SPECIAL REPORT

Alumina production in India and the trade prospects

By P R Bose and V B Lal

India has important bauxite resources and the potential for developing a strong vertically integrated aluminium industry. In this article P R Bose and V B Lal look at the Indian production, consumption and export of alumina.

Introduction

The manufacture of alumina is an important intermediate stage in making aluminium metal from bauxite. About 95 per cent of alumina produced in the world is made from bauxite. Different types of alumina, namely hydrated, calcined, activated, tabular, and fused alumina, have different Al_2O_3 content, specific gravity and LoI. The characteristics and uses of the different types of alumina[1] are shown in Tables 1 and 2 respectively.

About 90 per cent of alumina produced is used in metal production. Typical calcined alumina used for metal making contains, apart from Al_2O_3, 0.02 per cent SiO_2, 0.02 per cent Fe_2O_3 and 0.03 per cent TiO_2 and traces of P_2O_5. A brief note on alumina extraction and the effect of chemical constituents of bauxite is given in the Annexure.

Global alumina production

Today 24 countries produce alumina. In 1980 the total alumina production of the world was 33.8 Mt which included 512 kt for India[2]. Australia is the largest producer followed by USA; together they account for 41.5 per cent of world production. Of the twelve members of the International Bauxite Association (IBA), namely Guinea*, Ghana, Sierra Leone, Dominican Republic, Guyana*, Haiti, Jamaica*, Surinam*, India*, Indonesia, Yugoslavia* and Australia* only 7 countries (marked by the asterisk) produce alumina.

There were ten countries namely France, Federal Republic of Germany, USSR, Yugoslavia, Canada, Jamaica, USA, Surinam, Japan and Australia which produced over a million tonnes of alumina each and as a whole accounted for 82 per cent of the total world production in 1980. Table 3 shows the

Table 1

Characteristics of alumina
(In per cent)

Types of alumina	Al_2O_3	LOI	Specific gravity	Remarks
Alumina hydrate	65	34.5	2.42	traces of SiO_2 Fe_2O_3, Na_2O.
Activated alumina	93	6	3.1	May be either in powder form, granules or hard porous spheres.
Tabular alumina	99.5	nil	3.65—3.8	
Calcined alumina				
ordinary calcined	99.2	—	3.7—3.9	
low-soda alumina	99.6—99.8	—	3.1	Permissible Na_2O is 0.05 to 0.1 %
Fused alumina				
brown	95	nil	3.95	
white	99	nil	3.95	

Source:
Mineral Facts & Problems: No 5, Monograph on Bauxite, India Bureau of Mines, Nagpur, November 1977, p 290.

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region-wise distribution of world alumina production from 1978 to 1984.

In Asia five countries namely Japan, China, India, Turkey and Taiwan produce alumina. Alumina production in India was recorded as 4 kt in 1945, which increased by 162 times in four decades and touched 649 kt in 1980. Table 4 indicates India's share in Asia and world production. It may be seen that while the Indian share in the Asian production has risen from 23.4 per cent in 1978 to 40.9 per cent in 1983 its share of world production has shown only a slight increase, from 2.2 to 3.3 per cent, during this period.

According to the world aluminium survey alumina refinery capacity in India in 1977 was 685 kt. (Approx 2.25 per cent of the world capacity of 30 345 kt in that year). The total alumina production capacity of the country in 1980 was 689 kt, and 829 kt in 1983[3]. Now, the new alumina plant of *National*

Table 2

Major uses of different types of alumina

Alumina hydrate	Calcined alumina	Activated alumina	Tabular alumina	Fused alumina
Manufacturing of chemical and aluminium compounds.	In metal making. Also used in refractories and fused alumina production.	Drying agents for oxygen, nitrogen, carbondioxide, carbon monoxide, chlorine, sulphur dioxide, helium, ethylene, butane etc.	Useful in making high alumina bricks for furnaces used for making glass and steel.	Used in abrasive industry for grinding.
Used in water purification, varnish paint, pigment and ink industries	Used as a component of polishing compounds.	Used in some processes like isomerisation, cracking and polymerisation where even a small quantity of water is harmful, this type of alumina is of special use.	Useful as filler in epoxy and polyester resins, and coating for welding electrodes.	Used for making refractories.
Useful as a flame retardant filler.	Manufacturing of rocket nozzles, guided missilevanes, combustion chamber lining and as a soft abrassive.		Good thermal conductivity, excellent resistance to thermal shock and high dielectric strength at high temperatures.	

