3rd International Conference SDIMI

RECOVERY SILVER AND GOLD BY DIRECT OXIDATIVE PRESSURE CYANIDATION

by

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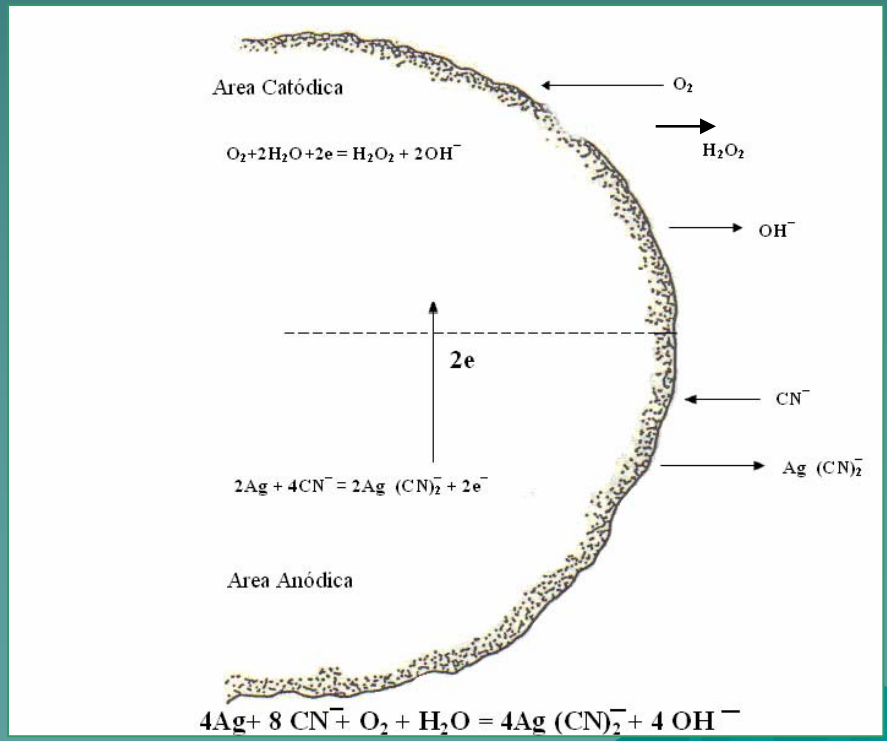
CYANIDE PROCESS
The McArthur-Forrest Process (1887)

Is a metallurgical technique for extracting gold from low grade ore by converting the gold to water soluble aurocyanide metallic complex ions

Leaching Time

42 -72 hrs.



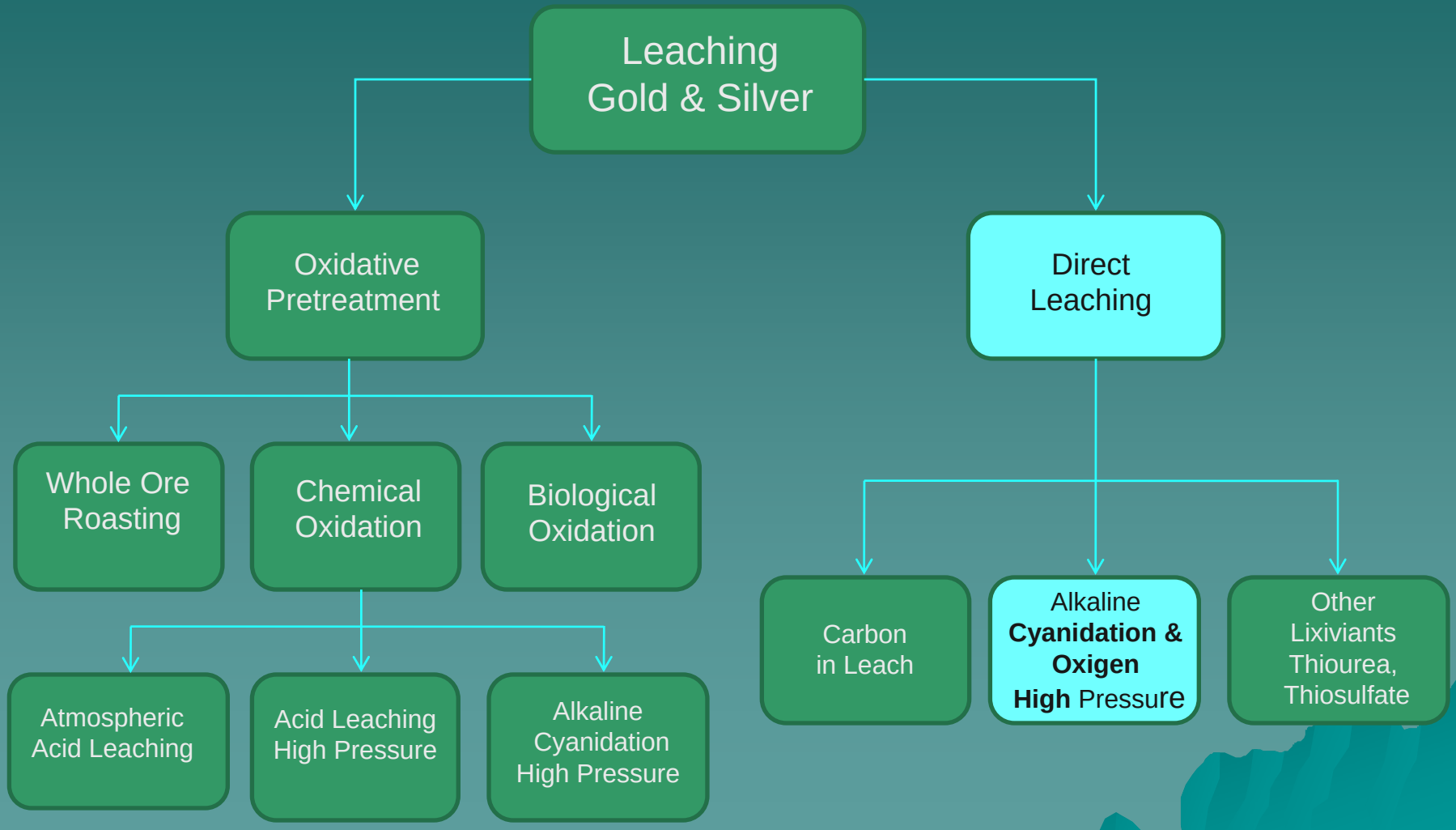
REFRACTING ORE

(Recovery less than 60 %)

IMPROVED TREATMENT PROCESSES:

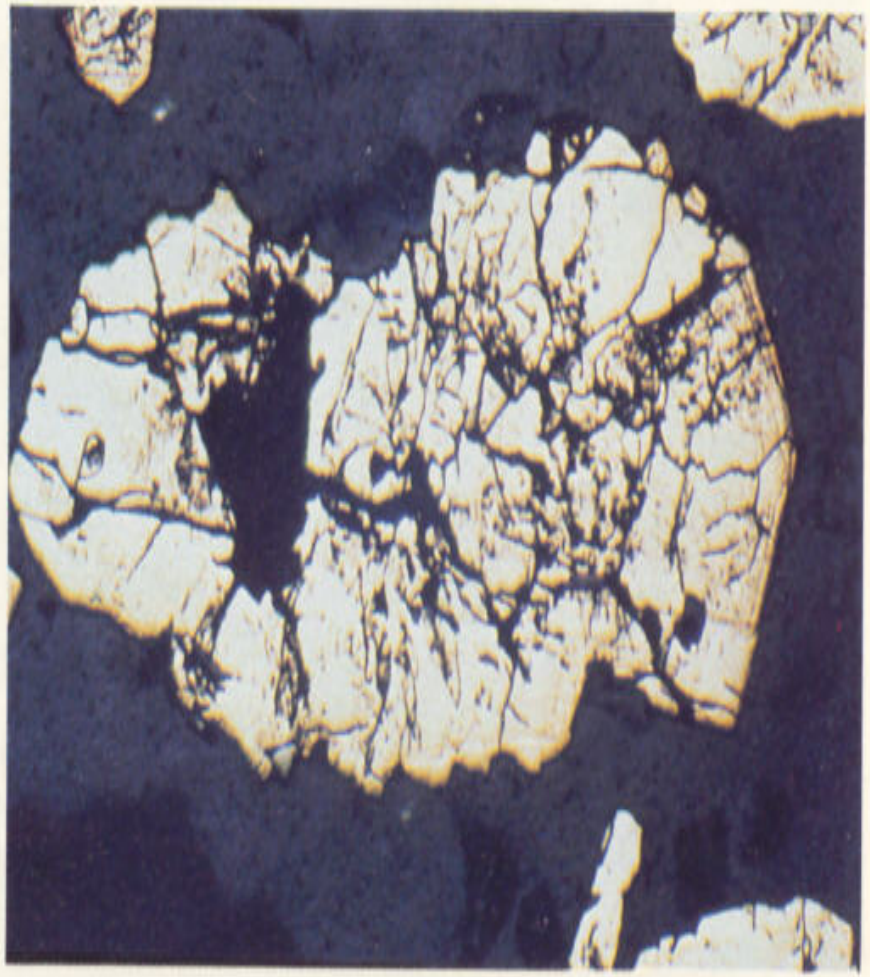
- Fluid Bed Roasting
- Whole Ore Roasting
- Pressure Leaching
- Biological Oxidation

