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A NOTE ON THE PROSPECTS OF DEMAND AND SUPPLY OF IRON ORES BY ORE TYPES */

Prepared by the
secretariat of UNIDO

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SUMMARY

(1) The past drastic changes in the world consumption pattern of iron ores by ore types are reviewed together with the current trade pattern of iron ores.

(2) The future iron ore requirements by ore types are estimated for the year 1985 and 2000, taking into account the past trends as well as the future tendency foresawn.

(3) The future iron ore supply capacity is examined for the year 1985 from announced iron ore mining and pelletization projects and compared with the requirements.

(4) The realization of all the iron ore mining projects which were announced to be comleted by 1985, would result in huge surplus of the order of 150 to 260 Mt in 1985 depending on the crude steel production levels at that time.

(5) Even the realisation of only under-construction projects would be sufficient to supply iron ore, if the crude steel production will not exceed 950 Mt in 1985.

(6) Pellets production capacity in 1985 would be by far surplus than required and over capacity may reach the order of 130 Mt if all the announced projects are realized at the announced scale and timing and the crude steel production is of the order of 950 Mt.

(7) In order to meet the expected demand for iron ore in the year 2000, 400 to 650 Mt of new mining projects other than currently known ones have to be identified, studied and implemented by that time. Pellet consumption might rise to 520 - 610 Mt by the year 2000 which is almost 3 times the present capacity. New projects corresponding to 100 - 200 Mt capacity need to be added to the already known projects.

Introduction

1. The Working Group Meeting on Iron Ore held in Vienna from 3 - 5 April 1978 examined various aspects of iron ore supply problems (UNIDO/EX.38), as requested by the First Consultation Meeting on the Iron and Steel Industry and its Bureau Meeting.

2. The Working Group specifically recommended to UNIDO the following for the presentation at the Second Consultation Meeting:

(i) UNIDO should strengthen its relations with UNCTAD, ILAFA, AISU, APEF and all other institutions concerned with iron ore reserves, production and distribution with a view to presenting to the Second Consultation Meeting an up-to-date appraisal of the reserves including as much detail by types as possible and indicating the stages of exploration. Table II in the Working Paper should be supplemented with information on the stages reached by the respective orefield development schemes, and on other orefields recently exhausted (UNIDO/Ex.38 para 11).

(ii) UNIDO should assess the market for lump ore, sinter fines and pellets in 1985 and 2000 in order to present to the Second Consultation Meeting a more precise appraisal of the problem of access to markets and guidelines for future orefield development (UNIDO/Ex.38 para 31).

3. This Note was prepared in order to fulfill the recommendation above with particular emphasis on the second recommendation. In doing so, UNIDO Secretariat made full use of information obtained at the Working Group, a series of papers prepared by UNCTAD [1/] in connextion with its Integrated Programme for Commodities, and various news and information stored in UNIDO.

4. Because of the magnitude of the problem as well as the uncertainty of the future steel industry (therefore also iron ore industry), this Note still remains a preliminary and indicative one, open for discussions.

The past evolution of iron ore consumption by ore types

5. As well known, the consumption patterns of iron ores have changed dramatically in the last two decades, in eager persuance of "better blast furnace burdens with the maximum economy" by the iron and steel industry of the world. Agglomerated ore (sintered ore and pellets) has become the most important burden for blast furnaces, instead of lump ores.

[1/] TD/B/IPC/IRON ORE/2,3,4, TD/B/IPC/IRON ORE/AC/4,7,8,9

It has become common practice to strictly control the size of lump ores. The average Fe content of ores [2/] used in the iron and steel industry has gone up by 10 % in 20 years, both by the dynamic development of high quality ore mines and by vigorous adaptation of beneficiation and concentration technologies at mine sites.

6. The evolution of sintered ores and pellets production in the recent past shown in Table 1 illustrates how fast their production have increased in the world. As a consequence, the requirement for iron ore by ore types has changed drastically as shown in Table 2. Now sinter fines occupies more than 50 % of total ore requirement. Pellet feeds increased from almost 0 % in 1955 to 19 % in 1976. The lump ores (sized and unsized), on the other hand, declined from 77 % in 1955 to less than 30 % in 1977.

