

MERCURY

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Mercury demand and production continue to be adversely affected by environmental and human health concerns. For example, diaphragm and membrane cells are increasingly replacing mercury cells in the electrolytic production of chlorine and caustic soda, the primary end-use for mercury; lithium, nickel-hydride and zinc-air batteries are substitutes for mercury-zinc batteries; indium compounds substitute for mercury in alkaline batteries; ceramic composites can replace dental amalgams; organic compounds have replaced mercury fungicides in latex paint; and digital instruments have replaced mercury instruments in many applications.

Against this backdrop, it could have been expected that the world price for mercury would have fallen. Instead, it increased by over 300% during 2004. Market quotations, which cover prime virgin mercury, began 2004 at US\$180-220/fl (each flask contains 34.50 kg nett). This price range was somewhat lower than actual levels at that time as mercury is not a commodity closely monitored by the trade publications due to its lack of interest to the trading fraternity. However, as the year progressed, the quotations gradually caught up with the market, moving up to US\$290-320/fl by mid March. After a quiet summer in the northern hemisphere the price moved sharply up again in September, to US\$400-450/fl and ended the year at US\$600-700/fl. Early in 2005, even these record levels were surpassed as prices moved above US\$1,000/fl.

The explanation behind this dramatic price increase, despite waning demand, is the severe curtailment of production caused partly by the environmental concerns associated with the metal.

Mercury is a naturally-occurring element and the only metal that is liquid at normal room temperature and pressure. It is sometimes called 'quicksilver'. It is indestructible and although it can be transformed into a less problematic compound, this chemical process is complex and costly. This means that there is a "global pool" of mercury circulating in society and the environment – between air, water, sediments, soil and living things.

Because mercury occurs naturally in the Earth's crust, some is released by natural processes such as volcanic activity. It can also be produced as a liquid metal by processing a naturally-occurring ore, cinnabar (mercury sulphide). Releases of mercury from its use in products and from other human activities, such as burning coal, increase the degree to which we and the environment are exposed to the metal.

Mercury and its compounds are highly toxic to humans and the environment. Large amounts can be fatal but even relatively low doses can seriously affect the nervous system.

Mercury can change in the environment into a more complex and harmful compound called methylmercury, which passes both the placental and the blood-brain barriers, and so can inhibit children's potential mental development, even before birth.

Methylmercury accumulates in certain fish and seafood (particularly in large predatory fish), that may form part of people's diet. Although most people in developed countries appear to be within internationally accepted safe levels for exposure to methylmercury, there is strong evidence that some people are around or above these levels in some developing countries, and even in the coastal areas of some developed countries and the Arctic regions.

Supplies of mercury can be of primary or secondary origin. Primary mercury arises from mining operations where mercury is the sole product or from operations where mercury is produced as a by-product of mining other metals such as copper, gold and zinc.

Primary supply

Primary world mercury resources are estimated at nearly 600,000 t (approximately 17 million flasks) and are located principally in China, Italy, Kyrgyzstan, Russia, Slovenia, Spain and Ukraine. Of the total resources, it is estimated that around 121,500 t (3.5 million flasks) could be mined economically (reserves) and 245,000 t (7.0 million flasks) recovered if cost was not a consideration (reserve base) (see Table 1).

World primary mercury supply in recent years has been dominated by Spain, Kyrgyzstan and Algeria, all of whom mined and produced mercury mostly for export. China is also a producer but output is mainly for its own fast-developing domestic market. The mercury mines in these countries are all state-owned although there have been unsuccessful attempts in recent years to privatise both the Spanish and Kyrgyzstan operations.

The Spanish mines, in the heart of La Mancha, are operated by Minas de Almaden. The company has an annual capacity of some 35,000 fl (1,200 t) but production has been running at much lower levels in recent years (see Table 2). The main reason for this was understood to be, and this idea was indeed encouraged by the producer, that Almaden was adjusting its production on an annual basis to prevent market over-supply, and to prevent prices from falling even further. In its position as the world's leading and largest mercury producer this was seen as a responsible strategy.

The reality appears, however, to be somewhat different in that the company was granted substantial EU subsidies in 1995, which were linked to a gradual phase-out of mercury mining. These subsidies, however, did not preclude the company from purchasing quantities of mercury from the Former Soviet Union (FSU) stockpiles, along with supplies of mercury from decommissioned chlor-alkali plants. This enabled Almaden to maintain its customer base while reducing primary production from mining operations, thereby complying with EU guidelines.

