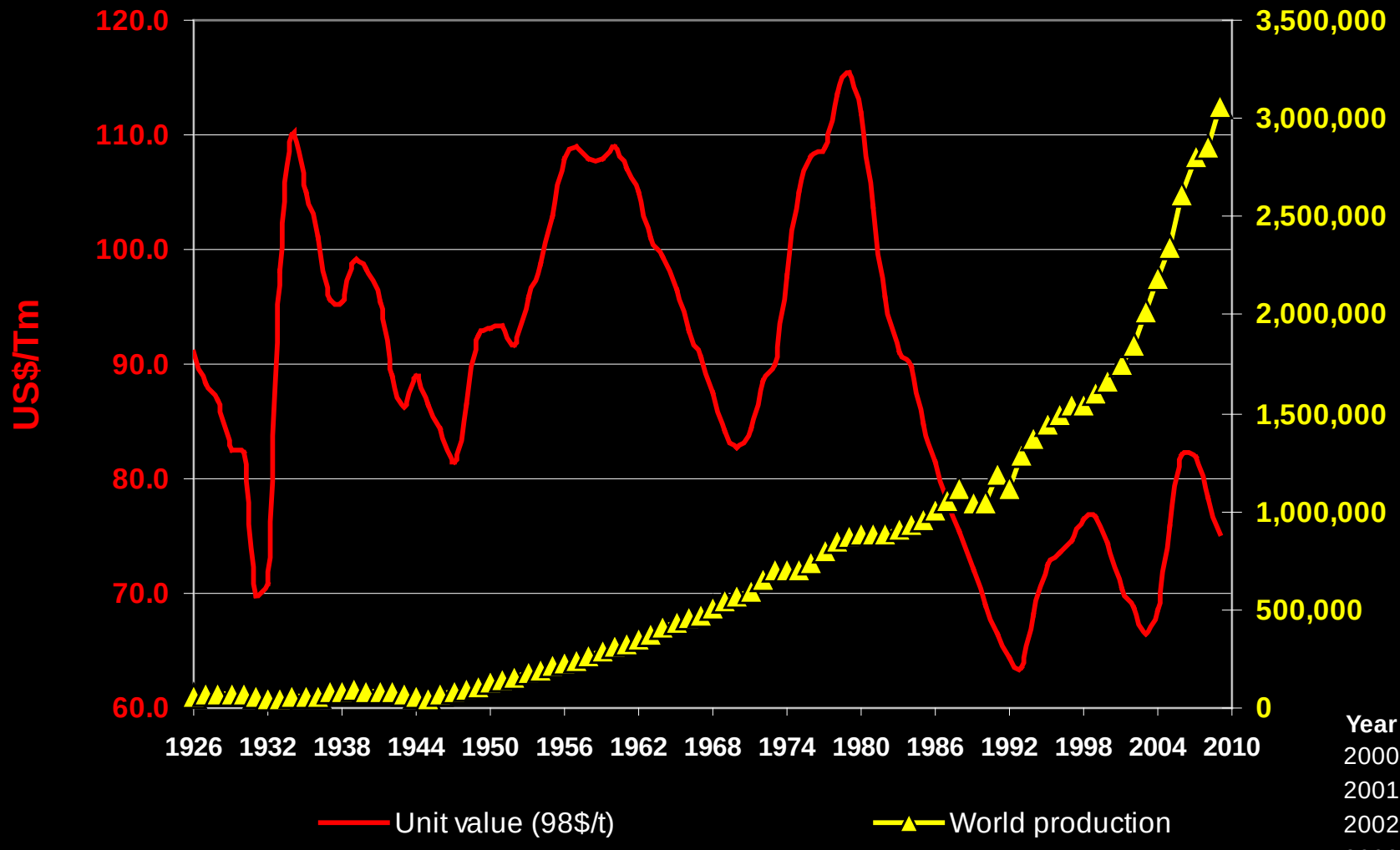
Orebody Modelling and Mine Planning at a Cement Plant in Peru

Presented by: Julio Villon, Eng

CEMENT IN THE WORLD

CEMENT

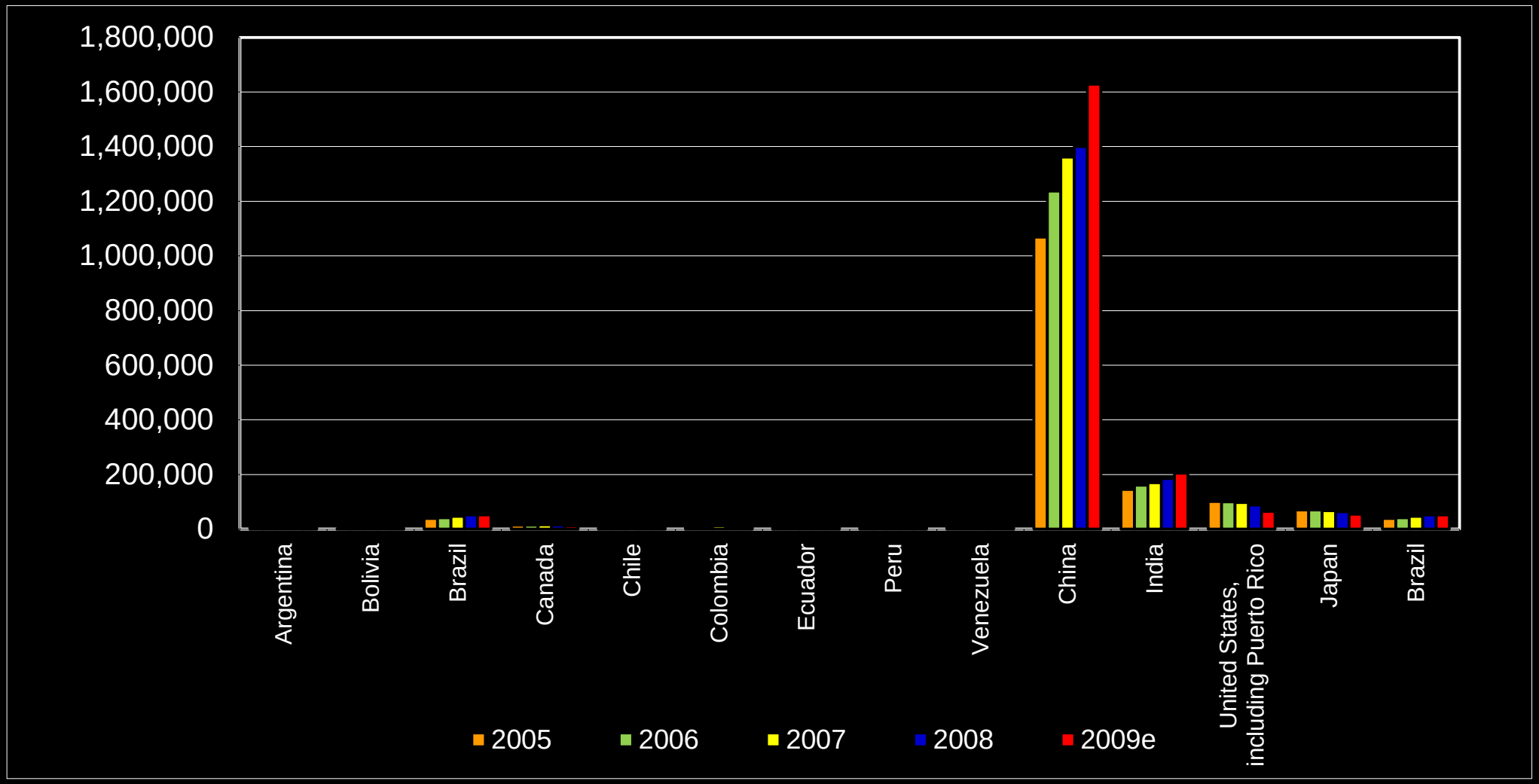


Year	Unit value (98$/t)	World production
2000	74.40	1,660,000,000
2001	70.40	1,750,000,000
2002	68.80	1,850,000,000
2003	66.40	2,020,000,000
2004	68.60	2,190,000,000
2005	75.90	2,350,000,000
2006	82.10	2,610,000,000
2007	81.80	2,810,000,000
2008	78.40	2,860,000,000
2009	75.20	3,060,000,000

By: U.S. GEOLOGICAL SURVEY

CEMENT PRODUCTION

(Thousand metric tons)

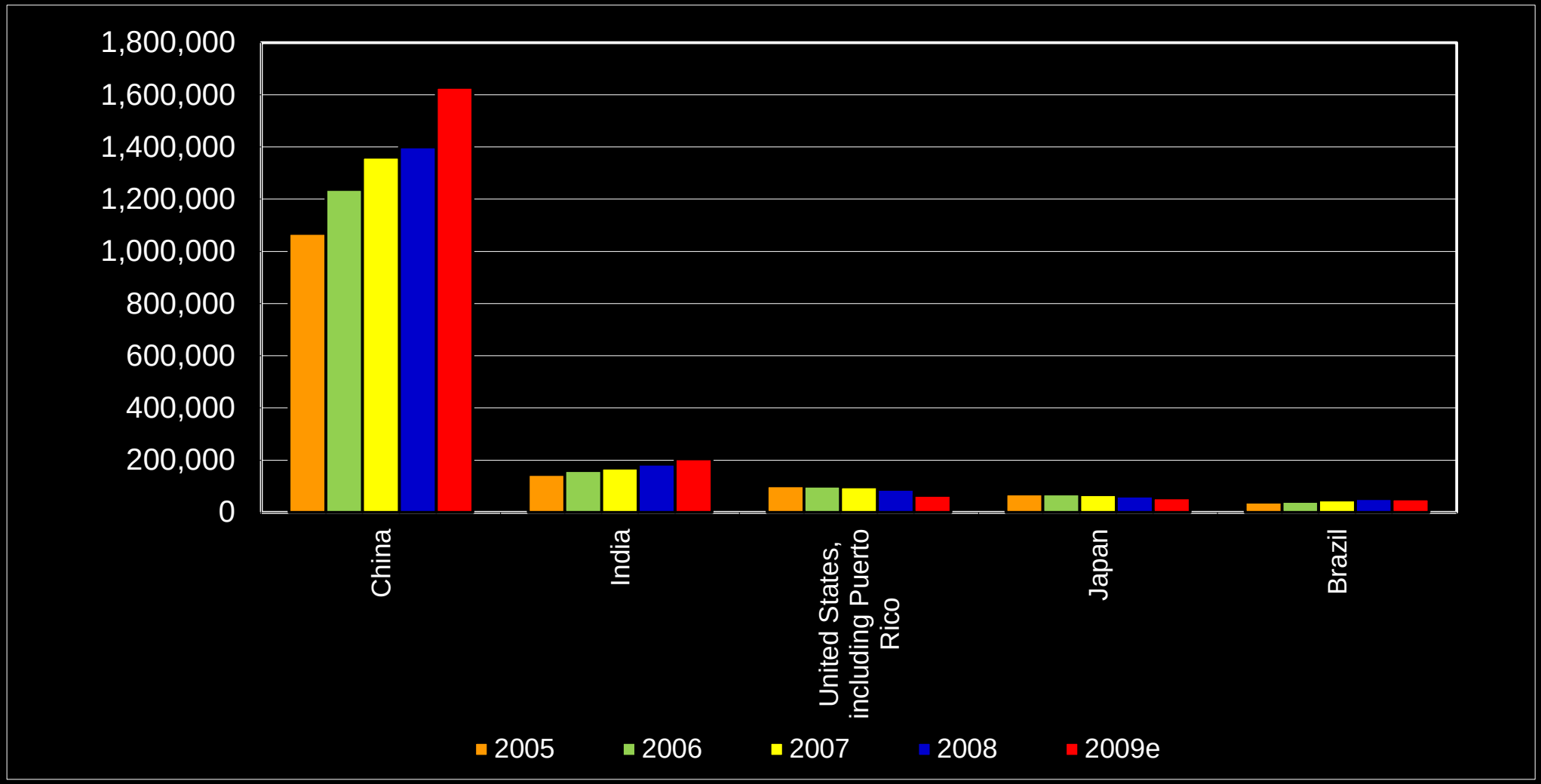


China (54% World Production)

By: U.S. GEOLOGICAL SURVEY

CEMENT PRODUCTION

(Thousand metric tons)

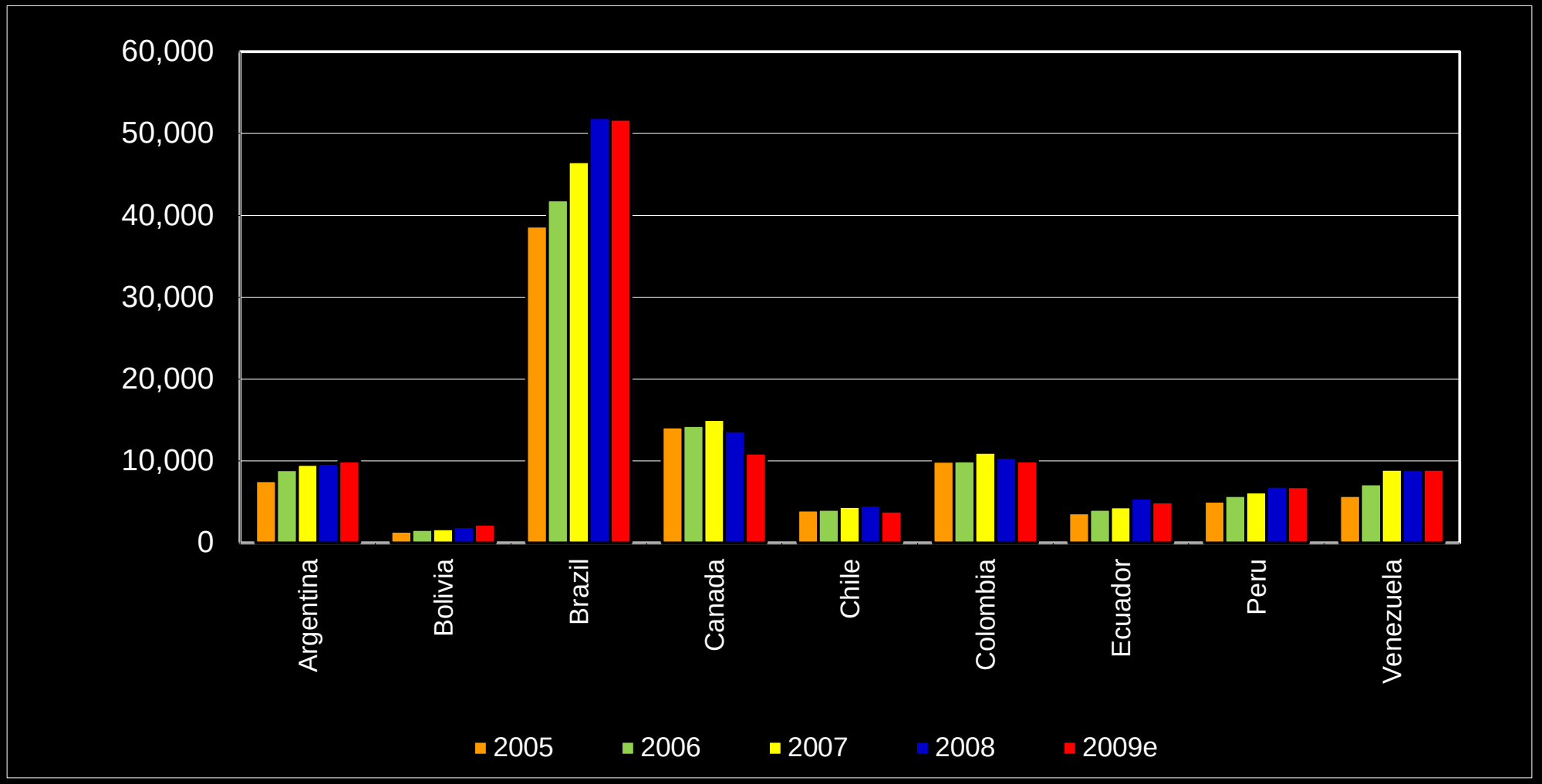


66% World Production

By: U.S. GEOLOGICAL SURVEY

CEMENT PRODUCTION SOUTH AMERICA AND CANADA

(Thousand metric tons)



4% World Production

By: U.S. GEOLOGICAL SURVEY

CEMENT TYPES

- ✓ Gray portland, cement is used for structural applications
- ✓ White portland cement has lower iron and manganese contents than gray portland cement and is used primarily for decorative purposes

- ✓ Type 1 - Normal portland cement. Type 1 is a general use cement.