Table 1. Evolution of sintered ores and pellets production in the world in Mt. (1955 - 1976) [a/]

	1955	1965	1976
A. Sintered ore			
Developed countries	103	314	496
- of which USSR	34	110	153
EEC	27	91	126
JAPAN	3	25	112
Developing countries	1	5	21
- of which Brazil	1	2	7
India	0	2	7
Mexico	0	0	3
B. Pellets			
Developed countries	2	46	150
- of which USA	1	32	63
USSR	0	0	31
Canada	0	10	27
Developing countries	0	1	16
- of which Brazil	0	0	5
Liberia	0	0	4
Mexico	0	0	3

a/ Derived from UNCTAD tabulation TD/B/IPC/IRON ORE/AC/4

2/ The average Fe content of run of mines, beneficiated and agglomerated ores. Calculated dividing iron ore production (Fe content) by iron ore production (actual weight) which appeared in statistical Tables (UNCTAD: TD/B/IPC/IRON ORE/AC/4).

Table 2 The changes in the iron ore consumption pattern in the world (1955 - 1976) [a/]

		1955	1960	1965	1970	1976	Growth/year (%)
Iron ore production (Mt)		378	512	624	768	877	4.1
(Average Fe content) (%)		47	49	52	56	57	-
Iron ore used		403	506	625	771	859	3.7
As lump ores	(Mt)	309	319	298	273	237	-1.3
	(%)	(77)	(63)	(48)	(35)	(27)	
As sinter fines	(Mt)	92	171	281	381	455	7.9
	(%)	(23)	(34)	(45)	(49)	(53)	
As pellet feeds	(Mt)	2	16	47	118	167	25.2
	(%)	(0)	(3)	(7)	(15)	(19)	

[a/] Calculated based on iron ore (actual weight and Fe content), sintered ores and pellets production data shown in UNCTAD tabulations TD/B/IPC/IRON ORE/AC/4

7. There are, however, considerable differences in the iron ore consumption patterns by nations and regions, depending on the types of locally available ores, ore import sources, etc. For example: [3/]

- Canada and USA: Those two countries alone produce some 60 % of world pellets. It is estimated that total blast furnace burden [4/] consists of 55/60 % pellets, 20 % sintered ore and the balance lump ores.

- EEC of 9: Three quarters of burdens are sintered ore and the use of pellets is less extent, of the order of several percent.

- Japan: Blast furnace burden consists of 72 % sintered ore, 11 % pellets and 17 % sized lump ores.

- E.Europe including USSR: Three quarters of burdens are sintered ore. The use of pellets is increasing rapidly in the last ten years and estimated to reach 15 % in 1976. Lump ores, therefore, represent 10 % or less of total burden.

[3/] Based on various information including ECE 'Annual Bulletin of Steel Statistics' and 'Steel/GE.3/R.3/Add.1'

[4/] In this Note, the term "blast furnace burden" signifies only sintered ores, pellets and lump ores and does not include other iron bearing materials such as manganese ore, pyrites cinder, etc.

8. Since the production of sintered ores in developing countries is a rather new development as already shown in Table 1, sintered ores seem to occupy less than 40 % of the blast furnace burden with most of the balance as lump ores (sized and un-sized). The pellets production has increased very much, but most of them are exported or used for feed for direct reduction processes, thus their use in blast furnace seems to be rather limited.

9. With regard to pre-reduced iron production and the pellets consumption for that, it occupies a rather small part of new iron production (blast furnace pig iron plus sponge iron) and pellet consumption in the world. In 1976, sponge iron production for electric arc furnace use was around 6 Mt, compared to the pig iron of 487 Mt. Pellets, used for all pre-reduced iron production were estimated to be also some 6 Mt which is less than 4 % of total pellet production. It would, however, be appropriate to treat pellet consumption for direct reduction purpose separately from that for blast furnace uses when one considers future requirement of iron ores and pellets, because of dynamic expansion envisaged of this process.

The current iron ore trade pattern in the world

10. Since UNCTAD and other bodies are actively working on the subject of iron ore trade, the descriptions here on the trade are limited to the minimum required for the analysis of the future prospects of demand and supply in the world scene.

