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PHELPS DODGE, MORENCI BRANCH

Description: Slightly unaltered Monzonite Porphyry

Minerals: Chalcedony (SiO_2); Chrysocolla ($CuSiO_3 \cdot 2H_2O$); Pyrolusite (MnO_2); Hematite (Fe_2O_3); Limonite ($2Fe_2O_3 3H_2O$); Malachite ($Cu_2(OH)_2CO_3$)

Gangue: Quartz Monzonite Porphyry

Copper content (%): 0.5

Location (Mine): Rollo Lease
(District): Morenci-Metcalf, Greenlee County
(Place: ½ mile west of Metcalf

Operator: Phelps Dodge Corporation, Morgnci Branch
Owner: " " " "
Donor: " " "
Mine: Inactive

Notes: Typical oxide minerals derived from the action of oxidizing solutions containing H_2SO_4, $FeSO_4$ and CO_2 plus considerable oxygen. The feldspars in the porphyry are not completely altered to Kaolin and Alunite, but are still sericitized.

PHELPS DODGE, MORENCI BRANCH

Description: Typical leaching ore with stringers and disseminations of Pyrite, Chalcopyrite and Covellite or Chalcocite in small amounts.

Minerals: Pyrite (FeS_2) (Yellow)
Chalcopyrite ($CuFeS_2$) (Mixed with Pyrite)
Covellite (CuS) (Blue) Thin film on outside of Pyrite
Kaolinite ($H_4Al_2Si_2O_4$)

Gangue: Altered Monzonite Porphyry- Feldspars altered to Kaolin (or Kaolinite)
Note: Smooth feel and tendency to stick to the tongue

Copper Content: 0.25% to 0.50% Cu.

Depth: 100 to 150 feet below original surface

Location: Clay mine 4900 bench up to 5000 bench
(District): Morenci-Metcalf, Greenlee county, Arizona
(Place): One-half mile north of Morenci, Arizona

Operator: Phelps Dodge Corporation, Morenci Branch

Owner: " " "

Donor: " " "

Mine: Active, being developed

Note: This type of ore comes in areas which appear to have a deficiency of Chalcopyrite mixed with Pyrite. The values are largely in narrow stringers such as is shown in this specimen with relatively minor dissemination of values.

Rec'd June, 1941

Minerals: Limonite (yellow-brown); Calcite ($CaCO_3$) (white); Pyrolusite (MnO_2) (black); Quartz (SiO_2) also some opal and chalcedony; Hematite (Fe_2O_3) (red); Kaolin ($H_4Al_2Si_2O_9$) Kaolinite.

Gangue: Altered Quartz Monzonite Porphyry (porous and leached)

Copper content (%): ---

Depth: Surface to 100 feet

Location (Mine: (Clay) Morenci open pit mine
(District): Morenci-Metcalf, Greenlee county
(Place)): Near Morenci, Arizona

Operator and owner: Phelps Dodge Corporation, Morenci Branch

Mine: Active

Notes: The oxide minerals are the result of oxidation of sulphides (Pyrite-Pyrrhotite) magnetite, feldspar and other minerals present in original monzonite porphyry. Solutions contained H_2SO_4, $FeFeSO_4$ (Ferric Sulphate(CO_2). Limonite is the end product of the oxidation of pyrite or magnetite (especially in presence of kaolin). Silica from the various silicates goes into opal or chalcedony, or secondary quartz (in tiny stringers or vug linings). Residual silica is little effected (quartz phenocrysts in original porphyry). Sericitized feldspars change to kaolin or alunite (the latter largely is transferred downward to be deposited at the water table).

Minerals: Pyrite (FeS_2) Main Sulphide mass
Chalcopyrite ($CuFeS_2$) Mixed with Pyrite
Chalcocite (Cu_2S) Gray films replacing chalcopyrite and chalcocite
Quartz (SiO_2) Minute clear crystals (Probably in small veins about as wide as the specimen)
Kaolin - Like material from alteration of original Feldspars in Porphyry (White)

Gangue: Quartz with badly altered Monzonite porphyry as wall rock.

Copper content: 1% to 2½% Cu.

Depth: 150 to 200 feet below original surface

Location: Clay mine - 4950 Bench
(District): Morenci-Metcalf, Greenlee county, Arizona
(Place): One-half mile north of Morenci, Arizona

Operator: Phelps Dodge Corporation, Morenci Branch

Owner: " " " " "

Donor: " " " " "

Mine: Active, being developed.

June, 1941

Minerals: Brochantite ($Cu_4SO_4(OH)_6$); Chrysocolla ($CuSiO_3,2H_2O$); Limonite ($2Fe_2O_3,3H_2O$)

Gangue: Heavily oxidized Monzonite Porphyry grading into Granite Porphyry.

Copper content (%): 0.4 to 0.6

Depth: Surface to 30 feet

Location: Mine Rollo Lease
District, Morenci-Metcalf, Greenlee county
Place, 1 mile south of Metcalf

Operator and owner: Phelps Dodge Corporation, Morenci branch

Mine: Inactive

Covellite. Wall rock is quartz monzonite porphyry.

Minerals: Pyrite (FeS_2) Main mass
Chalcopyrite ($CuFeS_2$) In micrographic intergrowth with Pyrite
Kaolinite ($H_4Al_2SiO_2O_9$) (White)
Gypsum (Small amounts resulting from H_2So_4 attacking Calcium Feldspar)
Chalcocite (Cu_2S) Gray - "Sooty Chalcocite" (Black spots)

Gangue: Largely Pyrite (Wall rock for this veinlet is Quartz Monzonite Porphyry. The vein is formed by Sulphide replacement of Porphyry out from a small fracture) These stringers and veinlets generally occur on sheeting or jointing fractures in the Porphyry.

Copper content: 2% to 2½% Cu.

Depth: 100 to 150 feet below original surface

Location: Liverpool Mine - 4825 bench (Test Pit)
(District): Morenci-Metcalf, Greenlee County, Arizona
(Place): One-half mile northwest of Morenci, Arizona.

Operator: Phelps Dodge Corporation, Morenci Branch

Owner: " " " " "

Donor: " " " " "

Mine: Active (ore being treated in No. 6 Concentrator at present)

June, 1941

Minerals: Malachite ($Cu(OH)_2CO_3$) (Dark green); Cuprite (Cu_2O) (ruby red); Chrysocolla $CuSiO_3,2H_2O$) (light green blue); Limonite ($2Fe_2O_3,3H_2O$) (yellow brown); Pyrolusite (MnO_2) (black); Hematite Fe_2O_3) (red brown).

Gangue: Altered Monzonite Porphyry and Limestone (on Poryhyry-limestone contact)

Copper content (%): 3 - 4

Depth: 40 feet

Location (Mine): Clay Mine (part of Morenci open pit mine)
(District): Morenci-Metcalf (Greenlee county)
(Place): 1 mile N. W. of Morenci

Operator and owner: Phelps Dodge Corporation, Morenci Branch

Mine: Active

Notes: End product of oxidation by $FeSO_4 + H_2SO_4 + O + H_2SO_4$

erals: Chrysocolla ($CuSiO_3.2H_2O$) (blue green); Melaconite (CuO) (ebony black); Pyralusite (MnO_2) (black); Limonite ($2Fe_2O_33A_2O$) (yellow brown)

Gangue: Badly altered Monzonite Porphyry

Copper content (%): ± 4

Depth: Surface

Location (Mine): Rollo Lease
(District): Morenci-Metcalf, Greenlee County
(Place): 1 mile South from Metcalf

Operator and owner: Phelps Dodge Corporation, Morenci Branch

Mine: Inactive

Notes: Typical oxidation of primary sulphides (Pyrite (Fe_5S_2) or Chalcopyrite ($CuFeS_2$) and porphyry minerals (Mica-Feldspars) by H_2SO_4 + Co_2 + $FeSO_4$ + O solutions

Minerals: Malachite ($Cu_2(OH)_2CO_3$); Chrysocolla ($CuSiO_3.2H_2O$); Azurite ($Cu_3(OH)_2(CO_3)_2$); Limonite ($2Fe_2O_3.3H_2O$); Pyrolusite (MnO_2); Chalcedony (SiO_2)

Gangue: Altered Monzonite Porphyry or Limestone (largely limonite).

Copper content (%): ± 2

Depth: Surface or near surface

Location (Mine): E. Liverpool Mine
(District): Morenci-Metcalf, Greenlee County
(Place): ½ mile North Morenci

Operator and Owner: Phelps Dodge Corporation, Morenci Branch

Mine: Active

Notes: Chalcedony or opal are end products of solution of aluminum silicates in porphyries during oxidation of primary sulphides ($CuFeS_2$ + Cu_5FeS_4 or FeS_2). Note the pseudomorphic replacement of mammatary malachite by chrysocolla. This type of replacement is quite common in oxidation processes.

Fault

Minerals: Quartz (SiO_2) Primary
Chalcedony (SiO_2) Secondary
Kaolinite ($H_4Al_2Si_2O_9$) (White)
Pyrite (FeS_2) (Yellow)
Chalconthite ($Cu_2So_4 \cdot 5H_2O$) (Green)
Covellite (CuS) (Indigo Blue)

Gangue: Quartz Monzonite Porphyry

Copper content: 0.75% to 1.25% Cu.-Oxide Cu. 0.09 to 0.12%

Depth: 50 to 100 feet below original surface

Location: Liverpool Mine - 4850 bench
(District): Morenci-Metcalf, Greenlee County, Arizona
(Place): One-half mine to three-fourths mile north of Morenci, Arizona

Operator: Phelps Dodge Corporation, Morenci Branch

Owner: " " " " "

Donor: " " " " "

Mine: Active - Producing ore for No. 6 Concentrator at present.

June, 1941

Minerals: Brochantite ($Cu_4SO_4(OH)_6$) (fibrous radiating chrystals); Chrysocolla ($CuSiO_3 \cdot 2H_2O$) (blue green non-chrystalline); Limonite, hematite, calcite, etc.

Gangue:

Copper content (%): 0.4

Depth: Surface

Location (Mine): North edge Morenci Open Pit Mine
(District): Morenci-Metcalf, Greenlee county
(Place): 2 miles north Morenci

Operator and owner: Pelps Dodge Corporation, Morenci Branch

Mine: Active

Notes: Note pseudomorphic replacement of Brochantite by chrysocolla in places.

... ... ($CuO_2(OH)_2CO_3$); Manganite (Mn_2O_3); Pyrolusite (MnO_2); Limonite ($2Fe_2O_3.H_2O$); Hilomelane (MnO_2) ($H_2O.BaO$ and K_2O); possibly Geothite ($2Fe_2O_3.2H_2O$) or Turgite ($2Fe_2O_3.H_2O$)

Gangue: Completely replaced Monzonite Porhyry or Limestone

Copper content (%): 7%

Depth: 60 feet

Location (Mine): Clay Mine (part of Morenci Open Pit Mine)
(District): Morenci-Metcalf (Greenlee county)
(Place): 2 miles north Morenci

Operator and owner: Phelps Dodge Corporation, Morenci Branch.

Mine: Active

Minerals: Malachite ($Cu_2(OH)_2(CO_3)$); Azurite ($Cu_2(OH)_2(CO_3)_2$) ; Limonite ($2Fe_2O_3 3H_2O$); Psilomelane ($MnO_2.H_2O$); Calcite ($CaCO_3$)

Gangue: Oxidized Limestone

Copper content (%): 2%

Depth: Surface

Location (Mine): Liverpool Mine (Morenci Open Pit Mine)
(District): Morenci-Metcalf (Greenlee county)
(Place): Near Morenci

Operator and owner: Phelps Dodge Corporation, Morenci Branch

Mine: Active

Notes: Oxidation has resulted in the formation of Limonite (from Pyrite), Azurite and Malachite (from Chalcopyrite) and removal of Calcium and Sulphur to form $CaSO_4$ (Gypsum as an end product). Part of SO_4 and copper were transported below to enrich the primary sulphide "protore" (near-ore), converting it to workable ore. (Enriching sulphides are Covellite (CuS) and Chalcocite (Cu_2S).

Minerals: Pyrite (FeS_2); Chalcopyrite ($CuFeS_2$); Chalcocite-Covellite ($Cu_2S.CuS$); Chalcanthite ($CuSO_4.5H_2O$); Kaolinite ($H_4Al_2Si_2O_9$)

Gangue: Monzonite Porphyry (Altered)

Copper content (%): 0.75 to 1.25

Depth: 150 to 300 feet

Location (Mine: Morenci Open Pit Mine
(District): Morenci-Metcalf, Greenlee county
(Place): Near Morenci

Operator and owner: Phelps Dodge Corporation, Morenci Branch

Mine: Active

Notes: This specimen (like 8, 9, 10, 11, 12, 13, 14 and 15) are illustrations (in various stages) of the processes involved in themineralization and enrichment of a typical low grade material into commercial ore (particularly in Porphyries). The solution (supergene) probably contained in sulphuric acid (H_2SO_4), Ferric sulphate ($FeSO_4$), oxygen (90) and sometimes CO_2).

The probable sequence of events was:

1. Fracturing of the original Monzonite Porphyry, Quartz Monzonite Porphyry, or Granite Porphyry.
2. Introduction of Quartz (Silica) in fractures or as replacements and impregnations out from the fractures accompanied by K_2O (Potash) in form of Sericite Mica. The latter replaced Aluminum Silicates such as the Feldspars.
3. Reopening of fractures.
4. Introduction of primary sulphides in reopened fractures: Pyrite (FeS_2), Chalcopyrite ($CuFeS_2$), Bornite (Cu_5FeS), Enargite ($Cu_3A_5S_4$), Alabandite (MnS), Molybdenite (MoS_2)
5. Oxidation of Primary Sulphides, conversion of Primary Minerals to Oxides and Secondary Sulphides

(over)

conversion of Primary Minerals to Oxides and Secondary Sulphides (Covellite (CuS) and Chalcocite (Cu_2S) according to the following chemical equations:-

1. $CuFeS_2$ (Chalcopyrite) + 8O = $CuSo_4$ + $FeSO_4$ (Ferric Sulphate)

2. $5Cu_5FeS_4$ + $11CuSO_4$ + $8H_2O$) = $18Cu_2S$ (Chalcocite) + $5FeSO_4$ + $8H_2SO_4$

3. Cu_5FeS_4 + $CuSO_4$ = $2Cu_2S$ + $2CuS$ + $FeSO_4$

4. FeS_2 (Pyrite) + $7CuSO_4$ + $4H_2O$ = $&CuS$ + $4FeSO_4$ + $4H_2O$

   or $5FeS_2$ + $14CuSO_4$ + $12H_2O$ = $7Cu_2S$ + $5FeSO_4$ + $12H_2SO_4$

Reversable -

5. $5CuS$ + $3CuSO_4$ + $4H_2O$ = $4Cu_2S$ + $4H_2SO_4$

6. $4Cu_2S$ + $4H_2SO_4$ = $5Cu^S$ + $3CuSO_4$ + $4H_2SO_4$

The sequences in Morenci seem to be: -

Equation 1 - 3 and 4 - 6

The composition of enriching solution was changed at the water table by conversion of Ferric Suplhate to Ferrous Sulphate and presence of H_2S or Co_2. Oxygen was used up producing a reducing atmosphere favorable to the precipitation of secondary sulphides Covellite and Chalcocite. Aluminum silicates were altered to Kaolinite or Alunite, and secondary silica (Opal or Chalcedony), Iron went into Limonite orTurgite or other iron oxides and hydrous oxides. Alabandite (MnS) was converted into Pyrolusite, Monzonite or Psilomelane. Oxidation of copper sulphides resulted in Malachite, Azurite, Chrysocolla, Brochantite, Chalcanthite, Turquois, Cuprite, Melaconite, etc.

Description: Typical example of slightly enriched "Protore".

Minerals: Pyrite (FeS_2), Chalcopyrite ($CuFeS_2$), Chalcocite (Cu_2S), Quartz (in fractures areas)

Gangue: Altered Monzonite Porphyry

Copper content (%): .8 to 1.0

Depth: 80 ft.

Location: (Mine): Liverpool (Morenci Open Pit)
(District): Morenci-Metcalf, Greenlee county
(Place): Near Morenci

Operator and owner: Phelps Dodge Corporation, Morenci Branch

Mine: Active

Notes: Note quartz impregnated and filled fractures, reopening and primary sulphides being enriched in reopened areas . (See &-a for processes).