Cement Types

- ✓ **Type 2 - Is used for structures in water or soil containing moderate amounts of sulfate, or when heat build-up is a concern.**

- ✓ **Type 3 - High early strength. Used when high strength are desired at very early periods.**

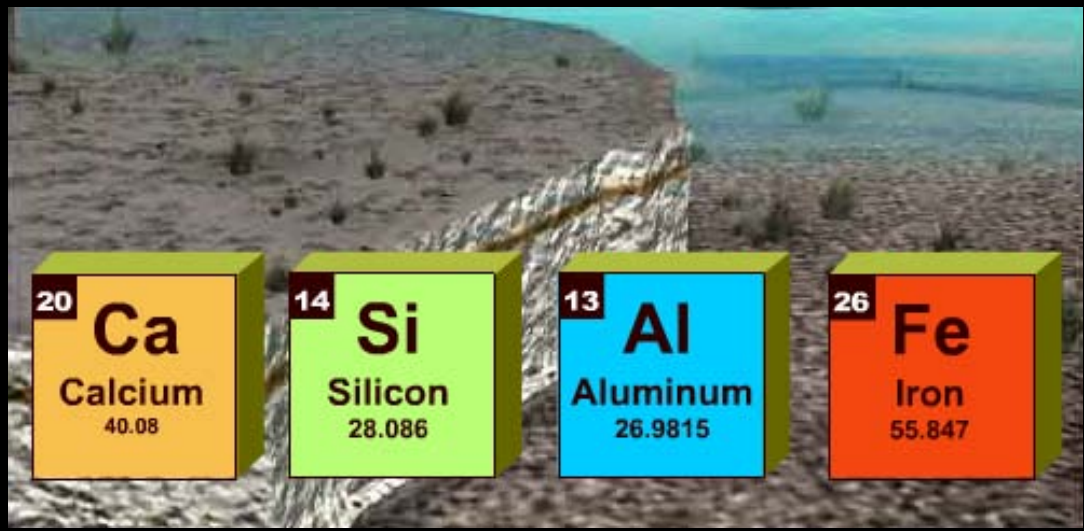
Cement Types

- ✓ **Type 4 - Low heat portland cement. Used where the amount and rate of heat generation must be kept to a minimum.**

- ✓ **Type 5 - Sulfate resistant portland cement. Used where the water or soil is high in alkali.**

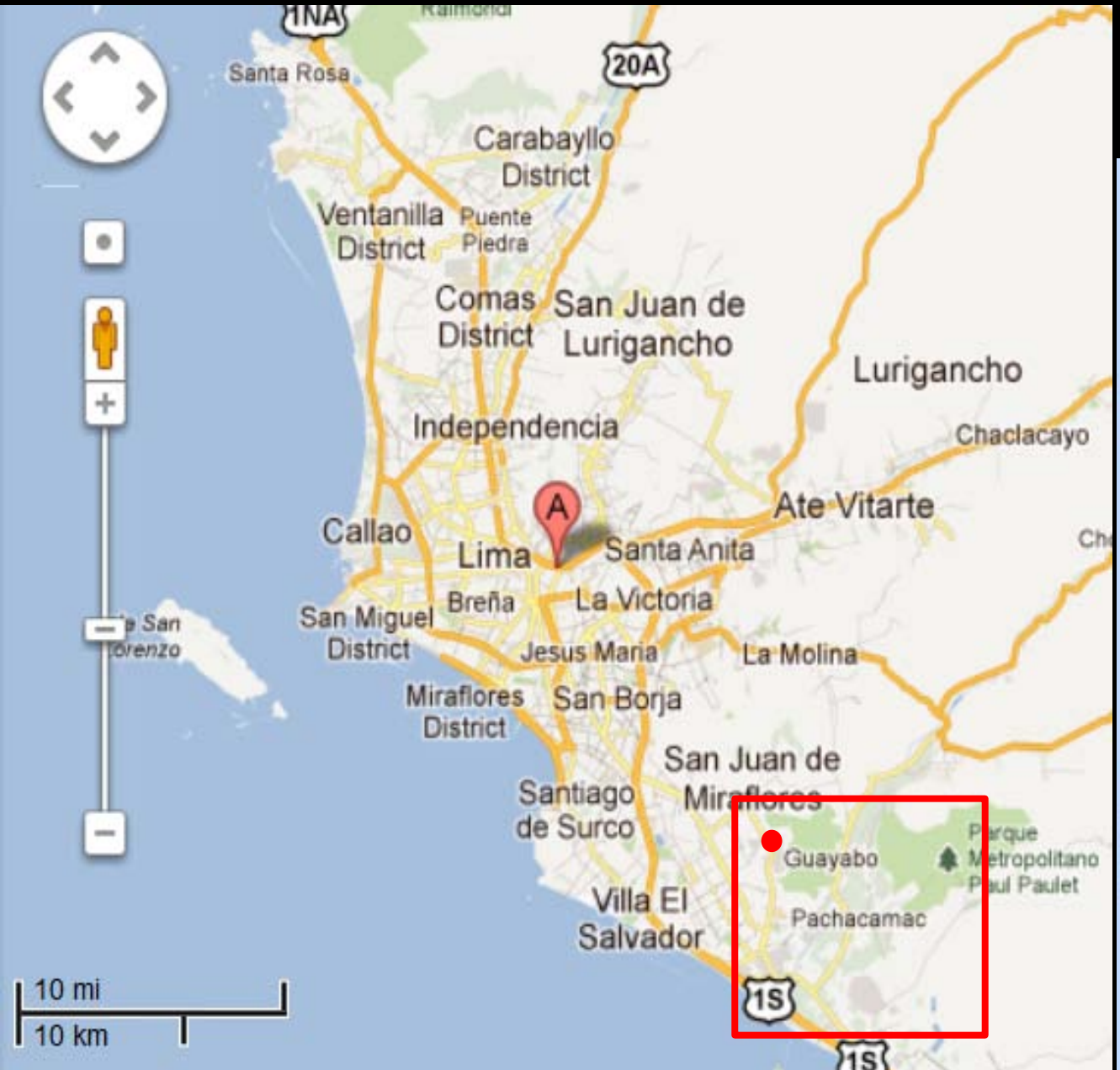
PORTLAND CEMENT

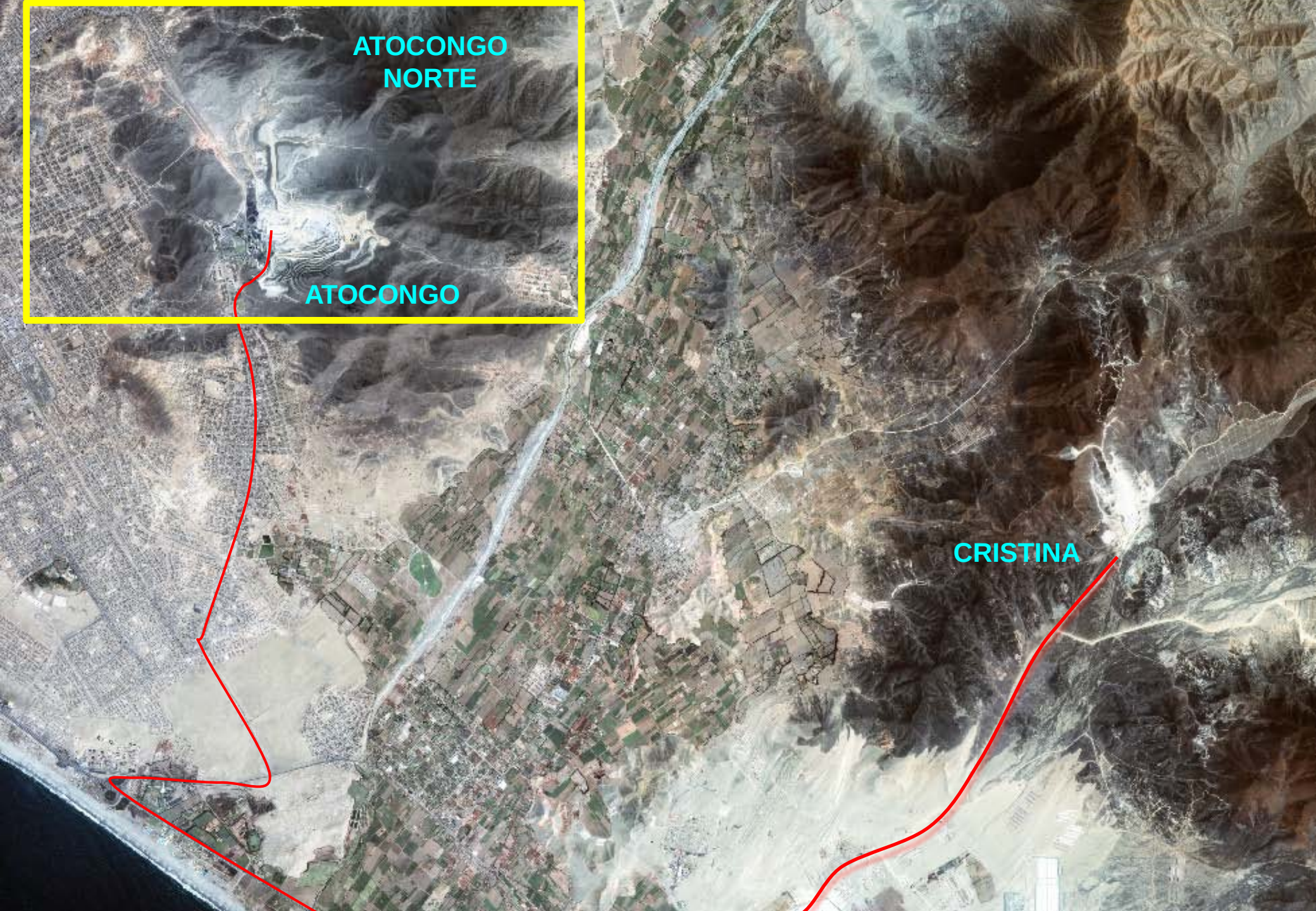
- ✓ **Portland cement is a fine powder, gray or white, that consists of a mixture of hydraulic cement materials**
- ✓ **More than 30 raw materials are known to be used in the manufacture of portland cement, and these materials can be divided into four categories:**
  - **Calcareous** (impure limestone known as "cement rock")
  - **Siliceous**
  - **Argillaceous**
  - **Ferrifrous**



PRODUCTION OF PORTLAND CEMENT AT CEMENTOS LIMA

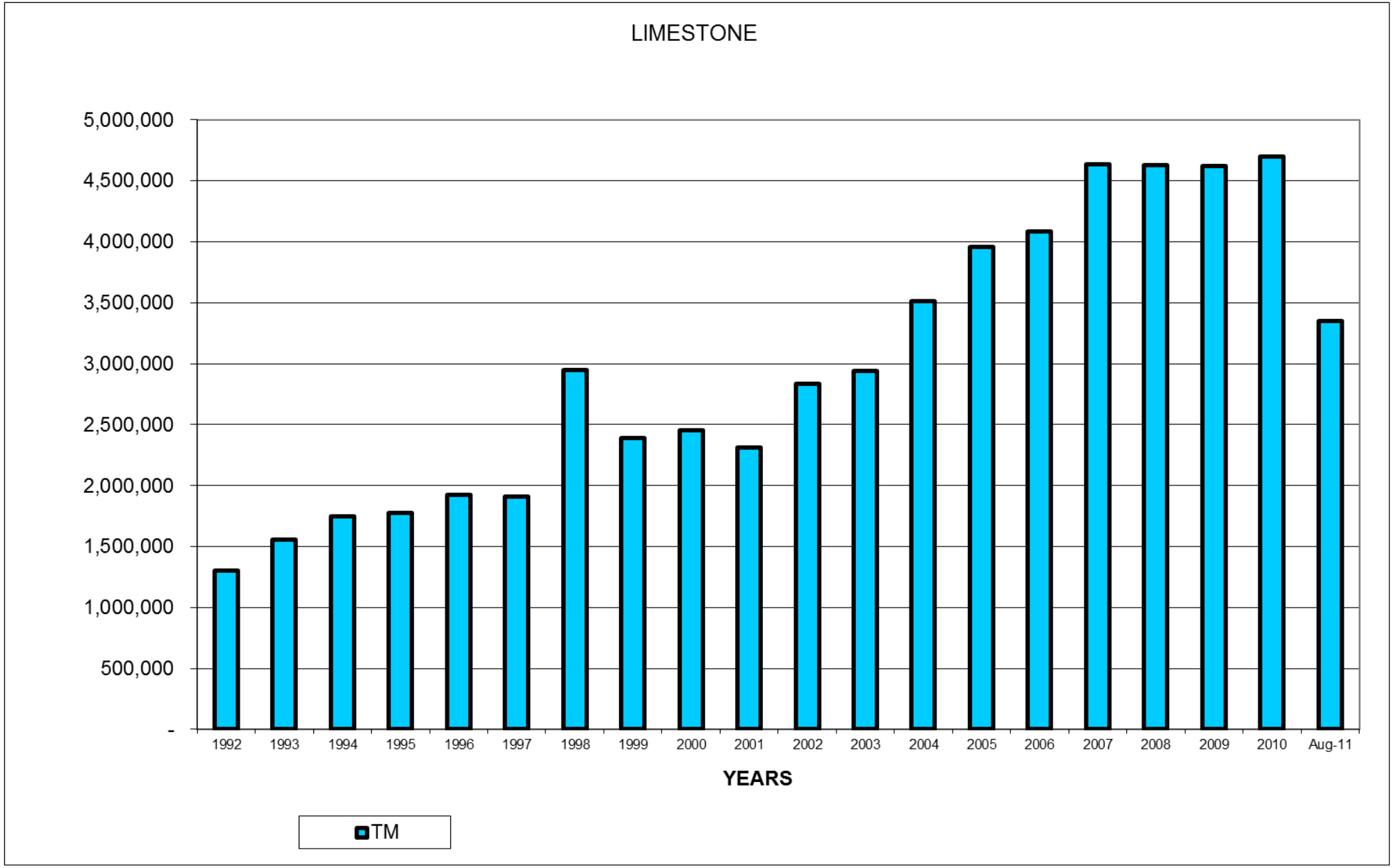
CEMENTOS LIMA

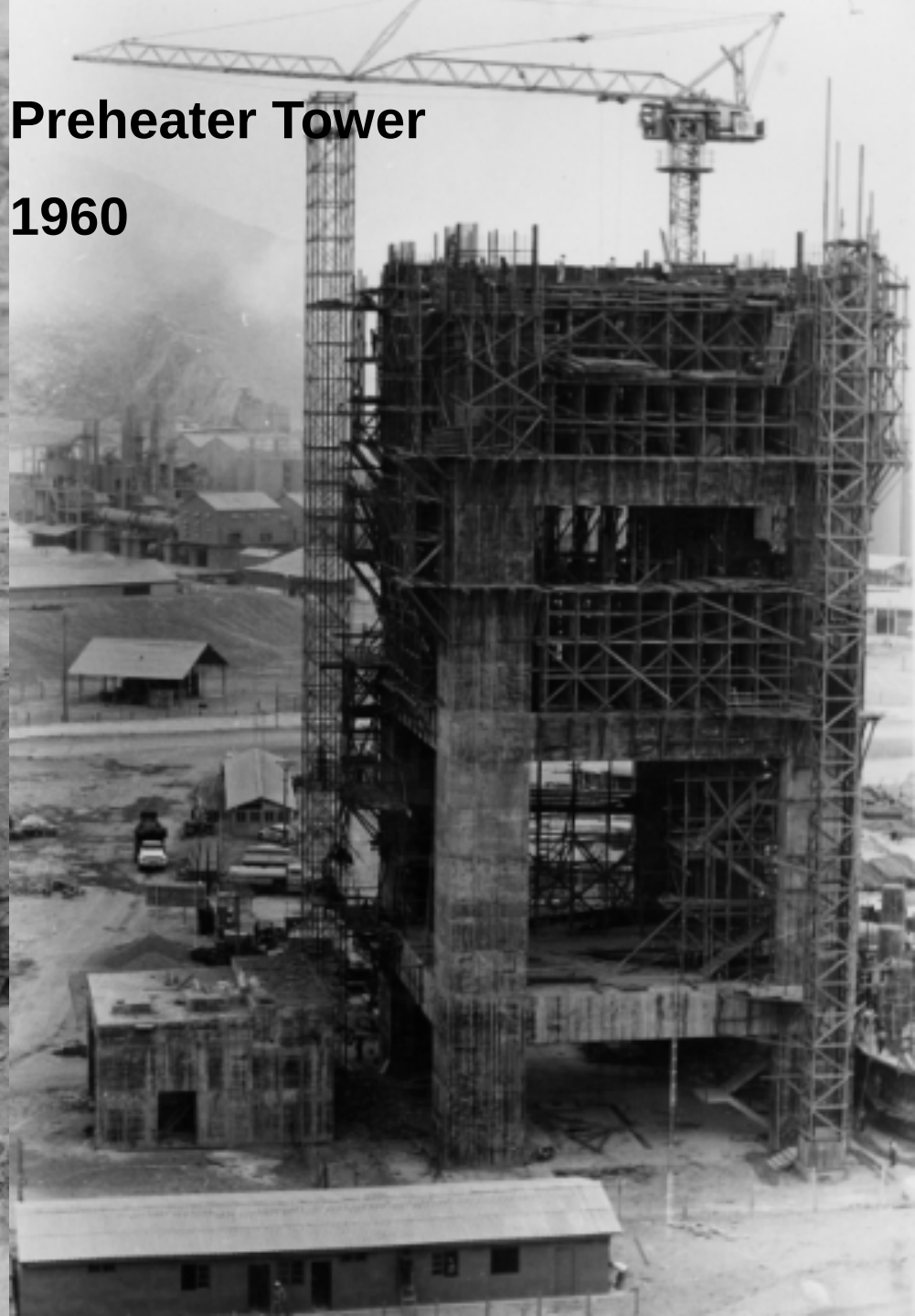



ATOCONGO
NORTE
ATOCONGO
CRISTINA


NUEVA ESPERANZA
ATOCONGO NORTE
CPR PICA PIEDRA
ATOCONGO
TABLADA DE LURIN
CPR GUAYABO
JOSE GALVEZ
26 De Noviembre
Atocongo
Pachacutec
© 2009 Google
© 2009 Google
© 2009 DMapas

YEARLY PRODUCTION IN CEMENTOS LIMA



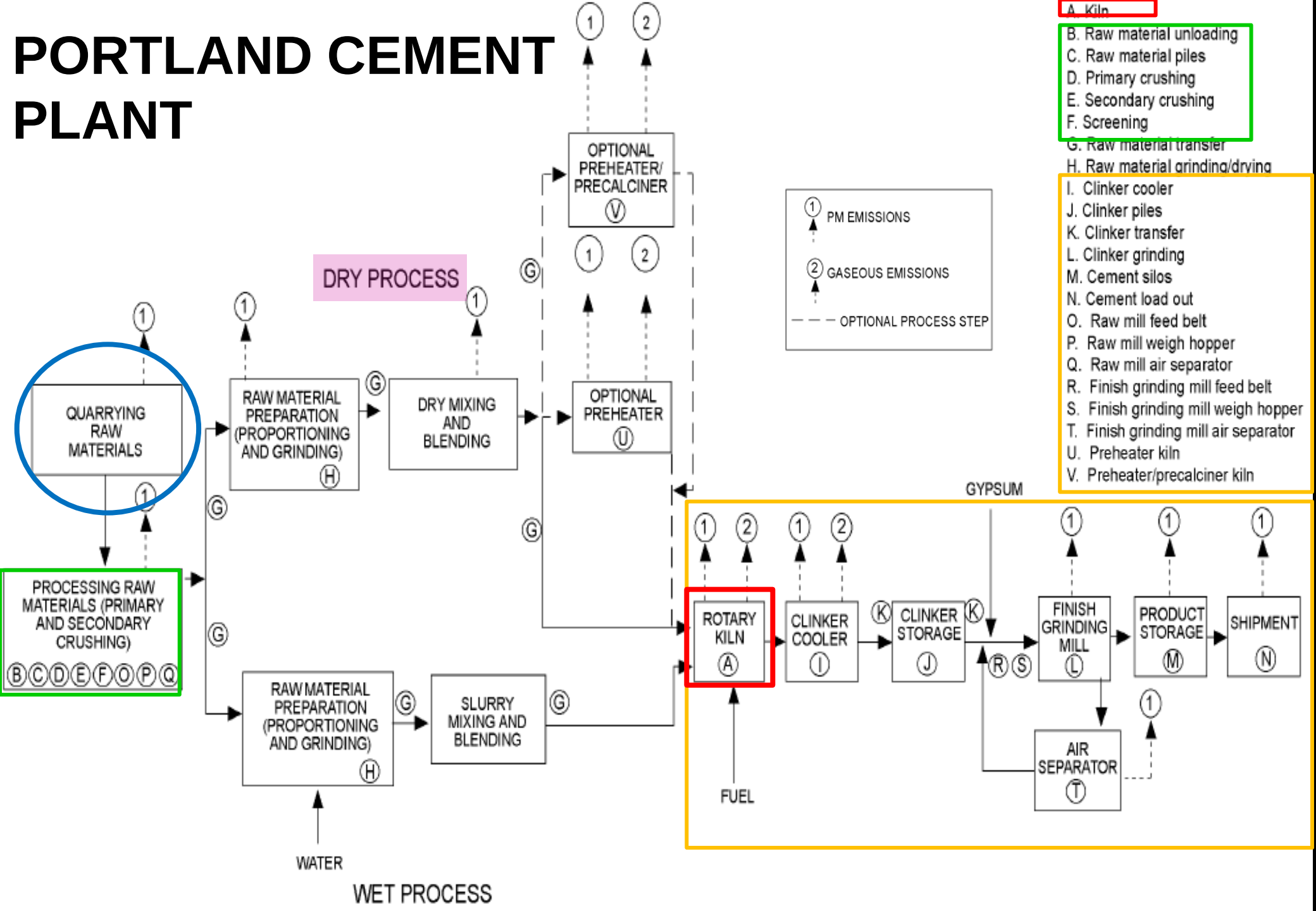


Preheater Tower

1960

CEMENTOS LIMA

PORTLAND CEMENT PLANT



CEMENT

- ✓ **Portland cement plants: wet process kilns and dry process kilns**
- ✓ **The raw mix is pneumatically blended and stored in silos, then it is fed to the pyroprocessing system**