Refractory Gold & Silver Ores



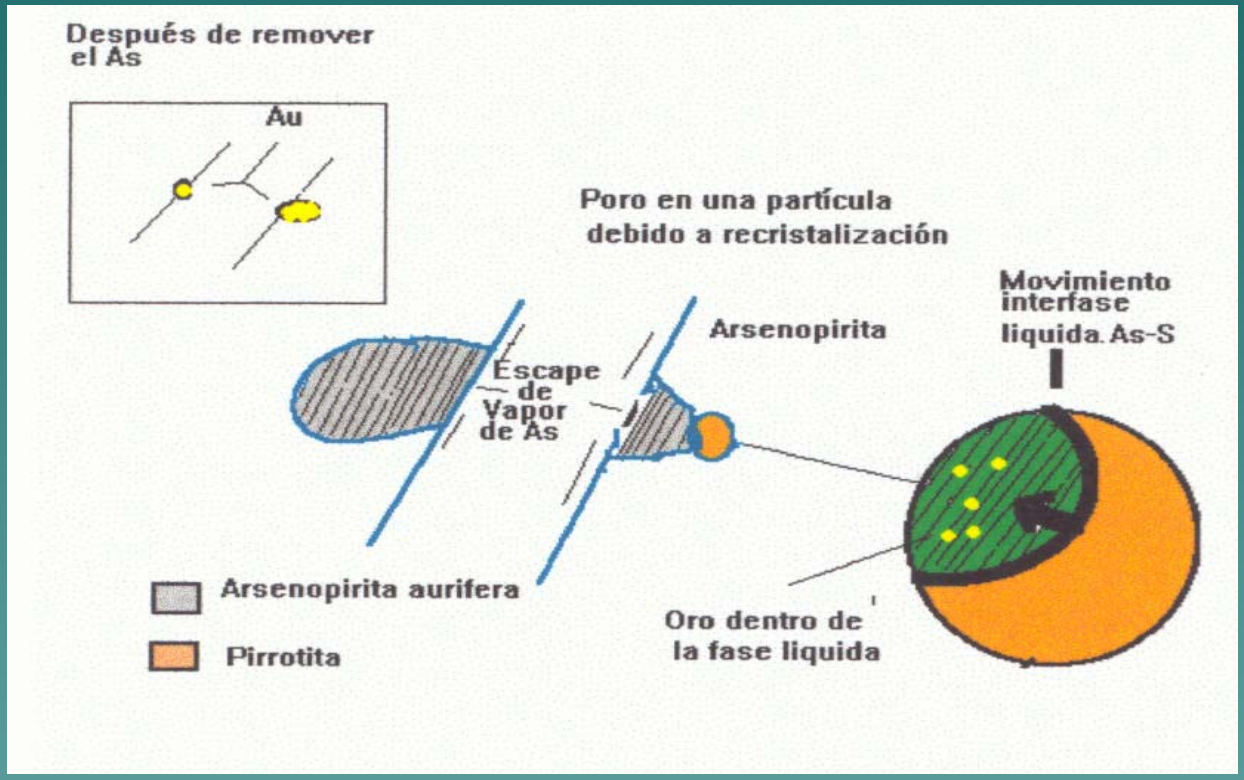
Biological Oxidation

Pyrite particle before biooxidation with bacteria.

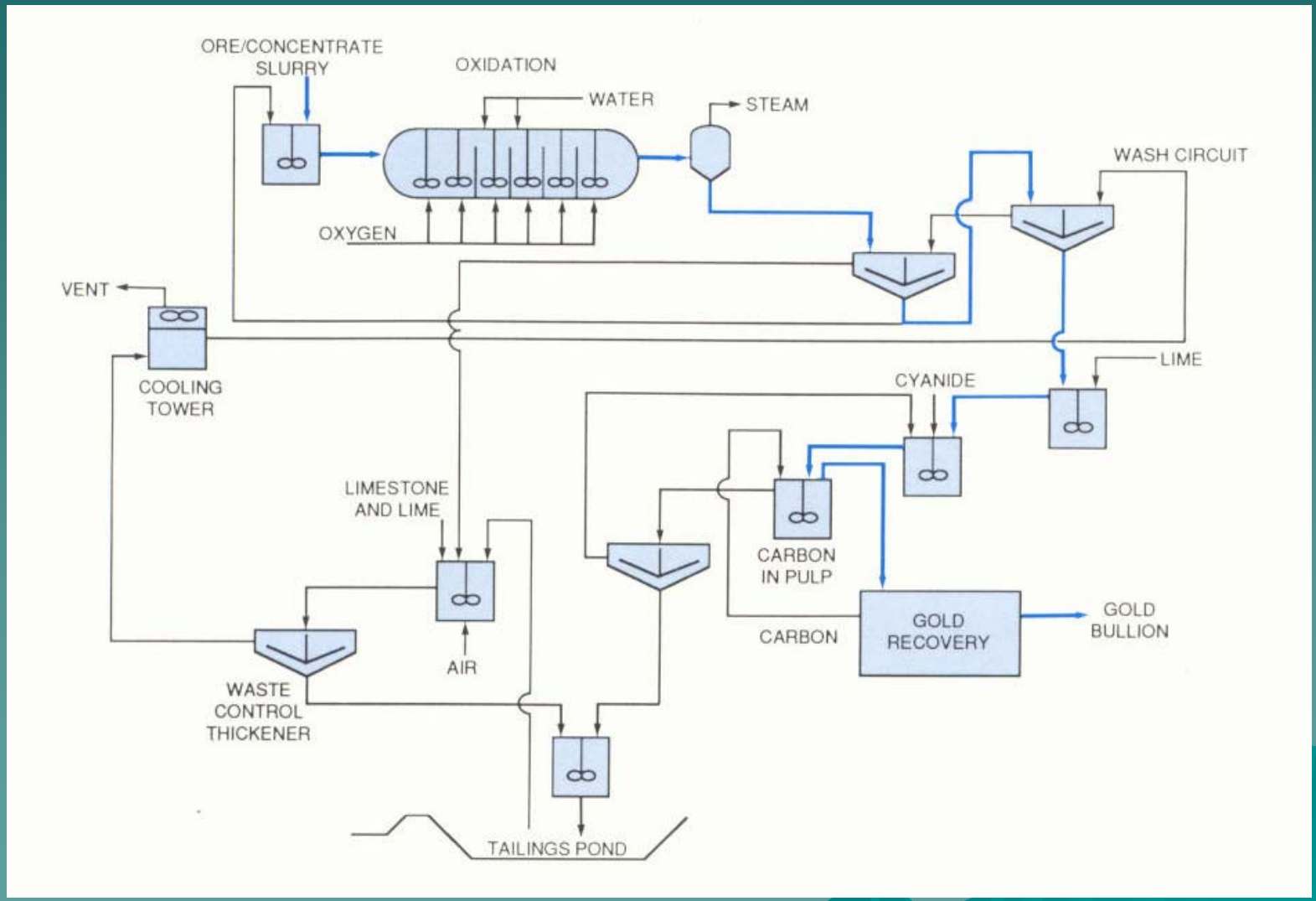


The sample pyrite particle after 30 days of biooxidation with bacteria. The bacteria are causing "corrosion" of the pyrite resulting in exposure of occluded gold.

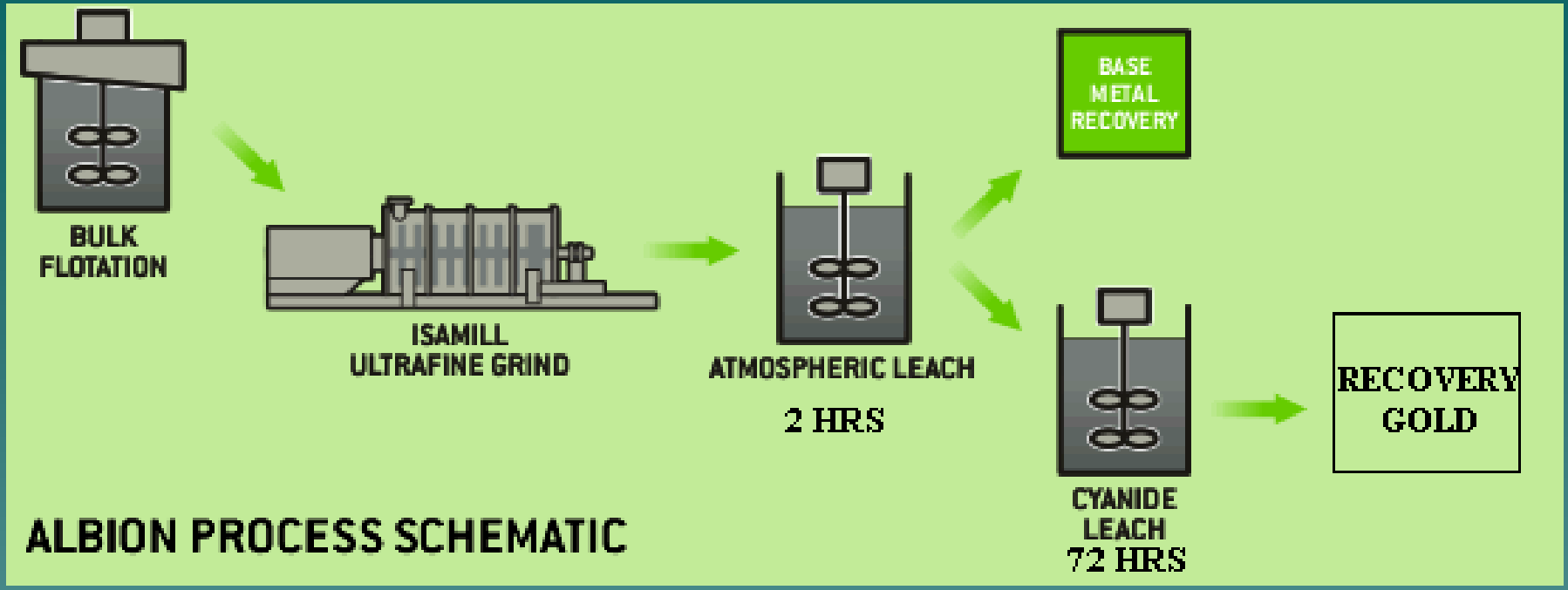
Whole Ore Roasting



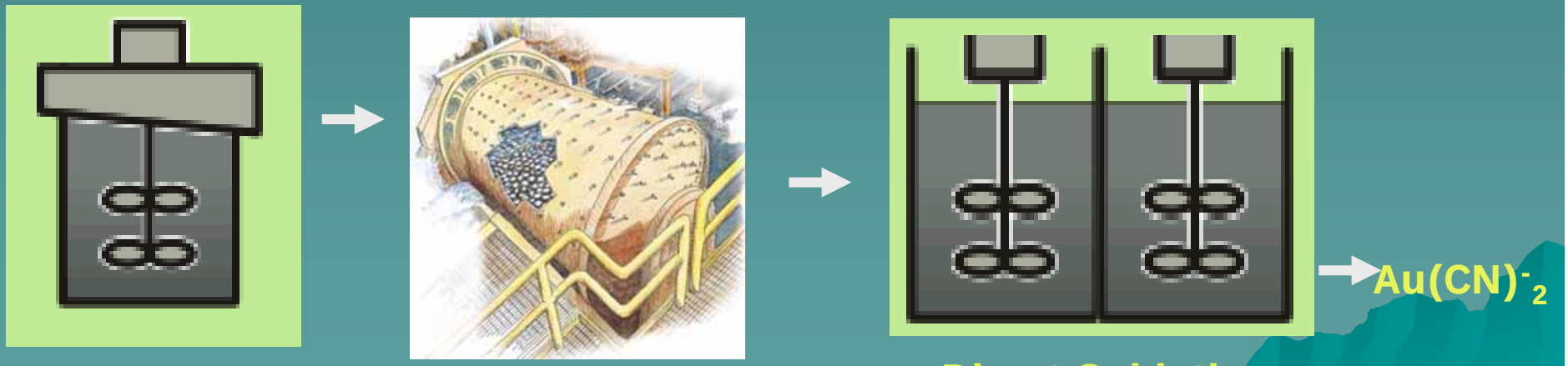
Pressure Oxidation of Refractory Gold Ores



