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R. J. L.

September 19, 1973

MEMORANDUM

The attached descriptive data and typical calculations illustrate several methods to obtain the value per ton of crude ore at a mine-mill plant. In the early periods of an exploration project, certain assumptions will have to be made, nevertheless, a fairly good idea of the value of the crude ore can be estimated. The calculations also show the wide difference between the gross value of the metals (the quoted price for refined metal times the contents) and the amount received.

For the geologists in Tucson Office, I plan to have several discussion sessions on the contents to clarify any points.

L.P. Entwistle

LPE:ym

ESTIMATION OF THE VALUE OF CRUDE ORE

L.P. Entwistle

September, 1973

INTRODUCTION

This brief outline traces metals from the crude ore through the concentration and smelting, and back to the value received at the mine-mill plant per ton of crude ore and per unit value in the mill heads. One purpose is to acquaint the geologist with the vast spread between quoted metal prices and the price received after the various losses and charges. The net value to the mine-mill plant is the amount used to determine the viability of a property.

The calculation involved are not difficult and even in the very early stages some reasonable estimates can be made, or at least certain maximums and minimums can be established.

The first point for the geologist to determine is the type of ore to be treated. For this demonstration, only sulfide ores are considered.

The mineralogy is important. For copper ores, mill recoveries usually will be lower for enriched chalcocite ores than for clean chalcopyrite ores. Some enriched chalcocite ores dilute the concentrate with pyrite due to thin coatings of chalcocite. On the other hand, chalcocite in sandstones will yield high recovery with high-grade concentrate. Other sulfide copper minerals, such as, enargite and tennantite, need special consideration because of the arsenic and antimony content, both of which carry severe penalties at the smelter.

The more complex sulfide ores, that is, those that have recoverable values in copper, lead, and/or zinc, present some complications. The geologist with only a hand lens often can make a reasonably accurate guess on mill recoveries and grades of concentrates by examination of grain size and interlocking of crystals. If both galena and chalcopyrite are contained, and if the amount of the latter is small in relation to the former, commonly only a Pb-Cu concentrate is produced.

Lead should be checked for bismuth, and any lead mineralization for the presence of the sulfo salts, since antimony and arsenic also command penalties. The color of the sphalerite can be a clue to the grade of zinc concentrates--the black sphalerite occasionally will not produce a marketable (or only difficultly marketable) concentrate.

The smelter charges change frequently, especially escalations, therefore, the attached calculations are only estimates of returns.

MILL RECOVERIES AND CONCENTRATES

Concentrate grades and recoveries vary greatly with specific ores, nevertheless, certain reasonable assumptions can be made at the outset.

Chalcopyrite will usually give a higher recovery than chalcocite, the former in the 90-93% range and the latter in the 84-88% range.

Galena, if not too fine-grained and too tightly interlocked with other minerals, will give 82-90% recovery. Sphalerite is similar. In both cases, lower recovery is also associated with the lower grade ore.

To calculate a concentrate, one first assumes the assay of the principal metal. For example, for a Zn-Pb ore, you may assume that the Pb concentrate will contain 60% Pb and the recovery will be 85%. If the mill heads are taken at 3.0% Pb, then the ratio of concentration is

$$\frac{\text{Grade of Pb Concentrate}}{\text{Pb\% in heads x mill recovery}} = \frac{60\%}{3.0\% \times 85\%} = 23.53$$

The ratio of concentration is then used to determine the amount of gold and silver the lead concentrate will contain. By multiplying the ratio of concentration by the recovered precious metals, (assay of mill heads times mill recovery) the assay in the concentrate is obtained.

Certain precautions must be used when the crude ore contains Pb-Cu-Zn, because in most places only a Pb-Cu concentrate is made. In this case, the assay of the Pb is assumed and the Cu is calculated. If either the grade of the Pb concentrate is assumed too high or the recoveries are too high, then an impossible concentrate can result from the calculation. For example, let us assume an ore containing 3.0% Pb and 1.0% Cu, and mill recoveries of 88% and 80%, respectively, We will also assume a Pb-Cu concentrate with 60% Pb. Therefore,

60.0% ÷ (3.0% Pb x 88%) = 22.73 ratio of conc.

and,

22.73 x (1.0% Cu x 80%) = 18.18% Cu in Pb conc.

therefore,

60.0% Pb x 1.155	=	69.30% galena
18.18% Cu x 2.90	=	52.72% chalcopyrite
		122.02% sulfide

If the Pb in the Pb-Cu concentrate is reduced to 45%, then

45.0% x (3.0% Pb x 88%) = 17.05 ratio of conc.

and,

17.05 x (1.0% Cu x 80%) = 13.64% Cu in Pb conc.

therefore,

45.0% Pb x 1.155	=	51.98% galena
13.64% Cu x 2.90	=	39.56% chalcopyrite
		91.54% sulfide

Since all concentrates contain some extraneous material, the combined pay sulfide content should be kept at around 90%, except in the case of secondary chalcocite where the pyrite content may exceed the chalcocite.

SMELTER TERMS

The smelter in all cases will reduce the assay of each metal in the concentrate and pay for only a specific percentage of the remainder. Additionally, for most all metals, the quoted price is reduced for delivery, refining and other charges.

The smelter has a base charge for treatment and the base charge is subject to escalations. These escalations are related to certain floor rates for hourly labor, fuel, and power.

Zinc is a special case, for which the smelter escalates on the price of the metal. The present base charge of $62.00 per ton is based on zinc at 12.5¢ per lb. For each one cent variation in zinc metal price (fractions in proportion), the base charge is increased or decreased $1.50 per ton. The smelter pays for 85% of the contents of zinc when the assay is 53.33% Zn or more; under 53.33% Zn the deduction is 8% from the assay.

All copper paid for in any concentrate is subject to the copper pollution tax. The tax is 1.5¢ per lb. of copper paid for when the price of copper is over 50¢ per lb., and 1.0¢ when copper is 50¢, or less, per lb.

Note also that basic freight rates are on a dry ton basis, and an additional 10% should be allowed for moisture in figuring freight costs.

In the examples given herein, certain additional charges have not been taken into consideration. Amongst these are:

a) Any terminal loading and unloading charges,
b) Special charges for shipments in sacks, or shipments by truck,
c) Insurance paid by shipper,
d) Umpire assay charges and special representation at the smelter,

e) In the case of shipments from foreign sources, the U.S. duty on lead and zinc (for lead the pounds per ton contained less 40 lb. times 0.75 cents per lb., for zinc the pounds contained per ton less 120 lb. times 0.667 cents per lb.).

The smelter will penalize, or charge for, certain elements. Arsenic, antimony and bismuth are common ones that carry penalties. Others that might be present in only very small quantities are highly undesirable; these include fluorine, mercury, nickel, tin, and barite. If any of these are present in important amounts and will move into the concentrate, caution should be exercised and proper inquiries made. If a property is under serious consideration, a spectrographic analysis of the mill products from any test work should be made, however, this will not give the contents of certain elements that will have to be checked by usual chemical methods.

Mr. Kroha has provided some round numbers that can be used for estimating net smelter return values of metals in normal concentrates (f.o.b. smelter).

Copper in copper concentrates
E&MJ price f.o.b. refinery less 15¢* per lb.
for cement copper deduct 12¢* per lb.
*Apparently does not include copper pollution tax.

Lead in lead concentrates
E&MJ delivered price less 8¢ per lb.

Zinc in zinc concentrates
E&MJ delivered price less 12¢ per lb.

Silver in lead or copper concentrates
Handy & Harman price less 12¢ per oz.

Gold in base metal concentrates
95% of London final price less 50¢ per oz.

THE SMELTER TERMS USED IN THE SEVERAL EXAMPLES ARE NOT RIGID. UP-TO-DATE OPEN SCHEDULES SHOULD BE USED FOR EACH EXERCISE.

METAL PRICES. The metal prices, as published in Metals Week, are used for calculations.

Gold - London final price
Silver - Handy & Harman
Copper - E&MJ U.S. Producer f.o.b. refinery for domestic producer.
Lead - E&MJ U.S. Producer delivered
Zinc - E&MJ U.S. Producer, prime western, delivered.

CRUDE ORE VALUES

The main point of all these calculations is to arrive at the value of a ton of crude ore at the mill.

The "net to shipper" of each concentrate is divided by the ratio of concentration for the particular concentrate and their sum, if more than one concentrate is produced, represents the value at the mill.

UNIT METAL VALUES

It is frequently desirable to calculate the value per unit for each metal in the crude ore, so that the income for various grades of crude ore can be estimated. For gold and silver, the unit can be one troy ounce, for base metals, one per cent.

The usual method is to apply all shipping and selling costs to the principal metal in the concentrate.

The general formulas for calculation of unit metal values in crude ore are:

V = value of principal metal in concentrate

v = value of minor metals in concentrate

S = shipping and selling costs

A = assay of metal in concentrate

R = mill recovery

U = unit value of metal in mill feed
For principal metal (one only in concentrate):

(a) $U = (V - S) \div A \times R$
For minor metals in concentrate:
(b) $U = v \div A \times R$

The following calculations are based on the several attachments, as noted.

A. EXAMPLE NO. 1 The value per ton of crude ore equals $4.67 for mill heads of 0.65% Cu, therefore, each 1% Cu in the heads equals

$$\frac{\$4.67}{0.65} = \$7.18$$

For crude ore of the same type that has the following assays, the value per ton of crude ore will be:

0.45% Cu x $7.18	$3.23
0.75% Cu x $7.18	$5.39

B. EXAMPLE NO. 2 This copper ore has payable precious metals, but since there is a constant deduction for the assay of each precious metal, and the amount is low in the concentrate, projections always may not be accurate. Nevertheless, the crude ore values will check closely if the assay of the precious metal is not varied greatly.

In the mill heads each metal unit is worth:

Gold:	$4.91 ÷ 0.079 oz. x 35% recovery	= $ 21.75/oz.
Silver:	$8.41 ÷ 3.98 oz. x 35% recovery	= 0.74/oz.
Copper:	($276.46 - $51.75) ÷ 27.5% x 93% rec.	= 7.60/1%

If we change the head grade to 0.008 oz. Au per ton, 0.45 oz. Ag per ton and 0.50% Cu, the new value per ton of crude ore becomes:

Au:	$21.75 x 0.008 oz.	$0.174
Ag:	$ 0.74 x 0.45 oz.	$0.333
Cu:	$ 7.60 x 0.50% Cu	$3.800
		$4.31

This value checks precisely with that made by going through the full calculation.

