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**CONSULTING GEOLOGISTS**

# STRUCTURAL ANALYSIS AS AN AID IN EXPLORATION FOR COPPER IN ARIZONA

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# STRUCTURAL ANALYSIS AS AN AID IN EXPLORATION FOR COPPER IN ARIZONA

## INTRODUCTION

I have tried for years to discover fundamental guides to ore, in order to delimit certain areas as more favorable than other areas and so permit systematic regional exploration. The following report sets forth some ideas which might aid systematic exploration for major copper deposits in Arizona.

I have studied the structure and geologic history of Mexico in relation to Mexican ore deposits for many years. I have been struck by the fact that although regional structural trends there were initiated as early as the start of the Mesozoic, perhaps earlier, successive deformations, even including those of the Late Tertiary, followed the older structural grain, which is dominantly northwest over most of the country. Laramide folds follow the structural contours of older sedimentary troughs and basins; Tertiary faults follow the trend of the much older troughs and folds.

Later this study was extended to the western United States. Here in many places the same relations hold, notably in the Great Basin in Nevada, where Nevadan and Laramide folds trend dominantly north, and so do the Basin and Range faults.

Geosynclines especially have strongly localized deformation, intrusion and metallization. Since the Mexican geosyncline invaded southeast Arizona in the Cretaceous, just preceding the Laramide revolution, ideas derived from study of that trough in Mexico might apply equally well in Arizona. These ideas form in part the basis of this report.

## GENERAL GEOLOGY OF ARIZONA

Well-known facts are only briefly touched on in this summary.

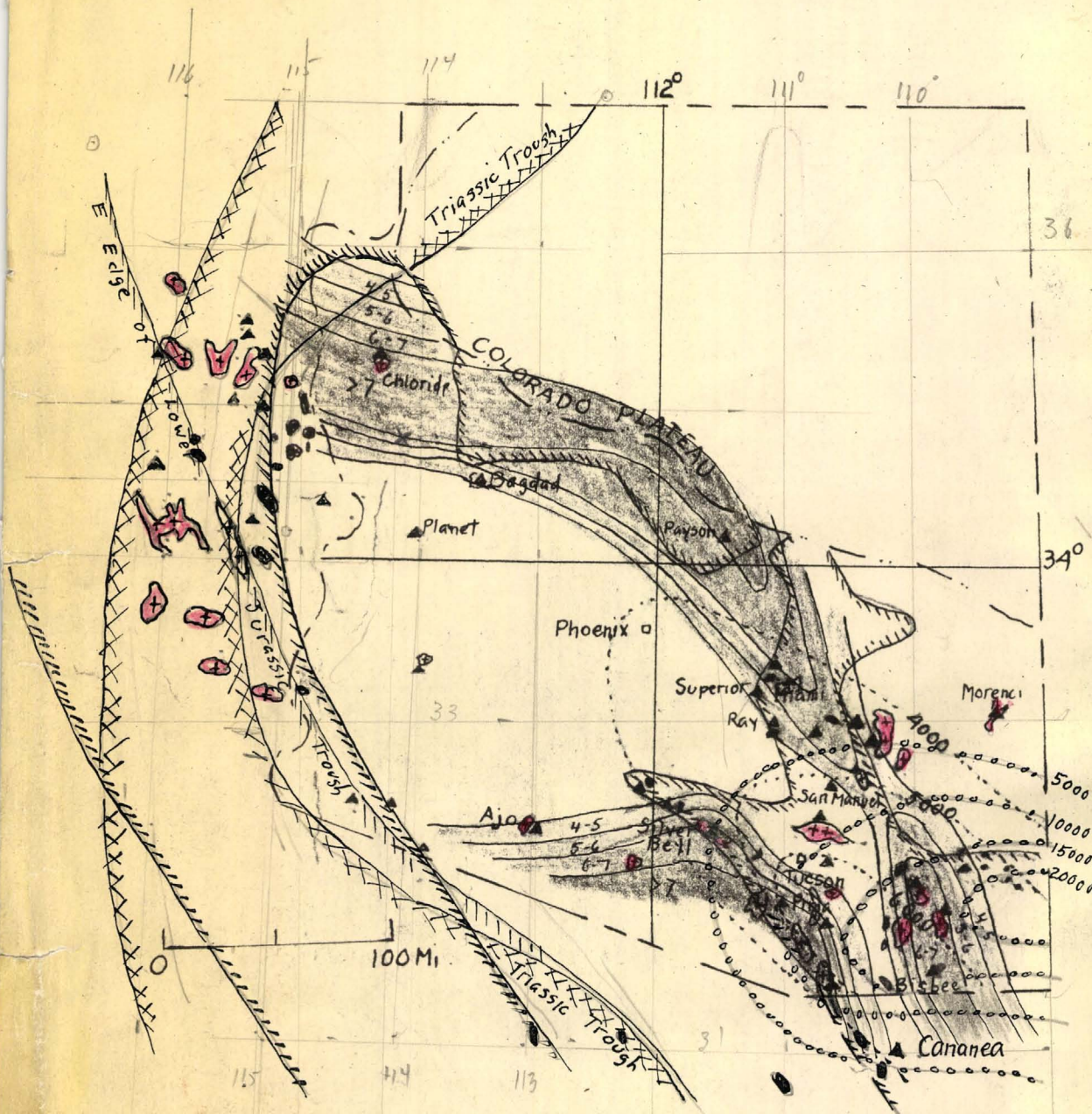
Arizona is divided into two provinces, on the basis of rock formations, structure, and metallization. The dividing line passes roughly from the northwest to the southeast corner of the state. Northeast of this line lies the Colorado Plateau, southwest of it, the Arizona portion of the Basin and Range province (Plate 1).

The Basin and Range province in Arizona is divided into the Mountain Region, or Mexican Highland, and the Desert Region. The Mountain Region borders the Plateau on the southwest from the Cerbat Mountains to the Miami area, where it leaves the Plateau border and passes through the southeast corner of the state. Individual ranges in the Mountain Region are closely spaced; maximum elevations exceed those of the Plateau northeast of the Mountain Region.

In the Desert Region the mountains are relatively low but steep; they are long and narrow and are separated by broad desert plains which make up 50-75% of the region (Butler and Wilson, 1938, p.9).

The physiography of Arizona reflects the underlying structure. On the Plateau the exposed rocks, mainly Upper Paleozoic and Mesozoic sediments and Tertiary and younger flows lie nearly flat and have never been subjected to orogenic forces. Major granitic intrusions are lacking, and so are the ore deposits commonly referred to as hydrothermal. Copper deposits in undisturbed sediments exist there, but none have so far been proven commercial and this type is not considered in the present report.

In sharp contrast to the undisturbed Plateau, the southwestern



COPPER DEPOSITS AND GRANITIC INTRUSIONS IN RELATION TO SEDIMENTARY TROUGHS AND TO DISTRIBUTION OF TRACE ELEMENTS IN CHALCOPYRITE

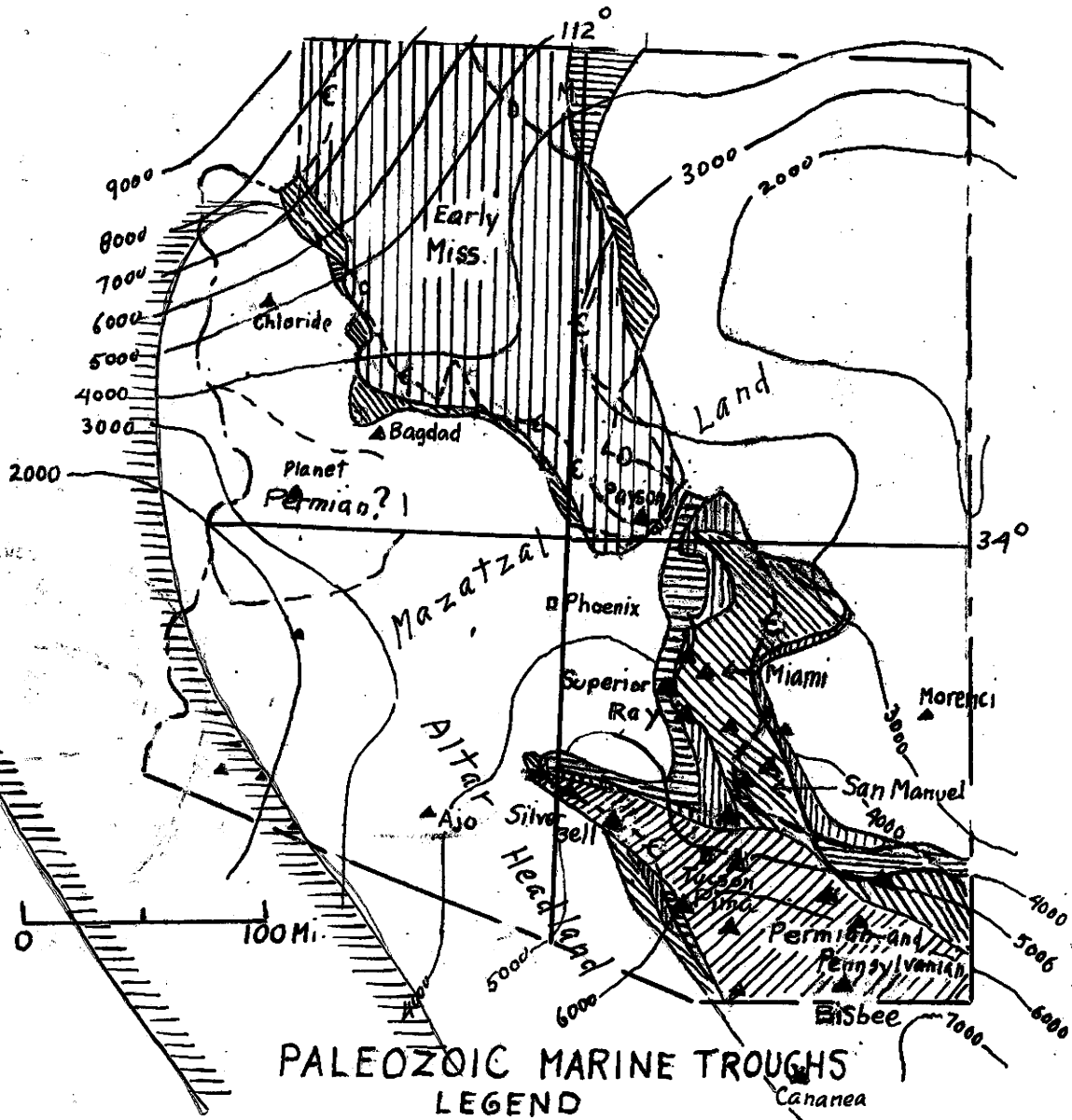
Pilares

**LEGEND**





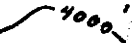

- Isopachs of Upper Cretaceous Trough: 4000
  - Paleozoic Troughs: Triassic Trough:
  - Cretaceous or Tertiary granitic intrusions: Lower Jurassic Trough:
  - Copper mine or prospect:
  - Log product trace elements in chalcopryrite (PPM):
- |     |  |
|-----|--|
| >7  |  |
| 6-7 |  |
| 5-6 |  |
| 4-5 |  |

FIG. 2

FIG. 2



**PALEOZOIC MARINE TROUGHS**  
**LEGEND**

Permian and Pennsylvanian (troughs only, except in western Arizona):   
 Early Mississippian:   
 Late Devonian:   
 Middle Cambrian:   
 Isopach showing Total Paleozoic sedimentation:   
 Copper mine or prospect: 

After Stoyanow (1942, Plate 5), and McKee (1951, Plate 3C).

FIG. 1



half of the state has suffered repeated and violent deformation, extensive intrusion and widespread metallization (Plate 1). Erosion following repeated uplifts has stripped the sedimentary cover from the Early Precambrian crystalline basement over nearly the entire southwest half of the state, except on the north, adjacent to the Plateau, and in the extreme southeastern portion of the state; in these areas Paleozoic and Mesozoic rocks have been to a considerable degree preserved.

A partial reason for this is shown in Figures 1 and 2. Figure 1 shows two separate basins of Paleozoic sedimentation, one in the northwestern, the other in the southeastern part of the state. The Paleozoic seas, although withdrawing at times, persistently filled the same troughs, from Middle Cambrian through Mississippian times, in the case of the northwest trough, and from Middle Cambrian through Permian times, in the case of the southeast trough. In the extreme northwest, and extreme southeast, Paleozoic rocks exceeded 6000 feet in thickness; this accounts in part for their preservation.

The two troughs never connected, but represented encroachments, respectively from the northwest and southeast, upon a positive element extending northeast across the state, called by Stoyanow Mazatzal Land (1942, p.1261). This positive element accounts for the thinness of the Paleozoic in central southwestern Arizona. Exposure of the basement there is partly due to the thinness of the cover.

This fact is emphasized in Figure 2, which shows, among other things, basins of Cretaceous sedimentation. The 4000' isopach for the

Upper Cretaceous is controversial. It is taken from Reeside (1944); other paleogeographers place the 1000' isopach in about this position. It is certain, at any rate, that Cretaceous sediments were very thin or nonexistent in central southwest Arizona. Since the Paleozoic was thin also here, the extensive exposure of the crystalline basement is not surprising.

The Cretaceous troughs in southeastern Arizona lay at the northwest end of the Mexican geosyncline. As shown in the Figure, Cretaceous deposits were extremely thick here, and this accounts for the large degree of their preservation.

The fact that in this area of thick Paleozoic and Mesozoic sedimentation Cambrian and Precambrian rocks are exposed, in places at elevations exceeding 5000' (Mule Mountains, containing the Bisbee district, and elsewhere) attests the amount of deformation which this area has undergone.

The most obvious signs of deformation in southwestern Arizona are high-angle faults. Most or all of the long, narrow ranges, composed of Older Precambrian crystallines, in the Desert Region are thought to be of tectonic origin, bounded on one or both sides by high-angle faults. Similar ranges persist into the Mountain Region, at its northwest end (Cerberat Mountains area). Here the ranges trend north-south, but the trend swings southeast south of the Cerberat Range. In the Swansea-Wickenburg area this trend is interrupted by a pronounced northeast direction of the ranges (Harcuvar and Harquahala Ranges); but the southeast trend is resumed south of here, and continues to the Mexican border, west of longitude 112°.

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In the southeast portion of the state, east of longitude  $112^{\circ}$ , both north-south and southeast trends exist.

These elongate mountains of presumably tectonic origin do not exist in the Mountain Region, where it adjoins the Colorado Plateau (northwest of Miami). The closely-packed ranges here appear mainly due to erosion; they have various trends, but the Mountain Region in this segment seems to be separated from the Desert Region by a zone of high-angle faults (Plate 1, faults north and east of Wickenburg).

Low-angle thrusts are not uncommon, notably the Artillery Peak thrust northeast of Planet, that bounding the Tanque Verde Mountains on the southwest, the thrust along the southwest side of the Dos Cabezas Mountains, and that in the Swisshelm Mountains east of Gleeson (Plate 1). Lesser thrusts, such as the Gold Hill thrust at Bisbee and that at Pima, cannot be shown.

Strong folding, of alpine type, is limited to areas of thick sediments, notably in the southeast part of the state, where the Swisshelm Mountains north of Douglass contain a major recumbent anticline broken by a thrust. Close folding is exhibited also in the Chiricahua, Santa Rita and Patagonia mountains. Elsewhere, where the sediments are thinner, notably in the central and western portions of southwest Arizona (formerly Mazatzal Land) folding is gentle or absent and the chief agent of deformation has been faulting.

Mesozoic and Tertiary granitic intrusions in Arizona are concentrated largely in the area of deep sedimentation and profound deformation in the southeast portion of the state (Plates 1 and 2; Fig. 2). West of this area they are sparse, although some granitic masses assigned to the Precambrian in this Desert Region may be much younger.

## COPPER DEPOSITS

The great copper deposits at Jerome are considered, on apparently firm grounds, to be Precambrian in age: Cambrian sediments were laid down over one such ore body after oxidation of the ore had been well advanced. Similar direct evidence is lacking for the other copper deposits in Precambrian schist in the Bradshaw Mountains south of Jerome (Plate 1 and 2) but Lindgren (1926, p. 31-32) offers convincing indirect evidence for a Precambrian age. The copper deposits of this region, on that assumption, although quite possibly worthy of study, lie outside the scope of the present investigation and will not be discussed.

The remaining copper deposits, mainly associated with granitic intrusions of Mesozoic to Tertiary age, are, like the main swarm of these intrusions, concentrated in the area of deep sedimentation and intense deformation in the southeast part of the state (Plates 1 and 2; Figures 1 and 2). This area contains every important copper deposit in the state except Morenci, Ajo, and Bagdad.

Distribution of zinc and lead deposits very nearly coincides with that of copper deposits. Important deposits of copper and zinc occur together at Bisbee, and in close proximity at Johnson, Pima and in the San Manuel district. Zinc occurs on the fringe of the copper ore body at Superior; minor zinc and lead deposits occur at Miami, Miami and Silver Bell. Lead and zinc veins are found near the Bagdad porphyry copper deposit.

The southeast area, containing the great bulk of major copper deposits, produced, to 1948, 67% of Arizona zinc and 74% of Arizona lead

(Wilson, 1950, p. 13). The next largest productive area lies toward the northwest end of the Mountain Region. Here the Wallapai (Chloride, Cerbat) and Cedar Valley (Antler) district (Plate 1) produced 80% of Arizona zinc and 8.5% of the lead, to 1948.

If the Precambrian Jerome copper deposits are excluded, surely the southeast area, containing Ray-Miami, San Manuel, Silver Bell and Bisbee, must play as dominant a role with regard to copper as it does with regard to lead and zinc.

The major copper deposits, except for Bisbee (and Precambrian Jerome) are all of the disseminated "porphyry" type. As pointed out by Sales (1954) they fall into two classes, late magmatic (Ajo) and hydrothermal (Morenci, Ray-Miami, Bisbee and others). The recent discovery of the Pima ore body suggests a possible third class.

#### TYPES OF DISSEMINATED COPPER DEPOSITS

Late Magmatic Type.- The only example wholly representative of this type is Ajo.

##### Ajo

The New Cornelia disseminated copper ore body occupies only a small part of the Cornelia quartz monzonite stock; the quartz monzonite containing the ore body is markedly porphyritic, with fine-grained groundmass, while the texture of the main stock is equigranular (Gilluly, 1948, p. 29). The porphyry occupies a ridge or cupola superimposed on the main intrusive mass. During a late phase of intrusion, the porphyry ascended into the frozen "hood" of the stock, forming the cupola or "blister". The porphyry carried with it most of the primary copper, which was later distributed during cooling and crystallization, depositing in innumerable minor fractures, as chalcopyrite and bornite, with quartz.

Prior to entry of the copper into the "crackled" porphyry cupola, the latter was intruded by solutions which deposited abundant potash feldspar and quartz, forming pegmatite masses. Silica spread widely from the channels which brought in the pegmatite, "flooding" the rock. Magnetite closely followed the pegmatite, and the sulphides followed the magnetite. All of the above solutions followed essentially the same channels, so that introduced potash feldspar, introduced quartz and introduced magnetite are guides to ore at Ajo. These events took place during the "late magmatic stage". Simple sulphides, chalcopyrite and bornite, characterize this stage; so does a scarcity of pyrite and a lack of sericitic alteration.

On the east fringe of the ore body pyrite and sericite are relatively abundant; these represent the hydrothermal stage, when sulphur had become an important constituent of the underlying parent magma, still differentiating. By this time temperatures had decreased. Charles Meyer tells me that the late magmatic or orthoclase stage takes place at temperatures of 600°C or higher, while the hydrothermal or sericite-pyrite stage operates below that critical temperature. Increasing partial pressure of water vapor in the magma has little effect in promoting the late magmatic stage; the critical factor is temperature. At Ajo, the hydrothermal stage, quite local, took place as temperatures were dropping.

For extensive supergene sulphide enrichment of copper, the presence of considerable pyrite is needed. It is significant that during the mid-Tertiary weathering of the New Cornelia ore body, the pyritic fringe was mainly exposed, and extensive supergene enrichment occurred. In relatively

recent times, faulting and tilting removed the pyritic fringe from exposure to weathering, and substituted the primary ore with sparse pyrite. Supergene enrichment this time was negligible, the sulphides oxidizing in place.

At Ajo the primary ore carries about 1% copper and is being mined.

#### Bagdad

Data from Anderson, Scholz and Strobell (1955).

A quartz monzonite stock intrudes Older Precambrian rocks. As at Ajo, the disseminated copper deposit occupies only a portion of the main mass. The quartz monzonite ranges in texture from porphyritic to seriate (Size of crystals varies gradationally). It seems likely that the dominant texture is porphyritic, because the more or less equigranular texture of the rock in and near the ore body is due to introduction of secondary orthoclase which approaches in size that of the primary plagioclase phenocrysts.

As at Ajo, the hypogene alteration associated with the sulphides was characterized by orthoclase and quartz, here with addition of albite and biotite. Pyrite is more abundant than at Ajo, but as at Ajo, it is most abundant on the fringes of the ore body. The chief primary copper mineral is chalcopyrite. Molybdenite occurs both at Ajo and Bagdad.

As might be expected from the relative abundance of pyrite, supergene enrichment is much more prominent at Bagdad than that which occurred during the recent period of weathering at Ajo, but the chalcocite blanket was thin, averaging not much over 100 feet in thickness.

The primary ore, now being mined, is much lower grade than that at Ajo, averaging only about 0.5% copper.

Bagdad seems to represent a type of deposit transitional between late magmatic and hydrothermal.

Hydrothermal Type.-

Ray-Miami

Data from F.L. Ransome (1919) and Peterson, Gilbert and Quick (1946).

The Miami disseminated ore bodies occur along the north lobe of the Schultz granite, a large stock of presumably Laramide age which has been intruded into Precambrian Pinal schist. The main granite mass, while porphyritic, has a fairly coarse-grained groundmass; but the north lobe, in and near the ore, is a decided porphyry with fine-grained groundmass. The quartz monzonite porphyry which carried ore in the No. 1 mine at Ray has an equally fine-grained groundmass.

At Miami most of the disseminated ore lies in schist near the north contact of the porphyry. At Ray much of the ore in the No. 1 mine lay in porphyry, but the No. 2 mine ore is entirely in schist.

In both districts the ore changes neither in mineralogy nor grade in passing from porphyry to schist.

The primary sulphides do not constitute ore in either camp, except that at Miami much of the protore is slightly enriched and may be ore at present. At Ray the protore averages only about 0.5% copper.

Pyrite is by far the most abundant primary sulphide; the primary copper sulphide is chalcopyrite. Sparse molybdenite occurs. The alteration minerals associated with the primary sulphides are sericite and quartz.



### Other Hydrothermal Districts

The salient features of the hydrothermal type are as follows:

1. Association of sericite (and in some districts clay minerals) with ore.
2. Deposition of ore not only in the porphyry with which it seems to be associated, but also in the intruded rock at some distance from the porphyry.
3. The generally low copper content of the protore, the dominant sulphide of which is pyrite, unlike the late magmatic protore.
4. Relative abundance of pyrite induced, under proper climatic conditions, extensive supergene enrichment. Most hydrothermal disseminated deposits are mineable only because of their blankets of supergene chalcocite.

At Morenci the quartz monzonite porphyry containing the disseminated ore body is far larger than the ore body. It has a fine-grained groundmass. Sericite accompanies the primary sulphides, which carry less than 0.5% copper. Ore mined in early days came from limestone replacements well away from the stock, and from veins. Bisbee is quite like Morenci.

At San Manuel monzonite porphyry, with fine-grained groundmass, intrudes Precambrian quartz monzonite. Ore occurs in both rocks. The primary sulphides are pyrite and chalcopyrite, pyrite increasing at depth to the virtual <sup>exclusion</sup> of chalcopyrite. Here much primary ore is mineable.

At Silver Bell stocks of alaskite, dacite porphyry and monzonite intruded Paleozoic and Mesozoic sediments. The latest of these, monzonite, appears most closely associated with the primary ore, in time and space; but sulphides occur not only in monzonite, but in alaskite, dacite porphyry and dacite agglomerate as well. Pyrite dominates over

chalcopyrite in the primary ore, and is more widely distributed. Alteration associated with the metallization produced argillic minerals, sericite, alunite quartz and other minerals. The argillic minerals are those most closely associated with the copper. The two main ore bodies are mineable solely because of supergene enrichment.

The Pima ore body consists of a central layer of high-grade chalcopyrite ore in a limestone bed now clay and garnet, encased in a much larger body of low-grade ore, disseminated through serpentized dolomitic limestone, on the north or footwall side, and quartzite, on the south or hanging wall side. Pegmatite appears to have been injected into the hanging wall quartzite. This fact, together with the abundant garnet, magnetite and other "contact metamorphic" minerals suggests the nearby presence of a sizeable stock. The presence of pegmatite suggests a late magmatic type, but the relatively high pyrite and the occurrence of the sulphides in sediments point to the hydrothermal type. Until more is known, it seems best to classify this ore body as a member of an "heretical" type of copper deposit.

Structural Environments of Late Magmatic Type, and of Hydrothermal Type.- Ajo lies midway between the northwest and southeast basins of sedimentation described above, and the Cordilleran geosyncline, which in earlier Paleozoic and recurrently at later times bordered Arizona on the west (Figures 1, 2). This persistently positive spine between the eastern and western belts of thick sedimentation extended southeast for hundreds of miles in Mexico in Paleozoic and Mesozoic times. Bagdad, which shows characteristics both of the late magmatic

and of the hydrothermal types of copper deposits, lies along the same positive axis, but near its northwest end and close to the northwest persistent trough of Paleozoic sedimentation.

All copper deposits of the hydrothermal types except Morenci are in southeast Arizona, within the area of Paleozoic and Mesozoic deep geosynclinal troughs (Figures 1,2). This group includes Cananea (except the magmatic Colorado ore body) and Pilares, in Sonora (Figure 2).

Deposits of the hydrothermal type show far more structural control than do those of the late magmatic type. At Ajo, Gilluly failed to find evidence for any notable structural control of the monzonite intrusion or of the ore body, in which the mineralized veinlets show chaotic orientation. At Bagdad in contrast the stocks are aligned along a northeast axis and the mineralized veinlets show three dominant trends. At Bisbee the Sacramento Hill stock invaded the Dividend fault; away from the stock replacement ore bodies in the limestone show strong control by fissures and sheeted zones, the principal members of which strike north-northeast. At Morenci the quartz monzonite porphyry is elongated in a northeast direction and ore-bearing veins follow that trend. At Miami two parallel northeast trends govern the ore, the northerly one containing the Castle Dome and Copper Cities copper deposits, the southerly one, the Miami-Inspiration copper zone. At Castle Dome the mineralized veinlets strike dominantly northeast.

At Silver Bell the three major plutons are believed by Richards and Courtright (1954, p.1095) to have successively invaded a great fault between Paleozoic and Cretaceous sediments. This "line of profound structural weakness" controlled also the solutions effecting the hydrothermal alteration associated with the metallization.

According to Sales (1954, p. 502-505), the series of events leading to the formation of porphyry copper deposits, both of the late magmatic and of the hydrothermal types, is as follows:

1. Intrusion of a granitic batholith.
2. Cooling, differentiation, fractional differentiation.
3. Intrusion of part of the fluid magma up into the now crystallized granite hood or into the roof rocks, forming a sub-hood cupola.

If the subhood intrusion occurred at a stage so early that no copper had collected or concentrated in the magmas in commercial amounts, the porphyry will be barren as the majority are. If the intrusion took place at a stage when differentiation had developed an aqueous magmatic residue composed of water, volatiles, some sulphur and metals, and the materials which form orthoclase and mica (potash, silica, alumina, iron, magnesia), the intrusion would bring up with it part of the copper, which was distributed during cooling and crystallization as seams and veinlets of chalcopyrite and bornite forming in "crackled" portions of the porphyry mass. This is the late magmatic type of deposit, where orthoclase is the typical mineral associated with ore.

Gilluly believes the "crackling", with chaotic orientation of joints, typical of late magmatic deposits, to have been due to accumulation of vapor pressure in the cupola to a point where it exceeded the strength of the congealed rock in the upper part of the cupola.

4. Meanwhile the main magma below is still differentiating. Sulphur and various metals, copper, lead and zinc, are increasing in the residue. But crustal fissuring is needed to tap this residue. This is the reason why hydrothermal deposits depend so strongly on structural control, largely fissuring and faulting.

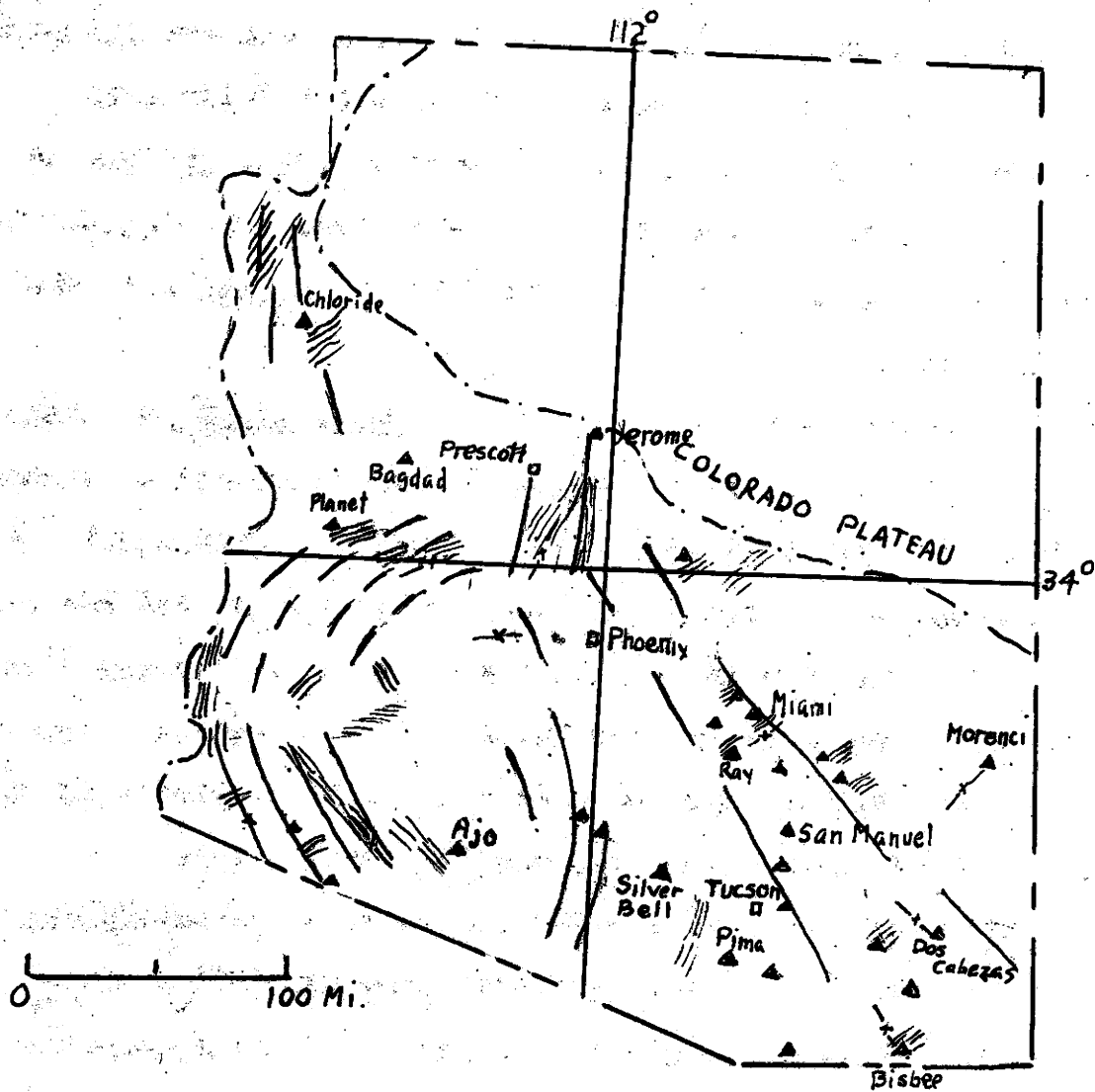
Late magmatic and hydrothermal processes of metallization may occur in the same place. This was the case at Ajo. In other camps, hydrothermal alteration may have sericitized orthoclase derived from late magmatic activity and thus destroyed the evidence for that activity.

It has been shown that the protore in porphyry coppers of the hydrothermal type is usually lower in copper content than late magmatic protore. This opposes Sales' theory, which was based primarily on Butte, where extremely rich copper ores were deposited in fissures by hydrothermal solutions. Meyer (personal communication) hazards the guess that hydrothermal solutions may have leached part of the copper in porphyries formed in the late magmatic stage, adding the copper to the supply from which they deposited rich ore bodies in the nearby wall rock (Bisbee, Morenci, Old Dominion mine at Miami).

#### STRUCTURAL HISTORY OF ARIZONA

Obviously there are at least two types of disseminated copper ore bodies to look for in Arizona: (1) late magmatic (Ajo, and in the main, Bagdad). With this type the protore may be mineable, and owing to the characteristic sparseness of pyrite, supergene enrichment may not be notable. (2), hydrothermal type. Here structural control is important, grade of protore will probably be low, and the deposit will depend on supergene enrichment to make it mineable. Cycles of weathering will therefore be critical factors. (3): The Pima ore body may not form a third type, but rather, suggest that unorthodox types which defy pigeonholing should be watched for.

Where shall we look for new deposits? The structural history of the region may supply hints.



**OLDER PRECAMBRIAN STRUCTURAL GRAIN AND  
PRESENT MOUNTAIN SYSTEMS**

**LEGEND**

- Trend of mountain system with Older Precambrian core:
- Structural grain in Older Precambrian:
- Major axis of elongate granite mass:
- Strike of schistosity:

After Stoyanow (1942, Fig. 1).

**FIG. 3**

Precambrian.- Detailed history of the Older Precambrian (Archean) has not been deciphered because of the difficulty of correlating non-fossiliferous formations in space and time. Apparently the great intrusions of Precambrian granite took place before deposition of the Younger Precambrian Apache group; but whether there was one or several epochs of intrusion, and whether the extreme deformation exhibited by much of the Older Precambrian schists springs from one or several orogenies is not known.

Important from our standpoint is the structural grain of these ancient rocks, shown by trend of schistosity and alignment of elongate granite masses and roof pendants. Butler and Wilson (1938, p. 20) point out the accordance of the trends of Laramide intrusions and ore fissures, and later Tertiary veins, on the one hand, and the Precambrian grain, on the other, and suggest that Precambrian structures strongly influenced these later deformations. Pennebaker, in a paper read before the A.I.M.E. in 1954, documented this thesis with examples.

Figure 3 reproduces in part a structural map by Stoyanow (1942, Fig. 1), which shows the trends of present schistose and granitic mountains. To this I have added known trends of Precambrian grain. Presumably these mountains, mainly of tectonic origin, owe their shapes to later Tertiary or even younger deformation, but there are striking correlations with the ancient grain, shown especially by the transverse ranges east of Planet, the northwest ranges west of Ajo, and the nearly north-south ranges west of Tucson. In the Miami-Bisbee belt the ranges trend at right angles to the Precambrian grain, but the northeast Precambrian

grain has strongly influenced Laramide deformation, intrusion and metallization. This influence is especially strong at Morenci, east of this belt.

Paleozoic.- (Data mainly from Stoyanow, 1942). Refer to Figure 1.

#### Cambrian

In early Middle Cambrian the shallow Tapeats sea invaded from the northwest, as an arm of the Cordilleran geosyncline on the west. The Tapeats sea encroached on Mazatzal Land, the positive element crossing Arizona in a northeast direction. The Tapeats sea soon retreated northwest but in late Middle Cambrian another sea invaded southeastern Arizona, depositing the TROY and Bolsa quartzite. This sea retreated also, in the course of its retreat depositing the Abrigo limestone.

As shown in Figure 1, the Cordilleran geosyncline bounded Arizona on the west and extended far into western Mexico. The area of this trough is separated from that of the trough in southeastern Arizona by a wide belt of Older Precambrian schist and granite which connects to the northwest with similar rocks in southwest Arizona. This belt, trending northwest, is called by Stoyanow the Altar Headland of Mazatzal Land. It has been a persistently positive belt since the start of the Paleozoic.

#### Ordovician, Silurian and Early Devonian

During these epochs Mazatzal Land expanded so greatly that most of Arizona was out of water.

#### Late Devonian

Seas entered Arizona from the northwest and from the southeast



filling troughs which correspond uncannily to those of the Cambrian ingressions. Neither the Cambrian nor the Late Devonian seas effected a junction, although they almost met near Payson.

Northwest and southeast of the Payson area of Maxatzal Land, the Devonian lies conformably above the Cambrian, but in the Payson area Devonian rests with unconformity on Precambrian rocks.

#### Mississippian

Both the northwest and the southwest troughs persisted into the Early Mississippian, but the southeast trough deepened much more than did the northwest one. In the southeast trough the Escabrosa sediments were laid down conformably above the Devonian Martin. The <sup>ca</sup>Escabrosa thins rapidly northwest, toward Payson.

In the Late Mississippian all of Arizona rose above the sea except the area of the Chiricahua Mountains.

#### Pennsylvanian

In the Pennsylvanian the sea once again invaded southeastern Arizona, reaching the Payson area. The northwestern trough, however, remained land; as a trough it was permanently destroyed at the close of Early Mississippian.

#### Permian

During part of this time Arizona toward the western edge of the great Permian Basin, which extended eastward across New Mexico and into Texas and Oklahoma. Most of this sea was shallow, but in southeast Arizona deeper-sea deposition went on well into the Permian.

