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Çayeli Underground Cu-Zn Mine

M.Yumlu
Çayeli Bakır İşletmeleri AŞ (CBI), Rize, Turkey

ABSTRACT: Çayeli Bakır işletmeleri AŞ (CBI) is a joint venture between Inmet Mining of Canada (49%) and two Turkish partners. Eti Holding AŞ (45%) and Gama Endüstri AŞ (6%). During construction and through the first five years of production, the operator, Inmet Mining, has successfully brought a 2880-ton-per-day underground Cu-Zn mine into production. The Çayeli underground mine is located at Madenköy, about eight kilometers south of the coastal town of Çayeli on the northeast Black Sea coast of Turkey. In 1994, CBI began development and production from a massive sulfide ore body dipping to the northwest at about 70 degrees. A retreat transverse/longitudinal long hole stoping method with post backfill was developed utilizing trackless mining equipment. CBI has been able to achieve low mining costs and high productivity using this mining system. This paper will briefly review the Çayeli mine in general. Specifically, a brief history of the mine, the geology of the deposit, the mining method, backfilling, ground support, ventilation and dewatenng, ore haulage, hoisting and finally staffing will be outlined.

1 INTRODUCTION

Çayeli mine is located in the Black Sea region of northeast Turkey. The mine is approximately 28 km east of Rize and 100 km west of the border with Georgia (Fig. 1). The nearest town is Çayeli, 8 km away. The Çayeli mine site is located in the foothills of the Pontid mountain range. This region is characterised by high topographic relief and high rainfall.

The mine is operated by Çayeli Bakır işletmeleri AŞ (CBI) and produces copper and zinc concentrates by processing massive sulphide ore.

The concentrates are transported by truck to the port of Rize and are then shipped to domestic and overseas smelters.

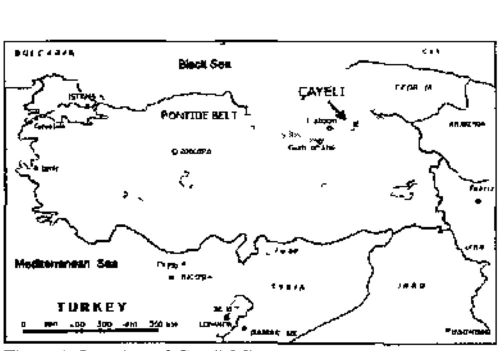

Figure 1. Location of Çayeli Mine.

CBI has been in operation since August 1994 and has undergone a series of technological changes since then, such as the completion of a shaft to replace truck haulage from underground, and the introduction of paste backfill. Ore production has increased virtually every year, and the 2001 target is 1.0 million tonnes of ore

This paper gives a brief account of the discovery of the Cayeh ore deposit, the background of CBI. the on-site operations and the outlook for the future.

2 DISCOVERY AND BACKGROUND

Mining activities along the Black Sea coast and at Çayeli date back at least a thousand years. At the turn of this century, minor exploration by the Russians was reported and, between 1930 and 1955, various shafts and adtts were driven and some minor production took place.

The work which led to the present mine was started İn 1967 by the Turkish Mineral Research and Exploration Institute (MTA). MTA carried out a geophysical *survey* and drilling programme, and drove an adit into the massive sulphide ore. In 1981, CBI was formed as a joint venture between Etibank (now Eti Holding AS), Phelps Dodge and Gama Endüstri AŞ to develop the ore body. Phelps Dodge sold its share to Metall Mining (now Inmet Mining) in 1988. Further underground work and metallurgical testing were done in the period 1988 to 1991. After positive results, a production decision was made and site construction started in 1992. The basic mine infrastructure was commenced in 1993 and in August 1994 the first concentrate was produced. Table 1 below presents a summary of the operation.

The mining rate has increased, from 1350 tonnes per day in 1995 to 2880 m 2000 (Table 2). Recoveries and concentrate quality have improved since start-up. The total capital cost of the project was over $US 200 million.