If the precious metal content is varied substantially, then the short method, by unit values, does not check as closely, for example, with mill feed of 0.025 oz. Au pt, 1.40 oz. Ag pt, and 0.50% Cu, the unit value calculation gives:

Gold:	0.025 oz. x $21.75	$ 0.544
Silver:	1.40 oz. x $0.74	1.036
Copper:	0.50% x $7.60	3.80
		$ 5.38

The long method, following the form of Example No. 2, gives $5.83 per ton crude ore. The reason for the difference is that a smelter's constant deduction from assay on the precious metals represents a greater percentage of the metal content of the concentrate.

C. EXAMPLE NO. 3 As this ore has larger amounts of precious metals in the concentrate, the effect of the constant deductions by the smelter is not as serious. Gold is worth $41.20 per ounce, silver $1.63 per ounce. Copper returns $7.36 per 1% in the heads.

With new mill heads at 0.035 oz. Au, 2.60 oz. Ag, and 2.45% Cu, the new value per ton of crude ore becomes:

Au:	$41.20 x 0.035	$ 1.44
Ag:	$1.63 x 2.60	$ 4.24
Cu:	$7.36 x 2.45%	$18.03
		$23.71

The detailed calculation gives $23.75 per ton.

D. EXAMPLE NO. 4 As more metals are paid for and more concentrates are made, the estimation of Unit Values becomes more complex. In this example, gold and silver are paid for in the copper and in the zinc concentrates, therefore, the two must be combined, as follows:

Gold:	Cu conc. $158.18 ÷ 1.92 oz. x 45%	=	$37.07
	Zn conc. $11.27 ÷ 0.187 oz. x 45%	=	$27.12
	1 oz. Au in mill feed at $90.00		$64.19
Silver:	Cu conc. $160.46 ÷ 57.87 oz. x 65%	=	$ 1.80
	Zn conc. $2.76 ÷ 2.16 x 25%	=	$ 0.32
	1 oz. Ag in mill feed at $3.00		$ 2.12
Copper:	($250.38-$51.02) ÷ 25% x 78%	=	$ 6.22 1% Cu
Zinc:	($177.34 - $89.25) ÷ 56% x 87%	=	$ 1.37 1% Zn

The above values are applied to the varying mill feeds.

G. EXAMPLE NO. 7 This example represents the most complex of the Pb-Zn-Cu-Ag-Au calculations because a number of combinations must be made for each metal to account for pay metal in these concentrates.

Gold			
Cu conc.	$34.80 ÷ 0.438 oz. x 50%	=	$39.73
Pb conc.	$19.15 ÷ 0.25 oz. x 30%	=	$22.98
Zn conc.	$0.58 ÷ 0.027 oz. x 15%	=	$ 3.22
	One oz. Au in mill feed at $90.00		$65.93
Silver			
Cu conc.	$41.62 ÷ 15.75 oz. x 30%	=	$ 0.79
Pb conc.	$60.66 ÷ 22.50 oz. x 45%	=	$ 1.21
Zn conc.	$ 3.24 ÷ 2.15 oz. x 20%	=	$ 0.30
	One oz. Ag in mill feed at $3.00		$ 2.30
Copper			
Cu conc.	($208.65 - $49.85) ÷ 21% x 60%	=	$ 4.54
Pb conc.	$66.59 ÷ 8.33% x 25%	=	$ 2.00
Zn conc.	no pay		-----
	1% Cu in mill feed at 60¢ per lb.		$ 6.54
Lead			
Cu conc.	$46.47 ÷ 21.88% x 25%	=	$ 0.53
Pb conc.	($117.49-$38.50) ÷ 50% x 60%	=	$ 0.95
Zn conc.	$0.47 ÷ 1.80% x 10%	=	$ 0.03
	1% Pb in mill feed at 16¢ per lb.		$ 1.51

Zinc
Zn conc. ($183.68-$89.25) ÷ 58% x 85% = $ 1.38 1% Zn

H. EXAMPLE NO. 8 For this gold-silver ore treated by flotation and sold as a concentrate, the value per ounce of each precious metal becomes (dividing the shipping and selling costs equally between the two metals):

Gold: ($164.42-$18.25) ÷ 1.995 x 95% = $69.60 per oz. Au

Silver: ($174.31-$18.25) ÷ 62.78 x 93%= $ 2.31 per oz. Ag

I. EXAMPLE NO. 9 When a gold-silver ore is treated by cyanidation, the final precipitate is usually smelted at the plant and a bullion produced. In the course of smelting the slag will contain good values in the precious metals; it is saved and shipped periodically. The amount and contents of the slag is difficult to estimate, therefore the calculations assume that all the precious metals are converted to bullion.

The fineness of the bullion will vary considerably, but it has been assumed at 700 fine; the remainder consists of base metals, largely zinc from the zinc dust used as a precipitant.

The smelter charges are based on gross weight of the bullion. The sampling and assaying is charged at $10.00 per thousand ounces with a minimum of $80.00. It has been assumed that the shipments would be 8,000 ounce lots.

With mill heads of 0.14 oz. Au per ton and 4.50 oz. Ag per ton and at the recoveries and bullion fineness as illustrated in this example, the net income per ounce of each metal would be:

Gold: ($16,671.92-$115.00) ÷ (23.52 x 8) x 95% = $83.59 per oz.
Silver: ($15,751.70-$115.00) ÷ (676.48 x 8) x 85%= $ 2.46 per oz.

It is worth noting the smelter cost per ounce or per pound, excluding mill recovery and shipping costs, in the several examples given in the attachments.

	Au/oz.	Ag/oz.	Pb/lb.	Cu/lb.	Zn/lb.
Metal prices	$60.00	$3.00	16¢	60¢	20¢
		Cost of Smelting			
Attachment					
A - Example No. 1	-----	----	--	16.51¢*	--
B - Example No. 2	$27.85	0.89	--	17.69¢*	--

	Au/oz.	Ag/oz.	Pb/lb.	Cu/lb.	Zn/lb.
			Cost of Smelting		
Attachment (cont'd)					
C - Example No. 3	$15.10	0.29	--	17.08¢*	--
D - Example No. 4					
In Cu conc.	$ 7.61	0.23	--	18.53¢*	--
In Zn conc.	$29.73	1.72	--	---	11.42¢*
E - Example No. 5					
In Pb conc.	-----	0.23	6.66¢*	---	--
In Zn conc.	-----	1.34	14.45¢	---	11.17¢*
F - Example No. 6					
In Pb conc.	$10.74	0.27	7.46¢	19.06¢*	--
In Zn conc.	$39.62	1.16	13.10¢	40.28¢	11.55¢*
G - Example No. 7					
In Cu conc.	$10.55	0.36	5.38¢	20.29¢*	--
In Pb conc.	$13.40	0.30	7.10¢*	21.23¢	--
In Zn conc.	$68.52	1.49	14.69¢	---	11.17¢*
H - Example No. 7	$14.73**	0.45**	--	---	--
I - Example No. 8	$ 1.74**	0.10**	--	---	--

* All smelter charges applied, except where concentrate contains copper where copper pollution tax is applied against copper.

** Smelter charges divided equally between the two metals.

EFFECT OF CHANGES IN METAL PRICES

Increment changes in metal prices as they reflect on the value per ton of crude ore are often a necessary figure so as to show how the outcome will vary. Such calculations are done simply and quickly from the data already assembled in the attachments, as noted.

A. EXAMPLE NO. 1 The only figure to vary is the price of copper. If the price drops below 50¢ per lb., then the copper pollution tax becomes 1¢ per lb. paid for.

Copper price = 65¢ per lb.

($353.63 - $53.07) ÷ 57.92 = $ 5.19

($5.19 - $4.67) ÷ 5 = $ 0.104 per ton per 1¢ change

Copper price - 50¢ per lb.

($262.96 - $50.04) ÷ 57.92 = $ 3.68
($4.67 - $3.6) ÷ 10 = $ 0.099 per ton per 1¢ change at 50¢, or less, per lb.

B.&C. EXAMPLES NO. 2 and 3. Since some precious metals are involved, variations in their prices must also be taken into account.

Gold price = $100.00 per ounce (Example No. 2)

($5.46 - $4.91) ÷ 45.49 = $0.012 per $10 change

Silver price = $3.10 per ounce

($8.69 - $8.41) ÷ 45.49 = $0.006 per 10¢ change

G. EXAMPLE NO. 7 There are five metals that are paid for in the crude ore and some are in several concentrates, therefore, the metal price changes must be accounted for in several concentrates.

Gold price = $100.00 per ounce

Copper Conc.	($38.66 - $34.80) ÷ 35.0 =	$0.110
Lead Conc.	($21.28 - $19.15) ÷ 33.33=	$0.064
Zinc Conc.	($0.65 - $0.58) ÷ 7.18 =	$0.001
		$0.175 per $10 change

Silver price = $3.10 per ounce

Copper Conc.	($43.02 - $41.62) ÷ 35.0 =	$0.040
Lead Conc.	($62.70 - $60.66) ÷ 33.33 =	$0.061
Zinc Conc.	($3.35 - $3.24) ÷ 7.18 =	$0.015
		$0.116 per 10¢ change

Copper price = 61¢ per lb.

Copper Conc.	($212.55 - $208.65) ÷ 35.0=	$0.111
Lead Conc.	($67.92 - $66.59) ÷ 33.33 =	$0.040
Zinc Conc.	no pay	-----
		$0.151 per 1¢ change

Lead price = 17.0¢ per lb.

Copper Conc.	($50.34 - $46.47) ÷ 35.0 =	$ 0.111
Lead Conc.	($126.71 - $117.49) ÷ 33.33 =	$ 0.277
Zinc Conc.	($ 0.51 - $ 0.47) ÷ 7.18 =	$ 0.006
		$ 0.394 per 1¢ change

Zinc price = 21.0¢ per lb.

Zinc Conc. ($193.54-$183.68-$1.50) ÷ 7.18=$1.164 per 1¢ change

Graphs can be constructed so that changes in mill feed assays, changes in mill recovery, and changes in metal prices are reflected in the value per ton of crude ore.