CEMENTOS LIMA

- ✓ **Rotary kilns are long, cylindrical, slightly inclined furnaces that are lined with refractory to protect the steel shell and retain heat within the kiln**

Kiln 2

Lenght 85.0m

Diameter 5.5m

7,500 tonnes/day

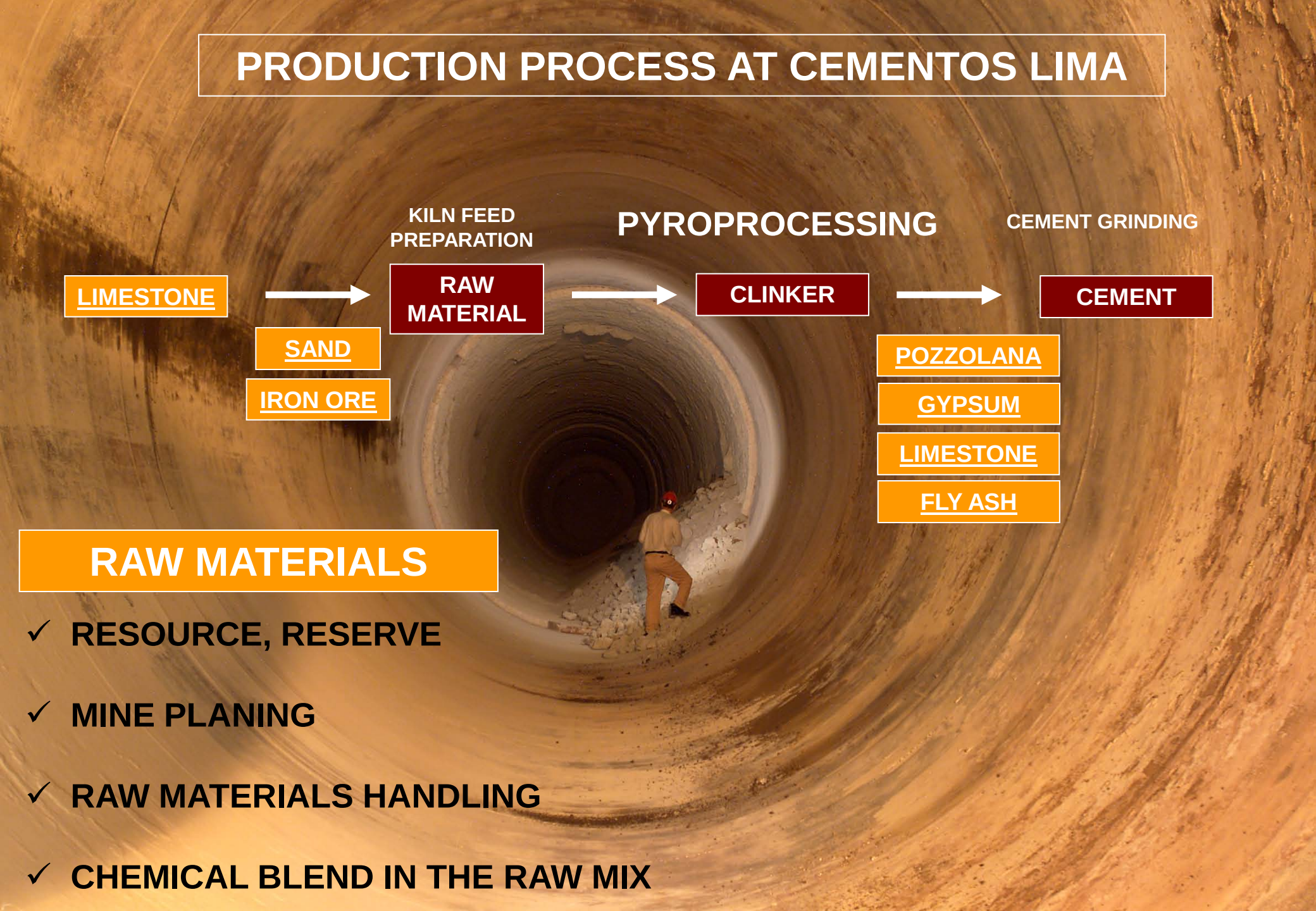
Kiln 1

Lenght 83.0m

Diameter 5.0m

3,500 tonnes/day

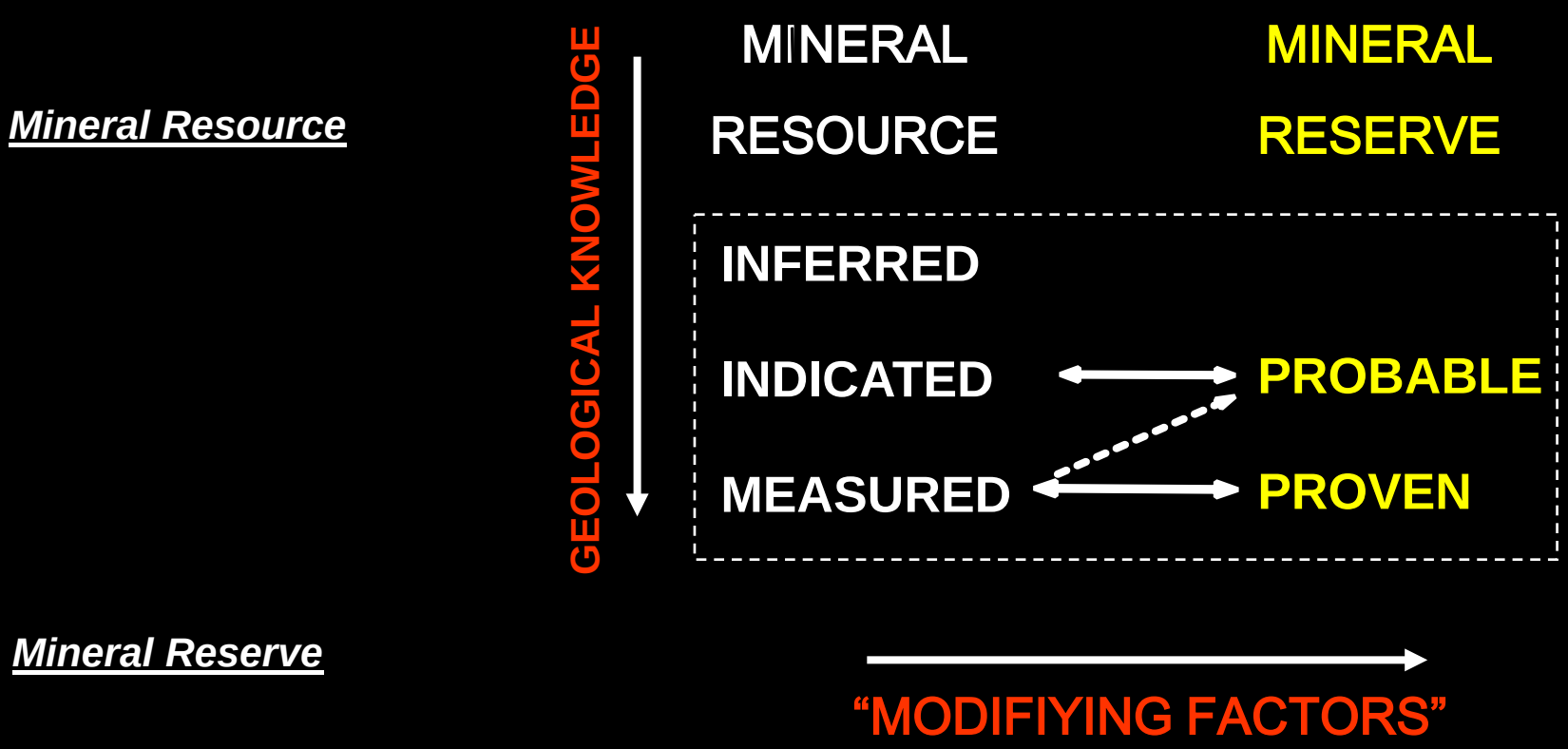
PRODUCTION PROCESS AT CEMENTOS LIMA



RAW MATERIALS

- ✓ RESOURCE, RESERVE
- ✓ MINE PLANING
- ✓ RAW MATERIALS HANDLING
- ✓ CHEMICAL BLEND IN THE RAW MIX

CEMENTOS LIMA RESOURCE, RESERVE



✓ Long Term Planning

- ✓ Exploration
- ✓ Geological Modelling and Resource Estimation
  - ✓ Kriging (CaO, Al_2O_3, SO_3, Fe_2O_3, MgO, SiO_2, Na_2O, K_2O)
- ✓ Environment and RSE
- ✓ Raw Material 20 years
  - ✓ Design and Optimization, Mine Planning (sceneries)
  - ✓ Cost
  - ✓ Handling

ATOCONGO	LIMESTONE	RESERVE
ATOCONGO NORTE	LIMESTONE	RESERVE
CRISTINA	LIMESTONE	RESERVE
MIGUEL SEGUNDO	LIMESTONE	RESERVE
ATOCONGO	POZZOLANA	RESERVE

LAS HIENAS	GYPSUM	RESERVE
VIRGEN DE FATIMA	GYPSUM	RESOURCE
CANETE	LIMESTONE	RESOURCE
CANETE	POZZOLANA	RESOURCE

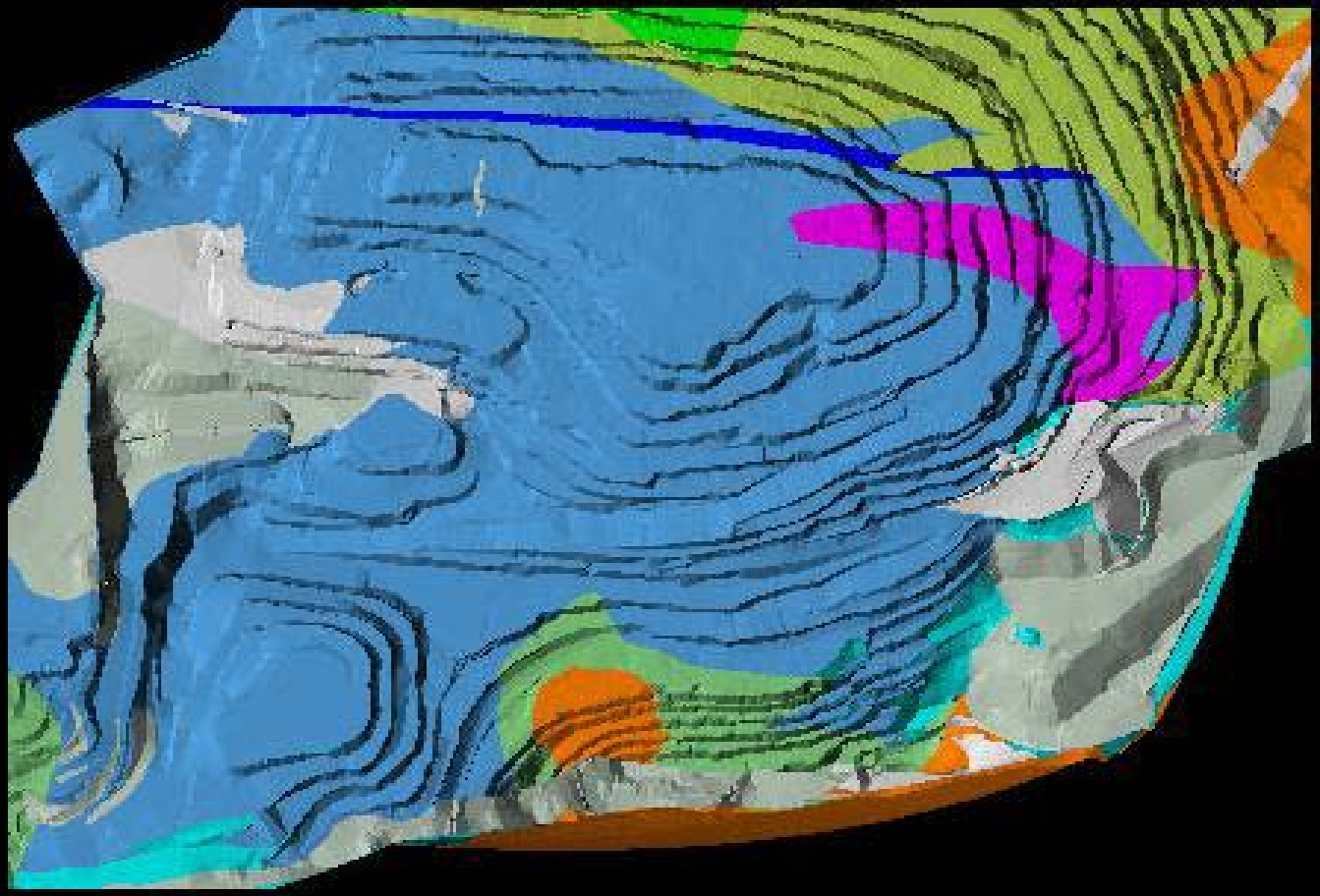
LAS DUNAS	GYPSUM	RESERVE
CRISTINA II	ORE IRON	RESOURCE

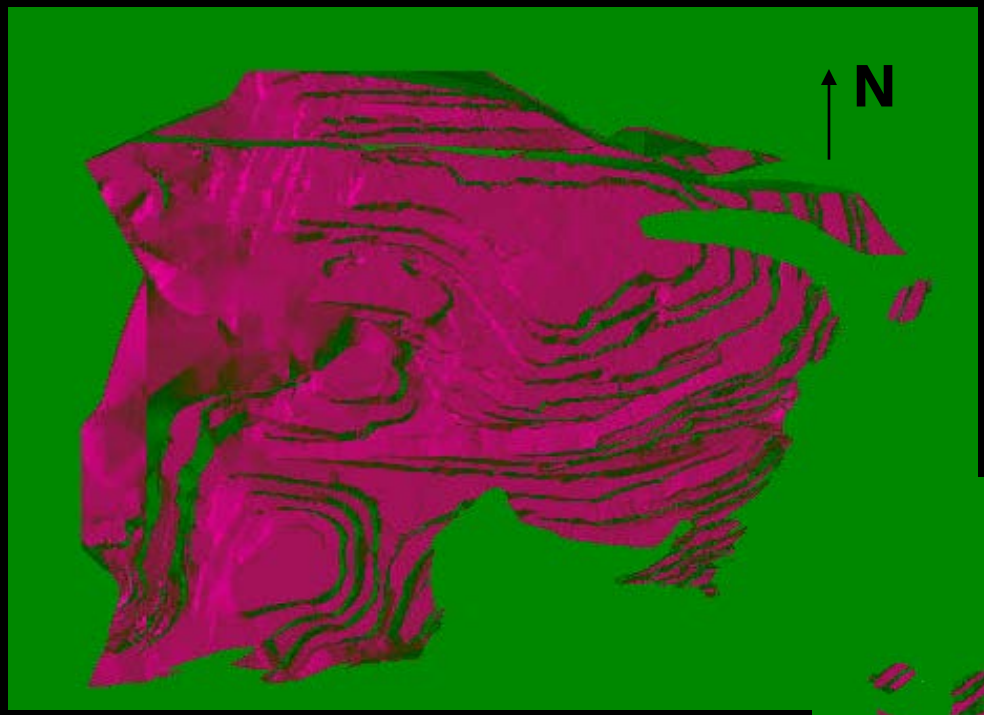
SANTA ADA	LIMESTONE	RESOURCE
PARCO	SAND	RESOURCE
RONCHAS	GYPSUM	RESOURCE
SAN AGUSTIN	ORE IRON	RESOURCE

SAMA, CHERO	GYPSUM	RESERVE
ALIANZA MILLUNE	LIMESTONE	RESOURCE
ALIANZA MILLUNE	POZZOLANA	

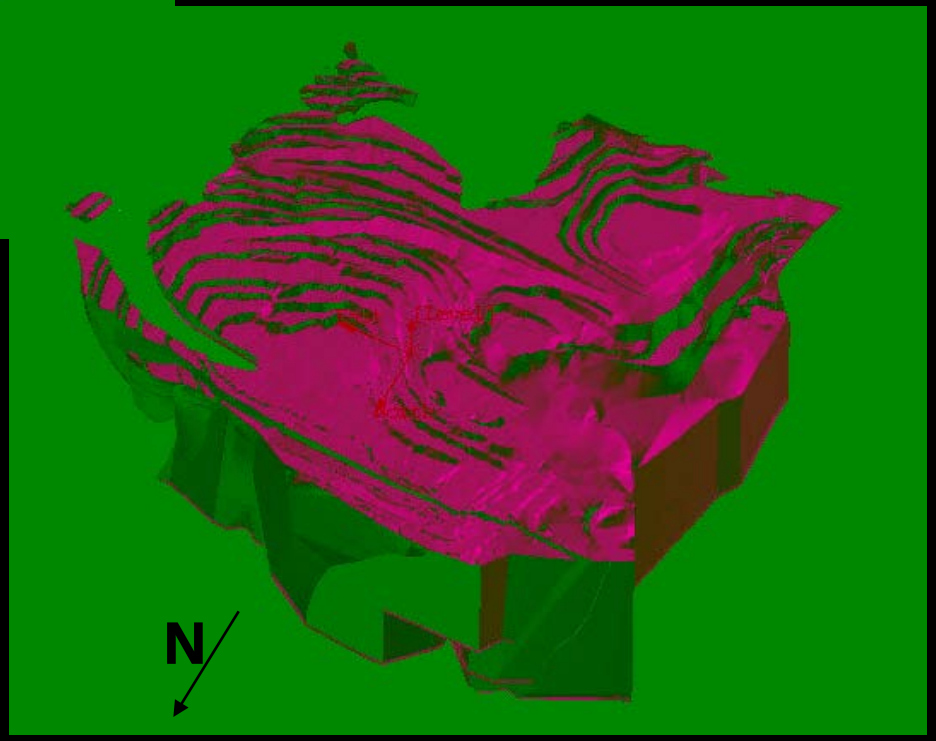
- ✓ Exploration
- ✓ Geological Modelling and Resource Estimation

