralized material to be reduced in size to the consistency of fine sand.

For the first step in this, mineralized material from the open pit 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 in. 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 Semi-autogenous (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, as it is preferable to handle coarse material dry to prevent freezing during cold conditions. An escape tunnel also will be provided for worker safety, with ventilation as required.

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 mills 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 in. (“pebbles”). Material passing through the screens will be sent to the ball mills while 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 will be adjusted to pH 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 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% 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 pumps to transfer it via the concentrate pipeline to the port. At the port, pressure filters will reduce the moisture to approximately eight percent. The filter product will be stored in a covered building at the port site. The filtrate will be returned via pipeline to the process.

The molybdenum concentrate will be thickened in a high-rate thickener to 55% solids by weight. The thickener underflow will be pumped to the molybdenum concentrate filter press, where the moisture content will be reduced to 12%. The filtered concentrate will be further dewatered by a dryer to 5% moisture before being bagged, containerized, and shipped.

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 will either be diverted by non-contact water diversion channels, or collected in sediment ponds as appropriate, and pumped to the main 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% solids, will be pumped to the Bulk TSF. The pyritic tailings will be thickened, mixed with WTP sludge, and pumped to the Pyritic TSF. The overflow streams from each thickener will be returned to the process. Supernatant water in the bulk and pyritic TSFs 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. Any surplus 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, including:

- **Minimize potential impact to environmental resources.** The selected sites are within valleys supporting mixed uplands and wetland shrub/herbaceous shrub. The valleys include tributaries to the NFK that have experienced intermittent flows. Index counts indicate lower fish presence than at other locations. Potential impacts to waterfowl are likewise reduced by avoiding areas with high-value habitats for nesting, breeding, molting, or migration.
- **Provide adequate storage capacity.** The sites will accommodate tailings for the 20-year life of the Project.
- **Reasonable proximity.** The sites minimize the distance to the process plant, which reduces power consumption and the overall project footprint.
- **Facilitate closure.** Segregating the pyritic tailings and PAG waste allows for placement of both in the pit at the end of the mine life, thus eliminating this structure from the long-term closure plan.

The TSFs will be designed to meet or exceed the standards of the Alaska Dam Safety Program (ADSP) prepared by ADNDR, including as required the draft 2017 *Guidelines for Cooperation with the Alaska Dam Safety Program*. The TSFs will be designed to the standards of a Class I hazard potential dam (the highest classification).

The final TSF designs will incorporate the following:

- Permanent, secure, and total confinement of bulk tailings solids within an engineered disposal facility.
- Secure, and total confinement of pyritic tailings and PAG waste rock within a fully lined, engineered facility, with these materials relocated to the pit at closure.
- 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 sufficient freeboard within the Bulk TSF that the entire volume of the Inflow Design Flood (IDF) will not flood the entire tailings beach, maintaining the beach between the maximum operating pond and the Bulk TSF embankments.
- Limiting the volume of stored water within the Bulk TSF and keeping the operating pond away from the dam face.
- Maintaining the pyritic tails and PAG waste in a sub-aqueous state to prevent oxidation.
- The consideration of long-term closure management at all stages of the TSF design process.
- The inclusion of monitoring instrumentation for all aspects of the facility during operations and after closure.
- The design includes flattened slopes to increase the static factor of safety.

16.5.3.2 TAILINGS DEPOSITION

Each tailings stream will be delivered to its respective 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.

PAG waste rock will be placed in a ring around the interior of the Pyritic TSF. Pyritic tailings from the cleaner scavenger flotation circuit will be discharged into the Pyritic TSF at sub-aqueous discharge points, with the level maintained just below the upper bench level for the PAG waste being stored. The sub-aqueous discharge is necessary to prevent oxidation and potential acid generation.

16.5.3.3 PROPOSED FACILITY

Separate TSFs will be constructed for the bulk and pyritic tailings located primarily within the NFK watershed. Total TSF capacity will be sufficient to store the 20 year mine life tailings volume (1.3 billion tons). Approximately 88% of the tailings will be bulk tailings and approximately 12% will be pyritic tailings.

The unlined Bulk TSF has two embankments – main and south. The Pyritic TSF will be lined and has three embankments – north, south, and east.

Starter embankments for both facilities will be constructed as part of the initial TSF construction. The main embankment of the Bulk TSF 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 TSF basin to provide preferred drainage paths for seepage flows. The Pyritic TSF will be a fully lined facility with an underdrain system below the liner.

The Pyritic TSF, which will also contain the PAG waste, will have a full water cover during operations, while the bulk tailings cell will have a small supernatant pond, located away from the embankments, to promote large tailings beach development upstream of the embankments.

The Bulk 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 1,730 ft above sea level for bulk TSF. Embankment heights, as measured from lowest downstream slope elevation, will be 545 ft (main) and 300 ft (south).

The Pyritic TSF downstream embankment slopes will be maintained at 2.6H:1V. The final crest elevation will be 1,620 ft above sea level. The north embankment height will be 335 ft, the south embankment height will be 215 ft, and the east embankment height will be 225 ft.

The embankments will be constructed using suitable rockfill or earthfill materials, including quarried rock, NPAG and non-ML waste rock excavated from the open pit, if available, and stripped overburden.

Bulk TSF

The main embankment will be constructed using the centerline construction method with local borrow materials. The centerline construction method provides a high level of embankment stability while reducing the embankment material requirements associated with the downstream method.

The embankment foundation will be prepared by removing overburden materials to competent bedrock prior to the placing structural fill materials. Construction begins with a cofferdam to capture upstream runoff during starter embankment construction. The starter embankment will be constructed to a height of approximately 265 ft and provide capacity to store tailings for the first 24 months of operation.

The material for the starter embankments will be sourced from a quarry located within the impoundment area. The Bulk TSF 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.

The earthfill/rockfill embankment will include engineered filter zones and a crushed or processed aggregate drain at the topographic low point. This drain will provide a preferable seepage path from the tailings mass to downstream of the embankment toe. Additional underdrains running parallel to the embankment will allow for drainage of seepage collected along the embankment.

The south embankment will be constructed using the downstream construction method to facilitate lining of the upstream face, which is constructed at a 3H:1V slope. The downstream slope will be at 2.6H:1V. Overburden materials will be removed to competent bedrock below the embankment. The earthfill/rockfill embankment will include engineered filter zones and a grout curtain to reduce seepage below the embankment.

Pyritic TSF

The embankments will be constructed using the downstream method with an overall downstream slope of 2.6H:1V. The embankments will be constructed using select borrow materials and include a liner bedding layer, overlain by a liner, on the upstream slope and over the entire internal basin. Basin underdrains will collect and convey any seepage to the downstream seepage collection ponds.

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 270 MW. The plant will use high-efficiency combustion turbine generators operating in a combined-cycle configuration. The units will be fired by natural gas provided to the site via pipeline. Design-appropriate controls will be used to manage airborne emissions and meet ADEC air quality criteria and best management practices (BMPs). A closed-loop glycol system will capture some heat from the system for space heat with the unused waste heat rejected through a closed-loop, water cooled system that circulates water through the steam condenser to a mechanical draft cooling tower.

The various mine load centers would be serviced by a 69 kV 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. Traffic associated with

in-pit activity will be segregated from access road traffic to avoid cross-contamination of vehicles with mud and dust from the pit.

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. Non-resident personnel will be flown in and out of the Iliamna Airport and transported to the site by road. Workers will remain on site throughout their work period. Site rules will prohibit hunting, fishing, or gathering while on site to minimize impacts to local subsistence resources.

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.

Diamond Point Port operations will be serviced by the fiber optic cable. Radio and/or cell service will be provided for communications at the port with the antenna located with the port facilities.

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 and logistics systems will be imported to the Diamond Point Port using marine barges. The expected maximum parcel size for delivery is four million gallons, which will allow for extended periods between shipments in winter months. The Diamond Point 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 Diamond Point 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 to the mine site. Additional containers will be stored at the mine site to provide for a fuel reserve in the event of a supply disruption.

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 will be stored and maintained on site wherever fuel will be dispensed.

Fuel will be dispensed to a pump house located in a fuel storage area for fueling light vehicles. It will also be dispensed to the fuel tanks in the truck shop complex, which are used 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 proposed 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 is effectively managed. To do so, the Project facility layout, process requirements, area topography, hydrometeorology, aquatic habitat/resources, and regulatory discharge requirements for managing surplus water are all carefully assessed. The foundation of the program is the water balance, comprised of three primary models: the Watershed Model, the Groundwater Model, and the Mine Plan Model.