PRESSURE LEACHING PROCESS



NEW TECHNOLOGY



Bulk Flotation

Grinding

Direct Oxidative
Pressure Cyanidation
90 Minutes

CHEMICAL AND MINERALOGICAL ANALYSIS

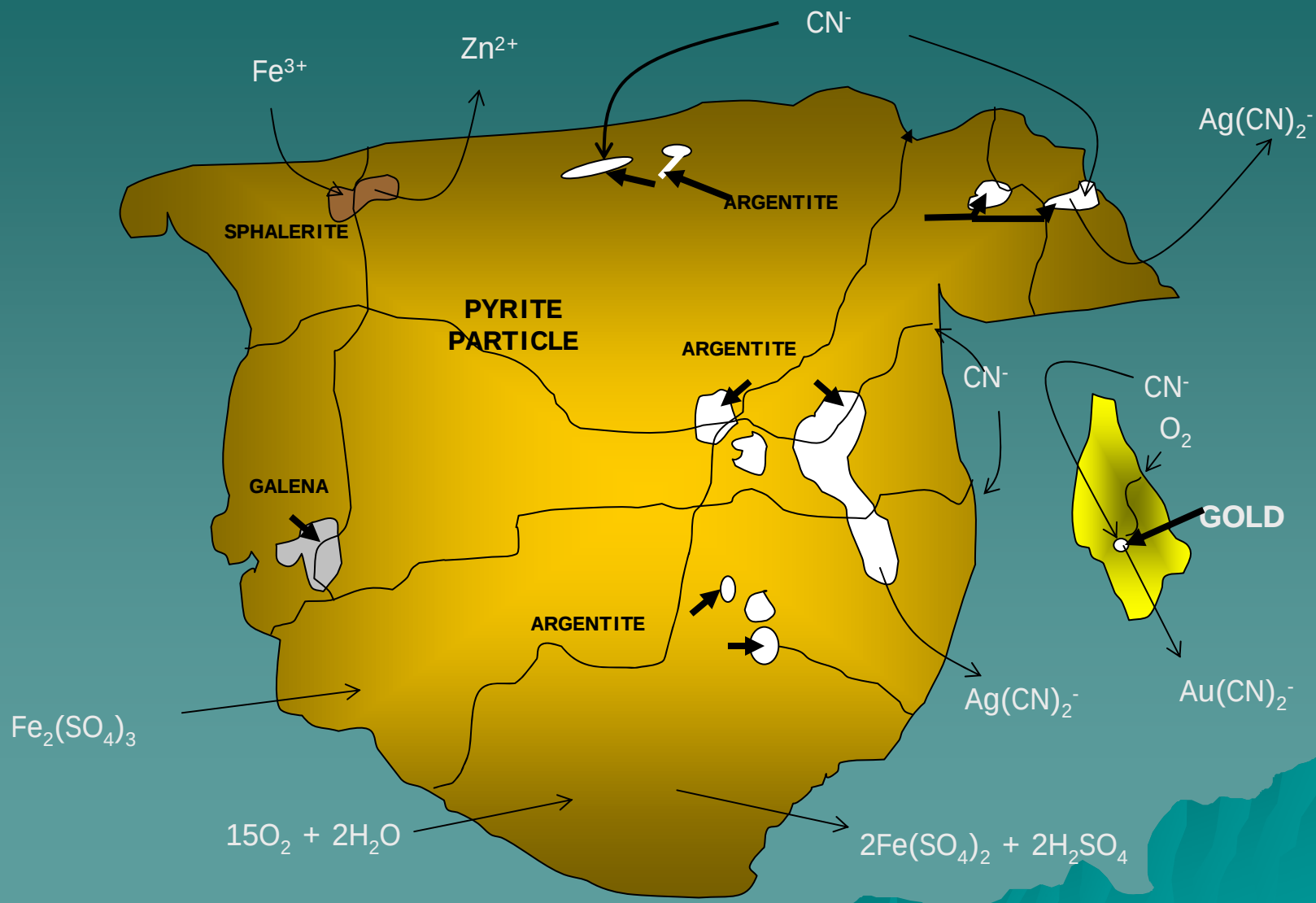
	g/ton		%					
	Au	Ag	Pb	Zn	Cu	Fe	As	S
Concentrate	87.09	12320	2.6	3.8	0.5	29.2	0.15	32
Ore	4.12	289	0.5	0.4	0.04	3.67	0.1	3.7

THE MINERALOGICAL ANALYSIS ARE:

- *Silver Iron Sulfide*
- *Argentite , Pyrite*
- *Pyrrhotite, Arsenopyrite*
- *Chalcopyrite, Covellite*
- *Hematite and Magnetite*
- *Quartz and Calcite*

Schematic mechanism of gold and silver leaching

60 minutes



SIMULTANEOUSLY OXIDATION AND CYANIDATION LEACHING

The primary reactions are:

$$2FeS_2 + 7O_2 + 2H_2O = 2Fe^{2+} + 4SO_4^{2-} + 4H^+ \quad (1)$$

$$FeS_2 + 2H^+ = Fe^{2+} + H_2S + S^0 \quad (2)$$

Ferrous ions produced by reaction (1) and (2) are subsequently oxidized to ferric ions:

$$2Fe^{2+} + 1/2O_2 + 2H^+ = 2Fe^{3+} + H_2O$$

The ferric ions an also contribute to the oxidation of silver iron sulfide, argentite, pyrite, pyrrhotite, sphalerite and chalcopyrite:

$$AgFe_2S_3 + Fe^{3+} = Ag^{+} + 3\,Fe^{2+} + 2S^{2-} + S^{0}$$

$$Ag_2S + 2Fe^{3+} = 2Ag^{+} + 2Fe^{2+} + S^{0}$$

$$ZnS + 2Fe^{3+} = Zn^{2+} + 2Fe^{2+} + S^{0}$$

$$CuFeS_2 + 4Fe^{3+} = Cu^{2+} + 5Fe^{2+} + 2S^{0}$$

Then, elemental sulfur may also be further oxidized to sulfate by oxygen or by ferric sulfate:

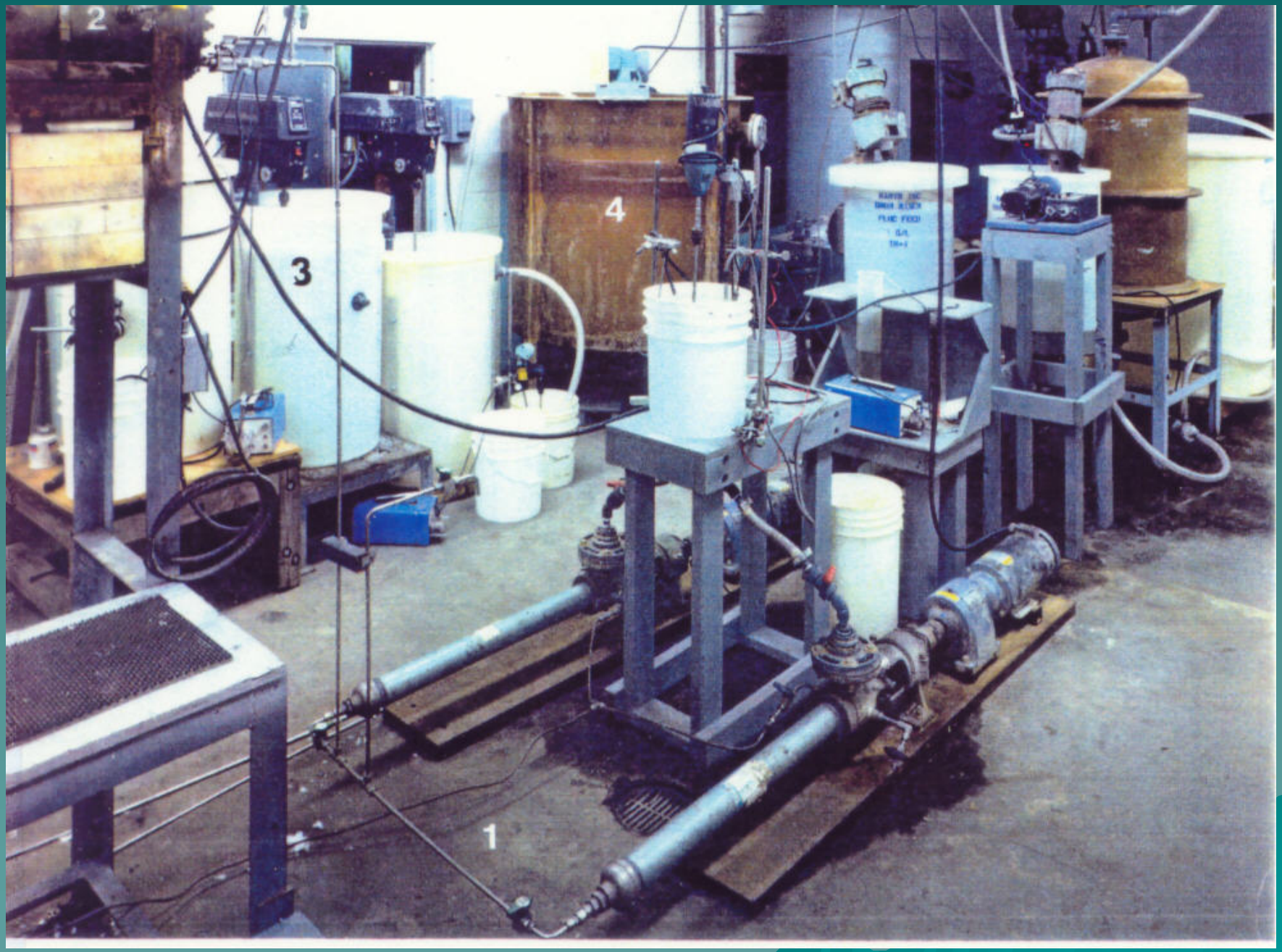
$$2S^0 + 3O_2 + 2 = 4H^+ + 2SO_4^{2-}$$

$$S^0 + 6Fe^{3+} + 4H_2O = 6Fe^{2+} + 8H^+ + SO_4^{2-}$$

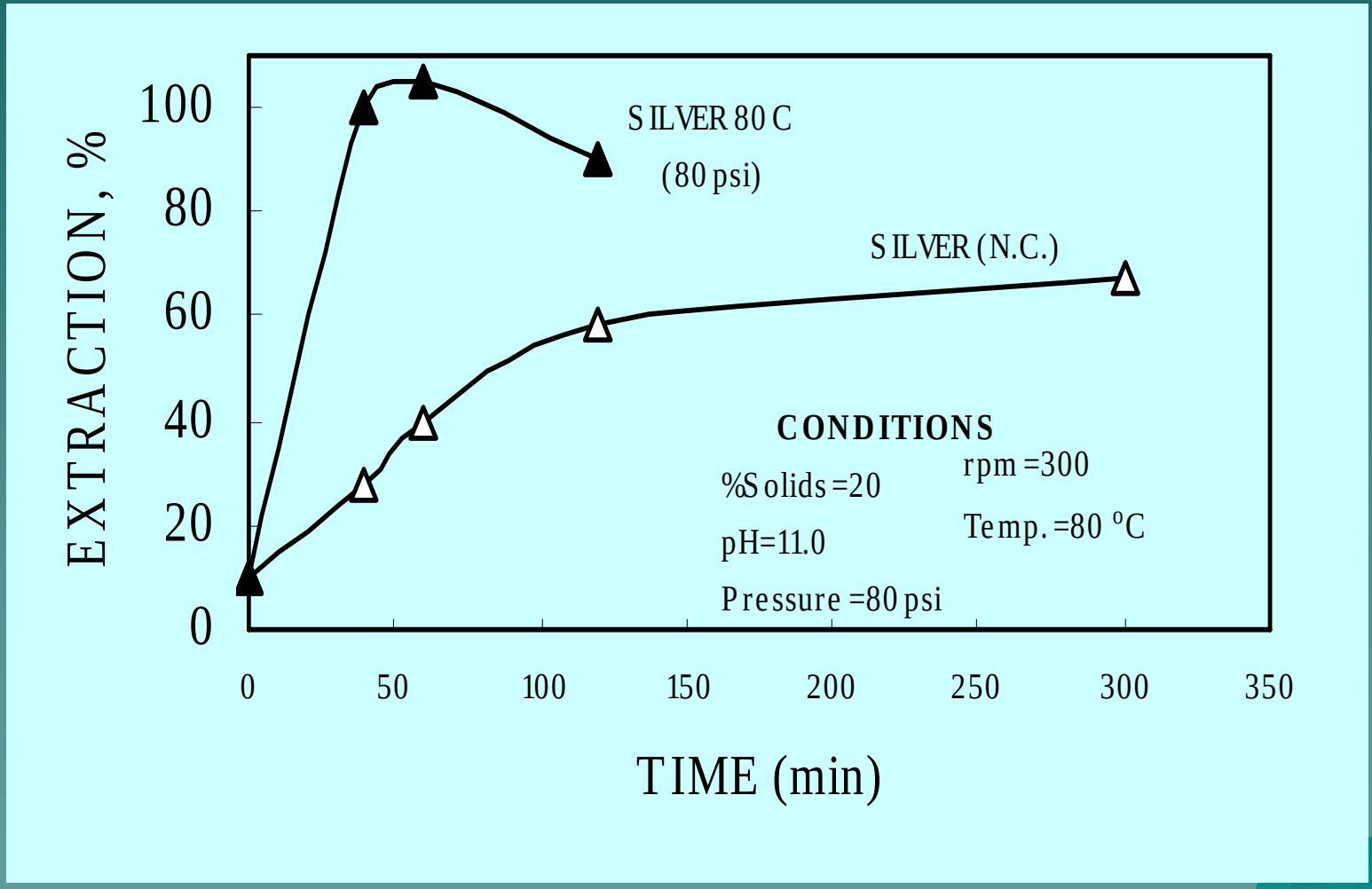
This results in the formation of a porous,but nonprotective, elemental sulfur layer, thus allowing cyanide and dissolved oxygen to access to the previously locked gold, silver and electrum

$$Ag_2S + 4CN^- = 2Ag(CN)^-_2 + S^{2-}$$

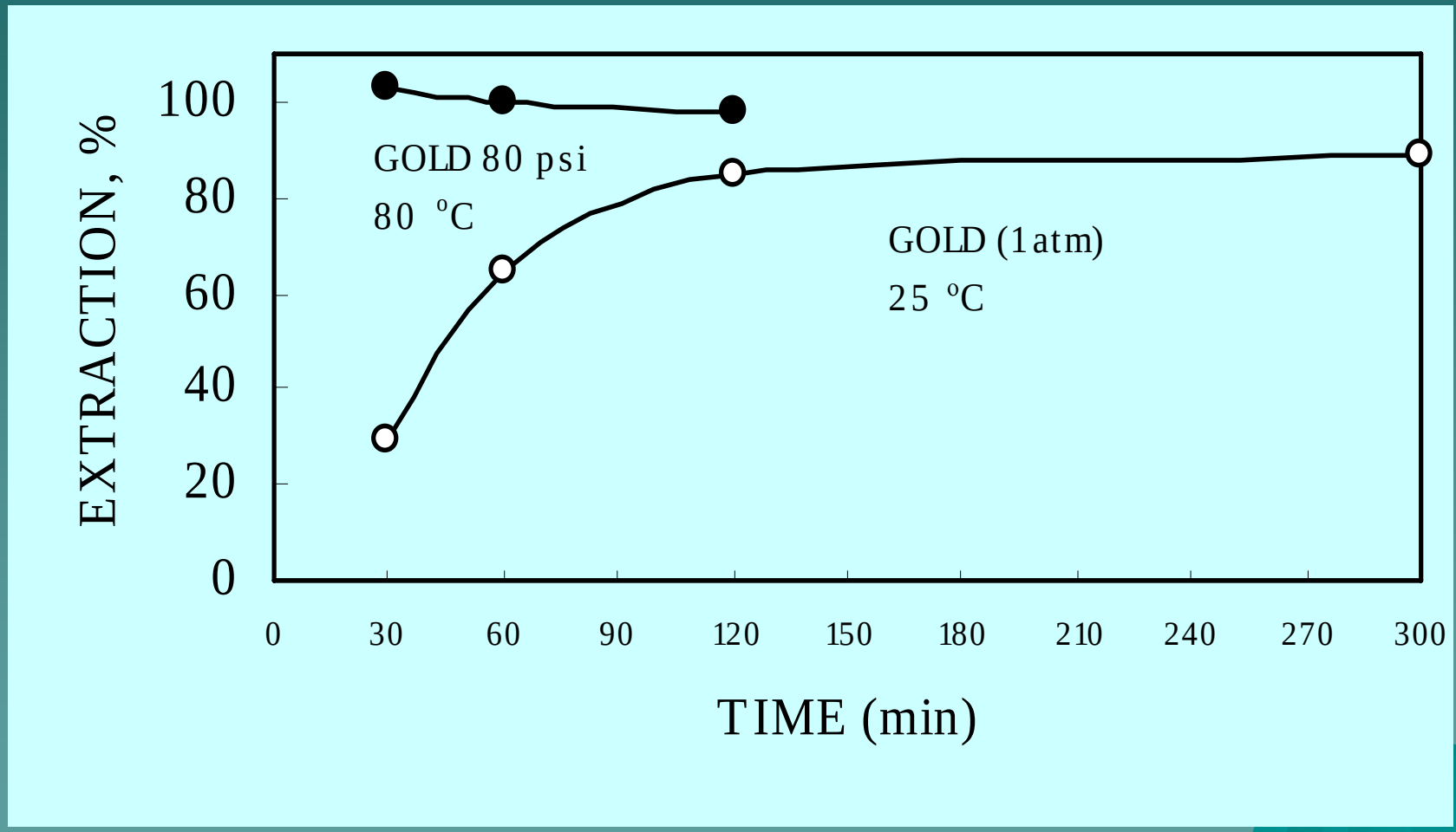
$$4\,Au + 8CN^- + O_2 + H_2O = 4Au(CN)^-_2 + 4OH^-$$