Table 1 Summary of the operation

1967	First geophysical survey and drilling program by MTA
1981	CBI was formed as a joint venture between Etibank (now Eti Holding AS). Phelps Dodge and Gama Endüstri AŞ
1988	Phelps Dodge sold its share to Metal! Mining (now Inmet).
1988-91	U/G work and metallurgical testing was done
1992	Site construction started
1993	Basic mine infrastructure commenced
1994	First concentrale was produced in August
1995	Engineering and design for shaft started
1998	Shaft commissioned in July
1999	Paste backfill plant commissioned
2000	Achieved 4 million tonnes production since start-up and mining rate increased from 1350 t/dml995to2880t/d.

Table 2. Main operational statistics

Year	Production, Tonnes	Feed grade	
		Cu%	Zn%
1994	70,641	4 48	7.72
1995	485,815	3.66	7 55
1996	654,448	3.53	8 54
1997	761,608	4.71	704
1998	707,992	4.56	6.63
1999	896,749	511	5 34
2000	860,763	4.87	4.45
Total	4,438,016	4.51	6 42

3 GEOLOGY, ORE RESERVES AND EXPLORATION

3.1 *Ore reserves and exploration*

The January I[s1], 2001 estimate of the resource (measured, indicated and inferred) was 15.9 million tonnes with 4.13% copper, 6.18% zinc, 0.70 g/t gold and 53 g/t silver at a 2.5% copper equivalent cut-off. Mining commenced in 1994 and up to the end of 2000, 4.44 million tonnes with 4.51% copper and 6.42% zinc were mined (Table 2).

The continuing exploration program has led to the indication and identification of additional geological resources adjacent to the main ore body and below the present lowest level, which add up to 5 million tonnes of mineable reserves beyond the original ore resources reported in 1994.

Two recent exploration successes are the far north extension of the Main Ore Zone and the down-dip extent of the Deep Ore Zone. The current focus of exploration is the Deep Ore, which is still open along the strike and down dip, where the next phase of production is planned.

3.2 *Regional and heal geology*

The eastern Black Sea volcamc province (Pontid Belt) bounding the eastern Black Sea coast of Turkey extends for over 500 km from the west of Samsun to the Lesser Caucasus in the Republic of Georgia. It is cut off to the south by the North Anatolian Fault. The Pontid Belt is thought to be part of a large ensialic island arc system of Jurassic to Miocene in age, comprised of calc-alkaline and tholeitic volcanic rocks and flysch-type sediments. During the Mid- to Late Cretaceous period, the Pontid region was dominated by mafic arc volcanism that evolved to explosive felsic volcanism. The Çayeli deposit was formed during the transition from mafic to felsic volcanism.

The Çayeli ore body occurs at the top of a felsic flow/dome sequence. The overlying sequence consists of interlayered tuffs and basalts. The deposit dips to the northwest at approximately 70° and stratigraphie tops are to the northwest.

The ore body does not outcrop but strikes parallel to a small valley where there are extensive exposures of highly altered material which forms the immediate footwall of the massive sulphides.

The ore body has been divided into two parts, the upper Main Zone and lower Deep Zone. The two zones are separated by a major discontinuity, which is interpreted to be a synvolcanic growth fault. This feature strikes sub-parallel to the ore body and dips to the east. The two zones are in contact at the southern end of the deposit and become progressively more widely separated towards the north.

3.3 *Description of the deposit and ore types*

The Çayeli deposit is a volcanogenic massive sulphide with many affinities to bodies of the Kuroko type. Mineralisation is known over a strike length of 920 metres. The measured resource has a strike length of about 600 metres, vertical depth of over 400 metres and varies in thickness from a few metres to 80 metres, with a mean of about 20 metres. The hangingwall sequence is a series of intercalated acid to intermediate pyroclastic and basaltic layers with some minor carbonate beds. The footwall consists of altered to highly altered acid volcanics and pyroclastics.

The Main Ore Zone consists of massive sulphide conglomerates, breccias and sandstones with more than 90% sulphide minerals and minor gangue. The major sulphides in the massive sulphide are pyrite, chalcopyrite and sphalerite with minor galena, bornite, and tetrahedrite. Gangue minerals include barite, dolomite, quartz, sericite and kaolinite.