11. Figure 1 indicates main iron ore importing regions together with import sources in developing and developed countries, which is derived from UNCTAD tabulation. It is clearly shown that Japan and EEC are by far the largest iron ore importing regions, followed by E.Europe (excluding USSR) and USA. W.European countries other than EEC countries are also net importers of iron ores but the market size is 15 Mt/y. A few developing countries (Republic of Korea, Argentina, etc.) are the net importers of iron ores but total market size is only 3 Mt/y at the present moment, although this market would expand rapidly in the future particularly in Far East, South East and Middle East Asia.

12. This indicates that the iron ore industry in developing and developed countries excluding USSR is very much, almost totally, effected by the consumption levels of iron ore in Japan, EEC, USA of which the steel industry is in deep recession since 1975. Also the future demand pattern of iron ores by ore types in the international market will be largely determined by those three and E.European countries.

The future demand levels of iron ore

13. Needless to say, the iron ore demands (Fe content) are almost completely decided by the new iron production levels which are in turn mostly governed by the crude steel production levels. The crude steel production levels in the future years are very uncertain

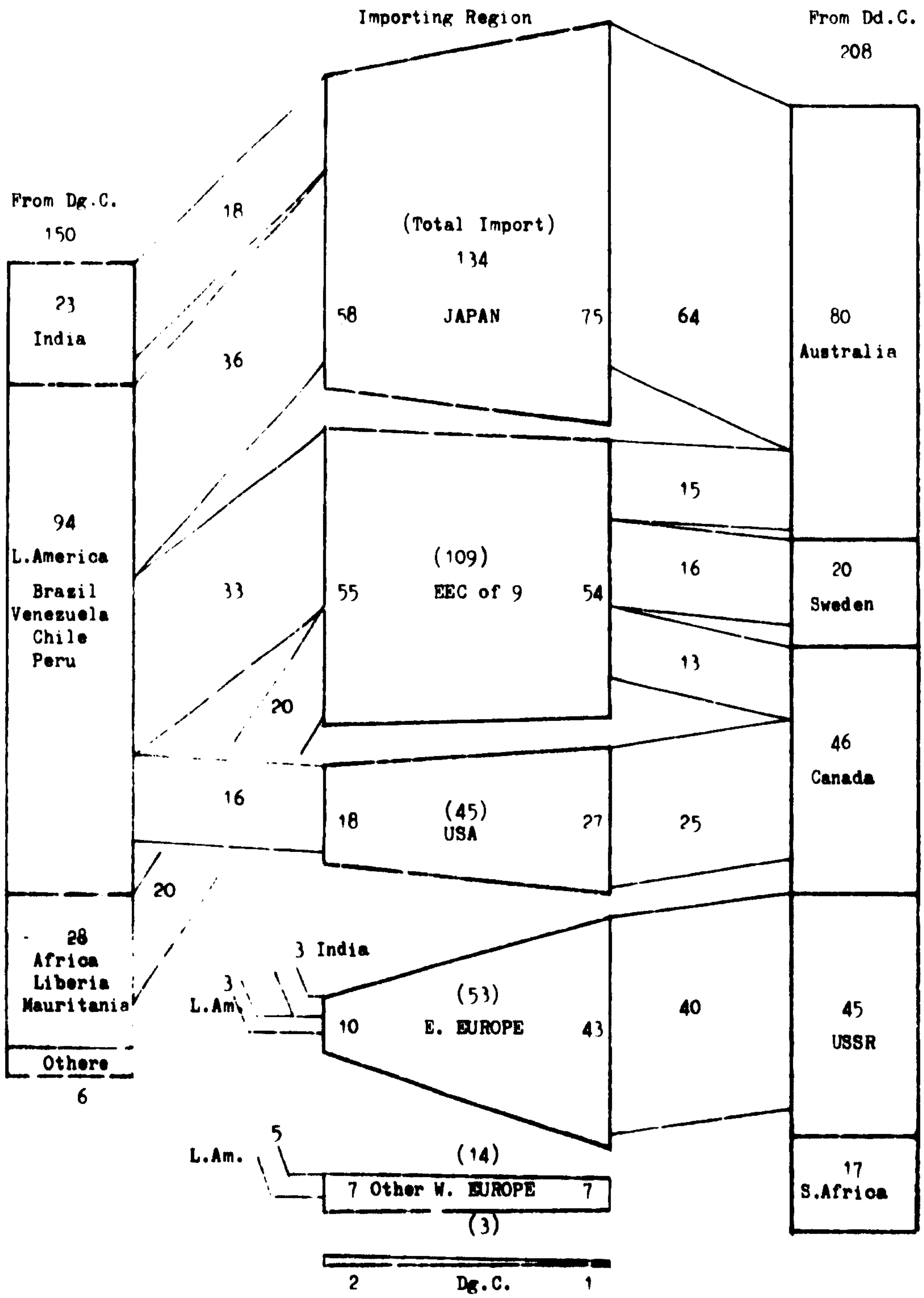

Fig.1 Simplified world import pattern of iron ore by area of origin in Mt of actual weight (1976) (Intra EEC Trade ommitted, based on TD/B/IPC/IRON ORE/AC/4)

at the present moment. Therefore in this Note, two alternatives are assumed as the basis for further discussions. These alternatives, other basic assumptions made, and calculated iron ore requirements are shown in Table 3.

Alternative 2 for the crude steel production levels is the figures discussed in the First Consultation Meeting, and Alternative 1 is the arbitrarily selected figures by the UNIDO Secretariat taking into account the effects of 1975 - 1978 slump in the world steel production and observation of a few informed personnel.

As for the sponge iron production level for electric arc furnace use in the future, it is assumed that 80 - 90 % of announced projects [5] would be realized by 1985 and operated at 85 % capacity utilization ratio. For the year 2000, it is arbitrarily assumed that 10 % of new iron production would be based on sponge iron routes.

14. What will be the ratio of sintered ores, pellets and lump ores as blast furnace feed in the future years, particularly sintered ores and pellets ratio?

