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WASTE RESOURCE MANAGEMENT

LUNDIN MINING

NI 43-101 TECHNICAL REPORT FOR THE NEVES-CORVO MINE, PORTUGAL

June 2017

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June 2017

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1 SUMMARY

1.1 Introduction

Wardell Armstrong International Limited ("WAI") was commissioned by Lundin Mining Corporation ("Lundin") to prepare an updated Technical Report in accordance with the disclosure requirements of Canadian Securities Administrators' National Instrument 43-101, Standard of Disclosure of Mineral Projects ("NI 43-101") to disclose recent information about the Neves-Corvo underground mine located on the Neves-Corvo integrated Mining Concession, and the surrounding Exploration Concession (collectively "Neves-Corvo"). This information has been derived from a Feasibility Study ("FS") undertaken by Lundin on the Zinc Expansion Project ("ZEP") at Neves-Corvo and includes an updated Mineral Resource and Mineral Reserve estimate.

WAI undertook a technical due diligence of the Neves-Corvo mine and this study considered all aspects of the mine from geology and Mineral Resources and Mineral Reserves estimates in accordance with guidelines of the Canadian Institute of Mining, Metallurgy and Petroleum (CIM) "CIM Definition Standards For Mineral Resource and Mineral Reserves 2014", exploration potential, mining, processing, economics, and environmental and social issues.

Lundin is a base metals mining company that produces copper, nickel, zinc and lead at four mines operate by indirect subsidiaries in Portugal (Neves-Corvo), Chile (Candelaria Mining Complex), United States of America (Eagle Mine) and Sweden (Zinkgruvan Mine). In addition, Lundin indirectly holds an equity stake in the Freeport Cobalt Oy business which includes a cobalt refinery located in Kokkola, Finland. Neves-Corvo is operated by Sociedade Mineira de Neves-Corvo SA ("SOMINCOR") a 100% subsidiary of Lundin Mining.

1.2 Description & Location

The Neves-Corvo polymetallic base metal mine is located approximately 220km southeast of Lisbon within the western part of the world-class Iberian Pyrite Belt which runs through southern Spain and Portugal. The mine is situated in the Alentejo province of southern Portugal, some 15km southeast of the town of Castro Verde. The area has an excellent transport network with international airports at Faro some 80km to the south and Lisbon 150km to the northwest.

SOMINCOR holds the Neves-Corvo Integrated Mining Concession comprised of the Neves-Corvo Mining Area and the Semblana Mining Area, as further described ("Neves-Corvo Mining Concession"). In addition, SOMINCOR holds an expanded Exploration Concession surrounding the Neves-Corvo Mining Concession. The deposits located within the Neves-Corvo Mining Concession consist of Neves, Corvo, Graça, Zambujal, Lombador, Monte Branco and Semblana.

1.3 Geological Setting & Mineralisation

The deposits are classified as volcanogenic massive sulphide and typically occur as lenses of polymetallic (Cu, Zn, Sn, Pb) massive sulphides and stockworks that formed at or near the seafloor in

submarine volcanic environments. The deposits are located near the top of a dominantly volcanic sequence of Late Devonian-Early Carboniferous age, 360-342Ma. Overlying the mineralisation there is a repetition of volcanic-sedimentary and flysch units, approximately 350m thick. The whole assemblage has been folded into a gentle anticline orientated northwest-southeast, which plunges to the southeast, resulting in orebodies distributed on both limbs of the fold. All the deposits have been affected by both sub-vertical and low angle thrust faults, which has resulted in repetition and thickening of the massive sulphides, in some areas up to 30m thick.

1.4 Exploration

Drilling has been on-going at Neves-Corvo since 1977. Initially drilling was undertaken from surface before underground development in 1982 allowed the commencement of underground exploration drilling. Since then, underground drilling has been continuous. Surface drilling campaigns have been important over the years in stepping out beyond the limits of underground development to explore extensions to mineralisation and discovering new deposits. To date a total of 1,037 surface drill holes for 822,266m and a total of 5,928 underground drill holes for 591,557m have been completed. The drilling has defined the seven mineralised zones of Neves, Corvo, Graça, Zambujal, Lombador, Monte Branco and Semblana with a combined total strike length of over 5,000m and to depths of up to 1,400m from surface.

1.5 Mineral Resource Estimates

Mineral Resource estimation for the purpose of this Technical Report was undertaken by SOMINCOR and reviewed by WAI. Mineral Resource estimation involved the usage of drill hole, face sampling and geological mapping data to construct three dimensional wireframes to define mineralised domains. Samples were selected inside these wireframes, coded and composited. Boundaries were treated as hard with statistical and geostatistical analysis conducted on composites identified in individual domains. Grades were estimated into a geological block model representing each domain. Grade estimation was carried out predominantly by ordinary kriging. Estimated grades were validated globally, locally, and visually prior to tabulation of the Mineral Resource estimates. Reconciliation indicates that the Mineral Resource models perform well when compared to plant production data.

Mineral Resources are as defined by the CIM. The effective date of the Mineral Resource estimate is June 30, 2016. A summary of the Mineral Resource statement is shown in Table 1.1, Table 1.2 and Table 1.3.

The stated Mineral Resource estimates are not materially affected by any known environmental, permitting, legal, title, taxation, socio-economic, marketing, political or other relevant issues, to the best knowledge of the authors. There are no known mining, metallurgical, infrastructure, or other factors that materially affect this Mineral Resource estimate, at this time.

Table 1.1: Total Mineral Resources for Copper Zones at Neves-Corvo at a Cut-Off Grade of 1.0% Cu

Resource Classification	Tonnage (Kt)	Grade				Metal			
		Cu (%)	Zn (%)	Pb (%)	Ag (g/t)	Cu (Kt)	Zn (Kt)	Pb (Kt)	Ag (Moz)
Measured	14,732	4.2	0.9	0.3	44	625	137	38	21
Indicated	55,254	2.2	1.1	0.4	45	1,232	580	199	80
Measured + Indicated	**69,986**	**2.7**	**1.0**	**0.3**	**45**	**1,857**	**717**	**237**	**101**
Inferred	12,758	1.7	1.2	0.4	37	222	158	46	15

Notes:
1. Mineral Resources are reported in accordance with the guidelines of the CIM Code (2014);
2. Mineral Resources are not Mineral Reserves until they have demonstrated economic viability based on a feasibility study or pre-feasibility study;
3. Mineral Resources are reported inclusive of any Mineral Reserves;
4. Grade represents estimated contained metal in the ground and has not been adjusted for metallurgical recovery and;
5. Numbers may not add due to rounding.

Table 1.2: Total Mineral Resources for Zinc Zones at Neves-Corvo at a Cut-Off Grade of 3.0% Zn

Resource Classification	Tonnage (Kt)	Grade				Metal			
		Zn (%)	Cu (%)	Pb (%)	Ag (g/t)	Zn (Kt)	Cu (Kt)	Pb (Kt)	Ag (Moz)
Measured	15,464	7.7	0.3	1.7	67	1,183	48	266	33
Indicated	91,355	5.9	0.3	1.2	56	5,344	283	1,115	164
Measured + Indicated	**106,819**	**6.1**	**0.3**	**1.3**	**58**	**6,527**	**331**	**1,381**	**198**
Inferred	11,386	4.4	0.3	1.0	52	499	39	118	19

Notes:
1. Mineral Resources are reported in accordance with the guidelines of the CIM Code (2014);
2. Mineral Resources are not Mineral Reserves until they have demonstrated economic viability based on a feasibility study or pre-feasibility study;
3. Mineral Resources are reported inclusive of any Mineral Reserves;
4. Grade represents estimated contained metal in the ground and has not been adjusted for metallurgical recovery and;
5. Numbers may not add due to rounding.

Table 1.3: Total Mineral Resources for Copper Zones at Semblana at a Cut-Off Grade of 1.0% Cu

Resource Classification	Tonnage (Kt)	Grade				Metal			
		Cu (%)	Zn (%)	Pb (%)	Ag (g/t)	Cu (Kt)	Zn (Kt)	Pb (Kt)	Ag (Moz)
Inferred	7,807	2.9	-	-	25	223	-	-	6

Notes:
1. Mineral Resources are reported in accordance with the guidelines of the CIM Code (2014);
2. Mineral Resources are not Mineral Reserves until they have demonstrated economic viability based on a feasibility study or pre-feasibility study;
3. Mineral Resources are reported inclusive of any Mineral Reserves;
4. Grade represents estimated contained metal in the ground and has not been adjusted for metallurgical recovery and;
5. Numbers may not add due to rounding.

1.6 Mining and Mineral Reserves

Neves-Corvo has been developed as an underground operation and exploits a number of polymetallic sulphide orebodies. The mine currently hoists approximately 3.5Mt of ore per year via a 5m diameter shaft from the 700m level (underground elevations relate to a datum of 1,000m below sea level with the mine surface elevation at approximately 220mASL, or 1,220m above datum). Ore from the deeper levels is transported to the 700m level via an incline conveyor from the 550 level. Principle access to the mine is via a ramp from surface and the numerous internal ramps serving the various mining areas. Mining methods have been dictated by geology and geotechnical considerations and at the present time, drift and fill as well as bench and fill mining methods are utilised with the fill comprising predominantly paste fill.

To expand zinc production at Neves-Corvo a ZEP FS was undertaken by Lundin in 2015 (ZEP FS 2015) and updated in 2017 (ZEP FS 2017 Amendment).

This “maximised for zinc” Life-of-Mine (“LoM”) plan allows for a substantial increase in zinc production in the early years of the project with minimum levels of capital investment in the new production areas. The increased ore throughput from the existing areas is dependent on resolution of a number of materials handling constraints discussed below.

Zinc ore production from the existing areas is increased in the higher grade areas of Lombador Phase 1 (“LP1”) and Corvo South-East (“CSE”). Over 70% of the contained zinc metal in the expansion scenario is sourced from these two areas.

The ZEP is reliant on three principle mining upgrades to provide the increased zinc ore throughput to the mill. These are:

- An increase of zinc ore production from the existing mill constrained mining areas;
- The development of a new, deeper production area denoted as Lombador Phase 2 (“LP2”); and
- An upgrade to the materials handling capacity of the shaft and the Lombador orebody area.

The latter point has two major components; the crushing, conveying system and the shaft hoisting system.

It is also important to emphasise that the increase in zinc production requires an increase from all existing mining areas in addition to the expansion of the Lombador deposit mining area. The current production areas are capable of sustaining a production rate of 1.7Mtpa of zinc ore without reliance on any new expansion areas.

Marginal improvements to copper production will also result from the accelerated zinc mining rates by liberating footwall copper areas faster, as well as from the improvements to the materials handling system.

The LP2 area is situated down-dip of LP1 and includes all of the zinc mineralisation below 300L on the northeast side of the major N-S 01 Fault. In addition, this area includes the copper mineralisation below 260L and all mineralisation below 260L in Lombador North. LP2 ranges in depth from 1,000 – 1,200m below surface.

Production from LP2 has been scheduled on an as needed basis to top up production from the existing orebodies for an overall zinc ore throughput of 2.5Mtpa. This allows the capital development in LP2 to be delayed as much as possible.

The expansion area includes both the North and South orebodies in LP2. The South area is a contiguous expansion to the current mining area, however, the North area of the orebody is separate from the existing LP1 North mineralisation.

The production capability for LP2 is constrained by the throughout requirements to maintain a constant 2.5Mtpa feed to the mill. Phase 2 production will increase up to 1.4Mtpa zinc and 0.7Mtpa of copper ores during 2025. After 2025 production, will decrease due to lower stope availability.

1.6.1 Mineral Reserves

Mining wireframes are defined against the Mineral Resource block model, based on the Net Smelter Return ("NSR") break even cut off values and Mineral Resource classification. The stopes are classified as copper or zinc stopes, based on the metal with most predominant economic value. In calculating the Mineral Reserves, dilution and recovery estimates have been based on data gained from similar mining methods in the existing operation.

The Mineral Reserve estimate for Neves-Corvo is classified in accordance with the CIM Definition Standards on Mineral Resources and Mineral Reserves (2014). The effective date of the Mineral Reserve estimate is June 30, 2016. A summary of the Mineral Reserve statement for Neves-Corvo (including ZEP) is shown in Table 1.4.

Table 1.4: Total Mineral Reserves for Neves-Corvo (including ZEP)					
Copper Zone Mineral Reserves					
	Tonnage (kt)	**Grade**			
		Cu (%)	**Zn (%)**	**Pb (%)**	**Ag (g/t)**
Proven	6,423	3.7	0.9	0.2	35
Probable	22,193	2.3	0.7	0.2	34
Proven + Probable	**28,616**	**2.6**	**0.7**	**0.2**	**34**
Zinc Zone Mineral Reserves					
	Tonnage (kt)	**Grade**			
		Zn (%)	**Cu (%)**	**Pb (%)**	**Ag (g/t)**
Proven	7,425	8.5	0.3	2.1	75
Probable	26,664	7.2	0.4	1.8	64
Proven + Probable	**34,089**	**7.5**	**0.4**	**1.8**	**66**

Notes:
1. Mineral Reserves are as defined by CIM Definition Standards on Mineral Resources and Mineral Reserves (2014);
2. Mineral Reserves are reported above their relevant NSR breakeven prices;
3. Metal prices used in the NSR evaluation are US$2.75/lb for copper, US$1.00/lb for zinc, US$1.00/lb for lead, and US$4.16/oz for silver;
4. The NSR is calculated on a recovered payable basis taking in to account copper, lead, zinc and silver grades, metallurgical recoveries, prices and realization costs. ;
5. Mining, processing and administrative costs were estimated based on actual costs;
6. Outside of LP2, the copper Mineral Reserve estimates are reported above a site average cut-off grade equivalent to 1.3% and for zinc Mineral Reserve estimates an average cut-off grade equivalent to 5.2% is used. For the LP2 area, Mineral Reserves average equivalent cut-offs are 1.6% for copper and 6.8% for zinc; and
7. Numbers may not add due to rounding.

1.6.2 Mine Design

The ZEP assumes maintaining the mining methods unaltered in the existing areas. In the expansion area (LP2) the mining method used for mining zinc ores is optimised bench and fill (OBF) as per LP1.

The key features of the OBF stoping method include:

- All OBF stopes are 15m-wide, 20m-high, and mined in a bottom up sequence with paste backfill. Primary stopes on a new level are never more than one level ahead of the secondary stopes below; and
- Primary stopes are filled with paste backfill containing 5% cement. Secondary stopes are filled with paste containing only 1% cement to prevent liquefaction.

In LP2, this method and the associated access development have been further modified in order to reduce operating as well as capital costs. These cost saving modifications include in LP2 South:

- Placement of the upper part of the Lombador North ramp inside the massive sulphide lens; and
- Placement of the level and stope access development within the massive sulphide mineralisation. This allows a portion of the access development to be located within low grade ore with an NSR greater than the cost of development at €41/t.

Mining of the copper ores in LP2 will be through the Bench-Fill (BF) method. Although the key design parameters for BF mining of the copper stopes are unaltered from those in the current mining areas of Neves-Corvo, the broken rock excavation drift is designed to be mined through the pastefill of the previous stope, as versus ramping 5m above the level horizon into the ore immediately above the

pastefill mass. BF stope dimensions are 10m wide (strike) by 20m high (floor to floor) and up to a maximum length of 110m. Extraction is in the transverse direction retreating to the access.

1.6.3 Materials Handling

The existing 550L crushing and conveying system that is situated closest to the zinc expansion areas of CSE and Lombador is presently operated at full capacity. A separate materials handling study in 2014 demonstrated that a new dedicated crushing and conveying system to deliver ore to the existing production shaft is preferred to truck haulage or an upgrade to the existing 550L system.

The proposed new materials handling system includes:

- New primary crusher station complete with jaw crusher, rock breaker, vibrating grizzly feeder, shuttling silo distribution conveyor, magnetic separator and ancillary equipment at the 280L;
- Two silos for storage of zinc ore, copper ore, and waste, each with a vibrating conveyor feeder;
- Approximately 3.2km of ramp conveyor system in three sections, to elevate material from the 280L to the existing 700L facilities; and
- Upgrade to existing St Barbara shaft and skip loading system to increase its capacity to 5.4Mtpa.

1.6.4 Mine Equipment

As no significant mining method changes are proposed, the mobile equipment fleet selected is based on existing machinery at Neves-Corvo. The additional fleet requirements for the ZEP LoM have been calculated to require a capital expenditure of €11.7M. These requirements for the ZEP project have been determined through a Lundin model which determines annualised productivity rates for each of the primary equipment types, from first principles.

1.6.5 Mine Services

Expansions to the existing mine ventilation networks, pumping facilities, backfilling systems, power reticulation and other infrastructure systems have been designed to meet the needs of the LP2 expansion.

1.6.6 Mine Schedules

The schedule is based on the 2016 Base Case LoM plan, the Unconstrained Base Case LoM Plan (“Optimised” or “maximised for zinc” LoM); and the ZEP, which is the summation of the Optimised LoM with the LP2 expansion area.

The LP2 mine area has been scheduled to supplement zinc production from the Optimised Base Case plan to ensure that the expanded 2.5Mtpa zinc plant is maintained at this capacity for as long as

possible. The LP2 ore is treated as an intermediate priority production source, complementing existing high grade zinc areas as necessary. This is a key consideration in the scheduling work as it tries to fulfil production targets, as dictated by production limits from the other mine-wide areas, and ensures that capital development in LP2 is delayed as much as possible.

The overall production summary for the ZEP is shown in Table 1.5.

Table 1.5: ZEP - Mine Production Summary

		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Zinc	**Tonnes (kt)**	1,098	1,207	1,558	2,405	2,629	2,245	2,573	2,625	2,654	2,323	2,269	2,274	1,625	1,420
	Zn (%)	8.6	7.8	7.7	7.7	8.2	8.0	8.0	7.6	7.8	7.3	7.1	7.0	6.8	6.5
Copper	**Tonnes (kt)**	2,404	2,543	2,618	2,653	2,394	2,685	2,291	1,813	1,922	1,631	802	578	541	499
	Cu (%)	2.4	2.3	2.4	2.6	2.6	2.3	2.2	2.2	2.2	2.4	2.3	2.1	2.3	2.2

1.7 Mineral Processing, Metallurgical Testing and Recovery Methods

The Neves-Corvo plants have been significant producers of copper and zinc using conventional flowsheets consisting of crushing, grinding and flotation. There are two processing plants, namely the Copper Plant and Zinc Plant. The Copper Plant has undergone several stages of expansion and now treats up to 2.7 Mtpa through two separate grinding lines with a common flotation circuit. In 2006, the Zinc Plant began treating zinc ores at a rate of 0.45Mtpa, the capacity of which was increased to 1.1Mtpa in 2011. This plant is capable of processing both copper and zinc ores.

In October 2015, SOMINCOR in conjunction with Amec Foster Wheeler ("AMEC"), completed the ZEP FS (2015) aimed at increasing zinc ore production from the current 1.1Mtpa to 2.5Mtpa. Although the ZEP FS (2015) showed a positive financial outcome at the time, the implementation of the project was not approved pending improved zinc metal market conditions and greater stability at the existing operations. By September 2016, it was judged that these objectives had been met and an Early Works Programme (EWP) for project implementation was authorised.

As part of this programme, a "Cold Eyes Review" by Ausenco Ltd ("Ausenco") resulted in the identification of approximately €10M to €15M in direct capital cost reductions. These were principally related to the modification of the ore storage, new grinding plant design and reconfiguration of the new flotation areas.

Changes already made to the zinc circuit pots the 2015 ZEP FS included:

- The removal of copper flotation;
- Reconfiguring the Pb circuit to better handle high Pb grades; and
- Reduction in lime addition and operating pH to improve zinc circuit chemistry.

WAI notes that the predicted recoveries for the Zinc Plant expansion have been based primarily on laboratory rougher flotation test results in conjunction with the modelling of the plant cleaner circuit performance. The predicted recoveries (and lead concentrate grades) are higher than those achieved to date and are the result of the anticipated improved metallurgy in the expanded plant where cleaner residence times will increase, a more consistent and stable grinding circuit will be in place and a more reliable water supply installed. Laboratory testwork investigations are continuing in order to give better confidence in the predicted metallurgical performance. It is also anticipated that the improved water quality resulting from the new water treatment plant will also result in improved flotation response.

All concentrates, both copper and zinc, are sold under long term contracts directly to mainly European smelters although the company also has a direct contract with a Latin American copper smelter. The commercial terms under the contracts are negotiated on an annual basis based on the prevailing long term market conditions. With the expected increase of zinc concentrates production due to the ZEP, such strategy will not change. The Company expects to be able to allocate the majority of the increase in zinc concentrate production to existing customers. Furthermore, interest in the increased zinc concentrate production has also been expressed by other smelters. Lead concentrate of commercial quality has been produced at Neves-Corvo since 2012. Contracts have been negotiated on an annual basis for 100% of the annual production.

Tailings from the mine are stored into a 190ha tailings management facility ("TMF") bounded to the north by a rockfill embankment across a natural river valley. The facility was originally developed for sub-aqueous tailings deposition, but was converted to a thickened tailings deposition facility in 2010 with an accompanying thickened tailings plant to increase the storage capacity.

In their review, Ausenco deemed the 2015 TMF PFS capital costs to be appropriate and these were incorporated into the ZEP FS (2017 Amendment). With the expansion of the zinc processing plant and the volume of tailings produced, there will also be a need to expand the tailings thickening plant.

A Feasibility level study for expanding the TMF will start in May 2017. The Study will provide a comprehensive tailing development scenario and will better define the capital cost for the ongoing development.

1.8 Environmental Studies, Permitting and Social or Community Impact

WAI reviewed the environmental and social performance of Neves-Corvo, including the ZEP.

Permitting activities are coordinated at the mine by the relevant departments, depending on the projects. There are multiple ongoing and pending permitting activities at SOMINCOR, relating primarily to the update of the operational Environmental License, the approval for the ZEP EIA and the associated expansion of the TMF, as well as the approval for any activities within the National Ecological Reserve ("REN").

Previous work has highlighted potential negative environmental impacts of the ZEP and has identified a range of possible best-practice mitigation measures to reduce these impacts.

SOMINCOR has developed a corporate and site strategy for reducing energy use and GHG are monitored and reported as part of the Air Quality Greenhouse Gas Management Plan ("AQGHGMP"), although this system has only recently been put in place.

To meet water quality discharge thresholds the water management system has been recently redesigned and reengineered. Portuguese discharge quality standards have been met since the introduction of these new systems. Overall water consumption and discharge into surface water bodies is expected to increase as a result of the ZEP, but will stay well within the permitted requirements due to improvements in water recycling and water management on site.

Approximately 66% of the ZEP area falls within a REN, including the industrial area of Neves-Corvo. More specifically, the location of the CPV23 surface exhaust fan falls within the area and the proposed construction of infrastructure may necessitate the removal of some protected Holm Oak trees. Further licensing will be needed if there is a need to cut any of the holm oaks or if the TMF does encroach on the REN, as anticipated in the preliminary studies.

SOMINCOR has a Community Investment Policy that seeks to build capacity in local communities, improve the social and environmental conditions in communities nearest the operations and to create opportunities for employees to be SOMINCOR ambassadors in their communities. To date, $173,000 has been spent on education, community wellness, local supplier development and road safety initiatives. The SOMINCOR Community Investment Policy outlines the company's mission statement, objectives, priorities, exclusions and application process for funding organisations and projects.

In 2015, SOMINCOR reviewed the 2011 Mine Reclamation & Closure Plan ("MRCP") and submitted it to the DGEG authority in February 2016. SOMINCOR is revising the MRCP in 2017; and an update of the document is anticipated to be completed in 2019. Current permitting for the mine requires the preparation of updated mine closure plans on a 5-year cycle.

1.9 Capital and Operating Costs

The total estimated capital expenditure for the ZEP is €256.5M including an average 15% contingency on direct and indirect costs. A summary of the ZEP capital costs are shown in Table 1.6.

Table 1.6: ZEP Capital Cost Distribution (EURO'000)						
WBS		**Total**	**2017**	**2018**	**2019**	**2020**
	Total Project	**256,502**	**34,923**	**131,459**	**87,986**	**2,134**
1000	Mining	118,169	20,439	56,817	39,056	1,857
2000	Site Development	350	175	175	-	-
3000	Process Facilities	54,316	1,629	37,758	14,929	-
4000	Process Plant Services	19,627	1,513	7,415	10,698	-
5000	On Site Infrastructure	-	-	-	-	-
6000	Off Site Facilities	-	-	-	-	-
7000	Indirects	19,533	5,509	7,735	6,289	-
8000	Owner's Cost	11,132	1,113	4,453	5,566	-
9000	Contingency	33,375	4,544	17,105	11,449	278

Average operating costs during the 2020 to 2030 operating period of the ZEP were estimated at €44.76/t. The ZEP operating costs are shown in Table 1.7.

Table 1.7: Operating Costs Summary – Zinc Expansion Project (EURO/t)	
Area	**2020-2030***
Mine	24.05
Plants	11.52
Water & Tailings	1.59
G&A	7.61
Total	**44.76**
** Note: Financial results are presented for the economic project life from 2017 to 2030. Operating costs are demonstrated for the selected economic project between 2020 – 2030.*	

1.10 Economic Analysis Results

The ZEP FS (2017 Amendment) for Neves-Corvo concludes that the ZEP adds significant incremental value to the Neves-Corvo business. The capital estimate of €256.5M with 15% contingency is to a level of accuracy expected. Approximately 25% of the capital cost involves brownfield components, and it is in these areas that the most significant challenges lie, particularly in respect of the detailed planning and safe execution of machinery, pipework, electrical tie-ins and plant shutdowns.

Financial analyses resulted in a post-tax incremental NPV (at an 8% discount rate) of the ZEP project of €180M (US$207M), a post-tax IRR of 21.5% and breakeven zinc price of $0.71/lb (to NPV at an 8% discount rate of 0) using long term metal prices of $1.00/lb Zn and $3.00/lb Cu, for the economic project life of 2017-2030. The forecast payback period is less than four years from production start and the forecast average C1 cash cost between 2020 and 2030 is $0.28/lb Cu net of by-product credits or alternatively $0.29/lb Zn net of by-product credits.

The sensitivity analysis indicates the project is most sensitive to the euro/dollar exchange rate. As of the date of this report the euro/dollar is approximately 1.12 (-3% from 1.15); using this value in the financial analysis would generate an NPV (at 8% discount) rate of €199M. The project is also sensitive to change in Zn price, followed by project operating and capital costs.

2 INTRODUCTION

This Technical Report has been prepared by Wardell Armstrong International Limited ("WAI") in accordance with the disclosure requirements of NI 43-101 to disclose recent information about Neves-Corvo. This information has resulted from a Feasibility Study (FS) undertaken by Lundin on the Zinc Expansion Project ("ZEP") at Neves-Corvo and includes an updated Mineral Resource and Mineral Reserve estimate.

Lundin is a base metals mining company that produces copper, nickel, zinc and lead at four mines operated by indirect subsidiaries in Portugal (Neves-Corvo), Chile (Candelaria Mining Complex), United States of America (Eagle Mine) and Sweden (Zinkgruvan Mine). In addition, Lundin indirectly holds an equity stake in the Freeport Cobalt Oy business which includes a cobalt refinery located in Kokkola, Finland. The Neves-Corvo mine is operated by Sociedade Mineira de Neves-Corvo SA (SOMINCOR) a 100% subsidiary of Lundin Mining.

Neves-Corvo is an active base metal production mine located approximately 220km southeast of Lisbon, situated within the western part of the world-class Iberian Pyrite Belt which runs through southern Spain and Portugal.

A technical due diligence of the Neves-Corvo operation was undertaken by WAI. This study considered all aspects of the mine including geology, exploration, mining, mineral processing, economics, and environmental and social issues. Mineral Resource and Mineral Reserve estimation, for the purposes of this Technical Report, was undertaken by SOMINCOR and reviewed by WAI. The Mineral Resource and Mineral Reserve estimates are reported in accordance with the CIM standard referenced in NI 43-101. This Technical Report has been prepared in accordance with the requirements of Form 43-101F1.

2.1 Independent Consultants

WAI has provided the mineral industry with specialised geological, mining and mineral processing expertise since 1987, initially as an independent company, but from 1999 as part of the Wardell Armstrong Group ("WA"). WAI's experience is worldwide and has been developed in the coal and metalliferous mining sector.

Our parent company is a mining engineering/environmental consultancy that services the industrial minerals sector from nine regional offices in the UK and international offices in Almaty, Kazakhstan and Moscow. Total worldwide staff compliment is in excess of 400.

WAI, its directors, employees and associates neither has nor holds:

- Any rights to subscribe for shares in Lundin either now or in the future;
- Any vested interests in any mining or exploration concessions ("licences") held by Lundin;
- Any rights to subscribe to any interests in any of the licences held by Lundin either now or in the future;

- Any vested interests in either any licences held by Lundin or any adjacent licences; or
- Any right to subscribe to any interests or licences adjacent to those held by Lundin, either now or in the future.

WAI's only financial interest is the right to charge professional fees at normal commercial rates, plus normal overhead costs, for work carried out in connection with the investigations reported here. Payment of professional fees is not dependent either on project success or project financing.

WAI has a demonstrated track record in undertaking independent assessments of Mineral Resources and Mineral Reserve estimates, project evaluations and audits, MERs and independent feasibility evaluations to bankable standards on behalf of exploration and mining companies and financial institutions worldwide.

2.2 Qualified Persons, WAI Review and Site Visit

Qualified Persons in respect of Lundin's Mineral Resource and Mineral Reserve estimates for Neves-Corvo (Corvo, Graca, Zambujal, Neves and Lombador orebodies) were Nelson Pacheco, Chief Geologist for Neves-Corvo and Antonio Salvador, Group Mining Engineer for Lundin Mining, respectively.

Qualified Person in respect of Lundin's Mineral Resource estimates for the Semblana orebody was Graham Greenway, Group Resource Geologist for Lundin Mining.

Qualified Persons from WAI who have reviewed the Mineral Resource and Mineral Reserve estimates and supervised the production of this report are as follows:

- Richard Ellis, BSc, MSc (MCSM), CGeol, EurGeol, FGS, Principal Resource Geologist; and
- Phil Newall, BSc (ARSM), PhD (ACSM), CEng, FIMMM, Managing Director, WAI

These consultants are considered to be independent Qualified Persons according to the definitions given in NI 43-101. The responsibilities of WAI during the preparation of the different sections of this Technical Report are shown in Table 2.1.

Table 2.1: Authors Responsibilities	
Author	**Responsible for Preparation of Section/s**
Richard Ellis	1. Summary; 2. Introduction; 3. Reliance on Other Experts; 4. Property Description and Location; 5. Accessibility, Climate, Local Resources, Infrastructure and Physiography; 6. History; 7. Geological Setting and Mineralisation; 8. Deposit Types; 9. Exploration; 10. Drilling; 11. Sample Preparation, Analyses and Security; 12. Data Verification; 14. Mineral Resource Estimates; 23. Adjacent Properties; 24. Other Relevant Data and Information; 25. Interpretation and Conclusions; 26. Recommendations; 27. References
Phil Newall	1. Summary; 13. Mineral Processing and Metallurgical Testing; 15. Mineral Reserve Estimates; 16. Mining Methods; 17. Recovery Methods; 18. Project Infrastructure; 19. Market Studies and Contracts; 20. Environmental Studies, Permitting and Social or Community Impact; 21. Capital and Operating Costs; 22. Economic Analysis; 24. Other Relevant Data and Information; 25. Interpretation and Conclusions; 26. Recommendations; 27. References

Other WAI consultants who contributed to this report, including review of the Neves-Corvo ZEP Feasibility Study included:

- Alex Hill, BEng (ACSM), Technical Director of Mining;
- Philip King, BSc, CEng, FIMMM, Technical Director of Mineral Processing;
- Stephen Holley, BSc MSc ACSM MCSM CEng, Senior Mining and Geotechnical Engineer;
- Stuart Richardson, BSc MSc IEng ACSM MCSM, Senior Mining Engineer;
- Veronica Luneva, Dip Economist, IMC (CFA UK member), Senior Financial Analyst; and
- Edvard Glücksman, BA, BSc, MSc, PhD, CSci, GradMIMMM, Senior Environmental and Social Specialist.

A site visit to the Neves-Corvo Property was undertaken by Richard Ellis, Alex Hill and Philip King between April 26 to April 27, 2017, covering aspects related to access and infrastructure, geology, exploration, QAQC, mineralogy, mining, laboratory testwork, mineral processing and environmental and social issues.

2.3 Units and Currency

All units of measurement used in this report are metric unless otherwise stated. Tonnages are reported as metric tonnes (“t”), precious metal values in grams per tonne (“g/t”) or parts per million (“ppm”).

Unless otherwise stated, all references to currency or “US$” are to United States Dollars (US$).

3 RELIANCE ON OTHER EXPERTS

This Technical Report has been prepared by WAI on behalf of Lundin Mining Corporation ("Lundin") for which WAI has wholly relied upon the data presented by Lundin in formulating its opinion. The information, conclusions, opinions, and estimates contained herein are based on:

- Information made available to WAI by Lundin and SOMNCOR at the time of preparing this Technical Report including previous internal and external reports (on the varied disciplines) prepared by or for Lundin on these Neves-Corvo; and
- Assumptions, conditions, and qualifications as set forth in this Technical Report.

In the preparation of this report WAI have relied on the opinion and content of several reports and include:

- NI 43-101 Neves-Corvo plus Semblana Final (V3.0) Report (WAI), January 2013;
- SOMINCOR internal report dated November 07, 2016 and titled: "Neves-Corvo Mineral Resources Update; Date – June 30, 2016";
- Zinc Expansion Project Feasibility Study Report (SOMINCOR), dated October 2015;
- Neves-Corvo Zinc Expansion Project Amendment Report (SOMINCOR), April 2017;
- ZEP Cold Eyes Review Zinc Plant and Surface Infrastructure Report (Ausenco), October 2016;
- Neves-Corvo ZEP FS Update, Phase 2 Report – Zinc Plant and Surface Infrastructure Report (Ausenco), March 2017; and
- Environmental Impact Assessment: Zinc Expansion Project Report (PROCESL), November 2016.

WAI have not carried out any independent exploration work, drilled any holes or carried out any sampling and assaying at the various project areas.

The authors have not reviewed the land tenure situation and have not independently verified the legal status or ownership of the properties or any agreements that pertain to the licence areas. The results and opinions expressed in this report are based on the authors' field observations and assessment of the technical data supplied by Lundin.

The metallurgical, geological, mineralisation, exploration techniques and certain procedural descriptions, figures and tables used in this report are taken from reports prepared by others and provided to WAI by Lundin.

Though WAI is confident that the opinions presented are reasonable, a substantial amount of data has been accepted in good faith. Whilst WAI has endeavoured to validate as much of the information as possible, WAI cannot be held responsible for any omissions, errors or inadequacies of the data received. WAI has not conducted any independent verification or quality control sampling, or drilling.

WAI has not undertaken any accounting, financial or legal due diligence of Neves-Corvo or the associated company structures and the comments and opinions contained in this Technical Report are restricted to technical and economic aspects associated with Neves-Corvo.

WAI has not undertaken any independent testing, analyses or calculations beyond limited high level checks intended to give WAI comfort in the material accuracy of the data provided. WAI cannot accept any liability, either direct or consequential for the validity of information that has been accepted in good faith.

Except for the purposes legislated under provincial securities laws, any use of this Technical Report by any third party are at that party's sole risk.

4 PROPERTY DESCRIPTION AND LOCATION

The Neves-Corvo polymetallic base metal deposits are located within the western part of the world-class Iberian Pyrite Belt of southern Spain and Portugal. The mine is situated in the Alentejo province of southern Portugal, some 15km southeast of the town of Castro Verde. The area has an excellent transport network with international airports at Faro some 80km to the south and Lisbon 150km to the northwest. The location of the Neves-Corvo within southern Portugal is shown in Figure 4.1.

Figure 4.1: Location of Neves-Corvo, Southern Portugal
(Base map from www.lib.utexas.edu)

Neves-Corvo has been developed as an underground operation, exploiting a number of polymetallic sulphide orebodies. The mine hoists approximately 3.5Mt of ore per year via a 5m diameter shaft from the 700m level (underground elevations relate to a datum of 1,000m below sea level with the mine surface elevation at approximately 220mASL, or 1,220m above datum), whilst further access is provided by declines to the 550m elevation. Ore from the deeper levels is transported to the 700m level via an incline conveyor. Mining methods have been dictated by geology and geotechnical considerations and, at the present time, both drift and fill and bench and fill are utilised with the fill comprising predominantly paste fill derived from tailings.

The mine produces a variety of copper-rich ores (chalcopyrite is the only commercially significant copper mineral) as well as zinc-rich ores.

The SOMINCOR operations in Portugal consist of the following facilities:

- The Neves-Corvo underground mine, mineral processing facilities and central administration offices at the mine site;
- Private harbour and loading facility at Setúbal;
- Sand extraction facilities at Alcácer do Sal; and
- Lisbon office.

4.1 Permitting

The Neves-Corvo operation comprises the following licences:

- A Neves-Corvo Mining Concession. The Mining Concession Agreement between the Portuguese State and SOMINCOR was signed in November 24, 1994 based on several mining permits granted in 1981 and 1985, and as of 1st July 2014, covered an integrated area of 28.9km^2. The concession provides the rights to exploit the Neves-Corvo (Area A) and Semblana (Area B) deposits for copper, zinc, lead, silver, gold, tin and cobalt for an initial period of fifty years (until November 23, 2044) with two further extensions of twenty years each;
- The integrated Neves-Corvo Mining Concession comprises the Neves-Corvo area with 13.5km^2 that includes Neves, Corvo, Graça, Zambujal, Lombador and Monte Branco deposits, and Semblana area that covers an area of 15.4km^2 and includes the Semblana deposit; and
- An Exploration Concession named Neves, granted to SOMINCOR on May 2015 that surrounds the combined Neves-Corvo Mining Concession. The exploration licence covers an area of 141km^2 and is valid for an initial period of 3 years from the date of signature of the exploration concession agreement (currently under negotiation) with two extensions of one year each.

The extent of the licence areas is shown in Figure 4.2.

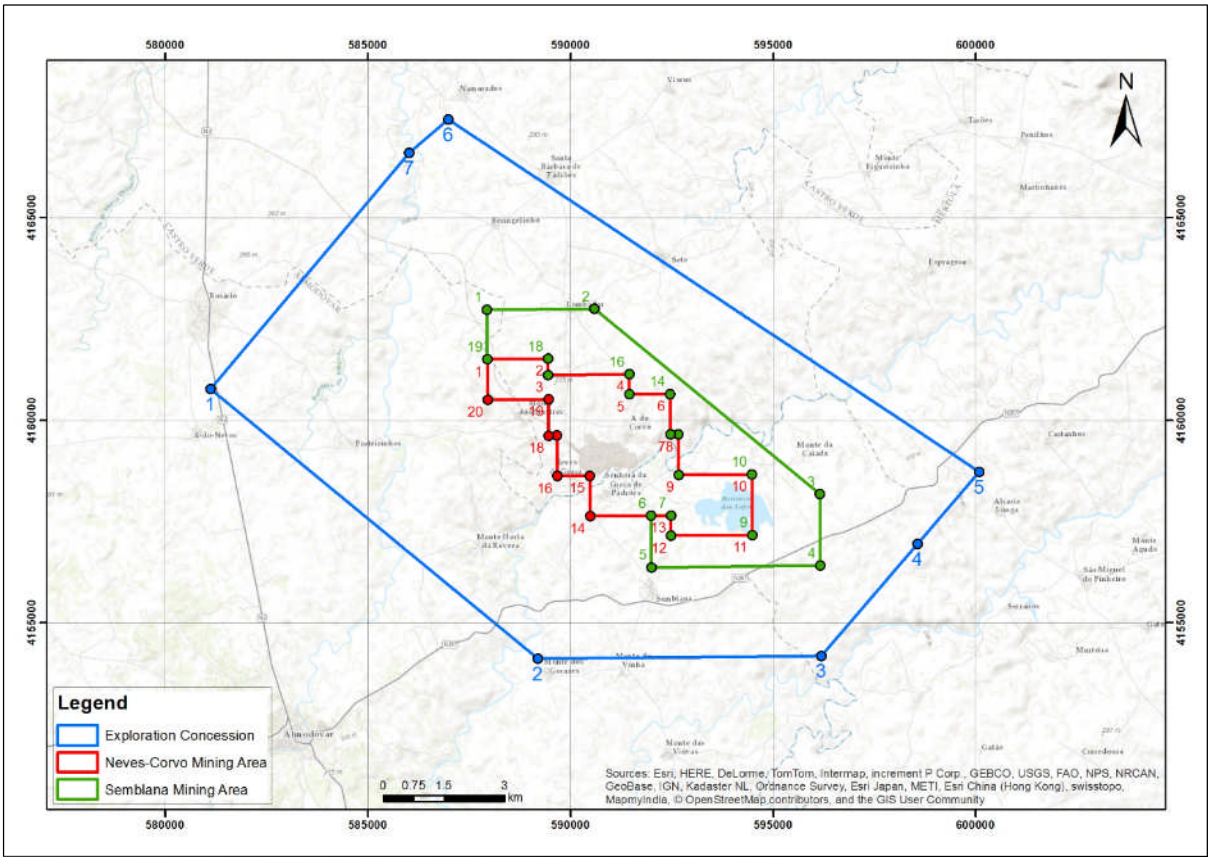


Figure 4.2: Location of Licence Areas

4.1.1 Mining Concessions

Neves-Corvo mining operations are mandated in the Mining Concession Agreement between the State and SOMINCOR. The integrated Neves-Corvo Mining Concessions are located in the parishes of Santa Bárbara de Padrões and Senhora da Graça de Padrões, counties of Castro Verde and Almodôvar, district of Beja. Under the concession agreement, SOMINCOR is obliged to:

- Advise the government of any changes contemplated in the share ownership of the company as the State has certain rights under some change of control circumstances;
- Submit annual operating plans to the State's technical advisor for approval;
- Undertake the investigations and reconnaissance necessary to complete the evaluation of the mineral resources occurring in the concession and to proceed to their exploitation, subject to a technical, economic and financial Feasibility Study;
- Use Portuguese metallurgical refineries/smelters, if such should come into existence in the country and provided they offer competitive international terms;
- Pay either a profit-related royalty of 10% or a revenue-based royalty of 1.0% (at the State's discretion) on the Neves-Corvo area (Area A). SOMINCOR have paid the 10% profit related royalty for several years; and
- Pay a 4% revenue-based royalty for copper and associated payable metals and a 3.5% revenue-based royalty for zinc and associated payable metals on the Semblana area (Area B).

The royalty payments may be reduced to between 2% to 6% of the profit royalty or of the revenue royalty provided that the corresponding amount of such percentage is spent on (a) mineralogical or metallurgical research projects, (b) projects of a social nature, granting of scholarships, (c) projects of an environmental nature with the purpose to maximize the use and valorisation of mineral contents, the social responsibility and the environmental awareness as well as the industrial mining archaeology, and (d) local projects proposed by municipalities or parishes covered by the concession area, respectively, provided those projects are approved by the Portuguese State. Those deductions are only eligible if they correspond to a maximum of 50%, in case of projects under (a) above, 66% in case of (b) and (c) and 90% in case of (d) of the Company's contribution for each supported project.

Under a partnership agreement entered into between SOMINCOR and EDM, the Portuguese State mining company, on January 14, 2005, EDM is granted the preferential rights to participate (*partnership right*) in future investments related to exploration of mineral deposits (*mining projects*), located in Portugal, in which SOMINCOR is a party effective at the date of the agreement. On December 31, 2014, EDM formally exercised its definitive option right to invest 15% in the Semblana Project. The partnership agreement, however, does not apply to the Neves-Corvo Mining Area and its effect is only valid until January 13, 2020.

4.1.1.1 Neves-Corvo Mining Area

The Neves-Corvo Mining Area covers 13.5km^2. The concession provides the rights to exploit the deposits of Neves, Corvo, Graça, Zambujal, Lombador and Monte Branco for copper, zinc, lead, silver, gold, tin and cobalt. A summary of the licence coordinate locations in the European Datum System 1950 (ED50) is shown in Table 4.1.

Table 4.1: Coordinates of the Neves-Corvo Mining Area		
Coordinate Point	**Easting (m) (ED50)**	**Northing (m) (ED50)**
1	587,948	4,161,501
2	589,447	4,161,515
3	589,451	4,161,115
4	591,450	4,161,134
5	591,455	4,160,634
6	592,454	4,160,643
7	592,464	4,159,643
8	592,664	4,159,645
9	592,673	4,158,646
10	594,472	4,158,662
11	594,486	4,157,163
12	592,487	4,157,144
13	592,482	4,157,644
14	590,483	4,157,625
15	590,474	4,158,625
16	589,674	4,158,618
17	589,665	4,159,617
18	589,465	4,159,616
19	589,456	4,160,515
20	587,957	4,160,501

4.1.1.2 Semblana Mining Area

The Semblana Mining Area covers 15.4km^2. The concession provides the rights to exploit the Semblana deposit for copper, zinc, lead, silver, gold, tin and cobalt. A summary of the licence coordinate locations in the European Datum System 1950 (ED50) is shown in Table 4.2.

Table 4.2: Coordinates of the Semblana Mining Area		
Coordinate Point	**Easting (m) (ED50)**	**Northing (m) (ED50)**
1	587,936	4,162,726
2	590,595	4,162,750
3	596,149	4,158,177
4	596,166	4,156,403
5	591,994	4,156,365
6	591,982	4,157,639
7	592,482	4,157,644
8	592,487	4,157,144
9	594,486	4,157,163
10	594,472	4,158,662
11	592,673	4,158,646
12	592,664	4,159,645
13	592,464	4,159,643
14	592,454	4,160,643
15	591,455	4,160,634
16	591,450	4,161,134
17	589,451	4,161,115
18	589,447	4,161,515
19	587,948	4,161,501

4.1.2 Exploration Concessions

An Exploration Concession surrounds the combined Neves-Corvo Mining Concession. The Exploration Concession located beyond the Mining Concession covers an area of 112km^2. The concession was granted in May 2015 and negotiations for the Exploration Concession agreement started May 2017. The Exploration Concession shall be for an initial period of 3 years following signature, with a provision for two one year extensions subject to a 50% reduction in area each time. EDM, the Portuguese State mining entity, has the option to purchase up to 15% participation upon conversion to a mining concession if it occurs before Januray 13, 2020. A summary of the licence coordinate locations in the European Datum System 1950 (ED50) is shown in Table 4.3.

Table 4.3: Exploration Concession

Coordinate Point	Easting (m) (ED50)	Northing (m) (ED50)
1	581,111	4,160,765
2	589,189	4,154,113
3	596,186	4,154,178
4	598,562	4,156,946
5	600,085	4,158,717
6	586,978	4,167,418
7	586,015	4,166,597

5 ACCESSIBILITY, CLIMATE, LOCAL RESOURCES, INFRASTRUCTURE AND PHYSIOGRAPHY

5.1 Accessibility

Neves-Corvo is connected by a good road into the national road network and is approximately a one hour drive from Faro to the south or one and a half hours from Lisbon to the north. In addition, the mine has a dedicated link into the Portuguese rail network and the port of Setúbal where the mine has a private harbour facility for concentrate shipments.

There are no major centres of population close to the mine, although several small villages with populations numbered in the hundreds lie within the Neves-Corvo Mining Concession.

5.2 Climate

The climate of the region is semi-arid with an average July temperature of 23°C (maximum 40°C) and an average minimum temperature in winter of 3.8°C. Rainfall averages 426mm, falling mainly in the winter months.

5.3 Local Resources & Infrastructure

The Neves-Corvo area in southern Portugal is well served by excellent transport facilities including a dedicated railhead to the mine site, a major highway within 25km and the international airport of Faro 80km to the south.

Fresh water is supplied to the mine via a 400mm diameter pipeline from the Santa Clara reservoir, approximately 40km west of the mine. Supply capacity is 600m^3/hr whilst storage facilities close to the mine hold 30 days' requirements. The current total fresh water requirement for the mine and plant is approximately 180m^3/hr with as much as 75% of the volume being reused.

The mine is connected to the national grid by a single 150kV, 50MVA rated, overhead power line 22.5km long. The Neves-Corvo Mining Concession provides sufficient surface rights to accommodate the existing mine infrastructure and allow expansion as contemplated by ZEP.

The area supports low intensity agriculture confined to stock rearing and the production of cork and olives.

5.4 Physiography

The topography around the mine is relatively subdued, comprising low hills with minimal rock outcrop. The mine shaft collar is 210m above sea level.

6 HISTORY

6.1 Ownership History

Mineralisation at Neves-Corvo was discovered in 1977 following an exploration joint venture comprising exploration drilling to test a number of favourable gravity anomalies. The companies involved in the venture were Sociedade Mineira de Santiago (legally succeeded by EMMA – subsequently renamed EDM), Societe d'Etudes de Recherches et d'Exploitations Minieres (SEREM) and Sociétè Minière et Metallurgique de Peñarroya, S.A. (SMMP). Following discovery, SOMINCOR was formed to exploit the deposits. The shareholders were EDM 51%, SMMP 24.5% and Coframines 24.5%.

Rio Tinto became involved in the project in 1985 effectively forming a 49:51% joint venture with the Portuguese government (EDM). This change in shareholding led to a reappraisal of the project with eventual first production commencing from the Upper Corvo and Graça orebodies on January 01, 1989, achieving 1.0Mt of throughput in that year. Total capital cost for the mine was approximately US$350M. During the development of the mine, significant tonnages of high grade tin ores were discovered, associated with the copper mineralisation, which led to the rapid construction of a tin plant at a cost of some US$70M. The plant was commissioned in 1990 and in that year some 270,000t of tin-bearing ore was treated. The railway link through to Setúbal was constructed between 1990-1992 to allow shipment of concentrates and the back-haul of sand for fill. This was followed between 1992-1994 by a major mine deepening exercise, at a cost of US$33M, to access the Lower Corvo orebody through the installation of an inclined conveyor ramp linking the 700m and 550m levels. Access to the orebody of North Neves was also completed in 1994 and significant production tonnage has since come from this area.

On June 18, 2004, EuroZinc acquired a 100% interest in SOMINCOR. The consideration paid was €128,041,000.

In 2006, zinc production was commenced at Neves-Corvo with processing through the modified tin plant.

On October 31, 2006 Lundin and EuroZinc merged, retaining the Lundin name, listing on the Toronto Stock Exchange, OMX Nordic Exchange (Stockholm) and New York Stock Exchange under the symbols of LUN, LUMI, and LMC respectively. Lundin voluntarily de-listed from the New York Stock Exchange in 2009.

In June 2007, Silverstone Resources Corporation (Silverstone – subsequently acquired by Silver Wheaton Corporation) agreed to acquire 100% of the life of mine payable silver production from Neves-Corvo (Area A). The mine produces approximately 0.5Moz of payable silver annually in the copper concentrate.

Zinc production was suspended in November 2008 due to the low prevailing zinc price. In mid-2009, a copper tailings retreatment circuit was commissioned to recover both copper and zinc, and in late 2010, tailings disposal changed from subaqueous to paste methods at the Cerro do Lobo facility.

In September 2009, the decision was made to expand the zinc plant at an estimated cost of €43M, to a nominal design capacity of 1.0 Mtpa of zinc ore. The plant was commissioned in the second half of 2011. In May 2017, the results of a Feasibility Study on the ZEP were announced. The ZEP contemplates increasing zinc mining and processing capacity from 1.1 to 2.5mtpa.

6.2 Exploration History

From 1973 to 1984 the joint venture between the Portuguese government (EDM) (51%), SMMP (24.5%) and Conframines (24.5%) completed a total of 239 drill holes for 113,842m during the discovery stage of the project.

From 1985 to 2004 during the joint venture between Rio Tinto and EDM, a total of 3,219 drill holes for 432,393m were completed during the feasibility and mine expansion phase of the project.

On June 18, 2004, EuroZinc acquired a 100% interest in SOMINCOR. During this phase a total of 564 drill holes for a total of 62,721m were completed.

On October 31, 2006 Lundin and EuroZinc merged, retaining the Lundin name. A total of 2,945 drill holes for a total of 805,616m have been drilled up to June 2016 by Lundin.

In October 2010, surface exploration drilling focusing on a prospective area close to the Neves-Corvo mine discovered the Semblana deposit, a new high-grade, copper-rich massive sulphide deposit located 1.3km to the northeast of Zambujal. A maiden Mineral Resource estimate for Semblana was published in December 2011.

On July 25, 2012 Lundin issued a press release on the discovery of the Monte Branco deposit, located 1.2km south of Semblana and to the west of the tailings management facility. Monte Branco represented a new centre of concentrated sulphide mineralisation, covering approximately 250m by 200m in area, including both massive and stockwork type sulphides. Sulphides were intercepted at approximate depths of between 540m and 700m below surface. Exploration drilling by Lundin is on-going and the potential for new discoveries is considered high.

A summary of the historical exploration drilling by company and year is shown in Table 6.1 and includes both surface and underground drilling.

Table 6.1: History of Exploration Drilling by Company and Year

EDM, SMMPP, Conframines			EDM, Rio Tinto			Eurozinc			Lundin Mining		
Year	No. Drill Holes	Meters (m)	Year	No. Drill Holes	Meters (m)	Year	No. Drill Holes	Meters (m)	Year	No. Drill Holes	Meters (m)
1973	2	747	1985	51	14,883	2004	164	13,485	2007	219	54,928
1977	6	2,669	1986	181	23,873	2005	168	19,050	2008	264	68,795
1978	24	12,192	1987	192	24,253	2006	232	30,186	2009	244	93,097
1979	23	12,829	1988	123	18,138	**Total**	**564**	**62,721**	2010	304	98,610
1980	31	18,406	1989	189	22,248				2011	384	133,685
1981	30	17,055	1990	134	15,651				2012	383	142,869
1982	30	16,031	1991	165	25,922				2013	334	107,601
1983	31	14,902	1992	165	28,062				2014	199	43,064
1984	62	19,011	1993	223	39,511				2015	412	50,886
Total	**239**	**113,842**	1994	92	14,053				2016	200	11,334
			1995	187	28,242				**Total**	**2,943**	**804,869**
			1996	233	34,706						
			1997	166	27,177						
			1998	178	22,913						
			1999	182	20,764						
			2000	196	21,163						
			2001	203	17,902						
			2002	162	15,871						
			2003	197	17,060						
			Total	**3,219**	**432,393**						

6.3 Production

Commercial production has been continuous at Neves-Corvo since 1989. A summary of copper and zinc mine production at Neves-Corvo during this time is shown in Table 6.2 below.

Table 6.2: Neves-Corvo Copper and Zinc Production by Year								
	Year							
	1989	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
Copper Ore Processed (Kt)	1,003	1,590	1,648	1,524	1,610	1,587	1,790	1,838
Head Grade (Cu %)	11.2	10.6	10.1	10.3	9.8	8.8	7.9	6.4
Zinc Ore Processed (Kt)	-	-	-	-	-	-	-	-
Head Grade (Zn %)	-	-	-	-	-	-	-	-
	Year							
	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Copper Ore Processed (Kt)	1,812	2,181	2,128	1,614	1,942	1,739	1,679	1,882
Head Grade (Cu %)	6.4	5.8	5.2	5.3	4.9	5.1	5.4	5.7
Zinc Ore Processed (Kt)	-	-	-	-	-	-	-	-
Head Grade (Zn %)	-	-	-	-	-	-	-	-
	Year							
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Copper Ore Processed (Kt)	2,041	1,947	2,181	2,410	2,570	2,475	3,198	2,512
Head Grade (Cu %)	5.0	4.6	4.8	4.3	3.9	3.4	2.7	2.6
Zinc Ore Processed (Kt)	-	148	397	399	-	100	63	543
Head Grade (Zn %)	-	8.4	7.8	7.3	-	5.7	6.4	7.3
	Year							
	2013	**2014**	**2015**	**2016**				
Copper Ore Processed (Kt)	2,525	2,503	2,542	2,386				
Head Grade (Cu %)	2.6	2.5	2.7	2.5				
Zinc Ore Processed (Kt)	974	1,102	1,014	1,039				
Head Grade (Zn %)	7.1	8.0	8.0	8.2				

7 GEOLOGICAL SETTING AND MINERALISATION

7.1 Regional Geology

The Neves-Corvo Mine is located in the western part of the Iberian Pyrite Belt ("IPB") that extends through southern Spain into Portugal and which has historically hosted numerous major stratiform volcano-sedimentary massive sulphide ("VMS") deposits including the famous Rio Tinto mine, worked for gold and copper since Roman times. The location of Neves-Corvo within the regional geology is shown in Figure 7.1.

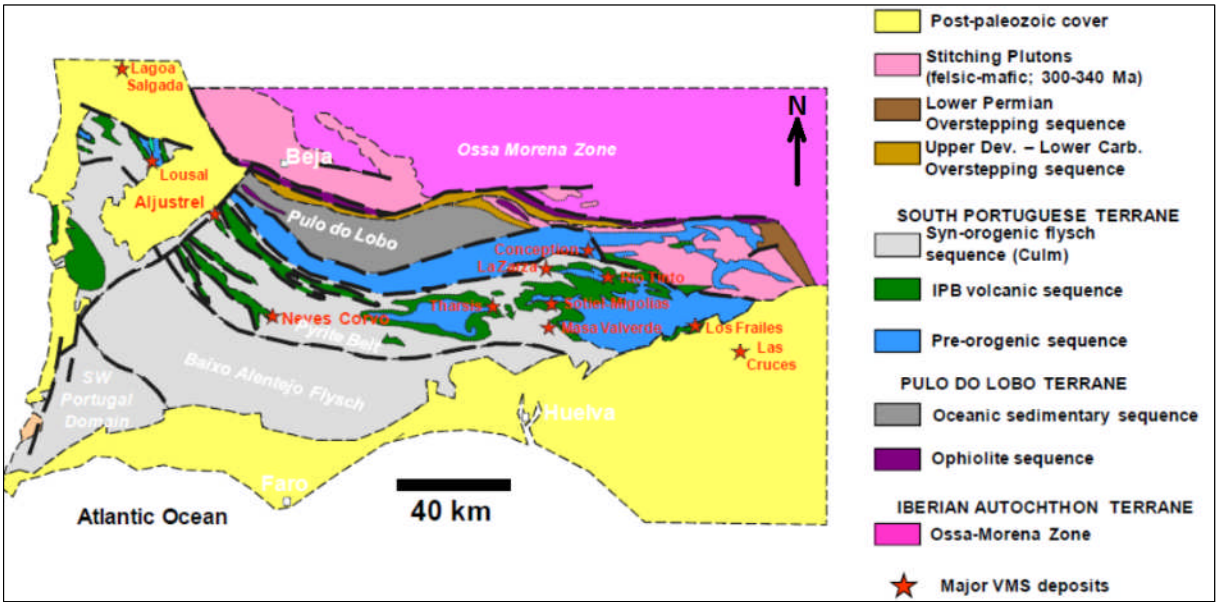


Figure 7.1: Iberian Pyrite Belt and Principal Deposits

The IPB formed within a basin located on the passive margin of the South Portuguese Zone (SPZ) that underwent a northward oblique subduction and later collision with the autochthonous Iberian Terrane. The transpressional deformation resulted in the formation of a major volcanic belt, the IPB, within a highly compartmentalised sedimentary basin on the outermost margin of the SPZ. To the north the IPB is limited by the Pulo do Lobo accretionary prism, while to the south the IPB is thrust over the Baixo Alentejo Unit.

At the base, the IPB consists of a pre-orogenic sequence of shales and arenites (phyllites and quartzites) known as the PQ Group and was developed on a stable epicontinental shelf. The top of the PQ Group is marked by a major sedimentary break resulting from a rupture of the platform leading to an increase in clastic content and the development of a very heterogeneous facies, including shallow to sub-aerial reef limestones, delta-related deposits and mass flow deposits.

The PQ Group is conformably overlain by a 200 to 700m thick volcanic-sedimentary succession, the Volcanic Siliceous Complex (VSC) of Late Devonian-Early Carboniferous age, 360-342Ma (Relvas et al, 2006). The VSC comprises fine grained clastic sediments and felsic to mafic (bimodal) volcanic rocks. The entire sequence shows pervasive hydrothermal alteration.

Conformably overlying the VSC are the Upper Visean Flysch Group rocks characterised by a thick turbidite sequence of argillite, siltstone and greywackes, which filled the foreland basin of the collisional orogen.

Massive sulphide deposits within the IPB are interbedded with the VSC, at different vertical levels, and hosted by both igneous and sedimentary rocks. The deposits vary in size from a few hundred thousand tonnes to greater than 400Mt, and vary mineralogically from massive pyrite, through complex base metal sulphides and sulphide stockwork zones. The precious metal content of the mineralisation can be significant.

The massive sulphide deposits are generally interpreted as syngenetic in origin, ranging from sulphide precipitates to re-worked sulphide/silicate sediments, lying close to acid submarine volcanic centres and with associated extensive pyrite +/- chalcopyrite stockwork zones. The mineralisation has been dated at 350Ma.

The Late Palaeozoic Hercynian Orogeny has folded and faulted the above units and is responsible for the present distribution of the Palaeozoic stratigraphy. Anticlinal folds trend northwest and verge to the southwest. Thrust faults appear to have removed the intervening synclines; however these structures are poorly documented. It should be noted that north to northeast trending faults have offset the folded and thrusted stratigraphy by 10's to 100's of m.

The location of the main VMS deposits within the IPB are shown in Figure 7.2.

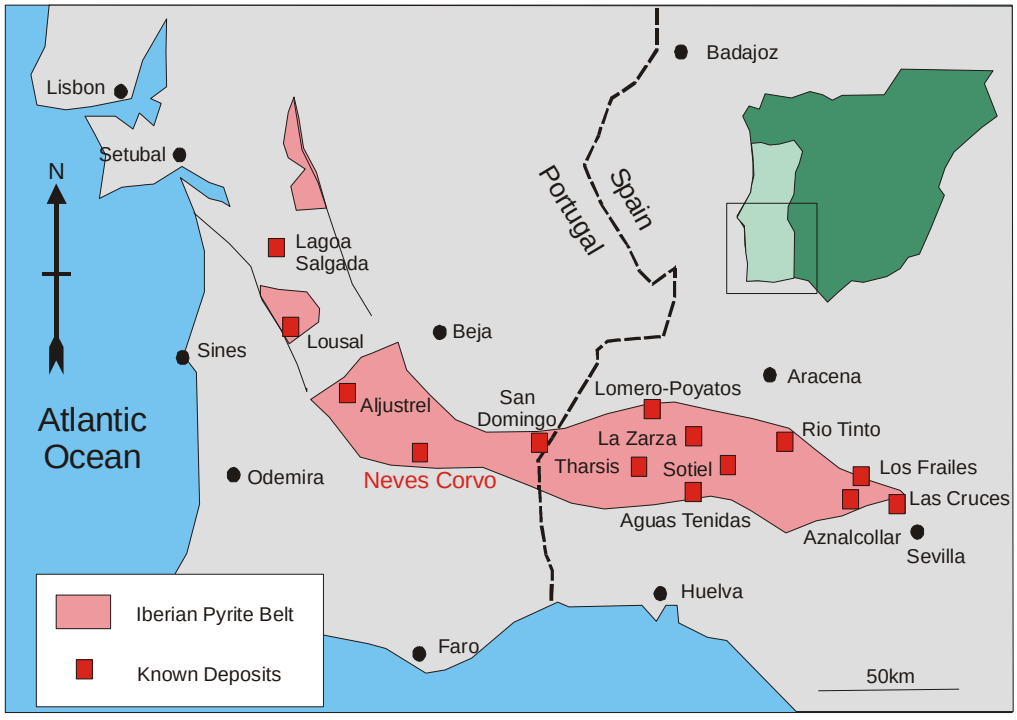


Figure 7.2: Location of Neves-Corvo other VMS Deposits within the IPB

7.2 Property Geology

The Neves-Corvo deposits are located near the top of a dominantly volcanic sequence of the VSC, which consists of two chemically distinct intervals of felsic volcanics separated by shale units, with a discontinuous black shale horizon immediately below the massive sulphide lenses. The thickness of the VSC in the Neves-Corvo area is approximately 300m.

Overlying the mineralisation there is a repetition of volcano-sedimentary and flysch units, approximately 350m thick. The whole assemblage has been folded into a gentle anticline orientated northwest-southeast, which plunges to the southeast, resulting in orebodies distributed on both limbs of the fold. All the deposits have been affected by both sub-vertical and low angle thrust faults, which has resulted in repetition and thickening of the massive sulphides, in some areas up to 30m thick.

The geology of the Neves-Corvo Mining Concession area is shown in Figure 7.3.

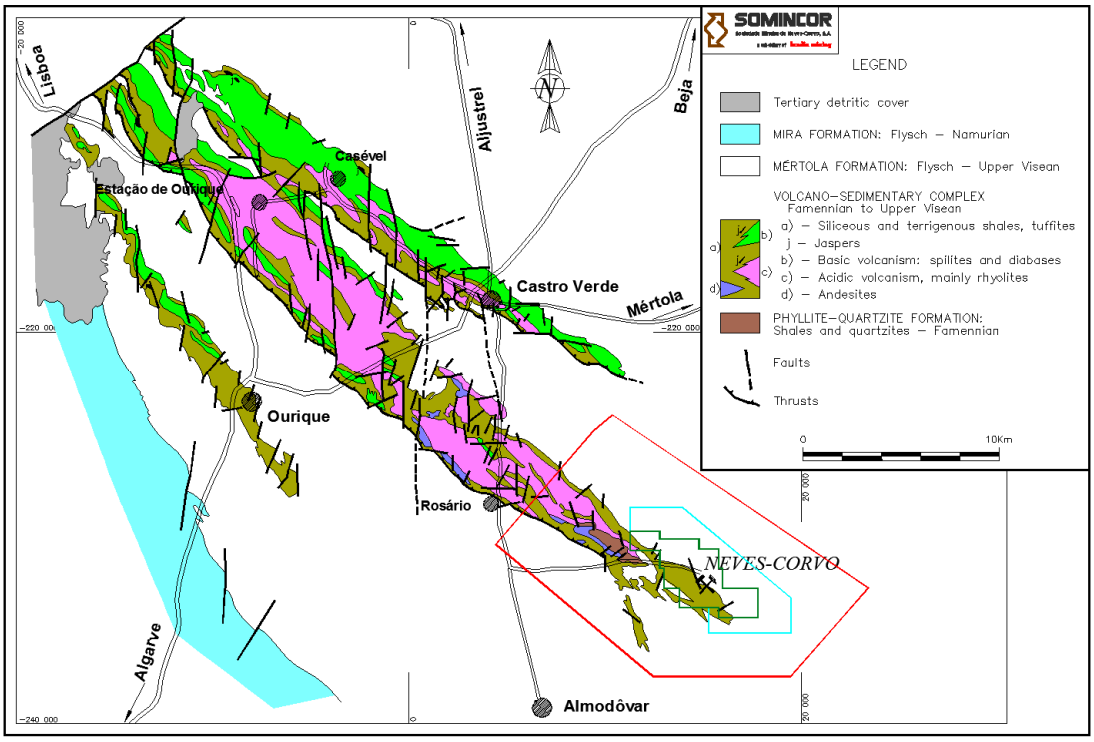


Figure 7.3: Geology of the Neves-Corvo Area

Mineralisation is also concentrated within the footwall and hangingwall rocks, and although the deposits are similar to others found in the IPB, the copper, tin and zinc grades are uniquely high and the strong metal zonation patterns are well developed.

The geology is consistent with a setting peripheral to a major submarine felsic volcanic centre with significant variations in paleo-sea floor topography. Facies changes are abrupt and lithological units above and below the sulphide lenses are highly variable.

A representative stratigraphic sequence indicating the position of the mineralisation in the Neves-Corvo Mine area is shown in Figure 7.4.

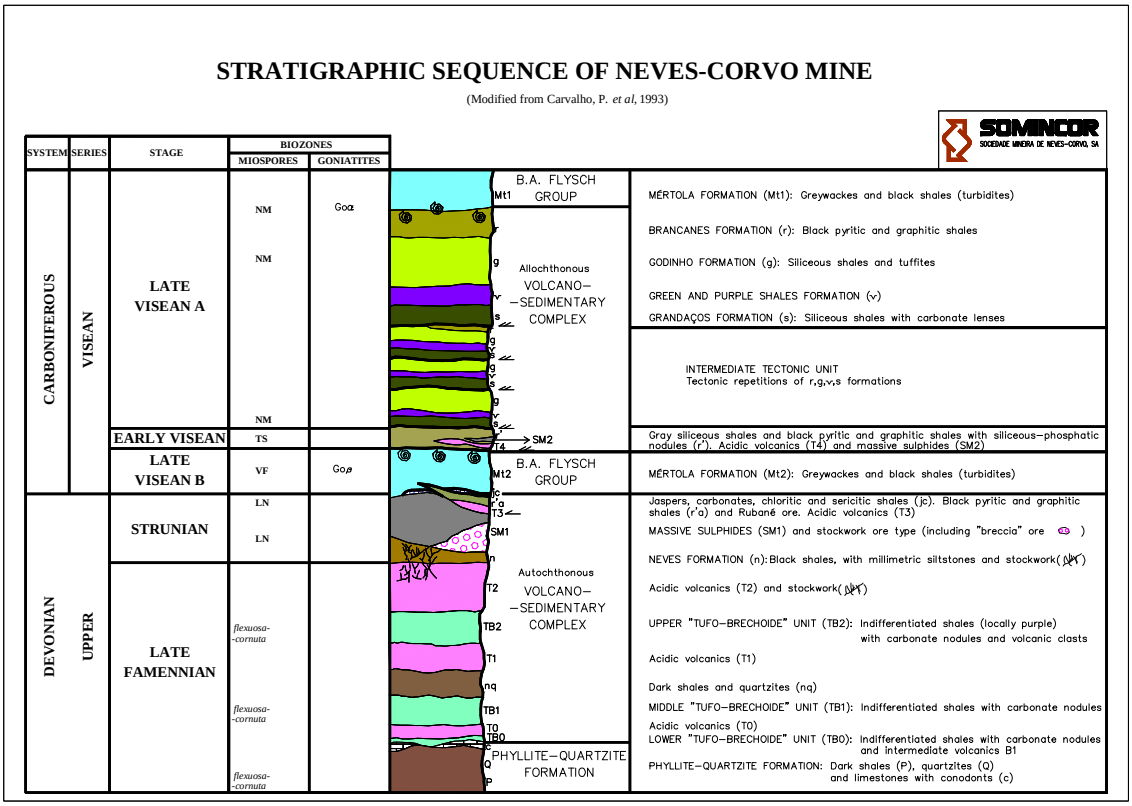


Figure 7.4: Stratigraphic Sequence of the Neves-Corvo Mine

7.3 Description of Mineralised Zones

Six massive sulphide mineralised zones have been defined within the Neves-Corvo Mining Area and comprise Neves, Corvo, Graça, Zambujal, Lombador and Monte Branco. The Semblana massive sulphide zone is located within the Semblana Mining Area and is located 1.3km northeast of Zambujal.

The mineralised zones lie on both flanks of the Rośario-Neves-Corvo anticline. The mineralised zones of Neves, Corvo, Graça, Zambujal and Lombador are connected by thin massive sulphide “bridges” over the crest of the fold and are conformable with the stratigraphy. Within the area of these five main deposits this has resulted in an almost continuous complex volume of mineralised rock showing a large range in both style of mineralisation and geological structure. The mineralised zones are located at depths of 230m to 1,400m below surface.

The mineral deposits occur as concentrations of high-grade copper and/or zinc mineralisation within massive sulphide pyritic lenses, and copper mineralisation within stockwork zones that typically underlie the massive sulphide. Base metal grade distributions within the massive copper/zinc sulphide lenses typically show good internal continuity, but laterally can terminate abruptly in barren pyrite. The massive sulphide deposits are generally very large, regular, continuous and predictable. However,

the geometry of the high-grade zinc and copper zones within the deposits can be very complex. In many cases, boundaries between ore grade mineralisation and barren pyrite may be almost parallel to the stratigraphic contacts of the sulphide lens.