Summarizing the Paleozoic, there is no record of intense and extensive diastrophism, but the alternate sinking and wiping out of marine troughs is a striking feature. Within Arizona, the southeast trough

was deepest at its extreme southeast end through each Paleozoic invasion. Every transgression started from the southeast, and during withdrawals waters stayed there longer or lingered until the time for a new northwest advance.

The permanent location of marine troughs throughout the Paleozoic suggests a northwest belt of structural weakness, interrupted by the northeast resistant rib of Mazatzal Land, crossing the weak belt at Payson. The southeast member of the weak belt was the weaker of the two, for this basin is sharper than that to the northwest, and it deepened more with each ingression. Especially noteworthy is the western embayment in the basin, from Tucson to Silver Bell, and which formed, in exactly the same place, in the Cambrian, Devonian, Mississippian, Pennsylvanian and Permian.

Relation of Granitic Intrusives and Copper Deposits to Paleozoic Troughs.- Figure 1 shows strikingly the concentration of major copper districts within the southeast trough; Figure 2, where this trough is outlined, shows the swarm of granitic intrusives within it. Figure 2 shows also the concentration of Mesozoic and Tertiary intrusives in far southeastern California within the Cambrian and Triassic major geosynclines. The habit of plutons to invade sharply-defined and deep geosynclinal "furrows" is exemplified all over the world. The string of great batholiths extending from Alaska to the south tip of Baja California, <sup>invaded</sup> a deep and narrow trough which persisted almost through the entire Mesozoic.

Mesozoic.- Data mainly from McKee (1951).

#### Triassic

At the close of the Paleozoic the southern half of Arizona rose above the sea. The most vigorous uplift seems to have taken place in the

Upper Triassic. It took the form of a northwest peninsula extending through southern and central Arizona, between the deep Cordilleran trough on the southwest (Figure 2) and a shallow, broad sea on the northeast. It was, in effect, an uplift of the Altar Headland (Figure 1).

#### Jurassic

In the Triassic the Cordilleran geosyncline, passing down from Utah through Nevada and bounding Arizona on the west, connected with the Pacific Ocean; but in the Jurassic the northwest landmass or Altar Headland advanced northwestward and cut off the Cordilleran geosyncline forever from the Pacific. During the rest of the Mesozoic the truncated geosyncline became the Utah trough. The southeast extension of the Altar Headland, extending many hundreds of miles into Mexico as a spine separating the Mexican trough from troughs bordering the Pacific, became in the late Jurassic the locus of vigorous uplift (Occidental geanticline). At the end of the Jurassic this uplift was felt in Arizona, where a rising landmass of strong relief provided, in the Lower Cretaceous, the coarse cobbles and boulders of the Gance conglomerate.

#### Lower Cretaceous

The major displacement on the Dividend fault at Bisbee presumably took place at the end of the Jurassic or start of the Cretaceous. The northeast block was relatively uplifted and the entire Paleozoic section stripped from it by erosion before deposition of the Gance conglomerate. Gance conglomerate is found high in the Huachuca Mountains, near Helvetia, and in the Tanque Verde and adjoining ranges northeast of Tucson (Plate 1). This whole region must have been one of high relief at the time, but soon there came a dramatic reversal, from strong uplift to marked downwarping, because in the Lower Cretaceous the Mexican

trough grew northwestward and the sea invaded southeastern Arizona once again, occupying nearly the same area as did the Paleozoic seas (Figure 2).

The landmass which furnished material for Lower Cretaceous sediments was the Occidental geanticline, the old Altar Headland, which continued to rise vigorously in the early Lower Cretaceous, as shown by the great thickness and coarseness of the lower members of the Bisbee group in northern Sonora. As the trough continued to sink and the land to be eroded, the sediments changed from clastics to limestone (Mural limestone).

Another reversal of movement seems to have taken place at the end of the Lower Cretaceous; central and southern Arizona were again uplifted.

#### Upper Cretaceous

The region remained above water until latest Cretaceous, when the Mexican trough, which had retreated to the southeast, again advanced and once more flooded southeastern Arizona. This final trough sank the deepest of all Paleozoic or Mesozoic troughs (Figure 2).

Laramide Revolution.- At the end of Cretaceous and extending into early Tertiary time, the Laramide revolution found its expression here mainly in a sudden expansion eastward of the Occidental geanticline, which wiped out and uplifted the Mexican trough. The deformation was accompanied by sharp folding, in places, of the sediments in the southeast area of thick sedimentation; by thrusting and high-angle faulting; by volcanism, intrusion and metallization.

Later Tertiary.- This was a period mainly of <sup>erosion.</sup> volcanism and normal faulting which culminated in the Basin and Range faulting which gave

the desert ranges of Arizona their present shape.

In Pliocene-Pleistocene time an accentuation of differential uplift, by warping and block faulting created a series of high ridges separated by deep valleys in which the Gila conglomerate was laid down (Figure 4). For the most part the ridges and valleys follow northwest structural trends initiated by the sedimentary troughs of the Paleozoic and accentuated in Mesozoic time by similar troughs and by the rise of the Occidental geanticline.

#### DISTRIBUTION OF COPPER DEPOSITS IN THE STRUCTURAL FRAMEWORK

The copper deposits involved in the present study presumably were formed during the Laramide revolution. A picture of the structure of Arizona at the end of that period might offer hints on the localization of some of these deposits.

Much deformation, chiefly faulting and perhaps, warping, succeeded the Laramide orogeny. But as repeatedly pointed out, younger deformations were strongly influenced by earlier ones. It seems especially true that post-Laramide faulting and warping followed in large part in the footsteps of the Laramide orogeny, merely accentuating faults and upwarps initiated during or before the Laramide deformation. If this be so, the present topography of the crystalline basement may reflect, in large part, Laramide deformation.

Topography of the Crystalline Basement.- Plate 2 is an attempt to depict the topography of the basement on which the Paleozoic and Mesozoic strata were laid down. Data permit only a fragmentary presentation, and the problem is further complicated by the fact that at the start of the Cretaceous the Paleozoic cover was stripped away in many parts

of Arizona, before the Lower Cretaceous sediments were deposited. Since the structural contours on top of the crystalline basement were drawn in part by projecting downward the dips of the lowest strata, the above fact makes trouble; but in spite of this, the picture offered by Plate 2 offers some interesting suggestions.

The first notable feature involves the Colorado Plateau. Although the surface of the Plateau averages about 6000 feet above sea-level, the crystalline basement there slopes gently down to the north, and passes as much as 3000 feet below sea-level. Elevations of the basement reach their maxima in the Mountain Region, along the southern border of the Plateau.

The cover has been largely stripped from the basement in the Mountain regions so that depiction of the shape of the basement surface is impossible. But elevations above sea-level of the basement rocks give minimum values for the amount of uplift; and although these absolute elevations may be due in part to epirogenic elevation, in Pliocene time, of the entire western region of the continent, relative elevations are not invalidated, because the lower country rose with the higher.

As Plate 2 shows, the Mountain Region, not only where it borders the Plateau on the northwest segment, but where it swings away from the Plateau, in the southeast segment, was the locus for exceedingly strong relative uplift, presumably dating from the Laramide. Minimum present elevations for this elongate uplift reach 5000 feet on the northwest (Hualpai Mountains) and nearly 11,000 feet on the southeast (Pinalena Mountains).

From Miami northwest the uplift took place mainly in Mazatzal Land, where the sedimentary cover was thin and the basement lay at relatively high elevations to begin with. Here Laramide uplift was moderate. But from Miami southeast the uplift affected the area of deep sedimentary <sup>deposition</sup>; just before the uplift, in latest Cretaceous, the basement lay thousands of feet below sea-level; since basement rocks at present reach elevations of nearly 11,000 feet above sea-level, uplift along the orogenic belt here has been tremendous.

In the Desert Region, southwest of the Mountain Region uplift, elevations attained by the scattered ranges are only moderate, for the most part. The sedimentary cover has been almost entirely removed from this region, and it might be supposed that erosion has cut so deeply into the basement complex as to remove even the roots of any ore bodies that may have existed. I doubt if this is the case. Sparse remnants of Permian (?) sediments fringing mountain ranges in the western part of the region lie at elevations of only 1000 or 2000 feet, although the crests of these ranges, from which the cover has been stripped, rise to over 5000 feet in places (Harcuvar and Harquahala Mountains, Plate 2). Topography of the top surface of the basement evidently was highly irregular, with high areas separated by much lower basins; but in general the Desert Region marks a dying out of uplift to the southwest, away from the axis of maximum uplift now represented by the Mountain Region.

Structural contours on the top surface of the basement (Plate 2) show that uplift was throughout markedly differential, not broad, uniform, epeirogenic. Most individual uplifts are elongated parallel to the structural grain of the region, in most areas northwest. In the southeast area, these uplifts are separated by marked depressions.

In terms of folding, there are two main types. One involves simple flexing upward of the beds along the margins of uplifts, quite like the flexing of beds along the eastern edge of the Front Range in Colorado, or the margins of the Big Horn Range in Montana and Wyoming. This type is exemplified by the Flomosa Range in western Arizona, by the range west of it, and probably by the Harquahala Range. It is shown also by the Tanque Verde and Huachuca elongate uplifts.

The Mule Mountains, containing Bisbee, have been thoroughly studied. The cover has not been entirely stripped from the crest of this broad northwest anticline, unlike the case of the other uplifts mentioned and the Mule Mountains probably offer a picture of the original structure of the other uplifts. It is almost certain that the Mule Mountains broad anticline was formed during the Laramide revolution, and it is safe to assume that the others did also, and that their structure has merely been accenuated, in some cases, by later deformations following the same structural trends.

Simple <sup>↑</sup>uplifts of this type are in my opinion due to differential vertical movements and not to compression exerted tangentially.

The other type of folding approaches the Appalachian type, with long parallel fold axes. Unlike the first type, which tends to stretch the sedimentary cover, the close folds of the second type tend to shorten it laterally. Folds of this type are confined entirely to the southeast area of deep and repeated sedimentation, and are exemplified in the Swisshelm and Chiricahua mountains. The structural contours of Plate 2 suggest a series of very large Appalachian folds in the Johnson-Gleeson area.



Not only are Appalachian folds confined to the area of deep sedimentary basins, but their axes follow faithfully the structural contours of the youngest basin, in this case that of the Upper Cretaceous, which sagged just before the folding. (Plate 2, Figure 2). Curiously, one of the Paleozoic basins appears to have influenced Laramide folding, and that is the sharp northwest embayment containing Silver Bell (Fig. 1). At Silver Bell, Paleozoic and Mesozoic strata, although distorted, strike in general west-northwest, parallel to the axis of the embayment.

This nearly east-west trend seems to have extended east of the embayment within the main trough, because folding at Pima trends east-west.

Relation of Intrusives and Copper Deposits to Basins of Sedimentation and to Basement Deformation.- Concentration of granitic intrusions and major hydrothermal copper deposits in the Paleozoic and Cretaceous basins has been pointed out (Figures 1, 2). These intrusions and ore deposits lie also in the southeast segment of the Mountain Region belt of strong uplift; thus they lie in that belt, but only where it has uplifted the area of deep and repeated crustal sag, alternating with earlier, but less severe uplift. Important copper deposits of post-Archean age are lacking northwest of Miami, where the uplift involves the positive element of Mazatzal Land. (Bagdad will be discussed under late magmatic deposits).

The reason for this localization of hydrothermal copper deposits is not hard to find. The basin or trough area had been one of extreme crustal weakness long before the Laramide orogeny; it was weakest of all just before that orogeny, and for that reason became a locus of maximum deformation, intrusion and metallization.

Within this productive deformed area note that porphyry coppers typically occur close to the contact between the crystalline basement and the sedimentary cover (Miami-Ray, Bisbee; outside the basin area, Morenci). At Bisbee, if current ideas are sound, the Cretaceous sediments, at least the lower formations, were present when the stock intruded the Dividend fault, but the intrusion refused to enter the inhospitable Glance conglomerate.

The second point of importance is that porphyry coppers, as well as copper deposits in the sediments, favor crests or flanks of uplifts. Thus Miami lies along northeast structures (Precambrian in origin) on the crest of a northwest broad anticline. Superior and Ray are on the east flank of a still broader uplift. Xmas lies on the east flank of a narrow ridge between two sharp troughs. Folding is sharper in the Johnson-Gleason area, but these districts are on the northeast flank of a major northwest anticlinorium.

Bisbee lies on the southeast flank of the Mule Mountains anticlinal uplift. Helvetia is on the northeast flank of a long, narrow uplift probably continuous with the Huachuca uplift, while Duquesne lies on the east flank of the Patagonia Mountains north-south uplift.

It might be argued that the basins in this region, where the basement and even the Paleozoic and Mesozoic cover are not exposed, might contain an equal number of copper deposits. There are however sound theoretical reasons for disbelieving this. Under deformation, it is the positive, rising elements, anticlines and domes, that crack and fissure best, and the sagging basins which fissure least. The copper deposits of this basin area are of the hydrothermal type; strong deformation, concentrated in the positive elements, provided the deep-going fissures needed to tap the magmatic sources of the ore solutions.

Relation of Intrusives and Copper Deposits to the Occidental Geanticline or Altar Headland.- Intrusives favor the crests of geanticlinal uplifts as well the deep troughs of sedimentation, although to a less degree. Although deformation of sharp, deep troughs produces the strong fracturing that favors hydrothermal type copper deposits, I see no reason why late magmatic type deposits may not, under the right circumstances, be found in such regions also. Nevertheless, the locus for late magmatic type deposits in Arizona seems to be the crest of the Occidental geanticline, the former Altar Headland (Fig. 1). At least, the only two known examples, Ajo and Bagdad, lie here. I can think of only a negative reason for this, namely that the crests of broad anticlines fracture less than do deformed basin belts. Structural control of the Ajo intrusive is not evident. In some way the stock rose without much if any aid from preexisting structure; but it has one thing in common with stocks of the basin area, namely that its main mass lies in the Precambrian; apparently only the cupola containing the ore body extended up into the volcanic cover.

#### APPLICATION OF ABOVE IDEAS TO EXPLORATION FOR COPPER

I do not pretend to sit in an office and tell field men where to find an ore deposit. The present report merely offers background for the field work; the hope is that some of the generalizations, after testing in the field, might make the search for copper deposits a little more systematic. The following suggestions, therefore, are entirely tentative.

Favorable Areas.- Obviously the basin area, from the neighborhood of Miami south to the Mexican border, was originally the most favorable, and in spite of intensive exploration, it may still be. (Figures 1, 2). This area includes not only that of the main basins, but the north-northwest Paleozoic embayment containing Silver Bell and including the Lakeshore and Reward-Vekol districts.

A favorable area not hitherto discussed is a belt extending northeast from Safford to, and perhaps beyond, Morenci (Plate 1 and 2). The strong northeast structural grain in this belt does not fit any of the basic ideas advanced in this report. It is doubtless of Precambrian origin, but why it was intruded and metallized in the Laramide orogeny is not clear. I examined the San Juan prospect some years ago, and turned it down on the basis of exposures there; but the mineralization, in porphyry but perhaps not of the true "porphyry" type, follows strong northeast fractures pointing right at similar ore fractures at Morenci. The fact that flows obscure the picture at San Juan makes this area all the more attractive, since it might explain failure to develop a porphyry copper deposit here.

In considering other possibly favorable areas beside the two rather obvious ones mentioned, consideration might be given to the work of Burnham (1955), who analysed spectrographically specimens of common ore minerals collected from mining districts, to determine the contained trace elements (silver, cobalt, indium, nickel and tin). His most striking results were secured from chalcopyrite. Concentrations of such elements are expressed by logarithms of the product obtained by multiplying concentrations of each trace element (in parts per million). Concentrations at the sample points are contoured into zones (Plate 1, Figure 2).

The main zone, starting near Chlicride and barely including Bagdad, follows the Mountain Region uplift, and the southwest edge of the northwest Paleozoic trough as far as Payson, where it swings southeast, still following the Mountain Region uplift, and enters the southeast Paleozoic basin area (Figure 2). This metalogenetic zone agrees therefore remarkably well with a tectonic zone.

A second zone of strong trace-element concentration follows the southwest edge of the Paleozoic basin area from the Mexican border to Silver Bell, and includes the Pima mine. Burnham extends this zone west from Silver Bell to Ajo; but this extension is based solely on samples from Ajo and from the small deposit at Gunsight near Ajo, so that this extension looks dubious, especially as it has no structural basis, so far as known.

Burnham's main zone might ~~might~~ encourage more attention than would otherwise be given to that segment of the Mountain Region uplift between Miami and Payson, to the Payson district itself, and to the segment from Payson through Bagdad to the California and Nevada borders (Figure 1).

The above list includes all more or less restricted <sup>Areas</sup> of possible promise known to me. There remains the great expanse of the Occidental geanticline, the former Alter Headland positive area, which extends northwest from the Mexican border and carries Ajo on its broad crest, and Bagdad toward its northwest end.

The chief hope for this region lies in the possibility that not all of the granitic rocks shown on Plates 1 and 2 are Precambrian, and that stocks of Laramide age are concealed within larger Precambrian granitic masses, as seems to be the case in the Twin Buttes district which contains the Pima mine.

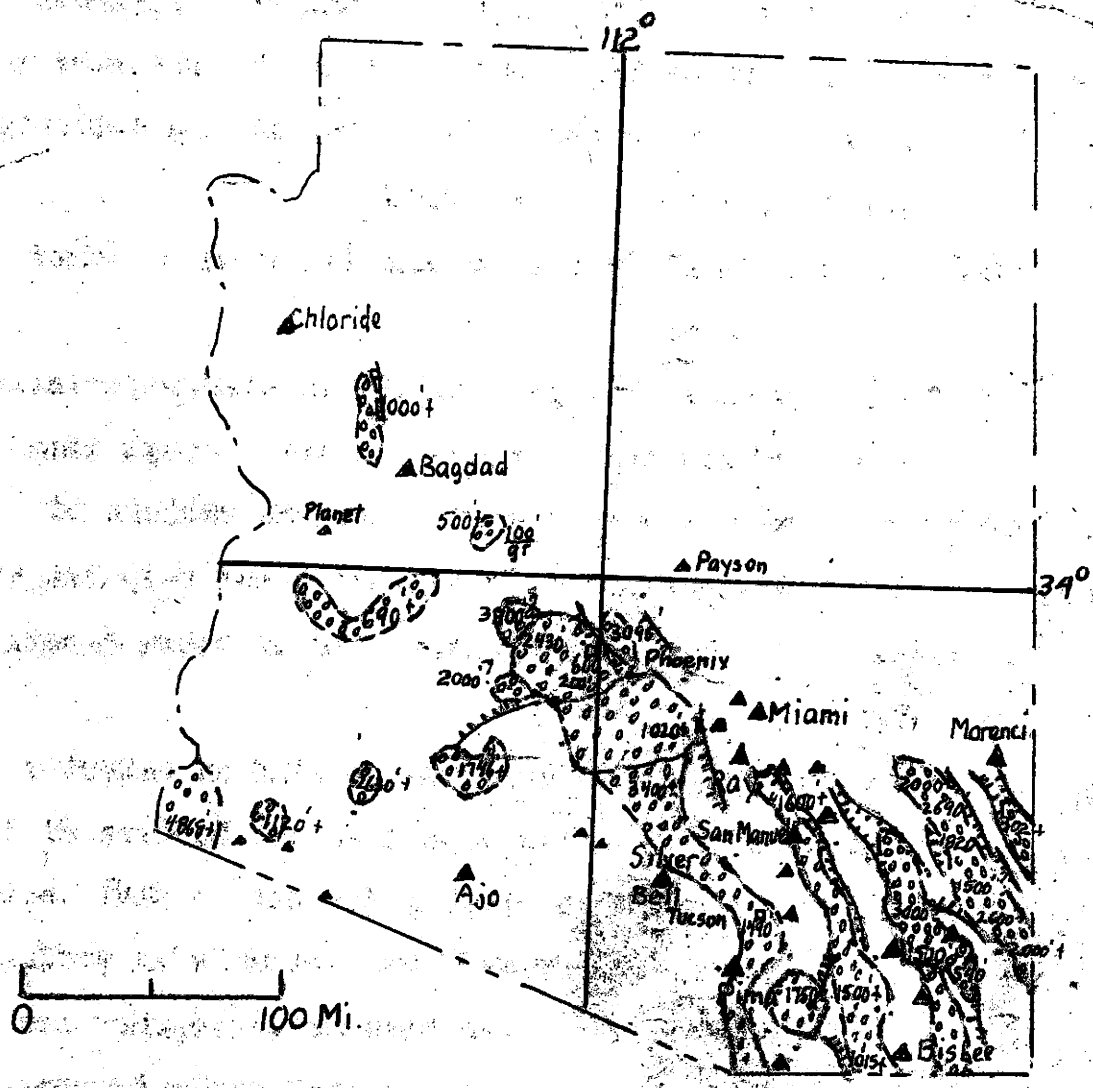
Suggestions for Exploration within the Favorable Areas. - Data at hand are too fragmentary to permit me suggest individual favorable localities within these areas; that is the function of the field men and outside the scope of this report. It must suffice that I offer a few general suggestions for the various areas.

### Southeast Basin Area

Porphyry coppers not yet found, if they exist in this well-explored area, must be hidden, or nearly so (San Manuel). They will probably be of the hydrothermal type, exhibiting relatively high pyrite, in the primary ore, and sericitic and/or kaolinic alteration. Protore will be low-grade, probably, and the value of such a deposit will depend on supergene enrichment.

Careful mapping of structure might lead to discovery of such a deposit, since emplacement of porphyries of this type was largely controlled by structure. Structure to be mapped is not only local (fractures, faults etc.) but regional to disclose the presence or extension of anticlinal uplifts, on the crest or flanks of which the deposit sought for may lie. The contacts between the crystalline basement and the sedimentary cover, on the crest or flanks of uplifts, offer a promising lead, especially where a northeast structural grain is well developed.

Where the upper surface of the basement lies at depth, copper deposits in the sedimentary cover may suggest a porphyry copper below. A little less erosion and Morenci might have been known only as a district of veins and limestone replacements. A little less erosion, and Bisbee would possibly never have been discovered at all. Copper Creek, in the Calaveras Mountains, is a district of productive copper-bearing pipes in Cretaceous volcanics, for the main part. There might be a porphyry copper deposit at depth, although whether or not within depth limits of mining I have no idea. Copper Creek is brought in, not as a recommendation but only to indicate the kind of ore environment I have in mind.



**CENOZOIC DEPOSITS IN PRINCIPAL BASINS OF ARIZONA**

After McKee (1961, Fig. 3)

FIG. 4

### Safford-Morenci Belt

I understand that one or more field parties have been mapping this area, for which I feel hopeful. I understand also that the possibility of pre-ore volcanics is kept in mind, and the chance that alteration and trace elements in such volcanics might indicate the presence of a copper ore body below, or even suggest an ore body in the volcanics themselves. This investigation is well worthwhile.

### Tracing Structural Trends beneath Alluvium or other Cover

Obviously all field men have this possibility in mind, especially since discovery of the Pima ore body. Figure 4 gives a rough idea of the depth of Cenozoic deposits in the intermontane valleys of southern Arizona. It is only along the fringes of these deep basins that geophysical exploration along the prolongation of known trends is feasible.

In this connection a matter which everyone working in desert regions is familiar with perhaps deserves emphasis: the borders of desert ranges are underlain in many places by rock pediments, so that careful search may reveal rock exposures in areas that resemble in profile alluvial fans. Even if such exposures have been detected, they are usually too small individually to appear on regional geologic maps. For this reason. In view of this, a general reconnaissance party might be set <sup>up</sup> (if not already organized). Such a party would carefully examine promising areas where no exposures of interest appear on regional maps, for example, the area between Pima and Silver Bell, that around Silver Bell, and that between Silver Bell and Winkol. There are many small granitic exposures in the Sulphur Spring Valley region, and in the broad San Pedro Valley northwest of Bisbee.



### Ajo-Bagdad Region (Occidental Geanticline).

Looking for major copper deposits in this great region is somewhat like looking for a needle in a haystack, because major fractures here are of Basin and Range origin, and while they mostly follow older trends, they have little or no relation to possible ore bodies. Furthermore, any ore bodies which may be discovered here are likely to be of the late magmatic or Ajo type, which does not seem to be governed much by preexisting structures. Nevertheless this region should be looked over in reconnaissance fashion, to determine whether Laramide stocks are contained in larger exposures of Precambrian granite. With late magmatic metallization, sericite may not be the dominant type of alteration associated with ore; more likely the principal type will be pegmatite. Many Precambrian granites show pegmatite, but attention would naturally be focussed on granite masses showing signs of copper mineralization. With the late magmatic type of deposit, sparse pyrite may prevent much leaching of copper, which as at Ajo may be fixed in the zone of oxidation as carbonates, silicates etc. Porphyry coppers in this region might not show the typical "leached out-crop" with clay and sericite. The rock might even look fairly fresh.

At Alamo in the Kofa Range (Plate 1) a stock of presumably Laramide age is bounded on the west by a shear zone mineralized with chrysocolla and malachite (Wilson, 1933, p. 120). In the northern part of the Cabeza Prieta Mountains (Plate 1) dikes of pegmatite and aplite cut granite. Many dikes carry chrysocolla and malachite in veinlets and small cavities (Wilson, op. cit., p. 163). The same holds for the Copper Mountains (Plate 1). The Mohawk Mountains and other ranges described by Wilson in this region also carry copper-stained pegmatite dikes. These showings may be of little importance in themselves, but they do suggest possibilities for this de-

sert region. I do not think that erosion has everywhere cut so deeply into the basement complex in this region as to have removed completely ore bodies that might have been formed there.

#### CONCLUSION

If generalizations developed in this report prove sound, they may suggest to field men better applications to practical exploration than I can think of in this office. While data on which my generalizations are based are incomplete, they may be amplified by further field and office research, and their study may lead workers in the field to more useful ore guides than I have been able to arrive at.

Berkeley, Calif.  
August 17, 1956

*E. W.*  
Edward Wisser

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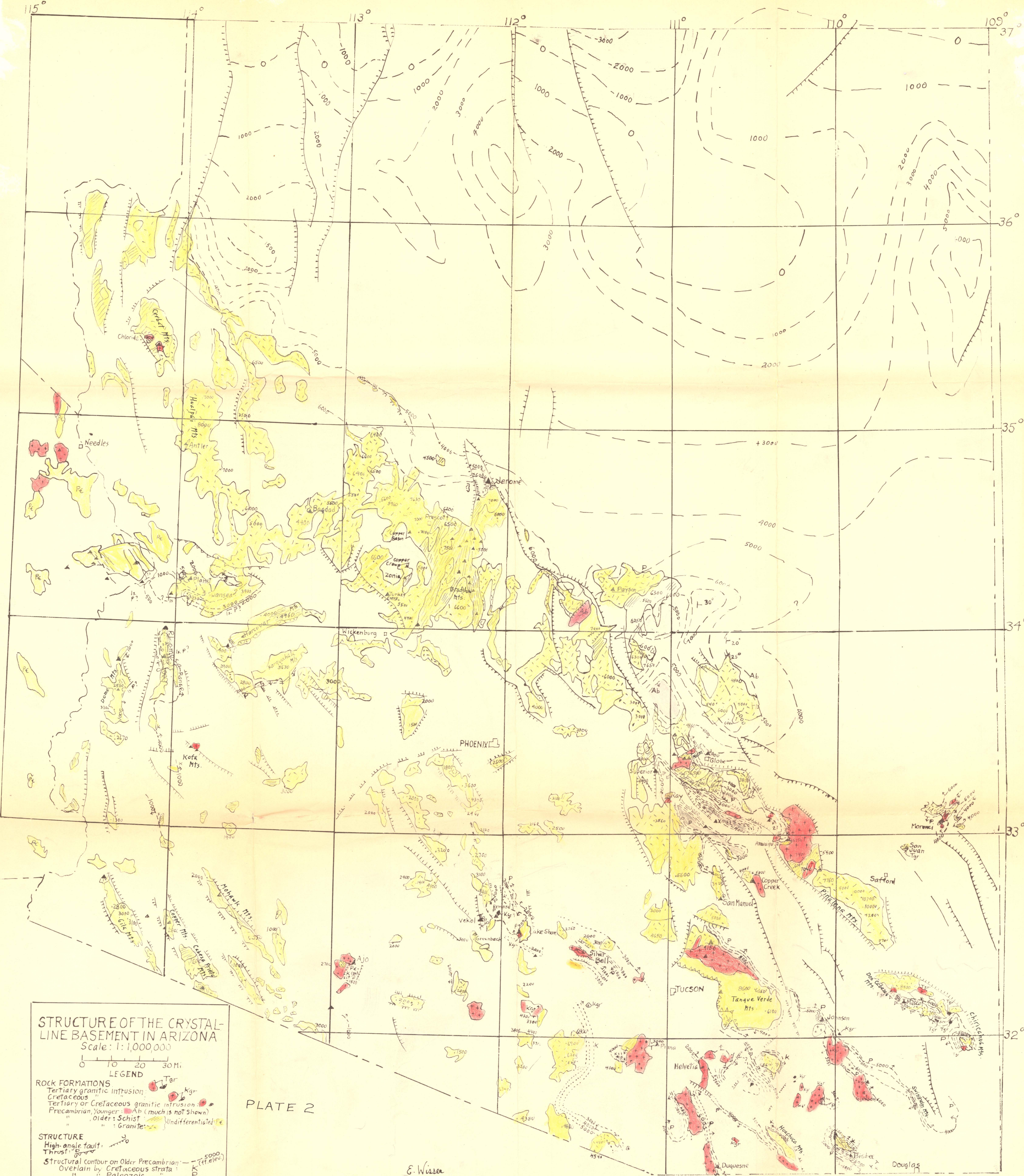
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**STRUCTURE OF THE CRYSTALLINE BASEMENT IN ARIZONA**  
 Scale: 1:1,000,000

0 10 20 30 Miles

**LEGEND**

**ROCK FORMATIONS**

- Tertiary granitic intrusion:
- Cretaceous:
- Tertiary or Cretaceous granitic intrusion:
- Precambrian, younger: (much is not shown)
- Older: Schist:
- Granite: Undifferentiated:

**STRUCTURE**

- High-angle fault:
- Thrust:
- Structural contour on Older Precambrian: (5000 ft. elev.)
- Overlain by Cretaceous strata: K
- " Paleozoic: P
- " Younger Precambrian: Ab

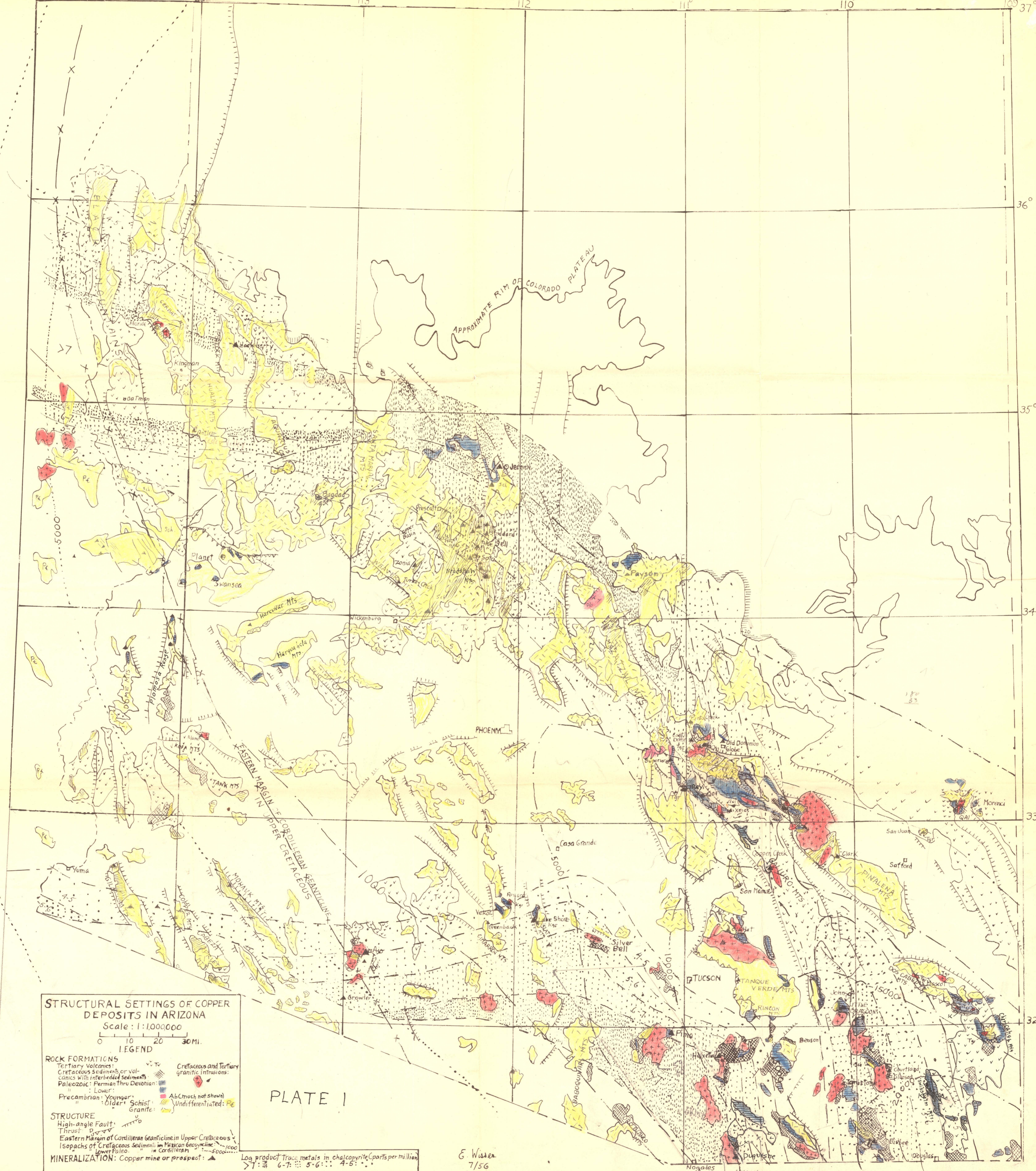
**MINERALIZATION**

- Copper mine or prospect:

PLATE 2

E. Wiser  
 7/56

Isopach of Lower Paleozoic Sediments in Cordilleran Geosyncline



**STRUCTURAL SETTINGS OF COPPER DEPOSITS IN ARIZONA**  
 Scale: 1:1,000,000

0 10 20 30 Mi.

**LEGEND**

**ROCK FORMATIONS**

|   |  |
|---|--|
| Tertiary Volcanics:   | Cretaceous and Tertiary granitic intrusions: |
| Cretaceous Sediments or volcanics with interbedded sediments: |  |
| Paleozoic: Permian thru Devonian:                             |  |
| Lower:  |  |
| Precambrian: Younger:   | Ab (much not shown):                         |
| Older: Schist:  | Undifferentiated:                            |
| Granite:  |  |

**STRUCTURE**

High-angle Fault:

Thrust:

Eastern Margin of Cordilleran Geantillinan in Upper Cretaceous:

Isopachs of Cretaceous Sediments in Mexican Geosyncline:

Lower Paleozoic in Cordilleran:

**MINERALIZATION: Copper mine or prospect:**

Log product trace metals in chalcopyrite (parts per million):  
 >7: 6-7: 5-6: 4-5:

PLATE 1

E. Wisler  
7/56

THE COPPER MINING INDUSTRY 1966-1970

BY: B. H. GERWIN  
Assistant to Director

ARIZONA DEPARTMENT OF MINERAL RESOURCES

Fairgrounds Phoenix, Arizona

Frank P. Knight, Director

OCTOBER 1969

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## THE COPPER MINING INDUSTRY 1966 - 1970

The experiences being recorded in the present history of the copper mining industry are very closely paralleling the chronology of events that took place just prior to, during, and after the last prolonged copper mining industry strike which took place in 1959 and 1960. It remains to be seen whether there will be a continuation of the parallels, with 1970 (three years after the beginning of the long strike in 1967) duplicating the curtailments in output and sales that were experienced in 1962, (three years after the beginning of the long strike in 1959).

The 1959 Minerals Yearbook of the Bureau of Mines, Vol. I stated on page 385:

"Although copper production in the United States reached a record rate in the first 6 months of 1959, the year ended with the lowest annual total since 1949. Operations at most of the principal copper mines, smelters, and refineries were halted by the longest strike in history".

In 1959, mine production had dropped to 824,846 tons.

The 1960 Minerals Yearbook of the Bureau of Mines, Vol. I stated on page 403:

"Record production, record exports, a lower consumption rate, and rising stocks characterized the U. S. copper industry in 1960. Strikes that had begun in mid-1959 continued into early 1960. The need for primary source materials at smelters and refineries after settlement of the strikes stimulated production from the domestic mines and caused near-record imports of blister copper. Mine production in the United States was the largest since 1957. Copper recovery from domestic ores set a new record; production at smelters from imported materials more than doubled; and recovery of copper from scrap increased one third.

"Consumption of copper declined considerably in the United States in 1960. However, demand for copper in the rest of the world was unusually great. Stocks at U. S. refineries at the beginning of the year were the lowest since the turn of the century because of the continuing strikes and the relatively high rate of consumption in 1959. Return to work at primary refineries resulted in near capacity output. The brisk export of domestic copper in the more active Western European markets failed to prevent stock additions in April through December.

"Despite labor disputes and political unrest, world copper production was at a record high. Planned production cutbacks by some producers to limit stock buildups and prevent price declines were more than offset by expanded output from other producers and entry of new facilities in the productive stage."



The 1961 Minerals Yearbook of the Bureau of Mines, Vol. 1 p 497 stated:  
"Domestic production rose 8 percent to a new record; 1961 output was 6 percent above the former peak of 1,104,000 tons in 1956. The new record in mine production was attributed largely to strike-free operations and to the startup of production ahead of schedule at the Mission project in Arizona."