There have been many discussions over relative merits of sintered ore and pellets. Many factors have to be considered besides availability of suitable raw materials. Main factors would be quality, prices and siting of plants. Further the current well accustomed burden preparation and selection practices of the main ore consumers could play important role in selection of the future burden materials.

15. Of the many quality factors pellets have distinct superiority over sintered ore in the cold state strength, as far as acid pellets are concerned. Further, reducability of pellets seems somewhat better than for sintered ore. Sintered ores, on the other hand, have better high temperature strength (or better melting characteristics) and wider range of chemical composition (and other qualities) adjustment. The production of self-fluxing sintered ores is general practice, while application of basic pellets is rather limited. Further day-to-day close control of sinter quality best suited to the condition of blast furnaces is possible, taking advantage of controllability of sintered ore quality as well as of the fact that sinter plants, in almost all the cases are located in the steelworks.

16. It is a fact that almost all the super blast furnaces (say above 3,000 m3) which require special care of burden control, use 75-95 % of sintered ore as burdens. Some large size blast furnaces (2000 - 3000 m3) (e.g. Kakogawa of Kobe Steel, Hirohata of Nippon Steel, Ijmuiden of Hoogovens, etc.) use pellets up to 50 % together with sintered ores. Almost all the blast furnaces of USA which uses 75 to 95 % pellets have sizes of less than 2000 m3. Many blast furnace engineers who deal with super blast furnaces seem to be of the opinion that the pellet ratio is limited to 20 - 30 % for the stable operation

[5] J. Millers' tabulation appeared in Metal Bulletin Monthly June 1977

Table 3 Assumptions made for calculations of future iron ore requirement

Items	Actual				Assumption and Estimation			
					1985		2000	
	1960	1965	1970	1976	Alt.1	Alt.2	Alt.1	Alt.2
1. Crude steel production (Mt)	345	458	599	682	950	1050	1550	1750
2. New iron/crude steel ratio	0.701	0.711	0.715	0.723	0.72	0.72	0.73	0.73
3. New iron production (Mt) (1x2)	242	326	429	493	684	756	1095	1278
3.1 Pig iron (Mt)	242	326	427	487	648	715	985	1150
3.2 Spong iron (Mt)	—	—	1	6	36	41	110	128
4. Iron ore (Fe content) /New iron production	1.01	1.00	1.00	1.02	1.00	1.00	1.00	1.00
5. Fe content of iron ore	0.479	0.523	0.555	0.574	0.59	0.59	0.62	0.62
6. Iron ore requirement (Mt) (3x4/5)	512	624	768	877	1148	1269	1743	2033
6.1 For pig iron (Mt)	512	624	767	869	1098	1212	1589	1854
6.2 For sponge iron (Mt)	—	—	1	8	50	57	154	179

Notes Item 2: Assumed remains at almost same level, considering scrap availability decrease by continuous casting and higher yield of rolling but increase through intensified scrap collection and slower steel production growth rates in the future.