The location of the mineralised zones is shown in Figure 7.5.

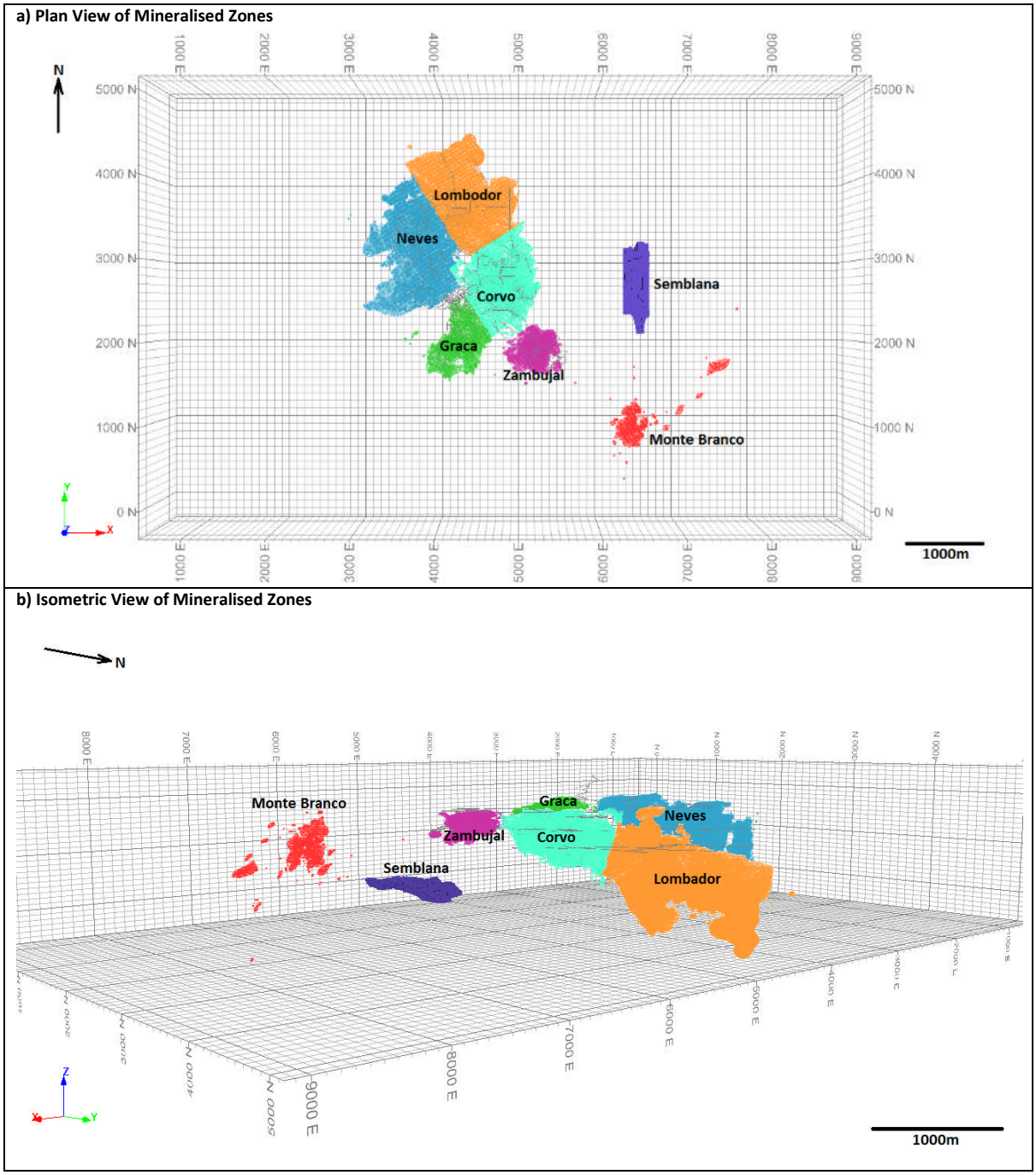


Figure 7.5: Location of Mineralised Zones at Neves-Corvo and Semblana

The base metal grades are segregated by a strong metal zoning into copper, tin and zinc zones, as well as barren massive pyrite. Three styles of mineralisation have been identified at Neves-Corvo:

- Rubané mineralisation - characterised by thin banded alternations of shales, breccias and massive sulphide or tin mineralisation (found mainly in Corvo but now predominantly mined out);
- Massive sulphide mineralisation; and
- Stockwork (fissural) sulphide mineralisation.

Fourteen main mineralisation types have been classified by SOMINCOR including three barren or low grade classes as shown in Table 7.1.

Table 7.1: Neves-Corvo Mineralisation Types

Mineralisation Type	Description	Major Ore Mineral
MC	Massive Copper	Chalcopyrite
MT	Massive Tin	Cassiterite
MZ	Massive Zinc	Sphalerite
MP	Massive Lead	Galena
FC	Stockwork Copper	Chalcopyrite
FT	Stockwork Tin	Cassiterite
FZ	Stockwork Zinc	Sphalerite
5C (MCZ)	Massive Copper and Zinc	Chalcopyrite and Sphalerite
5Z (MZP)	Massive Zinc and Lead	Sphalerite and Galena
RT	Rubané Tin	Cassiterite
RZ	Rubané Zinc	Sphalerite
ME	Massive Pyrite	Barren/Low Grade
FE	Stockwork Pyrite	Barren/Low Grade
RE	Rubané Pyrite	Barren/Low Grade

Due to the structural complexity of the orebodies, different ore types are often juxtaposed, even over short distances both vertically and laterally. Grade zones in the sulphide lenses are typically either copper or zinc, although they do occur together in some areas. In a general sense, grade continuity is better within the massive sulphide lenses than it is within adjacent stockwork and “bridge” zones. The geometry of the copper mineralisation tends to be more complex than that of the zinc mineralisation.

Base metals within the deposits are commonly zoned from zinc-rich zones near the top to copper-rich zones at the base of the massive sulphide. This zoning is interpreted to be largely a result of primary metal re-zoning caused by temperature, pressure and chemical gradients soon after deposition.

Disruptions and tectonic deformation of the lenses and stockworks have been observed related to the three tectonic events that deformed the Neves-Corvo region.

Massive, cassiterite rich, tin mineralisation was associated with the rich copper mineralisation and in the copper rich rubané. The tin mineralisation was mainly found in the Corvo orebody, associated with north-south faults along a north-south oriented corridor. The underlying stockwork also contained tin mineralisation. However, much of the high grade tin mineralisation is now depleted.

The following mineralological and morphological descriptions relate to the orebodies in their original state, prior to mining.

7.3.1 Corvo

The Corvo orebody lies between 230m-800m below surface, dips to the northeast at 10-40° and has a strike of approximately 600m. The orebody attains a maximum thickness of 95m and consists of a basal layer of copper ore up to 30m thick, overlain by barren pyrite containing intermittent lenses of copper mineralisation.

The main massive sulphide orebody is predominantly overlain by a complex mineralised sequence known as “Rubané” which comprises an assemblage of chloritic shales, siltstones and chert-carbonate breccias that are all mineralised with cross-cutting and bedding-parallel sulphide veinlets and occasional thin lenses of massive sulphides. The sulphides are predominantly copper-rich and Rubané ore historically contributed over 15% of the total copper content of Corvo, however is now predominantly mined out. Rubané mineralisation is interpreted as a stockwork emplaced in the hanging wall of the massive sulphide by low angle reverse faults (thrust faults).

Cupriferous sulphide stockwork zones (fissural mineralisation), consisting of veinlet sulphides cutting footwall shales, quartzites and acid volcanics, underlie the massive sulphide lens over part of its area.

Tin-rich ores occur closely associated with the copper ores, principally in the massive sulphide material and Rubané (now predominantly mined out). Massive sulphide tin ore, also containing high copper values, is distributed throughout the copper mineralisation at Corvo defining a north-south trend. At the north end, near the edge of the massive sulphides, the Rubané contained high grades of tin and the underlying stockwork also contained some tin ores.

Zinc mineralisation develops laterally to the southeast of the copper and tin ores within the massive sulphide.

A geological cross-section through Corvo and Graça deposits is shown in Figure 7.6.

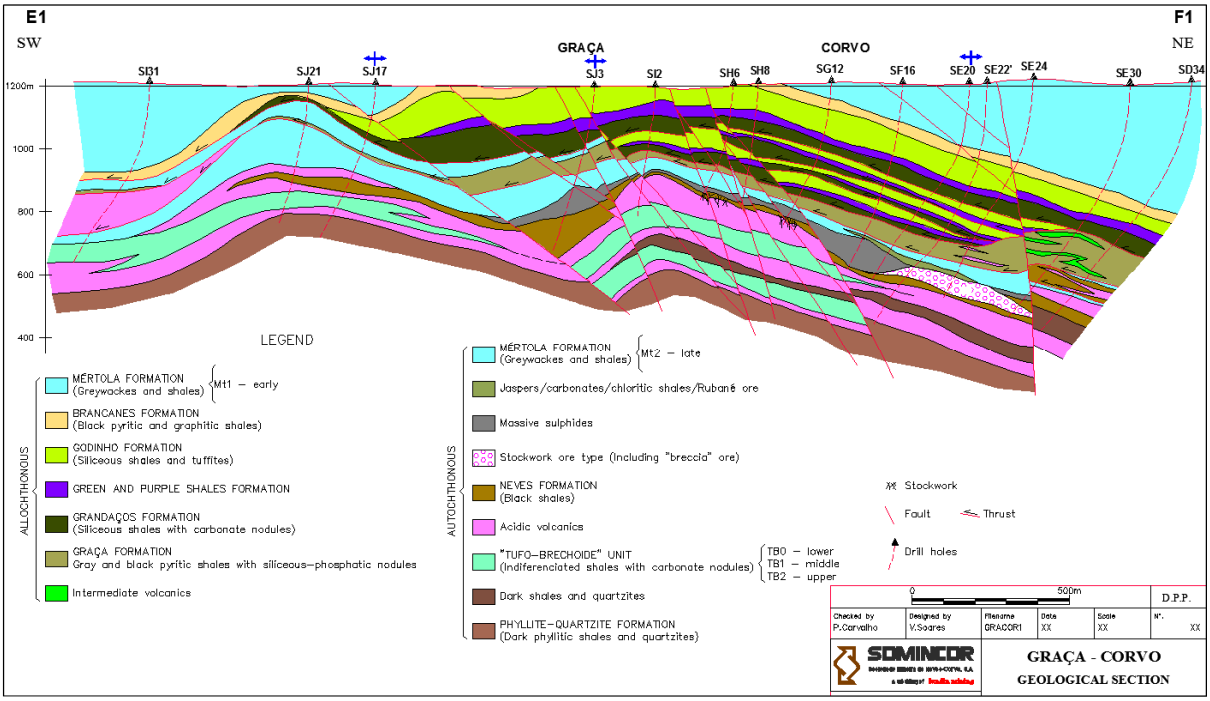


Figure 7.6: Geological Cross-Section through the Corvo and Graça Deposits

7.3.2 Graça

The Graça orebody is up to 80m thick, extends for 700m along strike, 500m down dip and ranges in depth below surface from 230-450m. The orebody is linked to Corvo by a bridge of thin continuous sulphide mineralisation. As with Corvo, much of the copper ore occurs as a basal layer overlain by barren pyrite in which there are also intercalations of copper ore. The majority of copper mineralisation within the Graça orebody has been mined out with the exception of a small extension to the southeast; that lies on the southern flank of the anticline and dips to the south at 10-70°.

A significant massive zinc zone has been exploited in Graça SW.

Massive sulphide tin ores occur as a trend through the copper ores from northeast to south west, similar to that seen at Corvo. However, there is no significant development of Rubané, although stockwork copper ore is being exploited in the southeast section of the orebody and extensions to this mineralisation are being investigated. In the massive sulphide there is again strong lateral metal zoning and zinc occurs preferentially in the southwest limit of Graça.

7.3.3 Neves

The Neves deposit consists of two lenses of mineralisation, joined by a thin bridge, which dip north at 0-35°. The maximum true thickness is 55m with a strike length of 1,200m and 700m down dip. The southern lens, Neves South, contains mostly of zinc ore with significant lead, silver and copper grades and minor barren pyrite, underlain by copper ore which is locally tin-bearing. Zinc mineralisation tends

to be very fine grained (<25microns) and does contain deleterious elements such as As, Sb and Hg. In addition, silver is present within tennantite-tetrahedrite, typically freibergite ($(CuAgFe)_{12}Sb_4S_{13}$).

In contrast, Neves North is copper-rich and occurs mainly as a basal massive sulphide and as stockwork in the underlying shale and volcanic rocks. The stockwork is well developed and extends well beyond the limits of the massive sulphide lens.

A geological cross-section through Neves and Lombador deposits is shown in Figure 7.7.

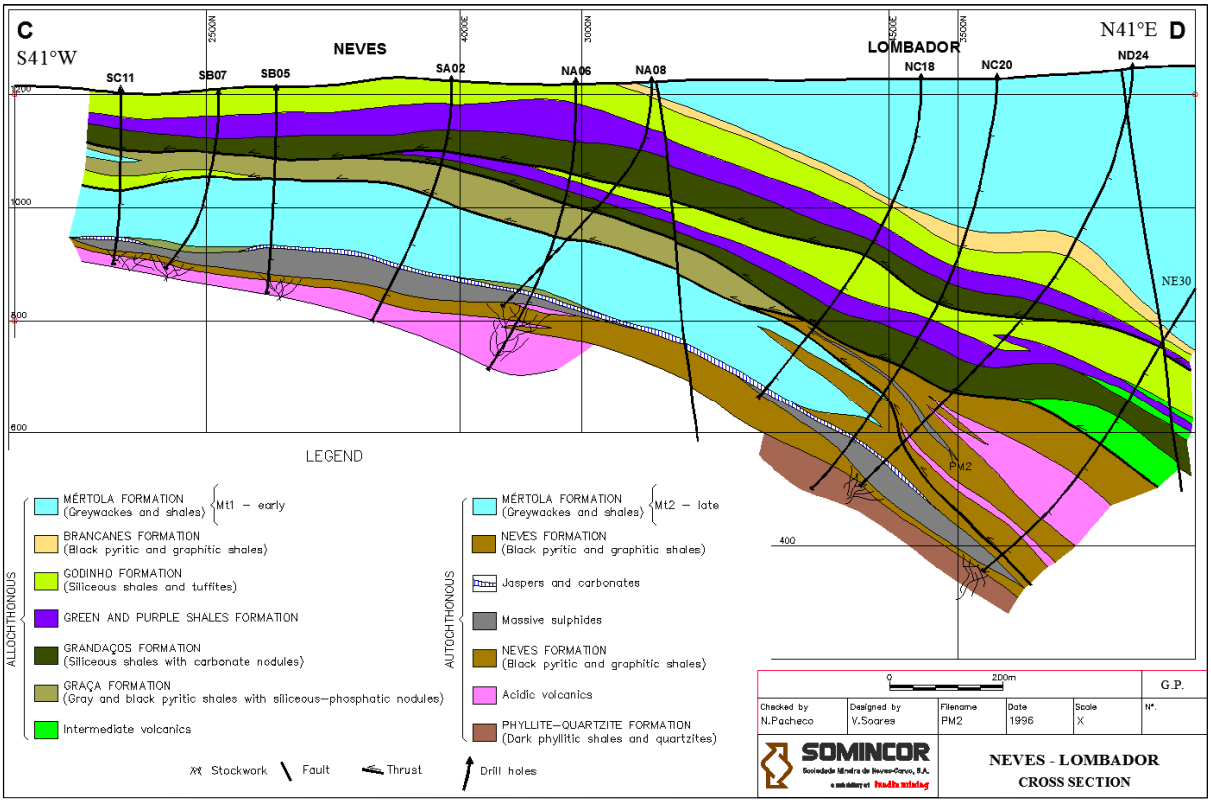


Figure 7.7: Geological Cross-Section through the Neves and Lombador Deposits

7.3.4 Zambujal

The Zambujal orebody comprises significant copper and zinc mineralisation. Recent exploration has increased MC and MCZ mineralisation. Furthermore, on-going exploration has discovered bridge mineralisation linking it to Lower Corvo. Areas of Zambujal are known to contain elevated levels of deleterious elements such as As, Sb and Hg which require blending with other ores prior to processing. A geological cross-section through the Zambujal deposit is shown in Figure 7.8.

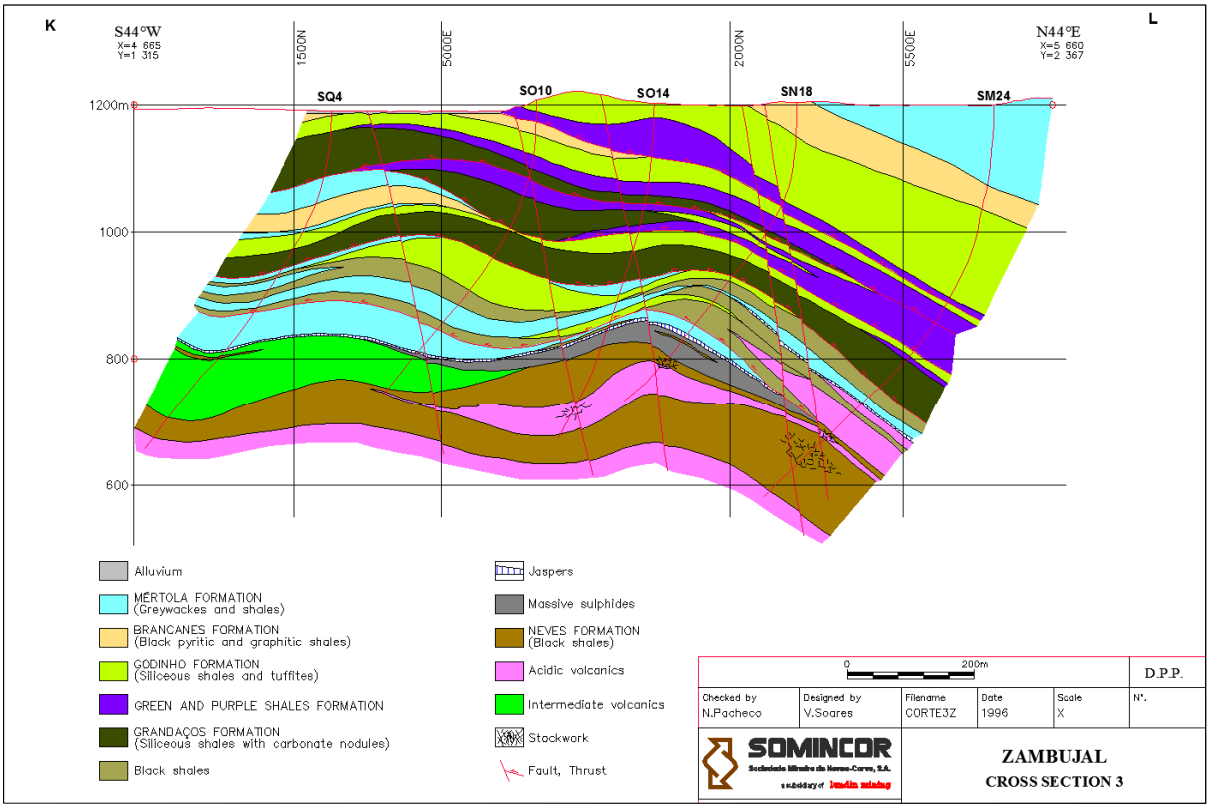


Figure 7.8: Geological Cross-Section through the Zambujal Deposit

7.3.5 Lombador

The Lombador deposit is the largest of the five massive sulphide deposits at Neves-Corvo situated on the north-eastern flank of the anticline, on the northern side of the Neves-Corvo mine lease. It is located at a depth of 400m at its western end and extends down to a depth of 1,200m below surface. It dips to the northeast at approximately 35° but steepens at depth and has a shallow plunge to the northwest. The sulphide lens has dimensions of up to 15m in thickness and extends for approximately 1,400m down dip and at least 1,600m along strike. The limits of the mineralisation do not appear to have been reached by the current drilling in the northwestern and southeastern directions. The Lombador mineralisation is connected by a “bridge” with the massive sulphide lenses of Corvo to the south and Neves to the west.

The Lombador deposit is affected by at least three tectonic events that deformed the Neves-Corvo region resulting in the following:

- A system of north-south orientated sub-vertical faults;
- Low angle thrust shears that resulted in duplications of the stratigraphy; and
- Normal left-lateral sub-vertical faults oriented N30°W and N30°E, which dislocate all the sequences, including the massive sulphides.

The north-south and the sub-vertical faults displace the massive sulphide lenses in places by up to 10's of metres. A significant north-south fault separates the massive sulphide of Lombador South from Lombador East.

The massive sulphide lenses are bounded on both the footwall and the hanging-wall by thrusts, and additional thrusts occur further into the hanging-wall lithologies. In places, the thrusts within the mineralisation have resulted in duplications that have further increased the thickness of the sulphide mineralisation. However, the thrusting can result in geotechnical problems when thick zones of broken rock occur in the hanging-wall of stopes or development drives.

At Lombador, the stratigraphic thickness of the VSC comprises predominantly of massive sulphides containing mostly zinc rich mineralisation (MZ and 5Z). These occur as lenses (approximately 20 to 70m thick) that show a continuous horizontal development. The copper-rich massive sulphide ores (MC type) mostly consist of massive chalcopyrite, with pyrite as the second most voluminous sulphide. A broad continuous zone of copper-rich stringer/stockwork ores (FC ore) extends for some 400 m at the bottom of the MC ore.

Within this large massive sulphide lens are several zones of higher grade zinc, copper and copper plus zinc mineralisation. These have been sub-divided into the Lombador East and Lombador South zinc deposits (with associated copper-rich stockwork zones) and the Lombador North area. The Lombador South and East deposits, comprise two high-grade zinc +/- copper zones, both of which are enclosed within the much larger massive sulphide lenses. The two deposits are separated by approximately 150m of barren pyrite. A copper-rich stockwork zone in the footwall to the massive sulphide lens trends across this barren zone to connect the two deposits. This copper zone extends outside of the zinc mineralisation laterally, into the area between Lombador East and South.

It is noteworthy that the Lombador massive sulphides are overlain by predominantly felsic volcanic rocks.

A geological cross-section through the Lombador and Neves deposits is shown in Figure 7.9.

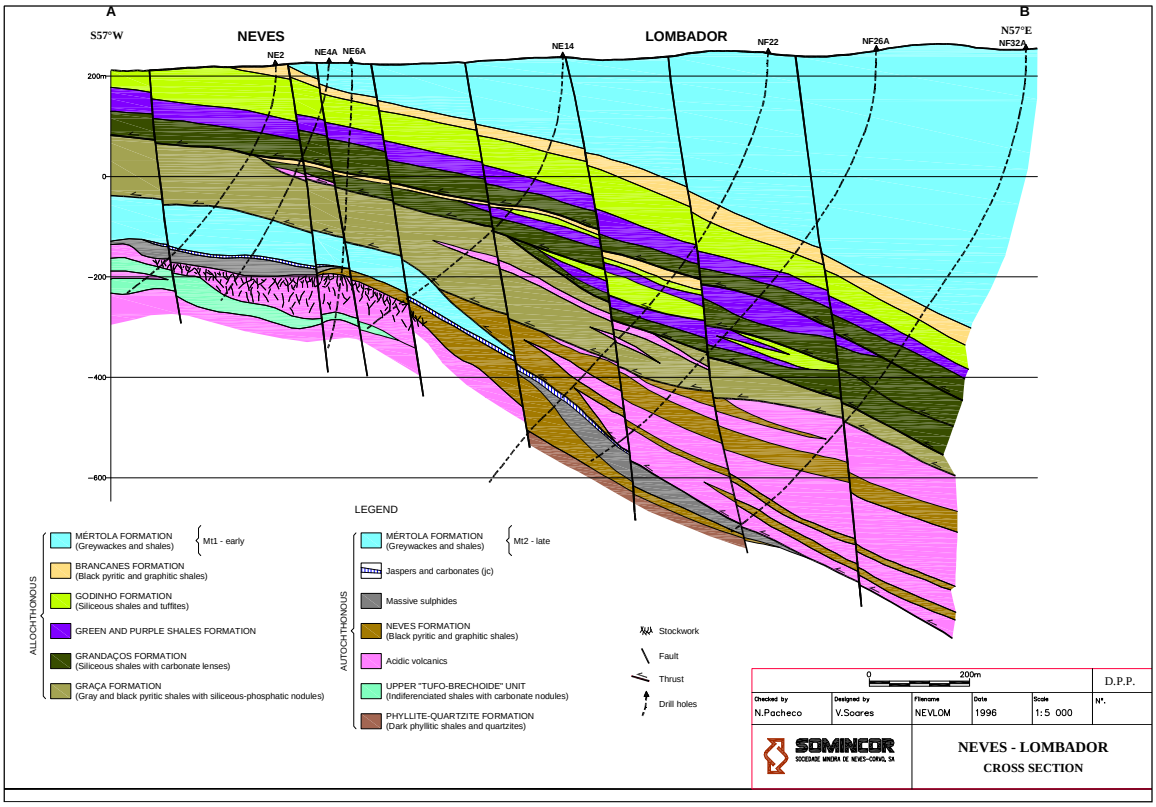


Figure 7.9: Geological Cross-Section through the Lombador and Neves Deposits

7.3.6 Monte Branco

The Monte Branco deposit was discovered in 2011 from surface exploration drilling. The deposit is located approximately 1.2km to the south of Semblana and just west of the Cerro do Lobo TMF and comprises six discontinuous lenses that have been strongly affected by tectonic shearing. Monte Branco represents a new centre of strong, concentrated sulphide mineralisation, currently covering approximately 250m by 200m in area and at depths of between 540m and 700m below surface. The deposit contains significant copper sulphide mineralisation and includes both massive and stockwork type sulphides.

7.3.7 Semblana

The Semblana deposit is almost flat and has gentle dip (15-20°) to the north and is located at a depth of 790m below surface. Most drill holes have intersected copper bearing stockwork (FC) (clean ore) mineralisation, although several small zones of massive copper (MC) in lenses have also been identified. The hangingwall stratigraphy is identical to that at Corvo and Zambujal, but rhyolites are seen exclusively in the footwall at Semblana, with widths varying from a few metres to tens of metres. Mineralisation in the rhyolites is occasionally observed but is not considered economic.

Tin is sometimes present both in the stockwork and the massive ores, but is confined to the northern part of the orebody, whilst discrete pods of zinc mineralisation have been identified in the south.

Although Mineral Resources are reported for massive and stockwork copper, no stockwork zinc has been identified.

A geological cross-section through the Semblana deposit is shown in Figure 7.10.

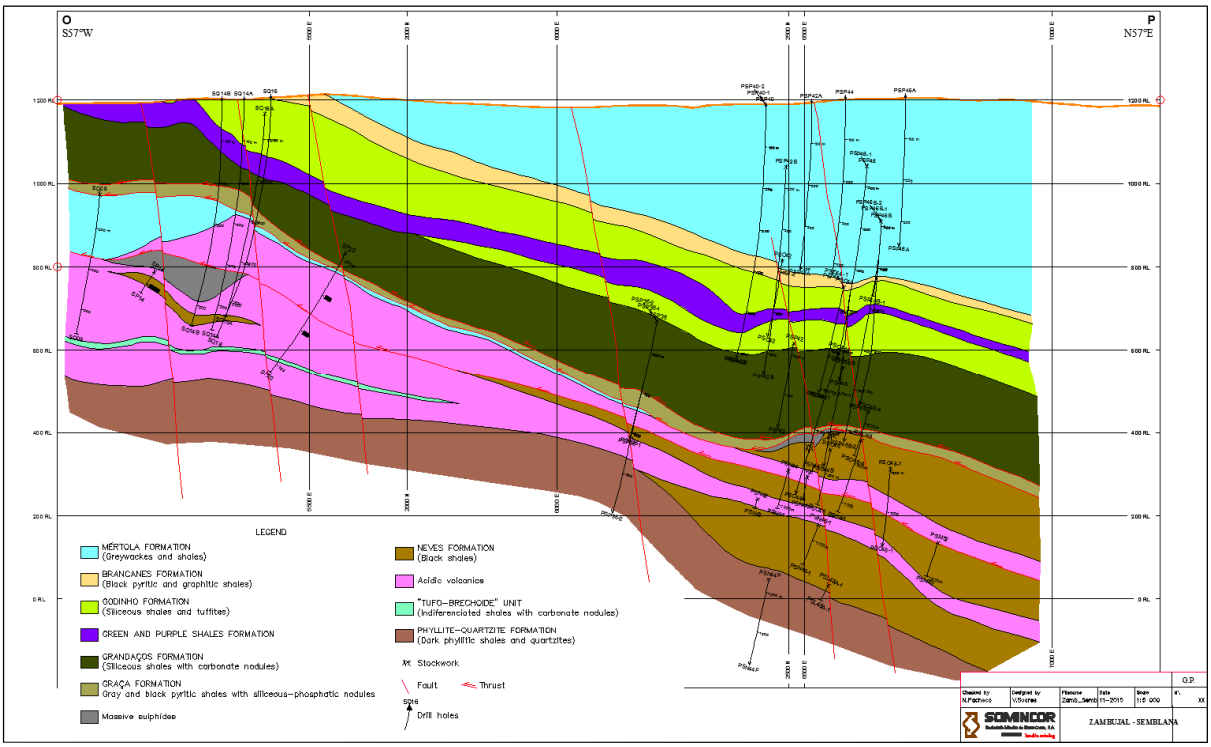


Figure 7.10: Geological Cross-Section through the Semblana Deposit

8 DEPOSIT TYPES

8.1 Mineral Deposit Type

The mineral deposits at Neves-Corvo are classified as volcanogenic massive sulphide (VMS) deposits. They typically occur as lenses of polymetallic (Cu, Zn, Sn, Pb) massive sulphides that formed at or near the seafloor in submarine volcanic environments. They formed from accumulations of the focussed discharges of hot metal-enriched fluids associated with seafloor hydrothermal convection, typically in tectonic areas of active submarine volcanism, including rift spreading centres and island arc subduction zones. The massive sulphide lenses are commonly underlain by sulphide-silicate stockwork vein systems, although the stockwork systems may extend into the hanging-wall strata above the massive sulphide lenses. The immediate host rocks can be either volcanic or sedimentary. The deposits are overlain by a repetition of volcanic-sedimentary and flysch units.

VMS deposits readily accommodate strain during regional deformation because of the ductile nature of massive sulphide bodies, and can therefore display much higher degrees of recrystallisation and remobilisation than the surrounding volcanic and sedimentary strata. The tectonic remobilisation may result in duplication of the stratigraphy further localising the sulphide mineralisation.

The model for mineral deposition for VMS deposits is shown in Figure 8.1.

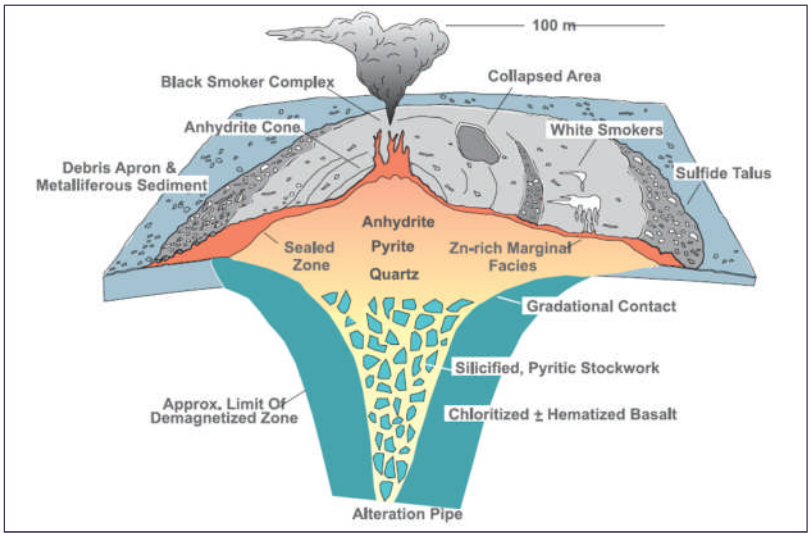


Figure 8.1: Classification of VMS Deposits by Hannington et al (1995)

8.2 Exploration Model

Studies of many VMS districts worldwide and analogous studies of mineralisation on the modern sea floor enable some criteria for targeting VMS deposits. VMS districts occur within large volcanic edifes, calderas and crustal structures. Large deposits, more than 50 or 100 million tonnes, are uncommon. Some large deposits are associated with a major long-lived crustal structure (i.e. Kidd Creek), or with thick successions of volcaniclastic rocks (i.e. Bathurst), or occur in more stable rifted continental margin settings (i.e. Iberian Pyrite Belt). The large deposits tend to be associated with large, diffuse

low temperature alteration systems. Polymetallic and precious metal rich deposits can be related to specific regional, local and compositional characteristics. Deposits associated with mafic dominated terranes tend to be copper and copper-zinc endowed. Large deposits such as Kidd Creek, Flin Flon and Horne have exceptional endowments of copper, gold and/or value added metals (e.g. In and Sn at Kidd Creek). Continental margin or successor rifted arc-hosted deposits with felsic volcaniclastic-sedimentary host rocks have a higher Pb-Zn endowment (e.g. Zinkgruvan, Bergslagen, Sweden) or Pb-Au-Ag concentrations (e.g. Roseberry, Tasmania; Petiknas, Sweden; Eskay Creek, Canada; Greens Creek, Alaska). The exception being Neves-Corvo, which has a large copper-tin endowment. Strongly metamorphosed deposits commonly found in Archean or Proterozoic terranes tend to have coarser grained sulphides and consequently metal recovery is commonly better than for finely crystalline sulphides in some of the less metamorphosed districts. Recrystallisation can also complicate recoveries with metal intergrowth and substitution of deleterious metals, eg Se and Tl, but can also thermally and mechanically “purify” deposits of such metals as Hg, As and Sb (Gibson et al (2007)).

9 EXPLORATION

Exploration surrounding the Neves-Corvo mine has focused on the search for further blind massive sulphide deposits. Exploration techniques employed by SOMINCOR at Neves-Corvo include soil geochemistry, geological mapping, various geophysical techniques including airborne magnetics, residual ground gravity survey, airborne gravity survey, ground electromagnetic (EM) survey and 3D seismic survey and exploration drilling. Summary plans are shown in Figure 9.1.

The discovery of the Semblana deposit in 2010 was an important milestone in the history of exploration at Neves- Corvo and marked the first discovery of a new deposit since 1988. The discovery (located at a depth of 790m below surface) resulted from the combination of geophysical anomalies and geological interpretation as being part of the northeast limbs of the Zambujal and Corvo orebodies. Surface drill hole PSO48 confirmed the presence of mineralisation at Semblana by intersecting massive sulphides. Borehole electromagnetic (BHEM) surveying was performed in the drill hole, resulting in the identification of a strong off-hole conductor, thereby confirming the source of the geophysical anomaly as concentrated sulphide mineralisation. Subsequent follow up drilling from 2010-2013 resulted in the current Mineral Resource estimate for the Semblana deposit.

Closely following the discovery of Semblana, the Monte Branco deposit was discovered in 2011 by surface exploration drilling whereby discovery drill hole SCA26 intercepted a 32.5m thick section of strong stockwork type copper sulphides grading 2.2% Cu and including a higher grade interval of 11.0m grading 3.9% Cu (Lundin press release dated December 15, 2011). The deposit is located approximately 1.2km to the south of Semblana and just west of the Cerro do Lobo TMF. The deposit is located at depths of between 540m and 700m below surface.

The discoveries of the Semblana and Monte Branco deposits provides clear evidence that the immediate area surrounding Neves-Corvo remains underexplored and that the potential for new discoveries remains high.

In 2011 a high-resolution 3D seismic survey was completed by HiSeis Pty Ltd over a 21km^2 area surrounding the Neves-Corvo mine. The results clearly imaged the recently discovered Semblana deposit and verified the effectiveness of this exploration technique in the search for blind massive sulphide deposits.

Future regional exploration to be undertaken by SOMINCOR is planned based on analysis of the 3D seismic data in conjunction with EM and geological structural interpretation. The analysis, being undertaken in the first half of 2017, is to be incorporated into a mineral inventory range analysis (MIRA) to prioritise exploration drilling targets that could be brought into production within two years.

A total of 12 surface exploration drill holes for a total of 18,400m with a 200m spacing and to depths of around 1,500m are planned for 2017. The aim of the drilling is to target the gap area between Zambujal, Corvo and Semblana to attempt to intercept potential near-mine copper mineralisation. The 2017 budget for underground drilling within the mine area is €3.4M with a total of 34,000m of underground drilling planned. Lombador is the main target for this drilling. Regional exploration

drilling for 2017, 2018 and 2019 is budgeted at 2,000m per year. The drill targets for the regional exploration will be dependent on the outcome of the MIRA.

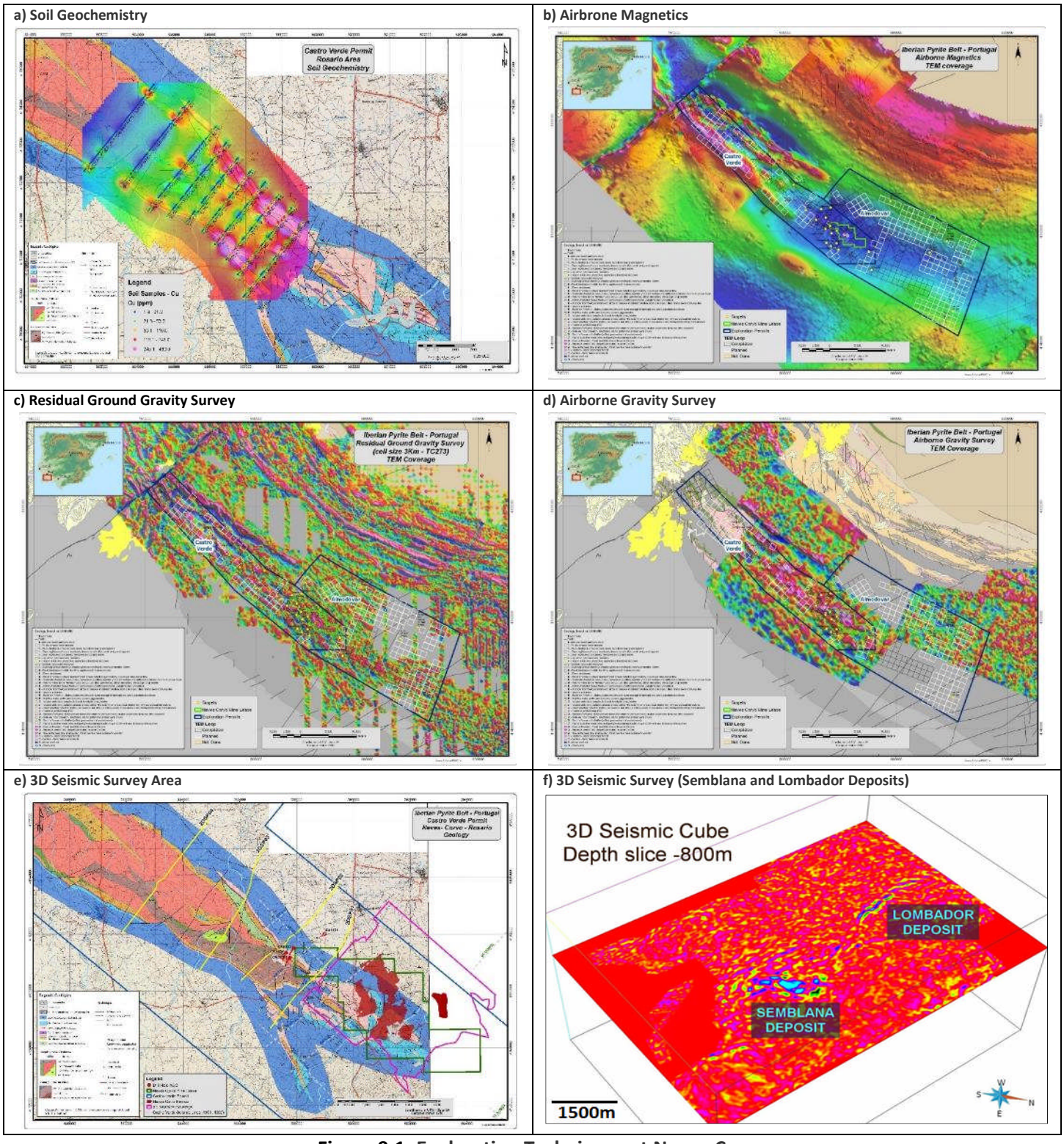


Figure 9.1: Exploration Techniques at Neves-Corvo

10 DRILLING

Drilling is undertaken using both surface and underground drilling methods. Underground drilling is a continuous activity at Neves-Corvo focusing on the delineating and upgrading of existing Mineral Resources as well as the exploration of peripheral Inferred Mineral Resource estimates. Surface drilling campaigns have been important over the years in stepping out beyond the limits of underground development to explore extensions to mineralisation. Underground drilling is typically undertaken on 35m spacing, whereas surface drilling is typically undertaken on 70m to 100m spacing or greater. Drill sections are orientated along profiles at 057° and are orientated perpendicular to the general strike of the deposits.

Historically, diamond drilling was undertaken by both mine employees and contractors. Underground diamond drilling was undertaken by SOMINCOR using two Diamec hydraulic drill rigs operated by mine employees. Further underground diamond drilling was undertaken by Drillcon (Swedish drilling contractor with a Portuguese subsidiary based in Braga) and Hy Tech Drilling Ltd (Canadian drilling contractor from Smithers, BC, with a local office in Castro Verde). Surface drilling was undertaken by Hy Tech Drilling Ltd using three Tech-5000 compact hydraulic diamond drill rigs capable of drilling depths of up to 1,500m.

From 2015, only underground diamond drilling has been undertaken at Neves-Corvo for exploration. All drilling is undertaken by Swick drilling contractors using three Atlas Copco jumbo mounted diamond drill rigs. The drill rigs are contractor owned. The jumbo mounted drill rigs were introduced to reduce drill site set up time compared to skid mounted drill rigs. No surface exploration drilling was carried out during this period.

Within the current concession areas at Neves-Corvo and as of June 30, 2016, a total of 1,037 surface drill holes for 822,266m have been completed and 5,928 underground drill holes for 591,557m have been completed. A summary of the surface and underground drilling completed at Neves-Corvo is shown in Table 10.1 and Table 10.2, respectively. All drilling was conducted by diamond core drilling.

Table 10.1: Summary of Surface Drilling at Neves-Corvo by Deposit

Company	Year	Neves		Corvo		Graça		Zambujal		Lombador		Monte Branco		Semblana		Regional		Total	
		Drill Holes	Length (m)	Drill Holes	Length (m)	Drill Holes	Length (m)	Drill Holes	Length (m)	Drill Holes	Length (m)	Drill Holes	Length (m)	Drill Holes	Length (m)	Drill Holes	Length (m)	Drill Holes	Length (m)
EDM, SMMPP and Conframines	1973	1	244	-	-	-	-	-	-	-	-	-	-	-	-	1	503	2	747
	1977	5	2,108	1	562	-	-	-	-	-	-	-	-	-	-	-	-	6	2,669
	1978	12	5,647	6	3,367	3	1,352	1	554	-	-	-	-	-	-	2	1,272	24	12,192
	1979	3	1,206	19	11,092	1	531	-	-	-	-	-	-	-	-	-	-	23	12,829
	1980	5	2,944	8	5,320	7	3,330	8	4,727	-	-	2	1,224	-	-	1	861	31	18,406
	1981	5	2,196	12	7,911	7	2,837	5	3,323	1	788	-	-	-	-	-	-	30	17,055
	1982	5	2,370	14	9,668	7	3,264	-	-	-	-	-	-	-	-	2	599	28	15,900
	1983	4	2,058	5	3,328	10	4,572	-	-	1	987	2	1,739	-	-	2	1,172	24	13,855
	1984	3	1,553	14	7,128	9	3,133	-	-	-	-	3	1,548	-	-	1	955	30	14,318
EDM and Rio Tinto	1985	11	5,470	2	862	2	723	-	-	-	-	1	276	1	265	10	5,646	27	13,242
	1986	3	1,573	4	1,538	11	4,621	-	-	-	-	-	-	-	-	1	980	19	8,712
	1987	4	1,904	6	1,074	-	-	-	-	1	1,004	-	-	-	-	-	-	11	3,982
	1988	9	3,714	-	-	1	507	-	-	4	3,423	-	-	-	-	-	-	14	7,645
	1989	5	1,990	4	2,752	12	5,351	1	494	2	1,569	-	-	-	-	-	-	24	12,156
	1990	-	-	2	1,498	-	-	1	524	8	7,020	-	-	-	-	-	-	11	9,042
	1991	2	1,584	6	3,961	3	1,293	-	-	6	5,033	-	-	-	-	-	-	17	11,871
	1992	1	713	3	2,700	-	-	-	-	8	6,143	-	-	-	-	3	2,937	15	12,492
	1993	6	4,378	1	713	-	-	1	745	10	10,199	-	-	-	-	2	2,657	20	18,692
	1994	1	346	1	495	-	-	1	593	1	1,352	-	-	-	-	3	4,468	7	7,253
	1995	2	1,181	-	-	-	-	3	2,213	2	2,349	-	-	-	-	3	4,018	10	9,762
	1996	2	573	-	-	1	361	-	-	10	10,018	1	1,101	-	-	3	1,942	17	13,995
	1997	-	-	-	-	-	-	-	-	7	7,051	-	-	-	-	5	5,615	12	12,666
	1998	-	-	-	-	-	-	8	4,696	1	1,228					2	2,697	11	8,621
	1999	-	-	-	-	-	-	11	5,701	-	-	-	-	-	-	-	-	11	5,701
	2000	1	474	-	-	1	565	5	2,902	-	-	-	-	-	-	1	890	8	4,830
	2001	-	-	-	-	-	-	4	2,399	-	-	-	-	-	-	2	1,800	6	4,199
	2002	2	1,076	-	-	1	491	-	-	-	-	-	-	-	-	2	1,938	5	3,506
	2003	4	1,550	-	-	-	-	-	-	-	-	-	-	-	-	2	1,987	6	3,537
Euro Zinc	2004	3	1,189	-	-	-	-	-	-	-	-	-	-	-	-	1	814	4	2,003
	2005	9	3,184	-	-	6	2,610	-	-	-	-	-	-	-	-	-	-	15	5,794
	2006	8	2,851	2	916	-	-	-	-	10	8,637	-	-	-	-	-	-	20	12,404
Lundin Mining	2007	-	-	3	2,612	-	-	3	1,514	38	34,221	-	-	-	-	4	2,244	48	40,591
	2008	15	6,795	3	3,410	-	-	1	477	42	38,675	-	-	-	-	1	1,888	62	51,246
	2009	10	5,432	3	2,869	-	-	-	-	64	62,533	-	-	-	-	8	6,024	85	76,858
	2010	12	6,965	5	5,909	-	-	-	-	35	40,898	-	-	26	25,570	3	1,720	81	81,062
	2011	-	-	1	1,387	-	-	-	-	9	10,686	11	10,552	72	70,493	5	5,314	97	97,045
	2012	-	-	4	3,858	-	-	-	-	-	-	54	50,248	43	40,036	11	14,804	109	106,475
	2013	-	-	-	-	-	-	1	966	-	-	43	46,279	9	8,546	-	-	57	59,649
	2014	-	-	-	-	-	-	-	-	-	-	9	7,748	-	-	1	1,515	10	9,263
Total		**153**	**73,269**	**129**	**84,930**	**82**	**35,542**	**54**	**31,828**	**260**	**253,814**	**126**	**120,714**	**151**	**144,910**	**82**	**77,259**	**1,037**	**822,266**

Table 10.2: Summary of Underground Drilling at Neves-Corvo by Deposit

Company	Year	Deposit																	
		Neves		Corvo		Graça		Zambujal		Lombador		Monte Branco		Semblana		Regional		Total	
		Drill Holes	Length (m)	Drill Holes	Length (m)	Drill Holes	Length (m)	Drill Holes	Length (m)	Drill Holes	Length (m)	Drill Holes	Length (m)	Drill Holes	Length (m)	Drill Holes	Length (m)	Drill Holes	Length (m)
EDM, SMMPP, Conframines	1982	-	-	2	131	-	-	-	-	-	-	-	-	-	-	-	-	2	131
	1983	-	-	7	1,047	-	-	-	-	-	-	-	-	-	-	-	-	7	1,047
	1984	-	-	32	4,693	-	-	-	-	-	-	-	-	-	-	-	-	32	4,693
EDM and Rio Tinto	1985	-	-	24	1,641	-	-	-	-	-	-	-	-	-	-	-	-	24	1,641
	1986	-	-	104	10,293	58	4,868	-	-	-	-	-	-	-	-	-	-	162	15,161
	1987	-	-	114	13,400	67	6,871	-	-	-	-	-	-	-	-	-	-	181	20,271
	1988	-	-	85	8,259	24	2,234	-	-	-	-	-	-	-	-	-	-	109	10,493
	1989	46	4,599	99	4,877	20	616	-	-	-	-	-	-	-	-	-	-	165	10,092
	1990	-	-	103	5,753	20	857	-	-	-	-	-	-	-	-	-	-	123	6,609
	1991	33	4,460	108	9,455	7	136	-	-	-	-	-	-	-	-	-	-	148	14,051
	1992	19	2,011	109	11,792	22	1,767	-	-	-	-	-	-	-	-	-	-	150	15,570
	1993	82	10,321	84	6,298	37	4,200	-	-	-	-	-	-	-	-	-	-	203	20,819
	1994	45	4,476	36	2,058	4	266	-	-	-	-	-	-	-	-	-	-	85	6,800
	1995	117	12,565	52	5,038	8	877	-	-	-	-	-	-	-	-	-	-	177	18,481
	1996	119	9,822	31	3,257	66	7,631	-	-	-	-	-	-	-	-	-	-	216	20,711
	1997	69	4,761	53	5,497	32	4,253	-	-	-	-	-	-	-	-	-	-	154	14,511
	1998	123	11,864	29	1,686	15	742	-	-	-	-	-	-	-	-	-	-	167	14,292
	1999	95	9,271	73	5,582	3	210	-	-	-	-	-	-	-	-	-	-	171	15,062
	2000	109	10,981	63	4,849	16	502	-	-	-	-	-	-	-	-	-	-	188	16,333
	2001	111	7,059	74	6,001	12	642	-	-	-	-	-	-	-	-	-	-	197	13,703
	2002	76	2,761	66	7,393	1	31	14	2,180	-	-	-	-	-	-	-	-	157	12,365
	2003	78	1,742	97	9,506	2	21	14	2,255	-	-	-	-	-	-	-	-	191	13,524
Euro Zinc	2004	24	869	83	3,770	-	-	24	3,635	29	3,208	-	-	-	-	-	-	160	11,482
	2005	39	2,278	57	1,728	2	16	35	6,223	20	3,011	-	-	-	-	-	-	153	13,256
	2006	51	2,487	79	5,511	25	2,536	21	3,246	36	4,002	-	-	-	-	-	-	212	17,782
Lundin Mining	2007	57	4,896	56	2,524	20	2,470	24	2,401	14	2,046	-	-	-	-	-	-	171	14,337
	2008	101	9,285	24	365	6	211	51	4,612	20	3,076	-	-	-	-	-	-	202	17,549
	2009	61	5,085	12	244	-	-	31	3,359	55	7,552	-	-	-	-	-	-	159	16,239
	2010	144	3,913	19	1,080	-	-	17	1,702	43	10,852	-	-	-	-	-	-	223	17,548
	2011	148	9,911	25	2,071	-	-	56	5,010	58	19,648	-	-	-	-	-	-	287	36,640
	2012	95	8,252	38	2,558	-	-	16	1,163	125	24,421	-	-	-	-	-	-	274	36,394
	2013	48	6,927	25	1,601	1	69	9	697	194	38,658	-	-	-	-	-	-	277	47,952
	2014	26	1,194	92	13,722	-	-	8	140	63	18,745	-	-	-	-	-	-	189	33,801
	2015	75	5,791	49	8,161	-	-	209	12,679	79	24,255	-	-	-	-	-	-	412	50,886
	2016	78	6,315	68	2,919	-	-	28	1,213	26	887	-	-	-	-	-	-	200	11,334
Total		**2,069**	**163,898**	**2,072**	**174,759**	**468**	**42,026**	**557**	**50,514**	**762**	**160,360**	**-**	**-**	**-**	**-**	**-**	**-**	**5,928**	**591,557**

10.1 Drilling by EDM, SMMPP and Conframines (1973-1984)

As part of the joint venture between the Portuguese government (EDM) (51%), SMMPP (24.5%) and Conframines (24.5%) a total of 198 surface drill holes for 107,971m and 41 underground drill holes for 5,871m were completed during the discovery stage of the project. Surface drill holes were predominantly located at Neves, Corvo and Graça with underground drilling at Graça.

10.2 Drilling by EDM and Rio Tinto (1985-2004)

Rio Tinto became involved in the project in 1985 effectively forming a 49:51% joint venture with the Portuguese government (EDM). A total of 251 surface drill holes for 171,904m and 2,968 underground drill holes for 260,489m were completed during the feasibility and mine expansion phase. Surface drilling continued at Neves, Corvo and Graça and included expansion into Zambujal and Lombador deposits. Underground drill holes were predominantly located at Neves, Corvo and Graça with first production commencing from the Upper Corvo and Graça deposits on January 01, 1989.

10.3 Drilling by Eurozinc (2004-2006)

On June 18, 2004, EuroZinc acquired a 100% interest in the project. During this phase a total of 39 surface drill holes for a total of 20,201m were completed and a total of 525 underground drill holes for a total of 42,520m were completed.

10.4 Drilling by Lundin Mining (2006-2017)

On October 31, 2006 Lundin and EuroZinc merged, retaining the Lundin name. A total of 551 surface drill holes for a total of 522,936m and 2,394 underground drill holes for a total of 282,680m have been drilled up to June 2016 by Lundin Mining. Drilling during this phase also included the discovery of the Semblana and Monte Branco deposits and subsequent maiden Mineral Resource estimates on these in 2011 and 2013, respectively. Drilling by SOMINCOR is still ongoing to date.

10.5 Drill Core Diameter

Underground drill core can be either NQ or BQ depending on the drilling contractor. Surface drilling normally intersects the mineralised zones with NQ size core. Typically, surface holes begin with HQ and reduce to NQ before intersecting mineralisation. This provides the opportunity to reduce rod size and pass problematic zones of poor ground. Occasionally both surface and underground holes are reduced to BQ to pass problematic zones within the sulphides.

10.6 Drill Core Recovery

Sulphide mineralisation at Neves-Corvo is generally very competent. As a result core recovery is generally very good with an average of 98% for surface drilling and 97% for underground drilling. No correlation between metal grades and recovery has been observed. WAI consider that there are no

material issues resulting from the reported drill core recovery and that the reported core recovery is acceptable for use in Mineral Resource estimation.

10.7 Extent of Drilling

To date, drilling has defined the seven main mineralised zones of Neves, Corvo, Graça, Zambujal, Lombador, Monte Branco and Semblana with a combined total strike length of over 5,000m and to depths of up to 1,400m from surface. Neves, Corvo, Graça, Zambujal and Lombador have the most extensive drilling completed to date and include both underground and surface drilling. Monte Branco and Semblana are relatively new discoveries and have been drilled only from surface.

10.8 Drill Hole Collar Surveys

Surveying of drill hole collar locations is done by the mine survey team using Leica system equipment. Underground surveying is done using Leica TCR705 or TCR805 instruments. Surface holes are spotted with hand held GPS units and then surveyed by the mine using Leica TCR1205 instrument.

10.9 Downhole Surveys

All drill holes are downhole surveyed on roughly 30m intervals. Prior to 2008, underground drill holes were surveyed using the Kodak Eastman Single Shot tool. Since 2008, underground drill holes have been surveyed with Reflex Ez-Trac equipment. Surface holes are surveyed with the Reflex Easy Shot system, both travelling in and out of the hole. The Devico directional drilling tool was used to guide surface drilled holes to targets and maintain an even grid spacing. During the directional drilling process, parts of the hole are surveyed independently by the Devico sub-contractors, providing an additional verification on the EZ Shot survey data.

10.10 Drill Sections

Relevant drill sections showing the geological interpretation at the Neves-Corvo deposits are contained in Section 7.3. The location of the surface and underground drill hole collars within the different licence areas are shown in Figure 10.1.

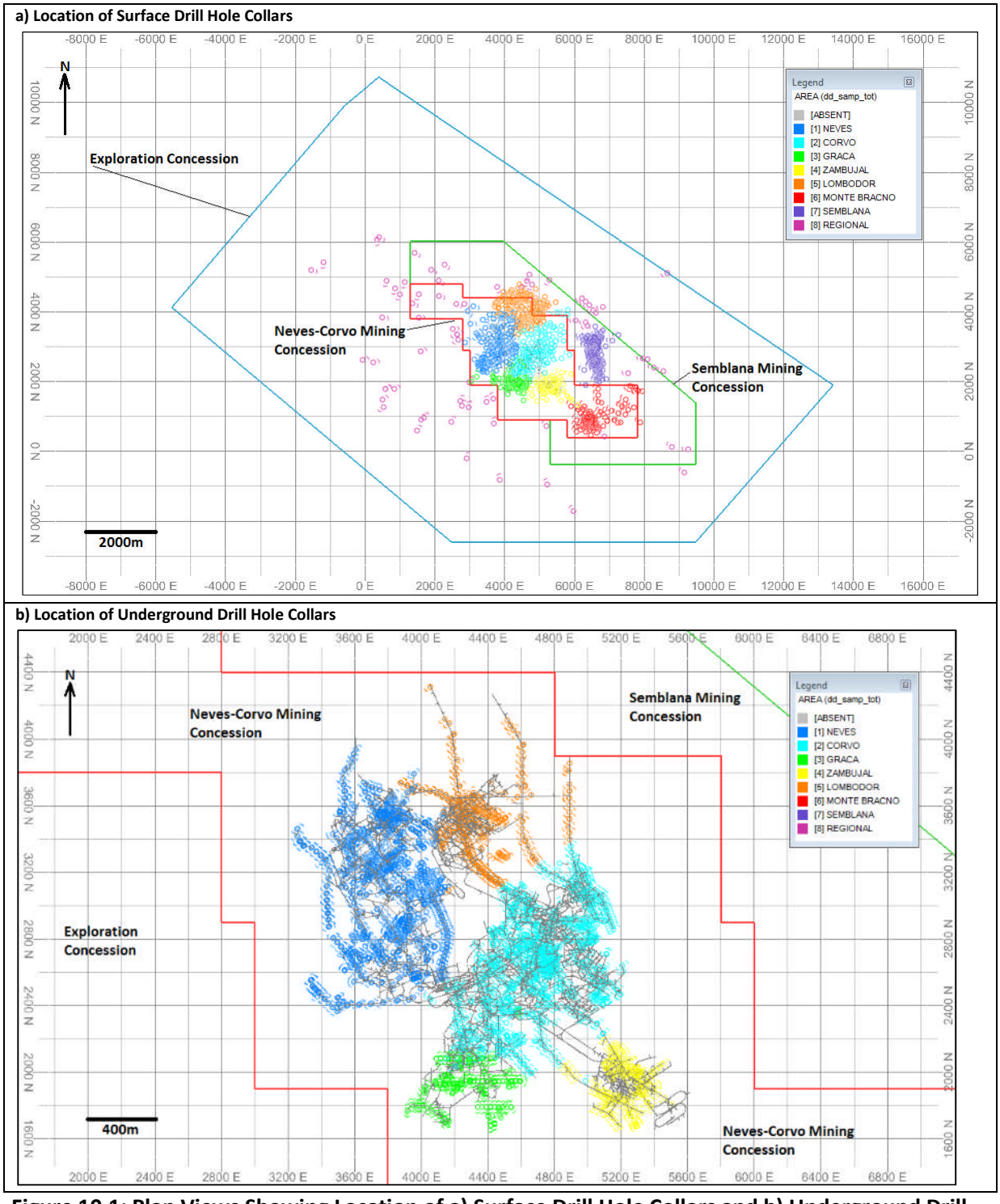


Figure 10.1: Plan Views Showing Location of a) Surface Drill Hole Collars and b) Underground Drill Hole Collars within the Neves-Corvo Areas

11 SAMPLE PREPARATION, ANALYSES, AND SECURITY

The sampling methodology, preparation and analyses differ depending on whether the sample is drill core or face sample. All samples are collected by SOMINCOR geological staff with all sample preparation and analysis currently undertaken at the Neves-Corvo mine site and laboratory. Previously sample preparation was undertaken at the Lombador exploration facility located 4km north of the mine. The same sample preparation procedures were used at the Lombador exploration facility and sample analysis was also undertaken at the Neves-Corvo mine laboratory.

11.1 Face Sampling

Underground production faces are sampled by chip sampling in which the 5m x 5m faces are divided equally into sampling areas dependent on the style of mineralisation. Radial chip sampling is carried out in massive mineralisation in which the face is divided into a 3 x 3 grid of radial samples of 1m diameter. Channel chip sampling is carried out in stockwork mineralisation in which the face is divided into a 2 x 3 (horizontal x vertical) grid of vertically aligned channel samples each of 1m in length. Each face is sampled every second or third advance, which equals a sampling interval of 6-9m. Access to the highest samples is attained using a truck mounted access lift with safety cradle. Samples comprise of fragments, chips and mineral dust, and are extracted using a chisel and hammer. The obtained sample is deposited into a heavy duty sample bag and labelled with the face ID and sample number. Samples are then returned to the surface and dispatched to the sample preparation facility. Geological mapping of each face is undertaken using electronic tablets.

11.2 Core Sampling

Sampling procedures are the same for both underground and surface drill core. Drill core is removed from the core barrel and placed into core boxes. Sample intervals are recorded on the core box and on separators used to define the sample interval. Core boxes are transported from the drill sites to the on-site logging facilities at Neves-Corvo mine.

The drill core is wetted with water, photographed and core recovery and RQD measurements are taken for each sample of core. The drill core is geologically logged for colour, texture, alteration, structures and mineralisation using electronic tablets which are uploaded to the mine SQL database. A geologist is responsible for determining and marking the intervals to be sampled, selecting them based on geological, mineralisation, alteration or structural logging. Sample intervals are marked on the boxes and core using a lumber crayon. Sampling is undertaken from top to bottom of the drill hole. Historically, 1m sample intervals were used within the massive sulphide mineralisation while sample intervals of up to 2m were allowed within the stockwork mineralisation. However, from 2015, 1m sample intervals have been adopted for all mineralisation types (primarily to better reflect the variability in stockwork mineralisation).

Core sample intervals selected for analyses are halved with splitting performed by diamond saw in such a way that two equal halves of core are produced. Prior to 1999, quarter core was used for sampling with three quarter core archived; however this was deemed to be less representative,

particularly for stockwork mineralisation. The majority of resources originally evaluated using quarter core samples have since been mined out or re-evaluated using half core. Therefore, any bias associated with this sampling is not considered significant to the current Mineral Resource estimate. Grade control and production drill core is whole core sampled with pulp duplicates stored for archive.

The sample is then placed in a heavy duty plastic sample bag with identifying sample tags and secured with zip ties. Samples are then dispatched for sample preparation. Remaining half drill core (from exploration drilling) is returned to the core box for archive and storage.

11.3 Bulk Density Determination

Geological staff conduct density measurements by a variation of the standard water displacement technique. The core facility has three stations for measuring density. The density stations consist of a water tight vertical metal cylinder fixed to a stable base plate. Near the top of the metal cylinder is a spout with an attached plastic hose. A long metal cage is used to lower the samples into the cylinder. The following points detail the density measurement method:

- Samples are placed in a plastic tub and weighed on a balance;
- The metal cylinder is filled with water until it flows out of the hose and is level with the opening of the spout. The metal cage is in place during the filling so that its volume is displaced;
- Core is placed in the metal cage and lowered into the metal cylinder;
- The displaced water is collected in the plastic tub and weighed on the balance; and
- The weight of the sample and water are recorded and the sample bulk density is calculated.

Naturally the densest material corresponds to those of massive mineralisation with the stockwork and rubańe being much more variable because of their large ranges in sulphide content. Studies on grade versus density have been conducted and regression formulae devised. Density measurements were previously undertaken on all drill core samples, however recently the number of density measurements has been reduced for established areas such as Neves, Corvo, Graça and Zambujal where a significant database of density measurements already exists.

11.4 Sample Preparation

Sample preparation is conducted at the Neves-Corvo sample preparation facility located within the Neves-Corvo mine site for all samples with the exception of drill core from the Semblana exploration drilling where sample preparation was undertaken at the ALS laboratory in Seville, Spain.

The SOMINCOR sample preparation laboratory consists of the following equipment:

- 2 jaw crushers;
- 2 pulverizers;
- 2 mills;

- 1 riffle splitter -16 slot; and
- 2 ovens.

The sample preparation procedures consist of the following:

- Samples are received at the sample preparation laboratory located at the back of the mine site analytical laboratory;
- Samples are placed in metal trays and dried at 105°C;
- Jaw crushers are used to reduce the samples to <6.3mm. Crushers are calibrated weekly and quartz sand is run between samples to avoid cross contamination;
- Crushed material is rolled to homogenize and passed through a 16 slot riffle splitter. Coarse reject material is bagged;
- The sample split is pulverized to <1mm and passed through a riffle splitter;
- Archive pulp is placed in a labelled plastic pill bottle;
- Split fraction for analysis is milled to <150 microns; and
- Milled samples are placed in labelled paper bags and organised for analyses.

The SOMINCOR Geology Department implemented a bar code system of sample tagging in 2008, which further protects against sample swapping.

Sample preparation for exploration drill hole samples from Semblana in 2011 was not undertaken at the Neves-Corvo laboratory. Instead half core from the Lombador exploration facility was sent to the ALS laboratory in Seville, Spain for sample preparation from which a 150g pulp sample was derived for analysis. The remaining coarse reject was returned to the Lombador exploration facility from which a further duplicate sample was split.

11.5 Sample Analysis

Sample analyses is conducted at the Neves-Corvo (SOMINCOR) analytical laboratory located within the Neves-Corvo mine site for all samples with the exception of drill core from the Semblana exploration drilling. Following sample preparation at ALS, Seville, the Semblana samples were then sent for analysis at ALS, Vancouver, for analysis.

The SOMINCOR analytical laboratory is accredited by the Instituto Português da Qualidade (IPQ), certificate 93/L.106, renewed every 3 years and submitted annually to quality audits by the same Institute, and also to internal audits. The laboratory has been accredited for ISO NP EN 450001, changed in 2002 to the new ISO/IEC 17025, for 47 analytical methods and around 100 determinations. Of these methods, 17 are for operational and commercial purposes and 30 are needed for environmental controls. The laboratory is also responsible for sampling the concentrate leaving the mine by train and at the Setúbal port facility.

Laboratory activity is ruled by written contracts, stating for example:

- Number and frequency of samples to be delivered to the laboratory;
- Analytical methods;
- Period to report the results; and
- Security of data and samples.

The Neves-Corvo laboratory regularly deals with three types of sample: underground production samples, production drill core and exploration drill core.

Analytical results are copied to a specific location on the SOMINCOR computer server that has access restricted to the Chief, Resource and Database Geologists.

Laboratory samples were historically analysed using Atomic Absorption (AA) and X-Ray Fluorescence (XRF) methods. Since April 2011 analysis by Inductive Coupled Plasma (ICP) is also undertaken.

The following describes the basic analytical procedures:

- All samples are analysed by XRF for Cu, Pb, Zn, S, Fe, As, Sn, Sb, Bi, Se and In;
- Ag is analysed by the AA flame method and Hg by AA vapour;
- Copper XRF results that fall between 0.7% and 10% are re-analysed by AA and XRF results of greater than 10% are re-analysed by the electro-gravimetric method with an AA finish; and
- Zinc XRF results between 0.5% and 20% are re-analysed by AA, results greater than 20% are analysed by the volumetric method.

Comparison of the results of XRF analysis with other assay methods show a distinct analytical bias. The values of both copper and zinc are consistently lower when assayed using XRF compared with AA or electro-gravimetric methods. This assay bias varies from year to year but is generally around 4%. The sample bias is continually monitored by the laboratory, but no correction factor is applied to the XRF results.

To prevent any further bias in the database, assay results based solely on the XRF analysis for Cu, Pb, Zn, S, Fe, As, Sn, Sb, Bi, Se and In are used for the purposes of Mineral Resource estimation for the deposits of Neves, Corvo, Graça, Zambujal, Lombador and Monte Branco. The use of the wet chemical and AA techniques are being continued to provide verification of the XRF results.

Exploration drill hole samples from Semblana in 2011 were analysed by ICP analysis at ALS, Vancouver. Assay methods by ALS included Au-AA23l, ME ICP61+In, Sn-XRF10, HG-CV42. If the ICP results were over limit for any one of Ag, Cu, Pb, Zn, then an OG46 assay was assay was conducted for Ag, Cu, Pb, Zn and As. The Mineral Resource estimate for Semblana is therefore primarily based on assay results derived by ICP analysis rather than XRF as at Neves-Corvo.

11.6 Sample Security and Chain of Custody

Sample collection and transportation of drill core and face samples is undertaken by SOMINCOR Geology Department staff.

Exploration core boxes are transported to the core logging facilities located at the Neves-Corvo mine site where there is sufficient room to layout and examine several drill holes at a time. Once logging and sampling have been performed, the core is transferred to the permanent storage facility located in the same compound or at the Lombador facility. The drill core boxes are covered. The on-site storage facility is dry with internal lighting and metal shelving for core storage. Pulp duplicate material is stored in the same facilities.

Where whole core sampling has been undertaken for production samples no remaining core is available. Pulp duplicates of these samples, drill core photographs taken during core logging and the Neves-Corvo laboratory assay certificates of these samples are however available.

11.7 Quality Assurance and Quality Control Programmes

The implementation of a quality assurance / quality control (QAQC) programme is current industry best practice and involves establishing appropriate procedures and the routine insertion of certified reference material, blanks and duplicates to monitor the sampling, sample preparation and analytical process. Analysis of QAQC data is made to assess the reliability of sample assay data and the confidence in the data used for the estimation.

Analysis of exploration samples (except for the Semblana samples in 2011) is undertaken at the Neves-Corvo laboratory (ISO17025 accreditation). Sample flow through the laboratory is carefully monitored to ensure sample swapping does not occur. Equipment is calibrated using certified reference materials to ensure accuracy. Internal QAQC procedures are undertaken by the laboratory. Repeat results are monitored and checks are made when results fall outside of the accepted repeatability ranges.

Primary samples submitted for analysis by the geological department are termed as Type 1. To detect possible changes or sample contamination, the geological department inserts the following samples into the sample stream for drill holes:

- Duplicate samples (Type 2) – 3 control samples for every 100 samples submitted;
- Blank samples (Type 10) – 4 control samples for every 100 samples submitted;
- Copper standard reference material (Type 11) - 2 control samples for every 100 samples submitted; and
- Zinc standard reference material (Type 12) – 2 control samples for every 100 samples submitted.

Only blank samples are submitted for analysis by the geological department as a control for face samples. WAI do not consider that this represents a risk to the Mineral Resource estimate as face samples are taken from production headings and are supported by reconciliation data.

