

### Cu(-Mo) Ore Deposits, Prospects and Showings in ARMENIA

#### Cu-Mo porphyry type deposits

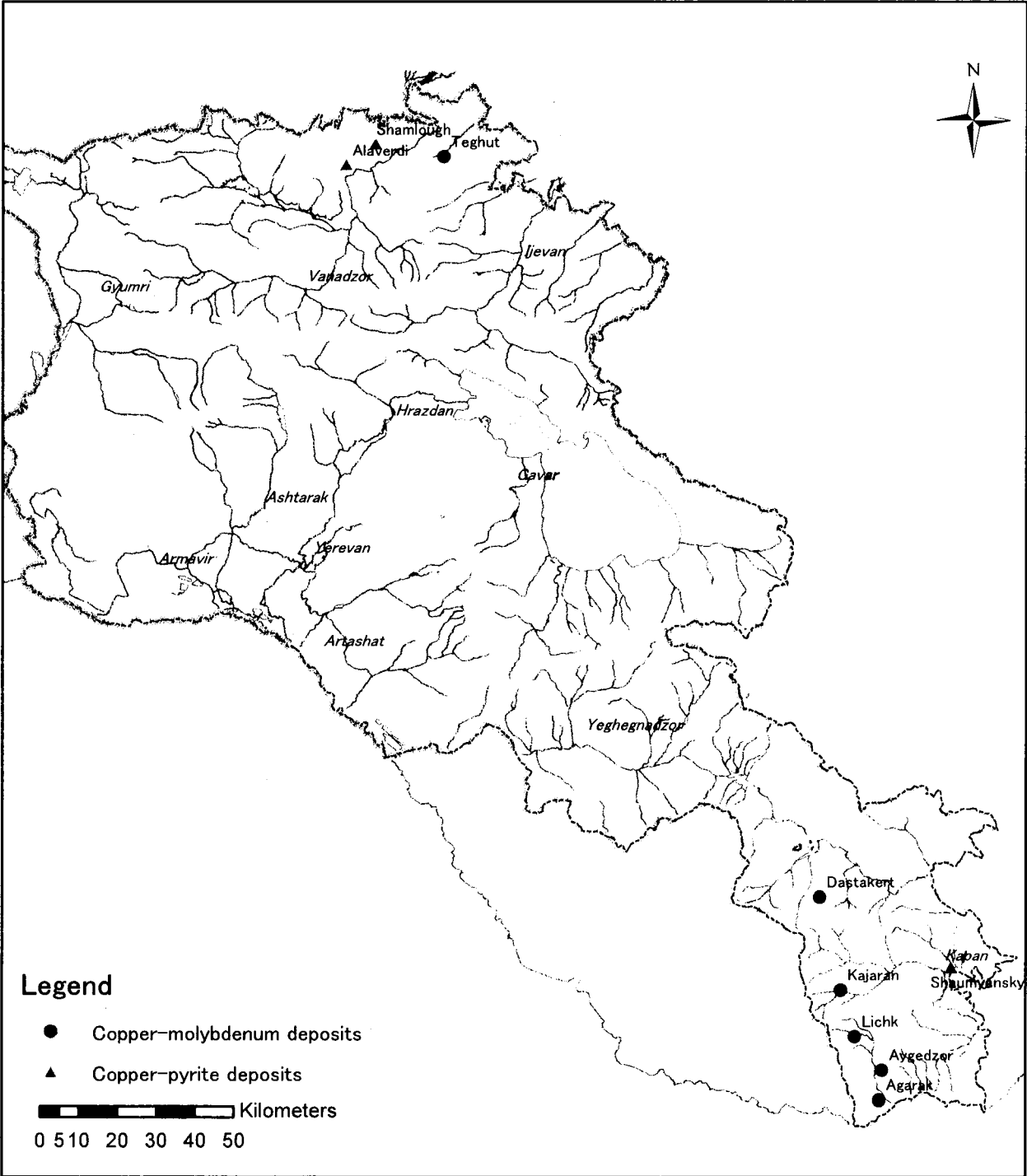
	name	ore reserve (million t)	metal content		grade	category
1	Agarak	45	Cu	203.0 thn t	0.46 %	B+C1
			Mo	12.1 thn t	0.027 %	
			Au	1.1 t	0.025 g/t	
			Ag	52.5 t	1.19 g/t	
2	Aygedzor	236	Cu	385.4 thn t	0.16 %	C1+C2
			Mo	76.9 thn t	0.03 %	
			Au	11.8 t	0.05 g/t	
			Ag	261.0 t	0.11 g/t	
3	Dastakerd	9.6	Cu	91.2 thn t	0.95 %	
			Mo	4.1 thn t	0.043 %	
			Au	t	g/t	
4	Kajaran	1619	Cu	4355.1 thn t	0.27 %	B+C1+C2
			Mo	673.2 thn t	0.055 %	
			Au	49.3 t	0.03 g/t	
5	Lichk	34	Cu	214.2 thn t	0.63 %	B+C1
			Mo	0.5 thn t	0.033 %	B+C1
			Au	1.7 t	0.05 g/t	
6	Tekhut(Teghout)	460	Cu	1630.0 thn t	0.35 %	B+C1+C2
			Mo	99.1 thn t	0.022 %	
			Au	4.7 t	0.01 g/t	

total    Cu    6,871.1 thn t  
              Mo    866 thn t  
              Au    68.6 t  
              Ag    313.5 t

