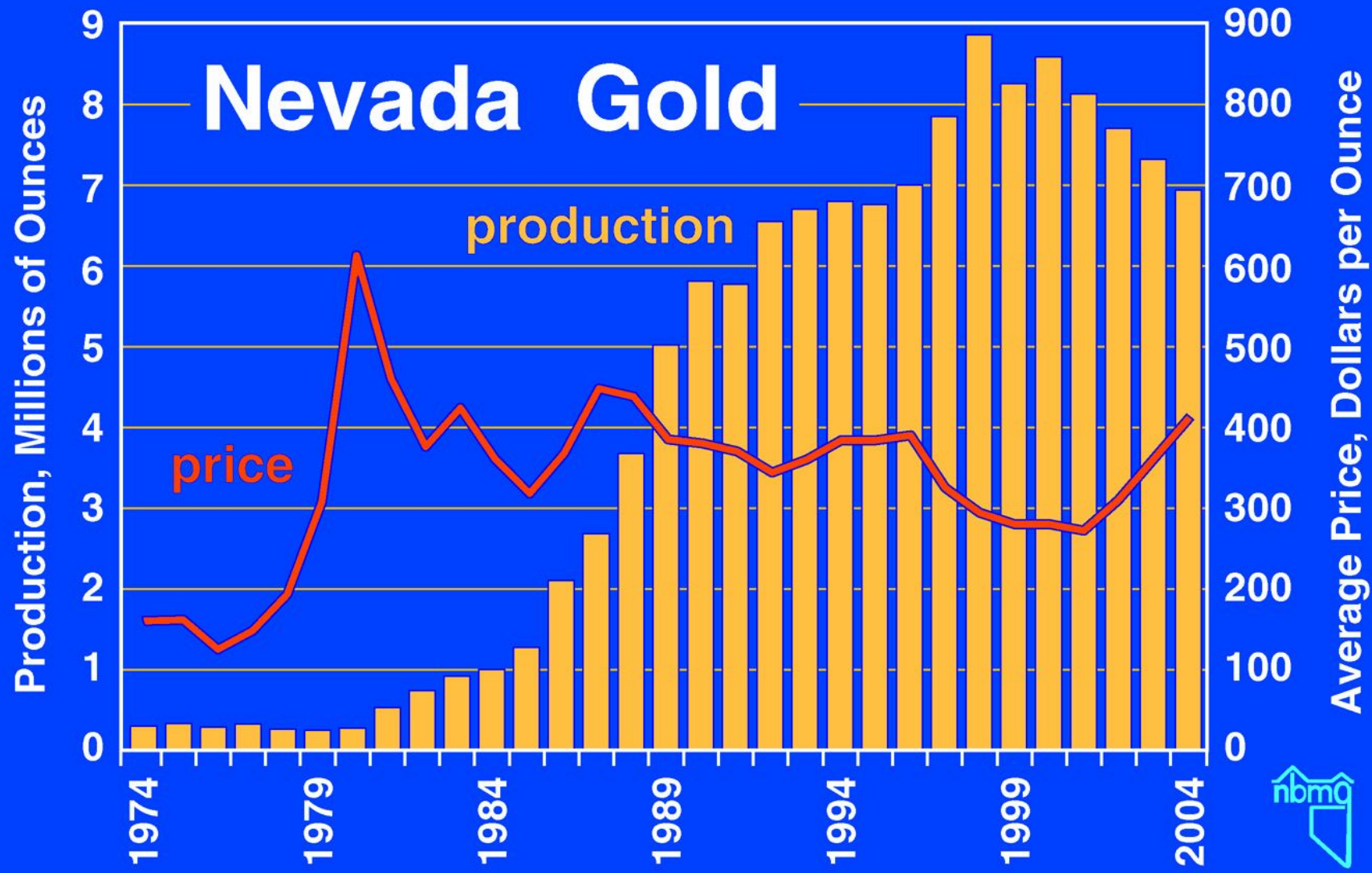
Byproduct Mercury Production in Modern Precious Metals Mines in Nevada

