

## MODULE 9 ZINC MINING IN MEXICO

## Summary

Several mines are overcoming operational issues in 2015/2016 but this is essentially negated by poor 2016 production performance at Goldcorp's Peñasquito mine. As illustrated in Table 1, production should increase markedly in 2017 assuming all mines return to normal operations. New production should be expected in 2017/2018 from ramp ups commencing at Peñoles's Rey de Plata mine, Fresnillos's San Julian mine and Americas Silver San Rafael mine. The Fresnillo mine is moving into higher zinc grade ore.

Typical Zn + Pb grades are generally less than 4% so most mines rely upon precious metals and copper by-products and/or high throughput to remain viable. The net result of this is that there are very few mines that will benefit in a huge way with a zinc price run up. They have been viable due to previous low zinc price leverage but conversely they will not benefit much at higher prices either. Americas Silver is the only small miner about to become more leveraged to zinc but the current market capitalization suggests limited upside and as Nevsun experienced in the past, the precious metal premium in stock prices disappears when shareholders realize they have an unsexy base metal miner in their portfolio instead.

Table 1 Summary of Zinc Mine Production for Mexico, Actual and Forecast

Company	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Goldcorp	174000	150000	179000	209000	134000	200600	200600	200600	200600	200600	200600
Peñoles	158478	194492	238308	219116	233990	224000	244000	264000	264000	264000	264000
Fresnillo	24928	24882	31700	46022	53000	68000	85000	87000	87000	87000	87000
Sth. Copper	89766	99434	70289	65736	86900	100910	100910	100910	100910	103910	107910
Min. Frisco	70250	63675	58913	72000	72000	72000	72000	72000	72000	72000	72000
1 <sup>st</sup> Majestic	2246	3054	5724	7949	5700	5000	5000	5000	5000	5000	5000
Gr. Panther	1478	1673	1675	1850	1600	1800	1800	1800	1800	1800	1800
P.Am. Silver	5600	7700	8910	9700	9500	16000	16000	16000	16000	16000	16000
Gold Res.	5600	6760	13195	13900	12900	13000	13000	13000	13000	13000	13000
Americas S.	7470	6600	5730	5283	4750	5000	10000	16000	18000	18000	18000
Capstone	7811	8085	6509	5860	4200	5000	6000	6000	9000	9000	9000
Excellon	4750	4500	4550	3350	2600	3000	0	0	0	0	0
Other	107972	71687	35375	27980	30000	30000	30000	30000	30000	30000	30000
<b>Total</b>	<b>660349</b>	<b>642542</b>	<b>659878</b>	<b>687746</b>	<b>651140</b>	<b>744310</b>	<b>784310</b>	<b>812310</b>	<b>817310</b>	<b>820310</b>	<b>824310</b>

**Other:**

**2012-2014** includes past producers now closed (Peñoles' Naica and Nyrstar's Campo Morado), small miners and statistical differences between government and company reported figures.

**2015-** includes small miners and statistical differences between government and company reported figures.

**2016-2022-** includes small miners only. It is assumed Naica and Camp Morado remain closed during the study period.

**Total:**

**2012-2015** Government statistics from Cámara Minera de México.

**2016-2022** Derived by adding forecast mine production to small miner output provision.

Table 2 summarizes the zinc mine supply for the countries reviewed in various Modules to date. As illustrated, zinc production will not return to 2015 levels during the study period cumulatively for the countries reviewed to date.

**Table 2 Summary of Actual and Expected Mined Zinc Production for Countries Reviewed to Date**

Mod.	Country	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
2	Canada	622.6	412.8	332.5	295.6	316.1	332.0	320.0	319.0	264.0	160.0	105.0
3	USA	738.0	774.0	812.0	817.0	769.0	751.0	736.0	721.0	682.0	662.0	659.0
4	India	738.5	764.7	758.7	744.2	546.0	854.0	624.0	984.0	892.0	729.0	688.0
5	Australia	1,541.2	1,524.5	1,561.1	1,547.0	840.3	841.8	1,016.5	1,078.0	1,051.7	1,011.0	972.7
7	Peru	1,204.3	1,262.5	1,250.1	1,342.0	1,273.2	1,408.6	1,415.5	1,425.0	1,447.7	1,416.1	1,422.0
8	Europe	1,000.8	988.3	990.2	907.1	911.7	902.0	906.3	931.5	958.5	980.5	986.5
9	Mexico	660.3	642.5	659.9	687.7	651.1	744.3	784.3	812.3	817.3	820.3	824.3
		<b>6,505.8</b>	<b>6,369.4</b>	<b>6,364.5</b>	<b>6,340.7</b>	<b>5,307.5</b>	<b>5,833.7</b>	<b>5,802.5</b>	<b>6,270.8</b>	<b>6,103.2</b>	<b>5,778.9</b>	<b>5,657.5</b>
			-2.1%	-0.1%	-0.4%	-16.3%	9.9%	-0.5%	8.1%	-2.7%	-5.3%	-2.1%

## Discussion

The curious thing about zinc mining in Mexico is that only Peñoles really identifies themselves as zinc miners. Even then, it only constitutes 17.3% of their mining revenue when 75% owned subsidiary Fresnillo is included. Virtually every other company considers themselves to be either precious metal miners or copper miners. This has two key impacts:

- 1) In times of zinc market oversupply, zinc production is not curtailed since it is a by-product;
- 2) Conversely, in times of zinc market undersupply, zinc production is not increased either.

The challenge in this Module has been to track down the clear majority of producers to reconcile government statistics with mine reported statistics and then to ask the question, who can increase production (prior to 2022) or conversely, who is running out of ore?

Quite frankly, I was disappointed by the level of disclosure with respect to mining, geology and reserves for numerous companies. These companies want the luxury of accessing our capital markets but in many cases, are unwilling to provide basic information such as reserves by mine site. This unwillingness to provide an adequate level of disclosure therefore leads to my unwillingness to be a shareholder in the company. It is a real shame that a very small miner such as Great Panther Silver has better disclosure than a behemoth like Southern Copper.

Zinc mining in Mexico can be subdivided into six areas:

- 1) Goldcorp's Peñasquito mine;
- 2) Peñoles's six mines;
- 3) Fresnillo's three precious metal mines;
- 4) Southern Copper's (IMMSA) five mines;
- 5) Minera Frisco's three mines;
- 6) Small silver miners.

Only Peñoles's production is somewhat sensitive to the price of zinc. Goldcorp considers their mine to be a gold/silver mine. Southern Copper is more preoccupied with expanding their copper operations and the numerous small miners are also concerned more with silver/gold mining.

Like Peru, Mexico does a good job of tracking zinc mine production on an annual basis and the 2015 summary report is located [here](#). I have split out and reproduced the zinc data for 2015 and cross referenced it with the producer below.

The government statisticians have made one serious error in this table which is to list the zinc concentrate production for Peñoles's Velardeña mine in Cuencamé municipality and not the zinc in concentrate. Data presented for the prior year of 83,783 T Zn for Cuencamé was essentially correct but this then increases to 176,104 T for 2015 whereas the mine only produced 80,538 T Zn according to Peñoles. They have therefore overstated annual production for Mexico by 95,566 T in 2015. They have also double counted La Platosa's production of ~3,400 T since it is mined in one municipality but then trucked and milled in another. I have taken the liberty to correct their data. This report therefore identifies 22 mines constituting 96% of the mined zinc production in Mexico with the remainder attributed to very small miners. Like Peru, I also suspect some of this remaining 4% is related to miners reporting the zinc present in lead or copper concentrates although this is not recoverable nor payable.

All zinc production is from underground mines apart from Goldcorp's very large Peñasquito open pit mine. This is an important consideration since ramping up production in response to commodity price increases is more difficult for underground operations.

State	CÁMARA MINERA DE MÉXICO REPORTED Municipality	T Zinc	T Zinc	COMPANY REPORTED Mine	Company	Small miners/ Adjustments
<b>Aguascalientes</b>	Asientos	30,529	30,529	Asientos	Minera Frisco	-
<b>Chihuahua</b>	Aquiles Serdan	2,453	2,453	Santa Eulalia	S. Copper	-
	Ascensión	42,043	41,325	Bismark	Peñoles	718
	Cusihiuriachi	543				543
	Hidalgo del Parral	766				766
	San Francisco del Oro	23,823	23,823	San Francisco del Oro	Minera Frisco	-
	Santa Bárbara	34,555	34,555	Santa Barbara	S. Copper	-
	Urique	668				668
<b>Durango</b>	Canelas	9				9
	Cuencamé	176,104	80,538	Velardeña	Peñoles	95,566
	Indé	1,120				1,120
	Mapimí	3,755	3,339	La Platosa	Excellon	416
	Nombre de Dios	7,948	7,949	La Parrilla	First Majestic	- 1
	Otaez	83				83
	Pánuco de Coronado	2,144				2,144
	Santiago Papasquiaro	7,658	5,970	Cienego	Fresnillo	1,688
	Tepehuanes	1,474				1,474
	Topia	3,340	1,850	Topia Mine	Great Panther	1,490
<b>Guerrero</b>	Arcelia	495		C. Morado (closed)	Nyrstar	495
<b>Hidalgo</b>	Zimapan	12,119		Unknown		12,119
<b>Jalisco</b>	Bolaños	4				4
<b>Mexico</b>	Zacazonapan	45,430	40,996	Tizapa	Peñoles	4,434
	Zacualpan	955				955
<b>Oaxaca</b>	San Pedro Totalapam	14,964	13,900	Arista Mine	Gold Res. Corp.	1,064
<b>Queretaro</b>	Cadereyta de Montes	537				537
<b>San Luis Potosa</b>	Charcas	28,728	28,728	Charcas	S. Copper	-
<b>Sinaloa</b>	Concoria	31				31
	Cosalá	5,807	5,284	Cosalá Operations	Americas Silver	523
<b>Zacatecas</b>	Chalchihuites	9,460	8,910	Note 1 La Colorada	Pan American	550
	Fresnillo	55,348	19,029	Fresnillo Mine	Fresnillo	15,296
			21,023	Saucito	Fresnillo	
	Mazapil	207,844	209,000	Peñasquito	Goldcorp	- 20,314
			19,158	Tayahua, note 2	Minera Frisco	
	Miguel Auza	3,462		Note 3		3,462
	Morelos	51,085	42,610	Madero	Peñoles	2,615
			5,860	Cozamin	Capstone	
	Sombrerete	11,490	13,738	Sabinas	Peñoles	- 2,248
		786,774	660,567			126,207
	Cuencamé adjustment	- 95,566		Note 4		- 95,566
	La Platosa adjustment	- 3,462		Note 5		- 3,462
<b>Adjusted Mexico Production</b>		<b>687,746</b>	<b>660,567</b>			<b>27,179</b>

Note 1 Zacatecas State figures reconcile to within 639T

Note 2 Tayahua production is Q1-Q3 prorated to 12 months

Note 3 La Platosa ore is milled here. Therefore, it has been double counted.