QAQC performance is continually monitored by both the Neves-Corvo laboratory and the geological department. To ascertain levels of precision and accuracy and to identify if there are any sampling errors the geological department undertakes the following statistical analysis:

- *Thompson and Howarth Plot* (Precision Pairs), showing the mean relative percentage error of grouped assay pairs across the entire grade range, used to visualise precision levels by comparing against given control lines;
- *Rank HARD Plot*, which ranks all assay pairs in terms of precision levels measured as half of the absolute relative difference from the mean of the assay pairs (HARD). Used to visualise relative precision levels to determine the percentage of the assay pairs population occurring at a certain precision level;
- *Relative Difference Plots,* allows negative or positive differences to be calculated. This plot gives an overall impression of precision and also shows whether or not there is significant bias between the assay pairs by illustrating the mean percentage half relative difference between the assay pairs (mean HRD); and
- *Correlation Plots*, plot of the value of T1 against T2. This plot allows an overall visualisation of precision and bias over selected grade ranges. Correlation coefficients are also used;
- *QQ Plots and PP Plots*, plot comparing quantiles of T1 against T2 to determine the populations have a common distribution (QQ plot), plot of empirical cumulative distribution function and theoretical cumulative distribution function (PP plot); and
- *Shewhart X Charts*, control charts used to monitor SRM performance in comparison to the upper and lower standard deviation boundaries and the mean of the data set.

The following sections have been subdivided into samples assayed at Neves-Corvo and samples from the Semblana exploration drilling (2010-2013) assayed at ALS, Vancouver.

11.7.1 Neves-Corvo Laboratory Samples

A summary of the QAQC performance of samples analysed at the Neves-Corvo laboratory using the data from February 01, 2015 to February 29, 2016 is given in the sections below.

11.7.1.1 Duplicates (Type 2)

Duplicate analysis results (Type 2) are compared to the primary assays (Type 1) to monitor analytical precision as well as any potential bias in the process caused by improper cutting of the sample in the case of core, homogeneity, washing during the cutting or loss of fines during preparation. Prior to March 2012 all duplicate samples were derived from quarter core sampling. From March 2012 onwards all duplicate samples comprised of pulp duplicates.

Summary plots of the primary and duplicate analysis for copper from 646 samples undertaken at the Neves-Corvo laboratory are shown in Figure 11.1.

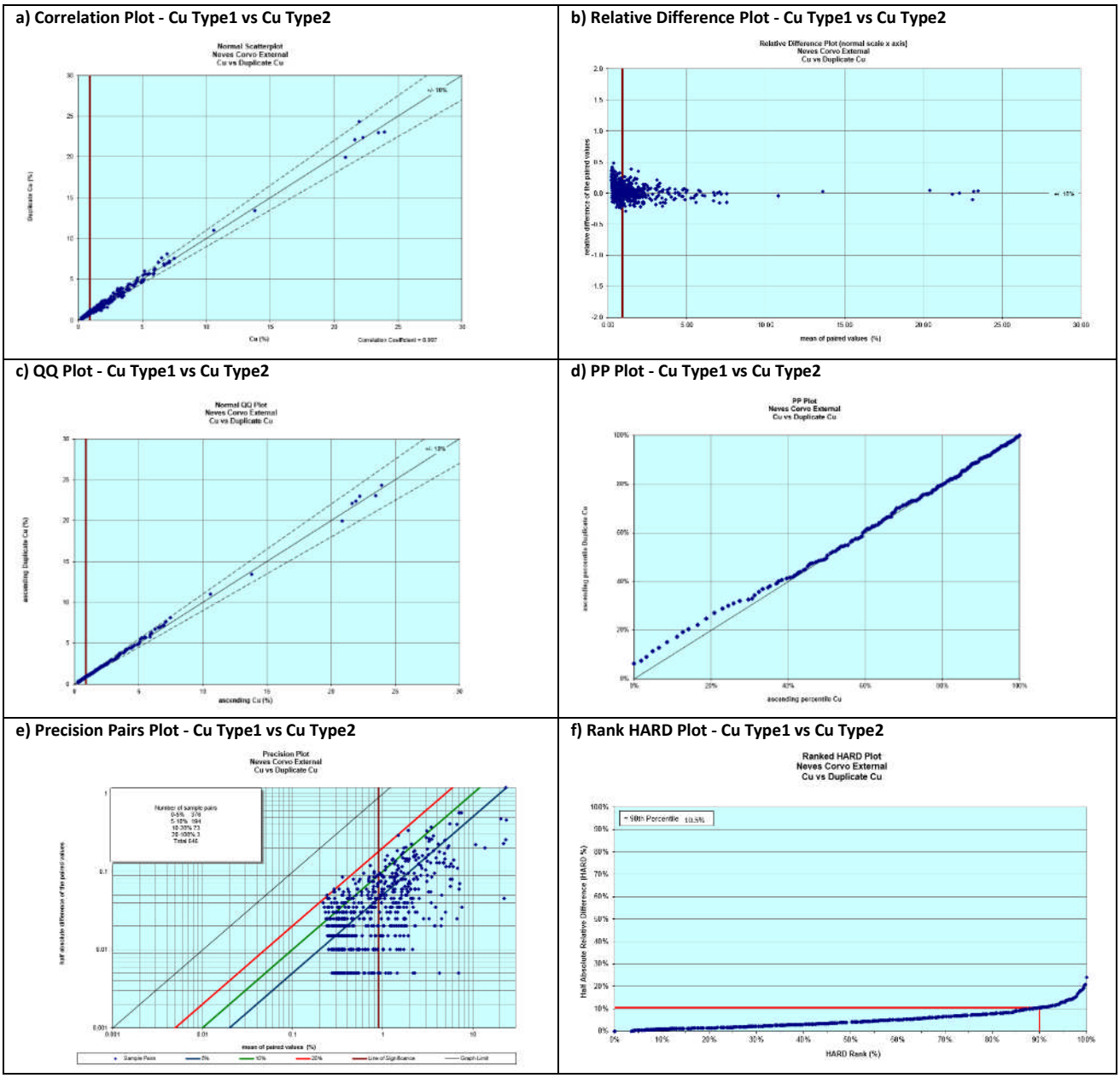


Figure 11.1: Pulp Duplicate Analysis Plots for Copper Type1 vs Type2 Samples (Neves-Corvo)

Summary plots of the primary and duplicate analysis for zinc from 646 samples undertaken at the Neves-Corvo laboratory are shown in Figure 11.2.

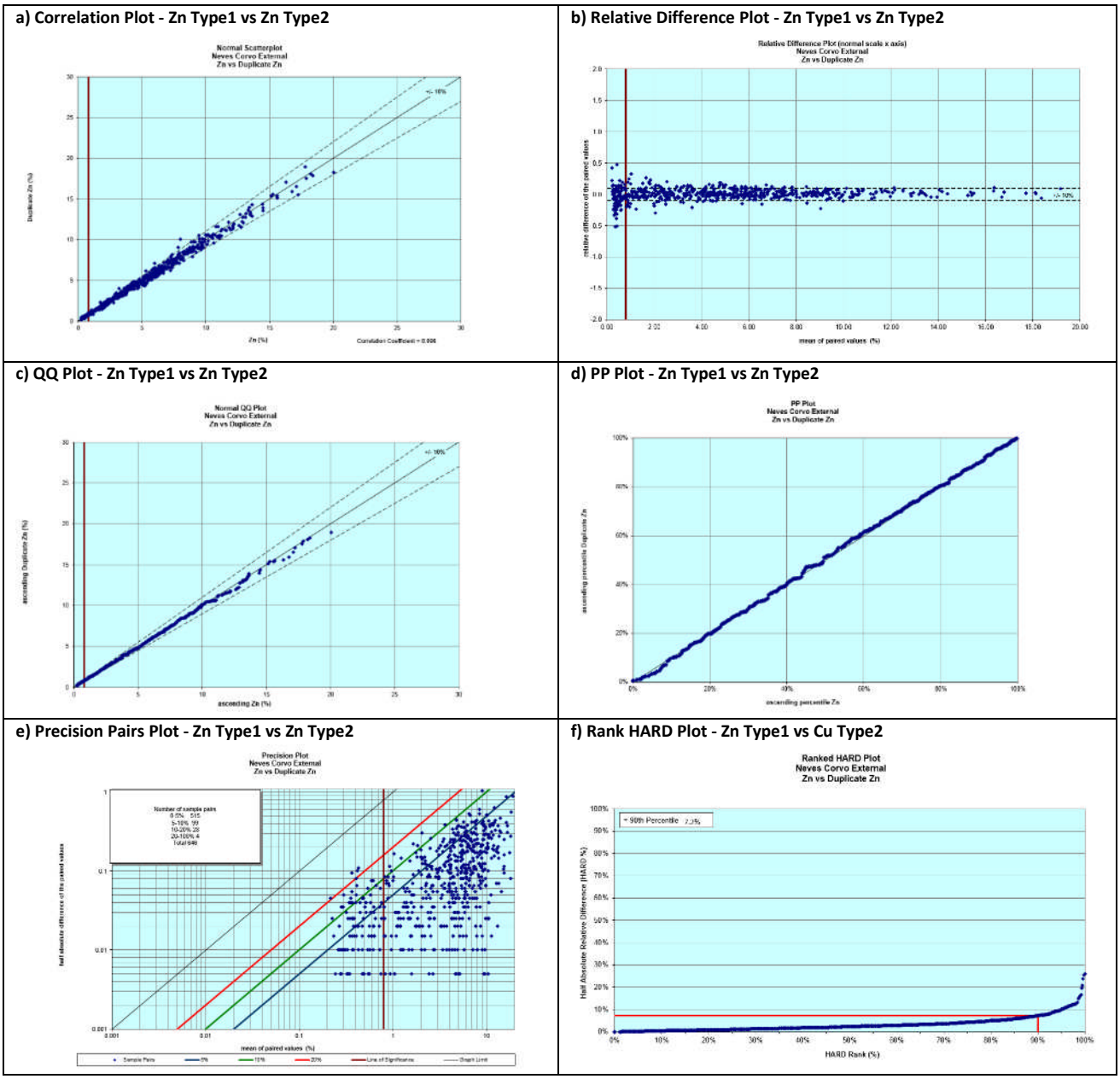


Figure 11.2: Pulp Duplicate Analysis Plots for Zinc Type1 vs Type2 Samples (Neves-Corvo)

11.7.1.2 Blanks (Type 10)

A greywacke rock selected from non-mineralised core was used as blank material to monitor contamination in the sample preparation and analysis. Summary plots of the blank analysis for copper and zinc during analysis of 885 drill hole samples and 417 face samples at the Neves-Corvo laboratory are shown in Figure 11.3. The results indicate that the incidents of contamination are likely to be low, although the blank material used is not considered to be totally barren.

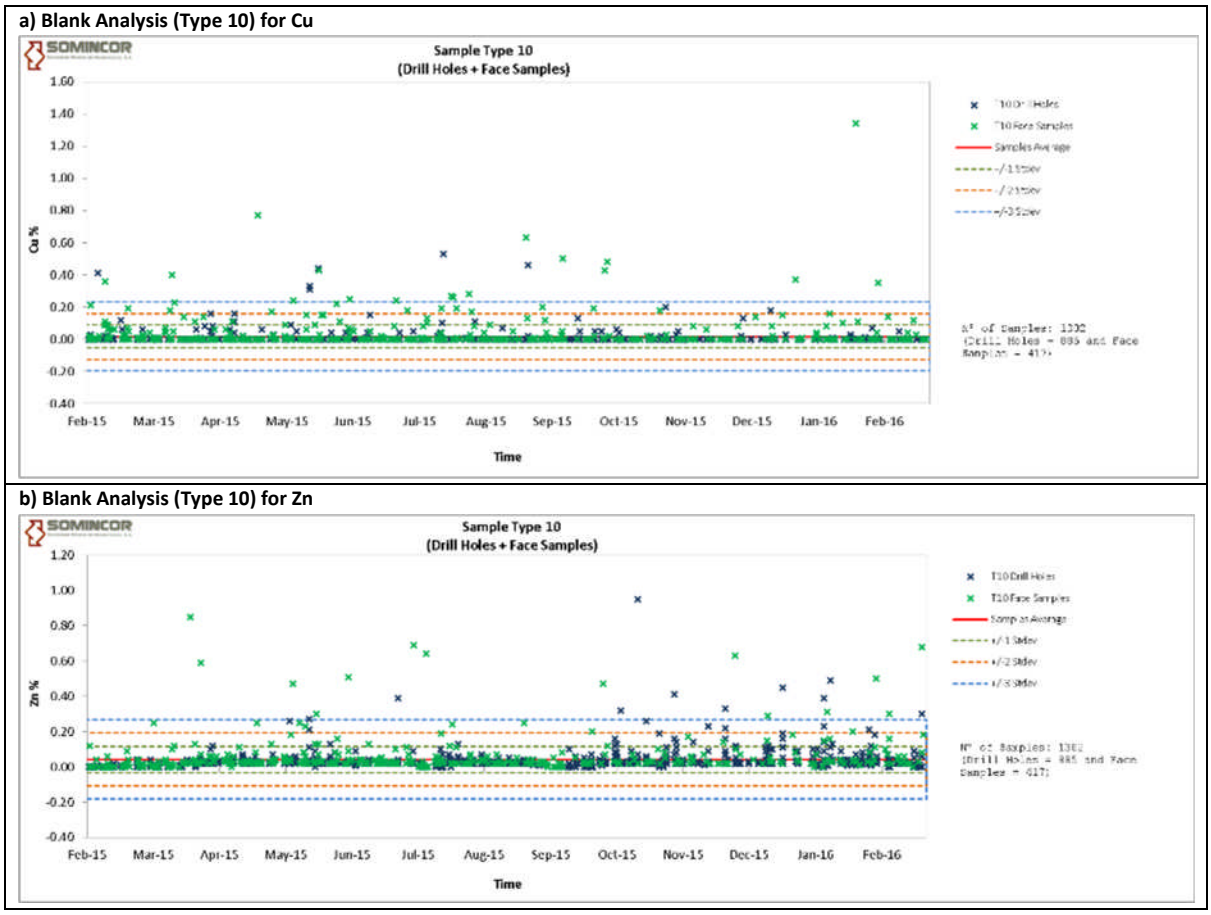
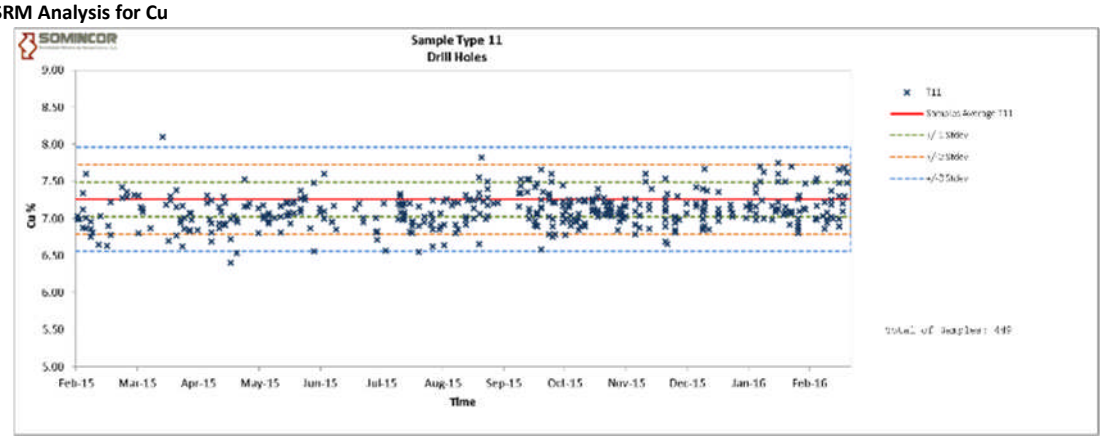


Figure 11.3: Blank Sample Analysis (Type10) for Copper and Zinc (Neves-Corvo)

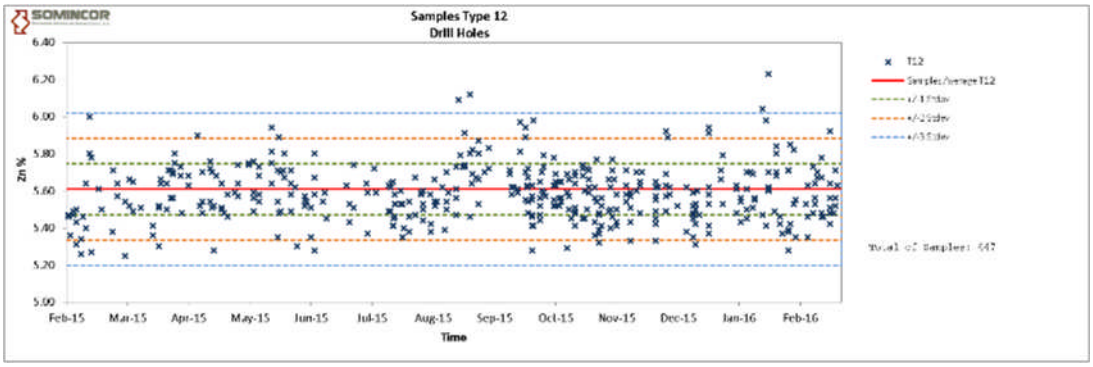
11.7.1.3 Standard Reference Material (Type 11)

Two standard reference materials ("SRM's") that were prepared in-house from pulp reject material are used. Although these SRM's are not considered to be of the same quality as commercially prepared SRM's their performance indicates that a reasonable level of accuracy has been attained in the analysis, as can be seen in Figure 11.4.

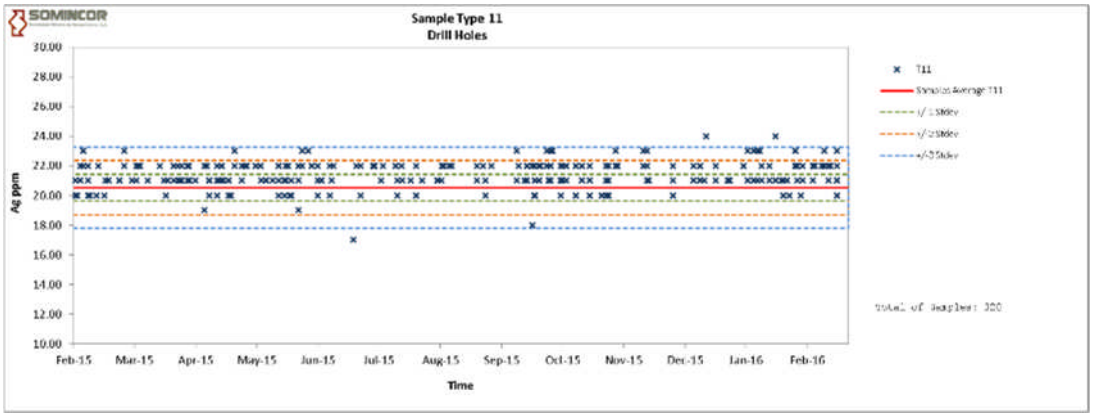
a) SRM Analysis for Cu



b) SRM Analysis for Zn



c) SRM Analysis for Ag (Cu SRM)



d) SRM Analysis for Pb (Zn SRM)

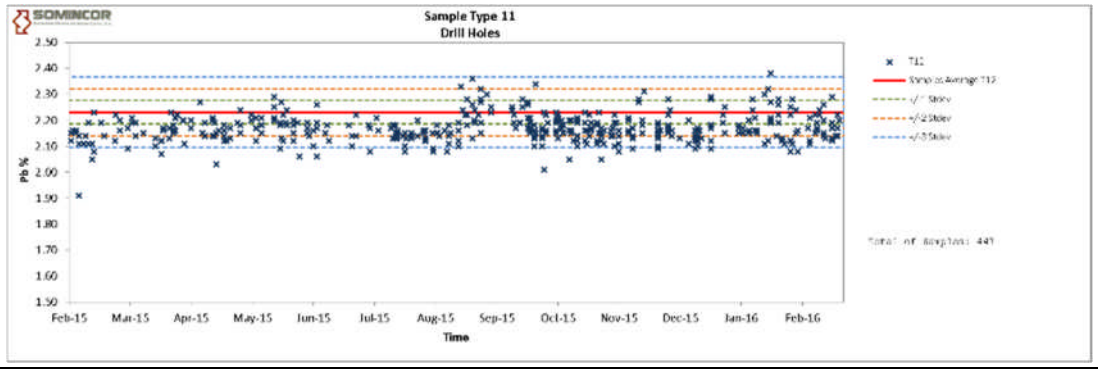


Figure 11.4: SRM Sample Analysis for Copper, Zinc, Silver and Lead (Neves-Corvo)

11.7.1.4 External Duplicate Analysis

External duplicate analysis was not undertaken by SOMINCOR in 2015/2016.

11.7.1.5 XRF vs AA/ICP Analysis

An analytical bias is known to exist whereby assay results derived by XRF analysis understate assay results derived by other assay methods such as electro-gravitmetric methods, AA or ICP. This assay bias varies from year to year but is generally around 4%. The sample bias is continually monitored by the Neves-Corvo laboratory, but no correction factor is applied to the XRF results. Summary QQ plots showing Copper and Zinc analysed by both XRF and AA are shown in Figure 11.5 and highlight the general trend towards higher grades from AA analysis compared to XRF.

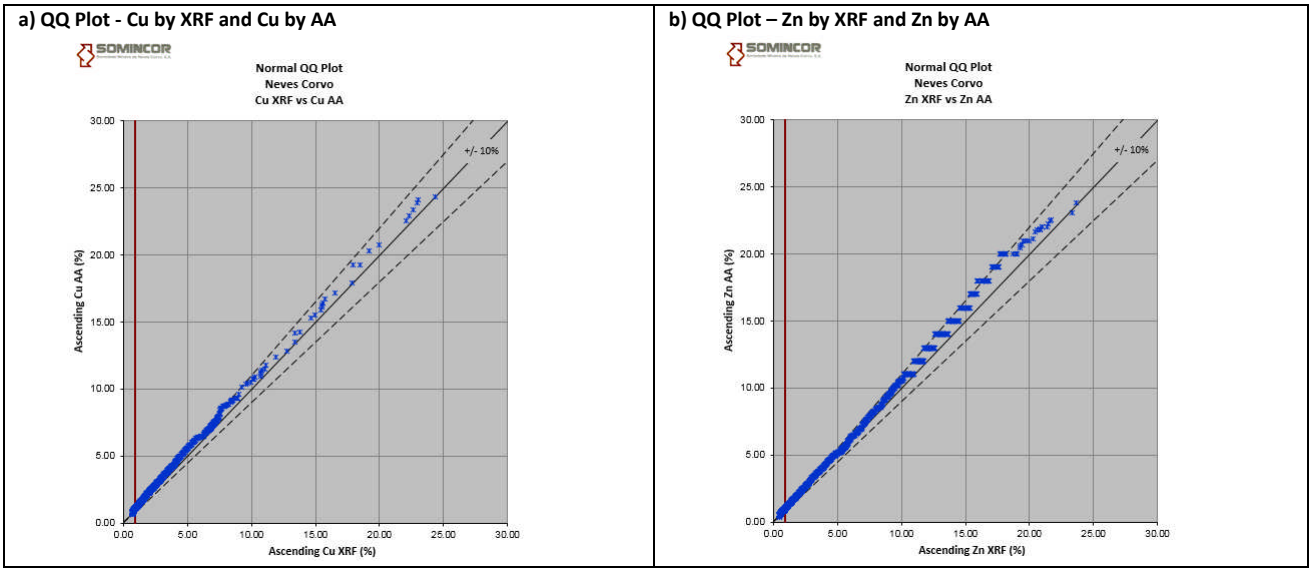


Figure 11.5: QQ Plots showing Comparison of Cu and Zn assays by XRF and AA analysis

To prevent any bias in the database, assay results based on the XRF analysis for Cu, Pb, Zn, S, Fe, As, Sn, Sb, Bi, Se and In are used for the purposes of Mineral Resource estimation for the deposits of Neves, Corvo, Graça, Zambujal, Lombador and Monte Branco. The use of the wet chemical and AA techniques are being continued to provide verification of the XRF results. WAI supports this approach.

11.7.2 Semblana Exploration Drill Samples (2010-2013)

A summary of the QAQC performance of samples analysed at ALS, Vancouver using the Semblana exploration drill sample data from 2010 to 2013 is given in the sections below. Sample insertions for control samples (blanks and standards) were 1 control sample in 5 samples analysed (20%).

11.7.2.1 Duplicates (Type 2)

Duplicate analysis of the ALS assay results was undertaken at the Neves-Corvo laboratory using the returned coarse reject material. The following procedures were used in the duplicate analysis at Neves-Corvo:

- Selection of 5% of the returned coarse grained rejects, each batch was represented.
- Selection of coarse grained rejects based on:
  - Grades near the cut-off (0.7-1% Cu);
  - Average grade (2-3% Cu); and
  - Grade below the cut-off (<0.7% Cu).
- All selected coarse grained rejects were homogenised with a riffle splitter,
- 1 in each 5 samples (20%) were control samples (blanks and standards);
- Blanks were comprised of pulverised barren quartz material (not greywacke core); and
- Final sample weight provided for analysis was 150g.

A summary of the duplicate analysis of the Semblana samples is shown in Figure 11.6.

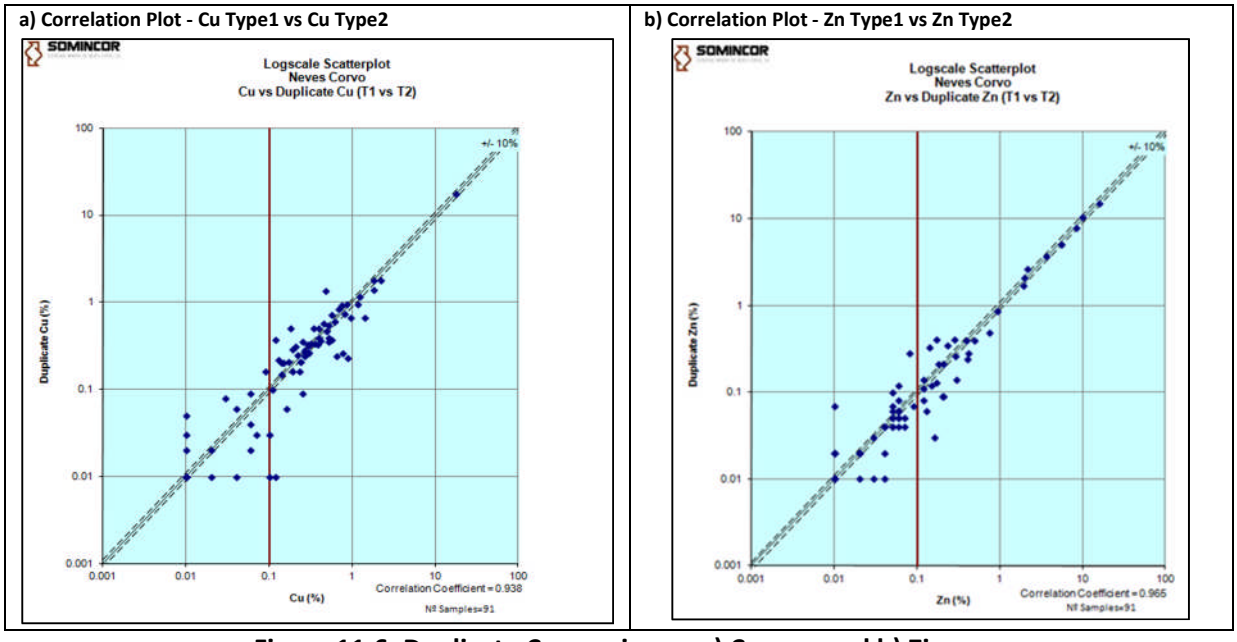


Figure 11.6: Duplicate Comparison – a) Copper and b) Zinc

11.7.2.2 Blanks (Type 10)

Greywacke rock (100g sample) selected from non-mineralised core was used as blank material to monitor contamination in the sample preparation and analysis by ALS. The results for copper, zinc and lead during the analysis by ALS is shown in Figure 11.7. Again, the results indicate that the incidents of contamination are likely to be low, although the blank material used is again not considered to be totally barren.

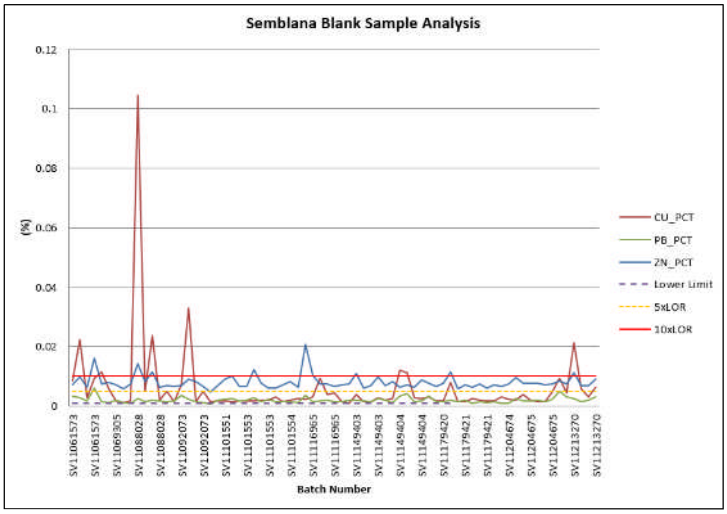


Figure 11.7: Blank Sample Analysis (Type10) for Copper, Zinc and Lead (ALS)

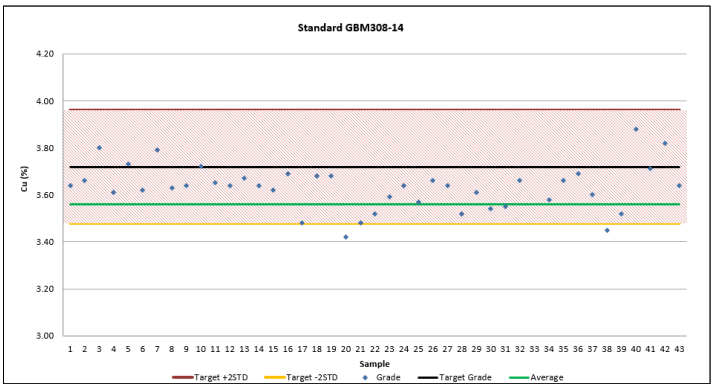
11.7.2.3 Standard Reference Material (Type 11)

Two commercial SRM's were used during the analysis of the Semblana exploration samples and were analysed by ALS. The SRM's comprised base metal reference material produced by Geostats Pty Ltd. A summary of the SRM's used is shown in Table 11.1 and summary plots of the SRM analysis by ALS is shown in Figure 11.8. WAI considers that no significant issues are identified in the SRM analysis.

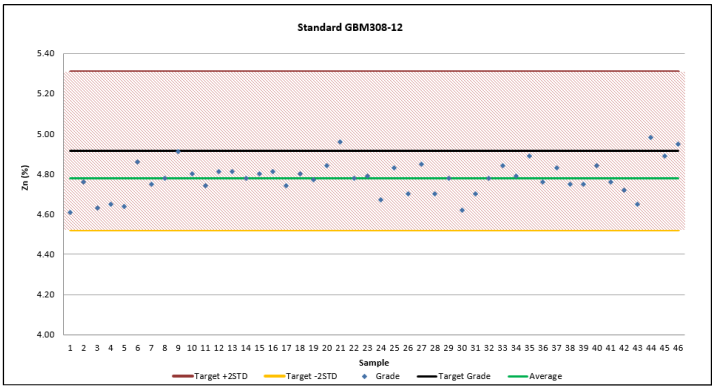
Table 11.1: Summary of Standard Reference Material used for Semblana Analysis

Supplier	Standard	Grade Cu (%)	Cu Standard Deviation	Grade Zn (ppm)	Zn Standard Deviation	Grade Pb (ppm)	Pb Standard Deviation	Grade Ag (ppm)	Ag Standard Deviation
Geostats	GBM308-12	0.516	0.017	4.914	0.198	2.145	0.097	43.0	2.4
Geostats	GBM308-14	3.719	0.122	1.903	0.084	0.651	0.023	40.20	2.6

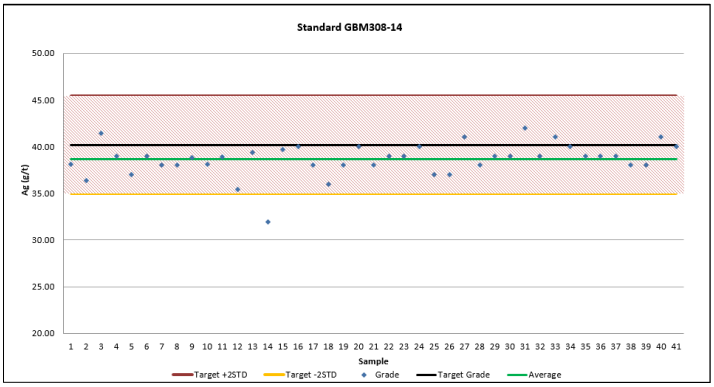
a) SRM Analysis for Cu (GBM308-14)



b) SRM Analysis for Zn (GBM308-12)



c) SRM Analysis for Ag (GBM308-14)



d) SRM Analysis Pb (GBM308-12)

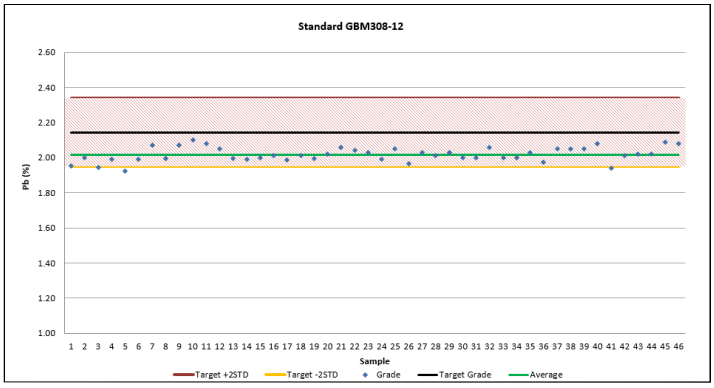


Figure 11.8: SRM Sample Analysis for Copper, Zinc, Silver and Lead (ALS)

11.7.3 Adequacy of Procedures

Only blank samples are submitted for analysis by the SOMINCOR Geological Department as a control for face samples. WAI do not consider the absence of duplicates or SRM's in the face sample analysis represents a risk to the Mineral Resource estimate as face samples are taken from production headings and are supported by reconciliation data. In addition, external duplicate analysis is not always undertaken as part of the geological sample stream. Again, WAI do not consider that this represents a risk to the Mineral Resource estimate as the Neves-Corvo laboratory routinely undertakes its own external duplicate analysis to maintain ISO accreditation.

WAI considers that the sample preparation, security and analytical procedures for samples sent to both the Neves-Corvo and ALS Minerals laboratories have been conducted in accordance with acceptable industry standards and the assay results generated following these procedures are suitable for use in Mineral Resource estimation.

12 DATA VERIFICATION

Data entry, validation, storage and database maintenance is carried out by SOMINCOR staff using established procedures. Data used for Mineral Resource estimation included both mine data (face sampling) and drilling results (exploration and infill). All data are stored in a central SQL database located at the Neves-Corvo mine offices. The SQL database has a series of automated validation tools during import and export for error identification.

Cut-off dates for the databases used in the Mineral Resource estimate are shown in Table 12.1. Data collection is not on-going at Monte Branco or Semblana deposits therefore the databases for these deposits are still current as of June 30, 2016. The databases were received by WAI in Microsoft® Excel format for review.

Table 12.1: Database Cut-Off Dates by Deposit

Deposit	Face Samples Cut-Off Date	Drill Hole Samples Cut-Off Date
Corvo	January 22, 2016	January 13, 2016
Graça	January 20, 2016	January 28, 2016
Lombador	January 31, 2016	February 23, 2016
Neves	February 04, 2016	February 02, 2016
Zambujal	February 09, 2016	February 11, 2016
Monte Branco	N/A	June 30, 2016
Semblana	N/A	June 30, 2016

A summary of the data verification procedures carried out by WAI during the review are detailed below:

- Review of the geological and geographical setting of the Neves-Corvo and Semblana deposits;
- Review of the extent of the exploration work completed to date;
- Review of the sampling and sample preparation procedures;
- Inspection of the core logging, sampling and storage facilities;
- Inspection of selected drill core to assess the nature of the mineralisation and to confirm geological descriptions;
- Inspection of geology and mineralisation in underground workings at Neves, Graça and Lombador deposits;
- Verification that collar coordinates coincide with underground workings or topographical surfaces;
- Verification that downhole survey azimuth and inclination values display consistency;
- Evaluation of minimum and maximum grade values;
- Evaluation of minimum and maximum sample lengths;
- Assessing for inconsistencies in spelling or coding (typographic and case sensitive errors); and
- Ensuring full data entry and that a specific data type (collar, survey, lithology and assay) is not missing and assessing for sample gaps or overlaps.

The majority of the verification procedures carried out by WAI on the electronic databases confirmed the integrity of the data in these databases used for the purposes of deriving the Mineral Resource estimate presented in this document. Minor validation errors were discovered in terms of overlapping intervals, however these are not significant.

WAI has not undertaken any independent check analysis of any drill core and therefore cannot independently verify the data. However, WAI can independently state that the current database provided and used in the Mineral Resource estimate appears to be complete and is supported by the available information.

WAI have reviewed the current chain of custody procedures in place and conclude that there are no issues in terms of security of samples.

13 MINERAL PROCESSING AND METALLURGICAL TESTING

13.1 Introduction

The SOMINCOR process plants use conventional flowsheets consisting of crushing, grinding and flotation and the company is a significant producer of both copper and zinc concentrates. Operations are split between two processing plants, namely the Copper Plant and the Zinc Plant.

The Copper Plant began ore processing in 1988 and has undergone numerous stages of expansion. The plant now treats copper ore through two grinding lines with separate rougher flotation and common cleaning flotation circuits.

The current Zinc Plant was upgraded in 2010 and now has a zinc ore treatment design capacity of 1.1Mtpa. The ore is treated using a sequential copper/lead and zinc flowsheet.

Various testwork programs and studies were conducted prior to and during the ZEP Feasibility Study including:

- Historical and new (2014/ 2015) mineralogical testwork programs;
- Historical and new (2014/ 2015) comminution testwork;
- Evaluations of previous flotation testwork programmes;
- The 2014/2015 Flotation testwork program; and
- Sedimentation testwork for thickener sizing.

The 2014/ 2015 mineralogical, comminution and flotation testwork programs were performed on new composite samples obtained from available drill cores. Mineralogical and flotation testwork were performed on samples ZEP01F to ZEP09F and comminution testwork was performed on samples ZEP10C to ZEP21C.

The comminution samples – ZEP10C to ZEP21C - were submitted to WAI who performed SAG Mill comminution tests, Bond rod mill work index (RWi) tests, Bond ball mill work index (BWi) tests, and abrasion index (Ai) tests on the 12 drill core samples submitted.

In addition, mineralogical examinations on nine drill core flotation samples – ZEP01F to ZEP09F - were performed by taking QEMSCAN measurements. The information was collected and analysed to understand the nature of the future ores that would be treated in the ZEP circuit, and inform selection of key process design criteria such as target flotation feed and regrind sizes, and understand the potential variations in recoveries and concentrate qualities.

The sample location plan is shown in Figure 13.1.

Figure 13.1: Locations of Sample Composites in Lombador

For flotation testing, rougher kinetics testing on the nine drill core flotation samples - ZEP01F to ZEP09F - along with three plant surveys, were performed and data was collected to model the flotation circuit using JKSimFloat.

In addition, programmes of locked cycle testing were undertaken at both SOMINCOR and WAI laboratories.

13.2 Mineralogy

During the Feasibility Study QEMSCAN measurements were performed on the nine drill core samples ZEP01F to ZEP09F in April 2015.

QEMSCAN mineralogy was also conducted by Helford Geoscience LLP on flotation feed and tailing samples from the core testwork program.

The results are summarised as follows:

- A high degree of sphalerite liberation in the minus 16 µm fraction, decreasing significantly in the 16 µm to 63 µm fraction and very poor liberation in the plus 63 µm fraction. There is evidence of a minor bimodal grain size distribution in ZEP01F, ZEP02F

and ZEP03F feed samples resulting in slightly poorer liberation in the minus 16 µm fraction;

- A moderate to high degree of galena liberation in the minus 8 µm fraction for feed samples ZEP03F, ZEP05F, ZEP07F and ZEP08F, with a moderate degree of liberation in the other test samples. Liberation decreases significantly in all size fractions above 8 µm. There is evidence of a significant bimodal grain size distribution in the ZEP01F feed samples resulting in significantly poorer liberation in the minus 8 µm fraction; and
- A moderate degree of chalcopyrite liberation in the minus 8 µm fraction, increasing to high in the 8 µm to 16 µm in the ZEP01F, ZEP02F, ZEP04F and ZEP07F samples, indicating significant bimodal grain size distribution in these samples. Above 16 µm chalcopyrite liberation decreases significantly.

A comparison of recovery versus estimated liberation from flotation test results indicated the following:

- The ZEP03F and ZEP07F sphalerite recoveries were significantly below that indicated by liberation. Other tests produced recoveries slightly less than that indicated by liberation;
- The ZEP05F, ZEP07F and ZEP08F produced lead recoveries in close alignment with liberation recovery estimates. Reported liberation data for ZEP09F liberation produced data that is not consistent with other and historical data and is considered inaccurate. Other flotation tests produced galena recoveries that had moderate to major discounts to that indicated by liberation;
- Only ZEP01F produced a chalcopyrite recovery in alignment with liberation data. All other flotation tests produced chalcopyrite recoveries significantly lower than that indicated by liberation;
- Increased losses of liberated sub 8 µm sphalerite is often related to increased losses of liberated sub 8 µm galena. This may indicate associated surface passivation between the two minerals; and
- Tentative evidence suggests that increased iron oxide content in feed samples results in decreased sphalerite recovery.

Average grain sizes indicate the following nominal concentrate regrind requirements:

- Copper regrind – 13.1µm;
- Lead regrind – 9.7µm;
- Zinc regrind – 16.2µm; and
- Zinc RZ regrind – 10.8µm.

There was evidence of a minor bimodal sphalerite grain size distribution in ZEP01F, ZEP02F and ZEP03F feed samples resulting in slightly poorer liberation in the minus 16 µm fraction. There was also evidence of a significant bimodal galena grain size distribution in the ZEP01F feed samples resulting in

significantly poorer liberation in the minus 8 µm fraction. ZEP01F, ZEP02F, ZEP04F and ZEP07F samples all indicate significant bimodal grain size distribution. More regrind testwork at various P80 targets was recommended to better understand regrind sizes and determine optimum sizes and improve the overall metallurgy of each circuit.

13.3 Comminution Testing

During 2014 WAI was commissioned by SOMINCOR to perform SAG Mill Comminution (SMC) tests, Bond rod mill work index (RMWi) tests, Bond ball mill work index (BMWi) tests and abrasion index (Ai) tests on the 12 submitted drill core samples - ZEP10C to ZEP21C.

The SMC results for the JK Drop-Weight index (DWi) range from 7.39kWh/m^3 (ZEP19C) to 11.34kWh/m^3 (ZEP15C), with 72% of world ores in the JKTech database being softer than ZEP19C and 96%
of world ores tested being softer than ZEP15C.

Bond Ball (BMWi) and Rod (RMWi) Mill Work Indices were determined for the ZEP10C to ZEP21C samples and compared to the previous work performed on the various ore-body samples. The BMWi Indices ranged from 11.6kWh/t (ZEP16C) to 13.9kWh/t (ZEP11C) at the 106µm closing screen size. The results classify the material as being of “medium hardness” relative to world database ores. While the RMWi Indices ranged from 11.5kWh/t, classifying this material, relative to world ores, as being a “medium” ore-type, to 15.4kWh/t classifying this material as being a “hard” ore type.

Abrasion testing was also performed on the drill core samples. The average bond abrasion index value is 0.50g and the 80th percentile value is 0.67g. Sample ZEP11C had the highest bond abrasion index value of 0.93g. This sample represents the MZP head grade category of the LP2 Upper Group. The ZEP11C drill core represents a small fraction of the ore body so it will not have a major impact on the overall wear rate of steel. Other MZP drill core samples (ZEP12C, ZEP16C and ZEP18C) resulted in an average Bond abrasion index value of 0.39g signifying these three samples are slightly abrasive versus the 80th percentile values being very abrasive.

13.4 Flotation Testing

13.4.1 General

The flotation modelling and simulation tool JKSimFloat was utilized for the flotation circuit analysis and design. Flotation tests were conducted on core samples from future production areas for model calibration. This involved sampling surveys of the process combined with laboratory kinetics flotation testing to develop the scale-up models and the floatability component models. Simulations were performed to determine the required flotation cell sizing and resulting metallurgical performance with the expected future ore supply.

13.4.2 SOMINCOR Tests

From August, 2010 to March, 2011 the Neves-Corvo site laboratory conducted a series of 10 locked cycle tests on Lombador MZ ore. The campaign was conducted to confirm WAI flotation tests and further define metallurgical performance.

The tests were conducted to produce a "bulk" copper/zinc concentrate with one cleaner stage, and a clean zinc concentrate with either three, or four cleaning stages. The flotation feed grind for all tests was 80% passing 50µm, with a copper regrind P_{80} of 6µm and a zinc regrind P_{80} of 15µm. Reagent additions were either the SOMINCOR standard conditions, or those used in WAI tests. In all tests a one minute aeration stage was used prior to copper roughing.

The copper concentrate was characterised by low concentrate grades, varying from 11.0% Cu to 17.1% Cu, with variable levels of lead (0.6% Pb to 11.0% Pb), dependent on the lead feed grade, and high zinc content (5.2% Zn to 11.5% Zn). Copper recovery to copper concentrate was high, varying from 27.0% to 51.7%. The high copper recovery and high zinc grade in concentrate may be a function of the aeration stage.

The zinc concentrate grade was variable both in terms of zinc grade and copper and lead grade. Zinc grade varied from 44.9% Zn to 56.6% Zn, with copper varying between 0.9% Cu and 1.4% Cu and lead varying from 0.3% Pb to 5.3% Pb. Zinc recoveries were generally high, varying from 78.3% to 86.1%, although LC2 was low at 56.8%. It was noted in the report that zinc recoveries were expected to decrease as concentrate grade were improved.

13.4.3 Wardell Armstrong International

Reagent optimisation, rougher kinetic, concentrate regrind, open circuit cleaning and locked cycle tests were conducted by WAI over the period 2010 to 2014.

MZ samples typically gave good metallurgical response for zinc with locked cycle tests achieving zinc recoveries between 70.2% and 88.2% and zinc concentrate grades between 49.4% Zn and 55.2% Zn. Copper response though was generally poor, with either low concentrate grades or low recoveries achieved.

In many cases the MZP sample tests failed to demonstrate that separate, saleable concentrates of copper and lead could be produced from the MZP ore, but zinc concentrates from locked cycles achieved zinc recoveries between 65.7% and 84.6% and zinc concentrate grades between 44.2% Zn and 58.6% Zn. A number of the MZP results were achieved with very fine primary grind sizes (P80 30 µm).

14 MINERAL RESOURCE ESTIMATES

14.1 Introduction

The Mineral Resource estimates discussed in this Technical Report relate to Neves, Corvo, Graça, Zambujal, Lombador and Monte Branco deposits within the Neves-Corvo Mining Area and Semblana deposit within the Semblana Mining Area. The following sections describe in detail the methodology used to produce these Mineral Resource estimates. All Mineral Resource estimates were produced by SOMINCOR and subsequently reviewed by WAI.

14.2 Mineral Resource Estimate Data

Data used by SOMINCOR for Mineral Resource estimation included both mine data (face sampling) and drilling results (exploration and infill). The data used was based on the cut-off dates detailed in Section 12. Databases were received by WAI in Microsoft® Excel format for review.

Database import and preparation, compositing, block modelling and grade estimation were undertaken by SOMINCOR staff using Vulcan® software. Wireframe modelling of mineralised envelopes was undertaken using Leapfrog® software. Statistical and variographic analysis were undertaken using Supervisor® software. Data used in the Mineral Resource estimates were reviewed by WAI using Datamine® and Supervisor® software.

The database was reviewed by WAI and included the following checks. An evaluation of minimum and maximum grade values and sample lengths, assessing for inconsistencies in spelling or coding (typographic or case sensitive errors), ensuring full data entry and that a specific data type (collar, survey, lithology and assay) is not missing, assessing for sample gaps and overlaps and a review of assay detection limits and identification of problematic assay records. A spatial on-screen review of the grade and lithology distributions of drill holes and face samples was undertaken to identify any exhibiting data reliability issues. Overall the database was considered by WAI to be robust with no significant errors identified. A check on collar locations relative to underground workings and topography found only minor errors.

Problematic assay values were reviewed and updated by SOMINCOR prior to resource modelling. Assay values recorded as exactly zero were replaced by half detection limit. Assay values below the limit of detection were replaced with the detection limit value.

A summary of the drill hole and face sample database used by SOMINCOR for the purposes of Mineral Resource estimation are shown in Table 14.1. The database for Ag comprises approximately 20% of the total Cu, Zn or Pb assays as historically Ag was less comprehensively assayed. Areas of historical drilling and face sampling generally coincide with areas in which the resource has subsequently been depleted by mining operations. All recent drilling includes more comprehensive assaying for Ag.

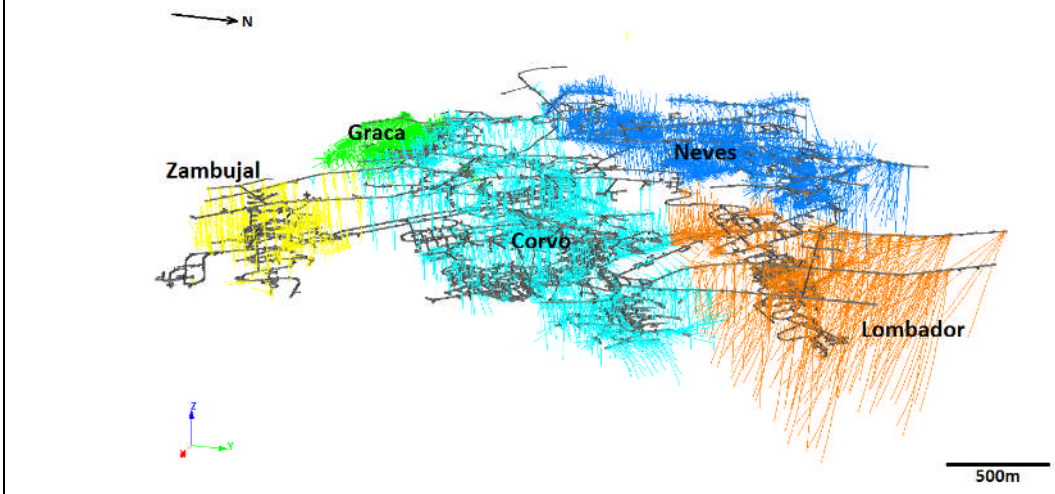
WAI considers the drill holes and face samples included in the Mineral Resource estimate to be sufficiently supported by QAQC and/or production reconciliation data.

Table 14.1: Drill Hole and Face Sample Data used for Mineral Resource Estimation

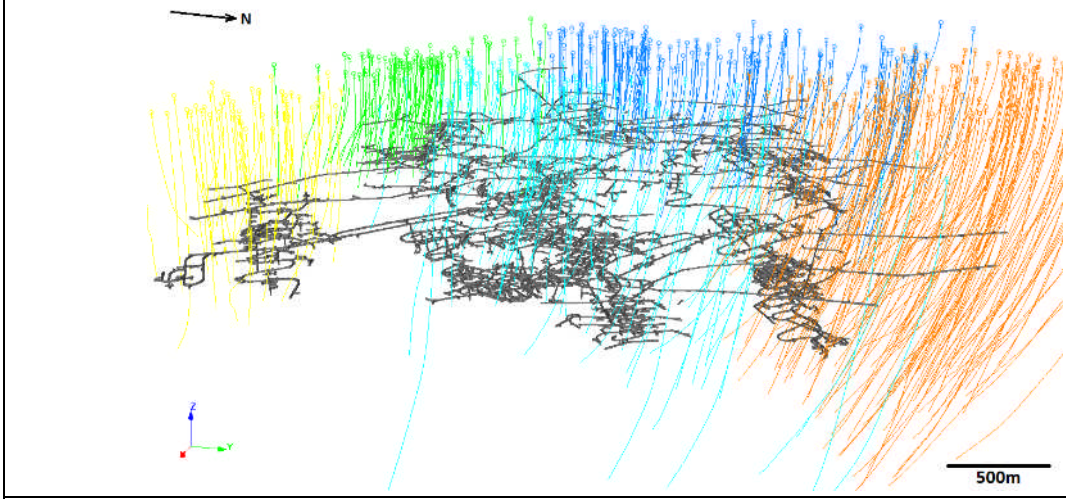
Deposit	Type	Number of Drill Holes / Face Samples	Number of Cu Assays	Number of Zn Assays	Number of Pb Assays	Number of Ag Assays
Neves	Surface Drill Holes	152	6,627	6,627	6,627	6,627
	Underground Drill Holes	2,087	101,478	101,478	101,478	28,842
	Face Samples	92,903	92,903	92,903	92,903	6,152
	Sub Total	**95,142**	**201,008**	**201,008**	**201,008**	**41,621**
Corvo	Surface Drill Holes	99	4,073	4,073	4,073	2,340
	Underground Drill Holes	1,677	62,496	62,496	62,496	17,421
	Face Samples	131,167	131,167	131,167	131,167	11,807
	Sub Total	**132,943**	**197,736**	**197,736**	**197,736**	**31,568**
Graça	Surface Drill Holes	80	2,108	2,108	2,108	1,644
	Underground Drill Holes	744	18,078	18,078	18,078	5,403
	Face Samples	65,858	65,858	65,858	65,858	7,017
	Sub Total	**66,682**	**86,044**	**86,044**	**86,044**	**14,064**
Zambujal	Surface Drill Holes	43	2,669	2,669	2,669	693
	Underground Drill Holes	478	28,849	28,849	28,849	6,957
	Face Samples	18,483	18,483	18,483	18,483	633
	Sub Total	**19,004**	**50,001**	**50,001**	**50,001**	**8,283**
Lombador	Surface Drill Holes	161	15,212	15,212	15,212	5,199
	Underground Drill Holes	513	40,911	40,911	40,911	8,729
	Face Samples	12,459	12,459	12,459	12,459	1,398
	Sub Total	**13,133**	**68,582**	**68,582**	**68,582**	**15,326**
Monte Branco	Surface Drill Holes	126	4,334	4,334	4,334	3,151
	Underground Drill Holes	-	-	-	-	-
	Face Samples	-	-	-	-	-
	Sub Total	**126**	**4,334**	**4,334**	**4,334**	**3,151**
Semblana	Surface Drill Holes	151	5,118	5,118	5,118	3,835
	Underground Drill Holes	-	-	-	-	-
	Face Samples	-	-	-	-	-
	Sub Total	**151**	**5,118**	**5,118**	**5,118**	**3,835**
Grand Total		**327,181**	**612,823**	**612,823**	**612,823**	**117,848**

Isometric views showing the drill holes and face samples at Neves-Corvo (not including Monte Branco or Semblana) are shown in Figure 14.1 along with underground development.

a) Underground drill holes at Neves-Corvo Mine



b) Surface drill holes at Neves-Corvo Mine



c) Face Samples at Neves-Corvo Mine

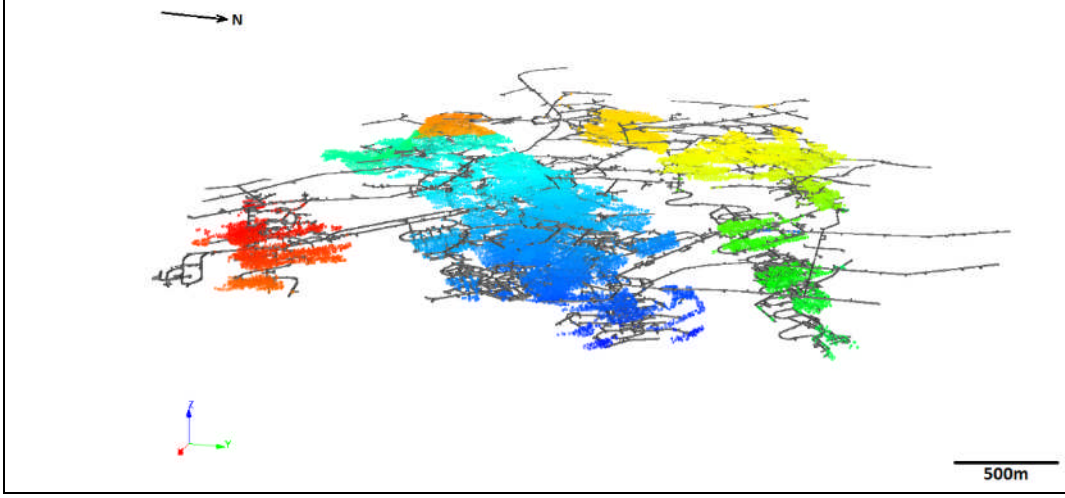


Figure 14.1: Location of a) Underground Drill Holes b) Surface Drill Holes and c) Face Samples at Neves-Corvo

14.3 Geological Interpretation and Domaining

The Neves-Corvo deposits are classified as volcanogenic massive sulphide ("VMS") and typically occur as lenses of polymetallic (Cu, Zn, Sn, Pb) massive sulphides and stockworks that formed at or near the seafloor in submarine volcanic environments. The Neves-Corvo deposits are located near the top of a dominantly volcanic sequence of the Volcanic Siliceous Complex ("VSC") of Late Devonian-Early Carboniferous age, 360-342Ma which consists of two chemically distinct intervals of felsic volcanics separated by shale units, with a discontinuous black shale horizon immediately below the massive sulphide lenses. The thickness of the VSC in the Neves-Corvo area is approximately 300m. Overlying the mineralisation there is a repetition of volcanic-sedimentary and flysch units, approximately 350m thick. The whole assemblage has been folded into a gentle anticline orientated northwest-southeast, which plunges to the southeast, resulting in orebodies distributed on both limbs of the fold. All the deposits have been affected by both sub-vertical and low angle thrust faults, which has resulted in repetition and thickening of the massive sulphides, in some areas up to 30m thick.

Seven sulphide deposits have been defined and comprise Neves, Corvo, Graça, Zambujal, Lombador, Monte Branco and Semblana deposits. The deposits are at various stages of exploration. Neves, Corvo, Graça, Zambujal and Lombador deposits are mature deposits with extensive exploration drilling and mining operations. Semblana and Monte Branco deposits are relatively new discoveries and are based on surface exploration drilling only.

The geological interpretation used by the SOMINCOR Geological Department in the Mineral Resource estimate is guided by drill hole, face sample and geological mapping data where available. Lithological and grade data are combined for domain purposes. The main mineralisation types (and their cut-off grades) used by SOMINCOR are shown in Table 14.2. Rubané mineralisation is now predominantly depleted and is no longer included for modelling. WAI considers that the lithological domains identified by SOMINCOR are based on extensive geological knowledge and are representative of the geological units present at the deposits.

Table 14.2: Neves-Corvo Mineralisation Types

Mineralisation Type	Description	Geological Modelling Cut-Off Grade	Major Ore Mineral
MC	Massive Copper	Cu >= 0.7%	Chalcopyrite
MT	Massive Tin	Sn >= 1%	Cassiterite
MZ	Massive Zinc	Zn >= 2%	Sphalerite
MP	Massive Lead	Pb >= 1%	Galena
FC	Stockwork Copper	Cu >= 0.7%	Chalcopyrite
FT	Stockwork Tin	Sn >= 1%	Cassiterite
FZ	Stockwork Zinc	Zn >= 2%	Sphalerite
5C (MCZ)	Massive Copper and Zinc	Cu >= 0.7% and Zn >= 3%	Chalcopyrite and Sphalerite
5Z (MZP)	Massive Zinc and Lead	Zn >= 2% and Pb >= 1%	Sphalerite and Galena
ME	Massive Pyrite	-	Barren/Low Grade
FE	Stockwork Pyrite	-	Barren/Low Grade

Lithological and grade modelling are carried out by SOMINCOR using Leapfrog® software to construct 3-dimensional wireframe solids. Prior to import into Leapfrog® the face sample and drill hole database is composited to 1m intervals based on mineralisation type and the composites coded as either -1 or 1 depending on the composite grade. Composites with a grade greater than the cut-off grade for the mineralisation type are coded as 1. Composites with a grade less than the cut-off grade for the mineralisation type are coded as -1. Wireframe solids are constructed using planes corresponding to the general strike and dip of the deposit to control the orientation of the generated wireframes. The extent of the modelled mineralisation is controlled by bounding wireframes to prevent over-extrapolation. Where available the geological mapping and structural interpretation (including faulting) are used to control the wireframe construction. The wireframe solids are then imported into Vulcan® for adjustment if required. Where the copper and zinc wireframes overlap, priority is given to the copper wireframes.

14.4 Drill Hole Data Processing

The domain wireframes for each deposit were used to select drill hole and face samples for further data processing. Where the deposits from contiguous zones, selected samples located just beyond the extent of the deposit area were allowed to be included in the estimation. Samples were identified where different structural orientations are present such as the location of different fold limbs. This included subdivisions of the Neves deposit into Neves North and Neves South, subdivision of Graça deposit into Graça SW, Graça, and Upper Corvo and subdivision of Zambujal into Zambujal NE and Zambujal SW comprising separate fold limbs. The samples were then coded by the principal domains and formed the basis of the Mineral Resource estimate.

14.5 Compositing

Historically, 1m sample intervals were used within massive sulphide mineralisation while sample intervals of up to 2m were allowed within the stockwork mineralisation. However, from 2015, 1m sample intervals have been adopted by SOMINCOR during logging and sample preparation for all mineralisation types (primarily to better reflect the variability in stockwork mineralisation). As a result, compositing is therefore undertaken using a 1m composite sample length for both massive and stockwork mineralisation. Histograms showing drill hole sample lengths for massive mineralisation (MC, 5C, MZ and 5Z) and stockwork mineralisation (FC and FZ) are shown in Figure 14.2. The massive mineralisation exhibits a major population of 1m sample lengths while the stockwork mineralisation exhibits a major population of 1m sample lengths and a minor population of 2m sample lengths. Going forward, WAI considers that use of a 1m composite length is acceptable given the variability associated with the stockwork mineralisation. De-compositing associated with the minor 2m sample length population is considered less significant.

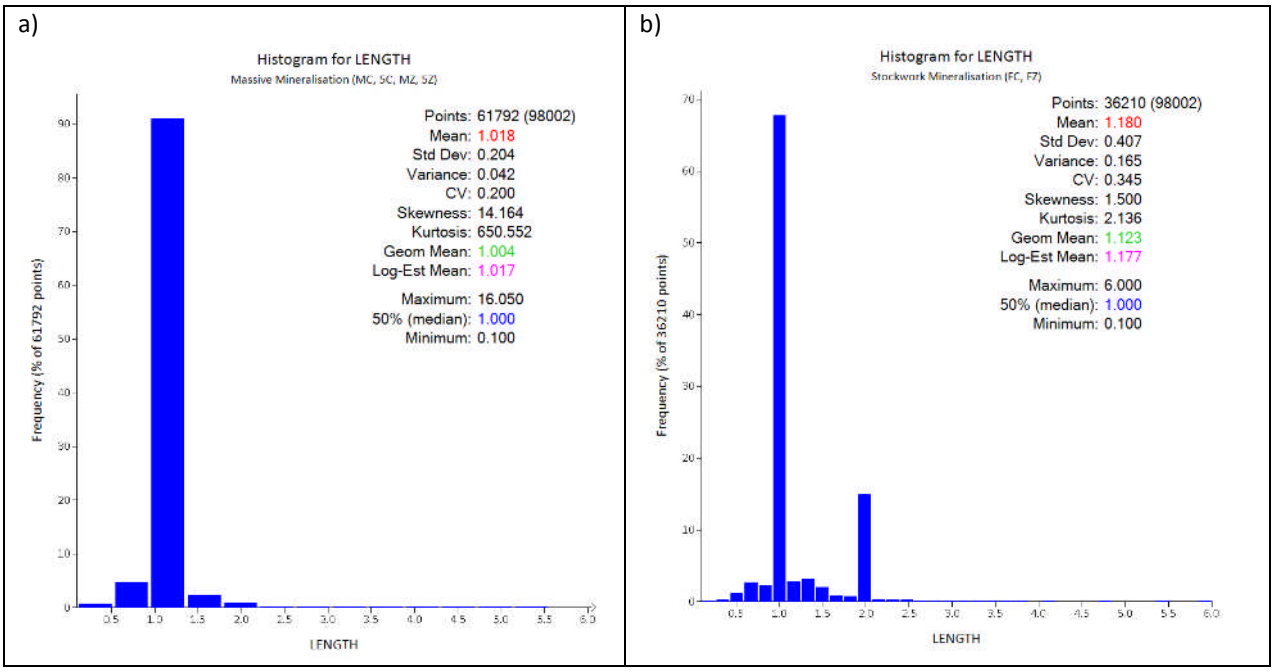


Figure 14.2: Histogram showing Sample Lengths for a) Massive Mineralisation and b) Stockwork Mineralisation

14.6 Grade Capping

Grade capping was not applied to the dataset. Instead SOMINCOR elect to apply outlier restrictions during grade estimation to limit the influence of composites with outlier values. Values higher than the designated outliers were used during the first pass of the grade estimation only and were excluded from the second and third estimation passes. A summary of the outlier values used in the grade estimation is shown in Table 14.3. Outlier values were reviewed by WAI using log probability plots for each domain. WAI considers that very few significant outlier values are present within the domains and as such is reflective of the style of mineralisation. In addition, it is noted that areas containing the highest copper and zinc grades have since been depleted by mining and therefore the influence of these grades on the Mineral Resource estimate is further reduced. WAI considers the outlier values used by SOMINCOR and the approach adopted for restricting outlier values in the grade estimation to be appropriate.

Table 14.3: Summary of Outlier Values Excluded from 2nd and 3rd Searches during Grade Estimation

Deposit	Mineralisation Type	Cu (%)	Pb (%)	Ag (ppm)	Hg (ppm)	As (ppm)	Sb (ppm)
Corvo	MC	30.00	4.70	1,150	330	44,000	30,000
	MCZ	-	4.00	1,100	450	70,000	30,000
	FC	-	4.00	500	350	65,000	27,000
	MZ	-	1.00	200	330	33,000	1,600
	MZP	-	12.00	200	390	26,000	1,500
	FZ	-	5.00	150	270	22,000	980
Neves North	MC	-	11.50	2,195	290	64,000	45,300
	MCZ	-	5.90	1,091	321	67,599	45,950
	FC	-	8.00	639	196	64,650	20,000
	MZ	-	-	175	248	22,300	2,510
	MZP	-	8.00	180	252	20,600	2,400
Neves South	MC	-	3.50	700	130	45,000	14,000
	MCZ	-	4.00	400	232	44,000	10,300
	FC	-	3.80	443	129	58,000	10,000
	MZ	-	-	186	283	36,000	1,785
	MZP	-	11.00	300	280	52,100	1,860
Zambujal	MC	29.00	7.50	300	200	36,000	34,000
	MCZ	-	4.00	480	-	90,000	45,000
	FC	15.00	1.80	150	150	40,000	10,000
	MZ	-	1.00	150	430	30,000	1,100
	MZP	-	6.50	170	480	24,000	1,150
	FZ	-	2.00	100	160	30,000	600

14.7 Metal Correlations

Correlation statistics were undertaken by SOMINCOR to identify relationships between elements of interest. Density (de) was also included in the analysis. The correlation between density and sulphur is used in the calculation of density in the Mineral Resource estimate and is discussed in further detail in Section 14.11. Correlation analysis is undertaken for all deposits and for each mineralisation type. An example of the metal correlations derived for 5Z (massive zinc and lead) zone at Lombador with the most significant correlations highlighted is shown in Table 14.4.

Table 14.4: Example Correlation Matrix for Metals and Density (De) for 5Z Zone at Lombador

	Cu	Zn	Sn	Pb	S	Fe	Ag	Hg	As	Sb	Bi	Au	Se	In	De
Cu	1.00	-0.20	0.04	-0.10	-0.08	0.05	0.28	-0.16	0.02	0.25	0.37	-0.09	0.04	-0.01	-0.15
Zn	-0.20	1.00	0.00	0.62	-0.10	-0.60	0.20	0.81	0.12	0.06	-0.05	0.17	-0.05	0.25	0.24
Sn	0.04	0.00	1.00	-0.01	0.06	0.04	-0.02	0.01	0.02	0.00	-0.05	-0.10	-0.03	-0.06	0.11
Pb	-0.10	**0.62**	-0.01	1.00	-0.16	-0.49	0.40	0.56	-0.03	0.23	0.00	0.25	-0.02	0.07	0.22
S	-0.08	-0.10	0.06	-0.16	1.00	0.63	-0.11	-0.19	0.07	-0.04	0.01	0.03	-0.07	0.16	0.83
Fe	0.05	-0.60	0.04	-0.49	**0.63**	1.00	-0.26	-0.56	0.02	-0.13	0.12	-0.07	-0.05	-0.20	0.59
Ag	0.28	0.20	-0.02	0.40	-0.11	-0.26	1.00	0.26	0.02	0.88	0.06	0.27	-0.03	0.08	0.16
Hg	-0.16	**0.81**	0.01	**0.56**	-0.19	-0.56	0.26	1.00	0.07	0.14	-0.07	0.18	-0.02	0.03	0.19
As	0.02	0.12	0.02	-0.03	0.07	0.02	0.02	0.07	1.00	0.05	0.15	-0.21	0.03	0.13	0.21
Sb	0.25	0.06	0.00	0.23	-0.04	-0.13	**0.88**	0.14	0.05	1.00	-0.01	0.06	-0.02	0.04	0.27
Bi	0.37	-0.05	-0.05	0.00	0.01	0.12	0.06	-0.07	0.15	-0.01	1.00	0.08	0.01	-0.05	0.04
Au	-0.09	0.17	-0.10	0.25	0.03	-0.07	0.27	0.18	-0.21	0.06	0.08	1.00	-0.07	-0.03	0.15
Se	0.04	-0.05	-0.03	-0.02	-0.07	-0.05	-0.03	-0.02	0.03	-0.02	0.01	-0.07	1.00	-0.06	0.03
In	-0.01	0.25	-0.06	0.07	0.16	-0.20	0.08	0.03	0.13	0.04	-0.05	-0.03	-0.06	1.00	-0.06
De	-0.15	0.24	0.11	0.22	**0.83**	**0.59**	0.16	0.19	0.21	0.27	0.04	0.15	0.03	-0.06	1.00
No Samples	6,675	6,675	6,675	6,675	6,675	6,675	4,477	4,157	6,675	6,675	6,675	1,058	6,451	6,451	1,616

14.8 Continuity Analysis

Continuity analysis was undertaken by SOMINCOR prior to variography and was based on a Normal Score transformation of the 1m composite data. Continuity analysis refers to the analysis of the spatial correlation between sample pairs to determine the major axis of spatial continuity. Horizontal, across strike and down dip continuity maps were examined (and their underlying variograms) to determine the direction of greatest and least continuity. Continuity analysis was undertaken for all domains and elements including Cu, Zn, Sn, Pb, Su, Fe, Ag, Hg, As, Sb, Bi, Au, Se and In where sufficient sample pairs were available. Continuity analysis was also subdivided for deposits where different structural orientations are present as a result of folding. These included subdivisions of the Neves deposit into Neves North and Neves South and subdivision of Graça deposit into Graça SW, Graça, and Upper Corvo. Zambujal was also subdivided into two structural zones, however only FC mineralisation type contained enough samples for analysis within the Zambujal SW fold limb. An example continuity analysis for Lombador 5Z zone is shown in Figure 14.3.