Table 3

Alumina — region wise world production
(in kt and per cent)

Region	1978	1979	1980	1981	1982	1983	1984
Europe	4 161 (16.6)	4 199 (16.1)	4 508 (16.0)	4 952 (18.6)	4 464 (20.1)	4 351 (18.6)	5 235 (19.3)
Africa	621 (2.5)	656 (2.5)	708 (2.5)	679 (2.6)	578 (2.6)	564 (2.4)	550 (2.0)
Asia	2 375 (9.4)	2 446 (9.4)	2 947 (10.5)	2 264 (8.5)	1 812 (8.1)	1 879 (8.1)	2 116 (7.8)
America	11 224 (44.6)	11 347 (43.6)	12 689 (45.1)	11 666 (43.8)	8 747 (39.4)	9 243 (39.6)	10 354 (38.3)
Australia	6 764 (26.9)	7 386 (28.4)	7 284 (25.9)	7 087 (26.6)	6 629 (29.8)	7 305 (31.3)	8 800 (32.6)
World total	**25 145**	**26 034**	**28 106**	**26 648**	**22 230**	**23 342**	**27 055**

Aluminium Company (NALCO) at Damanjodi near Koraput in Orissa is proposed to have two production lines of 400 kt per year each; 40—50 per cent of its alumina capacity is meant for exports.

Table 5 shows the alumina production and its growth in the country from 1965—84.

Alumina production in India

There are four aluminium producing companies in the country at present and the fifth, NALCO, is to start production soon. All of them have their own alumina production plants (see map p 46).

The present yield of alumina depends on the quality of the bauxite fed into the alumina plants; it is of the order of 30—40 per cent. The yield achieved by different companies in India during the

Table 4

Alumina production in India, in Asia and in the world
(in kt and per cent)

Years	India production	Asia production	India's share of Asian production (in %)	World production	India's share of world production (in %)
1984					
1983 (Jan—Sept)	567	1 387	40.9	17 026	3.3
1982	569	1 812	31.4	22 230	2.6
1981	620	2 264	27.4	26 648	2.3
1980	649	2 947	22.0	28 106	2.3
1979	568	2 446	23.2	26 034	2.2
1978	555	2 375	23.4	25 145	2.2

Source:
(For Table 3 and 4 *Economic Times*, Bombay, 1984-05-09, p II.

Table 5

Alumina production

Years	Production kt	Growth of production
1984	644	450
1983	532	372
1982	569	398
1981	620	434
1980	649	454
1975	337	236
1970	314	220
1965	143	100

Source:
Economic Times, 1984-05-09, p II, for the period 1978—83. *Mineral Facts & Problems*, No 5, Monograph on bauxite, Indian Bureau of Mines, Nagpur, Nov 1977, p 305, 313.