Item 3.2: Assumed 80 - 90 % project realization ratio of announced projects and 85 % capacity utilization ratio for 1985. For 2000, assumed 10 % of total new iron production will be based on sponge iron.

Item 5: Assumed improvement of Fe content will further continue at slower rates than in the past.

Item 6.2: Calculated by multiplying 1.4 to the sponge iron production (Item 3.2).

of their furnaces. It may be said, therefore, that for smaller (less than 2000 m3) blast furnace high ratio of pellet charge can be regarded as being a well established practice but for larger blast furnaces some doubts still exist towards the application of higher pellet ratio.

17. As for the relative prices of sintered ores and pellets, sintered ores seem to be advantageous compared to pellets. Table 4 shows a rough comparison of prices among lump ores, sinter fines and pellets. The costs of sintered ore production seem to be some 4 - 7 US$ per ton of sintered ore including the cost of raw materials other than sinter fines. Cost advantage of sintered ores is partly due to the fact that sintering utilizes in-plant generated materials and fuels such as coke breeze, iron bearing dusts and mill scales, and coke oven (and blast furnace) gas.

Table 4 Price comparison of sinter fines, pellets and sized lump ores (1977) [a]

Ores	US$ per ton	US$ per unit Fe ton
Sinter fines: (62 % Fe)	11 - 14	18 - 23
Pellets : (63 - 67.5 % Fe)	21 - 24	33 - 36
Lump ore (64 - 66 % Fe)	13 - 18	20 - 27

[a] Nominal contract prices of Australian ores in the Japanese market (FOB Australia) taken from TEX Iron Ore Manual.

18. Siting of pellet plant is much less restricting than sinter plant, because of easiness of transportation of pellets and less polluting nature of pellet production. It appears that many of the pellet production projects (in iron ore rich countries) have been triggered by the consideration that further sintering machines installation in already industrialized regions would not be appropriate from the pollution control point of view. Availability of reasonably priced fuels - on the other hand - can be regarded as a main concern for the siting of pellet plants because of very high proportion of fuel costs as production cost factors of pellets. Because of the existing large over-capacity of sintering facilities in Japan and EEC, highly advanced pollution control technologies (although they are costly), and high costs of fuels for pellet production, the merit of siting of pellet plants seems to be not able to play an important role in increasing pellet production capacity in the iron ore producing regions for the time being.

19. Considering the above factors and the past trends, sinter fines/pellets/lump ores requirement ratios for blast furnace use are assumed as shown in Fig.2. Based on this assumption, the future iron ore requirements by ore types were calculated and shown in Table 5.

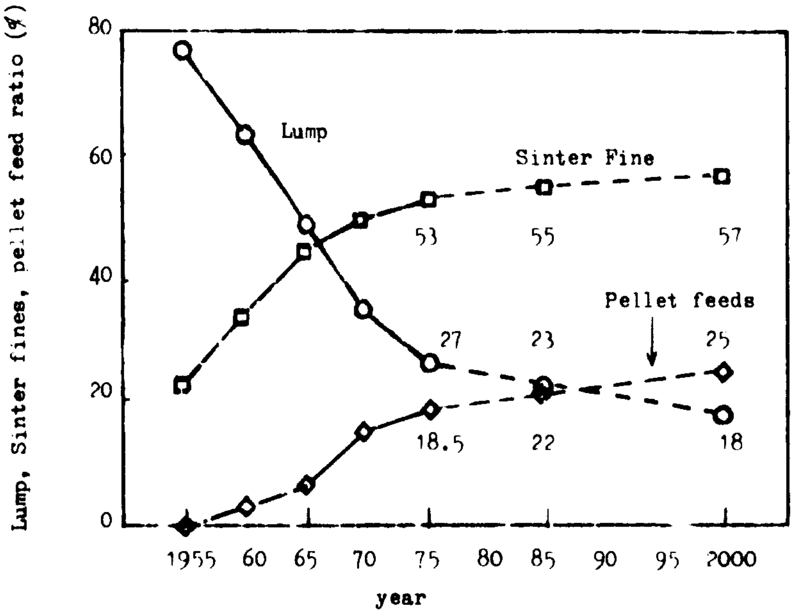

Fig. 2 **Assumed lump/sinter fines/pellet feed ratio for blast furnace iron production**