The Watershed Model for the NFK, SFK, and UTC drainages considers both surface and groundwater. This model incorporates all key components of the hydrologic cycle, including precipitation as rain and snow, evaporation, sublimation, runoff, surface storage, and groundwater recharge, discharge, and storage. The primary input is monthly precipitation and temperature data collected at the Iliamna Airport from 1942 through 2017. The model was calibrated to measured site flow data collected at various locations in all three drainages over a nine-year period. The Watershed Model also provided input for the instream fish habitat-flow model, as well as the initial boundary parameters associated with groundwater recharge and runoff conditions for the groundwater model.

The Groundwater Model focuses on the sub-surface movement of water within the NFK, SFK, and UTC drainages. It models hydrogeological conditions in a more sophisticated and detailed manner than the Watershed Model, and its outputs provide a check of reasonableness for the Watershed Model. In addition, the Groundwater Model simulates groundwater flow rates and groundwater-surface water interactions throughout the study area, whereas the Watershed Model considers surface and groundwater flow rates only at the streamflow gaging stations.

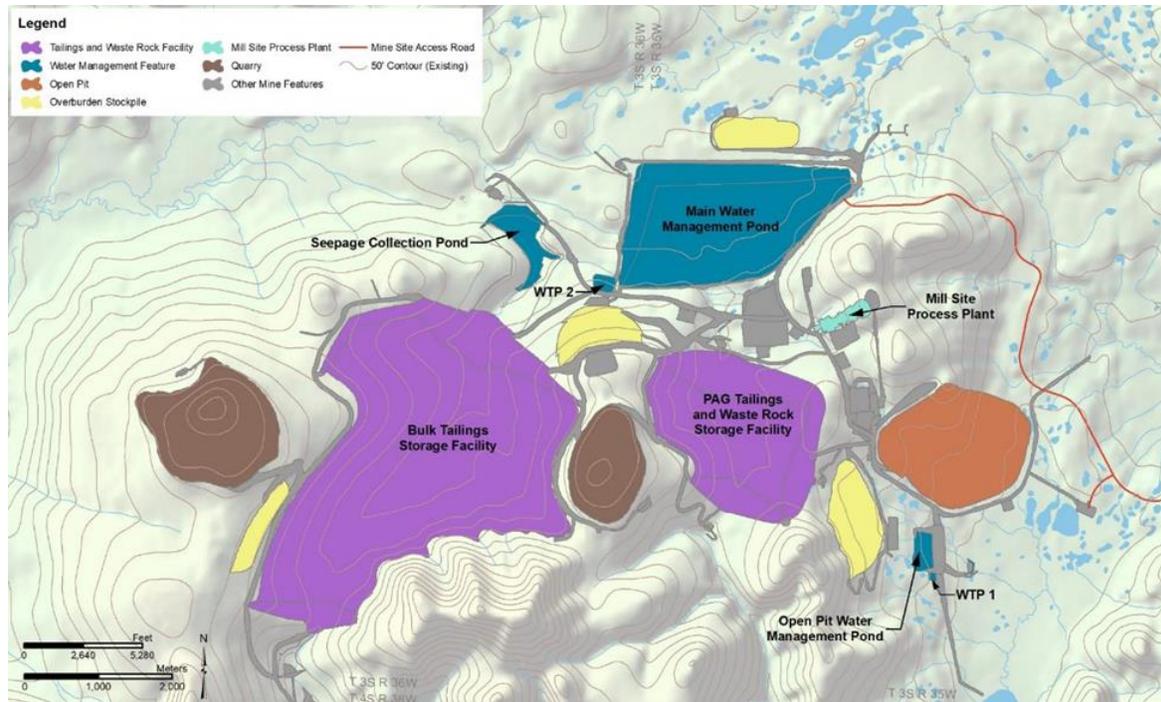
The Mine Plan Model focuses on water movement within the Pebble Project footprint area. The Mine Plan Model is a site-wide water balance and considers all mine facilities including the bulk TSF, pyritic TSF, open pit, process plant, and the Water Management Ponds (WMPs). This model tracks water movement throughout the Pebble Project footprint area including runoff from the mine facilities, water contained in the ore, groundwater inflows, evaporation and water stored in the tailings voids. It is used to predict the flow regime on the mine site and whether there is a water surplus or deficit. It will also be used to estimate the water storage capacity requirements for the mine under normal operating conditions.

The Physical Habitat Simulation System Instream-flow Model (PHABSIM) is an integral component of the site water balance design and is used to determine the most effective way of releasing the treated contact water that is surplus to the project needs. This model assesses the effects of changes in water flow to the instream fish habitat in streams downstream of the project site. It quantifies the areal extent of specific habitat changes that result from changes in flow throughout the year. Output from the model, together with a consideration of site-specific fish production limiting factors, will be used to inform and optimize the discharge of water from the site to minimize the effects of reduced flow and/or enhance instream fish habitat below the discharge points.

The comprehensive water management plan for the proposed mine at Pebble encompasses three phases – production, preproduction and closure/post-closure, with four stages in the closure/post closure plan.

Figure 16.5-3 is a layout of the proposed mine site showing the location of the main water management structures.

Figure 16.5-3 Key Elements of Water Management



Design considerations for the water management structures include the following:

- Diversion channels, berms, and collection ditches will be sized for the 100 year, 24 hour rainfall event.
- Diversion channels, berms, and collection ditches will be constructed with erosion-control features, such as geotextile or riprap lining, as appropriate, for site-specific condition. Energy dissipation structures, such as spill basins or similar control measures, will be included where required to reduce erosion at the outlets of the diversion channels and collection ditches.
- Sediment control ponds will be sized to attenuate and treat up to the 10 year, 24 hour rainfall event volume and to safely manage the 100 year, 24 hour rainfall event.
- Water management and sediment control ponds will be constructed using non-PAG rock and earthen fill embankments.
- During the preproduction phase, a temporary cofferdam will be constructed upstream of the main TSF embankment to manage water during the initial construction phase. Runoff from the undisturbed upstream catchment will be collected behind the cofferdam will be pumped downstream of all construction activities and released within the same watershed.
- Inflow Design Flood (IDF) for all WMPs during the production phase will be the 100 year, 24 hour rainfall event; IDF for the TSFs and main WMP will be the 24 hour PMP plus the 100-year snowpack equivalent water volume.

- Surplus water will be treated to meet the specified water quality criteria prior to discharge.

Preproduction and Production Phases

The proposed water management and sediment control plan during the preproduction and production phases consist of multiple aspects that will focus on minimizing contact water.

Water diversion, collection, and treatment systems will be installed around the site during the preproduction phase to address the effect of construction ground disturbance. Water management and sediment control structural Best Management Practices (BMPs), including installation of temporary settling basins and silt fences to accommodate initial site construction.

Among the first permanent facilities constructed will be the water management structures for use in adaptive management during operations, such as diversion and runoff collection ditches to minimize water contact with disturbed surfaces, and sediment control measures such as settling ponds to stop sediment from reaching water courses.

A series of dewatering wells will be drilled around the perimeter of the open pit prior to preproduction phase mining to provide sufficient time to draw down the water table in the area and allow uninterrupted overburden removal. If the water meets water quality criteria, it will be discharged, or sent to a water treatment plant for treatment prior to discharge.

During the production phase, runoff and sediment will be managed with BMPs and adaptive control strategies. Water collection, management, and transfer will occur through a system of water management channels, ponds, and pump and pipeline configurations. Where water cannot be diverted, it will be collected for use in the mining process or treated and discharged.

Water collected around the mine area and waste water from the Diamond Point Port site will require treatment prior to discharge. Treatment methods will include a mixture of settling for sediment removal, chemical additions to precipitate dissolved elements, and filtration to meet final discharge criteria. Two water treatment plants will be utilized during the preproduction and production phases: WTP #1 (the open pit WTP) and WTP #2 (the main WTP), employing treatment plant processes commonly used in the mining industry around the world. Both will have multiple, independent trains to enable ongoing treatment during mechanical interruption of any one train.

A water surplus is anticipated under normal and wetter-than-normal climatic conditions; however, the volume available to discharge will be less than the pre-mine flows within the mine footprint as some water will be consumed in the tailings voids and lost to evaporation and other minor uses. Surplus water will be treated and discharged throughout the year. An adaptive water management strategy is planned to deal with any variation, and includes additional temporary water storage capacity in the TSFs, surplus storage capacity within the WMPs, and by building additional capacity in the WTPs. There is redundancy built into the pumping and treatment systems, and additional water storage capacity in the open pit.