Immediately underlying the massive sulphide ore is a zone of felsic volcanics which have been altered to clay. Sulphides within this zone consist of disseminated pyrite and veins of pyrite and chalcopyrite.

A sulphide stockwork zone underlies the thickest sections of massive sulphides. It consists of siliceous multidirectional veins which are mineralised with pyrite and chalcopyrite.

The Main Ore Zone consists of two overlapping convex lenses with a strike length of 450 meters and a down dip extent of approximately 200 meters. The Deep Zone occurs below the structural discontinuity that cuts off the Main Ore Zone in a down-dip direction. The ore lithologies are the same as in the Main Ore Zone, but there is a higher proportion of clastic and black ore and proportionately less yellow ore. The ore stratigraphy is not as well defined as in the Main Ore Zone. There is limited information about the Deep Ore Zone, but it appears to be a sheet-like zone with variable thickness.

There are four main ore types. Stockwork ore underlies the main massive sulphide lens and is thickest where it is in close proximity to the synvolcanic fault which offsets the Main and Deep Ore lenses. Yellow ore (copper-rich) occurs immediately above the stockwork zone. Black ore (zinc-rich) occurs above or lateral to the yellow ore. Clastic ore, which is characterised by sphalerite fragments, occurs at the top or around the edges of the ore body.

The stockwork ore is characterised by veins of pyrite and chalcopyrite which occur in the footwall rhyolite. The mineralogy *of this* ore type is simple, with relatively coarse chalcopyrite and pyrite.

The yellow ore consists of pyrite and chalcopyrite clasts, up to 20 cm in size, in a sulphide matrix containing less than 10% sphalerite. The mineralogy of this ore type is also simple.

The black ore consists of pyrite and chalcopyrite clasts from 2mm to >20 cm in diameter in a fine-grained matrix of pyrite and sphalerite containing more than 10% sphalerite. Locally, the sphalerite contains fine inclusions of chalcopyrite, which affects the quality of the copper concentrate.

The clastic ore consists of pyrite, chalcopyrite and sphalerite clasts, from 2 mm to more than 20 cm in diameter in a sulphide matrix. Sedimentary textures, most notably graded bedding, are present. The sphalerite clasts are diagnostic of this ore type. This ore type is the most metallurgically difficult ore type owing to the fine inclusions of chalcopyrite in the sphalerite - the so-called chalcopyrite disease.

4 MINING

4.1 *Mining Method*

The mining method employed at CBI has been designed for 100% extraction with complete pillar recovery, while allowing no perceptible surface subsidence. The mining method is retreat transverse and/or longitudinal long hole stoping with post backfill.

The ore body *is* accessed from a ramp system located in the hangingwall (HW) and a production shaft located in the footwall (FW) of the ore body. The main levels are at 80-100-m vertical intervals with sublevels at 20-m intervals (Fig. 2).

The ore is developed by driving strike access drifts with a cross-section of 25 m^2 along the hangingwall or footwall or in the center of the ore body to the boundaries. Slope preparation is carried out by driving sill drifts across the strike to the hangingwall or footwall, or in the case of low-grade areas, to the boundary of the economic cut-off grade (Fig. 3a). The sill drifts are 7 m wide by 5 m high. The length of the sill drifts depends on the thickness of the ore body and the location of the strike access drifts. The average length of the sill drifts/stopes is presently 35 m.

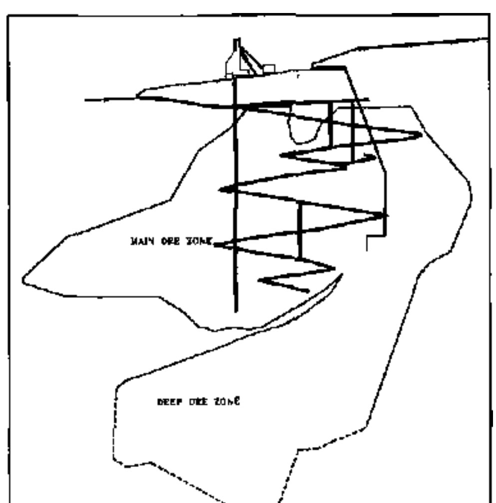

Figure 2. Schematic view of mine infrastructure.