Table 5 Future iron ore requirement by ore types

	1985		2000	
	Alt.1	Alt.2	Alt.1	Alt.2
For pig iron [a/]	1098	1212	1589	1854
- Lump ore	252	279	286	334
- Sinter fines	604	666	906	1057
- Pellets	242	267	397	464
For sponge [b/]	50	57	154	179
- Pellets	40	46	123	143
- Others	10	11	31	36
Total	1148	1269	1743	2033
- Lump	256	285	300	352
- Sinter fines	610	670	920	1074
- Pellets	282	313	520	607

a/ **Calculated based on assumed indexes in Fig.2**

b/ **Calculated assuming iron ore requirement is 1.4 times of sponge production of which 80 % uses pellets and the rest fines and lump.**

20. In the discription above, pre-reduced iron production for blast furnace use and pellet consumption for that was not separated from pellets for blast furnace feed. Because of significant advantages in coke ratio reduction in blast furnaces and effective usage of in-plant generated iron bearing fines (once considered as wastes), the production of pre-reduced iron for blast furnace use (most of them using solid reductant in rotary kiln furnaces) might increase considerably particularly in the developed countries. It is possible that this affects considerably sinter fines/pellets requirement ratio in the midium to long term future.

Iron ore supply capacity

21. Iron ore production of the world reached its peak of 900 Mt in 1974. During 1975 -76 several ore mines have been opened and the 1976 year end mining capacity of the world was estimated to be somewhere around 950 Mt.

22. A numerous number of iron ore mining also processing project had been announced as shown in detailed list prepared by UNCTAD [6/]. The list was examined together with supplementary data stored in UNIDO and the results were summarized in ANNEX 1 which shows mining and pelletization capacity increase which potentially can be realized by 1985 with rough classification of project status.

23. When the capacity increase above is added to the current capacity and exhausting capacity is subtracted, one can obtain probable 1985 mining and pelletization capacity which is shown in Table 6. Also assuming lump/sinter fines rat o of 30/70 for the new mining capacity, other than pellet feeds production capacity, iron ore supply capacity by ore types was calculated and shown in Table 7.

Prospects for iron ore demand and supply

24. The iron ore supply data (Table 7) was compared with iron ore requirement data (Table 5) in Table 8 and illustrated in Fig.3. It is apparent from the Table and Figure that the completion of already under-construction projects only will result in sufficient supply for 1985 iron ore demand if steel production is of the order of 950 Mt. Even when crude steel production level reaches 1050 Mt, realization of all known projects will result in huge surplus capacity of the order of 150 Mt.

25. Table 8 further indicates that:

(i) Lump and particularly sinter fines supply will be relatively tight when only the projects under-construction are realized.

6/ TD/B/IPC/IRON ORE/AC/4 Table XVI

Table 6 Iron ore mining and pelletization capacity in 1976 and 1985

	Iron ore mining a/			Pelletization b/		
		1985			1985	
	1976	Case A c/	Case B d/	1976	Case A c/	Case B d/
Developing countries	300	430	560	3[illegible]	105	15[illegible]
Developed countries	650	756	842	175	228	253
World total	950	1186	1417	206	334	411

a/ It is assumed that 50 Mt of existing (1976) mining capacity will be exhausted by 1985 (some [illegible] of existing capacity).

b/ Because of relatively new installation of pellet plants, close down of plants by 1985 is not assumed.

c/ Case A : Assumed only under construction projects are realized.

d/ Case B : Assumed all the projects are realized.

e/ There are a few contradicting data on 1976 pelletization capacity of the world. For example "Agglomeration 77" Chapter 1: 280 Mt, Chapter 6: 200 Mt; Metal Bulletin "Iron and Manganese ores" 210 Mt; LKAB unpublished data 222 Mt.