Water quantity and quality will be monitored, with all discharged waters monitored for compliance with state and federal permit requirements. Treated water will be strategically discharged at identified discharge locations in the NFK, SFK, and UTC in a manner that optimizes downstream aquatic habitat conditions as determined by PHABSIM and in accordance with ADEC and ADF&G permit conditions.

Closure/Post-Closure Phase

Plans for closure and post-closure water management address both the immediate physical closure of the site and associated reclamation activities in four phases: Years 0-15, 16-approximately 20 years, 21-approximately 50 years, and a long-term post-closure period with associated maintenance and monitoring activities. A third water treatment facility, WTP #3 will be brought on line. As areas of the site are reclaimed and WTP #1 and #2 are decommissioned, water that needs treatment will be redirected to WTP #3.

WTP #3 will treat two streams of water separately: a stream from the Bulk TSF Main Seepage Collection Pond and a stream from the open pit, employing treatment plant processes commonly used in the mining industry around the world. Water quality will be monitored with changes and adjustments to the treatment process as needed. The reclamation and closure bond package will include provisions for periodic replacement of water treatment facilities and ongoing operating and monitoring costs over the long-term.

16.5.4.2 OFF-SITE

Transportation Corridor

The Pebble Project mine site is located approximately 60 miles west of Cook Inlet. There are limited existing road networks in the region. The transportation corridor will extend 82 miles from Diamond Point to the mine site along the north shore of Iliamna Lake. It will parallel or replace portions of the existing Pile Bay/Williamsport road and intersect with the existing Iliamna/Newhalen road network (Figure 5.1-1).

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.

Road

The mine 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 supply truck haulage from the port to the mine site.

The access road will include seventeen bridges, eight of which will be single-span, two lane bridges that range in length from approximately 40 to 90 ft. There will be one large (550 ft) multi-span, two lane bridge across the Newhalen River and eight other multi-span, two lane bridges that range in length from approximately 125 to 245 ft. 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 standards and will meet USFWS guidelines (Culvert Design Guidelines for Ecological Function, U.S. Fish and Wildlife Service Alaska Fish Passage Program, Revision 5, February 5th, 2020).

Natural Gas, Concentrate and Water Return Pipelines

The natural gas pipeline, concentrate pipeline, water return pipeline, and fiber optic cable will be buried in a corridor adjacent to the access road. For bridged river crossings, the pipelines will be attached to the bridge structures.

The concentrate pipeline will consist of a single approximately 6.25 in. diameter API 5L X60 grade (or similar) steel pipeline with an internal HDPE liner to prevent corrosion. A cathodic protection (zinc ribbon or similar) system will be included for prevention of external corrosion. A pressure-based leak detection system, with pressure transmitters located along the pipeline route, will monitor the pipeline for leaks. Two electric pump stations will be required, one at the mine site and one at an intermediate point. Both pump stations will utilize positive displacement pumps in the 1000 horsepower range and the intermediate one will require a power generation facility (1-2 MW range). Rupture discs at the intermediate and terminal stations and pressure monitoring will be utilized to protect the pipeline from overpressure events. Manual isolation and drain valves will be located at intervals no greater than 20 miles apart.

The return water pipeline is sized to accommodate water from flushing operations with a diameter of approximately 8 in. The HDPE lined steel pipeline will have similar corrosion protection and safety controls to the concentrate pipeline. No intermediate pump station is required for the water return pipeline.

Transportation Corridor Traffic

To facilitate efficient cargo movement most material will be transported in shipping 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 Diamond Point Port to the mine site using ISO tank-container units, which have a capacity of 6,350 gallons. Truck/trailer units will be designed to haul up to three loaded containers per trip.

Daily transportation of fuel, reagents and consumables will require up to 18 round trips per day for each leg of the road, including three loads of fuel per day.

Diamond Point Port and Lightering Location

Incoming supplies such as equipment, reagents, and fuel will be barged to the Diamond Point 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. Bulk concentrate will be lightered by barges to Handysize bulk carriers at a mooring point located in Iniskin Bay. The port and proposed lightering locations are shown in Figure 16.5-4.

Figure 16.5-4 Diamond Point Port and Lightering Location



The Diamond Point Port will include shore-based facilities to dewater, store, and load the copper-gold concentrate, a pumping station for the water return pipeline, facilities to receive and store containers and fuel, as well as natural gas-powered generators, maintenance facilities, employee accommodations, and offices.

The marine component includes a causeway extending out to a marine jetty located in an 18-foot deep dredged basin. A dredged access channel will lead to deep water. Concentrate will be transferred from the shore-based facilities to the barge loader using an enclosed conveyor that follows the road before transitioning onto the causeway and jetty. Fuel will be pumped from fuel barges to the on-shore storage tanks using an 8-inch pipeline.

Dredging is needed to accommodate the 15-foot draft requirements of the concentrate and supply barges and tugs that are proposed for use during construction and operations. The dredged depth for the access channel and turning basin is 18 feet below Mean Lower Low Water (MLLW) to provide access to the jetty under all tidal conditions. This allows an additional three feet to accommodate for accumulated sedimentation. The channel will be approximately 2.9 miles in length and 300 ft wide (three times the maximum expected barge width), while the turning basin will incorporate an area of approximately 1,100 ft by 800 ft. Maintenance dredging (estimated at 20 in. every 5 years) is expected to total 700,000 cubic yards over twenty years (four times). Dredging will be accomplished using a barge mounted cutterhead suction dredge. Dredged material would either be pumped directly to shore from the dredge barge, or placed into a small barge (200 ft x 40 ft) and hauled to shore. The dredged material will be placed into two bermed stockpiles located in uplands adjacent to the port facility.

Up to 27 Handysize ships will be required annually to transport concentrate. Up to 33 marine line-haul barge loads of supplies and consumables will be required annually. Two ice-breaking tugboats will be used to support marine facility operations.

Natural Gas Pipeline

Natural gas will be supplied to the Diamond Point Port and the mine site by pipeline (Figure 1-1). The pipeline will connect to the existing gas pipeline infrastructure near Anchor Point on the Kenai Peninsula and will be designed to provide a gross flow rate of approximately 50 million standard cubic feet per day. A fiber optic cable will be buried in the pipeline trench or ploughed in adjacent to the pipeline.

A metering station will be constructed at the offtake point that connects to a compressor station located on a land parcel on the east side of the Sterling Highway. The steel pipeline will be designed to meet all required codes and will be a nominal 12 in. in diameter.

The compressor station will feed a 75 mile subsea pipeline across Cook Inlet that will be constructed using heavy wall nominal 12-inch-diameter pipe designed to have negative buoyancy and provide erosion protection against tidal currents. Horizontal directional drilling will be used to install pipe segments from the compressor station out into waters that are deep enough to avoid navigation hazards. From this point, the heavy wall pipe will be trenched into the sea floor as required to maintain pipe integrity.

The pipeline will come ashore in Ursus Cove utilizing trenching, cross Ursus Head and Cottonwood Bay before reaching the port site north of Diamond Point. Natural gas will be fed to the port site power station and used for site heating. The distance from the Diamond Point Port to the mine site is approximately 82 miles. The pipeline will be buried with concentrate and water return pipelines in a trench adjacent to the road prism and will follow the mine access road to the mine site. At bridged crossings the pipeline will be attached to the bridges, otherwise the pipeline will utilize trenching or horizontal directional drilling to cross streams.

Long-term corrosion protection and control will be provided by an external coating on the pipeline and components, combined with an impressed current and/or galvanic current cathodic protection system. The cathodic protection system will be installed and activated, as soon as is practical, after pipe installation to maximize the effect of corrosion protection. Metering stations and pig launching and receiving facilities would be located at the compressor station and offtake points as appropriate. Mainline sectionalizing valves will be installed as required by code, with a spacing of no more than 20 miles for the onshore sections of the pipeline.

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) and was the Lead Federal Agency for the development of the EIS document. USACE consulted with other Federal agencies to determine what additional Federal authorizations were required and how those agencies would participate in the EIS

process. Federal, State, and Tribal entities with special expertise on the project were also involved as cooperating agencies, and there were two public comment periods – one during the scoping phase and the second during the review of the Draft EIS.

The Final EIS (FEIS) document was published on July 24, 2020. 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.

Numerous environmental permits and plans will be required by federal, state, and local agencies. The Pebble Partnership will work with applicable permitting agencies and the State of Alaska large mine permitting team to provide complete permit applications in an orderly manner.

Table 16.5-4 lists the types of permits that are expected to be required for the Pebble Project. Multiple permits of certain types may have to be applied for to accommodate the full scope of facilities.