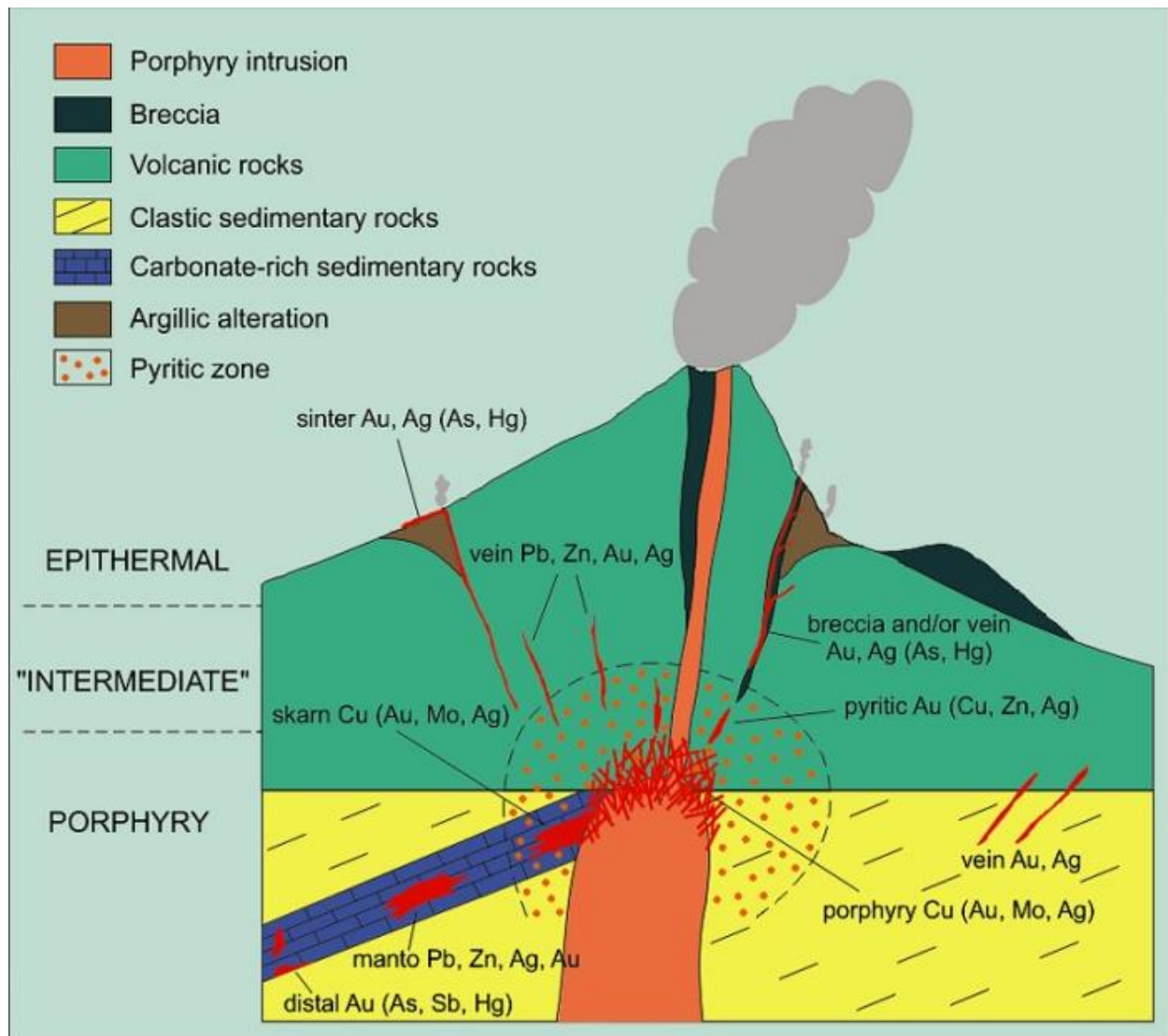
Note 4 Government statistical error.

Note 5 La Platosa double counting eliminated.

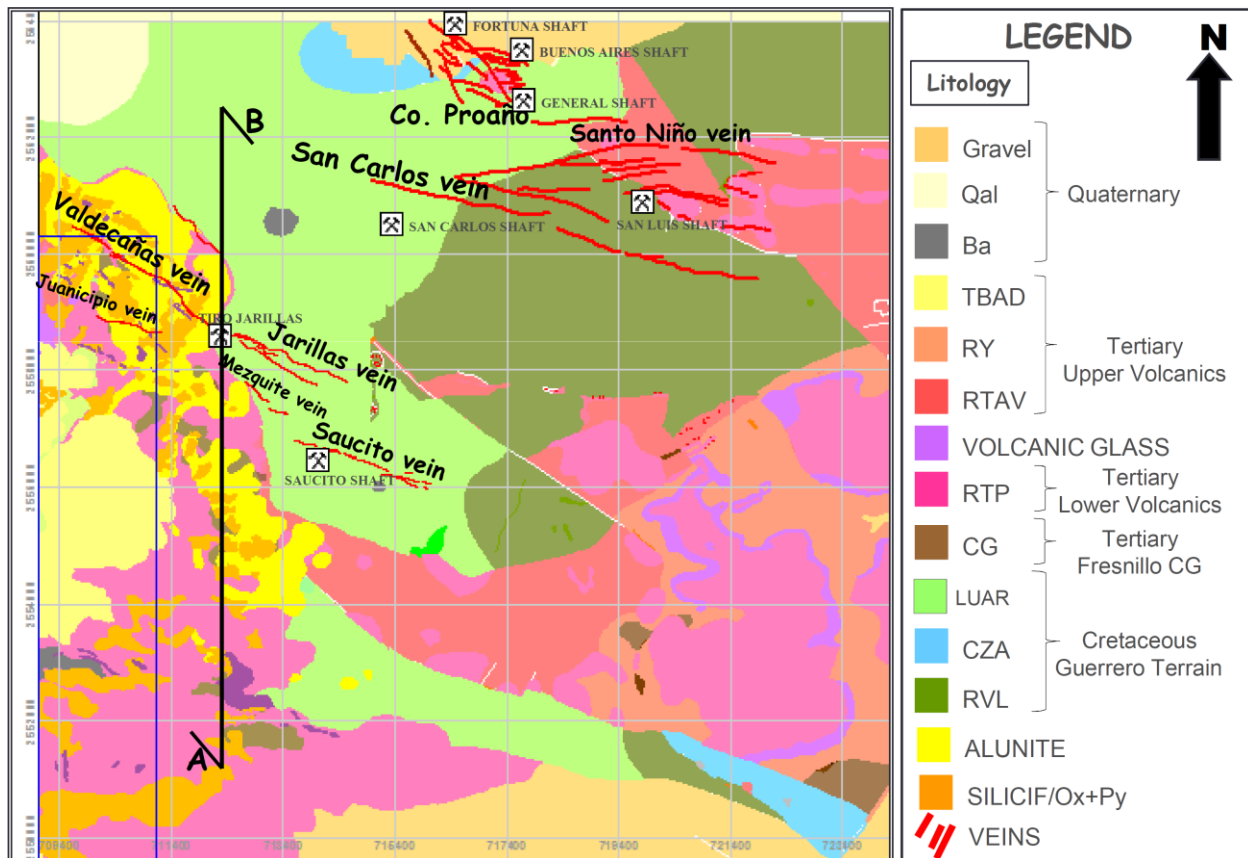
Figures in red is government data since data not reported by the company for 2015

## Deposit Geology

Mine by mine geological descriptions are generally not provided in this Module. Most deposits containing zinc that are being mined in Mexico are either carbonate replacement deposits (mantos, chimneys) or vein type deposits. The vein type deposits tend to be silver rich/ zinc poor whereas the carbonate replacement type deposits are more zinc rich/ silver poor. The figure below illustrates the idealized typical setting for both types of deposits (essentially identical to the model Tinka is using to guide exploration in Peru where they have discovered manto, distal and vein type ore near a porphyry).



Below is a plan view of the swarm of veins that constitute the prolific Fresnillo district, home to the Fresnillo and Saucito mines. Numerous mines in Mexico commenced mining in the 1500's.



In general, the small miners and Fresnillo are mining epithermal vein type deposits whereas Peñoles and Southern Copper are mining manto and chimney style carbonate replacement deposits. Insufficient information was located to properly classify Minera Frisco's mines.

## Goldcorp

You probably did not realize that Goldcorp operates one of the ten largest zinc mines in the world. The key reason why precious metal companies often play down their role in the base metal markets is that they realize that precious metal stocks trade at a premium in comparison to their unfortunate base metal cousins. The geology is not typical for Mexico and is described as:

*Peñasquito occurs as diatreme pipes that extend from shallow intrusives with most of the Ag-Au-Zn-Pb mineralisation hosted within diatremes that intrude the carbonate basement rocks in a synclinal fold hinge, that forms the valley low. The diatremes are considered to have breached the Paleosurface with the volcanic apron having been eroded away.*

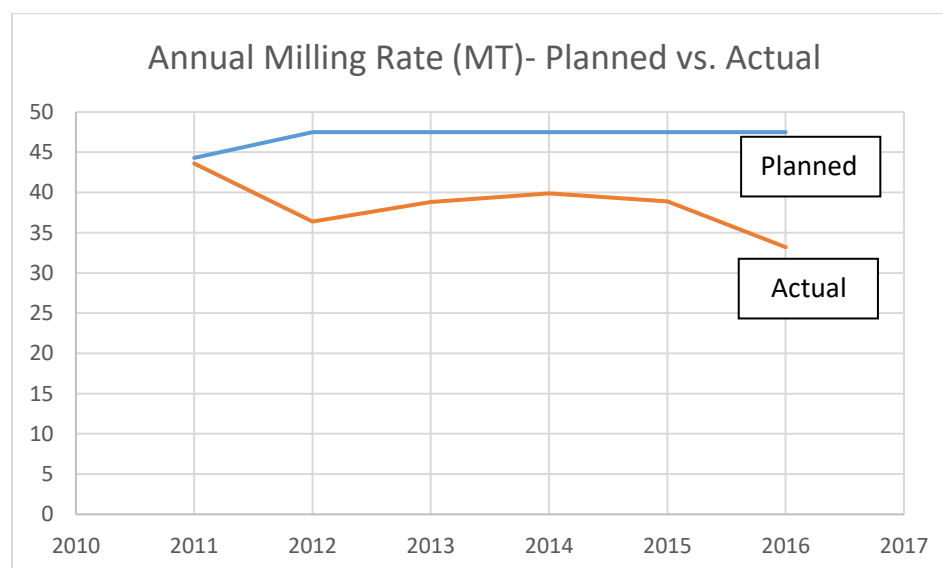
The base metal revenue is credited against precious metal mining costs. Companies such as New Gold can report negative gold mining costs at the New Afton mine for instance because the copper revenue streams pays all the bills at higher copper prices. Likewise, Freeport often reports negative copper production costs due to the often-large gold revenue stream at Grasberg.