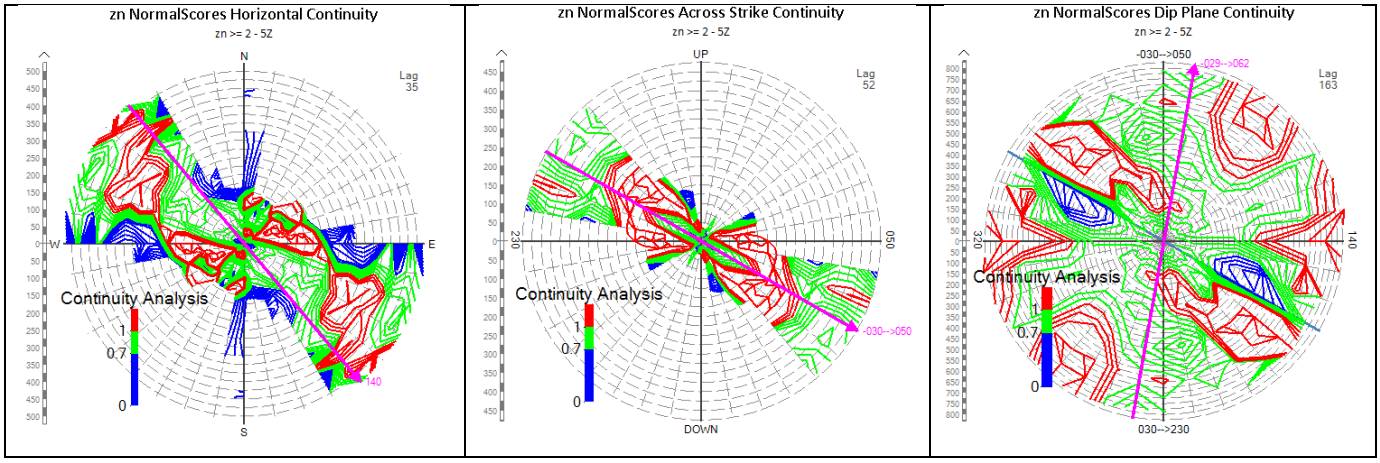


Figure 14.3: Example Continuity Map of Normal Score Zn Values at 5Z (massive zinc and lead) Zone at Lombador

14.9 Variography

Based on the continuity analysis variogram modelling was subsequently undertaken by SOMINCOR. Directional and down hole variograms were calculated for the 1m composites. In keeping with the general trend of mineralisation, the variograms were created in the orientation of the defined mineralisation as described by the continuity analysis. The same structural subdivisions used in the continuity analysis were also maintained. Variography was undertaken for all deposits except for Monte Branco where insufficient sample pairs were available. Variography was undertaken for each domain and each element (Cu, Zn, Sn, Pb, Su, Fe, Ag, Hg, As, Sb, Bi, Au, Se and In) where sufficient sample pairs were available. Major axis were defined based on the orientation of greatest continuity. Minor axis were defined based on the orientation of next greatest continuity and orientated perpendicular to the major axis. The remaining orthogonal direction, orientated perpendicularly to the major and minor axis, was then defined. The nugget variances were modelled from the down hole variograms. Variograms were modelled using 2 structure spherical models. An example of the modelled variograms for Lombador 5Z zone are shown in Figure 14.4. Following variogram modelling the resultant variogram model (based on the normal score transformation) was subsequently back transformed.

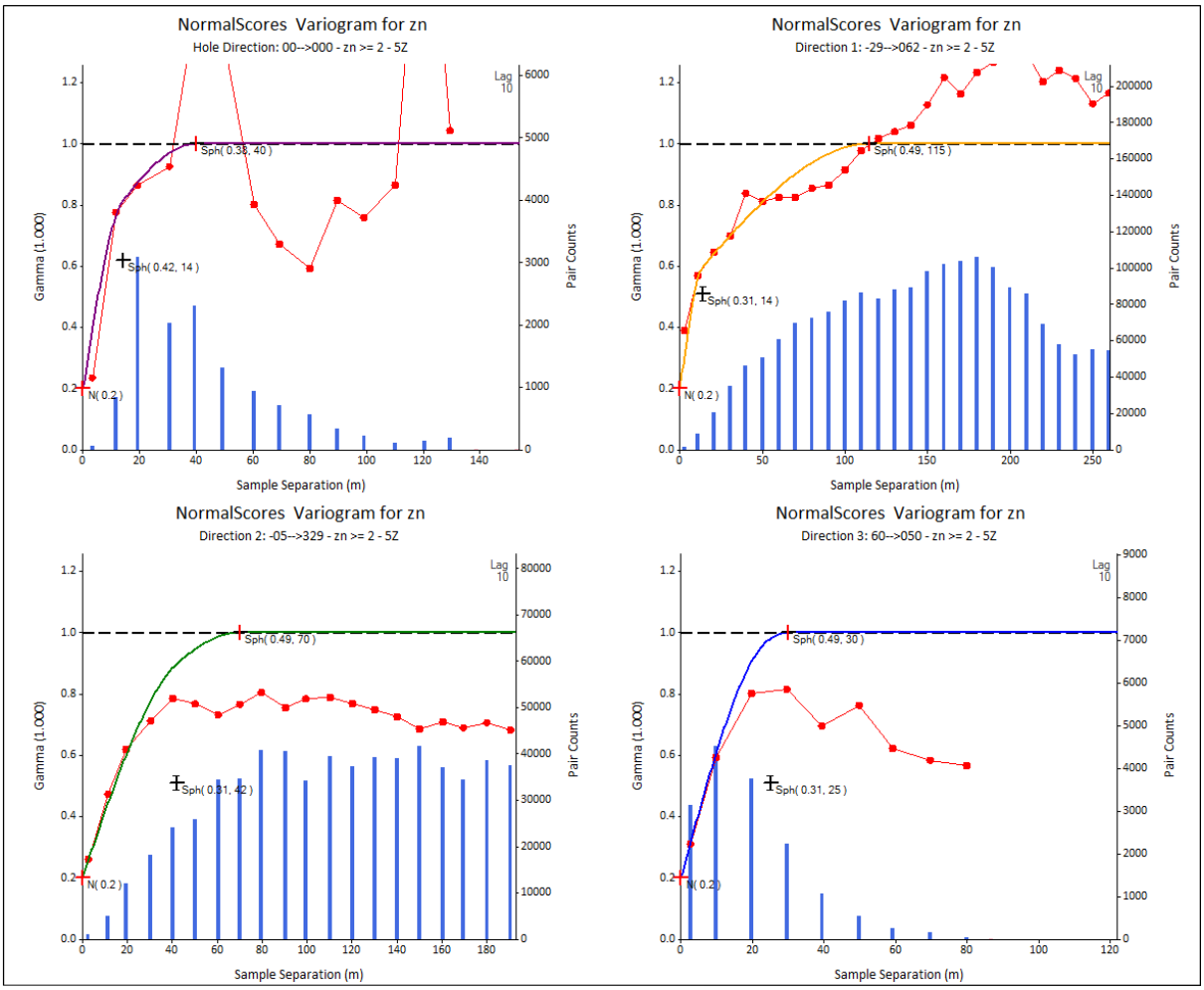


Figure 14.4: Example of Modelled Variograms for Normal Score Zn Grades at 5Z (massive zinc and lead) Zone at Lombador

WAI consider that the overall quality of the experimental variograms generated by SOMINCOR for the Neves-Corvo deposits (excluding Monte Branco) are acceptable and are generally based on a significant number of sample pairs which have been sufficiently domained. Confidence in the modelled variograms is therefore high as a result of the clearly defined continuity displayed by the experimental variograms. Variography for the Semblana deposit is based on wider drill hole spacing (>70m) and as such there is lower confidence in the variography. Semblana, however, is classified as wholly Inferred Mineral Resource. No variography could be defined at Monte Branco due to the limited number of sample pairs. Monte Branco is also classified as a wholly Inferred Mineral Resource.

14.10 Block Modelling

Block models defining the mineralised zones were constructed by SOMINCOR in Vulcan® using the domain wireframes which were used to code the principal domains. At Neves, Corvo, Graça, Zambujal, Lombador and Monte Branco deposits a model prototype comprising a parent cell size of 5m x 5m x 5m (X, Y, Z) was used for copper and tin mineralised zones while a parent cell size of 10m x 10m x 5m was used for zinc and barren zones. Sub-cell splitting was enabled down to a minimum cell size of 1m x 1m x 1m. A full block model comprising waste blocks located outside of the mineralised zone was

also constructed. The model prototype for the waste model comprised a parent cell size of 50m x 50m x 20m. The mineralised zone model and the full waste model were then combined. The models were rotated to 327° to align with the general strike of the Neves-Corvo deposits. At Semblana a model prototype comprising a parent cell size of 15m x 15m x 5m was used. Sub-cell splitting was enabled down to a minimum cell size of 7.5m x 7.5m x 5m. The Semblana model was not rotated.

14.11 Density

Due to the strong positive correlation between sulphur and density and given the larger number of sulphur values contained within the database, SOMINCOR elect to use this correlation to derive density within the Mineral Resource estimate. Where applicable, for each deposit density values were grouped based on similar domains and statistically analysed with sulphur to derive linear regression formula for calculation of density from sulphur grades estimated in the block model. Example plots of density and density vs sulphur for 5Z zone and FC zone at Lombador are contained in Figure 14.5 and Figure 14.6, respectively.

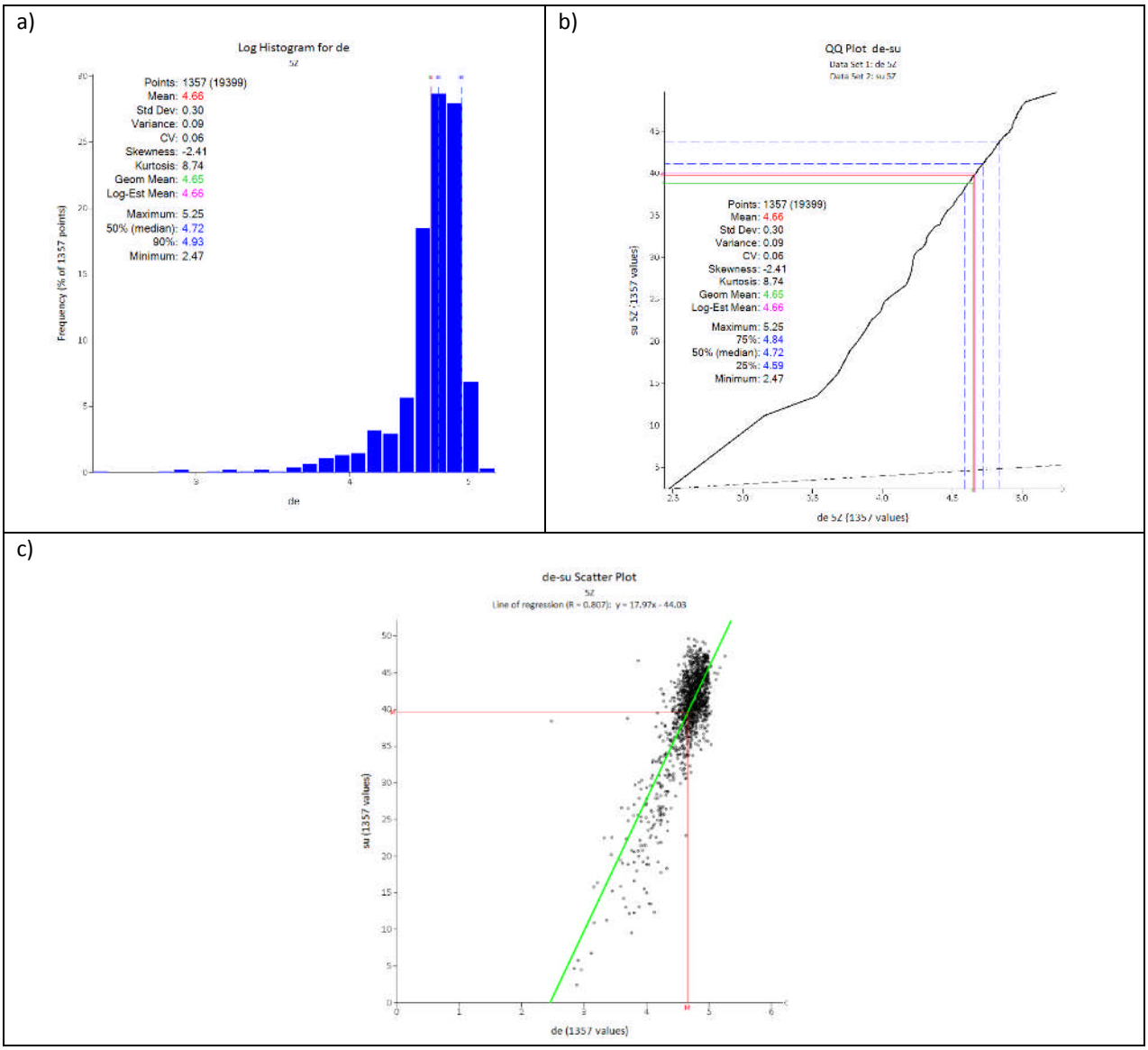


Figure 14.5: Example Plots of Density for 5Z (massive zinc and lead) Zone at Lombador a) Log Histogram of Density Measurements, b) QQ Plot of Density vs Sulphur and c) Scatter Plot of Density vs Sulphur

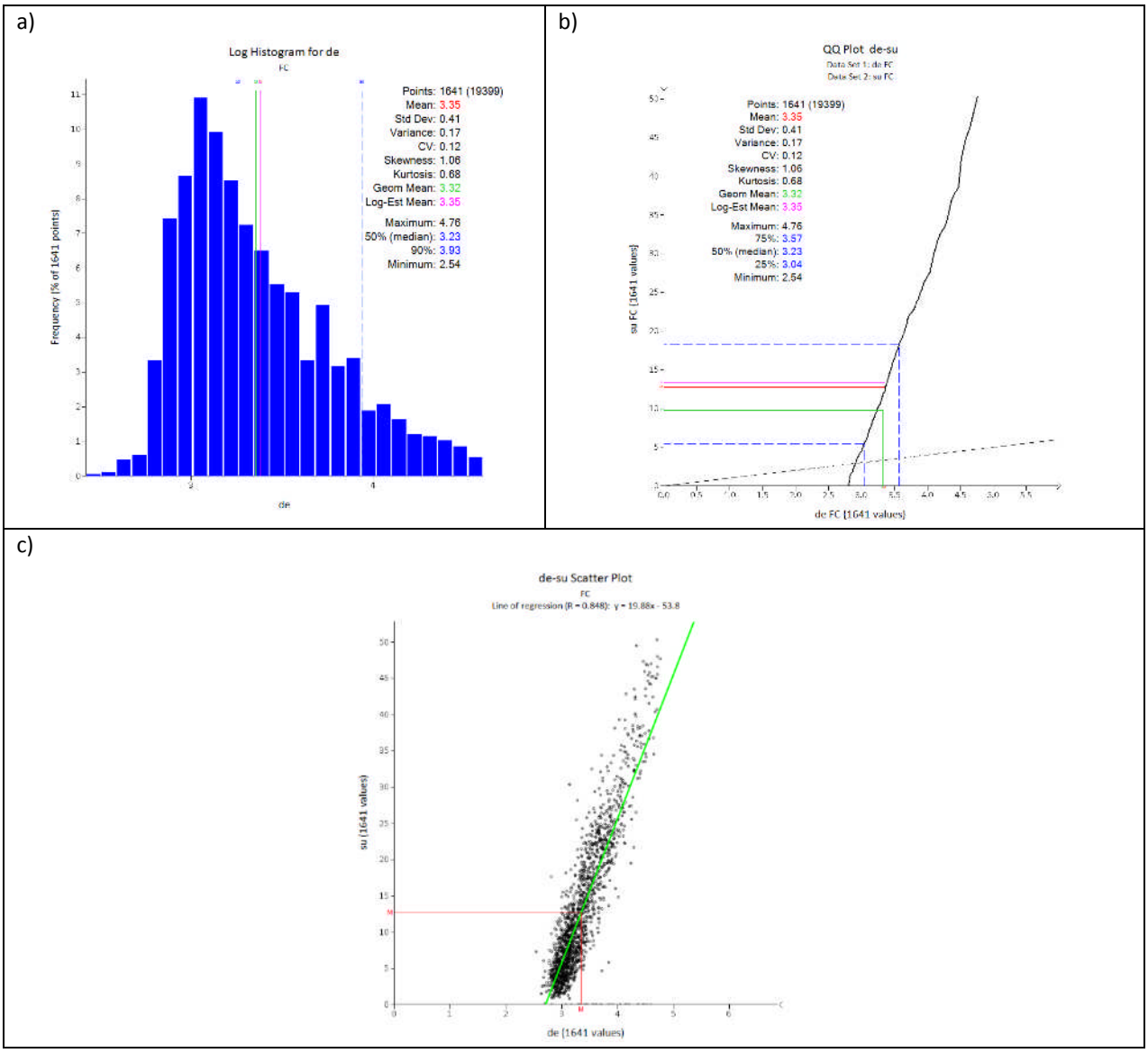


Figure 14.6: Example Plots of Density for FC (stockwork copper) Zone at Lombador a) Log Histogram of Density Measurements, b) QQ Plot of Density vs Sulphur and c) Scatter Plot of Density vs Sulphur

A summary of the derived linear regression formula for calculation of density from estimated sulphur grades used by SOMINCOR in the Mineral Resource estimate are shown in Table 14.5.

Table 14.5: Linear Regression of Density (de) from Sulphur (S) by Deposit		
Deposit	**Mineralisation Type**	**Density (de) Calculation**
Corvo	MC, MCZ, MT	de=0.036*S + 2.900
	ME	de=0.034*S + 2.999
	FC and FT	de=0.037*S + 2.724
	FE	de=0.032*S + 2.837
	MZ, MZP, MP, FZ	de=0.033*S + 3.152
Graça	MC, MCZ	de=0.042*S + 2.564
	ME	de=0.033*S + 2.984
	FC	de=0.032*S + 2.757
	FE	de=0.031*S + 2.787
	MZ, MZP, MP	de=0.027*S + 3.399
Lombador	MC	de=0.036*S + 3.015
	MCZ	de=0.034*S + 3.237
	ME	de=0.031*S + 3.194
	FC	de=0.036*S + 2.886
	FT, FE	de=0.035*S + 2.827
	MZ	de=0.032*S + 3.290
	MZP, MP	de=0.036*S + 3.219
	FZ	de=0.043*S + 2.880
Neves	MC, MCZ	de=0.032*S + 3.107
	ME	de=0.032*S + 3.024
	FC	de=0.037*S + 2.773
	FE	de=0.034*S + 2.804
	MZ, MZP, MP, FZ	de=0.041*S + 2.738
Zambujal	MC, MCZ	de=0.031*S + 3.232
	ME	de=0.032*S + 3.164
	FC	de=0.038*S + 2.876
	FE	de=0.038*S + 2.833
	MZ, MZP, MP, FZ	de=0.039*S + 2.897
Monte Branco	MC, MCZ	de=0.040*S + 2.698
	ME	de=0.040*S + 2.698
	FC	de=0.037*S + 2.567
	FT	de=0.037*S + 2.567
	MZ, MZP, FZ	de=0.039*S + 2.618
Semblana	MC	Density estimated into block model using drill hole data. Default density value of 4.4t/m^3 used for unestimated blocks
	FE	Density estimated into block model using drill hole data. Default density value of 3.2t/m^3 used for unestimated blocks

14.12 Grade Estimation

Grade estimation for Cu, Pb, Zn, S, Fe, Sn, As, Sb, Hg, Ag, Au, Bi, Se and In was performed only on mineralised material defined within each domain. The domains were treated as hard boundaries and as such composites from an adjacent domain could not be used in the grade estimation of another domain. Ordinary kriging (“OK”) was used as the principal estimation method for all deposits with the exception of Monte Branco where nearest neighbour (“NN”) estimation was undertaken. Grade estimation was run in a three pass plan, the second and third passes using progressively larger search radii to enable the estimation of blocks unestimated on the previous pass. The search parameters were derived from the variography, with the first search distances corresponding to the variogram range at 2/3^{rds} of the sill value, the second search corresponding to the variogram range and the third search expanded beyond the variogram range to estimate any remaining domain blocks. Sample weighting during grade estimation was determined by the variogram model parameters for the OK

method. NN estimation was used at Monte Branco as no suitable variograms for these zones could be derived. Search distances for Monte Branco were therefore based on the general drill hole spacing. A summary of the grade estimation plan is shown in Table 14.6.

Table 14.6: Grade Estimation Plan

Deposit	Search		Minimum Number of Composites	Maximum Number of Composites	Maximum Number of Composites Per Octant
Neves-Corvo Deposits	1st		5	32	4
	2nd		5	32	4
	3rd		5	32	4
Semblana	MC	1st	8	20	-
		2nd	5	20	-
		3rd	5	20	-
	FC	1st	6	15	-
		2nd	5	20	-
		3rd	5	20	-
	ME FE	1st	7	20	-
		2nd	5	20	-
		3rd	5	20	-

Notes:
1.Semblana MC - 1st search of 70m x 70m x 10m with an expansion of 1.5 times for search 2 and an expansion of 3 times for search 3. Max number of composites per drill hole is 7;
2.Semblana FC - 1st search of 70m x 70m x 10m with an expansion of 2 times for search 2 and an expansion of 3 times for search 3. Max number of composites per drill hole is 5;
3.Semblana ME, FE - 1st search of 80m x 80m x 15m with an expansion of 2 times for search 2 and an expansion of 3 times for search 3. Max number of composites per drill hole is 6;
4. Semblana search ellipse orientations controlled by dynamic anisotropy.

14.12.1 Grade Estimation Validation

Following grade estimation a statistical and visual assessment of the block model was undertaken to 1) assess successful application of the estimation passes 2) to ensure that as far as the data allowed, all blocks within mineralisation domains were estimated and 3) the model estimates performed as expected. The model validation methods carried out by SOMINCOR included an on-screen visual assessment of composite and block model grades, a statistical grade comparison as shown in Figure 14.7 and SWATH Analysis as shown in Figure 14.8. WAI considers that globally no indications of significant over or under estimation were apparent in the model nor were any obvious interpolation issues identified. From the perspective of conformance of the average model grade to the input data, WAI considers the grade estimation by SOMINCOR to adequately represent the sample data used.

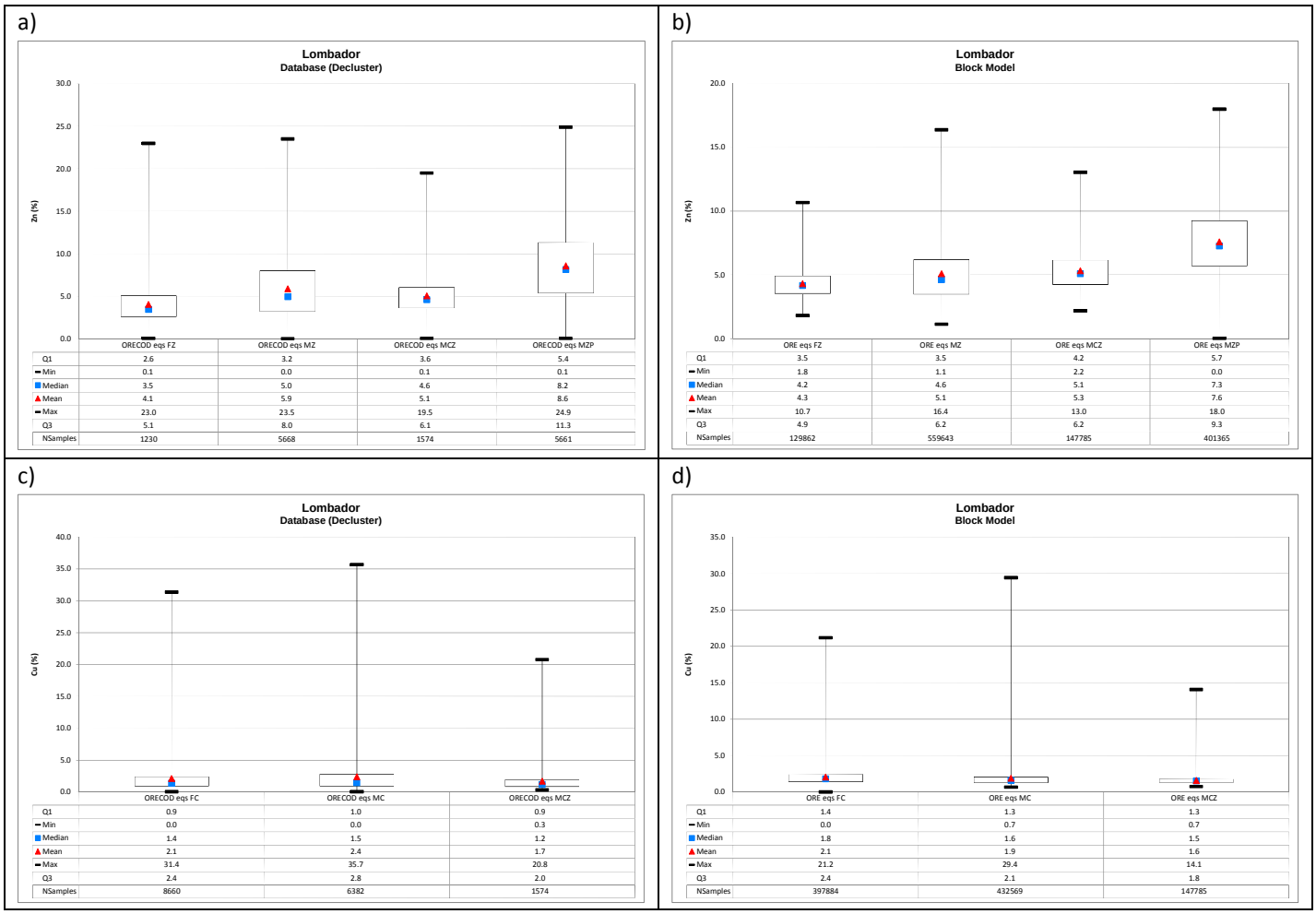


Figure 14.7: Example of Composites vs Block Model Statistical Comparison at Lombador for a) Zn (composites); b) Zn (block model) and c) Cu (composites); d) Cu block model)

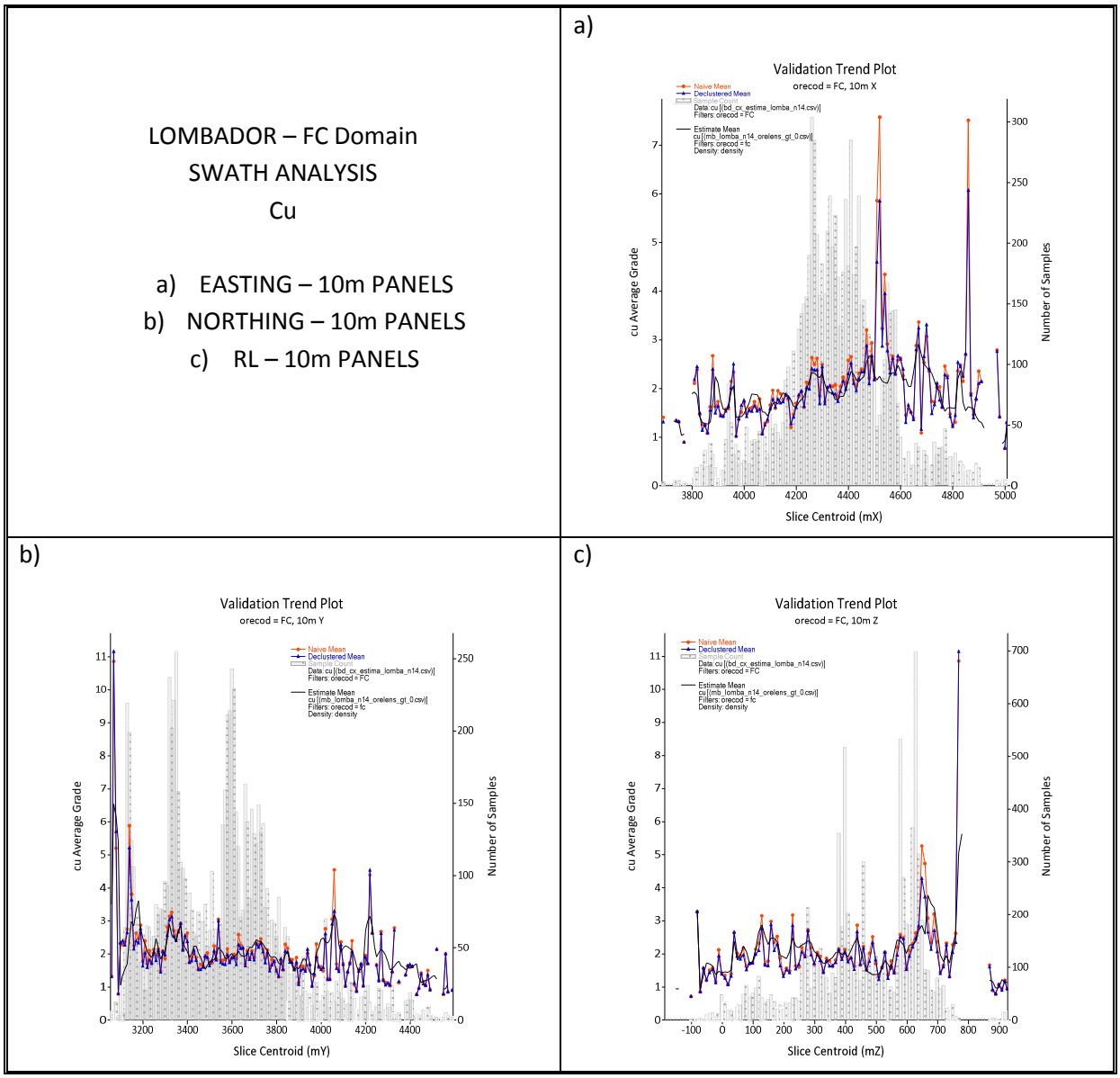


Figure 14.8: Example SWATH Analysis of Lombador FC Domain

14.13 Mineral Resource Reconciliation

Reconciliation comparing the block models used in the Mineral Resource estimates against planned and actual production data is undertaken by SOMINCOR as a means of validation. Reconciliation is undertaken by the SOMINCOR Geological Department on a monthly basis and includes the following:

- **Mineral Resource Model** – an evaluation of Mineral Resource estimates contained within the mined out stopes using the Cavity Monitoring System (CMS) survey over the reconciliation period. Sidewall dilution when mining next to backfill in secondary stopes and adjustments to account for material stored in surface stockpiles are accounted for;

- **Planned Production** – planned stope production based on the annual mine design. The resource model contained within the planned stopes is evaluated and factors applied for unplanned dilution and mining recovery;
- **Plant Production** – plant reported production figures based on tonnes processed and back calculated grade; and
- **'Broken Ore'** – Estimate of tonnage and grade of mined ore based on face samples from development headings. Grades are apportioned to areas on the development and plan weighted by distance from the face sample. Volume, tonnage and dilution are then calculated from survey data.

A summary of the annual reconciliation for the copper and zinc zones during 2016 is shown in Table 14.7 while the monthly reconciliations are charted in Figure 14.9.

Table 14.7: Summary of 2016 Annual Reconciliation

Copper Zones			
Source	**Ore Tonnes (t)**	**Cu Grade (%)**	**Cu Metal (t)**
Resource Model	2,372,988	2.40	57,050
Plant Production	2,386,184	2.55	60,810
Planned Production	2,367,564	2.78	65,888
'Broken Ore'	2,435,479	3.07	74,845
Zinc Zones			
Source	**Ore Tonnes (t)**	**Zn Grade (%)**	**Zn Metal (t)**
Resource Model	1,071,416	7.79	83,449
Plant Production	1,039,124	8.21	85,350
Planned Production	1,058,601	8.20	86,825
'Broken Ore'	1,090,689	8.23	89,767

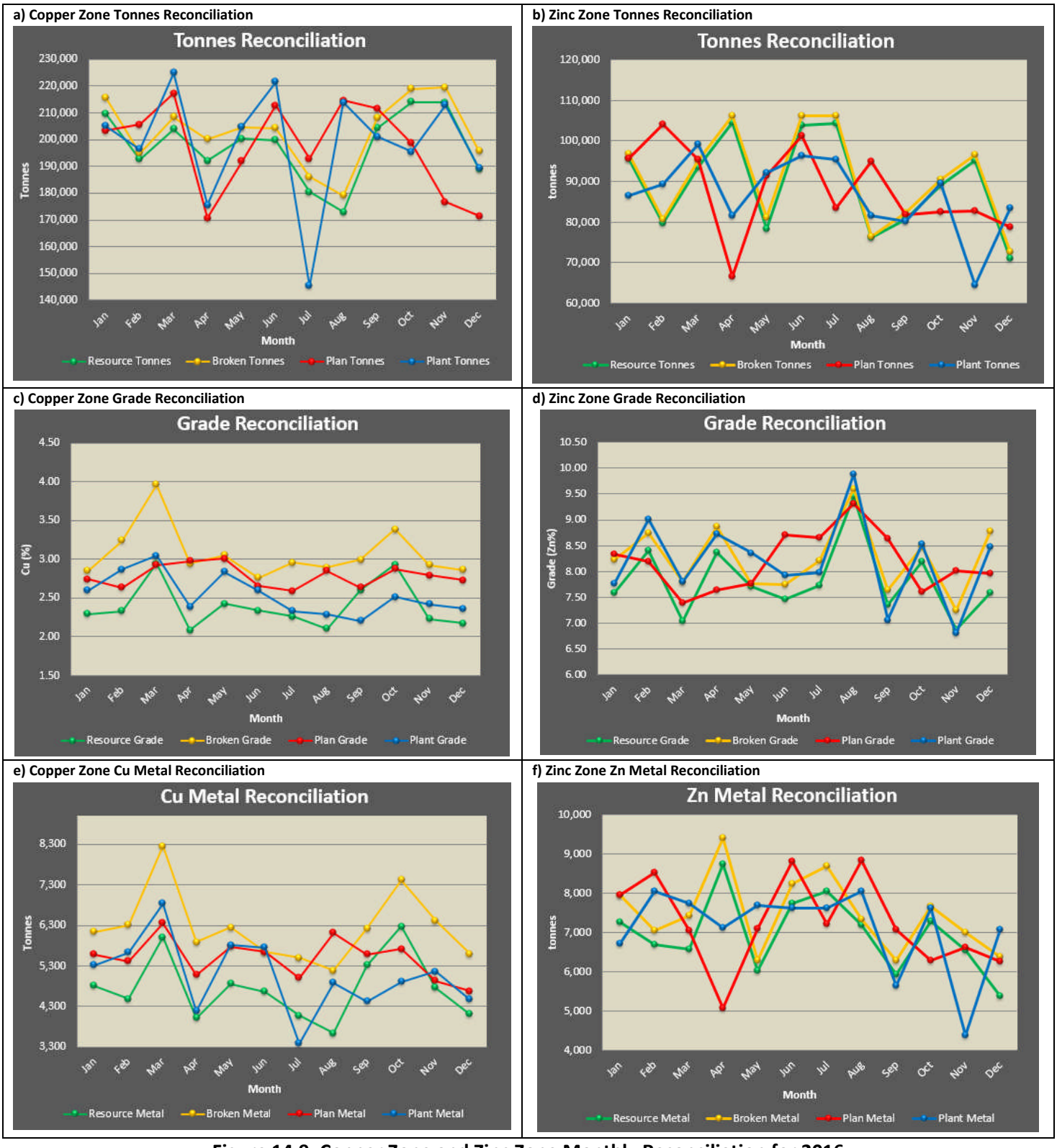


Figure 14.9: Copper Zone and Zinc Zone Monthly Reconciliation for 2016

Despite some variation on a monthly basis the annual ore tonnes reporting from the resource model, plant production, planned production and 'broken ore' are comparable and generally report within 2% of each other.

Grades reporting from the resource model tend to understate grades reporting from the plant production with the resource model reporting 6.2% less contained Copper metal for the copper zones and 2.2% less contained Zn metal for the zinc zones when compared to plant production data.

Grades reporting from the planned production tend to overstate both the resource model and plant production data. The planned production reports 13.4% and 7.7% more contained Copper metal for the copper zones compared to the resource model and plant production, respectively.

Grades reporting from the 'broken ore' data, particularly for the copper zones, appear to exhibit a systematic bias towards higher grades with the 'broken ore' reporting 21.8% higher Copper grades than the resource model and 17.1% higher Copper grades than the plant production data. SOMINCOR are aware that this systematic error exists but do not apply a correction factor to the 'broken ore' grades. The main reason given for the variation, is the simplified calculation method used to calculate the grade of the 'broken ore' in which face sample grades are a manual weighting over the development heading.

The reconciliation indicates that the resource models perform well when compared to the plant production data and support the resource modelling methodology used by SOMINCOR Geological Department. Ore tonnages reporting from the resource model and the plant production data are within 1%. Grades reporting from the resource model are 5.7% lower for Copper and 5.2% lower for Zinc compared to plant production data. WAI consider that these are within acceptable tolerances for reconciliation.

Resource model grade, plant production grade and 'broken ore' grade all vary against the planned grade on a month by month basis. In order for the mine to consistently meet the planned grade requires a complex interaction of many operational factors of which resource modelling is just one. Based on this, it is recommended that a review to identify the reasons for the higher Copper grades reporting from the planned production compared to the resource model be undertaken.

14.14 Mineral Resource Depletion and Non-Recoverable Mineral Resources

All underground development and stopes are regularly surveyed using Total Station and CMS survey methods. The information is imported by SOMINCOR into Vulcan® and used to build up 3D triangulations of the mined-out regions. These areas are then incorporated into the block model using a MINED field with all remaining unmined material coded as 0 which is then used to select the unmined resources within the block model during resource evaluation.

Non-recoverable Mineral Resources include areas which will never be exploited for reasons such as proximity to mine infrastructure. Non-recoverable Mineral Resources are defined by SOMINCOR using wireframes and coded into the block model using the field 'mcd'. A value of 99 is assigned in the block model to any resources that are considered non-recoverable. The last update of non-recoverable Mineral Resources was undertaken by SOMINCOR in December 2007. To better align the Mineral Resource and Mineral Reserve estimates it is recommended that the non-recoverable resources be updated to include any additional areas which are unlikely to be exploited by mining.

14.15 Cut-Off Grades for Mineral Resource Evaluation

Historically, cut-off grades of 1.0% Cu and 3.0% Zn have been used by SOMINCOR for resource evaluation of copper zones and zinc zones, respectively. These have been maintained by SOMINCOR since 2009 and allow for a year on year comparison of the Mineral Resource estimates. WAI consider the cut-off grades to be generally appropriate, however to better align the Mineral Resources and the Mineral Reserves it is recommended that a review of the cut-off grades used for resource evaluation be undertaken.

14.16 Mineral Resource Classification

The Mineral Resource classification for the Neves-Corvo and Semblana deposits was undertaken by SOMINCOR and incorporated the confidence in the drill hole data, the geological interpretation, geological continuity, data density and orientation, spatial grade continuity and confidence in the Mineral Resource estimation.

Mineral Resource classification was primarily set in the block models using the search pass encountered during grade estimation. A summary of the maximum (major axis) distances used during Mineral Resource classification are shown in Table 14.8. Following this a second level of Mineral Resource classification was used by SOMINCOR. At Neves, Corvo, Graça and Zambujal all blocks estimated on the first pass but which were estimated using only surface drill holes were re-classified as Indicated Mineral Resources. At Lombador North and Lombador South Phase II, all blocks estimated on the first pass were re-classified as Indicated Mineral Resources. Monte Branco and Semblana were classified as wholly Inferred Mineral Resources as these deposits were estimated using wide spaced surface drill holes only. Mineral Resource classification was recorded in the block models using the field ‘rcc’.

Table 14.8: Summary of Maximum Search Radius used for Mineral Resources Classification

Area		Mineralisation Type	*Measured Resources (m)*	*Indicated Resources (m)*	*Inferred Resources (m)*
Corvo		MC	0≤d_Cu≤21	21<d_Cu≤191	d_Cu>191
		MCZ	0≤d_Cu≤46	46<d_Cu≤125	d_Cu>125
		FC	0≤d_Cu≤22	22<d_Cu≤92	d_Cu>92
		FT	0≤d_Sn≤13	13<d_Sn≤71	d_Sn>71
		ME	0≤d_Cu≤15	15<d_Cu≤121	d_Cu>121
		FE	0≤d_Cu≤14	14<d_Cu≤71	d_Cu>71
		MT	0≤d_Sn≤8	8<d_Sn≤44	d_Sn>44
		MZ/FZ	0≤d_Zn≤16	16<d_Zn≤90	d_Zn>90
		MZP/MP	0≤d_Zn≤44	44<d_Zn≤141	d_Zn>141
Graça	1 (Graça SW)	MC	0≤d_Cu≤6	6<d_Cu≤88	d_Cu>88
		MCZ	0≤d_Cu≤32	32<d_Cu≤88	d_Cu>88
		FC	0≤d_Cu≤20	20<d_Cu≤82	d_Cu>82
		ME	0≤d_Cu≤1	1<d_Cu≤7	d_Cu>7
		FE	0≤d_Cu≤14	14<d_Cu≤71	d_Cu>71
		MZ	0≤d_Zn≤14	14<d_Zn≤104	d_Zn>104
		MZP/MP	0≤d_Zn≤31	31<d_Zn≤200	d_Zn>200
	2 (Graça)	MC	0≤d_Cu≤18	18<d_Cu≤72	d_Cu>72
		MCZ	0≤d_Cu≤33	33<d_Cu≤112	d_Cu>112
		FC	0≤d_Cu≤6	6<d_Cu≤101	d_Cu>101
		ME	0≤d_Cu≤2	2<d_Cu≤64	d_Cu>64
		FE	0≤d_Cu≤14	14<d_Cu≤71	d_Cu>71
		MZ	0≤d_Zn≤14	14<d_Zn≤104	d_Zn>104
		MZP/MP	0≤d_Zn≤31	31<d_Zn≤200	d_Zn>200
	3 (Upper Corvo)	MC	0≤d_Cu≤31	31<d_Cu≤144	d_Cu>144
		MCZ	0≤d_Cu≤66	66<d_Cu≤187	d_Cu>187
		FC	0≤d_Cu≤18	18<d_Cu≤78	d_Cu>78
		ME	0≤d_Cu≤15	15<d_Cu≤121	d_Cu>121
		FE	0≤d_Cu≤14	14<d_Cu≤71	d_Cu>71
		MZ	0≤d_Zn≤24	24<d_Zn≤93	d_Zn>93
		MZP/MP	0≤d_Zn≤25	25<d_Zn≤61	d_Zn>61
Lombador	1	MC	0≤d_Cu≤8	8<d_Cu≤45	d_Cu>45
		MCZ	0≤d_Cu≤7	7<d_Cu≤60	d_Cu>60
		FC	0≤d_Cu≤5	5<d_Cu≤46	d_Cu>46
		FT	0≤d_Sn≤15	15<d_Sn≤104	d_Sn>104
		ME	0≤d_Cu≤8	8<d_Cu≤274	d_Cu>274
		FE	0≤d_Cu≤20	20<d_Cu≤145	d_Cu>145
		MZ	0≤d_Zn≤27	27<d_Zn≤100	d_Zn>100
		MZP	0≤d_Zn≤25	25<d_Zn≤115	d_Zn>115
		FZ	0≤d_Zn≤15	15<d_Zn≤85	d_Zn>85
		MP	0≤d_Pb≤7	7<d_Pb≤41	d_Pb>41
Neves	1 (Neves N)	MC	0≤d_Cu≤8	8<d_Cu≤45	d_Cu>45
		MCZ	0≤d_Cu≤7	7<d_Cu≤60	d_Cu>60
		FC	0≤d_Cu≤5	5<d_Cu≤46	d_Cu>46
		ME	0≤d_Cu≤8	8<d_Cu≤274	d_Cu>274
		FE	0≤d_Cu≤20	20<d_Cu≤145	d_Cu>145
		MZ	0≤d_Zn≤27	27<d_Zn≤100	d_Zn>100
		MZP	0≤d_Zn≤25	25<d_Zn≤115	d_Zn>115
		FZ	0≤d_Zn≤15	15<d_Zn≤85	d_Zn>85
		MP	0≤d_Pb≤7	7<d_Pb≤41	d_Pb>41
	2 (Neves S)	MC	0≤d_Cu≤11	11<d_Cu≤152	d_Cu>152
		MCZ	0≤d_Cu≤11	11<d_Cu≤89	d_Cu>89
		FC	0≤d_Cu≤8	8<d_Cu≤80	d_Cu>80
		ME	0≤d_Cu≤8	8<d_Cu≤30	d_Cu>30
		FE	0≤d_Cu≤8	8<d_Cu≤43	d_Cu>43
		MZ	0≤d_Zn≤3	3<d_Zn≤70	d_Zn>70
		MZP	0≤d_Zn≤11	11<d_Zn≤75	d_Zn>75
		FZ	0≤d_Zn≤15	15<d_Zn≤85	d_Zn>85
		MP	0≤d_Pb≤5	5<d_Pb≤49	d_Pb>49
Zambujal	1 (Zambujal NE)	MC	0≤d_Cu≤12	12<d_Cu≤52	d_Cu>52
		MCZ	0≤d_Cu≤12	12<d_Cu≤112	d_Cu>112
		FC	0≤d_Cu≤2	2<d_Cu≤74	d_Cu>74
		ME	0≤d_Cu≤14	14<d_Cu≤162	d_Cu>162
		FE	0≤d_Cu≤2	2<d_Cu≤46	d_Cu>46
		MZ	0≤d_Zn<12	12<d_Zn≤163	d_Zn>163
		MZP/MP	0≤d_Zn<28	28<d_Zn≤125	d_Zn>125
		FZ	0≤d_Zn<11	11<d_Zn≤50	d_Zn>50
	2 (Zambujal SW)	FC	0≤d_Cu<3	3<d_Cu≤86	d_Cu>86

The Mineral Resources classification for Neves, Corvo, Graça, Zambujal and Lombador deposits are shown in Figure 14.10. Monte Branco and Semblana deposits are not shown but are classified as wholly Inferred Mineral Resources.

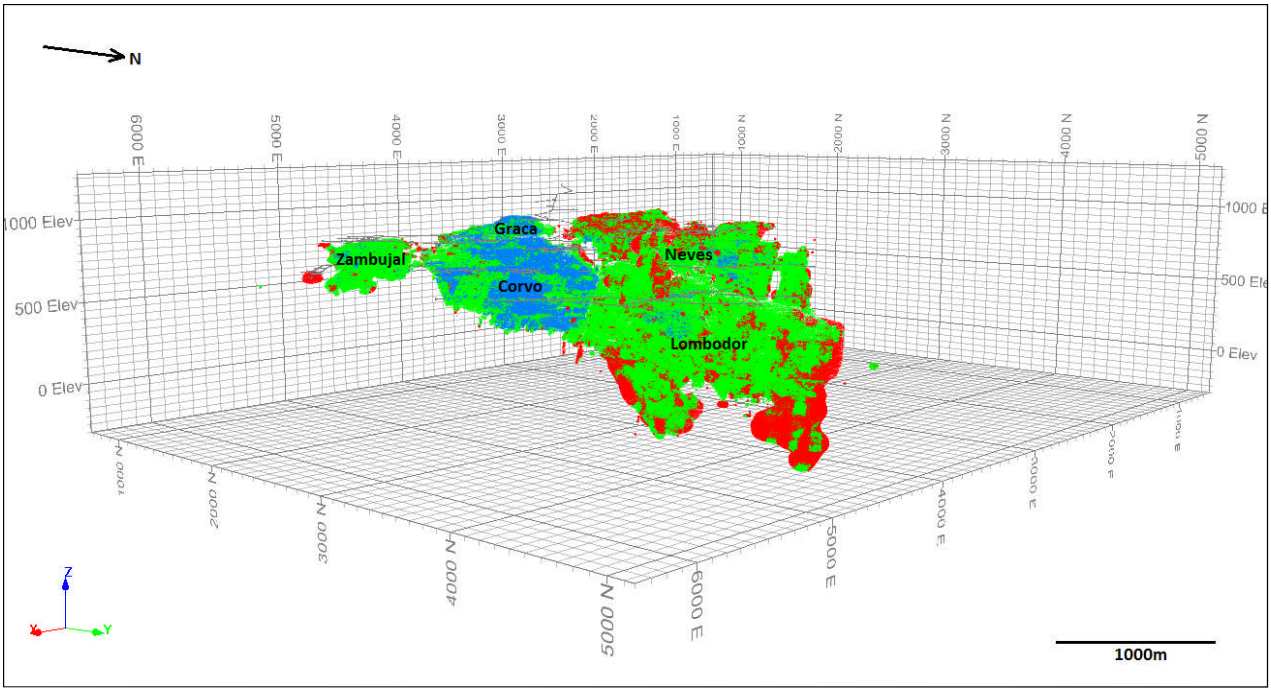


Figure 14.10: Isometric View of Block Model Showing Mineral Resource Classification for Neves, Corvo, Graça, Zambujal and Lombador Deposits (Measured Resources in Blue, Indicated Resources in Green and Inferred Resources in Red)

WAI consider the Mineral Resource classification methodology employed by SOMINCOR to be generally acceptable and presents no significant issues in areas of high data density. However, in areas of lower data density such as the deep levels at Lombador, it is recommended that an additional level of Mineral Resource classification be incorporated using perimeter strings or wireframes to prevent Indicated Mineral Resources being derived from widely spaced surface drill holes.

14.17 Mineral Resource Statement

The Mineral Resource estimate for the Neves-Corvo and Semblana deposits is classified in accordance with the CIM Standards.

The stated Mineral Resources are not materially affected by any known environmental, permitting, legal, title, taxation, socio-economic, marketing, political or other relevant issues, to the best knowledge of the author. There are no known mining, metallurgical, infrastructure, or other factors that materially affect this Mineral Resource estimate, at this time.

The effective date of the Mineral Resource estimate is June 30, 2016. A summary of the Mineral Resource statement is shown in Table 14.9, Table 14.10 and Table 14.11.

Table 14.9: Total Mineral Resources for Copper Zones at Neves-Corvo at a Cut-Off Grade of 1.0% Cu

Resource Classification	Tonnage (Kt)	Grade				Metal			
		Cu (%)	Zn (%)	Pb (%)	Ag (g/t)	Cu (Kt)	Zn (Kt)	Pb (Kt)	Ag (Moz)
Measured	14,732	4.2	0.9	0.3	44	625	137	38	21
Indicated	55,254	2.2	1.1	0.4	45	1,232	580	199	80
Measured + Indicated	**69,986**	**2.7**	**1.0**	**0.3**	**45**	**1,857**	**717**	**237**	**101**
Inferred	12,758	1.7	1.2	0.4	37	222	158	46	15

Notes:
1. Mineral Resources are reported in accordance with the guidelines of the CIM Code (2014);
2. Mineral Resources are not reserves until they have demonstrated economic viability based on a feasibility study or pre-feasibility study;
3. Mineral Resources are reported inclusive of any reserves;
4. Grade represents estimated contained metal in the ground and has not been adjusted for metallurgical recovery and;
5. Numbers may not add due to rounding.

Table 14.10: Total Mineral Resources for Zinc Zones at Neves-Corvo at a Cut-Off Grade of 3.0% Zn

Resource Classification	Tonnage (Kt)	Grade				Metal			
		Zn (%)	Cu (%)	Pb (%)	Ag (g/t)	Zn (Kt)	Cu (Kt)	Pb (Kt)	Ag (Moz)
Measured	15,464	7.7	0.3	1.7	67	1,183	48	266	33
Indicated	91,355	5.9	0.3	1.2	56	5,344	283	1,115	164
Measured + Indicated	**106,819**	**6.1**	**0.3**	**1.3**	**58**	**6,527**	**331**	**1,381**	**198**
Inferred	11,386	4.4	0.3	1.0	52	499	39	118	19

Notes:
1. Mineral Resources are reported in accordance with the guidelines of the CIM Code (2014);
2. Mineral Resources are not Mineral Reserves until they have demonstrated economic viability based on a feasibility study or pre-feasibility study;
3. Mineral Resources are reported inclusive of any Mineral Reserves;
4. Grade represents estimated contained metal in the ground and has not been adjusted for metallurgical recovery and;
5. Numbers may not add due to rounding.

Table 14.11: Total Mineral Resources for Copper Zones at Semblana at a Cut-Off Grade of 1.0% Cu

Resource Classification	Tonnage (Kt)	Grade				Metal			
		Cu (%)	Zn (%)	Pb (%)	Ag (g/t)	Cu (Kt)	Zn (Kt)	Pb (Kt)	Ag (Moz)
Inferred	7,807	2.9	-	-	25	223	-	-	6

Notes:
1. Mineral Resources are reported in accordance with the guidelines of the CIM Code (2014);
2. Mineral Resources are not reserves until they have demonstrated economic viability based on a feasibility study or pre-feasibility study;
3. Mineral Resources are reported inclusive of any reserves;
4. Grade represents estimated contained metal in the ground and has not been adjusted for metallurgical recovery and;
5. Numbers may not add due to rounding.

15 MINERAL RESERVE ESTIMATES

15.1 Introduction

The following section describes the Mineral Reserves estimation methodology and review performed by WAI in May 2017.

This Mineral Reserve estimate includes the current Neves-Corvo operating areas as well as the ZEP expansion (LP2) area, which provides an additional 10.6 Mt of zinc ore with 8.3% Zn grade and 2.5 Mt of copper ore with 2.3% Cu.

15.2 Design

The Base Case mineable shapes were obtained by the mine planning team as follows:

- First, ISO-shells wireframes are developed in Vulcan for each of the corresponding cut-off-values (COVs);
- Secondly, the wireframes are sliced either horizontally every 5m in the Drift-Fill areas or vertically every 12 or 15m in the Bench and Optimized-Bench and fill areas, respectively;
- The slices are manually adjusted to conform to mineable shapes;
- Isolated areas were tested for economical viability by determining the breakeven development length (cost) based on the NSR of the same area; and
- The mine uses an effective minimum mining width of 5.0m in determining stope designs.

Dilution and recovery factors are subsequently applied to the shapes and Studio 5D Planner was used to filter and tabulate the result.

When areas of a given block model are planned to be mined by a different (adjacent) production area the COV of the producing area is applied. For example, areas within the Lombador North block model are planned to be mined by the Neves production area, as such the Mineral Reserve has been estimated using the Neves COV.

The LP2 expansion area mineable shapes were produced using a stope optimisation code commonly referred to as the Mineable Shape Optimiser (MSO). MSO provides a stope shape that maximises the recovered Mineral Resource value above a cut-off while also catering for practical mining parameters such as; minimum and maximum mining width, anticipated wall dilutions, minimum and maximum wall angles, minimum separation distances between parallel and/or sub-parallel stopes, minimum and maximum stope heights and widths, separation of ore types, etc.

Mineable shapes are defined against Mineral Resource block models, based on the NSR break even cut-off values and Mineral Resource classification. Bench-and-fill (BF) stopes are broken down into individually designed stopes and sills. Drift-and-fill (DF) stopes are modelled in the 5m high lifts with

which they are mined. The stopes are classified as copper or zinc stopes, based on the most predominant economic value.

In estimating the Mineral Reserves similar dilution and recovery estimates have been made compared to the same mining methods in the existing operation. It should be noted the Mineral Reserve has increased from the FS (2015) due to infill geological drilling, converting Inferred Mineral Resources to Indicated Mineral Resources and hence Probable Mineral Reserves.

Mining has taken place as two primary mining methods, DF and BF, both of which have proved highly successful in the large but locally complex high grade ores. In addition, historic areas have also seen employed Mini Bench-and-Fill (MBF) and a specialised method for sill pillar recovery. With production in Lombador Phase 1 ("LP1"), a modified version of the BF method denoted as Optimised Bench-and-Fill (OBF) was selected.

Figure 15.1 illustrates the outline string of one 20m high lift in the Lombador orebody.

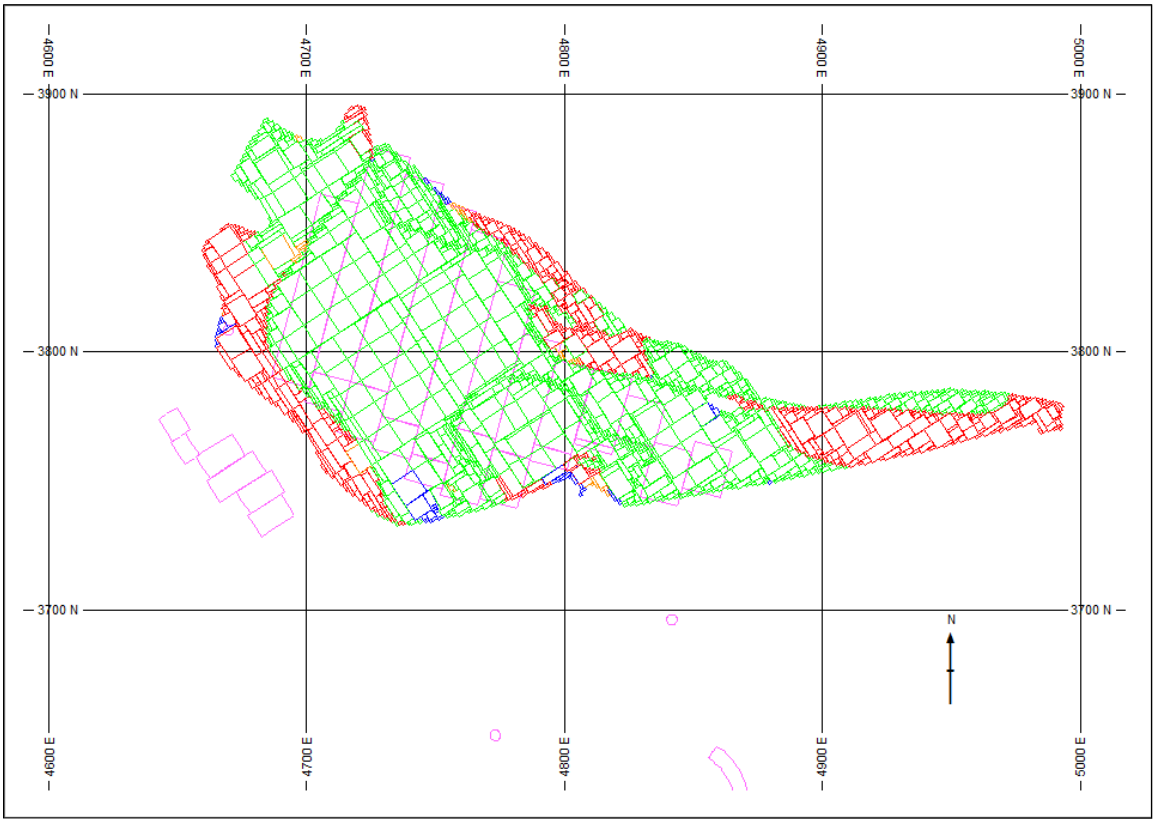


Figure 15.1: Optimised Bench and Fill Stope Outlines for the Lombador Orebody (Level 166)

Figure 15.2 presents a three dimensional view of the stope wireframes constructed from the MSO outlines. The OBF method uses more complex three dimensional wireframes.

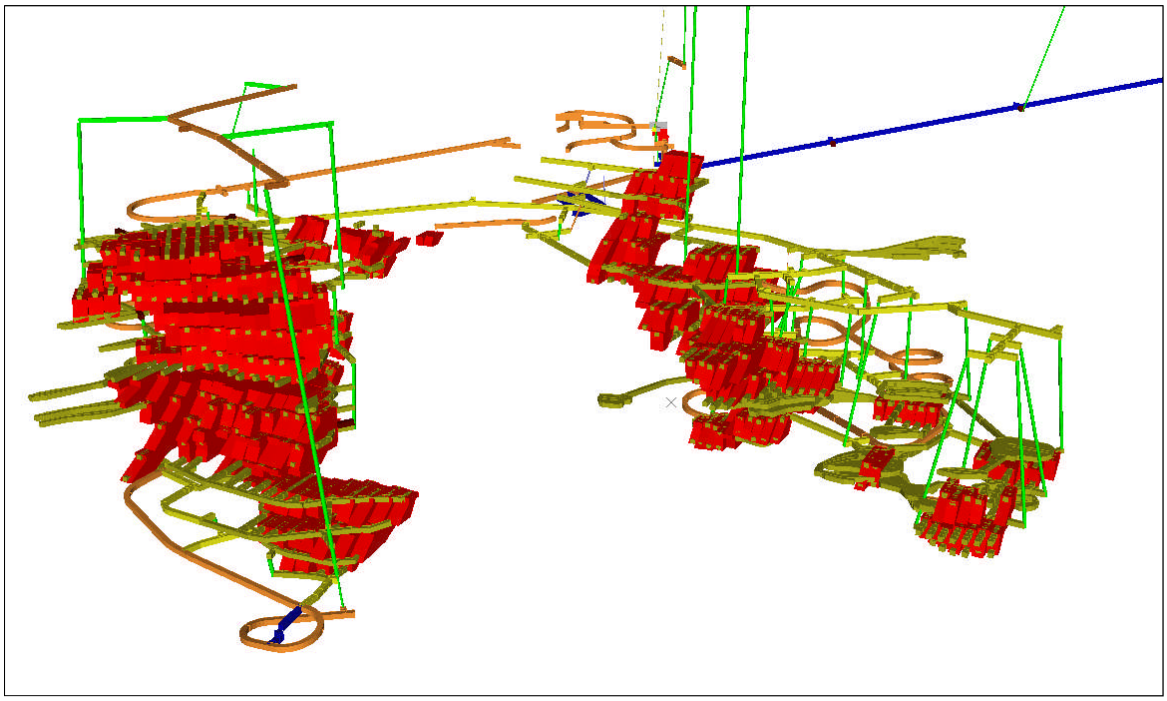


Figure 15.2: Lombador Phase 2 Optimised Bench and Fill Stopes Design

Drift and fill (DF) stopes are modelled using one 5m high lift of a drift-and-fill stope. A three dimensional view of DF stopes in Zambujal is presented in Figure 15.3.

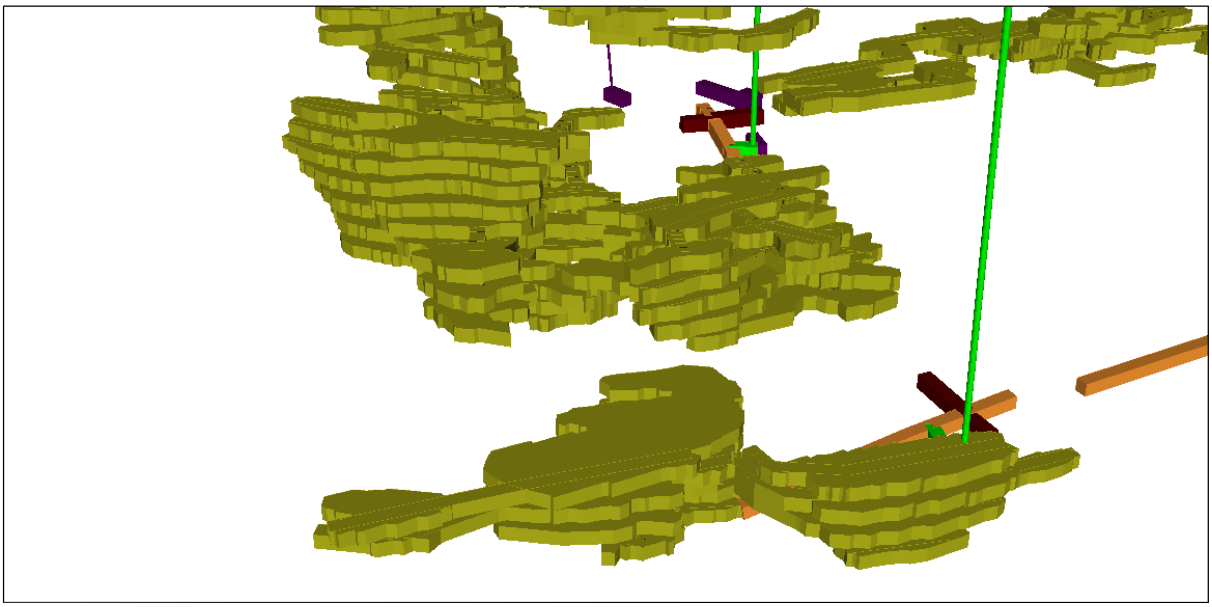


Figure 15.3: Zambujal Drift and Fill Stope Design

The stope and development designs are then processed in Datamine® Studio 5D Planner and EPS software to provide design quantities after modifying factors, activity constraint relationships and resource levelled schedules.

15.3 Mining Cut-Off

Neves-Corvo mine utilises a Net Smelter Return (NSR) calculation to determine the value of each individual stope or stope block. This is due to the polymetallic nature of orebodies, the Mineral Reserves are all calculated on a recovered payable basis taking into account copper, lead, zinc and silver grades, metallurgical recoveries, prices and realisation costs.

Each block of the Mineral Resource model is valued on the NSR and equated against the COV which is based on the variable plus sustaining costs of mining. The key drivers in the COV calculation are mining area and mining method due to the variable costs with support; ventilation; working time; materials handling etc. Table 15.1 presents the COV's used in the preparation of the Base Case Neves-Corvo 2016 Mineral Reserves.

Table 15.1: 2016 Cut-Off Values

Copper Ores		Corvo -680	Corvo +680	Graca*	Neves North	Neves South	Zambujal	Lombador Phase 1
Drift & Fill	€/t	40.77	44.18	42.37	43.52	42.43	42.41	47.05
Bench & Fill	€/t	33.93	37.34	35.53	36.68	35.59	35.57	40.20
Mini B&F	€/t	41.19	44.60	42.78	43.94	42.84	42.82	47.46
OBF	€/t							40.93
Zinc Ores		**Corvo -680**	**Corvo +680**	**Graca***	**Neves North**	**Neves South**	**Zambujal**	**Lombador Phase 1**
Drift & Fill	€/t	43.31	46.72	44.90	46.06	44.96	44.95	49.58
Bench & Fill	€/t	37.21	40.62	38.81	39.96	38.87	38.85	43.49
Mini B&F	€/t	43.61	47.03	45.21	46.37	45.27	45.25	49.89
OBF	€/t							44.18

* Includes Corvo +700 and Corvo +812.
Levels (elevations) relate to a datum of 1,000m below sea level.

In the expansion area (LP2) the following cut-off -values were determined to provide the preferred economic outcome: €60/t ore and €50/t ore Cut-Off Value (COV) for zinc OBF and copper BF stope ore respectively.

For Neves-Corvo, outside of LP2, the resulting average copper Mineral Reserve cut-off grade is equivalent to 1.3% and for zinc Mineral Reserve the cut-off grade is equivalent to 5.2%. For the LP2 area, Mineral Reserves average equivalent cut-offs are 1.6% for copper and 6.8% for zinc. The resulting site average equivalent cut-off grade for Mineral Reserves is 1.3% for copper ore and 5.7% for zinc ore.

15.4 Dilution

Mining dilution has been applied to the various mining areas and mining methodsby volume, this was selected as the most accurate means of reporting dilution correctly due to relative differences in

density between materials. Dilution is applied on the basis of development profile or stope lift-height, as per Table 15.2 below. The most typical dilution factors are highlighted in bold.

Table 15.2: Dilution by Volume (%)

Profile	Dimensions		Single Phase			Primary Phase			Secondary Phase		
	Width (m)	Height (m)	(%)	Sidewall (m)	Floor (m)	(%)	Sidewall (m)	Floor (m)	(%)	Sidewall (m)	Floor (m)
B1	**12.0**		**8.33**	**1.0**	**0.0**	**0.0**	**0.0**	**0.0**	**16.7**	**2.0**	**0.0**
B2	10.0		10.0	1.0	0.0	0.0	0.0	0.0	20.0	2.0	0.0
B3	8.00		12.5	1.0	0.0	0.0	0.0	0.0	25.0	2.0	0.0
B4	15.0		6.67	1.0	0.0	0.0	0.0	0.0	13.3	2.0	0.0
B5	5.00		20.0	1.0	0.0	0.0	0.0	0.0	40.0	2.0	0.0
B6	6.00		16.7	1.0	0.0	0.0	0.0	0.0	33.3	2.0	0.0
B7	4.50		22.2	1.0	0.0	0.0	0.0	0.0	44.4	2.0	0.0
B8	18.0		5.56	1.0	0.0	0.0	0.0	0.0	11.1	2.0	0.0
M4		4.50	12.7	0.3	0.3	6.7	0.0	0.3	18.7	0.6	0.3
M5		**5.00**	**12.0**	**0.3**	**0.3**	**6.0**	**0.0**	**0.3**	**18.0**	**0.6**	**0.3**
M6		**6.00**	**11.0**	**0.3**	**0.3**	**5.0**	**0.0**	**0.3**	**17.0**	**0.6**	**0.3**
M7		7.00	10.3	0.3	0.3	4.3	0.0	0.3	16.3	0.6	0.3
S1		1.00	36.0	0.3	0.3	30.0	0.0	0.3	42.0	0.6	0.3
S2		2.00	21.0	0.3	0.3	15.0	0.0	0.3	27.0	0.6	0.3
S3		**3.00**	**16.0**	**0.3**	**0.3**	**10.0**	**0.0**	**0.3**	**22.0**	**0.6**	**0.3**
S4		4.00	13.5	0.3	0.3	7.5	0.0	0.3	19.5	0.6	0.3
T1		1.00	36.0	0.3	0.3	30.0	0.0	0.3	42.0	0.6	0.3
T2		2.00	21.0	0.3	0.3	15.0	0.0	0.3	27.0	0.6	0.3
T3		3.00	16.0	0.3	0.3	10.0	0.0	0.3	22.0	0.6	0.3
T4		4.00	13.5	0.3	0.3	7.5	0.0	0.3	19.5	0.6	0.3

The most typical dilution volume factors are as follows:

- Bench and Fill = 8.33%, and
- Drift and Fill = M5 (5.0m height) 12.0%, M6 (6.0m height) 11.0%.

15.5 Mining Recovery

A global recovery factor of 95% is applied to account for extraction losses; in sill pillars mining recovery of 75% is applied.

15.6 Mineral Reserve Statement

The Mineral Reserve estimate for the Neves-Corvo deposits is classified in accordance with the CIM Standards. The effective date of the Mineral Reserve estimate is June 30, 2016. A summary of the Mineral Reserve statement for Neves-Corvo (including ZEP) is shown in Table 15.3 below.

Table 15.3: Total Mineral Reserves for Neves-Corvo (including ZEP)

Copper Zone Mineral Reserves					
	Tonnage (kt)	Grade			
		Cu (%)	Zn (%)	Pb (%)	Ag (g/t)
Proven	6,423	3.7	0.9	0.2	35
Probable	22,193	2.3	0.7	0.2	34
Proven + Probable	**28,616**	**2.6**	**0.7**	**0.2**	**34**
Zinc Zone Mineral Reserves					
	Tonnage (kt)	Grade			
		Zn (%)	Cu (%)	Pb (%)	Ag (g/t)
Proven	7,425	8.5	0.3	2.1	75
Probable	26,664	7.2	0.4	1.8	64
Proven + Probable	**34,089**	**7.5**	**0.4**	**1.8**	**66**

Notes:
1. Mineral Reserves are as defined by CIM Definition Standards on Mineral Resources and Mineral Reserves (2014);
2. Mineral Reserves are reported above their relevant NSR breakeven prices;
3. Metal prices used in the NSR evaluation are US$2.75/lb for copper, US$1.00/lb for zinc, US$1.00/lb for lead, and US$4.16/oz for silver;
4. The NSR is calculated on a recovered payable basis taking in to account copper, lead, zinc and silver grades, metallurgical recoveries, prices and realization costs. ;
5. Mining, processing and administrative costs were estimated based on actual costs;
6. Outside of LP2, the copper Mineral Reserve estimates are reported above a site average cut-off grade equivalent to 1.3% and for zinc Mineral Reserve estimates an average cut-off grade equivalent to 5.2% is used. For the LP2 area, Mineral Reserves average equivalent cut-offs are 1.6% for copper and 6.8% for zinc; and
7. Numbers may not add due to rounding.

16 MINING METHODS

16.1 Introduction

Underground mining at Neves-Corvo has been continuously conducted since 1988, with the current production plan for 2017 budgeted to be 2.4Mt copper ore grading 2.4% Cu and 1.1Mt zinc ore at a grade of 8.6% Zn.