Table 7 Iron ore supply capacity by ore types

Ore types	1976		1985 Case A c/		1985 Case B d/	
	Mt	(%)	Mt	(%)	Mt	(%)
Lump a/	248	(26)	256	(22)	302	(21)
Sinter fines a/	486	(52)	596	(50)	704	(50)
Pellet feeds b/	206	(22)	334	(28)	411	(29)
Total	950	(100)	1186	(100)	1417	(100)

a/ It is arbitrarily assumed that lump/sinter fines ratio of new capacity other than pellet feeds capacity is 30/70.

b/ It is assumed pelletization capacity is equal to pellet feeds supply capacity.

c/ d/ See foot note of Table 6

(ii) However, pellet plants might have an over-capacity of 52 Mt. If all the projects are realized the over-capacity might go up to 129 Mt which corrssponds to 46 % surplus capacity, if capacity utilization ratios of pellet plants are 100 %.

(iii) Lump ores and sinter fines will also be in oversupply if all the projects are realized at the announced scale by 1985, but surplus capacity remains in the order of 15 %.

Table 8 The prospects of supply and demand or iron ores of the world by ore types in 1985[a/]
(For the curde steel production level of 950 Mt)

Casss	Items	Lump	Sinter fines	Pellets	Total
When only under-construction projscts are realized	Supply capacity (Mt)	256	596	334	1186
	Dsmand (Mt)	256	610	282	1148
	Surplus (Mt)	0	-14	52	38
	Surplus ratio (%)[b/]	(0)	(-2)	(18)	(3)
When all the projects are realized	Supply capacity (Mt)	302	704	411	1417
	Demand (Mt)	256	610	282	1148
	Surplus (Mt)	46	94	129	263
	Surplus ratio (%)[b/]	(17)	(15)	(46)	(23)

a/ It is assumed that ore mine capacity as well as pellst plants operate at 100 % of capacity utilization ratio.

b/ Surplus dividsd by demand.

26. When one looks at the increass of pslletization capacity in the developing countries (74 to 131 Mt by 1985 as shown in ANNEX 1), the trade pattern of iron ores (as shown in Fig.1) and ths fact that most of the pellet projects in developed countries are rathsr for domestic use, one might concluds that export capacity of psllets from developing countries is far mors than adequate.

27. It is true that many pellet projscts in developing countries ars joint ventures with developed countries' consumers and havs concrete long term contracts for export, obliging partners and contractors to use pellets to some extent. This might result in mors consumption of pellets by importing nations than assumsd. Also projects already announced might be reduced in capacity and be deferrsd by some years. In the rsality, therefore, too much over-capacity situation will be avoided. Neverthelsss, the prospect of pellet projects is rather pessimistic at least for the time being.