Table 6

Yield percentage of alumina from bauxite

Company	1977	1978	1979	1980	1981
BALCO	37.2	40.2	38.8	37.5	36.3
HINDALCO	36.6	36.8	36.2	36.4	35.6
INDALCO Muri	33.5	31.5	31.3	28.6	31.8
Belgaum	33.4	34.9	33.0	32.4	32.4
MALCO	39.3	36.0	38.3	35.7	39.4

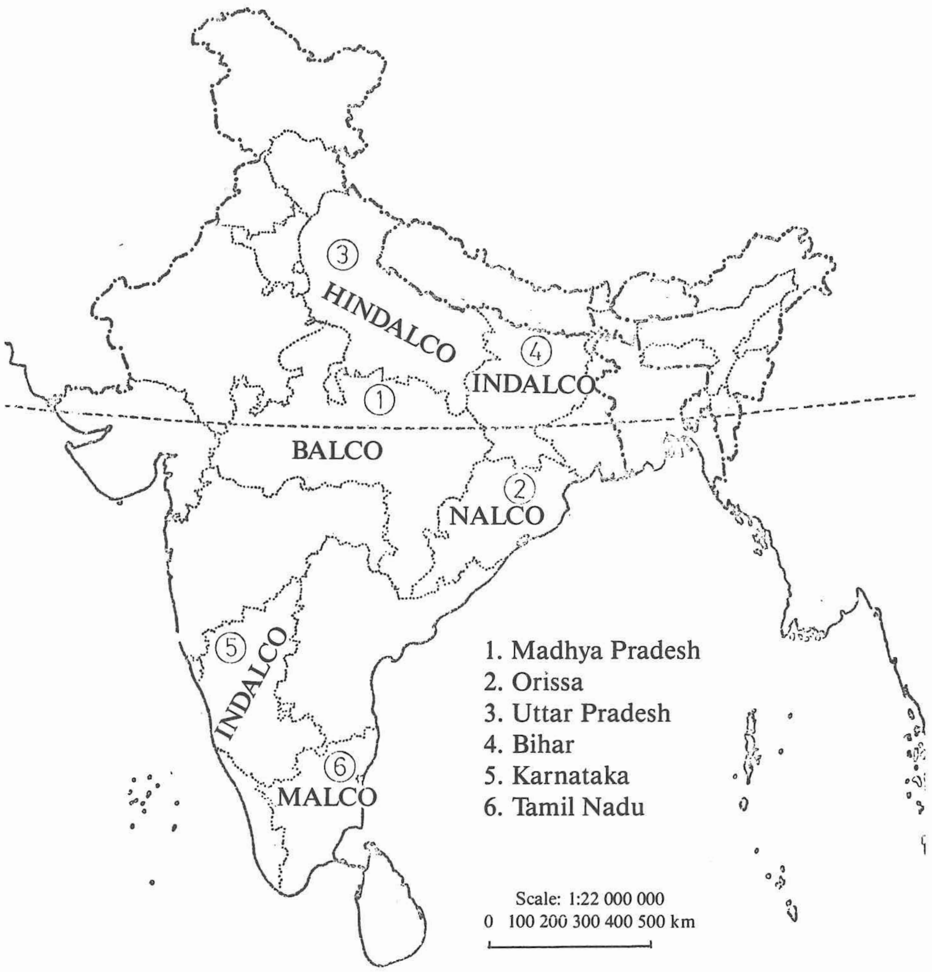
Table 7

Alumina production
in kt (figures in brackets indicate per cent)

Company	1977	1978	1979	1980	1981
BALCO	116 (27.2)	127 (25.8)	117 (23.6)	144 (28.9)	109 (22.0)
INDALCO	113 (31.2)	192 (39.0)	185 (37.3)	159 (31.9)	177 (35.7)
HINDALCO	146 (34.3)	129 (26.2)	151 (30.4)	152 (30.4)	177 (35.7)
MALCO	31 (7.3)	44 (9.0)	43 (8.7)	44 (8.8)	33 (6.6)
Total	**426**	**492**	**496**	**469**	**496**

Fig 4

India: location of alumina plants



Company	Nature of sector	Foreign share (per cent)		Indian share (per cent)		Production sites	Location
BALCO	Public sector		Nil	Government	100.0	Korba	Madhya Pradesh
NALCO	Public sector		Nil	Government	100.0	Damonjodi	Orissa
HINDALCO	Pvt sector	Kaiser	27.0	Birla Group	73.0	Renukoot	Uttar Pradesh
INDALCO	Pvt sector	Alcan	50.5	Private	49.5	i) Belgaum	Karnataka
						ii) Muri	Bihar
MALCO	Pvt sector	Montedison	27.0	Government	73.0	Mettur	Tamilnadu