- ✓ Geological Modelling and Resource Estimation
  - ✓ Atocongo Pit

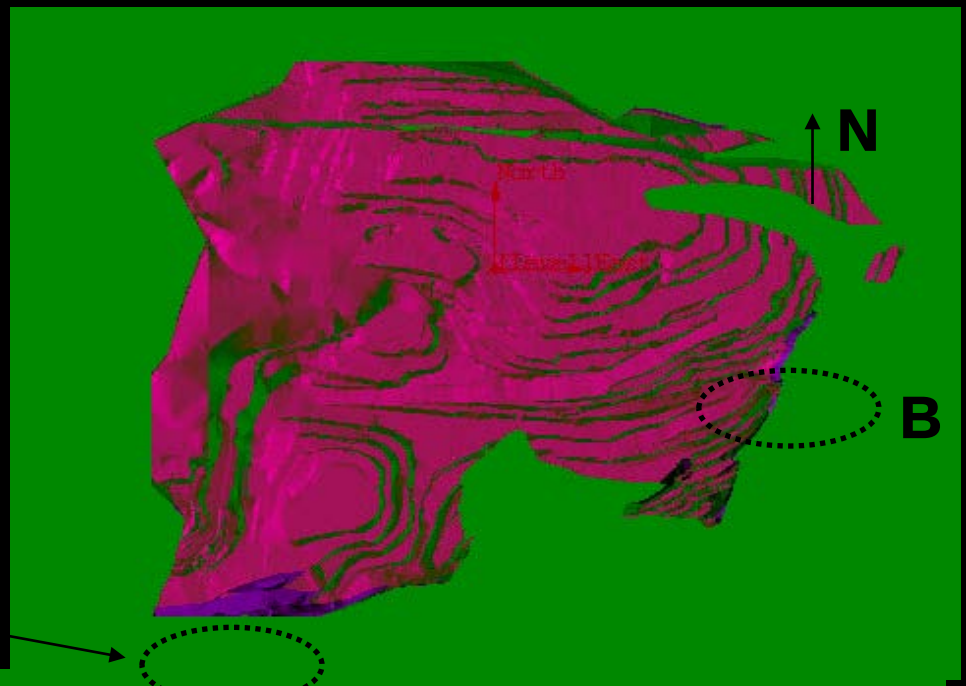


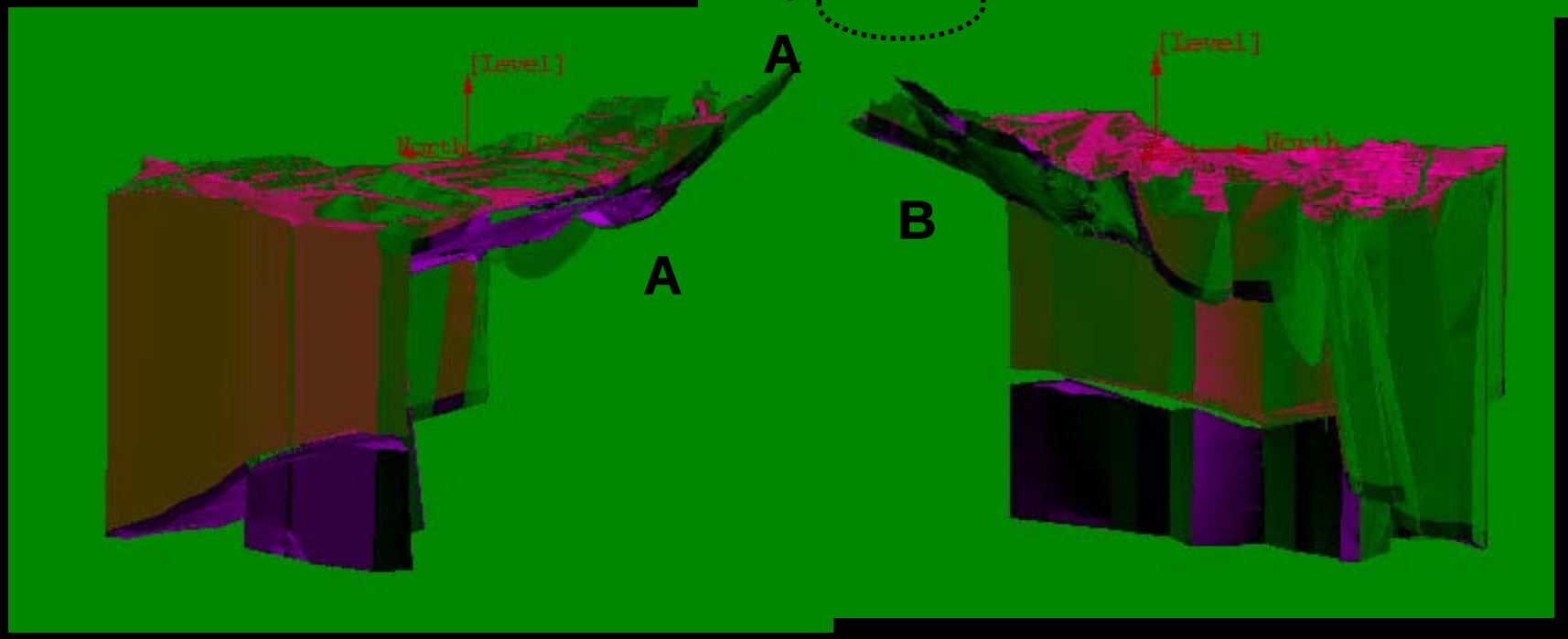


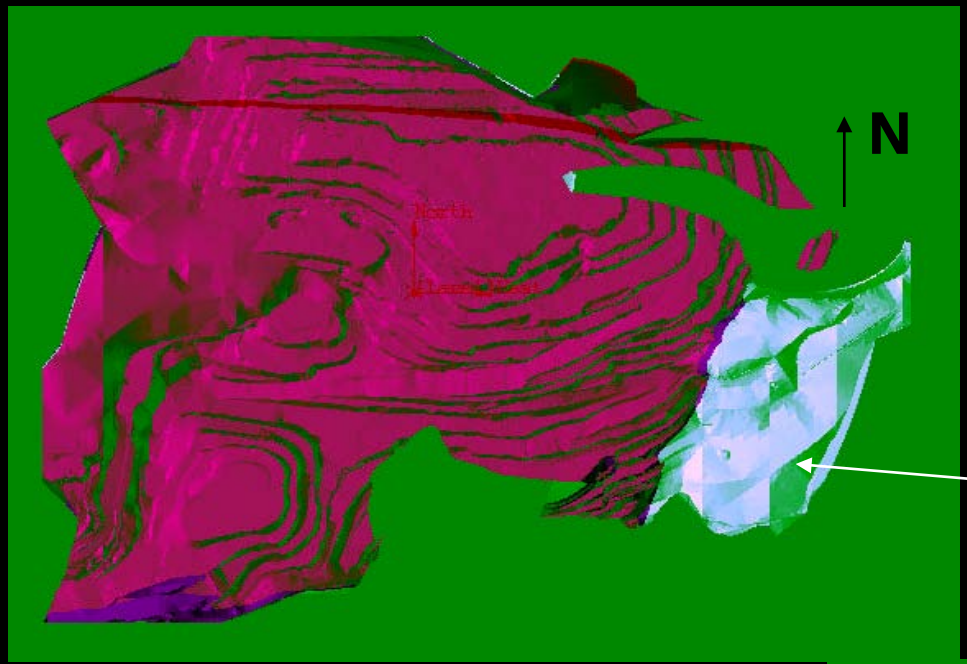
Caliza de la Fm. Atocongo



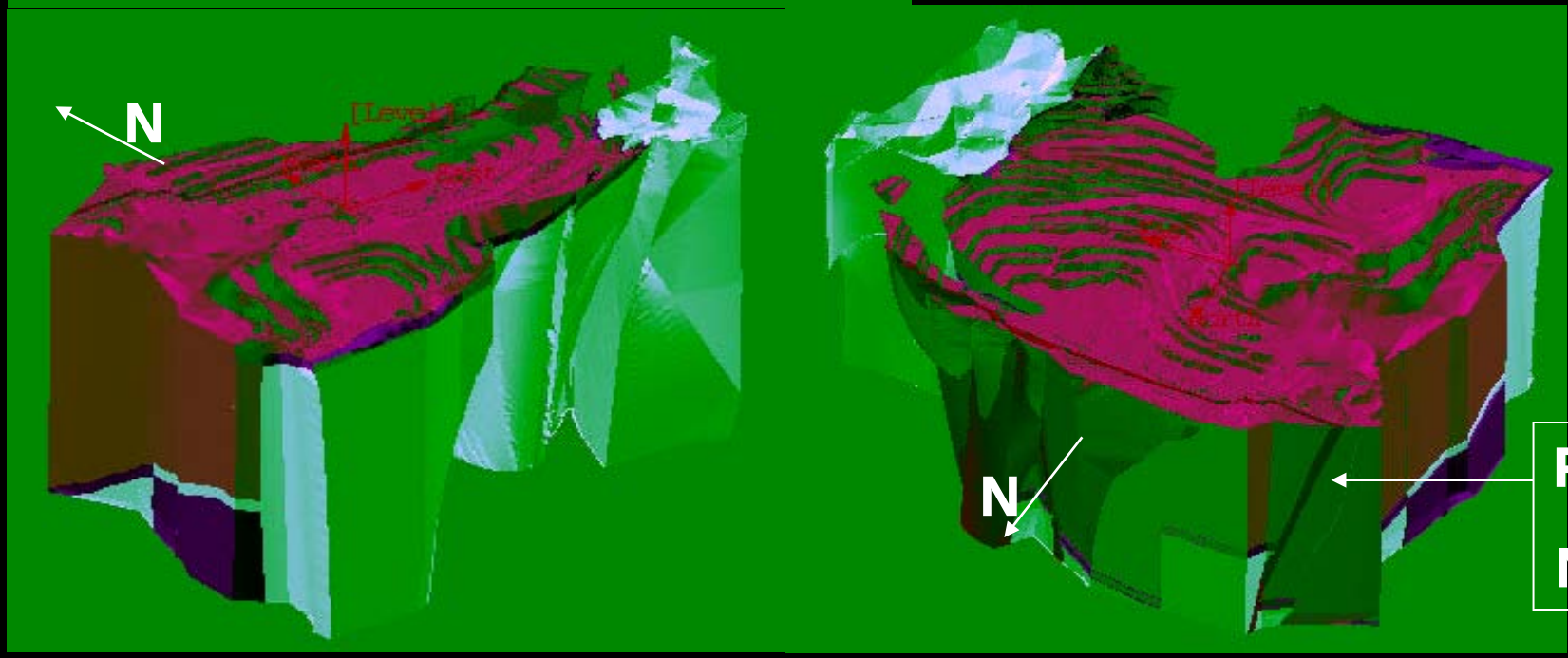
Intercalación de horizontes de caliza laminar y limolitas de la Fm. Pamplona



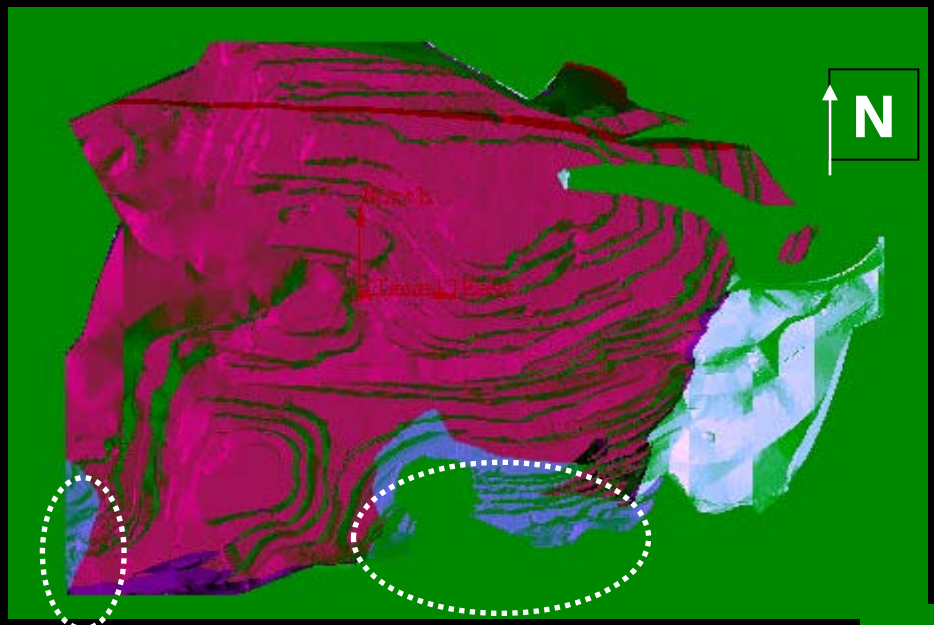




Hornfels, producido por El metamorfismo de las rocas limoarcillosas pre-existentes



Falla Norte

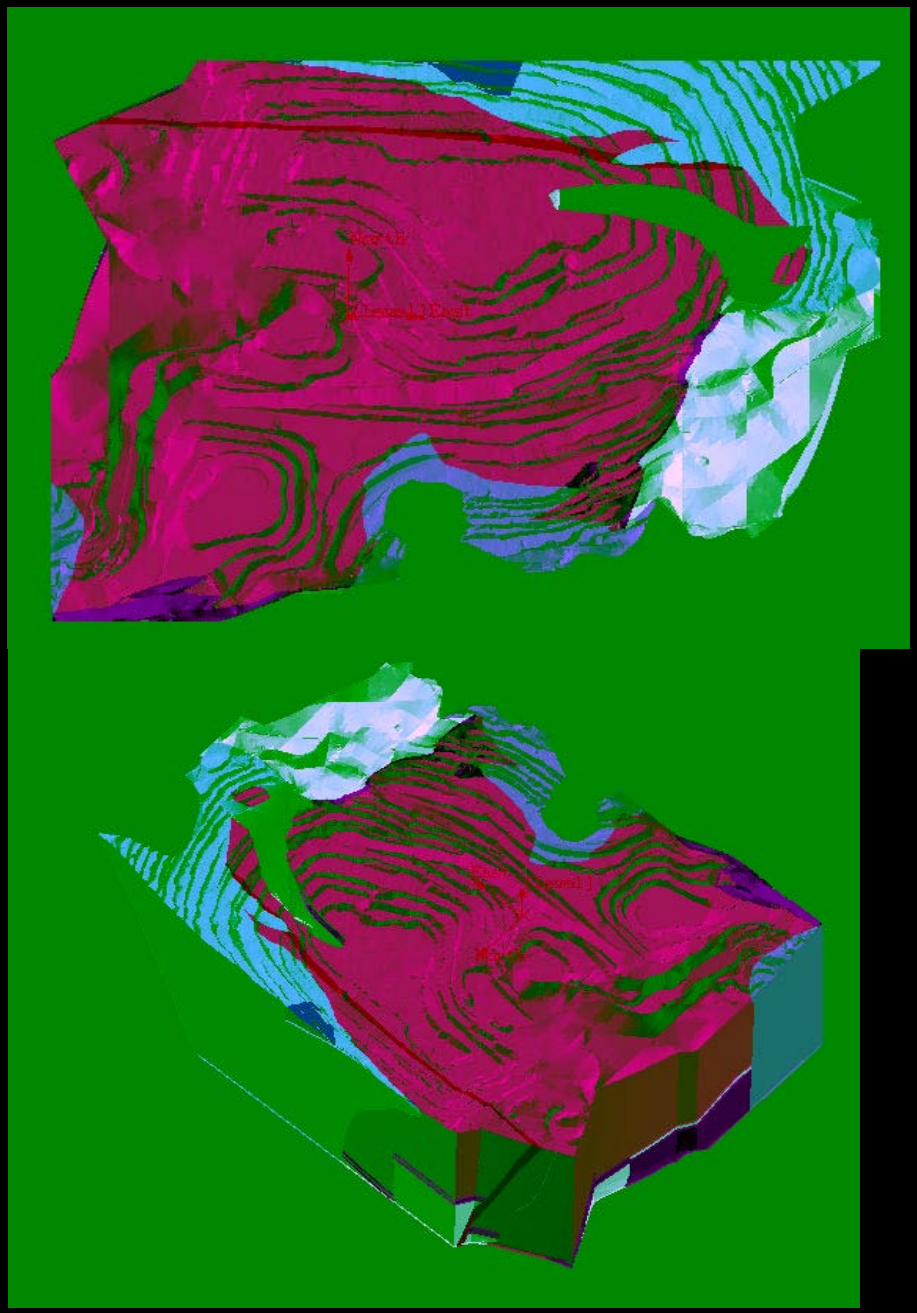


Skarn de piroxenos

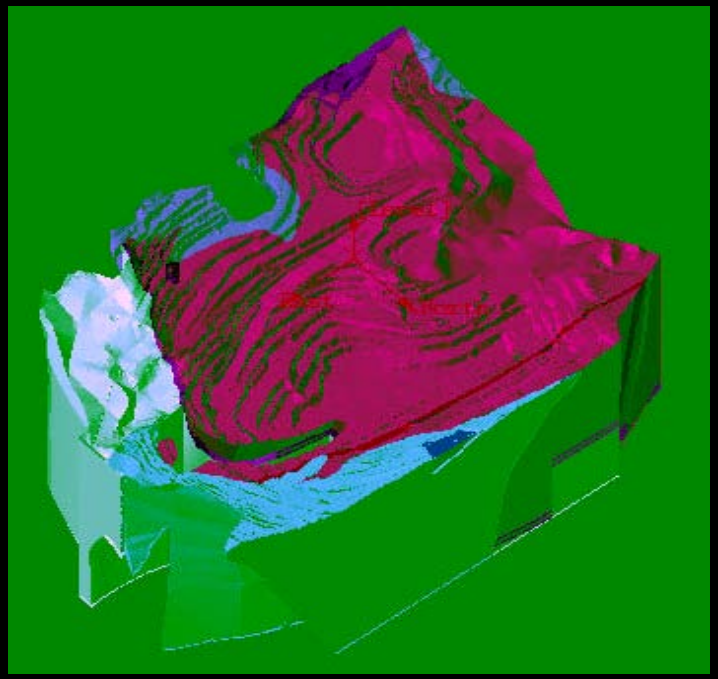
Generado por el contacto

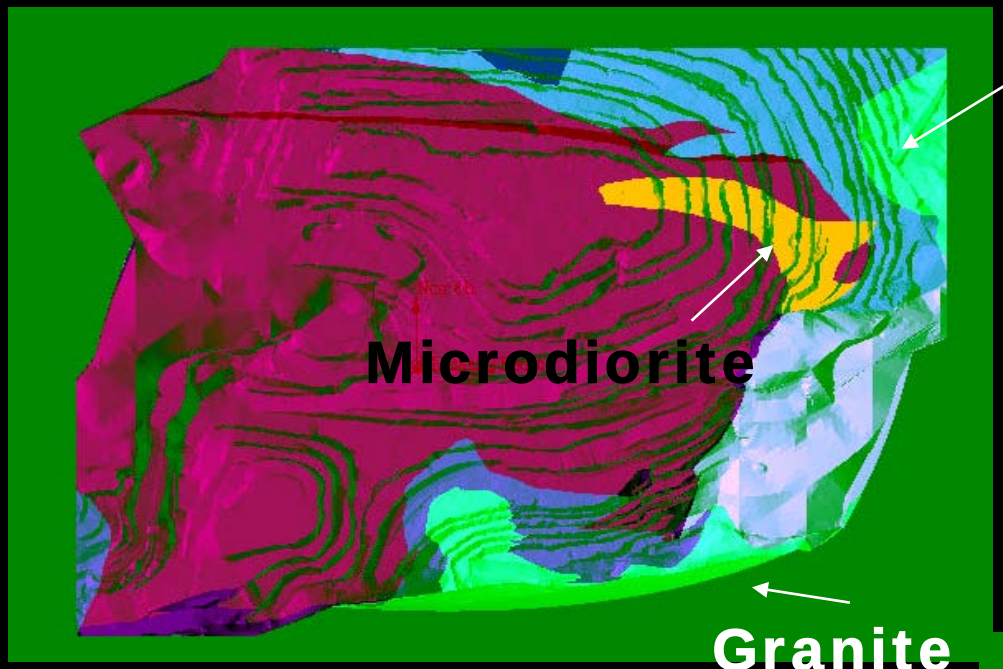
Con intrusivos granitoides

Al sur de la cantera



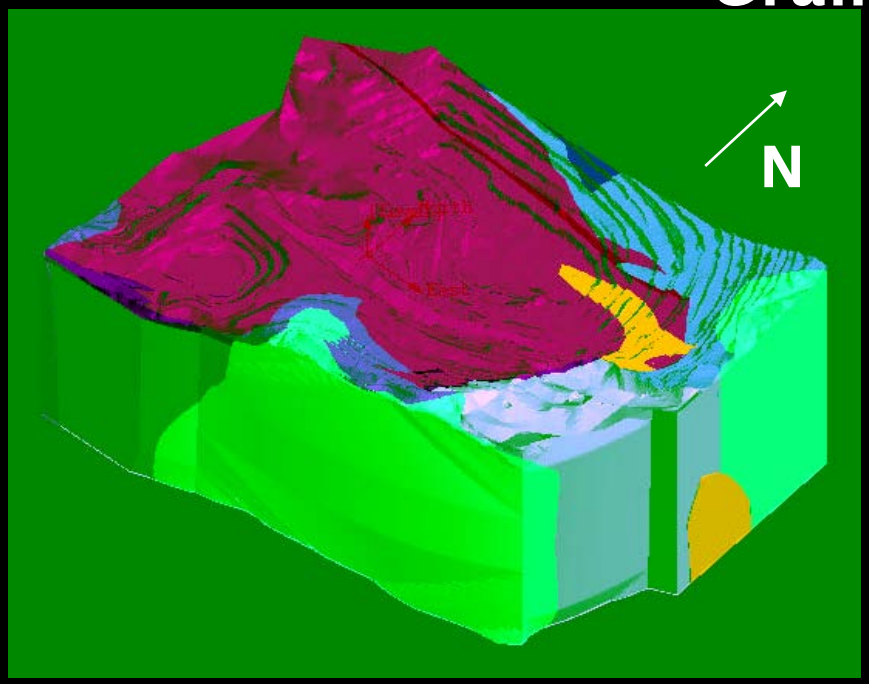
Intrusivos y lavas de composición andesítica,
Se encuentran cortando
Y sobre yaciendo a la
Secuencia sedimentaria
respectivamente