The 1962 Minerals Yearbook of the Bureau of Mines, Vol. 1 p 483 stated:  
"Rates of copper production, which began to accelerate in late 1961, continued to rise through the first 6 months of 1962. Supplies began to exceed requirements, and in mid-July producers here and abroad inaugurated curtailments in output and sales. The price of electrolytic copper in the United States, established at 31 cents per pound on May 19, 1961 was unchanged throughout 1962, and the price on the London Metal Exchange was fairly stable at 29.25 cents."

During that period the domestic electrolytic copper price dropped from 33 cents a pound on November 12, 1959 to 29 cents a pound on January 17, 1961.

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In appraising the parallels between 1959, 1960 and 1961 with 1967, 1968 and 1969 respectively with the suggested probability that 1970 will follow the experience of 1962, it is of interest to consider the following similarities.

1967 Although copper production in the United States reached a record in the first six months of 1967 of 757,713 tons, (both Arizona and the United States broke all previous records for a single month's production in March 1967), the year ended with the lowest annual total since 1959. Operations at most of the principal copper mines, smelters, and refineries were halted by the longest strike in history. In 1967 mine production had dropped to 954,064 tons.

1968 The strikes that had begun in mid-1967 continued with few exceptions until the end of March and in some cases into April 1968. The need for primary source materials at smelters and refineries after settlement of the strikes stimulated production from both domestic and foreign mines and from added capacities installed during the strikes which came into operation. New production from the mines on a monthly basis during the post-strike period exceeded the average monthly production prior to the strike. (See Exhibit A). In the United States the average monthly apparent primary consumption, total monthly refined consumption (including scrap) and monthly consumption by fabricators were lower after the strike than before the strike. (see Exhibit A) Stocks of blister in transit and in process, and refined stocks abroad averaged higher than they did before the strike, and refined stocks at domestic fabricators, while averaging slightly less per month than they did during the entire strike period, were greatly in excess of the average carried before the strike build-up.

1969 Records thus far available for the first six months of 1969 reflect all-time record-breaking production of recoverable copper in ores both in this country and

abroad, especially abroad. While the crude production outside of the United States as reported by the Copper Institute, amounted to 2,534,212 tons in the entire 1966 (an average of 211,184 tons per month), it increased to 2,632,276 tons in 1967, 2,817,320 tons in 1968, and 1,510,280 tons during the first six months of 1969 (an average of 251,713 tons per month) with an all time high of 268,397 tons having been set in May. The foreign production given above does not include the U.S.S.R., Japan, Yugoslavia, Norway, Sweden, Finland, the Messina and the Palabora mines in Africa, and the production of several small producing countries.

Under "Price" and "Future Copper Capacities" these subjects are discussed at length. Predictions offered by those willing to guess are very guarded and are usually confined to short periods. It seems to be the consensus that the current run-up in the London Metal Exchange price was attributed to technical factors such as speculative buying and short covering. But the Engineering and Mining Journal of July 1969, while pointing out that mine production during May rose for the third consecutive month to an all-time high, says, "however, big consumer demand and Communistic Bloc buying have outstripped this production, and consequently copper prices have responded by rising. ."

On the other hand, Metal Week, in its August 11, 1969 issue does not feel that the run-up was attributed to active business, with a worldwide surplus appearing in the making, which "is expected to bear down on the price". It also states: "Consumers of copper are generally worried about the overall economic climate and are not sure that they will need as much of the metal in the future. On top of this Japan is expected to sell another 10,000-15,000 tons of copper on the world market. So buyers are now using their stock rather than buying at the current price."

A close study of the statistics obtainable, and which are presented in this report, does not support the claims of inventory shortages and lack of sufficient production to fulfill orders.

Perhaps the most likely interpretation of the present situation and of things to come is the statement made by E. L. McL. Tittmann, Chairman, and Charles F. Barber, President, in ASARCO's report to stockholders for the second quarter of 1969.

"Looking ahead to the balance of 1969, wage and material costs are advancing at an ever increasing rate. At present writing, demand and prices for metals are still strong. This strength seems, however, to reflect existing inflationary pressures. Once these pressures are contained, past experience would suggest an easing in demand and prices for metals. With the continuing rise in production costs, a squeeze on the profits of the metal producers may develop."

## THE VARIOUS PERIODS IN COPPER MINING IN

1966 - 1969

During the troublesome era beginning with January 1966 and extending through the first quarter of 1969, the industry passed through a number of distinctly different periods, with each of the periods presenting its own problems for study. The

calendar years are not adequate time spans for grouping data which endeavor to present a summary of the industry's experiences during such distinguishable periods.

Therefore, <sup>for</sup> the purpose of segregating the various periods in order to record the data for each as they contributed to the changing conditions, the entire 1966-1969 era is divided into the following periods:

1. Normal operations - January 1966 thru June 1966.
2. Pre-strike Build-up period - July 1966 through June 1967, during which time the imminence of an industry-wide strike expected to begin about July 1, 1967 was ever before the industry, and preparations were being made to cushion the harmful effects of the possible interruption in production. This was accomplished by producing companies increasing their output to the utmost, and by the fabricating companies augmenting inventories through all purchasing possible of imports even though it seriously contributed to our adverse trade balance, through pressure upon the producers, and through obtaining all <sup>possible</sup> merchant copper and even scrap copper at ever increasing prices. (See Department of Mineral Resources reports of September 1967 and October 1968 for details).
3. The Strike period - from July 1967 through March 1968. While the strike started on July 15, 1967 and continued through the latter part of March 1968, the inclusion of July production in the strike-period and of July labor statistics in the pre-strike grouping tend to slightly ameliorate the apparent strike-period effects. This is made necessary by the fact that the Employment Security Commission of Arizona and the U. S. Bureau of Labor Statistics base their reported figures on the "full and part-time wage and salary workers who are employed during the pay-period which includes the 12th of the month". Therefore the July 1967 labor figures represent data corresponding to the period when the mines were in full production, since the strikes did not start until July 15th and the labor sampling for "the pay-period which includes the 12th of the month" fell within the "pre-strike period".
4. Post-strike period - from April 1968 through December 1968 covers the period encompassing the recovery from the strike. During this period the inventory build-up that started in July 1966, a whole year prior to the strike and was not reduced to below the June 1966 level until January 1968, two months before the strike ended, was restored to well-above pre-strike levels. At the end of the post-strike period (December 1968), the inventory build-up by the United States fabricators reached 514,553 tons compared with 446,235 tons in May 1966 (the low point before the pre-strike build-up), 641,083 tons in June 1967 (the high point reached the month before the strikes started), and 424,960 tons in March 1968, at the time the strikes ended.
5. Return to normal operations. Beginning with January 1969 conditions are regarded as again normal, with all properties in the United States running on a full-time basis except Calumet and Hecla in Michigan, which has been shut down by a strike since August 21, 1968 - and by the Quincy Mining Company whose operations at Torch Lake, Michigan came to an end in 1967. The increased production from

capacity increases installed in 1967 and 1968 show up in the figures, and only the normal interruptions because of weather conditions and operating problems have affected production.

The Copper Statistics on an "average tons per month" basis presented on the next page in Exhibit "A" set forth the comparative results allocable to each of the respective five periods covering the span from January 1966 through March 1969.

During the 12-month "pre-strike build-up period", the United States mine production is computed to have been increased by an average of 2992 tons per month (of which Arizona's increase amounted to 176 tons per month) over the prior "normal operations" period, while the world's production outside of the United States (excluding U.S.S. R., Japan, Yugoslavia, Norway, Sweden, Finland, the Messina and Palabora mines in Africa and the production of several small producing countries) increased by almost the same increment (3,223 tons per month).

In the "post-strike period", however, total United States production increased only 508 tons per month - while Arizona's production increased 1,064 tons a month - indicating that Arizona's output was raised by over 12,000 tons per annum while the entire country's output was raised only about 6000 tons per annum. At the same time the production outside of the United States was stepped up from an average 212,654 tons per month to an average 236,800 tons per month, or an added production of approximately 290,000 tons per annum. Output outside of the United States increased far more rapidly than production in the United States and Arizona's increase saved the country from a decrease in production during the comparable periods.

Between the normal operation of 1966 and the return to normal operations in 1969, United States production increased by an average of 4,612 tons per month (approximately 55,000 tons per year) while the rest of the world's production increased from an average 209,431 tons per month to 239,314 tons per month (approximately 360,000 per annum). Arizona's incremental production from expanded operations at existing mines and from incipient operations at new mines averaged 3,384 tons per month - or about 40,000 tons of the total 55,000 tons additional United States mine output.

#### THE STRIKE PERIOD

Exhibit A gives the production figures for the strike period.

A computation of the tonnage of copper that could have been but was not extracted and processed as a direct result of the strike during the period of the shut down and the time required for the resumption of full operations is determined as follows:

(please continue on page 7)

## EXHIBIT A

## COPPER STATISTICS

## Comparison of Pre-Strike, Strike, and Post-Strike Periods

## Average Tons Per Month

| Period   | From<br>To | Normal     | Pre-Strike | Strike    | Post-      | Return    |
|--|------------|------------|------------|-----------|------------|-----------|
|  |            | Operations | Build-up   | Period    | Strike     | To Normal |
|  |            | Jan 1966   | July 1966  | July 1967 | Apr 1968   | Jan 1969  |
|  |            | Jun 1966   | Jun 1966   | Mar 1968  | Dec 1968   | Mar 1969  |
| Number of Months   |            | 6          | 12         | 9         | 9          | 3         |
| Crude Production<br>Outside USA (e)                        |            | 209,431    | 212,654    | 226,238   | 236,800    | 239,314   |
| U.S. Mine Production<br>(Bureau of Mines)                  |            | 119,539    | 122,531    | 32,033    | (c)123,039 | 124,151   |
| Imports  |            | 39,053     | 51,307     | 67,125    | 48,332     | 29,501    |
| Exports  |            | 26,390     | 20,013     | 15,907    | 30,454     | 17,288    |
| Net Imports  |            | 12,663     | 31,294     | 51,218    | 17,878     | 12,213    |
| Net Primary Copper Into<br>Pipe Line                       |            | 132,202    | 153,825    | 83,251    | 140,917    | 136,364   |
| Concentrates Processed<br>Abroad                           |            | 329        | 57         | 11,204    | 4,344      | 95        |
| Total Primary Copper<br>Availability                       |            | 132,531    | 153,882    | 94,455    | 145,261    | 136,459   |
| <b>Consumption</b>   |            |            |            |           |            |           |
| Apparent Consumption-<br>Primary                           |            | 123,383    | 145,333    | 79,433    | 143,889    | 139,000   |
| Total Refined Con-<br>sumption-Actual<br>(Including Scrap) |            | 198,525    | 193,519    | 116,435   | 173,486    | 177,925   |
| Consumption by Fab-<br>ricators (d)                        |            | 197,159    | 165,042    | 106,411   | 150,994    | 162,372   |
| <b>Stocks</b>  |            |            |            |           |            |           |
| Blister in Transit<br>and in Process                       |            | 273,500    | 279,000    | 239,444   | 299,667    | 266,333   |
| Refined at Refineries                                      |            | 42,900     | 41,342     | 31,400    | 40,322     | 46,867    |
| Refined at Fabricators                                     |            | 454,672    | 562,567    | 502,645   | 498,790    | 514,703   |
| Refined Abroad   |            | 286,331    | 294,500    | 290,438   | 303,544    | 301,557   |
| ARIZONA MINE PRODUCTION                                    |            | 62,776     | (a) 62,952 | 18,265    | (c) 64,016 | 66,160    |
| ARIZONA % OF U.S. MINE<br>PRODUCTION                       |            | 52.5       | (b) 51.4   | 57.0      | 52.0       | 53.3      |

(a) July-December 1966 60,486 (b) July-December 1966 50.9%  
 January-June 1967 65,419 January-June 1967 51.8%

(c) November and December Production Reported by Bureau of Mines are Preliminary figures.(USBM) (d) Reported by U.S. Copper Association

(3) From American Bureau of Metal Statistics as reported by members of the Copper Institute. Excludes production of U.S.S.R., Japan, Yugoslavia, Norway, Sweden, Finland, the Messina & Palabora mines in Africa and the production of several small producing countries.

|   | <u>Arizona</u>      | <u>Total United States</u> |
|---|---------------------|----------------------------|
| <u>Mine Production - Short Tons</u>                         |                     |                            |
| January-June 1967   | 392,513             | 757,713                    |
| July-December 1968  | <u>386,476</u>      | <u>746,449</u>             |
| Total 12 months normal operations                           | 778,989             | 1,504,162                  |
| <u>Mine Production during period affected by the strike</u> |                     |                            |
| July - December 1967  | 109,228             | 196,351                    |
| January - June 1968   | <u>244,820</u>      | <u>452,841</u>             |
| 12 months affected by the strike                            | 354,048             | 649,192                    |
| Loss of production caused by the strike                     | <u>424,941 tons</u> | <u>854,970 tons</u>        |

The mining, smelting and refining companies incurred a considerable expense in maintaining their plants, equipment, organizations, employees' homes, hospitals, etc. during the entire non-productive periods; merchants and service companies suffered from loss of business; the state, counties, and cities had to forgo community services due to curtailed income from taxes, licenses, and fees; the entire communities in which the mines, mills, smelters and refineries are located, suffered; and the employees lost tremendously in wages not earned.

The approximate amount of earnings lost to the wage earners because of the shut down of the mines for a period extended to over 8 months is summarized in Exhibit B (see pages 8-9) from labor data by monthly averages for the five separate periods from 1966 through the first quarter of 1969.

While both the Employment Security Commission of Arizona and the U. S. Bureau of Labor Statistics furnish monthly data in connection with the earnings of "Production Workers" included in Copper Mining, in order to also include the earnings by Smelting and Refining Workers, data from Arizona copper smelters and refineries have been secured from the Employment Security Commission of Arizona, and for the United States, the information used is that for "Non-Ferrous Metals" in Schedules B<sub>2</sub> and C<sub>2</sub> of "Employment and Earnings" published by the Bureau of Labor Statistics. While the latter figures include the processing of non-ferrous metals other than copper, a number of plant operations that had been shut down during the strike were affected by their inclusion in the Unions' demands for company-wide and coalition bargaining.

It has been computed as shown by Exhibit B that there were an average 10,257 copper miners and copper smeltermen per month not working at the mines and smelters in Arizona during the period of the shutdown, and an average total of 36,429 copper miners and non-ferrous smelter and refinery employees not working at their jobs in the United States during the shut-down months. The wages lost by these employees because of the strike approximated \$59,272,000 in Arizona and \$282,451,000 in the United States. These losses only cover "production workers" as classified by the government and do not include full and part-time salary workers.

Before the strike was called, the Arizona copper miner worked an average of 44.97 hours per week, of which 6.85 hours were overtime, and his average hourly earnings  
(please continue on page 10)

EXHIBIT B

COMPARISON OF LABOR DATA

FOR NORMAL, PRE-STRIKE, STRIKE, POST-STRIKE AND RETURN TO NORMAL PERIODS

(MONTHLY AVERAGES)  
ARIZONA

|   |    | UNITED STATES     |                     |               |                    |                  |                   |                     |               |                    |                  |
|---|----|-------------------|---------------------|---------------|--------------------|------------------|-------------------|---------------------|---------------|--------------------|------------------|
|   |    | ARIZONA           |                     |               | UNITED STATES      |                  |                   |                     |               |                    |                  |
| From                                      | to | Normal Operations | Pre-Strike Build-up | Strike Period | Post-Strike Period | Return To Normal | Normal Operations | Pre-Strike Build-up | Strike Period | Post-Strike Period | Return To Normal |
|   |    | Jan 1966          | Jul 1966            | Aug 1967      | Apr 1968           | Jan 1969         |                   |                     |               |                    |                  |
|   |    | Jun 1966          | Jul 1967            | Mar 1968      | Dec 1968           | Mar 1969         |                   |                     |               |                    |                  |
| <b>COPPER MINING</b>                      |    |                   |                     |               |                    |                  |                   |                     |               |                    |                  |
| All Employees                             |    | 14,933            | 15,500              | 7,363         | 16,322             | 16,900           | 31,850            | 32,369              | 12,063        | 36,256             | 37,200           |
| Production Employees                      |    | 12,459            | 12,548              | 4,141         | 13,259             | 13,853           | 26,333            | 26,735              | 6,475         | 28,556             | 29,700           |
| Average Weekly Hours                      |    | 44.85             | 44.97               | 38.31         | 45.28              | 43.74            | 43.30             | 43.57               | 40.41         | 47.79              | 46.46            |
| Computed Overtime Incl'd                  |    | 6.53              | 6.85                | 1.75          | 6.92               | 5.80             | 4.96              | 5.45                | 2.73          | 9.61               | 8.46             |
| Average Hourly Earnings                   |    | \$3.283           | \$3.352             | \$3.251       | \$3.550            | \$3.607          | \$3.185           | \$3.266             | \$3.185       | \$3.463            | \$3.480          |
| Average Weekly Earnings                   |    | \$147.24          | \$150.72            | \$124.55      | \$160.70           | \$157.77         | \$137.91          | \$142.29            | \$128.71      | \$165.50           | \$161.68         |
| <b>COPPER SMELTING &amp; REFINING (a)</b> |    |                   |                     |               |                    |                  | (b)               |                     |               |                    |                  |
| All Employees                             |    | 1,847             | 1,855               | 462           | 1,873              | 1,935            | 76,450            | 80,469              | 67,725        | 83,856             | 85,533           |
| Production Employees                      |    | 1,536             | 1,541               | 158           | 1,549              | 1,604            | 59,250            | 62,031              | 49,138        | 64,889             | 66,533           |
| Average Weekly Hours                      |    | 45.31             | 45.51               | 35.29         | 45.69              | 45.47            | 42.00             | 42.16               | 42.34         | 42.54              | 42.27            |
| Computed Overtime Incl'd                  |    | 6.99              | 7.39                | 0.95          | 7.51               | 7.54             | 3.67              | 4.04                | 4.63          | 4.35               | 4.33             |
| Average Hourly Earnings                   |    | \$3.132           | \$3.199             | \$3.229       | \$3.455            | \$3.453          | \$3.038           | \$3.133             | \$3.272       | \$3.411            | \$3.477          |
| Average Weekly Earnings                   |    | \$141.90          | \$145.59            | \$113.95      | \$157.86           | \$157.01         | \$127.60          | \$132.07            | \$138.54      | \$145.10           | \$146.97         |
| <b>NON-PRODUCTIVE EMPLOYEES</b>           |    |                   |                     |               |                    |                  |                   |                     |               |                    |                  |
| Copper Mining                             |    | 2,474             | 2,952               | 3,222         | 3,063              | 3,047            | 5,517             | 5,634               | 5,588         | 7,700              | 7,500            |
| Smelting & Refining                       |    | 311               | 314                 | 304           | 324                | 331              | 17,200            | 18,438              | 18,587        | 18,967             | 19,000           |
| TOTAL                                     |    | 2,785             | 3,266               | 3,526         | 3,387              | 3,378            | 22,717            | 24,072              | 24,175        | 26,667             | 26,500           |
| <b>PRODUCTIVE EMPLOYEES</b>               |    |                   |                     |               |                    |                  |                   |                     |               |                    |                  |
| Copper Mining                             |    | 12,459            | 12,548              | 4,141         | 13,259             | 13,853           | 26,333            | 26,735              | 6,475         | 28,556             | 29,700           |
| Smelting & Refining                       |    | 1,536             | 1,541               | 158           | 1,549              | 1,604            | 59,250            | 62,031              | 49,138        | 64,889             | 66,533           |
| TOTAL                                     |    | 13,995            | 14,089              | 4,299         | 14,808             | 15,457           | 85,583            | 88,766              | 55,613        | 93,445             | 96,233           |
| <b>TOTAL EMPLOYEES</b>                    |    |                   |                     |               |                    |                  |                   |                     |               |                    |                  |
| Copper Mining                             |    | 14,933            | 15,500              | 7,363         | 16,322             | 16,900           | 31,850            | 32,369              | 12,063        | 36,256             | 37,200           |
| Smelting & Refining                       |    | 1,847             | 1,855               | 462           | 1,873              | 1,935            | 76,450            | 80,469              | 67,725        | 83,856             | 85,533           |
| TOTAL                                     |    | 16,780            | 17,355              | 7,825         | 18,195             | 18,835           | 108,300           | 112,838             | 79,788        | 120,112            | 122,733          |

(a) From Employment Security Commission of Arizona

(b) "Non-Ferrous Metals" workers in Schedules B2 and C2 of "Employment and Earnings" published by the U.S. Bureau of Labor Statistics.

EARNINGS LOST BY PRODUCTION WORKERS BECAUSE OF STRIKE

ARIZONA - FROM EXHIBIT B

|   | Copper<br>Mining | Copper<br>Smelting | TOTAL        |
|---|------------------|--------------------|--------------|
| Production Workers - Aug 1967-Mar 1968  | 33,131           | 1,264              | 34,395       |
| Ave. Per Month                          | 4,141            | 158                | 4,299        |
| 12 Months Normal Operations 1967-1968   | 156,048          | 18,619             | 174,667      |
| Ave. Per Month                          | 13,004           | 1,552              | 14,556       |
| Ave. Per Month Unemployed During Strike | 8,863            | 1,394              | 10,257       |
| Wages Paid - Aug 1967-Mar 1968          | \$16,500,445     | \$576,967          | \$17,077,412 |
| Plus 2 Weeks                            | 1,031,278        | 36,060             | 1,067,338    |
| Wages Paid During Strike                | \$17,531,723     | \$613,027          | \$18,144,750 |
| Normal Wages in 8 Months Period         | 69,321,521       | 8,094,918          | 77,416,439   |
| ARIZONA LOST WAGES BECAUSE OF STRIKE    | \$51,789,798     | \$7,481,891        | \$59,271,689 |

UNITED STATES - FROM EXHIBIT B

|   | Copper<br>Mining | Non-Ferrous<br>Smelting &<br>Refining | TOTAL         |
|---|------------------|---------------------------------------|---------------|
| Production Workers - Aug 1967-Mar 1968        | 51,800           | 393,100                               | 444,900       |
| Ave. Per Month                                | 6,475            | 49,138                                | 55,613        |
| 12 Months Normal Operations                   | 332,400          | 772,100                               | 1,104,500     |
| Ave. Per Month                                | 27,700           | 64,342                                | 92,042        |
| Ave. Per Month Unemployed During Strike       | 21,225           | 15,204                                | 36,429        |
| Wages Paid - Aug 1967-Mar 1968                | \$26,716,968     | \$136,387,384                         | \$163,104,352 |
| Plus 2 Weeks                                  | 1,669,811        | 8,524,212                             | 10,194,023    |
| Wages Paid During Strike                      | \$28,386,779     | 144,911,596                           | 173,298,375   |
| Normal Wages in 8 mos. period                 | 146,053,715      | 309,696,147                           | 455,749,862   |
| UNITED STATES WAGES LOST<br>BECAUSE OF STRIKE | \$117,666,936    | \$164,784,551                         | \$282,451,487 |



were \$3.352. His weekly pay averaged \$150.72. The average Arizona copper miner lost wages totalling \$5,843 while the mines were shut down.

During the first quarter of 1969 - which may be regarded as return to normal - he worked an average of 43.74 hours per week, of which 5.80 hours were overtime, and his average hourly earnings were \$3.607. His weekly pay averaged \$157.77 - an increase of \$7.05 per week according to figures derived from the Arizona Employment Security Commission reports. The increase includes the second year wage increases that went into effect at some of the companies in Arizona in January 1969.

In the Phelps Dodge Corporation Annual Report for 1968, Robert G. Page, Chairman of the Board and George B. Munroe, President state:

"The labor settlements which ended the strikes were expensive, representing an average increase in wages and other benefits of about \$1.13 per hour over the 40-month term of the new contracts, which run until mid-1971."

From Exhibit B it will be noted that the average hourly earnings increased from \$3.352 per hour (which included overtime pay on 6.85 hours per week) during the year prior to the strike to an average \$3.550 per hour earnings (which included 6.92 hours of overtime a week for the average worker) for the remainder of 1968 after the settlement of the strikes. It is therefore computed that for the balance of the year after the settlement of the strikes, the payments made for work performed increased an average of 19.8 cents per hour for the Arizona copper mines worker.

While the \$1.13 per hour increase referred to by Messrs. Page and Munroe is to be spread over 40 months, an aliquot part of the 19.8 cents increase in 1968 for all Arizona copper workers ascribable to Phelps Dodge would indicate that approximately one-half of the aggregate increase is represented by wages -- and the balance by fringe benefits. In an article by Raymond W. Pasnik, Public Relations Director, United Steelworkers of America in the September 1968 issue of Mining Magazine, he states that "wage increases ranging from 51 to 57 cents per hour over the new contract periods are provided" and "By the effective date of the last of the wage and increment improvements, the minimum rate paid in the copper operations of the 'big four' chains will be \$2.98 per hour or more. The highest rates at that time will reach \$4.44 for some properties. With few exceptions, the smaller independent producers follow this pattern."

He wrote of improvements made toward equalizing health and welfare coverage at the various properties of the non-ferrous companies; eliminating employee contributions to medical and other insurance programs in almost every chain; increased weekly sickness and accident benefits; revision of income and severance pay programs for laid-off employees; an additional paid holiday in some cases; and some vacation improvements.

Mr. Pasnik stressed the fact that "other than wages, it was in the area of pensions that the most significant contract improvements were achieved". From the figures presented above "wage increases ranging from 51 to 57 cents per hour over the new contract periods" and Phelps Dodge reported "average increase in wages and other

benefits of about \$1.13 per hour over the 40-month term of the new contracts, which run until mid-1971", it appears that over the period of 40 months only one-half of the added cost of labor to the employer will appear in the employees' payroll before deduction for increased taxes. The average wage loss to the average Arizona copper miner for the 8-1/2 months they were out was \$5,843.

Although Mr. Pasnik stressed gains in the area of pensions, Mr. Douglas H. Soutar, Vice President, American Smelting and Refining Co. wrote:

"It is also fair to note that newspaper reports of settlement costs were substantially overstated, too little attention being paid to: (a) the fact that the settlements cover a four year period or more; and (b) the very substantial portions of these settlements represented by pensions, on which there had been no negotiations for five years in the case of three of the companies and six years in the case of Asarco. Obviously the cost catchup required to update pension programs after this relatively long hiatus constituted a very substantial part of the total settlements - a fact not understood by most and which obviously casts the remainder of the package in a different perspective." (Mining Magazine - September 1968)

#### THE FUTURE

While there is general - but guarded - expression of opinion to the effect that balance of supply and demand may be reached by the end of this year - there is preponderance of opinion that there is a probability of surplus of production over consumption in the early years of the 1970's - with a possible shortage developing after 1975. If this position is subscribed to, thought should be given to further expansions in Arizona to start producing after 1975, but not before then, if possible, except as replacement tonnage - (as where the tonnage to be derived from Phelps Dodge's Metcalf mine will not add to Arizona's present production but will replace the tonnage produced at their Bisbee mines which will become exhausted by 1975.)

Insofar as current production is concerned, Arizona is leading the way in increasing United States production but is just about offsetting the failure of the other states to produce the quantities expected. However, according to figures released by the Copper Institute the rest of the Free World is increasing production by appreciable increments. Between 1960 and 1963, its production averaged 2,369,000 tons per annum. From 1964 to 1967, it averaged 2,567,000 tons per annum with a record for a single month of 238,947 tons in December 1965. In 1968, 2,817,320 tons were produced outside of the United States and in five of the first six months of 1969 (except for the 28-day February) the monthly production exceeded the previous December 1965 record by wide margins, the productions of April and May reaching 262,047 and 258,397 tons respectively.

A review of mine production records over the past 20 years as tabulated in the Yearbooks of the American Bureau of Metal Statistics discloses that in the year 1968, record production of copper was achieved in 14 of the nations of the Free

World, namely Canada, Bolivia, Brazil, Peru, Ireland, Spain, Yugoslavia, Israel, Japan, Philippines, Republic of the Congo, Rhodesia, Republic of South Africa and Zambia.

In spite of droughts, landslides, and strikes Chile's production of 725,559 tons was only 2,227 tons less than the record 727,786 tons produced in 1967. In Sweden, in spite of the shutdown of the Boliden mine, production dropped only 958 tons because of the starting up of the new Aitik mine. Planned increases at other old mines and new production will raise Sweden's production substantially.

As far as the Soviet sphere countries are concerned important production increases were reported by the U.S.S.R., Bulgaria, and Poland, and sustained high production was reported by East Germany and China.

As far as figures from U.S.S.R. are obtainable, the transition of Russia from an importing nation to a self-sustaining and even an exporting nation is indicated by the following data published in the (London) Mining Annual Review of May 1968 as extracted from the Russian Publication "Exploration and Conservation of Natural Resources":

|      | <u>Imports</u><br>(Primary forms) | <u>Metric tons</u><br><u>Exports</u><br>(Primary forms) | <u>Production</u> |
|------|-----------------------------------|---|-------------------|
| 1962 | 106,400                           | 71,300  | 690,000           |
| 1963 | 88,000                            | 72,000  | 735,000           |
| 1964 | 9,500                             | 89,500  | 790,000           |
| 1965 | 700                               | 93,100  | 845,000           |
| 1966 | 7,400                             | 120,100   | 900,000           |
| 1967 | 5,000                             | 140,000   | 960,000           |

Since there is so much activity in increasing copper production in foreign countries there are indications that the supply-demand balance for the early future may be reached sooner than some of the prognosticators are predicting, especially in view of the fact that there is no way of differentiating between "demand" and "consumption".

As shown in Exhibit A - Average Monthly Refined Stocks are as follows:

|                                       | <u>at Fabricators in U.S.A.</u> | <u>Abroad</u> |
|---------------------------------------|---------------------------------|---------------|
| Normal Operations - Jan-June 1966     | 454,672 tons                    | 286,331 tons  |
| Pre-Strike Build-Up Jul 1966-Jun 1967 | 562,567 "                       | 294,500 "     |
| Strike Period Jul 1967-Mar 1968       | 502,645 "                       | 290,438 "     |
| Post Strike Period Apr 1968-Dec 1968  | 498,780 "                       | 303,544 "     |
| Return to Normal Jan 1969-Mar 1969    | 514,713 "                       | 301,557 "     |

While reports appearing in print repeat the existence of a continued "tight supply", a question now being posed, in view of the inventory figures, is whether the continued demand also contains the elements of a hedge against the possibility or probability of continued fears of inflation.

## FOREIGN PRODUCTION

The vast increases in copper production outside of the United States, and the still further gigantic production capacities under construction or contemplation, are largely accounted for by the mines of the Copperbelt in Africa (The Republic of the Congo and Zambia), and to those of Chile and Peru.

As discussed under "Future Copper Capacities" (page 29) these four underdeveloped nations produced 43.2 percent of the Free World's copper in 1968, but consumed very little. However, together they sell about 70% of the copper exported in the world, (Engineering & Mining Journal - Sept. 1968) and each of the four nations is extending its domination over the copper produced in that nation and sold abroad.

### COPPERBELT:

In a narrow strip of land extending along the northern boundary of Zambia and along the southern boundary of the Republic of the Congo, in the last five years the following tonnages have been produced in a comparatively small area:

|      |                | <u>% of Free World Production</u> |
|------|----------------|-----------------------------------|
| 1964 | 1,114,631 tons | 25.3                              |
| 1965 | 1,085,104 "    | 23.7                              |
| 1966 | 1,036,272 "    | 21.8                              |
| 1967 | 1,083,931 "    | 24.3                              |
| 1968 | 1,161,834      | 23.7                              |

(a) Republic of the Congo: "On January 3, 1967, the Union Miniere du Haut Katanga, S.A. (fourth largest copper producer in the world) announced that on December 31, 1966, the Council of Ministers of the Democratic Republic of the Congo confirmed its previously announced decision to dispossess Union Miniere of its mining concessions and of all its assets situated on Congolese territory. The Government decrees became effective on January 1, 1967" (Skinner's Mining Year Book 1968).

The Generale Congolaise de Mineraiise (government successor to Union Miniere) has increased its copper production to a record 350,000 metric tons annually and plans already being worked on call for a further annual increase of 5 percent each year. In addition, the Congolese Government together with Japanese interests are contemplating the construction of a new mine and plant at the Musoshi deposit which is scheduled to ship to Japan an additional 53,000 metric tons per annum of contained copper beginning in October 1972.

(b) Zambia ranks as the free World's No. 2 copper producer behind the United States. Two companies, the Anglo-American Corp. of South Africa, (third largest copper producer in the world) and the Roan Selection Trust (fifth largest copper producer in the world) produce about 98% of Zambia's copper, or about 12% of the non-Communist world's output. The mines of the two companies account for about two-thirds of Zambia's state revenues, one-half of its gross national product, and about 96% of its exports.

In October 1968 the Zambian government formed a new company which would give it control over the copper sales policies by reviewing sales contracts and generally

overseeing the conditions under which copper is sold and to whom. Negotiations have just been started by the Zambian government seeking to have the two big producers "give a controlling 51% of their shares to the state".

Zambia collects royalties and an export tax on its copper based on the London Metal Exchange price, and also a corporation income tax. Only 50% of the remaining profit may be distributed abroad. In the fiscal year ending June 30, 1968, Zambia's taxes and royalties amounted to 33.4 percent of the total sales intake.

As so large a part of Zambia's state revenues is derived from the mines in the Copperbelt, just as the Republic of the Congo derives a great deal of its income from the Copperbelt, both of these nations are pushing the expansion of copper production by the reopening of old mines previously shut down; development of new mines; increasing of production at existing mines; as well as <sup>by</sup> joint exploration projects with Japanese interests and with interests already domiciled in Zambia to find new copper deposits.

In Zambia, the following additional annual tonnages are now being provided for:

|   | <u>Added Capacity</u> | <u>To Start</u> |
|---|-----------------------|-----------------|
| Kalewanga - Roan Selection Trust        | 19,000                | 1970            |
| Luanshaya "                             | 7,000                 | 1969            |
| Chambishi "                             | 5,000                 | 1970            |
| Bwana Mkubwa - Anglo American           | 15,000                | 1970            |
| Bancroft "                              | 12,000                | 1969            |
| Kansanshi "                             | 15,000                | 1975            |
| Mufulira Roan Selection Trust           | 29,000                | 1971            |
| Baluba "                                | 24,600                | 1975            |
| River Load Pit (Nchanga) Anglo American | 13,500                | 1969            |
| Mimbula Fitula "                        | 40,000                | 1969            |
| Nchanga "                               | 17,100                | 1969            |

Sir Ronald Prain, Chairman of the Roan Selection Trust replied to Zambian President Kaunda's claim that the major reason for the takeover was the failure of R.S.T. and Anglo American to develop new mining areas, by noting that production has increased to nearly 330,000 tons a year in 1969 (fiscal year) from 270,000 tons in 1964. Sir Ronald said this had been achieved in the face of most adverse conditions following neighboring Rhodesia's unilateral declaration of independence.

The Copperbelt is adequately equipped with smelters and refineries so that there is not an expensive addendum to costs to ship the concentrates from the mine-mill area to a smelter located at a distant point, and the resulting blister to a point many hundreds or thousands of miles away to produce the copper in the form in which it is salable to the mills. Copper is shipped to all parts of the world from the Copperbelt in the form that the fabricator wants it (billets, wire bars, ingots, ingot bars, cakes, slabs, cathodes) and at the time he wants it.

Therefore the competition that Arizona must meet from the Copperbelt alone is considerable and is enhanced by the ability of the national governments to tailor prices to command sales.

As pointed out in Exhibit C, page 26, while presently-contemplated copper capacity increases in the United States (including Puerto Rico) through 1975 total only 797,750 tons, the increases presently-contemplated in the remaining Free World nations amount to 2,406,250 tons. In addition to the Congo and Zambia, Chile and Peru exerted pressure to increase the output in their countries so that more income may result.

Chile: On December 22, 1964, President Frei of Chile announced that agreements had been reached with the big U. S. copper companies operating in Chile for a partnership between them and the State. The agreements announced by President Frei, varied from one company to another but, in all, would have enabled copper production to be doubled and refinery capacity to be tripled.

Kennecott's large Braden mine became a new corporation called "Sociedad Minera el Teniente S.A.", in which the Chilean State, through its Copper Department - which in the future will be called "The Chilean Copper Corporation" - would purchase 51 percent of the stock and Kennecott (second largest copper producer in the world) would retain the remaining 49 percent. The \$80 million paid Kennecott for its 51 percent of the stock of Braden would not be withdrawn from Chile but would be re-invested to increase "Teniente" production from 180,000 to 280,000 tons per annum-- (which increase is ahead of schedule with completion now set for late 1970).

The Comtel message of December 22, 1964, in further reporting the agreements announced by President Frei, states;

"In the case of Anaconda (largest copper producer in the world) the mines and companies now in being and under exploitation will not be included in the partnership. But Anaconda has agreed to form a new corporation with a State contribution of 25 percent of stock to operate the new mineral ore body called 'La Exotica'.

"It is also agreed to form another corporation in which the State will own 49 percent of stock to make an exhaustive study of all those other properties owned by Anaconda but still unexploited. Should such exploration work warrant operating any such deposit, new corporations to exploit each will be formed, with the state owning one-third of the stock.

"President Frei also recalled the first agreement, reached even before he came to power, with Cerro Corporation in which the State will own 25 percent of the stock of Sociedad Minera Andina, owner of the Rio Blanco ore body. (State participation was raised to 30% in October 1968)

"The complete results of this new copper policy will be attained by 1970, President Frei said. It will mean an increase to 1,200,000 tons by then from 617,000 now produced, while refined copper output will rise to 700,000 from 274,000 tons.

"The President also said this will mean increased purchase of many goods in Chile with the possibility of planning, 'with a large market in view', many lines of national production.