Table 8

Norm of consumption of raw materials in Indian alumina plants
(Norms given per t of alumina produced)

		Raw material								
Company	Location	Bauxite (t)	Soda (kg)	Lime (kg)	Fuel oil (l)		Coal (t)	Power (kWh)	Steam (t)	Remarks
					Boilers	Kilns				
INDALCO	Muri	3.0	84	40	—	107	1.10	300	6.00	1974
	Belgaum	3.0	90	38	215	106	—	240	3.25	1974
HINDALCO	Renukoot	2.75	100	50	—	320	1.5	—	—	1971
BALCO	Korba	2.59	120	150		130	—	—	3.57	Sep 1975
NALCO	Mettur	3.0	100	23	—	130	0.35	325	—	General figures

Sources:
Mineral facts and problems: No 5, monograph on bauxite, Indian Bureau of Mines, Nagpur, November, 1977, p 317.

period from 1977 to 1981 is indicated in the Table 6.

India produced 40 kt of surplus alumina in 1981 and it was estimated that a surplus production of 1 770 kt per year would be available for export by the year 1985. However, a rescheduling of production plans at NALCO may necessitate revision of this figure.

Norms of raw materials consumption and cost of production

Norms of consumption of raw material and the range of chemical and mineralogical composition of bauxite determines the volume of alumina production. The variation in chemical and mineralogical composition will bring the variation in the norm of consumption of raw materials required for alumina extraction. Table 8 shows company wise raw materials consumption for producing 1 t of alumina.

Table 9 shows the actual raw materials consumption to produce one tonne of alumina from 1978—79 to 1982—83 at *Bharat Aluminium Company* (BALCO).

Table 10 shows consumption of materials, power and fuel for the production of one ton of alumina at *Hindustan Aluminium Corporation* (HINDALCO) from 1977 to 1982. Table 11 shows comparative cost of one ton of alumina production at Hindalco, in 1977 and 1982. The cost of one ton of alumina production in 1977 and 1982. The cost of one ton of alumina production in 1977 was 994.22 Indian Rupees (INR), which increased to 2003.00 INR in 1982. This increase is 201.5 per cent of the cost of 1977.

Analysis of Table 9 and 10 indicates that the quantity of bauxite consumption for alumina production at BALCO is less than HINDALCO to produce one ton of alumina. The consumption of caustic soda & lime in both BALCO and HINDALCO presents interesting features. In BALCO, Caustic soda con-

Table 9

Actual raw material consumption at BALCO

Raw material	Unit	1978—79	1979—80	1980—81	1981—82	1982—83
Bauxite	t	2.4	2.5	2.5	2.5	2.5
Caustic soda	kg	132.9	120.7	118.1	113.5	100.9
Lime	kg	85.2	138.6	128.2	128.2	160.9
Furnace oil	l	139.4	136.5	134.4	133.1	132.6
Steam	t	3.8	3.6	3.2	3.3	3.7
Starch	kg	2.1	1.6	1.8	1.9	2.0

Source:
Data supplied by BALCO.

Table 10

Consumption of materials, power and fuel per ton of alumina production at Hindalco (t)