The Peñasquito mine has overpromised and underdelivered for years. 2015 production figures and reserves are illustrated in Table 3.

**Table 3 Proven and Probable Reserves as of December 31,2015, and 2015 Production**

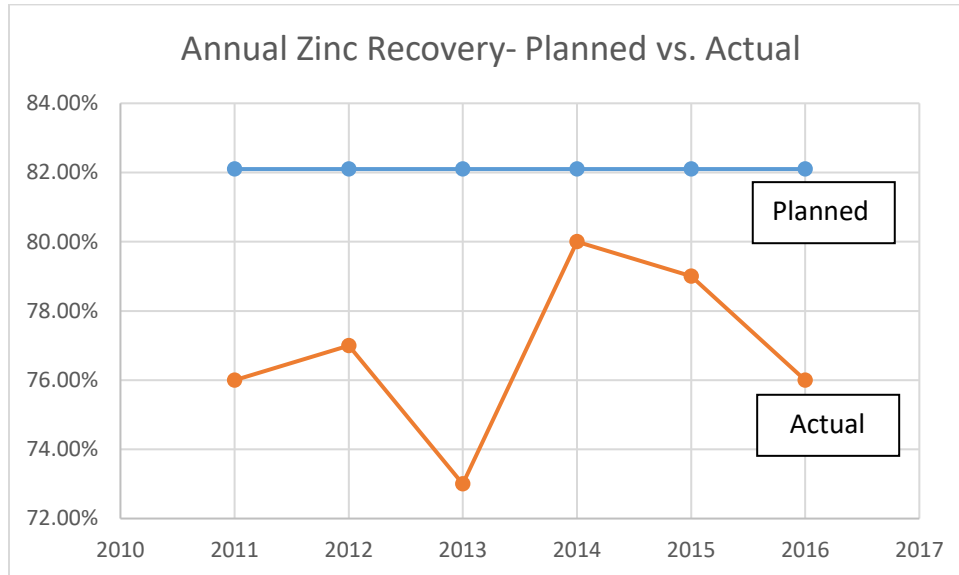
	Tonnes	Zn%	Pb%	Au (g/t)	Ag (g/t)
<b>P+P Reserves</b>	586,680,000	0.69	0.29	0.52	30.04
<b>2015 Production</b>	38,870,100	0.68	0.3	1	28.5

The figure below illustrates the 2010 NI 43-101 planned production schedule milled tonnage versus actual for 2011-2016. No production schedules were provided in the 2014 and 2015 NI 43-101 reports. Planned production for 2015 was recently expected to be 45 MT but as illustrated, this is another missed target.



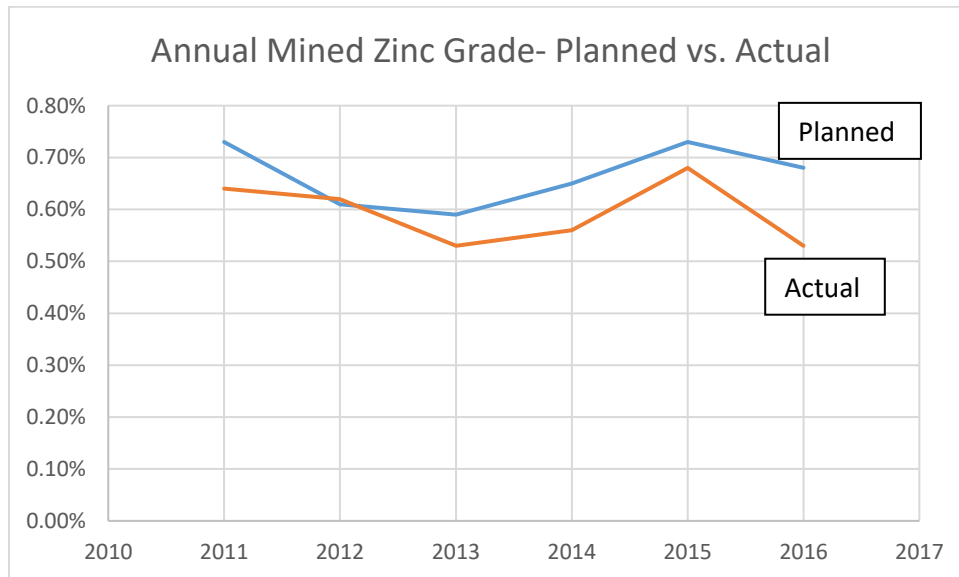
2016 performance is Q1-Q3 prorated to 12 months. Goldcorp indicates they expect to improve upon this rate for Q4.

Likewise, zinc recovery has consistently underperformed the 82.1% used for reserve calculations in the 2015 NI 43-101.



The planned zinc recovery listed is from the 2015 NI 43-101. 2016 is ytd.

Finally, annual zinc grades have also consistently been less than anticipated in the 2010 NI 43-101 as illustrated below. Due to the large tonnage processed, this apparently minor grade slip can amount to 50,000 T of zinc annually.



I would, therefore, rather use my estimate of performance going forward instead of that provided by Goldcorp. Table 4 lists anticipated annual zinc production based upon:

40,000,000 T milled grading 0.635% Zn at 79% Zn recovery for 200,660 T of annual zinc output.



The grade chosen is 95% of that listed in the 2010 NI 43-101 production schedule for years 2017-2022. Yearly zinc production will likely vary around the 200,000 T mean by upwards of plus or minus 30,000 T due to annual zinc grade swings.

**Table 4 Actual and Expected Zinc Production for Peñasquito**

2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
174,000	150,000	179,000	209,000	134,000	200,600	200,600	200,600	200,600	200,600	200,600

2012-2016 figures were derived by multiplying reported mill tonnage by ore grade and zinc recovery, rounded to the nearest thousand. 2016 figures are Q1-Q3 prorated to 12 months. Goldcorp indicates they expect to do better in Q4 than ytd.



**References:** NI 43-101 Reports December 31, 2010  
January 8, 2014  
December 31, 2015 [www.sedar.com](http://www.sedar.com)

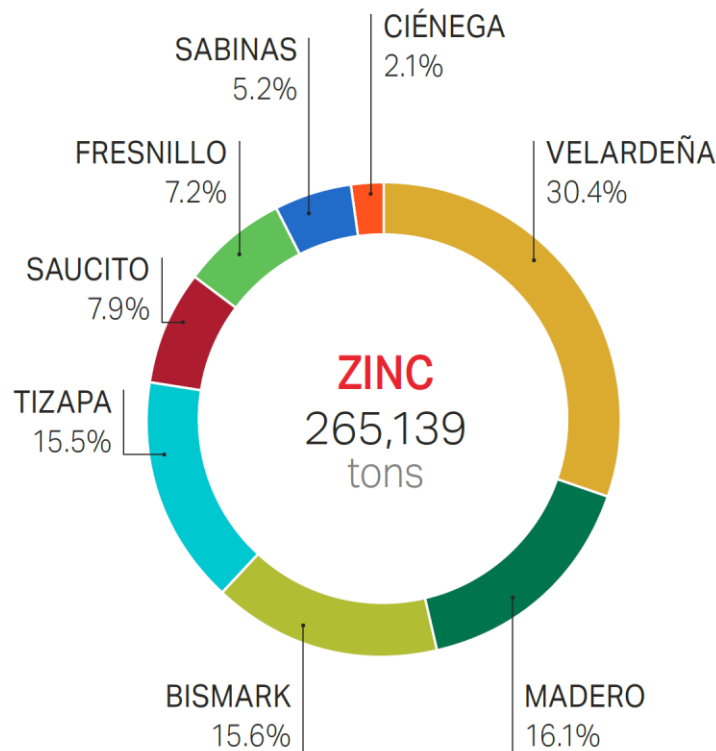
## Peñoles

Peñoles operates five underground zinc/lead/silver mines and is developing a sixth. An additional mine, Naica, was closed permanently late 2014 due to flooding. Peñoles also owns 75% of Fresnillo which is predominantly a gold/silver miner with zinc and lead by-product production from three mines. This means Peñoles obtains zinc production from a total of eight mines. The proportion of production for 2015 is illustrated below for the eight mines. Note that although Peñoles reports figures in tons, these are metric tonnes.

All mines, apart from perhaps Bismark, appear to have ample reserves to continue steady state mining throughout the study period. No brownfield expansion plans have been announced. Bismark's zinc grades have gradually decreased with time.

The Peñoles operated mines are typical carbonate replacement type deposits. Bismark ore is near vertical and related to a contact. Velardeña and Madero are typical manto type deposits. Information on individual mines is somewhat sparse but good operating and cost data is available.

The tonnes processed for each mine and the reserves as of December 31, 2015 is illustrated in the table below. Individual annual mining grades for each mine are not reported by Peñoles.



**Table 5 2015 Mined Tonnage and Reserves**

Proven and Probable Reserves as of December 31,2015							
Mine	2015 T Production	Tonnes	Zn%	Pb%	Cu%	Au (g/t)	Ag (g/t)
Sabinas	1,232,570	15,934,000	1.70	1.04	0.39	0	97.8
Bismark	778,206	4,042,000	5.37	0.62	0.38	0	34.6
Tizapa	873,518	9,835,000	5.70	1.36	0.30	1.79	236
Madero	2,252,200	36,574,000	2.10	0.68	0.07	0	19.7
Velardeña	2,023,650	31,340,000	3.60	0.38	0.21	0.18	23.2
Rey de Plata	0	22,796,000	3.38	0.78	0.81	1.25	119

The Tizapa mine is a joint venture with Dowa Mining (39%) and Sumitomo (10%)

Table 6 lists actual and expected production for Peñoles' mines. The Rey de Plata mine is under development with first production expected in 2018. Peñoles indicates that steady state production will be 40,000 T zinc a year. This may ultimately replace Bismark production.