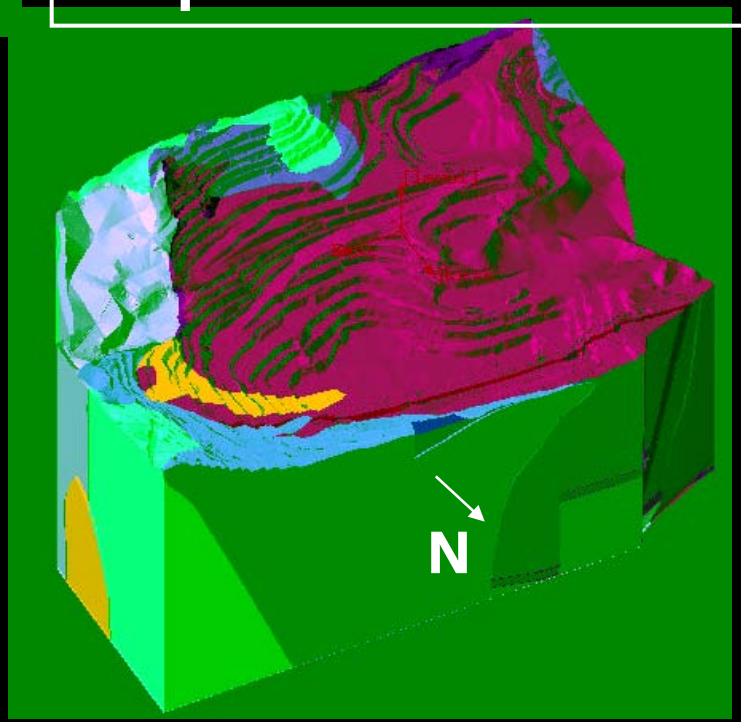


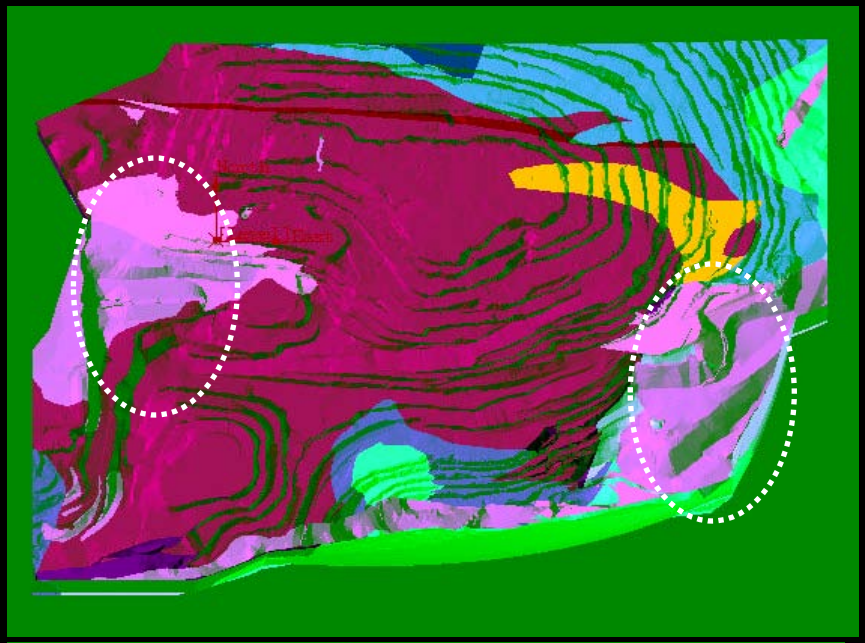


Monzo-granodiorite

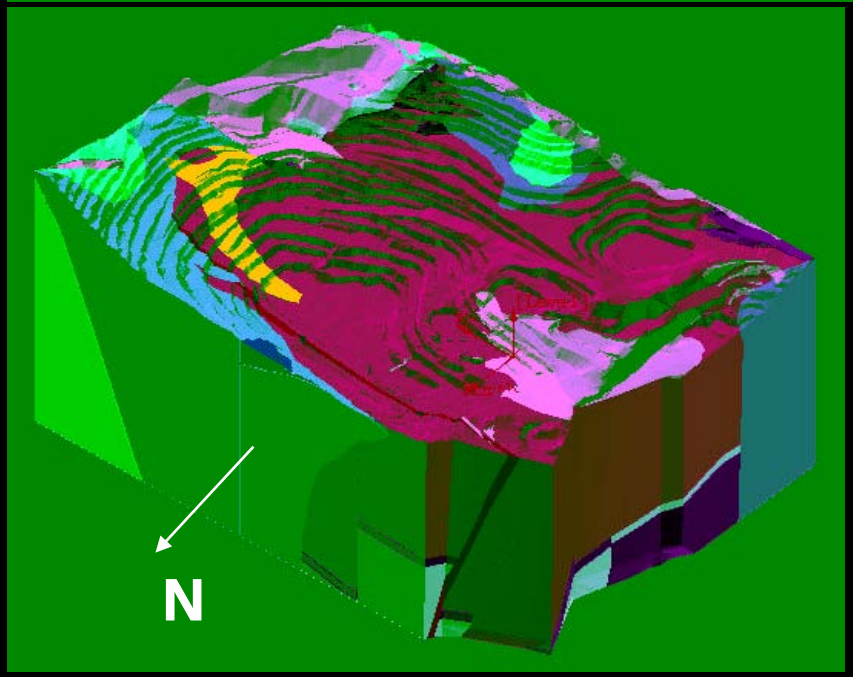
Intrusivos granitoides ,
Se encuentran cortando
Secuencia sedimentaria
Y volcánica
respectivamente