Years	1977	1978	1979	1980	1981	1982
Production of alumina						
Hydration:						
Bauxite	2.78	2.70	2.76	2.73	2.79	2.85
Caustic soda	0.091	0.094	0.090	0.091	0.091	0.093
Lime	0.04	0.03	0.04	0.06	0.06	0.07
Starch	0.002	0.002	0.002	0.001	0.001	0.001
Filter cloth (m)	0.63	0.68	0.72	0.77	0.56	0.24
Soda ash	0.019	0.018	0.017	0.017	0.017	0.018
Morar floc	0.0001	0.0001	0.0002	0.0004	0.0003	0.0001
LD oil (m^3)	0.0002	0.0003	0.0013	0.0004	0.0004	0.0010
HSD oil (m^3)	—	—	—	—	0.00013	—
Steam coal	0.91	0.85	0.93	0.93	0.93	1.10
Electricity (kWh)	349	353	358	352	339	290
Calcination:						
Fuel oil (m^3)	0.134	0.135	0.138	0.139	0.138	0.131
Power (kWh)	38	39	40	39	38	39
Prebaked carbon electrodes:						
CP coke	0.82	0.84	0.83	0.83	0.84	0.80
Hard pitch	0.32	0.34	0.32	0.32	0.32	0.31
Hard coke	0.027	0.022	0.012	0.022	0.019	0.017
Fuel oil	0.258	0.276	0.267	0.253	0.235	0.177
Steam coal	0.14	0.14	0.15	0.15	0.15	0.17
Power (kWh)	248	277	245	249	237	228
Production of aluminium metal:						
Alumina	1.98	2.00	1.98	2.00	2.00	1.98
Baked anodes	0.45	0.45	0.45	0.45	0.44	0.46
Cryolite	0.028	0.014	0.018	0.009	0.008	0.014
Aluminium Fluoride	0.025	0.027	0.027	0.029	0.026	0.023
Borax	0.001	0.001	0.001	0.001	0.001	0.001
Relining mix	0.025	0.015	0.023	0.025	0.022	0.023
Soda ash	0.001	0.002	0.002	0.003	0.003	0.005
Power (kWh)	16 706	16 488	16 611	16 450	16 606	16 600

Source:
Data supplied by HINDALCO.

sumption has come down from 132.9 kg/t in 1978—79 to 100.9 kg/t in 1982—83 — a decrease of 24.01 per cent. This reduction is to be seen in the context of more or less a constant consumption of bauxite. The consumption of lime over the same period shoots up from 85.2 kg/t to 160.9 kg/t. In HINCALCO, while the consumption of bauxite rises from 2.70 kg/t in 1978 to 2.85 in 1982, it is accompanied by more or less a constant consumption of caustic soda though the consumption of lime rises from 30 kg/t to 70 kg/t which is notably lower than the lime consumption at BALCO.

Table 11 shows the comparative cost analysis of alumina production at HINDALCO during the period 1977 and 1982. It indicates that the rise in cost is almost double in alumina hydrate and

Table 11

Cost of per ton of alumina production at HINDALCO

	1977			1982		
Particulars	**Quantity (t)**	**Rate in INR[1]**	**Cost INR/t**	**Quantity (t)**	**Rate in INR**	**Cost INR/t**
Alumina hydrate						
Bauxite	2.778	79.05	219.55	2.852	147.26	420.00
Caustic soda	0.0907	2 035.54	184.59	0.0927	5 465.87	506.71
Lime	0.038	306.18	11.58	0.074	552.68	40.85
Starch	0.0023	2 581.39	5.99	0.0008	4 137.62	3.24
Filter cloth (m)	0.6316	15.90	9.59	0.238	33.53	7.99
Soda ash	0.0187	1 175.82	22.01	0.0181	2 466.30	44.68
Morar floc	0.0001	8 283.80	1.00	0.0003	15 758	4.29
Power	349	14.3	49.93	289.5	28.13	81.41
Steam coal	0.91	107.70	98.42	1.10	216.67	237.31
Wages/salary			71.56			102.56
L D oil	0.0002	1 072.64	0.25	0.0009	3 128.40	2.98
Repairs & maint			11.12			4.03
Stores			72.81			123.37
Depreciation			26.41			15.12
Overhead			55.90			27.22
Hydrate cost			*840.71*			*1 621.76*
Calcination:						
Fuel oil (kl)	0.1341	1 007.73	135.10	0.13	2 655.65	347.86
Power	38 unit	14.29	5.45	39 units	28.12	10.98
Wages/salary			3.10			5.11
Stores & other			7.14			14.31
Depreciation			0.29			0.20
Overhead			2.43			2.78
Calcination		*153.51*			*381.24*	*cost*
Add: Alumina hydrate cost			*840.71*			*1 621.76*
Total calcinated alumina cost			**994.22**			**2 003.00**

Source:
Data supplied by HINDALCO.