Table 16.5-4 Environmental Permits Required for the Pebble Project

Agency	Approval Type	Project-related Examples
Federal		
BATF	License to Transport Explosives	Construction explosives acquisition and use
	Permit and License for Use of Explosives	Construction explosives acquisition and use
BSEE	Right-of-Way Authorization for Natural Gas Pipeline	Subsea natural gas pipeline in OCS waters
DHS	Airport Security Operations Plan	Iliamna Airport
	Port Facility Security Coordinator Certification	Port site
	Port Security Operations Plan	Port site
EPA	Facility Response Plan (required to be submitted to EPA, however EPA does not provide plan approvals)	Fuel storage facilities, fuel transport on the mine roadway
	RCRA Registration for Identification Number	Storage and disposal of hazardous wastes
	Spill Prevention, Control, and Countermeasure (SPCC) Plan (SPCC plans are not required to be submitted or approved by EPA. The plan will be reviewed and certified by a Professional Engineer licensed in Alaska)	Fuel storage facilities
FAA	Notice of Controlled Firing Area for Blasting	Construction and mining blasting activity
FCC	Radio License	Radios
MSHA	Mine Identification Number	Mine site
	Notification of Legal Identity	Mine site
NMFS	Magnuson-Stevens Fishery Conservation and Management Act Consultation documentation	Necessary in areas where mine, road, or port site activity affect essential fish habitat

Agency	Approval Type	Project-related Examples
USACE	Clean Water Act Section 404 permit for Discharge of Dredge or Fill Material into Waters of the U.S.	Fill into wetlands for a variety of facilities at the mine, road, pipelines, port site
	Rivers and Harbors Act Section 10 Construction of any structure in or over any Navigable Waters of the U.S.	Road bridges and causeway; port site docking and ship-loading facilities and maintenance dredging.
USCG	Facility Response Plan	Fuel storage facilities
	Fuel Offloading Plan; Person in Charge Certification	Offloading fuel from barges at the port
	Hazardous Cargo Offloading Plan; Port Operations Manual Approval	Offloading hazardous cargo from ships
	Navigation Lighting and Marking Aids Permit	Port facilities
USDOT	Rivers and Harbors Act Section 9 Construction Permit for a Bridge or Causeway across Navigable Waters	Bridge along road
	Registration for Identification Number to Transport Hazardous Wastes	Transport of hazardous wastes to approved disposal site
USFWS	Bald and Golden Eagle Protection Act Programmatic Take Permit	May be necessary in areas where mine, road, or port site activity may disturb eagles
	Migratory Bird Treaty Act Consultation documentation	May be necessary in areas where mine, road, or port site activity may disturb migratory birds
USFWS/NMFS	Endangered Species Act Incidental Take Authorization	May be necessary at the port site and for sub-sea pipeline construction where activities could disturb northern sea otter, Beluga whale, Steller sea lion, Steller's eider
	Marine Mammal Protection Act Incidental Take Authorization; Letter of Authorization	May be necessary at port site where activities could disturb northern sea otter, Beluga whale, Steller sea lion, harbor seal, Dall's porpoise
State		
ADEC	Alaska Solid Waste Program Integrated Waste Management Permit/Plan Approval	Tailings disposal, waste rock disposal, landfills
	Reclamation Plan Approval and Bonding	Required prior to construction.
	Alaska Solid Waste Program Solid Waste Disposal Permit; Open Burn Permit	Construction waste material disposal
	Clean Water Act Section 402 Alaska Pollutant Discharge Elimination System Water Discharge Permit	Water discharges from water treatment plans at the mine site.
	Approval to Construct and Operate a Public Water Supply System	Mine and port, and construction camps
	Clean Air Act Air Quality Control Permit to Construct and Operate – Prevention of Significant Deterioration	Power plant and other non-mobile air emissions; fugitive dust; applicable to mine, road, and port
	Clean Air Act Title V Operating Permit	Power plant and other non-mobile air emissions; fugitive dust; applicable to mine and road
	Clean Air Act Title I Operating Permit	Non-mobile air emissions; stationary sources, fugitive dust; applicable to port and Kenai compressor station
	Clean Water Act Section 401 Certification	Certification of the Section 404 Permit.

Agency	Approval Type	Project-related Examples
	Clean Water Act Section 402 Stormwater Construction and Multi-Sector General Permit; Stormwater Discharge Pollution Prevention Plan	Surface water runoff discharges at mine, road, and port site
	Food Sanitation Permit	Mine and port, and construction camps
	Oil Discharge Prevention and Contingency Plan (ODPCP or "C" Plan)	Fuel storage and transfer facilities, port and mine
ADF&G	Fish collection permits for monitoring	Required for construction and monitoring
	Fish Habitat Permit	Required for most work in anadromous streams and for most work in resident fish streams that might affect fish passage.
ADNR	Alaska Dam Safety Program Certificate of Approval to Construct a Dam	Tailings dam, seepage control dams
	Alaska Dam Safety Program Certificate of Approval to Operate a Dam	Tailings dam, seepage control dams
	Reclamation Plan Approval and Bonding	Required prior to construction.
	Lease of other State Lands	Any miscellaneous other state lands to be used by the Pebble Project – none identified at this time
	Material Sale on State Land	Materials removed from quarry sites for construction
	Mill Site Permit	All facilities on state lands
	Mining license	All facilities on state lands
	Miscellaneous Land Use Permit	All facilities on state lands
	National Historic Preservation Act Section 106 Review	Area of Potential Effect
	Pipeline Rights-of-Way Lease	Natural gas, concentrate, and water return pipelines on State lands and natural gas pipeline in State waters
	Fiber Optic Cable Right-of-Way Lease	Fiber Optic Cable on State lands and in State waters
	Powerline Right-of-Way Lease	Powerlines to support electric power distribution
	Road Right-of-Way Lease	Road between mine and port site
	Temporary Water Use Permit; Permit to Appropriate Water	Surface and groundwater flow reductions
Tidelands Lease	Port structures below high tide line	
Upland Mining Lease	All facilities on state lands	
ADOL	Certificate of Inspection for Fired and Unfired Pressure Vessels	
ADOT&PF	Driveway Permit	Road
	Utility Permit on Right-of-Way	Natural gas pipeline on the Kenai Peninsula
ADPS	Approval to Transport Hazardous Materials	Transport of hazardous materials along the road
	Life and Fire Safety Plan Check	Mine and port
	State Fire Marshall Plan Review Certificate of Approval	For each individual building
Local		
KPB	Conditional Use Permit	
	Floodplain Development Permit	

Agency	Approval Type	Project-related Examples
	Multi-Agency Permit Application	
L&PB	Lake and Peninsula Borough Development Permit	Mine and road area within the Lake and Peninsula Borough

ADEC = Alaska Department of Environmental Conservation
 ADF&G = Alaska Department of Fish and Game
 ADOT/PF = Alaska Department of Transportation and Public Facilities
 ADPS = Alaska Department of Public Safety
 BATF = U.S. Bureau of Alcohol, Tobacco, and Firearms
 BSEE = Bureau of Safety and Environmental Enforcement
 DHS = U.S. Department of Homeland Security
 EPA = U.S. Environmental Protection Agency
 FAA = Federal Aviation Administration
 FCC = Federal Communications Commission
 FERC = Federal Energy Regulatory Commission
 L&PB = Lake and Peninsula Borough
 MSHA = U.S. Mine Safety and Health Administration
 NMFS = National Marine Fisheries Service
 RCRA = Resource Conservation and Recovery Act
 SHPO = State Historic Preservation Officer
 USACE = U.S. Army Corps of Engineers
 USCG = U.S. Coast Guard
 USDOT = U.S. Department of Transportation
 USFWS = U.S. Fish and Wildlife Service

17.0 INTERPRETATION AND CONCLUSIONS

17.1 GENERAL

The 2020 Technical Report for the Pebble Project has been completed in accordance with NI 43-101. The report describes the results of an August 2020 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-rhenium 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.

Estimates 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.

There are no differences between the 2017 Pebble resource and the current 2020 resource estimate for copper, gold, molybdenum and silver. The current Pebble resource differs from the 2017 resource only in that rhenium has been added to the list of metals that have been quantified at the level defined by NI 43-101.

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

This study assessed and estimated the amount of rhenium in the Pebble deposit. Elevated levels of palladium, vanadium, titanium and tellurium have been noted in raw analytical data and in metallurgical studies that should be assessed.