Minerals: Quartz (crystals in rough "Cokade" structure), Chalcocite (Cu_2S) (Steel gray)
Covellite (CuS) (indigo blue), Pyrite (FeS_2), Chalcopyrite ($CuFeS_2$) Primary,
Kaolinite ($H_4Al_2Si_2O_9$) (white)

Gangue: Altered Monzonite Porphyry

Copper content (%): 12-15

Depth: 100 feet

Location (Mine): Colorado Mine (Morenci Open Pit Mine)
(District): Morenci-Metcalf (Greenlee county)
(Place): 1 mile north of Morenci

Operator and owner: Phelps Dodge Corporation, Morenci Branch

Mine: Active

Notes: See explanation Specimen 7-a (Enrichment)

Minerals: Bornite (Cu_5FeS_4) (lavender), Chalcopyrite ($CuFeS_4$) (yellow), Pyrite (FeS_2)(gold yellow), Chalcocite (Cu_2S) (steel gray), Kaolinite ($H_4Al_2Si_2O_9$), Quartz (SiO_2)

Gangue: Monzonite Porphyry or Quartz Monzonite Porphyry

Copper content (%) $\pm$ 1%

Depth: 75 to 100 feet

Location (Mine): Liverpool (Morenci Open Pit Mine)
(District): Morenci-Metcalf, Greenlee county
(Place): Near Morenci

Operator and owner: Phelps Dodge Corporation, Morenci Branch.

Mine: Active

Notes: See explanation Specimen 7-a (enrichment)

Minerals: Chalcocite (Cu_2S), Pyrite (FeS_2), Chalcopyrite ($CuFeS_2$)

Gangue: Monzonite Porphyry

Copper content (%): 10-15

Depth: 100 feet

Location (Mine): Liverpool (Morenci Open Pit Mine)
(District): Morenci-Metcalf, Greenlee county
(Place): Near Morenci

Operator and owner: Phelps Dodge Corporation, Morenci Branch

Mine: Active

Notes: See explanation Specimen 7-2 (enrichment)

Description: Typical High Grade

Minerals: Chalcopyrite ($CuFeS_2$), Pyrite (FeS_2), Chaloocite (Cu_2S), (Covellite (CuS), Sericite Mica, Kaolinite or Alunite

Gangue: Altered Monzonite Porphyry

Copper content (%): 12 -15

Depth: 150 feet

Location (Mine): Liverpool (Morenci Open Pit Mine)
(District): Morenci-Metcalf, Greenlee county
(Place): Near Morenci

Operaton and owner: Phelps Dodge Corporation, Morenci Branch

Mine: Active

Notes: See explantaion Specimen 7-a (quations 5 and 6) for relation between Covellite and Chalcocite. Note that Covellite is in thin film on chaloocite and primary minerals both.

Description: Typical "Good" ore

Minerals: Pyrite (FeS_2), Chalcocite (Cu_2S), Chalcopyrite ($CuFeS_2$), Kaolinite ($H_4Al_2Si_2O_9$), Chalcanthite (Minor) ($CuSO_4 \cdot H_2O$)

Gangue: Altered Monzonite Porphyry

Copper content (%): 4 - 8

Depth: 100 feet

Location (Mine): Liverpool (Morenci Open Pit Mine)
(District): Morenci-Metcalf, Greenlee county

Owner and operator: Phelps Dodge Corporation, Morenci Branch

Mine: Active

Notes: See explanation Specimen 7-a (Enrichment)

Description: "Protore" (Quartz-Pyrite Vein)

Minerals: Pyrite (FeS_2) plus Microscopic Chalcopyrite, Chalcocite (faint bluish-gray stain), Quartz (SiO_2) (chrystals)

Gangue: Quartz Monzonite Porphyry

Copper content (%): Trace

Depth: 500 feet

Location (Mine): Longfellow Mine
(District): Morenci-Metcalf, Greenlee county
(Place): ½ miles E and N of Morenci

Operator and owner: Phelps Dodge Corporation, Morenci Branch

Mine: Inactive

Notes: Pyrite being converted to chalcocite as follows:-

$$5FeS_2 + 14Cu_2SO_4 + 12\ H_2O \doteq 7Cu_2S + 5FeSO_4 + 12H_2SO_4$$

Thus far the process of enrichment has barely begun. Oxidation is slight also.

Minerals: Pyrite (in cubes) (FeS_2), Quartz (SiO_2) (clear crystals), Kaolinte ($H_4Al_2Si_2O_9$) (black)
Chalcopyrite ($CuFeS_2$) (mixed with Pyrite)

Gangue: Quartz Monzonite Porphyry

Copper content (%) 0.8

Depth: 100 feet

Location (Mine): Liverpool (Morenci Open Pit Mine)
(District): Morenci-Metcalf (Greenlee county)
(Place): Near Morenci

Operator and owner: Phelps Dodge Corporation, Morenci Branch

Mine: Active

Notes: Note Pseudomorphic replacement of Pyrite cubes by Chalcocite (in Quartz-Pyrite veinlet).
Note hexagonal section of Quartz in Kaolinite.

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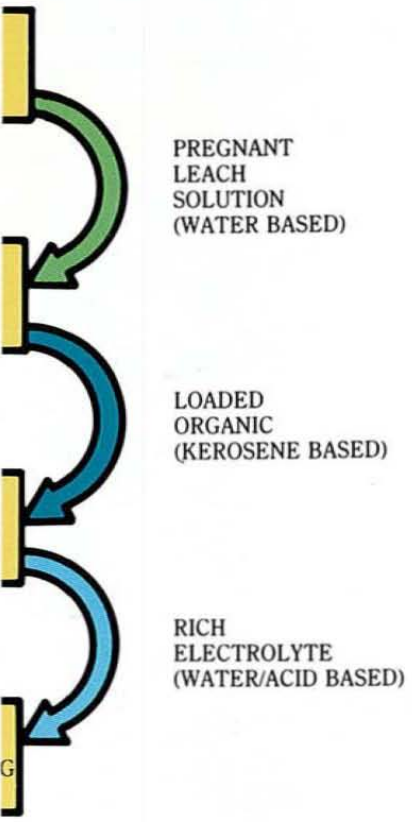

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RENCI INC.

phelps dodge MORENCI INC.

SOLVENT EXTRACTION ELECTROWINNING (SX/EW) PLANT

THE LARGEST SX/EW COMPLEX IN THE UNITED STATES

- *OVER 200 MILLION POUNDS OF COPPER PER YEAR AT A PRODUCTION COST OF LESS THAN 30 CENTS PER POUND.*
- *A CLEAN PROCESS WITH ENVIRONMENTAL SAFEGUARDS.*
- *CONSTRUCTION COST: 145 MILLION DOLLARS.*
- *OVER 80 MILES OF PIPE ARE USED IN THE CYCLING OF PROCESS FLUIDS.*

Brief History of the Morenci Mining District

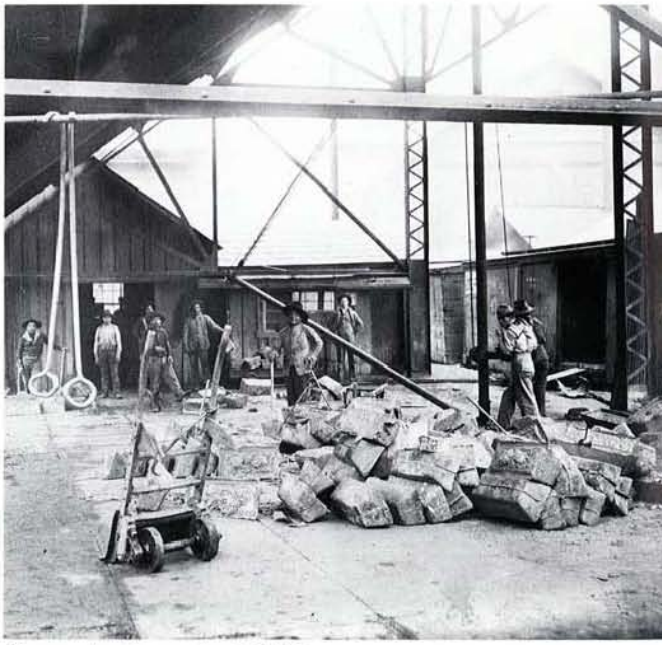
The first recorded mineral discoveries in the Clifton-Morenci district were made in about 1865 by volunteer Union soldiers from California who passed through the area. The first prospectors arrived in 1870, looking for gold. They failed to discover significant quantities of gold, but were intrigued by the rich copper deposits they found on both sides of Chase Creek.

The Longfellow Copper Company began operating the Longfellow mine in 1872 in Old Morenci, a site that is now part of the Morenci open pit. Ore mined from the Longfellow mine averaged 20 percent copper — 25 times the copper content of the ore now being mined at Morenci!

Phelps Dodge entered the Morenci mining picture in 1881 with its purchase of an interest in the Detroit Copper Mining Company, which also was operating underground mines in Old Morenci. Phelps Dodge acquired the remainder of the Detroit Copper Mining Company in 1897. Phelps Dodge and the Arizona Copper Company, a Scottish firm that had purchased the Longfellow Copper Company holdings in 1882, were the dominant companies in the district until 1921, when Phelps Dodge acquired the Arizona Copper Company and became the sole operator in the district.

For the first six decades all mining in the district was by underground methods. During the Great Depression copper prices fell so low that by 1932 all mining had been suspended. The underground mines never reopened.

Development of the Morenci open pit began in 1937.



Copper ingots — about 1900

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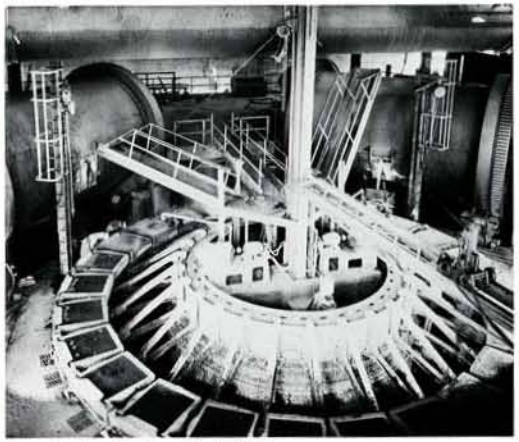
began in 1937.

Since that time more than 2.6 billion tons of ore and other rock material have been removed from the giant mine.

Over the years, copper has been produced in the Morenci District in several forms: first as ingots from smelters located both in Clifton and Morenci, later as anodes from the Morenci Smelter built in 1942, still later as concentrates and precipitates. Now a part of the copper production is in cathode form.



Anode wheel — about 1950

THE SX/EW PROCESS

The solvent extraction/electrowinning plant at Morenci uses a relatively simple process to produce practically pure copper from water that has been percolated through huge stockpiles of copper-bearing rock.

In the past, mining at Morenci was conducted primarily to satisfy the ore requirements of the concentrators. Rock that contained some copper, but too little to be recovered profitably in the normal concentrating-smelting-refining processes, was sent to the low grade ore stockpiles where it is now available to provide feed to the new plant. In addition, having this new way of making salable copper, Morenci will be able in the future to allocate copper-bearing material between the concentrators and the low grade ore stockpiles in a way that will maximize the economic return from this mineral resource.

The SX/EW process consists of four steps, as shown on the simple flow sheet on the back of this brochure. Three interdependent process solution streams transfer the copper from one step to the next.

Leaching

The first step, leaching, starts with the sprinkling of slightly acidic water on one of the low grade ore stockpiles. The water percolates through the stockpile, dissolving copper minerals contained in the rock as it descends. The copper-laden water, now called "pregnant leach solution," exits from the bottom of the stockpile, flows to a collection pond, and is pumped to one of the solvent extraction plants.

Extraction

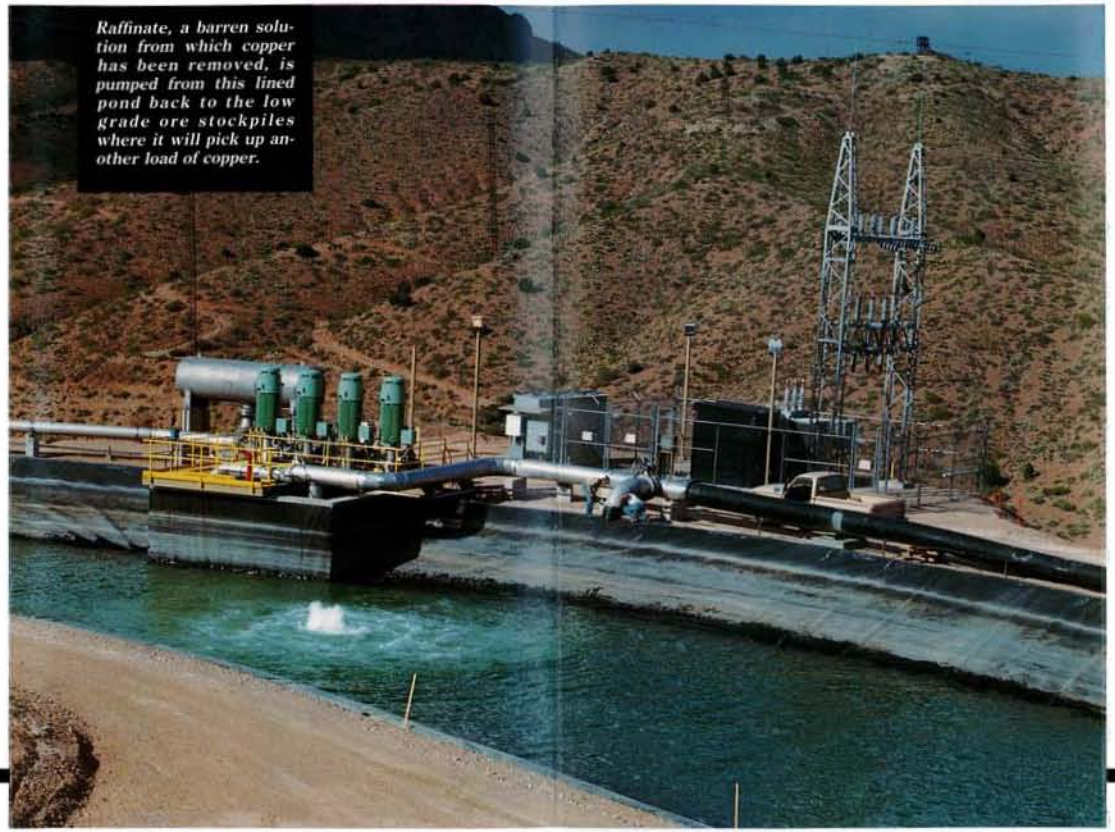
In the second step, extraction, the pregnant leach solution is mixed vigorously with an equal volume of kerosene-based solvent that contains an organic chemical specifically designed to extract copper. After the solutions have been mixed for about two minutes the mixture is allowed to settle.

The leach solution, which has given up its copper to the organic chemical, is the heavier of the two solutions and sinks to the bottom. Now called "raffinate," it is pumped back to the top of the stockpile to begin another cycle. The solvent containing the copper-laden organic chemical, called "loaded organic," floats to the top and is pumped to the next section of the solvent extraction plant.

The solvent extraction plants at Morenci are capable of processing up to 48,000 gallons of pregnant leach solution per minute.

Stripping

In the third step, stripping, the loaded organic is mixed with a copper-bearing sulfuric acid solution, called "electrolyte," and the copper migrates from the organic to the electrolyte. The mixed solutions then are allowed to settle; the solvent that has been stripped of its copper, called "barren organic," floats to the top and is sent back to the extraction step to pick up another load of copper. The electrolyte containing the copper, called "rich electrolyte," settles to the bottom and is pumped to the electrowinning tankhouse.



Raffinate, a barren solution from which copper has been removed, is pumped from this lined pond back to the low grade ore stockpiles where it will pick up another load of copper.

Electrowinning

In the final step, electrowinning
pumped through a series of tanks
tanks are insoluble lead plates alter
per. Each lead plate serves as the
circuit; each cathode pole begins a
pure copper. A direct current is pa
lyte, reducing some of the copper io
accumulates on the starter sheet.

After seven days in the cell a
to a slab of virtually pure copper w
At that point it is removed from th
new starter sheet. The harvested c
or for further processing into oth
electrolyte that has passed throug
depleted of its copper and thus ca
returned to the stripping step to
upgraded once again.