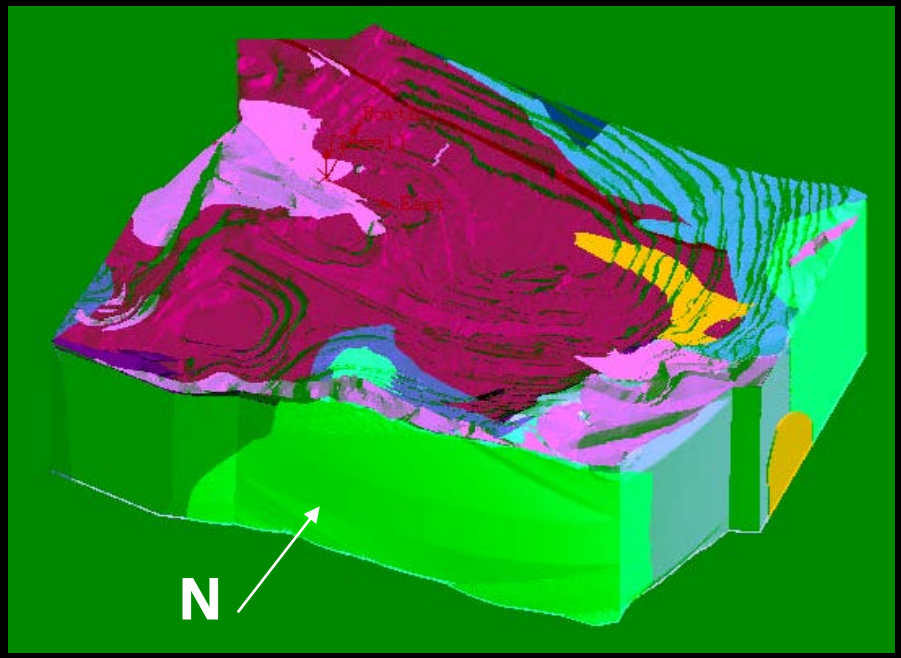




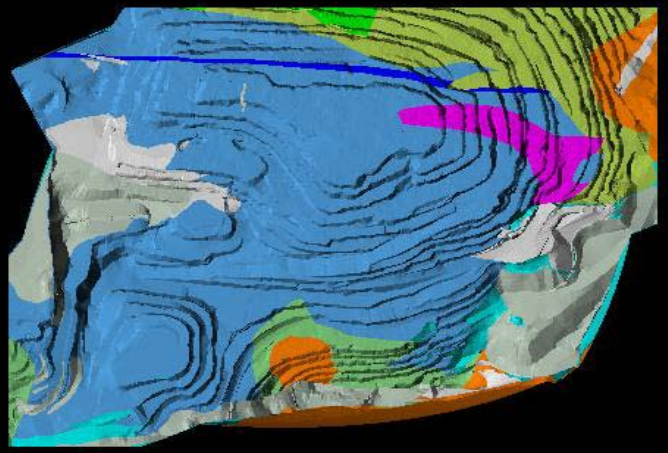


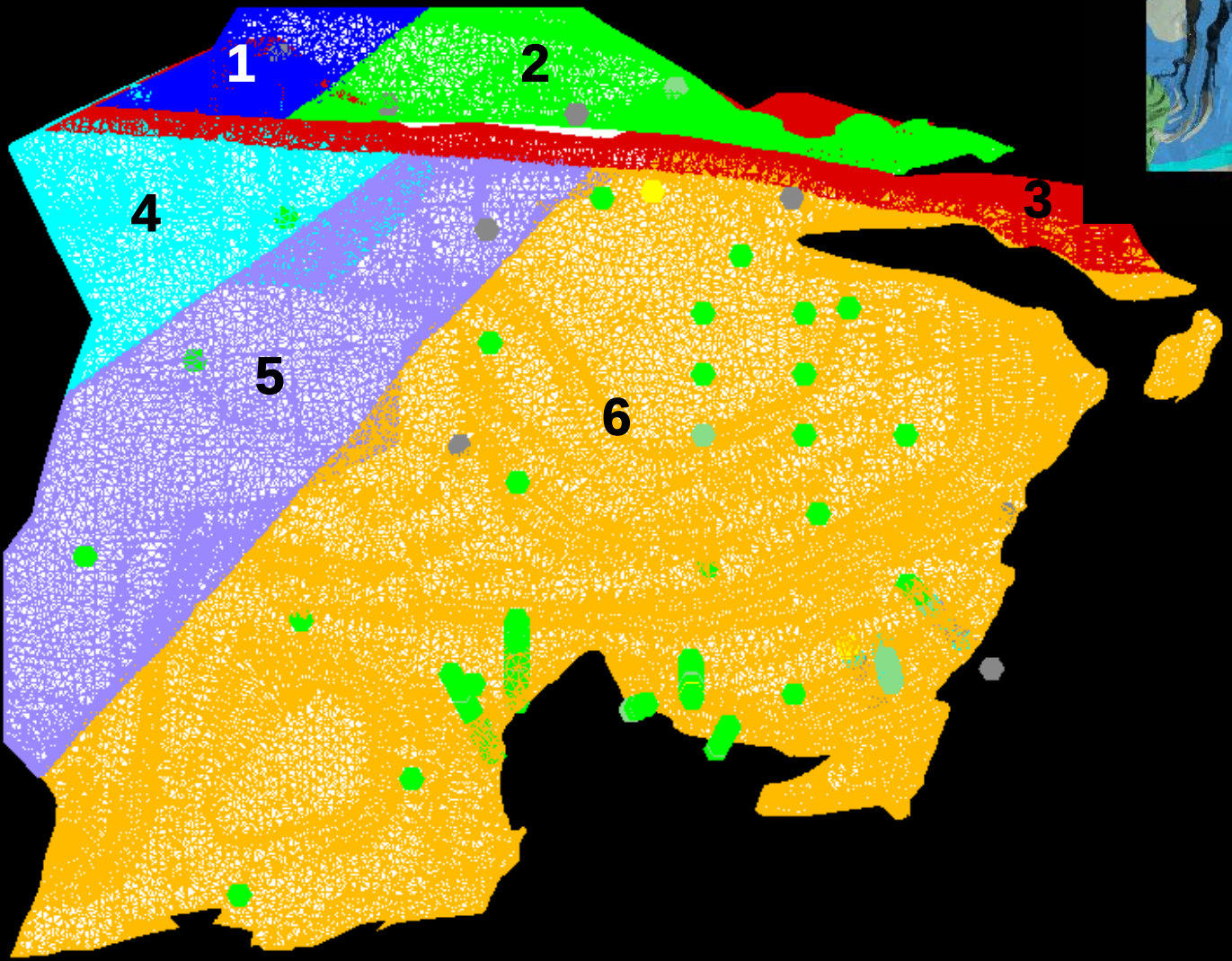
Cuaternario coluvial

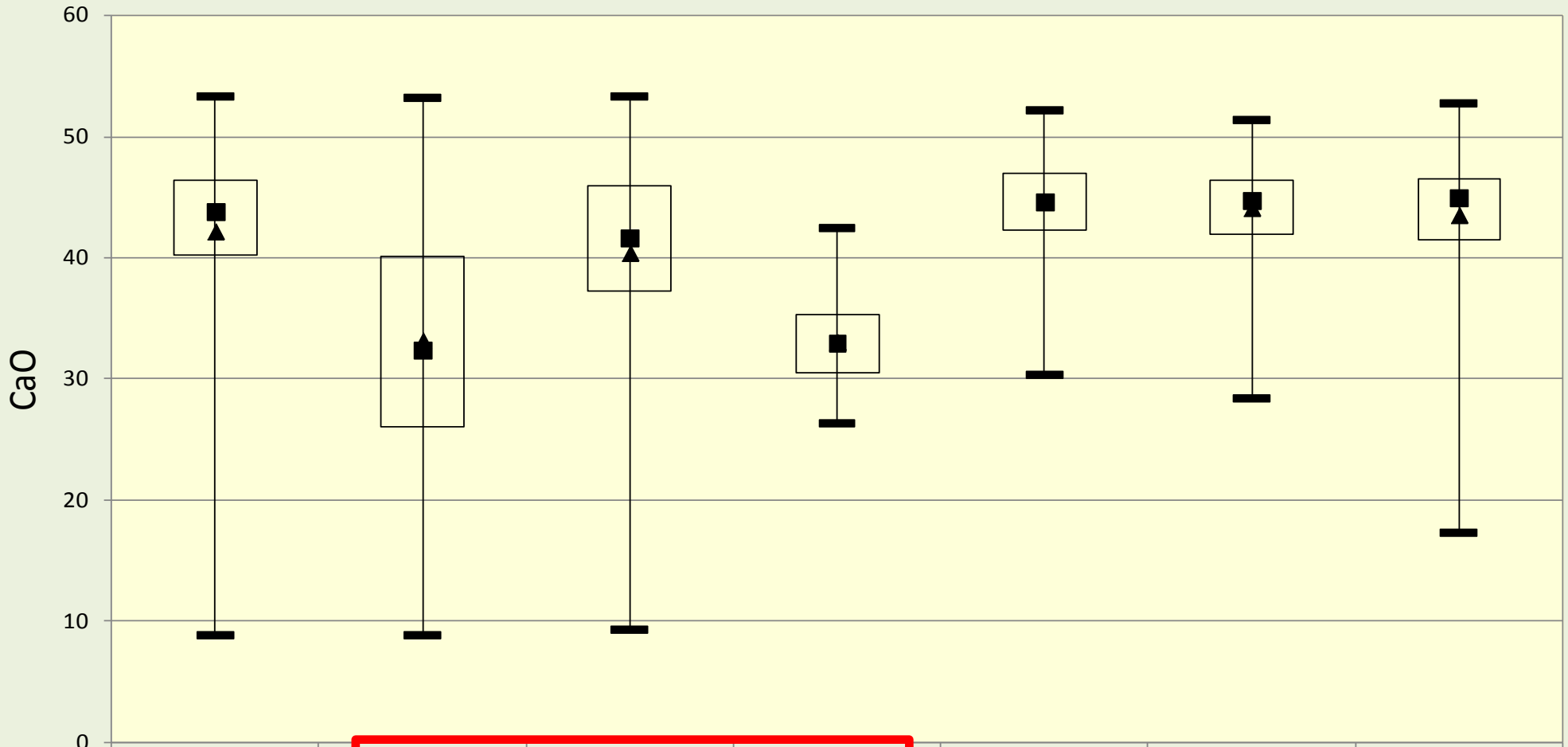




Limestone Atocongo

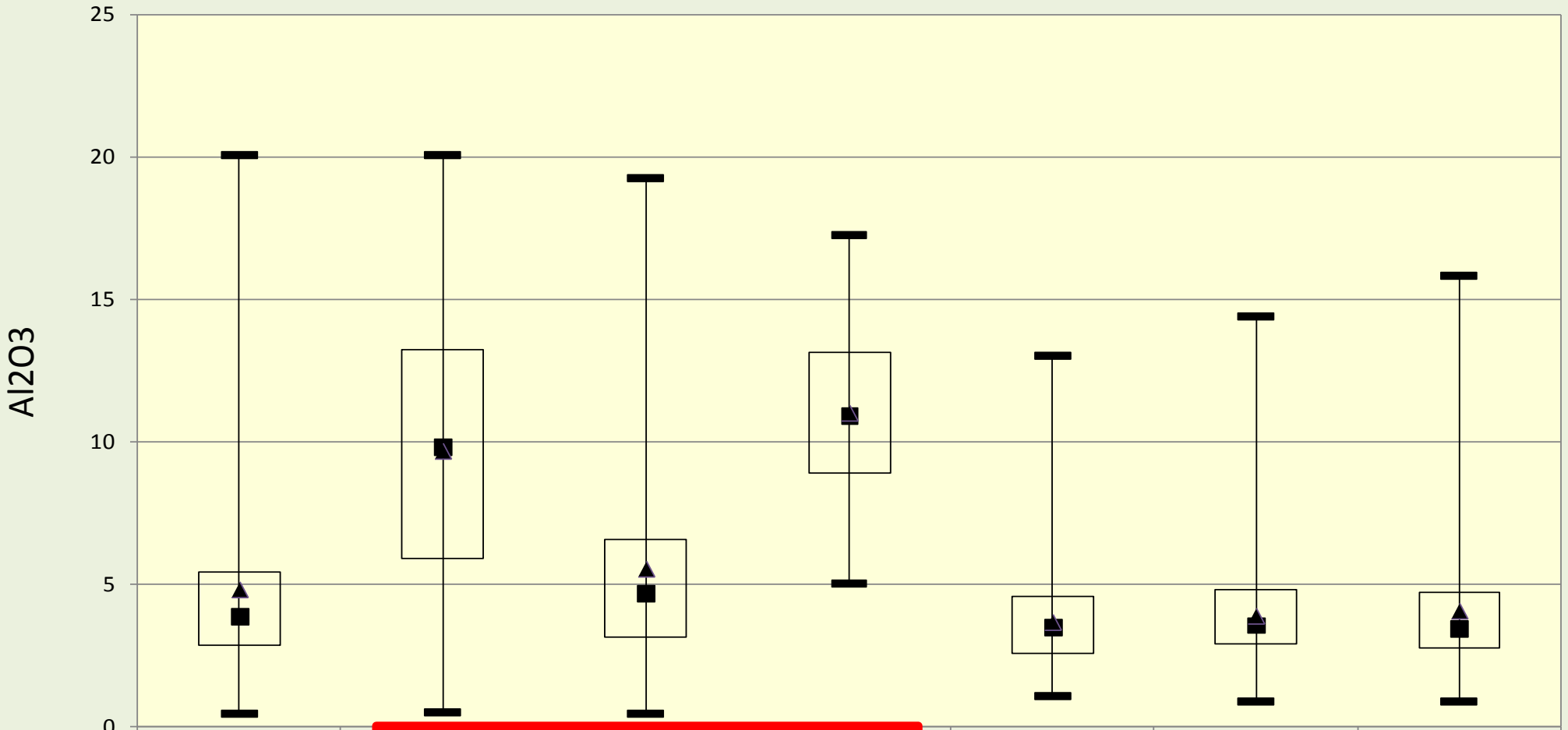






	Todo	1	2	3	4	5	6
Q1	40.2	26.1	37.2	30.5	42.2	41.9	41.5
━ Min	8.8	8.8	9.2	26.4	30.3	28.4	17.3
■ Median	43.8	32.3	41.6	32.9	44.6	44.7	45.0
▲ Mean	42.1	33.2	40.4	33.0	44.6	44.1	43.5
━ Max	53.3	53.2	53.3	42.5	52.2	51.4	52.8
Q3	46.3	40.1	45.9	35.3	46.9	46.4	46.5
NSamples	3454	269	744	41	527	516	1357

Sólido

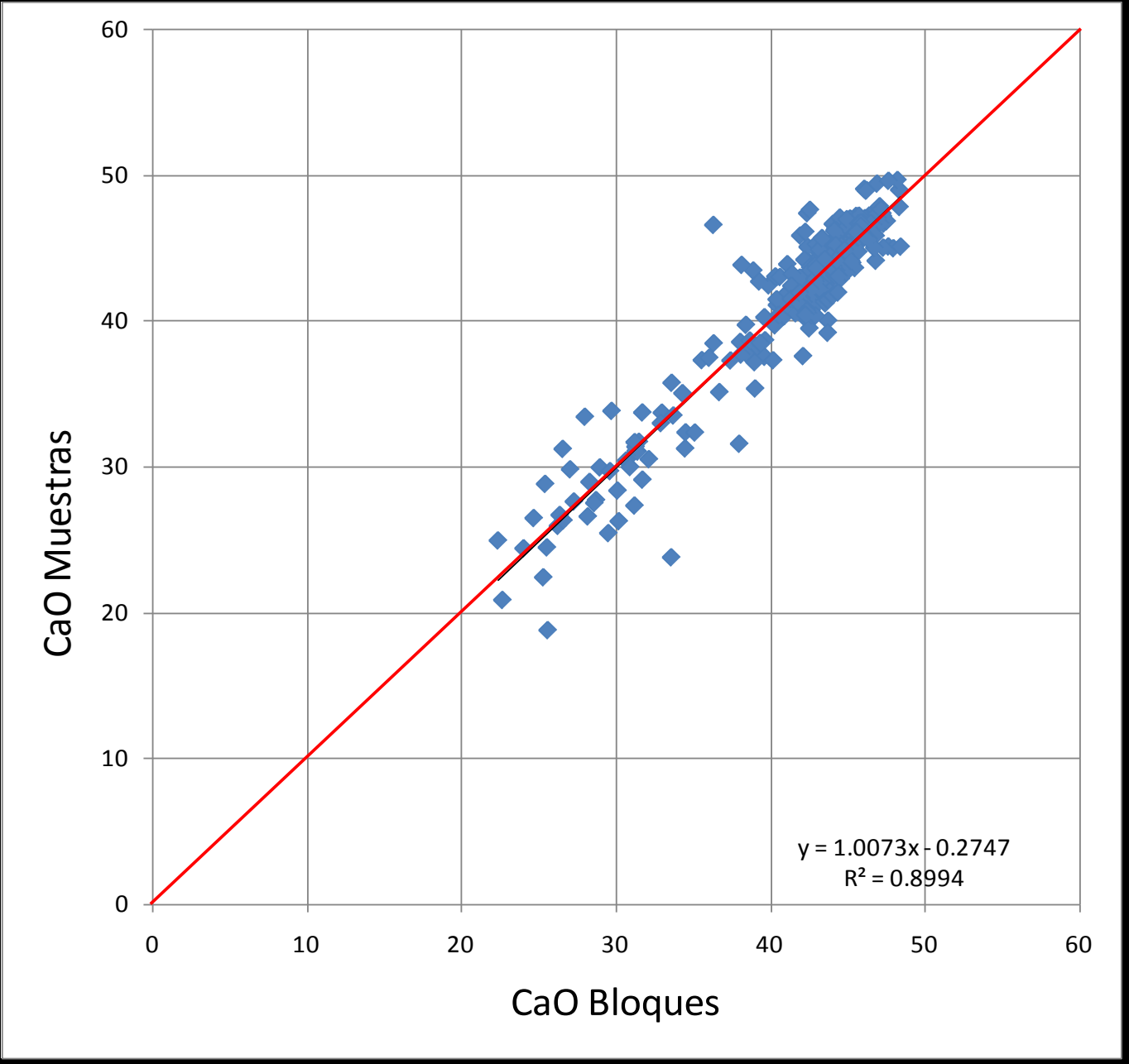


	Todo	1	2	3	4	5	6
Q1	2.900	5.908	3.185	8.907	2.590	2.930	2.787
Min	0.470	0.530	0.470	5.040	1.080	0.890	0.920
Median	3.890	9.850	4.710	10.940	3.510	3.575	3.450
Mean	4.845	9.704	5.569	11.041	3.699	3.919	4.096
Max	20.060	20.060	19.250	17.270	13.030	14.420	15.830
Q3	5.460	13.253	6.580	13.173	4.608	4.830	4.742
NSamples	3454	269	744	41	527	516	1357

Sólido

Atocongo

Scater plot

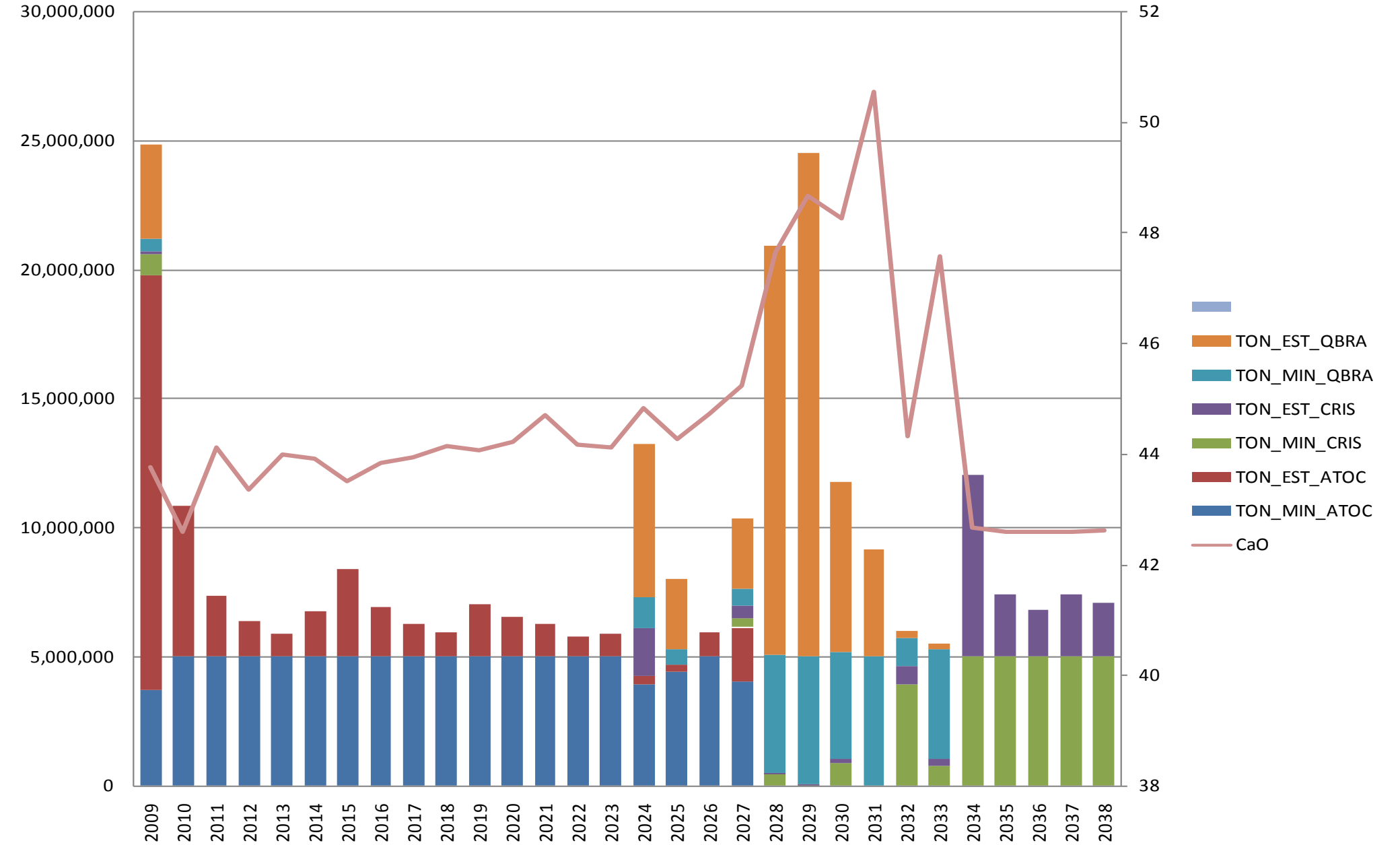


Samples – Model Block

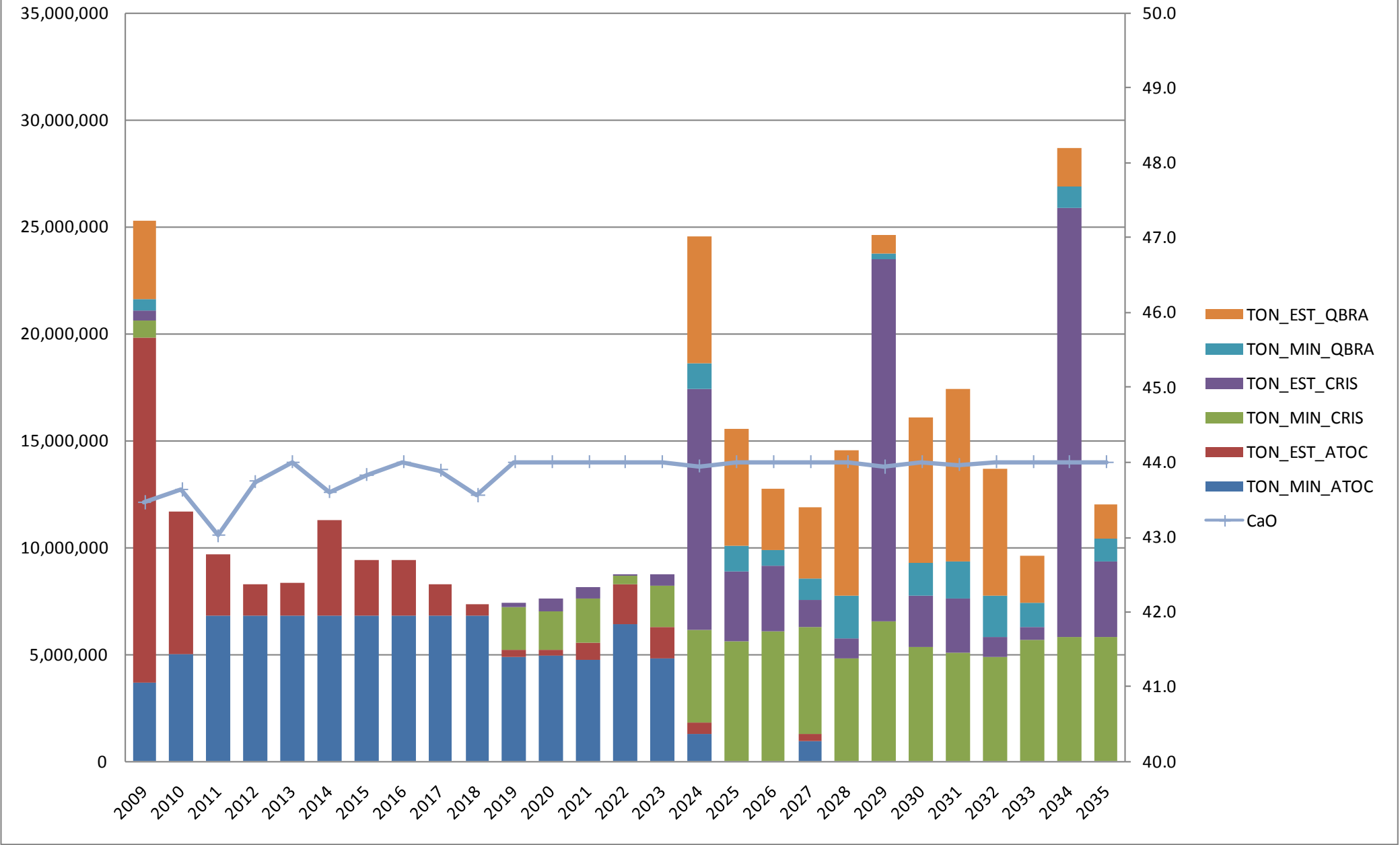
✓ Design and Optimization, Mine Planning (Scenaries)

SCENARY	CONDITIONS
F_1	5 million tonnes/year, low limit CaO 42.6%, minimize mining cost
F1_1	5 million tonnes/year, low limit CaO 42.6%, high limit CaO 43.5%, minimize mining cost
F1_2	5 million tonnes/year, low limit CaO 42.6%, high limit CaO 43.5%, minimize mining cost, Minimum Production Cristina 1 million tonnes/year
F_4	5 million tonnes/year, low limit CaO 42.6%, high limit CaO 43.5%, minimize mining cost, Minimum Production Cristina 1 million tonnes/year and cut off 40.5% CaO
F_5	6.8million tonnes/year, low limit CaO 42.6%, minimize mining cost

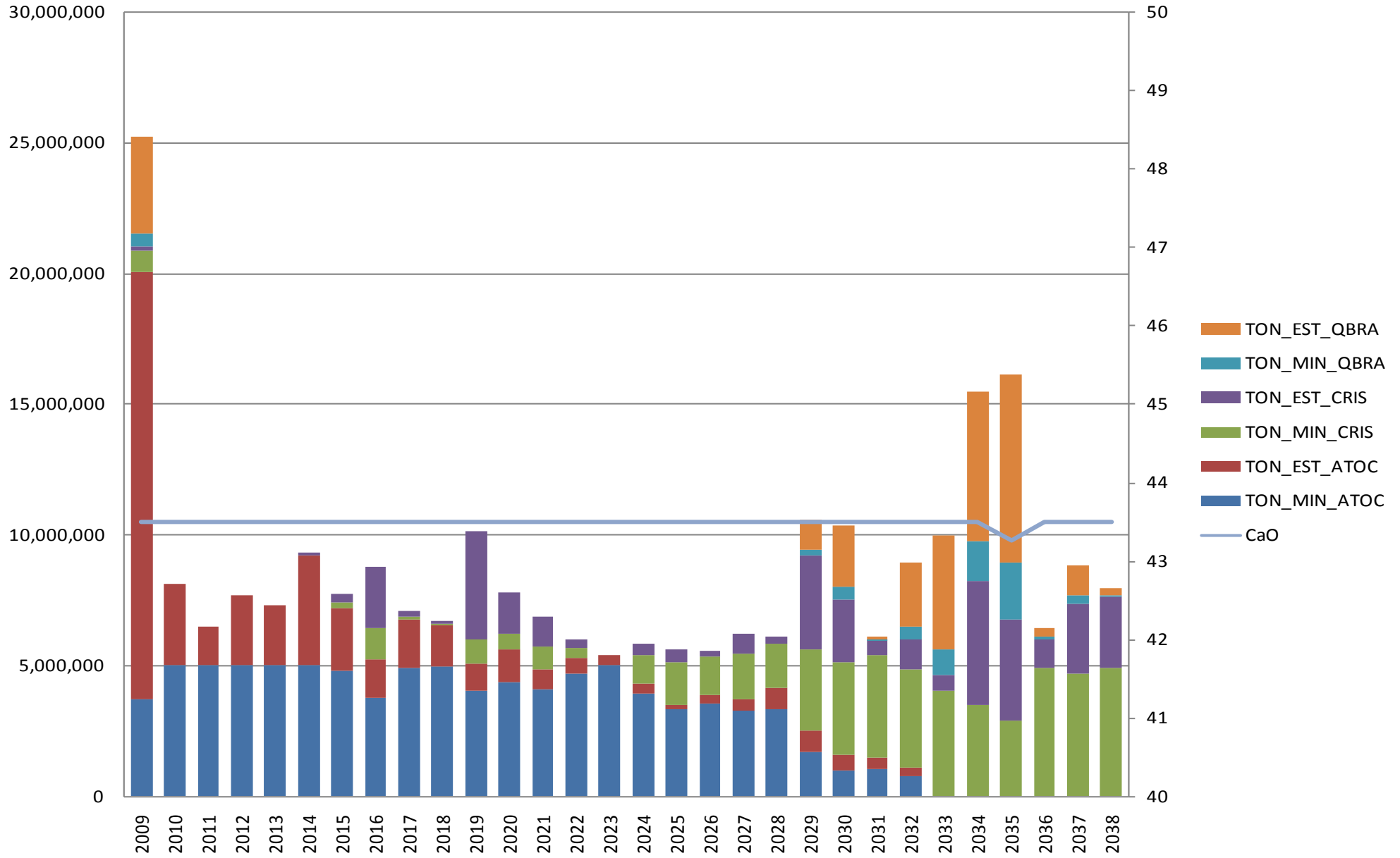
✓ Design and Optimization, Mine Planning (Scenary F_1)