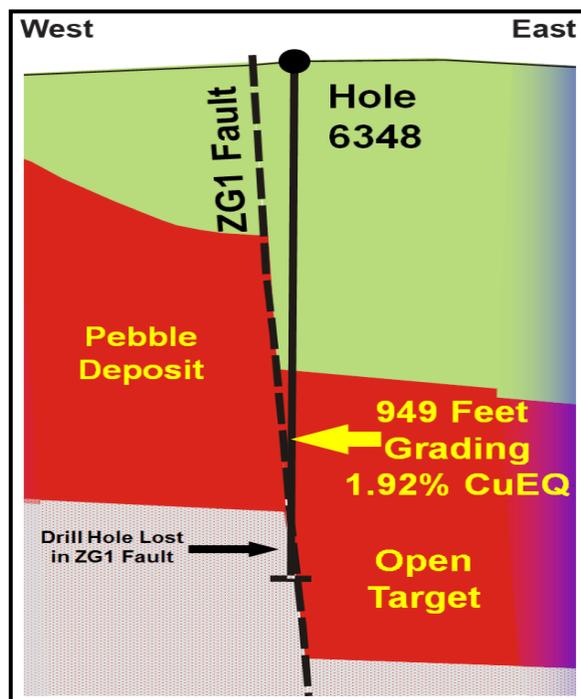
17.2.1 Updating of Inferred Resource

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



17.3 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.

The molybdenum concentrate will contain significant rhenium. The reported grades in the locked cycle flotation results are between 791 to 832 g/t Re.

A preliminary hydrometallurgical test program was also completed on the rougher and cleaner molybdenum concentrates for the recovery of molybdenum and rhenium. The process includes a pressure oxidation (POX) via Molybdenum Autoclave Process (MAP) and Hot Cure process, as well as a series of metal extractions/purifications from the pregnant leach solution.

At the current stage, a conventional flotation process is proposed to produce copper concentrate and molybdenum concentrate. The 2018 projections of copper, gold, silver and molybdenum remain the same in this technical report, while a high-level recovery estimate of rhenium to be about 70.8% on average for all the domains.

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.

17.5 OTHER STUDIES

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

Additional resource evaluation

- 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.

Additional metallurgical testwork

- 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; Future testwork to optimize molybdenum recovery can be investigated by (1) increasing the cleaning circuit retention time and (2) optimizing reagent dosages.
- Variability metallurgical testwork should be carried out to further investigate the behaviours and responses of silver and rhenium of the samples across the Pebble deposit. This can be completed by conducting batch and locked cycle flotation tests with variable samples. At present, there are 10 locked cycle tests with silver and rhenium assays to support a mass balance calculation, while the remainder of the tests only contained the assay results of the bulk concentrate;
- 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; and
- Further testwork for MAP on high grade molybdenum concentrates and metal extractions are recommended to establish baseline hydrometallurgical process flowsheets. A preliminary

economical assessment is recommended to fully evaluate the application of the hydrometallurgical method for molybdenum and rhenium recovery.

18.0 RECOMMENDATIONS

18.1 RECOMMENDED PROGRAM

This study assessed and estimated the amount of rhenium in the Pebble deposit. Elevated levels of palladium, vanadium, titanium and tellurium have been noted in raw analytical data and in metallurgical studies. A scoping level program is recommended to determine their potential for inclusion in future resource estimates. Such a study would focus on these metals' deportment, distribution and the best approach to their quantification.

\$100,000

Review metallurgical testwork to date to identify opportunities to optimize treatment of supergene mineralization within the deposit, and provide recommendations on future sampling and testwork. .

\$50,000

Complete an initial assessment of potential treatment methods of molybdenum concentrates to optimize the value of molybdenum and rhenium.

\$50,000

19.0 REFERENCES

19.1 GEOLOGY

- Amato, J.M., Foley, C., Heizler, M., and Esser, R., 2007, $^{40}\text{Ar}/^{39}\text{Ar}$ and U-Pb geochronology, geochemistry, and tectonic setting of three episodes of Cretaceous-Eocene calc-alkaline magmatism in the Lake Clark Region, southwestern Alaska: in Ridgway, K.D., Trop, J.M., Glen, J.M.G., and O'Neill, J.M., eds., *Tectonic Growth of a Collisional Continental Margin: Crustal Evolution of Southern Alaska: Geological Society of America Special Paper 431*, p. 455-475.
- Anderson, E.D., Hitzman, M.W., Monecke, T., Bedrosian, P.A., Shah, A.K., and Kelley, K.D., 2013, Geological analysis of aeromagnetic data from southwestern Alaska: Implications for exploration in the area of the Pebble porphyry Cu-Au-Mo deposit. *Economic Geology*, in press.
- Bouley, B.A., St. George, P., and Wetherbee, P.K., 1995, Geology and discovery at Pebble Copper, a copper-gold porphyry system in southwest Alaska: in Schroeter, T.G., ed., *Porphyry Deposits of the Northwestern Cordillera of North America*, CIM Special Volume 46, p. 422-435.
- Bundtzen, T.K., and Miller, M.L., 1997, Precious metals associated with Late Cretaceous-early Tertiary igneous rocks of southwestern Alaska: in Goldfarb, R.J., and Miller, L.D., eds., *Mineral Deposits of Alaska: Economic Geology Monograph 9*, p. 242-286.
- CIM, 2003, *Best Practices in Uranium Estimation Guidelines*
- Clark, A.H., 1993, Are oversized porphyry copper deposits either anatomically or environmentally distinctive? *Society of Economic Geologists Special Publication 2*, p. 213-283.
- Couture, J.F., and Siddorn, J., 2007, Technical report on the Whistler Cu-Au exploration project, Alaska Range, Alaska. Available on www.sedar.com, 92 p.
- Decker, J., Bergman, S.C., Blodgett, R.B., Box, S.E., Bundtzen, T.L., Clough, J.G., Coonrad, W.L., Gilbert, W.G., Miller, M.L., Murphy, J.M., Robinson, M.S., and Wallace, W.K., 1994, Geology of southwestern Alaska: in Plafker, G., and Berg, H.C., eds., *The Geology of Alaska. Geological Society of America, The Geology of North America*, v. G-1., p. 285-310.
- Detterman, R.L., and Reed, B.L., 1973. Surficial Deposits of the Iliamna Quadrangle, Alaska, U.S. Geological Survey Bulletin 1368-A, 64 p.
- Detterman, R.L., and Reed, B.L., 1980, Stratigraphy, structure, and economic geology of the Iliamna quadrangle, Alaska: U.S. Geological Survey Bulletin 1368-B, 86 p.
- Foley, J.Y., Light, T.D., Nelson, S.W., and Harris, R.A., 1997, Mineral occurrences associated with mafic-ultramafic and related alkaline complexes in Alaska; in Goldfarb, R.J., and Miller, L.D., eds., *Mineral Deposits of Alaska. Economic Geology Monograph 9*, p. 396-449.

- Gaunt, J.D., Rebagliati, C.M., Lang, J., Titley, E., Melis, L., Barratt, D., and Hodgson, S., 2010, Technical report on the 2009 program and update on mineral resources and metallurgy, Pebble copper-gold-molybdenum project, Alaska. Available on www.sedar.com, 195 p.
- Gaunt, J.D., C.M., Lang, J., Titley, E., and Lu, T., 2014, Technical report on the Pebble Project, Southwest Alaska, USA. Available on www.sedar.com, 170 p.
- Gaunt, J.D., C.M., Lang, J., Titley, E., Lu, T., and Hodgson, S. 2018, Technical report on the Pebble Project, Southwest Alaska, USA. Available on www.sedar.com, 191 p.
- Goldfarb, R.J., 1997, Metallogenic evolution of Alaska; in Goldfarb, R.J., and Miller, L.D., eds., Mineral Deposits of Alaska, Society of Economic Geologists Monograph 9, p. 4-34.
- Goldfarb, R.J., Hart, C.J.R, and Anderson, E.D., 2013, Regional tectonic framework of the Pebble deposit: Economic Geology, in press.
- Gregory, M.J., 2017. A fluid inclusion and stable isotope study of the Pebble porphyry copper-gold-molybdenum deposit, Alaska. Ore Geology Reviews, v. 80, p. 1279-1303.
- Gregory, M., and Lang, J., 2009, Hydrothermal controls on copper sulphide speciation, metal distribution and gold deportment in the Pebble porphyry Cu-Au-Mo deposit, southwest Alaska: Proceedings of the 10th Biennial Meeting of the Society for Geology Applied to Mineral Deposits, Townsville, Australia, p. 524-526.
- Gregory, M.J., and Lang, J.R., 2011, Controls on Au deportment in the Pebble Cu-Au-Mo porphyry deposit, Alaska: in Williams, P.J., Oliver, N., and Rusk, B., eds., Let's Talk Ore Deposits: Proceedings of the Eleventh Biennial SGA Meeting, Antofagasta, Chile, p. 524-526.
- Gregory, M.J., and Lang, J.R., 2012, The Pebble porphyry Cu-Au-Mo deposit, Alaska. Society of Mining Engineers Annual Meeting, Seattle, preprint 12-141.
- Gregory, M.J., Lang, J.R., Gilbert, S., and Hoal, K.O., 2013, Geometallurgy of the Pebble copper-gold-molybdenum deposit, Alaska: Implications for gold distribution and paragenesis: Economic Geology, in press.
- Gustafson, L.B., and Hunt, J.P., 1975, The porphyry copper deposit at El Salvador, Chile: Economic Geology, v. 70, p. 857-912.
- Gustafson, L.B., and Quiroga G., J., 1995, Patterns of mineralization and alteration below the porphyry copper orebody at El Salvador, Chile: Economic Geology, v. 90, p. 2-16.
- Haeussler, P.J., and Saltus, R.W., 2005, 26 km of offset on the Lake Clark fault since late Eocene time: U.S. Geological Survey, Professional Paper 1709A, 4 p.
- Haeussler, P.J., and Saltus, R.W., 2011, Location and Extent of Tertiary Structures in Cook Inlet Basin, Alaska, and Mantle Dynamics that Focus deformation and Subsidence, in Dumoulin, J.A., and