The mine operates on a four panel shift system with three crews working Monday to Saturday and two crews working on Sunday. Shifts are 7.5 hours in length.

The mining department has at present a total of 700 staff in production, development services, maintenance, engineering, planning, rock mechanics, geology and exploration.

The mine is accessed by a 5m diameter circular concrete-lined shaft situated to the west of the main Corvo orebody and a main ramp, which has been developed from surface to the 700 Level. Underground levels (elevations) relate to a datum of 1,000m below sea level. The mine surface elevation is approximately 220mASL, or 1,220m above datum.

The shaft is 600m deep and extends marginally beyond the 700 Level; it is equipped with rope guides, a 2.5MW double drum winder and two 17.8t (wet load) capacity skips. Potential peak capacity of the shaft has been established at 5.4Mtpa.

The upper underground crusher station is located at the 700 Level and crushes ore and waste from the Upper Corvo, Neves, Zambujal and Graça orebodies. This facility has four 1,500t capacity storage bins and a jaw crusher capable of handling up to 600t/hr.

A second crusher at the 550 Level currently services the lower section of the mine, which extends from the 700 Level to below the 550 Level. This currently crushes ore from Lower Corvo and Lombador, into three storage bins. Material from the storage silos feeds onto a short sacrificial conveyor and subsequently to the TP12 inclined conveyor, which delivers the crushed material to the 700 Level bins. This system also has an installed capacity of 600t/hr.

The main access ramp from surface has been developed at an average gradient of 17%, has a cross sectional area of 18m^2 and provides vehicular access to the mine. This ramp handles all the movement of men and materials in and out of the mine. On day shift there are up to 300 persons underground and about 150 on each of the other shifts.

Additional internal ramps have been developed within the mine to access the various orebodies and carry out exploration development. Development for the future conveyor ramps to the lower part of the Lombador orebody was initiated in May 2017. The access ramp for the Lombador orebody is currently at 220 Level.

There is a small cage in the hoisting shaft which can be used for emergency egress. The cage can hoist eight men at a time with a cycle time of about eight minutes. The cage cannot operate when the skips are working since it is not in a separate bratticed compartment. As an addon emergency egress system platforms can be installed in the skips, each of which can take five or six men.

Conventional electro-hydraulic development drill rigs and diesel powered LHD units, hauling to ore passes in the footwall drives, are employed. Support is generally provided by Swellex friction rock bolts in ore and resin rebar in waste, both installed on a regular pattern, with additional support requirements addressed by the installation of cablebolts and the application of shotcrete.

The mine has five fully equipped underground workshops for mobile and fixed plant repair situated at the 810, 700 and 590, 550 and 380 Levels. A new 3,300 m^3 workshop is planned on or about the 220 Level for LP2, to be initially used by the development contractor during development of the materials handling excavations and LP2 access ramps, then subsequently servicing LP2 North and South as well as the crusher station.

In parallel with the production increases from the existing areas, new access development and materials handling infrastructure will be built to prepare the Lombador orebody for higher throughput rates and for expansion at depth. Overall views are provided in Figure 16.1 and Figure 16.2.

Production throughput has been maintained at consistent levels at Neves-Corvo, as demonstrated by the production results from the last five years, shown Table 16.1 below.

Table 16.1: Neves-Corvo Total Mine Production Figures 2012-2016 inc.

		2016	2015	2014	2013	2012
ORE MINED	**Unit**					
Copper	('000 t)	2,351	2,501	2,540	2,535	2,507
Zinc	('000 t)	1,041	1,000	1,119	968	530
ORE MILLED						
Copper	('000 t)	2,386	2,542	2,503	2,525	2,512
Zinc	('000 t)	1,039	1,014	1,102	974	543
HEADGRADE						
Copper (%)	(%)	2.5	2.7	2.5	2.6	2.6
Zinc (%)	(%)	8.2	8.0	8.0	7.1	7.3

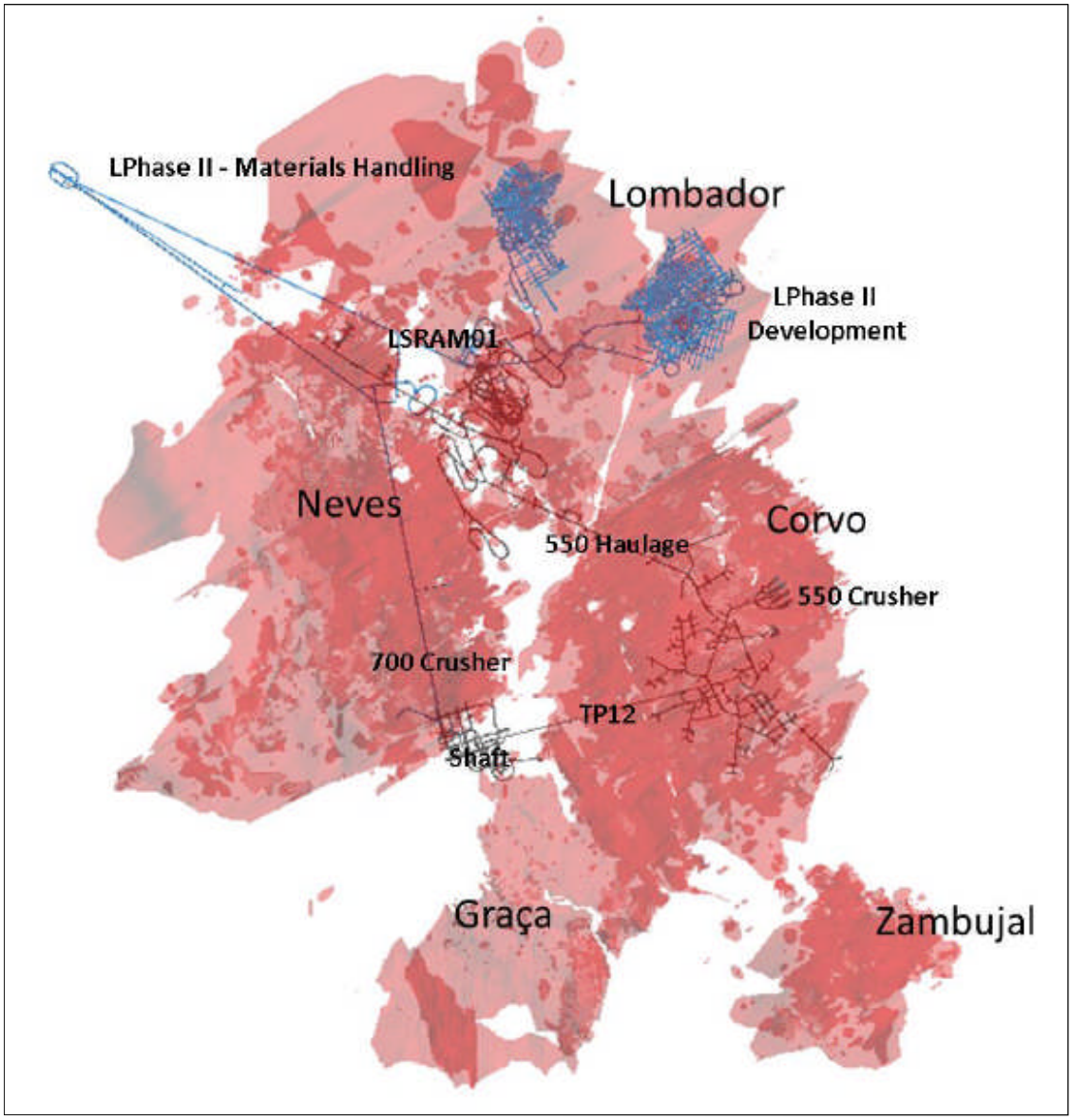


Figure 16.1: Plan View Showing Neves-Corvo Orebodies with the Main Existing and Proposed Extraction Facilities

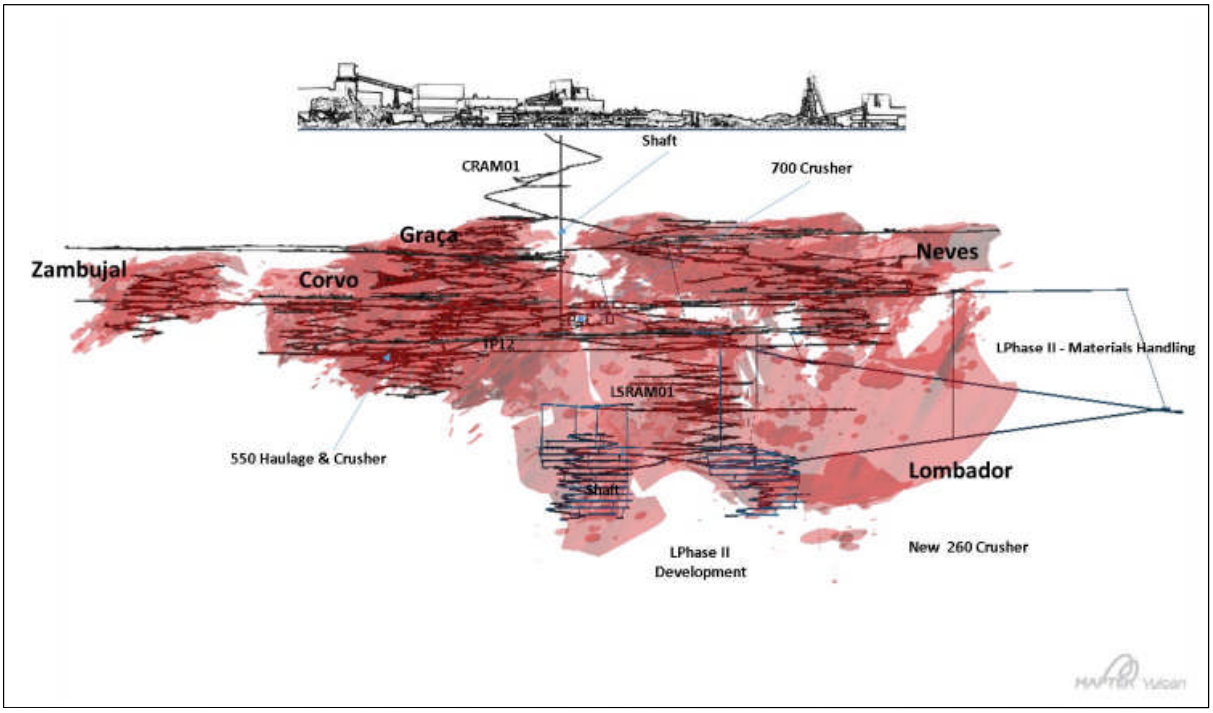


Figure 16.2: Vertical Section Showing Neves-Corvo Orebodies with the Main Existing and Proposed Extraction Facilities

16.2 The Base Case

The term Base Case is used extensively throughout this report and refers to the current operations at Neves-Corvo, without the ZEP and consequently without LP2. In summary, it includes the following assumptions:

- A copper process plant with a throughput capacity of 2.5Mtpa;
- A zinc process plant with a throughput capacity of 1.1Mtpa;
- A hoisting shaft with a capacity of approximately 4.9Mtpa; and
- A TMF with an approved design through to 2019, but licensing is done in stages so the total facility is sufficient for Base Case operations through to approximately 2030.

Further details of the capacities of existing systems and facilities are provided in the various main report sections.

The existing Base Case Neves-Corvo Mineral Reserves (excluding ZEP) are summarised in Table 16.2 below. This excludes the new LP2 area.

Table 16.2: Neves-Corvo Mineral Reserves (excluding ZEP) as of June 2016										
Ore Reserve Category	**Copper Ore (kt)**	**Cu (%)**	**Zn (%)**	**Pb (%)**	**Ag (g/t)**	**Zinc Ore (kt)**	**Cu (%)**	**Zn (%)**	**Pb (%)**	**Ag (g/t)**
Proven	6,423	3.7	0.9	0.2	35	7,425	0.3	8.5	2.1	75
Probable	19,716	2.3	0.7	0.2	35	16,024	0.4	6.5	1.4	63
Total Neves-Corvo	**26,139**	**2.7**	**0.7**	**0.2**	**35**	**23,449**	**0.4**	**7.2**	**1.6**	**67**

Note: The copper Mineral Reserves are reported above a site average cut-off grade equivalent to 1.3% Cu, and for zinc Mineral Reserves at an average cut-off grade that is equivalent to 5.2% Zn is used.

The current Neves-Corvo Base Case Life-of-Mine ("LoM") includes a steady rate of copper metal production of between 40,000 – 55,000tpa through to 2022, thereafter copper output is projected to decline allowing for spare shaft capacity. However, zinc mining can be sustained for over 20 years providing metal prices and operating costs remain favourable.

Based on the current 2016 LoM plan, costs, and metal prices for Neves-Corvo, Base Case operations continue until 2030. Also based on the current LoM, excluding an expansion, zinc metal production is expected to remain steady between 65,000tpa to around 75,000tpa until 2030.

16.3 Zinc Expansion Project (ZEP)

16.3.1 Introduction

In 2011 a FS identified positive results for expanding zinc production capacity at Neves-Corvo from identified Mineral Resources discovered in the Lombador orebody, this expansion became known as LP1. As LP1 was below the existing material handling infrastructure (700-1,000m below surface), new decline access (ramps), fuel stations, workshops, and service installations were required for LP1.

The development of the Lombador decline ramp provided access for further geological drilling of deeper areas of the resource, which identified further extensions to the Lombador orebody. Subsequent analysis indicated that additional zinc Mineral Reserves would be required to justify further expanding the zinc processing plant. It was also recognised that to achieve effective and economic production from the new deeper area, it would require a new underground materials handling system to more efficiently transport ore from a depth of approximately 1,200m below surface, this system upgrade forms an integral part of what has been termed; Lombador Phase 2 ("LP2").

A series of studies were then initiated to examine materials handling and throughput rate options;

- Future Materials Handling studies, which demonstrated marginal economic conditions for a copper and zinc expansion to 2.7 and 3Mtpa respectively, with large-scale new materials handling systems to surface;
- A conceptual assessment of LP2 mining, which demonstrated a number of options to reduce waste development, culminating in the positioning of some ramp and sublevel development within low grade mineralisation of sufficient value to cover the

development costs and a revised mining method known as optimised bench-and-fill; and

- A series of more modest materials handling solutions, culminating in a new 260 Level crusher and new conveyor system to 700 Level.

These studies culminated in recommendations to proceed to a full Feasibility Study, the scope of which included a new crusher on 260 Level and a new conveyor system to 700 Level, an upgrade to the existing Santa Barbara hoisting shaft and an expanded zinc plant to a capacity of 2.5Mtpa. This was named the ZEP for which a FS was completed in 2015.

Consequently, the ZEP is reliant on three principal mining upgrades to provide the increased zinc ore throughput to the mill. These are:

- An increase of zinc ore production from the existing mill constrained mining areas;
- The development of a new, deeper production area denoted as Lombador Phase 2 (LP2); and
- An upgrade and expansion to the materials handling system.

The latter point has two major components; a new crushing and conveying system for the Lombador orebody and the shaft hoisting system.

It is also important to emphasise that the increase in zinc production requires an increase from all existing mining areas in addition to the expansion of the Lombador mining area.

In September 2016, an Early Works Programme was initiated which included a “Cold Eyes” review of the technical parameters and designs of selected areas of the ZEP, including, underground materials handling, ventilation and shaft upgrade. These reviews resulted in the identification of a number of optimizations incorporated below.

16.3.2 Life of Mine Production Plan

Base Case zinc production at Neves-Corvo is currently constrained by the existing mill capacity of 1.1Mtpa. Aside from an additional economic grade copper discovery, the best opportunity to improve operating margins on site is to increase zinc production. Such an opportunity exists due to the presence of zinc Mineral Reserves located at depth below the current LP1 workings. A series of studies have now been completed to integrate this deeper, LP2 mining area, and contribute to a sustainable increase in zinc production from the site.

This ZEP FS (2015) and its subsequent Amendment (2017) provides a definition of the additional Mineral Reserves offered by the new LP2 area. Table 16.3 below summarises the Mineral Reserves added with the approval of the ZEP.

A total of 1.5Mt of zinc ore included in the LP2 mining schedule, has been removed from the LP1 (Base Case) schedule, to avoid creating unnecessary sill pillars and the consequential sterilisation of Mineral

Reserves. These Mineral Reserves have not been included in the table below to avoid duplication with the Base Case Mineral Reserve.

Table 16.3: LP2 Expansion Mineral Reserves as of June 2016

Category	Copper Ore (kt)	Cu (%)	Zn (%)	Pb (%)	Ag (g/t)	Zinc Ore (kt)	Cu (%)	Zn (%)	Pb (%)	Ag (g/t)
Proven	-	-	-	-	-	-	-	-	-	-
Probable	2,477	2.3	0.4	0.1	23	10,640	0.3	8.3	2.3	65
Total LP2	2,477	2.3	0.4	0.1	23	10,640	0.3	8.3	2.3	65

Based on an equivalent cut-off-grade of **1.6%** Cu for Bench & Fill stopes and **1.8%** for Drift & Fill stopes
Based on an equivalent cut-off grade of **6.8%** Zn for OBF stopes and **7.8%** Zn for Drift & Fill stopes

As a result, approval of the ZEP increases the overall Neves-Corvo Mineral Reserves to as shown in Table 16.4.

Table 16.4: Neves-Corvo Mineral Reserves with ZEP as of June 2016

Category	Copper Ore (kt)	Cu (%)	Zn (%)	Pb (%)	Ag (g/t)	Zinc Ore (kt)	Cu (%)	Zn (%)	Pb (%)	Ag (g/t)
Proven	6,423	3.7	0.9	0.2	35	7,425	0.3	8.5	2.1	75
Probable	22,193	2.3	0.7	0.2	34	26,664	0.4	7.2	1.8	64
Total LP2	28,616	2.6	0.7	0.2	34	34,089	0.4	7.5	1.8	66

In the Neves-Corvo ZEP copper Mineral Reserves reported above, the resulting site average equivalent cut-off grade is 1.3% for Cu. For zinc Mineral Reserves the resulting site average equivalent cut-off grade is 5.7% Zn.

Previous studies have demonstrated that the main obstacles to expansion are the existing shaft capacity of 4.9Mtpa and the zinc plant capacity of 1.1Mtpa. The ZEP FS includes an upgrade to these facilities. Key physical parameters for the ZEP, compared to the Base Case, are presented in Table 16.5 and Figure 16.3 illustrates the metal outputs for both zinc and copper, for the Base Case and ZEP FS Amendment of 2017. The expansion will allow the site to produce in excess of 150,000 tonnes of zinc metal per year through the peak production periods of 2020 to 2025, along with a significant increase in lead production.

Table 16.5: Summary of Key Physical Inputs			
Physical Inputs	**Units**	**Base Case 2020-2030**	**ZEP Case 2020-2030**
Copper Ore	Mt	14	18
Zinc Ore	Mt	12	25
Average Copper Grade	%	2.4	2.4
Average Zinc Grade	%	7.2	7.5
Average Lead Grade	%	1.6	1.9
Average Copper Recovery	%	84.0	85.3
Average Zinc Recovery	%	80.6	81.9[1]
Average Lead Recovery	%	24.1	44.9
Copper Metal Produced	kt	289	362
Zinc Metal Produced	kt	730	1571
Lead Metal Produced	kt	47	214
Average Annual Copper Metal	kt	26	33
Average Annual Zinc Metal	kt	66	143
Average Annual Lead Metal	kt	4	19

1. The 81.9% includes a 6-month ramp-up period. If the ramp-up period is not considered, then the average zinc recovery is 82.2% for the period

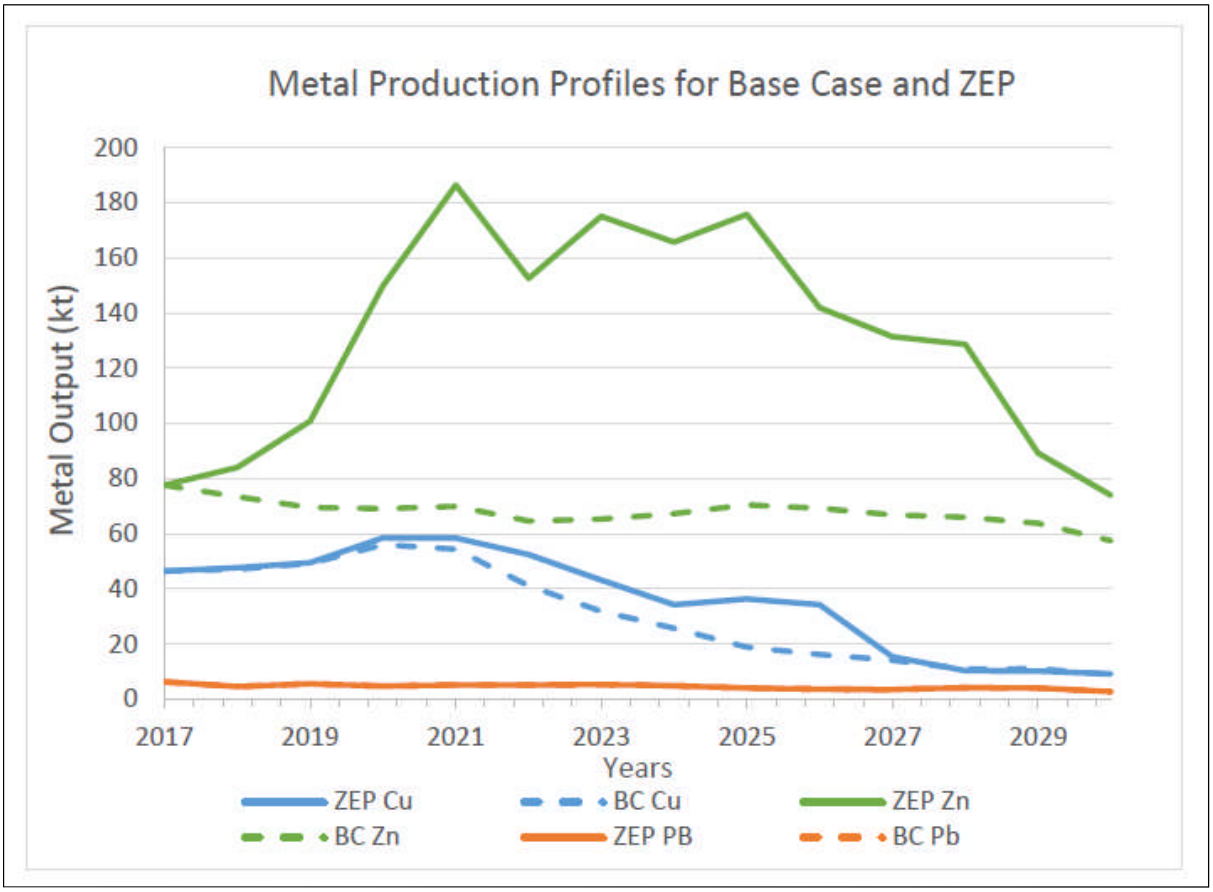


Figure 16.3: Metal Production Profiles for Base Case and ZEP Amendment

16.3.3 Underground Excavation Development

The critical path for the project within the mine lies in completing the excavation for the underground crusher and conveyors so that mechanical installation can commence during 2018. If work is delayed, then the zinc plant expansion will not be able to run at its full capacity. However, this risk can be offset by the mine's ability to produce additional ore from orebodies outside LP2.

The underground development work plan has been issued to the current horizontal development contractor at Neves-Corvo, so that the work can start immediately. The work has been incorporated into the existing contract, which has been renegotiated to a lower rate. If the work is delayed, then a contingency plan can be drawn up to increase the mill feed rate for a limited time using truck haulage and the existing crushers.

16.3.4 Risks and Opportunities

A comprehensive risk assessment was completed during the ZEP FS. This has been updated as part of the FS Amendment Study. Opportunities for further improvements are:

- Optimisation of the current LoM to derive more value from the business; and
- Inferred Resources are not included in the Mineral Reserves and it is therefore probable that the total mineable tonnage can expand.

16.3.5 Zinc Expansion Plan – LP2 Overview

With reference to the second of the main points associated with the ZEP, an integral part of the Project is the development of a new, deeper production area, LP2.

The new area, LP2, is a down-dip continuation of the large massive sulphide zinc deposit currently being mined in LP1. The Lombador orebody is of particularly high zinc grade in comparison to the other Neves-Corvo mining areas. There is also a stockwork hosted copper Mineral Resource located in the footwall of this massive sulphide body.

The mining methods proposed for the new LP2 area are:

- Optimised-bench-and-fill (OBF) for zinc stopes within massive sulphide mineralisation;
- Bench-and-fill (BF) for the copper stopes within stockwork mineralisation; and
- Limited Drift-and-Fill (DF) stoping is also planned for both the zinc and copper ore.

OBF was successfully implemented in LP1 for the first time and is being rolled out to other areas of the mine. DF and BF has been in use throughout various Neves-Corvo orebodies since the mid-1990s.

The backfill types used in the new production area, LP2, are: Paste fill (PF) made from cycloned process tailings; cemented rock fill (CRF); and rock fill (RF) produced from underground development waste. As is the case in LP1, no plan has been made to use hydraulic sandfill.

The principal differences in mining LP2, relative to mining in the current operating areas are: the greater depth, and consequent stress and heat; and the position of the level development within or close to the orebody due to the marginal value of the ore.

A new crusher-conveyor rock handling system will be located in the footwall of the Lombador orebody at approximately 260 Level between the northern and southern mine areas (notionally termed the 260L Crusher). Ramps have been designed to extend into the two mine areas (Lombador South and Lombador North), with trucks from both ramps tipping into the 260 Level Crusher bins. Rock will be conveyed from the 260 Level Crusher bins (two bins) to the two 700 Level bins for hoisting to surface via an upgrade to the Santa Barbara Shaft.

16.4 Underground Grade Control Sampling

The mine utilises two main forms of stope development, namely DF where the orebodies are thin and high grade, with dips between 15-45°; and BF or OBF where the ore is >16m thick, be of a single ore type and dip at >45° or <15° (mini bench-and-fill is used where the ore is <10m thick).

For DF, current grade control sampling involves face sampling to a particular pattern dependent on the ore type being sampled. For massive ores, nine chip samples are collected from a 5m x 5m face. For fissural ores, six channel samples are collected across each face.

For low grade copper bench-and-fill stopes, grade control requires the drilling of between two to six core holes in any one bench as blast holes cannot be used because the chalcopyrite is washed out of the holes. These results are then used for stope definition and resource input.

Underground samples are located during collection by measuring from the closest survey point. Each sample is assigned 3D coordinates in Vulcan and imported into the geological database (BDGeo).

16.5 Stoping Methods

The mining methods used across the Neves-Corvo operations have been tried, tested and developed over more than 25 years of continuous mining.

Two mining methods make up the majority of production at Neves-Corvo, these being Drift-and-Fill and Bench-and-Fill stoping. Both of these methods have been well adapted and tailored to the large but locally complex high grade ores present throughout the operations. Further details on these and the other mining methods are laid out below.

16.5.1 Drift-and-Fill

Drift-and-fill was the original mining method selected for Neves-Corvo. Although the method has relatively low productivity rates and high unit costs, it was chosen because it is highly flexible and can achieve high recovery rates in high grade orebodies with complex and flat dipping geometries. The initial copper reserves at Neves-Corvo, largely in the Graça and Upper Corvo orebodies, averaged in excess of 8.0%Cu and it was important to select a method that extracted all of this high grade mineralisation. Figure shows the typical drift-and-fill layouts used at the mine.

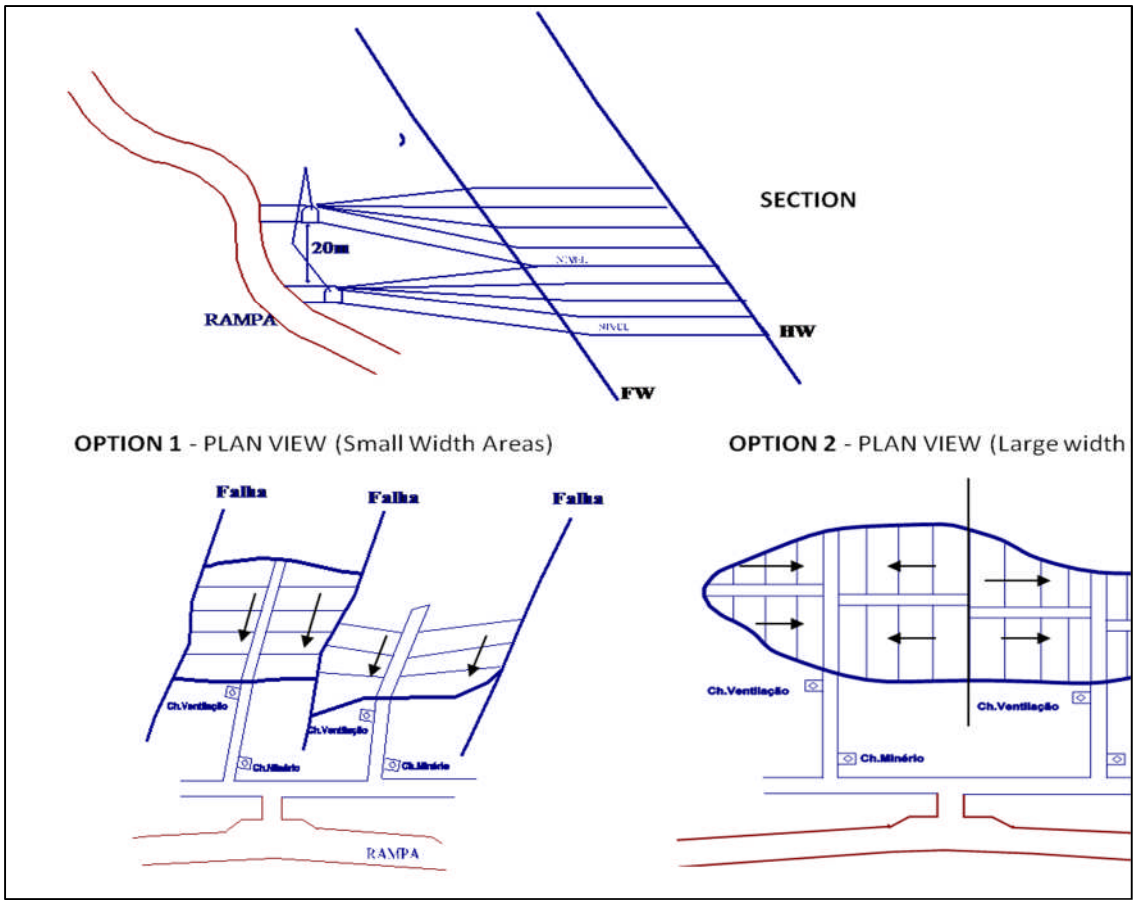


Figure 16.4: Typical Drift-and-Fill Mining Layouts used at Neves-Corvo

Drift-and-fill stopes at Neves-Corvo are normally accessed from a footwall ramp with footwall access drives driven along the orebody strike at 20m vertical intervals. Access crosscuts are driven down from the footwall access drives in to the orebody. A horizontal slice is subsequently mined using drifts developed either longitudinally or transversely in sequence. Standard drift dimensions are 5.0m x 5.0m, with the sidewalls often being slashed before backfilling. Following completion of a drift it is tightly backfilled with hydraulic sand fill or Paste fill before the drift alongside is mined. When a complete 5m high orebody slice is mined and filled, the back of the access drive is “slashed” down and mining recommences on the level above.

Drift-and-Fill is generally applied to areas of the mine with a mining thickness of less than 10m and has become the prevalent mining method at Neves-Corvo as the thicker parts of the orebodies that are more suitable for bench and fill mining have become depleted.

16.5.2 Bench and Fill

The bench-and-fill mining method has long been used at Neves-Corvo in areas where the mineralisation is of sufficient thickness and continuity. The method is more productive and has lower operating costs than drift and fill mining. The method is generally applied in areas of the orebodies greater than 20m in vertical thickness.

Bench-and-fill stopes are also accessed from a footwall ramp, with footwall drives driven along strike in waste at 20m vertical intervals. Upper and lower access crosscuts are driven across the orebody to the hangingwall contact, as shown in Figure 16.5.

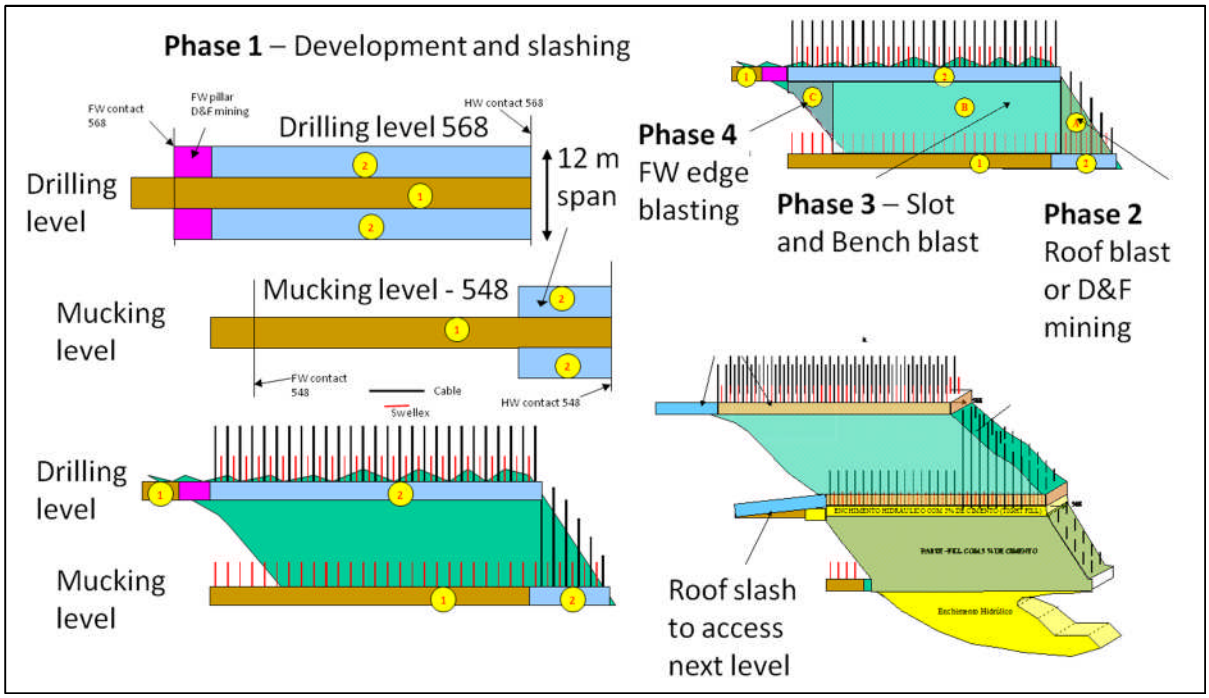


Figure 16.5: Bench-and-Fill Mining Method (Schematic)

The top access is normally opened up to the full 12m stope width and appropriate support installed, including cablebolts and shotcrete as required. A slot raise is opened at the hangingwall end of the stope and is then enlarged, providing free face for the whole width of the stope. Vertical rings of large diameter drill holes are then drilled and blasted on retreat to the footwall. Loading of the broken ore takes place from the lower access using remote-controlled load-haul-dump vehicles.

Primary BF stopes have been mined up to 120m long, but secondary stopes are more typically broken in to 30 to 40m across-dip lengths before being backfilled. The stopes are normally mined in an up-dip primary-secondary sequence. Primary stopes are normally filled with cemented paste fill and then tightly filled with hydraulic sand fill. Secondary stopes are filled with either waste rock or low cement

paste fill and then also tight filled with hydraulic sand fill, with the exception being in the Lombador area, where hydraulic fill has not been used.

Following the satisfactory completion of the backfilling process for each BF stope, the back of the former drilling level is slashed out to establish a new mucking level for the next stope above.

Plans are in place to alter the BF mining method slightly in some areas by no longer slashing out the backs of former drilling levels when creating subsequent mucking levels. Instead, mucking levels would be created by mining through or on-top of the in-situ backfill in the drill drives and re-establishing the existing excavation.

16.5.3 Mini Bench-and-Fill

Mini bench-and-fill (MBF) is a hybrid method providing greater productivity than conventional drift-and-fill where orebody thicknesses are between 10-15m. Accesses are again developed in the footwall via ramps and footwall drives. In mini bench-and-fill, drilling and mucking take place on different horizons but from opposing ends with crosscuts 5 to 10m apart vertically, as shown in Figure 16.6.

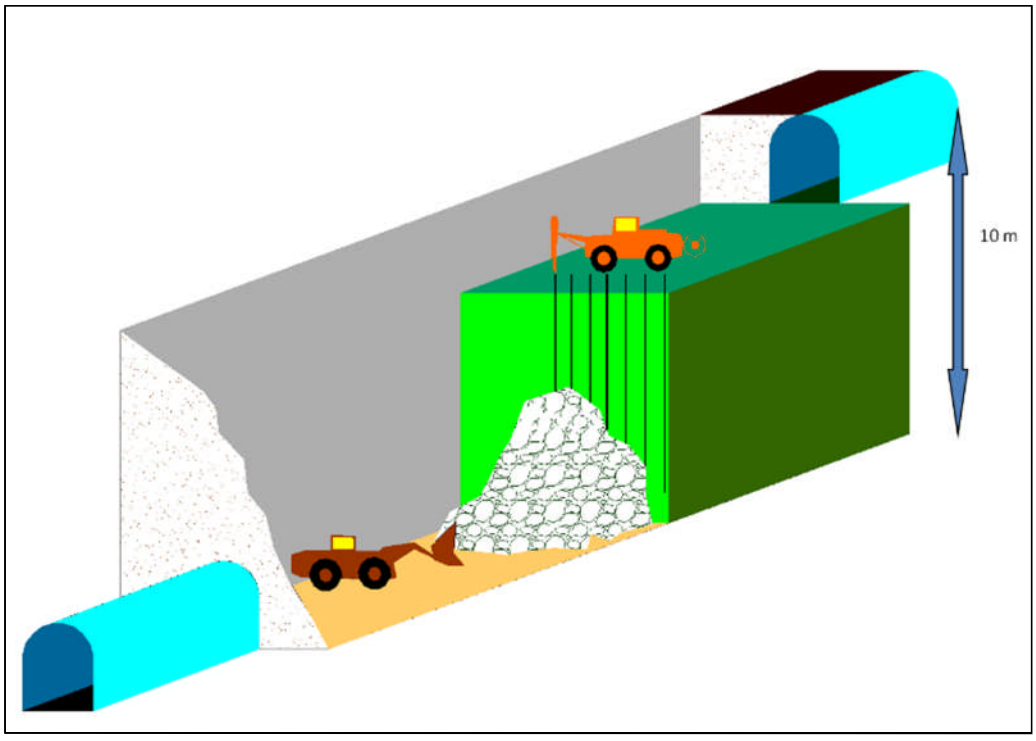


Figure 16.6: Mini Bench-and-Fill Mining Method (Schematic)

Unlike BF, MBF stopes are sometimes mined along strike. Typically, 5.0m x 5.0m drifts from the upper crosscut are mined along strike until they reach the back of the lower crosscut (usually 40m) and they break through to form a drawpoint. Vertical holes are then drilled and blasted in retreat from the drawpoint back to the upper crosscut, with mucking taking place via the lower crosscut. Mini bench-and-fill stopes are normally mined in a primary-secondary sequence, with tight filling achieved using

hydraulic sand fill. The current Life-of-Mine plan only includes very small tonnages to be mined by this method.

16.5.4 Sill Pillar

A sill pillar mining method was developed at Neves-Corvo to extract the ore remaining in sill pillars created between up-dip mining panels.

From the footwall access a central crosscut is developed through the orebody to the hangingwall and is heavily supported with cablebolts breaking in to the fill above, close pattern rockbolting and shotcrete. A hangingwall access is then driven along the strike of the orebody outside the overlying backfill and from this drive crosscutting drifts are developed to the footwall contact, as shown in Figure 16.7.

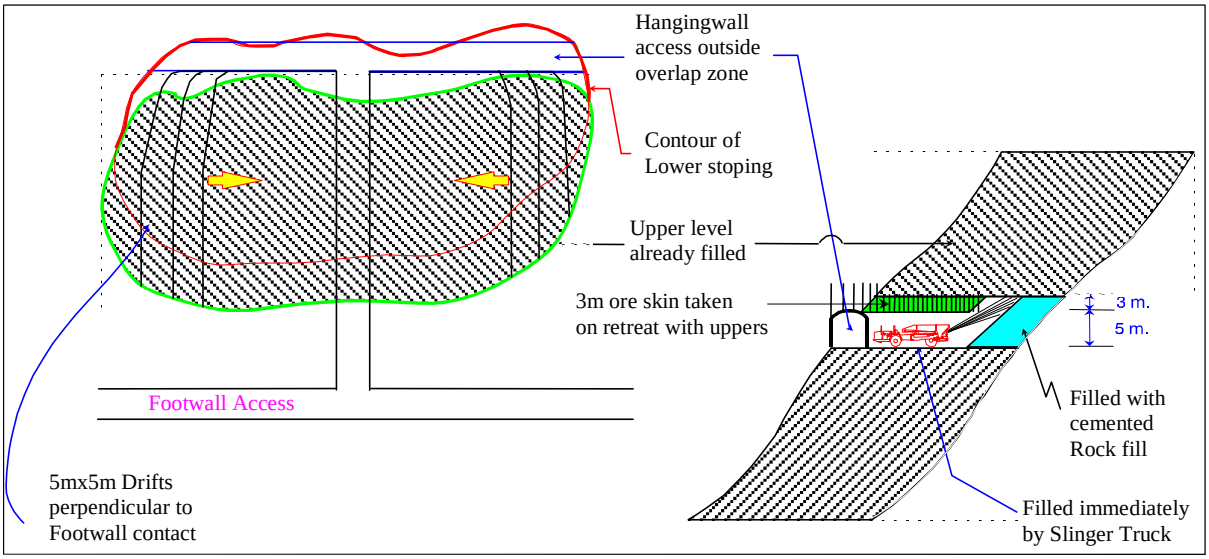


Figure 16.7: Sill Pillar Mining Method (Schematic)

This final 8m thick slice beneath the overlying backfill is removed in two stages, one slice of 5m when the normal drift is developed in advance and then a final 3m slice, which is blasted down from the roof of this drift in retreat. This final slice is slashed off the back and rapidly backfilled using CRF applied with a slinger truck to fill achieve as tight a fill as possible from a safe, remote position. Successive crosscutting drifts are then mined back to the central access drive accordingly. Up to 95% ore recovery of some high-grade sill pillars has been achieved using this method.

Note that LP2 has a zinc orebody with a lower net smelter return in comparison to the previous and current Neves-Corvo copper orebodies. Therefore, this high cost extraction method is not envisaged for use in LP2.

16.5.5 Optimised Bench-and-fill

Optimised Bench-and-Fill was developed to benefit from the competent massive sulphide hosted MZ ore and obtain a lower cost mining method with similar recovery rates of BF. During the previous LP1 studies, investigations into suitable low cost mining methods, including caving and variations thereof, were conducted and reported. Following several financial analyses, OBF was adopted as the preferred method. Optimised Bench-and-Fill presents significantly less geotechnical challenges than a traditional stacked bench or Long-Hole-Open-Stoping (LHOS) solution, while maintaining high levels of Mineral Reserve recovery and lower operating costs cost than the traditional Neves-Corvo BF.

Optimised Bench-and-Fill has been successfully implemented in LP1 and later in other Neves-Corvo orebodies. This method is described below and is recommended as the primary method of extraction for the LP2 expansion.

The OBF mining method is a bottom-up method utilising transverse stopes accessed from footwall ramps and crosscuts. It involves the initial extraction of primary stopes followed by backfilling and subsequent extraction of secondary stopes formed between the previously mined and paste filled primary stopes. Primary and secondary stopes will be 15m wide by 20m high and will vary in length depending on the width of the orebody. The primary and secondary stope extraction is completed before production starts on the next level above, see Figure 16.8.

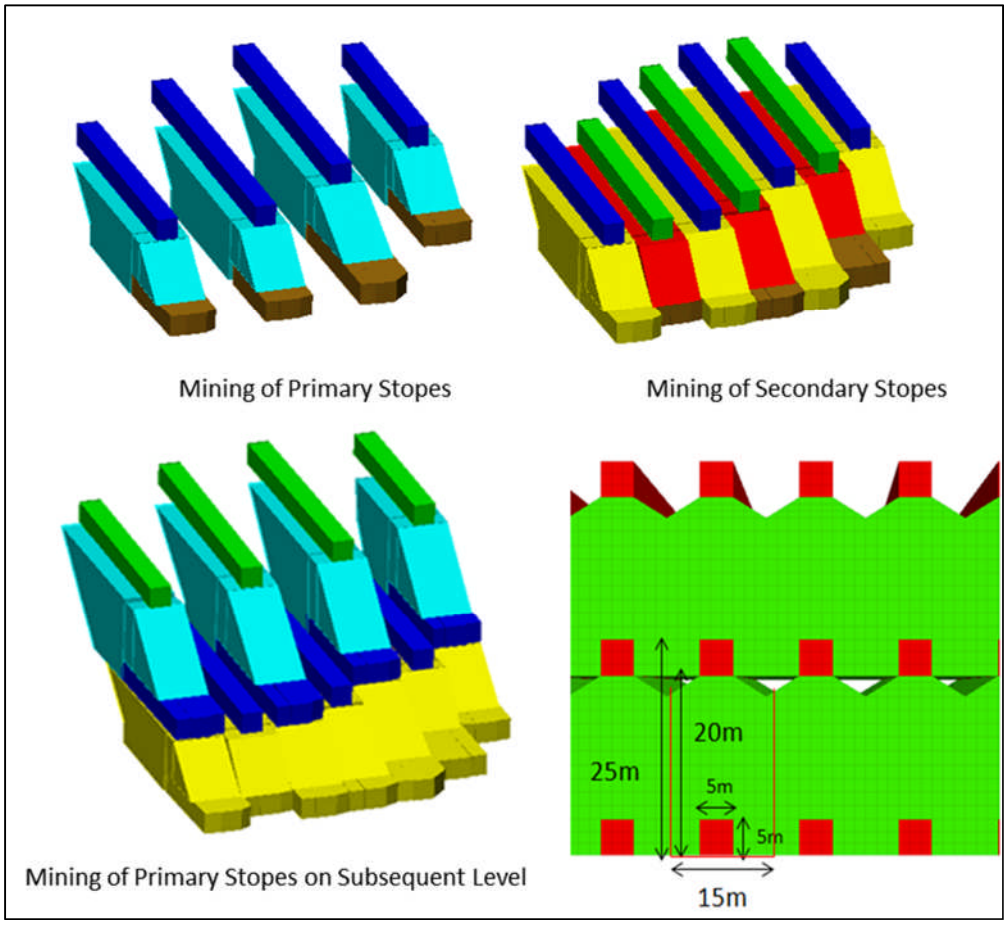


Figure 16.8: Optimized Bench-and-Fill Mining Method (Schematic)

16.6 Lombador Phase Two Expansion

The LP2 expansion area fills the shortfall in zinc production created as a result of the accelerated zinc production plan. The LP2 area is situated down-dip of LP1 and includes all of the zinc mineralisation below 320 Level in Lombador South, as well as the copper mineralisation below 280L and all mineralisation below 220 Level in Lombador North, (see Figure 16.9). LP2 ranges in depth from 900 – 1,200m below surface.

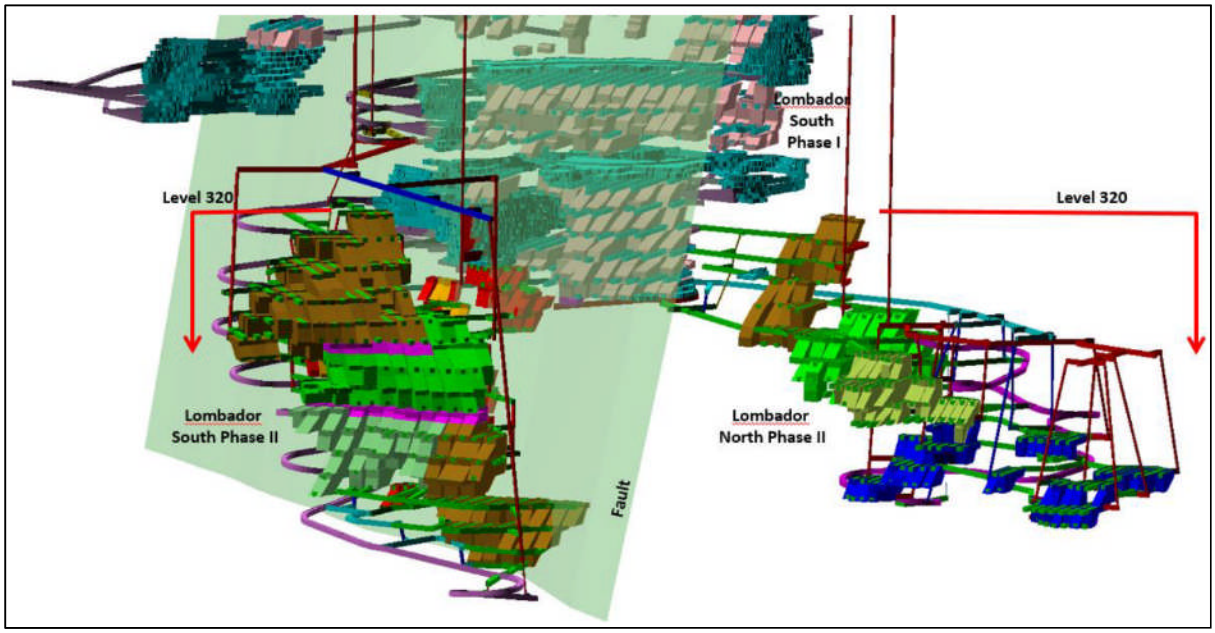


Figure 16.9: Lombador Phase 2 Expansion Area

As per the other orebodies, the Lombador orebody is comprised of a massive sulphide lens underlain by an area of stockwork that dips to the northeast at about 35° (ranging from 10° to 55°) and has a shallow plunge to the northwest. The massive sulphide lens is up to 100m thick in the deeper areas and extends for approximately 1,100m down-dip and 1,600m along strike.

The mineralised zone of the lens has a length of approximately 900m down-dip and 400m along the strike.

The LP2 FS design area is situated approximately between the 320 Level and 0 Level. The southern part of LP2 is a contiguous down-dip extension of the LP1 stopes. However, Phase 1 and Phase 2 are defined by a major fault intersecting the massive sulphide. The northern part of LP2, however, is not contiguous with LP1 designs. The LP2 stope designs terminate at a depth of 1,200m, on 20 Level, as shown in Figure 16.10. The existing Lombador ramp (for LP1) is located in the footwall of the Lombador orebody and terminates at approximately 220L.

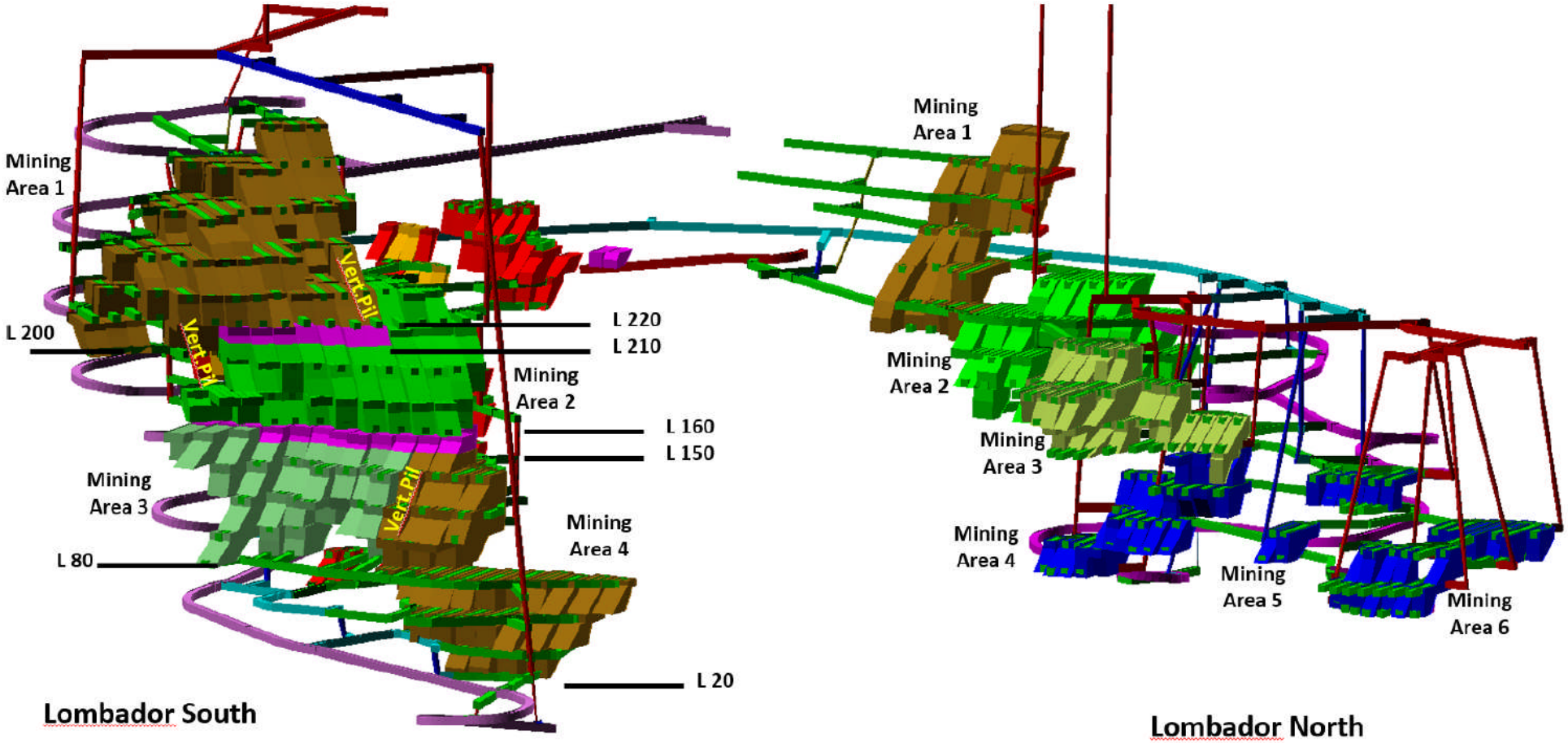


Figure 16.10: LP2 Mining Areas and Levels

16.7 LP2 Mine Stoping Layouts

16.7.1 Stoping Design General

The Datamine Mineral Resource model ("n14lomb") used for the updated designs in the LP2 FS-Amendment is a conversion from the Vulcan geology model "somlombador-3001000_n14.bmf".

This model represents the Lombador Mineral Resource as of 2016 and is described in the Geology section of this report. The Datamine Mineral Resource model also includes NSR values for the Zn and Cu mineralisation.

The LP2 stope designs for the MZ sulphide orebodies use primarily the OBF mining method. The FC orebodies use the BF method. Both methods are variants of benching with backfill described in section 16.12.

The OBF method is not applicable to the LP2 stockwork orebodies (zinc or copper) due to geotechnical conditions and the BF is generally not applied in MZ orebodies due to higher unit rate excavation costs.

Tests are ongoing with OBF stoping in limited areas of stockwork in the current operations. If these tests prove successful there is an opportunity to further reduce operating costs in some copper mining which may also be applicable to LP2.

During the conceptual phase of the expansion study a trade-off was carried out with various COV against varying production rates. See COV discussion in Section 15.3 of this report.

16.7.2 Development Design General

Table 16.6 and Table 16.7 summarise the development design requirements as estimated in the FS by excavation type and accounting category for the life of the LP2 expansion. Development dimensions range between approximately 5-6m in width and 5-6m in height, depending on functionality.

Table 16.6: Capital Development Requirements by Mine Area				
Capital Development	**Unit**	**South**	**North**	**Total**
Ramp, ramp stockpiles, sumps, bays and allowances	metres	3,822	3495	7317
Level Development	metres	4,449	2,977	7,426
Substations	metres	155	155	310
Ventilation Accesses	metres	3,501	1,601	5,102
Ventilation Intake/Exhaust (Raisebored)	metres	1,765	507	2,272
Ventilation Intake/Exhaust (drop-raise)	metres	248	107	355
Egress (Raisebored)	metres	256	217	473
Service Holes (Raisebored)	metres	855	394	4,649
Conveyor Drive and Transfer Points	metres	-	-	3,400
Access to Conveyor & Crusher	metres	-	-	1,560
Electrical Rooms Conveyor & Crusher	metres	-	-	32
Electrical Holes Conveyor & Crusher	metres	-	-	311
Ventilation drifts Conveyor & Crusher	metres	-	-	937
Ventilation raises Conveyor & Crusher	metres	-	-	1,901
Crusher Chamber and bins	m^3	-	-	6,850
Dumping Bays and accesses	m^3	-	-	7,691
Pump Station	metres	-	-	209
CRF Plant	metres	-	-	39

Table 16.7: Operating Development Requirements by Mine Area				
Operating Development	**Unit**	**South**	**North**	**Total**
Cu Crosscut – Waste	metres	1,386	1,981	3,367
Cu Crosscut – Low grade ore	metres	1,444	2,065	3,509
Cu Stope Development in Paste fill	metres	887	855	1,742
Zn Crosscut– Waste	metres	1,046	669	1,715
Zn Crosscut – Low grade ore	metres	8,001	1,940	9,941
Zn Stope Development in Paste fill	metres	897	0	897

16.7.3 Ramp and Ramp Related Infrastructure

Figure 16.11 provides an overall view of the mine access development as designed in the FS, namely ramps extending from the existing LP1 ramp (LSRAM01). The footwall and hangingwall level development is shown, along with the intake and exhaust airways.

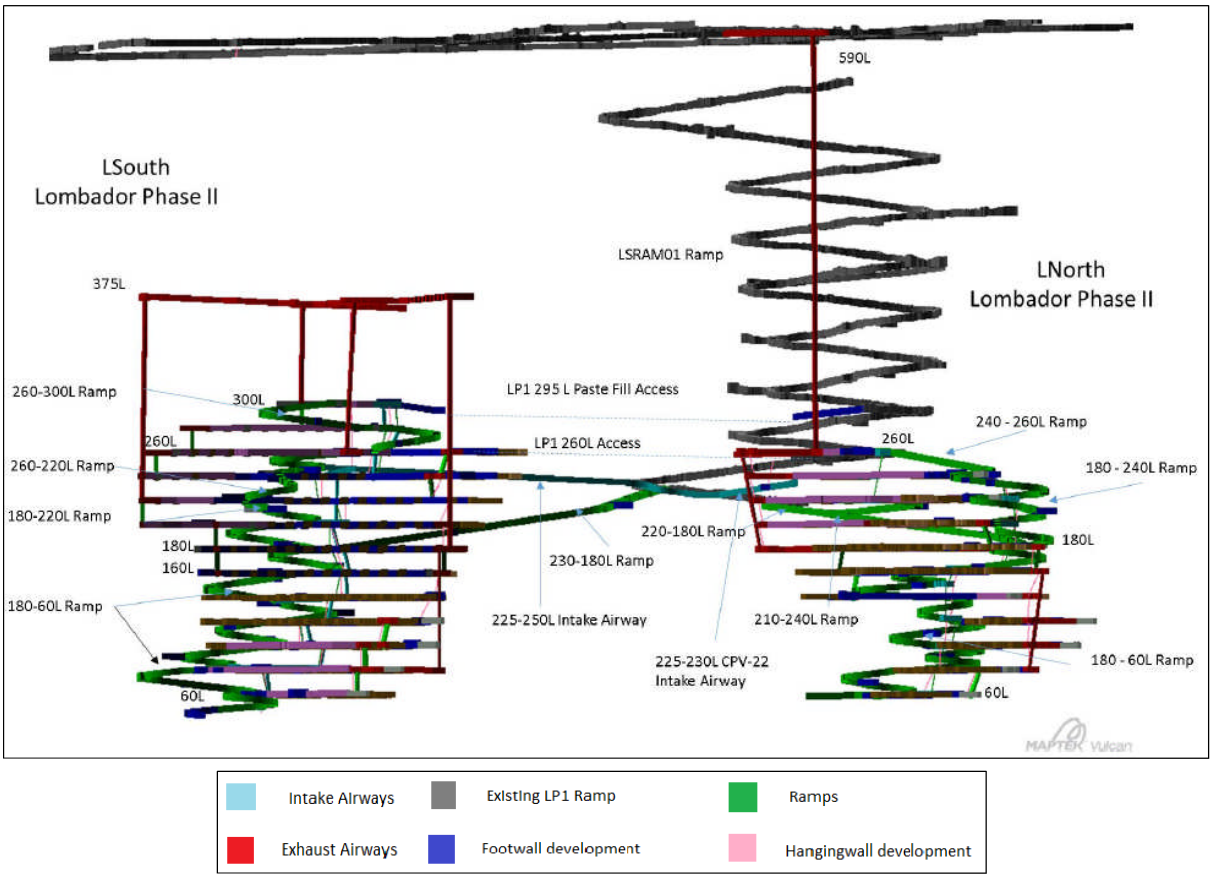


Figure 16.11: Perspective View of Ramps looking South-West (FS)

16.7.4 Vertical Development and Infrastructure

Vertical development in LP2 is utilised for one of three basic functions:

- ventilation;
- emergency egress; and
- service corridors.

Since the broken excavated rock is trucked up from the levels to the new 260 Level crusher there are no ore passes in the design.

16.7.4.1 Ventilation Raises

Three main types of exhaust raises are used in the exhaust system:

- A main exhaust raise to surface will be required, parallel to the existing CPV[1]21, denoted as CPV23. This raise will be raisebored 4.1m in diameter with two legs. The first leg is from surface (1240 Level) to 590 Level air collector. The second leg will go from 590 Level air collector to 375 Level air collector. Remote shotcreting has been assumed for the first 100m from surface, as per the rock conditions encountered in CPV21;
- Vertical exhaust raises connect the first-stage production levels (first-stage ventilation horizon) to the collector drifts; and
- The exhaust from the initial working areas is routed through a series of return air raises connected to return air collectors on 375 Level and on 590 Level, both located in the hangingwall of the mining areas. These raisebored raises are located on the flanks of the orebody and traverse from the hangingwall (LP1) to footwall side of the massive sulphide lens varying in length from 82 to 343m, with 4.1m diameter. Remote shotcreting is included as required based on the McCracken and Stacey stability method of analysis.

All raisebored raises longer than 250m will be guided with directional pilot holes, Rotary Vertical Drilling System, to reduce deviation from design.

Subsequent-stage production levels (ventilation horizons) are interconnected to the first-stage using vertical raises within the massive sulphide lens. As the mining sequence advances up-dip, the exhaust-air moves counter-cyclic to this direction (down-dip) via dropraises that interconnect each level at the strike extremity. The interconnections exhaust air to their respective production stage (ventilation horizon). Inter-level raises are generally 20m in length and 3m x 3m in section. See Figure 16.12 for a representation of these return air raises as designed in the FS. Longer inter-level raises are raisebored and generally 3.1m in diameter.

[1] Surface ventilation shafts are designated with the prefix “CPV”.

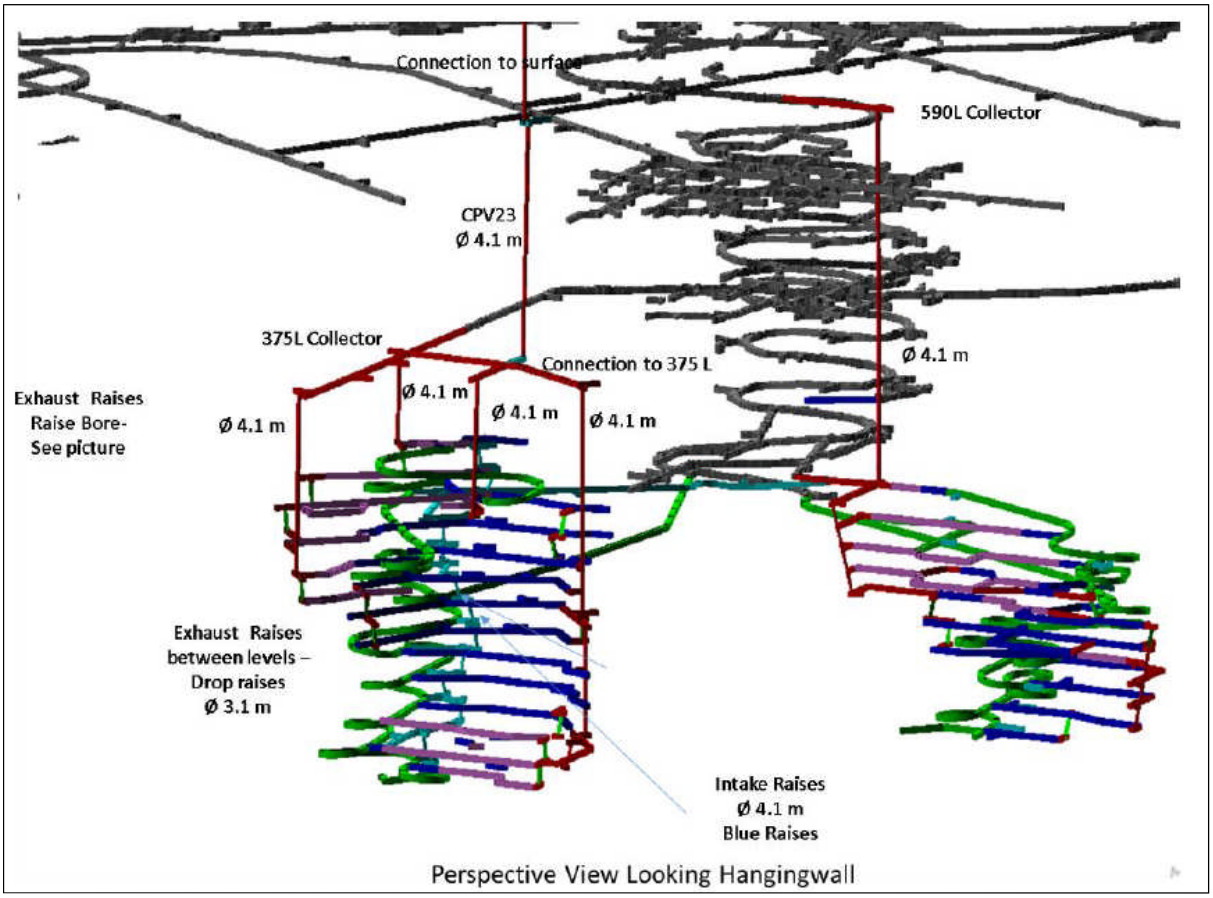


Figure 16.12: LP2 Exhaust Ventilation System (FS)

The intake air system comprises a 4.1m diameter raisebored raise developed in parallel with the ramp interconnecting each production level. The progressive development of this raise system minimises the distance between the active mining faces and the primary intake air system. This system is an extension of CPV22 in LP1.

16.7.4.2 Service Corridor Holes

A service corridor hole of 1m diameter is planned from 375 Level to 300 Level for water tie-in to LP1. A similar service hole will be required from 295 Level to 280 Level for tie-in to the existing paste fill reticulation in LP1. In addition, inter-level 1m diameter shared service holes will be required, parallel to the new emergency egress and fresh air raise for onward distribution of industrial water and paste fill to the producing levels.

The total length of service corridor holes required in the first three years of the project totals just over 1000m, which has a total capital cost of €0.5M.

In addition, two electrical service corridor holes 1m in diameter are planned, one from the 455 Level and another from the 295 Level both to the future electrical room (0HV) at the 260 Level (crusher station), these will provide independent routes between the 0HV6 and the crusher station. A similar electrical hole is planned from transfer point #4, in the new conveyor system, to the existing electrical

room on the 700 Level. These costs are included in the capital costs for the electrical infrastructure for ore handling.

16.7.4.3 Emergency Egress

Installation of the "SafeScape" emergency egress system requires that a series of 1.0m diameter raises are developed parallel to and in parallel with the fresh air intake raises. This system of interconnecting raises at each level will provide an alternative egress system to the ramp. If required a similar system can be installed parallel to the exhaust raises located at the flanks of the orebody.

16.7.5 Material Handling Development and Infrastructure

The key design features of the materials handling excavations include:

- Crusher on 260 Level, with two dumping bays and two bins;
- Three conveyor legs;
  - Conveyor leg #1 - 955m long inclined at 18%;
  - Conveyor leg #2 - 1059m long inclined at 18%; and
  - Conveyor leg #3 - 623m long inclined at 18%;
- Multiple (5) counter attack headings available for rapid development; and
- Two bins at 680 Level, taking advantage of a pre-existing excavated bin.

A development allowance of 2% has been incorporated into the design of each leg to account for minor unspecified development activities, with exception to the re-mucking drifts, which have been accounted for in the design.

The materials handling development can be divide into three major areas of work: 260 Level crusher area, conveyor legs and 680 Level area.

Figure 16.13 shows a section view of the general arrangement of the materials handling excavations in relation to the LP2 production stopes and the existing infrastructure.

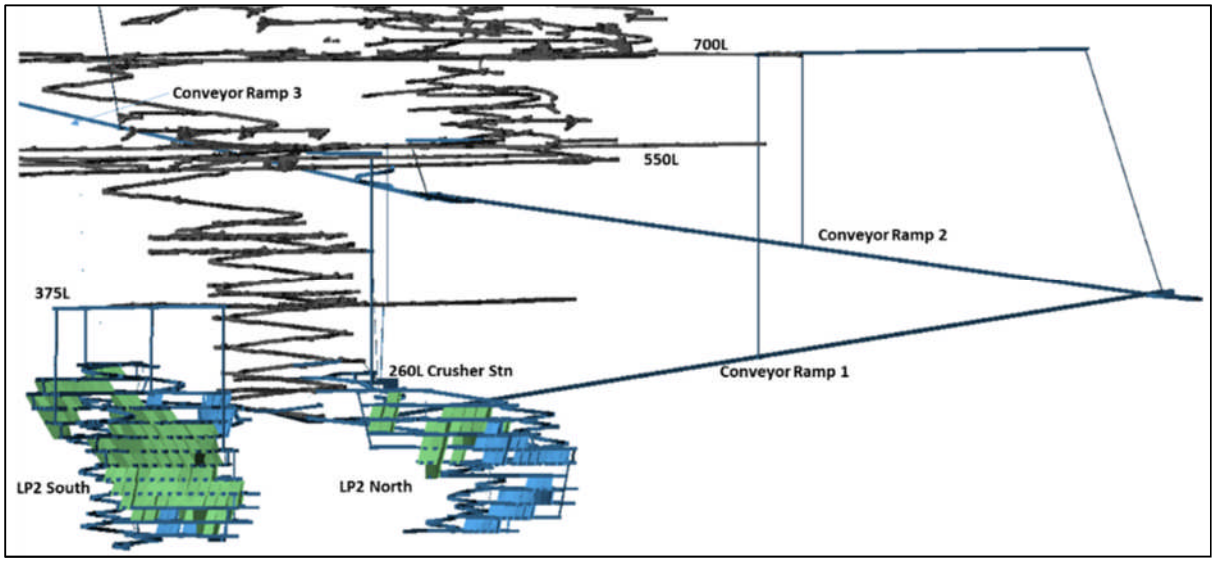


Figure 16.13: Section View of Materials Handling System (FS)

Figure 16.14 shows the general arrangement of the excavations from the truck dump position, north - east corner of the plan, to the existing production shaft at the south-east corner of the plan.