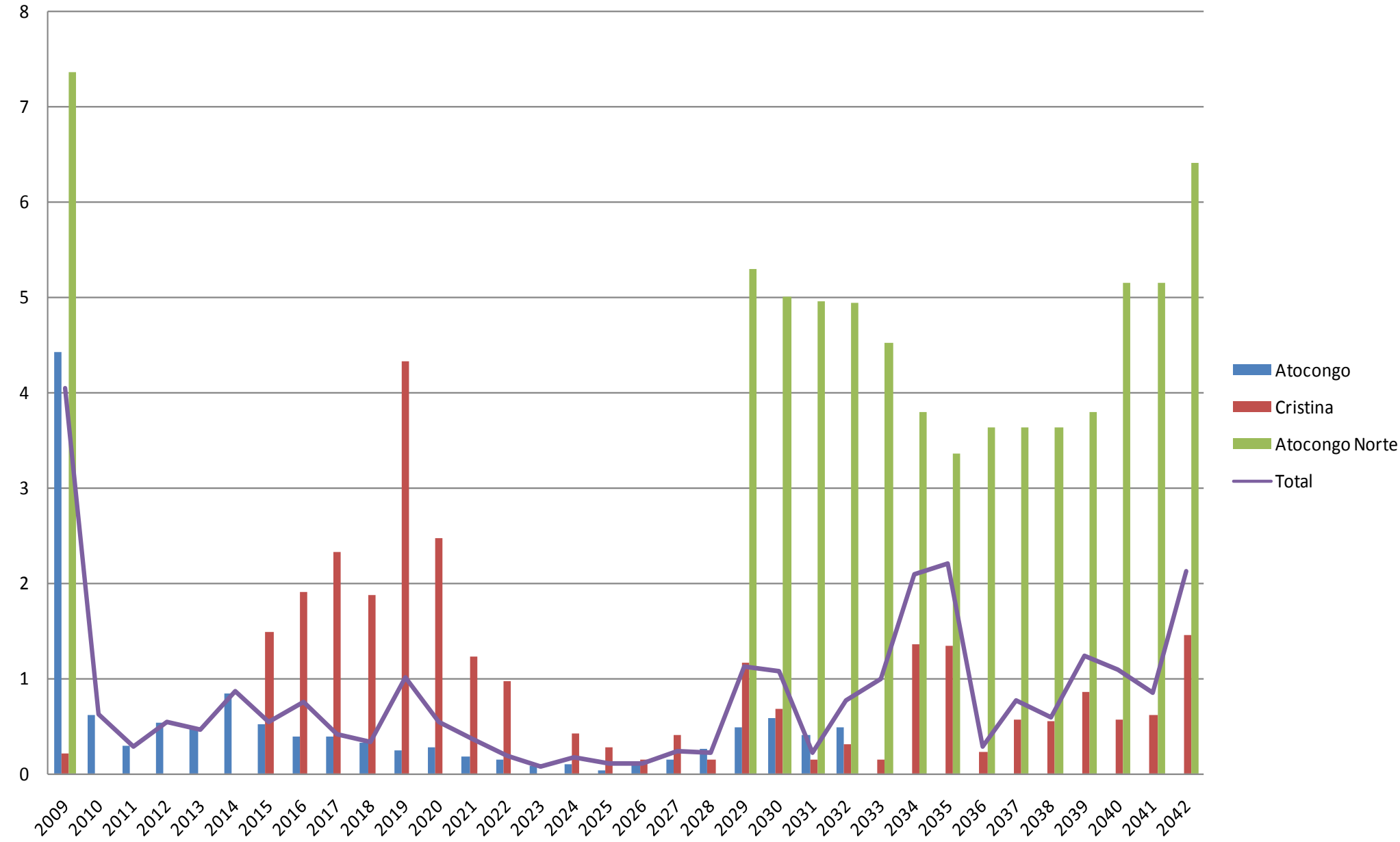
✓ Design and Optimization, Mine Planning (Scenary F_5)



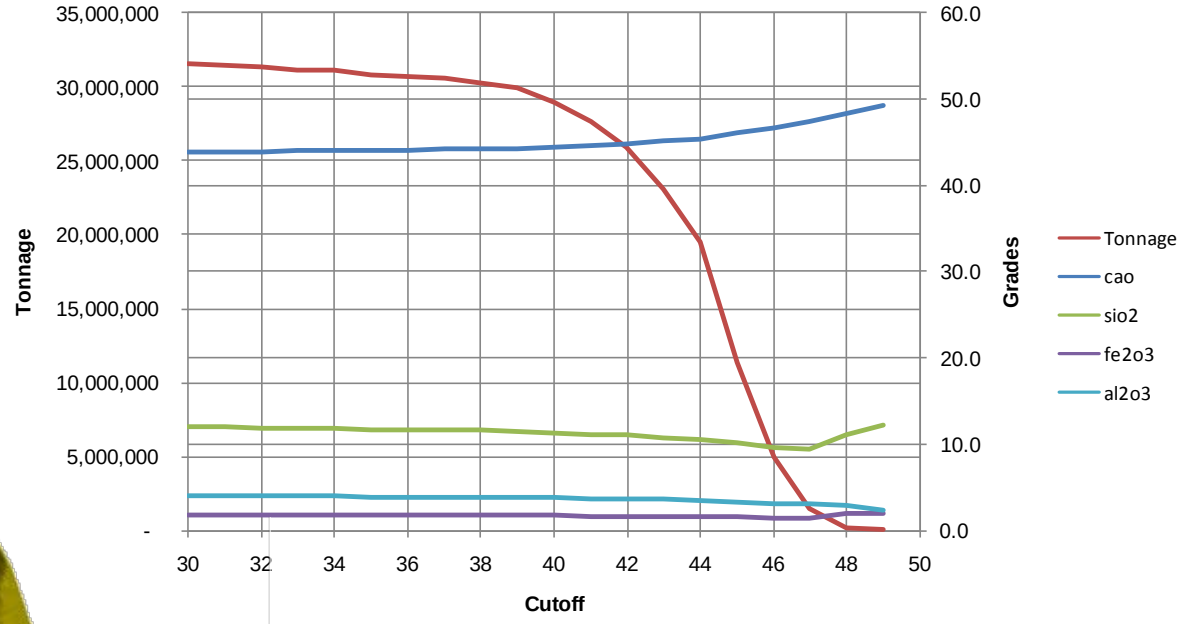
✓ Design and Optimization, Mine Planning (Scenary F1_1)

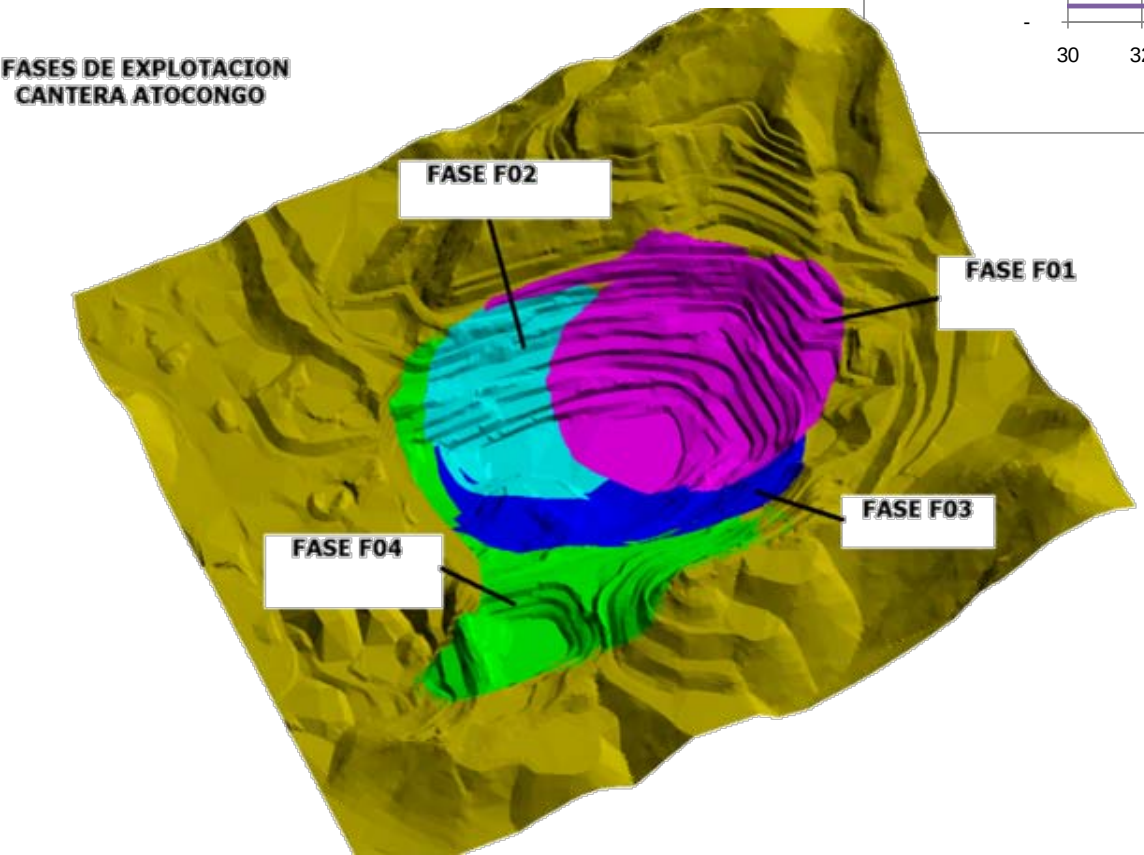


✓ Design and Optimization, Mine Planning (Scenary F1_1)

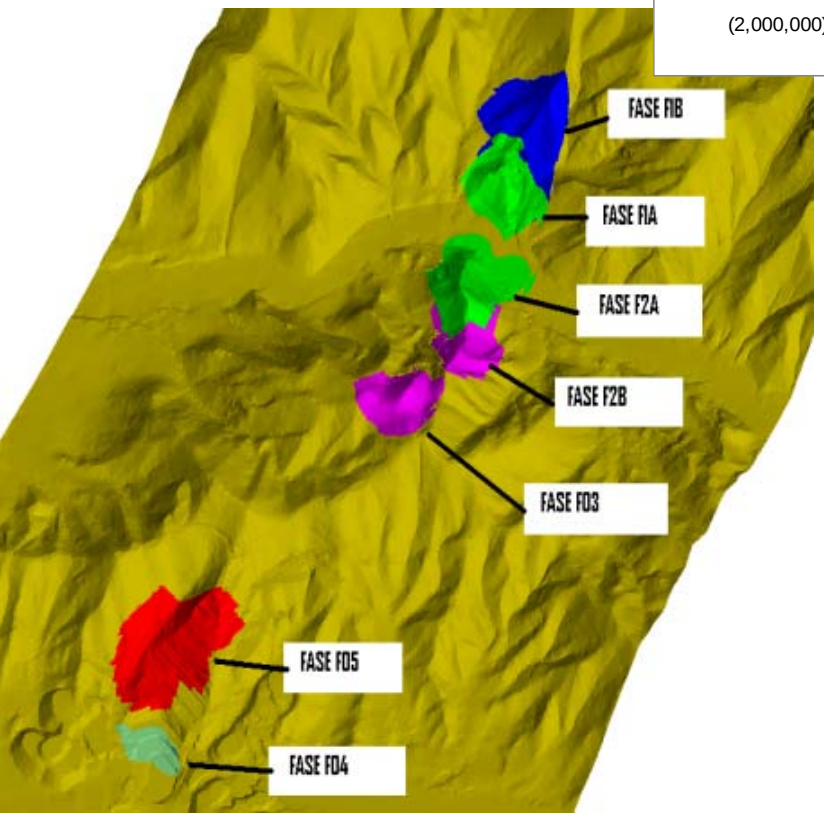


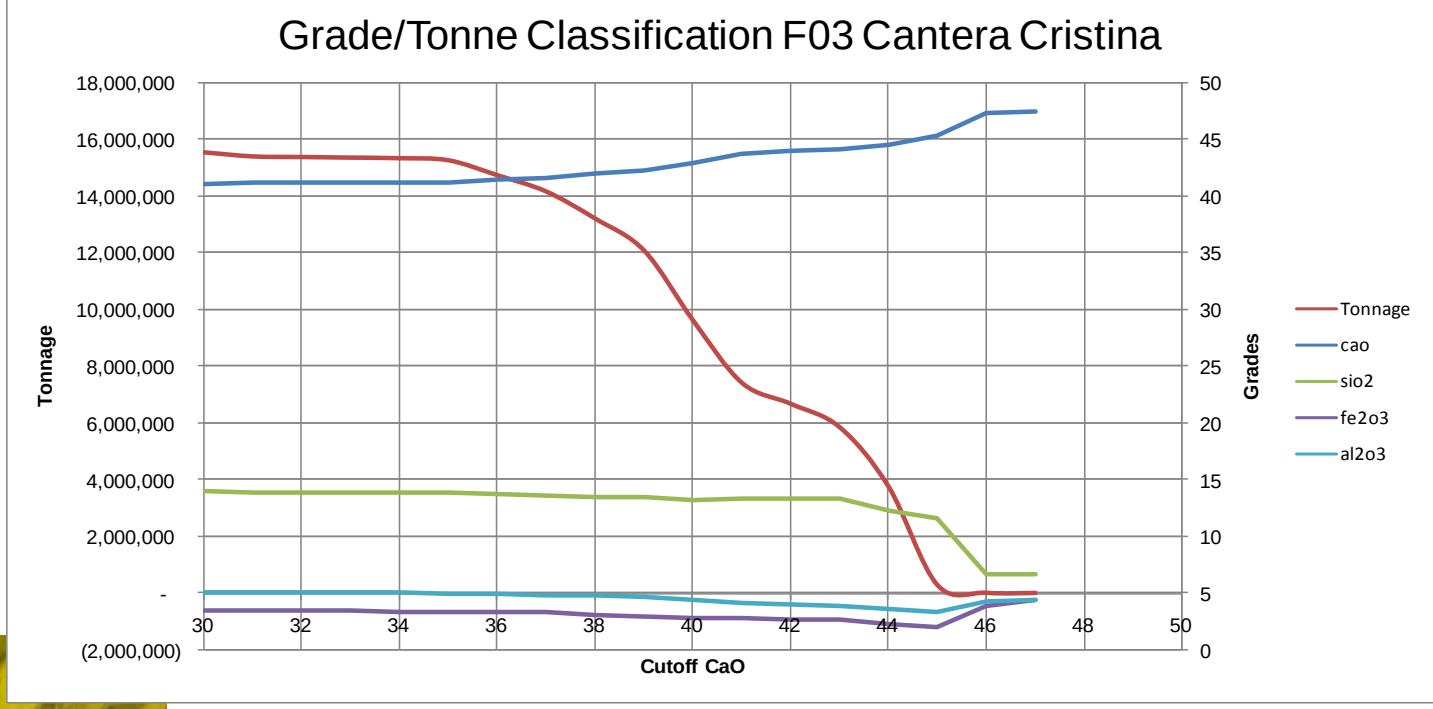
✓ ATOCONGO


Grade/Tonne Classification F04 Cantera Atocongo
35,000,000
30,000,000
25,000,000
20,000,000
15,000,000
10,000,000
5,000,000
-
Tonnage
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Grades
30
32
34
36
38
40
42
44
46
48
50
Cutoff
Tonnage
cao
sio2
fe2o3
al2o3


FASES DE EXPLOTACION
CANTERA ATOCONGO
FASE F02
FASE F01
FASE F03
FASE F04

✓ CRISTINA


FASE FIB
FASE FIA
FASE F2A
FASE F2B
FASE F03
FASE F05
FASE F04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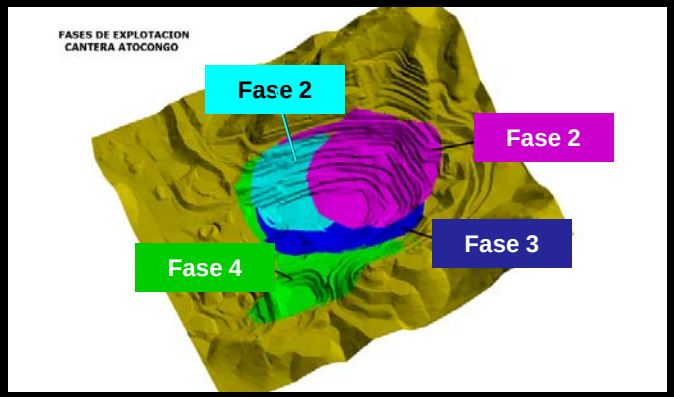
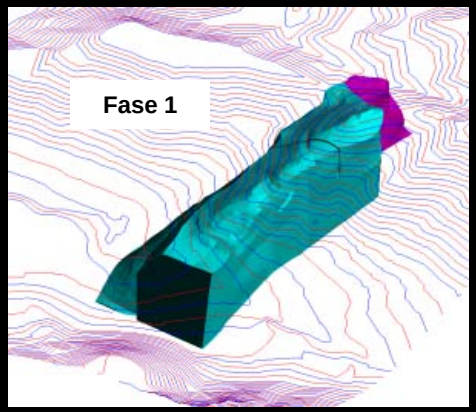
Tonnage
18,000,000
16,000,000
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
-
(2,000,000)
Grades
50
45
40
35
30
25
20
15
10
5
0
30
32
34
36
38
40
42
44
46
48
50
Cutoff CaO
Tonnage
cao
sio2
fe2o3
al2o3

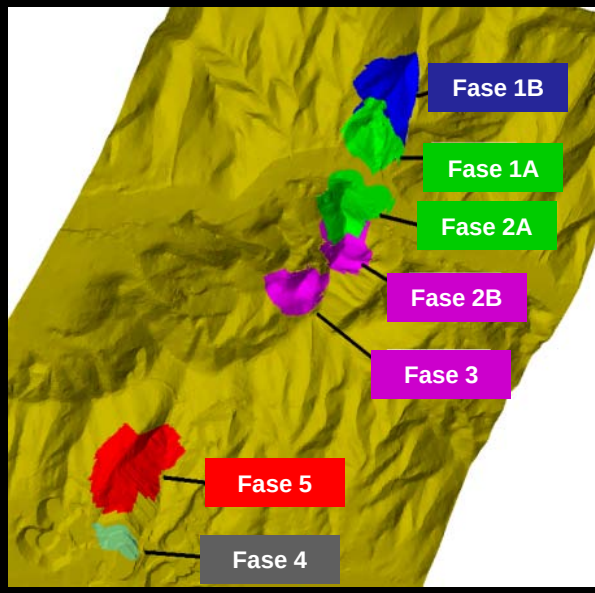
✓ Medium Term Planning

- ✓ Exploration (Gypsum, Iron Ore, Pozzolana), intensive
- ✓ Geological Modelling and Resource Estimation (update, Atocongo Norte)
  - ✓ Kriging (the grade modelling is the same as for long term planning)
- ✓ Environment and RSE (Exploration, Operation)
- ✓ Raw Material 5 years
  - ✓ Design and Optimization, Mine Planning (At, At N)
  - ✓ Contractors (Equipment productivity, fixed term contracts)
  - ✓ Cost