**Table 6 Actual and Expected Zinc Production for Peñoles**

Mine	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Velardeña	0	41,197	83,968	80,538	88,109	85,000	85,000	85,000	85,000	85,000	85,000
Tizapa	35,506	38,730	40,978	40,996	40,317	40,000	40,000	40,000	40,000	40,000	40,000
Madero	45,455	43,060	42,485	42,610	47,321	45,000	45,000	45,000	45,000	45,000	45,000
Naica	18,185	21,777	19,694	0	0	0	0	0	0	0	0
Sabinas	19,829	15,828	13,112	13,738	13,793	14,000	14,000	14,000	14,000	14,000	14,000
Bismark	39,504	33,899	38,071	41,325	44,449	40,000	40,000	40,000	40,000	40,000	40,000
Rey de Plata	0	0	0	0	0	0	20,000	40,000	40,000	40,000	40,000
Total	158478	194492	238308	219116	233990	224000	244000	264000	264000	264000	264000

Unit cost data for the Peñoles mines in 2015 is illustrated in Table 7.

**Table 7 2015 Cash Costs for Peñoles**

Mine	Cash Cost/T milled \$US	Cash Cost/lb zinc \$US
Sabinas	\$56.70	\$0.70
Bismark	\$68.60	\$0.87
Tizapa	\$78.20	\$0.52
Madero	\$32.70	\$0.89
Velardeña	\$43.70	\$0.68

Cash cost = cost of production without depreciation and employee profit sharing + treatment charges, freight and penalties+ extraordinary mining taxes. For cash cost/lb zinc- by-product credits are deducted.

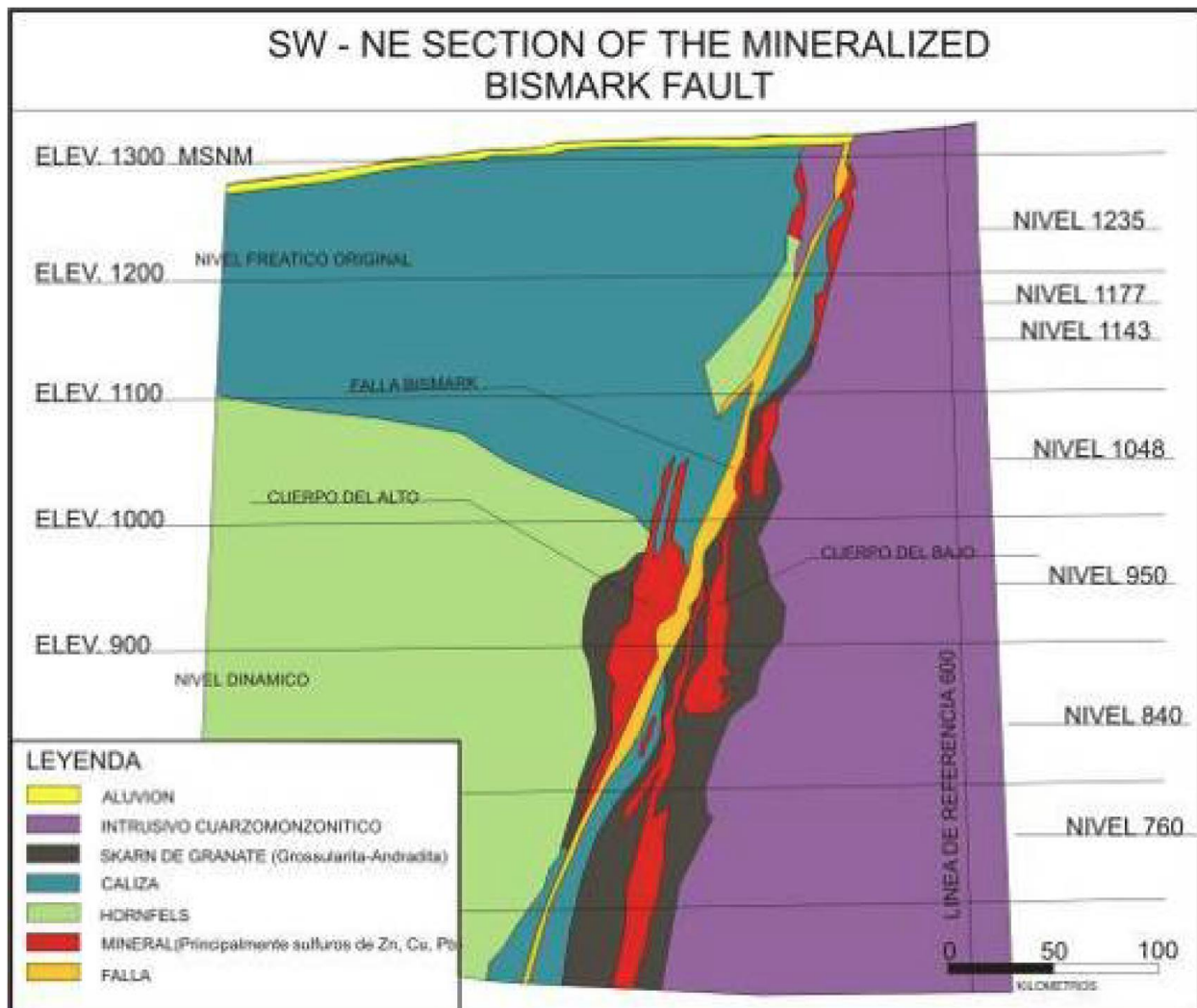
**Reference:** 2015 Peñoles Annual Report [here](#)





**The Velardeña Surface Plant and Underground Room and Pillar Mining**





**The Bismark Mine Geology and Surface Plant**

## Fresnillo

Zinc accounts for only roughly 5% of total Fresnillo revenue so it is very much a by-product of silver and gold mining. The mines appear to be well run with staffing levels appropriate for the narrow vein nature of the underground mining. However, the mills struggle with zinc recovery. Table 8 lists recent production tonnage and reserves. Table 9 presents recent and expected zinc production.

## Fresnillo Mine

This 8,000 T per day mine is struggling to maintain production tonnage since the veins at depth are narrowing. Additional development resources have been added to counter this. Zinc production is expected to increase since the ore at depth is more zinc rich. Recent zinc grades have been considerably less than half reserve grade.

## Ciénega

Zinc production at this 4,000 T per day is expected to remain relatively static since zinc mining grades are equivalent to reserve grades and current production levels are expected to be maintained. Zinc recovery is relatively poor (60% range).

## Saucito

This mine has recently completed an expansion to 6,000 T per day. The mill is being further debottlenecked to 7,500 T per day. I expect zinc production to continue to increase since recent mining grades in the 1.4% Zn range are well below reserve grade of 2.93% Zn. Zinc recovery is relatively poor (60% range).

## San Julian

A 6,000 tpd floatation plant (Phase 2) will be commissioned shortly to mill disseminated ore from this new underground mine. Disseminated probable reserves are:

16,700,000 T @ 1.36% Zn, 0.57% Pb, 0.08 g/t Au, 211 g/t Ag

I assume steady state zinc by-product production of 20,000 T zinc assuming 75% Zn recovery with a two year ramp up to full production.

**Table 8 2015 Mined Tonnage and Reserves**

Mine	2015 T Production	Proven and Probable Reserves as of December 31,2015				
		Tonnes	Zn%	Pb%	Au (g/t)	Ag (g/t)
<b>Fresnillo</b>	2,410,033	21,168,000	3.53	1.75	0.77	296
<b>Ciénega</b>	1,329,364	13,270,000	0.97	0.57	1.89	162
<b>Saucito</b>	2,339,096	12,983,000	2.93	1.49	1.75	313

**Table 9 Actual and Expected Zinc Production for Fresnillo**

Mine	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Fresnillo	14,966	14,914	15,199	19,029	24,000	26,000	28,000	30,000	30,000	30,000	30,000
Ciénega	8,171	5,459	6,000	5,970	7,500	7,000	7,000	7,000	7,000	7,000	7,000
Saucito	1,791	4,509	10,501	21,023	21,500	25,000	30,000	30,000	30,000	30,000	30,000
San Julian	0	0	0	0	0	10,000	20,000	20,000	20,000	20,000	20,000
Total	24,928	24,882	31,700	46,022	53,000	68,000	85,000	87,000	87,000	87,000	87,000

2016 data is Q1-Q3 prorated to 12 months.

Unit cost data for the Fresnillo mines is illustrated in Table 10.

**Table 10 2015 Cash Costs for Peñoles**

Mine	Cash Cost/T milled \$US
Fresnillo	\$48.20
Ciénega	\$63.00
Saucito	\$42.50

Cash cost = cost of production without depreciation and employee profit sharing + treatment charges, freight and penalties+ extraordinary mining taxes.

**Reference:** 2015 Fresnillo Annual Report [here](#)



**Fresnillo Mine**



**Saucito Mine**



## Southern Copper

The IMMSA subsidiary of Southern Copper appears to be somewhat the neglected relative. Southern Copper, and parent Grupo Mexico, is in the process of a major open pit copper mine expansion program so these underground zinc/lead/silver assets appear to be of lesser importance in the overall scheme of things.

Although Southern Copper has five zinc/lead/silver mines, two (San Martin and Taxco) have been shut since 2007 due to labour disputes. A third mine, Santa Eulalia has been shut more years than not since 2000 due to heavy water inflows underground.

The two remaining mines, Santa Barbara and Charcas, have typically operated at 75% of annual mill nameplate capacity. In 2013, Southern stopped reporting production figures for individual mines. The table below is from the most recent 10-K filing with the SEC. Zinc production is highlighted.