Attachment J is a graph of a simple copper concentrate, without values in precious metals. For this purpose the freight has been eliminated. The grade of the concentrate is assumed, and for any price of copper between 45¢ and 75¢ per lb. the value of each 1% copper in the concentrate can be read off the graph. This value is then multiplied by (a) the grade of the crude ore, and (b) by the mill recovery. For example, if we take the data given in Attachment A, the value of 1% Cu in the concentrates is worth $8.70 is read off the graph (32% Cu concentrate at 60¢ per lb.). The assumed freight rate in Example No. 1 is $8.00 per ton of concentrates, or $0.25 per 1% Cu in the concentrate ($8.00 ÷ 32% Cu). Therefore, ($8.70 - $0.25) x 0.65% Cu x 85% mill recovery equals $4.67 value per ton of crude ore at the mine-mill plant.

COPPER ORE

EXAMPLE NO. 1

TYPE: Chalcocite, partly on pyrite; no precious metals.

Assumed mill heads: 0.65% Cu
Assumed mill recovery: 85%
Assumed concentrate grade: 32% Cu
Assumed metal prices: 60¢ per lb.

RATIO OF CONCENTRATION

Concentrate grade ÷ (mill heads x mill recovery)
32% ÷ (0.65% x 85%) = 57.92

SMELTER LIQUIDATION

(32.0% - 1.0%) x 97.5% x 2000 x (60¢-6.5¢)		$323.41
Deductions:		
Treatment inc. escalations	$36.00	
Freight, assumed	$ 8.00	
Cu pollution tax 604.5 lb. x 1.5¢	$ 9.07	$ 53.07
Net to shipper		$270.34
VALUE PER TON CRUDE ORE $270.34 ÷ 57.92		$ 4.67

EXAMPLE NO. 2

TYPE: Chalcopyrite with minor values in precious metals

Assumed mill heads	0.005 oz. Au pt	0.25 oz. Ag pt	0.65% Cu
Assumed mill recoveries	35%	35%	93%
Assumed grade of copper conc.			27.5% Cu
Assumed metal prices	$90	$3.00	60¢

RATIO OF CONCENTRATION

Concentrate grade Cu ÷ (mill head x recovery Cu)
27.5% ÷ (0.65% x 93%) 45.49

Calculated concentrate grade

Gold	0.005 x 35% x 45.49	0.079 oz. Au pt
Silver	0.25 x 35% x 45.49	3.98 oz. Ag pt

SMELTER LIQUIDATION

Au:	(0.079 - 0.02) x 92.5% x $90.00	$ 4.91
Ag:	(3.98 - 1.0) x 95% x ($3.00 - 0.03)	$ 8.41
Cu:	(27.5% - 1.0%) x 97.5% x 2000 x (60¢-6.5¢)	$276.46
		$289.78

Deductions:

Treatment, inc. escalations	$36.00	
Freight, assumed	$ 8.00	
Cu pollution tax 516.75 lb. x 1.5¢	$ 7.75	$ 51.75
Net to shipper		$238.03

VALUE PER TON CRUDE ORE $238.03 ÷ 45.49 $ 5.23

COPPER ORE

EXAMPLE NO. 3

TYPE: Enargite with values in precious metals.

Assumed mill heads	0.025 oz. Au pt	3.0 oz Ag pt	2.8% Cu
Assumed mill recoveries	55%	60%	88%
Assumed grade of copper conc.			36%
Assumed metal prices	$90	$3.00	60¢

RATIO OF CONCENTRATION

Concentrate grade ÷ (mill heads x mill recovery)
36% ÷ (2.8% x 88%) = 14.61

Calculated concentrate grade
Gold 0.025 x 55% x 14.61 = 0.20 oz. Au pt
Silver 3.0 x 60% x 14.61 = 26.30 oz. Ag pt

SMELTER LIQUIDATION

Au:	(0.20 - 0.02) x 92.5% x $90.00	$ 14.98
Ag:	(26.30 - 1.0) x 95% x ($3.00 - 0.03)	$ 71.38
Cu:	(36.0% - 1.0%) x 97.5% x 2000 x (60¢-6.5¢)	$365.14
		$451.50

Deductions:

Treatment, inc. escalations	$36.00	
Freight, assumed	$ 8.00	
Arsenic penalty (14.2%*-1.0%)x 75¢	$ 9.90	
Cu pollution tax 682.5 lb. x 1.5¢	$10.24	$ 64.14
Net to shipper		$387.36

VALUE PER TON OF CRUDE ORE $387.36 ÷ 14.61 $ 26.51

* $\frac{\text{As \% in enargite}}{\text{Cu \% in enargite}} = \frac{\text{x\% As in conc.}}{\text{Cu\% in conc.}}$

$\frac{19.1}{48.3} = \frac{x}{36}$

x = 14.2% As

COMPLEX ORES

EXAMPLE NO. 4

TYPE: Sphalerite-chalcopyrite with precious metal values

	Au oz. pt	Ag oz. pt	Cu%	Zn%
Assumed mill heads	0.06	1.25	0.45	9.3
Assumed mill recoveries				
Copper concentrate	45%	65%	78%	-
Zinc concentrate	45%	25%	19%	87%
Assumed grade - copper concentrate			25%	
- zinc concentrate				56%
Assumed metal prices	$90	$3.00	60¢	20¢

RATIOS OF CONCENTRATION

	Conc. grade ÷ (mill heads x mill recovery)		
Copper concentrate -	25% ÷ (0.45% x 78%)	=	71.23
Zinc concentrate -	56% ÷ (9.3% x 87%)	=	6.92

Calculated grade of concentrates

Copper concentrate			
Gold	0.06 x 45% x 71.23	=	1.92 oz. Au pt
Silver	1.25 x 65% x 71.23	=	57.87 oz. Ag pt
Zinc concentrate			
Gold	0.06 x 45% x 6.92	=	0.187 oz. Au pt
Silver	1.25 x 25% x 6.92	=	2.16 oz. Ag pt
Copper	0.45 x 19% x 6.92	=	0.59% Cu

COPPER SMELTER LIQUIDATION

Au:	(1.92 - 0.02) x 92.5% x $90.00	$ 158.18
Ag:	(57.87 - 1.0) x 95% x ($3.00-0.03)	$ 160.46
Cu:	(25.0% - 1.0%) x 97.5% x 2000 x (60¢-6.5¢)	$ 250.38
		$ 569.02

Deductions:		
Treatment, inc. escalations	$36.00	
Freight, assumed	$ 8.00	
Cu pollution tax 468.0 lb. x 1.5¢	$ 7.02	$ 51.02
Net to shipper		$ 518.00

ZINC SMELTER LIQUIDATION

Au:	(0.187 - 0.02) x 75% x $90.00	$ 11.27
Ag:	(2.16 - 1.0) x 80% x ($3.00 - $0.03)	$ 2.76
Cu:	(0.59% - 1.5%)	no pay
Zn:	56.0% x 0.85% x 2000 x (20¢ - 1.3715¢)	$ 177.34
		$ 191.37

Deductions:		
Base charge	$62.00	
Price escalation (20¢-12.5¢)x$1.50	$11.25	
Other escalations	$ 8.00	
Freight, assumed	$ 8.00	$ 89.25
Net to shipper		$ 102.12

VALUE PER TON CRUDE ORE

Copper credit	$518.00 ÷ 71.23	$ 7.27
Zinc credit	$102.12 ÷ 6.92	$ 14.76
TOTAL		$ 22.03

COMPLEX ORES

EXAMPLE NO. 5

TYPE: Sphalerite-galena with silver, cadmium in sphalerite.

	Ag oz. pt	Pb%	Zn%
Assumed mill heads	3.0	2.8%	12.0%
Assumed mill recoveries			
Lead concentrate	75%	82%	-
Zinc concentrate	20%	12%	87%
Assumed grade - lead concentrate	-	58%	-
- zinc concentrate	-	-	58%
Assumed metal prices	$3.00	16¢	20¢

RATIOS OF CONCENTRATION

	Conc. grade	÷	(mill heads x mill recovery)		
Lead concentrate -	58%	÷	(2.8% x 82%)	=	25.26
Zinc concentrate -	58%	÷	(12.0% x 87%)	=	5.56

Calculated grade of concentrates

Lead concentrate			
Silver	3.0 x 75% x 25.26	=	56.84 oz. Ag.pt
Zinc concentrate			
Silver	3.0 x 20% x 5.56	=	3.34 oz. Ag pt
Lead	2.8% x 12% x 5.56	=	1.87%

LEAD SMELTER LIQUIDATION

Ag:	(56.84 -1.0) x 95% x ($3.00 -$0.03)	=	$ 157.55
Pb:	(58% - 1.5%) x 95% x 2000 x (16¢ - 3.25¢)	=	$ 136.87
			$ 294.42

Deductions:		
Treatment, inc. escalations	$28.50	
Freight, assumed	8.00	$ 36.50
Net to shipper		$ 257.92

ZINC SMELTER LIQUIDATION

Ag:	(3.34 - 1.0) x 80% x ($3.00 -$0.03)	=	$ 5.56
Pb:	(1.87% - 1.5%) x 65% x 2000 x (16¢ - 4.0¢)	=	$ 0.58
Zn:	58% x 85% x 2000 x (20¢ - 1.3715¢)	=	$ 183.68
Cd:	(8 lb. - 4 lb.) x 60% x ($3.50 -$0.75)	=	$ 6.60
			$ 196.42

Deductions:		
Base charge	$62.00	
Price escalation (20¢-1255¢)x$1.50	$11.25	
Other escalations	$ 8.00	
Freight, assumed	$ 8.00	$ 89.25
Net to shipper		$ 107.17

VALUE PER TON CRUDE ORE

Lead credit	$257.92	÷ 25.26	=	$ 10.21
Zinc credit	$107.17	÷ 5.56	=	$ 19.28
				$ 29.49

COMPLEX ORES

EXAMPLE NO.6

TYPE: Sphalerite-galena-chalcopyrite with values in precious metals.
Make two concentrates.

	Au oz. pt	Ag oz. pt	Cu%	Pb%	Zn%
Assumed mill heads	0.02	1.35	0.58	1.65	4.8
Assumed mill recoveries					
Lead-copper concentrate	65%	70%	60%	85%	-
Zinc concentrate	30%	25%	35%	11%	87%
Assumed grade- Pb-Cu conc.	-	-	-	45%	-
Zn conc.	-	-	-	-	55%
Assumed metal prices	$90	$3.00	60¢	16¢	20¢

RATIOS OF CONCENTRATION

	Conc. grade	÷	(mill heads x mill recovery)		
Lead-copper conc.	45%	÷	(1.65% x 85%)	=	32.09
Zinc conc.	55%	÷	(4.8% x 87%)	=	13.17

Calculated grade of conc.