Slope production comprises the extraction of the 15-m-higb bench between two sill drifts (Fig. 3b). A drop raise is excavated between sublevels at the end of the sill drifts. The raise is widened out to a slot to create a free breaking surface. The remainder of the bench is blasted towards the open slot (Fig. 3c). The ore is mucked from the lower sill drift using remote-controlled LHDs. The open stope is then backfilled to the floor level of the upper sill drift (Fig. 3d). The backfilled floor becomes the mucking floor for the next lift. Once two adjacent primary stopes are completely backfilled, the intermediate primary pillar can be mined as a secondary stope. The primary stopes then become backfill pillars. The secondary stopes are also backfilled. The overall sequencing of the mining method is as follows; *(i)* retreat from the boundary of the ore body to the central pillar, *(u)* retreat up dip from main levels, *(lii)* alternating primary and secondary transverse stopes, *(iv)* secondary stopes are mined between primary stopes after consolidation of the cemented backfill, and *(v)* completion of a mining area (main levels) by mining tertiary stopes (longitudinal sloping) in the strike direction between strike access drifts.

4 2 *Drilling and Blasting*

For drilling ore and waste drifts Atlas Copco 282 two-boom electro-hydraulic jumbos with a drill rod length of 4.0 m are used (Fig. 3a). The drill hole diameter İs 45-48 mm. The advance per round is 3.6 m.

In stoping, the initial slot between two levels is prepared by a Cubex Megamatic drill machine fitted with a V-30 Machines Roger raise drill (Fig. 3b). The Cubex drills a hole of 203 mm from the upper to the lower level or vice versa, then enlarges this with a 762-mm reamer head from the bottom up. Stope blast holes are drilled with Tamrock H695 Solomatic top hammer drills (Fig. 3b). Blast holes with a diameter of 64-89 mm are drilled in a variety of patterns, depending on the ore and stope types. The blast holes can be drilled either from the upper or lower sill drift. Stopes are usually completely drilled before production starts.

The main blasting agent is ANFO with a NONEL initiation system, which is transported by Paus trucks and pneumatically loaded. Blasting of the stopes is carried out sequentially with mucking, blasting one to two rows at a time until the stope is completed (Fig. 3c). There İs a central blasting system in use and blasting times are at the end of shifts.

4.3 *Mucking and Haulage*

The ore from development faces and stopes is mucked by Wagner LHDs equipped with ejector buckets. Two sizes of LHD are İn operation; for development, ST 6C is used, and for stoping, ST 8B. All the ST 8Bs and one ST 6C are equipped with remote control. Remote control operation is mandatory in stope production The ore is loaded onto Wagner MT 400 series mine trucks with a nominal capacity of 28 tonnes.

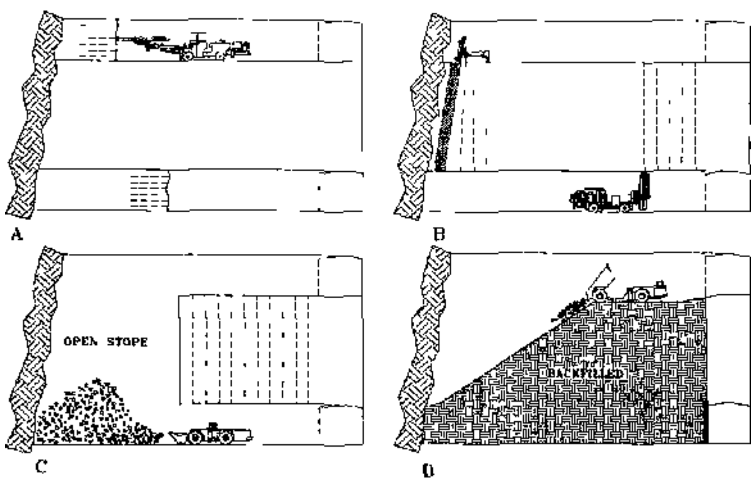

Figure 3. Mining method and mining cycle, a) development, b) drilling, c) blasting and mucking, d) backfilling

Until the middle of 1998 (before commissioning of the shaft), all ore was hauled via the ramp directly to the ore storage bins on the surface. The trucks now dump the ore at the ore pass loading stations on levels 960, 940 and 920. The haulage distances on levels 900 to 960 do not exceed 200 meters. Ore from the upper levels is hauled to the 960 level.