#### Cu-pyrite type deposits

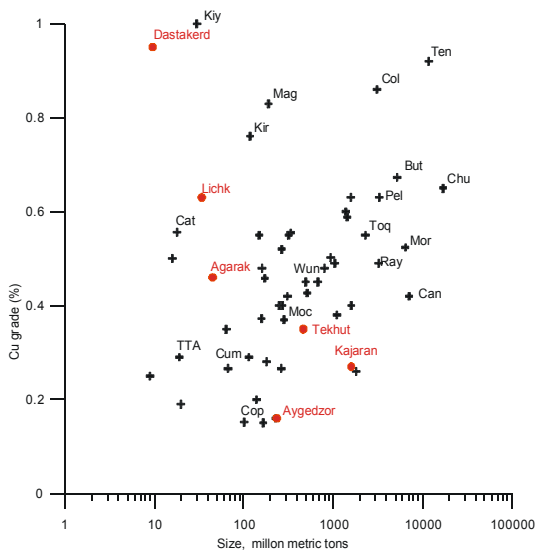
	name	ore reserve (million t)	metal content		grade	category
7	Alaverdi	5	Cu	171.7 thn t	3.4 %	B+C1+C2 C2
			Au	0.66 t	0.12 g/t	
8	Kapan	21	Cu	209.2 thn t	0.99 %	B+C1+C2 C1 C1
			Au	0.6 t	0.2 g/t	
			Ag	39.4 t	5.3 g/t	
9	Shamloukh	4	Cu	154.4 thn t	3.53 %	A+B+C1+C2
			Pb	4.9 thn t	1.70 %	
			Zn	14.2 thn t	4.96 %	
			Au	1.8 t	1.03 g/t	
			Ag	29.8 t	8.1 g/t	

total    Cu    535.3 thn t  
              Au    3.06 t  
              Ag    69.2 t

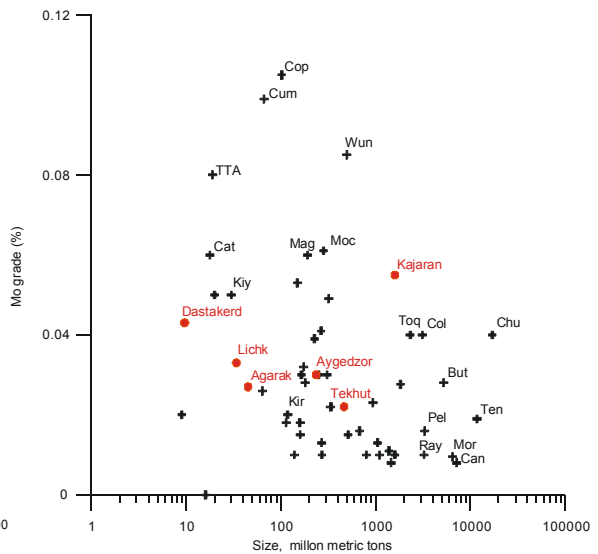


Location Map of Copper-Molybdenum and Copper-Pyrite Deposits in Armenia

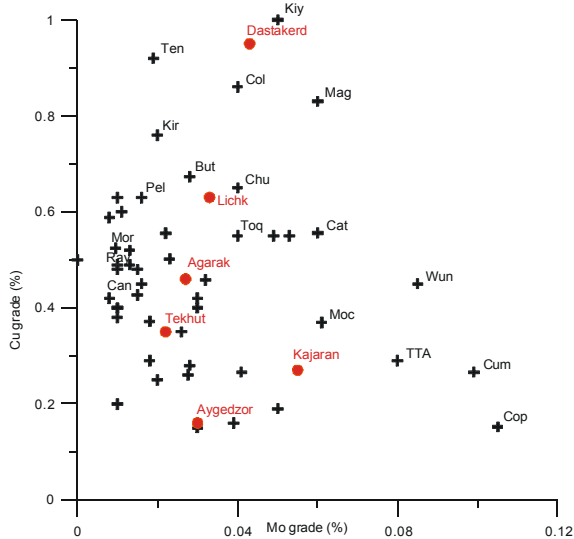
## Appendix 2-25



Cu grade - tonnage diagram



Mo grade - tonnage diagram



Cu-Mo GRADE OF PORPHYRY Cu-Mo DEPOSITS

● : Deposits in Armenia  
 + : Deposits in the World

### Ore Reserve and Grade of Principal Copper-Molybdenum Porphyry Deposits

Butt=Continental/Butte,USA : Can=Cananea,Mexico : Cat=Catheart Mt.,USA : Chu= Chuquicamata,Chile : Col=Collahuasi,Chile : Cop=Coppin Gap,Australia : Cum=Cumobabi, Mexico : Kir=Kirwin,USA : Kiy=Kiyalykh-uzen,Russia : Mag=Magistral,Peru : Moc=Mococa, Colombia : Mor=Morenci- Metcalf,USA : Pel=Los Pelambres Chile : Ray=Ray, USA : Ten= El Teniente,Chile : Toq=Toguepala,Peru : TTA=Taca Taca Alto,Argentina : Wun= Wunugetushan,China