Lead-copper conc.		
Gold	0.02 x 65% x 32.09	= 0.417 oz. Au pt
Silver	1.35 x 70% x 32.09	= 30.33 oz. Ag pt
Copper	0.58 x 60% x 32.09	= 11.17% Cu
Zinc conc.		
Gold	0.02 x 30% x 13.17	= 0.079 oz. Au pt
Silver	1.35 x 25% x 13.17	= 4.44 oz. Ag pt
Copper	0.58 x 35% x 13.17	= 2.67% Cu
Lead	1.65% x 11% x 13.17	= 2.39% Pb

LEAD SMELTER LIQUIDATION

Au:	(0.417 - 0.02) x 92.5% x $90.00	= $ 33.05
Ag:	(30.33 - 1.0) x 95% x ($3.00 - 0.03)	= $ 82.75
Copper:	(11.17% - 1.5%) x 97.5% x 2000 x (60¢ - 10¢)	= $ 94.28
Lead:	(45.0% - 1.5%) x 95% x 2000 x (16¢ - 3.25¢)	= $ 105.38
		$ 315.46

Deductions:		
Treatment, inc. escalations	$28.50	
Freight, assumed	$ 8.00	
Cu pollution tax 188.565#x 1.5¢	$ 2.83	$ 39.33
Net to shipper		$ 276.13

ZINC SMELTER LIQUIDATION

Au:	(0.079 - 0.02) x 75% x $90.00	= $ 3.98
Ag:	(4.44 - 1.0) x 80% x ($3.00 - 0.03)	= $ 8.17
Cu:	(2.67% - 1.0%) x 65% x 2000 x (60¢ - 10¢)	= $ 10.86
Pb:	(2.39% - 1.5%) x 65% x 2000 x (16¢ - 4.0¢)	= $ 1.39
Zn:	55% x 85% x 2000 x (20¢ - 1.3715¢)	= $ 174.18
		$ 198.58

Deductions:		
Treatment	$62.00	
Price escalations(20¢-12.5¢)x$1.50	11.25	
Other escalations	8.00	
Freight, assumed	8.00	
Cu pollution tax, 21.71 x 1.5¢	0.33	$ 89.58
Net to shipper		$ 109.00

VALUE PER TON CRUDE ORE

Lead-copper credit	$276.13 ÷ 32.09	= $ 8.60
Zinc credit	$109.00 ÷ 13.17	= $ 8.28
		$ 16.88

COMPLEX ORE

EXAMPLE NO. 7

TYPE: Sphalerite-galena-chalcopyrite with precious metals. Make three concentrates.

	Au oz. pt	Ag oz. pt	Cu%	Pb%	Zn%
Assumed mill heads	0.025	1.50	1.0	2.5	9.5
Assumed mill recoveries					
Copper concentrate	50%	30%	60%	25%	-
Lead concentrate	30%	45%	25%	60%	-
Zinc concentrate	15%	20%	10%	10%	85%
Assumed grade					
Copper concentrate	-	-	21%	-	-
Lead concentrate	-	-	-	50%	-
Zinc concentrate	-	-	-	-	58%
Assumed metal prices	$90	$3.00	60¢	16¢	20¢

RATIOS OF CONCENTRATION

	Conc. grade	÷ (mill heads x mill recovery)	
Copper conc.	21%	÷ (1.0% x 60%)	= 35.0
Lead conc.	50%	÷ (2.5% x 60%)	= 33.33
Zinc conc.	58%	÷ (9.5% x 85%)	= 7.18

Calculated grade of concentrates

Copper conc.		
Gold	0.025 x 50% x 35.0	0.438 oz. Au pt
Silver	1.50 x 30% x 35.0	15.75 oz. Ag pt
Lead	2.5% x 25% x 35.0	21.88% Pb
Lead conc.		
Gold	0.025 x 30% x 33.33	0.25 oz. Au pt
Silver	1.50 x 45% x 33.33	22.50 oz. Ag pt
Copper	1.0% x 25% x 33.33	8.33% Cu
Zinc conc.		
Gold	0.025 x 15% x 7.18	0.027 oz. Au pt
Silver	1.50 x 20% x 7.18	2.15 oz. Ag pt
Copper	1.0% x 10% x 7.18	0.72% Cu
Lead	2.5% x 10% x 7.18	1.80% Pb

COPPER SMELTER LIQUIDATION

Au:	(0.438 - 0.02) x 92.5% x $90.00	$ 34.80
Ag:	(15.75 - 1.0) x 95% x ($3.00 - 0.03)	$ 41.62
Cu:	(21.0% - 1.0%) x 97.5% x 2000 x (60¢ - 6.5¢)	$ 208.65
Pb:	(21.88% - 1.5%) x 95% x 2000 x (16¢ - 4.0¢)	$ 46.47
		$ 331.53

Deductions:		
Treatment, inc. escalations	$36.00	
Freight, assumed	$ 8.00	
Cu pollution tax 390# x 1.5¢	$ 5.85	$ 49.85
Net to shipper		$ 281.68

LEAD SMELTER LIQUIDATION

Au:	(0.25 - 0.02) x 92.5% x $90.00		$ 19.15
Ag:	(22.50 - 1.0) x 95% x ($3.00 - 0.03)		$ 60.66
Cu:	(8.33% - 1.5%) x 97.5% x 2000 x (60¢ - 10¢)		$ 66.59
Pb:	(50.0% - 1.5%) x 95% x 2000 x (16¢ - 3.25¢)		$ 117.49
			$ 263.89
	Deductions:		
	Treatment, inc. escalations	$28.50	
	Freight, assumed	$ 8.00	
	Cu pollution tax 133.185# x 1.5¢	$ 2.00	$ 38.50
	Net to shipper		$ 225.39

ZINC SMELTER LIQUIDATION

Au:	(0.027 - 0.02) x 92.5% x $90.00		$ 0.58
Ag:	(2.15 - 1.0) x 95% x ($3.00 - 0.03)		$ 3.24
Cu:	(0.72% -1.5%)		$ no pay
Pb:	(1.80% - 1.5%) x 65% x 2000 x (16¢ - 4.0¢)		$ 0.47
Zn:	58% x 85% x 2000 x (20¢ - 1.3715¢)		$ 183.68
			$ 187.97
	Deductions:		
	Base charge	$62.00	
	Price escalation(20¢-12.5¢)x $1.50	$11.25	
	Other escalations	$ 8.00	
	Freight, assumed	$ 8.00	
	Cu pollution tax	none	$ 89.25
	Net to shipper		$ 98.72

VALUE PER TON CRUDE ORE

Copper credit	$281.68 ÷ 35.0	$ 8.05
Lead credit	$225.39 ÷ 33.33	$ 6.76
Zinc credit	$ 98.72 ÷ 7.18	$ 13.75
		$ 28.56

GOLD-SILVER ORE

EXAMPLE NO. 8

TYPE: Gold and silver associated with sulfides, essentially pyrite. Flotation concentrate.

Assumed mill heads	0.14 oz. Au pt		4.50 oz. Ag pt
Assumed mill recovery	95%		93%
Assumed ratio of concentration		15 to 1	
Calculated grade of conc.	1.995 oz. Au		62.78 oz. Ag

SMELTER LIQUIDATION (Lead Schedule)

Au:	(1.995 - 0.02) x 92.5% x $90.00		$ 164.42
Ag:	(62.78 - 1.0) x 95% x ($3.00 - 0.03)		$ 174.31
			$ 338.73
	Deductions:		
	Treatment, inc. escalations	$28.50	
	Freight, assumed	$ 8.00	$ 36.50
	Net to shipper		$ 300.23

VALUE PER TON CRUDE ORE $300.23 ÷ 15 $ 20.02

GOLD-SILVER ORE

EXAMPLE NO. 9

TYPE: Gold and silver, cyanide treatment.

Assumed mill heads	0.14 oz. Au	4.50 oz. Ag
Assumed recovery	95%	85%
Assumed fineness of bullion	28.8 oz. Au	773.12 oz. Ag

The fineness of the bullion can be estimated as follows:

Assumed fineness of precious metals in bullion	700
Recovered gold per ton	0.133 oz.
Recovered silver per ton	3.825

Ratio of recovered metals Au: Ag = 1 : 28.76
Therefore,

700 ÷ (1 + 28.76) = 23.52 parts gold
676.48 parts silver

If shipments are made in lots of 8,000 troy ounces, gross weight then:

Au:	(23.52 oz. x 8) x 99% x ($90.00 - $0.50)	$16,671.92
Ag:	(676.48 oz. x 8) x 99% x ($3.00 - $0.06)	$15,751.70
		$32,423.62

Min. refining charge per shipment	$50.00	
Sampling and assaying at $10.00 per 1,000 ounces, min. $80.00	$80.00	
Shipping, assumed	$100.00	$ 230.00
Net to shipper		$32,193.62

To produce this amount of bullion, the following calculation can be made to determine the value per ton of crude ore