Glenn Miller

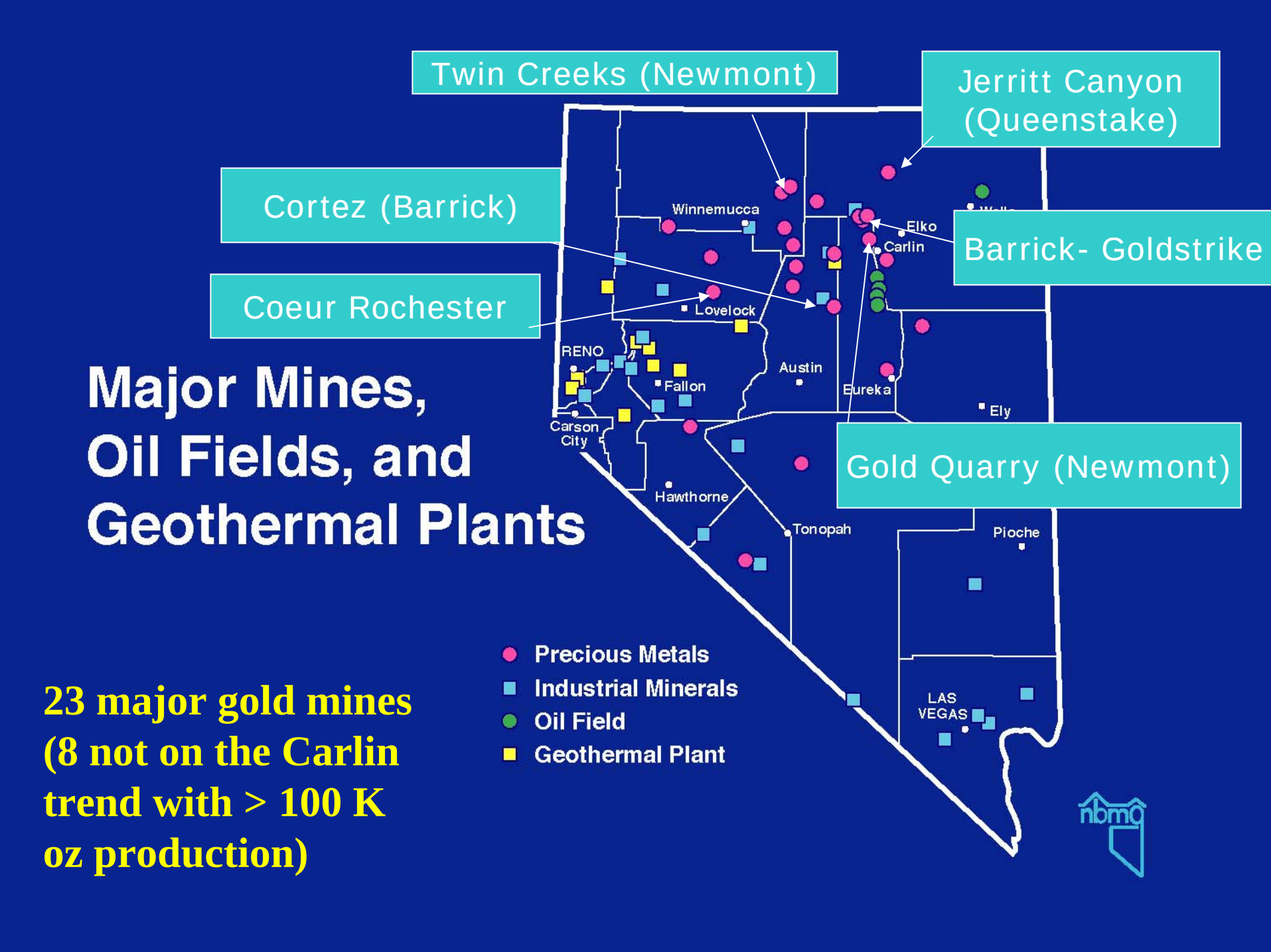
Department of Natural Resources and Environmental Science

University of Nevada, Reno


Nevada Gold
production
price
Production, Millions of Ounces
Average Price, Dollars per Ounce
0
1
2
3
4
5
6
7
8
9
0
100
200
300
400
500
600
700
800
900
1974
1979
1984
1989
1994
1999
2004
nbmg

Current Gold Mines

- Mercury is **not** used to extract gold or silver in Nevada mines (although still in developing countries)
- Mercury release to the environment is related to the co-incidence of mercury in many gold ores in Nevada, and released from the ore during processing
- Mercury is produced as a byproduct from gold mines in Nevada, and is the largest source of new mercury in the U.S.
- Mercury byproduct production is preferable to release to the atmosphere, or release in a dissolved and available form to tailings impoundments.


Twin Creeks (Newmont)
Jerritt Canyon (Queenstake)
Cortez (Barrick)
Barrick- Goldstrike
Coeur Rochester
Gold Quarry (Newmont)
Major Mines, Oil Fields, and Geothermal Plants
Winnemucca
Elko
Carlin
Lovelock
RENO
Fallon
Austin
Eureka
Ely
Carson City
Hawthorne
Tonopah
Pioche
LAS VEGAS
Precious Metals
Industrial Minerals
Oil Field
Geothermal Plant
23 major gold mines (8 not on the Carlin trend with > 100 K oz production)
nbmg

Mercury in Gold Ore

- Concentration varies substantially between mines, from less then 0.1 mg/kg to over 100 mg/kg
- Roasting ore is the largest source of byproduct mercury. If a large roaster processes 2 million tons of ore with 20 mg/kg mercury, 30-36 tons of mercury are volatilized and available for capture by air pollution control devices.

Gold Mining- Ore Types

- Oxide ore: low sulfide- directly amenable to cyanidization.
- Sulfide ore: sulfide sufficiently high to react with cyanide to form thiocyanate, which is inefficient for gold recovery. Requires thermal treatment for removal of sulfides
- Carbonaceous ore: Reduces gold cyanide recovery- competes with the charcoal for gold cyanide. Requires thermal treatment (generally roasting) for removal of carbon.