		2015	2014	2013	Variance 2015-2014	
					Volume	%
Average annual operating days(*)		234	247	307		
Total material mined and milled	(kt)	2,631	2,471	3,066	160	6.5%
<b>Zinc:</b>						
Zinc average ore grade	(%)	2.68	3.00	3.58	(0.32)	(10.7)%
Zinc average recovery	(%)	87.88	89.73	90.62	(1.85)	(2.1)%
Zinc concentrate produced	(kt)	115.0	124.0	185.3	(9.0)	(7.3)%
Zinc concentrate average grade	(%)	53.81	53.74	53.64	0.07	0.1%
<b>Zinc in concentrate</b>	<b>(kt)</b>	<b>61.9</b>	<b>66.6</b>	<b>99.4</b>	<b>(4.7)</b>	<b>(7.1)%</b>
<b>Lead:</b>						
Lead average ore grade	(%)	0.96	1.06	0.96	(0.1)	(9.4)%
Lead average recovery	(%)	82.05	85.16	81.63	(3.11)	(3.7)%
Lead concentrate produced	(kt)	32.8	36.1	40.1	(3.3)	(9.1)%
Lead concentrate average grade	(%)	63.15	61.72	59.69	1.43	2.3%
Lead in concentrate	(kt)	20.7	22.3	23.9	(1.6)	(7.2)%
<b>Copper:</b>						
Copper average ore grade	(%)	0.38	0.39	0.39	(0.01)	(2.6)%
Copper average recovery	(%)	55.32	54.31	53.59	1.01	1.9%
Copper concentrate produced	(kt)	23.5	20.1	23.9	3.4	16.9%
Copper concentrate average grade	(%)	23.82	25.95	26.78	(2.13)	(8.2)%
Copper in concentrate	(kt)	5.6	5.2	6.4	0.4	7.7%
<b>Silver:</b>						
Silver average ore grade	(ounces)	2.31	2.71	2.79	(0.4)	(14.8)%
Silver average recovery	(%)	81.53	81.14	79.24	0.39	(0.5)%
Silver concentrate average grade	(ounces/)	29.2	27.5	24.8	1.7	6.2%

Combined reserves for all mines are listed as of December 31, 2015 in the 10-K filed on [www.sec.gov](http://www.sec.gov) as:

43.9 MT @ 2.88% Zn, 0.98% Pb, 0.5% Cu

Presumably, this includes reserves from the two idle mines also.

## Charcas

The 10-K describes the mine as follows:

*The Charcas mining complex is located 111 kilometers north of the city of San Luis Potosi in the State of San Luis Potosi, Mexico. Charcas is connected to the state capital by a paved highway of 130 kilometers. It was discovered in 1573 and operations in the 20th century began in 1911. The complex includes three underground mines (San Bartolo, Rey-Reina and La Aurora) and one flotation plant that produces zinc, lead and copper concentrates, with significant amounts of silver. The Charcas mine is characterized by low operating costs and good quality ores and is situated near the zinc refinery. Regarding its geology, economic ore is found as replacement sulfurs in carbonates host rock. The ore mineralogy is comprised predominantly of calcopyrite (CuFeS<sub>2</sub>), sphalerite (ZnS), galena (PbS) and silver minerals as diaphorite (Pb<sub>2</sub>Ag<sub>3</sub>Sb<sub>3</sub>S<sub>8</sub>). The Charcas mine is now Mexico's largest producer of zinc.*

*In October 2015, an earthquake damaged some underground facilities as well as the access to the mine. Consequently, normal mine operations were interrupted. By December 31, 2015 most of the damage was corrected and normal operations were restored. However, as a result of the damage, production decreased 45%.*

A very dated technical paper [here](#) (I also authored a paper on McArthur River uranium in that volume, page 281, not available online unfortunately) describes La Aurora orebody to be 15 to 60 m thick and 15 to 80 m in height with a dip of 20 to 35 degrees. The rock strengths provided are high. These dimensions would be suitable for blasthole stoping (like Tara in Ireland) yet the mine is, or at least was, using an underhand room and pillar mining method which is probably twice the cost. This seems to be a common theme in Mexico. The underground photos I have seen show very competent ground at various mines yet the mining methods used don't appear to exploit this stability to reduce costs.

## Santa Barbara

The 10-K describes the mine as follows:

*The Santa Barbara mining complex is located approximately 26 kilometers southwest of the city of Hidalgo del Parral in southern Chihuahua, Mexico. The area can be reached via paved road from Hidalgo del Parral, a city on a federal highway. It was discovered in 1536 and mining activities in the 20th century began in 1913. Santa Barbara includes three main underground mines (San Diego, Segovidad and Tecolotes) and a flotation plant and produces lead, copper and zinc concentrates, with significant amounts of silver.*

*Regarding its geology, economic ore minerals include sphalerite (ZnS), marmatite (ZnFeS), galena (PbS), chalcopyrite (CuFeS<sub>2</sub>) and tetrahedrite (Cu<sub>12</sub>Sb<sub>4</sub>S<sub>13</sub>). Due to the variable characteristics of the ore bodies, four types of mining methods are used: shrinkage stoping, long-hole drilled open stoping, cut-and-fill stoping and horizontal bench stoping. The ore, once crushed, is processed in the flotation plant to produce concentrates.*

*The Santa Barbara mining complex is located approximately 26 kilometers southwest of the city of Hidalgo del Parral in southern Chihuahua, Mexico. The area can be reached via paved road from Hidalgo del Parral, a city on a federal highway. Chihuahua, the state capital is located 250 kilometers north of the Santa Barbara complex. Additionally, El Paso on the Texas border is located 600 kilometers north of Santa Barbara. Santa Barbara includes three main underground mines (San Diego, Segovidad and Tecolotes) and a flotation plant and produces lead, copper and zinc concentrates, with significant amounts of silver. Gold-bearing veins were discovered in the Santa Barbara district as early as 1536. Mining activities in the 20th century began in 1913.*

*The mining operations at Santa Barbara are more diverse and complex than any of the other mines in our Mexican operations, with veins that aggregate approximately 21 kilometers in length. Each of the three underground mines has several shafts and crushers. Due to the variable characteristics of the ore bodies, four types of mining methods are used: shrinkage stoping, long-hole drilled open stoping, cut-and-fill stoping and horizontal bench stoping. The ore, once crushed, is processed in the flotation plant to produce concentrates. The flotation plant has a capacity of 5,700 tons of ore per day.*

### **Santa Eulalia**

The 10-K describes the mine as follows:

*The mining district of Santa Eulalia is located in the central part of the state of Chihuahua, Mexico, approximately 26 kilometers east of the city of Chihuahua, and is connected to the city of Chihuahua by a paved road (highway no. 45). It was discovered in 1590 but exploitation began in 1870. The main mines in Santa Eulalia are The Buena Tierra mine and the San Antonio mine.*

*Regarding its geology, the mineralization corresponds in its majority to ore skarns: silicoaluminates of calcium, iron and manganese with variable quantities of lead, zinc, copper and iron sulfides. Economic ore include sphalerite (ZnS), galena (PbS) and small quantities of pyrrargyrite (Ag<sub>3</sub>SbS<sub>3</sub>).*

*The Santa Eulalia mine suspended operations from October 2000 to December 2004, during which time rehabilitation work was completed at the San Antonio shaft and pipes were installed to expand the pumping capacity to 10,500 gallons per minute. In January 2005, operations were restarted. In May 2010, the Santa Eulalia mine suspended operations due to a flooding in the area brought on by the failure of a dike caused by excess water pressure. In 2011, the rehabilitation work was interrupted by a second flooding which required us to extend the pumping work. The pumping work was completed in 2012 allowing us to restore production.*

### Production Forecast

In Table 11 I have assumed that the Charcas and Santa Barbara mines continue to operate at 75% of nameplate mill capacity and that the Santa Eulalia also finally has a string of good luck and does the same. This appears to be the highest zinc grade asset. Year to date results are an improvement but there is no indication which mine(s) this is coming from. I assume that the Santa Martin and Taxco mines remained mired in the courts. Southern stopped providing individual mine production grades after 2013 so for 2014-15 I have used government statistics for the individual mines (which are about 8% higher cumulatively than company figures). The fall off in production has been due to the water issues at Santa Eulalia and ground issues at Charcas. I have assumed they get on top of these issues which they indicate they have recently.

Charcas-	1,200,000 T @ 4% Zn @ 97% recovery	=	46,560 T
Santa Barbara-	1,500,000 T @ 2.5% Zn @ 86% recovery	=	32,250 T
Santa Eulalia-	400,000 T @ 6.5% Zn @ 85% recovery	=	22,100 T

**Table 11 Actual and Expected Production for IMMSA Zinc Mines**

Mine	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Charcas	49935	45618	24156	28728	33900	46,560	46,560	46,560	46,560	46,560	46,560
St. Barbara	32839	34406	36886	34555	33000	32,250	32,250	32,250	32,250	32,250	32,250
St. Eulalia	6851	19284	9247	2453	20000	22,100	22,100	22,100	22,100	22,100	22,100
Angangueo	0	0	0	0	0	0	0	0	0	3,000	7,000
	89766	99434	70289	65736	86900	100,910	100,910	100,910	100,910	103,910	107,910

2016 production is Q1-Q3 prorated to 12 months. 2016 total is recent company guidance due to the recovery of St. Eulalia. The relative split between mines is my guesstimate. 2014-15 figures are from the government and do not reconcile cumulatively with figures reported previously in this section.

You will see in the table above production from “Angangueo”. Southern Copper states:

*With an estimated investment of \$174.7 million, Angangueo will include a concentrator plant with an estimated average annual production of 10,400 tons of copper and 7,000 tons of zinc in the first seven years. Over the life of the mine, average annual concentrate production is expected to contain 2.4 million ounces of silver and 1,500 ounces of gold. Through December 31, 2015, we have invested \$27.4 million on the project. The project is on hold waiting for the environmental permits.*

## Minera Frisco

No reserve statement could be located for any of their operations and the company did not answer my query about this. Although I would like to provide a little colour on geology and mining, virtually no pertinent information could be located either. For a publicly traded company, this is bad behaviour to say the least. The 198 page 2015 Annual Report in Spanish is absolutely useless unless you are an anal-retentive accountant. Moody's mentions limited reserves at a number of operations but does not mention which ones. So at least the bond rating agencies have had a glimpse at the assets. I pity the shareholders though.

The company provided good production data for Q1-Q3 2015 and then dropped the ball by reporting nothing for Q4. So, I have utilized 2014 data below.

Minera Frisco has three underground mines that produce zinc as a by-product. Table 12 summarizes 2014 production results. Mill capacity at Asientos and San Francisco Del Oro is 4,000 T per day. The mill at Tayahua is 5,500 T per day but may be tripled in size to mill low grade copper ore from a deposit 6 km away. Zinc production levels will not be impacted.