## Appendix 2-26

### Au(-Ag) Ore Deposits, Prospects and Showings in Armenia

#### Au-Quartz Vein Type Deposits

	name	ore reserve (million t)	metal content		grade	category
1	Bartsravan	0.5	Au	2 t	3-4 g/t	P2
2	Getik	5.0	Au	10-15 t	2-3 g/t	P2
3	Kakavasars	2.0	Au Ag	8 t 200 t	4 g/t 100 g/t	P1
4	Karaberd	1.0	Au	2.5 t	2.5 g/t	C2
5	Lousajour	1.0	Au Ag	7 t 10 t	7 g/t 10 g/t	C2
6	Mgart		Au Ag	2.0 t 2.0 t	? ?	?
7	Meghradzor	1.2	Au Ag	21.3 t 25.2 t	15.9 g/t 18.4 g/t	A+B+C1
8	Tandzut(Tandzout)	5.0	Au	10 t	2-2.5 g/t	P1
9	Tuhmanuk	1.5	Au Ag	10 t 20 t	6 g/t 15 g/t	C2
10	Voskedzor	1.5	Au	6 t	4 g/t	P1
11	Zod (Sotk)	25	Au Ag Au	122.3 t 177.4 t 214.3 t	8.0 g/t 8.5 g/t 1.2 g/t	C1+C2  potential )

total Au 201.1 t  
Ag 434.6 t

#### Polymetal Type Deposits

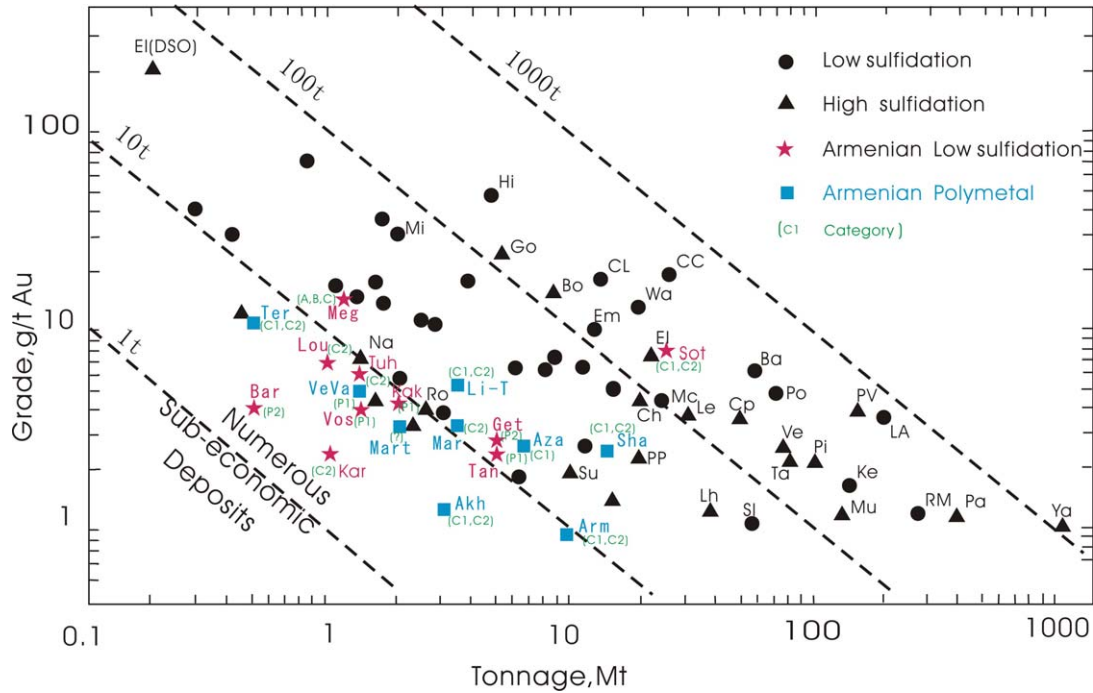
	name	ore reserve (million t)	metal content		grade	category
12	Akhtala	1.2	Au Ag Cu Pb Zn	1.5 t 119.4 t 7.1 thn t 20.5 thn t 55.0 thn t	1.3 g/t 104 g/t 0.58 % 1.67 % 4.48 %	C1+C2  A+B+C1+C2
13	Armanis	10	Au Ag Cu Pb Zn	12.3 t 161.2 t 158.6 thn t 178.8 thn t 388.0 thn t	0.97 g/t 11.3 g/t 1.09 % 1.21 % 2.65 %	C1+C2
14	Azatek	6.5	Au Ag Cu Pb Zn	17.5 t 393.6 t 13.2 thn t 37.2 thn t 18.8 thn t	2.67 g/t 55.4 g/t 0.19 % 1.00 % 0.28 %	C1
15	Lichkvaz-Tey	3.5	Au Ag Cu	17.9 t 115.5 t 14.6 thn t	5.61 g/t 34.30 g/t 0.45 %	C1+C2
16	Marjian	3.5	Au Ag Cu Pb Zn	12.2 t 436.4 t 7.2 thn t 57.5 thn t 46.3 thn t	3.39 g/t 71.3 g/t 0.2 % 1.60 % 1.28 %	C2
17	Martsiget	2.0	Au Ag	7 t 18 t	3.48 g/t 9.08 g/t	
18	Shahumian	15	Au Ag Cu Pb Zn	39.8 t 776.5 t 91.3 thn t 24.2 thn t 384.6 thn t	2.5 g/t 49.8 g/t 0.61 % 0.15 % 0.45 %	C1+C2
19	Terterasar	0.5	Au Ag Cu	2.1 t 16.9 t 1.0 thn t	11 g/t 74.8 g/t 0.45 %	C1+C2
20	Verin Vardanadzor	1.5	Au	7 t	5 g/t	P1