2
3
4
1

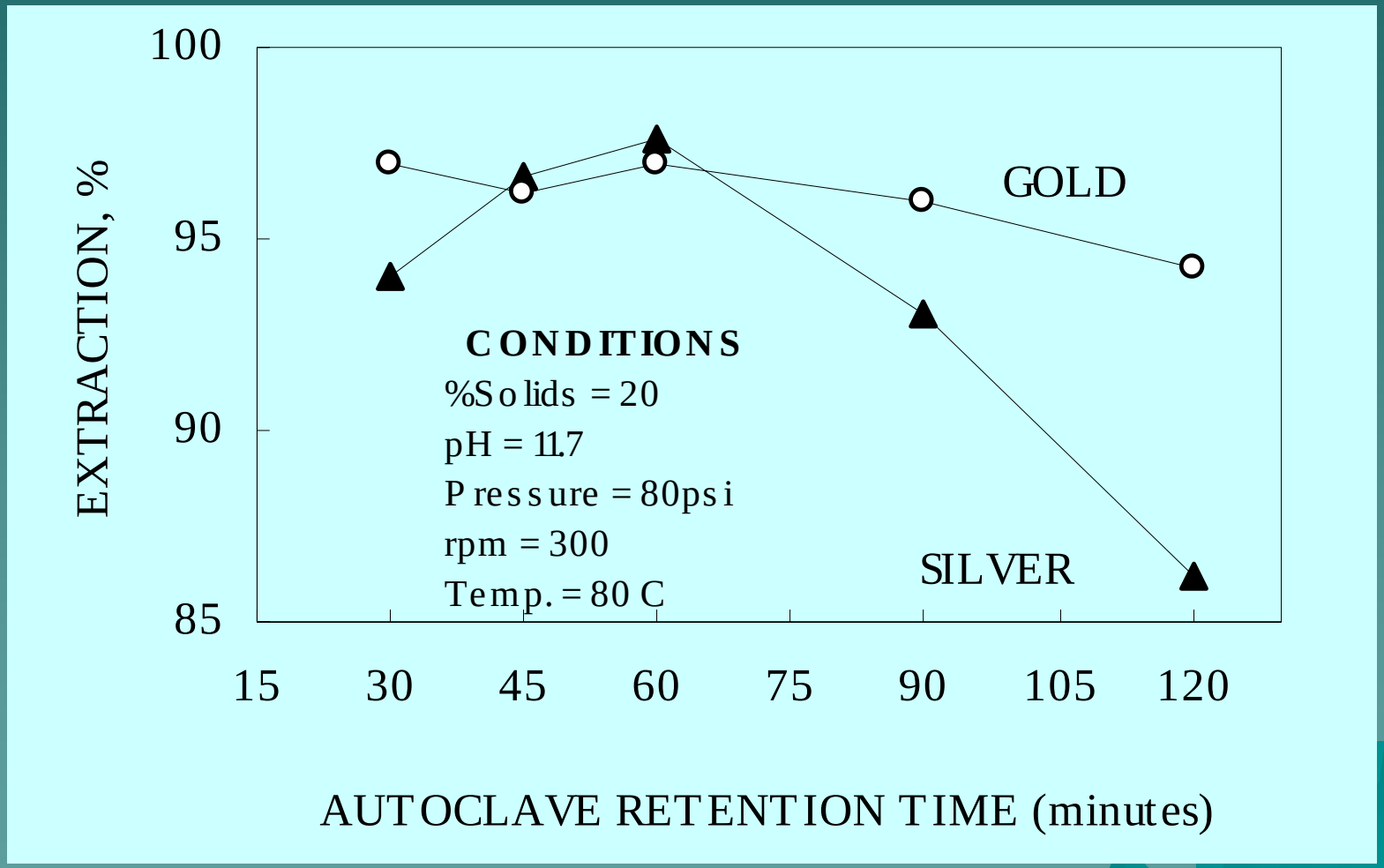
Comparison of silver extraction at ambient conditions and high pressure



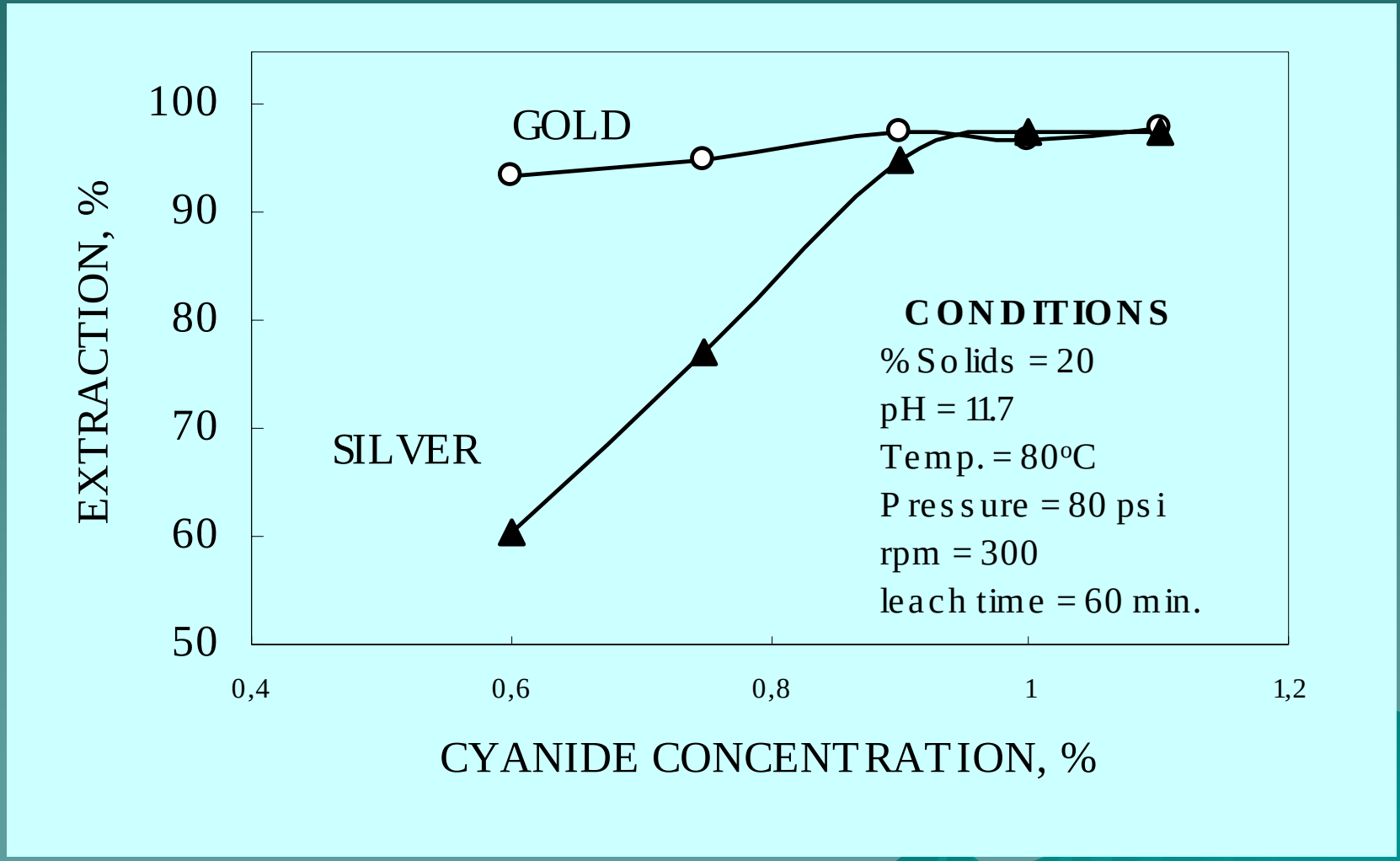
Comparison of gold extraction at ambient conditions and high pressure



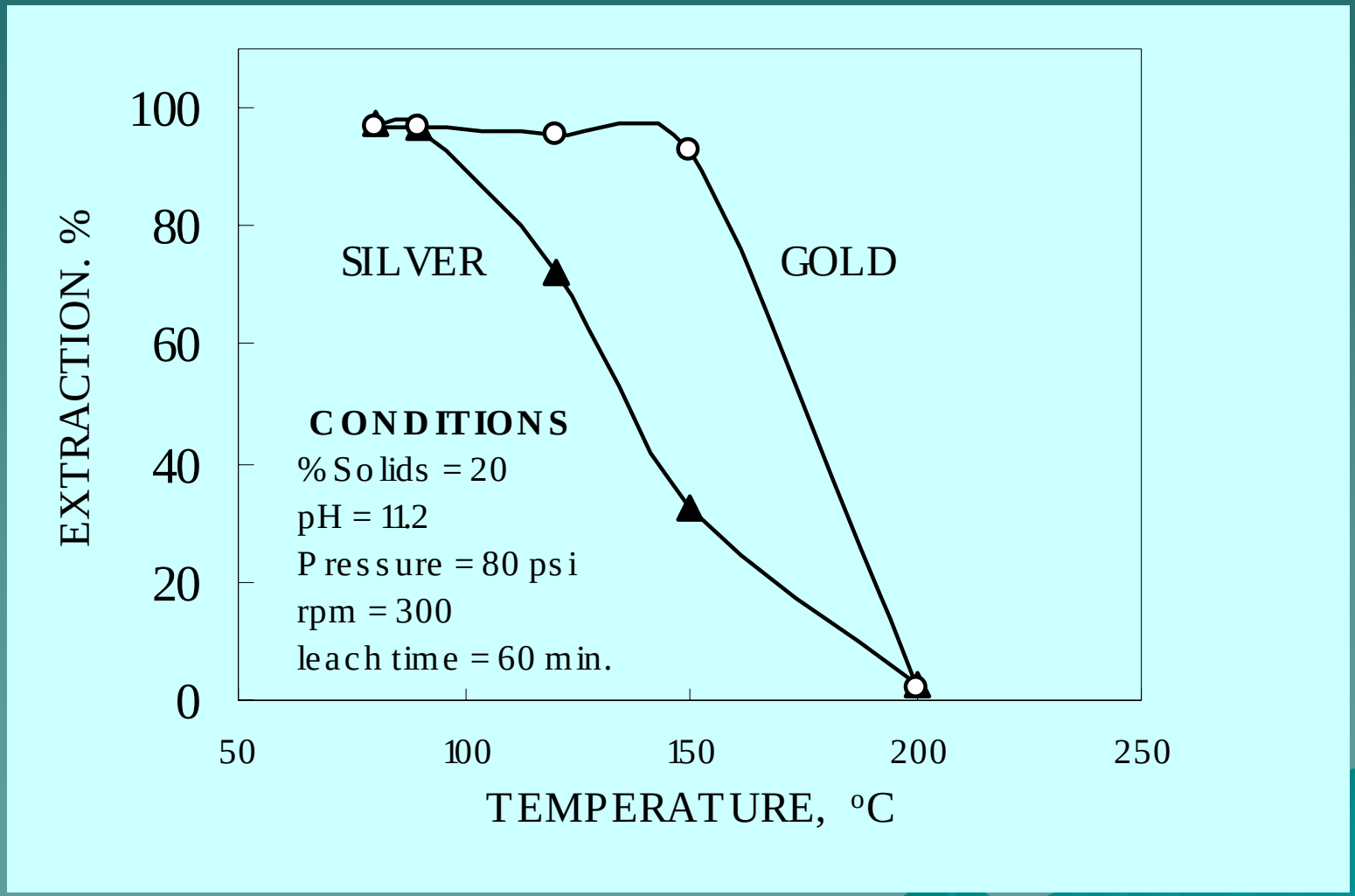
Effect of autoclave retention time on gold and silver extraction