Note:
[1] **INR = Indian Rupees.**

2.5 times higher in calcination. This change is due to two factors; the rise in unit costs of various raw materials and also the increase in their consumption. Between 1977—1982, the consumption of bauxite, caustic soda, coal, all registered an increase. Together these three items accounted for 71.7 per cent of the cost of production of alumina hydrate in 1982. The cost of alumina hydrate in alumina production constituted 84.5 per cent in 1977 and 81 per cent in 1982. The rise in cost was 1.9 times in bauxite, 2.7 times in caustic soda, 3.5 times in lime, double in soda ash and 2.4 times in steam coal. In calcination fuel oil is the major raw material, and though its consumption came down marginally, the cost, because of rising prices, went up 2.6 times by 1982.

Structure of alumina industry

The world aluminium industry as a whole has been dominated by six large vertically integrated companies namely Alcoa, Alcan, Reynolds, Kaiser, Pechiney and Alusuisse. Four of these companies have their bases in North America and two in Europe. The direct and indirect interests of these six companies in domestic and foreign mines, refineries and smelters at present account for 45.7 per cent of the Western World bauxite capacity, 52.5 per cent of primary aluminium capacity and 63.7 per cent of alumina[4]. In the world as a whole the share of these companies accounts for 33.5 per cent of the world bauxite capacity 43.3 per cent of aluminium capacity and 51.9 per cent of alumina capacity in 1982[5]. Governments control approximately 25 per cent of the Western World bauxite capacity, 12—13 per cent of alumina capacity and 16—18 per cent of primary aluminium capacity.

In the East Block countries there is complete state ownership. The share of

Table 12

Alumina imports by major source, 1979

		Quantity imported (kt)	Share of total imports (in per cent)
USA		3 770	
	Australia		76.5
	Jamaica		15.6
	Surinam		6.3
	Others		1.6
Norway		1 165	
	Australia		25.2
	Surinam		26.7
	Jamaica		13.1
	USA		4.4
	Others		30.6
Canada		953	
	Australia		49.1
	Jamaica		18.8
	USA		16.3
	Others		5.8
Japan		761	
	Australia		97.4
	Others		2.6
UK		610	
	Jamaica		65.9
	Surinam		17.4
	Guyana		5.9
	Others		10.8
Netherlands		563	
	Surinam		39.4
	Greece		39.7
	France		16.5
	Others		4.4
Spain		545	
	Guinea		49.2
	Jamaica		35.0
	France		11.9
	Others		3.9
W Germany		458	
	Australia		50.0
	Italy		28.8
	Guinea		3.2
	Others		18.0

Source:
World Aluminium Industry, Vol I. Australian Mineral Economics Pvt Ltd, Sydney, Feb 1982, p 181, 192.

East Block countries in the world production of bauxite, alumina and aluminium is about 15—20 per cent and has been about constant[5]. In addition governments enjoy total ownership of a large numer of companies in Asia, Africa, Latin America and Western Europe.

There is a growing trend among bauxite producing countries to convert bauxite into alumina and then export it to the aluminium making countries. The reason is that the exporter gets a higher price and the importer has to handle less quantity of material.

In 1960 alumina sales to non-integrated aluminium producers were approximately 9 per cent of total Western World alumina sales, which increased to the volume of 20 per cent by the year 1975[4]. The marketing arrangement of the IBA member countries during 1979 shows that only about 12 per cent of the alumina produced is transferred to local smelters; about 65 per cent is exported to affiliated smelters and 23 per cent is sold to third parties, mainly by Alcoa of Australia, Queensland Alumina, and Suralco.