total Au 117.28 t  
Ag 2,037.5 t  
Cu 293.0 thn t



Location Map of Gold and Gold-Gold-Polymetallic Deposits in Armenia

## Appendix 2-28



### Ore Grade and Reserve Diagram of Hydrothermal Gold Deposits (modified from GOLD IN 2000, p263)

Ba=Baguio,Philippines : Bo=Boliden,Sweden : CC=Cripple Creek,Colorado : Ch=Chinkuashih,Taiwan : CL=Comstock Lode,Nevada : Cp=Chelopech,Bulgaria : EI=El Indio,Chile : EI(DSO)=El Indio direct shipping ore : Em=Emperor,Fiji : Go=Goldfield,Nevada : Hi=Hishikari,Japan : Ke=Kelian,Indonesia : La=Ladolam,Papua New Guinea : Lh=Lahóca,Hungary : Le=Lepanto,Philippines : Mc=McLaughlin,California : Mi=Midas,Nevada : Mu=Mulatos,Mexico : Na=Nansatsu district deposits,including Kasuga,Japan : Pa=Pascua,Chile : Pi=Pierina,Peru : Po=Porgera,Papua New Guinea : PP=Paradise Peak,Nevada : PV=Pueblo Viejo(oxide+sulfide),Dominican Republic :Ro=Rodalquilar,Spain : RM=Round Mountain,Nevada : SI=Sleeper,Nevada(average ore) : Su=Summitville,Colorado : Ta=Tambo,Chile : Ve=Veladero,Argentina : Wa=Waihi,Martha Hill,New Zealand : Ya=Yanacocha,Peru

Akh=Akhtala : Arm=Armanis : Aza=Azatek : Bar=Bartsravan : Get=Getik : Kak=Kakavasar : Kar=Karaberd : Li-T=Lichkvas-Tey : Lou=Lousajour : Mar=Marjian : Mart=Martsiget : Meg=Meghradzor : Sha=Shahumian : Sot=Sotk : Tan=Tandzut : Ter=Terterasrar : Tuh=Tuhmanuk : VeVa=Verin Vardanzor : Vos=Voskedzor

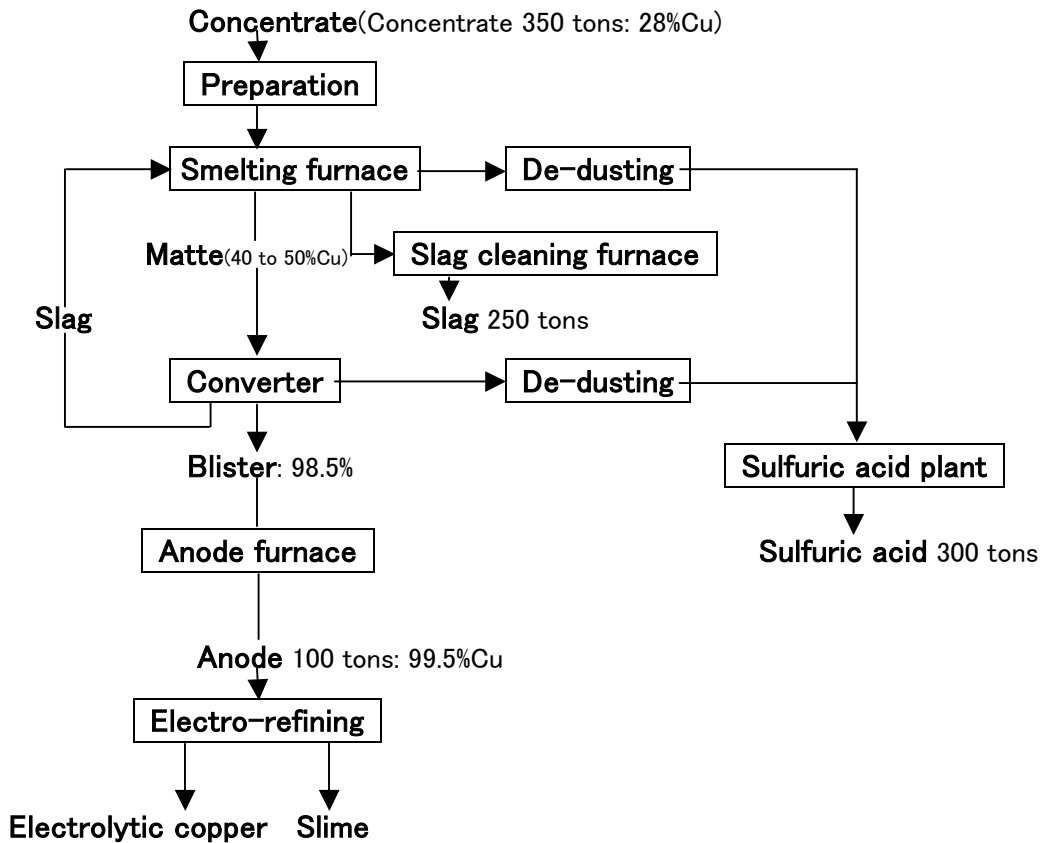
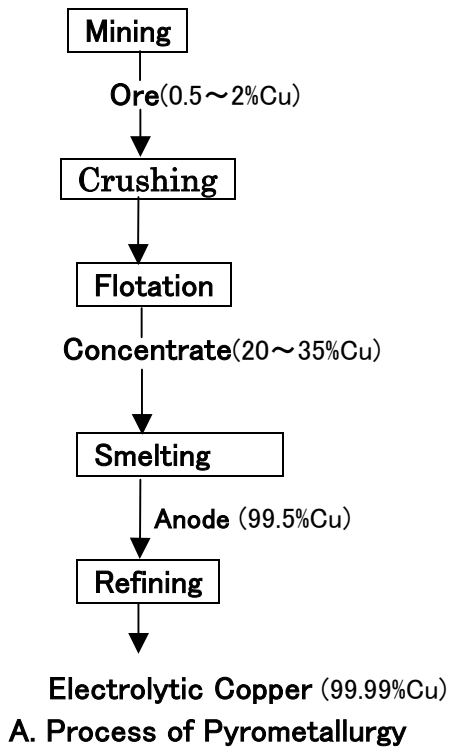
# Appendix 2-29