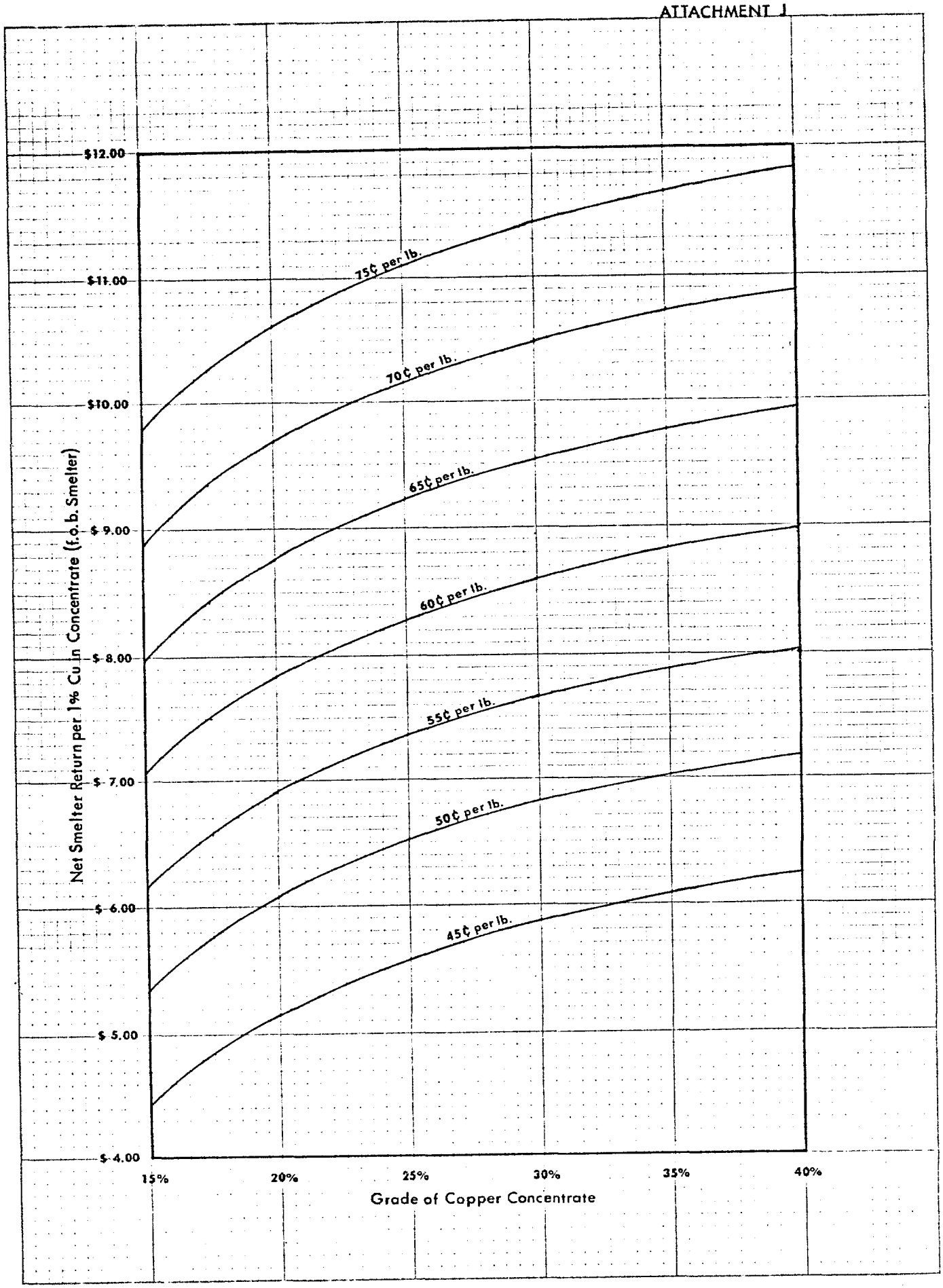
0.14 oz. Au pt x 95%	0.133 oz. Au recovered pt
23.52 ÷ 0.133	176.8 tons crude ore

To check:

4.50 oz. Ag pt ÷ 85%	3.825 oz. Ag recovered pt
676.48 ÷ 3.825	176.8 tons crude ore

then, $\frac{\$32,193.62}{8}$ ÷ 176.8 tons $ 22.76 per ton

ATTACHMENT 1



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'Mining, Minerals and Me':

Arizona Program Brings Mining Into the Classroom

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'Mining, Minerals and Me':
Arizona Program Brings Mining Into the Classroom

For the Arizona Mining Association, belief in the philosophy "today's children are tomorrow's decision makers" has spurred the development of an educational program that may soon become a model for industries nationwide.

This year, 85,000 elementary students in Arizona will learn the story of mining through the comprehensive, multi-media program, "Mining, Minerals & Me." The state mining association, whose 18 member firms produce 65 percent of the nation's copper, supported the program as an effort to educate young people on the essential role of minerals and the mining industry in their daily lives. According to J.L. McBiles, author of the program, its underlying theme focuses on the origins of things in our society and the processes required to transform minerals into useful products.

"Most people never consider how and where we get the things we use every day," McBiles explained, "and I never cease to be surprised at the general lack of mineral literacy that exists in this country. Few teachers have any knowledge about the most basic economic principles of the mining industry or have an appreciation for the strategic importance of our nation's minerals, and this is attributable to a major void in our educational system."

Phase I of the mineral education program, which includes textbooks, filmstrips, posters, teaching picture cards and a full range of student activities, was completed last spring at a cost of $258,000 to the association. All instructional materials are offered free of charge to interested elementary schools throughout the state.

Program fills an educational gap

Association President C.J. Hansen said the organization's commitment to developing the full-scale program responded to an identified need by educators and industry officials for having timely, authoritative instructional materials for classroom use.

"The amount of information available to assist elementary teachers in explaining basic mineral concepts has been largely non-existent," Hansen said, "and surveys show this trend is prevalent nationwide. Our program is a constructive attempt to bridge this educational gap."

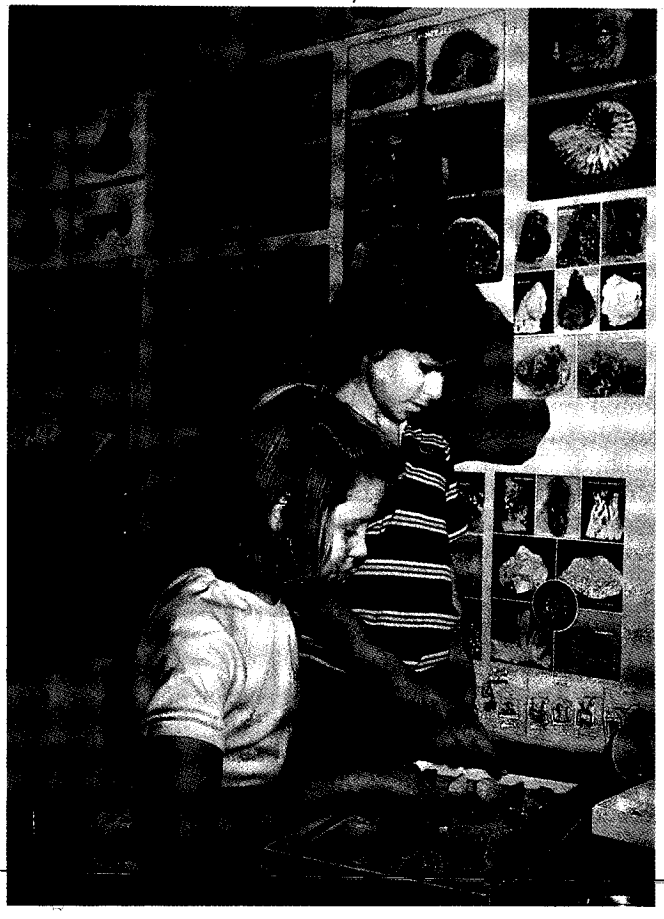
Hansen said Arizona educators have called the project "the most comprehensive instructional program of its kind" because of its interdisciplinary design. The program incorporates all areas of the elementary curriculum: language arts, mathematics, science, social studies, Arizona studies, current events and others are used to teach students mineralogy and mining.

Peter Steen, president and chief executive officer of Inspiration Consolidated Copper Co. and immediate past chairman of the association, said the program gives children a "balanced viewpoint of the total economy."

"There is an emphasis on teaching environmental concerns in today's classroom and a general lack of instruction on economic concerns," Steen explained. "This translates to an unbalanced view of the world for children. They're only getting half of the story, which suggests how industry is contributing to environmental problems. Our main objective in undertaking this program is to help children grow up with an appreciation and understanding of both concerns—that industry is also responsible for a sound economy and a way of life that we often take for granted."

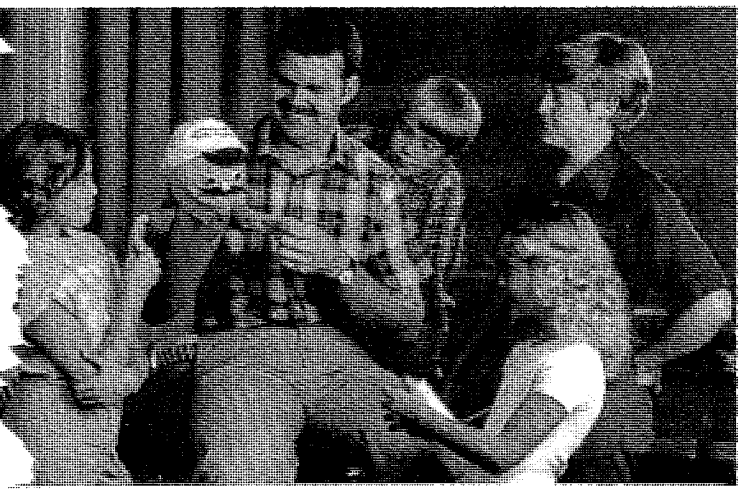
Despite the greatly depressed copper industry, Arizona Mining Association has not been dissuaded from its commitment to the program. The 18 member firms recently were faced with some cutback alternatives and determined that the educational program was the most significant area of involvement for the organization and should not be compromised, Steen said.

Arizona schoolchildren find the study of minerals fascinating as it is presented through "Mining, Minerals and Me." The program is a culmination of years of development and represents close cooperation between educators and industry



The high priority given the program has been maintained and enhanced by current association leaders: G. R. Wyman, who chaired the education committee last year and presently serves as chairman of the board, and A. R. Jacobs, who is vice chairman of the association and now heads the committee.

"We believe this program is having more impact on the image of the mining industry than any other form of public information we have pursued," Wyman underscored. "And, through the take-home projects, we are also exposing students' parents to what mining is all about."



Larry McBiles, author of the minerals program, tells the mining story with help of "Professor Rocky." The puppet will be included in the classroom kit for Phase II of the program, which is being designed for kindergarten through third grade

Author is former Arizona classroom teacher

Receptivity to the program has been enhanced by the fact that it was created by a former Arizona classroom teacher and is not viewed as a "P.R. job," Hansen said.

McBiles, a native Arizonan and the son of a fourth generation mining family, has taught at the primary, intermediate and secondary levels. He was reared and later taught in Ajo, a town noted for its copper mining, where he began work on a unit of study on mining more than six years ago. The concepts and strategies he developed for use in his classroom, which later became the prototype for the statewide program, evolved out of a desire to introduce supplemental subjects more current and pertinent to his students' futures.