The two ore pass systems allow the transport of two different ore types to be controlled. Generally, the spec ore consists of two ore types, yellow ore and black ore, which are produced simultaneously. The clastic ore, which currently accounts for about 15% of the total ore mined, is hauled in campaigns, replacing one of the other ore types.

The ore passes are of 400 tonnes capacity between sublevels and must be pulled constantly. Ore pass hang-ups rarely occur due to the excellent fragmentation of the generally friable ore at CBI.

On the 900 level, the ore is loaded by an ST 6C from the discharges of the ore passes to a feed hopper with a grizzly, which limits the block size to 300 x 300 x 450 mm. The amount of oversized material from the ore passes is fairly limited.

The haulage distance from the ore passes to the feed hopper is 25 m and 50 m, respectively. The different ore types from the ore passes are strictly separated by feeding only ore from one ore pass at a time. When the ore type changes, the feed hopper is emptied completely before the feeding of another ore type.

Waste rock is hauled from the development faces by trucks either to the surface or directly to stopes for backfilling.

4.4 *Backfilling*

Backfilling is an essential part of the mining process at CBI (Fig. 3d). Several types of fill are used for backfilling, namely, cemented rockfill (CRF), cemented paste fill (PF), and uncemented waste fill (WF).

For primary stopes, CRF and/or PF are used. The primary requirement here is to stabilize the ground to permit the extraction of the adjacent ore. The fill is exposed by the subsequent ore extraction, and hence must have sufficient strength to support itself when the constraining ore walls are removed. The primary stopes are filled with CRF or PF with 5% cement depending on the availability and stope requirements.

Secondary stopes, except for the brow section, which will be exposed during tertiary extraction are backfilled with uncemented development waste material or 2% cemented paste fill. Here, the voids generated after secondary extraction are filled to provide regional support. Use of WF for the most part facilitates disposal of waste from development mining, eliminating the need to truck or skip the material to surface waste stockpiles. A portion of secondary stope fill will be exposed during extraction of tertiary stopes. In order to minimize dilution, secondary stopes on the access drift side are filled with CRF or PF (with 5% cement).

Tertiary and longitudinal stopes are backfilled with cemented rock fill and/or paste fill with 5% cement.

The uppermost sill drifts on main levels usually require the backfill to be tight against the back to minimize spans and to improve regional stability.

Generally, cement dosing for CRF and PF is 5%. However, the stope geometry and the prevailing mining conditions dictate the final dosage of cement in backfill.

4.5 *Ventilation*

Fresh air for primary ventilation to the mine is supplied through two down cast raises and the shaft, at a combined maximum rate of 245 m/s. The ventilation raises are equipped with one 220-kW fan each, with a maximum capacity of 110 mVs. The two ventilation raises are located in the hangingwall, with a diameter of 3.6 m each and inclination of 70 degrees. On the surface, these raises are accessed by a orizontal drift. Ventilation raise No. 1 (In section N1730), serving the mining area between levels 900 and 980, reaches down to the 960 level, and then continues in section N1710 to the 920 level. Ventilation raise No. 2, located in section N1710, ends at the 1000 level and serves mining areas above the 1000 level only. The shaft is equipped with a 30-kW fan, which provides 25 m^3/s fresh air through a 900 mm ventilation duct to the shaft sump at the 830 level.

The fresh air from the raises is diverted on intake air levels to the active mining areas. Several raises within the ore body, with diameters between 0.8 and 3.0 m, serve as exhaust raises. Exhaust air is returned through exhaust levels (typically the top level of a mining area) to the main ramp and to the exploration ramp (above the 1000 level only).