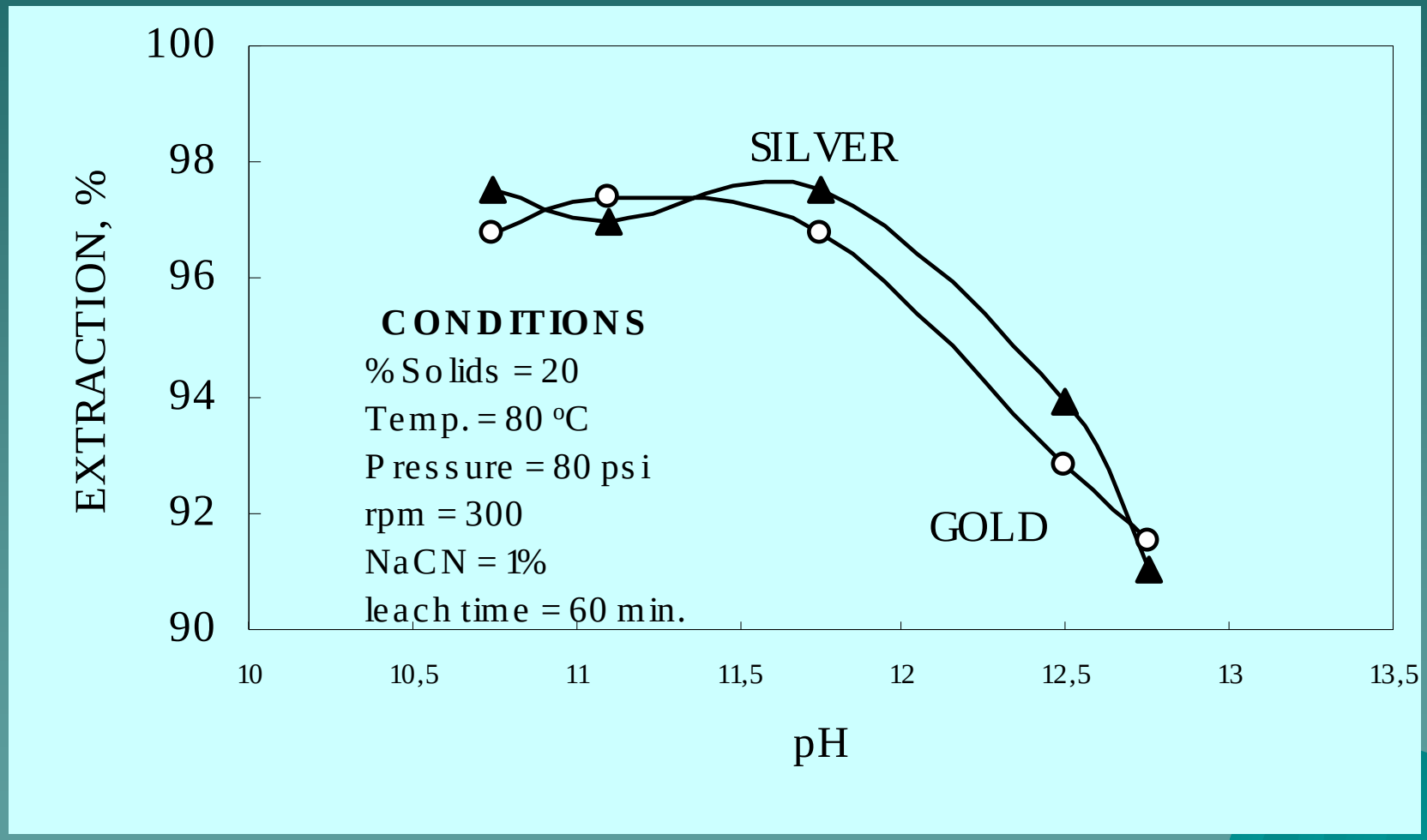
Effect of the cyanide concentration on gold and silver extraction



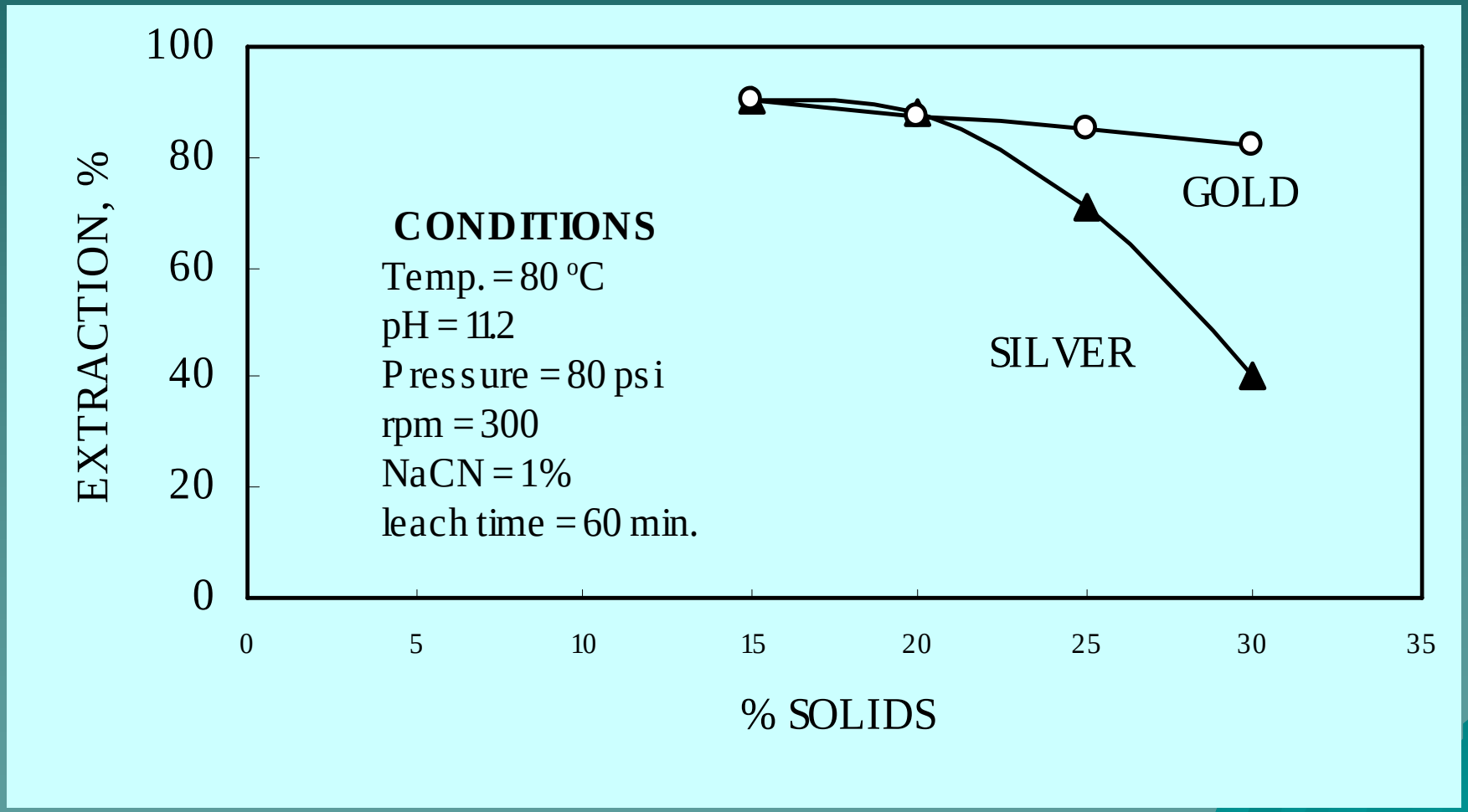
Effect of temperature on gold and silver extraction