"It will also mean decisive intervention by the Chilean State in the international market for copper. (underline added)

"The companies, in turn, receive stabilization as far as taxation of profits is concerned and will be assured of non discrimination if new taxes are created. This means that the era of looking at copper companies as possible means of financing various projects will come to an end, the President added."

President Frei originally started out with what was generally termed the "Chileanization" of the copper industry -- a percentage of government ownership in a private company's operation, with assured stabilization of taxation of profits and non-discrimination if new taxes were created.

Notwithstanding the December 22, 1964 covenant which for a period of twenty years was to govern the relationship between the copper companies and the State, "President Frei, as part of his state-of-the-nation address in May, said Chile will seek an ownership interest in the remaining Anaconda mines (Chuquicamata and El Salvador) and a larger earnings share from the copper mining operations of all companies in Chile." (Engineering and Mining Journal - July 1969)

Anaconda has not agreed to such joint ownership and "the agreement finally hammered out by Chilean and Anaconda officials amounts to progressive nationalization of Chuquicamata and El Salvador . . ." "Anaconda later said the nationalization plan did not apply to the Exotica pit now nearing the construction stage." (same Journal)

Provisions of the agreement called for the transfer, effective January 1, 1970 of the assets and liabilities of two subsidiaries of Anaconda to new Chilean mining companies in which 51 percent of the stock will be "purchased" by Chile at a stock value set at \$197 million.

The American Metal Market of August 26 quotes the H. Bache & Co. correspondent in Chile as saying, concerning the takeover of Anaconda Co.'s Chuquicamata and El Salvador properties by the Chilean government, that the government "will commence to operate this mine and plant in September and the political aspirants to well-paid jobs (in dollars) are legion." He added that the Chilean government also "has cast covetous eyes at many mines in the medium-size copper mines bracket."

Peru: While Peru has not as yet indicated an intent to expropriate or nationalize American copper companies she is a member of the CIPEC group and according to the September 6, 1968 issue of the London Mining Journal; "Peru plans to develop its copper production over the next four years to reach almost 400,000 m/tons from the current 197,000 m/tons year. According to the Peruvian Minister of Development, Dr. Carriquiri, revenue from this source will increase by \$473 million between 1968-1972. Looking further ahead, Peru is hoping to invest \$465 million in the copper industry between 1973-1975 to bring production to 635,000 ton/year by 1976" In 1968, Peru produced 235,318 short tons of copper.

Now that Anaconda's Chilean mines are to become nationalized, her expansion of exploration activities, and advancements in the technologies of mining and metallurgy have made it possible <sup>for her</sup> to produce increasing tonnages of copper from United States mines. She is about to bring into production the new Twin Buttes mine near Tucson which will initially produce 60,000 tons of copper a year. In the letter to the Stockholders reporting on second quarter 1969 earnings, Mr. C. Jay Parkinson, Chairman of the Board, points out that "This and other Arizona properties could well produce a much larger tonnage of copper."

A promising new orebody is currently under development at Anaconda's Britannia Beach mine in British Columbia, with initial production scheduled for 1971, and two important properties in Montana are available for immediate development - which will justify a copper production between 25,000 and 40,000 tons per year.

Recently announced plans to build a 1,000 ton-per-day mill in conjunction with Cominco Ltd. (who will hold a 25% interest) have been made for Bathurst, New Brunswick.

Mr. Parkinson refers to the Chilean situation thus:

"With these skills we intend to combine the orderly reduction of our participation in Chilean operations with substantial diversification and expansion of domestic and foreign facilities to serve such basic industries of the world as construction, transportation, electric utilities, and the broad spectrum of communications, electronics, and machinery and equipment, in the belief that these markets will grow and expand and that we will retain the capacity to grow and expand with them."

Chile is determined that her copper production will be expanded to over 1,200,000 tons a year by 1972. Her national intake from copper is tremendous but she still is upping her shares of the copper sales prices received by the mining complexes. If the time comes when it will not be necessary to pay exorbitant prices for the comparatively small portion of our copper that must be brought in from abroad - Chile will very drastically reduce her price in order to keep getting dollars from this market -- and there will be keen competition in the United States between copper produced in Chile and copper produced in the United States.

#### COPPER PRICE

Copper is a world commodity and it should be expected that through the workings of the Law of Supply and Demand, there would be a World Price for copper. However, there is no longer such a price.

The Minerals Yearbook of the United States Department of the Interior, Bureau of Mines (1967 Edition) reports mine production in 53 countries and smelter production in 32 countries. The Yearbook of the American Bureau of Metal Statistics (issued June 1969) reports Refined Copper consumption in 1968 by at least 37 countries.

There is no free price for copper. The price is determined by their own sales by the American producers; by producing companies in four foreign countries (who



produced 43.3 percent of the Free World's 1968 copper, as reported by the American Bureau of Metal Statistics); by the Noranda Mines; by the French copper monopoly; by the London Metal Exchange (known also as the L.M.E.); by the New York Commodity Exchange; by the New York merchant market; by Refiner's No. 1 copper scrap; and by custom smelters.

Prices quoted in the American Metal Market for July 24, 1969 and August 21, 1969 were as follows:

| (All prices in cents per pound)                              |                  |                  |
|--|------------------|------------------|
| "  | <u>July 24</u>   | <u>August 21</u> |
| Domestic Producer's Electrolytic Delivery U.S.               |                  |                  |
| Wirebar  | 46.00-46.25      | 48.00-48.25      |
| Cathode, full plate  | 45.00-45.87-1/2  | 47.00-47.87-1/2  |
| Lake (Copper Range)  | 50.00            | 50.00            |
| Foreign Electrolytic (U.S. Duty 1.3¢ suspended)              |                  |                  |
| Chilean Delivery U.S. destinations                           | 66.42            | 74.89            |
| Outside U.S.   | 66.42            | 74.89            |
| Canadian outside U.S. (Noranda Mines)                        | 66.42            | 74.89            |
| Katangan c.i.f. N.Y. (Societe Generale des Minerals)         | 66.42            | 74.89            |
| Zambian outside U.S. (Anglo American & Roan Selection Trust) | 66.42            | 74.89            |
| French Agency GIRM-F.A.S. New York                           | 66.25            | 73.96            |
| London Metal Exchange  |                  |                  |
| Electrolytic wirebar (closing) (based on \$2.40 lb.          |                  |                  |
| Sterling) Cash (bid)   | 65.78            | 75.10            |
| 3 mos. (bid)   | 63.85            | 71.89            |
| Commodity Exchange Standard Copper                           |                  |                  |
| Sept.  | 62.20            | 68.40            |
| Oct.   | 60.85            | 67.00            |
| Dec.   | 58.90            | 65.55            |
| New York Merchant Market                                     |                  |                  |
| Electrolytic market  |                  |                  |
| Aug.   | Nom. 64.50-65.00 | 70.50-70.75      |
| Sept.  | Nom. 64.00-64.25 | 69.50-69.75      |
| Oct.   | Nom. 63.00-63.50 | 68.50-68.75      |
| Refiners' No. 2 copper scrap                                 | Nom. 50.00       | 53.00            |

"These prices reflect present market conditions, but consumers cannot necessarily buy all the copper they desire at the listed producer and scrap prices.

"Furthermore some refiners charge on a formula based on their copper source; foreign or domestic, or outside market (London Metal Exchange, Commodity Exchange, merchant and scrap).

"When scrap prices are not officially issued by custom smelters, they are obtained from industry sources and are listed as nominal. When merchant market quotations are unavailable the prices are estimated and termed nominal."

For a number of years, the important producers of copper throughout the world endeavored to maintain the price of copper at reasonable levels - consistent with the cost

of production including development of new ores; fair return to stockholders; retention of sufficient earnings to reinvest in discovery and development of new ore deposits and in research in order to increase efficiency and treat ores of declining grade; and keeping copper competitive with other metals. Production of copper was tailored to the demand. When inventories rose to unwieldy heights and the financing of the inventory-carry became a matter of high cost, the rate of operations was cut. At times, a sudden pick-up in demand after a period of curtailment, caused an insufficiency in supply until resumed production could "catch up" with the increased demand. Such a situation occurred in 1964 when a mounting number of strikes in Peru, Chile, Zambia, the United States, Australia and other countries, cut into the steady flow of copper supplied by the producers at the "producer's" price. Consumer prices were first bid up on the marginal copper production sold at above the producer's price on the London Metal Exchange. This was followed by pressures by the political powers in Chile and Zambia (and later by the Republic of the Congo and Peru) upon the prime producers in these countries to unrealistically raise their selling price so that these underdeveloped nations could reap an opulent harvest of added income for use on their projects.

In 1964, as the price for marginal copper was bid up, Chile arbitrarily dictated rising prices for the copper produced in Chile. Zambia soon followed suit and their producers were forced to abandon their realistic producer prices and adhere to the arbitrary prices being escalated by the two countries. The producers had no other alternative but to pattern their price on the ever-rising LME.

A historical account of price manipulations is contained in the report on the "Copper Industry" for 1966 issued by the Arizona Department of Mineral Resources in September 1967, pages 8-11.

Until 1940 the United States mined more copper than it consumed and was an exporter of copper on balance (i.e. exports minus imports), except for 1929 and the depression years 1930-1932. Beginning with 1941 it became an importer on balance because its mill demands were in excess of its domestic mine production. Net imports averaged 230,638 tons per annum between 1956 and 1960, 148,050 tons per annum between 1961 and 1965, and 354,683 tons per annum between 1966 and 1968 (which increase was prompted by anticipated and actual requirements during the strike). From the table appearing above, it is noted that on the copper imported from countries where their governments dictate the mining and selling policies of producers, as of July 24th and August 21st, 1969, the prices paid were 66.42 cents and 74.89 cents per pound respectively.

The fabricators in the United States have been and are having a very difficult time getting the entire quantity of copper they desire or need from the producers at the producer's price. The United States producer's 46.00-46.25 cent price (raised to 48.00-48.25 cents on August 4) is the lowest in the world; but the fabricators average cost is quickly escalated by purchase of non-producer copper.

The United States supply of producers' copper is restricted by the current requirement of a "set aside" of 19 percent of their total output (beginning October 1, the set aside will be reduced to 16 percent), as a reserve to fill military requirements, which, according to William A. Meissner, Director of the Business and Defense

Service Administration's Copper Division is roughly 24,000 tons per month (to be reduced to approximately 20,000 tons per month beginning October 1). The government has also ceased supplying the fabricators with any stockpiled copper for defense needs. Mr. Rolle, the material specialist who keeps up with service needs in the Pentagon said he expects "defense contractors will be ordering metals at about the 1969 rate; 450 million pounds of copper and copper base alloys". Defense-rated orders must be based on a price of 46 cents a pound (increased to 48 cents a pound on August 4), not on the average cost of the fabricators' copper purchases.

Copper scrap is an important part of the supply. At the smelters and refineries, secondary copper or copper scrap is retreated and reproduced as refined copper. The Chase National Bank letter of April 1969 states that "in recent years (scrap copper) has accounted for some 19 percent of total refined production". To the extent that scrap copper enters the fabricator's pipe line, the cost to him would now be about 53 cents a pound.

The amount of marginal copper that is not sold at the producer's selling price (or at the price that the nationalistically inclined countries dictate), or sold by smaller producers through custom smelters or metal merchants, is very small and most often is sold on the London Metal Exchange.

Dr. James Boyd, President of Copper Range Co. estimates that "less than one percent of the Free World copper actually passes through that market but over 60 percent of the Free World copper is sold on the basis of the flexible market (The London Metal Exchange)". He also stated that "some small domestic producers have been selling on the open market at prices in the upper 50-cent to 60-cent range".

The 20-cent premium on some 60 percent of the Free World copper adds a decided increment to the price the fabricators must pay since the United States consumes more copper than it produces.

As a result of wage increases, increased costs of materials and supplies, and increased taxes, the United States producers had to increase the price of copper by an additional 2 cents a pound to 46.00-46.25 on May 8 and an additional 2 cents a pound to 48.00-48.25 cents on August 4th.

At the present time the volatile conditions in the copper market draw changing and conflicting statements from the well-informed sources both to why there is a 20¢ per pound difference in the producer's price and the so-called "world price" as represented by the London Metal Exchange price, and as to predictions of the copper price in the near future as well as in the year ahead. As stated in the August 18, 1969 issue of "Metals Week":

"The copper market has been very volatile since the beginning of the year and every bit of bad news about copper -- and there's been a lot of it -- has been successful in driving up the price of the metal."

The May 17, 1969 issue of Business Week summed up the situation as follows:

"An industry source speculates that the new round of increases spells the beginning of the end of the two-price situation that has characterized the Free World copper market ever since 1965. That year the U.S. Government pressured domestic producers to keep their price artificially lower than that prevailing overseas. Most people feel that the two-price system makes no sense. Copper is an international commodity, and the same copper competes in the U. S. and World markets".

Sir Ronald L. Prain, (Chairman of Roan Selection Trust) is quoted as saying:

"I think it fair to say that today's price is rather higher than what the market generally foresaw a year ago. Several factors contributed to the high price level, including re-stocking after the marathon strike in the U.S., some upturn in demand, the effect of the U.S. East Coast dock strike, currency fears which have led to some purchasing of commodities, and, more lately, buying by the United States industry of marginal copper at world prices, as opposed to the U.S. domestic price."

In his report to Stockholders at Kennecott's annual meeting on May 6, 1969, Mr. F. R. Milliken, President said:

"The unusually high price of domestic scrap copper and the even higher prices quoted on the London Metal Exchange for primary copper give rise to questions as to why we have not further increased our domestic prices. While we do not believe that current shortages which give rise to these high prices are apt to be resolved in the immediate future, we do believe that it is in the long range best interests of the company to exercise pricing restraint. But certain market conditions place limitations on what we can achieve. Restraint in our primary copper pricing would cease to accomplish this purpose if prices of the products of our customers - the copper fabricators - were to balloon".

In commenting upon this statement, on May 7th, the American Metal Market stated:

"As far as 'ballooning' of copper fabricators' product prices, virtually all brass mills are now basing their product selling prices on a 'blended' copper cost of 50 cents a pound, copper content.

"At least one mill is now selling commercial and industrial tube on a 53-cent blended copper cost. Most wire makers are now basing their copper magnet wire quotes on 53.50 cent copper.

"The 'blended' cost used by fabricators is based on what they pay U.S. producers and premium prices paid on the outside (non-producer) prices."

After the producers raised their price to 46 cents, the Wall Street Journal on May 12, 1969 stated that "this brings the pricing level to one based on a price of 52 cents reflecting a 'blend' of the price of U. S. produced copper and copper from other sources, which is more expensive to buy than U. S. copper."

As a result of the second increase in producer's price on August 4, and the increased non-producer price the fabricators naturally had to incur an increased "blended" cost on non-rated orders, and such blended cost now exceeds 56 cents a pound.

In a letter issued to Kennecott stockholders in late March, Mr. Milliken said: "The degree of firmness of the primary copper market at this time, almost a full year after the termination of the U.S. strike and in the face of record world copper production rate has been surprising."

China is reported to be buying 2,000 tons of copper a week on the London Metal Exchange (a large tonnage in view of the relatively small tonnage for sale on the Exchange itself), and precautionary and speculative buying that follows in the wake of political and financial uncertainties have been instrumental in sustaining the high price for copper sold on the London Metal Exchange.

In the American Metal Market issue of September 16, 1968, a point stressed throughout the strike by the Arizona Department of Mineral Resources is confirmed as follows:

"Despite constant and repeated alarms, and dire shaking of the heads--there was never a real shortage of copper for both defense and commercial needs--if any consumer was willing to pay the price. On occasion, some fabricating facilities curtailed operations and even were prepared to shut down because of a lack of copper raw materials. But even this lack of copper was caused by extraneous matters -- such as when U.S. stevedores in support of the copper industry's striking unions -- temporarily refused to handle imported copper and forward it to U.S. destinations.

"The biggest mystery of the entire strike, and which has not been fully solved nor is a final solution ever expected to come to light, was the fact that copper continued to be available at a price."

In its April 11, 1969 issue the Mining Journal (London) states:

"Now looking back over the past months, it is seen that far from falling, LME prices have moved ahead by around £100 per ton. The question must therefore be asked, has the supply or demand situation changed so materially over the last months that the whole foundation for earlier arguments that copper prices were too high has been radically undermined? Has the introduction of new primary productive capacity been drastically slowed down? Or, has there been a real surge in consumption either in conventional outlets or in some new field? The answers to these queries must surely be no!

"There are, however, many other influential factors both in production and consumption which can severely distort any appraisal based on such a simple premise. For example, it must be recognised that much of the Free World's copper is produced in countries which are prone, either potentially or as a historical fact, to the vicissitudes of political and/or labour disturbances."

In its December 27, 1968 issue the Mining Journal (London) states:

"Despite these set backs, it still seems that 1968 will be a year in which primary copper production exceeded real consumption perhaps at a year-end rate of as much as 200,000 ton/annum. It is something of

an engima on the copper market that this has yet to be reflected in prices and some informed quarters suggest that the import of the surplus will not be seen until well into 1969"

(Statistics published in the Year Book of the American Bureau of Metal Statistics for 1968 - issued in July 1969 - show Free World Production of the World on a Smelter or Comparable Basis of 5,629,238 tons and Copper consumption of the World of 5,403,317 tons - a production excess of 226,921 tons).

Beginning with early 1969 until quite recently, the knowledgeable copper sources all have been predicting a 1969 surplus of at least 200,000 tons and it is the consensus that the LME price will fall back to around "a minimum of £400 (i.e. 43¢) and within the broad range of £400-£500 (43¢-53.6¢) as expressed by the Mining Journal on April 11, 1969.

The question of adequate supplies is an important one to all segments of the industry, including producers, consumers (mills, foundries, etc.), consumers of semi-fabricated products, and service metal centers which play an important role in distributing mill products. In its April 17, 1969 issue, the American Metal Market states that "with announced and unannounced expansion plans, it could mean a Free World copper surplus of around one million tons by the end of 1973".

Yvonne Levy of the Federal Reserve Bank of San Francisco in "Copper - Red Metal in Flux", states, that "looking ahead to early 1970's, U.S. copper users are counting on ample supplies of the metal --even at reduced prices. Mr. John V. Hall, President of Anaconda in discussing "External Forces that have influenced the Production and Marketing of Copper", at the Minneapolis Society of Mining Engineers, as quoted by the American Metal Market on February 12, 1969, stated: "Government controls, government persuasion, strikes, export quotas, speculative transactions, tariffs, subsidies, taxes, cold wars and hot wars, political instability, sabotage and other non-economic factors -- because of these, the 'invisible hand' has had a most difficult time in this industry."

There is almost unanimity of opinion to the effect that the actual physical shortage of copper (if one really did exist) has already ended or will soon end. It is borne out by: (a) comparison of average monthly inventories shown on 8 and in Exhibit A; (b) excess of production over consumption in 1968, 226,921 tons (see first full paragraph-this page); the cut back or suspension of refined copper shipments from Zambia to Japan; and the permission granted by the Japanese Ministry of Trade and Industry to export from Japan part of the 40,000 tons of refined copper which is stored there and is deemed to be excess inventory.

There is no doubt about an eventual closing of the gap between the foreign (i.e. LME) price and the domestic producers' price. However, while it is reasonably to be expected that there should be a material drop in the LME price, it must be remembered that the Governments of Chile, Zambia, the Republic of the Congo and Peru have dictatorial powers to arbitrarily set the selling price for their copper - and will undoubtedly exercise such power until the time arrives when production from other countries reaches the point when other nations can very well do without the production of Chile, Zambia, the Republic of the Congo and Peru.

In this connection it should be recalled that in 1953, Chile maintained the price for copper at more than 6 cents a pound above the level for United States metal and as a result it accumulated 180,000 tons of copper that it was unable to sell. In order to prevent its dumping on the market the U. S. Government in March 1954 finally agreed to buy 100,000 tons of the metal at the old price of 30 cents a pound for use in the U. S. stockpile.

Mr. George B. Munroe, President of Phelps Dodge Co. has been reluctant to make predictions concerning the domestic producer price trend. However, he has made known a feeling that eventually the 20-cent or so a pound spread between the U. S. producer quote and the Free World market price will narrow or even be eliminated; a hope that a balance in supply and demand may occur by the end of this year; and a refusal to predict when an adequate supply position might develop.

In the years gone by, the United States companies have invested heavily in foreign properties. The average grade of the United States ores mined has been low as compared with the foreign ores. A large tonnage of domestic sub-ore grade could not be treated economically, and investments abroad were necessary to provide sufficient copper for our fabricating units.

Things have changed. The domestic expenditure of vast sums of money on exploration and mine development with vastly improved mining and metallurgical technologies, including the development of modern, gigantic equipment, is bearing fruit. New fields are being developed and very low grade ore is being mined and processed successfully. The United States probably could revert to self-sufficiency in the production of copper - as was the case prior to 1940. From the data presented on page 17, it would not require an unsurmountable increase in our production. Chile might do well to remember her experience with nitrates.

If the United States were self-sufficient in the production of copper, the prices paid by the fabricator would be reasonable and the United States would no longer suffer an exaggerated balance of payments deficit.

Copper prices in the United States, however, must keep pace with built in yearly wage increases with liberal increases in fringe benefits; increases in taxes - local, state and federal; and increasing inflation of other costs; and the industry should not be pressured by the Government to refrain from price increases to do so.

The United States should bear in mind the importance of the copper industry to her welfare and defense, and should adopt a mineral policy in support of it, and other branches of the mineral industry.

#### PRESENTLY CONTEMPLATED FUTURE COPPER PRODUCTION CAPACITIES

On September 16, 1968, the American Metal Market said:

"Industry quarters estimated that the Free World consumption of copper, if it continues to rise the 'traditional' 4-1/2 percent per annum, will be about 6,173,000 tons annually by the end of 1972."

Presently contemplated copper production capacities as indicated by the various companies of the world will amount to 7,267,880 tons by the end of 1972. Sir Ronald Prain has stated that "many of us have for years worked on projections which

assume a shortfall between capacity and production of 7%, i.e. an operating rate of 93%".

Using the average production rate of 93% of capacity and the Arizona Department of Mineral Resources computation of Free World capacity, production will approximate 6,759,000 tons in 1972, leaving a surplus (if there is no curtailment in that year due to overproduction), of approximately 600,000 tons.

As previously pointed out, in its April 17, 1969 issue American Metal Market stated: "With announced and unannounced expansion plans, it could mean a Free World surplus of around one million tons by the end of 1973".

The presently contemplated copper productive capacities determined by the Arizona Department of Mineral Resources from records appearing in a number of trade statistical sources and announcements appearing in a number of technical, financial, and mining magazines, appear in Exhibit C attached hereto:

contemplated  
The future capacities as compared with production in 1966 and 1968 are summarized as follows:

|                                       | <u>United States Plus Canada</u> |               |              | <u>CIPEC Nations</u> | <u>Other Free World</u> | <u>Total Free World</u> |
|---------------------------------------|----------------------------------|---------------|--------------|----------------------|-------------------------|-------------------------|
|                                       | <u>United States</u>             | <u>Canada</u> | <u>Total</u> |                      |                         |                         |
| <b>Production</b>                     |                                  |               |              |                      |                         |                         |
| 1966                                  | 1,429,152                        | 508,300       | 1,937,452    | 1,932,167            | 919,867                 | 4,789,486               |
| 1968                                  | 1,204,621                        | 608,311       | 1,812,932    | 2,122,711            | 978,423                 | 4,914,066               |
| <b>Contemplated Future Capacities</b> |                                  |               |              |                      |                         |                         |
| 1969                                  | 1,727,700                        | 690,100       | 2,417,800    | 2,366,400            | 1,021,130               | 5,805,330               |
| 1970                                  | 1,892,800                        | 827,500       | 2,720,300    | 2,589,000            | 1,174,890               | 6,484,190               |
| 1971                                  | 1,954,100                        | 890,600       | 2,844,700    | 2,772,500            | 1,192,940               | 6,810,140               |
| 1972                                  | 2,086,400                        | 996,900       | 3,083,300    | 2,923,090            | 1,261,490               | 7,267,880               |
| 1973                                  | 2,161,900                        | 1,015,900     | 3,177,800    | 3,161,790            | 1,477,940               | 7,817,530               |
| 1974                                  | 2,198,200                        | 1,083,900     | 3,282,100    | 3,181,090            | 1,620,640               | 8,083,830               |
| 1975                                  | * 2,364,500                      | 1,147,900     | 3,512,400    | 3,447,990            | 1,679,140               | 8,639,530               |

\* Includes Puerto Rico and Minnesota 116,000 tons contemplated production which is more or less problematical.

In studying the future production schedules, distinction is made between (a) that part of the Free World where production is on a free competitive basis, with private mining companies governing their operations to conform with the need for copper and seeking to obtain a reasonable price for their copper without restriction; and (b) that part where very little copper is consumed but where the bounties of nature have been generously heaped upon these underdeveloped nations in the form of gigantic

(please continue on page 29)



EXHIBIT C

PRESENTLY CONTEMPLATED COPPER PRODUCTION CAPACITIES

|  | PRODUCTION |             | CONTEMPLATED FUTURE CAPACITIES AT END OF |           |           |           |           |           |            |  |
|--|------------|-------------|--|-----------|-----------|-----------|-----------|-----------|------------|--|
|  | 1966       | 1968        | 1969                                     | 1970      | 1971      | 1972      | 1973      | 1974      | 1975       |  |
| Arizona                                  | 739,569    | (a) 627,961 | 878,800                                  | 980,700   | 1,026,200 | 1,032,200 | 1,086,400 | 1,122,400 | 1,122,400  |  |
| Remainder of U.S.<br>(Incl. Puerto Rico) | 689,583    | (b) 576,660 | 848,900                                  | 912,100   | 927,900   | 1,054,200 | 1,075,500 | 1,075,800 | 1,242,100  |  |
| Total U.S.                               | 1,429,152  | 1,204,621   | 1,727,700                                | 1,892,800 | 1,954,100 | 2,086,400 | 2,161,900 | 2,198,200 | 2,364,500  |  |
| Canada                                   | 508,300    | 608,311     | 690,100                                  | 827,500   | 890,600   | 996,900   | 1,015,900 | 1,083,900 | 1,147,900  |  |
| U.S. plus Canada                         | 1,937,452  | 1,812,932   | 2,417,800                                | 2,720,300 | 2,844,700 | 3,083,300 | 3,177,800 | 3,282,100 | 3,512,400  |  |
| Chile                                    | 701,456    | 725,559     | 874,900                                  | 1,060,700 | 1,117,900 | 1,233,190 | 1,233,190 | 1,233,190 | 1,233,190  |  |
| Peru                                     | 194,439    | 235,318     | 247,500                                  | 254,500   | 295,500   | 300,500   | 455,500   | 455,500   | 663,500    |  |
| Chile Plus Peru                          | 895,895    | 960,877     | 1,122,400                                | 1,315,200 | 1,413,400 | 1,533,690 | 1,688,690 | 1,688,690 | 1,896,690  |  |
| Zambia                                   | 687,174    | 804,134     | 858,200                                  | 868,700   | 934,700   | 945,700   | 951,700   | 951,700   | 991,300    |  |
| Republic of Congo                        | 349,098    | 357,700     | 385,800                                  | 405,100   | 424,400   | 443,700   | 521,400   | 540,700   | 560,000    |  |
| TOTAL COPPERBELT                         | 1,036,272  | 1,161,834   | 1,244,000                                | 1,273,800 | 1,359,100 | 1,389,400 | 1,473,100 | 1,492,400 | 1,551,300  |  |
| TOTAL CIPEC                              | 1,932,167  | 2,122,711   | 2,366,400                                | 2,589,000 | 2,772,500 | 2,923,090 | 3,161,790 | 3,181,090 | 3,447,990  |  |
| Australia                                | 116,484    | 110,980     | 133,200                                  | 161,450   | 165,450   | 176,450   | 176,450   | 176,450   | 176,450    |  |
| Oceania                                  | 336        | 400         | 900                                      | 900       | 900       | 900       | 187,400   | 247,400   | 247,400    |  |
| Free Europe                              | 173,425    | 215,301     | 229,900                                  | 244,650   | 251,700   | 270,450   | 279,900   | 279,900   | 286,900    |  |
| Remaining Free Nations                   | 629,622    | 651,742     | 657,130                                  | 767,890   | 774,890   | 813,690   | 834,190   | 916,890   | 968,390    |  |
| Total                                    | 919,867    | 978,423     | 1,021,130                                | 1,174,890 | 1,192,940 | 1,261,490 | 1,477,940 | 1,620,640 | 1,679,140  |  |
| Other Free Nations                       | 4,789,486  | 4,914,066   | 5,805,330                                | 6,484,190 | 6,810,140 | 7,267,880 | 7,817,530 | 8,083,830 | 8,639,530  |  |
| TOTAL FREE WORLD                         | 5,709,353  | 5,892,489   | 6,826,460                                | 7,659,080 | 8,003,080 | 8,529,370 | 9,295,470 | 9,704,470 | 10,318,670 |  |

Short Tons

(a) 141,656 Production Lost in 1968 Due to Strike  
 (b) 151,952 Production Lost in 1968 Due to Strike

## EXHIBIT C -1

## PRESENTLY CONTEMPLATED CAPACITY INCREASES

|  | 1969    | 1970    | 1971    | 1972    | 1973    | 1974    | 1975    | TOTAL     |
|--|---------|---------|---------|---------|---------|---------|---------|-----------|
| Arizona                                  | 63,500  | 101,900 | 45,500  | 6,000   | 54,200  | 36,000  | -       | 307,100   |
| Remainder of U.S.<br>(Incl. Puerto Rico) | 97,450  | 63,200  | 15,800  | 126,300 | 21,300  | 300     | 166,300 | 490,650   |
| Total United States<br>Canada            | 160,950 | 165,100 | 61,300  | 132,300 | 75,500  | 36,300  | 166,300 | 797,750   |
|  | 14,200  | 137,400 | 63,100  | 106,300 | 19,000  | 68,000  | 64,000  | 472,000   |
| United States Plus Canada                | 175,150 | 302,500 | 124,400 | 238,600 | 94,500  | 104,300 | 230,300 | 1,269,750 |
| Chile                                    | 57,900  | 185,800 | 57,200  | 115,290 | -       | -       | -       | 416,190   |
| Peru                                     | 6,000   | 7,000   | 41,000  | 5,000   | 155,000 | -       | 208,000 | 422,000   |
| Chile Plus Peru                          | 63,900  | 192,800 | 98,200  | 120,290 | 155,000 | -       | 208,000 | 838,190   |
| Zambia                                   | 54,100  | 10,500  | 66,000  | 11,000  | 6,000   | -       | 39,600  | 187,200   |
| Republic of Congo                        | 18,300  | 19,300  | 19,300  | 19,300  | 77,700  | 19,300  | 19,300  | 192,500   |
| Total Copperbelt                         | 72,400  | 29,800  | 85,300  | 30,300  | 83,700  | 19,300  | 58,900  | 379,700   |
| TOTAL CIPEC                              | 136,300 | 222,600 | 183,500 | 150,590 | 238,700 | 19,300  | 266,900 | 1,217,890 |
| Australia                                | 4,400   | 28,250  | 4,000   | 11,000  | -       | -       | -       | 47,650    |
| Oceania                                  | 500     | -       | -       | -       | 186,500 | 60,000  | -       | 247,000   |
| Free Europe                              | 14,650  | 14,750  | 7,050   | 18,750  | 9,450   | -       | 7,000   | 71,650    |
| Remaining Free Nations                   | 38,800  | 110,760 | 7,000   | 38,800  | 20,500  | 82,700  | 51,500  | 350,060   |
| TOTAL OTHER FREE NATIONS                 | 58,350  | 153,760 | 18,050  | 68,550  | 216,450 | 142,700 | 58,500  | 716,360   |
| TOTAL FREE WORLD                         | 369,800 | 678,860 | 325,950 | 457,740 | 549,650 | 266,300 | 555,700 | 3,204,000 |

## ARIZONA

ESTIMATED ANNUAL COPPER PRODUCTIVE CAPACITY  
(Estimated by the Arizona Department of Mineral Resources)

|                                   | Short Tons     |                |                  |                  |                  |                  |
|-----------------------------------|----------------|----------------|------------------|------------------|------------------|------------------|
|                                   | 1969           | 1970           | 1971             | 1972             | 1973             | 1974-5           |
| ASARCO - Silver Bell              | 24,800         | 24,800         | 24,800           | 24,800           | 24,800           | 24,800           |
| Mission                           | 70,000         | 70,000         | 70,000           | 70,000           | 70,000           | 70,000           |
| N. San Xavier                     | a              | a              | a                | a                | a                | a                |
| Arizona Ranch & Metal             |                |                |                  |                  |                  |                  |
| Mineral Hill                      | 2,500          | 2,500          | 2,500            | -                | -                | -                |
| Anaconda Twin Buttes              | 10,000         | 60,000         | 60,000           | 60,000           | 60,000           | 60,000           |
| Bagdad                            | 20,000         | 20,000         | 20,000           | 20,000           | 20,000           | 20,000           |
| Cyprus                            |                |                |                  |                  |                  |                  |
| Old Dick                          | 2,500          | 2,500          | 2,500            | -                | -                | -                |
| Pima                              | 64,000         | 64,000         | 64,000           | 64,000           | 64,000           | 64,000           |
| Duval                             |                |                |                  |                  |                  |                  |
| Esperanza                         | 26,000         | 26,000         | 26,000           | 26,000           | 26,000           | 26,000           |
| Mineral Park                      | 30,000         | 30,000         | 30,000           | 30,000           | 30,000           | 30,000           |
| Sierrita                          | 15,000         | 60,000         | 81,500           | 81,500           | 81,500           | 81,500           |
| El Paso Natural Gas               |                |                |                  |                  |                  |                  |
| Emerald Isle                      | 2,500          | 2,500          | 2,500            | 2,500            | 2,500            | 2,500            |
| Hecla                             |                |                |                  |                  |                  |                  |
| Lakeshore                         | 4,000          | 4,000          | 4,000            | 4,000            | 35,000           | 35,000           |
| Inspiration-Inspiration           | 55,000         | 55,000         | 55,000           | 55,000           | 55,000           | 55,000           |
| Christmas                         | 8,000          | 8,000          | 9,000            | 9,000            | 9,000            | 9,000            |
| Ox Hide                           | 2,000          | 6,000          | 8,000            | 8,000            | 8,000            | 8,000            |
| Red Hill                          | -              | -              | -                | -                | 3,000            | 3,000            |
| Kennecott - Ray                   | 100,000        | 100,000        | 100,000          | 100,000          | 100,000          | 100,000          |
| Magma                             |                |                |                  |                  |                  |                  |
| San Manuel                        | 102,000        | 102,000        | 127,000          | 150,000          | 150,000          | 150,000          |
| Superior                          | 21,800         | 21,800         | 21,800           | 21,800           | 57,000           | 57,000           |
| McAlester Fuel -Zonia             | 2,200          | 2,200          | 2,200            | 2,200            | 2,200            | 2,200            |
| Phelps Dodge                      |                |                |                  |                  |                  |                  |
| Morenci                           | 150,000        | 150,000        | 150,000          | 150,000          | 150,000          | 150,000          |
| New Cornelia                      | 70,000         | 70,000         | 70,000           | 70,000           | 70,000           | 70,000           |
| Lavender Pit                      | 31,000         | 31,000         | 23,000           | 17,000           | 8,000            | 5,000            |
| Copper Queen                      | 24,000         | 24,000         | 18,000           | 12,000           | 6,000            | -                |
| Metcalf                           | -              | -              | -                | -                | -                | 50,000           |
| Ranchers Exploration              |                |                |                  |                  |                  |                  |
| Bluebird                          | 4,500          | 5,400          | 5,400            | 5,400            | 5,400            | 5,400            |
| Tennessee Miami                   | 9,000          | 9,000          | 9,000            | 9,000            | 9,000            | 9,000            |
| Copper Cities                     | 24,000         | 24,000         | 24,000           | 24,000           | 24,000           | 24,000           |
| Castle Dome                       | 2,000          | 2,000          | 2,000            | 2,000            | 2,000            | 2,000            |
| Standard Antler                   | -              | 2,000          | 2,000            | 2,000            | 2,000            | 2,000            |
| Miscellaneous -<br>(Small & B.P.) | 2,000          | 2,000          | 12,000           | 12,000           | 12,000           | 12,000           |
| <b>TOTAL</b>                      | <b>878,800</b> | <b>980,700</b> | <b>1,026,200</b> | <b>1,032,200</b> | <b>1,086,400</b> | <b>1,127,400</b> |

(a) Included in "Miscellaneous"

high-grade copper ore deposits. The nations in part (b) have formed the Council of Intergovernmental Copper Exporting Countries (known as CIPEC). In 1968 Zambia, Chile, the Republic of the Congo, and Peru, the four nations comprising CIPEC, produced 2,122,711 or 43.2% of a Free World total of 4,914,066 tons of copper contained in ore, but, according to figures presented in the American Bureau of Metal Statistics, out of a total of 5,652,400 tons of refined copper (primary and secondary) consumed in the Free World, Chile consumed 25,000 tons and the other three nations didn't consume enough to list separately - but it was no more than an aliquot part of 6,000 tons consumed in "Other America" and 7,700 tons in "Other Africa".

However with the production of 43.2% of the Free World's copper and with only a negligible consumption, the CIPEC is an organization headquartered in Paris with a purpose of increasing production and raising sales prices so that the mines of the four member countries may pay higher taxes and a larger share of their sales proceeds for what the countries regard as the removal of their natural resources.

Of course all of the mines being seized (as in the Republic of the Congo) or "nationalized" (as in Chile) or asked "to donate 51% of their stock" (as in Zambia), have been developed by foreigners entirely with foreign risk capital -- and regardless of the name given to the takeover, no cash is being paid for the property taken over. The hope for the investors in the properties being taken over, is that the payments will be paid out of future dividends accruing to the state.