There has, however, been very little material available from the FSU stockpiles in the past two years and current EU policy is restricting availabilities of mercury from chlor-alkali plants. As a result, Almaden raised its mine production in 2003, and could have been expected, especially in view of the rising price, to have increased output even further in 2004. Production was halted for four months at the end of 2003 whilst modifications were made to Almaden's gas treatment process. The plant reopened in January 2004, working at a capacity of 10,000 flasks (345 t)/y, and had reached normal production levels of 20,000-25,000 fl (690-862 t)/y by mid-February.

At the end of July 2004, mine output was suspended. The company announced that it was not going to extract any more mineral and that it was working on a plan to turn the mine into a tourist attraction! The plant would continue to recover mercury from disused industrial installations for treatment and resale, as well as from its existing stocks of ore. These are estimated to be around 100,000 t which yield 3.5 kg of metal per 100 kg, representing a possible 100,000 fl (3,450t) of mercury.

These actions led the company to ration sales to about 60% of regular customers' usual requirements. On this basis, Almaden estimated that its stocks would be sufficient for a further 4-5 years. In May 2005, however, Almaden stopped treating its ore altogether but continued selling from its stockpiles of treated material, estimated to be between 100-200,000 fl (3,450-6,900 t). The company was also hopeful that the continuing treatment of secondary mercury would provide a further 10,000 fl (343 t) during the year and it was rumoured that it had purchased some quantities of mercury from Kyrgyzstan and Japan to bolster its stocks.

It would appear that the world's largest mercury mine, which has been producing since Roman times, and which has been responsible for producing one-third of the world's total mercury output, is at the end of its road. If the EU has its way the treatment of any type of mercury, in Spain or elsewhere in Europe, will also cease.

Kyrgyzstan has the world's third-largest resources of mercury after Spain and China, but is the world's second-largest producer after Almaden. There are about 400 known mercury deposits, two of them comprising large fields (Chonkoi and Khaidarkan containing more than 20,000 t) and one medium field (Zardobuka, with 1,500 t). The remaining deposits are relatively small. The Khaidarkan Mercury Combine (KMC), the only mercury producer in Central Asia, is based in the Batken region of southern Kyrgyzstan. Production of mercury ore at Khaidarkan, the main source of ore for the combine, is moving towards deep mining. The resource base is now confined to the western end of the district, with an average ore grade of 0.4% Hg, and proven reserves available for commercial development will support production at current levels for another ten years.

Water problems caused by flooding in 2003 were finally solved in the early part of 2004 after an investment of about US\$2 million to restore production. In

October 2004, plans were unveiled to buy new mine equipment for the first time in 20 years. Whether or not this will happen is uncertain as the mine has been included on a tentative list of enterprises that may be handed over to Russia towards settlement of the country's debt. Its inclusion on the list followed another unsuccessful attempt by the Kyrgyz Government, in February 2005, to sell a 99.98% stake in the mine. Nevertheless, KMC's production was up in 2004, at 14,148 fl(488.10 t), and there are plans to raise output to 14,500 fl (500 t) in 2005. The combine's total annual capacity is understood to be close to 17,500 fl (600 t). Most of KMC's output is sold directly into China.

Algeria has been a significant supplier of Mercury in the past but halted supplies during the second half of 2003. The official line by Enterprise Nationale des Produits Miniers Non-Ferreux et des Substances Utiles (Enof) was that production had been stopped for a few months in order to rehabilitate the equipment of the mine and factory, as well as the reinforcement of mining work with a view to restarting production in January 2005. In the meantime, Enof had meagre stocks and the small amounts produced prior to the closure did not allow the company to honour even existing contracts.

The plant and equipment is indeed old, dating back to the 1970s and, as with much of Algeria's public sector, the mine has suffered from years of neglect due to a lack of funds, mismanagement and the State's focus on fighting a brutal Islamic uprising. Capacity at the Azzaba mine, located some 400 km east of the capital Algiers, was around 7,000-8,000 fl (200-230 t)/y, which it was advised would increase to 8,000-10,000 fl (230-290 t)/y after the improvements, but local residents have long complained of environmental problems and diseases linked to the mine.

Several years ago the local mayor called for the mine to close, and closure was rumoured to have occurred in mid 2005. It is understood the mine was continually being flooded by an underground river and that pumping has proved unsuccessful. No official announcement has been made but neither has there been any Algerian mercury available to the market since the end of 2003, nor any contact possible with the producer.