Roasting and Autoclaving

- Roasting is used to remove carbon and sulfide from ore. 80-90+% of mercury is removed from the ore
- Mercury control systems include quenching of off-gasses by water spraying; particulate removal systems, SO_2 scrubbers, carbon adsorption, and calomel and hypochlorite scrubbers

Calomel and Hypochlorite

- Calomel systems:

$$HgCl_2 + Hg^o \longrightarrow Hg_2Cl_2$$

- Hypochlorite systems:

$$NaOCl + 2Hg^o \; HCl \longrightarrow Hg_2Cl_2 + NaOH$$

Both systems operate in packed towers to remove elemental mercury

Byproduct Mercury Production in the Cyanidization Process

$$Au + O_2 + CN^- \longrightarrow Au(CN)_2^- \quad \text{(water soluble)}$$

$$Hg + O_2 + CN^- \longrightarrow Hg(CN)_2 + Hg(CN)_4^{2-}$$

(water soluble)

Both gold and mercury cyanide complexes are trapped on carbon (charcoal), stripped from the carbon and recovered by electrowinning or the Merrill Crow process, using zinc.

Mercury is distilled (retorted) from the gold and collected as liquid mercury and sold.

Sources of Mercury During Gold Recovery that is Available for Capture

- *Carbon Kilns;* Since, mercury is not completely removed from carbon during stripping, charcoal is heated in carbon kilns to remove the mercury.
- *Electrowinning cells* can release mercury during recovery of elemental gold and silver.
- *Retorts* are the primary source of byproduct production in oxide gold mines. The primary use of retorts is for mercury removal from gold and silver.
- *Dore Furnaces*: Residual mercury can be released during dore furnace treatment, where the ore is melted at 1500^{o} C in a refinery furnace to produce dore (gold and silver).

How is Byproduct Managed

- Sold or transferred to three primary mercury recyclers
  - Bethlehem Apparatus Co. Inc., Hellertown, PA;.
  - D.F Goldsmith Chemical and Metal Corp, Evanston, IL
  - Mercury Waste Solutions, Inc., Mankato, MN
- Each of these companies is regulated by the EPA
- Hg produced in NV is 114 metric tons 2006
- Management and transfer is conducted in a safe and reliable manner

Previous records for Hg Production from the Nevada Division of Minerals (lbs)

Mine	1988	1989	1990	1991	1992	1993	1995	1999	2000
Hycroft							54000	40000	7447
Paradise Peak	237708	252000	227000	164075					
Newmont	5548	16264	12388	8512	16872	14187			14192
Borealis	1824								
Hog Ranch			7953	8208					
McDermitt (primary Hg mine)	846488		1008216	0	0				

Total Mercury By-Product Recovered for Sale (pounds and metric tons) (provided by each company- VMRP program)

	1999	2000	2001	2002	2003
Jerritt Canyon	4,041	4,313	3,709	5,045	
Placer Dome (Pipeline)	831	814	1,068	903	888
Placer Dome (Bald Mtn)	1,203	248		***	***
Barrick	13,629	63,701	133,784	204,477	
Newmont (E. Operations)	*N/A*	14,192	19,484	16,944	16,888
Newmont (W. Operations)	*N/A*		7,986	8,367	11,891
Total pounds		*83,268*	*166,031*	*235,736*	
Total Metric Tons		*37.8*	*75.3*	*106.9*	

Mercury Reports for 2004 to NDEP, (lbs)

Mine	Hg Produced
Gold Quarry (Newmont)	7609
Twin Creeks (Newmont)	26,746
Gold Strike (Barrick)	173,538
Jerritt Canyon (Queenstake)	1570
Bald Mtn (Barrick)	825
Pipeline (Barrick)	1744
Marigold (Glamis)	140
Rochester (Coeur)	31,875
Total (NV)	**244,160**
	111 Metric tons

Mercury Reports for 2006 to NDEP, *Preliminary* (tons)*

Mine	Hg Produced
Gold Quarry (Newmont)	2.62
Twin Creeks (Newmont)	5.4
Gold Strike (Barrick)	98.4
Jerritt Canyon (Queenstake)	2.96
Bald Mtn (Barrick)	Not recorded
Florida Canyon (Apollo)	0.2
Marigold (Glamis)	Not Recorded
Rochester (Coeur)	16.1
Total (NV) (U.S. tons)	**126**
Total (NV) (Metric tons)	**114**

*Uncertainties exist in reporting for some of the mines that need to be resolved

Conclusions and Recommendations

- Uncertainties exist as to the total amount of mercury that can be captured for byproduct, and the total amount of byproduct mercury could increase if regulatory agencies require mass balance determinations and a minimization of mercury discharged to tailings facilities.
- Byproduct mercury production should be reported from all mines in the U.S. It is required in new Nevada regulations for precious metals mines.
- Mercury byproduct production will likely vary substantially as mines are closed and others opened. Byproduct production is very mine specific.