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SELENIUM AND TELLURIUM

(FINAL RELEASE)

GOVERNMENT OF INDIA
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14 Selenium and Tellurium

Selenium and tellurium are rare elements widely distributed within the Earth's crust. They do not occur in concentrations high enough to justify mining solely for their content. They are recovered as by-products, mostly from anode mud or slime obtained during electrolytic refining of copper. Tellurium is found mostly in tellurides associated with metals such as bismuth, lead, gold and silver. It is found with selenium in the anode slime from electrolytic copper refineries.

EXTRACTION

Selenium and tellurium metals were being recovered as allied products at Ghatsila Copper Smelter of HCL in Jharkhand, where the annual installed capacity to produce selenium was 14,600 kg. HCL has not reported production of selenium since 2006-07 and that of tellurium since 2004-05. HCL has developed its own Precious Metal Recovery Plant at ICC successfully. Presently, the plant is not operational. A tellurium recovery plant has also been developed by R & D Wing. Hindalco Industries Ltd reported 73,870 kg production of selenium from imported copper concentrates at its Dahej Smelter in Gujarat during 2010-11 and thereafter no production data is available.

USES

Selenium

Selenium is used as a decolourising agent in the Glass Industry. Approximately, 1 kg selenium is used for about 150 tonnes of glass production. It is also used in architectural plate glass to reduce solar heat transmission. High purity selenium compounds were used principally as photoreceptors on the drums of older plain paper copiers which are gradually being replaced by newer models that do not use selenium in the reproduction process. Dietary supplement for livestock is the largest agricultural usage of selenium. Also, selenium is known to be added to fertilizer to enrich selenium-poor soils.

Selenium is added to steel, copper and lead alloys to improve machinability which enables faster production with better surface finish and casting properties. Selenium is added to low antimony-lead alloys used in the support grids of lead acid storage batteries. The addition of 0.02% selenium by weight as a grain refiner improves the casting and mechanical properties of alloy. Metallurgical applications of selenium also include its use in the production of Electrolytic Manganese Metal (EMM), wherein about 2 kg of SeO_2 is required per tonne of electrolytic manganese metal produced.

Selenium is proving to be a useful Solar PV material in increasing the efficiency of absorption of light.

Chemical uses of selenium are in industrial and pharmaceutical applications. The principal pharmaceutical use of selenium is in anti-dandruff hair shampoos. Selenium is also used as a human dietary supplement. Other industrial chemical uses are as lubricant, rubber compounding catalysts and as a promoter in the reformation of naptha.

In pigment applications, selenium is used to produce colour changes in cadmium sulphide-based pigments. Sulphoselenide pigments have good heat stability, resistant to light and chemical attack and hence are used in ceramics, plastics, paints, inks and enamels. Selenium is used in catalysts to enhance selective oxidation and in plating solutions to improve appearance and durability. It is also used in blasting caps and gun bluing.

The use of selenium in glass has increased due to higher colourless glass production. The use of selenium in fertilizer and supplements in the plant-animal human chain and as human vitamin supplements increased as its health benefits were documented. The use of selenium in copper-indium-gallium-diselenide (CIGD) solar cell has increased.

Selenium is recovered from used electronic and photocopier components and recycled. The estimated global use of selenium was in metallurgy (40%), glass (25%); agriculture; chemicals & pigments; electronic (10% each) and other industries (5%).

Tellurium

Tellurium (Te) demonstrates properties similar to those of elements known to be toxic to humans and has application in industrial processes, which is rapidly growing in importance and scale. Tellurium is used principally as an alloying element in the production of free-machining low carbon steel, where additions up to 0.1% tellurium greatly improves machinability. It is also used as a minor additive in copper alloys to improve machinability without reducing conductivity. Tellurium catalysts are used chiefly for the oxidation of organic compounds and also in hydrogenation and halogenation reactions. Tellurium chemicals are used as vulcanising and accelerating agents in processing of rubber compounds. It finds use as a component of catalysts for synthetic fibre production that is increasingly used in cadmium-tellurium-based solar cells. In plain paper copiers and in thermoelectric and photoelectric devices, tellurium is used along with selenium. Mercury-cadmium telluride is used as a sensing material for thermal imaging devices. Tellurium is also used as an ingredient in blasting caps and as a pigment to produce colours in glass and ceramics. High purity tellurium is used in alloys for electronic applications.

SUBSTITUTES

The use of selenium as an alloy to substitute for lead in plumbing continued to increase in response to requirements of Public Law for safe drinking Water Act Amendment 1996. High-purity silicon has replaced selenium in high-voltage rectifiers and is the major substitute for selenium in low and medium voltage rectifiers and solar photovoltaic cells. Other inorganic semi-conductor materials, such as, silicon, cadmium, tellurium, gallium and arsenic as well as organic photoconductors are the substitutes for selenium in photoelectric applications. Cerium oxide is substitutes of selenium as either a colorant or decolorant in glass. Amorphous silicon and organic photoreceptors are substitutes of selenium in plain paper photocopiers. Sulphur dioxide can be used as a replacement for selenium dioxide in the production of electrolytic manganese metal.