"Even the most fundamental questions, like 'What are rocks made of,' 'what are minerals,' 'where are they found and why are they important,' were not readily answered in existing elementary materials," McBiles explained. "Whether a child grows up in a mining town or a major city, these questions are paramount for helping young people understand the relationships between everyday products and their origins."

Parents, teachers also learn about mining

With financing provided by the Arizona Mining Association, McBiles' prototype was developed into a multimedia program for fourth, fifth and sixth grade students. McBiles, now a full-time employee of the association as its educational consultant, directs all activities of the project in Arizona's elementary schools and has started a subsequent program (Phase II) for children in kindergarten through third grade. Yet he is quick to point out that "Mining, Minerals & Me" is more than just an educational program for children.

"Most problems faced by mining interests stem from the simple fact that mining is not appreciated," McBiles said. "Yet we need to recognize that appreciation is a byproduct of understanding, and that, in turn, understanding is the out-growth of knowledge."

"Mining, Minerals & Me represents an effort to tell the story of mining to our young people and to those who help shape their perceptions—namely, their teachers and their parents."

In conjunction with the program, member companies of the Arizona Mining Association hired 12 educators from elementary schools throughout the state for summer employment at their mining operations in 1981. These teachers spent 10 weeks learning from first hand experience about the mining industry.

State superintendent of education endorses program

Carolyn Warner, superintendent of the Arizona Department of Education, called the summer employment program "a concept unprecedented in either Arizona or the nation.

"Of great concern to me is the fact that we, as a society, have generally low economic IQs," she said. "This translates into a specific concern that many of those responsible for teaching our children about the free enterprise system are themselves relatively uneducated about the importance and the functioning of that system."

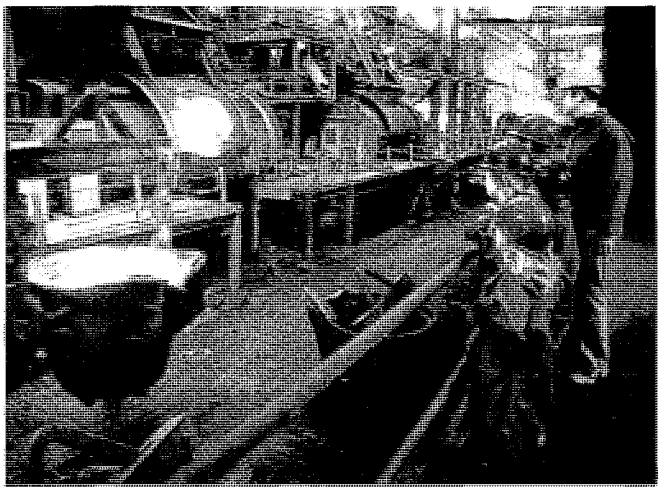
The Department of Education has had significant input in all phases of "Mining, Minerals & Me." Warner not only endorses the program but also has publicly commended the association for taking a leadership role in the area of education.

"For a number of years, I have encouraged Arizona business and industry to become more involved with our public schools," she said. "I am totally committed to the principle that a partnership between the two sectors will have significant, far-reaching benefits for both. Therefore, I applaud the efforts of our state's mining industry to provide relevant instructional materials to our schools and our young people."

Warner said she also expects the program "to become a national model for public education-private sector cooperation."

The Arizona Department of Education has had significant input in all phases of the mineral education program. Here, McBiles meets with state superintendent of education Carolyn Warner; Tom Reno, associate superintendent for education services; and Dave Bolger, assistant to the superintendent

"Mining, Minerals and Me" is an activity-oriented program, with field trips a favorite for the students. Youngsters get a close look at Arizona's greatest resource (above), then follow the copper through a nearby smelter (below)



Program evolved through years of development

When members of the Arizona Mining Association first learned of the innovative course being taught by McBiles, they recognized an educational effort that offered an excellent opportunity to become more involved with the state's schools.

The concern for mineral education is not a new commitment by the association. For many years, it has pursued a variety of educational programs to provide high school students with greater insight into the state's economy and industry. Yet previous programs had never been directed to the elementary level.

Through the assistance of the Ajo Chapter of WAAIMEs (Women's Auxiliary of the American Institute of Mining, Metallurgical and Petroleum Engineers), McBiles' work received statewide attention from the mining industry. A principal advocate of his project was Sara Jo Metz of Tucson, chairwoman of WAAIMEs' "Engineers for Tommorrow" committee, who arranged a meeting between McBiles and association president-emeritus James K. Richardson.

"I have always felt that the important task of implementing a working system of mineral study in the schools has unfortunately been one of the most neglected," Richardson explained.

"The concept of 'Mining, Minerals & Me' is especially exciting because it is aimed at younger children who are just beginning to search for explanations on how our system works."

McBiles was hired by the association to further develop the program, implement it in the schools and monitor its use, Richardson said.

The transformation of his teacher-made materials—the collection of more than five years of research and preliminary field testing with over 30 students into a prototype that could be evaluated and mass produced involved numerous developmental phases spanning two years.

Geologists were consulted to confirm the accuracy of the instructional materials. The Arizona Department of Education was contacted to review and evaluate the materials and the methodology for their use.

Advisory board, pilot test feedback give constructive assessments

To formalize the teaching materials and the plans for implementing the program in the schools, a 38-member Program Advisory Board comprised of classroom teachers, administrators and curriculum consultants was organized.

"Specifically, this group provided an intensive and constructive assessment of the program for application in the elementary curriculum," McBiles said. "Yet an equally important role of the advisory board was to create a network of awareness and support for the program throughout the state."

Sample materials were then produced and pilot-tested in 55 classrooms in 26 schools, representing metropolitan, suburban and rural elementary schools. Teachers were asked to use the course for a period of weeks and provide feedback based on children's receptivity and comprehension, and also on their own perceptions of the program.

Suggestions from the pilot study validated the program, McBiles said. The study showed students not only demonstrated fascination and enjoyment in studying the themes, but also gained valuable insights and skills.

Approximately 1000 program 'kits' were produced and distributed last spring. To assure teachers' understanding of the program and its most effective use in the classroom, McBiles conducted a series of more than 40 "in-service training sessions" for teachers throughout the state.

"The in-service training sessions offered teachers an opportunity to review the materials with me and ask questions based on their individual classroom needs. The main point I stressed is that the program can be used in a number of ways to supplement their existing curriculum." McBiles said the instructional plan is comprehensive and easy to follow, yet it also allows teachers flexibility to use their own creativity.

Informational program introduces 'Mining, Minerals & Me'

Recognizing that implementation of the program is as significant to its success as its design, the association organized an extensive informational campaign about "Mining, Minerals & Me" that involved visits to schools, press conferences, and a myriad of correspondence.

As Richardson pointed out, a major challenge of industry-sponsored educational programs has been not only getting teachers to accept the materials but also to use them.

"In the past, we relied on teachers to do the implementing for us and this is where previous programs often got hung up. I believe there must always be someone responsible for generating enthusiasm among educators and then monitoring their use of the program on a continuing basis—not just one year from now, but five and 10 years from now."

Introductory materials were developed to explain the program to parents, teachers and the community at large, and were designed to reflect the same high quality and unbiased presentation of the instructional materials.

An attractive and in-depth brochure accompanied by a letter of endorsement from the Department of Education was distributed to teachers and administrators throughout the state. Follow-up correspondence included a comprehensive 'question and answer' guide on "Mining, Minerals & Me." In addition, an audio visual program was prepared for use in presentations to Arizona educators.

"We recognized from the beginning that every piece of literature and every public service announcement associated with the program contributed to its image and the subsequent acceptance of the program," McBiles said. "The association was especially motivated to convey its commitment to the program—that this was not just some fly-by-night attempt."

Due to the growing sensitivity to industry-sponsored 'propaganda' programs, special attention was given to neutralizing preconceived suspicions. A letter describing the program to students' parents is also included in the Teachers Resource Guide. Representatives of the news media have been involved at every developmental stage, and have been invited to review the materials and interview teachers participating in the pilot study to obtain candid opinions about the scientific relevance of the program.

"We have been especially sensitive to the need for maintaining an unbiased posture, and 'telling it like it is,'" McBiles explained. "The instructional materials don't try to paint the mining industry as being perfect. No industry is perfect."

The association also has made a commitment to a continuing program of assessment. Teachers are encouraged to provide feedback to help maintain the program's high level of relevancy.

Basic objectives woven throughout instructional design

To accomplish its purpose of encouraging a better understanding of minerals and the mining industry, "Mining, Minerals & Me" is designed to help students:

- discover the nature of minerals, and their importance in the origin of society
- become aware of the role mining plays in providing for our advanced technology
- develop an appreciation and concern for the development and conservation of non-renewable natural resources.

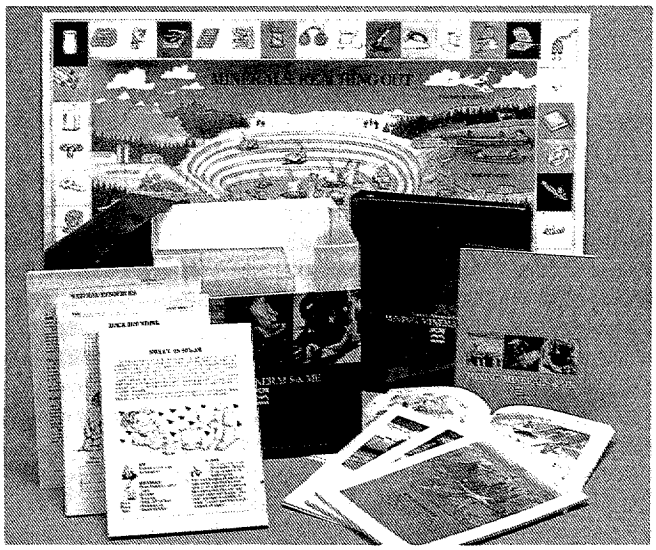
These themes are woven throughout the instructional design of the program. In addition, "Mining, Minerals & Me" is highly activity-oriented, and utilizes a variety of experiments, projects and discussions for the classroom and at home.

The materials in "Mining, Minerals & Me" reflect the scientific, environmental and economic factors involved in mineral processing in a balanced, objective manner.

"The educational needs of the children are first and foremost," McBiles said. "Therefore it's important for them to get a balanced view. I'm trying to show them that our world is full of trade-offs." For example, an in-depth discussion of the environmental concerns of mining is covered in a chapter called "The Earth as a Friend."