Late in 1966, the Congo seized the huge mining and processing complex of the Union Miniere du Haut Katanga (UMK). No agreement has been reached yet concerning how much the Congo will pay UMK for the takeover.

Zambia, Chile and the Congo depend heavily on the foreign exchange earned by their copper exports (since they use very little of their copper production themselves), so that they are dedicated to the proposition that the more they can force the foreign companies to produce and export, the more "hard money" will be coming into their tills for home distribution.

From Exhibit C it will be observed that beginning with 1966, a year of previous high production and until 1973, when the forced Chilean and Zambian expansions will have been placed in operation, United States production will be increased in the 7 year period by 51.3 percent, while the CIPEC tonnage will be increased by 63.6 percent.

It will be noted that these increases are well in excess of the traditional 4-1/2 percent per annum increase in copper consumption - in further support of the fears that unless mines are operated at less than capacity beginning shortly - a large surplus of copper will build up again.

In contrast with CIPEC, Japan produces little copper but is a large consumer. The Japanese Ministry of International Trade and Industry has calculated that Japan will consume 1,020,000 metric tons of copper in the year 1975. The production from their own mines cannot be expected to increase to over 170,000 metric tons by then and copper reclaimed from scrap will amount to about 110,000 metric tons, leaving

740,000 metric tons needed from abroad by 1975. She therefore is scouring the earth in search for copper in all forms, - ores, concentrates, blister, and refined. She is anticipating imports from overseas mines developed by Japanese companies of 210,000 tons and has purchased from foreign concerns under long-term contracts thus far an additional 110,000 tons. There is a deficit still to be provided of 420,000 tons per year. The major tonnage of the new production from Oceania (Bougainville, West Irian, Malaya), nearly all of the production from British Columbia, Iran and the Philippines - both present production and future increases - are destined for Japan. Therefore, of the 1973-1975 production increases of the entire Free World, amounting to a total of 1,371,650 tons, Japan will procure 463,000 tons (equivalent to 420,000 metric tons) or over one-third.

The production capacity in Arizona and the United States will increase from 1968 to 1972 by 262,563 tons and 588,171 tons to 1,032,200 tons and 2,086,400 tons respectively (34% and 39% respectively).

Canadian capacity will increase from 1968 to 1972 by 389,000 tons to 996,900 tons or 64% (with the large British Columbia increase destined for Japan).

CIPEC capacity will increase between 1968 and 1972 by 800,379 tons to 2,903,090 or 38%.

For the rest of the Free World capacity will increase between 1968 and 1972 by 283,069 tons to 1,261,490 tons or 29%.

It is thus evident that the planned increases in capacity far exceed the traditional 4-1/2 percent per annum increase in consumption and the CIPEC group of nations who use exceedingly little copper will produce an additional increment of over 800,000 tons, while the United States which according to the World Bureau of Metal Statistics consumed over 33 percent of the Free World's refined copper in 1968, in the four years between 1968 and 1972 will add 588,000 tons to its capacity to produce. That, too, exceeds the 4-1/2 percent increase in consumption rate.

"Copper - Red Metal in Flux" issued by the Federal Reserve Bank of San Francisco, while arriving at practically the same annual production potential of American mines by 1972 as the Arizona Department of Mineral Resources, warns that:

"In view of the fact that capacity moved ahead of consumption during the 1967-1968 strike, growth in consumption at that rate (5.3 percent) over the next four years could still leave the industry well over a million tons excess capacity by 1972; an end to hostilities in Vietnam might increase that surplus even more."

However, after 1972, the picture changes. Between 1973 and 1975, the following incremental capacities have been planned:

|  | <u>Tons</u>      | <u>% of 1972<br/>Capacity</u> |
|--|------------------|-------------------------------|
| Arizona  | 90,200           | 8.7                           |
| Remainder of U.S. (excluding<br>Puerto Rico and Minnesota) | 71,900           | 6.8                           |
| Canada   | 151,000 *        | 15.1                          |
| CIPEC  | 524,900          | 18.0                          |
| Other Free Nations   | <u>417,650 *</u> | <u>24.8</u>                   |
| Total Free Nations (excluding<br>Puerto Rico & Minnesota)  | 1,255,650        | 17.3                          |

\* Due to large Japanese commitments in British Columbia, Oceania and Philippines.

The foresightedness of Japan in providing for her future needs is overmatched by the CIPEC group pressuring of producers to increase their production even though sacrifices in price might be necessary in order to dispose of the increase.

In the United States, assuming no increment in the traditional 4-1/2% per annum increase in consumption, the excess production capacity installed through 1972 would be spread out beyond 1972 to absorb the deficiency in planned production between 1972 and 1975 - and unless planned increases in capacity by 1975 are on the boards, the United States will be faced with either a shortage of domestic copper or the forced necessity of buying CIPEC copper.

Arizona and the United States are looking forward to Anaconda's increasing Arizona, Montana, and Canadian copper production to take the place of the Chilean copper which will become nationalized in about seven years.

Sir Ronald Prain has made the interesting point that Roan Selection Trust has encountered three separate mineralized areas containing some 200 million tons of copper content of just under 0.9 percent and "that in many parts of the world such mineral reserves could be regarded as ore bodies, i.e. economically viable deposits. In Zambia, however, the present fiscal conditions are such that the exploitation of such deposits with a high stripping ratio and remote location would not be economically viable. Now with the expectation that there will be a change in the fiscal conditions in Zambia, the company has been encouraged to launch a more detailed examination of the Lumwana deposits, about 150 miles from the Copperbelt".

Ores of 0.9 percent are well above the average grade of current United States production. The 3 to 4.5 percent ores treated in the Copperbelt are "out of sight".

As stated in the Arizona Department of Mineral Resources' Copper Industry report for 1967:

"The need for copper is expected to more than double by 1985. Therefore, Arizona's copper resources are of great importance to the Nation's economy and defense. Her copper mines have been producing more

than half of the copper produced in the United States, the largest producer of copper in the Free World (U.S.S.R. is by far the second largest producer). However, the copper developments in the world all have an affect upon Arizona, because copper has a world market. She has met the challenges of the past with tremendous advances in mining technology, and expects to continue to meet them. However, there has been a noticeable increase in U. S. investment in foreign mines. Capital will go where profit is greatest, and it behooves Arizona and the Nation to look to their mineral policies. Capital, never too available, wants the greatest possible stability of economic conditions, including that provided by protection against excessive imports of low cost, foreign copper. The Nation needs her copper mines and the capital investment necessary to find and develop them."

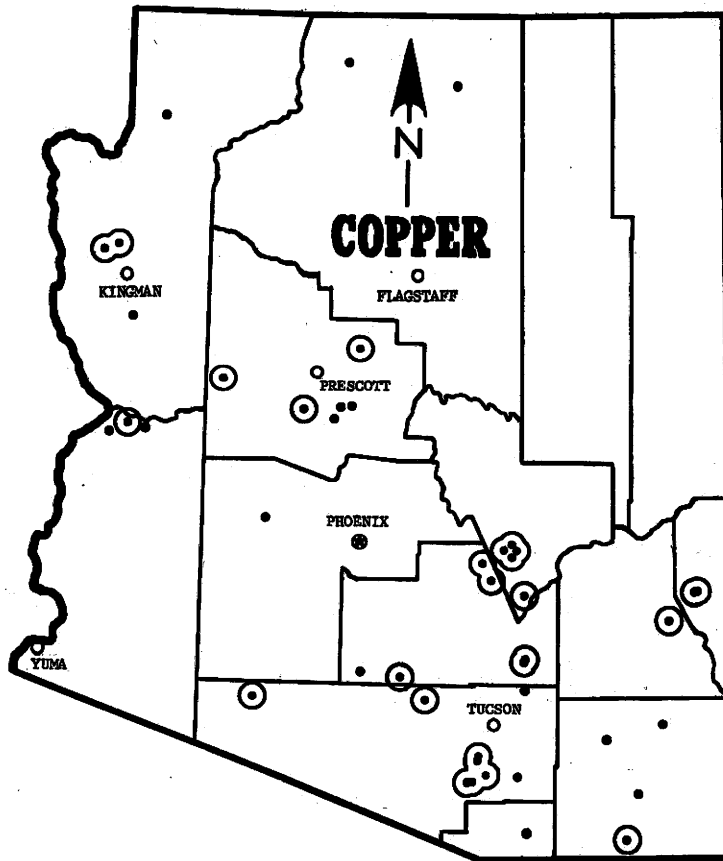
**NOTE:**

Tabulations of detailed statistics of Copper Mining and Smelting employment, and of monthly copper statistics, for periods covered by this paper, "The Copper Mining Industry 1966-70", are available in very limited supply, and may be obtained from the Department by those concerned with the industry to whom such detail may be of assistance, as long as the supply lasts.

FRANK P. KNIGHT,  
Director.

**DEPARTMENT OF MINERAL RESOURCES  
STATE OF ARIZONA  
PHOENIX, ARIZONA**

**FRANK P. KNIGHT, DIRECTOR**



**31st Annual Report  
for  
Year Ending June 30, 1970**



Honorable Jack Williams  
Governor of Arizona  
Capitol Building  
Phoenix, Arizona

Dear Sir:

The Annual Report of the Department of Mineral Resources, covering the fiscal year July 1, 1969 to June 30, 1970, is submitted herewith.

The report contains, as formerly, a review of mining activity in the State, and of this department's activities which are directed towards the development and welfare of Arizona's mining industry.

Very truly yours,

*Frank P. Knight*

FRANK P. KNIGHT  
Director.

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## ARIZONA'S MINERAL PRODUCTION

The value of Arizona's total mineral production in 1969 increased to \$859,475,000, an all-time record, 39 percent above 1968. Copper accounted for \$761,840,000 or 89 percent of the 1969 total value. The copper recovered from ores in 1969 amounted to 738,760 short tons, 110,799 tons more than in 1968. The copper recovered from each ton of ore was only 11.6 pounds. In 1960 it was 15 pounds.

The grand total of the value of Arizona's mineral production to the end of 1969, is approximately 13.1 billion, of which approximately 84.2 percent has come from copper. Arizona mined 51.9 percent of the Nation's copper production in 1969, ranking first among the United States as it has done since 1910. It ranked 2nd in silver, 4th in gold, 16th in lead, 13th in zinc and 2nd in molybdenum production. Arizona has at San Manuel the largest underground copper mine, and at Morenci, the second largest open pit copper mine, in the Nation.

Details of the mineral production are to be found in the Appendix to this report.

### ACTIVE MINES

Two major open pit copper mines started production in the fiscal year; development of a large underground copper deposit and a large open pit copper project were started; two large copper expansion projects were started; feasibilities of other developments were being studied; and exploration activity held at a high level, in this important year of Arizona copper mining. The number of producing mines is shown in Table VI on page VII of the Appendix. In April 1970, a department survey showed 36 producing copper mines, including one with ore containing important amounts of zinc; 4 lead and/or zinc mines; 6 gold and/or silver; and 41 other producers of metallic or non-metallic minerals; making a total of 87, 9 more than in April 1969. Sand & gravel, stone, common clay and solid and liquid fuel producers are omitted from the lists. The United States Bureau of Mines has reported the following number of base metal mines producing during 1969: 48 copper, 3 with copper-zinc ores; 15 gold and/or gold-silver; 18 silver; and 8 lead and/or zinc; ranging in size from a placer gold mine with production of 5 ounces of the metal, to the largest of the State's copper mines with production of 136,827 tons of copper.

### EMPLOYMENT

Information supplied by the Arizona Employment Security Commission is that in 1969 (1968 in parentheses) there were employed in Arizona mining, quarrying and smelting an average of 20,983 (16,913) covered employees on payrolls with total wages of \$185,278,726 (\$144,782,917) or an average of \$8,830 (\$8,560) per year per employee. The "total covered wages" reported by the Commission represent the payroll amounts paid by the employer directly to the employees for straight time wages and for certain "fringe benefits" including time-off for vacations, jury duty, holidays, etc., and additional premiums paid for overtime and for shift

differentials. Other "fringe benefits" are the labor costs not paid directly to the worker, such as statutory employer payroll taxes for social security and unemployment compensation, supplementary unemployment compensation reserves, group life and health insurance, retirement plan contributions, etc. It is estimated that the total "fringe benefits" amount to a figure well in excess of 30 percent of the total labor costs for hours actually worked on a straight time basis, and that over half of the total is outside of the payroll. Not included are costs of workmen's compensation and disability expenses. These are regarded as operating costs of insurance against injuries.

## COPPER

The 801,363 tons of copper produced from Arizona's mines in 1969, made an all-time record as did its value of \$761,800,000, and it again was more than the combined tonnage of all of the other states.

Production from the 16 largest copper mines in Arizona is given for the years 1968 and 1969 in Table VI of the Appendix. These mines produced 97.5 percent of the total copper production of the state in 1968 and 96.3 percent in 1969. Included in the production figures are copper tonnages recovered from waste dumps by leaching. The copper recovered from ores mined at the 16 mines averaged only 11.8 pounds per ton in 1968 and 11.9 in 1969. In 1960, the Arizona ores yielded 15 pounds per ton.

Anaconda's Twin Buttes mine south of Tucson started operating at part capacity in September 1969 and the mine will show a substantially greater production for 1970. In the second quarter of 1970, Anaconda announced their study of developing their leased Helvetia and Eisenhower ore deposits.

Duval Sierrita's new operation southwest of Tucson mined and stockpiled some 1,500,000 tons of ore in 1968 and 1969, but the new concentrator did not go into operation until early 1970. Plans were announced for increasing production capacity from 66,000 to 72,000 ore tons per day.

Phelps Dodge started its \$100 million project to develop its Matcalf mine near Morenci late in 1969.

Hecla in December 1969 started twin 7500 ft. inclined development shafts at the Lakeshore property south of Casa Grande.

Magma proceeded with shafts and other facilities for expansion projects at its San Manuel and Superior divisions estimated to cost more than \$135 million, and announced plans for an electrolytic refinery with capacity of 200,000 tons of refined copper annually, beginning with 1972.

Asarco in the spring of 1970 announced plans for a 4000 ore tons per day leaching facility at its San Xavier mine southwest of Tucson.

Copper leaching operations continued in the fiscal year at the Miami, Castle Dome, Blue Bird, and Ox Hide mines of Gila County; Zonia and Big Hole mines in Yavapai; Emerald Isle in Mohave; and San Juan mine in Graham County. Some leaching also was done at the Name in Cochise and the Mineral Hill mine in Yuma County. Inspiration took over the Sanchez property in Graham County and

proceeded with experimental leaching and exploratory drilling.

Increasing regulation of pollution from copper smelters alarmed the copper producers, especially when Asarco cut its smelter input by 15 percent because of pollution restrictions. The cut caused stocking of concentrates by Asarco customers, Anaconda, Duval, Pima and Bagdad, and their consideration of using foreign facilities. Intensive research in chemical extraction of copper, and sulphur, plus large increases in expenditures for reduction in particulate matter and sulphur in smelter gases, were undertaken.

Copper exploration continued at a high level with several significant findings being actively explored and studied as to feasibility of operation.

#### Copper-Zinc

The Old Dick mine near Bagdad continued to supply most of the zinc output of the state.

Early in 1970, Standard Metals Corp. completed its 250 t.p.d. copper-zinc mill east of Yucca, and started to feed it ores from its Antler and Copper World mines.

#### LEAD-ZINC

Arizona's lead production dropped to a mere 217 tons in 1969, and was 171 tons for the first six months of 1970. In the period 1947-1952 the state averaged 25,388 tons of lead annually. And it may be a long time before it has another mine like the Iron King at Humboldt, which for many years up to 1969 was its major producer of lead and zinc.

Arizona produced 9,039 tons of zinc in 1969, over two-thirds of it coming from the Old Dick mine mentioned above. 5,013 tons were produced in the first half of 1970.

Far Mining Enterprises in the Aravaipa area and Magnum Consolidated near Signal attempted to restore lead-zinc production in the areas, but work by both has died down.

#### GOLD - SILVER - MOLYBDENUM

Practically all of Arizona's production of these metals comes as by-products from copper, lead-zinc and complex ores.

#### Gold

In 1969 Arizona produced 110,878 troy ounces of gold worth \$4,603,000 or 16 percent more quantity and 23 percent more value than in 1968. The average price received in 1969 was \$41.51 per troy ounce as against \$39.26 in 1968. In the first half of 1970 the State produced 56,172 ounces, 5 percent less than in the first half of 1969, according to figures of the U.S. Bureau of Mines. The market

price also declined and on June 30, 1970, gold at London was \$35.49. The Bureau reported one placer gold mine in Arizona in 1969 which produced 5 ounces only, and 7 dry gold lode mines which produced an average of 71 ounces each.

Seven of Arizona's larger base metal mines were in the top 25 gold producers in the Nation in 1968. They, with their ranks in parentheses, were New Cornelia (6), Bisbee (7), San Manuel (10), Morenci (13), Magma (16), Iron King (18) and Christmas (20). All except Iron King were copper mines.

### Silver

The average price received for Arizona's silver production fell 16 percent from \$2.14 per troy ounce in 1968 to \$1.79 in 1969. This was more than offset by a 24 percent increase in quantity and the value of Arizona's production rose from \$10,633,000 in 1968 to \$10,997,000 in 1969. The price also declined in the first half of 1970 to \$1.61 at the end of June. The State's production of silver for 1969 was 6,141,022 ounces. Production for the first half of 1970 was 3,549,242 ounces, up 18 percent from the first half of 1969. The major Arizona silver producing mines, with their national ranking in 1968 in parentheses were Pima (10), Mineral Park (12), Bisbee (13), Morenci (15), Mission (16), New Cornelia (22), and Magma (23). All are copper mines.

96 percent of Arizona's 1969 silver output came from copper ores. A total of 83,110 ounces was produced by 18 lode silver mines, according to Bureau of Mines reports.

### Molybdenum

Molybdenum has become the most important by-product of a number of the copper producers of Arizona. Its total value in 1969 was \$20,947,000, 9 percent over 1968 and 34 percent above the combined value of the gold and silver produced in 1969. It ranked second behind copper in value among minerals produced in the state.

Molybdenum is of particular importance to the new \$165,000,000 Sierrita operation of Duval Sierrita Corp. which is expected to nearly double the amount of Arizona's 1969 production of the metal.

## URANIUM - VANADIUM

### Uranium

The amount of Arizona's production of  $U_3O_8$  in 1969 has not been reported publicly. However, it is reported that New Mexico, Wyoming, Colorado, Texas and Utah combined produced 99 percent of the domestic output and that the balance of 1 percent "came primarily from Arizona." Since production at the Orphan mine at Grand Canyon, the last uranium producer of much consequence active in Arizona, stopped in April 1969, it is probable that production in the fiscal year has been small and the lowest in over 20 years.

Uranium exploration, however, continued to be active.

## OTHER METALS AND NONMETALLIC MINERALS

1969 production figures for other Arizona metals and nonmetallic minerals are included in Table II of the Appendix. The more important ones for which individual figures are given, are: helium, down 13% from 1968; lime, up 9%; natural gas, up 29%; petroleum, down 28%; pumice, down 12%; sand and gravel, up 20%; and stone, down 14% from 1968.

An important mineral, coal, is about to become prominent in Arizona mining. Peabody Coal Co. has contracted to supply 117 million tons of coal to a 1,580,000 KW power plant being built in Nevada across from Bullhead City, Arizona, and 210 million tons to a 2,311,000 KW plant to be built near Page, Arizona. The first unit of the "Mohave" plant in Nevada was scheduled to go on line in Mid-1970. Ground has been broken for the Page plant at which the first unit is scheduled for operation in mid-1974. The coal for the Mohave plant is supplied by a slurry pipeline and slurry preparation and movement is handled by Black Mesa Pipe Line, Inc. Coal for the Page Plant is to move by shuttle trains. Power from both plants will be used in the southwest, especially the Los Angeles area. Power from the Page plant is partly for future use for the Central Arizona Project. The Black Mesa coal to be mined is in Navajo and Navajo-Hopi lands of northern Arizona.

## DEPARTMENT ACTIVITIES

The statutory duties of the department are transcribed on page II of the Appendix. They are summarized in the first paragraph, which reads: "Aid in the promotion and development of the Mineral Resources of the State."

Reliable geological and mining information is a prime requisite for the attraction of interest in and capital for mineral exploration and the development of mines. Therefore, a major part of the department's budget was devoted to the collection of such information and its dissemination in publications including statistical reports, by correspondence and verbally. The department's extensive library of Arizona Mining, including its files of individual mine information, was in constant and effective use. Cataloging has been in progress for a number of years but needs to be completed as quickly as possible.

Department personnel met, conferred and corresponded with parties interested in Arizona mining, including other state and federal agencies, and conducted economic and technical studies of problems arising therefrom. Federal legislation related to Arizona mineral exploration and development was studied, discussed with others, and commented upon in hearings and correspondence with parties concerned.

The director during the year attended three meetings of the Western Governor's Mining Advisory Council as a delegate and chairman of its Mineral Taxation committee; two meetings of the Mining Advisory Committee of the Four Corners Regional Commission of which he is a member; and meetings of the Rocky Mountain Mineral Law Institute, American Mining Congress; American Institute of Mining, Metallurgical and Petroleum Engineers, Mining and Ecology Symposium, and the Arizona Small Mine Operators Association. One or more of the field engineers attended meetings of the last three groups listed.

The department published a revision of its booklets, Mining in Arizona, and prepared for publication a revision of its booklet, Laws and Regulations Governing

Mineral Rights in Arizona. The former was jointly printed, the Arizona Mining Association ordering 15,000 copies for its educational program and the department ordering 10,000.

The following statistical reports were mimeographed and distributed to a mailing list of approximately 300 including news media:

|   | <u>Pages</u> |
|---|--------------|
| The Copper Mining Industry 1966-1970                  | 32           |
| Copper Industry Statistics for 1968                   | 31           |
| Inventory of Arizona Lands as of June 30, 1968        | 8            |
| Lead and Zinc 1968                                    | 28           |
| Gold, Silver and Molybdenum - 1968,1969 (Preliminary) | 31           |

Other papers mimeographed and made available were:

|   |    |
|---|----|
| Active Mine List, as of October 1969  | 10 |
| Active Mine List, as of April 1969  | 10 |
| Directory of State and Federal Agencies in<br>Arizona of Interest to Mining | 4  |
| Arizona Registered Engineers Available for<br>Consulting Work               | 4  |
| Pertinent Data for New Mining Operations in Arizona                         | 3  |

During the year, the field engineers were available in the field for consultation at announced places and times. They travelled 27,709 miles; attended 118 meetings of the A.S.M.O.A.; made 484 mine visits; and discussed mining problems with 1600 individuals, 261 in the field, 500 in their offices and 839 by telephone.

There were 2051 visitors and 5659 phone calls to the department during the year.

The museum continued to be supported by the Arizona Mining Association. The department continued to furnish utilities and janitor services.

Expenditures for the year were as follows:

APPROPRIATION - Fiscal 1969-1970 93,650.00

EXPENDITURES

|                                    |                 |                 |
|------------------------------------|-----------------|-----------------|
| Personal Services                  | \$ 62,099.01    |                 |
| Professional Services              | 6,000.00        |                 |
| Travel - State                     | 5,244.47        |                 |
| Travel - Out of State              | 957.88          |                 |
| Current Expenditures               |                 |                 |
| Tel & Tel                          | 1,399.72        |                 |
| Utilities                          | 1,554.14        |                 |
| Postage                            | 1,070.00        |                 |
| Printing                           | 1,281.05        |                 |
| Mtnce. & Repairs                   | 799.17          |                 |
| Office Supplies                    | 1,172.07        |                 |
| Janitor Supplies                   | 292.46          |                 |
| Mtnce. Supplies                    | 111.05          |                 |
| Other Supplies                     | 96.87           |                 |
| Subscriptions & Dues               | 224.75          |                 |
| Fixed Charges                      | 35.00           |                 |
| Building & Equipment Ins.          | 88.00           |                 |
| Capital Outlay                     | <u>1,740.96</u> |                 |
| TOTAL EXPENDITURES                 |                 | 84,166.60       |
| Balance - Returned to General Fund |                 | <u>9,483.40</u> |
|                                    |                 | 93,650.00       |



The large amount returned to the General Fund was mostly unused allotment for salaries and the remainder was due to the below normal employment. During the year it was unusually difficult to get adequate replacements at the salaries available.

DEPARTMENT OF MINERAL RESOURCES

STATE OF ARIZONA

BOARD OF GOVERNORS

William T. Elsing, Phoenix - Chairman  
(term expires January 31, 1971)

Jack W. Still, Prescott (to 8/25/69)

Matt Danenhauer, Clifton  
(term expires January 31, 1972)

Kenrick L. Lamb, Kingman  
(term expires January 31, 1973)

Robert C. Bogart, Bagdad (8/25/69)  
(term expires January 31, 1974)

Stephen H. Congdon, Tucson (to 1/31/70)

Robert E. Heineman, Tucson (2/1/70)  
(term expires January 31, 1975)

PERSONNEL

|                                     |                                    |
|-------------------------------------|------------------------------------|
| Frank P. Knight                     | Director                           |
| B. H. Gerwin (to 12/15/69)          | Assistant to Director              |
| Gerald W. Irvin                     | Field Engineer - Southern District |
| Fremont T. Johnson                  | Field Engineer - Northern District |
| John H. Soule' (to 11/1/69)         | Field Engineer - Central District  |
| Glen Walker (5/1/70)                | Field Engineer - Central District  |
| Mrs. Glenn W. Pare                  | Administrative Assistant           |
| Mrs. Pauline Halloren               | Secretary                          |
| Mrs. Ray E. Sparkes                 | Secretary                          |
| Mrs. Robert E. McIndoo (to 2/27/70) | Secretary                          |
| Lester R. Brown                     | Consultant                         |

OFFICES

Phoenix Office - Mineral Building, State Fairgrounds  
Tucson Office - Room 106, State Office Building

## STATUTORY POWERS AND DUTIES

"Aid in the promotion and development of the Mineral Resources of the State .

Conduct studies of the economic problems of prospectors and operators of small mines for the purpose of assisting in their solution.

Assist in discovering sources of supply for persons desiring to buy minerals .

List and describe available mining properties .

Make mineral resource surveys and conduct other investigations which may interest capital in the development of the state's mineral resources .

Serve as a bureau of mining information in conjunction with the Arizona Bureau of Mines .

Publish and disseminate information and data necessary or advisable to attain its objectives .

Cooperate with the state land department to encourage mining activity on state lands .

Cooperate with the corporation commission in its investigations and administration of laws relating to the sale of mining securities .

Cooperate with the Arizona Bureau of Mines , and deliver to the Bureau problems which the field work of the division shows to be within the scope of the activities of the Bureau .

Cooperate with federal and other agencies designed to develop mines and minerals .

Oppose congressional acts favoring reciprocal or duty free imports of foreign minerals .

Use its authority in other ways to assist in more extensive exploration and development of the mineral resources of the state ."

TABLE I

Arizona production and value of the six principal metals in 1969, as reported by the United States Bureau of Mines, were as follows:

|            |                 |   |             |                   |
|------------|-----------------|---|-------------|-------------------|
| 801,363    | tons copper     | @ | 47.5¢/lb    | \$ 761,840,000    |
| 217        | tons lead       | @ | 15.0¢/lb    | 65,000            |
| 9,039      | tons zinc       | @ | 14.6¢/lb    | 2,639,000         |
| 110,878    | ozs. gold       | @ | \$41.514/oz | 4,603,000         |
| 6,141,000  | ozs. silver     | @ | \$ 1.791/oz | 10,997,000        |
| 12,699,000 | lbs. molybdenum | @ | \$ 1.650/lb | <u>20,947,000</u> |
|            |                 |   |             | \$801,091,000     |

This compares with the following final figures for 1968:

|            |                 |   |              |                   |
|------------|-----------------|---|--------------|-------------------|
| 627,961    | tons copper     | @ | 41.8¢/lb     | \$ 525,566,000    |
| 1,704      | tons lead       | @ | 13.2¢/lb     | 450,000           |
| 5,441      | tons zinc       | @ | 13.5¢/lb     | 1,469,000         |
| 95,999     | ozs. gold       | @ | \$ 39.261/oz | 3,769,000         |
| 4,958,000  | ozs. silver     | @ | \$ 2.145/oz  | 10,633,000        |
| 12,127,000 | lbs. molybdenum | @ | \$ 1,584/lb  | <u>19,207,000</u> |
|            |                 |   |              | 561,094,000       |

TABLE II

MINERAL PRODUCTION IN ARIZONA IN 1969 <sup>1/</sup>

|  | Quantity | Value<br>(Thousands) |
|--|----------|----------------------|
| Clays ----- thousand short tons  | 120      | \$394                |
| Copper (recoverable content of ores, etc.) short tons  | 801,363  | 761,840              |
| Diatomite ----- short tons   | 725      | W                    |
| Gem stones ----- NA  | NA       | 153                  |
| Gold (recoverable content of ores, etc.) troy ounces   | 110,878  | 4,603                |
| Gypsum ----- thousand short tons   | 83       | 424                  |
| Helium, grade a <sup>2/</sup> ----- thousand cubic feet  | 56,300   | 1,126                |
| Iron ore (usable) -- thousand long tons, gross weight  | 18       | 136                  |
| Lead (recoverable content of ores, etc.) short tons  | 217      | 65                   |
| Lime ----- thousand short tons   | 283      | 5,074                |
| Mercury ----- 76-pound flasks  | W        | W                    |
| Molybdenum (content of concentrate) thousand pounds  | 12,699   | 20,947               |
| Natural gas (marketed) ----- million cubic feet  | 1,136    | 199                  |
| Petroleum (crude)-----thousand 42-gallon barrels   | 2,433    | 7,056                |
| Pumice ----- thousand short tons   | 910      | 814                  |
| Sand and gravel----- thousand short tons   | 16,744   | 18,224               |
| Silver (recoverable content of ores, etc.) thousand troy ounces  | 6,141    | 10,997               |
| Stone ----- thousand short tons  | 2,827    | 5,812                |
| Tungsten concentrate (60-percent WO <sub>3</sub> basis) short tons   | 1        | 2                    |
| Uranium (recoverable content U <sub>3</sub> O <sub>8</sub> ) thousand pounds   | W        | W                    |
| Zinc (recoverable content of ores, etc.) short tons  | 9,039    | 2,639                |
| Value of items that cannot be disclosed: Asbestos,<br>cement, feldspar, mica (scrap), perlite,<br>pyrites, vanadium, vermiculite, zeolite,<br>and values indicated by symbol W,----- | XX       | 18,970               |
| coal (bituminous, 1968)  |          |                      |
| Total -----  | XX       | 859,475              |
| Total 1967 constant dollars -----  | XX       | <u>p/725,125</u>     |

<sup>p/</sup> Preliminary. NA Not available. W Withheld to avoid disclosing individual company confidential data; included with "Value of items that cannot be disclosed."  
XX Not applicable.

<sup>1/</sup> Production as measured by mine shipments, sales, or marketable production (including consumption by producers.)

<sup>2/</sup> Bureau of Mines estimate from non-company sources.

Source: U.S. Bureau of Mines

TABLE III

## ARIZONA'S MINE PRODUCTION OF

|      | GOLD    |           | SILVER  |        | COPPER |        | MOLYBDENUM          |      | LEAD |      | ZINC |             | VALUE       |  |
|------|---------|-----------|---------|--------|--------|--------|---------------------|------|------|------|------|-------------|-------------|--|
|      | ozs.    | ozs.      | ozs.    | ozs.   | tons   | tons   | (Thousands)<br>Lbs. | tons | tons | tons | tons | (Thousands) | (Thousands) |  |
| 1959 | 124,627 | 3,898,336 | 430,297 | 3,181  | 9,999  | 37,325 | 286,996             |      |      |      |      |             |             |  |
| 1960 | 143,064 | 4,774,992 | 538,605 | 4,359  | 8,495  | 35,811 | 371,551             |      |      |      |      |             |             |  |
| 1961 | 145,959 | 5,120,007 | 587,053 | 4,878  | 5,937  | 29,585 | 376,333             |      |      |      |      |             |             |  |
| 1962 | 137,207 | 5,453,585 | 644,242 | 4,412  | 6,966  | 32,888 | 422,282             |      |      |      |      |             |             |  |
| 1963 | 140,030 | 5,373,058 | 660,977 | 5,553  | 5,815  | 25,419 | 433,622             |      |      |      |      |             |             |  |
| 1964 | 153,676 | 5,810,510 | 690,988 | 6,296  | 6,147  | 24,690 | 481,275             |      |      |      |      |             |             |  |
| 1965 | 150,431 | 6,095,285 | 703,377 | 9,399  | 5,913  | 21,757 | 535,215             |      |      |      |      |             |             |  |
| 1966 | 142,528 | 6,338,696 | 739,569 | 10,161 | 5,211  | 15,985 | 572,211             |      |      |      |      |             |             |  |
| 1967 | 80,844  | 4,588,081 | 501,471 | 9,261  | 4,771  | 14,330 | 414,221             |      |      |      |      |             |             |  |
| 1968 | 95,999  | 4,958,162 | 627,961 | 12,127 | 1,704  | 5,441  | 561,094             |      |      |      |      |             |             |  |
| 1969 | 110,878 | 6,141,022 | 801,363 | 12,699 | 217    | 9,039  | 801,091             |      |      |      |      |             |             |  |

TABLE IV

## RELATIVE 1969 PRODUCTION

|                         | ARIZONA    |              | LEADING STATE |            |
|-------------------------|------------|--------------|---------------|------------|
|                         | U. S.      | Rank in U.S. |               |            |
| Gold                    | 1,733,176  | 4th          | South Dakota  | 593,146    |
| Silver                  | 41,906,311 | 2nd          | Idaho         | 18,929,697 |
| Copper                  | 1,544,579  | 1st          | Arizona       | 801,363    |
| Lead                    | 509,013    | 16th         | Missouri      | 355,452    |
| Zinc                    | 553,124    | 13th         | Tennessee     | 124,532    |
| Molybdenum lbs in Conc. | 99,807,000 | 2nd          | Colorado *    | 62,610     |

Source: U.S. Bureau of Mines

\* Preliminary figure.

TABLE V

COPPER, GOLD, SILVER AND MOLYBDENUM RECOVERED  
FROM MINES IN ARIZONA IN 1967, 1968 and 1969

|  | <u>1967</u>       | <u>1968</u>        | <u>1969</u>        |
|--|-------------------|--------------------|--------------------|
| Ozs. gold from<br>copper ores mined                          | 66,933            | 89,419             | 108,718            |
| Ozs. silver from<br>copper ores mined                        | 3,996,587         | 4,697,394          | 5,899,843          |
| Lbs. molybdenum from<br>copper concentrates                  | 9,261,000         | 12,127,000         | 12,699,000         |
| Lbs. copper from copper<br>ores mined, including<br>clean-up | 902,150,000       | 1,146,574,000      | 1,477,557,000      |
| Lbs. copper from<br>precipitates                             | <u>98,718,600</u> | <u>106,604,800</u> | <u>116,023,000</u> |
| TOTAL LBS. COPPER FROM<br>COPPER MINES                       | 1,000,868,600     | 1,253,179,200      | 1,593,580,000      |
| TOTAL LBS. COPPER FROM<br>OTHER MINES                        | <u>2,613,400</u>  | <u>2,742,800</u>   | <u>9,146,000</u>   |
| GRAND TOTAL LBS COPPER<br>FROM ALL MINES                     | 1,003,482,000     | 1,255,922,000      | 1,602,726,000      |
| TOTAL TONS COPPER ORES<br>MINED                              | 74,289,203        | 101,293,963        | 127,848,828        |
| TOTAL TONS ALL ORES<br>MINED                                 | 74,809,009        | 101,643,870        | 128,433,322        |

Source: U.S. Bureau of Mines

TABLE VI

COPPER PRODUCTION OF LARGE ARIZONA COPPER MINES

| <u>Mine</u>       | <u>Company</u>            | <u>1968</u>                   |  | <u>1969</u>                   |  |
|-------------------|---------------------------|-------------------------------|--|-------------------------------|--|
|                   |                           | <u>Tons<br/>Ore<br/>Mined</u> | <u>Tons<br/>Copper<br/>Recovered *</u> | <u>Tons<br/>Ore<br/>Mined</u> | <u>Tons<br/>Copper<br/>Recovered *</u> |
| 1. Morenci        | Phelps Dodge              | 15,474,029                    | 106,857                                | 19,270,608                    | 136,827                                |
| 2. San Manuel     | Magma                     | 11,367,640                    | 72,074                                 | 15,280,816                    | 95,722                                 |
| 3. Ray            | Kennecott                 | 6,746,163                     | 55,407                                 | 11,653,549                    | 90,803                                 |
| 4. New Cornelia   | Phelps Dodge              | 9,018,377                     | 58,544                                 | 10,736,239                    | 67,792                                 |
| 5. Pima           | Pima                      | 13,060,328                    | 64,487                                 | 14,104,752                    | 65,612                                 |
| 6. Inspiration    | Inspiration               | 6,167,134                     | 34,862                                 | 8,514,309                     | 51,755                                 |
| 7. Mission        | Asarco                    | 6,009,700                     | 38,059                                 | 7,939,500                     | 48,661                                 |
| 8. Lavender       | Phelps Dodge              | 4,715,382                     | 24,701                                 | 5,550,147                     | 32,528                                 |
| 9. Copper Queen   | Phelps Dodge              | 622,597                       | 22,606                                 | 781,959                       | 29,555                                 |
| 10. Mineral Park  | Duval                     | 6,226,284                     | 28,704                                 | 6,030,700                     | 28,721                                 |
| 11. Silver Bell   | Asarco                    | 3,907,900                     | 24,282                                 | 3,874,100                     | 22,651                                 |
| 12. Esperanza     | Duval                     | 5,473,156                     | 24,390                                 | 5,487,589                     | 22,446                                 |
| 13. Copper Cities | Miami Div.<br>Tenn. Corp. | 3,359,097                     | 16,787                                 | 4,644,525                     | 21,792                                 |
| 14. Bagdad        | Bagdad                    | 2,099,223                     | 18,238                                 | 2,030,112                     | 17,624                                 |
| 15. Superior      | Magma                     | 333,607                       | 14,706                                 | 422,629                       | 17,618                                 |
| 16. Twin Buttes   | Anaconda                  | - - -                         | - - -                                  | 3,014,557                     | 11,140                                 |
| 17. Christmas     | Inspiration               | 1,173,407                     | 7,641                                  | 1,913,813                     | 10,651                                 |

\* Includes precipitate copper.