As can be seen, this operati
and refining steps of the pyrometal

An Environmentally Clean

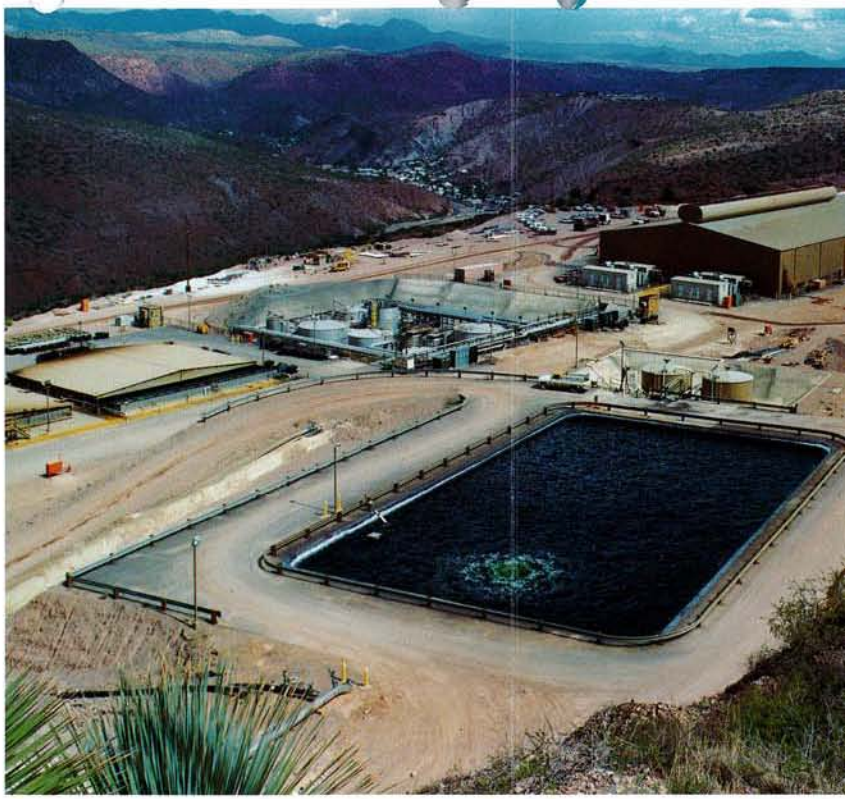
In the Morenci solvent extraction
there are no discharges of any pr
ronment. The leach solutions cont
the low grade ore stockpiles and t
organic circulates between the e
stripping section; and the electroly
stripping section and the electrowi

Surface water quality and gro
tected by a $9 million flood control
million dam that cuts off both surfa
flows in Chase Creek. Groundwat
the dam is checked in a series of r

Even before there was any
District, the Chase Creek waters
Francisco River contained appreciat
other metals that had been dissol
through the mineralized district
Morenci mine.

One of the water quality prot
with the Morenci SX/EW project
system that collects Chase Cree
mineralized area, pipes them com
and leaching operations, and discha
Creek downstream of the flood co
Creek waters that enter the San F
purer than they were at any time i
tion of this project!

Finished copper cathodes that are removed from the cells measure about three feet square and about ¾" thick. They weigh about 200 pounds each and are very pure, ready for direct sale or further processing to other copper products.



(Photo above) The building at the far left is a mixer-settler where copper is transferred from pregnant leach solution to an electrolyte, which is then sent to the electrowinning tankhouse — the large building at the right. Finished copper cathodes are the end product of the electrowinning tankhouse. The lined pond in the foreground contains pregnant leach solution to be fed to the solvent extraction plant.

(Photo at right) The Lower Chase Creek Dam is large enough to contain runoff from floods caused by a 100 year–24 hour precipitation event. It cuts off surface and alluvial subsurface flows.

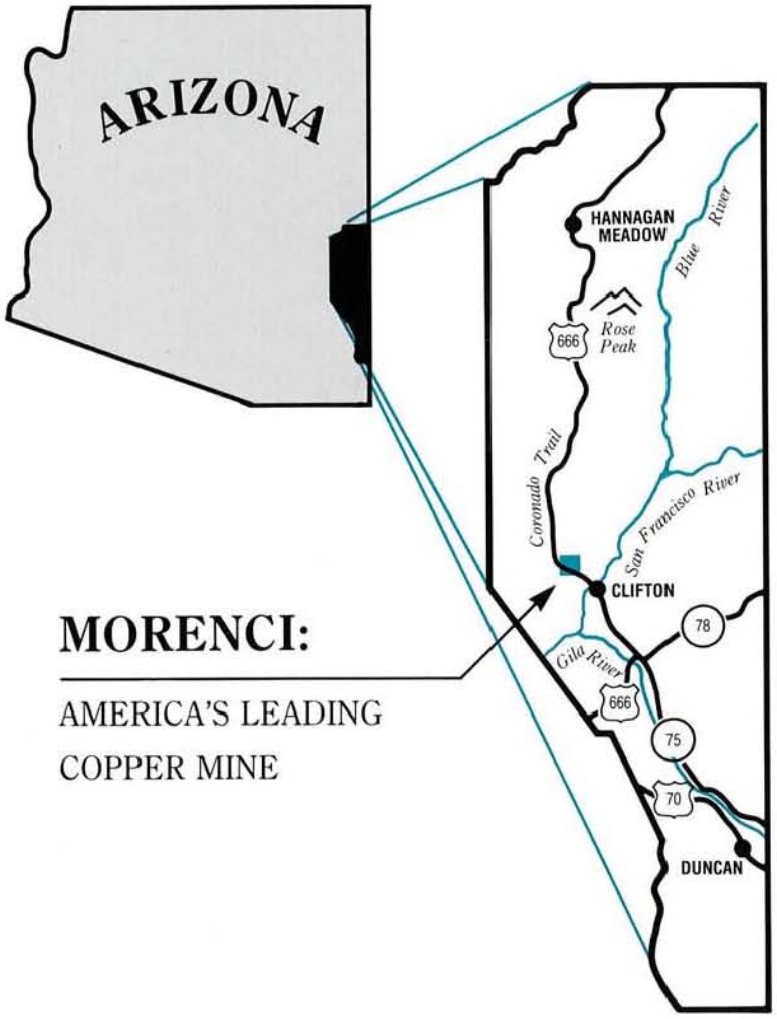
The pumps in the foreground will be used to evacuate flood waters.

phelps dodge MORENCI INC.

ARIZONA:

AMERICA'S FOREMOST

COPPER-PRODUCING STATE



MORENCI:

AMERICA'S LEADING

COPPER MINE

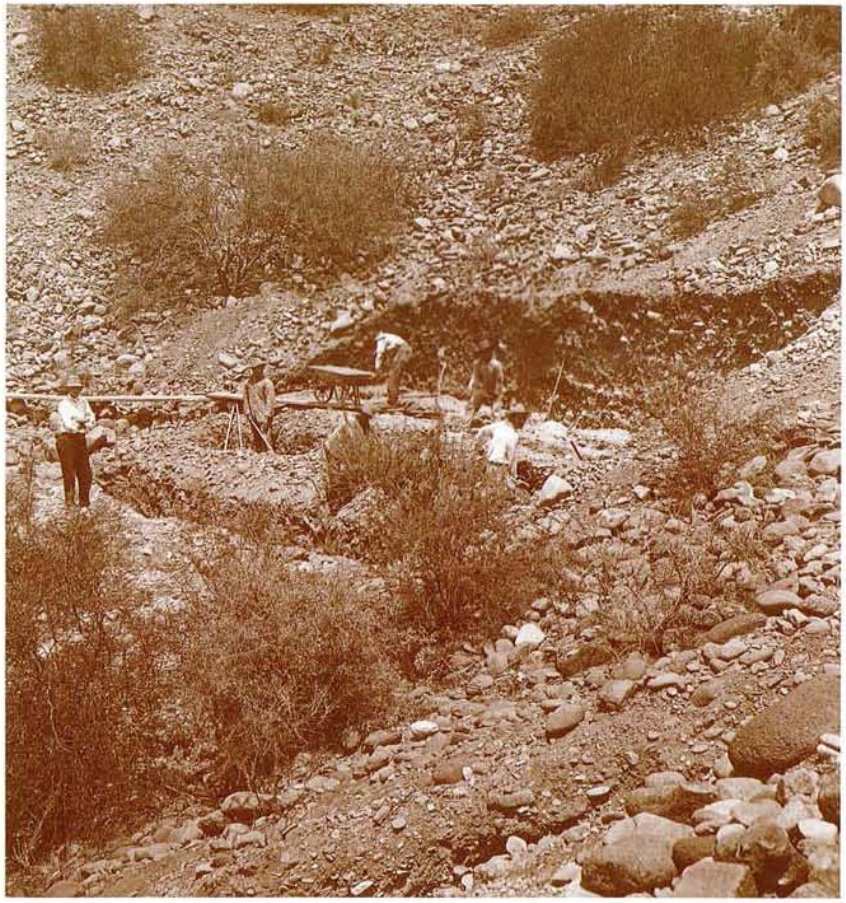
GREENLEE COUNTY

MORENCI'S STORY

When copper miners get together anywhere in the world, they very likely soon will be discussing copper mine sizes, the richness of the ore, and, never to be ignored for very long, the rich and interesting history associated with most large copper mines. The mine at Morenci is world class by anyone's measure, rich in copper mineral resources and with an exciting history which mirrors the development of the West and indeed the United States from the late 19th century into present times. The Morenci District has developed in a little over a century from a time when a few hardy pioneer miners risked their lives against marauding Indians into what is now America's leading copper mine operated by the country's largest copper producer, Phelps Dodge Corporation.

A Morenci mine truck with a haulage capacity of approximately 190 tons is loaded by a 22-yard shovel.

How does one haul all the ore and other material that is being moved on a continuous basis at America's leading copper mine? Today, it is done with a large fleet of very active trucks that have haulage capacities of either 170 or 190 tons. The switch to the 170-ton truck from the 100-ton truck previously employed was an important step in mining efficiency undertaken in 1982. Since then, haulage capacities have been augmented by the addition of 190-ton trucks. These were among the latest in a long series of haulage improvements that have characterized mining in the Morenci District since the first mineral discoveries were made in about 1865.



Early miners used hand tools and wheelbarrows.

Before the arrival of railroads and trucks, ore was transported by wagon train.

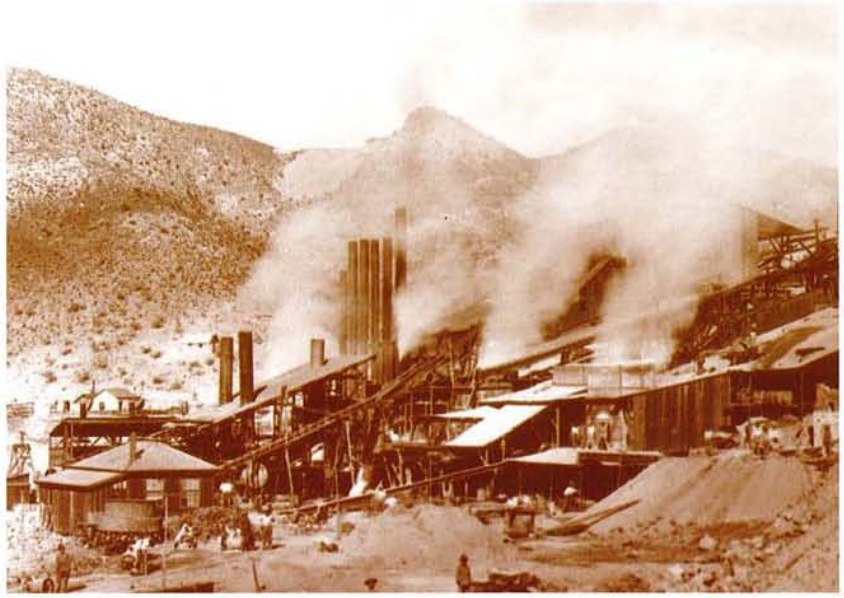
Copper ore obtained from the early underground Longfellow Copper Company mines, which began operating in 1872, was hauled in horse or mule-drawn wagons. Originally called the Frisco Mining Company, then the Gila Mining Company, the Longfellow Copper Company was the first mining company to operate in the District. It was organized by Henry and Charles Lezinsky. Before the end of that decade, in 1879, the first railroad in the District was built. Called the Coronado Railroad, this was a "baby gauge" track, only 20 inches wide, that ran from the Longfellow incline in Chase Creek to Clifton, about four miles. The first locomotive arrived in 1880. One of the original locomotives from this era is now on exhibit in Clifton.

Ore cars being pulled by a mule.

A "baby gauge" locomotive of the 1880s. The distance between the rails was only 20 inches.

During the next year, in 1881, Phelps Dodge, until then mostly a trading and mercantile company in New York City, loaned the Detroit Copper Company $50,000 to acquire 50% of the company which had been founded in 1874. The community in the vicinity of the Detroit Copper Company was called "Joy's Camp." This name was later changed to "Morenci" by the president of the Detroit Copper Company, William Church. The Detroit Copper Company originally smelted its ores in a smelter south of Clifton on the San Francisco River.

The Detroit Copper Company smelter in 1896. This site is now under a mine stockpile on the south side of the Morenci pit.



William Church, however, built a new smelter in Morenci in 1884. The first copper concentrator in Arizona was built by the Detroit Copper Company at Morenci in 1886. Six years later, in 1892, an economic depression caused the Detroit Copper Company to shut down, and in 1897 Phelps Dodge purchased all its holdings. Phelps Dodge operated in the District as the Detroit Copper Company until 1921 when it adopted the name Phelps Dodge Corporation, Morenci Branch.

In the early 1900s, the Shannon Copper Company operated this smelter in Clifton.

In 1901, the Shannon Copper Company, another early mining company of the District, began operating mines above the town of Metcalf which was a short distance north of Morenci. Their concentrator and smelter were located in Clifton. The Arizona Copper Company purchased the Shannon Copper Company in 1920.

A locomotive on the Coronado Railroad track. The track was widened from 20 inches to 36 inches. The 36-inch track is called "narrow gauge."

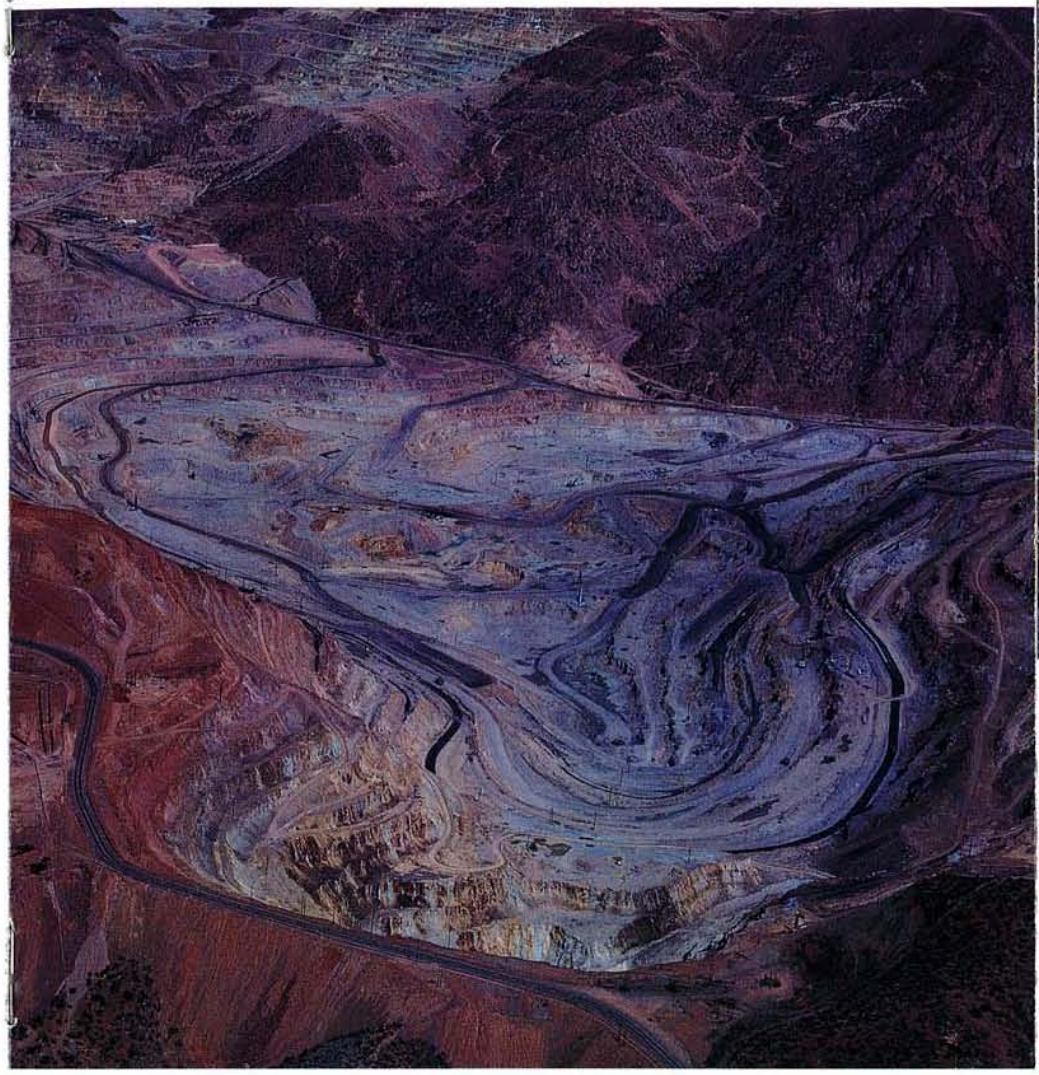
This rare photograph taken in Clifton in the 1920s shows a narrow gauge train with slag cars. Behind it is a standard gauge boxcar. The standard gauge track is 56.5 inches wide.