Table 3. Present ventilation system.

Ventilation raise No. I intake	80 m^3/s
Ventilation raise No. 2 intake	80 m^3/s
Shaft intake	25 m^3/s
Hangingwall ramp exhaust	160 m''s
Exploration ramp exhaust	25 mVs

Presently, 22 auxiliary fans with a total installed power of 957.5 kW support the diversion of the airflow to meet actual requirements. Approximate parameters of the present ventilation set-up are presented m Table 3 below.

The total ventilation requirement of the mine is calculated using the total kW of underground machinery in use in accordance with Ontario, Canada regulations (0.06 ra^3/s per kW). At CBI, Cogema fans are used due to their low noise generation, The ventilation network of the mine is regularly measured and calculated using VNETPC software.

4.6 *Ground Support*

The hangingwall and footwall are normally weaker than the ore body and require additional support. The ground support measures applied are adapted to the ground conditions and to the expected operation time of drifts. The ground support measures consist of: *(i)* Steel Fiber Reinforced Shotcreting (SFRS) or Mesh Reinforced Shotcreting (MRS), *(ti)* standard bolting with mesh and split sets (2.4 m), Swellex (2.4m) or Super Swellex holts (3.3-4.0m), and *(in)* cable bolting (9.0 m).

The equipment employed in ground support is a Normet shotcrete applicator, with shotcrete transported from a batch plant on the surface to underground by 5.0-m^3 Normet and 2.5-m^3 Paus 10 concrete mixers and Memco MacLean platform bolters. The holes for cable bolts are drilled by Tamrock Solomatic drills.

All waste drifts are supported with SFRS or MRS and bolts. The bolt pattern is 9 bolts per row (Super Swellex) at a row distance of 1.5 m. The shotcrete thickness is about 10 cm. SFRS is applied in one pass, while MRS is applied in two passes with a mesh layer in between.

The hangingwall, footwall, and central ore development access drifts are supported by split sets and Swellex bolts. In addition, 9-m-long fully grouted cable bolts are regularly installed in a pattern of 4 bolts per row with a row distance of 2.5 m. where required shotcrete is also applied.

Sill drifts are supported by standard bolts (approx. 90% split sets) İn a pattern of 9 bolts per row with a row distance of 1.25 m.

Considerable bolting and shotcreting is required in the rehabilitation of ore development and sill drifts. Rehabilitation requirements due to deterioration of installed support demand tight sequencing of development and stoping.

4 7 *Mobile Equipment*

The main elements of the current underground mobile equipment fleet are listed in Table 4.

4.8 *Mine Drainage and Dewatermg*

The main dewatermg pump is installed adjacent to the shaft on the 900 level. Water flows through drainage holes and ditches to the 900 level main dirty water sump and is pumped to the surface through the shaft. The main dewatermg pump used is a 132-kW Geho duplex double-acting crankshaft-driven high-pressure piston diaphragm pump, model ZPM 700. The pump operates at 65 mVh at an operating pressure of a maximum 53 bar.

Furthermore, a standby pumping station on the 1000 level pumps clear water to the surface through the exploration ramp, employing two Mather and Piatt pumps.

The total mine water pumped to the surface on average is 25 mVh (approximately 40-45% of which is service water consumed underground).

4.9 *Hoisting and Surface Transport*

Two conveyor belts (100 m and 15 m long) with a feed rate of 350 tonnes/hr connect the discharge of the feed hopper with a 50-m^3 feed bin at the shaft loading area. The two skip loading hoppers can take 5.67 tonnes each. The skips with a volume of 1.89 m^a each operate with an average load of 5.35 tonnes. The rated capacity of the shaft, based on a hoisting speed of 7.7 m per second, is 260 tonnes ore per hour.

On the surface, the skips can discharge into two bins, a 200-tonne bin assigned for ore and a 50-tonne bin assigned for waste. The waste ore bin can also take ore The ability to use the waste ore bin for ore is important in avoiding delay while the ore type changes and the 200-tonne ore bin is not empty. The waste bin then acts as an intermediate buffer.