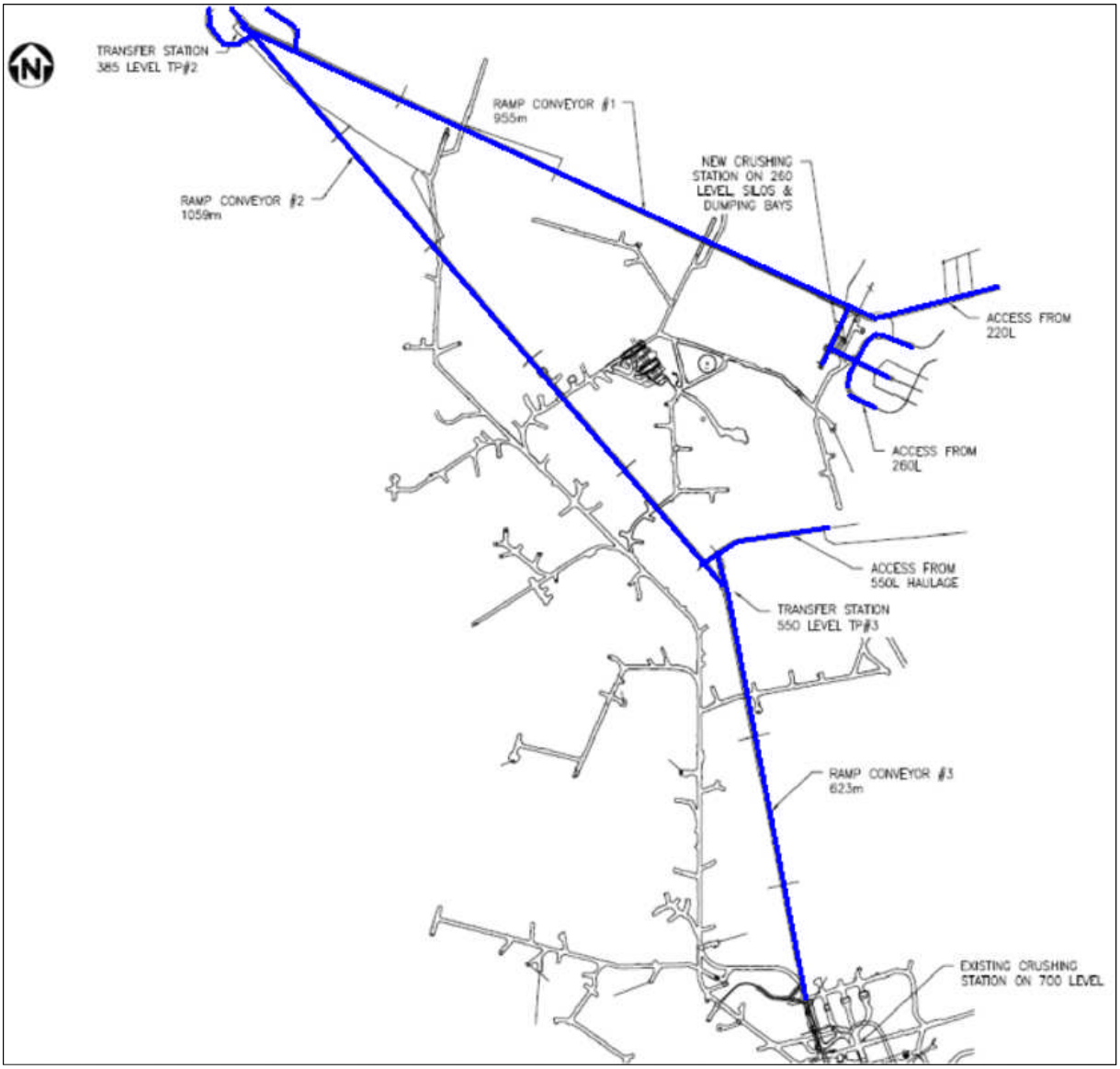


Figure 16.14: Plan View of Ore Handling System (FS Amendment)

The 260 Level crusher area as shown in Figure 16.15 is connected to the existing LP1 access ramp (LSRAM01) at 260L.

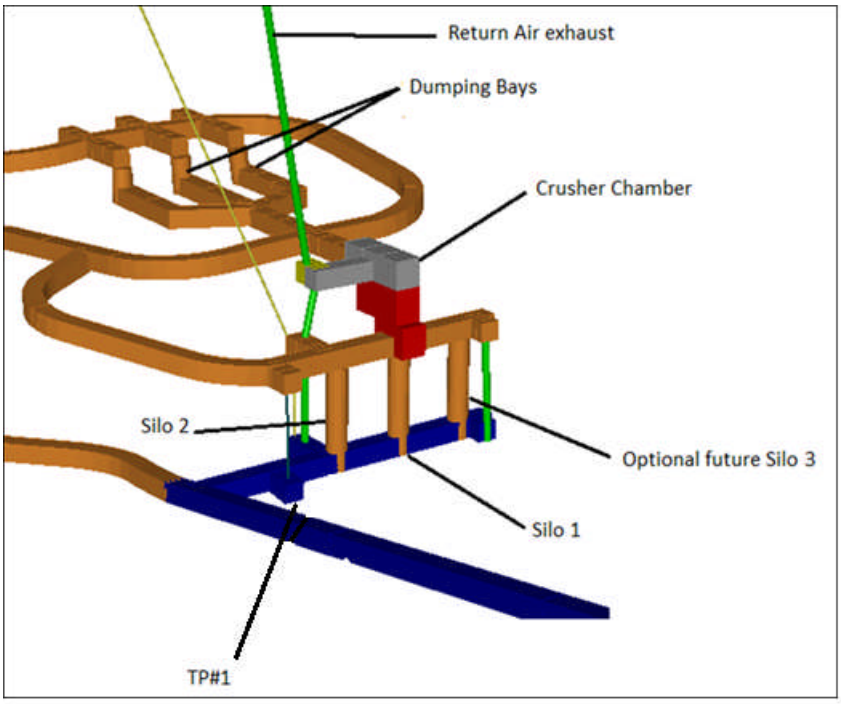


Figure 16.15: New Crusher layout on 260 Level

The 260 Level crusher area is comprised of:

- One crusher chamber 19m wide x 32m long x 27m high;
- Two dumping bays 6m wide x 12m high;
- One electrical room (0HV) 6.6m wide x 12m long x 5.5m high;
- All accesses in this area are designed with a cross-section of 5.5m x 5.5m to allow for use by 50t and 60t trucks;
- A ramp connects the crusher station level to the top of the bins at -18% inclination;
- Two bins between the crusher and the first leg of the conveyor, measuring 6m diameter x 30m height, with an approximate live volume of 708m³. A third bin location has been identified for possible future expansion; and
- A shuttle conveyor will be used to direct flow from the crusher chamber to the relevant bin.

A further connection to LSRAM01 at 220 Level provides access to the pumping station, bin unloading level and to transfer point (TP) #1. The horizontal unloading level will be equipped with a sacrificial conveyor 100m in length, which will in turn feed the first leg of the inclined conveyors.

16.7.6 Mine Development – Capital Costs

The capital cost estimate for the ZEP was developed during the FS by the project team with mine planning input from AMC, and current on site contractor and supplier's rates and later updated by the mine planning department in the FS-Amendment with up to date designs and contractor rates.

The unit costs for the horizontal capital development are based on the current contractor rates. These costs are calculated based on cross-section, drive inclination and type of support. For the purposes of the FS and in order to be conservative, all unit costs were calculated considering ground support with shotcrete. The breakdown of ore handling development costs in the FS-Amendment is shown in Table 16.8.

Table 16.8: Ore Handling Development – Capital Costs (€M)	
Crusher Chamber and access drives	1.79
Bins, 700 and 260 level distribution excavations	3.21
Dumping bays and access drives	1.89
Conveyor drives and access drives and transfer points	14.61
Electrical Infrastructure (Holes, rooms)	0.34
2% Growth allowance	0.44
Haulage	-
TOTAL	**22.28**

Vertical development costs are based on an average unit rates for 125m long raises for raises without Raise Vertical Directional Guidance System (RVDS) and an average length of 350m for raises with RVDS. For ZEP it is assumed that the first 100m (from surface) for the main raise (4.1 diameter) will be lined. Internal raises have been costed with and without support lining based on the recommendations of SRK's stability analysis. The service holes and electrical holes are estimated based on 1.0m diameter raises.

A summary of the capital development costs of the FS-Amendment is shown in Table 16.9.

Table 16.9: Capital Development Costs (€M)	
Ventilation Development	19.33
Horizontal Access Development	20.50
Service facilities and Utilities Development	2.15
Ore Handling Development	22.21
TOTAL	**64.19**

16.8 Rock Engineering Design

16.8.1 Summary Descriptions

The Lombador deposit is one of six massive sulphide lenses that comprise the Neves-Corvo deposits. The Lombador Massive Sulphide Unit is found near the boundary between a phyllite and quartzite formation (PQ) and the Volcanic Siliceous Complex (VSC). The unit consists of Massive Sulphide Pyrite located in the VSC and underlying Fissural Stockwork Sulphide Pyrite located in the PQ. Lower rock mass quality shale and black shale formations are present in both the PQ and the VSC.

The regional structure is located on the eastern limb of a northwest trending anticline that is intersected by a system of north-south trending sub-vertical faults. The massive sulphide lenses are bounded by thrust faults on both the footwall and the hangingwall.

The structural data available for LP1 and the surrounding deposits has been used to determine the structure for LP2. The data sources consist of structural mapping carried out by SOMINCOR, Acoustic Televiewer survey data for a shaft in LP1 and mapping carried out by SRK in the deepest part of LP1. Major structural features; faults, contacts and shear zones were determined by mine geology based on diamond drill hole intersections.

The massive sulphides of Lombador are divided into three orebodies, Lombador South, East and North. These orebodies are very similar, differing principally in thickness and grades. Typical characteristics of the different ore zones are as follows:

- **Lombador South (LP1 and above)** includes massive copper (MC average true thickness 10-15m), and massive zinc (MZ), maximum true thickness 23m), plus some copper stockwork ores (FC), average true thickness 10-20m) in the footwall. The hangingwall rocks are greywackes and shales (GX) in the southern area, and black shales (XN) to the north-west. The footwall rocks are typically acidic volcanics (V) from the south-western margin to the deposit centre, and from here to the extreme north-east shales and quartzites (PQ).
- **Lombador East (LP2)** has increased massive zinc (MZ) components and thickness (up to 50m true thickness) and copper stockwork ore (FC), average true thickness 17m). The hangingwall rocks are mainly black shales, while the footwall rocks are mainly shales and quartzites (PQ).
- **Lombador North (LP1 and LP2)** also includes in the south-west massive copper (MC (average true thickness 5m), but towards the north-east the massive copper increases up to 30m thick, the massive zinc (MZ) up to 50m thickness, and some copper stockwork ore (FC) averages 15-20m in the footwall. The hangingwall rocks are mainly black shales intercalated with volcanics. The footwall rocks are volcanics towards Lombador South, changing to largely mixed shales and quartzites northwards and with depth.

16.8.1.1 Stability Analysis

The copper stopes and the major segment zinc stopes in LP2 have been laid out with the same dimensions and utilising the same mining methods as those currently successfully being used for mining the LP1 orebody. The minor segment zinc stopes have substantially smaller dimensions than the major segment stopes and were therefore not analysed. The stope dimensions analysed by SRK Consulting were:

- MZ orebody: OBF – stope width 15m, stope height 25m and stope length up to 82m. The stope long axis above 160m level is orientated along an azimuth of 030° and below 160m level along an azimuth of 050°; and
- FC orebody: BF – stope width 10m, stope height 25m and stope length up to 28m. The stope long axis is orientated along an azimuth of 050° above and below the 160m level.

The Stability Graph Method was utilised to determine if these stope design parameters are suitable for the predicted geotechnical characteristics and greater mining depth of the LP2 orebody.

The Q' range of values derived from the geotechnical characterisation have been used in conjunction with the stability graph parameters A, B and C to determine the Modified Stability Number (N') for stope backs, end walls and side walls for both massive sulphide stopes and copper stockwork stopes.

The stress parameter "A" was estimated using mining induced stresses produced from the results of LP2 finite element numerical modelling. Input parameters for which, in terms of in-situ stresses and rock mass strength, were provided by a parallel stress analysis study undertaken by Itasca for the LP2 orebody.

16.8.1.2 Support

Based on the stability graph cable bolt charts, using the N' values and stope hydraulic radii along with the conservative 20th percentile Q' value, the following stope back support is required:

- MZ stopes – 9m long cable bolts installed on 2.5m centres; and
- FC stopes – 6m long cable bolts installed on 2.0m centres.

Based on a ubiquitous joint assessment, it was determined that wedges formed by the interaction of joint sets 1, 3 and 4 provided the greatest potential for the development of unstable joint bounded blocks in the back and shoulders of the OBF stopes.

The theoretical optimum support pattern based on this assessment comprises of:

- Nine 6m long twin strand cable bolts installed around the periphery of the top drilling cross cut at 1.5m in-ring spacing with rings spaced 2m apart along the axis of the cross cut;
- Surface support is provided by three 2.4m long Swellex bolts in the roof of the drilling cross cut at 1.25m in-ring spacing with rings spaced 1m apart along the axis of the cross cut; and
- If required side wall support can be provided by installing three twin strand cable bolts installed from the mucking drive of the secondary stopes. These bolts will be of varying lengths, 8m, 10m and 12m, bottom to top respectively.

By ensuring the stability of the shoulders of the stope, the height of the stope sidewalls is reduced to an effective 12m, potentially eliminating the requirement for support in the sidewalls under average ground conditions.

The current LP1 OBF stope roof support design includes:

- Three 7.2m long cable bolts in the roof at a 2m ring spacing;
- Two 3.6m long cable bolts in the top drift sidewalls at a 2m ring spacing; and

- Six 2.4m long Swellex bolts in the roof at a 1m ring spacing. The stope sidewalls are currently not supported.

With the exception of the length of the cables, the theoretical support pattern required in LP2 is similar to current practice in LP1. It should be noted that LP1 stope shoulders generally do not show signs of instability. Consequently, the stope sidewall height is effectively limited and no additional sidewall support has been required to date.

The LP1 support design includes cable bolt support for the stope end wall to prevent break back to the weaker contact shear zone. In addition to these cable bolts, there is also the requirement to maintain a massive sulphide skin pillar, of no less than 8m, between the end of the stope and the contact shear.

In LP2 the low grade halo on the hangingwall side of the zinc orebody ensures that the massive sulphide skin pillar is generally greater than 10m. SRK were of the opinion that the hangingwall stope support may not be required if it can be confirmed that the hangingwall skin pillar exceeds 10m.

16.9 Production Schedule

The schedule for the ZEP FS Amendment is based on the 2016 Base Case LoM plan, the Unconstrained Base Case LoM Plan ("Optimised" or "maximised for zinc" LoM); and the ZEP plan, which is the summation of the Optimised LoM with the LP2 expansion area.

The Optimised schedule was prepared by applying maximum stope, panel and level production rates to the current areas with the exception of Neves South where, given its lower zinc grades, rates were constrained by copper production requirements and therefore, allow the high grade LP2 to ramp up. The current sequencing rules for production have all been maintained.

The LP2 mine area has been scheduled to supplement zinc production from the Optimised Base Case plan to ensure that the expanded 2.5Mtpa zinc plant is maintained at the expanded capacity for as long as possible. The LP2 ore is treated as an intermediate priority production source, complementing existing high grade areas as necessary. This is a key consideration in the scheduling work as it tries to fulfil production targets as dictated by the production limits of the other mine-wide areas. This ensures that capital development in LP2 is delayed as much as possible.

The Base Case and ZEP schedules are illustrated in Figure 16.16 and Figure 16.17.

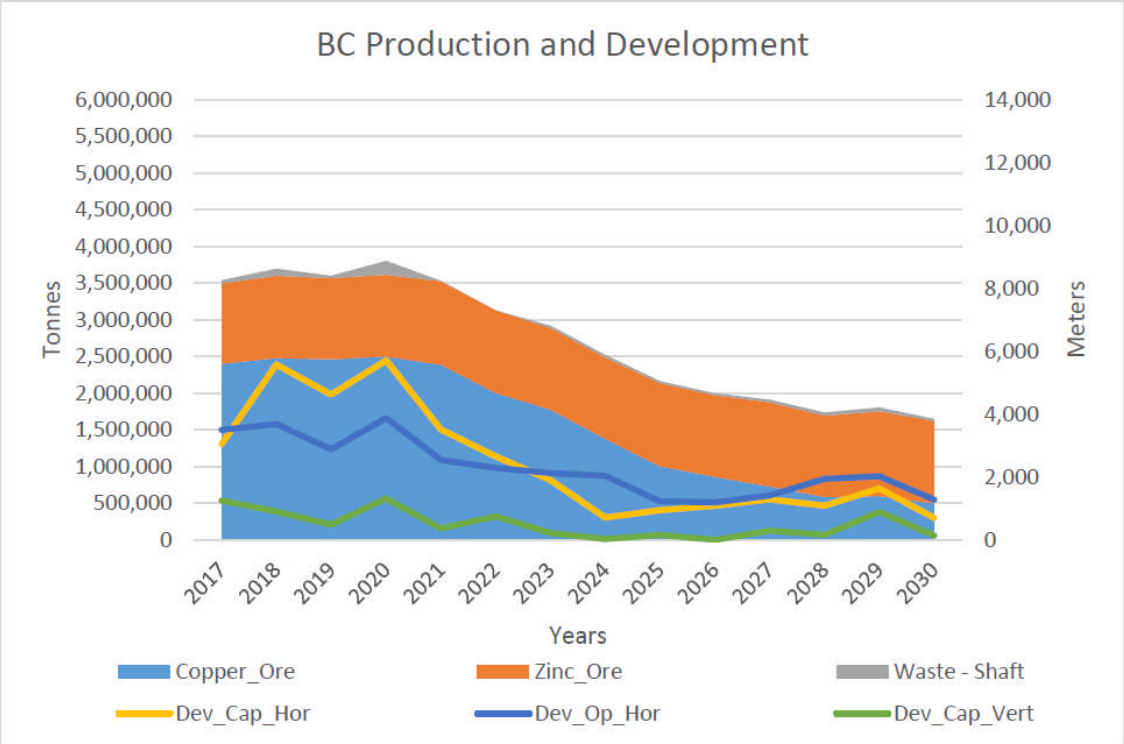


Figure 16.16: Base Case Production and Development

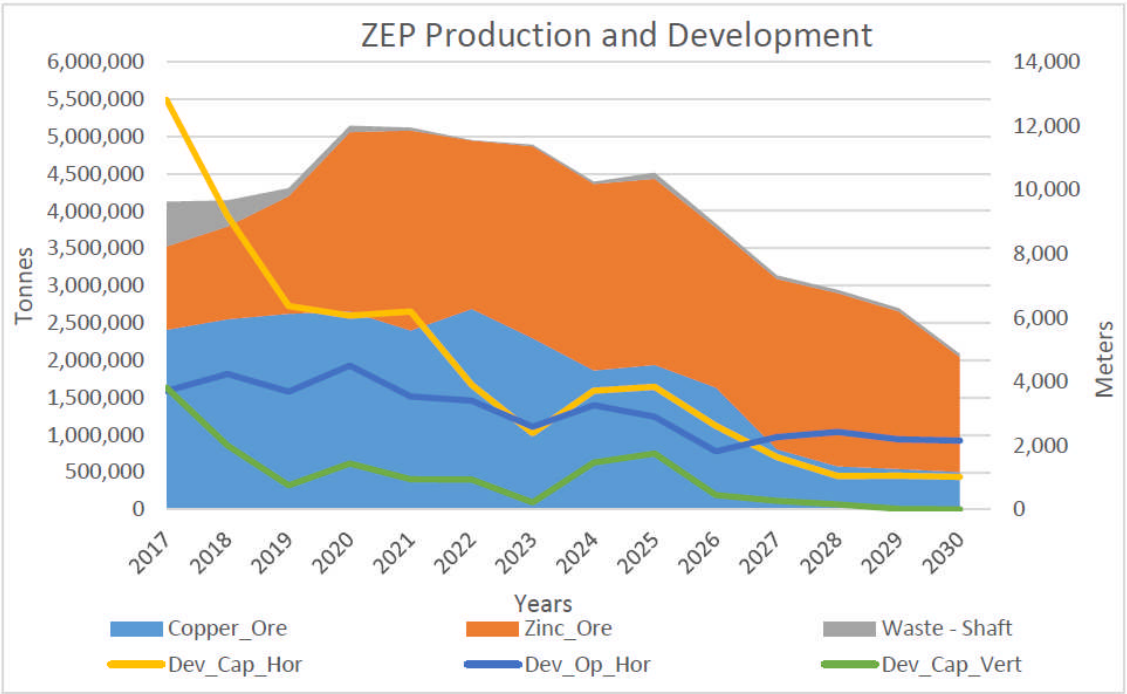


Figure 16.17: ZEP Production and Development

These figures show a marked increase in development required in 2018 primarily for the materials handling infrastructure, followed by the increase in zinc ore production in 2020. Also of note is the improved copper profile from 2022 onwards as new copper ore production areas in LP2 become available.

The other key feature of the LP2 expansion is its incremental economic sensitivity to the timing of capital expenditure, versus revenue generated (as determined from previous study work). Minimising capital and operating development outside of the payable mineralisation to improve incremental project economics has been a key consideration in the LP2 mine design work.

Early in the production cycle the developed capacity in LP2 is not being fully utilised, due to shared constraints (for example, a proportion of zinc plant capacity and hoist shaft capacity). The option to realise a higher production contribution through the use of a stockpiling strategy is not available due to oxidisation-recovery issues (with rapid oxidisation reducing zinc metal recovery).

There is room for further optimisation in the FS LoM, including:

- Just in time scheduling of the level development;
- Re-sequencing of stopes in LP2 North and South;
- Delay and smoothing of Lombador North schedule;
- Verification of waste rock quantities hoisted; and
- Smoothing of zinc ore production post 2025.

The above considerations should be seen as improvement opportunities and should have a positive impact on the project. Work has commenced on production of a new LoM that will incorporate these considerations and will be used for execution.

The ZEP schedule with ore grades is presented in Table 16.10.

Table 16.10: ZEP- Mine Production Summary

		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Zinc	**kt**	1,098	1,207	1,558	2,405	2,629	2,245	2,573	2,625	2,654	2,323	2,269	2,274	1,625	1,420
	% Zn	8.6	7.8	7.7	7.7	8.2	8.0	8.0	7.6	7.8	7.3	7.1	7.0	6.8	6.5
Copper	**kt**	2,404	2,543	2,618	2,653	2,394	2,685	2,291	1,813	1,922	1,631	802	578	541	499
	% Cu	2.4	2.3	2.4	2.6	2.6	2.3	2.2	2.2	2.2	2.4	2.3	2.1	2.3	2.2

Delaying capital and operating development to be as-late-as-possible (ALAP) has also been a major objective for scheduling to improve the incremental project economics.

16.10 Mobile Mining Equipment Fleet

As no significant mining method changes are proposed, the mobile equipment fleet selected is based on existing practices at Neves-Corvo. The additional fleet requirements to handle the increased mining rates for the ZEP project have been determined through an in-house model, which determines annualised productivity rates for each of the primary equipment types, from first principles, presented in Table 16.11 below.

Table 16.11: Lombador Mobile Mine Equipment Fleet Requirements				
Equipment Type	**Make**	**Model**	**Total**	**Primary Selection Reason**
Jumbos	Atlas Copco	Boomer S2	2	Modernisation of current fleet
Rockbolting Rigs	Atlas Copco	Boltec MD	2	Modernisation of current fleet
FELs/LHDs	Caterpillar/Sandvik	966H/LH621	5	Matches current fleet
Explosive Loading Platforms	Normet	Chargetec UV2	2	Matches current fleet

The mobile fleet estimate for the ZEP expansion is shown in Table 16.12. These estimates are based on the specified capacities, the current availabilities of 70-90%, and utilisations of 50-100%. As noted previously, this indirectly includes consideration of some spare equipment becoming available from the existing mine by not rounding up the fleet estimates.

The mobile equipment purchasing schedule is presented for the project life in Table 16.13. This schedule is for fleet expansion only and does not include equipment replacement, which is considered under sustaining capital.

16.10.1 Equipment Capital Costs

The unit cost for the mobile equipment are based on recent equipment acquisitions or quotations. It should be noted that in general, equipment of a similar nature and capacity from other manufacturers will be competitively priced and, if alterative suppliers were selected, it would not materially change the cost of the overall fleet.

The total capital for mobile equipment is €11.7M. Costs in the financial analysis have been allocated 70% on the year of equipment delivery and 30% twelve months prior, on ordering.

Table 16.12: Mobile Production Equipment Schedule – LoM ZEP

Equipment	Make	Model	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
Twin Boom	Atlas Copco	Boomer S2	**6.6**	**7.9**	**7.9**	**8.8**	**8.4**	**7.6**	**9.2**	**7.4**	**5.8**	**4.7**	**4.5**	**4.1**	**3.7**	**3.5**	**2.4**	**2.7**	**2.3**	**1.8**	**1.9**	**1.2**
Longhole Rig	Atlas Copco	Simba M6C	**3.3**	**2.7**	**2.9**	**4.0**	**4.5**	**4.3**	**4.7**	**4.5**	**3.8**	**2.9**	**3.0**	**2.4**	**1.6**	**0.5**	**0.6**	**0.8**	**0.6**	**0.4**	**0.3**	**0.2**
Rockbolt Rig	Atlas Copco	Boltec MD	**7.1**	**8.4**	**8.4**	**9.5**	**9.0**	**7.9**	**9.8**	**7.8**	**6.1**	**4.9**	**4.8**	**4.5**	**4.1**	**3.8**	**2.6**	**2.8**	**2.4**	**1.8**	**2.1**	**0.3**
Cablebolt Rig	Sandvik	DS420-C	**1.6**	**2.1**	**2.0**	**2.3**	**2.2**	**1.9**	**2.2**	**1.6**	**1.3**	**1.0**	**1.0**	**0.9**	**0.8**	**0.7**	**0.5**	**0.6**	**0.5**	**0.4**	**0.4**	**0.3**
Cablebolt Inserter	Supplier 1	Spare 1	**0.4**	**0.4**	**0.4**	**0.5**	**0.5**	**0.4**	**0.5**	**0.4**	**0.3**	**0.3**	**0.3**	**0.2**	**0.2**	**0.2**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
Charging Rig	Normet	Chargetec UV2	**5.7**	**6.8**	**6.8**	**7.6**	**7.2**	**6.5**	**7.7**	**6.3**	**4.9**	**4.0**	**3.9**	**3.5**	**3.2**	**3.0**	**2.1**	**2.3**	**2.0**	**1.6**	**1.7**	**1.0**
LHD	Sandvik	LH621	**3.4**	**3.5**	**3.7**	**4.5**	**4.6**	**4.3**	**4.7**	**4.2**	**3.4**	**2.7**	**2.7**	**2.4**	**1.9**	**1.4**	**1.1**	**1.2**	**1.0**	**0.7**	**0.7**	**0.5**
FEL	Cat	966H	**7.0**	**7.2**	**7.4**	**9.0**	**9.1**	**8.4**	**9.3**	**8.0**	**6.6**	**5.3**	**5.2**	**4.6**	**3.6**	**2.7**	**2.1**	**2.4**	**2.0**	**1.5**	**1.5**	**0.9**
Truck	Atlas Copco	MT65	**5.9**	**6.3**	**6.9**	**7.4**	**8.2**	**7.7**	**10.2**	**9.2**	**7.6**	**5.6**	**5.7**	**4.5**	**3.5**	**2.2**	**1.7**	**1.9**	**1.5**	**1.0**	**1.1**	**0.8**
Shotcrete	Supplier 1	Spare 1	**1.8**	**2.1**	**2.2**	**2.4**	**2.3**	**2.1**	**2.5**	**2.0**	**1.6**	**1.3**	**1.2**	**1.1**	**1.0**	**1.0**	**0.7**	**0.7**	**0.6**	**0.5**	**0.5**	**0.3**
Longhole Cablebolting	Atlas Copco	Simba M6C	**2.4**	**3.1**	**3.0**	**3.5**	**3.3**	**2.9**	**3.3**	**2.4**	**2.0**	**1.5**	**1.5**	**1.4**	**1.2**	**1.1**	**0.8**	**0.8**	**0.7**	**0.5**	**0.5**	**0.4**
Pick-ups	Toyota	Hilux	**118**	**127**	**131**	**146**	**148**	**143**	**148**	**136**	**124**	**111**	**111**	**103**	**95**	**84**	**79**	**83**	**77**	**74**	**73**	**69**

Table 16.13: Mobile Production Equipment increase in Fleet Size (excluding replacement units)

Equipment	Make	Model	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
Twin Boom	Atlas Copco	Boomer S2	-	1.0	-	1.0	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-
Longhole Rig	Atlas Copco	Simba M6C	-	-	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rockbolt Rig	Atlas Copco	Boltec MD	-	1.0	-	1.0	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-
Cablebolt Rig	Sandvik	DS420-C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cablebolt Inserter	Supplier 1	Spare 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Charging Rig	Normet	Chargetec UV2	-	1.0	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FEL/LHD	Cat/Sandvik	966H/LH621	3.0	-	1.0	1.0	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	Atlas Copco	MT65	-	-	-	-	1.0	-	2.0	-	-	-	-	-	-	-	-	-	-	-	-	-
Shotcrete	Supplier 1	Spare 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Longhole Cablebolting	Atlas Copco	Simba M6C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pick-ups	Toyota	Hilux	-	9.0	6.0	16.0	5.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

16.11 Ore and Waste Handling System

16.11.1 Existing Systems Overview

Mined ore and development waste from the Neves-Corvo operations is transferred to primary crushers located on the 700 and 550 Levels using a combined system of LHDs, orepasses, FELs and truck haulage. The bins on 550 Level discharge ore or waste to TP12 and TP13 conveyor systems for transfer to the skip loading facilities on 700 Level. A loading pocket is located in the shaft just below the 700 Level, from there, crushed ore or waste is loaded into 17.8t (wet load capacity) skips and hoisted to surface.

The 550 Level system situated closest to the zinc expansion areas of CSE and Lombador is presently operated at full capacity. A materials handling study for the ZEP has demonstrated that a new dedicated crushing and conveying system to deliver ore from Lombador to the existing production shaft is preferred to truck haulage and upgrade of the existing 550 Level system.

16.11.2 Existing Crushing and Conveying

The mine currently has two underground primary crushers located at the 700 Level and 550 Levels respectively, which are fed ore and waste by the underground load and haul fleet.

The 700 Level crusher station is equipped with a Svedala R150120-250-2 jaw crusher, with an opening size measuring 1,500 x 1,200mm. This crushes material to sub-200mm in size and feeds in to four 1,500t capacity storage bins ahead of the Santa Barbara shaft loading pocket; namely Bins 1,2,3 and 4. The material for hoisting is fed by a short conveyor from the storage bins for skip hoisting at the loading pocket. The 700 Level crusher has a 600t/hr capacity that currently crushes ore and waste from the Upper Corvo, Neves, Graça, Zambujal and Corvo Southeast orebodies.

The 550 Level crusher is equipped with a Metso C120 jaw crusher, with an opening size measuring 1,200 x 800mm. This crushes material to sub-200mm in sizer and feeds into three storage bins of 450t to 700t capacity. The bins feed a sacrificial 160m long conveyor followed by a 625m long inclined conveyor on a 25% gradient which delivers the crushed material to the 700 Level bins. The conveyor is suspended from the roof of a 4m x 4m conveyor gallery. It runs at a speed of 3.15m/s, has a width of 1,000mm and an installed capacity of 600t/hr. It is powered by two 225kW motors.

16.11.3 Existing Shaft Facilities at Santa Barbara Shaft

The existing Santa Barbara Shaft is a modern hoisting facility, which has been well maintained and is in good general condition. It comprises a 5m diameter concrete lined circular shaft situated to the west of the main Corvo orebody, 600m deep extending to below the 700 Level. It is equipped with counter balanced skips with tail ropes for rock hoisting and a small “Mary Ann” cage for man access.

Rock hoisting utilises a conventional ground-mounted 2.5MW double drum winder, hoisting opposed 17.8t (wet load) capacity bottom dump skips each travelling on four 38mm rope guides. The shaft has

been installed with an automatic skip loading system and has a potential rock hoisting capacity of 5.4Mtpa based on 24 hours a day, 7 days per week continuous operating period.

16.11.4 ZEP Ore and Waste Handling

To address the additional materials handling requirements resulting from the increased zinc ore production in the Lombador orebodies, Terra Nova Technologies Inc. (TNT) was engaged to prepare a study and Class III capital cost estimate of a proposed underground material handling system, and associated infrastructure.

The proposed system includes:

- New primary crusher station complete with jaw crusher, rock breaker, vibrating grizzly feeder, shuttling silo distribution conveyor, magnetic separator and ancillary equipment at 260 Level;
- Two bins for storage of zinc ore, copper ore, and waste, each with a vibrating feeder for feed to ramp conveyor system at the top and bottom of a conveyor system;
- Approximately 3.2km ramp conveyor system (in three legs); and
- Upgrades to existing shaft and skip loading system to increase capacity to 5.4mtpa.

16.11.4.1 Crusher and Conveyor Design

A new materials handling system is proposed to handle run of mine materials (ore and waste) from the 260 Level at the top of LP2 to the existing production shaft. The design criteria of this system is summarised below in Table 16.14.

Table 16.14: Design Criteria Summary

	Units	Crushing	Conveying
Effective operating hours / shift	h	4.50	6.25
Production hours/year	h	3,604	5,005
Production(nominal)	Mtpa	2.0	2.2
System Utilisation	%	45	63
Nominal Capacity	t/h	555	440
Design factor	t/h	1.2	1.25
Design capacity (peak)	t/h	666	550

The crushing plant design has a vibrating grizzly feeder ahead of the jaw crusher which results in a large portion of undersize rock bypassing the crusher. A Metso C120 crusher operating with a variable closed side setting of 150 – 180mm has been selected to provide SAG mill feed in the case of Zn ores and secondary crusher feed in the case of copper ores.

The new materials storage systems in the design includes: two dumping bays with 7,700m³ storage, two bins between the crusher and the first leg of the conveyor with a live volume of 700m³ each, and two bins at the top of the inclined conveyor system and ahead of the skip loading conveyor with a live volume of 800 – 1,100m³ each. An option for a third storage silo at both 260 Level crusher station and

the head end of the conveyor system at 680 Level may be considered at a later date and will not be part of the initial installations.

16.11.4.2 Shaft Upgrade

For the ZEP FS Amendment an expansion of the shaft capacity to 5.4Mtpa has been determined, which is in line with the peak hoisting tonnage requirement of 5.15Mtpa in year 2020 as indicated in the LoM plan.

RSV Consulting were used for the evaluation of the shaft expansion alternatives. RSV spent considerable time on-site and measured the power draw of the shaft motor over a five-day period and concluded that the required 5.4Mtpa capacity can be achieved. To achieve this potential capacity, RSV proposed the following focus areas:

- An alternative skip bucket unloading system at the unloading station;
- An alternative material of construction for the skip bucket;
- Removal of the tail-rope;
- Supplementary cooling capacity for the hoist motor ventilation system;
- Supplementary cooling for the converter transformer;
- An alternative flask weighing system for the skips at the loading station;
- Tight and slack rope detection and monitoring system; and
- An alternative head rope, Multi Stranded Rope (MSR), for the hoisting system.

These changes are of a lesser extent to those originally proposed in the ZEP FS. Consequently, this means that the long term planned shutdown of the shaft complex for motor replacement and other subsidiary changes, now need no longer occur. This has positive implications for the project economics beyond the simple savings in capital expenditure, as significant production losses due to stoppages can be averted.

16.12 Backfill

16.12.1 Existing Backfill System at Neves-Corvo

The current backfill systems at Neves-Corvo are cyclone tailings paste fill (PF) and whenever possible uncemented rockfill. The hydraulic sand fill plant has been placed on care and maintenance, but can be revived to supplement backfilling capacity as required under current proposals in the ZEP.

A breakdown of the fill types per mining method utilised in Neves-Corvo is shown in Table 16.15 below.

Table 16.15: Backfill Specification by Mining Method					
Mining Method	**Maximum exposed height**	**Fill Type**	**Constituents**	**% Cement**	**Minimum Strength (kPa)**
Drift & Fill	5m	Hydraulic*	Sand	3 - 5	120
		Paste	Tailings	5	120
Sill Pillar	8m	Slinger CRF	-50mm	7	500
		Slinger CRF	+14mm rock		
Bench & Fill	20-30m	CRF*	-150mm	5	1,000
		CRF	+70mm		
		Paste (for tight filling as required)	Tailings	1 - 5	120 – 437
Mini-Bench & Fill	10m	Paste	Tailings	1 - 5	120 – 350
Optimised Bench & Fill	20-30m	Paste	Tailings	1 - 5	120 - 437
Notes: CRF = Cemented Rock Fill, * Decommissioned					

16.12.2 Backfill Demand and Supply

The LP2 mining will utilise the existing backfill plants at Neves-Corvo. The current PF plant and associated reticulation has an installed capacity of 800,000m³/yr, with an average rate of 102m³/h at 75% utilisation. A summary of the Backfill Plant throughput is shown in Table 16.16.

Table 16.16: Backfill Plant Throughput						
Plant	**Average Daily Volume (m³/d)**	**Maximum Daily Volume (m³/d)**	**Average gravity rate (m³/h)**	**Maximum gravity rate (m³/h)**	**Average pumped rate (m³/h)**	**Maximum pumped rate (m³/h)**
Paste	1,800	3,104	102	125	102	120
Hydraulic	850	3,671	240	280	-	-

Under the current production schedule LP2 will utilise both Paste fill (PF) and Rockfill (RF). Primary stopes are backfilled using PF with 5% cement by weight ("standard" strength), and secondary Zn stopes are backfilled weaker strength PF (with 1% cement,) or using RF with no cement if there is sufficient waste availability.

The annual waste produced (with acid-generating waste proportion) compared to the total LP2 waste varies during the project life. Also of note, is that approximately 24% of the LP2 waste is distinctly acid-generating. Lombador North has the higher proportion with 33% while Lombador South is 16%.

Peak additional backfill demand for LP2 is 530,000m³ of paste fill in 2025 and 138,000m³ waste fill in 2024, as displayed in Figure 16.18.

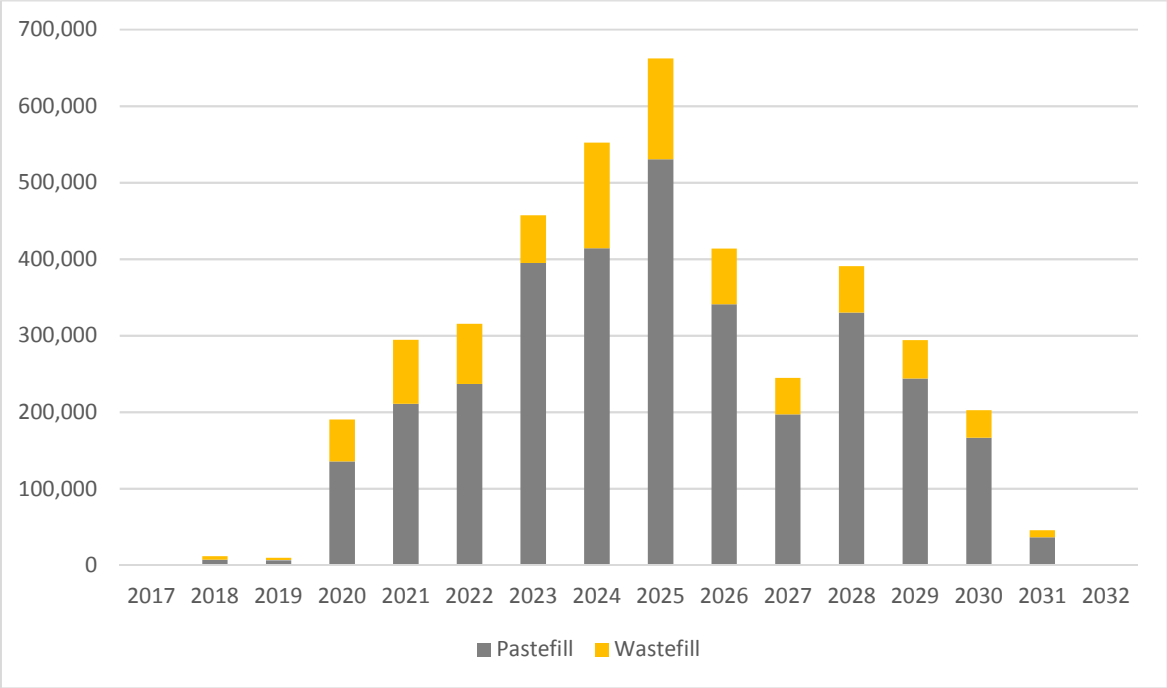


Figure 16.18: LP2 Annual Backfill Requirements

16.12.3 ZEP Project Backfill Demand

The total backfill demand arising from the ZEP Project for Neves-Corvo + LP2, is shown in Figure 16.19. Peak paste fill and waste fill demands are 1,208,000m³ (in 2023) and 412,000m³ (2018) respectively.

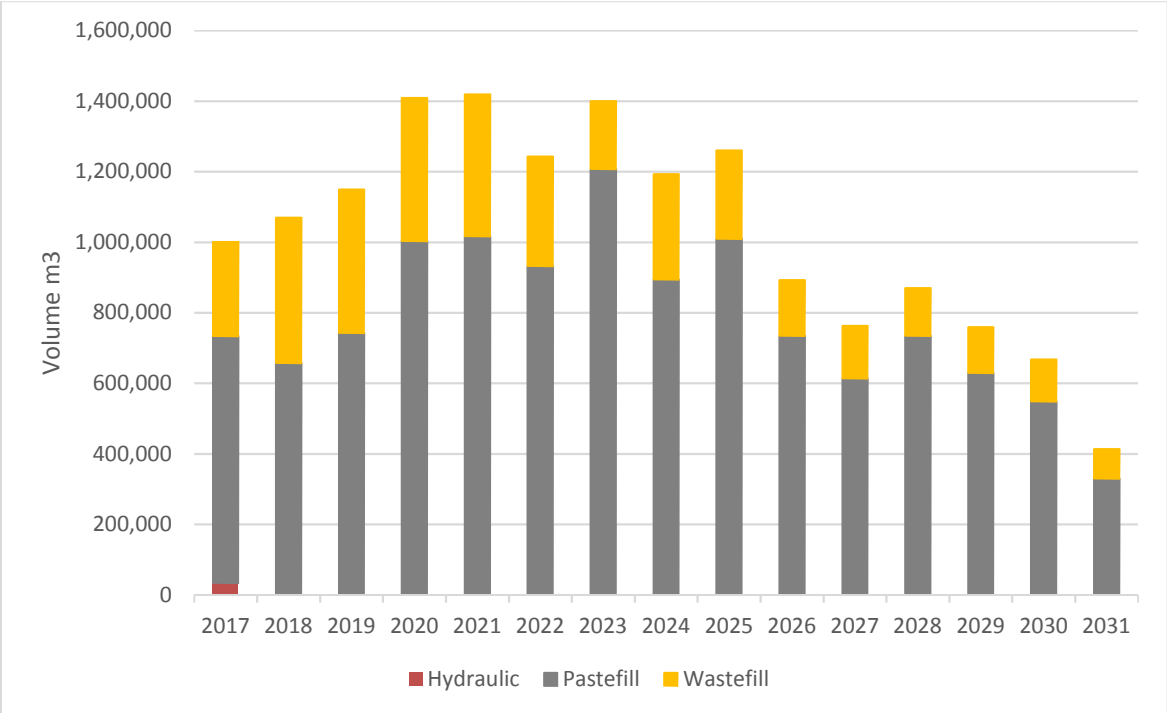


Figure 16.19: ZEP Backfill Demand

The future pastefill volume demand in the ZEP LoM schedule exceeds the paste fill plant capacity between 2020 and 2025. A preliminary trade off study has indicated reactivation the hydraulic fill plant as the preferred means by which to address this shortfall. Nonetheless, a study of a pastefill plant expansion will be undertaken as part of the basic engineering in the execution phase of the project.

16.12.4 Cement Rock Fill Slurry Plant

Level development placement within, or close to, low grade ore requires that the level accesses are on occasion located within stope shapes. For these instances, the stope shapes are segmented to allow mining the bulk of the stope while maintaining level access, egress and level ventilation with the smaller segmented stope portions mined later on retreat. A minimum 8m rib pillar has been designed against the major segmented stope split wall.

Major secondary segment zinc stopes assume a CRF fence is formed against the future minor segment exposure face. The CRF volume is a constant 3,240m³ per major segment stope. The remaining major secondary segment void is backfilled with rockfill and is shown in Table 16.17.

Table 16.17: Summary of CRF and RF needs

CRF and RF needs	Unit	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
All stopes RF possible	m^3	11,016	61,947	25,465	8,436	25,213	52,094	19,478	24,143	0	0
All stopes CRF required	m^3	0	3,240	12,960	3,240	0	8,024	11,416	0	9,720	3.240

For CRF requirements in Lombador South, it is assumed development waste will be trucked directly to the stope and dosed with cement en-route via a relocatable cement slurry-tankage dispensing system (or colloidal mixer) located close to the stopes being backfilled. A 7% cement by weight recipe is assumed.

Small tonnages of CRF will be required to build these walls for which a small underground slurry plant, capable of producing up to 10m³/h of slurry, suitable for 100t/h of CRF has been selected.

16.12.5 Backfill Costs

The total cost of the CRF slurry plant is €0.4M, with an opportunity to rehabilitate one of the existing plants underground and reduce capital accordingly. The operational cost for the CRF slurry over the life of the project is €1.4M or €22/m³.

Additional capital of €0.27M has been set aside for the Paste fill reticulation expansion.

16.13 Ventilation

16.13.1 Introduction

The complexity of underground workings at Neves-Corvo makes for an intricate and extensive ventilation network. In general, however, there are four primary ventilation circuits: 1) Neves; 2) Graça, Zambujal and CSE; 3) Lower Corvo and Lombador. These main circuits intake air via the main intake raises and where necessary supplement with air from the main access ramps. Surface ventilation shafts are designated with the prefix “CPV”. The main Castro ramp from surface, connects to the bottom of the current mining horizon in Corvo and en-route splits off to service the Graça and Neves orebodies. The Santa Barbara Shaft is also used as an intake and airflow is controlled using doors at each shaft connection.

Exhaust from each area is returned/collected through a series of return air drifts (often referred to as collectors) located above the mining areas through a series of regulated raises. Control of airflow in these raises is achieved by partially covering the top of each (with regulators) in the return air drift. From these drifts, the return air is exhausted to surface through exhaust raises equipped with fans on surface. A schematic of the ventilation network is shown in Figure 16.20.

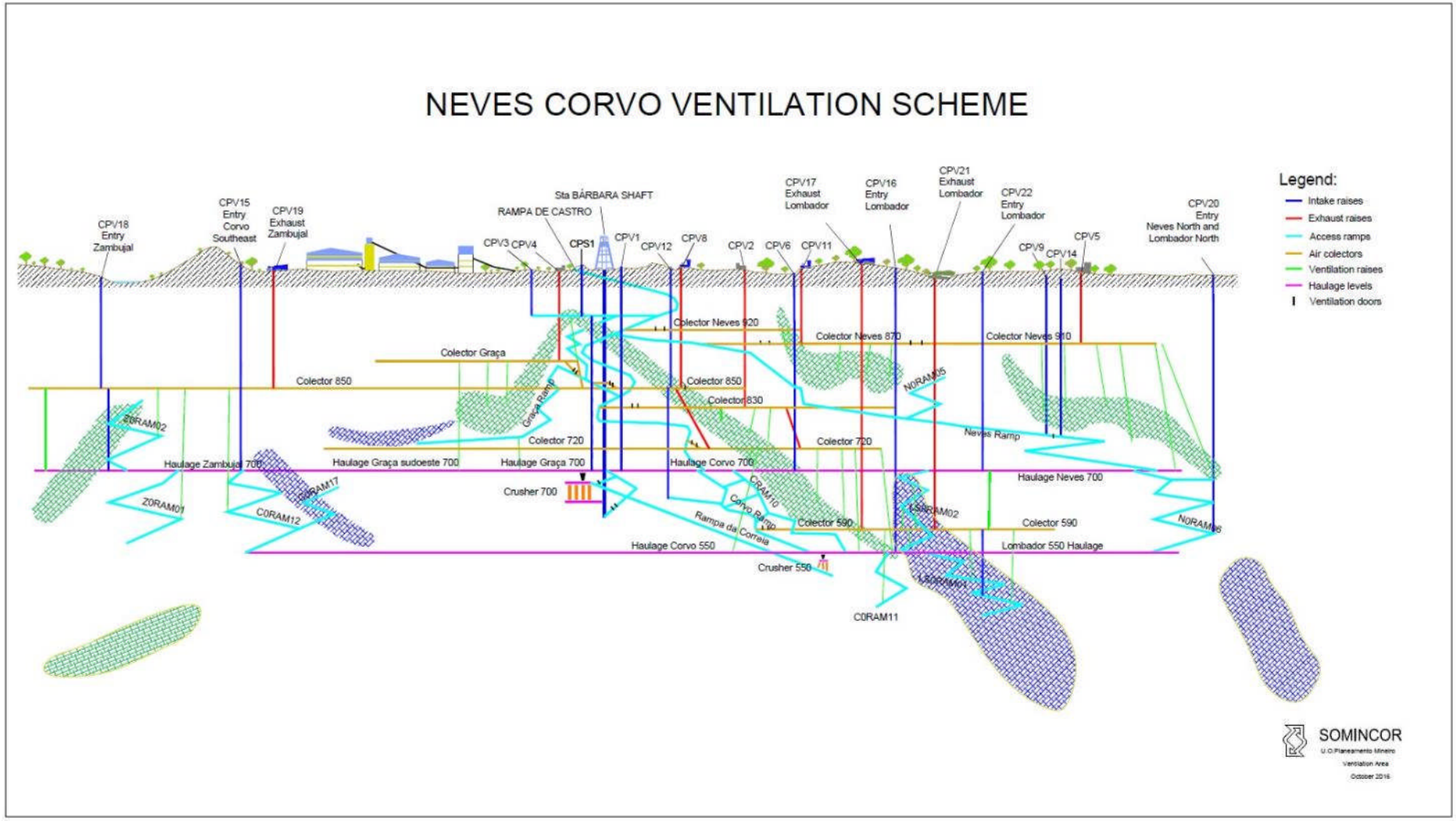


Figure 16.20: Mine Ventilation System (SOMINCOR)

A summary of the ventilation districts is shown in Table 16.18.

Table 16.18: Ventilation Districts

District	Intake	Exhaust
Neves	CPV06; CPV09; CPV14; CPV20	CPV05; CPV11
Graça/Zambujal/Corvo SE	CPV03; CPV15; CPV18	CPV04; CPV19
Corvo Inferior	CPV01; CPV12; CPV16	CPV02; CPV08; CPV17
Lombador	CPV16; CPV22	CPV17; CPV21

Utilised capacity in the ventilation circuit is currently 1,450m^3/s. The main ventilation in the mine is supplemented in development headings and stopes by auxiliary fans and flexible ducting (850-1,000mm) that can be easily extended when required.

Mine Ventilation Services (MVS) examined the ventilation system (requirements and infrastructure) for the ZEP as part of the FS. Their work was based upon the equipment load, ventilation model, thermal measurements, and mine layout provided by Lundin. The study examined the required airflow distribution for diesel fume dilution and climatic conditions. Budgetary costs were obtained for the additional required ventilation infrastructure.

Since the completion of the FS, the LP1 project has experienced issues with working temperatures during periods of elevated surface temperatures in the summer months, despite the fact that production from the area has not yet achieved the planned maximum throughput. A specialist ventilation consultant, Morvent Mining Ltd, provided an updated review of the ventilation design for the FS-Amendment.

16.13.2 Proposed LP2 Ventilation Circuit Layout

The main ventilation layout for LP2 is based on an extension of the LP1 circuit, (Figure 16.21). Airflow downcasts through both the existing access ramp (LSRAM01) and the existing parallel raise system (CVP22) in the LP1 area. This brings airflow to the top of the North and South mining areas of LP2 where it circulates to the production and development areas through the main access ramp (LSRAM03) and an extension to the parallel raise CVP22. Additional air intake will also occur via the new conveyor ramp legs. After the air has passed through the production and development areas it exhausts at the end of the levels up to the 260, 375, and 590 collection levels as shown in Figure 16.21 and Figure 16.22.

A new 4.1m diameter exhaust raise to surface (CPV23) will supplement the current CPV21 and provide exhaust for both the LP1 and LP2 areas. The existing CPV16 raise in the Corvo orebody will continue to provide exhaust for the Lower Corvo production areas as well as the upper mining areas in LP1. The existing CPV5 will continue to provide exhaust to the Neves production area as well as to the conveyor transfer station at 385L.

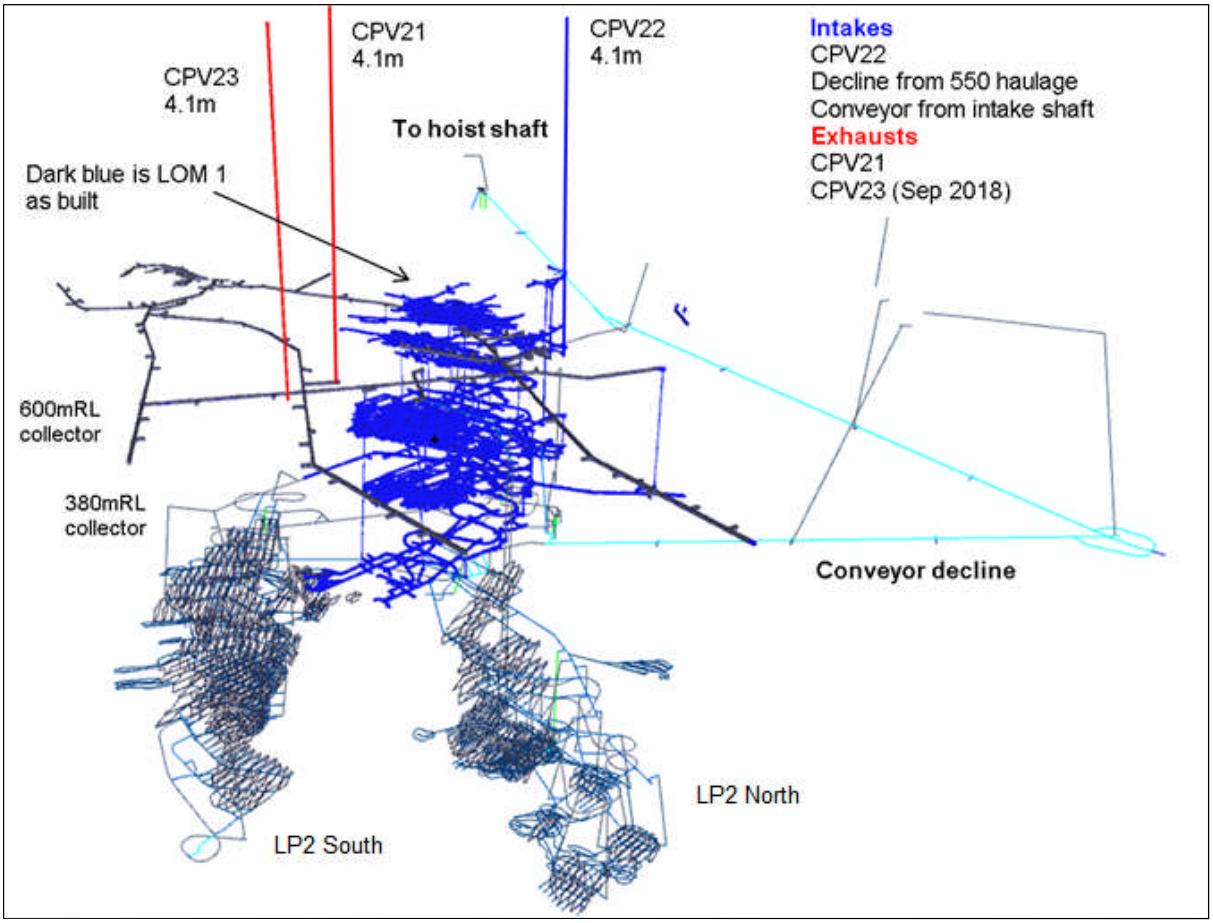


Figure 16.21: Perspective View of Main Intake/Exhaust Airways for Lombador and the New Materials Handling system. (After SOMINCOR)

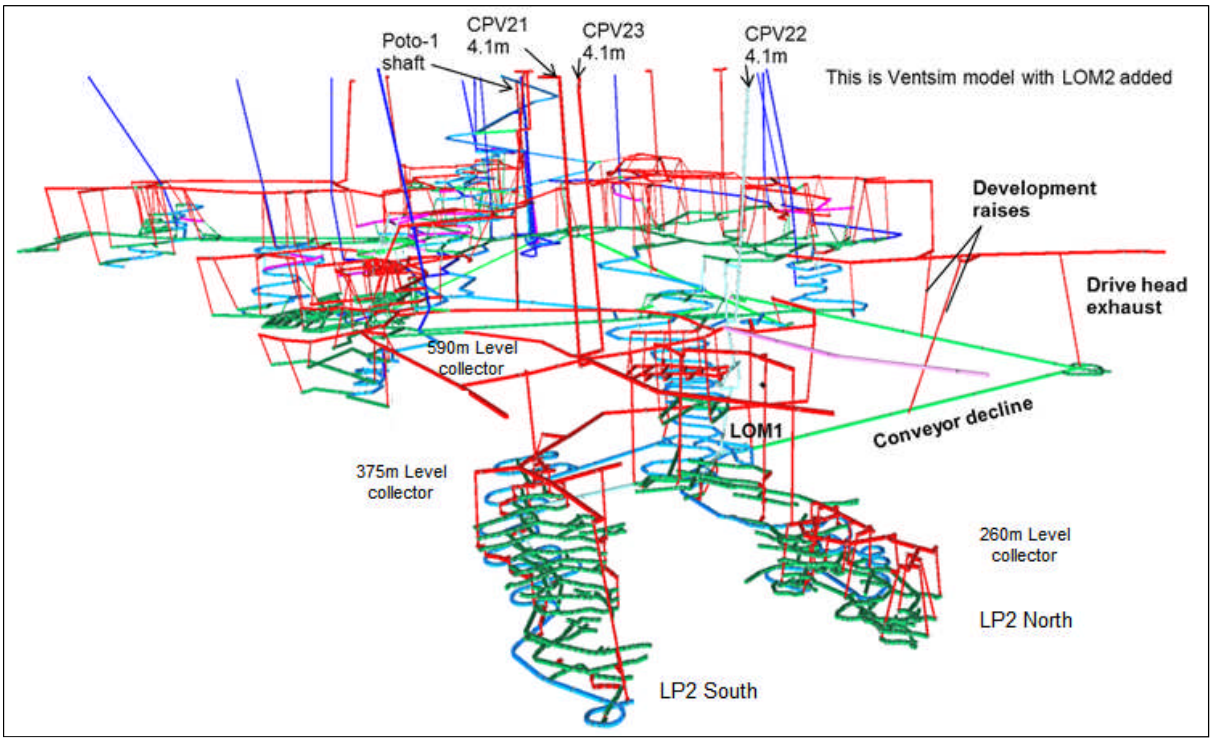


Figure 16.22: LP2 Ventilation Network. (After SOMINCOR)

With consideration to the heat management problems encountered at depth, the recommended refrigeration strategy is to install 4.5MWr (Megawatts of Refrigeration) of cooling capacity at the collar of CPV22 for the Base Case. Without any refrigeration during summer months, deeper development and production will continue to be constrained.

Further modification and optimisation of the refrigeration system will undoubtedly continue as further experience is gained in the system, which will prove invaluable in advance of the anticipated requirement of an additional 4.5MWr of refrigeration prior to the full ramp up of the LP2 area.

16.13.3 Ventilation Network Analysis Results

The ventilation system was modelled with the VnetPCPro+ network simulation program to reflect the volumetric ventilation requirements in 2023, the peak production year. By "fixing quantities" to be achieved in each working area to the values determined from the diesel fume dilution at 0.060m³/s/kW and the thermal criterion, the software then calculated the airflow required through the rest of the system and determined what is required to achieve this airflow distribution, i.e. the fan operating criteria. The calculated main fan operating points for Lombador are shown in Table 16.19.

Table 16.19: Fan Operating Duties for Three Different Airflow Conditions

Fan	0.047m³/s/kW Airflow (m³/s)	Pressure (kPa)	0.060m³/s/kW Airflow (m³/s)	Pressure (kPa)	Thermal Criteria Airflow (m³/s)	Pressure (kPa)
CPV21	276.9	3.444	317.7	4.693	310	5.3
CPV23	145.0	2.290	200.0	3.463	300	5.8

16.13.4 Principle Fan Selection

Based on the ventilation network analysis, the new principal fan for CPV23, will under peak production conditions operate at 300m³/s and a pressure of 5.8kPa.

16.13.5 Surface Facilities

The location of the new surface exhaust raise (CPV23) was selected in consultation with the environmental department in order to avoid land use restrictions and environmentally protected areas and therefore facilitate permitting and construction. The location of CVP23 recommended exhaust orientations are shown in Figure 16.23.

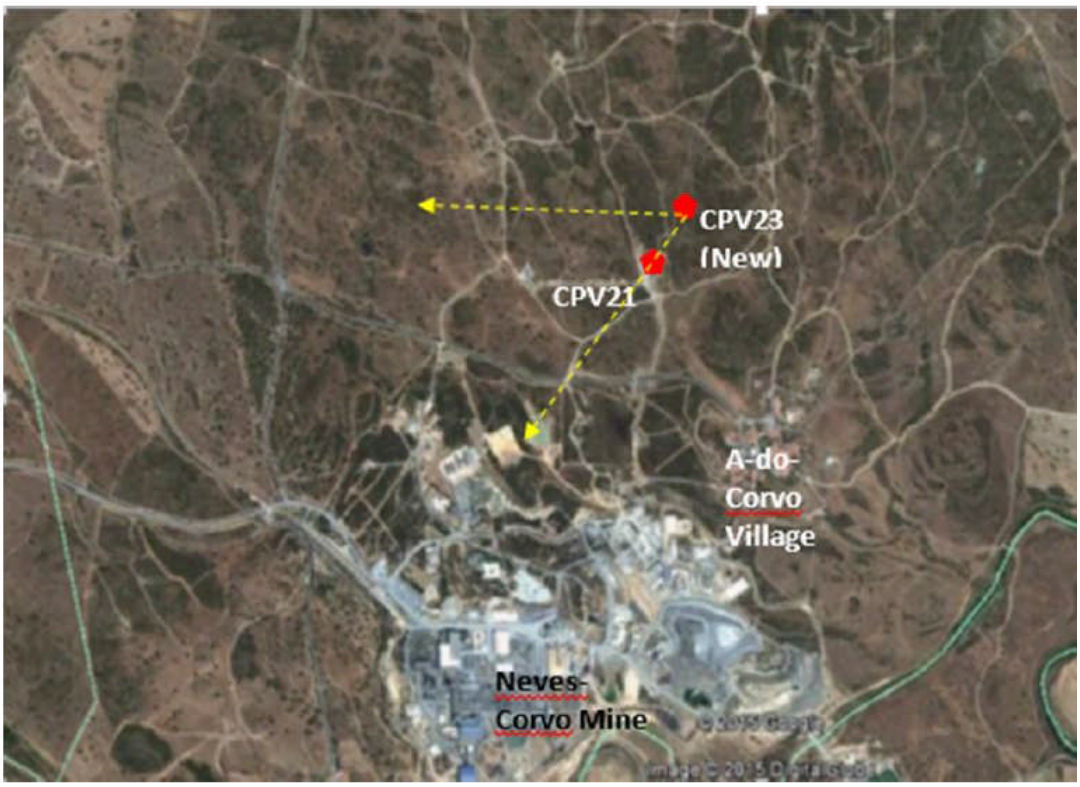


Figure 16.23: Location of CVP23 and Recommended Exhaust Orientations

Due to the proximity to A-do-Corvo village, a number of mitigation measures to attenuate noise generated by the exhaust fan are recommended. These mitigations will be incorporated into the design during engineering.

A review conducted by Morvent Mining Ltd also suggests the installation of a capture hood on the surface infrastructure at the collar of CPV22 intake raise for increased flexibility with regard to potential installations of refrigeration plant. A generic plan view of what this set up could resemble is shown below in Figure 16.24.

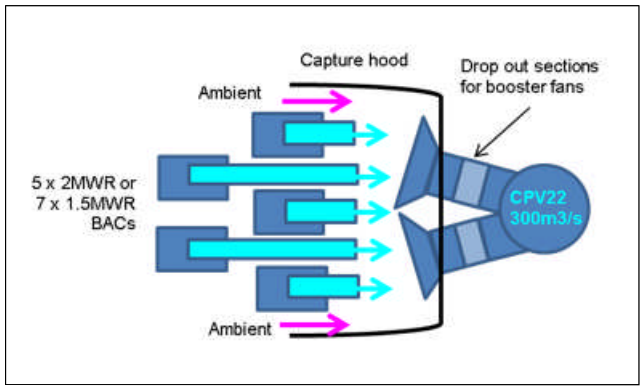


Figure 16.24: Generic Capture Hood Design for CPV22, after SOMINCOR

There is also an inclusion for drop out sections in the ducting to allow for the installation of booster fans if required at a later stage if the raise needs extending at depth.

16.13.6 Underground Facilities

In order to control the airflow pressures and airflow direction, preventing short-circuiting in the ventilation system, a number of bulkheads and doors are required.

As part of the ongoing ventilation improvements associated with Lombador, there are some additional underground alterations under consideration. Notable modifications include the potential stripping of the existing collector drifts. By slashing the profile out to 5.5m x 5.5m in certain collectors and providing additional crosscuts to the exhaust raise returns from these drifts, the pressure and friction losses could be reduced enough to improve the base case ventilation capacity without the need for additional infrastructure in other areas of the ventilation system.

16.13.7 Ventilation Cost Estimates

Ventilation costs for the preferred solution were developed in the FS by MVS. These costs have been updated to include refrigeration costs as estimated by Morvent Mining Ltd.

The project capital costs for ventilation are shown in Table 16.20 and include:

- LP2 and Materials Handling ventilation development to the end of 2019;
- Main ventilation fan, including installation costs;
- Pre-production secondary fans and ducting;
- 4.5MWr expansion of the Base Case refrigeration plant;
- Rental of two portable chilling units for the development of the lower conveyor leg and LSRAM3 access ramp; and
- Pre-production power for the main fans and chillers;
    - Secondary ventilation fan power costs during the project phase are included as indirect costs of the same development.

The total project capital cost for ventilation excavations is €19.3M and €8.9M for equipment, for a breakdown refer to Table 16.20. The capital cost for an initial 4.5MWr refrigeration plant has been allowed for in the Base Case capital cost to improve working conditions in the existing LP1 area.

Table 16.20: ZEP Ventilation Capital Cost Estimate

Category	Quantity	Installation (€)	Total Cost (€)
Principal Ventilation System	1		
CPV23 – Equipment (mechanical and electrical)	1	227,769	1,565,963
CPV23 – Civil	1	350,000	358,750
Fixed Chillers Allowance	1		4,000,000
Bulkheads, regulators and doors	35		356,693
Secondary Ventilation Systems (pre-production)			**463,198**
Mobile Chillers			
Conveyor Lower, LSRAM03 (Rental 2 units for 1 year)	108w		367,770
Conveyor -Lower (installation/move/remove)	730d		710,837
Power (pre-production)			**1,047,697**
Totals			**8,870,908**

The new principal fan, CPV23, will be equipped with Variable Speed Drives allowing for a ramp up in power as a function of production increase in LP2. The total annual operating cost estimated for the additional main fans in 2023 (peak production) is estimated at €1.2M.

16.14 Mine Services

16.14.1 Introduction

The LP2 expansion will require the following general mine services, described in detail in the following sections:

- Underground mobile equipment workshop;
- Pump station;
- Communications, including; fibre-optics, telephone, leaky-feeder radio;
- Water distribution;
- Back fill networks;
- Power distribution;
- Main ventilation; and
- Secondary egress and emergency equipment.

16.14.2 Workshops

As a guide, in a large multi-million tonnes per annum operation, mobile equipment shops should in general be available every 200m(v). Currently mobile production equipment workshops are available near the geographical centre of the operation at 810, 590 Levels and at the north-western extremity of the mine at 550 Level. A workshop is also available on 700L for mobile haulage equipment.

A new main workshop for LP1 is located to the north-west of ramp LS0RAM01 on 380m level. A satellite underground workshop facility for LP2 is conceptually planned for 220L servicing LP2 North and South as well as the crusher station.

The total capital allowance for the workshop is €1.0M, in which €0.5M is for the excavation (3,300m^3) and €0.5M for the equipment and installation.

16.14.3 Communications

Communication networks for LP2 will comprise:

- Leaky-feeder radio;
- Telephone; and
- Fibre optics.

16.14.3.1 Radio

The leaky-feeder radio network will tie-in to the existing network in LP1 and provide the principal means of communication to the development and production headings in LP2. It will also provide complementary means of communications to the workshops, PS, CRF station and the new material handling system.

The total cost of the leaky-feeder network extension is approximately €0.3M.

16.14.4 Telephone

The telephone network will be extended as the principle means of voice communications to the fixed installations such as: PS; workshop; CRF Plant; Material handling system and as an alternative means of communication to each working level.

The network will comprise at least one telephone on each sublevel located at either the mobile transformer station or the level sump, and in the workshops, PS, CRF Plant and Material handling. A total of 20 telephones are estimated each using different pair of cables.

The total cost of the telephone network extension is €0.05M.

16.14.4.1 Fibre Optics

The Lombador fibre optic network will connect to the existing mine network at 0HV6, then run parallel to the high voltage power network to each of the new electrical rooms located at the new crusher station, materials handling transfer stations, workshop, CRF Plant, PS, as well as to each mobile transformer station on the production levels. Redundancy connections are provided on 700 Level to 0HV2.

The total cost of the fibre optic network extension is approximately €0.1M.

16.14.5 Water Supply

16.14.5.1 Industrial Water

The water supply network for LP2 ties-in to the existing network in LP1. Industrial water is currently provided from the 550 Level pressure break-down tank (150m³) adjacent to the LSRAM01 ramp and continues via reticulation to 220 Level via the Lombador ramp.

Industrial water is also provided from the 700 Level pressure break-down tank (270m³) adjacent to LSCEN188 (service hole) and can be reticulated via the CPV22 fresh air raise system (CPV22-4 to CPV_6) down to 220 Level.

Industrial water available in LSRAM01 at 260L and 220L will be utilised during the construction phase to develop the ramps into LP2 and the Materials Handling excavations.

For ore production purposes, the LP2 water network will tie in to the existing network on 375 Level where a pressure break-down tank with 370m³ capacity is to be built. This tank has been designed to support one full LP2 production shift in accordance with a ratio of 0.15m³/t of ore produced. From this tank a 1m diameter hole is raisebored to 300 Level. Reticulation to the lower levels continues via short raisebored holes of 1.0m in diameter parallel to the intake airway system (CPV22).

The industrial water reticulation system will also be available for fire-fighting purposes.

The total costs for the tank, civils and control systems is €0.1M. The water distribution network will comprise a total of 2.586m of 6" diameter, Schedule 40 (A106) pipes throughout. The total cost of the network extension will be €0.4M.

16.14.6 Backfill Reticulation

16.14.6.1 Paste Fill Network

The PF network to LP2 will utilise the existing mine reticulation network to 295 Level in LP1. Below 295 Level the pipeline will pass via a new borehole service corridor parallel to the fresh air system.

The network will comprise a total of 1,395m of 6" diameter, Schedule 80 (A106) pipes throughout. The total capital cost for the pre-production extension of the backfill networks is €0.3M.

The water and paste fill networks share a common system of small diameter (1m) raises for routing pipelines inter levels.

16.14.7 Power Supply

The power distribution study for the underground workings comprises two distinct components, first an assessment of the necessary upgrades to the existing network and secondly an assessment of the expansion network required for power supply to LP2 as well as for the new fixed installations, including the materials handling system. To determine the upgrade and expansion required a specialist engineering firm, Optieng was consulted. Optieng utilised the available load lists to determine consumption and an ETAP® model to analyse the behaviour of the installation with the new loads.