## Summary of Main Mines in Armenia

Item	Kajaran Mine	Agarak Mine	Kapan Mine	Araverdi Mine
Production Capacity	SC-ISC with a open pit mine and plant. Production capacity is 18,000 tpa copper and 4,000 tpa molybdenum concentrate. It is the largest mine in reserve and production capacity in Armenia. It has 2400 workers.	SC-ISC with a open pit mine and plant. Production capacity is 12,000 tpa copper and 750 tpa molybdenum concentrate. After Kajaran Mine supported Agarak Mine in purchases and sales in 2000, it has renewed its production level. But stockpile low grade ore began to be treated to make up for crude ore production. It has 789 workers.	SC-ISC with two underground mines, open pit mine and processing plant. Production capacity is 3,700 tpa copper and 6,000 tpa zinc in concentrate. It has 759 workers.	A private company with a U/G mine, plant and smelter. Production capacity is 120,000 tpa conc. and 20,000 tpa in blister. It restarted smelting operation in 1998 and has reproduced crude ore from underground since last year and just started a processing plant this year. It has 720 workers. Besides, it has 152 workers in Yerevan Head Office.
Location	It is located in some 340 km from Yerevan and 22 km from Kapan. At this point the valley is narrow and steep sided, some 2000 m ASL. Population is 8,000.	It is located at the southern most corner of the country on the borders of Iran and Azerbaijan. Its elevation is about 1,120 m. Population of the city is some 4,000.	It is located near the border of Azerbaijan, in some 320 km from the Capital, Yerevan. The city is a capital of Sournik Province. Population of the city is 45,000.	It is located at the northern most corner of the country some 165 km from Yerevan and 50 km from the border of Georgia. Its elevation is about 800 m. Population of the city is some 15,000.
History	The deposit was discovered in 1925. Exploration was commenced in 1929, and first developed, explored, exploited and treated high grade veins ore by underground method in 1949. Afterwards it was changed to open pit and has been expanded gradually in production scale to 9.2 Mtpa.	The deposit was discovered in the 1880's. High-grade veins were initially mined in the underground. The recovery of molybdenum was studied in the 1930's and limited production was begun in a small open pit. The plant was built in 1963 and operated without stop. But the mine production dropped seriously by influence of the conflict with Azerbaijan and the collapse of FSU. Whereas it's been recovering by Kajaran's support since 2000 and it recovered up to almost 2 Mta.	The deposit was discovered in the 19th Century, and it has been operating continuously since 1946. In early primitive mining, high grade parts only were exploited. Shafumian polymetallic deposit was discovered in the 1930's and developed from 1935 to 1943. New explorations of Shafumian were carried out in 1980's and its re-open was determined in 1997. It is preparing to increase its production.	The deposit was discovered in the 1770's. Modern mining method was introduced in the end of 19th Century. Mining operation was continued by FSU. But the mine was closed in 1944 by a flood which filled the underground with water and killed 4 persons. The smelter continued operation but stopped it 1989 by an environmental problem. After privatization, it restarted smelting operation in 1998. The underground was reordered and a mineral processing plant was newly constructed in 2002, and total mining operation just has begun this year.
Ore Reserve	Cu 4.37Mt (metal) 0.25% (crude ore grade) Mo 6.78Mt (metal) 0.038% (crude ore grade) Au 49.440kg, Ag 2,756,800kg	Cu 206,000t (M) 0.46% (COG) Mo 17,000t (M) 0.021% (COG) Au 1,140kg, Ag 53,300kg	Central: Cu 0.21Mt (M) 0.99% (COG) Shahumian: Cu 911t (M) 0.53% (COG) Zn 985Tht (M) 2.83% (COG) Au 40t Ag 777t	Cu 130,000t (M) 3.17% (COG)
Mining	Method	Open Pit	Open Pit, Underground (Shrinkage & Sublevel)	Underground (Shrinkage)
	Open Pit	Drilling Explosives Loading Dump Truck Bench height Stripping Dilution Slope Angle Mining Level Pit Bottom Ore Transport Waste Dump	φ250 mm, length 15 m R1-R2-R3-R4, Emulsion, ANFO Electric Shovels with 5m <sup>3</sup> & 8m <sup>3</sup> Bolaz modo 40t, 110t 15m Ore: Waste = 1t:1.4m <sup>3</sup> (3.5t) unknown (No internal waste) 23° ~35° (partially 0°) 1030mL~985mL 985mL (the 1st stage), 895mL (the 2nd stage) by dump truck, underground haulage under study 4 dumps and 1 low-grade ore stock	φ150 mm, length 12 m Mainly ANFO Diesel Shovel with 1.2m <sup>3</sup> Bolaz modo 25t 10m unknown unknown unknown 970mL~930mL 930mL Ore Pass from the bottom to Underground unknown