- Galloway, J.P., eds., Studies by the U.S. Geological Survey in Alaska 2008–2009: U.S. Geological Survey Professional Paper 1776–D, 26 p. Hamilton, T., and Klieforth, R.F., 2010, Surficial geologic map of parts of the D-6 and D-7 quadrangles, Pebble project area, southwestern Alaska: Alaska Division of Geological & Geophysical Surveys, Report of Investigation 2009-4, 19 p.
- Hames, B.P., and Roberts, M.D. (2020). The Whistler porphyry Au-Cu deposit, Alaska. In Sharman, E.R., Lang, J.R., and Chapman, J.B. (Eds.) *Porphyry Deposits of the Northwestern Cordillera of North America: A 25-Year Update*. Canadian Institute of Mining and Metallurgy Special Volume 57. Montreal, QC: Canadian Institute of Mining, Metallurgy and Petroleum. In Press.
- Hampton, B.A., Ridgway, K.D., and Gehrels, G.E., 2010, A detrital record of Mesozoic island arc accretion and exhumation in the North American Cordillera: U-Pb geochronology of the Kahiltna basin, southern Alaska: *Tectonics*, v. 29, TC4015, doi:10.1029/2009TC002544, 21p.
- Hanley, J., Kerr, M., LeFort, D., Warren, M., Mackenzie, M., and Sedge, C., 2020, Platinum-group element (PGE) enrichment in alkalic porphyry Cu-Au deposits in the Canadian cordillera: new insights from mineralogical and fluid inclusion studies. In Sharman, E.R., Lang, J.R., and Chapman, J.B. (Eds.) *Porphyry Deposits of the Northwestern Cordillera of North America: A 25-Year Update*. Canadian Institute of Mining and Metallurgy Special Volume 57. Montreal, QC: Canadian Institute of Mining, Metallurgy and Petroleum. In Press.
- Harraden, C.L., McNulty, B.A., Gregory, M.J., and Lang, J.R., 2012, Shortwave infrared spectral analysis of hydrothermal alteration associated with the Pebble porphyry copper-gold-molybdenum deposit, Iliamna, Alaska, USA: *Economic Geology*, in press.
- Hart CJR, 2010. Intrusive rocks associated with the Pebble porphyry Cu-Au-Mo deposit, southwest Alaska. GSA Denver annual meeting abstract 182738.
- Hart, C.J., Lang, J.R., Goldfarb, R.J., and Farmer, G.L., 2010, Intrusive rocks associated with the Pebble porphyry Cu-Au-Mo deposit, southwest Alaska. *Geological Society of America Abstracts with Programs*, v. 42, p. 676.
- Haslinger, R.J., Payne, J.G., Price, S., and Rebagliati, C.M., 2004, 2003 Summary report on the Pebble porphyry gold-copper project, Iliamna Lake area, southwestern Alaska, USA. Available on www.sedar.com, 119 p.
- Hawley, C., 2004 Alaska resource data file, Iliamna quadrangle, Alaska: U.S. Geological Survey Open-File Report 2004-105, 118 p.
- Haynes, F.H., and Titley, S.R., 1980, The evolution of fracture-related permeability within the Ruby Star Granodiorite, Sierrita porphyry copper deposit, Pima County, Arizona: *Economic Geology*, v. 75, p. 673-683.
- Iriondo, A., Kunk, M.J., and Wilson, F.H., 2003, $^{40}\text{Ar}/^{39}\text{Ar}$ geochronology of igneous rocks in the Taylor Mountains and Dillingham quadrangles in SW Alaska: U.S. Geological Survey Open-File Report 03-0421.

- John, D.A., Ayuso, R.A., Barton, M.D., Blakely, R.J., Bodnar, R.J., Dilles, J.H., Gray, F., Graybeal, F.T., Mars, J.C., McPhee, D.K., Seal, R.R., Taylor, R.D., and Vikre, P.G., 2010, Porphyry copper deposit model, chapter B of Mineral Deposit Models for Resource Assessment. U.S. Geological Survey, Scientific Investigations Report 2010-5070-B, 169 p.
- John, D.A., Seal, R.R., II, and Polyak, D.E., 2017, Rhenium, chapter P of Schulz, K.J., DeYoung, J.H., Jr., Seal, R.R., II, and Bradley, D.C. (eds.), Critical mineral resources of the United States—Economic and environmental geology and prospects for future supply. U.S. Geological Survey Professional Paper 1802, p. P1–P49
- Kalbas, J.L., Ridgeway, K.D., and Gehrels, G.E., 2007, Stratigraphy, depositional systems, and provenance of the Lower Cretaceous Kahiltna assemblage, western Alaska Range: Basin development in response to oblique collision: in Ridgeway, K.D., Trop, J.M., Glen, J.M.G, Evolution of Southern Alaska: Geological Society of America Special Paper 431, p. 307-344.
- Kelley, K.D., Eppinger, R.G., Lang, J., Smith, S.M., and Fey, D.L., 2011, Porphyry Cu indicator minerals in till as an exploration tool: example from the giant Pebble porphyry Cu-Au-Mo deposit, Alaska, : Geochemistry: Exploration, Environment, Analysis, v. 11, p. 321-334.
- Khashgerel, B., Rye, R.O., Kavalieris, I, and Hayashi, K., 2009, Thesericitic to advanced argillic transition: Stable isotope and mineralogical characteristics from the Hugo Dummett porphyry Cu-Au deposit, OyuTolgoi district, Mongolia: Economic Geology, v. 104, p. 1087-1110.
- Koehler, R.D., and Reger, R.D., 2011, Reconnaissance evaluation of the Lake Clark fault, Tyonek area, Alaska. State of Alaska Department of Natural Resources, Division of Geological & Geophysical Surveys, PRELIMINARY INTERPRETIVE REPORT 2011-1, 10 p.
- Koehler, R.D., 2010, Technical review of a trench across a potential fault scarp feature east of lower Talarik Creek, Lake Iliamna area, southwestern Alaska. State of Alaska Department of Natural Resources, Alaska Division of Geological & Geophysical Surveys, MISCELLANEOUS PUBLICATION 139, 12 p.
- Kreiner, D.C., Jones III, J.V., Kelley, K.D., and Graham, G.E. (2020). Tectonic and magmatic controls on the metallogenesis of porphyry deposits in Alaska. In Sharman, E.R., Lang, J.R., and Chapman, J.B. (Eds.) Porphyry Deposits of the Northwestern Cordillera of North America: A 25-Year Update. Canadian Institute of Mining and Metallurgy Special Volume 57. Montreal, QC: Canadian Institute of Mining, Metallurgy and Petroleum. In Press.
- Kremenetskii, A.A., Popov, V.S., and Gromalova, N.A., 2012, The formation age of ores from the Pebble Cu-Au-Mo giant deposit (Alaska, United States). Doklady Earth Sciences, v. 442, part 2, p. 196-201.
- Lang, J.R., Gregory, M.J., Rebagliati, C.M., Payne, J.G., Oliver, J.L., and Roberts, K., 2012, Geology and magmatic-hydrothermal evolution of the giant Pebble porphyry copper-gold-molybdenum deposit, southwest Alaska, USA. Economic Geology, in press.