Optieng was also consulted to run a site wide ETAP model of the surface power network. The power distribution network to the underground workings is comprised of a 15kV grid.

The ZEP project will require an additional 430A (5.7MVA) of power for mine related activities. Of this additional load, 220A is for mine related surface facilities, namely the shaft upgrade and the new Surface Fan (CPV23). The outstanding additional 210A of consumption occurs underground.

The loads used in the study have been determined from factors for the mobile production equipment, based on current ratios at each Mobile Transformer Station (PT) and from electrical equipment load lists for fixed equipment, e.g. materials handling system components and dewatering station. The locations of equipment loads are as follow:

- Production equipment on each of the initial production levels, ranging from 300 Level to 120 Level in the first three years and including the development headings;
- Dewatering station at the 220 Level;
- New Crushing station at the 260 Level; and
- Transfers points and corresponding conveyor headends at 385, 550 and 700 Levels.

The capital cost for the underground low and medium voltage power distribution network was prepared by the Mine Maintenance Department in collaboration with Optieng. The unit costs used to determine the overall capital cost for the underground power network are based on recent quotations for similar tasks and equipment. The total cost for equipment is €8.6M. The total cost of the excavations required for the electrical system is €0.2M.

16.14.8 Emergency Egress and Rescue

An emergency egress system is developed in parallel with the ramp development and the fresh air intake raiseboring. This progressive development, as versus campaigned development, minimises at all times the distance between the active mining faces and the emergency egress way.

With only a single access to the LP2 South orebody, below the 160 Level, and to LP2 North orebody, a secondary means is provided by equipping a small diameter (1m) raisebore hole parallel to the intake air system with a ladder way system by Safescape.

The capital estimate of the project also includes one 20-man Mine Arc refuge for use initially at the base of LP1 and later at the initial production horizon plus three, 12-man chambers, for each of the main development headings. The combined cost of these emergency systems is €0.5M.

16.15 Hydrology

A full dewatering evaluation and design for the original ZEP Feasibility Study in 2015 was undertaken by Schlumberger Water Services.

16.15.1 Hydrological Environment

Lombador is the only orebody where the workings will be deepened as part of the ZEP. Therefore, it has been assumed that only Lombador will contribute future groundwater storage inflows to the mine dewatering system. Once development ceases, the potential groundwater inflow from storage is anticipated to reduce until the massive sulphide unit has been drained. When the lowest planned development has been mined, it can potentially provide additional space for emergency water storage.

Unlike the other orebodies at Neves-Corvo, rainfall-recharge has not been observed in Lombador due to its depth below ground level and lateral distance from the Oeiras River. There is also no evidence of natural recharge in Lombador and lateral groundwater inflows are likely to be negligible.

It has been assumed that the service water inflow is directly proportional to the tonnes of ore produced, as is the backfill free water that will contribute to the general mine water inflow.

For planning purposes, a contingency of 20% was used for all the above contributors.

16.15.2 Current Dewatering System

The existing dewatering system comprises three key Pump Stations (PS): 700 Level PS, 550 Level PS and CRAM11 (530 Level). All three have components (sumps, tanks, pumps, etc.) on a number of different levels (not just the level indicated by the name). Two further PS are located at CRAM08 (500 Level) and Albraque 10 (620 Level). These are primarily for emergency and backup pumping.

For LP1 and continued development of LP2, multiple Flygt sump pumps are currently used from 220 Level to 550 Level (335m lift). This untreated water is pumped to the 550 Level PS sump.

Due to the high operating costs inherent to this type of system the cost of a new PS at the base of LP1 is assumed to be in part a Base Case cost.

16.15.3 Dewatering System for Lombador

An options study was carried out for the ZEP FS to determine the optimum design for a dewatering system that would improve the operational constraints and reduce the cost of pumping in LP1, and

simultaneously provide additional capacity for the expansion in LP2. The study concluded that the optimum design was one that made use of existing pumping infrastructure to dewater LP1 and LP2 in three stages.

The chosen pumping setup for Lombador assumes a sump and sump pump system installed in both LP2 North and South, below the 220 Level, with the water pumped in stages from these lower levels of the mine using Flygt pumps up to a new PS on 220 Level. A schematic of this system is shown in Figure 16.25, which includes the current installed system.

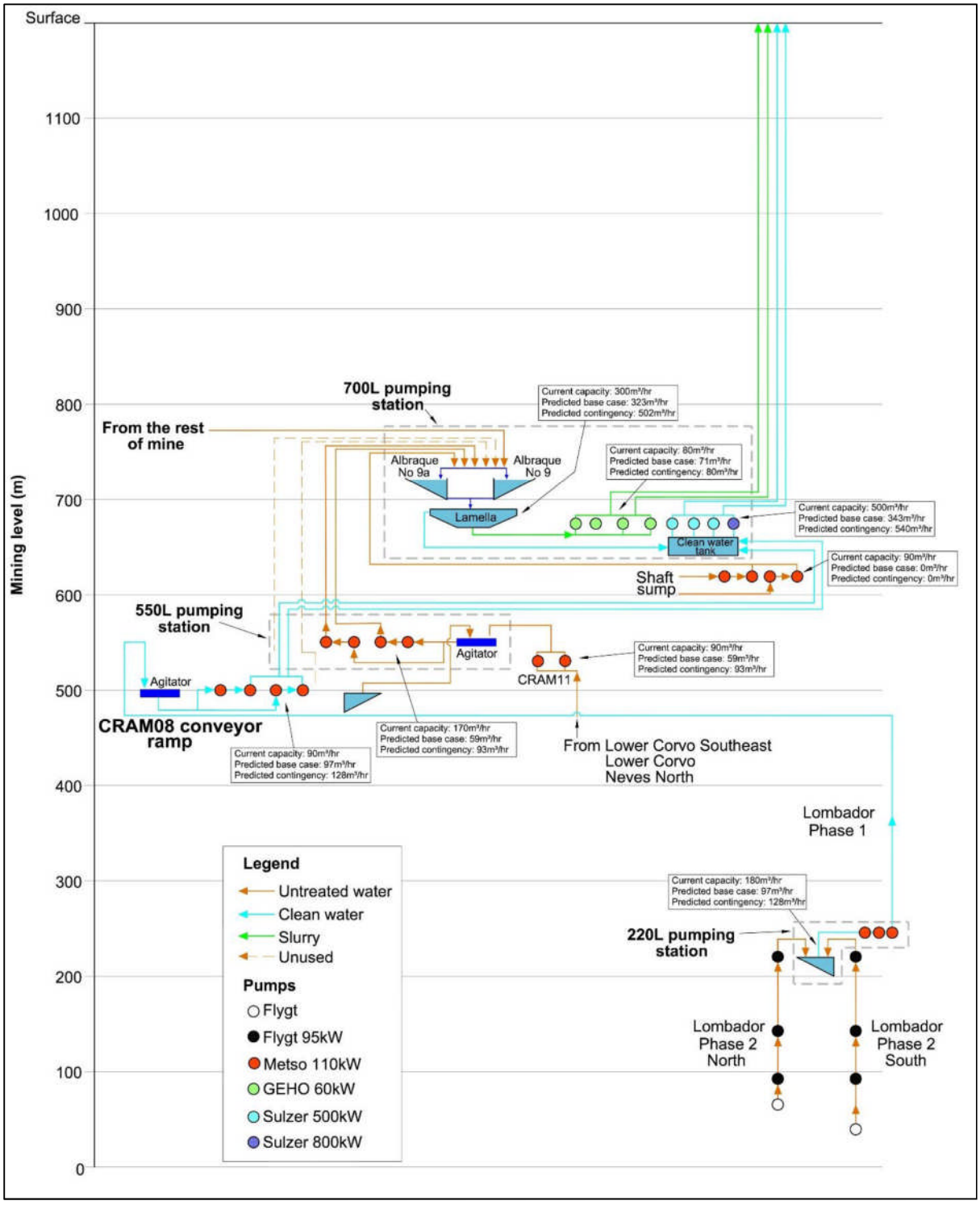


Figure 16.25: Schematic of Pumping Design for Lombador

At the new PS on 220Level two sets of four Metso HP100 LHC-D pumps in series (a total of eight pumps) will provide duty and standby capacity. Each pump will require a reinforced concrete base, with a gantry crane for installation and maintenance.

16.15.4 Surface Facilities

The clean water from the underground workings is pumped to the mine water treatment plant (ETAM) for subsequent discharge to the Oeiras River. The maximum discharge objective at any point in time is <10% of the river flow and it is company policy not to discharge to the river in the summer months when there is no flow.

16.15.5 Capital Cost Estimate

The capital estimate for the additional dewatering system required for the ZEP is €4.1M, of which €0.8M is for the electrical equipment.

As summarised previously, the current operating cost for dewatering in LP1, using the staged sump system, warrants the construction of a permanent pumping station with pumps that can provide a substantially lower operating cost. It is expected that the centrifugal Metso pumps system can reduce the current operating cost of dewatering in LP1 by €0.23/m^3. Therefore, €1.8M of the total estimated capital cost of €4.1M in dewatering has been assumed as Base Case cost.

17 RECOVERY METHODS

17.1 Copper Ore Processing

17.1.1 Introduction

The installed capacity of the Copper Plant is 2.5Mtpa. The operation starts at the coarse ore stockpiles, through pre-screening, crushing, grinding, flotation, filtration to concentrate storage and despatch and includes utilities and tailings management.

There are several copper ore types, namely:

- MC (Massive Copper);
- MCZ (Massive Copper Zinc ore);
- FC (Copper Stockwork); and
- MH (Massive Copper ore with elevated levels of penalty elements; As, Sb and Hg).

17.2 Copper Ore Processing

17.2.1 Copper Plant Description

The flowsheet for the Copper Plant is shown in Figure 17.1 below.

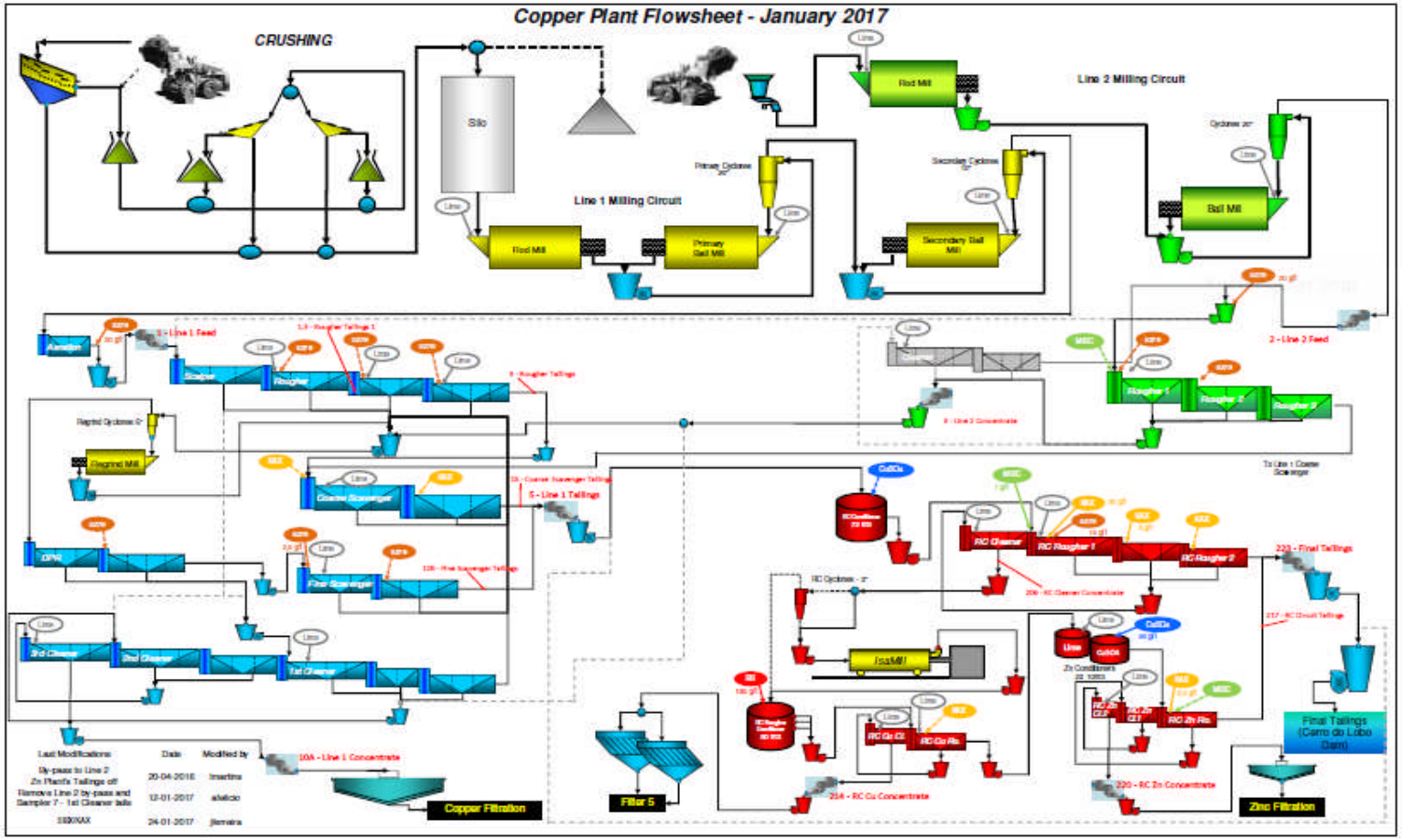


Figure 17.1: Neves-Corvo Copper Plant Flowsheet

The mills shown in yellow and the flotation cells shown in blue represent the main production (Line 1). Line 2 mills and cells are shown in green and the "RC circuit", which recovers copper and zinc from the rougher tailings, is shown in red.

17.2.1.1 Pre-Screening and Crushing

Coarse ore from the mine is delivered to dedicated surface stockpiles by conveyor and moving stacker. The ore is reclaimed from the stockpiles by a CAT 988 front end loader into two variable plate feeders, feeding either the pre–screening section and/or the crushers.

The Pre–Screen, installed upstream of the crusher circuit, is designed to remove the fines fraction (<19mm) existing in the run-of-mine ore. This increases the efficiency of the crushing circuit, especially when the ore has a high moisture content. The circuit consists of a Metso TS502 double deck screen, with a nominal capacity of 800tph.

The undersize discharges directly on to the conveyor belt which feeds the fine ore silo. Fine ore can be stored in the silo to feed the primary grinding line, or stockpiled beside the silo to feed the second grinding line installed in 2008.

Screen oversize is reclaimed by the front end loader and fed into the crushing circuit either alone, or mixed with run of mine ore, this is then conveyed to a 60" 'Superior' secondary crusher. All ore passes through the crusher to two 20' x 8' Allis Chalmers Screens.

Screen undersize at <19mm passes via a conveyor to the fine ore silo. Screen oversize passes to two 60" 'Hydrocone' crushers and the crushed product conveyed again to the screens.

Crushing plant throughput averages 350tph and is operated primarily at night to take advantage of cheaper electricity tariffs and to maximise available maintenance time whilst ensuring sufficient feed stock ahead of the grinding section. The silo has a capacity of 2,500t allowing 10 hours of rod mill feed.

17.2.1.2 Grinding and Regrind

The primary grinding circuit (Line 1) consists of a rod mill (Allis 3.8 x 5.5m with 1000kW) in open circuit and a primary and secondary ball mill (Allis 4.1 x 6.7m rubber lined with 1600kW) in closed circuit with hydrocyclones, Sala 20" for the primary and Sala 10" for secondary. Secondary cyclone overflow, at 80% passing 40 µm passes to the flotation circuit.

The second grinding line (Line 2) is fed by front-end loader from the fine ore stockpile adjacent to the silo. The circuit consists of a Rod Mill (3.0m x 5.6m, with 650kW) in open circuit and a primary ball mill (Allis 4.1 x 5.5m rubber lined with 1200kw) in closed circuit with Sala 20" hydrocyclones. Cyclone overflow, at 80% passing 45µm passes to the Flotation circuit.

Planned milling rate is 260tph (Line 1), and 80tph in the second line. The copper regrind mill (Allis 4.1m x 5.5m rubber lined with 1200kw) works in closed circuit fed by the underflow of 15 to 25 Sala 6" cyclones that can achieve a d80 of 18-25µm.

17.2.1.3 Copper Flotation

From the primary grinding circuit the slurry passes through two aerator conditioners (2 Dorr-Oliver 38m^3 cells) to the flotation circuit, 62 cells of 17m^3 and 12 of 38m^3, all Dorr Oliver.

Concentrate from the first bank of Rougher 1 (3 cells of 17m^3) feeds the first cleaner, but can also go to regrinding. The remaining three banks of Roughers 1 and 2 (11 cells of 17m^3) can either go to the regrind (normal) or to the first cleaner. Rougher tailings feed the coarse scavenger (6 cells of 38m^3), which produces a concentrate that goes to the regrind. Tailings from this section feeds the RC circuit.

Slurry from the second grinding line feeds a bank of 6 x 38m^3 cells for roughing and 7 x 17m^3 cells for cleaning. Cleaner concentrate then feeds the regrind circuit of the main cleaner circuit, while rougher tailings feed into the main line scavenger cells.

The copper cleaning is achieved in three stages using 17m^3 cells, with nine on the first clean, seven on the second clean and four on the third clean. The final 3rd Cleaner concentrate contains 23-24% Cu and goes to filtration. The tailings of the 1st Cleaner stage goes to the regrind circuit.

After regrinding, the slurry feeds the Regrind Rougher ("DPR"). This has seven cells of 17m^3 that produce a concentrate feeding the 1st cleaner and a tail feeding the Fine Scavenger. This Fine Scavenger has 7 cells of 17m^3; concentrate goes to the regrind and tailings feed to the tailings retreatment circuit.

17.2.1.4 Tailings Retreatment (RC) Circuit

In June 2009, the RC circuit was commissioned to recover copper and zinc values from the copper plant tailings. The circuit consists of a bulk rougher/cleaner stage of 10 + 3 17m^3 flotation cells. Concentrate feeds an M3000 Isa Mill to regrind the concentrates to < 10µm. Reground product is then conditioned with MBS to depress zinc, and floated in 8m^3 cells to produce a copper concentrate. This concentrate represents a further 3% in copper recovery. Copper sulphate is then added to activate the sphalerite, and a zinc concentrate is produced in a circuit with two stage cleaning.

The plant also includes a boiler to elevate pulp temperature to 65°C to aid zinc depression, although this is not currently used.

17.2.1.5 Filtration

The final copper concentrate is pumped to a 40m diameter thickener where it is thickened to 65-68% solids before passing to the Filter Plant Storage Tank. From the tank the slurry is pumped on demand

to the five Sala VPA 1530-40 Pressure Filters with a capacity of 25dtph each. Normal operation uses four filters, with one on stand-by for maintenance.

The Copper Plant zinc concentrate is pumped to the Zinc Plant thickener, and mixed with the zinc concentrates from the Zinc Plant.

17.2.1.6 Concentrate Handling

Filtered concentrate can either be loaded directly into containers via the conveyor load-out system, or stockpiled in a storage shed.

17.2.2 Sampling and On-Stream Analysis

Automatic samplers are used to produce daily composites of the mill feed, plant tailings and final copper concentrate. The sample collection and preparation is undertaken by dedicated samplers. The plant is equipped with three Thermo AnStat probes which are located on the plant feed, concentrate and tailings streams, and can determine Cu, As, Zn Sb, Sn and Pb. Up to 12 intermediate process streams are analysed using a Thermo MSA. The Plant has recently been fitted with an Expert system (METSO), to improve metallurgical control.

17.2.3 Utilities

All reagents for Copper (and Zinc) Plants are mixed in the Reagent Mixing Station and pumped as required.

Tailings are cycloned and the underflow is pumped to the paste backfill plants for use as underground backfill.

Final tailings are pumped to the final tails station before being pumped 4km to the TMF. Process water from all thickeners is re-cycled within the Plant and recycled water from the TMF paste plant is also utilised in processing.

17.2.4 Plant Consumables

The Copper Plant consumables are summarised in Table 17.2.

Table 17.1: Copper Plant Consumables (2016)		
Item	**Consumption**	**Units**
Total Steel Media	959	kg/t
Ceramic Media (RC Circuit)	21	kg/t
Lime (Process Plant)	1,477	kg/t
Lime (Tails Dam)	1,879	kg/t
Dithiophosphate	53	kg/t
Xanthate	21	kg/t
Copper Sulphate (RC Circuit)	253	kg/t
Sodium Bisulphite (RC Circuit)	153	kg/t
Flocculant	1.66	kg/t
Electricity	41.0	kWh/t

The consumption figures are typical for the treatment of a moderately hard, massive pyrite, copper ore.

17.2.5 Plant Performance

The Copper Plant production (not including Tin Plant copper production) since 2000 is summarised in Table 17.2.

Table 17.2: Copper Plant Production					
Year	**Tonnes Treated, 000t**	**Head Grade, % Cu**	**Cu Recovery, %**	**Concentrate Tonnage, 000t**	**Concentrate Grade, % Cu**
2000	1,342	5.34	86.04	319	23.89
2001	1,672	4.93	85.34	344	24.08
2002	1,739	5.08	86.97	319	24.17
2003	1,679	5.35	85.72	330	23.53
2004	1,882	5.74	88.39	401	23.88
2005	2,041	4.96	88.13	366	24.45
2006	1,947	4.56	88.40	319	24.66
2007	2,181	4.78	86.48	393	22.92
2008	2,338	4.29	85.80	366	24.29
2009	2,304	3.93	85.56	349	24.80
2010	2,256	3.43	86.37	304	24.16
2011	2,685	2.74	86.62	304	24.38
2012	2,325	2.64	87.97	245	23.93
2013	2,483	2.60	84.83	239	23.63
2014	2,486	2.53	80.21	217	23.69
2015	2,542	2.72	80.62	232	24.07
2016	2,386	2.55	76.56	199	23.35

The treatment rates in the Copper Plant steadily increased from 2000, and reached a peak of 2.685 Mtpa in 2011. In recent years copper recoveries have fallen, which is primarily attributed to a decrease in the quality of water being returned from the TMF, as well as due to the treatment of the more difficult MH ore types.

Copper concentrates grades have remained fairly steady with the average grade of concentrate produced in 2016 being 23.35% Cu. The plant head grades have fallen since 2004, particularly between 2007 and 2012 where grades have decreased from 4.78% Cu to 2.64% Cu. Over the last six years the head grades have been relatively consistent, between 2.53-2.74% Cu.

As a consequence of the lower head grades and recoveries, the quantity of copper concentrate produced has fallen, with 199kt being produced in 2016.

17.3 Zinc Ore Processing

17.3.1 Zinc Plant Process Description

A flowsheet for the current Zinc Plant is shown as Figure 17.2. The current zinc processing plant is described in detail in the following sections.

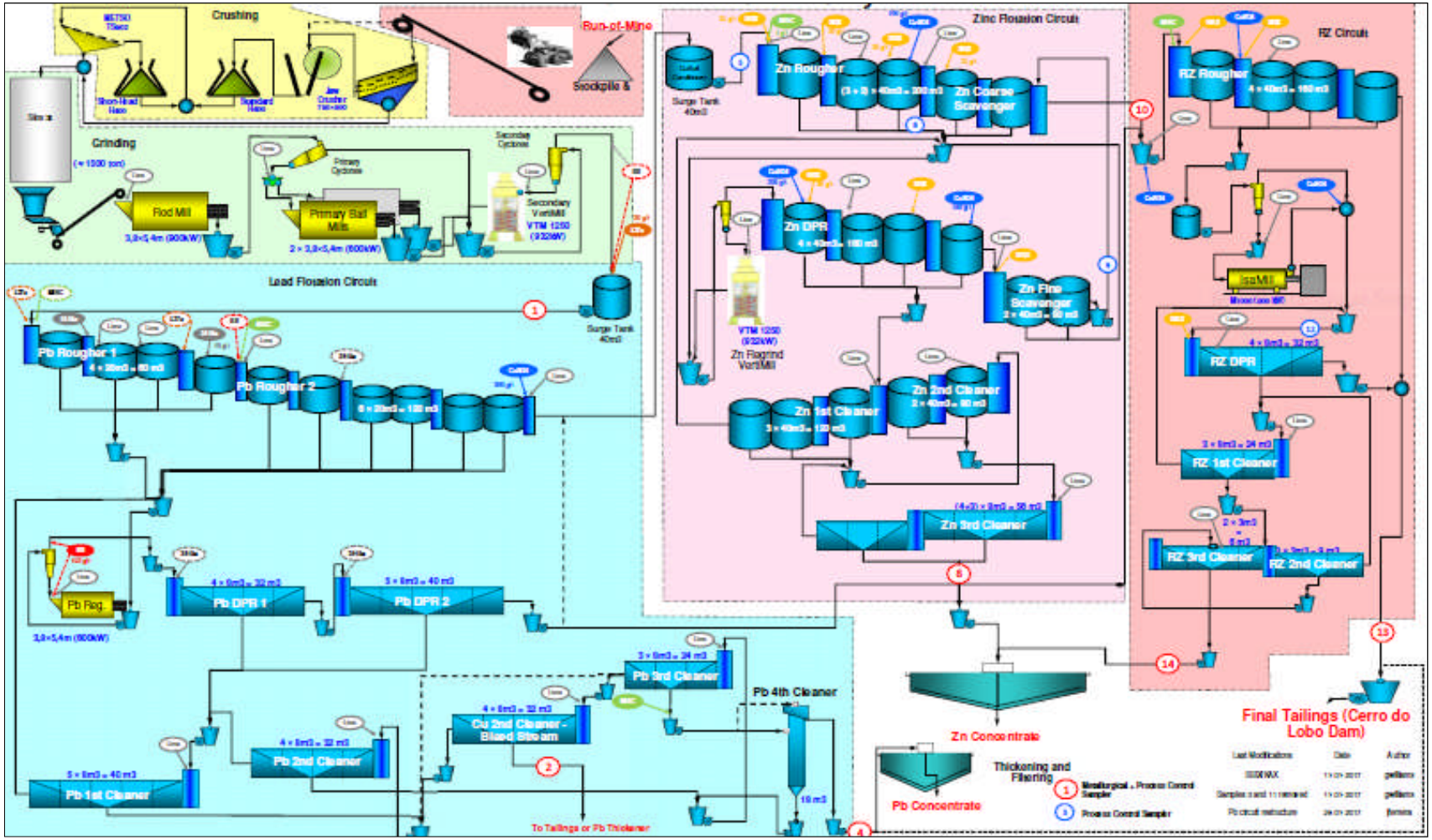


Figure 17.2: Neves-Corvo Zinc Plant

17.3.1.1 Crushing

Run-of-mine (ROM) ore is dumped from the mine stacker to the ore park. The ore is fed to a pre-screen for screening at 20mm. The oversize reports to the primary jaw crusher (750 x 500mm) while the undersize reports directly to one of the fine ore silos. The crushed coarse ore is conveyed to the secondary cone crusher (Standard H400 cone). The conveyor system has a rated capacity of 200tph. The secondary crusher product is conveyed to the tertiary crusher screen with the oversize (+20mm) reporting to the tertiary cone crusher (H400 Shorthead cone) and the undersize reporting to the fine ore bin.

17.3.1.2 Grinding

The crushed ore is reclaimed from one of three 500t ore silos via three feeders and fed to the rod mill feed conveyor. The grinding circuit consists of a single line consisting of a 3.81m diameter by 4.87m long rod mill (900kW), and two 3.00m diameter by 4.10m long (600kW) primary ball mills and a Vertimill (930kW). The rod mill product is pumped to the ball mill circuit via two feed distributors (one operating and one standby), for distribution to two primary ball mill sumps. The rod mill discharge, together with the ball mill discharge, is pumped to cyclone clusters for classification. The cyclone clusters operate in closed circuit with the ball mills. The cyclone overflow, at a P80 product size of 200µm, is fed to the secondary grinding mill circuit. The cyclone underflow returns to the ball mills.

The primary cyclone overflow together with the secondary grinding mill discharge is pumped to a cyclone cluster. The cyclone overflow, at a P80 product size of 60µm, is fed to the flotation circuit. The cyclone underflow is returned to the Vertimill.

17.3.1.3 Copper Flotation

When operating, copper flotation takes place in four 20m^3 tank cells. The copper rougher concentrate is reground in a 2.4 x 3.0m ball mill and cleaned in a bank of copper “re-cleaner” flotation machines (7 x 8m^3 cells). The copper recleaner concentrate is pumped to the copper first cleaner (5 x 8m^3 cells). The copper first cleaner concentrate is pumped to the copper second cleaner (4 x 8m^3 cells). The copper first cleaner tails are returned to the regrinding circuit. The copper second cleaner concentrate is the final copper concentrate and is pumped to the copper plant thickener feed tank. The copper second cleaner tail is returned to the copper first cleaner. The copper rougher tailings, together with the copper re-cleaner tailings, report to the lead circuit conditioner tank.

17.3.1.4 Lead Flotation

The reject products from the copper circuit report to a lead conditioner tank prior to gravitating to the lead rougher cells. The lead rougher concentrate, combined with the lead cleaner tails is reground in a 3m diameter by 4.10m long (600kW) ball mill. The ground lead rougher and lead cleaner tails are pumped and cleaned in the lead re-cleaner flotation machines (13 x 8m^3). The lead re-cleaner concentrate is pumped to the lead first cleaner cells (7 x 8m^3 cells).

The lead first cleaner concentrate is cleaned in the lead second cleaner cells (5 x 8m^3). The lead second cleaner concentrate passes to a third cleaning stage consisting of 7 x 3m^3 cells. The third cleaner concentrate can also be cleaned further in a 10m^3 column. The final lead concentrate is either pumped to final tailings or is thickened and filtered, depending on the concentrate grade. The lead second cleaner tailings are returned to the lead first cleaner flotation cells. The lead rougher tailings, together with the lead re-cleaner tailings, report to the zinc circuit conditioner tank.

17.3.1.5 Copper-Lead Bulk Flotation

The plant is currently configured to undertake a copper-lead bulk flotation. In this mode Cu-Pb rougher flotation takes place in ten 20m^3 cells with the rougher concentrate being reground in a 3m diameter by 4.10m long (600kW) ball mill. The reground concentrate (d80 = 10µm) is then cleaned four times in conventional cleaner cells, as described previously for the lead cleaning circuit.

17.3.1.6 Zinc Flotation

Main Circuit

Zinc roughing takes place in five 40m^3 tank cells. The rougher concentrate is ground in a stirred mill and pumped to a bank of 6 x 40m^3 zinc re-cleaner (DPR) flotation machines. The zinc re-cleaner concentrate is pumped to the zinc first cleaner (3 x 40m^3 cells). The zinc re-cleaner tail returns to the zinc rougher. The zinc first cleaner concentrate is pumped to the zinc second cleaner (2 x 40m^3 cells). The zinc first cleaner tails returns to the regrinding circuit. The zinc second cleaner concentrate is pumped to the zinc third cleaner (7 x 8m^3 cells). The zinc second cleaner tails return to the zinc first cleaner feed. The zinc third cleaner concentrate is the final zinc concentrate and is pumped to the zinc thickener feed tank. The zinc third cleaner tail returns to the zinc second cleaner. The zinc rougher tailings, together with the zinc re-cleaner tailings, report to the final tailings collection tanks for pumping to the copper plant tail discharge system.

RZ Circuit

The zinc RZ circuit is used to scavenge further zinc from the rougher circuit in a similar manner to that utilised in the Copper Plant. After further reagent additions, the zinc rougher tails are subjected to further flotation in four 40m^3 cells where coarse, unliberated sphalerite is recovered. This product is then reground in an IsaMill before being cleaned in four stages. The final RZ zinc concentrate is added to the main zinc concentrate thickener. The plant also has the option of sending the lead first cleaner (DPR) scavenger tails to the RC circuit to reduce the levels of lead entering the main zinc flotation circuit.

17.3.1.7 Concentrate Thickening and Filtering

The final copper concentrate, when produced, is pumped to the existing copper plant thickener. The final lead concentrate is thickened and filtered and then loaded into 20’ shipping containers for shipment.

The final zinc concentrate is thickened in a 20m diameter thickener. The thickened concentrate is pumped to a concentrate storage tank. The thickened slurry is filtered using 2 METSO VPM 1530-40 filter presses. The discharge from the filters is conveyed to the covered zinc concentrate storage building.

Water recovered from the concentrate thickening is combined with the water recovered from the filters and recycled to the process.

17.3.1.8 Tailings Disposal and Reclaim Water

Flotation tailings are pumped to the existing discharge systems described for the Copper Plant. Water reclaimed from the thickened tailings pond is returned to the Industrial water tank for recycling to the plant.

17.3.1.9 Plant Consumables

The Zinc Plant consumables are summarised in Table 17.3 below.

Table 17.3: Zinc Plant Consumables (2016)

Item	Consumption	Units
Total Steel Media	1.397	kg/t
Ceramic media	0.054	kg/t
Lime (Process Plant)	1.934	kg/t
Dithiophosphate	0.016	kg/t
Xanthate	0.144	kg/t
Aero 3418A	0.021	kg/t
Copper Sulphate	715	kg/t
Sodium Bisulphite	289	kg/t
Electricity	52.0	kWh/t
Filter Cloths	0.001	Per kt
Diesel	0.088	l/t

The consumption figures are typical for the treatment of a moderately hard, massive pyrite zinc ore.

17.4 Mill Labour

A Production Manager is responsible for both the Copper and Zinc Plant operations. The two concentrators are operated with five shift crew, each comprising one supervisor and fifteen operators. A day crew is used for routine tasks such as reagent mixing, ball loading, general clean-up etc. The plants are scheduled to operate twenty four hours per day, seven days per week. A summary of the manning levels is summarised in Table 17.4.

Table 17.4: Mill Labour (2016)	
Personnel	**Number of Staff**
Mill Manager	1
Production	89
Maintenance	72
Metallurgy	17
Geometallurgy	3
Dams and water	20
Concentrate transport	17
Total	**219**

17.4.1 Plant Performance

The performance of the Zinc Plant is summarized in Table 17.5 and Table 17.6.

Table 17.5: Zinc Plant - Zinc Production					
Year	**Tonnes Treated '000t**	**Head Grade %Zn**	**Zn Recovery %**	**Concentrate Tonnage**	**Concentrate Grade %Zn**
2006	148	8.44	60.2	15,301	49.0
2007	397	7.76	78.5	49,444	48.9
2008	399	7.26	77.9	45,901	49.2
2009	-				
2010	100	5.70	75.0	9,419	45.6
2011	63	6.42	27.3	2,232	49.6
2012	543	7.26	71.0	58,723	47.6
2013	974	7.07	74.2	107,040	47.7
2014	1,102	7.96	74.0	141,718	45.8
2015	1,014	8.01	71.8	130,379	44.7
2016	1,040	8.21	78.5	147,332	45.8

Table 17.6: Zinc Plant - Copper Production					
Year	**Tonnes Treated**	**Head Grade, %Cu**	**Cu Recovery, %**	**Concentrate Tonnage**	**Concentrate Grade, %Cu**
2000	347	6.76	89.5	86,872	24.2
2001	348	5.14	85.3	62,042	24.6
2002 -2006	-				
2008	72	4.17	89.1	10,588	25.2
2009	266	4.02	85.6	36,508	25.0
2010	219	3.42	84.8	25,155	25.3
2011	513	2.87	73.6	43,601	24.8
2012	187	2.67	84.3	16,848	25.0
2013	42	3.39	70.7	4.052	24.8
2014	17	1.95	75.2	992	25.0

The Zinc Plant (formerly the Tin Plant) produced copper concentrates from the tin ores up until 2001 after which time the tin ores were exhausted. After converting the Tin Plant to the Zinc Plant in 2005, copper ores have been processed at times when zinc ore processing was uneconomic. In general, a higher proportion of the dirtier MH ore type was treated, hence the lower recoveries.

17.5 Analytical Laboratory

The laboratory operates under the control of the Mill Manager and services the following areas:

- Geology department;
- Copper and Zinc Plants;
- Commercial (concentrate sampling and assaying) – SOMINCOR;
- Commercial (concentrate sampling and assaying) – Zinkgruvan;
- Environment; and
- TMF (water).

The laboratory is accredited to ISO/IECD 17025 for some 50 analytical methods. The laboratory is very well equipped and includes sample preparation facilities, X-Ray fluorescence (XRF), atomic adsorption spectrophotometry (AAS), Inductively Coupled Plasma (ICP), electro-gravimetric methods and a LECO analyser for sulphur determination.

The total number of staff employed in the laboratory is 31.

17.6 Tailings Management Facility (TMF)

Tailings from the mine are stored into a 190ha TMF bounded to the north by a rockfill embankment across a natural river valley. The facility was originally developed for sub-aqueous tailings deposition, but was converted to a thickened tailings deposition facility in 2010 with a thickened tailings plant to increase the storage capacity. The design included disposal of tailings with run-of-mine waste rock, which is potentially acid generating (PAG). The waste rock is used for dyke construction, where the dykes demark the deposition cells, and also in the current design it is included within the final cover, with a capillary break above, followed by clean rock and topsoil.

Figure 17.3 illustrates the current design showing the current arrangement of cells (left) and the final concentric terraces (right).

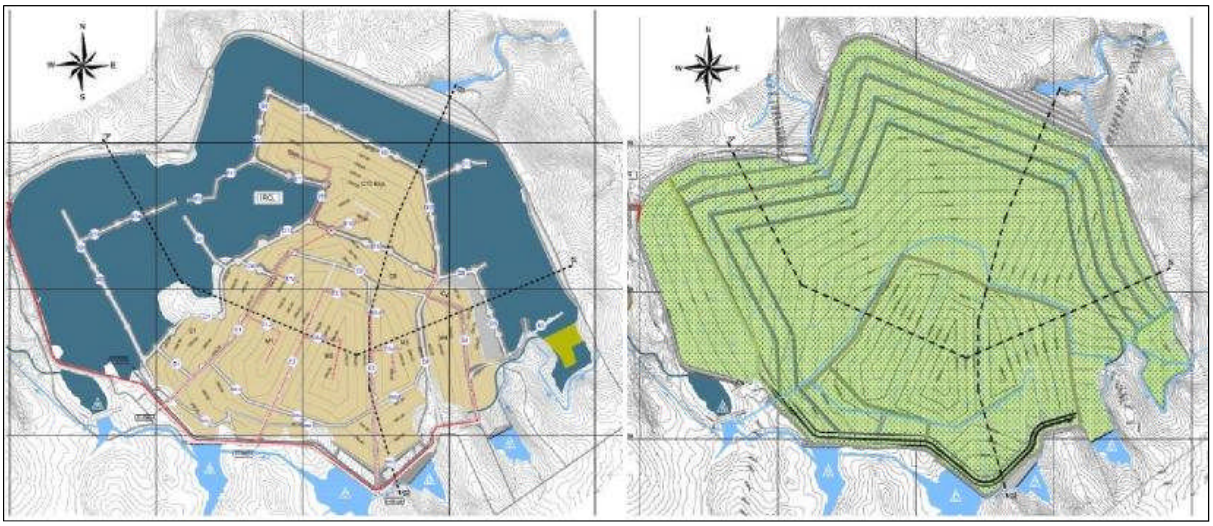


Figure 17.3: Cerro de Lobo Thickened Tailings Terraces

The current facility and design is permitted to 2019 and comprises five lifts of thickened tailings up to an elevation of 266m above mean sea level (amsl) for the final deposited tailings layer.

In 2015 a pre-feasibility level study was undertaken by Knight Piesold Consulting into the ultimate capacity of the current tailings impoundment area. The study concluded that the TMF could be expanded within the confines of the land currently owned by SOMINCOR to accommodate the tailings and waste rock from the expanded operation. The expansion scenario included the use of an additional 25ha of land to the south side of the dam and increasing the currently planned five lifts to fourteen lifts.

In their review, Ausenco deemed the 2015 PFS capital costs for the TMF to be appropriate and were incorporated into the 2017 FS Amendment. Expenditures have been advanced by one year, however, to allow for construction to start as soon as permitting is completed, in late 2018. This will ensure capacity in the current facility is not exhausted before the expansion is complete. It should be noted that, in relation to the present capital costs, the 2015 FS only included 33% of the TMF expansion capital costs as pre-production costs. Since the expansion is brought forward and the start of the project is effectively delayed by two years, the project pre-production capital is thus increased by the additional 67%.

With the expansion of the plant and the volume to tailings produced, there may be a need to expand the tailings thickening plant and this has been accounted for in the ZEP expansion capital cost.

A Feasibility level study for expanding the TMF will start in May 2017. The study will provide a comprehensive tailing development scenario and will better define the capital cost for the ongoing development.

17.7 ZEP (Zinc Plant Expansion)

17.7.1 ZEP Studies

In October 2015, SOMINCOR, in conjunction with AMEC, completed the ZEP FS aimed at increasing zinc ore production from the current 1.1Mtpa to 2.5Mtpa. The processing component of the study included an assessment of:

- New surface zinc ore stockpiles (principal stockpile covered) and a materials handling system feeding the mill;
- An expanded zinc processing plant, including a new building for grinding (new SAG Mill and VertiMill) and flotation; upgrades to flotation in the existing plant; expanded zinc and lead thickeners and filters; new blowers; expanded compressed air systems; new tailings cyclones and pumping; upgraded and expanded process control systems; and all associated services within the new and existing buildings;
- An expanded and upgraded lead concentrate handling facility on site and at the port facility in Setubal;
- Expansion and upgrade to existing surface infrastructure facilities, including water supply; water treatment; a new and re-located contaminated water dam (BAC2); electrical distribution networks; piping and pipe racks for water, tailings and paste backfill; and communications; and
- The TMF expansion options, including designs, costs, schedules etc.

Although the ZEP FS showed a positive financial outcome at the time, the implementation of the project was not approved, pending improved zinc metal market conditions and greater stability at the existing operations.

By September 2016 it was judged that these objectives had been met and an Early Works Programme (EWP) for project implementation was authorized. This EWP had the following components:

- A “Cold Eyes” review, undertaken by Ausenco, of the technical parameters and designs of selected areas (underground materials handling, ventilation, shaft upgrade and process plant layout) from the ZEP FS;
- An Update of the ZEP FS using existing data; and
- A Feasibility Study Amendment which included new engineering and cost information.

The review by Ausenco resulted in the identification of approximately €10M to €15M in direct capital cost reductions. These were principally related to the modification of the ore storage, new grinding and new flotation and equipment, as follows:

- Removal of the Coarse Ore Stockpile (COS) and using the existing stockpile and FEL loading (€4M);
- Removal of the coarse screen (€0.2M);

- Modify the grinding and flotation layout (€2M);
- De-rate the SAG motor (€1.5M);
- Removal of buildings for new grinding and flotation (€1M); and
- Retain BAC2 (€3M)

Ausenco stated that additional indirect cost savings could be realised, with significant potential for optimisation of the plant layout and design to reduce bulk materials quantities in the greenfield areas. They also concluded:

- The underground primary crushers need to be operated with a CSS of less than 130 mm;
- The SAG mill motor can be derated to approximately 6.5 to 7MW and the SAG mill operated as an AG mill, or with very minor ball addition;
- The process focus needs to further consider the importance of good lead flotation performance on zinc recovery and how this can best be achieved in the upgraded plant; and
- The risk associated with the Brownfields scope needs to be managed through a staged approach. The ZEP FS did not address the Brownfields work issues separately and may have underestimate the work (time and cost) required to make these areas safe and suitable for re-use.

Ausenco also stated that the execution strategy needs to include a shared vision at multiple levels of the project due to the scope diversity (U/G & surface, greenfield & brownfield site development).

17.7.2 Zinc Plant Expansion Recovery Predictions

17.7.2.1 Assessment of Current Metallurgical Performance

Major changes have been made to the zinc circuit since completion of the 2015 FS, including:

- The removal of copper flotation;
- Reconfiguring the Pb circuit to better handle high Pb grades; and
- Reduction in lime addition and operating pH to improve zinc circuit chemistry.

There was a steady improvement in zinc recoveries in 2016, but in recent months the recoveries have been variable. An intensive program is currently underway to determine the causes of the erratic performance.

Recoveries used in the ZEP FS (2017 Amendment) financial evaluation were based on testwork and modelling performed for the ZEP FS (2015) with consideration for recent lead and zinc circuit flotation circuit survey data and operating results. A comprehensive testwork program is underway, which is expected to confirm flotation performance of the expanded circuit. The site metallurgical team are confident that the stated recoveries can be achieved.

The expanded zinc plant will offer the following improvements compared with the current plant:

- A more reliable water supply due to the construction of a Water Treatment Plant (WTP);
- A more consistent and stable grinding circuit;
- A better designed flotation circuit with additional retention time, particularly for lead;
- More filter capacity; and
- A larger lead thickener.

In the ZEP FS (2017 Amendment), Ausenco reviewed the recovery calculations used in the ZEP FS (2015) as well as the recent lead and zinc circuit flotation circuit survey data and operating results. After discussions with operations personnel, a decision was made to continue using the recovery (and grade) formulas developed for the ZEP FS (2015) expansion case. A comprehensive testwork program is underway, which is expected to confirm flotation performance of the expanded circuit.

The final concentrate grade and metal recovery equations were developed by formulating regression equations for recovery and concentrate grades as a function of head grade. The grades and recoveries were generated in JKSimFloat simulations during the ZEP FS (2015) based on flotation kinetic testing on drill core samples representing future sections of the orebody.

17.7.2.2 Zinc Recovery

For the zinc circuit, it was found that there was no relationship between the concentrate grade and the head grade. The JKSimFloat results showed that the zinc concentrate grade is constant. SOMINCOR also stipulated a minimum zinc concentrate grade of 48% as a minimum acceptable smelter feed.

The overall zinc recovery equation is calculated by the following:

Zinc Recovery = 100 * (0.89 - EXP(- (Zinc Head Grade) * 0.36322))
– 0.00006 * EXP(30.52 * (Head Grade Pb:Zn))

This equation is valid for zinc head grades between 4% Zn and 13% Zn.

17.7.2.3 Lead Recovery

In the lead circuit, the lead metallurgical performance is affected by lead head grade. The simulations show that if the lead head grade is below 1% Pb, it may not be possible to produce a lead concentrate of 30% Pb, thus this material should be sent to tailings. If the lead head grade is greater than 1%, the lead concentrate material can be sent to the lead thickener.

For the lead circuit, the simulations showed the overall lead recovery rate can be determined from the following equation:

Lead Recovery = 36.201 * (Lead Head Grade) EXP 0.3667

The lead concentrate grade equation is based on the following equation:

Lead Concentrate Grade = Minimum (55, 21.602 * LN (Lead Head Grade) + 31.737)

These equations are valid for lead head grades between 0.4% Pb and 4.2% Pb only.

17.7.3 ZEP Engineering

17.7.3.1 Introduction

The ZEP will use much of the existing process equipment and related facilities currently installed and operating in the 1.1Mtpa Zinc Plant as well as incorporating new process equipment to expand capacity to 2.5Mtpa.

The new facilities require earthworks, with excavation required for the new Grinding and Flotation Buildings, and for the emergency feed system. Excavation is also required for new site roads to the south of the facility.

17.7.3.2 Ore Park, Surface Stockpiles and Coarse Ore Feed

The existing Ore Park is currently arranged with zinc ore stockpiled on the west side and copper ore stockpiled on the east side. As part of the expansion, the locations of the zinc and copper ore stockpiles will be swapped.

A zinc ore stockpile of approximately 30,000 tonne capacity will be established on the eastern side of the ore park. To facilitate the relocated copper ore stockpile, the copper ore feed conveyor will be extended approximately 30m to the west. Two of the existing copper feed hoppers will be relocated further to the west and one will be removed.

A new coarse ore feed system is provided to the east of the Ore Park. The feed system includes a Stockpile Reclaim Hopper, Stockpile Reclaim Feeder, and Stockpile Reclaim Conveyor. The stockpile reclaim conveyor and emergency stockpile reclaim conveyor will discharge onto a new SAG Mill Feed Conveyor, which delivers coarse ore to the new Grinding Building.

The Pebble Conveyor No.2 will discharge onto the SAG mill feed conveyor at a new transfer station located to the east of the new SAG Mill Building. The transfer station comprises an open steel structure.

A pebble crusher is not included in the design as it is not expected to be required. However, the layout provides for sufficient space to the north-east of the tower for a pebble crusher to be installed in future if deemed necessary.

17.7.3.3 New Grinding and Flotation Buildings

The new Grinding and Flotation Buildings are arranged in two sections to accommodate the new SAG mill and new lead and zinc rougher flotation cells.

New buildings will be constructed for the following areas:

- Grinding Building - containing the new SAG mill and ancillaries;
- Flotation Building - containing new flotation cells, pumpboxes and pumps;
- New Control Room (adjacent new Grinding Building); and
- New Electrical Substation and MCC Rooms.

The new Flotation Building will house two parallel rows of 6 x 100m^3 tank cells, with Pb roughers and scavengers in one row, and Zn roughers and scavengers in the other. The cells will be located on ground on a sloping concrete floor (falling a total of 5.5m in height), maximising the use of the natural terrain to reduce structural costs. Concentrate and tailings pump boxes and pumps will be located at the east end of the building approximately 2m below the last flotation cell in each row.

Secondary grinding will be achieved using the existing Rod Mill converted to an overflow ball mill. Conversion of the existing rod mill will require the mill to be offline for an extended period and will only be done after completion of SAG mill commissioning to avoid impacting plant operations.

17.7.3.4 New Pb Concentrate Thickener Area

Lead concentrate production will increase as a result of the plant expansion. The existing Pb Concentrate Thickener will be replaced with a new 10m diameter high rate thickener which will be located to the south of the existing lead concentrate loadout building.

17.7.3.5 New Pb Concentrate Filter Area

The existing filter will need to be expanded from 12 to 40 plates together with the addition of a new Pb filter to achieve the required capacity for the plant expansion. The new Pb Filter No.2 will be the same model as the existing, with 40 plates installed.

17.7.3.6 RZ Roughers, Zn DPR, Zn DPR Scavengers

New Zn RZ Rougher, Zn DPR and Zn DPR Scavenger Flotation Cells will be installed in the existing Zinc Plant Building. The building bay will be congested, with the eight new 100 m^3 flotation cells. The layout indicates that special fabrication of the flotation cell launders and outlets may be required due to limited space.

17.7.3.7 Zn Cleaner Flotation Area

The existing Zinc Rougher, Zinc DPR, Zinc DPR Scavenger and Zinc Cleaner flotation cells will be used as the expanded zinc cleaner flotation circuit. The flotation cells, pump boxes and pumps are assumed to be in good condition and do not require refurbishment. Likewise, the building and interior steelwork in this section does not require modification. The existing overhead crane will be retained for maintenance purposes.

17.7.3.8 Zinc Flotation RZ DPR Area

The existing flotation cells will continue to be used for the Zinc RZ DPR flotation duty. The flotation cells, pump boxes and pumps do not require refurbishment. Likewise, the structural steelwork in this section does not require modification.

17.7.3.9 Zinc RZ Cleaner Flotation Area

The existing Pb Cleaner flotation cells will form the expanded Zinc RZ cleaner circuit. The flotation cells, pump boxes and pumps are in good condition and do not require refurbishment. Likewise, the building and interior steelwork in this section does not require modification.

17.7.3.10 Zinc RZ Regrind Area

The existing Zinc RZ Regrind Mill does not have sufficient capacity for the plant expansion and a second Regrind Mill is required. The existing structure, previously installed to accommodate a new M1000 IsaMill does not require further modification.

17.7.3.11 Zinc Regrind Area

Regrinding of the zinc rougher concentrate is currently performed in a single VTM-1250 Zn Regrind Vertimill. The existing mill does not have sufficient capacity for the plant expansion and a second regrind mill is required. The existing tertiary mill (also a VTM-1250) becomes redundant when the new SAG mill circuit is commissioned and will be used for zinc regrinding as part of the ZEP.

17.7.3.12 Zn Concentrate Thickener Area

Increased zinc concentrate thickening capacity will be achieved by converting the existing Zinc Concentrate Thickener to a high rate thickener. This will involve replacing the bridge, drive, rake and feedwell, and addition of instrumentation for flocculant and underflow control.

17.7.3.13 New Zn Concentrate Filter Area

The two existing Metso VPA-1530-40 Zinc Filters will continue to be used for zinc concentrate filtration. Two new Metso pressure filters (same model), each equipped with 40 plates, are required

for the plant expansion. Only one new filter will be purchased; the second filter will be obtained from the surplus copper filters located in the Copper Plant.

17.7.3.14 New Tailings Pumping Facility

A new Tailings Pumping Facility will be located on the south side of the new Flotation Building. The new facility is designed to treat the tailings from the expanded Zinc Plant only and comprises Zn tailings cyclone feed pumps, cyclone clusters, underflow pumps and tailings pumps.

The new Zn Tailings Pumps and discharge pipeline are sized to accommodate both cyclone overflow and the full tailings flow in the event the cyclones are bypassed.

17.7.4 Current Status of Project

Following a competitive tendering process, AMEC have recently been awarded an EP contract for the ZEP, and AMEC personnel were being deployed on site in April 2017 to commence further engineering studies.

Laboratory testwork is continuing, both at SOMINCOR and WAI Laboratories in the UK, to confirm and optimise the recovery and concentrate performance on which the Project has been based.

18 PROJECT INFRASTRUCTURE

18.1 Overview

The Neves-Corvo operations consist of the following facilities:

- Underground mine, mineral processing facilities and central administration offices at the mine site;
- Private harbour and loading facility at Setúbal;
- Sand extraction facilities 12km South of Alcacer do Sal; and
- Lisbon office.

Mine site infrastructure includes a main headframe, two mineral process plants, paste backfill plant, rail facility, offices, surface workshops, mine store, laboratory, change house, medical building, restaurant, weighbridge and gatehouse (see Figure 18.1).

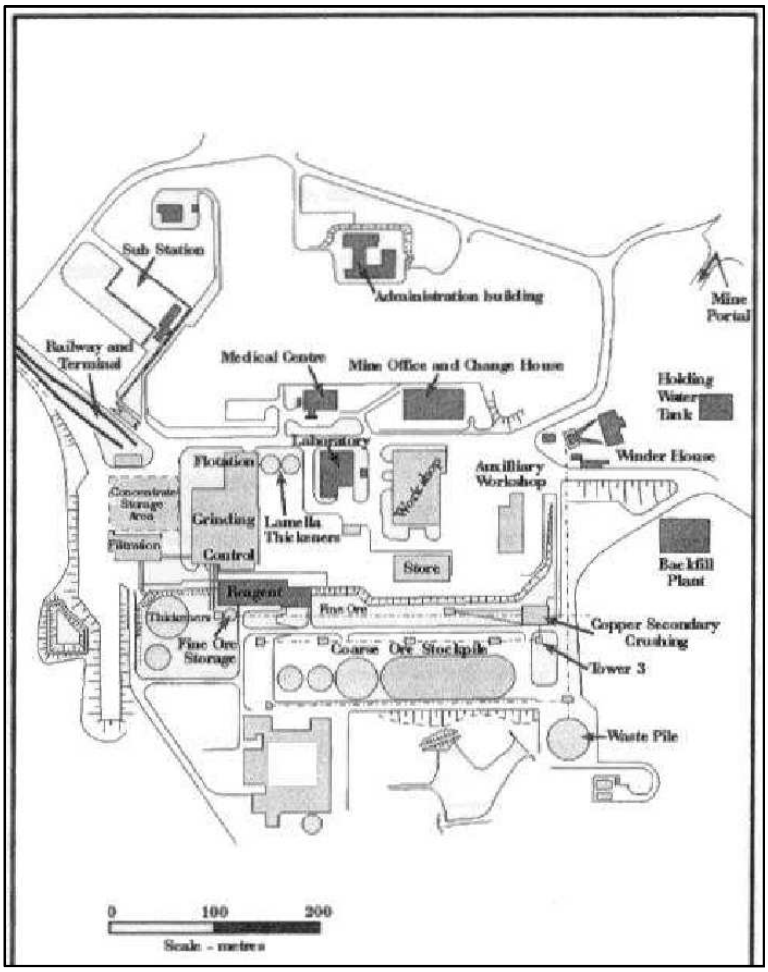


Figure 18.1: Site Plan Showing General Mine Site Buildings and Infrastructure Layout

The aeolian sand for the hydraulic fill is sourced from a quarry close to the port facility of Setúbal, owned by SOMINCOR. The sand is transported to the mine by rail some 100km from the site, using

where possible the same containers that are used to transport concentrate, as a backhaul on the return journey from the port.

18.2 Water Storage

Recent metallurgical performance at Neves-Corvo has deteriorated significantly due to the poor quality of the water returned from the TMF. The residence time of water in the TMF is reported to be as low as 6 hours which is insufficient time for the oxidation of sulphosalts. Accordingly, SOMINCOR are in the process of constructing a WTP to treat up to 950m^3/h of process water which will be constructed by the end of 2017. The construction of the plant is shown in Photo 18.1.

Photo 18.1: Construction of Water Treatment Plant

A water storage dam (Cerro da Mina) with a capacity of 1.4Mm^3 has also been constructed to store surplus water from the mine and is shown in Photo 18.2.

Photo 18.2: Cerro da Mina

Treated water from the WTP will be used for pump gland seals or discharged to the environment or the Cerro do Mina.

19 MARKET STUDIES AND CONTRACTS

19.1 Logistics

Storage capacity at the mine site is approximately 15,000 wmt for copper concentrates and 12,000 wmt for zinc concentrates both in covered warehouses.

Copper and zinc concentrates are loaded into 20' containers that are weighed on a static scale. The containers are loaded with a front end loader or directly from the filters, transported to the on-site train terminal, and craned on to rail wagons. Sampling for determination of concentrate quality is done as the front end loader loads the containers or before the filter drop.

The concentrates are railed 180km from the mine site to the port of Setúbal on the Atlantic coast. The Setúbal port installation is partially owned by SOMINCOR (warehouses and other facilities) and partially owned by the Setubal Port Authorities as a private concession to SOMINCOR and another mining company, Almina (pier). SOMINCOR operates the whole installation and has shipped concentrate from the same facility in Setúbal since operations commenced in 1988.

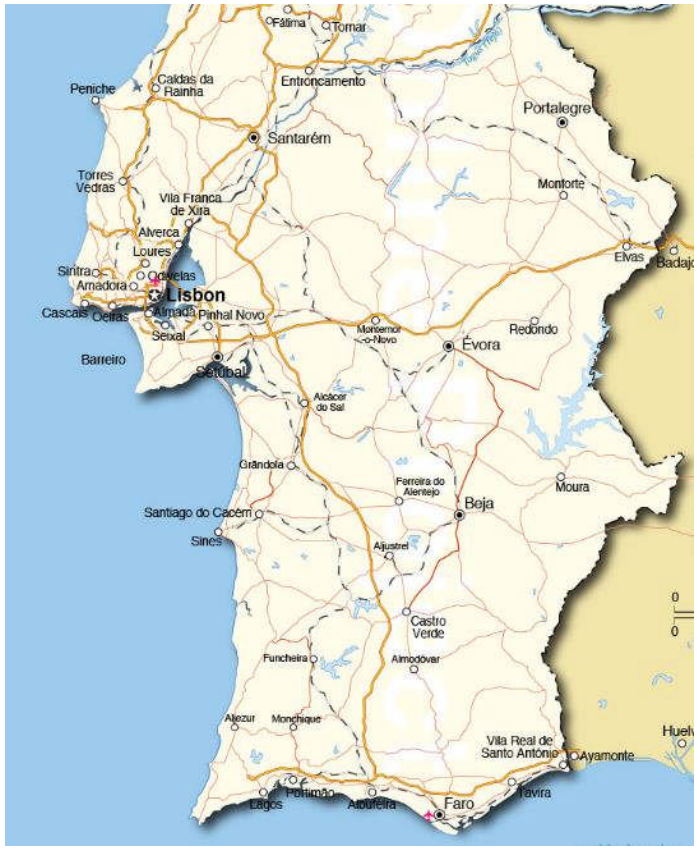


Photo 19.1: Neves-Corvo and Setúbal port locations

From the train terminal there is a system of conveyer belts which connect to the warehouse and to a shiploader at the dock. The Setúbal installation has two warehouses, but only the main one is being used for Neves-Corvo concentrates.

The main warehouse has a total gross capacity of 39,000 tons divided into 3 sections. The copper concentrate is stored in the first section which has a capacity of 28,000 tons. The zinc concentrate is stored in the second section which has a capacity of 7,000 tons. The copper and zinc piles are separated by a wall which reduces some of the net capacity. The third section is treated as a contingency storage space and has a storage capacity of 4,000 tons.

The warehouse contains a linear stacker that feeds all 3 storage sections. The linear stacker feeds the copper and zinc stockpiles directly whereas to feed the contingency storage area, the stacker dumps on to a smaller conveyor that will take the concentrate to the contingency storage area.

The warehouse also contains a reclaimer machine to load the stockpiles into a vessel. The reclaim can service the zinc and the copper storage sections in the warehouse. The reclaimer dumps the stockpiles onto a conveyor that carries the concentrate to the ship loader on the pier.

Photo 19.2: Main Setúbal Warehouse for Neves-Corvo Concentrates with a Stacker and Reclaimer

The contingency storage section cannot be served by the reclaimer. The loading of this pile into a vessel is done through a front end loader which dumps into a hopper which feeds the conveyors out to the pier. This warehouse is used as a backup or for direct shipments from the train terminal to the vessel.

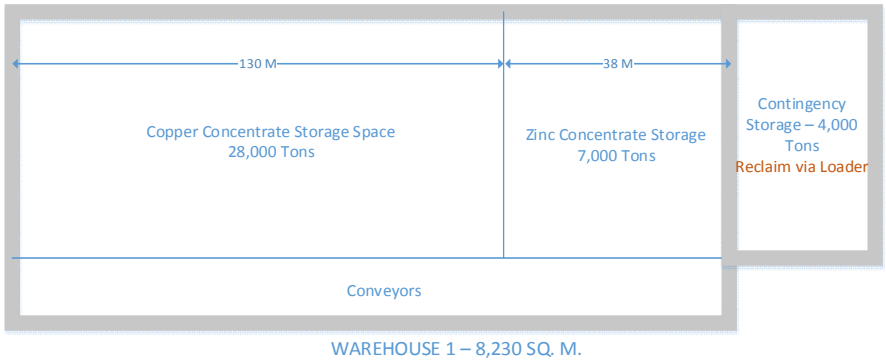


Figure 19.1: Concentrate Store

The second warehouse can also be used for concentrates, however there are currently no conveyors that can move concentrate from trains into this warehouse. The concentrate is brought to the facility

through trucks and stacked in the bays using loaders. Due to the space needed for the loader movement, each bay has between 5,000 tons to 7,000 tons of storage. There is also a hopper which was placed into one of the storage bays which reduces the capacity of that storage bay to 2,500 tons. This warehouse is currently rented to a third party (between 5,000-10,000 tons space) and the contract expires in 2024. In case this warehouse is needed for Neves-Corvo's own production, the space allowed for the third party needs to be minimized. However a conveyor system connecting the area of unloading containers and this warehouse should also be considered.

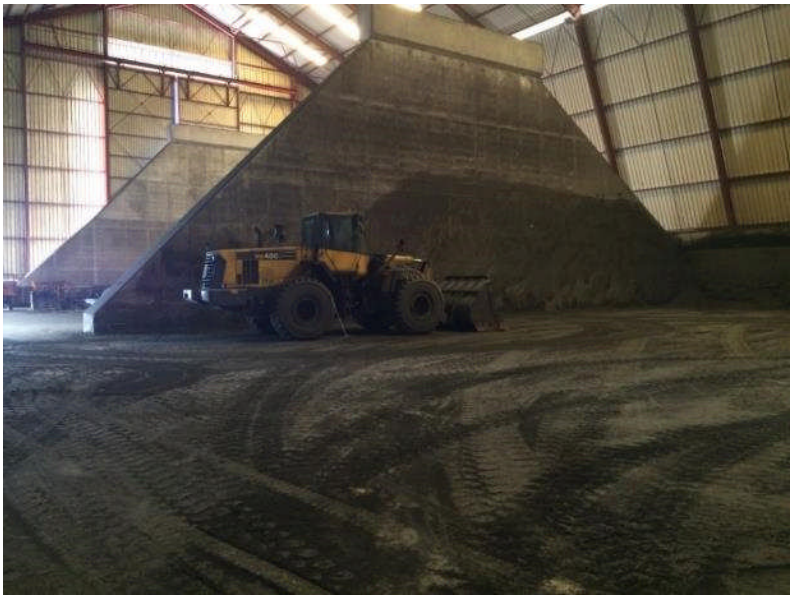


Photo 19.3: Secondary Warehouse with a Loader for Scale

At the main warehouse, NevesCorvo concentrates are loaded on to a conveyer belt inside the warehouse, passing over a belt scale and an automatic sampling system, before reaching the vessel which is docked at a pier. The average loading capacity is 500 wmt/hour, but during the operation, peaks of 1000 wmt/hour are easily reached. The vessels operating from this terminal are restricted to the following dimensions; draft 9m, LOA 185m and beam 24m.

Sampling is controlled by the SOMINCOR Laboratory which is accredited according with ISO 17025 and, the Setubal site specifically, is accredited for moisture determination (ISO 10251:2006) and TML determination (ISO 12742:2007). Sampling is performed by an automatic sampler fulfilling ISO 12743 and compliant with ISO 10251 moisture determination.

Dry mass is calculated from correction of wet mass by the moisture of each 500 wmt sub-lot calculated according with ISO 10251 - Copper, Lead, Zinc and Nickel sulphide concentrates - Determination of Mass Loss of Bulk Material.

The terminal is fully ISPS compliant and the loading operation has an ISO 9001:2008 certification.

Photo 19.4: Conveyer Belt from the Warehouses to the Vessel – View to the Vessel

Photo 19.5: Conveyer Belt from the Warehouses to the Vessel– View to the Warehouse

SOMINCOR maintains several Contracts of Affreightment with different ship-owners depending on the product and destination. The size of vessels varies between 3,000 wmt and 15,000 wmt, with 7,500 wmt being the most commonly used vessel size.

Official weighing and sampling is normally done at the discharge port under supervision by an internationally recognized inspection company.

19.2 Marketing Strategy

Both copper and zinc concentrates, are sold under long term contracts directly to mainly European smelters although the company also has a direct contract with a Latin American copper smelter.

The commercial terms under the contracts are negotiated on an annual basis based on the prevailing long term market conditions.

With the expected increase of zinc concentrates production due to the ZEP, such strategy will not change. The Company expects to be able to allocate the majority of the increase in zinc concentrate production to existing customers. Furthermore, interest in the increased zinc concentrate production has also been expressed by other smelters.

Lead concentrate of commercial quality has been produced at Neves-Corvo since 2012. Contracts have been negotiated on an annual basis for 100% of the annual production.

The lead concentrates, are loaded into 20' standard ISO lined containers at Neves-Corvo and sent by truck to a container terminal at Sines, Setubal or Lisbon and from there to China. The additional quantity coming from the ZEP is very small and it is not expected that any difficulties will arise in placing these lead concentrates in Europe or in Asia. The intention would be to sell the lead concentrates to more than one party under long term contracts and interest has been expressed by several smelters and trading companies.

All silver contained in the concentrates belongs to Silver Wheaton under a silver streaming agreement signed with Silverstone Resources (since acquired by Silver Wheaton) in 2007 and is invoiced separately when the silver content reaches payable levels.

Credit risks are managed under a strict credit management program which monitors the clients' payment performance as well as restricting credit exposure.

20 ENVIRONMENTAL STUDIES, PERMITTING AND SOCIAL OR COMMUNITY IMPACT

20.1 Scope of Study

The following section contains a review of the environmental and social performance of Neves-Corvo, including the ZEP. The report is based on a survey of existing documentation and data, including documents obtained during the site visit by the WAI team, supported by Lundin and SOMINCOR's Sustainability and Corporate Social Responsibility and Communications teams.

20.2 Method of Study and Information Sources

The main documents reviewed for this Technical Report were:

- Community Investment Policy, produced by SOMINCOR, 2017;
- Notes of AICEP Meeting with Licensing Agencies, dated 4 April 2017;
- Mina de Neves-Corvo – Zinc Expansion Project ("ZEP"), Feasibility Study ("FS") Project Amendment Report – produced by SOMINCOR, April 2017;
- Environmental Impact Assessment ("EIA"): ZEP, Technical Summary - produced by PROCESL, November 25, 2016;
- EIA: ZEP – produced by PROCESL, November 25, 2016;
- EIA: ZEP (Annexe) – produced by PROCESL, November 25, 2016;
- Neves-Corvo Mine, Environmental, Health & Safety and Product Stewardship Audit (referred to as the "EHS Audit") – produced by ERM, April 2017;
- ZEP, FS Report – produced by SOMINCOR, October 2015; and
- NI43-101 Technical Report for Neves-Corvo Mine and Semblana Deposit, Portugal – produced by Wardell Armstrong International ("WAI"), 2013.

The term "international best practice standards" refers to the sustainability standards of International Financial Institutions ("IFIs"), including the IFC Sustainability Framework and EBRD Environmental & Social Management Framework, as well as guidance offered by sector-specific institutions, such as the International Council on Mining & Metals ("ICMM").

20.3 Background

This section considers the environmental and social aspects of Neves-Corvo and ZEP, which includes a heightened production process and the adaptation of waste management infrastructure. The ZEP aims to more than double zinc output from the mine while the existing copper process plant will remain unchanged at a throughput of 2.5Mtpa.

The ZEP comprises the following components:

- Underground Expansion: expansion of all current zinc production areas and exploitation of the LP2;

- Installation of a new underground materials handling system and upgrade of the hoisting shaft;
- Expansion of the current zinc plant to a capacity of 2.5Mtpa;
- Surface Expansion: expansion and upgrade of the zinc mineral processing plant and supporting infrastructure; and
- Expansion of Cerro do Lobo TMF, located 3 km to the southeast of the mine.

As part of the ZEP FS (2017 Amendment), an Environmental Impact Assessment ("EIA") was carried out by the Portuguese firm PROCESL. The study covered environmental and social aspects of the ZEP, identifying predicted negative and positive impacts of development.

20.4 Impacts and Anticipated Schedule of Works

The EIA highlights the following aspects of the ZEP as potentially causing impact:

- Pre-construction phase;
  - Underground access to the LP2; and
  - Clearing of land to be occupied by the new facilities, including the new surface exhaust fan ("CPV23") and waste storage facility.
- Construction phase (start date – January 2018);
  - Construction of the CPV23 surface exhaust fan;
  - Construction of the new zinc mineral processing facility and extension of infrastructure to support the mine expansion; and
  - Work associated with the vertical expansion of the TMF; and
- Exploitation phase (start date – June 2019)
  - Exploitation activities for LP2;
  - Increased capacity of the Santa Bárbara shaft;
  - Increased consumption of water and energy;
  - Increased production of contaminated industrial wastewater and rainwater;
  - Increased waste production from the mine;
  - Activities associated with the operation of the new zinc mineral processing facility; and
  - Activities associated with the newly-expanded TMF.

20.5 Licenses and Permits

In Portugal, mining projects are regulated by specific legislation in terms of Mining Concessions, operational licensing and waste management operations given the specific characteristics and quantities of the waste generated.

The Mine applies for a Mining Concession that is granted for a pre-defined period. This application must be submitted to the DGEG (*General Department for Energy and Geology*, the licensing authority) accompanied the following technical documents:

- Mining Plan (*Plano de Lavra*) as defined in Article 27, Decree Law 88/90 16th March;
- Health and Safety Plan;
- Environmental and Landscape Recovery Plan; and
- Waste Management Plan.

Apart from the Mining Concession contract, the Mine is required to hold an integrated environmental permit (Environmental License or L.A.), which is reviewed by both the *Direcção-Geral de Energia e Geologia* ("DGEG") and the *Agência Portuguesa do Ambiente* ("APA", the Portuguese Environment Agency) and the Environmental Impact Declaration that is issued by the Ministry of Economy after the approval of the Environmental Impact Assessment Procedure. Both documents define the environmental requirements that must be addressed during operation and after closure.