The Arizona Copper Company was a Scottish firm that had been operating in the District since 1882 when it bought the Longfellow Copper Company holdings. To transport their ore from the Longfellow and Metcalf mines to the smelter in Clifton, the Arizona Copper Company extended the Coronado Railroad three miles from the Longfellow incline to Metcalf. After Phelps Dodge acquired the former Arizona Copper Company concentrator and smelter, they were operated continuously until 1932 when the Great Depression forced them to shut down. All mining, which until that time was underground, ceased in 1932. This also marked the end of underground mining in the District.

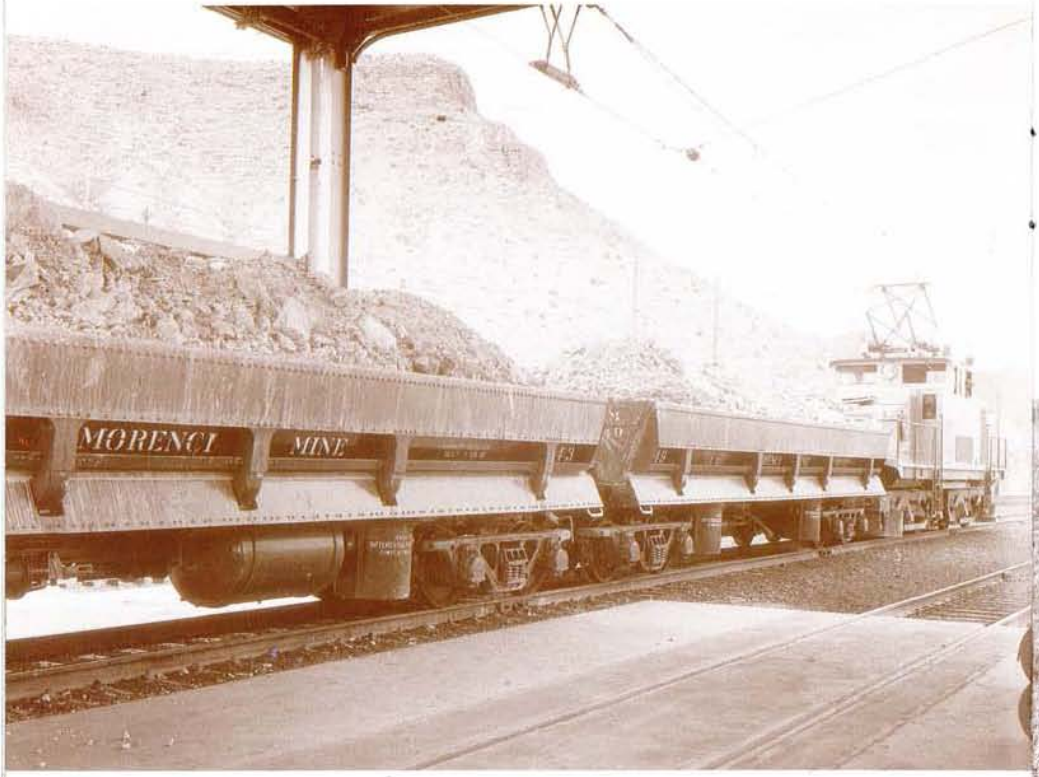
Above: A five-yard truck being loaded shortly after Morenci open pit mining began in 1937.

Below: These 22.5 yard trucks also were used in early mining of the Morenci open pit.

A big change in the manner of mining occurred in 1937 when Phelps Dodge began its open pit operations, which continue to this day in Morenci. Initially, haulage from this new mine was conducted by five-yard and 22.5 yard trucks. The trucks were chain driven.



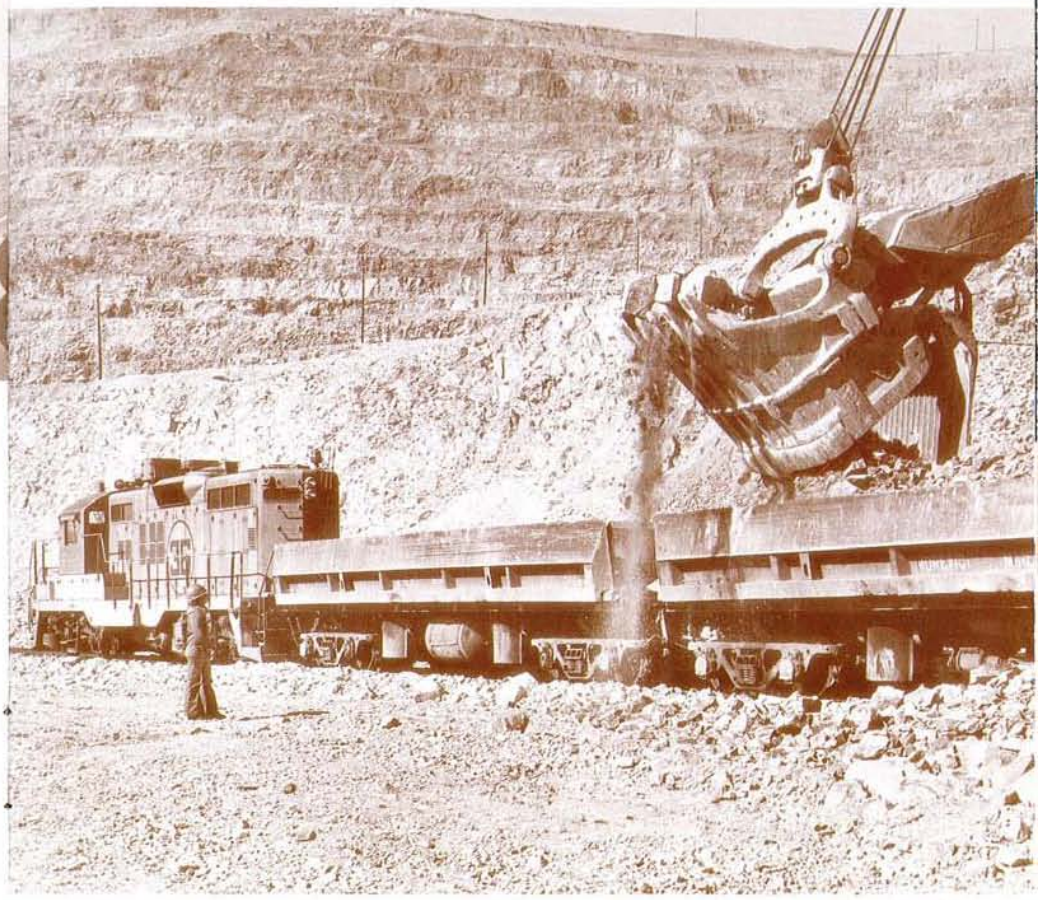
This 1987 aerial photograph of the Morenci mine was taken a half century after mining began by open pit methods.



In this 1940s picture, an electric-powered locomotive waits at the crusher. The pantograph atop the locomotive was connected to the overhead wires — the power source.

By 1939, Phelps Dodge had constructed railroads to service the open pit mine and began using small diesel-powered locomotives to haul rock to low grade ore stockpiles. Between 1940 and 1943, Phelps Dodge purchased 18 electric locomotives. Considerably larger than the diesel locomotives, the electric locomotives began transporting ore to the newly constructed Morenci concentrator in 1942. On the trips over the main line to the concentrator and back to the mine, the locomotives obtained their power from overhead trolley wires. At first, while operating within the mine where there were no trolley wires, the locomotives ran off batteries. Later, the batteries were replaced with diesel-powered generators.

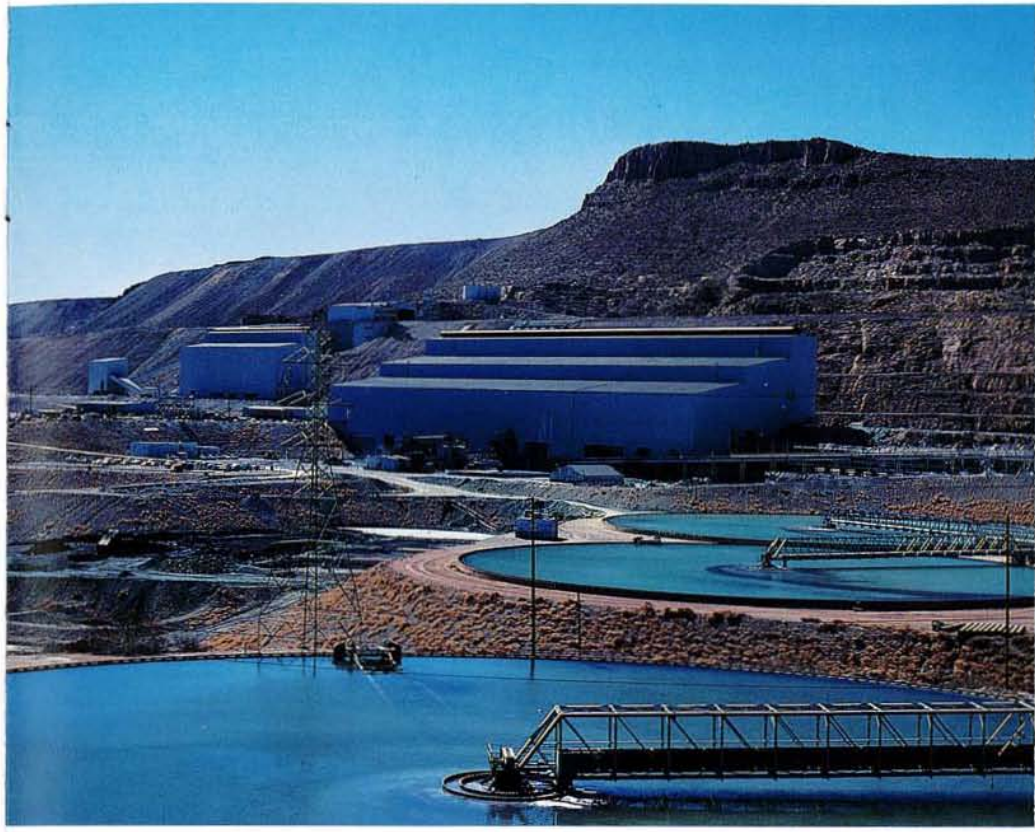
In the early 1960s, remote control equipment was installed so one operator could operate the locomotive from either end of the train or from the ground.



An operator with radio controls operates the train while standing beside it.

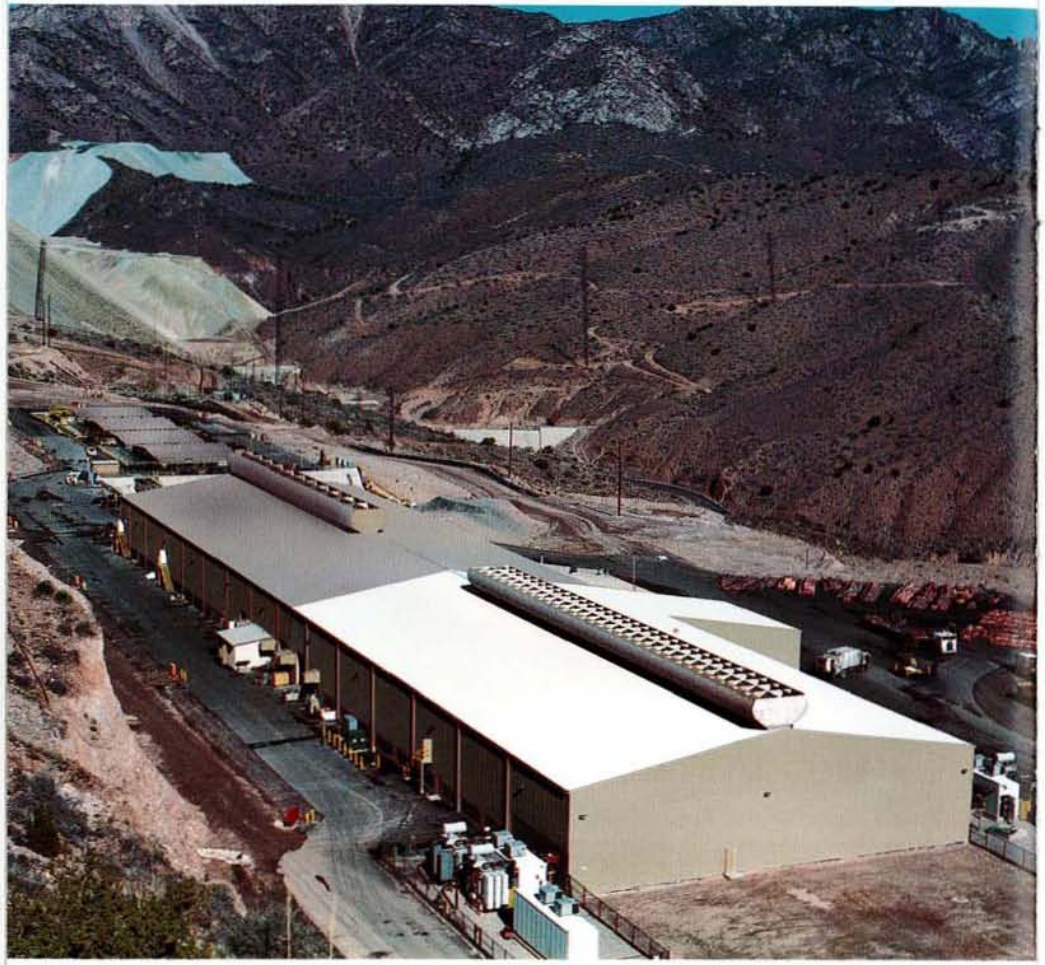
A miner gives directions to the driver of a 35-ton truck.

Throughout this period, trucks were used in conjunction with the trains to perform various mine haulage tasks. The 22.5-yard trucks were replaced with 25-ton trucks near the end of the 1940s. Around 1956, the 25-ton trucks were themselves replaced with 35-ton trucks. In 1968, capacities were further upgraded to 65 tons and shortly thereafter to 100 tons. By 1982, 170-ton trucks were being used and 190-ton trucks were introduced at Morenci in 1986.



Phelps Dodge Morenci Inc. operates two concentrators. The Morenci concentrator was built in 1942. Shown above is the Metcalf concentrator which began operating in 1974.

Train haulage was considerably decreased in 1986 when direct mining into rail cars ended. In 1989, construction of the in-pit crushing and conveying system (IPCC) eliminated the need to use trains to transport ore to the concentrators. The IPCC feeds ore to the concentrators through the use of conveyors. Trucks now make the relatively short hauls to deliver ore to the movable in-pit crushers and to place material on low grade ore stockpiles to produce copper in the Morenci SX/EW process. Trains are used to transport copper concentrate to Phelps Dodge smelters outside the District and to other markets worldwide.



This is the solvent extraction/ electrowinning (SX/EW) central site. The large building is the tankhouse which began producing cathode copper in September 1987. Cathode copper is stacked to the right of the tankhouse, awaiting shipment.