TABLE VII

PRODUCING MINES IN ARIZONA IN 1969 and 1970

MINES

|  | <u>During</u><br><u>1969*</u> | <u>April</u><br><u>1969 **</u> | <u>April</u><br><u>1970 **</u> |
|--|-------------------------------|--------------------------------|--------------------------------|
| Copper                                 | 45                            | 32                             | 35                             |
| Copper, with lead or zinc              | 3                             | 1                              | 4                              |
| Lead and/or zinc                       | <u>8</u>                      | <u>3</u>                       | <u>4</u>                       |
| Sub-total                              | 56                            | 36                             | 43                             |
| Dry gold lode                          | 7                             | -                              | 1                              |
| Dry gold-silver lode                   | 8                             | 2                              | 3                              |
| Dry silver lode                        | <u>18</u>                     | <u>4</u>                       | <u>2</u>                       |
| Sub-total                              | 33                            | 6                              | 6                              |
| Gold Placer . . . . .                  | 1                             | -                              | 1                              |
| Uranium . . . . .                      |                               | -                              |                                |
| Mercury . . . . .                      |                               | 2                              | 1                              |
| Silica (with or without metal content) |                               | 11                             | 11                             |
| Asbestos . . . . .                     |                               | 3                              | 4                              |
| Gypsum . . . . .                       |                               | 4                              | 4                              |
| Lime, limestone, cement. . . . .       |                               | 5                              | 5                              |
| Marble . . . . .                       |                               | 2                              | 2                              |
| Perlite . . . . .                      |                               | 2                              | 3                              |
| Bentonite . . . . .                    |                               | 2                              | 2                              |
| Mica . . . . .                         |                               | 1                              | 1                              |
| Feldspar . . . . .                     |                               | 1                              | 1                              |
| Iron ore or concentrate. . . . .       |                               | 2                              | 2                              |
| Diatomite . . . . .                    |                               | <u>1</u>                       | <u>1</u>                       |
| Totals                                 |                               | 78                             | 87                             |

\* Source: U.S. Bureau of Mines

\*\* Source: Arizona Department of Mineral Resources

TABLE VIII

VALUE OF MINERAL PRODUCTION IN ARIZONA, BY COUNTIES

| County          | 1967          | 1968          | Minerals produced in<br>1968 in order of value   |
|-----------------|---------------|---------------|--|
| Apache          | \$ 11,895,000 | \$ 12,190,000 | Petroleum, helium, sand and gravel, clays, natural gas, pumice, uranium, vanadium, stone.                            |
| Cochise         | 30,675,000*   | W             | Copper, lime, silver, stone, gold, sand and gravel, zinc, lead.  |
| Coconino        | 3,541,000     | 6,055,000     | Uranium, stone, sand and gravel, pumice, copper, silver, lead, zinc.   |
| Gila            | 43,680,000    | 61,248,000    | Copper, lime, asbestos, molybdenum, silver, stone, gold, sand and gravel, mercury, clays.                            |
| Graham          | 311,000       | 157,000       | Sand and gravel, copper, pumice, stone.  |
| Greenlee        | 64,893,000    | 92,925,000    | Copper, lime, silver, stone, gold, sand and gravel, molybdenum.  |
| Maricopa        | 6,229,000*    | 7,134,000     | Sand and gravel, lime, mercury, mica, stone, clays, copper, gold, silver, vermiculite.                               |
| Mohave          | 26,682,000    | 31,535,000    | Copper, molybdenum, silver, sand and gravel, stone, feldspar, zinc, gold, clays, lead.                               |
| Navajo          | 802,000       | W             | Sand and gravel, iron ore, stone.  |
| Pima            | 151,151,000*  | 198,077,000   | Copper, cement, molybdenum, silver, sand and gravel, gold, stone, zinc, clays, lead, tungsten.                       |
| Pinal           | 91,310,000*   | 129,325,000   | Copper, molybdenum, silver, gold, sand and gravel, perlite, gypsum, stone, lime, pyrites, diatomite, iron ore, lead. |
| Santa Cruz      | 581,000*      | W             | Sand and gravel, silver, stone, lead, tungsten concentrate, copper.  |
| Yavapai         | 30,488,000    | 30,312,000    | Copper, cement, zinc, molybdenum, stone, silver, lime, lead, sand and gravel, gold, gypsum, clays, iron ore, pumice. |
| Yuma            | 2,869,000*    | W             | Copper, sand and gravel, stone, silver, lead, tungsten concentrate, zinc.  |
| Undistributed   | 150,000       | 48,580,000    |  |
| Total <u>1/</u> | 465,255,000*  | 617,541,000   |  |

\* Revised

W Withheld to avoid individual disclosure. Included in Undistributed.

1/ Data may not add to totals shown because of independent rounding.

Source: U.S. Bureau of Mines.

COPPER INDUSTRY

STATISTICS FOR 1969 COMPARED WITH OTHER YEARS  
ARIZONA, THE UNITED STATES, AND THE WORLD

COMPILED BY ARIZONA DEPARTMENT OF MINERAL RESOURCES

Fairgrounds, Phoenix, Arizona

Frank P. Knight, Director

Lester K. Brown, Jr., Statistical Consultant

SEPTEMBER, 1970

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## C O P P E R

### PHYSICAL PROPERTIES\*

Symbol - Cu. Atomic Weight - 63.54. Specific Gravity - 8.96

Melting Point - 1981.4°F. Boiling Point - 4700°F

Electrical Resistivity - Microhm-cm. - 1.673

Tensile Strength (H.D. - 60,000 #/sq. in.) (annealed - 30,000)

Crystal Structure - Face-centered cubic. Valence - 1 & 2

Copper ranks next to iron as a metal of commercial importance. It has the best conductivity of any base metal; for example, measured on the ordinary basis of conductivity per unit of cross sectional area, aluminum's conductivity is only 61 per cent of that of copper, but 3.5 times that of iron. Copper is therefore the most important metal in the electrical field. Copper has enough strength for minor structural purposes (such as sheet-metal work, electrical manufactures, etc.), is easily rolled and drawn into wire, has great resistance to weathering, and is of moderate cost compared to competitive materials. In addition to these properties, copper is widely used alloyed with zinc to form brass, which is easily worked, offers good resistance to weathering and most solutions (principal exceptions are certain acids and alkalies), and is fairly strong and elastic; and alloyed with tin to form bronze, of note for its resilience. It has good thermal conductivity, so finds many uses in heat-transfer units, such as cooling fins and water heaters. In addition, a large percentage of copper may be recovered as scrap after it has outlived the usefulness for which it was originally intended. Of the total copper consumed in the United States it has been estimated that about 60 per cent eventually returns to use as copper or copper alloys.

\* U.S.B.M.'s "MATERIALS SURVEY"

## The Copper Industry in 1969

The United States produced 1,544,579 short tons of new mined copper in 1969, an all time record. It was more than 28 percent ahead of 1968 and over 8 percent ahead of the previous record set in 1966. Arizona produced more than one-half of it (51.9%), followed by Utah (19.2%), New Mexico (7.8%), Nevada (6.8%), and Montana, (6.7%). Record production was made by Arizona, New Mexico, and Nevada, while Utah's output had been only exceeded by the wartime record year of 1943.

World mine production outside of the United States also increased and at 5.11 million tons was more than 6 percent ahead of 1968 and more than 43 percent greater than in 1960. The major copper producing countries, the U.S.S.R., Zambia, Chile, Republic of the Congo (Kinshasa), Peru, and the Philippines all exceeded their past records. Canada suffered a 10 percent decrease due to lengthy strikes. Free World production, outside of the U.S., totaled 3.84 million tons, over 5 percent more than in 1968 and more than 33 percent ahead of 1960.

United States mine production includes copper recovered from (1) precipitates from leaching; (2) ores in which other metals predominate and (3) copper ores which are shipped directly to smelters or are first concentrated before shipping. The tonnage of the ores in (3) in 1969 was 223,751,510 and it contained 1,345,688 tons of recoverable copper. Arizona, Utah, Montana, Nevada, New Mexico, and Michigan occupied the top 6 positions in ore tonnages and their contents of recoverable copper were as follows: Arizona 11.6 lbs. per ton; Utah and Nevada 11.8 lbs. (given as a combined figure because their tonnages of leached ore are joined to avoid disclosing company confidential data); Montana, 11.4; New Mexico, 13.8 and Michigan 18.4 lbs per ton, respectively.

Domestic production of secondary scrap copper amounted to 1,375,493 tons in 1969, likewise an all-time record. This equaled 89 percent of the year's domestic mine output, down percentage-wise from 1968 and 1967 when comparable figures were 101 and 122 percent respectively. The 1960-1969 decade's low point domestically was 1961 when 849,000 tons of secondary copper production only amounted to 73 percent of the mine production. Fifty-eight percent of the 1969 secondary copper was credited to "New" scrap and 42 percent to "Old". "New" scrap consists of cuttings from new material which are re-melted and re-used. The total scrap production discussed here is not to be confused with the "Secondary Copper Recovered from Scrap as Unalloyed Copper" given in Tables I, IV, and XII and discussed on page 3.

World consumption of refined copper continued to climb, and totalled 7.704 million tons in 1969. This was over 8 percent ahead of 1968 and a striking 53 percent ahead of 1960.

### Refined Copper Consumption

#### A Decade Comparison a/

Short Tons

| Designated Area       | 1960      | 1969      | Percent Increase |
|-----------------------|-----------|-----------|------------------|
| World, Total          | 5,029,594 | 7,704,300 | 53.2             |
| Free World            | 4,189,930 | 6,249,200 | 49.1             |
| Europe                | 2,093,721 | 2,569,700 | 22.7             |
| U.S. <u>b/</u>        | 1,349,896 | 2,142,200 | 58.7             |
| Fed. Rep. Germany     | 568,682   | 730,700   | 28.5             |
| U. K.                 | 617,617   | 602,700   | (2.4)            |
| Asia, Total <u>c/</u> | 422,640   | 960,500   | 127.3            |
| Japan                 | 335,115   | 891,000   | 165.9            |
| Soviet Sphere, Total  | 839,664   | 1,455,100 | 73.3             |
| U.S.S.R.              | 679,728   | 992,100   | 46.0             |

a/ American Bureau of Metal Statistics.      b/ U.S. Bureau of Mines.

c/ Excludes Soviet Sphere Countries.      ( ) Decrease

At 2,142,000 tons the United States' consumption of refined copper in 1969 was almost 14 percent greater than in 1968 but 9 percent less than the record 2,360,000 tons for 1966. Within the major classes of domestic consumers as the demand for communication and power transmission cable expanded, the wire mills increased their consumption of refined copper from 828,800 tons in 1960 to 1,296,000 tons in 1969, a 56 percent gain. Likewise, the brass mills in taking 797,000 tons in 1969, registered a 64 percent increase over 1960.

In 1969, mine production plus secondary copper recovered from scrap as unalloyed metal, a total of 2,059,172 tons, was 96.1 percent of the actual United States consumption of refined copper, compared to 89.2 percent for the decade ending with 1969. <sup>The</sup> graph following Table XII, on page 20, shows the courses of mine and secondary copper production and of net imports of copper in the period 1950-1969. This graph shows that, especially since the low point in 1959, the U. S. copper available for consumption has increased markedly. They also show that the portion supplied by newly mined copper drifted lower from 1960 to 1968 and then reversed the trend. The portion supplied by secondary production has slowly, but steadily increased, and that supplied by net imports declined from a high of 32.3 percent to a low of 1.2 percent in 1961, 23.1 percent in 1967 and 8.9 percent in 1969.

The United States imports of primary copper amounted to 408,000 tons in 1969 and came principally from South America (Chile and Peru) and Canada with minor amounts from Africa and the Philippines. This was the lowest amount of primary copper imported in any year of the last two decades. 1969 exports were at a low point for the 1960's, and went principally to Italy, West Germany, and the United Kingdom. The U. S. still continued to be a net importer of copper, but the 1969 amount was the lowest in the last four years.

From 1960 to 1969 domestic consumption of copper increased 59 percent.

United States producer's stocks of refined copper, blister, and materials in process of refining (Table X) totalled 330,000 tons at the end of 1969 according to U. S. Bureau of Mines. The increase of 3 percent over 1968 was in the materials in process of refining, however, rather than in the refined stocks, which at year's end totalled 39,000 tons, down 19 percent from 1968, and well below the average of 49,000 tons for the decade. Refined copper stocks outside the United States totalled 234,739 tons at the end of 1969 according to the Copper Institute. This 1969 figure, down over 25 percent from 1968, was a decade "low" and in a manner similar to U.S. refined stocks, was well below the 1960's yearly average of 309,500 tons.

1969 was an exceptional year for copper. The strong demand continued; refined supplies were drawn down, primary production increased and the producer's price rose intermittently as the year progressed. The U.S. producer's price on January 1, 1969, was 42¢ a pound and after raises in January, May, August, and September, three major U.S. producers, Phelps Dodge, Anaconda, and Kennecott, were quoting 52 cents while Copper Range asked 56 cents. The 52 cent price then held until Jan. 1, 1970 when 4 cents were added. U. S. dealer and foreign prices were much higher during the year and were firm around 74½ cents at year end.

Effective January 1, 1969, the U.S. duty of 1.1 cents per pound on imports was suspended retroactively to June 30, 1969 and through June 30, 1970. However, it was stipulated that the suspension would not apply when the price of copper was under 36 cents per pound, and that if the price delivered Connecticut Valley dropped below 24 cents per pound for one calendar month, a duty of 1.8 cents per pound would be reimposed.

The average number employed in the U.S. copper industry in 1969 was 37,625, an all-time high. (Table XIII) This was an increase of over 27 percent from 1960. The average number of man-hours worked increased 36 percent to 90,570,000 in the same period. Average tons of ore and the average pounds of copper produced per man-hour in 1969, 2.47 and 29.72 respectively, compared with the respective 1960 figures of 2.29 and 33.96.

Average yearly earnings of employees of the copper industry in the United States were 134 percent higher in the period 1965-1969 than they were in the 1947-1949 base period. (Table XII) In the same periods the tons of copper ore produced per man-hour increased 86 percent and the pounds of copper produced, per man-hour increased 31 percent. Productivity continued to fall behind the pace of wage increases even although productivity had a great deal of help from improved technology and equipment. It should be noted, however, that the 1965-1969 ores yielded only an average of 12 pounds of copper per ton whereas the 1947-1949 ores averaged 18.2 ; and productivity should be weighed on an ore basis with due credit to improved technology and equipment.

In "The Copper Mining Industry, 1966-1970", a paper published by this department in October 1969, B. H. Gerwin wrote, "There is almost unanimity of opinion to the effect that the actual physical shortage of copper (if one really did exist) has already ended or will soon end". In 1969, mine production of recoverable copper in the Free World, (Table IV) was 5,388,600 tons. Adding assumed production of secondary copper of 1,100,000 tons (514,593 tons for the U.S.) gives a total of 6,488,600 tons. Table IV gives Free World consumption of 6,249,200 tons. Surplus production of approximately 240,000 tons is indicated.

Early in 1970, CIPEC, (American Metal Market Feb. 9), estimated a free world surplus of 310,000 metric tons for 1970; British Metals Corp., Ltd. (American Metal Mkt. Feb. 16) predicted Free World production in 1970 of 6,100,000 metric tons (up 400,000 or 7 percent from 1969) and consumption of 6,070,000 ( up 320,000 or 5.6 percent from 1969) to give a surplus of only 30,000 metric tons; and in a later article, John J. Lemon, president of Ametalco, Inc. (American Metal Mkt. 5/19) argued that copper may be coming to the end of its bull market, with 420,000 tons of new mine capacity scheduled for completion in the year, an increase of 7.5 percent, European fabricator's orders off; Chinese buying off; and Japanese stocks showing a small surplus.

Copper exploration is active throughout the world and new important deposits are being found in and outside of the great producing areas of the Free World, the Western United States, Zambia and Kinshasha in Africa, and Chile and Peru in South America. Huge developments requiring hundreds of millions of dollars are underway or planned; expansions of existing mines are continuing; mining technology grows to permit mining of lower grade ores; and copper could be in surplus for several years.

On the other hand, consumption of copper is far from static. The U.S. Bureau of Mines in 1969 predicted that nearly 6.3 million tons of newly mined copper will be needed by the United States by the year 2000, as against 1.7 million in 1969 Recent figures of growth of copper consumption outside of the United States are:

|               | <u>Pounds of Copper Consumed Per Capita</u> |             |
|---------------|---|-------------|
|               | <u>1949</u>                                 | <u>1969</u> |
| Japan         | 2   | 15          |
| Europe        | 7   | 15          |
| Asia & Africa |   | 3/4+        |



The "traditional" 4½ percent increase in annual Free World consumption appears slated to be far exceeded by growth in production to 1972 and probably for a few years thereafter. The U.S. growth in consumption was at the rate of 5.3 percent in 1967-68 and the Free World rate in 1969 was 5.6 percent, but, even if consumption should continue at these rates, the presently contemplated capacity increases, averaging over 6 percent per year for 1970 through 1975, would create large surpluses.

The recent increases in nationalization of copper properties in Chile, Zambia, Peru, and the Republic of the Congo, and drives by these countries to increase their producing capacities, plus drives by domestic copper producers to increase capacities to replace those lost to the CIPEC nations, are factors added to that of population explosion, which first prompted the expansion earlier in the past decade, all of which spur exploration and mine development. Whether or not they and other economic factors will result in copper surplus in the next several years is a matter of conjecture, but predominant opinion appears to be that scarcity will be more prevalent thereafter.

TABLE I

SALIENT U. S. COPPER STATISTICS <sup>1/</sup>

YEARS 1967, 1968, and 1969

|  | Unit: Short Tons  |                   |           |
|--|-------------------|-------------------|-----------|
|  | 1967              | 1968              | 1969      |
| Arizona Mine Production - Tons Copper                        | 501,741           | 627,961           | 801,363   |
| U. S. Mine Production - Tons Copper                          | 954,064           | 1,204,621         | 1,544,579 |
| World Mine Production - Tons Copper                          | r5,564,361        | r5,998,674        | 6,655,477 |
| Refined Stocks - Beginning of Period                         | 43,000            | 27,000            | 48,000    |
| Refined Stocks - End of Period                               | 27,000            | 48,000            | 39,000    |
| Refinery Production (From Domestic Ores)                     | 846,551           | 1,160,925         | 1,468,889 |
| Refinery Production (From Foreign Ores)                      | 286,431           | 276,461           | 273,926   |
| Secondary Copper Recovered from Scrap<br>as Unalloyed Copper | 423,054           | 433,041           | 514,593   |
| <b>IMPORTS:</b>  |                   |                   |           |
| Copper from Ore, Matte, Regulus                              | 32,971            | 27,559            | 39,048    |
| Blister Copper   | 269,322           | 270,718           | 237,949   |
| Refined Copper   | 330,571           | 400,278           | 131,171   |
| Total Imports - Crude and Refined                            | 632,864           | 698,555           | 408,168   |
| <b>EXPORTS:</b>  |                   |                   |           |
| Copper in Ores, etc.   | 59,692            | 80,739            | 5,517     |
| Refined Copper   | 159,353           | 240,745           | 200,269   |
| Total Exports - Crude and Refined                            | 219,045           | 321,484           | 205,786   |
| EXCESS IMPORTS OVER EXPORTS                                  | 413,819           | 377,071           | 202,382   |
| <b>CONSUMPTION:</b>  |                   |                   |           |
| New Refined (Apparent Consumption)                           | r1,320,200        | r1,575,919        | 1,682,717 |
| Total Refined (Actual)                                       | 1,935,592         | 1,880,300         | 2,142,218 |
| U.S. Mine Prod. % of Appar't Consumption                     | 72.3              | 76.4              | 91.8      |
| Average E/MJ Price of Copper                                 | 38.226¢ <u>a/</u> | 41.847¢ <u>b/</u> | 47.534¢   |

r - Revised

<sup>1/</sup> U.S. Bureau of Mines.a/ Based on first 8 mos. of 1967. Calculated average suspended Sept. thru Dec.b/ Based on last 9 mos. of 1968. Calculated average suspended Jan. thru Mar.

TABLE II

## MINE PRODUCTION OF RECOVERABLE COPPER IN THE UNITED STATES

1967 - 1969, BY STATES, IN SHORT TONS <sup>1/</sup>

| STATE                                | 1967           | 1968             | 1969             | Rank<br>in<br>1969 |
|--------------------------------------|----------------|------------------|------------------|--------------------|
| Alaska . . . . .                     | <u>2/</u>      | <u>2/</u>        | - - -            |                    |
| Arizona . . . . .                    | 501,741        | 627,961          | 801,363          | (1)                |
| California . . . . .                 | 788            | 1,182            | 1,129            |                    |
| Colorado . . . . .                   | 3,993          | 3,451            | 3,598            | (9)                |
| Idaho . . . . .                      | 4,210          | 3,525            | 3,332            | (11)               |
| Michigan . . . . .                   | 58,458         | 74,805           | 75,226           | (6)                |
| Missouri . . . . .                   | 3,215          | 5,494            | 12,664           | (8)                |
| Montana . . . . .                    | 65,483         | 69,480           | 103,314          | (5)                |
| Nevada . . . . .                     | 50,771         | 77,213           | 104,924          | (4)                |
| New Mexico . . . . .                 | 75,008         | 90,769           | 119,956          | (3)                |
| Oregon . . . . .                     | - - - -        | <u>2/</u>        | - - - -          |                    |
| Pennsylvania . . . . .               | 4,401          | 4,850            | 3,382            | (10)               |
| Tennessee . . . . .                  | 14,600         | 14,196           | 15,353           | (7)                |
| Utah . . . . .                       | 168,609        | 228,245          | 296,699          | (2)                |
| Washington . . . . .                 | 21             | 22               | 18               |                    |
| Wyoming . . . . .                    | - - - -        | - - - -          | <u>2/</u>        |                    |
| Other States <sup>3/</sup> . . . . . | 2,766          | 3,428            | 3,621            |                    |
| <b>TOTAL . . . . .</b>               | <b>954,064</b> | <b>1,204,621</b> | <b>1,544,579</b> |                    |

<sup>1/</sup> U.S. Bureau of Mines<sup>2/</sup> Included under "Other States". Combined to avoid disclosing individual company confidential data.<sup>3/</sup> Includes: Alaska, Maine in '68 and '69, Oklahoma, Oregon, and Wyoming.

TABLE III

## ARIZONA, UNITED STATES, AND WORLD MINE PRODUCTION OF COPPER, In Short Tons

## E/MJ DOMESTIC PRICE OF COPPER

By Years 1912 - 1969 Incl.

| Year   | Tons      | ARIZONA                           |                        | UNITED STATES |                        | WORLD<br>Tons | E/MJ<br>Price<br>Per<br>Pound |
|--|-----------|-----------------------------------|------------------------|---------------|------------------------|---------------|-------------------------------|
|  |           | % of<br>U. S.<br>Prod.            | % of<br>World<br>Prod. | Tons          | % of<br>World<br>Prod. |               |                               |
| Beginning<br>of Records<br>1874 thru<br>1911 | 1,757,554 | @14.403¢ per lb. = \$506,283,002* |                        |               |                        |               |                               |
| 1912   | 182,519   | 29.2                              | 16.2                   | 624,547       | 55.5                   | 1,125,656     | 16.431¢                       |
| 1913   | 203,962   | 33.0                              | 18.6                   | 617,755       | 56.2                   | 1,099,366     | 15.269                        |
| 1914 <u>1/</u>                               | 196,509   | 34.2                              | 19.0                   | 574,216       | 55.5                   | 1,034,487     | 13.602                        |
| 1915 <u>1/</u>                               | 229,986   | 30.9                              | 19.6                   | 744,036       | 63.4                   | 1,173,150     | 17.275                        |
| 1916 <u>1/</u>                               | 360,917   | 36.0                              | 23.2                   | 1,002,938     | 64.6                   | 1,553,498     | 27.202                        |
| 1917 <u>1/</u>                               | 356,083   | 37.6                              | 22.2                   | 947,717       | 59.1                   | 1,602,914     | 27.180                        |
| 1918 <u>1/</u>                               | 382,428   | 40.0                              | 24.2                   | 955,011       | 60.5                   | 1,579,246     | 24.628                        |
| 1919   | 269,050   | 44.4                              | 24.6                   | 606,167       | 55.3                   | 1,095,697     | 18.691                        |
| 1920   | 279,128   | 45.6                              | 26.4                   | 612,275       | 58.0                   | 1,056,014     | 17.456                        |
| 1921 <u>2/</u>                               | 92,517    | 39.7                              | 15.1                   | 233,095       | 38.0                   | 613,987       | 12.502                        |
| 1912<br>to<br>1921                           | 2,553,099 | 36.9                              | 21.4                   | 6,917,757     | 58.0                   | 11,934,015    | r20.649¢                      |
| 1922   | 200,022   | 41.5                              | 21.4                   | 482,292       | 48.2                   | 935,374       | 13.382¢                       |
| 1923   | 309,464   | 41.9                              | 22.8                   | 738,870       | 54.5                   | 1,355,327     | 14.421                        |
| 1924   | 338,876   | 42.2                              | 23.0                   | 803,083       | 54.5                   | 1,472,712     | 13.024                        |
| 1925   | 356,678   | 42.5                              | 22.6                   | 839,059       | 53.2                   | 1,576,998     | 14.042                        |
| 1926   | 361,648   | 41.9                              | 22.7                   | 862,638       | 54.0                   | 1,596,147     | 13.795                        |
| 1927   | 341,095   | 41.3                              | 20.5                   | 824,980       | 49.5                   | 1,666,694     | 12.920                        |
| 1928   | 366,138   | 40.5                              | 19.2                   | 904,898       | 47.5                   | 1,903,672     | 14.570                        |
| 1929   | 415,314   | 41.6                              | 19.3                   | 997,555       | 46.4                   | 2,150,587     | 18.107                        |
| 1930 <u>3/</u>                               | 288,095   | 40.9                              | 16.2                   | 705,074       | 39.7                   | 1,775,805     | 12.982                        |
| 1931 <u>3/</u>                               | 200,672   | 37.9                              | 13.0                   | 528,875       | 34.2                   | 1,545,425     | 8.116                         |
| 1922<br>to<br>1931                           | 3,178,002 | 41.3                              | 19.8                   | 7,687,324     | 48.1                   | 15,978,741    | 13.902¢                       |

Source: U.S. Geological Survey: Mineral Resources; U.S.B.M. Minerals Yearbooks.

\* Arizona Metal Production 1936, Elsing and Heineman, Arizona Bureau of Mines.

(continued)

TABLE III (Continued)

| Year           | ARIZONA   |                  | UNITED STATES    |           | WORLD            | E. & M. J. |                 |
|----------------|-----------|------------------|------------------|-----------|------------------|------------|-----------------|
|                | Tons      | % of U. S. Prod. | % of World Prod. | Tons      | % of World Prod. | Tons       | Price Per Pound |
| 1932 <u>3/</u> | 91,246    | 38.3             | 8.0              | 238,111   | 20.9             | 1,138,676  | 5.555¢          |
| 1933 <u>3/</u> | 57,021    | 29.9             | 4.9              | 190,643   | 16.4             | 1,159,000  | 7.025           |
| 1934 <u>3/</u> | 89,041    | 37.5             | 6.3              | 237,401   | 16.8             | 1,415,353  | 8.428           |
| 1935 <u>3/</u> | 139,015   | 36.0             | 8.4              | 386,491   | 23.5             | 1,647,939  | 8.649           |
| 1936 <u>3/</u> | 211,275   | 34.4             | 11.1             | 614,516   | 32.4             | 1,899,263  | 9.474           |
| 1937           | 288,475   | 34.3             | 11.2             | 841,998   | 32.8             | 2,567,916  | 13.167          |
| 1938 <u>4/</u> | 210,797   | 37.8             | 9.3              | 557,763   | 24.5             | 2,274,045  | 10.000          |
| 1939 <u>5/</u> | 262,117   | 36.0             | 10.6             | 728,320   | 29.4             | 2,481,277  | 10.965          |
| 1940 <u>5/</u> | 281,169   | 32.0             | 10.5             | 878,086   | 32.7             | 2,688,510  | 11.296          |
| 1941 <u>5/</u> | 326,317   | 34.1             | 11.2             | 958,149   | 33.0             | 2,903,458  | 11.797          |
| 1932 to 1941   | 1,956,473 | 34.7             | 9.7              | 5,631,478 | 27.9             | 20,175,437 | 10.564          |
| 1942 <u>5/</u> | 393,387   | 36.4             | 12.9             | 1,080,061 | 35.5             | 3,039,041  | 11.775¢         |
| 1943 <u>5/</u> | 403,181   | 37.0             | 13.2             | 1,090,818 | 35.6             | 3,064,394  | 11.775          |
| 1944 <u>5/</u> | 358,303   | 36.8             | 12.5             | 972,549   | 33.9             | 2,866,000  | 11.775          |
| 1945           | 287,203   | 37.2             | 12.0             | 772,894   | 32.2             | 2,400,000  | 11.775          |
| 1946           | 289,223   | 47.5             | 14.1             | 608,737   | 29.6             | 2,056,000  | 13.820          |
| 1947           | 366,218   | 43.2             | 14.6             | 847,563   | 33.9             | 2,500,000  | 20.958          |
| 1948 <u>6/</u> | 375,121   | 44.9             | 14.4             | 834,813   | 32.1             | 2,600,000  | 22.038          |
| 1949 <u>6/</u> | 359,010   | 47.7             | 14.4             | 752,750   | 30.1             | 2,500,000  | 19.202          |
| 1950           | 403,301   | 44.4             | 14.4             | 909,343   | 32.5             | 2,760,000  | 21.235          |
| 1951           | 415,870   | 44.8             | 14.3             | 928,330   | 32.0             | 2,900,000  | 24.200          |
| 1942 to 1951   | 3,650,817 | 41.5             | 13.7             | 8,797,858 | 33.0             | 26,685,435 | 17.103          |

(Continued)

TABLE III (continued)

| Year               | ARIZONA      |   |                  | UNITED STATES |                  | WORLD      | E/MJ            |  |
|--------------------|--------------|---|------------------|---------------|------------------|------------|-----------------|--|
|                    | Tons         | % of U. S. Prod.  | % of World Prod. | Tons          | % of World Prod. | Tons       | Price per Pound |  |
| 1952               | 395,719      | 42.8  | 13.1             | 925,359       | 30.6             | 3,020,000  | 24.200¢         |  |
| 1953               | 393,525      | 42.5  | 12.9             | 926,448       | 30.4             | 3,050,000  | 28.798          |  |
| 1954 <sup>7/</sup> | 377,927      | 45.2  | 12.2             | 835,472       | 27.0             | 3,100,000  | 29.694          |  |
| 1955               | 454,105      | 45.5  | 13.3             | 998,570       | 29.2             | 3,420,000  | 37.491          |  |
| 1956               | 505,908      | 45.7  | 13.4             | 1,104,156     | 29.1             | 3,790,000  | 41.818          |  |
| 1957               | 515,854      | 47.5  | 13.3             | 1,086,859     | 27.9             | 3,890,000  | 29.576          |  |
| 1958               | 485,839      | 49.6  | 12.9             | 979,329       | 25.9             | 3,780,000  | 25.764          |  |
| 1959               | 430,297      | 52.2  | 10.7             | 824,846       | 20.4             | 4,040,000  | 31.182          |  |
| 1960               | 538,605      | 49.9  | 11.6             | 1,080,169     | 23.2             | 4,650,000  | 32.053          |  |
| 1961               | 587,053      | 50.4  | 12.1             | 1,165,155     | 24.0             | 4,850,000  | 29.921          |  |
| 1952<br>to<br>1961 | 4,684,832    | r47.2   | 12.5             | 9,926,363     | 26.4             | 37,590,000 | 31.236¢         |  |
| 1962               | 644,242      | 52.4  | 12.7             | 1,228,421     | 24.2             | 5,085,000  | 30.600¢         |  |
| 1963               | 660,977      | 54.5  | 13.0             | 1,213,166     | 23.8             | 5,088,000  | 30.600          |  |
| 1964               | 690,988      | 55.4  | r13.0            | 1,246,780     | r23.5            | r5,297,000 | 31.960          |  |
| 1965               | 703,377      | 52.0  | 12.7             | 1,351,734     | r24.4            | r5,549,000 | 35.017          |  |
| 1966               | 739,569      | 51.7  | r12.8            | 1,429,152     | r24.6            | r5,800,000 | 36.170          |  |
| 1967               | 8/501,741    | 52.6  | r 9.0            | 8/954,064     | r17.1            | r5,564,000 | 38.226*         |  |
| 1968               | 8/627,961    | 52.1  | 10.5             | 8/1,204,621   | 20.1             | r5,999,000 | 41.847**        |  |
| 1969               | 9/801,363    | 51.9  | 12.0             | 9/1,544,579   | 23.2             | 6,655,000  | 47.534          |  |
| 1962<br>to<br>1969 | 5,370,218    | 52.8  | 11.9             | 10,172,517    | 22.6             | 45,037,000 | 36.675 ¢        |  |
| 1874<br>to<br>1969 | ARIZONA ONLY | 23,152,662 Tons at 23.825¢ per pound = \$11,032,412,000 |                  |               |                  |            |                 |  |

r Revised

\* Based on first 8 months of 1967

\*\* Based on the last 9 months of 1968

TABLE III Continued

NOTES: 1/ World War I 1914 - 1918.

2/ Post World War I Recession. Lasted about one year.

3/ Depression began in 1930; was at its worst in 1933; gradually improved till 1937.

4/ Recession in 1938. Recovery in 1939 caused by War demand.

5/ World War II began in 1939; copper consumption reached its height in 1944.

6/ In the year 1948 and the early months of 1949, copper was being produced in the United States at the rate of 68,000 short tons per month, imports were at the rate of 18,000 tons of blister copper and 22,000 tons of refined copper, and exports were at the rate of 12,000 tons per month. The price of copper averaged 22.5 cts. during this period, varying from 21-3/8 to 23-3/8 cts.

In March 1949 the copper import tax was suspended, and during the months following the suspension, domestic demand fell drastically, and for four months net domestic consumption of copper was at or below the level of domestic production, even though the latter was severely curtailed. During this period, imports continued at practically the same rate. The price of copper dropped from 23-3/8 cts. to 16-1/2 cts. per pound. Many mines were forced to close down, and the large low-cost producers curtailed production. The average monthly production dropped from a high of 78,000 to a low of 56,000 tons.

7/ Curtailment early in the year, and a series of strikes in August and September caused a loss in production of over 100,000 tons. Reduced consumption in the U. S. was offset by an appreciable rise in the use of copper outside of this country, chiefly Europe. Result: a short supply of copper at the end of the year.

8/ The 1967 Copper Strike started July 16, 1967, ending in March 1968.

9/ 1969, Highest annual production in history.

TABLE IV

## MINE PRODUCTION OF COPPER - WORLD

UNITED STATES PRODUCTION OF SECONDARY UNALLOYED COPPER

## WORLD CONSUMPTION OF REFINED COPPER

(Primary and Secondary)

## SHORT TONS

| Year | MINE PRODUCTION <sup>1/</sup> |   |                        | SECONDARY UNALLOYED COPPER PRODUCTION |                             |
|------|-------------------------------|---|------------------------|---------------------------------------|-----------------------------|
|      | United States                 | Remainder of Free World (By Difference) | Soviet Sphere          | <sup>2/</sup> Total World             | United States <sup>1/</sup> |
| 1960 | 1,080,169                     | 2,883,731                               | 686,100                | 4,650,000                             | 300,259                     |
| 1961 | 1,165,155                     | 2,911,145                               | 773,700                | 4,850,000                             | 290,805                     |
| 1962 | 1,228,421                     | 2,961,479                               | 895,100                | 5,085,000                             | 301,374                     |
| 1963 | 1,213,166                     | 3,037,175                               | 837,659                | 5,088,000                             | 314,643                     |
| 1964 | 1,246,780                     | r3,153,145                              | r897,075               | r5,297,000                            | 366,197                     |
| 1965 | 1,351,734                     | r3,233,897                              | r963,369               | 5,549,000                             | 462,811                     |
| 1966 | 1,429,152                     | r3,350,221                              | r1,020,627             | 5,800,000                             | 509,084                     |
| 1967 | 954,064                       | r3,539,004                              | r1,070,932             | r5,564,000                            | 423,054                     |
| 1968 | 1,204,621                     | r3,641,219                              | r1,153,160             | 5,999,000                             | 433,041                     |
| 1969 | 1,544,579                     | 3,844,021 <sup>p</sup>                  | 1,266,400 <sup>p</sup> | 6,655,000 <sup>p</sup>                | 514,593                     |

## WORLD CONSUMPTION OF REFINED COPPER

| Year | United States <sup>1/</sup> | Remainder of Free World (By Difference) | Soviet Sphere <sup>3/</sup> | TOTAL WORLD <sup>3/</sup> |
|------|-----------------------------|---|-----------------------------|---------------------------|
| 1960 | 1,349,896                   | 2,840,034                               | 839,664                     | 5,029,594                 |
| 1961 | 1,462,830                   | 3,033,270                               | 1,038,300                   | 5,534,400                 |
| 1962 | 1,599,676                   | 2,922,024                               | 1,091,200                   | 5,612,900                 |
| 1963 | 1,744,273                   | 3,061,327                               | 1,147,500                   | 5,953,100                 |
| 1964 | 1,825,281                   | 3,525,119                               | 1,174,000                   | 6,524,400                 |
| 1965 | 2,004,623                   | r3,504,677                              | 1,231,300                   | 6,740,600                 |
| 1966 | 2,359,954                   | r3,402,846                              | 1,300,700                   | 7,063,500                 |
| 1967 | 1,935,592                   | r3,434,008                              | 1,344,800                   | 6,714,400                 |
| 1968 | 1,880,300                   | r3,808,900                              | 1,405,500                   | 7,094,700                 |
| 1969 | 2,142,218                   | 4,106,982                               | 1,455,100                   | 7,704,300                 |

r Revised

<sup>1/</sup> U. S. Bureau of Mines<sup>2/</sup> Includes total and recoverable ore content. See Table V.<sup>3/</sup> American Bureau of Metal Statistics.