**Table 12 2014 Milling Tonnes and Grade**

Mine	2014 T Production	Zn%	Pb%	Cu%	Au (g/t)	Ag (g/t)
<b>Asientos</b>	1,201,710	2.74	0.71	0.19	0.77	45
<b>Tayahua</b>	1,810,470	1.29	0.26	0.87	0.17	25
<b>San Francisco Del Oro</b>	1,250,613	1.75	0.95	0.28	0.28	48

Zinc production and the implied recoveries are listed in Table 13 for 2014.

**Table 13 Reported 2014 Zinc Production and Implied Recovery**

Mine	2014 Zn Production	Zn Recovery %
<b>Asientos</b>	25,707	78.7
<b>Tayahua</b>	16,678	71.4
<b>San Francisco Del Oro</b>	16,528	75.5
<b>Total</b>	58,913	75.3

Since Minera Frisco has reduced me to a guessing game going forward, Table 14 is my shot in the dark with respect to production levels.

**Table 14 Actual and Guesstimated Zinc Production for Minera Frisco**

Mine	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Asientos	29,051	31,362	25,707	30,529	28,000	30,000	30,000	30,000	30,000	30,000	30,000
Tayahua	22,897	19,210	16,678	19,158	24,000	23,000	23,000	23,000	23,000	23,000	23,000
San.Fran.	18,302	13,104	16,528	23,823	20,000	19,000	19,000	19,000	19,000	19,000	19,000
Total	70,250	63,675	58,913	73,510	72,000	72,000	72,000	72,000	72,000	72,000	72,000

2012-2014 figures are from Minera Frisco. 2015 figures are government statistics 1,900T higher than the total figure reported by the company. 2016 total is Q1-Q3 prorated to 12 months. Relative split by mine for 2016 is a guesstimate. 2017-2022 figures are a total crapshoot.

**Reference:** Waste your time [here](#) and [aqui](#)

### Small Producers

Numerous silver miners produce small quantities of by-product zinc. For more information on these mines readers should review respective NI 43-101 reports listed.

#### First Majestic Silver- La Parrilla Mine

**Geology:** Epithermal Vein type

**Mining:** Underground, Mechanized Cut and Fill

**Milling:** 700 tpd cyanidation circuit for oxide ore (no Zn recovery), 1,000 tpd flotation circuit

**Unit Cash Cost/Tonne milled:** \$US 42.35 (AISC ~\$US61.00)

#### 2015 Proven and Probable Reserves and Production Results

	Tonnes	Zn%	Pb%	Ag (g/t)
<b>P+P Reserves</b>	1,546,999	2.12	1.99	200
<b>2015 Production</b>	667,702	nr	nr	145

Sulphide reserves only. Production includes oxides. nr= not reported

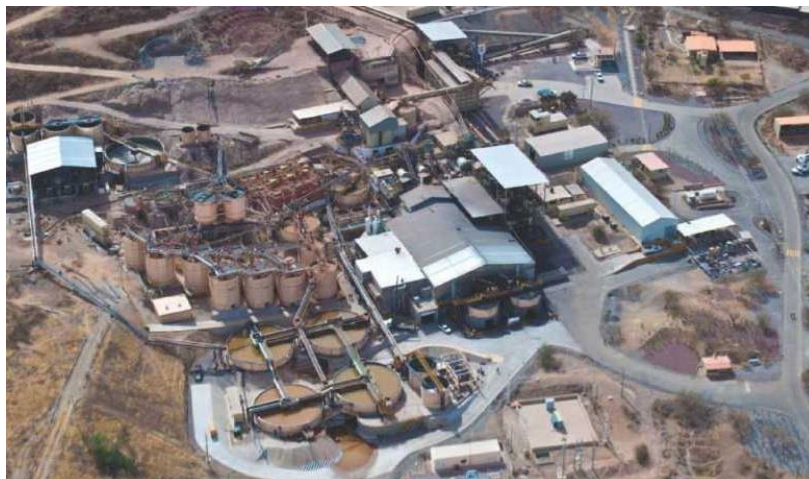
#### Actual and Expected Mined Zinc Production

2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
2,246	3,054	5,724	7,949	5,700	5,000	5,000	5,000	5,000	5,000	5,000

2016 is Q1-3 prorated to 12 months. Zn recoveries 50-70% typical.

**Reference:** La Parrilla NI 43-101, September 8, 2011. [www.sedar.com](http://www.sedar.com)

Corporate web page [here](#)



**Great Panther Resources- Topia Mine****Geology:** Epithermal Vein type, 40 separate veins**Mining:** Underground, narrow vein cut and fill with resuing**Milling:** 275 tpd flotation circuit**Unit Cash Cost/Tonne milled:** \$US 143.00 (AISC ~\$US155.00)**Measured and Indicated Resources as of Nov. 30,2014 and 2015 Production**

	Tonnes	Zn%	Pb%	Au (g/t)	Ag (g/t)
<b>M+I Resources</b>	346,200	4.19	4.5	1.31	624
<b>2015 Production</b>	71,074	2.99	1.94	0.48	356

Includes 5,687 T of custom milling. M+I Resources are undiluted. Dilution levels appear to be ~100%.

**Actual and Expected Mined Zinc Production**

2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
1,478	1,673	1,675	1,850	1,600	1,800	1,800	1,800	1,800	1,800	1,800

2016 is Q1-3 prorated to 12 months. Zn recoveries 92% typical.

**Reference:** Topia Mine NI 43-101, August 18, 2015. [www.sedar.com](http://www.sedar.com)



**Pan American Silver- La Colorada Mine****Geology:** Epithermal Vein type, breccia pipes, mantos**Mining:** Underground, cut and fill, 3 separate mines**Milling:** 750 tpd flotation circuit and 650 tpd oxide circuit (no Zn recovery) increasing to 1,500 tpd combined in 2015 and 1,800 tpd combined late 2016 (see photo below of expansion construction).**Unit Cash Cost/Tonne milled:** \$US48.8 M direct costs/ 485,000 t = \$US100.60**Proven and Probable Reserves as of December 31, 2015 and 2015 Production**

	Tonnes	Zn%	Pb%	Au (g/t)	Ag (g/t)
<b>P+P Reserves</b>	7,000,000	2.57	1.42	0.32	406
<b>2015 Production</b>	485,000	2.20	1.01	0.28	379

Note: sulphide reserves grade ~3.5% Zn. Reserves are a combination of oxides and sulphides.

**Actual and Expected Mined Zinc Production**

2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
5,600	6,760	7,700	8,910	9,700	9,500	16,000	16,000	16,000	16,000	16,000

2016 forecast is mid range guidance. 2017- 400,000 T sulphides @ 2.9% Zn and 82.3% rec., 2018-2022 500,000 T @ 3.9% Zn.

**Reference:** La Colorada Mine NI 43-101, filed January 30, 2014. [www.sedar.com](http://www.sedar.com)

**Gold Resource Corporation- Arista Mine (Aguila Project)****Geology:** Epithermal Vein type**Mining:** Underground, cut and fill and longhole stoping**Milling:** 1,500 tpd flotation plant 1,220 tpd utilized in 2015.**Unit Cash Cost/Tonne milled:** \$US53.3M/413,626 T = \$US128/T. (Site costs (\$65.7M) minus offsite TC/RC's (\$12.4M))**Proven and Probable Reserves as of December 31, 2015 and 2015 Production**

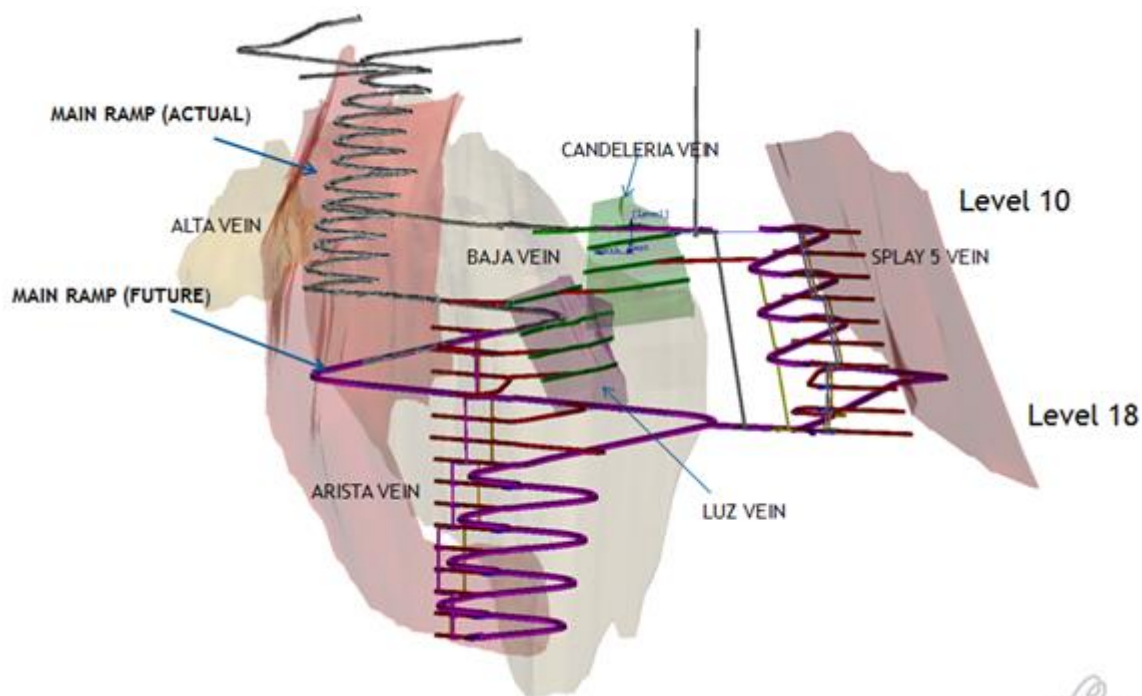
	Tonnes	Zn%	Pb%	Cu%	Au (g/t)	Ag (g/t)
<b>P+P Reserves</b>	1,644,500	3.5	1.3	0.3	2.41	162
<b>2015 Production</b>	413,626	4.04	1.37	0.4	2.47	203

**Actual and Expected Mined Zinc Production**

2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
5,600	6,760	13,195	13,900	12,900	13,000	13,000	13,000	13,000	13,000	13,000

2016 forecast is guidance. Assumes continued conversion of resources to reserves.