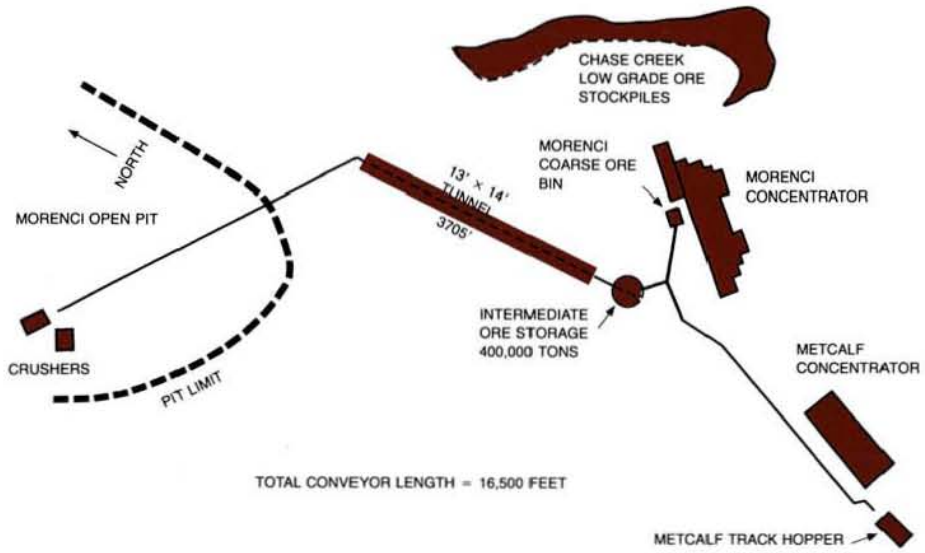
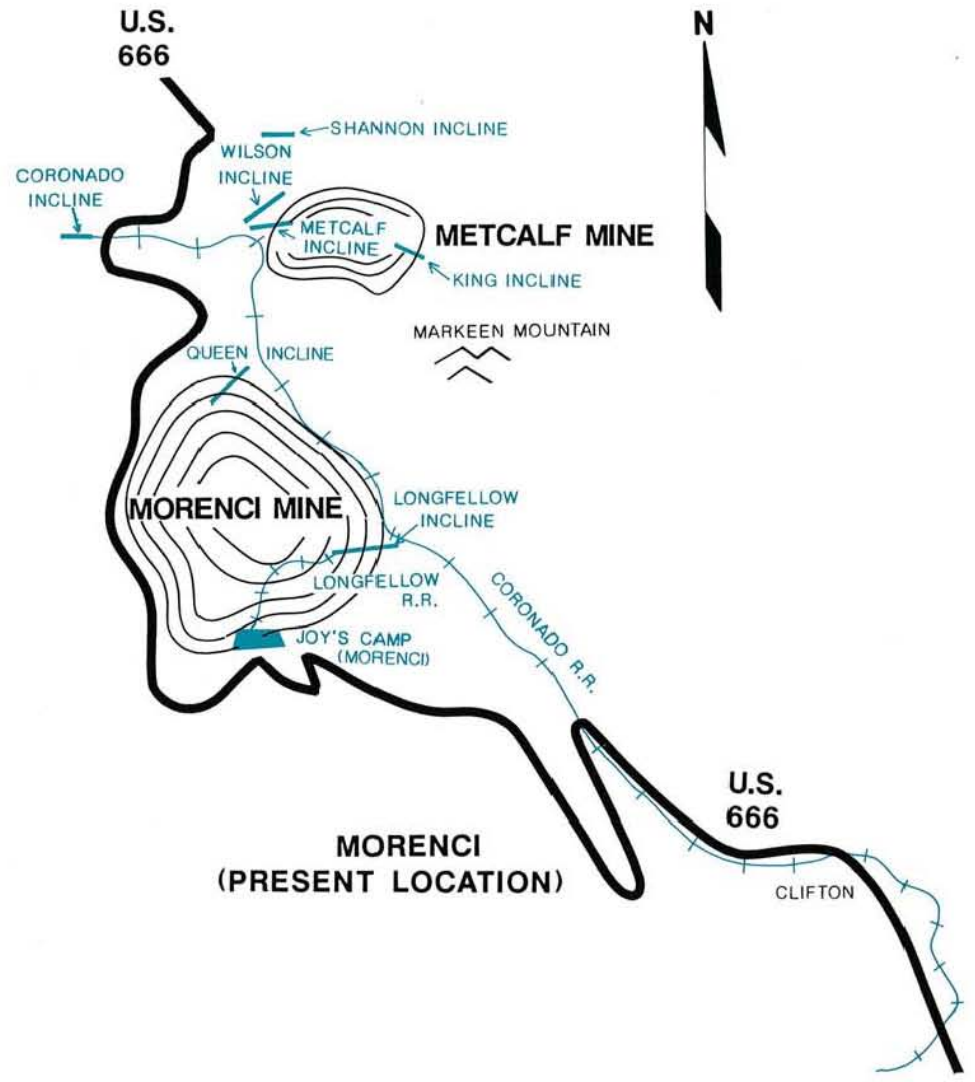


Diagram of the in-pit crushing and conveying system (IPCC). Ore crushed by movable crushers within the pit is transported to the concentrators by conveyors.

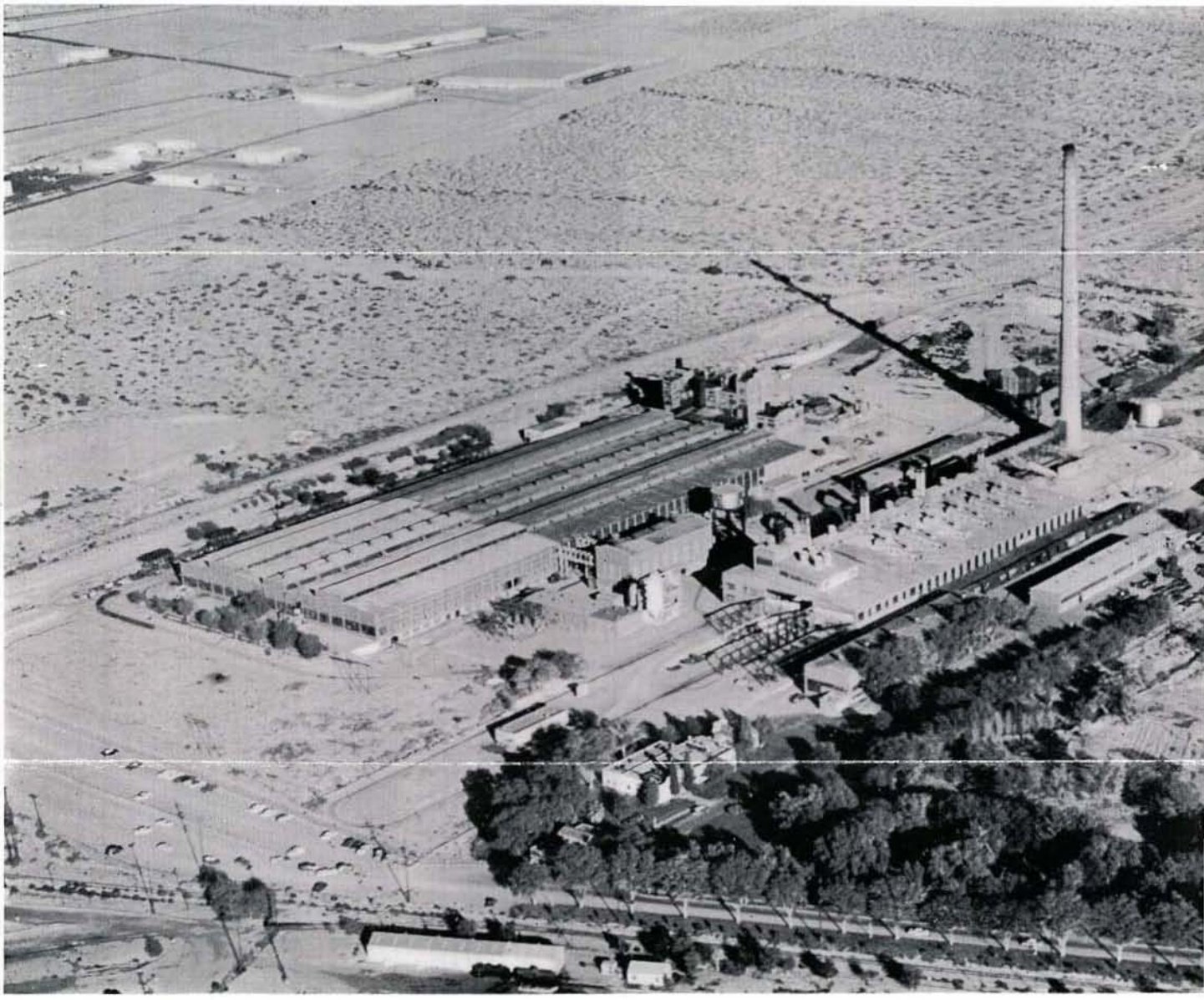
This picture of a newly painted Morenci mine locomotive was taken in Clifton in 1987. A baby gauge locomotive, the mining workhorse of the late 19th century, is on display in the background.



Superimposed on a map of the present-day Morenci area are the long-gone Coronado and Longfellow Railroads, the inclines that served the old underground mines, and the original location of Morenci which was first named "Joy's Camp."

PHELPS DODGE

REFINING CORPORATION
NEW YORK, N. Y. 10022



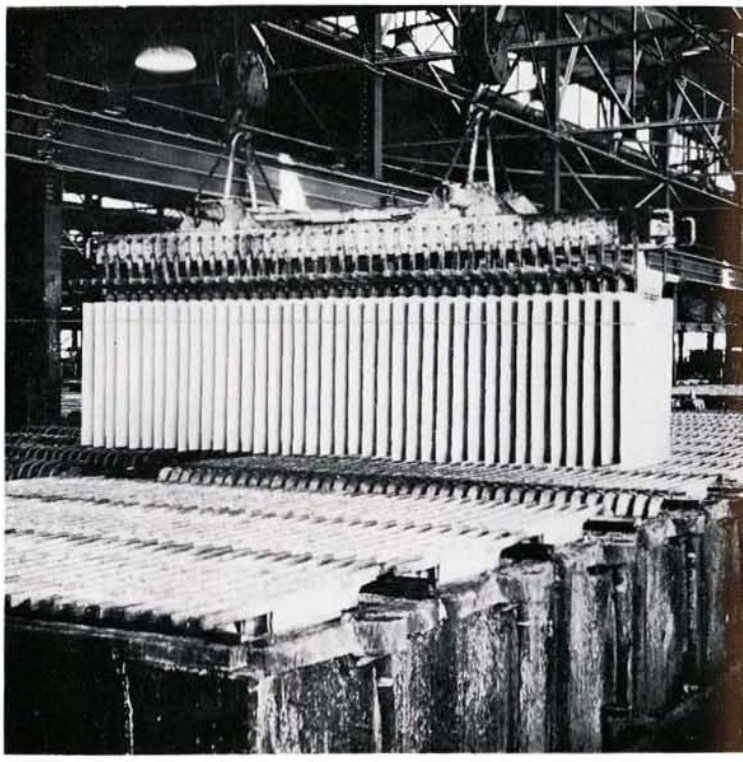
EL PASO REFINERY, El Paso, Texas

Most of the copper from the Phelps Dodge mines in Arizona is refined at the El Paso refinery, shown above. This plant, with a rated annual capacity of 290,000 tons of electrolytic copper, is one of the world's largest copper refineries.

Production of Copper Wire Bars

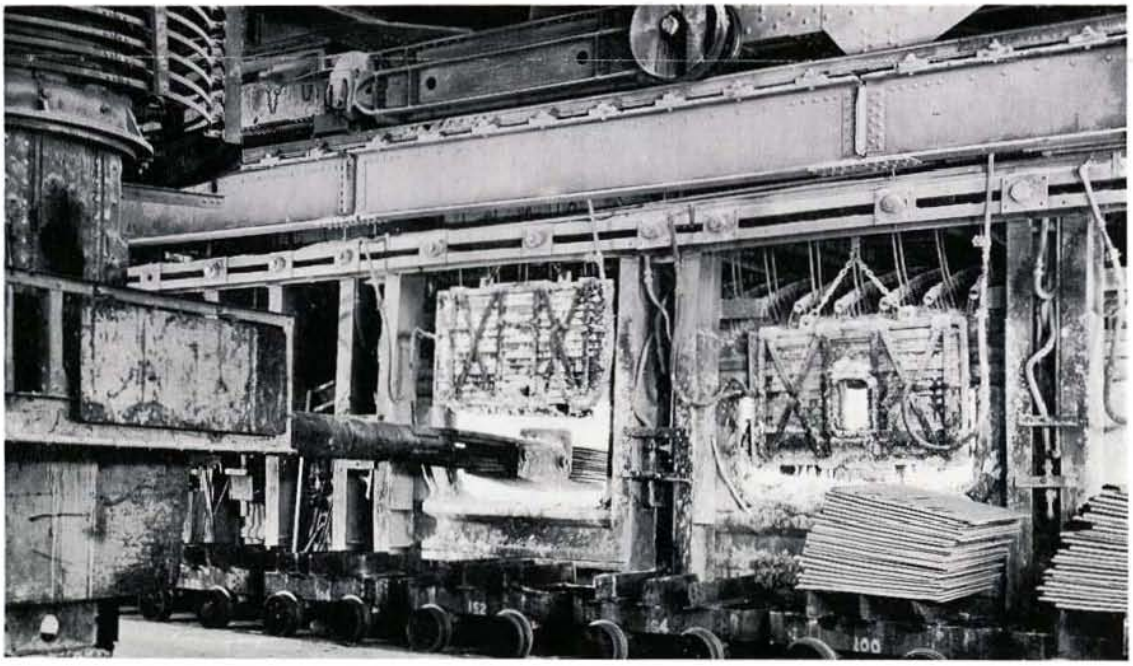
Copper anodes produced at the smelters contain small amounts of other elements, including some gold and silver. In the electrolytic refining process, the anodes are electrochemically dissolved and the copper is deposited on starting sheets as cathode copper. Along with other impurities, the gold and silver drop to the bottom of the tank and are later recovered.

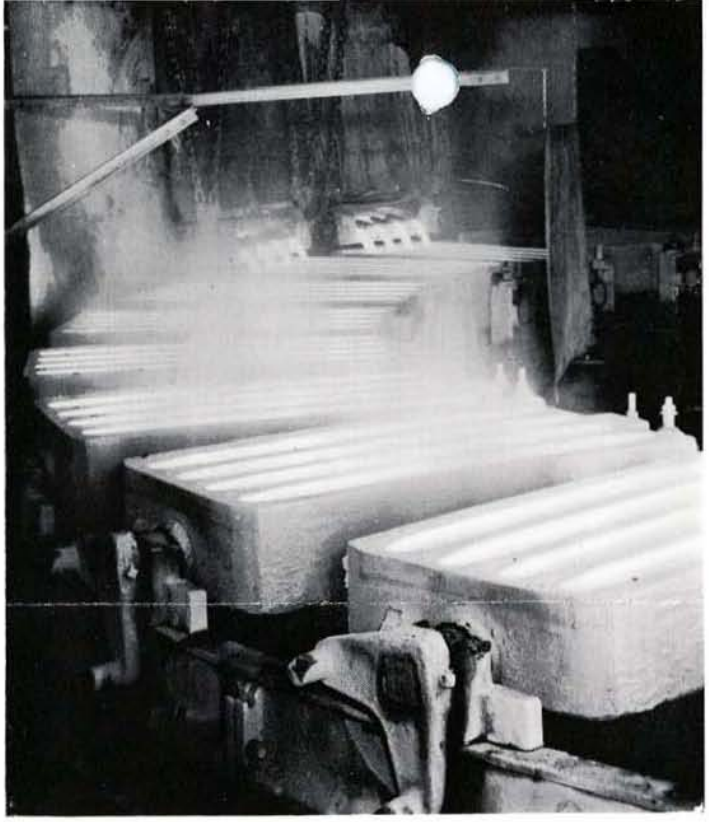
The pictures on these pages show the steps involved in the production of wire bars from cathode copper. The wire bar is the starting shape for the manufacture of wire and cable products, which consume more than half of the copper used in the United States today.



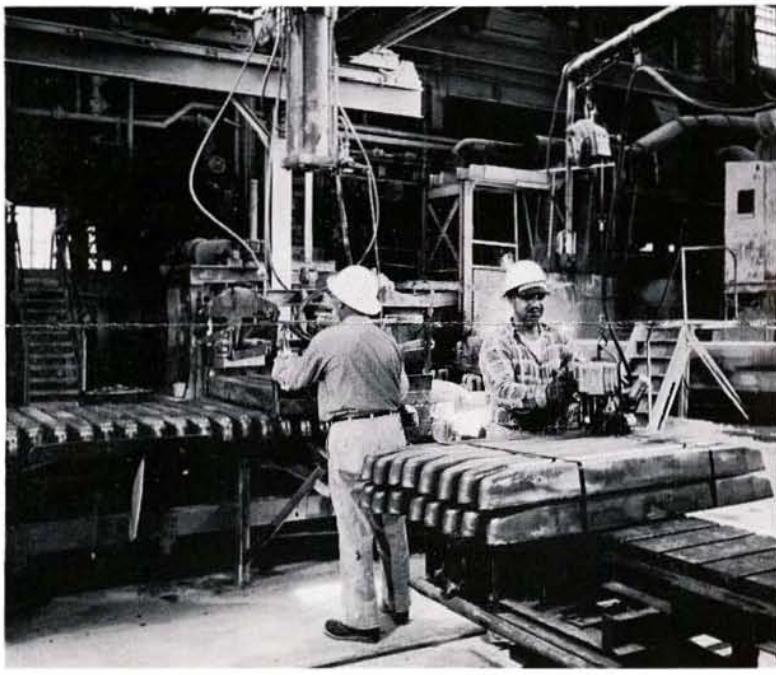
1 Finished copper cathodes are removed from one of the electrolytic tanks in the El Paso refinery.

2 Cathodes are placed in the reverberatory wire bar furnace by a mechanical charger.





3 Molten refined copper is poured from the furnace into wire bar molds.



4 The cooled wire bars are inspected, weighed, and strapped for easier handling.

5 Finished wire bars are loaded by fork lift truck into railroad cars for shipment.

PHELPS DODGE CORPORATION

PRODUCERS, REFINERS AND FABRICATORS OF COPPER

Principal Subsidiaries:

PHELPS DODGE REFINING CORPORATION

PHELPS DODGE COPPER PRODUCTS CORPORATION

General Offices:

300 PARK AVENUE • NEW YORK, N. Y. 10022

September 9, 1964

PHELPS DODGE CORPORATION

300 PARK AVENUE

New York, September 9, 1964

To the Shareholders:

We enclose our check in payment of the dividend of seventy-five cents ($.75) per share payable September 10, 1964, on the capital stock of this Corporation standing in your name. Please deposit your dividend check promptly.

It will not be necessary to acknowledge the enclosed check, as your endorsement thereon is sufficient for that purpose.