TABLE V

WORLD MINE PRODUCTION OF COPPER (TOTAL OR RECOVERABLE CONTENT OF ORE AS INDICATED),  
 BY CONTINENTS AND PRINCIPAL COUNTRIES IN THOUSAND SHORT TONS 1/ 2/  
 Years 1966, 1967, 1968 and 1969

|                              | 1966          | 1967          | 1968          | 1969p        |
|------------------------------|---------------|---------------|---------------|--------------|
| <b>NORTH AMERICA:</b>        |               |               |               |              |
| U.S.A. <u>3/</u>             | 1,429         | 954           | 1,205         | 1,545        |
| Canada <u>3/</u>             | 508           | r613          | 608           | 551          |
| Mexico                       | 62            | 62            | 67            | 73           |
| Others                       | r14           | r13           | r15           | 8            |
|                              | r2,013        | r1,642        | r1,895        | 2,177        |
| <b>SOUTH AMERICA:</b>        |               |               |               |              |
| Chile                        | 731           | 732           | r735          | 769          |
| Peru <u>3/</u>               | 194           | r212          | r234          | 237          |
| Others                       | r 8           | r10           | r12           | 9            |
|                              | r 933         | r954          | r981          | 1,015        |
| <b>EUROPE:</b>               |               |               |               |              |
| U.S.S.R. <u>4/</u>           | 825           | 880           | r937          | 992          |
| Yugoslavia                   | 69            | 70            | r 78          | 98           |
| Others                       | 159           | r177          | r201          | 270          |
|                              | 1,053         | r1,127        | r1,216        | 1,360        |
| <b>ASIA:</b>                 |               |               |               |              |
| China, mainland e            | 99            | 88            | 99            | 110          |
| Cyprus e                     | 20            | 17            | 19            | 22           |
| Japan                        | 123           | 131           | 132           | 133          |
| Philippines                  | 81            | 94            | r122          | 145          |
| Turkey                       | 40            | 35            | 32            | 30           |
| Others                       | 49            | 48            | r49           | 50           |
|                              | 412           | 413           | r453          | 490          |
| <b>AFRICA:</b>               |               |               |               |              |
| Zambia                       | 687           | 730           | 733           | 825          |
| Congo (Kinshasa)             | 348           | 352           | r358          | 399          |
| South Africa, Republic of    | 137           | r165          | r161          | 163          |
| Others                       | r85           | r 79          | r 80          | 82           |
|                              | r1,257        | r1,326        | r1,332        | 1,469        |
| <b>OCEANIA:</b>              |               |               |               |              |
| Australia                    | 123           | r103          | r120          | 143          |
| Fiji (exports)               | --            | --            | e1            | <u>5/</u>    |
|                              | 123           | r103          | r121          | 143          |
| <b>TOTAL WORLD <u>6/</u></b> | <b>r5,800</b> | <b>r5,564</b> | <b>r5,999</b> | <b>6,655</b> |

e Estimate p Preliminary r Revised

1/ U. S. Bureau of Mines

2/ Cuba, Hungary, Kenya, and Malasia also produce copper but production data are not available.

3/ Recoverable 4/ Output from U.S.S.R. in Asia included with U.S.S.R. in Europe. 5/ Less than 500 tons.

6/ Totals may not add, due to rounding.

TABLE VI

REFINED COPPER PRODUCED, NEW (PRIMARY), IMPORTED, EXPORTED, AND  
WITHDRAWN FROM SUPPLY ON DOMESTIC ACCOUNT

YEARS 1964 - 1969

Unit: Short Tons

|   | 1964      | 1965       | 1966       |
|---|-----------|------------|------------|
| Ref. Prod. of New Cu from U.S. Ores         | 1,259,852 | 1,335,660  | 1,353,087  |
| Ref. Prod. of New Cu from Foreign Ores      | 396,543   | 376,133    | 357,897    |
| Total Ref. Prod. of New Copper              | 1,656,395 | 1,711,793  | 1,710,984  |
| Imports of Refined Copper                   | 137,707   | 137,443    | r 164,328  |
| Stocks at beginning of period               | 52,000    | 37,000     | 35,000     |
| Total Available Supply                      | 1,846,102 | 1,886,236  | r1,910,312 |
| Exports of Refined Copper                   | 316,230   | 324,965    | 273,071    |
| Stocks at end of period                     | 37,000    | 35,000     | 43,000     |
| Total                                       | 353,230   | 359,965    | 316,071    |
| Withdrawn on Domestic Acc. (Apparent Cons.) | 1,493,000 | r1,526,271 | r1,594,241 |
| Reported Actual Consumption                 | 1,825,281 | 2,004,623  | 2,359,954  |

|   | 1967      | 1968      | 1969      |
|---|-----------|-----------|-----------|
| Ref. Prod. of New Cu from U.S. Ores         | 846,551   | 1,160,925 | 1,468,889 |
| Ref. Prod. of New Cu from Foreign Ores      | 286,431   | 276,461   | 273,926   |
| Total Ref. Prod. of New Copper              | 1,132,982 | 1,437,386 | 1,742,815 |
| Imports of Ref. Copper                      | 330,571   | 400,278   | 131,171   |
| Stocks at beginning of period               | 43,000    | 27,000    | 48,000    |
| Total Available Supply                      | 1,506,553 | 1,864,664 | 1,921,986 |
| Exports of Refined Copper                   | 159,353   | 240,745   | 200,269   |
| Stocks at end of period                     | 27,000    | 48,000    | 39,000    |
| Total                                       | 186,353   | 288,745   | 239,269   |
| Withdrawn on Domestic Acc. (Apparent Cons.) | 1,320,200 | 1,575,919 | 1,682,717 |
| Reported Actual Consumption                 | 1,935,592 | 1,880,300 | 2,142,218 |

r Revised

Source: U.S. Bureau of Mines

TABLE VII

## IMPORTS OF PRIMARY COPPER INTO UNITED STATES

1967, 1968, 1969

1964, 1965, 1966

| Short Tons  |         |          |          |
|---|---------|----------|----------|
|   | 1967    | 1968     | 1969     |
| Ore, Matte - Regulus (Copper Content)                   | 32,971  | 27,559   | 39,048   |
| Canada  | 7,229   | 7,214    | 9,181    |
| Chile   | 691     | - - -    | - - -    |
| Mexico  | 145     | 219      | 89       |
| Peru  | 6,615   | 4,637    | 9,664    |
| Phillippines  | 16,058  | 14,543   | 18,269   |
| Australia   | 708     | 942      | 1,662    |
| Other Countries   | 1,525   | 4        | 183      |
| Blister Copper<br>(Copper Content)                      | 269,322 | 270,718  | 237,949  |
| Mexico  | 2,937   | 5,067    | 2,816    |
| Chile   | 141,629 | 136,320  | 100,768  |
| Peru  | 84,329  | 89,033   | 107,385  |
| South Africa Republic of                                | 38,866  | 38,243   | 25,160   |
| Other Countries   | 1,561   | 2,055    | 1,820    |
| Refined Cathodes and Shapes                             | 330,571 | 400,278  | 131,171  |
| Canada  | 140,602 | 135,115  | 84,941   |
| Chile   | 30,791  | 42,860   | 21,470   |
| Germany, West   | 33,269  | 55,263   | 2,574    |
| Peru  | 27,694  | 18,525   | 4,372    |
| United Kingdom  | 20,468  | 22,572   | 3,950    |
| Zambia  | 9,577   | 22,898   | 999      |
| Other Countries   | r68,170 | r103,045 | 12,865   |
| TOTAL PRIMARY IMPORTS                                   | 632,864 | 698,555  | 408,168  |
| TOTAL PRIMARY EXPORTS<br>(refined & ore Concts & matte) | 219,045 | 321,484  | 205,786  |
| EXCESS IMPORTS  | 413,819 | 377,071  | 202,382  |
|   | 1964    | 1965     | 1966     |
| TOTAL PRIMARY IMPORTS                                   | 581,591 | 506,936  | r565,118 |
| TOTAL PRIMARY EXPORTS                                   | 321,625 | 340,475  | 275,220  |
| EXCESS IMPORTS  | 259,966 | 166,461  | r289,898 |

r Revised

Source: U. S. Bureau of Mines

TABLE VIII

## EXPORTS OF PRIMARY COPPER FROM THE UNITED STATES

1967, 1968, 1969

|  | Short Tons |         |         |
|--|------------|---------|---------|
|  | 1967       | 1968    | 1969    |
| Ore, Concts. & Matte                                   | 59,692     | 80,739  | 5,517   |
| Refined Ingots, Bars, Etc.                             | 159,353    | 240,745 | 200,269 |
| Argentina  | 241        | r273    | 191     |
| Belgium - Luxembourg                                   | r 2,794    | r7,336  | 2,206   |
| Brazil   | r 6,918    | 31,335  | 17,065  |
| Canada   | r 4,785    | 5,739   | 20,428  |
| France   | 18,821     | r30,403 | 17,055  |
| Germany, West  | r19,497    | r29,501 | 26,282  |
| India  | r 6,415    | r15,216 | 12,955  |
| Italy  | r27,200    | r38,992 | 37,953  |
| Japan  | 29,214     | r18,823 | 14,942  |
| Mexico   | 975        | 19      | 18      |
| Netherlands  | r 3,290    | 9,294   | 8,295   |
| Spain  | 336        | 794     | 2,705   |
| Sweden   | 1,126      | r 3,831 | 4,605   |
| Switzerland  | 1,341      | 2,313   | 2,350   |
| United Kingdom   | 26,588     | 37,773  | 24,436  |
| Yugoslavia   | - - -      | r 1,302 | 2,713   |
| Other Countries  | r 9,812    | r 7,801 | 6,070   |
| Total Exports of Primary Copper<br>(Crude and Refined) | 219,045    | 321,484 | 205,786 |

r Revised

Source: U. S. Bureau of Mines.

TABLE IX

STOCKS OF REFINED COPPER REPORTED BY  
U.S.B.M. AND COPPER INSTITUTE\*

| END OF<br>PERIOD | Short Tons |                  |                  |
|------------------|------------|------------------|------------------|
|                  | IN U.S.A.  |                  | OUTSIDE U.S.A.   |
|                  | U.S.B.M.   | COPPER INSTITUTE | COPPER INSTITUTE |
| Year 1960        | 98,000     | 139,272          | 288,510          |
| 1961             | 49,000     | 79,755           | 332,479          |
| 1962             | 71,000     | 117,441          | 358,856          |
| 1963             | 52,000     | 76,934           | 394,143          |
| 1964             | 37,000     | 45,594           | 277,303          |
| 1965             | 35,000     | 60,811           | 327,723          |
| 1966             | 43,000     | 65,707           | 293,167          |
| 1967             | 27,000     | 55,350           | 272,202          |
| 1968             | 48,000     | 56,609           | 316,090          |
| 1969             | 39,000     | 45,943           | 234,739          |

\* Inventory data of the Bureau of Mines and Copper Institute always differ owing to somewhat different bases. After Jan. 1, 1947 the differences were due chiefly to the method of handling metal in process of refining (included as "refined" by Copper Institute and as "unrefined" by the U.S.B.M.), and to other minor variations in interpretation until May, 1951. Then the Institute's inventory data began to include tonnages delivered to U. S. consumers at foreign ports. Bureau of Mines figures are on the basis of metal physically held at primary smelting and refining plants in the U. S. In the Bureau's classification cathodes to be used chiefly for casting into shapes are considered stocks in process and not refined stocks.

TABLE X

STOCKS OF REFINED COPPER, BLISTER, AND MATERIALS IN PROCESS  
REPORTED BY UNITED STATES BUREAU OF MINES

| END OF<br>PERIOD | Short Tons |                                      |         |
|------------------|------------|--------------------------------------|---------|
|                  | REFINED    | BLISTER & MATERIALS                  |         |
|                  |            | IN PROCESS OF REFINING <sup>1/</sup> | TOTAL   |
| Year 1960        | 98,000     | 261,000                              | 359,000 |
| 1961             | 49,000     | 236,000                              | 285,000 |
| 1962             | 71,000     | 246,000                              | 317,000 |
| 1963             | 52,000     | 252,000                              | 304,000 |
| 1964             | 37,000     | 246,000                              | 283,000 |
| 1965             | 35,000     | 246,000                              | 281,000 |
| 1966             | 43,000     | 270,000                              | 313,000 |
| 1967             | 27,000     | 220,000                              | 247,000 |
| 1968             | 48,000     | 272,000                              | 320,000 |
| 1969             | 39,000     | 291,000                              | 330,000 |

<sup>1/</sup> Includes copper in transit from smelter in the U.S. to refineries therein.

TABLE XI

## REFINED COPPER CONSUMED IN U. S. 1966-1969

BY CLASSES OF CONSUMERS <sup>1/</sup>

| Unit: Short Tons                |                |                  |                       |                 |                |               |                  |
|---------------------------------|----------------|------------------|-----------------------|-----------------|----------------|---------------|------------------|
| Class of Consumer               | Cathodes       | Wire Bars        | Ingots and Ingot Bars | Cakes and Slabs | Billets        | Other         | Total            |
| <b>1966:</b>                    |                |                  |                       |                 |                |               |                  |
| Wire Mills                      | 2,698          | 1,356,428        | 10,811                | - - -           | 22             | 883           | 1,370,842        |
| Brass Mills                     | 180,350        | 39,503           | 211,500               | 234,156         | 262,834        | 147           | 928,490          |
| Chemical Plants                 | - - -          | - - -            | 1,586                 | - - -           | - - -          | 732           | 2,318            |
| Secondary Smelt.                | 9,408          | - - -            | 9,968                 | 111             | - - -          | 204           | 19,691           |
| Foundries                       | 2,101          | 57               | 15,678                | 3/              | 395            | 1,261         | 19,492           |
| Miscellaneous <sup>2/</sup>     | 1,407          | 52               | 9,489                 | 3/              | 774            | 7,399         | 19,121           |
| <b>Total</b>                    | <b>195,964</b> | <b>1,396,040</b> | <b>259,032</b>        | <b>234,267</b>  | <b>264,025</b> | <b>10,626</b> | <b>2,359,954</b> |
| <b>1967:</b>                    |                |                  |                       |                 |                |               |                  |
| Wire Mills                      | 6,058          | 1,226,370        | 6,964                 | - - -           | - - -          | 844           | 1,240,236        |
| Brass Mills                     | 152,310        | 28,090           | 115,640               | 153,146         | 200,906        | 282           | 650,374          |
| Chemical Plants                 | - - -          | - - -            | 1,386                 | - - -           | - - -          | 1,014         | 2,400            |
| Secondary Smelt.                | 4,908          | - - -            | 3,816                 | - - -           | - - -          | 254           | 8,978            |
| Foundries & Misc. <sup>2/</sup> | 3,557          | 173              | 21,331                | 3/              | 1,119          | 7,424         | 33,604           |
| <b>Total</b>                    | <b>166,833</b> | <b>1,254,633</b> | <b>149,137</b>        | <b>153,146</b>  | <b>202,025</b> | <b>9,818</b>  | <b>1,935,592</b> |
| <b>1968:</b>                    |                |                  |                       |                 |                |               |                  |
| Wire Mills                      | 16,632         | 1,164,933        | 6,716                 | - - -           | - - -          | 993           | 1,189,274        |
| Brass Mills                     | 141,836        | 26,610           | 140,658               | 122,367         | 220,504        | 475           | 652,450          |
| Chemical Plants                 | - - -          | - - -            | 520                   | - - -           | - - -          | 1,123         | 1,643            |
| Secondary Smelt.                | 3,583          | - - -            | 2,583                 | - - -           | - - -          | 188           | 6,354            |
| Foundries & Misc. <sup>2/</sup> | 2,460          | 134              | 19,150                | 3/              | 1,083          | 7,752         | 30,579           |
| <b>Total</b>                    | <b>164,511</b> | <b>1,191,677</b> | <b>169,627</b>        | <b>122,367</b>  | <b>221,587</b> | <b>10,531</b> | <b>1,880,300</b> |
| <b>1969:</b>                    |                |                  |                       |                 |                |               |                  |
| Wire Mills                      | 50,631         | 1,237,939        | 4/                    | 4/              | - - -          | 7,746         | 1,296,316        |
| Brass Mills                     | 183,644        | 31,847           | 152,529               | 172,264         | 256,714        | 128           | 797,126          |
| Chemical Plants                 | - - -          | - - -            | 471                   | - - -           | - - -          | 2,624         | 3,095            |
| Secondary Smelt.                | 3,866          | - - -            | 3,025                 | - - -           | - - -          | 67            | 6,958            |
| Foundries & Misc. <sup>2/</sup> | 3,008          | 1,014            | 23,777                | 238             | 1,659          | 9,027         | 83,723           |
| <b>Total</b>                    | <b>241,149</b> | <b>1,270,800</b> | <b>179,802</b>        | <b>172,502</b>  | <b>258,373</b> | <b>19,592</b> | <b>2,142,218</b> |

<sup>1/</sup> U.S. Bureau of Mines

<sup>2/</sup> Includes iron and steel plants, primary smelters producing alloys other than copper, consumers of copper powder and copper shot, and misc. manufacturers.

<sup>3/</sup> Included with "Billets" to avoid disclosing individual company confidential data.

<sup>4/</sup> Included with "Other" to avoid disclosing individual company confidential data.

TABLE XII

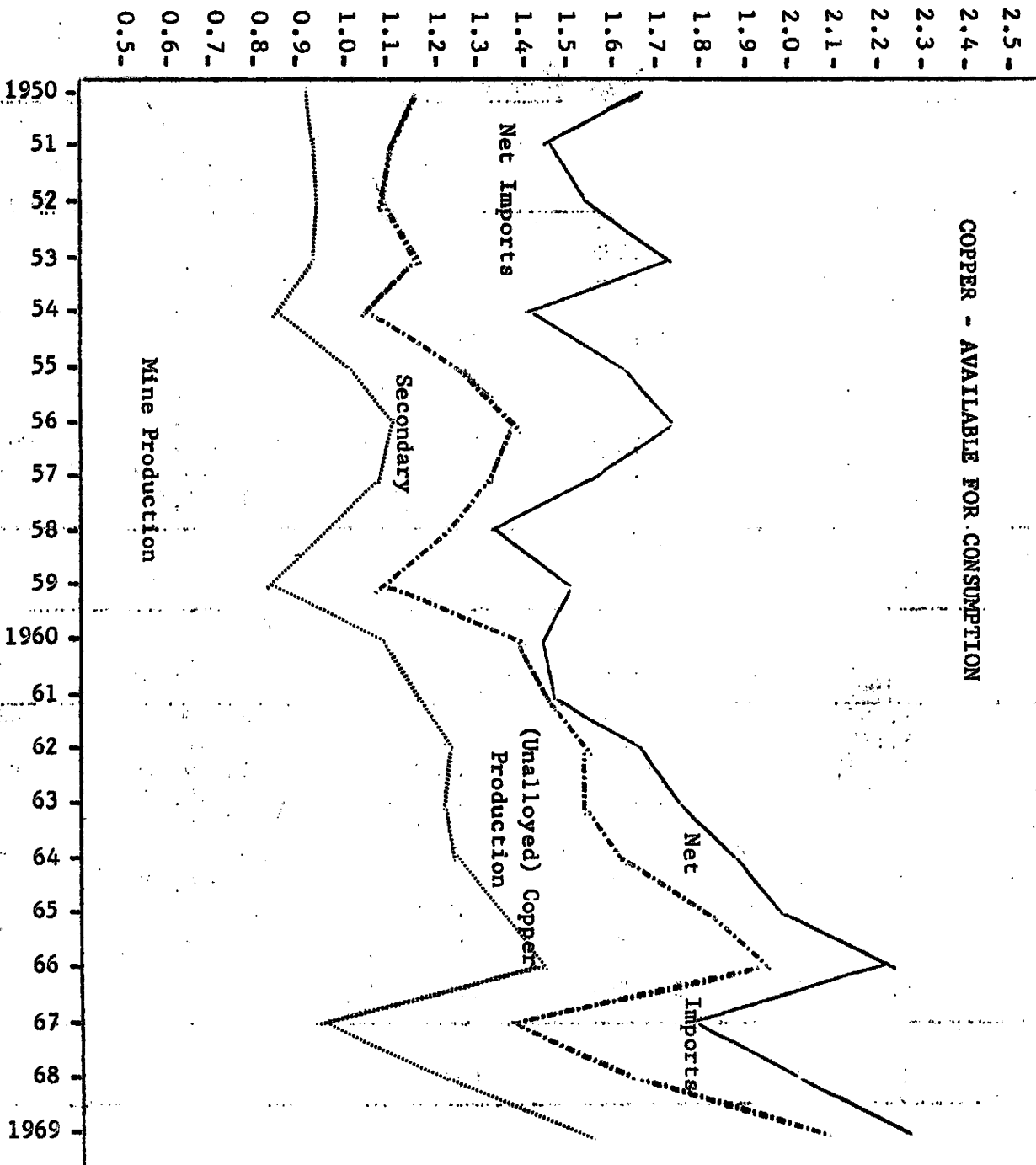
## U. S. PRODUCTION AND CONSUMPTION OF COPPER

| Short Tons    |                    |                          |                     |                                |   |
|---------------|--------------------|--------------------------|---------------------|--------------------------------|---|
| Year          | Mine<br>Production | Secondary<br>Production* | Total<br>Production | Total<br>Actual<br>Consumption | Total<br>Production<br>As % of<br>Consumption |
| 1950          | 909,343            | 260,704                  | 1,170,047           | 1,424,434                      | 82.2  |
| 1951          | 928,330            | 186,462                  | 1,114,792           | 1,416,865                      | 78.7  |
| 1952          | 925,359            | 173,904                  | 1,099,263           | 1,479,732                      | 74.3  |
| 1953          | 926,448            | 242,855                  | 1,169,303           | 1,494,215                      | 78.3  |
| 1954          | 835,472            | 212,241                  | 1,047,713           | 1,254,729                      | 83.5  |
| 1955          | 998,570            | 246,928                  | 1,245,498           | 1,502,004                      | 82.9  |
| 1956          | 1,104,156          | 273,060                  | 1,377,216           | 1,521,389                      | 90.5  |
| 1957          | 1,086,141          | 248,015                  | 1,334,156           | 1,347,815                      | 99.0  |
| 1958          | 979,329            | 255,121                  | 1,234,450           | 1,250,677                      | 98.7  |
| 1959          | 824,846            | 261,588                  | 1,086,434           | 1,463,031                      | 74.3  |
| <b>Totals</b> |                    |                          |                     |                                |   |
| 1950-59       | 9,517,994          | 2,360,878                | 11,878,872          | 14,154,891                     |   |
| <b>10 Yr.</b> |                    |                          |                     |                                |   |
| Avg.          | 951,799            | 236,088                  | 1,187,887           | 1,415,489                      | 83.9  |
| 1960          | 1,080,169          | 300,259                  | 1,380,428           | 1,349,896                      | 102.3   |
| 1961          | 1,165,155          | 290,805                  | 1,455,960           | 1,462,830                      | 99.5  |
| 1962          | 1,228,421          | 301,374                  | 1,529,795           | 1,599,676                      | 95.6  |
| 1963          | 1,213,166          | 314,643                  | 1,527,809           | 1,744,273                      | 87.6  |
| 1964          | 1,246,780          | 366,197                  | 1,612,977           | 1,825,281                      | 88.4  |
| 1965          | 1,351,734          | 462,811                  | 1,814,545           | 2,004,623                      | 90.5  |
| 1966          | 1,429,152          | 509,084                  | 1,938,236           | 2,359,954                      | 82.1  |
| 1967          | 954,064            | 423,054                  | 1,377,118           | 1,935,592                      | 71.1  |
| 1968          | 1,204,621          | 433,041                  | 1,637,662           | 1,880,300                      | 87.1  |
| 1969          | 1,544,579          | 514,593                  | 2,059,172           | 2,142,218                      | 96.1  |
| <b>Total</b>  |                    |                          |                     |                                |   |
| 1960-69       | 12,417,841         | 3,915,861                | 16,333,702          | 18,304,643                     |   |
| <b>10 Yr.</b> |                    |                          |                     |                                |   |
| Avg.          | 1,241,784          | 391,586                  | 1,633,370           | 1,830,464                      | 89.2  |

\* Unalloyed copper.

Source: U. S. Bureau of Mines

Million Short Tons



COPPER - AVAILABLE FOR CONSUMPTION



TABLE XIII

## COPPER MINING EMPLOYMENT, WAGES, AND HOURS IN THE U. S. AND ARIZONA

FOR THE YEARS 1965 THROUGH 1969

Averages for Base Period 1947-1949 are given as well  
as for the years 1965-1969

| Period   | "A"<br>Average Number<br>Employees |                    | "B"<br>Average Weekly<br>Earnings |                    | "C"<br>Average Weekly<br>Hours |                    | "D"<br>Average Hourly<br>Earnings |                    |
|----------|------------------------------------|--------------------|-----------------------------------|--------------------|--------------------------------|--------------------|-----------------------------------|--------------------|
|          | Arizona <sup>1/</sup>              | U.S. <sup>2/</sup> | Arizona <sup>3/</sup>             | U.S. <sup>4/</sup> | Arizona <sup>3/</sup>          | U.S. <sup>4/</sup> | Arizona <sup>3/</sup>             | U.S. <sup>4/</sup> |
| 1965     | 14,200                             | 29,900             | r\$146.10                         | \$136.71           | 45.01                          | 43.40              | \$3.246                           | \$3.150            |
| 1966     | 15,200                             | 32,350             | 150.06                            | r139.87            | 45.20                          | 43.45              | 3.320                             | 3.219              |
| 1967     | r12,158                            | 24,050             | r141.35                           | r136.51            | 42.60                          | 42.25              | 3.318                             | 3.231              |
| Jan-July | 15,657                             | 32,729             | r149.30                           | r142.77            | 44.54                          | 43.54              | 3.352                             | 3.279              |
| Aug-Dec  | 7,260                              | 11,900             | r130.41                           | 127.95             | 39.88                          | 40.44              | 3.270                             | 3.164              |
| 1968     | r14,125                            | 30,258             | r149.19                           | r156.06            | 43.02                          | 45.90              | 3.468                             | 3.400              |
| Jan-Mar  | 7,533                              | 12,267             | r118.38                           | r129.04            | 36.73                          | 40.20              | 3.223                             | 3.210              |
| Apr-Dec  | 16,322                             | 36,256             | r160.10                           | r165.53            | 45.11                          | 47.80              | 3.549                             | 3.463              |
| 1969     | 16,842                             | 37,625             | 166.65                            | 168.91             | 44.38                          | 46.29              | 3.755                             | 3.649              |
| Base     |                                    |                    |                                   |                    |                                |                    |                                   |                    |
| 1947-49  | 10,700                             | 27,100             | 64.20                             | 63.11              | 44.83                          | 44.10              | 1.432                             | 1.431              |
| 1965-69  | 14,505                             | 30,837             | 150.66                            | 147.39             | 44.04                          | 44.26              | 3.421                             | 3.330              |

r Revised

- 1/ Arizona estimates of copper mining employees include all full and part-time wage and salary workers who worked or received pay during the pay period which includes the 12th of the month. Proprietors, self-employed, unpaid family workers, domestics, and members of the armed forces are excluded.
- 2/ The U.S. figures are those reported for "All Employees".
- 3/ Estimates of hours and earnings of the Arizona Copper Mining Industry are based upon a sample of full and part-time production and related employees whose payroll and hours are reported for the pay period which includes the 12th of the month.
- 4/ The U.S. figures relate to Production workers in mining.

Sources: "Employment and Earnings and Monthly Report on the Labor Force," U.S. Department of Labor, Bureau of Labor Statistics; "Arizona Current Employment Development," & "Arizona Average: Earnings and Hours in Selected Industries," both published by the Employment Security Commission of Arizona

(continued)

TABLE XIII (continued)

| Period   | "E"<br>Man Hours<br>"A" x "C" x No. Weeks |            | "F"<br>Total Earnings<br>"E" x "D" |               | Average Earnings<br>Per Man<br>"F" ÷ "A" |         |
|----------|---|------------|------------------------------------|---------------|--|---------|
|          | Arizona                                   | U. S.      | Arizona                            | U. S.         | Arizona                                  | U. S.   |
|          | 1965                                      | 33,235,384 | 67,478,320                         | \$107,882,056 | \$212,556,708                            | \$7,597 |
| 1966     | 35,726,080                                | 73,091,590 | 118,610,586                        | 235,281,828   | 7,803                                    | 7,273   |
| 1967     | r26,932,402                               | 52,837,850 | r 89,361,710                       | 170,719,093   | 7,350                                    | 7,099   |
| Jan-July | 21,153,217                                | 43,225,381 | 70,905,583                         | 141,736,024   | 7,764                                    | 7,424   |
| Aug-Dec  | 6,273,174                                 | 10,426,863 | 20,513,279                         | 32,990,595    | 6,781                                    | 6,654   |
| 1968     | r31,598,190                               | 72,219,794 | r109,582,523                       | 245,547,300   | 7,758                                    | 8,115   |
| Jan-Mar  | 3,596,932                                 | 6,410,729  | 11,592,912                         | 20,578,440    | 6,157                                    | 6,710   |
| Apr-Dec  | 28,715,132                                | 67,538,436 | 101,910,003                        | 234,058,754   | 8,325                                    | 8,608   |
| 1969     | 38,867,294                                | 90,566,385 | 145,946,689                        | 330,476,739   | 8,666                                    | 8,783   |

|          |            |            |             |             |       |       |
|----------|------------|------------|-------------|-------------|-------|-------|
| Base     |            |            |             |             |       |       |
| 1947-49  | 24,943,412 | 62,145,720 | 35,718,966  | 88,930,525  | 3,338 | 3,282 |
| 1965-69  | 33,217,610 | 70,971,972 | 113,637,444 | 236,336,667 | 7,834 | 7,664 |
| Increase |            |            |             |             | 135%  | 134%  |

| Period          | "G"<br>Tons of Copper Ores<br>Sold or Treated,<br>Mine Production*<br>In Short Tons |             | "H"<br>Mine Production of<br>Recoverable Copper*<br>In Pounds |               |
|-----------------|---|-------------|---|---------------|
|                 | Arizona   | U. S.       | Arizona   | U. S.         |
|                 | 1965  | 92,859,535  | 173,286,198   | 1,308,809,700 |
| 1966            | 101,558,298   | 186,966,042 | 1,359,481,200   | 2,499,863,100 |
| 1967            | 74,289,203  | 127,066,097 | 901,853,500   | 1,608,078,200 |
| 1968            | 101,293,963   | 170,054,065 | 1,146,313,600   | 2,055,156,700 |
| 1969            | 127,848,828   | 223,751,510 | 1,477,520,000   | 2,691,376,400 |
| 1965-69 Average | 99,569,965  | 176,224,782 | 1,238,795,600   | 2,257,070,680 |
| Base            |   |             |   |               |
| 1947-49 Average | 38,082,754  | 82,875,490  | 641,029,770   | 1,511,500,639 |

| Period            | Tons of Copper Ore*<br>Produced Per Man Hour |        | Pounds of Copper*<br>Produced Per Man Hour |         |
|-------------------|--|--------|--|---------|
|                   | Arizona                                      | U. S.  | Arizona                                    | U. S.   |
|                   | 1965-1969 Average                            | 2.9975 | 2.4830                                     | 37.2933 |
| Base              |  |        |  |         |
| 1947-1949 Average | 1.5268                                       | 1.3336 | 25.6994                                    | 24.3219 |
| Increase          | 96%  | 86%    | 45%  | 31%     |

\* Does not include copper precipitate source material or cement copper produced.

TABLE XIV

SUMMARY OF ESTIMATED COPPER MINING EMPLOYMENT, WEEKLY EARNINGS,  
WEEKLY HOURS, HOURLY EARNINGS, IN ARIZONA AND UNITED STATES,  
BY YEARS 1947 TO 1969 INCLUSIVE

|                    | NO. OF EMPLOYEES      |                    | WEEKLY EARNINGS       |                    | WEEKLY HOURS          |                    | HOURLY EARNINGS       |                    |
|--------------------|-----------------------|--------------------|-----------------------|--------------------|-----------------------|--------------------|-----------------------|--------------------|
|                    | Arizona <sup>1/</sup> | U.S. <sup>2/</sup> | Arizona <sup>3/</sup> | U.S. <sup>4/</sup> | Arizona <sup>3/</sup> | U.S. <sup>4/</sup> | Arizona <sup>3/</sup> | U.S. <sup>4/</sup> |
| 1947               | 10,700                | 25,700             | \$ 59.40              | \$59.27            | 45.0                  | 44.8               | \$1.32                | \$1.32             |
| 1948               | 10,900                | 27,800             | 65.99                 | 65.81              | 45.2                  | 45.2               | 1.46                  | 1.46               |
| 1949               | 10,500                | 27,300             | 66.98                 | 63.96              | 44.3                  | 42.3               | 1.512                 | 1.512              |
| 1947-49<br>Average | 10,700                | 27,100             | \$ 64.20              | \$63.11            | 44.83                 | 44.1               | \$1.432               | \$1.431            |
| 1950               | 9,500                 | 25,800             | \$ 75.80              | \$72.05            | 46.5                  | 45.0               | \$1.63                | \$1.601            |
| 1951               | 10,100                | 25,900             | 83.01                 | 78.37              | 47.7                  | 46.1               | 1.74                  | 1.70               |
| 1952               | 10,700                | 26,500             | 90.31                 | 85.73              | 47.06                 | 45.6               | 1.92                  | 1.88               |
| 1953               | 11,400                | 28,600             | 96.03                 | 91.60              | 46.73                 | 45.8               | 2.055                 | 2.00               |
| 1954               | 11,900                | 27,400             | 96.60                 | 87.33              | 45.31                 | 42.6               | 2.132                 | 2.05               |
| 1955               | 11,800                | 27,200             | 104.90                | 95.70              | 47.0                  | 44.1               | 2.232                 | 2.17               |
| 1956               | 13,300                | 34,400             | 112.07                | 100.95             | 47.1                  | 43.7               | 2.377                 | 2.31               |
| 1957               | 14,000                | 32,500             | 106.22                | 98.23              | 43.8                  | 41.1               | 2.425                 | 2.39               |
| 1958               | 13,500                | 28,400             | 95.40                 | 94.62              | 39.8                  | 39.1               | 2.399                 | 2.42               |
| 1959               | 11,100                | 22,400             | 108.15                | 106.25             | 42.8                  | 42.5               | 2.526                 | 2.50               |
| 1960               | 12,733                | 29,600             | 116.83                | 114.75             | 43.69                 | 43.3               | 2.674                 | 2.65               |
| 1961               | 13,117                | 27,000             | 126.29                | 119.03             | 44.8                  | 43.6               | 2.817                 | 2.73               |
| 1962               | 13,350                | 28,500             | 129.29                | 120.98             | 44.3                  | 42.9               | 2.920                 | 2.82               |
| 1963               | 13,393                | 27,800             | 133.81                | 124.48             | 44.6                  | 43.1               | 3.003                 | 2.89               |
| 1964               | 13,275                | 27,000             | 140.97                | 130.42             | 45.0                  | 42.9               | 3.113                 | 3.04               |
| 1965               | 14,200                | 29,900             | r146.10               | 136.71             | 45.0                  | 43.4               | r3.246                | 3.15               |
| 1966               | r15,200               | r32,350            | 150.06                | r142.26            | 45.2                  | 43.5               | 3.32                  | 3.22               |
| 1967               | r12,158               | 24,050             | r141.35               | r136.51            | 42.6                  | 42.3               | 3.32                  | 3.23               |
| 1968               | r14,125               | 30,258             | r149.19               | r156.06            | 43.0                  | 45.9               | 3.47                  | 3.40               |
| 1969               | 16,842                | 37,625             | 166.65                | 168.91             | 44.4                  | 46.3               | 3.76                  | 3.65               |

r Revised

1/ See Footnote 1/ Table XIII

2/ See Footnote 2/ Table XIII

3/ See Footnote 3/ Table XIII

4/ See Footnote 4/ Table XIII

Sources: "Employment and Earnings and Monthly Report on the Labor Force", U.S. Department of Labor, Bureau of Labor Statistics; "Arizona Current Employment Development" and "Arizona Average; Earnings and Hours in Selected Industries," both published by the Employment Security Commission of Arizona.