Several materials can replace tellurium in most of its uses, but usually with loss in production efficiency or product characteristics. Bismuth, calcium, lead, phosphorus, selenium and sulphur can be used in place of tellurium in many free-machining steels. Several of the chemical process reactions catalysed by tellurium can be carried out with other catalysts or by means of non-catalytic processes. The chief substitutes for tellurium were selenium and sulphur in rubber compound applications and selenium, germanium and organic compounds in electronic applications.

WORLD REVIEW

Selenium

The world reserves of selenium at 99,000 tonnes only cover the estimated contents of economic copper deposits. Selenium was obtained as a by-product with copper. Substantial resources also exist in association with other metals, and in uneconomic copper deposits (Table - 1).

The world production of refined selenium is furnished in Table-2.

Global selenium and tellurium output cannot be determined easily because not all companies or countries report production and because trade in scrap and semi-refined products may be included with refined metal trade data.

Table – 1 : World Reserves of Selenium (By Principal Countries)

(In tonnes of Selenium content)

Country	Reserves
World: Total (Rounded off)	**99000**
Canada	6000
China	26000
Peru	13000
Poland	3000
Russia	20000
USA	10000
Other countries	21000

Source: *Mineral Commodity Summaries, 2019. USGS*

Table – 2: World Production of Refined Selenium (By Principal Countries)

(In tonnes)

Country	2015	2016	2017
Belgium[(e)]	200	200	200
Canada	154	176	49
Chile[(e)]	50	50	50
China	720	750	770
Finland	93	104	100
Germany[(e)(a)]	790	790	790
Japan	772	753	792
Kazakhstan[(e)]	130	130	130
Mexico	99	121	112
Peru	40	45	50[(e)]
Philippines[(e)]	70	70	70
Poland	87	82	74
Russia	143	197	197[(e)]
USA[(e)]	90	122	116
Other countries	75	76	76

Source: World Mineral Production, 2013-2017, BGS.
Note: *In addition to the countries listed, Australia, Iran, the Republic of Korea and Zimbabwe are believed to produce refined selenium.*
(a): includes selenium produced from imported material.

Tellurium

The world reserves of tellurium were at 31,000 tonnes contained in copper resources. Concentration of tellurium could also be found in lead and gold deposits. The quantities of tellurium in deposits of coal, copper and other metals that are of sub-economic grade are several times the amount of tellurium contained in identified economic copper deposits (Table-3).

More than 90% of tellurium is produced from anode slimes collected from electrolytic copper refining and the remainder is derived from skimmings at lead refineries and from flue dust and gases generated during the smelting of bismuth, copper and lead ores. The anode slimes of copper and lead refineries normally contain about 3% tellurium. The chief producers of refined tellurium in the world in 2017 were China, USA, Japan, Sweden, Russia and Canada contributing an estimated 457 tonnes to the world production compared to 454 tonnes produced in 2016 (Table-4).

Table – 3 : World Reserves of Tellurium (By Principal Countries)

(In tonnes of Tellurium content)

Country	Reserves
World: Total (Rounded off)	**31000**
Canada	800
China	6600
Sweden	670
USA	3500
Other countries	16000

Source: *Mineral Commodity Summaries, 2019, USGS*
Note: *In addition to the countries listed, Australia, Belgium,Chile, Colombia, Germany, Kazakhstan, Mexico, Philippines and Poland produce refined tellurium, but output was not reported and available information was inadequate to make reliable production and reserves estimates.*

Table – 4 : World Production of Refined Tellurium (By Principal Countries)

(In tonnes)

Country	2015	2016	2017
Canada	9	18	17
China	210	279	281
Japan	34	28	34
Russia	34	40	40
Sweden	33	39	35
USA[e]	50	50	50

Source: *World Mineral Production, 2013-2017, BGS.*

Note: *In addtion to the countries listed Germany and Belgium are also believed to produce refined tellurium.*

To give a generalised view of the development in various countries the counry-wise description as sourced from latest available publication of Mineral Yearbook 'USGS ' 2016 is furnished below.

China

China produced an estimated 920 tonnes of selenium in 2016, a 13% increase from 2015. China's estimated production of tellurium was 279 tonnes, a slight decrease from the year 2016.

In April, 2016, the Govt. of China announced plans to increase its PV capacity during the next 5 years, adding 15 to 20 GW of solar power generation capacity annually, reaching a total capacity of

75 to 120 GW. These new solar plans could drive up the consumption of minor metals, including cadmium, indium, gallium, selenium and tellurium.

China Triumph International Engineering Group Co. Ltd. started a new project to build a 1.5 GW per year CIGS solar cell production plan in Bengbu, Anhui Province. No time frame was given for the completion date. Triumph produced on solar cells through its subsidiary Jetion Solar China Co. Ltd. at a rate of one GW per year.