Please notify Manufacturers Hanover Trust Company, our Transfer Agent, of any change in your post office address by completing the enclosed form and mailing it as directed thereon.

R. D. BARNHART, *Treasurer*

PHELPS DODGE— NEW MORENCI BRANCH RESEARCH BUILDING

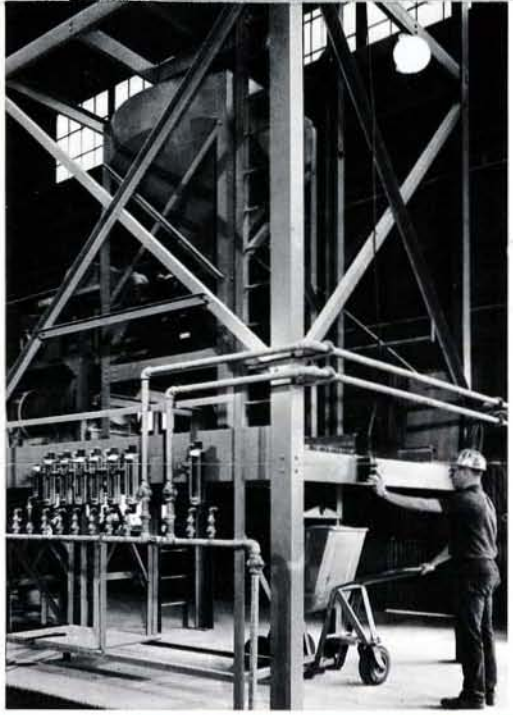
A new building was completed by the Morenci Branch Research Department during 1966. This department is engaged in applied research and development in extractive metallurgy. Its objective is to develop new processes or process improvements which will increase the recovery of valuable constituents from the company's ores or reduce processing costs. This research includes experimentation in mineral concentration, pyrometallurgy, chemical metallurgy, electrometallurgy, and process instrumentation.

The new building provides 6,000 square feet of laboratory space, 3,500 square feet of pilot plant space, staff offices, a library-conference room, and service facilities. The laboratories include a special laboratory for microscopic studies of mineral products, and special facilities for crushing, grinding, mixing, screening, and other sample preparation activities. General laboratory space is provided for the wide variety of experimentation in which this group engages. These adaptable laboratories are conveniently arranged around a central core storage room, with each staff office conveniently adjacent to laboratory space. Special equipment available in this new facility includes an X-ray spectrograph for rapid analysis of materials in connection with both laboratory and pilot plant work. The pilot plant area, in which miniature plants of various kinds can be erected for studies of continuous operations, is a high-bay structure with crane service throughout. A 500-pound per hour pilot ore concentrator is currently being used to develop design data for the concentrator at the company's property at Tyrone, New Mexico, now being developed for production.

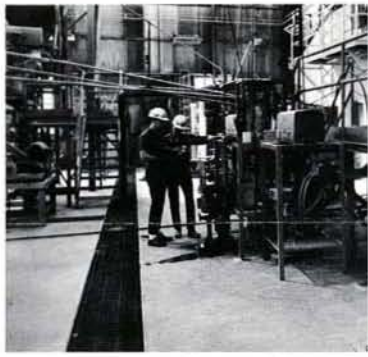
A special laboratory with complete illumination control is provided for microscope work. It is equipped with three different types of microscopes and their accessories.

Studies of chemical reactions involved in metallurgical operations are carried out in one of the laboratories.

An X-ray spectrograph is used for continuous analysis of the composition of flowing pilot plant process streams, and for determination of the composition of crystal structure of batch samples of research materials.

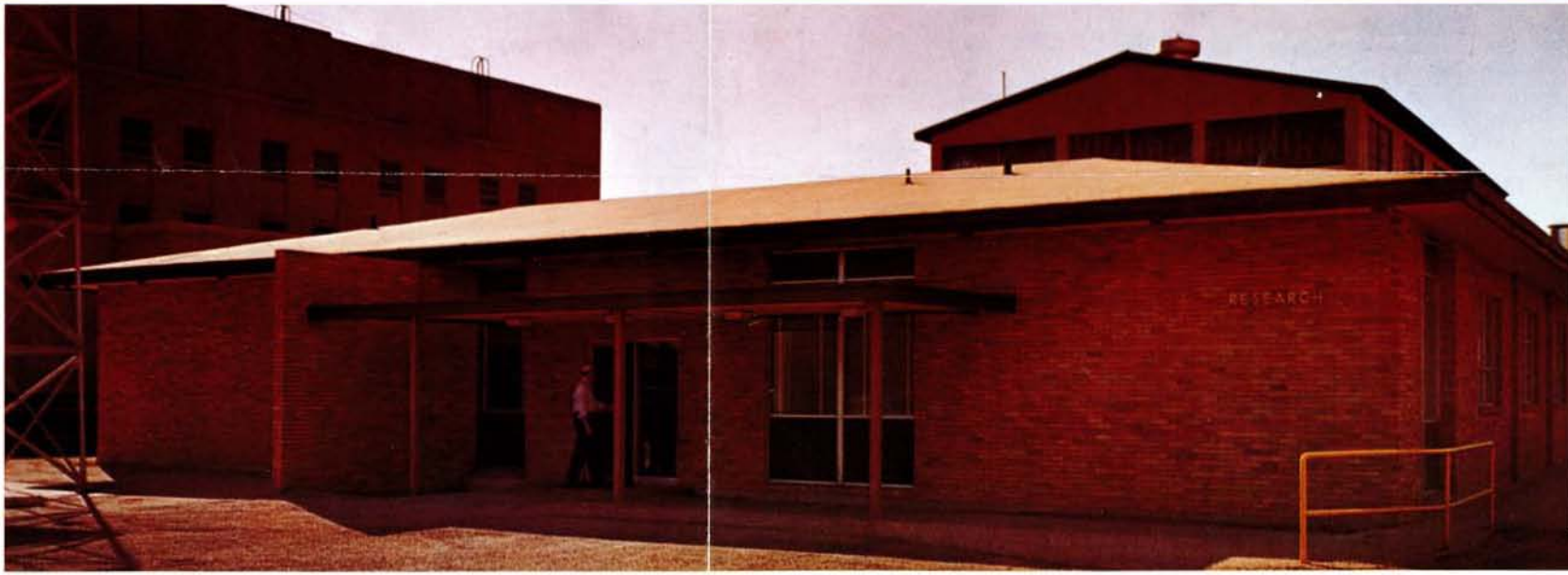


Pilot plant operations start with filling of the ore bin.



A variety of crushing, grinding classification and control equ is provided for pilot plant acti such as this plant treating ore company's property at Tyrone

The new Morenci Branch Research Building includes laboratory and office spaces in the foreground and a high-bay pilot plant area at the rear.



PHELPS DODGE CORPORATION

300 PARK AVENUE

New York, March 9, 1967

To the Shareholders:

We enclose our check in payment of the dividend of eighty-five cents ($.85) per share payable March 10, 1967, on the capital stock of this Corporation standing in your name. Please deposit your dividend check promptly.

It will not be necessary to acknowledge the enclosed check, as your endorsement thereon is sufficient for that purpose.

Please indicate any change in address on your dividend check, as follows, before handling it in the usual manner:

1. Draw line through the incorrect address;
2. Print correct address to the right of old one;
3. Insert Zip Code; and
4. Punch out die-cut circle marked "X" on back of check. Do this **only** if you report a change in address.

R. D. BARNHART, Treasurer

PHELPS DODGE CORPORATION

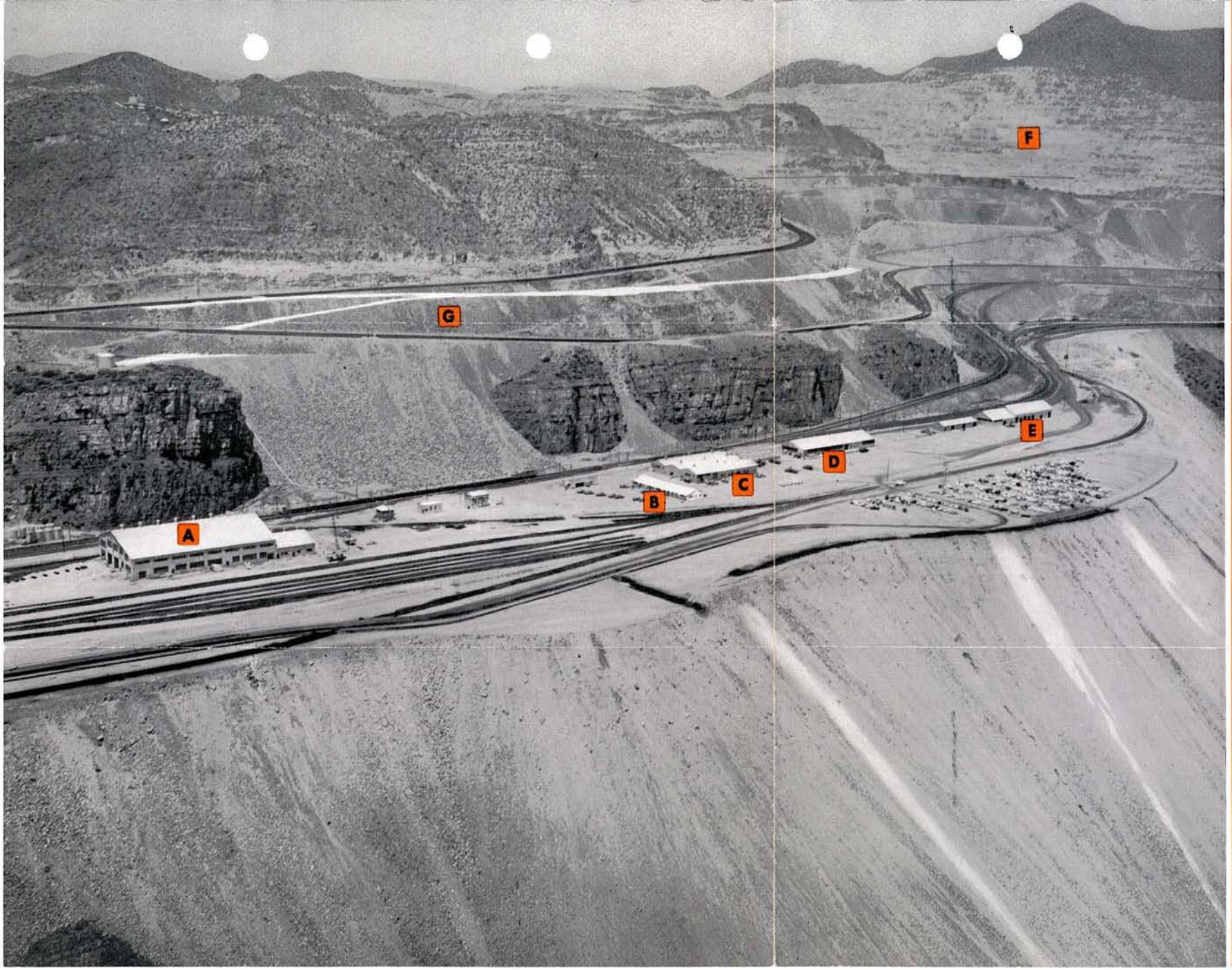
PRINCIPAL SUBSIDIARIES:

PHELPS DODGE INDUSTRIES, INC.
- Phelps Dodge Copper Products Corporation
- Phelps Dodge Magnet Wire Corporation
- Phelps Dodge Aluminum Products Corporation
- Phelps Dodge International Corporation

PHELPS DODGE REFINING CORPORATION

GENERAL OFFICES:

300 PARK AVENUE • NEW YORK, N. Y. 10022



Legend

A. Locomoti
B. Mine Offi
C. Change H
D. Supply W
E. Repair G
F. Open-Pit
G. South Sid

PHELPS DODGE CORPORATION

PRODUCERS, REFINERS & FABRICATORS OF COPPER

Subsidiary Companies:

PHELPS DODGE REFINING CORPORATION

PHELPS DODGE COPPER PRODUCTS CORPORATION

General Offices:

300 PARK AVENUE • NEW YORK 22, N. Y.

September 8, 1960

PHELPS DODGE CORPORATION

300 PARK AVENUE

New York, September 8, 1960

To the Shareholders:

Check is enclosed in payment of dividend of Seventy-five Cents ($.75) per share payable September 9, 1960, on the capital stock of this Corporation standing in your name. Please deposit your dividend check promptly.

It will not be necessary to acknowledge the enclosed check, as the endorsement thereon is sufficient for that purpose.

Please notify The Hanover Bank, our Transfer Agent, of any change in your post office address by completing the enclosed form and mailing it as directed thereon.

M. W. URQUHART, *Treasurer*

PHELPS DODGE CORPORATION

Morenci Branch - Morenci, Arizona

Relocation of Mine Buildings at the Morenci Open-Pit Mine, Morenci, Arizona

The relocation of all the plant facilities used in the mining operati became necessary with the expansion of the Morenci open-pit mine to t south.

The new location for the mine buildings is shown in the aerial pictu appearing in this circular. A portion of the mine is seen in the upper right ha corner. Also shown is part of the new south side railroad switchback syste constructed in connection with the expansion of the open-pit mine.

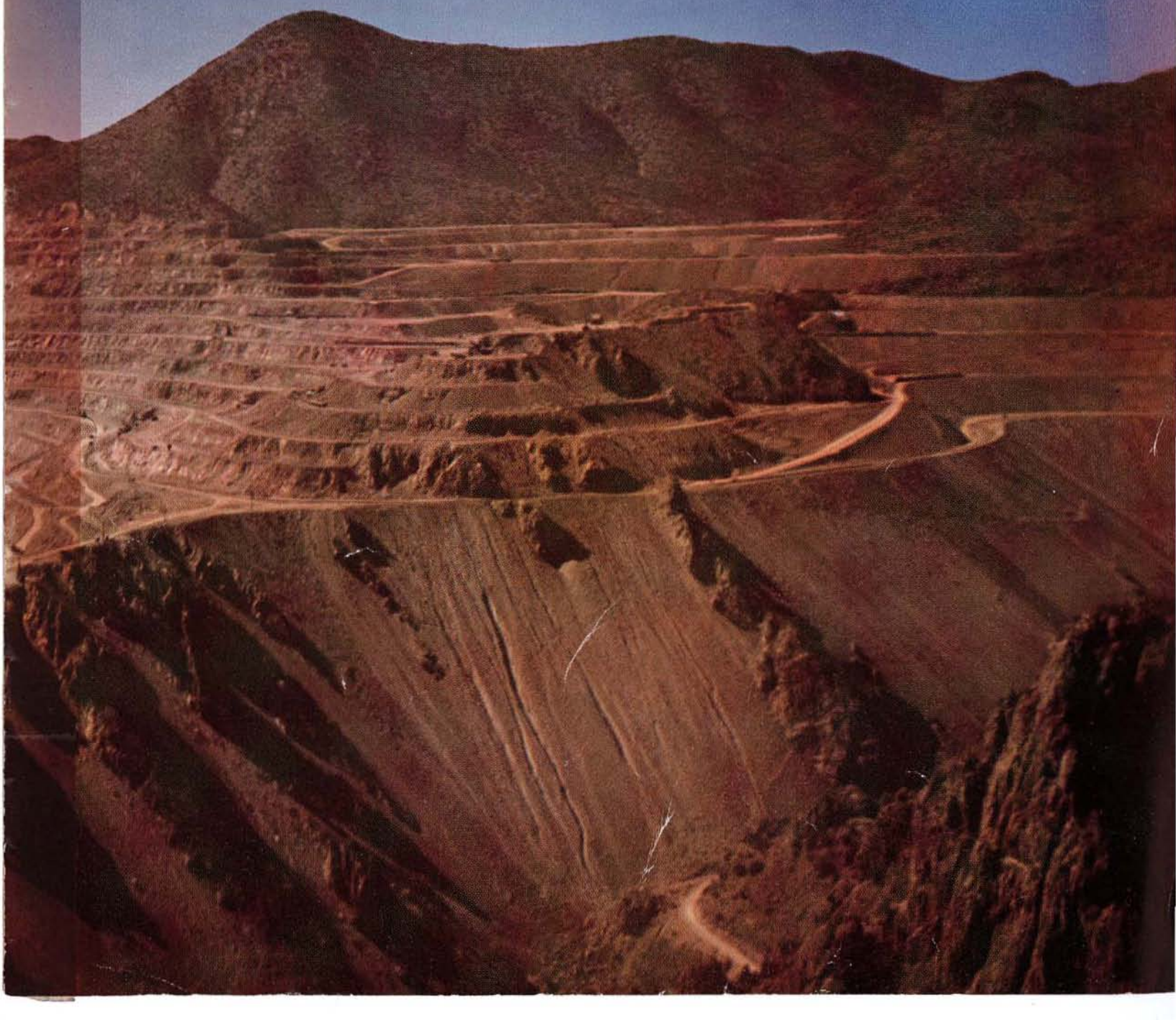
The construction program for the new mine buildings is scheduled f completion in 1961 and, when completed, eighteen buildings with their aiii equipment will have been relocated.