From the shaft, the ore is transported in Volvo A35 trucks with a payload of 32 tonnes to the ore stockpiles. The transport distance is approximately 400 m.

Table 4 CBI's primary mobile equipment

Jumbos	Three Atlas Copco 282 twin-boom face Jumbos
Production drills	Two Tamrock H629 Soiomatic drills One Cubex Megamatic ITH drill machine fitted wim V-30 Machines Roger raise drill
Bolters	Two Memco MacLean platform bolters
LHDs	Three Wagner ST8B Scooptrams Three Wagner ST6C Scooptrams One JS 200
Trucks	Four Wagner MT 433s (30 t) Two Wagner MT 4336Bs (33 t)
Shotcreling machines	Two Normet Unimixers ($5m^1$) One Normet Spraymec 6050 WPC (Second Normet Spraymec on order) One Paus mixer
Utility vehicles	Three Fargo scissors-lift trucks Five Paus platforms Two Paus ANFO trucks One personnel earner

4.10 *Supplies*

Shotcrete is prepared at a surface batch plant located close to the ramp portal and transported in mixer trucks of 2.5 and 5.0 m^3 capacity to the underground working places.

Consumable material supplies are transported underground by Paus truck.

The electrical energy supply to the mine is provided by 6.3-kV feeder lines through the shaft and the main ramp to 300- or 500-kVA substations on different sublevels. Distribution from the substations is at 380 volts.

The diesel fuel station is located near the ramp portal on the surface. LHDs, trucks and transport vehicles refuel at this station.

Compressed air supply is provided by four compressors (each 160 kW,10 bar, 380 lt./sec) on the surface. The main feed pipes, 100-200 mm in diameter, are installed in the shaft, in one ventilation raise, and in the main ramp.

Water supply lines, 50-100 mm in diameter, are installed in the shaft, in one ventilation raise and in the main ramp.

5 ACCESS AND INFRASTRUCTURE

5.1 *Ramps*

The main access to the mine for mobile equipment is provided by the ramp, located 60-100 m into the hangingwall of the Main Ore Zone (Fig.2). With the portal at the 1096-m level and with a cross-section of 25 m^2, the main ramp currently extends at an inclination of 15% down to the 840 level.

Furthermore, the ramp provides access to the top and bottom of the aggregate backfill raises, serves for equipment, material and employee transport into the mine, served until the middle of 1998 as a transportation ramp for ore truck haulage to the surface, and serves as an exhaust way for ventilation.

Access is also provided via the exploration ramp with a 9-m^2 cross-sectional area, at a 17% gradient down to the 1000 level. This ramp is used as a return airway and for services such as the pastefill reticulation system.

5.2 *Shaft and Ore Pass System*

The mine is serviced by a 5.5-m-diameter, 275-m-deep, vertical, circular and concrete-lined hoisting and man-riding shaft situated in the footwall.

The shaft collar elevation is at 1110 m with the shaft bottom reaching the 830 m level. Underground access to the shaft is at the 900 level only. Access to the shaft on the 900 level is by a 120-m-long cross cut. The shaft is equipped with two skips and a man cage.

The shaft is equipped with a 120"-diameter GEC 863 HP DC, direct drive, single-tooth-type clutch, double drum hoist with two 5.67-tonne-capacity skips. The second hoist will be used to extend the shaft to the 640 level without interrupting production. A small cage is installed for transporting men.

A system of two ore passes with a cross-section of 10.2 m^2 each, located in the central pillar of the Main Ore Zone (section N1760), connects the 960, 940 and 920 levels with the 900 level. The ore passes are concrete lined and provide a storage capacity of 400 tonnes each between two levels.

5.3 *Buildings and site works*

The surface buildings and site works include surface workshops, a warehouse with adjacent fenced yard, mill, shaft, covered-surface stockpile, laboratory, change houses, main administration office, batch plant, pastefill plant, medical building, weigh bridge, and gate house. Sewage reticulation, drainage, landscaping and lighting is also provided.