✓ Mining Costs before Primary crusher







Atocongo	US$/Tonne
Limestone	2.85
Waste	2.00
SR	0.50

Atocongo Norte	US$/Tonne
Limestone	2.80
Waste	1.85
SR	4.40

Cristina	US$/Tonne
Limestone	7.65
Waste	2.05
SR	0.75

✓ Short Term Planning

Environment and RSE (Operation)

Raw Material 1 years

- Ore Body Modelling (conciliation, update)
- Design (Atocongo, Atocongo Norte)
- Mine Scheduling (efficiency, profit)
- Contractors (Standards, goals, explosives)
- Blending
- Stock pile

✓ Short Term Planning

Environment and RSE (Operation)

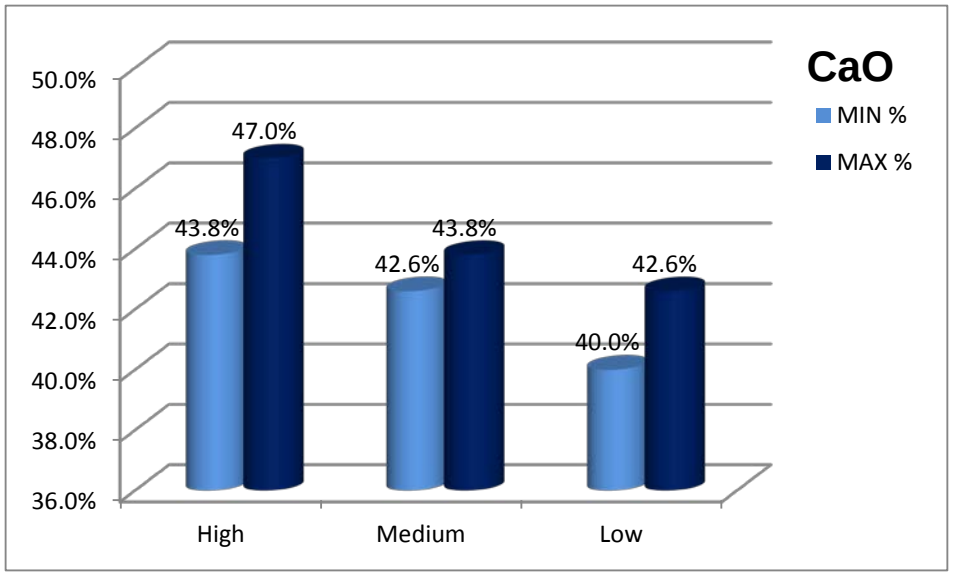
Raw Material 1 years

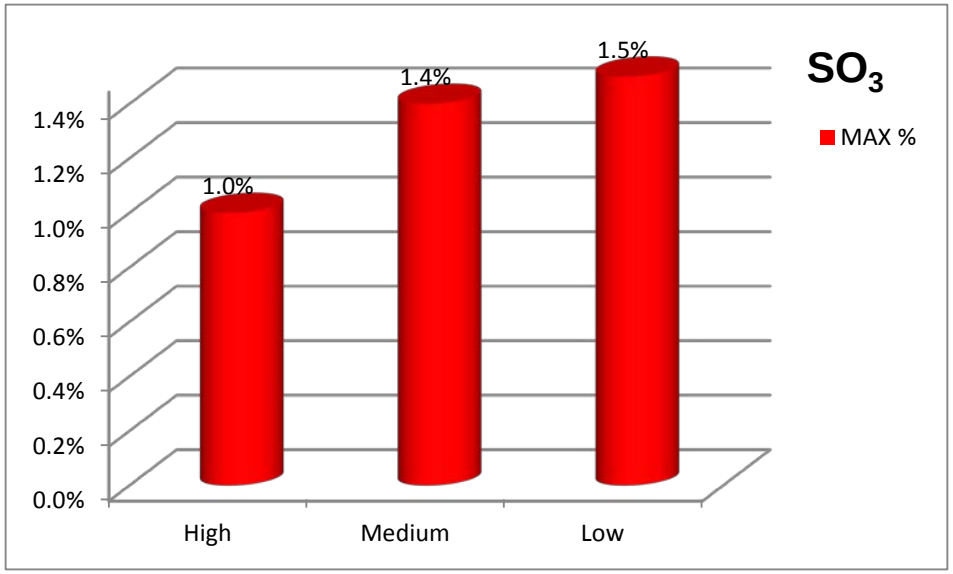
- Ore Control
- Contractors (Standars, explosives)
- Blending
- Stock pile

Name	Hole	Al2O3	AlcTot	CaO	Fe2O3	K2O	MgO	Na2O	SiO2	SO3
3383_148	559	2.75	0.41	46.7	1.19	0.461	2.36	0.107	8.37	1.19
3383_148	560	3.58	0.49	44.5	1.51	0.569	2.24	0.117	10.3	1.21
3383_148	561	2.67	0.4	46.6	1.11	0.451	2.43	0.106	7.94	1.17
3383_148	562	2.76	0.41	46.4	1.19	0.458	2.64	0.107	8.26	1.22
3383_148	563	2.82	0.43	46.2	1.34	0.492	2.57	0.105	8.42	1.39
3383_148	564	2.98	0.45	45.9	1.23	0.517	2.48	0.11	8.78	1.29
3383_148	565	3.05	0.49	45.8	1.4	0.572	2.47	0.111	8.92	1.43
3383_148	566	2.87	0.45	46.1	1.32	0.522	2.29	0.108	8.18	1.37
3383_148	567	2.73	0.38	46.2	1.36	0.415	3.12	0.102	7.75	1.43
3383_148	568	2.86	0.41	45.9	1.42	0.458	3.04	0.106	8.11	1.39
3383_148	569	2.86	0.45	45.9	1.25	0.512	2.64	0.109	9.06	1.19
3383_148	570	3.52	0.5	44	1.61	0.592	2.84	0.115	10.8	1.42
3383_148	571	3.21	0.49	45.4	1.4	0.565	2.45	0.114	9.19	1.24
3383_148	572	3.46	0.47	44.3	1.59	0.565	3.36	0.103	9.77	1.33
3383_148	573	2.99	0.45	46.1	1.23	0.52	2.48	0.109	8.81	1.29
3383_148	574	2.78	0.41	46.6	1.19	0.458	2.36	0.107	8.38	1.17
3383_148	575	3.61	0.49	44.6	1.52	0.568	2.25	0.114	10.5	1.19
3383_148	576	2.71	0.4	46.8	1.12	0.446	2.42	0.103	8.04	1.18
3383_148	577	2.85	0.41	46.4	1.19	0.458	2.61	0.107	8.34	1.22
3383_148	578	3.88	0.57	43.5	1.71	0.705	2.75	0.111	10.9	1.3
3383_148	579	3.53	0.51	44.5	1.51	0.61	2.64	0.111	9.94	1.4
3383_148	580	2.45	0.37	47	1.11	0.407	2.86	0.099	7.28	0.902
3383_148	581	2.87	0.41	45.9	1.42	0.456	3.02	0.105	8.11	1.38
3383_148	582	2.76	0.38	46.6	1.38	0.419	3.1	0.104	7.94	1.42
3383_148	583	2.93	0.45	45.9	1.32	0.52	2.28	0.109	8.41	1.36
3383_148	584	3.09	0.48	45.3	1.39	0.563	2.48	0.11	9.01	1.41
3383_148	585	2.84	0.43	46.1	1.33	0.485	2.52	0.108	8.36	1.38
3383_148	586	2.84	0.44	45.7	1.25	0.509	2.61	0.108	9	1.2
3383_148	587	3.51	0.51	44.5	1.52	0.61	2.63	0.111	9.94	1.41
3383_148	588	3.94	0.57	43.3	1.71	0.7	2.71	0.114	11.2	1.31
3383_148	589	3.22	0.48	45.2	1.39	0.558	2.4	0.116	9.32	1.22
3383_148	590	3.5	0.48	44.3	1.6	0.563	3.3	0.107	9.92	1.33
3383_148	591	3.55	0.5	43.9	1.6	0.588	2.79	0.118	10.9	1.42

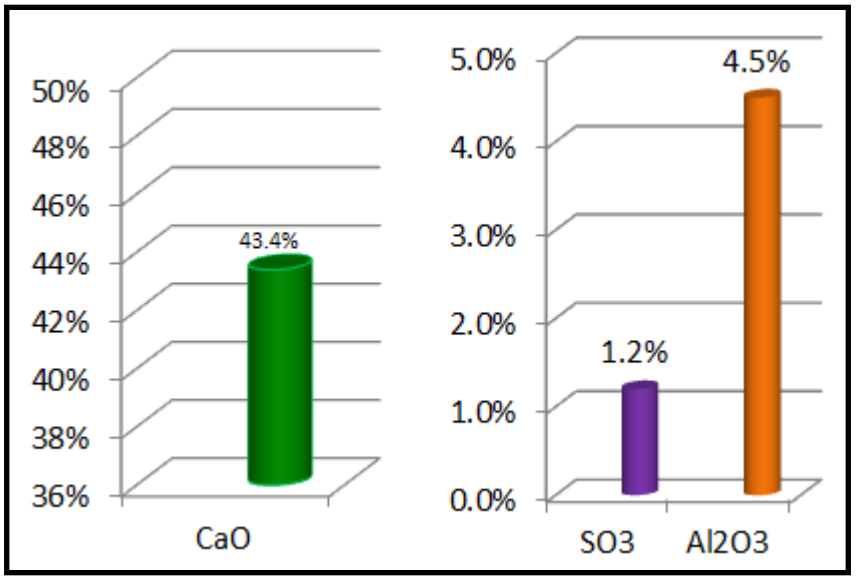
CEMENTOS LIMA

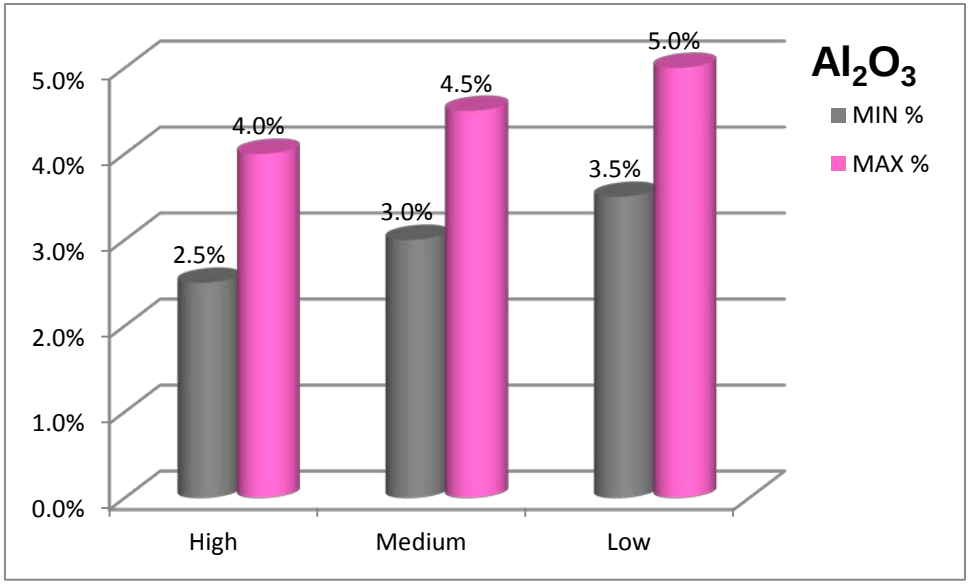
Limestone (Atocongo)





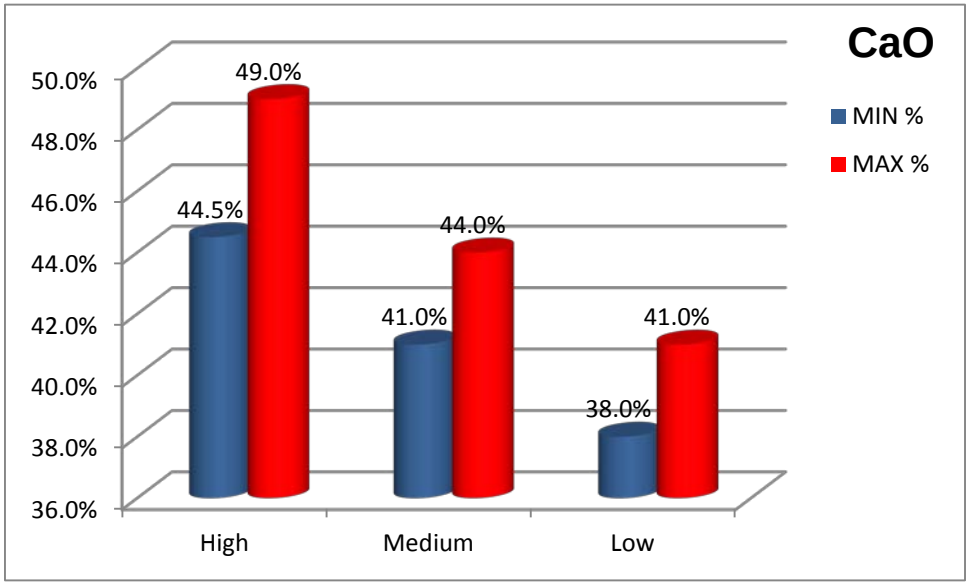
RAW MIX





CEMENTOS LIMA

Limestone (Cristina)



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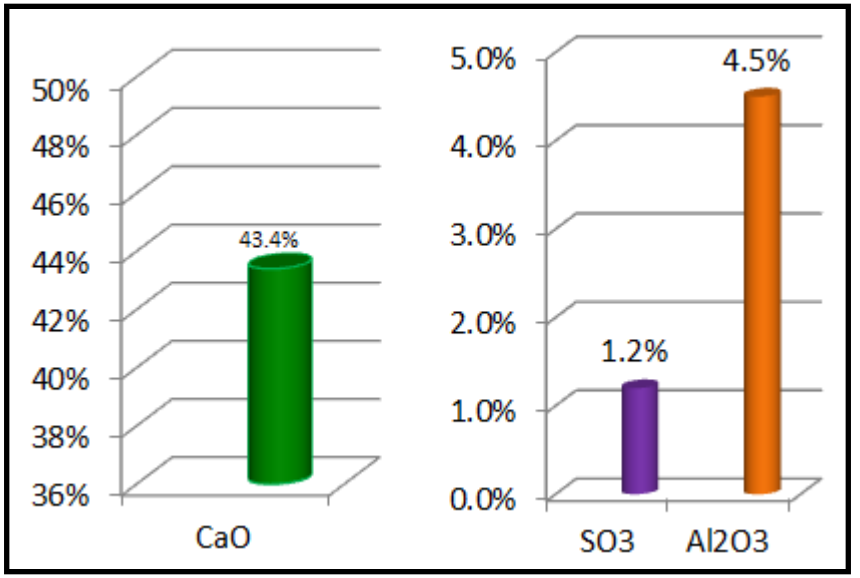

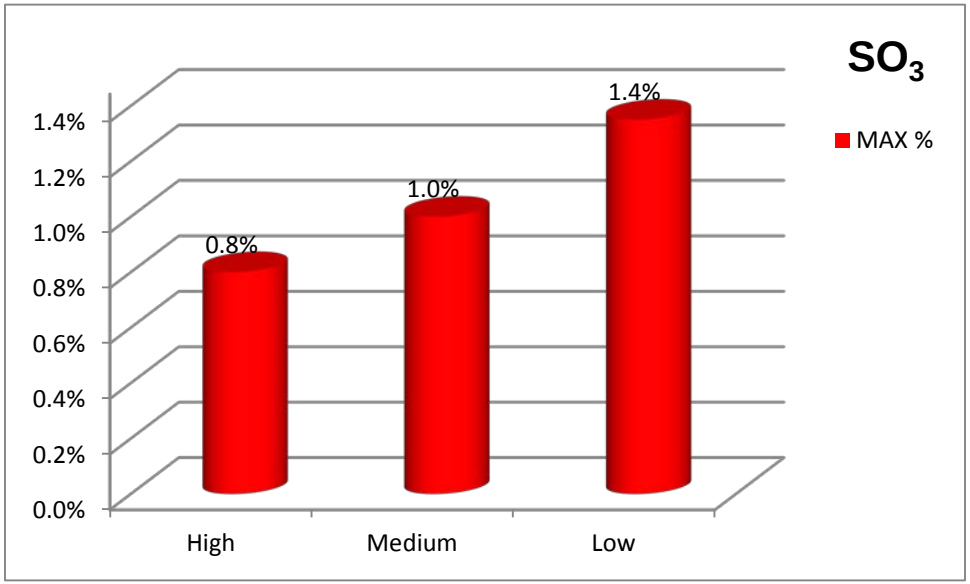

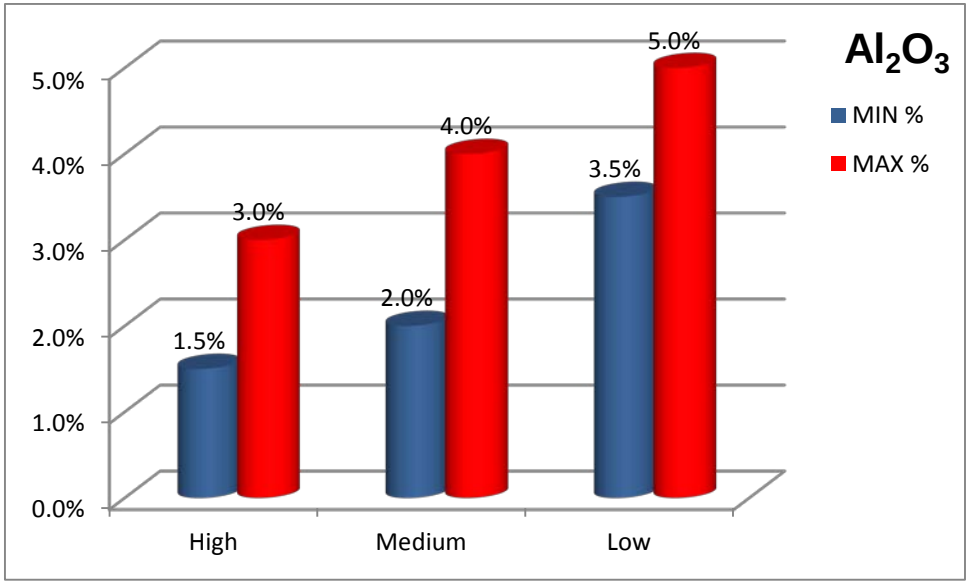

Orebody Modelling and Mine Planning at a Cement Plant in Peru

Presented by: Julio Villon, Eng