China's leading copper producer, Jiangxi Copper Co. Ltd. continued its normal output of SeO_2 and tellurium metal despite annual maintenance in May. The company's production of SeO_2 and tellurium in May was 25 tonnes and 2 tonnes respectively.

India

India planned to expand its solar capacity to 100 GW per year by 2022 from 5 GW per year in 2015. As a result of the ongoing expansion of the country's solar capacity, India's selenium consumption was estimated to have increased in 2016. Imports of selenium metal into India nearly doubled in 2016 to 565 tonnes from 296 tonnes in 2015.

Sweden

In Sweden, the production of by-product tellurium at New Boliden AB's Kankberg gold mine increased by 17% in 2016 to 38,700 kg from 33,000 kg in 2015. Boliden reopened the Kankberg gold mine in 2012 and the mine's life was expected to extend through 2020.

FOREIGN TRADE

Exports

Exports of selenium during 2017-18 decreased by 14% to 174 tonnes from 203 tonnes in 2016-17. Exports were mainly to China (30%), UAE & Hong Kong (29% each) and Netherlands (6%). There were no exports of tellurium during 2017-18 while there was only 1 tonne of exports of tellurium in the previous year (Tables-5 & 6).

Imports

Imports of selenium during 2017-18 decreased by 53% to 254 tonnes as compared to 539 tonnes in the preceding year. Imports were mainly from Japan (43%), Korea, Rep. of (25%), Belgium (17%), Germany (6%) and China & Netherlands (3% each). During 2017-18, imports of tellurium increased by 50% to 3 tonne as compared to 2 tonnes in the preceding year. Imports were mainly from China, Belgium and Japan (33% each) (Tables-7 & 8).

Table – 5 : Exports of Selenium
(By Countries)

Country	2016-17		2017-18	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**203**	**257267**	**174**	**374188**
China	125	151693	52	109235
UAE	38	42228	51	107911
Hong Kong	22	27588	50	107425
Netherlands	5	9954	10	21568
Switzerland	-	-	3	7721
Canada	3	7797	2	6226
Italy	-	-	2	4915
Belgium	7	10944	2	4907
Bangladesh	1	235	2	1277
USA	++	1693	++	977
Other countries	2	5135	++	2026

Table – 6 : Exports of Tellurium (By Countries)

Country	2016-17		2017-18	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**1**	**59**	**-**	**-**
Bangladesh	1	57	-	-
Singapore	++	2		
Other countries	++	++	-	-

Table – 7 : Imports of Selenium (By Countries)

Country	2016-17		2017-18	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**539**	**527923**	**254**	**585920**
Japan	150	176405	110	251824
Korea, Rep. of	85	84510	63	144927
Belgium	79	91430	43	100066
Germany	36	39610	16	37765
China	34	39144	7	17093
Netherlands	2	2707	7	15294
Chile	-	-	4	7934
USA	2	2595	2	6236
Russia	10	11743	2	4420
UK	15	19081	++	361
Other countries	126	60698	_	_

Table – 8 : Imports of Tellurium (By Countries)

Country	2016-17		2017-18	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**2**	**13212**	**3**	**13734**
China	1	3760	1	4890
Belgium	++	1502	1	4086
Japan	++	115	1	2991
Canada	-	-	++	873
Philippines	++	459	++	577
Germany	++	1060	++	247
USA	++	151	++	70
Russia	++	117	-	-
Hong Kong	1	4429	-	-
UK	++	1619	-	-

FUTURE OUTLOOK

The supply of selenium is dependent on the supply of main product from which it is derived, copper and also to a lesser extent by the supply of nickel where the nickel production is from sulphide ore. The selenium prices are often inversely related to the supply of the major product from which it is derived-copper.

China has been purchasing large quantities of crude selenium. As this material becomes scarer, the prices for standard grade selenium may rise. The combination of these two factors, the decline of selenium containing concentrates from North America and the growth of Chinese demand, should firm up the prices for selenium in the short term.

Demand for selenium in photoreceptors is likely to continue to decline as the cost of substituting organic compounds decreases. The Photoreceptor Industry which was once a major consumer of selenium and tellurium has reached the replacement stage. Selenium has been substituted by alternative material in newer models.

Further, use of selenium in cancer prevention and other health applications may eventually lead to increased consumption of the metal. Dosages taken directly for human consumption will not include large increase in demand for the metal because only minute quantities are necessary for effective therapy.

The demand and supply of tellurium has remained fairly balanced for a decade. In short term, significant increases are not anticipated in either consumption or production, although reduction in copper production may have a bearing on tellurium supply. An increase in demand for high purity tellurium for cadmium telluride solar cells might have a major impact on tellurium consumption. The use of tellurium alloys used in DVD's consumes only small amounts of tellurium and will, therefore, have minimal impact on tellurium demand.