China has the resources to match Spain as a mercury producer and was an important exporter up until the late 1980s. Deposits there, however, are low grade and widely spread geographically. Thus there are many small operations with relatively high production costs, and years of low prices have led many of them to close with the result that China has become a net importer. The recent boom in China's economy has led to the re-opening of many of these mines and, although no official figures are yet available for 2004, production is estimated to be up by about 6% on 2003, to some 18,840 fl (650 t).

The mining of mercury in China is supposedly strictly controlled to an official limit of 14,500 fl (500 t)/y but more is believed to be mined unofficially, especially in gold-mining areas. The largest refiner in northern China produced around 11,600 fl (400 t) in 2004, and plans similar levels for 2005, sourcing ores mainly from Xunyang. Otherwise, the producers are mostly in

Huizhou Province in the south, such as Wanshan Minerals, which produced only 580 fl (20 t) in 2004 but plans to increase this to 870 fl (30 t) in 2005. There are three or four other producers on this scale in the provinces, the largest of which had a total output of only 1160 fl (40 t) despite running at full capacity. Certainly, production has not yet increased to levels where China might again become an exporter.

Mercury is also recovered as a by-product of certain base-metal operations in order to avoid releases of the metal into the environment when the ores being treated also contain mercury as well as other elements. Amounts of by-product mercury vary but are usually small.

Probably the largest amounts come from the Yannacocha gold mine in Peru operated by Newmont Mining. The mercury is sent for refining in the US and annual arisings average around 2,500-3,000 fl (86-104 t). In Japan, Nomura Kohshan produces about 1,500 fl (50 t) from its zinc smelting operations but the final closure of the old imperial smelting furnace at the Porto Vesme lead and zinc refinery in Sardinia during 2004 means that no more mercury will arise from that source. The most consistent producer continues to be Outokumpu (part of the Swedish owned New Boliden Group) in Finland, which maintained production in 2004 at around 600 fl 921 t) from the refining of its zinc ores. Further small amounts of by-product mercury were recovered during the refining of copper ores in Slovakia and from gold and silver processing in the US and China.

Mercury has not been mined as a primary commodity in the US since 1992. By-product mercury is recovered from gold ore and as calomel from scrubbers at gold smelters, but no figures are reported. Secondary mercury, however, remains the principle domestic source of mercury in the US. The Defense National Stockpile (DNS) continues to hold 128,580 fl (4,436 t) of prime virgin mercury at locations in Hillsborough, New Jersey, New Haven in Indiana and Warren in Ohio. In addition, the US Department of Energy holds 4,232 fl (146 t) of secondary mercury at its facility in Oak Ridge, Tennessee. Although all of this material was authorised for disposal by Congress many years ago, sales have been suspended since 1994 due to environmental concerns. In May 2004, the Pentagon finally announced that selling onto the world market was no longer an option and that it planned to consolidate all of the material at one of five secure warehouse sites for as long as 40 years.

Stockpiles have been held in other countries, particularly in the Former Soviet Union, most of which has been sold in recent years. There remains an estimated 29,000 fl (1,000 t) or so available from Russia that was being offered to the world market and there could well be other quantities not yet known about.

Secondary supply

Due to the cutbacks in primary sources, secondary mercury has become more important. There are two main categories, the most significant of which is mercury recovered from the manufacture of caustic soda where mercury is used as an electrolyte to separate the chlorine. Apart from the mercury

wastes from contaminated old equipment, solids from water and brine purification etc that are routinely recycled or disposed of during normal operations, large quantities of mercury are recovered during the decommissioning of chlor-alkali facilities. For example, Russia's Sayanskkhimplast announced plans in June 2004 to abandon its outdated technology employing mercury electrolysis and to replace it with a membrane method to produce chlorine and caustic soda. As a result, the company could double output and reduce environmental risks and this would of course free up further supplies of reclaimed mercury. The project was expected to be completed by the end of 2004.

Of less importance is the recycling of waste products such as thermometers, barometers, manometers, dental amalgams, electrical switches and relays, thermostats, fluorescent (including compact fluorescent) tubes and lamps, high-intensity discharge lamps and batteries.

Many Western chlor-alkali plants have been dismantled in the past 20 years but there is still estimated to be a further 350,000-450,000 fl (12,000-15000 t) of mercury recoverable from such plants in the EU alone, if they convert their plants away from the mercury cell process. To this end, an agreement exists between Almaden and Euro Chlor (representing European caustic-soda producers) to treat and recycle this mercury. The parties claim that this provides a solution to the mercury arising from the decommissioning of the cells and provides a real substitute to mining fresh mercury.