Today Australia is the largest exporting country in the world. In 1979 Australia alone exported 6.4 Mt of alumina, which is 49.3 per cent of the world alumina export. Jamaica figures second having a share of 13.9 per cent and Surinam third with a share of 9.2 per cent in the world alumina export. Together these three countries, with a share of 72.4 per cent dominate the world exporting market[4].

USA is the biggest importer of alumina. Its share in world alumina imports in 1979 was about 31.5 per cent. Norway occupied second position with 9.7 per cent and Canada third with 7.9 per cent. Table 14 shows alumina imports in 1979 by major sources and the per centage share of total imports by country. The table clearly shows that the major importing countries are heavily dependent on Australia. Japan imports about 98 per cent from Australia, USA imports about 77 per cent, Canada and West Germany each imports about 50 per cent from Australia alone.

The place of India in the world alumina trade is insignificant. The export in 1978—79 was the highest, with 202 554 t, mainly to USA, West Germany, Belgium, Luxemburg and Netherlands. To fulfil the requirements of special alumina India has been obliged to make necessary imports. It is time attention is paid to this aspect and that the necessity of such imports is eliminated. Table 13 shows the alumina trade in India from 1971—82.

With the commissioning of NALCO's alumina plant the question of export of alumina will acquire urgency. Table 12 gives the major alumina-importing countries of the West, i e US, Canada, West Germany, Great Britain, Holland, Norway and Spain, along with their principal supply sources. Japan has since then sharply reduced its smelting capacity. Among the East Block countries, the Soviet Union is going for substantial imports. For a number of reasons it appears that it would be difficult for India to penetrate the field of traditional suppliers of alumina to the Western producers. The supplies are often intimately woven into the fabric of operations of multinational companies and cartels; and the production and supply costs are very competitive. Besides achieving a competitive edge in production cost, India has to look for markets elsewhere. The Soviet Union and the countries of the Eastern Block are obviously one region. However, a big opportunity may lie in the countries of the Middle East and Egypt. A number of countries in this region have expenditiously put up large smelting capacities for aluminium, though the region totally lacks the raw materials for aluminium production: bauxite, cryolite, fluorides and petroleum coke. Bahrain (120 kt/year) Dubai (135 kt/year) Iran (120 kt/year) and Egypt (166 kt/year) with a combined production capacity of 541 kt/year of aluiminium are major producers and exporters of aluminium from the region, and obviously they are large importers of alumina[5]. While Bahrain, Dubai and Iran obtain their alumina supplies from Australia, Egypt gets its alumina from Guinea, Australia and the USSR. India is geographically closer to these countries than Australia and Guinea, and in terms of goodwill also India seems to be well placed. It will be worthwhile to make concerted efforts to secure markets in these countries. Two other promising countries which will soon need large supplies of alumina are Algeria and Libya which are reported to be interested in having a smelting capacity of 280 kt/year and 200 kt/year respectively by 1990, all based on imported alumina. Nearer home, Malaysia has ambitious plans to set up 450—500 kt/year smelting capacity in association with transnational aluminium com-

Table 13

Alumina trade in India 1971 to 1982 (in t)

Year	Export	Import
1981—82	96	445
1980—81	77 380	384
1979—80	100 941	495
1978—79	202 554	512
1977—78	4 935	536
1977	1 821	423
1976	40 697	311
1975	42 811	489
1974	32 735	507
1973	30	486
1972	27	522
1971	13	566

Sources:
Mineral Statistics of India, Indian Bureau of Mines, Nagpur 1983, 15(1) p 68, 78, and 1981, 13(2), p 129, 154. Foreign Trade in Mineral and Metals 1976—77 to 1981—82. Indian Bureau of Mines, Nagpur, 1983, Vol 7, p 41, 45.

panies and the Hyundai group of South Korea. The entire capacity will be based on imported alumina[5]. It should be a natural market for India, which will have to compete with Australia as a supplier. Among the other immediate neighbours of India — Pakistan, Bangladesh, Burma, Sri Lanka — none has any smelting capacity for aluminium.