**Reference:** El Aguila Project NI 43-101 Technical Report, July 10,2012. Corporate website [here](#)  
 10-Q, 10-K filings [www.sec.gov](http://www.sec.gov)



**Americas Silver- Cosalá Operations****Geology:** skarn**Mining:** Underground, cut and fill and longhole stoping**Milling:** 1,600 tpd flotation plant**Unit Cash Cost/Tonne milled:** 2015 cost of Mexican sales- \$US22.2M/506,148 T = ~\$US44/T**Proven and Probable Reserves- Nuestra Señora as of December 31, 2015, and 2015 Production**

	<b>Tonnes</b>	<b>Zn%</b>	<b>Pb%</b>	<b>Cu%</b>	<b>Ag (g/t)</b>
<b>P+P Reserves</b>	593,000	1.69	0.81	0.19	98
<b>2015 Production</b>	506,148	1.36	0.61	0.26	86

Mining is expected to transition to San Rafael in mid-2017.

**Proven and Probable Reserves- San Rafael as of December 31, 2015 and 2015 Production**

	<b>Tonnes</b>	<b>Zn%</b>	<b>Pb%</b>	<b>Cu%</b>	<b>Ag (g/t)</b>
<b>P+P Reserves</b>	3,822,000	3.86	1.64	0.03	108
<b>2015 Production</b>	0				

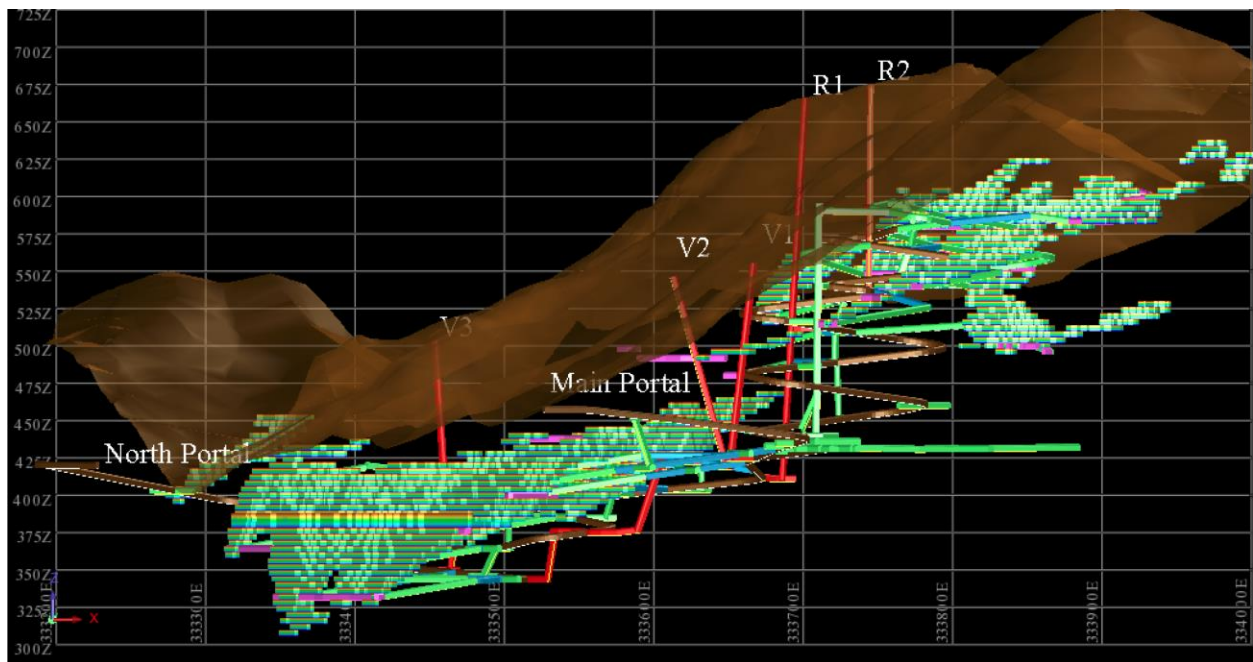
Board approval for San Rafael development was given in September, 2016. Commercial production is expected in Q3,2017. The existing mill will be utilized.

**Actual and Expected Mined Zinc Production**

<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>
7,470	6,600	5,730	5,283	4,750	5,000	10,000	16,000	18,000	18,000	18,000

2016 forecast is Q1-3 prorated to 12 months. 2017-2022 estimate by author after review of San Rafael NI-43-101. Assumes company remains a going concern.

**Reference:** San Rafael NI 43-101 Technical Report, filed April 29,2016. [www.sedar.com](http://www.sedar.com)Nuestra Señora NI 43-101 Technical Report, filed May 22,2013. [www.sedar.com](http://www.sedar.com)



**Planned mining at San Rafael**

**Capstone Mining- Cozamin****Geology:** mineralized vein/ fault structure**Mining:** Underground, cut and fill, longhole stoping, Avoca**Milling:** 3,300 tpd flotation plant**Unit Cash Cost/Tonne milled:** \$US42.44 /T**Proven and Probable Reserves as of December 31, 2015 and 2015 Production**

	Tonnes	Zn%	Pb%	Cu%	Ag (g/t)
<b>P+P Reserves</b>	7,216,000	0.71	0.17	1.50	42
<b>2015 Production</b>	1,080,000	0.84	0.14	1.56	53

62% Zn recovery in 2015.

Due to strengthening zinc prices, the nearby San Rafael zinc deposit is being assessed for mining. A partial shift into this zone is illustrated in the forecast. (Indicated resources of 2.1 MT grading 3.33% Zn plus Cu/Pb/Ag, not to be confused with the same deposit name above at Americas Silver).

**Actual and Expected Mined Zinc Production**

2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
7,811	8,085	6,509	5,860	4,200	5,000	6,000	6,000	9,000	9,000	9,000

2016 forecast is Q1-3 prorated to 12 months. Current life of mine is to 2021 but a good inferred resource base exists.

**Reference:** Cozamin NI 43-101 Technical Report, filed August 5, 2014. [www.sedar.com](http://www.sedar.com)



**Excellon Resources- Platosa Property****Geology:** mantos and chimneys**Mining:** Underground, room and pillar, cut and fill**Milling:** 350 tpd flotation plant 220 km away**Unit Cash Cost/Tonne milled:** \$US 275/ T**Measured and Indicated Resources as of December 31, 2014 and 2015 Production**

	<b>Tonnes</b>	<b>Zn%</b>	<b>Pb%</b>	<b>Ag (g/t)</b>
<b>M+I Resources</b>	428,000	9.88	8.28	760
<b>2015 Production</b>	56,849	7.2	4.56	491

The mine has no reserves

I am skeptical that this mine will resolve its water inflow issues. Inflow rates increase as mining proceeds deeper since they are essentially drawing down the water table for a very extensive region. This is like being on a treadmill that gets faster and faster the deeper you get. I show production to year end 2017 only but I wish them all the best. Grouting is a waste of time guys.

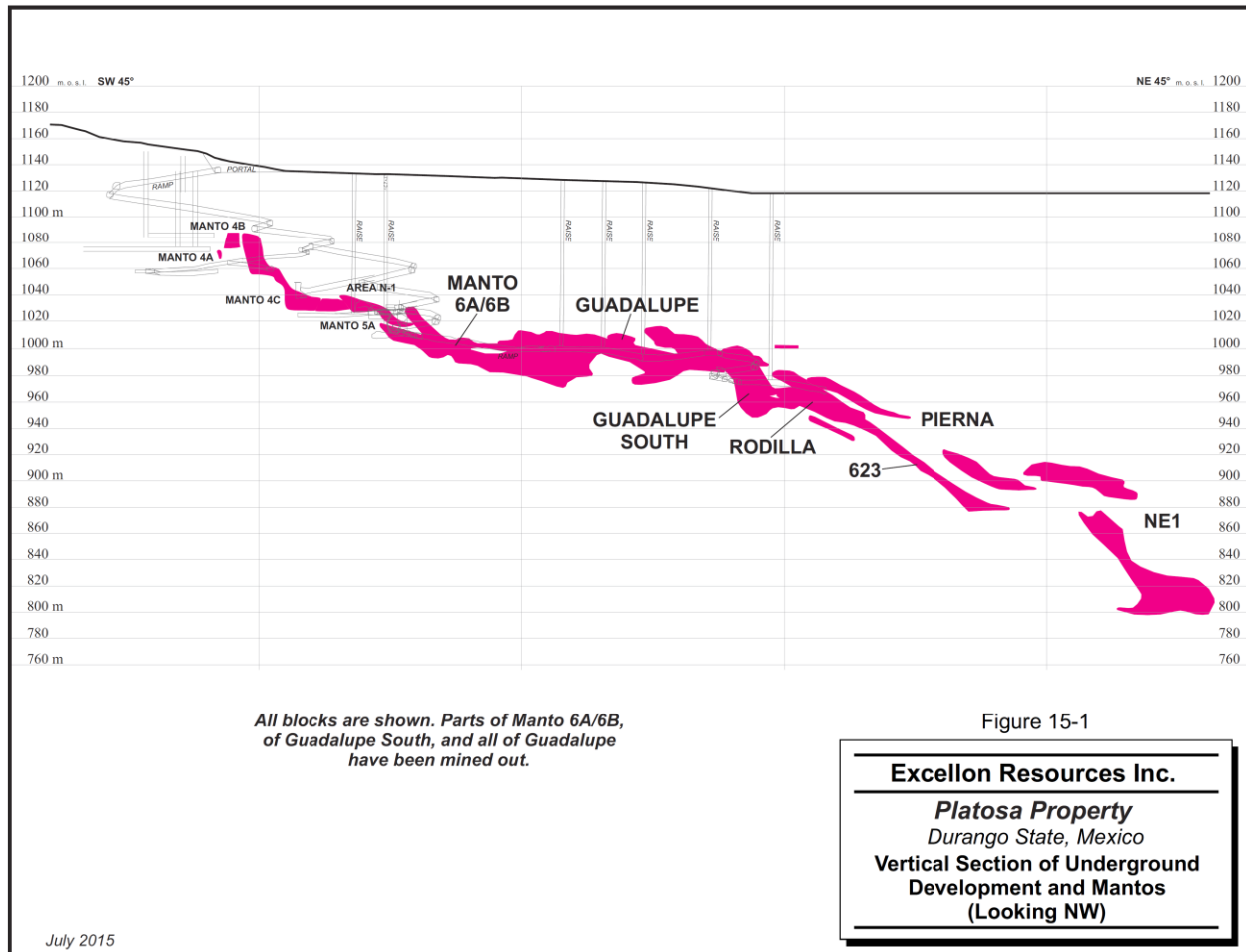
**Actual and Expected Mined Zinc Production**

<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>
4,750	4,500	4,550	3,350	2,600	3,000	0	0	0	0	0

Q1-Q3 2016 prorated to 12 months.