The new Locomotive Shop will house complete facilities for the mai tenance and repair of diesel locomotives, including seventeen 1750 HP dies electric locomotives. The Change Room provides shower and change faciliti for 1,000 men. The mine Supply Warehouse has 15,400 square feet of usab floor space.

THE PROSPECTOR

PUBLISHED BY PHELPS DODGE CORPORATION, MORENCI BRANCH
MORENCI, ARIZONA

Vol. 5 MARCH, 1953 No. 1



MECHANICAL DEPARTMENT EMPLOYEES JULY 5, 1928

There are 24 men in these group pictures who continue to make their homes in Morenci, most of whom are still employed by Phelps Dodge Corporation, Morenci Branch. When these pictures were taken the machine shop was located near the site of the present Morenci high school building.

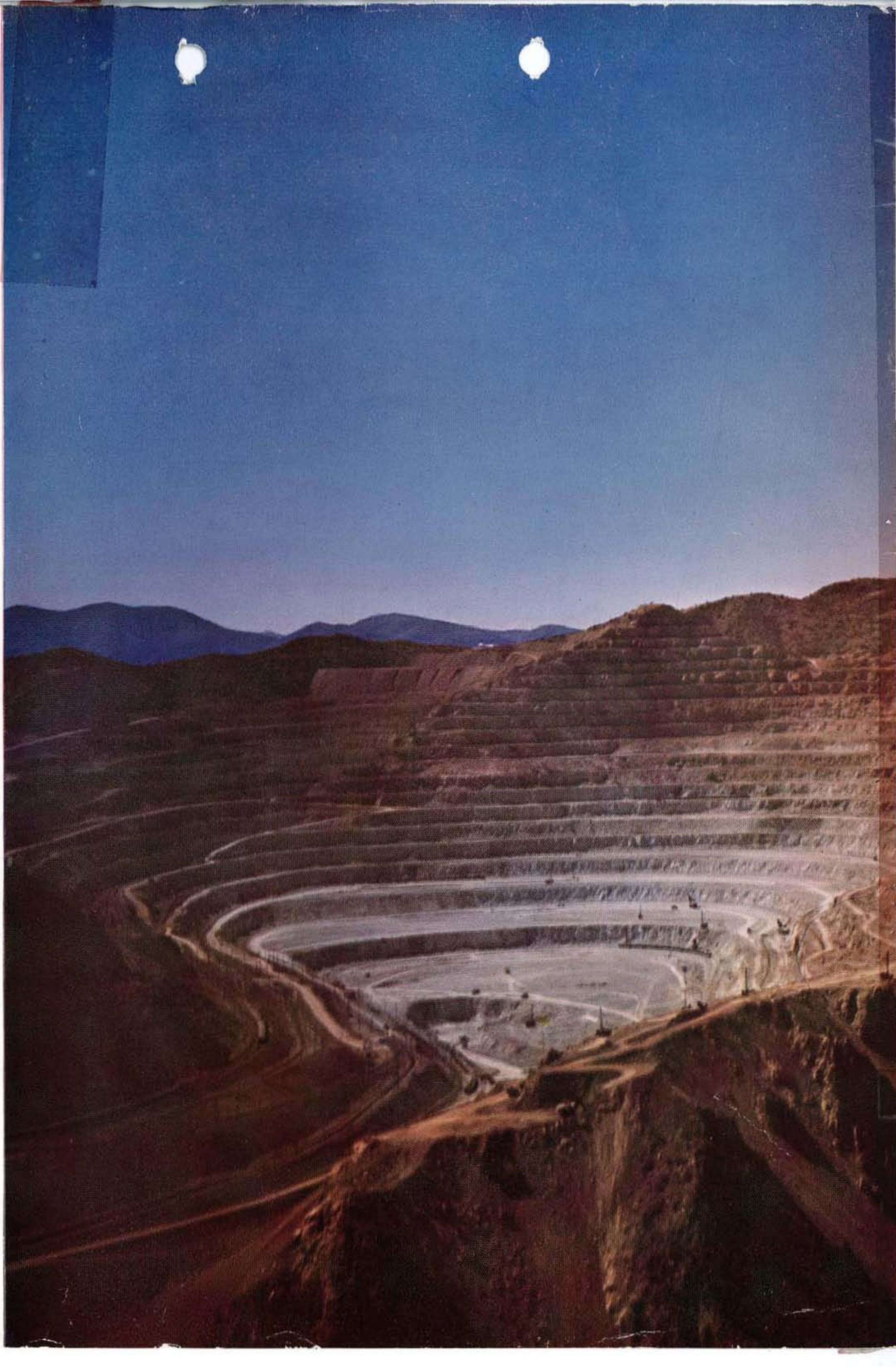
Articles of interest to our readers, photographs and sketches suitable for reproduction, are solicited and should be addressed to Editor, The Prospector, Phelps Dodge Corporation, Morenci Branch, Morenci, Arizona.

—Photo by Risdon Studio

EAGLE SCOUTS AND PROUD PARENTS

Left to right: Eagle Scout Don Sorells and parents, Mr. and Mrs. S. W. Sorells; Eagle Scout Allen Brown and parents, Mr. and Mrs. L. E. Brown; Eagle Scout Jim Hardcastle and parents, Mr. and Mrs. A. C. Hardcastle.

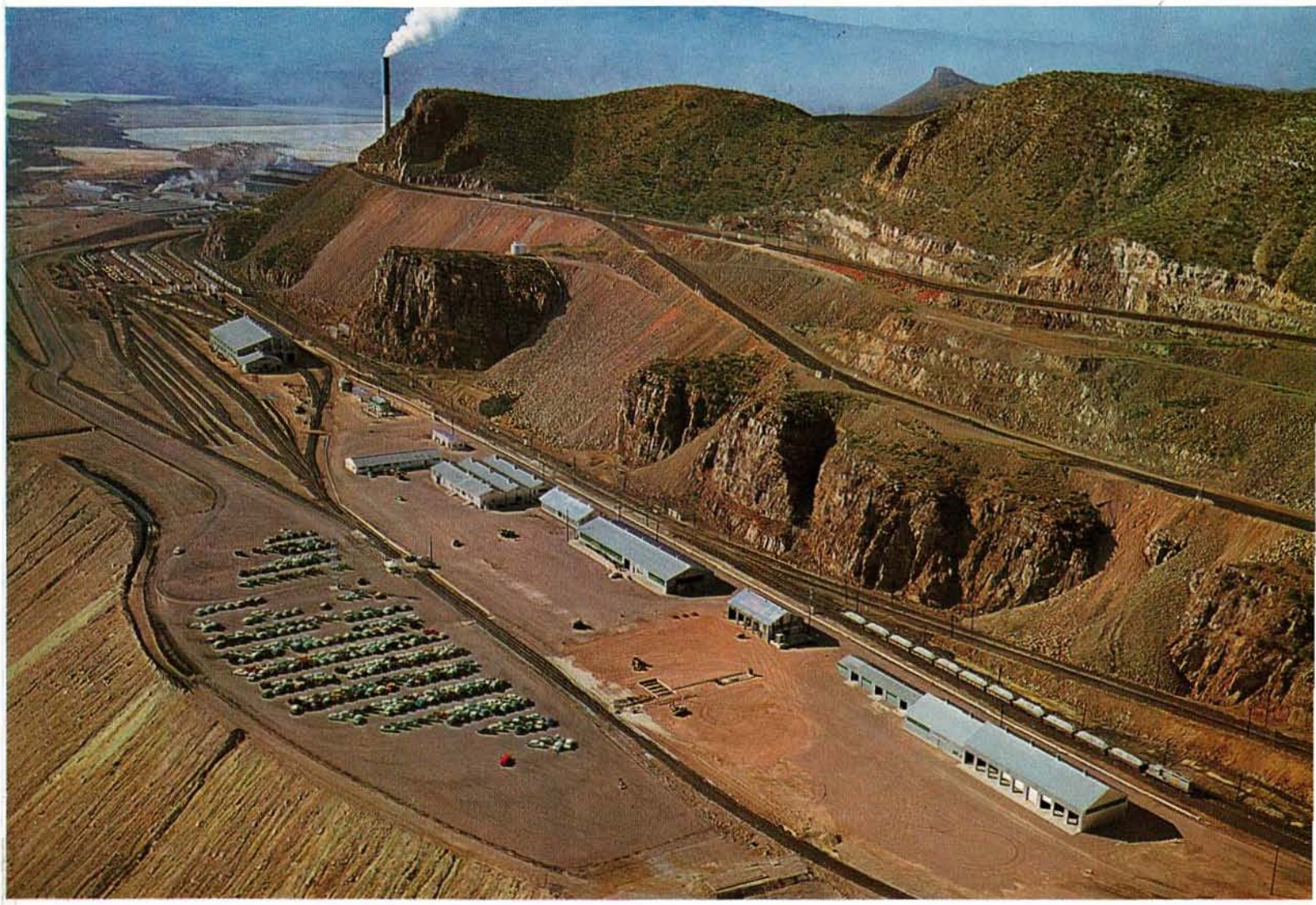
COPPER PCD COPPER



The Morenci Mine

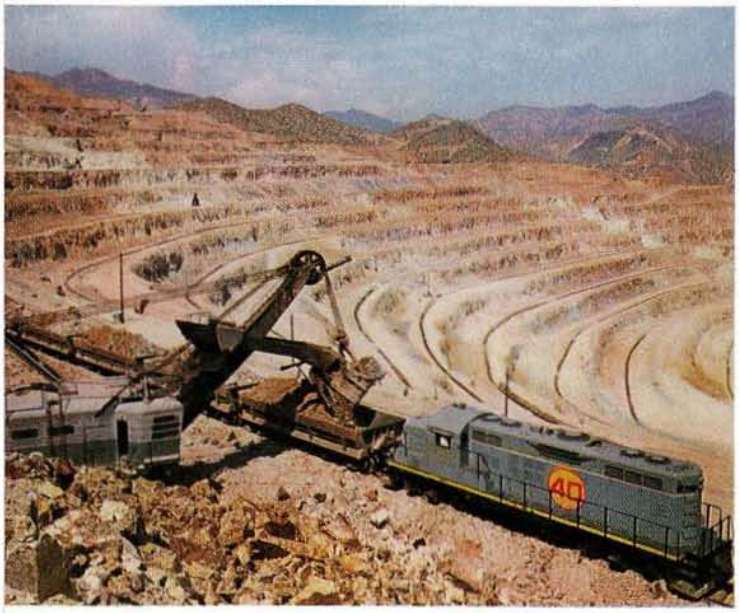
At the Company's open-pit mine at Morenci, Arizona, the mining area has been extended (as shown on the mine picture which follows this page) to include ore indicated by development drilling carried out in recent years.

As part of this extension, it has been necessary to construct an additional access for the mine railroad and to relocate the mine plant facilities.



The new mine plant facilities area, shown above, is located on former mine waste dumps midway between the open pit and the reduction works, and includes the locomotive shop, mine office, change room, supply warehouses, and maintenance and repair shops. Above this area is one of the new switchbacks for the mine railroad. There are more than 75 miles of standard-gauge track in the mine haulage system.

A primary blast at the Morenci mine. Forty-nine 12-inch diameter drill holes were loaded with 63,000 pounds of explosive to break 380,000 tons of rock. The rock broken by this one blast would fill an ore train more than 38 miles long.



The broken material is loaded into trains by shovels like the one shown at the left. The shovel dipper has a capacity of 9 cubic yards, or approximately 13 tons of broken rock.

The train shown at the right is in position to dump ore at the primary crusher, where the initial step in the treatment of the ore at the concentrator takes place. Each ore train consists of eleven cars and hauls approximately 880 tons of ore per trip.

THE MORENCI MINE

AREA SCHEDULED FOR MINING AS OF JANUARY 1, 1953

ADDITIONAL AREAS SCHEDULED AS OF JANUARY 1, 1961

The average diameter of the pit is about 1⅓ miles and the maximum depth is about ¼ mile. Trains and shovels are discernible on some of the mining levels.

Morenci

Rubs His Lamp and Brings Forth Copper.

s of the earth's crust have estimated that r deposits of the Morenci district are about years old. The first indications of copper liscovered in the surface rocks in 1870 by a rospectors. The first copper was produced uantities in 1872 by crude methods. This from the surface, requiring little more than and was easily obtainable at small cost bor and investment.

ng the early ore discoveries, an influx of us fortune seekers drifted in, locating claims stence—picturesquely named—Copper King, lountain, William Tell, Last Chance, Fair-an's Dream, Liverpool, King Edward, Veiled nverness, Missing Link, Waterloo, Tough d S., Christmas Gift, Perplexity, Jolly Liar, Jack, Tombstone, and Lone Star, indelibly dreams of riches, thoughts of the "little eft at home, the literary taste, the national-haps the old home town of the staker. it the years many of these mining claims great producers. Others have left no rec-t on the rolls of the tax assessor. Most, if the claimants have passed to their reward. ese claims started their owners on the road justifying the dreams or the canniness of pector or promoter.

lly, through the intervening years, these e been consolidated into the holdings now the Morenci operation, the largest pro-opper in the State of Arizona and the sec-t operating copper mine in the United has been a long step from the production of n ore with a copper content of 600 pounds the present day recovery of copper from ing but 20 pounds per ton. This is the of Morenci mining.

renci district is the oldest producer of cop-ona. For 75 years the district has made ontributions to mankind, not the least of been its contribution to Arizona's produc-per which played so important a part in he material needed by the armed forces in r II. Aircraft, radar, shipping, guns, am-ransportation—almost every machine, in-weapon depended upon copper and its aximum perfection and usefulness.

MORENCI OPEN PIT MINE

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ORE BODY, MORENCI PIT MINE

The final chapter of the Morenci
be written. The present operation h
life of many years. Additional disc
bearing "rocks," together with furthe
technical advances permitting the tr
ore than has been possible at the pr
ise an added lifespan.

Mining at Morenci, which began i
a very small scale, with only hand lab
old burro as the accepted means for
of ore, limited mining supplies and
even meager food and water for the
district. At Morenci, as elsewhere,
up. From the small beginning eac
through the years brought increased
copper deposits of the district until—
ing, exploration and geological and m
—the present porphyry ore body to

Geologists and engineers co-ordina
tion developed and found more than
of ore suitable for treatment. Wit
it was a simple calculation to det
five billion pounds of copper was a
long life for a type of operation ne
district, which will produce in the c
than three times the copper realized
ceding seventy-five years. But even
edge, only men with vision and cou
take an investment of many million
the work which was commenced in

Before the exhaustion of the pres
open pit excavation will have attai
limits of more than a mile long, ne
and more than a quarter of a mile
ton of commercial ore an addition
material must be handled. Most o
terial is barren rock called "capping
200 feet in thickness and overlying
Some 50 million tons of this capp
before production of copper began
this waste is useful in making rail
roads, but most of it is hauled to ca
ore limits and dumped. Literally, t
are being removed and valleys filled
varying in tints from yellowish brow

Mining operations are conducted by means of a series of benches at vertical intervals of fifty feet, shown in the accompanying photographs. These benches are connected by ramps or switchbacks. A typical mining cycle consists of drilling, blasting, loading and hauling the ore and waste from these benches, plus engineering, supervision and the daily maintenance of equipment.