5.4 *Other Major Installations*

Two backfill raises for aggregate storage are located in the hangingwall. The raises are 3.1m in diameter and are inclined at 85 degrees. The loading level of both raises is the 1080 level. One raise discharges on the 1040 level, the second on the 1020 level.

An underground workshop with two work bays is located on the 1020-m level adjacent to the backfill raise load out. The workshop comprises 100 m of 25-m^2 drift, hosting two equipment bays and a small storage area for parts and consumables.

The explosives magazine, comprising 120 m of drift, has a 40-tonne capacity and is located on the 1040 level.

Refuge stations are provided throughout the mine. The communication system comprises telephones on each level. Crews are also equipped with wireless communication units through a leaky feeder system. Furthermore, mere is a leaky feeder video transmission, which is used for the control of filling operations when backfilling stopes with paste.

5.5 *Water Supply*

Fresh water is supplied to the mine from 7 wells on the bank of the Büyük Dere river. The wells have a supply capacity of 450 m^3/h. Potable water is supplied by the Madenli municipality. The storage facilities for process water and potable water have a capacity of 1000 m^3 and 60 m^3, respectively. The total water requirement of the mine and the mill is estimated to be over 350 m^3/h.

5.6 *Electric Power Supply*

The mine is connected to the national power grid by a single 31.5-kV, 30-MVA-rated overhead power line to the TEK substation north of the town of Madenli. The substation at Madenli is equipped with one 25-MVA transformer, and one 10-MVA transformer as a back-up reserve.

At the mine site, the power line terminates at a transformer and switchyard, where a 31.5-kV/6.3-kV substation equipped with two AEG 15 MVA transformers is installed.

6 MILL AND METALLURGY

6.1 *Milling*

CBI has an onsite concentrator, which performs crushing, grinding, differential flotation and pressure filtration. The concentrator utilizes a conventional differential flotation to produce Cu and Zn concentrates. There are two circuits; a zinc circuit and a copper circuit. Mill feed is prepared by blending various types of ores according to their copper and zinc grades. Crushed ore is fed to the grinding circuit, which consists of two-stage ball milling. The grinding circuit produces a flotation feed of 70% passing 36|im. The metallurgically difficult clastic ore is milled in campaigns. Start-up recoveries and concentrate grades have improved. This was made possible through a series of on-going technological changes.

6.2 *Concentrate Transport and Port Facilities*

The copper and zinc concentrates are transported 30 km by truck to the Rize port facilities. At the port, the concentrate is discharged into a covered stockpile area with a capacity of 30,000 tonnes of concentrate. Reclaim for ship loading is by conveyors. The concentrates are shipped to a variety of smelters around the world.

6.3 *Tailings Disposal*

Full plant tailings are used as a paste backfill which is pumped underground or pumped via an 8-km-long HOPE overland pipeline to an undersea disposal site, which is located 3 km off shore at a depth of 385 m, well below the oxygenated surface waters of the Black Sea.

7 MANPOWER

As of the end of December 2000, the labour force is as given below (Table 5). The majority of workers are recruited locally. Underground, plant and maintenance workers work 7.5-hour shifts, with 3 shifts per day, 7 days per week. The shifts start at 8 a.m., 4 p.m. and midnight. Administrative and support staff work a nine-hour day, five days a week.

Table 5. Work force.

Category	Number
Executive	2
Human Resources	2
Ankara Office	10
Finance	32
Security	15
Mill	52
Mine	127
Maintenance	70
Technical	S2
Safety, Health and Environment	7
Administration	18
TOTAL	387

8 CONCLUSIONS

The Çayeli mine is an efficient low-cost copper and zinc producer. Since start-up the operation has been very successful and has undergone major technological changes. The results have been particularly noteworthy considering much of the workforce had no previous mining experience. The mine has sufficient reserves to last for at least 13 years and there is excellent exploration potential for additional reserves at depth and along the strike.

CBI is confident that the company's current healthy position on the world copper production cost curve can be maintained or improved through better use of manpower and technology.

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