**Reference:** La Platosa Mine NI 43-101 Technical Report, July 9, 2015. [www.sedar.com](http://www.sedar.com)





## Additional Potential Production Prior to 2022

### Re-start of Campo Morado

Nyrstar has their zinc mines for sale and have successfully completed disposal of assets in Honduras and Chile. This mine closed due to “local security issues”. It is therefore extremely unlikely that they will re-open this mine when their intent is to exit mining entirely. They will dispose of this asset instead and leave it to someone else to payoff the union bosses and local mafia to recommence production. Predicting an outcome here is not possible. There could be a resolution in 2017 for instance or it could deteriorate into the situation at Southern Copper’s Taxco and San Martin mines which have been closed since 2007.

The table below lists the current measured and indicated resources. Zinc production in 2014 was 22,000T .

	Tonnes	Zn%	Pb%	Cu%	Au (g/t)	Ag (g/t)
<b>M+I Resources</b>	7,900,000	4.43	0.87	0.87	1.27	112

I won’t bother with the blow by blow here but you can read Nyrstar’s closure press release [here](#).

### San Nicolás - Teck Resources

A bankable feasibility study was completed in 2002 for this copper/zinc open pit deposit located in Zacatecas. Below is the press release that Western Copper put out at that time.

*Western Copper Holdings Ltd. ("Western") has received a bankable feasibility study from Teck Cominco for the San Nicolas massive sulfide deposit in Zacatecas, Mexico. AMEC Simons Mining & Metals was the primary consultant for the preparation of the seven volume report. Western's interest, currently 21%, will range between 18.75% and 29.75%, once a production decision has been made, depending on various options available to Teck Cominco. The study is presently under review by Western as to its completeness, accuracy and assumptions.*

*The project proposed under the feasibility study is designed to treat 15,000 tonnes of ore per day, and over its projected twelve-year mine life will produce 2.1 billion pounds of zinc, 1.4 billion pounds of copper, 171,000 ounces of gold and 18 million ounces of silver. Sensitivity analysis demonstrates that the project as currently designed is most sensitive to changes in metal prices and freight costs.*

*Because zinc will be the primary metal produced during the first years of operation, it is expected that consideration will be given to a production decision at the time of projected higher zinc prices. Work is continuing in various areas toward optimizing the economics of the project.*

*The San Nicolas property is 60 kilometers southeast of the city of Zacatecas on the Mexican plateau, a high desert approximately 2,150 meters above sea level. The topography is essentially flat, the climate arid, and vegetation consists mainly of cacti and low bushes.*



*The feasibility study is based on conventional open pit mining of a volcanogenic massive sulfide deposit covered by an average 170-meter depth of overburden. The estimated mineral reserves included in the mine plan total 65 million tonnes with an average grade of 1.32% copper, 2.04% zinc, 0.53g/t gold and 32.1 g/t silver. These reserves include 1.9 million tonnes of proven mineralization with an average grade of 0.71% copper, 3.51% zinc, 0.94 g/t gold and 44.8 g/t silver; and 63.3 million tonnes of probable mineralization averaging 1.34% copper, 2.01% zinc, 0.52 g/t gold and 31.7 g/t silver. The sulfide body contains an upper high-grade zinc zone and a lower copper-rich zone and is open at depth. A significant tonnage of copper mineralization present below the defined mineral reserves could be accessed from the bottom of the pit after open pit mining is complete, if conditions warrant.*

*The feasibility study projects that ore will be mined and processed at a rate of 15,000 tonnes per day (5.5 million tonnes per year). Average production is estimated at about 230,000 tonnes per annum of copper concentrates with an average grade of 23.8% copper over the 12 year mine life; and 190,000 tonnes per annum of zinc concentrates with an average grade of 50% zinc over a ten year period. Overall copper and zinc recoveries are estimated to be 76.3% and 71.0%, respectively. Based on metallurgical results to date, gold and silver recoveries are low and will only contribute about 4% to the net smelter return.*

*The capital cost estimate of US\$245.6 million includes a contingency of \$26.8 million. Life of mine operating costs total US\$8.53 per tonne milled (\$2.18 mining, \$5.99 milling and \$0.36 G&A).*

*The major infrastructure required to develop San Nicolas is minimal. A three-kilometer access road is needed to link the project site with an existing paved highway, and a thirty-kilometer power line is required to connect the site to the existing power grid.*

Development did not proceed at that time. Zinc prices were at a 60 year low in real terms and cutbacks were the order of the day. Even Red Dog was losing money at grades of 26.5% Pb+Zn.

The project has essentially gone backwards since then with a Scoping Study being completed in 2012.

The prospects of this deposit being in full production prior to 2022 are slim to none in my mind. I suspect Teck will focus on Fort Hills and the balance sheet likely through 2018 and then focus on maintaining production levels at Red Dog instead. But this project could get a construction decision in the 2020 timeframe if the zinc market remains in deficit.

Ironically, Western Copper became Western Silver and then went on to advance the Peñasquito project. More information on San Nicolas can be found in the 2002 Annual Information Form for Western Silver, filed Feb. 21, 2002, [www.sedar.com](http://www.sedar.com)

### Silver Standard- Pitarrilla Project

Silver Standard deferred development of this project following taxation changes in Mexico and the inability to secure water rights. The deposit has some similarities to Peñasquito in that it is a low grade silver/lead/zinc deposit. A portion of the reserves would be leached for silver recovery only and a portion would be milled in a conventional 16,000 T per day floatation/leaching plant for silver/lead/zinc production. Probable reserves for the floatation plant feed only are listed in the table below. These are from the 2012 NI 43-101 and differ from that reported in the most recent AIF. Average annual production would be 24,000 T Zn. Silver Standard now lists an underground mining reserve also.

	Tonnes	Zn%	Pb%	Cu%	Ag (g/t)
<b>Probable Reserves</b>	113,200,000	0.93	0.34	0.87	96.5

Extensive project details are presented in the NI 43-101 technical report referenced below.

**Reference:** Silver Standard NI 43-101 Technical Report, Pitarrilla Project, December 14, 2012.

[www.sedar.com](http://www.sedar.com)

### Goldcorp's Peñasquito

There are no plans to increase mill throughput. The zinc tailings will be leached to increase gold recovery. Zinc recoveries may improve slightly over time.

### Southern Copper

#### Re-start of Taxco and San Martin Mines

Prior to labour issues in 2007, the 4,400 T per day San Martin underground cut and fill mine produced in the 1.2 MT a year range from ore grading 2.2% Zn and 1.0% Cu. Zinc production was in the 20,000 T a year range. Typical vein and skarn mineralization was mined.

The 2,000 T per day mill capacity Taxco underground cut and fill/ room and pillar mine produced at only roughly 800 T per day. But zinc grades were in the 7% range resulting in about 12,000 T of zinc in concentrate annually.

Reserves for either site were not located but a potential restart cannot be ruled out.

Southern Copper has identified zinc rich resources at their Buenavista copper mine but are still assessing the economics of this project. From their 10-K:

**Buenavista-Zinc.** *The Buenavista-Zinc site is located in the state of Sonora, Mexico and is part of the Buenavista ore body. Drilling and metallurgical studies have shown that the zinc-copper deposit contains approximately 36 million tons of mineralized material containing 29 grams of silver per ton, 0.69% copper and 3.3% zinc. A "scoping level" study indicates that Buenavista-Zinc*

*may be an economic deposit. In 2011, 11,956 meters of diamond drilling were executed to confirm grade and acquire geotechnical information. In 2012, the Buenavista-Zinc mine plan was integrated with the overall mine plan of the Buenavista pit. The metallurgical testing was completed early in 2013 indicating some recovery problems with oxidized zinc. During 2013, we drilled 15,128 additional meters to locate the oxidized zinc for new modelling and metallurgical testing. In 2014, we received the results of the metallurgical testing and we adjusted our estimation of mineralized material to 75.6 million tons with an average zinc content of 2.06%, 0.58% of copper and 20.8 grams of silver per ton. In 2015, we drilled 26,635 meters. In 2016, we will use the samples obtained with the 2015 drilling program to test an alternative metallurgical process that includes a selective flotation, bulk flotation and Cu-Zn separation process, in order to obtain a product that fulfills the requirements to be processed at San Luis Potosí zinc facilities.*

Southern could probably develop this deposit quickly since the mineralization appears to be contained in, or immediately adjacent to the existing copper mine pit.

Southern Copper also discusses the Chalchihuites deposit but there is little likelihood of production prior to 2022 if ever.

### **Peñoles**

Peñoles has been actively drilling adjacent to their Velardeña mine (La Industria) and results will be evaluated in 2016 as a possible satellite mine. The target is listed as vein type material which differs from the manto mined at Velardeña. This appears to be their only project with production potential prior to 2022.

Peñoles continues to list reserves for Naica so a partial restart cannot be ruled out.

As an aside, Peñoles would likely be a good joint venture partner for Tinka in Peru.

### **Fresnillo**

Fresnillo has two projects under development and several advanced exploration projects. Only San Julian appears to have by-product zinc that can be in production prior to 2022 and it is included in production statistics already.

### **Other Projects**

I don't see any likelihood of the following projects containing zinc advancing to production by 2022 if ever:

Chesapeake Gold, Metates Project, NI 43-101 Technical Report, May 3, 2016 [www.sedar.com](http://www.sedar.com)

Xtierra Inc., Bilbao Project, NI 43-101 Technical Report, April 28, 2014 [www.sedar.com](http://www.sedar.com)

Zinco Mining Corp, Cuale Project, corporate filings at [www.sedar.com](http://www.sedar.com)

Firma Holdings, Don Ramon Project, NI 43-101 report [here](#)

I am sure there are probably another dozen or so explorers looking for silver/gold that may have zinc as a by-product but they have not hit my radar screen.

Mexico has adequately illustrated one of the issues over the years with the zinc market. It is very much a by-product of mining for other minerals. Profits from silver for instance would cross subsidize zinc recovery during low zinc commodity price cycles. Peñoles is the only company to readily identify themselves as zinc miners in Mexico yet this is only a small fraction of their revenue. I found nothing that I would want to invest in here since I have never been a fan of predominantly precious metal miners. Their shares tend to be priced as if the mines continue into perpetuity but this is not the case. These companies need to keep re-inventing themselves every few years as reserves run out and this entails utilizing any free cash flow from existing mines to do so. Next up will be a look at Africa.

#### **DISCLOSURE**

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