Mineral Processing	Ore Mineral	chalcopryite, molybdenite	chalcopryite, molybdenite with minor amounts of chalcocite and bornite	polymetallic: chalcopryite, sphalerite and bornite including Au & Ag copper: chalcopryite, pyrite, bornite, covellite and tennantite
	Mineral Processing	Mo-Cu is depressed by bulk flotation, and then Mo is separated from Cu Gyratory Crusher (1st), Cone Crusher (2nd), Cone Crusher (3rd) Grinding 3 FAG's, 14 Dall Mills 75μ60% Flotation Process Bulk Flotation & Differential Flotation MoO <sub>3</sub> is produced by roasting a part of Mo conc. in a rotary kiln Concentrate Dewatering Cu: Thickener → Vacuum Drum Filter → Moisture 8%, Mo: thickener → Vacuum Belt Filter → Moisture 4to 6% by Rotary Dryer Tailings Dam No 1 to No 4 Dams are full. Tailings are sent 35 km naturally to No.5 Dam whose life is 30 years. 2 steel pipes with φ 720mm are hung across the 2 valleys.	Mo-Cu is depressed by bulk flotation, and then Mo is separated from Cu Jaw rucher (1st), Cone Crusher (2nd), Cone Crusher (3rd) 1st. Dall Mill, 2nd Dall Mill, 00μ02% Bulk Flotation & Differential Flotation Cu-Mo is depressed by bulk flotation and then Cu is floated and Mo is depressed Cu: Cyclon → Thickener → Vacuum Drum Filter → Moisture 8 to 10 %, Mo: Thickener → Vacuum Filter → Rotary Dryer No 1 to 3 Dams have remaining space with total capacity of 6.5 Mm <sup>3</sup> . Besides, there is a space for No.4 Tailings Dam.	polymetallic: Cu is first separated from Zn Copper: Cu is depressed by diff. flotation polymetallic & copper: Jaw rucher (1st.), Cone Crusher (2nd.) 3 Rod Mills, 5 Dall Mills polymetallic: Cu-Zn is separated by roughing and Cu is cleaned. Zn is roughed and cleaned. copper: Cu is depressed polymetallic: Cu&Zn: thickener → Vacuum Drum Filter, copper: Thickener → Vacuum Drum Filter → Moisture 10 to 12% The old dam is located 3 km from the plant and full. So tailings are sent to Kajaran No.5 Dam which raised its height. Pumps' capacity at its limits.
Machines at Sites	Machines at the site are generally old, but are used by many repairs. Some machines looks to have passed its depreciations. * A report says some spillage of tailings from steel pipes occurred and some tailings flowed into the river. But the mine denied the fact.	Machines at the site are generally old, but are used by many repairs. Some used flotation cells from Kajaran are re-utilized. The mine has enough capacity for tailings, but some contaminated water from the processing plant is flowing into the Arax River. Moreover oil contamination was occurred reportedly by copper concentrate stockpile due to a closure of the Araverdi Smelter.	Machines at the site are generally old, but are used by many repairs. Some machines looks to have passed its depreciations. A report says actual power of pumps is not enough to send tailings up to the Kajaran Tailings Dam, and so tailings are sent to the river. But the mine explains tailings are sent to the tailings dam.	Machines at the site are generally old. Mining machines are mostly used ones. Repair shop is needed to be equipped. It cannot afford to install an enrichment because it has just begun its total operation. The most impressive scene at the mine is exhaust of sulfuric acid gas from the chimney that is a symbol of the smelter.
Environmental Issues				
Result of Ore Treated	8,067,000 t ( as of 2001)	1,855,000 t ( as of 2001) Cu 0.325%, Mo 0.0212%	264,620 t ( as of 2001)	450 t Cu 2.81% ( as of 2001) 35,000 t (production plan of 2002 ) 80,000 t (production estimate of 2003)
Concentrate Production	11,430t Cu & 666t Mo in conc. MoO <sub>3</sub> 1,117t	3,989t Cu & 426t Mo in concentrate.	984t Cu-metal & 745t Zn-metal in concentrate.	1,054t Cu-metal for 2002 plan. It has no result, because concentrate production just has begun this year.
Metal to be evaluated	Copper conc.: Cu, Au, Ag Molybdenum conc.: Mo MoO <sub>3</sub> : Mo	Copper conc.: Cu Molybdenum conc.: Mo	(polymetallic) Cu conc.: Cu, Au, Ag Zn conc.: Zn, Au, Ag (copper) Copper conc.: Cu	Copper conc.: Cu, Au, Ag
Clients of concentrate	Cu conc.: ①Graanco(Switzerland)50% Araverdi smelter 50% Mo conc.: ①Yerevan Pure Iron 2500t ②Samsung 1000t ③Greensand 1000t ④Comsup800t MoO <sub>3</sub> : ①Comsup almost all ②Molybex 10t (NB) Conc. Salling Contract: FOB	Sales of the concentrate is managed by Kajaran Mine. Clients are just same as Kajaran.	All conc.: Ural International Limited	All concentrate is treated in its own smelter.
P/L	Sales: 27 M\$ (as of 2001) P/L: ▲3 M\$ (as of 2001)	Sales: 3 M\$ (as of 2001) P/L: ▲85 thousands\$ (as of 2001)	(NB) Salling FOB on border of Iran Sales: 1.67 M\$ (as of 2001) P/L: ▲10 thousands\$ (as of 2001)	Any data were not presented.