Permitting activities are coordinated at the mine by the relevant departments, depending on the projects. Most relevant projects requiring permitting (e.g. licenses, environmental impact studies, etc) fall under the responsibility of the 'Special Projects Department' who then communicates with the Environmental Department. Applicable environmental requirements are then identified and kept updated by the environmental and legal departments. The Environment Department undertakes a comprehensive review and analysis of the permits to assess their applicability. To support the current ZEP permitting processes, SOMINCOR has initiated the organization of a centralized permitting function that will coordinate with the relevant functional areas and oversee regulatory communications and submissions.

There are multiple ongoing and pending permitting activities at SOMINCOR, relating primarily to the update of the Environmental License (Environmental License or L.A. - Processo PL2016101800891), with purpose of having licensed the change in the deposition of thickened tailings in TMF, this new Environmental License also includes other changes registered since 2008 and a summary of more than 40 outstanding Water Resource Licenses. This License represents the current operation in Neves-Corvo, and is the base case for the EIA of the ZEP. The approval of the zinc expansion project will take the following steps:

i. Approval of the EIA of the ZEP, submitted in the feasibility study phase, in progress;
ii. Approval of RECAPE 1 (Environmental Compliance Report of the Execution Project with the DIA) Phase 1 - Expansion of the Zinc Plant and Mine Expansion – Lombador;
iii. Update of the Mining Plan (Plano de Lavra) for approval by the DGEG;
iv. Renewal of the Environmental License Phase 1 - Expansion of the Zinc Plant and Mine Expansion – Lombador;
v. Approval of RECAPE 2 (Environmental Compliance Report of the Implementation Project with the DIA) Phase 2 - Expansion of the TMF;
vi. Updating of the Mining Plan, Expansion of the TMF, for approval by the DGEG;
vii. Renewal of the Environmental License Phase2 - Expansion of TMF.

A unique aspect of the ZEP program was the declaration of ZEP as a *Projecto Interesse Nacional* ("PIN", or Project of National Importance) in early 2017 by the *Agência para o Investimento e o Comércio Externo de Portugal ("*AIECP"). As such, AICEP became a key stakeholder and regulatory

communications coordinator in the approvals process, providing monitoring of the regulatory processes and supporting facilitation of communications between the various regulatory agencies, including the APA and the DGEG. In addition to the AICEP, the Municipalities of Almodôvar and Castro Verde (CMCV) are also very involved in licencing and will be responsible for issuing related Municipal construction permits upon successful completion of the ZEP EIA process and receipt of the DIA.

20.6 Climate Change, Energy Use, and Greenhouse Gas (GHG) Emisions

The EIA reports that the ZEP's construction and operation phases are not envisaged to significantly impact on climate. However, for the Neves-Corvo, SOMINCOR has developed a site strategy for reducing energy use and GHG emissions. This is reported in the Annual Environmental Reports, and as a contribution to the annual LMC Coporate Sustainability Reports, and annual Carbon Disclosure Project ("CDP") Report. In 2015, SOMINCOR prepared the PREn (*Plano de Racionalização do Consumo de Energia*, 2015-2020 [Nº PREn: OP457-PREN]), setting out objectives and measures for energy reduction.

GHG emissionsare monitored and reported as part of the Air Quality Greenhouse Gas Management Plan (AQGHGMP), although this system has only recently been put in place and was proposed as an action point in the 2016 Environmental Audit report. Indirect targets for carbon reduction are set by legislation as the Mine is a major consumer of fossil fuels. SOMINCOR will also continue to continuously liaise with representatives of local communities to confirm the efficacy of impact mitigation strategies and to better understand any grievances relating to energy use and GHG emissions. GHG emissions will also be monitored in the context of EU air emissions legislation (for which the legal basis is Regulation EU No 691/2011) and the sustainability standards of IFIs, primarily for the GHGs carbon dioxide (CO_2), nitrous oxide (N_20) and methane (CH_4).

It is understood that SOMINCOR is actively seeking opportunities to reduce power consumption within the constraints of the production target requirements. Some of the actions being undertaken to reduce energy consumption include:

- Introduction of Energy Management System at the Mine site;
- Reactive power compensation system installation at the zinc plant;
- Air compressor leakage detection and repair programme across the Mine site;
- Improving ventilation fan control during shift changes and weekends at the Mine;
- Avoiding the use of compressed air in underground mining;
- Replacing power cables with types comprising a higher cross-section, reducing energy loss and voltage drops at the copper plant;
- Replacing two blower electric motors with high-efficiency synchronous motors and variable speed drivers at the copper plant;
- Replacing existing belt drives with high-efficiency belt drives on 71 motors at the copper plant; and
- Replacing fluorescent light and sodium vapour lamps across the Mine site with LED lighting.

20.7 Hydrology and Hydrogeology

In terms of surface water, the project area is located in the Oeiras River basin, which is a sub-basin of the Guadiana River. The mine is supplied by surface water from the Santa Clara reservoir, which is in the Mira River basin, about 40 km from Neves-Corvo in the municipality of Odemira. The amount of fresh water drawn from the Santa Clara reservoir has decreased over recent years due to the increased use of recycled water for industrial purposes.

For processing operations at the mine, water remains untreated. For human consumption at the mine and three nearby villages (Neves da Graça, Senhora da Graça de Padrões and A-do-Corvo), water is treated at a Portable Water Treatment Plant.

Mine water drained from the mine and office waste water from the mine complex is, along with water drained from the thickened tailings, recirculated for industrial purposes or treated at the Mine Water Treatment Plant and Reverse Osmosis Plant and subsequently discharged into the Oeiras River. The official Guadiana Hydrographic Region Review lists the Oeiras River water quality as “inferior to good”.

Contaminated rainwater in the form of industrial runoff is diverted into 5 contaminated water retention dams and then recirculated for industrial purposes.

SOMINCOR continuously monitors the quality of water discharged into the Oeiras River. Monitoring reveals that:

- Treated industrial effluent discharged into the Oeiras River still contains significant concentrations of sulphates but very low levels of regulated metals;
- Recirculated water is of sufficient quality; and
- The Oeiras River water quality affected by the discharge in a localised manner, with near-complete recovery downstream and with no impact in the downstream Guadiana River.

Neves-Corvo has permission to discharge to the Oeiras River when it is under high flow conditions. Following resolution of past water quality issues, Neves-Corvo is investigating options to reduce fresh water supply requirements and introduce a passive wetlands treatment step, thereby controlling environmental issues throughout the water balance.

In the meantime, to meet water quality discharge thresholds, the 2016 Environmental Audit reports that the water management system has been recently redesigned and reengineered, with the open water areas of the TMF being reduced and replaced with thickened paste tailings cap, new water treatment facilities, a major new water impoundment (Cerro da Mina, west of the TMF) and new engineered run-off and stream diversions around the TMF and Cerro da Mina (see Chapter 18 for further description of the new Water Treatment Plant). Portuguese discharge quality standards have been met since the introduction of this system; however, the beneficial loss of water from the treatment cycle by natural evaporation, and problems with sludge build up in the ETAM prior to

discharge mean that water treatment is still at the stage of pilot studies and was in process of resolution at the time of the Audit.

The updated 2016 EIA also reports overall water consumption and discharge into surface water bodies is expected to increase because of the ZEP, but will stay well within the permitted requirements due to improvements in water recycling and water management on site. In line with international best practice standards, proposed mitigation measures include implementing monitoring of changes to the water balance as well as training of staff in environmental awareness.

The 2016 EHS Audit reported that there is potential risk of site-wide soil and groundwater impacts of the Mine as only one pond at Neves-Corvo is lined (Cerro da Mina), with others being unlined and some receive contaminated water. Whilst the walls of the TMF are lined for geotechnical stability reasons, the base is not and gradual dispersal of leachate via the base of the TMF is a feature of the original design. Groundwater impacts from these waterbodies are largely captured in the Mine dewatering cone or through pumping wells around the mine. This water is not treated but is, rather, pumped to the TMF within a captured loop within the mine site.

There is potential for groundwater impacts from the TMF to be migrating offsite, either via a diffuse plume or via a fracture pathway. As a result, the EHS Audit recommended the hiring of consultants to assess the existing soil and groundwater monitoring network and to propose improvements to be subsequently incorporated into the closure plan, and this work has been initiated by the Mine with support from LMC Corporate.

20.8 Surface Infrastructure and Transportation Links

The ZEP FS (2017 Amendment) considers changes to surface infrastructure including:

- Industrial water supply;
- Gland water supply;
- Power supply and reticulation;
- Tailings and industrial water lines and pipe rack reinforcement; and
- Compressed air.

Electrical power demand will increase both on the surface and underground. The ZEP FS (2017 Amendment) states that existing infrastructure can accommodate the increased power demands for the ZEP and that the operator of the national power grid (*Rede Eléctrica Nacional*) has confirmed that the power line to Neves-Corvo has the capacity to deliver necessary power. The distribution network is to be upgraded to feed the new ventilation shaft, the new underground materials handling infrastructure, expanded tailings thickening plant and the zinc mineral processing plant expansion.

According to the ZEP FS (2017 Amendment), no upgrades to existing fresh water supply infrastructures are required based on estimated increases in fresh water consumption due to the ZEP. Industrial water consumption is expected to increase almost 50% with the ZEP. Tailings pumping capacity and

additional pipelines will be modified with the higher volumes of tailings from the mineral processing plant.

The ZEP will not require any upgrades or modifications to off-site facilities, beyond minor rearrangement of some of the existing warehouse space.

The ZEP will not require any upgrades to existing water supply infrastructure to the mine, although an increase of fresh water consumption of approximately 33 m^3/hr is predicted. A discharge of 23 m^3 / hour of water into the environment is anticipated. Any proposed increase in water extraction associated with changes to the project description would have to be reviewed in accordance with national and EU legislation as well as against existing infrastructural capacity.

The ZEP FS (2017 Amendment) deems the rail network, port and warehouses to be of an adequate capacity for the ZEP's predicted volumes of concentrate. International best practice recommends that changes to transportation arrangements and, specifically, their impacts on the environment and local communities, should be reviewed in line with changes to project design within a formalised review process.

20.9 Soils, Topography, Land Use and Ownership

A 1989 baseline study, carried out prior to the start of mining operations in and around the mine area, showed that natural levels of arsenic, mercury and iron in the soil were within national standards. Naturally occurring levels of zinc and copper were shown to exceed national legislation thresholds, which the EIA (2016) states is to be expected in areas of mineralogical enrichment associated with the presence of significant geological resources of metallic ores. The leaching of soils and waste rock, leaking from BAC ponds and drains, process water and spills, was identified as a potential risk pathway within the 2016 Environmental Audit Report. At present this high-concentration leachate, observed in the enlarged unsaturated zone in the cone of depression, is understood to be captured by the Mine dewatering system. The infiltration of contaminated water to soils in the Industrial Area was recommended by the Audit Report to be controlled by sealing over active areas, fixing cracks in existing concrete and improving materials handling processes to reduce spills and leaks.

The ZEP will be developed mainly within the currently permitted industrial area of site. The new CPV23 surface exhaust fan will be built on a currently unoccupied area whereas the southern expansion of the TMF will take place on an area currently occupied by dams holding retained and diverted rainwater, and will occupy REN's land, not previously affected. The major changes to the environmental footprint associated with the construction of the ZEP are:

- New SAG facility building;
- New ore storage stockpile;
- New TAI tank;
- Ventilation shaft, CPV23 (outside of existing industrial area); and
- Expansion of the TMF in the REN (*Reserva Ecológica Nacional*).

The Neves-Corvo mine stands out across the area's mostly agricultural and rural landscape. However, the ZEP will not cause any additional visual impacts. The expansion of the zinc mineral processing facilities will also have minor visual impacts, since this will occur within an existing industrial area. The new ventilation shaft CPV 23 surface fan building will be visible across the local landscape.

The EIA reports that excavation and landfill aspects of the construction phase will cause alterations to the morphology of localised terrain and erosion, though with minor impact on surrounding areas. Other possible impacts relate to the risk of accidents in and around the site, with the potential to contaminate soils in the area. Proposed mitigation measures include the development of appropriate geotechnical zoning and construction of asphalted roads wherever possible.

The EIA also reports that impacts of the ZEP on land take are minimal since most infrastructure, including the expansion of the zinc processing facility, will be placed on industrial land already developed and operated by SOMINCOR.

The view of the new ventilation shaft CPV 23 surface building is unlikely to have a major negative impact on local communities, although it is recommended that consultation meetings are held with affected communities to assess feedback.

20.10 Biodiversity (Flora and Fauna)

In terms of vegetation, the Montado *de Azinho* area is characterised by the presence of Holm Oaks, which are protected in Portugal under Decree-Law No. 169/1001 "Protecting Cork Oak and Holm Oak Forests", and the invasive species of Giant Cane (*Arundo donax*).

Over 300 species of fauna were characterised within the EIA study area, mostly birds and aquatic invertebrates. The EIA anticipates that impacts of the ZEP on flora and fauna will be minor during the construction phase, with only the expansion of the TMF and associated land take affecting existing flora. Subsequent developments are anticipated to have minor impacts on fauna and local vegetation due to actions associated with the maintenance of the site, though negative potential impacts may occur on aquatic fauna resulting from discharge of treated water from the site into the Oeiras River.

Biomonitoring occurs annually in the Oeiras River, undertaken by the *Instituto do Mar* (IMAR - Institute of Marine Research). It is understood that the most recent monitoring activity took place in 2016 during April, recording aquatic macroinvertebrates and macrophytes, bivalves as well as physical characteristics of the water body.

The ZEP also increases the potential of invasive floral species colonising the area. Proposed mitigation includes reducing noise and traffic levels whenever possible as well as controlling for invasive species and keeping to a minimum the amount of water discharged into the Oeiras River.

According to the EIA, around 66% of the ZEP area falls within a National Ecological Reserve ("REN", Decree-Law No. 93/90 dated 1990), including the industrial area of Neves-Corvo. More specifically, the location of the CPV23 surface exhaust fan falls within a national conservation area and the

proposed construction of infrastructure necessitates the removal of some protected Holm Oak trees. Further licensing will be needed if there is a need to cut any of the holm oaks or if the TMF does encroach on the REN, as anticipated in the preliminary studies.

Proposed mitigation measures include reducing the physical footprint of the ZEP as much as possible and carrying out actions in the shortest possible period. It is required that any destruction of protected species, and associated mitigation measures, comply with national and EU legislation. A Biodiversity Action Plan ("BAP") has been developed by SOMINCOR, involving the conservation of biodiversity by preserving areas with no impact, improving conditions in areas with low impact and high impact after removal of disturbance and, in areas where impacts cannot be avoided, to create habitat offsets or improve the conditions of existing habitats in areas without impact. If impacts on protected species are confirmed, the BAP will need to be amended in line with relevant international standards.

The 2016 annual Environmental Report for Neves-Corvo covers monitoring of species existing in the SOMINCOR properties as well as control of the activities in these areas. SOMINCOR developed a partnership protocol with the authority of *Parque Natural do Vale do Guadiana* ("PNVG") with the objective of managing riparian habitats in the Vascão River as compensation for impacts on the Oeiras river. Vascão River is a tributary of the Guadiana River and is classified as a Site of Community Interest (PTCON0036 – Guadiana) and as Wetland of International Importance (Ramsar Convention). For river restoration of a section of Vascão river, SOMINCOR supported cleaning activities and removal of cane fields, slope consolidation and margin planting for recovery and densification of riparian vegetation, providing shade in summer to preserve the threatened fish species *Anaecypris hispanica*.

20.11 Air Quality

The EIA identifies the movement of mining equipment and vehicles as well as the handling and transportation of ore as the main sources of particulate emissions around the mine. Monitoring has shown that impacts from the deposition of heavy metals on the topsoil because of the dust produced by mining activities were registered up to 2 km away from the site.

Monitoring by a local contractor reveals that air quality has improved in and around the mine area during the years 2013-16 because of several mitigation measures put into place by SOMINCOR.

The EIA predicts temporary potential negative impacts to air quality during the construction phase because of traffic and the movement of machinery, especially on unpaved roads. These actions are predicted to temporarily increase levels of airborne dust particles, vehicle emissions and to reduce visibility in and around the site and mitigation and monitoring will continue to be undertaken to address this potential. The receptor communities most likely to be affected by any potential temporary impacts to air quality are communities in the settlements of Neves da Graça and Monte da Várzea da Forca, which are the villages closest to the mines's access points. During subsequent phases of the ZEP, it is not expected that air quality impacts will become more severe. Mitigation measures throughout the life of the mine include the implementation of suppression techniques (cleaning and spraying with water) on local roads as well as the transportation of materials in appropriately-equipped vehicles (with covers, whenever necessary).

SOMINCOR will also continue to monitor and implement their management systems, as well as continuously liaise with representatives of local communities to confirm the efficacy of impact mitigation strategies and to better understand any grievances relating to air quality.

20.12 Noise and Vibration

The Neves-Corvo mine is in an area characterised by low population density, where urban centres are dispersed and most surrounding land is either agricultural, forest or bushland. The EIA lists the primary noise receptors near the mine area as the human settlements of Aldeia do Corvo to the northeast and, to the south, Sr.ª da Graça dos Padrões and the Monte da Várzea da Forca, and to the southwest the settlement of Aldeia do Neves.

Noise levels in the areas surrounding the mine differ by distance to the project and the type of terrain. The EIA reports that noise from the project can be perceived at the nearest active receptor sites, an impact that is especially pronounced during night-time hours. Noise from the mine represents the main source of sound in the area because of the absence of other major industry in and around the Project.

The EIA reports that vibrations from mining activity at Neves-Corvo have not been identified as having predicted harmful effects on either infrastructure (buildings) or human health. The ZEP's anticipated impact on increased noise levels relates primarily to the operation of a new surface exhaust fan (CPV23) and other infrastructure relating to the new zinc processing facility. Proposed mitigation measures, in line with international best practice, include ensuring that construction methods and equipment produce the minimum possible noise emissions and that louder operations are restricted to daytime hours (7:00-20:00) on working days only. Other aspects of the ZEP occur underground, so their impact on surface noise levels will be minimal.

20.13 Waste and Environmental Management Systems

SOMINCOR monitors and handles waste from the mine per the Waste Management Plan (WMP) included within the broader Environmental Management System. According to the WMP, waste rock from the mine will be used to backfill the mine and to construct dikes and tailings deposition cells, as well as to cover the TMF. Remaining mine residues will be sent for reuse or recycling, whenever possible.

The EIA reports that the ZEP's impact on waste and waste management actions during the construction phase relate broadly to the waste generated by the accessing the LP2 area of the mine. Non-mining waste is predicted to comprise only 0.1% of all the waste generated by the mine in general. Construction activities are also anticipated to produce waste, including that relating to the packaging of new equipment. In subsequent phases of the ZEP, waste impacts relate mainly to the extraction of ore and processing activities, highlighting the need to expand the existing TMF and to create an expanded facility.

Environmental aspects of the project are monitored by SOMINCOR for their impact on human health and the environment. The EIA predicts that negative environmental impacts will only occur from the ZEP in the event of an extreme, low-probability scenario, such as the rupture of the TMF because of abnormally high precipitation rates. SOMINCOR have also developed a series of recommendations for management of naturally-occurring mercury present in Neves-Corvo concentrates, ensuring processing and shipment methods are compliant with international best practice and requirements.

Proposed mitigation measures in line with international best practice include the continuous updating and application of the WMP, which prescribes how mine waste is deposited in the TMF, how mine waste can be reused to backfill the mine, or how some waste may be collected by the appropriate licensed entities.

20.14 Socioeconomics, Human Resources and Stakeholder Engagement

Settlements located near the mine site are characterised by older populations and low education levels. The local economy is poorly developed compared with other areas in the region. SOMINCOR is one of the main employers in the region, both directly and indirectly.

The EIA predicts that the ZEP will positively impact upon local communities by creating employment and generally raising standard of living in the area surrounding the mine. This impact is predicted to be particularly prominent during construction. Further positive impacts relate to the operator's commitment to hire locally whenever possible. The negative impacts of the ZEP relate to the effect of environmental changes on local populations, for example, reduction of air quality and increased levels of noise.

SOMINCOR has not historically had any difficulties recruiting staff for the Neves-Corvo mine. There are no large population centres close to the mine but there are several villages with populations in the hundreds and 2 towns with populations greater than 4,000 residents within 20 km of the mine. The ZEP is not expected to present challenges in terms of recruitment although some challenges are expected to occur during the construction phase, with an additional 300-350 personnel on site, placing strain on existing service facilities.

The ZEP entails the same activities and technologies as currently employed at the site, so no changes are required to the training policy or operating standards of safe working with one notable exception: the installation of the semi-autonomous grinding (SAG) mill represents new technology for the site and will require specific operator training.

Contractor numbers at Neves-Corvo are typically around 1,000 workers. Peak number of contractors on site for the ZEP, during construction, is expected to be an additional 300-400 personnel. It is understood that SOMINCOR plan to hire 3 extra safety officers to mitigate risks of injury to personnel during commissioning and start-up of the expansion.

SOMINCOR has made several recent investments in local communities in recent years, including towards the funding of local schools in nearby villages. In 2017, SOMINCOR's total community

investment budget is $242,842 USD. To date, $173,000 USD has been spent on education, community wellness, local supplier development and road safety initiatives. The SOMINCOR Community Investment Policy outlines the company's mission statement, objectives, priorities, exclusions and application process for funding organisations and projects.

The Lundin Foundation will invest a further $400,000 USD in 2017-18 to advance economic diversification and local supplier development in the communities surrounding SOMINCOR operations, including to support economic diversification towards generating jobs and income benefits beyond mine operations. Anticipated projects include a baseline assessment of economic diversification opportunities across local municipalities and, subsequently, launching initiatives based on recommendations from the assessment. The communities in question include the settlements of Castro Verde, Almodôvar, Aljustrel, Mértola and Ourique.

From 2018 onwards, SOMINCOR will invest at least $300,000 USD annually in projects and organizations that advance the following priority areas:

- Economic diversification;
- Community safety and emergency preparedness;
- Education and training;
- Sustainable agricultural practices; and
- Environmental stewardship and Community wellness.

International best practice recommends that these ventures continue to be logged and that future ventures continue to be co-created based on engagement with local communities through official and informal stakeholder engagement channels. It is also recommended that the formal Stakeholder Engagement Plan currently being developed is completed and is continuously updated as the ZEP is constructed.

Lundin has been involved in several formal meetings with stakeholders, including in April 2017 with the AICEP, where SOMINCOR and Lundin presented a summary of the ZEP project, the EIA and a schedule of various future steps.

20.15 Archaeology and Cultural Heritage

A cultural heritage survey described in the EIA listed 40 objects of cultural heritage interest in and around the site. Of these, 4 were registered within the indirect area of influence of the site, including 2 in the industrial area near the zinc mineral processing plant and 2 near the TMF.

The EIA reports that the construction phase of the ZEP is most likely to have negative impacts on aspects relating to archaeology and cultural heritage, specifically because of deforestation and activities likely to cause a clearing of vegetation and land take, disturbing the landscape which is locally considered to hold heritage value. Proposed mitigation measures include systematic archaeological studies conducted in parallel with construction and operation phases to ensure that objects of

archaeological and cultural heritage value are flagged and that appropriate measures are put in place to reduce the impact on these aspects.

20.16 Environmental Management Systems

SOMINCOR has deployed Best Available Techniques plans and extensive environmental monitoring throughout operations of the Neves-Corvo mine. The Environmental License of the mine requires continuous monitoring of air and water quality, including atmospheric emissions and water discharge into groundwater and surface bodies, as well as the generation of waste.

Official documents state that SOMINCOR remain committed to long-term relationships with local communities and stakeholders, mainly through the following reports:

- A Responsible Mining Policy outlines the company's policy commitments and principles for Responsible Mining; and
- Lundin's Responsible Mining Framework outlines the company's commitment to develop and implement management systems and operating practices that take into consideration applicable international guidelines, and defines the way they manage material economic, social, and environmental issues.

SOMINCOR will continue to report its environmental and social activity on an annual basis through Lundin's Sustainability Report, which adheres to the Global Reporting Initiative ("GRI") standards. SOMINCOR also collects energy and GHG emissions data annually for contribution to the LMC Carbon Disclosure Project ("CDP") Report.

20.17 Mine Closure and Reclamation

Several mine closure studies have been carried out for SOMINCOR at the Mine, including:

1. In 1992, Golders prepared a report on closure of the mine site and the Cerro do Lobo TMF, assuming a mine life to 2015:
    - Closure of the mine site involved recovering underground and surface plant, treatment of mine entries, demolition of most buildings, retention of several parts of the infrastructure including power and water supply, retention of usable buildings such as offices, clean-up and removal of contaminated material to the TMF and landscaping; and
    - Several options were considered for closure of the TMF. The preferred option was 'wet closure', i.e. retaining a water cover on the tailings and managing it as a wetland.
2. In 1998, SRK prepared a second mine closure study, which also assumed a mine life to 2015 and considered:
    - A review of closure options for the TMF and a recommendation for a dry closure option including the installation of a hydraulic sand cover (to facilitate drawing down the water) and an impermeable liner over the tailings. The wet closure option was not considered feasible because of the continued requirement for water input;

- Closure requirements for the Setubal Port facility; and
- Adoption of the previous Golders closure plan for the mine site, with an update of costs.

3. In 1998 Biodesign prepared a plan, with costs, for rehabilitation of the Areeiro do Formosinho sand quarry.
4. In 1999 SOMINCOR reviewed and updated the closure costs for the TMF, mine site and Setubal port, based on a mine life to 2029, and projected forward the closure fund provision. The costs for closure of the TMF were based on a further variation of the dry closure option. The cost of maintaining water treatment for dam drainage for 50 years was included in this review.
5. In 2001, Knight Piésold considered closure options and costs for the waste rock dumps.
6. In March 2007, the Golder study into the feasibility of paste tailings disposal considered the closure options and costs for this option for the TMF.
7. In 2008 a full Mine Reclamation and Closure Plan (MRCP) was prepared by EnviEstudos of Lisbon, with costings, covering the environmental aspects of closure.
8. In 2010 the MRCP was extended and updated by EnviEstudos to include the proposed LP1 development[2].

In 2015, SOMINCOR reviewed the 2011 Mine Reclamation & Closure Plan ("MRCP") and submitted it to the DGEG authority in February 2016. SOMINCOR is revising the MRCP in 2017; an update of the document is anticipated to be completed in 2019. Current permitting for the mine requires the preparation of updated mine closure plans on a 5-year cycle.

The objectives of the MRCP are to:

i) Comply with local legislation and standards;
ii) Describe the methodologies used in the closure of the mine per future usage scenarios considered for this location, and integration with the surrounding environment;
iii) Minimize future maintenance activities and monitoring of the site;
iv) Reduce (or eliminate) potential sources of impact to the the Oeiras River and surrounding areas;
v) Store mining waste on-site, in a controlled way and minimizing footprint;
vi) Reduce the risk to acceptable levels for the future use of the site;
vii) Comply with local legislation and standards;

[2] Mine Reclamation and Closure Plan (MRCP) of Neves Corvo Mine – update with Lombador Phase One Expansion Pre-Feasibility Study, December 2010. Prepared by EnviEstudos, Lisbon.
Plano de Encerramento e Pllano Ambientale de Recuperação Paisagístiica (PARP) da Mina de Neves-Corvo - Actualização com inclusão da 1ª Fase do Projecto de Expansão do Lombador, Estudo de Pré-Viabilidade, DEZEMBRO DE 2010

viii) Estimate and quantify the cost of closing the mine; and

ix) Establish effective environmental monitoring programmes.

Achieving these objectives will provide SOMINCOR with an overview of the implications and obligations associated with the mine closure process as well as the related costs for each future scenario considered. The scope of the existing MCRP covers Environmental and Land Use aspects; it does not yet include consideration of social or community issues.

The improvements to the MCRP that SOMINCOR will implement between 2017 and 2019 are based on findings from previous and ongoing studies, including the 2016 Environmental Audit report, which recommends:

- Involving a broader range of stakeholders (apart from mine workers) in the mine closure planning process;
- Identifying critical aspects of the Plan for which there is high-risk that overall closure costs will grow (e.g. long-term water management and the potential site-wide and off-site migration of groundwater impacts);
- Improving mine closure costs to address uncertainty for the critical aspects of the Plan;
- Consideration of early closure and sustainability as a core concept of mine closure; and
- Integrating the various key activities (e.g. the ZEP Expansion), departments (e.g. HR, Finances, Community Relations, Legal, Operations and Environment) and ancillary operations (e.g. port and sand quarry), as needed, in mine closure planning.

21 CAPITAL AND OPERATING COSTS

21.1 Capital Costs

The total estimated capital expenditure for the ZEP is €256.5M including an average 15% contingency on direct and indirect costs. The capital estimate is developed using costs from SOMINCOR's in-house data base, third party consultants for major packages and supplier budgetary prices for major equipment for the plant and underground. WAI considers that capital costs estimate is appropriate. A summary of the Neves-Corvo LoM Capital Costs to 2030 is presented in Table 21.1.

Table 21.1: Neves-Corvo Capital Costs Summary (2017 to 2030)

Zinc Expansion Project Capital Costs	**K Euro**	**256,502**
Shaft	K Euro	0
Mine Development	K Euro	65,607
Other Mining	K Euro	52,562
Site Development	K Euro	350
Process Facilities	K Euro	54,316
Process Plant Services	K Euro	19,627
Indirect Costs	K Euro	19,533
Owner's Cost	K Euro	11,132
Contingency	K Euro	33,375
Base Case Projects Capital Costs	**K Euro**	**44,256**
Total Sustaining Capital Costs	**K Euro**	**381,563**
Neves-Corvo excluding LP2	K Euro	280,290
LP2	K Euro	101,273

The estimate conforms to an ASCE Class 3 estimate, suitable for budget authorisation, and is considered accurate to -10%, +20% at the summary level. During the capital estimate definition, each section of the project was evaluated based on design definition, confidence in unit rate and potential for changes. Based on this analysis, there are contingencies included in the estimate for each of these areas. The sum of the individual contingences accounts for 13% of Work Breakdown Structure (WBS) areas 1000 to 8000 inclusive. An owner's discretionary contingency of 2% was added to bring the overall contingency value to 15%.

A graphical ZEP capital cost breakdown is presented in Figure 21.1. As can be seen from the figure below, mine development, which totals €72M (including contingency), constitutes 26% of the total capital. The estimated project capital cash flow per year is shown below.

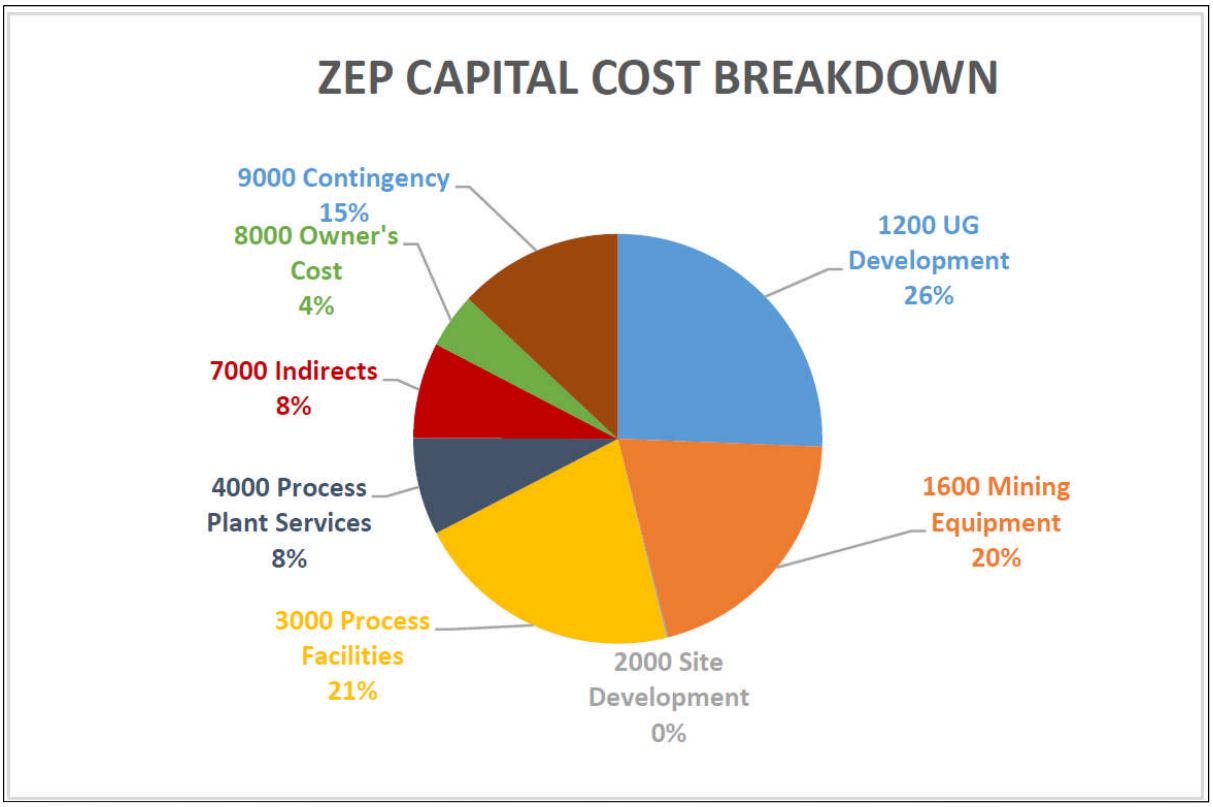


Figure 21.1: ZEP Capital Cost Breakdown

The ZEP WBS summary is shown in Table 21.2.

Table 21.2: ZEP Capital Cost Distribution (EUR'000)

WBS		Total	2017	2018	2019	2020
	Total Project	**256,502**	**34,923**	**131,459**	**87,986**	**2,134**
1000	Mining	118,169	20,439	56,817	39,056	1,857
2000	Site Development	350	175	175	-	-
3000	Process Facilities	54,316	1,629	37,758	14,929	-
4000	Process Plant Services	19,627	1,513	7,415	10,698	-
5000	On Site Infrastructure	-	-	-	-	-
6000	Off Site Facilities	-	-	-	-	-
7000	Indirects	19,533	5,509	7,735	6,289	-
8000	Owner's Cost	11,132	1,113	4,453	5,566	-
9000	Contingency	33,375	4,544	17,105	11,449	278

According to the ZEP FS (2017 Amendment), to calculate the new mining capital expenditure, the unit rates used in the ZEP FS (2015) were updated to current contract values with EPOS, the mine development contractor onsite. There were also negotiations held with EPOS based on the scope of work in the ZEP and updated proposals were received from the contractor for execution of the same. These new unit rates are applied to an updated mine design completed in house through the mine planning department at Neves-Corvo. Important notes on the mine design and the associated capital expenditure are summarised below:

- The mine development unit rates are based on updated contractor rates;

- All material handling accesses, major excavations, transfer points and conveyor drives have been designed to a level determined for cost estimates to the accuracy level stated;
- Development for supporting infrastructure such as electrical rooms, service holes are based on factored estimates;
- A 2% growth allowance on materials handling development costs is included in the estimate;
- All ramps and accesses to the LP2 ore body are designed in the model;
- Access levels or footwall drives are also designed and taken off from the model; and
- Development for supporting infrastructure for electrical transformers, pump cut outs, etc. are included as a growth allowance of 5% on all development costs.

The bulk of the surface scope of work was developed by Ausenco's team in Brisbane and through collaboration with the SOMINCOR team and local contractors. The following are the highlights:

- 80% of all tagged equipment (by dollar value) was costed from quotes;
- A 3-dimensional process plant model was produced by Ausenco which formed that basis for quantities used in the model;
- Unit rates for concrete, steelworks, mechanical bulks, equipment installation and electrical bulks were calculated through budget quotes from local contractors;
- Productivities were calculated based on Gulf Coast and then factored for site conditions;
- Construction is based on a 40 hour work week by construction trades;
- Growth allowances are included for all items except mechanical equipment, electrical equipment and mechanical bulks;
- Shipping is calculated on a line by line basis as a factor of the direct costs;
- First fills, spare parts and other indirect costs are recalculated; and
- Cranage for construction is included for small cranes through the labour rates per hour. However, a large 250T crawler is included in the project indirect costs for a duration of 8 months.

The costs not covered under mining and Ausenco such as project indirect costs, owners' costs and contingency are all re-calculated based on the changes in the scope of the project.

It should be noted that approximately 25% of the ZEP is a brownfield project and this is factored into the pricing and productivities through increased number of hours required to execute work.

Estimation of the sustaining capital expenditure follows the current practice at Neves-Corvo: capital waste development cost is calculated based on the planned annual development metres at the budget cost per metre. Other sustaining capital expenditure is based on detailed estimates of equipment requirements for the first 5 years of the plan, and beyond that using a historical unit cost per tonne factor.

21.2 Operating Costs

The project benefits from the historic operation, knowledge of the existing mineral processing plants, current routes of product to market, operating and site general and administration corporate costs.

Operating costs for the ZEP Amendment Study were developed based on the SOMINCOR 2017 budget, modified to the expanded tonnage. WAI is of the opinion that the forecast estimate of operating costs is reasonable.

Adjustments were made to account for Lombador haulage distances and additional mining ventilation requirements. The new conveyor operating cost is based on estimates by consultants TNT and the expanded zinc plant operating cost is based partly on estimates by Ausenco. The total operating cost per tonne milled is €5/t lower than the cost estimate of the ZEP FS (2015) (see Table 21.3.)

WAI notes that the ZEP FS (2017 Amendment) provides a cost summary for the selected range of project years, in particular, from 2020 to 2030, which comprises the economic production period of the ZEP project.

Table 21.3 below provides a summary of the previously and currently estimated operating costs.

Table 21.3: Operating Costs Summary – Zinc Expansion Project (EUR/t)

Selected Time Period:	ZEP LoM (2015 ZEP FS) 2018-2030	ZEP LoM (FS-Amendment) 2020-2030
Mine	27.55	24.05
Plants	12.23	11.52
Water & Tailings	1.82	1.59
G&A	8.23	7.61
Total	**49.83**	**44.76**

** Note: Financial results are presented for the economic project life from 2017 to 2030. Operating costs are demonstrated for the selected economic project between 2020 – 2030.*

The operating cost for the site has reduced from the ZEP FS (2015) as a result of improvements in operating practices, cost saving initiatives and productivity efficiencies in the underground operations.

Mining operating costs are primarily based on the 2017 budget costs. Exceptions to this are the costs of the new or upgraded infrastructures, namely the new crusher and conveyor and the upgraded shaft. These latter costs are based on estimates by TNT, with SOMINCOR in-house data to calculate labour, power and maintenance costs. Specific adjustments have also been made to account for the additional ventilation requirements in the LP2 area.

Plant operating costs are mainly based on the SOMINCOR 2017 budget. Ausenco updated the consumables consumption rates for the expanded zinc plant, and these were combined with the consumables prices from the current SOMINCOR budget to calculate the ZEP operating costs.

The zinc plant operating cost is composed of the following items:

- *Materials handling* – Materials handling in the ore stockpile is planned to transition from the current contractor opration to self operation;
- *Processing* – this includes power, consumables, reagents and other miscellaneous costs associated with the processing facilities and is calculated through multiplying the cost per tonne in the copper and zinc plants by the projected tonnes processed in each plant;
  - The budgeted operating electrical consumption for the current zinc plant is 51.2 kW/t. Ausenco have calculated an expanded consumption rate of 60.0 kW/t, resulting in an increase of €0.54/t;
  - The cost of reagents, on a €/t basis is expected to remain the same with the expanded plant;
  - The cost of grinding media is expected to decrease by €0.40/t due the use of a SAG mill (using a very low ball charge) as the primary mill and conversion of the primary rod mill to a secondary ball mill; and
  - The cost of mill liners is expected to decrease slightly by €0.25/t with the mill expansion.
- Labour –Labour costs are based on the 2017 budget and are considered mainly fixed as the personnel in the plants do not change with production; and
- Maintenance – this includes labour costs related to maintenance operations, material and equipment purchases and replenishment of spares, and is based on the 2017 budget. The labour is assumed to be 60% fixed and 40% variable, while all the other maintenance costs are assumed to be 100% variable. As the expanded plant will no longer require a crushing plant, the annual maintenance costs associated with this part of the plant have been removed from the ZEP case, representing a €0.52/t decrease in costs.

TMF operating costs are based on a model developed by Knight Piésold, which includes cost estimates for waste rock, tailings and water management.

Other operating costs are the remaining G&A costs, which include Management, Finance, HR, IT, H&S, Environment, Quality, Purchasing, Marketing and Logistics. These are mainly fixed, except for the concentrate transportation cost, included in Logistics, which is 100% variable. G&A has a significant fixed component and for this reason, the cost per tonne has decreased.

22 ECONOMIC ANALYSIS

22.1 Summary

WAI has reviewed the cash flow model provided by Lundin that provides an economic analysis of the expanded mine production.

WAI considers the cash flow model to be a realistic representation of the proposed project expansion plans for an increase in zinc production as contemplated by the ZEP. There are no obvious structural omissions in the cash flow model and the reasoning of the capital and operating costs are conventional for the mining industry.

The model includes all taxes, royalty, construction costs for mining underground development and Zinc Plant capital requirements, accompanying by revisited operating costs.

Given that the ZEP will require the use of the existing infrastructure, the project value has been calculated through the difference between the case with expansion (ZEP case) and the case without expansion (Base Case).

In summary, the analysis produced the following results:

- NPV at 8% discount rate of €180M (US$ 207M) for the LoM (2017-2030);
- IRR of 21.5%;
- Zinc breakeven price of US$0.71/lb;
- Zinc breakeven recovery of 60%;
- At the current zinc recovery levels of approximately 78%, the ZEP generates an incrementak NPV at an 8% discount rate of €158M and an IRR of 20.0%, compared to €180M and IRR 21.5% for the planned improved recovery of 81.9%;
- Simple Payback in April 2023 (based on undiscounted cash flows);
- Life-of-Mine: 2017-2030;
- C1 cash cost of US$0.28/lb Cu (vs Base Case value of US$1.40/lb for the period 2020-2030), and US$0.29/lb Zn (vs the Base Case value of US$0.28/lb also for 2020-2030); and
- All-in sustaining cost of US$0.80/lb Cu (vs Base Case value of US$1.80/lb for 2020-2030), and US$0.42/lb Zn (vs Base Case value of US$0.46/lb for 2020-2030).

22.2 Metal Prices

The anticipated metal prices shown in Table 22.1 are considered reasonable. Although, WAI considers the selected copper price to be moderately high given the current market conditions, while other metals' prices being in line or more on the conservative side compared to World Bank expectations. Nevertheless, the ZEP project demonstrated highest sensitivity to variation in zinc price compared to copper or lead, and, therefore, the higher copper prices have been balanced by conservative zinc and lead price assumptions.

Additionally, WAI has considered the financial model using the World Bank model price forecast. The ZEP NPV at 8% discount rate increases from €180M to €247M using the World Bank expectations.

Table 22.1: Project LoM Commodity Prices					
Time Period	Average for the LoM				
Metal Prices	US$ /lb			US$/t	
Copper	2.91			6,417	
Zinc	1.03			2,275	
Lead	0.90			1,984	
ZEP Project Base Metal Prices in US$/t					
Years	**2017**	**2018**	**2019**	**2020**	**2021 onwards**
Copper	4,960	5,512	6,614	6,614	6,614
Zinc	2,205	2,646	2,535	2,425	2,205
Lead	1,984	1,984	1,984	1,984	1,984
World Bank Metal Prices Outlook, US$/t (dated Q2 2017)					
	2017	**2018**	**2019**	**2020**	**2025**
Copper	5,750	5,838	5,927	6,017	6,490
Zinc	2,750	2,600	2,583	2,566	2,481
Lead	2,200	2,208	2,215	2,223	2,261
Project EUR / US$ exchange rate	**1.15**	**1.15**	**1.15**	**1.15**	**1.15**

22.3 Key Project Inputs and Assumptions

The financial model has been developed in Q1 2017 using Euros with no inflation or escalation of prices applied. Tax and royalty rates are those currently in place (income tax rate ranging between a minimum of 22.5% and a maximum of 29.5% and royalty rate being the higher of either 10% on net profit or 1% on Net Smelter Return). A summary of the key technical and financial input parameters and assumptions for the selected economic project life (2020-2030) is presented in Table 22.2 below.

Table 22.2: Operational Assumptions (Economic LoM 2020-2030)		
Production Summary		
ROM feed to Copper Plant	kt	18,066
ROM feed to Zinc Plant	kt	25.216
Total Ore feed	**kt**	**43,282**
Copper in Copper concentrate	Kt	362
Zinc in Zinc concentrate	Kt	1,571
Lead in Lead concentrate	Kt	214
Production Cost Structure (LoM)		
Total Opex	EUR/t	**44.76**
Mine	EUR/t	24.05
Plants	EUR/t	11.52
Water & Tailings	EUR/t	1.59
Other G&A	EUR/t	7.61
Average Sustaining Capital Costs	**EUR M/year**	**25**

A summary of project cash costs for the economic LoM (2020 – 2030) is given below in Table 22.3.

Table 22.3: Project Cash Costs (Economic LoM: 2020-2030)		
Copper Cash Costs		**2020-2030**
Total Opex	US$'000	2,228,010
Shiping & Insurance Cost	US$'000	30,783
TC, RC and penalties	US$'000	229,630
By-product credits	US$'000	2,276,611
C1 Copper	US$'000	211,812
Royalties	US$'000	79,201
Sustaining Capex	US$'000	318,747
All-In Sustaining copper	**US$'000**	**609,760**
Payable Copper	lb'000	766,019
C1 Copper	US$ /lb	0.28
All-In Sustaining Copper	**US$ /lb**	**0.80**
Zinc Cash Costs		**2020-2030**
Total Operating Cost	US$'000	2,228,010
Shiping & Insurance Cost	US$'000	86,739
TC, RC and penalties	US$'000	842,529
By-product credits	US$'000	2,331,135
C1 Zinc	US$'000	826,142
Royalties	US$'000	79,201
Sustaining Capex	US$'000	318,747
All-In Sustaining Zinc	**US$'000**	**1,224,090**
Payable Zinc	lb'000	2,884,895
C1 Zinc	US$ /lb	0.29
All-In Sustaining Zinc	**US$ /lb**	**0.42**

22.4 Sensitivity Analysis

The ZEP has a strongly positive incremental NPV of €**180M** for the economic project life of 2017-2030.

A sensitivity analysis was performed on key parameters within the financial model to assess the impact of changes upon the NPV of the ZEP.

In order to examine the sensitivity of the ZEP NPV to changing economic and operational conditions each parameter was variated within the following ranges:

- Operating Costs (+/-20%);
- Capital Costs (+/- 20%); and
- Change in Zinc and Copper Prices (+/-20%)

The results of the sensitivity analysis for NPV (at 8% discount rate) (Base case) are shown in Figure 22.1.

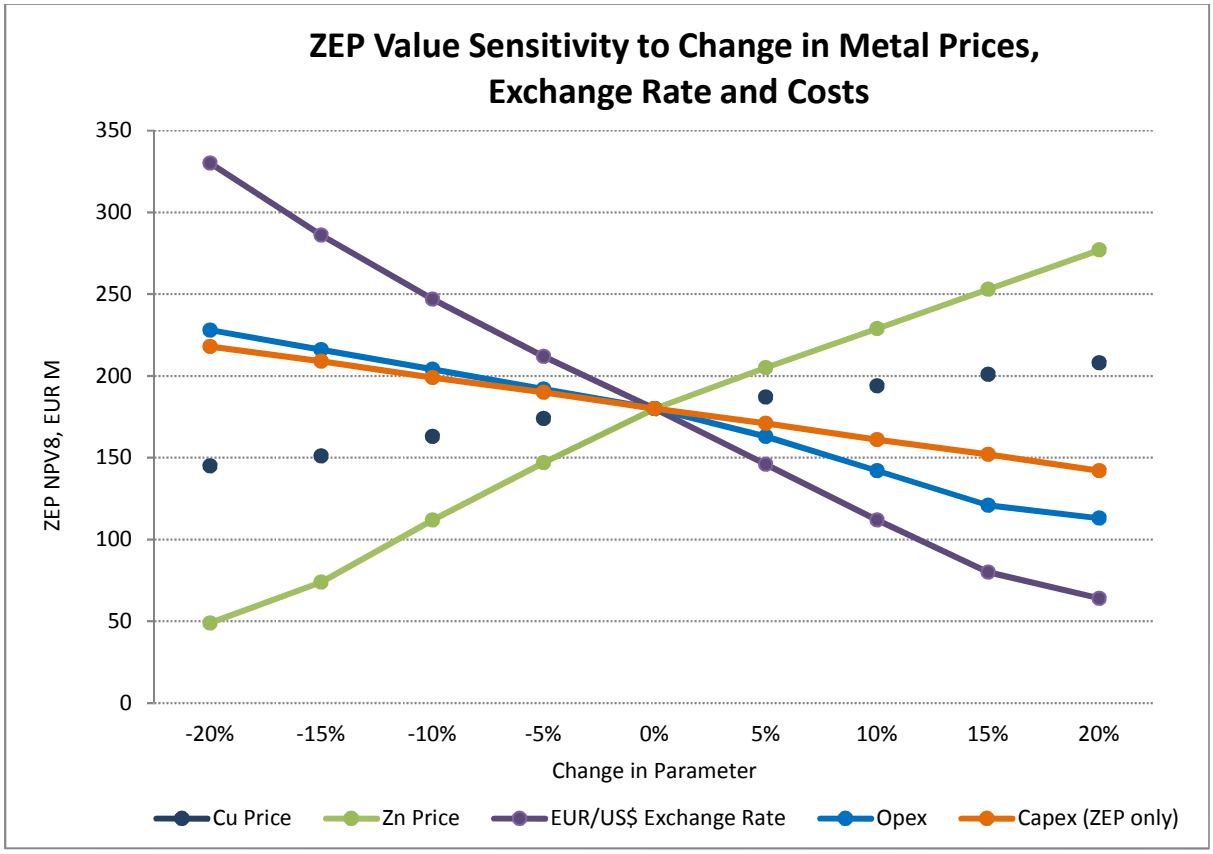


Figure 22.1: Sensitivity Analysis Results

The analysis indicates the project is most sensitive to the euro/dollar exchange rate. A plus/minus 20% variation represents an FX rate ranging from 0.92 to 1.38. As of the date of this report the Euro/Dollar is approximately 1.12; using this value in the financial analysis would result in an NPV (at 8% discount rate) of €199M.

The project is also sensitive to changes in zinc price, followed by the project operating and ZEP capital costs. It is noted that none of the performed individual sensitivity analysis results produce a negative NPV for the ZEP.

The following table displays a sensitivity analysis to simultaneous changes in zinc price and euro/dollar exchange rate, demonstrating the robustness of the project value.

Table 22.4: Sensitivity Analysis to Change in Zinc Price and Exchange Rate (LoM 2017-2030)

Zinc Price (average 2017-2030)		0.83	0.88	0.93	0.98	1.03	1.08	1.14	1.19	1.24
EUR/US$ Exch. Rate (average 2017-2030)		*-20%*	*-15%*	*-10%*	*-5%*	*0%*	*5%*	*10%*	*15%*	*20%*
0.92	*-20%*	194	229	263	296	**330**	361	391	421	452
0.98	*-15%*	157	190	223	255	**286**	314	343	372	400
1.04	*-10%*	117	155	186	217	**247**	274	300	327	354
1.09	*-5%*	79	118	148	183	**212**	238	263	288	313
1.15	*0%*	**49**	**74**	**112**	**147**	**180**	**205**	**229**	**253**	**277**
1.21	*5%*	16	52	76	112	**146**	175	199	222	244
1.27	*10%*	- 12	21	56	78	**112**	143	171	193	215
1.32	*15%*	- 39	- 7	26	60	**80**	110	140	162	189
1.38	*20%*	-55	- 33	- 2	30	**64**	80	109	131	158

23 ADJACENT PROPERTIES

There is no information regarding adjacent properties applicable to the Neves-Corvo Property for disclosure in this Technical Report.

24 OTHER RELEVANT DATA AND INFORMATION

There are no other relevant data or information to report in this Technical Report.

25 INTERPRETATION AND CONCLUSIONS

25.1 Mineral Resource Estimate

An updated Mineral Resource estimate has been prepared for the Neves-Corvo and Semblana polymetallic base metal deposits. The Mineral Resource estimate is based on drilling and face sample data of acceptable quality from drilling and sampling programs conducted between 1977 and 2016. All of the drilling was conducted by diamond core drilling.

All Mineral Resource estimates were produced by SOMINCOR and reviewed by WAI. Mineral Resource estimation involved the use of drill hole, face sample and geological mapping data to construct three dimensional wireframes to define mineralised domains. Grades were estimated into a geological block model representing each mineralised domain. Grade estimation was carried out predominantly by ordinary kriging. Estimated grades were validated globally, locally, and visually prior to tabulation of the Mineral Resources. Reconciliation indicates that the Mineral Resource models perform well when compared to plant production data.

As of June 30, 2016, and at a cut-off grade of 1.0% Cu, the total Measured and Indicated Mineral Resources for the copper zones within the Neves-Corvo Area of the Mining Concession are estimated to be 69,986Kt with an average grade of 2.7% Cu, 1.0% Zn, 0.3% Pb and 45g/t Ag. Total Inferred Mineral Resources are estimated to be 12,758Kt with an average grade of 1.7% Cu, 1.2% Zn, 0.4% Pb and 37g/t Ag.

As of June 30, 2016, and at a cut-off grade of 3.0% Zn, the total Measured and Indicated Mineral Resources for the zinc zones within the Neves-Corvo Area of the Mining Concession are estimated to be 106,819Kt with an average grade of 6.1% Zn, 0.3% Cu, 1.3% Pb and 58g/t Ag. Total Inferred Mineral Resources are estimated to be 11,386Kt with an average grade of 4.4% Zn, 0.3% Cu, 1.0% Pb and 52g/t Ag.

As of June 30, 2016, and at a cut-off grade of 1.0% Cu, the total Mineral Resources (wholly Inferred) for the Semblana Area of the Mining Concession are estimated to be 7,807Kt with an average grade of 2.9% Cu and 25g/t Ag.

25.2 Mineral Reserve Estimate

An updated Mineral Reserve estimate has been prepared to include the ZEP.

As of June 30, 2016, and at an average cut-off grade equivalent of 1.3% Cu, the total Proven and Probable Mineral Reserves for the copper zones within the Neves-Corvo Area of the Mining Concession are estimated to be 28,616Kt with an average grade of 2.6% Cu, 0.7% Zn, 0.2% Pb and 34g/t Ag.

As of June 30, 2016, and at an average cut-off grade equivalent of 5.7% Zn, the total Proven and Probable Mineral Reserves for the zinc zones within the Neves-Corvo Area of the Mining Concession are estimated to be 34,089Kt with an average grade of 7.5% Zn, 0.4% Cu, 1.8% Pb and 66g/t Ag.

25.3 Mining

Underground mining at Neves-Corvo has been continuous since 1989, with the current production plan for 2017 budgeted for 2.4Mt of copper ore at 2.4% Cu and 1.1Mt of zinc ore at 8.6% Zn.

The focus of the ZEP FS has been to demonstrate the economic benefits that can be realised from the increased exploitation of the zinc mineralisation at Neves-Corvo. Consequently, the Neves-Corvo ZEP is reliant on three principle mining upgrades to provide increased zinc ore throughput to the mill.

These are:

- An increase of zinc ore production from the existing mill constrained mining areas;
- The development of a new, deeper production area denoted as LP2; and
- An upgrade to the materials handling capacity of the shaft and the Lombador orebody area.

The development of the LP2 area is a fundamental part of the ZEP as this expansion area fills the shortfall in zinc production created as a result of the accelerated zinc production plan. The designs and schedules for LP2 were developed to FS order-of-accuracy, notionally within +/-10-20% accuracy.

Since LP2 production will ramp-up over a period of time to compliment the decline in production from other areas, development of the entire expansion area is not immediately required, minimising the early capital development costs of the ZEP.

Optimised extraction zones are integral to the economic success of LP2 and are planned throughout the orebody, with the majority of zinc production coming from Optimised Bench-and-Fill stopes. Development access and service corridor excavations are optimised to reduce capital development costs, with considerable proportions of the access development planned within the orebody boundaries to generate a net positive cash flow.

Upgrades to the materials handling infrastructure specifically include:

- New primary crusher station complete with jaw crusher, rock breaker, vibrating grizzly feeder, shuttling silo distribution conveyor, magnetic separator and ancillary equipment at 260L;
- Two silos for storage of zinc ore, copper ore, and waste, each with a vibrating feeder for feed to ramp conveyor system at the top and bottom of a conveyor system;
- Approximately 3.2km ramp conveyor system (in three legs); and
- Upgrades to existing shaft and skip loading system to increase capacity to 5.4Mtpa.

Numerous studies and reviews have been conducted with regards to these materials handling upgrades, which have produced optimal designs and recommendations for the ZEP. Upgrades are required in other areas of the operation in order to realise the potential of the ZEP. Additions are required to the mobile equipment fleet, with capital investment in mobile mining equipment anticipated to stand at €11.7M. Improvements to the backfill and ventilation systems are also necessary, with refrigerated ventilation needed for the deepening and expansion of mining in Lombador.

25.4 Mineral Processing

The SOMINCOR mineral processing plants have been significant producers of copper and zinc concentrates using conventional flowsheets consisting of crushing, grinding and flotation. The Copper Plant has undergone several stages of expansion since 1989 and now treats up to 2.7Mtpa of ore through two separate grinding lines with a common flotation circuit. The Zinc Plant was constructed in 2006 and now treats up to 1.1Mtpa of ore, with a planned expansion to 2.5Mtpa.

The mineral processing operations are therefore well established with a significant track record in base metal concentrate production. Since operations began there has been a relatively low turnover of staff in the metallurgical departments with the result that there is now a highly experienced workforce with extensive experience in the processing of fine grained base metals ores.

In recent years there has been a general deterioration in metallurgical performance which is partially attributed to the deterioration in the quality of water being returned from the TMF, caused by the switch to thickened paste method of tailings disposal. A water treatment plant is currently being constructed to improve the quality of water used in flotation and this will be completed by the end of 2017.

Recoveries used in the ZEP FS (2017 Amendment) financial evaluation were based on testwork and modelling performed for the ZEP FS (2015) with consideration for recent lead and zinc circuit flotation circuit survey data and operating results. A comprehensive testwork program is currently underway, which is expected to confirm flotation performance of the expanded circuit. The site metallurgical team are confident that the stated recoveries can be achieved.

WAI notes that the predicted recoveries (and lead concentrate grades) in the study are higher than those achieved to date and are the result of anticipated improved metallurgy in the expanded plant where cleaner residence times have been increased, a more consistent and stable grinding circuit and a more reliable water supply.

Laboratory testwork investigations are continuing in order to give better confidence in the predicted metallurgical performance. It is also anticipated that the improved water quality resulting from the water treatment plant will also result in improved flotation response.

The feasibility of expanding zinc production to 2.5Mtpa has been extensively studied by SOMINCOR and AMEC with a “Cold Eyes” review by Ausenco. The expansion of the flotation, thickening and

filtration sections of the plant have been extensively studied and much of the design data for the expansion is based on operational experience.

The selection of SAG milling represents the only significant step change in the process design and it is in this area that the greatest technical risk exists, although this has been mitigated to some extent by the experience of the consultants used in the design of the grinding circuit.

25.5 Environmental Studies, Permitting and Social or Community Impact

Based on the documents reviewed, the environmental and social aspects are considered in compliance with Portuguese legislation and international best practice.

A ZEP EIA has been undertaken and is anticipated to be approved in July 2017. It is understood that permits for water abstraction and emissions are in line with Portuguese legislation, though it is recommended that SOMINCOR obtains necessary permissions or deploys appropriate mitigation measures such that the ZEP minimises destruction of endangered or protected species such as the holm oak.

26 RECOMMENDATIONS

26.1 Mineral Resources

- **Reconciliation** – Mineral Resource model grade, plant production grade and 'broken ore' grade all vary against the planned grade on a month by month basis. In order for the mine to consistently meet the planned grade requires a complex interaction of many operational factors of which resource modelling is just one. Based on this, it is recommended that a review to identify the reasons for the variability of the copper grades reporting from the planned production compared to the resource model be undertaken;
- **Mineral Resource Classification** - it is recommended that an additional level of Mineral Resource classification override be incorporated into the resource models using perimeter strings or wireframes to prevent Indicated Mineral Resources being derived from widely spaced surface drill holes; and
- **Resource Evaluation** - To better align the Mineral Resource and Mineral Reserve estimates it is recommended that:
  - A review of the cut-off grades used for Mineral Resource reporting be undertaken; and
  - Non-recoverable Mineral Resources be updated to include additional areas which are unlikely to be exploited by mining.

26.2 Mining

- **Remote Loading** - It would not be unreasonable to assume that difficulties may be encountered when remote loading on a surface of backfill during some OBF and BF mining. It is understood that current practise is to improve mucking performance in these stopes by placing a layer of broken ore on the top of both backfilled Primary and Secondary stopes. This layer of material is then removed once the stope excavation is completed. This practice could result in excess paste fill diluting the recovery of the ore 'floor', or alternatively could lead to lower recoveries if some of the ore 'floor' cannot be fully cleaned out. The loading of this ore 'floor' may also increase the risk of getting remote LHDs stuck if the backfill underneath is not of a suitable strength. It is recommended to assess and quantify the dilution/recovery and operational risks associated with this in practise, to determine if an alternative solution is required, for example increased cement content in backfill capping pours;
- **Design Profiles for Materials Handling Development** - The reduction in the cross-sectional size of the main materials handling conveyor ramps has been proposed in order to reduce unnecessary excavation costs during the development phase of these ramps. Whilst this can be justified from an operational and capital expenditure aspect, it should be noted that a combination of the reduced dimensions and the low hanging conveyor belt could lead to operational difficulties being encountered if significant quantities of spillage/overthrow from the belt are required to be removed, due mainly to limited equipment access;

- **Scheduling/Ventilation** - The development peak that occurs at the resumption of access development in to LP2 North between 2023 and 2026 could cause capacity issues with the currently planned ventilation system for Lombador. If this peak can be smoothed out by bringing forward the commencement of re-access to LP2 North; then there is greater confidence in the capacity capabilities of the system.
- **Congestion Issues** - An initial assessment of potential future congestion issues in the Lombador ramps is recommended, during the peak of the development and materials handling construction schedules. This would be a pre-cursor to the planned detailed simulation of mine traffic in the same areas, using requisite dynamic systems simulation software;
- **Expansion of Paste Backfill Plant** - Due to the capacity shortfall in backfill availability during peak requirement periods, it is recommended to conduct an utilisation study to determine if an expansion of the paste backfill plant is warranted. There may be a benefit in reducing the size of the paste tailings plant expansion; and
- **Further Optimisation** - There is still room for further optimisation in the ZEP FS LoM plan. These opportunities were left unexplored due to time constraints, therefore the new LoM plan must consider:
  - Level development coming in too early in the mining schedule;
  - More efficient sequencing of stopes in LP2 North and South;
  - Use of Lombador North ramp as an emergency water storage;
  - Delay and consequent smoothing of Lombador North development schedule;
  - Verification of waste rock quantities hoisted;
  - Selection of appropriate backfill methods; and
  - Smoothing of zinc ore production post 2025.

26.3 Geotechnical

- **Major Structures** - Investigation programmes identified a major structure through LP2, detailed 3D stress modelling has been conducted as well as stand-off pillars adjacent to stopes within the projected fault path for mining. Near intersection of the fault, adaptive mine planning and geotechnical response is recommended in case revision to mine design or additional support is required;
- **Geotechnical Mapping** - Further geotechnical mapping when development is progressed further into LP2 is recommended, to update the mine geotechnical model;
- **Underground Stope Back Analysis** - Updates with current stoping and with planned stoping in LP2 stope back analysis is recommended;
- **GCMP Update** - The ground control management plan (GCMP) is typically regarded as a 'live' document for geotechnical reference and design. The GCMP should be kept up to date with current data and investigations; and
- **Additional Geotechnical Data** - Any additional geotechnical data, such as mapping, logging, or testing should be used to reduce data gaps, enhance the geotechnical database, update the rock mass structural model, and refine the hydrogeological model. Designs should be optimised when additional geotechnical information becomes available.

26.4 Mineral Processing

- **Process Plant Recoveries and Concentrate Grades** - Further testwork studies are required to confirm that the plant recoveries and concentrate grades used in the ZEP study are realistic and achievable. This work is ongoing at SOMINCOR and WAI Laboratories;
- **Water Quality Effect on Flotation Performance** - The effect of water quality on flotation performance also requires further study and this work is also being planned; and
- **SAG Milling** - The selection of SAG milling represents a major change in the process flowsheet and a more detailed appraisal of the testwork and more detailed benchmarking with similar operations is merited.

26.5 Environmental Studies, Permitting and Social or Community Impact

- **Permitting -** It is recommended that SOMINCOR continues to actively track ongoing and pending permitting activities to ensure that these are in compliance with national legislation;
- **GHG Emissions** – GHG emissions are monitored and reported as part of the AQGHGMP. Although this system has only recently been put in place, it is recommended that GHG emissions continue to be monitored and the AQGHGMP amended as the project develops;
- **Water Quality** - It is recommended that SOMINCOR continues to monitor changes to the water balance. There is potential for groundwater impacts from the TMF to be migrating offsite and it is recommended that consultants are hired to assess existing soil and groundwater monitoring networks and to propose improvements to be incorporated into the closure plan. This work has been initiated by the SOMINCOR with support from Lundin; and
- **Social Engagement** - From 2018 onwards, SOMINCOR will invest at least $300,000 USD annually in projects and organizations that advance several priority areas. It is recommended that the formal Stakeholder Engagement Plan currently being developed is completed and is continuously updated as the ZEP is constructed.

26.6 Project Costs

- **Mine Ventilation Costs** - At the time of publication of the ZEP FS (2017 Amendment), a detailed ventilation report was not available. It is known that refrigeration of air into the mine will be required for the base case, and that additional refrigeration will be required as mining moves into the LP2. Allowance for these developments has been made in the Capital cost, but a more detailed evaluation of the mine ventilation costs is recommended.

27 REFERENCES

- Environmental Impact Assessment: Zinc Expansion Project Report (PROCESL), November 2016.
- Gaspar, OC., 2002. Mineralogy and sulphide mineral chemistry of the Neves-Corvo ores, Portugal: Insight into their genesis. The Canadian Mineralogist, Vol. 40, pp. 611-636.
- Gibson, HL., Allen, RL., Riverin, G., and Lane, TE., 2007. The VMS Model: Advances and Application to Exploration Targeting. Proceedings of Exploration 07: Fifth Decennial International Conference on Mineral Exploration, pp 713-730.
- Hannington, MD., Jonasson, IR., Herzig, PM., and Petersen, S., 1995. Physical and chemical processes of seafloor mineralization at mid-ocean ridges: Seafloor Hydrothermal Systems: Physical, Chemical, Biological and Geological Interactions, v. AGU Geophysical Monograph 91, pp. 115-157.
- Neves-Corvo ZEP FS Update, Phase 2 Report – Zinc Plant and Surface Infrastructure Report (Ausenco), March 2017; and
- Neves-Corvo Zinc Expansion Project Amendment Report (SOMINCOR), April 2017;
- NI 43-101 Neves-Corvo plus Semblana Final (V3.0) Report (WAI), January 2013;
- SOMINCOR internal report dated November 07, 2016 and titled: “Neves-Corvo Mineral Resources Update; Date – June 30, 2016”;
- ZEP Cold Eyes Review Zinc Plant and Surface Infrastructure Report (Ausenco), October 2016; and
- Zinc Expansion Project Feasibility Study Report (SOMINCOR), dated October 2015.

DATE AND SIGNATURES

The effective date of this Technical Report, entitled “NI 43-101 Technical Report for the Neves-Corvo Mine, Portugal” is 23 June 2017.

Richard Ellis **(Signed and Sealed) "*Richard Ellis*"**	**Date: 23 June 2017**
Phil Newall **(Signed and Sealed) *"Phil Newall"***	**Date: 23 June 2017**

CERTIFICATE OF AUTHOR

I, Richard John Ellis, BSc, MSc, MCSM, FGS, CGeol, EurGeol, do hereby certify that:

- I am a Principle Resource Geologist of: Wardell Armstrong International Ltd Wheal Jane, Baldhu, Truro, TR3 6EH, United Kingdom;
- I graduated with a Bachelor of Science Degree in Geology from the University of Bristol (UK) in 2001 and a Master of Science Degree in Mining Geology from the Camborne School of Mines (UK) in 2003;
- I am a Fellow and Chartered Geologist of the Geological Society of London (Membership No. 1013201) and member of the European Federation of Geologists;
- I have practiced my profession continuously for the last 13 years in a variety of countries and geological environments and have prepared Mineral Resource estimates for volcanogenic massive sulphide deposits for more than 5 years;
- I have read the definition of "qualified person" set out in National Instrument 43-101 ("NI 43-101") and certify that I am a "qualified person" for the purposes of NI 43-101;
- I last visited the property from April 26 to April 27, 2017;
- I am responsible for the preparation of sections 1. Summary; 2. Introduction; 3. Reliance on Other Experts; 4. Property Description and Location; 5. Accessibility, Climate, Local Resources, Infrastructure and Physiography; 6. History; 7. Geological Setting and Mineralisation; 8. Deposit Type; 9. Exploration; 10. Drilling; 11. Sample Preparation, Analyses and Security; 12. Data Verification; 14. Mineral Resource Estimates; 23. Adjacent Properties; 24. Other Relevant Data and Information; 25. Interpretation and Conclusions; 26. Recommendations; 27. References;
- I am independent of the issuer, Lundin Mining Corporation as defined by NI 43-101;
- I have read the Instrument NI 43-101 and the Technical Report has been prepared in compliance with NI 43-101 and;
- As of the date of this certificate and 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 23rd day of June, 2017

(Signed and Sealed) "*R. J. Ellis*"

Name: **R J Ellis BSc, MSc, MCSM, FGS, CGeol, EurGeol**

CERTIFICATE OF AUTHOR

I, Phil Newall, BSc (ARSM), PhD (ACSM), CEng, FIMMM do hereby certify that:

- I am the Managing Director of: Wardell Armstrong International Ltd Baldhu House, Wheal Jane Earth Science Park, Baldhu, Truro, Cornwall, United Kingdom TR3 6EH;
- I graduated with a Bachelor Degree in Geology from Imperial College, London, UK in 1983 and with a PhD from Camborne School of Mines (UK) in 1991;
- I am a Fellow and Chartered Engineer of the Institution of Materials, Minerals & Mining (Membership No. 48891);
- I have practiced my profession continuously for the past 30 years in areas of gold and base metals evaluation in a number of countries around the world;
- I have read the definition of "qualified person" set out in National Instrument 43-101 ("NI 43-101") and certify that I am a "qualified person" for the purposes of NI 43-101;
- I am responsible for the preparation of sections 1. Summary; 13. Mineral Processing and Metallurgical Testing; 15. Mineral Reserve Estimates; 16. Mining Methods; 17 Recovery Methods; 18. Project Infrastructure; 19. Market Studies and Contracts; 20. Environmental Studies, Permitting and Social or Community Impact; 21. Capital and Operating Costs; 22. Economic Analysis; 24. Other Relevant Data and Information; 25. Interpretation and Conclusions; 26. Recommendations; 27. References;
- I am independent of the issuer, Lundin Mining Corporation as defined by NI 43-101;
- I have read the Instrument NI 43-101 and the Technical Report has been prepared in compliance with NI 43-101 and;
- As of the date of this certificate and 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 23rd day of June, 2017

(Signed and Sealed) *"**P. Newall**"*

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