Notes:

[1] *Mineral Facts & Problems* No 5, Monograph on bauxite, Indian Bureau of Mines, Nagpur, November 1977.

[2] *World Mineral Statistics, 1976—80*; Production, Export, Imports, London, HMSO, 1982.

[3] Kumar, R: *Status of the semi-products aluminium industry in some developing countries*, UNIDO/10.512, 1982-09-07.

[4] *The World Aluminium Industry*, Vol I Australian Mineral Economics Pvt Ltc, Sydney, February 1982.

[5] Tegen, A, Dryden, J: Basic facts on the bauxite alumina and aluminium industries, *Raw Materials Report*, Vol 2 No 1 (1983). ■

Annexure

Smelter grade alumina for making aluminium is of two types namely, 'floury' and 'sandy'. The major difference is in the grain size and in the specific surface; sandy is more coarse. About 90 per cent of the alumina produced in the world uses the Bayer process of treated bauxite (about 5 per cent of alumina is produced by a more complicated method — the pyrogenic-combined technology)[2]. the Bayer process has been in practice for about a century and is still the standard process for making alumina throughout the world. This method is dependent on bauxite of reasonably good quality, preferably containing more htan 46 per cent total available alumina and less than 2.5—2.8 per cent silica and caustic soda of at least 98 per cent purity. The method involves the leaching of ground bauxite at high temperature and pressure by caustic soda, and the separation of the resultant sodium aluminate solution which is precipitated as hydrated aluminium oxide by seed crystallization.

Effects of chemical constituents of bauxite

In the making of alumina from bauxite the presence of various chemicals in the ore affects the production. Bauxite with more than 7 per cent of total silica is normally unsuitable for use in Bayer process, and silica content below 3 per cent is generally preferred. Non-reactive silica (quartz, sand, chalcedony etc), is chemically inactive and is rejected as such in the red mud during the process. Its presence adds to the waste burden. The presence of reactive silica clay or other silicates causes loss of caustic soda as well as alumina. Every one gram increase of silica content in bauxite, increases a loss of 0.5—0.7 gm of Na_2O and 0.85—2.0 gm of Al_2O_3[1]. Another method for alumina making is lime sinter process, which has been tried in Germany, the Soviet Union and Austria. The lime-sinter process in combination with Bayer process can treat high silica bauxite without causing much loss of soda used in digesting. The comparative requirements of soda and other raw materials at different percentage of SiO_2 and Al_2O_3 for producing one tonne of alumina is given in Table 14.

The combination of Bayer and lime-sinter processes may prove useful in India also which has high siliceous low grade bauxite deposits in abundance.

Among the iron compounds the ferric oxide (Fe_2O_3) passes directly to the red mud and adds to the quantity of waste, which causes the additional transport, handling problems and affects the productivity. Iron carbonate during the process is reduced to FeO and CO_2 which causes higher consumption of soda and also makes the filtering process difficult. Titania is eliminated in the red mud while vandadium is not completely eliminated and appears as a deleterious constituent in aluminium metal. For EC grade metal, vanadium content should not exceed 0.02 per cent.

Table 14

Comparative requirement of raw materials for varying silica and alumina contents

Raw materials	Unit of consumption	Bayer process at SiO_2 3 % Al_2O_3 55 %	Bayer process at SiO_2 13 % Al_2O_3 50 %	Combination Bayer and lime-sinter process SiO_2 13 % Al_2O_3 50 %
Bauxite (dry)	t	2.0	3.0	2.2
Soda	kg	80	400	120
Lime	kg	60	300	100
Natural Gas	m^3	251	179	633
Limestone	kg	—	—	700