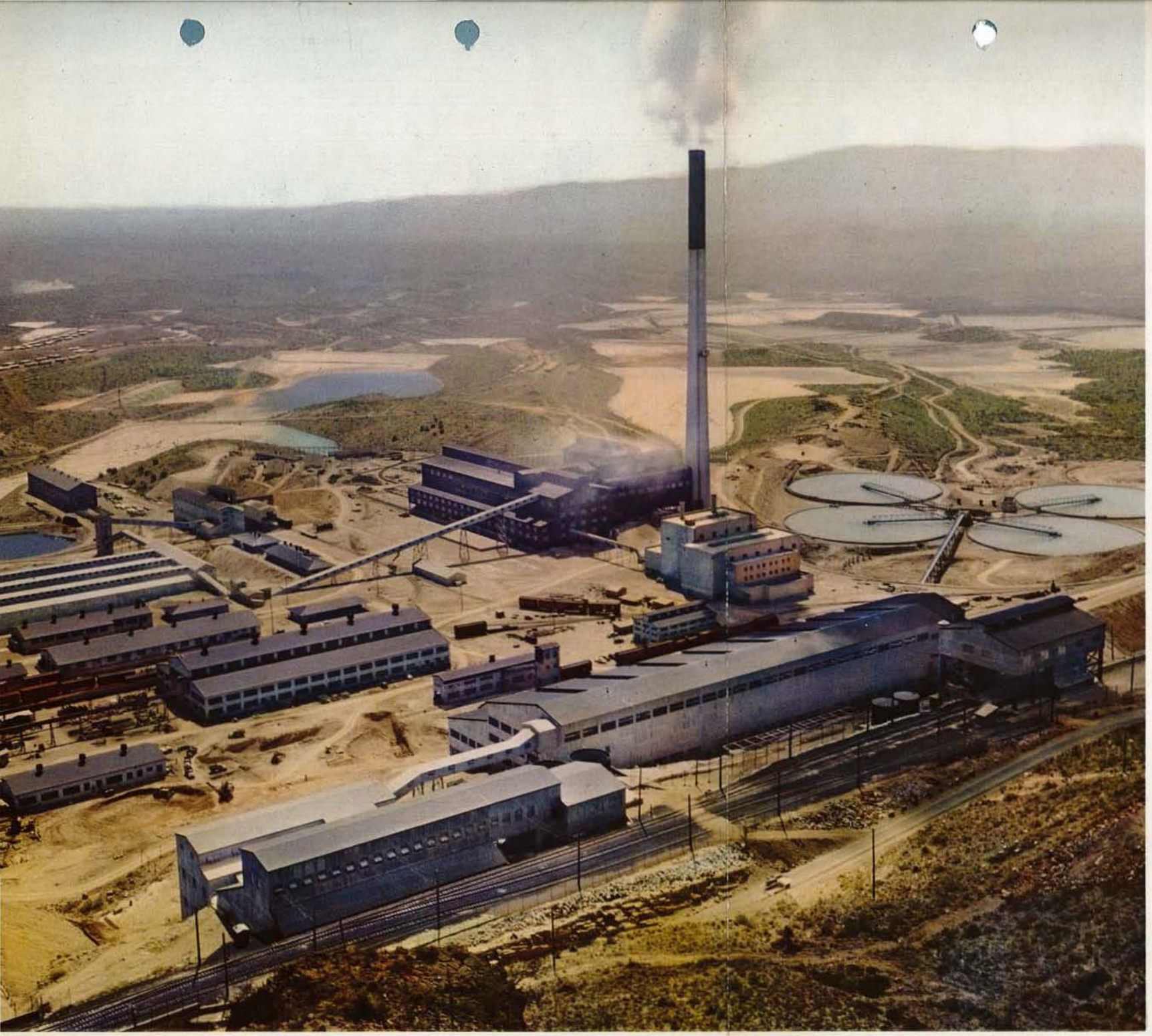
It has been a long series of steps from the first drilling methods used in the Morenci district. Seventy-five years ago, to blast his ore the miner laboriously drilled short holes one inch in diameter, using a sledge hammer and drill steel sharpened by hand—often by the miner himself. Today, the fifty-foot benches are drilled by electrically driven machines mounted, for mobility, on caterpillar treads, using drill steel twenty-five feet long and weighing a ton and a half—two men often drilling one hundred lineal feet of hole, nine inches in diameter, in a single drift. A blast has increased from a few sticks of dynamite, breaking a few tons of ore, to the use of 50,000 pounds of powder in a single blast, breaking 275,000 tons of ore.

It would have taken the miner of seventy-five years ago his entire day to load the amount of ore now handled at each scoop of the 4½-yard electrically operated shovels of today. These shovels are marvels of efficiency. They are mounted on caterpillar treads for traveling purposes. The shovel operator, without leaving his seat, manipulates all movements of the shovel with electric control levers. Thus, large tonnages of material are moved daily.

In seventy-five years, the little ore car pushed by hand or pulled by a burro or mule over narrow gauge tracks, with rails made of wood or steel rails weighing 12 pounds to the yard, has increased its capacity 85 times. The huge 40-yard dump cars of today are roller-bearing, moved by electric power over a standard gauge railroad with steel rails of 131 pounds to the yard, and dumped with compressed air by merely pushing a lever.

In seventy-five years, the locomotive has grown in size to 125 tons. For power it uses electric current from the central power plant or produces its own electricity by means of diesel engines. A standard train is eight 40-yard cars—a "pay load" for the mill of almost 700 tons. The electric locomotive carries storage batteries permitting it to operate for short distances independently of trolley lines. Briefly, these are some of the advances in the science of mining and transportation that have made it possible to supply the needs for copper from low grade ore which seventy-five years ago was considered worthless.

SHOVEL LOADING ORE TRAIN



Ore from the Open Pit Mine is
louble-tracked railroad, much of
leling the Coronado Trail, termin
tion Works. Here the ore is su
grinding, concentrating and smelt
metallic copper 99.75 per cent pu
odes" and loaded into railroad ca

The Reduction Works site pr
about thirty-five acres, at an eleva
railroad grade from the mine, and
location of buildings and equipm
fully utilized as material moves fo
ment, avoiding unnecessary use an

Trains of ore from the mine ar
Primary Crushing Plant located
in a solid rock cliff. Here ore du
a car (eighty-five tons) per minu
transformation into metallic coppe

The treatment of the ore begins
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the world. In addition to large ca
trator equipment embodies the hi
ficiency so far attained. A few y
or waste, from old concentrators
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treated today.

The Smelter at Morenci compri
verberatory furnaces and six conv
stack, rising 615 feet with an ins
feet at the top, is an inspiring landm
of the Smelter is sufficient to sme
Dodge Morenci production and th
dependent mines in the district
processes have kept pace with th
tices known to the industry.

The heart of the entire Moren
in the steam power plant, and
transmission lines carrying electric
every phase of the operation is
power plant, which utilizes waste h
furnaces for about half its electrica
the largest capacity of any withi
zona and generates sufficient elec
needs of a large city.

Within the Reduction Works
cated a spacious, splendidly equip
an electric shop, carpenter shop, w
ern change room so arranged as to
each plays in the general scheme

MORENCI MINE File

Beginning a New Era in Morenci

Over 50 Years of open-pit copper

Did you know that the first ore was mined from the Morenci Open Pit over 50 years ago?

Although mining had started two years earlier, it then consisted only of stripping rock from the top of the ore body.

In 1939, a small amount of ore mining commenced for testing purposes, about 1,500 tons per day. This compares with more than 110,000 tons per day of ore being mined today.

An even more unbelievable contrast is evident when we read that early-day mining in the 1870s was done by wheelbarrow and today is done with 170- and 190-ton trucks.

In 1932, mining copper by underground methods ended when the Humbolt Mine in old Morenci shut down because of the Great Depression. Five years later, in 1937, work on the Morenci Open Pit Mine started.

Enough rock had been stripped away by 1939 to expose a small amount of ore. This area of ore, called the "test pit," was segregated from the rest of the mining which focused on the removal of overburden. Thus, 50 years ago, ore was being mined for test-mill operations to determine proper milling techniques.

The ore was much lower grade in copper content than had ever been mined before at Morenci. Methods of milling and smelting that ore had to be devised. An old concentrator and an old smelter were used. Our present concentrator and smelter had not yet been built. They were completed in 1942.

The concentrator was the No. 6 concentrator in old Morenci. It was built in 1906, by the Arizona Copper Company, to handle ore from the underground Humbolt Mine. Phelps Dodge acquired ownership of the concentrator and the Humbolt Mine in 1921, when it became sole owner of all the mines and property in the district.

In 1938, a test mill was reconditioned in the old No. 6 to handle the ore from the "test pit," and in early 1939, ore was delivered to the mill. To determine the most effective means of separating the ore minerals from the rock, different methods were tried. Fifteen hundred tons of ore per day were sent to the mill from the test pit.

Concentrate from the test mill was sent to the old Clifton Smelter. Its 300-foot stack still stands near the highway south of Clifton. That smelter was built in 1913 by the Arizona Copper Company. Phelps Dodge began operating it in 1921. It was shut down in 1932 and reactivated in the late '30s to handle scrap, precipitate and concentrate.

Two years later, in 1942, the present Morenci concentrator and smelter were completed. They were many times larger and more productive than the old plants. Ore was delivered to the new reduction works and the first copper anodes were shipped from the new smelter in April 1942.

Ore production from the new mine in 1942 amounted to 40,000 tons per day. The mill was expanded during World War II and ore production increased. By the 1960s, the mine was producing 60,000 tons per day of ore and 180,000 total tons per day.

In 1969, mining began in the new Metcalf Open Pit with ore being produced for the new Metcalf Concentrator by 1976. During the 1980s, all mining has been confined to the Morenci Pit. There are plans to reestablish mining at Metcalf during the 1990s.

Today, we mine more than 110,000 tons per day of ore and about 250,000 tons per day of ore, and leach rock!

And now, with the recent announcement of the Northwest Extension expansion project and solvent extraction—electrowinning technology, a new era of mining at Morenci has begun.

- Phelps Dodge Morenci, Inc. offers an excellent guided tour of the open pit mine and related facilities. Tour guides are retired Phelps Dodge employees.

- You may schedule a tour by calling our Employee Service Department at (602) 865–4521, extension 435. The free tours are approximately three hours in duration and are conducted Monday through Friday, usually beginning at 8:30 a.m. and 1:30 p.m.

The first mineral discoveries in the Clifton-Morenci District were made around the year 1865 when a group of California volunteers pursuing renegade Apache Indians came through this area. The commanding officer, General James H. Carlton, wrote to Washington about colorful mineral outcrops that he had observed.

Two mining companies were organized in the Clifton-Morenci District in the early 1870's. One was the Longfellow Copper Company.

The second was the Detroit Copper Company. The founders of the Detroit Copper Company were Captain E. Ward, Joe Yankee and others. The company enlisted a small force of men to work for Captain Miles Joy who had developed the original mining claims. They mined copper in the area which later would become Morenci.

In 1872, Robert and James Metcalf staked claims in the area later known as the town of Metcalf. They also located the Longfellow claim. This claim contained high-grade copper deposits and was located in an area now incorporated into the southeast portion of the Morenci Open Pit Mine.

The Metcalf brothers enlisted the financial support of Henry Lezinsky, a successful store owner in Las Cruces, New Mexico, and together they formed the "Francisco Mining Company" in 1872. One year later the name was changed to the "Gila Mining Company" and finally to the "Longfellow Mining Company" in 1874.

The first ore mined from the Longfellow Mine assayed as high as 80 percent copper, and averaged 20 percent copper over the first 10 years of mining. By comparison, the ore we are mining today averages less than 1 percent copper.

The copper was shipped by wagon trains, such as is shown in the accompanying photograph taken in Chase Creek, to such far away markets as San Francisco and Kansas City or to Kit Carson, Colorado, which was the nearest railroad.

Early mining by the Detroit Copper Company ceased after a short time because of the danger of Indian raids and the remoteness of the mines, but it was reactivated a few years later with the arrival of William Church.

Church mined copper at different sites in and around the town of Morenci.

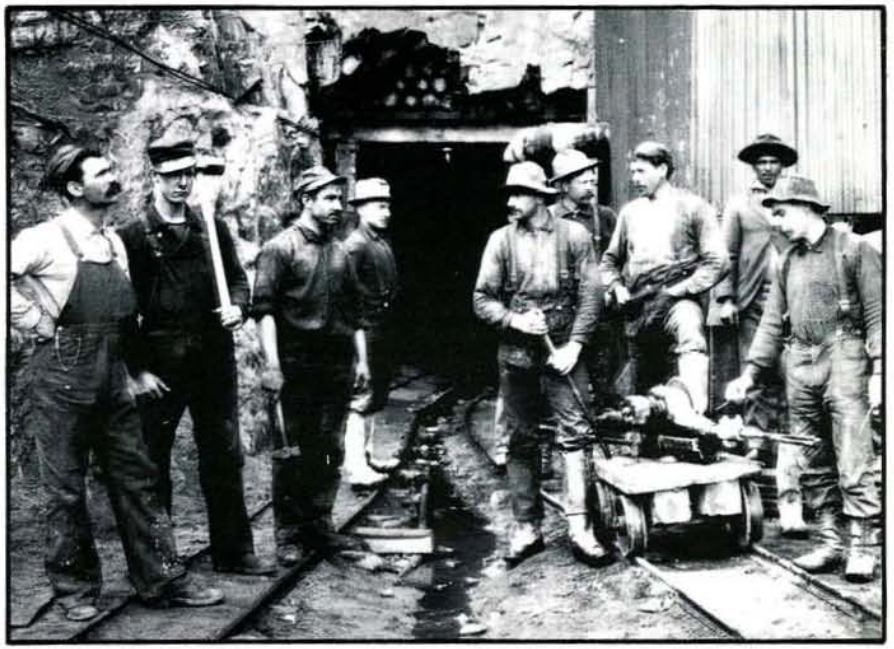
In 1880, Church made the decision to build a smelter to handle the ore from his mines. He didn't have the required capital, so he journeyed to New York by wagon, then by rail, to seek a loan.

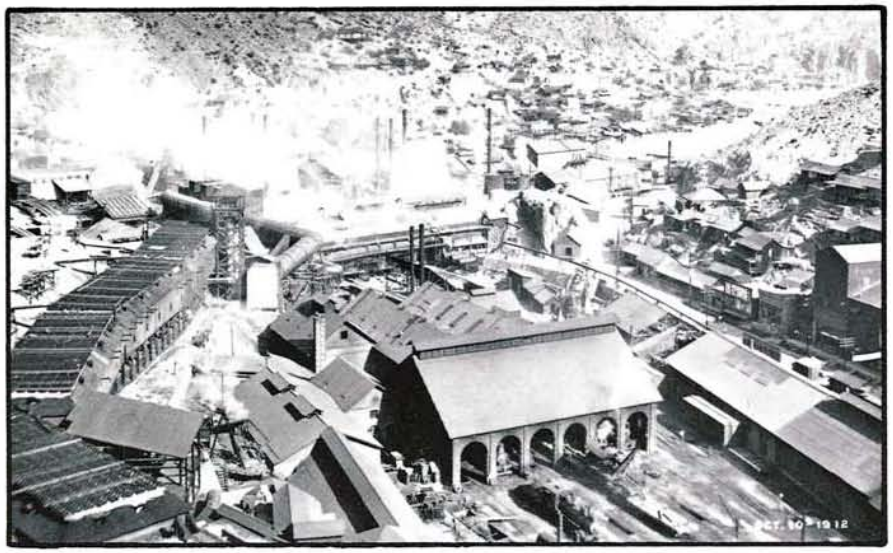
On a historic day in 1881, Church entered the office of Phelps Dodge & Company in New York City and asked for a loan. Phelps Dodge was not then in the mining business. Instead, it was in the business of exporting commodities such as cotton, and importing metals, primarily tin, copper, brass and zinc.

Phelps Dodge did not immediately extend the loan, but asked Dr. James Douglas, a renowned metallurgist, to examine Church's claims. (In later years, Dr. Douglas was to become President of Phelps Dodge. Douglas, Arizona was named in his honor.) Douglas reported favorably and also recommended that Phelps Dodge invest in mining properties in Bisbee, Arizona that same year.

As a result of Douglas' favorable report, Phelps Dodge & Company advanced $50,000 to Church and became part owner of the Detroit Mining Company.

Church thereby acquired the money to build a smelter and Phelps Dodge & Company reached a major turning point—resulting in more than 100 years of mining copper in Arizona.





Clifton was a smelter town from the late 1870s until 1932.

The first smelter to be built in this location, in the late 1870s, was owned by Longfellow Copper Company. Arizona Copper Company took over the smelter in 1882. From then until 1913, it was maintained and enlarged by Arizona Copper Company.

An interesting and unusual aspect of the smelter was that it actually used a mountain for a smoke stack!

Behind the smelter, a tunnel was driven into the mountain. The tunnel intersected a shaft which collared at the top of the mountain. A short smoke stack was installed at the top of the shaft.

As you drive into Clifton from Three-way, one of the first landmarks you see is an old smelter stack that maintains a lonely vigil below the left side of the highway. This was the Arizona Copper Company smelter built in 1913, replacing the old smelter in Clifton.

This "new" smelter built in 1913 was operated until 1921 by Arizona Copper and from then until 1932 by Phelps Dodge Corporation. It was torn down, except for the stack, in the early 1940s.

Before the year 1882, Clifton and Morenci were practically isolated from the rest of the world. Wagon trains were the only mode of transporting people and materials to and from the district. These wagon trains were often raided by bands of renegade Indians.

The first railroad in the area was built in 1879. It connected Clifton with the Longfellow Mine incline located in Chase Creek Canyon about three miles north of Clifton.

By 1882, the Clifton-Morenci area was a flourishing copper mining district. Interest was high to connect Clifton to the rest of the world with a railroad. Several companies looked at building a railroad, but backed off when they saw the rugged landscape.

The Arizona Copper Company, a new mining company in the district, decided to build a railroad from Clifton to Lordsburg, New Mexico. Surveying for the line began in 1882.

After construction of the narrow-gauge railroad started, the towns of Duncan and Guthrie sprang up along its route. Both towns were named after directors of the Arizona Copper Company.

The New Mexico portion of the railroad was named "Clifton and Lordsburg Railway," and the Arizona portion "Clifton and Southern Pacific Railway."

In 1924, the El Paso and Southwestern Railroad, including the old A&NM, became part of the Southern Pacific Railroad and remains so today.