The EC even recommended in a report issued in September 2002 that all existing EU members and prospective new members proceed as per the Euro Chlor-Minas de Almaden agreement, thus making it easier for the EC to control the supply of mercury without imposing new legal restrictions. This recommendation, however, has not satisfied some ecological groups, such as the Ban Mercury Working Group (BMWG). This group held a conference entitled 'Towards a Mercury-Free World' during April 2005 close to Almaden's head office in Madrid. Euro-Chlor members are committed to phasing out mercury use by the year 2020 but the EU is calling for a ban on exports by 2011. Quite what would happen to any mercury arisings between those years is unclear.

The US has responded to the EU proposals by announcing it would propose an international partnership to track mercury emissions from the chlor-alkali industry as its voluntary alternative to the EU plans to launch an international treaty process to curb mining and trade in the substance. But the partnership plan, which was to be formally proposed at the February 2005 United Nations Environment Programme (UNEP) governing council meeting in Nairobi, Kenya, is drawing criticism from environmentalists, who say it fails to address global sources of mercury adequately.

The proposed plan by the US and others will ask country and industry partners to share information on emission-control techniques and to measure progress towards reductions in the chlor-alkali sector. However, the plan sets no deadline to consider any emissions data provided under the study.

New chlorine production processes that do not require mercury have been available for around 20 years, and some are in operation. But observers acknowledge that the old technology will be around for a while in China, India, Russia and Mexico, so there is really little chance of reaching a binding international agreement, as the EU is proposing.

The only alternatives to treating secondary mercury are permanent storage as with the US stockpile, which is expensive, or landfill. However, in Europe, an EU directive in July 2004 severely reduced the number of sites permitted to accept mercury-bearing waste products thereby limiting the options for disposal. This, in itself, should encourage recycling.

In Japan, nearly all manufacturers have announced proposals to phase out the use of mercury and other toxic metals by 2006 but demand is likely to continue in less developed countries. If recycled material from chlor-alkali plants that are closing in the EU is not made available to fulfil this demand then world mercury prices are likely to remain high. This will encourage increased mine production, particularly in China and FSU countries, and possibly even in Turkey, Slovenia and Mexico. It will also provide more impetus for schemes such as the Irish company Minco announced in April 2004. The company has secured a licence to extract 14 Mt of tailings from a lake in the Zacatecas region of Mexico where 17% of the world's silver is produced. Hundreds of years of Spanish colonial silver production in the area has contaminated the lake and subsequently local drinking water. Minco will extract the tailings and leach out the metals, including an estimated 87,000 fl (3,000 t) of mercury, with non-toxic thiosulphate chemicals. Micon of Canada was appointed to carry out a feasibility study. Minco planned to raise US\$24 million in order to commence production in 2005 although by August 2005 a start date was still not known.

The future of mercury would appear to depend not upon supply and demand, as with other commodities, but on the decisions taken by world governments within the next few years in response to the environmental lobby.

Table 1
World reserves and reserve base: (t)

	Reserves	Reserve Base
Algeria	-	5,000
Italy	-	69,000
Kyrgyzstan	7,500	13,000
Spain	76,000	90,000
US	-	7,000
Other countries	38,000	61,000
World total	121,500	245,000

Source: US Geological Survey Mineral Commodity Summaries. January 2005

Table 2
World primary and by-product mine production by country (t)

	2000	2001	2002	2003	2004
Algeria	216 r	320	620	300 e	
China	200	190 r	495	610	650 e
Finland	76	71	42	30	21
Italy	20	20	15	7	6
Japan	-	-	-	50	70 e
Kyrgystan	257 r	300 r	537	370	488
Kazakhstan	-	-	-	13	-
Mexico	15 r	15 r	20	N/A	N/A
Peru	-	-	-	-	100
Russia	50 r	20	-	N/A	N/A
Slovakia	N/A	N/A	N/A	-	-
Slovenia	N/A	N/A	-	-	-
Spain	476 r	524	726	745	350
Tajikistan	40	30	-	-	-
Ukraine	N/A	N/A	-	-	-
US	N/A	N/A	-	-	-
TOTALS	1,350	1,490	2,455	2,125	1685
Flasks	39,130	43,188	71,160	61,594	48,840

r = Revised. e = Estimated na =not available

Sources: US Geological Survey Mineral Commodity Summaries January 2005 much of which contains estimated figures. Accordingly adjustments have been made where more accurate information has been obtained.