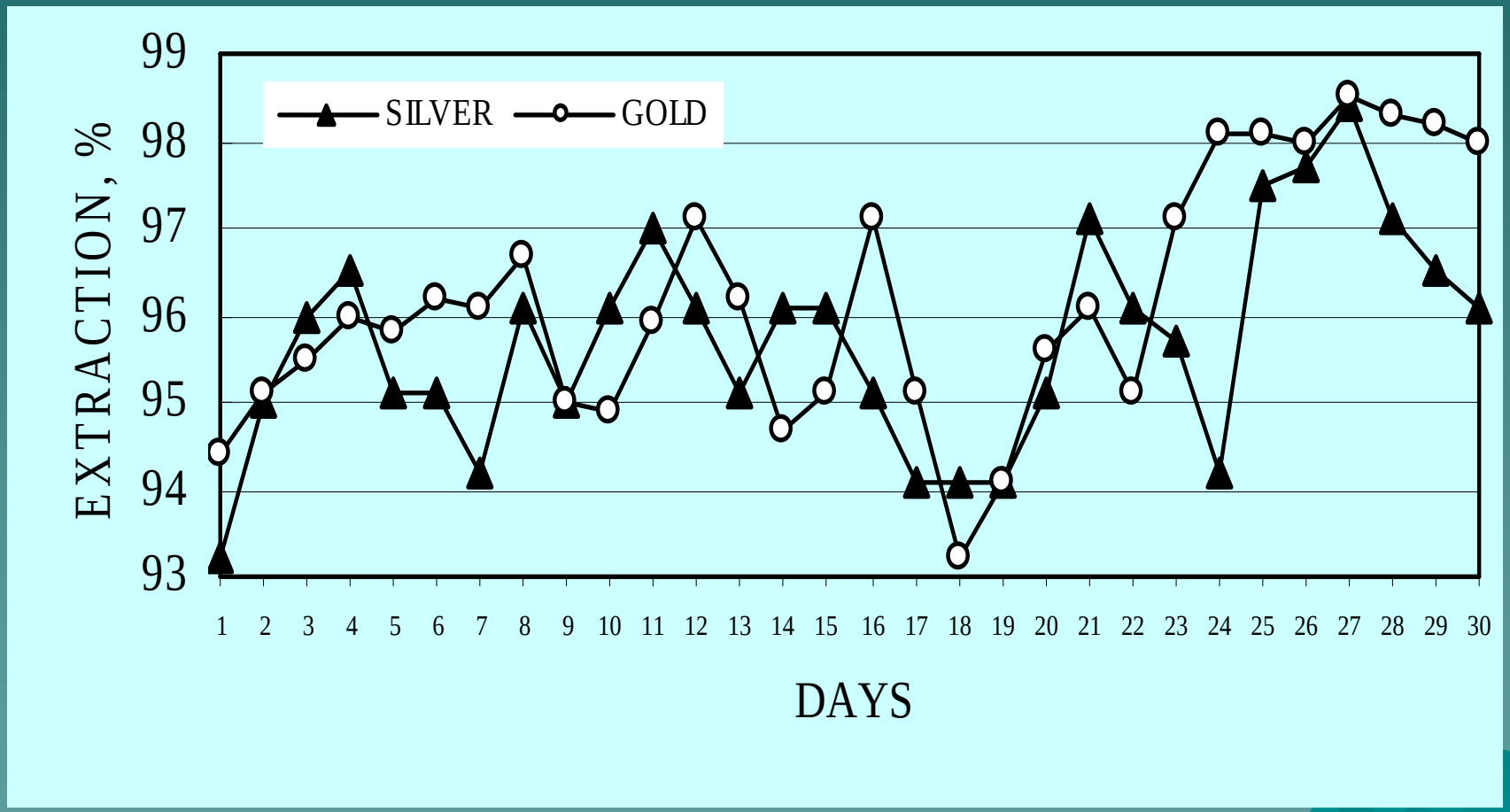
Effect of pH on gold and silver extraction