\*NB. Not only the machines in mining section but also any machine in Armenia are in the general well-used and old like used cars, Russian construction machines, old manufacturing machines in small factories and so on. It describes an economic difficulty of Armenia after collapse of FSU.

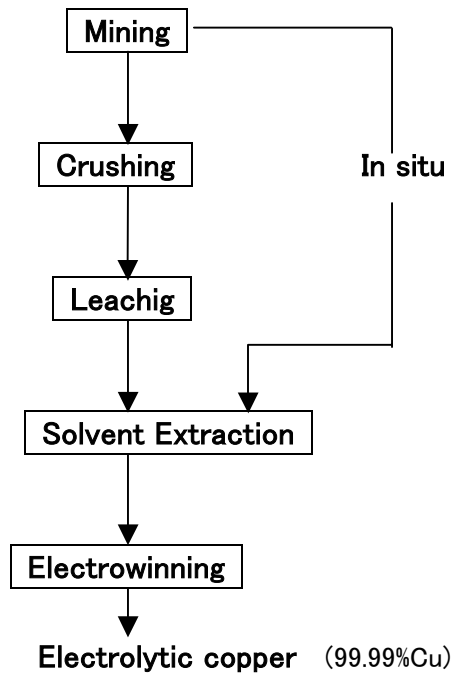
## Appendix 2-30



(The above figure shows copper concentration as well as the quantity when the anode production is 100 tons.)



## Appendix 2-31



Outline of Hydrometallurgy

## Appendix 2-32

### Cost Data of the Alaverdi Smelter

2001 result	Summary	
Blister A+B	7056 ton	
	x 1000 AMD	x 1000 USD
Sales revenue	5,237,573	9,189
Material cost	3,814,866	6,693
Operating cost	758,092	1,330
Factory benefit	664,616	1,166
Over head	1,314,037	2,305
Transportation Cost	641,413	1,125
Benefit	-1,290,834	-2,265

#### SALES REVENUE 2,001

Production to outside	@ x1000 AMD	x1000 AMD	Smelting plant ton	Scrap ton
Slag	2	11,478	6,999	
Blister A	766	3,843,022	5,017	
Blister B	701	1,383,073		1,973
Total		5,237,573		

Average of LME in 2001  
1,560 US\$/t

Blister unit price in US\$.  
1,344 US\$/t  
1,230 US\$/t

#### TRANSPORTATION FEE

Products to outside	QTY	From	To	USD	@
Slag	6,999				
Blister A	5,017	Alaverdi	Germany	576,955	115
Blister B	1,973	Alaverdi	Germany	226,895	115
Total					
Material from outside					
Cu concentrate	11,084	Kajaran 640km	Alaverdi	321,436	29
Total				1,125,286	

Blister A: Product from concentrate

Blister B: Product from scrap

**PRODUCTION COST**

Cu % in conc. Is 28%. Cu% in scrap is 95%.

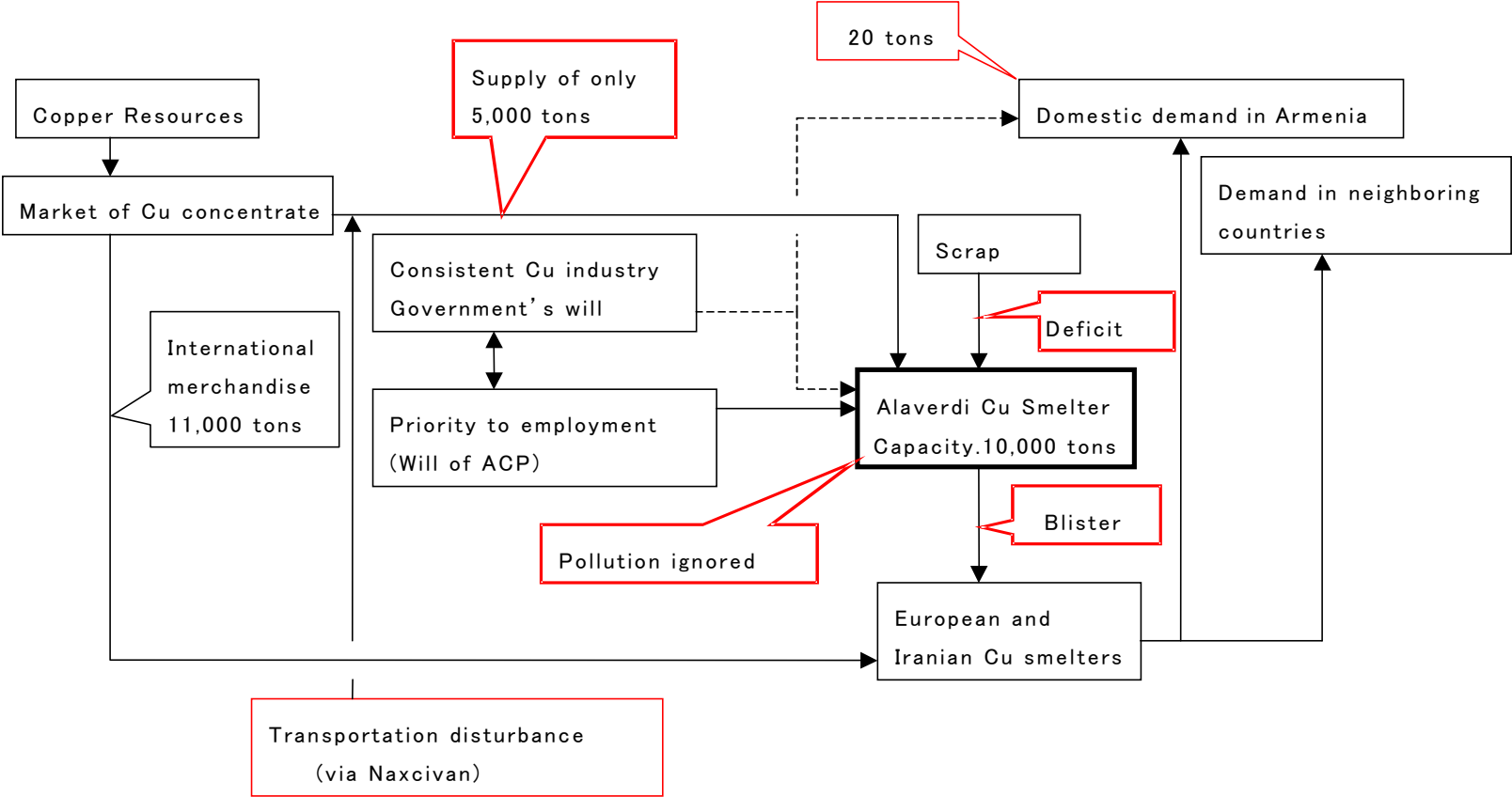
PRODUCTION /Y		*1000 AMD	SMELTING PLANT		SCRAP TREATMENT		Total	
			4,955	TON	2,101	TON	7,056	TON
			@	QTY	@	QTY	@	QTY
<b>MATERIALS</b>								
Cu CONCENTRATE	TON	1,814,736	154	11,784			154	11,784
SiO2 fine	TON							
SiO2 coase	TON							
Scrap	TON	2,000,130	570	1,308	570	2,201	570	3,509
REFRACTORIES	TON							
OTHERS	TON							
<b>UTILITIES</b>								
ELECTRIC POWER	KWH	20,919	17	1,026,130	17	241,712	17	1,267,842
WATER	M3	12,990	21	618,500	21	48	21	618,548
NATURAL GAS	M3	402,593	38	10,163,936	38	478,216	38	10,642,152
<b>MAN POWER</b>								
OPERATORS	MY	137,312	909	126	909	25	909	151
ENGINEER.OFFICER	MY	28,670	1,686	13	1,686	4	1,686	17
<b>FACTORY OVERHEAD</b>								
		197,134						
<b>MAINTENANCE</b>								
		115,000						
<b>OTHERS</b>								
SAMPLING		21,748						
ANALYSIS		18,860						
<b>OVER HEAD</b>								
RENT		125,740						
PERSONAL		619,451					1,122	552
HEAD OFFICE WORKER		371,712					2,398	155
Grand total		5,886,995						