TABLE XV

## UNITED STATES COPPER MINING - OUTPUT OF COPPER ORE; AMOUNT AND VALUE OF

COPPER, GOLD, AND SILVER RECOVERED THEREFROM. <sup>1/</sup>

| Year                     | Tons Copper Ore Annual Rate | Gold Ounces & Value                   | Silver Ounces & Value      | Copper <sup>2/</sup> Pounds & Value | Pounds Copper Per Ton of Ore & Price <sup>3/</sup> | Value of Copper, Gold & Silver |
|--------------------------|-----------------------------|---------------------------------------|----------------------------|-------------------------------------|--|--------------------------------|
| 1947 )<br>to )<br>1949 ) | 82,875,491                  | 479,589                               | 7,785,382                  | 1,511,500,640                       | 18.2   | \$338,495,580                  |
| 1960                     | 134,994,082                 | \$16,785,615<br>539,249               | \$7,045,770<br>9,469,133   | \$314,664,195<br>1,970,387,781      | 20.818¢<br>14.6                                    | \$659,011,675                  |
| 1961                     | 142,721,798                 | \$18,873,715<br>532,215               | \$8,569,565<br>10,385,661  | \$631,568,395<br>2,145,224,433      | 32.053¢<br>15.0                                    | \$670,101,672                  |
| 1962                     | 150,216,710                 | \$18,627,525<br>483,243               | \$9,601,544<br>10,944,522  | \$641,872,603<br>2,239,326,000      | 29.921¢<br>14.9                                    | \$714,022,067                  |
| 1963                     | 146,449,540                 | \$16,913,505<br>438,537               | \$11,874,806<br>10,309,897 | \$685,233,756<br>2,178,498,800      | 30.600¢<br>14.9                                    | \$695,157,023                  |
| 1964                     | 155,200,464                 | \$15,348,795<br>430,630               | \$13,187,595<br>11,470,890 | \$666,620,633<br>2,280,880,781      | 30.600¢<br>14.7                                    | \$718,638,672                  |
| 1965                     | 173,286,198                 | \$15,072,050<br>567,531               | \$14,831,861<br>12,801,638 | \$688,734,761<br>2,430,879,000      | 31.960¢<br>14.0                                    | \$887,637,002                  |
| 1966                     | 186,966,042                 | \$19,863,585<br>547,327               | \$16,552,518<br>13,230,411 | \$851,220,899<br>2,499,863,100      | 35.017¢<br>13.37                                   | \$940,463,849                  |
| 1967                     | 127,066,097                 | \$19,156,445<br>321,398               | \$17,106,921<br>8,351,423  | \$904,200,483<br>1,608,078,200      | 36.170¢<br>12.66                                   | \$638,894,936                  |
| 1968                     | 170,054,065                 | \$11,248,930<br>405,863               | \$12,942,033<br>9,532,341  | \$614,703,973<br>2,055,156,700      | 38.226¢<br>12.09                                   | \$896,398,989                  |
| 1969                     | 223,751,510                 | \$15,934,506 <sup>4/</sup><br>579,297 | \$20,443,059<br>13,581,516 | \$860,021,424<br>2,691,376,400      | 41.847¢<br>12.03                                   | \$1,327,687,865                |
|                          |                             | \$24,048,994 <sup>5/</sup>            | \$24,320,013               | \$1,279,318,858                     | 47.534¢  |                                |

<sup>1/</sup> U. S. Bureau of Mines <sup>2/</sup> Does not include precipitate copper.<sup>3/</sup> E/MJ Annual Average Metal Prices, Domestic Refinery, E/MJ, Mar. 1970 p 70<sup>4/</sup> Calculated average annual price, \$39.2608/Troy Ounce.<sup>5/</sup> Calculated average annual price, \$41.5141/Troy Ounce.

ARIZONA SECTION

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## ARIZONA'S COPPER INDUSTRY

Arizona's mines produced 801,363 tons of recoverable copper in 1969, more than ever before, and more than all of the other states combined. Furthermore, even the increase over 1968 of 173,402 tons was more copper than was produced by any other state in the nation except Utah. 1969 production was 8.4 percent ahead of the record set in 1966 and 27.6 percent ahead of 1968. The 1969 production value of \$761.8 million, was likewise ahead of 1968, reflecting the price increases referred to previously in this report.

Over two-thirds (67.7 percent) of the total production came from mines operated by four companies, namely Phelps Dodge Corp., (33%); Magma Copper Co., (14%); Kennecott Copper Corp., (11%) and the American Smelting and Refining Co., (9%). (See Table XIX) In 1960, four-fifths (80%) of the total production came from the mines of the Phelps Dodge Corp., Magma Copper Co., Kennecott Copper Corp., and the Inspiration Consolidated Copper Company.

The recoverable content of Arizona's copper ores was 0.58 percent in 1969 (not including precipitate copper) as compared to 0.75 percent in 1960. This drop from 15.0 to 11.6 pounds of copper per ton of ore is a decrease of 23 percent in grade of ore.

The value of Arizona's copper production in 1969, \$761.8 million amounted to 88.6 percent of the total value of all minerals produced. In addition, the copper ores were the source of all of the State's molybdenum output plus most of the gold and silver, valued at \$20.9 million, \$4.6 million, and \$11.0 million respectively. The total value of the four metals was \$798.3 million or 92.9 percent of the value of the total mineral output. In 1960, the value of the copper output was 83.2 percent of the total mineral value and that of the four metals was 86.7 percent of the total.

Arizona's unequalled mine production in 1969 resulted from both long established properties that had a year of steady, uninterrupted operation and new mines that came on stream after years of planning and preparation.

After more than four years of planning, overburden removal, and construction, The Anaconda Company's new Twin Buttes mine south of Tucson started operations on schedule in September with expectation of reaching an annual production rate of 60,000 tons of copper early in 1970. The company has reported that Twin Buttes reserves would permit increasing production at an appropriate time. The mine is an open pit from which ore and waste are removed by an extensive conveyor belt system. Molybdenum is an important by-product of the operation.

After more than 2 years of mine development and plant construction, Duval Sierrita Corp.'s big, new, copper-molybdenum mine south of Tucson at the end of 1969 was about ready to start production. Initially designed to process 66,000 tons of ore per day, it was soon announced that capacity would be increased to 72,000 tons per day. The Sierrita ore body is estimated to contain 414 million tons of ore with an average content of 0.35 percent copper and 0.036 percent molybdenum.

1969 saw the start of projects of the Magma Copper Co. to expand its San Manuel and Superior divisions in Pinal County. An over-all investment of more than \$135 million is estimated for the projects. Production at the underground San Manuel mine will be increased from about 40,000 to over 60,000 ore tons per day by 1972.

In addition, an electrolytic refinery will be built with a capacity to extract 200,000 tons of refined copper per year beginning in 1972. At the Superior division, production is to be increased from 1,500 tons of ore per day to 2,500 tons by 1974 by means of an additional shaft and expansion of mine and mill facilities. It is projected that Superior ore production will reach 3,000 tons per day by 1975. Plans call for the ultimate closing of the Superior smelter and shipment of concentrates to the San Manuel smelter.

Kennecott Copper Corporations' Ray Mines Division in 1969, completed an electrowinning plant to produce refined cathode copper from solutions from its silicate ore, vat leaching plant at Ray, also completed in the year. The \$35 million project, designed to treat 10,000 tons of ore daily, also involved completion of a \$13 million contact acid plant with a designed capacity of 750 tons per day.

Inspiration Consolidated Copper Co. in February 1969 started production of copper rod in its new mill at Miami. The 5/16 inch rod is supplied to Arizona wire and cable manufacturers. The company is the first to become an integrated, mine to manufactured product, copper producer in the State.

In December 1969, Hecla Mining Co., equal owner with El Paso Natural Gas Co. and to be operator of the Lakeshore copper property in Pinal County, started twin 7500 ft. inclined shafts as initial development work towards mining of the 470 million ton orebody averaging 0.75 percent copper discovered by El Paso Natural Gas in 1967-1969.

Phelps Dodge Corp. in June 1969 announced plans to develop its Metcalf mine near Morenci in Greenlee County. The \$100 million project including facilities for handling 30,000 tons of ore per day, was started late in the year and is scheduled for completion by early 1973. The production rate of 50,000 tons per year of copper is to replace the expected decline of production from its Bisbee mines.

Exploration for copper properties in Arizona continues to be very active, and several recent discoveries are being studied as to their economic feasibility.

1969 was a good year for copper in Arizona.

TABLE XVI

ARIZONA COPPER MINING - OUTPUT OF COPPER ORE; AMOUNT AND VALUE OF  
COPPER, GOLD, SILVER, AND MOLYBDENUM RECOVERED THEREFROM 1/

| Year    | Tons of Copper Ore | Annual Rate | Gold Ounces & Value | Silver Ounces & Value | Molybdenum 2/ (Thousands) Pounds & Value | Copper 3/ Pounds & Value | Pounds Copper & Price 4/ | Value of Copper, Gold, Silver & Molybdenum |
|---------|--------------------|-------------|---------------------|-----------------------|--|--------------------------|--------------------------|--|
|         |                    |             |                     |                       |  |                          |                          |  |
| 1947 to |                    |             |                     |                       |  |                          |                          |  |
| 1949    |                    |             | \$2,786,420         | \$2,356,154           | \$ 3495/                                 | \$150,588,843            | 20.818¢                  | \$156,080,417                              |
| 1960    | 66,032,439         |             | 115,602             | 3,689,622             | 4,359                                    | 993,370,700              | 15.0                     |  |
|         |                    |             | \$4,046,070         | \$3,339,108           | \$5,211                                  | \$318,405,110            | 32.053¢                  | \$331,001,288                              |
| 1961    | 71,918,991         |             | 129,184             | 4,380,458             | 4,878                                    | 1,092,360,900            | 14.6                     |  |
|         |                    |             | \$4,521,440         | \$4,049,690           | \$6,232                                  | \$ 326,845,305           | 29.921¢                  | \$341,648,435                              |
| 1962    | 78,868,147         |             | 117,362             | 4,571,370             | 4,412                                    | 1,200,945,700            | 15.2                     |  |
|         |                    |             | \$4,107,670         | \$4,959,936           | \$5,864                                  | \$ 367,489,384           | 30.600¢                  | \$382,420,990                              |
| 1963    | 80,615,132         |             | 121,177             | 4,494,239             | 5,553                                    | 1,217,337,700            | 15.1                     |  |
|         |                    |             | \$4,241,195         | \$5,743,132           | \$7,584                                  | \$ 372,505,336           | 30.600¢                  | \$390,073,663                              |
| 1964    | 86,132,039         |             | 133,983             | 4,915,362             | 6,296                                    | 1,279,898,700            | 14.9                     |  |
|         |                    |             | \$4,689,405         | \$6,355,563           | \$9,532                                  | \$ 409,055,625           | 31.960¢                  | \$429,632,593                              |
| 1965    | 92,859,535         |             | 133,830             | 5,352,850             | 9,399                                    | 1,308,809,700            | 14.1                     |  |
|         |                    |             | \$4,684,050         | \$6,921,235           | \$15,880                                 | \$ 458,305,893           | 35.017¢                  | \$485,791,178                              |
| 1966    | 101,558,298        |             | 127,431             | 5,595,644             | 10,161                                   | 1,359,481,200            | 13.39                    |  |
|         |                    |             | \$4,460,085         | \$7,235,168           | \$17,812                                 | \$ 491,724,350           | 36.170¢                  | \$521,231,603                              |
| 1967    | 74,289,203         |             | 66,933              | 3,996,587             | 9,261                                    | 901,853,500              | 12.14                    |  |
|         |                    |             | \$2,342,655         | \$6,193,431           | \$15,385                                 | \$ 344,742,519           | 38.226¢                  | \$368,663,605                              |
| 1968    | 101,293,963        |             | 89,419              | 4,697,394             | 12,127                                   | 1,146,313,600            | 11.32                    |  |
|         |                    |             | \$3,510,661 6/      | \$10,074,031          | \$19,207                                 | \$ 479,697,852           | 41.847¢                  | \$512,489,544                              |
| 1969    | 127,848,828        |             | 108,718             | 5,899,843             | 12,699                                   | 1,477,520,000            | 11.56                    |  |
|         |                    |             | \$4,513,330 7/      | \$10,564,672          | \$20,947                                 | \$ 702,324,357           | 47.534¢                  | \$738,349,359                              |

1/ U. S. Bureau of Mines

2/ Molybdenum content of recovered concentrate.

3/ Does not include precipitate copper.

4/ E/MJ Annual Average Metal Prices, Domestic Refinery, E/MJ, Mar. 1970 p70

5/ Calculated from values of molybdenum concentrates shipped from U.S. Mines, U. S. Bureau of Mines, Minerals Yearbook, 1949.

6/ Calculated average annual price, \$39.2608/Troy Ounce.

7/ Calculated average annual price, \$41.5141/Troy Ounce.



TABLE XVII

ARIZONA MINE PRODUCTION OF COPPER, LEAD, ZINC, GOLD AND SILVER

1858 - 1969 Incl. - In Terms of Recoverable Metals

|                 | COPPER     |                   | LEAD       |                   | ZINC       |                   |
|-----------------|------------|-------------------|------------|-------------------|------------|-------------------|
|                 | Short Tons | Value (thousands) | Short-Tons | Value (thousands) | Short Tons | Value (thousands) |
| 1874 - 1968     | 22,351,299 | \$ 10,270,572     | 651,305    | \$129,028         | 1,020,795  | \$ 249,154        |
| 1969            | 801,363    | 761,840           | 217        | 65                | 9,039      | 2,639             |
| Total 1874-1969 | 23,152,662 | \$ 11,032,412     | 651,522    | \$129,093         | 1,029,834  | \$ 251,793        |

|                   | GOLD       |                   | SILVER      |                   |
|-------------------|------------|-------------------|-------------|-------------------|
|                   | Ounces     | Value (thousands) | Ounces      | Value (thousands) |
| 1858 - 1968       | 13,640,412 | \$ 365,319        | 403,050,809 | \$ 336,423        |
| 1969              | 110,878    | 4,603             | 6,141,000   | 10,997            |
| Total 1858 - 1969 | 13,751,290 | \$ 369,922        | 409,191,809 | \$ 347,420        |

|   | TOTAL VALUE      |
|---|------------------|
| 1858 - 1968   | \$11,350,496,000 |
| 1969  | 780,144,000      |
| Total 1858 - 1969   | \$12,130,640,000 |
| Est. Value of Other Metals & Non-Metallics Produced thru 1968.      | \$ 888,701,000   |
| Est. Value of Other Metals & Non-Metallics Produced in 1969.        | 79,331,000       |
| Est. Value of Metals & Non-Metals produced thru 1969                | \$ 968,032,000   |
| Grand Total Estimated Value of Arizona Mineral Production thru 1969 | \$13,098,672,000 |

Source: U. S. Bureau of Mines.

TABLE XVIII

MINE PRODUCTION OF GOLD, SILVER, COPPER, LEAD AND ZINC IN ARIZONA, 1969, BY CLASSES OF ORE OR OTHER SOURCE MATERIALS, IN TERMS OF RECOVERABLE METALS

| Source  | Number of mines 1/ | Material sold or treated (short tons) | Gold (troy ounces) | Silver (troy ounces) | Copper (thousand pounds) | Lead (thousand pounds) | Zinc (thousand pounds) |
|---|--------------------|---------------------------------------|--------------------|----------------------|--------------------------|------------------------|------------------------|
| <b>Lode ore:</b>                              |                    |                                       |                    |                      |                          |                        |                        |
| Dry gold                                      | 7                  | 512                                   | 500                | 25                   | 5                        | --                     | --                     |
| Dry gold-silver                               | 8                  | 63,565                                | 139                | 4,245                | 1,057                    | --                     | --                     |
| Dry silver                                    | 18                 | 104,272                               | 153                | 83,110               | 677                      | 13                     | 2/                     |
| Total 3/                                      | 33                 | 168,349                               | 792                | 87,380               | 1,738                    | 13                     | 2/                     |
| Copper  | 45                 | 127,848,828                           | 108,718            | 5,899,843            | 1,477,520                | 1                      | 478                    |
| Copper-lead and lead-zinc 4/                  | 2                  | 2,945                                 | 4                  | 3,674                | 28                       | 241                    | 208                    |
| Copper-zinc                                   | 1                  | 103,838                               | 26                 | 36,460               | 6,404                    | 34                     | 17,307                 |
| Lead  | 8                  | 571                                   | 106                | 5,224                | 1                        | 126                    | 8                      |
| Total 3/                                      | 56                 | 127,956,182                           | 108,854            | 5,945,201            | 1,483,953                | 403                    | 18,001                 |
| <b>Other "lode" material:</b>                 |                    |                                       |                    |                      |                          |                        |                        |
| Gold-silver tailings                          | 1                  | 59,199                                | 533                | 21,211               | 176                      | --                     | --                     |
| Gold-silver cleanup                           | 5/                 | 20                                    | 2                  | 25                   | 1                        | --                     | --                     |
| Silver tailings                               | 1                  | 32,142                                | 341                | 85,723               | --                       | --                     | --                     |
| Copper cleanup                                | 5/                 | 178                                   | 6                  | 213                  | 37                       | --                     | --                     |
| Copper precipitates                           | 15                 | 83,418                                | --                 | --                   | 116,023                  | --                     | --                     |
| Copper tailings                               | 1                  | 133,617                               | --                 | --                   | 749                      | --                     | --                     |
| Lead cleanup, zinc cleanup and uranium ore 4/ | 5/                 | 6/ 217                                | 345                | 1,269                | 48                       | 18                     | 76                     |
| Total 3/                                      | 18                 | 308,791                               | 1,227              | 108,441              | 117,034                  | 18                     | 76                     |
| Total "lode" material                         | 90                 | 128,433,322                           | 110,873            | 6,141,022            | 1,602,726                | 434                    | 18,078                 |
| Placer  | 1                  | --                                    | 5                  | --                   | --                       | --                     | --                     |
| Total all sources                             | 91                 | 128,433,322                           | 110,878            | 6,141,022            | 1,602,726                | 434                    | 18,078                 |

1/ Detail will not necessarily add to totals because some mines produce more than one class of material.

2/ Less than 1/2 unit. 3/ Data may not add to totals because of independent rounding.

4/ Combined to avoid disclosing individual company confidential data.

5/ From properties not classed as mines. 6/ Excludes uranium ore tonnage.

Source: U. S. Bureau of Mines

TABLE XIX

COPPER PRODUCTION RECORD OF LARGE ARIZONA COPPER MINES  
YEARS 1968 and 1969

|                               | 1968                        |                               | 1969                        |                               |
|-------------------------------|-----------------------------|-------------------------------|-----------------------------|-------------------------------|
|                               | Tons<br>Copper Ore<br>Mined | Pounds<br>Copper<br>Recovered | Tons<br>Copper Ore<br>Mined | Pounds<br>Copper<br>Recovered |
| <b>PHELPS DODGE:</b>          |                             |                               |                             |                               |
| Morenci                       | 15,474,029                  | 190,550,991                   | 19,270,608                  | 250,900,610                   |
| Precipitate Copper            |                             | 23,162,309                    |                             | 22,753,650                    |
| New Cornelia                  | 9,018,377                   | 117,087,616                   | 10,736,239                  | 135,584,362                   |
| Lavender Pit                  | 4,715,382                   | 42,519,649                    | 5,550,147                   | 58,535,646                    |
| Precipitate Copper            |                             | 6,882,147                     |                             | 6,520,000                     |
| Copper Queen                  | 622,597                     | 44,808,595                    | 781,959                     | 58,628,154                    |
| Precipitate Copper            |                             | 402,401                       |                             | 481,502                       |
| <b>Sub-Total</b>              | <b>29,830,385</b>           | <b>425,413,708</b>            | <b>36,338,953</b>           | <b>533,403,924</b>            |
| <b>KENNECOTT - Ray</b>        |                             |                               |                             |                               |
| Precipitate Copper            | 6,746,163                   | 89,071,942                    | 11,653,549                  | 151,638,421                   |
|                               |                             | 21,741,698                    |                             | 29,967,592                    |
| <b>Sub-Total</b>              | <b>6,746,163</b>            | <b>110,813,640</b>            | <b>11,653,549</b>           | <b>181,606,013</b>            |
| <b>CITIES SERVICE - MIAMI</b> |                             |                               |                             |                               |
| Miami                         |                             | 11,076,950                    |                             | 13,755,800                    |
| Copper Cities                 | 3,359,097                   | 29,218,381                    | 4,644,525                   | 39,785,236                    |
| "    " Dump Leach             |                             | 4,355,962                     |                             | 3,799,103                     |
| Castle Dome                   |                             | 2,430,667                     |                             | 1,831,291                     |
| <b>Sub-Total</b>              | <b>3,359,097</b>            | <b>47,081,960</b>             | <b>4,644,525</b>            | <b>59,171,430</b>             |
| <b>INSPIRATION:</b>           |                             |                               |                             |                               |
| Precipitate Copper            | 6,167,134                   | 63,282,621                    | 8,514,309                   | 93,762,195                    |
| Christmas Division            | 1,173,407                   | 15,282,665                    | 1,913,813                   | 21,301,261                    |
| Precipitate Copper            |                             |                               |                             |                               |
| Ox Hide Mine                  | 1,070,230                   | 743,763                       | 3,908,540                   | 7,242,991                     |
| <b>Sub-Total</b>              | <b>8,410,771</b>            | <b>85,750,591</b>             | <b>14,336,662</b>           | <b>132,053,651</b>            |
| <b>MAGMA:</b>                 |                             |                               |                             |                               |
| San Manuel                    | 11,367,640                  | 144,148,653                   | 15,280,816                  | 191,443,365                   |
| Precipitate Copper            |                             |                               |                             |                               |
| Superior                      | 333,607                     | 29,412,021                    | 422,629                     | 35,236,396                    |
| <b>Sub-Total</b>              | <b>11,701,247</b>           | <b>173,560,674</b>            | <b>15,703,445</b>           | <b>226,679,761</b>            |

Continued

TABLE XIX (continued)

## COPPER PRODUCTION RECORD OF LARGE ARIZONA COPPER MINES (Continued)

YEARS 1968 and 1969

|                           | 1968                        |                               | 1969                        |                               |
|---------------------------|-----------------------------|-------------------------------|-----------------------------|-------------------------------|
|                           | Tons<br>Copper Ore<br>Mined | Pounds<br>Copper<br>Recovered | Tons<br>Copper Ore<br>Mined | Pounds<br>Copper<br>Recovered |
| A.S.& R. CO:              |                             |                               |                             |                               |
| Silver Bell               | 3,907,900                   | 43,665,411                    | 3,874,100                   | 40,076,810                    |
| Precipitate Copper        |                             | 4,908,962                     |                             | 5,226,103                     |
| Mission Unit              | 6,009,700                   | 76,118,920                    | 7,939,500                   | 97,322,040                    |
| Precipitate Copper        |                             |                               |                             |                               |
| San Xavier Unit           |                             |                               |                             |                               |
| Siliceous flux ore        | 41,873                      | 397,197                       | 69,684                      | 1,050,694                     |
| Sub-Total                 | 9,959,473                   | 125,090,490                   | 11,883,284                  | 143,675,647                   |
| PIMA MINING CO:           |                             |                               |                             |                               |
| Pima                      | 13,060,328                  | 128,973,406                   | 14,104,752                  | 131,222,891                   |
| Sub-Total                 | 13,060,328                  | 128,973,406                   | 14,104,752                  | 131,222,891                   |
| BAGDAD COPPER CORP:       |                             |                               |                             |                               |
| Precipitate Copper        | 2,099,223                   | 22,218,258                    | 2,030,112                   | 20,467,794                    |
| Precipitate Copper        |                             | 14,258,460                    |                             | 14,780,613                    |
| Sub-Total                 | 2,099,223                   | 36,476,718                    | 2,030,112                   | 35,248,407                    |
| DUVAL:                    |                             |                               |                             |                               |
| Esperanza                 | 5,473,156                   | 44,301,678                    | 5,487,589                   | 41,273,230                    |
| Precipitate Copper        |                             | 4,477,979                     |                             | 3,618,615                     |
| Mineral Park              | 6,226,284                   | 50,357,689                    | 6,030,700                   | 51,219,897                    |
| Precipitate Copper        |                             | 7,051,189                     |                             | 6,221,380                     |
| Sierrita                  | 490,958                     |                               | 1,034,473                   |                               |
| Precipitate Copper        |                             |                               |                             |                               |
| Sub-Total                 | 12,190,398                  | 106,188,535                   | 12,552,762                  | 102,333,122                   |
| ANACONDA CO:              |                             |                               |                             |                               |
| Twin Buttes               |                             |                               | 3,014,557                   | 22,280,200                    |
| Sub-Total                 |                             |                               | 3,014,557                   | 22,280,200                    |
| TOTALS                    | 97,357,085                  | 1,239,349,722                 | 126,262,601                 | 1,567,675,046                 |
| Other Copper<br>Producers | 4,529,873                   | 16,572,278                    | 1,775,506                   | 17,350,954                    |
| GRAND TOTAL               | 101,886,958                 | 1,255,922,000                 | 128,038,107                 | 1,602,726,000                 |

Source: Company Reports. U.S. Bureau of Mines figures used to compute amounts for "Other Copper Producers."

TABLE XX

## SUMMARY OF TOTAL COVERED EMPLOYMENT &amp; WAGES IN ARIZONA COPPER MINING

1948 -1969 INCLUSIVE

| COPPER<br>MINING   | Average No.<br>Covered<br>Employees | Covered<br>Wages | Average<br>Annual<br>Wage | Average<br>Weekly<br>Wage | Tons<br>Copper<br>Ores |
|--------------------|-------------------------------------|------------------|---------------------------|---------------------------|------------------------|
| 1948               | 11,493                              | \$ 41,318,524    | \$ 3,595                  | \$ 69.13                  | 39,072,204             |
| 1949               | 11,001                              | 40,612,224       | 3,692                     | 71.00                     | 37,365,611             |
| 1950               | 10,181                              | 41,994,321       | 4,125                     | 79.33                     | 41,757,273             |
| 1951               | 10,754                              | 47,825,698       | 4,447                     | 85.52                     | 42,784,388             |
| 1952               | 11,365                              | 54,950,235       | 4,835                     | 93.14                     | 44,472,522             |
| 1953               | 12,068                              | 62,742,982       | 5,199                     | 99.98                     | 45,187,838             |
| 1954               | 12,502                              | 65,518,853       | 5,241                     | 100.79                    | 43,072,894             |
| 1955               | 12,399                              | 71,293,263       | 5,750                     | 110.58                    | 52,189,728             |
| 1956               | 14,008                              | 83,568,996       | 5,966                     | 114.73                    | 60,468,580             |
| 1957               | 14,652                              | 85,125,320       | 5,809                     | 111.71                    | 59,571,834             |
| 1958               | 14,100                              | 74,726,972       | 5,300                     | 101.93                    | 56,255,809             |
| 1959               | 11,568                              | 72,095,130       | 6,232                     | 119.85                    | 53,121,545             |
| 1960               | 13,764                              | 90,312,848       | 6,562                     | 126.19                    | 66,032,439             |
| 1961               | 14,275                              | 97,271,286       | 6,814                     | 131.04                    | 71,918,991             |
| 1962               | 14,408                              | 101,920,108      | 7,074                     | 136.04                    | 78,868,147             |
| 1963               | 14,303                              | 104,291,588      | 7,292                     | 140.23                    | 80,615,132             |
| 1964               | 14,720                              | 113,792,031      | 7,730                     | 148.65                    | 86,132,039             |
| 1965               | 15,239                              | 122,163,124      | 8,016                     | 154.16                    | 92,859,535             |
| 1966 <sup>1/</sup> | 17,018r                             | 137,187,611      | 8,061r                    | 155.02r                   | 101,558,298            |
| 1967               | 13,426                              | 108,427,206      | 8,076                     | 155.31                    | 74,289,203             |
| 1968               | 15,734                              | 136,089,579      | 8,649                     | 166.33                    | 101,293,963            |
| 1969               | 19,459                              | 173,183,018      | 8,955                     | 171.15                    | 127,848,828            |

r - Revised

Sources: Arizona Employment Security Commission and the U. S. Bureau of Mines

<sup>1/</sup> Beginning with 1966, the number of covered employees includes the portion of copper smelter employees carried in Manufacturing.

TABLE XXI

AVERAGE NUMBER OF COVERED EMPLOYEES, TOTAL WAGES, AVERAGE ANNUAL WAGE  
AND AVERAGE WEEKLY WAGE

Base Period 1947-1949 and Years 1967, 1968 and 1969

ARIZONA INDUSTRIES COVERED BY SOCIAL SECURITY

|                                  | Average<br>No. of 1/<br>Employees | Total<br>Wages          | Average<br>Annual<br>Wage | Average<br>Weekly<br>Wage |
|----------------------------------|-----------------------------------|-------------------------|---------------------------|---------------------------|
| <u>Base Period 1947-1949</u>     |                                   |                         |                           |                           |
| Copper Mining Only 2/            | 11,278                            | \$ 39,432,008           | \$3,496                   | \$67.23                   |
| Copper Smelting 3/               | 1,500                             | 5,175,000               | 3,450                     | 66.35                     |
| All Mining & Smelting            | 12,778                            | \$ 44,607,008           | \$3,491                   | \$67.13                   |
| Other Mining & Smelting          | 1,592                             | 4,913,010               | 3,085                     | 59.33                     |
| All Mining, Quarrying & Smelting | 14,370                            | \$ 49,520,018           | \$3,446                   | \$66.27                   |
| Manufacturing (Excl. Smelting)   | 12,639                            | 36,910,624              | 2,920                     | 56.15                     |
| Construction                     | 10,844                            | 35,424,826              | 3,267                     | 62.83                     |
| Trans. & Utilities (Excl. R.R.s) | 10,530                            | 29,948,944              | 2,844                     | 54.69                     |
| Wholesale & Retail Trade         | 36,213                            | 91,916,860              | 2,538                     | 48.81                     |
| Services (Misc. Incl. Agri.)     | 18,643                            | 43,103,526              | 2,312                     | 44.46                     |
| <b>TOTALS AND AVERAGES</b>       | <b>103,239</b>                    | <b>\$286,824,798</b>    | <b>\$2,778</b>            | <b>\$53.42</b>            |
| <u>YEAR 1967</u>                 |                                   |                         |                           |                           |
| Copper Mining Only 2/            | 12,761                            | \$103,324,280           | \$8,097                   | \$155.71                  |
| Copper Smelting 4/               | 665                               | 5,102,926               | 7,674                     | 147.58                    |
| All Copper Mining & Smelting     | 13,426                            | \$108,427,206           | \$8,076                   | \$155.31                  |
| Other Mining & Quarrying         | 1,363                             | 9,646,675               | 7,078                     | 136.12                    |
| All Mining, Quarrying & Smelting | 14,789                            | \$118,073,881           | \$7,984                   | \$153.54                  |
| Manufacturing (Excl. Smelting)   | 78,011                            | 554,221,621             | 7,104                     | 136.62                    |
| Construction                     | 23,535                            | 190,096,812             | 8,077                     | 155.33                    |
| Trans. & Utilities (Excl. R.R.s) | 22,990                            | 162,796,174             | 7,081                     | 136.17                    |
| Wholesale - Retail Trade         | 98,117                            | 463,417,889             | 4,723                     | 90.83                     |
| Services Misc. (Incl. Agri.)     | 71,117                            | 349,470,467             | 4,914                     | 94.50                     |
| <b>TOTALS AND AVERAGES</b>       | <b>308,559</b>                    | <b>r\$1,838,076,844</b> | <b>r\$5,957</b>           | <b>\$114.56</b>           |

Source: Arizona Employment Security Commission

(Continued)

TABLE XXI (Continued)

|                                  | YEAR 1968                                |                        |                           |                           |
|----------------------------------|--|------------------------|---------------------------|---------------------------|
|                                  | Average<br>No. of <u>1/</u><br>Employees | Total<br>Wages         | Average<br>Annual<br>Wage | Average<br>Weekly<br>Wage |
| Copper Mining Only <u>2/</u>     | 14,906                                   | \$129,262,538          | \$8,672                   | \$166.77                  |
| Copper Smelting <u>5/</u>        | 828                                      | 6,827,041              | 8,245                     | 158.56                    |
| All Copper Mining & Smelting     | 15,734                                   | \$136,089,579          | \$8,649                   | \$166.33                  |
| Other Mining & Quarrying         | 1,179                                    | 8,693,338              | 7,373                     | 141.79                    |
| All Mining, Quarrying & Smelting | 16,913                                   | \$144,782,917          | \$8,560                   | \$164.62                  |
| Manufacturing (Excl. Smelting)   | 83,555                                   | 625,968,789            | 7,492                     | 144.08                    |
| Construction                     | 26,680                                   | 224,007,626            | 8,396                     | 161.46                    |
| Trans. & Utilities (Excl. R.R.s) | 23,851                                   | 178,990,171            | 7,505                     | 144.33                    |
| Wholesale - Retail Trade         | 102,655                                  | 510,816,657            | 4,976                     | 95.69                     |
| Services Misc. (Incl. Agri.)     | 76,600                                   | 400,111,753            | 5,223                     | 100.44                    |
| <b>TOTALS AND AVERAGES</b>       | <b>330,254</b>                           | <b>\$2,084,677,913</b> | <b>\$6,312</b>            | <b>\$121.38</b>           |

|                                  | YEAR 1969                                |                        |                           |                           |
|----------------------------------|--|------------------------|---------------------------|---------------------------|
|                                  | Average<br>No. of <u>1/</u><br>Employees | Total<br>Wages         | Average<br>Annual<br>Wage | Average<br>Weekly<br>Wage |
| Copper Mining Only <u>2/</u>     | 18,372                                   | \$163,930,795          | \$8,923                   | \$171.60                  |
| Copper Smelting <u>6/</u>        | 1,087                                    | 9,252,223              | 8,512                     | 163.69                    |
| All Copper Mining & Smelting     | 19,459                                   | \$173,183,018          | \$8,900                   | \$171.15                  |
| Other Mining & Quarrying         | 1,524                                    | 12,095,708             | 7,937                     | 152.63                    |
| All Mining, Quarrying & Smelting | 20,983                                   | \$185,278,726          | \$8,830                   | \$169.81                  |
| Manufacturing (Excl. Smelting)   | 92,370                                   | 723,505,497            | 7,833                     | 150.63                    |
| Construction                     | 33,303                                   | 307,238,608            | 9,226                     | 177.42                    |
| Trans. & Utilities (Excl. R.R.s) | 25,544                                   | 203,764,145            | 7,977                     | 153.40                    |
| Wholesale - Retail Trade         | 112,774                                  | 592,249,783            | 5,252                     | 101.00                    |
| Services Misc. (Incl. Agri.)     | 85,118                                   | 477,274,188            | 5,607                     | 107.83                    |
| <b>TOTALS AND AVERAGES</b>       | <b>370,092</b>                           | <b>\$2,489,310,947</b> | <b>\$6,726</b>            | <b>\$129.35</b>           |

1/ This number includes all covered employees on payroll, and is not restricted to production workers only, on which the average hourly and weekly earnings report.

2/ This number includes all copper mining and milling employees and some copper smelting employees not reported under Manufacturing by the Employment Security Commission.

3/ Smelting Employment has been segregated from Manufacturing as reported by the Employment Security Commission.

4/ Total covered Smelting Employees - 1,265 in 1967.

5/ Total covered Smelting Employees - 1,558 in 1968.

6/ Total covered Smelting Employees - 1,986 in 1969.

TABLE XXII  
MINERAL PRODUCTION IN ARIZONA IN 1969 <sup>1/</sup>

|   | Quantity | Value<br>(Thousands) |
|---|----------|----------------------|
| Clays ----- thousand short tons   | 120      | \$394                |
| Copper (recoverable content of ores, etc.) short tons   | 801,363  | 761,840              |
| Diatomite ----- short tons  | 725      | W                    |
| Gem stones ----- NA   | NA       | 153                  |
| Gold (recoverable content of ores, etc.) troy ounces  | 110,878  | 4,603                |
| Gypsum ----- thousand short tons  | 83       | 424                  |
| Helium, grade a <sup>2/</sup> ----- thousand cubic feet   | 56,300   | 1,126                |
| Iron ore (usable) -- thousand long tons, gross weight   | 18       | 136                  |
| Lead (recoverable content of ores, etc.) short tons   | 217      | 65                   |
| Lime ----- thousand short tons  | 283      | 5,074                |
| Mercury ----- 76-pound flasks   | W        | W                    |
| Molybdenum (content of concentrate) thousand pounds   | 12,699   | 20,947               |
| Natural gas (marketed) ----- million cubic feet   | 1,136    | 199                  |
| Petroleum (crude) ----- thousand 42-gallon barrels  | 2,433    | 7,056                |
| Pumice ----- thousand short tons  | 910      | 814                  |
| Sand and gravel ----- thousand short tons   | 16,744   | 18,224               |
| Silver (recoverable content of ores, etc.)<br>thousand troy ounces  | 6,141    | 10,997               |
| Stone ----- thousand short tons   | 2,827    | 5,812                |
| Tungsten concentrate (60-percent WO <sub>3</sub> basis) short tons  | 1        | 2                    |
| Uranium (recoverable content U <sub>3</sub> O <sub>8</sub> ) thousand pounds  | W        | W                    |
| Zinc (recoverable content of ores, etc.) short tons   | 9,039    | 2,639                |
| Value of items that cannot be disclosed: Asbestos,<br>cement, feldspar, mica (scrap), perlite,<br>pyrites, vanadium, vermiculite, zeolite,<br>and values indicated by symbol W, ----- | XX       | 18,970               |
| coal (bituminous, 1968)   |          |                      |
| Total -----   | XX       | 859,475              |
| Total 1967 constant dollars -----   | XX       | p/725,125            |

<sup>p/</sup> Preliminary. NA Not available. W Withheld to avoid disclosing individual company confidential data; included with "Value of items that cannot be disclosed."

XX Not applicable.

<sup>1/</sup> Production as measured by mine shipments, sales, or marketable production (including consumption by producers.)

<sup>2/</sup> Bureau of Mines estimate from non-company sources.

Source: U.S. Bureau of Mines