Designed as a sequential learning system, the program begins with a look at minerals, what they are and how they are formed. It traces the early mining endeavors and the use of minerals. Methods of mining and mining's importance in everyday life are also discussed, as well as the economics of mining, mineral conservation and the future of mining.

"Students are encouraged to think beyond the text, and they have many opportunities to do their own experiments and research projects," McBiles said.



Each classroom kit contains textbooks for 30 children, activity packets, teacher's material and audio visuals

Instructional kits are activity-oriented

"Mining, Minerals & Me" utilizes a variety of teaching materials packaged in individual kits. Each 26-pound kit is designed to accommodate the needs of a teacher and a class of 30 students.

The basic instructional tool is an 80-page text, attractively and functionally designed with color photographs, illustrations, an index and a glossary. Other materials include three colorful wall chart posters which show relationships between minerals and aspects of our daily lives; 32 full-color teaching picture cards which illustrate the processes involved in mineral production; and 30 fact sheets designed to provide supplemental information to the text.

Also included are 10 in-class activities for each grade level which consist of exercises that challenge the student. For example, there's an exercise called "rock-hounding." The student is invited to find a rock sample and record information as to its size, color and texture on a chart provided. The important skills of observation and measuring are emphasized in this activity.

A discovery series consisting of 45 cards is also included in the kit. Each card outlines a stimulating scientific experiment to be conducted by an individual student or small groups of students. One such experiment is

called "streak lightning," which is designed to illustrate how the streak test aids in identifying minerals.

One experiment even suggests that the students build a working model of an oil well. The materials include a large can, dry sand and gravel, 500 grams of plasticine, a length of rubber tubing attached to a funnel, two metal tubes and a can of water.

There is also a Teachers Resource Guide offering a complete, adaptable instructional program. It includes step-by-step guidelines on how the materials can be used most effectively.

"The Idea Banks in the Teacher's Guide provide all the brainstorming for teachers," McBiles said. "Ideas range from low to high in intellectual challenge, and represent each area of the elementary curriculum."

For example, a suggestion for a math problem involves having the pupil check the newspaper for the current price of copper and compute the dollar value of a copper anode, given its weight of 750 lb.

In the art category, pupils are encouraged to use copper wire and other metals in a sculpture or collage.

Phase II and beyond

Even with the kits distributed in virtually every elementary school in the state, the tasks for McBiles and Arizona Mining Association are hardly over. More in-service training sessions will be conducted this fall and McBiles will continue to monitor the program in the schools. In addition, he is formulating the materials for Phase II of the program, designed for use in kindergarten through third grade.

A Program Development Panel of teachers and curriculum experts was retained this summer to provide input on the content and components of the instructional kits. A puppet called "Professor Rocky" that McBiles developed for his younger students is being mass produced for the primary grade kits. Plans are to begin pilot-testing the Phase II materials in February.

McBiles, who also travels extensively to promote the mining industry's involvement in education, will be a keynote speaker in the American Mining Congress Communications Workshop to be held in Reno, Nev. in November. He has visited a number of other state mining associations to discuss plans for implementing similar programs in their states.

Both education and mining officials in Arizona believe the "Mining, Minerals & Me" is highly adaptable for other industries and states. "By helping introduce children to minerals and mining development, we do not expect any immediate benefits to the mining industry," said Hansen. "The 'Mining, Minerals and Me' program is a sincere attempt to assist our schools in presenting concepts and facts that have been largely untaught to date. Yet, in the long term, such efforts can only lead to a better informed citizenry: a win-win status which will accrue to all."

Anyone wishing to obtain further information about the "Mining, Minerals & Me" program should contact Larry McBiles, Arizona Mining Association, Suite 1720, 100 W. Clarendon, Phoenix, AZ 85013 (602) 266-4416.

Copies of the 82-page textbook are available at $10 each. Complete kits containing instructional material, activities, teacher's aids, and audio visuals for a class of 30 are also available on a limited basis for $500.

MINING, MINERALS & ME

A mineral education program
Prepared by the
Arizona Mining Association

WHAT

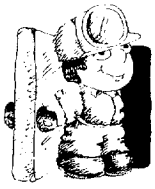
MINING, MINERALS and ME is a multi-media educational program for grades four through six. It is a comprehensive learning system, incorporating a "hands-on" approach with an interdisciplinary, activity-oriented design. This mineral education program is packaged in kits. Each kit includes: 30 Children's Textbooks, 45 Experiment Cards, 30 Class Activities, 10 Take-Home Activities, 25 Fact Sheets, 32 Teaching Picture Cards, three Posters, two Filmstrips with Audio Cassettes and one Teacher's Resource Guide.

A parallel curriculum designed for kindergarten through the third grade is now being developed.

WHO

MINING, MINERALS and ME is sponsored by the Arizona Mining Association, with the assistance and endorsement of the Arizona Department of Education. It was originated and developed by Mr. Larry McBiles, a former Arizona educator. Mr. McBiles, a consultant to the Association, directs the activities of the project in Arizona's elementary schools.

HOW



MINING, MINERALS and ME evolved from a unit of study created by Mr. McBiles in his elementary classroom. The concepts and materials he developed served as the prototype for development of the comprehensive program during 1980-81. His materials and teaching strategies were reviewed by a panel of classroom teachers, district administrators and curriculum coordinators, as well as by Arizona Department of Education staff members. The resulting program was pilot tested in 55 classrooms in 26 school districts throughout Arizona during the fall 1981-82 term.

WHY

Development of MINING, MINERALS and ME was based on the identified need to educate young people about the essential role of minerals in their daily lives. Both advanced and developing nations are entirely dependent upon the successful endeavor to locate, extract and process mineral resources. As the mining industry continues efforts to supply society with these crucial resources, their work must be understood. In this regard, MINING, MINERALS and ME is more than just an educational program. It addresses the fundamental concept of the public's *need to know*, thereby strengthening our ability to anticipate and solve the challenges of tomorrow.

Published in the interest
of Arizona classroom teachers

News

MINING, MINERALS & ME
Arizona Mining Association, 100 West Clarendon, Phoenix, Arizona 85013

FALL 1982

Teachers Rate Program High

The Arizona Department of Education, which has had significant input in all phases of the "Mining, Minerals & Me" program, recently conducted a survey of teachers who have been using the materials to solicit their feedback.

Specifically, the survey was designed to ascertain: if the teachers and students enjoyed working with the materials; if the materials were educationally valid; and if the students were in fact learning through this particular process.

According to Dr. Thomas Reno, associate superintendent for education services of the Department of Education, the survey efforts revealed that teachers consider the materials to be of high quality, easy to use, and their design to be colorful and educationally stimulating.

"Teachers enthusiastically supported the program and reported that they have modified or expanded it in many creative ways," Dr. Reno said.

Other outcomes of the survey showed that the comprehensive format of the teacher's guide as well as the variety of teaching media make the kit adaptable to various kinds of classroom environments. In addition, the integration of materials from all aspects of the elementary curriculum makes the use of the kit

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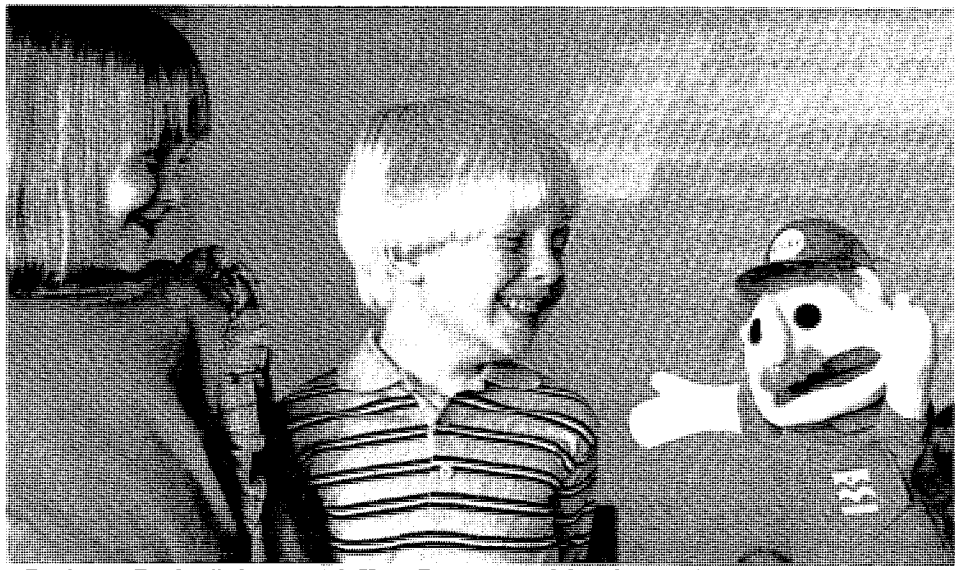


"Professor Rocky," shown with Kate Petersen and Stephen Weber of Kiva Elementary (Scottsdale), will introduce K through 3 students to mining and minerals in the Phase II program.

Filmstrips Enhance Program

Two mineral education filmstrips designed for fourth, fifth and sixth grade students were produced this summer and will complete the list of components in Kit II. The filmstrips, entitled "Let's Visit a Copper Mine" and "Within This Earth", are being mailed this month to elementary schools throughout the state.

Conceived as an integral part of the "Mining, Minerals & Me" program, the filmstrips feature exciting color photography with full narration provided on synchronized audio cassette tapes.

"Let's Visit a Copper Mine" embodies a field trip in pictures, authenticated by action photographs and sound effects acquired on location at one of Arizona's copper mines. The program traces the steps of a class of students as they observe various mineral processing stages — the blasting of copper-bearing rocks; milling the ore with incredible grinding machines; smelting it into a molten liquid and refining it until it is 99.99 percent pure copper. The filmstrip encourages children to use their imagination as it broadens their perspective of the tremendous processes required to transform ore-bearing rocks into useful products.

Questions such as "what are minerals, where do they come from, how are they formed, and why are they important?" serve as the guiding theme for "Within This Earth." This filmstrip contrasts scientific terms and phe-

(continued on page 4)

Teachers, cont'd.

appropriate to teach science, math, and social studies as well as language arts, teachers reported.