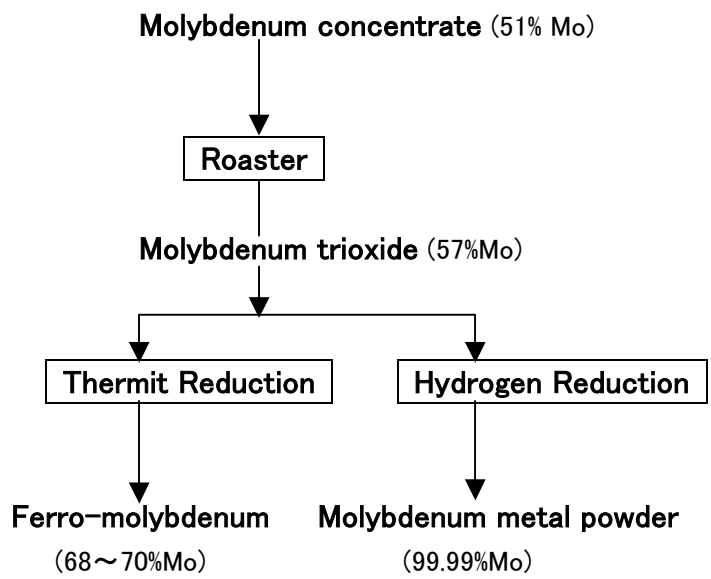
## Appendix 2-33

### Smelters' Capacities in the World

Country	Company	Name	Production (t/y)	Smelting furnace
Chile	Codelco	Chuquicamata	530,000	FSF, CMT, Reverberatory
Chile	Codelco	El Teniente	375,000	Reverberatory
Germany	Norddeutsche	Hamburg	370,000	FSF
Korea	Lucky metal	Onsan	360,000	FSF, MI
Russia	Uralkromed Copper		320,000	
Japan	Nippon Mining	Saganoseki	320,000	FSF
Mexico	Mexicana de Cobre	La Caridad	300,000	FSF, CMT
USA	Kennecott	Garfield	300,000	FSF, FS Converter
Zambia	ZCCM	Nkana	300,000	Reverberatory
Peru	SPCC	Ilo	280,000	Reverberatory, CMT
USA	Magma	San Manuel	275,000	FSF
Australia	Mount Isa mine	Mount Isa	250,000	ISASMELT
Japan	Sumitomo	Toyo	240,000	FSF
Australia	WMC	Olympic dam	215,000	FSF (Direct)
Japan	Hibi kyoudou	Tamano	210,000	FSF
Japan	Mistubishi	Naoshima	210,000	MI
Botswana	BCL	Selebi-Phikwa	26,000	FSF
Africa		Various	21,000	Electric furnace
Canada	Falconbridge	Sudbury	21,000	Reverberatory
Germany	Mansfeld	Mansfeld	20,000	BF
Italy	Nuova Samin	Porto Marghera	20,000	TBRC
Oman	Oman mining	Sohar	20,000	Electric F.
India	HCL	Ghataila	18,000	FSF
Turkey	Ergani	Etibank	16,000	Reverberatory
Bulgaria	Polimet	Elisenia	15,000	BF
Iran	NIRU	Ganiebad	15,000	Reverberatory
Turkey	Karadeniz Bakir	Murgul	15,000	Reverberatory
Albania	Albanian Ministry	Lac	10,000	BF
Poland	Hutmen	Hutmen	10,000	BF
France	Affcuivre	Poissy	8,000	BF
Albania	Albanian Ministry	Kukes	6,000	BF
Albania	Albanian Ministry	Rubic	4,000	BF

# Issues of Copper Smelting Industry in Armenia





Molybdenum Process