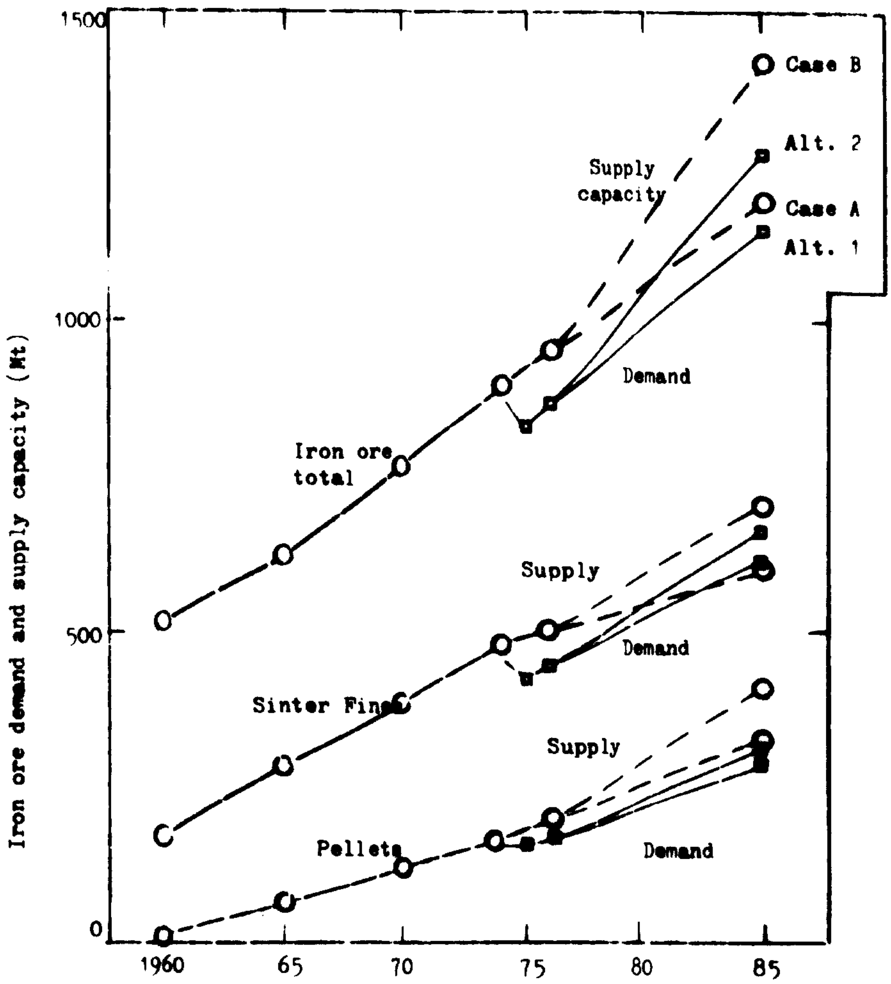

Fig. 3 Iron ore demand and supply capacity balance of the world

Alt.1 : Crude steel production 950 Mt
Alt.2 : - " - 1050 Mt
Case A: Case when only under construction projects are realised
Case B: Case when all projects are realised

28. The demand supply balance of pellets being rather gloomy for suppliere, pellet projects should be carefully examined in the context of international market. Firm long term contracts with consumere preferably with financial involvement, seem to be the must for the investment decision for the export oriented pellet projects in developing countries.

29. As for the longer term (up to the year 2000) prospects of iron ore, the currently known projecte are not enough to eupply iron ore demand. Projecte totalling 400 to 650 Mt of new mining capacities have to be identified, studied and implemented by that time. Requirements for higher quality ores, the needs for thorough utilization of iron content of the deposits in view of raw material and environmental coneervation, and the proepecte of fastly developing direct reduction procese will certainly call for concentrated and agglomerated iron ore, particularly pellets. It is estimated that pellet consumption might rise to 520 - 610 Mt in the year 2000 which is almost 3 times of the present capacity.

ANNEX 1 Capacity increase of iron ore mining and pelletization which potentially can be realized by 1985.

Country and region	Mining capacity increase Under-construction	Mining capacity increase Others	Pelletization capacity increase Under-construction	Pelletization capacity increase Others
Algeria	2	10	-	-
Angola	-	7.2 (P)	-	6
Argentina	3.5 (P)	-	2	-
Brazil	37	60	25	16
Chile	2.9 (P)	-	4	5
Gabon	-	10 (L)	-	-
Guinea	-	8 (S)	-	-
India	18.5	15.5	3.8	2
Iran	5	-	7.5	-
Ivory Coast	12 (P)	-	12	-
Liberia	8.5 (P)	13.5 (S,P)	10	11
Libyan AJ	-	5	-	-
Mauritania	-	6 (S)	-	-
Mexico	1.5 (P)	-	1.5	-
Peru	-	-	-	3.5
Philippines	-	2	-	-
Turkey	3.6 (S,P)	6 (P)	1.6	6
Venezuela	-	-	6.6	2
Yugoslavia	-	2.2	-	-
China and Korea, DPR[a/]	50	-	-	-
Sub total	144.5	145.4	74.0	51.5
Australia	11 (L,S)	42 (L,S)	-	-
Canada	-	4	-	4
S.Africa	13 (L,S)	15 (L,S)	-	-
Spain	5.5 (P,S)	-	3.8	-
Sweden	-	-	1	3
USA	20.3 (P)	17.5 (P)	20.1	17.5
Other W.Europe	0.7	7.5	1.2	-
E.Europe and USSR	90[b/]	-	27[c/]	-
Sub total	140.5	86	53.1	24.5
Total	284.5	231.4	127.1	76.0

a/ It was assumed that ore production will almost double the one of 1976.
b/ Assumed that ore production increase at 3.5 % annual growth rate.
c/ Assumed that pellet production is about 30 % of ore mining capacity increase.
(L), (S) and (P) stand for lump ore, sinter fines and pellet feeds.

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