- Lang, J.R., Rebagliati, C.M., Roberts, K., and Payne, J.G., 2008, The Pebble copper-gold-molybdenum porphyry deposit, southwest Alaska USA: Proceedings of PACRIM 2008, AUSIMM, p. 27-32.
- Lang, J.R., Stanley, C.R., and Thompson, J.F.H., 1995, Porphyry copper-gold deposits related to alkaline igneous rocks in the Triassic-Jurassic arc terranes of British Columbia. In: Pierce, F.W, and Bolm, J.G., eds., Porphyry Copper Deposits of the American Cordillera. Arizona Geological Society Digest, v. 20, p. 219-236.
- McCandless, T.E., Ruiz, J., and Campbell, A.R., 1993, Rhenium behaviour in molybdenite in hypogene and near-surface environments: Implications for Re-Os geochronometry: *Geochimica et Cosmochimica Acta*, v. 57, p. 889-905.
- McClelland, W.C., Gehrels, G.E., and Saleeby, J.B., 1992, Upper Jurassic-Lower Cretaceous basal strata along the Cordilleran Margin: Implications for the accretionary history of the Alexander-Wrangellia-Peninsular Terrane: *Tectonics*, v. 11, p. 823-835.
- McFall, K.A., Naden, J., Roberts, S., Baker, T., Spratt, J., and McDonald, I., 2018, Platinum-group minerals in the Skouries Cu-Au (Pd, Pt, Te) porphyry deposit. *Ore Geology Reviews*, v. 99, p. 344-364.
- Meyer, C., and Hemley, J.J., 1967, Wall rock alteration. In: Barnes, H.L., ed., *Geochemistry of hydrothermal ore deposits*: New York, Holt, Rinehart and Winston, p. 166-235.
- Olson, N.H. (2015). The geology, geochronology, and geochemistry of the Kaskanak batholith, and other Late Cretaceous to Eocene magmatism at the Pebble porphyry Cu-Au-Mo deposit, SW Alaska. Unpublished M.Sc thesis, Oregon State University.
- Olson, N.H., Dilles, J.H., Kent, A.J.R., and Lang, J.R. (2017). Geochemistry of the Cretaceous Kaskanak batholith and genesis of the Pebble porphyry Cu-Au-Mo deposit, Southwest Alaska. *American Mineralogist*, v. 102, p. 1597-1621.
- Olson, N.H., Lang, J.R., and Dilles, J.H. (2020). The Pebble porphyry Cu-Au-Mo deposit, southwestern Alaska. In Sharman, E.R., Lang, J.R., and Chapman, J.B. (Eds.) *Porphyry Deposits of the Northwestern Cordillera of North America: A 25-Year Update*. Canadian Institute of Mining and Metallurgy Special Volume 57. Montreal, QC: Canadian Institute of Mining, Metallurgy and Petroleum. In Press
- Pavlis, T.L., Sisson, V.B., Foster, H., Nokleberg, W.J., and Plafker, G., 1993, Constraints on crustal extension in the western Yukon-Tanana terrane, central Alaska: *Tectonics*, v. 12, p. 103-122.
- Phillips, C.H., Gambell, N.A., and Fountain, D.S., 1974, Hydrothermal alteration, mineralization and zoning in the Ray deposit: *Economic Geology*, v. 69, p. 1237-1250.
- Plafker, G., and Berg, H.C., 1994, Overview of the geology and tectonic evolution of Alaska: in Plafker, G., and Berg, H.C., eds., *The Geology of Alaska*: Geological Society of America, *The Geology of North America*, v. G-1, p. 989-1021.

- Rebagliati, C.M., and Haslinger, R.J., 2003, Summary report on the Pebble copper-gold porphyry project, Iliamna Lake area, southwestern Alaska, USA. Available on www.sedar.com.94 p.
- Rebagliati, C.M., and Payne, J.G., 2006, 2005 summary report on the Pebble porphyry copper-gold project, Iliamna Lake area, southwestern Alaska, USA. Available on www.sedar.com.111 p.
- Rebagliati, C.M., and Payne, J.G., 2007, 2006 summary report on the Pebble porphyry copper-gold-molybdenum project, Iliamna Lake area, southwestern Alaska, USA. Available on www.sedar.com.119 p.
- Rebagliati, C.M., Lang, J.R., Titley, E., Gaunt, J.D., Melis, L., Barratt, D., and Hodgson, S., 2010, Technical report on the 2009 program and update on mineral resources and metallurgy, Pebble copper-gold-molybdenum project, Iliamna Lake area, southwestern Alaska, USA. Available on www.sedar.com, 194 p.
- Rebagliati, C.M., Lang, J.R., Titley, E., Gaunt, J.D., Rennie, D., Melis, L., Barratt, D., and Hodgson, S., 2008, Technical report on the 2007 program and updates on metallurgy and resources. Available on www.sedar.com.
- Rebagliati, C.M., Lang, J.R., Titley, E., Gaunt, J.D., Rennie, D., Melis, L., Barratt, D., and Hodgson, S., 2009, Technical report on the 2008 program and updates on mineral resources and metallurgy. Available on www.sedar.com.
- Rebagliati, C.M., Payne, J.G., and Lang, J.R., 2005, 2004 summary report on the Pebble porphyry gold-copper project, Iliamna Lake area, southwestern Alaska, USA. Available on www.sedar.com.79 p.
- Rebagliati, M., and Lang, J., 2009, The Pebble porphyry copper-gold-molybdenum discovery, Alaska, USA. Conference Proceedings, New GenGold 2009, Case Histories of Discoveries, Perth, p. 121-132.
- Rebagliati, C.M. and Haslinger, R.J., 2003. Technical Report on the Pebble Project January 2003.
- Rebagliati, C.M. and Haslinger, R.J., 2004. Technical Report on the Pebble. January 2004.
- Rebagliati, C.M. and Haslinger, R.J., Payne, J.G., and Price, C.M., 2004. Technical Report on the Pebble Project. May 2004.
- Rebagliati, C.M. and Payne, J.G., 2005. Technical Report on the Pebble Project March 2005.
- Rebagliati, C.M. and Payne, J.G., 2006. Technical Report on the Pebble Project March 2006.
- Rebagliati, C.M. and Payne, J.G., 2007. 2006 Summary Report on the Pebble Porphyry Copper-Gold-Molybdenum Project. Iliamna Lake Area, Southwestern Alaska, USA. March 2007. 119 pages.
- Rebagliati, C.M., Lang, J.R., Titley, E., Gaunt, J.D., Melis, L., Barratt, D., Hodgson, S., 2010. Technical Report on the 2009 Program and Update on Mineral Resources and Metallurgy. Pebble Copper-

- Gold-Molybdenum Project, Iliamna Lake Area, Southwestern Alaska, USA for Northern Dynasty Minerals Ltd. March 2010. 194 pages.
- Rebagliati, C.M., Lang, J.R., Titley, E., Gaunt, J.D., Rennie, D., Melis, L., Barratt, D., Hodgson, S., 2008. Technical Report on the 2007 Program and Updates on Metallurgy and Resources. March 2008.
- Rebagliati, C.M., Lang, J.R., Titley, E., Gaunt, J.D., Rennie, D., Melis, L., Barratt, D., Hodgson, S., 2009. Technical Report on the 2008 Program and Updates on Mineral Resources and Metallurgy. February, 2009.
- Reed, B.L., and Lanphere, M.A., 1973, Alaska-Aleutian Range batholith: Geochronology, chemistry, and relation to circum-Pacific plutonism: Geological Society of America Bulletin, v. 84, p. 2583-2610.
- Rombach, C., and Newberry, R., 2001, Shotgun deposit: Granite porphyry-hosted gold-arsenic mineralization in southwestern Alaska, USA: Mineralium Deposita, v. 36, p. 607-621.
- Schrader, C.M., 2001, Geochronology and geology of the Pebble Cu-Au-Mo porphyry and the Sill Au-Ag epithermal deposits, southwest Alaska. Unpublished M.Sc thesis, University of Georgia, Athens, 109 p.
- Seedorff, E., Dilles, J.H., Proffett, J.M., Einaudi, M.T., Zurcher, L., Stavast, W.J.A., Johnson, D.A., and Barton, M.D., 2005, Porphyry deposits: Characteristics and origin of hypogene features: in Hedenquist, J.W., Thompson, J.F., Goldfarb, R.J., and Richards, J.P., eds., Economic Geology 100th Anniversary Volume, 1905-2005. Society of Economic Geologists, p. 251-298.
- Shah, A., Bedrosian, P., Anderson, E., Kelley, K., and Lang, J., 2009, Geophysical data used to characterize the regional setting of the Pebble porphyry deposit in southwest Alaska: Geological Society of America Annual Meeting, Program with Abstracts, v. 41, p. 493.
- Sillitoe, R.H., 2010, Porphyry copper systems: Economic Geology, v. 105, p. 3-41. Sinclair, W.D., Jonasson, I., Kirkham, R.V., and Soregaroli, A.E., 2009, Rhenium and other platinum-group metals in porphyry deposits. Geological Survey of Canada, Open File 6181.
- Srivastava, M, 2020 Prediction of Missing Rhenium for Pebble, 2020, Internal Company Memo
- Wallace WK, Hanks CL and JF Rogers, 1989, The southern Kahiltna terrane: Implications for the tectonic evolution of southwestern Alaska. GSA Bulletin 101, 1389-1407.
- Wallace, W.E., Hanks, C.L., and Rogers, J.F., 1989, The southern Kahiltna terrane: Implications for the tectonic evolution of southwestern Alaska: Geological Society of America Bulletin, v. 101, p. 1389-1407.
- Young, L.E., St. George, P., and Bouley, B.A., 1997, Porphyry copper deposits in relation to the magmatic history and palinspastic restoration of Alaska: in Goldfarb, R.J., and Miller, L.D., eds., Mineral Deposits of Alaska: Society of Economic Geologists Monograph 9, p. 306-333.