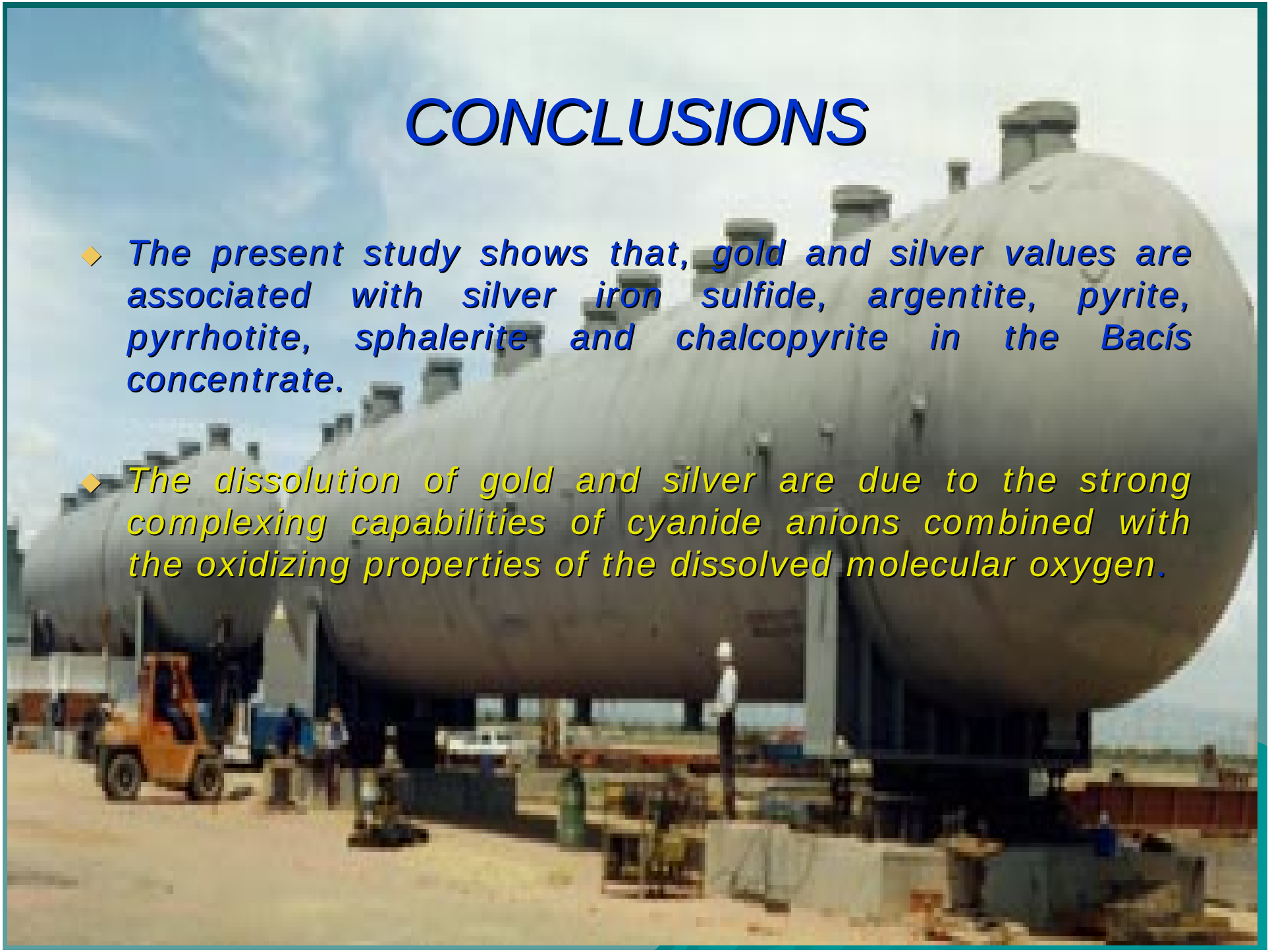


Effect of percent solids in the extraction of gold and silver



Results of continuous plant operation

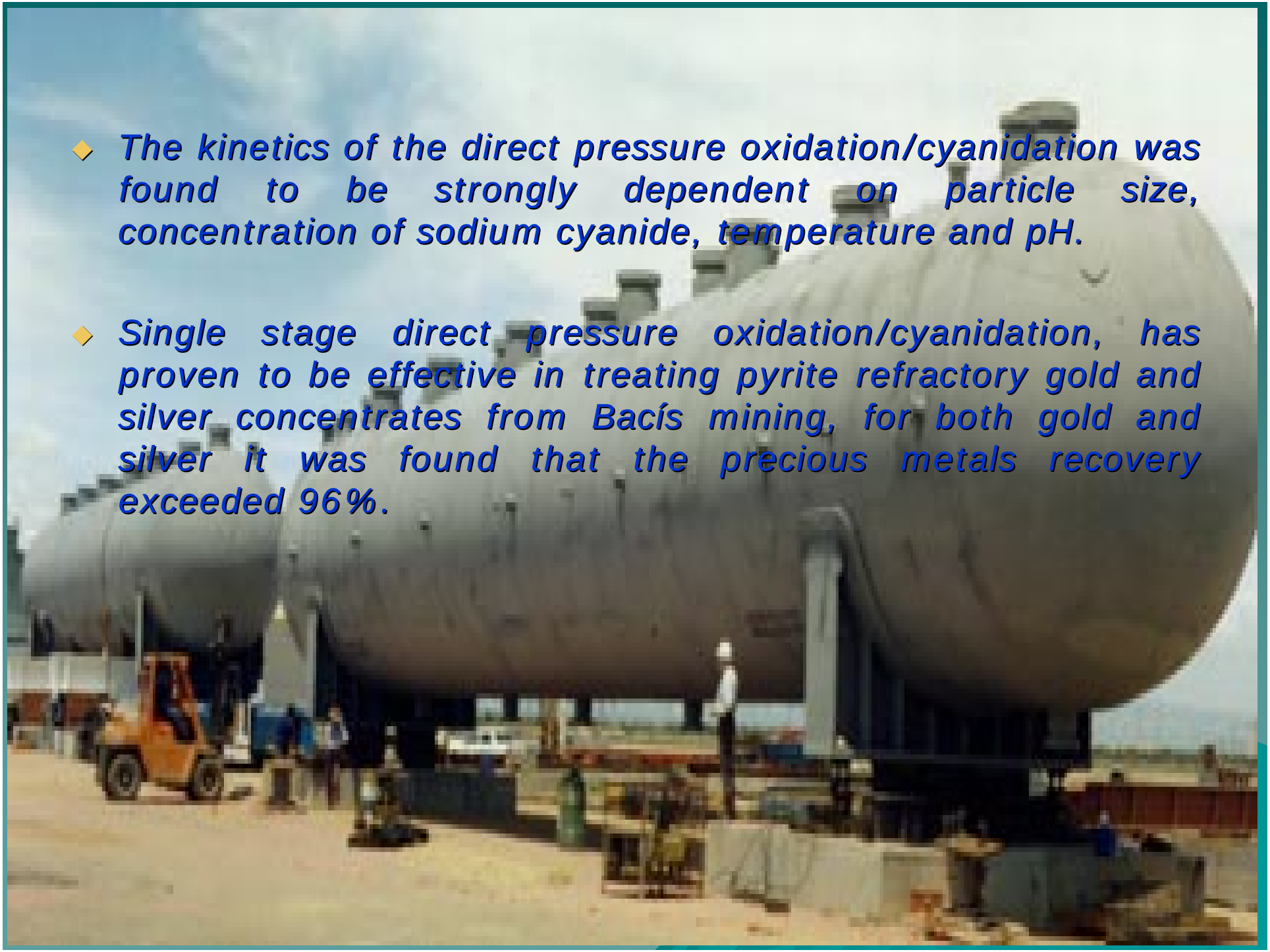




CONCLUSIONS

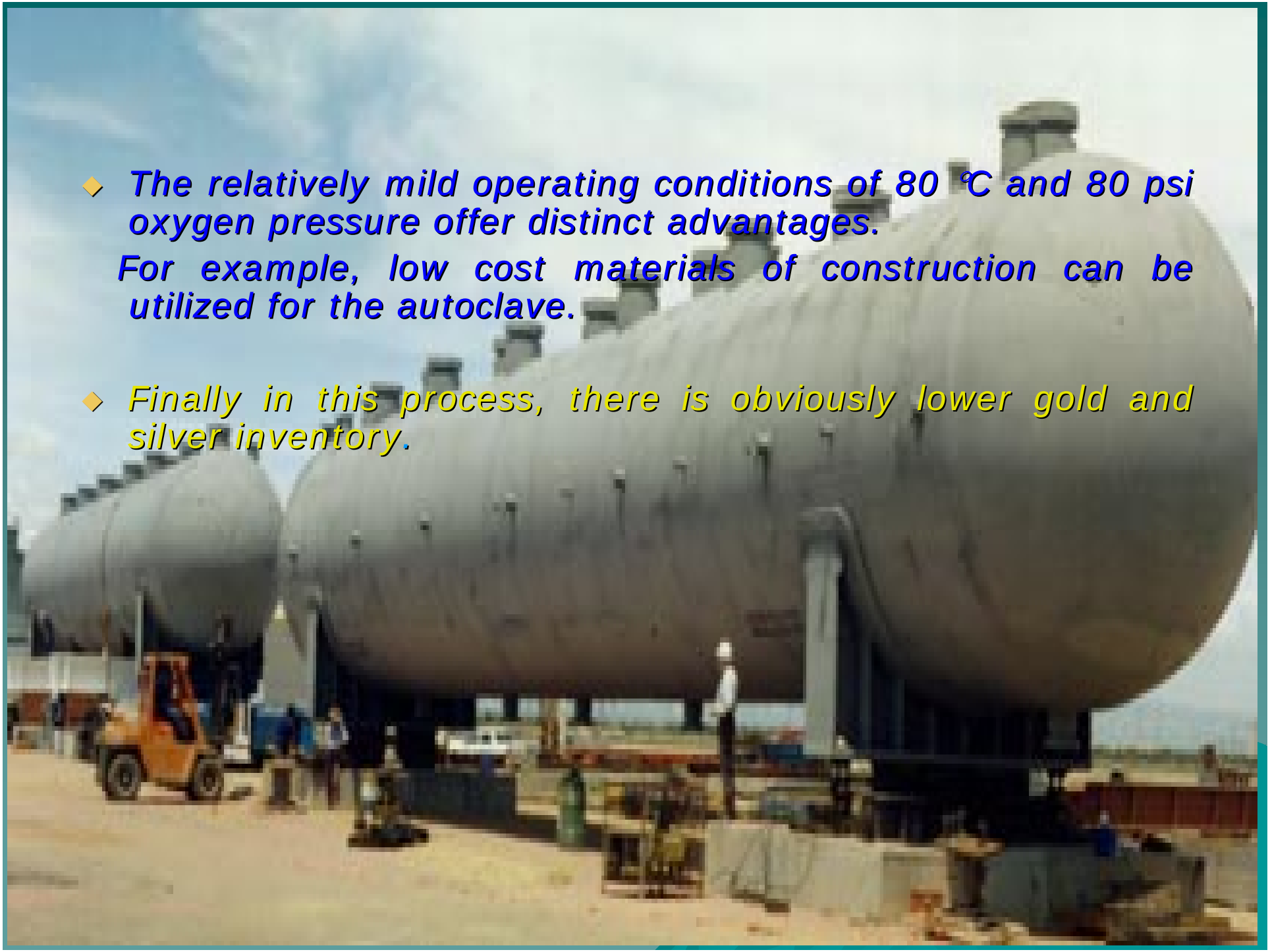
- *The present study shows that, gold and silver values are associated with silver iron sulfide, argentite, pyrite, pyrrhotite, sphalerite and chalcopyrite in the Bacís concentrate.*

- *The dissolution of gold and silver are due to the strong complexing capabilities of cyanide anions combined with the oxidizing properties of the dissolved molecular oxygen.*



- *The kinetics of the direct pressure oxidation/cyanidation was found to be strongly dependent on particle size, concentration of sodium cyanide, temperature and pH.*

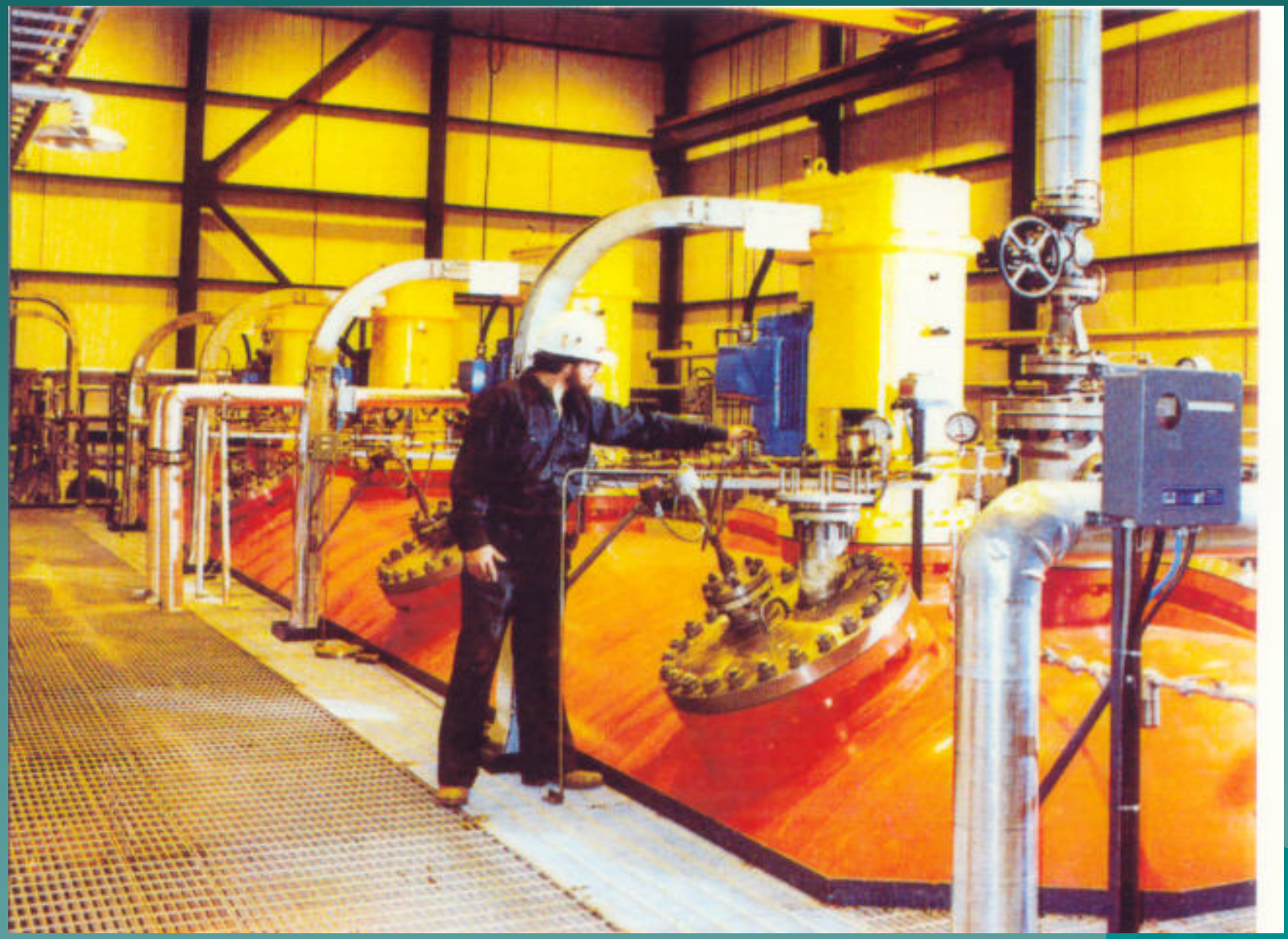
- *Single stage direct pressure oxidation/cyanidation, has proven to be effective in treating pyrite refractory gold and silver concentrates from Bacís mining, for both gold and silver it was found that the precious metals recovery exceeded 96%.*



- *The relatively mild operating conditions of 80 ℃ and 80 psi oxygen pressure offer distinct advantages.*

  For example, low cost materials of construction can be utilized for the autoclave.

- *Finally in this process, there is obviously lower gold and silver inventory.*



Thank you for your attention

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Principales Centros Mineros en el Estado de Sonora

1.- LA HERRADURA (Oro)
2.- CERRO COLORADO (Oro)
3.- SECOTEC (Oto)
4.- LA COLORADA (Oro)
5.- MEXICANA DE CANANEA (Cobre)
6.- MEXICANA DE COBRE (Cobre)
7.- PILARES (Wollastonita)
8.- COBACHI (Barita)
9.- ZONA GRAFITERA
10- EL VOLCAN (Fierro)
11.- EL TAYMUCO (Yeso)
12.- YAVAROS (Sal)
13.- SALINA DE LOBOS (Sal)
14.- LOS HALCONES (Perlita)
15.- MOLIMEX (Molibdeno)
16.- CALERA NACOZARI (Cal)
17.- SALINERA KINO (Sal)
18.- CEMENTOS PORTLAND (Cemento)
19.- CEMENTOS DEL YAQUI (Cemento)
20.- CALHIDRA DE SONORA (Cal)
21.- CARBON SAN ANTONIO (Carbón)
22.- FIERRO CARBO (Fierro)
23.- FIERRO BACANORA (Fierro)
24.- PRODUCTOS CALCAREOS (Cal)
25.- EL YESO (Yeso)
26.- MAZATAN (Barita)
27.- BACADEHUACHI (Sulfato de sodio)

10 nuevos proyectos mineros en operación en el período 2004-2009

PROYECTO EL CHANATE
Oro

PROYECTO CERRO COLORADO
Oro

PROYECTO SAN ANTONIO
Oro, Cobre

PROYECTO PIEDRAS VERDES
Cobre

PROYECTO MILPILLAS
Cobre

PROYECTO MARIQUITA
Cobre

PROYECTO LLUVIA DE ORO
Oro

PROYECTO BACADEHUACHI
Sulfato de Sodio

PROYECTO MULATOS
Oro

PROYECTO ALAMO DORADO
Plata