"The Department of Education is particularly pleased with the interest shown by the Arizona Mining Association for the education of young people of our state," Dr. Reno said. "Further, their involvement in this learning process makes its own history in that this cooperative venture between business and education is unique . . . and in the sense that the mining industry tremendously impacted the origin, growth and development of the state of Arizona."

IDEA CORNER

Do you have some imaginative ways to teach "Mining, Minerals & Me" in your classroom?

The program is not only designed to encourage children to be creative, but teachers as well. Perhaps you have discovered an activity — a skit, an art project or an outing — that is especially exciting and educational for your students. Through this newsletter and other correspondence, your ideas can be shared with teachers throughout the state.

Simply mail your suggestion(s) to the Arizona Mining Association and watch this space for more information on how "Mining, Minerals & Me" can be creatively adapted to your classroom. **Send to:**

Mr. Larry McBiles
Arizona Mining Association
100 West Clarendon, Suite 1720
Phoenix, Arizona 85013
(602) 266-4416

Top Educators Named to Panel

They came bearing bags of rocks, stacks of books, modeling clay, construction paper and even a guitar. For weeks they met behind closed doors in intensive sessions. To the average onlooker, it would have been difficult to discern that this was a group of uniquely qualified teachers on a very special mission: to help create a prototype for teaching mining and minerals concepts to children in kindergarten through third grade.

Fourteen outstanding Arizona educators were brought together this summer to serve on the developmental panel for Kit I of the "Mining, Minerals & Me" program. Under the direction of program author and coordinator Larry McBiles, the group developed the kit curriculum which will undergo pre-pilot-testing.

Selection of the panel members was made in cooperation with the Department of Education. They represent a broad range of school grade teaching and curriculum specialization. The panel members are:

Mrs. Lani Comp, First Grade, Lowell School, Mesa Unified Schools; **Mr. Art de Fillippo**, K-8, Zimmerman School, Pima County Schools; **Mrs. Sue Funk**, Third Grade, Loma Linda School, Creighton School District; **Mrs. Barbara Grubb**, Art/Music, Echo Mountain School, Paradise Valley School District; **Mr. Andrew Harank, Jr.**, Kindergarten, Kyrene del Norte, Kyrene Elementary Schools; **Mr. Allan Jones**, Fifth Grade, Holdeman School, Tempe Elementary Schools; **Mrs. Shelley S. Kauffman**, Teaching Assistant in Child Development, Arizona State University; **Mr. Mark Kauppila**, First Grade, Acacia School, Washington Elementary Schools; **Mrs. Mindy Morris**, First Grade, Alma School, Mesa Unified Schools; **Dr. Shelly Rodin**, Puppet Designer and former Teacher; **Mrs. Judy Rye**, Third Grade, Four Peaks School, Apache Junction Unified Schools; **Mrs. Alice Wells**, Curriculum Consultant, Cartwright School District; **Dr. Barbara Young**, Gifted, Waggoner School, Kyrene Elementary Schools.

Program Underway for Younger Students

Phase II of the "Mining, Minerals & Me" program, which is designed for children in kindergarten through third grades, is progressing on schedule and will have its first exposure in the classroom this spring.

According to program coordinator Larry McBiles, a qualified prototype has been created and will undergo two developmental phases to refine and validate it prior to being mass produced. Beginning in January, McBiles will conduct a series of guest teaching sessions to test the program's concepts and ideas with children in classroom settings. Once the findings from this study are incorporated into the prototype, a formal pilot-test will be launched next fall.

The Department of Education will be instrumental in selecting a representative sample of classrooms throughout Arizona. Teachers participating in the pilot test will be asked to use the materials for a period of weeks and evaluate them based on children's receptivity to the program and their ability to comprehend the concepts.

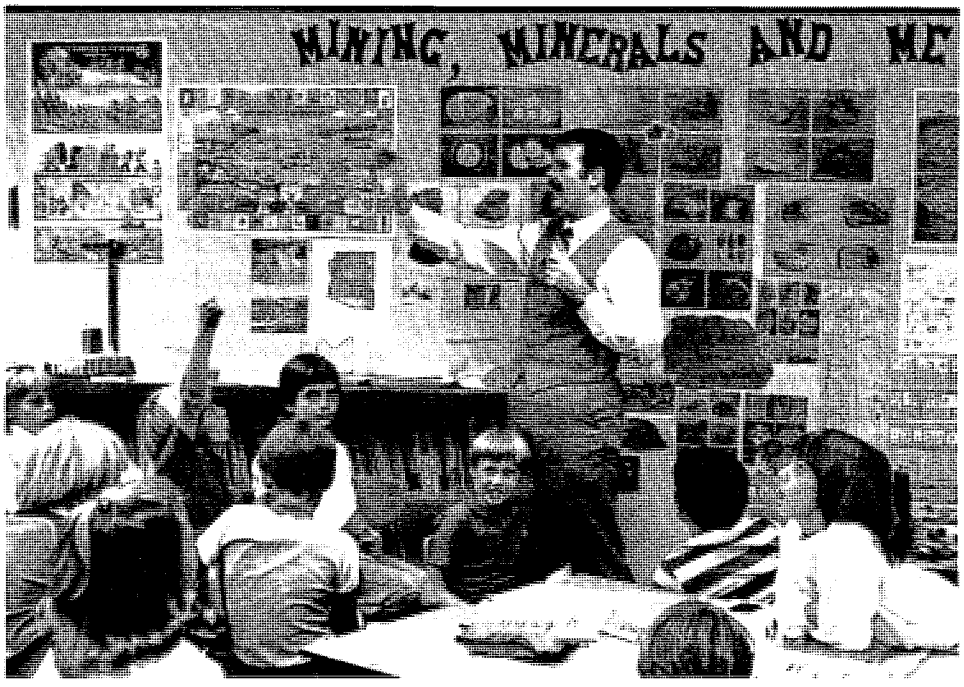
Formulation of the program's curriculum was accomplished with the input of a developmental panel of Arizona teachers.
Building on a framework conceived by McBiles, the group provided creative and technical direction for the components that will comprise the individual kits.

Each kit will contain a variety of teaching materials designed to provide a hands-on, activity approach to learning about mining and minerals. Components include a Teacher's Guide; seven teaching modules; an ABC Card Set, Activity Card Set and Discovery Card Set; a filmstrip, a puppet and a rock bag. Also included is a script for the puppet and colorful posters.

McBiles said Kit I represents the student's first exposure to the formal study of earth science. "The activities in Kit I will enable children to develop skills which will be valuable to all school learning. Experiences in making observations, experimentation, recording information, making comparisons and seeing relationships are designed to introduce students to the processes of science that they will draw upon everyday of their lives. The important skills of writing, speaking, listening and reading are also emphasized," he said.

The seven teaching modules are built around "key questions" that are central to the study of minerals and mining. Each module includes: lesson cards which contain vocabulary, suggested class experiences and media/materials needed for class projects; idea banks with exciting curriculum titles, including Art Escapades, Math Movers, Science Sensations and others; and Resources, such as bulletin board ideas, suggested field trips, potential guest speakers, songs and take-home activities. The modules are titled: 1) My Home, The Earth; 2) Rocks All Around Me; 3) Mineral Resources and Me; 4) A Long, Long Time Ago; 5) From the Mine to My Home; 6) Mining and My Environment; and 7) In the Days Ahead.

McBiles said Phase II will be completed and distributed throughout Arizona during the Spring term of 1984.



Larry McBiles, program coordinator, is guest teaching this spring to test the concepts and strategies of Kit I in the classroom.

Arizona Program May Be National Model

As envisioned by Arizona educators and industry officials, the "Mining, Minerals & Me" program is extending beyond state boundaries. Elementary students in Nevada, Wyoming, Colorado and Alaska will join the ranks of young Americans learning about the vital role of minerals and mining in their daily lives as a result of widespread interest generated by the program.

According to C.J. Hansen, president of the Arizona Mining Association, the amount of information available to assist teachers in explaining basic mineral concepts has been extremely limited until now.

"What makes this program universally valid is that it is geared to young students and provides their first exposure to the relationship between science and economics," Hansen explained. "In the past, this subject has been reserved for secondary students who have already formed many of their views on the world as a system."

The Nevada Mining Association is providing "Mining, Minerals & Me" kits to 12 of its State's elementary schools this fall as an interim action toward creating a full-fledged program of its own. Included with the introductory program will be a "Nevada supplement" comprised of materials specially designed around Nevada's mining history and industry. Significant interest in the program has also been expressed by educators and mining industry officials in Wyoming, Alaska and Colorado.

"We feel the initiative being taken in these and other states attests to the significance of what we're doing for the educational system here in Arizona," Hansen said. "We sincerely hope such efforts will truly bridge the educational gap that has existed in the past, and will accrue benefits for all."

Filmstrips, cont'd.

nomenon such as the formation of igneous, sedimentary and metamorphic rocks with aspects of children's everyday lives that are linked to minerals. The program begins with a view of the earth billions of years ago and highlights the historic progression of mineral development throughout civilization.

Excellent photographs of mineral samples are identified in association with their geographic locations in the U.S. The filmstrip also focuses on the restoration of depleted mining land and the need for conservation of all nonrenewable natural resources.

Workshops Stress Feedback

Conducting a series of in-service training sessions for 1600 teachers throughout Arizona is no easy task. Yet it fully represents the Arizona Mining Association's commitment to maintaining a true partnership with the state's elementary schools via the "Mining, Minerals & Me" program.

Last spring, roughly 700 program kits were 'hand delivered' to schools participating in one of the in-service training sessions held in their area, and an estimated 200 will be distributed this fall. The purpose of conducting these sessions is to assure teachers' understanding of the program and its most effective use in the classroom.

Teachers have an opportunity to review the instructional materials and discuss application of the program based on their individual classroom needs, explains program coordinator Larry McBiles. "The main point I stress with teachers is that the program can be used in a number of ways to supplement their existing curriculum and it also allows them flexibility to use their own creativity."

Besides providing teachers with a comprehensive introduction to the program, the in-service training sessions serve as a valuable feedback mechanism for the state Mining Association.

"We are sincerely interested in knowing what teachers think of the program and how we can assure that it continues to meet their needs," McBiles said. "The in-service training session provides one means for exchanging ideas, and there will be others. The Mining Association has planned for an on-going program of review and assessment to maintain the program's accuracy and compatibility with the contemporary elementary curriculum."

Additional in-service training sessions will be offered this fall in conjunction with a series of workshops conducted by the Department of Education.