Website

SEDAR (System for Electronic Document Analysis and Retrieval): www.sedar.com

US Geological Survey (USGS), 2017. Rhenium, Chapter P of Critical Mineral Resources of the United States—Economic and Environmental Geology and Prospects for Future Supply. <https://pubs.usgs.gov/pp/1802/p/pp1802p.pdf>

19.2 MINERAL PROCESSING

G & T Metallurgical Services Ltd., 2011. Copper Molybdenum Separation Testing on a Pebble Bulk Concentrate. September 22, 2011.

Outotec (Canada) Ltd., 2010. Outotec Thickener Interpretations and Recommendations for Test Data. Report TH-0493, Pebble Project, April 9, 2010.

Outotec (Canada) Ltd., 2010. Outotec Thickener Interpretations and Recommendations for Test Data. Report TH-0497, Pebble Project. June 17, 2010.

SGS-Lakefield Research Ltd., 2010. An Investigation into the Pebble East and Pebble West Metallurgical Programs. Project #12072-002 Final Report, May 3, 2010.

SGS-Lakefield Research Ltd., 2010. An Investigation into the Recovery of Copper, Gold, and Molybdenum from Samples from Pebble East and West Deposits. Project #12072-002-Report #2, May 10, 2010.

SGS-Lakefield Research Ltd., 2014. A Summary of Pebble East and West Metallurgical Programs. September 5, 2014.

SGS-Lakefield Research Ltd., 2010. An Investigation into the Recovery of Copper, Gold, and Molybdenum from Samples from Pebble East and West Deposits. Project #12072-003/007-Report #3 Rev 1, September 24, 2014.

SME Mineral Processing & Extractive Metallurgy Handbook, 2018 Review of MAP Development Work, Dreisinger Consulting Inc., September 16, 2012

19.3 ENVIRONMENTAL

Alaska Department of Fish and Game (ADFG), 2010. 2009 Bristol Bay Area Annual Management Report. Fishery Management Report No. 10-25.

Alaska Department Fish and Game (ADFG), 2013. Anadromous Waters Catalog. <https://www.adfg.alaska.gov/sf/SARR/AWC/index.cfm>

- Alaska Department of Fish and Game (ADFG), 2020. Bristol Bay Salmon Escapement (2019). <https://www.adfg.alaska.gov/index.cfm?adfg=commercialbyareabristolbay.escapement>
- Alaska Department of Natural Resources, 2005. Bristol Bay Area Plan for State Lands. http://dnr.alaska.gov/mlw/planning/areaplans/bristol/pdf/bbap_complete.pdf
- Jones, M. et al, 2012. 2012 Bristol Bay Area Management Report No. 13-20.
- Mine Environmental Neutral Drainage Program, 1991. Acid Road Drainage Prediction Manual, MEND Project 1.16.1b, CANMET – MSL Division, Department of Energy, Mines and Resources, Canada.
- PLP (Pebble Limited Partnership), 2012. Pebble Project Environmental Baseline Document 2004 through 2008. Pebble Limited Partnership, Anchorage, AK (available online at <https://www.pebbleprojecteis.com>.)
- PLP, 2018. Pebble Project Supplemental Environmental Baseline Document. Pebble Limited Partnership Anchorage, AK (available online at <https://pebbleprojecteis.com>)
- [PLP, 2020. Pebble Project Description. POA-2017-271 Updated May 2020 \(available online at https://pebbleprojecteis.com\)](https://pebbleprojecteis.com)
- US Army Corps of Engineers, 2020. Pebble Project EIS Final Impact Statement. Department of the Army. Alaska District. July 2020 (available online at <https://pebbleprojecteis.com>)
- U.S. Fish and Wildlife Service, Culvert Design Guidelines for Ecological Function, U.S. Fish and Wildlife Service Alaska Fish Passage Program, Revision 5, February 5th, 2020
- US Geological Survey (USGS), 2013. Watershed Boundary Dataset. <https://www.usgs.gov/core-science-systems/ngp/national-hydrography/watershed-boundary-dataset>
- State of Alaska, Department of Labor and Workforce Development, January 18, 2013 Press Release No. 13-03.

20.0 CERTIFICATES

David Gaunt, P.Geol.
15TH FLOOR, 1040 WEST GEORGIA ST.
VANCOUVER, BRITISH COLUMBIA
Telephone: 604-684-6365 Fax: 604-662-8956
davidgaunt@hdimining.com

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

1. I am co-author of this report entitled “2020 Technical Report on the Pebble Project, Southwest Alaska, USA”, effective date August 18, 2020. I am responsible for sections 6.3, 6.4, and 14 and jointly responsible for sections 1, 12, 17, 18 and 19.1 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: Engineers and Geoscientists 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 of 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 30 day of September, 2020,

J. David Gaunt

J. David Gaunt, P.Geol.

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 Engineers and Geoscientists British Columbia, Registration Number 25376.
- 4) I have worked as an economic geologist for 34 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 “2020 Technical Report on the Pebble Project, Southwest Alaska, USA”, effective date August 18, 2020. I am solely responsible for sections 1.4, 6.1, 7.0, 8.0, 9.0, and 15.0 and am jointly responsible for sections 10.0, 12.0, 17.2 and 19.1 of this report.
- 7) I have been physically present at the project area every year from 2003 to 2019 for a total of over 625 days. From 2007 through 2010 I acted as resident Chief Geologist for the project. My most recent visit was in September 2019. 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 30 day of September, 2020,

James 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.Ge., 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 Engineers and Geoscientists British Columbia.
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, and 11, and jointly responsible for sections 10 and 12 of the report entitled “2020 Technical Report on the Pebble Project, Southwest Alaska, USA” (the “Technical Report”). The Technical Report has an effective date of August 18, 2020. 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 30 day of September, 2020,

Eric D. Titley

Eric D. Titley, P.Ge.

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 “2020 Technical Report on the Pebble Project, Southwest Alaska, USA”, effective date August 18, 2020 (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 Engineers and Geoscientists 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, 17.5 and 19.2 and jointly responsible for sections 12 and 18 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 30 day of September, 2020 at Vancouver, British Columbia.

Ting Lu

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

Stephen Hodgson, P.Eng.
627 N Street, Unit #4, Anchorage, Alaska, USA 99501
stephenhodgson@hdimining.com

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

1. I am an officer of Northern Dynasty Minerals Ltd., with a business office at Suite 1500-1040 West Georgia Street, Vancouver, British Columbia and an officer of Pebble Limited Partnership, with a business office at Suite 505 – 3201 C Street, Anchorage, Alaska, United States 99503.
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 Engineers and Geoscientists 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, “2020 Technical Report on the Pebble Project, Alaska, USA”, effective date August 18, 2020, which relates to the Pebble Project, Alaska, United States. I am responsible for Sections 2-5, 16, 17.4 and 19.3, and co-responsible for Sections 1, 12, 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 2019. 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 2014, 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 30 day of September, 2020,

Stephen Hodgson

Stephen Hodgson, P.Eng.